Table of Contents

Table of Contents (cont'd)

List of Tables

Table of Contents (cont'd)

List of Figures

Table of Contents (cont'd)

Table of Contents (cont'd)

Table of Contents (cont'd)

List of Appendices

Section 2: Plan Area and Basin Setting

2.1 Plan Area

This section describes the South American Subbasin (SASb) Groundwater Sustainability Plan (GSP) area including the following plan area components:

- Major streams
- Institutional entities
- Agricultural and urban land uses
- Locations of groundwater wells
- State, federal, and tribal lands
- Watersheds

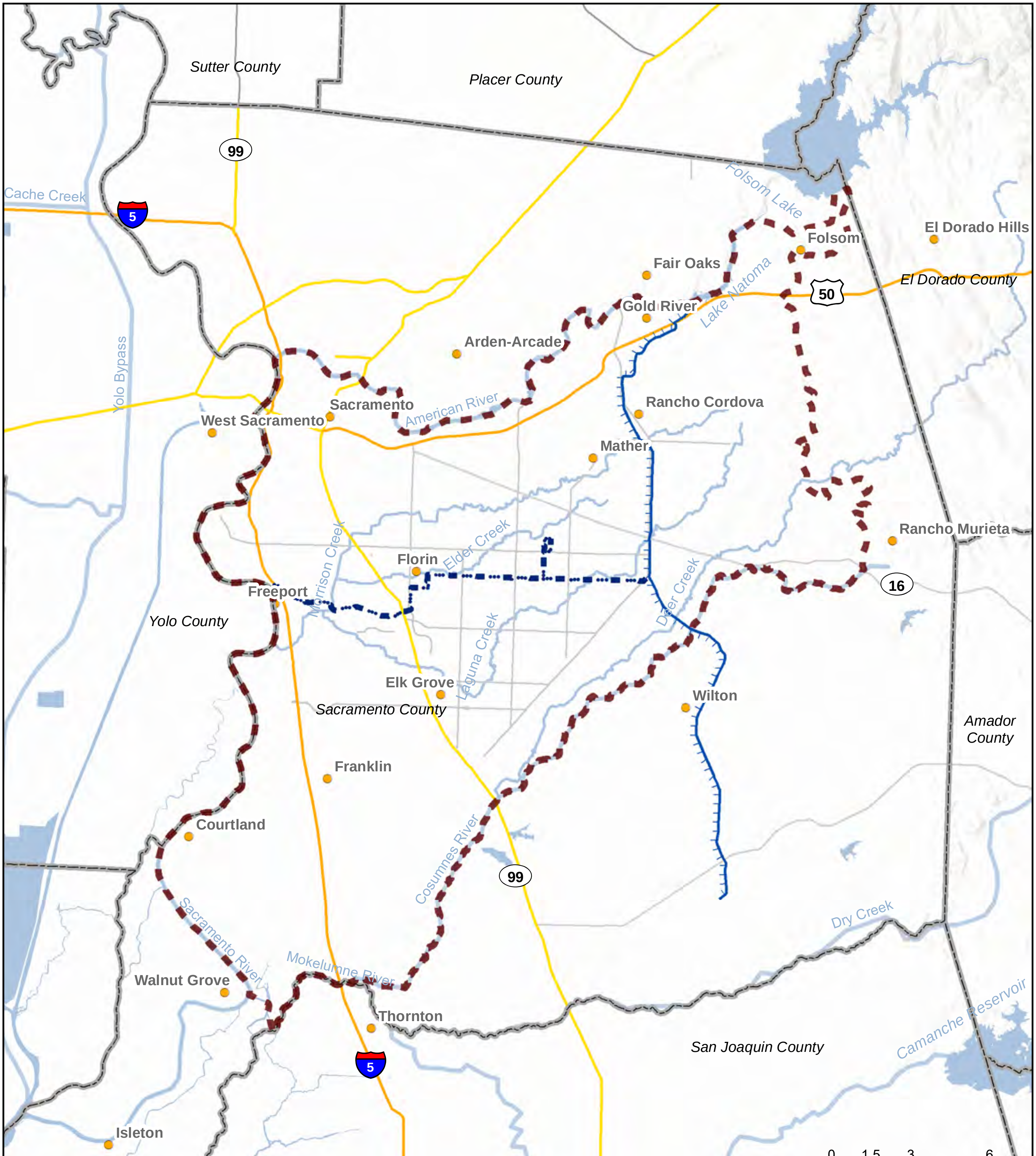
This section also describes existing monitoring programs for surface water flow and water quality, groundwater elevation and quality, subsidence, municipal and remediation operations, plus water management plans in the SASb. Information in this section was gathered from publicly available sources.

2.1.1 Plan Area Definition

The SASb (defined as Basin 5-21.65 in Bulletin 118) encompasses roughly 388 square miles of the southeastern portion of the Sacramento Valley Groundwater Basin (SVGB) and spans the border between the Sacramento River Hydrologic Region and the San Joaquin River Hydrologic Region. The SVGB is a structural trough that represents the northern portion of the Great Central Valley of California. **Figure 2.1-1** shows the key geographic features in the SASb, which are described below.

According to DWR's *Bulletin 118 Update 2016: California's Groundwater* (Bulletin 118), the SASb is generally bounded on the north by the American River, on the east by the Sierra Nevada, on the south by the Cosumnes and Mokelumne Rivers, and on the west by the Sacramento River. The northern boundary begins at the confluence of the American River and Sacramento River and extends upstream, where the eastern boundary becomes the geologic contact between alluvial sediments and fractured bedrock. The southern boundary extends along the Cosumnes River to the confluence with the Mokelumne River and continues to Dead Horse Cut canal. The western boundary includes Dead Horse Cut, Snodgrass Slough, and the Delta Cross Channel and then follows the Sacramento River north to its confluence with the American River (DWR, 2016a).

The SASb is located entirely within the central portion of Sacramento County and contains an estimated population of nearly 752,000 residents (DWR, 2016b). The majority of these residents are located in the cities of Elk Grove, Rancho Cordova, the southern portion of Sacramento, the southern portion of Folsom, and an unincorporated area of Sacramento County that falls within the SASb. The cities of Sacramento and Elk Grove are in the mid- to north-central portion of the SASb along Highway 99 and Interstate 5. Rancho Cordova is located along the central northern boundary and Folsom is in the northeastern portion of the SASb along Highway 50. Natural waterways within the SASb include Alder, Buffalo, Morrison, Elder, Beacon, Laguna, and Deer Creeks. Major anthropogenic water features in the SASb include Lake Natoma, the Freeport Regional Water Authority Pipeline, and the northern portion of the Folsom South Canal.



South American Subbasin GSP

Key Geographic Features

Figure 2.1-1

Legend

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

South American SUBBASIN

Map Created: June 2020

2.1.2 Plan Area Setting

2.1.2.1 Overview

The SASb is one of 16 subbasins that comprise the SVGB. The SASb occupies the southeastern corner of the SVGB and is bordered to the southwest by the Solano Subbasin, to the northwest by the Yolo Subbasin, and to the north by the North American Subbasin. The San Joaquin Valley Groundwater Basin borders the SVGB to the south and constitutes the southern portion of the Great Central Valley of California. The SASb is bordered to the south by the Eastern San Joaquin Subbasin and the Cosumnes Subbasin. **Figure 2.1-2** shows the neighboring subbasins within the SVGB and San Joaquin Valley Groundwater Basin.

There are six GSAs that cooperatively manage groundwater within the SASb. As shown in **Figure 2.1-3**, the jurisdictional boundaries of these GSAs cover the entirety of the SASb, leaving no unmanaged area. There are no adjudicated areas in the SASb.

The SASb falls entirely within Sacramento County and is bordered on the west by Yolo County and on the south by San Joaquin County as shown in **Figure 2.1-4**.

2.1.2.2 Regional Watersheds

As mentioned above, natural waterways in the SASb include the American, Sacramento, Mokelumne, and Cosumnes Rivers, which bound the basin on the North, West, and South sides. In addition, Alder, Buffalo, Morrison, Elder, Beacon, Laguna, and Deer Creeks flow through the basin. **Table 2.1-1** shows the SASb's overlying watersheds as defined by U.S. Geological Survey (USGS) Watershed Boundary Dataset. **Figure 2.1-5** shows the watersheds that overlie the SASb.

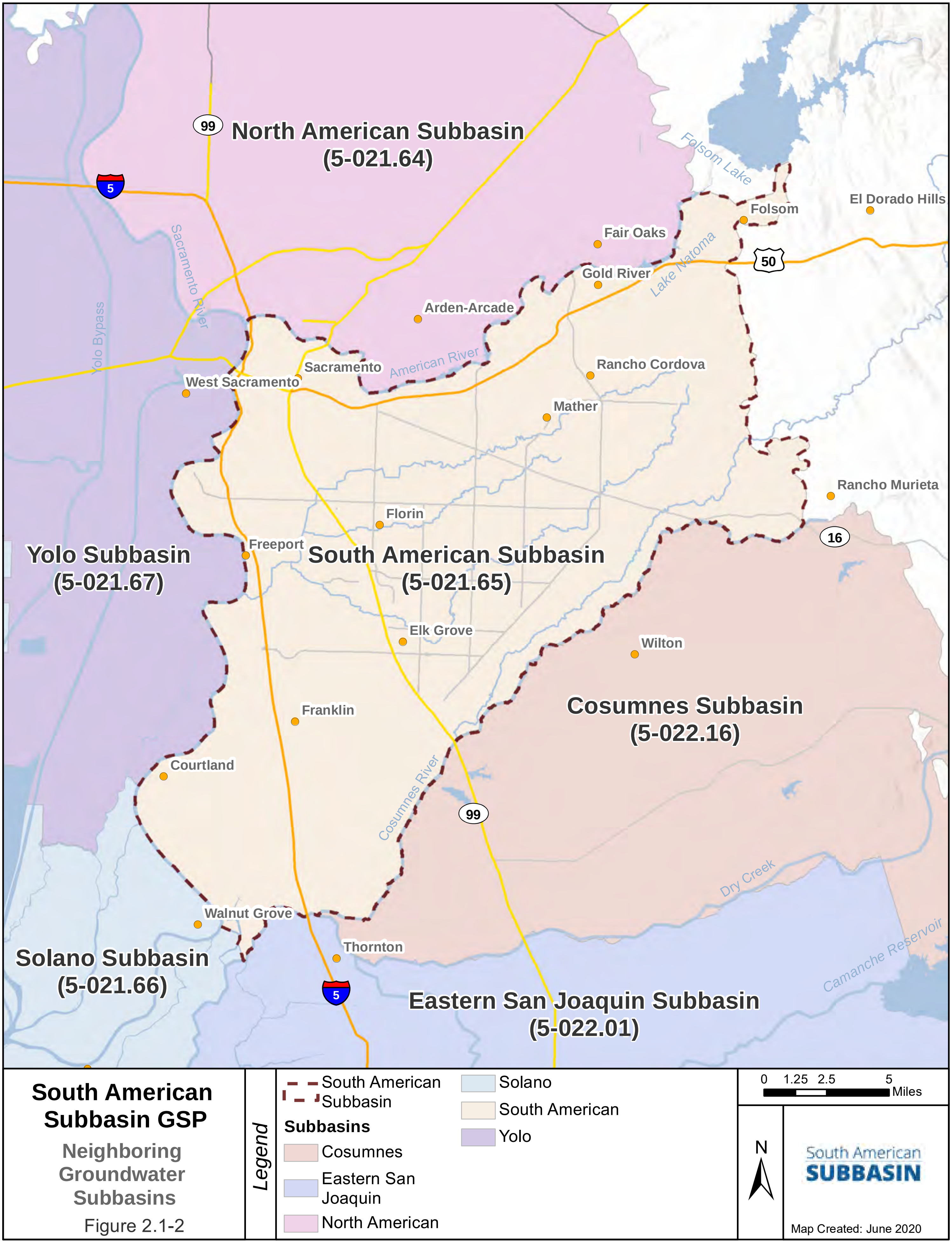
Table 2.1-1: Regional Watersheds

HUC-8	Watershed
18020111	Lower American
18020163	Lower Sacramento
18040012	Upper Mokelumne
18040013	Upper Cosumnes

Note:
HUC-8 = eight-digit hydrologic unit code

2.1.2.3 Water Purveyors

There are nine municipal and three agricultural water purveyors in the SASb. Municipal water purveyors include the California American Water Company, City of Folsom, City of Sacramento, Elk Grove Water District, Florin County Water District, Golden State Water Company, Rancho Murieta Community Services District, Sacramento County Water Agency (SCWA), and the Tokay Park Water Company. Agricultural purveyors include Sacramento Regional Sanitation District, and North Delta Water Agency. The Sacramento Regional County Sanitation District is the only recycled water purveyor in the SASb. **Table 2.1-2** lists the total water distributed by water purveyors for the 2018 water year in acre-feet per year (AF/year) (SCGA, 2020).



South American Subbasin GSP

Neighboring Groundwater Subbasins

Figure 2.1-2

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk.

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\2. Figure 2-2 Neighboring Groundwater Basins.mxd

South American Subbasin GSP

South American Subbasin GSAs

Figure 2.1-3

Legend

South American Subbasin

GSAs

- Northern Delta GSAs
- OHWD GSA (SASb)
- RD 551 GSA
- SCGA GSA
- SRCD GSA (SASb)
- Sac Co GSA

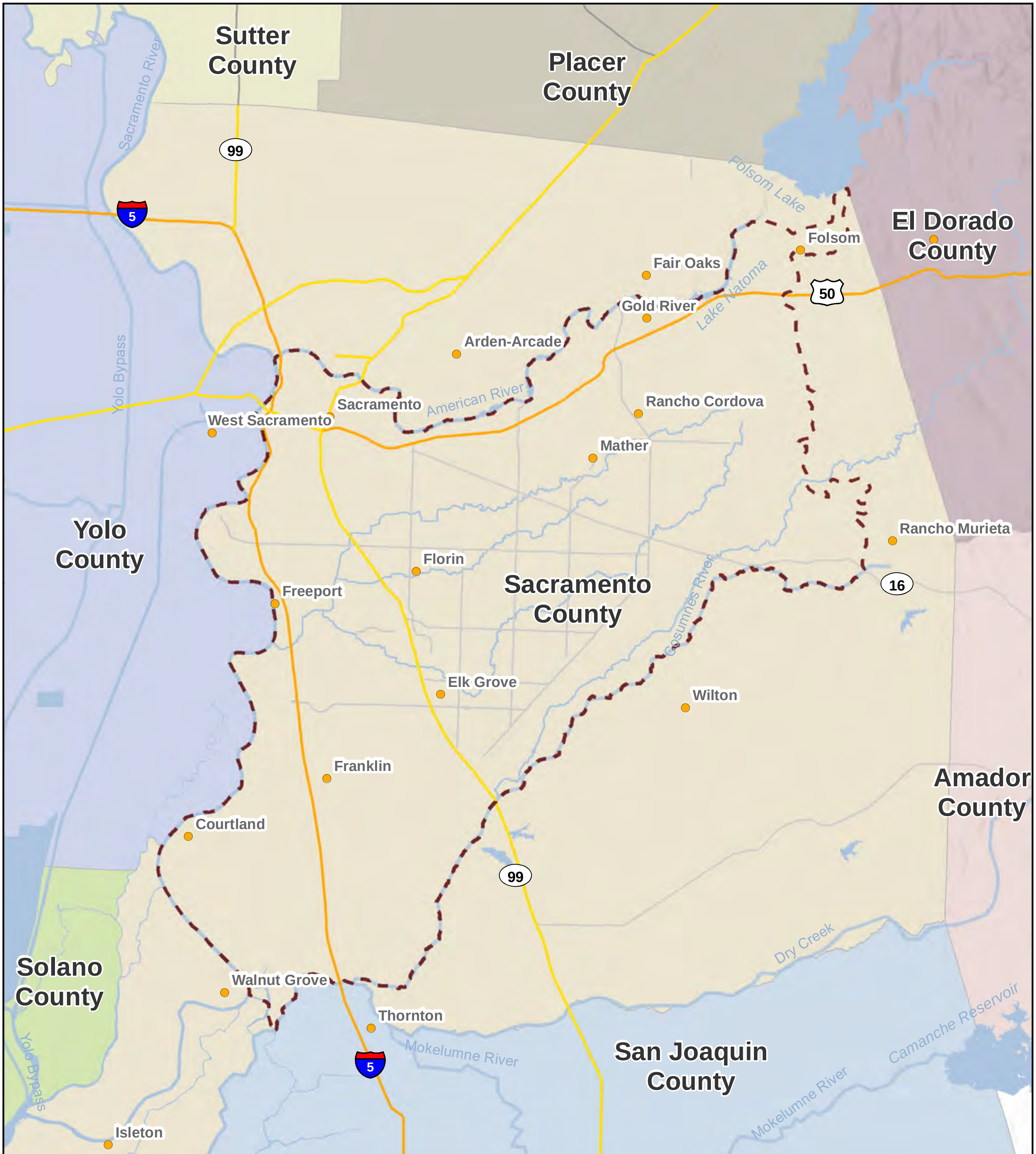
0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Figure Exported: 10/4/2021 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\2-3 South American Subbasin GSAs.mxd



South American Subbasin GSP

Counties Overlying South American Subbasin

Figure 2.1-4

Legend

South American Subbasin

Counties

- Amador
- El Dorado
- Placer
- Sacramento
- San Joaquin
- Solano
- Sutter
- Yolo

0 1.25 2.5 5 Miles

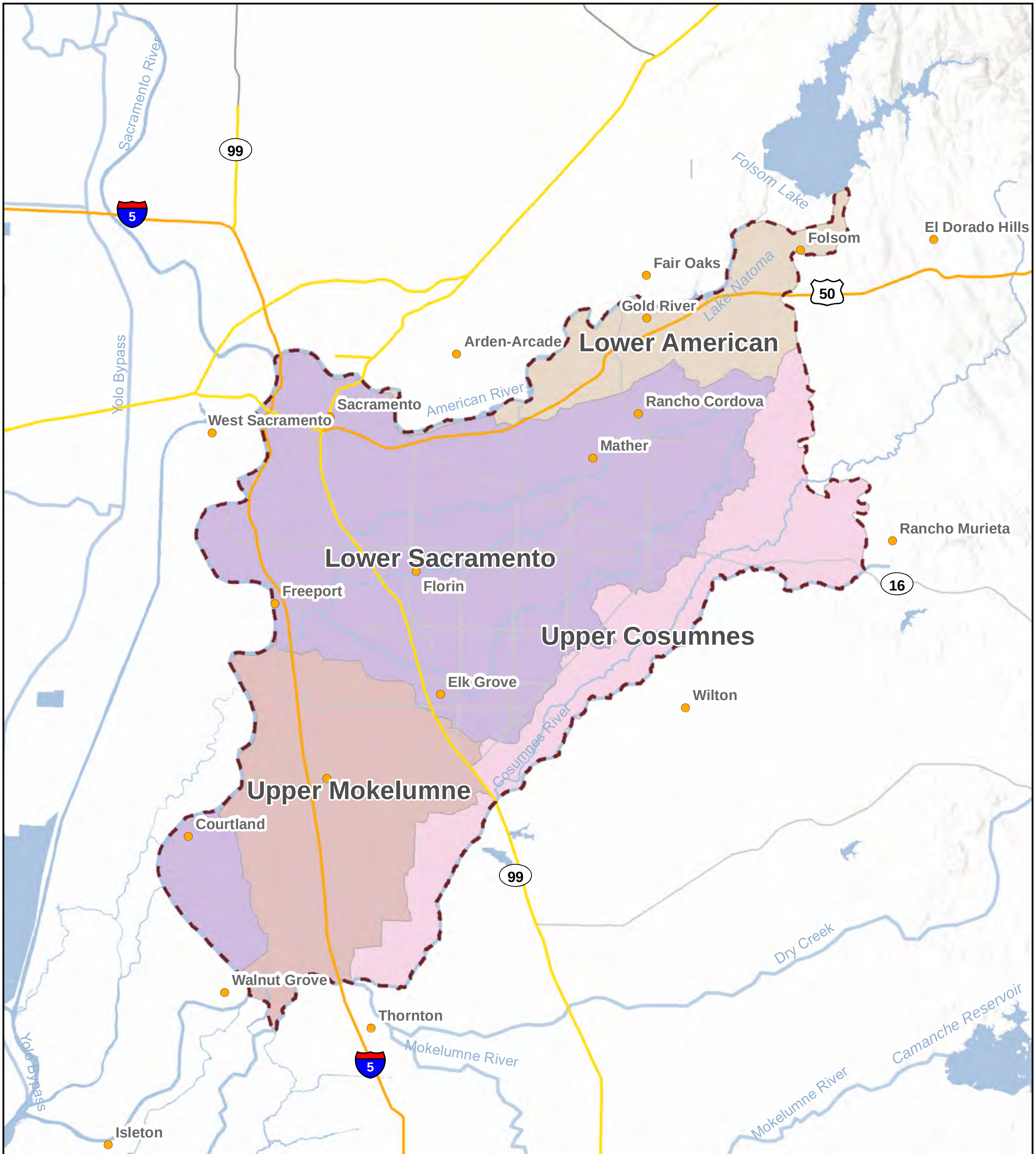
N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk.

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\4. Figure 2-4 Counties Overlying SASb.mxd



South American Subbasin GSP

Regional Watersheds

Figure 2.1-5

Legend

South American Subbasin

Watersheds

Lower American

Lower Sacramento

Upper Cosumnes

Upper Mokelumne

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Table 2.1-2: Water Purveyors 2018 Water Year, Total Water Use

Water Purveyor	2018 Water Year (AF/year)
California American Water Company	13,825
City of Folsom	9,981
City of Sacramento	60,672
Elk Grove Water District	4,075
Florin County Water District	2,647
Fruitridge Vista Water Company (now part of the California American Water Company)	3,377
Golden State Water Company	8,213
Rancho Murieta Community Services District	464
SCWA	33,329
Tokay Park Water District	163
Sacramento Regional Sanitation District	119
North Delta Water Agency	2,323

Note:
Source: SCGA, 2020

2.1.2.4 The Water Forum

In 1993, the City of Sacramento and Sacramento County created the Water Forum to address growing concern for the environment and for access to water amid the area's increasing population and water demand. On April 24, 2000, the Water Forum Agreement was executed by stakeholder organizations representing business and agricultural leaders, citizen groups, environmentalists, water managers, and local governments. As shown in **Table 2.1-3**, Water Forum signatories are included as members of one of four caucuses (business, environmental, public, water) that meets periodically to coordinate their activities. Members of all four caucuses meet quarterly at Water Forum Plenary meetings to coordinate actions and provide mutual updates (Water Forum, 2020).

Table 2.1-3: Water Forum Caucuses

Caucus	Members
Business	• AKT Development • Associated General Contractors • North State Building Industry Association • Sacramento Association of Realtors • Sacramento Metropolitan Chamber of Commerce • Sacramento Sierra Building and Construction Trades Council
Environmental	• Environmental Council of Sacramento • Friends of the River • Save the American River Association, Inc. • Sierra Club Mother Lode Chapter
Public	• City of Sacramento • Sacramento County • League of Women Voters of California • Sacramento County Taxpayers League • Sacramento Municipal Utility District

Caucus	Members
Water	• California American Water Company • Carmichael Water District • Citrus Heights Water District • City of Folsom • City of Roseville • Clay Water District • Del Paso Manor Water District • El Dorado County Water Agency • El Dorado Irrigation District • Fair Oaks Water District • Galt Irrigation District • Georgetown Divide Public Utility District • Golden State Water Company/Arden-Cordova Water District • Natomas Central Mutual Water Company • OHWD • Orange Vale Water Company • Placer County Water Agency • Rancho Murieta Community Services District • Regional Water Authority • Rio Linda/Elverta Community Water District • Sacramento County Farm Bureau • Sacramento Suburban Water District • San Juan Water District

Source: Water Forum, 2020

Groundwater Management is one of seven elements included in the Water Forum Agreement and allows the region to maintain a balanced approach toward groundwater sustainability. Sacramento Water Forum members agreed to establish a comprehensive program to manage these groundwater supplies. As part of the Water Forum Agreement, the Sacramento region was divided into three locally defined areas in Sacramento County, each managed by a different authority, and each provided with an annual sustainable yield:

- The North Area is located north of the American River and is governed by the Sacramento Groundwater Authority.
- The Central Area is located between the American and Cosumnes Rivers and is governed by the SCGA.
- The South Area is located south of the Cosumnes River and is governed by the Southeast Sacramento County Agricultural Water Authority.

2.1.2.5 Land Ownership

Figure 2.1-6 shows state and federal lands in the SASb. These protected areas include the Stone Lake State Park and Wildlife Management Area, Delta Meadows State Park, the Prairie City State Vehicular Recreation Area, and small portions of the Cosumnes River Ecological Reserve. The only tribal land that falls within the SASb is located south of Elk Grove near the intersection of Kammerer Road and Hwy 99.

2.1.2.6 Land Use Types

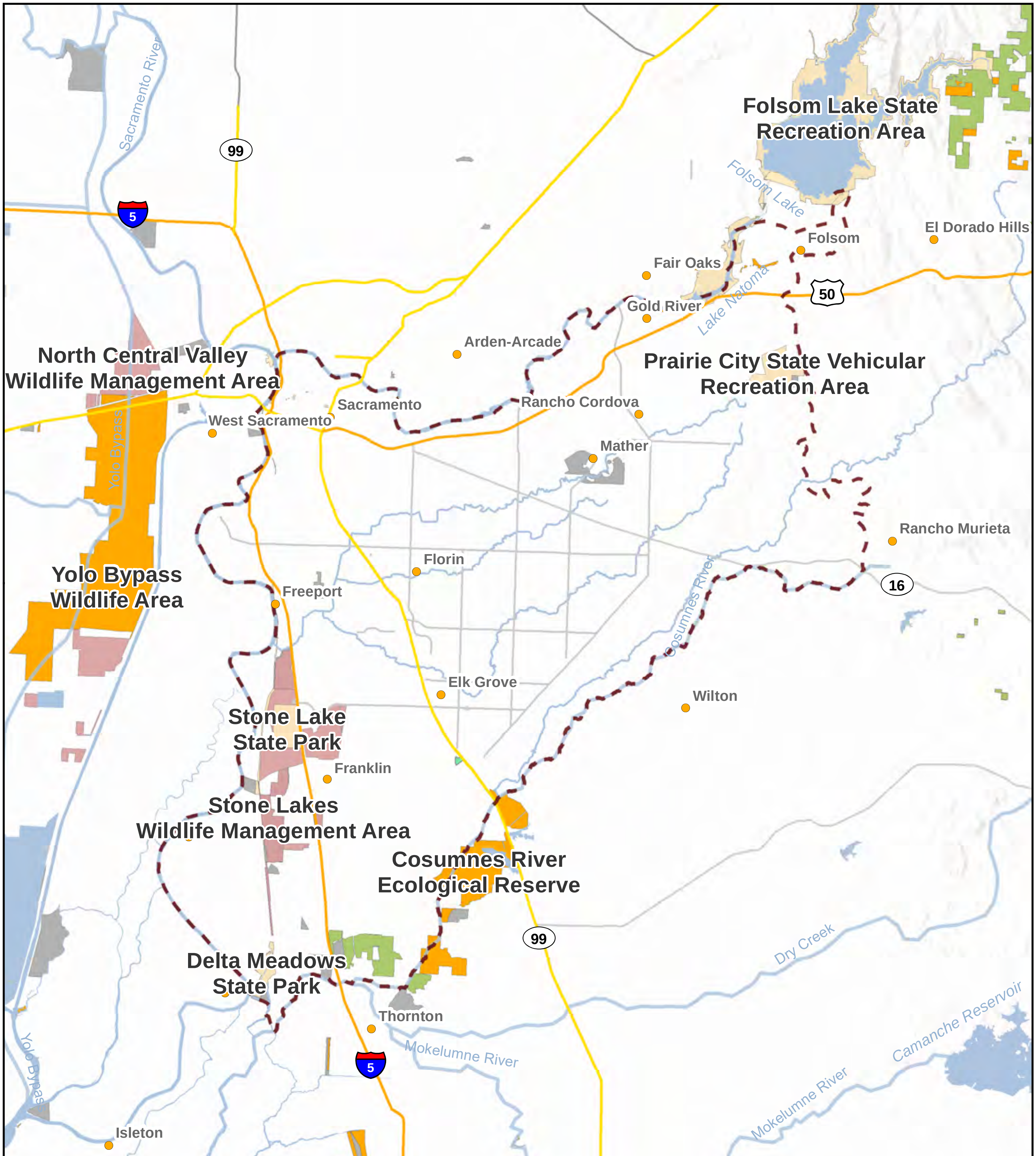
Land use types within the SASb include residential, agricultural, commercial, industrial, recreational, and wildlife preserves and easements. **Figure 2.1-7** shows urban and agricultural land use in the SASb as included in the DWR 2015 land survey of Sacramento County. There were an estimated 57,089 acres of agricultural land in the SASb during 2015. **Table 2.1-4** lists the local crop types and estimated acreages.

Table 2.1-4: Local Crop Types and Estimated Acreages

Crop	Acres
Alfalfa	5,059
Almonds and pistachios	204
Corn	4,365
Citrus	57
Cucurbits	416
Dry beans	673
Field crops	1,211
Grain	11,873
Idle	1,142
Orchards	3,119
Pasture	10,064
Rice	821
Safflower	677
Tomatoes	2,307
Truck crops	1,388
Vineyards	13,713
TOTAL	**57,089**

Source: DWR 2015

Agricultural irrigation water in the SASb is provided by surface water, groundwater, and a mix of surface and groundwater. Irrigated areas and water sources are shown in **Figure 2.1-8**.



South American Subbasin GSP

Federal and State Lands

Figure 2.1-6

Legend

- South American Subbasin
- U.S. Fish and Wildlife Service
- U.S. Dept. of the Interior - Bureau of Land Management
- CA Dept. of Parks and Recreation
- CA Dept. of Fish and Wildlife
- Native American / Tribal Land
- Other State and Federal

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: October 2021

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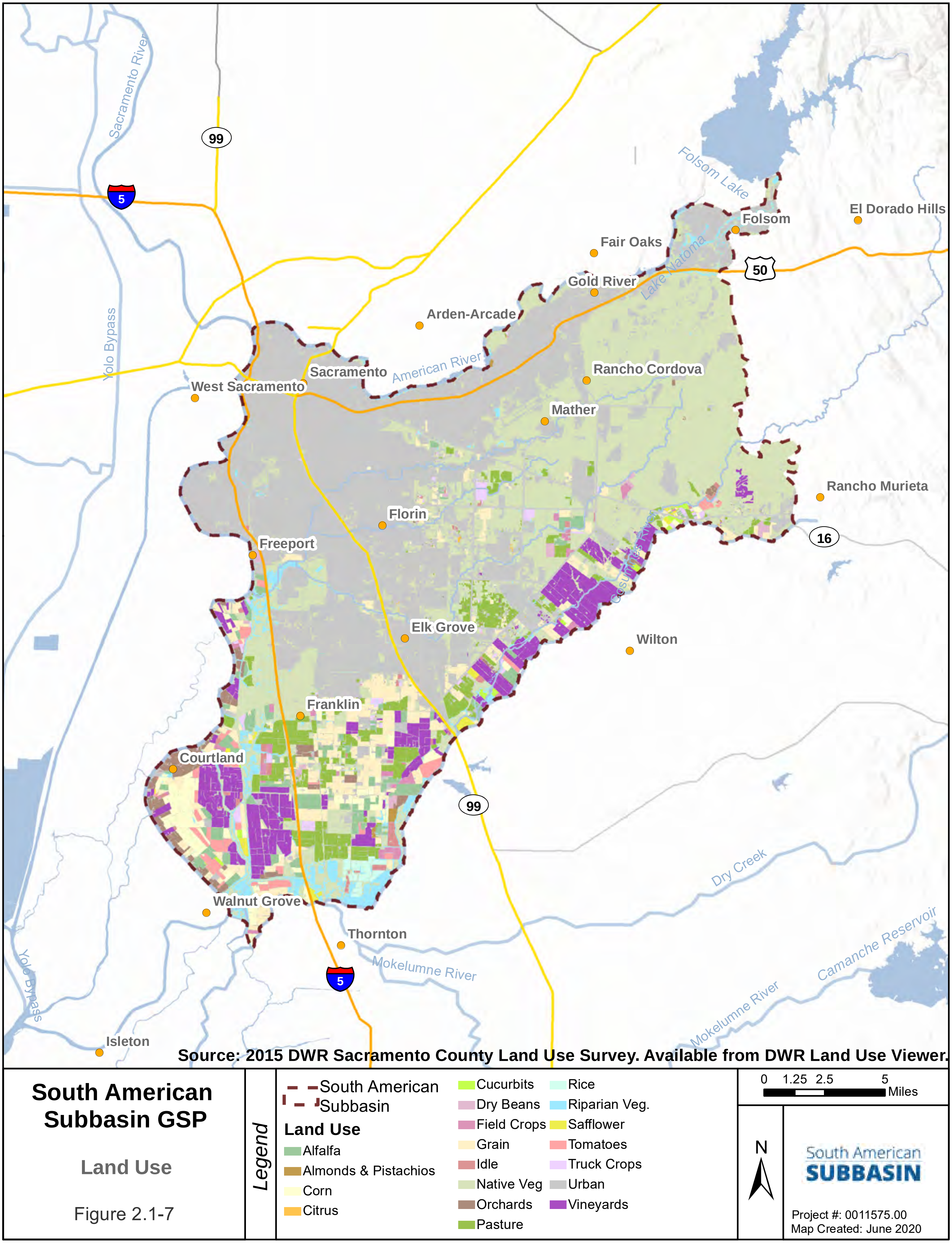
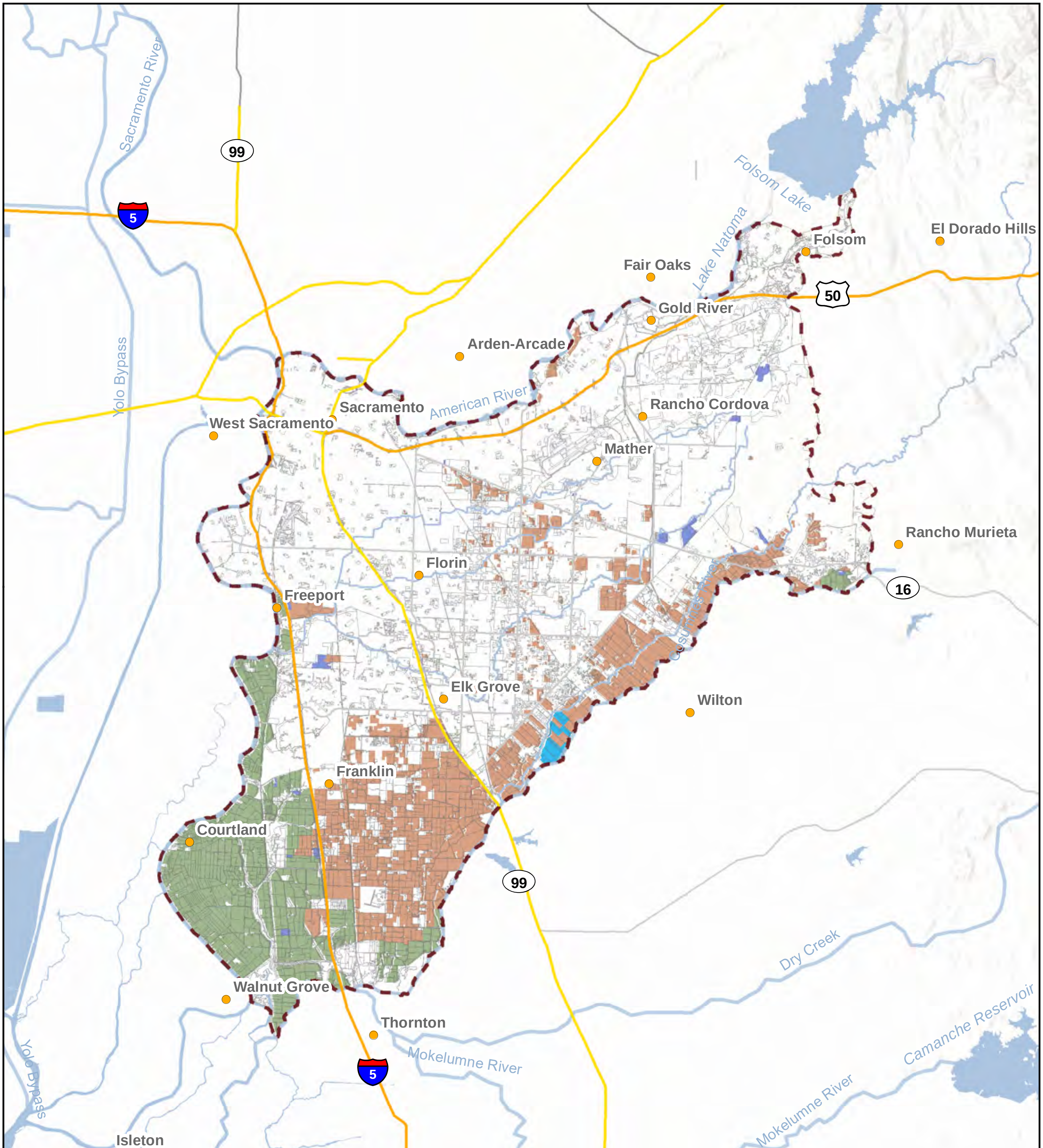


South American Subbasin GSP

Land Use

Figure 2.1-7

Project #: 0011575.00
Map Created: June 2020



Source: 2015 DWR Sacramento County Land Use Survey. Available from DWR Land Use Viewer.

South American Subbasin GSP

Land Use by Water Use

Figure 2.1-8

Legend

South American Subbasin

Irrigation Water Source

- Surface Water
- Surface and Groundwater
- Groundwater
- Unknown Source

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

2.1.2.7 Wells

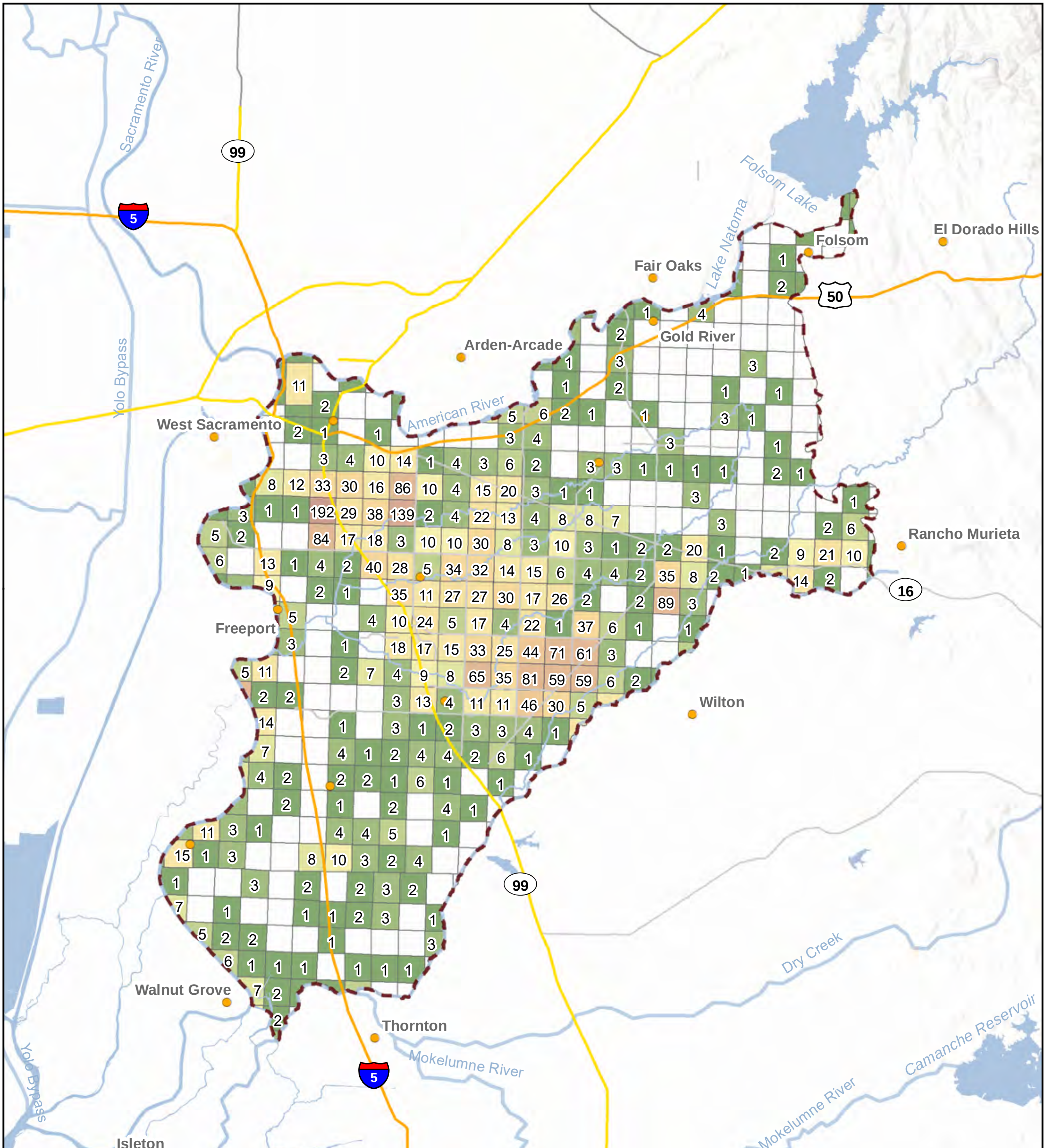
Figure 2.1-9 through **Figure 2.1-11** show the estimated total number of domestic, production, and public wells in each square mile of the SASb and was downloaded from DWR's Well Completion Report Map Application. This application allows government agencies and the public to review these data as well density information per the Public Land Survey System section (DWR, 2020b). DWR's well designations are based on information contained in well completion reports and have not been modified or verified for this GSP.

Figure 2.1-9 shows the approximate number of domestic wells in the SASb. There are approximately 3,337 domestic wells in the GSP area with well completion depth ranging from 25 to 1,330 feet (DWR, 2020b).

Figure 2.1-10 shows the approximate number of production wells in the SASb. There are approximately 915 production wells in the GSP area with well completion depth ranging from 67 to 1,493 feet (DWR, 2020b).

Figure 2.1-11 shows the approximate number of public wells in the SASb. There are approximately 254 public wells in the GSP area with well completion depth ranging from 80 to 1,493 feet (DWR, 2020b).

Note that these figures contain information about wells drilled after 1947, and some wells may not have been reported to DWR and therefore, are not included in the database or in these figures. Furthermore, designations of each well as a domestic, production, or public well by DWR were based on information contained in the well completion reports and have not been verified or modified for this document. Finally, some wells that have been abandoned or destroyed may not be designated as such in the database. For these reasons, the information contained in the well completion report database only provides an approximate estimate of the number of active pumping wells in the SASb.



Source: Department of Water Resources, Well Completion Report Map Application,

South American Subbasin GSP

Domestic Well Density

Figure 2.1-9

Legend

South American Subbasin

\# Number of Wells

Domestic Well Count

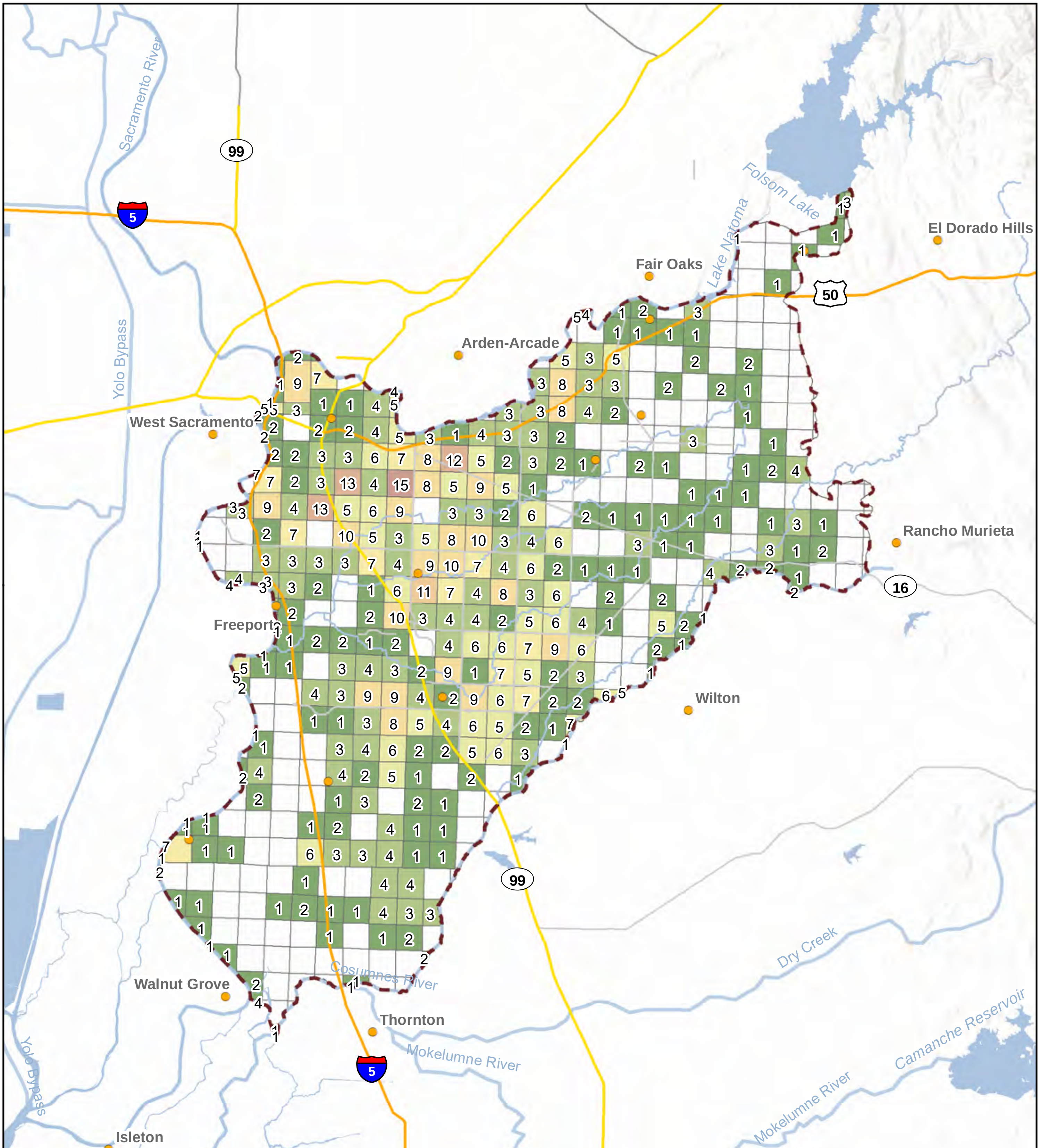
- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 100
- 101 - 150
- 151 - 192

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020



Source: Department of Water Resources, Well Completion Report Map Application,

South American Subbasin GSP

Production Well Density

Figure 2.1-10

Legend

South American Subbasin

Number of Wells

Production Well Count

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10
- 11 - 12
- 13 - 14
- 15

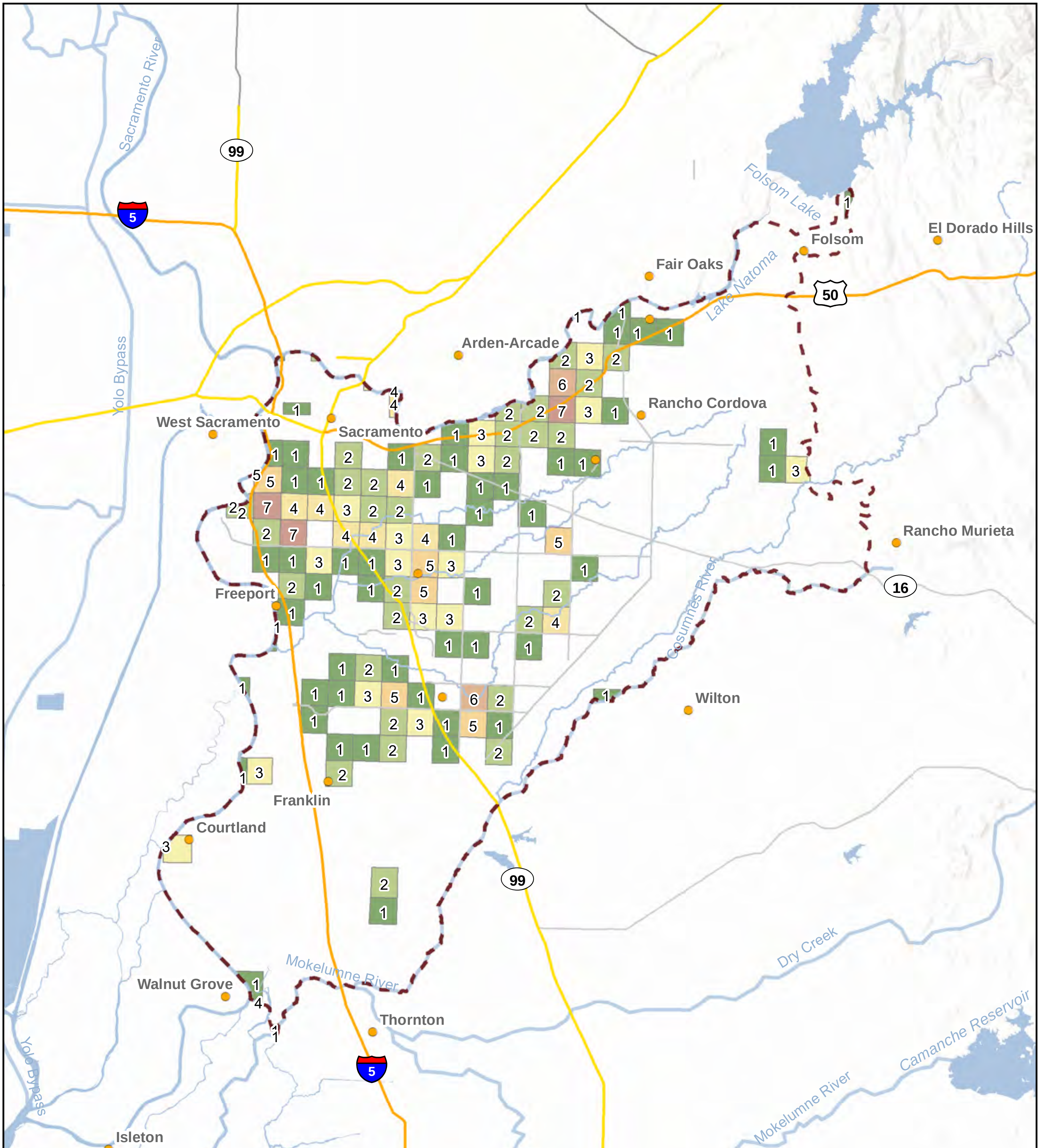
0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\10. Figure 2-10 Production Well Density.mxd



Source: Department of Water Resources, Well Completion Report Map Application,

South American Subbasin GSP

Public Well Density

Figure 2.1-11

Legend

South American Subbasin

\# Number of Wells

Public Well Count

1
2
3
4
5
6
7

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

2.1.3 Description of Beneficial Uses and Users of Groundwater

The *Water Quality Control Plan* (Basin Plan) *for the California Regional Water Quality Control Board, Central Valley Region, The Sacramento River Basin and San Joaquin River Basin* (Central Valley Regional Water Quality Control Board [CVRWQCB], 2018) defines beneficial uses of groundwater in the SASb as municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply. The quantities of pumping for each of these uses is described in the water budget section of the GSP. Other beneficial uses include environmental uses, including groundwater dependent ecosystems (GDEs).

2.1.4 Surface Water Monitoring

Surface water is used extensively in the SASb to augment the region's water supply and increase its reliability. American River surface water diverters in the SASb include the Golden State Water Company, Sacramento Municipal Utility District, and cities of Folsom, and Sacramento. Sacramento River water diverters include SCWA and the City of Sacramento (Water Forum, 2015). Agricultural use of surface water occurs primarily at diversions in the Delta and along the Cosumnes River (SCGA, 2020). **Table 2.1-5** summarizes total surface water extractions in the SASb for the 2018 water year.

Table 2.1-5: Total Surface Water Use

Water Sector	2018 Water Year Total (AF/year)
Municipal	90,414
Agricultural	31,219
Rural Residential	0
Remediation	0
Total	**121,633**

Source: SCGA 2010[??] for 2018 totals[?]

The USGS monitors surface water flow in the SASb. USGS, DWR, and various agencies reporting to the California Data Exchange Center (CDEC) monitor surface water quality in the SASb. Historical and current surface water monitoring in the SASb is described below.

2.1.4.1 Surface Water Flow Monitoring Programs

2.1.4.1.1 USGS—National Water Information System

The USGS monitors surface water flow in the SASb at four active stream gages: American River near Fair Oaks, Sacramento River near Freeport, and Laguna Creek and Morrison Creek (**Table 2.1-6** and **Figure 2.1-12**). In addition, there are active stream gages east of the SASb in Deer Creek and the Cosumnes River, and north of the SASb on the Sacramento River, American River, Arcade Creek, Magpie Creek, and Strong Ranch Slough.

Table 2.1-6: Surface Water Flow Gages in the SASb

Reporting Agency	Gage	Location	Status	Years of Record
USGS	11447500	Sacramento River near Sacramento	Inactive	1948–1979
USGS	11447000	American River near Sacramento	Inactive	1943–1959
USGS	11447650	Sacramento River near Freeport	Active	1948–2021
USGS	11446500	American River near Fair Oaks	Active	1904–2021
USGS	11335000	Cosumnes River at Michigan Bar	Active	1907-2021
USGS	11336000	Cosumnes River near SR 99	Inactive	1936–1982
USGS	11336585	Laguna Creek near Elk Grove	Active	1995–2021
USGS	11336580	Morrison Creek near Sacramento	Active	1959–2021

2.1.4.1.2 DWR—CDEC

CDEC installs, maintains, and operates a hydrologic data collection network including automatic snow reporting gages for the Cooperative Snow Surveys Program and precipitation and river stage sensors for flood forecasting (CDEC, 2020). Four active sensors and one inactive sensor are located in the SASb. **Table 2.1-7** and **Figure 2.1-12** show the flow monitoring stations.

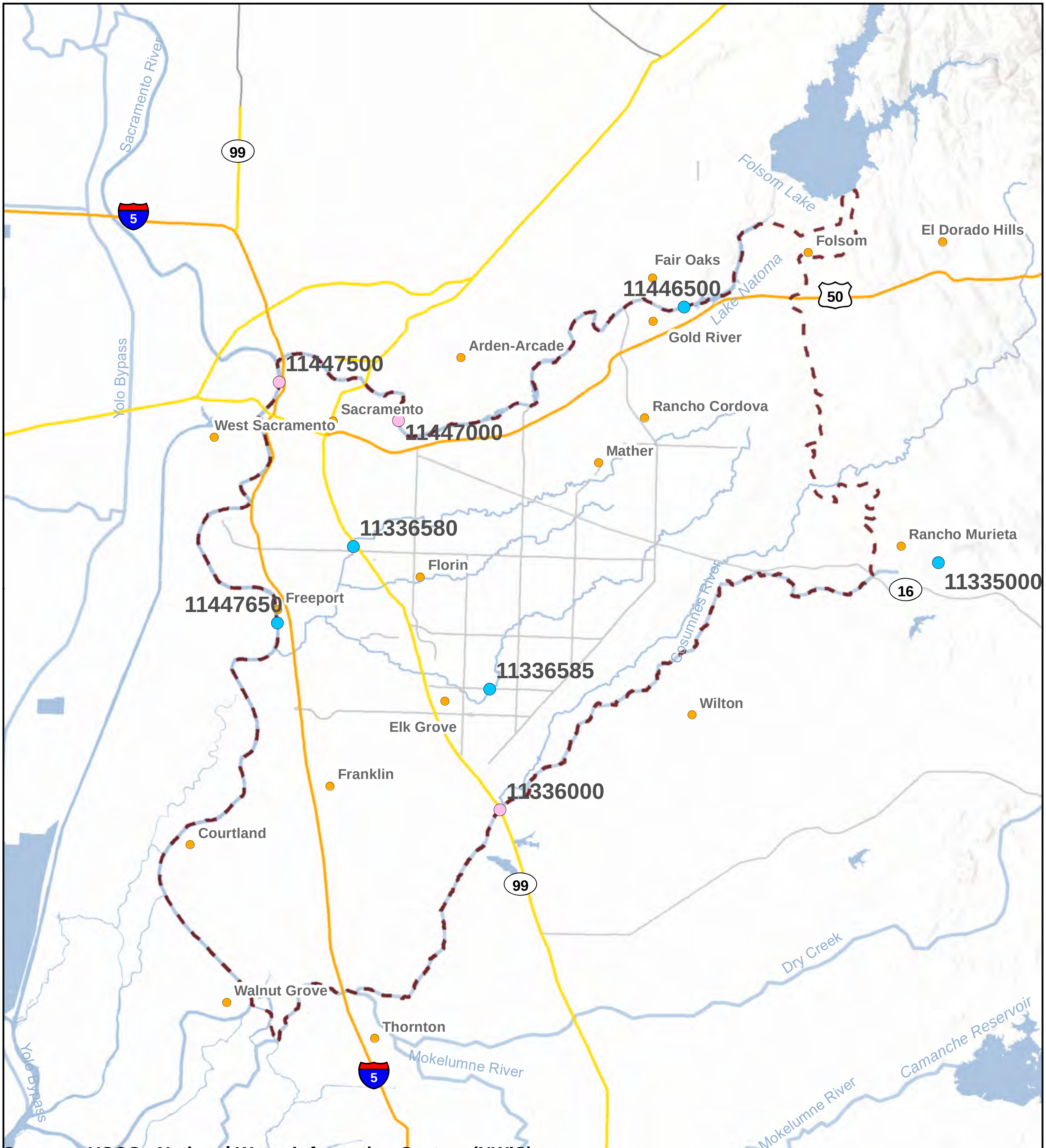
Table 2.1-7: CDEC Flow Stations in the SASb

Station	Station Name	Monitoring Agency	Active
FPT	Sacramento River at Freeport	USGS	Yes
FPX	Sacramento River at Freeport Auxiliary	USGS	No
IST	Sacramento River at I Street Bridge	DWR/North Central Region Office	Yes
MFR	Morrison Creek at Florin Road	USGS	Yes
SPE	Sacramento Regional Wastewater Treatment Plant	Sacramento County	Yes

2.1.4.2 Surface Water Quality Monitoring

2.1.4.2.1 USGS—National Water Information System

USGS monitors surface water quality in the SASb. There are 17 active and 48 inactive surface water quality monitoring stations in the SASb with available data from 1951 through 2020 (**Table 2.1-8** and **Figure 2.1-13**). In addition, there are active surface water quality stations east of the SASb in Deer Creek and the Cosumnes River, and north of the SASb in the Sacramento River, American River, Arcade Creek, Magpie Creek, and Strong Ranch Slough.



Sources: USGS - National Water Information System (NWIS)

South American Subbasin GSP

Surface Flow Monitoring

Figure 2.1-12

Legend

South American Subbasin

Stream Gages

USGS NWIS - Active (5)

USGS NWIS - Inactive (3)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

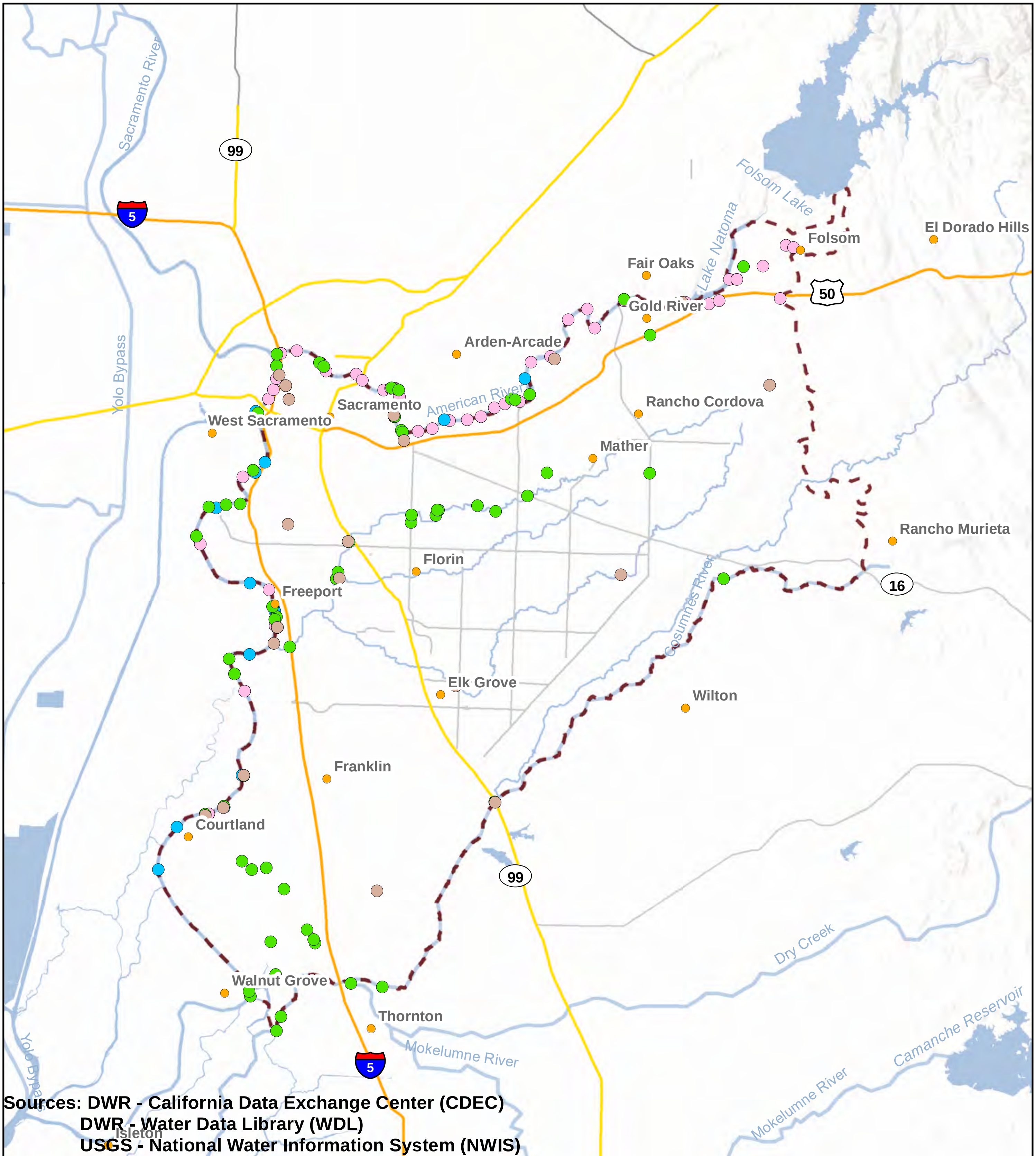
Project #: 0011575.00
Map Created: June 2020

Table 2.1-8: Surface Water Quality Gages

Station	Station Name	Monitoring Agency	Active
11446500	AMERICAN R A FAIR OAKS CA	Active	1951–2003
11446700	AMERICAN R A WILLIAM B POND PARK A CARMICHAEL CA	Active	2015–2017
11446980	AMERICAN R BL WATT AVE BRDG NR CARMICHAEL CA	Active	2014 - 2017
382825121311301	DELTA RMP SACR-007	Active	2019–2019
381852121343801	DELTA RMP SACR-009	Active	2019–2020
382732121300901	DELTA RMP SACR-010	Active	2019–2019
383052121324401	DELTA RMP SACR-011	Active	2019–2019
382018121335501	DELTA RMP SACR-013	Active	2019–2019
383205121310901	DELTA RMP SACR-015	Active	2020–2020
11336585	LAGUNA C NR ELK GROVE CA	Active	unavailable
11336580	MORRISON C NR SACRAMENTO CA	Active	unavailable
11447650	SACRAMENTO R A FREEPORT CA	Active	1958–2020
382205121311300	SACRAMENTO R A HOOD CA	Active	1977–2020
11447540	SACRAMENTO R A PIER A WEST SACRAMENTO CA	Active	2018–2019
382605121310401	SACRAMENTO R A R MILE 44.0 CA	Active	1999–2019
383225121304601	SACRAMENTO R A R MILE 55.8 NR SACRAMENTO CA	Active	2016–2019
11447800	SACRAMENTO R A SNODGRASS SLOUGH NR HOOD CA	Active	1972–2019
383816121115001	ALDER C A FOLSOM BLVD NR NIMBUS CA	Inactive	2003–2003
383824121091601	ALDER C A PRAIRIE CITY RD NR FOLSOM CA	Inactive	2003–2003
383809121121601	ALDER C POND A HWY 50 A NIMBUS CA	Inactive	2003–2003
383344121234300	AMERICAN R 0.5 MI AB HOWE AVE BR NR SACRAMENTO CA	Inactive	1981–1981
383609121293200	AMERICAN R 1 MI AB MOUTH CA	Inactive	1981–2016

Station	Station Name	Monitoring Agency	Active
11447230	AMERICAN R A 16TH ST BR AT SACRAMENTO CA	Inactive	1978–1981
383603121301200	AMERICAN R A I5 BR. CA	Inactive	1981–1981
383515121264400	AMERICAN R A I80 BR. CA	Inactive	1981–1981
383729121181000	AMERICAN R A LO ROSSMOR BAR CA	Inactive	1981–1981
11446400	AMERICAN R A NIMBUS DAM CA	Inactive	1960–1981
383444121250800	AMERICAN R A NORTHROP AVE. CA	Inactive	1981–1981
383501121253100	AMERICAN R A PARADISE BEACH CA	Inactive	1981–1981
383531121281600	AMERICAN R A POWERLINES AB 16TH ST CA	Inactive	1981–1981
383615121185100	AMERICAN R A RANCHO CORDOVA PARK CA	Inactive	1981–1981
11447000	AMERICAN R A SACRAMENTO CA	Inactive	1960–1998
383751121172200	AMERICAN R A SAN JUAN RAPIDS CA	Inactive	1981–1981
383527121270000	AMERICAN R A SOUTHERN PACIFIC RR BRIDGE CA	Inactive	1981–1981
383810121155000	AMERICAN R A SUNRISE BIKE BR. CA	Inactive	1981–1981
383602121194000	AMERICAN R A UP GOETHE PARK CA	Inactive	1981–1981
383404121221600	AMERICAN R A WATERTON PARK NR CARMICHAEL CA	Inactive	1981–1981
383411121214100	AMERICAN R A WHITEWATER WAY NR SACRAMENTO CA	Inactive	1981–1981
383443121200500	AMERICAN R AB ARDEN STP CA	Inactive	1981–1981
383338121241900	AMERICAN R AB HOWE AVE BR. CA	Inactive	1981–1981
383500121251700	AMERICAN R AB HOWE AVE STP CA	Inactive	1981–1981
383438121204200	AMERICAN R BL ARDEN STP CA	Inactive	1981–1981
383429121210900	AMERICAN R BL ARDEN STP SECOND CHANNEL CA	Inactive	1981–1981
383501121252000	AMERICAN R BL HOWE AVE STP CA	Inactive	1981–1981

Station	Station Name	Monitoring Agency	Active
383457121254900	AMERICAN R BL PARADISE BEACH CA	Inactive	1981–1981
383401121230000	AMERICAN R BL WATT AVE. CA	Inactive	1981–1981
383714121170200	AMERICAN R NR UP ROSSMOR BAR CA	Inactive	1981–1981
11336000	COSUMNES R A MCCONNELL CA	Inactive	1960–1967
383431121304201	DELTA RMP SACR-019	Inactive	unavailable
382451121311701	DELTA RMP SACR-022	Inactive	unavailable
382939121332101	DELTA RMP SACR-023	Inactive	unavailable
382046121323601	DELTA RMP SACR-026	Inactive	unavailable
382813121302401	DELTA RMP SACR-027	Inactive	unavailable
384010121090601	HUMBUG C A E BIDWELL ST NR FOLSOM CA	Inactive	2003–2003
382702121300501	SACRAMENTO R 0.35 MI DS OF FREEPORT BR A FREEPORT	Inactive	2018–2018
11447810	SACRAMENTO R A GREENS LANDING CA	Inactive	1971–2018
382740121301201	SACRAMENTO R A R MILE 46.4 A FREEPORT CA	Inactive	2016–2018
383155121314101	SACRAMENTO R A SHERWOOD HARBOR NR W SACRAMENTO CA	Inactive	2017–2018
383430121302001	SACRAMENTO R AT TOWER BRIDGE AT SACRAMENTO CA	Inactive	1931–2003
383859121110701	WILLOW C 0.1 MI US LK NATOMA NR FOLSOM CA	Inactive	2003–2003
384006121084601	WILLOW C A E BIDWELL ST NR FOLSOM CA	Inactive	2003–2003
384030121063601	WILLOW C A GOLF LINKS DRIVE NR FOLSOM CA	Inactive	2003–2003
383927121100201	WILLOW C A SIBLEY RD NR FOLSOM CA	Inactive	2003–2003



South American Subbasin GSP

Surface Water Quality Monitoring

Figure 2.1-13

Legend

South American Subbasin

Stream Gages

- CDEC (23)
- DWR WDL (64)
- USGS NWIS - active (17)
- USGS NWIS - inactive (48)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

2.1.4.2.2 DWR—Water Data Library

The DWR Water Data Library (WDL) contains data on chemical and physical parameters found in drinking water, groundwater, and surface water throughout the state collected via discrete grab-type water quality sampling stations (DWR, 2020a). The SASb has 65 surface water quality stations distributed in the American River, Buffalo Creek, Cosumnes River, Mokelumne River, Morrison Creek, Sacramento River, Snodgrass Slough, and Willow Creek. Data are available from 1951 through 2020 (locations shown in **Figure 2.1-13**). Additional surface water quality stations outside of the SASb are west in the Sacramento River, east in Carson and Deer Creeks, and south in Snodgrass Slough and the Mokelumne River.

2.1.5 Groundwater Monitoring

SCGA and DWR collect groundwater elevation monitoring data in the SASb on a semi-annual basis from 29 California Statewide Groundwater Elevation Monitoring Program (CASGEM Program) wells. DWR, the California Department of Pesticide Regulation (CDPR), the Sacramento County Department of Health Services, and various contamination cleanup sites report groundwater quality monitoring information for the SASb. Municipal water purveyors also collect and report water quality data that are compiled by the State Water Board Division of Drinking Water (DDW), which regulates public drinking water systems. Historical and current groundwater elevation and quality monitoring in the SASb are described below.

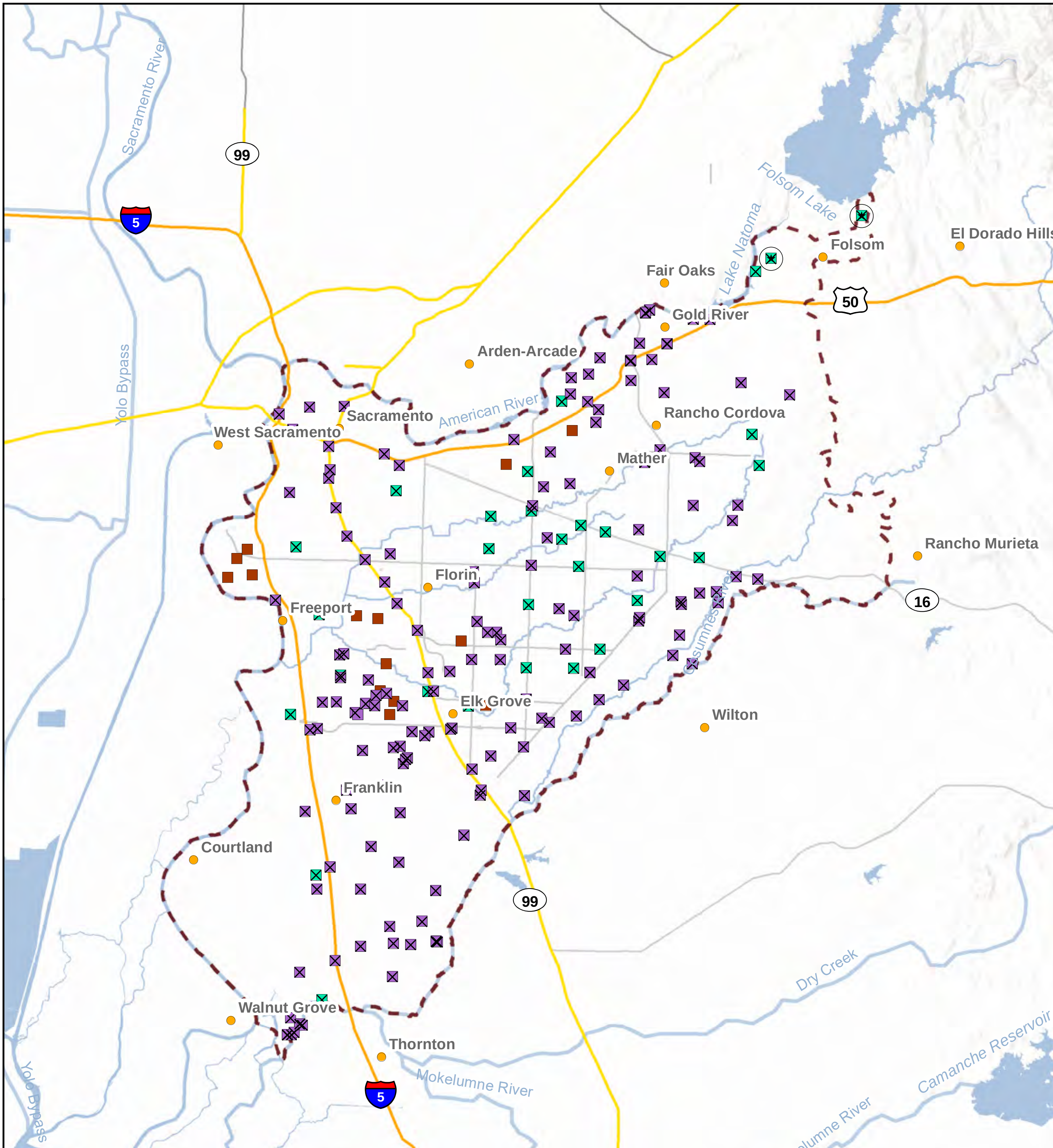
2.1.5.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring in the SASb began prior to the 1950s. Groundwater elevation wells in the basin are shown in **Figure 2.1-14**. In 2012, SCGA formed a monitoring network of 29 wells, including two wells in the Cosumnes Subbasin, as part of the original CASGEM Program to improve the overall quality of data being collected. The CASGEM monitoring network has been revised to 30 wells, including three additional wells in the western SASb area and excluding the two wells in the Cosumnes Subbasin. While there are multiple monitoring entities that may include state and federal agencies, private well owners, and public universities, SCGA is the agency responsible for the CASGEM Program in the SASb (SCGA, 2020).

DWR–Water Data Library

DWR's Water Data Library (WDL)[1] reports groundwater data collected from a variety of well types including irrigation, stock, domestic, and public supply wells. There are two wells that record continuous groundwater elevation measurements and 185 wells that have periodically reported groundwater elevation measurements in the SASb. Continuous groundwater elevation readings are taken at 15-minute and 1-hour intervals from automated recorders operated by DWR (California Natural Resources Agency [CNRA], 2020a). Periodic groundwater elevation readings are taken manually twice per year during the spring and fall which are typically the respective high and low elevations, but may be recorded more frequently (CNRA, 2020b). These readings are reported to the WDL by the SCGA, Sacramento Groundwater Authority, and Sacramento County. The DWR dataset also includes data collected through the CASGEM Program.

[1] https://wdl.water.ca.gov/



Sources: DWR - Water Data Library (WDL); DWR - California Statewide Groundwater Elevation Monitoring (CASGEM) Program; USGS - National Water Information System (NWIS)

South American Subbasin GSP

Groundwater Elevation Monitoring

Figure 2.1-14

Legend

South American Subbasin

Groundwater Wells

- DWR - CASGEM well (30)
- DWR - Voluntary well (156)
- DWR WDL - continuous (2)
- DWR WDL - periodic (185)
- USGS NWIS - active (15)

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\14. Figure 2-14 Groundwater Elevation Monitoring.mxd

USGS—National Water Information System

The USGS's National Water Information System contains measurements of depth to water in wells throughout California. In the SASb there are 15 active and 518 inactive groundwater monitoring wells. **Table 2.1-9** lists active wells in the SASb.

Table 2.1-9: USGS Water Elevation Monitoring Wells

Reporting Agency	Gage	Status	Years of Record
USGS	382906121322201	Active	1998–2019
USGS	382941121320601	Active	2008–2019
USGS	382911121312301	Active	1997–2019
USGS	382718121224901	Active	2006–2019
USGS	382757121261101	Active	1998–2019
USGS	382800121270701	Active	1998 - 2019
USGS	382629121254801	Active	1998–2019
USGS	382537121260001	Active	1998–2019
USGS	382515121262501	Active	1998–2019
USGS	382450121253601	Active	1998–2019
USGS	382517121252601	Active	1998–2019
USGS	382515121214401	Active	2006–2019
USGS	383000121313601	Active	1997–2019
USGS	383410121183401	Active	2006–2019
USGS	383301121211301	Active	2006–2019

Source: USGS, nd

DWR –CASGEM Program

The CASGEM Program collects monitoring data to track seasonal and long-term groundwater elevation trends in collaboration with local monitoring entities. There are 30 CASGEM Program wells and 156 additional voluntary wells in the SASb; although one CASGEM Program well (385541N1211812W001) was reported destroyed during the spring-to-fall reporting period in 2012 (SCGA, 2020). The 29 active CASGEM Program wells are shown in **Table 2.1-10**. Data for some of these wells are available from the 1930s through 2020. Monitoring frequencies for the groundwater elevation monitoring network vary from a minimum of bi-annual seasonal spring and fall measurements taken manually each year, to monthly measurements, often taken by private well owners and researchers for various studies (SCGA, 2016).

Table 2.1-10: CASGEM Program Wells in the SASb

Local Designation	State Well Number	Well Usage	Total Well Depth (feet)
06N05E31L003M	06N05E31L003M	Residential	125
COSAC1	--	Stockwatering	175
ND2	05N05E30A004M	Observation	20
SCGA 1	07N05E18C001M	Irrigation	Unknown
SCGA 10	08N04E36L001M	Residential	172
SCGA 11	08N05E21H002M	Unknown	72
SCGA 12	08N06E17H001M	Residential	236
SCGA 13	08N06E20R001M	Residential	101
SCGA 14	08N06E26K001M	Residential	160
SCGA 15	08N06E27H002M	Irrigation	425
SCGA 16	08N06E27N001M	Residential	Unknown
SCGA 17	08N06E30C001M	Residential	164
SCGA 18	08N06E31F001M	Residential	132
SCGA 19	08N06E34R001M	Irrigation	300
SCGA 2	07N05E26P002M	Residential	Unknown
SCGA 20	08N07E02N001M	Irrigation	675
SCGA 21[a]	08N07E14C001M	Stockwatering	208
SCGA 22	08N07E31J001M	Irrigation	300
SCGA 23	08N07E33E001M	Residential	130
SCGA 24	09N06E33R001M	Residential	85
SCGA 27	09N07E02N001M	Observation	170
SCGA 28	09N07E02G001M	Observation	101
SCGA 29	10N08E29J001M	Observation	85
SCGA 3	07N05E29D001M	Irrigation	170
SCGA 4	07N05E36A001M	Other	508
SCGA 5	07N06E08H001M	Residential	225
SCGA 6	07N06E12A001M	Irrigation	340
SCGA 7	07N06E14Q001M	Irrigation	300
SCGA 8	07N06E20J001M	Irrigation	Unknown
SCGA #9	07N06E22R002M	Residential	210

Notes:

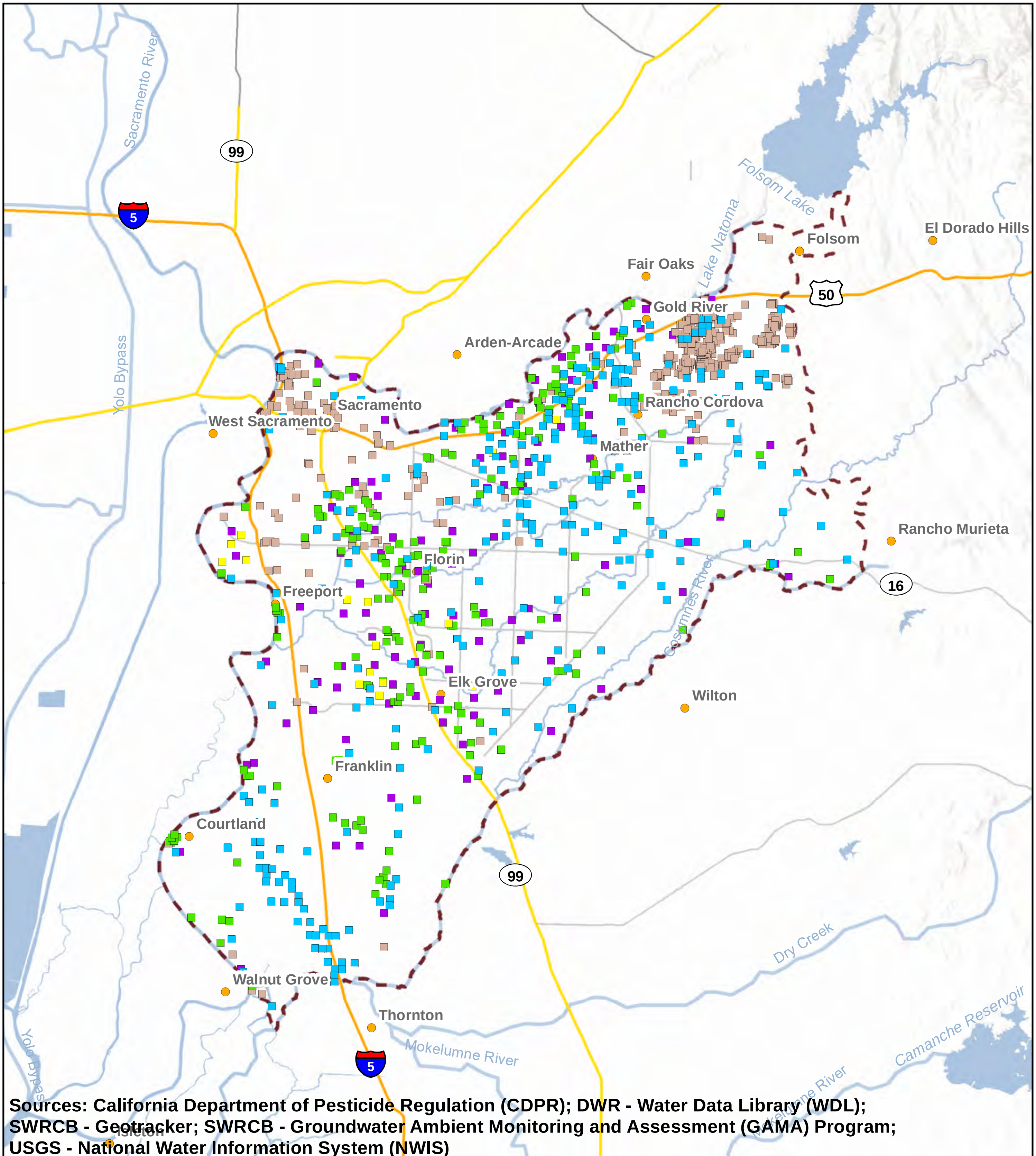
[a] Denotes well was reported destroyed.
Source: DWR, 2019

2.1.5.2 Existing Groundwater Quality Monitoring Programs

DWR, USGS, and water purveyors in the SASb maintain a record of water quality data. Groundwater quality wells in the basin are shown in **Figure 2.1-15**. Historical and current groundwater quality monitoring in the SASb is described below.

California Department of Drinking Water, Title 22

Water purveyors have compiled available historical water quality data for constituents monitored as required under the California Code of Regulations Title 22. Testing occurs at wells operated for public water supply. The current level of groundwater quality monitoring is sufficient under existing regulatory guidelines to ensure that the public is provided with a safe and reliable drinking water supply (MWH, Water Forum & SCWA, 2006).



Sources: California Department of Pesticide Regulation (CDPR); DWR - Water Data Library (WDL); SWRCB - Geotracker; SWRCB - Groundwater Ambient Monitoring and Assessment (GAMA) Program; USGS - National Water Information System (NWIS)

South American Subbasin GSP

Groundwater Quality Monitoring

Figure 2.1-15

Legend

- South American Subbasin
- CDPR (131)
- SWRCB - GAMA (216)
- SWRCB - GeoTracker (462)
- USGS - NWIS (15)
- DWR - WDL (316)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

DWR—WDL

The WDL contains data on chemical and physical parameters found in drinking water, groundwater, and surface water throughout the state collected via discrete grab-type water quality sampling stations (DWR, 2020a). There are 316 groundwater quality stations throughout the SASb. Data are available for various periods from 1951 through 2021.

State Water Resources Control Board—GeoTracker

The State Water Resources Control Board's (State Water Board's) GeoTracker database contains records for sites that impact, or have the potential to impact, groundwater quality. There are 45 leaking underground storage tank (LUST) sites and 417 Cleanup Program sites with an open status in the SASb. **Table 2.1-11** shows the status of the sites.

Table 2.1-11: GeoTracker Sites in the Subbasin

Status	Cleanup Site	LUST Site	Total
Open—Assessment and Interim Remedial Action	78	4	82
Open—Assessment and Interim Remedial Action (Land Use Restrictions)	1		1
Open—Eligible for Closure	4	6	10
Open—Inactive	15	5	20
Open—Remediation	110	2	112
Open—Remediation (Land Use Restrictions)	9		9
Open—Site Assessment	192	15	207
Open—Verification Monitoring	7	13	20
Open—Verification Monitoring (Land Use Restrictions)	1		1
Total	**417**	**45**	**462**

Source: State Water Board, 2020

State Water Board—Groundwater Ambient Monitoring and Assessment Program

The State Water Board's Groundwater Ambient Monitoring and Assessment (GAMA) Program was established in 2000 to create a comprehensive groundwater monitoring program throughout California and increase public availability and access to groundwater quality and contamination information (State Water Board, 2018). A total of 216 wells in the SASb report data to the GAMA Program. **Table 2.1-12** shows the number of GAMA Program wells by database source.

Table 2.1-12: GAMA Program Wells in the SASB

Source	Reported Wells
California Department of Pesticide Regulation	40
Sacramento County Department of Health Services	170
GAMA Domestic	1
GeoTracker	5
Total	**216**

Source: State Water Board, nd

USGS—National Water Information System

USGS's National Water Information System contains extensive groundwater quality data collected from wells throughout California. In the SASb, there are 15 active monitoring wells with data available since 1997 and 381 inactive groundwater monitoring wells.

CDPR

The CDPR well inventory dataset is used to monitor pesticides and compile sample data as part of its Groundwater Protection Program. The goal of this program is to improve understanding of the environmental impact and behavior of pesticides and develop pesticide-use practices that reduce threats to groundwater. There are 131 wells in the SASb with data reported by CDPR from 1985 through 2018 (CDPR, 2020).

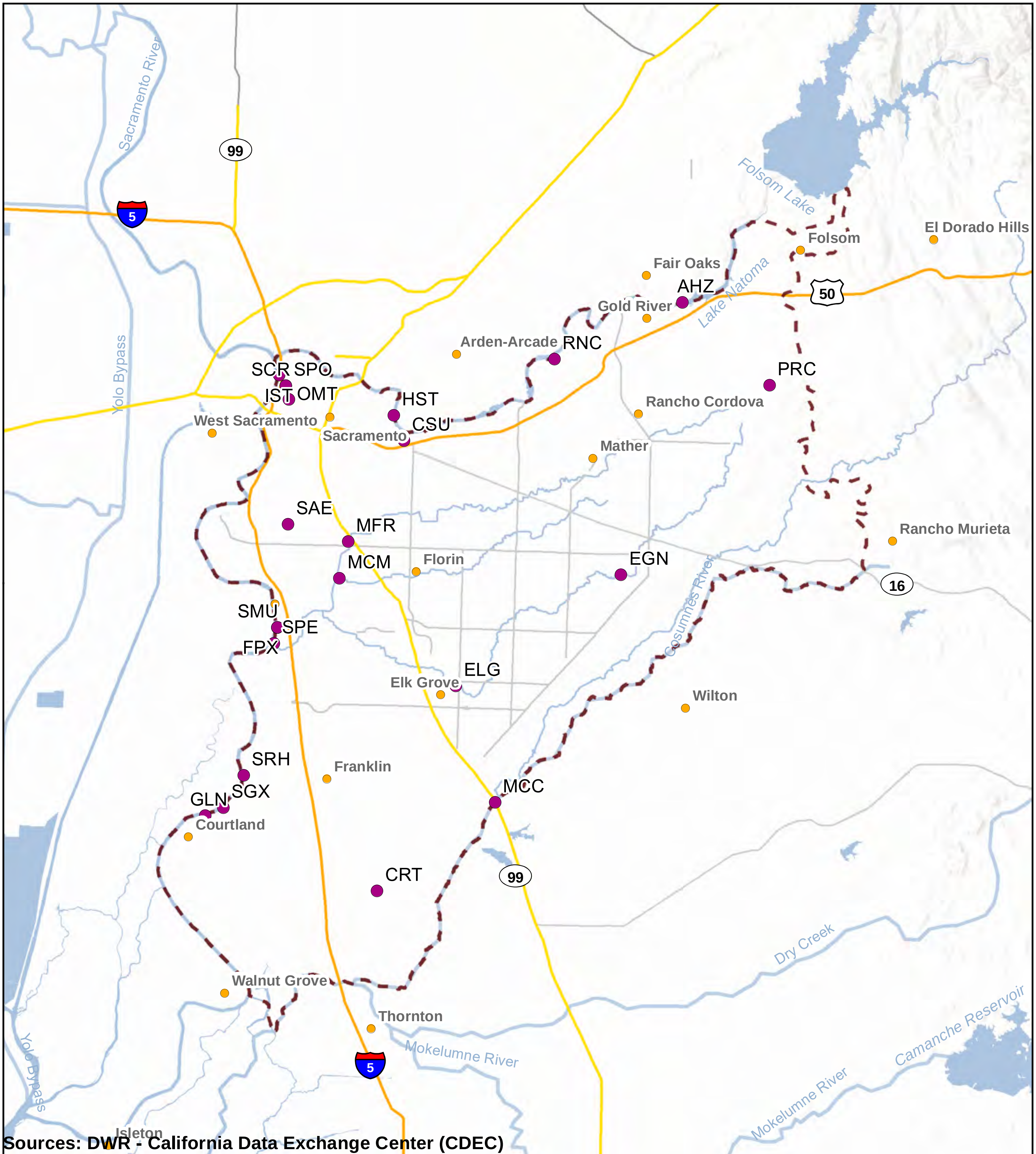
2.1.6 Interconnected Surface Water Monitoring

Surface water and groundwater interconnectedness was monitored at the Cosumnes River near Grant Line Road and State Route 99 (SR 99). Monitoring has continued at near-levee groundwater elevations along the American River to establish correlations between river stage and groundwater elevations at varying depths (SCGA, 2020). Developing a greater understanding of the surface water and groundwater interconnection along the American, Cosumnes, and Sacramento Rivers is a goal of the *Central Sacramento County Groundwater Management Plan* (CSCGMP) monitoring program (MWH, Water Forum & SCWA, 2006).

Municipal monitoring in the SASb includes the State Water Board monitoring and the regulated wastewater discharges from El Dorado Irrigation District into Deer Creek. and the Cosumnes River. Increased state water quality requirements for discharge to surface waters have reduced discharges to Deer Creek and have unavoidably impacted the SASb. However, regulation of surface water quality is outside the control of the SCGA GSA or any other GSA in the SASb (SCGA, 2016).

2.1.6.1 California Data Exchange Center

CDEC collects applicable data in the SASb, including air temperature, flow, precipitation, and river stage. **Figure 2.1-16** shows the location of these stations within the Basin.



South American Subbasin GSP

Interconnected Surface Water and Groundwater Monitoring

Figure 2.1-16

Legend

South American Subbasin

Stream Gages

CDEC (23)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

2.1.7 Subsidence Monitoring

Subsidence monitoring data in the SASb are collected using a continuous global positioning system (cGPS) station installed in the southwest portion of the SASb along Interstate 5 (I--5) as shown in **Figure 2.1-17**. This station is maintained by the University Navstar Consortium's (UNAVCO's) Plate Boundary Observatory (PBO) program. Additional UNAVCO cGPS stations are also located nearby, outside of the SASb. The National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) also provides interferometric synthetic aperture radar (InSAR) data for the Sacramento County region. Extensometers have not been installed in the SASb, although one existing extensometer is located in the Yolo Subbasin, to the east of Woodland.

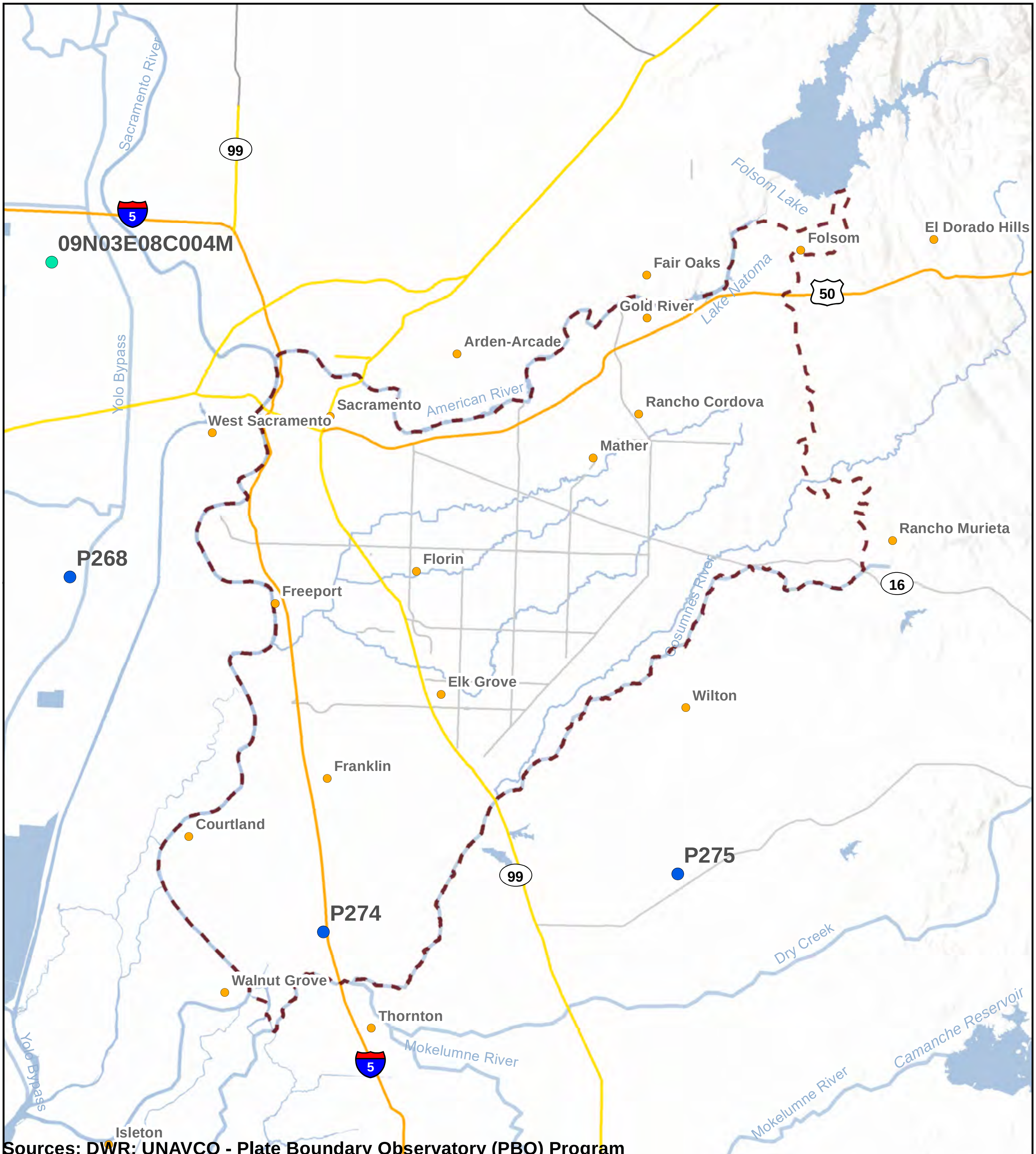
In 2008, and again in 2017, SCGA participated in the Sacramento Valley Subsidence Project conducted by DWR and the U.S. Department of the Interior's Bureau of Reclamation, and eight stations were monitored in the northern portion of the SASb. The project's findings indicated little to no significant subsidence in Sacramento County during the period 2008-2017 (SCGA, 2020).

2.1.7.1 University Navstar Consortium Plate Boundary Observatory Data

The UNAVCO PBO network consists of nearly 1,100 cGPS stations in the western U.S. that monitor subsidence. There is one cGPS station in the SASb in the southern portion near the intersection of the I-5 and Twin Cities Road in the Stone Lakes National Wildlife Reserve. Additional cGPS stations are located east of the SASb near Herald, , and immediately west of the SASb on farmland (UNAVCO, 2019).

2.1.7.2 NASA JPL InSAR Data

This dataset represents measurements of vertical ground displacement rates derived from InSAR data that are collected by the European Space Agency Sentinel-1A satellite and processed by the NASA JPL, under contract with DWR. The data cover April 2015 through September 2020.



Sources: DWR; UNAVCO - Plate Boundary Observatory (PBO) Program

South American Subbasin GSP

Subsidence Monitoring

Figure 2.1-17

Legend

- South American Subbasin
- DWR Extensometers
- UNAVCO Continuous GPS Sites

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: October 2021

2.1.8 Municipal and Remediation Monitoring

Groundwater remediation is necessary for the protection of drinking water supplies in the SASb. Known contaminant plumes and sites in the SASb are shown on **Figure 2.1-18**. Cleanup extractions of contaminated groundwater take place under various state and federal regulatory programs and through orders for the protection of human health (SCGA, 2020). Local groundwater management agencies have no jurisdiction over extractions and cleanup activities and must adaptively manage groundwater conditions as changes in the cleanup programs occur over time (SCGA, 2016).

Table 2.1-13 shows estimated groundwater remediation pumping for the 2018 water year. Extractions were reported or estimated for the Boeing Inactive Rancho Cordova Test Site, Aerojet Superfund Site, Mather Air Force Base (Mather AFB), Kiefer Landfill, Sacramento Army Depot, Union Pacific Downtown railyard, and the former Union Pacific Curtis Park railyard. Although other contamination such as cleanup programs and LUST sites exist in the SASb, these plumes are the largest and have the greatest impact on existing groundwater use.

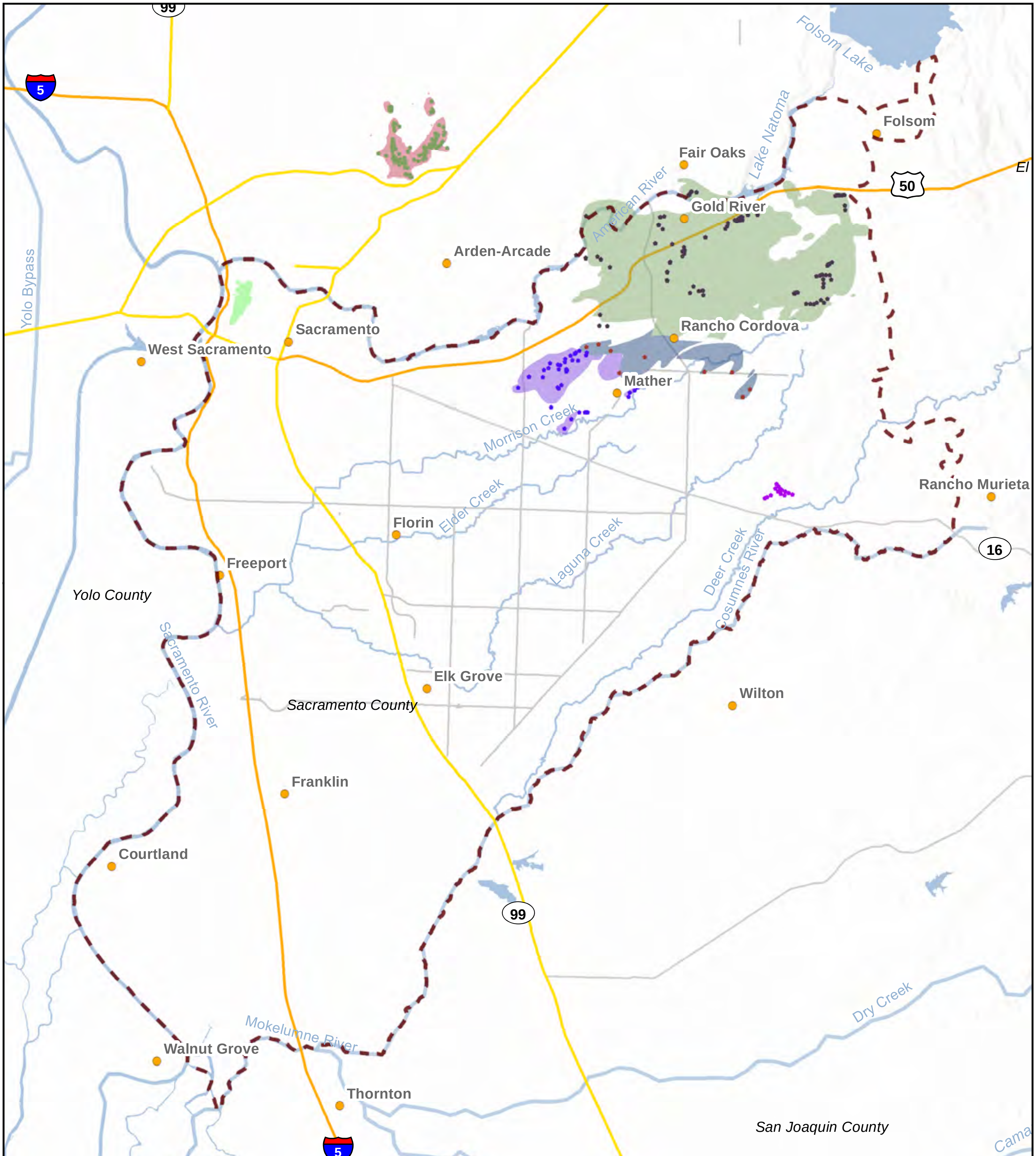
Table 2.1-13: Estimated Remediation Water Use

Remediation Site	2018 Water Year (AF/year)
Boeing Inactive Rancho Cordova Test Site	5,067
Aerojet Superfund Site	26,075
Mather AFB	2,232
Kiefer Landfill	621
Sacramento Army Depot	24
Union Pacific Downtown	240
Union Pacific Curtis Park	192
Total	**34,451**

Source: SCGA, 2020

Industrial, manufacturing, and defense industries have been a key part of the development of the greater Sacramento area since the early 1900s along with aerospace industries since the late 1950s. Many of these industries developed large sites to produce industrial chemicals, rocket-fuel, and other hazardous substances and have a long history of environmental pollution. Sites such as military bases, large aerospace operations, and chemical manufacturing facilities, disposed of vast quantities of toxic and unknown substances on site. Due to a lack of regulations and public awareness, these adverse waste disposal activities continued unchecked for decades until the 1980s.

Awareness of remediation activities has increased since the 1980s as groundwater supplies have been compromised, and as contaminant plumes continued to migrate downgradient. Groundwater extractions for the purpose of remediation have also increased over the years.



South American Subbasin GSP

Contamination Plumes and Remediation Wells (2008)

Figure 2.1-18

Legend

Remediation Wells	Contamination Plume
Aerojet	Aerojet
Boeing	Boeing
Mather	Mather
McClellan	McClellan
Kiefer	Union Pacific Downtown / Curtis Park

0 1 2 4 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: October 2021

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Note:** Remediation well data was not available for UPRR or Sacramento Army Depot. Contamination plume data was not available for Sacramento Army Depot or Kiefer Landfill.

Groundwater remediation is a necessary operation to protect drinking water quality for the region and take precedence over the potential risk of groundwater depletion. Remediation also helps to protect the environment, including the American River, creeks, flora and fauna, and individuals who live in communities located near them. SCGA and other GSAs have worked with regulators and responsible parties of these sites for education, reporting, and developing strategies to negate the impact of remediation on groundwater resources in the basin. This GSP acknowledges the necessity to adaptively manage these resources while recognizing that remediation activities will be conducted according to other regulatory requirements, beyond the GSP's control, until groundwater conditions reach a steady-state condition.

Other County and State cleanup programs also extract groundwater for treatment with discharge to sewer systems or evaporation ponds. While most are small in scope compared to larger state and federal programs, the overall result is a loss of water to the basin and slight lowering of groundwater levels in the SASb.

Major sources of contamination within the SASb are primarily from the Aerojet Superfund Site, the McDonnell Douglas Inactive Rancho Cordova Test Site (IRCTS), and Mather AFB, and other lesser sites. The extent of the groundwater contaminant plumes emanating from the major sources are shown in **Figure 2.1-18**. Localized contamination by industrial and commercial point sources, such as dry-cleaning facilities and numerous petroleum fuel stations, throughout the basin are also of concern. While the GSA governance bodies do not have the authority or responsibility for remediation of this contamination, it is committed to coordinating with responsible parties and regulatory agencies to stay informed on the status and disposition of known contamination in the basin.

Most areas of the water level decline have occurred on the eastern side of the subbasin and are situated in close proximity to multiple groundwater remediation programs. These remediation projects are intended to contain the migration of contaminated groundwater by drawing groundwater levels down and increasing flow gradients toward the remediation wells. The expectation is that additional remediation systems will be installed to address the currently untreated source areas within the center of the Aerojet Superfund Site. Thus, the objective of these remediation projects is to intentionally cause declining water levels (below basin-wide thresholds) and steeper gradients in these discrete areas of the SASb.

2.1.8.1 Mather Air Force Base

The U.S. Environmental Protection Agency (EPA) designated Mather AFB as a Superfund Site. Additional information can be found here: https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0902793#bkground

The Mather AFB was a former 5,845-acre Air Force Base located along the northern boundary of the South American Subbasin. Mather AFB was built in 1918 as a flight training school and served as an active air base for training of military personnel until 1993, when it closed under the Base Realignment and Closure Act. Following the base closure, the majority of the base was leased to various entities. In 1995, Mather Airport opened as a 2,675-acre cargo airport, while an additional 1,432 acres were developed for housing, business parks, a VA Medical Center, and the Federal Aviation Administration's TRACON Facility.

In 1982, environmental investigations began to find areas with significant soil/sediment contamination from fire training areas, drainage ditches, waste pits, oil/water separators sites, spill sites, landfills, and a wastewater treatment plant. Soils were contaminated with toxic and hazardous materials such as petroleum, oils, lubricants, solvents, and protective coatings used during routine operation and maintenance of Mather AFB. Five contaminated groundwater plumes were identified. One of the plumes at the Aircraft Control and Warning (AC&W) Disposal Area, contains Trichloroethylene (TCE). Another plume, associated with the Site 7 Disposal Area, contains chlorinated solvents thought to have come from neighboring landfills. The plume with the greatest concern is the Main Base/Strategic Air Command (SAC) Area Plume, which is two plumes that have commingled and migrated over a mile off base to residential areas.

2.1.8.1.1 Historical, Current, and Future Operations

The AC&W Disposal Area was listed on the USEPA National Priorities List in 1987 and the entire base was listed in 1989. Mather AFB began participating in the Installation Restoration Program (IRP), a specially funded program established by the Department of Defense in 1978 to identify, investigate, and control the migration of hazardous contaminants at military and other Department of Defense facilities.

Remedial investigations and cleanup activities were implemented under this program for environmentally affected IRP sites. These activities included the installation of groundwater monitoring wells to evaluate groundwater contamination both on the former base and beyond the Mather property. Approximately 570 groundwater wells and 27 operating extractions were included in the groundwater monitoring program. The site has been addressed in five stages, immediate actions and four long-term remedial phases focusing on the cleanup of the AC&W Disposal Area, the landfills, groundwater, and soils.

Immediate action began with the US Air Force clean up of three soil areas and provision for alternate sources of drinking water to residents along the western boundary of the Mather AFB where drinking water wells had been contaminated by base operations. Initially, this response included delivery of bottled water, but later involved connection to a nearby drinking water system.

The AC&W Disposal Area resulted from disposal of solvents in a waste disposal pipe or dry well from 1958 to 1966. A groundwater extraction and treatment system was selected as the remedy in 1993. This system became operational in 1995 and includes four extraction wells and one air stripper treatment system. From 1998 to 2003, up to 50 gpm of the treated water was used by Sacramento County for irrigation near Mather Lake. Mather changed to discharge of treated groundwater to Lake Mather in 1997. Since then, the AC&W plume has been contained and contaminant concentrations are declining.

The source area for the Site 7 plume was a gravel borrow pit used as a landfill into which waste was disposed from 1953 to 1966. The borrow pit was used to dispose of petroleum, oil, and lubricant wastes, empty drums, sludge from plating shops, absorbent sand used for cleaning oil and solvent spills, and at least one load of transformer oil that may have contained PCBs. The Site 7 groundwater extraction and treatment system has operated intermittently since 1998. The system was shut down for short periods to accommodate for off-base mining and reclamation activities. The groundwater extraction and treatment system used air stripping to remove volatile contaminants and, in 1997, a granular activated carbon (GAC) system was installed to treat

PFAS contamination. The discharge water has been reinjected into the groundwater system. The northeast plume at Site 7 is being monitored to determine if contaminant concentrations are decreasing over time.

The Main Base/SAC Area (MBSA) comingled plume resulted from industrial activities, equipment maintenance, dry cleaning, and fuel storage and delivery at several sites. The comingled plume has a groundwater extraction and treatment system with air stripping technology and a GAC system to remove PFAS contamination. The discharge water is being reinjected into the groundwater system.

The off-base area includes portions of the MBSA and Site 7 plumes that have migrated beyond the property boundaries. Mather AFB is monitoring large water supply wells, nearby monitoring wells, and smaller, private-owned supply wells downgradient from the plumes.

The potential exposure to contaminated groundwater has been eliminated at Mather AFB. Groundwater pumping and treatment will continue to operate until all groundwater cleanup levels are achieved. Discharges will continue into Lake Mather and the groundwater basin.

2.1.8.1.2 Effects on subbasin supply

Pumping data was only available for Mather Air Force Base during the period from 2017-2019. During this period, an average of 1,221 AFY of water was pumped and discharged, as displayed in **Table 2.1-14.**

Table 2.1-14: Mather Air Force Base Groundwater Pumping

Year	Amount (AFY)
2017	1,683
2018	1,218
2019	763
Average	**1,221**

2.1.8.1.3 Migration of Contaminated Water

The AC&W groundwater extraction and treatment system successfully operated to remove mass from the groundwater contamination plume. Approximately 1.95 pounds of TCE were removed in 2019. Monitoring has demonstrated that the plume has not increased in concentration. Monitoring of TCE concentration trends in the upgradient portion of the plume will continue. Water level and concentration data have been used to define the TCE plume and conclude that the plume is captured by the extraction wells as demonstrated in **Figure 2.1-19**.

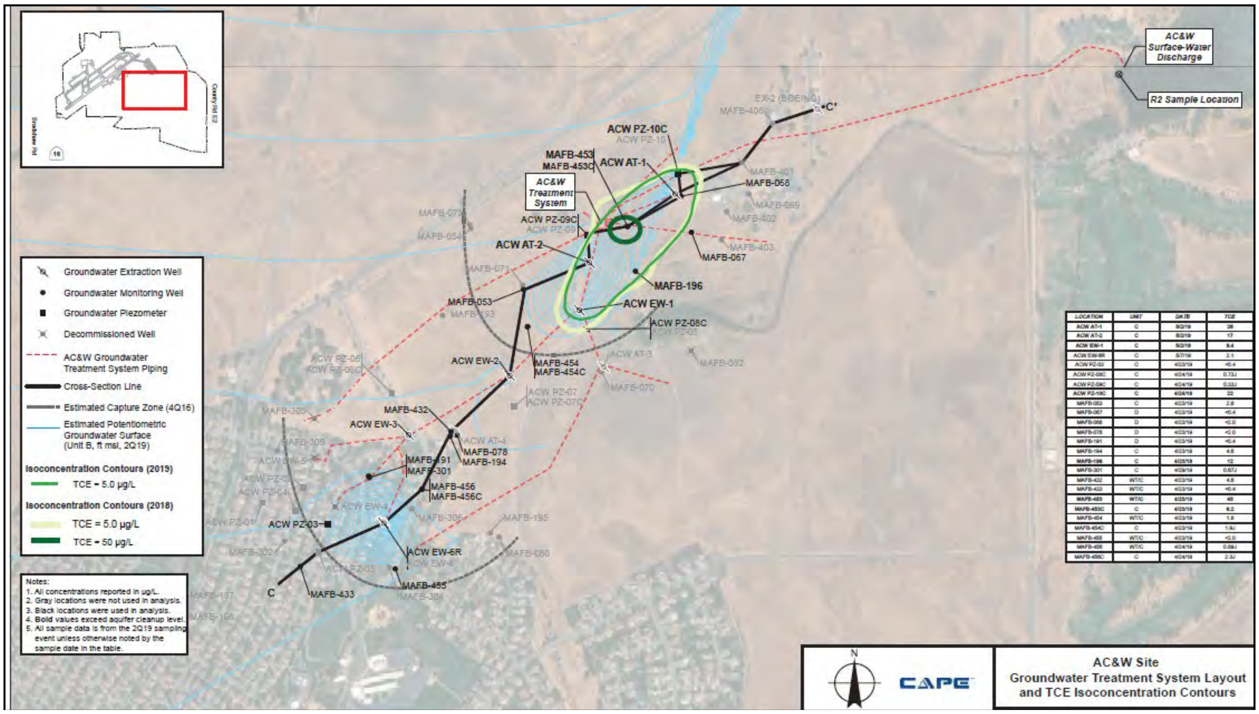


Figure 2.1-19: Mather AC&W Site TCE Concentrations

Source: Mather Annual and Fourth Quarter 2019 Groundwater Monitoring Report_Figure 4-1_pg210

The Site 7 groundwater extraction and treatment system successfully removed mass from the groundwater contamination plume in 2019. Contaminant concentrations in wells generally increased to include more wells with concentration above the action cleanup level (ACL) than 2018. This is likely due to higher water levels which could indicate that the groundwater has come into contact with soils having some residual contamination. Water level and concentration data have been used to define the plume and show that it is being captured by the extraction wells (**Figure 2.1-20**). Progress is being made toward achieving the objectives of the remedial action at this site.

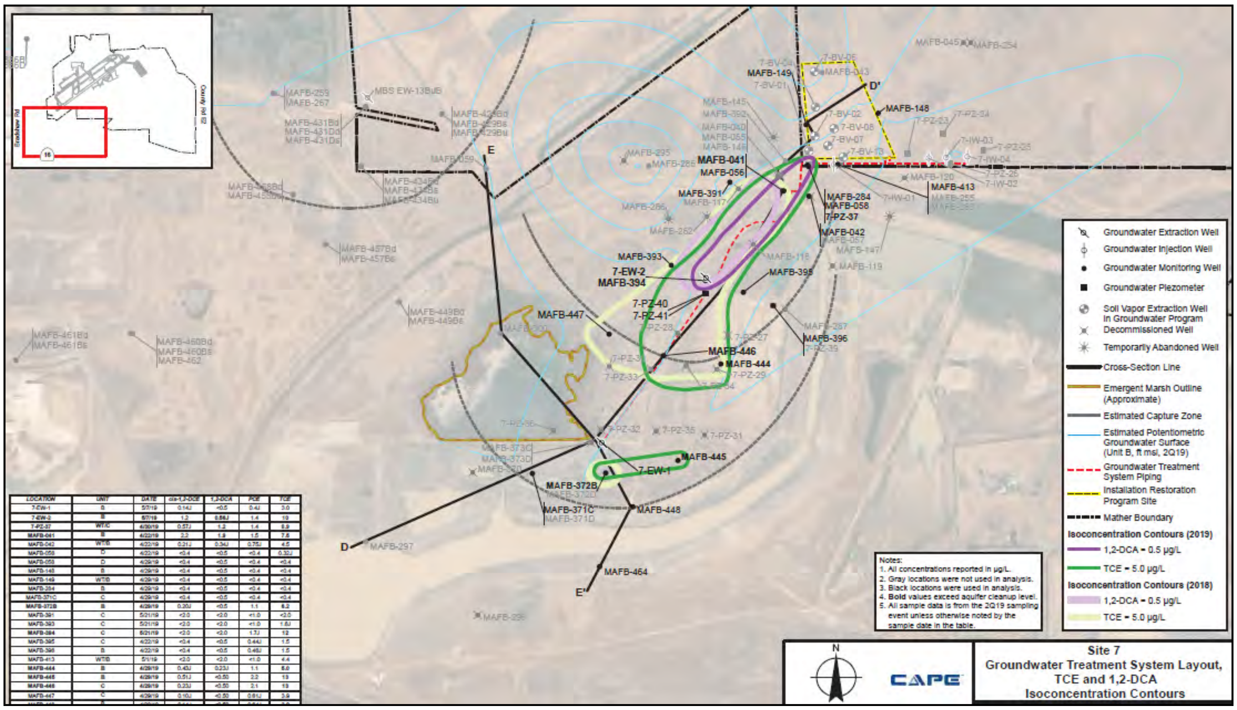


Figure 2.1-20: Mather Site 7 TCE Concentrations

Source: Mather Annual and Fourth Quarter 2019 Groundwater Monitoring Report_Figure 5-1_pg213

The MBSA plume areas and TCE and Tetrachloroethylene (PCE) concentrations have remained the same over the past year. See **Figure 2.1-21**. The MBSA groundwater extraction and treatment system is achieving the objectives of the remedial action plan. Extraction well flow rates will continue to be evaluated to improve capture and optimize remediation of the MBSA plume. In 2020, communications systems at the extractions wells will be upgraded to improve operational efficiency.

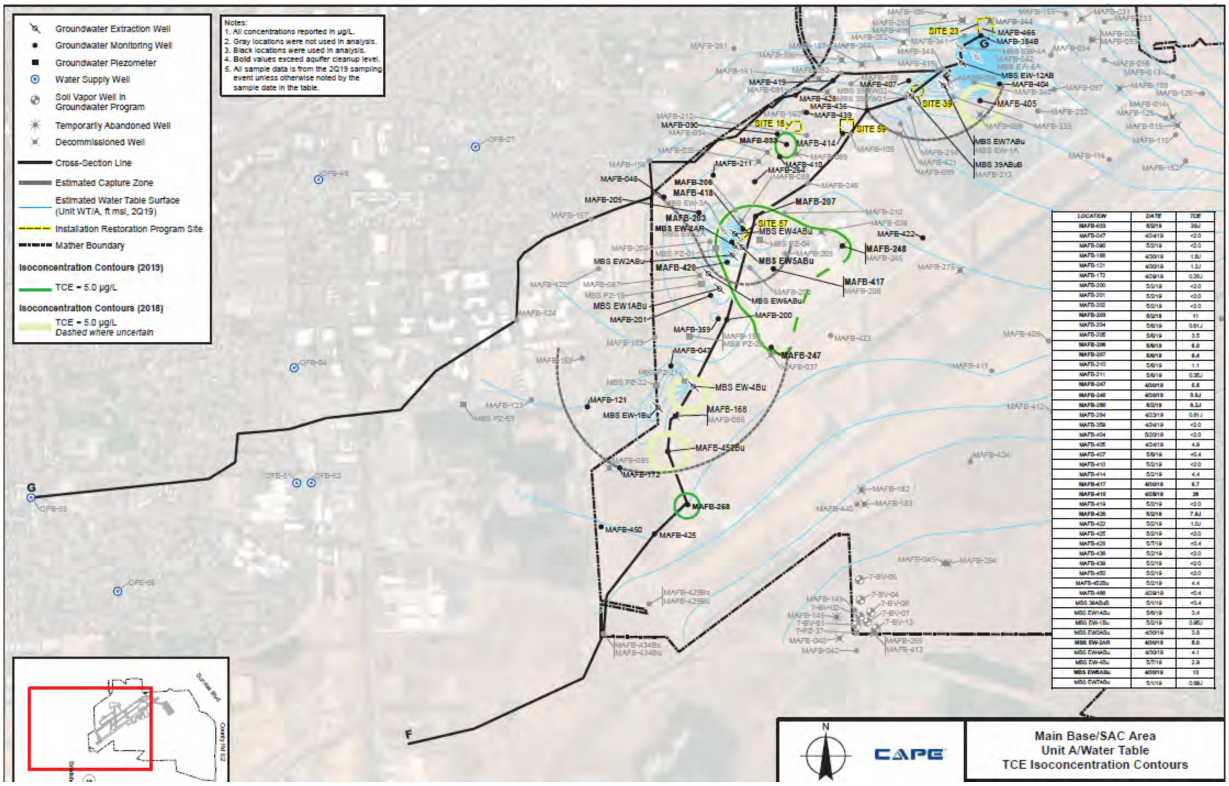


Figure 2.1-21: Mather MBSA Site TCE Concentrations

Source: Mather Annual and Fourth Quarter 2019 Groundwater Monitoring Report_Figure 6-1_pg219

2.1.8.2 Aerojet Superfund Site

The EPA designated the Aerojet General Corporation site as a designated Superfund Site. Additional information can be found here:
https://cumulis.epa.gov/supercpad/CurSites/csitinfo.cfm?id=0901718&msspp=med

The Aerojet Superfund Site is a complicated facility located in the northeastern quadrant of the subbasin and was used to manufacture and test rocket propulsion systems and for chemical manufacturing. The site currently covers 5,900 acres and is located 15 miles east of Sacramento in Rancho Cordova, and half a mile from the American River as shown in **Figure 2.1-22**. The figure also includes the IRCTS which was a late 1950s to early 1970s rocket assembly and testing facility operated by the McDonnell Douglas Corporation.

Aerojet began operations at the site in 1953. Its operations also included the production of liquid and solid propellants for rocket engines and motors for military and commercial use. The formulation of chemicals included rocket propellant agents, pesticides, medical intermediaries, and other industrial chemicals. Aerojet and others disposed of unknown quantities of hazardous waste and chemicals, including TCE, and other waste in surface impoundments, landfills, leachate fields, open burning, and other adverse waste disposal mechanisms. Most of the toxic waste was left unregulated until the late 1970s and early 1980s when environmental investigations began. These former activities at Aerojet resulted in extensive soil and groundwater contamination in the South American Subbasin.

Volatile organic compounds (VOCs), primarily trichloroethylene (TCE), were found off-site in private wells. Perchlorate, a component of solid rocket fuel, was found in drinking water wells off-site in 1997. Nitrosodimethylamine (NDMA) is a contaminant in liquid hypergolic rocket fuels and a combustion byproduct, and was addressed by the 1980s groundwater remediation systems on east side of the site. During the 2000s. NDMA was detected in offsite monitoring wells at 30 times the new Maximum Contaminant Level (MCL).

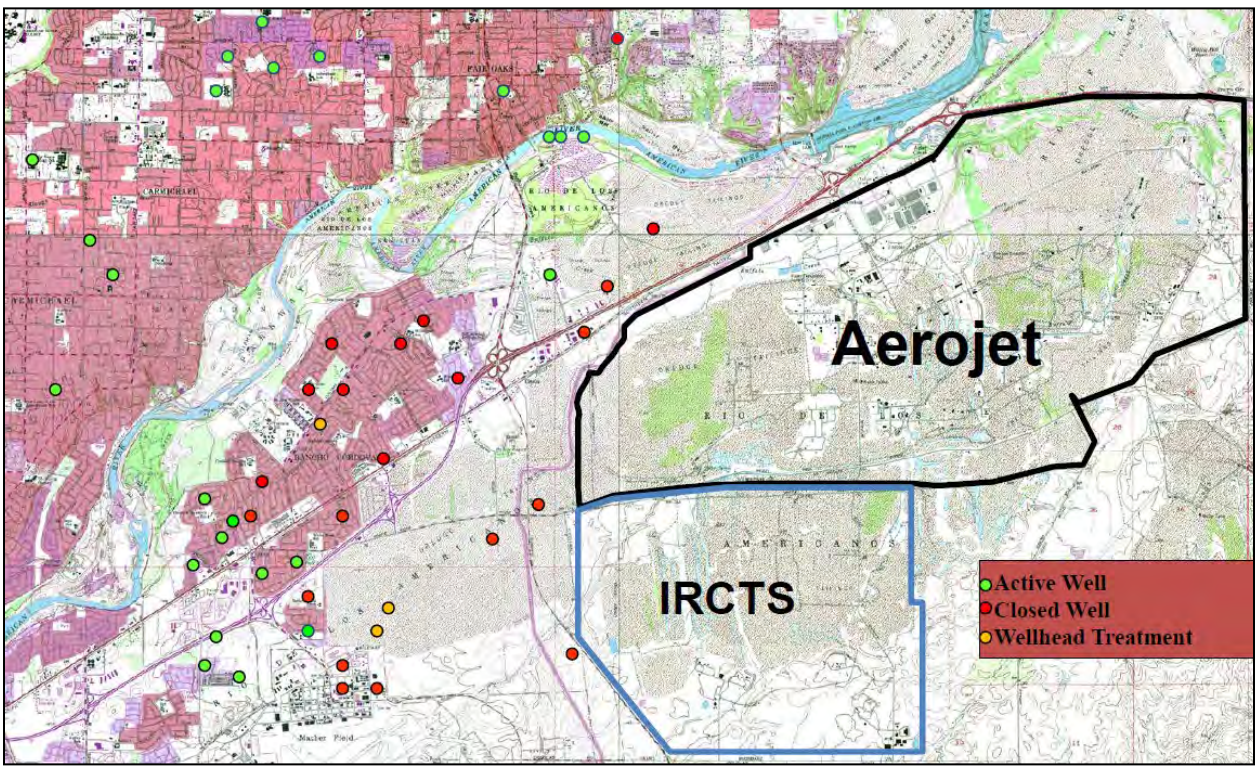


Figure 2.1-22: Aerojet Site Location Map

Source: Central Basin Groundwater Presentation 2019_Pg 3

2.1.8.2.1 Historical, Current, and Future Operations

The Aerojet Superfund Site was one the first sites added to the USEPA's National Priorities in 1983 and is one of the largest and most extensive Superfund groundwater cleanups in California. Over the past 37 years, multiple cleanup efforts have been mandated under the direction of the U.S. Environmental Protection Agency (EPA), the California Regional Water Quality Control Board, Central Valley Region (Regional Board), and California Department of Toxic Substances Control (DTSC).

The site sits atop a large miles-long groundwater plume that is polluted with various chemicals of concern, including TCE (**Figure 2.1-23**), Perchlorate (**Figure 2.1-24**), and/or NDMA (**Figure 2.1-25**). The aquifer beneath the site has been divided into six hydrostratigraphic layers (Layers A through F). In general, the layers thicken and deepen from east to west. Various constituents are located throughout Layers A-E, depending on the location on the Aerojet Site. Concentrations occur in all layers but are primarily in Layers C, D, and E.

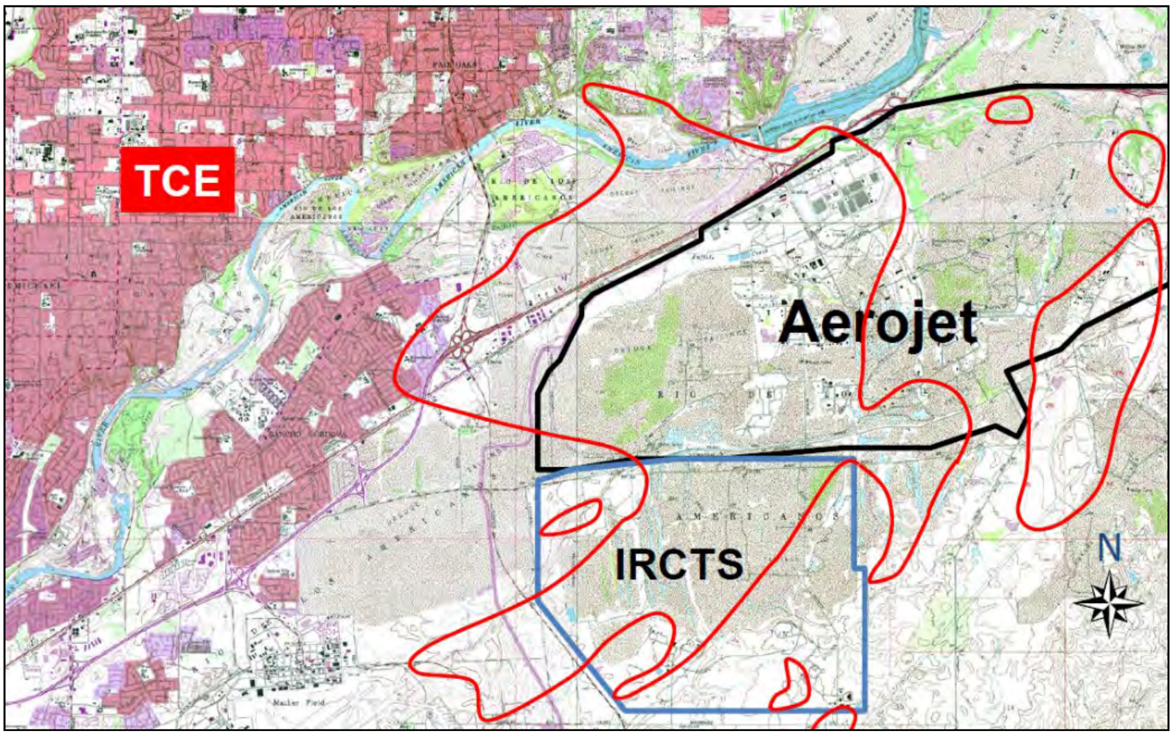


Figure 2.1-23: Aerojet and IRCTS TCE Plumes 2019

Source: Central Basin Groundwater Presentation 2019_Pg 4

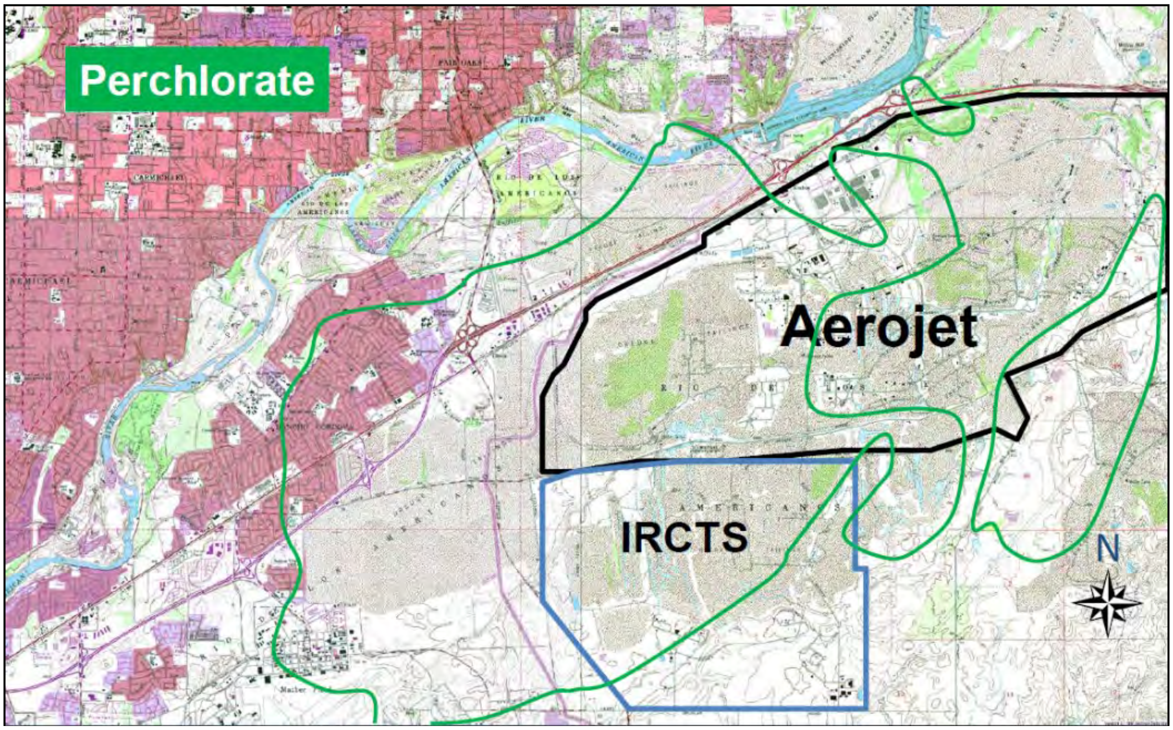


Figure 2.1-24: Aerojet and IRCTS Perchlorate Plume

Source: Central Basin Groundwater Presentation 2019_Pg 5

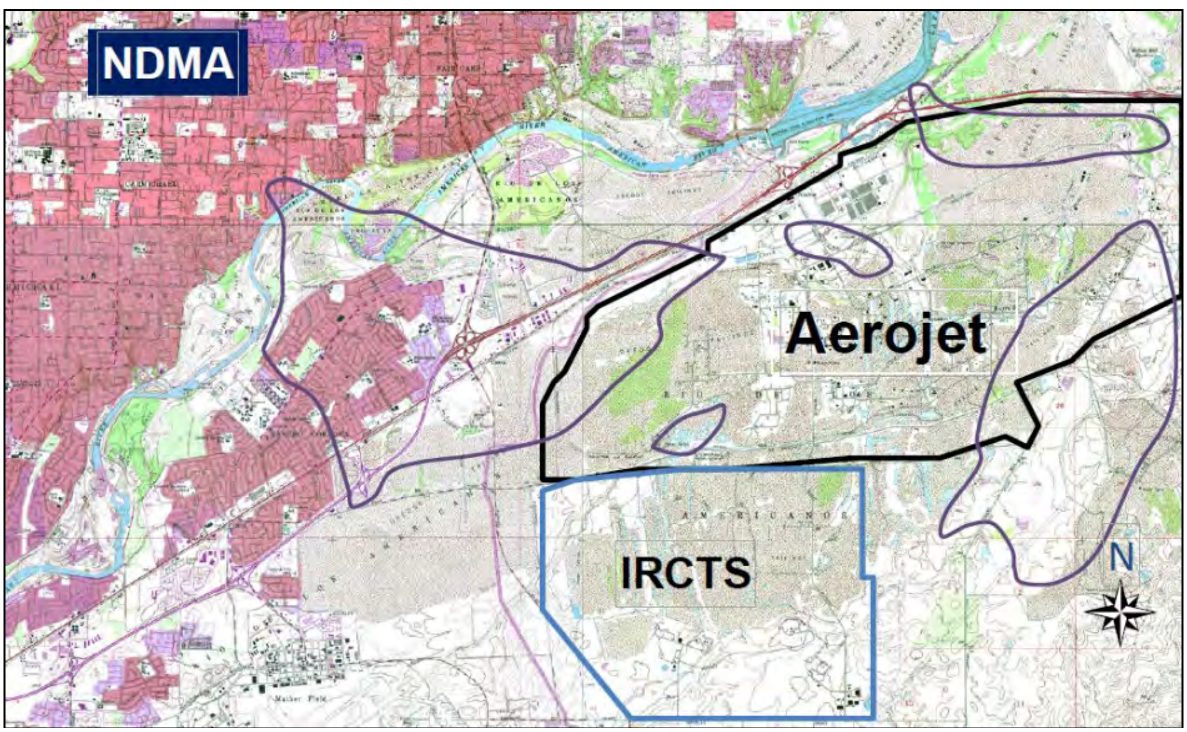


Figure 2.1-25: Aerojet NDMA Plume

Source: Central Basin Groundwater Presentation 2019_Pg 6

Aerojet has installed several groundwater extraction and treatment systems (GETs) (see **Figure 2.1-26**) to contain the contaminated groundwater plume, which was originally delineated by Aerojet at a total of 8,600 acres. The site was originally divided into seven sectors (A-G) and then into four zones prioritizing the cleanup schedule. During the early 2000s, the site was reorganized into 12 operable units (OUs) to facilitate the remedial activities, including three mostly offsite groundwater OUs, six mostly interior soil and groundwater OUs, and three sitewide OUs.

In 1982, Aerojet installed the first GET (D) to begin control of the flux of pollutants in groundwater at the site boundary. Between 1982 – 1987, four additional GETs (A, B, E, F) were constructed on the property. In 1997, ARGET began operations with a wellfield on the northside of the American River. Five additional GETs were installed off-property between 2004 and 2010 to control and cleanup the toes of off-site plumes to the west, southwest, and northwest of the site.

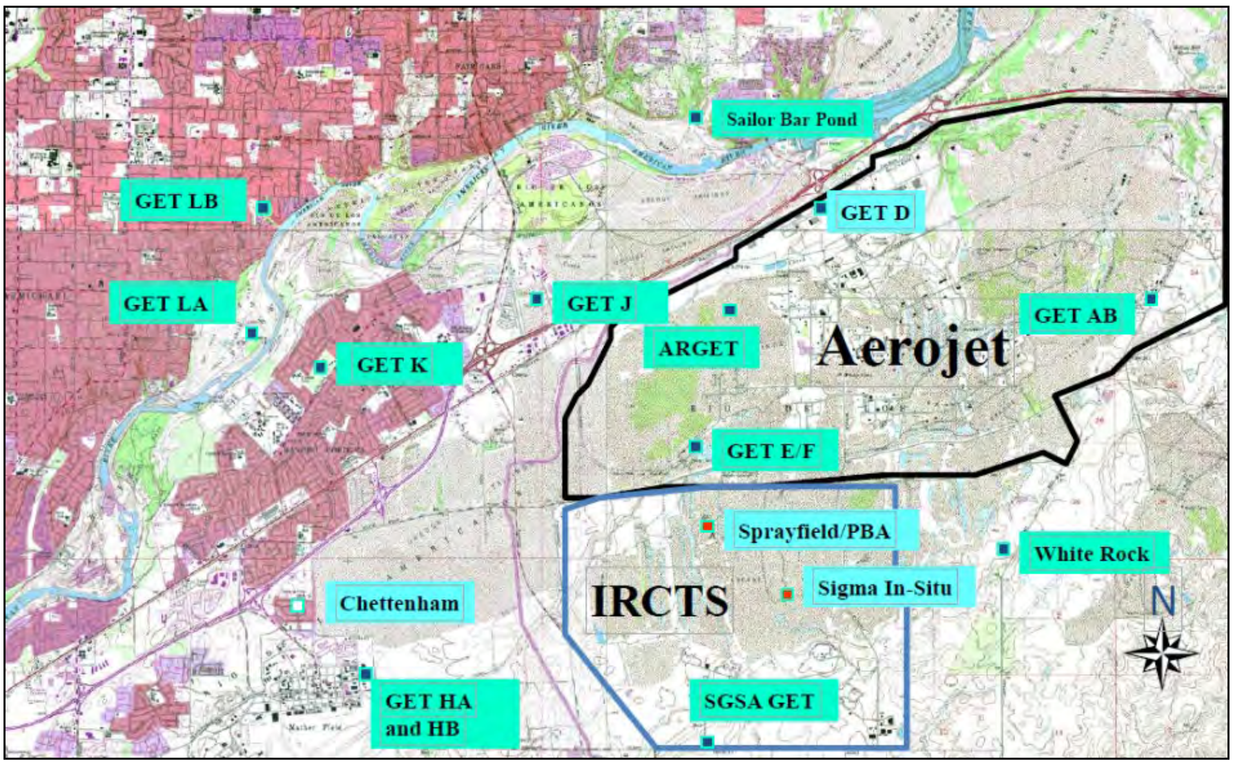


Figure 2.1-26: Aerojet and IRCTS Groundwater Extraction and Treatment Systems

Source: Central Basin Groundwater Presentation 2019_Pg 7

During the 1980s and 1990s, Aerojet was discharging remediated water via recharge wells intended to facilitate a capture zone and reduce further plume migration or by discharging the water onto porous dredge tailings. This capture and recharge approach did not remove much groundwater from the subbasin. However, the first perchlorate treatment facility (fluidized bed bioreactor) produced biosolids that, in 1998, clogged the recharge wells, and the discharge of treated groundwater shifted to Buffalo Creek (American River). Over time, Aerojet phased out the use of other recharge wells and the dredge tailings. Aerojet discharges a majority of its remediated groundwater to the American River and to Morrison Creek under a permit from the National Pollutant Discharge Elimination System (NPDES).

The IRCTS is located on the south side of the Aerojet Site and is the origin for several TCE or perchlorate plumes due to aerospace activities by the McDonnell Douglas Corporation (MDC) and to some extent by Aerojet. Aerojet plumes along its southwestern boundary have commingled with the IRCTS plumes. The Boeing Company, as the successor to MDC, has install several GETs at the IRCTS and at Mather Field.

Aerojet claims ownership of its groundwater discharges (**Figure 2.1-27**) to the American River and to Morrison Creek and, during the early 2000s, began seeking partners to perfect these claims. Golden State Water Company (GSWC) is currently authorized to withdraw an annual volume of 5,000 AF/year of Aerojet water from the river. Beginning in 2017, in conjunction with Carmichael Water District (CWD), a pipeline was installed beneath the American River to connect GSWC to CWD so that Aerojet water can be conveyed to GSWC in the SASb. CWD utilizes its existing Ranney Collector to capture river underflows and treat the water via a pressurized filtration plant before conveying the water via the pipeline to GSWC south of the American River and back into the SASb. This collaboration allows GSWC to reduce its SASb groundwater extractions. Similarly, Sacramento County Water Agency (SCWA) is authorized to withdraw an annual volume of 8,900 AF/year of Aerojet water at the Freeport Intake along the Sacramento River, less the loss factor (10%) of recharge via the river. This water is then conveyed to the eastern side of the SCWA service area and treated at the Vineyard Surface Water Treatment Plant for distribution in the SCWA service area in the SASb. Aerojet has reserved the remainder of its treated water for use as municipal water for its planned development of property in Rancho Cordova. In addition, Aerojet has considered various options to change its discharge from Morrison Creek (GET H-A) to the American River.

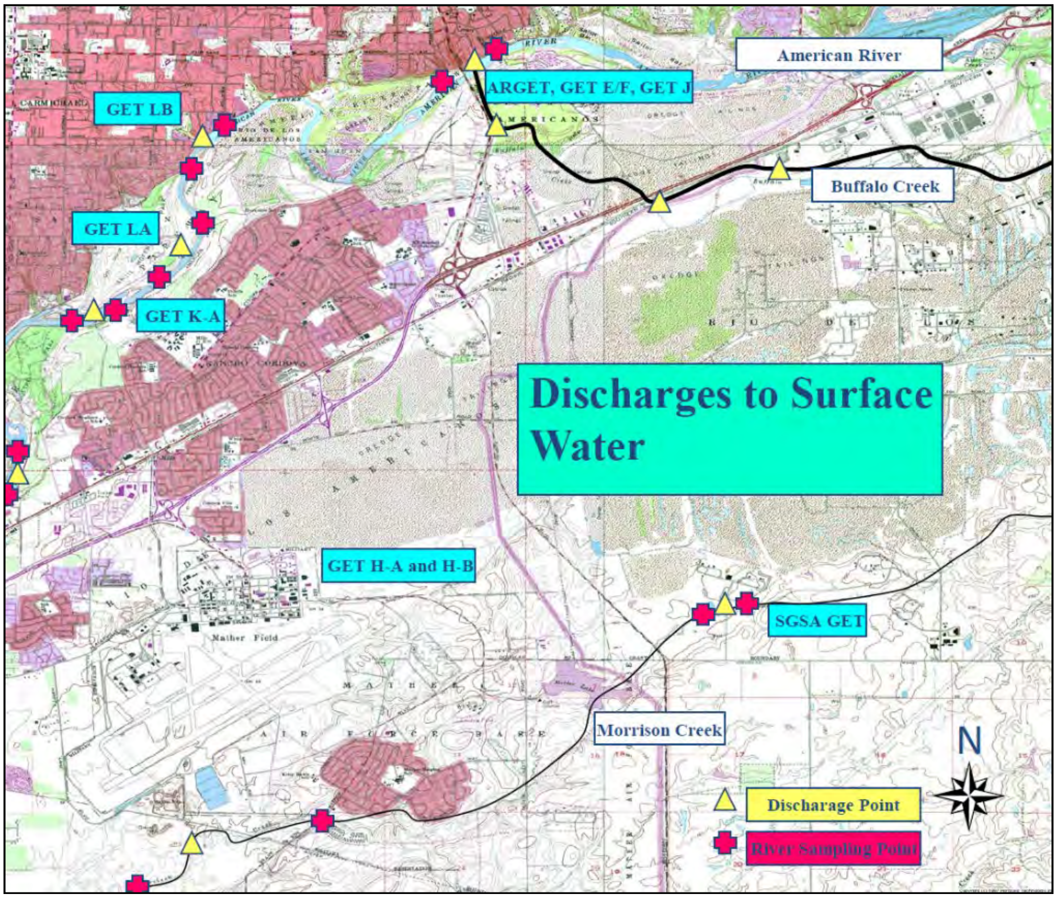


Figure 2.1-27: Aerojet and IRCTS Surface Water Discharges

Source: Central Basin Groundwater Presentation 2019_Pg 11

The Aerojet GET operations are subject to quarterly reporting and their effectiveness is evaluated annually. To further reduce contamination, additional extraction wells have been added periodically. The presence of Per- and Poly-fluoroalkyl Substances (PFAS) was evaluated at each GET and while detected in the parts per trillion range at some GETs, was not found to be a significant issue. The Aerojet and IRCTS monitoring network consists of over 2,000 monitoring wells but only a few hundred are monitoring on a quarterly or semiannual frequency.

The Aerojet groundwater model is mostly complete and addresses contaminant concentrations in Layers A-F and extends into the NASb since the plumes have migrated north beneath the American River.

Current activities include increasing plume capture, developing contingency plans, and installing 10 to 12 monitoring well clusters to further define the plumes. Additional extraction wells are not currently planned. Future remediation activities will focus on the interior of the Aerojet Site and the continued evaluation of reusing treated groundwater.

Aerojet operated two wastewater disposal wells under a CVRWQCB permit between 1963 and 1985 and injected 85 million gallons of a dense aqueous phase brine into the upper Ione

Formation. The brine exhibits a sodium-chloride/sulfate character and includes volatile organic chemicals. The wells were destroyed in 1994 under the oversight of EPA and the DTSC, and post-closure monitoring is conducted under a RCRA Post-Closure Permit.

2.1.8.2.2 Effects on subbasin supply

The Aerojet and IRCTS GETs discharge to various outfalls leading to the American River and Morrison Creek. Since 2010, Aerojet has pumped an average of 27,075 AFY of contaminated water as displayed in **Table 2.1-15**.

Table 2.1-15: Aerojet and IRCTS Groundwater Pumping

Year	Amount (AFY)
2010	24,938
2011	26,809
2012	28,391
2013	20,311
2014	24,228
2015	22,179
2016	30,836
2017	32,025
2018	31,267
2019	29,766
Average	**27,075**

Note:
AIRCTS = Inactive Rancho Cordova Test Site

2.1.8.2.3 Migration of Contaminated Groundwater

The GETs currently have a permitted total flow capacity of 30,200 gpm but averages 14,000 gpm. To date, 171 billion gallons of water have been treated and over 1,517,000 pounds of contaminants have been removed. The system removes approximately 130 pounds of chemicals per day. Aerojet continues to install additional monitoring wells at various GETs to help refine the plume definition. Aerojet is also evaluating the potential for additional extraction wells along the west central part of the plume to increase capture and speed up cleanup time. According to the EPA, due to the complexity of the hydrogeology and extent of contamination, the cleanup time for the Western Groundwater OU is estimated at 200 years.

2.1.8.3 Kiefer Landfill

Sacramento County conducts remedial activities at the Kiefer Landfill under CVRWQCB WDR Order R5-2016-0013. Additional information can be found here: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2016-0013.pdf

The Kiefer Landfill is a 1,084-acre facility with an active class III, 300-acre solid waste disposal site that is owned and operated by Sacramento County (**Figure 2.1-28**). The site is located 20 miles east of Sacramento in the southeast quadrant of the SASb. The Kiefer Landfill has accepted household waste from the public, businesses, and private waste haulers since 1967. The landfill also accepts recyclable materials and other special waste. Groundwater contamination was discovered in 1987 through a Solid Wastewater Quality Assessment Test, and discovered several VOCs: TCE, PCE, 1,2-dichloroethene, and vinyl chloride. The County of Sacramento was directed to remediate the groundwater under an approved Correction Action Plan required under California Water Quality Control Board Cleanup and Abatement Order No. 91-725. Sacramento County was issued Order No. 89 to install a network of monitoring wells.

Figure 2.1-28: Kiefer Landfill Site Map

Source: 2011 Kiefer Landfill Groundwater Remediation Status Presentation by Sacramento County Department of Waste Management and Recycling

2.1.8.3.1 Historical, Current, and Future Operations

The landfill sits atop valley alluvium bearing three groundwater zones. Zone A, middle sands in the upper Mehrten Formation, sits at approximately 30 feet MSL. Zone B, deep sands in the upper Mehrten Formation, sits between 0 and -50 feet MSL. Zone C in the lower Mehrten Formation sits between -150 and -200 feet MSL. Ninety percent of the contamination was found in the shallow Zone A with concentrations of VOCs over 20 ppb. Zone B contained less than 5 ppb. Contamination has not been found in the deeper Zone C.

Groundwater remediation activities began in the 1990s to prevent contamination from migrating into Zone C, which supplies regional drinking water. In order to remediate the groundwater plume, Sacramento County began a groundwater remediation program. Sacramento County achieved hydraulic containment of the plume and reduced concentrations with groundwater extraction wells and a treatment plant, which began operation in 1995. The plant includes 15 extraction wells that withdraw contaminated water from Zone A and Zone B and remove contaminants with air-stripping technology. Approximately 650,000 gallons of water are treated per day. Through a NPDES permit, treated water was discharged at a rate of up to 1,000 gallons per minute (gpm) to nearby Deer Creek, a tributary to the Cosumnes River, until 2018. Since then, on-site infiltration basins have been placed into service as part of an approved pilot program to manage effluent from the treatment plant.

The groundwater remediation program includes source abatement with the operation of the landfill gas (LFG) extraction system, and leachate collections and removal systems (LCRS). The County does consistent monitoring of groundwater parameters and LFG control to track the progress of the remedial program and for compliance with Water Quality Protection Standards (WQPS) at detection monitoring sites located beyond the perimeter of the plume. Currently, the monitoring network at Kiefer consists of 65 monitoring wells.

Sacramento County has made significant progress on groundwater remediation. The infiltration basin pilot study was successful, and the County has received approval for permanent use. The County of Sacramento will continue the remediation program long-term until the Regional Board approves modification.

2.1.8.3.2 Effects on subbasin supply

Since 2010, an average of 1,457 AFY have been pumped by the groundwater treatment system at the Kiefer Landfill (see **Table 2.1-16**). Since 2018, the treated water has been discharged at onsite infiltration basins and returned to the subbasin. Remediation activities at the Kiefer Landfill do not have a significant impact to the subbasin supply.

Table 2.1-16: Kiefer Groundwater Pumping

Year	Amount (AFY)
2010	1,099
2011	1,142
2012	391
2013	518
2014	507
2015	460
2016	380
2017	475
2018	599
2019	650
Average	**622**

2.1.8.3.3 Migration of Contaminated Groundwater

The plume at the Kiefer Landfill is contained and under hydraulic control. Total VOC concentrations in the plume have significantly decreased with the groundwater extraction and treatment systems. Contamination in Zones A and B have decreased by 86 percent and 76 percent respectively, while Zone C and drinking water wells have not been impacted by contamination from the landfill. In 1995, total VOCs in Zone A were estimated at 663 pounds.

Today, concentrations are estimated at less than 90 pounds. Total VOCs in Zone B were estimated at 54 pounds in 1995 and are estimated at less than 13 pounds today. Overall, the groundwater extraction and treatment system has helped cleanup over 80 percent of groundwater contamination since 1995.

2.1.8.4 Other Groundwater Remediation Sites

Other known groundwater contaminant plumes within of near the SASb are:

- McDonnell-Douglas (Boeing) IRCTS site: The Boeing Company, in coordination with Aerojet, conducts remediation at the IRCTS under CVRWQCB Waste Discharge Requirement (WDR) Order R5-2010-0126. Additional information can be found here: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2010-0126.pdf.

- Sacramento Army Depot site: The EPA has designated the Sacramento Army Depot site as a Superfund Site. Additional information can be found here: https://cumulis.epa.gov/supercpad/CurSites/csitinfo.cfm?id=0902715&msspp=med.

- Union Pacific Downtown site. Additional information can be found here: https://cumulis.epa.gov/supercpad/CurSites/csitinfo.cfm?id=0903909.

- Union Pacific Curtis Park site. Additional information can be found here: https://cumulis.epa.gov/supercpad/CurSites/csitinfo.cfm?id=0903909.

In addition to the Kiefer Landfill, the following other landfills located in the subbasin that are subject to RWQCB orders for contaminant concerns:

- 28th Street Landfill: PFAS have been detected in groundwater.
- Dixon Pit Landfill: contains minimal VOCs and inorganics in groundwater.
- Elk Grove Landfill: has low-level VOCs.
- Gerber Road Landfill: has a low concentration of organics in groundwater.
- L&D Landfill: contains minimal VOCs and inorganics in groundwater.

2.1.8.5 Effects on Subbasin Supply

Remediation activities at the Aerojet Site, IRCTS, Mather Field, and Kiefer Landfill have resulted in a small increase in extraction of groundwater associated with cleanup actions. Four sites are pumping nearly 30,000 AFY as shown in **Table 2.1-17**. While the Mather AFB and Kiefer Landfill sites extraction have remained steady over time, extractions by the Aerojet Site and IRCTS have increased slightly (<3% per year for 10-year period). . Remediation will continue at all four sites until cleanup levels are obtained. The SASb GSAs will continue working with the responsible parties and CVRWQCB and will adaptively and sustainably manage the groundwater resources of the basin for beneficial uses well into the future.

Table 2.1-17: South American Subbasin Remediation Site Groundwater Pumping

Site	Average Annual Amount (AFY)
Aerojet & IRCTS	27,075
Mather AFB	1,221
Kiefer	1,457
Total	**29,753**

2.1.9 Existing Water Management Programs

Existing water management plans and programs are described below.

2.1.9.1 2000 Water Forum Agreement

As stated in **Section 2.1.4**, Water Forum negotiations began in 1993 between the City of Sacramento and Sacramento County to identify water supply and environmental concerns during a period of regional population growth and declining groundwater levels. On April 24, 2000, the Water Forum Agreement was executed by 40 stakeholder organizations representing business and agricultural leaders, citizen groups, environmentalists, water managers, and local governments. The Water Forum identifies two coequal objectives as follows:

- Provide a reliable and safe water supply for the Sacramento region’s long-term growth and economic health.
- Preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.

To achieve these two coequal objectives, all signatories to the Water Forum Agreement were required to endorse and, where appropriate, participate in each of the Agreement’s seven elements as listed below:

- Increased surface water diversions.
- Actions to meet customers’ needs while reducing diversion impacts in drier years.
- Support for an improved pattern of fishery flow releases from Folsom Reservoir.
- Lower American River Habitat Management Element.
- Water Conservation Element.
- Groundwater Management Element.
- Water Forum Successor Effort.

The Water Forum Agreement identified the need for a groundwater management organization in the “Central Basin” (ultimately developed by the Groundwater Forum and established as SCGA by adoption of a Joint Powers Agreement in August of 2006) and established a sustainable annual groundwater yield of 273,000 acre-feet. As part of the SASb’s continuing groundwater management, SCGA developed a groundwater level monitoring and reporting program, a groundwater data management system, monitored groundwater contamination/remediation activities, identified improvements to the existing groundwater management plan, and evaluated a potential Well Protection Program. Successful implementation of this GSP will help maintain the Water Forum Agreement’s groundwater management practices as described in the Groundwater Management Element of the Agreement. The Groundwater Management Element provides valuable resources related to potential concepts, projects, and monitoring strategies that can be incorporated into the SASb GSP. No limitations to operational flexibility in GSP implementation in the SASb are expected due to Water Forum activities.

2.1.9.2 Central Sacramento County Groundwater Management Plan

The *Central Sacramento County Groundwater Management Plan* (CSCGMP) (MWH, Water Forum & SCWA, 2006) created an outline for maintaining sustainable groundwater use in the Sacramento Central Basin. As stated in the CSCGMP, "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" (MWH, Water Forum & SCWA, 2006). The CSCGMP was developed by approximately 40 stakeholders (Groundwater Forum) representing agricultural interests, agricultural-residential groundwater users, business interests, environment/community organizations, local government/public agencies, and water purveyors. Five basin management objectives (BMOs) provided the foundation of the CSCGMP as listed below:

- Maintain a long-term average groundwater extraction rate of 273,000 AF/year.
- Establish specific minimum groundwater elevations within all areas of the basin consistent with the Water Forum "Solution."
- Protect against any potential inelastic land surface subsidence.
- Protect against any adverse impacts to surface water flows.
- Develop specific water quality objectives for several constituents of concern.

A monitoring program was identified as one of five CSCGMP program component action items to help achieve the above BMOs as well as developing a greater understanding of the surface water and groundwater interconnection along the American, Cosumnes, and Sacramento Rivers (MWH, Water Forum & SCWA, 2006). Although the CSCGMP will no longer be in place after adoption of the GSP, the GSP will incorporate the existing BMOs and the GSP monitoring program will maintain the existing monitoring network along with additional efforts to achieve sustainability.

2.1.9.3 SCGA Groundwater Elevation Monitoring Plan

The SCGA *Groundwater Elevation Monitoring Plan* (MWH, Water Forum & SCWA, 2006) outlined the objectives and actions required of the SCGA as the responsible CASGEM Program monitoring and reporting entity for the SASb. The CASGEM Program network consists of 29 active wells that have historically been monitored by SCWA and DWR. Identification of future wells would be based on the need to maintain or improve the reliability of the existing network or increase coverage within a data gap area created by loss of an existing monitoring well. The plan also established the monitoring schedule and monitoring and reporting protocol for the CASGEM Program network. Groundwater elevation monitoring will continue to occur semi-annually during April and October, which allows the network to document seasonal high and low groundwater levels. The plan included standard operating procedure for determining depth to water including equipment, preparation, procedures, quality assurance/quality control, and data reporting to the CASGEM Online Submittal System (SCGA, 2012). The scope of this GSP is consistent with the SCGA *Groundwater Elevation Monitoring Plan* and will incorporate the existing groundwater elevation monitoring network of the SASb. Operational flexibility during the

GSP implementation in the SASb will not be limited by the Groundwater Elevation Monitoring Plan.

2.1.9.4 Zone 40 Groundwater Management Plan

The *Zone 40 Groundwater Management Plan* (SCWA, 2004) was an interim step to developing the CSCGMP and included both required and voluntary components that the SCWA would implement to maintain a sustainable, high-quality groundwater resource. Zone 40 is located in the central portion of Sacramento County and consists of portions of the cities of Elk Grove and Rancho Cordova, the Florin-Vineyard Community Area, the Mather/Sunrise areas of unincorporated Sacramento County, and rural residential and agricultural land. The goal of the *Zone 40 Groundwater Management Plan* was to ensure a viable groundwater resource for beneficial uses including water for adjacent purveyors, agricultural, agricultural-residential, industrial, and municipal supplies that support the Water Forum Agreement'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.

Five BMOs were adopted to meet the *Zone 40 Groundwater Management Plan* goals as listed below:

- Maintain or improve groundwater quality in the Zone 40 area for the benefit of basin groundwater users.
- Maintain groundwater elevations that result in a net benefit to basin groundwater users.
- Protect against any potential inelastic land surface subsidence.
- Protect against adverse impacts to surface water flows in the American, Cosumnes, and Sacramento Rivers.
- Protect against adverse impacts to water quality resulting from interaction between groundwater in the basin and surface water flows in the American and Sacramento Rivers.

Elements of the Water Forum Agreement included in the BMOs are to reduce lower American River diversions during dry years and not to exceed agreed upon aggregate groundwater extractions of 273,000 AF/year, on average. The monitoring program addressed the five BMOs listed above. The *Zone 40 Groundwater Management Plan* was superseded by the CSCGMP.

The *Zone 40 Groundwater Management Plan* provides valuable resources related to potential concepts, projects and monitoring strategies that can be incorporated into the SASb GSP. The scope of this GSP is consistent with the Zone 40 GMP's groundwater management plan and will incorporate the BMO. Operational flexibility during the GSP implementation in the SASb will not be limited by the *Zone 40 Groundwater Management Plan*.

2.1.9.5 Central Valley Regional Water Quality Control Board—Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 to prevent agricultural runoff from impairing surface waters, with regulation of discharges to groundwater added in 2012 (CVRWQCB, nd). On March 12, 2014, the CVRWQCB adopted *Waste Discharge Requirements General Order for Growers within the Sacramento River Watershed that are Members of a Third-Party Group* (General Order WDR R5-2014-0030-R1). The Sacramento

Valley Water Quality Coalition developed and implemented a Monitoring and Reporting Program (MRP) to meet the requirements of the General Order. The MRP analyzes water quality for chemical, physical, and microbiological parameters in surface waters receiving agricultural runoff to identify potentially significant concentrations that exceed ILRP trigger limits. The ILRP trigger limits are established to identify potential sources of contamination and inform potential users of constituents of concern (Sacramento Valley Water Quality Coalition, 2017). The parameters include the following:

- Water column and sediment toxicity
- Physical and conventional parameters
- Organic carbon
- Pathogen indicator organisms
- Trace metals
- Pesticides
- Nitrogen and phosphorous compounds

The SASb is located within the Sacramento River Watershed jurisdictional boundary of the CVRWQCB ILRP, but no ILRP monitoring sites (surface water and groundwater) are located within the SASb. Operational flexibility in GSP implementation in the SASb is not expected to be limited by ILRP activities.

2.1.9.6 Sacramento County Environmental Management Department Wells Program

The Sacramento County Environmental Management Department Wells Program is responsible for authorizing the construction, modification, repair, inactivation, or destruction of wells in Sacramento County via a permit and inspection process. The Environmental Management Department maintains a database that includes the permitted well information and conducts enforcement actions against persons that violate provisions of the Sacramento County well code (Sacramento County, 2020). Operational flexibility in GSP implementation in the SASb is not expected to be limited by this program.

2.1.9.7 Central Valley Salinity Alternatives for Long-Term Sustainability Initiative

The Central Valley Salinity Alternatives for Long-Term Sustainability Initiative (CV-SALTS) is a collaborative stakeholder-driven and managed program initiated in 2006 to find solutions to salt and nitrate problems. CV-SALTS is charged with developing sustainable, long-term salinity and nitrate management strategies for the Central Valley (Central Valley Salinity Coalition, 2020). The CV-SALTS process has included a broad group of agricultural, municipal, industrial, non-governmental organizations, and regulatory agencies. Goals adopted for the CV-SALTS program include the following:

- Sustain the Central Valley's lifestyle.
- Support regional economic growth.
- Retain a world-class agricultural economy.
- Maintain a reliable, high-quality water supply.
- Protect and enhance the environment.

The *Central Valley Salt and Nitrate Management Plan* (SNMP) (CV-SALTS, 2016) was completed in December 2016 to address both the ongoing salt and nitrate issue in the

Central Valley and the state's recycled water policy. The SNMP establishes the following three goals:

- Ensure a safe drinking water supply.
- Achieve balanced loadings of nitrate and salt (total dissolved solids / electrical conductivity).
- Implement managed aquifer restoration program.

In May 2018, the CVRWQCB adopted a Basin Plan amendment to codify the key elements of the SNMP. In October 2019, the State Water Resource Control Board conditionally approved this Basin Plan amendment.

While CV-SALTS has identified a temporary monitoring program for the SNMP, a Surveillance and Monitoring Program will be established to monitor water quality and ensure the SNMP helps CV-SALTS achieve its goals (Central Valley Salinity Coalition, 2020).

The SASb has not been listed as a priority basin for nitrate management under the CV-SALTS Basin Plan amendment. Salinity management in the Central Valley (and SASb) will be addressed as a result of the findings of a Prioritization and Optimization Study performed under the direction of the Central Valley Salinity Coalition, which will address long term salinity management plans and occur over the next ten to fifteen years. Operational flexibility in GSP implementation in the SASb is not expected to be limited by CV-SALTS activities.

2.1.9.8 Delta Plan

The Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act) established the Delta Stewardship Council to manage the Delta's water and environmental resources. The Delta Stewardship Council's *Delta Plan* (Delta Stewardship Council, 2020) includes 14 regulatory policies and 73 recommendations to achieve the State's coequal goals of a reliable statewide water supply and a protected, restored Delta ecosystem. The *Delta Plan*'s policies include the following:

- Develop detailed findings to establish consistency with the *Delta Plan.*
- Reduce reliance on the Delta through improved regional water self-reliance.
- Practice transparency in water contracting.
- Develop Delta flow objectives.
- Restore habitats at appropriate elevations.
- Protect opportunities to restore habitat.
- Expand floodplains and riparian habitats in levee projects.
- Avoid introducing/habitat improvements for invasive nonnative species.
- Locate new urban development wisely.
- Respect local land use when siting water or flood facilities or restoring habitats.
- Prioritize state investments in Delta levees and risk reduction.
- Require flood protection for residential development in rural areas.
- Protect floodways.
- Protect floodplains.

These policies and their associated recommendations address current and future challenges related to the Delta's ecology, flood management, land use, water quality, and water supply reliability (Delta Stewardship Council, 2020). The *Delta Plan* provides resources related to potential concepts, projects, and monitoring strategies that can be incorporated into the SASb GSP during development, and all policies and recommendations will be considered during both project implementation and future GSP updates. Operational flexibility in GSP implementation in the SASb is not expected to be limited by the Delta Plan activities.

2.1.9.9 Zone 40 Water Supply Master Plan

The *Zone 40 Water Supply Master Plan* service area extends from Rancho Cordova in the north to Elk Grove in the south and includes portions of the Elk Grove Water District (Elk Grove wholesale area) and portions of the future California American Water Company service area in Rio del Oro (SCWA, 2016). The overall objective of the *Zone 40 Water Supply Master Plan* is to meet future water demands through a conjunctive use program of groundwater, surface water, and recycled water supplies. Specific objectives include:

- Identify assumptions and recommendations from the 1987 *Zone 40 Water Supply Master Plan* that are no longer appropriate.
- Develop a set of water supply alternatives that provide a long-term balance between water demands and available supplies that include demand management, groundwater (including groundwater from the East Sacramento County Replacement Water Supply Project), surface water, and recycled water as the building blocks for water management alternatives.
- Evaluate the engineering, institutional, social, financial, and environmental aspects associated with implementing each of the potential water management alternatives.
- Recommend a water management alternative that is flexible and can be modified as situations change and additional information becomes available.
- Identify an appropriate and flexible means of financing the recommended water management alternative.
- Provide a foundation on which to develop a *Water Supply Infrastructure Plan* to base decisions regarding the acquisition, construction, operation and maintenance of facilities required for the production, transmission, distribution, sale, and demand management of water.
- Maintain consistency with the adopted *Zone 40 Groundwater Management Plan* and the proposed Central Sacramento County Groundwater Basin Groundwater Management Plan.

Although a *Zone 40 Water Supply Master Plan Amendment* was developed in 2013 (Cordova Hills) and 2016 (Newbridge) to address water supply for these projects and to update changes in water demands, the growth rate, and water supplies since the 2005 *Master Plan*, the specific and overall objectives remain the same (SCWA, 2016). *Zone 40 Water Supply Master Plan* objectives will be considered during implementation of this GSP and when developing the monitoring network and plans. Implementation of this GSP will help the *Zone 40 Water Supply Master Plan* continue to promote a reliable and sustainable water supply in Zone 40. Operational flexibility in GSP implementation in the SASb is not expected to limit this program.

2.1.9.10 City of Sacramento Water Conservation Plan

The goal of the City of Sacramento's *Water Conservation Plan* (WCP; City of Sacramento Department of Utilities, 2013) is to maximize the City's existing water and fiscal resources through a comprehensive and economically supported approach. The primary objectives of the WCP include the following:

- Deliver cost-effective water conservation and water use efficiency measures to maximize opportunities to sustainably meet the future water needs of the City.
- Offset and/or delay the need to construct additional water production capacity in the future.
- Help reduce ratepayer cost for treatment and delivery of water and treatment of wastewater, and reduce water-related energy consumption.
- Meet state and federal water conservation mandates as follows:
  - Achieve or exceed 20 percent per-capita water use reduction statewide by 2020.
  - Maintain commitments to the California Urban Water Management Council and Water Forum, and initiate measures most likely to achieve targets established in the 2010 *Urban Water Management Plan* (UWMP).
- Demonstrate environmental stewardship as follows:
  - Foster wise, innovative, responsible and efficient practices.
  - Establish a WCP that helps support the health of rivers and groundwater integral to the region's quality of life.

The WCP is comprised of multiple water conservation measures to educate, incentivize, or mandate conservation among residential, commercial, institutional, and irrigation accounts. Estimated water savings in 2020 were planned to come from automatic meter infrastructure and water conservation pricing, system water loss reduction, new and existing plumbing codes and standards, and successful implementation of programs and measures by the Water Conservation Office (City of Sacramento, 2013). Implementation of this GSP will promote efficient use of water to sustain groundwater supply and help the City of Sacramento to achieve its water conservation goals. The primary objectives of the WCP will were considered during GSP plan development. Operational flexibility in GSP implementation in the SASb is not expected to limit this program.

2.1.10 General Plans

Sacramento County has the largest jurisdiction in the SASb and encompasses the entire SASb GSP area. The *Sacramento County 2030 General Plan* (Sacramento County, 2017) covers the SASb area outside of the cities of Sacramento, Elk Grove, and Rancho Cordova. The combination of the *Sacramento 2035 General Plan* (City of Sacramento, 2015), the *Folsom 2035 General Plan* (City of Folsom, 2018), the City of Elk Grove *General Plan* (City of Elk Grove, 2019), and the City of Rancho Cordova *General Plan* (City of Rancho Cordova, 2006) ensure the entirety of the SASb is managed through an applicable general plan.

2.1.10.1 Sacramento County 2030 General Plan

The Conservation and Delta Protection Elements of the *Sacramento County 2030 General Plan* (Sacramento County, 2017) are the most relevant sections for development of this GSP because of the interconnection between water resources and aquatic/natural resources. The

Land Use Element is also important. **Table 2.1-18** summarizes the *Sacramento County 2030 General Plan* elements relevant to the GSP.

Table 2.1-18: *Sacramento County 2030 General Plan* Elements Relevant to the GSP

Goal	Objective	Policy
Conservation Element		
Water Resources— Ensure that a safe, reliable water supply is available for existing and planned urban development and agriculture while protecting beneficial uses of Waters of the State of California, including important associated environmental resources.	Optimize the use of available surface water in all types of water years (wet/normal, dry, and driest years)	CO-1 through CO-6
	Manage groundwater to preserve sustainable yield	CO-7 through CO-12
	Ensure the most efficient use of water in urban and agricultural areas.	CO-13 through CO-17
	Manage water supply to protect valuable water-supported ecosystems.	CO-18 through CO-23
	Manage the quality and quantity of urban runoff to protect the beneficial uses of surface water and groundwater	CO-24 through CO-32
	Manage municipal and industrial water supplies efficiently to serve existing and proposed development within the Urban Policy Area.	CO-33 through CO-36
Aquatic Resources— Preserve, protect, and manage the health and integrity of aquatic resources in Sacramento County	Preserve, protect, and enhance natural open space functions of riparian, stream and river corridors	CO-87 through CO-130
Delta Protection Element		
Natural Resources— Preserve and protect the natural resources of the Delta. Promote protection of remnants of riparian habitat and aquatic habitat. Encourage compatibility between agricultural practices and wildlife habitat.	--	DP-25 through DP-34
Water Resources: Protect and enhance long-term water quality in the Delta for agriculture, municipal, industrial, water-contact recreation, and fish and wildlife habitat uses, as well as all other beneficial uses.	--	DP-48 through DP-49
Land Use Element		
Commercial and Industrial Land Use	Commercial and Industrial Land Use	Commercial and Industrial Land Use
Agricultural-Residential Land Uses inside the Urban Services Boundary	Agricultural-Residential Land Uses inside the Urban Services Boundary	Agricultural-Residential Land Uses inside the Urban Services Boundary

Goal	Objective	Policy
A viable rural and recreational economy in all non-metropolitan areas outside of the Urban Service Boundary.	A viable rural and recreational economy in all non-metropolitan areas outside of the Urban Service Boundary.	A viable rural and recreational economy in all non-metropolitan areas outside of the Urban Service Boundary.

Source: Sacramento County, 2017

Goals, objectives, and policies from the *Sacramento County 2030 General Plan* (Sacramento County, 2011) will help shape GSP implementation and were considered during development of the SASb's monitoring network and projects.

The goals of this GSP are aligned with the goals of the *Sacramento County 2030 General Plan* in establishing sustainable management of water resources in the SASb and conservation of land use and agriculture while promoting economic growth. Implementation of this GSP will help achieve the goals, objectives, and policies of the *Sacramento County 2030 General Plan*.

2.1.10.2 City of Elk Grove *General Plan*

The City of Elk Grove *General Plan* (City of Elk Grove, 2019) established a framework for future planning and addresses issues that are considered essential to maintaining and improving the quality of life in Elk Grove. **Table 2.1-19** summarizes City of Elk Grove *General Plan* goals and policies relevant to the GSP.

Table 2.1-19: City of Elk Grove *General Plan* Goals and Policies Relevant to the GSP

Goal	Policy	Action
Natural Resources		
NR-3—Clean and Adequate Water Supply	Water Quality	NR-3-1 through NR-3-3
	Water Supply and Conservation	NR-3-4 through NR-3-14
Disaster and Emergency Risk Reduction		
ER-6—An Adaptable and Resilient Community	Loss of Snowpack and Decreased Water Supplies	ER-6-6 through ER-6-8
Urban Infrastructure		
ER-6—An Adaptable and Resilient Community	Water Service	INF-1-1 through INF-1-3
	Recycled Water	INF-1-4
Rural Area Community Plan		
Context-Sensitive Services	Water Service	RA-2-4 through RA-2-5

Source: City of Elk Grove, 2019

Goals, policies, and actions from the Elk Grove *General Plan* will help shape GSP implementation and were considered during development of the SASb's monitoring network and projects.

The goals of this GSP are aligned with the goals of the Elk Grove *General Plan* in establishing sustainable management of water resources within the SASb and promoting a reliable and safe water supply. Implementation of this GSP will help achieve the goals, objectives, and policies identified in the Elk Grove General Plan.

2.1.10.3 Folsom 2035 General Plan

The *Folsom 2035 General Plan* (City of Folsom, 2018) provides a framework for physical development of Folsom. The *General Plan* is comprised of seven elements: Land Use, Mobility, Economic Prosperity, Housing, Natural and Cultural Resources, Public Facilities and Services, Parks and Recreation, Safety and Noise. **Table 2.1-20** summarizes *Folsom 2035 General Plan* goals and policies relevant to this GSP.

Table 2.1-20: *Folsom 2035 General Plan* Goals and Policies Relevant to the GSP

Goal	Policy
Natural and Cultural Resources	
NCR 1.1—Protect and enhance Folsom's natural resources for current and future residents	NCR 1.1.1—Habitat Preservation
	NCR 1.1.2—Preserve Natural Resources
	NCR 1.1.3—Wetland Preservation
NCR 4.1—Preserve and protect water quality in the city's natural water bodies, drainage systems, and groundwater basin	NCR 4.1.1—Water Quality
	NCR 4.1.3—Protection
Land Use	
LU 1.1—Retain and enhance Folsom's quality of life, unique identity, and sense of community while continuing to grow and change	LU 1.1.13—Sustainable Building Practices
LU 9.1—Encourage community design that results in a distinctive, high-quality built environment with a character that creates memorable places and enriches the quality of life of Folsom's residents.	LU 9.1.6—Community Beautification
Public Facilities and Services	
PFS 3.1—Maintain the City's water system to meet the needs of existing and future development while improving water system efficiency	PFS 3.1.1—Water Master Plan
	PFS 3.1.2—Urban Water Management Plan
	PFS 3.1.3—Water Efficient Landscape Ordinance
	PFS 3.1.4—New Technologies
	PFS 3.1.5—Agency Coordination
	PFS 3.1.6—Water Quality
	PFS 3.1.7—Water Supply
	PFS 3.1.8—Water Resources
	PFS 3.1.9—Water Conservation Programs
	PFS 3.1.10—Water Conservation Standards
	PFS 3.1.11—Resilient System
	PFS 3.1.12—Non-Potable Water

Source: City of Folsom, 2018

Goals and policies from the *Folsom 2035 General Plan* will help shape GSP implementation and were considered during development of the SASb's monitoring network and projects.

The goals of this GSP are aligned with the goals of the *Folsom 2035 General Plan*, including sustainably managing the region's groundwater to maintain water supply reliability, protecting natural resources, and promoting water conservation and system efficiency. Implementation of this GSP will help achieve the goals, objectives, and policies of the *Folsom 2035 General Plan*.

2.1.10.4 City of Rancho Cordova General Plan

The Rancho Cordova *General Plan* (City of Rancho Cordova, 2006) is the first general plan adopted by the City of Rancho Cordova. The *General Plan* contains policies and programs designed to provide decision makers with a solid foundation for land use and development decisions. The *General Plan* consists of the following elements: Land Use; Urban Design; Economic Development; Housing; Circulation; Open Space, Parks and Trails; Infrastructure, Services, and Finance; Natural Resources; Cultural and Historic Resources; Safety; Air Quality; and Noise. **Table 2.1-21** summarizes City of Rancho Cordova *General Plan* goals and policies relevant to the GSP.

Table 2.1-21: City of Rancho Cordova *General Plan* Goals and Policies Relevant to the GSP

Goal	Policy
Land Use	
LU.2—Establish growth patterns based on smart growth principles and the city building blocks concepts	Policy LU2.7—Promote sustainable development that reduces the impact of projects on energy, water, and transportation systems. Encourage sustainable development to occur in ways that complement the built form
Natural Resources	
NR.5—Protect the quantity and quality of the City's water resources	Policy NR.5.1—Promote water conservation within existing and future urban uses.
	Policy NR.5.2—Encourage the use of treated wastewater to irrigate parks, golf courses, and landscaping.
	Policy NR.5.3—Protect surface and groundwater from major sources of pollution, including hazardous materials contamination and urban runoff.
	Policy NR.5.4—Prevent contamination of the groundwater table and surface water, and remedy existing contamination to the extent practicable.
	Policy NR.5.5—Minimize erosion to stream channels resulting from new development in urban areas consistent with State law.
	Policy NR.5.6—Incorporate Storm Water, Urban Runoff, and Wetland Mosquito Management Guidelines and Best Management Practices into the design of water retention structures, drainage ditches, swales, and the construction of mitigated wetlands in order to reduce the potential for mosquito-borne disease transmission.
	Policy NR.5.7—Continue to cooperate and participate with the County, other cities, and the Regional Water Quality Control Board regarding compliance with the joint National Pollutant Discharge Elimination System (NPDES) Permit CAS082597 or any subsequent permit and support water quality improvement projects in order to maintain compliance with regional, state and federal water quality requirements.
	Policy NR.5.8—The City shall require groundwater impact evaluations be conducted for the Grant Line West, Rio Del Oro, Westborough, Glenborough, Aerojet, Mather and Jackson Planning Areas to determine whether urbanization of these areas would adversely impact groundwater remediation activities associated with Mather, Aerojet, or Boeing prior to the approval of large-scale development. Should an adverse impact be determined, a mitigation program shall be developed in consultation with applicable local, state, and federal agencies to ensure remediation activities are not impacted. This may include the provision of land areas for groundwater remediation facilities, installation/extension of necessary infrastructure, or other appropriate measures.

Source: City of Rancho Cordova, 2006

The goals and policies identified in the City of Rancho Cordova *General Plan* will help shape GSP implementation and were considered during development of SASb's monitoring network and projects.

The goals of this GSP are aligned with the goals of the City of Rancho Cordova *General Plan* in protecting the quality and quantity of Rancho Cordova's water resources. Implementation of this GSP will help achieve the goals and policies of the City of Rancho Cordova *General Plan*.

2.1.10.5 City of Sacramento 2035 General Plan

The City of Sacramento *2035 General Plan* (City of Sacramento, 2015) provides an outline for the City of Sacramento's development. The *2035 General Plan*'s citywide goals and policies are detailed in 10 elements: Land Use and Urban Design, Historic and Cultural Resources, Economic Development, Housing, Mobility, Utilities, Education, Recreation, Culture, Public Health and Safety, Environmental Resources, Environmental Constraints. The *2035 General Plan* goals and policies that are relevant to the GSP are summarized in **Table 2.1-22**.

Table 2.1-22: City of Sacramento *2035 General Plan* Goals and Policies Relevant to the GSP

Goal	Policy
Citywide Land Use and Urban Design	
LU 2.2 City of Rivers—Preserve and enhance Sacramento's riverfronts as signature features and destinations within the city and maximize riverfront access from adjoining neighborhoods to facilitate public enjoyment of this unique open space resource.	LU 2.2.2—Waterway Conservation
LU 9.1 Open Space, Parks, and Recreation—Protect open space for its recreational, agricultural, safety, and environmental value and provide adequate parks and open space areas throughout the city	LU 9.1.1—Open Space Preservation
	LU 9.1.1—New Parks and Open Spaces
Utilities: Water Systems	
U 2.1 High-Quality and Reliable Water Supply—Provide water supply facilities to meet future growth within the city's Place of Use and assure a high-quality and reliable supply of water to existing and future residents	U 2.1.1—Exercise and Protect Water Rights
	U 2.1.2—Increase water supply sustainability
	U 2.1.3—Water Treatment Capacity and Infrastructure
	U 2.1.4—Priority for Water Infrastructure
	U 2.1.5—Comprehensive Water Supply Plans
	U 2.1.7—Water Supply During Emergencies
	U 2.1.8—Emergency Water Conservation
	U 2.1.10—Water Conservation Standards
	U 2.1.11—Water Conservation Programs
	U 2.1.12—Water Conservation Enforcement
	U 2.1.13—Recycled Water
	U 2.1.17—Water Conservation Outreach
	U 2.1.18—Future Water Supply
Environmental Resources: Water Resources	
ER 1.1 Water Quality Protection—Protect local watersheds, water bodies and groundwater resources, including creeks, reservoirs, the Sacramento and American Rivers, and their shorelines	ER 1.1.2—Regional Planning
	ER 1.1.8—Clean Watershed
	ER 1.1.9—Groundwater Recharge
	ER 1.1.10—Watershed Education

Source: City of Sacramento, 2015

The goals and policies identified in the *2035 General Plan* will help shape GSP implementation and were considered during development of the SASb's monitoring network and projects.

The goals of this GSP are aligned with the goals of the *2035 General Plan* in maintaining high-quality water in both distribution infrastructure and the environment. Implementation of this GSP will help achieve the goals and policies of the *2035 General Plan*.

2.1.11 Community Plans and Special Projects

2.1.11.1 Cordova Community Area

The Cordova Community Area includes properties outside of the City of Rancho Cordova boundary but within the Cordova planning area (Sacramento County, 2003). The *Cordova Community Plan* was adopted through Resolution 2003-0551 by the Sacramento County Board of Supervisors. Although the *Cordova Community Plan* does not include any SGMA-related policies, implementation of the GSP will promote sustainable groundwater use in the area.

2.1.11.2 Delta Community Area Plan

The Delta Community Area is bound by the Sacramento City limits on the north, I-5 on the east, and the Sacramento County line on the south and west. While the *Sacramento County 2030 General Plan* (Sacramento County, 2011) covers this area, the goals and policies of the *Delta Community Area Plan* (Sacramento County Board of Supervisors, 1983) provide specific direction for implementation in the area. The *Delta Community Area Plan* cover the following topics:

- Natural hazards
- Natural resources
- Agriculture
- Residential development
- Commercial and economic development
- Public services and facilities
- Mineral resources

Policies in the *Delta Community Area Plan* were considered during the development of the monitoring network and projects and will be considered during the implementation of the GSP as appropriate.

The goals of this GSP are aligned with the policies of the *Delta Community Area Plan*. Implementation of this GSP will help achieve the goals and policies of the *Delta Community Area Plan*.

2.1.11.3 Florin-Vineyard Community Plan

The Florin-Vineyard Community Area is generally bound by Elder Creek Road on the north, Bradshaw Road on the east, the Churchill Downs neighborhood to the south, and the Union Pacific Railroad tracks on the west. The *Florin-Vineyard Community Plan* (Sacramento County Board of Supervisors, 2010) was adopted through Resolution 2010-1004 by the Sacramento County Board of Supervisors. The community plan includes policies relating to residential, commercial, industrial, open space, streetscape, and public facilities resources.

Policies identified in the *Florin-Vineyard Community Plan* were considered during GSP development of the SASb's monitoring network and projects and will be considered during GSP implementation as appropriate.

Implementation of this GSP will help achieve the policies of the *Florin-Vineyard Community Plan*.

2.1.11.4 South Sacramento Area Community Plan

The *South Sacramento Area Community Plan* (Sacramento County Board of Supervisors, 1978) was adopted through Resolution 78-1431 by the Sacramento County Board of Supervisors. The *South Sacramento Area Community Plan* includes policies relating to 10 elements: Land Use, Economic, Social, Transportation, Environmental, Housing, Schools, Parks and Recreation, Community Aesthetics and Open Space, and Public Services.

The policies identified in the *South Sacramento Area Community Plan* were considered during GSP development of the SASb's monitoring network and projects and will be considered during GSP implementation as appropriate.

The goals of this GSP are aligned with the policies of the *South Sacramento Area Community Plan*. Implementation of this GSP will help achieve the goals and policies of *the South Sacramento Area Community Plan*.

2.1.11.5 Vineyard Community Plan

The Vineyard Community Area is generally bound by Jackson Highway and Kiefer Boulevard on the north, Sunrise Boulevard and Grant Line Road on the east, Calvine Road on the south, and Elk Grove-Florin Road on the west. The *Vineyard Community Plan* (Sacramento County Board of Supervisors, 1985) was adopted through Resolution 85-899 by the Sacramento County Board of Supervisors. Although the *Vineyard Community Plan* does not include any SGMA-related policies, Implementation of the GSP will promote sustainable groundwater use in the Vineyard Community Area.

2.1.12 Urban Water Management Plans

Urban Water Management Plans (UWMPs) are prepared by urban water suppliers every 5 years to ensure that adequate water supplies are available to meet existing and projected water needs (DWR, 2020d). The UWMPs not only promote efficient use of water supply but will support GSP goals of providing a long-term sustainable supply of groundwater for beneficial uses. In their respective UWMPs, urban water suppliers must do the following:

- Assess the reliability of water sources over a 20-year planning horizon.
- Describe demand management measures and water shortage contingency plans.
- Report progress toward meeting a targeted 20 percent reduction in per-capita urban water consumption by 2020.
- Discuss the use and planned use of recycled water.

UWMPs describe water purveyors' existing and planned water systems, supplies and demands, and water conservation measures. UWMPs also address Senate Bill X7-7, which required a statewide per-capita water use reduction of 20 percent by 2020. **Table 2.1-23** describes the seven UWMPs submitted by agencies within the SASb GSP area and their 2015 and 2020 actual and 2020 target gallons per-capita per day use.

Table 2.1-23: UWMPs in the GSP

Reporting Agency	Senate Bill X7-7 2020 Target: 10-Year Baseline (GPCD)	10-Year Baseline (Years)	Actual 2015 (GPCD)	Actual 2020 (GPCD)	Target 2020 (GPCD)
California American Water Company–Sacramento District[1]	216	1999–2008	130	125	173
Elk Grove Water District	239	1999–2008	111	137	191
Folsom, City of	426	1999–2008	261	256	352
Fruitridge Vista Water Company (now part of the California American Water Company)	154	2010–2020	N/A	N/A	123
Golden State Water Company–Cordova	400	1999–2008	235	288	320
Sacramento, City of	282	1996–2005	158	169	225
SCWA	295	1995–2004	153	229	236

Notes:

[1] Includes the Antelope, Arden, Dunnigan, Isleton, Lincoln Oaks, Parkway, Security Park, Suburban-Rosemont, Walnut Grove, and West Placer service areas

[2] Since 2020 data were not available at the time of development of the CoSANA model, water budget estimates are based on reported 2015 values from UWMPS (see Section 2.4)

Source: DWR, 2020c

Implementation of the GSP will help maintain sustainable groundwater management in each water supplier's service area and will generate more robust and comprehensive data for surface water and groundwater resources in the SASb and promote the efficient use of water.

2.1.13 Plan Elements from California Water Code Section 10727.4

Per Water Code Section 10727.4, the following plan elements can be found in the following sections:

- Control of saline water intrusion. **(Section 2.3.3)**
- Wellhead protection areas and recharge areas. **(Appendix 3-C), (Section 2.2.8.4)**
- Migration of contaminated groundwater. **(Section 2.1.8)**
- A well abandonment and well destruction program. **(Section 4.7.1)**
- Replenishment of groundwater extractions. **(Section 4)**
- Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage. **(Section 4)**
- Well construction policies. **(Section 4.7.1)**
- Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects. **(Section 2.1.8)**

- Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use. **(Section 4)**
- Efforts to develop relationships with state and federal regulatory agencies. **(Section 5)**
- Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity. **(Section 5)**
- Impacts on groundwater dependent ecosystems. **(Section 2.3.7)**

2.2 Hydrogeologic Conceptual Model

This section describes the Hydrogeologic Conceptual Model (HCM) for the South American Subbasin (SASb). The HCM is developed in the Groundwater Sustainability Plan (GSP) to understand and convey the physical conditions by which water moves through the basin and is foundational for the development of the water budget and the sustainable management criteria, the monitoring networks, and projects and management actions.

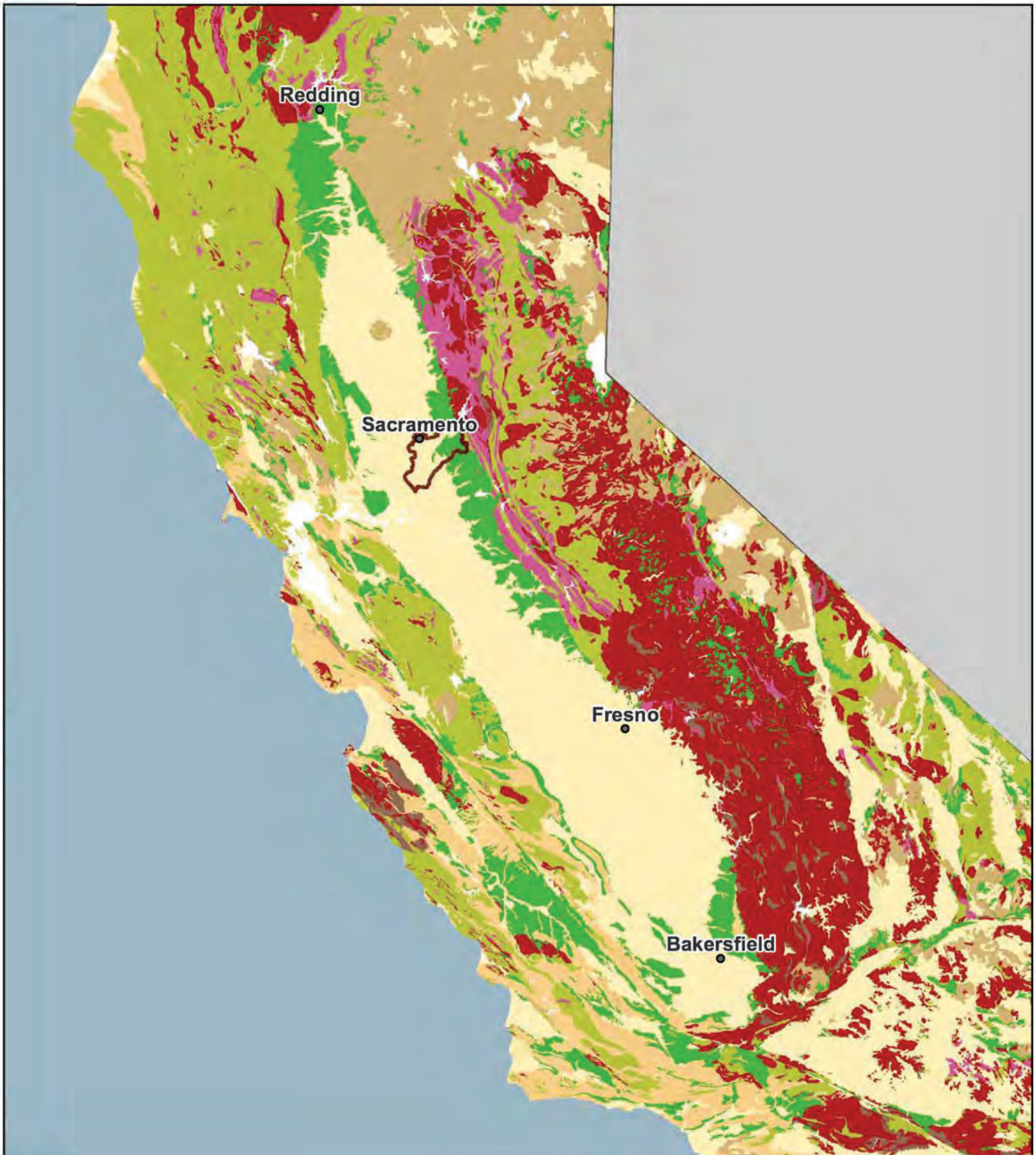
Consistent with the Sustainable Groundwater Management Act (SGMA) regulations, the HCM:

- Provides an understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the basin.
- Provides the context to develop water budgets, mathematical (analytical or numerical) models, including an accounting for the effects of climate change.
- Provides the context to develop monitoring networks for the sustainability indicators.

2.2.1 Regional Geologic and Structural Setting

The SASb is in the southeastern portion of the Sacramento Valley abutting the Sierra Nevada foothills (**Figure 2.2-29**). The Sacramento Valley is the northern portion of the California Central Valley, a broad, northwest-trending asymmetrical syncline, with a more gently dipping eastern limb. The synclinal trough is bounded by the eastern Sierra Nevada and California Coast Ranges, forming a depositional basin that has accumulated a thick sequence of sedimentary deposits. It is the upper portions of those sedimentary deposits that provides the framework for the aquifer system being managed through this GSP.

The subsurface of the Sacramento Valley is composed of marine and continental sedimentary deposits ranging in age from the Cretaceous to Quaternary (see **Appendix 2-A** for a geologic time scale). Marine sedimentary deposits range in age from the mid-Cretaceous to the Eocene and continental sedimentary deposits range in age from the Eocene to Quaternary (California Department of Water Resources [DWR], 1974). The eastern portion of the SASb consists of steeper topography, exposing outcrops of Eocene to Miocene-age sedimentary rock. Sedimentary deposits are underlain by an older, Mesozoic-age crystalline basement that is similar to outcrops found in the Sierra Nevada (DWR, 1974). The crystalline basement dips gradually to the west, resulting in an increasingly thick sedimentary wedge from east to west.



South American Subbasin GSP

Regional Geologic Setting

Figure 2.2-29

Legend

- South American

Generalized Rock Types

- Marine and Nonmarine (Continental) Sedimentary Rocks
- Marine Sedimentary and Metasedimentary Rocks
- Marine Sedimentary Rocks
- Metavolcanic Rocks
- Mixed Rocks
- Nonmarine (Continental) Sedimentary Rocks
- Plutonic Rocks
- Volcan ic Rocks

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. <bol>Data Sources: California Geological Survey, Department of Conservation

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\00 575.00- SCGA GSP\G. GIS\2. MXD\Regional Geologic Setting.mxd

2.2.2 Geologic History

The Sacramento Valley (and consequently the SASb) was primarily formed from the late Jurassic through the Quaternary through a complex combination of orogenic events, sea-level transgressions and regressions, volcanic activity and glaciation.

The first important geologic event with respect to the Sacramento Valley was formation of the ancestral Sierra Nevada during the Nevadan Orogeny, which occurred during the late Jurassic and early Cretaceous. These events formed the mountain range through a process of folding, faulting and igneous intrusion (DWR, 1974).

In the Cretaceous period, the ancestral Sierra Nevada was heavily eroded, and the detrital material was deposited in marine sediments in the Cretaceous Sea west of the Sierra Nevada. The sea gradually transgressed over the eroded surface of the ancestral Sierra Nevada and Cretaceous-age marine sediments were deposited on top of the granitic rocks formed during the Nevadan Orogeny. This transgression was accompanied by a gradual subsidence of the ancestral Sierra Nevada (Olmsted and Davis, 1961). Marine sediments were deposited from the Paleocene into the Eocene epoch, with a north-south shoreline spanning the eastern portion of the Sacramento Valley (DWR, 1974).

From the middle or late Eocene, continuing intermittently into the Miocene, volcanic eruptions deposited pyroclastic and flow material at the crest of the Sierra Nevada. Subsequent erosion of these volcanic rocks resulted in the westward deposition of volcanic sediments. By the middle Miocene, the sea had regressed from the Sacramento Valley and volcanic activity renewed along the crest of the Sierra Nevada after a relatively brief period of inactivity (DWR, 1974). Volcanic activity continued into the middle to late Pliocene, covering much of the Sierra Nevada and Sierra Nevada foothills in andesitic volcanic debris. At the same time, the Sierra Nevada was being uplifted and tilted westward. By the middle to late Pliocene, volcanic activity ceased, and the Sierra Nevada underwent a period of erosion and where large quantities of sediment were deposited into the Central Valley (DWR, 1974).

Glaciation in the Sierra Nevada during the Pleistocene formed deep cut canyons into underlying bedrock of the Sierra Nevada. The sediment eroded from these canyons deposited an extensive gravel pediment on the valley floor, covering much of the Sacramento Valley (DWR, 1974). During the Pleistocene, sea levels fluctuated by hundreds of feet between glacial and interglacial periods. During interglacial periods, the sea level was approximately 100 feet higher than the current sea level and shorelines were as far inland as the central part of Sacramento County. Along these historical shorelines, widespread deposits of near-shore sediments have accumulated (Olmsted and Davis, 1961).

At present, streams are eroding the low-lying alluvial plains and dissected uplands, aggrading the river flood plains and channels and flood basins (Olmsted and Davis, 1961).

2.2.3 Geologic Formations/Stratigraphy

Stratigraphy in the SASb consists of a sequence of unconsolidated to partly consolidated continental deposits of Eocene to Quaternary age overlying older marine sedimentary rocks of late Cretaceous to Eocene age. These marine and continental deposits overly Mesozoic crystalline granitic and metamorphic bedrock (Olmsted and Davis, 1961). Individual geologic units found in the Basin are described in detail below, in order of youngest to oldest in deposition.

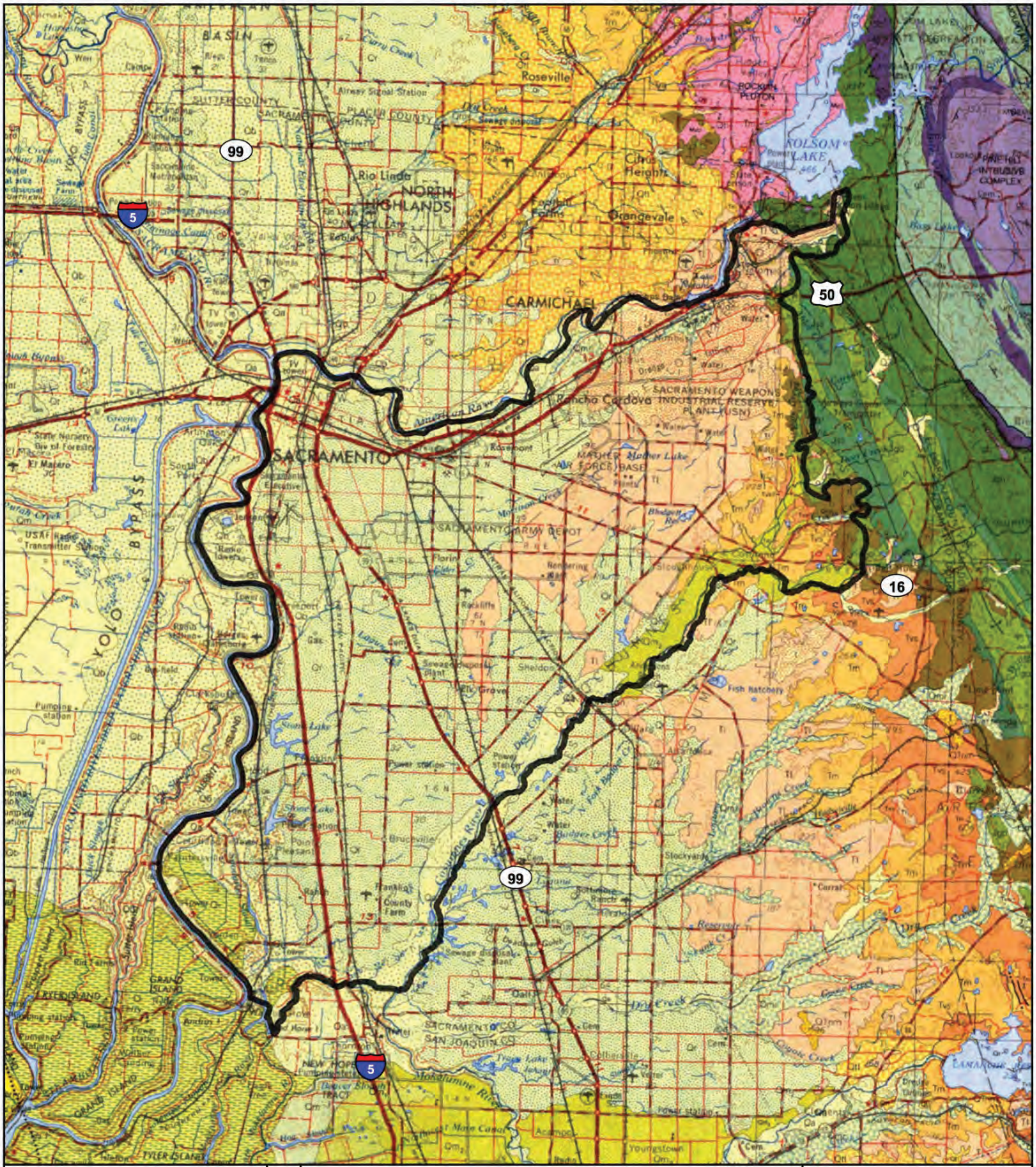
Geologic units mapped at the surface are shown in **Figure 2.2-30A**. The associated geologic map legend is shown in **Figure 2.2-30B**. A generalized stratigraphic column of geologic formations in the SASb is shown in **Figure 2.2-31**, and is based on older literature with formation names that are no longer in use: the Victor and Fair Oaks Formations. The Victor Formation is generally correlated with the modern Modesto and Riverbank formations and the Fair Oaks Formation is generally correlated with the modern Turlock Lake Formation (Marchand and Allwardt, 1981).

2.2.3.1 Water Bearing Stratigraphic Units of the South American Subbasin

Stratigraphic units in this section are presented from youngest to oldest. DWR prepared a generalized cross section of the SASb and surrounding area in 1974. Additionally, cross sections were prepared from the CoSANA model layers which are described in detail in report documenting the development of the model (**Appendix 2-B**). **Figure 2.2-32** shows the DWR cross section locations and well sample locations discussed in **Section 2.2.7**. **Figure 2.2-33** shows the location of cross sections derived from the CoSANA model layers.

The geologic cross sections are shown individually in **Figure 2.2-34** and **Figure 2.2-35**. The DWR cross sections show the relationship of the Victor, Fair Oaks, Laguna, and Mehrten Formations and the older/deeper sediments and basement rocks in and near the SASb. As noted above, **Figure 2.2-34** and **Figure 2.2-35** display formation names (= Victor and Fair Oaks) that are no longer in use. The cross sections also show approximate well sample locations and the associated Stiff diagrams that are discussed in **Section 2.2.7**.

The cross sections derived from the CoSANA model layers are shown individually in **Figure 2.2-36** to **Figure 2.2-39**. Note that the Alluvium model layer (orange) is correlated with the Modesto Formation, Riverbank Formation and Arroyo Seco Gravels. The Laguna model layer (yellow) is correlated with the Turlock Lake and Laguna Formations. The Mehrten, Valley Springs and Ione model layers (green, blue, purple, respectively) are correlated with the Mehrten, Valley Springs and Ione Formations, respectively.



South American Subbasin GSP

Geologic Map

Figure 2.2-30A

Legend

South American Subbasin

0 1.25 2.5 5 Miles

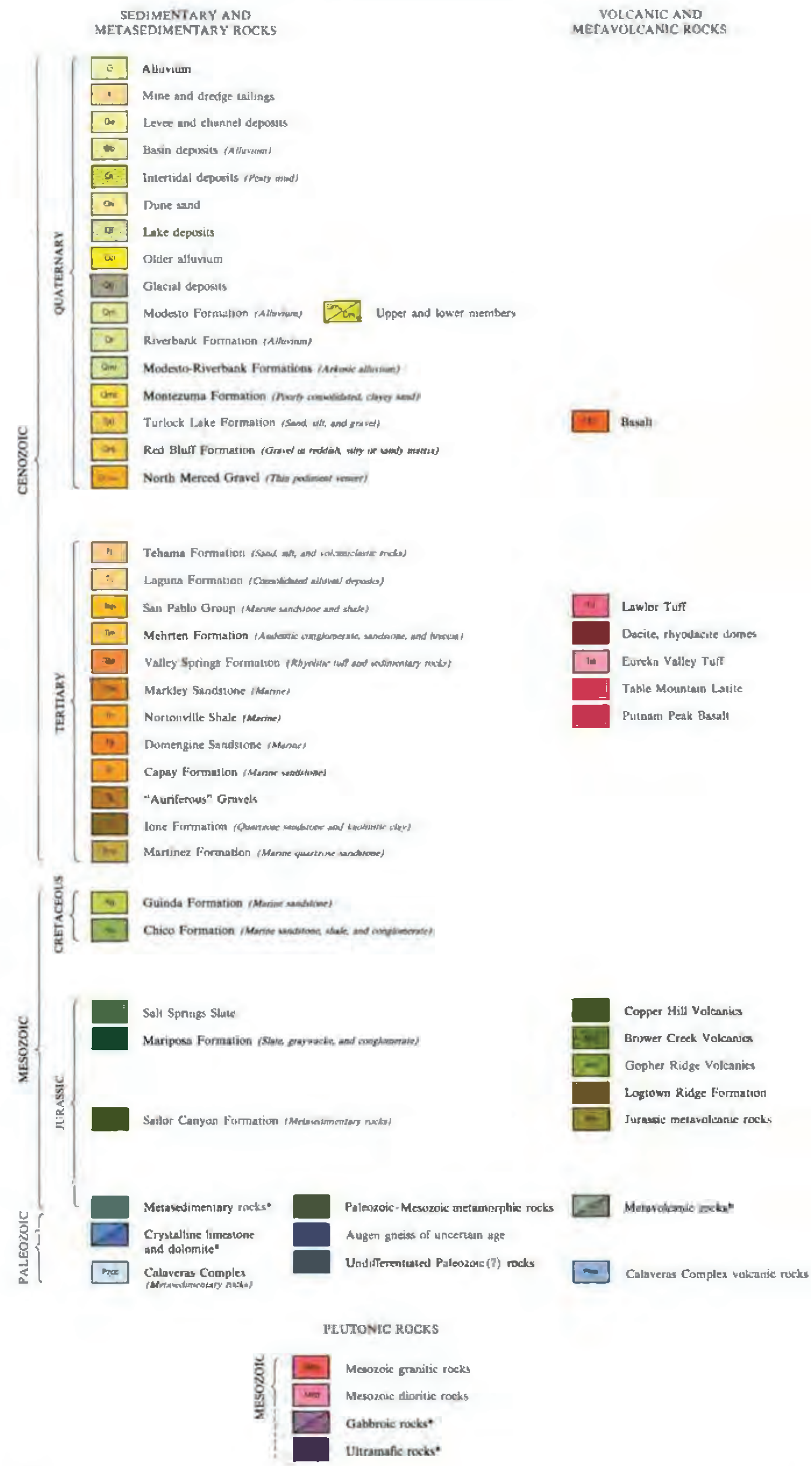
N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions.
Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:** Wagner, et al., 1981

Figure Exported: 12/14/2020 By: vdeanda



South American Subbasin GSP

Geologic Map Legend

Figure 2.2-30B

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

COSANA Model Layer	Old Literature's Formation Names[1,2]	Formation[2,3]	Thickness[1,2]	Physical Characteristics[1,2]	Aquifer[1]
Alluvium	-	Alluvium	0-100	Unconsolidated sand, gravel, silt and clay	Upper Portion
	Victor Formation	Modesto Formation	0-100	Unconsolidated sand, silt, and clay, some hardpan	Upper Portion
		Riverbank Formation	0-100	Unconsolidated sand, silt, and clay, some hardpan	Upper Portion
	-	Arroyo Seco Gravel	20-50	Sand and gravel, iron-cemented clay matrix	Upper Portion
Laguna	Fair Oaks Formation	Turlock Lake Formation	0-225	sand, silt, and clay with hardpan, mostly present north of American River	Upper Portion
	Fair Oaks Formation / -	Laguna Formation	125-200	Bedded silts, clays, and sands	Upper Portion
Mehrten	-	Mehrten Formation	200-1200	Beds of black volcanic sand, brown clay and sand, andesitic origin	Lower Portion
Valley Springs	-	Valley Springs Formation	75-125	Beds of light colored sand and ash, greenish brown silty sand, rhyolitic origin	Lower Portion
Ione	-	Ione Formation	100-400	medium grained quartz sandstone, thick beds of clay	Below Aquifer
Basement	-	Chico Formation	200-15,000	brown marine fossiliferous sandstone and shale	Below Aquifer
	-	Basement	-	Slate, sandstone, greenstone, schist, metavolcanics, granodiorite	Below Aquifer

1 : Adapted from DWR, 1974
2 : Adapted from Marchand and Allwardt, 1981
3 : Adapted from Helley and Hardwood, 1985

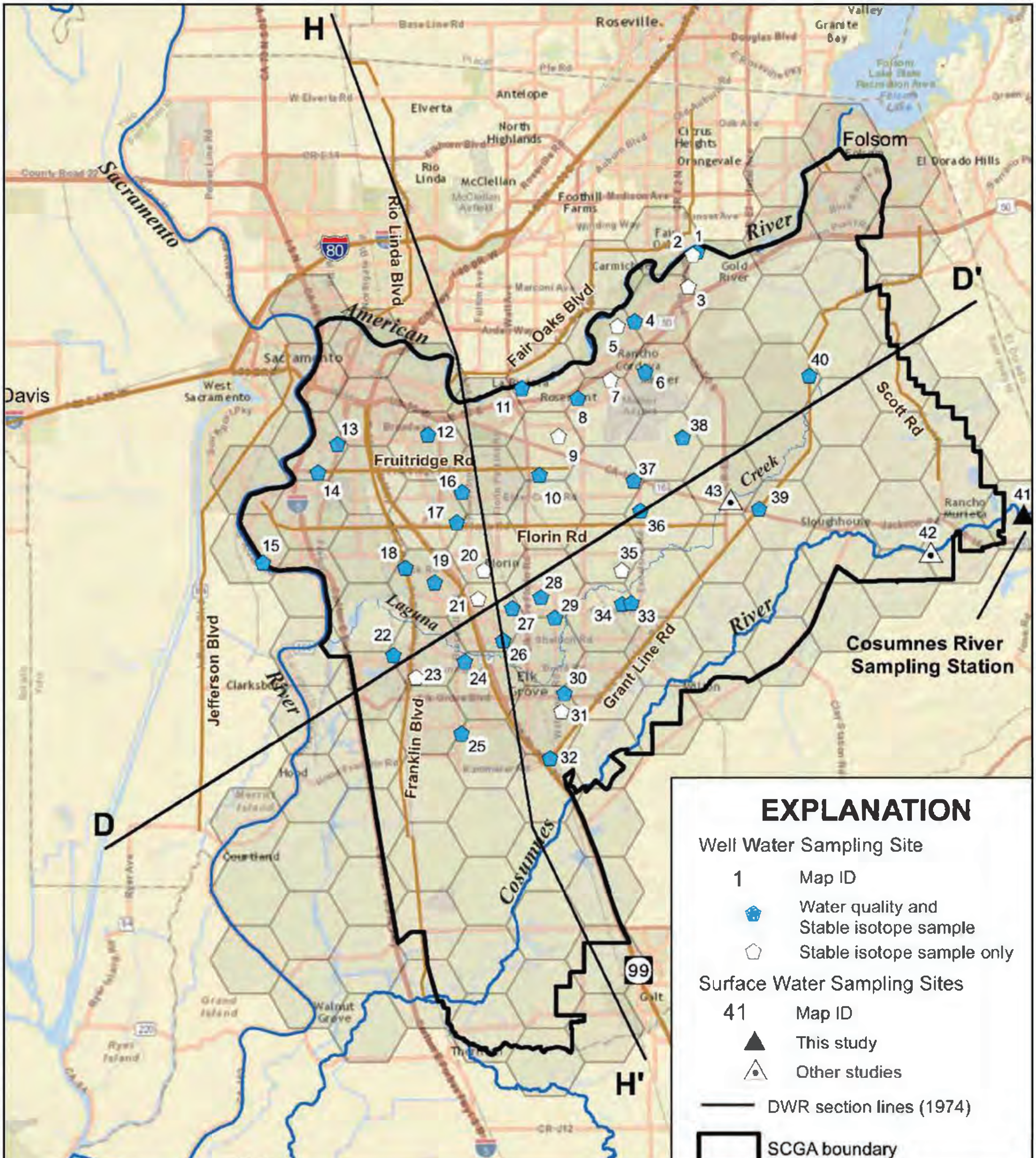
South American Subbasin GSP

Stratigraphic Column

Figure 2.2-31

South American SUBBASIN

Map Created: June 2020



South American Subbasin GSP

Cross Sections and Water Sampling Locations

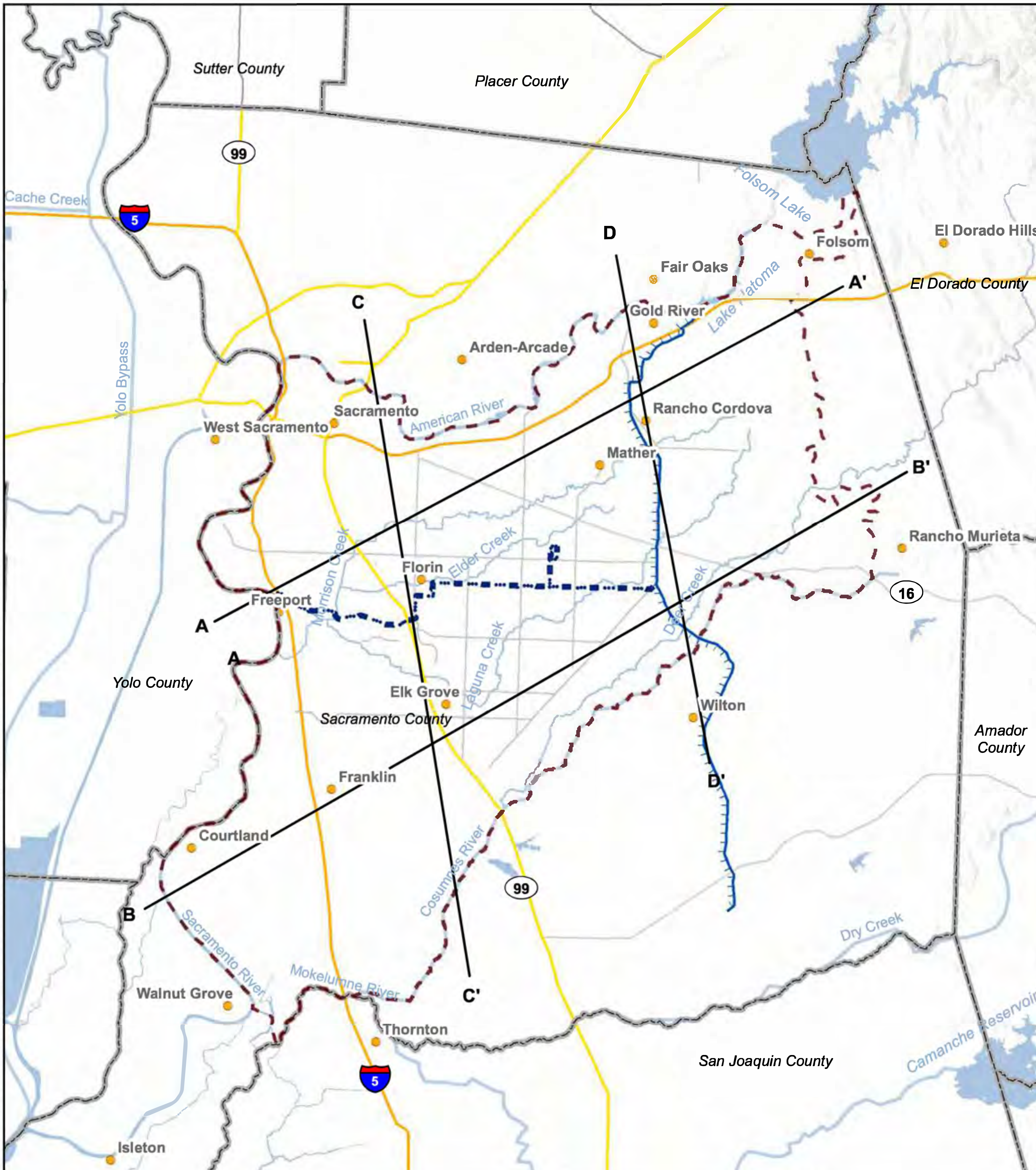
Figure 2.2-32

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Figure Exported: 12/14/2020 By: vdoanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575 00- SCGA GSP\G. GIS\2. MXD\Cross Section and Sampling Locations.mxd

 Data Sources: Prepared by RMC Water and Environment for the Sacramento Central Groundwater Authority, 2015.



South American Subbasin GSP

CoSANA Model Layer Cross Section Locations

Figure 2.2-33

Legend

- Cross Section Location
- South American Subbasin
- Cities and Towns
- Rivers and Creeks
- Folsom South Canal
- Freeport Pipeline
- Counties

0 1.25 2.5 5 Miles

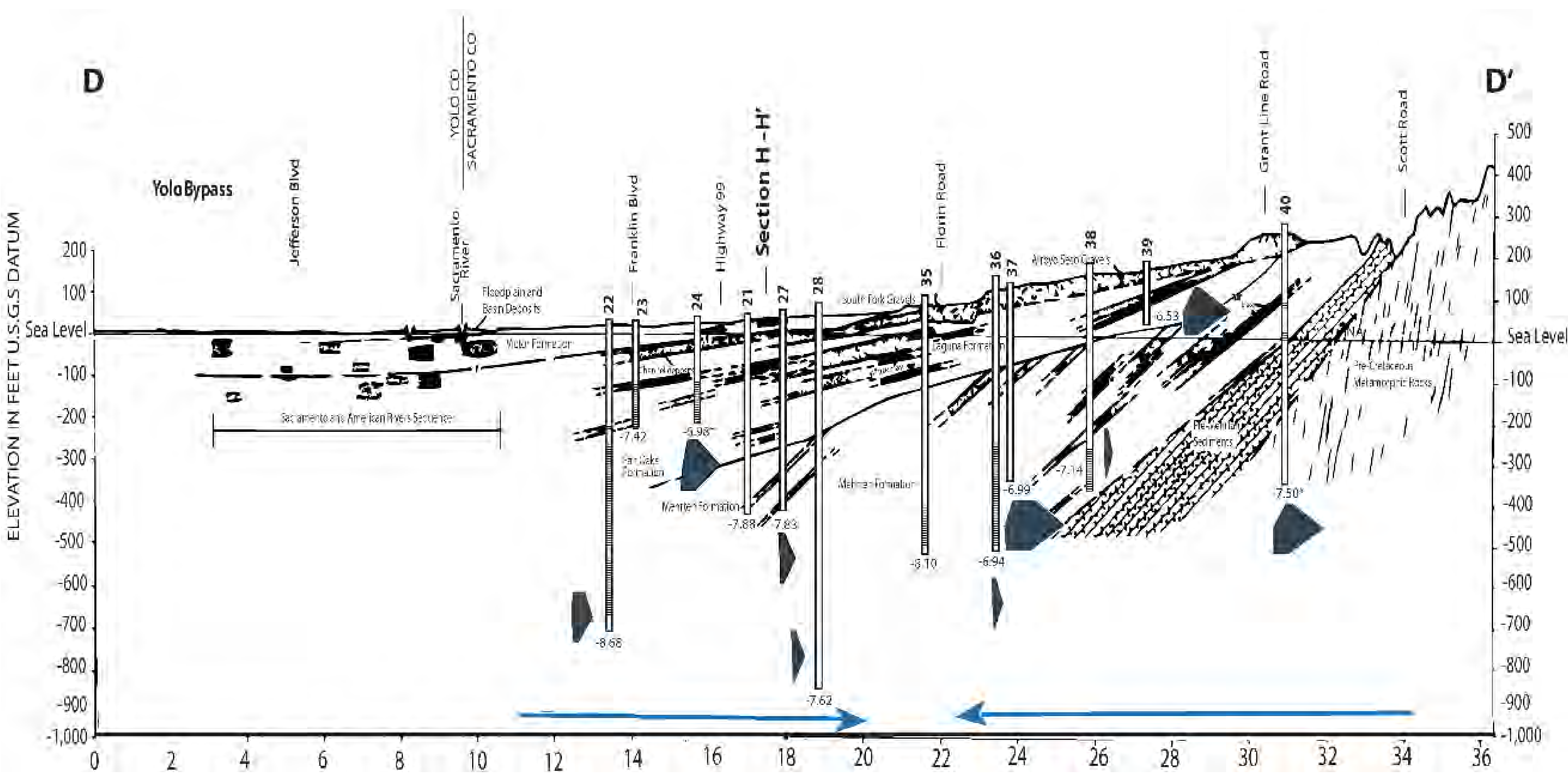
N

South American SUBBASIN

Project #: 0011575.00
Map Created: June 2020

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk.

Figure Exported: 12/14/2020 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\3-5 CoSANA Model Layer Cross Section Locations.mxd



South American Subbasin GSP

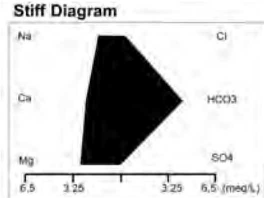
Cross Section D-D'

Figure 2.2-34

Legend

Inferred groundwater direction

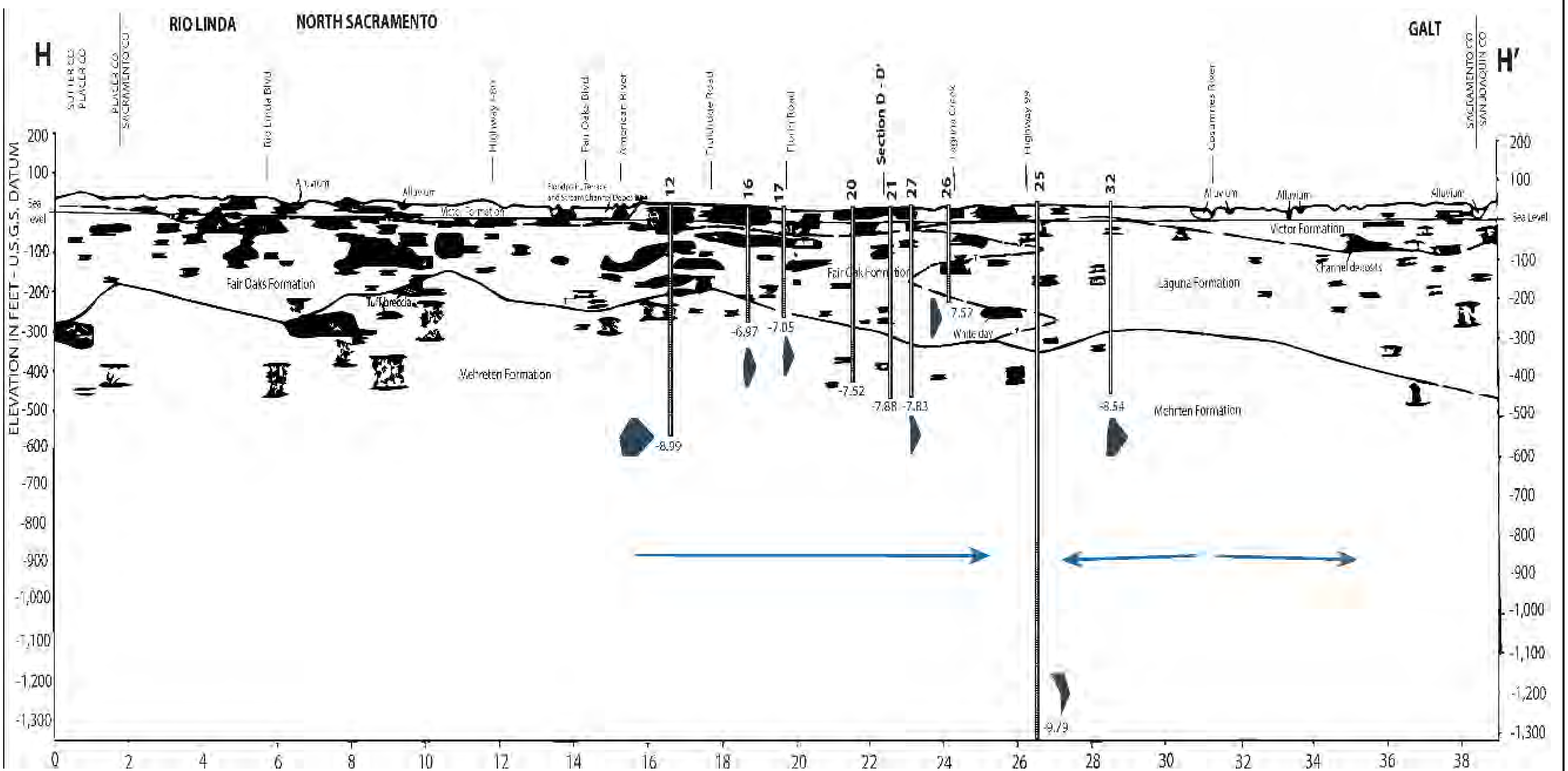
Stiff Diagram



N

South American SUBBASIN

Map Created: October 2021



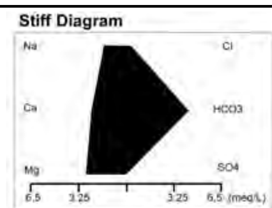
South American Subbasin GSP

Cross Section H-H'

Figure 2.2-35

Legend

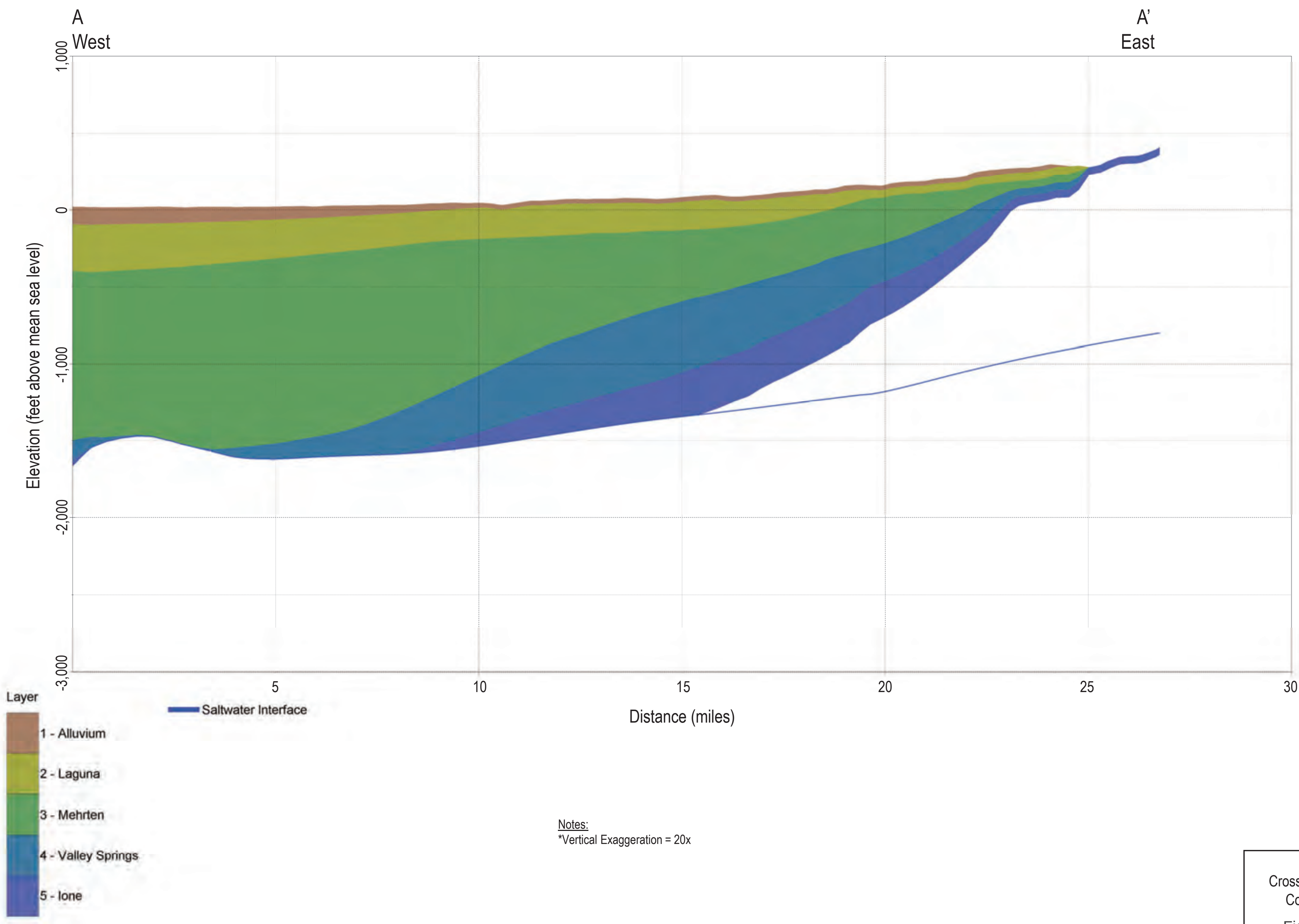
Inferred groundwater direction



N

South American SUBBASIN

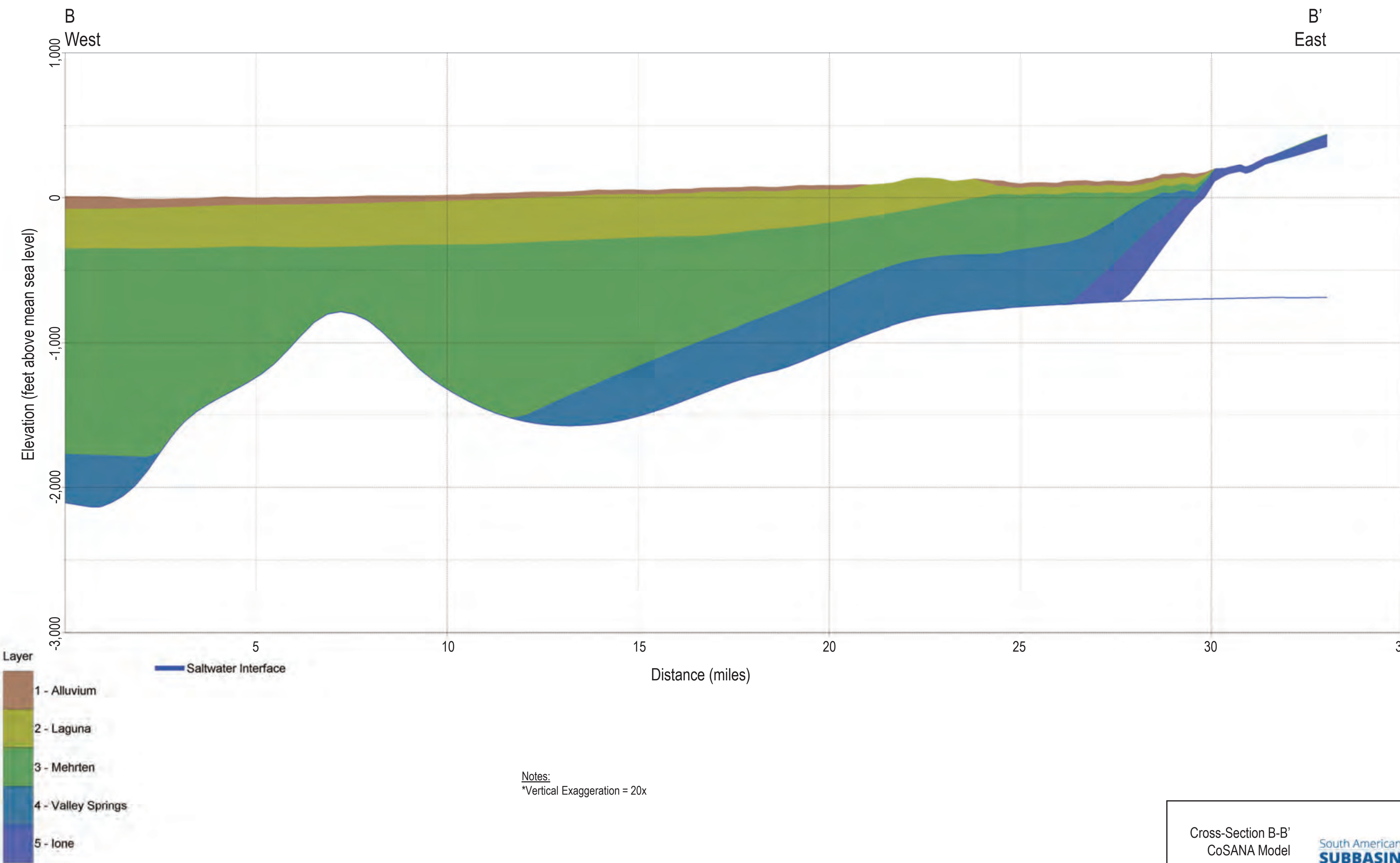
Map Created: October 2021



Notes:
*Vertical Exaggeration = 20x

Cross-Section A-A'
CoSANA Model
Figure 2.2-36

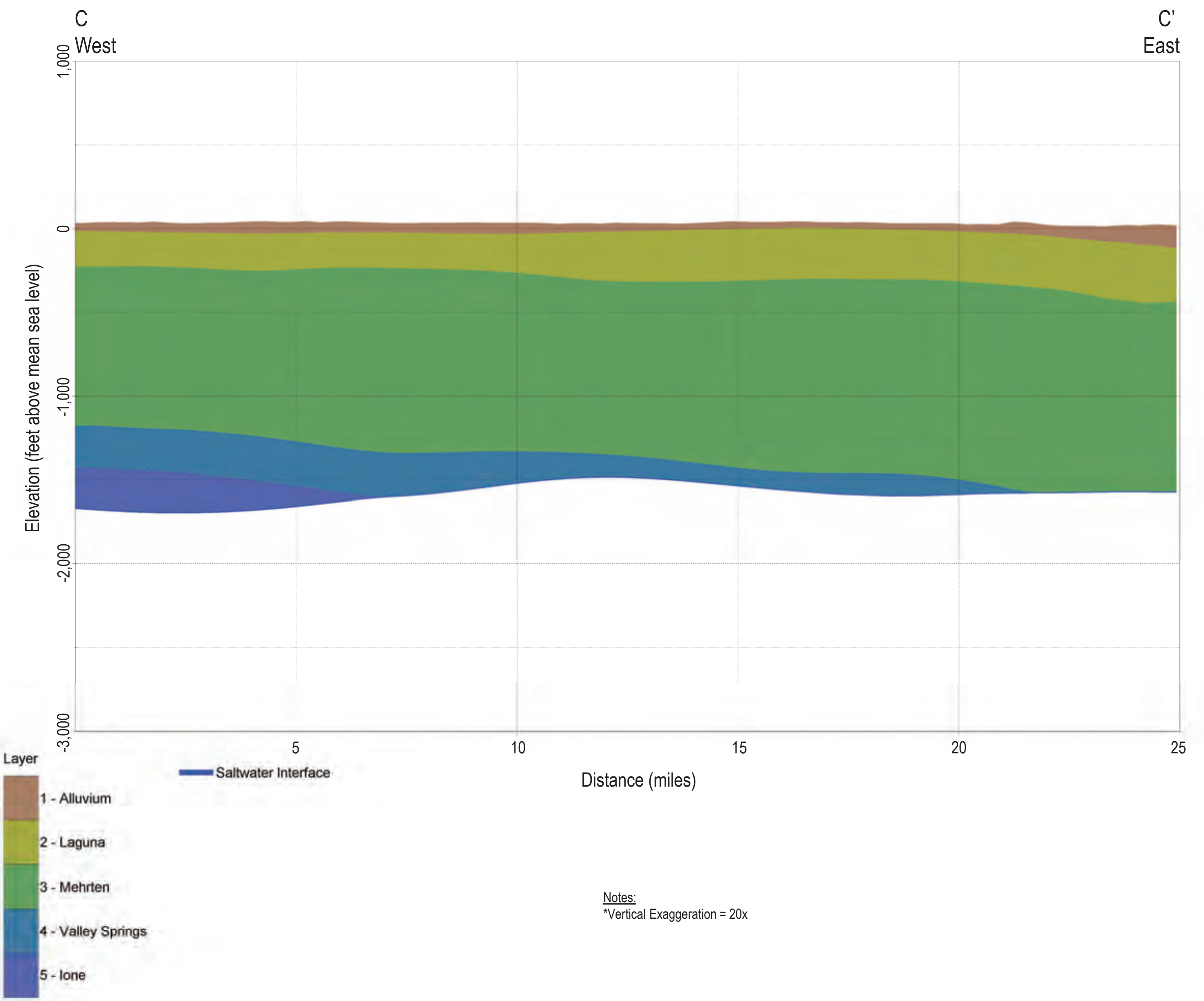
South American SUBBASIN



Notes:
*Vertical Exaggeration = 20x

Cross-Section B-B'
CoSANA Model
Figure 2.2-37

South American SUBBASIN

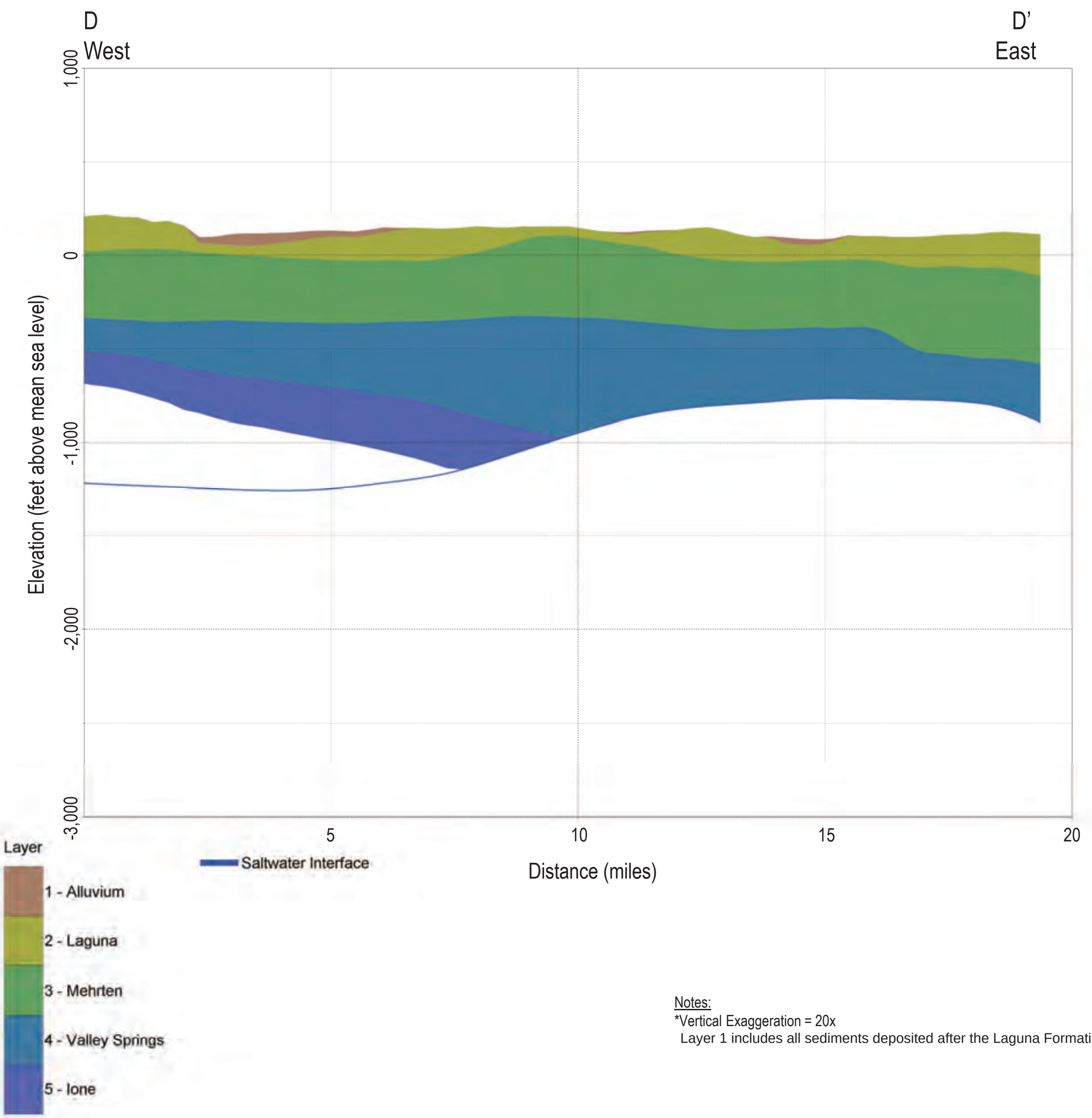


Notes:
*Vertical Exaggeration = 20x

Cross-Section C-C'
CoSANA Model

Figure 2.2-38

South American SUBBASIN



Notes:
*Vertical Exaggeration = 20x
Layer 1 includes all sediments deposited after the Laguna Formation

Cross-Section D-D'
CoSANA Model
Figure 2.2-39

South American SUBBASIN

Dredge Tailings

Dredge tailings are exposed primarily along the American River in the northeastern portion of the SASb. They consist of surficial deposits of alternating ridges and valleys resulting from the activities of gold dredging operations. The ridges are composed of sand, gravel, cobbles, and boulders while the valleys are composed of fine sand, silt, and clay (slickens). The larger dredges could reach depths of more than 100 feet below the ground surface. Tailings cover an area of approximately 12,000 acres and are an important groundwater recharge area given their high hydraulic conductivities (DWR, 1974), drainage is internal (little or no runoff), and the tailings are located in the higher precipitation areas.

Flood Basin Deposits

Flood basin deposits occur along the western margin of the SASb adjacent to the Sacramento River. These deposits consist primarily of silts and clays but may be interbedded with stream channel deposits of the Sacramento River (DWR, 2004).

Stream Channel Deposits

Stream channel deposits consist of unconsolidated sand and gravel occurring in streambed deposits and point bar deposits. These deposits are primarily transported by present-day streams and river systems and overlie the Modesto and Riverbank Formations (formerly the Victor Formation) (DWR, 1974).

Quaternary Alluvium

Quaternary alluvium consists of un-weathered gravel, sand and silt deposited by present-day stream and river systems of the Sierra Nevada. These deposits outlie stream channel deposits but are inside the first low terraces flanking modern stream channels (Helley and Hardwood, 1985). Permeabilities in these units range from high to low, and, in certain areas, the alluvium acts as a recharge area for percolating surface water to infiltrate into groundwater (DWR, 1974). Thickness of the alluvium varies from up to 30 feet deep (Helley and Hardwood, 1985).

Modesto Formation

The Modesto Formation is the youngest unit comprising the Pleistocene alluvium and forms distinct alluvial terraces and some alluvial fans and abandoned channel ridges. The formation is composed of tan and light-gray gravel, sand, silt and clay in unconsolidated, unweathered deposits and unconsolidated, slightly weathered deposits (Helley and Hardwood, 1985). The Modesto Formation was deposited by present-day rivers and streams because the deposits typically border existing rivers and streams.

Riverbank Formation

The Pleistocene-age Riverbank Formation forms distinct alluvial terraces and fans and is composed of reddish weathered gravel, sand, silt, and minor amounts of clay and semi-consolidated gravel, sand and silt. The Riverbank Formation typically contains fragments of mafic igneous rocks (Helley and Hardwood, 1985).

South Fork Gravels

South Fork Gravels are a discontinuous belt of partially cemented channel gravel deposits that extend from Mormon Island Dam to Elk Grove. These deposits are about one mile wide. The gravels are composed of rounded pebbles and cobbles in a granitic sand matrix with some micaceous clays present that serves to bind the larger fragments (DWR, 1974). The South Fork Gravels dip southwest at a gradient of 5 to 20 feet per mile (DWR, 1974).

Arroyo Seco Gravels

Arroyo Seco Gravels are present as a thin veneer capping hills in the east-central portion of Sacramento County (DWR, 1974). These gravels are present as a series of discontinuous beds and lenticular deposits of stream-laid detritus. The Arroyo Seco Gravels were deposited as a pediment by many rivers and streams that drained the Sierra Nevada during the middle and late Pleistocene. These deposits are typically composed of well-rounded pebbles, weathered andesite with lesser amounts of quartz, chert and occasional fragments of weathered granitic rock. These rock fragments are cemented in a matrix of red, iron-rich, granitic sand and clay. The Arroyo Seco Gravels dip southwest at a gradient of 20 feet per mile. The estimated thickness of the pediment ranges from 20 to 50 feet (DWR, 1974).

Turlock Lake Formation

The Turlock Lake Formation occurs in the SASb as low gravel deposits along the ancestral American River channel (i.e., south of the present American River). The Turlock Lake Formation is composed of deeply weathered and dissected arkosic gravels with metamorphic rock fragments and quartz pebbles with sand and silt present along the south and east sides of the Sacramento Valley (Helley and Hardwood, 1985). The Turlock Lake Formation is located topographically higher than younger alluvial fans and terraces and displays as much as 90 feet of erosional relief. The Turlock Lake Formation represents eroded alluvial fans derived from primarily plutonic rock of the Sierra Nevada to the east (Helley and Hardwood, 1985).

Laguna Formation

The Laguna Formation is exposed in the eastern portion of Sacramento County, where it comprises much of the foothills, and extends from Deer Creek to approximately one mile south of Highway 50. The Pliocene to early Pleistocene-age Laguna Formation is composed of a heterogenous assemblage of silt, clay and sand with lenticular gravels deposited by slow, meandering streams (Olmsted and Davis, 1961). Sediments in the Laguna Formation are locally variable, with some areas consisting of compacted silt, clay with lenses of poorly sorted gravel, sand and silt, while other areas of the formation are predominantly sand with few interbeds of clay and silt (DWR, 1974). The Laguna Formation has a gradational contact with the Mehrten Formation, and the lower portion of the Laguna Formation has been named the Laguna-Mehrten Transitional Zone. This zone consists of beds of non-volcanic Laguna Formation sediments interbedded with Mehrten Formation volcanic sediments. The formation dips westward at an average gradient of approximately 90 feet per mile. The estimated thickness of the formation ranges from 200 to 400 feet, thickening from east to west (DWR, 1974).

Mehrten Formation

The Mehrten Formation outcrops discontinuously in a broad portion of eastern Sacramento County, extending from Cosumnes River to the American River in the eastern portion of the Subbasin. The middle Miocene to middle Pliocene-age Mehrten Formation can be divided into two distinct units. The first unit is composed of gray to black andesitic sands and interbedded blue to brown clay. The second unit is composed of hard gray tuff-breccia (DWR, 1978). The formation dips westward at a gradient of approximately 1 to 2 degrees and becomes essentially horizontal along the axis of the Central Valley. The estimated thickness of the formation ranges from approximately 200 feet up to 1,200 feet, thickening from east to west (DWR, 1974).

DWR discussed the Mehrten Formation extensively in the *Bulletin 118-3* (DWR 1974). DWR describes two distinct units of the Mehrten Formation as follows:

> The first unit of the Mehrten Formation is composed of well-sorted black sands, which are a significant water bearing unit often accessed by municipal wells. They were formed as fluvial deposits derived from eroded andesitic material originating in the Sierra Nevada. Beds of black sand are laminated and typically about 5 feet thick but have been observed at over 20 feet thick. These beds commonly exhibit cross bedding and foreset bedding, indicative of deposition in a beach or deltaic environment. Well-rounded pebbles and cobbles of andesite are common in certain horizons. Lenticular beds of stream gravel containing andesitic cobbles and boulders or beds of blue to brown clay and silt are associated with these black sands. Near the base of the first unit, a series of hard, gray sandstone beds are present and coated in authigenic montmorillonite (DWR, 1974).
>
> The second unit of the Mehrten Formation is tuff-breccia, which is very dense, hard and composed of angular pieces of fine-grained to porphyritic andesite. Breccia fragments range from less than an inch to several feet in diameter and are contained in a cemented ground mass composed of andesitic lapilli and ash. The tuff-breccia unit is derived from large quantities of volcanic ash that washed down existing stream channels, acquiring blocks of andesite that were then incorporated into the mass. This material spread out over the sloping plains and solidified as a hard pavement ranging in depth from a few inches to over 30 feet deep (DWR, 1974).

Valley Springs Formation

The Valley Springs Formation is exposed along the eastern side of Sacramento County from the southeast corner northward to Carson Creek. The Valley Springs Formation is of Miocene age and commonly contains varying amounts of rhyolite ash, vitreous tuff, quartz sand containing glass shards and ashy clays. Many of the clays have a greenish color. The sediments often contain fragments of pumice, up to 0.25 inch in diameter (DWR, 1974).

The Valley Springs Formation unconformably overlies the Ione Formation and older metamorphic rocks to the east. The formation dips west at a fairly uniform angle ranging from 1.5 to 2 degrees with a thickness that ranges from 75 to 125 feet. The preserved thickness of the formation may not be the entire thickness deposited during the Miocene as the materials are easily erodible and a large part of the upper formation may have been stripped off prior to deposition of the overlying formation (DWR, 1974). Within the SASb, the Valley Springs Formation is a significant source of water only in the far eastern portions of the subbasin.

Ione Formation

The Ione Formation is exposed in eastern Sacramento County from Carbondale Road north to Folsom. The middle Eocene-age Ione Formation can be divided into three distinct members. The upper member of the formation is primarily composed of uniformly graded, medium to coarse-grained quartz sandstone, containing flakes of anauxite, a micaceous clay derived from the weathering of the Sierra Nevada grandodiorite (DWR, 1978). Below the sandstone member, a thick bed of white clay abundant in anauxite is present, indicating deposition in relatively still waters. In some areas, this clay is stained red to yellow, and in areas of intense staining, is cemented and present as ocher. Staining is primarily derived from the precipitation of limonite from groundwater percolation of heavily weathered bedrock. The lower member is composed of blue to gray clay and occasional seams of lignite. At the base of the formation, a zone of gravel composed of quartz and metamorphic fragments is reportedly present (DWR, 1974).

The Ione Formation overlies older metamorphic and marine sedimentary rock to the east and is overlain by younger sediments to the west. The formation has a westward dip of approximately 5 degrees and extends at least as far as the Sacramento River in the subsurface. The Ione Formation has a stratigraphic thickness ranging from 100 to 400 feet. The formation merges along the eastern margin with auriferous gravels of the Sierra Nevada, indicating contemporaneous deposition in a deltaic and littoral environment (DWR, 1974). Within the SASb, the Ione Formation is a significant source of water only in the far eastern portions of the subbasin.

2.2.3.2 Stratigraphic Units Below Water Bearing Units

Chico Formation (Marine Sediments)

The Chico Formation outcrops northwest of Folsom near Auburn-Folsom Road (DWR, 1974). These Cretaceous-age marine sediments are composed of a tan, yellowish-brown to light-gray marine sandstone with lenticular beds of pebbles to fine-grained cobble conglomerate. Conglomerate clasts include chert, quartz, quartzite, granite and greenstone. Calcite-cemented concretions and layers of fossil fragments are commonly present. The sandstone is composed of fine-grained to medium-coarse, angular to subrounded grains of quartz, plagioclase, alkali feldspar, lithic fragments and detrital chert (Helley and Hardwood, 1985). Due to the marine depositional environment, this formation is typically saline and not used for water supply purposes. These marine sediments unconformably overlie granitic and metamorphic bedrock and underlie Eocene sediments of the Ione Formation (DWR, 1974). The formation has a westward dip and its estimated thickness ranges from 3,000 to 15,000 feet, thickening east to west (DWR, 1978).

Granitic and Metamorphic Rocks

Metamorphic rocks are exposed east of the Cosumnes River north to the American River near Folsom and are part of the basement complex formed during the Nevadan Orogeny. These metamorphic rocks are typically composed of amphibolite, greenstone, and meta-igneous rocks belonging to the Logtown Ridge Formation of Carboniferous age (DWR,1974). Outcrops of white quartz occur as sharply dipping veins up to 10 feet thick. Discontinuous belts within the Logtown Ridge Formation are slate and shale that are part of the Mariposa Formation. All of the metamorphic rocks have been deformed into isoclinal folds with a near vertical dip (DWR, 1974). The granitic rocks are a portion of the Sierra Nevada batholith that was formed during the

Jurassic and early Cretaceous. These rocks generally range in composition from granite to peridotite with granodiorite and quartz diorite being the most extensive (Olmsted and Davis, 1961).

This metamorphic and granitic basement forms a relatively impermeable boundary for the groundwater basin. The granitic and metamorphic rock slope gently southwest from the outcrops found in the Sierra Nevada to depths greater than 15,000 feet in the Central Valley (Page, 1986).

2.2.4 Faults and Structural Features

Sediments in the SASb do not contain any regional-scale folds or faults (DWR, 1974).

2.2.5 Basin Boundaries

2.2.5.1 Lateral Boundaries

DWR defined the boundaries for the SASb in the brief report “B118 Basin Boundary Description 2016 – 5_021_65 South American Subbasin” (DWR, 2020). This report describes the subbasin boundaries as seven boundary segments, and described with the following text:

The South American Subbasin is a portion of the Sacramento Valley Groundwater Basin located in the Northern Region of California. The northern boundary is the American River, beginning at its confluence with the Sacramento River, and extending northeasterly, upstream to the City of Folsom where the boundary becomes the geologic contact between sediments and fractured bedrock for a short distance further northeast. The eastern boundary is the geologic contact between sedimentary rock and fractured bedrock. The southern boundary extends southwesterly along the Cosumnes River to the confluence with the Mokelumne River and continues southwesterly to Dead Horse Cut (canal). The western boundary includes a short segment for Dead Horse Cut, Snodgrass Slough, and the Delta Cross Channel and then follows the Sacramento River north to its confluence with the American River. (DWR, 2020)

The seven segments described by DWR include five segments that are groundwater divides, one segment that is a boundary with impermeable bedrock, and one boundary segment identified by the political boundary between Yolo and Sacramento Counties, which is coincident with the Sacramento River. The types of basin and subbasin boundaries that DWR uses to establish groundwater basins and subbasins are described in 2003 Bulletin 118 update, Appendix H, and summarized below.

Bulletin 118 update 2003 defined a groundwater divide as:

A groundwater divide is generally considered a barrier to groundwater movement from one basin to another for practical purposes. Groundwater divides have noticeably divergent groundwater flow directions on either side of the divide. The location of the divide may change as water levels in either one of the basins change, making such a “divide” less useful. Such a boundary is often used for Subbasins. (DWR, 2003) In many areas, including the SASb, groundwater divides may provide only a limited barrier to groundwater movement. This barrier may be more pronounced for near-surface groundwater, where rivers and streams have more influence, but may not substantially limit deeper interbasin flow as evidenced by the Aerojet plume migration into NASb and the flow of water between the SASb and CoSb.

An impermeable bedrock boundary is defined as: "Impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock" (DWR, 2003).

2.2.5.2 Boundaries with Neighboring Basins

Boundaries with neighboring subbasins are hydrologic divides as defined above, with a portion of the boundary with the Yolo Subbasin being defined as a political boundary matching the boundary between Yolo and Sacramento Counties which is coincident with the Sacramento River.

2.2.5.3 Bottom of the South American Subbasin

The bottom of the SASb is the shallower of either the base of fresh water or the bottom of the Valley Springs Formation. The base of fresh water is considered the depth at which the specific conductivity of groundwater is 3,000 micromhos per centimeter, which corresponds to a total dissolved solids (TDS) concentration of approximately 2,000 mg/L (Berkstresser, 1973), and is approximately 1400 feet bgs in the central part of SASb.

2.2.6 Principal Aquifers and Aquitards

The SASb is underlain by one principal aquifer, primarily composed of post-Eocene sedimentary deposits. Principal aquifers are defined in the GSP regulations as "aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems." The aquifer system composing the principal aquifer in the SASb is typically divided into an upper zone and a lower zone. The upper zone is contained in Pleistocene to Quaternary-age sediments including the Modesto, Riverbank, and Laguna Formations, South Fork Gravels and Arroyo Seco Gravels. The lower zone is contained in Miocene to Pliocene-age volcanic sediments, including the Mehrten Formation and portions of the underlying Valley Springs and Ione Formations (DWR, 1974). These zones are partially separated by a discontinuous clay layer in the lower portion of the Laguna Formation that can act as a semi-confining layer for the lower zone of the aquifer (Sacramento Central Groundwater Authority [SCGA], 2012).

2.2.6.1 Upper Zone of the Primary Aquifer

The upper zone of the primary aquifer in the SASb is unconfined that consists of alluvium that extends approximately 200 to 300 feet below the ground surface (SCGA, 2012; DWR, 2003). Quaternary deposits consist of flood basin deposits, dredge tailings, alluvium and stream channel deposits. Pliocene to Pleistocene-age deposits consists of compacted sand, silt and gravel that include the Modesto, Riverbank, Turlock Lake and Laguna Formations, Arroyo Seco Gravels and South Fork Gravels (DWR, 2004; Marchand and Allwardt, 1981). Permeable sand and gravel deposits are typically enclosed by less permeable silt and clay, resulting in a network of tabular water-bearing zones (DWR, 1974). The upper zone groundwater is typically of high quality and is often used for private domestic and/or irrigation wells in SASb (SCGA, 2012).

2.2.6.2 Lower Zone of the Primary Aquifer

The lower zone of the primary aquifer in the SASb primarily consists of volcanic deposits that include the Mehrten Formation and portions of the underlying Valley Springs and Ione formations (DWR, 1974; DWR, 2003). The Mehrten Formation is composed of units of andesitic sand, stream gravel, silt and clay interbedded with tuff-breccia. The andesitic sand and gravel unit is highly permeable and is capable of producing high yields, while the tuff-breccia units are relatively impermeable and act as confining layers. (DWR, 2004). The Valley Springs Formation contains varying amounts of rhyolite ash, vitreous tuff, quartz sand containing glass shards and ashy clays. The Ione Formation is composed of three distinct layers: quartz sandstone, white clay and blue to brown clay (DWR, 1974). The base of freshwater in the lower zone of the aquifer is at an average approximate depth of 1,400 feet below ground surface (bgs), as defined by TDS exceeding 2,000 mg/L. In areas where interference with domestic wells could occur, larger municipal supply wells often target the deeper black sand of the Mehrten Formation where high production rates can be achieved with minimal impacts to domestic wells screened in the upper zone of the aquifer (SCGA, 2012).

2.2.6.3 Hydraulic Conductivity

Hydraulic conductivity is defined as the “measure of the capacity for a rock or soil to transmit water” (DWR, 2003). Hydraulic conductivity within the SASb is variable in the principal aquifer, varying laterally, vertically, and among the two zones of the aquifer. In general, hydraulic conductivities are highest near the margins of the American and Sacramento Rivers, and are lowest near the margins of the Sierra Nevada foothills. In 1978, DWR, in coordination with the U.S. Geological Survey (USGS), mapped average hydraulic conductivity values in a nodal grid pattern throughout the Sacramento Valley, based on available drillers’ logs in sections of the Public Lands Survey System (PLSS) (DWR, 1978). Hydraulic conductivity values ranged from approximately 20 to 260 gallons per day per square foot (2.7 to 35 feet per day [ft/d]) at varying depths up to 550 feet bgs in the approximate SASb area. Average hydraulic conductivities were typically higher in wells assumed to be in the Modesto, Riverbank and Laguna Formation, and were variable in wells assumed to be in the Mehrten Formation. Lower hydraulic conductivities in the Mehrten Formation are observed in the relatively impermeable tuff-breccia units, while higher hydraulic conductivities are observed in the black sand units. (DWR, 1978).

Table 2.3-1 shows the range and average hydraulic conductivity for each layer in the CoSANA model.

Table 2.2-1: Estimated Hydraulic Conductivity (feet per day) for each CoSANA Model Layer

Layer	Minimum	Average	Maximum
1 – Alluvium	2.1	34	108
2 – Laguna	2.2	26	87
3 – Mehrten	0.7	17	50
4 – Valley Springs	0.9	15	42
5 – Ione	0.3	11	38

2.2.6.4 Transmissivity

Transmissivity is defined as an aquifer's "ability to transmit groundwater horizontally through its entire saturated thickness" and is "the product of hydraulic conductivity and aquifer thickness". (DWR, 2003). In 1978, DWR, in coordination with USGS, mapped aquifer transmissivity in post-Eocene deposits for the Sacramento Valley using information from drillers' logs in PLSS sections of the Sacramento Valley (DWR, 1978). Transmissivity values mapped in the SASb area ranged from 10,700 to 26,100 square feet per day. Transmissivity values were highest along the Sacramento River, decreasing toward the Sierra Nevada foothills (DWR, 1978).

Table 2.2-2 shows the range and average transmissivity for each layer included in the CoSANA model.

Table 2.2-2: Estimated Transmissivity (square feet per day) for each CoSANA Model Layer

Layer	Minimum	Average	Maximum
1 – Alluvium	64	1,930	12,955
2 – Laguna	123	5,199	20,770
3 – Mehrten	204	11,303	69,562
4 – Valley Springs	27	2,578	14,984
5 – Ione	0.2	599	3,736

2.2.6.5 Specific Yield and Specific Storage

Specific yield is defined as the "ratio of the volume of water a rock or soil will yield by gravity drainage to the total volume of the rock or soil" (DWR, 2003). Specific yield is a measurement specific to unconfined aquifers, such as the upper zone of the primary aquifer in the SASb. USGS calculated a specific yield for the low plains south of the American River (from a depth of 20 to 200 feet bgs) of 0.07. Calculated specific yields range from 0.054 in flood plain deposits to 0.1 in stream channel deposits (Olmsted and Davis, 1961).

In 1978, DWR, in coordination with USGS, mapped storage coefficient values in post-Eocene deposits for the Sacramento Valley, based on drillers' logs in PLSS sections of the Sacramento Valley (DWR, 1978). Storage coefficient values mapped in the approximate SASb area range from 0.07 to 0.1 (DWR, 1978).

Table 2.2-3 and **Table 2.2-4** show the range and average specific yield and specific storage for each layer included in the CoSANA model. Storage coefficient is the product of specific storage and aquifer thickness.

Table 2.2-3: Estimated Specific Yield (unitless) for each CoSANA Model Layer

Layer	Minimum	Average	Maximum
1 – Alluvium	0.06	0.12	0.24
2 – Laguna	0.07	0.12	0.22
3 – Mehrten	0.07	0.12	0.20
4 – Valley Springs	0.07	0.12	0.21
5 – Ione	0.07	0.10	0.20

Table 2.2-4: Estimated Specific Storage (1/foot) for each CoSANA Model Layer

Layer	Minimum	Average	Maximum
1 – Alluvium	0.000003	0.000039	0.000076
2 – Laguna	0.000002	0.000040	0.000070
3 – Mehrten	0.000002	0.000039	0.000073
4 – Valley Springs	0.000005	0.000038	0.000061
5 – Ione	0.000010	0.000050	0.000078

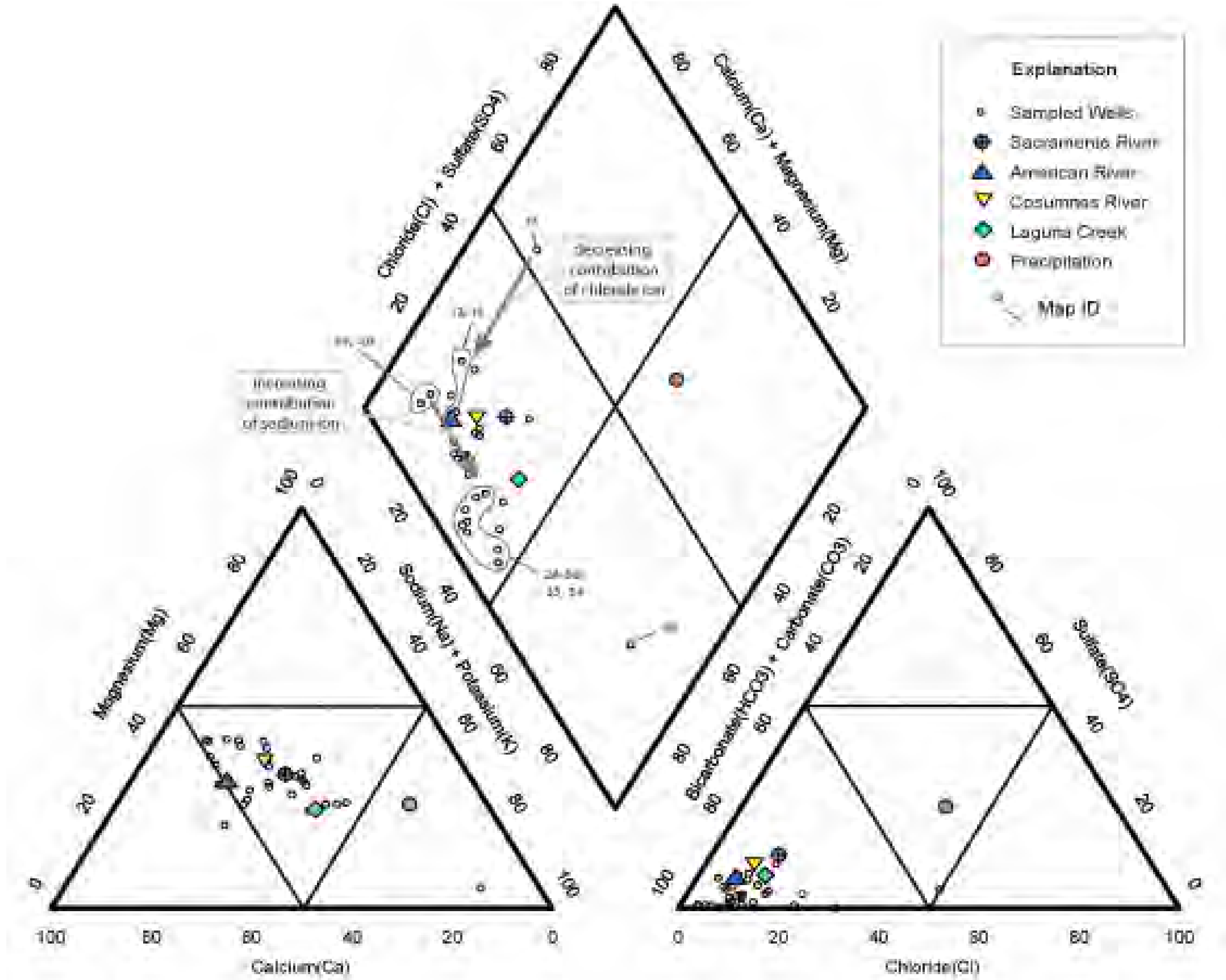
2.2.7 Natural Water Quality Characterization

According to the 2006 *Central Sacramento County Groundwater Management Plan*, water quality analyses in the aquifer underlying the SASb have generally shown that groundwater in the upper zone of the aquifer is of higher quality than water in the lower zone of the aquifer with the exception of arsenic detections in a few locations (SCGA, 2006). Water in the lower zone of the aquifer typically has higher concentrations of iron, manganese and TDS. At depths below approximately 1,400 feet bgs (variable throughout the subbasin), the TDS exceeds 2,000 mg/L, making the groundwater unsuitable for potable use and not part of the SASb.

Iron concentrations in the potable region of the lower zone of the aquifer have ranged from less than 10 micrograms per liter (µg/L) to 16,000 µg/L, with the majority of wells having an average value of less than 200 µg/L. Manganese concentrations in the potable region of the lower zone of the aquifer range from less than 2 to 1,700 µg/L with the majority of wells having an average value of less than 50 µg/L.

In 2015, RMC Water and Environment prepared the *Sacramento Central Groundwater Authority Recharge Mapping and Field Study Technical Memorandum* for the SCGA that included testing major-ion composition for samples from municipal, park irrigation and domestic water wells throughout the Central Sacramento Groundwater Basin. The test results show that anions were primarily dominated by bicarbonate, and cations were dominated by either calcium, magnesium or sodium. In general, ionic content is relatively low at wells located near the American and Sacramento Rivers. Samples collected more centrally within the study area and from near Laguna Creek show a relative increase in total ionic content (RMC Water and Environment, 2015).

Saline water is present at depths between 1,000 to 2,000 feet (varying throughout the aquifer). The saline water appears to originate from marine deposition as TDS concentrations range between 15,000 to 28,000 mg/L (sea water is typically 34,000 mg/l) and are dominated by a high concentration of sodium and chloride ions (RMC Water and Environment, 2015). **Figure 2.2-40** shows a Piper diagram for select well chemical data throughout the SASb. **Figure 2.2-41** shows the location of these select water wells and provides a Stiff diagram of the chemical data.



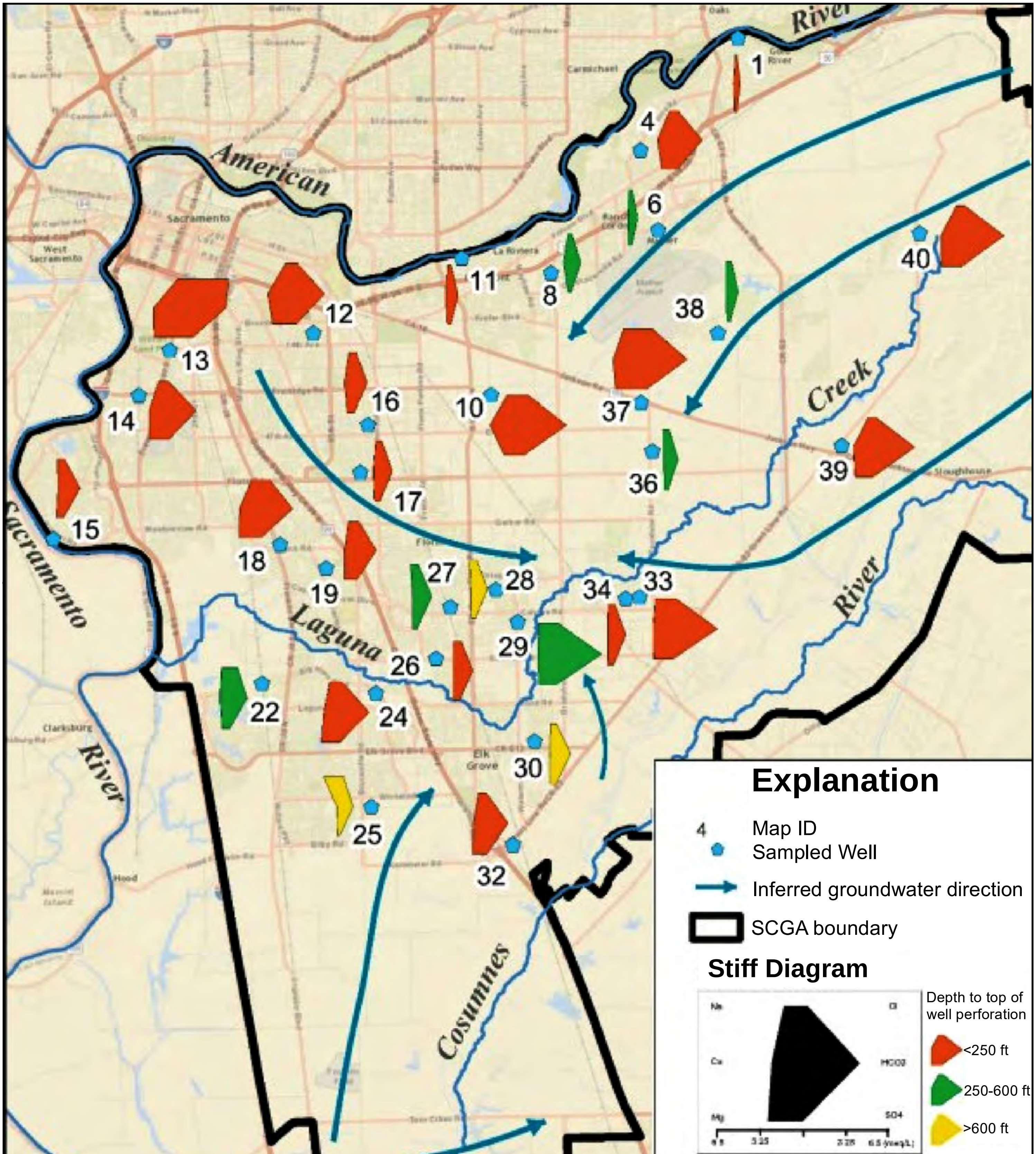
Surface water data sources (See Figure 2 for sample locations).:

Sacramento River data- USGS sampling site Sacramento R A Freeport CA collected on 1/14/2015
American River data- USGS sampling site American R A Sacramento CA collected on 4/16/1998
Cosumnes River data- USGS sampling site Cosumnes R A Michigan Bar collected on 10/30/2014
Laguna Creek data- Collected by GEI Consultants on 12/2/2012 just north of Highway 16.

Precipitation data source:

Average rainfall chemistry (1987-2002) for National Atmospheric Deposition Station CA 88 located in Davis California

Figure 2.2-40: Piper Diagrams



South American Subbasin

0 1 5 Miles

N

South American Subbasin GSP

Well Location Map for Data on the Piper Diagram

Figure 2.2.41

Legend

South American SUBBASIN

Project #: 0011575.00
Map Created: October 2021

2.2.8 Topography, Surface Water and Recharge

This section describes the topography, surface water, soils, and groundwater recharge potential in the SASb. Imported water supplies are not utilized by the SASb and is not discussed further.

2.2.8.1 Topography

The lowest elevations are along the southwest boundary, where the Sacramento River enters the Sacramento-San Joaquin Delta (Delta) at approximately sea level, while the highest point in the SASb is approximately 500 feet along the eastern margin of SASb. **Figure 2.2-42** shows the topographic characteristics of the SASb. Topography gradually flattens from the base of the Sierra Nevada foothills toward the western margin of the SASb along the Sacramento River.

2.2.8.2 Surface Water Bodies

Several surface water bodies are located in the SASb area, including the Sacramento, American, and Cosumnes Rivers, the Folsom South Canal and Lake Natoma, and the perennial stream tributaries. The rivers and streams in the southwesterly portions of the subbasin are affected by tides, including the Cosumnes River and Sacramento River. The surface water bodies are shown in **Figure 2.2-43** and described below:

- **Sacramento River –** The Sacramento River is located on the western margin of the SASb and flows from an elevation of approximately 10 feet to slightly above sea level from its northern inlet to the SASb to its southern outlet from the SASb. The Sacramento River is a perennial river and drains the Sacramento River Basin. Daily flows recorded at Freeport from 1948 to 2021 range from 4,000 cubic feet per second (cfs) in 1977 to 115,000 cfs in 1986. During high flow periods, a significant portion of flow from the Sacramento River Basin is diverted through the Yolo Bypass west of the Sacramento River and SASb.

- **American River –** The American River is located on the northern margin of the SASb and flows from an elevation of approximately 240 feet to 10 feet from its eastern inlet to the SASb near Folsom Dam to its outlet into the Sacramento River. The American River is a perennial river with recorded daily flows at Fair Oaks from 1904 to 2021. Since Folsom Dam was constructed in 1955, the lowest recorded flow was 215 cfs in 1977 and the highest recorded flow was 131,000 cfs in 1986.

- **Cosumnes River –** The Cosumnes River flows from an elevation of approximately 140 feet at its eastern inlet to the SASb from the Sierra Nevada foothills to approximately sea level as it drains into the Mokelumne River in the Delta. The Cosumnes River is a seasonal stream in the SASb, with recorded flows at Michigan Bar from 1907 to 2019. The lowest flow is zero when portions of the river are dry in most summers, and the highest recorded daily flow was 61,600 cfs in 1997.

- **Folsom South Canal –** Folsom South Canal is a 26.7-mile concrete lined canal that originates at Nimbus Dam on the American River and extends southward into the Cosumnes Subbasin at Clay, California. The canal has a bottom width of 34 feet and a maximum water depth of 17.8 feet. The Folsom South Canal has a capacity of 3,500 cfs. (USBR, 2006)

South American Subbasin GSP

Topography

Figure 2.2-42

Legend

South American Subbasin

Elevation within Subbasin (Feet)

High: 526.8

Low: -7.7

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: June 2020

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South American Subbasin GSP

Surface Water Bodies

Figure 2.2-43

Legend

- Cities and Towns
- Rivers and Creeks
- Folsom South Canal
- Freeport Pipeline
- South American Subbasin

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: June 2020

- **Lake Natoma –** Lake Natoma is located immediately downstream of Folsom Lake on the northeast side of the SASb. Lake Natoma is an afterbay that regulates flow releases to the American River from Folsom Lake. (USBR, 2005) Lake Natoma was created by the construction of Nimbus Dam in 1955, which is a concrete gravity dam structure measuring 87 feet in height and 1,093 feet in length. Eighteen radial gates, each 40 feet by 24 feet, control flows from Lake Natoma and has a capacity of 8,760 acre-feet and a surface area of 540 acres with an average water depth of 16 feet. (USBR, 2005)

- **Streams –** Laguna Creek and Morrison Creek are perennial streams that are tributary to the Sacramento River and Deer Creek is tributary to the Cosumnes River.

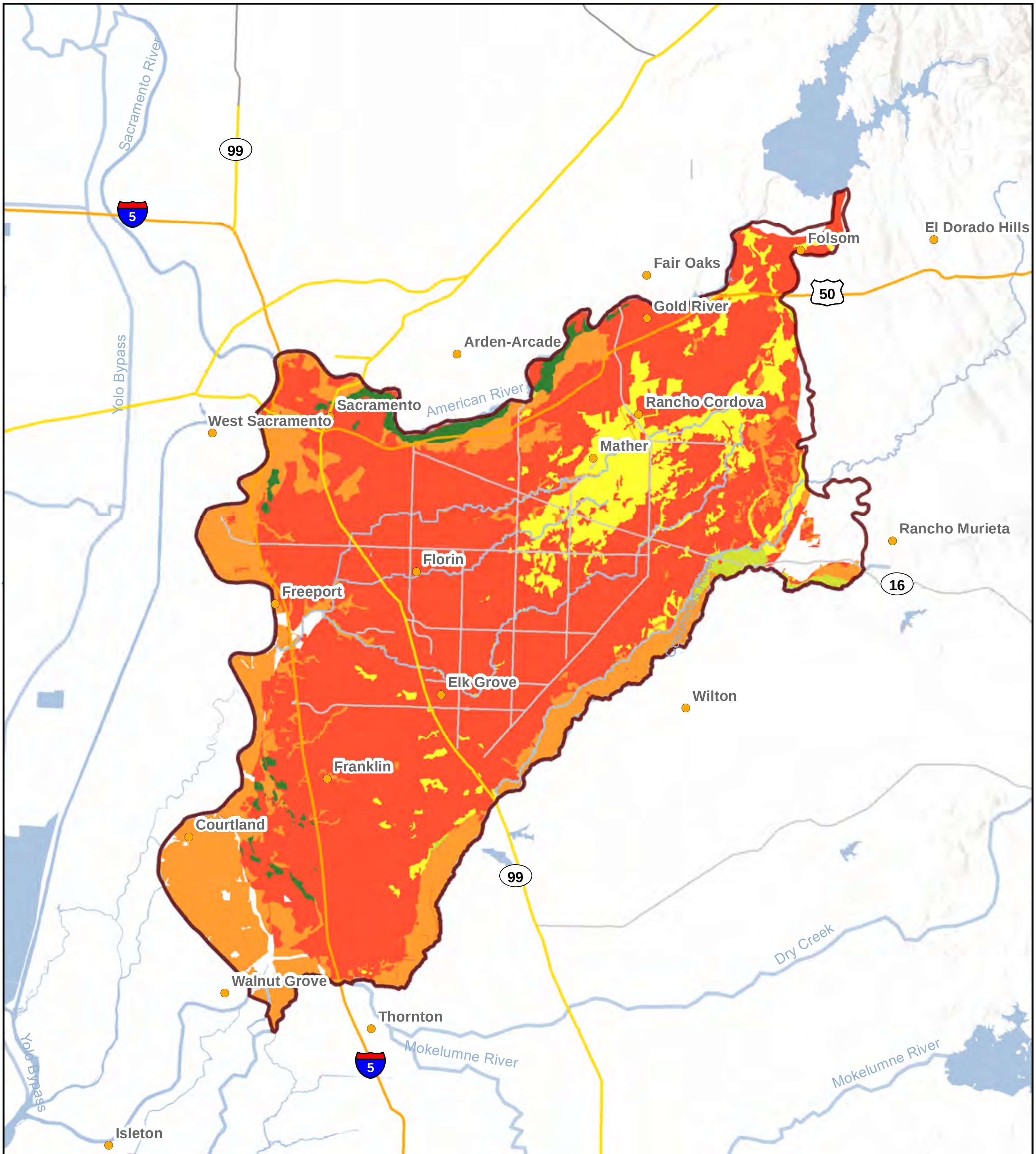
2.2.8.3 Surface Waters with Potential to Affect Groundwater Quality

The Subbasin include portions that are located within the Legal Delta and are traversed by Delta waterways that experience tidal influences resulting from the connection to Suisun Bay, San Francisco Bay, and the Pacific Ocean to the west of the Subbasin. Although Delta waterways are tidally influenced, the water quality conditions in these waterways are generally dominated by freshwater outflows from the Sacramento River and San Joaquin River watersheds, as indicated by salinity conditions in these waterways. The historical volumes of freshwater surface outflows have maintained freshwater-dominated conditions in this part of the Subbasin since the 1950s. Any future potential for groundwater quality impacts from salinity intrusion leading to brackish surface waters in the Subbasin are likely more dependent on the surface water outflows conditions from the Sacramento River. Freshwater outflow through the Delta has historically maintained a fresh tidal zone in and adjacent to the Subbasin, although altered surface water flow regimes within the Delta, upstream changes in surface water flows, and/or changing sea level conditions could result in altered salinity conditions. Salinity intrusion tends to be persistent and requires significant freshwater outflows to improve conditions. Consequently, these changes in surface water conditions could affect groundwater directly through salinity intrusion.

2.2.8.4 Areas of Recharge, Potential Recharge, and Groundwater Discharge Areas

Areas of recharge and potential recharge are primarily located along the American River, the upper portion of the Cosumnes River (i.e., near the eastern SASb boundary), isolated areas near the Sacramento River and in the central to northeastern portion of the SASb. **Figure 2.2-44** shows areas with potential for groundwater recharge, as identified by the Soil Agricultural Banking Index (SAGBI). SAGBI indexes the potential rate of groundwater recharge for agricultural lands by considering deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. While SAGBI is used to describe recharge conditions generally in the subbasin, it should be noted that alternative approaches to recharge may be able to allow for successful recharge efforts in areas noted a poorly suitable in SAGBI.

Analytical results discussed in the *Sacramento Central Groundwater Authority Recharge Mapping and Field Study Technical Memorandum* indicate the majority of recharge occurs in areas where soils are coarse (e.g., southwest of Folsom) and where there is extensive application of agricultural applied water (e.g., south of Elk Grove and between Grant Line Road and the Cosumnes River) (RMC Water and Environment, 2015). The study also indicates that recharge rates were lower from Elk Grove to the northwest, roughly between Morrison Creek and Grant Line Road. This area is largely suburban, rural residential, or undeveloped land on relatively low permeability soils (RMC Water and Environment, 2015)). According to the study, most recharge occurs from streams and rivers and a combination of rainfall and applied water.



South American Subbasin GSP

Recharge Areas

Figure 2.2-44

Legend

South American Subbasin

SAGBI Soils

- Very Poor (0-14)
- Poor (15-29)
- Moderately Poor (30-49)
- Moderately Good (50-69)
- Good (70-84)
- Excellent (85-100)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Project #: 0011575.00
Map Created: October 2021

Several potential new recharge projects are currently being considered in the SASb and are described in **Section 4: Projects and Management Actions**.

Discharge from the SASb is from groundwater pumping and extraction and baseflow to streams and rivers. No current or historical springs or seeps are known within the SASb.

Soils

Surface soils in SASb were mapped, described and categorized by the National Resources Conservation Service STATSGO2 Database. According to NRCS, the SASb is composed mostly of clayey, fine-loamy and sandy soil (NRCS STATSGO2, 2020). Clayey soils generally occur adjacent to the Sacramento River and south of Rancho Cordova to the Cosumnes River. Sandy soils generally occur adjacent to the Sacramento River and south of Folsom to Rancho Cordova. The remaining central portion of the SASb tends to consist of fine loamy soils.

Figure 2.2-45 shows soils in the SASb by taxonomic soil groups. **Figure 2.2-46** shows soils in the SASb by hydrologic soil groups, which are sorted by permeability, with class A being the most permeable and class D being the least permeable. Most of the soils in the central portion of SASb have moderate to low permeabilities (listed as class C or D) with higher permeabilities (listed as class A or B) located near the American and Cosumnes Rivers, or for dredge tailings in the northeastern area of SASb, and in isolated areas near the Sacramento River. Permeability is generally poorest near the base of the Sierra Nevada foothills and in the flood basin areas of the Sacramento River.

2.2.9 Hydrogeologic Conceptual Model Data Gaps

Significant data gaps were not identified for the SASb that would create uncertainty that would affect the ability of the GSP to achieve sustainability by 2042. However, all hydrogeologic conceptual models are uncertain to a limited extent and can be improved with additional data. The following SASb HCM data gaps require additional information and will be updated with future monitoring, modeling, and data refinement efforts.

Aquifer Characteristics

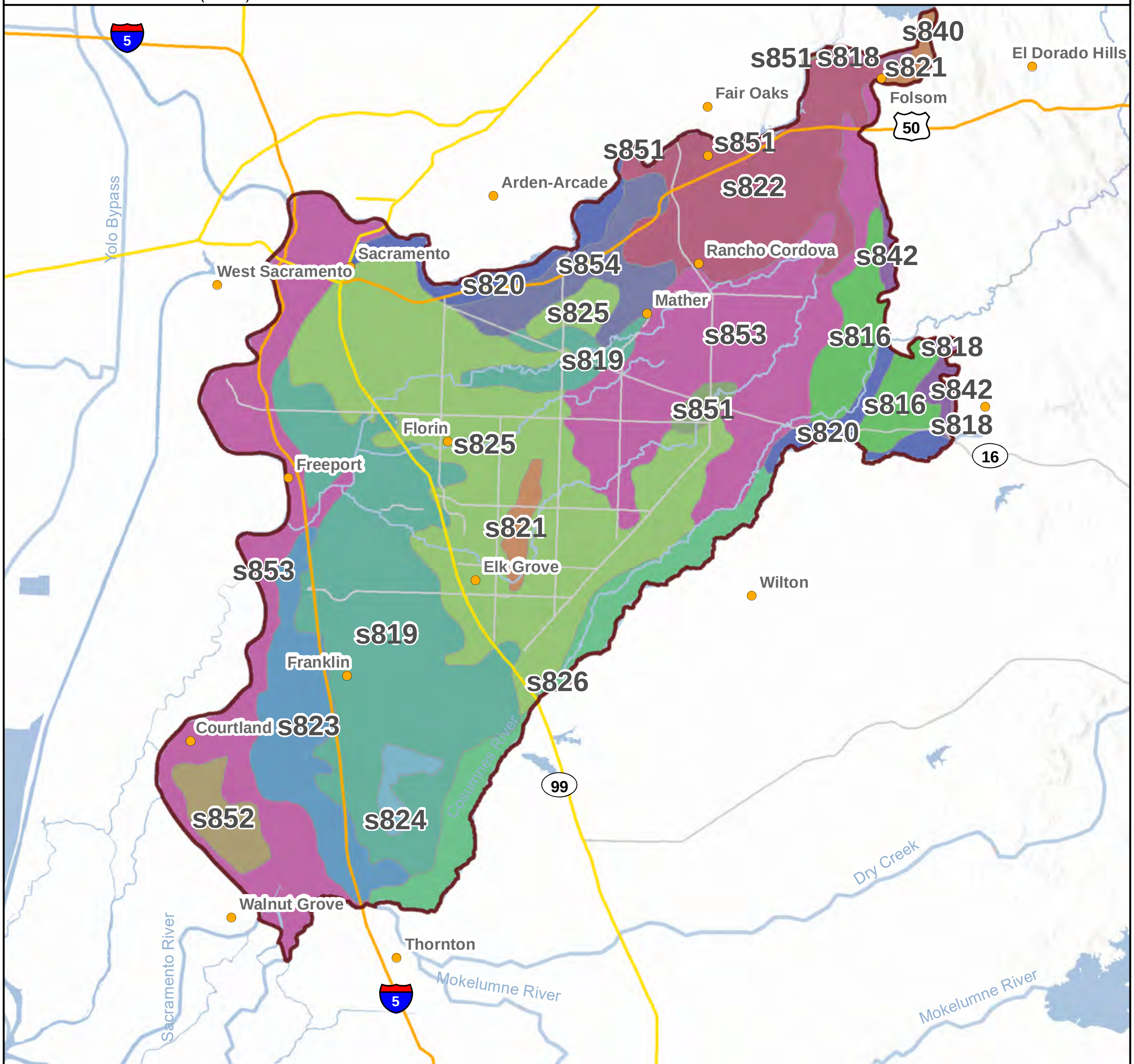
- Further definition of aquifer characteristics (e.g., hydraulic conductivity, transmissivity, and storage parameters) within and near Subbasin boundary areas, including aquifer tests.

Groundwater Level Data

- Depth- or zone-specific water levels to assess vertical interconnection, including zones within the principal aquifer.
- Additional shallow groundwater data near surface waters and natural communities commonly associated with groundwater (NCCAGs).
- Additional groundwater level data near major creeks and rivers to improve quantification and understanding of subsurface flows between groundwater subbasins and surface water-groundwater interaction.

STATSGO2 Soils

- Dierssen (s823)
- Pentz-Hadselville (s816)
- Redding-Corning (s821)
- Rindge-Gazwell-Egbert (s852)
- Rock outcrop-Mokelumne variant-Mokelumne (s842)
- Ryer-Rossmoor-Columbia (s820)
- Sailboat-Cosumnes-Col... (s826)
- San Joaquin (s825)
- San Joaquin-Galt (s819)
- Sierra-Caperton-Andregg (s817)
- Sobrante-Rock outcrop-Auburn (s840)
- Stockton-Clear Lake-Capay (s824)
- Sycamore-Sailboat-Egbert (s853)
- Urban land-Fiddyment-Cometa (s851)
- Urban land-San Joaquin-Pits-Natomas-A... (s854)
- Water (s8369)
- Whiterock-Rock outcrop-Auburn (s818)
- Xerorthents-Xerofluvents (s822)



South American Subbasin GSP

Taxonomic Soil Groups

Figure 2.2-45

Legend

South American Subbasin

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: October 2021

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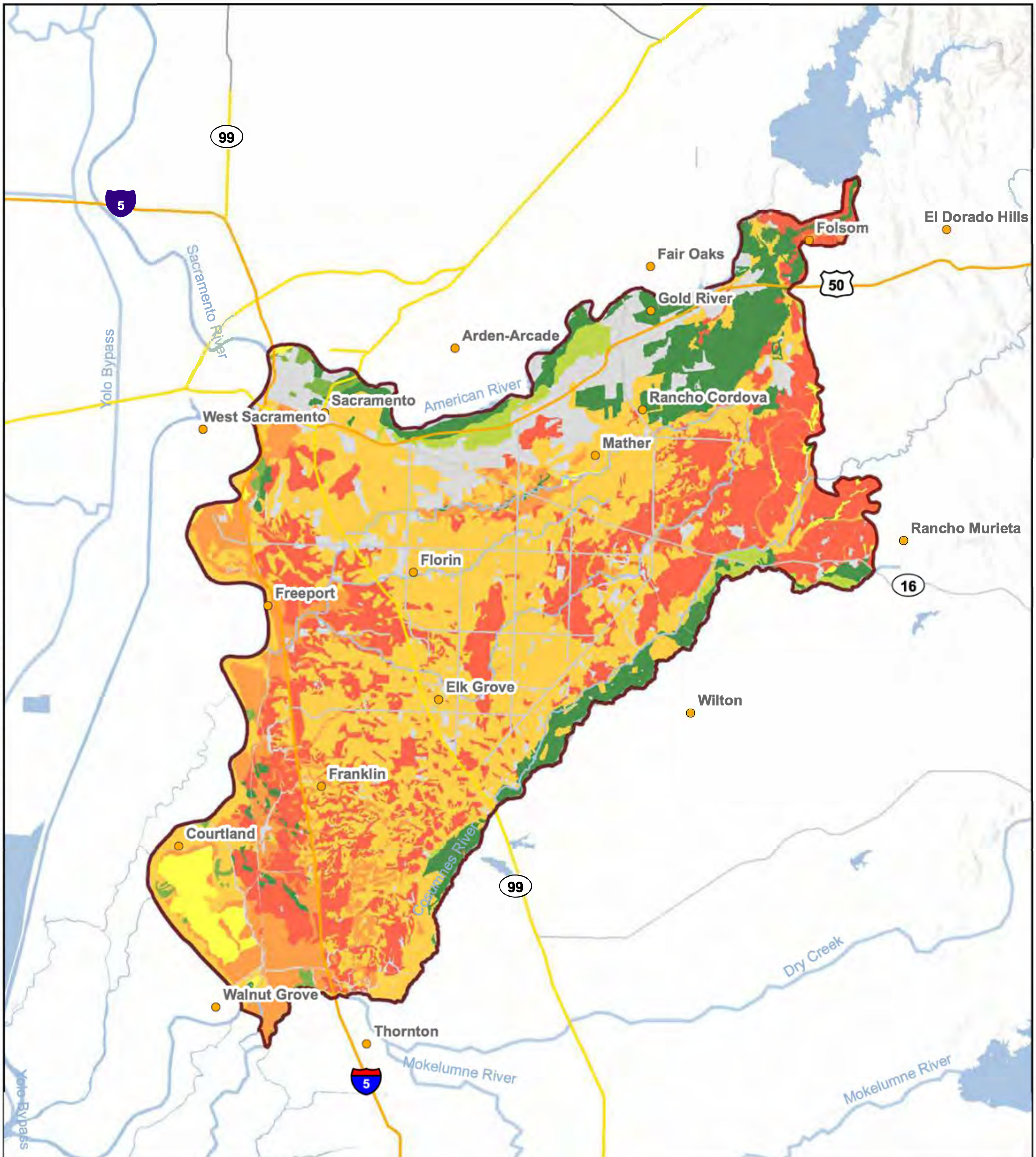

South American GSP

Hydrologic Soil Groups

Figure 2.2-46

Legend

South American Subbasin

Hydrologic Soil Group

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not Classified

South American SUBBASIN

Map Created: June 2020

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Groundwater Quality Data

- Additional water quality monitoring at various depths will help inform the understanding of water quality. This can be achieved through installation of new monitoring wells, the use of other existing well and/or through determination of screened intervals of existing monitoring wells.
- Additional depth-specific water quality data will inform SMCs for degraded water quality.

Subsurface Conditions

- Improved characterization of near-surface soil conditions as they relate to recharge.

2.3 Groundwater Conditions

This section provides a description of current and historical groundwater conditions in the South American Subbasin, organized by sustainability indicators. The current and historical groundwater conditions in the SASb are the result of a long history of changes in land and water use throughout the region, together with periods of wet, dry, and normal precipitation and streamflow conditions. An understanding of this historical context is important when considering the current and projected future groundwater conditions.

Groundwater has played an important role in domestic, agricultural, and urban water supply in the SASb since the early 1900s. Starting around 1890, the demand for irrigation water grew as large land grants were subdivided into 10- and 20-acre parcels for small farms. Coupled with the development of more advanced well drilling, well construction, and pumping techniques, the increasing irrigation demand resulted in increased groundwater pumping. By 1928, 28 percent of the irrigated land in the Subbasin was using groundwater, and the water table was reported to be in decline. The Great Depression of the 1930s slowed the spread of farming until the early 1940s. Shortly thereafter, the Carmichael, Citrus Heights, and Fair Oaks Irrigation Districts and the City of Sacramento began utilizing groundwater to meet increasing demands. During the rapid urbanization following World War II, several small water districts were formed. (DWR, 1974)

Since the mid-20th century, population has steadily increased in the area. Although including areas beyond the SASb, the Sacramento metropolitan statistical area population trends show a steady increase from around 276,000 in 1950 to a little more than 2,300,000 in 2020, highlighting the urban growth in the Subbasin (US Census Bureau, 1950, 2020). Much of this urban growth displaced irrigated agriculture (notably in the western and southern areas of the Subbasin) or undeveloped rangeland (notably in the northern and eastern areas of the Subbasin). The conversion from irrigated agriculture to urban development typically replaced shallow agricultural groundwater use with deeper municipal groundwater use or municipal surface water use. With some exceptions, urban growth occurred primarily with dependence on surface water in the City of Sacramento, City of Folsom, and Rancho Murieta, with groundwater primarily supplying water to the remaining growth areas.

In the mid-1980s, many urban land use agencies recognized that continued urban growth solely on groundwater would not be sustainable. As a result, Zone 40 of the Sacramento County Water Agency was formed to plan for and construct a regional water distribution system capable of optimizing the use of available surface water in the wet years with the ability to turn to groundwater in the dry and critical years. This concept of conjunctive water management took advantage of the available sources of natural “in-lieu” recharge in the wet years to off-set higher than average groundwater pumping volumes in the dry years. Further, in order to enforce and maximize the conjunctive use potential within the SASb, Sacramento County General Plan land use policies established that new growth within unincorporated areas be conditioned upon perfecting supplemental water supplies. As a result, much of the impetus to begin importing surface water to the area south of the City of Sacramento between Interstate 5 and Highway 99 occurred in the mid-1990s. SCWA has made significant investments in water infrastructure, including the wheeling of treated surface water from the City of Sacramento’s Sacramento River Water Treatment Plant, the recycled water program by the Sacramento Regional Sanitation District, the joint East Bay Municipal Utility District/SCWA Freeport Intake and Pipeline to the Folsom South Canal, and the SCWA Vineyard Surface Water Treatment Plant to deliver potable water to the Zone 40 area including portions of the cities of Elk Grove and Rancho Cordova.

Urban growth in the Subbasin since the 1950s was substantially supported by military and industrial expansion in the area, including Mather Field and Aerojet facilities. These facilities served critical wartime and post-war functions but left a legacy of significant groundwater contamination currently being remediated to protect the water supply. Recent efforts have allowed for capture and re-use of some of this remediated groundwater.

Groundwater conditions reflect these growth patterns and shifts in water supplies, as well as the variable hydrology in the Subbasin and associated watersheds. The Subbasin has experienced many droughts and wet periods that are reflected in the groundwater conditions due to associated changes in recharge and groundwater use. The drought of 2012-2016 also caused significant urban conservation activities to occur, which lowered urban water demands across the Subbasin. Much of this water conservation behavior has persisted beyond the drought.

Drought and drought-planning has been driven by voluntary and state-mandated demand management in the region, which has steadily increased since the 1990s. State-mandated conservation, both through the Urban Water Management Plan process and during drought conditions, has contributed significantly to hardened demand in the region. While the hardened demand is lower due to conservation, it means that there is less ability to cut demand during periods of drought.

This section presents details on current and historical groundwater conditions to allow for a better understanding of the groundwater system. This understanding is necessary to help distinguish long-term trends associated with land and water uses and short-term trends associated with hydrologic conditions. In addition to providing details on conditions related to each of the sustainability indicators, a section is included to list data gaps that, if filled, would improve the understanding of groundwater conditions.

2.3.1 Groundwater Levels

Groundwater levels within the SASb have fluctuated within each year due to seasonal recharge and use variations; over a year or series of years due to short-term droughts and wet periods; and over decades due to changes in land and water use or longer-term hydrologic conditions.

Like most of California, groundwater levels in the SASb typically decline in summer and fall and increase in winter and spring. The summer and fall are periods of reduced natural recharge from precipitation and streamflow and also are periods of higher groundwater production to meet higher urban and agricultural demands during that period. Conversely, the winter and spring have higher recharge and lower groundwater production. The magnitude of seasonal fluctuation in groundwater levels depends on the connectivity of the aquifer with surface recharge sources; the volume and depth of groundwater production in the area; and aquifer characteristics.

The following subsections describe in greater detail how groundwater conditions have changed in the Subbasin in recent decades, including discussions of groundwater hydrographs, vertical gradients, and elevation contours, all of which were based on available groundwater level monitoring data.

Groundwater Elevation Data Processing

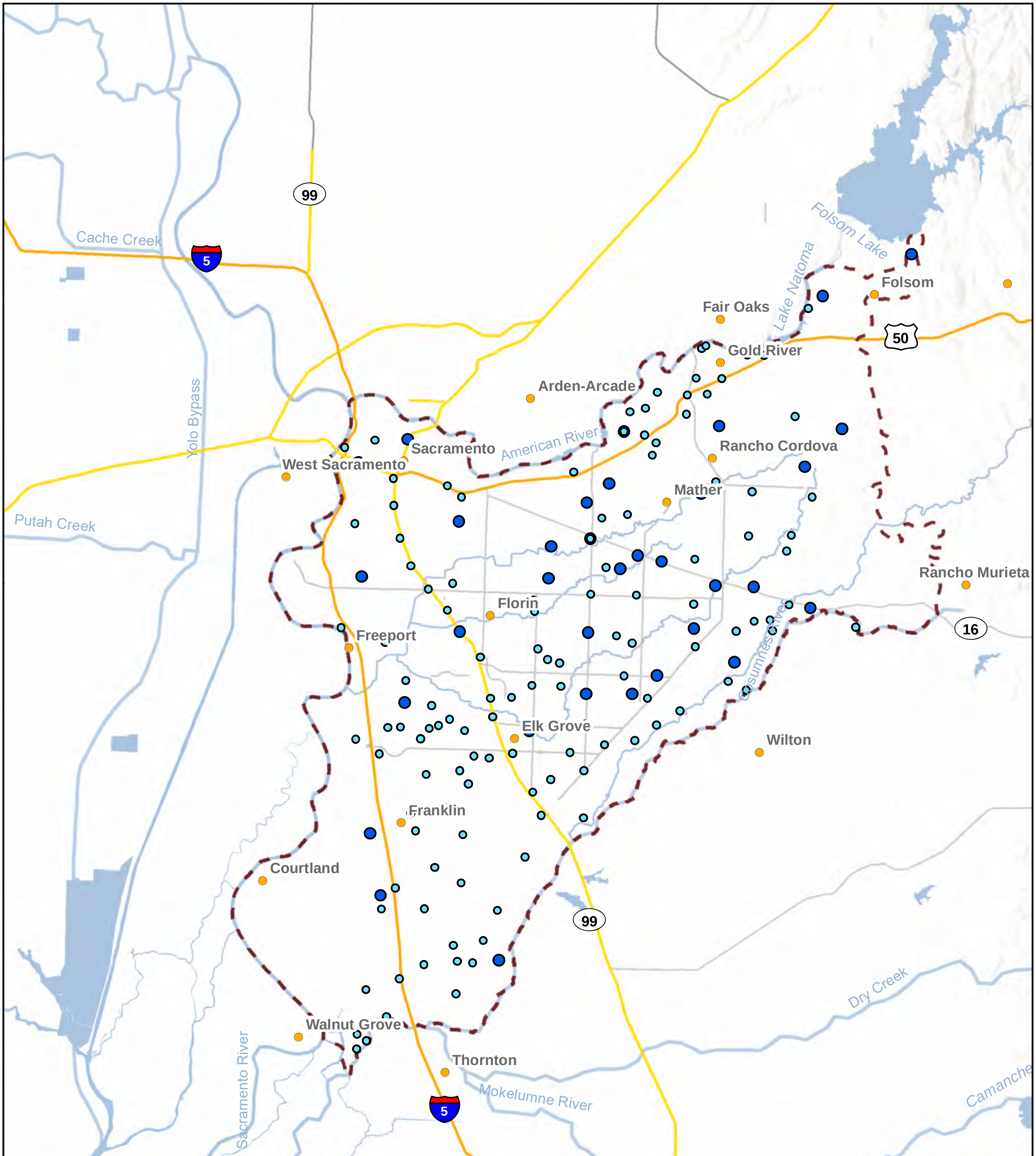
Groundwater well information and groundwater level monitoring data were compiled from six sources, including :

- USGS
- DWR
- University of California at Davis (UCD)
- The Nature Conservancy (TNC)
- Aerojet Rocketdyne
- Elk Grove Water District

Data provided by these sources included well information such as location, construction, owner, and elevation, and groundwater elevation data such as date measured, depth to water, groundwater elevation, data quality codes, and comments. At the time of this analysis, groundwater elevation data were available from 1929 to September 2020[2]. Within this timeframe, many wells provide historical monitoring data but no recent measurements, and a smaller number of wells with monitoring data recorded for periods of greater than 50 years. **Figure 2.3-1** through **Figure 2.3-2** show well locations with available monitoring data and the entity that maintains monitoring records at each well. These figures also show if the monitoring well is currently being monitored (classified as having measurements between January 2018 and September 2020).

Figure 2.3-1 shows the locations of well data received from the DWR database. Wells with data within the last three years, from January 2018 to 2020, are considered "active" monitoring wells for this analysis. Roughly one third of the wells from DWR's database contain monitoring data from 2018 to 2020. Wells in DWR's database are generally concentrated within the topographically flat western two-thirds of the Subbasin. Fewer wells are located in the hills of the eastern third of the Subbasin. Many wells in DWR's database have been typically measured twice a year, with one measurement in the spring and one measurement in the fall. Some of these wells have been measured on a monthly or quarterly basis.

[2] The analysis shown in this section was performed in the fall of 2020 and does not reflect data that may have been collected after September 2020. In addition, the analysis reflects the available data as provided by each entity.



South American Subbasin GSP

Wells with Monitoring Data Provided by the DWR

Figure 2.3-1

Legend

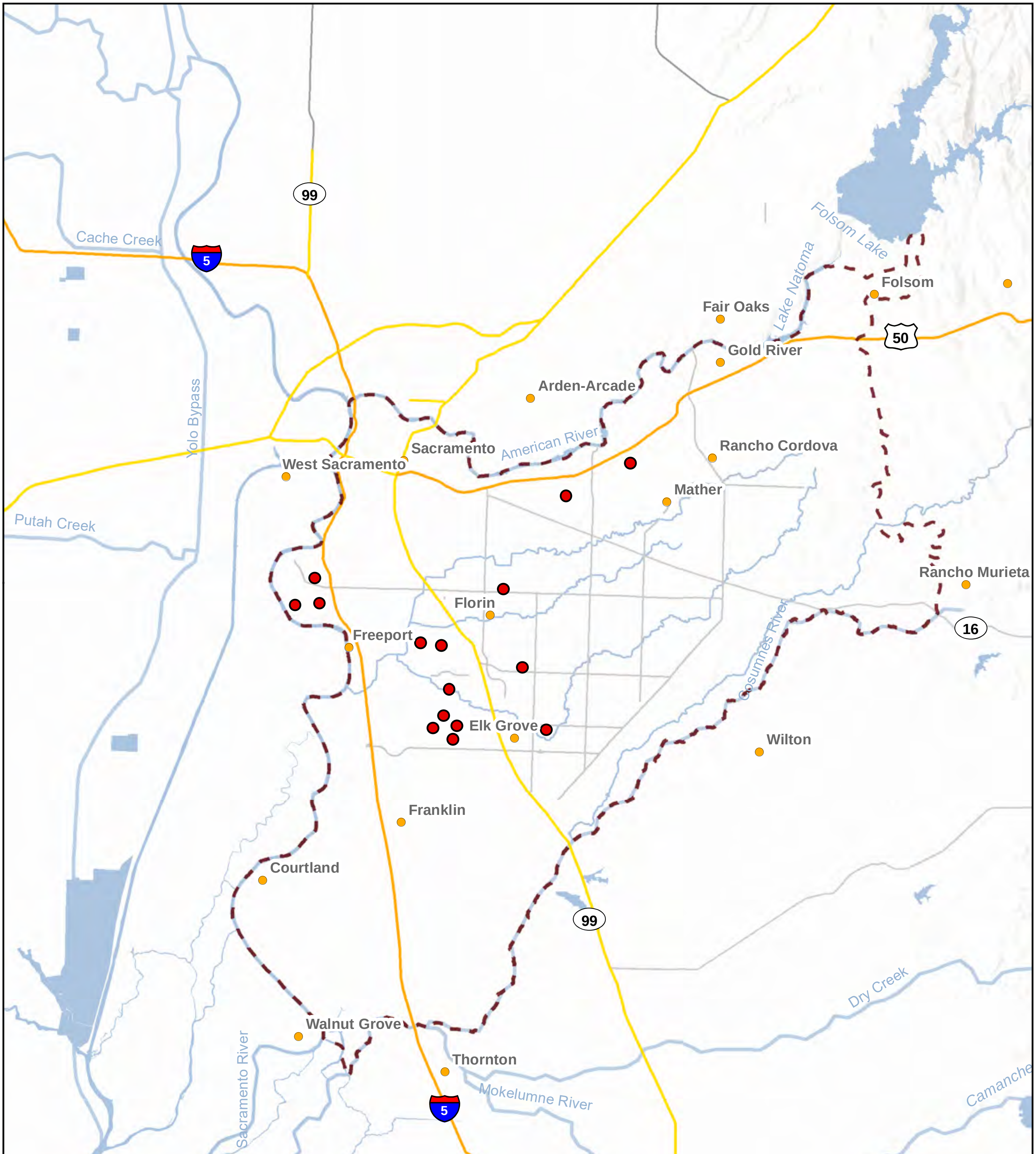
- South American Subbasin
- DWR Wells Last Measured in 2018 to 2020
- DWR Wells Last Measured in 2017 or Earlier

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: December 2020



South American Subbasin GSP

Wells with Monitoring Data Provided by the USGS

Figure 2.3-2

Legend

South American Subbasin

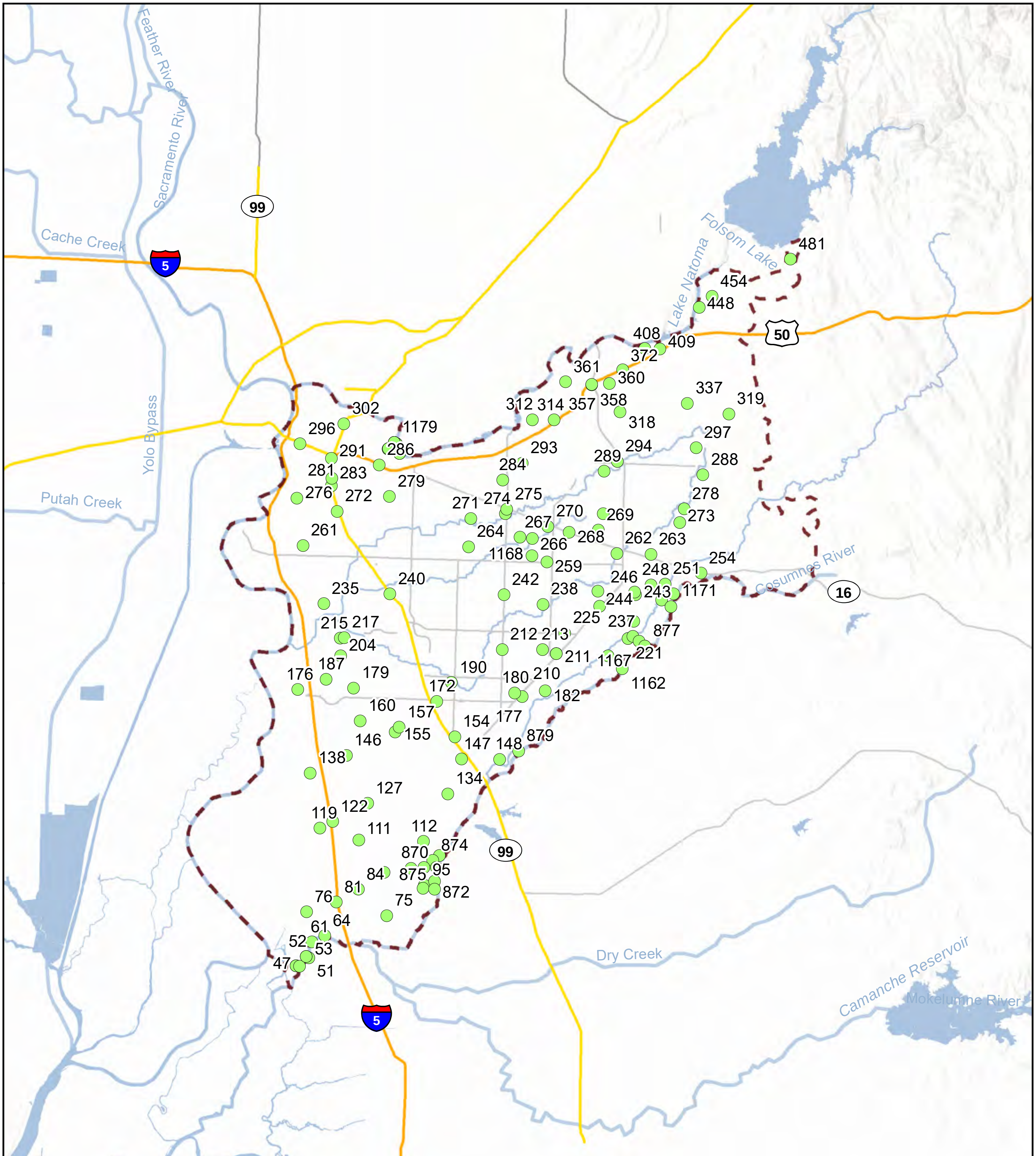
USGS Database Active Monitoring Well

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: December 2020



South American Subbasin GSP

Wells with Monitoring Data Provided by UCD & TNC

Figure 2.3-3

Legend

South American Subbasin

Wells Privided by UCD & TNC

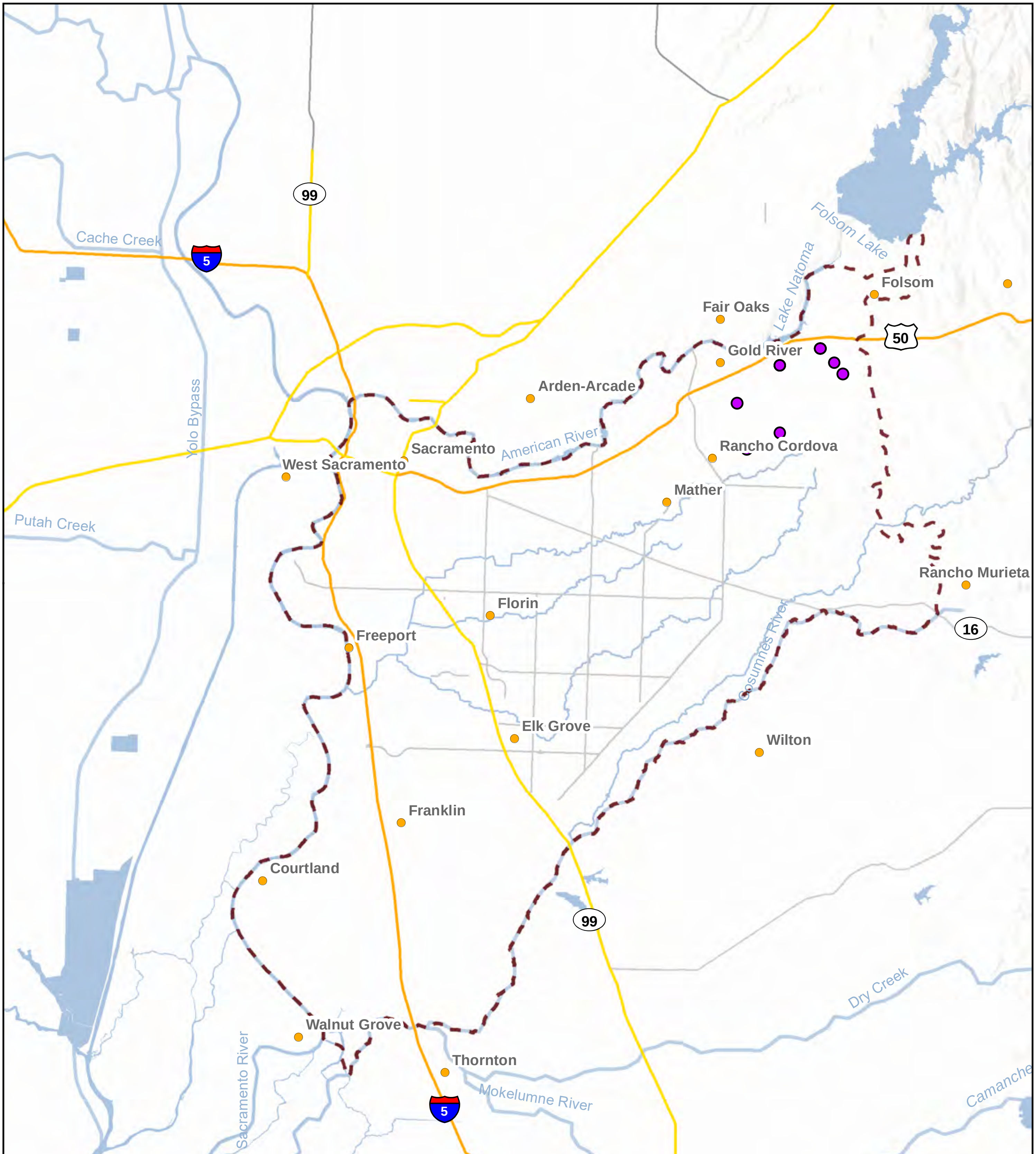
Note: Numbers next to each well correspond to the Well ID used in this GSP.

0 1.5 3 6 Miles

N

South American SUBBASIN

Map Created: Sept 2020



South American Subbasin GSP

Wells with Monitoring Data Provided by Aerojet Rocketdyne

Figure 2.3-4

Legend

South American Subbasin
Aerojet Rocketdyne Provided Monitoring Well

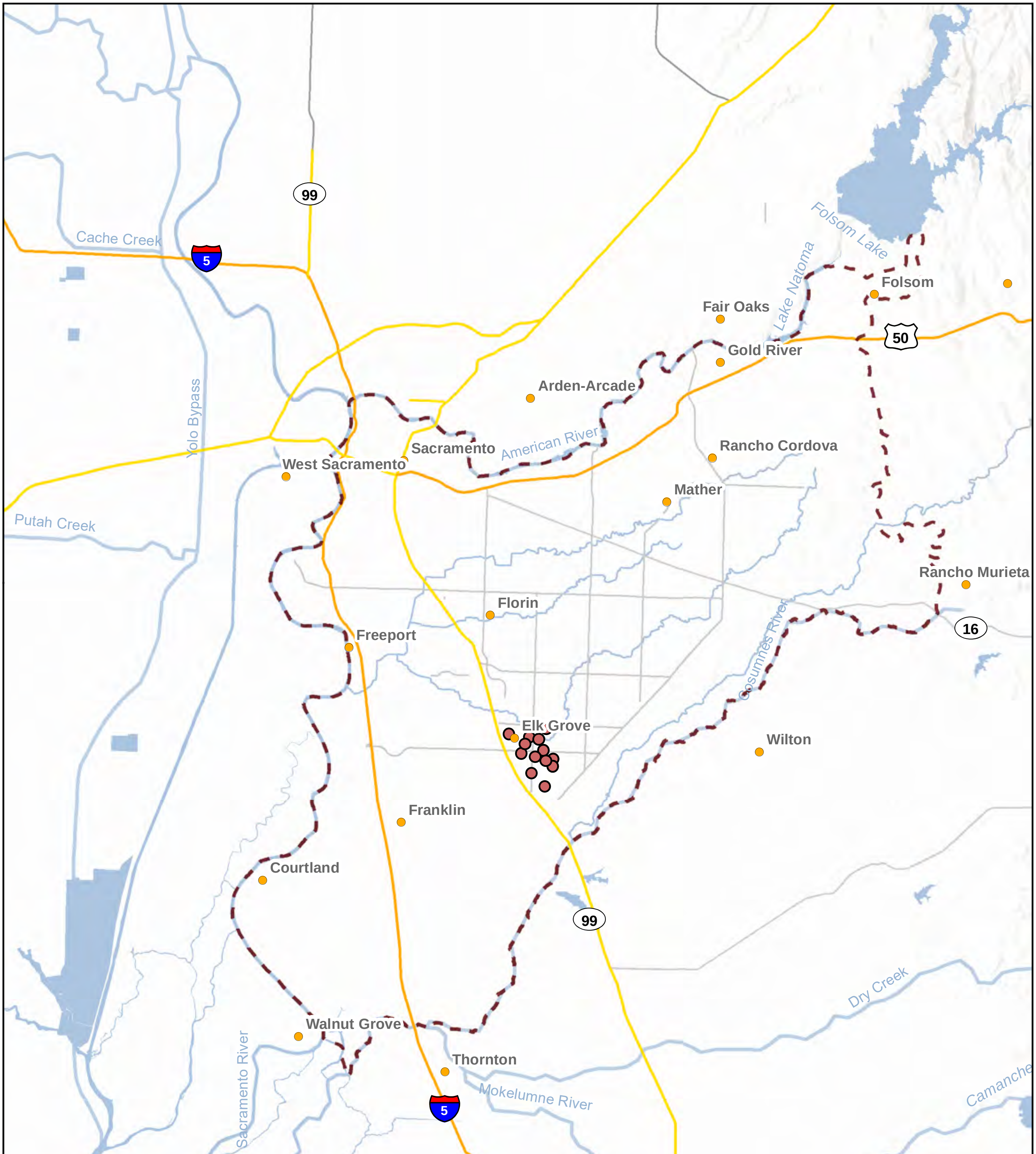
0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: December 2020

Figure Exported: 1/4/2021 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\Aerojet Wells.mxd



South American Subbasin GSP

Wells with Monitoring Data Provided by EGWD

Figure 2.3-5

Legend

- South American Subbasin
- EGWD Monitoring Wells

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: December 2020

Figure 2.3-2 shows the locations of active monitoring well data received from the USGS database. Some of these wells are duplicative of wells contained in the DWR database. All active monitoring wells from the USGS were monitored at least once since 2018. The majority of the USGS wells are located on the western portion of the Subbasin, west of Highway 99. A small number of monitoring wells are located in the central portion of the Subbasin between Florin and Mather. Many of the wells in the USGS database have been typically measured twice a year, with one measurement in the spring and one measurement in the fall.

Figure 2.3-3 shows the locations of well data received from UCD and TNC. All of the wells provided by UCD and TNC were monitored in 2018 - 2020. The wells monitored by UCD and TNC include those that are located along the Cosumnes River in the southern and central portions of the Subbasin where measurement data are collected and recorded continuously by pressure transducers and data loggers.

Figure 2.3-4 shows the locations of well data received from Aerojet Rocketdyne. All of the wells from Aerojet Rocketdyne were monitored in 2018-2020 and are located in the northeastern portion of the Subbasin between Rancho Cordova and Folsom. Data collected in many of these wells are typically measured twice a year with one measurement in the spring and one measurement in the fall. However, some wells are measured (or have historically been measured) on a quarterly basis.

Figure 2.3-5 shows the locations of well data received from Elk Grove Water District (EGWD), which are monitored on a quarterly basis, and most have data from 2012 to 2020. These wells are located in the south-central part of the Subbasin. The wells are generally screened at one of two different depth intervals, which provides useful data in understanding variability of groundwater levels with depth.

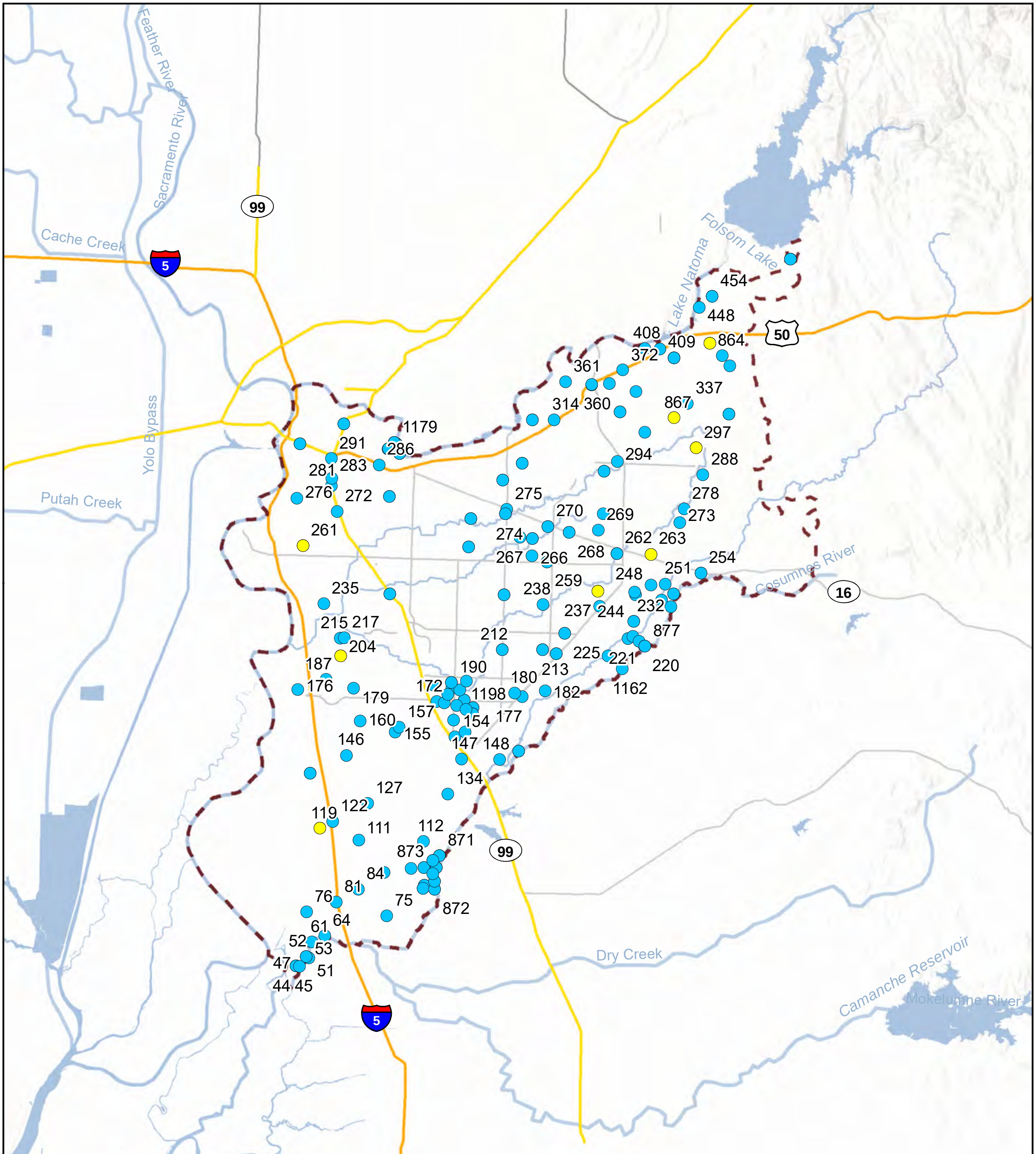
Groundwater Hydrographs

Groundwater hydrographs, i.e., charts of groundwater levels over time at a particular well or set of wells, were developed to identify groundwater trends throughout the Subbasin. Measurements from each well with historical monitoring data were compiled into one hydrograph for each well. Hydrographs for all wells, showing data from 1970 to 2020, are presented in **Appendix 2-C**. Hydrographs for selected wells are provided below.

Figure 2.3-6 shows the location of wells with measured groundwater levels since 2018 within the Subbasin. **Figure 2.3-7** to **Figure 2.3-14** show hydrographs of groundwater levels from 1970 to 2020 in selected wells. These wells were selected because they broadly represent Subbasin conditions in their areas. **Table 2.3-1** provides details of the general location of the wells, depth of the wells, and the associated aquifer zone.

Table 2.3-1: Selected Wells Providing Representative Data Across the Basin

General Area	Well Number	Well Depth (feet)	Zone of the Principal Aquifer
Western Basin	119	125	Upper
	204	170	Upper
	261	172	Upper
Eastern Basin	297	675	Lower
	244	340	Lower
	263	130	Upper
	864	Unknown	Unknown
	867	Unknown	Unknown



South American Subbasin GSP

Wells with GWLs Since 2018

Figure 2.3-6

Legend

- South American Subbasin
- Wells with GWLs since 2018
- Example Wells

Note: Numbers next to each well correspond to the Well ID used in this GSP.

South American SUBBASIN

Map Created: Sept 2020

Figure Exported: 10/5/2021 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\Wells with Hydrographs 20200908.mxd

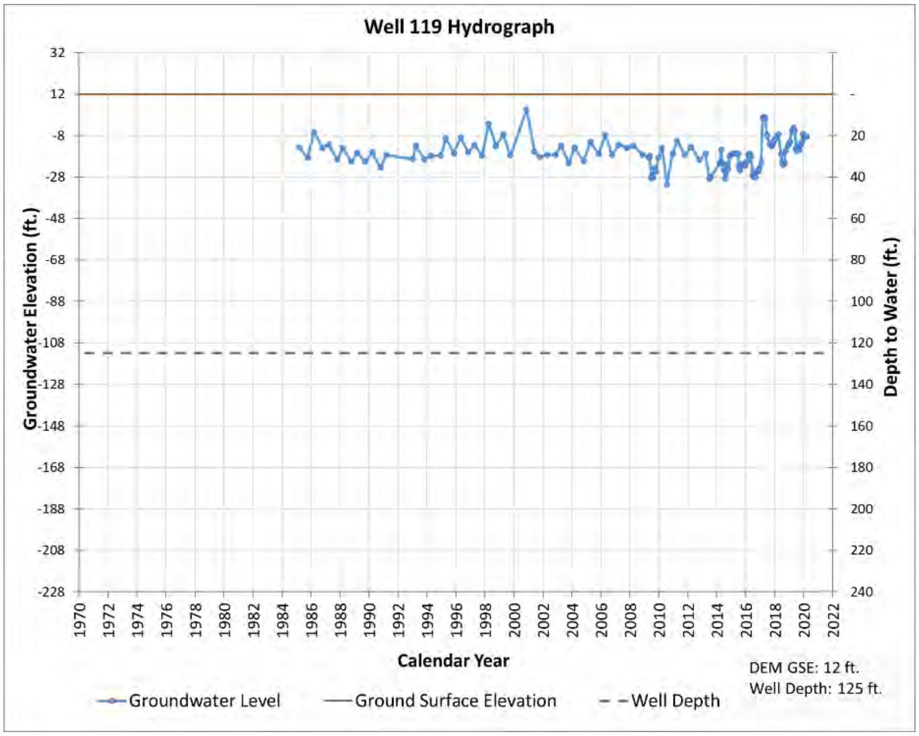


Figure 2.3-7: Well 119 Hydrograph

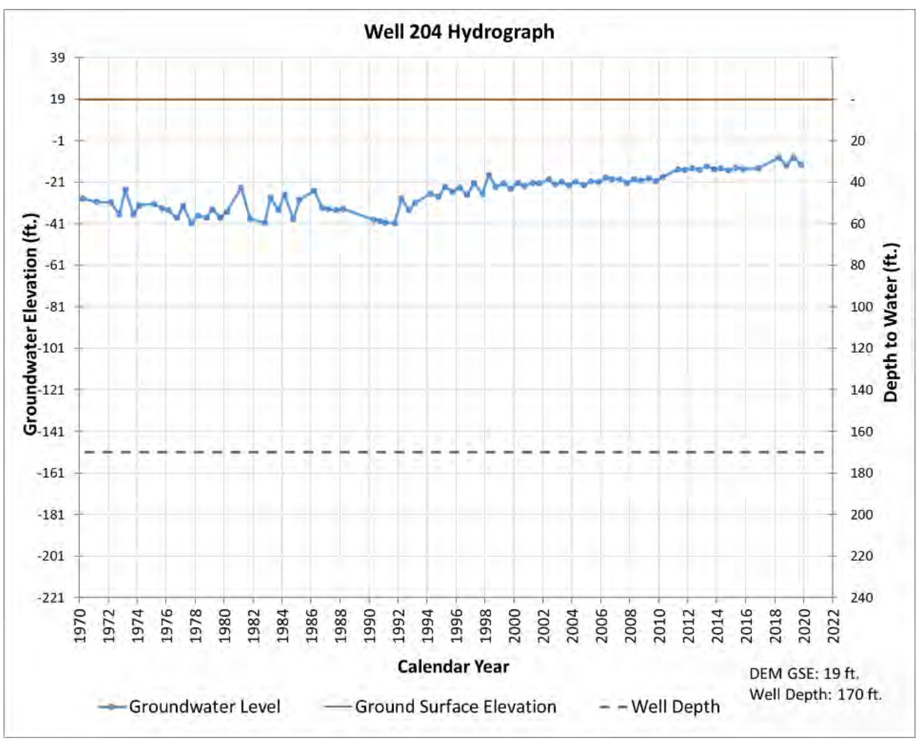


Figure 2.3-8: Well 204 Hydrograph

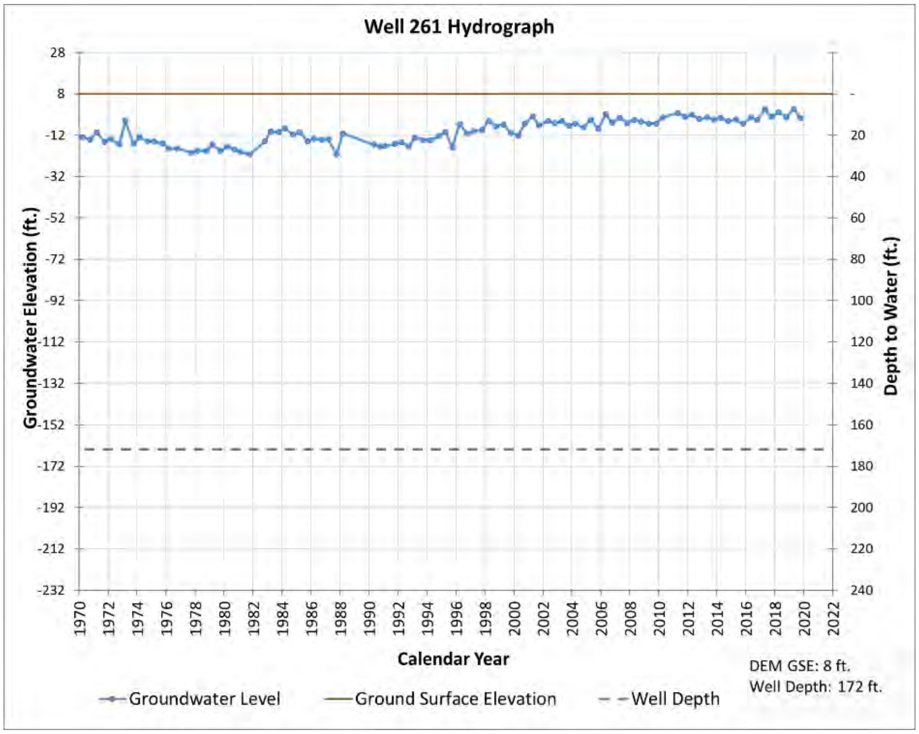


Figure 2.3-9: Well 261 Hydrograph

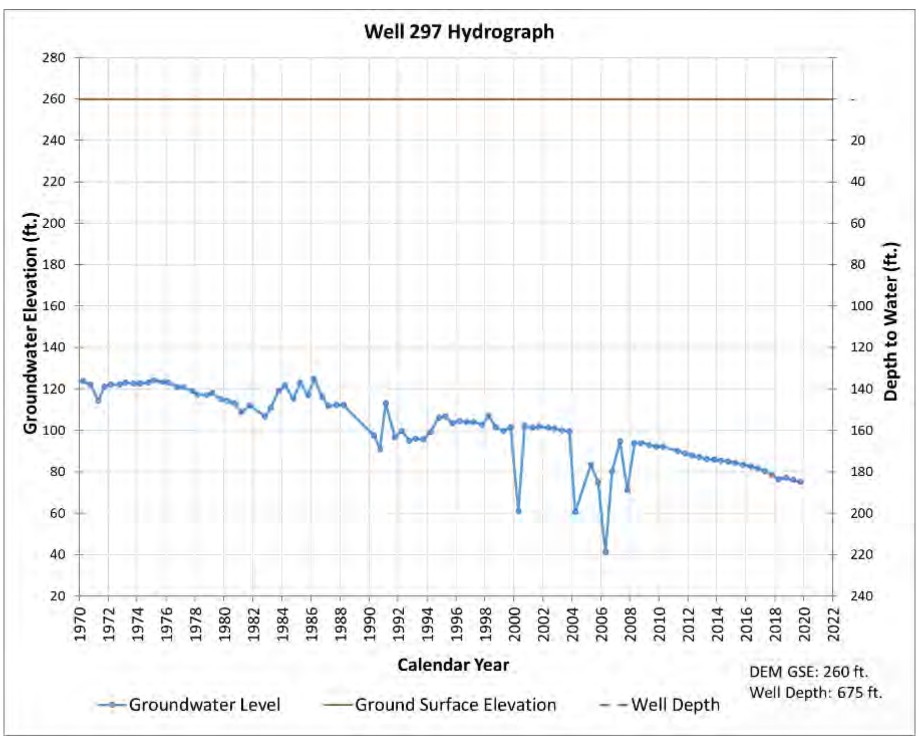


Figure 2.3-10: Well 297 Hydrograph

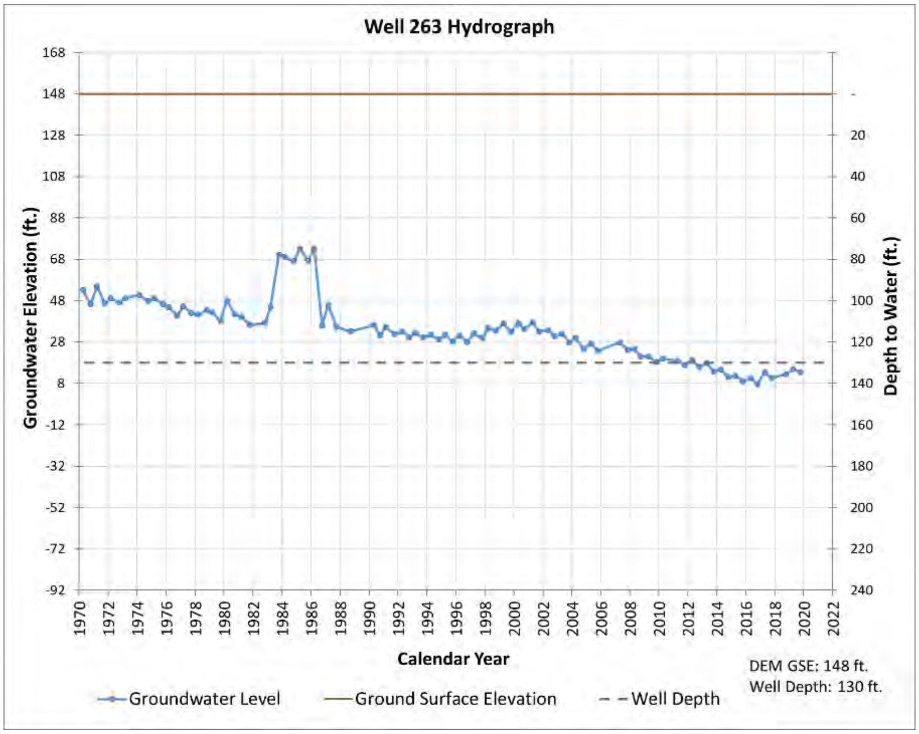


Figure 2.3-11: Well 263 Hydrograph

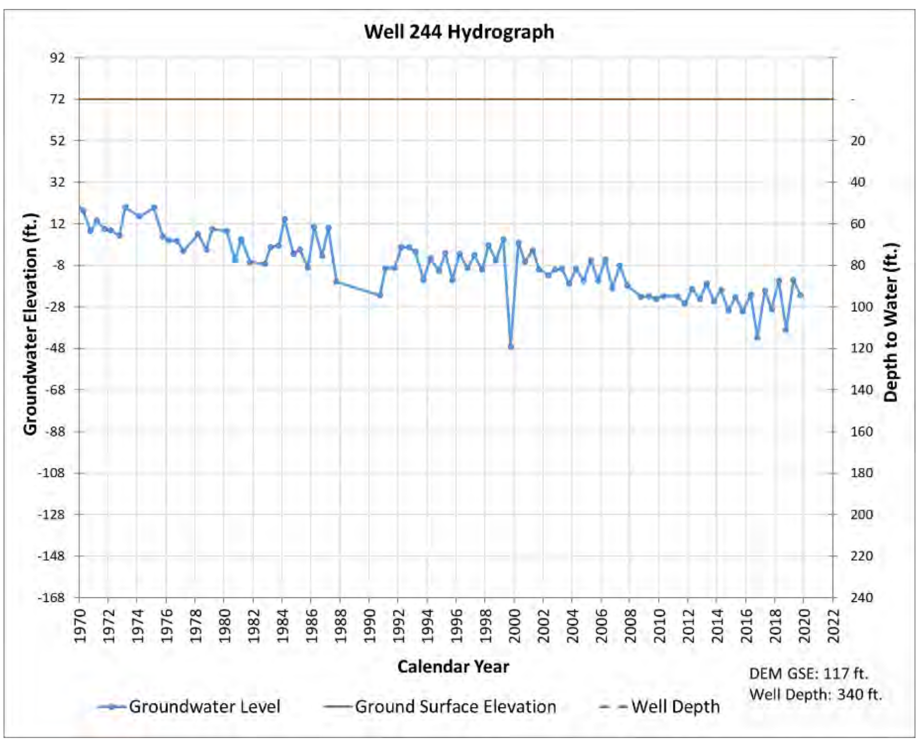


Figure 2.3-12: Well 244 Hydrograph

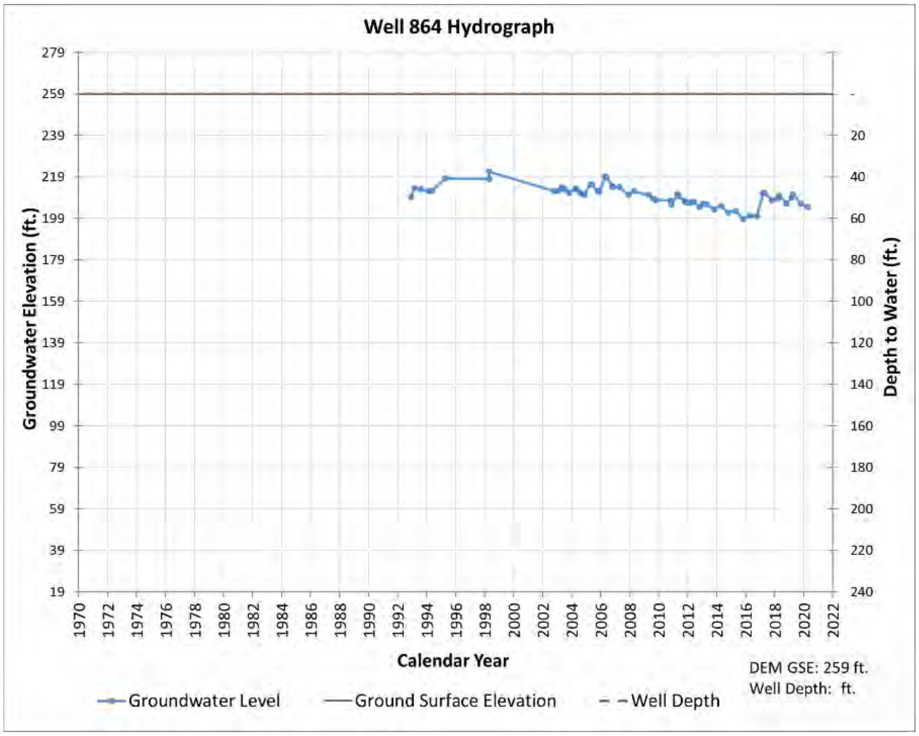


Figure 2.3-13: Well 864 Hydrograph

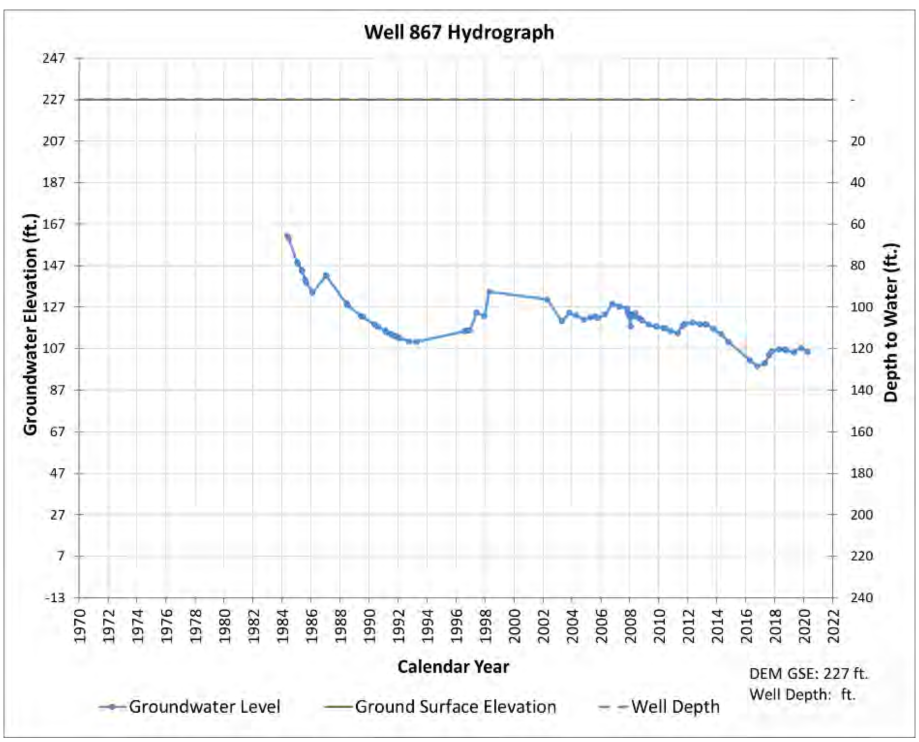


Figure 2.3-14: Well 867 Hydrograph

As previously described, changes in historical groundwater conditions have been influenced by climactic patterns in the Subbasin. Historical precipitation has been highly variable, with several relatively wet years and some multi-year droughts. In addition, groundwater pumping has varied significantly over the historical period as water demands and the availability of surface water have changed from year to year. These variations in water supply and water use over time have resulted in increasing and decreasing groundwater levels in the Subbasin at different points during the historical period between 1970 and 2020.

In general, across the Subbasin, groundwater levels decreased during the 1970s, which included the severe drought of 1977-1978, but then recovered during the wet period in the early 1980s, only to decrease again during the 1987-1992 drought. Overall, in the 1980s, groundwater levels were generally stable. Groundwater levels increased in the wet late 1990s, with the trend continuing into the variable 2000s and a wet start to the 2010s. Much of this recovery can be attributed to the increased use of surface water and implementation of urban demand management measures (i.e., conversion from flat rate to metered billing, education, and enforcement) in the SASb, and the fallowing of previously irrigated agricultural lands that transitioned into new urban development areas.

Note that historical monitoring in the Subbasin was more focused at shallower depths normally accessed by agricultural and private domestic users, with less monitoring at deeper depths often accessed for urban uses. Thus, improvements noted at shallower depths attributed to agricultural-to-urban conversion may be missing changes in less monitored deeper semi-confined zones of the aquifer. More information on this issue is presented in the data gap section.

Groundwater conditions also vary across different parts of the Subbasin. For example, many of the rivers and streams that flow along the boundaries or within the Subbasin are sources of groundwater recharge. Other zones are utilized for pumping for both domestic and agricultural uses, while some areas of the Subbasin have contamination plumes that require constant remediation pumping.

Wells in the western portion of the Subbasin show an overall increase in groundwater levels since 1970 to present. **Figure 2.3-7** to **Figure 2.3-9** shows hydrographs of Wells 119, 204 and 261 in the western portion of the Subbasin near Interstate 5. Groundwater levels in these wells generally declined from 1970 to 1982 by approximately 10 feet, recovered approximately 10 feet during the wet period from 1982 to 1986, and then declined during the drought period from 1987 to 1992 by approximately 5 – 10 feet. All three wells have shown an increase in groundwater levels since then, with levels increasing by 20 – 25 feet in Wells 261 and 204 during this period.

Declining trends are seen in the eastern portions of the Subbasin. Wells 297, 263, and 244 (**Figure 2.3-10** to **Figure 2.3-12**) are located generally along Laguna Creek from near Douglas Road to just south of Jackson Highway and show a relatively steady decline in groundwater levels of 40 feet over the 1970-2020 period. Wells 864 and 867 (**Figure 2.3-13** and **Figure 2.3-14**), located generally south of Folsom, also show recent declines in groundwater levels, with a 10 -foot decline since the 1990s at Well 864 and a 40-foot decline since the 1980s at Well 867, with the bulk of the decline between 1984 and 1993. The causes of these declines are not well understood but could be attributed to remediation activities at Mather Field, the

Aerojet Superfund Site, and the Inactive Rancho Cordova Test Site together with an aquifer that becomes thin and low-yielding in this area.

Vertical Gradients

As discussed in **Section 2.2**, the SASb has one principal aquifer composed primarily of post-Eocene sedimentary deposits. However, the principal aquifer is divided into upper and lower zones. The upper zone is contained in Pleistocene to Quaternary-age sediments including the Modesto, Riverbank, and Laguna Formations, South Fork Gravels and Arroyo Seco Gravels. The lower zone is contained in Miocene to Pliocene-age volcanic sediments including the Mehrten Formation and portions of the underlying Valley Springs and Ione Formations (DWR, 1974). These zones are partially separated by a discontinuous clay layer in the upper portion of the Mehrten Formation that can act as a semi-confining layer for the lower zone (SCGA, 2012). These two zones of the principal aquifer are important for determining vertical gradients.

A vertical gradient describes the vertical flow direction of groundwater perpendicular to the ground surface and is typically measured by comparing the elevations of groundwater in a well with multiple completions that are of different depths. If groundwater elevations in the shallower completions are higher than in the deeper completions, the gradient is identified as downward. If groundwater elevations in the shallower completions are lower than in the deeper completions, the gradient is identified as upward. If groundwater elevations are equal in both completions, a vertical gradient is not present. Note that a vertical gradient only indicates a potential for vertical groundwater flow. If a confining layer is present, flow will not occur between the zones.

Two types of wells can provide data to assess vertical gradients: multi-completion wells (also known as nested wells), and clustered wells. Multi-completion wells are constructed in the same borehole and contain multiple casings (typically two to four) with perforations at different depths that are isolated from each other by cement grout or by a bentonite layer. Clustered wells are typically two or more individual wells with perforations at different depths that are located close to one another.

In addition, the potentiometric map of two zones (shallow and deep) can be used to evaluate vertical gradients even if different wells (minimum 3 well per zone) were used to define the contours of the groundwater elevation.

Data on multiple completion monitoring wells are typically not readily available as they have generally been installed to support groundwater remediation efforts or to support operations of municipal water agencies. In both these cases, groundwater level data are generally not available on DWR's Water Data Library or other readily available datasets, although data may be available through various reports. Within the northeastern portion of the SASb, hundreds of multiple completion wells are thought to be present at the Aerojet, IRCTS, and Mather remediation sites. Further, SCWA is thought to maintain several multiple completion wells near its facilities. As the contaminated areas are of less interest to the regional potable water supply and as the SCWA data was not available at the time of writing, two multiple completion wells with recent available measurement data, shown in **Figure 2.3-15**, were analyzed for vertical gradients. These wells are located in the central or eastern portion of the Subbasin.

Figure 2.3-16 shows the combined hydrograph for the multi-completion wells designated as Wells 858 through 861, which were installed by Aerojet. Well 858 through 861 are four completions in a single borehole, each at different depths as follows:

- Well 858 is the shallowest completion with a screened interval from 67 to 72 feet bgs.
- Well 859 is the second deepest completion with a screened interval from 88 to 98 feet bgs.
- Well 860 is the third deepest completion with a screened interval from 124 to 134 feet bgs.
- Well 861 is the deepest completion with a screened interval from 155 to 165 feet bgs.

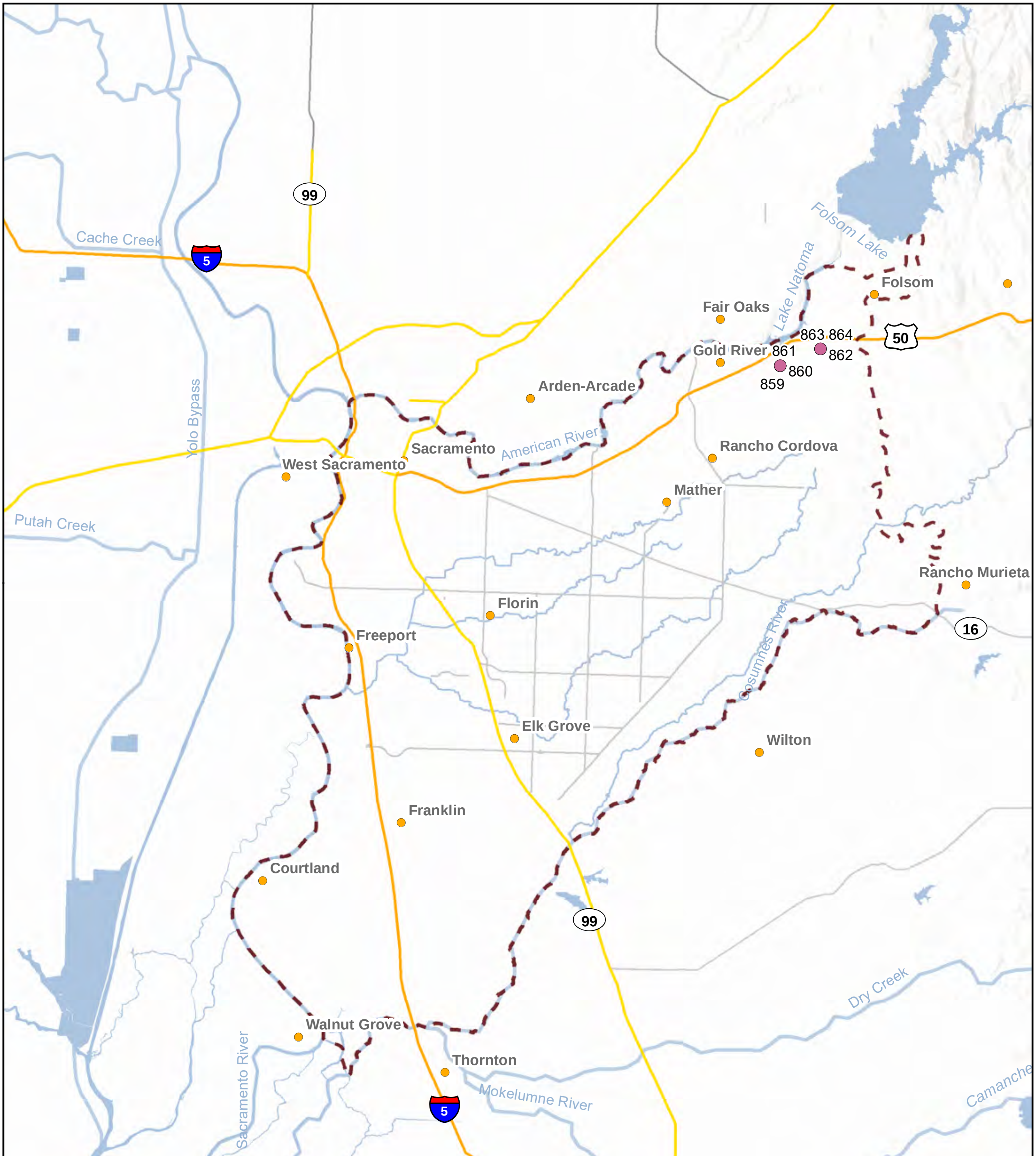
The hydrographs of the four completions show that groundwater elevations in the deepest completion are higher than those in the three shallower completions in the winter and spring, indicating a consistent, slight upward gradient from a depth of at least 155 to 165 feet bgs at this location.

Figure 2.3-17 shows the combined hydrograph for the multiple completion designated as Well 862 through 864, which were also installed by Aerojet. Wells 862 through 864 are three completions in a single borehole, each at different depths as follows:

- Well 862 is the shallowest completion with a screened interval from 43 to 64 feet bgs.
- Well 863 is the second deepest completion with a screened interval from 94 to 104 feet bgs.
- Well 864 is the deepest completion with a screened interval from 128 to 138 feet bgs.

The hydrographs of the three completions shows that groundwater elevations are nearly the same at each completion, thus not showing any significant vertical gradient at depths above 138 feet bgs at this location.

Figure 2.3-19 shows the combined hydrograph for all the wells for which data was provided by EGWD. As shown in **Figure 2.3-5**, these wells are located close to each other in the vicinity of Elk Grove. Four wells (1185, 1191, 1192 and 1197) have depths between 400 and 600 feet and three wells (1187, 1195 and 1198) have depths between 1,000 and 1,200 feet. The groundwater elevations in the four shallower wells range from -20 feet to -40 feet, while the groundwater elevations in the deeper wells range from about -60 feet to -80 feet. An additional deeper well (1184) has perforations in both the upper and lower aquifer zones and therefore shows groundwater level depths in between the other groups of wells. These data suggest a downward gradient in the Elk Grove area, likely driven by newer urban production wells screened in the deeper aquifer. The preference for deeper screening is partially due to a desire to avoid conflicts with private domestic and agricultural wells, which are typically screened at shallower depths.



South American Subbasin GSP

Mutiple Completion Wells

Figure 2.3-15

Legend

South American Subbasin

Multiple Completion Well

0 1.25 2.5 5 Miles

N

WOODARD & CURRAN

Project #: 0011575.00
Map Created: October 2021

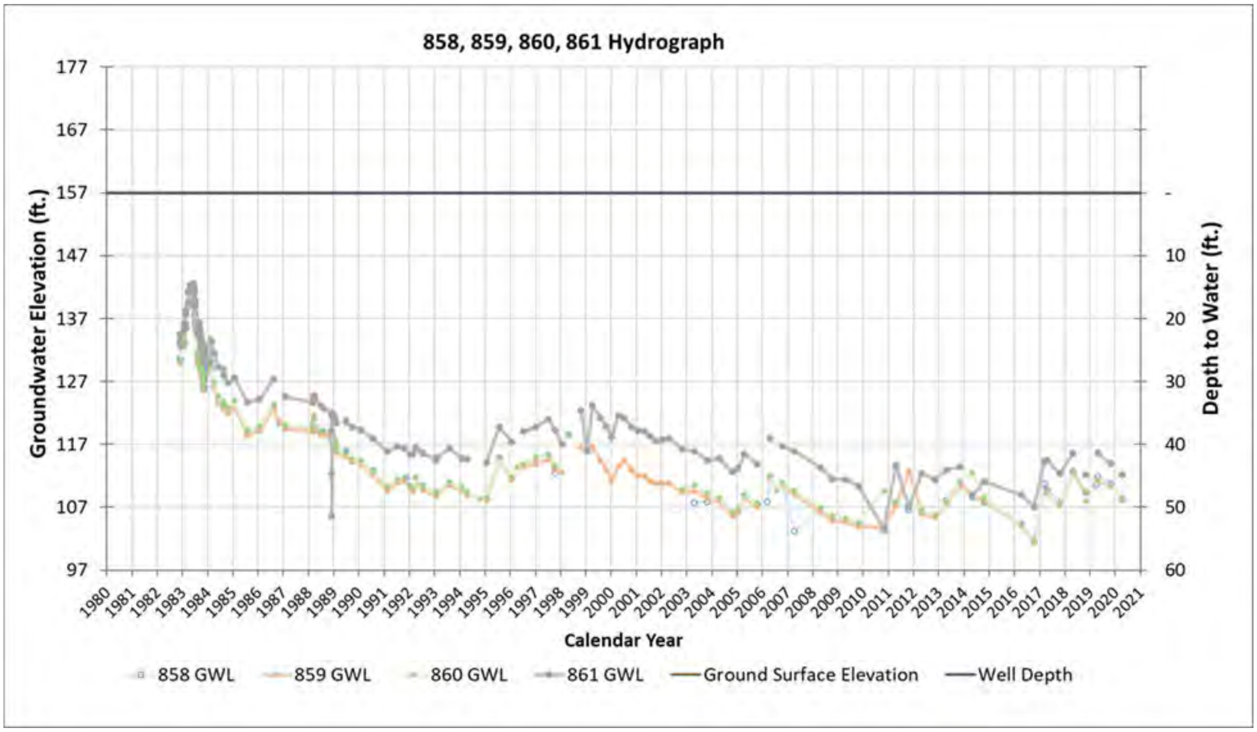


Figure 2.3-16: Wells 858, 859, 860 and 861 Hydrograph

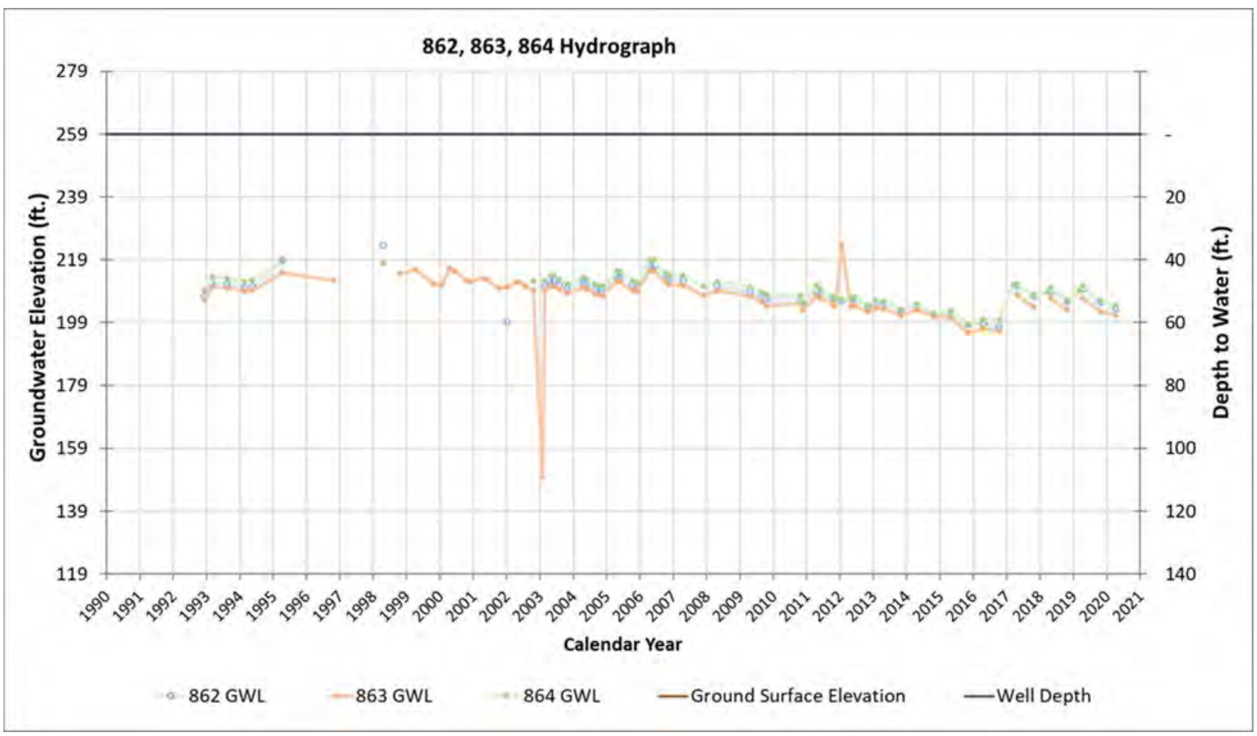


Figure 2.3-17: Wells 862, 863 and 864 Hydrograph

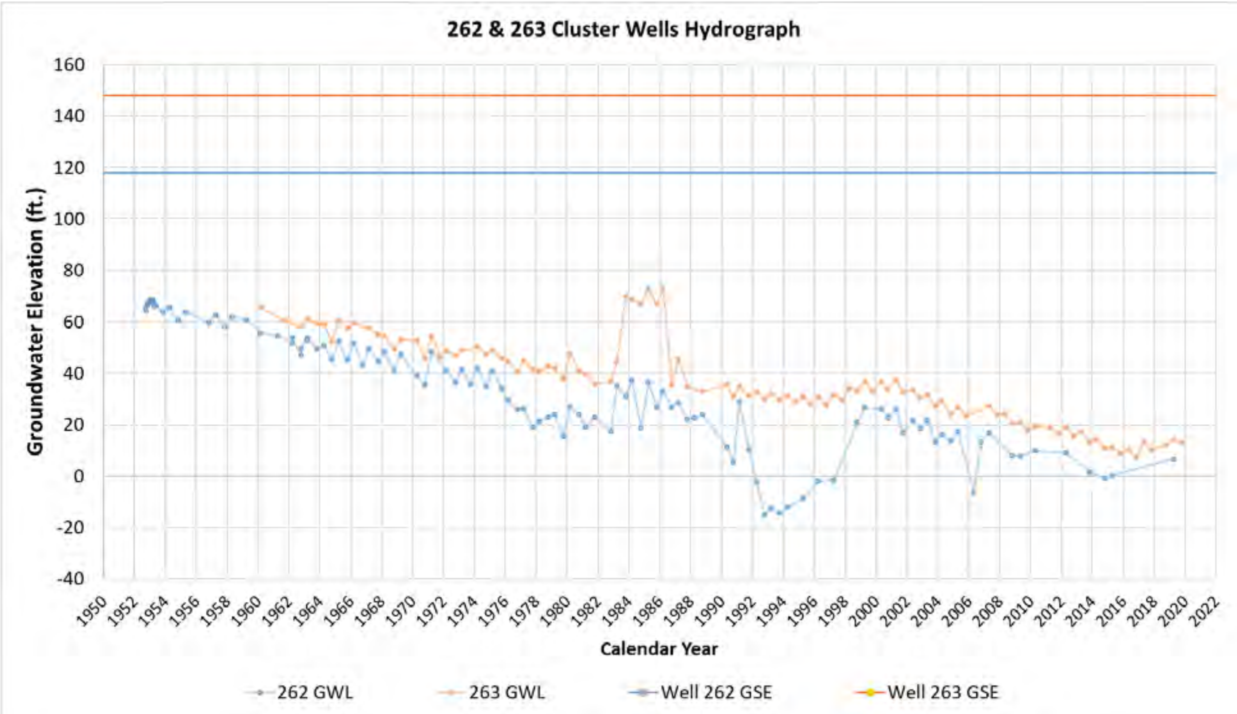


Figure 2.3-18: EGWD Cluster Wells Hydrograph

Groundwater Contour Maps

Groundwater contour maps are presented to provide information on groundwater elevations across the Subbasin. A contour map shows this information by interpolating groundwater data between monitoring sites and plotting a contour line at locations of equal elevation. The These elevation contours are then used to identify groundwater flow directions and to calculate the gradient of horizontal flow.

Groundwater elevation contour maps are shown for the following time periods:

- Fall 1977 Critically dry water year (WY)
- Fall 1986 Wet WY
- Fall 2005 Wet WY
- Fall 2015 Critically dry WY
- Spring 2019 Wet WY
- Fall 2019 Wet WY

These periods were selected for contours because they are representative of recent and historical conditions, and because they identify conditions near January 1, 2015, when SGMA came into effect.

In addition, seasonal fluctuations can be seen in the spring and fall maps for 2019, and depth to water contours are also provided for 2019.

These contours follow the same general format: 20-foot interval contour elevations shown with white numeric labels, and measurements at individual monitoring points shown with black numeric labels. The groundwater contours were also developed with a limited amount of available data so wells with various completions and depths within the principal aquifer were used to accumulate enough data points.

Note that available data differs between the contour maps and some variability between the maps can be attributed to these differences, while other components are due to actual changes in the groundwater system. Each map shows the wells with data used in the contouring for each map.

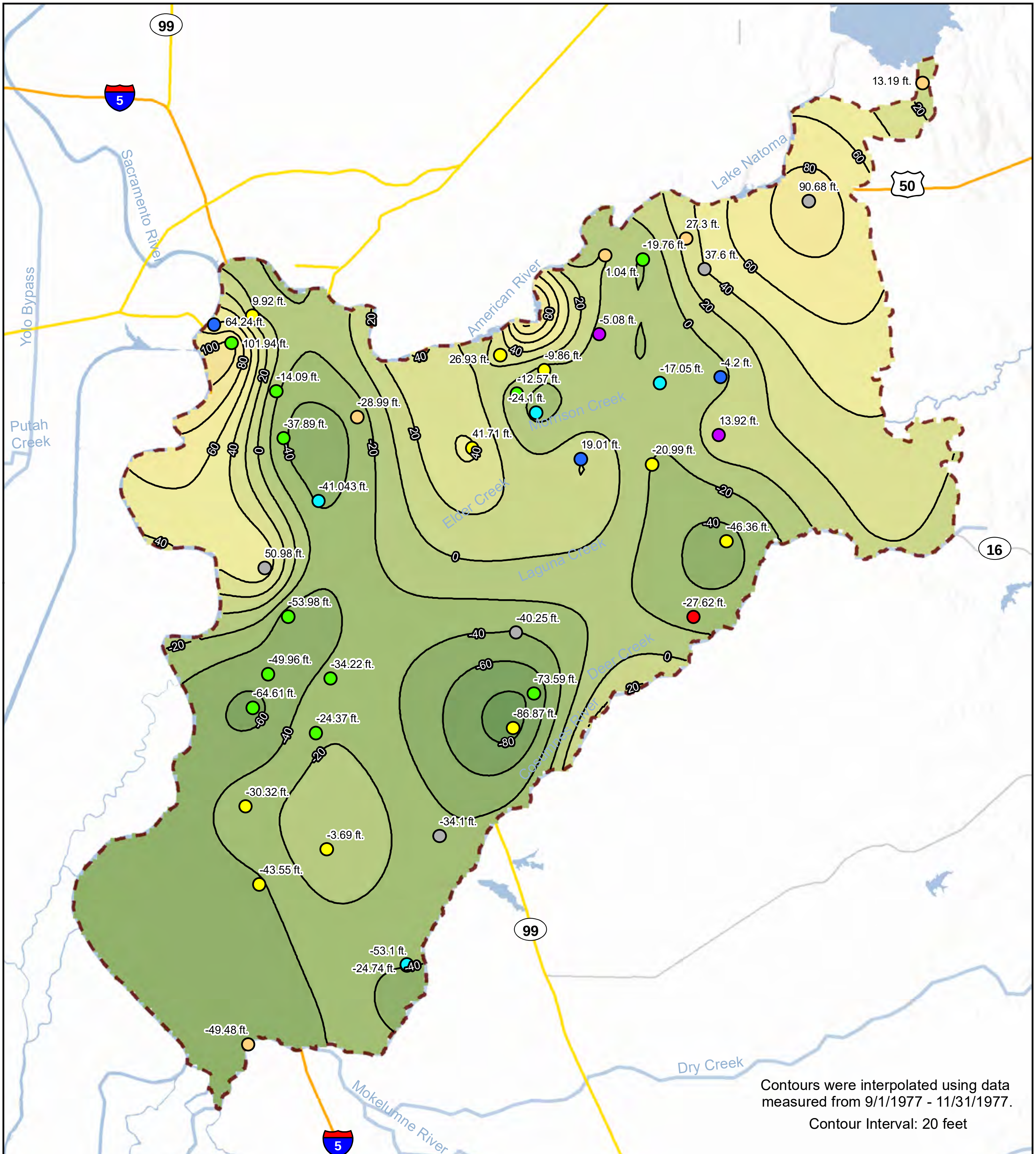
Figure 2.3-19 shows groundwater elevation contours for Fall 1977, which represents conditions at the end of one of the worst droughts recorded in California's history. The index (0.84) for WY 1977 is the second lowest in the 120-year WY record. The groundwater flow direction in the Subbasin was generally westward from the eastern edge of the SASb toward the center of the SASb and from the west towards the center of the Subbasin. Several groundwater depressions were present in the central portion of the Subbasin. The deepest depression is located near Elk Grove, east of Highway 99, with groundwater levels as low as 87 feet below sea level. Groundwater generally flowed radially toward this groundwater depression.

Figure 2.3-20 shows groundwater elevation contours for Fall 1986, which occurred at the end of an extended wet period which provided recharge to the Subbasin. While the flow directions are similar, the Elk Grove groundwater depression shifted location to the west side of Highway 99 and the elevation rose 17 feet to about 70 feet below sea level. Groundwater continued to flow radially toward the groundwater depression.

Figure 2.3-21 shows groundwater elevation contours for Fall 2005. Similar to 1977 and 1986, groundwater flow in the Subbasin was generally westward from the eastern margin of the subbasin and from the wester margin toward the groundwater depression at Elk Grove. The location of the depression shifted eastward to straddle Highway 99 and the lowest elevation rose to 55 feet below sea level. The groundwater depression is defined by the -40-foot contour which is located within a trough of low groundwater elevations (less than -20 feet) that traverses the subbasin north to south. As is consistent with a depression, groundwater generally flowed radially toward the depression.

Figure 2.3-22 shows groundwater elevation contours for Fall 2015 at the peak of the recent drought. The WY index (0.81) for 2015 is the lowest on record. Again, the groundwater flow directions were generally from the eastern and western margins toward the Elk Grove groundwater depression. Horizontal gradients were steepest along the eastern margin and shallowest in the western portion of the Subbasin on the Sacramento Valley floor. The Elk Grove groundwater depression (-40-foot contour) has migrated to the west side of Highway 50 and is somewhat smaller with the lowest elevation at 43 feet below sea level. However, the -20-foot contour encompasses a much larger area that encroaches into the adjacent Cosumnes Subbasin to the south. Groundwater generally flowed radially toward the center of the depression, albeit with a lower gradient due to the smaller depression.

Note that the indicated reduction in this pumping depression may be impacted by a monitoring network that has more shallow wells than deep wells, and observed benefits accruing in the shallow zone may not necessarily be accruing in the deeper zone. The focused monitoring in the shallow zone is due to its importance for many users in the Subbasin, which led to a high



South American Subbasin GSP

Fall 1977 Groundwater Level Contours

Figure 2.3-19

Legend

- South American Subbasin
- Groundwater Elevation Contours

Well Depth (feet)

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

NOTE: Numbers next to each well indicate the groundwater elevation during the measurement period. The color of each well point corresponds to the depth of the well completion.

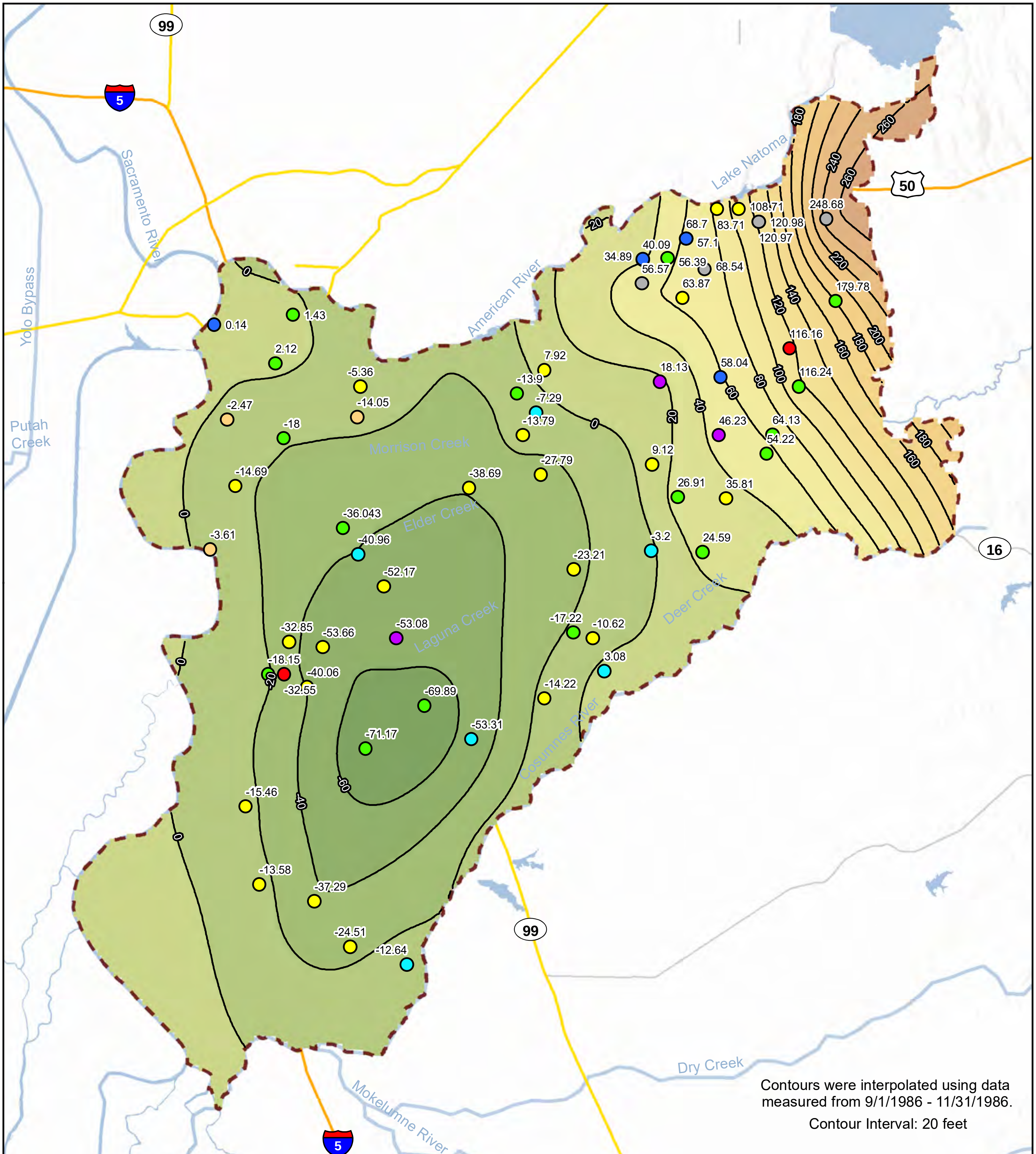
0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020

Figure Exported: 1/4/2021 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\Fall 1977 Contouring - GWE.mxd



South American Subbasin GSP

Fall 1986 Groundwater Level Contours

Figure 2.3-20

Legend

- South American Subbasin
- Groundwater Elevation Contours

Well Depth (feet)

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

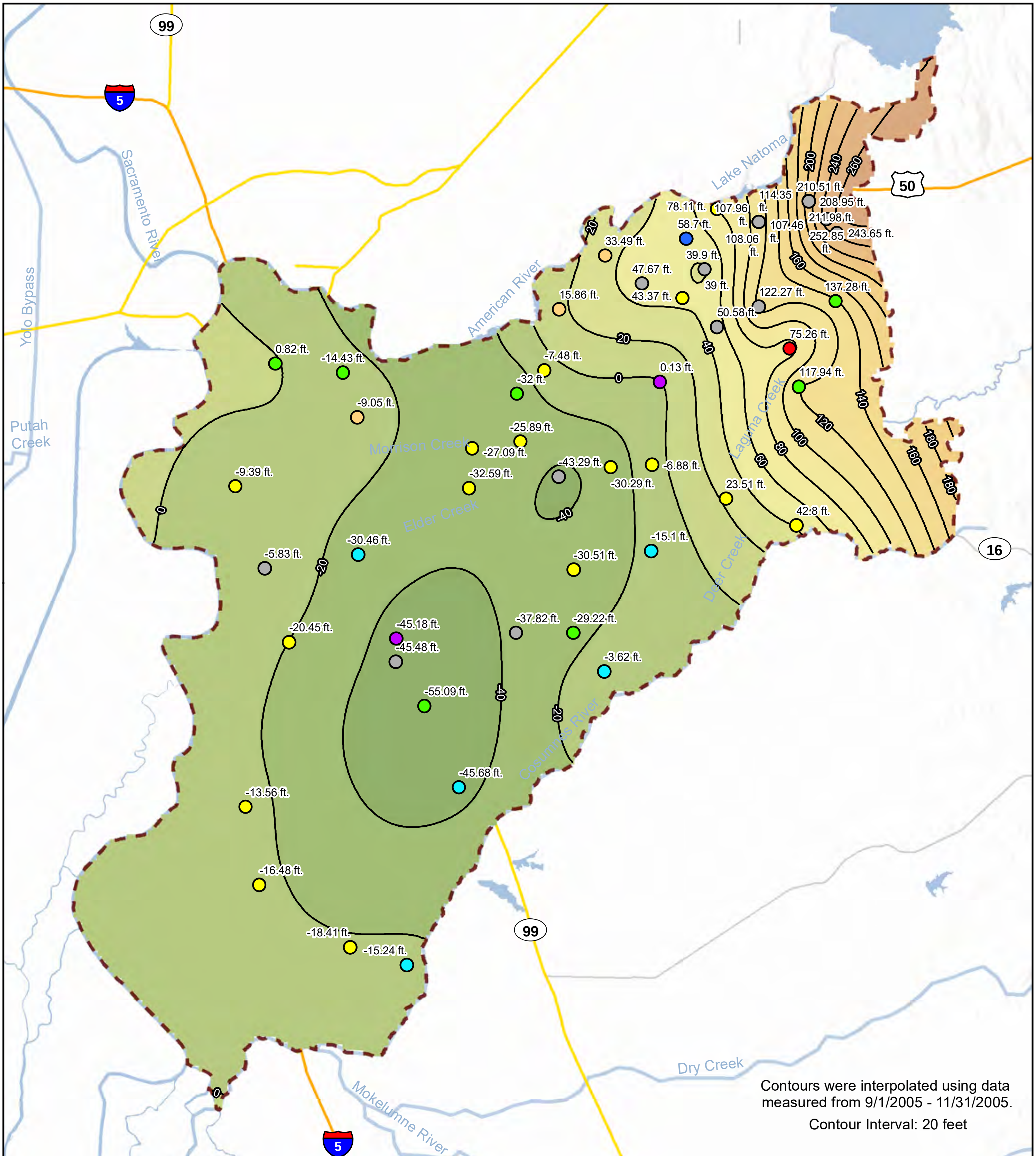
NOTE: Numbers next to each well indicate the groundwater elevation during the measurement period. The color of each well point corresponds to the depth of the well completion.

0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020



South American Subbasin GSP

Fall 2005 Groundwater Level Contours

Figure 2.3-21

Legend

- South American Subbasin
- Groundwater Elevation Contours

Well Depth (feet)

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

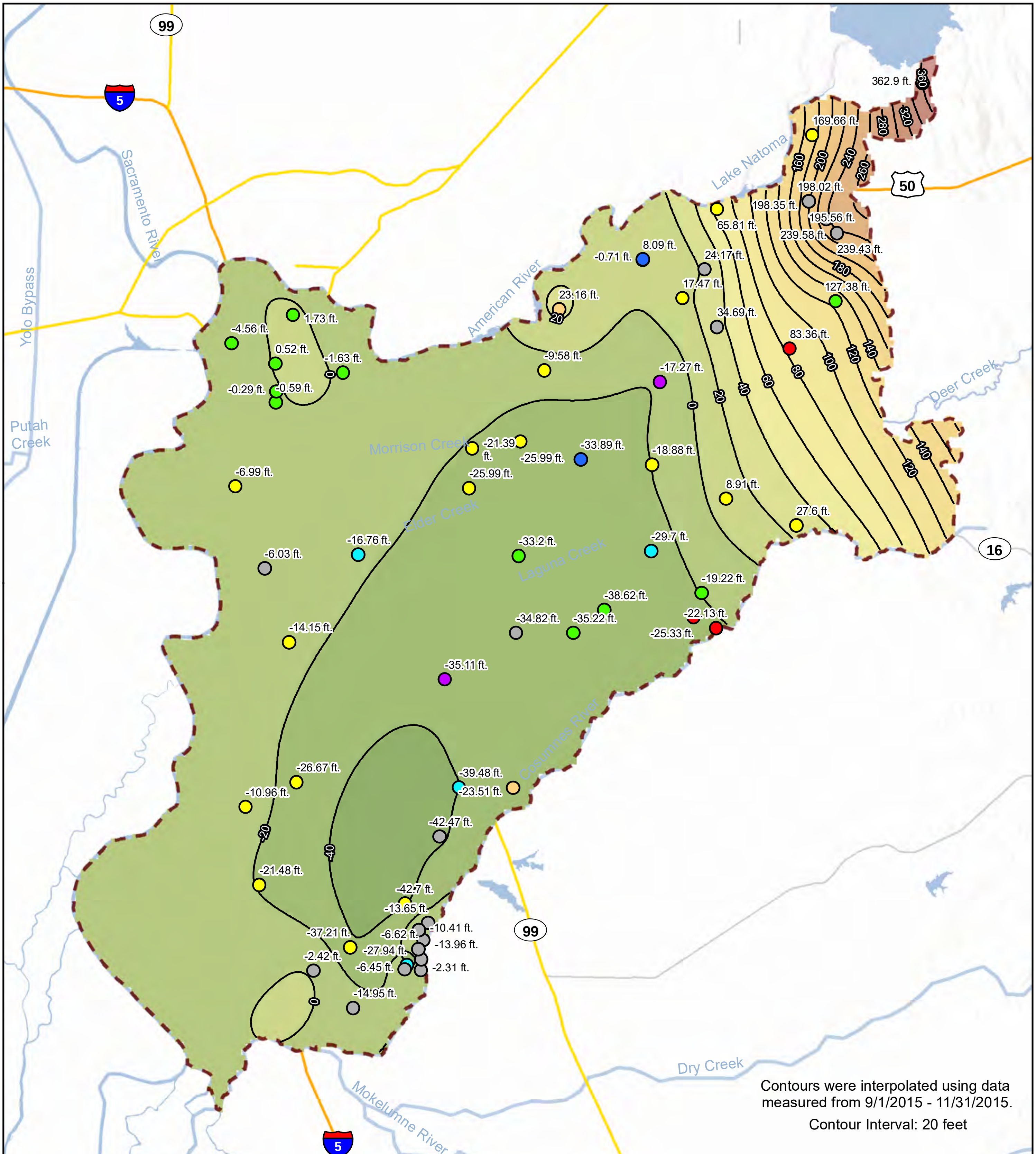
NOTE: Numbers next to each well indicate the depth to water during the measurement period. The color of each well point corresponds to the depth of the well completion.

0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020



South American Subbasin GSP

Fall 2015 Groundwater Level Contours

Figure 2.3-22

Legend

- South American Subbasin
- Groundwater Elevation Contours

Well Depth (feet)

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

NOTE: Numbers next to each well indicate the depth to water during the measurement period. The color of each well point corresponds to the depth of the well completion.

0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020

priority for monitoring and management. Beginning in the early 1990s, municipal water purveyors started drilling more costly deep wells, requiring treatment of iron and manganese to protect the shallow aquifer and causing a downward vertical gradient that kept these same constituents and salts from upwelling into the shallow aquifer. Consideration of deeper monitoring is discussed in the data gaps section.

Contours were developed for both Fall and Spring 2019 to allow for a comparison of seasonal trends within the SASb over the most recent period for which sufficient data was available. Seasonal groundwater contour maps for both elevation and depth to water for Spring 2019 and Fall 2019 are provided in **Figure 2.3-23** through **Figure 2.3-26**.

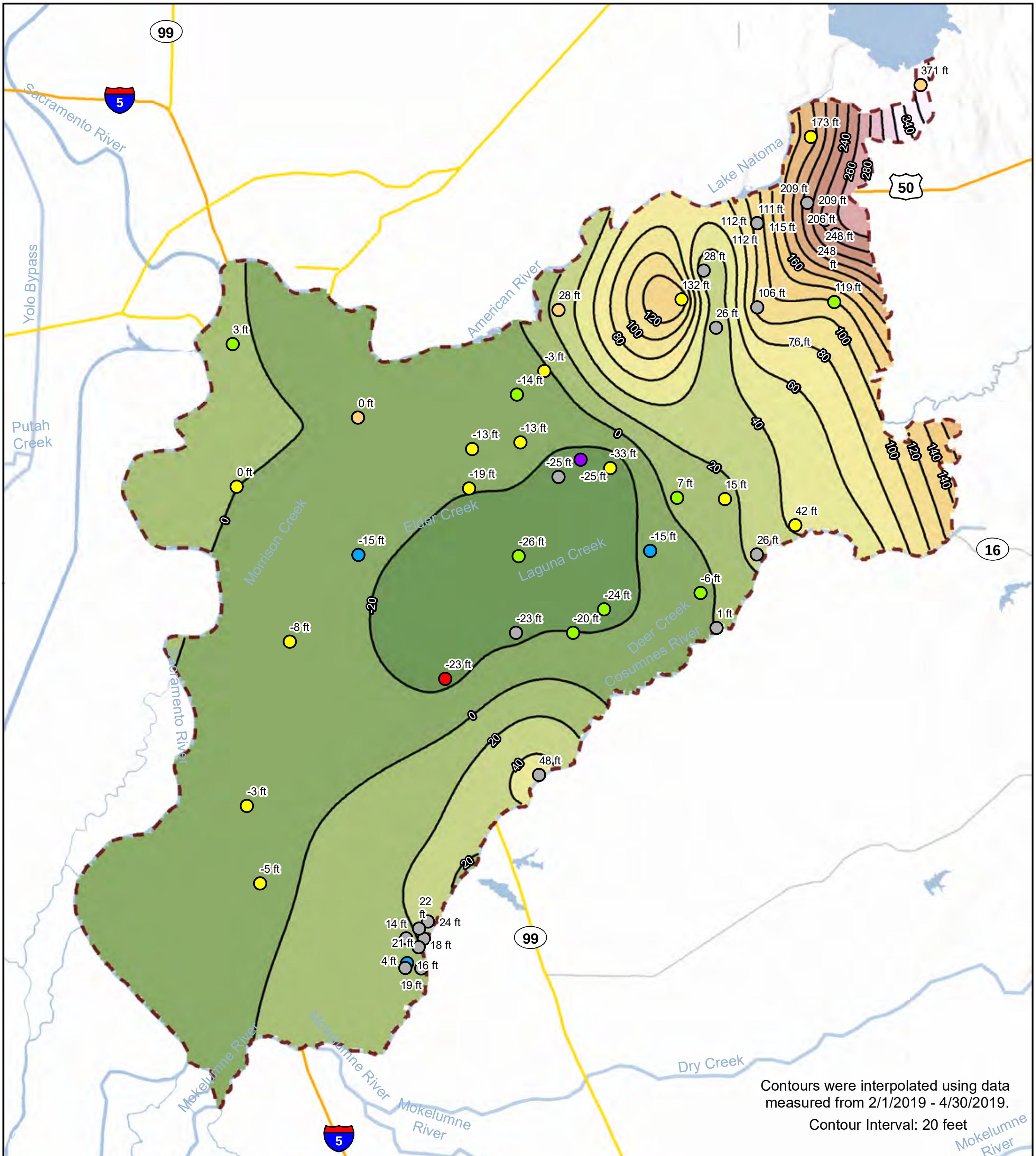
Data included to develop these contours were from April through May for Spring 2019, and September through November for Fall 2019. If multiple measurements for a well were available during this time, the measurement closest to the middle of the season (mid-April for Spring and mid-October for Fall) were used.

Figure 2.3-23 shows groundwater elevation contours for Spring 2019. Similar to previous periods, groundwater flow in the Subbasin was generally westward from the eastern margin of the subbasin and eastward from the western margin toward the groundwater depression northeast of Elk Grove. Horizontal gradients were steepest in the eastern portion of the Subbasin and shallowest in the western portion on the Sacramento Valley floor. Groundwater in the northwest corner appeared to flow toward the adjacent North American Subbasin. A groundwater high was present along the Cosumnes River and creates a shallow gradient in the western portion of the SASb toward the Sacramento River.

Figure 2.3-24 shows depth to water contours for spring 2019. In the western portion of the Subbasin, from the western boundary to California State University – Sacramento (CSUS), Florin, and Elk Grove, depth to water was between approximately 20 to 60 feet bgs. In the central part of the Subbasin, between Florin and Mather depth to water was between approximately 60 and 80 to 100 feet bgs. For the northeastern portion of the Subbasin near Folsom, depth to water was between approximately 20 to 60 feet bgs. Depth to water was greatest along the eastern and southeastern Subbasin boundary where groundwater could be as deep as 200 feet bgs, although data are limited in this area and the topography is more variable. In the southeastern portion of the Subbasin, depth to water near the Cosumnes River varied between 80 and 100 feet, somewhat deeper than near the American River.

Figure 2.3-25 shows groundwater elevation contours for fall 2019. As in spring, groundwater flow was generally from the eastern margin and from the western area toward the groundwater depression in the south-central area of the subbasin, northeast of Elk Grove and south of Mather. The groundwater elevation was as low as 28 feet below sea level. Horizontal gradients were steepest on the eastern side and shallowest on the western side.

Figure 2.3-26 shows depth to water contours for Fall 2019. In the western portion of the Subbasin, from the western boundary to CSUS, Florin, and Elk Grove, depth to water was between approximately 20 to 60 feet bgs. In the central part of the Subbasin between Florin and Mather, depth to water was between approximately 60 to 120 feet bgs. For the northeastern portion of the Subbasin near Folsom, depth to water was between approximately 20 to 60 feet bgs. Depth to water was greatest along the eastern and southeastern Subbasin boundary where groundwater is deeper than 180 feet bgs. Depth to water along the Cosumnes River in the eastern half of the subbasin was somewhat deeper than near the American River.



South American Subbasin GSP

Spring 2019 Groundwater Elevation

Figure 2.3-23

Legend

- South American Subbasin
- Groundwater Elevation (feet)

Well Depth below GSE

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600

NOTE: Numbers next to each well indicate the groundwater elevation during the measurement period. The color of each well point corresponds to the depth of the well completion.

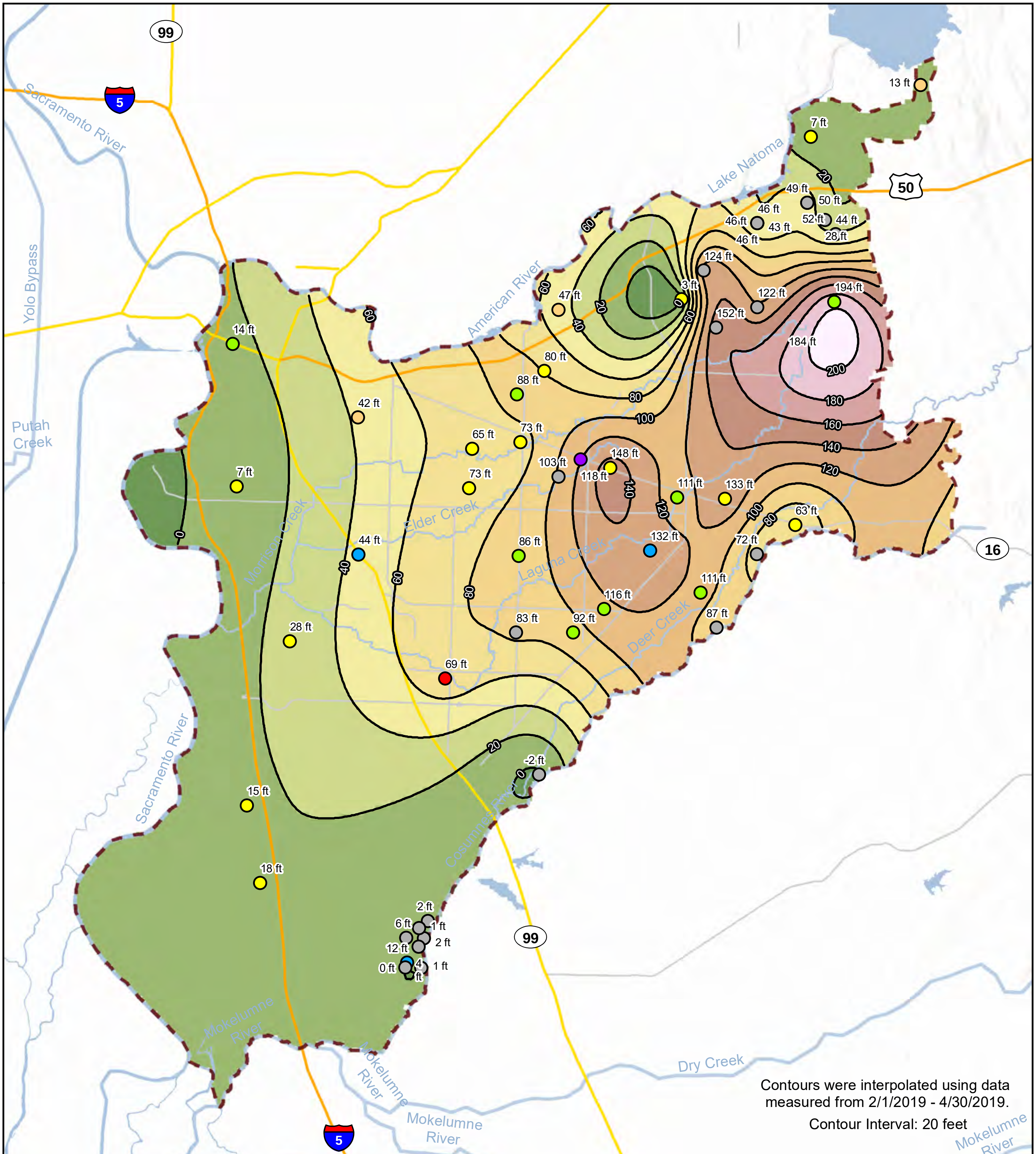
0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020

Figure Exported: 2/5/2021 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00 - SCGA GSP\G. GIS\2. MXD\Spring 2019 Groundwater Elevation.mxd



South American Subbasin GSP

Spring 2019 Depth to Groundwater

Figure 2.3-24

Legend

- South American Subbasin
- Depth to Groundwater (feet)

Well Depth below GSE

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600

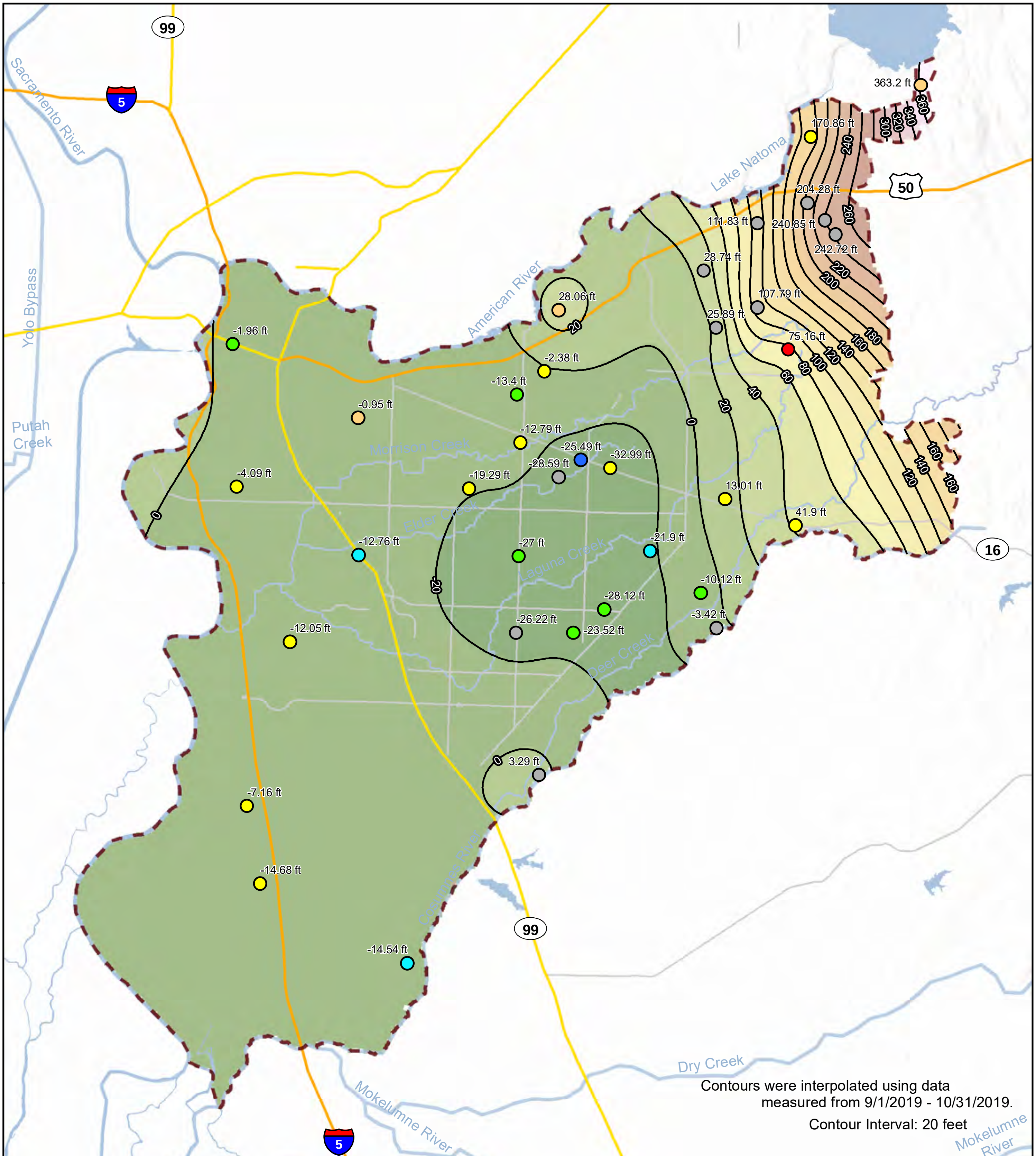
NOTE: Numbers next to each well indicate the depth to water during the measurement period. The color of each well point corresponds to the depth of the well completion.

0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020



South American Subbasin GSP

Fall 2019 Groundwater Elevation

Figure 2.3-25

Legend

- South American Subbasin
- Groundwater Elevation (feet)

Well Depth from GSE

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

NOTE: Numbers next to each well indicate the groundwater elevation during the measurement period. The color of each well point corresponds to the depth of the well completion.

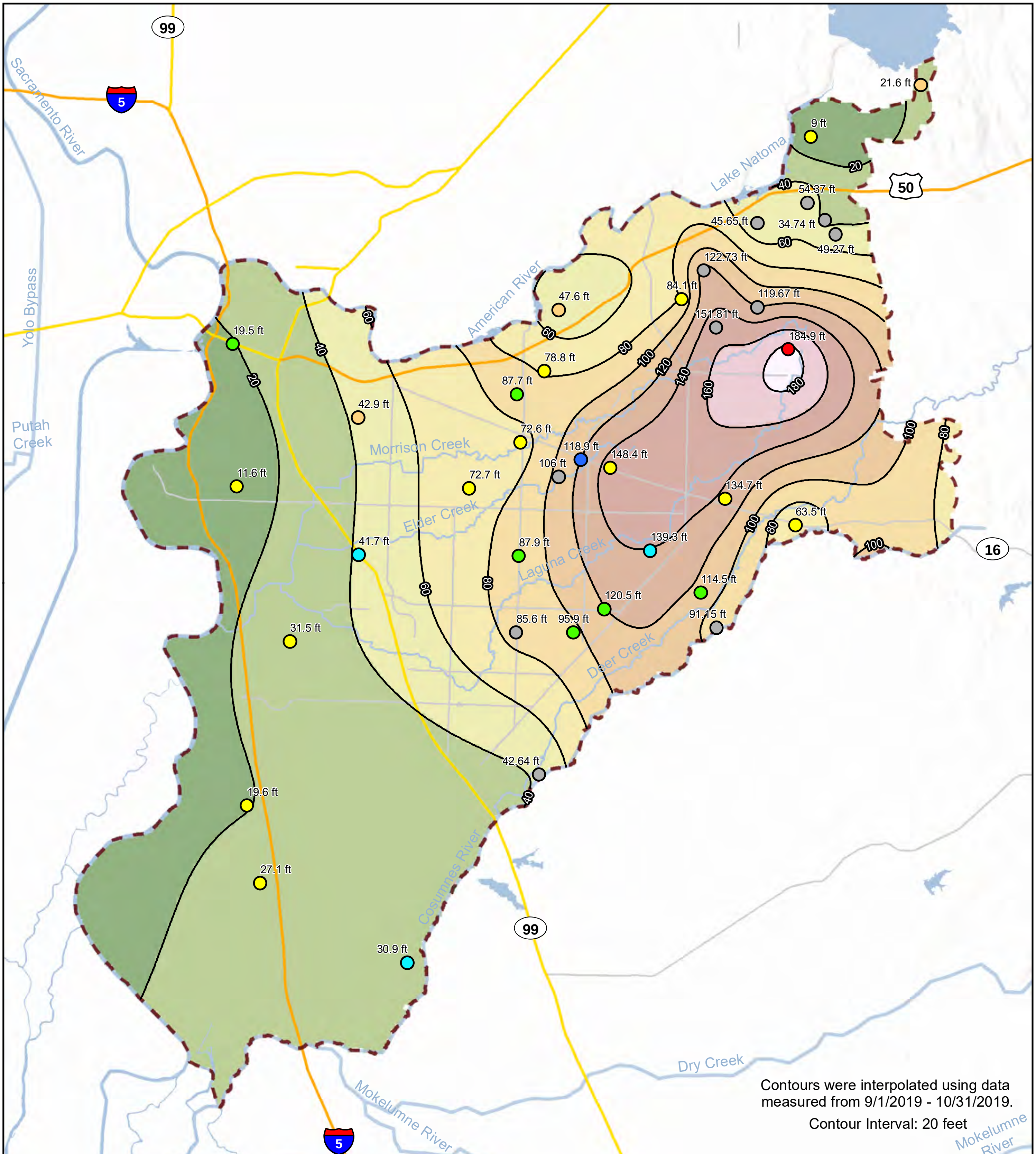
0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020

Figure Exported: 1/4/2021 By: vdeanda Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0509 Sac Central Groundwater Authority\0011575.00- SCGA GSP\G. GIS\2. MXD\Fall 2019 Groundwater Elevation v2.mxd



South American Subbasin GSP

Fall 2019 Depth to Groundwater

Figure 2.3-26

Legend

- South American Subbasin
- Depth to Groundwater (feet)

Well Depth (feet)

- Unknown
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700

NOTE: Numbers next to each well indicate the depth to water during the measurement period. The color of each well point corresponds to the depth of the well completion.

0 1 2 4 Miles

N

South American SUBBASIN

Map Created: Dec. 2020

2.3.2 Change in Groundwater Storage

The CoSANA model was used to estimate historical changes in storage of SASb from 1990-2018. **Figure 2.3-27** shows annual total storage for the SASb as well as the cumulative change in storage, and water year type. Between 1990 and 2018, the cumulative storage in the subbasin is estimated to have increased by 188,000 acre-feet. For the most recent 10-year period (2009-2018), the cumulative storage increase is estimated to be about 77,000 acre-feet.

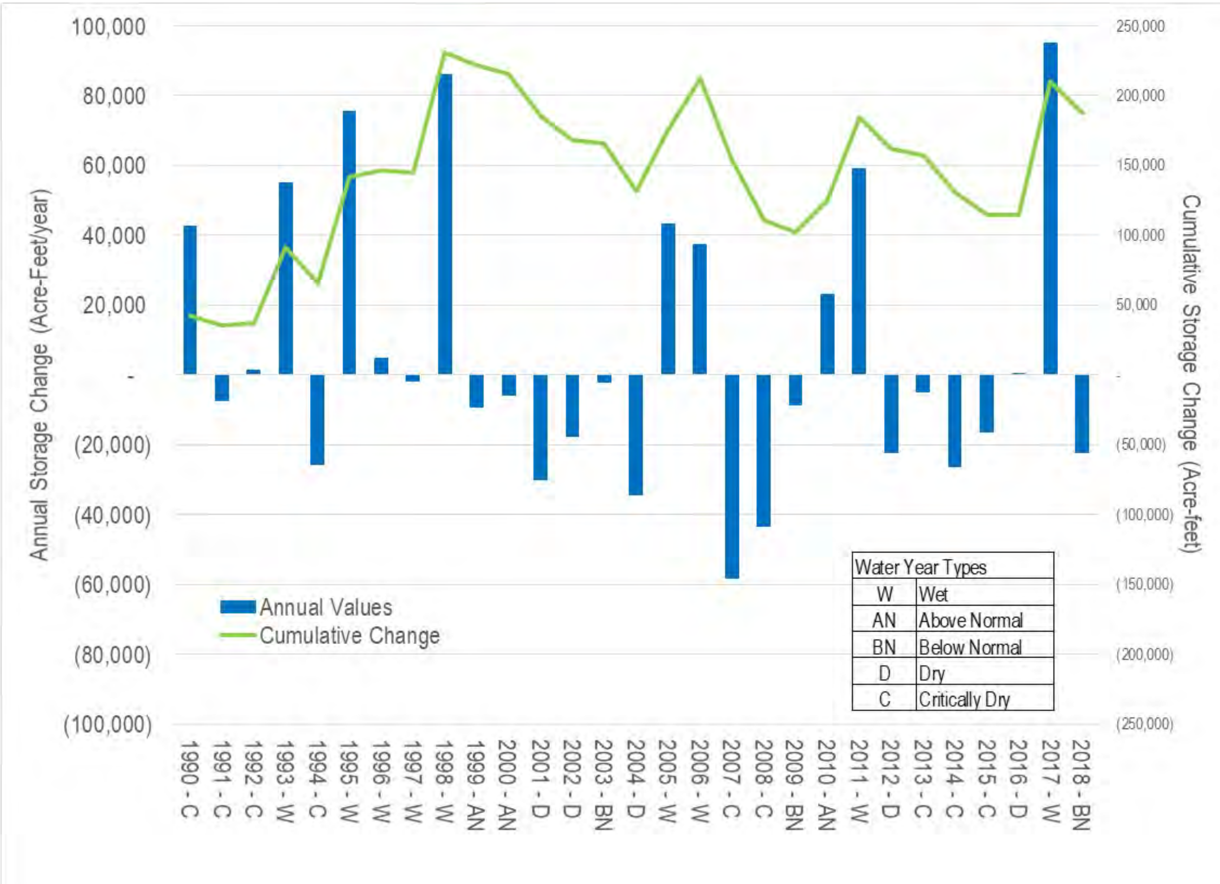


Figure 2.3-27: Groundwater Storage by Year, Water Year Type, and Cumulative Volume

2.3.3 Seawater Intrusion

Seawater intrusion is not an issue in the SASb due to the distance between the Subbasin and the Pacific Ocean, which at its closest is approximately 30 miles west at San Francisco Bay. Part of the Sacramento-San Joaquin Delta overlies the western margin of the Subbasin. Salinity in the Delta is regulated by a series of natural and manmade conditions and is managed using the "X2", or the distance in kilometers from the Golden Gate Bridge where salinity is 2 ppt (seawater is usually 35 ppt). The location of X2 is influenced seasonally by precipitation and outflows from rivers and dams such as the Sacramento and American Rivers and Folsom and Oroville Dams. X2 also fluctuates daily with normal tides. The Delta also hosts an array of hydraulic barriers, gates, and channels that are utilized to control flows and manage salinity. The Delta Atlas (DWR, 1995) documents salinity intrusion (1000 ppm chloride) into the Delta.

Between 1921 and 1943, the maximum salinity intrusion occurred in 1931, a critical WY, and was midway between Courtland and Hood on the Sacramento River when salinity control was minimal compared now. Between 1944 and 1990, the maximum salinity intrusion occurred at Rio Vista in 1977, another critical WY.

2.3.4 Groundwater Quality

This section presents Subbasin groundwater quality information, including a discussion of numeric thresholds set by federal and state agencies, the processing of available water quality data, and the findings of the water quality data evaluation performed for the GSP.

To determine what groundwater quality constituents in the Subbasin may be of current or near-future concern, a reference standard was defined to which groundwater quality data were compared. The regulatory standards are named maximum contaminant levels (MCLs) and they dictate the maximum concentration at which a specific constituent may be present in potable water sources. There are two categories of MCLs: Primary MCLs are established based on human health effects from constituents and are enforceable standards for public water supply wells and state small water supply wells; and Secondary MCLs (SMCLs), which are unenforceable standards established for constituents that may negatively affect the aesthetics of drinking water quality, such as taste, odor, or appearance.

Groundwater in the Subbasin is generally of good quality and meets local needs for municipal, domestic, and agricultural uses. Exceedances of constituents may be caused by localized conditions and generally are not reflective of regionally poor groundwater quality.

Groundwater Quality Data Processing

Groundwater quality data were downloaded from the Groundwater Ambient Monitoring and Assessment Program (GAMA) Groundwater Information System[3] on May 22, 2020, and included 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 Programs (Electronic Deliverable Format (EDF) 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 (DDW)
- U.S. Geological Survey (USGS)

Additional data for nitrate, total dissolved solids (TDS), chloride, arsenic, iron, and manganese were obtained directly from GEI Consultants, Inc., which developed the SASb 2016 Alternative. All data were then compiled into a database for analysis.

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

Groundwater Quality Trends According to Available Historical Data

The combined database from GAMA and GEI Consultants was evaluated for nitrate, TDS, and arsenic. Data solely from the GAMA database was evaluated for hexavalent chromium, and the larger family of per- and poly-fluoroalkyl substances (PFAS), which are an emerging contaminant of concern. These constituents were included in the evaluation because they were cited in previous studies of the Subbasin, or they were discussed during public meetings as being of concern to stakeholders in the Subbasin. Groundwater quality samples collected from less than 300 feet bgs were assigned to the shallow zone, while samples collected from greater than 300 feet were assigned to the deep zone. With the exception of PFAS, only measurements from wells located entirely in either the shallow zone or the deep zone are included in this evaluation. Wells of all depths are analyzed for PFAS, as monitoring data are sparse and less temporally extensive than the other constituents. GAMA data from State and Regional Water Board Regulatory Programs (EDF) are omitted from the analysis presented in this Chapter because they are representative of site-specific conditions and are not indicative of regional groundwater conditions (evaluation of PFAS includes EDF data as the data is sparse). Data evaluation was conducted for chloride, iron, and manganese; evaluation of these constituents, as well as evaluation of nitrate, TDS, arsenic, hexavalent chromium, and PFAS, including the EDF data, are presented in **Appendix 2-D**.

The following subsections present the evaluation of nitrate, TDS, arsenic, hexavalent chromium, and PFAS. Variations of nitrate and TDS over time were plotted as “box and whisker” plots, where the box represents the concentration range for the middle 50 percent of the data (first quartile middle to third quartile middle, or interquartile range), the mean is represented as an ‘x’, and the median is shown as the line in the center of the box. The top whisker extends to the highest concentration that is less than or equal to the sum of the third quartile and 1.5 times the interquartile range; and the bottom whisker extends to the lowest concentration that is greater than or equal to the difference of the first quartile and 1.5 times the interquartile range. Regulatory limits are displayed as a dashed red line, and the concentration is displayed on the left side of each plot. Box and whisker plots of arsenic, hexavalent chromium, and PFAS are included in **Appendix 2-D**.

GAMA data include numerous estimated values (where the value was detected at a concentration below the reporting limit, but above the method detection limit). These estimated values are included in the box and whisker plots as their reported result in the GAMA database. A small number of ND results are included in the GAMA data, these data are not included in this evaluation.

Figures of spatial groundwater quality data plot the location of wells where groundwater quality samples were collected and indicate the maximum sampled concentration at each well for the entirety of the dataset. With the exception of PFAS, individual maps are provided for samples collected from the shallow zone and deep zone of the aquifer. Due to the scarcity of PFAS data, wells of all depths are included in one map.

Nitrate

Nitrate data in the SASb were extensive and spanned from 1951 to present. **Figure 2.3-28** illustrates variation in nitrate for seven time intervals, The primary MCL is displayed as a dashed red line (10 mg/L for Nitrate as N). As shown, nitrate concentrations in both the shallow and deep zones were relatively consistent throughout the period of evaluation. Concentrations in the shallow zone increased slightly between the period 1991-95 and 1996-00; however, this increase was minor and not representative of an increasing trend. Nitrate concentrations in the deep zone have remained relatively stable throughout the period of analysis. It is noted that the elevated average and statistical distribution shown for the deep zone during the period 1986-90 is the result of one high estimated value (10 mg/L).

Nitrate data are plotted spatially for the shallow zone in **Figure 2.3-30** and the deep zone in **Figure 2.3-31**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the MCL (indicated as a green point), wells where at least one sample was above 50 percent of the MCL (indicated as a yellow point), and wells where at least one sample was above the MCL (indicated as a red point). It is noted that not all wells analyzed are drinking water supply wells; therefore, a single exceedance of the MCL may not be a violation of the limits as the State Water Board has set nitrate MCL compliance to be determined by a running annual average.

Figure 2.3-30 shows that nitrate is less than 50 percent of the MCL in the majority of shallow wells. Evaluation of wells where the maximum nitrate concentration was greater than 50 percent of the MCL, or greater than the MCL, indicated that municipal community water systems deliver domestic water supply to these areas, and that domestic well density is low. **Figure 2.3-31** shows that one deep well contained nitrate at a concentration greater than the MCL, while nitrate is less than 50 percent of the MCL in all other wells.

Total Dissolved Solids (TDS)

TDS data were extensive and spanned from 1955 to present. TDS concentrations below the Recommended SMCL of 500 mg/L are desirable for a higher degree of consumer acceptance, while concentrations up to the Upper SMCL of 1,000 mg/L are also deemed to be acceptable. **Figure 2.3-29** illustrates variation in TDS for seven time intervals; the SMCL and Upper SMCL are displayed as dashed red lines. As illustrated, TDS concentrations measured in the deep zone were consistently below the SMCL value of 500 mg/L and remained relatively stable throughout the period of evaluation. Concentrations in the shallow aquifer remained relatively stable from 1986 to 2005 and exhibit higher concentrations during the years 2006 to 2020; however, these elevated concentrations are still deemed acceptable.

TDS data are plotted spatially for the shallow zone in **Figure 2.3-32** and the deep zone in **Figure 2.3-33**. The maps divide the wells into four categories: wells where all samples were below 250 mg/L (indicated as a green point), wells where at least one sample was greater than 250 mg/L (indicated as a yellow point), wells where at least one sample was greater than 500 mg/L (indicated as an orange point), and wells where at least one sample was greater than 1,000 mg/L (indicated as a red point). **Figure 2.3-32** shows an overall increasing trend in shallow TDS values from the east to the west; however, the majority of shallow wells produced a maximum TDS concentration below the SMCL of 500 mg/L. **Figure 2.3-33** shows that all TDS data for deep wells were less than the upper SMCL value of 1000 mg/L.

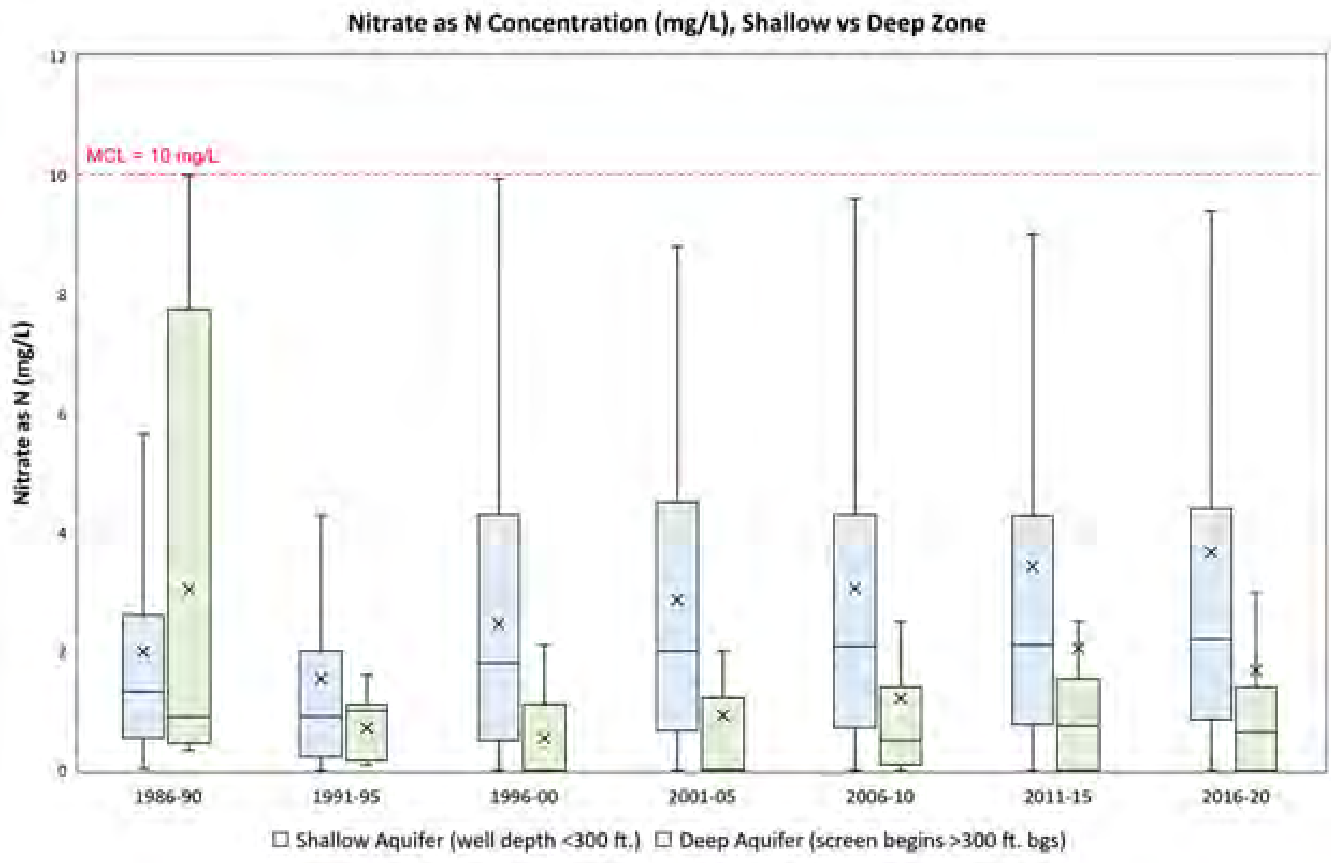


Figure 2.3-28: Historical Range of Nitrate Concentrations

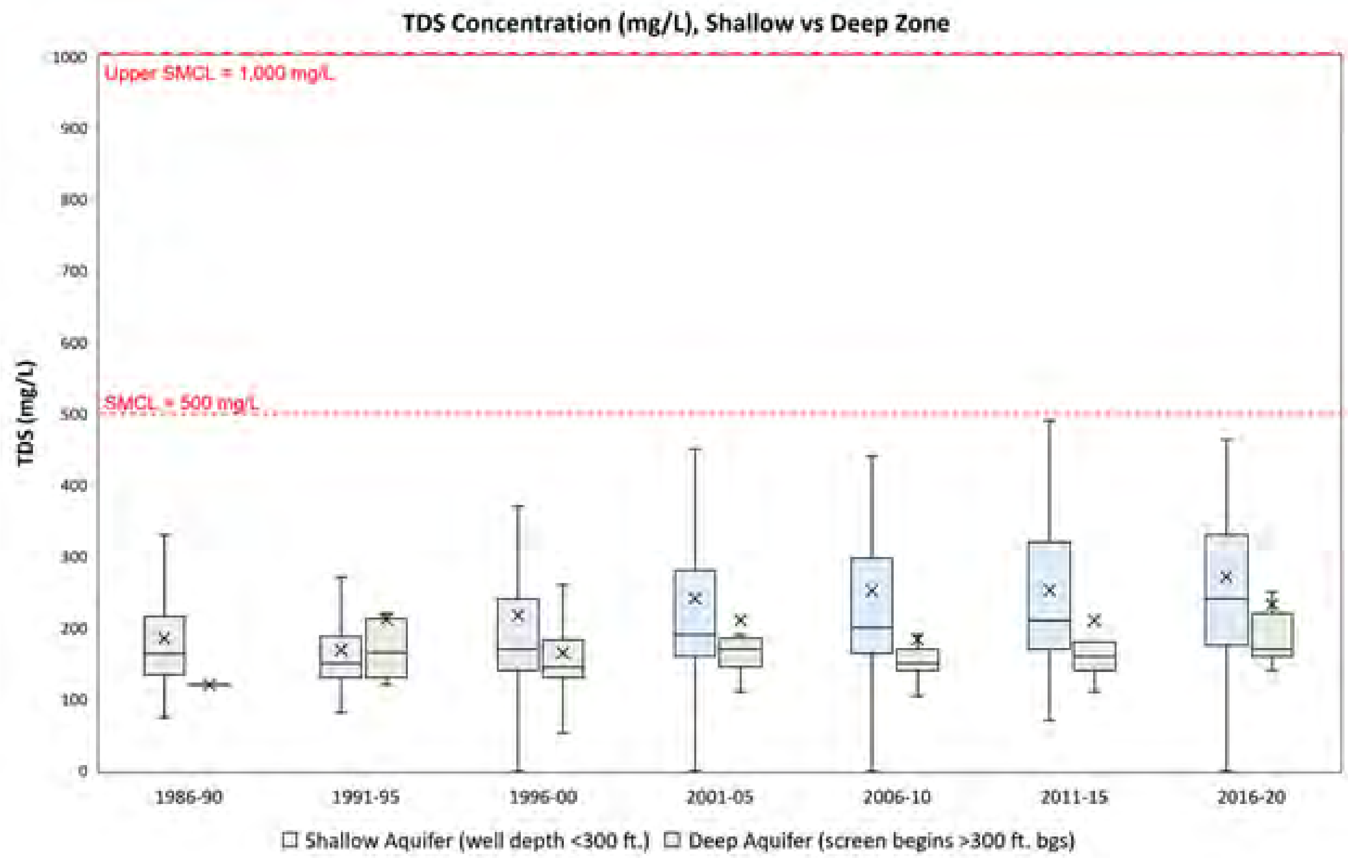
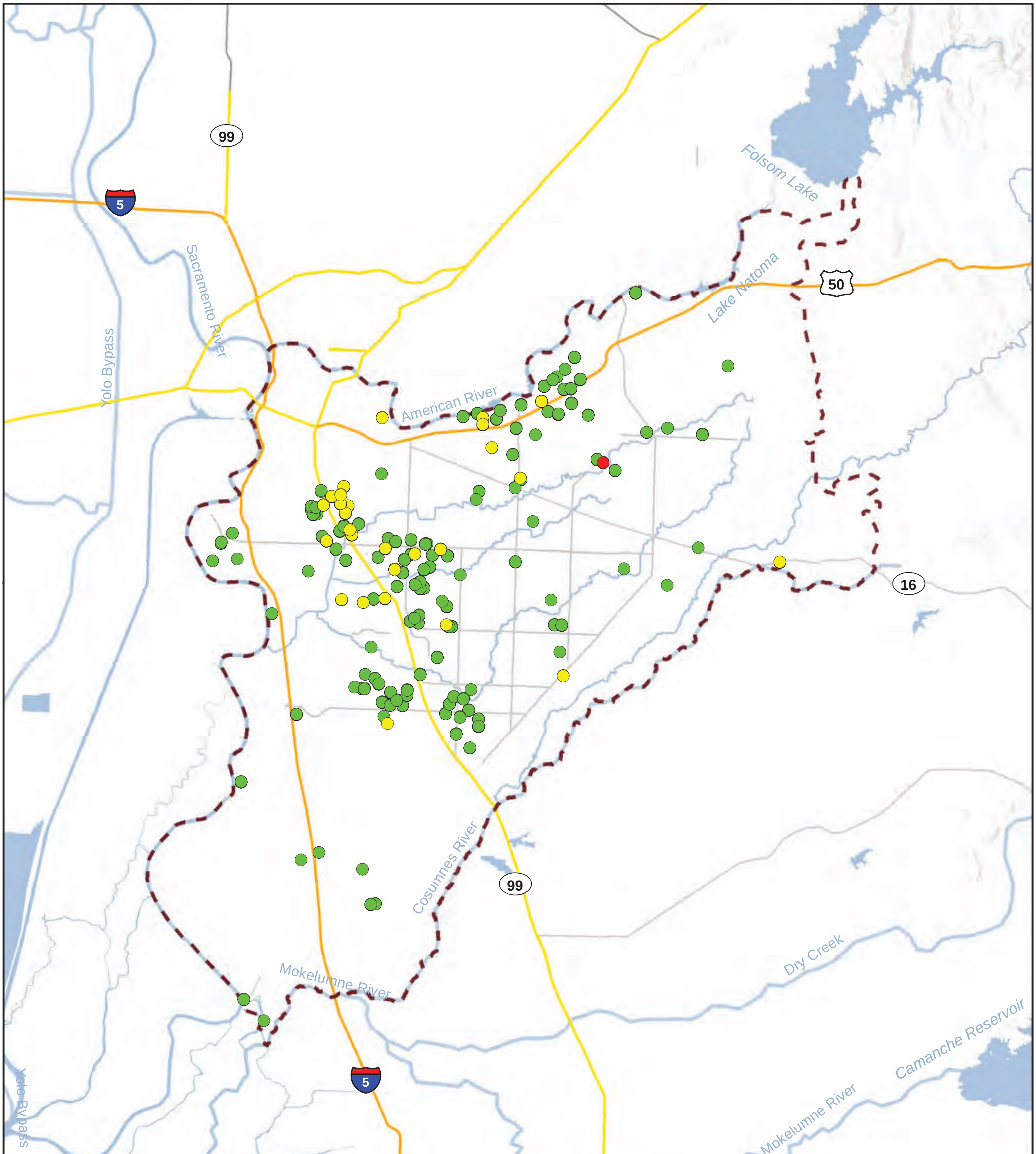


Figure 2.3-29: Historical Range of TDS Concentrations



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South American Subbasin GSP

Nitrate Concentrations in the Shallow Zone (<300 Ft. Depth), GAMA

Figure 2.3-30

Legend

South American Subbasin

Maximum Nitrate as N (1955 - 2020), Shallow Zone

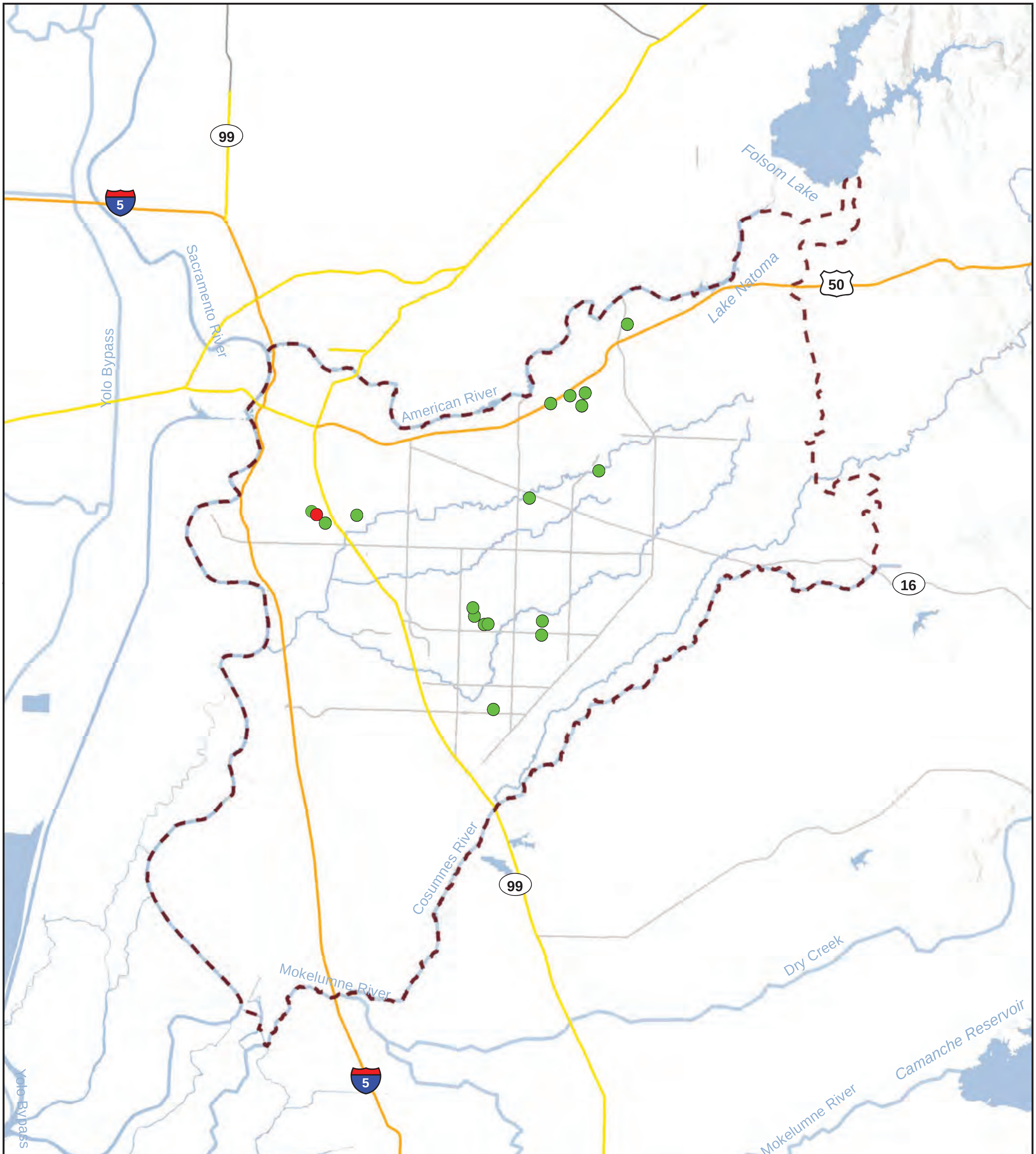
- Below 50% MCL (0 - 5 mg/L)
- Above 50% MCL (> 5 - 10 mg/L)
- Above MCL (> 10 mg/L)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021



South American Subbasin GSP

Nitrate Concentrations in the Deep Zone **(Screen Begins >300 Ft. bgs)**

GAMA

Figure 2.3-31

Legend

South American Subbasin

Maximum Nitrate as N (1986 - 2020), Deep Zone

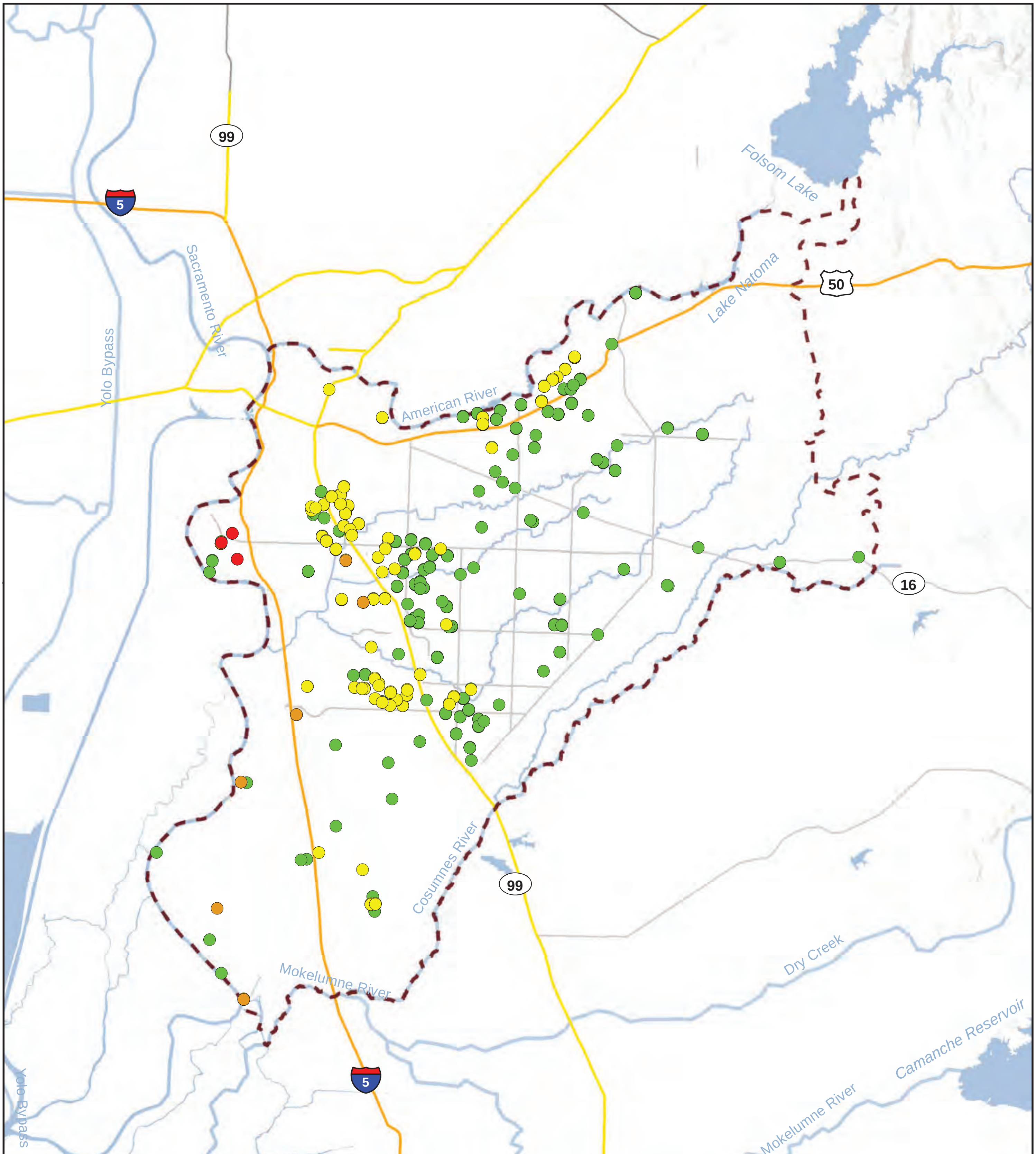
- Below 50% MCL (0 - 5 mg/L)
- Above 50% MCL (> 5 - 10 mg/L)
- Above MCL (> 10 mg/L)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021



South American Subbasin GSP

TDS Concentrations in the Shallow Zone **(<300 Ft. Depth), GAMA**

Figure 2.3-32

Legend

South American Subbasin

Maximum TDS (1955 - 2020), Shallow Zone

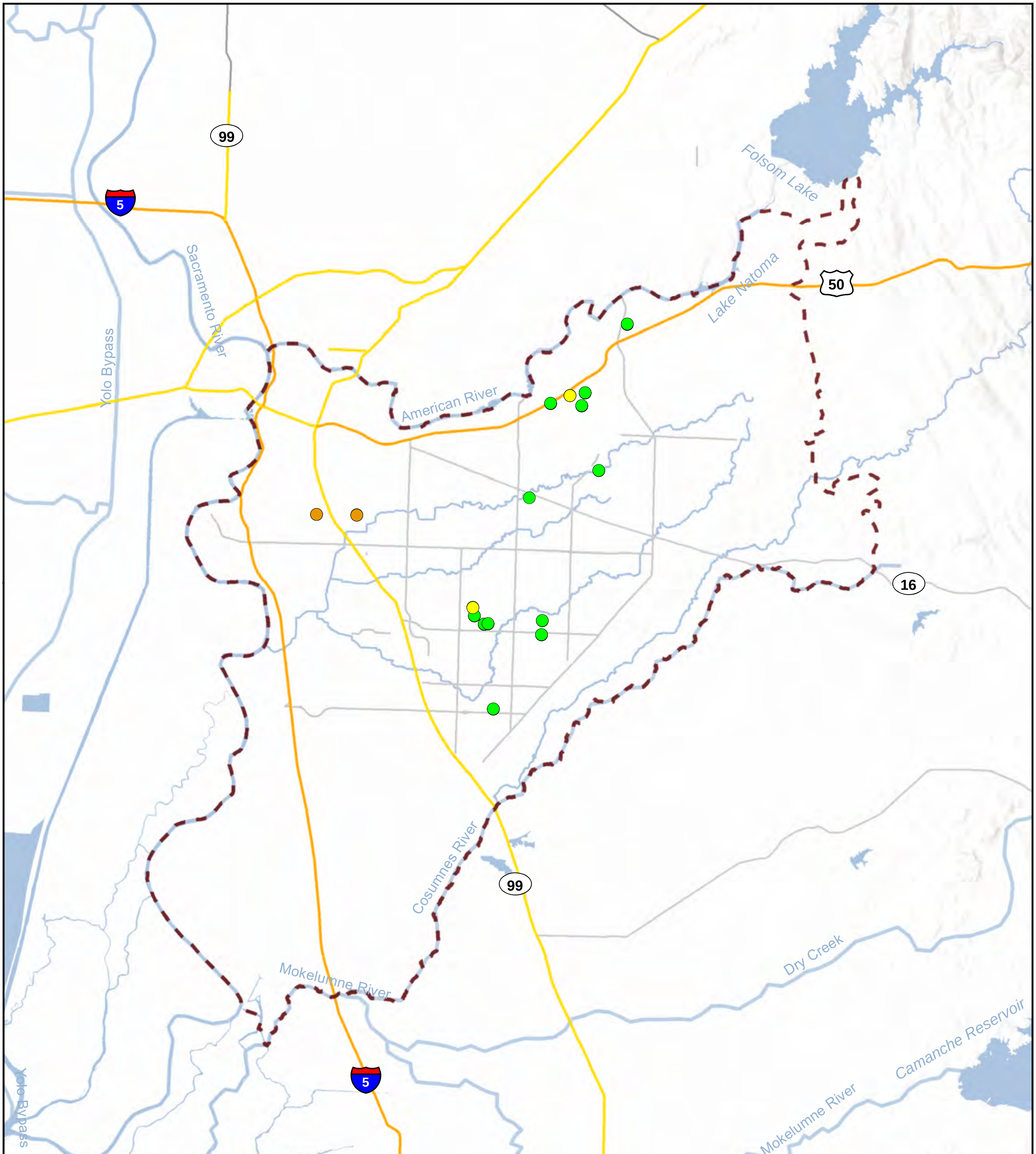
- 0 - 250 mg/L
- > 250 - 500 mg/L
- > 500 - 1,000 mg/L
- > 1,000 mg/L

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021



South American Subbasin GSP

TDS Concentrations in the Deep Zone (Screen Begins >300 Ft. bgs) GAMA

Figure 2.3-33

Legend

South American Subbasin

Maximum TDS (1986 - 2020), Deep Zone

- 0 - 250 mg/L
- > 250 - 500 mg/L
- > 500 - 1,000 mg/L
- > 1,000 mg/L

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021

Arsenic

Arsenic data were extensive and spanned from 1982 to present. Arsenic data from 2005 – 2020 are plotted spatially for the shallow zone in **Figure 2.3-34** and the deep zone in **Figure 2.3-35**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the MCL of 10 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the MCL (indicated as a yellow point), and wells where at least one sample was above the MCL (indicated as a red point).

Figure 2.3-34 shows that exceedances of arsenic occur in the shallow zone of the aquifer, with 25 of the 131 sampled wells experiencing one or more exceedances. Evaluation of wells where the maximum arsenic sampled concentration was greater than 50 percent of the MCL, or greater than the MCL, indicates that municipal community water systems deliver domestic water supply to these areas, and that domestic well density is low. Within water system boundaries, monitoring and treatment should be available to protect beneficial users of groundwater. The boundary of municipal community water systems is shown in the figure. **Figure 2.3-35** shows that high arsenic values are less prevalent in the deep zone, with no wells exceeding the MCL.

Because arsenic is known to occur naturally in the aquifer sediments, some trace is expected to occur in shallow wells. Whether the arsenic is released from a geologic source into groundwater depends on the chemical form of the arsenic, the geochemical conditions in the aquifer, and the biogeochemical processes that occur. It is noted that recent groundwater pumping, observed through land subsidence, may result in increased arsenic aquifer concentrations (Smith et al., 2018). It is unclear if this is the cause of elevated arsenic in the Basin; regardless, increased land subsidence is not predicted, and therefore is not expected to result in increased arsenic concentrations in the shallow zone.

Hexavalent Chromium

Hexavalent chromium data span from 2001 to present and are plotted spatially for the shallow zone in **Figure 2.3-36**, and the deep zone in **Figure 2.3-37**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the proposed MCL of 10 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the proposed MCL (indicated as a yellow point), and wells where at least one sample was above the proposed MCL (indicated as a red point). As shown, hexavalent chromium was not present in shallow wells above the proposed MCL, and was not present in deep wells above 5 µg/L.

Polyfluoroalkyl Substances (PFAS)

Monitoring of PFAS began more recently, with data beginning in 2017. MCLs have not been established for PFAS substances; alternatively, the DDW has instituted guidelines for local water agencies to report the presence of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in drinking water at 5.1 and 6.5 nanograms per liter (ng/L) or parts per trillion, respectively. PFOA and PFAS data are plotted spatially in **Figure 2.3-38**, and indicate that 31 of 55 samples have PFOS concentrations greater than 6.5 ng/L, and 22 of 43 samples have PFOA concentrations greater than 5.1 ng/L.

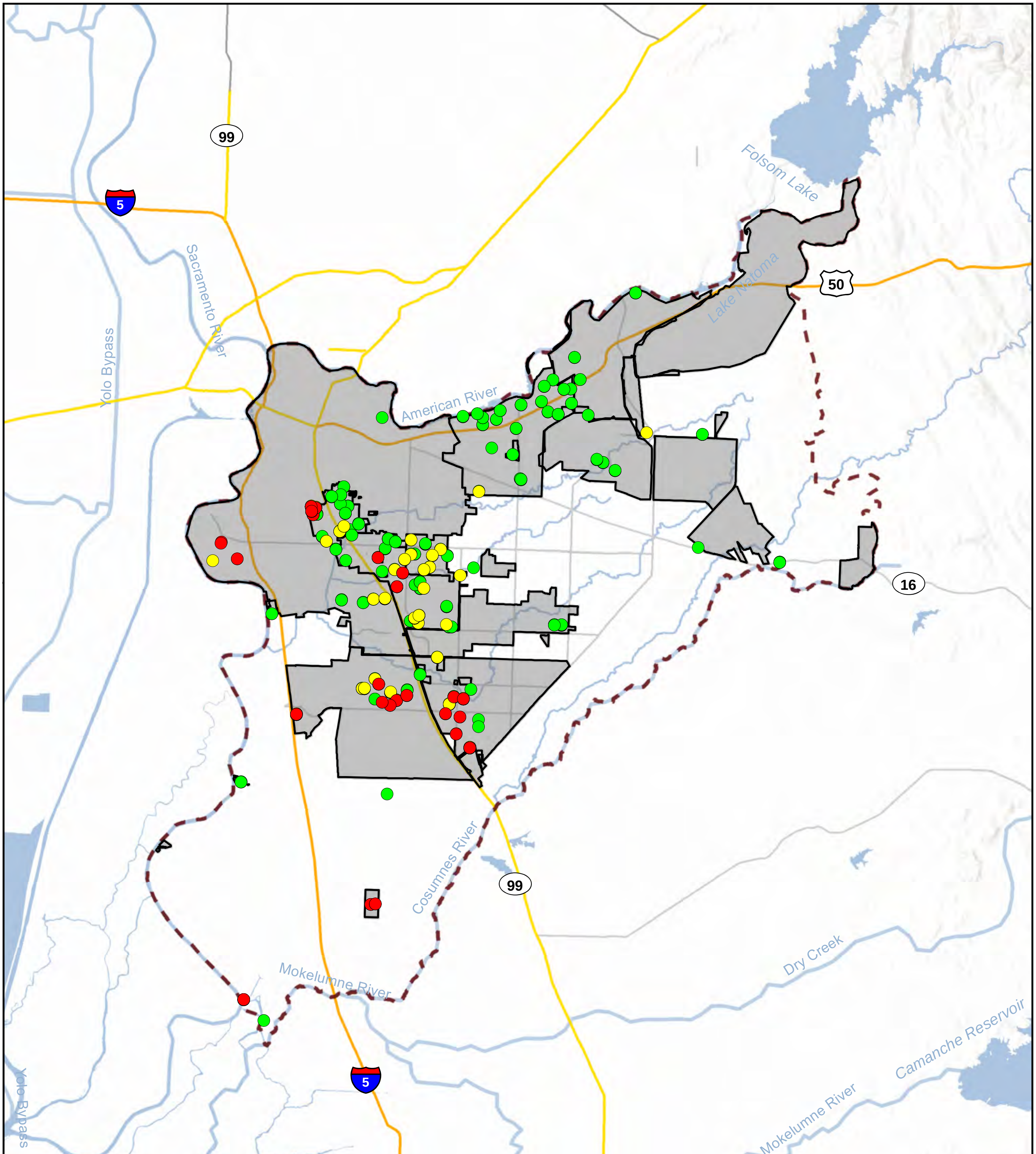


Figure Exported: 10/12/2021 By: OlinA Using: C:\Users\olina\Dropbox (LWA)\Olin A\601.0.3 - GSP 2020, LF\SAS GIS - Template and Final Figures\Sec 2-3 - As_Shallow_Aquifer_Max_noMWs_wWatersystem_05-20_10_7_2021.mxd

South American Subbasin GSP

Arsenic Concentrations in the Shallow Zone (<300 Ft. Depth), GAMA

Figure 2.3-34

Legend

South American Subbasin

Maximum Arsenic (2005-2020), Shallow Zone

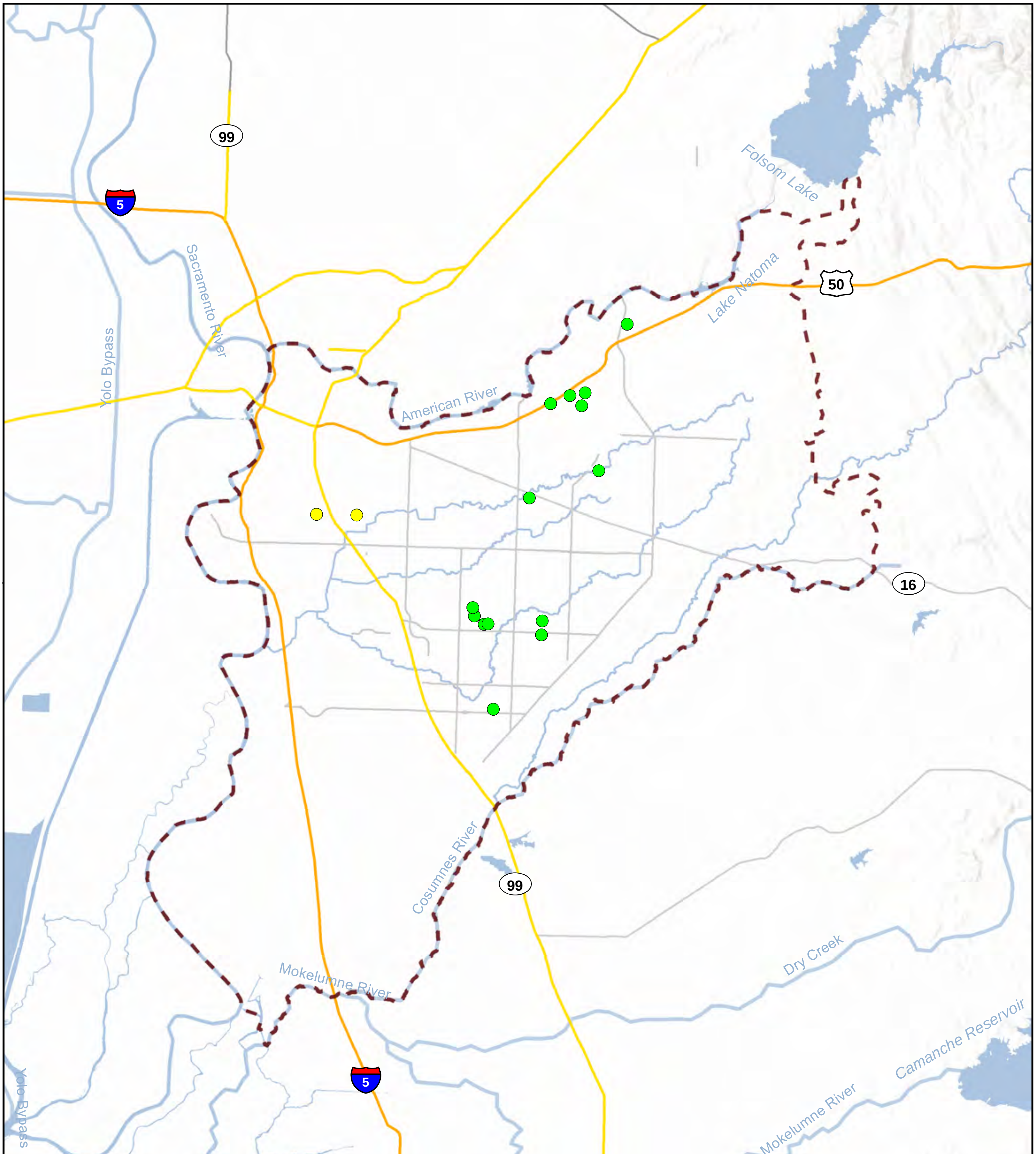
- Below 50% MCL (0 - 5 µg/L)
- Above 50% MCL (>5 - 10 µg/L)
- Above MCL (> 10 µg/L)
- Municipal Community Water System

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 10 2021



South American Subbasin GSP

Arsenic Concentrations in the Deep Zone (Screen Begins >300 Ft. bgs) GAMA

Figure 2.3-35

Legend

South American Subbasin

Maximum Arsenic (2005-2018), Deep Zone

- Below 50% MCL (0 - 5 µg/L)
- Above 50% MCL (>5 - 10 µg/L)
- Above MCL (> 10 µg/L)

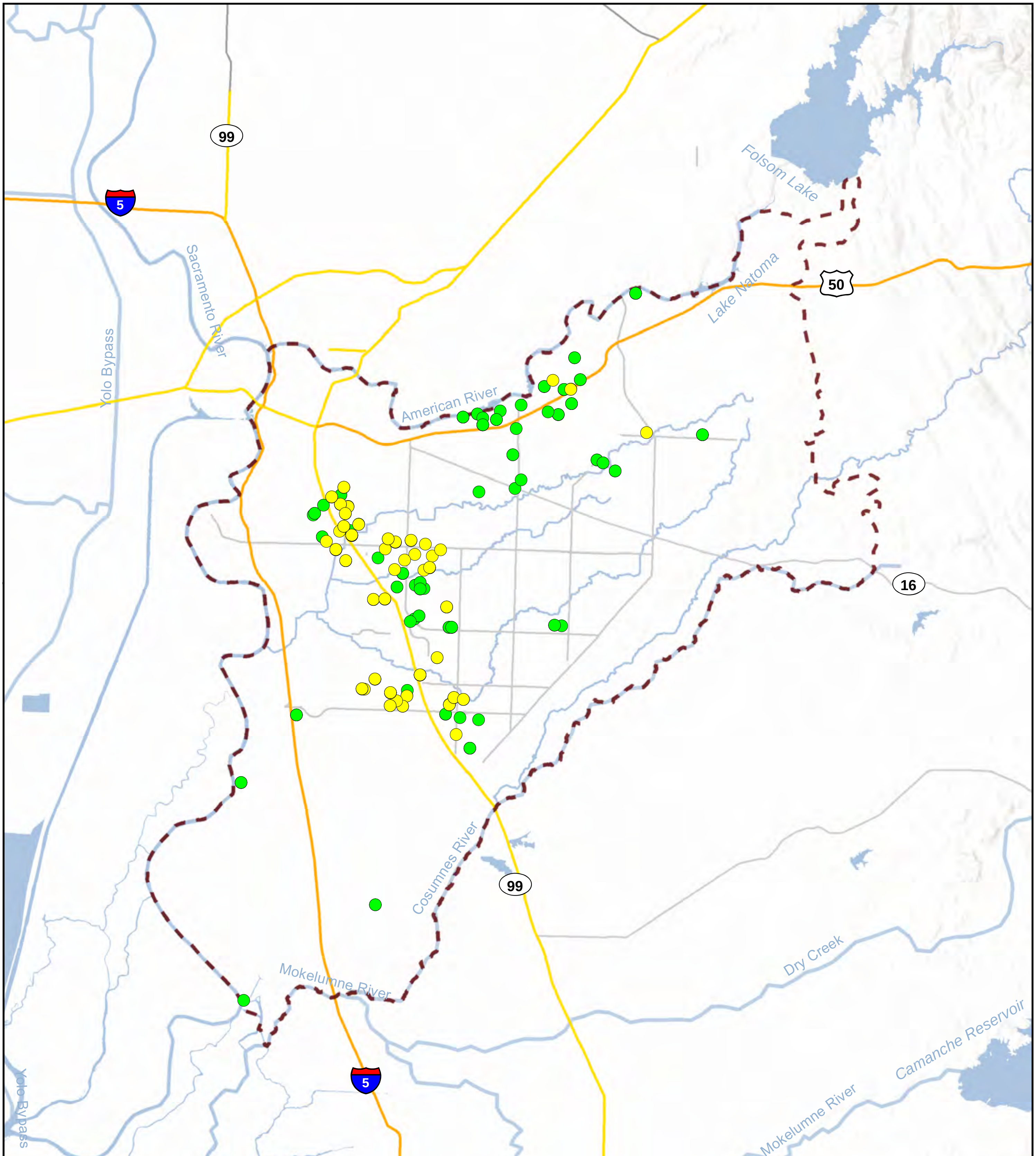
0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 10 2021

Figure Exported: 10/12/2021 By: OlinA Using: C:\Users\olina\Dropbox (LWA)\Olin A\601.0.3 - GSP 2020, LF\SAS GIS - Template and Final Figures\Sec 2-3 - As_Deep_Aquifer_Max_wMWs_15-20_Value_10_6_2021.mxd



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South American Subbasin GSP

Hexavalent Chromium Concentrations in the Shallow Zone (<300 Ft. Depth), GAMA

Figure 2.3-36

Legend

South American Subbasin

Max. Hexavalent Chromium (2001-20), Shallow Zone

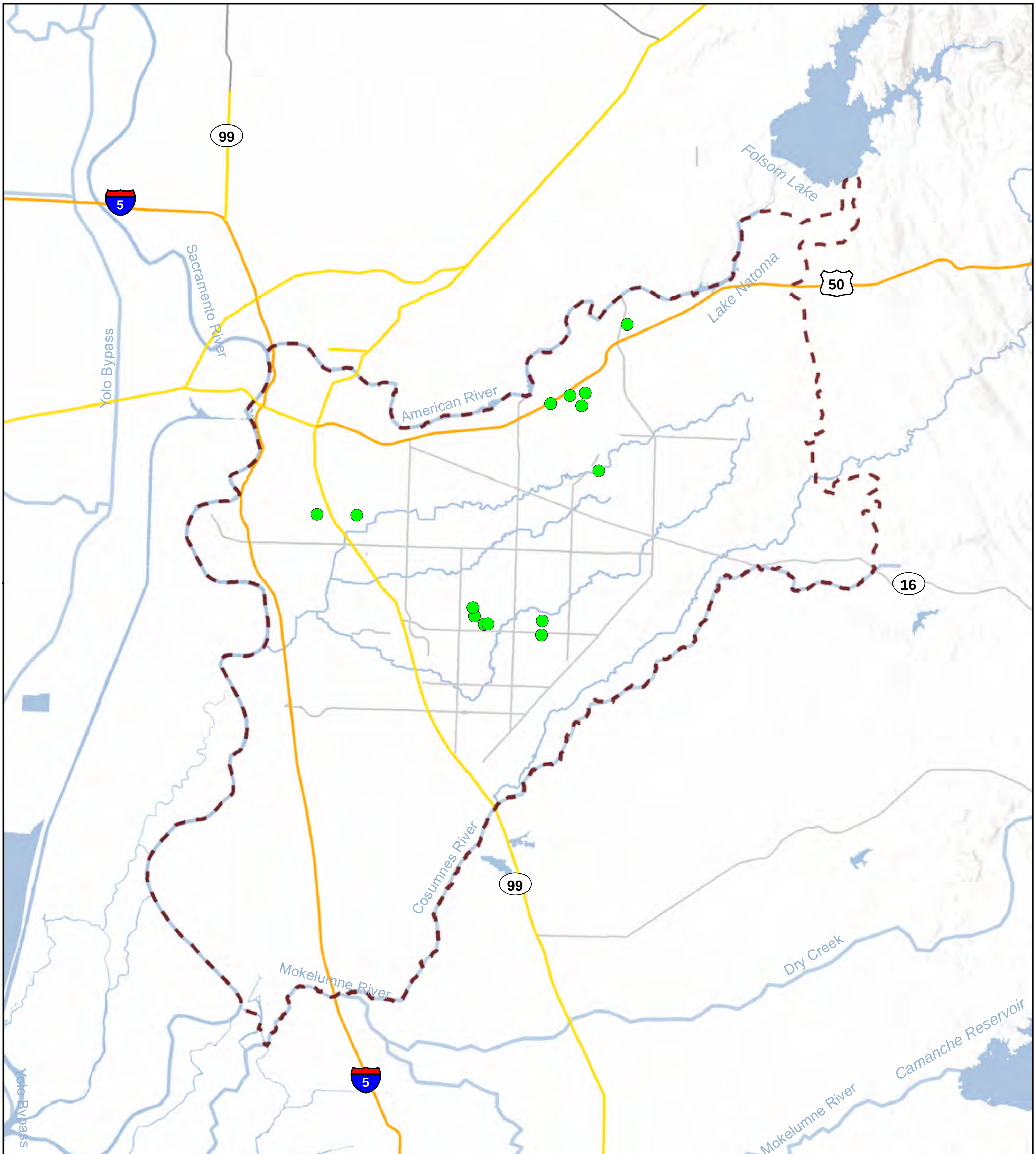
- Below 50% Proposed MCL (0 - 5 µg/L)
- Above 50% Proposed MCL (> 5 - 10 µg/L)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021



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South American Subbasin GSP

Hexavalent Chromium Concentrations in the Deep Zone (Screen Begins >300 Ft. bgs), GAMA

Figure 2.3-37

Legend

South American Subbasin

Max. Hexavalent Chromium (2001-18), Deep Zone

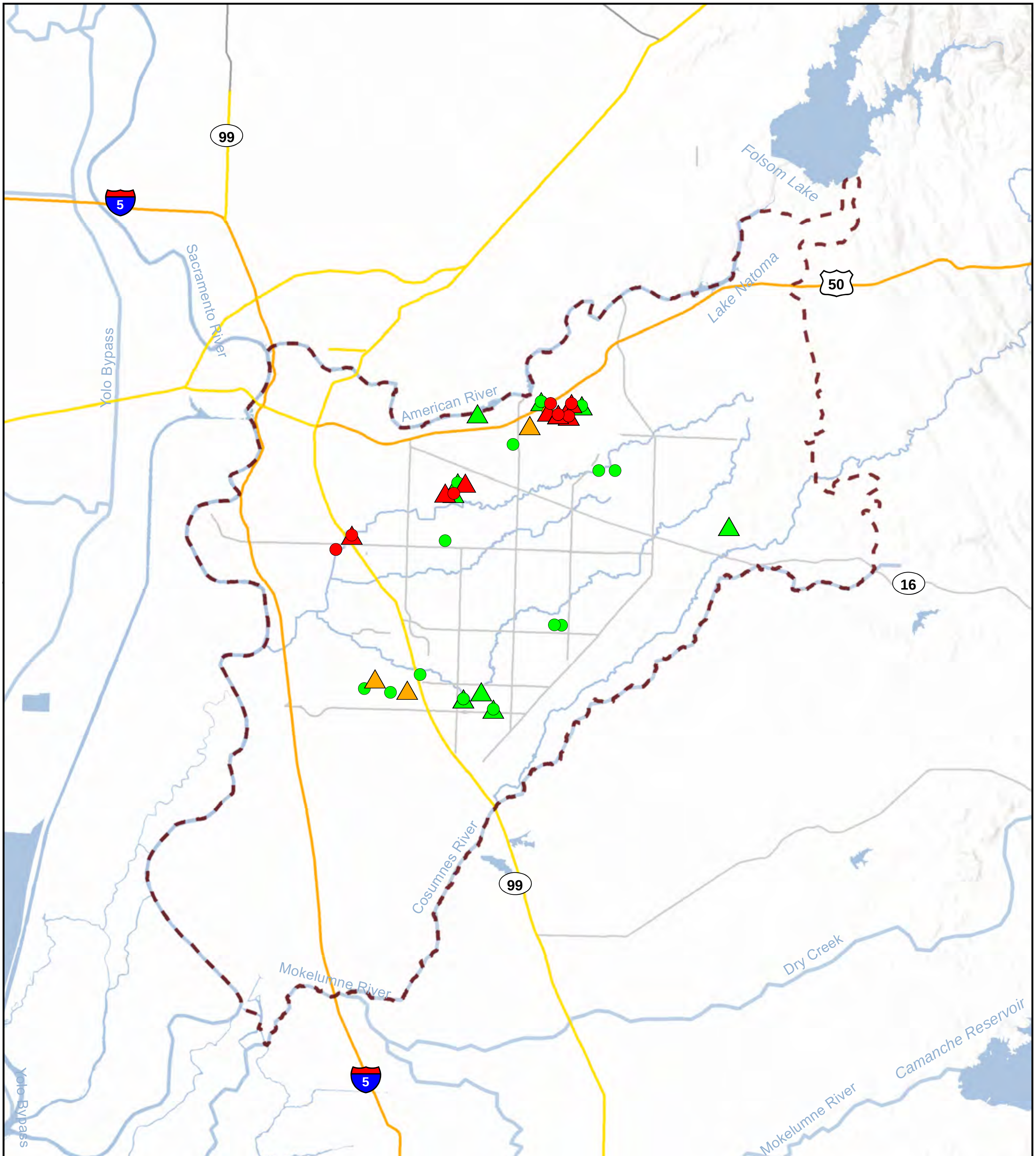
Below 50% Proposed MCL (0 - 5 μg/L)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 02 2021



South American Subbasin GSP

PFOA and PFOS Concentrations in Groundwater

Figure 2.3-38

Legend

South American Subbasin

Max. PFOA (2017-20)

- <50% NL (0-2.55 ng/L)
- >50% NL (>2.55-5.1 ng/L)
- Above NL (>5.1 ng/L)

Max. PFOS (2017-20)

- <50% NL (0-3.25 ng/L)
- >50% NL (>3.25-6.5 ng/L)
- Above NL (>6.5 ng/L)

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 10 2021

2.3.5 Land Subsidence

Land subsidence is the lowering of the ground surface elevation and is often caused by groundwater pumping from an aquifer with a substantial number of clay layers. Land subsidence can be elastic and inelastic. Elastic subsidence is small, reversible lowering and rising of the ground surface and can be cyclical with seasonal changes year to year. Inelastic subsidence is irreversible. Land subsidence is not known to be historically or currently significant in the South American Subbasin.

Previous Land Subsidence Studies

Previous studies of land subsidence in the SASb have shown small-to-zero amounts of subsidence having occurred. Such efforts have mainly been through leveling profiles studied between 1947 and 1966, the 2006 GMP, a 2008 DWR and the US Bureau of Reclamation subsidence project throughout the Sacramento Valley using GPS technology (Frame Surveying & Mapping, 2008), and DWR's more recent Sacramento Valley 2017 GPS Survey program (specific results are summarized in SCGA [2018]), all of which demonstrated that subsidence has been very minimal, clearly not significant or unreasonable, across the SASb during the time period 2008-2017.

Current Data Sources and Analysis

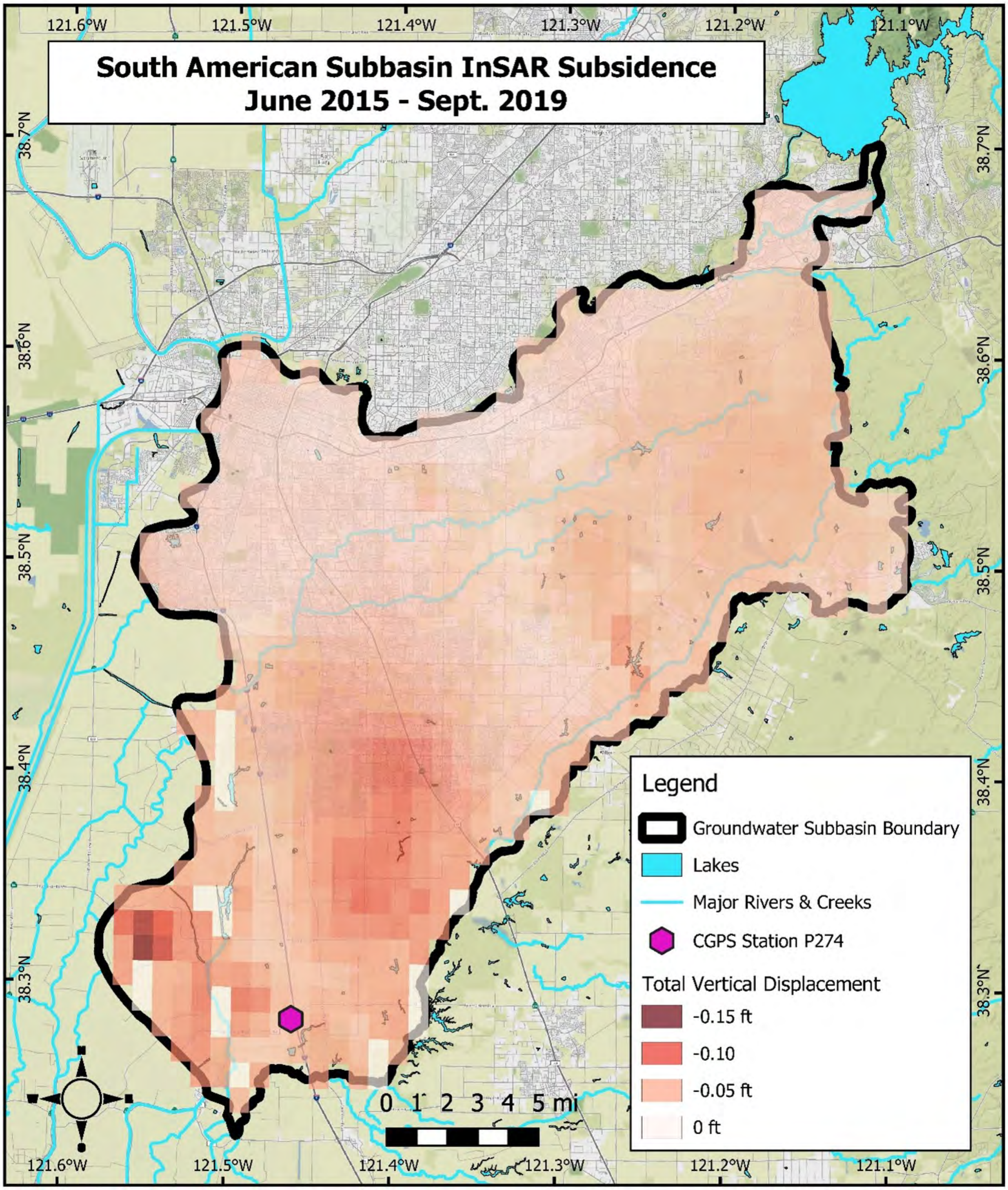
DWR published Interferometric Synthetic Aperture Radar (InSAR) satellite data on their SGMA Data Viewer web map , providing an estimate of land subsidence for the time period from June 13, 2015, to October 1, 2020. **Figure 2.3-39** shows total vertical displacement between June 2015 and September 2019. The maximum total displacement is 0.15 feet or 1.8 inches and is located on the west side of SASb at two locations west of Elk Grove and at one location along the Sacramento River. The figure shows considerably smaller values throughout the remainder of the subbasin. These data are processed by TRE Altamira and are made available by DWR as downloadable raster and point datasets for monthly time steps, updated annually.

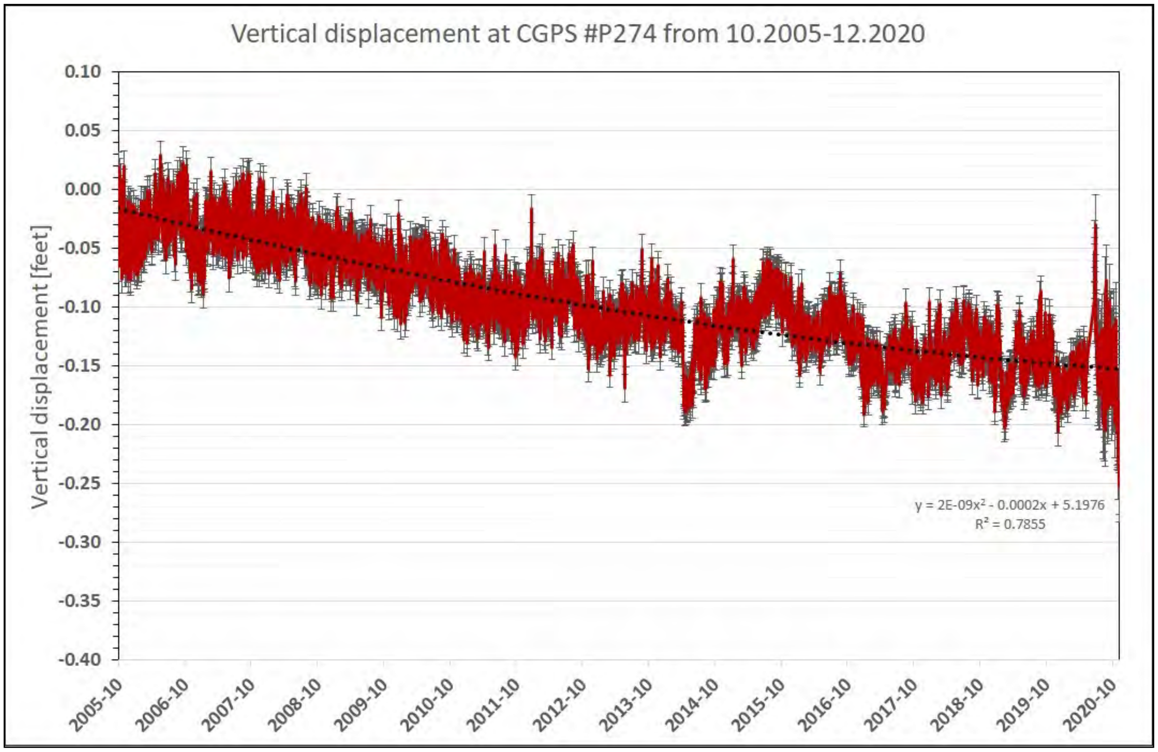
Elevation data are recorded daily at one continuous global positioning satellite (CGPS) station (P274), located in the southwestern corner of SASb. **Figure 2.3-40** is a time series plot of the elevation data, beginning in October 2005 to through October 2020. The trend line suggest minimal land subsidence has occurred at the station since October 2005, equating to -0.14 feet in total, or less than -0.01 feet/year.

The analysis of CGPS and InSAR data confirm the results of previous studies, i.e., minimal occurrence of subsidence in the SASb. Additional information on InSAR data can be found on the CNRA data access webpage[4].

[4] https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence

Figure 2.3-39: South American Subbasin InSAR Subsidence, June 2015 – September 2019





1. Note: Trend line added solely for the purpose of added assistance with the interpretation of subsidence time series data. Trend line equation included for reference.

Figure 2.3-40: South American Subbasin CGPS Station (UNAVCO #P274) Subsidence, October 2005 – December 2020[1]

2.3.6 Interconnected Surface Water Systems

This section presents a characterization of present-day Interconnected Surface Water (ISW) within the Subbasin. ISW are distinguished from disconnected systems in that they are connected by a continuous saturated zone to the regional groundwater system. A detailed description of historical, present day, and future ISW (under projected groundwater conditions and climate change) is discussed in **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**, and a summary of historical and present day ISW is presented here.

Identification of interconnected surface water systems

Groundwater levels change over time, and thus ISW locations also change over time. To assess the timing of ISW interconnection and disconnection, all available shallow groundwater elevation data were used to krige groundwater elevation surfaces at spring and fall seasons between 2005 and 2018. Next, the best available streambed elevation[5] data were combined with local soil maps as an estimate of the clogging layer beneath the thalweg. If the groundwater elevation intersects the clogging layer, a stream node is considered ISW for the time considered,

[5] Streambed locations and elevations used in this analysis are the same as those in the CoSANA groundwater flow model to maintain consistency in data and models.

otherwise, it is considered disconnected (**Figure 2.3-41**). The surface waters considered in this analysis included only major surface water systems represented in the CoSANA model (**Figure 2.3-42**), which are subdivided in 21 reaches (**Figure 2.3-43**).

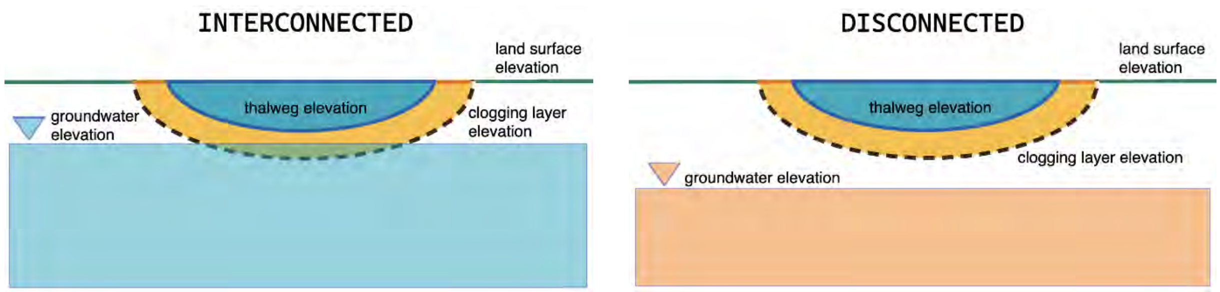


Figure 2.3-41: Classification of Interconnected Surface Water (ISW) and Disconnected stream nodes depends on a comparison of the clogging layer elevation beneath the streambed and the groundwater elevation.

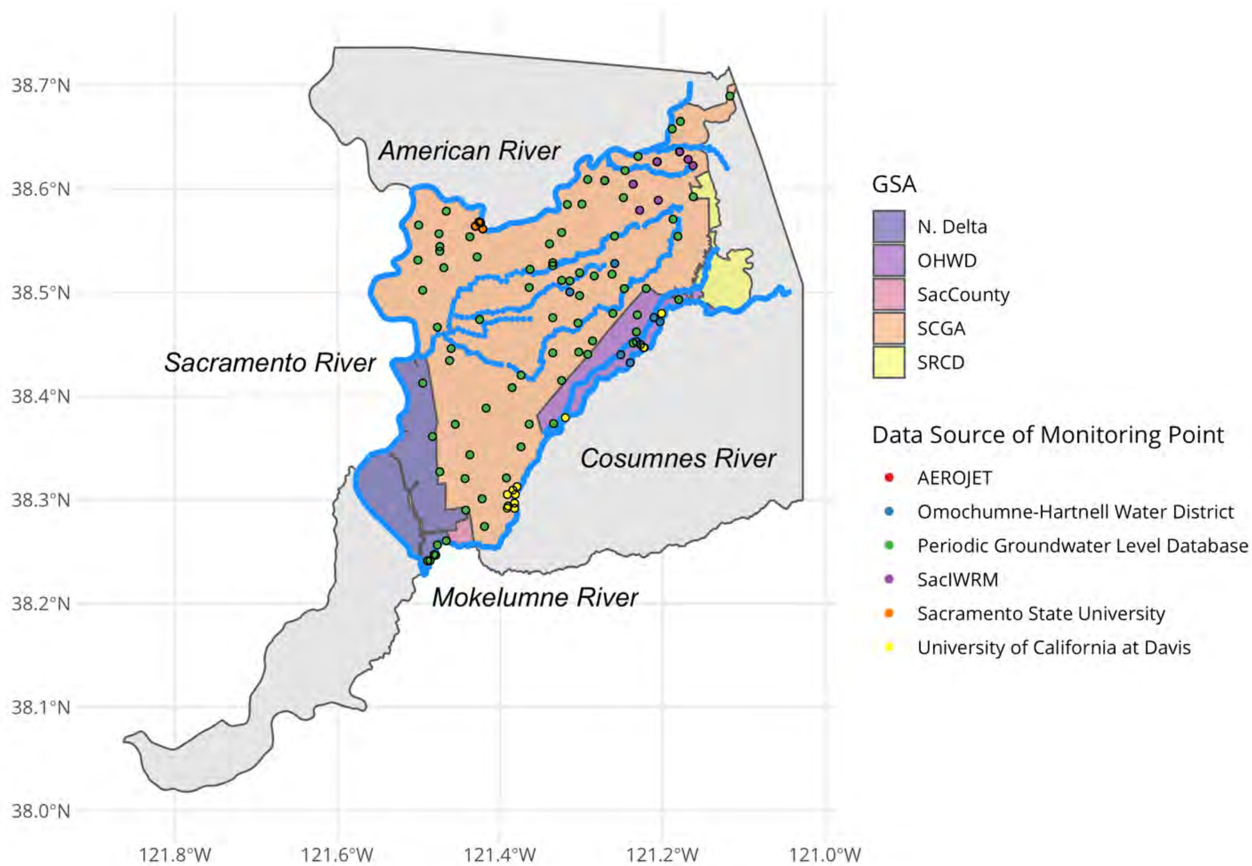


Figure 2.3-42: South American Subbasin surface water nodes in the CoSANA model, GSAs, and locations of groundwater level monitoring locations and sources used for seasonal groundwater level interpolation.

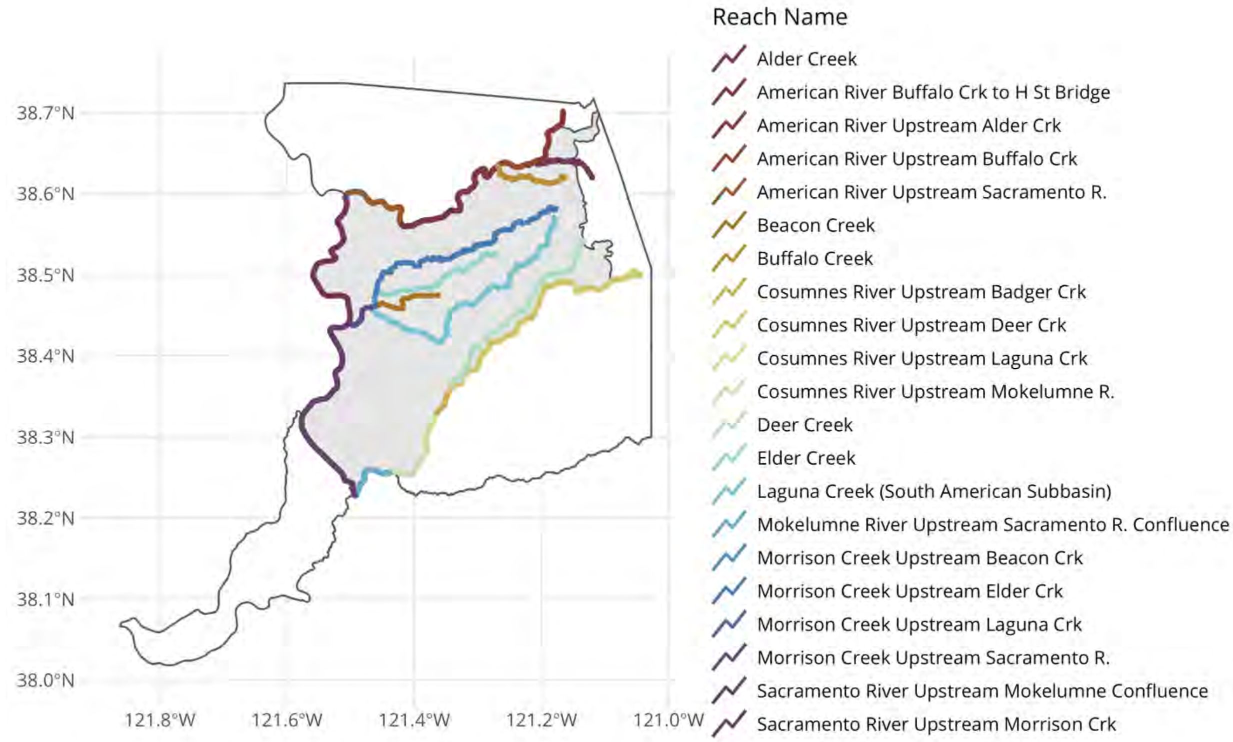


Figure 2.3-43: Major surface waters in the South American Subbasin divided into 21 reaches, based on CoSANA surface node representation.

Location of interconnected surface water systems

After seasonal groundwater elevations were intersected with the elevation of the clogging layer, the percentage of seasons over the historical period were evaluated to determine whether a stream node was interconnected to groundwater. **Figure 2.3-44** shows the percentage of seasons where surface water is historically connected to groundwater (A) for the various stream reaches and final ISW classification (B).

Finally, present day ISW was defined by considering historical variation in ISW. Disconnected stream reaches are persistently disconnected from groundwater at all seasons evaluated, whereas Interconnected reaches (ISW) are conservatively defined as having at least the majority of nodes connected for > 0% of all seasons evaluated. In other words, if the majority of surface water nodes in a reach are connected for at least one season in the historical period considered, the entire reach is considered ISW. Results indicate ISW along the entire Sacramento and Mokelumne rivers that border the South American Subbasin, and along reaches of the American River and Cosumnes River. Alder Creek and Morrison Creek above the Sacramento River are also identified as ISW. This characterization of ISW is consistent with The Nature Conservancy's ICONS web tool (TNC, 2021), which uses a similar methodology of comparing streambed elevation and groundwater levels.

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, so this reach is considered a data gap for planning purposes and more research is needed to understand stream-aquifer interactions in this region.

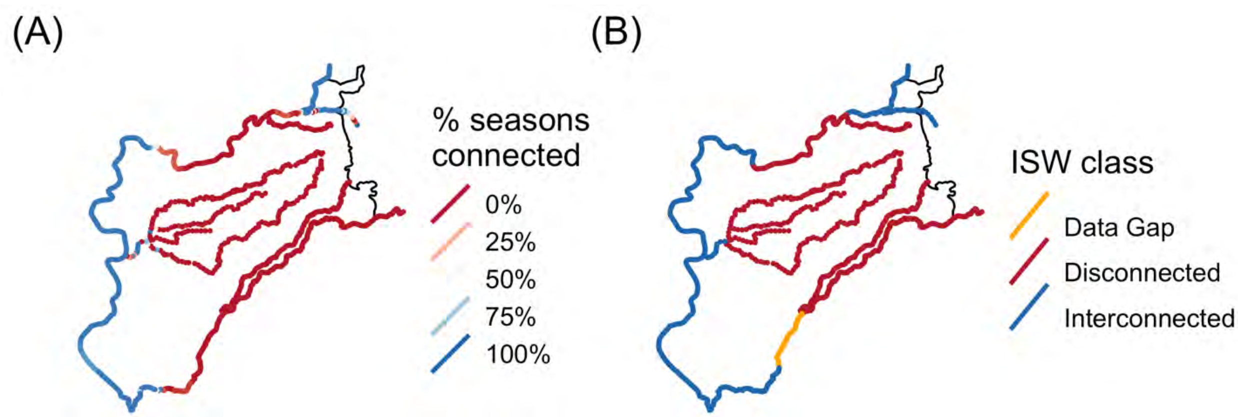


Figure 2.3-44: South American Subbasin Interconnected and Disconnected stream nodes according to (A) historical percentage of seasons between 2005-2018 that the node is connected to groundwater; and (B) final classification of ISW.

Estimates of timing and quantity of interconnected surface water depletions

Stream-aquifer interaction is, in practice, very difficult to measure in the field and hence the timing and quantity of ISW depletion (i.e., seepage) is almost always estimated by a model. In this case, stream seepage is estimated by the CoSANA integrated surface and groundwater model and evaluated along ISW reaches. Negative seepage indicates a losing stream system and positive seepage indicates a gaining stream system. All ISW reaches identified are persistently gaining or losing across the CoSANA current conditions baseline (**Figure 2.3-45**). Importantly, analysis to support the development of Sustainable Management Criteria (**Section 3**) rely on comparison of the baseline ISW seepage to ISW seepage under projected groundwater management and climate change scenarios.

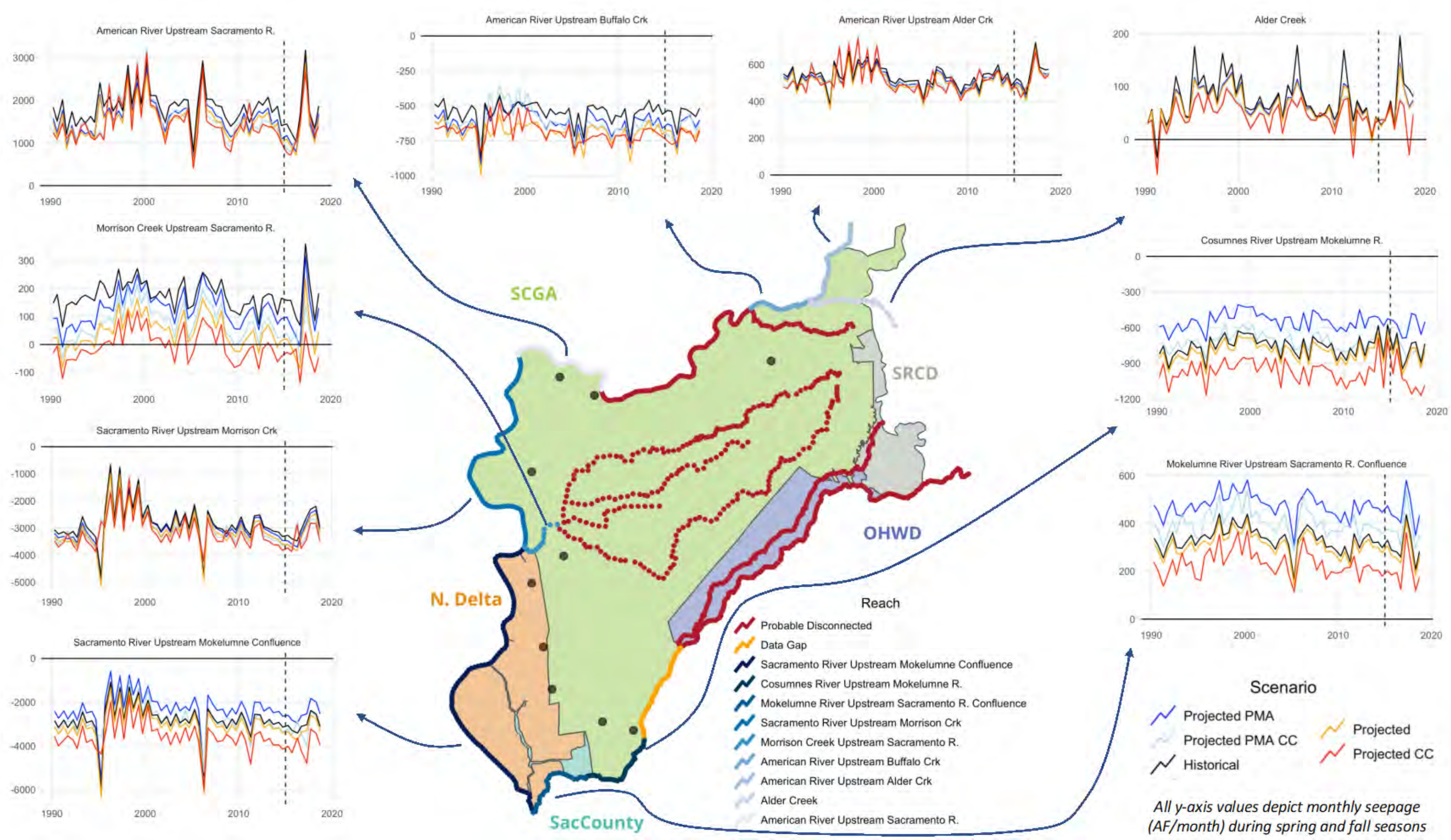


Figure 2.3-45: Seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches. The black line represents historical to near present-day conditions. See Section 3.3.1.2 for more details on projected scenarios.

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

[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**).

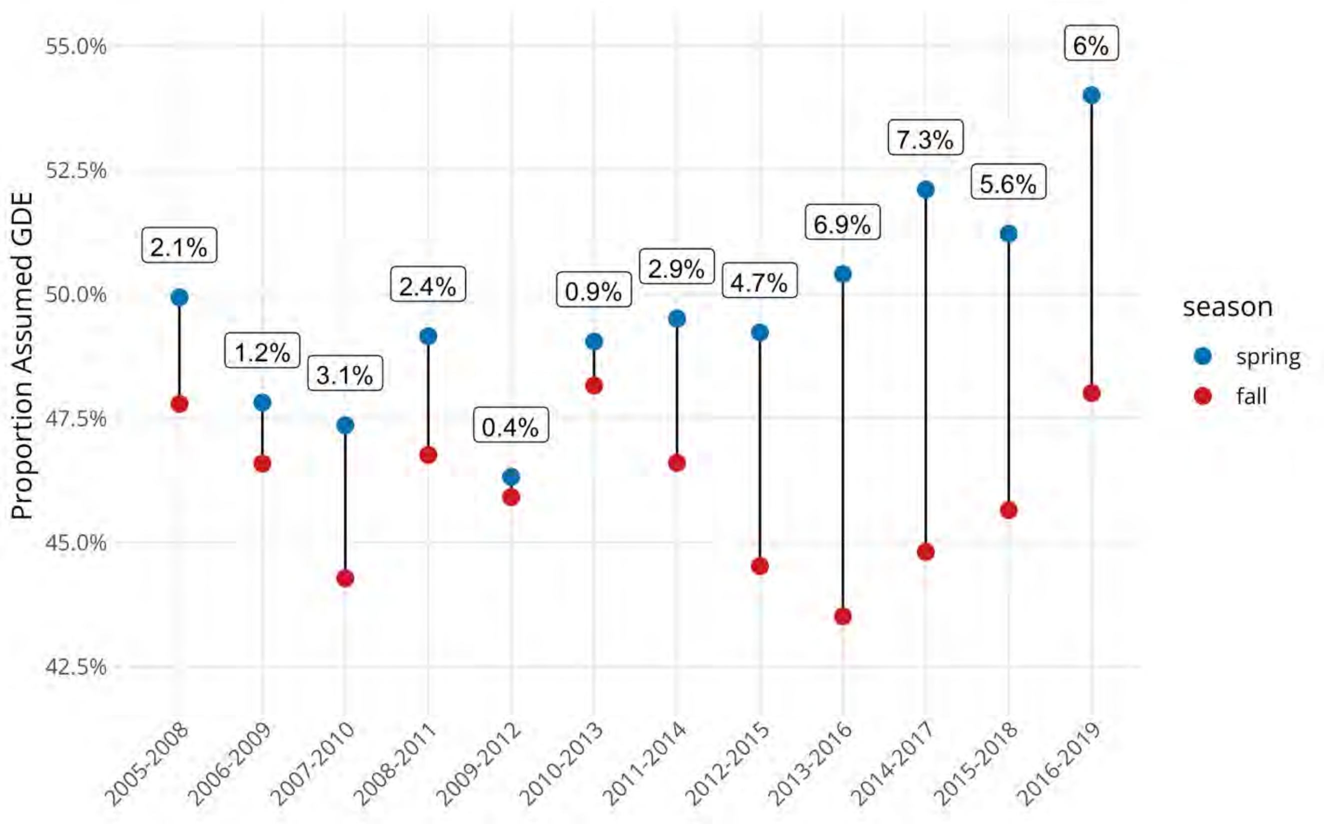


Figure 2.3-46: GDE classification based on the application of a 30-foot depth to groundwater threshold on mapped potential GDEs. Text labels indicate the range between the spring and fall GDE area (relative to all potential GDEs).

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%

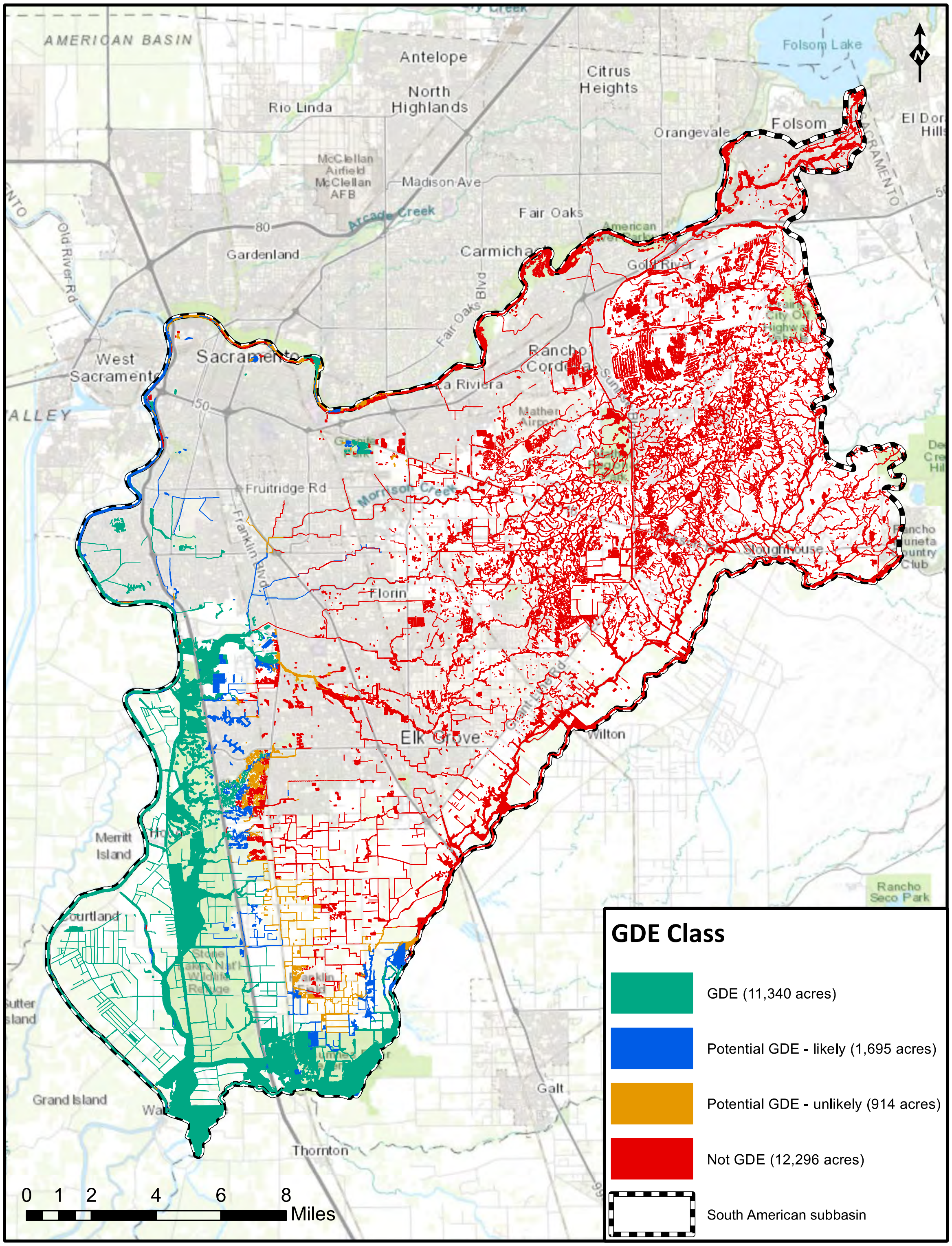


Figure 2.3-47: GDE likelihood classification of potential GDEs from 2005-2018

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.

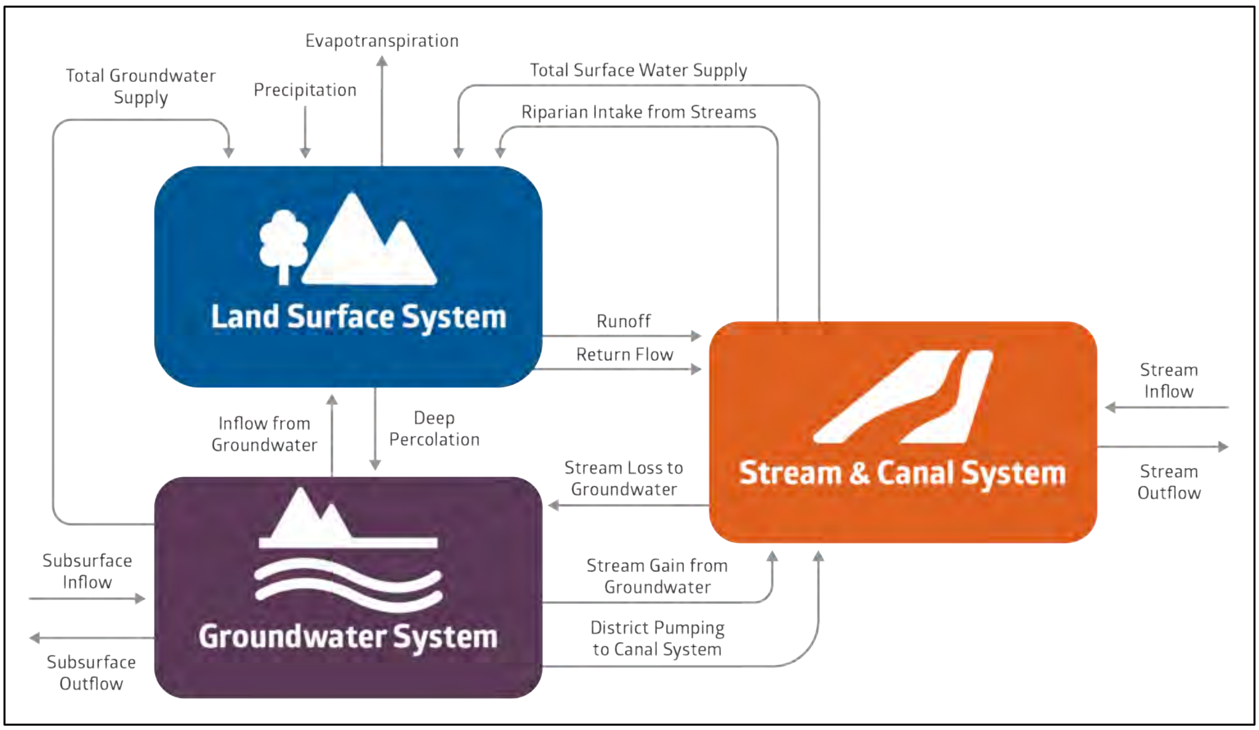


Figure 2.4-1: Generalized Water Budget Diagram

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.

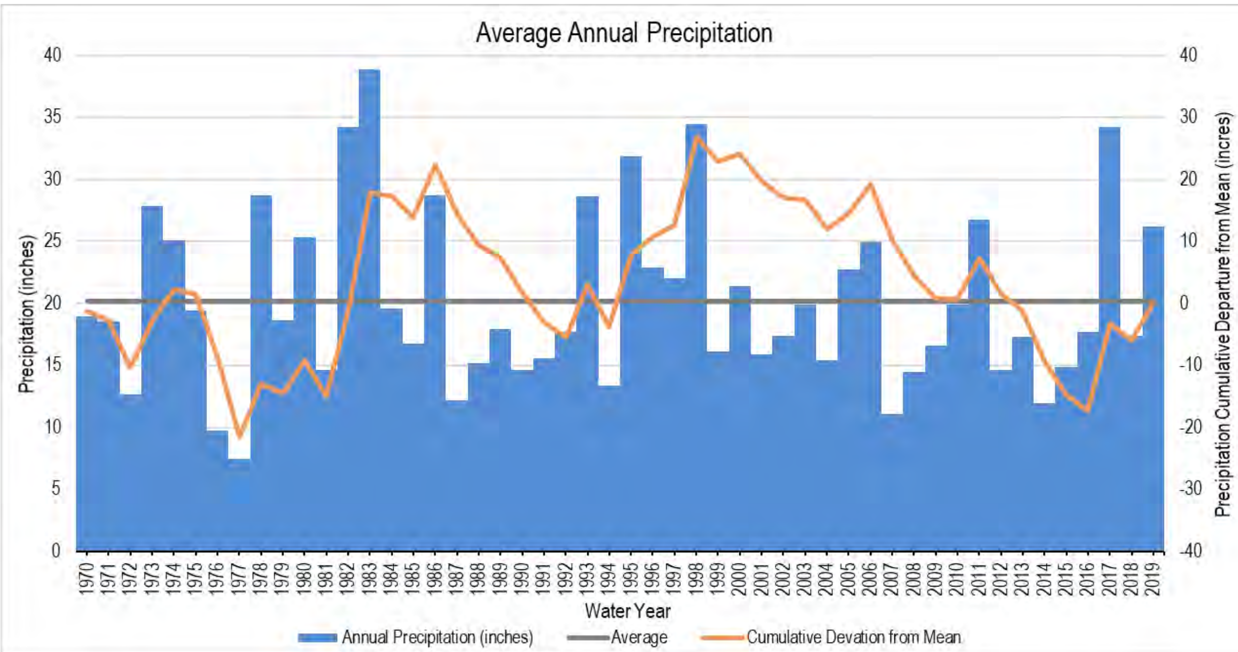


Figure 2.4-2: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation in the South American Subbasin

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).

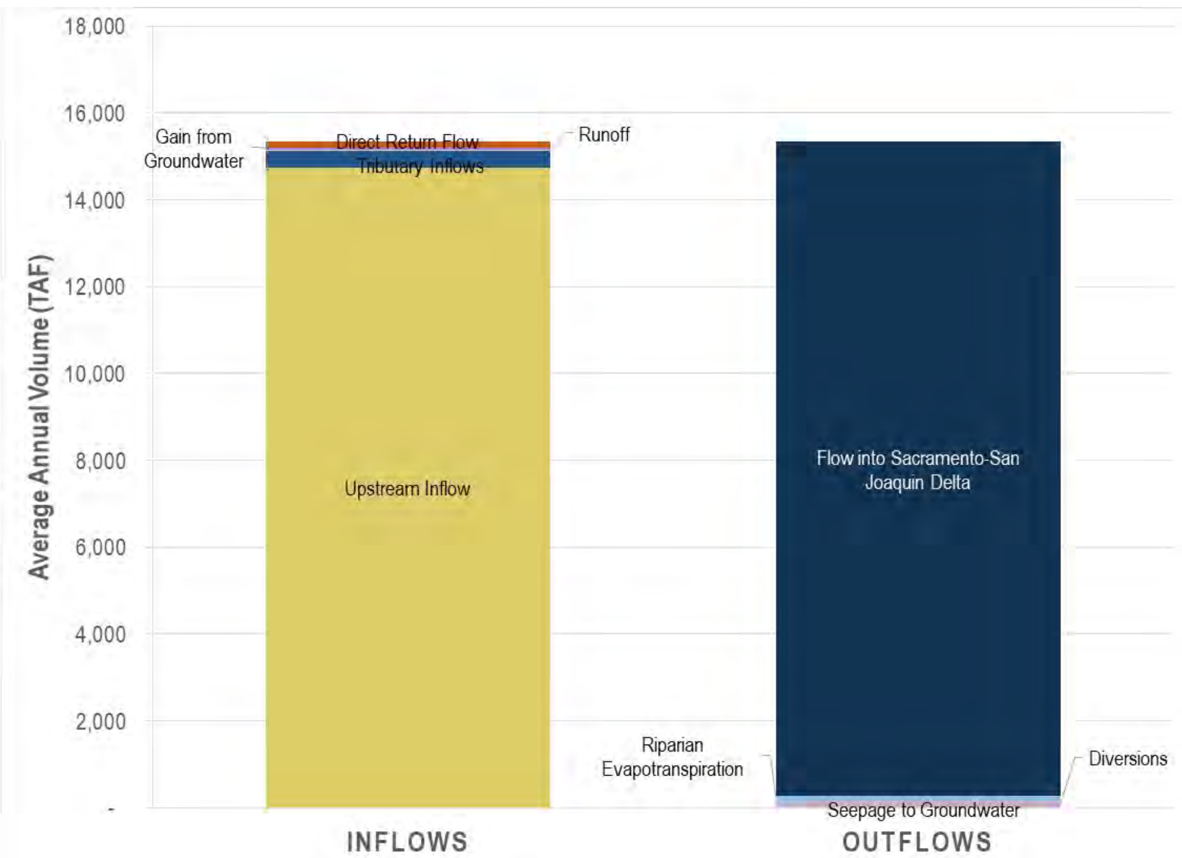


Figure 2.4-3: Historical Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

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).

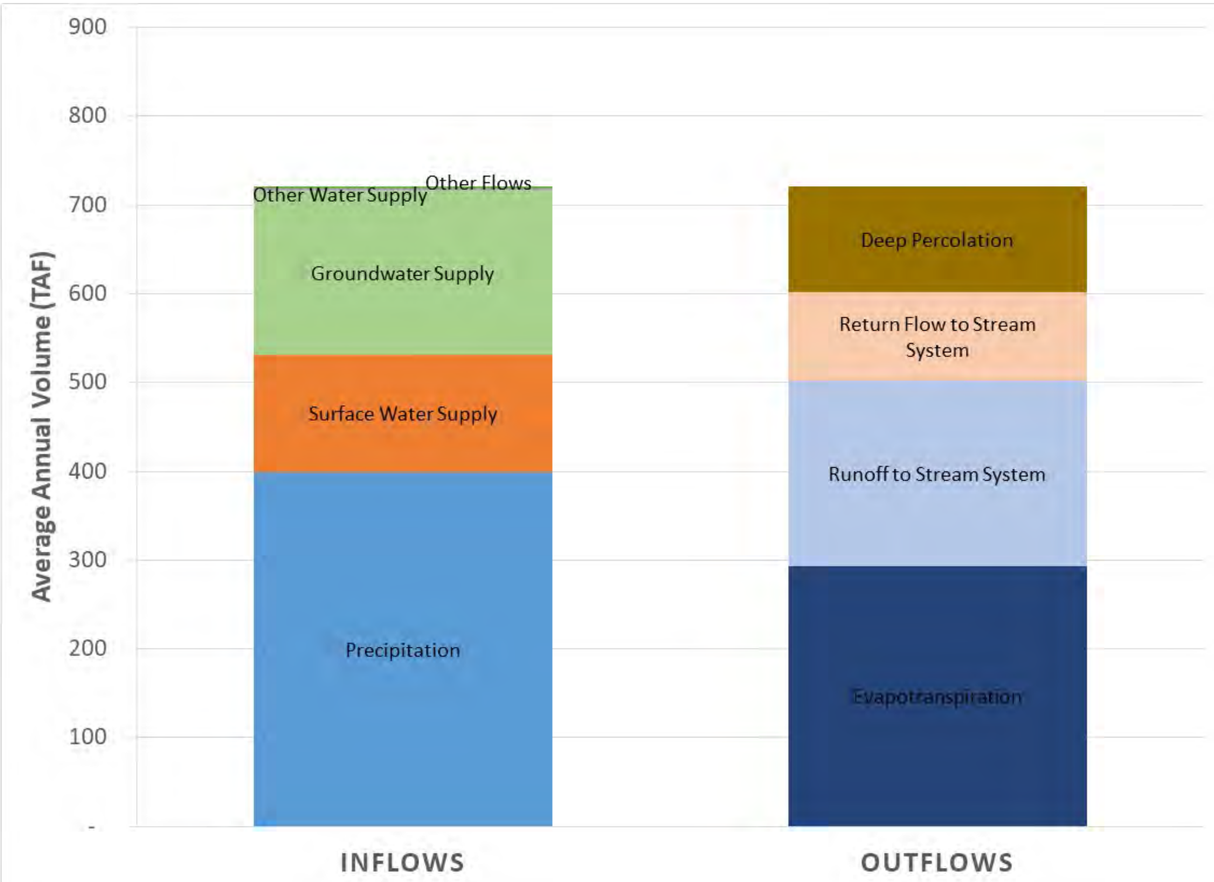


Figure 2.4-4: Historical Average Annual Water Budget – Land Surface System, South American Subbasin

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).

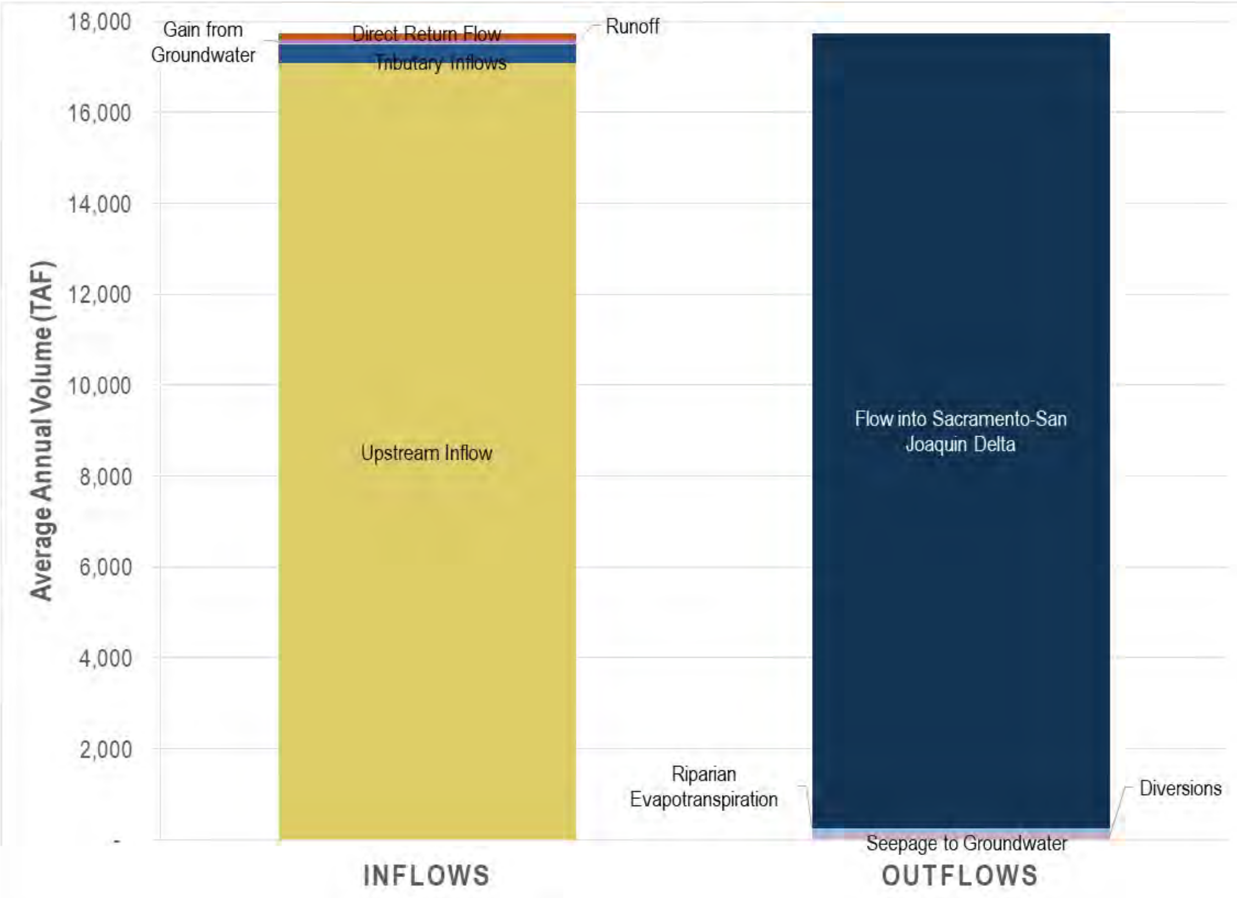


Figure 2.4-6: Current Conditions Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

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.

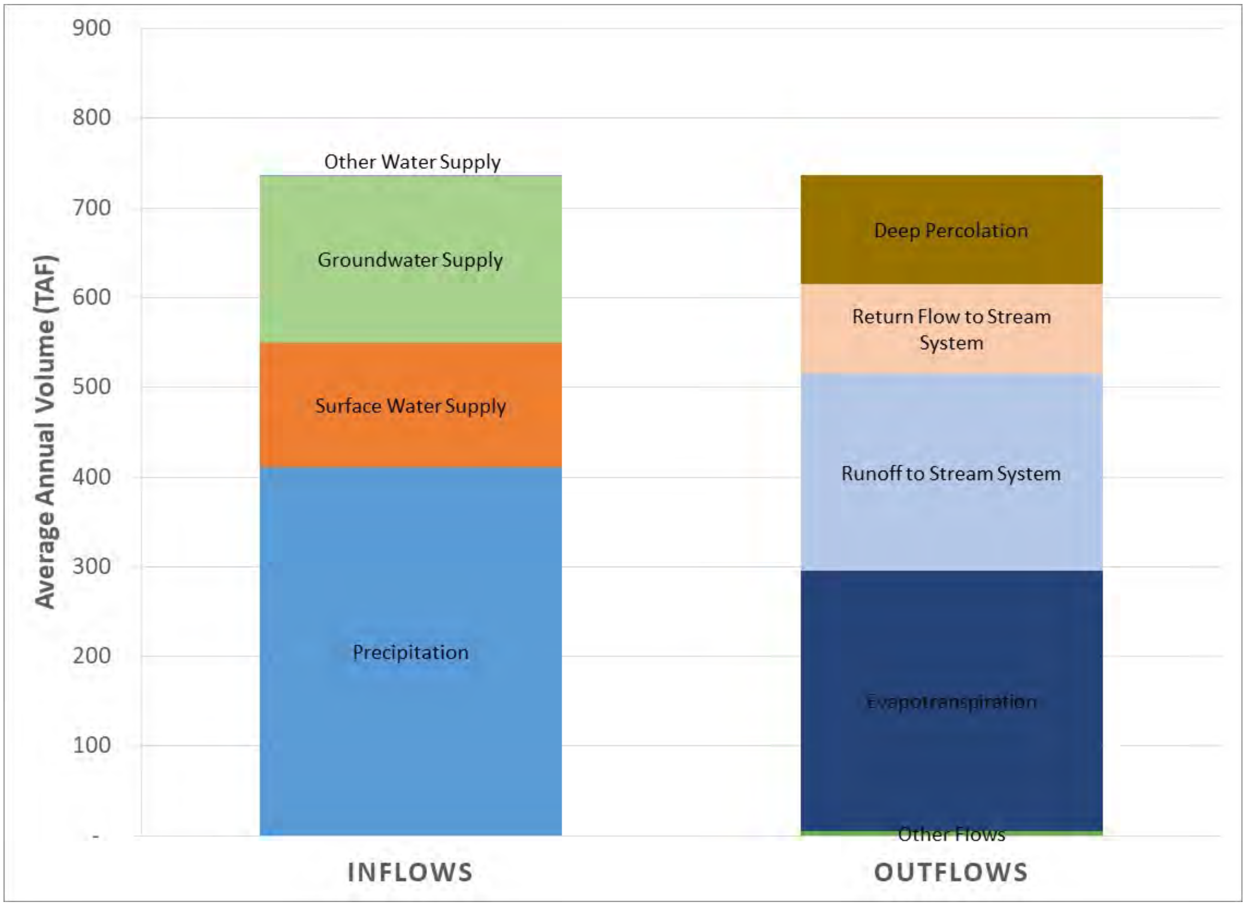


Figure 2.4-7: Current Conditions Average Annual Water Budget – Land Surface System, South American Subbasin

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.

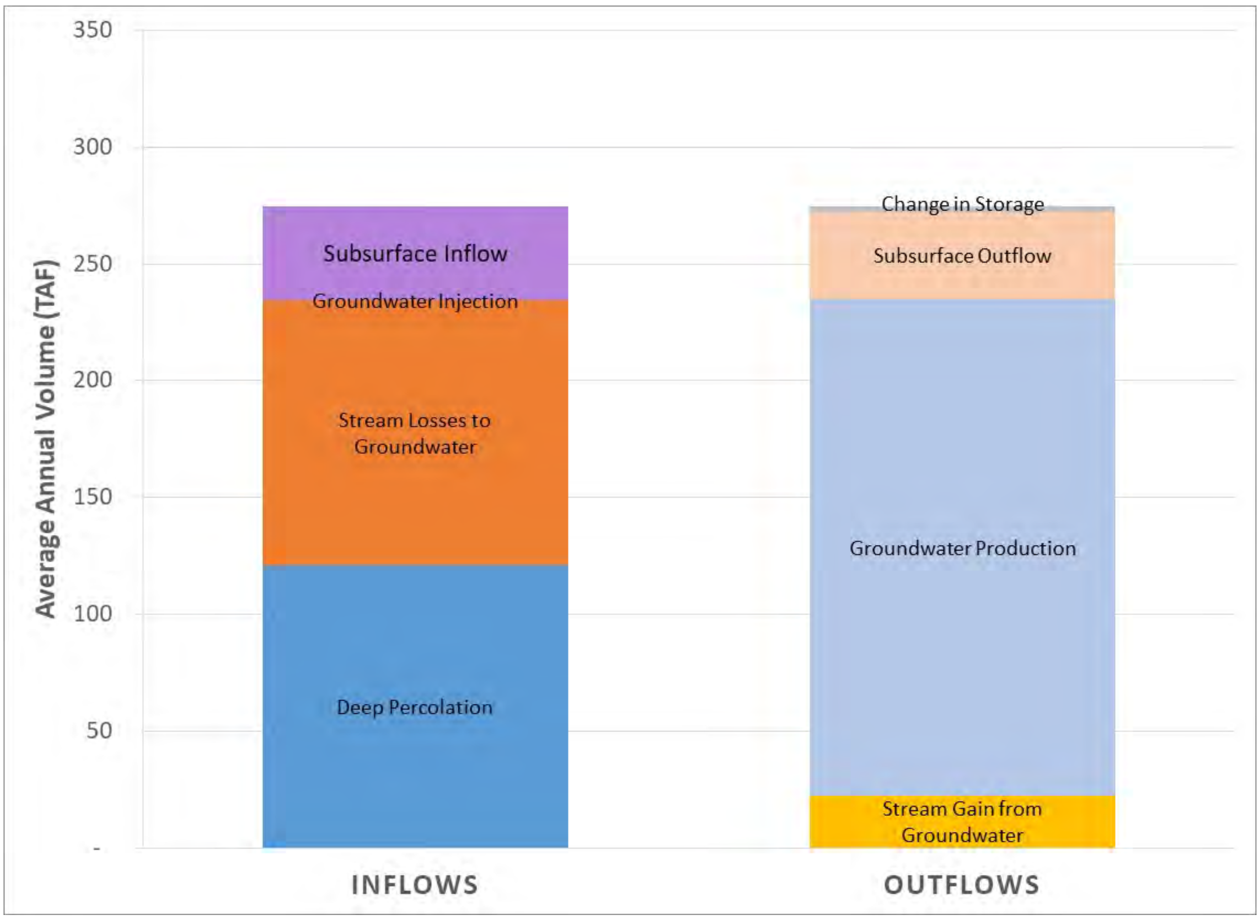


Figure 2.4-8: Current Conditions Average Annual Water Budget – Groundwater System, South American Subbasin

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.

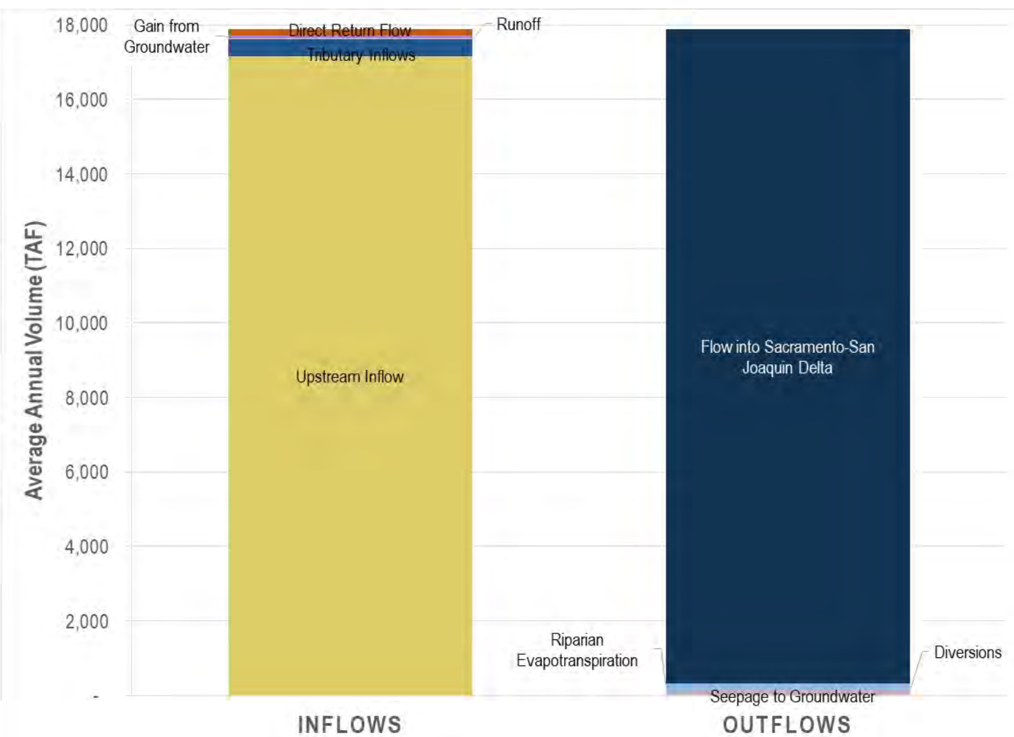


Figure 2.4-9: Projected Conditions Without Climate Change Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

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.

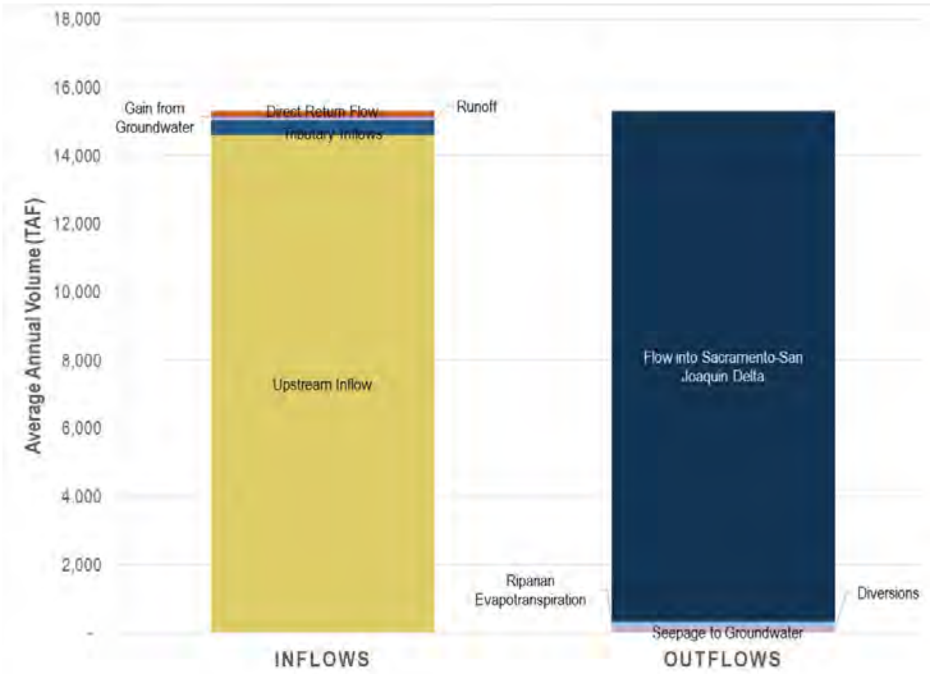


Figure 2.4-12: Projected Conditions With Climate Change Average Annual Water Budget – Stream and Canal Systems, South American Subbasin

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.

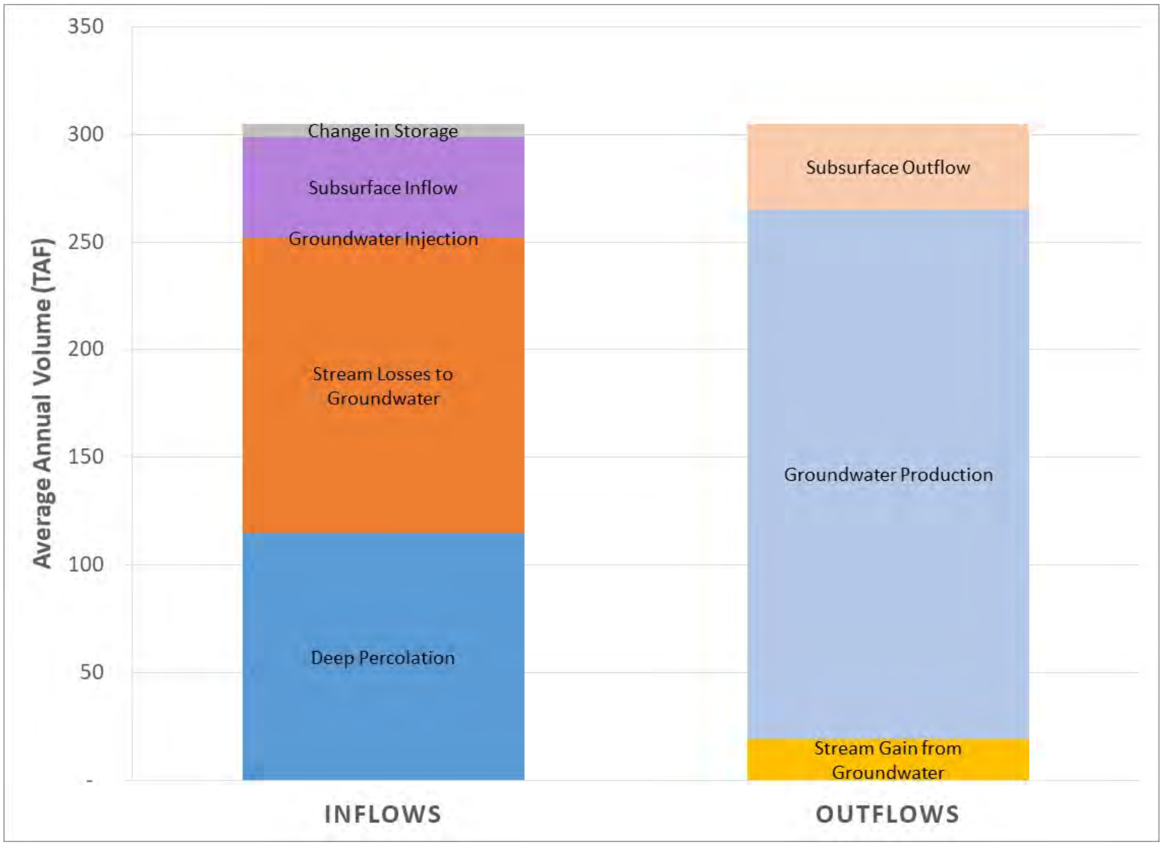


Figure 2.4-14: Projected Conditions With Climate Change Average Annual Water Budget – Groundwater System, South American Subbasin

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.

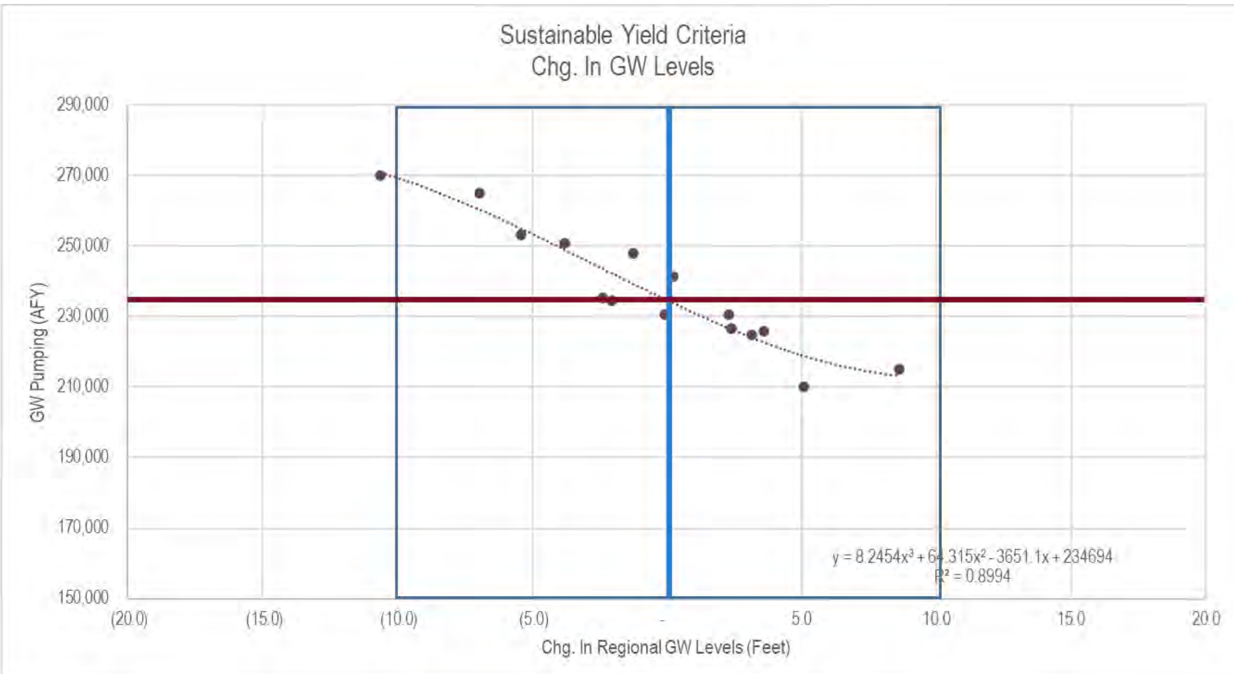


Figure 2.5-1(a) Relationship between Groundwater Pumping and Change in Groundwater Levels

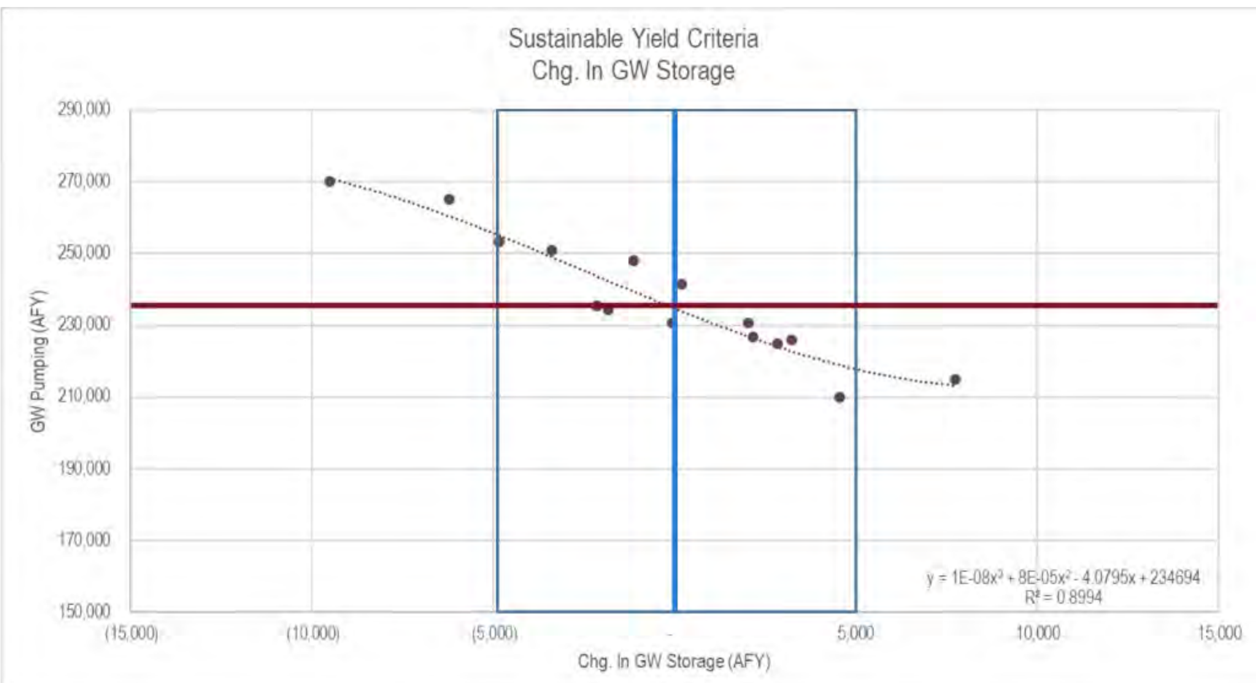


Figure 2.5-1(b) Relationship between Groundwater Pumping and Change in Groundwater Storage

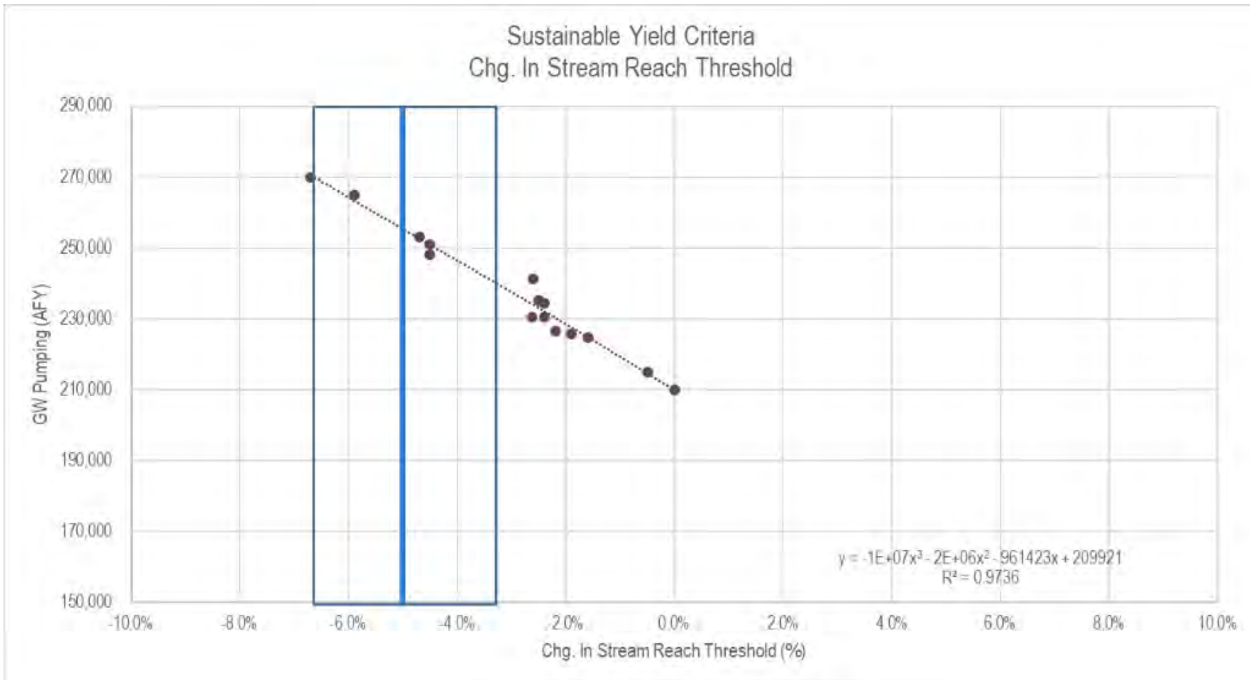


Figure 2.5-1(c) Relationship between Groundwater Pumping and Change in ISW Stream Reach

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**.

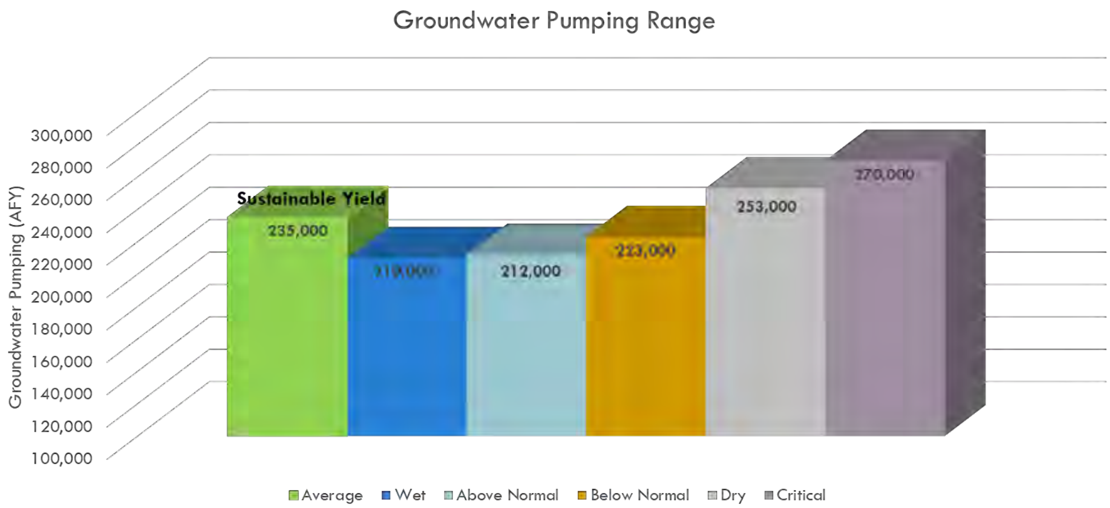


Figure 2.5-2: Operational Flexibility Provided by the SASb Sustainable Yield