NORTH AMERICAN SUBBASIN
Groundwater Sustainability Plan

PREPARED FOR:

RD1001 GSA

Sacramento Groundwater Authority GSA

South Sutter Water District GSA

Sutter County GSA

West Placer County GSA

DECEMBER 2021

This page left intentionally blank

North American Subbasin Groundwater Sustainability Plan

Prepared for:

Sacramento Groundwater Authority GSA
Reclamation District 1001 GSA
South Sutter Water District GSA
Sutter County GSA
West Placer GSA

Prepared by:

GEI Consultants
2868 Prospect Park Drive, Suite 400
Sacramento, CA 95670

December 2021

This page left intentionally blank

Table of Contents

List of Figures

List of Tables

List of Appendices

Acronyms and Abbreviations

Act (or SGMA)	Sustainable Groundwater Management Act
AB	Assembly Bill
AFB	Air Force Base
AF	acre-feet
AFY	acre-feet per year
APN	assessor parcel number
As	arsenic
ASR	Aquifer Storage and Recovery
AWMP	Agricultural Water Management Plan
Basin Plan	Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin
bgs	below ground surface
BMP	Best Management Practice
CASGEM	California Statewide Groundwater Elevation Monitoring
CCBL	Current Conditions Baseline
CCR	California Code of Regulations
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
CFWID	Camp Far West Irrigation District
cfs	cubic feet per second
CGPS	continuous global positioning stations
CrVI	hexavalent chromium
CoSANA	Cosumnes-South American-North American groundwater model
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DAC	Disadvantaged Community
DDW	Division of Drinking Water
DMS	data management system
DWR	California Department of Water Resources
EC	electrical conductivity
EPA	U.S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
Fe	iron
Ft	feet
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	groundwater dependent ecosystem
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
ILRP	Irrigated Lands Regulatory Program
InSAR	interferometric synthetic aperture radar
IRWMP	Integrated Regional Water Management Program
JPA	Joint Powers Authority
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
Mn	manganese
M&I	municipal and industrial
MO	measurable objective

MOA	Memorandum of Agreement
msl	mean sea level
MT	minimum threshold
MW	monitoring well
N	nitrogen
NASb or Subbasin	North American Subbasin
NAVD88	North American Vertical Datum of 1988
NAWQA	National Water-Quality Assessment Program
NBCHCP	Natomas Basin Conservancy Habitat Conservation Plan
NCC	Natomas Cross Canal
NCCAG	Natural Communities Commonly Associated with Groundwater
NDMA	N-Nitrosodimethylamine
NDVI	Normalized Difference Vegetation Index
NEPA	National Environmental Policy Act
NID	Nevada Irrigation District
NM	no measurement code
NULE	Non-Urban Levee Evaluation
NMWC	Natomas Mutual Water Company
NWIS	National Water Information System
OWHD	Omochumne-Hartnell Water District
PCBL	Projected Conditions Baseline
PCBL+CC	Projected Conditions Baseline with Climate Change
PCE	perchloroethylene
PCWA	Placer County Water Agency
PFAS	per- and poly-fluoroalkyl substances
Plan	Groundwater Sustainability Plan
PMA	Projects and Management Actions
PWS	public water system
RCIC	Regional Contamination Issues Committee
RD	Reclamation District
RD 1001	Reclamation District 1001
RP	reference point
RPWS	reference point to water surface
RMS	representative monitoring site
RWA	Regional Water Authority
RWRP	Regional Water Reliability Plan
SAFCA	Sacramento Area Flood Control Agency
SAFER	Safe and Affordable Fund for Equity and Resilience
SAGBI	Soil Agricultural Groundwater Banking Index
SASb	South American Subbasin
SB	Senate Bill
SB X7-7	Water Conservation Act of 2009
SCEHD	Sutter County Environmental Health Division
SCEMD	Sacramento County Environmental Management Department
SCWA	Sacramento County Water Agency
SDAC	Severely Disadvantaged Community
SGA	Sacramento Groundwater Authority
SGMA	Sustainable Groundwater Management Act
Sierra Nevada	Sierra Nevada Mountain range
SJWD	San Juan Water District
SMC	Sustainable Management Criteria

SMCL	Secondary Maximum Contaminant Level
SSWD	South Sutter Water District
State Water Board	California State Water Resources Control Board
Subbasin	North American Subbasin
SWRCB	State Water Resources Control Board
TCE	Trichloroethylene
TDS	total dissolved solids
TSS	Technical Support Services Program
U.S.	United States of America
UAIC	United Auburn Indian Community
USBR	United States Bureau of Reclamation
USGS	United States Geologic Survey
UWMP	Urban Water Management Plan
WAF	Water Accounting Framework
Water Code	California Water Code
WCR	well completion report
WD	Water District
WDR	Waste Discharge Requirements
WEP	Water Efficiency Program
WFA	Water Forum Agreement
WPGSA	West Placer Groundwater Sustainability Agency
WSCP	Water Shortage Contingency Plan
WWTP	wastewater treatment plant

Executive Summary

Overview

In 2014, the California Legislature passed the Sustainable Groundwater Management Act (SGMA), which became effective on January 1, 2015. SGMA requires local Groundwater Sustainability Agencies (GSAs) to develop Groundwater Sustainability Plans (GSPs) that, among other things, explain how the basin will be managed sustainably over a 20-year timeframe. SGMA provides authorities to support locally controlled sustainable management of groundwater – meaning in a way that does not produce undesirable results such as chronic lowering of groundwater levels, causing subsidence or degrading water quality.

The North American Subbasin (NASb or Subbasin) includes five GSAs that have worked cooperatively to develop this single GSP covering the 535 square-mile subbasin that includes portions of Placer, Sacramento, and Sutter counties. The GSAs include: Reclamation District 1001 (RD 1001) GSA; Sacramento Groundwater Authority (SGA) GSA; South Sutter Water District (SSWD) GSA; Sutter County GSA; and West Placer GSA.

SGMA requires certain information be included in every GSP. This includes, among other things, the subbasin setting, a hydrogeological conceptual model, a comprehensive water budget, a basin-wide monitoring network, sustainable management criteria, and projects and management actions necessary to ensure the Subbasin's sustainability. A summary of each of the primary NASb GSP sections is provided below.

ES 1 – Introduction

SGMA effectively prescribes four basic steps to the management process: 1) form a GSA; 2) develop and adopt a GSP; 3) implement the GSP to achieve a sustainability goal and avoid undesirable results within 20 years; and 4) report the implementation activities to DWR to document whether progress towards the sustainability goal and the avoidance of undesirable results are being achieved.

Ultimately, five GSAs were formed to manage groundwater in the NASb, completing Step 1. Figure ES-1 shows the location of the Subbasin and the GSAs. This GSP and adoption by each GSA will complete Step 2. The GSP will be assessed every 5 years as additional information becomes available. Steps 3 and 4 will be implemented over the next 20 years.

The NASb is bounded by four adjacent subbasins. Figure ES-1 shows the location of the NASb along with the adjacent subbasin names and locations. The NASb is closely coordinating with these subbasins.

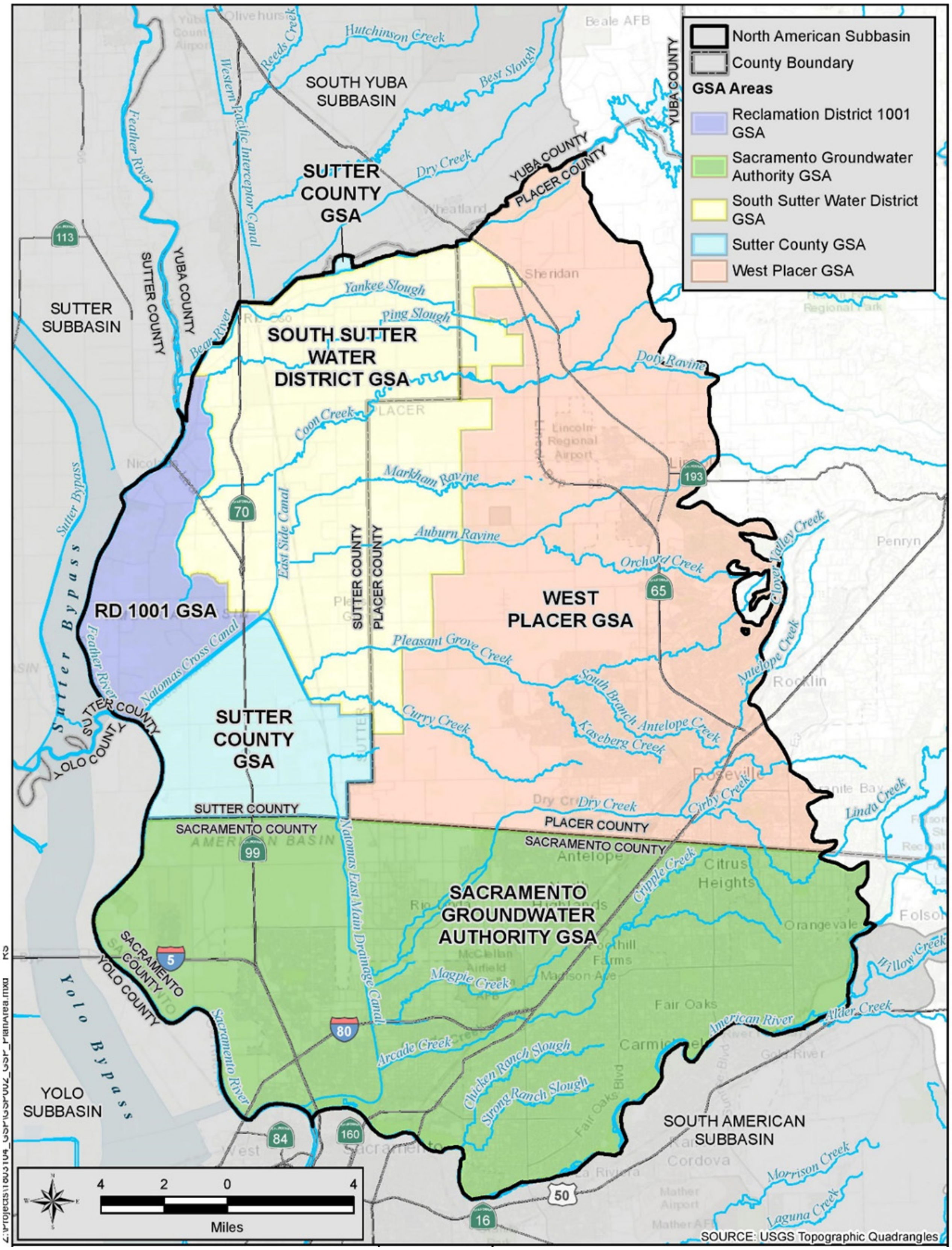


Figure ES-1. North American Subbasin, GSAs and Adjacent Subbasins

ES 2 – Agency Information

The five GSAs, by mutual agreement, selected the SGA GSA to be the Plan manager and lead agency for the preparation and implementation of the NASb GSP. The GSAs have entered into a Memorandum of Agreement (MOA) for the implementation of this GSP, which includes monitoring and reporting in the Subbasin along with projects and management actions.

ES 3 – Plan Area

The NASb encompasses about 342,000 acres in Sutter, Placer, and Sacramento counties and is bounded by the American, Bear, Feather, and Sacramento rivers. The Sierra Nevada foothills form the eastern boundary of the Subbasin. The NASb is about 40 percent urban, 30 percent farmland (mostly in Placer and Sutter counties), and less than 1 percent riparian vegetation. About 30 percent of the land is either native vegetation or fallowed farmland that could not be fully characterized. Most of the urban area is in Sacramento County and the southeastern portion of Placer County. Currently, the NASb has about 16,900 acres of habitat conservation preserves and easements, of which about 1,700 acres is riparian habitat. Figure ES-2 shows the general locations of these water use sectors.

Within the NASb, there are federal, state, county, and tribal agencies with land use jurisdiction. Within Placer and Sacramento counties, there are 20 water agencies, water districts, city/county water departments and water wholesalers that provide water to residents in the cities and towns. There are also over 40 small community water and non-community non-transient water systems, that are overseen by the counties and the state, whose water supply is from groundwater. Irrigation districts are also present that provide surface water for agriculture. Within many of the irrigation districts and cities are reclamation districts that are responsible for managing and maintaining the levees, freshwater channels, or sloughs, canals, pumps, and other flood protection structures in the area.

Surface water is available to most areas of the Subbasin and is supplemented with groundwater. There are about 3,800 water supply wells present in the Subbasin (about 2,600 domestic, 800 agricultural, 400 municipal and industrial wells).

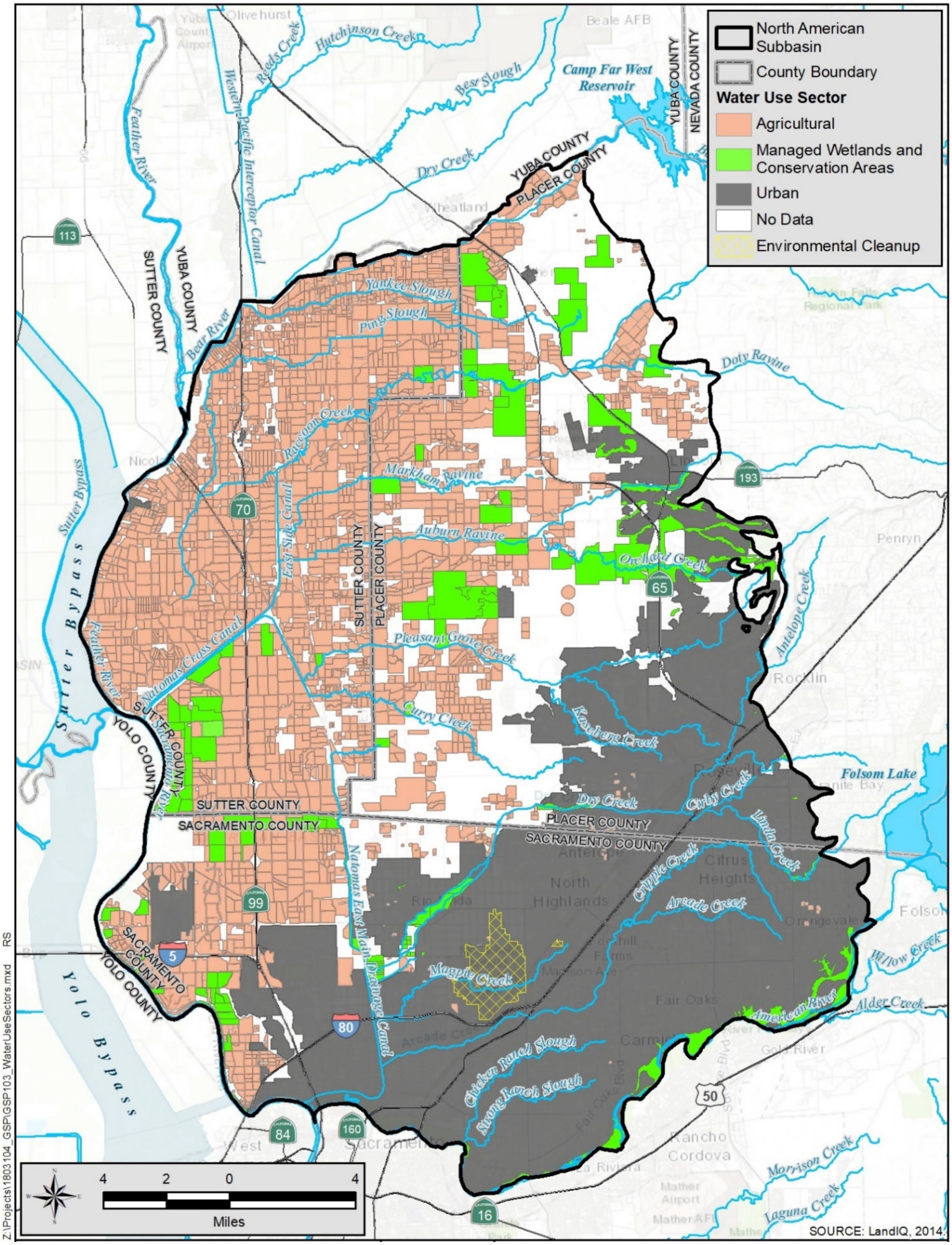


Figure ES-2. Water Use Sectors

ES 4 – Hydrogeologic Setting

The NASb is in the Sacramento Valley and is filled largely with sediments derived from the adjacent Sierra Nevada foothills, which contain fresh water. In general, these fresh-water bearing sediments beneath the NASb are thinnest to the east and thicken up to 2,000 feet to the west (see Figure ES-3). The sediments consist of alternating layers of clays, silts, sand and gravel. The sand and gravels layers into which wells are constructed are referred to as aquifers. These sand and gravel layers were deposited by meandering rivers and creeks, so they are not continuous across the entire Subbasin. Although the sediments are not present as continuous layers, they are interconnected. This was demonstrated by observing that groundwater levels in the various sand and gravel layers have similar levels and trends. Based on this information, the NASb is interpreted as having one principal aquifer.

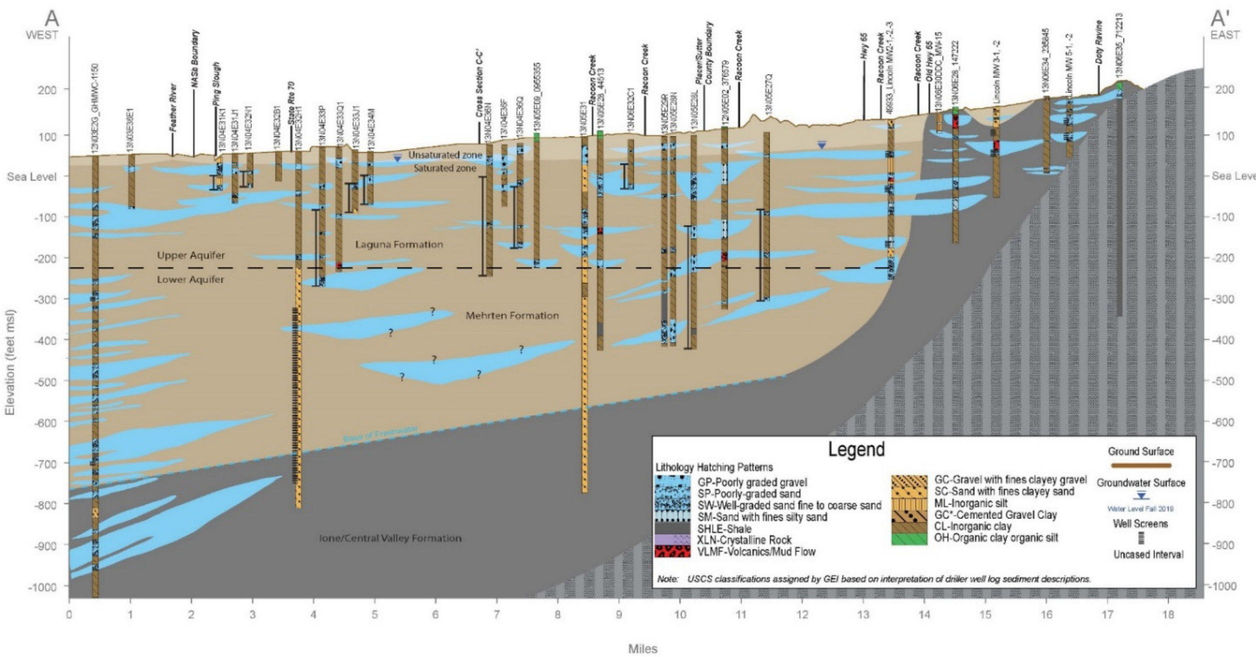


Figure ES-3. Geologic Section

Groundwater is recharged from throughout the surface of the Subbasin and from groundwater inflow from adjacent subbasins. No geologic sediments are impermeable, so some recharge occurs in all areas that are not covered by impermeable surfaces (such as asphalt or concrete). This is particularly important in agricultural areas where, even though there are low permeability soils, there are more than one hundred thousand acres of land that have applied or ponded water throughout the growing season, which results in large volumes of recharge to the Subbasin.

ES 5 – Groundwater Conditions

Groundwater levels in the western portion of the Subbasin are generally stable through time dating back to early in the 20th century. Groundwater levels in the central part of the Subbasin showed long-term declines in the north-central portion until the mid-1960s and in the south-central portion until the mid-1990s, when conjunctive use programs arrested these declines and allowed groundwater levels to begin to recover. Groundwater levels in the eastern portion of the subbasin have been generally stable since the 1970s, but they do show declines during dry periods with recovery during wet periods.

The groundwater contours show a pumping depression in the center of the Subbasin that is currently about 30 feet below mean sea level. Groundwater flows radially toward this depression, from the fringes of the Subbasin toward the center. The depression has been stabilized, with groundwater levels generally declining during dry periods and recovering during wet periods.

Limited land subsidence due to groundwater pumping was documented up to the early 1990s, but there were no documented impacts associated with the subsidence. Since then, the subsidence has been negligible.

Areas with surface water that is interconnected with groundwater were identified along portions of the American, Bear, Feather, and Sacramento rivers, along with creeks primarily in the western part of the Subbasin.

Potential groundwater dependent ecosystems (GDEs) identified in the natural communities commonly associated with groundwater dataset were evaluated using groundwater levels and the types of vegetation to classify them as *Likely*, *Less Likely* or *Unlikely* GDEs. Classifications of the species types and diversity of vegetation were used to further prioritize these areas. In many cases, GDEs were identified along canals and natural waterways that are used to convey surface water to agricultural users. In some cases, GDEs were identified in areas that could be supported by groundwater, but it appears their primary source of supply is groundwater pumped from wells.

Generally, the quality of groundwater in the Subbasin is suitable for nearly all uses, with the exception of contamination plumes and localized, naturally-occurring and human-caused quality issues, which may affect the supply, beneficial uses, and potential management of groundwater in the Subbasin if not properly managed. Total dissolved solids (TDS) and nitrate were identified as constituents that represent general conditions in the Subbasin, with some wells displaying upward trends. Nitrate is below the drinking water standards for all wells in the Subbasin. TDS exceeds the drinking water standards in some wells, predominantly in the western and eastern portions of the Subbasin. The higher salinity concentrations are generally considered to be present due to natural sources.

In the NASb, there are a few large groundwater contamination sites and multiple smaller sites that could affect supply and beneficial uses of groundwater in the Subbasin. The most significant of these sites are the former McClellan Air Force Base (AFB) and the Aerojet Superfund Site (outside of the Subbasin). Cleanup activities, as overseen by U.S. Environmental Protection Agency, SWRCB, and the California Department of Toxic Substances Control, have been in progress for years and contaminants appear to be contained. SGA and interested water agencies meet with regulators on a quarterly basis to discuss the plumes' containment and how groundwater management activities may affect the remediation.

ES 6 – Water Budgets

Water budgets were created utilizing the Cosumnes-South American-North American (CoSANA) model, a fully integrated surface and groundwater numerical flow model that covers the entire NASb as well as the adjacent South American and the Cosumnes subbasins. CoSANA integrates the groundwater aquifer with the surface hydrologic system and land surface processes and operations. CoSANA was used to preform analyses of hydrogeologic conditions, agricultural and urban water demands, agricultural and urban water supplies and an evaluation of current and projected future regional conditions, including climate change, for the NASb. Because the model is integrated with the adjacent subbasins to the south, future projected conditions, along with climate change and projects, were assessed for the entire region.

The water budget for current conditions in the NASb showed the Subbasin has a current surplus of water, which was confirmed by groundwater levels rising in the central portions of the Subbasin. This surplus continues into the future, but in lesser amounts. The future conditions modeling included planned new developments, along with changes in agriculture and projected changes in water supply. When the future conditions were modeled with a central tendency climate change scenario, the Subbasin has an estimated future deficit of about 3,500 acre-feet per year. Table ES-1 shows the average annual estimated change in groundwater storage under each of these conditions.

Table ES-1. Estimated Groundwater Change in Storage

Model Baseline Condition	Average Annual Groundwater Storage Change (acre-feet)
Historical (water years 2009 through 2018)	31,900
Current (water years 1970 through 2019)	14,900
Projected Future Demands over 50 years (using 1970 through 2019 hydrology)	5,400
Projected Future Demands over 50 years with Climate Change (using 1970 through 2019 hydrology)	-3,500

ES 7 – Monitoring Networks

Groundwater levels and water quality are currently being monitored by the GSAs, local agencies, counties, DWR and federal entities in over 160 wells, not including those present near contamination sites. Representative monitoring wells were selected from this larger network that are spatially distributed, actively being monitored, and have construction details to prove which portion of the aquifer they are monitoring. A total of 41 representative monitoring wells for groundwater levels (to monitor for chronic lowering of groundwater levels, reduction of storage, the potential for subsidence, and surface water depletion) were selected. The monitoring locations were developed to protect beneficial uses and users including, domestic well owners, GDEs and interconnected surface water.

Separate representative groundwater quality monitoring networks were developed. Sixteen shallow groundwater monitoring wells were selected to monitor water quality in the shallow portions of the aquifer in areas that are used by domestic well owners. The deeper portions of the aquifer, commonly used by public water systems, will be monitored by over 200 public supply wells that are required to monitor and report the analyses to state agencies.

There are instances of poorer water quality along the westerly and eastern edges of the Subbasin, so a separate sentry well monitoring network was developed to track the potential movement of these waters into the Subbasin. This sentry well network is not designated as being representative monitoring wells where minimum thresholds and measurable objectives would have been established.

ES 8 – Sustainable Management Criteria (SMC)

The NASb sustainability goal is to:

> *Manage groundwater resources sustainably for beneficial uses and users to support the lasting health of the Subbasin's community, economy, and environment. This will be achieved through:*
>
> - *The monitoring and management of established SMC;*
> - *Continued expansion of conjunctive management of groundwater and surface water;*
> - *Proactively working with local well permitting and land use planning agencies on effective groundwater policies and practices;*
> - *Continued GSA coordination and stakeholder engagement; and*
> - *Continued improvement of our understanding of the Subbasin.*

Undesirable results, minimum thresholds, and measurable objectives were developed for five of the six SGMA sustainability indicators: chronic lowering of groundwater levels, reduction of storage, land subsidence, degradation of water quality, and surface water depletion. Seawater intrusion has not occurred in the past and is unlikely to occur in the future and, therefore, sustainability criteria were not established for this sustainability indicator. As allowed under SGMA, the NASb uses groundwater elevations as a proxy for minimum thresholds and measurable objectives for its applicable sustainability indicators, with the exception of degradation of water quality. Undesirable results are summarized in Table ES-2 below.

Table ES-2. NASb Undesirable Results

Sustainability Indicator	Undesirable Result Definition
Chronic lowering of groundwater levels	*20% or more of all NASb representative monitoring sites have minimum threshold exceedances for 2 consecutive Fall measurements (8 out of 41 wells)*
Reduction of storage	*20% or more of all NASb representative monitoring sites have minimum threshold exceedances for 2 consecutive Fall measurements (8 out of 41 wells)*
Degraded groundwater quality	For public water system wells • *The basin wide average TDS concentrations of* <u>*all*</u> *public water system wells exceeds 400 mg/l* *OR* • *The basin wide average nitrate (as N) concentration of* <u>*all*</u> *public water system wells exceeds 8 mg/l* For the shallow aquifer (i.e. domestic and self-supplied) wells • *25% of the representative monitoring sites' (RMS) TDS or nitrate (as N) concentrations exceed state maximum contaminant levels (MCLs)*
Land Subsidence	*The rate of inelastic subsidence exceeds 0.5 feet over a five-year period over an area covering approximately five or more square miles*
Depletion of surface water	*20% or more of the NASb interconnected surface water (ISW) representative monitoring sites (RMSs) have minimum threshold exceedances for 2 consecutive Fall measurements (5 out of 21)*

ES 9 – Projects and Management Actions

Because the water budget estimated that the Subbasin may be about 3,500 AFY in deficit with future demands and with climate change, the NASb evaluated a conjunctive use project that can resolve the deficit and has a net benefit of reducing groundwater pumping by 5,000 AFY. The project uses, for the most part, existing infrastructure, so project costs are minimal and are to be funded by the public water suppliers participating in the program.

A second planned project will make improve flood protection and habitat for aquatic species in the Natomas Cross Canal. As part of the continued water resources management of the NASb, six supplemental projects that are in the conceptual or planning level stages are also identified in the event projected conditions are worse than expected.

Five management actions are identified. The first management action is to continue development of the Sacramento Regional Water Bank, which will expand conjunctive use to further ensure basin sustainability. The second action is to explore potential revisions to Placer, Sacramento, and Sutter counties' and the City of Roseville's well permitting programs to assess whether the permitting ordinances can be improved to be more protective of domestic wells, GDEs and interconnected surface water, along with reducing potential impacts to designated representative wells. The third action is to proactively coordinate with land use agencies on their development of plans and approvals of new developments, to improve communications with the agencies and inform them of findings of this GSP, annual report findings, and whether groundwater can be relied upon for future growth without causing undesirable results. The fourth action will improve data collection and communication with domestic and other shallow well owners to protect these beneficial users of groundwater in the NASb. The fifth action will continue monitoring and assessment of the NASb's GDEs to better understand these ecosystems to help protect them.

ES 10 – Plan Implementation

The NASb GSAs estimate a budget of $1.15 million over the next five years for monitoring, reporting, GSP assessment and update, data management, coordination, outreach, and management actions. The budget also includes a 20 percent contingency for unanticipated expenses. The GSAs have also identified a funding plan in an MOA for GSP implementation. The budget does not include estimates of the costs for conjunctive use or development of the Sacramento Regional Water Bank, which already have funding through individual participating agencies. The budget also does not include the value of the in-kind time being provided by the participating GSAs.

The GSP identifies 28 specific implementation actions with associated schedules, where applicable. These actions are organized into the following categories: monitoring; data management; data analysis; coordination and outreach; and other management activities.

ES 11 – Notice and Communications

The GSAs reached out to the public by developing a website (nasbgroundwater.org) and a list of more than 300 interested parties. The GSAs sought input from small community water systems by notifying them through direct mailer post cards. The GSAs developed informational materials and held over 40 public meetings (both at board and city councils and monthly technical committee meetings) and four NASb-wide public workshops.

The public had opportunities to comment directly on this GSP during releases of draft chapters, through workshops and on the Public Draft GSP. If a comment was specific to an individual section of the GSP, the GSP text was revised. General comments that raised substantial technical or policy issues may have resulted in changes to multiple GSP sections. Comments that were general in nature or that did not raise substantial issues were noted, but no changes were made. The GSAs plan to continue public outreach and stakeholder engagement through the GSP implementation phase through various activities, including an annual public meeting to release the results of the Annual Report and the status of projects and management actions.

1. Introduction

In 2014, the Sustainable Groundwater Management Act (SGMA) was signed by the Governor of the state of California, setting the framework for local agencies to sustainably manage California's groundwater basins. To avoid potential State intervention, SGMA requires groundwater basins/subbasins designated by the California Department of Water Resources (DWR) as medium- or high-priority to follow four basic steps: 1) form a Groundwater Sustainability Agency (GSA); 2) develop and adopt a Groundwater Sustainability Plan (GSP or Plan); 3) implement the Plan to achieve a sustainability goal and avoid undesirable results within 20 years; and 4) report the implementation activities to the DWR to document whether the sustainability goal and the avoidance of undesirable results is being achieved. Ultimately, five GSAs were formed to manage groundwater in the North American Subbasin (NASb or Subbasin), completing Step 1. This GSP and adoption by each GSA will complete Step 2. This GSP will be assessed every 5 years, with amendments as needed to ensure the Plan is meeting its sustainability goal.

This GSP is a framework to provide for the sustainability of the NASb of the Sacramento Valley Groundwater Basin for the next 20 years. The NASb, designated as subbasin No. 5-021.64 by the DWR, is bounded on the north by the Bear River, on the south by the American River, to the west by the Feather and Sacramento rivers, and on the east by the Sierra Nevada foothills (*see* **Figure 1-1**). The NASb was designated by DWR as a high priority subbasin and therefore the formation of GSAs and the completion of a GSP is required to avoid potential State Water Resources Control Board (SWRCB) intervention. Surrounding subbasins were also designated as medium- or high-priority and are required to comply with SGMA. Groundwater is a critical resource to the Subbasin's community, economy, and environment by providing an average of 280,000 acre-feet per year (AFY) for public and agricultural supply or just under 50 percent of total water supply.

Agencies in the NASb have been actively managing groundwater for decades and have achieved positive groundwater management results. Groundwater levels within the Subbasin have been relatively stable for decades and have shown the ability to recover after periods of prolonged pumping and droughts. The passage of SGMA created an opportunity for a cooperative endeavor to develop a single GSP for the entire NASb. Beginning in January 2017, representatives of local agencies began coordination meetings that ultimately led to agreement to form five GSAs to cover the entirety of the Subbasin, while ensuring broad representation of the various stakeholder interests throughout the parts of the three counties comprising the NASb.

This GSP is organized into the following sections:

Section 1 – Introduction – Provides an overview of SGMA and associated requirements and introduces the contents of the Plan.

Section 2 – Agency Information – Provides a description of each GSA, contact information, implementation authority, and estimated costs for Plan implementation.

Section 3 – Plan Area – Describes the geography, historical and projected land uses, jurisdictional areas, water use sectors and water sources, existing water resources management plans, existing monitoring networks, and conjunctive use programs. The section also assesses the potential effects of implementing the Plan on water supplies.

Section 4 – Basin Setting – Describes the geologic conditions that control how groundwater moves in the Subbasin, recharge and discharge areas, general water quality, and principal aquifers.

Section 5 – Groundwater Conditions – Describes historical and current groundwater levels, changes in groundwater storage, water quality, subsidence, change in storage, and identification of interconnected surface water and groundwater dependent ecosystems.

Section 6 – Water Budgets – Provides a historical water budget and forecasts future groundwater use for the next 50-years to assess whether groundwater conditions will remain sustainable including the influence of climate change.

Section 7 – Monitoring Networks – Describes the monitoring networks to be used to assess sustainability indicators and monitoring protocols. Establishes an annual reporting mechanism to assess the management performance and for 5-year assessments of this GSP to maintain the Subbasin's sustainability.

Section 8 – Sustainable Management Criteria – Describes locally defined sustainability goals and undesirable results for the SGMA groundwater sustainability indicators. Establishes management criteria, the operating range in which groundwater levels will be maintained, in the form of minimum thresholds and measurable objectives.

Section 9 – Projects and Management Actions – Identifies current, planned, and supplemental projects and management actions to maintain groundwater sustainability.

Section 10 – Plan Implementation – Provides an overview of how the GSAs will regularly perform the activities needed to manage the Subbasin.

Section 11 – Notice and Communications – Provides a summary of GSA activities with interested parties.

Section 12 – References – List of materials used to develop this Plan.

This Plan was developed cooperatively by the GSAs in the NASb along with input from stakeholders and in coordination with the adjacent South Yuba, Sutter, Yolo, and South American subbasins.

Figure 1-1. North American Subbasin

This page intentionally left blank

2. Agency Information

This section provides a description of GSAs in the NASb and their legal authority to implement the GSP, along with contact information for the Plan manager. A cost estimate for implementing the GSP is provided along with a general description of how the GSAs plan to fund these expenses.

2.1 GSA Organization and Management Structure

Five agencies in the NASb filed with DWR to become GSAs to cover the entire NASb. DWR designated them as exclusive in 2016 and 2017. The five GSAs are listed below:

- Sacramento Groundwater Authority GSA
- Reclamation District 1001 (RD 1001) GSA
- South Sutter Water District (SSWD) GSA
- Sutter County GSA
- West Placer GSA

Figure 2-1 shows the areas covered by each GSA. All the GSAs have the legal authority to implement this GSP. A brief description of each GSA is provided below.

2.1.1 Sacramento Groundwater Authority GSA

The Sacramento Groundwater Authority (SGA) is a Joint Powers Authority formed in 1998 to manage the groundwater basin in Sacramento County north of the American River. In January 2016, SGA became the exclusive GSA in conformance with SGMA for its portion of the North American Subbasin.

The SGA draws its authority from a joint powers agreement executed by the cities of Citrus Heights, Folsom, and Sacramento and the county of Sacramento utilizing their common police powers. The signatories chose to manage the basin cooperatively by creating a governing board of directors comprised of representatives of 14 water agencies and other water users within their jurisdiction:

- California American Water
- Carmichael Water District
- Citrus Heights Water District
- City of Folsom
- City of Sacramento
- County of Sacramento
- Del Paso Manor Water District
- Fair Oaks Water District
- Golden State Water Company
- Natomas Central Mutual Water Company
- Orange Vale Water Company
- Rio Linda/Elverta Community Water District
- Sacramento Suburban Water District
- San Juan Water District
- Agricultural Representative
- Commercial/Industrial Self-supplied Representative

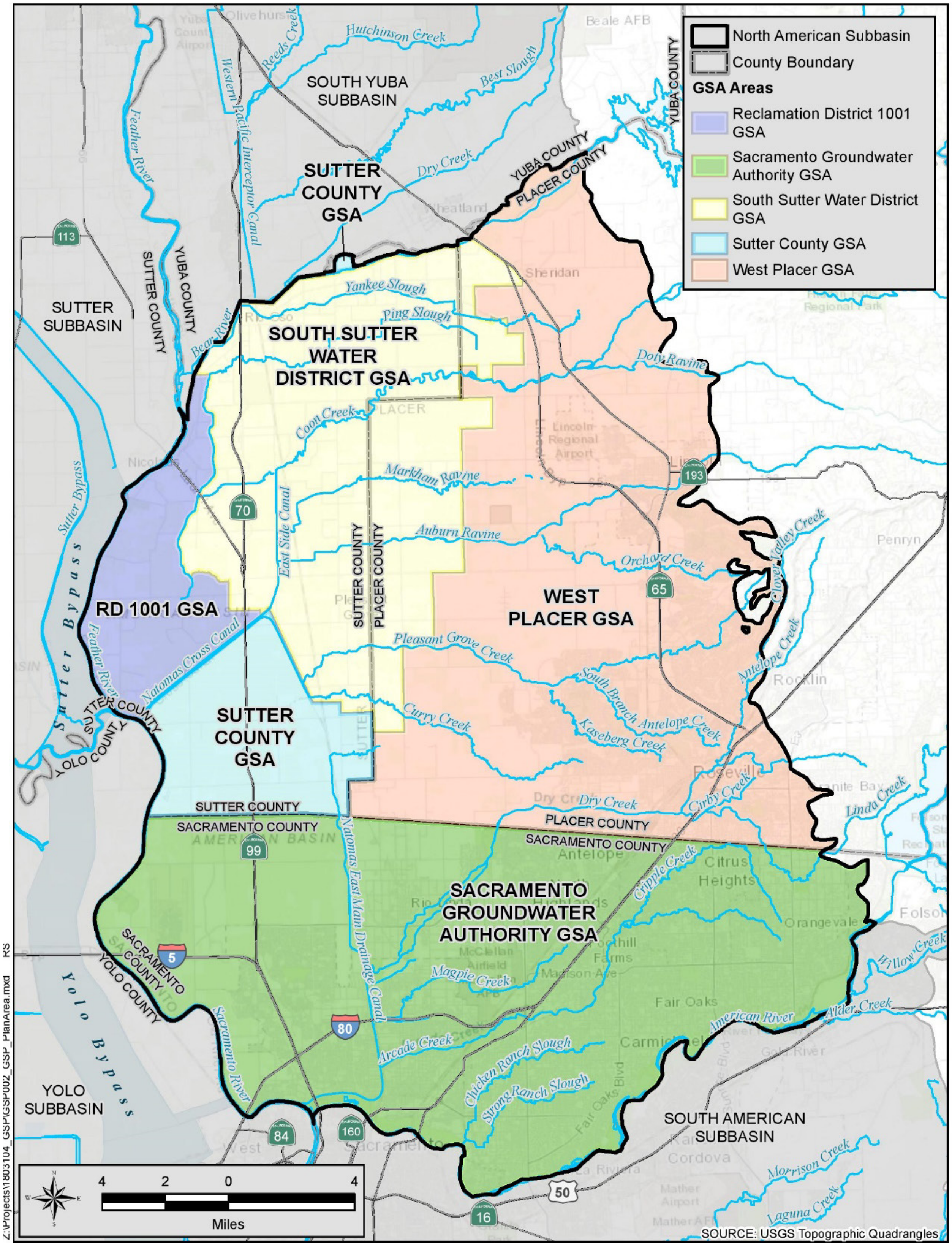


Figure 2-1. GSP Plan Area and GSAs

2.1.2 RD 1001 GSA

RD 1001 is a special-purpose district that provides flood protection for approximately 43,395 acres, including the communities of East Nicolaus, Nicolaus, Pleasant Grove, Rio Oso, Trowbridge, and Verona. The Reclamation District (RD) is governed by elected board members who own property or work on land in RD 1001.

RD 1001 is delegating certain activities regarding the implementation of SGMA to the Pleasant Grove-Verona Mutual Water Company, which is located within its service area, through a separate MOA.

2.1.3 South Sutter Water District GSA

SSWD is a California water district organized, existing, and operating under the provisions of the California Water District Law, California Water Code Section 34000 et seq., and is thus a local agency authorized to exercise powers related to groundwater management under California Water Code Section 10721. SSWD was established in May 1954 to develop, store, and distribute surface water to reverse the effects groundwater pumping was having on the declining groundwater levels. The SSWD GSA covers some area within Placer County that is in the SSWD boundary. Placer County and SSWD have signed a MOA describing the management of shared lands to ensure that all areas are managed appropriately.

2.1.4 Sutter County GSA

The Sutter County Board of Supervisors serves as the legislative body for Sutter County and provides policy direction for all branches of county government. The Board of Supervisors authorized the Development Services Department to submit the necessary documents to form the Sutter County GSA and oversee the preparation of the GSP and its implementation in the NASb within Sutter County that is not represented by another GSA.

Sutter County is delegating certain activities regarding the implementation of SGMA to the Natomas Central Mutual Water Company, which is located within its service area, through a separate MOA.

2.1.5 West Placer GSA

The West Placer GSA consists of four public agencies with water management or land use authority in a portion of the NASb located within Placer County. The member agencies are Placer County, the cities of Roseville and Lincoln, and Placer County Water Agency, all of which are water purveyors. In addition, through a separate participation agreement, the GSAs will allow for California American Water (an investor-owned utility) to participate in the West Placer GSA since they are a water supplier within the West Placer GSA portion of the Subbasin. The agencies have entered into an MOA to manage the groundwater within West Placer County.

Other local agencies that provide water to areas of the West Placer GSA portion of the Subbasin including San Juan Water District, Camp Far West Irrigation District, Citrus Heights Water District, Nevada Irrigation District, RD 1001, and a land-use agency, the City of Rocklin. These agencies do not supply groundwater within the West Placer GSA area and have not requested to be part of the GSA. Nevada Irrigation District was a GSA participant, but elected to withdraw in November 2021.

2.2 Plan Manager Contact Information

The five GSAs, by mutual agreement, selected SGA to be the Plan manager and lead agency for the preparation and implementation of the NASb GSP. SGA contact information is provided below:

Agency Name:	Sacramento Groundwater Authority	Contact person:	Rob Swartz
Agency Address:	5620 Birdcage Street, Suite 180 Citrus Heights, CA 95610	Phone Number:	(916) 967-7692
Agency Website:	https://www.sgah2o.org	Email:	rswartz@rwah2o.org

2.3 Implementation Authority

Any local public agency that has water supply, water management, or land use responsibilities in a basin can become a GSA under SGMA. All five of the NASb GSAs meets at least one of these criteria and has legal authority to jointly prepare, adopt, and implement a GSP. Each GSA in the NASb has the legal authorities granted to a GSA under the California Water Code (Water Code) to manage groundwater in their area.

All five of the GSAs have entered into an MOA for the implementation of this GSP, which will include management of the Subbasin along with projects and management actions. The GSAs have designated SGA as the lead agency. **Appendix A** provides a copy of the GSP Implementation MOA.

3. Description of Plan Area

3.1 GSP Plan Area

The NASb encompasses about 342,000 acres in Sutter, Placer, and Sacramento counties bounded by the American, Bear, Feather, and Sacramento rivers. The Sierra Nevada foothills form the eastern boundary of the Subbasin. **Figure 3-1** shows the plan area. The eastern portion of the Subbasin is characterized by low rolling dissected uplands, while the western part is a nearly flat flood basin for the Bear, Feather, Sacramento, and American rivers. Between the rivers are several small tributaries that have low elevation and small watersheds. Most of the small tributaries drain to the Natomas Cross Canal, East Side Canal, and the Natomas East Main Drain Canal, which convey runoff to the Feather and Sacramento rivers. Some of the tributaries are used by irrigation and RDs to convey water to their customers. Several miles of agricultural drains are used by the RDs to control flooding and are also used to recapture excess applied water for reuse.

Water uses in the Subbasin include agricultural, municipal, industrial, domestic, and native vegetation and aquatic species. Some water purveyors rely exclusively on either groundwater or surface water, but most rely on a combination of surface water and groundwater.

Urban areas dominate in Sacramento County and the southeastern portion of Placer County, while the rest of the Subbasin is predominately agriculture and undeveloped land. Permanent crops dominate the western, eastern, and northern edges of the Subbasin and along the rivers, while rice and other non-permanent crops dominate the central and western portions of the Subbasin.

3.2 Adjudicated Areas

The Subbasin is not adjudicated, nor are any of the surrounding subbasins.

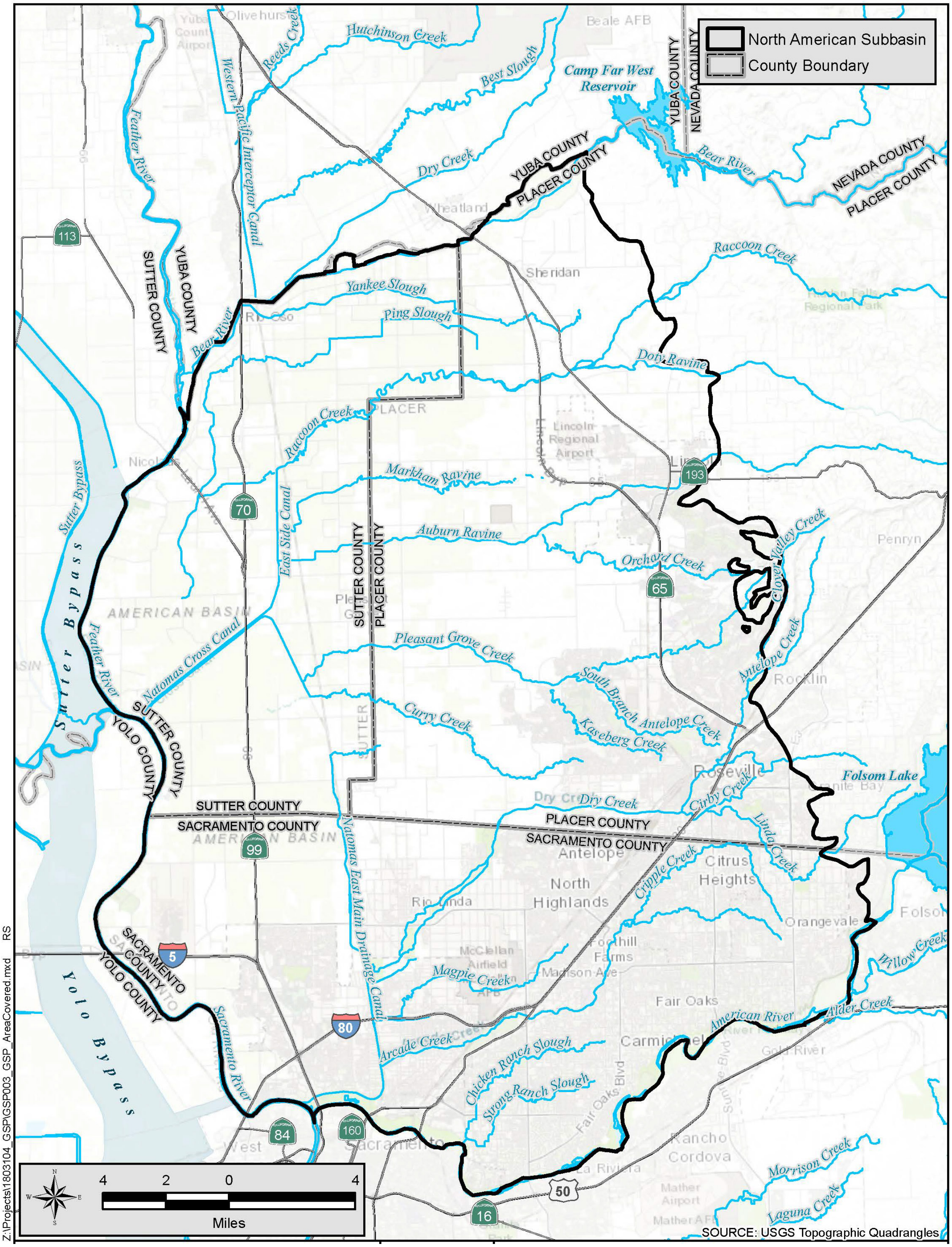


Figure 3-1. Area Covered by GSP

3.3 Jurisdictional Areas

Within the NASb, there are federal, state, county, and tribal agencies with land use jurisdictional responsibilities. Within each county, there are cities with land-use authorities and water agencies that serve water within the Subbasin. Irrigation districts are also present that provide surface water for agriculture. Within many of the irrigation districts and cities are RDs that are responsible for managing and maintaining the levees, freshwater channels, or sloughs, canals, pumps, and other flood protection structures in the area. The following sections describe the jurisdictional areas and agencies within the Subbasin. **Figures 3-2 through 3-4** show these jurisdictional areas.

3.3.1 Federal

The United States (U.S.) Army Corps of Engineers has jurisdictional authorities on all navigable waterways in the Subbasin. The U.S. Bureau of Reclamation (Bureau of Reclamation) contracts to deliver Central Valley Project and settlement agreement surface water through diversions from the Sacramento and American rivers.

The federal government (Air Force) retroceded jurisdiction for all portions of the former McClellan Air Force Base during post-closure of the base. This means that the U.S. Government no longer has “federal legislative jurisdiction” over any portion of the former base, i.e., the U.S. Government does not make or enforce laws/regulations for/on this land area any longer. The Air Force Real Property Agency still owns some of the parcels overlying contaminated areas, but will ultimately transfer those properties as cleanup is achieved.

The federal government also owns a small parcel (less than 1 acre) that is managed by Beale Air Force Base west of the city of Lincoln.

Figure 3-2 shows the federal lands in the Subbasin where the federal government may voluntarily agree to participate in administration of a GSP. Federal government officials have been invited to participate in the development of this GSP.

3.3.2 State of California

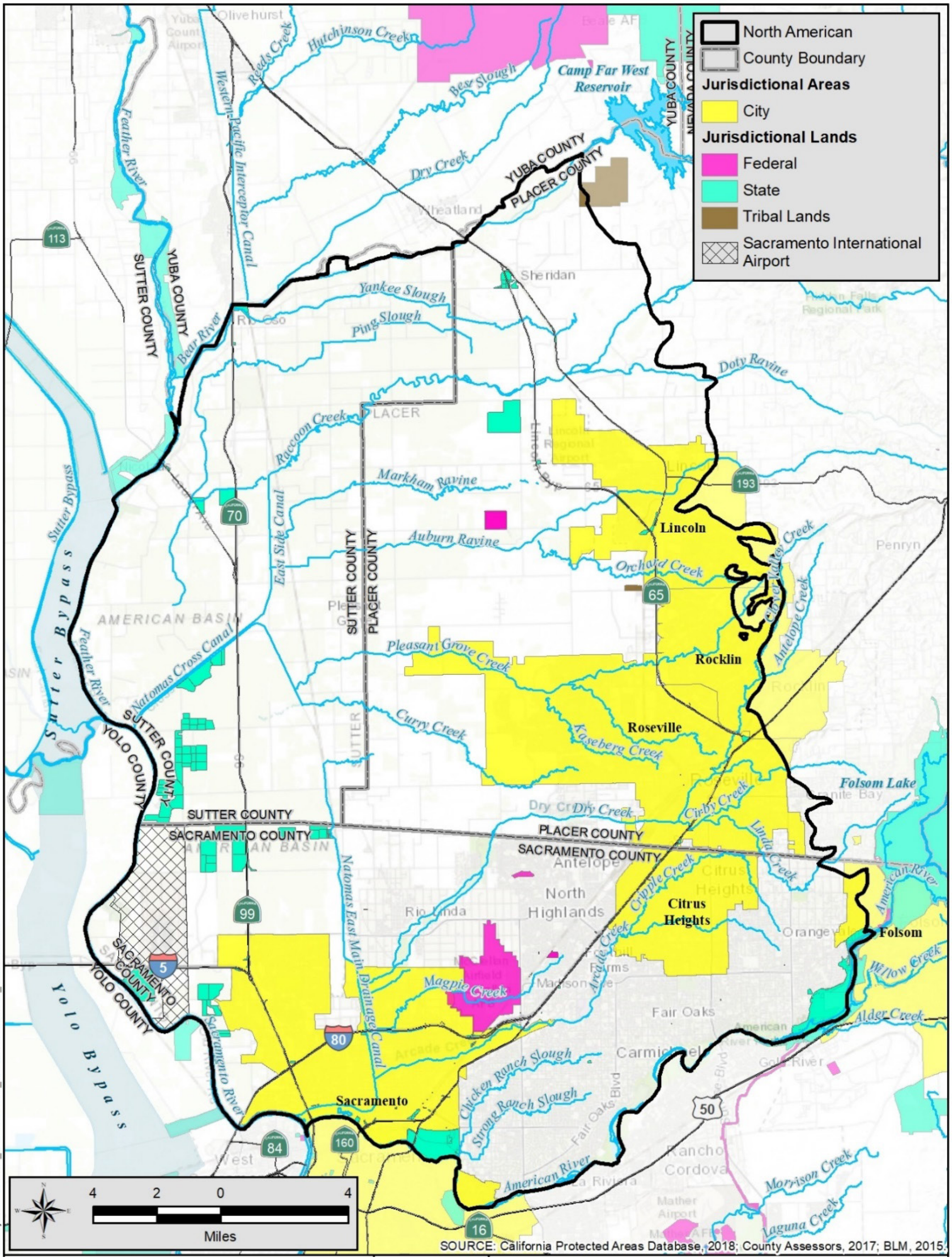
The California State Department of Transportation has authority for lands occupied by freeways and highways and maintenance yards. The State Department of Parks and Recreation has authority over the Folsom State Recreational Area, which extends along a portion of the American River west of Folsom Dam. The California State Lands Commission has authority over the Natomas Basin Conservancy area, located in the western portion of Sutter and Sacramento counties. The state also has authority over some small specific conservation land and preserves. DWR has jurisdictional authority for maintaining State Plan of Flood Control levees along the Sacramento and Feather rivers. **Figure 3-2** shows the state-owned lands in the

Subbasin where SGMA does not apply, but the state government officials have been invited to assist in the development of this GSP.

3.3.3 California Native American Tribes

United Auburn Indian Community has jurisdiction over land in Placer County southeast of the city of Lincoln and northeast of the town of Sheridan, within the Subbasin. Similar to the federal government, any federally recognized Indian tribe may voluntarily agree to participate in administration of a GSP.

Tribal community members have been invited to participate in the development of this GSP and were sent public outreach information about SGMA and GSP development. **Figure 3-2** shows the tribal lands in the Subbasin.



Z:\Projects\1803104_GSP\GSP004_JurisdictionalAreas_CoStFed.mxd RS

Figure 3-2. City, County, State, and Federal Jurisdictional Areas and Lands.

3.3.4 County

Placer, Sacramento, and Sutter counties each cover about one-third of the NASb. **Figure 3-2** shows the county boundaries. Each of the counties has a general planning and land use authorities. Sacramento County also has land-use management authority along the American River Parkway and along Dry Creek and lands associated with Sacramento International Airport.

3.3.5 City

There are six incorporated cities within the NASb (**Figure 3-3**), including Citrus Heights, Folsom (just a small portion located within the NASb), Lincoln, Rocklin, Roseville, and Sacramento. Each of the cities has land use management and planning authority granted through the state of California, which is derivative of the city or county general police power. This power allows cities and counties to establish land use and zoning laws that govern development.

3.3.6 Water Agencies

The following water agencies, water districts, city/county water departments and irrigation districts (classified as community water systems) are located within the Subbasin and provide potable water to residents (DWR, 2019). **Figure 3-3** shows the location of the water entities. Some are public entities, while others are private water companies. Their water supplies are derived from surface and groundwater or a combination of both.

- California American Water
- Carmichael Water District
- Citrus Heights Water District
- City of Folsom
- City of Lincoln
- City of Roseville
- City of Sacramento
- County of Sacramento
- Del Paso Manor Water District
- Fair Oaks Water District
- Golden State Water Company
- Orange Vale Water Company
- Rio Linda/Elverta Community Water District
- Sacramento Suburban Water District
- Sacramento County Water Agency
- San Juan Water District
- Placer County Water Agency
- Nevada Irrigation District
- Placer County (Area of Sheridan)

San Juan Water District (SJWD) is also a water wholesaler and provides treated surface water to Fair Oaks Water District, Orange Vale Water Company, and Citrus Heights Water District. SJWD also has interties to provide water to California American Water and the city of Roseville and a small portion of the city of Folsom (north of the American River) and periodically to another 171,000 customers in the Sacramento Suburban Water District.

Figure 3-3 also shows the relationship of disadvantaged and severely disadvantaged communities (DAC and SDAC) to the water agencies. Most DACs in Sacramento County and in the southern portion of Placer County are provided drinking water by water agencies. Some portions of northwest Placer County do not have water service provided by water agencies and would rely on domestic wells.

3.3.7 Small Community Water Systems

There are multiple small community water and non-community non-transient water systems, in the Subbasin, that are overseen by the counties and the state. Their water supplies are from groundwater. **Figure 3-3** shows the location of some of these small community water systems and also their relationship to DACs and SDACs.

Water System Name
American River College
Antelope Springs
Brown's Elementary School
Building Trades Association
Burton and Kathryn Lauppe
California State Fair
Caltrans (Elkhorn I-5 Rest Area)
Csp Labs & Micro Paradox
E. L. H. Sutter Properties
East Nicolaus Joint Union High
East Nicolaus MWC
Edwin A. and Marjorie E. Willey
Eleven Oaks Mobile Home
Grant Union High School
Holt Of California
Huppe Moore Landscape
I B E W Training Center
Imperial Manor Mobile Home
Javed and Amna Siddiqui
Lincoln High School Farm
Marcum Illinois Elementary School
McClellan Mobile Home Park
National American Corp. Lp-Lak

Water System Name
Natomas Basin Conservancy
Odysseus Farms Partnership
On The Y
Pape Machinery
Pleasant Grove Elementry School
Rio Oso
Rio Ramaza CSD
River Oaks Golf Club
Rosecrest Mutual
Sacramento County
Sacramento County (Boat Launch)
Sacramento County (Discovery Park)
Sacramento County International Airport
Stafford Meat Company
Sysco Food Services of Sacramento
Teal Bend Golf Course
Trowbridge
Valley Hi Country Club
Verona Marina Launch & R.V.
Verona Village River Resort
Virgin Sturgeon
William S. Cummings

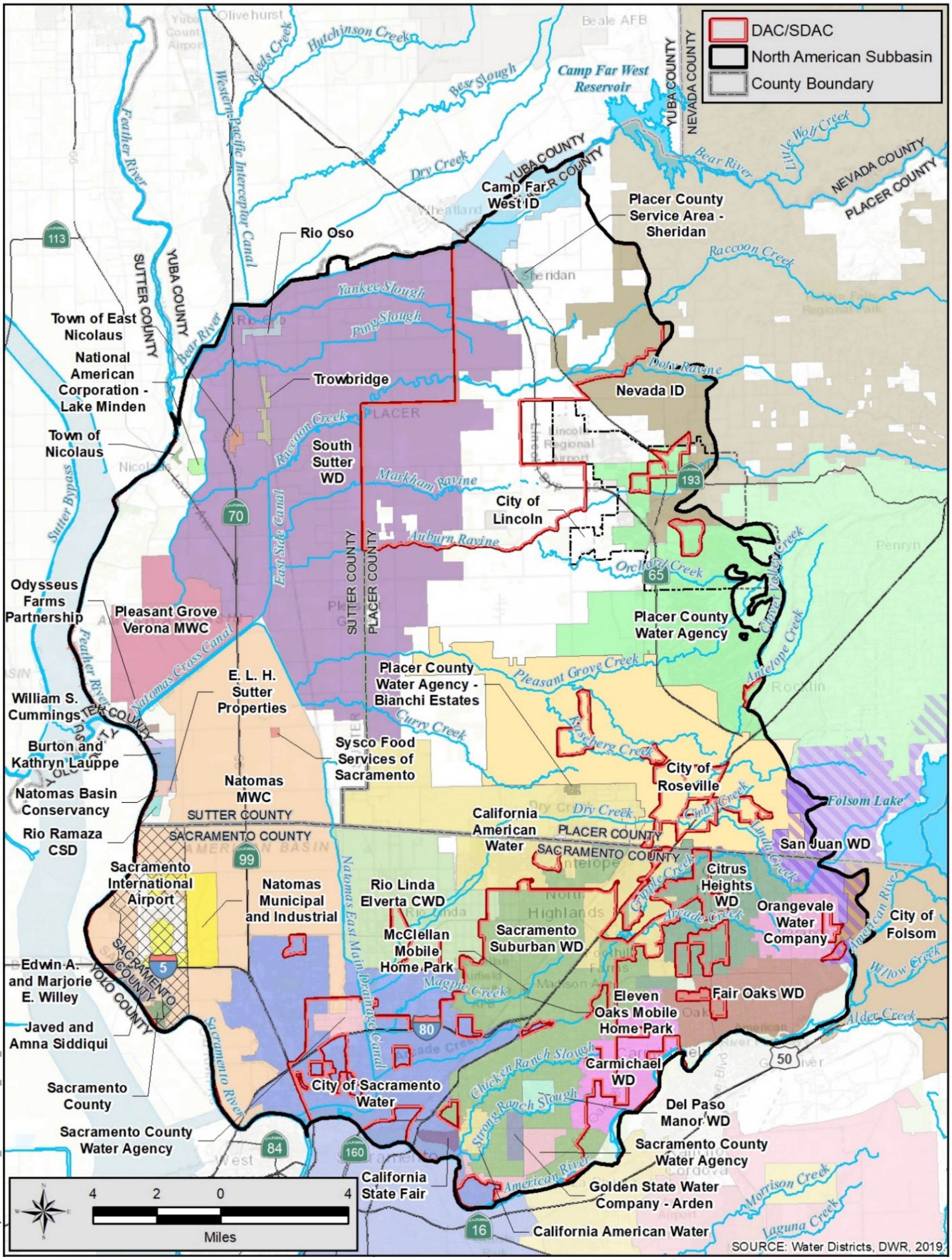


Figure 3-3. Water Districts and Systems Areas

3.3.8 Agricultural Water Providers

The Sutter County area of the NASb is almost entirely agricultural, Placer County is about 60 percent agricultural, and Sacramento County is about 20 percent agricultural. Surface water is supplied to agriculture by:

- Camp Far West Irrigation District
- Natomas Mutual Water Company
- Nevada Irrigation District
- Pleasant Grove-Verona Mutual Water Company
- South Sutter Water District

The water companies typically only supply a portion of the water supplies for agricultural use. The unmet demand is provided by privately owned wells.

3.3.9 Reclamation Districts

RDs are a form of special-purpose districts in the United States that are responsible for reclaiming and/or maintaining land for agricultural, residential, commercial, or industrial use that is threatened by permanent or temporary flooding. Within the NASb are RD 1000 along the Sacramento River and RD 1001 along the Bear, Feather and Sacramento rivers. Along the Bear River, RD 817 and RD 2103 have small areas within the NASb. Some of the RD areas overlie other water and irrigation district areas. **Figure 3-4** shows the RDs in the NASb.

3.4 Land Use Designations

In 2014, the NASb was roughly about 40 percent urban, 30 percent farmland, and less than 1 percent riparian vegetation (Land IQ, 2017). About 30 percent of the land was not classified. The total acres by each significant land use category and crops are summarized in **Table 3-1**. **Figure 3-5** shows the 2014 land use in the Subbasin.

Most of the urban development is in Sacramento County and the southeastern portion of Placer County. The population is projected to increase by about 200,000 people by 2030 (DWR, 2019), with an increase in urban development extending the urban areas to the north and west. **Figure 3-6** shows the locations of approved urban development areas in the Subbasin as identified from Placer, Sacramento, and Sutter counties, and each city's General Plans.

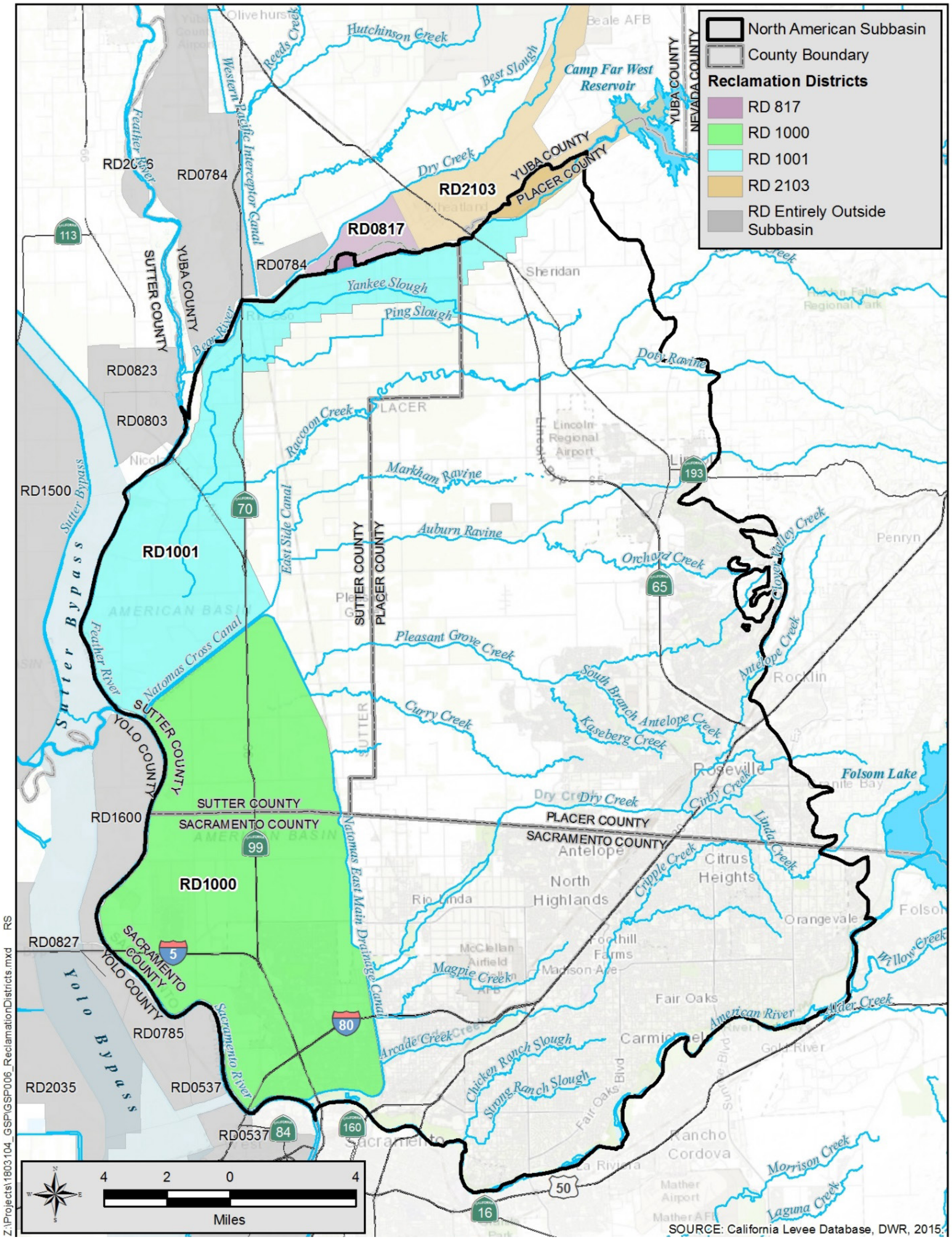


Figure 3-4. Reclamation Districts Jurisdictional Areas

Table 3-1. Land Use Summary

Land Use	Acres	Percent
Urban	**131,504**	**38.39%**
Urban	131,504	38.39%
Agriculture	**115,446**	**33.71%**
Citrus and Subtropical	99	0.03%
Deciduous Fruits and Nuts	11,529	3.37%
Field Crops	2,867	0.84%
Grain and Hay Crops	2,242	0.65%
Idle	30,083	8.78%
Pasture	11,331	3.31%
Rice	56,316	16.44%
Truck Nursery and Berry Crops	660	0.19%
Vineyard	45	0.01%
Young Perennial	275	0.08%
Managed Wetlands	**1,745**	**0.51%**
Riparian Vegetation	1,745	0.51%
Not Classified	**93,821**	**27.39%**
No Data	93,821	27.39%
Total	**342,516**	**100%**

Source: Land IQ, 2014

The Subbasin is a significant producer of pears, prunes, rice, tomatoes for processing, walnuts, peaches, beans, row crops, corn, and grapes. Agriculture uses about 50 percent of its acreage for growing rice and 10 percent for permanent crops, including orchards and vineyards. About 10 percent of the total farmland acreage is idle.

Urban development is projected to continue to increase, which will decrease agricultural lands. This has the potential to shift surface water use on permeable land to groundwater use on non-permeable ground thus, having a negative impact on the groundwater basin. **Figure 3-6** shows the locations of future urban development areas in the Subbasin as identified in Placer, Sacramento, and Sutter counties General and Specific Plans and their proposed water sources. Planned development areas will likely use groundwater as their initial sources of supply and ultimately plan to use both surface water and groundwater as their source of supply.

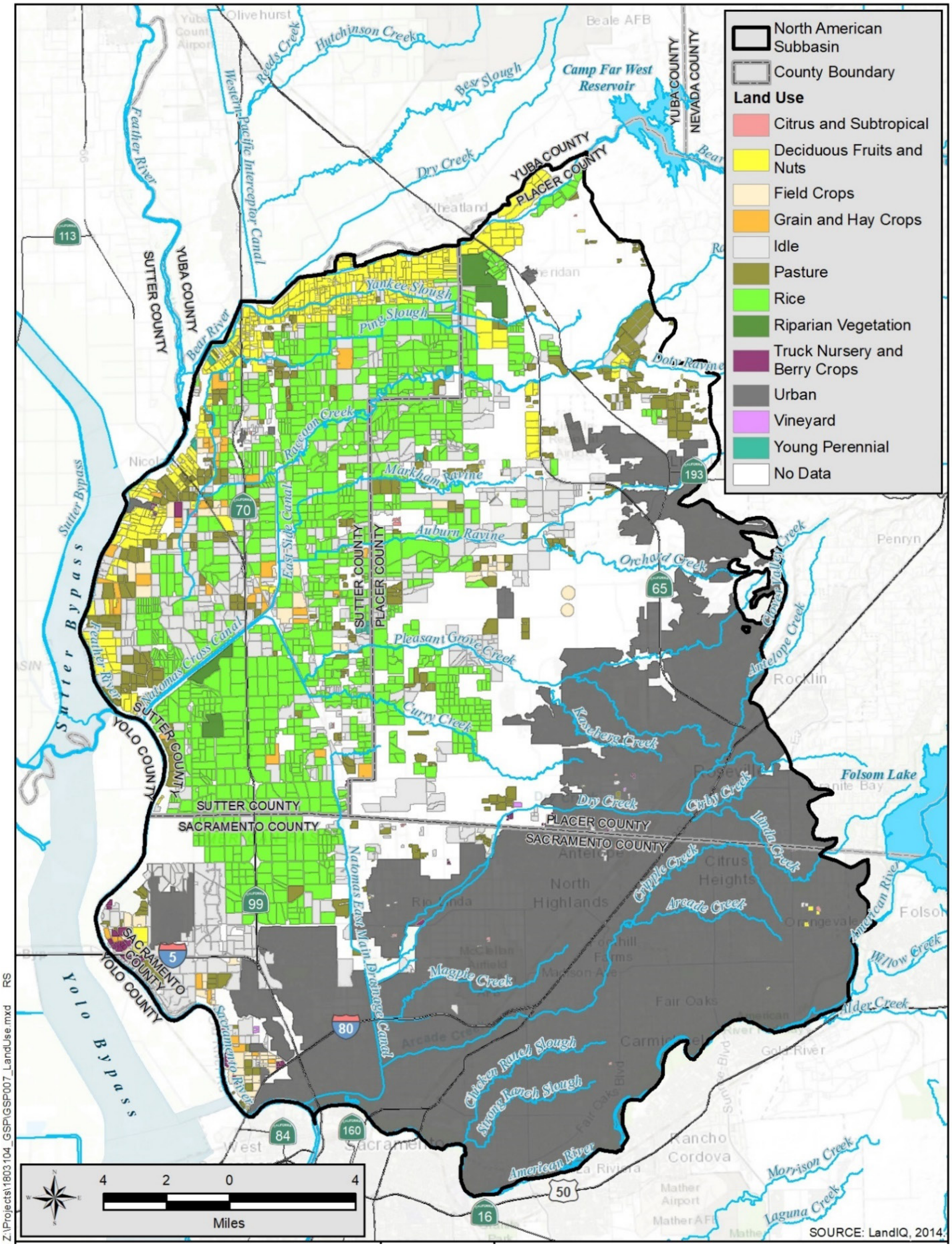


Figure 3-5. Existing Land Use Designations

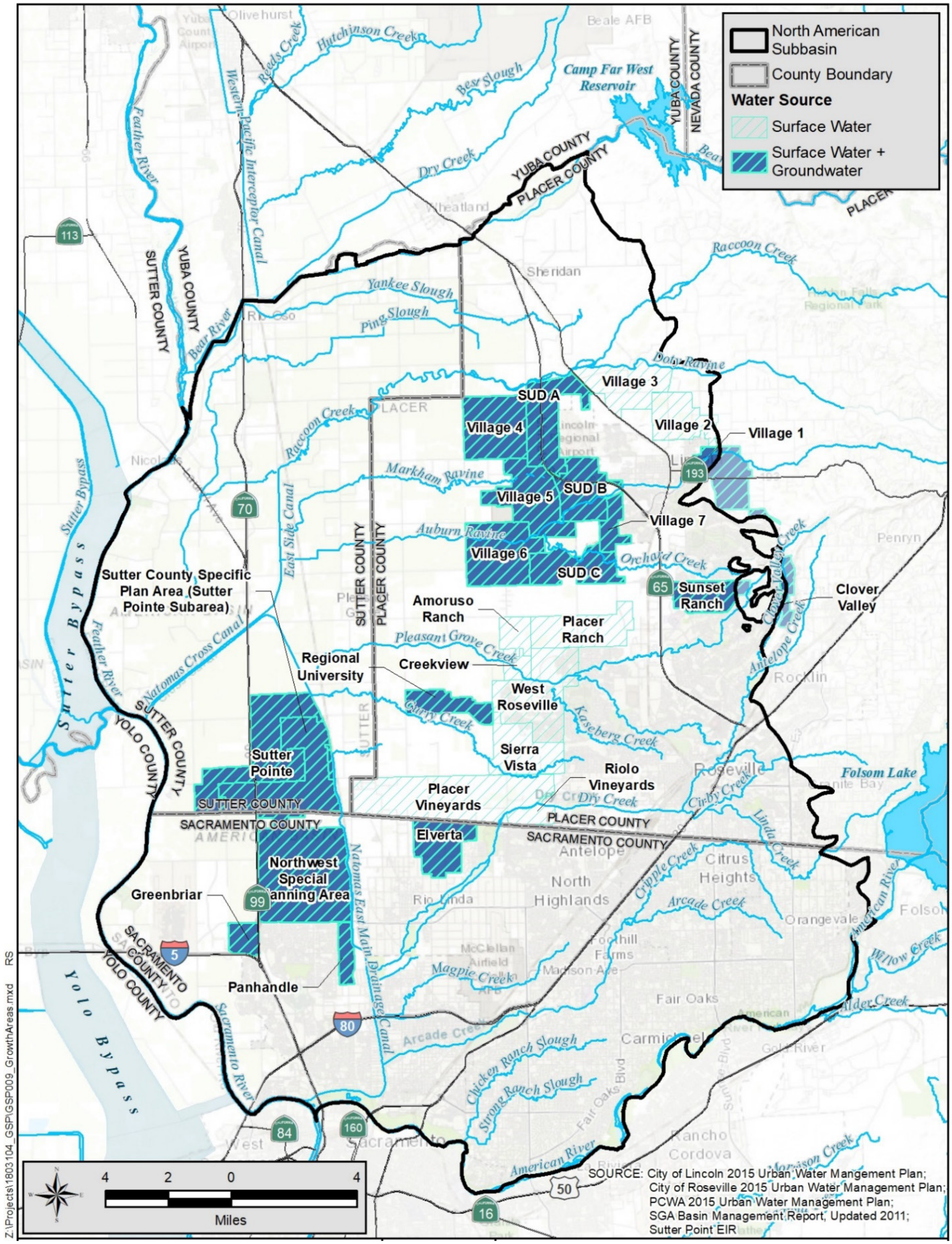


Figure 3-6. Planned Development Areas and Planned Water Source Types

3.5 Habitat Preserves and Easements

The counties in the NASb have each prepared conservation and habitat plans to assess current preserves and easements and provide goals and plans for the next 50 years to continue to increase these areas (Placer County Conservation Plan 2020, Natomas Basin Habitat Conservation Plan 2003). The Placer County Conservation Plan was jointly developed by the County of Placer, the City of Lincoln, the Placer County Water Agency and the South Placer Transportation Authority. The Natomas Basin Habitat Conservation Plan was jointly developed by Sutter and Sacramento counties along with other parties. Currently, the NASb has about 16,900 acres of habitat conservation preserves and easements. **Figure 3-7** shows the locations of existing reserves, preserves, and easements. Some of the preserves do not have water supplies and rely on precipitation while others have access to surface water and groundwater.

Riparian vegetation typically occurs along the fringes of the rivers, canals, and tributaries. Natural marsh habitats are generally present near the Feather and Sacramento rivers in the area, generally known as the Natomas Basin. Key natural marsh areas include Pritchard Lake north of Sacramento International Airport and the area adjacent to Natomas Mutual Water Company's Elkhorn Pumping Plant, which also contains riparian habitat. Other natural marsh areas are scattered in approximately five small areas throughout unincorporated Sacramento County. In unincorporated western Placer County, some fresh emergent marsh habitats are created by irrigation runoff and many of the wetland habitats are fed by leakage or runoff from irrigation canals or irrigated pastures. Riparian habitat occurs on the American and Bear River corridors and along Raccoon Creek, lower Auburn Ravine, and lower Dry Creek. Other habitat types include scattered pasture, idle, and ruderal lands, and include about 290 acres of grassland habitat adjacent to Natomas East Main Drainage Canal.

3.6 Disadvantaged Communities

Disadvantaged and severely disadvantaged communities are present in the Subbasin (DWR, 2018). **Figure 3-8** show their locations. Most are located within Placer and Sacramento Counties. Those within Sacramento County are located within urban areas, while those in Placer County are located in rural areas.

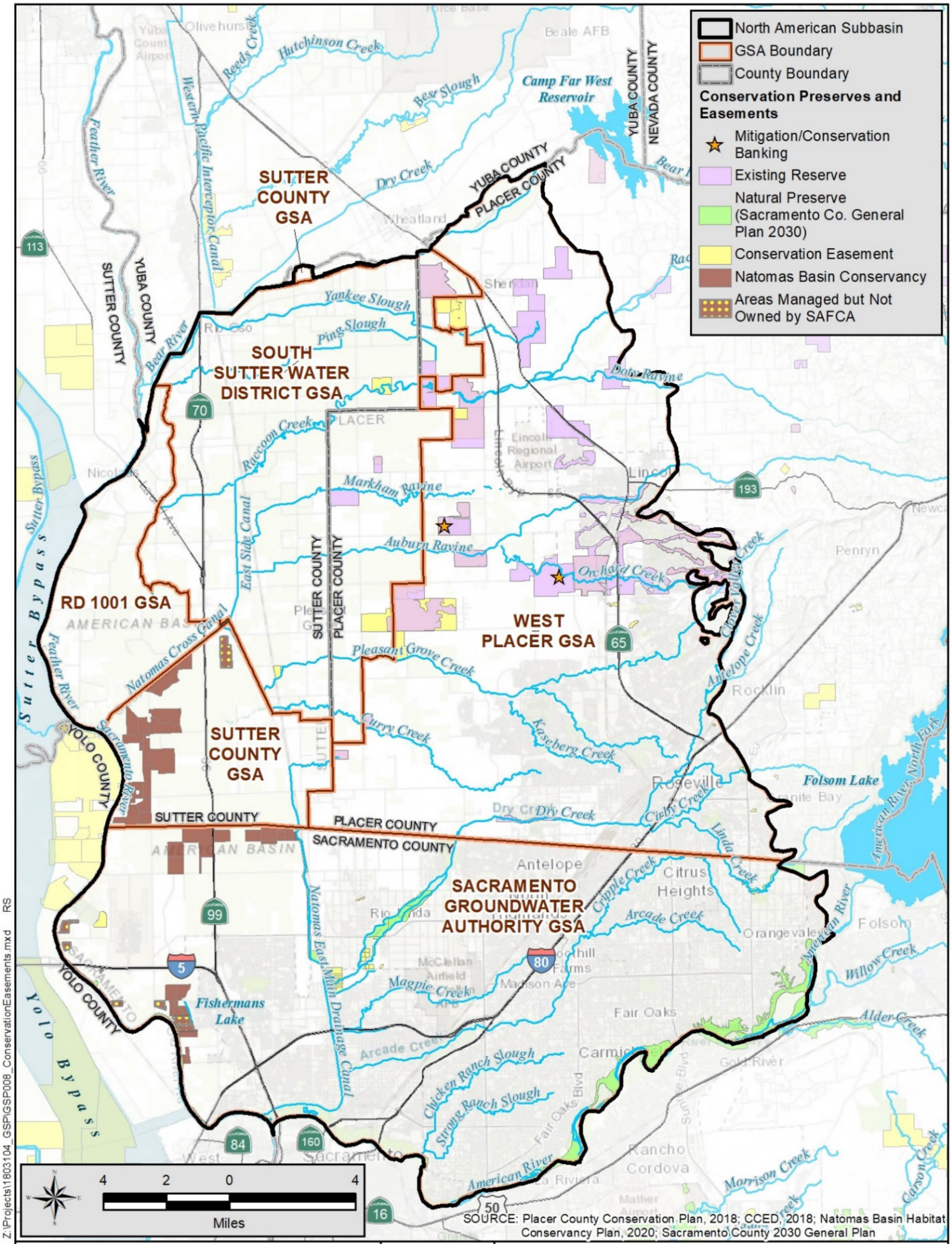


Figure 3-7. Habitat Conservation Preserves and Easements

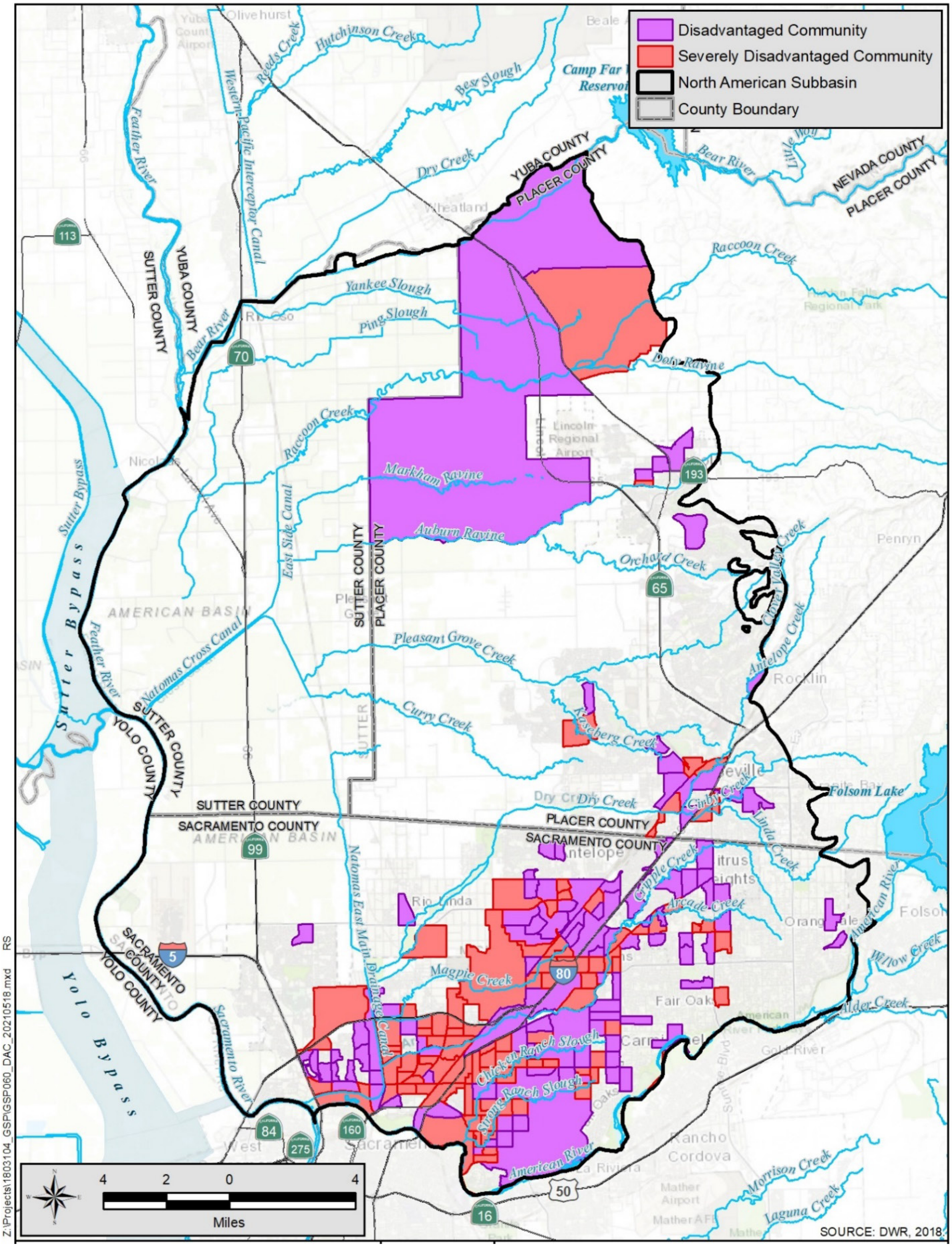


Figure 3-8. Disadvantaged and Severely Disadvantaged Communities

3.7 Water Use Sectors

Water use sectors in the Subbasin are urban (industrial included in this category), domestic, agriculture, environmental (native habitat, managed wetlands, and conservation areas) and groundwater remediation sites. **Figure 3-9** shows the water use sectors in the Subbasin, except for domestic users. Some of the water use sector areas may change with time as urbanization continues (*refer to* **Figure 3-6**).

Environmental cleanup is in progress in the Subbasin and some sites pump and treat groundwater to remove contaminants. Some of the water is used for municipal purposes while at other facilities the treated water is discharged to surface water.

3.7.1 Urban

Land in the southern and eastern portions of the Subbasin is primarily urban and is served by groundwater and surface water, for the most part by multiple agencies, as shown on **Figure 3-9**. This widespread urban development initially used groundwater, and by the 1960s, a significant groundwater depression had developed in the Sacramento County portion of the Subbasin. By the 1980s, urban water supplies were augmented by surface water. In 1993, the Water Forum (*see* Section 3.9.2 for details) began a collaborative process among stakeholders to develop a regional approach to ensuring a reliable water supply for the Sacramento region, including work to develop conjunctive use projects in the area, which expanded the option to use surface water. Currently, only the communities of Rio Linda, Arden, and Del Paso Manor rely solely on groundwater. **Figure 3-9** shows the water sources for urban areas.

3.7.2 Domestic

Domestic wells are used to supply groundwater to households in both urban and rural areas. They are scattered through the Subbasin.

3.7.3 Agriculture

Land in the northern and western portions of the Subbasin are predominately agriculture. A significant amount of surface water irrigates pastures, orchards, rice fields, and farms. Farmers in the Subbasin receive surface water from federal and local projects. Many also pump groundwater to augment their surface water supplies. During the dry year of 2014, surface water deliveries fell, causing farmers to rely more heavily on groundwater. Water districts, companies and irrigation districts manage surface water and encourage surface water use and basin recharge during wet years and groundwater use during dry years. **Figure 3-9** shows the availability of water sources for these agricultural areas.

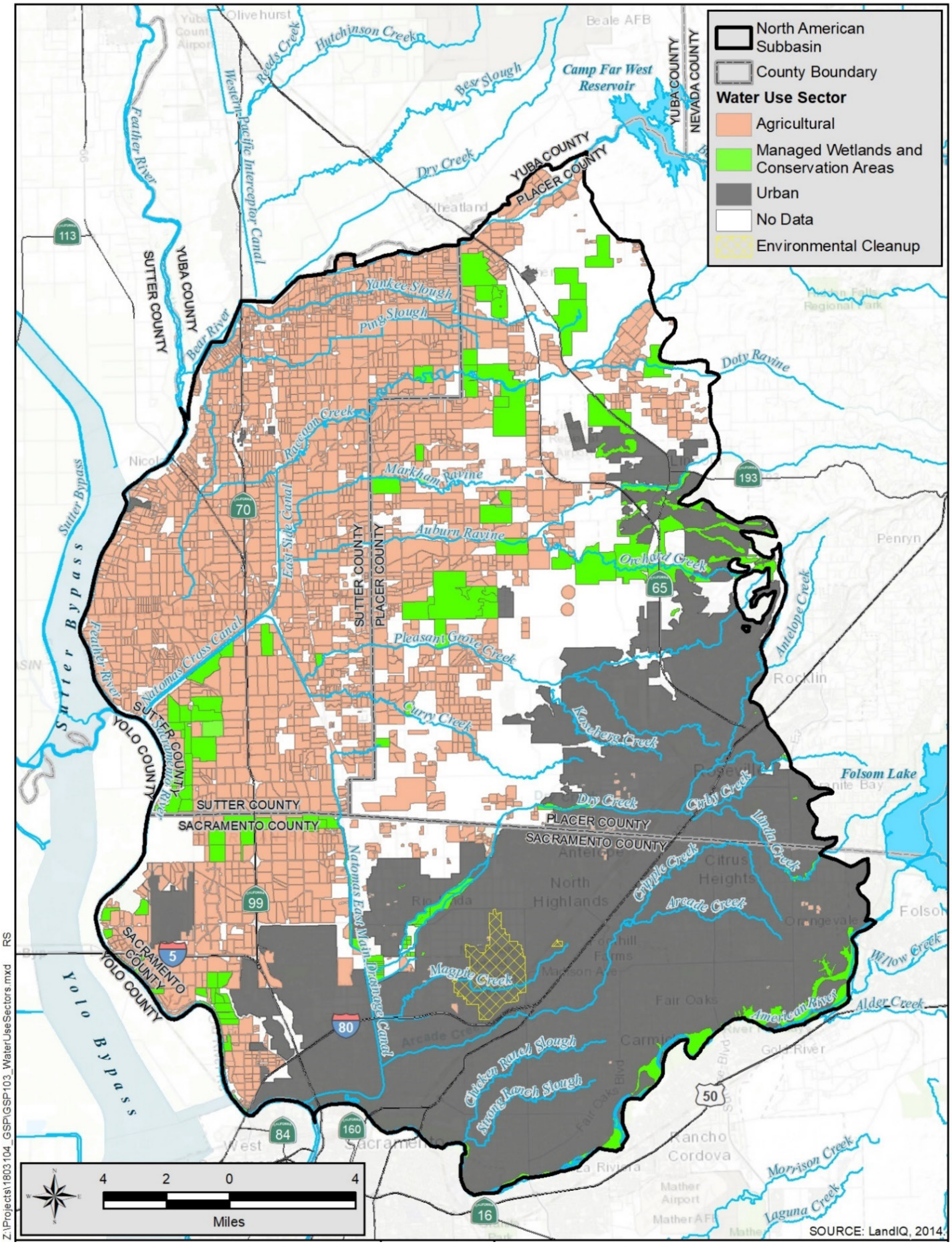


Figure 3-9. Water Use Sectors

3.7.4 Environmental

Rivers and streams in the Subbasin support more than 40 species of native and nonnative fish, including naturally spawning fall-run Chinook salmon, steelhead, and American shad. Several of these species are of primary management concern because of their declining numbers or their importance to recreational/commercial fisheries. Auburn Ravine in Placer County is also a habitat area for Chinook salmon and steelhead. The banks of the many rivers and streams within the Subbasin provide riparian habitat, both scrub and forest consisting of cottonwood, valley oak, and willow, with occasional white alder, box elder, and Oregon ash. Emergent marsh habitat is found in still or slow-moving shallow water located on the edges of the rivers and on the banks of open water areas. These areas constitute about three percent of the total NASb area. **Figure 3-10** shows vegetation and wetlands (NCCAG, 2018). Groundwater pumped and used to support some of the habitat preserves in Sutter and Sacramento counties is shown on **Figure 3-7**.

3.7.5 Groundwater Remediation

The federal government is in the process of remediating groundwater contamination beneath and near the former McClellan Air Force Base. Some of the cleanup involves pumping, treating, and discharging the treated groundwater to surface water. Pumping of the groundwater for cleanup of contaminants is relatively small, on the order of about 2,000 AFY and is expected to continue for about 30 to 200 years.

Aerojet also is performing groundwater remediation and is pumping wells north of the American River, in the vicinity of Fair Oaks and Carmichael and extracts about 3,000 AFY.

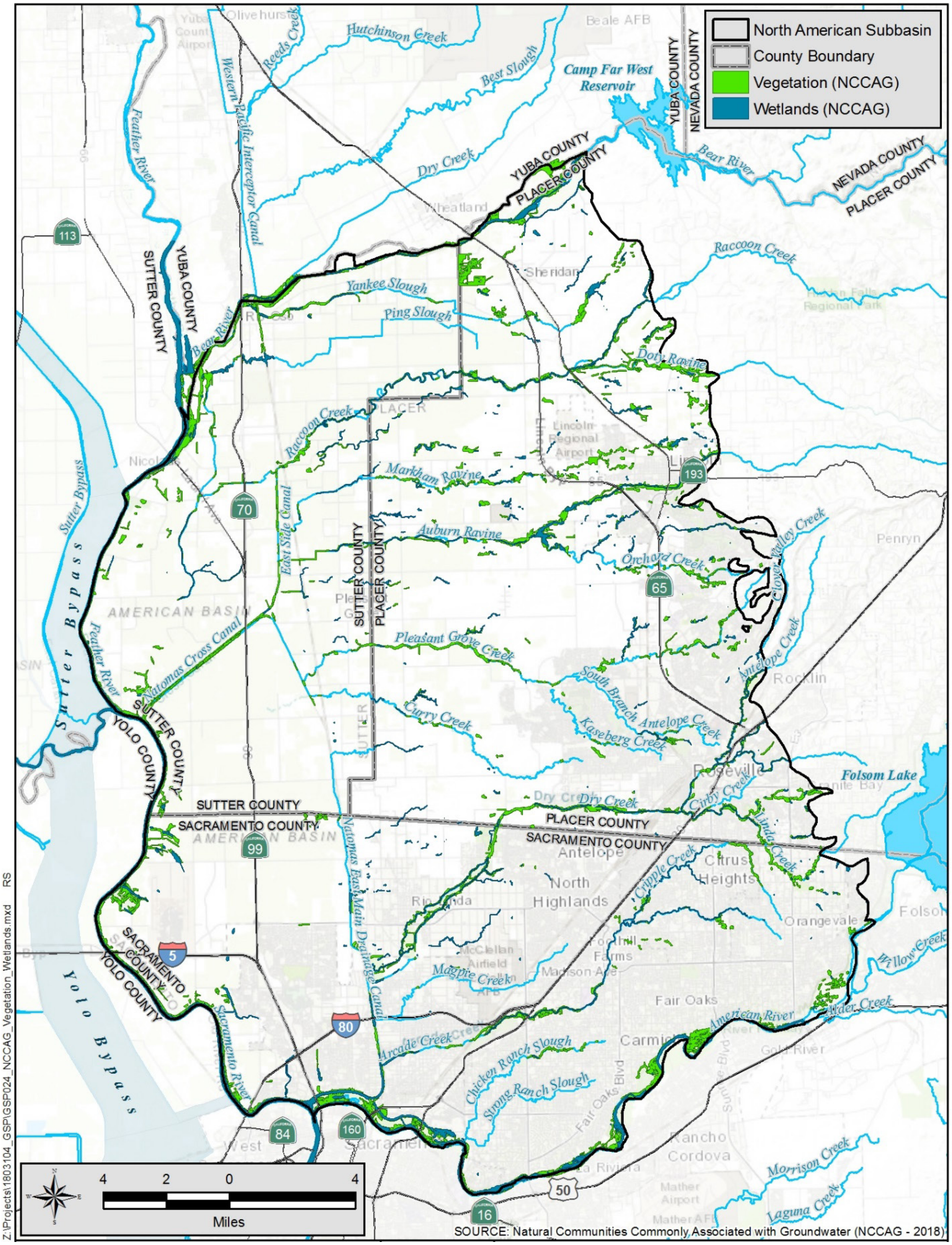


Figure 3-10. Natural Communities Commonly Associated with Groundwater

3.8 Water Source Types

In general, water agencies in the NASb meet water demands with a mixture of surface water and groundwater. Groundwater is used to supply about 40 percent of the water needs in the Subbasin, with about 60 percent being surface water (DWR, 2019). Both the cities of Roseville and Lincoln are using recycled water and are planning to increase this use. Irrigation and RDs also reuse runoff from agricultural fields.

Water source types in the Subbasin are groundwater and surface water, with limited recycled water (treated wastewater) use at this time. Excess applied water to agricultural lands is reused by the irrigation and RDs. **Figure 3-11** shows the areas and water supply source types in the Subbasin. Due to the limited recycled water use and the extensive water reuse in the Subbasin, areas with these sources are not shown on **Figure 3-11** but are described in the following text. Most urban areas in Placer County, other than for the city of Lincoln, utilize surface water for their primary needs and only use groundwater during emergency, drought or other conditions. In Sacramento, most urban areas conjunctively use groundwater during dry periods and use surface water when abundant. **Figure 3-11** shows where groundwater is the sole source of water in the Subbasin. Some of the water source type areas shown on **Figure 3-11** may change as areas are developed as shown (*refer to* **Figure 3-6**). Most of the agricultural areas have groundwater and surface water sources and, therefore, can conjunctively use these resources to manage groundwater in those areas.

3.8.1 Groundwater

There are about 13,600 wells in the Subbasin, of which about 3,800 are production wells and include domestic, agricultural, and municipal water supply wells (DWR WCR, 2019). Wells were classified by DWR as production wells if the well casing was greater than or equal to 4 inches, and the total depth was greater than or equal to 22 feet. Most of the production wells in the Subbasin are domestic wells, which may be classified as de-minimis extractors that pump less than 2 AFY. **Table 3-2** summarizes the types of well categories.

Table 3-2. Well Type Summary

Well Type	Count	Percent
Production - Domestic	2,563	19%
Production - Agriculture	847	6%
Production - Municipal	372	3%
Production Well Total	**3,782**	**28%**
Monitoring	2,558	19%
Remediation	809	6%
Other/Abandoned/Unknown	6,471	48%
TOTAL	**13,620**	**100%**

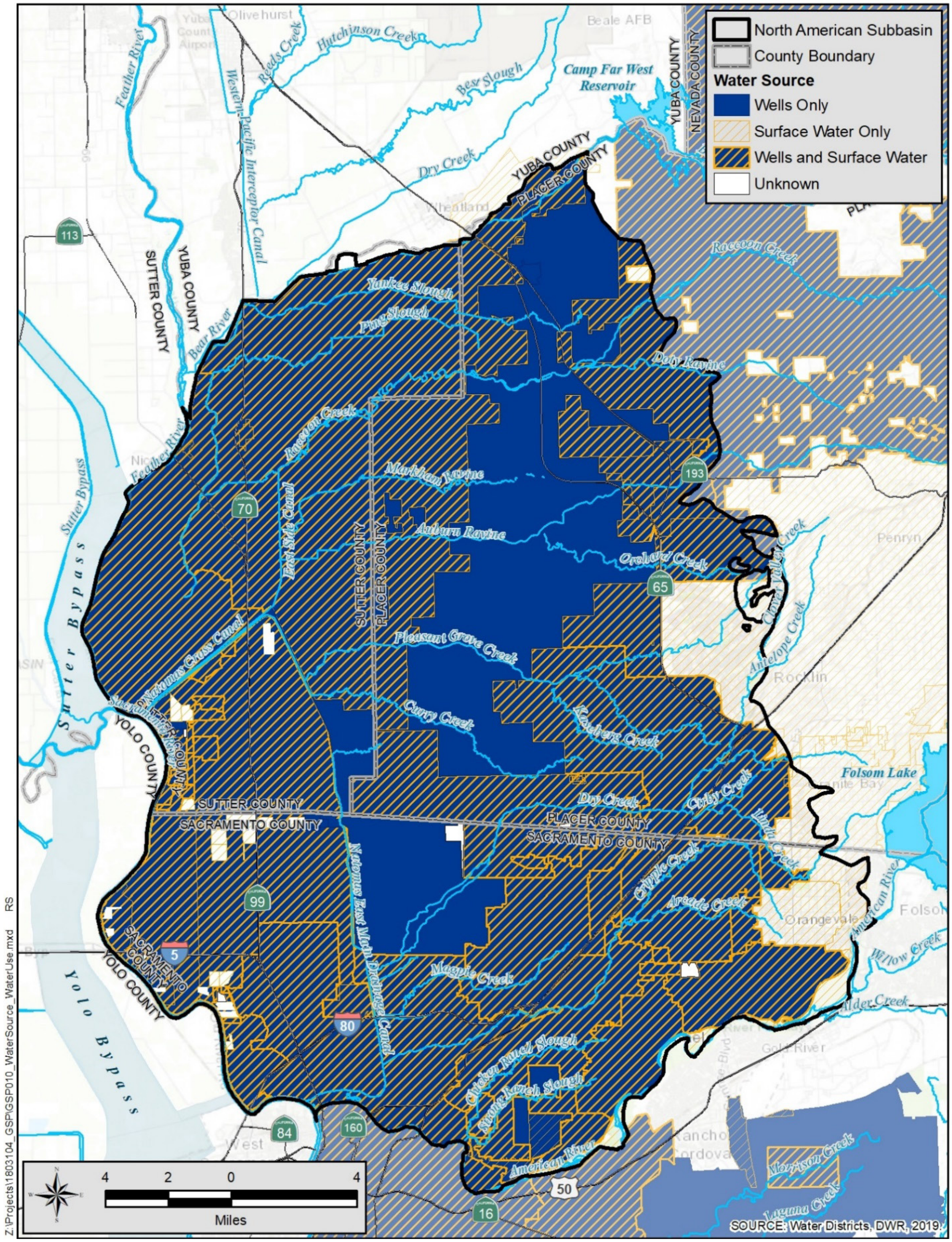


Figure 3-11. Water Source Types

3.8.2 Surface Water Sources

The SGA area of the NASb derives most of its surface water from the American and Sacramento rivers. The eastern two-thirds of the SGA region lies within the lower American watershed, and surface water served to that area typically comes from the American River. Four agencies within the SGA boundaries identified in **Table 3-3** have water rights on the American River—Carmichael Water District, City of Folsom, City of Sacramento, and San Juan Water District (SGA, 2014).

Within the SGA GSA, Natomas Mutual Water Company (NMWC) has been using mostly surface water for many years, pursuant to riparian claims and water rights dating back to 1916 on the Sacramento River. In 1964, NMWC executed a settlement agreement with the Bureau of Reclamation to accommodate the development and operation of the Central Valley Project. The settlement agreement provided a supplemental supply (Project Water: previously stored water from Shasta Reservoir) during times determined by the parties that the water rights were deficient. The senior water rights of NMWC and the security of the settlement contract have provided for a secure surface water supply for agricultural use which incidentally provides recharge to the groundwater basin. Water is diverted from the Sacramento River system at four points within the NASb: two diversions from Natomas Cross Canal, and two from the Sacramento River near the Sutter-Sacramento county line and near Elkhorn Road. About 75 percent of the water demand in the service area is met with surface water while groundwater makes up the remaining portion of the demand.

Within RD 1001 GSA, Pleasant Grove-Verona Mutual Water Company has a similar settlement agreement as NMWC identified above except the quantities are less and the specific details of the water rights are slightly different. Surface water is diverted from the Sacramento River through the Natomas Cross Canal.

South Sutter Water District (SSWD) holds post-1914 appropriative water rights to store up to 102,100 AFY of water in the Camp Far West Reservoir located approximately six miles east-northeast of the city of Wheatland (*refer to* **Figure 3-3**), as well as direct diversion rights for the diversion and use of water from the Bear River and other small streams transecting the District. Pursuant to an agreement between Camp Far West Irrigation District (CFWID) and SSWD during the construction and enlargement of the reservoir, CFWID is entitled to the first 13,000 AF released from the reservoir each year to satisfy its senior water rights along the Bear River. CFWID also holds direct diversion water right licenses for small streams transecting the district service area. SSWD only provides surface water to agricultural users to meet about one-third of water demand, with the remaining two-thirds being met from private groundwater wells.

In addition to its rights and licenses on the Bear River and small streams, SSWD receives supplemental sources of surface water from Nevada Irrigation District (NID) via releases to Auburn Ravine except during the driest years. The amount of water received from NID ranges from zero to 20,000 AFY. The principal raw water delivery outside of the NID has been to SSWD.

Surface water is brought into the Placer County portion of the NASb by the city of Roseville, NID, Placer County Water Agency (PCWA), and San Juan Water District. The city of Roseville and San Juan Water District divert water from the American River from Folsom reservoir. PCWA's surface water supply sources consist of water purchased from PG&E from the Yuba and Bear rivers, Middle Fork Project water from the upper American River, and Central Valley Project water from the American River (Brown & Caldwell 2006). NID's primary source of supply is local surface water derived principally from the Yuba River, Bear River, and Deer Creek watersheds that are diverted and stored under the NID's pre-1914 and post-1914 appropriative water rights. The water rights allow for a diversion of up to 450,000 AFY. NID has an extensive system of small storage reservoirs. Through PCWA water rights and an agreement with the city of Roseville, the city treats surface water and delivers potable water to the California American Water service area in Placer County. The city of Lincoln purchases treated surface water from PCWA. PCWA also treats NID surface water to potable standards for delivery to NID areas within the city of Lincoln.

There are other small diverters of surface water with riparian water rights in the NASb. No attempt was made to identify and locate their diversion for this GSP from the SWRCB databases.

3.8.3 Recycled Water

Wastewater from urban areas and new developments will be treated at one of six wastewater treatment plants (WWTPs). **Figure 3-12** shows the location of the WWTPs. Five of the WWTPs are in the NASb, while one, the Sacramento Regional WWTP, is located outside of the Subbasin, in the South American Subbasin, as shown on **Figure 3-12**. The Sacramento Regional treatment plant receives water from the SGA area as well as other areas in Sacramento County. Interior urban water use, which originated from both groundwater and surface water supplies, is exported outside of the Subbasin to the Sacramento Regional WWTP.

Treated wastewater from the five WWTPs in the Subbasin is reused for irrigation of beltways, golf courses, and some agriculture along with some water features at golf courses. In 2016, about 23,000 AF of wastewater was treated by the cities of Lincoln and Roseville, of which about 3,600 AF was reused. Excess treated water, about 6,000 AF, was discharged into Dry and Pleasant Grove Creeks and Auburn Ravine (GEI SBR, 2018). The city of Roseville's Dry Creek WWTP is required to release an average of 10,000 AF for environmental purposes. The Urban Water Management Plans for the cities of Lincoln and Roseville detail reuse of the water currently being discharged to the creeks, other than flows that are committed for environmental purposes. Placer County operates the Sheridan WWTP, which does not discharge to nearby creeks but uses the water for irrigation of pasture. Wastewater from the Auburn area, which is outside of the Subbasin, is treated and then discharged to Auburn Ravine and enters the Subbasin near the city of Lincoln. Water from the northern portions of Auburn are sent to the city of

Lincoln's WWTP and is discharged to Auburn Ravine via Orchard Creek. In 2016, about 1,300 AF was discharged and potentially entered the Subbasin from Auburn.

Table 3-3. Water Supply Sources

Individual Agencies by GSA	Groundwater	Surface Water					
		American River		Sacramento River		Bear River	
		Water Rights	Contracts and Agreements	Water Rights	Contracts and Agreements	Water Rights	Contracts and Agreements
SGA GSA							
Carmichael WD	x	x					
City of Folsom		x	x				
City of Sacramento North	x	x		x			
California American Water - Arden Area	x						
Del Paso Manor Water District	x		x				
Sacramento Suburban WD - Town & Country	x		x				
Golden State Water Company - Arden Town	x						
SCWA - Arden Park Vista	x						
Portion of Natomas MWC	x(1)			x	x		
Sacramento Suburban Water District – North Service Area	x		x				
California American Water - Antelope and Lincoln Oaks	x						
Rio Linda/Elverta Community Water District	x						
Sacramento International Airport	x			x	x		
SCWA - Northgate	x						
Citrus Heights Water District	x		x				
Fair Oaks Water District	x		x				
Orange Vale Water Company	x		x				
SJWD - Sacramento County		x	x				
WP GSA							
Placer County (Sheridan)	x	x					
City of Roseville	x		x				
Placer County Water Agency	x	x	x	x			
SJWD - Placer County Retail Area			x				
Nevada Irrigation District	x		x			x	x
Camp Far West Irrigation District						x	x
SSWD GSA							
SSWD	x(1)					x	x
RD1001 GSA							
Pleasant Grove-Verona Mutual Water Company	x(1)			x	x		
Sutter County GSA							
Portion of Natomas MWC	x(1)			x	x		

(1) Groundwater is used by landowners within company boundaries but is pumped from privately owned wells.
x = Existing available water supply

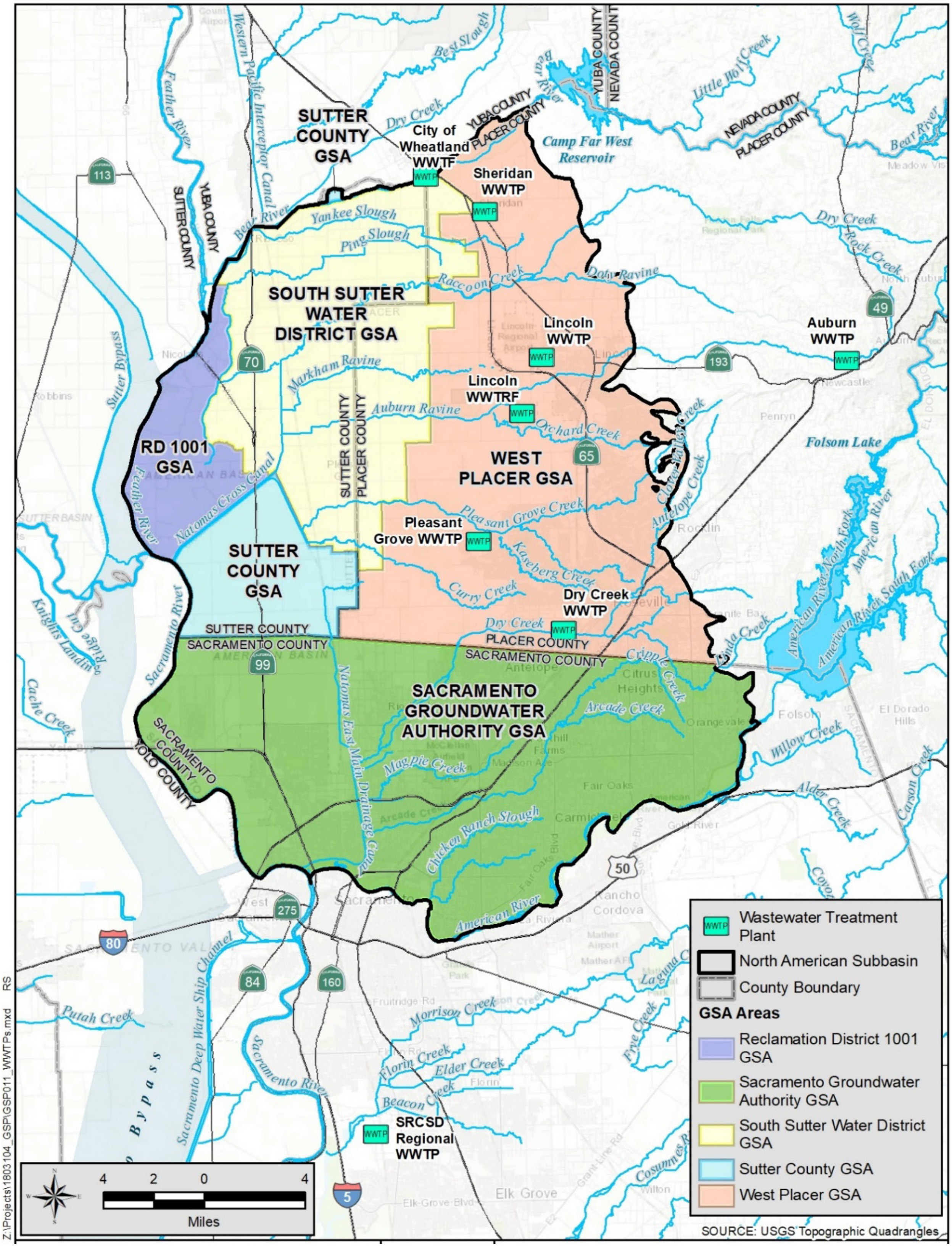


Figure 3-12. Wastewater Treatment Plants

3.8.4 Water Reuse

Excess applied surface water from agricultural fields either percolates into the soils or is returned to drains where it is recaptured by the RDs in the Subbasin. Shallow groundwater may also discharge to these drains, but only in areas where the groundwater surface is near the ground surface. In SSWD and RDs 1001 and 1000, excess applied surface water from agricultural fields is recaptured by drains and returned to the conveyance system to meet further water demands downstream.

Natomas Mutual Water Company has developed a complex closed system of unlined canals, laterals, drains, and lift pumps that circulate surface water around the service area. This system allows water users to take water from the system at any time during the irrigation season. The system also captures all return flow and recirculates it into the system for use by others. During a normal irrigation season, no agricultural drainage water returns to the Sacramento River until after October 15 each year.

3.9 Density of Wells

Groundwater in the Subbasin is used for municipal, industrial, irrigation, domestic, stock watering, frost protection, and other purposes. **Table 3-2** provides a summary of the number of wells by general type in the Subbasin. It should be noted that the number of wells is based on well logs filed and contained within DWR's Water Well Drillers Reports and may not reflect the actual number of active wells. Some wells contained in DWR files may have been destroyed, mis-located, mis-classified, constructed into granites beneath the Subbasin and are very old and may no longer be active.

Figures 3-13 through 3-15 show the density of domestic wells, as refined by GSP efforts, and production (agricultural and industrial) and municipal wells (from DWR database) per square mile. Outlines of DACs and SDACs are also shown on the domestic and municipal well density figures. They show that within northern Placer County these communities likely use domestic wells. There are many sections where disadvantage communities are designated but no domestic or municipal wells are present. **Appendix B** provides a description of the methods used to refine density and minimum depths of the domestic well database along with new figures illustrating the density and top of well screens.

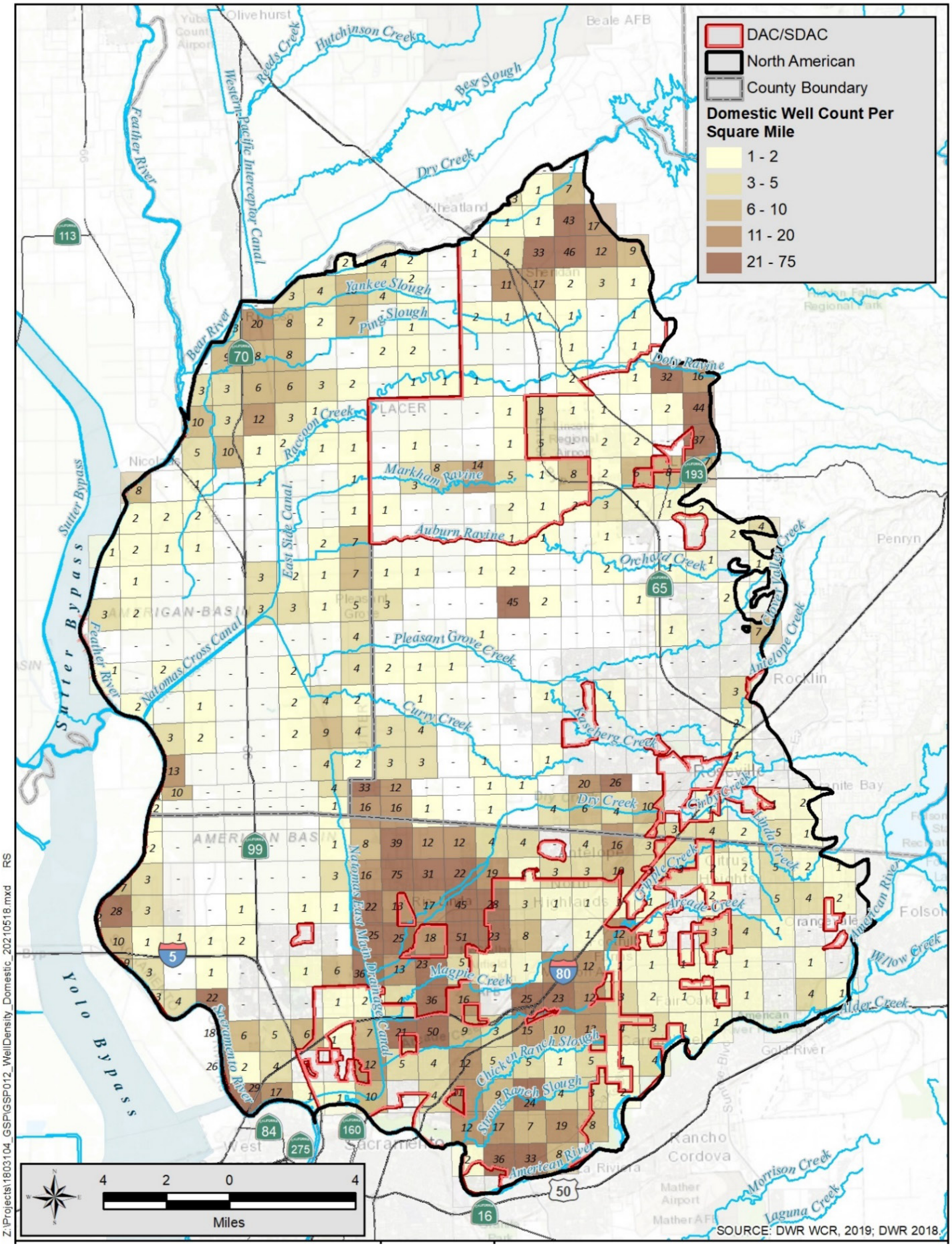
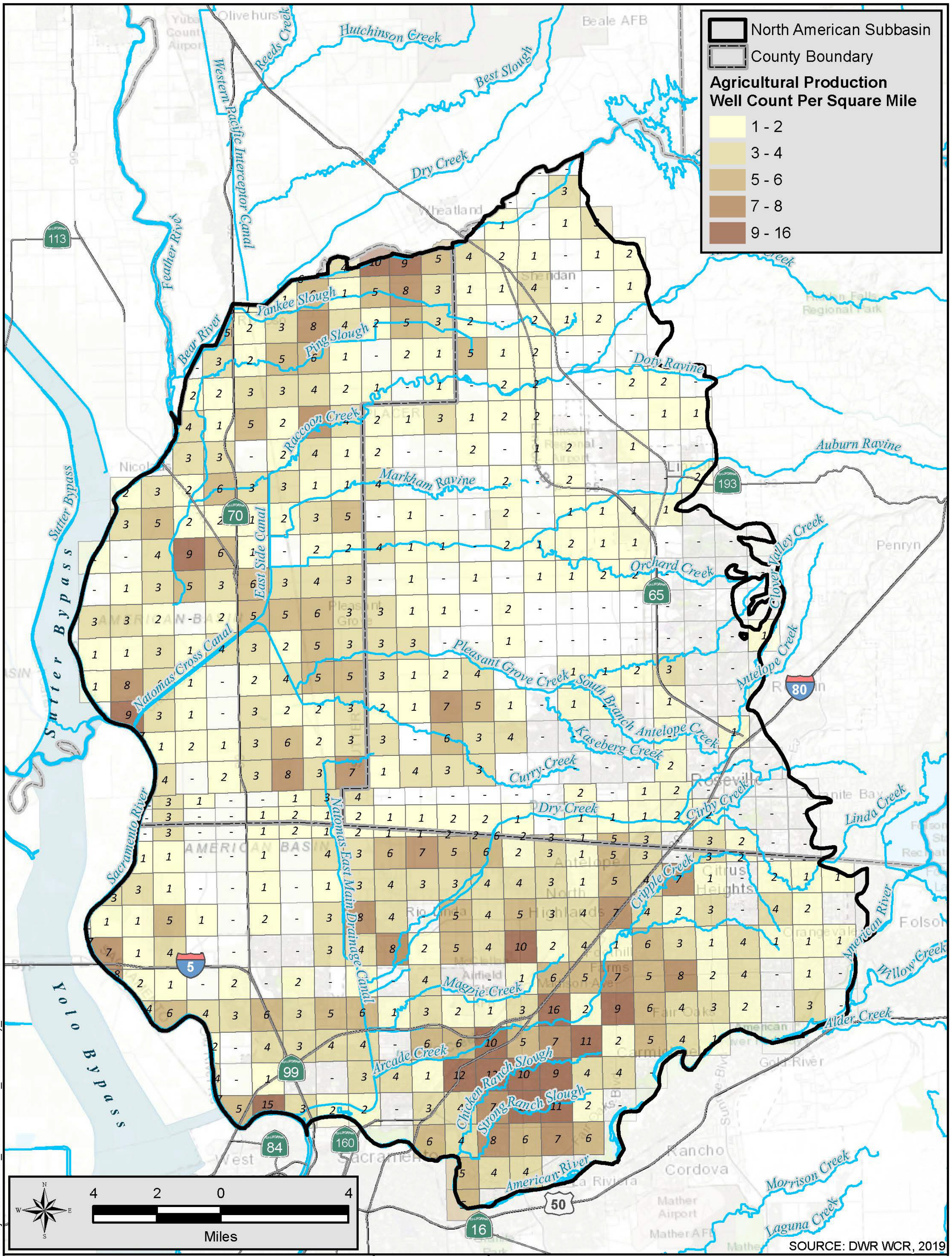


Figure 3-13. Density of Domestic Wells Per Square Mile



Z:\Projects\1803104_GSP\GSP014_WellDensity_Production.mxd RS

Figure 3-14. Density of Production Wells Per Square Mile

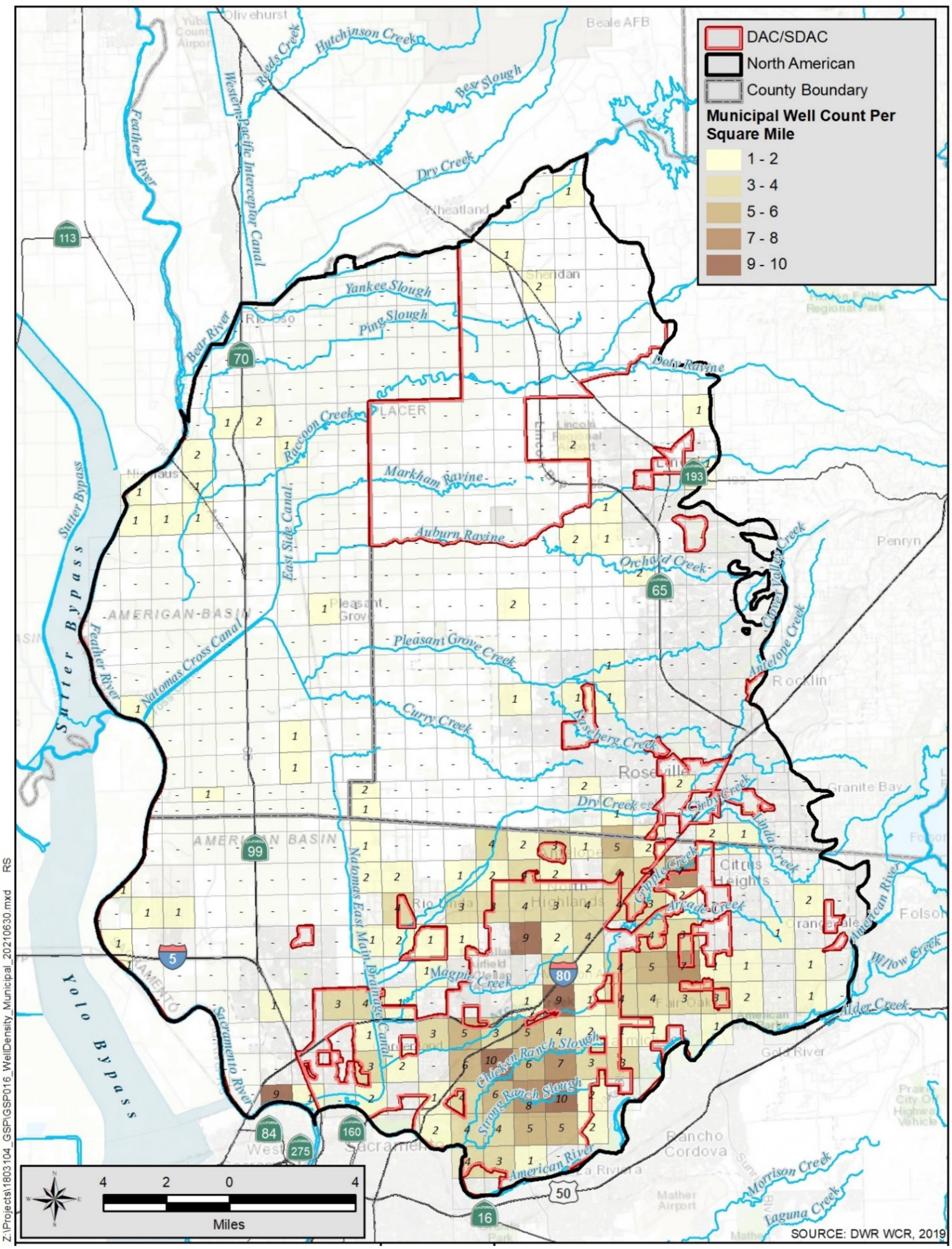


Figure 3-15. Density of Municipal Wells Per Square Mile

3.10 Existing Water Resources Management Plans

The Subbasin has many water resources management plans that cover activities that induces additional complexity to managing water resources. The following subsections provide a summary of other existing plans that the GSAs considered in the development of this GSP to manage groundwater resources in the Subbasin.

3.10.1 Groundwater Management Plans

In 1992, the California State Legislature enacted Assembly Bill (AB) 3030, and in 2002 the Legislature enacted Senate Bill (SB)1938. SB 1938 required adoption of a groundwater management plan as a prerequisite to obtaining funding assistance for groundwater projects from funds administered by DWR. These two pieces of legislation were incorporated into the California Water Code, Section 10753, to encourage local public agencies/water purveyors to voluntarily adopt formal plans to manage groundwater resources within their jurisdictions. **Table 3-4** provides a list of these groundwater management plans that separately covered the entire NASb. These existing groundwater management plans will be replaced with this GSP. Natomas Mutual Water Company has also prepared a groundwater management plan for its service area.

Table 3-4. Groundwater Management Plans

Groundwater Management Plan	AB3030	SB1938
SGA GMP 2014	x	x
Sutter County GMP 2012	x	x
WPC GMP 2007	x	x
SSWD GMP 2009	x	x

3.10.2 Water Forum Agreement

Representatives of water suppliers, local governments, citizens groups, environmental organizations, and businesses began the Water Forum in 1993 with the goal of developing a plan to ensure reliable long-term water supplies while protecting the lower American River. Following more than six years of analysis, professionally facilitated discussion, and negotiations, 40 diverse stakeholder groups signed the Sacramento Water Forum Agreement (WFA) in April 2000 (Water Education Foundation, 2002). An Environmental Impact Report for the WFA was completed in October 1999. The WFA included the following co-equal objectives:

- Provide a reliable and safe water supply for the region’s economic health and planned development through the year 2030
- Preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River

To achieve its objectives, WFA signatories approved an integrated package of seven elements:

- Increased surface water diversions
- Actions to meet customer needs while reducing diversion impacts in drier years
- Support for improved pattern of fishery flow releases from Folsom Reservoir
- Lower American River habitat management
- Water conservation
- Groundwater management
- Water Forum Successor Effort

The Water Forum effort continues today, with many successes and some ongoing challenges to meeting its objectives. Most importantly, a majority of the signatory stakeholder groups are still focused on supporting and achieving the WFA's objectives more than 20 years after its execution. While each of the elements of the WFA is critical to achieving its co-equal objectives, the groundwater management element is most relevant to local groundwater management efforts and to this GSP. The groundwater management element provides a framework for protecting and using groundwater in a sustainable manner. The WFA is currently being updated and will reflect the enactment of SGMA and implementation requirements of this GSP.

3.10.3 American River Basin Integrated Regional Water Management Plan

The greater Sacramento area has been involved in integrated water planning and implementation for two decades. In 2001, water suppliers in the Sacramento area formed the Regional Water Authority (RWA) as a joint powers authority to help implement elements of the Water Forum Agreement. RWA developed the first American River Basin Integrated Regional Water Management Plan (IRWMP) in 2006, with updates in 2013 and 2018. The IRWMP area includes SGA and West Placer GSAs.

Integrated Regional Water Management is an effective way to address complex water resources challenges and is driven by stakeholders that identify major water and related resource management issues and their proposed solutions. It maximizes economic and societal benefits in an equitable manner while maintaining the ecosystem critical to water resource sustainability.

The IRWMP identifies specific projects and implementation programs and agreements between different affected agencies to identify projects to put conjunctive use in place. The intended purpose of the IRWMP is to provide and encourage regional opportunities for water resources planning and project development.

3.10.4 North Sacramento Valley Integrated Regional Water Management Plan

The North Sacramento Valley IRWMP covers a large planning area and includes the Sutter County portion of the NASb and RD 1001, Sutter County, and portions of the SSWD GSA areas.

The IRWMP also includes specific projects and implementation programs and agreements between different affected agencies to identify projects to put conjunctive use in place.

3.10.5 Urban Water Management Plans

The Urban Water Management Planning (UWMP) Act was developed in response to the state's water shortages, droughts, and other factors. Every urban water supplier that provides over 3,000 AF of water annually or serves more than 3,000 service connections is required to submit a UWMP. UWMP requirements include updating water shortage contingency plans (WSCP), extended drought risk assessments, and energy intensity reporting. Required elements of an UWMP include a report on the progress that urban water suppliers are making in meeting their water use efficiency targets, current and projected water demands, current and projected water sources, water management actions to improve supply reliability, and an evaluation of the sufficiency of supplies to meet the forecasted demands under both normal and drought conditions. Entities within the NASb with UWMPs include:

California American Water	Nevada Irrigation District
Carmichael Water District	Orangevale Water Company
Citrus Heights Water District	Placer County Water Agency
City of Folsom	Rio Linda/Elverta Community Water District
City of Lincoln	Sacramento County Water Agency
City of Roseville	Sacramento Suburban Water District
City of Sacramento	San Juan Water District
Fair Oaks Water District	

Within UWMPs, the WSCPs are an important temporary demand management tool. WSCPs have required water shortage stages that allow local agencies to call for temporary demand reductions during periods of constrained supply. These reductions are an important management action to adapt to dry conditions.

3.10.6 Urban Water Use Efficiency Program

The RWA has managed a Regional Water Efficiency Program (WEP) since 2002. The WEP has 19 urban water suppliers participating throughout the greater Sacramento region, with 14 of those agencies being in the NASb. The Program's primary focus is a regional public and education program with the goal of assisting urban water suppliers with informing customers on how to use water more efficiently. Program activities include a public facing educational website (https://bewatersmart.info/), development of an annual public outreach campaign, radio, television, online and social media advertising, and a public service announcement-focused video contest for students. In 2021, the U.S. Environmental Protection Agency (EPA) honored the RWA WEP with the national 2021 WaterSense® Partner of the Year Award for its dedication to helping consumers and businesses save water, even with the challenges presented by the COVID-19 pandemic in 2020. This is the second WaterSense award for the Program (awarded WaterSense® Excellence in Education and Outreach Award in 2016).

In addition to public outreach and education, the WEP has been successful in securing grants to assist water suppliers in issuing rebates for water saving devices (e.g., toilets, showerheads, irrigation controllers). Since 2003, the program has secured nearly $14.7 million from highly competitive grant programs. In 2020, the WEP received $2.4 million in grant funding from Proposition 1 (The Water Quality, Supply, and Infrastructure Improvement Act of 2014) for several new multi-year programs and incentives focused on customer rebates and system water loss recovery and efficient irrigation practices and equipment.

As a result of the WEP's efforts over the last 20 years, the region's water use has remained steady even though the population grew 37 percent from 1.5 million to 2.1 million people. Additionally, every supplier in the region has successfully met and exceeded (by an average of 20%) the Water Conservation Act of 2009 (SB X7-7) requirements to increase water use efficiency by 20 percent by the year 2020. Looking forward, new water conservation regulations resulting from the passage of Senate Bill 606 and Assembly Bill 1668 (2018) are currently under development with implementation starting in 2023. These new regulations have a statute-defined goal of producing more savings than SB X7-7 and incorporate water efficiency standards for residential indoor use, residential outdoor use, commercial, industrial, and institutional landscape use and supplier system water loss.

3.10.7 Agricultural Water Management Plans

The Water Conservation Act of 2009 (SB X7-7) requires agricultural water suppliers serving more than 25,000 irrigated acres (excluding recycled water deliveries) to adopt and submit to DWR an Agricultural Water Management Plan (AWMP). These plans must include reports on the implementation status of specific Efficient Water Management Practices that were required under SB X7-7.

Required components of the plans include:

- Annual water budget
- Identification of water management objectives to improve system efficiency
- Quantification of water use efficiency with all water uses being accounted for including; crop water use, agronomic use, environmental use, and recoverable surface flows
- A Drought Plan for periods of limited water supplies that describes actions for drought preparedness

Districts within the NASb which have adopted AWMPs are:

- SSWD
- Natomas Mutual Water Company
- Nevada Irrigation District

3.10.8 Salt/Nutrient Management Plan

In February 2009, the SWRCB adopted Resolution No. 2009-011, which established a statewide Recycled Water Policy. Central to this Policy was the requirement that local water and wastewater entities, together with local salt- and nutrient-contributing stakeholders, develop a Salt and Nutrient Management Plan for specified groundwater basins and subbasins in California. The plans include management strategies, plans for stormwater and recycled water use, a monitoring program, and an antidegradation analysis. In response, the Sacramento Valley Water Quality Coalition was formed to perform studies and to represent growers in the Sacramento Valley, including the NASb. The Coalition developed a Groundwater Quality Assessment Report (CH2MHill, 2016) and a Comprehensive Groundwater Quality Management Plan. The Groundwater Quality Management Plan presents a baseline picture of groundwater quality, establishes a framework under which salt and nutrient issues can be managed, and streamlines the permitting process of new recycled water projects while meeting water quality objectives and protecting beneficial uses. This plan excluded areas where rice is grown.

The California Rice Commission also prepared a Groundwater Quality Assessment Report (CH2MHill, 2013). Rice is primarily grown in eight Sacramento Valley counties (Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Yolo, and Yuba). Rice lands overlie eleven subbasins in the Sacramento Valley Groundwater Basin, including the NASb. The California Rice Commission has issued rice-specific Waste Discharge Requirements (WDR), which requires groundwater trend monitoring and reporting at representative wells (one well is sampled in the NASb). Rice acreage has been identified as having a low vulnerability for nitrates.

3.10.9 Water Quality Control Plan for the Sacramento River Basin

The Central Valley Regional Water Quality Control Board (CVRWQCB) prepared a Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin (Basin Plan). The objective of the Basin Plan is to show how the quality of the surface water and groundwater in the Sacramento Region should be managed to provide the highest water quality reasonably possible. Water uses and water benefits vary depending upon the location in the basins. Water quality is an important factor in determining use and benefit. For example, drinking water must be of higher quality than the water used to irrigate pastures. Both are legitimate uses, but the quality requirements for irrigation are different from those for domestic use. The Basin Plan recognizes such variations.

The Basin Plan lists beneficial users, describes the water quality, which must be maintained to allow those uses, and contains an implementation plan, SWRCB, and CVRWQCB plans and policies to protect water quality, and statewide surveillance and monitoring as well as regional surveillance and monitoring programs.

Present and potential beneficial uses for inland waters in the basins are surface water and groundwater as municipal (water for community, military, or individual water supplies); agricultural; groundwater recharge; recreational water contact and non-contact; sport fishing; warm freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and, spawning, reproduction, and/or early development of fish.

Water Quality Objectives for both groundwater (drinking water and irrigation) and surface water are provided.

3.11 Existing Water Resources Monitoring Programs

Existing management and monitoring plans in the NASb are described below. Some of the programs will be incorporated into the GSP monitoring network or were used to develop this GSP.

3.11.1 Groundwater Level Monitoring Programs and Networks

Historical groundwater level data measurements were made by DWR, SGA, local water districts, and the United States Geological Survey (USGS).

Groundwater level monitoring is being performed by designated monitoring entities in the NASb as part of the California Statewide Groundwater Elevation Monitoring (CASGEM) program. This network of groundwater level monitoring wells provides data that is the foundation for many groundwater management decisions. Designated monitoring entities include: SGA, Placer County, City of Roseville, SSWD, and Sutter County. DWR also continues to monitor groundwater levels in the Subbasin. The CASGEM groundwater level monitoring network and others are shown on **Figure 3-16**.

Appendix C provides the monitoring well construction details. Many of the wells are dedicated nested monitoring wells (small diameter wells that are screened opposite individual aquifers). The NASb GSAs rely upon these dedicated monitoring wells to assess the groundwater conditions in the basin since these wells are not affected by local pumping, as are the voluntary wells that are commonly active pumping wells. SSWD, RD 1001, and the Sutter County GSAs use more voluntary wells than dedicated monitoring wells.

Groundwater level monitoring is also performed as part of DWR and the Bureau of Reclamation's Water Transfer Program, which allows for three categories of transfers: 1) groundwater substitution, 2) cropland idling and crop shifting, and 3) reservoir storage releases. Groundwater substitution transfers make surface water available for transfer by reducing surface water diversions and replacing that water with groundwater pumping. The monitoring of groundwater levels is required as part of the transfer agreement. The monitoring networks developed for the water transfers include the groundwater production wells participating in the transfer and additional monitoring wells to assess the effects of the transfer. The monitoring frequency varies from weekly to monthly. Monitoring begins just prior to the start of water transfer pumping and continues until groundwater levels have recovered to their seasonal highs the following spring.

The USGS monitors thousands of wells across the nation. The extensive water data, which includes manual measurements of depth to groundwater in wells throughout California, are stored in the National Water Information System (NWIS) online database (https://waterdata.usgs.gov/nwis). The database stores historical observations of active and discontinued sites in addition to current conditions with measurements transmitted hourly.

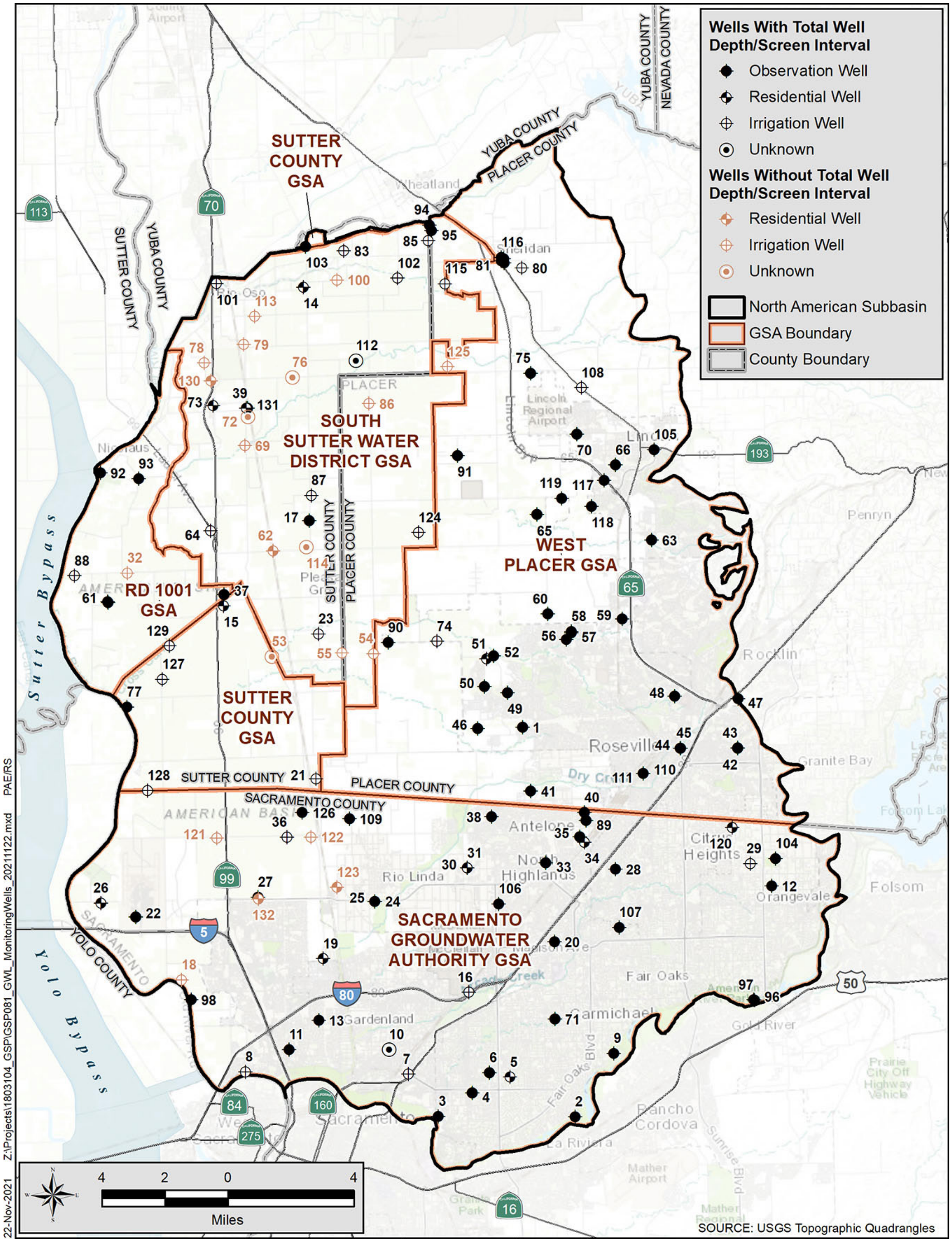


Figure 3-16. Groundwater Level Monitoring Network

Groundwater level measurements at these wells are taken approximately once per quarter. The USGS actively monitors 10 well sites within the NASb.

3.11.2 Groundwater Quality Monitoring Programs and Network

Groundwater quality is monitored under several different programs and by different agencies, as described below:

- Municipal and community water purveyors collect water quality samples on a routine basis for compliance monitoring and reporting to the SWRCB's Division of Drinking Water.
- The USGS collects water quality data under the Groundwater Ambient Monitoring and Assessment (GAMA) and National Water Quality Assessment programs.
- The Irrigated Lands Regulatory Program (ILRP) required the development of a Salt Nutrient Management Plan and, more recently, the development of a Groundwater Trend Monitoring Work Plan to identify wells for sampling and a groundwater quality monitoring protocol. Only one well has been designated in the Subbasin.
- West Placer selectively monitors 16 dedicated monitoring wells on an annual basis to assess water quality trends in wells that are approaching or have exceeded the maximum contaminant levels (MCLs) and for select water quality constituents with pending MCLs.

Figure 3-17 shows the locations of the water quality monitoring wells used for the programs described above.

In addition to these monitoring programs, there are multiple sites groundwater quality samples are collected and analyzed as part of investigation or compliance monitoring programs through the Central Valley Regional Water Quality Control Board.

The SWRCB, under the California's Safe and Affordable Fund for Equity and Resilience (SAFER) Program is evaluating on an annual basis water quality and risks to domestic wells and state small water systems. An aquifer risk map has been developed with the intent to help prioritize areas where domestic wells and state small water systems may be accessing groundwater that does not meet primary drinking water standards (maximum contaminant level or MCL). The combined risk layer combines the water quality risk ranking with the domestic well and state small system density of an area to calculate the overall risk to domestic well and state small systems. By combining these two data elements, areas with a relatively high density of reported domestic wells or state small water systems, and a high relative risk to water quality, are assigned the highest combined risk. The risk map will be used by SWRCB staff to help prioritize areas for available SAFER funding. Water quality results for the past 20 years from each well were analyzed. Of the 43 small community water systems within the NASb, only seven water systems were considered to be potentially at risk.

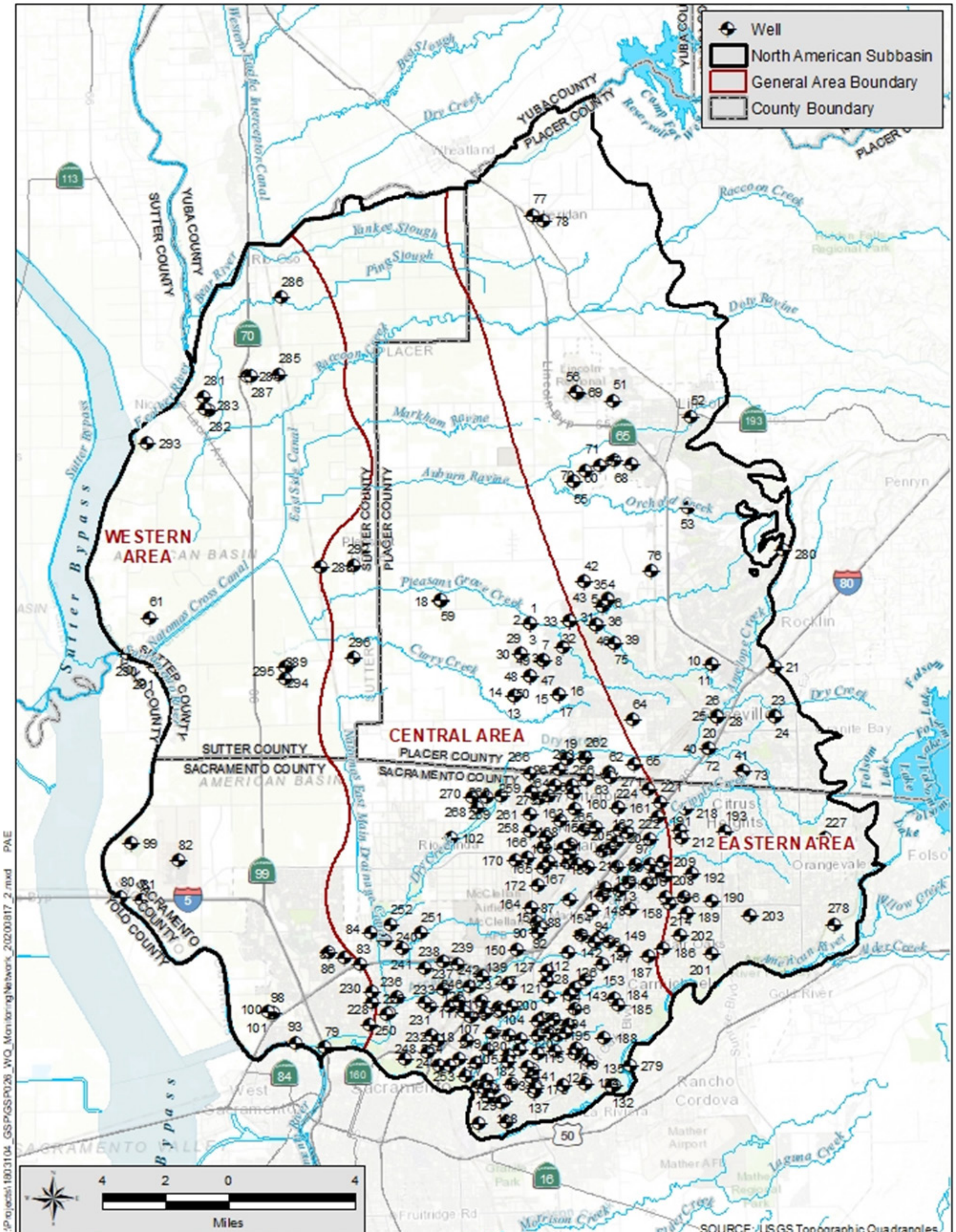


Figure 3-17. Groundwater Quality Monitoring Network

3.11.3 Surface Water Monitoring Networks

DWR, USGS, Placer County, and Sacramento County maintain surface water gages along the rivers, creeks, and sloughs in the NASb with publicly available data online. Depending on the station, they may measure only the level of water (stage) or the discharge. **Figure 3-18** shows the location of these gages. Note that the figure only shows a subset of the gages monitored by Sacramento County. This GSP uses the data collected by these agencies from some of these gages.

Surface water diversions into the Subbasin are also monitored by SSWD, NMWC, Pleasant Grove-Verona Mutual Water Company, Nevada Irrigation District, and Placer County Water Agency, cities of Sacramento and Roseville, San Juan Water District, and Carmichael Water District.

3.11.4 Precipitation Monitoring Network

Precipitation is measured at 29 stations located in the NASb, although many of the stations do not have a long period of record. **Figure 3-17** shows the location of these stations. This GSP uses the data collected by various agencies that maintain and report the data.

The closest station to the NASb with a long period of record, dating back into the 1880s, is the Sacramento 5ESE station, which is just south of the Subbasin but is likely representative due to its geographic location. The average precipitation, using the state climatologist definition of a recent representative period of years, water year 1988-89 through 2008-09 is 18.65 inches, at this location. **Figure 3-19** shows the precipitation by water year (October 1–September 30 of any given year).

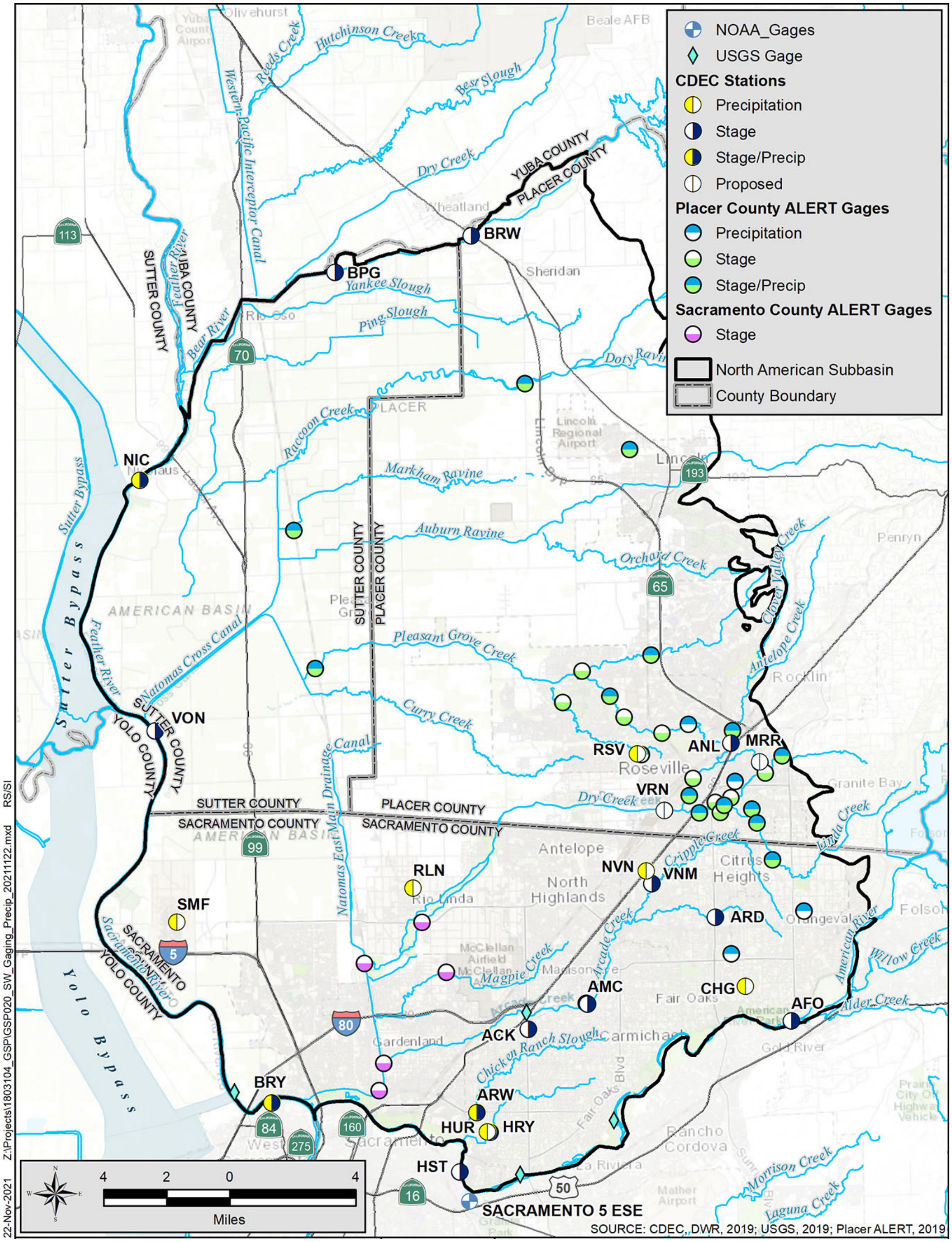


Figure 3-18. River Gages and Precipitation Stations

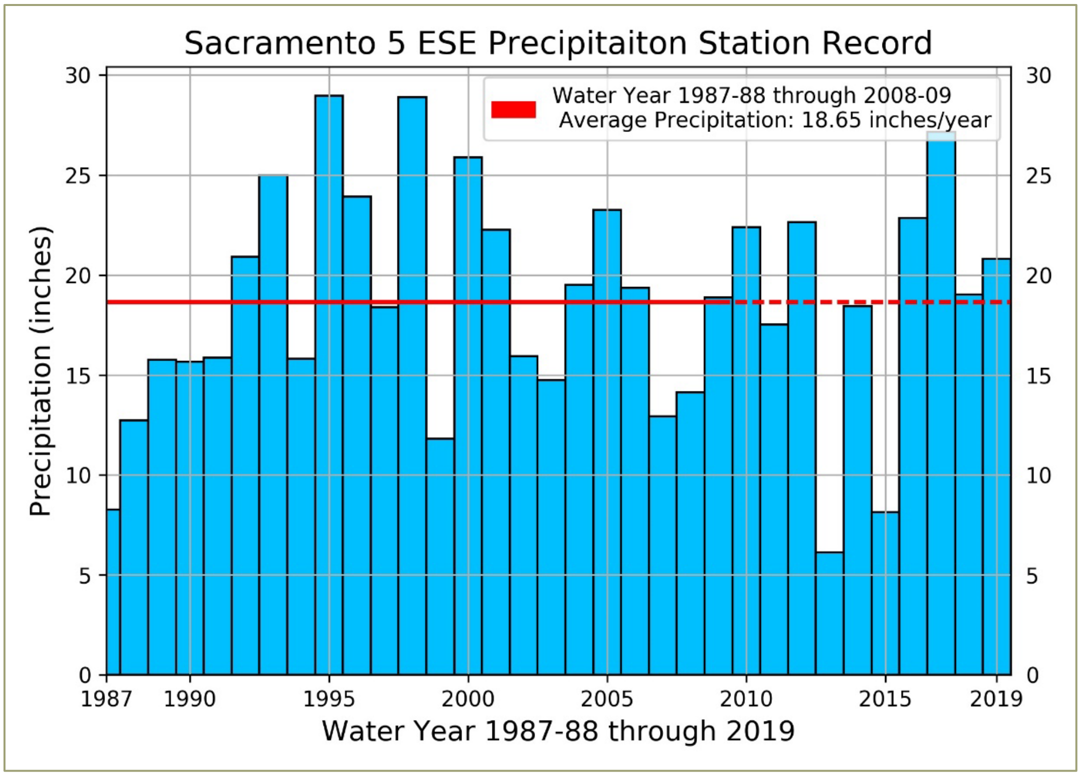


Figure 3-19. Water Year Precipitation

3.11.5 Subsidence Monitoring Network

DWR established a Sacramento Valley-wide benchmark network in 2008 and then resurveyed the benchmarks in 2017 to assess if and where subsidence occurred (DWR, 2018). DWR plans to resurvey this benchmark network about every 5 years or as funding is appropriated.

DWR constructed and monitors for subsidence at the Sutter extensometer (SUT Ext), located near the western edge of the Subbasin, near the Natomas Cross Canal at Highway 99 as shown on **Figure 3-20**. A nearby monitoring well SUT-P (11N04E04N005M) provides groundwater levels to assess if subsidence is related to changes in groundwater levels.

This GSP relies on data from these benchmarks and the extensometer and plans to incorporate them as part of the monitoring network for the NASb, as measured or coordinated by DWR. **Figure 3-20** shows the location of these benchmarks and the extensometer.

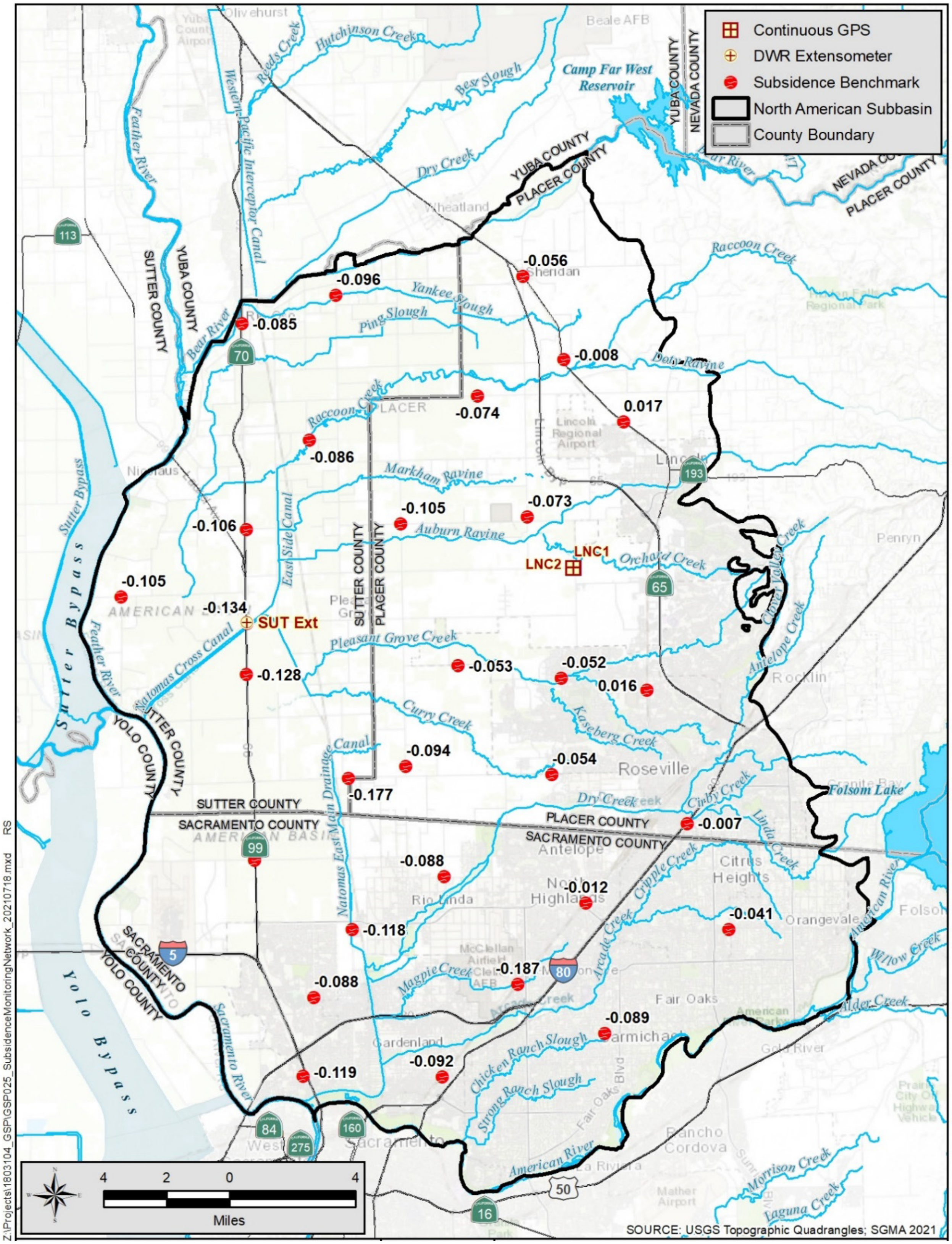


Figure 3-20. Subsidence Monitoring Network

3.12 Limits to Operational Flexibility

None of the existing water resources management or monitoring programs are expected to limit operational flexibility in the basin. Rather, they are seen as complementary to groundwater sustainability. They promote integrated management of water resources, water demand management, and water quality management. These are all fundamental to groundwater sustainability.

3.13 Conjunctive Use Programs

Conjunctive use is the planned, coordinated use of groundwater and surface water to optimize available water supplies. Surface water is used when it is available, and groundwater is used when surface water supplies are reduced or not available. The aquifer is utilized as a storage reservoir that can be recharged from precipitation, subsurface inflow, applied surface water, or injection wells. This stored water is then available when needed.

In 1993, the Water Forum began a process to develop a plan to ensure a reliable water supply for the Sacramento region, including work to develop conjunctive use projects in the area. This resulted in the formation of SGA in 1998. SGA focused the effort started by earlier agencies to manage groundwater in the Sacramento County portion of the NASb. Since the 1990s, SGA and its member agencies have managed groundwater and implemented conjunctive use projects, thereby reversing the decline of groundwater levels in the North Basin.

Currently, public water supplier agencies in the NASb meet water demands with a mixture of a little more than half surface water and a little less than half groundwater. To the extent practicable, the agencies maximize the use of surface water in wet years to maximize the amount of groundwater stored in the basin. The SGA and Regional Water Authority (with member agencies in the NASb and also in the South American and Consumes subbasins and surrounding watersheds) are committed to expanded conjunctive use operations and are investigating a variety of ways to recharge water into the available storage space in the NASb. Most of the recharge occurring through current conjunctive use is from in-lieu recharge (i.e., this is recharge that occurs naturally from rivers, streams, and surface percolation by simply reducing groundwater extractions).

The SGA has developed a Water Accounting Framework (WAF) that has been used by SGA member agencies in the Sacramento County portion of the Subbasin to ensure a safe and sustainable water supply for the greater Sacramento region by encouraging water purveyors to "bank" water in the basin, when available, for use during dry periods. This includes the establishment of a WAF that supports groundwater banking programs by setting forth rules for operating a model groundwater bank and monitoring the basin to ensure its sustainability as the program is implemented. Since 2012, SGA has maintained an accounting of groundwater "deposits" and "withdrawals" associated with implementing their conjunctive use program.

Well ahead of any formal conjunctive use programs, SSWD was formed for the purpose of providing surface water supplies to offset the decline of groundwater levels. The first year of operation of Camp Far West Reservoir and associated facilities was 1964. The operation of these facilities was successful in reversing the decline of groundwater levels such that by 1970 the potential of drainage problems were identified if greater quantities of groundwater were not put to use.

Although not a formal program, water and irrigation districts and mutual water companies that provide surface water for agricultural use in the NASb also provide conjunctive use by increasing their deliveries of surface water during times of surplus, thereby reducing the amount of groundwater pumped by private well owners.

In addition to the active conjunctive use programs described above, Sacramento County has an existing General Plan Conservation Element, Policy C-01 that states to "Support conjunctive use water supply for development." This will help ensure that conjunctive use continues in developing areas of the County.

3.14 Land Use Plans

Land use management and planning authority is granted through the state of California and is derivative of a city's or county's general police power. This power allows cities and counties to establish land use and zoning laws that govern development. Agencies with land use authority in the NASb are the cities of Citrus Heights, Folsom, Lincoln, Rocklin, Roseville, and Sacramento along with counties of Placer, Sacramento, and Sutter. The cities of Roseville and Sacramento are considered charter cities, which provides them with additional constitutional freedoms to govern municipal affairs even if a conflict with state law exists.

General Plans and UWMPs have been developed by the cities of Citrus Heights, Folsom, Lincoln, Roseville, and Sacramento along with Sutter, Placer, and Sacramento counties. Their planning horizons (out to 2030 or 2035) include the anticipated planned growth in the region.

Water purveyors also have a voice in land use planning, but not necessarily an authority. Because they provide water supply, any new development is required to prove adequate water supply will be made available to serve the project and, therefore, may affect land use. Proof of adequate water supplies is required under SB 610 and SB 221, which are intended to assist water suppliers, cities, and counties with integrating water and land use planning. SB 221 prohibits a city or county from approving a residential subdivision of more than 500 units unless there is written verification that sufficient water supply for 20 years is, or will be, available. SB 610 requires retail water agencies with responsibility under prescribed circumstances to prepare water supply assessments for the purpose of predicting and ensuring long-term (20-year) water supply reliability for those projects that are subject to the California Environmental Quality Act (CEQA).

It should be noted that California American Water and Golden State Water Company, although not public water agencies, have similar authority to the public water agencies for the determination of adequate water supplies for new developments.

Water supplies for new developments (*refer to* **Figure 3-6**) will be a mixture of surface water and groundwater. Placer County, Policy 4.C.2, requires for approval that new urban and suburban developments should rely on public water systems using surface water supply. In Placer County, the development near and south of Pleasant Grove Creek will be provided with surface water. Those in the Lincoln area will be a mixture of surface water and groundwater. The early phases of the Sutter Pointe development in Sutter County will rely on groundwater and ultimate planned combination of groundwater and surface water to meet the needs of the community. Surface water would be obtained from NMWC. Planned development areas within Sacramento County will likely use groundwater as their initial sources of supply and ultimately plan to use both surface water and groundwater as their source of supply.

3.15 GSP Implementation Effects on Land Use

The General Plans in the Subbasin provide guidelines to facilitate anticipated growth within the sustainable capacity of existing resources. Successful land use planning promotes sustainable water supply and use within the region. Due to the complementary nature of the General Plans and the GSP, the goals and policies in the General Plans support the ability of the GSAs to achieve sustainability.

Implementation of the GSP, including changes in groundwater management, may influence the type of land use and location of future development. The result will depend on the level of changes set forth by the GSP such as enacted programs, plans, and policies. While General Plan implementation may result in land use changes and changes in water consumption, minimal change in water demand is expected from GSP implementation. The potential for future management actions, which could impact water supplies and development, is discussed in **Section 9 – Projects and Management Actions**.

Most of the land within the Subbasin is currently developed to some use, and conversion from agricultural uses to urban uses is not anticipated to increase water demand. However, conversion from agriculture to urban use may have an effect on water source, depending on the location in the Subbasin, and may shift supply from groundwater to surface water.

3.16 GSP Implementation Effects on Water Supply

The water budgets for the Subbasin show that it is currently within balance and that projected conditions with climate change results in only a slight imbalance. One project is planned that can bring the water budget into balance and within its sustainable yield. The GSAs have also six long-term Supplemental Projects, as discussed in **Section 9 – Projects and Management**

Actions, that are in process of being developed that should groundwater level measurements indicate there is an imbalance the GSAs can easily rectify any short fall. Therefore, with these conditions this GSP does not intend to curtail groundwater use.

3.16.1 Urban Water Supply

The reliability of urban suppliers is expected to improve with implementation of this GSP through expansion of their conjunctive use programs (*see* **Section 9 – Projects and Management Actions**). These conjunctive use programs benefit the entire Subbasin.

3.16.2 Agricultural Water Supply

Agriculture uses about 50 percent groundwater to grow crops (*see* **Section 6 – Water Budgets)**. Conversion of fallow land and rice lands to orchards were included in the modeling assumptions for the projected future with climate change. The model is showing that even with these changes groundwater sustainability indicators will not be adversely affected. Therefore, implementation of this GSP is not expected to affect agricultural water supply.

3.16.3 Domestic Water Supply

Groundwater levels are expected to remain near their current levels (*see* **Section 8 – Sustainable Management Criteria**) and, therefore, no domestic wells are projected to go dry. Because agriculture and municipal wells are typically deeper than domestic wells, implementation of this GSP is not expected to affect these water supplies.

3.16.4 Environmental Water Supply

Groundwater dependent ecosystems are predominately located near the rivers which will continue to maintain shallow groundwater levels (*see* **Section 8 – Sustainable Management Criteria**). Groundwater levels are expected to remain near their current levels and, therefore, groundwater supply to potential groundwater dependent ecosystems is not expected to be lowered or reduced during implementation of this GSP. During drought periods groundwater levels are expected to decrease, which will mimic the natural cycle of wet and dry periods.

Surface water depletion may increase from the Sacramento River with construction of an already approved development (Sutter Pointe). However, the increase in surface water depletion will be offset by the reduction of surface water diversions as the land is converted from agriculture to urban.

3.17 Well Permitting

DWR has responsibility for developing standards for wells for the protection of water quality under California Water Code Section 231. All counties and cities and water agencies, where appropriate, were required to adopt a well ordinance that meets or exceeds DWR's Water Resources Bulletin 74-81, "Water Standards: State of California" and Bulletin 74-90. Four agencies have well-permitting authority in the NASb for both new and replacement wells and well destruction.

- The **Placer County Water Well Construction Ordinance** provides the minimum requirements for construction, repair, and destruction of water wells, cathodic protection wells, and monitoring wells. Whoever wishes to drill a well within the county's boundaries, except for those within the city of Roseville, must first obtain a County Environmental Health permit. Placer County administers the well permitting program for the entire county, except for lands within the city of Roseville. Any wells planned within the city of Lincoln must first be approved by the city prior to the issuance of a County Environmental Health permit.
- **Roseville's Environmental Utilities Engineering Division** is the permitting agency for wells located within Roseville's city limits. To permit a well in Roseville, a Well Construction Application and Permit Form must be filed with the Environmental Utilities Department.
- The **Sacramento County Environmental Management Department (SCEMD)** approves permit applications for a new well or to deepen, reconstruct, recondition, or destroy a well. Any well that is constructed in Sacramento County must have a permit from the Environmental Management Department prior to the start of construction unless it is specifically exempted in the Sacramento County Code. The conditions and process for obtaining well permits are governed under Sacramento County Code, Title 6, Chapter 6.28.
    - Section 6.28.025 defined a "prohibition area" as that portion of the unincorporated territory of the county bounded on the east and south by the former McClellan Air Force Base, on the south by Sacramento city limits, on the west by Dry Creek Road, and on the north by I Street. No permits shall be issued for, and no person shall dig or drill a new water well within the prohibition area.
    - The permit requires that any applicant shall contact the CVRWQCB to assess the potential for groundwater contamination in the vicinity of the well and can require special sanitary seal requirements to prevent the spread of contaminants.
    - SCEMD also, when required, requests copies of CEQA documentation prior to the approval of the permits.
- **Sutter County Environmental Health Division (SCEHD)** is the well-permitting agency for Sutter County. One permit application is used for a new well or to deepen, reconstruct, recondition, or destroy a well. The permit application requires a site plan showing the location of the well and the accessor's parcel number. The design and construction of the well shall be in conformance with the California Department of Water Resources Bulletin

74-81, “Water Standards: State of California” as outlined in the County of Sutter Department of Public Works Improvement Standards (2005, rev. 2010).

All of the permitting agencies have requirements for wellhead protection including minimum well heights, well seals and concrete pads to surround the well and to promote drainage away for the wells.

None of the well permitting agencies coordinates with county or city land developers. There are no setbacks or special investigation requirements for construction of supply wells near the rivers or tributaries.

3.18 Land Use Plans Outside of the NASb

During coordination with the Yuba, Sutter, and Yolo subbasins, representative GSAs disclosed that there were no planned developments or land use changes near our common boundaries that would affect the NASb’s ability to maintain sustainable groundwater management to our north and west. To the south, the NASb has closely coordinated on development of a groundwater model with the South American Subbasin. While there are planned changes in land use and conjunctive management practices to our south, modeling indicates that these changes would not affect our ability to maintain sustainable groundwater management. This modeling is documented in **Section 9.2.1 - Project #1 - Regional Conjunctive Use Expansion** of this GSP.

This page intentionally left blank

4. Hydrogeologic Setting

This section describes the geologic conditions that control how groundwater moves in the NASb, the Subbasin extent, recharge and discharge areas, general water quality, and defines the principal aquifers.

4.1 Basin Boundaries

The NASb lies in the eastern central portion of the Sacramento Valley Groundwater Basin. A subbasin designation indicates that aquifers beneath the NASb may extend into the adjacent South American, South Yuba, Sutter, and Yolo subbasins.
The NASb is surrounded on three sides by rivers and on one side by bedrock; the Bear River is its northern boundary, the Feather and Sacramento rivers are its western boundary, and the American River is its southern boundary. The eastern boundary, a roughly north-south line extending from the Bear River south to the American River, represents the approximate edge of the alluvial basin, where little or no groundwater flows into or out of the groundwater basin from the bedrock of the Sierra Nevada mountain range (Sierra Nevada) (DWR, 1997).

The bottom of the Subbasin is defined as either bedrock (igneous and metamorphic) that can be found cropping out in the foothills east portion of the Subbasin or the top of the marine sediments (base of fresh water). Fresh water is defined as water having salts that result in an electrical conductivity measurement of less than 3,000 micromhos (Berkstresser, 1973). The base of fresh water occurs near ground surface in the eastern portions of the Subbasin and deepens westward to more than 2,000 feet below mean sea level (msl) near the southwestern corner of the Subbasin. **Figure 4-1** shows the base of fresh water.

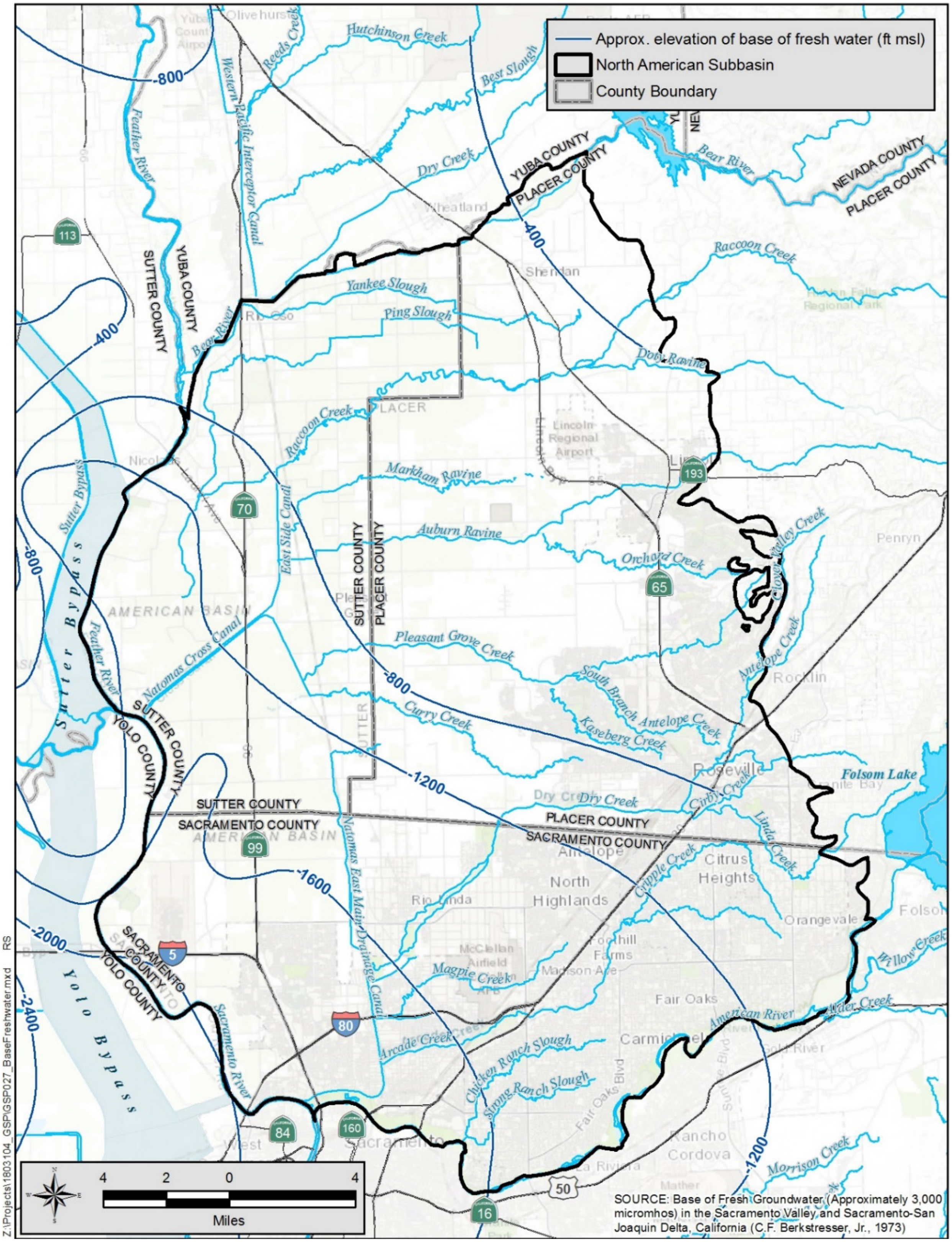


Figure 4-1. Base of Fresh Water

4.2 Topography

The topography in the NASb is irregular in the eastern portion of the Subbasin whereas the western portion of the Subbasin is nearly flat. The elevation in the Subbasin ranges from about 20 to 300 feet above msl. In the eastern portion of the NASb, ground surface is characterized by low rolling dissected uplands. The western half of the Subbasin is nearly flat, with elevations ranging from 20 feet above msl near the Feather and Sacramento rivers to about 50 feet above msl in the central portion of the Subbasin. The lowest land elevations are located near the southwestern corner of the Subbasin, near the confluence of the Sacramento and American rivers. The topography of the Subbasin is shown in **Figure 4-2**.

4.3 Surface Water Bodies

There are no large lakes or reservoirs in the NASb. There are numerous lakes and reservoirs within the Bear and American watersheds that contribute water to the NASb. The lowest elevation reservoirs in the watershed are Folsom and Camp Far West, which control flows in the American River and the Bear River, respectively. There are numerous smaller reservoirs above both Folsom and Camp Far West reservoirs.

Below Folsom Reservoir and within the NASb is Lake Natoma, which is a small lake that ponds water and may provide some recharge to the Subbasin. Outside of the Subbasin and watershed, to the north, are Lake Oroville and Shasta reservoirs, which regulate flow to the Feather and Sacramento rivers, respectively. Flows in these rivers, especially during the summer months, are predominantly due to regulated releases through dams that created these reservoirs and lakes.

The Subbasin is drained by numerous creeks and ravines that are tributary to the American, Bear, Feather, and Sacramento rivers (**Figure 4-2)**. Most of the creeks and ravines drain either to the East Side Canal and Natomas Cross Canal or the Natomas East Main Drainage Canal. These canals were constructed to reclaim and provide flood protection for lands west of the canals.

Water in the tributaries is present due to rain (winter months), tailwater from Placer County Water Agency and Nevada Irrigation District canal systems, conveyance of transferred water, and treated water from wastewater treatment plants. In the western portion of the Subbasin, groundwater may discharge seasonally to drainage canals and the Feather and Sacramento rivers.

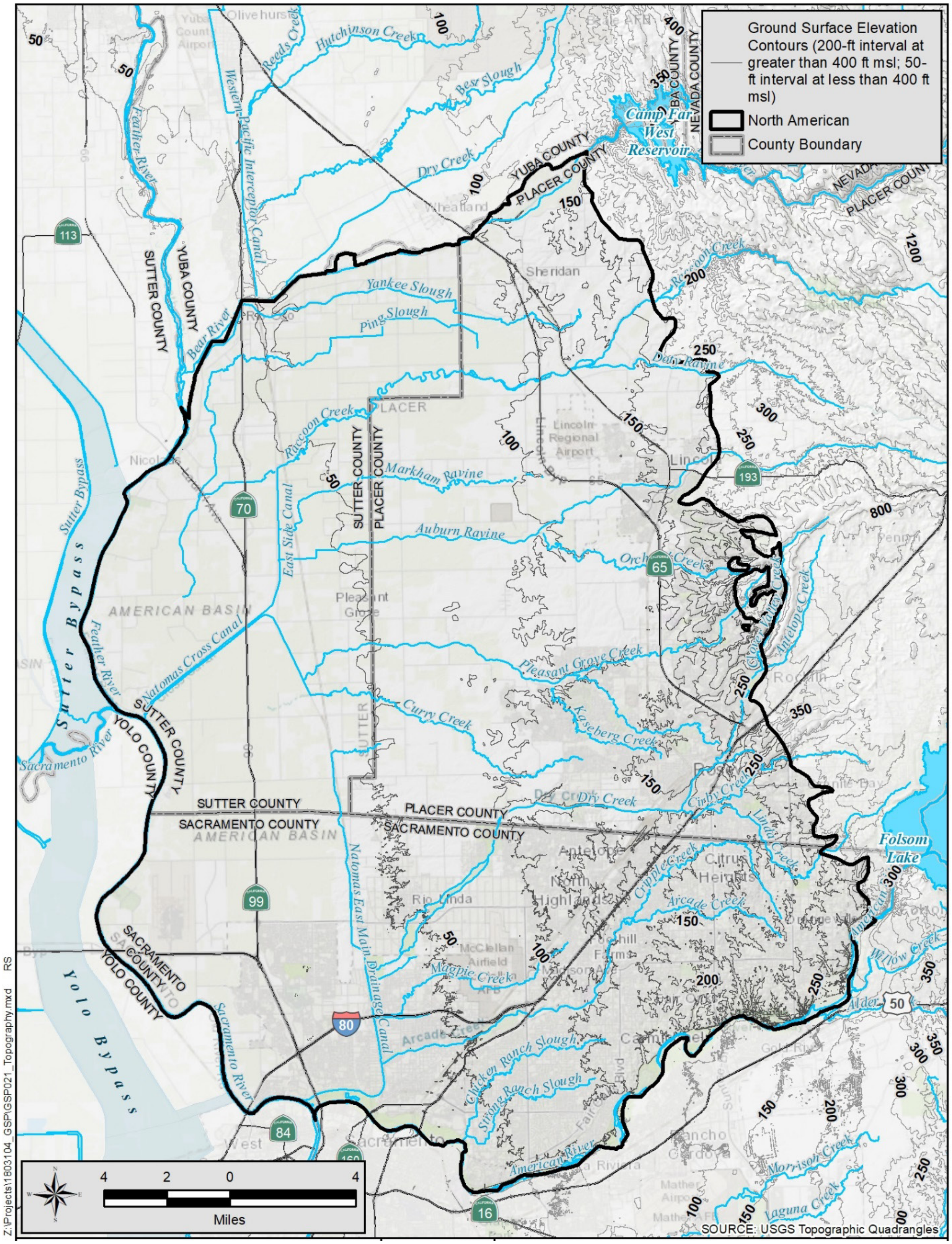


Figure 4-2. Topography

4.4 Soils

The NASb is covered by soils whose age, in general, corresponds with the relative age of the geologic units. The oldest soils lie along the eastern margin of the study area, with progressively younger soils toward the west. Most of the soils in the eastern three-fourths of the study area have well-developed profiles, usually with claypans and hardpans (U.S. Soil Conservation Service, 1980 and 1987). The dense subsoil in these areas may limit deep percolation of precipitation and applied irrigation water.

Soil permeability provides an initial indication of where recharge to the underlying aquifers may occur. Soil types and attributes have been mapped in the NASb by the U.S. Department of Agriculture’s Natural Resources Conservation Service and are contained in a database (SSURGO, 2019). The Hydrologic Soils Grouping describes the soil’s drainage characteristics. The groups range from Type A soils, which are well drained (high infiltration rates), Type B that are moderately drained, Type C that are poorly drained, and Type D soils that are very poorly drained (very slow infiltration rates). **Figure 4-3** shows the soil types by hydrologic groupings in the Subbasin. Much of the Subbasin is covered with poorly drained Type C and D soils. While these poor infiltration rate soils often inhibit flow to the subsurface, these soils classifications are generalizations of soil types and localized windows of connection to the underlying aquifers can exist, particularly when streams are incised through the soil profile. Most of the coarse-grained, well-drained soils occur along rivers and major stream channels and some along the eastern margins of the Subbasin.

While the Hydrologic Soils groups shown on **Figure 4-3** indicate the hydrologic characteristics of the soils, the Soil Agricultural Groundwater Banking Index (SAGBI), developed by researchers at UC Davis (O’Green, et al., 2015), also considers factors that affect the suitability of active agricultural lands for groundwater recharge, including root zone residence time, topography, chemical limitations, and soil surface condition. The UC Davis researchers developed an index that ignores restrictive layers in the first 6 feet. This “modified SAGBI” is shown on **Figure 4-4** and assumes that tillage practices could break up the shallow restrictive layers. These kinds of tillage (or ripping) practices may already have been used in certain areas that may have greatly enhanced the soil's hydrologic characteristics and increased their permeability. **Figure 4-4** shows a much larger area of more permeable soils than shown on the SSURGO soils map in **Figure 4-3**. Note that the white/gray areas do not contain the data necessary to calculate the SAGBI.

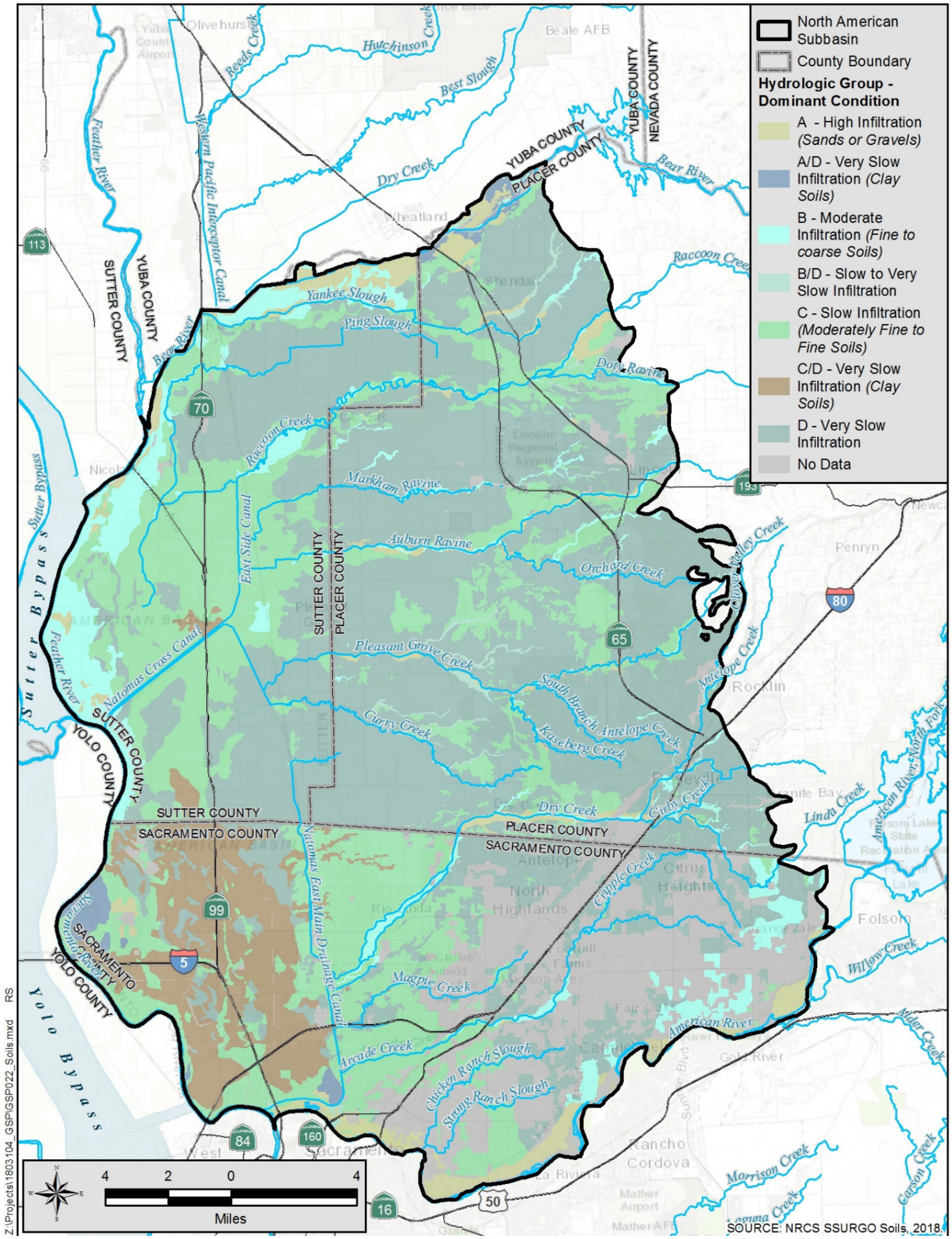


Figure 4-3. Hydrologic Soils Classification

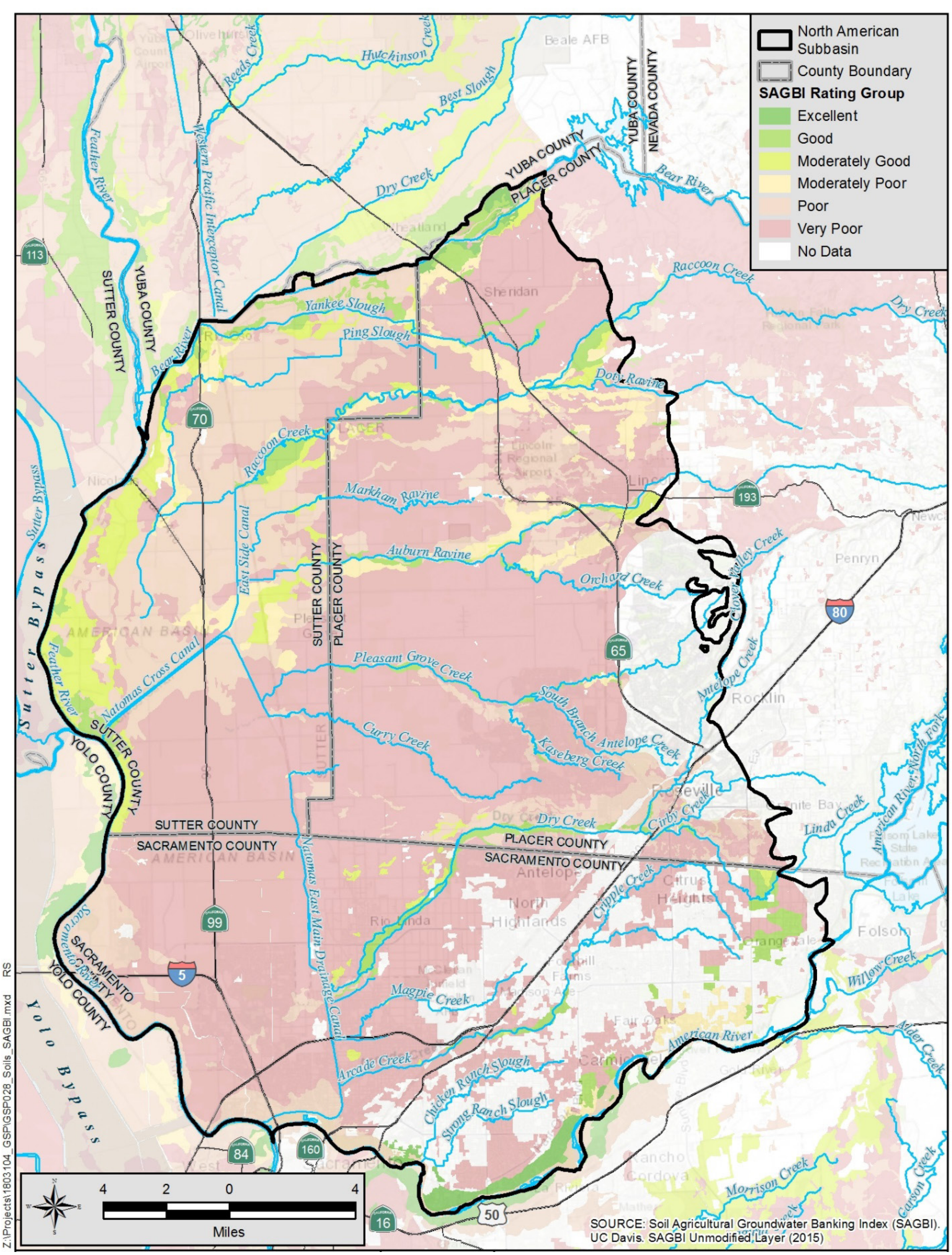


Figure 4-4. SAGBI Soils

4.5 Regional Geology

The Sacramento Valley is a large depression bounded on the east by the Sierra Nevada, a block mountain range faulted upward on the east and dipping westward beneath the Sacramento Valley. The Sierra Nevada consists of metamorphic rocks intruded by igneous rocks. The Sacramento Valley is bounded on the west by the Coast Range mountains.

Younger river and creek-lain deposits comprise the major portion of the freshwater aquifer system in the Sacramento Valley. The sediments beneath the NASb depict a regional change in the environments, from one previously dominated by marine sedimentary processes to one with continental sedimentary processes. The Sacramento Valley, including the NASb, is filled with marine sedimentary rocks that contain ancient seawater and traps of natural gases. The Valley Springs and Ione formations were deposited during the conversion from marine to continental environments. These formations contain both fresh and brackish water (having salts that result in an electrical conductivity measurement of greater than 3,000 micromhos). Both formations are overlain by younger, continentally derived sediments that have been grouped into the Younger Alluvium and the Modesto, Riverbank, Turlock Lake, Laguna, and Mehrten formations. **Figure 4-5** shows the distribution of these sediments in the Subbasin at ground surface. These formations contain fresh, mostly potable water. Clear distinctions and confining layers that separate formations often do not exist and water movement between formations can occur.

4.6 Geologic Structure

During the deposition of sediments, the valley has been gently down-warped due to tectonic activities and consolidation of the sediments. Sediments generally dip toward the center of the valley at about a 4-degree dip. Therefore, near the eastern edge of the Subbasin, older sediments such as the Mehrten Formation are exposed at the ground surface while to the west these sediments occur as deep as 2,000 feet below ground surface.

Faults may affect groundwater flow by bringing geologic materials with different hydraulic properties into contact across the fault plane or by fracturing the sediments, which could either increase or decrease permeability. Faults might, therefore, act as a boundary or barrier affecting the lateral flow of groundwater between adjacent areas and could act as a conduit allowing vertical upward flow within the fault zone. There are no known active faults within the Subbasin (DWR, 1997), but there are older inactive faults that may affect groundwater quality. One of these older faults is the Willows Fault, which is a northwest-southeast trending reverse fault that dips 74 degrees to the east and extends from the Stockton area through the NASb and to the north end of the Sacramento Valley (Harwood and Helley, 1987). **Figure 4-5** shows the location of the fault. Displacement along the Willows Fault is approximately 1,600 feet and displaces older marine sediments up to the time of deposition of the Ione Formation (Harwood and Helley, 1987). It does not continue into the fresh water-bearing sediments and therefore is not a barrier to groundwater flow. Although the fault is not designated by the state as active, the fault does appear to have some movement. The slip rate on the Willows Fault is very small, estimated to be 0.00055 inches per year (McPherson and Garven, 1999, referenced in DWR, 2014), but still suggests some activity.

4.7 Fresh Water-Bearing Formations

Fresh water-bearing sediments in the NASb from shallow/youngest to deepest/oldest sediments include the Quaternary Alluvium and the Modesto, Riverbank, Turlock Lake, Laguna, and Mehrten formations. These formations are of similar ages and have been grouped together for discussion purposes below. Surface outcrop locations of the formations are shown in **Figure 4-5**.

4.7.1 Quaternary Alluvium

Quaternary Alluvium is the youngest geologic unit (current to 10,000 years old) in the Subbasin. Laterally extensive outcrops of the Quaternary Alluvium deposits occur along the American, Bear, Feather, and Sacramento rivers. The alluvium is separated into three types: those associated with stream channels, with flood basins, and with alluvial fans (sediments deposited by streams as they emerge onto the valley floor).

The stream channel deposits originate in the channels of active streams and as overbank deposits of those streams, terraces, and local dredge tailings. Alluvium consists of sand, gravel, silt, and minor clay. The most extensive deposits occur along the American, Bear, Feather, and Sacramento rivers. Near the junction of the Bear and Feather rivers, coarse-grained sediments are present at depths up to 140 feet. However, the deeper sediments probably belong to the Modesto and Riverbank formations. Along the Bear River, the thickness of the alluvium is estimated to be 25 to 60 feet thick (Olmstead and Davis, 1961). The alluvium is also exposed along the smaller streams draining the Subbasin and is probably only a few tens of feet thick.

Flood basin deposits consist primarily of poorly drained silts and clays, although local lenses of sand and gravel may occur from the deposition of migrating ancestral river channels. The thickness of each of these units may be up to 100 feet (Olmstead and Davis, 1961). Flood basin deposits crop out on the western margin of the Subbasin, immediately east of the Sacramento River.

Alluvial fan deposits are derived from the Sierra Nevada and are generally coarse-grained. They are present along the eastern edge of the Sacramento Valley where they overlie the Mehrten, Ione, and Valley Springs formations.

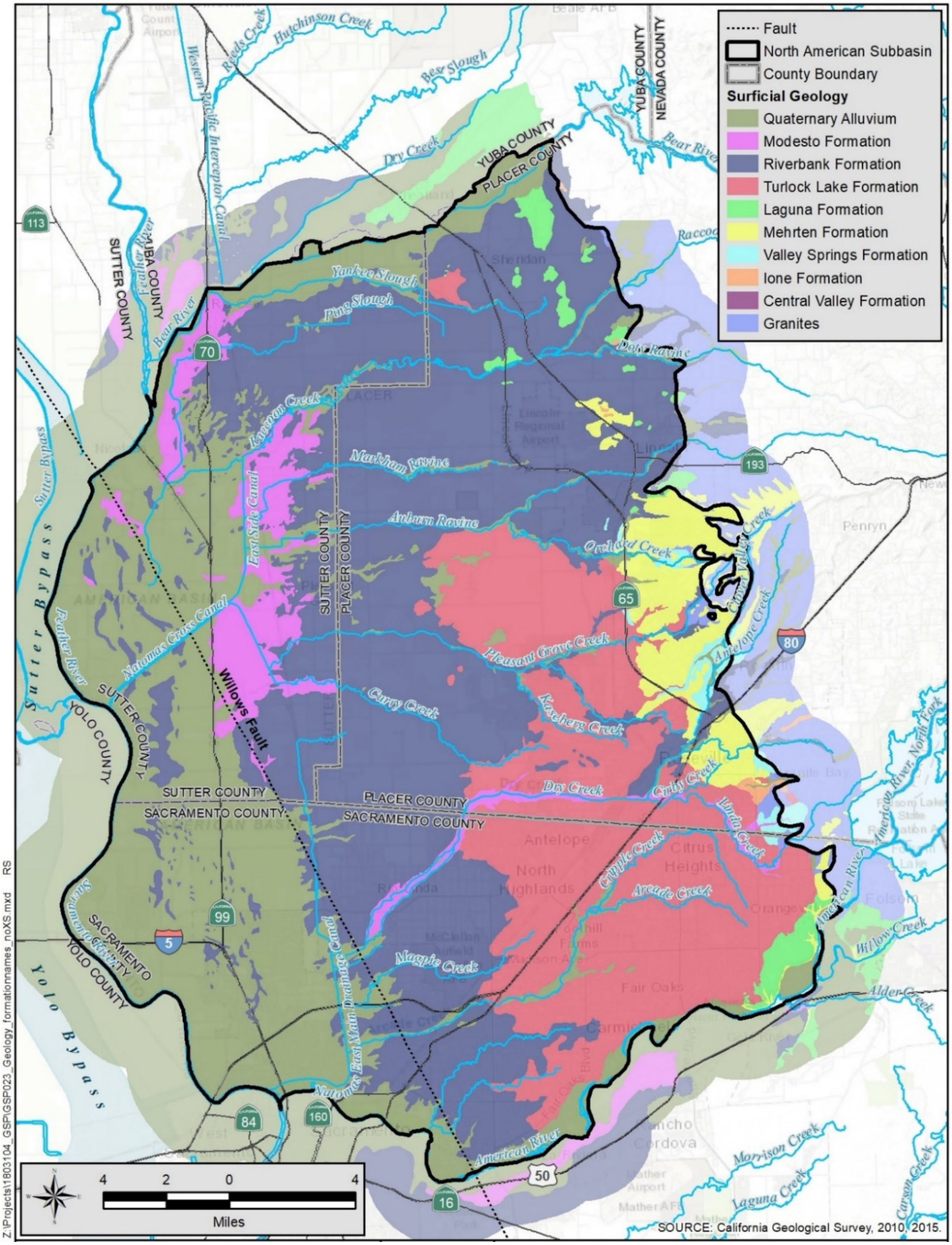


Figure 4-5. Surface Geology

4.7.2 Modesto and Riverbank Formations

The Pleistocene-age (10,000 to 2 million years) Modesto and Riverbank formations are the most widely exposed geologic units in the study area. They unconformably overlie the Turlock Lake, Laguna, and Mehrten formations and the metamorphic and igneous rocks near the eastern margin of the Subbasin. The Modesto and Riverbank formations were derived from similar parent rocks and are indistinguishable (lithologically) in the subsurface, composed of mixtures of silt, sand, gravel, and clay that are very heterogeneous both laterally and vertically. The combined thickness of these two formations can be up to 75 feet. These two formations are moderately permeable but include highly permeable coarse zones (Olmstead and Davis 1961).

4.7.3 Turlock Lake and Laguna Formations

Underlying the Modesto and Riverbank formations are the early Pleistocene-age (2 to 10 million years) Turlock Lake Formation and Pliocene-age Laguna Formation. The Turlock Lake and Laguna formations unconformably overlie the Mehrten Formation. The units underlie dissected uplands along the eastern margin of the study area and dip westward beneath the land surface toward the axis of the valley. The exposures of the Laguna Formation are small and discontinuous, generally less than a few square miles in area, and limited to the northeastern corner of the NASb. The Turlock Lake Formation is exposed on ground surface in a wide band near the southeastern corner of the NASb.

The Turlock Lake and Laguna formations are lithologically indistinguishable. They are differentiated in outcrop by the presence of a preserved clay soil horizon in the Turlock Lake Formation (Helley and Harwood, 1985). The Turlock Lake and Laguna formations consist of a heterogeneous mixture of tan to brown interbedded silt, clay, and sand. Gravel lenses are scarce and, where present, are poorly sorted and have low permeability. Pebbles and cobbles of quartz and metamorphic rocks generally dominate the gravels (DWR, 1974; Olmstead and Davis, 1961). The combined thickness of the two units is probably less than 200 feet.

Due to the predominantly fine-grained character of these two formations, wells completed in them reportedly have low to moderate yields, usually less than 1,000 gallons per minute.

4.7.4 Mehrten Formation

The Mehrten Formation is early to mid-Pliocene age and crops out along the southeastern Sacramento and Northern San Joaquin valleys and within the NASb. It is exposed only on the eastern side of the Subbasin near the City of Lincoln and south toward the City of Roseville and has been penetrated by wells as far west as the town of Nicolaus. The Mehrten Formation was deposited on an irregular eroded surface (unconformable) of marine sediments of the Valley Springs and Ione formations (Olmstead and Davis, 1961).

Depending on location, the Mehrten Formation is between 200 and 1,200 feet thick (DWR, 2003). It is thinnest in the eastern portion of the NASb and thickens towards the west. The thickness of the Mehrten Formation in the Sacramento Valley is about 200 feet where exposed and ranges between 400 and 500 feet in thickness in the subsurface (Page, 1986). Black sands are characteristic of the Mehrten Formation.

Two distinct units in the Mehrten Formation have been described in the Sacramento Valley—an upper unit composed of unconsolidated black sands interbedded with blue-to-brown clay, and a lower unit composed of hard, angular rock fragments in a fine grained matric (breccia), which is sometimes reported by well drillers as "lava" (DWR, 1978; Page, 1986). This breccia may act as a confining layer in the subsurface. The volcanic source material is from the Sierra Nevada.

Wells completed in the sand and gravel units have reported pumping capacities of over 3,000 gallons per minute.

4.8 Non-Water or Non-Fresh Water Bearing Formations

Non-water or non-fresh water bearing formations in the NASb include the Tertiary-age Ione and Valley Springs formations and the Paleocene to Eocene Central Valley Formation. These strata are underlain by crystalline igneous and metamorphic basement rock like those exposed in the foothills east of the Subbasin. The Ione and Valley Springs formations exist beneath the Mehrten Formation and are thought to be a transitional system that contains a mixture of saline and fresh groundwater.

4.8.1 Valley Springs Formation

The Valley Springs Formation is a sequence of mostly fluvial sediments that unconformably overlies the Ione Formation, and is composed of sandy clay, sand, rhyolitic ash, and siliceous gravel (Davis and Hall, 1959). Well-log information and outcrop exposure in the Sacramento Valley indicated that the Valley Springs Formation is estimated to be up to 200 feet thick (Piper and others, 1939; DWR, 1978). Fine ash and clay in the Valley Springs Formation limit the quantity of water produced by wells (Page and Balding, 1973). The Valley Springs Formation is exposed along Antelope Creek and in the community of Granite Bay.

4.8.2 Ione Formation

The Ione Formation was deposited on eroded surfaces (unconformably) of the Central Valley Formation and crystalline and metamorphic rocks near the eastern portion of the Subbasin. The formation is near the surface in most of the Placer County portion of the Subbasin generally east of Highway 65 and the foothills. The western extent of the Ione Formation is characterized by shallow marine deposition in the remnants of the inland sea, while the eastern extent of the formation is characterized by non-marine deltaic deposition (Redwine, 1984; Springhorn, 2008). It is exposed in the clay pit area near the city of Lincoln. The thickness of the formation varies because the top is eroded. The formation is about 200 to 300 feet thick in the vicinity of the city of Roseville, 500 to 600 feet thick in the vicinity of the city of Lincoln and thickens to about 1,000 feet at the western margin of Placer County. There are also small exposures in the Granite Bay area.

Clean sands of the Ione Formation are partially and erratically flushed by fresh waters in the area between the foothills and Highway 65. However, there is very little movement of groundwater in this formation, and due to low yields and poor water quality, it is not considered an economical source of groundwater for irrigation. Owing to the degree of consolidation and clay content, the Ione Formation yields a limited quantity of water to wells (DWR, 1978; Page, 1986).

4.8.3 Central Valley Formation

Overlapping the granite and metamorphic crystalline bedrock are the Upper Cretaceous marine sedimentary rocks that compose the Central Valley Formation. The strata form a wedge thickening generally westward beneath the Subbasin. Water contained in these sediments is generally saline and of very low yield to wells. The total thickness of the Central Valley Formation near the eastern portion of the Subbasin where it overlaps on the bedrock is only a few hundred feet thick, but it increases to several thousand feet thick near the western boundary of the Subbasin.

The Central Valley Formation and other marine formations contain economic quantities of natural gases. Several small gas fields are located primarily along the western border of the Subbasin, near the Willows Fault. Drilling and operation of natural gas wells are highly regulated by the California Geologic Energy Management Division (commonly known as “CalGEM”), formerly known as Division of Oil, Gas, and Geothermal Resources, which was formed in 1913. However, exploration holes and abandoned wells drilled prior to 1913 and not properly sealed could affect freshwater quality. At this time, no water quality problems in the Subbasin can be directly attributed to these holes or wells. **Figure 4-6** shows the locations of the natural gas wells in the Subbasin, illustrating potential areas where old exploration holes may have been improperly abandoned but could provide vertical conduits for brackish water to intrude the freshwater aquifers.

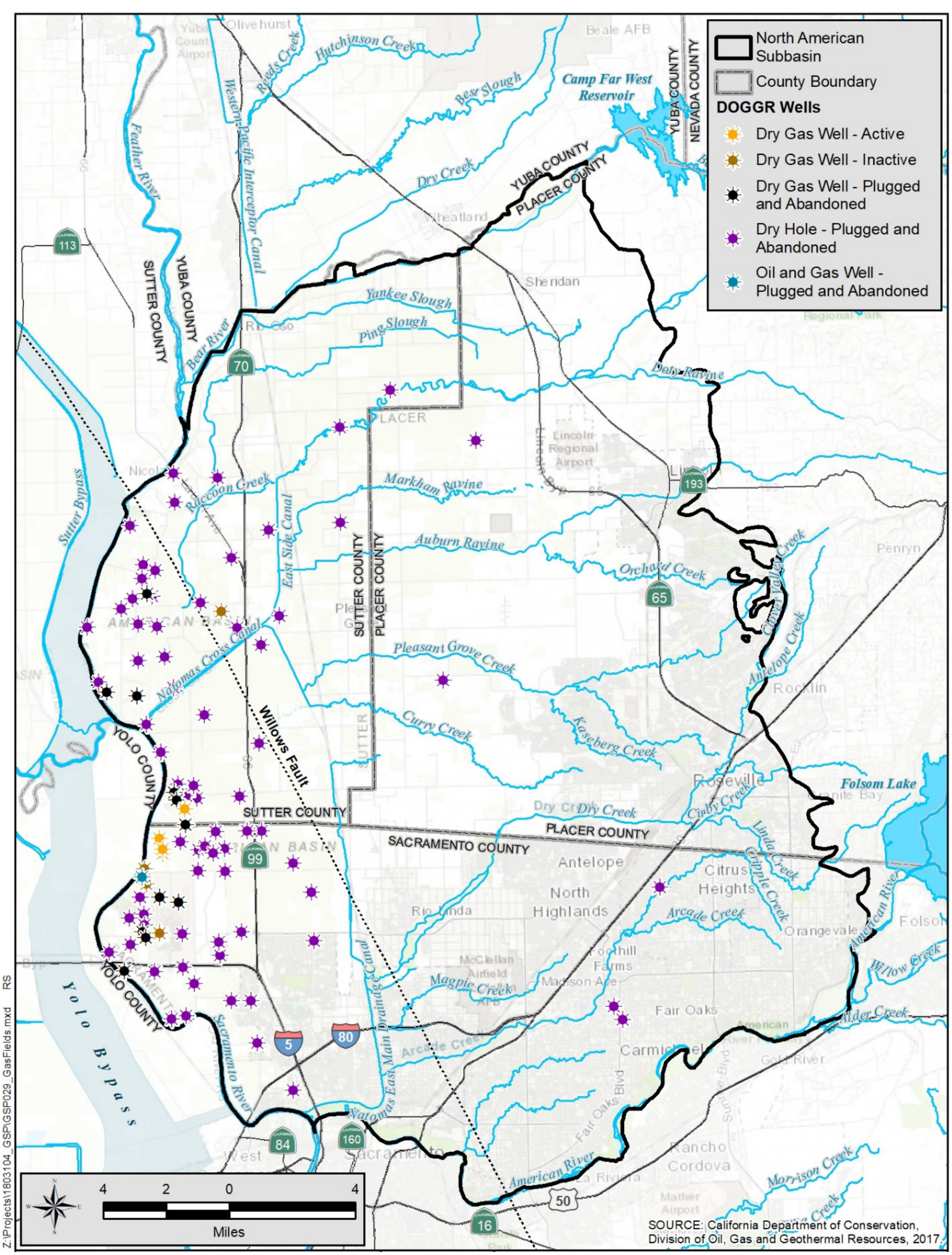


Figure 4-6. Natural Gas Wells

4.8.4 Basement Rocks

All of the formations and sediments mentioned above are underlain by igneous and metamorphic rocks, potentially similar to those exposed in the Coast Ranges and in the Sierra Nevada. Along the eastern margin of the Subbasin where the Ione and Central Valley formations are present at shallow depths, generally north of the city of Lincoln, domestic and agricultural well owners have constructed wells into the basement rocks, due to the low yielding and poor-quality water in the marine sediments, to obtain fresh water.

4.9 Regional Geologic Sections

Three geologic sections were created for this Groundwater Sustainability Plan (GSP) using previous sections developed by DWR (1997) and are straight lines through the Subbasin as shown on **Figure 4-7**. The coarse-grained sediments (sands and gravels) that are aquifers were deposited as stream or river channels that meandered through the Subbasin in a sinusoidal (snake like) pattern and therefore a straight profile may not show their full extent or their inter-connectedness. **Figure 4-8** illustrates these channel deposits and how they wander and may be stacked upon each other (DWR, 1974).

Geologic sections of the Subbasin exist from multiple sources, but historical sections did not cross the entire Subbasin. The longest and most detailed sections were prepared by DWR (1997). The DWR sections were used as a starting point and modified to extend across the entire Subbasin for this GSP effort. Lithologic information from well logs was normalized and digitized to generally conform with the Unified Soil Classification System. Lithology and well screens from dedicated groundwater monitoring wells, constructed after the DWR sections were created, were also added to the geologic sections for this GSP effort. The profiles are presented to illustrate the subsurface relationships and distribution of the formations and coarse-grained sediments that constitute principal aquifers. The profile locations are shown on **Figure 4-7**. **Figures 4-9, 4-10, and 4-11** illustrate the subsurface with sediment types, saturated sediments, and the base of fresh water. These figures were created from the well driller's reports attached in **Appendix D**.

The profiles show the general contact between the Mehrten Formation and younger formations. The profiles also show different dips of the aquifers respecting the unconformities previously documented.

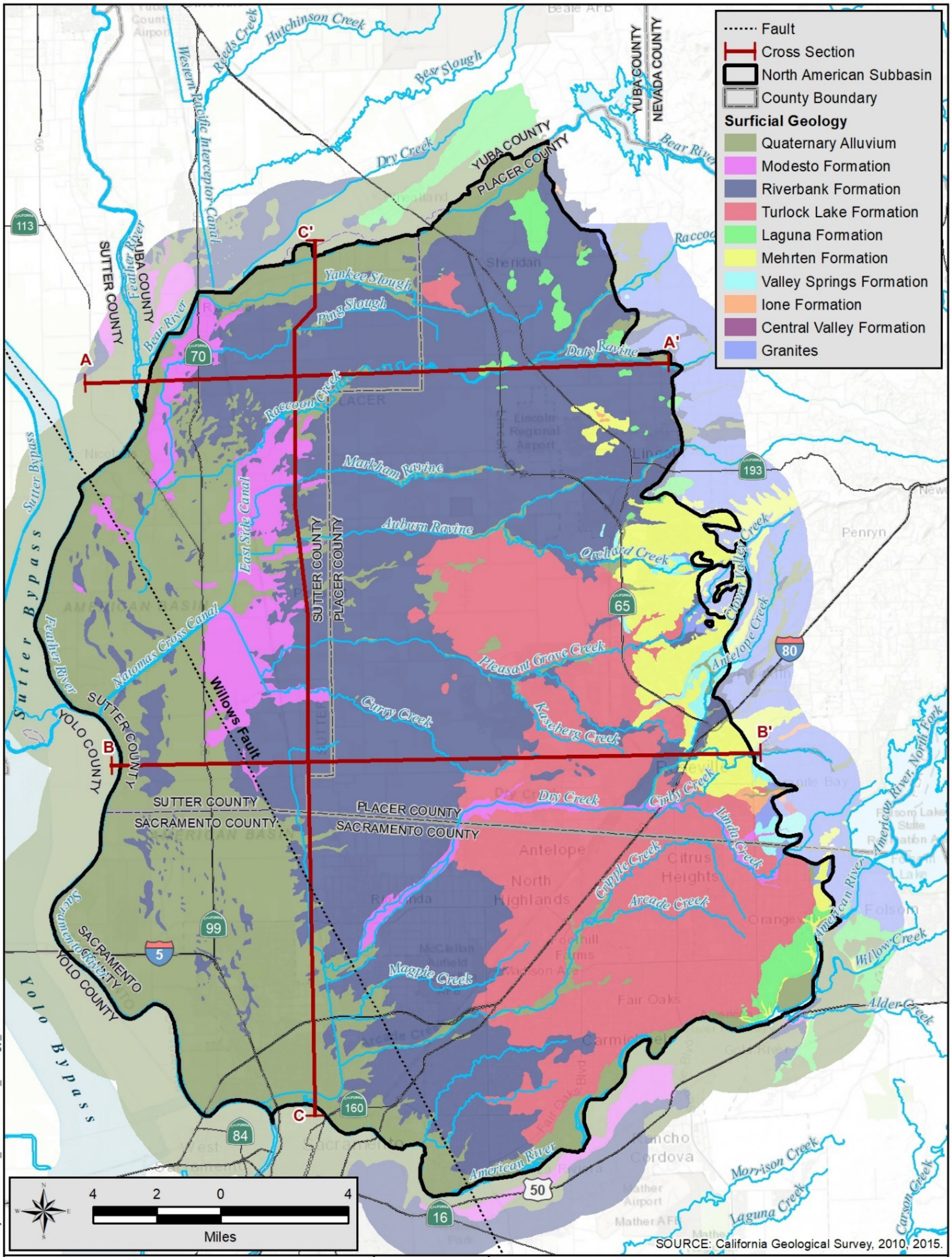


Figure 4-7. Geologic Section Locations

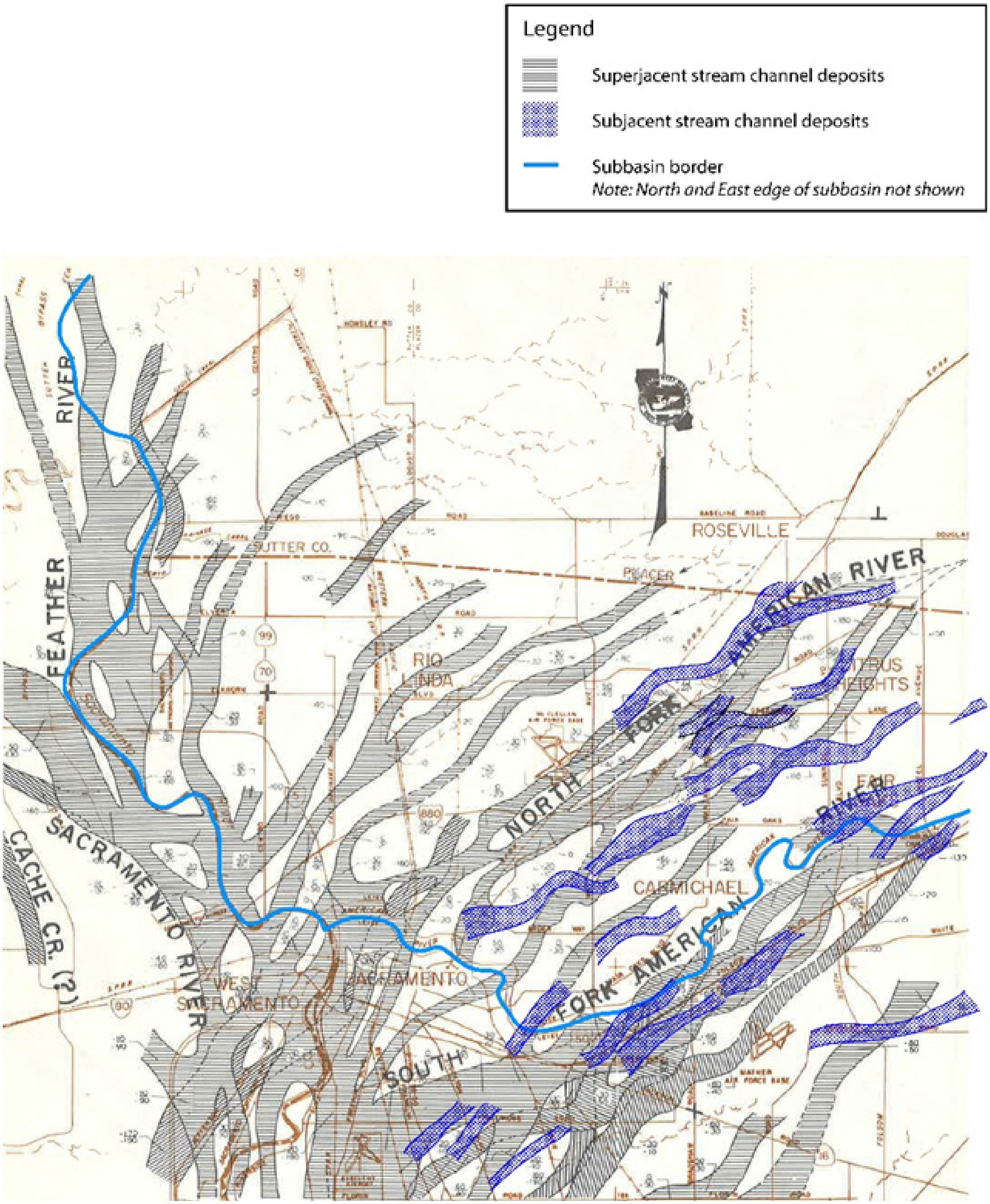


Figure 4-8. Stream Channel Deposits

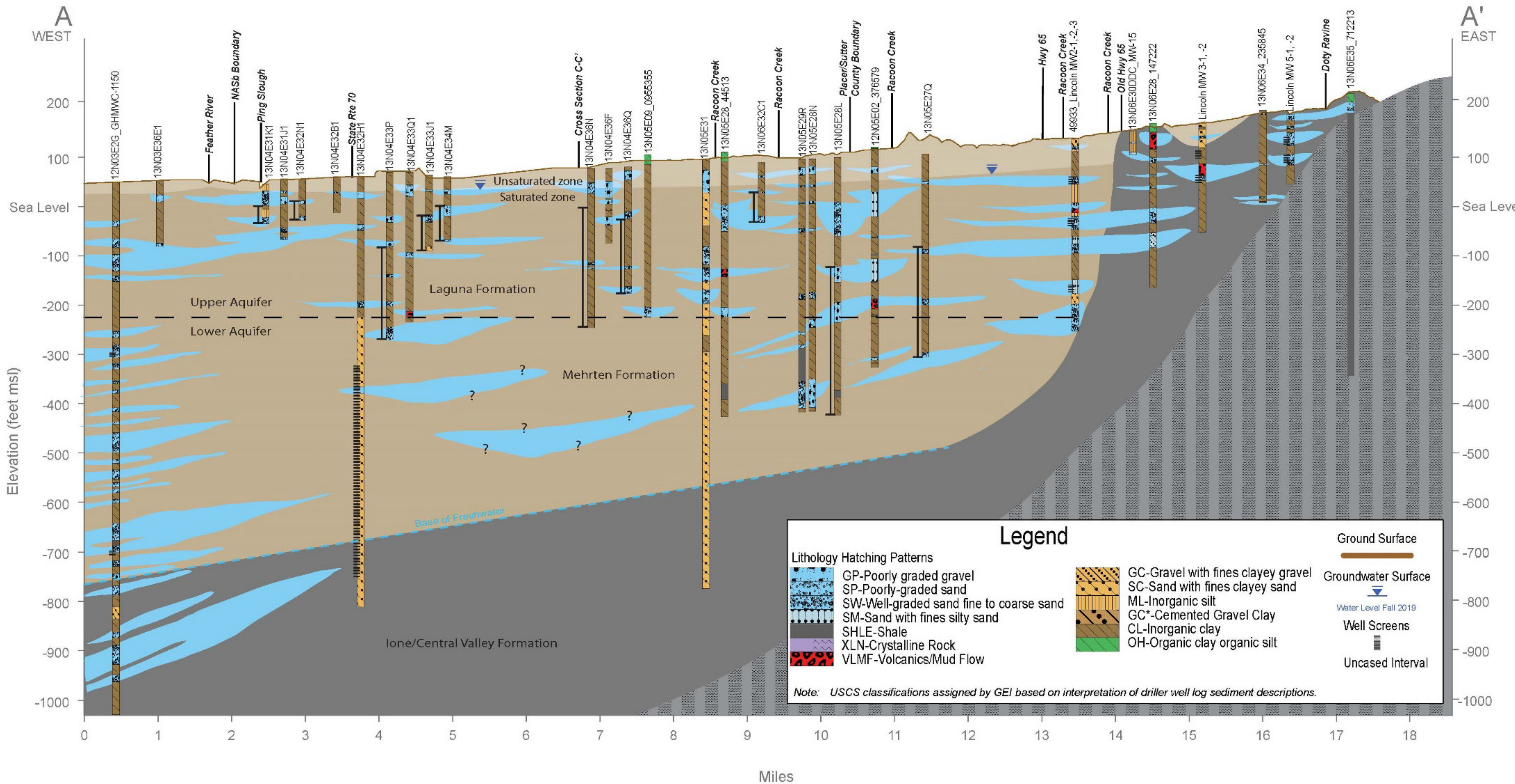
4.9.1 Section A-A'

Figure 4-9 shows Geologic Section A-A', a regional east-west profile through the northern portion of the Subbasin. Section A-A' generally runs parallel to the direction of groundwater flow.

Section A-A’ shows that the eastern area generally has clays and silts (shown in brown color), low permeability sediments near surface, and permeable sediments (sands and gravels shown in light blue) throughout the depth profile. Continuous layers of sand and gravels are not identified likely due the sinusoidal nature of the river channels associated with these types of sediments.

In the western portion of the Subbasin, fine-grained sediments are more prevalent and, supported by groundwater levels and water quality information, suggest that the shallow aquifer is unconfined and separate from the deeper semi-confined to confined aquifers in the Mehrten Formation.

Cross sections A-A' and B-B' show the general shape of the groundwater gradient at the northern end of the Subbasin where water levels are highest in the east and decrease to the west. The Ione Formation, or the base of fresh water, is at or near surface in the eastern portions of the Subbasin and has multiple permeable sediment layers that could contribute brackish water to the fresh-water-bearing aquifers in the Laguna and Mehrten formations. The top of the Ione Formation and the base of fresh water is relatively shallow in this portion of the Subbasin.



Source: DWR, 1995. Modified by GEI 2019. Berkstresser, 1973.

Figure 4-9. Geologic Section A-A'

This page left intentionally blank

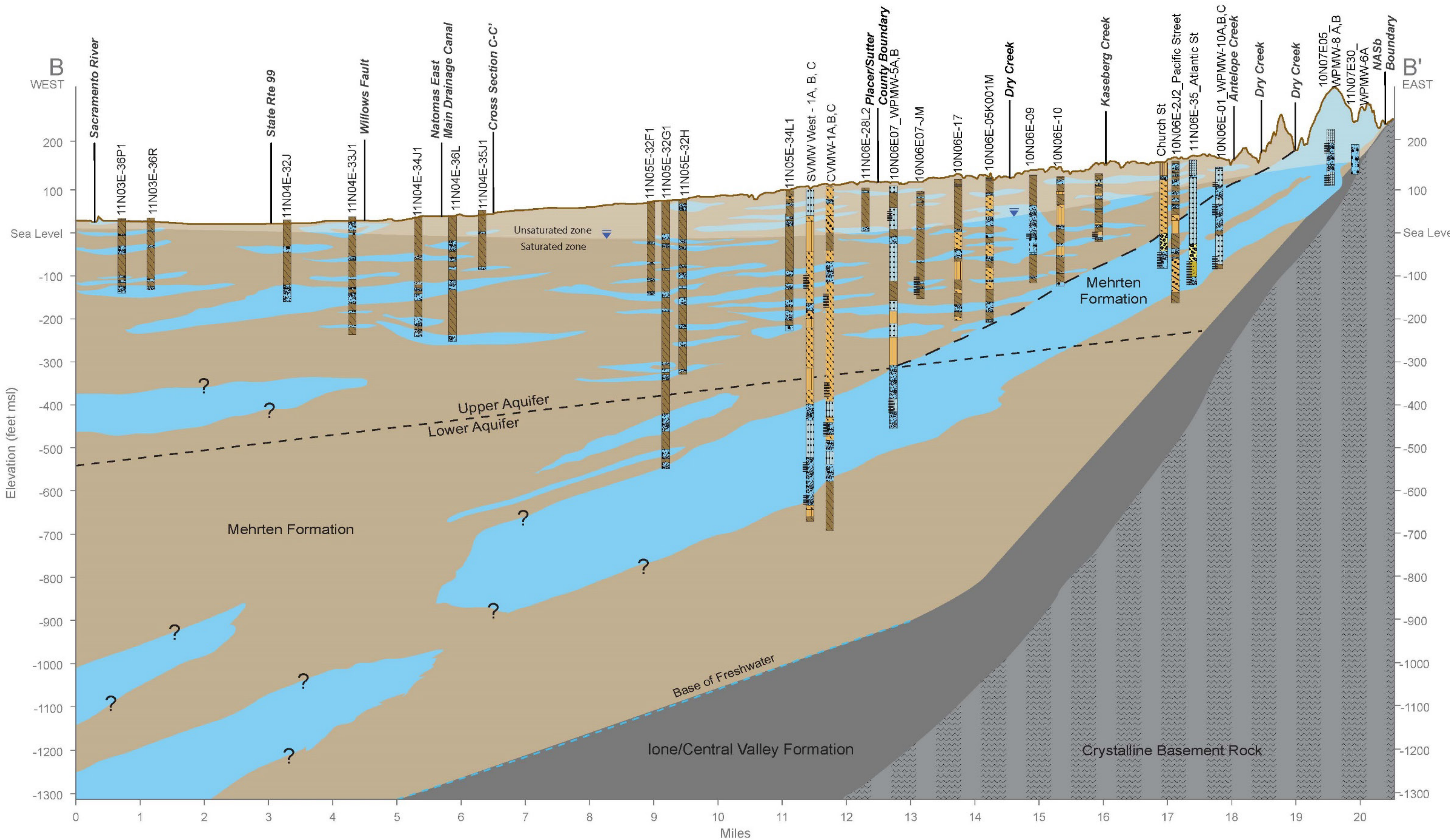
4.9.2 Section B-B'

Figure 4-10 shows Geologic Section B-B', an east-west profile located near the Sacramento, Placer, and Sutter County lines. Section B-B' generally runs parallel to the direction of groundwater flow.

Section B-B' shows the layering of Laguna, Mehrten, and Ione formations. The Mehrten Formation and its permeable sand and gravel are exposed at ground surface in the eastern portion of the Subbasin, near the city of Roseville, and can be traced to the west indicating this area can allow surface water to recharge the aquifers to the west. Toward the west, the Mehrten Formation thickens and deepens.

Section B-B' shows the groundwater levels across the central area of the Subbasin. Water levels are highest in the east, where recharge from the Sierra Nevada originates. To the west, water levels are depressed at the center of the Subbasin and are shallower further to the west. The base of fresh water is much deeper in this area than to the north as is shown on Section A-A'.

This page left intentionally blank



Source: DWR, 1995. Modified by GEI 2019. Berkstresser, 1973.

Figure 4-10. Geologic Section B-B'

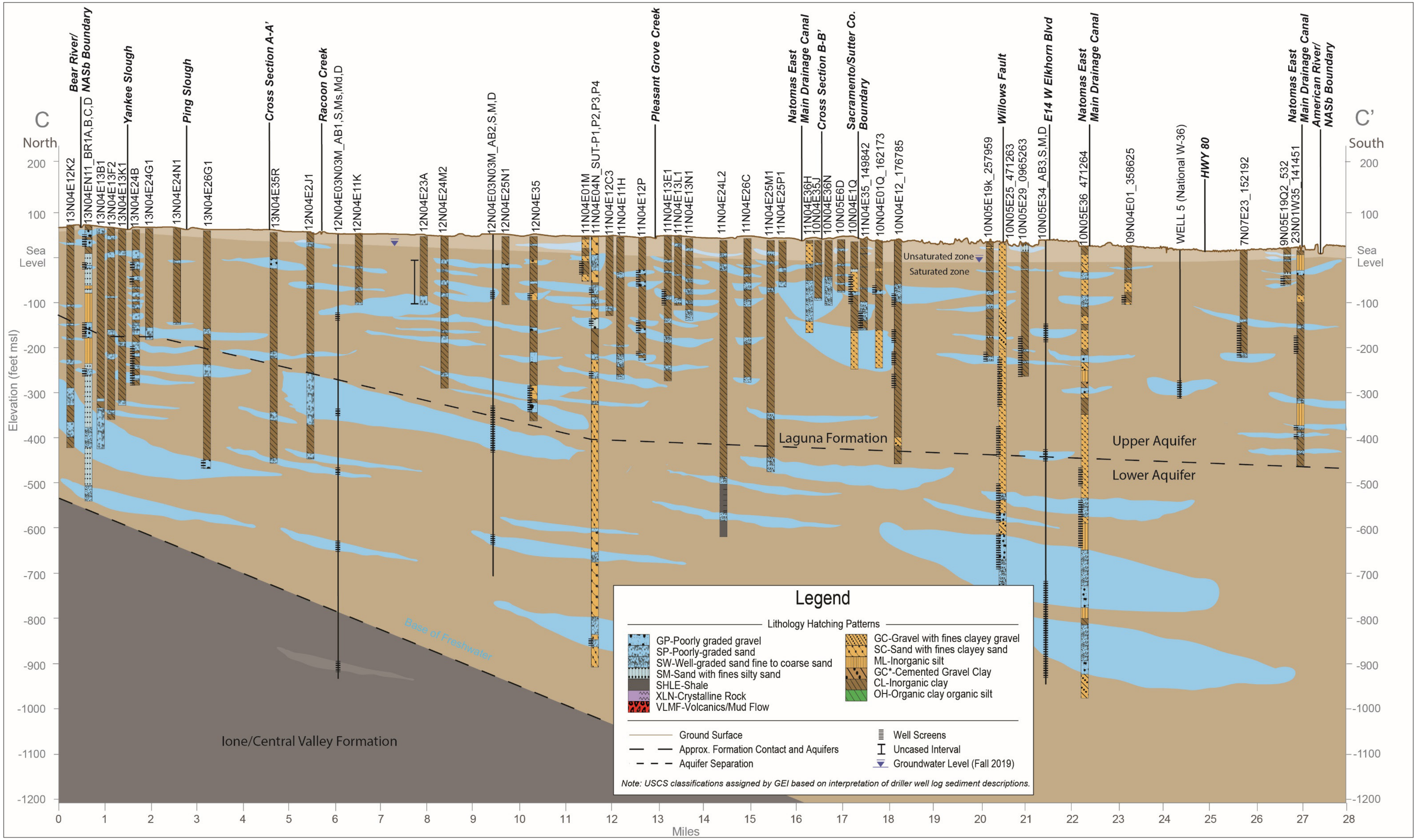
This page left intentionally blank.

4.9.3 Section C-C'

Figure 4-11 shows Geologic Section C-C', a north-south profile that extends the length of the Subbasin. Section C-C' is generally perpendicular to the direction of the deposition of the sediments (bedding dip).

Fine-grained sediments appear to be more prevalent in the northern portion of the Subbasin, while more interconnected aquifers exist along the southern portions of the section. The base of fresh water is shallower in the northern portions of the Subbasin and dips steeply to the south before projecting below the depth profile.

This page left intentionally blank



Source: DWR, 1995. Modified by GEI 2019. Berkstresser, 1973.

Figure 4-11. Geologic Section C-C'

This page left intentionally blank

4.9.4 Geotechnical Investigations Sections

In addition to these regional geologic sections, geotechnical investigations (to depths of up to 140 feet) have been performed along portions of the American, Bear, Feather, and Sacramento River levees. These studies provided subsurface information to design levee improvements to reduce seeps that could de-stabilize the levees during flood events. Profiles (geologic sections) were developed as part of these investigations. The investigations show sediment types where groundwater and surface water interactions occur, and where the Sacramento River (bathymetric elevations) has cut partially or entirely through coarse-grained sediments that are part of the shallow aquifer. They also show where man-made slurry walls were constructed that have reduced or eliminated this connectedness and where they are planned to be built. **Figure 4-12** shows the areas where slurry walls have been constructed. **Appendix E** provides these geologic profiles along the rivers. The sections do not contain a breakout of the geologic formations but, in general, dependent upon the location, would include Alluvium, Flood Basin Deposits, and Modesto and Riverbank formations.

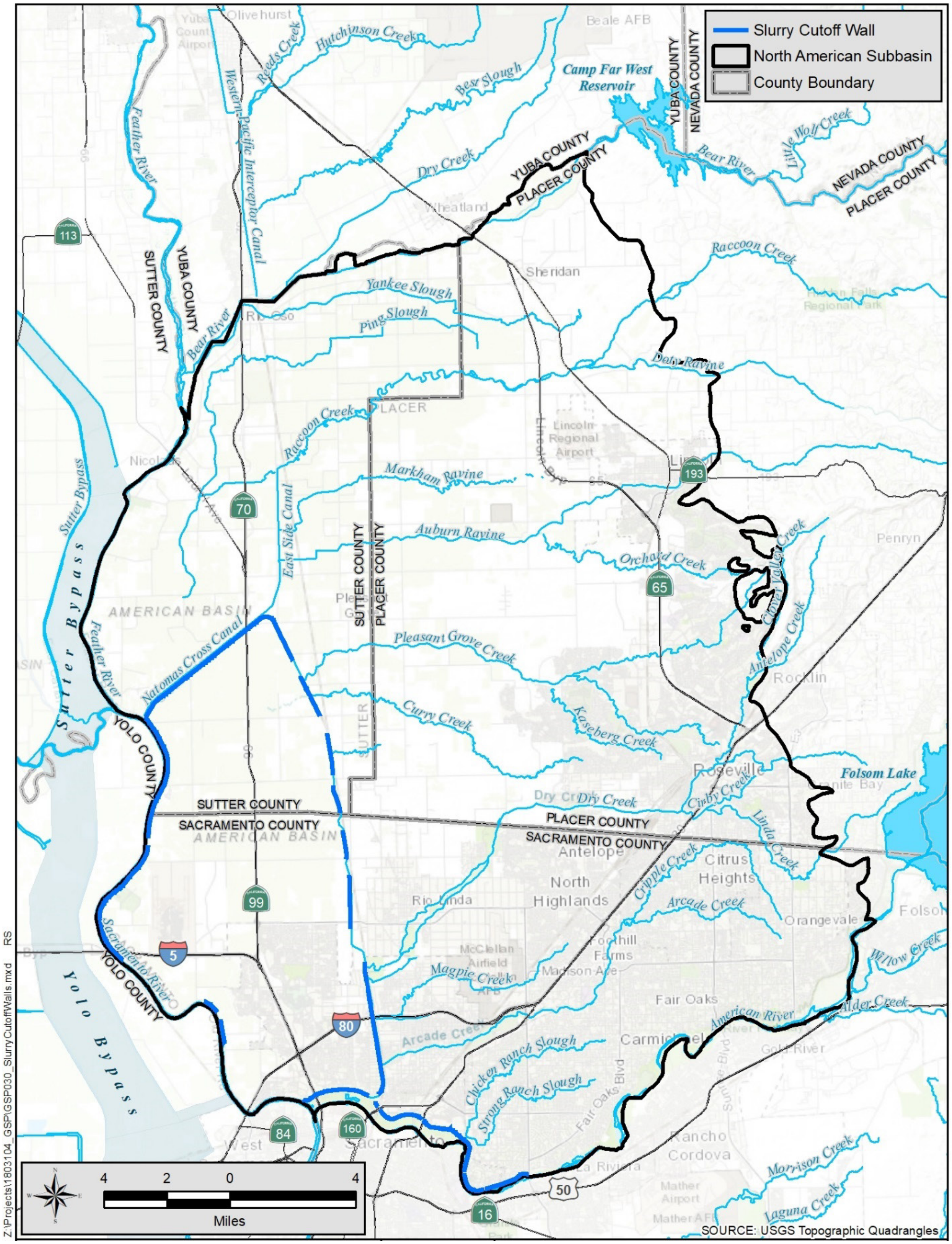


Figure 4-12. Detailed Geologic Sections - Slurry Cut Off Walls

4.10 General Water Quality

Most of the groundwater in the Subbasin can be grouped into two general types based on which minerals[1] are present at highest concentrations. If no one anion or cation are predominant, multiple names may be listed. Water Type 1 is a magnesium-calcium bicarbonate and is present in the shallowest aquifer zones sampled with one exception. Water Type 2 is a sodium bicarbonate water and is typically found at the intermediate depths (up to about 850 feet). Type1 resembles Type 2 except that the percentage of cations changes (sodium is becoming more dominant). **Figure 4-13** shows the distribution of the water types in the Subbasin. The relative percentages of anions are similar for both water types. This may support the idea of cation exchange as a major factor in the evolution of chemistry of the groundwater (DWR, 1997).

Monitoring wells have been installed to provide information on discrete changes in water chemistry with depth. Although the data are limited, there appears to be a trend in the water chemistry with depth (DWR, 1997) changing from calcium-dominated water to magnesium and from bicarbonate to sodium with depth.

In the deepest monitored zone (well AB-1 deep, located in South Sutter Water District's corporate yard), the chemistry changes significantly and is characterized as sodium chloride water. The chemistry of well AB-1 deep (screened below the base of fresh water) is considered to be water that was deposited at the time of deposition of the sediments (connate water) in the Sacramento Valley. This well has groundwater with an electrical conductivity of about 1,800 micromhos per centimeter and is considered to be brackish water. Because of the regional southwestern dip of formations in the area these waters are closer to ground surface in the eastern portions of the Subbasin. Sodium chloride water is known to occur near the Bear River and Highway 65 where the Ione Formation is near the ground surface (**Figure 4-13**). Water quality evaluations in the eastern portions of the Subbasin, north of the city of Lincoln, have not been able to distinguish any significant effects of connate water discharging to freshwater (GEI, 2019).

There are multiple wells with chloride as the predominant anion, which suggests there may be mixing of connate water with fresh water (DWR, 1997). **Figure 4-14** shows the types of water in some of the monitoring wells in the Subbasin. Sodium chloride water may also be present due to evaporation of water as seen in some localized areas.

---

[1] cations which are calcium, magnesium, and sodium; and anions which are bicarbonate, sulfate, and chloride

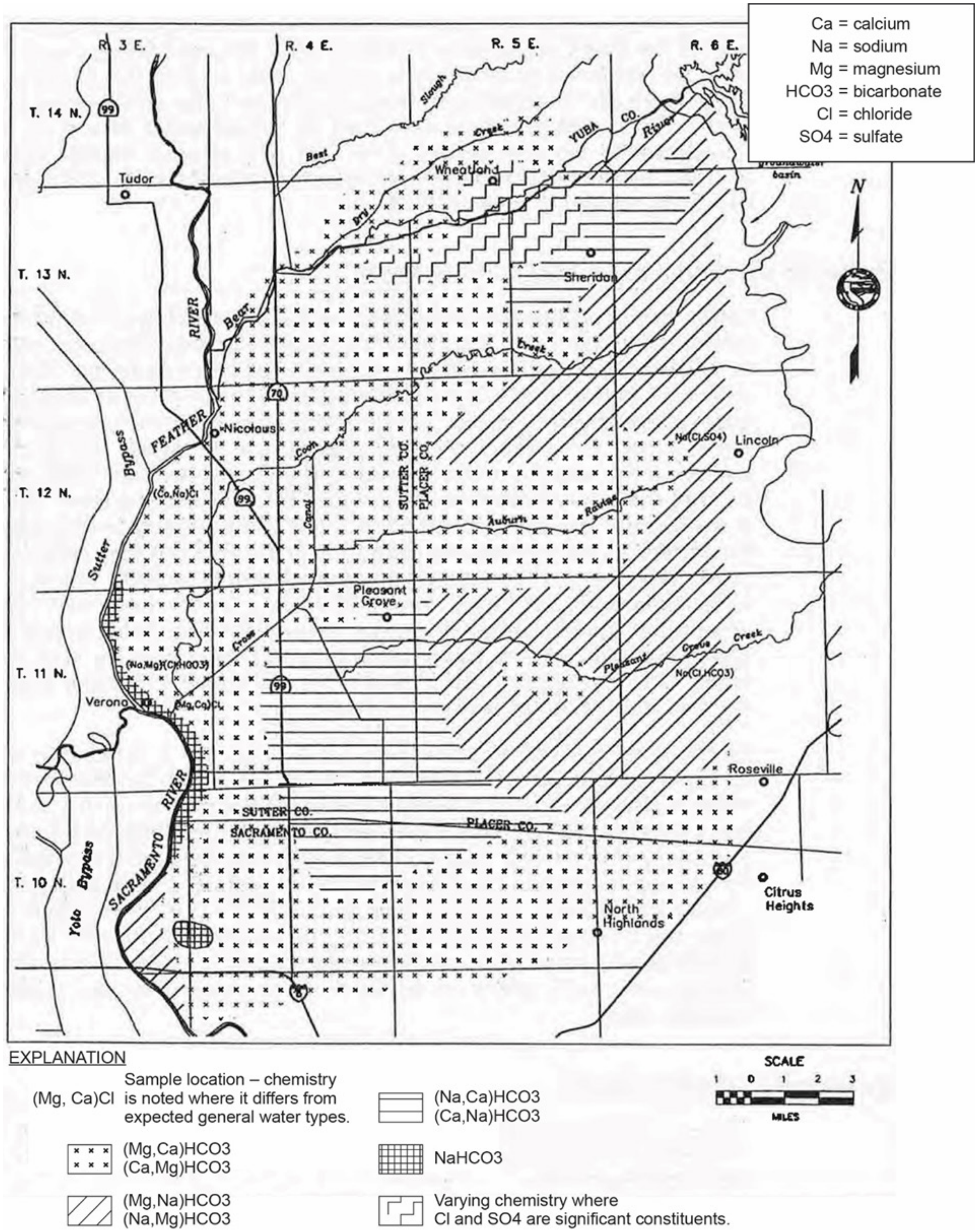


Figure 4-13. General Water Quality Types and Distribution

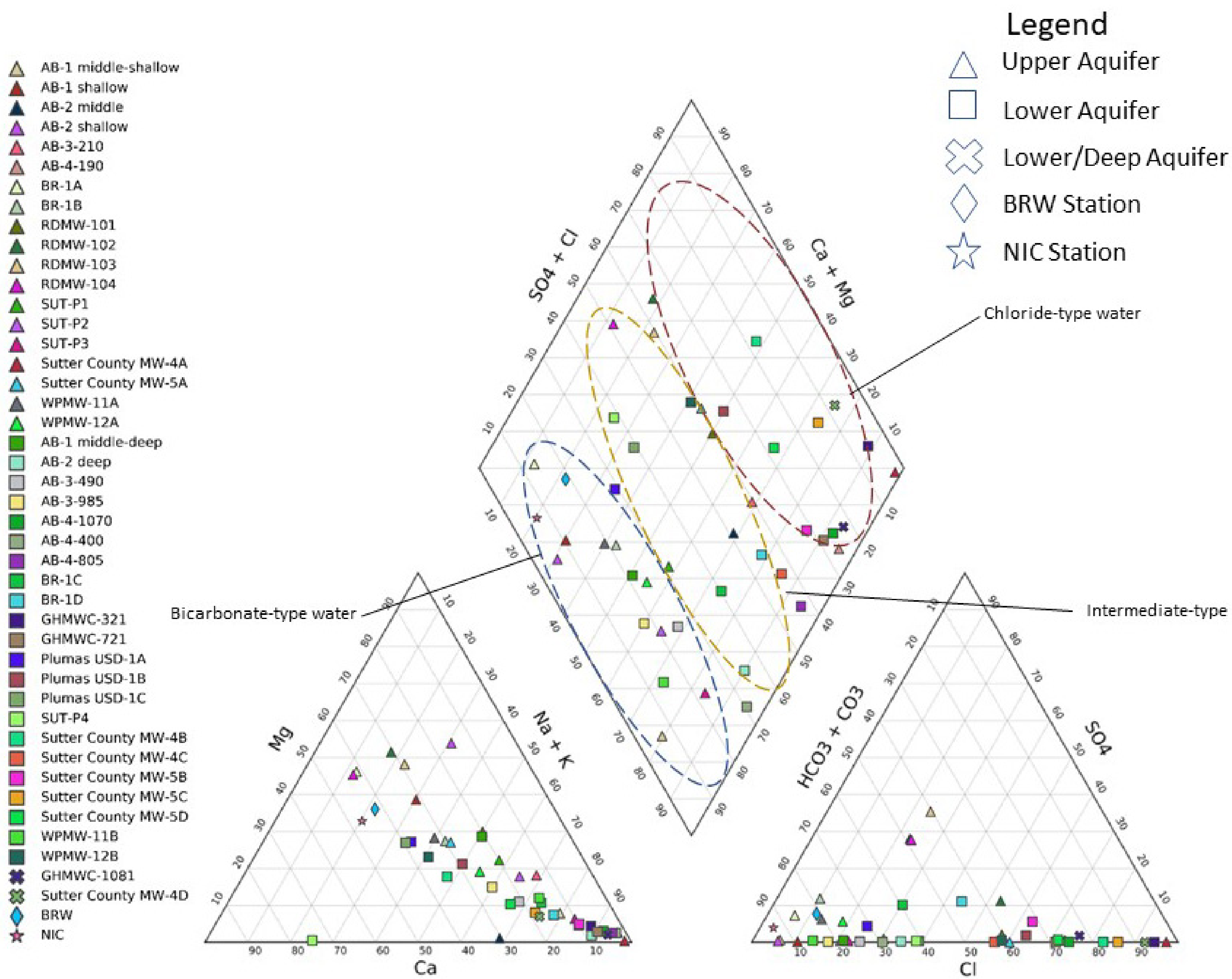


Figure 4-14. General Water Quality Types

This page left intentionally blank

4.11 Principal Aquifers

All sediments, to some extent, contain groundwater in the pores between particles. Near ground surface sediment pores are filled with mostly air but have some moisture. This moisture will gradually migrate down to the groundwater surface where the sediment pores will be entirely filled with water. At times there are low permeability sediment layers with a limited horizontal extent, where the moisture accumulates and fully fills the sediment pores, but the underlying sediments and pores are not filled with water. These occurrences are called ”perched” water and do not constitute a principal aquifer. At the edges of these low permeability sediments, the water may then resume its vertical path to the groundwater surface. Aquifers are those coarse-grained sediment layers whose pores are completely filled with water and can be managed.

The aquifers underlying NASb are composed of cobbles, gravel, and sand, which are interspersed with deposits of silt and clay. Those interspersed layers are deposited in stream channels, alluvial fans, or floodplains by rivers draining the Sierra Nevada and the upper Sacramento Valley. DWR’s Bulletin 118-3 describes the aquifers as “…a number of now-buried stream channel deposits. These deposits, which are composed of permeable sand and gravel, are enclosed by less permeable silt and clay. This has resulted in a network of meandering tabular aquifers.” A graphic interpretation of the location of those ancestral channels is shown on **Figure 4-8** (DWR, 1974) for portions of the NASb. This complex system of intertwined and interbedded, fine and coarse-grained sediments interconnects shallow and deeper aquifers (DWR, 1997).

The geologic units described above were grouped and separated into two aquifers, an upper and lower aquifer system, by DWR in its evaluation of a proposed conjunctive use program in the NASb in the mid-1990s (DWR, 1997). The upper aquifer was defined as the upper 200 to 300 feet of the aquifer system. The lower aquifer was defined as extending from about 200 to 300 feet below ground surface to the base of fresh water. “The division between the two aquifers is inexact, due to the difficulty in accurately determining the formation contacts.” The aquifer systems were, in part, defined by differences in groundwater levels. Since this was over 20 years ago, the geologic and groundwater information was re-evaluated to assess whether the aquifers should be divided into one or two principal aquifers. **Table 4-1** provides a summary of criteria used to determine if there is enough evidence to define two principal aquifers for the purposes of this GSP. Details of this analysis are provided in **Appendix F**. In addition to the hydrogeologic evidence a comparison of adjacent subbasin definitions of principal aquifers was made.

Table 4-1. Criteria Evaluated for Two Principal Aquifers

Criteria	Two Principal Aquifers? Yes	No	Maybe	Comments / Evidence
Depth and Extent of Confining Bed		X		No regionally extensive clay layer defined.
Groundwater Level Difference				
• *Vertical Head Difference*			X	Up to 20 feet difference in western portion suggesting semi-confined to confined conditions but similar in eastern portion, suggesting unconfined.
• *Response to Stress Difference*		X		Similar trends in both aquifers but slight lag time in Lower aquifer.
• *Groundwater Contour Difference*			X	Similar groundwater flow directions. Lower aquifer not showing influence from rivers.
Aquifer Hydraulic Characteristics	-	-	-	No high-quality, multi-well aquifer tests available.
Water Quality Difference		X		Nothing distinct within NASb, Yuba, or Sutter subbasins.
Adjacent Subbasins Approach				
• *Yuba*		X		GSP submitted
• *South American*		X		Alternative Submittal
• *Yolo*	-	-	-	Unknown
• *Sutter*	X			Alternative Submittal

There is not enough evidence to define multiple principal aquifers in the NASb; therefore, for this GSP, only one principal aquifer is present in the Subbasin. This definition corresponds with adjacent subbasins both north and south of the NASb.

4.12 Groundwater Recharge and Discharge Areas

Groundwater recharge occurs throughout the Subbasin in varying amounts based on the SAGBI hydrologic classification for soils, *refer to* **Figure 4-4**. The soil's ability to allow water to migrate to the aquifers is significantly reduced if the soils have been covered by impermeable surfaces such as roads and houses. In some cases, although the soils may be classified as being more permeable, recharge may be limited due to underlying low permeability sediments (clays), especially along the rivers and creeks.

4.12.1 Recharge Areas Inside of the Subbasin

Recharge areas in the Subbasin have been defined based on the soils' hydrologic classifications along with a variety of techniques including water quality, isotopes, well logs indicating coarse-grained sediments are present near ground surface, and crop types. Overall, no geologic sediments are impermeable, so some recharge occurs in all areas that are not covered by impermeable surfaces such as asphalt or concrete. This is particularly important in agricultural areas where even though there are low permeability soils, in excess of a hundred thousand acres of land that have applied or ponded water throughout the growing season that aggregate to a large volume of recharge.

Investigations conducted along the river levees provide detailed profiles that allow for assessment of where coarse-grained sediments are present and where they are connected to the rivers (*see* **Appendix E**). **Figure 4-15** shows the combination of these studies, referenced sources, and recharge areas, including reaches of the rivers and some creeks. **Figure 4-15** also shows a rather broad potential recharge area, between the eastern edge of the Subbasin and a dashed line approximating the western edge where water could infiltrate from ground surface through coarse-grained soils and sediments directly into the underlying aquifers. Generally, the rate of movement is ten times higher when water moves horizontally along aquifer beds rather than percolating vertically through the sediments. As shown, this is a broad band parallel to the eastern side of the Subbasin.

4.12.2 Recharge Areas Outside of the Subbasin

Aquifers in the NASb extend beyond the Subbasin boundary and into adjacent subbasins. Dependent upon the groundwater gradients, groundwater may flow into or leave the Subbasin. Therefore, recharge to the NASb may occur from adjacent subbasins or even beyond these subbasins. The recharge areas in adjacent subbasins will be identified in their respective GSPs, once completed.

4.12.3 Groundwater Discharge Areas

Groundwater discharge occurs along some of the creeks, canals, and rivers. The conditions may change seasonally from recharge to discharge conditions. **Figure 4-15** shows these potential areas, which are typically along the rivers as they represent topographic lows where the groundwater surface may intersect the ground surface.

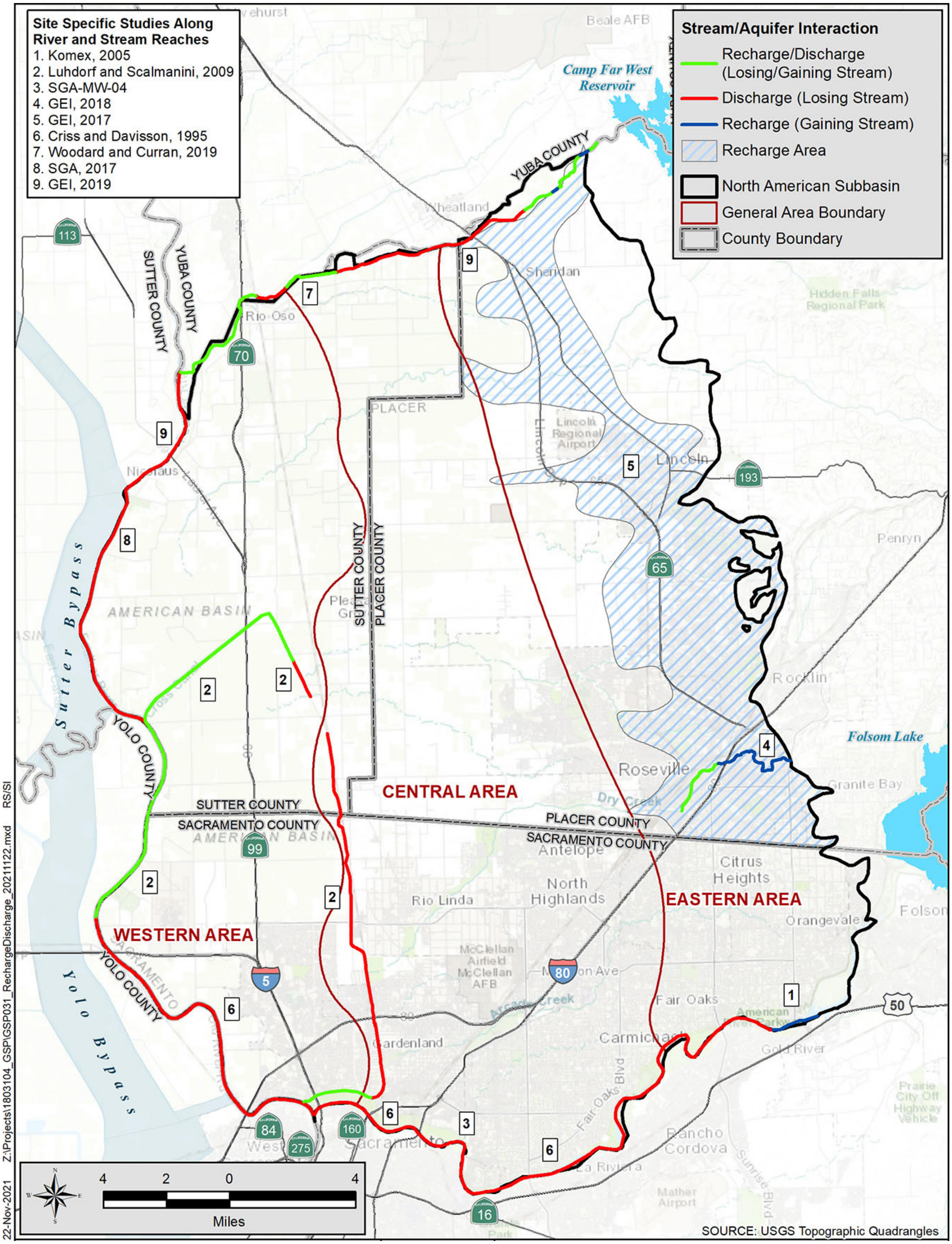


Figure 4-15. Recharge and Discharge Areas

4.13 Imported Water Supplies

For purposes of this GSP, imported water is defined as water that is brought in from areas outside of the Subbasin or its watershed. Diversions are defined as water that is diverted from rivers or tributaries within and adjacent to the Subbasin. For example, even though water in the Sacramento River may have originated from as far away as Lake Shasta, water diverted from the river is not considered to be imported because the river is adjacent to the Subbasin. The Subbasin does not have imported water other than water imported from the Yuba watershed into the Nevada Irrigation District and Placer County Water Agency service areas.

4.14 Data Gaps

The hydrogeologic conditions in the NASb have been investigated and documented since 1912 and continue through the present. Most of the recent improvements to data gathering have been construction of new monitoring wells to replace voluntary wells to improve the quality of groundwater levels. At this time, there are no data gaps that would affect the ability to sustainably manage the Subbasin within the next 5 years.

This page left intentionally blank

5. Groundwater Conditions

This section provides a description of historical and current groundwater conditions in the Subbasin. The North American Subbasin (NASb or Subbasin) can be divided into three areas (Eastern, Central, and Western) from a water resources standpoint based on the differences in groundwater conditions. Groundwater conditions between areas vary for several reasons, the primary reason being the extent to which surface water is accessible as a source in a given area. In order to understand how and why conditions vary, it is helpful to consider the historical development of water resources in the basin.

5.1 General

Current groundwater conditions are the result of both historical and current availability of surface water. Historically, where surface water was not available groundwater was used for agricultural, industrial, and urban growth.

In the Eastern and Western areas of the Subbasin, surface water has been available and delivered for agricultural and urban development. Today, both the Eastern and Western areas of the Subbasin continue to be served primarily with surface water, with some urban areas (city of Sacramento) in the Western area being served both groundwater and surface water. As a result of surface water availability, groundwater levels in the Eastern and Western areas of the Subbasin have remained relatively stable.

In the Central area of the Subbasin, a groundwater pumping depression (a lowering of groundwater levels as a result of pumping) developed by the mid-1960s. This was largely due to widespread agricultural and urban development and the lack of available surface water to this part of the basin. The pumping depression started in Sutter County, moving to the east and south.

Agricultural development in the 1950s relied exclusively on groundwater to meet crop demands and resulted in groundwater level declines through 1960. As a result of these declining water levels SSWD constructed Camp Far West Reservoir in 1964 and began supplying a portion of the crop demands with surface water. This action reversed the overall decline in water levels.

Demand on groundwater in the Central area also increased markedly around the 1950s as military and industrial facilities, such as McClellan AFB, were established accompanied by rapid suburban development. Groundwater wells provided water for the industrial and urban development. Falling groundwater levels moved the Sacramento County Board of Supervisors to take management actions and initiated the Water Forum Agreement and Sacramento Groundwater Authority (SGA).

Since the mid-1990s, water suppliers in the northern Sacramento County portion of the Central area implemented conjunctive use projects, thereby reversing the decline of groundwater levels, but the pumping depression still remains in the Central area of the Subbasin and extends into Placer and Sutter counties.

5.2 Groundwater Levels

Groundwater levels are used to track the use and recharge of groundwater in the Subbasin to avoid long-term lowering of groundwater levels. Historically, when downward trending groundwater levels have been observed in the Subbasin, management actions have been taken.

Groundwater levels are recorded at more than 160 wells in the Subbasin and reported to the CASGEM system. Groundwater levels were historically measured twice per year (Spring and Fall), but the frequency of the measurement in some wells has been increased to monthly or more frequently where wells have been instrumented with continuous recorders (transducers). Wells that were only measured a few times or where measurements were discontinued many years ago were not evaluated to establish groundwater conditions.

Figure 5-1 shows the location of 91 wells in the Subbasin evaluated to illustrate the groundwater conditions for this GSP. All of these wells have long-term records or are dedicated monitoring wells with shorter-term records. The dedicated monitoring wells with shorter-term records are used in place of CASGEM "voluntary wells" (privately owned domestic or agricultural wells) where groundwater levels may be affected by pumping at the well or construction details are not available. Due to the number of wells and the long CASGEM identification numbers, each well was provided with a unique number (**Figure 5-1**). A table correlating the unique numbers to CASGEM identification numbers is provided in **Appendix G** with well construction details and the DWR-defined aquifer being monitored. For those wells with known construction details there is a high degree of certainty that the groundwater levels are representative of the principal aquifer, other than for two wells that monitored perched water levels (water that has percolated from ground surface, but has yet to reach the principal aquifer). Where the well construction details (mostly voluntary wells) are unknown there is less certainty, but the hydrographs are provided to provide a long-term condition of the groundwater levels. **Appendices G through I** contain time-series groundwater level measurements (hydrographs) for wells in the Western, Central, and Eastern areas. All of the hydrographs, have consistent date ranges (1950 to present or 2004 to present) and vertical scales were attempted to be maintained at a consistent range unless otherwise noted.

All sediments, to some extent, contain groundwater in the pores between particles. Near ground surface sediment pores are filled with mostly air but have some moisture. This moisture will gradually migrate down to the groundwater surface where the sediment pores will be entirely filled with water. At times there are low permeability sediment layers with a limited horizontal extent, where the moisture accumulates and fully fills the sediment pores, but the underlying sediments and pores are not filled with water. These occurrences are called perched water and do not constitute a principal aquifer. Evidence to support that the groundwater levels in these areas is perched are that the groundwater levels are higher than in underlying aquifers (principal aquifers) and that the groundwater levels in the principal aquifers never rise to the levels of the perched water, showing they are disconnected.

The following sections include a description of the depth to groundwater and trends by area. **Figure 5-2** shows the depth to groundwater in the Subbasin. **Figure 5-3** shows representative time series graphs of groundwater levels (hydrographs) to show general trends in groundwater levels for each of the areas. **Appendices G through I** contain time-series groundwater level measurements (hydrographs) for wells by the Western, Central, and Eastern areas.

5.2.1 Western Area

The Western area of the Subbasin is bounded by the Feather and Sacramento rivers on the west and approximately by the Sutter/Placer County Line and Natomas East Main Drainage Canal on the east (**Figure 5-1)**. The Western area has surface water deliveries, but groundwater is used to supplement the surface water supplies. In general, groundwater levels in this area are stable and have historically been near the surface.

Groundwater levels in the Western area in shallow wells typically range from near ground surface to 20 feet below ground surface (bgs) (**Figure 5-2**). The shallow groundwater levels are due to the area being at the topographic bottom of the Subbasin and potentially from the adjacent rivers. Groundwater levels in deep wells in this area have slightly deeper groundwater levels, ranging from about 15 to 40 feet bgs.

Figure 5-3 shows the trends in groundwater levels in some wells in the Subbasin to illustrate the differences in groundwater levels and general trends in different portions of the Subbasin. The wells typically experience seasonal fluctuations. During the most recent drought, 2012 through 2016, groundwater was relied upon more heavily and the groundwater levels declined in response to increased pumping, but then recovered to pre-drought levels as of 2019, although a few wells have not fully recovered. **Appendix G** provides hydrographs for wells in this area.

Perched groundwater has not been documented in this area.

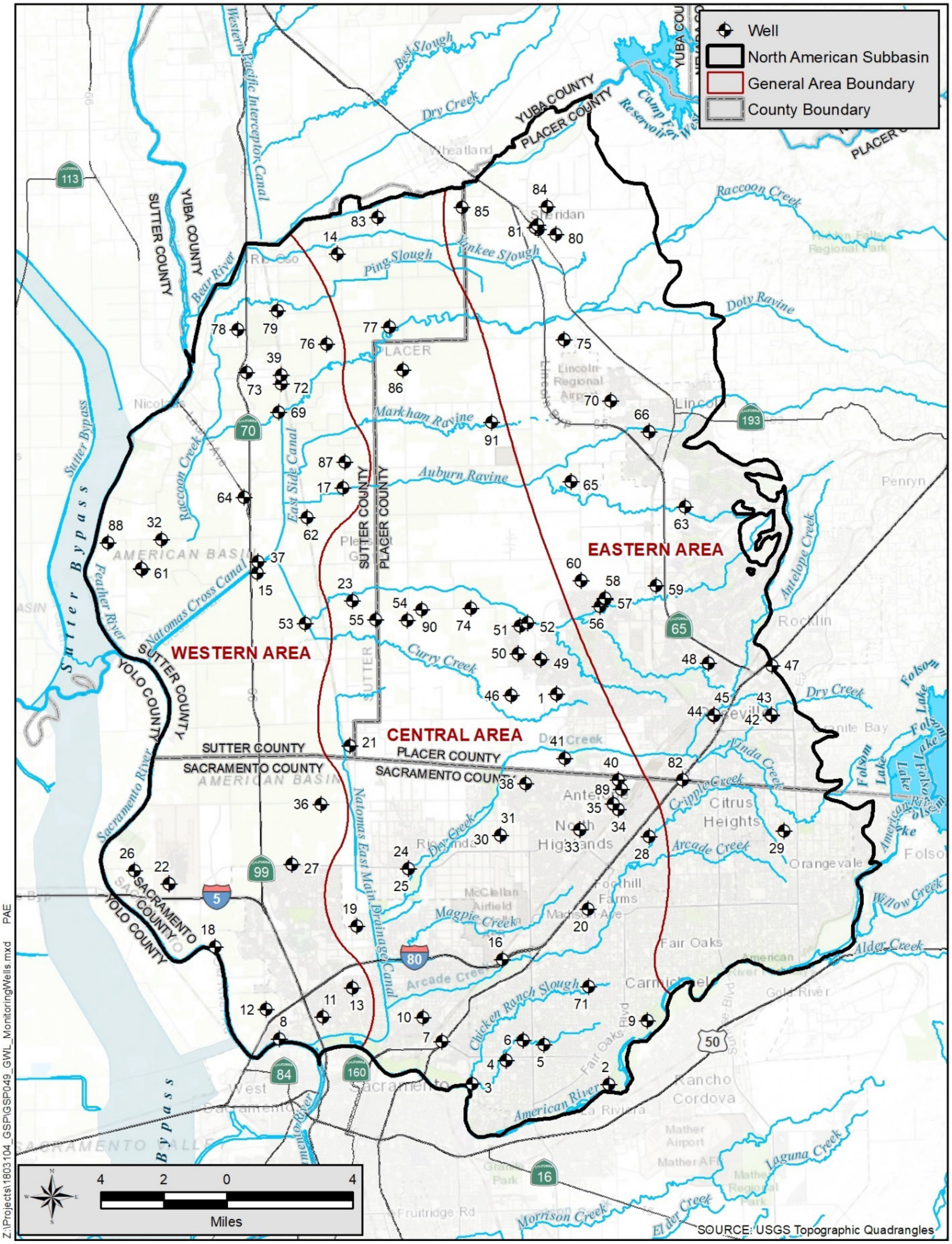


Figure 5-1. Groundwater Level Monitoring Wells

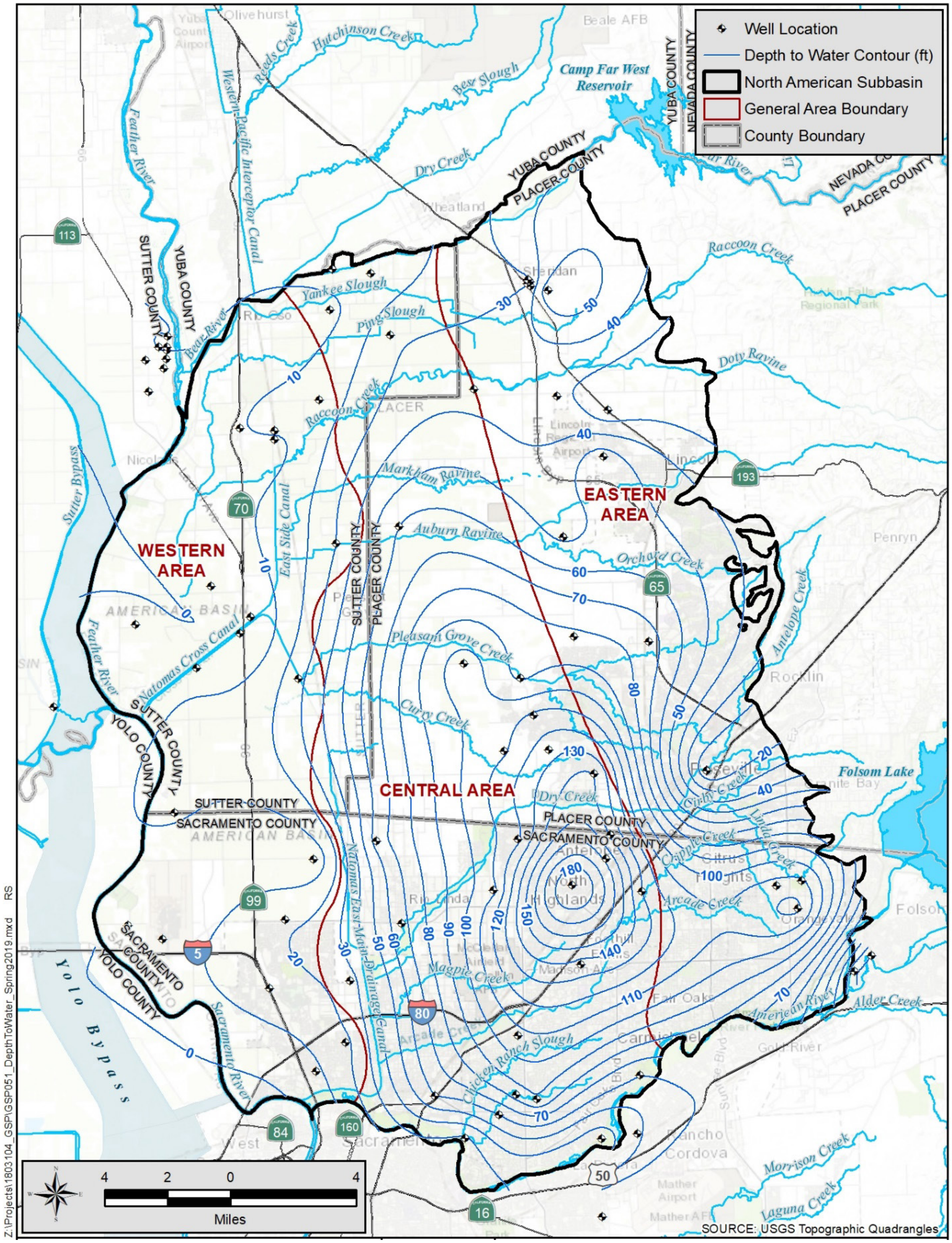


Figure 5-2. Depth to Groundwater – Spring 2019

This page left intentionally blank

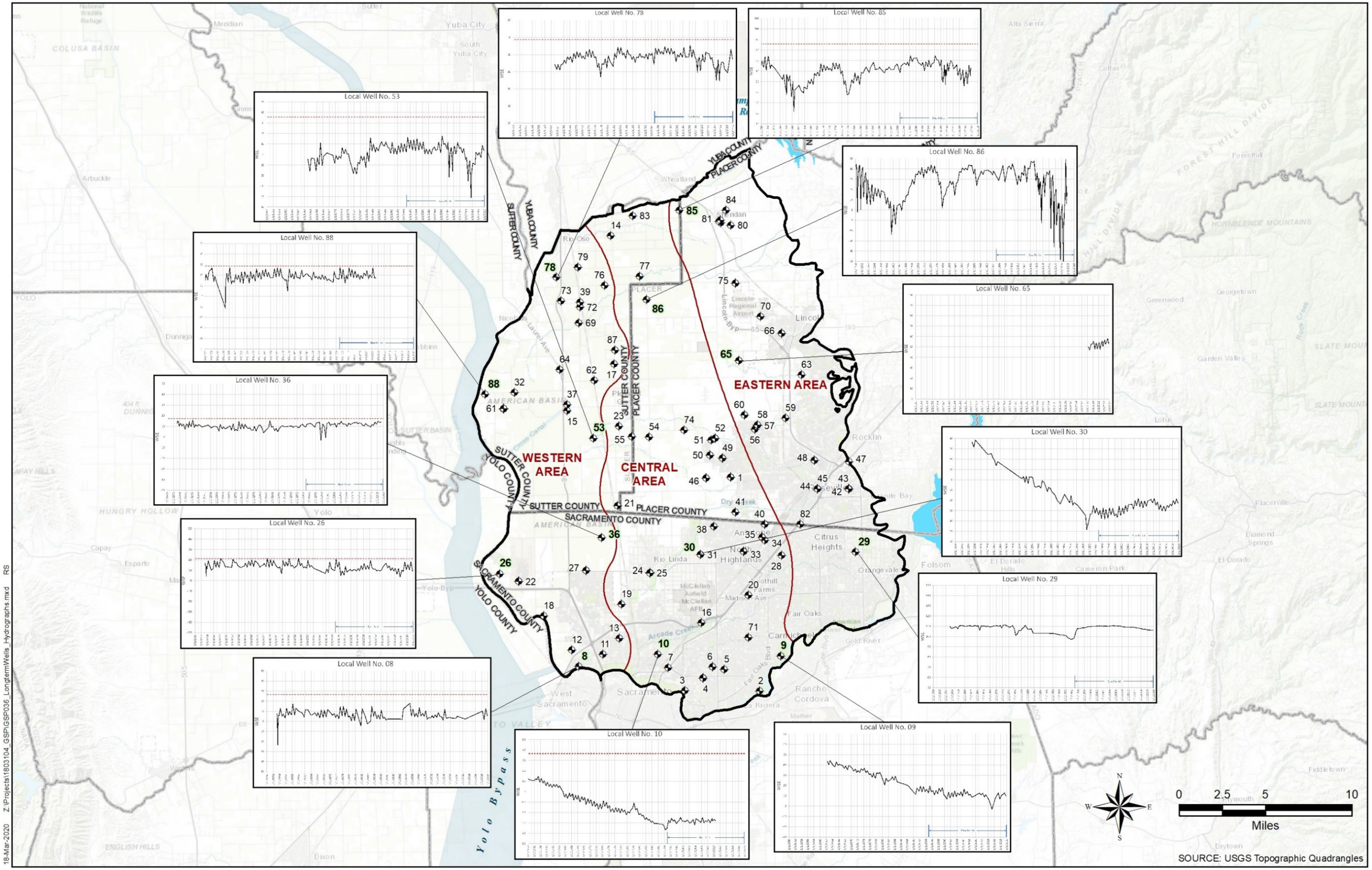


Figure 5-3. Representative Groundwater Level Hydrographs

[This page intentionally left blank.]

5.2.2 Central Area

The Central area of the Subbasin is bounded generally on the west by the Sutter/Placer County Line and the Natomas East Main Drainage Canal and extends east to about Citrus Heights and the city of Lincoln (*refer to* **Figure 5-1**). **Appendix H** provides hydrographs for the Central area. This area historically relied predominantly on groundwater. Groundwater levels in this area have shown a wide range of fluctuations but since the mid-1990s are relatively stable and sometimes rising. Currently the groundwater levels are between 0 and 15 feet bgs near the American and Bear rivers with as much as 150 feet bgs within the Sacramento County portion of the area (*refer to* **Figure 5-2**).

Two groundwater level trend patterns are present in the northern (Placer and Sutter counties) and southern (Sacramento County) portions of the Central area (*refer to* **Figure 5-3**).

In the Placer and Sutter counties portion of the Central area, groundwater levels declined by about 30 to 40 feet between the early 1950s and 1960s, until Camp Far West Reservoir was completed in 1964 (MBK, 2016). Groundwater levels rose in response to decreased groundwater use but still vary in response to climatic conditions when surface water availability decreases and groundwater pumping increases. Seasonal fluctuations in this portion of the Central area are greater than those seen in Sacramento County. Groundwater levels declined noticeably during the 2012 to 2016 drought, but began to recover following the end of that drought. However, they have not generally fully recovered to pre-drought levels.

In the Sacramento County portion of the Central area, groundwater levels declined at a rate of nearly 1.5 feet per year from around the 1950s through the mid-1990s, with groundwater levels being lowered by up to 60 feet. Groundwater levels stabilized in the mid-1990s due, in substantial part, to expanded conjunctive-use operations, making surface water available to this area. Groundwater levels have continued to rise overall since that time, with slight declines from 2007 through 2009 when dry conditions were experienced throughout California. During the most recent drought conditions of 2012 to 2016 groundwater levels declined slightly, but recovered following the end of that drought as of 2019, except for a few wells.

Perched water can be present in the Central area. Perched water was observed during the construction of a nested monitoring well (*refer to* **Figure 5-**1, monitoring well number 91) at a depth of 4 feet bgs, while the depth-to-water in monitoring well 91 was 70 feet bgs. Several contamination site investigations within the Roseville area also show perched groundwater levels.

5.2.3 Eastern Area

The Eastern area extends roughly from Citrus Heights and the City of Lincoln east to the edge of the Subbasin. There are only a few wells in the Eastern area with long-term historic measurements because this area primarily utilizes surface water. **Appendix I** provides hydrographs for the Eastern area. With urbanization of the area and development of groundwater management organizations, over 40 monitoring wells have been constructed since 2003.

The depth to groundwater in the Eastern area ranges from about 5 to 70 feet bgs and groundwater levels are generally stable (*refer to* **Figures 5-2 and 5-3**). Shallower groundwater levels are typically seen in monitoring wells near the foothills and near streams or where perched water is present. Long-term groundwater level trends are limited in this area, with most monitoring wells in this area being constructed in about 2003. **Appendix I** provides hydrographs for these shorter-term groundwater levels and show that for the most part groundwater levels are rising in this area, but a few did not recover completely since the 2012 to 2016 drought as of 2019.

A small pumping depression is present near the City of Lincoln and varies in depth seasonally by about 5- to 10-feet and based on the water year type. The depression was first identified in 2012, but may have been present in earlier years. Monitoring wells 65, 66, 70 and 75 provide the hydrographs for this area. Groundwater levels in these wells rose between 2003 and 2011. At well 65, groundwater levels recovered and are currently at or about 2 feet higher than in 2011. Groundwater levels in wells 66, 70 and 75 are still about 3 feet lower than pre-drought conditions as of 2019.

Perched groundwater is present locally in the Eastern area. Perched water has been found in MW 1-4 (monitoring well number 65) located near Auburn Ravine and at multiple locations within the city of Roseville, generally in the area north and south of Dry Creek (GEI, 2018). Perched water may also be present in the area north of Lincoln and east of old Highway 65 on top of the Ione Formation (GEI, 2019).

5.3 Historic Groundwater Contours

Groundwater contours reflect the historical groundwater use in the Subbasin. In general, groundwater conditions from the early 1900s through the 1950s essentially remained unchanged because there was little groundwater use. From the 1950s through the 1990s, pumping created a depression. After 1990 the groundwater levels stabilized or rebounded. Snapshots of the changes in groundwater contours during these periods are provided in **Figures 5-4 and 5-5**.

Contours representing little to no use of groundwater in the Subbasin were developed for the early 1900s (Bryan, 1923), as shown on **Figure 5-4**. The contours show groundwater entering the Subbasin from the east moving toward the west. The Eastern area of the Subbasin has depths to groundwater greater than 50 feet bgs, while the Western area has groundwater levels of about 15 feet bgs, similar to current conditions.

Groundwater contours did not change until about 1960 when a small depression, due to pumping, began to form near the junction of the Sutter/Placer/Sacramento County lines and extended up to Pleasant Grove (DWR, 1997). By 1970, the pumping depression was established as shown on **Figure 5-5** (MWH, 2005). Gradually over the years the depth of the central pumping depression became deeper and shifted to the east and south, extending from Placer County to almost the American River. By 1995, the pumping depression reached its maximum depth, to more than 40 feet below mean sea level, as shown on **Figure 5-5**. Between 1995 and 2004, groundwater elevations stabilized, as shown on **Figure 5-5**. From 2004 to 2019, significant recoveries of groundwater elevations have been observed within the main pumping depression in Sacramento County. As shown on **Figure 5-**6, groundwater elevations in the main depression have recovered from 10 to 20 feet. This stabilization and subsequent improvement is primarily due to groundwater management activities stemming from the Sacramento Suburban Water District's in-lieu groundwater recharge program in combination with regional water efficiency measures decreasing overall public water supply demand.

This page left intentionally blank

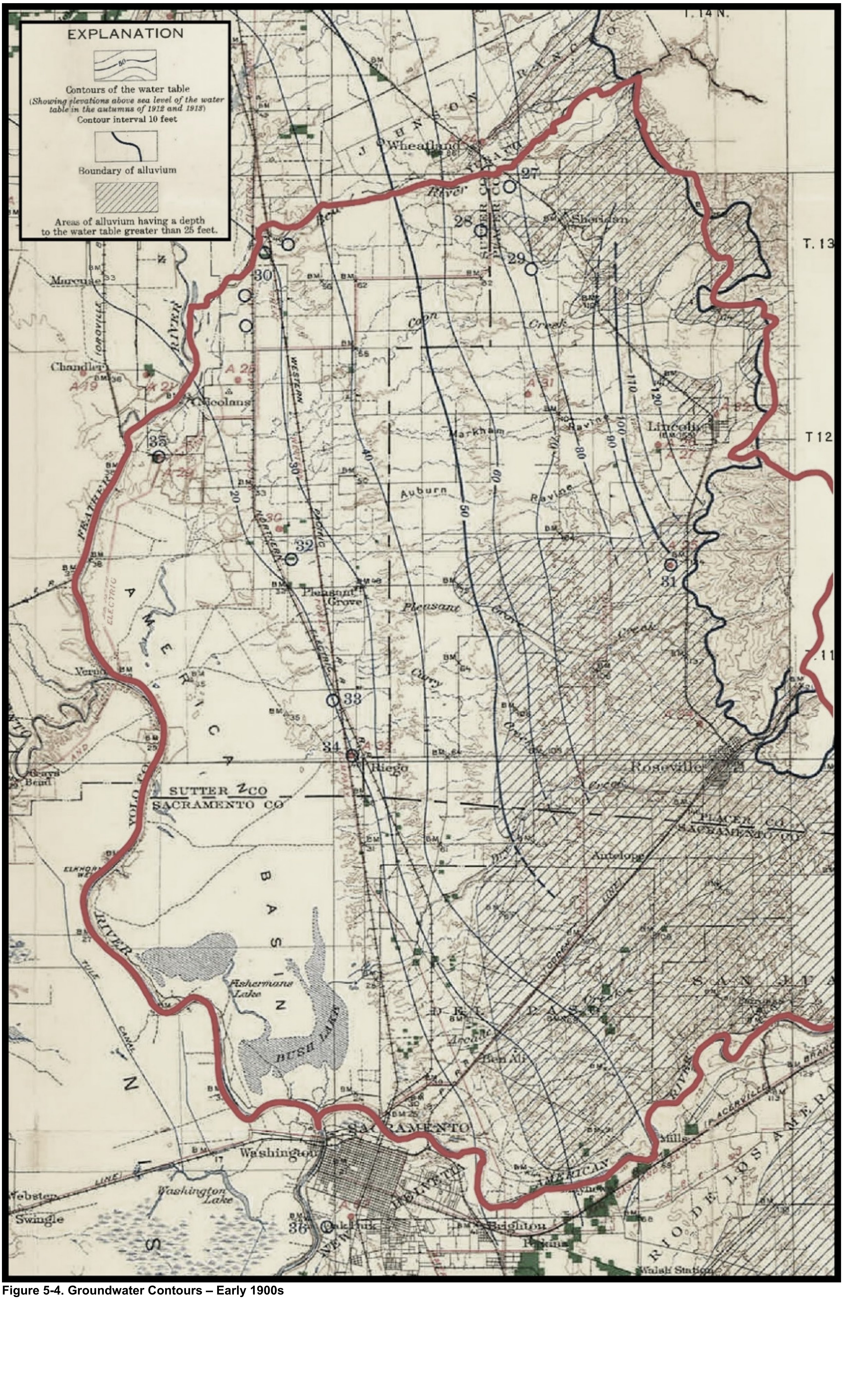
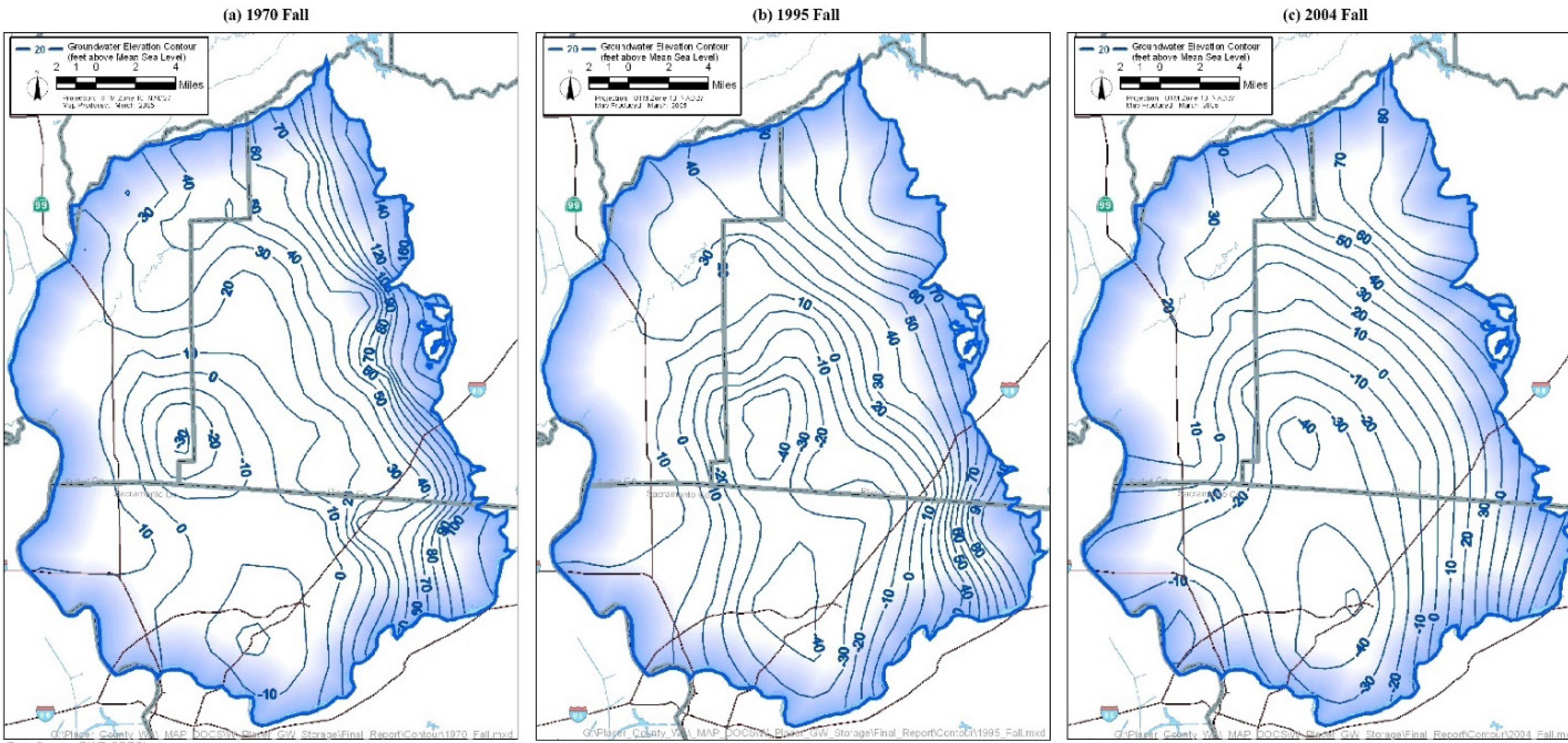


Figure 5-4. Groundwater Contours – Early 1900s

[This page intentionally left blank.]



(Data Source: DWR CDEC)

Figure 5-5. Groundwater Contours – 1970 through 2004

This page intentionally left blank

5.4 Current Groundwater Contours

Current groundwater surface elevation contours were developed to show the seasonal high and low water levels, groundwater flow directions, and regional pumping effects. These contours were based on Spring and Fall of 2019 groundwater levels using shallow wells (less than 300 feet total depth) as shown on **Figures 5-6 and 5-7,** respectively**.**

The current groundwater contours show a pumping depression in the center of the Subbasin that is about 20 feet below mean sea level. Groundwater flows radially toward this depression, from the fringes of the Subbasin toward the center. The depression extends from the American River but stops before reaching the Bear and Feather rivers. The depression extends westward toward the Sacramento River. This depression was created when groundwater pumping exceeded the natural recharge. The depression has been stabilized, with groundwater levels remaining similar or rising, by reducing pumping so that it is equal to or less than recharge. When a long-term pumping depression such as this one is created, sediments that previously contained groundwater are dewatered and there is groundwater-in-storage depletion. This condition is beneficial for management of the Subbasin by allowing for conjunctive use.

In the northern portions of the NASb, near the Bear River, the groundwater flow direction is perpendicular to the river, the contours do not show that the aquifer is receiving significant recharge from the river, and there is little inflow from the South Yuba Subbasin. Near the Feather and Sacramento rivers, the groundwater flow direction is parallel to the rivers, suggesting there is recharge from the rivers and potentially subsurface inflow from adjacent subbasins (Yolo and Sutter). Slight changes in the contours along the eastern side of the basin suggest recharge is occurring along the upper reaches of Dry Creek, Auburn Ravine, and Racoon Creek. The groundwater contours concur with the assessment of groundwater recharge and discharge areas discussed presented in **Section 4.12 – Groundwater Recharge and Discharge Areas**. The contours, along with the depths-to-water, provide an indication of areas where groundwater and surface water may be interconnected.

The groundwater gradients near the pumping depression are similar except from the east where they are steeper, potentially due to groundwater recharge effects. **Table 5-1** provides the gradients for Fall 2019.

Table 5-1. Groundwater Gradients Toward the Central Area

Groundwater Gradients (ft/ft)			
West	East	North	South
0.001	0.06	0.001	0.002

The current seasonal changes in groundwater levels were assessed for Spring and Fall of 2019, a wet water year. Changes in groundwater levels in the upper aquifer vary across the Subbasin. In the upper aquifer the seasonal changes from Spring to Fall range from about +2 to -14 feet.

These seasonal changes do not account for pumping levels at individual wells and may be greater in exceptionally dry years when reliance on groundwater is greater due to the reduction of surface water supplies.

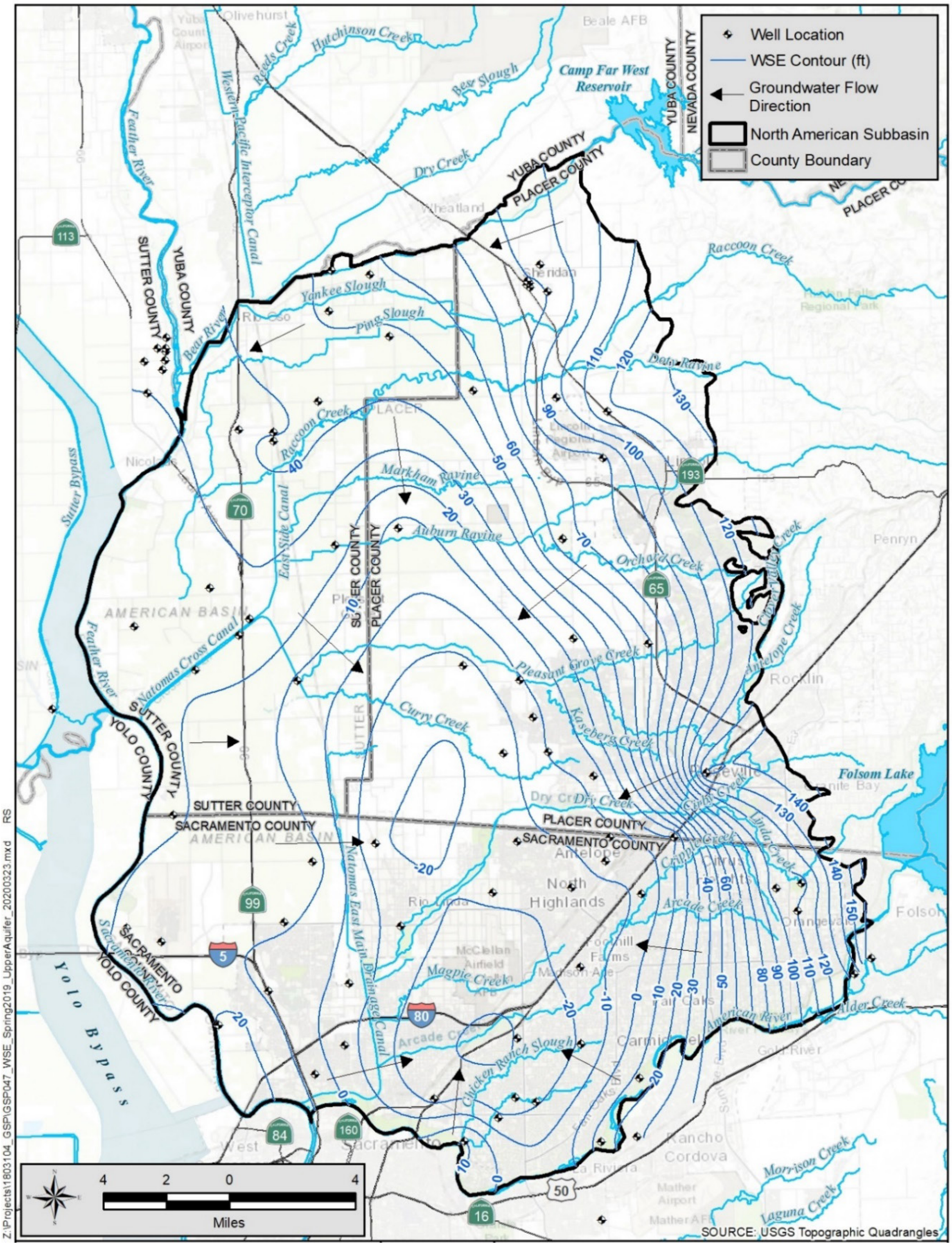


Figure 5-6. Groundwater Contours – Spring 2019

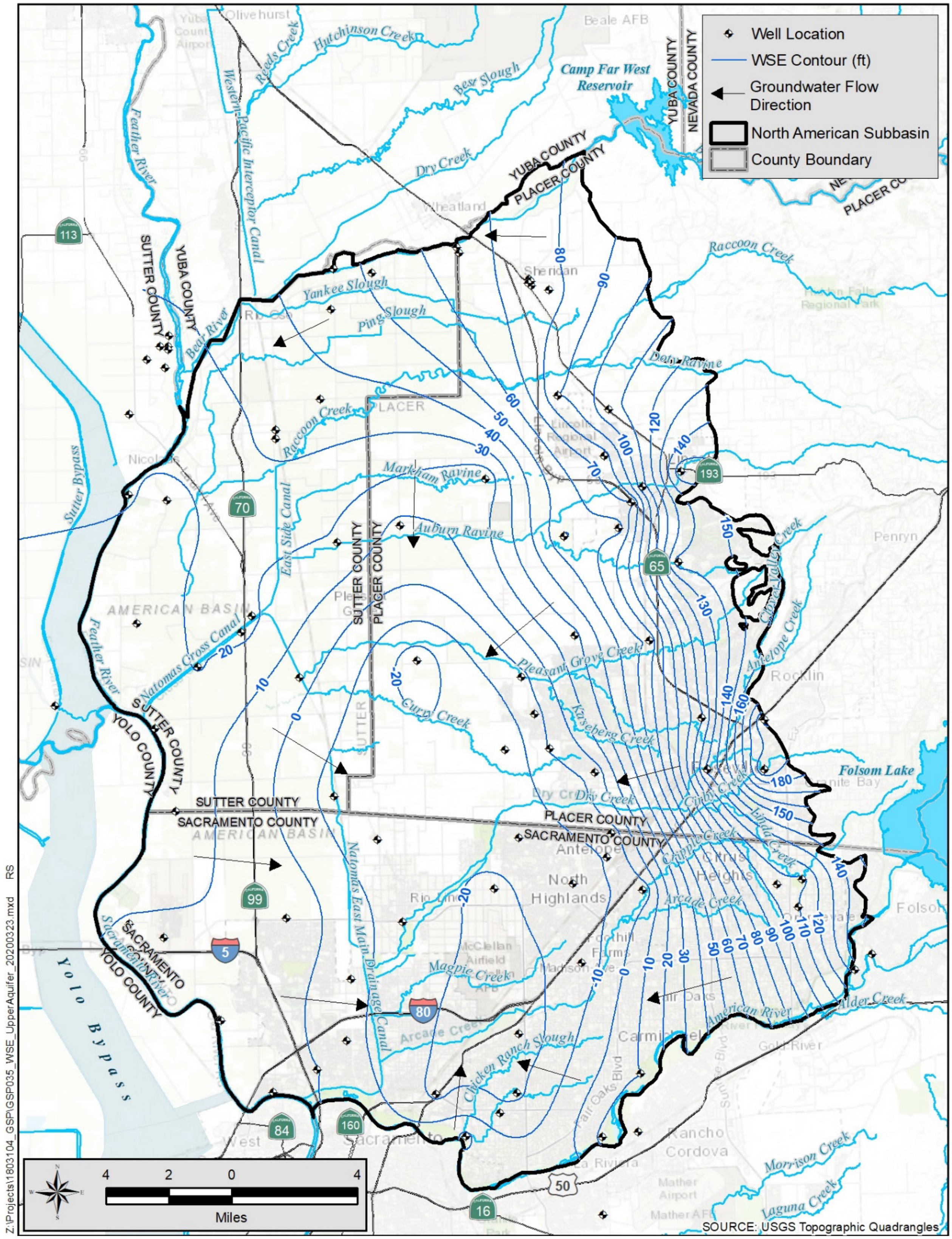


Figure 5-7. Groundwater Contours – Fall 2019

5.5 Hydraulic Gradients Between Aquifers

Since the mid-1970s dedicated monitoring wells have been constructed to monitor discrete intervals within the aquifer. When multiple monitoring wells are constructed in the same hole they are referred to as nested wells. Monitoring wells that are closely located but monitor different discrete intervals are called clustered wells. Nested and clustered monitoring wells were used to evaluate vertical groundwater gradients at varying depths of the aquifers, as sorted by the formation in which the aquifer occurs. There are 31 nested and clustered monitoring well locations in the Subbasin with up to five multiple-completion monitoring wells at each location (**Figure 5-8**). **Appendix J** contains the hydrographs for each set of nested or clustered wells. In some cases, the nested or clustered wells are all in the same aquifer or a monitoring well has been constructed below the base of fresh water into the marine formations (monitoring well number 39), potentially the Central Valley Formation.

Generally, the aquifer in the Tulare Lake and Laguna formations has been found to exhibit unconfined aquifer characteristics. Confinement has been found to increase with depth and to the west in the deeper portions of the aquifer (DWR, 1997). The deeper portions of the aquifer (Mehrten Formation) typically exhibit delayed responses to pumping and recharge effects imposed in the shallower portions of the aquifer, confirming hydraulic interconnection.

Figure 5-8 provides a graphic representation of vertical groundwater gradients (heads) between the shallower and deeper portions of the aquifer (in Fall 2019), just after high groundwater use in the summer months, when the difference in groundwater levels should be the greatest:

- In the Western area, the vertical gradients are all downward and the greatest groundwater level differences in the Subbasin, downward by 23 feet, occurs at AB-4. The head differences are less near the rivers and greater toward the east. The head differences in this area are likely due to the deeper portion of the aquifer being more confined allowing for greater differences in groundwater levels.
- In the Central area, the vertical gradients are not consistent and have both upward and downward heads, ranging from about +7 to -7 feet. This suggests unconfined to semi-confined conditions with increasing depth in the aquifer may be present.
- In the Eastern area, the groundwater head differences are small suggesting unconfined conditions.

Although there are head differences, hydrographs show that groundwater levels in the different depths of the aquifer have similar trends, indicating the interconnectedness and a similar recharge area.

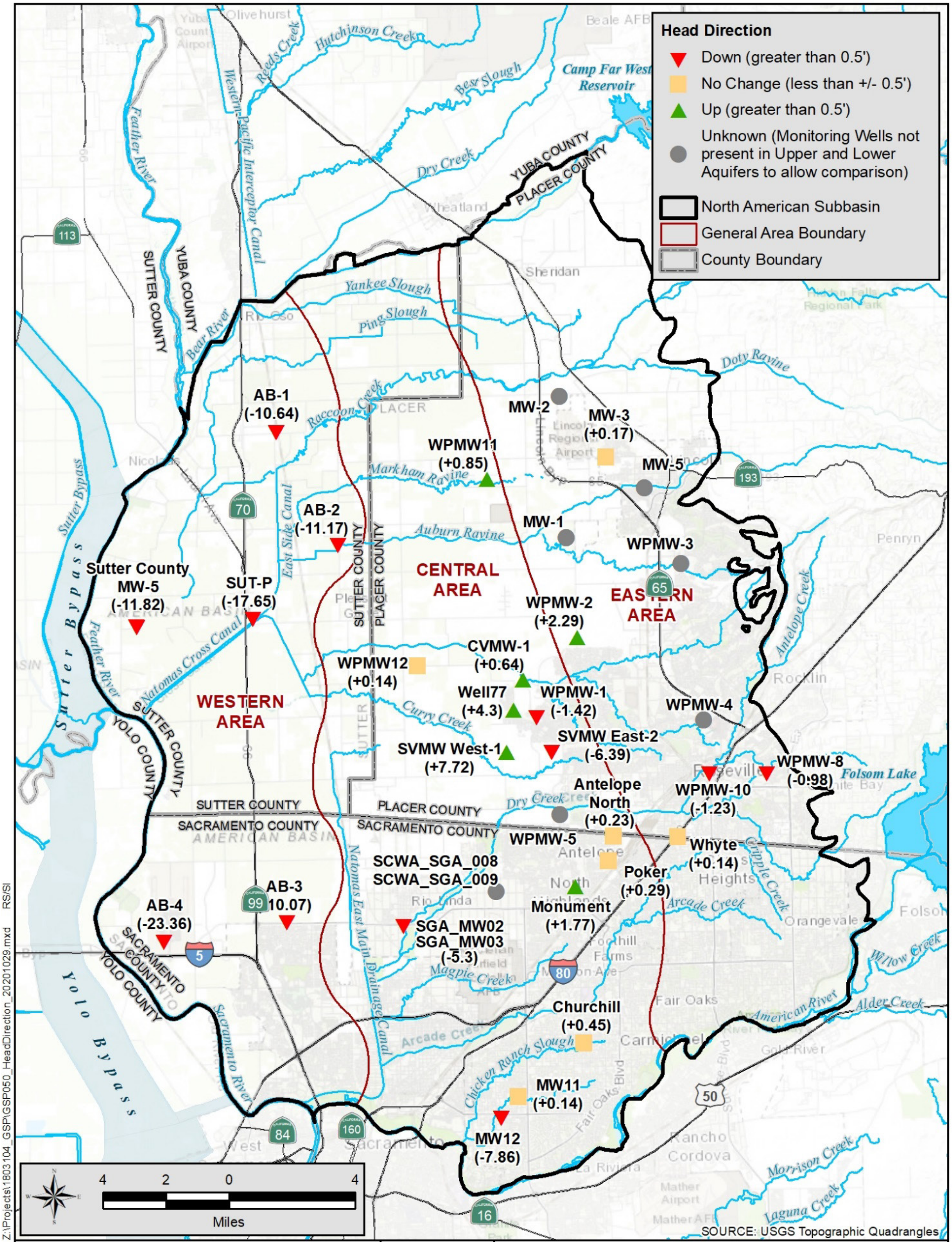


Figure 5-8. Vertical Gradients Upper to Lower Portions of the Aquifer – Fall 2019

5.6 Hydraulic Gradients Between Fresh and Non-Fresh Water Formations

Three of the deeper nested monitoring wells (monitoring wells 48, 63, 66, or wells MW5-2, WPMW-3B, and WPMW-4B) were constructed into the Ione Formation in the Eastern area of the Subbasin. These wells consistently have higher heads in the marine Ione Formation than in the other aquifers, indicating an upward head and suggesting the groundwater in the Ione Formation could discharge to the fresh-water aquifers. **Appendix K** provides these hydrographs which show the head differences are up to 50 feet upward at monitoring well 48.

One monitoring well (monitoring well 39 or AB-1 deep) was constructed below the base of fresh water, potentially into the Valley Springs or Central Valley Formation, in the Western area of the Subbasin. Groundwater levels (piezometric) in the formation in comparison to the fresh-water aquifers change seasonally, apparently due to pumping influences. During the winter months groundwater levels in the fresh water-bearing aquifers are higher than in the formation. During the summer months the groundwater levels are higher in the formation than in the fresh water. During the summer months the water in the formation could up-well into the fresh water-bearing formations. Historically, prior to 2006, the head differences during the summer months were only a few feet, but since then up to 15 feet of head differences have occurred. The greater head differences suggest an increase in groundwater pumping occurred locally in this area.

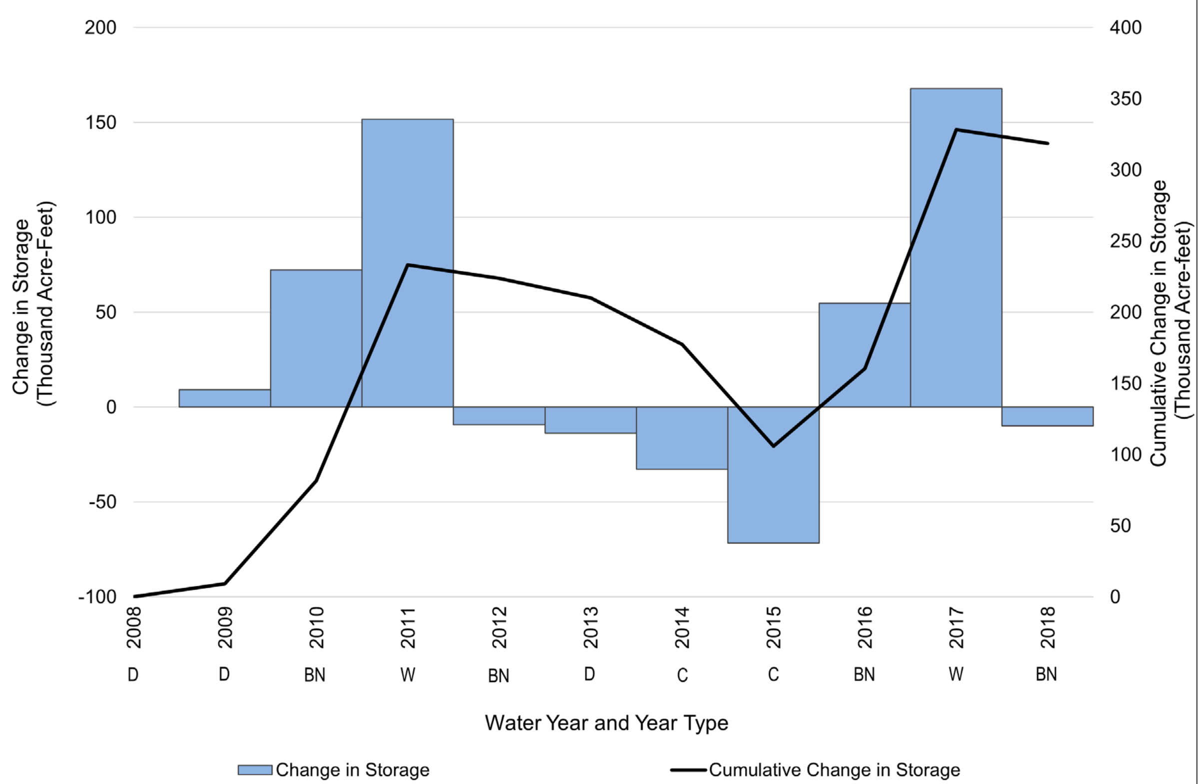
5.7 Change in Groundwater Storage

The amount of groundwater in storage changes annually and seasonally depending on the amount of groundwater use and recharge. The change in storage provides an indication of how much groundwater is in storage for dry years when there is more reliance on groundwater. The change in groundwater storage was estimated for the entire NASb using the calibrated groundwater model. The model includes actual groundwater pumping from municipal water purveyors and estimated groundwater pumping for agricultural areas from the NASb.

Table 5-2 shows the NASb-wide groundwater pumping for water years 2009 through 2018. **Figure 5-9** shows both the annual and cumulative changes in groundwater in storage in the Subbasin. The cumulative change in storage during this period, increased by about 300,000 acre-feet (AFY) which included the recent drought, or on average by about 30,000 AFY.

Table 5-2. Summary of Annual Extraction and Change in Storage

Water Year	Groundwater Extraction (acre-feet)	Change in Storage (acre-feet)	Water Year Classification
2009	313,120	9,395	Dry
2010	273,566	72,314	Below Normal
2011	252,800	152,057	Wet
2012	293,862	-9,524	Below Normal
2013	298,785	-13,615	Dry
2014	301,847	-32,603	Critical
2015	357,224	-71,725	Critical
2016	279,422	54,642	Below Normal
2017	279,942	168,082	Wet
2018	306,763	-10,024	Below Normal



Note: Water year type is based on the Sacramento Valley Water Year Hydrologic Classification Index.
2008 is included to highlight the starting point (zero) for the cumulative change in storage value. Annual storage change values are not shown for 2008
W=wet, AN=above normal, BN=below normal, D=dry, and C=critical

Figure 5-9. Annual and Cumulative Change in Storage

5.8 Groundwater Quality

Generally, the quality of groundwater in the Subbasin is suitable for nearly all uses, with the exception of contamination plumes and localized, naturally-occurring and human-caused quality issues, which may affect the supply, beneficial uses, and potential management of groundwater in the Subbasin. This section describes the distribution, concentration and trends of the more commonly encountered and primarily naturally-occurring dissolved constituents in groundwater, along with human-caused water quality contamination issues.

5.8.1 Occurrence of Commonly Evaluated Constituents in Groundwater

While there are over 50 elements (general minerals and metals) with established drinking water and agricultural standards, only a few elements typically occur in the Sacramento Valley at levels that warrant evaluation and tracking to assess their occurrence and distribution. The concentration and depth of the elements varies widely over the NASb and at any given location. Various studies have been performed and each has evaluated similar elements, and a few have evaluated additional elements. A Groundwater Quality Vulnerability Assessment of the SGA portion of the Subbasin identified seven elements (arsenic, chromium (total and hexavalent), iron, manganese, nitrate, total dissolved solids, and radon) that provide a general condition of the groundwater quality (SGA, 2011). It should be noted that some of these naturally-occurring elements may be either sourced from, or increased by, human activities. This GSP evaluates six of these seven elements (not radon), which were also identified and analyzed in other studies, plus boron because its presence can affect agriculture.

The groundwater quality presented in this GSP was developed using information from the California State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW), which maintains a database of public water systems' water quality analyses. DDW requires each public water system to analyze water quality for over 300 elements at intervals ranging from weekly to every 3 years. Because large portions of Placer and Sutter counties are agricultural, public water systems are scarce within those areas. Therefore, data from the DDW was supplemented with data from one well (monitoring well 61, *refer to* **Figure 3-15**) monitored for the Irrigated Lands Regulatory Program Sacramento Valley Water Quality Coalition Groundwater Quality Trend Monitoring program and data from domestic wells used by the USGS for their *Groundwater Quality Data in the Southern Sacramento Valley, California, 2005 – Results from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program* (Milby, et. al. 2005 and 2018) and water quality from local programs.

Water quality samples were collected from 24 domestic wells, between 2013 and 2017, with an average screen interval 129 to 178 feet bgs. The results showed TDS ranged between 70 and 459 mg/L. Nitrate (as nitrogen) ranged between 0.1 and 1.4 mg/L (Bennett, 2019). The concentrations indicate the water is suitable for drinking water with all concentrations below the secondary and primary drinking water standards (California Code of Regulations (CCR)-Title

22, 2021). However, about 15 percent of the wells had arsenic and manganese above their respective MCLs (Bennett, 2019).

Figures 5-10 through 5-16 show the most recent analyses and distribution of the selected elements in the Subbasin. The analyses dates range from 1967 to 2019. These figures also show where monitoring wells are located that could be used to supplement the data set. **Appendix L** provides a detailed list of the water quality analysis and wells used to create the figures. **Table 5-3** provides a list of the constituents, the number of samples analyzed, their minimum and maximum concentrations, and the average and percent of samples exceeding the MCL or Notification Level.

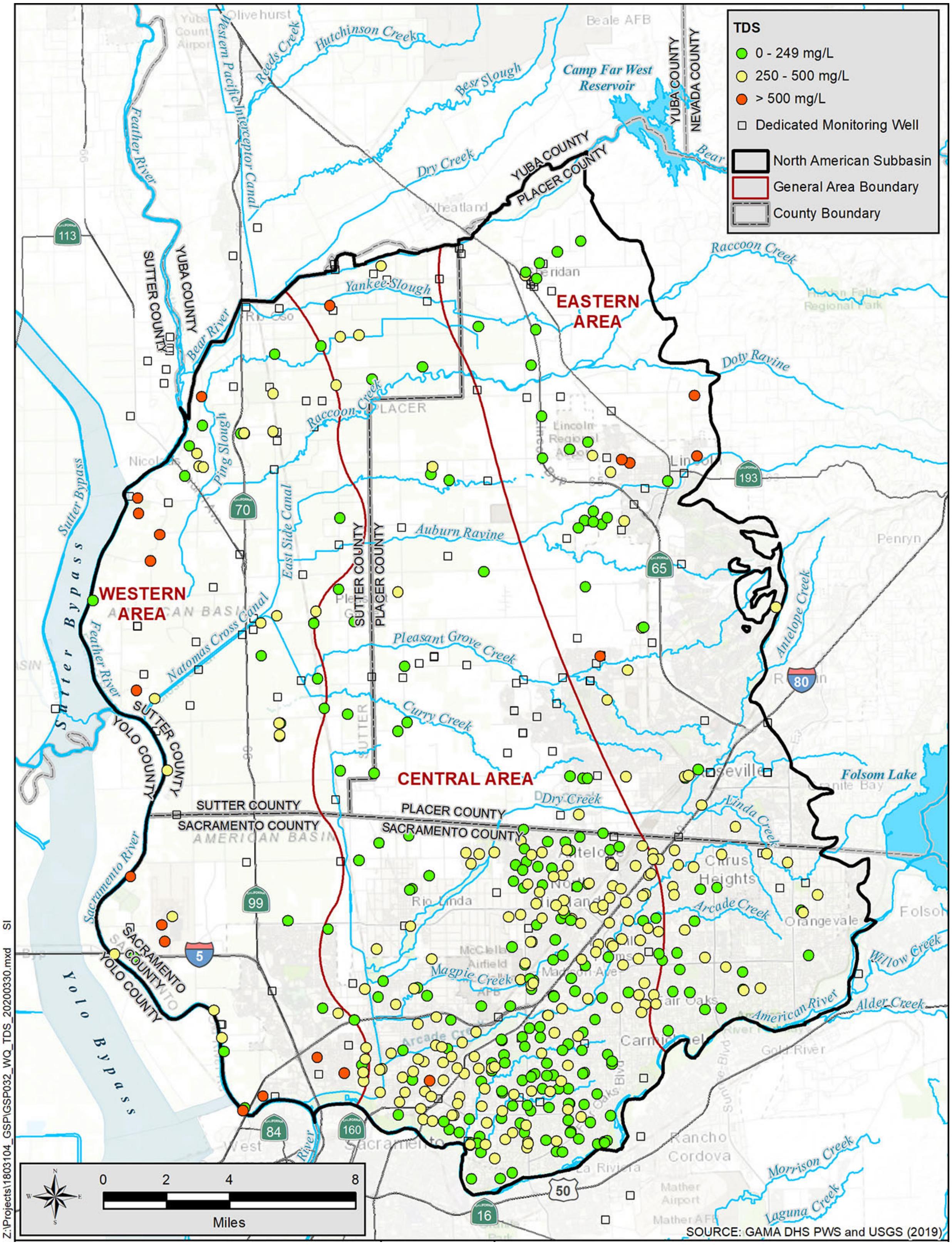


Figure 5-10. Distribution of TDS Concentrations

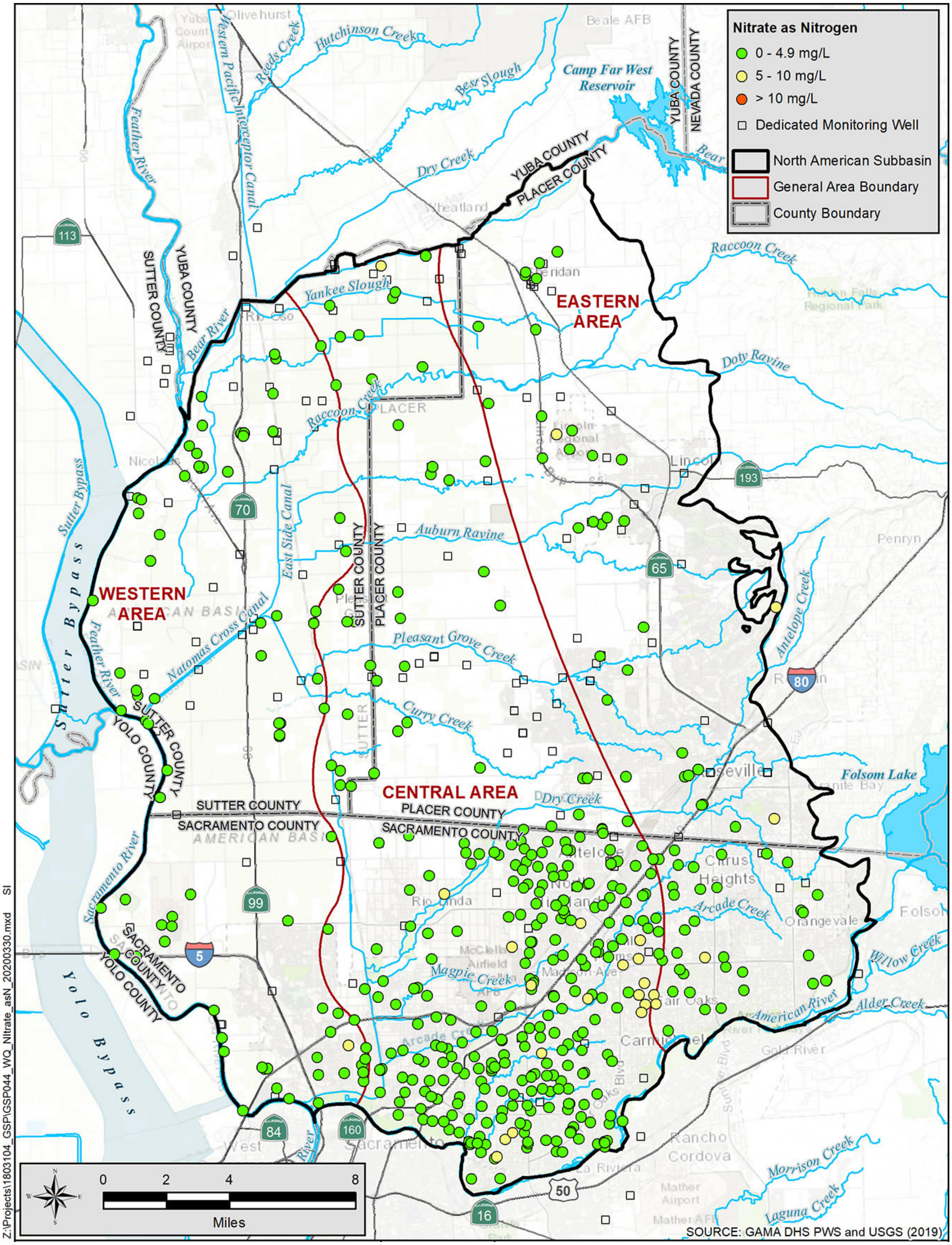


Figure 5-11. Distribution of Nitrate as Nitrogen Concentrations

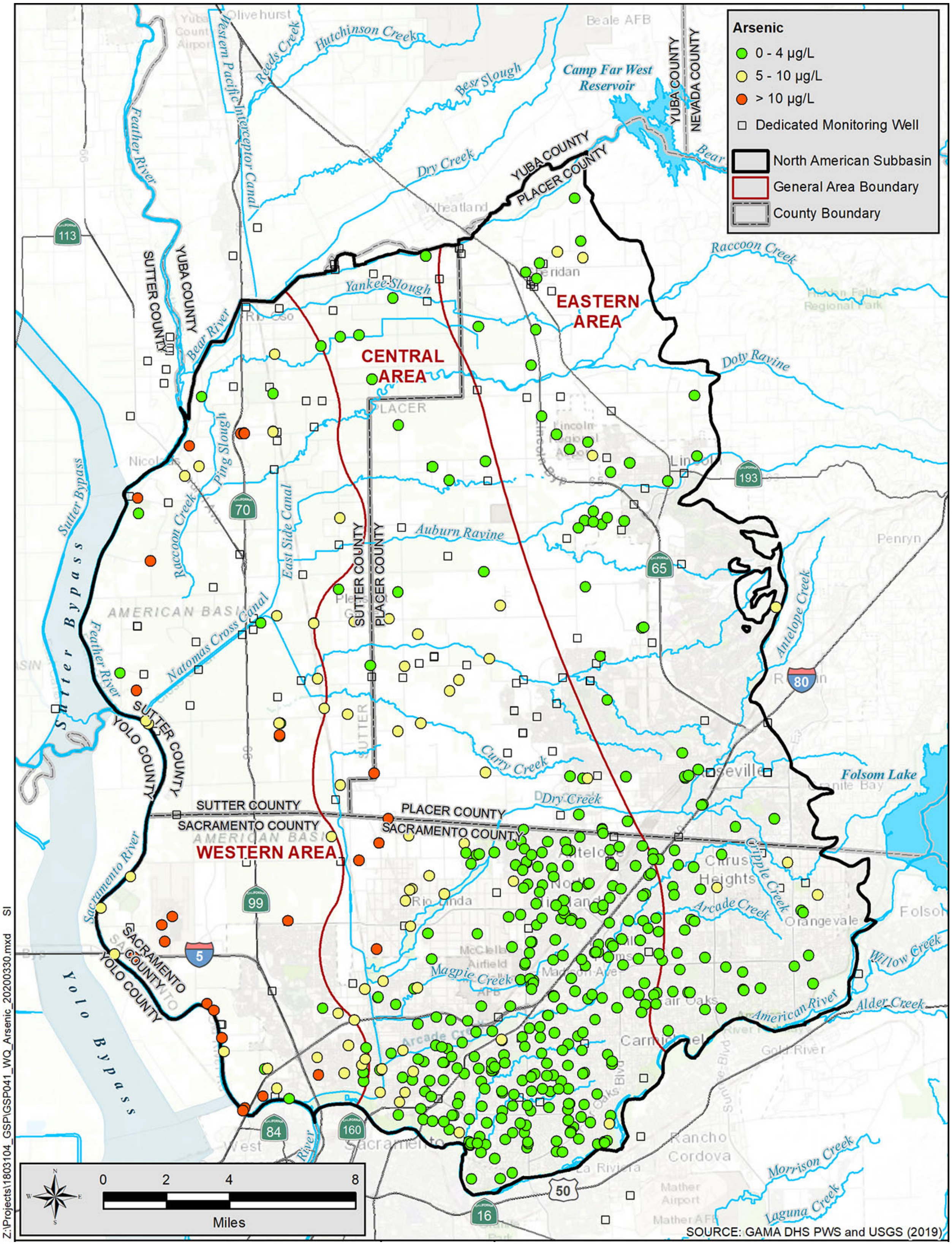


Figure 5-12. Distribution of Arsenic Concentrations

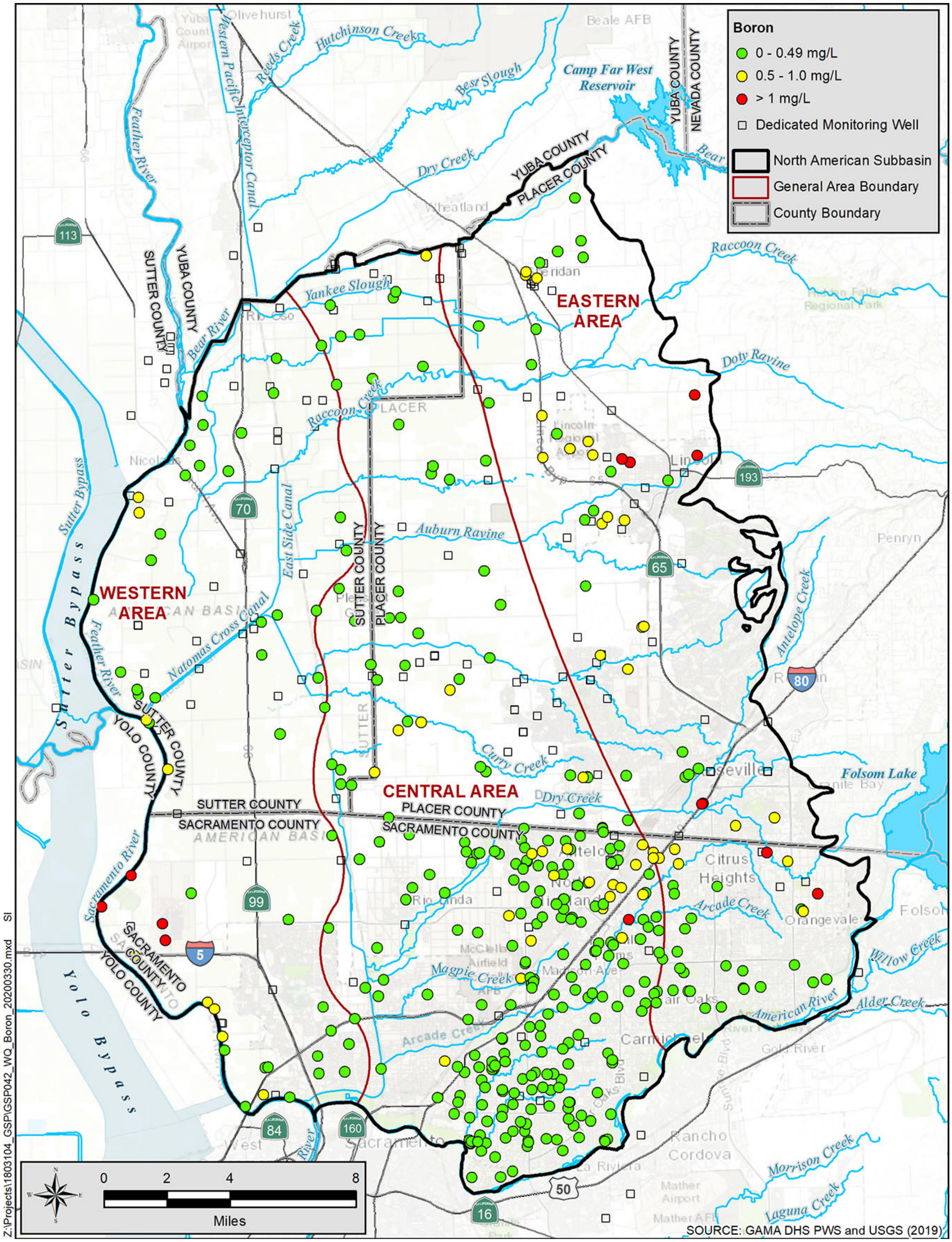


Figure 5-13. Distribution of Boron Concentrations

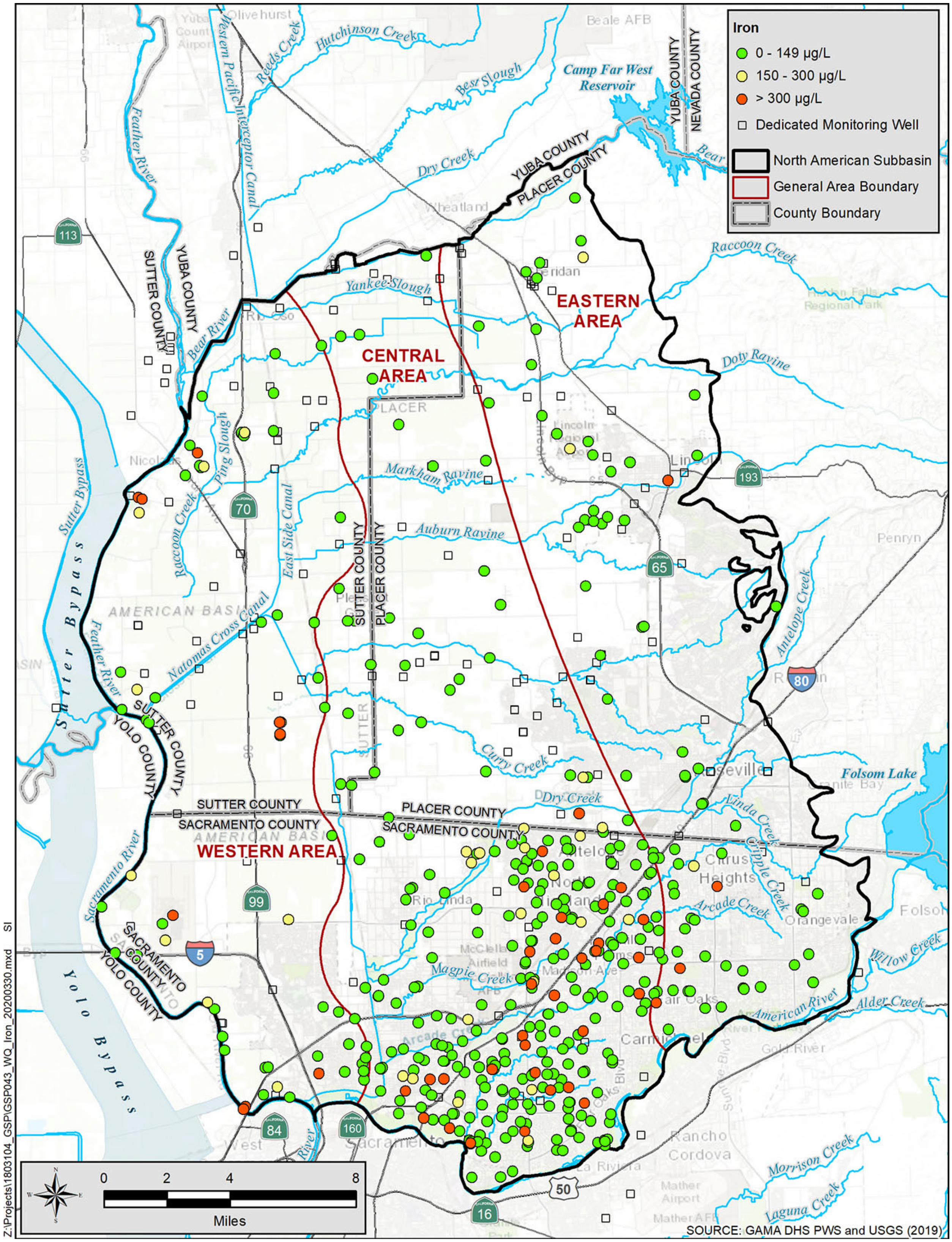


Figure 5-14. Distribution of Iron Concentrations

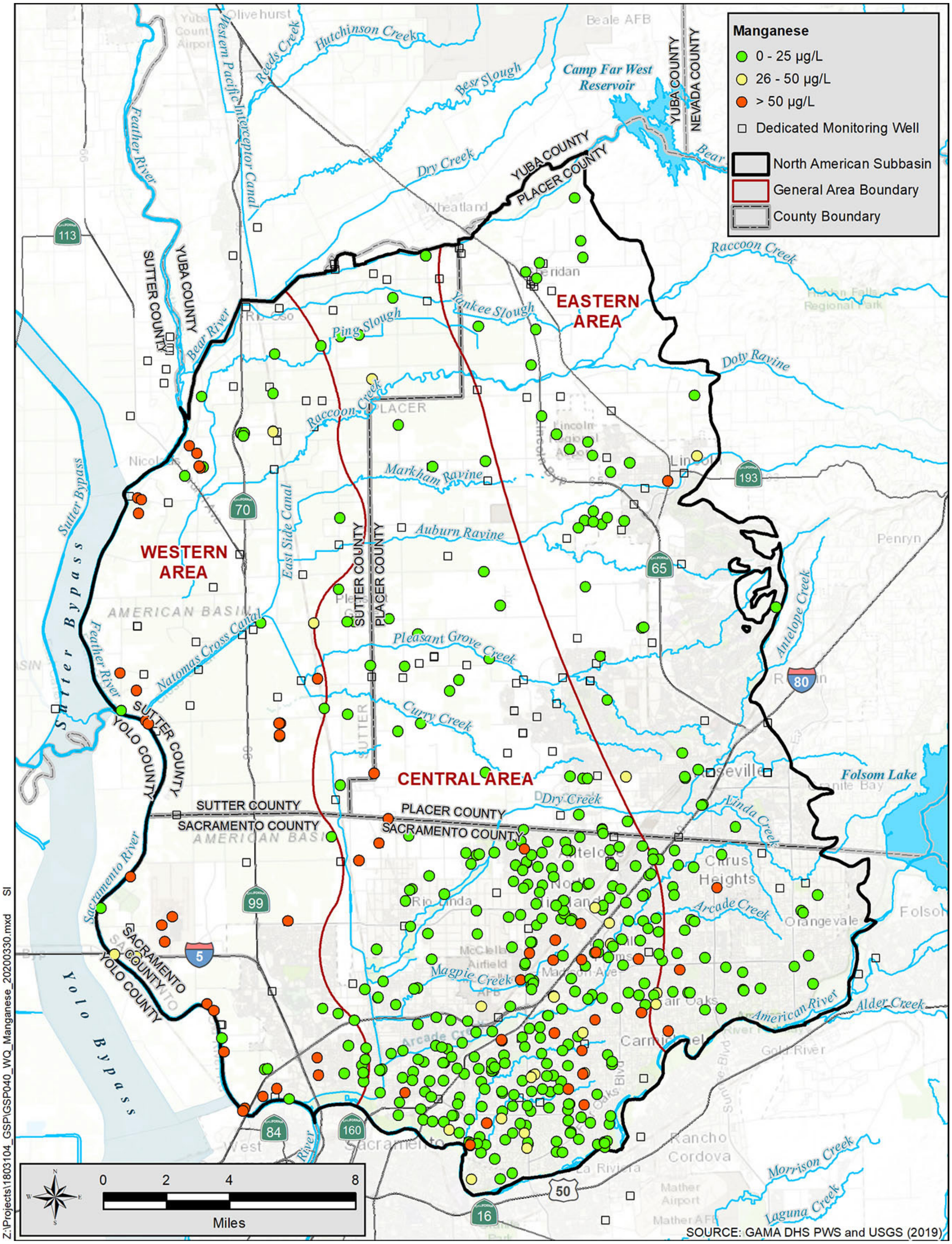


Figure 5-15. Distribution of Manganese Concentrations

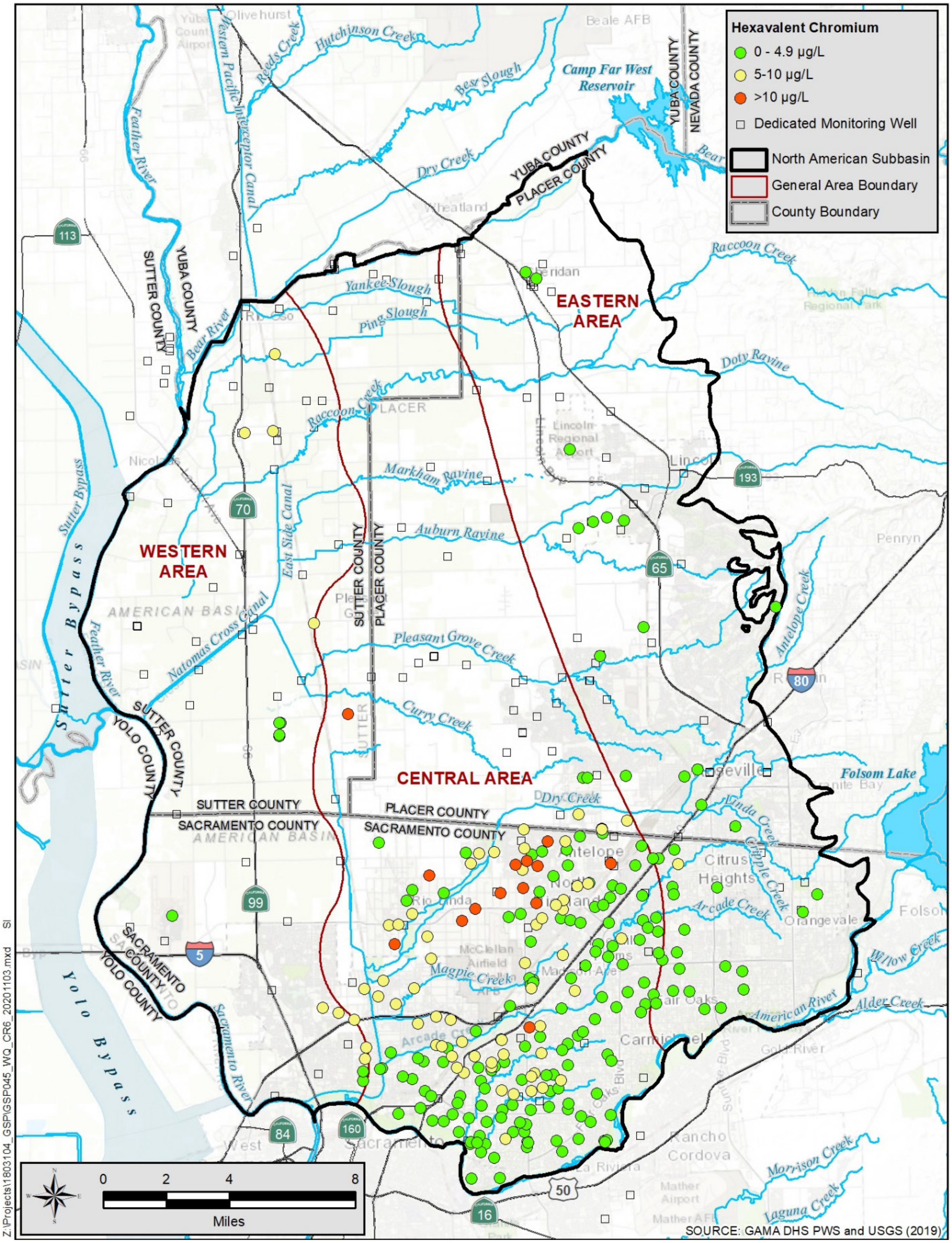


Figure 5-16. Distribution of Hexavalent Chromium Concentrations

Table 5-3. General Water Quality Summary

Constituents	Units	MCL or Notification Level	Number of wells with analytical results	Minimum Concentration[4]	Maximum Concentration	Average	Number of wells with most recent analysis exceeding MCL	Range of analysis (years)
Arsenic	ug/L	10	482	<2.0	78.1	4.09	29	1967-2019
Boron	mg/L	1[1]	410	<0.1	6.8	0.2	14	1969-2018
Hexavalent Chromium	ug/L	10[2]	252	<0.05	14	4.17	-	2001-2019
Iron	mg/L	0.3	488	<0.03	5.5	0.16	44	1957-2019
Manganese	mg/L	0.05	488	<0.01	3.6	0.05	62	1970-2019
Nitrate as Nitrogen	mg/L	10	494	<0.023	10	1.7	0	1964-2019
TDS	mg/L	500[3]	451	97	1,360	268.7	22	1969-2019

Notes: 1 = Notification level, no MCL
2 = No MCL, previous MCL shown
3 = Secondary standard, recommended level shown
4 = Reporting limit, may vary with historic analysis

This page left intentionally blank

Water quality in each of the areas varies and some elements with elevated levels are only present in a one or more areas while not in others. These findings align with previous studies in the Subbasin. Where concentrations are elevated, wells are often constructed into different aquifers where the water quality is better. In summary:

- In the Western area, elevated concentrations of arsenic, boron, and TDS are present near the Feather and Sacramento rivers. Studies in the area show variable water quality in the aquifers. Poor-quality water is present in the adjacent Sutter Subbasin. It is unknown if the poor-quality water is present in the Yolo Subbasin.
- In the Central area, elevated levels of arsenic and hexavalent chromium are generally found in the western portion of this area, in the vicinity of Rio Linda (SGA, 2011) with scattered occurrences elsewhere in the Subbasin. The areas of biggest concern for hexavalent chromium appear to be north of Interstate 80 near the communities of Rio Linda, Antelope, and North Highlands.
- In the Eastern area, scattered locations near Sheridan, Lincoln, and Roseville have elevated boron and TDS levels. High TDS concentrations are commonly associated with sodium chloride types of water and may be related to connate water from the marine Ione Formation. The effects of the Ione Formation water in this area appear to be of limited extent. Sodium chloride types of water are also present in deeper wells in the Subbasin near or below the base of fresh water.

Nitrate concentrations are typically below the MCL for drinking water in all three areas; however, nitrate concentrations are trending upward in many parts of the Subbasin. Elevated levels of boron appear to be present in most areas with some concentrated areas in the Western area south of Highway 5 and in the SGA area. Elevated iron and manganese levels (**Figures 5-15 and 5-16**) could be encountered in any of the three areas. Elevated levels of hexavalent chromium appear to be more concentrated in the SGA area, but this could in part be due to SGA having a greater number of wells with analyses.

5.8.2 Groundwater Quality Trends

Groundwater quality trends are evaluated to assess trends and where management actions may be required to reduce future degradation and keep the water potable. Water quality sampling in the Subbasin has been conducted for over 40 years as part of state and federal efforts to evaluate water quality throughout the state and nation and where future studies may be needed to maintain potable water supplies. Although many of the elements are naturally occurring, human activities may result in increased concentrations of elements and produce upward trends. In general, water quality trends in the NASb are not showing rising concentrations and are remaining in a consistent range with a few exceptions.

5.8.2.1 Previous Analyses

Water quality trends for TDS (a primary indicator of naturally occurring water quality) and nitrates (a primary indicator of human activities) were analyzed in historical reports and concluded the following trends.

In the SGA area, a Water Quality Vulnerability Assessment in 2011 using just public water supply wells found:

- TDS trends are, for the most part, stable and not increasing (SGA, 2014).
- In 19 wells, nitrate concentrations were rising somewhat over the period of record (earliest records in the database are generally from the mid-1980s or later) (SGA, 2014). In 10 wells, nitrate concentrations were trending downward. SGA concluded that there was no discernible overall trend in the data at that time. Regardless, SGA concluded there were no trends that would constitute a health concern with respect to nitrates in the SGA area.

In the West Placer GSA area:

- TDS levels are generally stable or decreasing but are increasing at one water supply well (GEI, 2020).
- Nitrate trends were not evaluated.

A Groundwater Assessment Report for most of the Sacramento Valley was performed as part of the Irrigated Lands Regulatory Program, which used all wells in the GAMA data files (CH2MHill, 2014). This report provides water quality covering the SGA, West Placer, SSWD, RD 1001 and Sutter GSA areas. It used a modified Mann-Kendall statistical approach. In the NASb:

- TDS levels trends were consistent.
- Nitrate concentrations are increasing at seven out of 20 wells, in the agricultural areas of west Placer County and Sutter County.

A Groundwater Assessment Report for rice areas in the Sacramento Valley, including in part some portion of all of the GSAs, was also performed as part of the Irrigated Lands Regulatory Program. No rigorous trend analysis was performed but graphs were provided for some wells. This analysis only used 12 wells in the NASb (CH2MHill, 2013). In the NASb:

- TDS concentrations were very consistent.
- Data was only sufficient at one well to evaluate nitrate trends (decreasing).

5.8.2.2 *Current Analyses*

Groundwater quality trends for this GSP were developed using data from public water supply wells, and USGS and DWR wells were used to develop the water quality distribution (*refer to* **Figures 5-10 through 5-16**). A statistical trend analysis of the data was performed using the Mann-Kendall method when a well had more than five samples for a given element. This method is a non-parametric (for example, does not assume a distribution in the data) test for identifying trends in time-series data. **Appendix M** provides the analysis and trend graphs for each constituent**. Figures 5-17 through 5-23** show the trends for each element. **Table 5-4** provides a summary of the analysis.

Table 5-4. Water Quality Trend Summary

Element	Units	Number of Wells with Greater Than Five Samples	Increasing Trends	Decreasing or Flat Trends
Arsenic	ug/L	245	7	238
Boron	mg/L	71	3	68
Hexavalent Chromium	ug/L	115	1	114
Iron	mg/L	241	9	232
Manganese	mg/L	241	2	239
Nitrate as Nitrogen	mg/L	316	69	247
TDS	mg/L	267	8	259

Similar to historical assessments, this GSP finds that groundwater quality is stable with the exception of nitrate. Although nitrate has the greatest number of wells with upward trends, and these upward trends are present in all areas, nitrate concentrations are well below the safe drinking water standard throughout the Subbasin. The nitrate is likely present due to historical agricultural fertilization practices, septic systems, and leaky sewers.

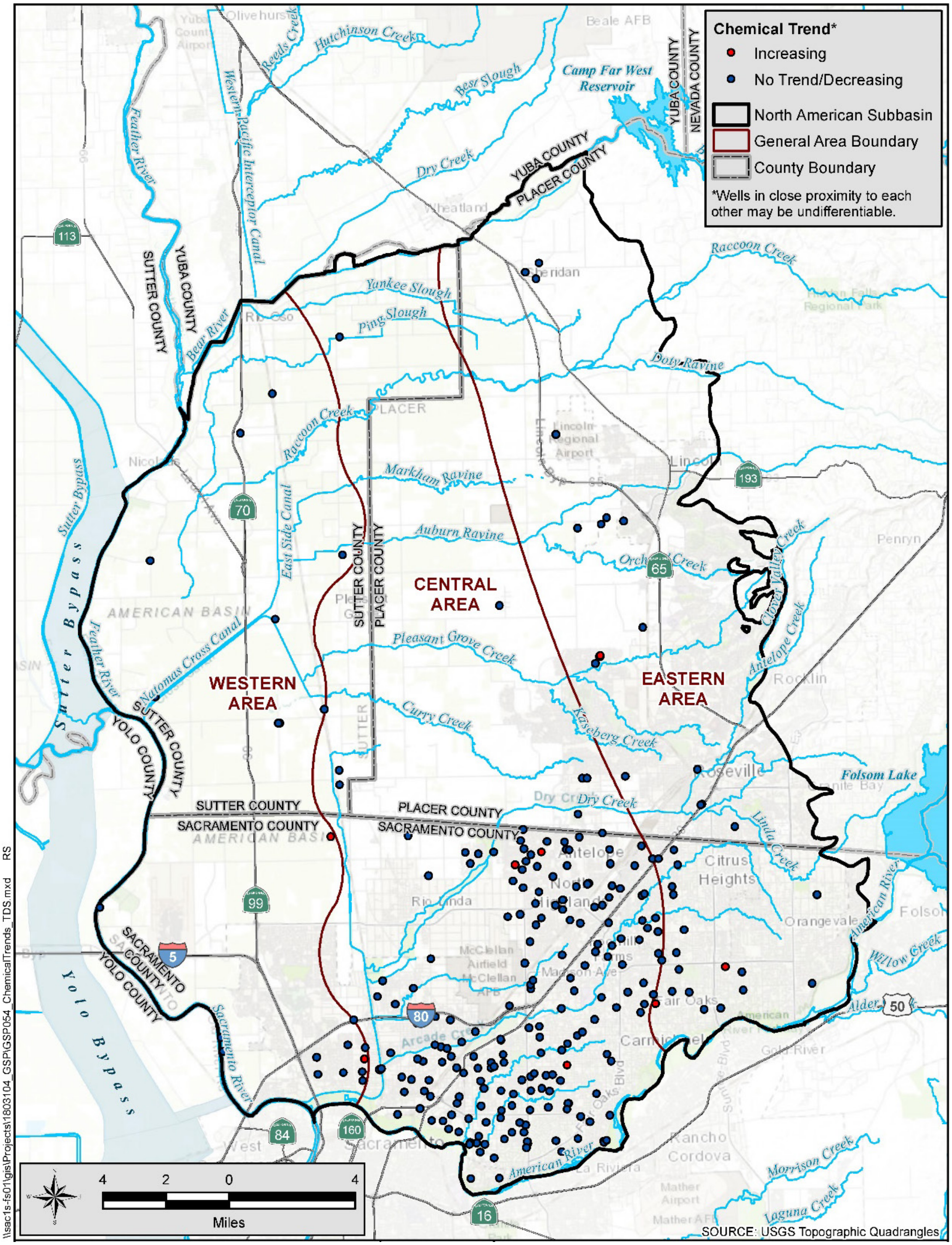
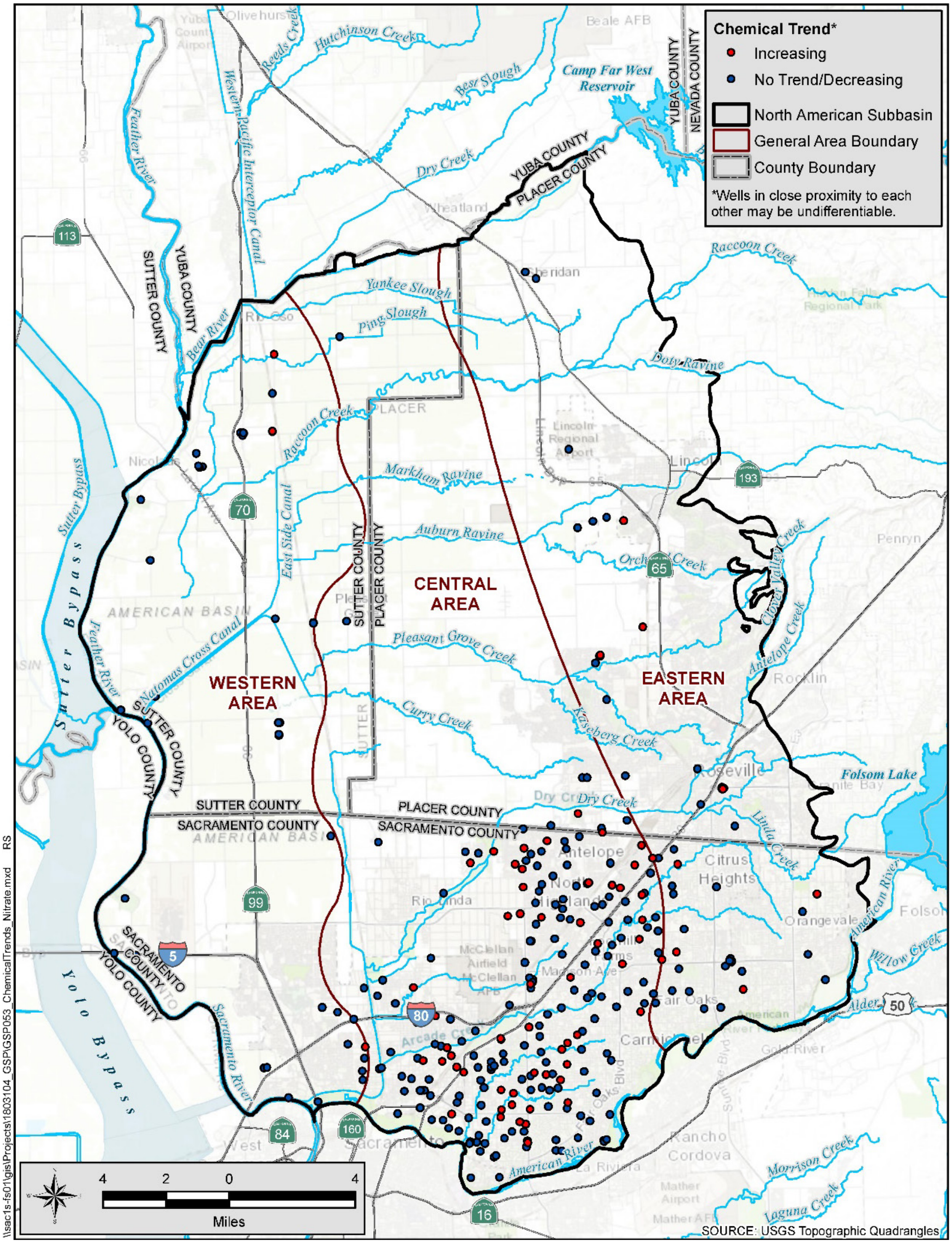


Figure 5-17. TDS Trends



\\sac1s-fs01\gis\Projects\1803104_GSP\GSP053_ChemicalTrends_Nitrate.mxd RS

Figure 5-18. Nitrate as Nitrogen Trends

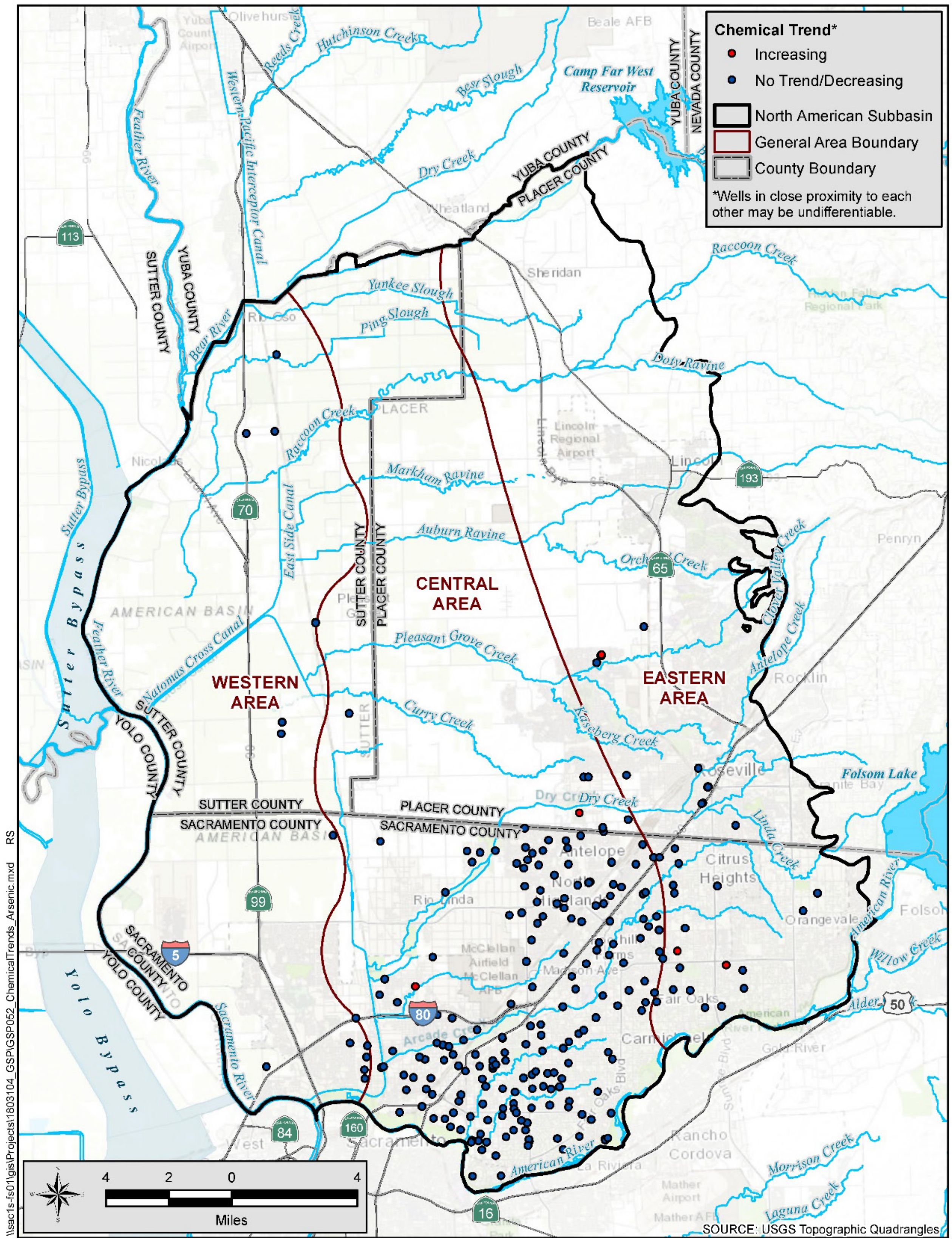


Figure 5-19. Arsenic Trends

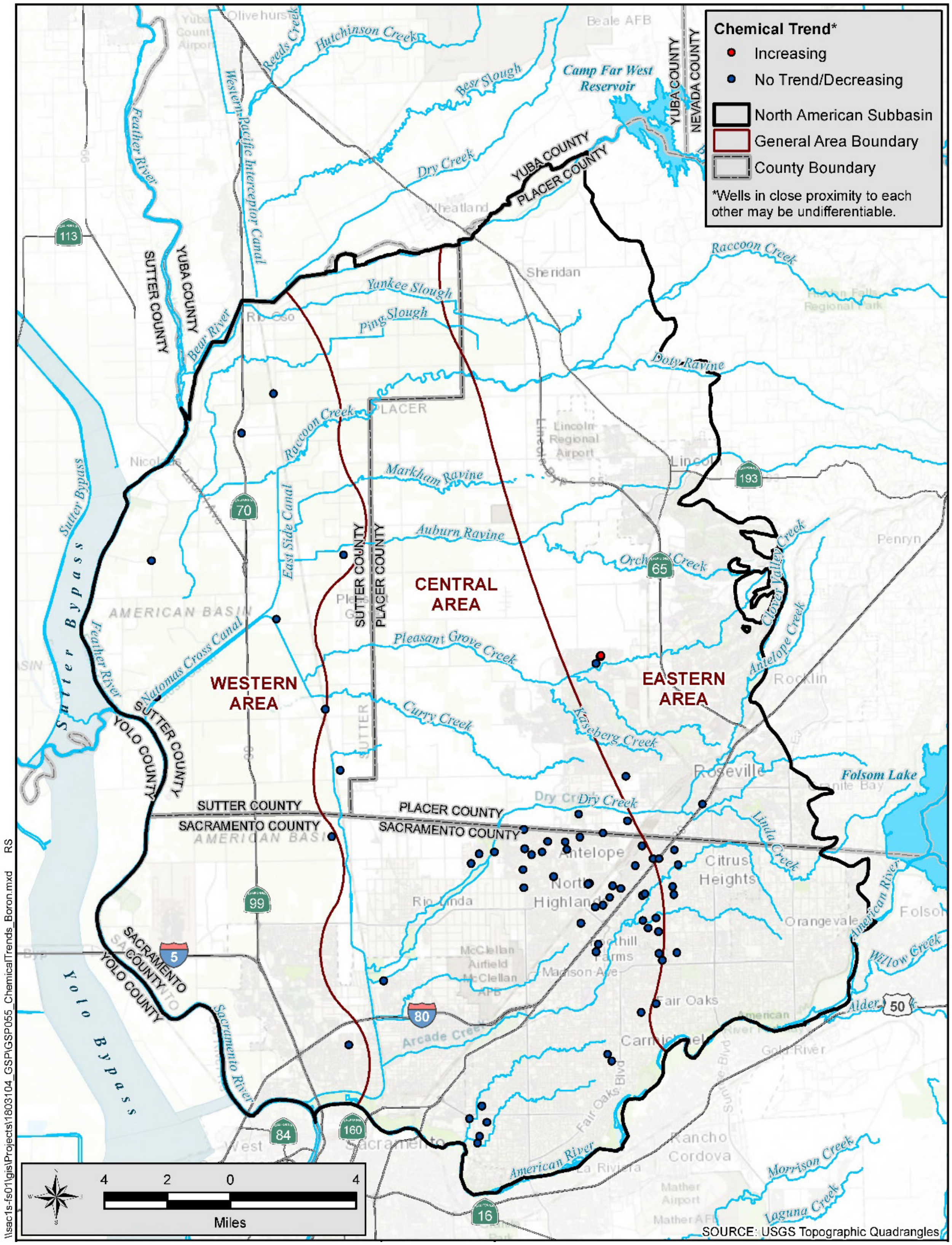
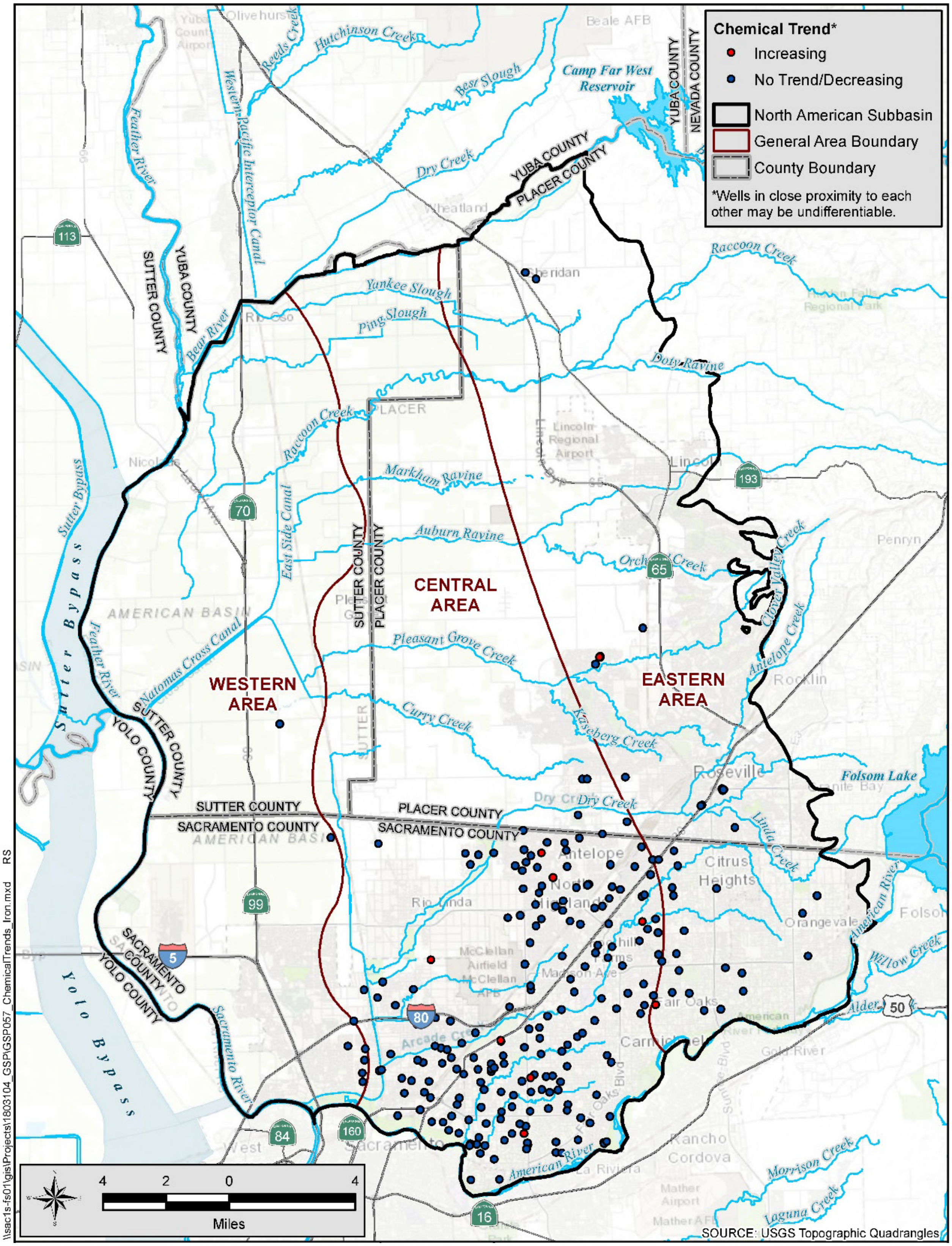
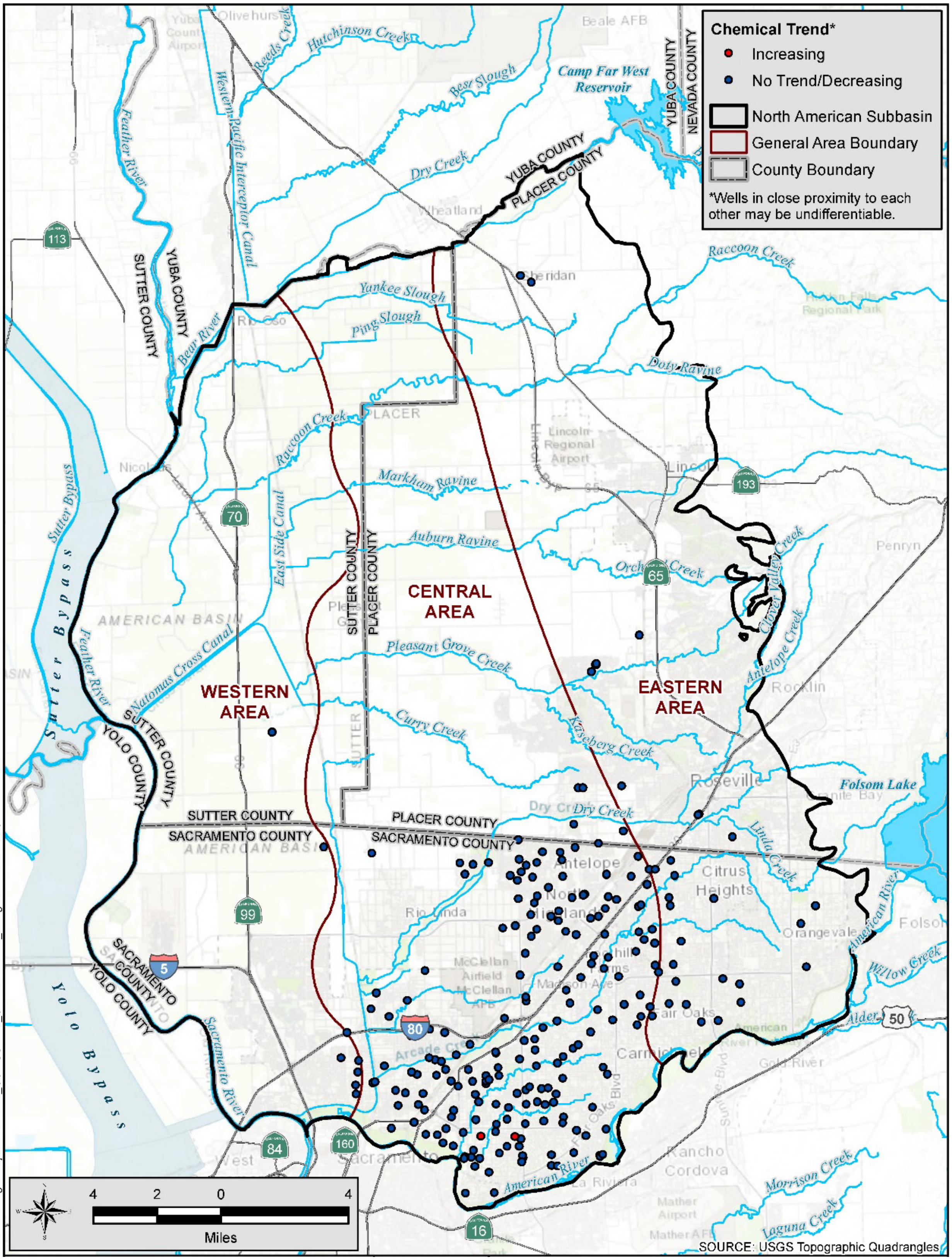


Figure 5-20. Boron Trends



\\sac1s-fs01\gis\Projects\1803104_GSP\GSP057_ChemicalTrends_Iron.mxd RS

Figure 5-21. Iron Trends



\\sac1s-fs01\gis\Projects\1803104_GSP\GSP058_ChemicalTrends_Manganese.mxd RS

Figure 5-22. Manganese Trend

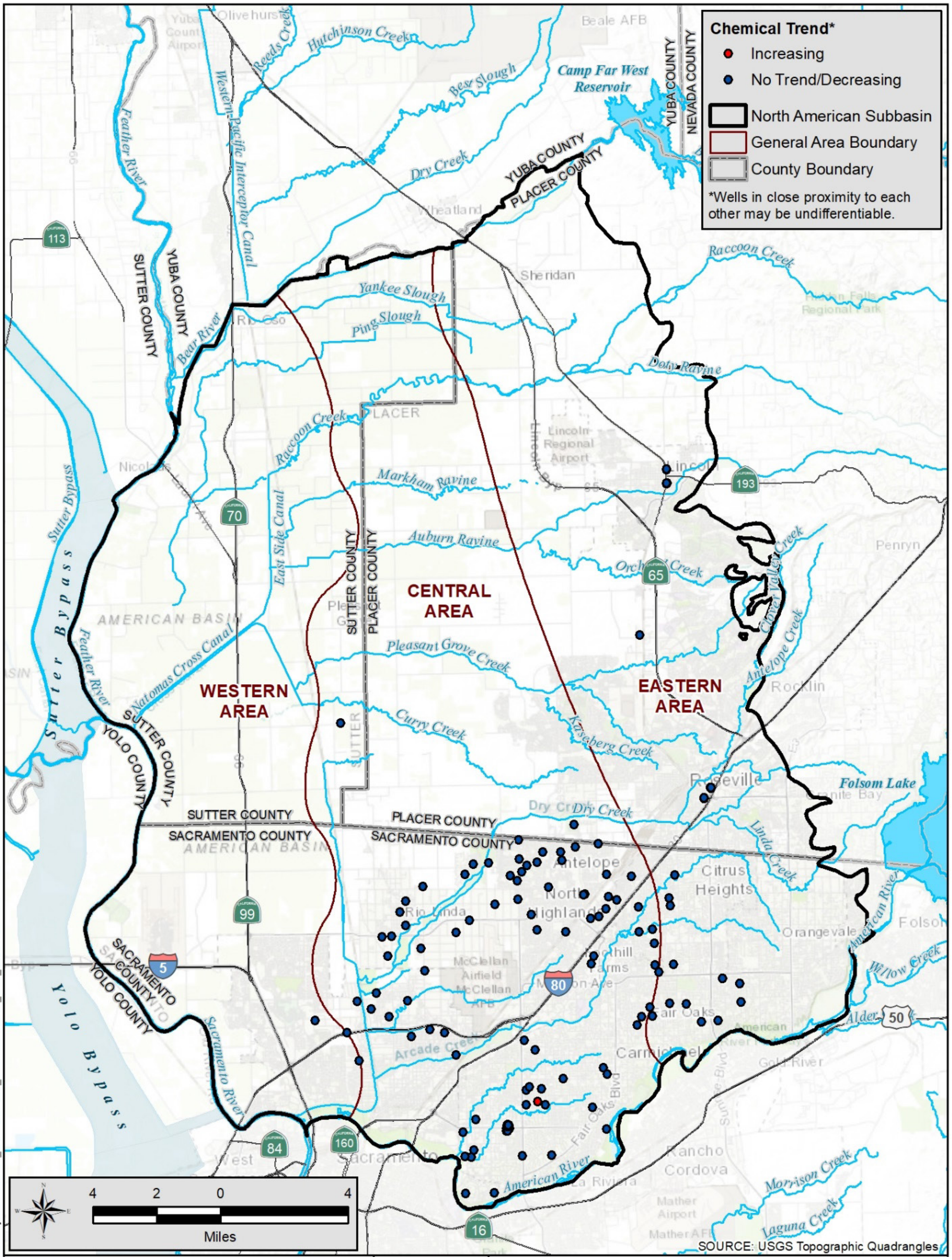


Figure 5-23. Hexavalent Chromium Trend

Z:\Projects\1803104_GSP\GSP056_ChemicalTrends_CR6_20201103.mxd RS

5.8.3 Groundwater Contamination Sites and Plumes

In the NASb, there are a few large and known groundwater contamination sites that could affect supply and beneficial uses of groundwater in the Subbasin. The most significant of these sites are the former McClellan AFB and the Aerojet Superfund Site (adjacent to the NASb to the south). **Figure 5-24** shows the extent of the plumes at these sites. Cleanup activities, as overseen by the U.S. Environmental Protection Agency, SWRCB, and the California Department of Toxic Substances Control, have been in progress for multiple years and contaminants appear to be contained. As described in the SGMA, the GSAs are required to manage the groundwater basin to avoid significant and unreasonable degradation of water quality. However, GSA's authorities under SGMA do not limit or supersede the authorities of the State Water Resources Control Board (SWRCB), the Regional Water Quality Control Boards to order investigations or remediation activities.

At the former McClellan AFB, one of the cleanup methods in use is air-sparging, which injects air up to depths of 106 feet bgs and requires groundwater levels to remain below this depth for the clean-up to be effective. The former McClellan AFB is within the Central area of the NASb and is part of the reason the pumping depression remains in this area. Their groundwater cleanup program is well established; mandated by Comprehensive Environmental Response, Compensation, and Liability Act and is not discretionary; and their pumping is relatively small, on the order of 2,000 acre-feet per year and will likely remain the same for years if not decades.

Although the Aerojet site is in the South American Subbasin, a contaminant plume (including perchlorate, trichloroethene or TCE, tetrachloroethene or PCE, and N-Nitrosodimethylamine or NDMA) extends north from Aerojet, under the American River, and into the NASb into the communities of Carmichael and Fair Oaks. The plumes are being remediated by Aerojet by pumping and treating the water to remove the contaminants.

There are other localized areas of groundwater contamination in the Subbasin that are generally smaller in size and the extent of contamination is typically localized near the properties and is being remediated (*refer to* **Figure 5-24)**.

PCE contamination is present near Interstate 80 and the Sacramento and Placer counties boundaries (Roseville, Citrus Heights, and Lincoln Oaks areas), but the source(s) has not been defined. A study by the SGA defined the extent of the plume. Currently, there are no active cleanup activities.

The Union Pacific Railroad site is located near Roseville Road and Vernon Street in Roseville. The primary constituents of concern are total petroleum hydrocarbons (including diesel, oil, and gasoline), volatile organic compounds (TCE, PCE, and others), semi-volatile organic compounds, dissolved arsenic, nickel and lead. Groundwater contamination assessment and remediation is in progress.

Remedial activities are occurring at two landfills in West Placer County along with cleanup activities of nitrate and perchlorate at the Alpha Explosives facility.

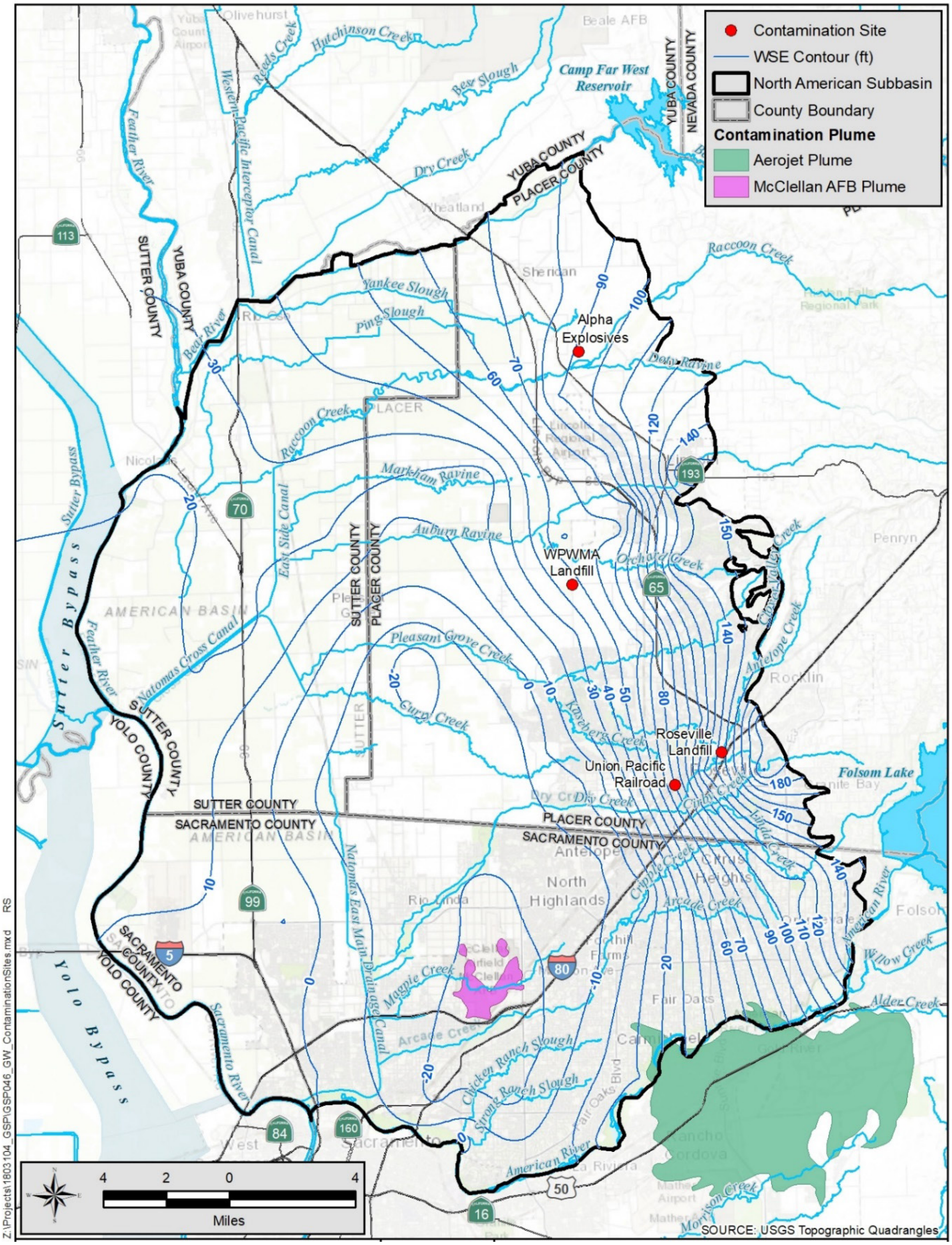


Figure 5-24. Groundwater Contamination Sites and Plumes

The presence of groundwater contamination plumes associated with defense-related and other industrial activities has been an issue of particular interest to the SGA. This contamination is known to limit local water purveyors' access to groundwater in a significant portion of the basin due to an exclusion zone for wells enforced by Sacramento County around the former McClellan Air Force Base. The SGA concern has been that if groundwater contamination is not managed properly, the region could potentially increase its reliance on surface water. This could in turn threaten the region's ability to implement the Water Forum Agreement.

In February 2004, SGA learned that NDMA associated with a contaminant plume from the Aerojet facility near Rancho Cordova had been detected in a monitoring well within Carmichael Water District north of the American River within the SGA area (see **Figure 5-24**). In response, SGA joined forces with the Sacramento Water Forum to establish what is now known as the Regional Contamination Issues Committee (RCIC) in June 2004. The RCIC is a forum for water purveyors, regulators and responsible parties to raise issues and discuss solutions for dealing with groundwater contamination issues that impact the region. The group has met continually since that time. Standing meetings are scheduled on a quarterly basis. State agencies represented include the Central Valley Regional Water Quality Control Board, the Department of Toxic Substances Control, and the SWRCB Division of Drinking Water. The federal government has been represented by the United States Environmental Protection Agency. The group has been very successful at collaborating on solutions that have kept these plumes from mobilizing, while progress on remediation has been made. There is active consultation and evaluation process established to understand the potential effects of new proposed municipal production as it relates to wells to ensure prevention of plume mobilization. Continued monitoring around the perimeter of the plumes shows that concentrations of contaminants are not increasing.

In 2011, an analysis of the capture effectiveness of the McClellan and Aerojet contamination was completed for the SGA (RMC, 2011). The study evaluated expanded conjunctive use operations by municipal water suppliers in the SGA area. Based on the analysis results, SGA concluded that the facilities each had effective capture of contaminants within the SGA area.

Finally, it is worth noting that Per- and poly-fluoroalkyl substances (PFAS) are a groundwater contaminant of emerging concern nationwide. Preliminary testing is being conducted under order of the State Water Resources Control Board to assess the extent of PFAS in groundwater. The NASb GSAs will closely monitor as results become available and consider appropriate actions to the extent that contamination could cause water quality concerns related to future use or management actions resulting from this GSP.

5.9 Seawater Intrusion

The NASb is more than 80 miles inland from the Pacific Ocean. However, tidal action and Delta outflow work to create a long and gradual salinity gradient from the ocean up the Sacramento River. Before Shasta Dam was constructed in 1943, seawater (defined as chloride concentration greater than 1,000 mg/L or about 5% seawater) had intruded up-river beyond Courtland (DWR, 1995), about 20 miles from the NASb. Since 1943, seawater intrusion into the river has remained below Isleton, about 40 miles from the NASb. Therefore, seawater intrusion is unlikely to occur in the vicinity of or in the Subbasin.

5.10 Land Subsidence

Substantial land subsidence could interfere with storm water drainage, canal delivery systems and transportation infrastructure. Subsidence monitoring in the NASb consists of one extensometer, two continuous positioning ground stations (CGPS) stations and benchmark surveys. The amount of subsidence is small with the maximum displacement, in a very small portion of the Subbasin, within the last 20 years being -0.25 foot or an average of -0.05 feet per year. **Figures 5-25 through 5-29** present the different surveys and stations results.

Historically, benchmark surveys showed about 0.3 feet of subsidence most likely due to groundwater levels declining by about 30 feet from the 1950s through 1970s or about 0.01 foot of land subsidence per foot of groundwater level decline (MWH, 2002); **Figure 5-25** shows this correlation. The location of the well that was used for this correlation is shown on **Figure 5-29**.

In 1994, DWR constructed the Sutter extensometer (SUT-Ext) and a nested monitoring well (SUT-P) in the Western area of the Subbasin, their locations are shown on **Figure 5-29**. **Figure 5-27** shows the changes in ground surface as they relate to the maximum change in groundwater levels at this location. Since 1994, the groundwater levels have remained stable, with Fall lows only changing by about 20 feet between 1994 and 2019, a 26-year period. The ground surface shows elastic response and potentially some inelastic subsidence of up to 0.04 foot (about one-half inch) or an average rate of -0.002 feet per year. The inelastic response during this time period is less than that predicted from earlier benchmark survey data.

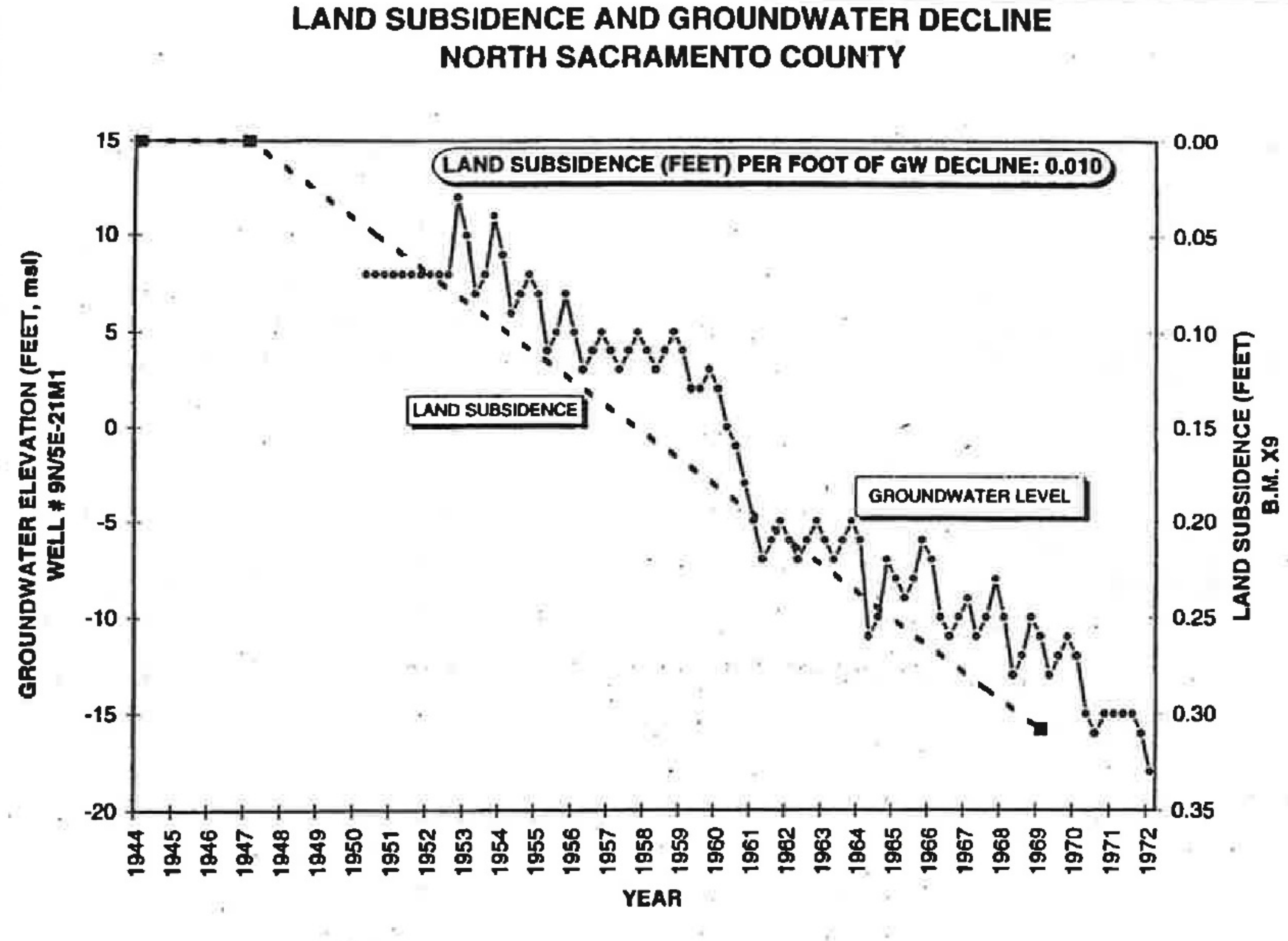
The Subbasin also has two CGPS stations (LCN1 and LCN2) but both stations appear to be at the same location. They are located about the center of the Subbasin in Placer County. **Figure 5-29** show their locations as a single point. **Figures 5-27 and 5-28** show the changes in ground surface as they relate to the maximum change in groundwater levels at this location. Vertical displacements range from -0.01 to -0.025 feet depending upon the evaluation period, from the last 1 to 10 years. The total displacement for the period of record (Oct 2004 through September 2019) was -0.026 feet or an average of -0.002 feet per year. The rate of vertical displacement ranges from -0.001 to -0.005 feet per year depending upon the evaluation period, from the last 1 to 10 years.

DWR performed a regional subsidence assessment by surveying benchmarks in the Sacramento Valley in 2008 and then again in 2017. **Figure 5-29** shows subsidence throughout the Subbasin over this 10-year period (DWR, 2018). The least amount of change has occurred in the Eastern area of the Subbasin with the greatest changes, -0.177 foot or 2 inches, in the south-Central and Western areas of the Subbasin. With any type of survey, there is some amount of error and uncertainty, which for this survey was approximately 0.17 foot. Therefore, any change less than

0.17 foot is not considered statistically significant (DWR, 2018). This uncertainty helps explain an inconsistency between the data from the DWR benchmark survey data report and the extensometer data, the report indicating 0.134 foot of subsidence whereas the more accurate extensometer only shows about -0.04 foot, so the subsidence in the Western portion may be less.

DWR's SGMA Data Viewer (DWR 2021) provides land subsidence based on satellite-based imagery (InSAR). The estimated error in the InSAR data is 0.1 foot. The interpretation of the results do not indicate whether the subsidence is elastic or inelastic subsidence. The InSAR data (**Figure 5-30**) from January 2015 through October 2020, shows land subsidence ranged from 0 to -0.25 feet with most of the area with less than -0.05 foot and just a small area in the western portion of the Subbasin where the subsidence is greater than -0.15 foot. In the northern portion of the Subbasin there are areas with subsidence up to -0.1 foot. The maximum average rate of displacement would be -0.05 feet per year.

This page left intentionally blank



Note: (1) Land subsidence corresponds to ground elevations measured at bench mark X9. Groundwater levels correspond to well number 9N/5E-21M1.

Figure 5-25. Land Subsidence and Groundwater Level Decline Correlation

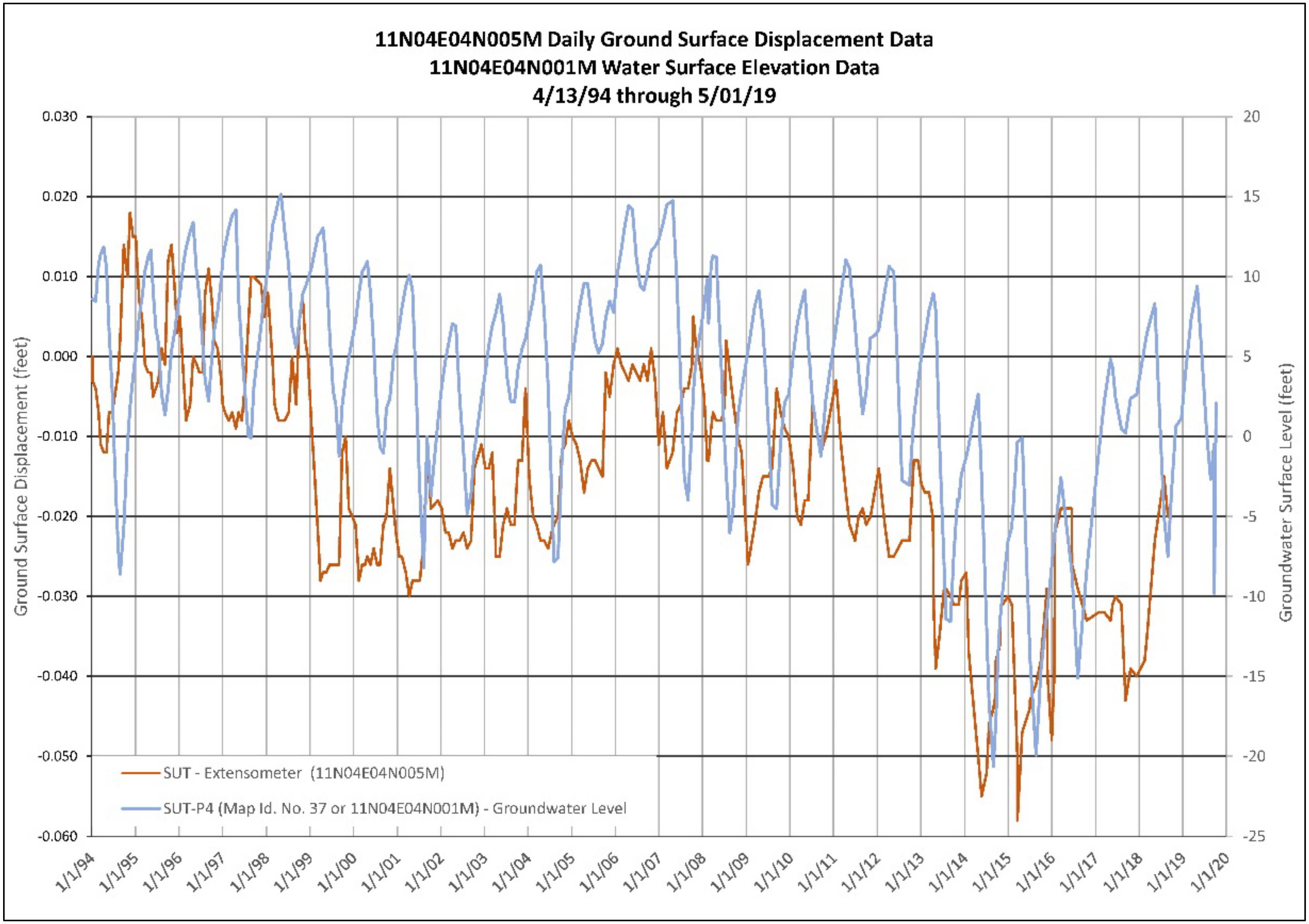


Figure 5-26. Extensometer versus Groundwater Levels

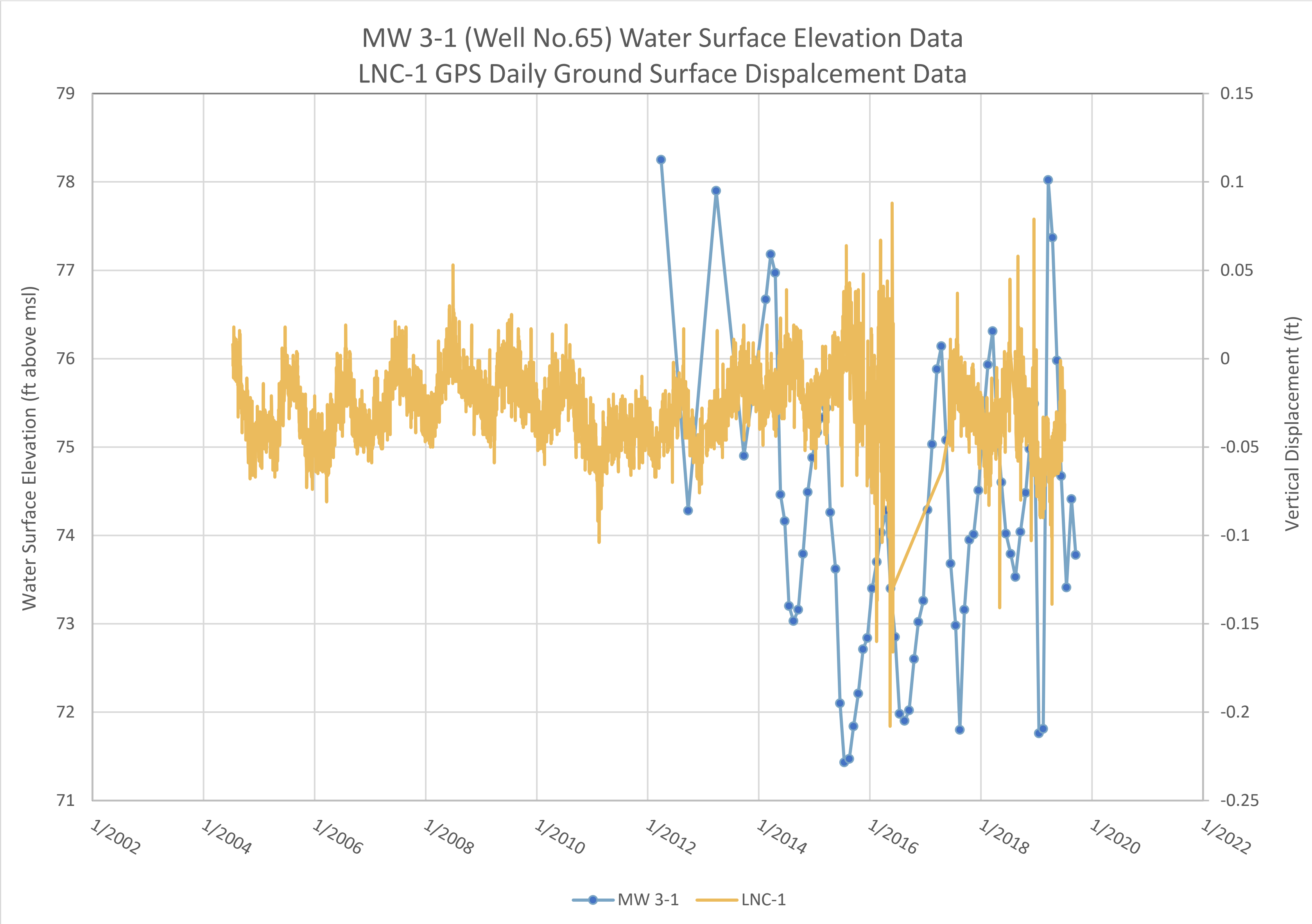


Figure 5-27. CGPS Station LCN1 versus Groundwater Levels

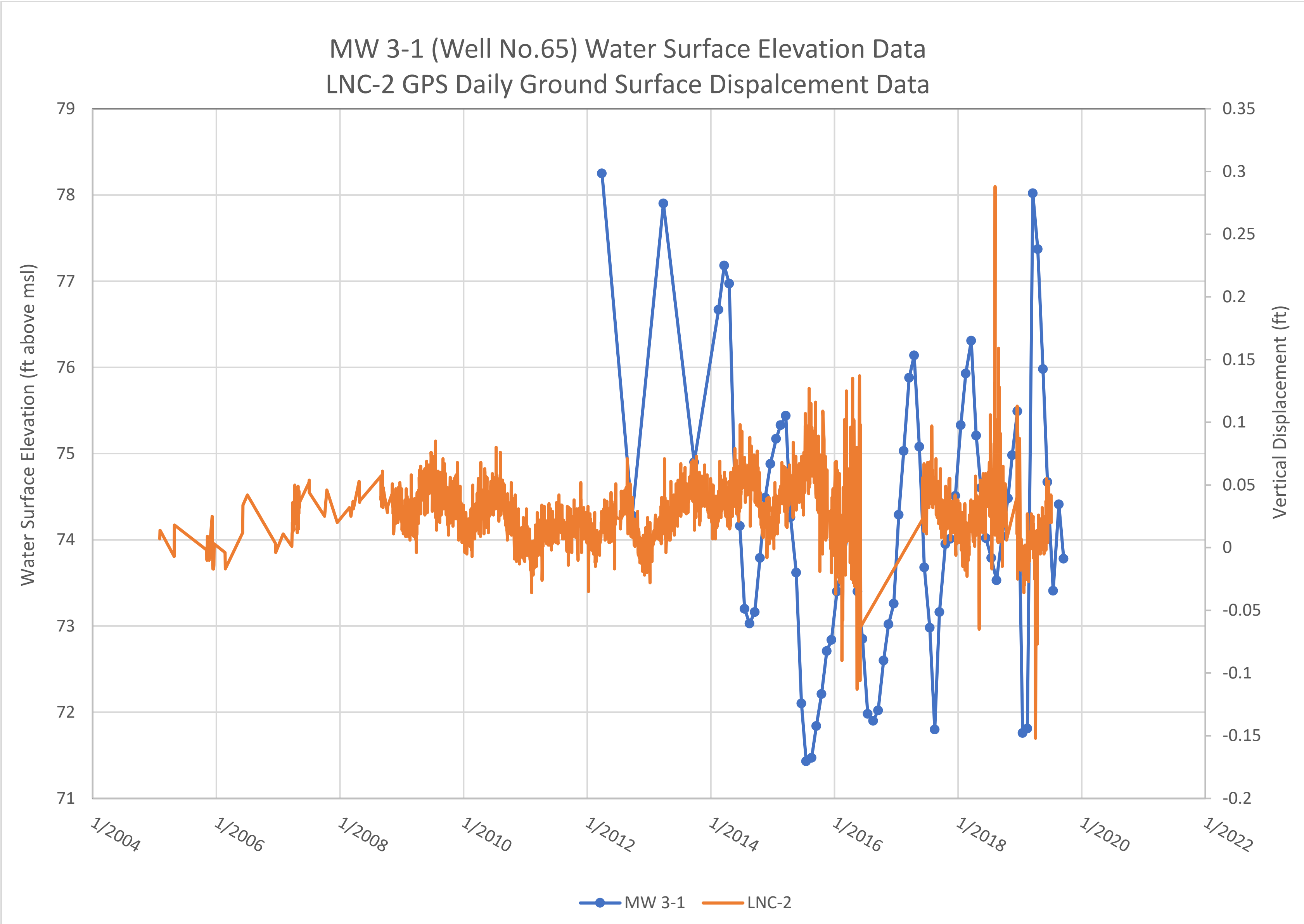


Figure 5-28. CGPS Station LCN2 versus Groundwater Levels

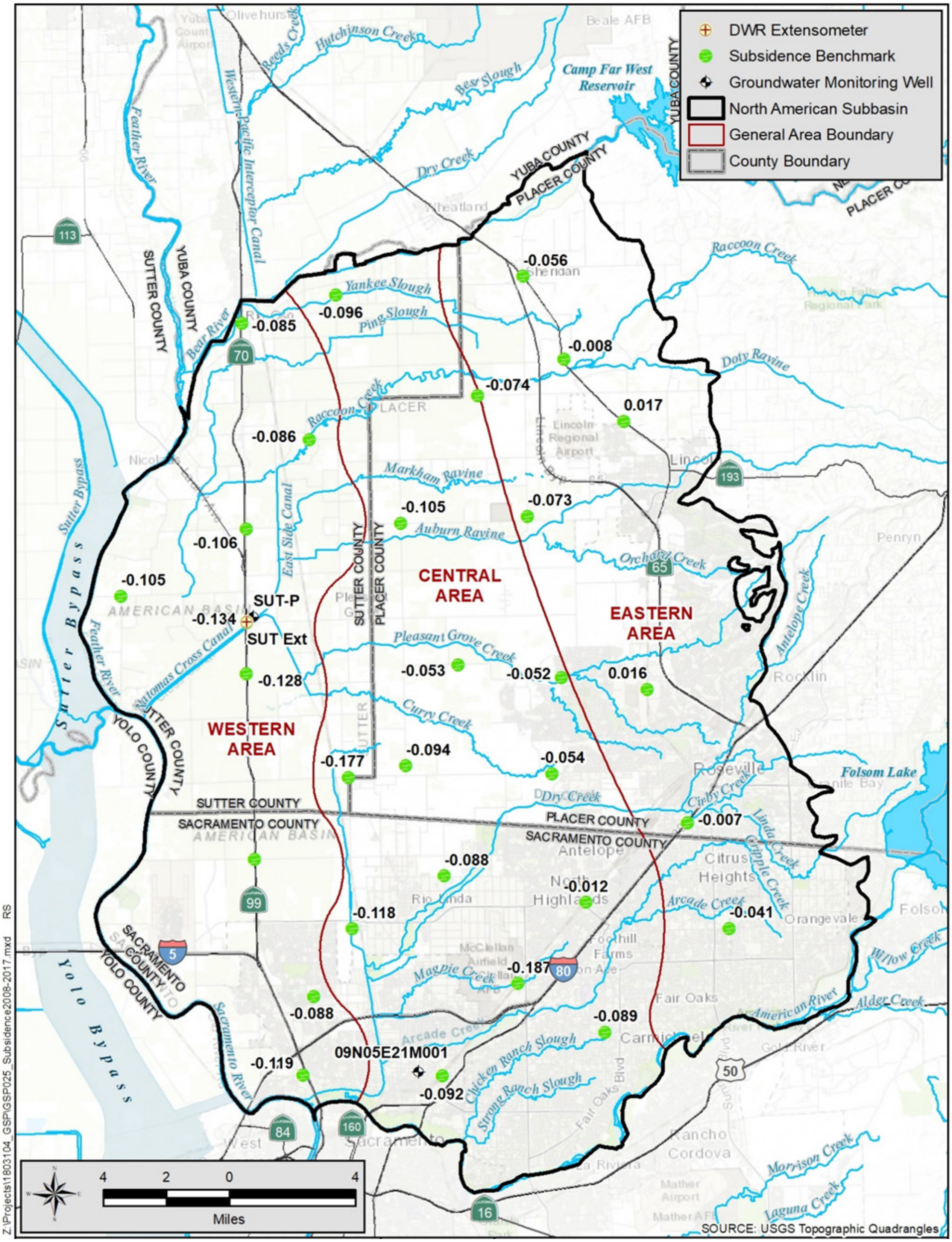


Figure 5-29. Benchmark Differences 2008-2017 (in Feet)

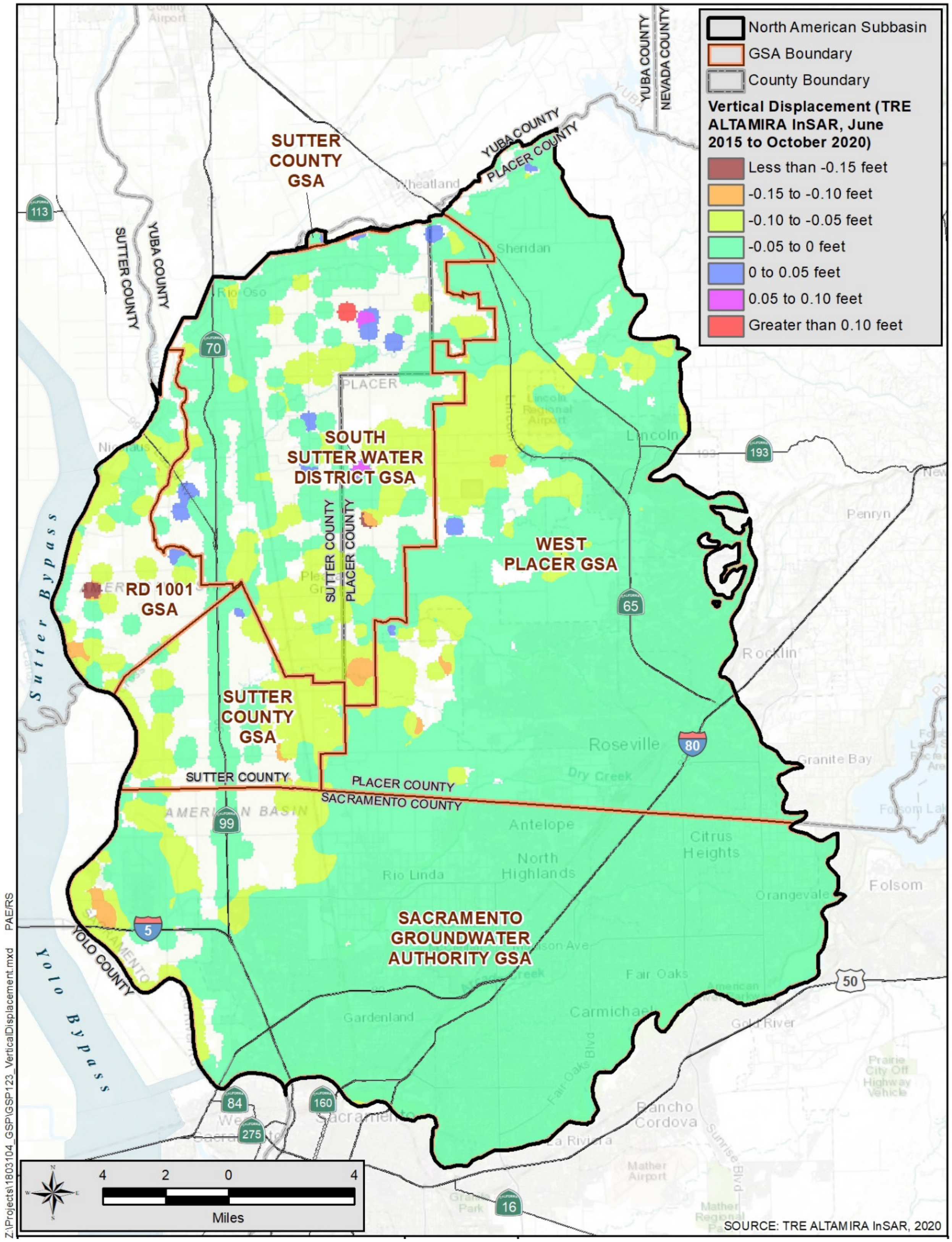


Figure 5-30. InSAR Subsidence 2015-2020 (in Feet)

5.11 Interconnected Surface Water

Interconnected surface water refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (DWR, 2016). In other words, all of the sediment pores in the area are filled with water, from ground surface to the groundwater table. The depth-to-water map provides an initial indication of whether the rivers and creeks are interconnected or disconnected. For purposes of this GSP, the rivers and creeks were assumed to be interconnected when the depth to water is less than 30 feet bgs (*see* **Appendix O** for description of methods used to determine depth to groundwater). In general, surface water and groundwater are considered interconnected along portions of the American, Bear, Feather, and Sacramento rivers.

Understanding interconnected surface water is important, because where this occurs lowering of groundwater levels regionally or by local pumping of groundwater has the potential to deplete surface water (to an extreme case of rivers or creeks going dry) and affect habitat and species dependent on surface water. In the NASb, California Department of Fish and Wildlife RareFind5 database, Central Valley Steelhead and Chinook Salmon are important aquatic species known to use the American, Sacramento, and Feather rivers for either spawning or migration. The species are not noted in the Bear River. Interior to the NASb, Central Valley Steelhead are noted in the Dry Creek system in western Placer County, and in Auburn Ravine in western Placer County. To get into these systems, fish migrate through Steelhead Creek and the Natomas Cross Canal, respectively, from the Sacramento River.

Monitoring wells have been constructed in the Subbasin at various locations along the rivers and creeks to evaluate the interconnectedness of surface water and groundwater based on groundwater levels and in some cases supported by water quality (stable isotopes; *refer to* **Figure 5-1** for monitoring well locations). Monitoring wells were also constructed along the Sacramento River to evaluate the levees and the effects of installation of man-made slurry walls. **Appendix N** contains the hydrographs from the wells along with surface water elevations and additional hydrographs from the levee studies.

Two patterns emerge from evaluating the groundwater level hydrographs and water quality parameters – groundwater levels that respond to changes in surface water (interconnected) and those that do not (disconnected). For example, at monitoring wells 94 and 95 (RDMW-103 and -104), groundwater levels do not respond to changes in water levels in the Bear River, and stable isotopes indicate the groundwater is from local origin and not from higher elevations in the watershed that flow through the river. The conclusion is that the river is not interconnected with groundwater at this location. Conversely, along the Feather River, at RDMW-101, the groundwater levels track similarly to water levels in the river and the stable isotopes show the influence of surface water in the groundwater (GEI, 2020).

With this documented relationship, groundwater levels in the monitoring wells adjacent to the rivers and creeks were evaluated for interconnectedness. **Figure 5-31** shows the locations where the hydrographs show the rivers and creeks are interconnected.

- In the Western area, groundwater is connected with the Sacramento and Feather rivers. Even within short distances this condition may change, as shown along the Sacramento River in studies performed for SAFCA (*see* Kleinfelder report in **Appendix N**).
- In the Central area, as described in **Section 5.2.2**, most groundwater levels are over 100 feet bgs and there is no continuous saturated zone as proven along lower Dry Creek at WPMW-5A (monitoring well number 41) where the shallow monitoring well constructed into the first sand and gravel layer is dry (the well has a screen interval from 80 to 100 feet bgs). The newly constructed WMPW-11A (monitoring well number 91), which is adjacent to Markham Ravine, also encountered groundwater during hand-auguring at about 4 feet bgs while the depth to groundwater at this location is over 70 feet bgs indicating a continuous saturated interval is not present (disconnected from the underlying aquifer). Along portions of the American and Bear rivers, the groundwater is interconnected with the rivers.
- In the Eastern area, there is interconnection along upper portions of Dry Creek and its tributaries, potentially along Auburn Ravine as it enters the Subbasin and Raccoon Creek west of Highway 65 as indicated by shallow depths to water. Studies along the upper reaches of Raccoon Creek, generally east of Highway 65, show the area is underlain by the Ione Formation and, due to its low permeability, would tend to perch water. Therefore, the surface water is not connected to the principal aquifer. East of Highway 65, near Raccoon Creek, groundwater levels decrease rapidly so the creek is not interconnected with groundwater. Groundwater levels are generally interconnected along the American River, with the exception of a segment that is disconnected near Rancho Cordova. Groundwater levels are generally interconnected along the Bear River, with the exception of a segment near well RDMW-103.

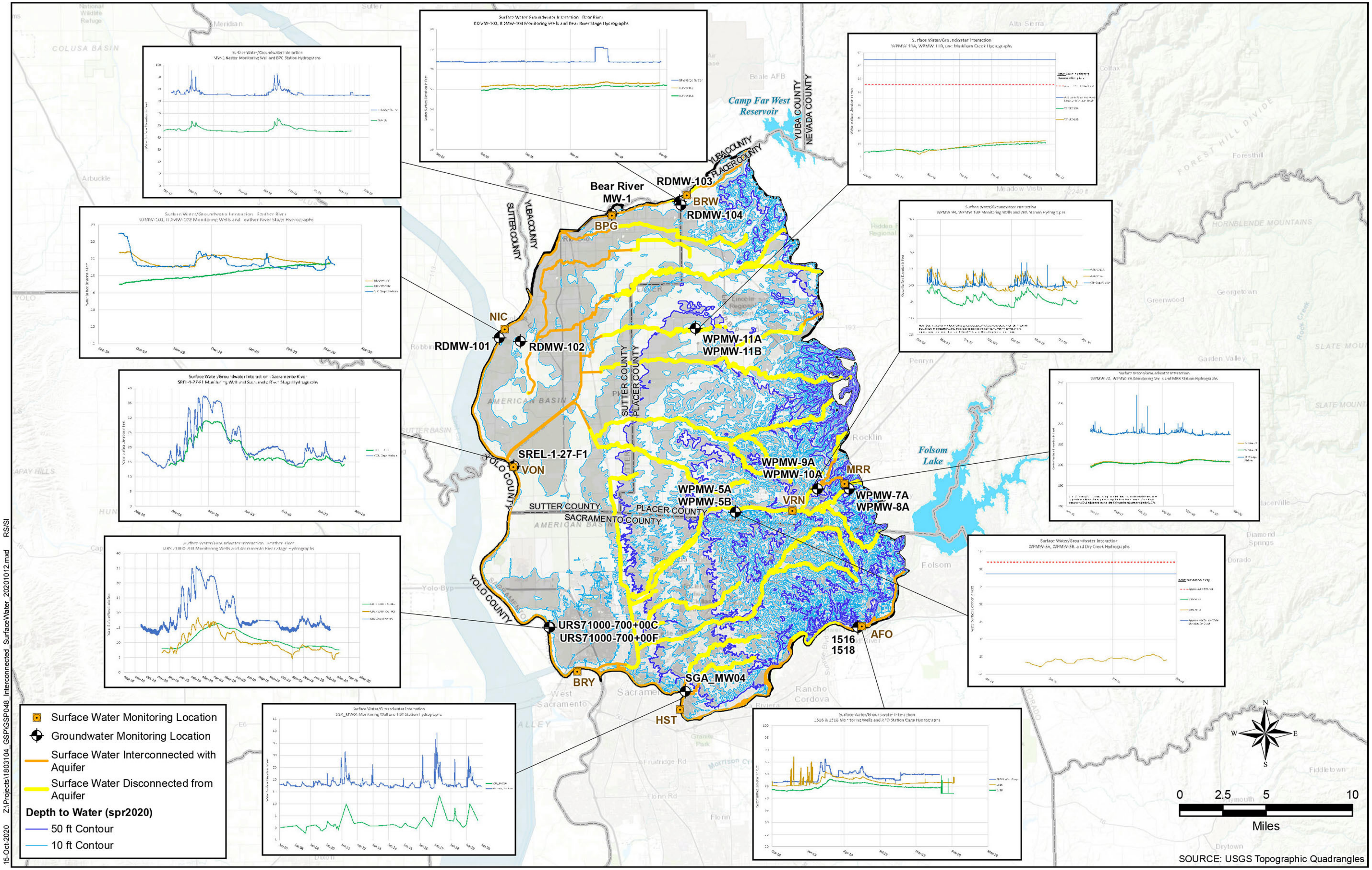


Figure 5-31. Interconnected Surface Water

This page intentionally left blank

5.12 Groundwater-Dependent Ecosystems

The Natural Communities Commonly Associated with Groundwater dataset (NCCAG, 2018) was used to provide the locations of potential GDEs. Likely GDEs were developed by plotting the depth to groundwater developed from shallow monitoring wells, those with screen intervals between 20 and 300 feet bgs along with ground surface elevations from the National Elevation Dataset and elevations of the bottom of the rivers and slough channels. Water surface elevations were then subtracted from ground surface elevations to obtain the depth to water throughout the Subbasin. Areas where groundwater levels are less than 30 feet bgs are areas where likely GDEs are present. All of the potential GDEs were then evaluated for the types of vegetation or species present to further refine whether the potential GDEs are likely, less likely or not likely to be present. **Figure 5-32** shows the results of this classification efforts. The likely and less likely GDE areas were then evaluated further based on whether critical species, diverse vegetation or a combination of both were present to prioritize those areas. **Figure 5-33** shows the results of this ranking. **Appendix O** contains a detailed description of the approach used.

The 30-foot bgs interval was used to identify GDEs, because it is associated with the overwhelming majority of GDE plant species' maximum rooting depths, and thus would most likely contain groundwater-supported priority habitat. While some Valley Oak (Quercus lobata) has been noted at rooting depths of up to 80 feet, the optimal depth is more in the vicinity of 33 feet (Howard, 1992). To better assess whether using 30 feet bgs would represent a meaningful difference in terms of identifying or protecting GDEs, a map of the occurrence of Valley Oak from the NCCAG dataset was prepared using depth intervals of less than 30 feet bgs, from 30 to 80 feet bgs, and greater than 80 feet bgs. The resulting map is shown on **Figure 5-34**. In the NASb, there are 4,335 acres identified as having Valley Oak. Of those, about 37 percent (1,618 acres) are at depths of less than 30 feet and about 44 percent (1,925 acres) are at depths between 30 and 80 feet bgs. Additionally, 18 percent (792) of Valley Oak are noted in the same channels where depth to groundwater is greater than 80 feet bgs, which would not be supported by groundwater.

For the areas that are between 30 and 80 feet bgs (shown in orange on **Figure 5-34),** note that almost all Valley Oak is located along creeks, ravines, and rivers. Auburn Ravine, Pleasant Grove Creek, and Dry Creek all receive year-round flows from wastewater treatment plants (see **Figure 3-12**) and other urban runoff, Arcade Creek has year-round flow associated with urban runoff based on records from the Sacramento County stormwater monitoring program, and the American River has year-round flow as managed by the Bureau of Reclamation. Based on this occurrence data, the NASb GSAs believe that the Valley Oak occurring at greater than 30 feet bgs is maintained by surface water flow and is not groundwater supported.

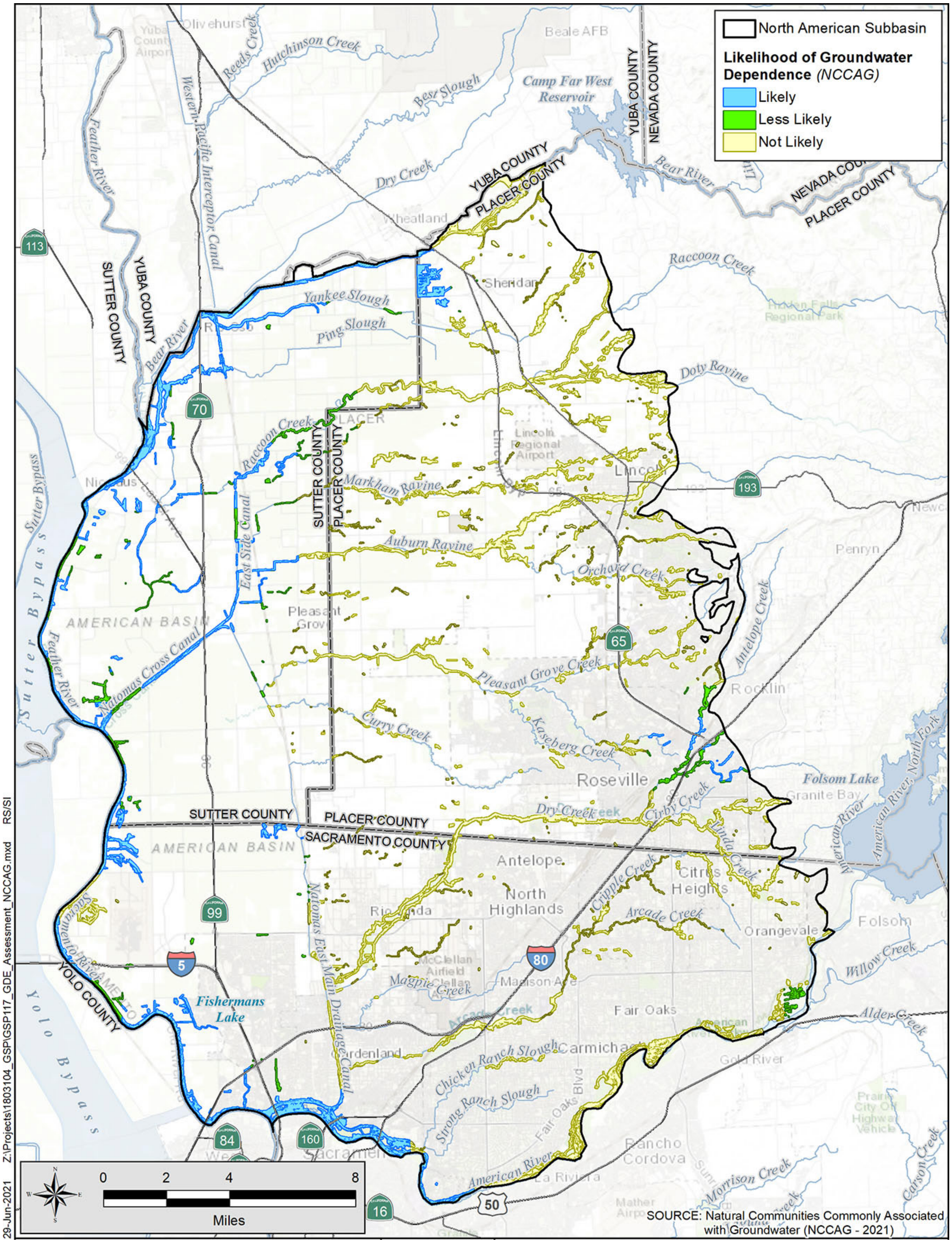


Figure 5-32. Likely Groundwater Dependent Ecosystems

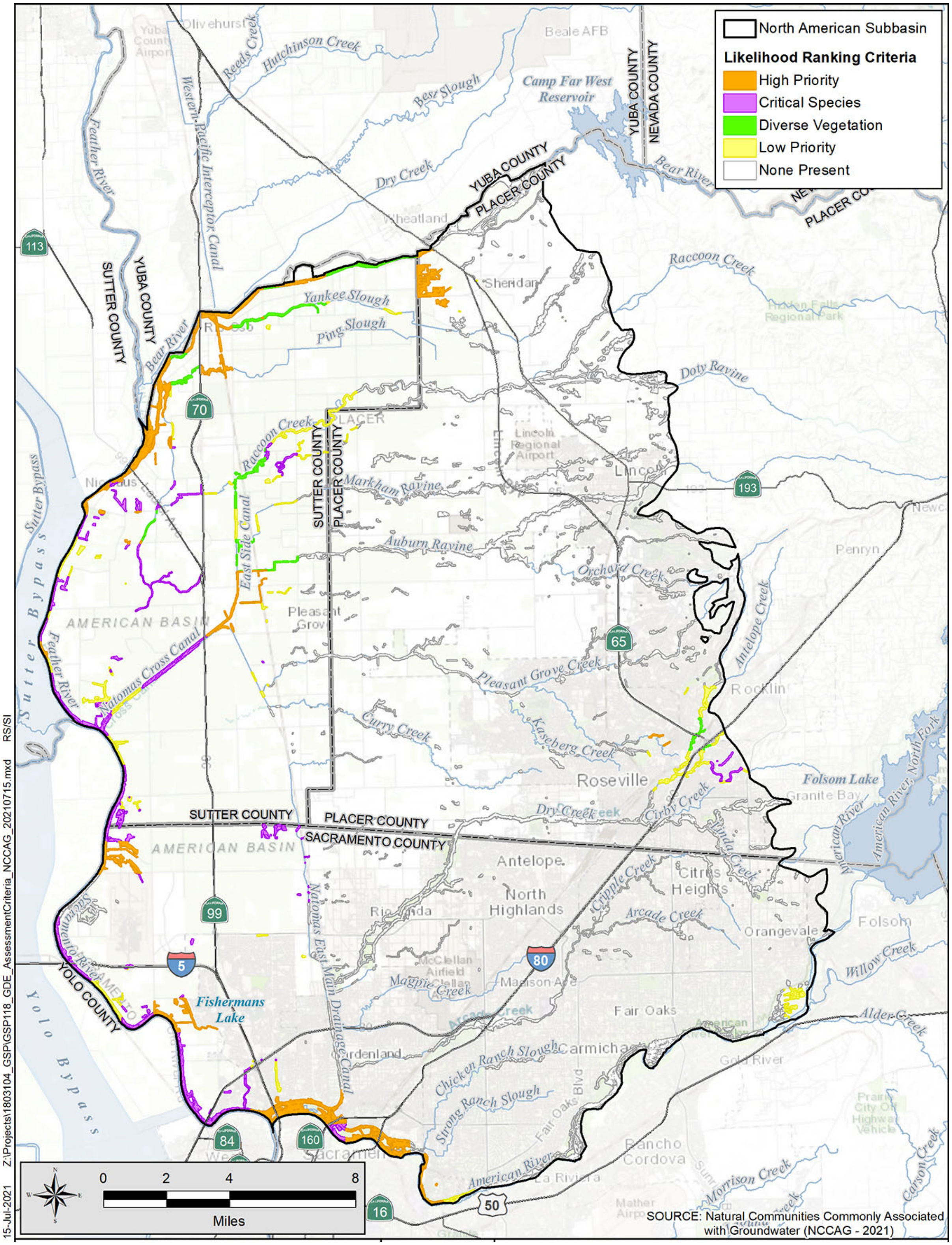


Figure 5-33. Rankings of Likely and Less Likely GDE Areas

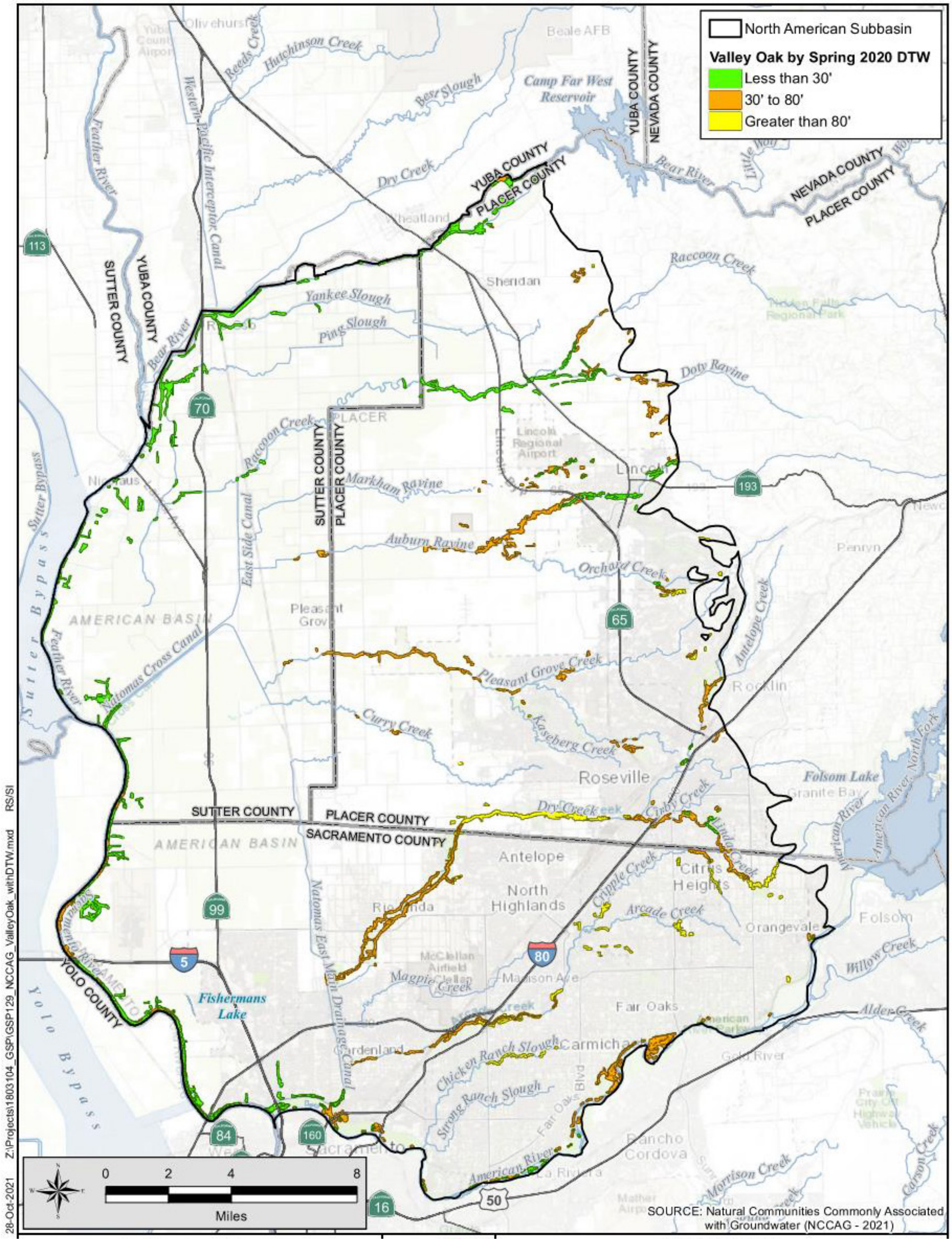


Figure 5-34. Occurrence of Quercus Lobata (Valley Oak)

5.13 Data Gaps

The groundwater conditions in the NASb have been investigated and documented since at least 1912 through present. Most of the recent improvements to data gathering were the construction of new monitoring wells to replace voluntary wells to improve the quality of groundwater level data. At this time, there are no data gaps in the understanding of groundwater conditions that would affect the ability to sustainably manage the Subbasin.

Information that would improve the overall knowledge of groundwater conditions in the Subbasin are:

- **Water Quality** – continued water quality sampling should provide enough water quality data to further assess water quality trends in the northern portions of the Subbasin.
- **Aquifers Assessment** – groundwater levels in the aquifers are stable as shown by the hydrographs but warrant further assessment in the Western area because groundwater levels in deeper nested monitoring wells in the Mehrten Formation are up to 23 feet deeper than groundwater levels in the Laguna Formation as seen in most monitoring wells in the Central and Eastern areas. Further evaluation could include the following:
    - groundwater pumping in adjacent Subbasins in the deeper aquifers
    - relation of the Willows Fault to the affected aquifers
    - use of new geophysical tools to map the extent of aquifers (statewide program proposed by DWR)
- **Interconnected Surface Water –** confirmation of areas likely to be interconnected.

This page left intentionally blank

6. Water Budgets

6.1 Water Budget Information

Water budgets were developed to provide a quantitative account of water entering and leaving the NASb. 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. As in the California Department of Water Resources' (DWR's) Water Budget BMP (DWR 2016c), water budgets are presented separately for the land surface system, stream and canal system, and groundwater system. The different frame of reference for each of these systems provides insight into how the overall system behaves, which is critical for successful management. **Figure 6-1** highlights the interconnectivity of stream, surface, and groundwater components of the natural and human related hydrologic system used in this analysis.

The values presented in the water budget provide information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate conditions, such as 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, aiding in understanding how water flows beneath the surface. Global climate models simulate water budgets that incorporate atmospheric water, allowing for simulation of climate change conditions. In this document, consistent with the Regulations (CCR, Title 23), the water budgets investigate the combined land surface, stream, and groundwater systems for the NASb.

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. The water budget analyses are performed on a monthly basis using the CoSANA model and are aggregated to annual budgets. However, for the purposes of this Groundwater Sustainability Plan (GSP), the water budgets are presented on a long-term average annual basis, as well by hydrologic year type.

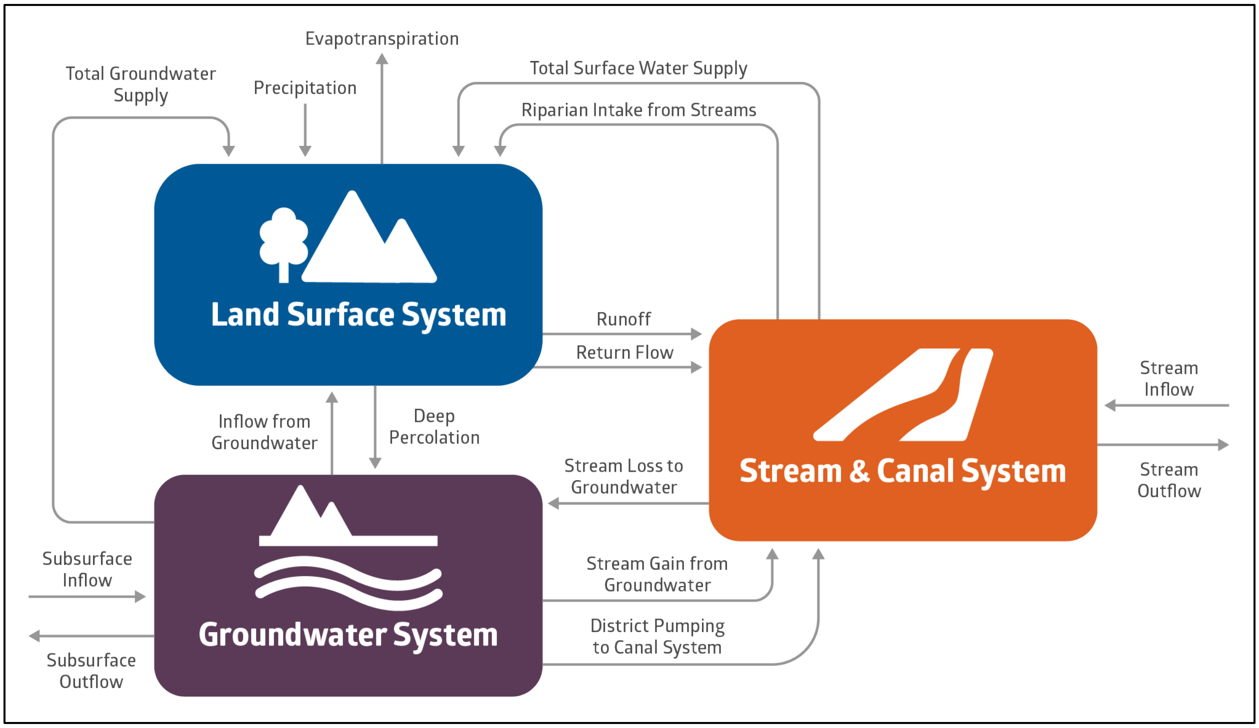


Figure 6-1. Generalized Water Budget Diagram

The Regulations require the annual water budgets to 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 CoSANA model and associated data in water budget development; and on the budget estimates.

6.2 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 incorporate a 50-year hydrologic period in order to reflect long-term average hydrologic conditions. Precipitation data for the Subbasin is derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset of DWR’s California Simulation of Evapotranspiration of Applied Water model. Precipitation for the NASb 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.

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. A chart is used to graphically illustrate the cumulative departure of the spatially averaged rainfall within the Subbasin (**Figure 6-2**). 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 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 based on these data sets and 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 dramatically dry conditions (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.

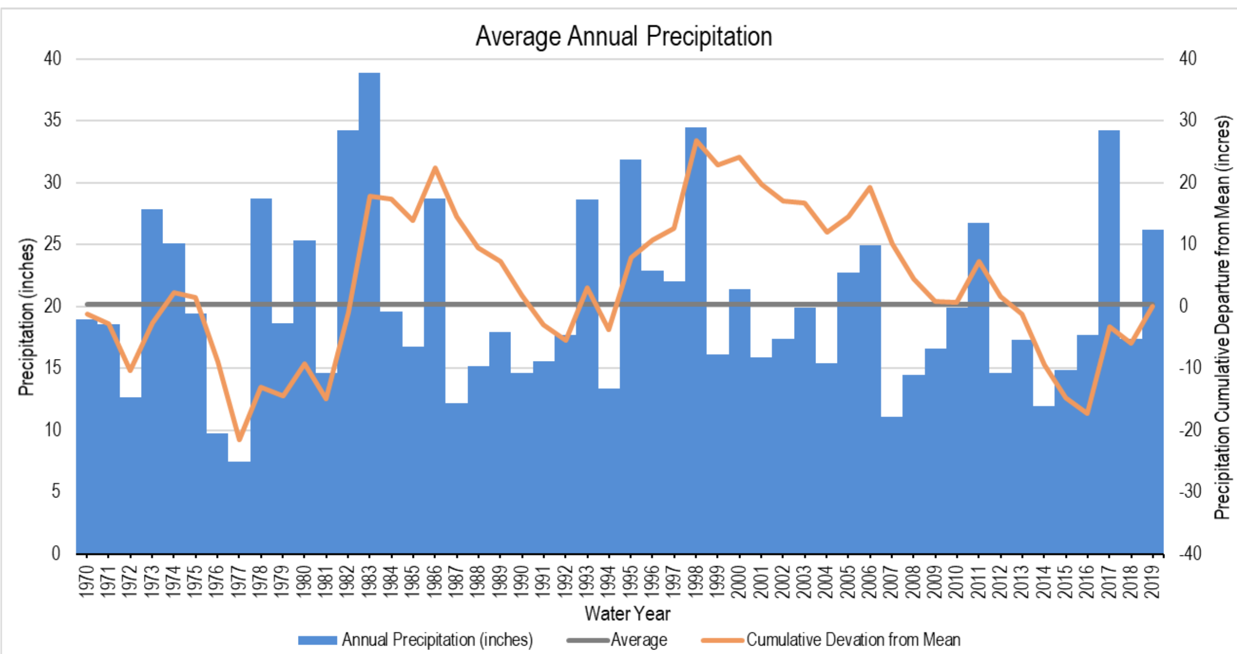


Figure 6-2. 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation in the North American Groundwater Basin

6.3 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 NASb as well as the adjoining South American and Cosumnes Subbasins. CoSANA was developed with the 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 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 GSP development.

Additional information on the data and assumptions used to develop the CoSANA model is included in **Appendix P**.

With the CoSANA model as the underlying framework, model simulations were developed to allow for the estimation of water budgets. Four model simulations were used to develop the water budgets for historical, current, projected and projected with climate change conditions, which are discussed in detail below:

- The **historical water budget** is based on a simulation of historical conditions in the NASb.
- The **current water budget** is based on a simulation of current 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.
- The **projected with climate change water budget** is based on a simulation of future land and water use over hydrologic conditions modified to reflect future climate.

6.4 Water Budget Definitions and Assumptions

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

6.4.1 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 2009 through 2018 was analyzed to provide a period of representative hydrology while capturing recent operations in the Subbasin. The period WY 2009 through 2018 has an average annual precipitation of approximately 19.0 inches, compared to the long-term (1970 - 2019) average of 20.2 inches and includes wet and dry periods as follows, according to the Sacramento Valley Index:

- Critical: 2014, 2015
- Dry: 2009, 2013
- Below normal: 2010, 2012, 2016, 2018
- Above normal: none
- Wet: 2011, 2017

6.4.2 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, 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 conditions described in **Table 6-1**.

Table 6-3. Current Water Budget Conditions Summary

Component	Description
Hydrologic Period	Water years 1970-2019 (50-year hydrology)
River Flow	Historical records from the United States Geological Survey (USGS) and California Data Exchange Center (CDEC), and the simulation of small-stream watersheds
Land Use	2014 statewide California crop mapping
	2015 Sacramento County land use survey
	Local ground truthing and refinement
Urban Water Demand	2015 demands as reported in the 2015 Urban Water Management Plan (UWMP)
	Municipal pumping records
Agricultural Water Demand	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 2019

6.4.3 Projected Water Budget

The projected water budget is intended to assess the conditions of the Subbasin under projected conditions of land use; water supply; and agricultural and urban demand. The Projected Conditions Baseline applies future land and water use conditions and uses a 50-year hydrologic period of WY 1970-2019. The Projected Conditions Baseline is analyzed with and without climate change.

The Projected Conditions Baseline includes the conditions described in **Table 6-2**

Table 6-4. Projected Water Budget Conditions Summary

Component	Description
Hydrologic Period	Water Years 1970-2019 (50-year hydrology)
River Flow	Historical records from the USGS and CDEC, and the simulation of small-stream watersheds
Land Use	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	Decadal population projections from 2015 UWMPs for most users
Agricultural Water Demand	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 2019

Table 6-3 provides a summary of the groundwater budget assumptions for each of the three water budget types.

Table 6-5. Summary of Groundwater Budget Assumptions

Water Budget Type	Historical	Current	Projected
Scenario	Historical Simulation	Current Conditions Baseline	Projected Conditions Baseline
Hydrologic Years	WY 2009-2018	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

6.4.4 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 6-4**)
- Bear River starting at the boundary of the groundwater subbasin, approximately 1.5 miles downstream from Camp Far West Dam, to the confluence with Feather River (**Table 6-5**)
- Sacramento River from the Feather River confluence to the American River confluence (**Table 6-6**)
- Feather River from Bear River confluence to the Sacramento River confluence (**Table 6-7**)

A composite water budget for these stream reaches is shown in **Table 6-8**. 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 system
  - Surface water deliveries
  - Stream outflows

Total inflows to the subbasin are summarized in **Table 6-9**. Note that **Tables 6-4 through 6-8** include upstream inflows, which are the inflows of the four major rivers into the Subbasin, and tributary inflows, which are inflows from the tributaries into the major rivers. As such, **Tables 6-4 through 6-8** do not include total inflows entering the subbasin, values which are provided in **Table 6-9**.

The primary components of the land surface system in the NASb (**Table 6-10**) 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 NASb **(Table 6-11**) are:

- Inflows:
  - Deep percolation
  - Infiltration from the stream system
  - Subsurface inflow
- Outflows: