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Acronyms and Abbreviations Used in This Report

AB	Assembly Bill
ACS	American Community Survey
ACWA	Association of California Water Agencies
ADP	Auburn Dam Project
af	acre-feet
af/yr.	acre-feet per year
AFRP	Anadromous Fish Restoration Program
ASR	aquifer storage and recovery
BDCP	Bay Delta Conservation Plan
BLM	U.S. Bureau of Land Management
BMO	basin management objective
BO	biological opinion
CABY	Cosumnes, American, Bear, and Yuba
CASGEM	California Statewide Groundwater Elevation Monitoring
CDPH	California Department of Public Health
cfs	cubic feet per second
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWA	Clean Water Act
CWC	California Water Code
CWP	California Water Plan
CWS	community water system
DAC	disadvantaged community
Delta	Sacramento-San Joaquin River Delta
DPR	California Department of Pesticide Regulation

DWF	California Department of Fish and Wildlife
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity
EFT	environmental flow target
EI	energy intensity
EIR	environmental impact report
EOS	End-of-September
ERP	CALFED Ecosystem Restoration Program
FCWCD	flood control and water conservation district
FERC	Federal Energy Regulatory Commission
FRWF	Freeport Regional Water Facility
FRWP	Freeport Regional Water Project
GAMA	Groundwater Ambient Monitoring and Assessment
GCM	global climate model
GHG	greenhouse gas
GIS	geographic information system
gpm	gallons per minute
GPS	global positioning system
GWMP	groundwater management plan
HCP	habitat conservation plan
HIP	high population scenario
ILRP	Irrigated Lands Regulatory Program
IRWM	integrated regional water management
IWM	integrated water management
kWh/af	kilowatt hours per acre-foot
LLNL	Lawrence Livermore National Laboratory
LOP	low-population growth scenario
maf	million acre-feet

maf/yr.	million acre-feet per year
MCL	maximum contaminant level
MFP	Middle Fork Project
mgd	million gallons per day
M&I	municipal and industrial
MOCA	*The Measure of California Agriculture*
MOU	memorandum of understanding
NBA	North Bay Aqueduct
NCCP	Natural Communities Conservation Plan
NCMWA	Natomas Central Mutual Water Company
NECWA	Northeastern California Water Association
NID	Nevada Irrigation District
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OHV	off-highway vehicle
O&M	operations and maintenance
OWTS	onsite wastewater treatment system
PA	planning area
PCE	tetrachloroethylene
PCWA	Placer County Water Agency
PG&E	Pacific Gas and Electric
ppb	parts per billion
PPG	Performance Partnership Grant
PRWA	Pit River Watershed Alliance
ROD	Record of Decision
RWMG	regional water management group
RWQCB	regional water quality control board
SAFCA	Sacramento Area Flood Control Agency
SB	Senate Bill

SDAC	severely disadvantaged community
SPFC	State Plan of Flood Control
SRBPP	Sacramento River Bank Protection Project
SRCSD	Sacramento Regional County Sanitation District
SRFCP	Sacramento River Flood Control Project
SRSC	Sacramento River Water Rights Settlement Contractors
SSWD	South Sutter Water District
SWP	State Water Project
SWRCB	State Water Resources Control Board
Sy	specific yield
taf	thousand acre-feet
taf/yr.	thousand acre-feet per year
TCC	Tehama-Colusa Canal
TDS	total dissolved solids
TMDL	total maximum daily load
TRD	Trinity River Diversion
TRFES	Trinity River Flow Evaluation Study
TRLIA	Three Rivers Levee Improvement Authority
UAIC	United Auburn Indian Community of the Auburn Rancheria
Update 2013	California Water Plan Update 2013
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDCWA	Woodland-Davis Clean Water Agency
WRCC	Western Regional Climate Center
WWTP	wastewater treatment plant
YCWA	Yuba County Water Agency
YRDP	Yuba River Development Project

Feather River near Oroville, CA. Selected restoration sites along this section of the Feather River, downstream of Oroville Dam and Thermolito Diversion Dam, received more than 7000 cubic feet of gravel to enhance conditions for spawning salmon. The Feather River lies within the Sacramento River watershed, as does Lake Oroville, the largest storage reservoir of the State Water Project (SWP). The SWP fills water supply needs within and beyond the watershed.

Sacramento River Hydrologic Region

Sacramento River Hydrologic Region Summary

The Sacramento River Hydrologic Region (see Figure SR-1 includes the entire California drainage area of the Sacramento River (the state's largest river) and its tributaries. The region extends from Chipps Island in Solano County north to Goose Lake in Modoc County. It is bounded by the Sierra Nevada on the east, the Coast Ranges on the west, the Cascade and Trinity mountains on the north, and the Sacramento-San Joaquin River Delta (Delta) on the south. The Sacramento River Basin actually begins in Oregon, north of Goose Lake, a near-sink that intercepts the Pit River drainage at the California-Oregon border.

Some key issues for this region are summarized here and discussed further later in this report.

Agriculture. Between 2005 and 2010, the region supported about 1.95 million acres of irrigated agriculture on average. Approximately 1.58 million acres is irrigated on the valley floor. The surrounding mountain valleys add about 370,000 irrigated acres to the region's total — primarily as pasture and alfalfa.

The gross value of agricultural production in the Sacramento Valley for 2011 was about $4.1 billion (California Department of Food and Agriculture 2013). Rice and walnuts are the highest grossing crops in the region followed by almonds and tomatoes. The direct, indirect, and induced effects of the agricultural industry to the regional economy are discussed in this report.

Groundwater. With a 2005-2010 average annual extraction volume of 2.7 million acre-feet (maf), groundwater pumping in the Sacramento River Hydrologic Region accounts for 17 percent of all the groundwater extraction in California — the third highest among the 10 hydrologic regions in California, behind Tulare Lake Hydrologic Region with 38 percent and San Joaquin River Hydrologic Region with 19 percent of the total.

Overall, groundwater contributes to about 31 percent of the total water supply. Most groundwater extraction in the region occurs for agricultural water use (2.4 maf), meeting about one-third of agricultural water demands. Groundwater extraction for urban water use is significantly less (465 thousand acre-feet [taf]), which meets about half of the urban water needs.

Groundwater levels for much of the region have declined from 2005 to 2010. Groundwater level declines ranging from 20 to 30 feet are seen in the northwestern portion of the Sacramento Valley Groundwater Basin. Declines ranging from to 10 to 20 feet are seen in the northern, the mid- to south-western, and the southeastern portions of the valley. For the rest of the Sacramento Valley Groundwater Basin and the Redding Area Groundwater Basin, groundwater level declines have ranged from zero to 10 feet.

Flood. Exposure to a 500-year flood event in the region threatens approximately one in three residents, almost $65 billion in assets (crops, buildings, and public infrastructure), 1.2 million acres of agricultural land, and over 340 sensitive species. Almost 95 percent of Sutter County residents, more than 55 percent of Yuba County and Yolo County residents, and more than 50 percent of agricultural land region-wide are exposed to the 500-year flood event.

Figure SR-1 Sacramento River Hydrologic Region

Climate Change. Several different climate regions overlie portions of the Sacramento River Hydrologic Region. Air temperature data collected for the past century has been summarized by the Western Regional Climate Center (WRCC) for the different regions which are outlined below.

Within the WRCC North Central climate region, mean temperatures have increased by about 0.8 to 1.7 °F (0.4 to 0.9 °C) in the past century, with minimum and maximum temperatures increasing by about 1.2 to 2.1 °F (0.7 to 1.2 °C) and 0.1 to 1.5 °F (0.1 to 0.8 °C), respectively. Within the WRCC North East climate region, mean temperatures have increased by about 0.8 to 2.0 °F (0.5 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing by about 0.9 to 2.2 °F (0.5 to 1.2 °C) and by 0.5 to 2.1 °F (0.3 to 1.2 °C), respectively. Within the WRCC Sierra climate region, mean temperatures have increased by about 0.8 to 2.0 °F (0.5 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing and decreasing by about 1.7 to 2.8 °F (0.9 to 1.5 °C) and by -0.2 to 1.3 °F (-0.1 to 0.7 °C), respectively. Within the WRCC Sacramento-Delta climate region, mean temperatures have increased by about 1.5 to 2.4 °F (0.9 to 1.3 °C) in the past century, with minimum and maximum temperatures increasing by about 2.1 to 3.1 °F (1.2 to 1.7 °C) and by 0.8 to 2.0 °F (0.4 to 1.1 °C), respectively (Western Regional Climate Center 2013).

The region also is currently experiencing impacts from climate change through changes in statewide precipitation and surface runoff volumes, which in turn affect availability of local and imported water supplies. During the last century, the average early snowpack in the Sierra Nevada decreased by about 10 percent, which equates to a loss of 1.5 maf of snowpack storage (California Department of Water Resources 2008). Projections and impacts based on modeling of climate change are included in this report.

Current State of the Region

Setting

Watersheds

Land development within the region has had its impact on parts of the Sacramento River corridor. Continuous tracts of vegetation have been converted to other vegetation types leading to scattered fragments of original habitat. Pre-Shasta Dam factors that have also impacted the Sacramento fishery include railroad construction upstream of Shasta Dam, drainage from Iron Mountain Mine, and historical gold mining in the Feather and Yuba basins. In the lower Feather River, hydraulic mining impacted its channel and floodplain with up to 20 feet of sediment (Anderson 2012). In the Yuba River, mining debris completely covered salmon spawning beds and floodplain for up to one and one-half miles from the river with sediments 5 to 10 feet in thickness (Yoshiyama et al. 1998 as referenced by Vogel 2011).

Water development projects have also altered natural geomorphic river processes resulting in reduced spawning habitat and fragmented riparian systems. Spring-run salmon cannot access most of their historical spawning and rearing habitats above the dams, and spawning is now restricted to the main stem of the Sacramento River and a few tributaries. On the positive side, the dams provide increased flexibility with cold water releases and increased flows during summer months to create conditions more favorable to salmon (Vogel 2011).

In recent years, salmon populations have been a concern to the extent that the Pacific Fisheries Marine Council and the National Marine Fisheries Service (NMFS) closed commercial and most recreational fishing in 2007, 2008, and 2009. At issue in the Central Valley is the potential loss of the genetic diversity that Central Valley Chinook populations lend to the species. This region has the southern-most spawning populations, which are at a greater risk of extinction than most coastal populations. Central Valley populations may lend the genetic diversity necessary for the species survival and are therefore considered a high priority for conservation (Zueg et al. 2011).

In light of these issues, habitat conditions for anadromous fish have significantly improved over the last two decades. Adult fish passage has improved with the removal of major fish barriers; water temperatures have improved downstream of the major dams; discharges from Iron Mountain Mine have been remediated; and major efforts have been undertaken to screen unscreened or inadequately screened water diversions (Vogel 2011). These efforts continue under several federal and State programs focused on species and ecosystem components considered to be at high risk.

In addition to these federal and State programs, numerous local partnerships exist as evidenced by the Sacramento River Watershed Partners which has over 34 current partners including resource conservation districts, watershed groups, conservancies, and other local partners with the goal to insure that the efforts of all these partners are recognized and to provide a way to exchange information and collaborate on common goals. The stated mission of the Sacramento River Watershed Program is “To ensure that current and potential uses of the watershed’s resources are sustained, restored, and where possible, enhanced, while promoting the long-term social and economic vitality of the region.” The Sacramento River Watershed Program has been monitoring water quality in the watershed since 1998. The following provides a short description and summary of fishery issues for watersheds (see Figure SR-2) identified by the NMFS as having core populations of salmon and steelhead. These watersheds have the physical and hydrologic features considered necessary for the recovery of these species.

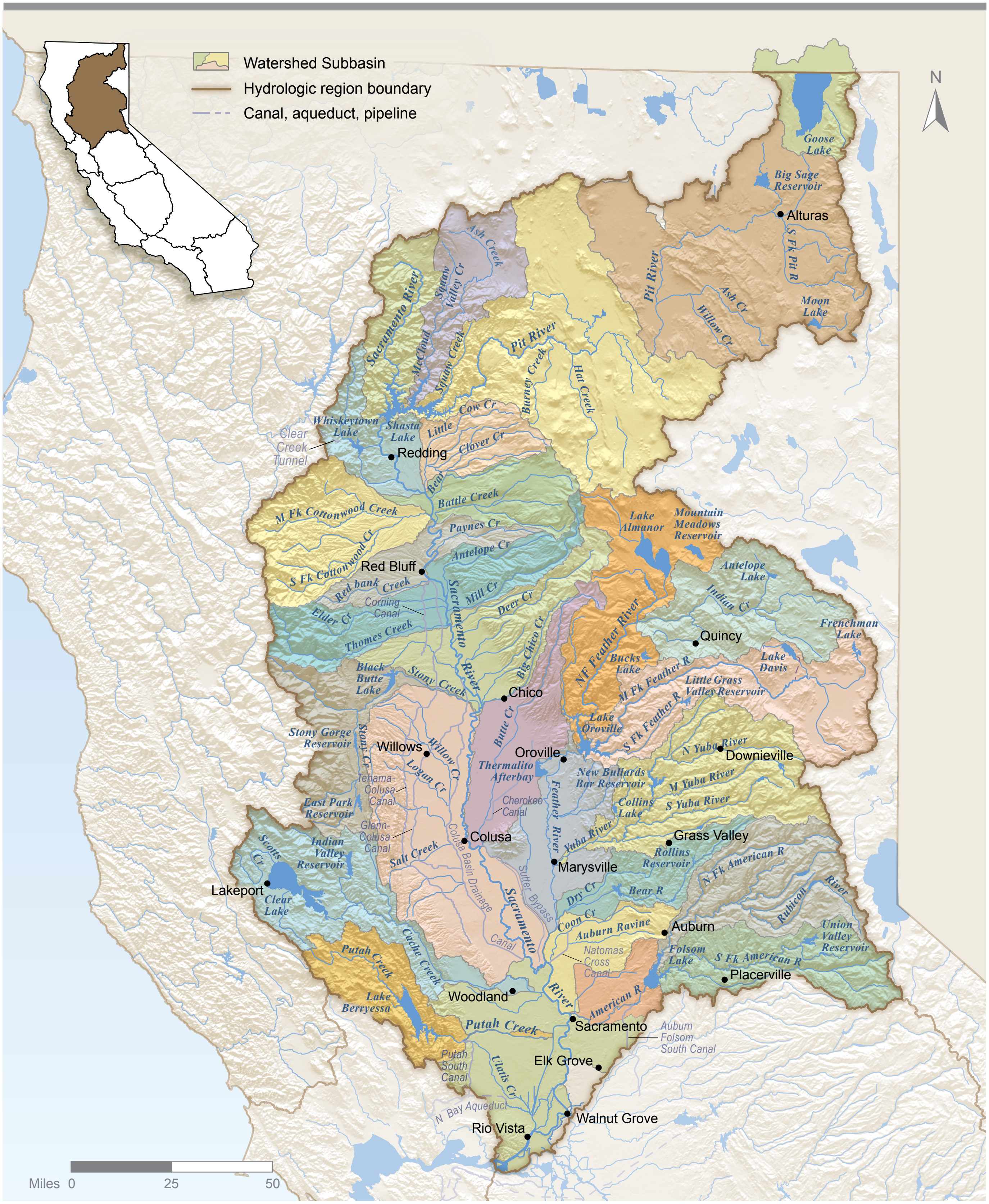
Clear Creek Watershed

Clear Creek originates in the mountains east of Clair Engle Reservoir and drains an area of approximately 238 square miles (National Marine Fisheries Service 2009a). Whiskeytown Dam stores and regulates runoff from the Clear Creek watershed. Flows provided to Clear Creek below Whiskeytown Dam are at least 200 cubic feet per second (cfs) from October through June. During the summer months, flows are maintained to provide adequate water temperatures for holding adult spring-run Chinook salmon and for rearing steelhead (National Marine Fisheries Service 2009a). Construction of Whiskeytown Dam and gold and gravel mining has reduced suitable spawning gravels and riparian habitat along the lower sections of Clear Creek (National Marine Fisheries Service 2009a).

Clear Creek is designated critical habitat for spring-run and Central Valley steelhead. Key threats and stressors for the creek include:

- Passage barrier at Whiskeytown Dam.
- Water temperature and quality.
- Habitat alteration and availability of instream gravel.
- Flow conditions.
- Sedimentation.

Figure SR-2 Sacramento River Hydrologic Region Watersheds



- Loss of floodplain habitat and natural river morphology.

The Clear Creek Floodway Rehabilitation Project, which began in 1998, has been responsible for helping to redefine the creek channel and floodplain, isolate salmon from stranding, and provide for riparian habitat. The general purpose of the project is to restore steam channels; determine long-term flow needs for spawning, incubation, and rearing; provide flows to meet the requirements of all life stages of Chinook salmon and steelhead trout; provide spawning gravel to replace supplies blocked by Whiskeytown Dam; and monitor the results.

Spawning habitat on Clear Creek is improving with restoration efforts, gravel augmentation, and increased flows for temperature control. Recent studies on Clear Creek using a gravel size suitable for steelhead have found that steelhead have utilized all newly added injection sites (National Marine Fisheries Service 2009a). By the year 2020, the overall goal for spawning gravel supplementation is to provide 347,228 square feet of usable spawning habitat between Whiskeytown Dam and the former McCormick-Saeltzer Dam. The annual spawning gravel supplementation target is 25,000 tons per year, but an average of 9,358 tons have been placed annually since 1996 due to funding constraints (U.S. Bureau of Reclamation 2011d).

The Central Valley Project Improvement Act (CVPIA) has provided funding for the design and permitting of projects on U.S. Bureau of Land Management (BLM) and California Department of Fish and Wildlife (DFW) lands to provide a long-term supply of spawning gravel. (The California Department of Fish and Wildlife, formerly known as the California Department of Fish and Game, is referred to as DFW throughout this report except in documents prepared under its former name.) The projects reduce the threat of mercury contamination through separation and relocation of contaminated materials and provide an economical 40-year supply of gravel while using renovated mine tailings to restore floodplain and upland habitats (U.S. Bureau of Reclamation 2011d). The value of potential spawning habitat may be reduced under future operations in critically dry years when cold water releases cannot be maintained from Whiskeytown Dam (i.e., years when Trinity River diversions are reduced and therefore not augmenting the available water in Clear Creek from the U.S. Bureau of Reclamations Whiskeytown Lake.).

Under CVPIA 3406(b)(2), interim flows have been increased to 200 cfs from 50 cfs for the period of September through mid-June and to approximately 70 to 90 cfs during the summer for temperature control. The flow of 200 cfs was based on flow studies conducted in the mid-1980s. The U.S. Fish and Wildlife Service (USFWS) has conducted new flow studies for both the lower and upper segments of the creek. Studies have also been conducted to develop channel maintenance flows to reactivate fluvial geomorphic processes. USFWS has set a minimum target pulse flow release of 3,250 cfs from Whiskeytown Dam for one day occurring 3 times during a 10-year period between the dates of March 1 and May 15. Results of pulse flows in 2010 suggested that higher flows are needed (U.S. Bureau of Reclamation 2011b). Other flow actions include pulse flows in May and June to attract spring-run to the higher reaches where cooler water temperatures can be maintained over the summer holding period (National Marine Fisheries Service 2009b).

Cottonwood Creek Watershed

The Cottonwood Creek watershed is the largest tributary to the Sacramento River on the west side of the valley and is an important source of spawning gravel to the upper Sacramento River

(California Department of Fish and Game 2011). It's estimated that the creek supplies almost 85 percent of the coarse sediments and spawning gravel for the Sacramento River between Redding and Red Bluff. As such, this creek plays an important role in the recovery of listed species. Changes in the creek that have occurred since the early 1970s include rapid shifts in stream channel alignment, increased bank erosion, and damage to adjacent properties in the lower 15 miles of the creek. The changes appear to be the result of aggregate extraction in excess of annual replenishment rates (Matthews 2003).

Cottonwood Creek itself does not have suitable habitat to support a spring-run Chinook salmon population (National Marine Fisheries Service 2009a). Viability potential for spring-run Chinook salmon is considered low. Viability for steelhead is considered moderate (National Marine Fisheries Service 2009a).

Cow Creek Watershed

The Cow Creek watershed is located in eastern Shasta County and encompasses about 430 square miles. The watershed consists of five main tributaries: Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek, and South Cow Creek.

Irrigation in the watershed consists of a series of diversions and lift-pumps in all tributaries. Water rights in the Cow Creek watershed are adjudicated, and there are approximately 278 recorded diversions. The primary water quality issues in the watershed are related to bacteria, temperature, and erosion/sediment discharge. North Fork Cow, Clover, Oak Run, and South Fork Cow creeks are all 303(d) listed as impaired water bodies for bacteria. The watershed provides habitat for fall-run and late fall-run Chinook salmon and steelhead.

The watershed has low viability potential to support spring-run Chinook salmon and moderate viability potential to support a population of steelhead (National Marine Fisheries Service 2009a). Sections of the watershed do not have suitable habitat, and insufficient flows result in warmer water temperatures. Extensive restoration is needed for a population of spring-run Chinook to persist (National Marine Fisheries Service 2009a). Key stressors to steelhead include passage impediments/barriers, flow conditions, water temperatures, predation, hatchery effects, and entrainment at unscreened diversions.

Antelope Creek Watershed

Antelope Creek is considered critical habitat for spring-run Chinook salmon and steelhead. According to the draft NMFS Recovery Plan, Antelope Creek has high potential to support a viable population of steelhead. The creek is characterized as having a moderate potential to support a viable population of spring-run Chinook. The upper reaches of the creek are fairly undeveloped. Issues in the watershed concern impaired streamflows and fish passage on the valley floor below agricultural diversion. The primary focus for restoration is on improving flow conditions and fish passage for upstream migrating adults.

Battle Creek Watershed

The Battle Creek watershed includes the southern slopes of the Latour Buttes, the western slope of Mount Lassen, and mountains south of the town of Mineral. The watershed drains an area of approximately 360 square miles.

Battle Creek may be the only remaining tributary to the Sacramento River that can sustain breeding populations of steelhead and all four runs of Chinook salmon. The watershed has been identified as having high potential for the recovery of spring-run Chinook salmon due to its relatively high and consistent cold waterflow. Battle Creek also has the largest baseflow season of any of the tributaries to the Sacramento River between Keswick Dam and the Feather River.

Current restoration actions include the installation of fish ladders and fish screens at three dams. Construction is expected to be completed in 2014. Other restoration actions include the removal of small dams on the South Fork Battle Creek, increasing flows from existing diversions, and hatchery releases. Once restoration actions are completed, 42 miles of additional habitat will be re-established, plus an additional 6 miles of habitat within area tributaries.

Big Chico Creek Watershed

Big Chico Creek begins in Chico Meadows and flows approximately 45 miles to its confluence with the Sacramento River. The creek can be divided into three zones: the upper zone extending from the headwaters to Higgin's Hole, a middle zone extending from Higgin's Hole to Iron Canyon, and the third zone extending from Iron Canyon to the Sacramento River (National Marine Fisheries Service 2009a).

Mud Creek and Rock Creek join Big Chico Creek about 0.75 miles before it enters the Sacramento River. These creeks provide seasonal flows from about November to June in the valley portions of their channels. An outflow weir at Lindo Channel diverts excess flows from Big Chico Creek through a diversion channel to Sycamore Creek, which then flows into Mud Creek (National Marine Fisheries Service 2009a).

The lowermost 24 miles of Big Chico Creek provide aquatic habitat for anadromous salmonids. The creek provides habitat for adult spring-run Chinook salmon holding and spawning, while Mud, Rock, and Sycamore creeks have been shown to be important non-natal rearing areas for salmonids (National Marine Fisheries Service 2009).

Bear River Watershed

The Bear River originates on the west side of the Sierra Nevada and flows to the southwest about 65 miles to its confluence with the Feather River. The upstream limit for anadromous fish is the South Sutter Irrigation District's diversion dam. The river contains a large volume of mining sediment stored in its main channel — estimated to be up to 160 million cubic yards (National Marine Fisheries Service 2009a).

The potential for Bear River to support a viable population of steelhead is considered low. This is due to a limited amount of habitat for spawning and rearing at suitable elevations. Inadequate streamflow prevents the establishment of a self-sustaining steelhead population (National Marine Fisheries Service 2009a).

Butte Creek Watershed

The Butte Creek watershed originates on the western slope of the Sierra Nevada and encompasses about 800 square miles. The watershed contains a series of dams, diversions, and canals that are mostly located in the middle and lower canyon portions of Butte Creek. The hydrology of Butte

Creek has been extensively modified and developed, contains multiple hydropower diversions, and imports water from other watersheds. Land use within the watershed includes agricultural uses (64 percent) with rice production being the most dominant crop, forest related uses (13 percent) with the remaining lands used for commercial, industrial, and residential uses (National Marine Fisheries Service 2009a).

Restoration actions have included the removal of Western Canal, McPherrin, McGowan, and Point Four dams; screening modifications or construction on five other diversions; and construction of a canal siphon along Butte Creek to aid fish passage (California Department of Fish and Game 2011).

Butte Creek is considered to have moderate potential to support a viable population of steelhead. Key stressors to spring-run Chinook salmon and steelhead include water temperatures, passage impediments/barriers, flow fluctuations, summer instream recreation, upper watershed conditions, and fire risk. Watershed management objectives and recommended actions to achieve the objectives are included in the Butte Creek Watershed Management Strategy (2000).

Mill Creek Watershed

The Mill Creek watershed originates on the southern slopes of Lassen Peak and encompasses about 134 square miles. Mill Creek initially flows though meadows and dense forests before descending through a steep rock canyon to the Sacramento Valley. Historically, there were three dams on Mill Creek. One dam failed in 1997 and was replaced with a siphon. The two remaining dams are operated by the Los Molinos Mutual Water Company.

During low-flow periods, existing water rights are sufficient to dewater the stream. There are cooperative agreements between resource agencies and water diverters to provide adequate flows for salmon during peak migration/spawning periods. An interagency water exchange agreement is in place that provides pumped groundwater to meet irrigation water needs during critical time periods (http://www.sacriver.org/).

Mill Creek supports the majority of its original native aquatic species assemblages (National Marine Fisheries Service 2009a). The main focus for spring-run Chinook salmon restoration is to maintain flow conditions for upstream migrating adults. Mill Creek is considered to have high potential to support a viable independent population with few restoration actions. Threats and stressors identified for spring-run Chinook salmon and steelhead include elevated water temperatures, low streamflows, and risk of catastrophic fire. Concerns about water temperatures apply mainly to the lower reaches of the creek.

Deer Creek Watershed

The Deer Creek watershed originates near the summit of Butt Mountain and drains an area of about 134 square miles. Deer Creek initially flows through meadows and dense forest and then descends through a steep canyon to the Sacramento Valley. Highway 32 runs parallel to Deer Creek in the upper watershed which is a major concern with respect to the possibility of a spill event (http://www.sacriver.org/).

Deer Creek contains about 40 miles of anadromous fish habitat with approximately 25 miles of adult spawning and holding habitat. The three diversion dams (the Cone-Kimball Diversion, Stanford-Vina Dam, and Deer Creek Irrigation District Dam) present passage impediments to adult steelhead during low flow periods. Water temperatures throughout the watershed are suitable for juvenile steelhead rearing except for summer months when temperatures in the lower watershed are too high (National Marine Fisheries Service 2009a). The viability potential for spring-run Chinook salmon and steelhead is considered high (National Marine Fisheries Service 2009a).

Feather River Watershed

The Feather River watershed is part of the northern Sierra Nevada and is the source of water for Lake Oroville. The U.S. Forestry Service manages over 80 percent of the Feather River upper watershed.

The watershed has two general terrains. Divided by the Sierra Crest, the west side of the watershed is made up of steep forested valleys; and the east side consists of less steep terrain and broad valley floors. Because of the steep terrain, west side surface streams are less susceptible to degradation from erosion and head cutting. The east side of the watershed is more degraded by the loss of riparian and upland vegetation, deep channel incision, and sediment runoff from forest logging roads.

Meadows are the most sensitive landforms in the watershed. Meadows are remnant lake bottoms with highly erodible soil types that can produce great volumes of sediments. Meadow restoration has been a major component of the restoration efforts in the region. Meadow restoration has reduced erosion, increased aquifer storage, and improved riparian vegetation.

Each of the main stems and tributaries of the Upper Feather River have some degree of degradation. Fish habitat and passage have been impacted by stream channelization to control flooding, sediment deposition resulting from bank erosion and runoff, and loss of riparian vegetation. The goals of the Upper Feather River Integrated Regional Water Management Plan support the rehabilitation of all streams to “functional, ecologically healthy conditions that support aquatic biota” (Ecosystem Sciences Foundation 2005).

Hydropower in the region includes projects on the North Fork Feather River and Lake Oroville. The Rock Creek-Cresta Project (Federal Energy Regulatory Commission License 1962) operated by PG&E (Pacific Gas and Electric) is located on the North Fork Feather River in Plumas and Butte Counties. In 1991, PG&E and DFW entered into a Fish and Wildlife Agreement to establish minimum streamflows and other resource management measures for the protection, mitigation, and enhancement of fish and wildlife resources (Ecosystem Sciences Foundation 2005).

The North Fork Feather River Project 2105 (FERC License 2105) is located in Plumas County. PG&E filed a settlement agreement with the Federal Energy Regulatory Commission (FERC) in 2004 as part of relicensing. Under the agreement, PG&E will operate Lake Almanor to specified lake levels and required releases below Canyon Dam. Fish flows in the Belden Reach and Seneca Reach will be increased depending on the month and water year type. PG&E will also release pulse flows in both reaches in certain months during wet or normal years.

There are two reaches of the Feather River where both fall-run and spring-run Chinook spawn: the low-flow channel from Oroville to Thermalito Afterbay outlet and the lower reach from Thermalito Afterbay outlet to Honcut Creek (Vogel 2011). Approximately 75 percent of the natural fall-run spawn in the 8-mile reach between the Fish Barrier Dam and the Thermalito Afterbay outlet (Vogel 2011). Gravel recruitment is an issue for the low-flow channel of the river. Water temperatures range from 47 °F in the winter to 65 °F in the summer (Vogel 2011). The summer water temperatures can limit salmon production.

Recovery and restoration actions identified for the Feather River include the development of a hatchery genetic management plan for the Feather River Fish Hatchery, development and implementation of a spring-run pulse flow schedule that is coordinated with Yuba River operations, gravel augmentation, and implement facility modifications to meet water temperature goals (National Marine Fisheries Service 2009a).

American River Watershed

The American River watershed is part of the Sierra Nevada and drains an area of approximately 1,895 square miles (Lee and Chilton 2007). The river accounts for about 15 percent of the Sacramento River flow. The medium historical unimpaired runoff is 2.5 maf, ranging from 0.3 to 6.4 maf.

Folsom Dam is located on the river and impounds the south and north forks of the American River. The dam is part of the Central Valley Project (CVP). Nimbus Dam and Powerplant are located 6.8 miles downstream of Folsom Dam. Nimbus Dam re-regulates water released from Folsom Dam and diverts water to the Folsom South Canal. Water not diverted to the canal is released to the American River. Both dams are a factor with respect to the restoration potential of the river. Bank erosion, channel degradation, riprap revetments, and reduced amounts of woody debris have all contributed to the decline of riparian vegetation.

The Nimbus Fish Hatchery is located adjacent to the American River approximately 15 miles east of the City of Sacramento. The goal of the hatchery is to mitigate for spawning habitat eliminated by the construction of the Nimbus Dam. Chinook salmon reared at the hatchery are considered part of the Central Valley fall-run.

The river currently provides about 23 miles of riverine habitat to anadromous salmonids. Warm water temperatures in the lower American River during the summer and fall are considered to be the primary stressor to steelhead. Above Folsom Lake, riverine habitat is available in the North, Middle, and South forks of the river; however, the quality of habitat needs to be assessed (National Marine Fisheries Service 2009a).

The potential for the lower American River to support a viable population of steelhead is considered low. The natural population is considered to be at high risk of extinction because most of the fish population is from the hatchery. The potential for a viable population above the dams is considered moderate for spring-run salmon and steelhead. The reintroduction of spring-run Chinook salmon to the North and Middle forks of the river would represent separate fish populations.

Yuba River Watershed

Yuba River is a tributary of the Feather River and provides about a third of the Feather River flow. The main stem of the river is about 40 miles long and is split between the North, Middle, and South forks. The confluence of the North and Middle forks is considered the beginning of the

Yuba River. The North Yuba River extends for about 61 miles and is impounded by New Bullards Reservoir after which in joins the Middle Yuba. New Bullards Bar Dam and Reservoir provides favorable conditions for over-summering spring-run Chinook in the lower Yuba River due to higher colder flows (Vogel 2011).

The Yuba River then flows southwest to Englebright Lake where it is joined by South Yuba. Construction of the Englebright Dam was completed in 1941 to hold back hydraulic mining debris from historic placer mining. The dam is located approximately 24 miles upstream of the Feather River. Prior to construction of dam, steelhead had been observed spawning in the uppermost reaches of the river.

Below Englebright Dam, the river is characterized as having high potential to support a viable population of steelhead. Daguerre Point Dam is located approximately 11.5 miles upstream of the Feather River. The dam was reconstructed in 1965; however, the fish ladders are considered suboptimal.

Flow, water temperature, and habitat conditions are generally suitable to support all life stage requirements. Proposed restoration actions include gravel augmentation below Englebright Dam and improvement of rearing habitat by increasing floodplain habitat availability. Above Englebright Dam, recovery actions include increasing minimum flows; providing passage at Our House, New Bullards Bar, and Log Cabin dams; and assessing the feasibility of passage improvement at natural barriers (National Marine Fisheries Service 2009a).

Groundwater Aquifers and Wells

Groundwater resources in the Sacramento River Hydrologic Region are supplied by both alluvial and fractured rock aquifers. Alluvial aquifers are composed of sand and gravel or finer grained sediments, with groundwater stored within the voids, or pore space, between the alluvial sediments. Fractured-rock aquifers consist of impermeable granitic, metamorphic, volcanic, and hard sedimentary rocks, with groundwater being stored within cracks, fractures, or other void spaces. The distribution and extent of alluvial and fractured-rock aquifers and water wells vary within the region. A brief description of the aquifers for the region is provided below.

Alluvial Aquifers

The Sacramento River Hydrologic Region contains 88 recognized alluvial groundwater basins and subbasins in California Department of Water Resources (DWR) *Bulletin 18-2003* and underlie approximately 7,800 square miles, or 29 percent of the region (California Department of Water Resources 2003). The majority of the groundwater in the region is stored in alluvial aquifers. Figure SR-3 shows the location of the alluvial groundwater basins and subbasins. Table SR-1 lists the associated names and numbers. Pumping from the alluvial aquifers in the region accounts for about 17 percent of California's total average annual groundwater extraction. The largest and most heavily used groundwater basins in the region are located primarily within the Sacramento Valley Groundwater Basin. Within the Sacramento Valley Groundwater Basin, the North American, Colusa, Solano, Yolo and East Butte subbasins account for 52 percent of the of the average 2.7 maf of groundwater pumped annually during the 2005-2010 period. Other significant groundwater basins in the region are Redding Area, Alturas Area, Big Valley and Fall River Valley Groundwater Basins.

Figure SR-3 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

Table SR-1 Alluvial Groundwater Basins and Subbasins within the Sacramento River Hydrologic Region

Basin/Subbasin		Basin Name	Basin/Subbasin		Basin Name
5-1		Goose Lake Valley		5-21.65	South American
	5-1.01	Lower Goose Lake Valley		5-21.66	Solano
	5-1.02	Fandango Valley		5-21.67	Yolo
5-2		Alturas Area		5-21.68	Capay Valley
	5-2.01	South Fork Pitt River	5-30		Lower Lake Valley
	5-2.02	Warm Springs Valley	5-31		Long Valley
5-3		Jess Valley	5-35		Mccloud Area
5-4		Big Valley	5-36		Round Valley
5-5		Fall River Valley	5-37		Toad Well Area
5-6		Redding Area	5-38		Pondosa Town Area
	5-6.01	Bowman	5-40		Hot Springs Valley
	5-6.02	Rosewood	5-41		Egg Lake Valley
	5-6.03	Anderson	5-43		Rock Prairie Valley
	5-6.04	Enterprise	5-44		Long Valley
	5-6.05	Millville	5-45		Cayton Valley
	5-6.06	South Battle Creek	5-46		Lake Britton Area
5-7		Lake Almanor Valley	5-47		Goose Valley
5-8		Mountain Meadows Valley	5-48		Burney Creek Valley
5-9		Indian Valley	5-49		Dry Burney Creek Valley
5-10		American Valley	5-50		North Fork Battle Creek
5-11		Mohawk Valley	5-51		Butte Creek Valley
5-12		Sierra Valley	5-52		Gray Valley
	5-12.01	Sierra Valley	5-53		Dixie Valley
	5-12.02	Chilcoot	5-54		Ash Valley
5-13		Upper Lake Valley	5-56		Yellow Creek Valley
5-14		Scotts Valley	5-57		Last Chance Creek Valley
5-15		Big Valley	5-58		Clover Valley
5-16		High Valley	5-59		Grizzly Valley
5-17		Burns Valley	5-60		Humbug Valley
5-18		Coyote Valley	5-61		Chrome Town Area
5-19		Collayomi Valley	5-62		Elk Creek Area
5-20		Berryessa Valley	5-63		Stonyford Town Area

Basin/Subbasin		Basin Name	Basin/Subbasin		Basin Name
5-21		Sacramento Valley	5-64		Bear Valley
	5-21.50	Red Bluff	5-65		Little Indian Valley
	5-21.51	Corning	5-66		Clear Lake Cache Formation
	5-21.52	Colusa	5-68		Pope Valley
	5-21.53	Bend	5-86		Joseph Creek
	5-21.54	Antelope	5-87		Middle Fork Feather River
	5-21.55	Dye Creek	5-88		Stony Gorge Reservoir
	5-21.56	Los Molinos	5-89		Squaw Flat
	5-21.57	Vina	5-90		Funks Creek
	5-21.58	West Butte	5-91		Antelope Creek
	5-21.59	East Butte	5-92		Blanchard Valley
	5-21.60	North Yuba	5-93		North Fork Cache Creek
	5-21.61	South Yuba	5-94		Middle Creek
	5-21.62	Sutter	5-95		Meadow Valley
	5-21.64	North American			

Based on a series of irrigation pump tests, groundwater pumping rates in the various basins and subbasins in the region were determined to range from about 275 gallons per minute (gpm) to about 2,500 gpm (Burt 2011).

Fractured-Rock Aquifers

Fractured-rock aquifers are generally found in the mountainous areas of a hydrologic region, extending from the edges of the alluvial groundwater basins and foothill areas, up into the surrounding mountains. Due to the highly variable nature of void spaces within fractured-rock aquifers, wells drawing from fractured-rock aquifers tend to have less capacity and less reliability than wells drawing from alluvial aquifers. On average, wells drawing from fractured-rock aquifers yield 10 gpm or less. Although the volume and rate of groundwater supplied by fractured-rock aquifers is small in comparison to groundwater resources supplied by alluvial aquifers, fractured-rock aquifers tend to be a critically important water supply source for many individual domestic wells and small public water systems within the Sacramento River Hydrologic Region.

The principle fractured-rock aquifers in the Fall River Valley Groundwater Basin are Pliocene to Holocene Volcanic rocks consisting of highly fractured basalt flows interbedded with layers of cinders. The basalt flows are the only component of the formation with a broad enough extent to be a significant source of groundwater. Where the basalt is fractured and open, well yields can be high; but where the basalt is impermeable, little to no groundwater can be produced.

More detailed information regarding the aquifers in the Sacramento River Hydrologic Region is available online from *California Water Plan Update 2013* (Update 2013), Volume 4, *Reference Guide,* in the article "California's Groundwater Update 2013," and in DWR *Bulletin 118-2003* (California Department of Water Resources 2003).

Well Infrastructure and Distribution

Well logs submitted to DWR for water supply wells completed from 1977 to 2010 were used to evaluate the distribution and uses of water wells in the Sacramento River region. Many wells could have been drilled prior to 1977 or without submitting well logs. As a result, the total number of wells in the region is probably higher than what is reported here. DWR does not have well logs for all the wells drilled in the region; and for some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Hence, some well logs could not be used in the current assessment; but for a regional scale evaluation of well installation and distribution, the quality of the data is considered adequate and informative.

The number and distribution of wells in the region are grouped by county and by the six most common well-use types — domestic, irrigation, public supply, industrial, monitoring, and other. Public supply wells include all wells identified in the well completion report as municipal or public. Wells identified as "other" include a combination of the less common well types, such as stock wells, test wells, or unidentified wells (no information listed on the well log).

Well log data for counties that fall within multiple hydrologic regions were assigned to the hydrologic region containing the majority of alluvial groundwater basins within the county. Of the 20 counties located completely or partially within the Sacramento River Hydrologic Region, 17 counties were included in the analysis of well infrastructure for the region. Nine of these 17 counties are fully contained with the region, while 8 counties are partially contained within the region. The well log information listed in Table SR-2 and illustrated in Figure SR-4 show that the distribution and number of wells vary widely by county and by use.

The total number of wells installed in the region between 1977 and 2010 is approximately 108,300 and ranges from a high of about 14,000 in Nevada County to under 400 in Sierra County.

The top six counties for domestic wells include Nevada, Placer, El Dorado, Butte, Tehama, and Shasta, with a range between approximately 7,500 and 13,300. Sacramento County has the highest number of monitoring wells with approximately 6,900 wells followed by Solano, Shasta, Butte, Yolo, and Placer counties with a range between approximately 900 and 1,600 wells per county. Counties having a high percentage of monitoring wells, compared to other well types, tend to also have a higher number of local groundwater quality problem areas. Counties with the most irrigation wells include Butte, Glen, Yolo, Sutter, and Tehama, with a range between approximately 600 and 1,200 wells per county.

Figure SR-5 shows that domestic wells make up the majority of well logs (72 percent) in the region, followed by monitoring wells (15 percent), and irrigation wells (about 6 percent).

Figure SR-6 shows a cyclic pattern of well installation for the region, with new well construction ranging from a low of 1,500 wells (year 2010) to a high of 5,300 wells (year 1990) per year. The average number of new wells constructed is about 3,200 wells per year.

Table SR-2 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977-2010)

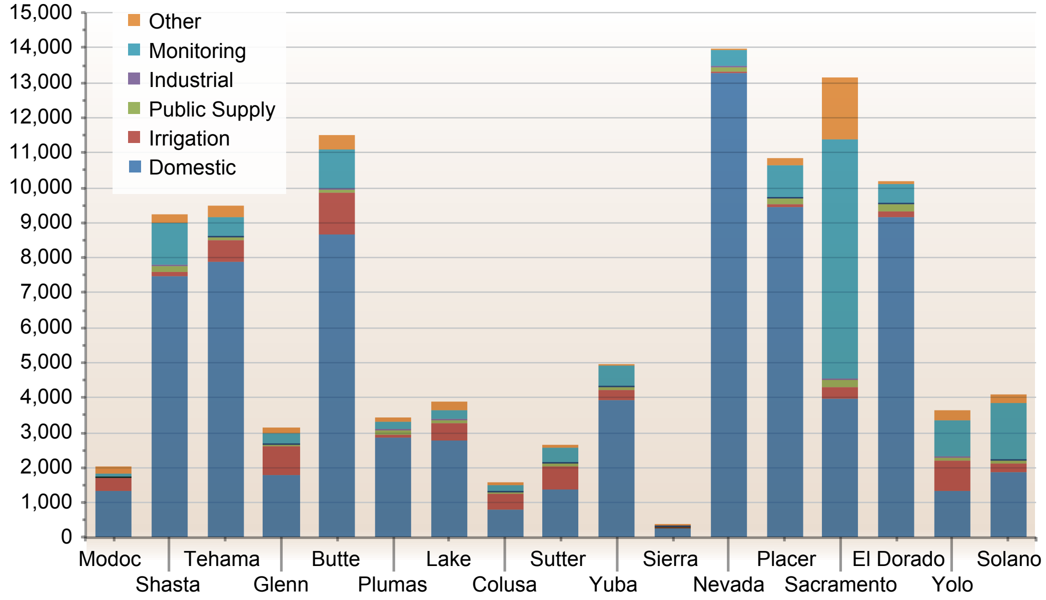
	Total Number of Well Logs by Well Use						
County	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	Total Well Records
Modoc	1,320	381	17	6	103	188	2,015
Shasta	7,453	145	160	32	1,210	252	9,252
Tehama	7,889	614	79	19	540	331	9,472
Glenn	1,784	845	18	20	322	165	3,154
Butte	8,678	1,170	108	48	1,076	447	11,527
Plumas	2,876	76	116	22	212	148	3,450
Lake	2,757	500	105	13	283	239	3,897
Colusa	815	425	36	25	192	108	1,601
Sutter	1,375	663	66	25	422	107	2,658
Yuba	3,931	282	69	17	625	46	4,970
Sierra	253	23	21	1	56	35	389
Nevada	13,284	27	151	10	468	53	13,993
Placer	9,461	67	152	8	941	228	10,857
Sacramento	3,991	302	209	41	6,858	1,754	13,155
El Dorado	9,165	176	180	3	563	114	10,201
Yolo	1,355	828	89	42	1,027	300	3,641
Solano	1,873	257	52	36	1,616	280	4,114
Total well records	**78,260**	**6,781**	**1,628**	**368**	**16,514**	**4,795**	**108,346**

Note: Table represents well log data as of July 2012.

As shown in Figure SR-6, irrigation well installation tends to closely follow changes in hydrology, cropping patterns, and availability of alternate agricultural water supplies. Irrigation well installation in the region peaked at around 800 wells per year following the 1976-1977 drought, and continued at an average installation rate of 400 wells per year through 1981. Irrigation well installation dropped to under 100 wells per year during the wet years of the mid-1980s, before increasing to an average of about 400 wells per year during the 1989-1994 drought and about 250 wells per year during the 2008-2009 drought. Much of the irrigation well infrastructure installed in the region during the late 1970s and early 1980s is still in use today.

The large fluctuation in domestic well drilling is likely associated with population booms and residential housing construction. The increase in the number of domestic wells drilled during the late 1980s and early 1990s as well as early through mid-2000s is likely due to growth in housing construction. Similarly, the decrease in the number of domestic wells drilled from 2007 to 2010

Figure SR-4 Number of Well Logs by County and Use for the Sacramento River Hydrologic Region (1977-2010)



is likely due to declining economic conditions and the related drop in housing construction. A portion of the lower number of well logs recorded for 2010 could also be due to delays in receiving and processing well drillers logs.

The onset of monitoring well installation in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. Between 1984 and 2010, monitoring well installation in the region has averaged approximately 600 wells per year.

More detailed information regarding assumptions and methods of reporting well log information is available online from Update 2013, Volume 4, *Reference Guide*, in the article, "California's Groundwater Update 2013."

Sacramento River Hydrologic Region Groundwater Monitoring

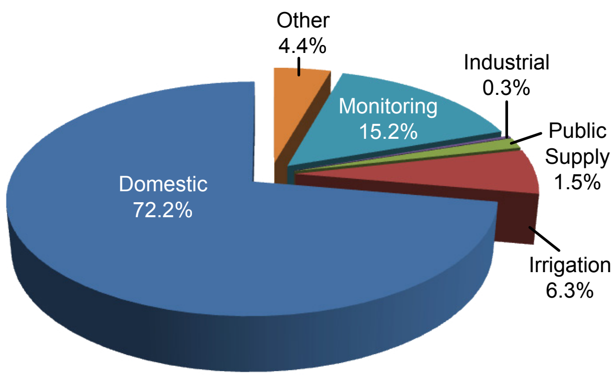
Groundwater monitoring and evaluation is a key aspect to understanding groundwater conditions, identifying effective resource management strategies, and implementing sustainable resource management practices. California Water Code (CWC) Section 10753.7 requires local agencies seeking State funds administered by DWR to prepare and implement groundwater management plans (GWMPs) that include monitoring groundwater levels, groundwater quality, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater level or quality. This section summarizes some of the groundwater level, groundwater quality, and land subsidence monitoring efforts within the Sacramento River Hydrologic Region.

Additional information regarding the methods, assumptions, and data availability associated with the groundwater monitoring is available online from Update 2013, Volume 4, *Reference Guide*, in the article, "California's Groundwater Update 2013."

Groundwater Level Monitoring

To strengthen existing groundwater level monitoring in the state by DWR, the U.S. Geological Survey (USGS), U.S. Bureau of Reclamation (USBR), local agencies and communities, the California Legislature passed Senate Bill (SB) 7X 6 in 2009 that requires groundwater elevation data be collected in a systematic manner on a statewide basis and be made readily and widely available to the public. DWR was charged with administering the program, which is now known as California Statewide Groundwater Elevation Monitoring (CASGEM).

Figure SR-5 Percentage of Well Logs by Use for the Sacramento River Hydrologic Region (1977-2010)



The locations of monitoring wells by monitoring entity and monitoring well type in the Sacramento River region are shown in Figure SR-7. Irrigation wells, observation wells, domestic wells, and other wells account for 36, 32, 21, and 11 percent of the monitoring wells in the region, respectively.

A list of the number of monitoring wells in the region is provided in Table SR-3. Groundwater levels have been actively monitored in 1,306 wells in the region since 2010. DWR monitors 635 wells in 36 basins and subbasins; the USBR monitors 150 wells in 6 basins and subbasins; and the USGS monitors 4 wells in 2 subbasins. In addition to the State and federal agencies, 6 cooperators and 14 CASGEM monitoring entities monitor 517 wells in 19 basins and subbasins.

CASGEM Basin Prioritization

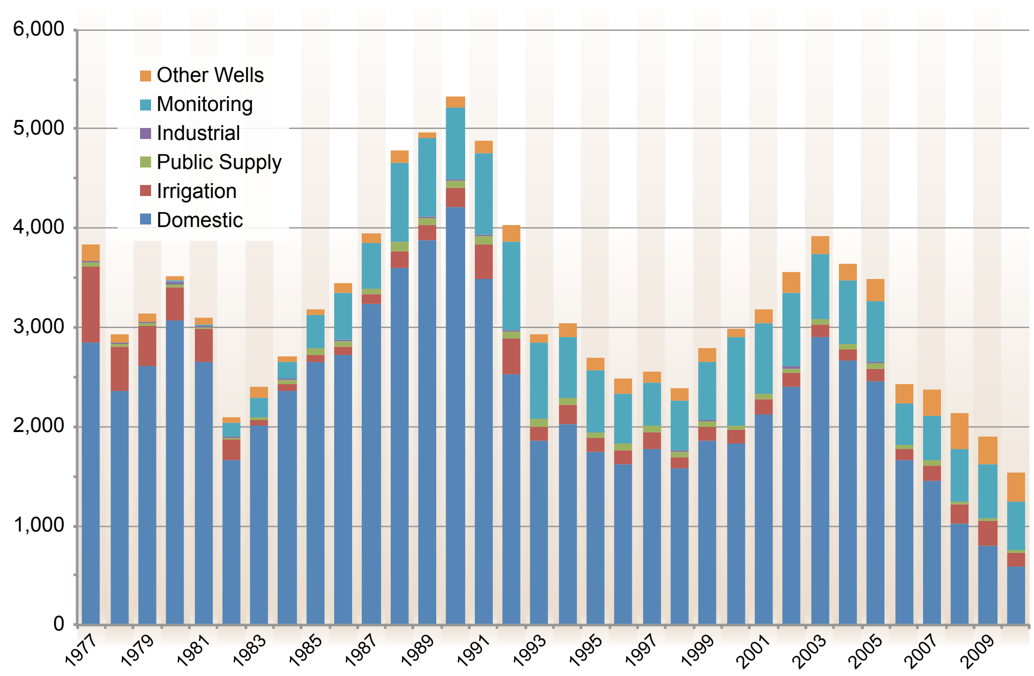
Figure SR-8 shows the groundwater basin prioritization for the region. Of the 88 basins and subbasins within the region, 5 subbasins (all in the Sacramento Valley Groundwater Basin) were identified as high priority, 16 basins and subbasins as medium priority, 7 basins and subbasins as low priority, and the remaining 60 basins and subbasins as very low priority. Table SR-4 lists the high and medium CASGEM priority groundwater basins for the region. The 21 basins and subbasins designated as high and medium priority include 98 percent of the population and account for 89 percent of groundwater supply in the region. Basin prioritization could be a valuable tool to help evaluate, focus, and align limited resources for effective groundwater management and reliable and sustainable groundwater resources.

More detailed information on groundwater basin prioritization is available at http://www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm.

Groundwater Quality Monitoring

Groundwater quality monitoring is an important aspect to effective groundwater basin management and is one of the components that are required to be included in groundwater management planning in order for local agencies to be eligible for State funds. Numerous

Figure SR-6 Number of Well Logs Filed per Year by Use for the Sacramento River Hydrologic Region (1977-2010)



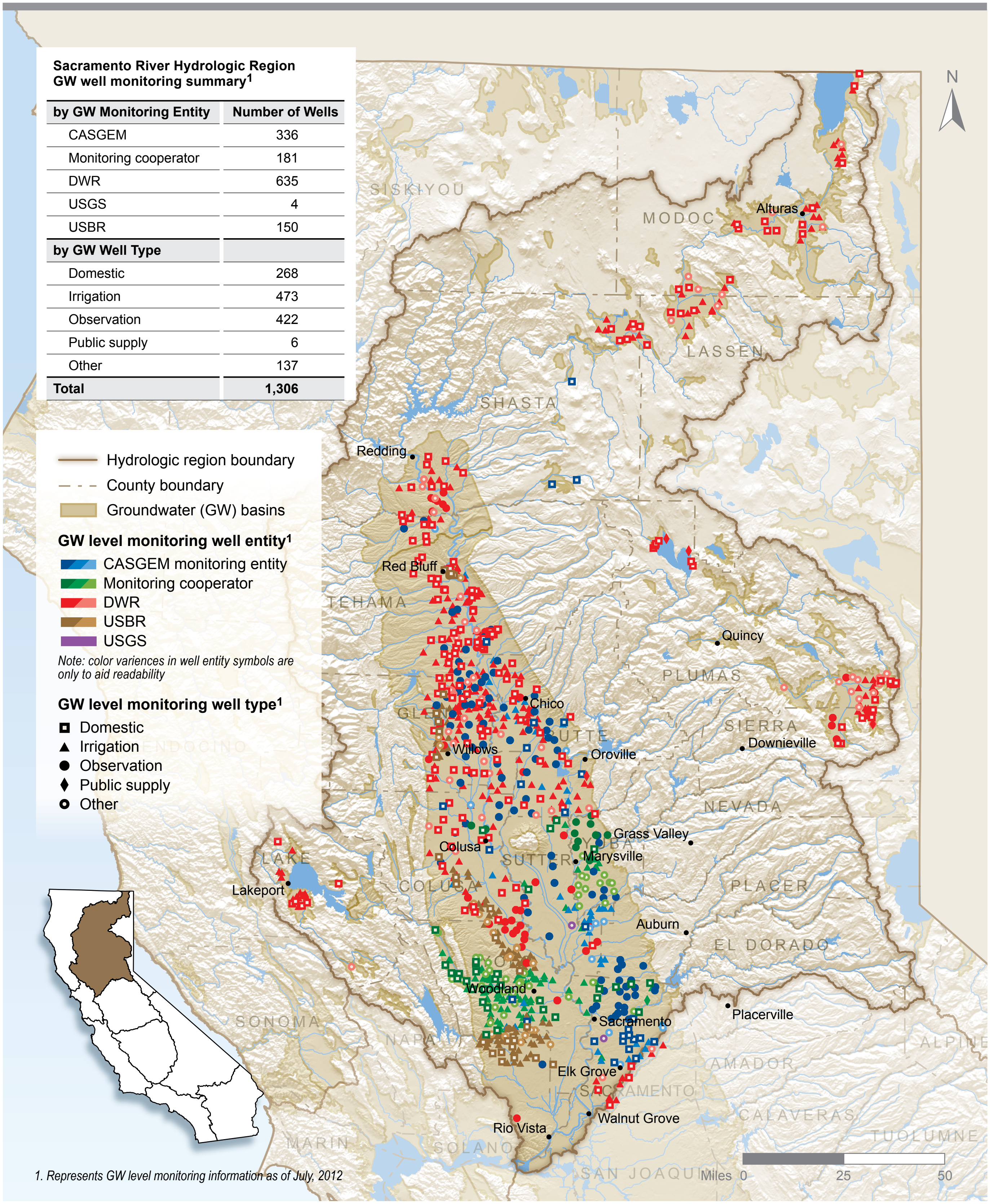
State, federal, tribal, and local agencies participate in groundwater quality monitoring efforts throughout California. A number of the existing groundwater quality monitoring efforts were initiated as part of the Groundwater Quality Monitoring Act of 2001, which implemented goals to improve and increase the statewide availability of groundwater quality data.

Regional and statewide groundwater quality monitoring information and data are available on the State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment Web site and the GeoTracker GAMA groundwater information system developed as part of the Groundwater Quality Monitoring Act of 2001. The GAMA Web site describes the GAMA program and provides links to all published GAMA and related reports. The GeoTracker GAMA groundwater information system geographically displays information and includes analytical tools and reporting features to assess groundwater quality. This system currently includes groundwater data from the SWRCB, regional water quality control boards (RWQCBs), California Department of Public Health (CDPH), California Department of Pesticide Regulation (DPR), DWR, USGS, and Lawrence Livermore National Laboratory (LLNL). In addition to groundwater quality data, GeoTracker GAMA has more than 2.5 million depth-to-groundwater measurements from the Water Boards and DWR, and also has oil and gas hydraulically fractured well information from the California Division of Oil, Gas, and Geothermal Resources. Table SR-5 provides agency-specific groundwater quality information.

Land Subsidence Monitoring

Land subsidence occurs in areas experiencing significant declines in groundwater levels. When groundwater is extracted from aquifers in sufficient quantity, the groundwater level is

Figure SR-7 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Sacramento River Hydrologic Region



Sacramento River Hydrologic Region GW well monitoring summary[1]

by GW Monitoring Entity	Number of Wells
CASGEM	336
Monitoring cooperator	181
DWR	635
USGS	4
USBR	150
by GW Well Type	
Domestic	268
Irrigation	473
Observation	422
Public supply	6
Other	137
Total	**1,306**

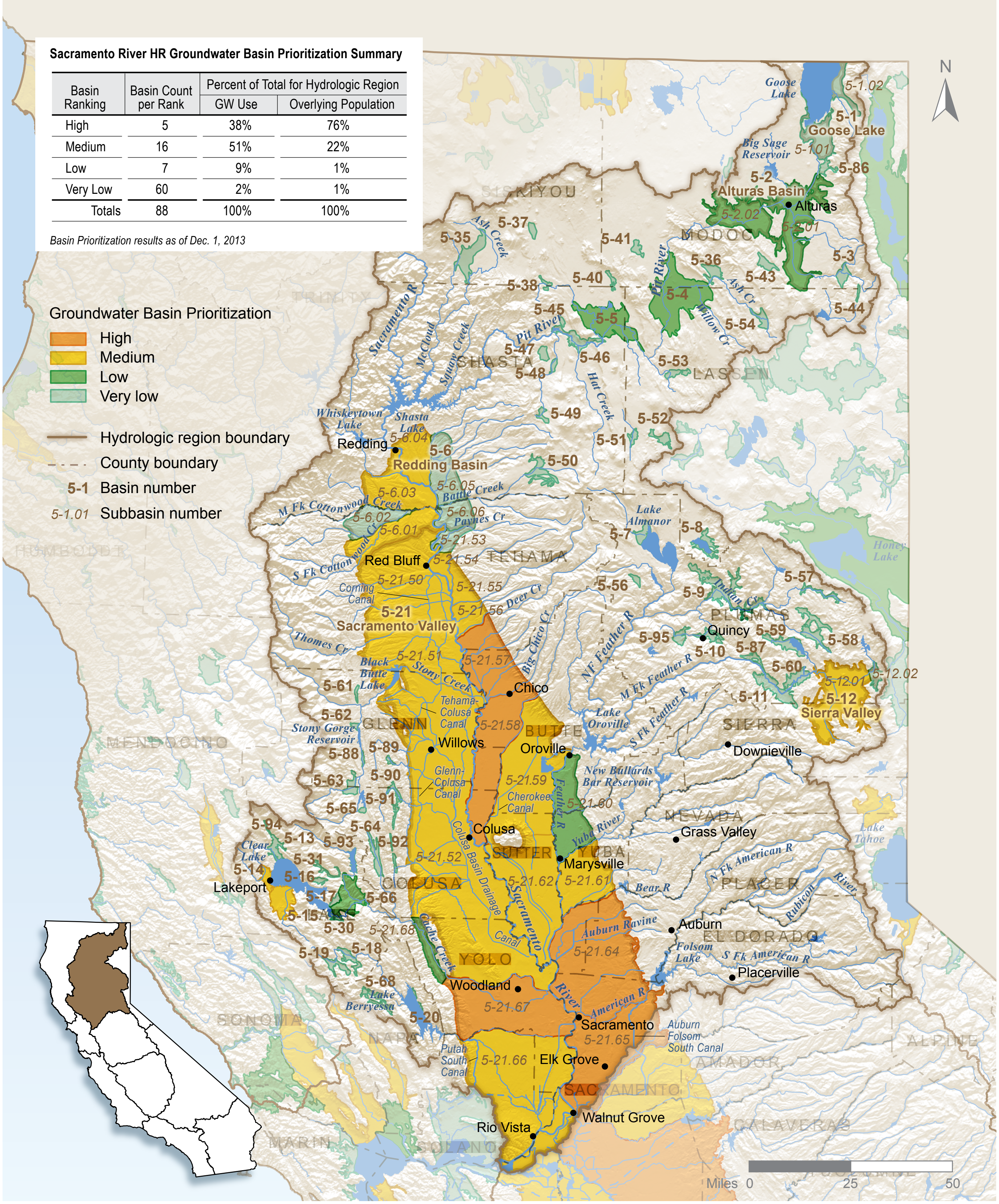
1. Represents GW level monitoring information as of July, 2012

Table SR-3 **Groundwater Level Monitoring Wells by Monitoring Entity in the Sacramento River Hydrologic Region**

State and Federal Agencies	Number of Wells
Department of Water Resources	635
U.S. Geological Survey	4
U.S. Bureau of Reclamation	150
Total State and federal wells	**789**
Monitoring Cooperators	**Number of Wells**
Colusa Rancheria	8
Sacramento County	18
Sutter County	6
Sutter South Water District	1
Yolo County Flood Control and Water Conservation District	118
Yuba County	30
Total cooperator wells	**181**
CASGEM Monitoring Entities	**Number of Wells**
Butte County Department of Water & Resource Conservation	70
City of Roseville	11
Colusa County	28
County of Glenn, Department of Agriculture	82
Feather Water District	4
Reclamation District No. 1500	7
Sacramento Central Groundwater Authority	24
Sacramento Groundwater Authority	35
Shasta County	3
South Sutter Water District	20
Sutter Extension Water District	9
Tehama County Flood Control & Water Conservation District	27
Water Resources Association of Yolo County	6
Yuba County Water Agency	10
Total CASGEM monitoring wells	**336**
Grand total	**1,306**

Notes:
CASGEM = California Statewide Groundwater Elevation Monitoring
Table includes groundwater level monitoring wells having publicly available online data.
Table represents monitoring information as of July 2012.

Figure SR-8 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region



Sacramento River HR Groundwater Basin Prioritization Summary

Basin Ranking	Basin Count per Rank	Percent of Total for Hydrologic Region: GW Use	Percent of Total for Hydrologic Region: Overlying Population
High	5	38%	76%
Medium	16	51%	22%
Low	7	9%	1%
Very Low	60	2%	1%
Totals	88	100%	100%

Basin Prioritization results as of Dec. 1, 2013

Table SR-4 CASGEM Groundwater Basin Prioritization for the Sacramento River Hydrologic Region

Basin Prioritization	Count	Basin/Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	1	5-21.58	Sacramento Valley	West Butte	36,152
High	2	5-21.65	Sacramento Valley	South American	718,113
High	3	5-21.64	Sacramento Valley	North American	832,746
High	4	5-21.57	Sacramento Valley	Vina	71,397
High	5	5-21.67	Sacramento Valley	Yolo	194,158
Medium	1	5-21.52	Sacramento Valley	Colusa	48,369
Medium	2	5-21.54	Sacramento Valley	Antelope	6,124
Medium	3	5-12.01	Sierra Valley	Sierra Valley	2,196
Medium	4	5-21.59	Sacramento Valley	East Butte	38,465
Medium	5	5-21.51	Sacramento Valley	Corning	18,852
Medium	6	5-14	Scotts Valley		6,553
Medium	7	5-21.62	Sacramento Valley	Sutter	82,125
Medium	8	5-6.04	Redding Area	Enterprise	68,627
Medium	9	5-15	Big Valley		6,344
Medium	10	5-21.66	Sacramento Valley	Solano	119,263
Medium	11	5-6.03	Redding Area	Anderson	52,937
Medium	12	5-6.01	Redding Area	Bowman	7,165
Medium	13	5-21.50	Sacramento Valley	Red Bluff	28,053
Medium	14	5-21.61	Sacramento Valley	South Yuba	45,014
Medium	15	5-21.56	Sacramento Valley	Los Molinos	2,220
Medium	16	5-21.55	Sacramento Valley	Dye Creek	1,626
Low	7	See *California Water Plan Update 2013*, Volume 4, *Reference Guide* article – "California's Groundwater Update 2013."			
Very Low	60	See *California Water Plan Update 2013*, Volume 4, *Reference Guide* article – "California's Groundwater Update 2013."			
Totals	**88**	**Population of groundwater basin area**			**2,450,515**

Notes:

Senate Bill 7X 6 (SB 7X 6; Part 2.11 to Division 6 of the California Water Code Sections 10920 et seq.) requires, as part of the CASGEM program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data that include the population overlying the basin, the rate of current and projected growth of the population overlying the basin, the number of public supply wells that draw from the basin, the total number of wells that draw from the basin, the irrigated acreage overlying the basin, the degree to which persons overlying the basin rely on groundwater as their primary source of water, any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and any other information determined to be relevant by the DWR."

Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 alluvial groundwater basins and categorized them into five groups - very high, high, medium, low, and very low.

lowered and the water pressure, which supports the sediment grains structure, decreases. In unconsolidated deposits, as aquifer pressures decrease, the increased weight from overlying sediments may compact the fine-grained sediments and permanently decrease the porosity of the aquifer and the ability of the aquifer to store water. Elastic land subsidence is the reversible and temporary fluctuation of earth's surface in response to seasonal groundwater extraction and recharge. Inelastic land subsidence is the irreversible and permanent decline in the earth's surface due to the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system (U.S. Geological Survey 1999). Land subsidence thus results in irreversible compaction of the aquifer and permanent loss of aquifer storage capacity and has serious effects on groundwater supply and development. Land subsidence due to aquifer compaction causes costly damage to the gradient and flood capacity of conveyance channels, to water system infrastructure (including wells), and to farming operations.

Land subsidence investigations in the Sacramento River Hydrologic Region include monitoring efforts such as,

- **Borehole Extensometer Monitoring**: A borehole extensometer is designed to act as benchmark anchored to a geologically stable portion of the lower aquifer. The first extensometer installed by DWR in the Sacramento River Hydrologic Region was in 1992; another was installed in 1994; and eight were installed in the early 2000s. In 1992, DWR began maintaining and monitoring an extensometer that USGS installed in 1988. The locations of the extensometers were based on geographic distribution in the center portion of the valley and where access to a site could be obtained. The extensometers range from 700 feet to over 1,000 feet deep within the unconsolidated sediments of the Sacramento Valley. DWR also measures groundwater levels in monitoring wells near each extensometer. Together, these data show a correlation between land subsidence and groundwater declines during the growing season, and land recovery as groundwater rises in winter.
- **Global Positioning System (GPS) Array Monitoring**: In 2008, DWR, together with 20 State, federal, and local agencies, installed and surveyed a land elevation measurement network in the Sacramento Valley. The Sacramento Valley Height-Modernization Project provides accurate measurements of land surface elevations with GPS technology using a consistent vertical datum known as "NAVD88." The GPS station network consists of 339 survey monuments spaced about 3 to 5 miles, 7 kilometers apart, and covers all or part of 10 counties. The network extends from northern Sacramento County eastward to the USBR's Folsom Lake network, southwest to DWR's Delta/Suisun Marsh network, and north to USBR's Lake Shasta network. The network is scheduled to be resurveyed on a 3-year frequency to measure elevation changes over time.

Results associated with the subsidence monitoring are provided under the "Land Subsidence" section later in this report.

Ecosystems

Much of the following ecosystem discussion is based around the Sacramento River riparian corridor. The Sacramento River corridor (river channel and floodplain) is composed of several habitat types. The habitats evolve with changes in channel movement, hydrology, and the different stages of plant communities and include riparian forests, shady and bare eroding stream banks, sloughs, side channels, riparian grasslands, large woody debris and snags, and sand and gravel bars.

Table SR-5 Sources of Groundwater Quality Information for the Sacramento River Hydrologic Region

Agency	Links to Information
State Water Resources Control Board http://www.waterboards.ca.gov/	Groundwater http://www.waterboards.ca.gov/water_issues/programs/#groundwater • Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml • Hydrogeologically Vulnerable Areas http://www.waterboards.ca.gov/gama/docs/hva_map_table.pdf • Aquifer Storage and Recovery http://www.waterboards.ca.gov/water_issues/programs/asr/index.shtml GAMA http://www.waterboards.ca.gov/gama/index.shtml • GeoTracker GAMA (Monitoring Data) http://www.waterboards.ca.gov/gama/geotracker_gama.shtml • Domestic Well Project http://www.waterboards.ca.gov/gama/domestic_well.shtml • Priority Basin Project http://www.waterboards.ca.gov/water_issues/programs/gama/sw_basin_assesmt.shtml • Special Studies Project http://www.waterboards.ca.gov/water_issues/programs/gama/special_studies.shtml • California Aquifer Susceptibility Project http://www.waterboards.ca.gov/water_issues/programs/gama/cas.shtml Contaminant Sites Land Disposal Program http://www.waterboards.ca.gov/water_issues/programs/land_disposal/ Department of Defense Program http://www.waterboards.ca.gov/water_issues/programs/dept_of_defense/ Underground Storage Tank Program http://www.waterboards.ca.gov/ust/index.shtml Brownfields http://www.waterboards.ca.gov/water_issues/programs/brownfields/
California Department of Public Health http://www.cdph.ca.gov/Pages/DEFAULT.aspx	Division of Drinking Water and Environmental Management http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx • Drinking Water Source Assessment and Protection (DWSAP) Program http://www.cdph.ca.gov/certlic/drinkingwater/Pages/DWSAP.aspx • Chemicals and Contaminants in Drinking Water http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chemicalcontaminants.aspx • Chromium-6 http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx • Groundwater Replenishment with Recycled Water http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Waterrecycling.aspx

Agency	Links to Information
California Department of Water Resources http://www.water.ca.gov/	Groundwater Information Center http://www.water.ca.gov/groundwater/index.cfm Bulletin 118 Groundwater Basins http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm California Statewide Groundwater Elevation Monitoring (CASGEM) http://www.water.ca.gov/groundwater/casgem/ Groundwater Level Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_level_monitoring.cfm Groundwater Quality Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_quality_monitoring.cfm Well Construction Standards http://www.water.ca.gov/groundwater/well_info_and_other/well_standards.cfm Well Completion Reports http://www.water.ca.gov/groundwater/well_info_and_other/well_completion_reports.cfm
California Department of Toxic Substances Control http://www.dtsc.ca.gov/	EnviroStor http://www.envirostor.dtsc.ca.gov/public/
California Department of Pesticide Regulation http://www.cdpr.ca.gov/	Groundwater Protection Program http://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm Well Sampling Database http://www.cdpr.ca.gov/docs/emon/grndwtr/gwp_sampling.htm Groundwater Protection Area Maps http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_maps.htm
U.S. Environmental Protection Agency http://www.epa.gov/safewater/	US EPA STORET Environmental Data System http://www.epa.gov/storet/
U.S. Geological Survey http://ca.water.usgs.gov/	USGS Water Data for the Nation http://waterdata.usgs.gov/nwis)

With respect to riparian plant communities, each plant community in the river corridor is a successional community or "stage" that leads to the establishment of the next successional stage and so on, until a final stage or climax plant community develops. Over time, one plant community replaces another plant community and each serves a variety of wildlife species. The dynamic nature of the river system is the essential component of this diversity. As the course of the river changes and as plant communities evolve, both the species and the composition of plant and wildlife communities change. Geomorphic processes that support this regeneration and habitat diversity include river meander, sediment deposition of spawning gravels and point bars, and gradual accretion of the floodplain. These processes are the focus of several restoration efforts in the corridor.

In its handbook, Sacramento River Conservation Area Forum (2003)estimates that approximately 23,000 acres of riparian habitat and valley oak woodland remain within the corridor which is about 11 percent of the original habitat. Over time, water development projects have altered natural geomorphic river processes resulting in a reduction of spawning habitat and fragmentation of riparian systems. With the construction of Shasta Dam, winter flows have lessened; and summer flows are higher. Levees have also had a role in the pattern of flooding and sediment deposition along the river, which has impacted plant community succession necessary for the natural establishment of riparian habitat. Other tributaries below Shasta Dam are unregulated and still contribute to flood flows necessary to aid in community succession.

There are four distinct reaches of the Sacramento River within the valley from Keswick Dam to Verona. The reaches are defined as follows:

- Keswick to Red Bluff.
- Red Bluff to Chico Landing.
- Chico Landing to Colusa.
- Colusa to Verona.

Each of the reaches are distinct from one another due to regional hydrology, geology, flood control measures, and habitat. The reach between Keswick Dam and Red Bluff is relatively confined due to geologic formations. Adjacent riparian vegetation is typically narrow. The floodplain is less than a mile wide and narrows to less than 500 feet in some places (Sacramento River Conservation Area Forum 2003). The reach of the river contains the only existing habitat for winter-run Chinook salmon. With the construction of Shasta and Keswick dams and the elimination of an estimated 187 miles of habitat that were available upstream of the dams, winter-run salmon were reduced from four independent populations to one dependent population. Fish habitat was also impacted with the elimination of recruitment spawning gravels, which is estimated to be on the order of 100,000 tons per year (Buer 1985). Since 1978, spawning gravel has been periodically replenished in the upper reaches of the river. CVPIA projects have also been implemented to increase the availability of spawning gravel and rearing habitat (California Department of Fish and Game 2011). Since completion of the temperature control device at Shasta Dam and increased flows, this reach of river can provide optimal water temperatures.

Within the reach between Red Bluff and Chico Landing, the river meanders over a broad alluvial floodplain ranging between 1.5 to 4 miles wide and provides some of the remaining riparian habitat. The river is also constrained in some places by older, more consolidated and erosion-resistant formations. Several tributaries drain surrounding uplands within this reach and the Keswick to Red Bluff reach and contribute to flood flows necessary for riparian forest succession.

Within the Chico Landing to Colusa reach, setback levees control the release of floodwater to adjoining basins through a system of weirs and bypasses. The setback levees allow for river meander creating extensive tracts of riparian vegetation. Stony Creek is the only tributary to the river.

The main channel of the Colusa to Verona reach is tightly leveed with much of the riparian vegetation existing as linear strips along the levees and levee berms. The river is essentially channelized. Most floodwater leaves the main channel through sloughs and weirs.

Flood

Flooding in the Sacramento River Hydrologic Region is slow-rise, flash, or stormwater flooding. In the Sacramento River Hydrologic Region, exposure to a 500-year flood event threatens approximately one in three residents, almost $65 billion of assets (crops, buildings, and public infrastructure), 1.2 million acres of agricultural land, and over 340 sensitive species. Also, almost

95 percent of Sutter County residents, more than 55 percent of Yuba County and Yolo County residents, and more than 50 percent of agricultural land region-wide are exposed to the 500-year flood event.

While the focus of this section is on major flooding events, smaller flooding often occurs every year and results in costs that must be borne at local levels — most of the time by the individual property owners. In addition, Highway 162 between Butte and Glenn counties is rendered inaccessible due to nuisance flooding nearly every year.

Early flood history most notably includes the 1861-1862 floods (the "Great Flood"). This flood was remarkable for the exceptionally high stages reached on most streams, repeated large floods, and prolonged and widespread inundation in the Sacramento River Basin. Lower elevations experienced heavy rain, and upper elevations received continuous snowfall. Reports published during this flooding period describe the lower Sacramento River basin as one vast sea of water. Overflow from the American River led to the flooding of the City of Sacramento, causing loss of life and property, while flooding from the Sacramento River enveloped large sections of the lowlands around Colusa, severely damaging ranches and drowning or starving cattle. It was this flood that provided the impetus for raising the levees around the City of Sacramento.

Since 1950, several sizeable floods have inundated portions of the Sacramento River Hydrologic Region. The floods of 1955, 1964, 1967, 1969, 1970, and 1974 were all characterized by extremely large flows, including record flows at some locations. The Sacramento River Flood Control Project and other flood management programs had been implemented, and project levees, dams, reservoirs, and waterways were employed to control much of the flood flows through the Sacramento system.

For a complete list of floods in the Sacramento River Hydrologic Region, refer to the *California's Flood Future Report Attachment C: Flood History of California Technical Memorandum* (California Department of Water Resources and the U.S. Army Corps of Engineers 2013a).

Climate

The northernmost area, mainly high desert plateau, is characterized by cold, snowy winters with only moderate rainfall, and hot, dry summers. The mountainous parts in the north and east typically have cold, wet winters with large amounts of snow providing runoff for summer water supplies. The Sacramento Valley floor has mild winters with less precipitation and hot, dry summers. Overall annual precipitation in the region generally increases from south to north and west to east. The snow and rain that fall in this region contribute to the overall water supply for the entire state.

Demographics

Population

The Sacramento River Hydrologic Region had a population of 2,983,156 people according to the 2010 census, placing it third — only to the South Coast and San Francisco Bay hydrologic regions — out of California's 10 hydrologic regions. The three largest cities are Sacramento, Roseville, and Redding. The region had a growth rate of 3.31 percent between 2006 and 2010

(98,714 people). According to the California Department of Finance, the population in the region is expected to increase to 3,679,614 by 2030 (Table SR-6).

Tribal Communities

There are a number of federally recognized tribes in the Sacramento River Hydrologic Region (Table SR-7). More information on tribal communities is also presented in the "Integrated Regional Water Management Plan Summaries" section later in this report.

Federal Clean Water Act (CWA) Programs and Tribes

In the Sacramento River Hydrologic Region, six federally recognized tribes are eligible for Clean Water Act Section 319 program funding to implement approved programs and on-the-ground projects to reduce non-point-source pollutions problems. The tribes are Big Valley Band of Pomo Indians, Cortina Indian Rancheria of Wintun Indians, Middletown Rancheria of Pomo Indians, Pit River Tribe, Redding Rancheria, and Robinson Rancheria of Pomo Indians.

Section 106 of the Clean Water Act allows tribes to address water quality issues by developing monitoring programs, water quality assessment, standards development, planning, and other activities intended to manage reservation water resources. In the Sacramento River Hydrologic Region, seven tribes are involved in Section 106 programs and activities: Big Valley Band of Pomo Indians, Cortina Indian Rancheria of Wintun Indians, Elem Indian Colony of Pomo Indians, Middletown Rancheria of Pomo Indians, Redding Rancheria, Robinson Rancheria of Pomo Indians, and Pit River Tribe.

Tribes with two or more grants and consistently good performance may be eligible to apply for a Performance Partnership Grant (PPG). Four tribes have PPGs: Middletown Rancheria of Pomo Indians, Redding Rancheria, Robinson Rancheria of Pomo Indians, and Pit River Tribe.

Disadvantaged Communities

The geographic area of the Sacramento River hydrologic region encompasses all or portions of 20 different counties. Almost all counties have at least one community that qualifies as a disadvantaged community (DAC). DWR defines DACs as communities and neighborhoods (census-designated places) with an annual median household income of less than 80 percent of the statewide average (or incomes less than $48,706). Of the region's 282 identified communities, 155 are defined as DACs.

Counties where 50 percent or more of the communities within the region qualify as disadvantaged include Butte (53 percent), Colusa (78 percent), Glenn (80 percent), Lake (80 percent), Modoc (88 percent), Nevada (58 percent), Plumas (72 percent), Shasta (68 percent), Siskiyou (100 percent), Tehama (67 percent), and Yuba (64 percent). Mapping tools to identify DACs can be found at http://www.water.ca.gov/irwm/grants/resourceslinks.cfm. The maps and GIS files are derived from the U.S. Census Bureau's American Community Survey (ACS) and are compiled for the five-year period 2006-2010.

Table SR-6 Population Estimates and Projections for the Sacramento River Hydrologic Region

County	Estimates[a]			Projections[b]			
	1990	2000	2010	2020	2030	2040	2050
Alpine	106	126	97	97	97	97	96
Amador	91	114	61	60	60	60	60
Butte	182,120	203,171	220,000	244,417	276,010	303,594	334,579
Colusa	16,275	18,804	21,419	24,521	28,112	31,573	35,043
El Dorado	61,214	75,428	85,120	95,169	103,873	112,256	120,707
Glenn	24,798	26,453	28,122	30,611	33,318	36,095	39,475
Lake	50,556	58,228	64,597	70,833	77,901	85,678	94,451
Lassen	3,831	3,740	3,337	3,279	3,248	3,228	3,213
Mendocino	0	0	0	0	0	0	0
Modoc	7,044	7,002	7,343	7,665	8,038	8,339	8,822
Napa	2,380	2,659	2,732	2,958	3,229	3,453	3,708
Nevada	69,247	77,782	82,126	86,094	90,440	93,799	98,038
Placer	161,580	233,571	334,907	381,188	438,797	504,156	573,210
Plumas	19,736	20,820	20,007	20,157	20,390	20,397	20,813
Sacramento	1,017,820	1,186,429	1,373,379	1,509,934	1,677,399	1,848,678	2,025,508
Shasta	147,036	163,256	177,223	196,087	210,997	222,459	233,524
Sierra	3,152	3,334	3,050	2,969	2,950	2,966	3,047
Siskiyou	11,282	11,368	10,636	10,884	11,124	11,288	11,462
Solano	90,765	111,996	117,796	127,295	139,262	150,885	162,237
Sonoma	0	0	0	0	0	0	0
Sutter	64,415	78,930	94,737	108,054	131,390	161,504	199,590
Tehama	49,625	56,039	63,463	68,769	75,522	82,290	90,918
Yolo	141,210	168,660	200,849	223,181	250,420	276,276	296,183
Yuba	58,228	60,219	72,155	83,363	97,037	112,790	131,531
Totals	2,182,511	2,568,129	2,983,156	3,297,585	3,679,614	4,071,861	4,486,215

Source: California Department of Finance 2010.

Notes:

Values represent population in the Sacramento River Hydrologic Region.

[a] Estimates are for April of each year.

[b] Projections are for July of each year.

Table SR-7 Federally Recognized Tribes in Sacramento River Hydrologic Region

Name of Tribe	Cultural Affiliation
Alturas Indian Rancheria	Achomawi
Berry Creek Rancheria of Maidu Indians	Tyme Maidu
Big Valley Band of Pomo Indians	Pomo
Cachil DeHe Band of Wintun Indians of the Colusa Indian Community	Wintun
Cedarville Rancheria	Northern Paiute
Cortina Indian Rancheria of Wintun Indians	Wintun
Elem Indian Colony of Pomo Indians	Pomo
Enterprise Rancheria of Maidu Indians	
Fort Bidwell Indian Community of the Fort Bidwell Reservation of California	Northern Paiute
Greenville Indian Rancheria of Maidu Indians	Maidu
Grindstone Indian Rancheria of Wintun-Wailaki Indians of California	Wintun, Wailaki
Habematolel Pomo of Upper Lake	Pomo
Koi Nation - Lower Lake Rancheria	Pomo
Mechoopda Indian Tribe of Chico	Maidu
Middletown Rancheria of Pomo Indians	Pomo, Lake Miwok
Mooretown Rancheria of Maidu Indians	Maidu
Paskenta Band of Nomlaki Indians	Nomlaki
Pit River Tribe (includes XL Ranch, Big Bend, Likely, Lookout, Montgomery Creek and Roaring Creek Rancherias)	Achomawi (Achumawi, Ajumawi), Aporidge, Astariwawi (Astarawi), Atsuge (Atsugewi), Atwamsini
Redding Rancheria	Wintu, Yana, Pit River
Robinson Rancheria of Pomo Indians	Pomo
Scotts Valley Band of Pomo Indians	Pomo
United Auburn Indian Community of the Auburn Rancheria	Miwok, Maidu
Hanhawi (Hammawi), Hewisedawi, Ilmawi, (Non recognized)	
Itsatawi, Kosalextawi (Kosalektawi), Madesi (Non recognized)	

Source: Federal Register, Vol. 78, No. 87, May 6, 2013, http://www.gpo.gov/fdsys/pkg/FR-2013-05-06/pdf/2013-10649.pdf. Accessed on August 6, 2014.

Land Use Patterns

The Sacramento River Hydrologic Region between 2005 and 2010 supported about 1.95 million acres of irrigated agriculture on average. Approximately 1.58 million acres is irrigated on the valley floor. The surrounding mountain valleys within the region add about 370,000 irrigated acres to the region's total — primarily as pasture and alfalfa (Table SR-8).

Agriculture and its Role in the Regional Economy

The gross value of agricultural production in the Sacramento Valley for 2011 was about $4.1 billion (California Department of Food and Agriculture 2013). Rice and walnuts are the highest grossing crops in the region followed by almonds and tomatoes. Though agricultural production in the valley is significant, the overall economic effect on the region, to some, might not be as obvious.

Determining the role of agriculture with respect to the local economy depends on how agriculture is defined. *The Measure of California Agriculture* (MOCA) by the University of California Agricultural Issues Center examines of the role of agriculture and its economic effects using 2002 data. The model used in this assessment shows agriculture's far-reaching effects and relative importance to the region.

Many industries are related to farm production. MOCA defines agriculture as including farm production, forestry, fishing, hunting, and support services such as soil preparation, planting, harvesting, and management. Agricultural "support" activities also include contract labor, fertilizer and pesticides manufacturing, packing and cooling, and cotton ginning. Agricultural "processing" includes animal feed, food and beverage industries. MOCA uses a model to help define the interactions between different industry sectors. For any given industry, the model enables quantification of outputs (value of production), jobs, labor income, and value added in relation to the entire economy.

Agricultural Production

The economic benefits derived from agriculture are based on three types of effects – direct, indirect, and induced. The direct effects of agriculture are the total production value, the number of jobs created, labor income, and value added. For Sacramento Valley (Butte, Colusa, Glen, Sacramento, Solano, Sutter, Tehama, Yolo, and Yuba counties), the total agriculture production value for 2002 was approximately $3.5 billion, roughly 9.5 percent of statewide cash farm receipts. Agriculture production created about 41,000 jobs with a labor income of about $900 million (University of California Agricultural Issues Center 2009).

The indirect effects are the secondary inter-agriculture business-to-business transactions such as sales of fertilizer, farm equipment, and other goods and services purchased by producers. The induced effects are the changes in household consumption of goods and services measured in employment and income. The total economic effects from Sacramento Valley agriculture production (including direct, indirect, and induced effects) brings about 62,000 jobs to the region with a labor income of about $1.5 billion (University of California Agricultural Issues Center 2009).

Table SR-8 Irrigated Acreage Estimates in the Sacramento River Hydrologic Region

Region	Data Analysis Unit(s)	Crop Type (acreage)
Sacramento Valley Floor	167, 166, 164, 170, 144, 162, 172, 142, 173, 186, 191, 163, 171, 168	Grain (117,900) Rice (504,300) Alfalfa (135,800) Pasture (125,100) Almonds/Pistachios (150,300) Other Deciduous (236,400) Tomatoes (70,000)
Pit River Watershed	132, 130, 134	Pasture (74,500) Alfalfa (24,800) Grain (15,500)
Redding/Cow Creek	145, 143, 141	Pasture (22,400)
Feather River Watershed	154	Pasture (46,000) Alfalfa (8,600)

Agricultural Processing

MOCA identifies over 4,600 businesses in California that process farm products to produce foods, beverages, and tobacco. Bakery and tortilla manufacturing has the largest number of establishments and employees. The beverage industry is the largest in terms of sales, followed by fruit and vegetable processing and dairy products. In Sacramento Valley, output from agricultural processing in 2002 was about $4.5 billion providing over 13,000 jobs. Labor income was on the order of $684 million. The total economic effects from agricultural processing (including direct, indirect, and induced effects) equates to about 40,000 jobs to the region with a labor income of about $1.5 billion (University of California Agricultural Issues Center 2009).

Total Economic Effects

It's important to note that indirect and induced effects of agricultural processing include some of the same jobs and labor income counted under agricultural production. These effects cannot be combined; however, when considering agricultural production and processing sectors as a whole, agriculture provided over 95,000 jobs with a labor income of over $3 billion in 2002 (University of California Agricultural Issues Center 2009).

Forecasting Economic Impacts of Reduced Water Supply

Agriculture is a dominant contributor to the local economy for many counties in the region. Several of these counties also have some of the highest percentages of DACs in the state. The relative importance of agriculture underscores the importance of irrigation water supplies to the region. Reduction of surface water supplies that result in crop fallowing reduces agricultural production, agricultural processing, jobs, labor income, and indirect business taxes. The degree of economic impact depends on the scale of the local economy and its reliance on surface water resources.

Rice is particularly dependent on surface water and is the highest grossing crop for Glenn, Colusa, Sutter, Yuba counties. Butte County also has a substantial rice crop. During periods of reduced water deliveries, low value crops are generally targeted for crop fallowing. Large reductions in rice acreage also occur relative to other crops.

Methods developed to forecast the impacts of reduced water supplies and fallowing focus on changes in irrigated acreage, crop type, revenue, and job-loss. The most apparent impact is reduced revenue. The impacts to jobs and labor income are less obvious, and general parameters have been established to help estimate these impacts. *Economic Impacts of Irrigation Water Cuts in the Sacramento Valley* by the University of California Agricultural Issues Center (1999) provides a summary of employment and income multipliers for the major crop types grown in Sacramento Valley. These multipliers vary depending on the county and the type of crop and can be used to estimate the regional impacts due to fallowing. For example, between 8.6 (Glenn County) and 13.3 jobs (Butte County) are lost per million dollars lost for rice; 7.2 (Tehama County) to 11.4 jobs (Butte County) are lost per million dollars lost for alfalfa and hay; and 11.6 (Tehama County) to 24.4 jobs (Sacramento County) are lost for fruits and tree nuts per million dollars lost (University of California Agricultural Issues Center 1999). The indirect impacts due to lost labor income can also be estimated with income multipliers developed by county and crop type.

Regional Resource Management Conditions

Water in the Environment

While water in the environment is critically important to support fisheries in this region, water also supports large tracts of land which support a diverse amount of native flora and fauna, including many identified to be endangered species. The region is an important part of the migratory route of the Pacific Flyway and is an important wintering site for migratory waterfowl. It is estimated that the valleys seasonal marshes and winter flooded rice fields attract approximately 5 million ducks each winter (California Rice Commission 2012).

The focus of several State, federal, and local agencies in the region is the restoration of spawning and rearing habitats of the major rivers and tributaries and the recovery of listed species. Winter-run salmon are listed as endangered under the federal Endangered Species Act and the California Endangered Species Act. Spring-run salmon, steelhead, and green sturgeon are listed as threatened. The loss of habitat and the different life cycles of winter-run salmon, spring-run salmon, and steelhead require that available resources are managed to provide the most optimal conditions possible to lessen the possibility of extinction.

One of the key recovery/habitat restoration programs for the Sacramento River Region has been the Anadromous Fish Restoration Program. AFRP was established in 1992 under the CVPIA and supports protection, restoration, and enhancement of special status species and habitat that are affected by the CVP. The purpose of the program is to determine baseline production estimates for Central Valley streams for naturally produced Chinook salmon and other anadromous species and to ensure their sustainability at levels not less than twice the average levels attained during the period 1967-1991. The AFRP fish population goals are fall run Chinook (750,000), late-fall run Chinook (68,000), winter run Chinook (110,000), and spring-run Chinook (68,000). During the period from 1967 to 1991, the total average annual fish population for all runs of Chinook was approximately 497,054. Since the enactment of AFRP, the total annual fish population for the period 1992 to 2010 was 410,790 — a decrease of almost 90,000 fish. This low population average is partially due to the 2010 fall run returns, which totaled 102,735 fish. On the positive side, the watershed doubling goal was exceeded for Clear Creek, Butte Creek, and Battle Creek (U.S. Bureau of Reclamation 2012). The six species identified for recovery under this program are Chinook salmon, steelhead, striped bass, American shad, white sturgeon, and green sturgeon (U.S. Bureau of Reclamation 2003).

Restoration/recovery projects that have received funding through CVPIA include the temperature control device on Shasta Dam, removal of the McCormick-Saeltzer Dam on Clear Creek, spawning gravel replenishment, and most recently, the Red Bluff Diversion Dam Fish Passage Improvement. The Anadromous Fish Screen Program (another CVPIA program) supports the AFRP and has facilitated the screening of 33 priority diversions since 1994. Currently, there are about 750 unscreened diversions (agricultural and M&I) in the Sacramento River system (U.S. Bureau of Reclamation 2011e).

The CALFED Ecosystem Restoration Program (ERP) is the principal CALFED program designed to restore the ecological health of the Delta and Central Valley. DFW is the implementing agency for the State. The ERP and associated plans are discussed in more detail below.

Other planning that addresses the recovery of listed species is the NMFS Public Draft Recovery Plan (2009a) for salmon and steelhead. The NMFS is required to evaluate factors affecting the species and identify recovery criteria and actions necessary to achieve recovery. The recovery plan identifies site-specific actions necessary for species recovery and provides measurable criteria necessary for delisting the species.

CALFED Ecosystem Restoration Program

With the signing of the CALFED Programmatic Record of Decision (ROD) in 2000, restoration efforts were put in motion that set the long-term direction of the 30-year CALFED program. The CALFED Program is made up of the Levee System Integrity Program, Water Quality Program, ERP, Water Use Efficiency Program, Water Transfer Program, Watershed Program, Storage Program, and Conveyance Programs. The implementing agencies are the USFWS, DFW, and the NMFS.

The intent of the ERP and Watershed Program is to restore the Bay-Delta ecosystem and recover listed species in the watersheds above the Bay-Delta Estuary. The foundation of the ERP is the restoration of processes associated with streamflow, stream channels, watersheds, and floodplains (California Department of Fish and Game et al. 2010). The purpose of the Watershed Program is to promote resource management programs and projects at the watershed level and to improve local management capacity within watershed communities. The program has helped to establish and maintain locally led watershed restoration, maintenance, conservation, and monitoring efforts, and to improve the scientific basis for flow-related actions.

The ERP was designed as a two-stage program. Implementation of Stage 1 began shortly after the issuance of the ROD. Stage 1 covered the first seven years of the 30-year program with the intention of building a foundation for long-term program actions. ERP studies and restoration projects have helped to identify how the Sacramento River flow regime and management actions influence habitats, species, and hydrogeomorphic processes (California Department of Fish and Game 2011). Examples of Stage 1 restoration projects include:

- Fish passage improvement projects on Butte Creek, Battle Creek, Clear Creek, and Mill Creek.
- Habitat restoration in the Yolo Bypass.
- Construction of two fish ladders and improvement of fish screens at the Anderson Cottonwood Irrigation District dam.
- Restoration of Battle Creek Salmon and Steelhead habitat through the removal of five dams and the addition of screens and ladders to three other dams.
- Construction of a new screen structure at Red Bluff Diversion Dam.

Stage 2 is intended to focus on the needs of species and ecosystem components considered to be at high risk. The program focus will be on habitat restoration, rehabilitation of ecological processes, reduction of stressor impacts, and on the actions necessary to meet specific information needs (California Department of Fish and Game et al. 2010). Examples of actions and projects identified include:

- Continue to prioritize fish habitat and fish passage restoration projects particularly for spring-run Chinook salmon and steelhead trout.
- Restore 50 to 100 miles of tidal channels in the Yolo Bypass by constructing a network of channels within the bypass that connect to the Delta.
- Remove small, non-essential dams on gravel-rich streams.
- Establish weed control programs to suppress the expansion of tamarisk, giant reed, locust, and other invasive non-native plants degrading habitat quality and native flora.
- Design, permit, and construct priority fish screen projects on the Sacramento River.
- Investigate whether individual species' respective range of distribution can be extended or changed.

National Marine Fisheries Service Central Valley Salmon and Steelhead Recovery Plan

The federal Endangered Species Act requires the NMFS to develop and implement recovery plans for listed species. The recovery plan for Sacramento River and Central Valley salmon and steelhead species was published in 2009. The plan identifies site-specific actions necessary for species recovery and provides measurable criteria necessary for delisting the species. Priorities for the reintroduction of selected species are also identified. The recovery plan is not a regulatory document, but serves as guidance for recovery efforts.

The plan identifies watersheds that have the physical and hydrological characteristics most likely to support viable fish populations and ranks the fish populations as Core 1, Core 2, and Core 3.

Core 1 populations have the highest priority for recovery actions based on the potential of the watershed to support independent fish populations. For a fish population within a watershed to be considered Core 1, the population must meet population-level criteria for low risk of extinction. Core 2 populations are considered important to recovery in that they provide for diversity, spatial distribution, and abundance of the species. Core 3 populations are not expected to reach population levels beyond that considered to be at a high risk of extinction but still provide for increased genetic diversity.

Table SR-9 identifies each water body and its NMFS priorities for recovery and/or species reintroduction.

State Water Resources Control Board Instream Flow Studies

The Delta Reform Act of 2009 requires the SWRCB and DFW to complete instream flow studies for high priority rivers and streams by 2018. The flow studies are intended to be based on what would be needed if fishery protection were the sole purpose for which waters were put to beneficial use. The studies do not take other beneficial uses into account such as municipal and agricultural water supplies and recreational uses. SWRCB recognizes that establishing flow objectives is a multidimensional balancing effort and that fishery protection represents only one of the factors (State Water Resources Control Board 2010a). The following are identified for instream flow assessments:

- McCloud River.
- Pit River.
- Clear Creek.
- Cottonwood Creek.
- Antelope Creek.
- Battle Creek.
- Big Chico Creek.
- Cow Creek.
- Lower Butte Creek.
- Mill Creek.
- Deer Creek.
- Lower Feather River.
- American River.
- Yuba River.
- Bear River.

Medical Marijuana Cultivation and Watershed Impacts

Some of the unanticipated consequences resulting from the passage of Proposition 215 in 1996 and SB 420 in 2003 (allowing for medical use of marijuana and its sale through collectives) are the rise in ecological damages that are occurring in California's watersheds. The impacts of growing medical marijuana vary depending on whether it is produced in national forest, private land, or by hydroponic operations. Some of the impacts include (California Department of Fish and Game 2012):

- Unauthorized diversions from rivers, creeks, and streams.
- Lack of best management practices for roads, stream crossings, ponds, and cleared areas.
- Pollution from petroleum products, fertilizers, soils amendments, killing agents, sediment, thermal pollution, trash, and human waste
- Deforestation, conversion, and fragmentation of natural areas and wildlife habitat.
- Impacts to sensitive species and habitats.

This is both an urban and rural problem. Regulatory and planning approaches to reduce the environmental impacts have had its impediments. One issue concerns the federal government. The federal government has threatened to prosecute local officials if actions prohibited under U.S. law (such as growing marijuana) are somehow sanctioned through permitting or zoning. Requiring permits or providing zoning ordinances to help address the environmental impacts of growing marijuana can be considered to be sanctions of a federally prohibited activity (Zuckerman 2013). This viewpoint is changing with recent federal guidance provided by the U.S. Department of Justice. The guidance identifies federal enforcement priorities focusing on criminal enterprises, interstate trafficking, firearms, preventing the growing or possession of marijuana on public lands, and preventing state-authorized activity from being used as a cover or pretext for trafficking of other illegal drugs or other illegal activity (U.S. Department of Justice 2013).

Permits that can be enforced deal with site development on private lands consistent with State and federal law. These permits and associated requirements apply to any site preparation work, regardless of crop. Cultivation of medical marijuana may ultimately fall under the Agricultural Lands Discharge Program. Discharges of waste from site development and growing activities on U.S. Forestry Service land are not authorized and are subject to immediate enforcement actions under the CWC (State Water Resources Control Board 2013b).

Efforts to reduce the environmental damage are a focus of the 2014-15 State budget. Funding is proposed for several positions to address illegal diversions and impacts to water quality and sensitive habitats. Excerpts from the budget are provided below.

- **Enforcement of Marijuana Cultivation Laws** — $1.8 million Waste Discharge Permit Fund and 11 positions (for SWRCB) to improve the prevention of illegal stream diversions, discharges of pollutants into waterways, and other water quality impacts associated with marijuana production. Currently, marijuana cultivation is threatening water quality and the sensitive habitat of endangered species. This proposal will be a coordinated effort with DFW.
- **Marijuana Related Enforcement** — $1.5 million from various special funds and seven positions (for DFW) to investigate and enforce violations of illegal streambed alterations and the Endangered Species Act associated with marijuana production. Currently, marijuana cultivation is threatening water supply, water quality, and the sensitive habitat of endangered species. This proposal will be a coordinated effort with the SWRCB.

Water Supplies

Surface Supplies

Surface water supplies are managed through a complex water rights system. In simple terms surface water that is diverted from a stream must be covered under one of a mix of types of water

Table SR-9 NMFS Recovery Priorities for Selected Water Bodies in Sacramento Valley

Water Body	NMFS Recovery Priorities (Species – Recovery Priority)	NMFS Reintroduction Priorities (Species – Recovery Priority)
McCloud River		Winter-run Chinook Salmon – Primary Spring-run Chinook Salmon – Primary Central Valley Steelhead – Primary (Dependent on successful passage programs above Keswick and Shasta Dams)
Little Sacramento River (above Shasta Dam)		Winter-run Chinook Salmon – Primary Spring-run Chinook Salmon – Primary Central Valley Steelhead – Primary (Dependent on successful passage programs above Keswick and Shasta Dams)
Clear Creak	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
Cottonwood Creek	Spring-run Chinook Salmon – Core 2 Central Valley Steelhead – Core 2	
Cow Creek	Central Valley Steelhead – Core 2	
Antelope Creek	Spring-run Chinook Salmon – Core 2 Central Valley Steelhead – Core 1	
Battle Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	Winter-run Chinook Salmon – Primary
Big Chico Creek	Spring-run Chinook Salmon – Core 3 Central Valley Steelhead – Core 1	
Bear River (Tributary to the Feather River)	Spring-run Chinook Salmon – Core 3 Central Valley Steelhead – Core 3	
Lower Butte Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 2	
Mill Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
Deer Creek	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	

Water Body	NMFS Recovery Priorities (Species – Recovery Priority)	NMFS Reintroduction Priorities (Species – Recovery Priority)
Lower Feather River	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	
American River	Central Valley Steelhead – Core 2	Upper America River Spring-run Chinook Salmon – Second Central Valley Steelhead – Primary
Tuba River	Spring-run Chinook Salmon – Core 1 Central Valley Steelhead – Core 1	

Source: National Marine Fisheries Service 2009a

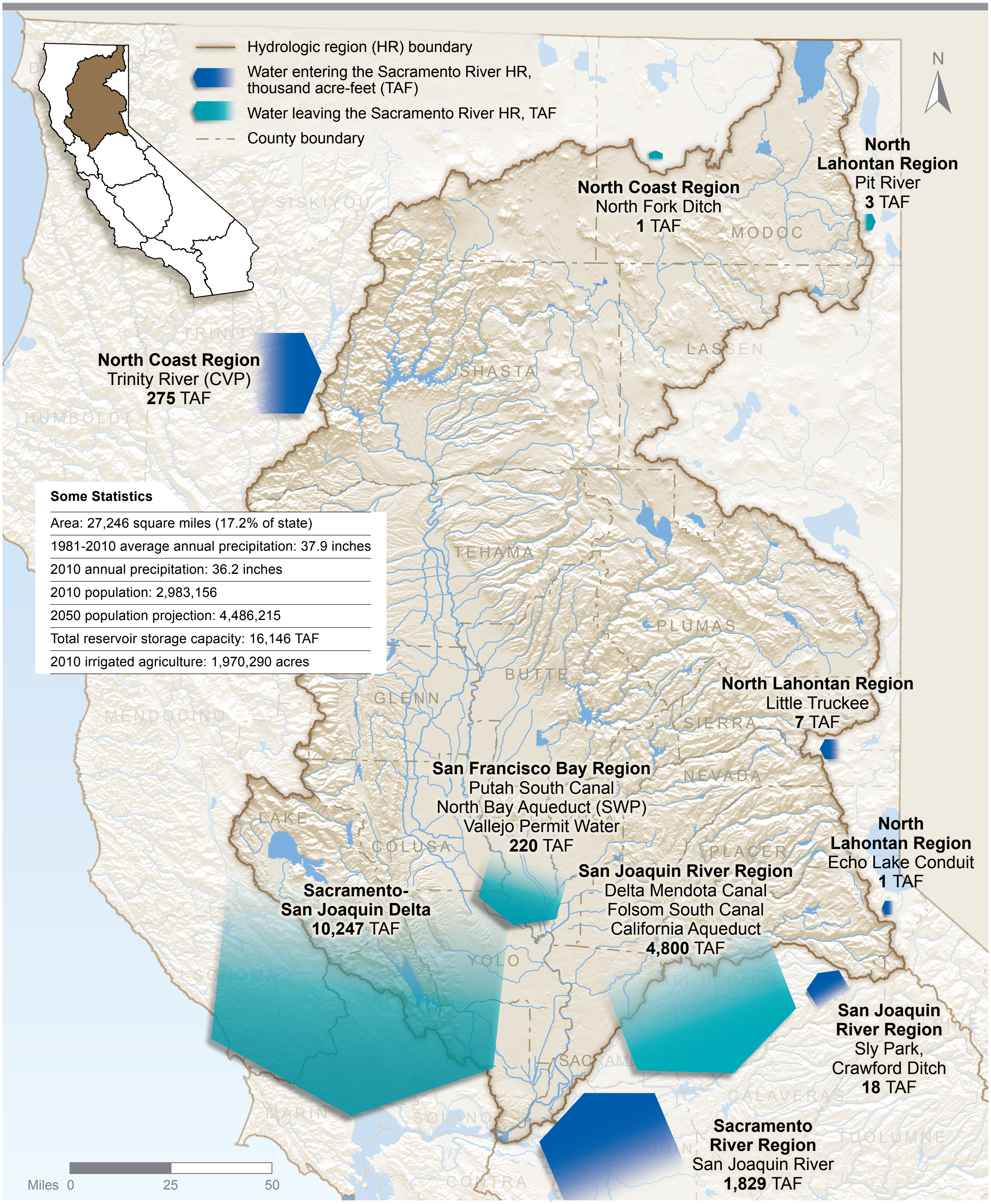
rights (Riparian, Pre and Post 1914 Appropriative, Tribal, Federal Reserved, and Spanish Land Grants) Many who receive water in this region do not directly hold a water right to divert from a stream but receive water as a contractor from a water district, the State Water Project (SWP) or the CVP, which are covered by a water rights held by the State and federal government for the benefit of their contractors. An overview of the regions inflows and outflows for 2010 is presented in Figure SR-9.

Surface water rights are administered by the Division of Water Rights, SWRCB. The priority to divert surface water in California is based on the type of right being claimed and the priority date amongst similar claimants. Post 1914 water right permits specify the season of use, purpose of use and place of use for the quantity of water authorized under the permit or license. In times of drought and limited supply, the most recent ("junior") right holder must be the first to discontinue use. In times of severe shortages, even senior water right holders will be required to reduce diversions and conserve water. In drought periods the State Water Board will notify certain water right holders in critically dry watersheds of the requirement to stop diverting water under their water right, based on their priority. A water right is not a guarantee of water, it can be compared it to a fishing license, you need one to fish but your success in landing a fish is not guaranteed.

For the SWP, the Department of Water Resources holds the water rights and manages the project for the benefit of their water contractors. Each year the contractors place a request for water and the Department forecasts what water is likely going to be available from the SWP. This is usually expressed as a percentage of the contract requests. This projection is done early and updated as more information is discovered each year closer to April, which essentially is the end of the season of precipitation. There is a priority amongst the contractors as well with the most senior allocations going to contractors with "settlement" contracts. These settlement contracts were negotiated in order to fulfill existing water rights that have been impacted due to the construction of the SWP facilities such as Oroville Dam.

For the CVP, the U.S. Bureau of Reclamation holds the water rights and manages the project for the benefit of their 271 water contractors similar to the operations of the SWP. The CVP has contractors north of Delta totaling 2,898,260 acre-feet (af) with a large portion of those being

Figure SR-9 Sacramento River Regional Inflows and Outflows in 2010



settlement contractors (2,115,620 af). The south-of-Delta contractors total 2,985,763 af (U.S. Bureau of Reclamation 2013, 2014).

CVP Water Supply

Most of the water delivered by CVP facilities in the Sacramento River Region is for agriculture use. Sacramento and Redding receive part of their water supply from CVP facilities. CVP water is delivered for agriculture and wildlife refuges through the Tehama-Colusa and Corning canals and is supplied from Red Bluff Diversion Dam on the Sacramento River. The canals serve about 160,000 acres of land in Tehama, Glenn, Colusa, and Colusa, and Yolo counties. CVP contractors and water rights settlement users also make direct diversions from the Sacramento River. The supplies listed include, where applicable, both project water and water rights settlement (base supply) water.

Releases from Folsom Reservoir on the American River serve Delta and CVP export needs and also provide supply agencies in the Sacramento metropolitan area.

Supply from Other Federal Water Projects

Monticello Dam in Napa County impounds Putah Creek to form Lake Berryessa, the principal water storage facility of USBR's Solano Project. The project provides urban and agricultural water supply to Solano County (partly in the Sacramento River region and partly in the San Francisco Bay region) and agricultural water supply to the University of California, Davis in Yolo County. Napa County uses about one percent of the supply for development around Lake Berryessa.

Orland Project

There are three reservoirs on Stony Creek north of Lake Berryessa. Two of these are East Park (1909) and Stony Gorge (1928) built on upper Stony Creek. Presently, their supply irrigates small acreages of land in Colusa and Glenn counties before becoming part of the water supply in Black Butte Reservoir. About 100 taf is released from Black Butte Reservoir for irrigation in Glenn County.

State Water Project Water Supply

Lake Davis, Frenchman Lake, and Antelope Lake are on Feather River tributaries in Plumas County and are used primarily for recreation, but also supply water to the City of Portola and local agencies that have water rights agreements with DWR. Lake Oroville and Thermalito Afterbay also supply the region. Local agencies that receive water rights delivered through Thermalito Afterbay include Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District. Agencies in the region holding long-term contracts for SWP supply are Plumas County Flood Control and Water Conservation District (FCWCD), Butte County, Yuba City, and Solano County Water Agency. The Solano County agency receives its SWP supply from the Delta through the North Bay Aqueduct.

Local Surface Water Supply

Water stored and released from Clear Lake and Indian Valley Reservoir into Cache Creek is diverted by the Yolo County FCWCD for irrigation in Yolo County. Since 1950, the district has diverted an average of 130 taf annually at Capay Diversion Dam on lower Cache Creek. No water supply from these sources was available during the 1977 and 1990 drought years. In Sutter County and in western Placer County, South Sutter Water District (SSWD) supplies irrigation water from Camp Far West Reservoir on the lower Bear River. SSWD also purchases surface water from Nevada Irrigation District to supplement irrigators' groundwater supplies. NID's supplies come from its reservoir on the Yuba-Bear River system. Yuba River supplies have also been developed by Yuba County Water Agency, which is New Bullards Bar Reservoir, the river's largest reservoir at 966 taf. The Sacramento metropolitan area, served by more than 20 water purveyors, is the largest urban area in the Sacramento River Hydrologic Region and is also the largest urban surface water user. Within Sacramento County, the City of Sacramento relies primarily on surface water (approximately 80 to 90 percent); water purveyors in unincorporated areas use both surface water and groundwater. The City of Sacramento diverts its CVP water supply from the American River at H Street and also diverts downstream from the confluence of the American and Sacramento rivers. The City of Folsom takes surface water from Folsom Lake.

Groundwater

The Sacramento Valley Groundwater Basin is recognized as one of the foremost groundwater basins in the state; and wells developed in the sediments of the valley provide sufficient supply for irrigation, municipal, and domestic uses (California Department of Water Resources 2003). Geologically, the valley has formations with sediments having variable permeabilities. As a result, wells developed in areas with coarser aquifer materials will produce larger amounts of water than will wells developed in fine aquifer materials. In general, well yields range from 100 gpm to several thousand gpm. Because surface water supplies have been so abundant in the valley, groundwater development for agriculture for the most part has been used to supplement the primary surface supply. Mountain valleys of the region can provide groundwater supplies for multiple uses.

Groundwater supply estimates are based on water supply and balance information derived from DWR land use surveys and from groundwater supply information that water purveyors or other State agencies voluntarily provide to DWR. Groundwater supply is reported by water year (October 1 through September 30) and is categorized according to agriculture, urban, and managed wetland uses. The groundwater information is presented by planning area (PA), county, and by the type of use. Although groundwater accounts for about 30 percent of the region's total water supply, the majority of groundwater supplies (about 84 percent) are used to meet agricultural use while about 16 percent goes to urban use. About three-quarters of a percent of the groundwater supply is used to meet managed wetlands use in the region.

Figure SR-10 depicts the planning area locations and associated 2005-2010 groundwater supply in the region. The estimated average annual 2005-2010 total water supply for the region is 9.0 maf, of which 2.7 maf is from groundwater supply (30 percent). (Reference to total water supply represents the sum of surface water and groundwater supplies in the region, and local reuse.) Groundwater pumping in the Sacramento River Hydrologic Region accounts for 17 percent of all the groundwater extraction in California — the third highest among the 10 hydrologic regions, behind the Tulare Lake Hydrologic Region with 38 percent and the San Joaquin River Hydrologic Region with 19 percent of the total.

Figure SR-10 Contribution of Groundwater to the Sacramento River Hydrologic Region Water Supply by Planning Area (2005-2010)

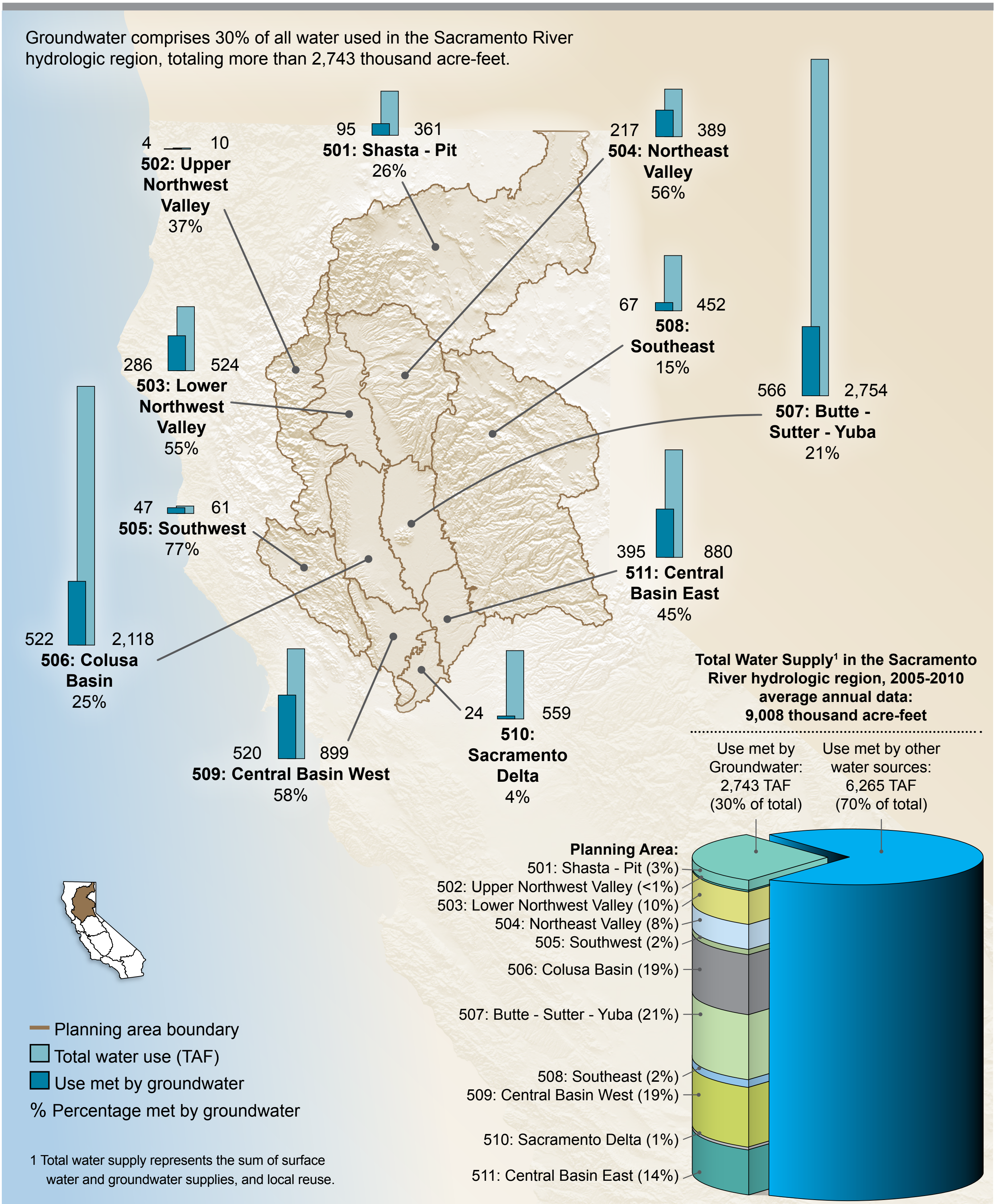


Figure SR-10 also shows that the Butte-Sutter-Yuba PA is the largest user of groundwater in the region: an average annual supply of 566 taf. The average annual groundwater pumping is also high in the Colusa Basin PA with 522 taf and the Central Basin West PA with 520 taf.

Table SR-10 provides the 2005-2010 average annual estimated groundwater supply by planning area and type of use. Groundwater supplies meet 47 percent (429 taf) of the overall urban water use and 30 percent (2,294 taf) of the overall agricultural water use. Groundwater contributes marginally (4 percent) to the supply required for meeting managed wetlands uses in the region, with all of the use (20 taf) occurring in Butte-Sutter-Yuba and Colusa Basin planning areas. Except Sacramento Delta and Southeast PAs, all other PAs are highly dependent on groundwater to meet their urban water uses with between 40 and 100 percent of the use being met by groundwater. Colusa Basin planning area, in particular, is 100 percent dependent on groundwater supply to meet its urban water use.

Regional totals for groundwater based on county area will vary from the planning area estimates because county boundaries do not necessarily align with planning area or hydrologic region boundaries.

For the Sacramento River Hydrologic Region, county groundwater supply is reported for 17 counties. Fifteen of those counties are fully or mostly contained within the region, while two counties — El Dorado and Modoc — are partially contained within the region. Groundwater supplies for five counties partially contained in the region — Alpine, Amador, Lassen, Napa, and Siskiyou — are discussed in the regional reports of the relevant hydrologic regions.

Similar to that for planning areas, groundwater supply estimates for counties are also based on water supply and balance information derived from DWR land use surveys and from groundwater supply information that water purveyors or other State agencies voluntarily provide to DWR. Table SR-11 shows that groundwater contributes to 31 percent of the total water supply in the 17-county area; ranging from 13 to 75 percent for individual counties. Although most of the groundwater in the 17-county area is pumped for agricultural water use (2,435 taf), groundwater supplies are used to meet about 31 percent of the agricultural water use. In contrast, although overall pumping for urban water use is significantly less (465 taf), groundwater supplies are used to meet about 45 percent of the urban water use. Groundwater supply contribution is marginal for meeting managed wetlands use in the 17-county area.

Changes in annual groundwater supply and type of use may be related to a number of factors, such as changes in surface water availability, urban and agricultural growth, market fluctuations, and water use efficiency practices. Figures SR-11 and SR-12 summarize the 2002 through 2010 groundwater supply trends for the region.

The right side of Figure SR-11 illustrates the annual amount of groundwater versus other water supplies, while the left side identifies the percent of the overall water supply provided by groundwater relative to other water supplies. The center column in the figure identifies the water year along with the corresponding amount of precipitation, as a percentage of the 30-year running average for the region. The figure indicates that between 2002 and 2010, the annual water supply for the region has fluctuated between 8.3 maf and 9.9 maf depending on annual precipitation amounts. The annual groundwater supply has fluctuated between 2.4 maf and 3.1 maf, providing between 28 and 32 percent of the total water supply.

Table SR-10 Sacramento River Hydrologic Region Average Annual Groundwater Supply by Planning Area (PA) and by Type of Use (2005-2010)

Sacramento River Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groudnwater	
PA NUMBER	PA NAME	TAF	%	TAF	%	TAF	%	TAF	%
501	Shasta – Pit	83.2	25	11.3	67	0.0	0	94.5	26
502	Upper Northwest Valley	3.3	35	0.4	62	0.0	0	3.7	37
503	Lower Northwest Valley	238.4	51	47.9	79	0.0	0	286.3	55
504	Northeast Valley	175.3	57	41.5	51	0.0	0	216.8	56
505	Southwest	42.1	81	5.1	54	0.0	0	47.1	77
506	Colusa Basin	498.7	26	14.0	100	9.2	6	521.9	25
507	Butte – Sutter – Yuba	508.3	21	47.2	69	10.9	4	566.4	21
508	Southeast	44.0	13	23.3	20	0.0	0	67.3	15
509	Central Basin West	473.0	57	47.0	65	0.0	0	520.0	58
510	Sacramento Delta	19.5	4	4.6	15	0.0	0	24.2	3
511	Central Basin East	208.5	47	186.4	43	0.0	0	349.9	45
2005-2010 annual average region total		**2,294.2**	**30**	**428.6**	**47**	**20.1**	**4**	**2742.9**	**30**

Notes:

TAF = thousand acre-feet, PA = planning area

Percent use is the percent of the total water supply that is met by groundwater, by type of use.

2005-2010 precipitation equals 96% of the 30-year average for the Sacramento River Hydrologic Region.

Figure SR-12 shows the annual amount and percentage of groundwater supply trends for meeting urban, agricultural, and managed wetland uses. The figure indicates that during the 2002 to 2010 period, about 81 to 87 percent of the annual groundwater supply met agricultural use. During the dry years of 2007 through 2009, groundwater pumping for agricultural use increased by about 500 taf when compared to the wet years that preceded and followed the dry years (about 2,500 taf versus 2,000 taf). The increase in groundwater extraction is attributed to a combination of increased irrigation demand and reduced surface water deliveries during these consecutive

Table SR-11 Sacramento River Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use (2005-2010)

Sacramento River Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetland Use Met by Groundwater		Total Water Use Met by Groundwater	
COUNTY	TAF	%	TAF	%	TAF	%	TAF	%
Butte	367.7	32	51.0	73	9.1	9	427.7	32
Colusa	231.6	19	7.9	98	7.7	5	247.2	18
El Dorado	0.6	4	9.0	15	0.0	0	9.6	13
Glenn	277.5	28	11.0	100	3.3	4	291.8	27
Lake	36.5	80	4.6	52	0.0	0	41.0	75
Modoc	90.9	25	3.0	92	0.0	0	93.9	20
Nevada	1.0	3	8.3	29	0.0	0	9.3	14
Placer	17.7	9	20.8	19	0.0	0	38.5	13
Plumas	14.4	18	9.0	65	0.0	0	23.4	25
Sacramento	179.1	44	191.2	46	0.1	0	370.5	44
Shasta	24.1	11	40.2	47	0.0	0	64.3	21
Sierra	23.9	30	1.0	87	0.0	0	24.9	30
Solano	254.6	46	20.1	21	0.0	0	274.8	43
Sutter	252.8	26	9.6	37	0.0	0	262.4	24
Tehama	227.6	66	20.6	92	0.0	0	248.2	67
Yolo	360.4	43	38.8	68	0.0	0	399.2	44
Yuba	74.4	21	19.1	98	0.0	0	93.5	24
2005-2010 annual average total	**2,434.7**	**31**	**465.2**	**45**	**20.2**	**4**	**2,920.0**	**31**

Notes:

TAF = thousand acre-feet

Percent use is the percent of the total water supply that is met by groundwater, by type of use. 2005-2010 precipitation equals 96% of the 30-year average for the Sacramento River Hydrologic Region.

dry years. Groundwater pumping to meet urban water use remained fairly stable during the 2002 to 2010 period – between 370 and 480 taf, ranging from 13 to 19 percent of the annual groundwater extraction. Groundwater remained a minor supply at less than 1 percent for meeting managed wetlands use.

Figure SR-11 Sacramento River Hydrologic Region Annual Groundwater Supply Trend (2002-2010)

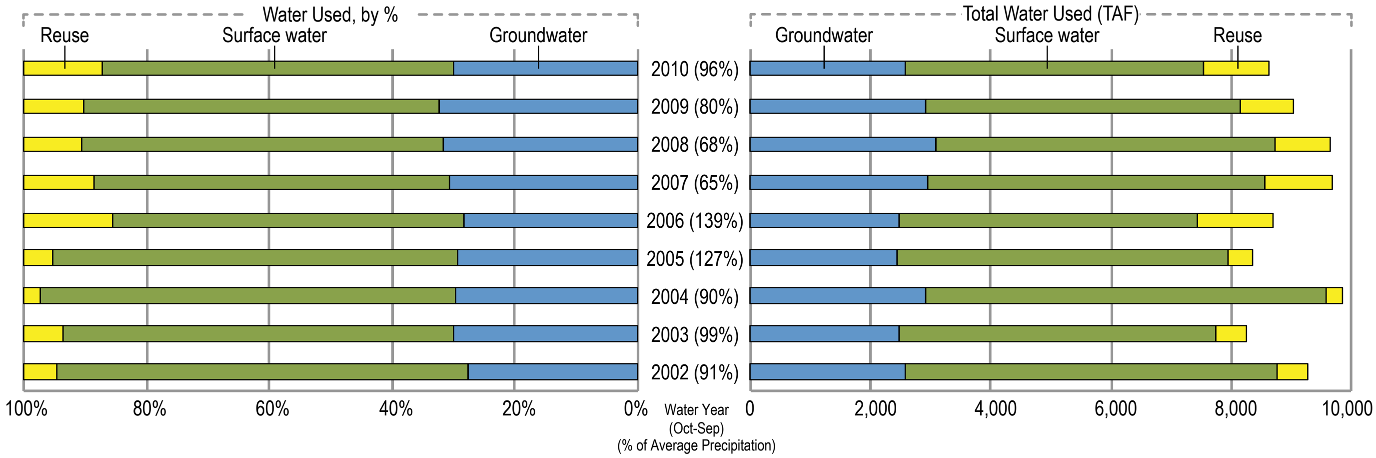
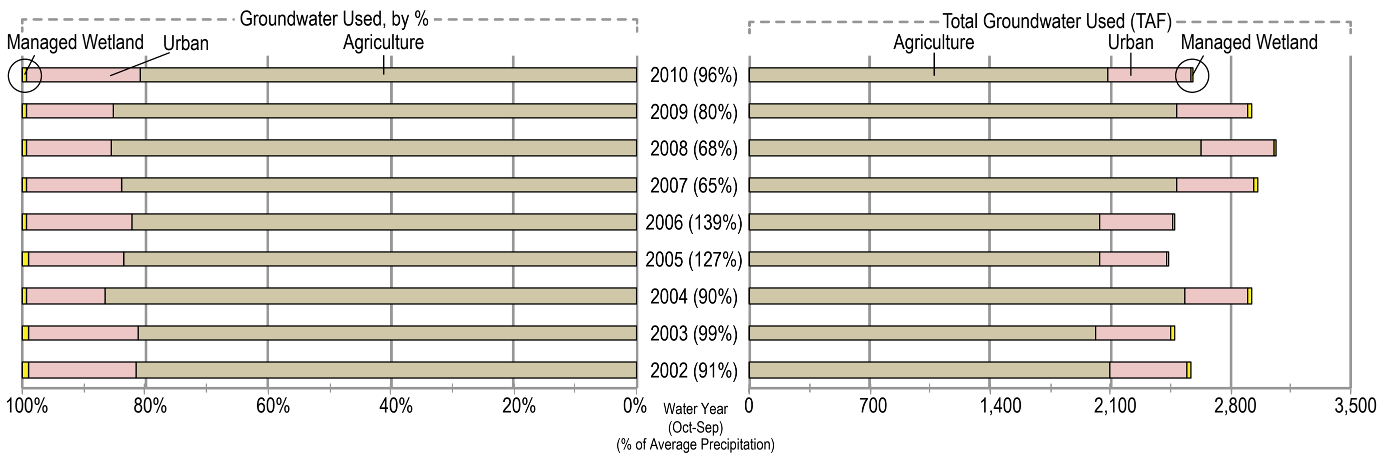


Figure SR-12 Sacramento River Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)



More detailed information regarding groundwater water supply and use analysis is available online from Update 2013, Volume 4, *Reference Guide,* in the article "California's Groundwater Update 2013."

Water Uses

Water use in the Sacramento River region is mostly for agricultural production with more than 2 million irrigated acres in the year 2000. Agricultural products include a variety of crops such as rice and other grains, tomatoes, field crops, fruits, and nuts. A substantial number of acres of rangeland in this region are also used for livestock management. Much of the economy of the region relies on agricultural water supplies, which are diverted and distributed through extensive systems of diversion canals and drains. Basin-wide, water use efficiency is generally high because many return flows from fields are captured by drainage systems and then resupplied to other fields downstream.

Drinking Water

The region has an estimated 504 community drinking water systems. The majority (over 80 percent) of these community drinking water systems are considered small (serving fewer than 3,300 people) with most small water systems serving fewer than 500 people (Table SR-12). Small water systems face unique financial and operational challenges in providing safe drinking water. Given their small customer base, many small water systems cannot develop or access the technical, managerial and financial resources needed to comply with new and existing regulations. These water systems may be geographically isolated, and their staff often lack the time or expertise to make needed infrastructure repairs; install or operate treatment; or develop comprehensive source water protection plans, financial plans, or asset management plans (U.S. Environmental Protection Agency 2012b).

In contrast, medium and large water systems account for less than 20 percent of region's drinking water systems; however, these systems deliver drinking water to over 90 percent of the region's population. These water systems generally have financial resources to hire staff to oversee daily operations and maintenance needs and to hire staff to plan for future infrastructure replacement and capital improvements. This helps to ensure that existing and future drinking water standards can be met.

Water Conservation Act of 2009 (SB X7-7) Implementation Status and Issues

Thirty-five Sacramento River urban water suppliers have submitted 2010 urban water management plans to DWR. The Water Conservation Act of 2009 (SB X7-7) requires urban water suppliers to calculate baseline water use and set 2015 and 2020 water use target. Based on data reported in the 2010 urban water management plans, the Sacramento River Hydrologic Region had a population-weighted baseline average water use of 271 gallons per capita per day and an average population-weighted 2020 target of 219 gallons per capita per day. The Baseline and Target Data for the individual Sacramento River urban water suppliers is available on the DWR Urban Water Use Efficiency Web site http://www.water.ca.gov/wateruseefficiency/.

The Water Conservation Act of 2009 (SB X7-7) requires agricultural water suppliers to prepare and adopt agricultural water management plans by December 31, 2012, and update those plans by December 31, 2015, and every five years thereafter. Five 2012 agricultural water management plans have been submitted to DWR, representing 13 Sacramento River agricultural water suppliers.

Water Balance Summary

The Sacramento River Hydrologic Region has 11 planning areas that range from sparsely populated mountainous areas to areas with populous major cities. Table SR-13 provides a hydrologic water balance summary for the Sacramento River region. Figure SR-13 illustrates a water balance for dedicated and developed supply by year. For more information on the water balances and portfolios, go to Volume 5, *The Technical Guide*.

Table SR-12 Summary of Large, Medium, Small, and Very Small Community Drinking Water Systems in the Sacramento River Hydrologic Region

Water System Size by Population	Community Water Systems (CWS)		Population Served	
	SYSTEMS	PERCENT	POPULATION	PERCENT
Large > 10,000	44	9	2,545,212	85
Medium 3,301 – 10,000	42	8	270,019	9
Small 500 – 3,300	85	17	125,252	4
Very Small <500	333	66	46,330	2
CWS that primarily provide wholesale water	0	0	---	---
Total	**504**	**---**	**2,986,813**	**---**

Source: California Department of Public Health (CDPH) Permits, Inspection, Compliance, Monitoring, and Enforcement database, June 2012.

Note: Population estimates are as reported by each water system to CDPH and may include seasonal visitors.

The Shasta Pit planning area averages about 17 taf per year (taf/yr.) urban applied water. Agricultural applied water ranges from about 325 to 425 taf/yr. Managed wetlands use has decreased from about 13 taf/yr. to 10 taf/yr. The McCloud River has a special wild and scenic river designation that wasn't included in Update 2005 (water year 2001), but was included in subsequent years. This flow, which ranges from 950 to 1,865 taf/yr., is reused downstream.

Supply for the Shasta Pit planning area is primarily local supply and reuse from the McCloud River, with about 100 af of groundwater extracted annually.

The Upper Northwest Valley planning area urban use is generally less than 1 taf/yr. Agricultural applied water ranges from 6.5 taf/yr. to over 13 taf/yr. There are no managed wetlands or instream environmental water use. Surface water consists of local deliveries (4-10 taf/yr.), CVP deliveries (1 taf to less than 2 taf annually), and reuse (0.5-1.3 taf annually). Until 2008, generally less than 2 taf of groundwater was extracted per year; from 2008 to 2010, the amount increased to about 5 taf/yr.

The Lower Northwest Valley planning area urban applied water is about 60 taf/yr. About half of the urban use is industrial and commercial. Agricultural applied water ranges from about 450 to more than 600 taf/yr. Instream requirements the Lower Northwest PA total about 2.2 million acre-feet per year (maf/yr.) which leaves the planning area, but is reused downstream. About 200 acre-feet per year (af/yr.) is applied to managed wetlands.

Supplies in the Lower Northwest Valley planning area consist primarily of CVP deliveries in years when CVP water is available. In years when CVP water is not available, local sources are used. In addition, 250 to 360 taf of groundwater is extracted each year.

The Northeast Valley PA planning area urban use is about 70-85 taf/yr., which is primarily residential. Agricultural use ranges from 250 to 350 taf/yr. Managed wetlands use about 1 taf/yr.,

Table SR-13 Sacramento River Hydrologic Region Water Balance for 2001-2010 (in taf)

Sacramento River (taf)	Water Year (Percent of Normal Precipitation)									
	2001 (67%)	**2002** (91%)	**2003** (99%)	**2004** (90%)	**2005** (127%)	**2006** (139%)	**2007** (65%)	**2008** (68%)	**2009** (80%)	**2010** (96%)
WATER ENTERING THE REGION										
Precipitation	35,895	49,488	54,171	49,026	69,646	76,503	35,542	37,535	44,229	52,576
Inflow from Oregon/Mexico	0	0	0	0	0	0	0	0	0	0
Inflow from Colorado River	0	0	0	0	0	0	0	0	0	0
Imports from Other Regions	700	2,067	2,260	2,374	4,268	8,739	2,220	1,817	1,420	2,198
Total	**36,595**	**51,555**	**56,431**	**51,400**	**73,914**	**85,242**	**37,762**	**39,352**	**45,649**	**54,774**
WATER LEAVING THE REGION										
Consumptive use of applied water[a] (Ag, M&I, Wetlands)	5,710	5,976	5,189	6,393	5,062	5,493	6,388	6,375	5,995	5,168
Outflow to Oregon/Nevada/ Mexico	0	0	0	0	0	0	0	0	0	0
Exports to other regions	4,657	6,783	7,686	7,485	7,908	6,676	5,958	3,452	3,309	6,825
Statutory required outflow to salt sink	4,486	4,843	6,431	6,539	6,999	10,128	4,501	4,464	4,680	5,323
Additional outflow to salt sink	3,795	4,407	7,692	8,381	8,073	31,136	1,715	2,211	2,033	4,923
Evaporation, evapotranspiration of native vegetation, groundwater subsurface outflows, natural and incidental runoff, ag effective precipitation & other outflows	21,507	30,165	28,630	16,504	44,115	33,036	24,097	26,950	30,936	31,916
Total	**40,155**	**52,174**	**55,628**	**45,302**	**72,157**	**86,469**	**42,659**	**43,452**	**46,953**	**54,155**
CHANGE IN SUPPLY										
[+] Water added to storage [-] Water removed from storage										
Surface reservoirs	-2,412	799	2,273	-2,263	2,968	349	-2958	-2051	664	2364
Groundwater[b]	-1,148	-1,418	-1,470	-1,639	-1,211	-1576	-1939	-2049	-1968	-1745
Total	**-3,560**	**-619**	**803**	**-3,902**	**1,757**	**-1227**	**-4897**	**-4100**	**-1304**	**619**
Applied water[a] (ag, urban, wetlands) (compare with consumptive use)	9,913	10,430	9,344	10,931	9,168	9,769	11,017	10,889	10,334	9,433

Notes:

taf = thousand acre-feet

M&I = municipal and industrial

[a] Definition: Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

[b] Definition: Change in Supply: Groundwater – The difference between water extracted from and water recharged into groundwater basins in a region. All regions and years were calculated using the following equation: change in supply: groundwater = intentional recharge + deep percolation of applied water + conveyance deep percolation and seepage - withdrawals.

This equation does not include unknown factors such as natural recharge and subsurface inflow and outflow. For further details, refer to Volume 4, *Reference Guide*, the article “California’s Groundwater Update 2013” and Volume 5, *Technical Guide*.

and there is no instream environmental. Supplies are about half surface water (local, reuse, and CVP) and half groundwater.

The Southwest planning area has about 10 to 11 taf in urban applied water and 51 to 67 taf in agricultural applied water. There is no environmental water use in this planning area. Surface water supplies (local deliveries and reuse, with a little CVP water) constitute about one-third to one-half of the supply, with groundwater extractions making up the difference.

The Colusa Basin planning area is primarily agricultural with 2.1 to 2.7 maf of agricultural applied water and only about 12-15 taf of urban applied water. There are significant managed wetlands here (160-175 taf/yr.) that are primarily associated with rice farming. Supplies are primarily surface water with most coming from CVP deliveries and reuse. About 460-600 taf of groundwater are also extracted annually.

The Butte-Sutter-Yuba planning area is similar to the Colusa Basin PA but with more urban, managed wetlands, and agricultural use overall. There is also some instream environmental water (800 taf/yr. to 1 maf/yr.) that is reused with the same planning area. Groundwater supplies are about the same as in Colusa Basin planning area, with surface water supplies being primarily local deliveries. CVP and SWP deliveries total about 150 to 450 taf/yr. There is also significant reuse of surface water supplies.

The Southeast planning area covers the northern part of the Mountain Counties subarea. It has some urban and agricultural areas within its mountainous terrain. There are about 100 to 133 taf of urban applied water and 330 to 400 taf/yr. of agricultural applied water. There are generally 1.9 to 4.4 maf of combined instream and wild and scenic applied water, most of which is reused downstream with the same planning area. There are some managed wetlands in which use varies from 1 to 17 taf/yr. Water supplies are primarily surface water (local deliveries and reuse of instream environmental water) with about 50 to 60 taf of groundwater extracted annually.

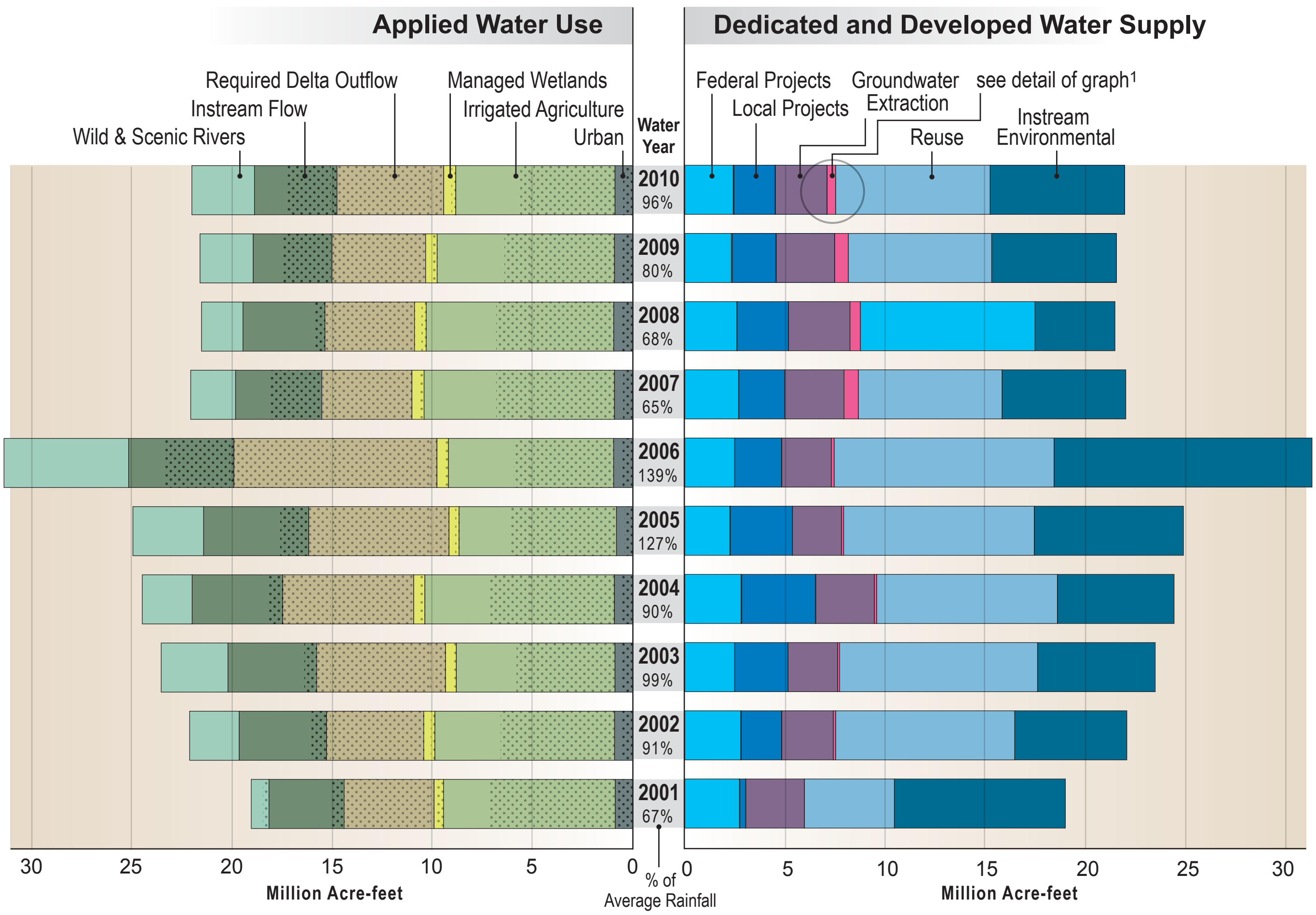
The Central Basin West planning area is also primarily agricultural in nature, with 55 to 80 taf in urban use and 750 taf to 1 maf of agricultural applied water. There are about 22 to 30 taf/yr. in instream flows and occasionally some managed wetlands use. Supplies are about half surface water (local deliveries, CVP, other federal deliveries, SWP, and reuse) and half groundwater.

The Sacramento Delta planning area covers most of the Delta area that lies north of the confluence of the Sacramento and San Joaquin rivers. There are about 20 to 40 taf urban applied water and 400 to 700 taf agricultural applied water in this planning area. Managed wetlands use about 15 to 60 taf/yr. This is the planning area wherein the Required Delta Outflow for the state is measured. The amounts are statutorily set and are dependent upon water year type in the Sacramento River and San Joaquin River regions. In DWR's 10 year study period, amounts ranged from 4.5 to 10.1 maf/yr. Supplies are primarily local surface water and inflows from other regions, with less than 40 taf/yr. of groundwater extracted.

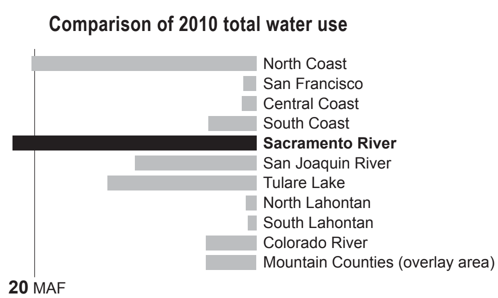
The Central Basin East planning area is the most metropolitan area in the hydrologic region, with between 380 and 480 taf/yr. in urban applied water. Agricultural applied water ranges from 430 to 520 taf/yr. Managed wetlands use less than 2 taf/yr. in applied water. Instream requirements use about 235 taf/yr. and wild and scenic rivers 7 to 40 taf/yr., all of which is reused downstream.

Figure SR-13 **Sacramento River Hydrologic Region Water Balance by Water Year, 2001-2010**

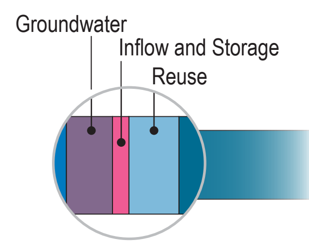
California's water resources vary significantly from year to year. Ten recent years show this variability for water use and water supply. Applied Water Use shows how water is applied to urban and agricultural sectors and dedicated to the environment and the Dedicated and Developed Water Supply shows where the water came from each year to meet those uses. Dedicated and Developed Water Supply does not include the approximately 125 million acre-feet (MAF) of statewide precipitation and inflow in an average year that either evaporates, are used by native vegetation, provides rainfall for agriculture and managed wetlands, or flow out of the state or to salt sinks like saline aquifers (see Table SR-13). Groundwater extraction includes annually about 2 MAF more groundwater used statewide than what naturally recharges – called groundwater overdraft. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years.



Stippling in bars indicates **depleted (irrecoverable) water use** *(water consumed through evapotranspiration, flowing to salt sinks like saline aquifers, or otherwise not available as a source of supply)*



[1] **Detail of bar graph:** *For water years 2001-2010, inflow & storage water varied from 0 to 711 TAF of the water supply.*



For further details, refer to Vol. 5, *Technical Guide*, and the Volume 4 article, "California's Groundwater Update 2013."

Key Water Supply and Water Use Definitions

Applied water. The total amount of water that is diverted from any source to meet the demands of water users without adjusting for water that is depleted, returned to the developed supply or considered irrecoverable (see water balance figure).

Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

Instream environmental. Instream flows used only for environmental purposes.

Instream flow. The use of water within its natural watercourse as specified in an agreement, water rights permit, court order, FERC license, etc.

Groundwater Extraction. An annual estimate of water withdrawn from banked, adjudicated, and unadjudicated groundwater basins.

Recycled water. Municipal water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource.

Reused water. The application of previously used water to meet a beneficial use, whether treated or not prior to the subsequent use.

Urban water use. The use of water for urban purposes, including residential, commercial, industrial, recreation, energy production, military, and institutional classes. The term is applied in the sense that it is a kind of use rather than a place of use.

Water balance. An analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region. It shows what water was applied to actual uses so that use equals supply.

Sacramento River Water Balance by Water Year Data Table (TAF)

	2001 (67%)	2002 (91%)	2003 (99%)	2004 (90%)	2005 (127%)	2006 (139%)	2007 (65%)	2008 (68%)	2009 (80%)	2010 (96%)
APPLIED WATER USE										
Urban	877	911	890	918	816	958	914	953	914	889
Irrigated Agriculture	8,567	8,964	7,914	9,455	7,852	8,241	9,497	9,357	8,847	7,942
Managed Wetlands	469	555	540	557	499	571	606	580	574	602
Req Delta Outflow	4,486	4,843	6,424	6,532	6,999	10,128	4,501	4,464	4,680	5,323
Instream Flow	3,748	4,357	4,425	4,516	5,238	5,251	4,295	4,091	3,917	4,117
Wild & Scenic R.	885	2,475	3,331	2,489	3,530	6,216	2,239	2,068	2,656	3,121
Total Uses	**19,032**	**22,105**	**23,524**	**24,467**	**24,935**	**31,363**	**22,052**	**21,512**	**21,588**	**21,994**
DEPLETED WATER USE (STIPPLING)										
Urban	770	606	572	539	405	515	488	532	505	491
Irrigated Agriculture	6,302	5,691	4,923	6,237	5,262	5,001	5,906	5,872	5,500	4,723
Managed Wetlands	378	226	176	239	192	200	239	229	222	222
Req Delta Outflow	4,486	4,843	6,424	6,532	6,999	10,128	4,501	4,464	4,680	5,323
Instream Flow	614	766	636	725	1,429	3,515	2,603	549	2,450	2,559
Wild & Scenic R.	321	0	0	0	0	0	0	0	0	0
Total Uses	**12,871**	**12,131**	**12,731**	**14,273**	**14,286**	**19,358**	**13,736**	**11,647**	**13,357**	**13,318**
DEDICATED AND DEVELOPED WATER SUPPLY										
Instream	8,554	5,609	5,885	5,837	7,461	12,901	6,188	3,999	6,241	6,727
Local Projects	289	2,022	2,664	3,694	3,102	2,342	2,293	2,565	2,185	2,063
Local Imported Deliveries	9	11	8	15	6	9	10	9	10	8
Colorado Project	0	0	0	0	0	0	0	0	0	0
Federal Projects	2,737	2,800	2,494	2,819	2,257	2,495	2,694	2,606	2,333	2,426
State Project	20	20	4	25	25	4	9	13	46	33
Groundwater Extraction	2,927	2,570	2,473	2,924	2,446	2,478	2,961	3,069	2,919	2,585
Inflow & Storage	0	121	104	117	111	143	711	517	686	429
Reuse & Seepage	4,497	8,952	9,893	9,037	9,527	10,992	7,187	8,734	7,168	7,724
Recycled Water	0	0	0	0	0	0	0	0	0	0
Total Supplies	**19,032**	**22,105**	**23,524**	**24,467**	**24,935**	**31,363**	**22,052**	**21,512**	**21,588**	**21,994**

Thirty to 40 percent of the water is supplied by groundwater pumping; and the rest is a combination of local surface water, CVP deliveries, and reuse.

Project Operations

The USBR and DWR operate the CVP and the SWP in accordance with a Coordinated Operations Agreement authorized by Congress though Public Law 99-546 in 1986. This agreement defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities. The agreement also works to provide coordinated operations for balanced conditions for the Sacramento Valley and the Delta while meeting water supply needs. “Balanced conditions” are defined as periods when releases from upstream reservoirs and unregulated flow approximate the water supply needed to meet Sacramento Valley in-basin uses and CVP/SWP exports (National Marine Fisheries Service 2009b).

Balanced conditions are further defined by biological opinions, SWRCB D-1641, SWRCB D-1485, and CVPIA 3406(b)(2). The 1993 National Oceanic and Atmospheric Administration’s Biological Opinion (BO) imposed operational constraints on the projects and introduced a combined CVP/SWP incidental take for Delta export facilities. The 2009 BO established in-stream temperature requirements, temperature management plans, End-of-September (EOS) storage requirements, and restoration goals for the CVP. SWRCB D-1641 requirements include X2 standards, export/inflow ratios, and other operational requirements. SWRCB D-1485 ordered the CVP and SWP to guarantee water quality protection for agricultural, municipal and industrial (M&I), and fish and wildlife uses.

The CVP was first authorized in 1935 and reauthorized in 1992 through the CVPIA. The CVPIA modified the original 1937 act and added mitigation, protection, and restoration of fish, wildlife, and associated habitats as a project purpose. The act specified that the dams and reservoirs of the CVP be used “first, for river regulation, improvement of navigation, and flood control; second, for irrigation, and domestic uses and fish and wildlife mitigation, protection, and restoration purposes; and third, for power and fish and wildlife enhancement.”

The CVPIA also dedicated water to fish, wildlife, and habitat restoration on an annual basis. Of this amount, 800 taf was dedicated to environmental needs as Section 3406(b)2 water, 200 taf was designated for wildlife refuges, and 200 taf was dedicated for increased Trinity River flows for fisheries restoration. Flexibility in project operations provides some of the dedicated water; however, the dedications also result in a reduction of CVP contractor water of 516 taf/yr. on average and 585 taf in dry years (U.S. Bureau of Reclamation 2011a).

The goals and objectives mandated by the water quality plans, decisions, regulatory requirements, and hydrologic conditions complicate project operations and the ability to meet all water demands. Meeting water demands are further complicated under future climate change scenarios and the related uncertainties of water supplies. The following provides an overview of the projects and operational requirements.

The Central Valley Project

Shasta and Keswick Dams

Shasta Dam is the primary storage and power-generating facility of the CVP. The watershed above the dam drains approximately 6,650 square miles and has an average annual runoff of 5.7 maf. Shasta Lake has a capacity of approximately 4.5 maf. Annual releases from the dam range from 9 maf in wet years to 3 maf in dry years. Construction of temperature control facilities at the dam in 1997 enables the release of water from different levels of storage to help meet temperature requirements downstream of Keswick Dam. Keswick Reservoir serves as an afterbay for releases from Shasta Dam and has a capacity of approximately 23,800 af. The dam also controls runoff from about 45 square miles of drainage area.

Operations at Shasta and Keswick dams are required to meet certain objectives and performance measures that affect flood control, water supply, water quality, riparian habitat, and the survival of several species within the Sacramento River. Flood control objectives for Shasta Lake require that releases be restricted to a flow of 79,000 cfs at Keswick Dam and a stage of 39.2 feet in the Sacramento River at Bend Bridge gauging station corresponding to a flow of approximately 100,000 cfs. A critical factor of flood operations is the amount of runoff entering the Sacramento River from Cottonwood Creek, Cow Creek, and Battle Creek. During rainfall events, local runoff between Keswick Dam and Bend Bridge can exceed 100,000 cfs (U.S. Bureau of Reclamation 2004).

A storage space of up to 1.3 maf below full pool at the lake is kept available for flood management purposes. From December 23 to June 15, the required flood management space varies based on seasonal inflow. Daily flood management operations consist of determining the required flood storage space reservation and scheduling releases in accordance with flood operations criteria. The goal of existing operations is to have vacant flood storage space in excess of flood requirements and then fill the pool to the maximum extent possible for water supplies for the remainder of the year (U.S. Bureau of Reclamation 2011a).

Historically, minimum navigation flows at Chico Landing were set at 5,000 cfs. This flow for navigation is no longer kept; however, water diverters have set their pump intakes just below this associated water level elevation. For this reason, CVP has been operated to meet the navigation flow requirement of 5,000 cfs to Wilkins Slough under most water supply conditions. At flows less than 5,000 cfs, water diversion operations become impacted. At 4,000 cfs, some pumps become inoperable (McInnis 2011).

The flow objectives established for the Sacramento River at Rio Vista require minimum monthly average flows of: 3,000 cfs during September of all year types, 4,000 cfs during October of all year types except critical years when flows of 3,000 cfs are required, and 4,500 cfs during November through December of all year types except critical years when flows of 3,500 cfs are required. The objective also requires that the 7-day running average flow is not less than 1,000 cfs below the monthly objective.

2009 Biological Opinion and Shasta Operations

With respect to water quality and habitat for salmon and steelhead, the 2009 BO identified several objectives for Shasta Operations to avoid adverse effects on winter-run and spring-run salmon (McInnis 2011):

- Ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning between Balls Ferry and Bend Bridge in most years without sacrificing the potential for cold water management in a subsequent year.
- Ensure suitable spring-run temperatures regimes, especially in September and October.
- Establish a second population of winter-run salmon in Battle Creek.
- Restore passage at Shasta Reservoir with experimental reintroductions of winter-run salmon to the upper Sacramento and/or McCloud rivers.

Actions to realize some of the above objectives focus on the EOS Shasta Reservoir carryover storage. The storage capacity of Shasta Reservoir is approximately 4.5 maf. EOS storage objectives have been set at 2.2 maf and 3.2 maf to be met 87 percent and 40 percent of the time, respectively. EOS storage is at 2.4 maf about 70 percent of the time. The EOS storage requirement of 2.2 maf is set to provide the water necessary to meet the minimum Balls Ferry temperature requirements for the following year (McInnis 2011).

Performance measures have also been established for water temperature at Clear Creek, Balls Ferry, Jelly's Ferry, and Bend Bridge compliance points. From April 15 to September 30, water temperatures are not to exceed 56 °F between Balls Ferry and Bend Bridge. From October 1 and October 31, water temperatures are not to exceed 60 °F provided conditions are sufficient to support and sustain compliance.

A fall monthly release schedule is required to be developed by November 1 of each year based on EOS and hydrologic projections. Release schedules are based on habitat needs, flood control needs (a maximum end-of-November storage volume of 3.25 maf is necessary for flood control), Bay/Delta water quality requirements, and conservation of storage for next year's cold water pool. If EOS is below 1.9 maf, Keswick releases will be reduced to 3,250 cfs unless higher releases are necessary to maintain temperature compliance points (McInnis 2011).

To conserve water in storage in the spring, USBR is required to make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff at a 90 percent probability of exceedance. NMFS reviews the draft forecast to determine whether both a temperature compliance point at Balls Ferry (from May to October) and EOS storage of at least 2.2 maf can be achieved. Release schedules are then devised based on temperature compliance points, EOS requirements, nondiscretionary delivery obligations, and legal requirements (McInnis 2011). USBR is required to develop and implement an annual Temperature Management Plan by May 15 of each year for the period of May 15 through October 31 to manage cold water supplies within the Shasta Reservoir and Spring Creek to provide suitable temperatures for listed species.

Enlargement of Shasta Dam and Reservoir has long been considered to increase the reliability of water supplies and to support the fishery. The draft feasibility report and environmental impact statement for the project was released in 2011. Box SR-1 provides a summary of the results of that investigation.

Trinity River Diversion

In 1955, Congress authorized the construction of Lewiston and Trinity dams on the Trinity River creating the Trinity River Diversion (TRD) for the export of water into the Central Valley. Operations of the TRD began in 1964 and were integrated with operations of Shasta Dam.

Box SR-1 Shasta Lake Water Resources Investigation (SLWRI) — Enlarging Shasta Dam and Reservoir

The draft feasibility report and preliminary environmental impact statement (EIS) for enlarging Shasta Dam and Reservoir was released by U.S. Bureau of Reclamation in November 2011. Copies of the documents can be found at http://www.usbr.gov/mp/slwri/documents.html. In conducting the investigation, USBR determined that expanding the capacity of Shasta Lake by modifying Shasta Dam would (1) increase survival of anadromous fish in the Sacramento River; (2) improve water supply reliability for agricultural, municipal and industrial (M&I), and environmental water users; and (3) address other related resource needs (U.S. Bureau of Reclamation 2011b).

Planning Objectives

Planning objectives for the project include (U.S. Bureau of Reclamation 2011a):

- Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream of the Red Bluff Diversion Dam.
- Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet current and future water demands.
- Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
- Reduce flood damage along the Sacramento River.
- Develop additional hydropower generation capabilities at Shasta Dam.
- Maintain and increase recreation opportunities at Shasta Lake.
- Maintain or improve water quality conditions in the Sacramento River and in the Delta.

Five Alternatives Evaluated

USBR evaluated the feasibility of five alternatives: Increases in dam elevation that were evaluated were 6.5, 12, and 18.5 feet. The alternative identified as providing the greatest net benefit is CP4. CP4 focuses on: “increased anadromous fish survival, while increasing water supply reliability and providing benefits to other resources through an 18.5-foot raise of Shasta Dam and 634,000 acre-foot enlargement of Shasta Reservoir” (U.S. Bureau of Reclamation 2011a).

Regional Concerns

Sites of cultural significance exist in and around Shasta Lake, many related to historical activities of Native Americans. The Winnemem band of the Wintu Indians have raised concerns about potential impacts of enlarging Shasta Dam on sites they value for historic and cultural significance (U.S. Bureau of Reclamation 2006).

The McCloud River Coordinated Research Management Plan, landowners, and various environmental groups have expressed concerns about potential impacts to the McCloud River. The California Wild & Scenic River System Act was amended in 1989 to include portions of the McCloud River (PRC 5093.542). The act states that no new dams, reservoirs, diversions, or water impoundment facilities are to be constructed on the McCloud River from 0.25 miles downstream from the McCloud Dam to the McCloud River Bridge — a reach length of approximately 24 miles. At gross pool, the existing Shasta Lake can inundate just over a mile of river reach upstream from the McCloud Bridge. Raising Shasta Dam would extend this area by about 2/3 of a mile (U.S. Bureau of Reclamation 2006).

Exports from TRD help to meet minimum flow requirements in the Trinity and Sacramento rivers, help to maintain reservoir storage levels, and facilitate operational compliance for water temperature below Keswick Dam.

Prior to construction of TRD, average annual discharge at Lewiston was approximately 1.2 maf with peak flows in excess of 100,000 cfs being recorded. Following construction of the dam, instream flow releases were set at 120,500 af/yr. (10 percent of the average unimpaired flow). From 1964 to 1996, TRD exports accounted for 14 percent of Keswick releases (U.S. Fish and Wildlife Service 1999). An outcome of TRD operations and the reduced instream flows of the Trinity River has been the degradation of fish habitat and reductions in anadromous fish populations. By 1980, it was estimated that fish populations had been reduced by 60 to 80 percent due to inadequately regulated harvest, excessive streambed sedimentation, and insufficient streamflow. The loss of fishery habitat was estimated to be 80 to 90 percent. To help address these problems, Congress passed the Trinity River Stream Rectification Act in 1980 (addressing sedimentation issues) and passed the Trinity River Basin Fish and Wildlife Management Act in 1984. The 1984 act directed efforts to restore fish and wildlife populations to levels that existed prior to TRD construction.

One of the provisions of the CVPIA was the establishment of a minimum flow volume for the Trinity River of 340,000 af. The CVPIA also directed the completion of a 12-year study (Trinity River Flow Evaluation Study [TRFES]) to establish permanent instream fishery flow requirements, operating criteria, and procedures for restoration and maintenance of the fishery (U.S. Fish and Wildlife Service 1999). SWRCB Order 90-5 set temperature objectives for each reach of the river by season. The TRFES report recommended specific annual flow releases, sediment management, and channel rehabilitation to provide necessary habitat.

The Trinity River Record of Decision of 2000 reduced the average annual export of the Trinity River to the Keswick Reservoir from 74 percent to 52 percent of flow. Since 2003, Trinity River restoration efforts have included improvements to floodplain infrastructure, channel rehabilitation, and peak flow releases. Since 2004, peak flow releases have ranged from 4,419 cfs to 10,100 cfs. Total annual flows have increased to a range of 368,600 to 452,600 af. Proposed future annual flows range from 368,600 to 815,000 af.

Sacramento River Division

The Sacramento River Division was authorized in 1950 to supply irrigation water to Tehama, Glenn, Colusa, and Yolo counties. The unit consists of Red Bluff Diversion Dam, Funks Dam, Corning Pumping Plant, Tehama-Colusa Canal (TCC), and the Corning Canal. Both canals provide irrigation water to approximately 100,000 acres. The TCC also provides water for about 20,000 acres of the Sacramento Valley refuges. The division contains 18 water contractors. Each contractor has its own service contract with USBR, which were renewed in 2005.

Construction of the Red Bluff Diversion Dam was completed in 1964. Historically, the gates of the dam were lowered by May 15 of each year creating Lake Red Bluff and raised on September 15 to allow for river flow-through. The dam has had issues with fish passage and agricultural water diversion reliability since its construction and has impeded both the upstream migration of audit fish to spawning habitat and the downstream migration of juveniles impacting both winter-run and spring-run Chinook salmon (McInnis 2009). Upstream of the diversion dam is also critical spawning and holding habitat for green sturgeon. To facilitate fish passage, the NMFS

2009 BO for the Red Bluff Diversion Dam required dam gates to be raised year-round by the year 2012. As a result of the fish passage improvement project by the Tehama-Colusa Canal Authority, the diversion now includes a 2,500 cfs pumping plant and flat-plate fish screen to the existing canal headworks to replace the loss of the diversion structure. This project received over $113 million from the American Recovery and Reinvestment Act as it was deemed "shovel-ready" in 2009. The investment created jobs during the construction period from spring of 2010 to when deliveries began in 2012. The project is aimed at a solution for providing reliable irrigation water deliveries while improving fish passage.

American River Division and Folsom and Nimbus Dams

The American River Division of the CVP provides water for irrigation, municipal and industrial use, hydroelectric power, and recreation. It consists of the Folsom, Sly Park, and Auburn-Folsom South units. The division is about midway between the northern and southern extremes of the Central Valley in Sacramento, San Joaquin, Placer, and El Dorado counties. Division lands stretch from Sugar Pine Dam in the north to Stockton in the south. Most lands served by the division lie in the southern portion of the division, between Sacramento and Stockton.

In addition, units of the American River Division provide a high degree of flood control along the American River, protecting several communities including the California capital, City of Sacramento. The American River Division consists of the Folsom, Sly Park, and Auburn-Folsom South units.

The Folsom and Sly Park units, though separate units of the American River Division, are often referred to together because both units were authorized as part of the CVP by the same legislation.

The Sly Park Unit is made up of Sly Park Dam and Jenkinson Lake, Camp Creek Diversion Dam and Tunnel, and Camino Conduit and Tunnel. These provide municipal and industrial water for the nearby community of Placerville, and irrigation water for the El Dorado Irrigation District. Camp Creek Diversion Dam diverts a portion of the flow of Camp Creek to Jenkinson Lake via Camp Creek Tunnel; and Camino Tunnel and Conduit delivers water from Jenkinson Lake to the El Dorado Irrigation District for irrigation and municipal use. All features of the Folsom and Sly Park units are complete and in operation.

The Folsom Unit consists of Folsom Dam and Lake, Folsom Powerplant, Nimbus Dam and Lake Natoma, Nimbus Powerplant, and Nimbus Fish Hatchery. Folsom Dam and Powerplant regulate the flow of the American River and provide water and power for municipal and industrial uses. Nimbus Dam and Lake Natoma act as an afterbay feature, regulating the outflows from the Folsom Powerplant. In addition, the Nimbus Powerplant provides supplemental electrical power to the area. The Nimbus Fish Hatchery compensates for the loss of salmon and trout spawning areas that were destroyed by construction of the dam. The lakes created by Folsom and Nimbus dams provide recreation to thousands of people year round.

Authorized in 1965, the Auburn-Folsom South Unit originally consisted of Auburn Dam, Reservoir, and Powerplant, County Line Dam and Reservoir, Sugar Pine Dam and Reservoir, and the Folsom South Canal. The Auburn-Folsom South Unit was designed to provide a new and supplemental water supply for irrigation and municipal and industrial needs and to alleviate the badly depleted groundwater conditions in the Folsom South service area. It was about one-third complete when construction was halted.

The completed portions of the project, Sugar Pine Dam and Reservoir, provide water for irrigation and municipal and industrial uses to the Foresthill Divide area.

The American River Division supplies water to several large municipal purveyors, including El Dorado Irrigation District; Foresthill Public Utilities District; cities of Folsom, Roseville, Carmichael, Sacramento; as well as San Juan and Sacramento Suburban water districts.

State Water Project

The SWP delivers water from Northern California to users in the lower Sacramento Valley, San Francisco Bay area, San Joaquin Valley, and Southern California. The DWR Oroville Field Division operates and maintains the facilities extending from Feather River lakes in Plumas County to the Oroville-Thermalito Complex on the Feather River. The facilities include three power plants, a fish hatchery, and a visitor's center. DWR operates the facility for water supply, power generation, recreation, fish and wildlife enhancement, and salinity control.

Lake Oroville has a storage capacity of 3,538 taf that is fed by the North, Middle, and South forks of the Feather River. Average annual unimpaired flow into the lake is approximately 45 maf. Local diversions are made directly from the Thermalito Afterbay by irrigation districts with water rights senior to the SWP. Oroville Dam provides up to 750 taf of flood control space.

DWR has operated the Oroville facilities under a license issued by the Federal Power Commission (FERC No. 2100-134) that expired on January 31, 2007. Prior to the expiration, DWR filed for a new license with FERC for continued operation of the facility. On March 24, 2006, DWR filed a settlement agreement with FERC for a new license for up to 50 years. DWR currently operates the Oroville facilities pursuant to an annual license by FERC. The SWP generates about half of the power it uses to move water throughout the state.

Project Water Supplies

Estimated 2001 demands for CVP water are about 3.4 maf for the Sacramento Basin and 3.5 maf for Delta export areas (U.S. Bureau of Reclamation 2004). DWR (2002) estimates the delivery for SWP water to be about 3.0 maf. Seventy percent of SWP water is supplied for M&I use providing water to about two-thirds of the state's population; the remaining 30 percent goes to agriculture — about 750,000 acres in San Joaquin Valley (California Department of Water Resources 2007). Estimated water demands for CVP and SWP water for the Sacramento Valley, Delta, and south of the Delta are summarized in Table SR-14.

A breakdown of CVP water deliveries by water user is summarized in Table SR-15.

With the passage of the CVPIA, fish and wildlife share coequal priority with other water users. One of the mandates of the act is for 800 taf of water to be left instream annually for fish, wildlife, and habitat restoration. In dry and critical water years, when deliveries to agricultural service contractors north of the Delta are reduced, this water can be reduced by up to 100 taf. This water can be reduced by up to 200 taf in critically dry water years (U.S. Bureau of Reclamation 2011c). Another of the act's provisions was establishment of the Refuge Water

Table SR-14 Estimates of Annual CVP/SWP Water Demand by Region

Project	Regions	Million acre-feet
State Water Project	Delta and South Delta	1.9
	Feather River Service Area	1.1
Central Valley Project	Delta and South of Delta	3.5
	Sacramento Valley	3.4

Source: California Department of Water Resources 2002; U.S. Bureau of Reclamation 2004

Table SR-15 Estimates of CVP Deliveries by Water User (Million Acre-Feet)

Water Use Area	Water Contracts	Agricultural Water Service Contracts	M&I Service Contracts	Refuge Water Supplies with Losses
(MILLION ACRE-FEET)				
Delta and South of Delta	0.9	2.1	0.3	0.2
Sacramento Valley	2.2	0.4	0.5	0.3
Total	3.1	2.5	0.8	0.5

Source: U.S. Bureau of Reclamation 2004

Notes:

CVP = Central Valley Project, M&I = municipal and industrial

Supply Program to meet the needs of 19 federal, State, and private wildlife refuges. Up to 555,515 af is to be supplied annually to refuges with 80 percent of the water provided by CVP supplies. During dry year conditions, this source of water can be reduced by a maximum of 25 percent.

The Monterey Agreement of 1994 allowed for a more equitable distribution of SWP water and set the amount of water available to individual contractors. Other outcomes of the agreement focused on restoration within the Feather River watershed. Elements of the agreement are summarized in Box SR-2.

CVP/SWP Supply Reliability

Water availability in the Central Valley is dependent on hydrologic conditions and operational needs of the Sacramento Valley and the Bay-Delta. The allocation of CVP water for any given water year is based on forecasted reservoir inflows, amounts of water in storage, regulatory requirements, and management of CVPIA Section 3406(b)(2) resources and refuge water. Though hydrologic conditions are the primary driver with respect to the availability of water, the

Box SR-2 The Monterey Agreement

The California Department of Water Resources and most State Water Project contractors entered into the Monterey Agreement in 1994. The original long-term contracts for SWP water required the contractors to pay annual charges to fund project bond interest payments, operations and maintenance costs, and other costs regardless of amount of water that was available for delivery. The cost to contractors never changed regardless of whether water was delivered. The contracts also required the agricultural contractors to forgo deliveries of water before cutbacks to urban contractors would be made during water shortages.

Long-term water contracts were restructured to allow for a more equitable distribution of water during water shortages. One of the outcomes is what is referred to as Table "A" Amounts. Table "A" Amounts is the quantity of project water available to the contractor and, under favorable conditions, the amount of water the contractor will receive. Water is allocated proportionally to all SWP contractors.

The original 1995 environmental impact report for the agreement was challenged in court for alleged violations of the California Environmental Quality Act. This ultimately led to a settlement agreement that was court approved in 2003 and required DWR to prepare a new EIR as well as other actions. One of the actions was a monetary settlement that funded Plumas Watershed Forum restoration efforts within the Feather River watershed. Goals of the Watershed Forum are to:

- Improve retention (storage) of water for augmented base flow of streams.
- Improve water quality and streambank protection.
- Improve upland vegetative management.
- Improve groundwater retention/storage in major aquifers.

The agreement also based the water supplied to Plumas County on the water supply available from Lake Davis. Water supplied to Plumas County will not be reduced during shortages provided that water is available from Lake Davis. DWR certified the EIR for the Monterey Agreement in 2010.

reliability of water supplies for water purveyors is dependent on the type of contract and policies for water allocation.

CVP Contracts

CVP water contractors in the Sacramento Valley fall into two categories: Sacramento River Water Rights Settlement Contractors and CVP Water Service Contractors. The contract terms and conditions vary depending on whether a contract is a water right, an agricultural water service, or a municipal/industrial type of contract.

Sacramento River Water Rights Settlement Contractors (SRSC) held water rights in the Sacramento Basin prior to construction of Shasta Dam. The water rights for SRSC exist independent of USBR. Supported by these underlying water rights, the CVP has contracts with SRSC totaling 2.2 maf for the Sacramento River and the San Joaquin River Exchange, and additional contracts totaling 0.9 maf for water right settlement contracts on the San Joaquin River. Contract amounts are supplied in full unless the forecasted Shasta Lake inflow constitutes a "Critical" water year. When Shasta Lake inflow is "Critical," San Joaquin Exchange contractor supplies may be limited to 650,000 af; and Sacramento River and other San Joaquin water rights settlement supplies can be reduced by up to 25 percent (U.S. Bureau of Reclamation 2004).

CVP Water Service Contractors can face greater cuts depending on water availability. These contractors are agricultural and M&I contractors that have entered into water service contracts for supplemental supplies (project water). These supplies are not based on pre-existing water rights. Water deliveries for this type of contract can be cut up to 100 percent depending on supply, operational requirements, hydrologic conditions, and available reservoir storage.

Cutbacks in water deliveries can be regional or statewide. As an example, water conveyance limitations across the Delta can result in shortage conditions for water contractors located south of the Delta as compared to those located north of the Delta. In 2008 and 2009, Sacramento Valley water service contractors received 100 and 40 percent of their full contract supplies respectively, as opposed to 50 and 10 percent for San Joaquin Valley contractors (Strickland 2011).

Yuba River Development Project

The Yuba River Development Project, FERC 2246, is a water supply, flood control, and power generation project that was put into service in 1970. The project is located in the Yuba River watershed overlying portions of Yuba, Placer, and Sierra counties.

The project includes New Bullards Bar (dam and storage reservoir), two diversion dams (Our House and Log Cabin), two diversion tunnels (Lohman Ridge and Camptonville, two power tunnels (New Colgate and Narrows 2), and three powerhouses (New Colgate, New Bullards Bar Minimum Flow Powerhouse, and Narrows 2) for a combined capacity over 395 megawatt. The Yuba River Development Project (YRDP) does not include Englebright Dam and Reservoir, Daguerre Point Dam, or the Narrows 1 Powerhouse. Narrows 1 Powerhouse is operated by PG&E, FERC 1403.

New Bullards Bar Reservoir has an estimated storage capacity of 966,103 af with a minimum pool of 234,000 af, leaving 732,000 af that can be regulated. Storage capacity of 170,000 af, below full pool is kept available for flood management.

New Bullards Reservoir captures winter and spring runoff and is augmented by diversions from the Middle Yuba River and Oregon Creek. The reservoir is operated to meet minimum carryover storage requirements to ensure that instream flows are met and at least 50 percent of the surface water deliveries are available for the following year as a drought protection measure. In wetter years, the reservoir is operated to an EOS target of 650,000 af. Other target levels are set for power generation and flood control operations. The average total inflow to the reservoir is about 1,200,000 af/yr., ranging from 163,000 af/yr. to 2,800,000 af/yr.

Englebright Dam (a U.S. Army Corps of Engineers facility) was constructed in 1941 as a sediment retention facility. The lake is located downstream from New Bullards Bar at the confluence of Middle Fork and South Fork Yuba Rivers. Narrows 1 (PG&E) and Narrows 2 (Yuba County Water Agency) power plants regulate the flow from Englebright Dam and provide for high flow reservoir releases and increased flood control.

Box SR-3 Lower Yuba River Accord

The Lower Yuba River Accord (Accord) is the result of negotiations between 17 stakeholders that included local irrigation districts, State and federal resource agencies, and conservation groups. It enables the Yuba County Water Agency (YCWA) to operate the Yuba River Development Project, FERC 2246, for hydropower, irrigation, flood control, recreation, and fisheries benefits.

The Accord consists of three agreements: Fisheries Agreement, Conjunctive Use Agreement, and a water purchase agreement between YCWA and the California Department of Water Resources (DWR). The Fisheries Agreement establishes instream flow schedules in the lower Yuba River to improve fisheries protection. The seasonal flow regime was developed from 2001 to 2004 to address stressors to fish as well as flood control requirements, water rights, delivery obligations, and reservoir carryover storage. The Accord and the instream flow schedules underwent California Environmental Quality Act /National Environmental Policy Act review in 2006-2007. The flow schedules were implemented on a pilot program basis in 2006 and 2007. The State of California approved the agreement in 2008 based upon the success of the pilot programs and approved petitions to change the water right permits of YCWA to implement the Accord (Lower Yuba Accord River Management Team Planning Group 2010).

The Conjunctive Use Agreement defines the approach for the conjunctive use of surface water and groundwater to ensure availability of local supplies. In separate conjunctive use agreements, member stakeholders will use groundwater to supplement storage releases up to a total of 30,000 acre-feet depending on instream flow requirements. Members will also use up to 15,000 acre-feet of groundwater in support of the Phase 8 Settlement Agreement. The extent to which member stakeholders can provide this amount of groundwater will depend on arrangements made with local landowners.

The water purchase agreement provides for water transfer payments by DWR to YCWA. Revenue from water purchases is intended to fund flood-control and water supply projects in Yuba County. DWR will enter into separate agreements with State Water Project contractors and the San Luis and Delta-Mendota Water Authority for water allocation and payment. The transferred water will include water released to meet instream flow needs of the lower Yuba River pursuant to the Yuba Accord Fisheries Agreement.

The agreements that were established as part of the Lower Yuba River Accord serve to establish seasonal operations and water resources management. A brief summary of the accord is provided in Box SR-3.

Placer County Water Agency Pump Station Project

In March 2008, the Placer County Water Agency (PCWA) Pump Station Project was completed. PCWA was pursuing the development of a year-round water diversion facility capable of diverting up to 35,500 af annually of PCWA's water entitlements from its Middle Fork Project (MFP) on the American River, and the USBR constructed the facilities to meet PCWA needs.

Prior to 1972, PCWA had installed pumps to lift water supplies to the Auburn Ravine Tunnel for delivery to the PCWA service area. The original pump location interfered with the construction of the Auburn Dam Project (ADP) which started in 1972. USBR installed temporary pumps to lift the supplies, but these had to be removed before the rainy season because of inundation. The ADP construction was abruptly halted after a 1975 earthquake near Oroville, which revealed a fault line that traversed the site of the thin arch dam. It soon became apparent the ADP was not to be restarted.

PCWA water supply still had to be addressed. The temporary pumps were problematic for both USBR and PCWA. The annual task of pulling the temporary pumps, reinstalling and maintaining them each year, was expensive and difficult. They were unreliable and did not fully meet PCWA's water supply requirements.

In the 1990s, PCWA needed greater access to its MFP water to meet its system demands, and USBR was under increasing pressure to restore the river. The Pump Station Project would address PCWA's needs, but there were several challenges that had to be faced before USBR and PCWA could move forward with the project. The sudden halt of construction of the Auburn Dam left safety issues such as loose sediment, a coffer dam, and a dangerous diversion tunnel, conditions that had to be addressed before public access or the replacement of the pumps could be accomplished. Rafters and environment and recreation groups were demanding access to the 3 miles of river that were off limits to the public. The same groups were also concerned with the location of the permanent pump station even though engineering narrowed the possible siting of the station. The possibility of lawsuits continually loomed.

In 2001, USBR, PCWA, and critical local Congressional representatives agreed to "re-water" the half-mile project site and return the 3-mile reach of the American River to the public. Work began in September 2003. With the work completed in 2008, PCWA has year-round access to its MFP water entitlements from the American River, a secure site, greater and efficient pumping capacity, a restored river and aquatic environment, and support from American River advocate groups. The new pumping station also has capacity for expansion for PCWA's additional water rights from the MFP.

Freeport Regional Water Facility

The Freeport Regional Water Project (FRWP) is a cooperative effort of the Sacramento County Water Agency and the East Bay Municipal Utility District (EBMUD) of Oakland to supply surface water from the Sacramento River to customers in central Sacramento County and the East Bay area of California. The diversion point and pumping facilities are located in the south part of Sacramento on the Sacramento River near the small community of Freeport. It provides Sacramento County Water Agency with up to 85 million gallons per day (mgd) of water to supplement groundwater use in the central part of the county. EBMUD will use up to 100 mgd of this supply only during dry years, estimated to be 3 out of every 10 years, as a supplemental water source to complement existing conservation programs.

Construction of the FRWP facilities began in 2007. Becoming operational in Sacramento in 2011 with the completion of the Vineyard Surface Water Treatment Plant, the facilities supply water to over 40,000 customers. EBMUD's facilities were also completed in 2011, but EBMUD will only use FRWP water during dry years. Water from the FRWP will serve 1.3 million customers in Alameda and Contra Costa counties.

Projects Under Consideration, Actively Planned or Under Construction

Sacramento Regional WWTP Upgrades to Tertiary Treatment

In 2010, the Central Valley Regional Water Quality Control Board (CVRWQCB) adopted a National Pollutant Discharge Elimination System (NPDES) permit for the Sacramento Regional County Sanitation District (SRCSD) Sacramento Regional Wastewater Treatment Plant that required an extensive upgrade to SRCSD's WWTP in Elk Grove. The permit requires SRCSD to reduce the concentrations of ammonia and nitrate in its discharge and provide tertiary filtration and enhanced disinfection to remove pathogens. The permit has been amended by the CVRWQCB and SWRCB since its adoption in 2010. The permit gives the SRCDS until May 2023 to fully comply with the requirements.

Recent studies suggested that ammonia and other nutrients may be disrupting the food web in the environmentally troubled Delta, contributing to the decline in native fish populations such as Delta smelt. Effluent from the WWTP has been identified as the largest single source of ammonia in the Delta watershed. The SRCSD estimates the upgrades would cost approximately $1.5 billion to $2.1 billion.

SRCSD is challenging the filtration and enhanced disinfection requirements of the NPDES permit and has a court date scheduled for Spring 2014. Design and construction of the new WWTP are under way, and the project is expected to be completed by 2023. A link to the permit is the following: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2010-0114-02.pdf.

Davis-Woodland Planned Diversion

In September 2009, the cities of Woodland and Davis established the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority, to implement and oversee a regional surface water supply project.

The regional project will replace deteriorating groundwater supplies with safe, more reliable surface water supplies from the Sacramento River. Once complete, the project will serve more than two-thirds of the urban population of Yolo County. It will also serve the University of California, Davis, a project partner. The project goals are to provide a new water supply to help meet existing and future needs, improve drinking water quality and improve the quality of treated wastewater

The project plans include a jointly owned and operated intake on the Sacramento River (WDCWA in partnership with RD 2035), raw water pipelines connecting the intake to a new regional water treatment plant, and separate pipelines delivering treated water to Woodland, Davis, and University of California, Davis. Improvements to existing water supply systems will vary for Woodland and Davis and will include facilities such as distribution pipelines, water storage tanks and booster pump stations.

The project will divert up to 45,000 af/yr. of water from the Sacramento River. Water rights were granted in March 2011 and will be subject to conditions imposed by the State. Water diversions will be limited during summer and other dry periods. A more senior water right for 10 taf was purchased from the Conaway Preservation Group to provide summer water supply. Groundwater will continue to be used by Woodland and Davis during when demand for water cannot be met with surface water supplies alone.

The water treatment facility will be constructed to supply up to 30 mgd, with an option for future expansion to 34 mgd. Of that amount, Woodland's share of treated surface water will be 18 mgd, with Davis' share at 12 mgd. Approximately 5.1 miles of pipeline will transport "raw" water from the surface water intake on the Sacramento River to the water treatment plant located south of

Woodland. From there, the treated water will travel 7.8 miles via pipeline to Davis and up to 1.4 miles to Woodland. For more information go to: http://www.wdcwa.com/the_project.

North Bay Aqueduct Alternative Intake

DWR proposes to construct and operate an alternative intake on the Sacramento River, generally upstream of the Sacramento Regional WWTP, and connect it to the existing North Bay Aqueduct (NBA) system by a new segment of pipe. The proposed alternative intake would be operated in conjunction with the existing NBA intake at Barker Slough. The NBA Alternative Intake Project would be designed to improve water quality and to provide reliable deliveries of SWP supplies to its North Bay contractors, the Solano County Water Agency and the Napa County FCWCD.

DWR, the lead agency under the California Environmental Quality Act, is preparing an environmental impact report. As part of the public involvement process for the EIR, the lead agencies are asking for input on the scope of the NBA Alternative Intake Project EIR through a series of meetings and a written comment period (scoping).

Natomas Mutual Water Company — Converting Irrigation Supplies to Urban Uses

Natomas Central Mutual Water Company controls water rights for use on 55,000 acres of agricultural lands in northwest Sacramento and southern Sutter County. Its 120 taf of water rights are held in six licenses, five of which allow for irrigation, industrial, municipal, and domestic use. Besides its licenses, NCMWC has other permits for winter water from the Sacramento River, drainage water, and groundwater facilities.

NCMWC has engaged Golden State Water Company to service 7,500 acres approved by the Sutter County voters for development. Sutter Pointe is a proposed planned community located approximately 4 miles north of the City of Sacramento. It is Sutter County's largest development and will accommodate 47,000 to 49,000 people over a 20- to 30-year build-out. The plan calls for 17,500 homes, 20,000 jobs, 3,600 acres (1,500 hectares) of employment designated uses, and 1,000 acres (400 hectares) of community service uses, which includes parks, schools, open space, and other community facilities.

Work on infrastructure, such as roads and levees, which will service the development, has been ongoing. However, the Sutter Pointe as a construction project has not yet started, probably due to the area's economic slowdown. Additional information can be found at: http://www.cpuc.ca.gov/Environment/info/esa/gswc_sp/index.html.

The Sacramento River Diversion

This is a joint venture for PCWA and City of Sacramento. Prior to the economic slowdown of 2008, PCWA was the lead agency pursuing a new diversion from the Sacramento River. The project is expected to continue, but not at this time.

PCWA has a 35,000 af water right was established by the Water Forum Agreement of 1997, a formal agreement of water purveyors, environmentalists, agriculturalists, business leaders, along with city and county governments in Sacramento, El Dorado and Placer counties promoting ecosystem preservation along the lower American River. Along with PCWA, the cities of Sacramento and Roseville, and the Sacramento Suburban Water District have their own allocations from this new diversion and were to take part in funding the project.

The new supplies from the Sacramento River are being planned for the expected growth in the Northern Sacramento, and Western Placer County area. The point of diversion is NCMWC facility several miles upstream from the confluence of the American and Sacramento Rivers. Supplies will be conveyed via pipeline to the treatment facilities within the individual purveyor service areas.

However, with the economic slowdown at the end of the last decade, the project is on hold. Because the project is the most economical option for PCWA to increase its supplies, it is believed that the project will be pursued again. Neither the City of Sacramento nor the other entities are pursuing the project at this time. Addition information can be found at: https://ucmshare.ucmerced.edu/docushare/dsweb/Get/Document-105308/02_exec_summ.pdf.

Water Quality

Generally, water quality in the Sacramento Valley is of high quality for both surface water and groundwater; however there are some water quality challenges in the region that should be addressed to protect the various beneficial uses in the region. An issue that is receiving increased attention is the salinity of surface water and the subsequent salt loading that occurs for south of Delta exporters (Central Valley Regional Water Quality Control Board 2011b). Salinity impacts to groundwater are also a concern with municipal recycled water.

The RWQCBs throughout the state adopt basin plans that lay out a framework for how each RWQCB will protect water quality in its region. The basin plans designate the beneficial uses and establish an implementation program to achieve the water quality objectives and protect the beneficial uses. The implementation program describes how a RWQCB will coordinate its regulatory and non-regulatory programs to address specific water quality concerns.

A primary goal of the CVRWQCB is the development of a comprehensive salt and nitrate management plan for the Central Valley. The long-term plan will identify and require discharger implementation of management measures aimed at the reduction and/or control of major sources of salt and nitrate as wells as support activities that alleviate known impairments to drinking water supplies.

Surface Water Quality

Salinity

Salt and salinity management is considered by many stakeholders as one of the most serious long-term water quality issues facing the Central Valley, which includes the Sacramento River Hydrologic region. Salinity levels (measured as electrical conductivity [EC]) are generally low in the Sacramento River region compared to other regions of the state. EC levels within upper reaches of the Sacramento River range from 84 to 140 µmhos/cm and gradually increase downstream as water comes in contact with natural salts in soil and human activities (e.g., fertilizer application, disposal of treated wastewater) introduce salts either directly to water bodies or into the soil. In general, the Feather River has lower salinity levels than the Sacramento River and dilutes EC below the confluence of the two rivers. Even though EC levels are relatively low in the Sacramento River, the total salt load exported from south of the Delta to the San Joaquin River Basin and Tulare Lake Basin are a concern to water purveyors in these regions. In general, more salt enters than leaves the San Joaquin River Basin and Tulare Lake Basin resulting in unavoidable degradation of groundwater. This is a focus of the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) initiative.

The CV-SALTS initiative is a collaborative stakeholder driven and managed program to develop sustainable salinity and nitrate management planning for the Central Valley. The recommended regulatory elements in the salt and nitrate management plans will identify regulatory structure and policies to support basin-wide salt and nitrate management, and the CVRWQCB will consider adopting the recommended regulatory elements as basin plan amendments. The recommended regulatory elements will include five key areas:

- Refinement of agricultural supply, municipal and domestic supply, and groundwater recharge estimates.
- Revision of water quality objectives for these uses.
- Establishment of policies for assessing compliance with the beneficial uses and water quality objectives.
- Establishment of management areas where there are large-scale differences in baseline water quality, land use, climate conditions, soil characteristics and existing infrastructure and where short- and long-term salt and/or nitrate management is needed.
- Development of an overarching framework to provide consistency for the development of management plans within the management areas.

In addition, the SWRCB's Recycled Water Policy was adopted in 2009 (Resolution No. 2009-0011) with a goal of managing salt and nutrients from all sources in a basin-wide or watershed-wide basis. This policy requires the development of regional or sub-regional salt and nutrient management plans for every groundwater basin/sub-basin in California. Each plan must include monitoring, source identification, and implementation measures. In the Central Valley, which includes the Sacramento River Hydrologic Region, the only acceptable process for developing salt and nutrient management plans is through the CV-SALTS initiative.

Additional information on the CV-SALTS initiative is available at http://www.cvsalinity.org/, and additional information on statewide salt and salinity management is included in Update 2013, Volume 3, Chapter 19, "Salt and Salinity Management."

Metals from Mining

Legacy issues associated with historic mining activities continue to be a problem today. Copper, cadmium, zinc, and lead are metals that are naturally found in high concentrations in the "Copper Crescent" in Shasta County. Mining activities increase the amount of metals that enter nearby waterways. Water bodies in the area are impaired due to the elevated levels of copper, cadmium, zinc and lead. These metals are toxic to aquatic life at elevated concentrations although concentrations that are toxic to aquatic life may not be high enough to cause human health impacts.

Copper mining in the Upper Feather River watershed has also caused copper, cadmium, and zinc impairments in several of the Upper Feather River tributaries. The largest mine in this area is the Walker Mine, an inactive copper mine about 12 miles east of Quincy in Plumas County. Acidic and metal-laden water (acid mine drainage) discharging from the mine and tailings has long affected the nearby streams of Dolly Creek and Little Grizzly Creek. The discharge was reported to have eliminated aquatic life in Dolly Creek, downstream from its confluence with the mine drainage, and in Little Grizzly Creek downstream from its confluence with Dolly Creek for a distance of approximately ten miles from the mine. Little Grizzly Creek flows to Indian Creek, a tributary to the North Fork of the Feather River.

Inorganic mercury enters waterways when soils erode, atmospheric dust falls to the ground, and mineral springs discharge. Another significant source is cinnabar ore (mercury sulfide) that was mined in the Inner Coast Ranges for elemental mercury (quicksilver). This liquid form of mercury was transported from the Coast Ranges to the Sierra Nevada for gold recovery where several million pounds of mercury were lost to the environment during the Gold Rush. In various aquatic environments, inorganic mercury can be converted to methylmercury which is a potent neurotoxin. Methylmercury is readily absorbed from water and food, and therefore concentrations multiply greatly between water and top predators of aquatic food chains. The cumulative result of this bioaccumulation is more than a million-fold increase in concentrations of methylmercury in predatory fish such as bass and fish-eating wildlife such as terns and eagles (Sacramento River Watershed Program 2010).

Many streams and reservoirs in the Sacramento River Hydrologic Region contain fish with elevated concentrations of methyl mercury. Cache Creek is one source that transports mercury from abandoned and orphaned mercury mines in the Coast Ranges to the Cache Creek Settling Basin and eastward to the Yolo Bypass. Cache Creek accounts for 60 percent of the mercury discharged within the Central Valley (U.S. Environmental Protection Agency 2012a).

Pesticides

Pyrethroid pesticides have become the dominant insecticide used in urban environments. They also for many years have had significant use as agricultural insecticides and are attracting renewed attention as alternatives for organophosphate insecticides (Sacramento River Watershed Program 2007). In the last 6 years, urban stormwater from new developments in western Placer County and the City of Sacramento were identified as sources of pyrethroid-caused aquatic toxicity (U.S. Environmental Protection Agency 2012a). In 2011, the DPR issued two sets of draft surface water protection regulations addressing pesticide applications. Research completed at University of California, Davis, suggests that application methods required by the DPR-proposed surface water quality regulations could yield an 80 percent reduction in exposure of aquatic life to toxic levels of pyrethroids (U.S. Environmental Protection Agency 2012a).

The CVRWQCB is addressing pesticide-caused aquatic resource impairments through its Nonpoint Source Program, Irrigated Lands Regulatory Program (ILRP), and stormwater permits program. The CVRWQCB is also developing water quality criteria and related control programs for current use pesticides for all waterways in the Central Valley that support aquatic life. Phase I of this effort includes organophosphate pesticides (diazinon and chlorpyrifos). Phase II will address pyrethroid pesticides and possibly other pesticides of concern.

State Programs that Address Surface Water Quality Issues

The CVRWQCB oversees the following water quality programs that are intended to protect and restore the quality of surface waters in the Sacramento River region.

Irrigated Lands Regulatory Program

The ILRP regulates discharges from irrigated agriculture through surface water monitoring and the development and implementation of management plans to address water quality problems identified in the surface water monitoring. This program addresses materials used in agricultural production that may end up in surface water, such as pesticides as well as pollutants that may be concentrated or mobilized by agricultural activities such as salt. In this program, coalition groups representing growers monitor to identify constituents of concern. Management plans are developed to identify management practices that individual growers implement to reduce the concentrations of the constituents of concern in surface water. Follow-up monitoring is conducted to confirm that water quality standards are met. Growers work together under a coalition group to meet the program requirements.

Coalition groups active in the Sacramento River Basin are the California Rice Commission, Goose Lake Water Quality Coalition, and Sacramento Valley Water Quality Coalition. Where there are repeated exceedances of water quality objectives, coalitions are required to prepare a management plan that addresses the source and corrective action needed for those exceedances. The coalitions have developed and implemented management plans addressing chlorpyrifos, diazinon, diuron, malathion, thiobencarb, water column and sediment toxicity, and E. coli (Central Valley Regional Water Quality Control Board 2011a). Because follow-up monitoring indicated no water quality exceedances, the coalitions were approved to remove the E. coli management plan for the Pit River subwatershed, chlorpyrifos management plans for Coon Creek in the Placer-Nevada-South-Sutter-North Sacramento subwatershed, and toxicity to Ceriodaphnia in Laguna Creek in the Sacramento Amador subwatershed and in Coon Hollow Creek in the El Dorado subwatershed (Central Valley Regional Water Quality Control Board 2012).

National Pollutant Discharge Elimination System Permit Program

The NPDES permit program regulates the discharge of point-source wastewater and urban runoff to surface water. Point-source wastewater can contain elevated levels of salt and nitrates, pesticides, mercury and other metals. Urban runoff can contain pesticides, mercury and other metals, and sediment. Permits prevent the discharge of elevated concentrations of these constituents. In cases where elevated levels of constituents of concern are being discharged, permits require dischargers to develop and implement measures to reduce the levels of these constituents.

Discharge to Land Program

The Discharge to Land Program oversees the investigation and cleanup of impacts of current and historical unauthorized discharges including discharges from historical mining activities. Historical mine impacts include mercury impairments from mercury mines found on the Coast Ranges side of the Central Valley and mercury impairments from the use of mercury to amalgamate gold in the mines on the Sierra side and in the Klamath-Trinity Mountains. Other metal impairments result from the copper mining that occurred in the “Copper Crescent” in Shasta County and the upper Feather River.

Water Quality Certification Program

The Water Quality Certification Program evaluates discharges of dredge and fill materials to assure that the activities do not violate state and federal water quality standards. One of the goals of the program is to protect wetlands and riparian areas from dredge and fill activities and to implement State and federal “no net loss” policies for wetlands. Constituents of concern addressed by this program are salts and nutrients, methylmercury, and temperature.

Timber Program

The Timber Program provides review, oversight, and enforcement of timber harvest activities on both private and U.S. Forest Service lands. The primary responsibility of the program is review and inspection of harvest activities. Timber harvest activities pose a threat to water quality through the potential for sediment and herbicide discharges and temperature increases to surface waters. During the past five years in the Sacramento River Hydrologic Region, private timberland owners have submitted 532 timber harvest plans that allow harvesting on over 173,000 acres.

Nonpoint Source Program

The Nonpoint Source Program supports local and regional watershed assessment, management, and restoration to enhance watershed conditions that provide for improved flow properties and water quality. Non-point-sources include agriculture, forestry, urban discharges, discharges from marinas and recreational boating, hydromodification activities and wetlands, riparian areas and vegetated treatment systems. For some of these sources, such as irrigated agriculture and forestry, the CVRWQCB has specific regulatory programs. The Nonpoint Source Program addresses sources where the CVRWQCB has not developed a specific program. This program assists stakeholders to obtain funding to address non-point-source pollution as well as conduct riparian and habitat restoration activities. Impacts from recreational activities such as off-highway vehicle (OHV) use fall under this program. In 2009, the CVRWQCB found that portions of the Rubicon Trail located in El Dorado County were severely eroded. Erosion was accelerated by OHV use, and sediment was being discharged to surface waters. In addition to the erosion, the board found that there were human sanitation problems, soil contamination from metals, and water contamination from petroleum-based fuels. To address this problem, the CVRWQCB issued a Cleanup and Abatement Order to El Dorado County and Eldorado National Forest to develop and implement plans to improve management of the trail and protect water quality (Central Valley Regional Water Quality Control Board 2009).

Groundwater Quality

The following contaminants have been found to occur regionally in groundwater:

- Arsenic.
- Boron.
- Localized contamination by organic compounds and nitrates.
- Chromium-6.

High concentrations of arsenic have been found in wells located toward the center of the Sacramento Valley along the Sacramento and Feather rivers. The source of the arsenic is from minerals dissolved from the volcanic and granitic rocks of the Sierra Nevada.

Boron has been detected at concentrations greater than the non-regulatory human-health notification levels of 1,000 µg/L in several aquifers located within southern and middle parts of

Sacramento Valley. High concentrations of boron found in wells located along Cache and Putah creeks are likely associated with old marine sediments from the Coast Ranges.

The solvent tetrachloroethylene (PCE) has been detected in some public supply wells in Butte County and Sacramento County at concentrations that exceed the maximum contaminant level (MCL) or drinking water standard. PCE was the main solvent used for dry cleaning. Its occurrence is also associated with textile operations and degreasing operations.

Nitrate levels in most public supply wells in the region are below drinking water standards; however, some wells along the west side of the Sacramento Valley have occasionally exceeded the nitrate MCL. Groundwater in the Chico urban area and the Antelope area of Red Bluff also has high nitrate levels. For the Chico urban area, the CVRWQCB has issued a prohibition of discharge from individual disposal systems or septic systems in the area.

Concentrations of chromium-6 at levels above the detection limit (above 1 μg/L) have been detected in many active and standby public supply wells along the west or valley floor portion of the Sacramento Valley. Chromium-6 is found to occur naturally in the environmental at low levels; and there are also areas of contamination in the state due to historical industrial use such as manufacturing of textile dyes, wood preservation, leather tanning, and anti-corrosion coatings (California Department of Public Health 2013a). In August 2013, the CDPH released a proposed Chromium-6 MCL of 10 parts per billion (ppb), and the final MCL is expected to be adopted in 2014.

Groundwater Quality Protection Strategy

In 2008 the CVRWQCB started a public process to solicit information from stakeholders on groundwater quality protection concerns in the entire Central Valley region, including the Sacramento River Hydrologic Region. In 2010, the CVRWQCB approved the following recommended actions:

- Development of Salt and Nutrient Management Plan.
- Implement groundwater monitoring program. Monitoring will focus on water quality and waste discharge requirements.
- Implementation of groundwater protection programs through Integrated Regional Water Management Plan Groups.
- Broaden public participation in all programs.
- Coordinate with State and local agencies to implement a Well Design and Destruction Program.
- Development of a groundwater quality database.
- Establishment of a regulatory process for alternative methods of dairy waste disposal.
- Development of individual and general orders for confined animal feeding operations.
- Implementation of a long-term irrigated lands program.
- Coordination with California Department of Food and Agriculture to identify methods to enhance fertilizer program.
- Reduce site cleanup backlog.

- Update guFidelines for waste disposal of land development consistent with the Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy) (SWRCB Resolution 2012-0032 adopted in compliance with CWC Section 13291).
- Implement the OWTS Policy, which includes a waiver from discharges from OWTS that are in conformance with the OWTS Policy.
- Develop methods to reduce the backlog and increase the number of facilities regulated.

State Programs that Address Groundwater Quality Issues

The CVRWQCB oversees the following water quality programs that are intended to protect and restore the quality of groundwater in the Sacramento River region.

Irrigated Lands Regulatory Program

The CVRWQCB's Irrigated Lands Regulatory Program, which has been focused on surface water, has been transitioning to a long-term program that will address both surface water and groundwater. Irrigated lands may be a source of salt, nitrates, and pesticides to groundwater.

Confined Animal Operations

The CVRWQCB has a program to regulate discharges from confined animal operations. Water quality issues associated with confined animal operations are salt and nutrients. In 2007, the CVRWQCB adopted Waste Discharge Requirements General Order for Existing Milk Cow Diaries (R5-2007-0035), which includes requirements for both the dairy production area and land application area and requires each dairy to fully implement their waste management plan by 2011 and nutrient management plan by 2012. The requirements for the waste and nutrient management plans are designed to protect both surface water and groundwater. In the Sacramento River Hydrologic Region, 85 dairies with over 41,000 cows are regulated under this general order (Central Valley Regional Water Quality Control Board 2010).

Onsite Wastewater Treatment Systems

The SWRCB has adopted regulations for the operation of onsite wastewater treatment systems or septic systems. Water quality concerns associated with septic systems include salt, nitrates, and pathogens. The CVRWQCB has updated its guidelines and established a program based on the new regulations. In the past, the CVRWQCB has prohibited discharge in problematic service areas. In the Sacramento River Hydrologic Region, the CVRWQCB has adopted 13 prohibitions of discharge from septic systems. Currently, 12 of these areas are served by community wastewater treatment systems. The other area is the Chico Urban Area in Butte County. The prohibition for the Chico Urban Area covers about 12,000 septic systems.

Drinking Water Quality

Recently, the SWRCB (2013a) completed its report to the Legislature titled Communities That Rely on a Contaminated Groundwater Source for Drinking Water. The report identified communities, that prior to any treatment, rely on a contaminated groundwater source for their drinking water. The report focused on chemical contaminants found in active groundwater wells used by community water systems (CWSs). A CWS is defined as a public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents (Health & Safety Code Section 116275). The findings of this report reflect the raw, untreated groundwater quality and not necessarily the water quality that is served to these communities.

In the Sacramento River Hydrologic Region, there are an estimated 504 CWSs and 1,199 active wells that are used by CWSs in the region. A total of 101 wells or 8 percent are affected by one or more chemical contaminants that exceed an MCL and require treatment. These affected wells are used by 61 CWSs in the region with 45 of the 61 affected CWSs serving small communities that often need financial assistance to construct a water treatment plant or alternate solution to meet drinking water standards (Table SR-16). The most prevalent groundwater contaminants in the region affecting CWS wells are arsenic, PCE, and nitrate (Table SR-17).

While most large CWS are able to construct, operate, and maintain a water treatment system to remove or reduce groundwater contaminants below drinking water standards, small CWSs often cannot afford the high cost to operate and maintain a treatment system. Therefore, some are unable to provide drinking water that meets primary drinking water standards. As of December 2013, there were 17 small CWSs in the Sacramento River Hydrologic Region that violate a primary drinking water standard primarily due to groundwater contaminants. Thirteen of the 17 small CWSs violate the arsenic MCL (California Department of Public Health 2013b).

Central Valley Drinking Water Source Policy

The CVRWQCB has been working with a workgroup made up of interested stakeholders — including federal and State agencies; drinking water agencies; and wastewater, municipal stormwater, and agricultural interests — to develop a drinking water policy to help protect drinking water supplies. These efforts resulted in a Drinking Water Policy for Surface Waters of the Delta and its Upstream Tributaries that was adopted by the CVRWQCB in July 2013. The policy includes narrative water quality objectives for the pathogens *Cryptosporidium* and Giardia, along with implementation provisions, and clarification that the narrative water quality objective for chemical constituents includes drinking water constituents of concern. The workgroup evaluated land use changes and potential control measures that could be expected to occur in the next 20 years. The workgroup concluded that organic carbon would not increase at drinking water intakes based on the cumulative effect of several factors that includes reduction in agricultural lands, development of new regulations, and expansion of urbanization. While pathogens were not specifically modeled in this effort, current monitoring indicates that the new narrative water quality objective is being met. Additional information is available at http://www.waterboards.ca.gov/centralvalley/water_issues/drinking_water_policy/index.shtml.

Groundwater Conditions and Issues

Groundwater Occurrence and Movement

Aquifer conditions and groundwater levels change in response to varying supply, demand, and climate conditions. During dry years or periods of increased groundwater extraction, seasonal groundwater levels tend to fluctuate more widely. Subject to annual recharge conditions, this may result in a long-term decline in groundwater levels, both locally and regionally. Depending on the amount, timing, and duration of groundwater level decline, nearby well owners may need to deepen wells or lower pumps to regain access to groundwater.

Table SR-16 Summary of Small, Medium, and Large Community Drinking Water Systems in the Sacramento River Hydrologic Region that Rely on One or More Contaminated Groundwater Well(s)

Community Drinking Water Systems and Groundwater Wells Grouped by Water System Population	Number of affected community drinking water systems	Number of affected community drinking water wells
Small Systems ≤ 3,300	45	57
Medium Systems 3,301 – 10,000	5	12
Large Systems > 10,000	11	32
Total	61	101

Source: *Communities that Rely on a Contaminated Groundwater Source for Drinking Water*. State Water Resources Control Board 2013.

Note: Affected wells exceeded a Primary Maximum Contaminant Level prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.

Table SR-17 Summary of Contaminants Affecting Community Drinking Water Systems in the Sacramento River Hydrologic Region

Principal Contaminant (PC)	Community Drinking Water Systems where PC Exceeds the Primary Maximum Contaminant Level (MCL)	Community Drinking Water Wells where PC Exceeds the Primary Maximum Contmainant Level (MCL)
Arsenic	41	73
Nitrate	9	9
Tetrachloroethylene (PCE)	7	10
Gross alpha particle activity	3	4
Benzene	2	2

Source: *Communities that Rely on a Contaminated Groundwater Source for Drinking Water*. State Water Resources Control Board 2013.

Notes:

Only the five most prevalent contaminants are shown.

Affected wells exceeded a primary maximum contaminant level (MCL) prior to treatment at least twice from 2002 to 2010. Gross alpha levels were used as a screening assessment only and did not consider uranium correction.

As groundwater levels fall, they can impact the surface water-groundwater interaction by inducing additional infiltration and recharge from surface water systems, which reduce groundwater discharge to surface water baseflow and wetlands areas. Extensive lowering of groundwater levels can also result in land subsidence due to the dewatering, compaction, and loss of storage within finer grained aquifer systems.

During years of normal or above normal precipitation, or during periods of low groundwater extraction, aquifer systems tend to recharge and respond with rising groundwater levels. As groundwater levels rise, they reconnect to surface water systems, contributing to surface water baseflow or wetlands, seeps, and springs. The Sacramento Valley Groundwater Basin has historically been considered a groundwater rich area. Major surface water systems such as the Sacramento, Feather, Yuba, Bear, and American rivers provide significant recharge to regional aquifers, and serve as important sources of surface water supply for agricultural, urban, and managed wetlands uses. In addition, numerous smaller creeks along the eastern edge of the valley provide source of local aquifer recharge. Reduced precipitation along the west side of the valley results in mostly ephemeral creeks; however, these surface water systems also serve as important sources of groundwater recharge.

The movement of groundwater is from areas of higher hydraulic potential to areas of lower hydraulic potential, typically from higher elevations to lower elevations. Under pre-development conditions, the occurrence and movement of groundwater in the region was largely controlled by the surface and the subsurface geology, the size and distribution of the natural surface water systems, the average annual hydrology, and the regional topography. However, under agricultural and urban development pressures, increasing groundwater extractions may have influenced the natural occurrence and movement of groundwater on a seasonal and, in some areas, on an ongoing basis. Groundwater extraction over portions of western Glenn, southern Tehama, Butte (between Chico and Durham), southern Colusa, Yolo, Solano, and Sacramento counties have created a patchwork of groundwater table depressions that serve to redirect and capture groundwater flow that may otherwise have contributed to nearby surface water systems. Deviation from natural groundwater flow conditions is also influenced by thousands of large production wells screened over multiple aquifer zones, creating a conduit for vertical aquifer mixing. In areas providing surface water for agricultural use, infiltration along miles of unlined water conveyance canals and percolation of applied irrigation water can also influence groundwater movement by creating significant areas of groundwater recharge where none previously existed.

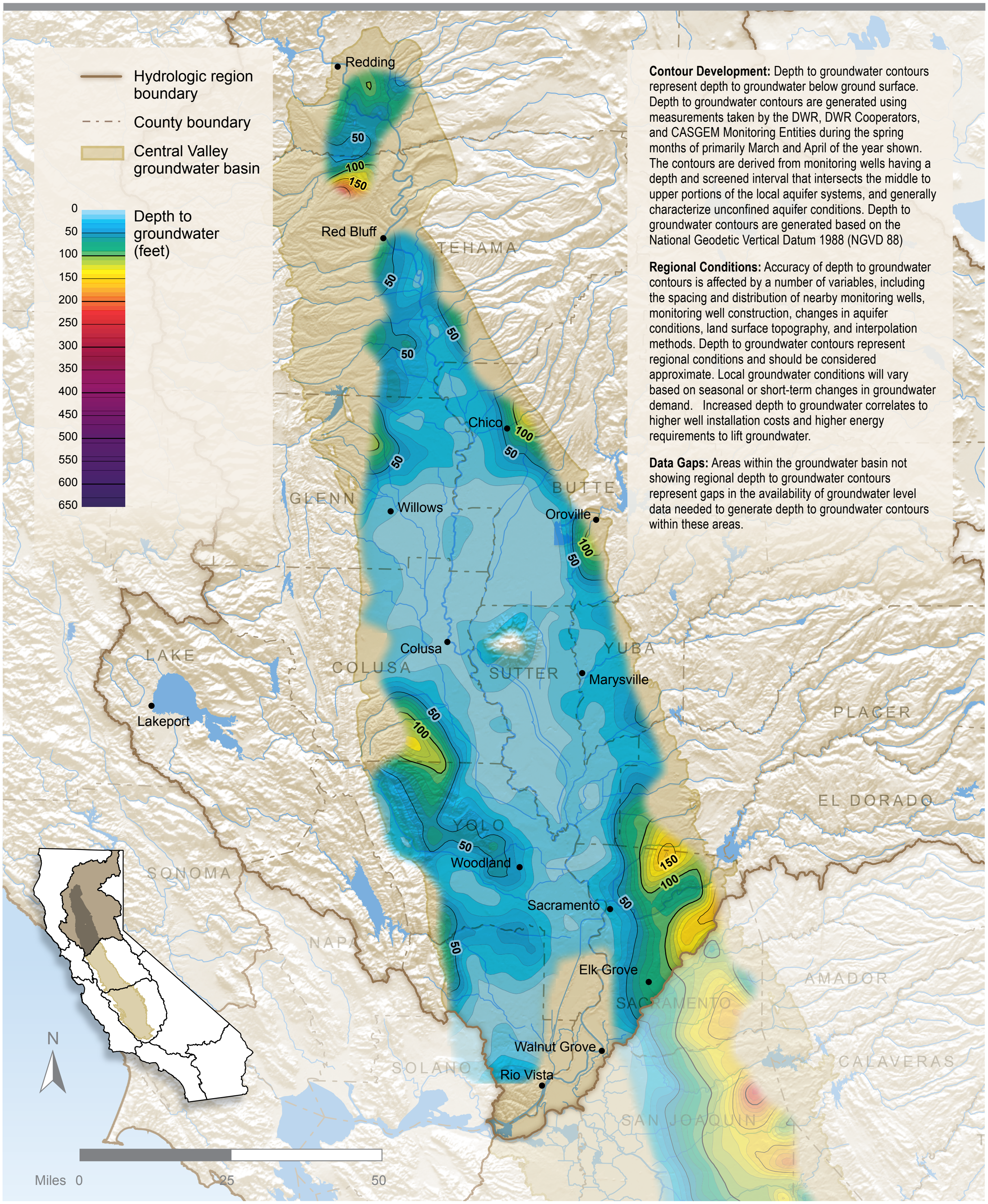
Depth to Groundwater and Groundwater Elevation Contours

Groundwater monitoring makes data available to prepare the depth-to-groundwater and groundwater elevation contours. The depth to groundwater has a direct bearing on the costs associated with well installation and groundwater extraction. Knowing the local depth to groundwater can also provide a better understanding of the interaction between the groundwater table and the surface water systems, and the contribution of groundwater aquifers to the local ecosystem.

Figure SR-14 is a spring 2010 depth-to-groundwater contour map for the Sacramento Valley and Redding Area Groundwater Basins using groundwater level data available online from DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/) and DWR's CASGEM system (http://www.water.ca.gov/groundwater/casgem/).

The contour lines in the figure represent areas having similar spring 2010 depth to groundwater values. Contour lines were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined groundwater conditions. Most of the areas with limited groundwater data fall within the Redding Area Groundwater Basin, the northwestern portion of the Sacramento Valley Groundwater Basin, and the Delta region in the southernmost portion of the Sacramento River Hydrologic Region. Depth-

Figure SR-14 Spring 2010 Depth to Groundwater Contours for the Sacramento River Hydrologic Region



to-groundwater contour map was not developed for groundwater basins outside the Central Valley. Information regarding depth to water in these basins may be obtained online through DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/).

Figure SR-14 shows that one-third of the Redding Area Groundwater Basin is characterized by a spring 2010 depth to groundwater of about 40 to 60 feet below ground surface. The areas of shallower groundwater typically occur over the center of the basin and adjacent to major surface water systems. Groundwater recharge associated with coarse-grained deposits along perennial streams and unlined agricultural distribution systems contributes to groundwater levels of less than 20 feet below ground surface in many smaller localized areas. Toward the edges of the basin, as the ground-surface elevation increases, the depth to groundwater quickly increases to over 100 feet below ground surface, reaching a maximum of about 200 feet below ground surface near the southernmost end of the basin.

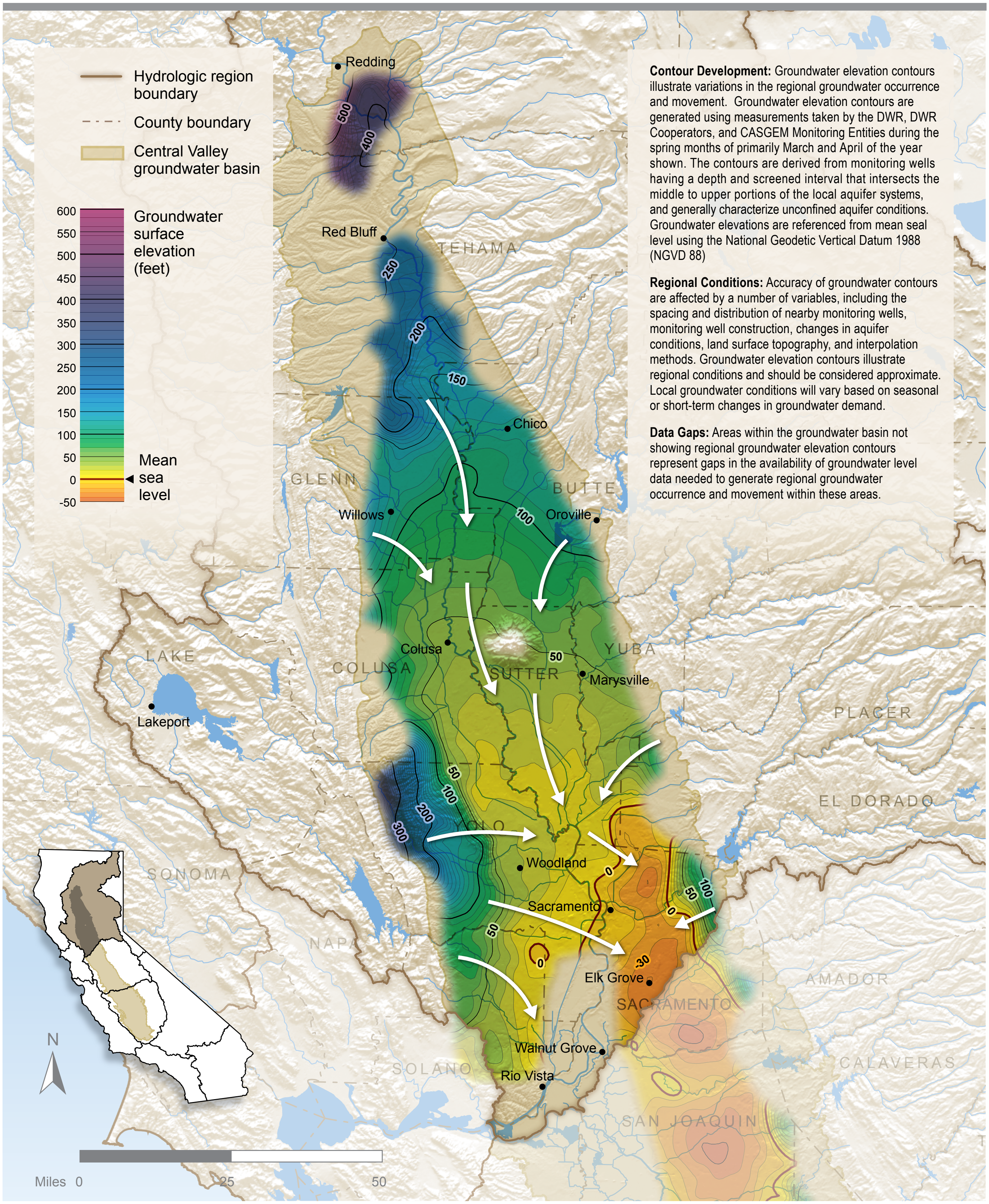
Figure SR-14 also shows that in the Sacramento Valley Groundwater Basin the spring 2010 depth to water is highly variable, ranging from a low of 10 feet below ground surface in areas adjacent to the Sacramento and Feather rivers, to a maximum of about 160 feet below ground surface within the North American Subbasin between Sacramento and Roseville. About half of the Sacramento Valley Groundwater Basin is characterized by spring 2010 groundwater levels that are less than or equal to 20 feet below ground surface. Much of the shallow groundwater occurs in areas surrounding the Sutter Buttes, where surface water is applied for rice production, and southward along the axis of the valley adjacent to the Sacramento River. The shallow groundwater table adjacent to surface water systems is indicative of interconnected surface water and groundwater systems.

Along the west side of the Sacramento Valley Groundwater Basin, adjacent to Interstate 5 between Williams and Zamora, the depth to groundwater is greater than in areas closer to the Sacramento River. This is likely due to a higher reliance on groundwater supplies for these areas, combined with relatively low recharge along the east-facing slope of the Coast Ranges. Local trends of increased depth to groundwater are also seen near the cities of Woodland and Davis, which rely entirely on groundwater for municipal water supplies. Smaller areas of increasing depth-to-groundwater trends also exist along the west side of Glenn County and in Butte County near Chico and south of Chico near Durham. However, the spring 2010 depth-to-groundwater map data for these areas are somewhat limited.

Groundwater elevation contours can help estimate the direction, gradient, and the rate of groundwater flow. Figure SR-15 is a spring 2010 groundwater elevation contour map for the Sacramento Valley and Redding Area Groundwater basins. Contour lines shown are generally indicative of the unconfined portion of the aquifer system and approximate the elevation of the groundwater table. Groundwater movement direction is shown as a series of arrows along the groundwater flow path; these flow direction arrows do not provide information regarding vertical flow within the aquifer system. Similar to the spring 2010 depth-to-groundwater contours, groundwater elevation contours were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined aquifer conditions.

Figure SR-15 shows that in the Redding Area Groundwater Basin the spring 2010 groundwater elevations range from a low of about 390 feet above mean sea level adjacent to the Sacramento River, to a high of about 590 feet above mean sea level in the northwestern foothill portions

Figure SR-15 Spring 2010 Groundwater Elevation Contours for the Sacramento River Hydrologic Region



of the basin. In the northern Sacramento Valley, the regional groundwater movement follows a relatively natural flow path from the edges of the basin to the Sacramento River and nearby drainages. The groundwater flow gradient remains relatively flat along the Sacramento River and the center axes of the basin, where topographic relief is low. The groundwater flow gradients increase rapidly at the edges of the basin as the topographic relief increases. Lack of groundwater monitoring in the South Battle Creek Subbasin and limited data in the Millville, Rosewood and Bowman subbasins rule out additional analysis in these areas. Additional information for the Redding Area Groundwater Basin indicates a strong connection between surface water and groundwater systems along the center of the basin, and a significant contribution from the shallow aquifer systems to the base flow of nearby streams and rivers.

Figure SR-15 also shows that for the Sacramento Valley Groundwater Basin, groundwater elevations range from below sea level near the Delta and in portions of the North and South American subbasins, to over 300 feet above mean sea level along western and northern portions of the basin. Spring 2010 groundwater elevation contours for the majority of the groundwater basin generally follow the valley topography, with groundwater flowing from the edges of the basin toward the Sacramento and Feather rivers and then southward along the valley axis. From Red Bluff to Colusa, the spring 2010 groundwater flow indicates the Sacramento River to be a gaining stream and the main corridor of groundwater discharge in the valley. Between Colusa and Knights Landing, the pattern of groundwater flow begins to change, indicating a transition whereby the Sacramento River begins to serve as a major source of recharge to the local aquifer systems. A series of depressions is observed in the North and South American subbasins that are likely the result of groundwater development for urban use in Sacramento and Davis areas. These radiating depressions in the groundwater table tend to induce infiltration from overlying surface water systems and capture adjacent groundwater underflow that may otherwise have discharged to nearby surface water systems and contributed toward their baseflow. A smaller groundwater depression and distortion of the natural pattern of groundwater flow occurs around the city of Woodland and to the adjacent areas toward the north. The depression in this area is likely caused by groundwater extraction for urban, agricultural, and industrial uses. By diverting and capturing the surrounding groundwater flow, these series of groundwater depressions can reduce amount of surface flow in streams.

Figure SR-15 illustrates several radiating patterns of groundwater recharge associated with key Sacramento Valley surface water systems. Key areas of spring recharge include the Stony Creek, between the Corning and Colusa subbasins; the Thermalito Afterbay, near where the Feather River enters the Sacramento Valley Groundwater Basin; the Yuba River, adjacent to the North and South Yuba subbasins divide; the Bear River, along the northern border of the North American Subbasin; Cache Creek as it exits the Capay Valley west of Woodland; and Putah Creek near Winters.

The topographic low point of the Sacramento River region includes the Delta in southernmost portion of the valley. This area has limited groundwater level data; however, existing data indicate that Delta groundwater elevations are generally at or slightly below sea level.

The springtime groundwater levels typically represent the highest groundwater levels of the year and a time when annual groundwater extractions are at a minimum and aquifer recharge is at the annual maximum. Additional comparison of the spring versus summer or fall groundwater levels is highly recommended in order to more fully understand seasonal variations of groundwater occurrence and movement and how these variations are affected by changes in annual precipitation, surface water deliveries, and demand. Summer groundwater elevation contours developed by DWR for the northern portion of the Sacramento Valley Groundwater Basin indicate that large reaches of the Sacramento River appear to be gaining flow during the spring months due to shallow groundwater discharge to the river, typically giving away to loosing reaches of the river (discharging surface water to adjacent aquifer systems) during the summer months that extend all the way north to Red Bluff.

Groundwater Level Trends

Groundwater levels within groundwater basins in the region are highly variable because of the physical variability of aquifer systems, the variability of surrounding land use practices, and the variability of groundwater availability and recharge. Plots of depth-to-water measurements in wells over time (groundwater level hydrographs) allow analysis of seasonal and long-term groundwater level variability and trends. The hydrographs presented in Figures SR-16A to SR-16J help explain how local aquifer systems respond to changing groundwater pumping quantities and to resource management practices. The hydrograph name refers to the well location (township, range, section, and tract).

Figure SR-16A shows hydrograph 38N07E23E001M, which is from a domestic well located in the Big Valley Groundwater Basin in the northern portion of the Sacramento River region. The Big Valley area is a rural cattle-ranching and hay-cropping area largely dependent on groundwater for irrigation during dry years. The well is constructed in the unconfined upper aquifer system. The hydrograph shows seasonal fluctuations in shallow aquifer groundwater levels of about 5 to 8 feet during years of average hydrology, and approximately 15 to 20 feet during drought periods. A long-term comparison of spring-to-spring groundwater levels shows a gradual decline and recovery of groundwater levels associated with the 1987-1992 drought and a partial recovery from the 2001 drought. Since 2000, spring-to-spring groundwater levels show a fairly steady trend of declining groundwater levels even during years of average hydrology and an increase in the seasonal groundwater level fluctuations due to increased groundwater pumping. Although the average groundwater level decline since 2000 is one-foot per year, the declines indicate that the annual rate of groundwater extraction is outpacing aquifer recharge. The hydrograph does indicate some aquifer recovery associated with above average precipitation during the 2010-2011 water year.

Figure SR-16B shows hydrograph 24N02W24D002-4M, which is from a multi-completion well located in Tehama County within the northern portion of the Vina Subbasin near the Sacramento River. The wells monitor three discrete aquifer zones with screened depths from 345 feet to 1,000 feet below ground surface. The difference in groundwater elevations shown on the hydrograph is due to the increase in head pressure in the different aquifers caused by different degrees of aquifer confinement. In this case, the pressure increases with depth, as the deepest well (24N02W24D002M) shows the shallowest water levels (greatest pressure) and the shallowest well (24N02W24D004M) shows the deepest water levels, indicating an upward gradient of groundwater flow, characterizing this location as a potential groundwater discharge area. The groundwater levels in each aquifer zone generally follow the same seasonal trends of low groundwater levels during the summer and fall, and high groundwater levels during the winter and spring. The highs and lows in the shallowest well (24N02W24D004M) are slightly greater than those in the two deeper wells, suggesting that the shallow aquifer is affected to a greater extent by nearby groundwater pumping. The overall 2006 to 2010 groundwater level trend in each zone of this multi-completion well is a decline of approximately one foot per year.

Figure SR-16C shows hydrograph 23N03W13C004-7M, which is from a multi-completion well located in the Corning Subbasin of the Sacramento Valley Groundwater Basin, within Tehama County near its southern border. The land use in the surrounding area is mixed with small orchards, pastures, idle lands, and rural communities that all rely on groundwater as primary water source. The wells monitor four discrete aquifer zones with screened depths from 25 feet to 970 feet below ground surface. The hydrograph shows the groundwater levels associated with the four aquifer zones, with a range of about 50 feet between the shallowest and the deepest zones. The shallowest well (23N03W13C007M) monitors groundwater levels from the shallowest aquifer zone, which is an unconfined aquifer that appears to be in direct communication with nearby surface water systems. Water levels in the well respond rapidly to changes in percolation associated with precipitation, applied irrigation water, and nearby surface water systems. The shallow intermediate zone (well 23N03W13C006M) and intermediate zone (well 23N03W13C005M) show similar groundwater elevations over time and are increasingly separated from surface recharge sources. As a result, they exhibit an increasingly muted and delayed response to seasonal fluctuations associated with winter recharge water. These wells are likely monitoring groundwater from a semi-confined aquifer, as the water depths in these wells, representing a potentiometric surface rather than an actual shallow water table, are generally 30-35 feet lower than the water table depicted in the shallow well. A seasonal fluctuation of approximately 20-25 feet is observed in the shallow intermediate and intermediate zoned wells. The deep intermediate zone (and deep zone), shown in hydrograph for well 23N03W13C004, likely depicts a potentiometric surface from a confined aquifer, or at least an aquifer that is under greater pressure than the aquifer above it and is separated by several hundred feet of alluvial material. The water levels in the deep intermediate well and deep well are generally 15 feet lower than the wells monitoring the intermediate shallow zone and intermediate zone, and show a seasonal fluctuation of approximately 10 feet. In these wells, the pressure decreases with depth, as the deepest well (23N03W13C004) shows the deepest water levels (least pressure) and the shallowest well (23N03W13C007) shows the shallowest water levels, indicating a downward gradient of groundwater flow, characterizing this location as a potential groundwater recharge area. Overall, for each of the zones depicted in the hydrograph, there is little net difference in groundwater levels from year to year, suggesting that this portion of the aquifer is being sustainably managed.

Figure SR-16D shows hydrograph 21N03W33A004M, which is from an irrigation well located in the Colusa County portion of the Colusa Subbasin. The well is located in the center of the upper portion of the subbasin, midway between the cities of Orland and Willows. The well is 750 feet deep and is constructed in the semi-confined to confined portions of the aquifer. The land use in the area of the well is predominately agriculture. The hydrograph shows a decline in groundwater levels during the 1970s, prior to bringing in surface water through the Tehama-Colusa Canal. During the 1980s, groundwater levels recover due to the combination of switching from groundwater to surface water supply and because of the wet hydrology associated with the 1982-1984 water years. The decline in groundwater levels in the early 1990s is likely due to many farmers switching back to groundwater supply because of surface water cutbacks and increased surface water price resulting from extended drought conditions. The most recent decrease in groundwater levels in the early 2000s is likely due to the recent trend of converting pasture, annual crops, and idle land to permanent orchard crops irrigated with groundwater. The hydrograph also shows that the seasonal fluctuation in groundwater levels can be as much as 70 feet over the period of record beginning in 1965. The lowest groundwater levels were during the drought in the late 1970s. Since 2009, the trend of declining groundwater levels has continued; and similar to many wells along the west side of the Sacramento Valley, groundwater levels are either at or approaching an all-time low.

Figure SR-16 Groundwater Level Trends in Selected Wells in the Sacramento River Hydrologic Region

Aquifer response to changing demand and management practices

Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

A Hydrograph 38N07E23E001M: shows a well with long term declining groundwater levels. The increasing seasonal fluctuations in the recent years indicate increased groundwater use.

B Hydrograph 24N02W24D002-4M: large seasonal fluctuations at the shallow monitoring level show that most of the pumping activity is concentrated in the shallower aquifer zone. Increasing potentiometric head with depth indicates an upward gradient of groundwater flow, characterizing this location as a potential groundwater discharge versus recharge area.

C Hydrograph 23N03W13C003-7M: large fluctuations in the intermediate and deep monitoring levels show that pumping activity is largely concentrated in the intermediate and deep aquifer zones. Decreasing potentiometric head with depth indicates downward gradient of groundwater flow, characterizing this location as a potential groundwater recharge area.

D Hydrograph 21N03W33A004M: illustrates a well with declining groundwater levels as a result of increased irrigation pumping due to drought or dry conditions. More recently there have been significant changes in land use and irrigation methods that further increased local groundwater demand.

E Hydrograph 22N01E28J003M: shows the effect dry periods have on groundwater levels in areas of heavy reliance on groundwater. During the dry periods, groundwater withdraws tend to outpace recharge resulting in declining groundwater elevation. At this well, the recovery was weak or missing following the last two dry periods.

F Hydrograph 14N01E14G001M: shows a very stable water table with a seasonal fluctuation of generally less than 10 feet. The land use in area is dominated by agricultural rice production that uses predominantly surface water.

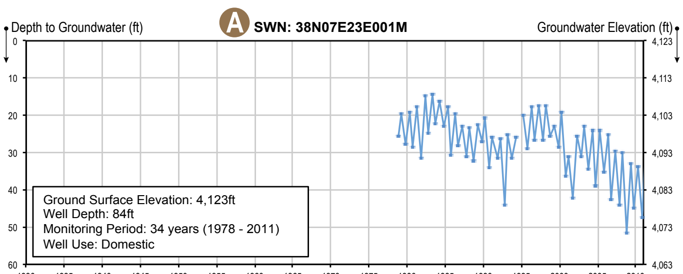
G Hydrograph 15N04E28D001M: shows the successful recovery of groundwater levels through the introduction of surface water supply in early 1980's, which resulted in reducing groundwater demand and facilitating in-lieu groundwater recharge.

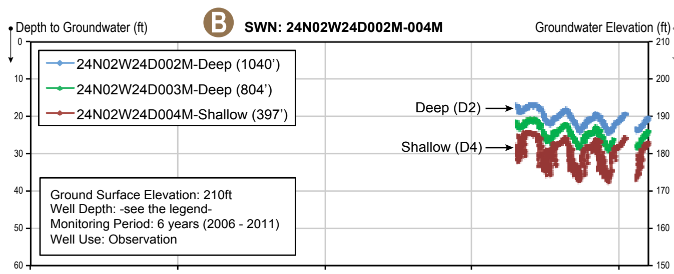
H Hydrograph 10N01W06D001M: highlights the impact of drought conditions on groundwater elevations. The seasonal measurements fluctuate more during dry years than during wet years.

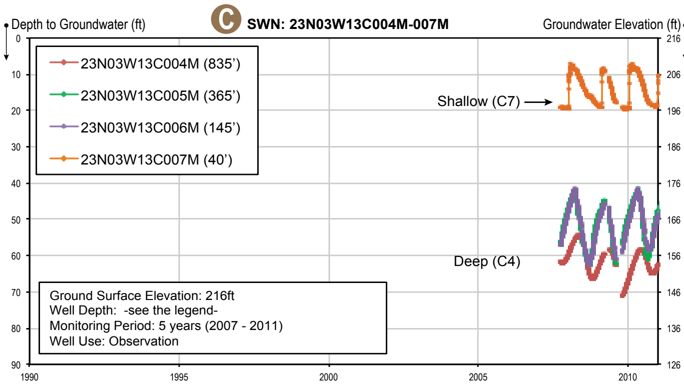
Regional locator map

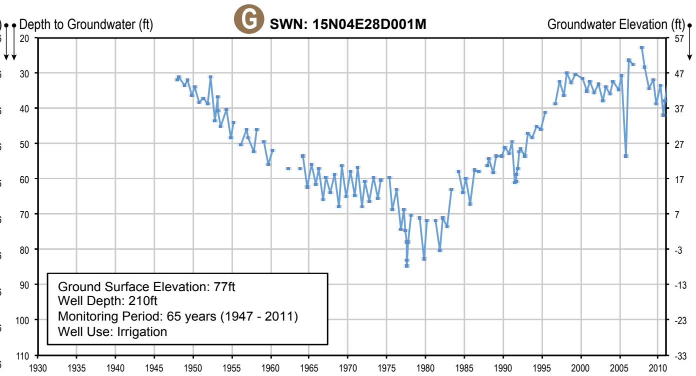
I Hydrograph 06N01W24N001M: shows the successful recovery of groundwater levels through the introduction of surface water supply in 1959, which resulted in reducing groundwater demand and facilitating in-lieu groundwater recharge.

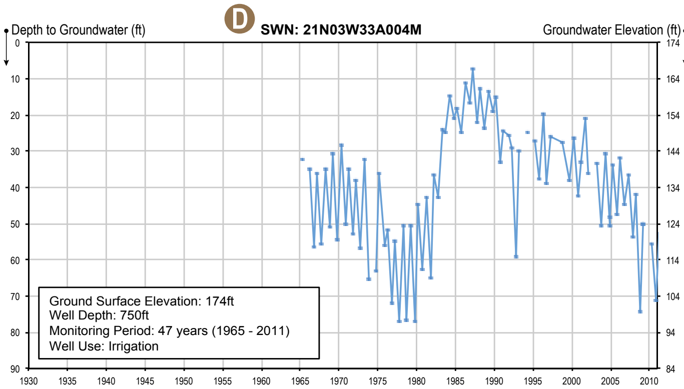
J Hydrograph 07N06E08H001M: illustrates the typical groundwater level trends observed in the wells located in Zone 40 portion of Sacramento County. The groundwater levels declined prior to the 1980s due to intensive groundwater use for domestic and agricultural purposes. After 1980s, the groundwater levels stabilized as surface water supplies became available for domestic use and as some of the agricultural land was transitioned into new residential developments.

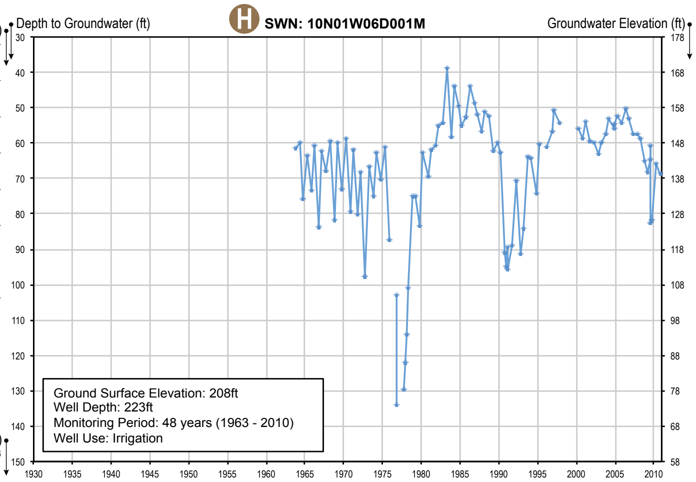


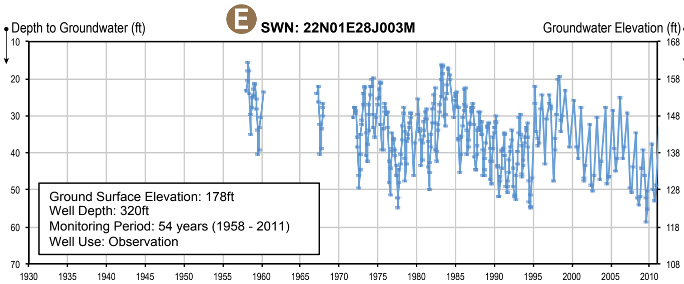


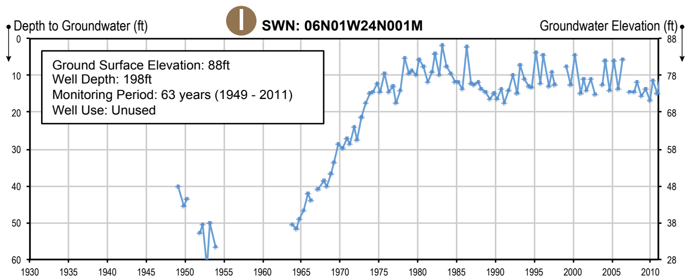

Depth to Groundwater (ft)
C SWN: 23N03W13C004M-007M
Groundwater Elevation (ft)
23N03W13C004M (835')
23N03W13C005M (365')
23N03W13C006M (145')
23N03W13C007M (40')
Shallow (C7)
Deep (C4)
Ground Surface Elevation: 216ft
Well Depth: -see the legend-
Monitoring Period: 5 years (2007 - 2011)
Well Use: Observation

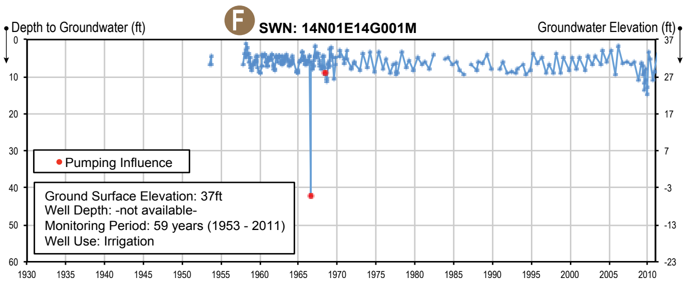

Depth to Groundwater (ft)
G SWN: 15N04E28D001M
Groundwater Elevation (ft)
Ground Surface Elevation: 77ft
Well Depth: 210ft
Monitoring Period: 65 years (1947 - 2011)
Well Use: Irrigation


Depth to Groundwater (ft)
D SWN: 21N03W33A004M
Groundwater Elevation (ft)
Ground Surface Elevation: 174ft
Well Depth: 750ft
Monitoring Period: 47 years (1965 - 2011)
Well Use: Irrigation


Depth to Groundwater (ft)
H SWN: 10N01W06D001M
Groundwater Elevation (ft)
Ground Surface Elevation: 208ft
Well Depth: 223ft
Monitoring Period: 48 years (1963 - 2010)
Well Use: Irrigation


Depth to Groundwater (ft)
E SWN: 22N01E28J003M
Groundwater Elevation (ft)
Ground Surface Elevation: 178ft
Well Depth: 320ft
Monitoring Period: 54 years (1958 - 2011)
Well Use: Observation


Depth to Groundwater (ft)
I SWN: 06N01W24N001M
Groundwater Elevation (ft)
Ground Surface Elevation: 88ft
Well Depth: 198ft
Monitoring Period: 63 years (1949 - 2011)
Well Use: Unused


Depth to Groundwater (ft)
F SWN: 14N01E14G001M
Groundwater Elevation (ft)
Pumping Influence
Ground Surface Elevation: 37ft
Well Depth: -not available-
Monitoring Period: 59 years (1953 - 2011)
Well Use: Irrigation

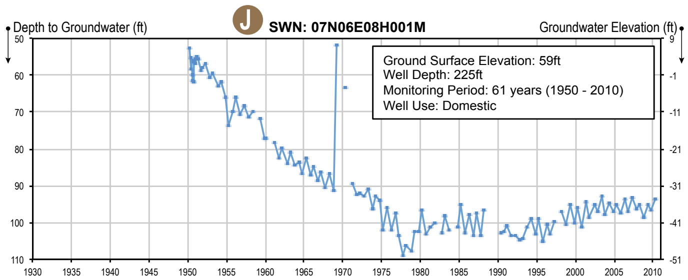

Depth to Groundwater (ft)
J SWN: 07N06E08H001M
Groundwater Elevation (ft)
Ground Surface Elevation: 59ft
Well Depth: 225ft
Monitoring Period: 61 years (1950 - 2010)
Well Use: Domestic

Figure SR-16E shows hydrograph 22N01E28J003M, which is from an observation well located in Vina Subbasin along the western edge of Chico and southern edge of the subbasin. The well is influenced by use of groundwater for urban use to the east and for agricultural use to the west. The well is constructed in the semi-confined portion of the aquifer. The local land use immediate to this well is almost 100 percent reliant on groundwater for urban and agricultural uses. The hydrograph shows seasonal fluctuations in groundwater levels of about 15 feet during years of average hydrology and up to 20 feet during drought periods. A long-term comparison of spring-to-spring groundwater levels shows a gradual decline and recovery of groundwater levels associated with the 1975-1977 and 1986-1994 droughts, and partial recovery associated with the 2001 drought. The hydrograph also shows a relatively weak groundwater level recovery from the 2007-2009 drought period after an above average water year during 2010-2011. During years of average precipitation, spring-to-spring groundwater levels show a trend of slightly declining groundwater levels since the mid-1980s, indicating that groundwater withdrawal is outpacing groundwater recharge.

Figure SR-16F shows hydrograph 14N01E14G001M, which is from a well located southwest of the Sutter Buttes in the Sutter Subbasin, less than half a mile east of the Sacramento River. The surrounding land use is dominated by agricultural rice production that uses predominantly surface water. The hydrograph illustrates that some areas within the Sacramento River region are characterized by very little seasonal and long term groundwater level changes. Seasonal groundwater level measurements since 1953 show a very stable water table with a seasonal fluctuation of generally less than 10 feet.

Figure SR-16G shows hydrograph 15N04E28D001M, which is from an irrigation well located in the South Yuba Subbasin of the Sacramento Valley Groundwater Basin, near the town of Linda in Yuba County. The hydrograph illustrates a typical groundwater response resulting from an in-lieu groundwater recharge operation. Prior to 1983, groundwater was the primary water source used for irrigation and other purposes in the South Yuba Subbasin, which over time created a widespread cone of depression within the aquifer. The depth to groundwater at this location increased from approximately 30 feet below the ground surface in 1947 to almost 85 feet in 1977, a decline of almost 2 feet per year. In 1983, surface water for irrigation was introduced into the South Yuba Subbasin by the Yuba County Water Agency; and groundwater levels began to recover to its historic high of 25 feet below ground surface in 2008, an increase of almost 2 feet per year. Throughout the period of record, the seasonal fluctuation of groundwater levels was generally within plus or minus 10 feet.

Figure SR-16H shows hydrograph 10N01W06D001M, which is from an irrigation well located in the Colusa Subbasin in Yolo County along the western boundary of the Sacramento Valley and approximately 2 miles north of Cache Creek. The hydrograph shows the impact of drought conditions on groundwater elevations. Prior to the 1976-1977 drought, groundwater levels seasonally fluctuated from 20 to 30 feet but were generally stable from year to year. However, between 1975 and 1977, the depth to groundwater declined from approximately 60 feet below ground surface in 1975 to 135 feet below ground surface in 1977. The hydrograph also shows the effects of wet years in the early 1980s that followed the dry years of the late 1970s. The effect of the drought on groundwater levels in this well appears to have been eliminated by 1980, and as shown in the hydrograph, the historical high groundwater level occurred in 1983. The effects of drought conditions in the early 1990s as well as in 2009 on groundwater levels are reflected in the hydrograph. The hydrograph also shows greater seasonal fluctuations during dry years and much smaller seasonal fluctuations during wet years.

Figure SR-16I shows hydrograph 06N01W24N001M, which is from an unused well located in the Solano Subbasin, within the southernmost portion of the Sacramento Valley Groundwater Basin and also within the northern portion of the Delta near the City of Vacaville. Although records for this well between 1953 and 1963 are incomplete, data after 1963 show groundwater levels to recover from more than 50 feet below ground surface to levels 10 feet or less below ground surface by 1975. Groundwater levels were at or just below ground surface numerous times through 2010. Groundwater levels recovered due to the introduction of surface water supplies to the area. In 1959, the City of Vacaville began receiving Solano Project water through an agreement with the Solano County Water Agency. Prior to completion of the Solano Project, which stores surface water in Lake Berryessa constructed in 1957, all water supplies for municipal and irrigation uses were from local groundwater. Prior to 1959, the groundwater levels were declining at a rate of approximately 5 feet per year, and likely reached depths far greater than the historical low of more than 60 feet below ground surface observed in 1953.

Figure SR-16J shows hydrograph 07N06E08H001M, which is from a domestic well located in the South American Subbasin in the central portion of rural Sacramento County. The hydrograph shows a consistent groundwater level decline of almost 60 feet from 1950 until around 1980. From 1980 through 2010, the depth to groundwater has been relatively stable, with a seasonal fluctuation of plus or minus 10 feet or less. The hydrograph is consistent with hydrographs from other nearby wells in the Zone 40 portion of Sacramento County. Prior to the 1980s, groundwater levels declined due to the intensive use of groundwater, which was the primary — if not the only — source of water in the area for domestic and agricultural purposes. Although development in the area continued to occur, the stabilization of the groundwater levels are attributed to the higher use of surface water supplies that became available to residential developments, and the fallowing of agricultural areas as they transitioned into new developments in accordance with the county's general plan. Groundwater levels have not recovered to 1950 levels because groundwater is continuing to be used for domestic and agricultural purposes. However, as shown by the stable hydrograph, groundwater and surface water supplies appear to be used in a balanced way in accordance with the objectives of the area's groundwater management plan.

Change in Groundwater Storage

Change in groundwater storage is the difference in stored groundwater volume between two time periods. Examining the annual change in groundwater storage over a series of years helps identify the aquifer response to changes in climate, land use, and groundwater management. If the change in storage is negligible over a period of average hydrologic and land use conditions, then the basin is considered to be in equilibrium under the existing water use scenario and current management practices. Declining storage over a relatively short period of average hydrologic and land use conditions does not necessarily mean that the basin is being managed unsustainably or is subject to overdraft. Utilization of groundwater in storage during years of diminishing surface water supply, followed by active recharge of the aquifer when surface water or other alternative supplies become available, is a recognized and acceptable approach to conjunctive water management. Additional information regarding the risks and benefits of conjunctive management can be found online from Update 2013, Volume 3, Chapter 9, "Conjunctive Management and Groundwater."

Annual and cumulative change in groundwater storage for the Sacramento Valley portion of the Sacramento River region was calculated between 2005 and 2010 using spring groundwater elevation data, a range of specific yield values for the aquifer, and a Geographic Information

Systems (GIS) analytical tool. The Sacramento Valley portion of the region includes the Redding Area and the Sacramento Valley Groundwater Basins.

Based on published literature, minimum and maximum specific yield (Sy) values of 0.07 and 0.17 were determined to be a good approximation of the range of regional aquifer storage parameters. For depth to water and groundwater elevation contour maps discussed previously, groundwater basins having insufficient data to contour and compare year-to-year changes in groundwater elevations were identified as "non-reporting" areas. Change in storage was also not estimated for these "non-reporting" areas.

Spring 2005 to Spring 2010 Change in Aquifer Storage

Figure SR-17 shows an overall decline in groundwater levels for much of the Sacramento Valley portion of the region from 2005 to 2010. In the Sacramento Valley Groundwater Basin, localized groundwater level declines from 20 to 30 feet are seen in the northwestern portion of the basin, while localized groundwater level declines from 10 to 20 feet are seen in the northern, mid- to south-western, and southeastern portions of the basin. In rest of the Sacramento Valley Groundwater Basin and the Redding Area Groundwater Basin, groundwater level declines from zero to 10 feet are observed.

Table SR-18 and Figure SR-18 show that the average annual change in groundwater elevation and related change in groundwater storage generally follow the annual precipitation or water year type. As Table SR-18 shows, the spring 2005-spring 2010 cumulative groundwater level decline over the basin is estimated to be over 3 feet. Figure SR-18 shows that the annual variability in groundwater storage change for the Sacramento Valley portion of the region is large. For example, the maximum single-year increase in groundwater storage between 503 taf and 1,221 taf occurred during the 2005-2006 period. The maximum single-year decline in groundwater storage between 929 taf and 2,255 taf occurred during the 2006-2007 period and represents between 34 and 82 percent of the average annual groundwater extraction for the entire Sacramento River region. The cumulative change in groundwater storage over the 2005-2010 period is estimated between 703 taf and 1,706 taf, which represents between 26 and 62 percent of the average annual groundwater extraction for the region. The large annual variation in groundwater storage changes points to high reliance on groundwater in the Sacramento Valley.

Additional information regarding the methods and assumptions for calculating change in groundwater storage is available online from Update 2013, Volume 4, *Reference Guide*, in the article "California's Groundwater Update 2013."

Land Subsidence

In the Sacramento River region, land subsidence associated with groundwater withdrawal has been documented in the North American and Yolo subbasins. As noted previously, DWR's Sacramento Valley subsidence monitoring network includes 11 extensometers and a GPS network. Some extensometers show land subsidence while others show a net land expansion due to wetting of clays. Eight of the 11 extensometers that DWR operates in the Sacramento Valley show no inelastic subsidence, although they do show elastic subsidence on the order of 0.03 foot. The other three extensometers show no elastic subsidence.

Figure SR-17 **Spring 2005 – Spring 2010 Change in Groundwater Elevation Contour Map for the Sacramento Valley Portion of the Sacramento River Hydrologic Region**

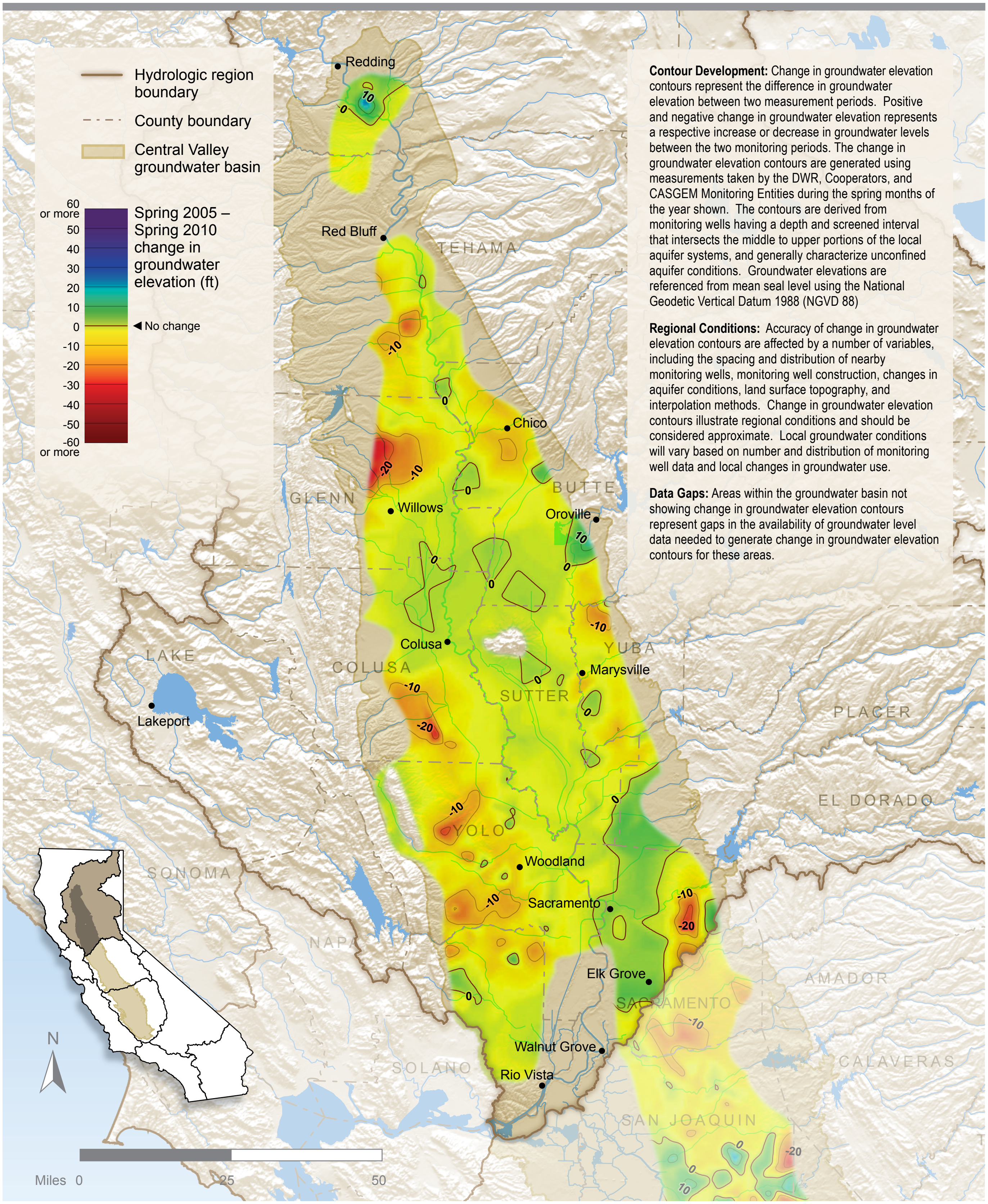


Table SR-18 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Sacramento Valley Portion of the Sacramento River Hydrologic Region

Sacramento River Hydrologic Region Spring 2005-2010 Change in Storage Estimates			
Reporting Area (Acres):	3,070,427		
Non-Reporting Area (Acres):	1,033,705		
Period Spring-Spring	Average Change in Groundwater Elevation (feet)	Estimated Change in Storage (taf)	
		ASSUMING SPECIFIC YIELD = 0.07	ASSUMING SPECIFIC YIELD = 0.17
2005-2006	2.3	502.6	1,220.7
2006-2007	-4.3	-928.6	-2,255.2
2007-2008	0.0	-1.6	-3.9
2008-2009	-1.8	-377.9	-917.7
2009-2010	0.5	103.0	250.1
2005-2010 (total)	-3.3	-702.5	-1,706.0

Notes:

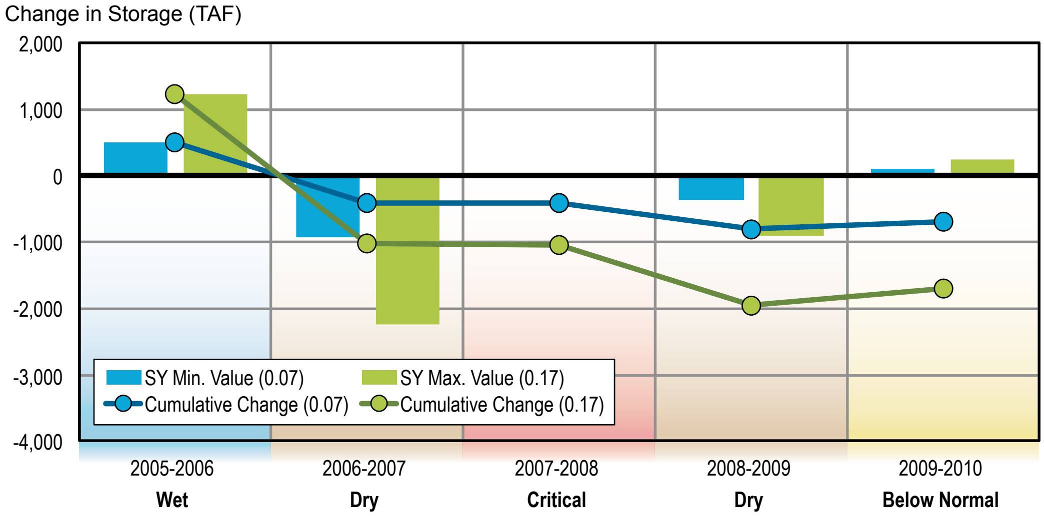
TAF = thousand acre-feet

Changes in groundwater elevation and storage are calculated for reporting area only.

The Zamora area within Yolo County portion of the Colusa Subbasin has experienced land subsidence due to groundwater pumping. Leveling surveys from 1950 to 1990 indicate that more than 4 feet of subsidence has occurred midway between Knights Landing and Zamora. The Zamora extensometer-11N01E24Q008M, the oldest extensometer in the area (Figure SR-19A), was installed to monitor subsidence. This extensometer has one of the longest histories of data, dating back to 1992. The data show a total land displacement of over one foot, with an average subsidence of -0.05 feet per year. The associated well data from the deep aquifer zone show an average decline in groundwater levels of -0.2 feet per year. The Yolo County FCWCD published a groundwater management plan in 2006, which covers Yolo County portion of the Colusa Subbasin. One of the goals of the plan is to "maintain or enhance local groundwater quantity and quality, resulting in a reliable groundwater supply for beneficial uses and avoidance of adverse subsidence." The plan includes basin management objectives (BMOs) that address the problem of land subsidence resulting from groundwater pumping. The BMOs have both a trigger and a response; the trigger occurs when monitoring data show that a certain condition has been reached, and the response is the action to address the condition (Yolo County Flood Control and Water Conservation District 2006). This type of action plan is a good model to follow when managing water resources in an area prone to land subsidence. By maintaining a long-term balance of groundwater production and recharge, the negative effects of land subsidence can be minimized.

Although some land subsidence is occurring in the southern portion of the Sacramento Valley, the central and northern portions of the valley have not yet recorded any inelastic land subsidence. Figure SR-19B shows time-graph of extensometer 17N02W09H002M established in 2005 and located northwest of Colusa in the Colusa Subbasin near the center of the Sacramento Valley.

Figure SR-18 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Sacramento Valley Portion of the Sacramento River Hydrologic Region



Data indicate that groundwater levels from the deep aquifer zone are declining at a rate of about -0.8 feet per year while land subsidence has not yet been observed.

Figure SR-19C shows time-graph of extensometer 22N02W15C002M, which is the northernmost extensometer site within the Sacramento Valley and located in the Corning Subbasin between Orland and Hamilton City. Data indicate that groundwater levels in the deep aquifer zone are declining at an average rate of -3.0 feet per year, while land is showing a slight expansion of +0.01 feet per year.

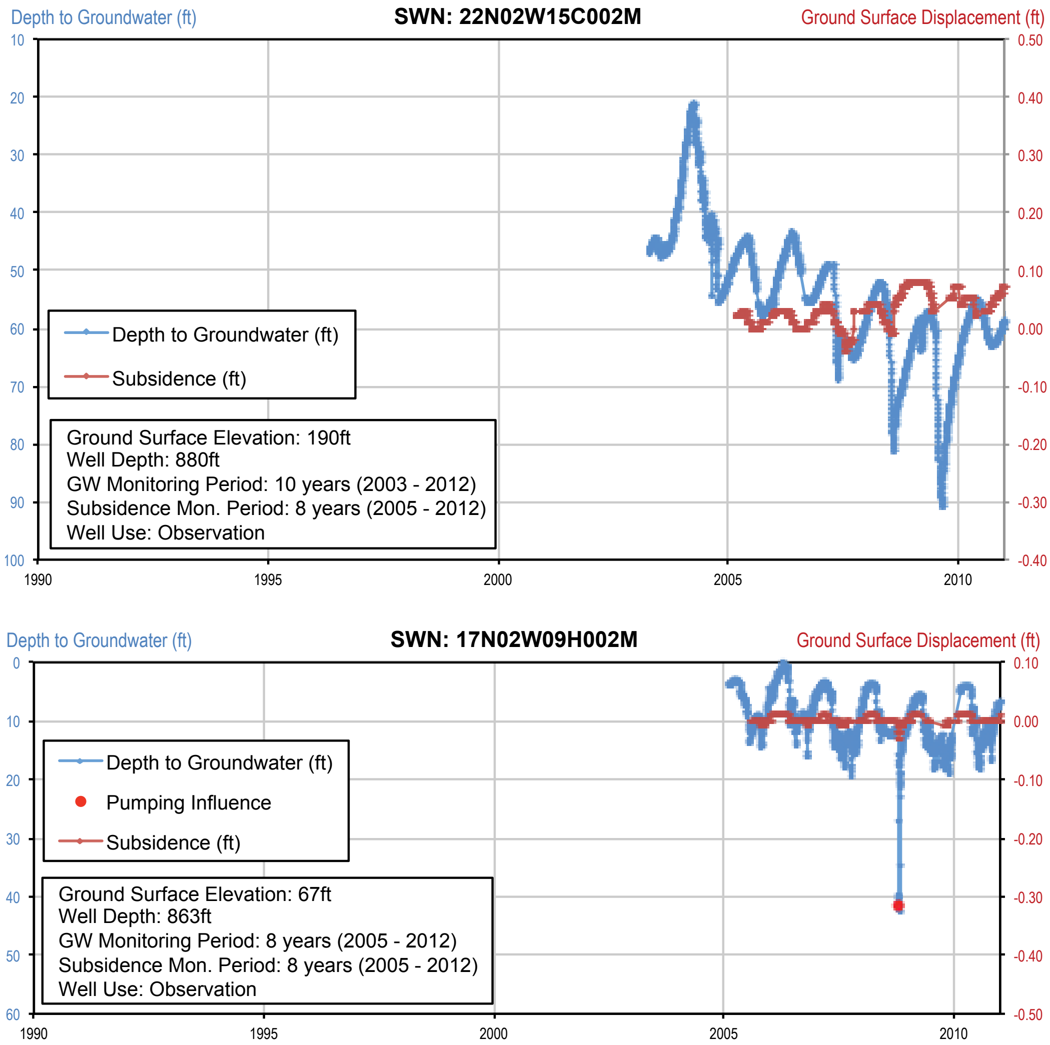
As groundwater pumping in the Sacramento Valley increases, the potential for land subsidence also increases. Although there is an existing land subsidence network in place, additional extensometers are needed for assembling a complete land subsidence monitoring grid. Two areas that show data gaps from the lack of extensometers are the area south of the Sutter Buttes and the area near Red Bluff. These areas are expanding in agriculture, and groundwater is being extracted at an increasing rate. Additional subsidence monitoring is needed in these areas to monitor the aquifers for potential subsidence. The GPS network constructed in 2008 unfortunately has not yet been resurveyed; therefore, no results from that effort could be reported.

Flood Management

Risk Characterization

Major floods are common in the Sacramento River Hydrologic Region. Slow-rise flooding would be nearly the exclusive cause of floods, but many miles of old and new levees — the older ones often raised by using materials at hand — has resulted in a high incidence of structure failure floods. Coastal flooding, caused by inundation due to water-level rise, occurs in the Delta and at Clear Lake. Some of the least substantial levees are in the Delta, where they are subject to continuous waterside inundation. Delta floods have been listed as coastal when levee failure is

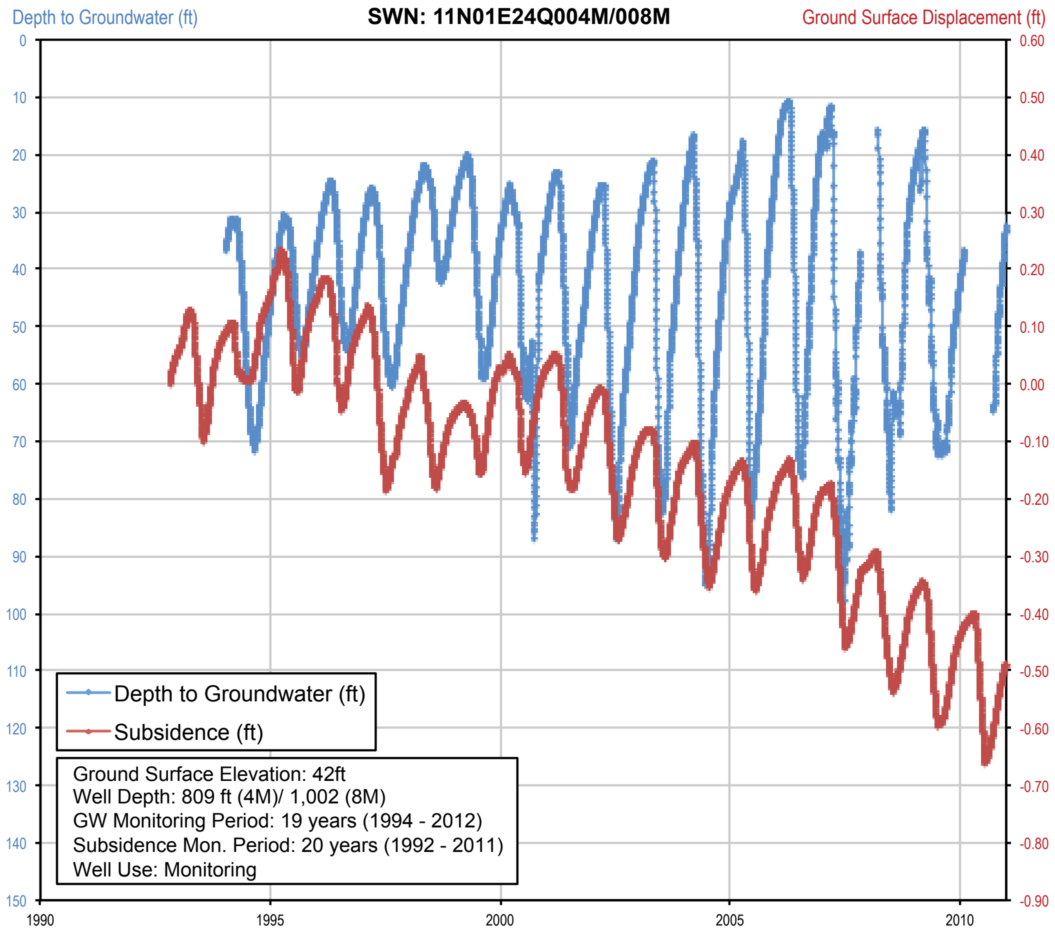
Figure SR-19 Selected Subsidence and Groundwater Level Hydrographs for the Sacramento River Hydrologic Region



not a contributor, and as structure failures when levees breach. Flood damage has been observed in the Sacramento River Hydrologic Region since at least 1805. Since the era of building levees began, floods have become less frequent and more damaging. Figures SR-20 and SR-21 provide statistics on the region's exposure to the 100-year and 500-year floodplains.

Damage Reduction Measures

Traditionally, the approach to flood management has been to alter or confine natural watercourses to reduce the chance of flooding, minimizing damage to lives and property. This approach looked at floodwaters primarily as a potential risk to be mitigated. Much of the Central Valley now derives its flood protection from the State Plan of Flood Control (SPFC). The SPFC refers to the facilities, lands, programs, conditions, and mode of operation and maintenance for the State/federal flood protection system.

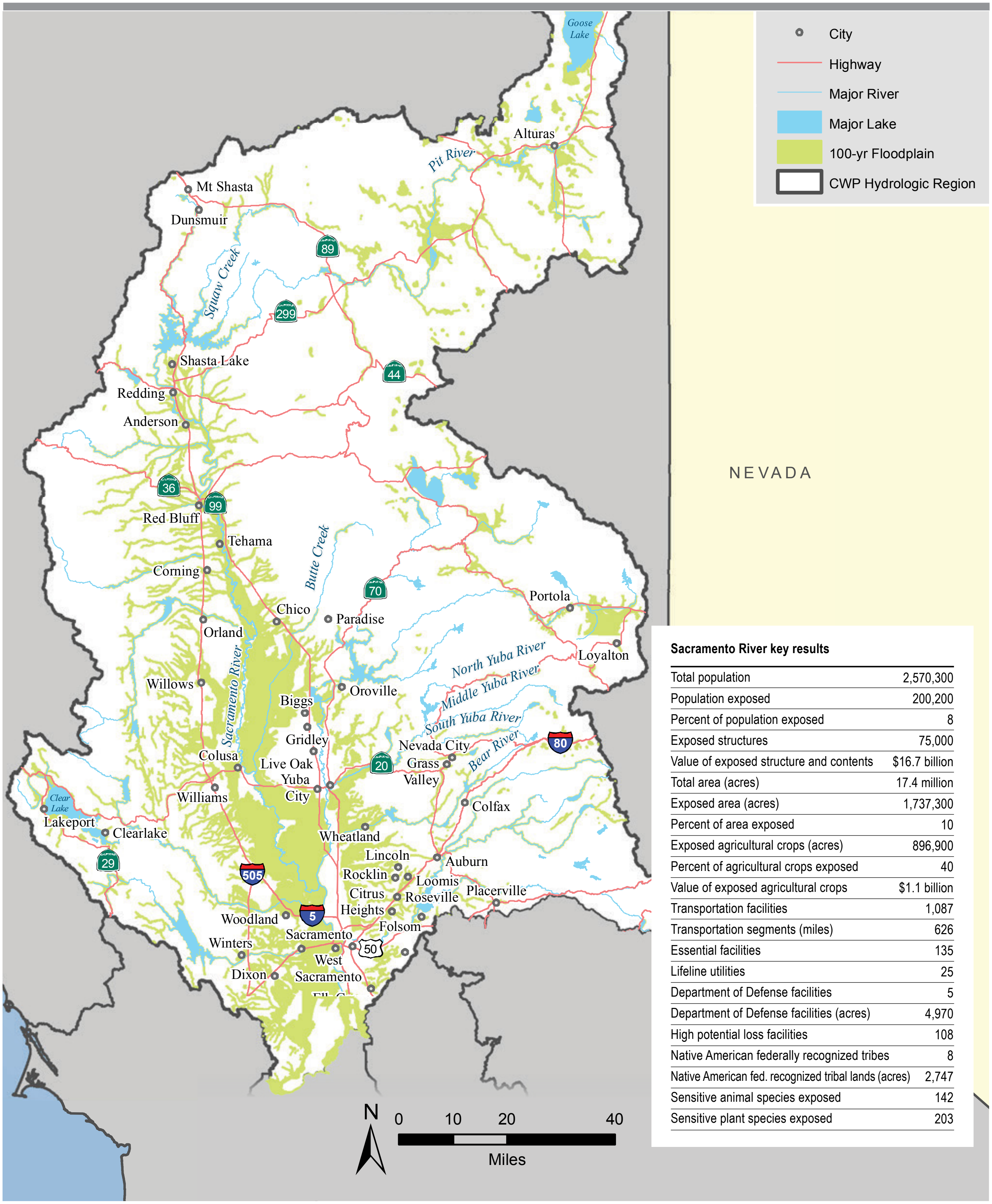


The SPFC system includes the following major facilities:

- About 440 miles of river, canal, and stream channels (including an enlarged channel of the Sacramento River from Cache Slough to Collinsville).
- About 1,000 miles of levees (along the Sacramento River channel, Sutter and Yolo basins, and Feather, Yuba, Bear, and American rivers).
- Four relief bypasses (Sutter, Tisdale, Sacramento, and Yolo bypasses).
- Knights Landing Ridge Cut to connect the Colusa Basin to the Yolo Bypass.
- Five major weirs (Sacramento Weir, Fremont Weir, and Moulton, Tisdale, and Colusa weirs).
- Two sets of outfall gates.
- Five major drainage pumping plants (California Department of Water Resources 2012).

These facilities were constructed as part of several large flood control projects:

Figure SR-20 Flood Hazard Exposure to the 100-Year Floodplain, Sacramento River Hydrologic Region

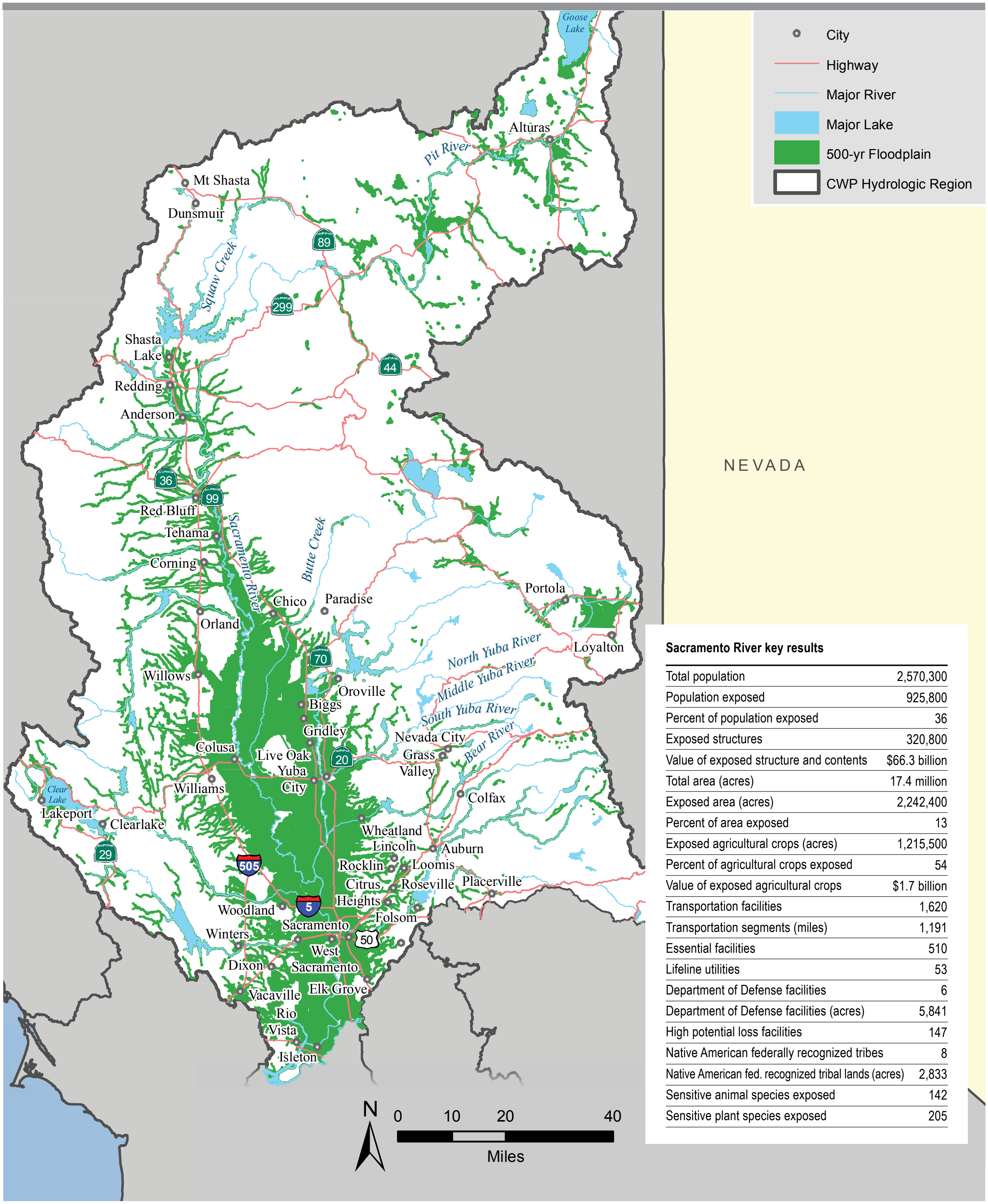


Sacramento River key results

Total population	2,570,300
Population exposed	200,200
Percent of population exposed	8
Exposed structures	75,000
Value of exposed structure and contents	$16.7 billion
Total area (acres)	17.4 million
Exposed area (acres)	1,737,300
Percent of area exposed	10
Exposed agricultural crops (acres)	896,900
Percent of agricultural crops exposed	40
Value of exposed agricultural crops	$1.1 billion
Transportation facilities	1,087
Transportation segments (miles)	626
Essential facilities	135
Lifeline utilities	25
Department of Defense facilities	5
Department of Defense facilities (acres)	4,970
High potential loss facilities	108
Native American federally recognized tribes	8
Native American fed. recognized tribal lands (acres)	2,747
Sensitive animal species exposed	142
Sensitive plant species exposed	203

Source: California's Flood Future Report

Figure SR-21 Flood Hazard Exposure to the 500-Year Floodplain, Sacramento River Hydrologic Region



Sacramento River key results

Total population	2,570,300
Population exposed	925,800
Percent of population exposed	36
Exposed structures	320,800
Value of exposed structure and contents	$66.3 billion
Total area (acres)	17.4 million
Exposed area (acres)	2,242,400
Percent of area exposed	13
Exposed agricultural crops (acres)	1,215,500
Percent of agricultural crops exposed	54
Value of exposed agricultural crops	$1.7 billion
Transportation facilities	1,620
Transportation segments (miles)	1,191
Essential facilities	510
Lifeline utilities	53
Department of Defense facilities	6
Department of Defense facilities (acres)	5,841
High potential loss facilities	147
Native American federally recognized tribes	8
Native American fed. recognized tribal lands (acres)	2,833
Sensitive animal species exposed	142
Sensitive plant species exposed	205

Source: California's Flood Future Report

- Sacramento River Flood Control Project.
- Sacramento River and Major and Minor Tributaries Project.
- Sacramento River Bank Protection Project.
- American River Flood Control Project.
- Sacramento River Project, Chico Landing to Red Bluff.
- Middle Creek Project.
- North Fork Feather River Project.

The Sacramento River Flood Control Project (SRFCP) is an umbrella term for six large U.S. Army Corps of Engineers (USACE) projects that, together with six reservoirs on the major rivers, constitute the state's largest flood management system. The SRFCP includes levees, bypasses, weirs, a debris basin, and appurtenant facilities. It extends from Elder Creek in Tehama County downstream to the Delta, a distance of 230 miles along the Sacramento River. The SRFCP has levees or other facilities on 5 major rivers, 15 creeks, and 13 sloughs. It incorporates 6 bypasses and 11 other constructed or improved channels. The project protects wide areas of the Sacramento Valley along the river and its tributaries, from the town of Tehama to downstream of Rio Vista.

The Sacramento River and Major and Minor Tributaries Project is another large project that was developed to reduce flooding and supply reservoir storage along the Sacramento River. The project also included levee construction and revetment, channel enlargement, and other tributary improvements.

The Sacramento River Project, Chico Landing to Red Bluff, was a modification and extension of the existing SRFCP that provided bank protection and channel improvements. The Sacramento River Bank Protection Project (SRBPP) is an ongoing project to construct bank erosion control works and setback levees within the limits of the existing levee system.

The American River Flood Control Project was developed to reduce flood risk along the lower American River between Carmichael Bluffs and the terminus of the SRFCP levee near the State Fairgrounds. The Middle Creek Project was developed to address localized flooding issues upstream of Clear Lake. The North Fork Feather River Project was developed to address localized flooding near Chester. This project consisted of construction of diversion dam, channel, and levees.

USACE bank protection projects in the region include:

- Sacramento River from Chico Landing to Red Bluff.
- Diversion dam, channel, and levees on the North Fork Feather River at Chester.
- Diversion channel, levees, and a pumping plant on Middle Creek and tributaries near Upper Lake.
- Improved channel for the Pit River through Alturas.

The region's eight major reservoirs with flood management reservations are Shasta Lake on the Sacramento River, Folsom Lake on the American River, Lake Oroville on the Feather River, New Bullards Bar Reservoir on the North Yuba River, Indian Valley Reservoir on North Fork Cache Creek, Highland Springs Reservoir on Highland Creek, Black Butte Lake on Stony Creek, and a small reservoir on Adobe Creek. USACE controls the flood management space on Shasta Lake, Folsom Lake, Black Butte, New Bullards Bar, and Lake Oroville reservoirs. Clear Lake, a natural lake, intercepts numerous tributaries to moderate Cache Creek. For the complete list of infrastructure in the Sacramento River Hydrologic Region, refer to the *California's Flood Future Report, Attachment E: Information Gathering Technical Memorandum* (California Department of Water Resources and the U.S. Army Corps of Engineers 2013b).

Today, water resources and flood planning involves additional demands and challenges, such as multiple regulatory processes and permits, coordination with multiple agencies and stakeholders, and increased environmental awareness. These additional complexities call for an integrated water management (IWM) approach that incorporates natural hydrologic, geomorphic, and ecological processes to reduce flood risk. Some agencies are transitioning to IWM, which is integral to the 2012 Central Valley Flood Protection Plan (CVFPP).

The CVFPP proposes a system-wide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the SPFC (California Department of Water Resources 2012). A substantial portion of the Sacramento River Hydrologic Region is within the implementation area of the CVFPP. The CVFPP is a flood management planning effort that addresses flood risks and ecosystem restoration opportunities in an integrated manner while concurrently improving ecosystem functions, operations and maintenance practices, and institutional support for flood management. Under this approach, California will prioritize investments in flood risk reduction projects and programs that incorporate ecosystem restoration and multi-benefit projects. The CVFPP was adopted by the Central Valley Flood Control Board on June 29, 2012. It is expected that the CVFPP will be updated every five years thereafter. The CVFPP proposes to address the following issues:

- Physical improvements in the Sacramento and San Joaquin River basins.
- Urban flood protection.
- Small community flood protection.
- Rural/Agricultural area flood protection.
- System improvements.
- Non-SPFC levees.
- Ecosystem restoration opportunities.
- Climate change considerations.

System repair, ecosystem restoration, and providing an urban level of flood protection has been a project successfully undertaken by the Three Rivers Levee Improvement Authority (TRLIA). A summary of local flooding issues and levee improvements in Yuba County is summarized in Box SR-4.

Water Governance

Development of California's water over time has resulted in several different agencies providing multiple layers of governance and management. Local, State, tribal, and federal agencies each provide some level of resource management and have mandates (sometimes conflicting mandates) to meet the needs of the environment, and urban and agricultural water users. For the management of surface water, there are approximately 145 settlement contractors and about

Box SR-4 Managing Levee Improvements in Yuba County

by Michael Ward, California Department of Water Resources

Yuba County has a long history of flooding. Historical accounts describe several flood events in the 1800s and 1900s. Major flood events in 1955, 1986, and 1997 were due to levee failures. The flood in 1955 was caused by several levee embankment failures that flooded nearly all of Yuba City and the town of Nicolaus, inundating approximately 156 square miles (EDAW 2006). This event prompted the formation of the Yuba County Water Agency and the construction of Bullards Bar dam for flood control as well as water storage and hydroelectric power.

Flooding in 1986 was due to a levee embankment failure adjacent to the Yuba River near the town of Linda, which flooded nearly 30 square miles including Linda and Olivehurst (EDAW 2006). The 1997 flood was due to a levee embankment failure south of Olivehurst flooding nearly 50 square miles, the towns of Olivehurst and Arboga, damaging up to 13,000 homes, and destroying up to 800 homes (EDAW 2006).

The floods of 1986 and 1997 resulted in a review of the methods used for evaluating levee performance including the effects of levee seepage and the revision of design criteria for strengthening existing levees (U.S. Army Corps of Engineers 2012). To a large extent, levee deficiencies in the region are related to seepage under and through levee soils during flood events (U.S. Army Corps of Engineers 2012).

To address these issues, Three Rivers Levee Improvement Authority (TRLIA), a joint powers authority (JPA), was formed by Yuba County and RD 784. The JPA agreement gives TRLIA the authority to provide improved flood protection in the county and the ability to finance improvements and associated operations and maintenance (O&M). Using available funding through the Costa-Machado Water Act of 2000 (Prop. 13) and Proposition 1E, TRLIA has made improvements to levees of the Yuba, Feather, and Bear rivers and the Western Pacific Interceptor Channel. Improvements included the installation of slurry walls, relief wells, monitoring wells, stability and seepage berms, new setback levees, rock erosion protection, and widened tow access corridors. Project objectives include providing flood protection for a flood event with a 1-in-200 chance of exceedance and to incorporate environmental mitigation as appropriate. Levee setbacks provide for habitat restoration and additional riparian habitat.

To help fund the project, Yuba County and local developers established a Mello-Roos Community Facilities District to generate the 30 percent local cost share requirement for proposition funding and to generate additional funding for project costs in excess of available proposition funding. To fund O&M activities, property owners voted for a property assessment based on the benefit to the property. For single-family dwellings, assessments range from $11.12 to $148.04 per year.

32 agricultural, municipal, and industrial water contractors in the region. Responsibilities for flood management are spread among more than 460 agencies, many with different governance structures. There are up to 41 water utilities.

Several resource planning efforts have been developed in the region since 2000. These efforts have been subregional and regional in scope and are generally supported by specific stakeholder types. Planning goals have generally been focused on subregional water supply needs or regional in scope to meet environmental needs. Regional planning efforts have included:

- Basinwide Water Management Plan.
- Sacramento Valley Water Management Agreement.
- Redding Basin Water Resources Management Plan.
- Regional Water Use Efficiency Program.

- Butte Integrated Water Resources Program.
- Yuba-Sutter Regional Recycled Water Master Plan.

Regional planning and policy development is now becoming more of a role for the integrated regional water management (IRWM) groups. Several groups in the Sacramento River region are currently at some level of plan development. These efforts are providing a vehicle for more collaborative dialogue and intergovernmental cooperation on local water issues. Area IRWM groups include the following:

- Upper Pit watershed.
- Upper Sacramento-McCloud.
- Upper Feather River watershed.
- Cosumnes American Bear Yuba.
- North Sacramento Valley Group.
- Westside (Yolo, Solano, Napa, Lake, Colusa).
- Yuba County.

Flood Agencies and Responsibilities

Although primary responsibility might be assigned to a specific local entity, aggregate responsibilities for flood management are spread among more than 460 agencies in the Sacramento River Hydrologic Region with many different governance structures. For a list of the entities that have responsibilities or involvement in flood and water resources management, refer to *California's Flood Future Report, Attachment E: Information Gathering Technical Memorandum* (California Department of Water Resources and the U.S. Army Corps of Engineers 2013b). More detail on flood management in the Sacramento Valley can be found in the CVFPP (California Department of Water Resources 2012).

Groundwater Governance

California does not have a statewide management program or statutory permitting system for groundwater. However, one of the primary vehicles for implementing local groundwater management in California is a groundwater management plan (GWMP). Some local agencies manage groundwater through adoption of groundwater ordinances, and others manage groundwater through authorities granted by special acts of the Legislature. Additional avenues of groundwater management include basin adjudications, IRWM plans, urban water management plans, and agricultural water management plans.

A summary assessment of some of the GWMPs in the region is provided below, while a detailed assessment is available online from Update 2013, Volume 4, *Reference Guide*, in the article "California's Groundwater Update 2013." The assessment was based on a GWMP inventory developed through a joint DWR/Association of California Water Agencies (ACWA) online survey and follow up communication by DWR in 2011 and 2012.

Groundwater Management Assessment

Table SR-19 lists the GWMPs in the region, while Figure SR-22 shows the location and distribution of the GWMPs. GWMPs prepared in accordance with the 1992 AB (Assembly Bill)

Table SR-19 Groundwater Management Plans in the Sacramento River Hydrologic Region

Map label	Agency Name	Date	County	Basin Number	Basin Name
SR-1	Anderson-Cottonwood Irrigation District	2006	Shasta	5-6.03	Anderson Subbasin
	No signatories on file		Tehama	5-6.04	Enterprise Subbasin
				5-6.01	Bowman Subbasin
				5-6.02	Rosewood Subbasin
SR-2	Biggs-West Gridley Irrigation District	1995	Butte	5-21.59	East Butte Subbasin
	No signatories on file			5-21.62	Sutter Subbasin
SR-3	Butte County Department of Water and Resource Conservation	2004	Butte	5-21.57	Vina Subbasin
	No signatories on file			5-21.58	West Butte Subbasin
				5-21.59	East Butte Subbasin
				5-21.60	North Yuba Subbasin
SR-4	Butte Water District	1996	Butte	5-21.59	East Butte Subbasin
	No signatories on file		Sutter	5-21.62	Sutter Subbasin
SR-5	City of Davis/UC Davis		Yolo	5-21.67	Yolo Subbasin
	No signatories on file				
SR-6	City of Lincoln	2003	Placer	5-21.64	North American Subbasin
	No signatories on file				
SR-7	City of Vacaville	2011	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-8	City of Woodland	2011		5-21.67	Yolo Subbasin
	No signatories on file				Non-B118 Basin
SR-9	Colusa County	2008	Colusa	5-63	Stonyford Town Area Basin
	No signatories on file			5-64	Bear Valley Basin
				5-65	Little Indian Valley Basin

Map label	Agency Name	Date	County	Basin Number	Basin Name
				5-90	Funks Creek Basin
				5-91	Antelope Creek Basin
				5-92	Blanchard Valley Basin
				5-21.52	Colusa Subbasin
				5-21.58	West Butte Subbasin
					Non-B118 Basin
SR-10	Dunnigan Water District	2007	Yolo	5-21.52	Colusa Subbasin
	No signatories on file				
SR-11	El Camino Irrigation District	1995	Tehama	5-22.50	Red Bluff Subbasin
	No signatories on file				
SR-12	Feather Water District	2005	Sutter	5-21.62	Sutter Subbasin
	No signatories on file				
SR-13	Glenn Colusa Irrigation District	1995	Colusa	5-21.52	Colusa Subbasin
	No signatories on file		Glenn	5-21.51	Corning Subbasin
					Non-B118 Basin
SR-14	Glenn County	2009	Glenn	5.21.52	Colusa Subbasin
	Provident Irrigation District			5-21.58	West Butte Subbasin
	Glide Water District			5.21.51	Corning Subbasin
	Willow Creek Mutual			5.61	Chrome Town Basin
	California Water Service			5-62	Elk Creek Area Basin
	Princeton-Codora-Glenn			5-63	Stonyford Town Area Basin
	Kanawha Water District			5-88	Stony Gorge Reservoir Basin
	Glenn-Colusa Irrigation District			5-89	Squaw Flat Basin
	Orland-Artois Water District			5-90	Funks Creek Basin

Map label	Agency Name	Date	County	Basin Number	Basin Name
	Western Canal				Non-B118 Basin
	Orland Unit Water Users Association				
SR-15	Lake County	2006	Lake	5-13	Upper Lake Valley Basin
	No signatories on file			5-14	Scotts Valley Basin
				5-16	High Valley Basin
				5-17	Burns Valley Basin
				5-18	Coyote Valley Basin
				5-19	Collayomi Valley Basin
				5-30	Lower Lake Valley Basin
				5-31	Long Valley Basin
				5-66	Clear Lake Cache Formation Basin
				5-94	Middle Creek Basin
				1-48	Gravelley Valley Basin
SR-16	Maine Prairie Water District	1995	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-17	Maxwell Irrigation District	2004	Colusa	5-21.52	Colusa Subbasin
	No signatories on file				
SR-18	Natomas Central Mutual Water Company	2009	Sutter	5-21.64	North American Subbasin
	No signatories on file		Sacramento		
SR-19	Orland-Artois Water District	2002	Glenn	5-21.51	Corning Subbasin
	No signatories on file				
SR-20	Reclamation District No. 108	2008	Colusa	5-21.52	Colusa Subbasin
	No signatories on file		Yolo		
SR-21	Reclamation District No.1500	2012	Sutter	5-21.62	Sutter Subbasin

Map label	Agency Name	Date	County	Basin Number	Basin Name
	No signatories on file				
SR-22	Reclamation District No. 2068	2005	Solano	5-21.66	Solano Subbasin
	No signatories on file				
SR-23	Richvale Irrigation District	1998	Butte	5-21.59	East Butte Subbasin
	No signatories on file				
SR-24	Sacramento Central County Water Agency	2006	Sacramento	5-21.65	South American Subbasin
	City of Elk Grove			5-22.16	Cosumnes Subbasin
	City of Folsom				
	City of Rancho Cordova				
	City of Sacramento				
	County of Sacramento				
SR-25	Sacramento Groundwater Authority	2008	Sacramento	5-21.64	North American Subbasin
	California American Water				Non-B118 Basin
	Carmichael Water District				
	Citrus Heights Water District				
	Del Paso Manor Water District				
	City of Folsom				
	Fair Oaks Water District				
	Natomas Central Mutual Water Company				
	Orange Vale Water Company				
	Rio Linda/Elverta Community Water District				
	City of Sacramento				
	Sacramento County				
	Sacramento Suburban Water District				
	San Juan Water District				
	Golden State Water Company				

Map label	Agency Name	Date	County	Basin Number	Basin Name
	Fair Oaks Water District				
	Natomas Central Mutual Water Company				
	Orange Vale Water Company				
	Rio Linda/Elverta Community Water District				
	City of Sacramento				
	Sacramento County				
	Sacramento Suburban Water District				
	San Juan Water District				
	Golden State Water Company				
SR-26	Redding Area Water Council	2007	Shasta	5-6.03	Anderson Subbasin
	Shasta County Water Agency			5-6.04	Enterprise Subbasin
	City of Anderson			5-6.05	Millville Subbasin
	City of Redding				
	City of Shasta Lake				
	Bella Vista Water District				
	Clear Creek Community Services District				
	Centerville Community Services District				
	Cottonwood Water District				
	Shasta Community Services District				
	Mountain Gate Community Services District				
	Keswick Community Services District				
	Jones Valley Community Services District				
	Anderson-Cottonwood Irrigation District				

Map label	Agency Name	Date	County	Basin Number	Basin Name
SR-27	Solano Irrigation District	2006	Solano	5-21.66	Solano Subbasin
	No signatories on file			2-3	Suisun-Fairfield Valley Basin
					Non-B118 Basin
SR-28	South Sutter Water District	2009	Sutter	5-21.64	North American Subbasin
	No signatories on file		Placer		
SR-29	Sutter County Public Works Department - Water Resources	2012	Sutter	5-21.59	East Butte Subbasin
	No signatories on file			5-21.62	Sutter Subbasin
				5-21.64	North American Subbasin
				5-21.61	South Yuba Subbasin
SR-30	Sutter Extension Water District	1995	Sutter	5-21.62	Sutter Subbasin
	No signatories on file			5-21.59	East Butte
SR-31	Tehama County Flood Control & Water Conservation District	1996	Tehama	5-6.01	Bowman Subbasin
	No signatories on file			5-6.02	Rosewood Subbasin
				5-6.06	South Battle Creek Subbasin
				5-21.50	Red Bluff Subbasin
				5-21.51	Corning Subbasin
				5-21.52	Colusa Subbasin
				5-21.53	Bend Subbasin
				5-21.54	Antelope Subbasin

Map label	Agency Name	Date	County	Basin Number	Basin Name
SR-30	Sutter Extension Water District	1995	Sutter	5-21.62	Sutter Subbasin
	No signatories on file			5-21.59	East Butte
SR-31	Tehama County Flood Control & Water Conservation District	1996	Tehama	5-6.01	Bowman Subbasin
	No signatories on file			5-6.02	Rosewood Subbasin
				5-6.06	South Battle Creek Subbasin
				5-21.50	Red Bluff Subbasin
				5-21.51	Corning Subbasin
				5-21.52	Colusa Subbasin
				5-21.53	Bend Subbasin
				5-21.54	Antelope Subbasin
				5-21.55	Dye Creek Subbasin
				5-21.56	Los Molinos Subbasin
				5-21.57	Vina Subbasin
SR-32	Western Canal Water District	2005	Butte	5-21.59	East Butte Subbasin
	No signatories on file		Glenn	5-21.58	West Butte Subbasin
SR-33	Western Placer County Group	2007	Placer	5-21.64	North American Subbasin
	Placer County Water Agency				
	City of Lincoln				
	City of Roseville				
	California-American Water Company				
SR-34	Westside Water District	2000	Colusa	5-21.52	Colusa Subbasin
	No signatories on file				
SR-35	Yolo County Flood Control and Water Conservation District	2006	Yolo	5-21.67	Yolo Subbasin

Map label	Agency Name	Date	County	Basin Number	Basin Name
				5-21.55	Dye Creek Subbasin
				5-21.56	Los Molinos Subbasin
				5-21.57	Vina Subbasin
SR-32	Western Canal Water District	2005	Butte	5-21.59	East Butte Subbasin
	No signatories on file		Glenn	5-21.58	West Butte Subbasin
SR-33	Western Placer County Group	2007	Placer	5-21.64	North American Subbasin
	Placer County Water Agency				
	City of Lincoln				
	City of Roseville				
	California-American Water Company				
SR-34	Westside Water District	2000	Colusa	5-21.52	Colusa Subbasin
	No signatories on file				
SR-35	Yolo County Flood Control and Water Conservation District	2006	Yolo	5-21.67	Yolo Subbasin
	No signatories on file			5-21.68	Capay Valley Subbasin
				5-21.52	Colusa Subbasin
				5-21.66	Solano Subbasin
SR-36	Yuba County Water Agency	2010	Yuba	5-21.60	North Yuba Subbasin
	No signatories on file			5-21.61	South Yuba Subbasin
NL-1	Alpine County	2007	Alpine	6-6	Carson Valley Basin
	No signatories on file				Non-B118 Basin
NL-2	Lassen County	2007	Lassen	6-104	Long Valley Basin
	No signatories on file			6-2	Madeline Plains Basin

Map label	Agency Name	Date	County	Basin Number	Basin Name
				6-3	Willow Creek Valley Basin
				6-4	Honey Lake Valley Basin
				6-94	Grasshopper Valley Basin
				6-95	Dry Valley Basin
				6-96	Eagle Lake Area Basin
				5-4	Big Valley Basin

Note: Table represents information as of August, 2012.

3030 legislation, as well as those prepared with the additional required components listed in the 2002 SB 1938 legislation are shown.

The GWMP inventory shows 38 groundwater management plans in the Sacramento River region, 28 of which have been developed or updated to include the SB 1938 requirements and are considered active for the purposes of the GWMP assessment.

The CWC Section 10753.7 requires that six components be included in a GWMP for an agency to be eligible for State funding administered by DWR for groundwater projects. The requirement associated with the 2011 AB 359 (Huffman) legislation, applicable to groundwater recharge mapping and reporting, did not take effect until January 2013 and was not included in the current assessment. In addition, the requirement for local agencies outside of the recognized groundwater basins is noted, as applicable, for any of the GWMPs in the region.

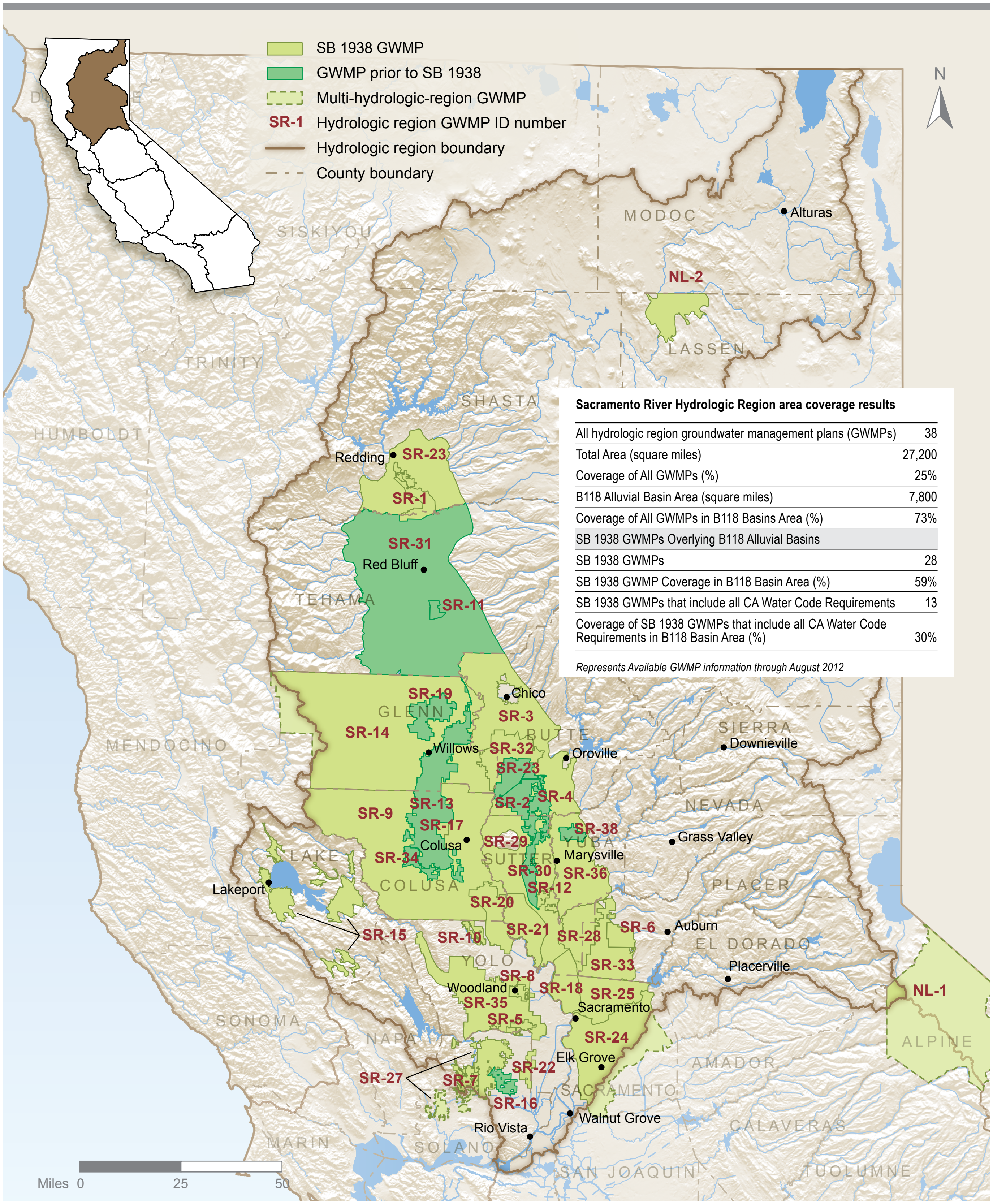
In addition to the six required components, CWC Section 10753.8 provides a list of 12 voluntary components that may be included in a GWMP. DWR *Bulletin 118-2003, Appendix C* (California Department of Water Resources 2003) provides a list of seven recommended components related to management development, implementation, and evaluation of a GWMP, that should be considered to help ensure effective and sustainable groundwater management.

As a result, the GWMP assessment was conducted using the following criteria:

- How many of the post SB 1938 GWMPs meet the six required components included in SB 1938 and incorporated into CWC Section 10753.7?
- How many of the post SB 1938 GWMPs include the 12 voluntary components included in CWC Section 10753.8?
- How many of the implementing or signatory GWMP agencies are actively implementing the seven recommended components listed in DWR *Bulletin 118-2003*?

A summary of the GWMP assessment is provided in Table SR-20.

Figure SR-22 Location of Groundwater Management Plans in the Sacramento River Hydrologic Region



Sacramento River Hydrologic Region area coverage results

All hydrologic region groundwater management plans (GWMPs)	38
Total Area (square miles)	27,200
Coverage of All GWMPs (%)	25%
B118 Alluvial Basin Area (square miles)	7,800
Coverage of All GWMPs in B118 Basins Area (%)	73%
SB 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	28
SB 1938 GWMP Coverage in B118 Basin Area (%)	59%
SB 1938 GWMPs that include all CA Water Code Requirements	13
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	30%

Represents Available GWMP information through August 2012

Table SR-20 Assessment of Groundwater Management Plan Components

SB 1938 GWMP Required Components	Percent of Plans that Meet Requirement
Met All Required Components and Subcomponents	46
Basin Management Objectives	50
BMO: Monitoring/Management Groundwater Levels	86
BMO: Monitoring Groundwater Quality	89
BMO: Inelastic Subsidence	82
BMO: SW/GW Interaction & Affects to Groundwater Levels and Quality	57
Agency Cooperation	96
Map	79
Map: Groundwater basin area	86
Map: Area of local agency	89
Map: Boundaries of other local agencies	75
Recharge Areas (1/1/2013)	Not Assessed
Monitoring Protocols	50
MP: Changes in groundwater levels	96
MP: Changes in groundwater quality	86
MP: Subsidence	93
MP: SW/GW Interaction & Affects to Groundwater Levels & Quality	50
SB 1938 Voluntary Components	**Percent of Plans that Include Component**
Saline Intrusion	64
Wellhead Protection & Recharge	71
Groundwater Contamination	61
Well Abandonment & Destruction	89
Overdraft	75
Groundwater Extraction & Replenishment	61
Monitoring Groundwater Levels and Storage	100
Conjunctive Use Operations	86
Well Construction Policies	93
Construction and Operation	39
Regulatory Agencies	100
Land Use	68

Bulletin 118-03 Recommended Components	Percent of Plans that Include Component
GWMP Guidance	75
Management Area	96
BMOs, Goals, and Actions	75
Monitoring Plan Description	75
IRWM Planning	68
GWMP Implementation	82
GWMP Evaluation	86

Notes:

BMO=basin management objective, IRWM=integrated regional water management, GWMP=groundwater management plan, MP=monitoring rotocols, SW/GW= surface water/groundwater

Factors Contributing to Success and Impediment to Groundwater Management

The survey participants were also asked to identify key factors that promoted or impeded successful groundwater management. Fifteen responding agencies from the region participated in the survey. Nine to 11 respondents identified sharing of ideas and information, data collection and sharing, adequate surface water supply, adequate storage and conveyance, outreach and education, understanding of common interest, and broad stakeholder participation as key factors for successful GWMP implementation while 6 respondents also identified other components as key factors.

Overall, survey respondents pointed to a lack of adequate funding as the greatest impediment to GWMP implementation. Funding is a challenging factor for many agencies because the implementation and the operation of groundwater management projects are generally expensive and because the sources of funding for projects typically are limited to either locally raised money or to grants from State and federal agencies. Unregulated pumping, understanding of local issues, and access to planning tools were also considered key limiting factors by three respondents. Outreach and education, participation, surface storage and conveyance, and data collection and sharing were also identified as factors that impede successful implementation of GWMPs.

Thirteen respondents felt long-term sustainability of their groundwater supply was possible; there were no opposing view on long-term sustainability of groundwater in the region.

More detailed information on the survey and assessment of the GWMPs are available online from Update 2013, Volume 4, *Reference Guide,* in the article "California's Groundwater Update 2013."

Groundwater Ordinances

Groundwater ordinances are laws adopted by local authorities, such as cities or counties, to manage groundwater. In 1995, the California Supreme Court declined to review a lower court decision *(Baldwin v. Tehama County*) that says that State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater under their police powers. Since 1995, the *Baldwin v. Tehama County* decision has remained untested; thus the precise nature and extent of the police power of cities and counties to regulate groundwater is still uncertain.

A number of counties in the region have adopted groundwater ordinances. The two most common ordinances are associated with groundwater wells. Nineteen of the 22 counties in the region have groundwater ordinances establishing well construction policies or ordinances that regulate the abandonment and destruction of groundwater wells; 15 of the counties have both. Twelve counties require permits for water exports. Three counties (Glenn, Butte, and Lassen) have extensive ordinances pertaining to groundwater management. The ordinances for these three counties include — but are not limited to — BMOs, monitoring protocols, agency cooperation, and guidance committees.

Special Act Districts

Special acts of the Legislature have granted greater authority to manage groundwater to a few local agencies or districts. These agencies generally have authority to (1) limit groundwater export and extraction (upon evidence of overdraft or threat of overdraft) or (2) require reporting of extraction and to levy replenishment fees.

Although the California Legislature has established many Special Act Districts within the state consisting of different authorities that may or may not have groundwater management authority, there are no Special Act Districts in the Sacramento River region.

Court Adjudication of Groundwater Rights

Another form of groundwater management in California is through the courts. Of the 24 groundwater adjudications in California, none is in the Sacramento River region.

Other Groundwater Management Planning Efforts

Groundwater management also occurs through other avenues such as IRWM plans, urban water management plans, and agricultural water management plans. Box SR-5 summarizes groundwater management aspects included in these planning efforts.

Current Relationships with Other Regions and States

As discussed previously under “Regional Resource Management Conditions,” the Sacramento River region is the location of the headwaters of both the SWP and the CVP. As a result, this region does have a relationship with the Trinity River through the Trinity River Diversion, which passes through this region. Water is delivered out of the region through these projects to many parts of the state. A full understanding of this region is incomplete without an understanding of the interrelationship of these water projects.

Box SR-5 Other Groundwater Management Planning Efforts in the Sacramento River Hydrologic Region

The integrated regional water management (IRWM) plans, urban water management plans, and agricultural water management plans in the Sacramento River Hydrologic Region that also include components related to groundwater management are briefly discussed below.

Integrated Regional Water Management Plans

The Sacramento River Hydrologic Region includes eight of the 48 IRWM plans that have been accepted or conditionally accepted statewide. Four of the eight IRWM plans have been adopted and are being implemented, while the remaining four are in development. Two of the IRWM regions extend into two adjacent hydrologic regions.

Of the four plans that are being implemented, one IRWM planning group says that groundwater in the region is poorly understood due to faulted and fractured geological conditions, and the IRWM plan defers groundwater management to city and county agencies, as well as irrigation districts. A few of the objectives of this group's IRWM plan are identifying suitable groundwater management practices to prevent groundwater contamination, assure that groundwater recharge and extraction are balanced, and supporting efforts to understand groundwater movement and quantities in the Sierra Nevada fractured rock systems through more study and analysis.

Another IRWM planning region has very little active groundwater management planning. No area is covered by a groundwater management plan, but there is a groundwater management district for one area of the IRWM region. However, the management district is only legislated to monitor groundwater declines from groundwater pumping and has few groundwater management components. The IRWM planning group acknowledges that there is a need for IRWM goals and objectives to be applied to the entire IRWM region.

One of the IRWM planning groups relies on four local agencies, or authorities with active groundwater management plans, for groundwater management. The IRWM plan states that groundwater management is important to the IRWM region for reducing water rights disputes/conflicts due to heavy reliance on groundwater by agricultural and residential users for water supplies. Among the IRWM region's objectives are identifying and resolving issues of conjunctive water management practices and groundwater contamination and evaluating effectiveness of regional groundwater monitoring systems by identifying data gaps and making recommendations for improvements to the groundwater monitoring systems.

One IRWM plan has been developed to provide guidance on planning and to support projects and programs implementation that would improve water management in the IRWM region. This IRWM group relies on local management of groundwater through the county's SB 1938 compliant groundwater management plan. The IRWM group has identified groundwater management as an important issue to protect and utilize the groundwater resources in the area sustainably. The overall goal for groundwater management is to prevent overdraft, protect overlying groundwater rights, and ensure that combined use of surface and groundwater resources sustainably meets current and future water uses.

Urban Water Management Plans

Urban water management plans are prepared by California's urban water suppliers to support their long-term resource planning and to ensure adequate water supplies are available to meet existing and future water uses. Urban use of groundwater is one of the few uses that meter and report annual groundwater extraction volumes. The groundwater extraction data are currently submitted with the urban water management plan and then manually translated by DWR staff into a database. Online methods for urban water managers to directly enter their water use along with their plan updates is under evaluation and review by DWR. Because of the time-line, the plans could not be reviewed for assessment for *California Water Plan Update 2013*.

Agricultural Water Management Plans

Agricultural water management plans are developed by water and irrigation districts to advance the efficiency of farm water management while benefitting the environment. New and updated agricultural water management plans addressing several new requirements were submitted to DWR by December 31, 2012, for review and approval. These new or updated plans provide another avenue for local groundwater management, but because of the time-line, the plans could not be reviewed for assessment for *California Water Plan Update 2013*.

Regional Water Planning and Management

Integrated Regional Water Management Coordination and Planning

Eight IRWM regions have been formed and accepted for the Sacramento River Hydrologic Region. They are identified as the American River Basin, Consumes American Bear Yuba, Northern Sacramento Valley, Upper Feather River watershed, Upper Pit River watershed, Upper Sacramento-McCloud, Westside (Yolo, Solano, Napa, Lake, Colusa), and Yuba County. Presently, the members of each group are either in the process of developing an IRWM plan for their area or updating an existing plan to meet current standards. IRWM members and stakeholders have reached out to a wide range of interest groups for assistance with the development of strategies to resolve current and future water management challenges in the region. The Sacramento River region has many tribes and DACs, and the IRWM groups are involving them in the planning process.

As a result of IRWM planning efforts, local agencies and stakeholders have developed an array of projects and programs to meet their IRWM regional water management objectives. The array includes projects that will sustain existing and future surface water and groundwater supplies and protect the environment. IRWM regions with existing plans are implementing projects that include habitat restoration, invasive species control, water use efficiency, and water and wastewater improvements. The newer IRWM regions are prioritizing projects that have been identified through the planning process. These projects include the types being implemented by the established IRWM regions as well as water storage, water quality improvements, habitat and watershed restoration, fish passage, groundwater recharge, flood mitigation and protection, database development, computer modeling of surface water and groundwater, and well abandonment.

More information on the IRWM regions and plans is presented in the "Integrated Regional Water Management Plan Summaries" section later in the report.

Accomplishments

Infrastructure

Freeport Regional Water Facility

The Freeport Regional Water Project (FRWP) is a cooperative effort of the Sacramento County Water Agency and the EBMUD of Oakland to supply surface water from the Sacramento River to customers in central Sacramento County and the East Bay area of California. Construction of the FRWP facilities began in 2007, became operational in Sacramento in 2011 with the completion of the Vineyard Surface Water Treatment Plant, and supplies water to over 40,000 customers.

The diversion point and pumping facilities are located in the south part of Sacramento on the Sacramento River near the small community of Freeport. It provides Sacramento County Water Agency with up to 85 mgd to supplement groundwater use in the central part of the county. EBMUD will use up to 100 mgd of this supply only during dry years, estimated to be 3 out of every 10 years, as a supplemental water source to complement existing conservation programs.

EBMUD's facilities were also completed in 2011, but EBMUD will only use FRWP water during dry years. Water from the FRWP will serve 1.3 million customers in Alameda and Contra Costa counties.

Red Bluff Diversion Dam

The Red Bluff diversion dam was replaced by the Red Bluff Pumping Plant and Fish Screen Project in 2012. The diversion dam, completed in 1964, created a barrier to fish migration. The dam was originally equipped with fish ladders, but the effectiveness of the ladders has always been an issue. With the completion of the pumping plant and fish screen, the new facility allows for unimpeded upstream and downstream passage for green sturgeon and four runs of listed salmon. The pumps provide up to 2,000 cfs (with the capacity to deliver 2,500 cfs with additional pumps) for the irrigation of 150,000 acres.

Regional Water Planning

IRWM Planning

In 2011, the CABY (Cosumnes, American, Bear, and Yuba) region was awarded a Proposition 84 planning grant to develop an IRWM plan. CABY was awarded a total of $4.615 million from Proposition 84 and Proposition 1E for planning and implementation for a variety of projects including water meter installation, water conservation planning, and habitat improvement.

In 2011, the Regional Water Authority of the American River Basin IRWM received $14.135 million in Proposition 84 funding to update the IRWM plan and to implement 17 integrated projects by various local agencies and organization in the region. The authority completed the 2013 IRWM plan update and developed a framework for the IRWM process.

The Yuba IRWM region recently received an IRWM planning grant to update its IRWM plan. The update will include varied outreach to increase stakeholder involvement and coordination and is intended to comply with the IRWM Planning Act and DWR's 2012 IRWM Guidelines. The plan update is scheduled for completion and adoption by March 2015.

The Westside IRWM Group completed its IRWM plan in June 2013 for managing water resources within Lake, Yolo, Napa, Solano, and a portion of Colusa counties through 2035. A formal agreement between the following five agencies established the Westside IRWM Group in 2010: Lake County Watershed Protection District, Napa County FCWCD, Solano County Water Agency, Water Resources Association of Yolo County, and Colusa County Resource Conservation District.

In 2011, the Northern Sacramento Valley IRWM region received a $900,000 planning grant for the development of its IRWM plan. Member counties include Butte, Colusa, Glenn, Shasta, Sutter, and Tehama counties.

Flood

Mid and Upper Sacramento River Regional Planning

The Mid and Upper Sacramento River region of the CVFPP received a $1.2 million grant in 2013 to improve local flood emergency plans, improve regional and interagency coordination during flood emergencies, and develop standardized emergency responder and flood fight training. The region also received $2.16 million planning grant in 2013 to describe current flood management conditions, opportunities for improving flood management, prioritization of potential projects, and development of a preliminary financing plan.

Watershed Planning and Restoration

Colusa County Watershed Management

Colusa County Resource Conservation District completed and released the Colusa Basin Watershed Management Plan in 2012. The plan is a non-regulatory, community-driven guide that addresses the concerns of a variety of stakeholders. The document sets management goals, objectives, and achievable programs and projects to sustain and enhance watershed functions, including water supply and water quality.

The district also released the final report of the Colusa Basin Watershed Streambank Analysis in 2010. This report addresses water quality issues along tributaries in the Colusa Basin watershed. The focus is on streambank erosion, invasive plant species, and riparian habitat.

The district released the Colusa Basin Watershed Assessment in 2008. The assessment serves as a history and a current conditions report on watershed conditions, including water quality and water supply.

Battle Creek Restoration

A cooperative agreement between the USBR, USFWS, NMFS, DFW, and PG&E was reached in 1999 to pursue a restoration project for Battle Creek. The 1999 memorandum of understanding (MOU) allows for funding of $28 million through California Bay-Delta Authority to be used toward the initial estimated cost of $50.7 million. As part of this agreement, PG&E who owns and operates the Battle Creek Hydroelectric Project, agreed to forgo energy generation as part of its contribution to the restoration agreement. The Battle Creek restoration includes the installation of fish ladders and fish screens at three dams. Construction is expected to be completed in 2014. Other restoration actions include the removal of small dams on the South Fork Battle Creek, increasing flows from existing diversions, and hatchery releases. Once restoration actions are completed, 42 miles of additional habitat will be reestablished plus an additional 6 miles of habitat within area tributaries.

Local Groundwater Management

Since 2008, several agencies and communities have developed and adopted GWMPs for their region. Agencies responsible for the plans and year of adoption are listed below:

- Colusa County (2008).

- Sacramento Groundwater Authority (2008).
- Reclamation District No. 108 (2008).
- Natomas Central Mutual Water Company (2009).
- South Sutter Water District (2009).
- Yuba County Water Agency (2010).
- City of Vacaville (2011).
- City of Woodland (2011).
- Glenn County (2012).
- Reclamation District No. 1500 (2012).
- Sutter County Public Works Department (2012).
- Tehama County Flood Control Water Conservation District (2012).

Looking to the Future

Future Conditions

Future Scenarios

Update 2013 evaluates different ways of managing water in California depending on alternative future conditions and different regions of the state. The ultimate goal is to evaluate how different regional response packages, or combinations of resource management strategies from Volume 3, perform under alternative possible future conditions. The alternative future conditions are described as future scenarios. Together the response packages and future scenarios show what management options could provide for sustainability of resources and ways to manage uncertainty and risk at a regional level. The future scenarios are composed of factors related to future population growth and climate change. Growth factors for the Sacramento River region are described below. Climate change factors are described in general terms in Update 2013, Volume 1, Chapter 5, "Managing an Uncertain Future."

Water Conservation

The Update 2013 scenario narratives include two types of water use conservation. The first is conservation that occurs without policy intervention (called background conservation). This includes upgrades in plumbing codes and end user actions such as purchases of new appliances and shifts to more water efficient landscape absent a specific government incentive. The second type of conservation expressed in the scenarios is through efficiency measures under continued implementation of existing best management practices in the California Urban Water Conservation Council's Memorandum of Understanding Regarding Urban Water Conservation in California (last amended September 2011) (California Urban Water Conservation Council 2011). These are specific measures that have been agreed upon by urban water users and are being implemented over time. Any other water conservation measures that require additional action on the part of water management agencies are not included in the scenarios, and would be represented as a water management response.

Sacramento River Growth Scenarios

Future water demand in the Sacramento River Hydrologic Region is affected by a number of growth and land use factors, including population growth, planting decisions by farmers, and size and type of urban landscapes. (See Table SR-21 for a conceptual description of the growth scenarios used in Update 2013.) Update 2013 quantifies several factors that together provide a description of future growth and how growth could affect water demand for the urban, agricultural, and environmental sectors in the Sacramento River Hydrologic Region. Growth factors are varied between the scenarios to describe some of the uncertainty faced by water managers. For example, it is impossible to predict future population growth accurately, so Update 2013 uses three different, but plausible population growth estimates when determining future urban water demands. In addition, it considers up to three different alternative views of future development density. Population growth and development density will reflect how large the urban landscape will become in 2050 and are used in Update 2013 to quantify encroachment into agricultural lands by 2050 in the Sacramento River Hydrologic Region.

For Update 2013, DWR worked with researchers at the University of California, Davis, to quantify how much growth might occur in the Sacramento River Hydrologic Region through 2050. The UPlan model was used to estimate a year 2050 urban footprint under the scenarios of alternative population growth and development density (see http://ice.ucdavis.edu/project/uplan for information on the UPlan model). UPlan is a simple rule-based urban growth model intended for regional or county-level modeling. The needed space for each land use type is calculated from simple demographics and is assigned based on the net attractiveness of locations to that land use (based on user input), locations unsuitable for any development, and a general plan that determines where specific types of development are permitted. Table SR-22 describes the amount of land devoted to urban use for 2006 and 2050 and the change in the urban footprint under each scenario. As shown in the table, the urban footprint grew by about 125,000 acres under low-population growth scenario (LOP) by 2050 relative to 2006 base-year footprint of about 700,000 acres. The urban footprint under the high population scenario (HIP), however, grew by about 355,000 acres. The effect of varying housing density on the urban footprint is also shown.

Table SR-23 describes how future urban growth could affect the land devoted to agriculture in 2050. Irrigated land area is the total agricultural footprint. Irrigated crop area is the cumulative area of agriculture, including multi-crop area, where more than one crop is planted and harvested each year. Each of the growth scenarios shows a decline in irrigated acreage over existing conditions, but to varying degrees. As shown in the table, irrigated crop acreage declines by about 9,000 acres by year 2050 as a result of low population growth and urbanization in the Sacramento River region, while the decline under high population growth was about 73,000 acres.

Sacramento River 2050 Water Demands

This section provides a description of how future water demands might change under scenarios organized around themes of growth and climate change described earlier in this chapter. The change in water demand from 2006 to 2050 is estimated for the Sacramento River Hydrologic Region for the agriculture and urban sectors under 9 growth scenarios and 13 scenarios of future climate change. The climate change scenarios included the 12 Climate Action Team scenarios described in Update 2013,Volume 1, Chapter 5, "Managing an Uncertain Future," and a 13th scenario representing a repeat of the historical climate (1962-2006) to evaluate a "without climate change" condition.

Table SR-21 Conceptual Growth Scenarios

Scenario	Population Growth	Development Density
LOP-HID	Lower than Current Trends	Higher than Current Trends
LOP-CTD	Lower than Current Trends	Current Trends
LOP-LOD	Lower than Current Trends	Lower than Current Trends
CTP-HID	Current Trends	Higher than Current Trends
CTP-CTD	Current Trends	Current Trends
CTP-LOD	Current Trends	Lower than Current Trends
HIP-HID	Higher than Current Trends	Higher than Current Trends
HIP-CTD	Higher than Current Trends	Current Trends
HIP-LOD	Higher than Current Trends	Lower than Current Trends

Figure SR-23 shows the change in water demands for the urban and agricultural sectors under the 9 growth scenarios shown in Table SR-21, with variation shown across 13 climate scenarios. The change in water demand is the difference between the historical average for 1998 to 2005 and future average for 2043 to 2050. Urban demand is the sum of indoor and outdoor water demand where indoor demand is assumed not to be affected by climate. Outdoor demand, however, depends on such climate factors as the amount of precipitation falling and the average air temperature. Change in water demand is shown under a repeat of historical climate conditions and for 12 scenarios of future climate change.

Urban demand increased under all nine growth scenarios tracking with population growth. On average, it increased by about 360 taf under the three low population scenarios, 560 taf under the three current trend population scenarios and about 900 taf under the three high population scenarios when compared to the historical average of about 840 taf. The results show change in future urban water demands are less sensitive to housing density assumptions or climate change than to assumptions about future population growth.

Agricultural water demand decreases under many growth scenarios due to a reduction in irrigated lands as a result of urbanization and additional water savings from background water conservation. However, when considering the potential effects of future climate change, many scenarios show an increase in agricultural water demand even when there is a reduction in irrigated crop area as shown in Table SR-23. Under high population scenarios, the decrease in water demand was about 75 taf; but under the three low and current trend population scenarios, the average increase in water demand was about 180 taf and 85 taf, respectively, when compared with the historical average of 7,490 taf. The results show that agricultural water demands are sensitive to assumptions about climate and to assumptions about population growth and housing density, which reduce the amount of lands for irrigated agriculture.

Evaluation of Water Management Vulnerabilities

Update 2013 is evaluating how implementing alternative mixes of resource management strategies could reduce Central Valley vulnerabilities. Management response packages are each

Table SR-22 Growth Scenarios (Urban) — Sacramento River Hydrologic Region

Scenario[a]	2050 Population (thousand)	Population Change (thousand) 2006[b] to 2050	Development Density	2050 Urban Footprint (thousand acres)	Urban Footprint Increase (thousand acres) 2006[c] to 2050
LOP-HID	3,894.6[d]	1,010.2	High	807.1	109.5
LOP-CTD	3,894.6	1,010.2	Current Trends	823.4	125.8
LOP-LOD	3,894.6	1,010.2	Low	839.5	141.9
CTP-HID	4,486.2[e]	1,601.8	High	882.9	185.3
CTP-CTD	4,486.2	1,601.8	Current Trends	906.6	209.0
CTP-LOD	4,486.2	1,601.8	Low	930.2	232.6
HIP-HID	5,892.6[f]	3,008.2	High	1,007.8	310.2
HIP-CTD	5,892.6	3,008.2	Current Trends	1,053.4	355.8
HIP-LOD	5,892.6	3,008.2	Low	1,098.1	400.5

Notes:

[a] See Table SR-21 for scenario definitions.

[b] 2006 population was 2,884.4 thousand.

[c] 2006 urban footprint was 697.6 thousand acres.

[d] Values modified by the California Department of Water Resources (DWR) from the Public Policy Institute of California.

[e] Values provided by the California Department of Finance.

[f] Values modified by DWR from the Public Policy Institute of California.

composed of a mix of resource management strategies selected from Volume 3 and implemented at investment levels and locations, as described in the Plan of Study (see Update 2013,Volume 4, *Reference Guide*, in the article "Evaluating Response Packages for the California Water Plan Update 2013, Plan of Study").

Results are presented here for the Sacramento River Region evaluated over 198 combinations of future population growth and climate scenarios. The growth scenarios are defined in Table SR-21. Future climate conditions were evaluated over 22 alternative climate scenarios including 5 derived from historical temperature as precipitation estimates, 5 from historical conditions with an added temperature trend, and 12 downscaled global climate model (GCM) estimates described in Chapter 5, Volume 1. For each scenario, an assessment of water supply, demand, and unmet demand in the urban and agricultural sectors was performed. The model also reported on changes in groundwater and how frequently instream flow requirements were met.

Reliability is defined as the percentage of years in which demand is sufficiently met by supply for the urban and agricultural sector and the percentage of months in which flows meet objectives for the environmental sector. It is one of several ways the California Water Plan (CWP) summarizes the projections of future urban and agricultural conditions. For the Sacramento River region,

Table SR-23 Growth Scenarios (Agriculture) — Sacramento River Hydrologic Region

Scenario[a]	2050 Irrigated Land Area[b] (thousand acres)	2050 Irrigated Crop Area[c] (thousand acres)	2050 Multiple Crop Area[d] (thousand acres)	Change in Irrigated Crop Area (thousand acres) 2006 to 2050
LOP-HID	1880.6	1895.1	14.5	-4.8
LOP-CTD	1876.6	1891.1	14.5	-8.9
LOP-LOD	1872.8	1887.2	14.4	-12.7
CTP-HID	1859.3	1873.6	14.3	-26.3
CTP-CTD	1853.3	1867.6	14.3	-32.3
CTP-LOD	1846.9	1861.1	14.2	-38.8
HIP-HID	1825.7	1839.8	14.1	-60.1
HIP-CTD	1813.2	1827.2	14.0	-72.7
HIP-LOD	1800.6	1814.5	13.9	-85.4

Notes:

a See Table SR-21 for scenario definitions.

[b] 2006 Irrigated land area was estimated by the California Department of Water Resources (DWR) to be 1,879.6 thousand acres.

[c] 2006 Irrigated crop area was estimated by DWR to be 1899.9 thousand acres.

[d] 2006 multiple crop area was estimated by DWR to be 20.3 thousand acres.

urban reliability is defined as the percentage of years for a given simulation in which 98 percent of urban demand is met with supply. Agricultural reliability is defined as the percentage of years in which 90 percent of agricultural demand is met with supply. Figure SR-24 shows the range of reliability results for the urban and agricultural sectors in the Sacramento River region. In the figure, each dot indicates the reliability for one of the 198 simulations, but many of the dots overlap. The vertical lines indicate the half-way point of each distribution, and the shaded areas indicate the results that fall within the middle half of the distribution (between the 25th and 75th percentiles). The figure clearly shows that both the urban and agricultural sectors in the Sacramento River region are projected to remain highly reliable across the futures evaluated.

Groundwater resources and environmental flows were evaluated for performance under the plausible futures. Figure SR-25 shows the change in groundwater from the present to 2050 across the 198 scenarios. About 45 percent of the futures lead to groundwater declines in the Sacramento River region. In general, the simulations based on the historical climate conditions range between a 3 percent decline to 3 percent increases in groundwater storage, whereas the futures based on the GCM-derived climate scenarios span the range of declines of 7 percent to increases of about 3 percent.

Figure SR-26 shows the reliability across the 45-year simulation period for the required instream flows and targets included in the response packages for the Sacramento River region across the

Figure SR-23 Change in Sacramento River Agricultural and Urban Demands for 117 Scenarios from 2006-2050

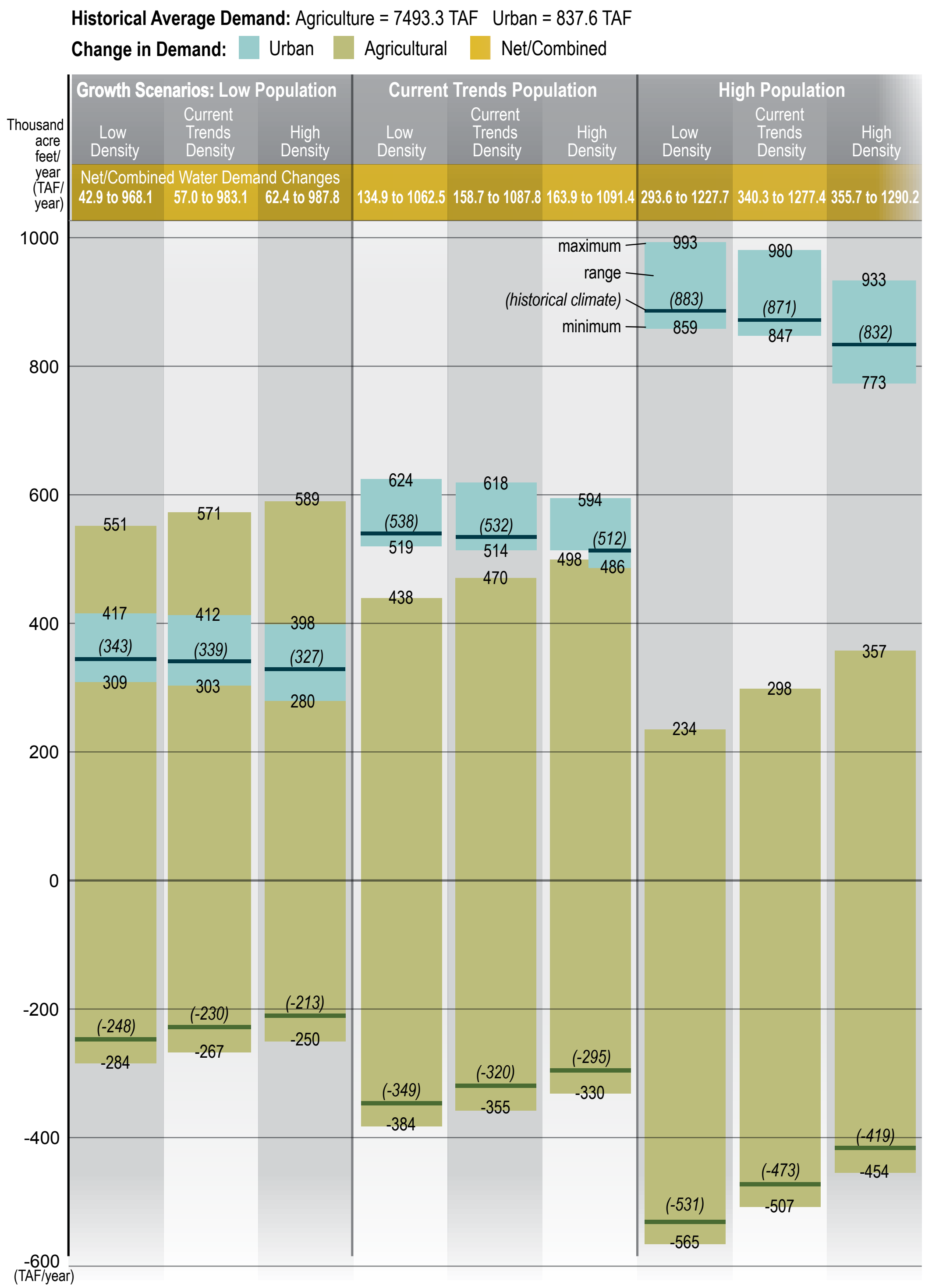


Figure SR-24 Range of Urban and Agricultural Reliability Results Across Futures for the Sacramento River Hydrologic Region

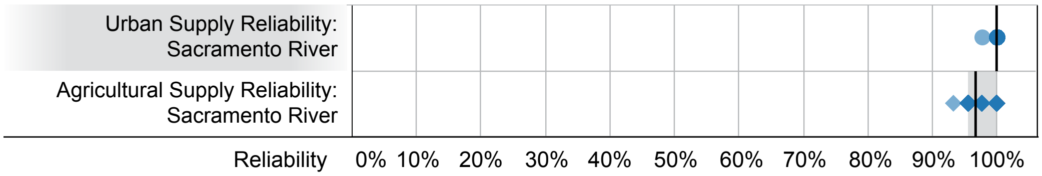


Figure SR-25 Range of Groundwater Storage Change for the Sacramento River Hydrologic Region Across Futures

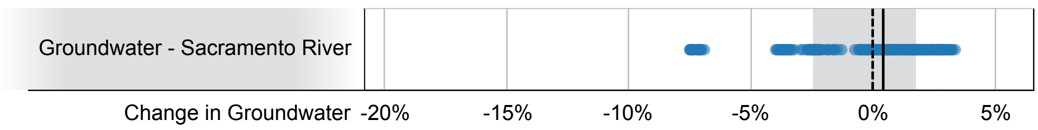
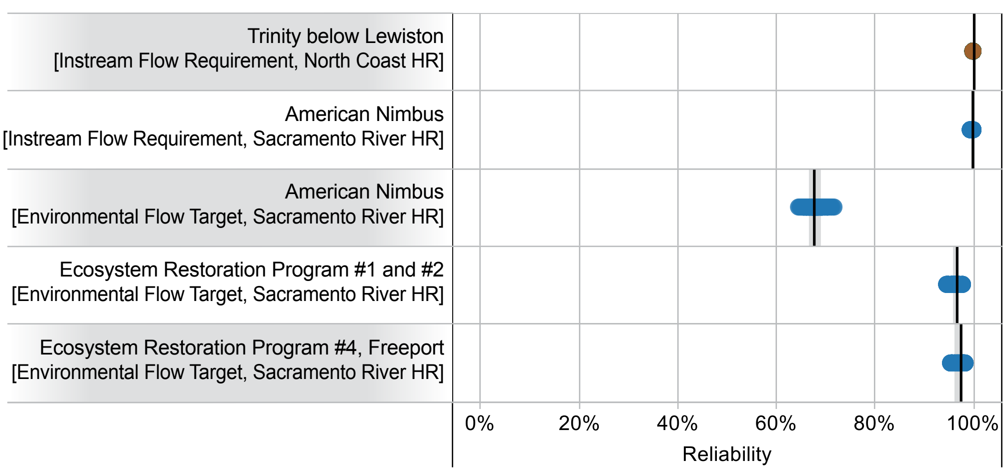


Figure SR-26 Range of Instream Flow Reliability for the Sacramento River Hydrologic Region Across Futures



Note: The Trinity River (brown) below Lewiston is located in the North Coast Hydrologic Region and is included in the Central Valley Water Evaluation and Planning (WEAP) model in relation to imports to the Sacramento River Hydrologic Region.

198 scenarios. Most Sacramento River instream flow requirements and targets are met with high reliability across the futures. The notable exception is the American River at Nimbus flow target. For this metric, reliability is less than 70 percent for about 90 percent of the futures.

Figure SR-27 summarizes results for each diversification level for the key metrics for the Sacramento River hydrologic region . The number and color within each square indicates the percentage of futures that do not meet the specified vulnerability thresholds — 95 percent annual reliability for urban and agricultural supply reliability, no groundwater change, and 95 percent monthly reliability for instream flow requirements and environmental flow targets. Therefore, cases in which there are few vulnerable futures are highlighted in green, and cases in which there are many vulnerable futures are highlighted in red. Note that the analysis of response packages evaluated 88 futures — 22 climate scenarios times 4 growth scenarios (CTD-CTD, HIP-LOD, LOP-HID, CTP-HID).

For the Sacramento River region, urban supply reliability is high for all futures across all diversification levels. Agricultural reliability declines below the 95-percent reliability vulnerability threshold in about one-third of all futures when additional environmental flow and groundwater recovery targets are implemented (Diversification Level 3). Reliability in about one-half of the newly vulnerable futures improves with the implementation of strategies in Diversification Level 5. Groundwater and environmental flows show significant improvements with Diversification Level 3, except for the additional target for the American River (Nimbus). While the inclusion of environmental flow targets (EFTs) in Diversification Levels 3 to 5 does not reduce the number of futures in which reliability is low for the American (Nimbus) EFTs, it does significantly increase the reliability — just not to the 95-percent reliability vulnerability threshold. Implementation costs increase with the significant conservation and recycling implemented in Diversification Levels 2 and higher. Note that the cost of adding environmental flow requirements and groundwater reduction targets in Diversification Level 3 are not accounted for in the figure.

In summary, the Sacramento River region is projected to remain highly reliable in both the urban and agricultural sectors. There is a modest range of projected changes in groundwater levels between 2012 and 2050 centered around no change. Instream flows remain reliable for all but the American River instream flow targets. Implementation of response packages increases groundwater levels and some environmental flows, but also reduces reliability in the agricultural sector for some futures.

Integrated Regional Water Management Plan Summaries

Inclusion of the information contained in IRWM plans into Update 2013 regional reports has been a common suggestion by regional stakeholders at the regional outreach meetings since the inception of the IRWM program. To this end, the CWP has taken on the task of summarizing readily available IRWM plans in a consistent format for each of the regional reports. (This collection of information will not be used to determine IRWM grant eligibility.)

All IRWM plans are different in how they are organized. Therefore, finding and summarizing the content in a consistent way proved difficult. It became clear through these efforts that a process is needed to allow those with the most knowledge of the IRWM plans, those that were involved in the preparation, to have input on the summary. It is the intention that this process be initiated following release of Update 2013 and continue to be part of the process of the update process for

Figure SR-27 Percent of Vulnerable Futures for Each Response Package for the Sacramento River Hydrologic Region

	Urban Supply Reliability	Agricultural Supply Reliability	Groundwater Change	Trinity below Lewston [IFR]	American (Nimbus) [IFR]	American (Nimbus) [EFT]	ERP #1 and #2 [EFT]	ERP #4, Freeport [EFT]	Average Annual Cost Above Current Plan
Currently Planned	0%	1%	43%	0%	0%	100%	14%	0%	$0.0M
Diversification Level 1	0%	0%	36%	0%	0%	100%	9%	0%	$106.6M
Diversification Level 2	0%	0%	36%	0%	0%	100%	9%	0%	$108.1M
Diversification Level 3	0%	36%	30%	0%	0%	100%	0%	0%	$108.1M
Diversification Level 4	0%	19%	27%	0%	0%	100%	0%	0%	$204.0M
Diversification Level 5	0%	15%	25%	0%	0%	100%	0%	0%	$304.0M

[IFR] = instream flow requirement [EFT] = environmental flow target

Update 2018. This process will also allow for continuous updating of the content of the "atlas" (described below) as new IRWM plans are released or existing IRWM plans are updated.

In addition to these summaries, all summary sheets will be provided in one IRWM Plan Summary "Atlas" as an article included in Volume 4, *Reference Guide*. This atlas will, under one cover, provide an "at-a-glance" understanding of each IRWM region and highlight each region's key water management accomplishments and challenges. The atlas will showcase how the dedicated efforts of regional water management groups (RWMGs) have individually and cumulatively transformed water management in California.

As can be seen in Figure SR-28, there are eight RWMGs in the Sacramento River Hydrologic Region.

Region Description

As of late 2013, the RWMGs in the Sacramento River Hydrologic Region have received about $268.3 million in funding from both State and non-State sources: $69,478,580 from the State and $198,833,960 from non-State sources. (Grant figures represent money awarded to specific RWMGs and do not represent the total amount of money spent on each hydrologic region because some regional water management groups straddle two or more hydrologic regions.) Table SR-24 provides a funding source breakdown for the region. No information was available for Upper Sacramento-McCloud group for Update 2013.

Figure SR-28 Integrated Regional Water Management Planning in the Sacramento River Region

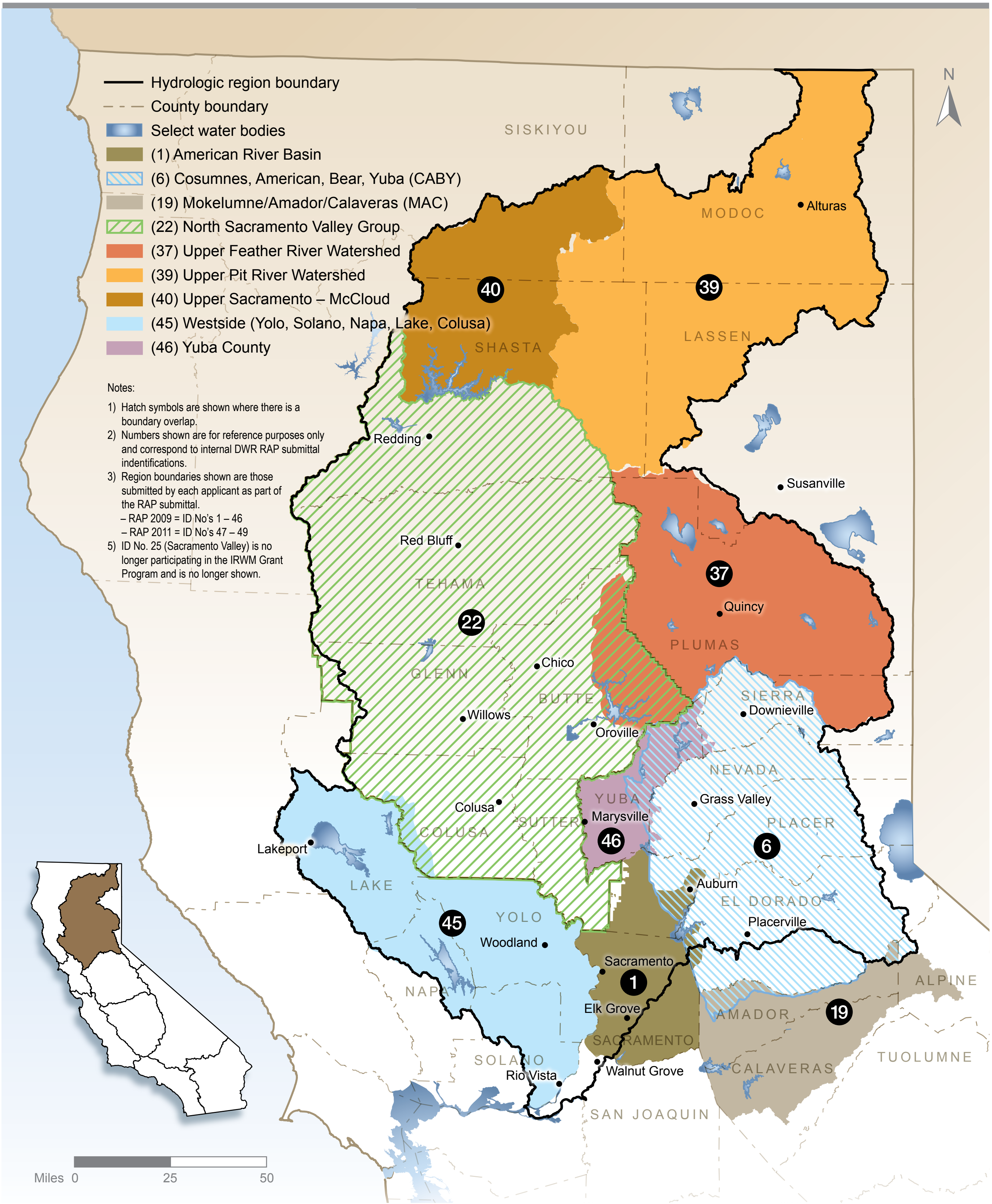


Table SR-24 Sacramento River IRWM Plan Funding

IRWM Region	Prop. 50 Planning Grant	Prop. 50 Implementation Grant	Prop. 84 Planning Grant	Prop. 84 Implementation Grant[a]	Prop. 1E Stormwater Grant	Regional Totals[b]
American River Basin	**$500,000** $919,224	**$25,000,000** $125,800,161	**$403,848** $134,616	**$16,030,766** $37,622,702	**$9,096,834** $9,785,891	$225,294,042
Consumes, American, Bear, Yuba	**$999,640** $515,742		**$647,593** $300,342	**$3,197,503** $183,524	**$770,000** $2,011,400	$8,625,744
Northern Sacramento Valley Group	**$999,920** $436,060	**$0** $11,889,083	**$900,000** $435,000			$14,660,063
Upper Feather River	**$500,000** $193,039	**$7,000,000** $6,966,586	**$679,657** $434,682			$15,773,964
Upper Pitt River			**$649,713** $244,795			$894,508
Westside	**$500,000** $292,565		**$1,000,000** $448,548			$2,241,113
Yuba County			**$603,106** $220,000			$823,106
Total	**$3,499,560** $2,356,630	**$32,000,000** $144,655,830	**$4,883,917** $2,217,983	**$19,228,269** $37,806,226	**$9,866,834** $11,797,291	
Grand Total $268,312,540						

Notes:

This table is up-to-date as of late 2013. Information on the Upper Sacramento-McCloud IRWM plan was not available for Update 2013.

Grant figures in **bold** are State-funded. Grant figures in regular type are non-State funded

[a] Does not include Proposition 84 Implementation Grant Round 2 Awards.

[b] Grant figures represent money awarded to specific regional water management groups and no not represent the total amount of money spent on each hydrologic region, as some regional water management groups straddle two or more hydrologic regions.

The following are short descriptions of the RWMGs and the areas they serve within the Sacramento River region.

American River Basin

The American River Basin IRWM region encompasses most of Sacramento County and portions of western Placer and El Dorado counties. Most of the American River Basin IRWM region is within the lower American River and lower Sacramento River watersheds, with a portion of the southern American River Basin IRWM region in the lower Cosumnes River watershed. There is a minor overlap between this IRWM region and the CABY region.

Cosumnes American Bear Yuba

The CABY region consists of four watersheds (Cosumnes, American, Bear, and Yuba) and 12 subwatersheds situated within the north central Sierra Nevada region. All or portions of nine counties are within the CABY region, including El Dorado, Placer, Nevada, Yuba, Sierra, Plumas, Alpine, and Amador counties. The region extends from the northern parts of the Yuba River watershed to the southern part of the Cosumnes River watershed. The region includes headwaters that drain large volumes of water into the Sacramento and Mokelumne rivers, ultimately serving the Sacramento Delta system.

North Sacramento Valley Group

The Northern Sacramento Valley IRWM region includes all or part of Butte, Colusa, Glenn, Shasta, Sutter, and Tehama counties. The watersheds included in the region are Antelope Creek, Battle Creek, Big Chico Creek, and Butte Creek. The region overlaps slightly with the Upper Feather IRWM region to the east and the Westside Sacramento (Yolo, Solano, Napa, Lake, and Colusa) IRWM region to the southwest. The intent is to share information and project development with these neighboring regions.

Upper Feather River Watershed

The Upper Feather River watershed region straddles the Northern Sierra Nevada Range between the Great Basin Desert and the Central Valley of California. The tributaries of the Upper Feather River flow southwest to eventually fill Lake Oroville, a major reservoir of the SWP. Water flows from Lake Oroville through canals to irrigate farms of the Central Valley, provide domestic water to Southern California, and enrich the aquatic ecosystem of the Delta. As such, the region is an important resource for California's water system.

Upper Pitt River Watershed

The Upper Pit River watershed region comprises four primary subwatersheds in northeastern California, the Upper Pit River, Fall River, Burney Creek, and Hat Creek. The northern, eastern, and southern boundaries of the region are defined by the Upper Pit River subwatershed; and the western boundary is defined by the Fall River, Burney Creek, and Hat Creek subwatersheds. The region includes portions of Modoc, Siskiyou, Lassen, and Shasta counties. The region is centered around the Pit River, an integral hydrologic feature for the region and a significant tributary to the Sacramento River. In 2012 the regional boundary for the region was modified to include the Goose Lake Region.

Westside (Yolo, Solano, Napa, Lake Colusa)

The Westside region is bounded by the Coast Ranges to the west and the Sacramento River and Delta on the south and east. The region includes all of Yolo County and portions of Lake, Napa, Solano, and Colusa counties that are within the Cache Creek and Putah Creek watersheds. Major cities within the region include Clearlake, Davis, Dixon, Lakeport, Rio Vista, Vacaville, West Sacramento, and Woodland.

Yuba County

The Yuba County IRWM region encompasses all of Yuba County, which extends from the Sacramento Valley floor to the foothill and mountainous areas of the Sierra Nevada. Traditional land uses in the valley are changing from agricultural lands to urbanized areas. The foothill and mountainous areas have limited agricultural development consisting mostly of grazing due to the steep topography. The higher elevation mountainous areas of the region are public lands within the Tahoe and Plumas National Forests. The Yuba County boundary overlaps with the CABY IRWM planning region in the foothill and mountain areas of Yuba County.

Key Challenges and Goals

American River Basin

The American River basin region faces the following challenges:

- Maintaining sustainable water resources for all uses under all hydrologic conditions.
- Maintaining reliable groundwater resources with the presence of several extensive contaminant plumes.
- Preserving and improving habitat in a highly urbanized environment.
- Protecting a large urban population in a flood-prone environment.

To address these challenges, the American River Basin region has identified the following goals/objectives:

- Provide reliable and sustainable water resources to meet existing and future needs.
- Protect and enhance the quality of surface water and groundwater.
- Protect and enhance the environmental resources of the watersheds within the region.
- Protect people, property, and environmental resources of region from damaging floods.
- Promote community stewardship of the region's water resources.

Cosumnes American Bear Yuba (CABY)

The CABY region faces the following challenges:

- Water supply.
- Water quality.
- Environment and habitat.
- Climate change.
- Human-landscape interaction.

To address these challenges, the CABY region has identified the following goals/objectives:

- Achieve sustainable surface and ground water supply.
- Reduce impacts from catastrophic fire.
- Provide multiple benefits from management of water resources, diversions, and infrastructure.
- Protect infrastructure, equipment, and property from flooding.
- Protect and improve watershed resources through land use practices.

- Manage sediment for water resources, infrastructure and habitat value.
- Reduce mercury contamination in waterways.
- Protect and improve fisheries and aquatic biota through water resources management.
- Reduce contamination of surface and ground water resources.

North Sacramento Valley Group

The North Sacramento Valley Group region faces the following challenges:

- Water supply.
- Flood risk.
- Surface and groundwater management.
- Land use.
- Environmental stewardship.

To address these challenges, the North Sacramento Valley Group region has identified the following goals/objectives:

- Enhance water supply reliability.
- Improve flood protection and planning.
- Provide water quality protection and enhancement.
- Provide watershed protection and management.
- Promote improved public education of water and information dissemination.
- Create IRWM sustainability.

Upper Feather River Watershed

The Upper Feather River watershed region faces the following challenges:

- Water quantity.
- Water quality.
- Flood control.
- Temperature/sediment.
- Groundwater management.

To address these challenges, the Upper Feather River watershed region has identified the following goals/objectives:

- Improve local water retention and reduce flood potential.
- Improve dry-season baseflows.
- Improve water quality (temperature and sediment).
- Improve water quality to meet CVRWQCB Basin Plan/Agriculture Waiver.
- Improve upland vegetation management.
- Improve groundwater retention and storage in major aquifers.
- Accommodate a salmon fishery in segments of the Upper Feather River watershed.

Upper Pitt River Watershed

The Upper Pitt River watershed region faces the following challenges:

- Water quality.
- Water quantity.
- Invasive species.
- Economic and community health.
- Habitat and the environment.

To address these challenges, the Upper Pitt River watershed region has identified the following goals/objectives:

- Maintain or improve water quality.
- Maintain and improve the quantity and availability of water for irrigation demands.
- Sustain/improve aquatic and terrestrial communities and habitat and ecological function.
- Control and prevent the spread of invasive species.
- Improve efficiency and reliability of community water supply and other water-related infrastructure.
- Strengthen community watershed stewardship and encourage better coordination of data collection, sharing, and reporting.
- Support community sustainability by strengthening natural resource-based economies.
- Improve agency programs and policies by increasing accuracy, accountability, and effectiveness.
- Provide adaptive management strategies for conserving energy and reducing greenhouse gas emissions.

Westside (Yolo, Solano, Napa, Lake Colusa)

The Westside region faces the following challenges:

- Provide safe and reliable water supplies.
- Improve habitat and ecosystem health.
- Manage risks.
- Sustain and modernize infrastructure.
- Address water quality concerns.

To address these challenges, the Westside region has identified the following goals/objectives:

- Acknowledge and respect the cultural values and resources of the region.
- Improve education and awareness throughout the region about water, watershed functions, and ecosystems and the need for sustainable resource management to protect community health and well-being.
- Improve the collective understanding of watershed characteristics and functions (natural and human-induced) within the region as needed to respond effectively to evolving water resources management challenges and opportunities (e.g., climate change).
- Improve the form and function of degraded natural channels.

- Improve water-related public health across the region and emphasize improvements for populations most in need.
- Preserve and enhance water-related recreational opportunities.
- Preserve, improve, and manage water quality to meet designated beneficial uses for all water bodies within the region.
- Promote reasonable use of water and watershed resources.
- Protect and enhance habitat and biological diversity of native and migratory species.
- Provide reliable water supplies of suitable quality for multiple beneficial uses (e.g., urban, agriculture, environmental, and recreation) within the region.

Yuba County

The Yuba County region faces the following challenges:

- Local flood protection and regional flood management.
- Water supply reliability.
- Ecosystem preservation and enhancement.
- Recreation and public access.

To address these challenges, the Yuba County region has identified the following goals/objectives:

- Protect the health, safety, life, and property of the citizens of Yuba County from flood damages using a multi-objective and multi-jurisdictional approach that maximizes opportunities for agricultural conservation and ecosystem protection and restoration.
- Continue to utilize surface water supply facilities to regulate waters of the Yuba River in coordination with groundwater pumping activities to enhance water supply reliability while also providing surface water to meet instream water needs and to make excess water available to outside Yuba County when needed.
- Prevent overdraft, protect overlying groundwater rights, and ensure that the combined use of surface water and groundwater resources provides for current and future water demands in a sustainable way.
- Understand the quality of existing surface water and groundwater sources and preserve, protect, and improve the quality of regional water supplies to ensure good-quality water for all beneficial uses.
- Protect fishery and related riparian resources of the Yuba River and at the same time provide a sustainable water supply and protect life and property through appropriate flood control facilities and flood plain management.
- Provide for expanded use of existing recreational opportunities and develop new recreational opportunities along the water courses in the plan area.

Water Supply and Demand

American River Basin

The American River Basin IRWM region primarily relies on a mixture of surface water, groundwater, and recycled water to meet water demands. In 2010, water demands in the region were estimated at 785,831 af/yr. The American River Basin IRWM plan projected 2020 water demands to increase to 859,013 af/yr. based on land use and population projections.

Cosumnes American Bear Yuba

Water supplies within the region are predominantly local in origin, and thus the region is dependent on local precipitation patterns. Groundwater is generally inadequate and unreliable for large-scale use. The CABY region relies heavily on rain and snowmelt stored in reservoirs and redistributed in time and location to provide reliable water supply year round. It is estimated that supply will increase from 753,623 af/yr. in 2015 to 836,942 af/yr. by 2030. Demand is projected to increase from 418,344 af/yr. in 2015 to 500,190 af/yr. by 2030.

North Sacramento Valley Group

The region primarily relies on both surface water and groundwater for water supply, with groundwater accounting for roughly 30 percent of the total supply. Agricultural users rely on both types of supply, while most municipalities and rural residential users rely on groundwater exclusively. Municipal and industrial water use within the six counties is expected to increase from 164,884 af/yr. at present to 293,029 af/yr. by 2035.

Upper Feather River Watershed

The region's water supply is a mix of groundwater and local surface water. Agriculture, urban, and industrial and commercial are the largest water demands within the region. Urban water demand in 2000 was roughly 10,626 af/yr., and is expected to grow to 11,562 af/yr. without conservation measures or 10,672 af/yr. with conservation measures by 2020. Additionally, the Feather River watershed represents a significant component of the SWP, supplying 3.2 maf/yr. for downstream urban, industrial, and agricultural use.

Upper Pitt River Watershed

The region uses an estimated 170,000 af/yr. of surface water and 50,000 af/yr. of groundwater. These water demand levels translates to roughly 33 percent of the total available surface water in the region and 13 percent of the available groundwater annually. Irrigation is the primary use of both sources of water. Based on irrigation well drilling records, reliance on groundwater is increasing significantly, which is estimated to have increased tenfold in the last 40 years. Due to the low development and population pressures, it is unlikely that the Upper Pit region will be facing any water supply shortage in the next decade.

Westside (Yolo, Solano, Napa, Lake Colusa)

Water supply for the region includes surface water (Lake Berryessa, Clear Lake, Sacramento River, and Indian Valley Reservoir), imported water from the SWP and the CVP, and groundwater. Roughly 1,050,000 af/yr. of surface water is delivered to the region in an average year. The IRWM plan estimates that average year water demands will grow from 1,573,000 af/yr. in 2010 to 1,614,000 af/yr. in 2035.

Yuba County

Groundwater comprises about 30 percent of the water supplied within the region and is primarily used for agriculture. The Yuba River is the primary source of surface water within the region and delivers about 304,000 af/yr.. Agriculture uses roughly 514,100 af/yr., while demand for urban users is about 49,000 af/yr.. Due to expected land use changes, agricultural demands are projected to decrease to 451,600 af/yr. by 2030. Based on projected population growth, urban water demand in the region is anticipated to grow to 131,000 af/yr. by 2030.

Water Quality

American River Basin

The region's surface and recycled water are generally of good quality and meet regulatory standards. There are numerous industrial groundwater contamination plumes that have directly impacted or continue to threaten groundwater quality for consumptive uses. Throughout the region, groundwater contamination plumes have forced some wells to be taken out of service and continue to threaten other local groundwater supplies as the plumes migrate.

Cosumnes American Bear Yuba

The region has generally high quality drinking water that meets or exceeds State and federal standards. Water quality concerns for ecosystems, however, include methyl mercury, temperature, and sediments, as well as other legacy mining contaminants. Aquatic invasive species also threaten water quality within the region. There are 14 water bodies within the region that are listed by the U.S. Environmental Protection Agency as impaired, mostly due to mercury contamination. The region is committed to improving water quality to support healthy ecosystems and dependent organisms.

North Sacramento Valley Group

Water from the Sacramento River and its major tributaries is generally of good quality as it is largely melted snow that collects in upstream reservoirs and is released according to various operating rules. However, there are several streams in the northern portion of the Sacramento River watershed that are listed as impaired due to abandoned mine drainage and high concentrations of copper, lead, and zinc. Other water quality issues include temperature, mercury, pesticides, nutrients, and salts. The region has recognized these water quality challenges and is actively addressing them by planning and implementing water quality improvement projects and programs.

Upper Feather River Watershed

Overall, the water quality within the region is excellent. However, surface water can suffer from increased temperatures and sedimentation. The primary sources of sedimentation are streambank erosion and erosion from road cut and fill slopes. Increased sediment in surface waters has negatively impacted fish and other biotic habitat. The region is exploring how altering grazing patterns will help decrease the frequency of bank erosion and is also currently working to establish mean daily maximum water temperatures, which will help decrease stresses to aquatic resources.

Upper Pitt River Watershed

While surface water quality is generally good within the region, temperature, dissolved oxygen, sediment, bacteria, nutrients, and pH threaten water quality. Activities attributed to agriculture and agricultural grazing contribute to the degradation of surface water quality. Ten water bodies within the region are listed as impaired under the Clean Water Act, including Upper Ash Creek; the Main, North, and South Forks of the Pit River; and Fall River. Groundwater quality data for the region is limited and is listed as an identified data gap that should be addressed moving forward.

Westside (Yolo, Solano, Napa, Lake Colusa)

There are several impaired surface waters within the region, for which total maximum daily loads (TMDLs) either have been or will be prepared. The major constituents of concern in surface waters within the region are pesticides, boron, nutrients, and mercury left from abandoned mines. Imported water quality suffers from high organic carbon and turbidity from the NBA intake location. Arsenic, boron, chromium, iron, manganese, nitrate, and total dissolved solids (TDS) are the primary constituents that affect groundwater quality within the region.

Yuba County

Surface water from the Yuba River is of good quality, however groundwater within the region suffers from contamination by a number of constituents. Some areas are impacted by high salinity levels which have forced users to abandon wells. Within the Wheatland Water District, at least two wells have been capped because of poor quality and more well closures are being considered. The region has committed to strategies that will improve surface water and groundwater such as increasing groundwater monitoring and identifying opportunities for agricultural water reuse.

Flood Management

American River Basin

Flood management has been identified as one of the region's major challenges. The primary flood management entity within the American River Basin region is Sacramento Area Flood Control Agency (SAFCA). Currently, the Sacramento region has the lowest level of flood protection of any major U.S. metropolitan area. Therefore, one of the key strategies of the American River Basin IRWM plan is to achieve a 200-year flood protection in applicable urban areas by 2025.

Cosumnes American Bear Yuba

Flooding is not a widespread issue within the CABY region; however, there are some localized concerns. The City of Placerville experiences severe flooding in the downtown commercial areas almost annually as a result of overflow from nearby Hangtown Creek. The City of Placerville Stormwater Management Plan is designed to help restore effective drainage and improve the creek to avoid flooding. Regional projects such as the City of Placerville Water Quality and Habitat Protection: Hangtown Creek Sewer Line Replacement help facilitate the implementation of the Stormwater Management Plan.

North Sacramento Valley Group

Flooding within the region occurs along the Sacramento River and its tributaries and is largely attributed to heavy winter rains. Flood protection and planning is an area of focus for the region with integrated and multi-benefit projects addressing regional flood concerns. The Lower Deer Creek Restoration and Flood Management project is anticipated to increase flood capacity, improve channel migration for fisheries, improve ecosystem restoration, and provide for a more reliable levee system.

Upper Feather River Watershed

Reducing flood potential has been identified by the region as a priority. The Plumas County FCWCD is one of the agencies within the region responsible for flood control. The region is committed to increasing flood protection through grazing management strategies, road rehabilitation and closures, and improving in-stream and riparian habitat. Multipurpose flood programs will protect property, improve water quality, and protect and improve wildlife habitat.

Upper Pitt River Watershed

Channel erosion is a major issue in the region and has contributed to the disconnection of streams to their historical floodplains. Flooding has not been identified as an issue with three exceptions: Parker Creek in Modoc County, in the town of Bieber where historical high flows have threatened bridges and homes, and in Alturas in the event that there would be a levee failure.

Westside (Yolo, Solano, Napa, Lake Colusa)

The two main areas at risk for flooding within the Westside region are in and around Clear Lake and in the low lying areas along the Sacramento River. Flood management facilities have been constructed over the years, and many studies have and continue to occur to address issues in these flood-prone areas. The region is working with DWR to develop additional details for implementation of the CVFPP to meet the objectives contained within the CVFPP; portions of the Valley Floor Planning Area are involved in the Lower Sacramento Delta North Regional Flood Management Planning. In the IRWM plan, providing an appropriate level of flood protection is listed as a challenge for the region, with several of the plan's goals focused on flood protection and management.

Yuba County

The region receives nearly half of its rainfall in the four-month period from December to March. Extreme rainfall events during these months result in rapid increases in flows and extremely high peak flows in river and stream channels. Both the Yuba and Feather rivers are "flashy" systems that quickly rise and recede in the upper watersheds and canyons. In the last 100 years, there have been 10 major flood events within the region. The region is committed to continuing its long history of flood management by securing Federal Emergency Management Agency certification of local levees and implementing projects that work toward meeting the mid-term flood protection goal of a 200-year level of protection.

Groundwater Management

American River Basin

Groundwater is actively managed in the American River Basin region. From north to south, the American River Basin region is covered by four GWMPs: Western Placer County GWMP adopted in 2007 by the cities of Roseville and Lincoln, Cal American Water, and Placer County Water Agency; northern Sacramento County GWMP adopted in 2008 by the Sacramento Groundwater Authority; central Sacramento County GWMP adopted in 2006 by the Sacramento Central Groundwater Authority; southern Sacramento County GWMP adopted in 2011 by the South Area Water Council.

Cosumnes American Bear Yuba

No groundwater management agencies service the CABY region; and as such, there are no GWMPs, groundwater supply projections, or guidelines. The interaction between surface water and groundwater resources is not well understood, though nearly all of the homes not served by a water purveyor are on private wells. The region has identified groundwater as a primary issue and seeks to prepare a summary of requirements for approving development projects that rely exclusively on groundwater.

North Sacramento Valley Group

There are two main groundwater basins that underlie the region: the Sacramento Valley Groundwater Basin and the Redding Groundwater Basin. Groundwater levels have remained relatively steady; however, individual subbasins have shown generally decreasing trends in water levels over time due to pumping for agriculture, potable, and industrial uses. On average, from 2005 to 2009, the 32,492 wells within the region were estimated to have extracted 1,565,000 af/yr. of water. Around 90 percent of this extracted groundwater went to agricultural use. Currently, there are a number of groundwater monitoring programs within the region, with monitoring wells run by DWR and local agencies.

Upper Feather River Watershed

There are 15 groundwater basins within the region, including the Sierra Valley, Middle Fork, and Lake Almanor basins. Sierra Valley, the largest of the basins, is estimated to store 7,500,000 af to a depth of 1,000 feet, although the quantity of usable water within the basin is unknown. Groundwater does provide a portion of the supply for the region, although surface water is the main source. Sierra Valley Groundwater Basin has suffered from overuse within the last few decades, and water levels are considered to be in a state of gradual decline.

Upper Pitt River Watershed

The region contains 20 groundwater basins as identified by DWR, with the Alturas and Big Valley basins being the largest. Groundwater supplies are generally reliable in areas that have sufficient aquifer storage or where surface water replenishes supply throughout the year. In areas that depend on sustained runoff, water levels can be significantly depleted in drought years. In 2011, Lassen County adopted a GWMP that includes a specific section addressing Big Valley. One goal within the GWMP is to provide sustainable, high-quality supply while protecting the health, welfare, and safety of residents. The GWMP identifies management objectives and supports implementation projects that will help achieve this goal.

Westside (Yolo, Solano, Napa, Lake Colusa)

There are 17 groundwater basins within the region. Regional stakeholders have emphasized preservation of groundwater aquifers through development of surface water projects, such as the Davis-Woodland Water Supply Project, and preparation and implementation of GWMPs. Groundwater within the region has been stable, with historical overdraft patterns reversing. For many water users, groundwater is the only readily accessible supply source. Storage within the region's groundwater basins varies; the Sacramento Valley Groundwater Basin generally has very high storage capacity, although sustainable yield is not yet fully understood.

Yuba County

The North Yuba and South Yuba subbasins are the two groundwater basins that underlie the region; both are subbasins to the larger Sacramento Valley Groundwater Basin. These two subbasins encompass an area of approximately 270 square miles. Despite historical overdraft, groundwater levels have largely recovered due to increased surface water irrigation supplies and reduced groundwater pumping. Groundwater storage within the region is estimated to be 7.5 maf.

Environmental Stewardship

American River Basin

Environmental stewardship is practiced through ongoing efforts to meet regional environmental strategies identified in the IRWM plan. Such efforts include projects for the Lower Cosumnes River. The American River Basin region has projects and management plans, as well as the CVPIA, that aim to improve aquatic and wildlife habitat. Habitat conservation plans (HCPs) have been created for the Lower American River, South Sacramento, Natomas, and Placer.

Cosumnes American Bear Yuba

The region supports a wide variety of vegetation and wildlife, as it encompasses a broad spectrum of environmental conditions such as elevation, slope, aspect, soils, and precipitation. Thirteen wildlife species are endemic to the Sierra Nevada region, many of which can be found within the CABY region. Preserving and restoring watershed health is a priority for the region. The region has committed to make an additional 15 miles of fish spawning habitat by 2020 and conduct fuels management on at least 10,000 acres by 2017.

North Sacramento Valley Group

The region is committed to environmental stewardship and strives to protect habitat that supports the region's varied wildlife. Butte, Colusa, and Tehama counties have adopted voluntary Oak Woodland Management Plans. These plans guide efforts for use of conservation easements, land improvements, research and education, and restoration to benefit oak woodlands, while also promoting the economic sustainability of farm and ranch operations.

Upper Feather River Watershed

There are 91 species of special concern within the region, including amphibians, birds, and mammals. Many of the river reaches within the region are historical habitat of Chinook salmon and steelhead trout, but are blocked because of Oroville Dam. If passage around the dam is found to be feasible during dam re-licensing, habitat segments of the Upper Feather River and its tributaries will be available to the salmon and trout. The region is committed to restoring historical habitat for both Chinook and steelhead during this process.

Upper Pitt River Watershed

The region is home to over 170 species and habitats of special concern, many of which are of great importance to the subsistence and culture of the Pit River Tribe. In 2010, the Pit River Resource Conservation District published several watershed management plans. The purpose of these documents is to align interests to better reach consensus about appropriate management actions. Particular emphasis is placed on opportunities to modify stream channel and landscape conditions to benefit water quality, aquatic habitat, wildlife habitat, and range and forest health. The recently completed IRWM plan has identified conservation of the natural attributes of the watershed as a goal for sustaining and improving aquatic and terrestrial communities. Objectives described in the plan include stabilizing and restoring ecological function to at least 25 miles of streams. Goals also include the enhancement of native fish habitat, the reduction of forest fuel loads and implementing the U.S. Forest Service Sage-Steppe Ecosystem Restoration Strategy.

Westside (Yolo, Solano, Napa, Lake Colusa)

Environmental stewardship has been ongoing in the region, with work in policy development, awareness, and education by both local agencies and non-government organizations. There are several HCPs that have been developed within the region, including the Solano HCP, the Yolo Natural Heritage Program HCP/Natural Communities Conservation Plan (NCCP), and the Bay Delta Conservation Plan (BDCP). The IRWM Plan identifies habitat and invasive species as challenges that the region is facing. The protection and enhancement of habitat and biological diversity of native and migratory species is a goal for the region.

Yuba County

A primary environmental concern for the region is the instream flows of the lower Yuba River, which is home to the threatened Chinook salmon and steelhead trout. The Lower Yuba River Accord, fully implemented in 2008, resulted in higher instream flow requirements on the Lower Yuba River to address this concern, along with an average of over 100,000 af of water transferred for fish and wildlife in the Bay-Delta estuary and for the cities and farms throughout the state, and water rights protection for local farmers in Yuba County. Additional efforts are under way to improve recreational and public access to the Yuba River and other water features within the region, while simultaneously improving riparian habitat.

Climate Change

Climate change is already affecting the hydrologic region and will have significant impacts on water and other resources in the future. Changes in timing, amount, and type of precipitation and runoff will affect the availability of water supplies and hydropower generation. Increasing temperatures, more increased winter runoff, and prolonged droughts will increase flood and wildfire risk, and impact ecosystem services, recreation, and public health in the Sacramento River Hydrologic Region.

The effects of climate change such as increased temperatures, reduced snowpack, and earlier snowmelt will increase the vulnerability of both natural and built systems in the region. Impacts to natural systems such as diminished water quality and quantity, and shifting ecoregions will challenge aquatic and terrestrial species. Built infrastructure will be impacted by changes in hydrology and runoff timing, which could entail increased flood risk as well as periods of severe drought.

American River Basin

The region faces a number of vulnerabilities to climate change associated with the variety of physical and cultural landscapes that make up the region. Instream temperature changes would impact fish and wildlife habitat. Changes in mountain snowpack and runoff amounts and seasonality would have impacts relating to water supply as well as flood risk. The region's connection to the Delta is cause for sea level rise concerns.

Cosumnes American Bear Yuba

The region is addressing climate change concerns by completing a vulnerabilities assessment and identifying adaptation strategies as part of the IRWM plan update process.

North Sacramento Valley Group

The North Sacramento Valley is already experiencing some of the effects of climate change, such as increased temperatures and reduced snowpack. The loss of natural snowpack storage and runoff timing will impact water supply within and outside of the region, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future water demand for both ecological processes and agriculture may be particularly challenging with less natural storage and less overall supply. Warmer waters will result in stress to fisheries, a reduction of cold water habitat for endangered species, and negatively impact restoration efforts. With projected higher summer air temperatures, the northern and eastern portions of the region will be at higher risk of wildfire, some having 4 times more risk than current levels by the end of the century. The region is currently incorporating strategies to address climate change into its IRWM plan and is collecting data required to identify regional vulnerabilities to climate change. Adaptation measures for water management systems and potential mitigation strategies for reduction of greenhouse gases are being identified and developed.

Upper Feather River Watershed

Climate change can increase temperature and alter precipitation patterns including timing and form. If temperature increases and more snow falls as rain, less water will be available during the late summer and early fall months when water within the region is most needed. Higher temperatures and early rains can also cause earlier snowmelt and increase flood risk. These future conditions could also lead to season water shortages within the region, necessitating increased groundwater pumping or imported water.

Currently, annual precipitation varies from more than 90 inches on the mountain tops along the crest and on the slopes of Mount Lassen to less than 11 inches on the arid east side. Much of the precipitation in the higher elevations falls in the form of snow, which provides valuable water storage for the region. In the spring and early summer, snowmelt provides the region with a clean, local water supply.

Upper Pitt River Watershed

The Upper Pit River watershed IRWM region is already experiencing some of the effects of climate change, such as increased temperatures, reduced snowpack, and earlier snowmelt. Climate projections indicate that temperatures will continue to rise by the end of the century diminishing April 1st snowpack. The shift in spring to winter runoff has implications for water use and management both within the watershed and the downstream areas. Current planning by PG&E in the region involves adaptive water management strategies with the assumption that climate impacts on snowpack and early snowmelt will likely accelerate change in annual snowpack into the future. The region has focused its resources on a completed vulnerability analysis and has coordinated with University of California, San Diego to perform climate modeling and project future impacts to the region.

Westside (Yolo, Solano, Napa, Lake Colusa)

Changes in timing, amount, and type of precipitation and runoff will affect the availability of both groundwater and surface water supplies. While increasing temperatures, more extreme floods, and prolonged droughts will impact agriculture and public health and safety in the region. As part of the IRWM plan update process, these impacts are being evaluated along with the development of adaptation strategies and mitigation measures.

Yuba County

Climate change will have significant impacts on water and other resources in the future. Changes in timing, amount, and type of precipitation and runoff will affect the availability of both groundwater and surface water supplies. While increasing temperatures, more extreme precipitation events, and prolonged droughts will increase flood and wildfire risk, and impact agriculture and public health in the region. These climate change vulnerabilities will be considered as part of the upcoming IRWM plan update process.

Tribal Communities

American River Basin

The American River Basin region has two federally recognized tribes. These include the United Auburn Indian Community of the Auburn Rancheria (UAIC) and the Wilton Rancheria. The Regional Water Authority (the RWMG for the region) contacted these tribes via invitation letter in June 2011 and extended an invitation to participate in the IRWM plan development. Additionally, the Regional Water Authority contacted a consultant to discuss UAIC water resource-related issues in May 2011. No issues were identified at that time. The Regional Water Authority intends to continue direct outreach to these tribes to identify opportunities to collaborate during implementation of the American River Basin IRWM plan.

Cosumnes American Bear Yuba

Initial tribal outreach efforts in the region included direct outreach to federally recognized tribes, but did not result in sustained communication or collaboration. The tribal entities contacted during the outreach process include the Buena Vista Rancheria, Wilton Rancheria, Miwok Tribe of the El Dorado Rancheria, Ione Band of Miwok Indians, Jackson Band of the Mi-Wuk, Nashville-El Dorado Miwok, Strawberry Valley Rancheria, Colfax-Todds Valley Consolidated Tribe, Tsi-Akim Maidu, Shingle Springs Band of Miwok, Washoe Tribe of Nevada and California, Nevada City Rancheria: Nisenan Tribe, and the Tyme Maidu/Berry Creek Rancheria.

A second round of outreach focused on project development and involved both federally and non-federally recognized tribe members. This effort produced several tribal-designed projects. However, participation in project development did not translate into participation in the planning committee meetings, resulting in a lack of tribal representation in this decision-making body. A third round of outreach was designed and coordinated by the California Environmental Indian Alliance. This third effort included outreach to not only tribal members resident to the CABY region, but also to tribal members with ancestral links to the region. This round of outreach did not meet the desired outcomes and did not result in ongoing working relationships between the CABY planning committee and tribal members. A fourth round of collaboration will be undertaken with the objective of identifying meaningful options of engaging CABY tribal members in the planning process.

North Sacramento Valley Group

The region has targeted outreach to tribes in an attempt to involve additional underrepresented stakeholders in the IRWM plan development process. County staff attended an all-day training session to better engage tribes in the IRWM planning process. In-person tribal outreach has been conducted by county staff. In addition to in-person outreach to tribes, hard copy letters signed by the RWMG board chair were sent to tribal chairpersons and other representatives (such as tribe environmental directors, project managers, and executive directors) periodically throughout the IRWM planning process.

Upper Feather River Watershed

Native Americans and Alaska Natives constitute 3 percent of the region's population, with approximately 1,500 Maidu people in the region. A few families live on the Greenville Rancheria, but most are scattered around the traditional lands in the watershed, and around Oroville and Redding. IRWM plan outreach efforts to these communities is unclear.

Upper Pitt River Watershed

A list of tribal contacts in the region was developed by the California Indian Environmental Alliance. It included not only tribes with a current physical presence in the area, but also tribes with historical roots or presence in the region. All contacts were initiated through the various tribal governments via paper mailings, e-mail, and phone calls. The Pit River Tribe (also representing the Bureau of Indian Affairs) was contacted through its Tribal Council and ultimately designated its environmental coordinator and a tribal council member as representatives to the RWMG in summer 2012. During the planning effort, team members attended five Tribal Council meetings, met with five tribal staff numerous times, and conducted two field visits. In turn, tribal representatives participated in numerous Project Review

Committee meetings, regularly attended RWMG meetings, provided substantial input into plan preparation, and worked with the assistance of team members to develop project materials to ensure that several tribal projects would be eligible for inclusion in the plan.

Westside (Yolo, Solano, Napa, Lake Colusa)

The tribal communities involved in the region's IRWM planning include Big Valley Band of Pomo, Yocha Dehe Wintun Nation, Scotts Valley Band of Pomo, Cortina Band of Wintun, Robinson Rancheria of Pomo, and the Suscol Intertribal Council. Collaboration with tribes is most active in native fish restoration projects, Clear Lake issues and management, invasive species council and task force, TMDL plans and implementation, sustainable agricultural practices, mercury clean-up restoration, and habitat protection and enhancement.

Yuba County

The Yuba County IRWM plan update process has a Tribal Outreach component that will incorporate tribal interests and projects and identify tribes in the region. The Tribal Distribution List for the Yuba region includes Nevada City Rancheria, Tsi Akim Maidum, Concow Maidu Tribe of Mooretown Rancheria, Mechoopda Indian Tribe of Chico Rancheria, Tyme Maidu Tribe of Berry Creek Rancheria, Maidu/Miwok, Enterprise Rancheria of Maidu Indians, Tyrone Gorre, Colfax-Todd Valley Consolidated Tribe, Washoe Tribe of Nevada and California, United Auburn Indian Community, Greenville Rancheria Tribe of Maidu Indians, Shingle Springs Rancheria, Pakan-Yani Band of Strawberry Valley Rancheria, Nisenan/Maidu, Maidu Nation, Maidu Cultural Development Group, and Susanville Indian Rancheria.

Disadvantaged Communities

American River Basin

DACs in the American River Basin region are generally not isolated communities with particular water supply or water quality concerns and are generally served effectively by water purveyor efforts that provide high-quality water supplies. Some DACs or individuals that would be considered disadvantaged reside in very small pockets of the region, served by a small water system and/or private wells. The region prepared and maintains a DAC contact and mailing list to encourage participation through direct solicitation, such as mailings, e-mail, or phone calls. Also, American River Basin stakeholders and project proponents are encouraged to identify projects with the potential to address DAC needs.

Cosumnes American Bear Yuba

DACs in the CABY region include River Pines, Plymouth, Kirkwood, Grizzly Flats, Soda Springs, Graniteville, Washington, North San Juan, Grass Valley, Rough and Ready, Penn Valley, Newcastle, North Auburn, Downieville, Alleghany, Pike, Dobbins, and Camptonville. Four of the 18 DACs in the region are part of the region's IRWM Planning Committee, while the rest were encouraged to participate in meetings and project development activities. Outreach to DACs has included face-to-face meetings with DAC staff, boards of directors, and volunteer representatives on a regular basis. The IRWM plan includes 12 projects that originate from and/or benefit DACs in the region. CABY also created a DAC Work Group that now includes representatives from most of the DACs in the region. CABY staff continues ongoing outreach to expand participation.

North Sacramento Valley Group

Five of the six counties in the region have a higher percentage of individuals living below the defined level of poverty than the statewide average of 12.4 percent. The RWMG has targeted outreach to DACs to involve additional underrepresented stakeholders in the IRWM plan development process. County staff also attended an all-day training session design specifically to better engage DACs in the IRWM planning process.

Upper Feather River Watershed

The entire Upper Feather River watershed is considered disadvantaged due to high unemployment and low incomes and in need of environmental, economic, and social justice. The region seeks to restore ecological balance in the Upper Feather River watershed and resolve existing environmental justice issues. The IRWM plan is built upon the seven mandatory plans, which included public and/or stakeholder involvement as an integral part of the planning process. However, potential obstacles to IRWM implementation exist, especially from private landowners, municipalities, and private corporations who may not feel direct and immediate benefits from implementation actions. Solutions to such obstacles are continuing to be pursued throughout the IRWM process.

Upper Pitt River Watershed

Of the 17 communities in the region, four are categorized as DACs and nine as severely disadvantaged communities (SDACs). Direct support and outreach to DACs was provided by the Project Team and through the Project Review Committee, which became the primary outreach and support for most of the regional DACs. Representatives of DACs were identified via local knowledge and contacted directly by phone or through a meeting to inform them of the IRWM process and cultivate their participation. Primary outcomes of the Project Review Committee for DACs included development of templates to ensure consistency of project development activities; a system for collaborating on options for integration of projects over time; a strategy for sharing resources to advance conceptual projects to a more ready-to-proceed status; and opportunities to realize an economy of scale when purchasing some hardware, computer-based mapping capabilities, and other project components or coordinating construction phasing. It is important to note that, as a result of the Project Review Committee, many of the affected DACs began to participate in other plan development activities, including plan document review.

Westside (Yolo, Solano, Napa, Lake Colusa)

DACs in the region are primarily located in Lake County, with a few DACs located in central and northern Yolo County. The IRWM plan discusses the broad socioeconomic makeup of the region and outlines specific actions taken to reach out to DACs in the region.

Yuba County

DACs exist throughout the county. The DACs are widely disbursed on the valley floor among the agricultural lands. In the foothill and mountain areas, the DACs are small communities dotted along the transportation corridors. Because of the rugged terrain and low population density, these few populated areas define the economic conditions of the area. Stakeholder outreach efforts included public meetings, informational letters targeting stakeholder groups, briefs to public officials, and comment periods for draft review of the plan. The Yuba County IRWM Plan update process has a DAC Outreach component that will incorporate DAC interests and projects and will identify DACs in the region.

Governance

American River Basin

The Regional Water Authority is a joint powers authority formed in 2001 to assist local water suppliers with protecting and enhancing the reliability, availability, affordability, and quality of water resources. The Regional Water Authority was officially recognized as the RWMG by DWR in 2009.

Cosumnes American Bear Yuba

A charter and an MOU have guided the governance of the CABY region. Since 2006, the charter has been used to define roles, responsibilities, and participation in the CABY group. The 2007 MOU describes a management structure that created and assigned roles to a planning committee, a coordinating committee, and various work groups. The planning committee is tasked with management decision-making authority, and the coordinating committee is responsible for assisting consultants and providing guidance on a more regular basis. The coordinating committee is comprised of four water agencies and four non-governmental representatives. In addition, work groups are convened as needed to address specific management topics and concerns.

North Sacramento Valley Group

The Northern Sacramento Valley RWMG was formed under an MOU. Consisting of six local agencies including the counties of Butte, Colusa, Glenn, Shasta, Sutter, and Tehama, the RWMG is responsible for overseeing the IRWM planning and implementation process. To aid in the technical aspects of planning, the RWMG formed a technical advisory committee, which is responsible for providing recommendations to the RWMG. All members of the board and technical advisory committee were appointed by the boards of supervisors from within the region.

Upper Feather River Watershed

The Upper Feather River IRWM plan is coordinated by the Feather River Watershed Authority, which is composed of a number of regional stakeholders, including Plumas County, Feather River Land Trust, and University of California, Davis. Agencies provide comments on issues, provide data for informed management decisions, and bring water conservation projects to the authority. The Plumas Watershed Forum and the Feather River Coordinated Resource Management Group are two other regional entities which provide insight and direction to the authority as needed.

Upper Pitt River Watershed

In 2011, a Letter of Agreement between the Northeastern California Water Association (NECWA) and the Pit River Watershed Alliance (PRWA) was executed. The agreement outlines that NECWA would take responsibility for contract management and billing/financial oversight, while PRWA would manage the planning process and plan preparation. Through an MOU, the PRWA also agreed to serve as the RWMG, which is responsible for confirming both a short-term and a long-term decision-making structure. Organizations who have formally joined PRWA by signing the MOU include local and State governments, water agencies, and resource districts.

Westside (Yolo, Solano, Napa, Lake Colusa)

In 2010, five organizations agreed to undergo planning of the region's IRWM plan. The Colusa County Resource Conservation District, Lake County Watershed Protection District, Napa County FCWCD, Solano County Water Agency, and Water Resources Association of Yolo County signed an MOU to develop the IRWM plan for the Westside region. These five organizations serve as the RWMG for the region and established a coordinating committee and project team to assist in the IRWM Plan development process.

Yuba County

The RWMG consists of representatives from public agencies and water purveyors in the region. The RWMG is responsible for the overall development of the IRWM plan and has decision-making authority. One of the major roles of the RWMG is to develop and implement a public involvement process to ensure proper coordination and consultation with local water agencies and government entities. Further, the RWMG is responsible for providing project information to the general public and citizens of Yuba County.

Resource Management Strategies

Volume 3, *Resource Management Strategies*, contains detailed information on the various strategies that can be used by water managers to meet their goals and objectives. A review of the resource management strategies addressed in the available IRWM plans is summarized in Table SR-25.

Conjunctive Management and Groundwater Storage

Conjunctive management, or conjunctive use, refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

A DWR/ACWA survey was undertaken in 2011 and 2012 to inventory and assess conjunctive management projects in California. Box SR-6 is a summary of the inventory effort.

Conjunctive Management Inventory Results

The DWR/ACWA survey identified 89 agencies or programs that operate a conjunctive management or groundwater recharge program in California, of which three agencies are in the Sacramento River Hydrologic Region — Yuba County Water Agency, Sacramento Suburban Water District, and City of Roseville.

Yuba County Water Agency has been operating an in-lieu groundwater recharge program in the North and South Yuba subbasins since 1991. In-lieu groundwater recharge is accomplished by providing surface water to users who would normally use groundwater, thereby leaving more groundwater in place for restoring groundwater levels or for later use. Some agencies also consider programs that reduce demands on groundwater via water conservation or water recycling as in-lieu recharge because these programs have the same effect in restoring groundwater levels as the provision of surface water. According to Yuba County Water Agency, the storage of its in-lieu program can reach 90,000 af/yr. when adequate surface water supplies are available.

Sacramento Suburban Water District has been operating an in-lieu conjunctive management program in the North American subbasin since 1998. The goals and objectives of the program are to address groundwater overdraft, protect groundwater quality, and to accommodate potential water transfer opportunities. The capacity of the program is 32,000 af/yr. On an annual basis, the in-lieu recharge volume has been between 12,500 and 18,000 af, with a cumulative recharge volume of 176,000 af since 1998. The estimated extraction in a dry year is up to 4,500 af, with a cumulative withdrawal of less than 10,000 af to-date. According to the Sacramento Suburban Water District, legal issues have been the most significant constraints for developing a conjunctive management program, while moderate constraints include political, water quality, and cost issues. Institutional constraints and limited aquifer storage have been identified as minor constraints.

The City of Roseville, in order to address water reliability for its water supply system, developed an aquifer storage and recovery (ASR) program in the North American Subbasin in 2003. The capital cost to develop the ASR program was approximately $3 million. The put and take capacity of Roseville's program is variable, but currently the program has a capacity of 5 million gallons per day (4,772 af/yr.).

The survey results, a statewide map of the conjunctive management projects, and additional details are available online from Update 2*013*, Volume 4, *Reference Guide*, in the article "California's Groundwater Update 2013." Also, information on conjunctive management in California including benefits, costs, and issues can be found online from Update 2013, Volume 3, Chapter 9, "Conjunctive Management and Groundwater."

Climate Change

For over two decades, the State and federal governments have been preparing for climate change effects on natural and built systems with a strong emphasis on water supply. Climate change is already impacting many resource sectors in California, including water, transportation and energy infrastructure, public health, biodiversity, and agriculture (U.S. Global Change Research Program 2009; California Natural Resources Agency 2009). Climate model simulations based on the Intergovernmental Panel on Climate Change's 21st century scenarios project increasing temperatures in California, with greater increases in the summer (Intergovernmental Panel on Climate Change 2013). Projected changes in annual precipitation patterns in California will result in changes to surface runoff timing, volume, and type (Cayan 2008). Recently developed computer downscaling techniques (model simulations that refine computer projections to a scale smaller than global models) indicate that California flood risks from warm-wet, atmospheric river-type storms may increase beyond those that we have known historically, mostly in the form of occasional more-extreme-than-historical storm seasons (Dettinger 2011).

Table SR-25 **Resource Management Strategies Addressed in IRWM Plans in the Sacramento River Hydrologic Region**

Resource Management Strategy	America River Basin	CABY	NSVG	Upper Feather River	Upper Pitt River	Westside[a]	Yuba County
Agricultural Water Use Efficiency	X	X	X	X	X	X	X
Urban Water Use Efficiency	X	X	X	X	X	X	X
Flood Management	X	X	X	X	X	X	X
Conveyance – Delta						X	
Conveyance – Regional/ Local		X	X		X	X	
System Reoperation		X	X		X	X	
Water Transfers		X	X		X	X	X
Conjunctive Management and Groundwater	X	X	X	X	X	X	X
Desalination - Brackish Water and Seawater							
Precipitation Enhancement			X		X		
Recycled Municipal Water	X	X	X		X	X	X
Surface Storage – CALFED			X				
Surface Storage – Regional/Local		X	X		X	X	X
Drinking Water Treatment and Distribution	X	X	X		X	X	
Groundwater/ Aquifer Remediation	X		X		X	X	X

Resource Management Strategy	America River Basin	CABY	NSVG	Upper Feather River	Upper Pitt River	Westside[a]	Yuba County
Match Water Quality to Use	X		X		X	X	
Pollution Prevention	X	X	X	X	X	X	X
Salt and Salinity Management	X	X	X		X	X	
Urban Stormater Runoff Management	X	X	X	X	X	X	X
Agricultural Lands Stewardship		X	X	X	X	X	
Ecosystem Restoration	X	X	X	X	X	X	X
Forest Management		X	X	X	X	X	
Land Use Planning and Management		X	X	X	X	X	X
Recharge Areas Protection			X	X	X	X	
Watershed Management	X		X	X	X	X	X
Economic Incentives - Loans, Grants, and Water Pricing	X	X	X		X	X	
Water-Dependent Recreation	X		X	X	X	X	X

Notes:

CABY = Cosumnes, American, Bear, and Yuba, NSVG = North Sacramento Valley Group

Information for the Upper Sacramento-McCloud IRWM plan was not available for Update 2013.

[a] Westside also uses other RMS strategies, Crop Idling for Water Transfers, Irrigated Land Retirement, and Rainfed Agriculture.

Box SR-6 Statewide Conjunctive Management Inventory Effort in California

The effort to inventory and assess conjunctive management projects in California was conducted through literature research, personal communication, and documented summary of the conjunctive management projects. The information obtained was validated through a joint survey by the California Department of Water Resources (DWR) and the Association of California Water Agencies (ACWA). The survey requested the following conjunctive use program information:

1. Location of conjunctive use project.
2. Year project was developed.
3. Capital cost to develop the project.
4. Annual operating cost of the project
5. Administrator/operator of the project.
6. Capacity of the project in units of acre-feet.

To build on the DWR/ACWA survey, DWR staff contacted by telephone and e-mail the entities identified to gather the following additional information:

1. Source of water received.
2. Put and take capacity of the groundwater bank or conjunctive use project.
3. Type of groundwater bank or conjunctive use project.
4. Program goals and objectives.
5. Constraints on development of conjunctive management or groundwater banking (recharge) program.

Statewide, a total of 89 conjunctive management and groundwater recharge programs were identified. Conjunctive management and groundwater recharge programs that are in the planning and feasibility stage are not included in the inventory.

Currently, enough data exist to warrant the importance of contingency plans, mitigation (reduction) of greenhouse gas (GHG) emissions, and incorporation of adaptation strategies, methodologies, and infrastructure improvements that benefit the region at present and into the future. While the State is taking aggressive action to mitigate climate change through GHG reduction and other measures (California Air Resources Board 2008), global impacts from carbon dioxide and other GHGs that are already in the atmosphere will continue to impact climate through the rest of the century (Intergovernmental Panel on Climate Change 2013).

Resilience to an uncertain future can be achieved by implementing adaptation measures sooner rather than later. Because of the economic, geographical, and biological diversity of California, vulnerabilities and risks from current and future anticipated changes are best assessed on a regional basis. Many resources are available to assist water managers and others in evaluating their region-specific vulnerabilities and identifying appropriate adaptive actions (U.S. Environmental Protection Agency and California Department of Water Resources 2011; California Emergency Management Agency and California Natural Resources Agency 2012). The most comprehensive report to date on climate change observations, impacts, and projections for the southwestern United States, including California, is the *Assessment of Climate Change in the Southwest United States* (Garfin et al. 2013).

Observations

Due to the region's large size, complex topography, and multiple climate zones, temperature and precipitation trends have considerable variation. Over the past century, air temperatures measured throughout the region indicate a general warming trend. Regionally specific air temperature data was retrieved through the WRCC (Western Regional Climate Center 2013). The WRCC acts as a repository of historical climate data and information. Air temperature records for the past century were summarized by the WRCC into distinct climate regions (Abatzoglou et al. 2009). Although having some similarities, DWR's hydrologic regions do not correspond directly to WRCC's climate regions (Figure SR-29). A particular hydrologic region may overlap more than one climate region and, hence, have different climate trends in different areas. For the purpose of this regional report, however, climate trends of the major climate regions are considered to be relevant trends for respective portions of the hydrologic region.

Locally in the Sacramento River region, within the WRCC North Central climate region, mean temperatures have increased by about 0.8 to 1.7 °F (0.4 to 0.9 °C) in the past century, with minimum and maximum temperatures increasing by about 1.2 to 2.1 °F (0.7 to 1.2 °C) and 0.1 to 1.5 °F (0.1 to 0.8 °C), respectively. Within the WRCC North East climate region, mean temperatures have increased by about 0.8 to 2.0 °F (0.5 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing by about 0.9 to 2.2 °F (0.5 to 1.2 °C) and by 0.5 to 2.1 °F (0.3 to 1.2 °C), respectively. Within the WRCC Sierra climate region, mean temperatures have increased by about 0.8 to 2.0 °F (0.5 to 1.1 °C) in the past century, with minimum and maximum temperatures increasing and decreasing by about 1.7 to 2.8 °F (0.9 to 1.5 °C) and by -0.2 to 1.3 °F (-0.1 to 0.7 °C), respectively. Within the WRCC Sacramento-Delta climate region, mean temperatures have increased by about 1.5 to 2.4 °F (0.9 to 1.3 °C) in the past century, with minimum and maximum temperatures increasing by about 2.1 to 3.1 °F (1.2 to 1.7 °C) and by 0.8 to 2.0 °F (0.4 to 1.1 °C), respectively (Western Regional Climate Center 2013).

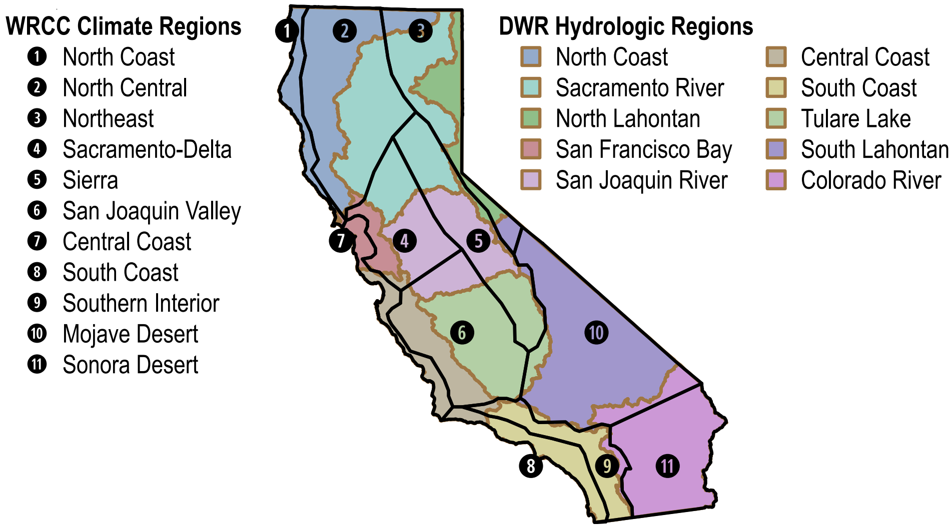
Over the past century, the mean sea level at the San Francisco tide gage near the Golden Gate Bridge has risen approximately 7 inches (California Department of Water Resources 2008). Mean annual precipitation in Northern California has increased slightly in the 20th century, and precipitation patterns in the region have considerable geographic and annual variation (California Department of Water Resources 2006). A hydrologic and climate sensitivity analysis in the Upper Feather River watershed indicated that historical air temperature and seasonal streamflow had statistically significant trends, suggesting that warmer air temperatures are causing snowmelt runoff to occur earlier in the water year (Huang et al. 2012).

The Sacramento River Hydrologic Region also is experiencing impacts from climate change through changes in statewide precipitation and surface runoff volumes, which in turn affect availability of local and imported water supplies. During the last century, the average early snowpack in the Sierra Nevada decreased by about 10 percent, which equates to a loss of 1.5 maf of snowpack storage (California Department of Water Resources 2008).

Projections and Impacts

While historical data is a measured indicator of how the climate is changing, it can't project what future conditions may be like under different GHG emissions scenarios. Current climate science uses modeling methods to simulate and develop future climate projections. A recent study by Scripps Institution of Oceanography uses the most sophisticated methodology to date and

Figure SR-29 DWR Hydrologic and Western Region Climate Center Climate Regions



The Western Region Climate Center (WRCC) divides California into 11 separate climate regions, and generates historic temperature time-series and trends for these regions (http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html). DWR maintains 10 hydrologic regions, with the Delta and Mountain Counties being overlays of other DWR hydrologic regions. Each DWR hydrologic region spans one or more of the WRCC climate regions.

indicates that by 2060-2069 temperatures will be 3.4 to 4.9 °F (1.9 to 2.7 °C) higher across the state than they were from 1985 to 1994 (Pierce et al. 2012). Annual mean temperatures by 2060-2069 are projected to increase by 4.0 °F (2.2 °C) for the WRCC North Central climate region, with increases of 3.1 °F (1.7 °C) during the winter months and 5.2 °F (2.9 °C) during summer. The WRCC North East climate region has similar projections with annual mean temperatures increasing by 4.7 °F (2.6 °C), winter temperatures increasing by 3.4 °F (1.9 °C), and summer temperatures increasing by 6.5°F (3.6 °C). The WRCC Sierra climate region projections have annual mean temperatures increasing by 4.5 °F (2.5 °C), winter temperatures increasing by 3.4 °F (1.9 °C), and summer temperatures increasing by 5.9 °F (3.3 °C). The WRCC Sacramento-Delta climate region projections have annual mean temperatures increasing by 4.1 °F (2.3 °C), winter temperatures increasing by 3.1 °F (1.7 °C), and summer temperatures increasing by 5.2 °F (2.9 °C). Climate projections for this region, from Cal-Adapt indicate that temperatures between 1990 and 2100 will increase by 8 °F (4.4 °C) in the winter and 12 °F (6.7 °C) in the summer (California Emergency Management Agency and California Natural Resources Agency 2012).

Changes in precipitation across California due to climate change could result in changes in type of precipitation (rain or snow) in a given area, in timing or total amount, and in surface runoff timing and volume. Most climate model precipitation projections for the state anticipate drier conditions in southern California, with heavier and warmer winter precipitation in northern California, including the Sacramento River Region (Pierce et al. 2012). Because there is less scientific detail on localized precipitation changes, there exists a need to adapt to this uncertainty at the regional level (Qian et al. 2010).

The Sierra Nevada snowpack is projected to continue to decline as warmer temperatures raise the elevation of snow levels, reduce spring snowmelt, and increase winter runoff. Based upon historical data and modeling, researchers at Scripps Institution of Oceanography project that by the end of this century the Sierra snowpack would experience a 48 to 65 reduction of its historical average snowpack (Pierce and Cayan 2013). Snowmelt dominated watersheds in the region will each have a unique snowmelt response depending on elevation and the amount of warming that occurs. Climate projections indicate that temperatures will continue to rise by the end of the century diminishing April 1 snowpack (Table SR-26). DWR projects that with a 1°C (1.8°F) rise, the Feather basin April 1 snow-covered area drops from 72 to 56 percent, while the Yuba basin drops from 50 to 42 percent and the American basin drops from 48 to 42 percent (California Department of Water Resources 2006). A projected temperature rise of 5° C (9 °F) would leave most basins within the Sacramento River Hydrologic region with 2 to 8 percent April 1 snow-covered area, except the American basin with 12 percent snow coverage. Additional modeling results by Huang et al. (2012) suggest the Upper Feather River watershed April 1 snowpack would be diminished by 63 percent with 3.6 °F (2 °C) of warming; all modeled climate scenario projections from this study lead to a negative impact on water supply.

A recent study explores future climate change and flood risk in the Sierra using downscaled simulations from three GCMs under an accelerating GHG emissions scenario that is more reflective of current trends. Results indicate a tendency toward increased three-day flood magnitude. By the end of the 21st century, all three projections yield larger floods for both the moderate-elevation northern-Sierra Nevada watershed and for the high-elevation southern-Sierra Nevada watershed, even for GCM simulations with 8 to 15 percent declines in overall precipitation. The increases in flood magnitude are statistically significant for all three GCMs for the period 2051 to 2099. By the end of the 21st century, the magnitudes of the largest floods increase to 110 to 150 percent of historical magnitudes. These increases appear to derive jointly from increases in heavy precipitation amount, storm frequencies, and days with more precipitation falling as rain and less as snow (Das et al. 2011). In addition, earlier seasonal flows would reduce the flexibility in how the state manages its reservoirs to protect communities from flooding while ensuring a reliable water supply.

Additionally, sea level is projected to continue to rise along California's coast. For the California coast south of Cape Mendocino, the National Research Council projects sea level rise of 1.5 to 12 inches (3.8 to 30 cm) by 2030, 4.5 to 24 inches (11.4 to 61 cm) by 2050, and 16.5 to 66 inches (41.9 to 168 cm) by 2100 (National Research Council 2012). Although the Sacramento River region has no coastline borders, its boundaries extend through the Delta to Chipps Island where waters are influenced by tidal fluctuations and sea level rise.

Warmer waters would result in stress to fisheries, a reduction of coldwater habitat for species of concern, and negatively impact restoration efforts. Thompson et al. (2012) concluded that long-term survival of spring-run Chinook salmon in Butte Creek (a significant tributary to the Sacramento River) is unlikely under climate change projections and that simple changes to water operations are not likely to decrease vulnerabilities to warmer temperatures. With higher summer air temperatures on land, the northern and eastern portions of the region would be at higher risk of wildfire, some having four times more risk than current levels by the end of the century (Westerling et al. 2009; California Emergency Management Agency and California Natural Resources Agency 2012).

Table SR-26 Sacramento River Hydrologic Region Snow Covered Area Changes with Temperature

Basin	Mean Elevation (ft)	Average Apr. 1 Snow Line (ft)	Total Area (sq. mi)	Snow Covered Area	1 °C (1.8 °F) Rise	2 °C (3.6 °F) Rise	3 °C (5.4 °F) Rise	4 °C (7.2 °F) Rise	5 °C (9 °F) Rise
				Snow coverage in percent of basin					
Sac/Delta	4,130	4,000	418	48	36	26	19	10	7
McCloud	4,370	4,000	607	56	40	25	16	10	6
Pit	4,830	4,000	4,768	81	62	42	24	11	6
Shasta	4,550	4,000	6,400	71	54	36	21	10	6
Bend	3,870	4,000	9,030	54	41	28	17	8	5
Feather	4,940	4,500	3,624	72	56	36	20	9	2
Yuba	4,470	4,500	1,191	50	42	34	28	17	8
American	4,300	4,500	1,900	48	42	34	26	19	12

Source: California Department of Water Resources 2006.

Another potential climate change impact from increasing temperatures is that net evaporation from reservoirs is projected to increase by 15 to 37 percent (Medellin-Azuara et al. 2009).

Adaptation

Climate change has the potential to impact the region, which the state depends upon for its economic and environmental benefits. These changes would increase the vulnerability of natural and built systems in the region. Impacts to natural systems will challenge aquatic and terrestrial species with diminished water quantity and quality, and shifting ecoregions. Built systems would be impacted by changing hydrology and runoff timing, loss of natural snowpack storage, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future water demand for both natural and built systems may be particularly challenging with less natural storage and less overall supply.

Water managers and local agencies must work together to determine the appropriate planning approach for their operations and communities. While climate change adds another layer of uncertainty to water planning, it does not fundamentally alter the way water managers already address uncertainty (U.S. Environmental Protection Agency and California Department of Water Resources 2011). However, stationarity (the idea that natural systems fluctuate within an unchanging envelope of variability) can no longer be assumed so new approaches will likely be required (Milly et al. 2008).

Local agencies, as well as federal and State agencies, face the challenge of interpreting new climate change data and information and determining which adaptation methods and approaches are appropriate for their planning needs. The *Climate Change Handbook for Regional Water Planning* (U.S. Environmental Protection Agency and California Department of Water Resources

2011) provides an analytical framework for incorporating climate change impacts into the regional and watershed planning process and considers adaptation to climate change. This handbook provides guidance for assessing the vulnerabilities of California's watersheds and hydrologic regions to climate change impacts and prioritizing these vulnerabilities.

The State of California has developed additional online tools and resources to assist water managers, land use planners, and local agencies in adapting to climate change. These tools and resources include the following:

- *Safeguarding California: Reducing Climate Risk* (http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf), which identifies a variety of strategies across multiple sectors (other resources can be found at http://www.climatechange.ca.gov/adaptation/strategy/index.html).
- *California Adaptation Planning Guide* (http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html) developed into four complementary documents by the California Emergency Management Agency and the California Natural Resources Agency to assist local agencies in climate change adaptation planning.
- Cal-Adapt (http://cal-adapt.org/), an online tool designed to provide access to data and information produced by California's scientific and research community.
- Urban Forest Management Plan Toolkit (http://www.ufmptoolkit.com/), sponsored by the California Department of Forestry and Fire Management to help local communities manage urban forests to deliver multiple benefits, such as cleaner water, energy conservation, and reduced heat-island effects.
- California Climate Change Portal (http://www.climatechange.ca.gov/).
- DWR Climate Change Web site (http://www.water.ca.gov/climatechange/resources.cfm)
- The Governor's Office of Planning and Research Web site (http://www.opr.ca.gov/m_climatechange.php).

Regionally, the Sierra Climate Change Toolkit, developed by the Sierra Nevada Alliance, is a comprehensive resource for resource managers, local governments, planners, and others that are interested in addressing climate change in Sierra watersheds and communities. The toolkit provides frameworks, specific strategies, and case studies for reducing GHG emissions and adapting to climate change impacts and additional resources to help planning processes or projects address climate change (Sierra Nevada Alliance 2011).

IRWM planning is a framework that allows water managers to address climate change on a smaller, more regional scale. Climate change is now a required component of all IRWM plans (California Department of Water Resources 2010, 2012). IRWM regions must identify and prioritize their specific vulnerabilities, and identify adaptation strategies that are most appropriate for their subregions. Planning strategies to address vulnerabilities and adaptation to climate change should be both proactive and adaptive, starting with strategies that benefit the region in the present-day while adding future flexibility and resilience under uncertainty.

CVP and SWP operations within the region are particularly sensitive to precipitation, reservoir carryover storage levels, demand, and Delta exports. Surface Storage-CALFED/State is a resource management strategy outlined in Volume 3 that would benefit the CVP and SWP under climate change. Additional reservoir storage would allow greater management flexibility to capture runoff as it occurs and act as a buffer between wet and dry periods. Operations can also be modified as a strategy to improve downstream flood protection while minimizing impacts to water storage in upstream reservoirs. Integrated flood management is a resource management strategy employed by DWR in the Yuba-Feather River system. DWR has developed the Forecast-Coordinated Operations Program to reduce downstream peak flows and maintain maximum reservoir capacities through improved forecasting and enhanced communication between local, State, and federal agencies.

Several of the resource management strategies in Volume 3 of Update 2013 can be singled out as providing benefits for adapting to climate change in addition to meeting water management objectives in the Sacramento River Hydrologic Region. These include:

- Chapter 4, “Flood Management.”
- Chapter 6, “Conveyance – Regional/Local.”
- Chapter 7, “System Reoperation.”
- Chapter 9, “Conjunctive Management and Groundwater Storage.”
- Chapter 11, “Precipitation Enhancement.”
- Chapter 13, Surface Storage – “CALFED.”
- Chapter 14, “Surface Storage – Regional/Local.”
- Chapter 18, “Pollution Prevention.”
- Chapter 22, “Ecosystem Restoration.”
- Chapter 23, “Forest Management.”
- Chapter 24, “Land Use Planning and Management.”
- Chapter 25, “Recharge Area Protection.”
- Chapter 27, “Watershed Management.”

The myriad of resources and choices available to managers can seem overwhelming, and the need to take action given uncertain future conditions is daunting. However, there are many actions that water managers can take to prepare for climate change, regardless of the magnitude of future warming. These actions often provide economic and public health co-benefits. Water and energy conservation are examples of strategies that make sense with or without the additional pressures of climate change. Conjunctive management projects that manage surface water and groundwater in a coordinated fashion could provide a buffer against variable annual water supplies. Forecast-coordinated operations would provide flexibility for water managers to respond to weather conditions as they unfold.

Water managers will need to consider both the natural and built environments as they plan for the future. Stewardship of natural areas and protection of biodiversity are critical for maintaining ecosystem services important for human society such as carbon sequestration, pollution remediation, and habitat for pollinators. Increased cross-sector collaboration between water managers, land use planners, and ecosystem managers provides opportunities for identifying common goals and actions needed to achieve resilience to climate change and other stressors.

Mitigation

California’s water sector consumes about 12 percent of total statewide energy (19 percent of statewide electricity, about 32 percent of statewide natural gas, and negligible amounts of crude

crude oil). As shown in Figure 3-28 "Energy Use Related to Water," water conveyance and extraction accounts for about 2 percent of energy consumption in the State, with 10 percent of total statewide energy use attributable to end-users of water (California Energy Commission 2005 2013; California Public Utilities Commission 2010). Energy is used in the water sector to extract, convey, treat, distribute, use, condition, and dispose of water and wastewater. Figure 3-29 "Water and Energy Connection" (Volume 1) shows all of the connections between water and energy in the water sector; both water use for energy generation and energy use for water supply activities. The regional reports in Update 2013 are the first to provide detailed information on the water-energy connection, including energy intensity (EI) information at the regional level. EI information is designed to help inform the public and water utility managers about the relative energy requirements of the major water supplies used to meet demand. Because energy usage is closely related to GHG emissions, this information can support measures to reduce GHG, as mandated by the State.

Figure SR-30 Energy Intensity per Acre-Foot of Water

Type of Water	Energy Intensity (small bulb = 1-250 kWh/AF, large bulb = 251-500 kWh/AF)	Percent of Regional Water Supply*
Colorado (Project)	*This type of water not available*	0%
Federal (Project)	<250 kWh/AF	28%
State (Project)	<250 kWh/AF	<1%
Local (Project)	<250 kWh/AF	30%
Local Imports	*This type of water not available*	0%
Groundwater	<250 kWh/AF	19%

Energy intensity (EI) in this figure is the estimated energy required for the extraction and conveyance of one acre-foot (af) of water. These figures reflect only the amount of energy needed to move from a supply source to a centralized delivery location (not all the way to the point of use). Small light bulbs are for EI greater than zero, and less than 250 kilowatt hours per acre foot (kWh/af). Large light bulbs represent 251-500 kWh/af of water (e.g., four light bulbs indicate that the water source has EI between 1,501-2,000 kWh/af).

*The percent of regional water supply may not add up to 100% because not all water types are shown in this figure. EI values of desalinated and recycled water are covered in Volume 3, *Resource Management Strategies*. For detailed descriptions of the methodology used to calculate EI in this figure, see Volume 5, *Technical Guide*.

Figure SR-30, "Energy Intensity per Acre-Foot of Water," shows the amount of energy associated with the extraction and conveyance of one af of water for each of the major water sources in this region. The quantity of each water source used in the region is also included, as a percentage. For reference, only extraction and conveyance of raw water in Figure 3-29 "The Water-Energy Connection" in Volume 1, Chapter 3, "California Water Today," are illustrated in Figure SR-30. Energy required for water treatment, distribution, and end uses of the water are not included. Not all water types are available in this region. Some water types flow mostly by gravity to the delivery location and may require little or no energy to extract and convey. As a default assumption, a minimum EI less than 250 kilowatt hours per af (kWh/af) was assumed for all water types.

Recycled water and water from desalination used within the region are not shown in Figure SR-30 because their EI differs in important ways from those water sources. The EI of both recycled

Box SR-7 Energy Intensity

Energy Intensity (EI) is the amount of energy needed to extract and convey an acre-foot (af) of water from its source to a delivery location. Extraction refers to the process of moving water from its source to the ground surface. Many water sources are already at ground surface and require little or no energy for extraction, while others (groundwater or sea water for desalination) require energy to move the water to the surface. Conveyance refers to the process of moving water from a location at the ground surface to a different location. Conveyance can include pumping water up and over mountains or can occur by gravity. EI should not be confused with total energy (i.e., the amount of energy [kilowatt hours] required to deliver all of the water from a source to regional customers). EI does not focus on the total amount of energy to deliver water to customers, but instead on the portion of energy required to extract and convey a single unit of water [in kilowatt hours per af (kWh/af)]. EI gives a normalized metric used to compare alternative water sources. (For detailed descriptions of the EI methodology and the delivery locations assumed for the water types, see Volume 5, *Technical Guide*).

In most cases, this information will not be sufficiently detailed for actual project-level analysis. However, these generalized, region-specific metrics provide a range in which energy requirements fall. The information can also be employed in more detailed evaluations by using such tools as WeSim, which allows modeling of water systems to simulate outcomes for energy, emissions, and other aspects of water supply selection.

Although not identical, EI is closely related to greenhouse gas (GHG) emissions (for more information, see the "Climate Change and the Water-Energy Nexus" section in Volume 1, Chapter 3, "California Water Today"). On average, generation of one megawatt-hour (MWh) of electricity results in about one-third of a metric ton of GHG (eGrid 2012). This estimate takes into account all types of energy generation through the state and for imported electricity.

Reducing GHG emissions is a State mandate. Water managers can support this by using EI in their decision-making process. It's important to note that water supply planning must consider different factors in addition to energy impacts, such as public safety, water quality, firefighting, ecosystems, reliability, energy generation, recreation, and costs.

Accounting for Hydroelectric Energy

Hydroelectricity generation is integral to many of the state's large water projects. The State Water Project (SWP), Central Valley Project (CVP), Los Angeles Aqueduct, Mokelumne Aqueduct, and Hetch Hetchy Aqueduct all generate large amounts of hydroelectricity at multi-purpose reservoirs at the heads of each system. In addition to hydroelectricity generation at head reservoirs, several of these systems also generate hydroelectricty by capturing the power of water falling through pipelines at in-conduit generating facilities, which are hydroelectric turbines placed along pipelines to capture energy as water runs downhill in a conduit. Hydroelectricity is also generated at hundreds of smaller reservoirs and run-of-the-river turbine facilities.

Because of the many ways hydroelectric generation is integrated into water systems, accounting for hydroelectric generation in EI calculations is complex. In some systems, such as the SWP and CVP, water generates electricity and then flows back into the natural river channel after passing through the turbines. In other systems, such as the Mokelumne Aqueduct, water can leave the reservoir by two distinct outflows, one that generates electricity and flows back into the natural river channel, and one that does not generate electricity and flows into a pipeline leading to water users. In both these situations, experts have argued that hydroelectricity should be excluded from EI calculations because the energy generation system and the water delivery system are, in essence, separate (Wilkinson 2000).

DWR has adopted this convention for its EI calculations. All hydroelectric generation at head reservoirs has been excluded. Consistent with Wilkinson (2000) and others, DWR has included in-conduit and other hydroelectric generation that occurs as a consequence of water deliveries, such as the Los Angeles Aqueduct's hydroelectric generation at plants on the system downstream of the Owen's River diversion gates. DWR has made one modification to this methodology to simplify the display of results: energy intensity has been calculated at each main delivery point in the systems. If the hydroelectric generation in the conveyance system exceeds the energy needed for extraction and conveyance, the EI is reported as zero. That means no water system is reported as a net producer of electricity, even though several systems (e.g., Los Angeles Aqueduct, Hetch Hetchy Aqueduct) produce more electricity in the conveyance system than is used. This methodology does not account for several unique benefits that hydroelectric generating facilities at reservoirs provide, including grid stabilization, backup for intermittent renewable energy sources, and large amounts of GHG-free energy.

and desalinated water depend not on regional factors but rather on much more localized-, site-, and application-specific factors. Additionally, the water produced from recycling and desalination is typically of much higher quality than the raw (untreated) water supplies evaluated in Figure SR-30. For these reasons, discussion of the EI of recycled and desalinated water are found separately in Volume 3, Resource Management Strategies. Energy Intensity is discussed in Box SR-7.

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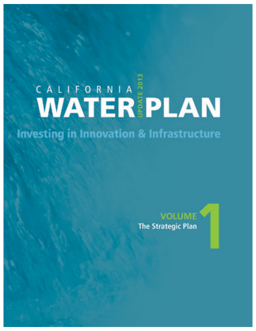

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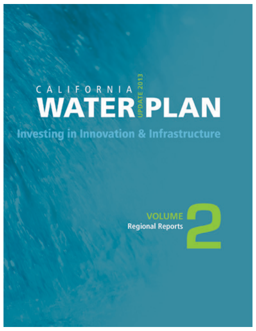

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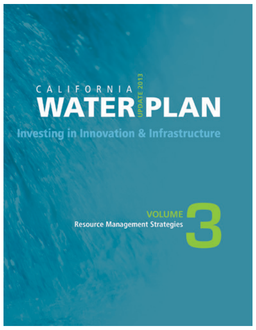

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DEPARTMENT OF WATER RESOURCES
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October 2014