Irrigated Lands Regulatory Program

Existing Conditions Report

December 2008



Prepared For:

Central Valley Regional Water Quality Control Board

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3-45 Kaweah River Watershed
3-46 Kern River Watershed
3-47 South Valley Floor Watershed
3-48 Grapevine Watershed
3-49 Coast Range Watershed
3-50 Fellows Watershed
3-51 Temblor Watershed
3-52 Sunflower Valley Watershed
3-53 Southern Sierra Watershed
3-54 DWR Land Use Kings River Watershed
3-55 DWR Land Use Kaweah River Watershed
3-56 DWR Land Use Kern River Watershed
3-57 DWR Land Use South Valley Floor Watershed
3-58 DWR Land Use Grapevine Watershed
3-59 DWR Land Use Coast Range Watershed
3-60 DWR Land Use Fellows Watershed

3-61 DWR Land Use Temblor Watershed
3-62 DWR Land Use Sunflower Valley Watershed
3-63 DWR Land Use Southern Sierra Watershed
4-1 Conceptual Groundwater Model
4-2 Sacramento River Groundwater Subbasins
4-3 Northern Portion of San Joaquin Valley Groundwater Basin
4-4 Tulare Lake Groundwater Basins
4-5 DWR Land Use Northern Portion of San Joaquin Valley Groundwater Basin
4-6 DWR Land Use Southern San Joaquin Valley Groundwater Basins

Acronyms and Abbreviations

µg/L	micrograms per liter
µmhos/cm	micro-reciprocal ohms per centimeter
µS/cm	microSiemens per centimeter
1988 Plan	State Water Resources Control Board 1988 *Nonpoint Source Management Plan*
2007 Review of Monitoring Data for ILRP	*Revised Draft of the 2007 Review of Monitoring Data for the Irrigated Lands Conditional Water Program*
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
2nd Circuit Court	United States Court of Appeals for the Second Circuit
AB 3030	Assembly Bill 3030
ACET	2-amino-4-chloro-6-ethylamino-s-triazine
ACID	Anderson Cottonwood Irrigation District
AMA	Agricultural Management Assistance
ARMP	Aggregate Resource Management Plan
ASAR	adjusted sodium adsorption ratio
Basin Plans	water quality control plans
BDAT	Bay Delta and Tributaries Project
BLM	Bureau of Land Management
BMPs	best management practices
BOD	biochemical oxygen demand
BWGWD	Biggs West Gridley Water District
CAC	County Agricultural Commissioners
CalEPA	California Environmental Protection Agency
CAS	California Aquifer Susceptibility assessment
CBR	Chili Bar
CCC	criteria continuous concentration (chronic regulatory standard)
CCID	Central California Irrigation District
CCRs	California Code of Regulations
CCWD	Corning Canal Water District
CD	compact disc
CDEC	California Data Exchange Center
CDF	California Department of Forestry and Fire Protection
CDFA	California Department of Food and Agriculture
CDPH	California Department of Public Health
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFAC	California Food and Agricultural Code
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIMIS	California Irrigation Management and Information System
CMC	criterion maximum concentration (acute regulatory standard)
Corps	U.S. Army Corps of Engineers
CSD	Community Service District

CTR	California Toxics Rule
CUP	Conditional Use Permit
CURES	Coalition for Urban/Rural Environmental Stewardship
CVP	Central Valley Project
CVPIA	1992 Central Valley Project Improvement Act
CWA	federal Clean Water Act
CWD	Chowchilla Water District
CWHR	California Wildlife Habitat Relationships
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
DACT	2,4-diamino-6-chloro-s-triazine
Dairy General Order	Waste Discharge Requirements General Order No. R5-2007-0035 for Existing Milk Cow Dairies
DBCP	1,2-dibromo-3-chloropropane
DDE	1, 1-dichloro-2,2'-bis-p-chlorophenyl-ethylene
DDT	1, 1, 1 -trichloro-2, 2'-bis-p-chlorophenyl-ethane
DEA	deethyl-atrazine
Delta	Sacramento–San Joaquin River DeltaDFG California Department of Fish and Game
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DOC	dissolved organic carbon
DOI	U.S. Department of the Interior
DPR	California Department of Pesticide Regulation
DWEL	Drinking Water Equivalent Level
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
EBMUD	East Bay Municipal Utilities District
EC	electrical conductivity
EIR	environmental impact report
EMS	Environmental Monitoring Section
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
ESA	federal Endangered Species Act of 1973, as amended
ESJWQC	East San Joaquin Water Quality Coalition
ESPP	Endangered Species Protection Program
Farm Bureau	California Farm Bureau Federation
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act, as amended
FQPA	Food Quality Protection Act of 1996
FRAP	Fire Resources Assessment Program
FREP	Fertilizer Research and Education Program
GAMA	Groundwater Ambient Monitoring Assessment
GCID	Glenn-Colusa Irrigation District
GIS	geographic information systems
gpm	gallons per minute
GWD	Grassland Water District
HA	hydrologic area (major tributaries)
HR	hydrologic region
HSA	hydrologic sub-area
HU	hydrologic unit (major rivers)
ID	identification number

ID	Irrigation District
IEP	Interagency Ecological Program
ILRP	Irrigated Lands Regulatory Program
IPM	integrated pest management
IPM	integrated pest management
IRIS	Integrated Risk Information System
KRCD	Kings River Conservation District
LMMWC	Los Molinos Mutual Water Company
MAA	Management Agency Agreement
MCL	maximum contaminant level
MFAR	Middle Fork American River
mg/kg	milograms per kilogram
mg/L	milligrams per liter
Mgd	million gallons per day
mi^2	square miles
mL/g	milliliters per gram
MPs	management practices
mS/cm	millisiemens per centimeter
MTBE	methy tertiary-butyl ether
NA	indicates that the particular type of criteria is not available
NAQWA	National Water Quality Assessment
NCWA	Northern CA Water Association
ND	non-detect
NEPA	National Environmental Policy Act
NFAR	North Fork American River
ng/L	nanograms per liter
NMP	Nutrient Management Plan
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NPS Implementation and Enforcement Policy	*Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program*
NPS Program Plan	State Water Resources Control Board January 2000 *Plan for California's Nonpoint Source Pollution Control Program*
NRCS	Natural Resources Conservation Service (formerly, Soil Conservation Service)
NWR	National Wildlife Refuge
OP	organophosphate
PCAs	Pest Control Advisors
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene, also known as perchloroethylene,
PG&E	Pacific Gas and Electric Company
pg/L	picograms per liter
PHG	public health goal
Policy	State Implementation Policy for Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California
Porter-Cologne Act	Porter-Cologne Water Quality Control Act
Ppb	parts per billion
ppm	parts per million
PUP	Pesticide Use Proposals

PWS	planning watershed
QAPP	quality assurance project plan
RBDD	Red Bluff Diversion Dam
RCD	Resource Conservation District
Reclamation	U.S Department of the Interior, Bureau of Reclamation
RM	river mile
ROWD	Report of Waste Discharge
RWA	Regional Water Authority
RWQCB	Regional Water Quality Control Board
Sacramento and San Joaquin Rivers Basin Plan	*Water Quality Control Plan for the Sacramento and San Joaquin River Basins*
SB	Senate Bill
SDWA	Safe Drinking Water Act
SFAR	South Fork American River
SGA	Sacramento Groundwater Authority
SJRECWA	San Joaquin River Exchange Contractors Water Authority
SJVFS	San Joaquin Valley Floor Subwatershed
SNARL	suggested no adverse response levels for non-cancer toxicity (mercury SNARL concentration is total)
SPWS	super planning watershed
SR	State Route
SS	suspended sediments
State Water Board	State Water Resources Control Board
SVFS	South Valley Floor Subwatershed
SVWQC	Sacramento Valley Water Quality Coalition
SWAMP	Surface Water Ambient Monitoring Program
SWP	State Water Project
TCC	Tehama Colusa Canal
TCCA	Tehama Colusa Canal Authority
TCE	trichloroethylene
TDS	total dissolved solids
THM	trihalomethane
TID	Turlock Irrigation District
TIE	toxicity identification evaluation
TMDL	total maximum daily load
TSS	total suspended solids
UFRW	Upper Feather River Watershed
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VADD	Vegetated Agricultural Drainage Ditches
VAMP	Vernalis Adaptive Management Plan
VOCs	volatile organic compounds
WA	Wildlife Area
Water Code	California Water Code
WDRs	waste discharge requirements
WSD	water storage district
WSJVDA	Westside San Joaquin Valley Drainage Authority

Chapter 1
INTRODUCTION

BACKGROUND

California's Porter-Cologne Water Quality Control Act (Porter-Cologne Act) established the State Water Resources Control Board (State Water Board) and divided the state into nine regional basins, each with a Regional Water Quality Control Board (Regional Board) (California Water Code [Water Code] Section 13200). The State Water Board is the "principle state agency with the primary responsibility for the coordination and the control of water quality" in California (Water Code Section 13201).

The Porter-Cologne Act authorizes the State Water Board to draft state policies regarding water quality and, in accordance with Water Code Section 13263, to develop general waste discharge requirements (WDRs) and project-specific WDRs for projects that would discharge into state waters. The Water Code requires that Regional Boards adopt water quality control plans (Basin Plans) in accordance with Section 13240. The State Water Board is allowed, but not required, to adopt Basin Plans in accordance with Section 13170 of the Water Code.

In January 2000, the State Water Board—in its continuing efforts to control nonpoint source (NPS) pollution in California—adopted the *Plan for California's Nonpoint Source Pollution Control Program* (NPS Program Plan) (State Water Board 1999). The NPS Program Plan upgraded the State's first *Nonpoint Source Management Plan* adopted by the State Water Board in 1988 (1988 Plan) (State Water Board 1988). Upgrading the 1988 Plan with the NPS Program Plan brought the State into compliance with the requirements of Section 319 of the federal Clean Water Act (CWA) and Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). On May 20, 2004, the State Water Board adopted the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (NPS Implementation and Enforcement Policy). The NPS Implementation and Enforcement Policy was adopted by the State Water Board in order to comply with the 1999 amendment of the Porter-Cologne Act to enforce the State's NPS pollution control program. The program requires the Regional Board to regulate all NPS pollution and must meet five key elements:

- The NPS pollution control implementation program's ultimate purpose must be explicitly stated and, at a minimum, address NPS pollution control in a manner that achieves and maintains water quality objectives.
- The NPS pollution control implementation program must include a description of the management practices (MPs) and other program elements expected to be implemented, along with an evaluation program that ensures proper implementation and verification.
- The NPS pollution control implementation program should include a time schedule and quantifiable milestones, if the Regional Board so requires.

- The NPS pollution control implementation program must include sufficient feedback mechanisms so that the Regional Board, dischargers, and the public can determine whether the implementation program is achieving its stated purpose(s), or whether additional or different MPs or other actions are required.
- Each Regional Board must make clear, in advance, the potential consequences for failure to achieve an NPS pollution control implementation program's objectives, emphasizing that it is the responsibility of individual dischargers to take all necessary implementation actions to meet water quality requirements.

The Regional Boards have primary responsibility for ensuring that appropriate NPS pollution control implementation programs are in place throughout the state. Regional Board responsibilities include, but are not limited to, issuing WDRs or a waiver of WDRs for individual discharges or a category of NPS discharges, or adopting a Basin Plan amendment that addresses NPS discharges. Since 1982, the Central Valley Regional Water Quality Control Board (Central Valley Water Board) has regulated NPS discharges from agricultural lands through a waiver of WDRs. Senate Bill (SB) 390 involved changes to Section 13269 of the Water Code relating to how the Central Valley Water Board adopts waivers. The legislative change required that, if the Central Valley Water Board adopts waivers, they must comply with the new Section 13269—or the dischargers operating under the 1982 waivers would need to submit Reports of Waste Discharge and obtain WDRs, or comply with the Water Code. To comply with the requirements of SB 390, the Regional Board adopted a conditional waiver of waste discharge requirements for discharges from irrigated agricultural lands (2003 waiver program).

IRRIGATED LANDS REGULATORY PROGRAM

As part of the 2003 waiver program the Regional Water Board directed staff to prepare an Environmental Impact Report (EIR) for a long-term irrigated lands regulatory program. The 2003 interim waiver program was set to expire in 2006. In 2006, the Regional Water Board adopted a new conditional waiver for discharges from irrigated agricultural lands that continued the 2003 interim program until 2011. In the 2006 conditional waiver, the Regional Water Board reaffirmed the goal to develop a long-term program and EIR.

Purpose of This Report

The purpose of this existing conditions report is to support the development of a long-term irrigated lands regulatory program and associated EIR for the Central Valley. The information collected to support this purpose includes:

- A comprehensive survey of readily available and relevant digital coverage for the entire Central Valley in a geographic information systems (GIS) format.
  - topography
  - land use cover
  - water bodies
  - watershed boundaries
  - political boundaries
  - major roadways

- A comprehensive study of existing information related to water quality observations within the Central Valley watersheds.
  - general watershed parameters (e.g., acreage, land uses, major tributaries, and flows)
  - impaired list status
  - constituents of concern
  - discharge pathways and sources of contaminants (to the extent known)
- A general description of groundwater conditions in the Central Valley Water Board's jurisdictional area.

Program Boundaries and Subdivisions

Central Valley Water Board Jurisdictional Area

The jurisdiction of the Central Valley Water Board stretches from the Oregon border to the northern tip of Los Angeles County and includes all or part of 38 of the state's 58 counties. Three major watersheds have been delineated within this region, namely the Sacramento River Basin, the San Joaquin River Basin, and the Tulare Lake Basin. The three basins cover about 40 percent of the total area of the state and approximately 75 percent of the irrigated acreage (Central Valley Water Board 2002a). Much of the surface water supplies in the Central Valley originate north of the Sacramento–San Joaquin River Delta (Delta), while much of the water use is south of the Delta. While there is plenty of surface water in the Sacramento River Basin to meet the present level of demand, surface water supplies in the San Joaquin River and Tulare Lake Basins are inadequate to support the present level of agriculture and other development. In these basins, groundwater resources are being used to meet existing water supply demands.

The crests of the Sierra Nevada on the east and the Coast Ranges and Klamath Mountains on the west border the Sacramento and San Joaquin River Basins. The Sacramento and San Joaquin River Basins cover about one-fourth of the total area of the state and contain over 43 percent of the state's irrigable land. Surface waters from these two basins meet and form the Delta, which ultimately drains to San Francisco Bay. Major groundwater resources underlie both river valley floors.

The Sacramento River Basin covers 27,210 square miles. The principal streams in the basin are the Sacramento River and its larger tributaries: the Pit, Feather, Yuba, Bear, and American Rivers on the east; and Cottonwood, Stony, Cache, and Putah Creeks on the west. Major reservoirs include Shasta, Oroville, and Folsom.

The San Joaquin River Basin covers 15,880 square miles. The principal streams in the basin are the San Joaquin River and its larger tributaries and the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno Rivers. Major reservoirs include Pardee, New Hogan, Comanche, Millerton, McClure, Don Pedro, and New Melones.

The Tulare Lake Basin comprises the drainage area of the San Joaquin Valley south of the San Joaquin River and encompasses approximately 17,650 square miles. The valley floor makes up slightly less than one-half the total basin land area. The Kings, Kaweah, Tule, and Kern Rivers, which drain the west face of the Sierra Nevada, provide the bulk of the surface water supply native to the basin. Major reservoirs are Pine Flat, Kaweah, Success, and Isabella. Imported surface water enters the Tulare Lake Basin through

the San Luis Canal/California Aqueduct System, Friant-Kern Canal, and the Delta-Mendota Canal. This watershed comprises the entire valley floor and is called the South Valley Floor Watershed.

All area in the jurisdiction of the Central Valley Water Board is described in this report.

Surface Water

The Central Valley is divided into three major surface water basins: the Sacramento River Basin, the San Joaquin River Basin, and the Tulare Lake Basin (Figure 1-1). Each of these three basins has been divided into watersheds delineated by the California Department of Water Resources (DWR) CalWater boundaries (see Figures 3-1, 3-2, and 3-3 in Chapter 3). Surface water is discussed in Chapter 3 of this report.

Groundwater

Groundwater is discussed in Chapter 4 of this report. The groundwater basins within the three major watershed basins of the Central Valley have been delineated using the boundaries contained in DWR Bulletin 118. Figures 4-2, 4-3, and 4-4 in Chapter 4 show the boundaries of these basins.

Methodology for Data Collection

Collection of resources and data for surface water quality descriptions was accomplished by using various state and federal agency websites, water quality reports from various water quality coalitions, and other hard copy reports. Most of the surface water information came from existing reports. Because this existing conditions report covers such a large geographical area, however, information to assess a particular watershed often was insufficient. In those cases, best professional judgment and technical hydrological experience were used in the analysis.

Many types of data for surface water analysis are available from government agencies (e.g., DWR; U.S. Geological Survey [USGS]; and U.S. Department of the Interior (DOI), Bureau of Reclamation [Reclamation]) that routinely measure river flow, temperature, salinity, and other water quality parameters. Different agencies have collected data during various periods, at different stations, and with different parameters. These data are stored in various public and private databases that are operated by multiple agencies—making it difficult for stakeholders, agencies, or interested persons to access the full range of available data. Each type of data must be individually downloaded, processed, compiled, and compared.

Sources of information for each groundwater subbasin primarily included reports and data from DWR, California Department of Pesticide Regulation (DPR) and USGS. Specifically, land use data came from the DWR land use surveys conducted periodically throughout California. DWR 2004 Bulletin 118 was the primary source of information for subbasin hydrogeologic and physiographic descriptions. Chapters 3 and 4 contain more detailed information about respective sources of information.

REPORT ORGANIZATION

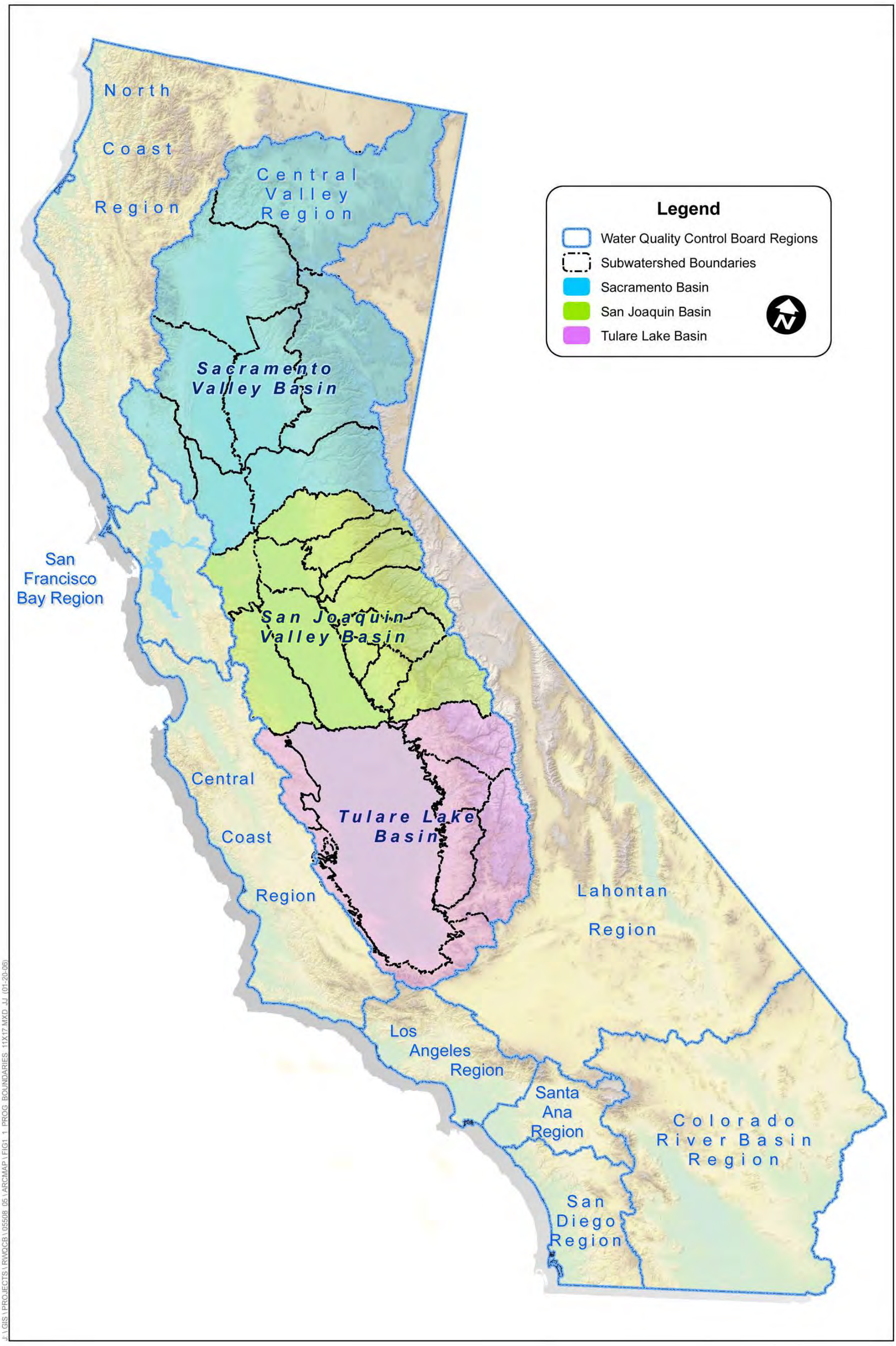
After this introductory chapter, the report is organized as follows:

- Chapter 2 provides the regulatory framework for the ILRP.
- Chapter 3 discusses surface water quality.
- Chapter 4 discusses groundwater quality.
- Chapter 5 describes irrigated lands and wetland management practices.
- Chapter 6 contains the references cited in the document.
- Appendices include detailed information related to surface water quality data, flow data, and water quality objectives for the watersheds addressed in the report.

PREPARERS

Preparation of the existing conditions report was overseen by staff of the Central Valley Water Board and was compiled by members of the ICF Jones & Stokes consultant team. ICF Jones & Stokes staff prepared the surface water and regulatory sections. HydroFocus compiled the Sacramento River Basin groundwater information, and Geomatrix compiled groundwater information for the San Joaquin River and Tulare Lake Basins. Agricultural land management practices were compiled by independent consultant Dr. Mark Roberson, and managed wetlands practices were compiled by independent consultant Joel Miller.

Adminsitrative Record
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ICF Jones & Stokes
an ICF International Company

Figure 1-1
Program Boundaries and Subdivisions

Chapter 2
REGULATORY SETTING

INTRODUCTION

Surface water and groundwater quality is regulated in California through many laws, regulations, and ordinances administered by local, state, and federal agencies. Water quality regulation and permitting processes are designed to limit the discharge of pollutants to the environment in an effort to achieve the highest surface water and groundwater quality, protect fish and wildlife and their habitats, and protect other beneficial uses (e.g., domestic and agricultural water supply and recreational resources). This section describes the regulations relevant to irrigated lands where water is applied to produce crops. These crops include, but are not limited to, land planted to vineyard, row, pasture, field, and tree crops; commercial nurseries; nursery stock production; managed wetlands; rice production; greenhouse operations with permeable floors; and other irrigated lands in California that do not currently discharge under waste discharge requirements (WDRs), National Pollutant Discharge Elimination System (NPDES) permits, Municipal Separate Storm Sewer System, or other NPDES permits.

Federal Programs Affecting Irrigated Lands Discharges

Clean Water Act

The federal Clean Water Act (CWA) was established to regulate discharges of pollutants into waters of the United States. Waters of the United States include all types of surface waters as defined in 40 CFR, Part 122.2; whereas waters of the state include any surface water or ground water, including saline waters, within the boundaries of the state, as defined in Water Code Section 13050. The CWA requires permits for all point source discharges, construction-related discharges, and direct discharges of fill into or excavations from waters of the United States, including wetlands.

Water runoff from irrigated cropland may contain pollutants that ultimately reach waters of the United States. Starting in the late 1980s, the U.S. Environmental Protection Agency (EPA) has led efforts to address polluted runoff (i.e., nonpoint sources), which is responsible for the majority of water quality impairments in the nation. These sources are not subject to CWA permits or other regulatory requirements under federal law. Under Section 319 of the CWA, assessment and management of NPS pollution, including agricultural runoff, is the responsibility of the states.

Clean Water Act Section 319

Section 319 requires that each state produce an NPS assessment report identifying the waters in that state impaired or threatened by NPS pollution and the sources contributing to the impairment. Under

Section 319, the state must also identify the best management practices (BMPs) or measures to be used to control each pollution source identified (NPS management program) and specific criteria that define successful pollution control practices and measures. EPA reviews and provides final approval for each state's NPS management program.

Coastal Zone Act Reauthorization Amendment of 1990

The Coastal Nonpoint Source Pollution Control Program (Section 6217) addresses NPS pollution problems in coastal waters. Significant portions of the threats to coastal waters are caused by NPS pollution. Major sources of NPS pollution in coastal waters include agriculture and urban runoff. Section 6217 requires the 29 states and territories with approved Coastal Zone Management Programs to develop coastal NPS control programs. In its program, a state or territory must describe how it will implement NPS pollution controls, known as management measures, that conform to those described in *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 1993). If the initial management measures fail to produce the necessary coastal water quality improvements, a state or territory then must implement additional management measures to address the remaining water quality problems.

The coastal NPS program strengthens the links between federal and state/territory coastal zone management and water quality programs to protect coastal waters and habitats from certain land management activities. EPA and the National Oceanic and Atmospheric Administration (NOAA) jointly administer this program. (EPA 2008.)

California has met the intent of both Section 319 of the CWA and CZARA by incorporating these requirements into a single NPS program rather than attempting to administer two separate programs.

National Toxics Rule (40 CFR Part 131.36)

The National Toxics Rule is EPA's rule promulgating the numeric water quality criteria necessary to bring all states into compliance with the CWA. The Toxics Rule applies to the 14 states and territories that were without EPA-approved criteria when the final rule was published (Alaska, Arkansas, California, Florida, Idaho, Kansas, Michigan, Nevada, New Jersey, Rhode Island, Vermont, Washington, District of Columbia, and Puerto Rico). For these states and territories, the criteria in the Toxics Rule are the legally enforceable standards for all purposes and programs under the CWA.

California Toxics Rule (40 CFR Part 131.38)

EPA's "California Toxics Rule" promulgates numeric water quality criteria for more than 126 priority pollutants. The numeric criteria in the California Toxics Rule must be achieved in the surface waters of the state with relevant beneficial uses (e.g., municipal supply, aquatic life). If these objectives are not met within a water of the state with a designated beneficial use, that water body would be listed as impaired.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act, as amended (FIFRA), requires EPA to regulate the sale and use of pesticides in the United States through registration and labeling of the pesticide products currently in use (EPA 2004). FIFRA directs EPA to restrict the use of pesticides as necessary to prevent unreasonable adverse effects on people and the environment, taking into account the costs and benefits of various pesticide uses. FIFRA prohibits sale of any pesticide in the United States unless it is registered and labeled indicating approved uses and restrictions. Use of a pesticide in a manner that is inconsistent with the label instructions violates the law. In addition, FIFRA requires EPA to re-register older pesticides based on new data that meet current regulatory and scientific standards. EPA must ensure that the use of pesticides it registers under FIFRA will not result in harm to species listed as endangered or threatened under the federal Endangered Species Act of 1973, as amended (ESA). The U.S. Fish and Wildlife Service (USFWS) provides technical assistance and consults with EPA during the registration and re-registration of pesticides to prevent and minimize the impacts of pesticides on fish, wildlife, and plants. In addition, the EPA's Endangered Species Protection Program (ESPP) was initiated in 1988. This program relies on cooperation between USFWS, EPA regions, states, and pesticide users. As part of this program, EPA has created bulletins for individual counties within the United States that can be accessed from the ESPP website. The bulletins provide information on pesticide use limitations intended to minimize impacts on threatened and endangered species. For more information, visit EPA's ESPP website at <http://www.epa.gov/espp/>.

Food Quality Protection Act of 1996

The Food Quality Protection Act (FQPA) of 1996 amended the FIFRA and the Federal Food, Drug, and Cosmetic Act (FFDCA). These amendments fundamentally changed the way EPA regulates pesticides. The requirements included a new safety standard (reasonable certainty of no harm) that must be applied to all pesticides used on foods. EPA's FQPA website provides background information on FQPA's provisions, discusses some of the specific issues raised by the Act, and describes the status of implementation of this important law. For information, visit EPA's FQPA website at <http://www.epa.gov/oppfead1/fqpa/>.

Concentrated Animal Feeding Operations (40 CFR Parts 122, 123, and 412)

EPA first issued NPDES regulations for concentrated animal feeding operations (CAFOs) in 1976 and then revised these regulations in February 2003. The new regulations require all CAFOs to apply for an NPDES permit, submit an annual report, and develop and implement a Nutrient Management Plan (NMP) for croplands where manure or wastewater from the CAFO is applied.

Under the new CAFO regulations, land application discharges from a CAFO are subject to NPDES permitting requirements except where the discharge is an agricultural storm water discharge. Section 122.23(e) of Title 40 CFR defines agricultural storm water discharge as

> …a precipitation related discharge of manure, litter or process wastewater from land areas under control of a CAFO…where the manure, litter or process wastewater has been applied in accordance with site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater, as specified in Section 122.42(e)(1)(vi)–(ix)….

On February 28, 2005, in response to a petition on the new CAFO regulations, the United States Court of Appeals for the Second Circuit (2nd Circuit Court) vacated several requirements of the new CAFO regulations. These include (1) the requirements that all CAFOs apply for an NPDES permit; and (2) the issuance of NPDES permits without public notice and opportunity to comment on NMPs without permitting authority review and approval of NMPs, and without incorporation of NMP terms into the permit as enforceable permit terms.

In response to the 2nd Circuit Court's decision, EPA has revised deadlines for newly defined CAFOs to apply for an NPDES permit and for permitted CAFOs to develop and implement an NMP. Both of these deadlines are now February 27, 2009. On March 7, 2008, EPA published a Proposed Rulemaking to revise the new CAFO regulations to address all of the 2nd Circuit Court's decision. This started a 30-day public review period. It is uncertain when EPA will finalize all revisions to the CAFO regulations.

Federal Endangered Species Act

The ESA was established in 1973 to conserve ecosystems and the species that depend on them. Section 4 of the ESA describes the listing process for determinations of endangered or threatened species. Section 7 requires that all federal agencies consult with USFWS (with jurisdiction over plants, wildlife, and resident fish) and NOAA's National Marine Fisheries Service (NOAA Fisheries) (with jurisdiction over anadromous fish and marine fish and mammals) prior to approving or initiating a project that may result in "take" of a listed species. Section 9 of the ESA prohibits the take of any fish or wildlife species listed as endangered, including the destruction of habitat that prevents the species' recovery. Take is defined as the action of or attempt to hunt, harm, harass, pursue, shoot, wound, capture, kill, trap, or collect a species. Section 9 prohibitions also apply to threatened species unless a special rule has been defined with regard to take at the time of listing. Candidate species and species that are proposed or under petition for listing receive no protection from the ESA.

Section 10 of the ESA requires all non-federal actions that are likely to adversely affect an ESA-listed species to obtain an incidental take permit (Section 10 Permit) from USFWS or NOAA Fisheries. Applications for Section 10 permits must include a Habitat Conservation Plan (HCP) and proof of compliance with the National Environmental Policy Act (NEPA).

The use of pesticides on irrigated land could negatively affect threatened and endangered species, and their habitats, which could be considered "take" under Section 9 and unlawful without a Section 10 permit.

Natural Resources Conservation Service Programs

Since 1935, the Natural Resources Conservation Service (NRCS, originally called the Soil Conservation Service) has provided leadership in a partnership effort to help America's private landowners and managers conserve their soil, water, and other natural resources. NRCS provides financial assistance for many conservation activities. Participation in NRCS programs is voluntary.

Some NRCS programs—such as the Farm Bill—help farmers and ranchers meet environmental challenges on their land, and enhance the long-term quality of the environment and conservation of natural resources. This includes aiding farmers in reducing NPS discharges and increasing wildlife habitats on their lands through Agricultural Management Assistance (AMA) and similar programs. For

more information, visit the NRCS website at <http://www.nrcs.usda.gov/Programs/ama>. AMA provides cost-share and incentive payments to agricultural producers to voluntarily address such issues as water management, water quality, and erosion control by incorporating conservation practices into their farming operations. Producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management, and transition to organic farming.

State Programs Affecting Irrigated Lands Discharges

Porter-Cologne Water Quality Control Act (Division 7 of California Water Code)

The Porter-Cologne Act establishes the State Water Board and divides the state into nine regional basins, each with a Regional Board. The State Water Board and nine Regional Boards are the primary state agencies responsible for protecting the quality of the state's surface water and groundwater resources.

The Porter-Cologne Act authorizes the State Water Board to draft state policies regarding water quality. In addition, Section 13263 of the Act authorizes the State Water Board and Regional Boards to issue WDRs for projects or activities that would discharge waste to waters of the state. The Porter-Cologne Act requires that the State Water Board or the Regional Board adopt water quality control plans (Basin Plans) for the protection of water quality. A Basin Plan must identify beneficial uses of water to be protected, establish water quality objectives for the reasonable protection of the beneficial uses, and establish a program of implementation for achieving the water quality objectives.

The Porter-Cologne Act, Section 13260, requires

> …any person discharging waste, or proposing to discharge waste that could affect the quality of the waters of the State, [to] file a report of discharge (an application for waste discharge requirements) along with a filing fee, in anticipation that the Regional Water Board will provide Waste Discharge Requirements (WDRs).

The Regional Board is obligated to prescribe WDRs except where the Regional Board finds that a waiver of WDRs for a specific type of discharge is in the public interest. Section 13269 also provides that any such waiver of WDRs is for a period not to exceed 5 years, is conditional, and may be terminated at any time by the Regional Board.

Regulatory Tools and Options

Waste Discharge Requirements (WDRs)

Individual permits, or WDRs, can be issued by a Regional Board to allow discharge of specified quantities and qualities of waste to land or surface waters. The limitations placed on the discharge are designed to ensure compliance with water quality objectives in the Basin Plans. To obtain WDRs, the discharger must submit a Report of Waste Discharge (ROWD), and the requirements of CEQA must be met. All dischargers must submit monitoring reports, and most dischargers pay an annual fee. The Regional Board can use this approach to regulate any discharge to State waters. The discharger would be

responsible for providing enough information to characterize the discharge and receiving waters to allow preparation of WDRs. (Central Valley Water Board 2001a.)

Conditional Waivers

The Regional Board is able to waive the requirement for an ROWD if the discharge is consistent with Basin Plan requirements and in the public interest. The waivers must be conditional and may be terminated at any time by the Regional Board. Waiver conditions can require actions by the discharger such as compliance with specified management practices and submittal of monitoring reports. If the ROWD is not waived, the discharger must provide sufficient information to verify that waiver conditions will be met.

Prohibitions of Discharge

The Regional Board may specify that a discharge of waste is not allowed in certain areas or that certain types of waste will not be permitted.

California Regional Water Quality Control Boards—Water Quality Control Plans

Regional Boards develop Basin Plans for their regions, issue WDRs, take enforcement action against violators, and monitor water quality within California. State policy for water quality control is directed at achieving the highest water quality consistent with the maximum benefit to the people of the state. To develop water quality standards consistent with the uses of a water body, the Regional Boards identify the beneficial uses (past, present, and probable future) for waters within its jurisdiction.

Preparation and adoption of Basin Plans are required by the California Water Code (Section 13240) and supported by the CWA. Section 303 of the CWA requires states to adopt water quality standards, which "consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses." According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives. State law also requires that Basin Plans conform to the policies set forth in the Water Code, beginning with Section 13000, and any state policy for water quality control. Because beneficial uses, together with their corresponding water quality objectives, can be defined per federal regulations as water quality standards, the Basin Plans are regulatory references for meeting the state and federal requirements for water quality control (40 Code of Federal Regulations [CFR] 131.20). One significant difference between the state and federal programs is that California's Basin Plans establish standards for groundwater in addition to surface water. Another significant difference is that the state Basin Plans include programs of implementation, which can allow for time schedules.

Total Maximum Daily Loads

Section 303(d) of the CWA requires the states to list waters that are not attaining standards after the technology-based limits are put into place. For waters on this list (and where the EPA administrator deems they are appropriate), the states are to develop total maximum daily loads (TMDLs).

A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. The Regional Board sets water quality standards in its Basin Plan. The Basin Plan identifies the uses for each water body (e.g., drinking water supply, contact recreation, and aquatic life support) and the water quality objectives to support that use. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the water body can be used for the purposes the State has designated. The calculation also must account for seasonal variation in water quality.

Central Valley Regional Water Quality Control Board—Interim Conditional Waiver Program

On March 26, 1982, the Central Valley Water Board adopted Resolution No. 82-036, "Waiving Waste Discharge Requirements for Specific Types of Discharge." The resolution listed 23 categories of waste discharges, including irrigation return flows and storm water runoff from agricultural lands, and the conditions required to comply with the waiver. Although the waiver had conditions, verification that dischargers were complying with conditions was not conducted because of insufficient resources. Thus, the 1982 waiver was largely a passive program.

In 1999, SB 390 was adopted and changed the section of the California Water Code authorizing waivers of WDRs. As a result of the changes, all waivers in place on January 1, 2000, would sunset on January 1, 2003, if the Regional Board had not readopted them. This change in the law meant that the 1982 waiver, which included irrigation return flows and stormwater runoff from agricultural lands in the Central Valley, would sunset. Additionally, waivers could no longer exceed 5 years in duration.

In response, in November 2000, Deltakeeper, San Francisco Baykeeper, and the California Public Interest Research Group submitted a petition asking the Central Valley Water Board to rescind the waiver and use WDRs to control discharges of pesticides from irrigated lands. The Central Valley Water Board held a workshop in July 2001 to receive information related to this issue. In September 2001, the Regional Board adopted a resolution denying the petition but directed staff to prepare recommendations on how to regulate this category of discharges by the end of 2002.

On December 5, 2002, the Central Valley Water Board adopted Resolution No. R5-2002-0201 and the associated conditional waiver of WDRs for discharges from irrigated lands. The conditional waiver was slated to terminate in 2 years. Public comment on the December conditional waiver was significant and came from a broad spectrum of interests. Additionally, Central Valley Water Board members had questions on certain aspects of the newly adopted waiver. The Regional Board directed staff to consider comments and questions, synthesize this input into key issues, analyze these issues, and provide options and recommendations to address them. Modifications to the waiver were proposed in April 2003; based on further public comment and Central Valley Water Board direction, further modifications were proposed in June 2003.

On July 10, 2003, Resolution No. R5-2002-0201 was rescinded. On July 11, 2003, Resolution No. R5-2003-0105 was adopted by the Regional Board. Resolution No. R5-2003-0105 adopted two conditional waivers that were intended to remedy perceived procedural concerns and to clarify conditions in the December 2002 waiver. Under Resolution No. R5-2003-0105, one conditional waiver is for coalition groups or other entities that form on behalf of individual dischargers to comply with the California Water Code and the Regional Board plans and policies. The second conditional waiver was for individual dischargers. These conditional waivers were set to expire in January 2006.

On February 26, 2004, Deltakeeper, Waterkeepers Northern California, Environment California, the Natural Resources Defense Council, Inc., and California Sportfishing Protection Alliance (collectively "Deltakeeper") filed a petition for peremptory writ of mandate in Sacramento County Superior Court (Court). Deltakeeper alleged that, in approving the conditional waivers, the Water Board violated the Porter-Cologne Act—including California Water Code Section 13269—and CEQA by relying on a negative declaration instead of preparing an environmental impact report (EIR).

On March 3, 2004, the California Farm Bureau Federation (Farm Bureau) also filed a petition for peremptory writ of mandate in Court. The Farm Bureau alleged that the scope of the required reports violated the California Water Code, that the Central Valley Water Board cannot require compliance with water quality objectives, that reports are subject to trade secret protection, and that access provisions of the waiver were improper.

On May 9, 2005, the Court substantially upheld the conditional waivers, including upholding the conditional waivers with respect to CEQA and California Water Code Section 13269. The Court granted, in part, the Farm Bureau's petition with respect to staff access to private property for inspections and confidentiality of monitoring reports. The Court also remanded the matter of the "tributary rule" to agricultural-dominated water bodies and constructed agricultural drains to the Central Valley Water Board to clarify:

> …the extent to which the Waiver is intended to apply to agricultural dominated waterways and constructed agricultural drains and other non-stream tributaries; the extent to which the Waiver purports to impose receiving water limitations upon such water bodies; and, in light of the foregoing, the extent to which the Waiver may rely on application of the Tributary Rule for these purposes. [Ruling, at page 77].

In response to this ruling, the Central Valley Water Board adopted two resolutions. Resolution No. R5-2005-0107 was adopted on August 5, 2005, amending Attachments B and C of the conditional waivers to address the issue of access to private property for inspections and confidentiality of monitoring reports. Resolution No. R5-2005-0137 was adopted on October 20, 2005; an information sheet was added to Resolution No. R5-2003-0105 in order to clarify application of the conditional waivers to agricultural-dominated waterways and constructed agricultural drains consistent with the tributary rule.

The conditional waivers were set to expire in January 2006; however, on November 28, 2005, the Central Valley Water Board voted to extend these conditional waivers for 6 months. The purpose of the extension was primarily to clarify rules pertaining to coalition group's membership lists and to clarify the monitoring and reporting program. In 2006, the Regional Water Board adopted a new conditional waiver for discharges from irrigated agricultural lands that continued the 2003 interim program until 2011. In the 2006 conditional waiver, the Regional Water Board reaffirmed the goal to develop a long-term program and EIR.

California State Water Resources Control Board—Nonpoint Source Pollution Control Program

California Water Code Section 13369 requires the State Water Board, in consultation with the California Coastal Commission and other appropriate agencies, to prepare a detailed program for the purpose of implementing and enforcing the state's NPS management plan.

In January 2000, the State Water Board made public and submitted to the Legislature the NPS Program Plan, pursuant to Section 13369 of the Water Code. The NPS Program Plan upgraded the 1988 Plan. Upgrading the 1988 Plan with the NPS Program Plan brought the state into compliance with the requirements of Section 319 of the CWA and Section 6217 of CZARA. On May 20, 2004, the State Water Board adopted the NPS Implementation and Enforcement Policy. The NPS Implementation and Enforcement Policy provides guidance to the Regional Boards on how to develop, structure, and enforce an NPS pollution control implementation program, which fulfills the requirements of Water Code Section 13369(a)(2)(B).

An NPS pollution control implementation program is a program developed to comply with State Water Board or Regional Board WDRs, conditional waivers of WDRs, or Basin Plan prohibitions. Such programs may be developed by a Regional Board; the State Water Board; an individual discharger; or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency.

The Regional Boards have primary responsibility for ensuring that the appropriate NPS pollution control implementation programs are in place throughout the state. Given the extent and diversity of NPS pollution discharges, the Regional Boards need to be as creative and efficient as possible in devising approaches to prevent or control NPS pollution, including developing third-party NPS pollution control implementation programs. Third-party programs allow Regional Boards to reach multiple dischargers that individually may be unknown.

Regional Boards are not required to endorse or approve any specific NPS pollution control implementation program. Each program brought before a Regional Board or the State Water Board is individually judged on its merits.

Key Elements of a Nonpoint Source Pollution Control Implementation Program

Before approving or endorsing a specific NPS pollution control implementation program, the Regional Board must determine that there is a high likelihood the implementation program will attain the Regional Board's stated water quality objectives. To be approved or endorsed, the NPS pollution control implementation program must meet the requirements of the five key structural elements described below. Development of Elements 1 and 2 are the primary responsibility of those who are developing the implementation program. Elements 3 and 4 may require consultation with the appropriate Regional Board. Element 5 is developed by the Regional Board.

For implementation programs developed by non-regulatory parties, the Regional Board must consider critical factors such as availability of funding, a demonstrated track record or commitment to NPS pollution control implementation, and a level of organization and group cohesion that facilitates NPS pollution control implementation. For regulatory programs, the availability of staff resources to administer the implementation may be a major concern.

Key Element 1. An NPS pollution control implementation program's ultimate purpose must be explicitly stated. Implementation programs must, at a minimum, address NPS pollution in a manner that achieves and maintains water quality objectives and beneficial uses, including any applicable antidegradation requirements.

Key Element 2. An NPS pollution control implementation program must describe the management practices and other program elements that are expected to be implemented to ensure attainment of the

implementation program's stated purpose(s), the process to be used to select or develop management practices, and the process to be used to ensure and verify proper management practice implementation.

A Regional Board must be able to determine that there is a high likelihood that the program will attain water quality objectives. This includes consideration of the management practices to be used and the process for ensuring their proper implementation. It also includes factors such as the level of discharger participation and the effectiveness of the management practices implemented.

Key Element 3. Where a Regional Board determines it is necessary to allow time to achieve water quality objectives, the NPS pollution control implementation program must include a specific time schedule and corresponding quantifiable milestones designed to measure progress toward reaching the specified requirements.

Key Element 4. An NPS pollution control implementation program must include sufficient feedback mechanisms so that the Regional Board, dischargers, and the public can determine whether the program is achieving its stated purpose(s), or whether additional or different management practices or other actions are required.

In all cases, the NPS pollution control implementation program should describe the measures, protocols, and associated frequencies that will be used to verify the degree to which the management practices are being properly implemented and are achieving the program's objectives, and/or to provide feedback for use in adaptive management. These efforts are necessary to determine whether the program is on time and on track in achieving its goals.

Key Element 5. Each Regional Board must make clear, in advance, the potential consequences for failure to achieve an NPS pollution control implementation program's stated purposes.

As part of the fifth element, the Regional Boards need to explain how significant non-compliance can be addressed in third-party programs. This explanation should include information concerning the criteria for measuring program success, what constitutes failure, and the actions that may be taken in response to failure. Individual dischargers need to be informed regarding what individual discharger actions or inactions will lead to individual enforcement. This explanation is necessary so that participating dischargers understand the ramifications of noncompliance, even if that noncompliance is by a third party they have selected as their representative. Options short of individual enforcement actions could include Regional Board actions such as changing a program to remove some autonomy or developing sequential enforcement phases related to triggering events built into the program. Ultimately, the ineffectiveness of a group through which a discharger participates in NPS control efforts cannot be used as an excuse for lack of individual discharger compliance.

A Regional Board implements enforcement through an

> ...escalating series of actions that allows for the efficient and effective use of enforcement resources to: (1) assist cooperative dischargers in achieving compliance; (2) compel compliance for repeat violations and recalcitrant violators; and (3) provide a disincentive for noncompliance.

In cases of individual noncompliance, selective enforcement actions may be taken. In cases of third-party noncompliance, an effort to revise the third-party program is an alternative. Generally, prior to initiating major revisions to a program, informal contact with dischargers, group representatives, or other third parties, if any, will be attempted in order to redirect unsuccessful efforts. Although the direction and efforts of a particular third-party program are being undertaken as a group effort—with group-designated

or accepted leadership, if the group or third party fails to follow through on their commitments, any Regional Board enforcement action taken will be against individual dischargers—not the third party.

Antidegradation Policy

A key policy of California's water quality program is the State's Antidegradation Policy. This policy, formally known as the *Statement of Policy with Respect to Maintaining High Quality Waters in California* (SWRCB Resolution No. 68-16), restricts degradation of surface and ground waters. In particular, this policy protects water bodies where existing quality is higher than necessary for the protection of beneficial uses. Under the Antidegradation Policy, any actions that can adversely affect water quality in all surface and ground waters must (1) be consistent with maximum benefit to the people of the State, (2) not unreasonably affect present and anticipated beneficial use of the water, and (3) not result in water quality less than that prescribed in water quality plans and policies.

Central Valley Water Board Confined Animal Facility Program

California regulations governing discharges from confined animal facilities are contained in Title 27 of the California Code of Regulations (CCR), Division 2, Subdivision 1, Chapter 7, Subchapter 2, Article 1 (Title 27). Section 22562(e) of Title 27 requires that "The Regional Board shall allow the discharge of facility wastewater and of collected precipitation and drainage waters to use or disposal fields only if such discharge is in accordance with Section 22563. Absent an NPDES permit for discharge to surface waters, the only other allowable discharge is to wastewater treatment facilities approved by the Regional Board." Section 22563(a) of Title 27 requires that "Application of manure and wastewater to disposal fields or crop lands shall be at rates which are reasonable for the crop, soil, climate, special local situations, management system, and type of manure." Section 22563(b) of Title 27 requires that "Discharges of facility wastewater to disposal fields shall not result in surface runoff from disposal fields and shall be managed to minimize percolation to ground water."

On May 3, 2007, the Central Valley Water Board adopted Waste Discharge Requirements General Order No. R5-2007-0035 for Existing Milk Cow Dairies (Dairy General Order). The Dairy General Order implements the requirements of Title 27 for confined animal facilities. Although it is not an NPDES permit and does not authorize discharge of pollutants that are subject to NPDES permit requirements, the order is compatible with EPA's CAFO regulations.

The Dairy General Order prohibits the discharge of:

- waste or storm water from the production area to surface water,
- wastewater to surface water from cropland, and
- storm water to surface water from a land application area where manure or wastewater has been applied unless the land application area has been managed consistent with a certified NMP.

The Dairy General Order requires that the owners and/or operators of existing milk cow dairies (dischargers):

- develop and implement a Waste Management Plan for the production area,
- develop and implement an NMP for all land application areas that are under the discharger's control,

- monitor all discharges from the production area and land application areas, and
- monitor the nutrient content of all solid manure and wastewater applied to land application areas that are under the discharger's control.

The Dairy General Order does not regulate third parties that receive wastes from an existing milk cow dairy but does require the discharger to complete manure/wastewater tracking manifests for all wastes (both solid manure and wastewater) exported from the dairy facility and to have a written agreement with each third party that receives wastewater from the discharger for the third party's use.

State Implementation Policy for Toxics Standards

The State Implementation Policy for Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (Policy)—adopted by the State Water Board on March 2, 2000, and effective by May 22, 2000—applies to discharges of toxic pollutants into the inland surface waters, enclosed bays, and estuaries of California subject to regulation under the Porter-Cologne Act and the CWA. The goal of the Policy is to establish a standardized approach for permitting discharges of toxic pollutants to non-ocean surface waters in a manner that promotes statewide consistency. The Policy is a tool to be used in conjunction with watershed management approaches and, where appropriate, the development of TMDLs to ensure achievement of water quality standards (i.e., water quality criteria or objectives and the beneficial uses they are intended to protect, as well as the state and federal anti-degradation policies).

The Policy establishes:

- implementation provisions for priority pollutant criteria promulgated by EPA through the National Toxics Rule and through the California Toxics Rule, and for priority pollutant objectives established by Regional Boards in their Basin Plans;
- monitoring requirements for 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) equivalents; and
- chronic toxicity control provisions.

Food and Agricultural Code

The California Department of Pesticide Regulation (DPR) within the California Environmental Protection Agency (CalEPA) is responsible for administering state regulations for the safe permitting, use, and storage of pesticides. The state's regulations are in addition to the federal regulations for pesticide use set down in FIFRA (described earlier). In general, the regulations establish a system of tracking and reporting pesticide use; permit requirements for the storage, use, and application of pesticides; rules for the application of pesticides, including restrictions on the time and place of use; and rules for licensing and training applicators. The regulations aim to avoid the overuse of pesticides, keep the pesticides out of surface water and groundwater supplies, minimize worker exposure, and ensure that pesticides do not leave the site to which they are being applied. These requirements are embodied in Title 3 of the CCR, commencing with Section 6000. DPR relies on County Agricultural Commissioners (CACs) to carry out permitting and inspection functions under these regulations.

In addition, DPR is charged to collaborate with CACs and manufacturers to:

- provide for the proper, safe, and efficient use of pesticides essential for production of food and fiber and for protection of the public health and safety;

- protect the environment by prohibiting, regulating, or ensuring proper use of pesticides;
- assure agricultural and pest control workers of safe working conditions where pesticides are present;
- permit agricultural pest control by competent and responsible licensees and permittees under strict control of the director and commissioners;
- assure consumers and users that pesticides are properly labeled and are appropriate for the use designated by the label, and that state or local governmental dissemination of information on pesticidal uses of any registered pesticide product is consistent with the uses for which the product is registered; and
- encourage development and implementation of pest management systems, stressing application of biological and cultural pest control techniques with selective pesticides when necessary to achieve acceptable levels of control with the least possible harm to nontarget organisms and the environment.

California Drinking Water Standards

The California Department of Public Health (CDPH) (i.e., maximum contaminant levels or MCLs) are found in Title 22 of the CCR. The regulations require sampling and testing of drinking water before and after treatment. The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. To ensure that tap water is safe to drink, drinking water must be tested and certified before it can be distributed to the consumer. All drinking water must not exceed the maximum contaminant levels (MCLs) for all listed pollutants, such as pesticides and herbicides, known to occur in drinking water sources. Water suppliers are required to meet MCL levels by treating the source water using ion exchange, reverse osmosis, lime softening, coagulation/filtration, or disinfection, as necessary.

California Food and Agriculture Regulations

The California Department of Food and Agriculture (CDFA) is responsible for ensuring the delivery of safe food and fiber through responsible environmental stewardship in a fair marketplace for all Californians. The policies of CDFA are carried out and enforced by the CACs or their respective representatives.

CDFA works to protect California's agricultural and natural resources against damage caused by exotic plant pests and diseases through the Division of Plant Health and Pest Prevention Services. The Division programs use pesticides in the initial exclusion, detection, and eradication of exotic pests. DPR is responsible for environmental monitoring of these projects. In addition, the Division works closely with other state and federal agencies to minimize environmental and human health impacts.

CDFA supports fertilizer programs that help prevent toxins and contaminants from entering the food chain. One of these programs is the Fertilizer Research and Education Program (FREP) that was created to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. Most of FREP's original work was concerned specifically with nitrate contamination of groundwater. FREP facilitates and coordinates research and demonstration projects by providing funding, developing and disseminating information, and serving as a clearinghouse for information on this topic. FREP serves growers, agricultural supply and service professionals, University of California Extension personnel, public agencies, consultants, and other interested parties. (CDFA 2005.)

The CDFA's Center for Analytical Chemistry, Environmental Monitoring Section (EMS), provides analytical support and services to the Center for Analytical Chemistry and programs in the DPR. DPR also relies on analytical support and service from other providers, such as the California Department of Fish and Game's (DFG's) Water Pollution Laboratory, to monitor the environmental fate of pesticides, as well as provide groundwater and surface water ambient monitoring. EMS does not analyze pesticides in food; however, the Pesticide Residue and Food Safety Laboratories carry out these duties.

California Environmental Quality Act

CEQA is the fundamental environmental law in California. CEQA encourages protection of all aspects of the environment by requiring state and local agencies to prepare multidisciplinary environmental impact analyses and to make decisions based on those studies' findings regarding the environmental effects of a proposed action.

CEQA's main objectives are to disclose to decision makers and the public the significant environmental effects of proposed activities and to require agencies to avoid or reduce the environmental effects by implementing feasible alternatives or mitigation measures. Disclosure is given in an EIR, negative declaration, or mitigated negative declaration—depending on whether effects caused by the project are significant, less than significant, or can be reduced to less than significant by incorporating mitigation into the project.

California Endangered Species Act

The California Endangered Species Act (CESA) was adopted in 1984 (California Fish and Game Code Section 2050 et seq.) to help protect threatened and endangered plant and animal species. Under CESA, the term "endangered species" is defined as a species of plant, fish, or wildlife that is "in serious danger of becoming extinct throughout all, or a significant portion of its range" and is limited to species or subspecies native to California. The term "threatened species" is defined as a plant or animal species that, "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future." Administered by DFG, CESA establishes a petitioning process for listing a threatened or endangered species. The California Fish and Game Commission is required to adopt regulations for this process and establish criteria for determining whether a species is endangered or threatened. Title 14 (CCR Section 670.1[a]) sets forth the required contents for such a petition.

Pursuant to CESA, a permit from DFG is required for projects that could result in take of a state-listed threatened or endangered plant or animal species. Under CESA, "take" is defined as an activity that would directly or indirectly kill an individual of a species but does not include "harming" or "harassing," as does the ESA. As a result, the threshold for take is higher under CESA than under the ESA (i.e., habitat modification is not necessarily considered take under CESA).

Under Section 2086 of the Fish and Game Code, incidental take is authorized for agricultural activities under approved management plans. Under Section 2087, accidental take during agricultural activities qualifies as an exception to the take prohibition.

County/Regional Programs Affecting Irrigated Lands Discharges

Agricultural Commissioners Programs

In California, CACs administer the DPR pesticide regulatory program and FIFRA by prohibiting, regulating, or ensuring proper stewardship of pesticides. CACs enforce regulations to protect groundwater and surface water from pesticide contamination, sometimes working with Regional Boards or the State Water Board. CACs are also responsible for reporting pesticide use, investigating accidents or incidents involving pesticide use, promoting BMPs, and monitoring applications in the field.

For additional information, see <http://www.cdpr.ca.gov/docs/comenu.htm>, <http://www.cdpr.ca.gov/docs/legbills/regshome.htm>, and <http://www.epa.gov/region5/defs/html/fifra.htm>. CACs have broad authority under Division 6 of the California Food and Agricultural Code (CFAC) to access private property for CFAC enforcement activities such as audits, inspections, investigations, sampling, and testing. The CFAC also authorizes the DPR and the CACs to discipline pesticide use violators through various types of sanctions and to protect the public by prohibiting or stopping hazardous activities.

CACs monitor the working conditions of agricultural and pest control workers, including the equipment, training, and safety measures in place to protect employees who work with or around pesticides.

CACs issue site-specific permits to purchase and use regulated agricultural chemicals. CACs evaluate proposed permit applications to determine whether the pesticide can be used safely, particularly in sensitive areas—such as near wetlands, residential neighborhoods, schools, or organic fields—and to ensure that applicators take precautions to protect people and the environment. Based on that evaluation, the CAC may issue or deny a permit, or require specific use practices for the pesticide.

Prior to issuing a permit, the CAC also considers the need for the pesticide application and whether a safer pesticide or better method of application could be effectively used to prevent misapplication or drift and possible harm to people or the environment.

Management Agency Agreement between the State Water Resources Control Board and the Department of Pesticide Regulation

The State Water Board and DPR, with CalEPA's concurrence have entered into a Management Agency Agreement (MAA). The purpose of the MAA is to promote technical and policy consultations concerning pesticide water quality issues; to implement a pesticide detection notifications system; to collect, exchange, and disseminate information on pesticides and impacts on the quality of the state's waters; and to ensure that compliance is achieved with the State Water Board and Regional Boards' established numerical and narrative water quality objectives. For more information on the MAA, please see <http://www.cdpr.ca.gov/docs/emon/surfwtr/maa.htm>.

Chapter 3
SURFACE WATER QUALITY

INTRODUCTION

This chapter provides a general description of surface water quality conditions in relation to irrigated agriculture operations in the Central Valley Water Board's jurisdictional area.

The Central Valley is a large, flat, fertile valley that dominates the central portion of California. The northern half of the Central Valley is referred to as the Sacramento Valley, and the southern half is referred to as the San Joaquin Valley. The two halves meet at the shared delta of the Sacramento and San Joaquin Rivers, which flow through the northern (Sacramento Valley) and southern (San Joaquin Valley) halves of the valley, respectively.[1]

The Central Valley is divided into three major hydrologic regions or surface water basins, which are illustrated in Figure 1-1 and are described below:

- The **Sacramento River Basin** contains the entire drainage area of the Sacramento River and its tributaries. It begins upstream of Shasta Lake near the Oregon border and extends south to the Sacramento-San Joaquin Delta, stretching roughly from the northeast corner of California to Sacramento County.
- The **San Joaquin River Basin** contains the entire drainage area of the San Joaquin River and its tributaries. It extends from the Delta and the Cosumnes River in the north to the southern reaches of the San Joaquin watershed, encompassing the area from Sacramento County (including the southeast corner of the county itself) to Madera County (and portions of Fresno County).
- The **Tulare Lake Basin** includes the Southern San Joaquin Valley. It ranges from the southern limit of the San Joaquin River watershed to the crest of the Tehachapi Mountains.

Each of the three basins is divided into watersheds delineated by DWR CalWater boundaries. This section identifies the three basins and their 30 associated watersheds, and all methods used to assess the surface water conditions of the basins. The three Central Valley surface water basins and their associated acreage, rivers/tributaries, and watersheds are listed below.

[1] <http://en.wikipedia.org/wiki/Central_Valley_(California)>.

Basin	Size	Rivers/Tributaries	Watersheds
I. Sacramento River Basin	27,210 square miles	Sacramento River Pit River Feather River Yuba River Bear River American River Cottonwood Creek Stony Creek Cache Creek Putah Creek	A. Pit River Watershed B. Shasta-Tehama Watershed C. Butte-Sutter-Yuba Watershed D. Upper Feather River–Upper Yuba River Watershed E. Lake-Napa Watershed F. Colusa Basin Watershed G. Solano-Yolo Watershed H. American River Watershed
II. San Joaquin River Basin	15,880 square miles	San Joaquin River Cosumnes River Mokelumne River Calaveras River Stanislaus River Tuolumne River Merced River Chowchilla River Fresno River	A. Cosumnes River Watershed B. Delta-Mendota Canal Watershed C. San Joaquin River Watershed D. San Joaquin Valley Floor Watershed E. Delta-Carbona Watershed F. Ahwahnee Watershed G. Mariposa Watershed H. Upper Mokelumne River–Upper Calaveras River Watershed I. Merced River Watershed J. North Valley Floor Watershed K. Stanislaus River Watershed L. Tuolumne River Watershed
III. Tulare Lake Basin	17,650 square miles	Kings River Kaweah River Tule River Kern River	A. Kings River Watershed B. Kaweah River Watershed C. Kern River Watershed D. South Valley Floor Watershed E. Grapevine Watershed F. Coast Ranges Watershed G. Fellows Watershed H. Temblor Watershed I. Sunflower Valley Watershed J. Southern Sierra Watershed

Importance of Surface Water

When compared, the Sacramento River basin represents a smaller land area than the San Joaquin River and Tulare Lake basins yet receives a much larger percentage of California's precipitation. As early as the late 1800s, planning efforts began to transfer excess water from the Sacramento River to dryer areas in the San Joaquin Valley by means of a number of canals and storage reservoirs along the Sacramento River system. The resulting projects, the Central Valley Project (CVP) and State Water Project (SWP) (described in more detail below) were constructed in the 1930s and 1960s, respectively, to provide flood control and water storage and distribution to support agricultural, urban, and industrial needs. The Central Valley's success as one of the world's most productive agricultural regions is due in large part to these

extensive water diversion projects, which drastically altered the natural drainage patterns of the Central Valley.

Central Valley Project—Reclamation's CVP is a federal water project undertaken in 1935 that was designed to move some of the abundant water supply in the northern end of the Central Valley to the dry southern end. Shasta Dam is the cornerstone of the CVP, and its waters are diverted for agricultural and municipal supply along the Sacramento River and south via the Delta-Mendota Canal. Up to 90 percent of this water is used for agriculture. The CVP also diverts water from the San Joaquin River into the Madera and Friant-Kern Canals along the east side of the Central Valley. CVP water irrigates more than 3 million acres of farmland and provides drinking water to nearly 2 million consumers.

State Water Project—The SWP was constructed in the late-1950s to convey water from northern to southern California through the Delta at the Harvey O. Banks Pumping Plant (Banks Pumping Plant). The SWP includes pumping and power plants; reservoirs, lakes, and storage tanks; and canals, tunnels, and pipelines that capture, store, and convey surface water. The project is operated by DWR. SWP deliveries are 70 percent urban and 30 percent agricultural, supplying 20 million California residents and more than 600,000 irrigated acres, respectively.

Figure 3 is a conceptual model of surface water hydrology as it pertains to agricultural operations (all figures are found at the end of the chapter).

Agricultural Contaminants—Agricultural production practices can result in a number of pollutants entering water bodies, including sediment, nutrients, pathogens, pesticides, and salts, that may degrade water quality and impose costs on water users. The descriptions of these pollutants that follow are based on Ribaudo and Johansson, 2006. While these descriptions focus on agricultural practices that contribute to water quality degradation, agriculture is not generally the sole source of these pollutants. Urban and industrial sources may also contribute to pollutant loads.

Sediment in surface water is largely a result of soil erosion, which is influenced by soil properties and site-specific agricultural practices. Sediment buildup can reduce the capacity of reservoirs, clog irrigation ditches and drainage canals, block navigation channels, increase dredging costs, increase the probability and severity of floods, increase the cost of water treatment for municipal and industrial water uses, and destroy or degrade aquatic wildlife habitat.

Nitrogen and phosphorus are important crop nutrients that are applied by farmers to cropland. Nitrogen and phosphorus can enter water bodies through runoff and leaching, resulting in eutrophication or increased algae growth—which can result in decreased oxygen levels, fish kills, clogged pipelines, and reduced recreational opportunities. Nitrogen in agricultural streams is correlated with nitrogen inputs from fertilizers, manure used on crops, livestock waste, septic tank systems, and, in some cases, wildlife.

Farmers apply a wide variety of pesticides to control insects (insecticides), weeds (herbicides), fungus (fungicides), and other problems. Potential impacts of pesticide residues on surface water quality include harm to freshwater and marine organisms, damage to recreational/commercial fisheries, and impacts on human health.

Some irrigation water applied to cropland may run off into ditches and receiving waters. This irrigation return flow often carries with it dissolved salts, nutrients, and pesticides. Increased salinity levels in irrigation water can reduce crop yields or damage soils such that some crops can no longer be produced. Increased concentrations of naturally occurring toxic minerals—such as selenium, molybdenum, and boron—can harm aquatic wildlife and impair water-based recreation. Increased levels of dissolved solids

and nutrients in public drinking water supplies can increase water treatment costs and force the development of alternative water supplies.

Pathogens are also an agriculture-related water quality concern, as diseases from micro-organisms in livestock waste can be contracted through direct contact with contaminated water, consumption of contaminated drinking water, and foods, or consumption of contaminated shellfish.

In arid regions such as California's Central Valley, high rates of evaporation and transpiration can cause minerals and salts to accumulate in soils being irrigated. Many of the soils in the Central Valley have soils containing high amounts of clay that cause water containing salts to accumulate in near-surface groundwater near the plant's root zone. To prevent the root zone from becoming water logged and to preserve the soils' productivity, farmers often install underground or sub-surface drainage facilities that improve drainage and allow the farmer to flush excess salts from the soil. These underground drainage systems (also known as tile drains) drain irrigation return waters into adjacent rivers and streams, providing pathways for the contaminants listed above. In addition, storm water runoff can serve to mobilize and transport agricultural-related contaminants, resulting in surface water pollution.

Organization and Elements

The watersheds located in each of the three main surface water basins are listed below. Figures 3-1, 3-2, and 3-3 delineate the boundaries of each watershed within the larger basin.

I. Sacramento River Basin (Figure 3-1)

I.A. Pit River Watershed

I.B. Shasta-Tehama Watershed

I.C. Upper Feather River–Upper Yuba River Watershed

I.D. Colusa Basin Watershed

I.E. Butte-Sutter-Yuba Watershed

I.F. Lake-Napa Watershed

I.G. Solano-Yolo Watershed

I.H. American River Watershed

II. San Joaquin River Basin (Figure 3-2)

II.A. Cosumnes River Watershed

II.B. Delta-Mendota Canal Watershed

II.C. San Joaquin River Watershed

II.D. San Joaquin Valley Floor Watershed

II.E. Delta-Carbona Watershed

II.F. Ahwahnee Watershed

II.G. Mariposa Watershed

II.H. Upper Mokelumne River–Upper Calaveras River Watershed

II.I Merced River Watershed

II.J. North Valley Floor Watershed

II.K. Stanislaus River Watershed

II.L. Tuolumne River Watershed

III. Tulare Lake Basin (Figure 3-3)

III.A. Kings River Watershed

III.B. Kaweah River Watershed

III.C. Kern River Watershed

III.D. South Valley Floor Watershed

III.E. Grapevine Watershed

III.F. Coast Range Watershed

III.G. Fellows Watershed

III.H. Temblor Watershed

III.I. Sunflower Valley Watershed

III.J. Southern Sierra Watershed

The discussion for each watershed includes a description of the watershed's general characteristics, land use patterns, Basin Plan status, hydrology, and surface water quality. The general description of each watershed identifies its boundaries, acreage and square miles, topography, climate, and major water bodies and drainages. For each watershed, a table lists the land use cover types according to DWR data and the California Department of Forestry and Fire Protection (CDF) Fire Resources Assessment Program GIS layer for vegetation (FRAPVEG), as available (see discussion under Land Use Data Collection and Methods for Watershed Boundaries).

The Basin Plan status section lists the beneficial uses identified for each watershed in the water quality control plan for its respective larger basin. In the hydrology discussion, flow information is described for the major water bodies and drainages, as well as those with water quality issues, as available. In the water quality section, a table describes the known agricultural contaminants and conditions that affect water quality in the specific watershed and the affected water bodies, as applicable. The table cites the parameter, the potential sources, and references data that support these conclusions. In addition, the rivers, creeks, and agriculture drains that the table represents are included in the notes at the bottom of the table. Appendix A is a compilation of data collected for analysis of water quality conditions. Appendix B contains summarized flow data for each of the watersheds. Appendix C contains the water quality objectives used to evaluate water quality monitoring data and identify where potential water quality problems exist.

General Sources of Information

Surface Water Quality Data Collection and Methods

Collection of resources and data for surface water quality descriptions was accomplished using various state and federal agency websites, water quality reports from various water quality coalitions, and the *Revised Draft of the 2007 Review of Monitoring Data for the Irrigated Lands Conditional Waiver Program* (*2007 Review of Monitoring Data for ILRP*) (Central Valley Water Board 2007a). U.S. Geological Survey (USGS) Water Resources Investigation Reports also were helpful in providing relevant data sources. Because this existing conditions report covers such a large geographical area, , information to assess a particular watershed often was insufficient and resulted in data gaps.

Many types of data for surface water analysis are available from government agencies (e.g., DWR, USGS, and Reclamation) that routinely measure river flow, temperature, salinity, and a variety of water quality parameters. Different agencies have collected data during various periods, at different stations, and with different parameters. These data are stored in public and private databases that are operated by multiple agencies. Each type of data must be individually downloaded, processed, compiled, and compared.

Each database has different sets of procedures for downloading data. Some databases offer web-based retrieval, and others are stored on a compact disc (CD) (e.g., USGS and EPA). Some databases have interactive maps, while others allow only text or number searches for station names or identification numbers, respectively. Without a map, it is difficult to identify station locations or names without extensive knowledge of each specific area. Some databases are not publicly viewable and must be accessed through individual agency staff. In short, each database has its own accessibility features and constraints. This section identifies the sources of information and the techniques and methods associated with the data collection.

Coalition Data—Central Valley Water Board *2007 Review of Monitoring Data for ILRP*

The Central Valley Water Board summarized the extensive water quality data collected by coalition groups in the *2007 Review of Monitoring Data for ILRP*. The Central Valley Water Board *2007 Review of Monitoring Data for ILRP* is referenced in the following sections instead of each individual coalition. The report presents the first region-wide assessment of data collected for the ILRP since its inception in 2003. Monitoring data were obtained not only from the multiple coalitions but also from individual dischargers, Water Board contracts (Phases I and II) with the University of California, the Surface Water Ambient Monitoring Program (SWAMP), and a small amount of monitoring by Central Valley Water Board staff.

Toxicity tests were conducted in conjunction with surface water column samples. In addition, toxicity identification evaluations (TIEs) were conducted as part of the ILRP monitoring. These are helpful in determining the types of chemicals that are affecting the environment. When TIEs were performed during the ILRP monitoring, it is discussed in each of the relevant sections below.

ILRP monitoring evaluated toxicity in surface water and sediment samples. Toxicity to algae (*Selenastrum capricornutum*), fathead minnow (*Pimephales promelas*), or water flea (*Ceriodaphnia dubia*) indicates surface water contamination and is generally indicative of herbicide, metal, or insecticide

contamination. Fecal coliform or *E. coli* is a pathogen indicator in the watershed that is typically associated with several potential sources, including animal confinement and grazing facilities.

Diazinon and chlorpyrifos are organophosphate pesticides historically used for urban and agricultural pest control throughout the Central Valley. Since 2001, however, EPA has mandated the phase-out of diazinon and chlorpyrifos use in urban areas and restrictions for agricultural use. Diazinon and chlorpyrifos both represent contaminants of high TMDL priority. In 2003, the Central Valley Water Board issued Resolution R5-2003-0148, which approved a Basin Plan amendment establishing TMDLs and implementation plans for diazinon in the Sacramento River and Lower Feather River. The Central Valley Water Board completed the diazinon and chlorpyrifos TMDL in September 2004.

California Data Exchange Center

The California Data Exchange Center (CDEC) (http://cdec.water.ca.gov) is maintained by DWR, through the Division of Flood Management. It contains current and historical flow data, physical water quality data, and meteorological datasets for locations throughout California. Users locate individual stations through a user-friendly map interface or by doing a key word search. Once the desired stations are located, a user may download one parameter from one station at a time, and the same limitations apply to downloading 3 or 4 years of hourly or 15-minute data at a time. After the data sequence is displayed on the screen, the user may select to save it to a file, or select a spreadsheet program to open it directly.

CDEC data are considered provisional and require some processing to ensure their accuracy. For example, processing 15-minute data or hourly data into daily and then monthly average data sets includes performing daily counts to ensure that the proper amount of data is included. Once data is in daily format, the data are reviewed to check for outliers. If an outlier is found, the date are checked and the original 15 minute or hourly data set is reviewed to determine whether the outlier is a single problematic data point, or multiple consecutive outliers. Once this is determined, the decision to delete or keep the data point is made. Once the daily data are finished processing, the data can be converted to monthly averages. Note that monthly averages are not representative of flow regimes for some locations due to the intensive daily flashy flows that some drainages may experience during the storm season. Nevertheless, due to the large number of creeks, rivers, and drainages in the Central Valley, the presentation of monthly average flows is the most feasible.

U.S. Geological Survey

The USGS maintains a database of current and historical flow and water quality data from many flow and water quality stations in California. These data can be accessed on the Internet at <http://water.usgs.gov/data.html>, as well as on a CD database product that is updated annually by a commercial vendor (Hydrosphere Data Products). This same vendor has a CD product with the EPA water quality database, called STORET. It is important to note that sometimes data between stations do not cross over between the website and the Hydrosphere product.

The USGS website has current and historical flow and water quality (i.e., grab sample) datasets. Hourly or 15-minute flow, stage, electrical conductivity (EC), and temperature data are available in the real-time portion of the database. Stations can be selected by various descriptors, such as state, station name, identification number (ID), and period of record. Once a station is selected, individual parameters can be

saved in a tab-separated file and then opened in a spreadsheet and error-checked. This USGS website is one of the more user-friendly database interface and retrieval systems available.

Bay Delta and Tributaries Project

Like the CDEC, the Bay Delta and Tributaries Project (BDAT) website (http://baydelta.water.ca.gov/index.html) is maintained by DWR. It consists of a database of water quality and meteorological datasets provided by more than 50 organizations. Although a map-based user interface to select data by location is being developed, data locations must currently be specified by location or ID code. This means that the user must already know the locations that are desired. Once a station is selected, the desired parameter(s) can be downloaded as an Excel file and then opened on the user's computer.

Department of Pesticide Regulation Surface Water Database

The Department of Pesticide Regulation maintains a Surface Water Database containing data from a wide variety of environmental monitoring studies designed to test for the presence or absence of pesticides in California surface waters. As part of DPR's effort to provide public access to pesticide information, the DPR maintains a website that provides access to data from DPR's Surface Water Database.

Land Use Data Collection and Methods for Watershed Boundaries

Watershed Boundaries

Watershed boundaries were derived from the California Interagency Watershed Map of 1999 (CalWater 2.2.1). Updated in May 2004, CalWater 2.2.1 is the State of California's working definition of watershed boundaries, beginning with the division of the state's 101 million acres into 10 hydrologic regions (HRs). Each HR is progressively subdivided into six smaller, nested levels: the hydrologic unit (HU—major rivers), hydrologic area (HA—major tributaries), hydrologic sub-area (HSA), super planning watershed (SPWS), and planning watershed (PWS). At the PWS level, where implemented, polygons range in size from approximately 3,000 to 10,000 acres.

With the exception of the Sacramento River Basin, watershed boundaries were derived for the current project by using HU boundaries. Where applicable, hydrologic units were lumped into regions with similar hydrology and land use characteristics. All boundaries in each watershed boundary dataset, including the Sacramento River Basin, were derived from some level of CalWater 2.2.1—whether it was HU, HSA, or PWS.

The San Joaquin River Basin also was derived from CalWater 2.2.1 boundaries. However, some of the watersheds were combined to reduce the amount of redundancy in the delineations. Tulare Lake Basin Watershed boundaries also used CalWater 2.2.1 and were not altered.

Compilation of California Department of Water Resources Spatial Data

Jones & Stokes obtained the most current data available for each county under the jurisdiction of the Central Valley Water Board. Data were downloaded from the DWR Land and Water Use website

(http://www.landwateruse.water.ca.gov/basicdata/landuse/digitalsurveys.cfm). For each basin (Sacramento River, San Joaquin River, and Tulare Lake), countywide data were aggregated into one dataset and then checked for matching edges; sliver polygons were repaired where necessary. Slivers were converted to the nearest land use classification where easily discernable. In ambiguous cases, they were classified as native vegetation. These sliver errors at county boundaries accounted for less than 0.035 percent by area within each basin (0.017 percent for the region as a whole).

Supplemental Spatial Data (California Department of Forestry and Fire Protection, Fire Resources Assessment Program Vegetation)

For several counties in the Central Valley Region, DWR land use spatial data are incomplete or unavailable for the higher elevations that generally are located above the major dams. To represent the entire Central Valley Water Board jurisdiction, the DWR land use data have been combined with the CDF FRAP GIS layer (Multi-Source Land Cover Data v02_2) when necessary. This GIS dataset was chosen from many available sources because it has the broadest and most complete coverage of California, as well as having been peer reviewed and well documented. Readers are encouraged to visit the FRAPVEG site (http://frap.cdf.ca.gov/projects/frap_veg/index.html), which has detailed documentation on methods, links to sites with the source data used in FRAPVEG, and an update schedule.

The FRAPVEG dataset uses the California Wildlife Habitat Relationships (CWHR) system classification, which is different from the DWR classification system because it focuses on land cover rather than land use. The main FRAP land use categories are agriculture, urban, and native vegetation. Calculations for irrigated agriculture includes citrus and subtropical; deciduous fruits and nuts; field crops; grain/hay crops; pasture; rice; semi agricultural and incidental agriculture; truck, nursery, and berry crops; vineyards; and agriculture. The “idle” category is excluded from calculating irrigated agriculture.

Urban land use includes urban, urban landscape, urban residential, commercial, and industrial land use categories. The native vegetation land use cover type includes riparian vegetation, annual grassland, conifer, hardwood, herbaceous, shrub, and wetland.

To develop uniform calculations and maps for this report, the FRAPVEG GIS data were reclassified to more closely represent the DWR land use classes. FRAPVEG classifications of conifer, desert, hardwood, herbaceous, and shrub are calculated as native vegetation. Although the DWR land use classifications do not have a wetland category, the FRAPVEG classification of wetland was retained.

Calculations and Statistics of Land Use Data

All calculations were performed using ESRI ArcGIS 9.1. A wide variety of geoprocessing tools were used to compile and analyze the data for this report, including Merge, Intersect, and Erase. All areas were calculated using *Summarize* or *Frequency* on tabular data and converted to appropriate units using Microsoft Excel.

Coordinate System

All spatial data are stored in Geodatabase format using the Teale Albers projection, NAD 1983 datum. For more information on the parameters of this coordinate system, visit <http://gis.ca.gov>.

Data Adequacy/Data Gaps

Where monitoring data are available for water bodies in the Central Valley Region, they are usually adequate to understand where water quality issues from agricultural practices may exist. Most of the data collected in the Central Valley Region that are easily accessible focus attention on a particular problem or area of concern. While not many water quality issues have been identified for undeveloped or non-agricultural areas, there may actually be issues in those areas that have not been detected due to the lack of monitoring. One issue that is apparent in the data is the lack of a long-term record in specific areas. Nevertheless, the data are generally sufficient to understand the water quality concerns that may result from agricultural practices and to understand what may happen as management measures are implemented to deal with identified concerns.

Overview of Agricultural Impacts on Surface Waters of the Central Valley

There are few agricultural impacts on surface waters within the upper watersheds (or watersheds located above storage reservoirs). The majority of agriculture-related impacts on surface waters are located below the major storage reservoirs in the Central Valley.

Assessing the extent and magnitude of agricultural impacts on surface water quality is complex due to the non-point source nature of agricultural runoff. Despite its significant impact on surface water quality, controlling agricultural pollution is a challenge because of the difficulty in cost-effectively monitoring non-point contributors; the volume of water used; and variability related to weather and site-specific characteristics, including soil type, topography, climate, and proximity to the water resource.

To date, Congress has exempted agricultural drainage from regulation under the CWA. However, under the Porter-Cologne Act, the Regional Board can regulate agricultural drainage discharges to surface water bodies. The *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Sacramento and San Joaquin Rivers Basin Plan) (Central Valley Water Board 2007b) is the primary policy document describing the legal, technical, and programmatic basis for water quality regulation in the Central Valley. The Basin Plan includes the beneficial uses of each water body in the region; water quality objectives to protect beneficial uses, and implementation plans for achieving water quality objectives.

The significance of water pollutants commonly produced by agriculture is suggested by information on impaired waters provided to EPA in accordance with Section 303(d) of the CWA. Impaired water bodies are waters that do not meet water quality objectives and cannot meet those standards through point-source controls alone. The water quality objectives used to evaluate water quality data and to identify water quality problems for each watershed are included in Appendix C.

In 2003, a monitoring program for irrigated agriculture was initiated to evaluate the effects of irrigated agriculture on Central Valley surface waters. The 2007 review of the first 3 years of monitoring (May 2004 through October 2006) that was conducted for the ILRP (*2007 Review of Monitoring Data for ILRP*) summarizes monitoring information and provides baseline information regarding surface water quality conditions.

In general, the parameters or constituents that were monitored can be categorized as follows:

- toxicity in sediment,

- toxicity in water,
- pesticides,
- metals,
- bacteriological analyses,
- dissolved oxygen (DO) and pH,
- salinity as measured by total dissolved solids and/or EC, and
- nutrients (phosphorus- and nitrogen-containing compounds, including phosphate, nitrate, and ammonia).

The monitoring results then were compared to water quality standards that are listed (numeric water quality standards) or described (narrative water quality standards) in the *Sacramento and San Joaquin Rivers Basin Plan* and the *Water Quality Control Plan for the Tulare Lake Basin* (Tulare Lake Basin Plan).

The watershed descriptions in this section describe the water quality issues related to agriculture in specific watersheds. The site-specific descriptions were based on several data sources that are referenced in the discussions. Some generalizations about water quality revealed through the monitoring are listed below:

Water column toxicity occurred to all species and is widespread in the Central Valley, although the causes of toxicity are not as apparent. The percentage of monitoring locations with toxicity, compared to those without, increased traveling north to south in the Central Valley.

Sediment toxicity occurred in all regions of the Central Valley. Studies conducted by the University of California in the Central Valley strongly suggest that sediment toxicity was caused by pyrethroids, which are replacement pesticides for organophosphates.

Predominant pesticides detected in water throughout the Central Valley monitoring sites include chlorpyrifos, diazinon, simazine, diuron, and DDT/breakdown products. Detections are not necessarily exceedances—some detections exceeded water quality trigger limits, while others did not.

Salinity, as measured by EC, is a concern throughout the Central Valley and most notably in the San Joaquin River Basin. Many areas rely on imported water for irrigation. Information that would clarify how much of the salinity is the result of background, or uncontrollable factors, and how much is contributed by irrigated agriculture is not available and will require additional study. At this time, there is a concerted effort by many state and local agencies to address issues of salinity in the Central Valley. More information regarding Central Valley salinity is available at <http://www.swrcb.ca.gov/centralvalley/water_issues/salinity/index.shtml>.

The presence of pathogen indicators, such as fecal coliform and *E. coli*, are ubiquitous in water samples collected throughout the Central Valley and are frequently measured at levels higher than the EPA recommended criterion for *E. coli*. Not all strains of *E. coli* are pathogenic, but the presence of *E. coli* or fecal coliform is an indicator of fecal contamination. Several coalitions funded a study to determine the sources of *E. coli* contamination. Part of the study was conducted in the San Joaquin Valley during August and September 2006. A similar study was conducted in the Sacramento Valley during winter and spring 2007. The University of California conducted these studies, which characterize the source type through DNA analyses. Because these studies were limited both spatially and temporally and the methodology is not well-established, further E. coli source investigations will be needed.

I. SACRAMENTO RIVER BASIN

Introduction

The **Sacramento River Basin** contains the entire drainage area of the Sacramento River and its tributaries, from the northeast corner of California to Sacramento County (see Figure 3-1 for watershed boundaries). The basin drains approximately one-third of total runoff in the state into the middle and lower reaches of the Sacramento River. For the purposes of this analysis, the Sacramento River Basin includes eight watersheds: the (A) Pit River, (B) Shasta-Tehama, (C) Butte-Sutter-Yuba, (D) Upper Feather River–Upper Yuba River, (E) Lake-Napa, (F) Colusa Basin, (G) Solano-Yolo, and (H) American River Watersheds (Figure 3-1).

Geologic provinces composing the Sacramento River Basin include the Sacramento Valley, the Coast Ranges, the Klamath Mountains, the Cascade Range, the Sierra Nevada, the Modoc Plateau, and the delta of the Sacramento River. Land uses in the Sacramento River Basin are principally forest and range lands in the upper reaches, with urban development focused around the City of Sacramento. Agriculture is the dominant land use on the valley floor, followed by urban development.

The Sacramento River Basin encompasses approximately 12.2 million acres. Of this amount, 2.4 million acres are classified as agricultural lands. The majority of these irrigated acres occur on the Valley floor, in the Solano-Yolo, Colusa Basin, and Butte-Sutter-Yuba Watersheds. Rice is the primary crop in the Sacramento River Basin, particularly in the Colusa and Butte-Sutter-Yuba Watersheds where poorly drained soils provide ideal conditions. Other predominant crop types include field crops, orchards, pasture, and grains.

Agricultural land uses account for less than 10 percent of total acreage in the Pit River, Shasta-Tehama, Upper Feather River–Upper Yuba River, American River, and Lake-Napa Watersheds.

Overview of Agricultural Impacts on Surface Water in the Sacramento River Basin

In general, agricultural operations have a greater impact on surface water in the Central Valley area around the Sacramento River than in the higher surrounding elevations of the Coast Ranges and Sierra Nevada. This is primarily due to the rich fertile valley topography allowing for much larger agricultural operations.

Water quality concerns in the Sacramento River Basin are concentrated in the Sacramento Valley, in watersheds that are heavily agricultural. These include the Solano-Yolo, Colusa Basin, Butte-Sutter-Yuba Watersheds where agricultural land uses constitute 60, 37, and 36 percent of total acreage, respectively. Section 303(d) listings related to irrigated agriculture occur in all of these watersheds, as well as in the American River Watershed.

While some water bodies in other watersheds of the Sacramento River Basin are also 303(d) listed as impaired, these sources of impairment likely are caused by timber harvesting, grazing, and resource extraction, not irrigated agriculture. Elevated levels of diazinon in the Shasta-Tehama Watershed are related to pesticide use; however, water quality in this watershed generally meets or exceeds water quality objectives. To date, there is no associated Section 303(d) listing.

Surface water quality in the Solano-Yolo, Colusa Basin, Butte-Sutter-Yuba, and American River Watersheds is described in more detail below.

The **Solano-Yolo Watershed** lies west of the Sacramento metropolitan area and follows the Sacramento River to the Delta near Suisun Bay. More than half of the watershed is in agricultural production. Within the watershed, the Lower Sacramento River and Lower Putah and Lower Cache Creeks are listed as impaired for diazinon, which is directly related to the practice of irrigated agriculture.

The **Colusa Basin Watershed** is located northwest of Sacramento on the west side of the Sacramento River. Soils in the watershed are well suited to agriculture, and drainage patterns in the watershed have been extensively altered by agricultural development. The watershed includes the Colusa Basin Drain, which flows with irrigation tailwater year-round and is the single largest source of agricultural return flows to the Sacramento River. A total of 49 miles of the Colusa Basin Drain are listed as impaired due to multiple chemicals, including azinphos-methyl, carbofuran, diazinon, Group A pesticides, malathion, methyl parathion, and molinate/ordram. A TMDL for diazinon and chlorpyrifos, associated with dormant spraying of fruit and nut orchards was adopted for the Sacramento and Feather Rivers in 2007.

The **Butte-Sutter-Yuba Watershed** spans from the eastern Sierra Nevada foothills west to the Sacramento River. Multiple water bodies within the watershed are listed as impaired by sources related to agriculture, including diazinon, chlorpyrifos, and Group A Pesticides. These include Butte Slough and the Lower Bear, Lower Feather, and Sacramento Rivers.

The headwaters of the **American River Watershed** originate east of Sacramento in the Sierra Nevada foothills. The watershed borders the Tahoe Basin on the east and extends west toward Sacramento. It includes the North, Middle, and South Forks of the American River. Agriculture comprises approximately 10 percent of land use in the American River watershed.

While the upper American River Watershed is primarily undeveloped, the lower watershed is dominated by the Sacramento metropolitan area and adjacent agricultural land uses. Land uses in the lower watershed generate both point-source and nonpoint-source discharges that contribute pollutants to surface waters. Therefore water quality conditions in the lower watershed are affected by a combination of urban, industrial, and agricultural land uses.

The lower American River Watershed includes the Natomas East Main Drain Canal, which drains approximately 180 square miles of the Sacramento metropolitan area. Portions of the canal are listed as impaired by chlorpyrifos, diazinon, and polychlorinated biphenyls (PCBs). The sources of these impairments include agricultural pesticides, urban runoff, storm water runoff, and industrial point sources.

A detailed analysis of the impacts on surface water in the Sacramento River Basin is broken up by watersheds and described below.

I.A Pit River Watershed

General Description

The Pit River Watershed is located in northeastern California and is bounded on the west by the Trinity Mountains, on the east by the Warner Mountains, to the north by the Oregon border, and to the south by Shasta Lake and the Lassen National Forest (Figure 3-1). The watershed encompasses approximately 3,008,012 acres (4,700 square miles) (Reclamation 2003). The general topography of the watershed varies significantly, ranging from the lower elevations of the Fall River Valley, to 9,892 feet in the rugged Warner Mountains, to 14,162 feet atop Mount Shasta (SVWQC 2004). The McCloud River and the Sacramento River also are located in the Pit River Watershed; they make up the North and Middle Forks of Lake Shasta. Figure 3-4 illustrates the entire Pit River Watershed and all of the major water bodies in the watershed.

Average annual temperatures in the watershed range from a low of approximately 30ºF to a high of over 100ºF. While summertime maximum temperatures can exceed 100ºF, temperatures are more commonly from 90 to 100ºF. Typically, the last frost occurs in May and the first frost occurs in September.

Land Use Patterns

More than 95 percent of the Pit River Watershed is classified as native vegetation (Figure 3-12), reflecting the presence of Modoc National Wildlife Refuge (NWR) in the northern part of the watershed, a state-owned wildlife area (Ash Creek) in the middle portion, and an additional state-owned reserve (Ahjumawi Lava Springs State Park) in the southwest portion of the watershed (SVWQC 2004). The Pit River and Fall River Watersheds contain nearly all of the irrigated land use in the watershed, with virtually no irrigated land in the McCloud River and Upper Sacramento River Watersheds. Irrigated agriculture represents less than 4 percent of the total land use in the watershed. Table 3-1 contains land use acreage according to DWR land use data for the Pit River Watershed.

Table 3-1. Land Use Acreage according to DWR Land Use Data for the Pit River Watershed

DWR Land Use Type	Acres	Percent Total
Agriculture		
Rice	6,673	0.2
Deciduous Fruits and Nuts	138	0.0
Field Crops	1,025	0.0
Grain and Hay	17,018	0.4
Pasture	132,717	3.0
Truck, Nursery, and Berry Crops	989	0.0
Idle	15,998	0.4
Semi agricultural and Incidental	2,524	0.1
Subtotal	177,082	4.0

DWR Land Use Type	Acres	Percent Total
Urban		
Urban—Unclassified	3,348	0.1
Urban Landscape	514	0.0
Urban Residential	9,388	0.2
Commercial	1,763	0.0
Industrial	1,726	0.0
Vacant	1,291	0.0
Subtotal	18,030	0.4
Native		
Native Vegetation	4,102,190	91.8
Barren and Wasteland	381	0.0
Riparian Vegetation	23,149	0.5
Water Surface	146,018	3.3
Subtotal	4,271,738	95.6
Total	**4,466,849**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Pit River Watershed. Table 3-2 lists the beneficial uses of Goose Lake, the Pit River, the Fall River, the McCloud River, and the Sacramento River (to Box Canyon).

Hydrology

Pit River

Drainage in the Pit River portion of the watershed originates with the North and South Forks (Figure 3-4). The North Fork historically originated at Goose Lake, which is now an enclosed basin. Water from Goose Lake has not spilled into the North Fork Pit River for over 100 years. The South Fork and its tributaries originate in the southern Warner Mountains and Moon Lake in Lassen County. The North and South Forks of the Pit River converge in the town of Alturas in Modoc County and then flow in a southwesterly direction into Shasta Lake in Shasta County (SVWQC 2004). The Fall River is a major tributary to the main Pit River, entering at Fall River Mills upstream of Lake Shasta. In addition to the Fall River, there are many small tributaries to the Pit River. Water quality in these smaller tributaries has not been assessed, and the Pit River is considered representative of the entire Pit River portion of the watershed.

The USGS currently maintains six gauging stations in the Pit River watershed, including a site on the South Fork of the Pit River near Likely (USGS 11345500) and the mainstem of the Pit River near Canby (USGS 11348500). Real time data are available at the Likely and Canby Stations, and they are the two stations used for flow information for the Pit River Watershed.

Average annual flow at the Likely Station between 1929 and 2005 was 49.5 cubic feet per second (cfs), and average annual flow at the Canby Station between 1932 and 2001 was 257 cfs (USGS 2005e). A

longer period of record was not used because of recent changes in flow associated with agriculture and other diversions. See Table B-1 in Appendix B for monthly average flows for the Pit River.

Table 3-2. Beneficial Uses in the Pit River Watershed

Beneficial Uses	Goose Lake	Pit River	Fall River	McCloud River	Sacramento River (to Box Canyon)
Municipal and Domestic		E	E	E	
Irrigation	E	E	E		E
Stock Watering	E	E	E		E
Process					
Service Supply					
POW (Power)			E	E	
Rec-1*	E	E, P	E	E, P	E
Rec-2*	E	E	E	E	E
Freshwater Habitat—Warm	E	E	E		
Freshwater Habitat—Cold	E	E	E	E	E
Migration—Warm					
Migration—Cold					
Spawning—Warm		E			
Spawning—Cold		E		E	
Wildlife Habitat	E	E	E	E	E
Navigation					

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

USGS also has collected flow data for the Fall River; however, the most complete record started in 1958 and stopped in 1967 (USGS Station 11353700). The calculated annual average flow is 483 cfs (USGS 2005e). This USGS flow gauge is close to the headwaters and is not representative of the entire Fall River flow. No better record is available.

McCloud River

The McCloud River originates above Lake McCloud in Siskiyou County and flows southwesterly for approximately 50 miles until its terminus at Lake Shasta (LMRWA 1998).The McCloud River is the dominant hydrologic feature in the McCloud Watershed and drains the steep, mountainous terrain between Lake McCloud and Lake Shasta. The Pit River Hydroelectric Project Dam at Lake McCloud

regulates stream flow into the river to maintain minimum flows for fish habitat (LMRWA 1998). A portion of the McCloud River is diverted from this facility to the Pit River for power generation. See Table B-1 in Appendix B for flow data for the McCloud River above Lake Shasta.

Sacramento River

The Sacramento River headwaters originate on the southwestern slopes of Mount Shasta and the Trinity and Klamath Mountains. There are approximately 40 river miles between the headwaters at Box Canyon Dam and Lake Shasta (DOI 2003). Flow data at Sacramento River above Lake Shasta (CDEC Station DLT) were used because this is the farthest downstream location prior to the river's confluence with Lake Shasta and is considered representative of the flow for the entire Upper Sacramento River Basin. As shown in Table B-1 in Appendix B, monthly average flows from 1995 to 2004 range from a low of 203 cfs during summer to a high of 7,188 cfs during winter.

Water Quality

The Pit River is listed on the 2006 Section 303(d) list as impaired for nutrients, organic enrichment/low DO, and temperature; while the Fall River is listed as impaired for sedimentation/siltation. Sedimentation and siltation can be a result of management practices, such as timber harvesting, or a result of a catastrophic wildfire. In addition, high magnitude flows of relatively short durations may disturb and re-suspend sediment, resulting in a higher turbidity.

In general, the available data indicate that the Pit River Watershed experiences little impact from irrigated agriculture. However, there are a few water quality concerns in the watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in Table 3-3.

A water quality investigation conducted by the Regional Board in the Pit River during 2001 and 2002 indicated that temperature was above and DO was below the criteria water quality objectives. The Regional Board collected data from eight locations between the headwaters of the Pit River and Pittville and found that 2001 and 2002 flows were far lower than the historical average. In addition, results at every station except one indicated that temperatures exceeded tolerance levels for coldwater species. Table 3-3 cites potential sources related to the water quality concerns in the Pit River. Factors contributing to elevated temperature are still under investigation.

Elevated levels of bacteria have been found in the Pit River. The likely sources of bacteria are animal confinement facilities and grazing lands. Algae toxicity was also found in the Pit River. Toxicity identification evaluation (TIE) indicates that toxicity to algae is generally indicative of herbicide or metal contamination. Since no metals were detected in the Pit River, the toxicity could have resulted from an herbicide (Central Valley Water Board 2007a).

Table 3-3. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Pit River Watershed

Parameter	Potential Agricultural Sources/Contribution to Water Quality Impairment	Sources
Temperature	Factors contributing to elevated temperature are under investigation.	2
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands and animal grazing may be connected to low DO.	2
Bacteria	Likely a result of animal confinement facilities land application of waste.	1
Toxicity (algae)	Toxicity to algae is generally indicative of herbicide or metal toxicity but has not been proven in this area.	1

Sources:
[1] Central Valley Water Board 2007a.
[2] USGS 2005c.

I.B Shasta-Tehama Watershed

General Description

The Shasta-Tehama Watershed is located in the far northern portion of the Sacramento River Basin (Figure 3-1), and encompasses approximately 2,925,162 acres (4,571 square miles). The northern boundary of the Shasta-Tehama Watershed abuts Lake Shasta and the Pit River Watershed to the north and east. Trinity County lies west of the watershed, and Glenn and Butte Counties border the watershed to the south and southwest. The general topography of the watershed ranges from approximately 6,000 feet elevation in the southwest portion of the watershed to approximately 150 feet around the Sacramento River area in the southern portion. The watershed shares a relatively small boundary with Plumas County on the east. Figure 3-5 delineates the entire boundary of the Shasta-Tehama Watershed.

The Sacramento River flows from north to south through the center of the Shasta-Tehama Watershed, from the base of Shasta Dam south to the Butte County line and beyond. The Sacramento River has numerous tributaries on each side of the valley floor. The major west side tributaries to the Sacramento River below Shasta Dam include Lower Clear Creek, Cottonwood Creek, Reeds Creek, Red Bank Creek, Elder Creek, and Thomes Creek. The major east side tributaries to the Sacramento River below Shasta Dam include Cow Creek, Battle Creek, Antelope Creek, Mill Creek, and Deer Creek. All of these tributaries located in the Shasta-Tehama Watershed drain naturally to the Sacramento River.

Annual average precipitation in the entire Sacramento River Basin is 36 inches and varies considerably from approximately 20 inches in the valley floor falling exclusively as rain to a range of 40–60 inches annually as rain and snow at higher elevations in the mountains.

The Shasta-Tehama Watershed contains several irrigation districts that supply surface water to agricultural users; including the Anderson-Cottonwood Irrigation District (ACID) based in Anderson and the Tehama-Colusa Canal Authority (TCCA) based in Red Bluff.

Land Use Patterns

The majority (about 89 percent) of land use in the Shasta-Tehama Watershed is categorized as native vegetation by DWR (Figure 3-13). Irrigated agriculture comprises approximately 8 percent of land use for the entire Shasta-Tehama Watershed. The majority of irrigated agriculture in the watershed consists of two crops: pastureland and deciduous fruits and nuts. However, not all pastureland in the Shasta-Tehama Watershed may actually be irrigated. DWR land use data for the Shasta-Tehama Watershed are summarized in Table 3-4.

Table 3-4. Land Use Acreage according to DWR Land Use Data for the Shasta-Tehama Watershed

DWR Land Use Type	Acres	Percent Total
Agriculture		
Citrus and Subtropical	20,728	0.7
Deciduous Fruits and Nuts	82,427	2.8
Field Crops	10,020	0.3
Grain and Hay	20,836	0.7
Idle	12,256	0.4
Pasture	63,648	2.2
Rice	2,746	0.1
Semi agricultural and Incidental	4,502	0.2
Truck, Nursery, and Berry Crops	1,502	0.1
Vineyards	189	0.0
Subtotal	218,854	7.5
Urban		
Urban—Unclassified	18,177	0.6
Urban Landscape	1,438	0.1
Urban Residential	66,799	2.3
Commercial	3,280	0.1
Industrial	5,617	0.2
Vacant	8,979	0.3
Subtotal	104,290	3.6
Native		
Native Vegetation	2,586,054	88.4
Barren and Wasteland	7,608	0.3
Riparian Vegetation	18,089	0.6
Water Surface	18,602	0.6
Subtotal	2,630,353	89.9
Total	**2,925,162**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Shasta-Tehama Watershed. Table 3-5 lists the beneficial uses of Lower Clear Creek (below Whiskeytown Reservoir), Cow Creek, Battle Creek, Cottonwood Creek, Antelope Creek, Mill Creek, Thomes Creek, and Deer Creek.

Table 3-5. Beneficial Uses in the Shasta-Tehama Watershed

	Municipal & Domestic	Irrigation	Stock Watering	Process (Industrial)	Service Supply	POW (Power)	Rec-1*	Rec-2*	Freshwater Habitat—Warm	Freshwater Habitat—Cold	Migration—Warm	Migration—Cold	Spawning—Warm	Spawning—Cold	Wildlife Habitat	Navigation
Clear Creek below Whiskeytown Reservoir	E	E	E				E	E	E	E		E	E	E	E	
Cow Creek	P	E	E			E	E	E		E		E	E	E	E	
Battle Creek		E	E			E	E	E	E	E		E	E	E	E	
Cottonwood Creek	E	E	E	P	P	P	E	E	E	E		E	E	E	E	
Antelope Creek	E	E	E				E	E	E	E		E	E	E	E	
Mill Creek	E	E	E				E		E	E		E	E	E	E	
Thomes Creek		E	E			P	E	E	E	E		E	E	E	E	
Deer Creek	E	E	E				E	E	E	E		E	E	E	E	

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

Lake Shasta

Sacramento River flows are largely controlled by the CVP storage and diversion facilities operated by Reclamation. Shasta Dam, located 12 miles upstream of Redding, forms Lake Shasta, the dominant reservoir on the mainstem of the Sacramento River. The principal rivers that flow into Lake Shasta are the Upper Sacramento River, the Pit River, and the McCloud River. Combined, these rivers drain a 6,665-square-mile drainage area above Lake Shasta. When Lake Shasta is full, it has storage capacity of approximately 29,500 acre-feet of water and 270 miles of shoreline.

Sacramento River

Stream flow patterns in the Sacramento River reflect a combination of natural runoff events and operational controls. Monthly average flows for the Sacramento River at Red Bluff are shown in

Table B-2 in Appendix B. In general, natural Sacramento River stream flow patterns are distinctly seasonal; however, managed reservoir releases have altered the natural flow regimes in recent history. A typical water year (starting on October 1) begins with low natural runoff flows, initiates reduced reservoir releases as the agricultural irrigation season ends, and includes minimum reservoir storage levels in preparation for winter inflows. With the return of winter rains, reservoir inflows and river flows increase exponentially. River flows and reservoir inflows are sometimes reduced slightly in late winter before the peak periods of mountain snowmelt that occur in spring. The irrigation season in the Central Valley typically begins around April 15, and river flows steadily increase through the summer as reservoirs are lowered (primarily Shasta Lake) for hydropower production and to meet agricultural irrigation demands of the Sacramento Valley, as well as to meet CVP operational demands and requirements.

Water Diversion Facilities

Water is released from Lake Shasta into the Lower Sacramento River at Shasta Dam, 9 miles upstream of Keswick Dam. Keswick Dam forms Keswick Reservoir, a regulating reservoir for Shasta Dam. There are two significant water diversions on the Sacramento River below Keswick Dam in the Shasta-Tehama Watershed: the ACID diversion located in Redding and the Red Bluff Diversion Dam (RBDD) located just south of the town of Red Bluff. ACID diverts water from a seasonal dam in the Sacramento River to gravity-feed a 39-mile irrigation canal that meanders south of Redding, primarily supplying pasturelands and a small amount of croplands in Anderson and Cottonwood. The RBDD was built by Reclamation in the mid 1960s and spans the width of the Sacramento River with 11, 60-foot-wide spillway gates. When the spillway gates are lowered during the irrigation season, the diversion dam raises the level of the Sacramento River by 17 feet upstream of the dam. This hydraulic head in turn allows TCCA to gravity-feed water deliveries to the Corning Canal and the Tehama-Colusa Canal. The Corning Canal is 15 miles long and serves three water districts, while the Tehama-Colusa Canal is 110 miles long and serves 14 water districts. TCCA annually supplies approximately 660,000 acre-feet of water to 200,000 irrigated acres along the west side of the Sacramento Valley in Tehama, Glenn, and Yolo Counties.

West Side and East Side Tributaries

As described earlier, the Sacramento River has numerous tributaries on each side of the valley floor. The major west side tributaries to the Sacramento River below Shasta Dam include Lower Clear Creek, Cottonwood Creek, Reeds Creek, Red Bank Creek, Elder Creek, and Thomes Creek. The major east side tributaries to the Sacramento River below Shasta Dam include Cow Creek, Battle Creek, Antelope Creek, Mill Creek, and Deer Creek. Table B-2 in Appendix B shows monthly average flows from 1995 to 2004 for Lower Clear Creek, Cow Creek, Mill Creek, Deer Creek, Cottonwood Creek, Elder Creek, and the Sacramento River at Red Bluff.

Clear Creek is one of the first major west side tributaries to the Sacramento River. Clear Creek begins in the Trinity Mountains and flows 35 miles to its confluence with the Sacramento River near Redding. Water is also diverted from the Trinity River to Clear Creek through the Clear Creek Tunnel to serve agricultural and municipal demands in the San Joaquin Valley as part of the CVP. The USGS monitors flows in Lower Clear Creek near Igo, as shown in Table B-2 in Appendix B.

Cottonwood Creek is the next major west side tributary to the Sacramento River. The headwaters of Cottonwood Creek originate on the eastern slopes of the North Coast Range, as well as the southern slopes of the Trinity Mountains. Cottonwood Creek flows eastward through the valley floor toward the Sacramento River, the confluence lying approximately 16 miles north of Red Bluff. The watershed has

three main tributaries: the North Fork, the Middle Fork, and the South Fork. The Cottonwood Creek Watershed drains approximately 938 square miles, and has an approximate annual runoff of 586,000 acre-feet. Monthly average flows for Cottonwood Creek are shown in Table B-2 in Appendix B.

Several additional west side tributaries located south of Cottonwood Creek include Reeds Creek, Red Bank Creek, Elder Creek, and Thomes Creek. Flow data are limited for Thomes Creek and Red Bank Creek, and there are no known flow monitoring stations for Reeds Creek. The average annual flow from 1960 to 1982 for Red Bank Creek near Red Bluff (11378800) was 35,260 cfs. The USGS monitored flows on Thomes Creek from 1920 until 1996. The annual average flow from 1920 to 1996 on Thomes Creek (11382000) was 292 cfs. Additional flow monitoring information for Elder Creek is included in Table B-2 in Appendix B.

Cow Creek is one of the first major east side tributaries downstream of Lake Shasta. The Cow Creek Watershed encompasses over 425 square miles (approximately 275,000 acres). There are eight hydroelectric facilities in the Cow Creek Watershed operated by private entities and more than 190 irrigation diversions in the Cow Creek Watershed (DOI 2003). Monthly average flows for Cow Creek are shown in Table B-2 in Appendix B.

The Battle Creek Watershed is situated on the volcanic slopes of Mt. Lassen in southeastern Shasta and northeastern Tehama Counties. PG&E owns and operates several hydropower facilities and water diversions throughout the Battle Creek Watershed. In addition, the Coleman National Fish Hatchery, the largest Chinook salmon fish hatchery in the world, is located near the mouth of Battle Creek and operated by USFWS (DOI 2003). Because limited flow records for Battle Creek are available from USGS, monthly average flows for Battle Creek are not included in Appendix B. However, historical annual average Battle Creek flow below the Coleman National Fish Hatchery from 1962 to 1983 was 528 cfs **(**USGS 2005e**)**.

Antelope Creek is the next major east side tributary south of Battle Creek. Antelope Creek flows southwest from the foothills of the Cascade Range and enters the Sacramento River 9 miles southeast of the town of Red Bluff. The Antelope Creek drainage is approximately 78,720 acres (123 square miles), and the average stream discharge is 107,200 acre-feet per year. USGS monitored flows at Antelope Creek near Red Bluff (11379000) from 1949 to 1982; the annual average flow was 150 cfs.

Mill Creek is another east side tributary located south of Antelope Creek. Mill Creek originates from the southern slopes of Lassen Peak in Lassen Volcanic National Park and receives inflow from snowmelt, rainfall, and groundwater infiltration. USGS monitors flows on Mill Creek near Los Molinos. Monthly average flows for Mill Creek are shown in Table B-2 in Appendix B.

Deer Creek is the next east side tributary located south of Mill Creek. Its drainage area is approximately 133,120 acres. USGS monitors flows on Deer Creek near Vina (11383500). Monthly average flows for Deer Creek are shown in Table B-2 in Appendix B.

Water Quality

Generally, water quality in the Shasta-Tehama Watershed meets or exceeds the water quality objectives in the Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b). Water bodies in the Shasta-Tehama Watershed that are impacted from fecal coliform or *E. coli* include Clover Creek, Oak Run Creek, South Cow Creek, Anderson Creek, and Burch Creek. Water bodies impacted by diazinon include the Sacramento River and Burch Creek. Table 3-6 identifies the known agricultural contaminants

that affect water quality in the Shasta-Tehama Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Water quality monitoring results that indicated statistically significant toxicity to *Selenastrum capricornutum* (algal species) included several locations in the Shasta-Tehama Watershed, including on Burch Creek, Antelope Creek, and China Slough. Burch Creek (at Woodson Bridge) also had multiple toxic results for *Ceriodaphnia* (water flea) and one measured value of diazinon above the Sacramento and San Joaquin Rivers Basin Plan objective.

The 2006 Section 303(d) list divides the Sacramento River into four sections—Keswick Dam to Cottonwood Creek, Cottonwood Creek to Red Bluff, Red Bluff to Knights Landing, and Knights Landing to the Delta. All four sections of the Sacramento River are listed on the Section 303(d) list for unknown toxicity.

Table 3-6. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Shasta-Tehama Watershed

Parameter	Potential Agricultural Sources/Contribution to Water Quality Impairment	Sources
Bacteria (fecal coliform/*E. coli*)	Agriculture, grazing, or other sources	1, 2
Diazinon	Pesticide use	2, 3
Unknown toxicity	Unknown source	1, 2

Sources:

1 2006 Section 303(d) list.

2 Central Valley Water Board 2007a.

3 Central Valley Water Board 2007c.

Note: Water bodies in the Shasta-Tehama Watershed that are impacted from fecal coliform or *E. coli* include Clover Creek, Oak Run Creek, South Cow Creek, Anderson Creek, and Burch Creek. Water bodies impacted by diazinon include the Sacramento River and Burch Creek. Water bodies impacted by unknown toxicity include the Sacramento River.

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I.C Upper Feather River–Upper Yuba River Watershed

General Description

The Upper Feather River–Upper Yuba River watershed is located in the foothills and mountains of the northern Sierra Nevada and encompasses 2,062,080 acres (3,222 square miles) (Figure 3-1). The watershed borders Placer County and the American River Watershed to the south. Lassen County forms a majority of the watershed boundary to the east and the northeast. The Butte-Sutter-Yuba watershed forms the western boundary. Figure 3-6 depicts the entire Upper Feather River–Upper Yuba River watershed. The general topography of the watershed ranges from approximately 6,774 feet elevation in the northern portion of the watershed to approximately 1,000 feet east of Lake Oroville. The major rivers in this watershed include the North Fork Feather River, Middle Fork Feather River, South Fork Feather River, North Yuba River, Middle Yuba River, Yuba River, and Bear River. Frenchman Reservoir is on the Feather River and Englebright Reservoir on the Yuba River.

Precipitation in this watershed ranges from 69.7 inches in the west to less than 12.2 inches in the east. This difference can be attributed to storm systems from the Central Valley, which move from west to east and deposit the majority of their precipitation along the west slope of the Sierra Nevada (SVWQC 2004).

Land Use Patterns

DWR classifies approximately 94 percent of the land use in the Upper Feather River–Upper Yuba River watershed as native vegetation (Figure 3-14). The entire watershed is relatively rural; urbanization constitutes just over 1 percent of the entire watershed.

Table 3-7 contains acreage according to DWR and FRAP land use data for the Upper Feather River–Upper Yuba River Watershed. Agriculture makes up only a small portion of the watershed, totaling 2.4 percent of land use; of this amount, 2.1 percent includes pasturelands in the vicinity of the Sierra Valley and the Indian Valley.

Table 3-7. Land Use Acreage according to DWR and FRAP Land Use Data for the Upper Feather River–Upper Yuba River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	58	0.0
Grain and Hay Crops	2,044	0.1
Idle	1,330	0.0
Pasture	64,100	2.1
Rice	7	0.0
Semi agricultural and Incidental	785	0.0
Truck, Nursery, and Berry Crops	468	0.0
Subtotal	68,790	2.3

Land Use	Acres	Percent Total
Urban		
Urban—Unclassified	2,333	0.1
Urban Residential	10,121	0.3
Urban Landscape	939	0.0
Commercial	2,445	0.1
Industrial	1,427	0.0
Vacant	1,114	0.0
Subtotal	18,380	0.6
Native		
Native Vegetation	2,368,492	78.1
Barren and Wasteland	230	0.0
Riparian Vegetation	29,379	1.0
Water Surface	53,776	1.8
Subtotal	2,451,877	80.8
FRAP Land Use Type		
Agriculture	5,082	0.2
Barren	19,716	0.7
Conifer	275,875	9.1
Hardwood	115,684	3.8
Herbaceous	26,702	0.9
Shrub	24,213	0.8
Urban	18,017	0.6
Water	7,512	0.2
Wetland	1,734	0.1
Subtotal	494,534	16.3
Total	**3,033,583**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses of waters in the Upper Feather River–Upper Yuba River Watershed. Table 3-8 lists the beneficial uses for the North Fork Feather River, Middle Fork Feather River, Yuba River, and Bear River.

Table 3-8. Beneficial Uses in the Upper Feather River–Upper Yuba River Watershed

		Middle Fork Feather River					Yuba River		
Beneficial Uses	North Fork Feather River	Source to Little Last Chance Creek	Frenchman Reservoir	Little Last Chance Creek to Lake Oroville	Lake Davis	Lakes Basin Lakes	Sources to Englebright Reservoir	Englebright Dam to Feather River	Bear River
Municipal & Domestic	E						E		E
Irrigation		E					E	E	E
Stock Watering		E					E	E	E
Process									
Service Supply								E	
POW (Power)	E						E	E	E
Rec-1*	E	E	E				E	E	E
Rec-2*	E	E	E				E	E	E
Freshwater Habitat—Warm		E	P					E	E
Freshwater Habitat—Cold	E	E	E				E	E	E
Migration—Warm								E	P
Migration—Cold								E	P
Spawning—Warm								E	P
Spawning—Cold	E	E	E				E	E	E
Wildlife Habitat	E	E	E				E	E	
Navigation									

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

Upper Feather River

The Upper Feather River Watershed includes 2,062,080 acres of land that drains west from the northern Sierra Nevada into the Sacramento River. The Feather River is considered unique because the North and Middle Forks originate east of the Sierra Nevada in the Diamond Mountains, and as these two forks flow west, they breach the crest of the Sierra Nevada (SVWQC 2004).

The Middle Fork of the Upper Feather River receives flow from Dolly Creek and Little Grizzly Creek. The USGS website does not have flow data for Dolly Creek but does contain flow data for Little Grizzly Creek from 1964 to 1979. The annual average flow from 1964 to 1979 for Little Grizzly Creek was 48 cfs. The USGS website does not contain flow data for any of the upper arms of the Feather River. Table B-3 in Appendix B shows monthly average flows for the Feather River at Oroville from 1995 to 2004.

Yuba River

The North Upper Yuba River feeds New Bullards Bar Reservoir. The Middle and South Yuba River merge above the Englebright Reservoir, a small reservoir located downstream of New Bullards Bar Reservoir. Englebright Reservoir is part of the Butte-Sutter-Yuba Watershed and is addressed in that section. The CDEC website monitors flow on the North Yuba River, the Middle Yuba River, and the South Yuba River. The North Yuba River flows are measured below the New Bullards Bar Dam. The Middle Yuba River flows are measured just before the confluence with the North Yuba River at Our House Dam. Here, the South Yuba River merges with the North and Middle Yuba River and flows are measured at Jones Bar. The South Yuba River has multiple tributaries, including Humbug Creek, Kanaka Creek, and Deer Creek, which are all listed on the 2006 Section 303(d) list for various non-agricultural pollutants. The USGS website and the CDEC website do not show any flow stations on either of these tributaries. Monthly average flow information for the three forks of the Yuba River is shown in Table B-3 in Appendix B.

Bear River

The Bear River originates in the vicinity of Emigrant Gap and Lake Spaulding in the Sierra Nevada foothills. The Bear River flows southwest out of the foothills and merges with the Feather River just north of the community of Nicolaus on the valley floor. The entire Bear River drainage area is 352,000 acres (MBK Engineers and Flood Control Study Team 2002). There are three reservoirs on the Bear River: Rollins Reservoir, Lake Combie, and Camp Far West Reservoir. Table B-3 in Appendix B shows monthly average flows for the Bear River below Camp Far West Reservoir from 1995 to 2004.

Water Quality

According to the 2006 Section 303(d) list of water quality–impaired rivers, the Upper Feather River–Upper Yuba River watershed is impaired for multiple pollutants, but none of the causes are related to agriculture. The majority of the problems are thought to come from resource extraction such as abandoned mines. Limited water quality data are available for the Upper Feather River–Upper Yuba River watershed from the *2007 Review of Monitoring Data for ILRP* (Central Valley Water Board 2007a). There were five monitoring sites in the Upper Feather River watershed and none in the Upper Yuba River watershed. One event resulted in toxicity to *Ceriodaphnia dubia* (water flea) at Spanish Creek below the confluence with Greenhorn Creek in the Upper Feather River watershed. The cause of toxicity was not determined. Multiple samples collected from Indian Creek, downstream from Indian Valley tested positive for *E. coli* bacteria (Table 3-9). This was attributed to grazing activities.

Table 3-9. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Upper Feather River–Upper Yuba River Watershed

Parameter	Potential Agricultural Sources/ Contribution to Water Quality Impairment	Source
Bacteria (fecal coliform/*E. coli*)	Agriculture, grazing, or other sources	1
Unknown toxicity	Unknown source	1

Source:
[1] Central Valley Water Board 2007a.

Note: Water bodies in the Upper Feather River–Upper Yuba River watershed that are impacted from fecal coliform or *E. coli* include Spanish Creek, downstream of Indian Valley on the East Fork of the North Fork Feather River.

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I.D Colusa Basin Watershed

General Description

The Colusa Basin Watershed is located northwest of Sacramento on the west side of the Sacramento River and encompasses approximately 1,655,846 acres (2,587 square miles) (Figure 3-1). The Sacramento River forms the entire eastern border of the watershed, and Lake County borders the watershed on the west (Figure 3-7). To the north, the watershed general borders the Glenn County and Tehama County line; to the south, the watershed extends near the City of Woodland. Major water bodies include Stony Creek, Cache Creek, Sulphur Creek, and Bear Creek and its tributaries.

Elevations in the Colusa Basin watershed range from 7,040 feet in the Coast Ranges in northwest Colusa County to 20 feet in southeast Colusa County. The annual precipitation in the Colusa Basin ranges between 16 and 24 inches, with most rainfall occurring during the winter and early spring seasons (SVWQC 2004).

The Colusa Basin is a large, shallow basin with predominantly deep, level, and fine-textured soils that are conducive to agriculture production. Typically, these soils drain slowly and are renowned for retaining and ponding water. Historically, water would pool in the Colusa Basin for extended periods during winter and spring rainfall events. However, drainage patterns in the Colusa Basin have been extensively altered during the past century of agricultural development. The Colusa Basin Drain, built by the Colusa Basin Drainage District between 1920 and 1940, is the main artery of the drainage system that now drains the Colusa Basin.

The Colusa Basin is home to a mix of irrigated cropland (primarily rice) and managed waterfowl habitat. The poorly drained soils in the Colusa Basin make it an ideal location for rice production, and the Colusa Basin contains some of the most productive rice farmland in the United States. The flooded rice fields of the Colusa Basin also create an abundance of waterfowl habitat along the Pacific Flyway. Therefore, the Colusa Basin is also home to multiple state and federal wildlife refuges, including the Sacramento NWR, the Delevan NWR, Colusa NWR, and the Colusa Bypass Wildlife Area.

Land Use Patterns

Approximately 60 percent of land use in the Colusa Basin watershed is classified by DWR as native vegetation (Figure 3-15). A predominant amount of this area of native vegetation includes the Coast Ranges foothills of western Glenn and Colusa Counties and the Mendocino National Forest lands. The foothills are mainly utilized for grazing cattle and sheep, as well as limited dryland farming. The mountainous topography of the Mendocino National Forest is used for livestock grazing, timber harvest, and recreation.

According to the DWR land use database, agricultural land use encompasses about 37 percent of the acreage in the Colusa Basin watershed. The main crop types include fruit and nut orchards (particularly walnuts and prunes), field crops, grain and hay, and rice. The majority of rice, grains, and row crops are grown west of the Sacramento River floodplain, where soils contain higher clay content and drain more slowly.

The Colusa Basin is relatively rural; urbanization is minimal, making up less than 1 percent of the land use in the watershed. Table 3-10 lists the DWR land use acreage for the Colusa Basin Watershed.

Table 3-10. Land Use Acreage according to DWR Land Use Data for the Colusa Basin

DWR Land Use Type	Acres	Percent Total
Agriculture		
Citrus and Subtropical	5,601	0.3
Deciduous Fruits and Nuts	77,535	4.7
Field Crops	80,851	4.9
Grain and Hay	78,068	4.7
Idle	17,509	1.1
Pasture	48,114	2.9
Rice	216,299	13.1
Semi agricultural and Incidental	6,583	0.4
Truck, Nursery, and Berry Crops	68,940	4.2
Vineyards	6,403	0.4
Subtotal	605,903	36.6
Urban		
Urban—Unclassified	2,819	0.2
Urban Landscape	523	0.0
Urban Residential	5,477	0.3
Commercial	887	0.1
Industrial	3,644	0.2
Vacant	12,440	0.8
Subtotal	25,790	1.6
Native		
Barren and Wasteland	4,651	0.3
Native Vegetation	958,908	57.9
Riparian Vegetation	38,239	2.3
Water Surface	22,405	1.4
Subtotal	1,024,203	61.9
Total	**1,655,896**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Colusa Basin Watershed. Table 3-11 lists the beneficial uses of the Colusa Basin Drain and Stony Creek.

Table 3-11. Beneficial Uses in the Colusa Basin Watershed

Beneficial Use	Colusa Basin Drain	Stony Creek (includes East Park and Black Butte Reservoirs)
Municipal & Domestic		
Irrigation	E	E
Stock Watering		E
Process		
Service Supply		
POW (Power)		
Rec-1*	E	E
Rec-2*		E
Freshwater Habitat—Warm	E	E
Freshwater Habitat—Cold	P	P
Migration—Warm	E	
Migration—Cold		E
Spawning—Warm	E	E
Spawning—Cold		E
Wildlife Habitat	E	E
Navigation		

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The Colusa Basin Watershed is divided into several watersheds, including Stony Creek, the Colusa Basin Drain, and the lower portion of Cache Creek. The Stony Creek Watershed originates in the northwest corner of Colusa County, within the Mendocino National Forest. Stony Creek flows northward, to East Park Reservoir, then to Stony Gorge Reservoir, and finally to Black Butte Reservoir. From Black Butte Dam, Stony Creek flows east and eventually flows into the Sacramento River south of Hamilton City. The USGS website does not contain any recent flow data for Stony Creek; therefore, monthly average flows could not be calculated. According to USGS data, the minimum flow at Stony Creek between 1980 and 1990 was 0 cfs, the average flow was 571 cfs, and the maximum flow was 22,900 cfs.

The Colusa Basin Drain is a constructed drainage channel that originates just east of Willows in Glenn County and conveys runoff and agricultural return flows from over 1,000,000 acres of irrigated farmlands in the Colusa Basin. The Colusa Basin Drain flows the length of eastern Colusa County and ultimately drains to the Sacramento River at Knights Landing in Yolo County. It is the single largest source of agricultural return flows to the Sacramento River. The Colusa Basin Drain flows throughout the year, as summer flow is maintained by irrigation tailwater. During high winter flows, the Colusa Basin Drain is sometimes diverted through the Knights Landing Ridge Cut to the Yolo Bypass. The CDEC web site lists daily mean discharges in cubic feet per second for the Colusa Basin Drain near Highway 20 (CDEC 2005). Table B-4 in Appendix B contains monthly average flows for the Colusa Basin Drain from 1998 to 2004.

Cache Creek flows from Clear Lake and Indian Valley Reservoir in Lake County to the Sacramento River in Yolo County. The upper portion of the Cache Creek Watershed is discussed in detail in the Lake-Napa Watershed section of this report. In Colusa County, Bear Creek and its tributaries, including Sulphur Creek, Trout Creek, and Mill Creek, drain Bear Valley and a small part of the Blue Ridge foothills south of the Bear Valley. Bear Creek flows into Cache Creek just north of the Capay Valley. The USGS website contained flow data for Cache Creek at Yolo. Monthly average flows from 1995 to 2004 are included in Table B-4 in Appendix B.

The Colusa Basin also has numerous irrigation districts, including Glenn-Colusa Irrigation District (GCID), Provident Irrigation District (ID), Maxwell ID, and Reclamation District 108—among others. GCID operates a 65-mile-long irrigation canal that supplies irrigation water from a pumping station on the Sacramento River located near Hamilton City. The GCID irrigation canal supplies irrigation water to approximately 141,000 acres of farmlands through a complex water delivery system of over 900 miles of irrigation laterals and drains. In addition, the GCID canal delivers water to 20,000 acres of wildlife habitat within the Sacramento, Delevan, and Colusa NWRs.

Many smaller creeks in the Colusa Basin watershed originate in the foothills of the Coast Ranges and flow generally eastward across the valley floor. Once on the valley floor, these creeks are typically channeled through cropland and eventually drain into the Colusa Basin Drain. Most of these creeks are ephemeral and intermittent streams that occasionally flood in their lower reaches during winter storms. There is no flow information available from the USGS for these small creeks.

Water Quality

The 2006 Section 303(d) list of water quality-limited segments for impaired water bodies designates 49 miles of the Colusa Basin Drain waterway as being impaired by multiple agricultural-related chemicals, including azinphos-methyl, carbofuran, diazinon, Group A pesticides, malathion, methyl parathion, molinate/ordram, and unknown toxicity. Potential sources of these impairments are thought to be agriculture and irrigation tailwater return flows to the Colusa Basin Drain. The TMDL priority status for these water quality impairments ranges from low to medium. Table 3-12 identifies the known agricultural contaminants and conditions that affect water quality in the Colusa Basin Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Extensive water quality data are available for the Colusa Basin Watershed from the *2007 Review of Monitoring Data for ILRP* (Central Valley Water Board 2007a) and the Rice Pesticide Program. There were multiple monitoring sites throughout the watershed, including irrigation laterals and tailwater return drains that contained contaminants in levels above water quality objectives. Water column samples that

were collected found that diazinon, chlorpyrifos, azinphos-methyl, carbofuran, Group A pesticides, malathion, methylparathion, and molinate/ordram were a result of agricultural operations.

Multiple sampling events resulted in toxicity to *Pimephales promelas* (fathead minnow) and *Ceriodaphnia dubia* (water flea). The cause of toxicity was not determined. Many samples resulted in toxicity to algal species (*Selenastrum capricornutum*). Site No. 90 (unnamed drain of Walker Creek on County Road28) had multiple significant toxicity results for water toxicity species (fathead minnow, water flea, and algal species) as well as one exceedance in sediment toxicity. In addition, multiple pesticide detections that exceeded objectives were observed. Site No. 79 (Spring Creek at Walnut Avenue) had multiple toxic results for water flea and algal species, as well as one for sediment toxicity. This particular monitoring site also had multiple detections of the organosphate pesticides diazinon and chlorpyrifos that largely were found to be a result of agriculture return flows (Central Valley Water Board 2007a, Weston et al. In Press).

Table 3-12. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Colusa Basin Watershed

Parameter	Potential Agricultural Source/ Contribution to Water Quality Impairment	Sources
Azinphos-methyl	Pesticide applied to agricultural crops	2
Carbofuran	Pesticide applied to agricultural crops	2
Diazinon	Pesticide applied to agricultural crops	1, 2
Group A pesticides	Pesticides applied to agricultural crops	2
Malathion	Pesticide applied to agricultural crops	2
Methyl parathion	Pesticide applied to agricultural crops	2
Molinate/ordram	Pesticide applied to agricultural crops	2
Chlorpyrifos (in water column)	Pesticide applied to agricultural crops	3
Unknown toxicity	Agriculture and irrigation tailwater return flows to the Colusa Basin Drain	1, 2
Bacteria (fecal coliform/*E. coli*)	Agriculture, grazing, or other sources	1
Bifenthrin (in sediment)	Pesticide applied to agricultural crops	3
Fenproprathin (in sediment)	Pesticide applied to agricultural crops	3
Chlorpyrifos (in sediment)	Pesticide applied to agricultural crops	3

Sources:

1 Central Valley Water Board 2007a (including Rice Pesticide Program).

2 2006 Section 303(d) list.

3 Weston et al. In Press.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include the Colusa Basin Drain, Jack Slough, portions of the Sacramento River, Stony Creek, Stone Corral Creek, Coon Creek, Spring Creek in Colusa County, an unnamed drain of Walker Creek on County Road 28, and an unnamed drain in Glenn County.

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I.E Butte-Sutter-Yuba Watershed

General Description

The Butte-Sutter-Yuba Watershed is located in northern California (Figure 3-1). The Sacramento River forms the western boundary of the Butte-Sutter-Yuba Watershed, and the Upper Feather River–Upper Yuba River Watershed forms the eastern boundary (Figure 3-8). To the north is generally the Butte and Tehama County line and to the south is approximately where the Feather River meets the Sacramento River. The Butte-Sutter-Yuba Watershed is approximately 1,697,969 acres **(**2,653 square miles). Elevation ranges from 6,754 feet in the eastern foothills to 91 feet in the west along the Sacramento River (SVWQC 2004).

The five main hydrologic features in the watershed are the Feather River, Lake Oroville, the Yuba River, the Bear River, and the Sacramento River. The Feather River flows from north to south, and the Yuba River and Bear River generally flow east to west until their confluence with the Feather River on the valley floor. Annual precipitation varies with elevation and ranges from 15 inches in western Sutter County to 80 inches in northeast Yuba County. The total annual precipitation is 21.04 inches at Marysville, at an elevation of 65 feet (SVWQC 2004).

Land Use Patterns

Native vegetation covers just over half (57 percent) of the Butte-Sutter-Yuba Watershed (Figure 3-16). Table 3-13 includes the land use acreages in the watershed according to DWR and FRAP land use data.

The Butte-Sutter-Yuba Watershed is under intensive agricultural production; almost 36 percent of the land area is agriculture. Rice is the predominant crop in the watershed, constituting 15.4 percent of the land use. Deciduous fruits and nut orchards are the second most prevalent land use in the watershed, representing 9.6 percent of the land use in the watershed. Field crops account for nother 3.5 percent of the total acreage, and urban for 4.3 percent of the land use in this watershed.

Table 3-13. Land Use Acreage according to DWR and FRAP Land Use Data for the Butte-Sutter-Yuba Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	8,173	0.5
Deciduous Fruits and Nuts	161,944	9.6
Field Crops	59,122	3.5
Grain and Hay	26,300	1.6
Idle	16,987	1.0
Pasture	33,003	2.0
Rice	260,439	15.4
Semi agricultural and Incidental	5,870	0.4
Truck, Nursery, and Berry Crops	35,371	2.1

Land Use	Acres	Percent Total
Vineyards	589	0.0
Subtotal	607,803	35.9
Urban		
Urban—Unclassified	34,311	2.0
Urban Residential	20,589	1.2
Urban Landscape	2,001	0.1
Commercial	2,045	0.1
Industrial	6,507	0.4
Vacant	6,782	0.4
Subtotal	72,237	4.3
Native		
Native Vegetation	889,633	52.5
Barren and Wasteland	11,279	0.7
Riparian Vegetation	62,446	3.7
Water Surface	37,538	2.2
Subtotal	1,000,897	59.0
FRAP Land Use Type		
Agriculture	30	0.0
Annual Grassland	1,957	0.1
Barren	13	0.0
Blue Oak Woodland	3,152	0.2
Blue Oak-Foothill Pine	700	0.0
Douglas-Fir	20	0.0
Mixed Chaparral	217	0.0
Montane Hardwood	5,851	0.4
Montane Hardwood-Conifer	1,279	0.1
Ponderosa Pine	1,187	0.1
Urban	94	0.0
Valley Oak Woodland	65	0.0
Water	86	0.0
Subtotal	14,657	0.9
Total	**1,695,596**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Butte-Sutter-Yuba Watershed. Table 3-14 lists the beneficial uses for the Feather River (from Oroville to the Sacramento River), Sutter Bypass, Yuba River (sources to Englebright Reservoir and from Englebright Dam to Feather River), Upper Bear River, and Butte Creek (to Butte Slough).

Table 3-14. Beneficial Uses in the Butte-Sutter-Yuba Watershed

Beneficial Uses	Feather River (from Oroville to the Sacramento River)	Sutter Bypass	Yuba River to Englebright Reservoir	Yuba River—Englebright Dam to Feather River	Upper Bear River	Butte Creek to Butte Slough
Municipal & Domestic	E		E		E	
Irrigation	E	E	E	E	E	E
Stock Watering			E	E	E	E
Process						
Service Supply				E		
POW (Power)			E	E	E	E
Rec-1*	E	E	E	E	E	E
Rec-2*	E		E	E	E	
Freshwater Habitat—Warm	E			E	E	E
Freshwater Habitat—Cold	E		E	E	E	E
Migration—Warm	E			E	P	
Migration—Cold	E	E		E	P	E
Spawning—Warm	E	E		E	P	E
Spawning—Cold	E		E	E	P	E
Wildlife Habitat	E	E	E	E	E	E
Navigation						

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but where there is generally no body contact with water, or any likelihood of ingestions of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

Lake Oroville lies in the foothills of the western slope of the Sierra Nevada. Lake Oroville has a storage capacity of more than 3.5 million acre-feet and is the largest State Water Project (SWP) facility in northern California. Lake Oroville stores runoff from the various large tributaries of the Feather River, including the North, South, and Middle Forks of the Feather River and the West Branch Feather River. The North Fork Feather River and the West Branch Feather River form the northern arm of Lake Oroville. The lower portions of the Middle Fork Feather River and South Fork Feather River form the eastern arm of Lake Oroville. The Feather River drains an area of approximately 2,304,000 acres at Lake Oroville (MBK Engineers and Flood Control Study Team 2002). The USGS monitors flow on the Feather River near Oroville (11407000), and monthly average flows are included in Table B-5 in Appendix B.

A majority of the Upper Yuba River Watershed, including New Bullards Bar Reservoir, is outside the Butte-Sutter-Yuba Watershed. The 60 river miles of the Lower Yuba River between the New Bullards Bar Reservoir release point and the confluence with the Feather River near Marysville are within the Butte-Sutter-Yuba Watershed. The USGS monitors flow on the Lower Yuba River near Marysville (11421000), and monthly average flows for the Lower Yuba River are included in Table B-5 in Appendix B.

The Bear River originates in the vicinity of Emigrant Gap and Lake Spaulding in the western Sierra Nevada foothills and flows southwest to its confluence with the Feather River on the valley floor. The entire Bear River drainage area is 352,000 acres (MBK Engineers and Flood Control Study Team 2002). All upstream reservoirs on the Bear River are outside the Butte-Sutter-Yuba Watershed and are not discussed in this analysis. The portion of the Bear River that falls within the boundaries of this watershed originates immediately downstream of Camp Far West Reservoir and flows into Feather River at Nicolaus. Average flows in the Bear River measured below Camp Far West Reservoir are shown in Table B-5 in Appendix B.

The drainage basin of Butte Slough lies east of the Sacramento River, south of Chico, and north of the Sutter Buttes. The Butte Slough drains into the Sacramento River upstream of the Feather River confluence near Colusa. During periods of normal flow, the Sutter Bypass enters the Sacramento River via the Sacramento Slough. During periods of high flow, the Sutter Bypass channel fills completely and is diverted to the Sacramento River. Average flows for Butte Creek near Chico and the Sutter Bypass are shown in Table B-5 in Appendix B.

The Feather River drains into the Sacramento River near the community of Verona. The Sacramento River at Verona includes a combination of the flow for the entire Butte-Sutter-Yuba Watershed, as well as all the upstream Sacramento River flows from east side and west side tributaries, and including flow releases from Lake Shasta. The Sacramento River flow at Verona is regulated by coldwater releases from both Shasta Dam and Oroville Dam. Average flows in the Sacramento River near Verona are shown in Table B-5 in Appendix B.

Water Quality

Multiple water bodies in the Butte-Sutter-Yuba Watershed are listed as impaired on the 2006 Section 303(d) list. Identified sources of impairments in the Butte-Sutter-Yuba Watershed are generally limited to agricultural and resource extraction (mining).

Butte Slough and the Lower Bear River (below Camp Far West Reservoir) are listed as impaired for diazinon. The Lower Feather River (from Lake Oroville to the confluence with the Sacramento River) is listed as impaired for chlorpyrifos, Group A pesticides, mercury, and unknown toxicity. Sacramento Slough is impaired for mercury from an unknown source. The Sacramento River (from Knights Landing to the Delta) is listed as impaired for mercury and unknown toxicity. These impairments are considered primarily to be attributable to agriculture and resource extraction.

According to water quality data for the Upper Feather River, the quality of water entering Lake Oroville is excellent, and Lake Oroville itself generally is excellent. The Upper North Fork of the Feather River and Lake Oroville are not listed as impaired on the 2006 Section 303(d) list for any contaminants; but the Feather River from Oroville Dam to its confluence with the Sacramento River is impaired for diazinon, Group A pesticides, mercury, and unknown toxicity.

Extensive water quality data are available for the Butte-Sutter-Yuba Watershed from the *2007 Review of Monitoring Data for ILRP* (Central Valley Water Board 2007a). The multiple monitoring sites in this watershed included Butte Slough at Lower Pass Road, Sacramento Slough Bridge, Yankee Slough, Hamilton Slough, the Bear River, and several sites on Butte Slough and the Wadsworth Canal.

The 2007 monitoring results from six monitoring events in the Butte-Sutter-Yuba Watershed demonstrated statistically significant toxicity to fathead minnow (*Pimephales promelas*). The 2007 monitoring results also showed that four monitoring events in the watershed resulted in toxicity to water flea (*Ceriodaphnia dubia*). Thirty-six monitoring events in the watershed resulted in statistically significant toxicity to algal species (*Selenastrum capricornutum*). Three monitoring events in the watershed indicated toxicity to *Hyalella azteca* (a sediment amphipod). Site No. 96 (Yankee Slough at Swanson Road) had multiple detections of chlorpyrifos, diazinon, and malathion over the trigger limits. This site also had multiple toxic results for algal species. Site No. 3, Butte Slough at Lower Pass Road, had multiple toxic results for fathead minnow, water flea, and algal species. Five tests for *E. coli* resulted in measurements above the objectives. (Central Valley Water Board 2007a.)

Table 3-15 lists the known agricultural contaminants and conditions that affect water quality in the Butte-Sutter-Yuba Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Table 3-15. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Butte-Sutter-Yuba Watershed

Parameter	Potential Agricultural Source/ Contribution to Water Quality Impairment	Sources
Diazinon	Pesticide applied to agricultural crops	2, 3
Chlorpyrifos	Pesticide applied to agricultural crops	2
Group A Pesticides	Pesticides used to protect agricultural crops	2
Bacteria (fecal coliform/*E. coli*)	Agriculture, grazing, or other sources	1
Toxicity	Unknown source	1, 2

Sources:

1 Central Valley Water Board 2007a.

2 2006 Section 303(d) list.

3 USGS 2005c.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Butte Slough, (Lower) Bear River, (Lower) Feather River, Sacramento River (Knights Landing to the Delta), Sacramento Slough, and the Sutter Bypass.

I.F Lake-Napa Watershed

General Description

The Lake-Napa Watershed is located in the southern portion of the central Coast Ranges, west of the valley floor in northern California (Figure 3-1). The entire Lake-Napa Watershed is approximately 897,881 acres (1,403 square miles). Mendocino County borders the Lake-Napa Watershed immediately to the west and northwest, while Sonoma County borders the watershed to the west and southwest (Figure 3-9). Elevations range from 4,299 feet at Mount Konocti to less than 700 feet in Big Valley. The two primary drainages in the Lake-Napa Watershed are Upper Cache Creek and Upper Putah Creek, which both originate in Lake County and flow east towards the valley floor, ultimately draining into the Sacramento River in Yolo County (SVWQC 2004). Three other major hydrologic features in the Lake-Napa Watershed are Clear Lake and the Indian Valley Reservoir in Lake County and Lake Berryessa in northeast Napa County.

The Lake-Napa Watershed has a Mediterranean climate, which is characterized by warm, dry summers and moist, cool winters. Precipitation in the Clear Lake area generally occurs only as rainfall. At lake level, the average annual rainfall is 30 inches per year, and the amount increases considerably at higher elevations surrounding the lake (SVWQC 2004).

Land Use Patterns

According to DWR, almost 86 percent of the land in the Lake-Napa Watershed is classified as native vegetation (Figure 3-17). Surface water areas, including Clear Lake, Lake Berryessa, and the Indian Valley Reservoir, are the second largest land use designation in the watershed—utilizing 7 percent of the land in the watershed. Table 3-16 presents land use acreage according to DWR land use data for the Lake-Napa Watershed.

Table 3-16. Land Use Acreage according to DWR Land Use Data for the Lake-Napa County Watershed

DWR Land Use Type	Acres	Percent Total
Agriculture		
Citrus and Subtropical	5	0.0
Deciduous Fruits and Nuts	11,122	1.2
Field Crops	8	0.0
Grain and Hay	2,079	0.2
Idle	5,077	0.6
Pasture	5,905	0.7
Rice	941	0.1
Semi agricultural and Incidental	961	0.1
Truck, Nursery, and Berry Crops	199	0.0
Vineyards	12,320	1.4
Subtotal	38,617	4.3

DWR Land Use Type	Acres	Percent Total
Urban		
Urban—Unclassified	367	0.0
Urban Residential	16,874	1.9
Urban Landscape	352	0.0
Commercial	1,466	0.2
Industrial	1,743	0.2
Vacant	667	0.1
Subtotal	21,469	2.4
Native		
Native Vegetation	770,172	85.9
Barren and Wasteland	1,012	0.1
Riparian Vegetation	1,400	0.2
Water Surface	65,212	7.3
Subtotal	837,796	93.4
Total	**896,865**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Lake-Napa Watershed. Table 3-17 lists the beneficial uses of Cache Creek (Clear Lake to the Yolo Bypass) and Putah Creek (Lake Berryessa to the Yolo Bypass).

Hydrology

The two primary drainages in the Lake-Napa Watershed are Upper Cache Creek and Upper Putah Creek, which originate in Lake County and flow east toward the valley floor, ultimately draining into the Sacramento River in Yolo County (SVWQC 2004).

The Upper Cache Creek watershed is divided into two drainages, the North Fork and the Main Fork. The North Fork Cache Creek originates in the mountains northwest of Indian Valley Reservoir in Lake County, and drains into the reservoir. The Main Fork Cache Creek originates below the Indian Valley Reservoir.

Clear Lake is the largest natural freshwater lake located entirely within California (SVWQC 2004). Clear Lake is characterized as a eutrophic lake. Lake depths range from 20 to 50 feet, and storage capacity is estimated to be approximately 313,000 acre-feet. Clear Lake discharges into the Main Fork Cache Creek through the Clear Lake Dam. Monthly average flows from 1995 to 2004 for the Main Fork Cache Creek measured near Lower Lake are included in Table B-6 in Appendix B. Some minor tributaries that join the lower portion of Lower Cache Creek in the Lake-Napa Watershed are Bear Creek and Harley Gulch.

The second hydrologic unit in the Lake-Napa County Watershed is Upper Putah Creek. Lake Berryessa is the major hydrologic feature of the Napa County portion of the Lake–Napa Watershed and has a storage capacity of 1, 602,000 acre-feet. Upper Putah Creek originates in the mountains above Lake Berryessa

and drains into Lake Berryessa on the northwest shore of the lake. Monthly average flows from 1998 to 2004 for Upper Putah Creek measured near Guenoc are included in Table B-6 in Appendix B. Lower Putah Creek originates below Lake Berryessa and is primarily located in the Yolo-Solano County Watershed.

Table 3-17. Beneficial Uses in the Lake-Napa Watershed

	Cache Creek		Putah Creek	
Beneficial Uses	Clear Lake[a]	Clear Lake to Yolo Bypass [b]	Lake Berryessa	Lake Berryessa to Yolo Bypass
Municipal & Domestic	E	E	E	E
Irrigation	E	E	E	E
Stock Watering	E	E	E	E
Process		E		
Service Supply		E		
POW (Power)			P	
Rec-1*	E	E	E	E
Rec-2*	E	E	E	E
Freshwater Habitat—Warm	E	E	E	E
Freshwater Habitat—Cold	P	P	E	P
Migration—Warm				
Migration—Cold				
Spawning—Warm	E	E	E	E
Spawning—Cold		E		
Wildlife Habitat	E	E	E	E
Navigation				

P = Potential, E = Existing.

(a) The following beneficial uses *Exist* in addition to those noted: Mud Slough (north): COMM and SHELL; Salt Slough: COMM, BIOL, and SHELL; Wetland Water Supply Channels: BIOL; Clear Lake: COMM.

(b) In addition to the beneficial uses noted in Table II-1, COMM exists for Cache Creek from Clear Lake to Yolo Bypass and in North Fork Cache Creek and Bear Creek only.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Water Quality

The 2006 Section 303(d) list of water quality-impaired rivers designates multiple reaches of several rivers in the Lake-Napa Watershed as impaired. Identified sources of impairment in the Lake-Napa Watershed are primarily resource extraction (mining).

The mercury TMDL for Clear Lake was approved by the Water Board in 2002 and subsequently approved by EPA in 2003. The mercury TMDL for Clear Lake is currently in the implementation phase. The mercury TMDL for Clear Lake identifies resource extraction to be the primary source, with unknown sources from the tributaries.

In addition, Clear Lake is listed as impaired for nutrients from an unknown source. Currently, Central Valley Water Board staff is working on a nutrient TMDL for Clear Lake. Nutrient reduction responsibilities have been identified in the draft TMDL report.

Ninety-six miles of Lower Cache Creek (from Clear Lake Dam to the Cache Creek Settling Basin near the Yolo Bypass) are impaired for unknown toxicity from an unknown source. Lake Berryessa is listed as impaired for mercury. The *Cache Creek, Bear Creek and Harley Gulch Mercury TMDL* was approved by the Water Board in 2005 and subsequently was approved by EPA.

Pesticide use in the Lake-Napa County Watershed primarily consists of pesticides applied to lands in the Napa County portion of the Upper Putah Creek drainage, and the majority of the pesticides are applied to wine grapes. However, no water bodies in the Lake-Napa County Watershed are listed as impaired for any pesticides.

Limited water quality data are available for the Lake-Napa County Watershed from the *2007 Review of Monitoring Data for ILRP* (Central Valley Water Board 2007a). Two water quality monitoring sites were located in tributaries to Clear Lake, and two water quality monitoring sites were located in tributaries to Lake Berryessa. One sampling event resulted in toxicity to C*eriodaphnia dubia* (water flea) at McGaugh Slough, at Finley Road East near Clear Lake. In addition, one sample collected from Capell Creek, upstream from Lake Berryessa, tested positive for *E. coli* bacteria. One of five samples collected from Pope Creek, upstream of Lake Berryessa, also tested positive for *E. coli* bacteria. Three of four water quality samples collected at McGaugh Slough at Finley Road East tested positive for *E. coli* bacteria. Table 3-18 lists the known agricultural contaminants and conditions that affect water quality in the Lake-Napa Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Table 3-18. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Lake-Napa Watershed

Parameter	Potential Agricultural Source/ Contribution to Water Quality Impairment	Sources
Nutrients	Source unknown	1, 2
Bacteria (fecal coliform/*E. coli)*	Agriculture, grazing, or other sources	2
Toxicity	Source unknown	1

Sources:
[1] 2006 Section 303(d) list.
[2] Central Valley Water Board 2007a.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Clear Lake, Lower Cache Creek, tributaries to Clear Lake, and Lake Berryessa.

I.G Solano-Yolo Watershed

General Description

The Solano-Yolo Watershed lies west of the Sacramento metropolitan area in northern California (Figure 3-1). It encompasses the Capay Valley to the northwest, and follows the Sacramento River to the Delta near Suisun Bay. The Solano-Yolo Watershed borders Sutter, Placer, Sacramento and San Joaquin counties to the east; and Napa and Lake Counties to the west (Figure 3-10). The Solano-Yolo Watershed is approximately 899,539 acres (1,406 square miles). The western portion of the watershed consists of the hilly to steep mountainous terrain of the Coast Ranges, with a maximum elevation of 2,819 feet. The remainder of the watershed lies on the floor of the Central Valley.

Average annual precipitation ranges from 16 inches in some of the southern parts of the watershed, to as much as 30 inches at the top of the Coast Ranges (SVWQC 2004). The major water features in the watershed include Lower Putah Creek, Lower Cache Creek, the Lower Sacramento River, the Yolo Bypass, the Sacramento River Deep Water Ship Channel, and the confluence of the Sacramento River and the Delta.

Land Use Patterns

Table 3-19 depicts the land use acreage according to DWR land use data for the Solano-Yolo Watershed. Agriculture constitutes a large portion of the Solano-Yolo Watershed, and approximately 58 percent of the land use in the watershed is in agricultural production. The largest single irrigated agricultural commodity in the Yolo-Solano Watershed is field crops.

The second largest portion of the land use in the Solano-Yolo watershed consists of native vegetation, which comprises 31 percent of the total acreage in the watershed (Figure 3-18). A majority of the native vegetation is located in the Coast Ranges foothills on the west side of the watershed, as well as the Montezuma Hills and Hill Slough Wildlife Area southeast of Vacaville.

Table 3-19. Land Use Acreage according to DWR Land Use Data for the Solano-Yolo Watershed

Land Use	Acres	Percent Total
Agriculture		
Citrus and Subtropical	291	0.0
Deciduous Fruits and Nuts	37,818	4.2
Field Crops	159,486	17.7
Grain and Hay	122,221	13.6
Idle	14,207	1.6
Pasture	86,503	9.6
Rice	14,414	1.6
Semi agricultural and Incidental	5,668	0.6
Truck, Nursery, and Berry Crops	67,979	7.6
Vineyards	14,091	1.6

Land Use	Acres	Percent Total
Entry Denied	2,697	0.3
Subtotal	525,375	58.4
Urban		
Urban—Unclassified	27,183	3.0
Urban Residential	4,942	0.6
Urban Landscape	1,891	0.2
Commercial	1,772	0.2
Industrial	7,004	0.8
Vacant	7,880	0.9
Subtotal	50,672	5.6
Native		
Native Classes Unsegregated	578	0.1
Native Vegetation	282,739	31.4
Barren and Wasteland	1,325	0.2
Riparian Vegetation	13,773	1.5
Water Surface	25,076	2.8
Subtotal	323,491	36.0
Total	**899,539**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Solano-Yolo Watershed. Table 3-20 lists the beneficial uses of the Yolo Bypass, Cache Creek (Clear Lake to the Yolo Bypass) and Lower Putah Creek (Lake Berryessa to the Yolo Bypass).

Table 3-20. Beneficial Uses in the Solano-Yolo Watershed

Beneficial Uses	Yolo Bypass	Cache Creek (Clear Lake to Yolo Bypass)	Lower Putah Creek (Lake Berryessa to Yolo Bypass)
Municipal & Domestic		E	E
Irrigation	E	E	E
Stock Watering	E	E	E
Process		E	
Service Supply		E	
POW (Power)			
Rec-1*	E	E	E
Rec-2*	E	E	E
Freshwater Habitat—Warm	E	E	E
Freshwater Habitat—Cold	E	P	P
Migration—Warm	E		

Beneficial Uses	Yolo Bypass	Cache Creek (Clear Lake to Yolo Bypass)	Lower Putah Creek (Lake Berryessa to Yolo Bypass)
Migration—Cold	E		
Spawning—Warm	E	E	E
Spawning—Cold		E	
Wildlife Habitat	E	E	E
Navigation			

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The major water features in the watershed include Lower Putah Creek, Lower Cache Creek, the Lower Sacramento River, the Yolo Bypass, the Sacramento River Deep Water Ship Channel, and the confluence of the Sacramento River and the Delta.

Upper Cache Creek is one of the many tributaries that flow into Clear Lake; Lower Cache Creek drains out of the bottom of Clear Lake and flows into the Yolo Bypass near West Sacramento. Upper Putah Creek feeds Lake Berryessa; Lower Putah Creek drains out of the bottom of Lake Berryessa and flows into the Yolo Bypass. Upper Putah Creek and Lake Berryessa are located in the Lake-Napa Watershed, and are discussed in detail in that section. Lower Putah Creek defines a majority of the boundary between Yolo and Solano Counties, except for its confluence with the Sacramento River. The CDEC website contains flow data for Lower Putah Creek near Winters. Monthly minimum, mean, and maximum flows on Lower Putah Creek from 1995 to 2004 are included in Table B-7 in Appendix B.

The Sacramento River forms the northeastern boundary of the Solano-Yolo Watershed from the confluence of the Feather River, until south of the Sacramento metropolitan area. Monthly average minimum, mean, and maximum flows from 1995 to 2004 for the Sacramento River at Freeport are included in Table B-7 in Appendix B.

The Sacramento Deep Water Ship Channel was built by the Corps in 1963 to provide easy access for ships to the Sacramento metropolitan area. The channel splits from the Sacramento River just north of the city of Rio Vista and travels north along the west side of the Sacramento River until it ends in the City of West Sacramento. The channel is about 30 feet deep, 200 feet wide, and 43 miles long. No known flow monitoring stations are located on the Sacramento River Deep Water Ship Channel.

The Yolo Bypass is a 59,000-acre floodway bypass that protects Sacramento and other Central Valley communities from flooding. The bypass originates near Knights Landing on the west side of the Sacramento River and ends a few miles north of the community of Rio Vista near the Delta. At this location, the Yolo Bypass joins Prospect Slough and Cache Creek Slough at the outlet of the Sacramento

Deep Water Ship Channel. Weirs connect the Yolo Bypass to the Sacramento River, as well as to Cache Creek. During wet years, the Yolo Bypass can be completely full of floodwaters. The Yolo Bypass contains the Vic Fazio Yolo Wildlife Area and forms a large wetland area during many months of the year. In summer, the Yolo Bypass is used for agriculture, primarily rice production.

Water Quality

The Lower Sacramento River and Lower Putah Creek are listed as impaired in the 2006 Section 303(d) list. Identified sources of impairment in the Solano-Yolo Watershed are agricultural and resource extraction (mining).

The Lower Sacramento River (from Knights Landing to the Delta) is impaired for mercury, unknown toxicity, and diazinon.

Lower Putah Creek is impaired for mercury along 28 miles of its lower reach, between Lake Solano and the Putah Creek Sinks (Central Valley Water Board 2007b). Ninety-six miles of Lower Cache Creek, from Clear Lake Dam to the Cache Creek Settling Basin near the Yolo Bypass, are listed as impaired for unknown toxicity from an unknown source. The *Cache Creek, Bear Creek and Harley Gulch Mercury TMDL* was approved by the Water Board in 2005, and subsequently approved by EPA.

Extensive water quality data are available for the Solano-Yolo County Watershed from the *2007 Review of Monitoring Data for ILRP* (Central Valley Water Board 2007a). The multiple monitoring sites throughout the watershed included irrigation laterals and tailwater return drains. Five sampling events resulted in toxicity to *Ceriodaphnia dubia* (water flea).

Six water quality monitoring samples resulted in statistically significant toxicity to algal species (*Selenastrum capricornutum*). Four sediment monitoring samples resulted in statistically significant toxicity to a sediment amphipod (*Hyalella azteca*).

In addition, 19 samples collected from various locations around the Solano-Yolo watershed tested positive for *E. coli* bacteria. Table 3-21 lists the known agricultural contaminants and conditions that affect water quality in the Solano-Yolo Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Table 3-21. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Solano-Yolo Watershed

Parameter	Potential Agricultural Source/ Contribution to Water Quality Impairment	Sources
Diazinon	Pesticide used to protect agricultural crops	1, 2
Bacteria (fecal coliform/*E. coli)*	Agricultural, grazing, or other sources	2
Toxicity	Unknown source	1, 2

Sources:

[1] 2006 Section 303(d) list.

[2] Central Valley Water Board 2007a.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Lower Sacramento River; Lower Putah Creek; and various irrigation canals, laterals, and drains throughout the Solano-Yolo Watershed.

I.H American River Watershed

General Description

The headwaters of the American River watershed originate east of Sacramento in the Sierra Nevada foothills. The American River watershed borders the Tahoe Basin on the east and extends west toward Sacramento (Figure 3-1). The Bear River generally follows the northern boundary of the watershed. The southern border of the watershed generally corresponds to the path of the Cosumnes River. The American River watershed encompasses approximately 1,805,605 acres (approximately 2,000 square miles) (Figure 3-11). Elevations in the American River watershed range from 10,400 feet in the high peaks of the Sierra Nevada to only 30 feet near Sacramento. The watershed is divided into three primary branches: the North and Middle Forks of the American River, which merge near the town of Auburn, and the South Fork of the American River, which flows directly into Folsom Lake.

In the upper elevations of the watershed, the annual average precipitation ranges from 65 to 75 inches. In the middle elevations of the watershed, the amount of annual average precipitation ranges between 35 and 45 inches. At the watershed's lowest elevations, near Folsom Reservoir, precipitation ranges from 22.5 to 27.5 inches per year.

Land Use Patterns

Over 40 percent of the American River watershed is undeveloped and categorized as native vegetation by DWR (Figure 3-19). These undeveloped areas are primarily located in the eastern foothills of the watershed. The western portion of the American River watershed is highly urbanized. Mixed agricultural land uses include rice farming, irrigated and non-irrigated pastureland, fruit tree crops, and livestock (SVWQC 2004).

Table 3-22 contains DWR and FRAP land use data by land use type. Urban land use consists of about 13 percent of the watershed area. Irrigated agriculture comprises approximately 10 percent of the American River watershed, and the largest irrigated agricultural commodity is rice.

Table 3-22. Land Use Acreage according to DWR and FRAP Land Use Data for the American River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	412	0.0
Deciduous Fruits and Nuts	6,684	0.4
Field Crops	20,014	1.1
Grain and Hay	18,097	1.0
Idle	13,736	0.8
Pasture	34,536	1.9
Rice	73,289	4.1
Semi agricultural and Incidental	3,092	0.2

Land Use	Acres	Percent Total
Truck, Nursery, and Berry Crops	2,935	0.2
Vineyards	961	0.1
Subtotal	173,757	9.6
Urban		
Urban—Unclassified	145,510	8.1
Urban Landscape	7,115	0.4
Urban Residential	21,500	1.2
Commercial	2,173	0.1
Industrial	10,351	0.6
Vacant	22,790	1.3
Subtotal	209,438	11.6
Native		
Native Vegetation	720,694	39.9
Barren and Wasteland	8,363	0.5
Riparian Vegetation	6,469	0.4
Water Surface	15,831	0.9
Subtotal	751,356	41.6
FRAP Land Use Type		
Agriculture	6,180	0.3
Barren	27,148	1.5
Conifer	397,516	22.0
Hardwood	106,395	5.9
Herbaceous	33,484	1.9
Shrub	59,930	3.3
Water Surface	15,609	0.9
Wetland	4,992	0.3
Urban	19,805	1.1
Subtotal	671,058	37.2
Total	**1,805,609**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the American River Watershed. Table 3-23 lists the beneficial uses of the American River: from the South Fork Source to Placerville, South Fork Placerville to Folsom Lake, Folsom Lake, and Folsom Dam to the Sacramento River.

Table 3-23. Beneficial Uses in the American River Watershed

	Municipal & Domestic	Irrigation	Stock Watering	Process (Industrial)	Service Supply	POW (Power)	Rec-1*	Rec-2*	Freshwater Habitat—Warm	Freshwater Habitat—Cold	Migration—Warm	Migration—Cold	Spawning—Warm	Spawning—Cold	Wildlife Habitat	Navigation
North Fork American River, Source to Folsom Lake	E	E					E	E	P	E				E	E	
Middle Fork American River, Source to Folsom Lake	E	E	E			E	E	E	P	E				E	E	
Desolation Valley Lakes							E	E		E				E	E	
South Fork American River, Source to Placerville	E					E	E	E	P	E				E	E	
South Fork American River, Placerville to Folsom Lake	E	E				E	E	E	E	E					E	
Folsom Lake	E	E			P	E	E	E	E	E			E		E	
South Fork American River, Folsom Dam to Sacramento River	E	E			E	E	E	E	E	E	E	E	E	E	E	

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The American River Watershed consists of the North, Middle, and the South Forks of the American River, and Folsom Lake and several smaller creeks that are described later in this section. Folsom Dam is operated by Reclamation and regulates runoff from all three forks of the American River. Folsom Dam has a storage capacity of 975,000 acre-feet (Geotechnical Consultants 2003). Folsom Lake provides both flood protection and recreational opportunities for the Sacramento metropolitan area. Flows in the Lower American River also are regulated by Nimbus Dam, a small regulating structure located downstream of Folsom Dam. A series of levees along the Lower American River also provides flood protection to the Sacramento metropolitan area.

The Federal Wild and Scenic Rivers Act, adopted by Congress in 1968, preserves selected rivers in a free-flowing condition when they possess one or more outstanding designated values. The state of California

also has a Wild and Scenic River system with an accompanying list of specially designated rivers. The lower American River is federally and state designated as "Recreational" from Nimbus Dam to the confluence of the Sacramento River. Under the California Wild and Scenic River System, portions of the North Fork American River are designated as "Wild" and "Scenic" in the vicinity of Forest Hill-Soda Springs Road.

American River

The South Fork American River flows east to west from the headwaters in the Sierra Nevada to Folsom Reservoir. At 537,166 acres in area (approximately 840 square miles), the South Fork American River watershed includes 81 topographically delineated sub-basins (SVWQC 2004). Flow data for the South Fork American River at Chili Bar are included in Table B-8 of Appendix B. Flow generally ranges from approximately 130 cfs during dry months to approximately 3,600 cfs during winter.

About 40 percent of the entire length of the South Fork American River above Folsom Reservoir is at an elevation greater than 5,000 feet (El Dorado County 2001). At the higher elevations, precipitation is often in the form of snow, with the maximum accumulation typically occurring by April 1 (SVWQC 2004). Portions of the watershed located above 6,000 feet in elevation maintain a snowpack until warmer weather causes snowmelt (usually March–June).

The lower basin of the American River is distinctly different from the upper basin. Below the town of Folsom, the American River emerges onto an alluvial plain with high, steep bluffs on the north side. Downstream, below Rancho Cordova, there is very little topography, and the American River meanders toward the confluence of the Sacramento River. Flows for the American River at Fair Oaks are included in Table B-8 of Appendix B. Flow generally ranges from approximately 1,000 cfs during dry months to up to 31,000 cfs during winter.

Other Creeks

Multiple drainages are located in the agricultural areas north of Sacramento, including Auburn Ravine, Markham Ravine Creek, Coon Creek, Pleasant Grove Creek, and Curry Creek. Auburn Ravine Creek and Coon Creek originate in the foothills near the town of Auburn, and flow west toward the Sacramento River through farmlands. All of these drainages flow into the Eastside Canal, a 4.5-mile-long floodwater conveyance, and then to the 5-mile-long Cross Canal, which empties into the Sacramento River near the town of Verona. Both the East Side Canal and the Cross Canal are flood control canals that were constructed specifically to channel flood waters around foothill communities to the Sacramento River.

Arcade Creek is one of the larger creeks in the urbanized area of Sacramento. Arcade Creek meanders through the urbanized areas of western Sacramento County and eventually drains to the Natomas East Main Drainage Canal. Approximately 80 percent of Arcade Creek's 25,600-acre (40-square-mile) watershed is urbanized. Historically intermittent, the creek now flows year-round due to modified runoff patterns from urbanization. In addition, Arcade Creek now periodically swells to flood stage during winter storms. The USGS maintains flow monitoring stations for Arcade Creek; monthly average flows for Arcade Creek at Del Paso can be found in Table B-8 in Appendix B.

Chicken Ranch Slough and Strong Ranch Slough are two small creeks that flow through highly urbanized areas of Sacramento and eventually drain to the American River. Chicken Ranch Slough drains an area of approximately 6 square miles. Strong Ranch Slough drains an area of approximately 7 square miles. Both

creeks merge and eventually drain to the lower American River prior to the American River confluence with the Sacramento River.

The Natomas East Main Drainage Canal drainage area, also known as Steelhead Creek, comprises approximately 180 square miles of land in the Sacramento metropolitan area. Just over half of the area in the Natomas East Main Drainage Canal is located in the Dry Creek Watershed. The Natomas East Main Drainage Canal is significant because it drains runoff from a large, rapidly urbanizing metropolitan area—including Dry Creek, Arcade Creek, Robla Creek, and Magpie Creek, as well as a large portion of the Natomas area. Flows for Arcade Creek are included in Table B-8 of Appendix B. Flows range from less than 1 cfs during dry months to approximately 230 cfs during winter. Flow data are not available for these other waterways.

Morrison Creek is an urbanized creek located in the southwest Sacramento area that also contains primarily urban runoff. The Morrison Creek Watershed covers approximately 150 square miles and drains to the Sacramento River. Elder Creek, Laguna Creek, and Elk Grove Creek are tributaries to Morrison Creek. Land use in the Morrison Creek Watershed is a mix of rural and urban uses, including grazing, agricultural, low- to high-density residential, industrial, and commercial. The USGS maintains flow monitoring stations for Morrison Creek. Monthly average flows for Morrison Creek can be found in Table B-8 in Appendix B.

Water Quality

Water quality conditions in the lower American River watershed are to a large degree affected by a combination of urban and industrial land uses, as well as some agricultural land uses. In contrast, the upper watershed is primarily undeveloped and water quality is affected more by the impacts of historical and current resource uses, as well as some agriculture.

A history of gold mining, and the historical legacy of mercury used to extract gold-bearing ore are assumed to be the cause of elevated levels of mercury in the American River watershed. The South Fork of the American River is listed on the 2006 Section 303(d) list for mercury from an unknown source in the reach of the river just below Slab Creek Reservoir to Folsom Lake. The reach of the Lower American River from Nimbus Dam to the confluence of the Sacramento River also is listed for mercury (State Water Board 2006). This same reach of the lower American River is listed for unknown toxicity from an unknown source (State Water Board 2006).

Unlike the upper American River Watershed, which is primarily undeveloped, the lower American River Watershed is dominated by the urbanized Sacramento metropolitan area and surrounded by agricultural land uses. These types of land uses generate both point-source and nonpoint-source discharges that contribute pollutants to surface waters.

The Natomas East Main Drain Canal drains approximately 180 square miles of the Sacramento metropolitan area. The portion of the Natomas East Main Drain Canal situated downstream of the confluence of Arcade Creek is listed as a high priority on the 2006 Section 303(d) list for diazinon, primarily from aerial deposition from agriculture and secondly from urban runoff and storm sewers. This same reach is listed as impaired for PCBs, caused by industrial point sources, agriculture, urban runoff and storm sewers. The portion of the Natomas East Main Drain Canal upstream of the confluence of Arcade Creek also is listed as impaired on the 2006 Section 303(d) list for PCBs— from the same types of agricultural, industrial, and urban sources. Table 3-24 lists the known agricultural contaminants and

conditions that affect water quality in the American River Watershed. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Table 3-24. Known Agricultural Contaminants and Conditions That Affect Water Quality in the American River Watershed

Parameter	Potential Agricultural Source/ Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Agricultural aerial deposition, urban runoff, storm sewers	1, 2
Diazinon	Pesticide use	1, 2
PCBs	Industrial point sources, agriculture, urban runoff, storm sewers	1
Toxicity	Unknown source	1

Sources:

[1] 2006 Section 303(d) list.

[2] USGS 2005c.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Arcade Creek, Morrison Creek, and the Natomas East Main Drain.

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II SAN JOAQUIN RIVER BASIN

Introduction

The **San Joaquin River Basin** drains a region that extends across the Central Valley to the Coast Ranges, between the Cosumnes River to the north and the San Joaquin River to the South (Figure 3-2). For the purposes of this analysis, the San Joaquin River Basin includes 12 watersheds: the (A) Cosumnes River, (B) Delta-Mendota Canal, (C) San Joaquin River, (D) San Joaquin Valley Floor, (E) Delta-Carbona, (F) Ahwahnee, (G) Mariposa, (H) Upper Mokelumne River–Upper Calaveras River, (I) Merced River, (J) North Valley Floor, (K) Stanislaus River, and (L) Tuolumne River Watersheds.

The San Joaquin River Basin encompasses approximately 9.8 million acres. In general, the basin is dominated by native vegetation. The primary tributaries in the basin are the Stanislaus River, Tuolumne River, and Merced River, which meet with the San Joaquin River in the Valley floor at the basin's southern end. The basin is dominated by agriculture at the confluence of the San Joaquin and these various rivers. The San Joaquin River Basin includes most of the Delta as well as the Delta-Mendota Canal, a highly manipulated component of the Central Valley Project. Multiple canals in the Delta Mendota Canal Watershed deliver water to agricultural operations and then back to the natural drainages. Many tributaries in the watershed that would otherwise be dry during the summer irrigation season flow year-round due to agricultural return flows.

Approximately 2 million acres within the basin are classified as agricultural. Agricultural land uses in the basin are concentrated in the Valley floor—specifically in the Delta-Mendota Canal, San Joaquin Valley Floor, Delta-Carbona, and North Valley Floor Watersheds. There is very little agriculture in the remaining watersheds, less than 1 percent in most cases. The primary crops that are produced in the San Joaquin River Basin include field crops, pasture, deciduous fruits and nut orchards, vineyards, and grain and hay.

Overview of Agricultural Impacts on Surface Water in the San Joaquin River Basin

In general, agricultural operations have a greater impact on surface water in the Central Valley area around the San Joaquin River than in the higher surrounding elevations of the Coast Range and Sierra Nevada Mountains. This is primarily due to the rich fertile valley topography allowing for much larger agricultural operations.

The water quality of the San Joaquin River is of critical interest because it flows to the Delta, which is a primary source of drinking water, and supplies irrigation water to farms in the western San Joaquin Valley. One of the primary water quality concerns in the San Joaquin River Basin is the transport of pesticides by agricultural return flows to water bodies and transport of pesticides that are applied to orchards during the dormant growing season (November to January) and are transported to water bodies during rainfall events.

Water quality concerns in the San Joaquin River Basin are concentrated in the watersheds that are heavily agricultural—specifically, the Delta-Mendota Canal, San Joaquin Valley Floor, Delta-Carbona, and North Valley Floor Watersheds. Agricultural land constitutes one-third to one-half of the total land use in each

of these watersheds. Correspondingly, all of these watersheds include water bodies impaired by Section 303(d)-listed pollutants that are associated with irrigated agriculture.

Water quality in the Delta-Mendota Canal, San Joaquin Valley Floor, Delta-Carbona, and North Valley Floor Watersheds is affected similarly by irrigated agriculture. Many of the rivers, creeks, and agricultural drainages in these watersheds contain low DO (generally associated with agricultural return flows), fluctuating pH, and elevated levels of EC (indicative of high salinity). Within each watershed, data indicate that chlorpyrifos, diazinon, permethrin, dieldrin, and DDT (and its breakdown products DDD and DDE) are frequently present in concentrations that exceed water quality objectives. Other pesticides are detected in these watersheds but not consistently in each watershed. These constituents include azinphos-methyl, carbofuran, cyhalthrin, cypermethrin, demeton, dieldrin, dimethoate, disulfoton, diuron, endrin, esfenvalerate/fenvalerate, linuron, malathion, methyl, methyl parathion, methomyl, simazine, thiobencarb, parathion, permethrin-1, permethrin-2, and total permethrin. In addition, elevated levels of naturally occurring metals that are mobilized and suspended in agricultural return flows are common in these watersheds—such as copper, arsenic, cadmium, boron, nickel, lead, and selenium.

A detailed analysis of the impacts on surface water in the San Joaquin River Basin is broken up by watersheds and described below.

II.A Cosumnes River Watershed

General Description

The Cosumnes River Watershed is located in central California (Sacramento and Amador Counties) (Figure 3-2). The watershed borders are San Joaquin and Calaveras Counties on the south and northern Sacramento and El Dorado Counties on the north. Sacramento County and Amador County land borders the rest of the watershed. The watershed is approximately 492,358 acres (769 square miles) and extends from the confluence of the Cosumnes and Mokelumne Rivers to the foothills of the Sierra Nevada. At its southernmost end, the watershed empties into the Mokelumne River. The two main tributaries to the Cosumnes River are Deer Creek and Laguna Creek. Elevation ranges from 80 to 4,462 feet (SVWQC 2004). (Figure 3-20.)

The watershed has a Mediterranean-type climate, characterized by dry summers and cool, moist winters. Sacramento County has an average annual precipitation that ranges from 15 to 24 inches. Rainfall totals increase as elevation increases in the eastern and northeastern parts of Sacramento County. The annual rainfall at the confluence of the Mokelumne and Cosumnes Rivers, the southwestern portion of the watershed, averages from 15 to 17 inches; Folsom, in the northeast, averages 24 inches. Approximately 80 percent of annual rainfall occurs between November and March (SVWQC 2004).

Land Use Patterns

The majority of land use in the Cosumnes River Watershed is classified as native vegetation (Figure 3-32). The surrounding area is relatively rural, and urbanization is minimal in the watershed. Table 3-25 shows the land use acreage in the watershed according to DWR and FRAP land use data. Irrigated agriculture makes up approximately 10 percent of land use.

Table 3-25. Land Use Acreage according to DWR and FRAP Land Use Data for the Cosumnes River Watershed

Land Use	Acreages	Percent Total
DWR Land Use Types		
Agriculture		
Citrus and Subtropical	209	0.0
Deciduous Fruits and Nuts	2,388	0.3
Field Crops	16,658	2.0
Grain and Hay	4,288	0.5
Idle	2,327	0.3
Pasture	22,565	2.8
Rice	186	0.0
Semi agricultural and Incidental	2,511	0.3
Truck, Nursery, and Berry Crops	2,250	0.3
Vineyards	24,051	2.9
Subtotal	77,432	9.5

Land Use	Acreages	Percent Total
Urban		
Urban—Unclassified	5,471	0.7
Urban Landscape	762	0.1
Urban Residential	15,888	1.9
Commercial	738	0.1
Industrial	4,433	0.5
Vacant	2,564	0.3
Subtotal	29,856	3.7
Native		
Native Vegetation	366,454	44.8
Barren and Wasteland	1,444	0.2
Riparian Vegetation	5,558	0.7
Water Surface	3,701	0.5
Subtotal	377,158	46.1
FRAP Land Use Types		
Agriculture	2,298	0.3
Barren and Wasteland	503	0.1
Conifer	165,820	20.3
Hardwood	91,608	11.2
Herbaceous	39,809	4.9
Shrub	19,488	2.4
Urban	11,943	1.5
Water	1,043	0.1
Wetland	413	0.1
Subtotal	332,924	40.7
Total	**817,370**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Cosumnes River Watershed. Table 3-26 lists the beneficial uses of the Cosumnes River from its source to the Delta.

Table 3-26. Beneficial Uses in the Cosumnes River Watershed

Beneficial Uses	Cosumnes River
Municipal & Domestic	E
Irrigation	E
Stock Watering	E
Process	
Service Supply	
POW (Power)	P
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	E
Migration—Cold	E
Spawning—Warm	E
Spawning—Cold	E
Wildlife Habitat	E
Navigation	

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The Cosumnes River originates in the El Dorado National Forest. The upper watershed portion of the Cosumnes River encompasses the North Fork, Middle Fork, and South Fork Cosumnes River (Figure 3-20). The two main tributaries to the Cosumnes River are Deer Creek and Laguna Creek. Portions of the virtually unregulated Cosumnes River are dry in the summer season as many creeks in the Sierra Nevada and the Sacramento Valley are intermittent. During winter, levees provide flood protection along the Cosumnes River in the lower watershed.

Laguna Creek is ephemeral, with several months of little to no flow. Table B-9 in Appendix B contains monthly flows for Laguna Creek. However, flow data are not available for Deer Creek. Flows in the Cosumnes River at Michigan Bar from 1994 to 2004 (Table B-9 in Appendix B) (Station Number 11335000) range from 5 cfs in summer to 7,000 cfs during winter.

Water Quality

There are relatively few water quality concerns in the Cosumnes River. The only known concern in the lower reaches of the river pertains to bioaccumulation of methylmercury. Methylmercury may be mobilized and transported by irrigation return flows; however, it is not directly connected to irrigated agricultural operations. The Cosumnes River is not on the 2006 Section 303(d) list for any stressors and is not significantly affected by irrigated agriculture. The Cosumnes River is one of two remaining significant free-flowing rivers from the Sierra Nevada left in California. While some mining took place upstream, there were no lasting effects on water quality from resource extraction (USGS 2005c). Because of its excellent water quality, the Cosumnes has been used in studies as a reference for unaffected water quality (USGS 2005c).

II.B Delta-Mendota Canal Watershed

General Description

The Delta-Mendota Canal (DMC) Watershed is located in Central California. Its boundaries include the San Joaquin River on the east and the Coast Ranges on the west. To the north lies the Delta, and to the south is the Tulare Lake Basin (Figure 3-2). The DMC Watershed encompasses approximately 1,276,102 acres (1,994 square miles) (DWR 2005c).

The watershed has a minimum elevation of 13 feet, a mean elevation of 750 feet, and a maximum elevation of 3,802 feet (USGS 2005a). The climate is typically Mediterranean, with wet winters and dry summers. Snow may occur in the upper elevations; however, snow does not accumulate in sufficient quantities to provide additional summer flows.

This section describes 17 west side tributaries and agricultural drains that flow to the valley floor section of the San Joaquin River. Like the east side tributaries, the lower portions of these drainages are in the rich agricultural area of the San Joaquin Valley. Generally, the area of irrigated agriculture is located between I-5 and the San Joaquin River, with small patches of irrigated agriculture located on the west side of I-5. (Figure 3-21.)

The drainages in the DMC Watershed from north to south are Ingram Creek, Hospital Creek, Del Puerto Creek, Boundary Drain, Salado Creek, Marshal Road Drain, Ramona Lake, Westly Wasteway, Orestimba Creek, Main Canal, Garzas Creek, Los Banos Creek, Mud Slough, San Luis Drain, Newman Wasteway, Salt Slough, and Island Field Drain.

Land Use Patterns

Native vegetation makes up the majority of land use in the DMC Watershed, totaling almost one-half of the DWR land use coverage and a very large portion of land use coverage in the FRAP vegetation dataset (Table 3-27). Irrigated agriculture makes up the next largest portion of land use in the DMC Watershed, totaling approximately one-third of the land use (Figure 3-33). Generally, I-5 makes up the western boundary for irrigated land, and the San Joaquin River makes up the eastern boundary. A large portion of the DMC Watershed extends up into the Coast Ranges just west of I-5; however, there is virtually no irrigated agriculture in this portion of the watershed. Table 3-27 contains land use acreage according to DWR and FRAP land use data for the DMC Watershed.

Table 3-27. Land Use Acreage according to DWR and FRAP Land Use Data for the Delta-Mendota Canal Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	745	0.1
Deciduous Fruits and Nuts	52,676	4.8
Field Crops	187,274	17.1
Grain and Hay	17,693	1.6

Land Use	Acres	Percent Total
Idle	3,741	0.3
Pasture	93,061	8.5
Rice	7,760	0.7
Semi agricultural and Incidental	5,902	0.5
Truck, Nursery, and Berry Crops	80,735	7.4
Vineyards	1,388	0.1
Subtotal	450,975	35.4
Urban		
Urban—Unclassified	8,118	0.7
Urban Residential	2,408	0.2
Urban Landscape	664	0.1
Commercial	398	0
Industrial	2,272	0.2
Entry Denied	95	0
Vacant	5,477	0.5
Subtotal	19,432	1.5
Native		
Native Vegetation	600,726	47.1
Riparian Vegetation	1,548	0.1
Water Surface	22,690	2.1
Subtotal	624,964	49.0
FRAP Land Use Type		
Conifer	2.5	0
Hardwood	71,998.80	40.1
Herbaceous	47,323.70	26.4
Shrub	58,818.90	32.8
Urban	1,382.10	0.8
Water	9.9	0
Subtotal	179,536	14.1
Total	**1,274,907**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the DMC Watershed. Table 3-28 lists the beneficial uses of the DMC, Mud Slough, Salt Slough, the San Joaquin River from Sack Dam to the mouth of the Merced River, and the San Joaquin River from the Mouth of the Merced River to Vernalis. The beneficial uses of other creeks in the DMC Watershed, such as Del Puerto and Orestimba, have not been specifically identified in the Basin Plan. However, the beneficial uses of any specifically identified water body generally apply to its tributary streams. Consequently, creeks are assigned the same beneficial uses as the two reaches of the San Joaquin River described above. Specifically, Los Banos Creek drains into the San Joaquin River

above the Merced River, while the remaining drainages are located on the San Joaquin River between the Merced River and Vernalis.

Table 3-28. Beneficial Uses in the Delta-Mendota Canal Watershed

Beneficial Uses	Delta-Mendota Canal	Mud Slough[a,b]	Salt Slough[b]	SJR (Sack Dam to Mouth of Merced	SJR (Mouth of Merced to Vernalis)
Municipal & Domestic	E			P	P
Irrigation	E	L[a,b]	E	E	E
Stock Watering	E	E	E	E	E
Process				E	E
POW (Power)					
Rec-1*	E	E	E	E	E
Rec-2*	E	E	E	E	E
Freshwater Habitat—Warm	E	E	E	E	E
Freshwater Habitat—Cold					
Migration—Warm		E	E	E	E
Migration—Cold				E	E
Spawning—Warm				E	E
Spawning—Cold				P	
Wildlife Habitat	E	E	E	E	E
Navigation					
COMM		E	E		
BIOL			E		
SHELL		E	E		

P = Potential, E = Existing, L = Existing Limited Beneficial Uses.

COMM = Commercial and Sport Fishing, BIOL = Preservation of biological habitats of special significance, SHELL = Shellfish Harvesting.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

[a] Mud Slough North.

[b] Elevated natural salt and boron concentrations may limit this use to irrigation of salt- and boron-tolerant crops. Intermittent low flow conditions also may limit this use.

Source: Central Valley Water Board 2007b.

Hydrology

The unaltered hydrology of the DMC Watershed (Figure 3-21) is dominantly ephemeral; however, most of the tributaries contain flow year-round due to agricultural return flows. During the storm season, the small drainages that comprise the DMC Watershed contain intermittent flows that reflect the intensity and duration of storms. The DMC Watershed is highly manipulated, with many canals delivering water to agricultural operations and back to the natural drainages. Flow data were available on the USGS website for some tributaries located in the DMC Watershed. Table B-10 in Appendix B contains monthly average minimum, mean, and maximum flows for Del Puerto Creek, Orestimba Creek, Mud Slough, San Luis Drain, and Salt Slough. Generally flows in the west side drainages are much lower than flows in the larger east side tributaries.

The DMC is part of the Central Valley Project (CVP); it starts at the Tracy Pumping Plant near Tracy and continues south to the Mendota Pool on the San Joaquin River. The majority of water deliveries through the DMC are for use by the San Joaquin River Exchange Contractors Water Authority (SJRECWA). The SJRWECWA consists of four irrigation districts who exchanged San Joaquin River Water for water pumped from the Delta. The water quality of the San Joaquin River is markedly different than that of the DMC primarily due to the agricultural return flows that drain into the San Joaquin River prior to the Stockton Deep Water Ship Channel, including the elevated salt loads received from Mud Slough and Salt Slough.

From the Mendota Pool, water is delivered via canal to the service areas of the Central California Irrigation District (CCID), the Firebaugh Canal Water District, the Columbia Canal Company, and the San Luis Canal Company. San Luis Canal Company deliveries are made 22 miles downstream of the Mendota Pool at Sack Dam on the San Joaquin River. No flow is released from Sack Dam into the lower portions of the San Joaquin River, except during extreme storm events. This water is again introduced into the San Joaquin River as drainage through various west side streams and built facilities. The water quality of the DMC is representative of south Delta water quality and has agricultural beneficial uses.

Water Quality

The water quality conditions in water bodies of the DMC Watershed are dominated by agricultural return flows during the dry season, which often transport pesticides to the San Joaquin River. In addition, pesticides are applied during the dormant spray season, which typically occurs between November and January, and can be transported to water bodies during rainfall events. Data indicate that chlorpyrifos, diazinon, parathion methyl, dieldrin, demeton, methomyl, azinphos-methyl, simazine, dimethoate, malathion, DDE, DDT, and DDD are present in concentrations that exceed water quality objectives (see Appendix C for water quality objectives) and are known to be associated with agricultural operations (Central Valley Water Board 2007a; Kratzer et al. 2002, 2004; Zamora et al. 2003; USGS 2005b, 2005c). Copper also has been detected at multiple locations in the DMC Watershed. Copper is a naturally occurring metal that is also used as a pesticide. Other naturally occurring metals such as arsenic, cadmium, boron, nickel, lead, and selenium also have been detected at elevated levels and are mobilized and suspended in agricultural return flows throughout the DMC Watershed (Central Valley Water Board 2007a).

Many of the creeks located in the DMC Watershed contain low DO. Factors contributing to low DO are still under investigation; however, nutrient loads from irrigated agriculture have been correlated with low DO in the San Joaquin River Basin (Kratzer et al. 2004). Many of the creeks in the DMC Watershed also have experienced fluctuating pH and elevated levels of EC (Central Valley Water Board 2007a).

Table 3-29 summarizes the contaminants with one or more elevated concentration above the applicable water quality objective, as well as other water quality parameters that may not meet the respective variable objectives. The table cites the known source of the contaminants, and if it is connected to irrigated agriculture. In addition, the creeks and agriculture drains that this table represents are included in the notes at the bottom of the table.

Toxicity tests and TIEs were performed for ILRP monitoring in an attempt to identify the causes of water toxicity in the test organisms. The results indicated that non-polar organics such as organophosphate insecticides (e.g., chlorpyrifos, diazinon, and parathion methyl) strongly point to the large toxicity problem in the DMC Watershed (see Table 3-29) (Central Valley Water Board 2007a).

Table 3-29. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Delta-Mendota Canal Watershed

Parameter	Potential Agricultural Source/Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Pesticide used to protect agricultural crops	1, 2, 3, 5
Diazinon	Pesticide used to protect agricultural crops	1, 2, 3, 5
Parathion methyl	Pesticide used to protect agricultural crops	1
Dieldrin	Pesticide used to protect agricultural crops	1
Demeton	Pesticide used to protect agricultural crops	1
Methomyl	Pesticide used to protect agricultural crops	1
Azinphos-methyl	Pesticide used to protect agricultural crops	4, 5
Simazine	Pesticide used to protect agricultural crops	1
Dimethoate	Pesticide used to protect agricultural crops	1
Malathion	Pesticide used to protect agricultural crops	1
DDE	Legacy pesticide potentially mobilized by irrigated agricultural operations	1, 5
DDT	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDD	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
Arsenic	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Cadmium	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Boron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1, 5
Nickel	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Copper	Occurs naturally but is also used as a pesticide	1
Lead	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Selenium	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1, 5
Bacteria	Likely a result of animal confinement facilities land application of waste	1
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands may be connected to low DO.	1, 6
EC	Factors contributing to high EC may involve elevated levels of salt on irrigated land.	1
pH	Factors contributing to high pH are under investigation.	1

Parameter	Potential Agricultural Source/Contribution to Water Quality Impairment	Sources
Toxicity (minnow, flea, algae, sediment)	Toxicity identification evaluations (TIEs) strongly point to organophosphate insecticides (e.g., chlorpyrifos and diazinon) being linked to much of the observed water toxicity. TIEs also indicate that bifenthrin and lambda-cyhalothrin are associated with much of the observed sediment toxicity in the DMC Watershed.	1,7

Sources:

1 Central Valley Water Board 2007a.
2 Kratzer et al. 2002.
3 Zamora et al. 2003.
4 USGS 2005c.
5 USGS 2005b.
6 Kratzer et al. 2004.
7 Weston et al. In Press.

Note: Water bodies in the DMC Watershed that are impacted by one or more of the contaminants listed in this table include Del Puerto Creek, Ingram Creek, Hospital Creek, Boundary Drain, Salado Creek, Marshal Road Drain, Ramona Lake, Westley Wasteway, Island Field Drain, Orestimba Creek, Main Canal, Garzas Creek, Mud Slough, San Luis Drain, Newman Wasteway, and Salt Slough.

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II.C San Joaquin River Watershed

General Description

The San Joaquin River Watershed is located in the southeastern portion of the Central Valley and extends up into the Sierra Nevada (Figure 3-2). The San Joaquin River Watershed covers approximately 1,091,883 acres (1,706 square miles) from the headwaters of the San Joaquin River high in the Sierra Nevada Mountains down to the edge of the valley floor. The watershed extends downstream to Millerton Lake. To the north are the Merced and Fresno Rivers, to the south is the Kings River, on the east are the Sierra Nevada Mountains, and on the west is the valley floor (Figure 3-22). Elevations range from 315 to 13,920 feet, the highest elevation in the larger San Joaquin River Basin. (USGS 2005a) The climate of the San Joaquin watershed varies greatly because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation is the primary land use type in the San Joaquin River Watershed (Figure 3-34). Urban land and agriculture each make up less than 1 percent of the land use in the watershed (Table 3-30). Table 3-30 shows land use acreage according to DWR and FRAP land use data for the San Joaquin River Watershed.

Table 3-30. Land Use Acreage according to DWR and FRAP Land Use Data for the San Joaquin River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	46	0.0
Semi agricultural and Incidental	1	0.0
Subtotal	47	0.0
Urban		
Urban—Unclassified	36	0.0
Urban Landscape	115	0.0
Urban Residential	39	0.0
Commercial	16	0.0
Vacant	29	0.0
Subtotal	235	0.0
Native		
Native Vegetation	43,540	4.0
Water Surface	2,322	0.2
Subtotal	45,862	4.2

Land Use	Acres	Percent Total
FRAP Land Use Type		
Agriculture	158	0.0
Barren/Other	179,489	16.4
Conifer	606,023	55.5
Hardwood	142,167	13.0
Herbaceous	23,786	2.2
Shrub	61,400	5.6
Urban	1,634	0.2
Water	21,960	2.0
Wetland	9,123	0.8
Subtotal	1,045,740	95.7
Total	**1,091,883**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the San Joaquin River Watershed. Table 3-31 lists the beneficial uses of the Upper San Joaquin River from its sources to Millerton Lake (including Millerton Lake).

Table 3-31. Beneficial Uses in the San Joaquin River Watershed

Beneficial Uses	Upper San Joaquin River (from source to Millerton Lake)
Municipal & Domestic	E
Irrigation	E
Stock Watering	E
Process	
POW (Power)	E
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	
Migration—Cold	
Spawning—Warm	
Spawning—Cold	
Wildlife Habitat	E
Navigation	

P = Potential, E = Existing.

COMM = Commercial & Sport Fishing. BIOL = Preservation of biological habitats. SHELL = Shell fish harvesting.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b

Hydrology

The San Joaquin River Watershed includes the Upper San Joaquin River from its sources in the southern Sierra Nevada to, and including, Millerton Lake and many tributaries. Millerton Lake and Friant Dam are owned and operated by Reclamation mainly for flood control and water supply purposes (Reclamation 2003).

There are many other dams and reservoirs located on the Upper San Joaquin River and its tributaries. PG&E and Southern California Edison operate these facilities for hydroelectric power and to meet downstream flow requirements. Reservoirs upstream of Millerton Lake include Shaver Lake on Stevenson Creek; Huntington Lake on Big Creek; Florence Lake on the South Fork San Joaquin River; Lake Thomas A. Edison on Mono Creek; and Mammoth Pool Reservoir, Redinger Lake, and Kerckhoff Lake all on the San Joaquin River. Bass Lake, on the North Fork of Willow Creek, can export water to the Fresno River, which is located outside of the San Joaquin River Watershed.

Inflow into Millerton Lake is influenced by the operation of the upstream reservoirs. The largest inflows occur in the late spring and early summer. On average, June receives the highest average inflow, at 5,661 cfs (CDEC Station SJA). The lowest average inflow occurs in November at 1,077 cfs. Table B-11 in Appendix B contains average monthly flow data for the San Joaquin River near Auberry.

Water Quality

There are few water quality concerns in the Upper San Joaquin River, and water quality conditions are not affected by irrigated agriculture. No 2006 Section 303(d)-listed pollutants are associated with the Upper San Joaquin River or its tributaries. This is likely due to the native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed.

II.D San Joaquin Valley Floor Watershed

General Description

The San Joaquin Valley Floor Watershed (SJVF Watershed) is located between the lower portion of the San Joaquin River and the Stanislaus River confluence in the Central Valley; the watershed covers approximately 1,792,389 acres (2,801 square miles) (Figure 3-2). Specifically, the SJVF Watershed extends from north of the Stanislaus River south to the section of the San Joaquin River between Friant Dam and the Mendota Pool. From west to east, it extends from the San Joaquin River to the Sierra Nevada foothills (Figure 3-23). Six major eastside tributaries to the San Joaquin River are considered in this section. From north to south, they are the Stanislaus River, the Tuolumne River, the Merced River, Bear Creek, the Chowchilla River, the Fresno River, and the San Joaquin River. Smaller tributaries and drains also are discussed.

The climate of the SJVF Watershed is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F for extended periods; winter temperatures are only occasionally below freezing (Jones & Stokes 1998). The region averages less than 10 inches of annual rainfall along State Route (SR) 99. The winter snowpack, which accumulates above 5,000 feet elevation (outside of this watershed) primarily in the Sierra Nevada, supplies the vast majority of water in the basin. Elevations in this watershed range from approximately 0 to 1,000 feet.

Land Use Patterns

Agriculture represents more than half of the land use in the SJVF Watershed (Figure 3-35). Native vegetation, which is predominantly in the eastern portion of the watershed, occupies about a third of the land use in the watershed.

Table 3-32 shows the land use acreage according to DWR and FRAP land use data for the SJVF Watershed. Almost all of the agricultural land is irrigated, although pastureland and certain crops such as wheat and safflower may not require irrigation. In addition, pasture may or may not be irrigated.

Table 3-32. Land Use Acreage according to DWR and FRAP Land Use Data for the San Joaquin Valley Floor Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	7,769	0.4
Deciduous Fruits and Nuts	371,893	20.7
Field Crops	225,157	12.6
Grain and Hay	57,454	3.2
Idle	14,019	0.8
Pasture	222,894	12.4
Rice	9,697	0.5
Semi agricultural and Incidental	35,605	2.0

Land Use	Acres	Percent Total
Truck, Nursery, and Berry Crops	41,189	2.3
Vineyards	140,922	7.9
Subtotal	1,126,599	62.8
Urban		
Urban—Unclassified	76,018	4.2
Urban Landscape	6,027	0.3
Urban Residential	22,313	1.2
Industrial	8,947	0.5
Commercial	2,424	0.1
Vacant	18,779	1.0
Subtotal	134,508	7.3
Native		
Native Vegetation	513,722	28.7
Barren and Wasteland	32	0.0
Riparian Vegetation	2,499	0.1
Water Surface	15,018	0.8
Subtotal	531,271	29.6
Not Surveyed	7	0.0
FRAP Land Use Type		
Pasture	0.14	0.0
Native Vegetation	0.03	0.0
Subtotal	0.17	0.0
Total	**1,792,389**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the SJVF Watershed. Table 3-33 lists the beneficial uses of the lower Stanislaus River (Goodwin Dam to San Joaquin River), Tuolumne River (New Don Pedro Dam to San Joaquin River), Merced River (McSwain Reservoir to San Joaquin River), Chowchilla River (Buchanan Dam to San Joaquin River), and Fresno River (Hidden Dam to the San Joaquin River). The table also includes beneficial uses for four sections of the San Joaquin River. The Basin Plan does not list irrigation as a beneficial use for the Merced River downstream of McSwain Reservoir even though some large agricultural diversions are downstream of McSwain Dam.

Table 3-33. Beneficial Uses by River in the San Joaquin Valley Floor Watershed

Beneficial Uses	Stanislaus River	Tuolumne River	Merced River	Yosemite Lake	Chowchilla River	Fresno River	San Joaquin River, Friant Dam to Mendota Pool	San Joaquin River, Mendota Dam to Sack Dam	San Joaquin River, Sack Dam to Merced River	San Joaquin River, Merced River to Vernalis
Municipal and Domestic	P	P	E		P	P	E	P	P	P
Irrigation	E	E			E	E	E	E	E	E
Stock Watering	E	E	E			E	E	E	E	E
Process	E		E		E		E	E	E	E
Service Supply	E		E							
Hydropower	E		E							
Rec-1*	E	E	E	E	E	E	E	E	E	E
Rec-2*	E	E	E	E	E	E	E	E	E	E
Freshwater Habitat—Warm	E	E	E	E	E	E	E	E	E	E
Freshwater Habitat—Cold	E	E	E	E			E			
Migration—Warm			E				E	E	E	E
Migration—Cold	E	E	E				E	E	E	E
Spawning—Warm	E	E	E				E	E	E	E
Spawning—Cold	E	E	E				P	P	P	
Wildlife Habitat	E	E	E	E	E	E	E	E	E	E
Navigation										

P = Potential, E = Existing.

Process is industrial use that depends on water quality.

Service supply is industrial use that is not dependent on water quality.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

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Hydrology

There are six major east side tributaries along with many smaller tributaries and drains in the SJVF Watershed (Figure 3-23). The eight major east side tributaries from north to south include the Stanislaus River, the Tuolumne River, Dry Creek, Merced River, Bear Creek, Chowchilla River, the Fresno River, and the San Joaquin River.

Stanislaus River

The Stanislaus River forms the northern boundary of Stanislaus and Tuolumne Counties and flows near the cities of Ripon, Riverbank, and Oakdale (Figure 3-23). It drains an area of about 1,075 square miles at its intersection with SR 99, about 15 river miles upstream of its confluence with the San Joaquin River.

Table B-12 in Appendix B shows minimum, mean, and maximum monthly average flows recorded at several flow stations along the Stanislaus River from 1995 to 2004. The USGS flow records show that flows at the New Melones Powerhouse are similar to those at Goodwin Dam during November–February; but during much of the rest of the year, flows at Goodwin Dam are less than at the powerhouse because of agricultural diversions. Flows at Ripon are only slightly greater (by an average of about 100 cfs) than those below Goodwin Dam. Monthly average flows at Ripon varied between approximately 300 and 6,500 cfs.

Tuolumne River and Dry Creek

The Tuolumne River flows from its headwaters in Tuolumne County through Stanislaus County. It passes by the city of Modesto and then, approximately 15 river miles from Modesto, enters the San Joaquin River. At Modesto, the Tuolumne River drains a watershed of approximately 1,900 square miles.

Dry Creek is a moderate-size tributary to the lower section of the Tuolumne River. It enters the river at the city of Modesto approximately 0.2 miles upstream of the USGS Tuolumne River flow gauge at Modesto. Dry Creek drains an area of about 190 square miles (City of Modesto 2003a). While Dry Creek flows are usually not large, except from major winter/spring storm events, they carry runoff from agricultural lands and dairies and storm season runoff from the City of Modesto (East San Joaquin County Water Quality Coalition 2004). Flows from Dry Creek generally contribute less than half of the flow gains in the Tuolumne River between La Grange and Modesto. Flow data for the Tuolumne River and Dry Creek are included in Table B-13 in Appendix B. Tuolumne River flows near Modesto range from approximately 200 cfs during the dry season up to approximately 15,000 cfs during the storm season. Dry Creek flows range from as low as 1 cfs to up to approximately 1,000 cfs during the storm season.

Merced River

The Merced River drains an approximately 1,276-square mile watershed just south of the Tuolumne River. Exchequer Dam forms Lake McClure, the largest reservoir on the Merced River, with a capacity of 1,046,000 acre-feet and a watershed of approximately 1,037 square miles. Downstream of Lake McClure, McSwain Dam forms Lake McSwain.

Downstream of Lake McSwain, Merced Falls Dam impounds water to be diverted into the North Side Canal for delivery to agricultural land. The largest water diversion occurs above Crocker-Huffman Dam, where water enters the Merced ID's Main Canal. This diversion accounts for the majority of the flow reduction between the Merced River below Merced Falls and the Merced River at Cressy. Flow data for the Merced River are included in Table B-14 in Appendix B. Seven private diversion ditches in the Snelling area also divert water for agricultural use to about 22,000 acres. A survey by DFG identified 244 diversions, mostly pumps, along the Merced River that predominately supply water for agricultural use.

The portion of the Merced River that falls in the SJVF Watershed extends from Merced Falls Dam downstream to the San Joaquin River. This portion of the Merced River is dominated by agricultural land use.

Small amounts of water are returned to the river downstream of Crocker-Huffman Dam at the North Side Canal spill; Livingston Canal spill; Highline Canal spill; Merced ID Garibaldi Lateral; Turlock Irrigation District (TID); Lower Stevinson Canal; Stevinson East Side Canal; and many smaller, private drains. A unique feature of the East Side Canal is that it intercepts, directly or indirectly, all creeks south of the Merced River and north of the Chowchilla River.

Of these agricultural return flows, the Highline Canal may be the most contaminated. Flows from the Livingston Canal during winter are dominated by urban runoff from the City of Atwater and the Town of Winton. Agricultural return flows are part of the reason that flows in the Merced River near Stevinson are sometimes greater than the flows in the Merced River near Cressy, approximately 23 miles upstream. Table B-14 in Appendix B contains flow data for the Merced River. During the summer of 3 of the last 5 years, flows were consistently greater at Stevinson than at Cressy. During winter, rainfall causes local inflows.

The Corps operates flood control reservoirs on Bear, Burns, and Canal Creeks as part of the Merced County Streams Group. Diversion channels for Miles Creek and the Black Rascal Creek Diversion also are part of the Merced County Streams Group.

Bear Creek

Bear Creek originates much lower in the Sierra Nevada than the Stanislaus, Tuolumne, and Merced Rivers. It starts in Mariposa County near the town of Bear Valley, which is at 2,050 feet elevation. Just before entering Merced County, Bear Creek flows through Bear Reservoir, a small flood control reservoir operated by the Corps. Flows are discharged from the reservoir via an ungated outlet. Flow data for Bear Creek is included in Table B-15 in Appendix B. Flows range from as little as 1 to as much as 1,300 cfs during the storm season.

Chowchilla River

Eastman Lake, formed by Buchanan Dam, is the only large reservoir in the Chowchilla River watershed. It has a capacity of 150,000 acre-feet, and its watershed area is 235 square miles. Eastman Lake is operated by the Corps. The only currently operated measurement station along the Chowchilla River is the CDEC station at Eastman Lake. Releases from the lake are shown in Table B-16 in Appendix B. Flow ranges from 0 to 7,000 cfs.

The lower Chowchilla River is north of the town of Chowchilla. Upstream of the town of Chowchilla, water is diverted south from the Chowchilla River to supply Barenda and Ash Sloughs (Vollmar 2001). Downstream of the town of Chowchilla (to the west), the Chowchilla River enters the East Side Bypass, which eventually flows into the San Joaquin River. The Chowchilla Water District (CWD) diverts water for agricultural use along the river. CWD operates two canals that spill to Merced ID's El Nido Canal.

Fresno River

Mostly dominated by rainfall, the Fresno River watershed is 500 square miles located at a relatively low elevation in Madera County. Hensley Lake, formed by Hidden Dam, is the only large reservoir in the Fresno River watershed. It is operated by the Corps and has a capacity of 90,000 acre-feet. The watershed area of the lake is approximately 237 square miles (Bookman-Edmonston 2003). The Madera ID obtains some of its water from the Fresno River. Historically, the Fresno River has had ephemeral flows consisting of large winter floods and no summer flows (Bookman-Edmonston 2003). The Madera Canal, operated by the Friant Water Users Association under contract from Reclamation, can spill water to the Fresno River when necessary. The Madera Canal originates at Friant Dam and delivers San Joaquin River water to contractors in the Madera and Chowchilla Water Districts.

The only currently operated measurement station along the Fresno River is the CDEC station at Hensley Lake. Releases from the lake are shown in Table B-17 in Appendix B. Flows range from 0 to 1,500 cfs.

San Joaquin River

The San Joaquin River between Friant Dam and the Delta forms the western and southern boundaries of the SJVF Watershed. The following description extends to the San Joaquin River at Vernalis, which is the sampling location upstream of any tidal influence from the Delta. Although Vernalis is about 2 miles north of the SJVF Watershed boundary, it is included with the valley floor description because Vernalis is a key water quality measurement location that represents the cumulative water quality conditions resulting from all the upstream inflows.

Most of the runoff stored in Millerton Lake is diverted south in the Friant-Kern Canal for agricultural use and is not conveyed down the San Joaquin River. Releases of about 150 cfs are made to the river to satisfy downstream water rights; consequently, the river is normally dry between Gravelly Ford (RM 229) and Mendota Pool (RM 206) except during flood operations. Water imported via the DMC is diverted into several irrigation canals from the Mendota Pool, with a portion of the flow remaining in the San Joaquin River to provide flows between Mendota Dam (RM 204.6) and Sack Dam (RM 182.1). Flows are then diverted into the Arroyo Canal by the Columbia Canal Company to serve irrigated agriculture and wetland demands. The river is again dewatered as far as the Sand Slough Control Structure (RM 168.5) in most years. Agricultural tailwater and groundwater seepage provide some flow downstream of the Sand Slough Control Structure. Flows remain low until the river passes the city of Stevinson and reaches Salt Slough and Mud Slough, which have fairly reliable flows during summer that are attributable to agriculture and wetland return flows. Just downstream of Salt Slough and Mud Slough, the flow is greatly increased at the confluence with the Merced River. According to USGS flow records of 1951 to 1995, 66 percent of the average flow at the downstream end of the San Joaquin River comes from three major east side river basins: the Merced River (15 percent), the Tuolumne River (30 percent), and the Stanislaus River (21 percent) (Kratzer 2002).

The variability in flows along the length of the San Joaquin River is presented in Table B-18 in Appendix B. All of these measurements are in areas of consistent flow. Releases from Friant Dam are generally greater than 100 cfs. The flows measured near Mendota are between Mendota Pool and Sack Dam, and are sustained by DMC flows into Mendota Pool. The Fremont Ford Bridge flows are sustained by flows from Salt Slough. Because Crows Landing is downstream of Mud Slough, the Merced River, and Orestimba Creek, flows are considerably higher. They are highest at Vernalis, which is downstream of all major inflows.

Other Drainages

In the SJVF Watershed area, multiple small drainages flow directly into the San Joaquin River. Water quality concerns have been identified for several of these, including Harding Drain and August Road Drain at Crows Landing. Both of these drains are located between the Merced and Tuolumne Rivers; the Harding Drain is north of the August Road Drain. Harding Drain, sometimes referred to incorrectly as TID Lateral Number 5, conveys agricultural runoff as well as discharge from the City of Turlock's wastewater treatment plant (TID 2005). Canal Creek (flows to Bear Creek), Miles Creek (flows to Owens Creek) and Owens Creek (flows to East Side Canal) also are present in the SJVF Watershed area. The Planada Community Services District discharges urban runoff and treated effluent to Miles Creek. The Le Grand Community Service District discharges urban runoff and treated effluent to Mariposa Creek.

Dutchman Creek and Duck Slough are two other small waterways with water quality issues. Dutchman Creek and Duck Slough are located between Bear Creek and the Chowchilla River. Dutchman Creek flows into Deadman Creek, which joins with Duck Slough at its downstream end.

Water Quality

The water quality of the SJVF Watershed is dominated by agricultural return flows during the dry season, which frequently transport pesticides to the San Joaquin River. In addition, pesticides are applied during the dormant spray season, which typically occurs between November and January, and can be transported to water bodies during rainfall events. Data indicate that chlorpyrifos, diazinon, thiobencarb, dieldrin, DDT, and DDD have been detected in one or more water bodies in concentrations that exceed water quality objectives (see Appendix C for water quality objectives and Table 3-34 for the constituents that exceeded these objectives) and are known to be associated with agricultural operations (Central Valley Water Board 2007a; Kratzer et al. 2002, 2004; Zamora et al. 2003; USGS 2005b, 2005c; Weston et al. In Press). Copper also has been detected at multiple locations in the SJVF Watershed. Copper is a naturally occurring metal that is also used as a pesticide. Other metals such as cadmium, boron, and lead have been detected at elevated levels and are mobilized and suspended in agricultural return flows throughout the SJVF Watershed (Central Valley Water Board 2007a).

Many of the rivers and agriculture drainages located in the SJVF Watershed contain low DO. Factors contributing to low DO are still under investigation; however, nutrient loads from irrigated agriculture and animal confinement facilities have been correlated to low DO in the San Joaquin River Basin (Kratzer et al. 2004). Many of the creeks in the SJVF Watershed also have experienced fluctuating levels of pH and elevated levels of EC (Central Valley Water Board 2007a). Table 3-34 summarizes all the contaminants with one or more elevated concentrations above the applicable water quality objective.

TIEs were performed to attempt to connect the toxicity results to a particular pesticide. TIEs were performed in most cases on the water samples that exceeded 50 percent mortality. The results indicated

that non-polar organics such as organophosphate insecticides (e.g., chlorpyrifos, diazinon, and parathion methyl) may be causing the large toxicity problem in the SJVF Watershed (see Table 3-34) (Central Valley Water Board 2007a).

Table 3-34. Known Agricultural Contaminants and Conditions That Affect Water Quality in the San Joaquin Valley Floor Watershed

Parameter	Potential Agricultural Sources/Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Pesticide used to protect agricultural crops	1, 2, 3, 4
Diazinon	Pesticide used to protect agricultural crops	1, 2, 3, 4
Thiobencarb	Pesticide used to protect agricultural crops	1
Malathion	Pesticide used to protect agricultural crops	1
Dieldrin	Pesticide used to protect agricultural crops	4
DDT	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDD	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
Copper	Occurs naturally but is also used as a pesticide	1
Boron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	4
Cadmium	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Lead	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Bacteria	Likely a result of animal confinement facilities land application of waste	1
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands may be connected to low DO.	1, 5
EC	Factors contributing to high EC may involve elevated levels of salt on irrigated land.	1
pH	Factors contributing to high pH are under investigation.	1
Toxicity (minnow, flea, algae, sediment)	Toxicity identification evaluations (TIEs) strongly suggest organophosphate insecticides (e.g., chlorpyrifos and diazinon) as the cause of minnow toxicity, algae toxicity, and water flea toxicity. TIEs also indicate that bifenthrin and lambda-cyhalothrin are associated with much of the observed sediment toxicity in the SJVF Watershed.	1, 6

Sources:
1 Central Valley Water Board 2007a.
2 Kratzer et al. 2002.
3 Zamora et al. 2003.
4 USGS 2005b, 2005c.
5 Kratzer et al. 2004.
6 Weston et al. In Press.

Note: Water bodies in the SJVF Watershed that are impacted by one or more of the contaminants listed in this table include the Stanislaus River, the Tuolumne River, the Merced River, Bear Creek, the Chowchilla River, the Fresno River, and the San Joaquin River. Smaller tributaries and drains include Ash Slough, August Road Drain, Brenda Slough, Black Rascal Creek, Deadman Creek, Dry Creek, Duck Slough, Highline Canal, Jones Drain, Lone Willow Slough, Prairie Flower Drain, Silva Drain, and Cottonwood Creek.

II.E Delta-Carbona Watershed

General Description

The Delta-Carbona Watershed is located within Contra Costa, Alameda, and San Joaquin Counties near the western margin of the Central Valley and east of San Francisco Bay (Figure 3-2). It encompasses most of the Delta, with an area of approximately 664,759 acres (1,039 square miles). The elevation ranges from –20 to 3,832 feet (USGS 2005a). The San Joaquin River and the North Mokelumne River form the northwestern boundary (Figure 3-24). The eastern boundary is located along Interstate 5 (I-5) east of the San Joaquin River. The watershed extends as far south as the Stanislaus River. The western boundary of the Delta-Carbona Watershed is on the inland edge of the Coast Ranges.

The climate of the Delta-Carbona Watershed is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. The Delta weather conditions are more moderate than in the rest of the Central Valley because of the moderating effect of the proximity of the Pacific Ocean. The winter snowpack that accumulates above 5,000 feet elevation primarily in the Sierra Nevada (which is outside of this watershed) supplies the vast majority of water in the basin.

The Delta is a complex web of waterways winding among agricultural islands that are close to or below sea level. Flows and water quality in the Delta are influenced primarily by:

- major inflows—the San Joaquin River, the Sacramento River, and ocean tides;
- major outflows—exports to the California Aqueduct at the Banks Pumping Plant and to the DMC at the Jones (Tracy) pumping plant;
- channel structure—channel dimensions and slope as well as the use of gates and construction of barriers such as the one used at the head of Old River to redirect flow to the mainstem San Joaquin River during certain times of the year; and
- Delta Cross Channel—diverts flows from the Sacramento River to Snodgrass Slough and the Mokelumne River to decrease salinity levels at the state and federal pumping plants.

Smaller inflows and diversions (such as Marsh Creek, the Calaveras River, the Mokelumne River, and agricultural diversions and returns) also play a role in influencing flow and water quality. Although the Sacramento River is a major contributor to Delta flow and water quality, it is not within the Delta-Carbona Watershed and therefore is not described in this section.

The Contra Costa Water District straddles the western edge of the Delta-Carbona Watershed. This water district obtains drinking water from the Delta and is vigilant about Delta water quality. The West Side ID, the Plain View Water District, and the Banta-Carbona ID all operate within the southern portion of the Delta-Carbona Watershed.

There are numerous waterways in the Delta-Carbona Watershed. Some of the larger ones, or ones that are of particular water quality concern, are described in the hydrology section.

Land Use Patterns

Irrigated agriculture is the primary land use type in the Delta-Carbona Watershed, encompassing almost half of the land use acreage (Figure 3-36). Native vegetation covers about one-third of the watershed, and urban land use represents about one-tenth of the land use in the watershed. Table 3-35 lists land use acreage according to DWR and FRAP land use data for the Delta-Carbona Watershed.

Table 3-35. Land Use Acreage according to DWR and FRAP Land Use Data for the Delta-Carbona Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	54	0.0
Deciduous Fruits and Nuts	17,956	2.7
Field Crops	106355	16.0
Grain and Hay	47,504	7.1
Idle	5,608	0.8
Pasture	61,451	9.2
Rice	801	0.1
Semi agricultural and Incidental	3916	0.6
Truck, Nursery, and Berry Crops	62,539	9.4
Vineyards	8,637	1.3
Subtotal	314,821	47.4
Urban		
Urban—Unclassified	53,940	8.1
Urban Landscape	2,209	0.3
Urban Residential	3,539	0.5
Commercial	902	0.1
Industrial	6,707	1.0
Vacant	9,284	1.4
Subtotal	76,581	11.5
Native		
Barren and Wasteland	60	0.0
Native Vegetation	177,507	26.7
Riparian Vegetation	8,713	1.3
Water Surface	41,948	6.3
Subtotal	228,228	34.3
FRAP Land Use Type		
Agriculture	2,598	0.4
Hardwood	5,667	0.9
Herbaceous	35,212	5.3
Shrub	138	0.0
Urban	1,235	0.2
Water	269	0.0

Land Use	Acres	Percent Total
Wetland	10	0.0
Subtotal	45,129	6.8
Total	**664,759**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Delta-Carbona Watershed. Table 3-36 lists the beneficial uses in the Delta.

Table 3-36. Beneficial Uses in the Delta-Carbona Watershed

Beneficial Uses	Sacramento–San Joaquin River Delta
Municipal & Domestic	E
Irrigation	E
Stock Watering	E
Process	E
Service Supply	E
Power	
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	E
Migration—Cold	E
Spawning—Warm	E
Spawning—Cold	
Wildlife Habitat	E
Navigation	E

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

Flows in the Delta are difficult to measure because the tidal influence means that there is no meaningful relationship between stage and flow. The USGS, however, has been using acoustic doppler to measure flow at some locations. Appendix B, Table B-19 shows the minimum, mean, and maximum of the monthly average values for data measured between 1995 and 2004 in the San Joaquin River. Because most of these locations have tidal flow, flows usually move both downstream (positive flow) and upstream (negative flow) within a day. The *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (SWRCB 1995) has standards for some of the biggest factors in Delta hydraulics: Delta outflow, Sacramento and San Joaquin River inflows, Delta exports, Delta Cross Channel gate position, and salinity gradients.

The downstream end of the San Joaquin River enters the southern end of the Delta-Carbona Watershed near its confluence with the Stanislaus River (Figure 3-24). It then flows north to the flow split at Old River, where there is sometimes a significant reduction in flow depending on the position of Delta barriers and the level of Delta exports. At Stockton, the San Joaquin River becomes known as the Deep Water Ship Channel (DWSC), which is dredged to allow passage of large cargo ships to the Port of Stockton. After passing through a web of Delta channels, the river terminates near the city of Antioch, where it merges with the Sacramento River.

In the past 20 years, average monthly flows at Vernalis have averaged about 1,000 cfs during summer (Table B-19 in Appendix B); flows have been as low as 400 cfs. The Vernalis flows are generally much less than the Sacramento River flows. Net flows near the downstream end of the San Joaquin River at Jersey Point are often similar to the flows at Vernalis, but a lot happens to the water between the two locations. Generally, more than half of the Vernalis flows go to the export pumps in the south Delta, and some of the Sacramento River flows contribute to flows in the central and south Delta via the Delta Cross Channel. Depending on flows in the San Joaquin River and the amount of exports, net flows at Jersey Point are sometimes negative.

Old River is basically a long, convoluted side channel of the San Joaquin River. The northern portion of Old River (starting at Vernalis to the southern portion of Old River), which flows east to west from the San Joaquin River to the DMC, has tidal flows; but, depending on flows and barriers, the net flow within this section of Old River can be very low (Jones & Stokes 2005a). North of the export pumps, Old River flows south to north from Clifton Court Forebay to Franks Tract and on to the San Joaquin River. Because of Delta exports, net flow in this section of river is often negative (i.e., in the upstream direction) (see Table B-19 in Appendix B).

Middle River starts near the upstream end of Old River. It then flows northwest, intersects many side channels, passes by flooded Mildred Island, and connects with the San Joaquin River. The southern portion of Middle River between Old River and Trapper Slough has relatively low flows because of its narrow, constricted channel. Farther north, Middle River carries significant flows—the flows often are toward the export pumps (see Table B-19 in Appendix B).

Marsh Creek originates on the eastern slopes of Mount Diablo. It merges with Dunn Creek, which carries mercury from the Mount Diablo Mine. Marsh Creek flows into a small reservoir, Marsh Creek Reservoir, and then discharges north into Big Break and the downstream end of the San Joaquin River near Jersey Point. Daily flows in the USGS database for September 2000–October 2004 for Marsh Creek near Brentwood ranged between 0.4 and 590 cfs, with an average of 8 cfs (Table B-19 in Appendix B).

Several side channels on the eastern edge of the Delta are included in this discussion. These are listed below in north to south order:

- Mosher Slough—Located at the northern edge of Stockton. It connects with Bear Creek at its downstream end and receives flow from Mosher Creek at its upstream end.
- Five Mile Slough—Originates in Stockton and extends to Fourteen Mile Slough.
- Turning Basin—The extension of the Stockton DWSC that is not part of the San Joaquin River. The Turning Basin allows ships to enter the Port of Stockton and provides room for turning around.
- Mormon Slough—Originates as a diversion from the Calaveras River at Bellota. It passes through Stockton and connects to the southern edge of the Turning Basin. Two sections of Mormon Slough have water quality issues. Commerce Street is located near the boundary between the Delta-Carbona Watershed and the North Valley Floor Watershed, and it is the dividing line for the two impaired sections of Mormon Slough. As a result, the downstream portion, from Commerce Street to the Turning Basin, is included in the Delta-Carbona Watershed, whereas the upstream portion is included in the North Valley Floor Watershed.
- Walker Slough—An eastern side channel to the Delta. Because it is predominantly outside of the Delta-Carbona Watershed, Walker Slough is included with its upstream watershed in the description of the North Valley Floor Watershed.

Water Quality

Water quality data from several studies and monitoring locations were evaluated to identify potential water quality issues in the Delta-Carbona Watershed (references are listed in Table 3-37). Data indicate that chlorpyrifos, diazinon, permethrin, and DDT are frequently present in concentrations that exceed water quality objectives (see Appendix C for water quality objectives).

The 2006 Section 303(d) list indicates that most areas of the Delta have elevated levels of chlorpyrifos and diazinon. During the past 10 years, however, the use of diazinon and chlorpyrifos in the Delta-Carbona Watershed has decreased substantially (Kratzer 2002). The concentration of these pesticides in the rivers also has decreased (Central Valley Water Board 2007b). See Table 3-37 for the potential sources of these contaminants.

The 2006 Section 303(d) list indicates that most of the Delta has elevated levels of DDT. There is a lack of data for DDT concentrations in the water column. DDT is a hydrophobic organochlorine pesticide that is extremely resilient in the environment and tends to bind to sediment. Thus DDT and its breakdown products, DDD and DDE, are typically found in the bed sediment of the river. DDT, DDD, and DDE are legacy pesticides that are no longer used.

In recent years, pyrethroids have been replacing some organophosphate use. Pyrethroids tend to bind with organic material and may be more likely to be present in sediment than in water (ESJWQC 2004). Total permethrin, permethrin-1, and permethrin-2 have been found in the Delta-Carbona Watershed in elevated concentrations (Central Valley Water Board 2007a). Table 3-37 describes the potential sources of these pesticides. Appendix C contains the water quality objectives used to identify the water quality concerns listed in the table.

Other pesticides that have been found in concentrations that exceed water quality objectives include disulfoton, dieldrin, carbofuran, methyl parathion, endrin, methomyl, esfenvalerate/fenvalerate, and

linuron (Central Valley Water Board 2007a, Kratzer et al. 2002, Zamora et al. 2003, USGS 2005b). In addition to pesticides, naturally occurring metals can be mobilized and transported to surface water from irrigation return flows. Arsenic, boron, and nickel have been found in elevated concentrations in the Delta-Carbona Watershed (Central Valley Water Board 2007a, USGS 2005b).

Fluctuating levels of pH, along with elevated levels of EC and low levels of DO, have been observed in the Delta-Carbona Watershed. Factors contributing to fluctuating pH are still under investigation. Elevated levels of EC are associated with agricultural return flows or seawater intrusion. Low DO has been associated with nutrients from agricultural return flows (Central Valley Water Board 2007a).

TIEs were performed to attempt to identify the cause(s) of significant toxicity observed in water column and sediment test species. TIEs generally were performed on water samples that exceeded 50 percent mortality. Toxicity resulted on the minnow, water flea, and algae species. The results indicated that non-polar organics such as organophosphate insecticides (e.g., chlorpyrifos, diazinon, and parathion methyl) are linked to the toxicity problem in the Delta-Carbona Watershed (see Table 3-37) (Central Valley Water Board 2007a). In addition, an independent study found that bifenthrin and lambda-cyhalothrin are associated with much of the observed sediment toxicity (Weston et al. In Press).

Table 3-37. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Delta-Carbona Watershed

Parameter	Potential Agricultural Sources/ Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Pesticide used to protect agricultural crops	1, 2, 3, 4
Diazinon	Pesticide used to protect agricultural crops	1, 2, 3, 4
Disulfoton	Pesticide used to protect agricultural crops	1
Dieldrin	Pesticide used to protect agricultural crops	1, 4
Carbofuran	Pesticide used to protect agricultural crops	1
Methyl parathion	Pesticide used to protect agricultural crops	1
Endrin	Pesticide used to protect agricultural crops	1
Methomyl	Pesticide used to protect agricultural crops	1
Dimethoate	Pesticide used to protect agricultural crops	1
Esfenvalerate/fenvalerate, total	Pesticide used to protect agricultural crops	1
Linuron	Pesticide used to protect agricultural crops	1
Permethrin, total	Pesticide used to protect agricultural crops	1
Permethrin-1	Pesticide used to protect agricultural crops	1
Permethrin-2	Pesticide used to protect agricultural crops	1
Cyhalthrin, lambodia, total	Pesticide used to protect agricultural crops	1
DDT	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDD	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDE	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
PCBs	Generally a result of commercial use	4

Parameter	Potential Agricultural Sources/ Contribution to Water Quality Impairment	Sources
Arsenic	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Boron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	4
Nickel	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Bacteria	Likely a result of animal confinement facilities land application of waste	1
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands may be connected to low DO.	1
EC	Factors contributing to high EC may involve elevated levels of salt on irrigated land.	1
pH	Factors contributing to high pH are under investigation.	1
Toxicity (minnow, flea, algae, sediment)	Toxicity identification evaluations (TIEs) strongly point to organophosphate insecticides (e.g., chlorpyrifos and diazinon) as the cause of such toxicity in the water column. Ammonia also was connected to toxicity in this watershed. TIEs strongly point to organochlorine pesticides and pyrethroids as the cause of such toxicity in the sediment. TIEs also indicate that bifenthrin and lambda-cyhalothrin are associated with much of the observed sediment toxicity in the Delta-Carbona Watershed.	1, 5

Sources:

1 Central Valley Water Board 2007a.
2 Kratzer et al. 2002.
3 Zamora et al. 2003.
4 USGS 2005b.
5 Weston et al. In Press.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Sand Creek, Marsh Creek, Kellogg Creek, Drain to South Canal, Drain to North Canal, Grantline Canal, Tom Paine Slough, Drain to Grantline Canal, Drain to Wing Levee Road, Unnamed Canal at Howard Road, Mid Roberts Drain, Return Irrigation Drain at MCD Road, Roberts Island Drain, Five Mile Slough, Mosher Slough, and the San Joaquin River source water canal at Holt and Nueger Roads.

II.F Ahwahnee Watershed

General Description

The Ahwahnee Watershed is located on the east side in the middle of the Central Valley (Figure 3-2). The Ahwahnee Watershed covers approximately 412,119 acres (644 square miles) from the headwaters of the Chowchilla and Fresno Rivers in the Sierra Nevada to the edge of the valley floor. The watershed extends downstream to and includes both Hensley Lake and Eastman Lake. The San Joaquin Valley Floor Watershed is located to the west, San Joaquin River Watershed to the south and southeast, Merced River Watershed to the north and northeast, and Mariposa Watershed to the northwest. (Figure 3-25.)

The climate of the Ahwahnee watershed is highly variable because of the broad range in elevation. Elevations range from 315 to 13,920 feet, the highest elevation in the larger San Joaquin River Basin. (USGS 2005a) At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation is the dominant land use in the Ahwahnee Watershed (Figure 3-37). Urban land use represents a relatively small proportion of the watershed. The combined acreage of urban, urban landscape, commercial, and residential designations totals less than 5 percent of the total acreage. Agriculture comprises less than 1 percent of the land use in the watershed. Much of this land could be non-irrigated, as it consists mainly of pasture and semi agricultural land, and pastureland may or may not be irrigated. Table 3-38 presents the land use acreages in the watershed.

Table 3-38. Land Use Acreage according to DWR and FRAP Land Use Data for the Ahwahnee Watershed

Land Use	Acreage	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	54	0.0
Pasture	644	0.2
Semi agricultural and Incidental	113	0.0
Vineyards	103	0.0
Subtotal	914	0.2
Urban		
Urban Landscape	9	0.0
Urban Residential	9,047	2.2
Commercial	29	0.0
Subtotal	9,085	2.2

Land Use	Acreage	Percent Total
Native		
Native Vegetation	221,091	53.6
Riparian Vegetation	0	0.0
Water Surface	2,181	0.5
Subtotal	223,272	54.2
FRAP Land Use Type		
Agriculture	143	0.0
Barren/Other	13	0.0
Conifer	21,816	5.3
Hardwood	101,767	24.7
Herbaceous	29,494	7.2
Shrub	16,612	4.0
Urban	8,681	2.1
Water	312	0.1
Wetland	7	0.0
Subtotal	178,845	43.4
Total	**412,119**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Ahwahnee Watershed. Table 3-39 lists the beneficial uses of the Chowchilla River from its source to, and including, Eastman Lake and the Fresno River from its source to Hensley Lake.

Table 3-39. Beneficial Uses in the Ahwahnee Watershed

Beneficial Uses	Fresno River, source to Hensley Lake	Chowchilla River, source to Eastman Lake
Municipal & Domestic	E	E
Irrigation	E	E
Stock Watering	E	E
Process		
Service Supply		
Power		
Rec-1*	E	E
Rec-2*	E	E
Freshwater Habitat—Warm	E	E
Freshwater Habitat—Cold	E	E
Migration—Warm		

Beneficial Uses	Fresno River, source to Hensley Lake	Chowchilla River, source to Eastman Lake
Migration—Cold		
Spawning—Warm		
Spawning—Cold		
Wildlife Habitat	E	E
Navigation		

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

In its upper watershed, the Chowchilla River has a West Fork, Middle Fork, and East Fork. The upper watershed is located in both Mariposa and Madera Counties (Figure 3-25). The East Fork tributary extends the farthest into the Sierra Nevada. It originates near the Chowchilla Mountains, which are less than 7,000 feet elevation. The downstream end of the Upper Chowchilla River extends to the intersection of Merced County, Mariposa County, and Madera County in the northwest corner of the watershed, about 6 miles downstream of Buchanan Dam.

Eastman Lake, formed by Buchanan Dam, is the only large reservoir in the Chowchilla River Watershed. It has a capacity of 150,000 acre-feet, and its watershed area is 235 square miles. At an elevation of 600 feet, summers are warm and winters mild. Eastman Lake is used for flood control, irrigation, and recreation. The only currently operated flow gauging station along the Chowchilla River is the CDEC station at Eastman Lake. Releases from the lake are typically less than 200 cfs. Inflow to the lake varies seasonally, with high flows in winter and spring and low flows in summer and fall. Table B-16 in Appendix B contains the monthly minimum, mean, and max flows for the inflow to the lake; these range from 0 to 7,000 cfs.

The Fresno River is located in Madera County (Figure 3-25). Hensley Lake, formed by Hidden Dam, is the only large reservoir in the Fresno River Watershed. It is operated by the Corps and has a capacity of 90,000 acre-feet. The watershed area of the lake is approximately 258 square miles. Hensley Lake is used for flood control, irrigation, resource management, and recreation. The Madera ID obtains some of its water from the Fresno River. The only currently operated flow gauging station along the Fresno River is the CDEC station at Hensley Lake. Flow measurements for inflow to Hensley Lake indicate high flows in late winter and low flows during summer to fall. Table B-17 in Appendix B contains the flow data on Hensley Lake. Average monthly flows range from 0 to 1,400 cfs. See the Valley Floor Watershed section for downstream information.

Water Quality

There are few, if any water quality concerns in the Upper Fresno River and Chowchilla River. No 2006 Section 303(d)-listed pollutants are associated with these rivers or their tributaries, and there are no known water quality problems in this upper watershed. This is likely due to the dominance of native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed.

II.G Mariposa Watershed

General Description

The Mariposa Watershed is located on the eastern side of the Central Valley just south of the Merced River Watershed. (Figure 3-2). The Mariposa Watershed is bordered by the Merced River Watershed to the north, Ahwahnee Watershed to the east and southeast, and the San Joaquin Valley Floor Watershed to the west (Figure 3-26). The Mariposa Watershed includes 209,002 acres (327 square miles) from the headwaters of Bear Creek to the edges of the valley floor.

The climate varies with elevation, which ranges from 308 to 4,252 feet. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The major water bodies in the watershed are Bear Creek, Owens Creek, and Upper Mariposa Creek.

Land Use Patterns

Native vegetation makes up almost the entire land use (approximately 98 percent) in the watershed (Figure 3-38). Urban land uses account for less than 2 percent, and irrigated agriculture occupies less than 1 percent of the land use in the watershed. Table 3-40 includes land use acreage according to DWR land use data for the Mariposa Watershed.

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Mariposa Watershed. The beneficial uses of Bear, Owens, and Upper Mariposa Creeks are designated through the tributary rule. As such, the beneficial uses for these creeks are the same as for the San Joaquin River between Sack Dam and the Mouth of the Merced River. Table 3-33 contains the beneficial uses of the San Joaquin River between Sack Dam and the Mouth of the Merced River.

Hydrology

Bear Creek originates much lower in the Sierra Nevada than the Stanislaus, Tuolumne, or Merced Rivers (Figure 3-26). It starts in Mariposa County near the town of Bear Valley, which is at 2,050 feet elevation. Just before entering Merced County, Bear Creek flows through Bear Reservoir, a small reservoir operated by the Corps.

USGS does not have any active gauges on Bear Creek. However, CDEC has a flow gauge in the watershed at Bear Reservoir. Average monthly flows range from 0 cfs during some summer months to almost 450 cfs during winter (Table B-21 in Appendix B).

Owens Creek flows out of the Guadalupe Mountains, a small range west of the Sierra Nevada, into Owens Reservoir, eventually reaching the valley floor. Owens Creek flows into Owens Reservoir are low

year-round, but the lowest flows are from July through November (0 cfs). The highest flows occur from January through March (110 cfs; Table B-21 in Appendix B).

Table 3-40. Land Use Acreage according to DWR Land Use Data for the Mariposa Watershed

DWR Land Use Type	Acres	Percent Total
Agriculture		
Citrus and Subtropical	9	0.0
Grain and Hay	15	0.0
Pasture	256	0.1
Semi agricultural and Incidental	202	0.1
Vineyards	53	0.0
Subtotal	535	0.3
Urban		
Urban—Unclassified	948	0.5
Urban Landscape	20	0.0
Urban Residential	2,797	1.3
Commercial	88	0.0
Industrial	117	0.1
Entry Denied	91	0.0
Vacant	25	0.0
Subtotal	4,086	2.0
Native		
Native Vegetation	204,175	97.7
Water Surface	206	0.1
Subtotal	204,381	97.8
Total	**209,002**	**100.0**

Although this watershed is outside the Central Valley, there are no FRAP land use data for the Mariposa Watershed.

Upper Mariposa Creek flows south through the western Sierra Nevada, then heads southwest as it flows out of the mountains into Mariposa Reservoir. Tributaries to Upper Mariposa Creek include Agua Fria Creek and Ganns Creek. Flows into Mariposa Reservoir are intermittent, with little to no flow (0 cfs) from July through October. The highest flows occur from December through March (815 cfs; Table B-21 in Appendix B).

Water Quality

There are few, if any, water quality concerns in the Mariposa Watershed. No 2006 Section 303(d)-listed pollutants are associated with Bear, Upper Mariposa, or Owens Creeks; and there are no known water quality problems in this watershed. This is likely due to the dominance of native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed.

II.H Upper Mokelumne River–Upper Calaveras River Watershed

General Description

The Upper Mokelumne River–Upper Calaveras River Watershed (MRCR Watershed) is located on the eastern side of the Central Valley, just east of Lodi and Stockton. The MRCR Watershed is bordered to the north by the Sacramento–Amador and El Dorado Watersheds and to the south by the Tuolumne River Watershed (Figure 3-2). To the west is the North Valley Floor Watershed and to the east are Alpine County and the Sierra Nevada. The watershed is approximately 626,776 acres (979 square miles) (DWR 2005c) (Figure 3-27). The topography ranges broadly in this watershed. The minimum elevation is 203 feet, the mean elevation is 3,839 feet, and the maximum elevation is 10,371 feet (USGS 2005a). The major water features in the watershed are the Upper Calaveras River and the Upper Mokelumne River.

The climate of the MRCR Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation is the primary land use type in the MRCR Watershed (Figure 3-39). Water surface accounts for slightly over 1 percent of the land use, and irrigated agriculture accounts for less than 1 percent of the land use in the watershed. Table 3-41 identifies land use acreage according to DWR and FRAP land use data for the MRCR Watershed.

Table 3-41. Land Use Acreage according to DWR and FRAP Land Use Data for the Upper Mokelumne River–Upper Calaveras River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Pasture	1	0.0
Subtotal	1	0.0
Urban		
Urban—Unclassified	99	0.0
Urban Residential	1,418	0.2
Commercial	93	0.0
Industrial	25	0.0
Vacant	28	0.0
Subtotal	1,663	0.3

Land Use	Acres	Percent Total
Native		
Native Vegetation	200,038	31.8
Riparian Vegetation	401	0.1
Water Surface	3,696	0.6
Subtotal	204,135	32.4
FRAP Land Use Type		
Agriculture	37	0.0
Barren/Other	1,794	0.3
Conifer	213,165	33.8
Hardwood	91,531	14.5
Herbaceous	54,051	8.6
Shrub	55,265	8.8
Urban	2,263	0.4
Water	5,585	0.9
Wetland	286	0.0
Subtotal	423,977	67.3
Total	**629,776**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the MRCR Watershed. Table 3-42 lists the beneficial uses of the Mokelumne River from its source to Pardee Reservoir and the Calaveras River from its source to New Hogan Reservoir.

Table 3-42. Beneficial Uses in the Upper Mokelumne River–Upper Calaveras River Watershed

Beneficial Use	Upper Mokelumne River	Upper Calaveras River
Municipal & Domestic	E	
Irrigation		
Stock Watering		
Process		
Service Supply		
Power	E	
Rec-1*	E	E
Rec-2*	E	E
Freshwater Habitat—Warm	E	E
Freshwater Habitat—Cold	E	E
Migration—Warm	E	E
Migration—Cold		

Beneficial Use	Upper Mokelumne River	Upper Calaveras River
Spawning—Warm	E	E
Spawning—Cold	E	E
Wildlife Habitat	E	E
Navigation		

E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The Upper Calaveras River drains east to west in Calaveras County (Figure 3-27). The Upper Calaveras River flows into New Hogan Reservoir (which is operated by the Corps), drains out of the base of the reservoir, and meanders westward by the city of Stockton and toward the Delta. However, this analysis covers only the part of the Calaveras River that flows into New Hogan Reservoir. The outflow from the reservoir is located in the North Valley Floor Watershed and is discussed further in that section. The storage capacity of New Hogan Reservoir is 317,100 acre-feet (DWR 2005d). Monthly average flow for the Calaveras River ranges from as little as 1 cfs during the dry season to as much as 2,800 cfs during the storm season, as shown in Table B-22 in Appendix B.

The portions of the Upper Mokelumne River in this watershed are the inflow into Pardee Reservoir, the outflow to Pardee Reservoir, and the inflow to Comanche Reservoir just north of the Upper Calaveras River (Figure 3-27). The Mokelumne River outflow from Comanche Reservoir is described in the North Valley Floor Watershed. The Upper Mokelumne River follows the border between Amador and Calaveras Counties. Above Pardee Reservoir, the Mokelumne River is divided between the North Fork, the Middle Fork, and the South Fork. The South Fork is unregulated and drains into the Middle Fork; however, the North Fork and Middle Fork contain diversions and dams. The main tributaries to the North Fork Mokelumne River are Blue Creek to Deer Creek, and Bear Creek. The main reservoir on the North Fork Mokelumne River is Salt Springs Reservoir, which has a storage capacity of 141,900 acre-feet. The tributary to the Middle Fork is Forest Creek. The Middle Fork has two reservoirs above Pardee—the Middle Fork Reservoir and the Jeff Davis Reservoir. The Middle Fork Reservoir has a storage capacity of 1,740 acre-feet, and the Jeff Davis Reservoir has a storage capacity of 1,750 acre-feet. Prior to reaching Pardee Reservoir, all three forks of the Mokelumne River converge to form one inflow to the reservoir, which has a storage capacity of 197,550 acre-feet (DWR 2005d). Monthly average flow for the Mokelumne River ranges from 300 cfs during the dry season to 5,600 cfs during the storm season and is presented in Table B-22 in Appendix B.

Water Quality

Few, if any water quality concerns have been identified in the Upper Mokelumne River and Upper Calaveras River. No 2006 Section 303(d)-listed pollutants are associated with the Upper Mokelumne River or Upper Calaveras River. This is likely due to the dominance of native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed. No known water quality problems are associated with these rivers.

II.I Merced River Watershed

General Description

The Merced River drains an approximately 816,640-acre (1,276-square mile) watershed on the western slope of the Sierra Nevada in the southern portion of California's Central Valley (Figure 3-2). Elevations in the basin range from 13,000 feet in Yosemite National Park to approximately 338 feet near Merced Falls (USGS 2005a). The Upper Merced River Watershed is bordered by the Tuolumne River Watershed to the north; the Mariposa, Fresno River, and San Joaquin River Watersheds to the south; the Valley Floor Watershed on the west; and the Tuolumne and San Joaquin River Watersheds on the east (Figure 3-28). Major water bodies include the Merced River and Lake McClure.

The climate of the Merced River Watershed is highly variable because of the large range in elevation. At the lower elevations around Lake McClure, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

The primary land use in the upper Merced River Watershed is native vegetation, accounting for more than 90 percent of the watershed (Figure 3-40). Very little irrigated agriculture exists in the watershed, accounting for less than 1 percent of the total land use acres. Table 3-43 shows land use acreage according to DWR and FRAP land use data for the upper Merced River Watershed.

Table 3-43. Land Use Acreage according to DWR and FRAP Land Use Data for the Merced River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	30	0.0
Pasture	2,471	0.4
Semi agricultural and Incidental	111	0.0
Vineyards	7	0.0
Subtotal	2,619	0.4
Urban		
Urban—Unclassified	250	0.0
Urban Landscape	392	0.1
Urban Residential	8,417	1.2
Commercial	194	0.0
Industrial	36	0.0
Subtotal	9,289	1.3

Land Use	Acres	Percent Total
Native		
Native Vegetation	583,543	83.0
Riparian Vegetation	344	0.0
Water Surface	6,254	0.9
Subtotal	590,141	83.9
FRAP Land Use Type		
Barren/Other	26,913	3.8
Conifer	68,026	9.7
Hardwood	877	0.1
Herbaceous	22	0.0
Shrub	2,809	0.4
Water	1,103	0.2
Wetland	1,488	0.2
Subtotal	101,238	14.4
Total	**703,287**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Merced River Watershed. Table 3-44 lists the beneficial uses of the Merced River upstream of McSwain Dam.

Table 3-44. Beneficial Uses in the Merced River Watershed

Beneficial Uses	Merced River (upstream of McSwain Dam)
Municipal & Domestic	P
Irrigation	E
Stock Watering	
Process	
Service Supply	
Power	E
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	
Migration—Cold	
Spawning—Warm	
Spawning—Cold	
Wildlife Habitat	E
Navigation	

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The principal tributaries of the South Fork Merced River include Merced Peak Fork, Lyell Fork, Triple Peak Fork, and Red Peak Fork; and Echo, Sunrise, Illilouette, Tenaya, Yosemite, Bridalveil, Cascade, Grouse, Avalanche, Indian, and Crane Creeks (Figure 3-28). The Merced River descends 8,000 feet from its headwaters through glacially carved canyons along a 24-mile path. When it enters Yosemite Valley, the river flows in a shallow channel approximately 100–300 feet wide in most places. Leaving the valley, the river winds through the narrow, steep-sided Merced River gorge at a gradient of 70 feet per mile.

The South Fork Merced River flows westward from its headwaters at about 10,500 feet elevation down to 3,500 feet at its confluence with the Merced River. Tributaries of the South Fork include Chilnualna Creek, Big Creek, Alder Creek, and Bishop Creek (NPS 2005).

Exchequer Dam forms Lake McClure, the largest reservoir on the Merced River, with a capacity of 1,046,000 acre-feet and a watershed of approximately 1,037 square miles. Downstream of Lake McClure, McSwain Dam forms Lake McSwain. Monthly average flows of the Merced River range from approximately 1 to approximately 8,000 cfs. Table B-23 in Appendix B contains minimum, mean, and maximum flows recorded at the Merced River inflow into McClure Reservoir from 1995 to 2004.

The Merced River is listed as a Wild and Scenic River under the Wild and Scenic River Act, which is intended to protect designated rivers from degradation. The designated area begins at its source (including Red Peak Fork, Merced Peak Fork, Triple Peak Fork, and Lyle Fork) in Yosemite National Park and extends to a point 300 feet upstream of the confluence with Bear Creek. The South Fork designation begins at its source in Yosemite National Park and extends to the confluence with the mainstem.

Water Quality

There are few, if any water quality concerns in the upper Merced River Watershed. No Section 303(d)-listed pollutants are associated with the upper Merced River or its tributaries. This is likely due to the dominance of native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed. However, it is important to note that downstream Merced River water quality is impaired for three pollutants. See the San Joaquin Valley Floor Watershed for more information.

II.J North Valley Floor Watershed

General Description

The North Valley Floor Watershed (NVF Watershed) is located east of the Delta in the Central Valley and covers approximately 571,000 acres (892 square miles) from the Sierra Nevada foothills to the eastern edge of the Delta (Figure 3-2). The NVF Watershed lies mostly within San Joaquin County, although the eastern edge extends (from north to south) into Amador, Calaveras, and Stanislaus Counties (Figure 3-29). The elevation in this watershed ranges from -3 to 2,582 feet.

The climate of the NVF Watershed is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. The weather conditions are somewhat more moderate than the rest of the Central Valley because of the effect of ocean air on the weather in the Delta. The winter snowpack in the Sierra Nevada, which accumulates above 5,000 feet elevation (outside of this watershed), supplies much of the water in the basin. Some small drainages, however, do not extend into the mountains.

The Mokelumne River and Calaveras River are the two largest watersheds in the NVF Watershed. Comanche Reservoir and Pardee Reservoir are located on the Mokelumne River, and New Hogan Reservoir is located on the Calaveras River. Additional details about the larger waterways in the NVF Watershed are provided in the hydrology section below.

Land Use Patterns

Irrigated agriculture accounts for more than one-third of the land use in the NVF Watershed (Figure 3-41). Urban land use accounts for slightly more than 5 percent of the land use. Table 3-45 contains land use acreage according to DWR and FRAP land use data for the NVF watershed.

Table 3-45. Land Use Acreage according to DWR and FRAP Land Use Data for the North Valley Floor Watershed

Land Use	Acres	Percent Total
DWR Land Use Types		
Agriculture		
Citrus and Subtropical	58	0.0
Deciduous Fruits and Nuts	51,692	9.1
Field Crops	22,371	3.9
Grain and Hay	31,120	5.5
Idle	6,233	1.1
Pasture	32,557	5.7
Rice	2,963	0.5
Semi agricultural and Incidental	4,466	0.8
Truck, Nursery, and Berry Crops	22,301	3.9
Vineyards	61,895	10.8
Subtotal	235,656	41.3

Land Use	Acres	Percent Total
Urban		
Urban—Unclassified	27,258	4.8
Urban Landscape	1,689	0.3
Urban Residential	3,559	0.6
Commercial	734	0.1
Industrial	2,825	0.5
Vacant	3,922	0.7
Subtotal	39,987	7.0
Native		
Native Vegetation	167,613	29.4
Barren and Wasteland	11	0.0
Riparian Vegetation	966	0.2
Water Surface	7,055	1.2
Subtotal	175,645	30.8
FRAP Land Use Types		
Agriculture	762	0.1
Barren/Other	280	0.0
Conifer	7,975	1.4
Hardwood	34,460	6.0
Herbaceous	70,008	12.3
Shrub	2,157	0.4
Urban	274	0.0
Water	3,793	0.7
Subtotal	119,709	21.0
Total	**570,998**	**100**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the NVF Watershed. Table 3-46 lists the beneficial uses of Comanche Reservoir, the lower Mokelumne River (from Camanche Dam to the Delta), and the Calaveras River from New Hogan Reservoir to the Delta.

Table 3-46. Beneficial Uses in the North Valley Floor Watershed

Beneficial Uses	Comanche Reservoir	Lower Mokelumne River	Lower Calaveras River
Municipal & Domestic	E		E
Irrigation	E	E	E
Stock Watering	E	E	E
Process			P
Service Supply			P

Beneficial Uses	Comanche Reservoir	Lower Mokelumne River	Lower Calaveras River
Power			
Rec-1*	E	E	E
Rec-2*	E	E	E
Freshwater Habitat—Warm	E	E	E
Freshwater Habitat—Cold	E	E	E
Migration—Warm	E	E	E
Migration—Cold		E	E
Spawning—Warm	E	E	E
Spawning—Cold	E	E	E
Wildlife Habitat	E	E	E
Navigation			

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The Mokelumne River is the largest river in the NVF Watershed. The lower Mokelumne River extends 28 miles from Camanche Dam to the Delta. The portion of the river in the NVF Watershed includes Comanche Reservoir and extends close to the Delta, approximately 7 miles upstream of the confluence with the Cosumnes River (Figure 3-29). Comanche Reservoir is the largest reservoir in the Mokelumne River watershed, with a capacity of 430,800 acre-feet. The East Bay Municipal Utility District (EBMUD) owns and operates the Comanche Reservoir, as well as Pardee Reservoir, which is upstream of Comanche Reservoir. EBMUD withdraws water from Comanche Reservoir and Pardee Reservoir via pipelines. Minimum instream flows are required below Comanche Reservoir to protect downstream beneficial uses in the Mokelumne River.

Monthly average releases from Comanche Reservoir vary between approximately 150 and 5,000 cfs (Table B-24 in Appendix B). Average releases are approximately 1,000 cfs during winter and spring and taper to approximately 300 cfs during fall. Flows downstream at Woodbridge (just northwest of the City of Lodi) are considerably lower, partly because of the diversions to the Woodbridge Canal at Lodi Lake.

New Hogan Reservoir, which is upstream of the NVF Watershed and has a capacity of 317,100 acre-feet, is the largest reservoir in the Calaveras River watershed and is operated by the Corps. The Calaveras River runs east to west through the middle of the NVF Watershed. The portion of the Calaveras River in the NVF Watershed extends from Jenny Lind Road (about 7 miles downstream of New Hogan Reservoir) to the Delta near Stockton. The monthly average releases from New Hogan Reservoir vary from

approximately 10 to 3,100 cfs, with average flows from spring through fall staying at approximately 100–200 cfs (Table B-22 in Appendix B).

Mormon and Walker Sloughs are small tributaries to the Delta. They have similar water quality problems that are associated with their proximity to the Stockton urban area.

Mormon Slough originates as a diversion from the Calaveras River at Bellota. It passes through Stockton and connects to the southern edge of the Turning Basin. Two sections of Mormon Slough have water quality issues. Commerce Street is located near the boundary between the Delta-Carbona Watershed and NVF Watershed, and it is the dividing line for the two impaired sections of Mormon Slough. The downstream portion, from Commerce Street to the Turning Basin, is included in the Delta-Carbona Watershed, and the upstream portion is included in the NVF Watershed.

Walker Slough is predominantly in the NVF Watershed although it extends into the Delta-Carbona Watershed. Walker Slough is a small section of channel about 2 miles long that is connected to Duck Creek at its upstream end and French Camp Slough at its downstream end. It is located south of Mormon Slough near the southern edge of Stockton.

Little Johns Creek is a small drainage that connects to French Camp Slough and the Delta. Little Johns Creek is not considered to have significant water quality problems, but some of its tributaries have water quality issues that are associated with their proximity to dairies. These small tributaries are:

- Lone Tree Creek—Lone Tree Creek runs along the southern edge of the NVF Watershed, with some small sections falling in the San Joaquin Valley Floor Watershed. Lone Tree Creek is a direct tributary to Little Johns Creek
- Temple Creek—Temple Creek is north of Lone Tree Creek and is a small tributary to Lone Tree Creek.
- Avena Drain—Avena Drain is also a tributary to Lone Tree Creek and is located between Lone Tree Creek and Temple Creek. Its main source of inflow is agricultural drainage and storm runoff.

Water Quality

Water quality data from several studies and monitoring locations were evaluated to identify potential water quality issues in the NVF Watershed (references are listed in Table 3-47). Data indicate that chlorpyrifos, diazinon, permethrin, and DDT are frequently present in one or more water bodies in concentrations that exceed water quality objectives (see Appendix C for water quality objectives).

The 2006 Section 303(d) list indicates that most of the Delta has elevated levels of chlorpyrifos and diazinon. During the past 10 years, however, the use of diazinon and chlorpyrifos in the NVF Watershed has decreased substantially (Kratzer 2002). The concentration of these pesticides in the rivers also has decreased (Central Valley Water Board 2004a). See Table 3-47 for the potential sources of these contaminants.

The Smith Canal, which is located in the urbanized environment of the City of Stockton and drains into the San Joaquin River, receives the majority of urban runoff from the City of Stockton. The Smith Canal is listed as being impaired for organophosphate pesticides, low DO, and pathogens. Because the impairments are a result of urban runoff and not irrigated agriculture, the Smith Canal is not included in Table 3-47.

The 2006 Section 303(d) list indicates that most of the Delta has elevated levels of DDT. There is a lack of data for DDT concentrations in the water column. DDT is a hydrophobic organochlorine pesticide that is extremely resilient in the environment and tends to bind to sediment. Thus DDT and its breakdown products, DDD and DDE, are typically found in the bed sediment of the river. DDT, DDD, and DDE are legacy pesticides that are no longer used. Data indicate that DDT, DDD, and DDE are still present in the NVF Watershed (Central Valley Water Board 2007a).

Table 3-47. Known Agricultural Contaminants and Conditions That Affect Water Quality in the North Valley Floor Watershed

Parameter	Potential Agricultural Sources/ Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Pesticide used to protect agricultural crops	1, 2, 3, 4
Diazinon	Pesticide used to protect agricultural crops	1, 2, 3, 4
Diuron	Pesticide used to protect agricultural crops	1
Dieldrin	Pesticide used to protect agricultural crops	1
Carbofuran	Pesticide used to protect agricultural crops	1
Methyl parathion	Pesticide used to protect agricultural crops	1
Azinphos-methyl	Pesticide used to protect agricultural crops	1
Dimethoate	Pesticide used to protect agricultural crops	1
Cypermethrin, total	Pesticide used to protect agricultural crops	1
Permethrin-1	Pesticide used to protect agricultural crops	1
Permethrin-2	Pesticide used to protect agricultural crops	1
Cyhalthrin, lambodia, total	Pesticide used to protect agricultural crops	1
DDT	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDD	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDE	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
Copper	Naturally occurring metal that is used as a pesticide	
Arsenic	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Boron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	4
Nickel	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Bacteria	Likely a result of animal confinement facilities land application of waste	1
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands may be connected to low DO.	1
EC	Factors contributing to high EC may involve elevated levels of salt on irrigated land.	1
pH	Factors contributing to high pH are under investigation.	1

Parameter	Potential Agricultural Sources/ Contribution to Water Quality Impairment	Sources
Toxicity (minnow, flea, algae, sediment)	Toxicity identification evaluations (TIEs) strongly point to organophosphate insecticides (e.g., chlorpyrifos and diazinon) as the cause of much of the observed water toxicity. TIEs also indicate that bifenthrin and lambda-cyhalothrin are associated with much of the observed sediment toxicity in the North Valley Floor Watershed.	1, 5

Sources:

1 Central Valley Water Board 2007a.
2 Kratzer et al. 2002.
3 Zamora et al. 2003.
4 USGS 2005b.
5 Weston et al. In Press.

Note: Water bodies that are impacted from one or more of the contaminants listed in this table include Bear Creek at Alpine Road, Calaveras River at Pezzi Road, Delta Drain—Terminous Tract off Glascock Road, Delta Drain—Terminous Tract off Guard Road, Drain to Brack Drive at Woodbridge Road, Duck Creek at Highway 4, French Camp Slough at Airport Way, Little John Creek at Newcastle Road, Little John Creek at Jack Tone Road, Lone Tree Creek at Bernnan Road, Lone Tree Creek at Jack Tone Road, Lone Tree Creek at Newcastle Road, Mokelumne River at Bruella Road, Mormon Slough at Jack Tone Road, Pixley Slough at Eightmile Road, Potato Slough at Highway 12, Drain 12 at French Camp Road, Drain 14 at Lone Tree Creek, Drain to Pixley Slough at Davis Road, Pixley Slough at Ham Lane, Sweet Lateral, Unnamed Slough to Lone Tree Creek at Jack Tone Road, and Unnamed Slough at Wildwood Road.

In recent years, pyrethroids have replaced some organophosphate use. Pyrethroids tend to bind with organic material and may be more likely to be present in sediment than in water (ESJWQC 2004). Total cypermethrin, cyhalthrin, permethrin-1, and permethrin-2 have been found in the NVF Watershed in elevated concentrations (Central Valley Water Board 2007a). Table 3-47 describes the potential sources of these pesticides.

Other pesticides that are used to protect agricultural crops but have been found to be problematic to water quality include azinphos-methyl, dieldrin, carbofuran, methyl parathion, dimethoate, and diuron (Central Valley Water Board 2007a, Kratzer, et al. 2002b, Zamora et al. 2003, USGS 2005b). Copper, a naturally occurring metal that is used as a pesticide, has been found in elevated concentrations in the NVF Watershed. In addition to pesticides, naturally occurring metals can be mobilized and transported to surface water from irrigation return flows. Arsenic, boron, and nickel have been found in elevated concentrations in the NFV Watershed (Central Valley Water Board 2007a, USGS 2005b).

Fluctuating levels of pH along with elevated levels of EC and low levels of DO have been found in the NFV Watershed. Factors contributing to fluctuating pH are still under investigation. Elevated levels of EC can be associated with agricultural return flows. Low DO has been associated with nutrients from agricultural return flows (Central Valley Water Board 2007a).

Toxicity tests and TIEs were performed for ILRP monitoring in an attempt to identify the causes of water toxicity in the test organisms. TIEs generally were performed on the water samples that exceeded 50 percent mortality. Toxicity was found to affect algae growth, the water flea, and the fathead minnow. The results indicated that non-polar organics such as organophosphate insecticides (e.g., chlorpyrifos, diazinon, and parathion methyl) are causing the toxicity problem in the NVF Watershed (see Table 3-47) (Central Valley Water Board 2007a). In addition, an independent study found that bifenthrin and Lambda-cyhalothrin are associated with much of the observed sediment toxicity (Weston et al. In Press).

II.K Stanislaus River Watershed

General Description

The Stanislaus River Watershed is located on the eastern side of the Central Valley, just east of the City of Ripon (Figure 3-2). The upper Stanislaus River forms the northern boundary of Stanislaus and Tuolumne Counties and flows near the cities of Ripon, Riverbank, and Oakdale. It drains an area of about 638,080 acres (997 square miles) from its source to Knights Ferry. Elevations range from 180 to 11,365 feet (USGS 2005a) (Figure 3-30). The upper Stanislaus River is the major water body in the watershed; many small drainages supply flow to the river.

The climate of the Stanislaus River Watershed is highly variable because of the wide range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation is the primary land use in the upper Stanislaus River Watershed (Figure 3-42). Water accounts for almost 3 percent of the land use. Very little irrigated agriculture is located in this watershed. Table 3-48 lists land use acreage according to DWR and FRAP land use data for the upper Stanislaus River Watershed.

Table 3-48. Land Use Acreage according to DWR and FRAP Land Use Data for the Stanislaus River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	8	0.0
Pasture	410	0.1
Semi agricultural and Incidental	117	0.0
Truck, Nursery, and Berry Crops	0.3	0.0
Vineyards	5	0.0
Subtotal	540	0.1
Urban		
Urban—Unclassified	703	0.1
Residential	2,553	0.4
Commercial	512	0.1
Industrial	299	0.0
Vacant	146	0.0
Subtotal	4,213	0.7

Land Use	Acres	Percent Total
Native		
Native Vegetation	501,410	78.6
Riparian Vegetation	230	0.0
Water Surface	11,701	1.8
Subtotal	513,341	80.5
FRAP Land Use Type		
Agriculture	156	0.0
Barren/Other	1,163	0.2
Conifer	39,831	6.2
Hardwood	33,489	5.2
Herbaceous	20,375	3.2
Shrub	16,001	2.5
Urban	2,195	0.3
Water	6,641	1.0
Wetland	131	0.0
Subtotal	119,982	18.8
Total	**638,076**	**100.0**

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the upper Stanislaus River Watershed. Table 3-49 lists the beneficial uses of the Stanislaus River from its source to Tulloch Reservoir.

Table 3-49. Beneficial Uses in the Stanislaus River Watershed

Beneficial Uses	Upper Stanislaus River (from source to Tulloch Reservoir)
Municipal & Domestic	E, P
Irrigation	E
Stock Watering	E
Process	
Service Supply	
Power	E
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	
Migration—Cold	
Spawning—Warm	
Spawning—Cold	

Beneficial Uses	Upper Stanislaus River (from source to Tulloch Reservoir)
Wildlife Habitat	E
Navigation	

P = Potential, E = Existing.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The largest reservoir in the Stanislaus River Watershed is New Melones, with a capacity of 2,420,000 acre-feet. Reclamation operates New Melones Reservoir on the Stanislaus River, east of Oakdale, to provide water for agricultural, municipal, and industrial uses. New Melones is fed by the Upper Stanislaus River Watershed (approximately 900 square miles) (Figure 3-30). Some of the larger water storage facilities in the upper watershed are New Spicer Meadow Reservoir, which is along Highland Creek; Beardsley Lake and Donnell Lake along the Middle Fork Stanislaus River; and Pinecrest Lake along the South Fork Stanislaus River. The highest mean flows into New Melones occur in May and June, at 3,109 and 2,836 cfs, respectively. The lowest mean inflow occurs in November at 652 cfs. For minimum, mean, and maximum monthly average flows, see Table B-26 in Appendix B.

Water Quality

There are few, if any, water quality concerns in the upper Stanislaus River Watershed. No Section 303(d)-listed pollutants are associated with the Upper Stanislaus River or its tributaries. This is likely due to the dominance of native vegetation and low occurrence of urban, industrial, irrigated agriculture, or other developed land uses in this watershed. However, it is important to note that Stanislaus River water quality is degraded downstream of Tulloch Reservoir; and the river is impaired for four different pollutants. See the San Joaquin Valley Floor Watershed description for further information.

II.L Tuolumne River Watershed

General Description

The Tuolumne River Watershed covers approximately 1,034,000 acres (1,116 square miles) from the headwaters of the Tuolumne River high in the Sierra Nevada down to the San Joaquin Valley floor (see Figure 3-3). The upper Tuolumne River Watershed extends as far downstream as the Tuolumne River at La Grange, which is approximately 5 miles downstream of Don Pedro Reservoir. The Tuolumne River Watershed lies almost entirely within Tuolumne County. Its western edge follows the Stanislaus County line, its southern edge follows the Mariposa County line, and its eastern edge follows the Mono County line (Figure 3-31). The elevation in this watershed ranges from 177 to 13,031 feet. The major water bodies include the Tuolumne River, the Clavey River, and Don Pedro Reservoir.

The climate of the Tuolumne River watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation and riparian vegetation account for almost all of the land use in the upper Tuolumne River Watershed (Figure 3-43). Water surface accounts for slightly over 2 percent of the land type. Irrigated agriculture represents less than 1 percent of the land use in the watershed. Table 3-50 includes land use acreage according to DWR land use data for the upper Tuolumne River Watershed.

Table 3-50. Land Use Acreage according to DWR Land Use Data for the Tuolumne River Watershed

Land Use	Acres	Percent Total
Agriculture		
Deciduous Fruits and Nuts	253	0.0
Pasture	738	0.1
Truck, Nursery, and Berry Crops	25	0.0
Semi agricultural and Incidental	262	0.0
Subtotal	1,278	0.1
Urban		
Urban—Unclassified	3148	0.3
Urban Landscape	488	0.0
Urban Residential	13,835	1.3
Commercial	1,092	0.1
Industrial	897	0.1
Vacant	463	0.0
Subtotal	19,923	1.9

Land Use	Acres	Percent Total
Native		
Native Vegetation	990,086	95.8
Barren and Wasteland	14	0.0
Riparian Vegetation	633	0.1
Water Surface	22,026	2.1
Subtotal	1,012,759	97.9
Total	**1,033,961**	**100.0**

Although this watershed is outside of the Central Valley, there are no FRAP land use data for the Tuolumne River Watershed.

Basin Plan Status

The Sacramento and San Joaquin Rivers Basin Plan (Central Valley Water Board 2007b) describes beneficial uses for waters in the Tuolumne River Watershed. Table 3-51 lists the beneficial uses of the Tuolumne River from its source to Don Pedro Reservoir.

Table 3-51. Beneficial Uses in the Tuolumne River Watershed

Beneficial Uses	Tuolumne River (from Source to Don Pedro Reservoir)
Municipal & Domestic	E
Irrigation	E
Stock Watering	E
Process	
Service Supply	
Power	E
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E
Migration—Warm	
Migration—Cold	
Spawning—Warm	
Spawning—Cold	
Wildlife Habitat	E
Navigation	

P = Potential, E = Existing, U = Undefined.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking,

Beneficial Uses	Tuolumne River (from Source to Don Pedro Reservoir)
beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.	

Source: Central Valley Water Board 2007b.

Hydrology

The largest reservoir in the Tuolumne River watershed is Don Pedro Reservoir, with a capacity of 2,030,000 acre-feet and a watershed of approximately 1,500 square miles. It provides flood control for the Tuolumne River, irrigation water supply for TID and Modesto ID, and domestic water supply for the Modesto area. Don Pedro is jointly operated by TID and Modesto ID.

The Tuolumne River originates in Yosemite National Park in Tuolumne Meadows, at the confluence of the Dana Fork and the Lyell Fork (Figure 3-31). Downstream of Tuolumne Meadows, the water flows into Hetch Hetchy Reservoir, owned by the City and County of San Francisco. Hetch Hetchy is the second largest reservoir on the Tuolumne River, with a capacity of 360,400 acre-feet. Both Hetch Hetchy and Lake Eleanor, a smaller reservoir with a storage capacity of 26,110 acre-feet, are located in Yosemite National Park. The Tuolumne River is listed as a Wild and Scenic River under the Wild and Scenic River Act, which was passed to protect designated rivers from degradation. The designated area is from its source to Don Pedro Reservoir.

Major tributaries to the Tuolumne River upstream of Don Pedro Reservoir include the North, South, and Middle Forks of the Tuolumne River; Cherry Creek; and the Clavey River. Cherry Lake is another large reservoir in the Tuolumne River watershed. It has a capacity of 274,300 acre-feet and is located on Cherry Creek. Some water from the South Fork of the Stanislaus River can enter the Tuolumne River watershed via the Tuolumne Canal for agricultural diversion near Long Barn.

The Clavey River is one of the longest undammed rivers in the Sierra Nevada. The Clavey flows from its source in alpine lakes in the Emigrant Wilderness (north of Yosemite National Park) for 47 miles to its confluence with the Tuolumne River.

Appendix B, Table B-27 contains the average inflow into Don Pedro Reservoir between 1995 and 2004. The values presented are the minimum, mean, and maximum of the monthly average values for data measured between 1995 and 2004. These flows are influenced primarily by rainfall, snowmelt, and operations at the upstream reservoirs. Diversion of water from the Hetch Hetchy to the Bay Area greatly influences the inflow into Don Pedro. The highest monthly average flows (up to 14,315 cfs) occur in winter and can extend through the spring snowmelt. The lowest monthly average flows (as low as 152 cfs) occur in late summer and fall.

Water Quality

Other than elevated mercury levels, there are no known water quality problems in the upper Tuolumne River Watershed. The USGS water quality database does not provide data for mercury in the water column in or near Don Pedro Reservoir. The determination of impairment was based on measurements of mercury in the tissue of predatory fish (largemouth bass). Between 1981 and 1987, 32 fish were sampled

and found to have an average methylmercury concentration of 0.54 milligram per kilogram (mg/kg) (Central Valley Water Board 2005c). This is greater than the EPA criterion of 0.3 mg methylmercury/kg for fish (EPA 2001). Mercury is known to originate from mine drainage in the upper Tuolumne River Watershed.

III. TULARE LAKE BASIN

Introduction

The **Tulare Lake Basin** encompasses a drainage area from Fresno to the southern end of the Central Valley near the Grapevine (see Figure 3-1 for watershed boundaries). For the purposes of this analysis, the Tulare Lake Basin includes 10 watersheds: the (A) Kings River, (B) Kaweah River, (C) Kern River, (D) South Valley Floor, (E) Grapevine, (F) Coast Range, (G) Fellows, (H) Temblor Valley, (I) Sunflower Valley, and (J) Southern Sierra Watersheds.

Much of the topography within the Tulare Lake Basin is dominated by steep river canyons and large mountains, typical of the Sierra Nevada and Coast Ranges. The basin encompasses several land holdings, including Sequoia National Park, Sequoia National Forest, the Golden Trout Wilderness Area, and the Tule Indian Reservation. The basin also includes two Superfund cleanup sites, the Coalinga Asbestos Mine and the Atlas Asbestos Mine.

The Tulare Lake Basin encompasses approximately 10.7 million acres. Of this amount, 3.6 million acres are classified as agricultural. The vast majority of this agricultural land is located in the South Valley Floor Watershed (3.5 million acres), largely due to topography. In comparison with other watersheds in the Tulare Lake Basin, the South Valley Floor Watershed is relatively flat. Consequently, the bulk of water quality concerns related to the Tulare Lake Basin involve agricultural operations and agricultural return flows in the South Valley Floor Watershed.

Due to the amount of land in the Tulare Lake Basin that is in the Sierra Nevada and the Coast Ranges, most of the basin is dominated by native vegetation and includes little urban development. In the upper watershed areas, irrigated agriculture accounts for less than 2 percent of land uses in the Kings River, Kaweah River, Kern River, Grapevine, Coast Range, Sunflower Valley, and Southern Sierra Watersheds—with just slightly more in the Temblor Watershed (3.3 percent). There is no agriculture in the Fellows Watershed. The primary crop types within the Tulare Lake Basin as a whole are grain and hay crops, pasture, and deciduous fruits and nuts. The primary crop types within the South Valley Floor Watershed are field crops, followed by deciduous fruits and nuts, vineyards, pasture, and grain and hay.

Overview of Agricultural Impacts on Surface Water in the Tulare Lake Basin Watershed

In general, agricultural operations have a greater impact on surface water in the Central Valley between the Fresno area and the Tehachapi Mountains. This is primarily due to the rich fertile valley topography allowing for much larger agricultural operations.

Section 303d water quality concerns within the Tulare Lake Basin are limited to the South Valley Floor Watershed. None of the other watersheds include water bodies with Section 303(d)-listed pollutants, and all physical parameters such as EC, pH, temperature, and turbidity are generally within Basin Plan standards. Factors such as selenium and sedimentation are believed to be naturally occurring (with the exception of the South Valley Floor Watershed). However, some water bodies have water quality concerns that are not reflected in the Section 303(d) list, such as those for which there are no quantitative criteria to measure against or for which there is uncertainty regarding the magnitude or frequency of exceeding a criteria that would result in nonsupport of a particular beneficial use.

The **South Valley Floor Watershed** is the largest watershed within the Tulare Lake Basin, at approximately 5,270,363 acres (about 8,235 square miles). The watershed is located in the southern Central Valley and is bounded to the north by the San Joaquin River, to the south by the Tehachapi Mountains, on the west by the Coast Ranges, and on the east by the Sierra Nevada. As noted, the South Valley Floor Watershed is relatively flat compared to the surrounding watersheds. Agriculture is the primary land use type in the watershed, encompassing approximately 66 percent (3,485,592 acres) of the total land area.

Surface water in the South Valley Floor Watershed is not sufficient to support land uses in the watershed, resulting in a large proportion of water being imported from other locations. The Friant-Kern Canal, the San Luis Canal/California Aqueduct System, and the Cross-Valley Canal are major water delivery facilities that have dramatically altered the way water is managed in the South Valley Floor Watershed; water is moved from one end of the valley to the next as needed. The Tulare Lake Basin is hydrologically closed for all intents and purposes. Because of the intensive water development that has occurred in the watershed, very few channels are not specifically maintained as water delivery features and there is very little monitoring or characterization of the watershed's water quality.

During the irrigation season, water bodies in the South Valley Floor Watershed are dominated by agricultural return flows, which often transport pesticides to the various east side and west side drainages. In addition, pesticides that are applied during the dormant spray season, which typically occurs between November and January, can be transported from fields during rainfall events. Data indicate that chlorpyrifos, azinphos-methyl, dimethoate, malathion, thiobencarb, esfenvalerate, cypermethrin, toxephene, DDE, DDT, and DDD are present in concentrations that exceed water quality objectives. Copper also has been detected at multiple locations in the South Valley Floor Watershed. Copper is a naturally occurring metal that is also used as a pesticide. Other metals such as arsenic, cadmium, boron, lead, molybdenum, manganese, zinc, iron, and selenium have been detected at elevated levels and are likely mobilized by agricultural return flows.

Many of the creeks and drainages located in the South Valley Floor Watershed contain low DO. Factors contributing to low DO are currently under investigation but are possibly associated with nutrient loads from irrigated agriculture. In addition, many of the creeks in the watershed experience fluctuating levels of pH and elevated levels of EC. Toxicity tests indicate that non-polar organics are causing toxicity problems in the South Valley Floor Watershed. Non-polar organics, including chlorpyrifos, diazinon, dimethoate, disulfton, diuron, cyfluthrin, dioxathion, simazine, and atrazine, were found in some of the samples tested and were identified as likely or potential causes of observed toxicity.

A detailed analysis of the impacts on surface water in the Tulare Lake Basin is broken up by watersheds and described below.

III.A Kings River Watershed

General Description

The Kings River Watershed is located on the eastern side of the Central Valley near the south end of the valley (Figure 3-3). The two major water features in the upper Kings River Watershed are the Kings River and Pine Flat Reservoir. Pine Flat Reservoir makes up the lower boundary of the upper Kings River Watershed. Virtually all irrigated agriculture is located downstream of Pine Flat Reservoir. Elevations in the watershed vary from 832 to 11,599 feet, with an average elevation of 6,670 feet. Note that because the release from Pine Flat Dam is in the South Valley Floor Watershed, the dam and its released waters are discussed in detail in the South Valley Floor Watershed section.

The climate of the upper Kings River Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

The majority of land use in the Kings River Watershed is made up of native vegetation (Figure 3-54). Urban land use accounts for less than 1 percent. Total irrigated agriculture also accounts for less than 1 percent. Table 3-52 shows the land use acreage for the upper Kings River Watershed according to DWR and FRAP land use data.

Table 3-52. Land Use Acreage according to DWR and FRAP Land Use Data for the Kings River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	2,560	0.2
Deciduous Fruits and Nuts	55	0.0
Field Crops	10	0.0
Grain and Hay	5	0.0
Pasture	25	0.0
Semi agricultural and Incidental	33	0.0
Truck, Nursery, and Berry Crops	7	0.0
Subtotal	2,695	0.2
Urban		
Urban—Unclassified	3	0.0
Urban Landscape	1	0.0
Urban Residential	1,032	0.1
Industrial	0.02	0.0
Vacant	0.01	0.0

Land Use	Acres	Percent Total
Subtotal	1,036	0.1
Native		
Native Vegetation	96,826	8.2
Water Surface	3,409	0.3
Subtotal	100,235	8.5
FRAP Land Use Type		
Agriculture	121	0.0
Barren/Other	235,833	19.9
Conifer	530,543	44.8
Hardwood	181,667	15.4
Herbaceous	33,902	2.9
Shrub	79,947	6.8
Urban	466	0.0
Water	12,540	1.1
Wetland	4,548	0.4
Subtotal	1,079,567	91.2
Total	**1,183,534**	**100**

Basin Plan Status

The *Water Quality Control Plan for the Tulare Lake Basin* (Tulare Lake Basin Plan) (Central Valley Water Board 2004a) describes beneficial uses for waters in the Kings River Watershed. Table 3-53 lists the beneficial uses of the Kings River (Upper North Fork, Main Fork above Kirch Flat, and Kirch Flat to Pine Flat Dam).

Table 3-53. Beneficial Uses in the Kings River Watershed

	Kings River		
Beneficial Uses	Upper North Fork	Main Fork (above Kirch Flat)	Kirch Flat to Pine Flat Dam (Pine Flat Reservoir)
Municipal & Domestic		E	
Irrigation			
Stock Watering			
Proc			
Ind			
Power	E		E
Rec-1*	E	E	E
Rec-2*	E	E	E
Freshwater Habitat—Warm	E	E	E
Freshwater Habitat—Cold	E	E	E
SPWN	E	E	

	Kings River		
Beneficial Uses	Upper North Fork	Main Fork (above Kirch Flat)	Kirch Flat to Pine Flat Dam (Pine Flat Reservoir)
Wildlife Habitat	E	E	E
RARE	E	E	
Groundwater Recharge			
Fresh Water Replenishment	E	E	E

E = Existing.

RARE = Rare, threatened, or endangered species; SPWN = Spawning, reproduction, and or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2004a.

Hydrology

The North Fork Kings River and the Main Fork Kings River flow into Pine Flat Reservoir (Figure 3-44). The many small tributaries on the North Fork of the Kings River include Dinkey Creek, Basin Creek, Patterson Creek, Weir Creek, Williams Creek, Teakettle Creek, Rancheria Creek, and Long Meadow Creek. The North Fork Kings River is a steep-sided canyon watershed; consequently, no irrigated agriculture is associated with this watershed, and these small tributaries are not discussed in detail.

At the confluence of the South Fork Kings River and the Middle Fork Kings River, the many small tributaries include Mill Flat Creek, Verplank Creek, Converse Creek, Spring Creek, Cabin Creek, Garlic Meadow Creek, Rough Creek, and Tenmile Creek. The South Fork Kings River tributaries include Lockwood Creek, Redwood Creek, and Boulder Creek—among others. The Middle Fork Kings River tributaries include Tombstone Creek, Wren Creek, Silver Creek, Crown Creek, and Crystal Creek—among others. This analysis does not discuss these small creeks in detail. The South Fork and Middle Fork Kings River also are steep-sided canyon watersheds, and there is virtually no agriculture within these watersheds. Portions of the Upper Kings River are listed as a Wild and Scenic River under the Wild and Scenic River Act, which was passed to protect designated rivers from degradation. The designated area extends from the confluence of the Middle Fork and the South Fork to a point at elevation 1,595 feet, from the Middle Fork from its headwaters at Lake Helen to its confluence with the mainstem, and from the South Fork from its headwaters at Lake 11599 to its confluence with the mainstem.

CDEC contains flow data for Kings River above Pine Flat Reservoir. Monthly average flows for the Kings River from 1997 to 2004 range from 30 to 1,000 cfs (see Table B-28 in Appendix B).

Water Quality

There are few, if any, water quality concerns in the upper Kings River Watershed. No Section 303(d)-listed pollutants are associated with the Upper Kings River. This is likely attributable to most of the upper watershed being included in the Kings Canyon National Park and the John Muir Wilderness. There is very little urbanization in the upper Kings River Watershed, and irrigated agriculture accounts for less than 1 percent of the land use. Generally, all physical parameters such as EC, pH, temperature, and turbidity are within Basin Plan standards. However, it is important to note that the Lower Kings River is listed on the 2006 Section 303(d) list as impaired for EC, molybdenum, and toxaphene. These impairments are discussed in detail in the South Valley Floor Watershed section.

III.B Kaweah River Watershed

General Description

The Kaweah River Watershed is located just south of the Kings River Watershed in the southern portion of the Central Valley (Figure 3-3). Its western boundary is defined where the foothills meet the valley floor. The upper Kaweah River Watershed is approximately 600,093 acres (about 938 square miles). The topography of the Kaweah River Watershed is similar to the Kings River Watershed. The minimum elevation is 400 feet, the average elevation is 4,080 feet, and the maximum elevation is 12,569 feet (DWR 2005c). The two major water features in the upper Kaweah River Watershed are Lake Kaweah and the Kaweah River. Because drainage from Lake Kaweah is outside of the watershed, it is discussed in the South Valley Watershed section. Figure 3-45 delineates the Kaweah River Watershed.

The climate of the Kaweah River Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Figure 3-55 illustrates the land use in the upper Kaweah River Watershed. Because this watershed is located in the higher elevations, the majority of land use is native vegetation. Urban land use accounts for less than 1 percent of the watershed. Irrigated agriculture accounts for only a small amount of the land use in the upper Kaweah River Watershed, primarily because of the watershed's topography. Total irrigated agriculture represents less than 1 percent of the watershed. Table 3-54 categorizes the land use acreage for the upper Kaweah River Watershed according to DWR and FRAP land use types.

Table 3-54. Land Use Acreage according to DWR and FRAP Land Use Data for the Kaweah River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	2,205	0.4
Deciduous Fruits and Nuts	149	0.0
Field Crops	87	0.0
Grain and Hay	5	0.0
Idle	6	0.0
Pasture	76	0.0
Semi agricultural and Incidental	49	0.0
Vineyards	37	0.0
Subtotal	2,614	0.4

Land Use	Acres	Percent Total
Urban		
Urban—Unclassified	10	0.0
Urban Landscape	5	0.0
Urban Residential	240	0.0
Commercial	0.12	0.0
Industrial	6	0.0
Vacant	7	0.0
Subtotal	268	0.0
Native		
Native Vegetation	105,288	17.5
Riparian Vegetation	21	0.0
Water Surface	43	0.0
Subtotal	105,352	17.6
FRAP Land Use Type		
Agriculture	118	0.0
Barren/Other	29,057	4.8
Conifer	132,704	22.1
Hardwood	239,916	40.0
Herbaceous	48,954	8.2
Shrub	37,621	6.3
Urban	554	0.1
Water	2,726	0.5
Wetland	208	0.0
Subtotal	491,858	82.0
Total	**600,093**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Kaweah River Watershed. Table 3-55 lists the beneficial uses of the Upper Kaweah River and Kaweah Lake.

Table 3-55. Beneficial Uses in the Kaweah River Watershed

	Kaweah River	
Beneficial Uses	Above Lake Kaweah	Lake Kaweah
Municipal & Domestic	E	
Irrigation		
Stock Watering		
Proc		
Ind		

	Kaweah River	
Beneficial Uses	Above Lake Kaweah	Lake Kaweah
Power	E	E
Rec-1*	E	E
Rec-2*	E	E
Freshwater Habitat—Warm	E	E
Freshwater Habitat—Cold	E	
SPWN	E	
Wildlife Habitat	E	E
RARE	E	
Groundwater Recharge		
Fresh Water Replenishment	E	E

E = Existing.

RARE = Rare, Threatened, or Endangered Species. SPWN = Spawning, reproduction, and or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2007b.

Hydrology

The Upper Kaweah River contains three main arms: the North, Middle, and South Forks (Figure 3-45). All three arms combine to form Lake Kaweah. Each arm of the Kaweah has many smaller tributaries. Some of the main tributaries to the North Fork Kaweah are Mankins Creek, Sheep Creek, Yucca Creek, Eshom Creek, Pierce Creek, Redwood Creek, Stoney Creek, Marble Fork, and Dorst Creek. It is important to note that the Middle Fork Kaweah also has an East Fork Kaweah branch. The Middle Fork Kaweah is by far the largest of the three arms. Some of the main tributaries that make up the Middle Fork Kaweah River include Salt Creek, the East Fork Kaweah River, Squirrel Creek, Elk Creek, Panther Creek, Dome Creek, Castle Creek, Mehrten Creek, Buck Creek, Cliff Creek, Granite Creek, and Lone Pine Creek. Some of the main tributaries that make up the South Fork Kaweah River include Gray Creek, Cinnamon Creek, Grouse Creek, Bennett Creek, Squaw Creek, Cedar Creek, Garfield Creek, and Hunter Creek. Many of these smaller tributaries are ephemeral streams, depending on the amount of snow pack or the duration of a storm.

For this analysis, only the three main arms are discussed in further detail due to the lack of data on all of the smaller tributaries. The USGS website contains flow information for various locations on the Kaweah River. However, the Middle Fork Kaweah River is the only arm that contains flows just above Lake Kaweah. The Kaweah River below Lake Kaweah is in the South Valley Floor Watershed and is further

discussed in that section. Monthly average USGS flows for the Middle Fork Kaweah River from 1985 to 1990 range from 10 to 2,000 cfs (see Table B-29 in Appendix B).

Water Quality

The Southern San Joaquin Valley Water Quality Coalition monitored four locations on the lower Kaweah River. For one sampling event, the water quality data did not indicate that agricultural contamination was present (SJVWQC 2005). However, it is important to note that these four sampling locations were downstream of Kaweah Lake and are outside of the upper Kaweah River Watershed. The State of the Watershed Report for Tulare Lake Watershed in the Water Management Initiative noted that Kaweah Basin contained elevated levels of copper, arsenic, and silver that are thought to be naturally occurring (Central Valley Water Board and CalEPA 2002). The Kaweah River is not listed on the 2006 Section 303(d) list for any impairment.

III.C Kern River Watershed

General Description

The Kern River Watershed is the second largest watershed in the Tulare Lake Basin and covers approximately 1,517,632 acres (2,371 square mile). The Kern River Watershed is bordered to the north by the Kings River Watershed, on the west by the Southern Sierra Watershed, on the east by the Sierra Nevada, and to the south by the Grapevine Watershed (Figure 3-3). The topography of the upper Kern River Watershed is similar to the Kings River and Kaweah River Watersheds and is dominated by steep river canyons and large mountains. The minimum elevation is 489 feet, the mean elevation is 6,791 feet, and the maximum elevation is 14,478 feet. Figure 3-46 shows the Kern River Watershed boundaries.

The primary water features in the upper Kern River Watershed are the Kern River, South Fork Kern River, Isabella Lake, and Kern River outflow from Isabella Lake.

The climate of the Kern River Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates above 5,000 feet elevation, supplies much of the water in this watershed.

Land Use Patterns

Figure 3-56 illustrates the land use in the upper Kern River Watershed. Urban land use accounts for a very small portion, less than 1 percent, of the land use in the upper Kern River Watershed. The total irrigated land in the watershed is also less than 1 percent of the watershed. Table 3-56 identifies land use acreage according to DWR and FRAP land use data for the upper Kern River Watershed.

Table 3-56. Land Use Acreage according to DWR and FRAP Land Use Data for the Kern River Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	69	0.0
Deciduous Fruits and Nuts	55	0.0
Field Crops	18	0.0
Grain and Hay	795	0.1
Idle	44	0.0
Pasture	2,943	0.2
Semi agricultural and Incidental	103	0.0
Truck, Nursery, and Berry Crops	693	0.0
Subtotal	4,720	0.3

Land Use	Acres	Percent Total
Urban		
Urban—classified	2,525	0.2
Urban Landscape	82	0.0
Urban Residential	3,230	0.2
Commercial	154	0.0
Industrial	57	0.0
Vacant	124	0.0
Subtotal	6,172	0.4
Native		
Native Vegetation	213,174	14.0
Riparian Vegetation	3,182	0.2
Water Surface	10,810	0.7
Subtotal	227,166	15.0
FRAP Land Use Type		
Barren/Other	110,061	7.3
Conifer	795,863	52.4
Desert	39,596	2.6
Hardwood	98,752	6.5
Herbaceous	50,865	3.4
Shrub	166,111	10.9
Urban	608	0.0
Water	2,666	0.2
Wetland	15,053	1.0
Subtotal	1,279,575	84.3
Total	**1,517,632**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Kern River Watershed. Table 3-57 lists the beneficial uses of the Kern River (above Lake Isabella, Lake Isabella, and from Lake Isabella to Kern River Powerhouse No.1).

Table 3-57. Beneficial Uses in the Kern River Watershed

	Kern River		
Beneficial Uses	Above Lake Isabella	Lake Isabella	Lake Isabella to Kern River Powerhouse No. 1
Municipal & Domestic	E		
Irrigation			
Stock Watering			
Process			
Ind			

	Kern River		
Beneficial Uses	Above Lake Isabella	Lake Isabella	Lake Isabella to Kern River Powerhouse No. 1
Power	E	E	E
Rec-1*	E	E	E
Rec-2*	E	E	E
Freshwater Habitat—Warm	E	E	E
Freshwater Habitat—Cold	E	E	E
SPWN	E		
Wildlife Habitat	E		E
RARE	E		E
Groundwater Recharge			
Freshwater Replenishment	E	E	

E = Existing.

RARE = Rare, threatened, or endangered species; SPWN = Spawning, reproduction, and/or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2004b.

Hydrology

Kern River

The headwaters of the Kern River originate in the Kings Kern Divide, from which the river travels through Kern Canyon in Sequoia National Park (Figure 3-56). The Kern River flows south, passing west of Mt. Whitney and through the Golden Trout Wilderness Area. Along its route, the Kern River has many small tributary creeks. The west side tributaries from north to south include Milestone Creek, Red Spur Creek, Chagoopa Creek, Funston Creek, Big Arroyo Creek, Rattlesnake Creek, Laurel Creek, Coyote Creek, Little Kern Lake Creek, Grasshopper Creek, Leggett Creek, Little Kern River, Freeman Creek, Needle Rock Creek, Peppermint Creek, Meadow Creek, South Creek, Tobias Creek, and Bull Run Creek. After Bull Run Creek, the Kern River becomes the North Fork arm of Isabella Lake. The east side tributaries include Tundall Creek, Wallace Creek, Whitney Creek, Rock Creek, Golden Trout Creek, Cold Creek, Nine Mile Creek, Osa Creek, Soda Creek, Rattlesnake Creek, Durrwood Creek, Brush Creek, Salmon Creek, Gold Ledge Creek, Corral Creek, Cannell Creek, and Caldwell Creek. No flow data are available for this part of the Kern River. However, downstream flow data are available and are discussed in the South Valley Floor Watershed section.

The Kern River is listed as a Wild and Scenic River under the Wild and Scenic River Act, which was passed to protect designated rivers from degradation. The designated area is the North Fork from the

Tulare-Kern County line to its headwaters in Sequoia National Park and the South Fork from its headwaters in the Inyo National Forest to the southern boundary of the Domelands Wilderness in the Sequoia National Forest.

South Fork Kern River

The headwaters of the South Fork Kern River originate just southeast of the main Kern River next to the Golden Trout Wilderness Area, from which the river travels down through the Rainshaw and Templeton Meadows (Figure 3-56). As the South Fork flows south through the South Sierra Wilderness Area, many small creeks join the river. The west side creeks from north to south include Kern Peak Stringer, Lewis Stringer, Strawberry Creek, Shaeffer Stringer, Soda Creek, Round Mt. Stringer, Snake Creek, Crag Creek, Lost Creek, Bitter Creek, Fish Creek, Trout Creek, Tibbets Creek, Manter Creek, Taylor Creek, and Bartolas Creek, after which the South Fork Kern River becomes the South Fork arm of Isabella Lake. The east side tributaries of the South Fork Kern River include Mulkey Creek, Dry Creek, Long Stringer, Monache Creek, Summit Creek, Honeybee Creek, Canebrake Creek, and Kelso Creek. Monthly average flow for the South Fork Kern River ranges from 1 cfs during the dry season to up to 1,500 cfs during the storm season and is included in Appendix B, Table B-30.

Isabella Lake, also located in Sequoia National Forest, has a storage capacity of 568,000 acre-feet (DWR 2005d). From Isabella Dam, the Kern River flows southwest into the valley floor, passes through Bakersfield, and ultimately empties into the Outlet Canal that feeds the East and West Side Canal. Once the Kern River reaches the valley floor, it is outside of the Kern River Watershed; this part of the river is a part of the South Valley Floor Watershed. Monthly average flow of the Kern River from the USGS website is shown in Appendix B, Table B-30 and ranges from 200 to 4,500 cfs. Flow at Kern River near Democrat Springs, just downstream of Isabella Dam, is the total outflow from Isabella Dam and represents the combination of inflow from the main Kern River and the South Fork Kern River.

Water Quality

There are few, if any, water quality concerns in the upper Kern River Watershed. No 2006 Section 303(d)-listed pollutants are associated with the Upper Kern River. This is likely attributable to this watershed's location primarily in the Sequoia National Park, Sequoia National Forest, and Golden Trout Wilderness Area. There is very little urban development or irrigated agriculture in this watershed. Generally, all physical parameters such as EC, pH, temperature, and turbidity are within Basin Plan standards.

III.D South Valley Floor Watershed

General Description

The South Valley Floor Watershed (SVF Watershed) is located in the southern Central Valley and is bounded to the north by the San Joaquin River and to the south by the Tehachapi Mountains (Figure 3-3). On the west are the Coast Ranges, and the Sierra Nevada are on the east. The SVF Watershed is the largest watershed in the Tulare Lake Basin, at approximately 5,270,363 acres (about 8,235 square miles). Figure 3-47 delineates the boundaries for the SVF Watershed. The general topography of the SVF Watershed is relatively flat in comparison to the surrounding watersheds. Elevation ranges from 154 feet in the lowest areas, to 4,131 feet at the base of some of the dams (USGS 2005a). The main natural water features in the SVF Watershed include the Kings River, the Kaweah River, the Tule River, the Kern River, and the west side drainages. The Friant-Kern Canal, the San Luis Canal, and the Cross-Valley Canal are major water delivery facilities that have dramatically altered the way water is managed in the SVF Watershed.

The climate is typically Mediterranean, with wet winters and dry summers. Snow may occur in the upper elevations; however, snow does not accumulate in sufficient quantities to provide additional summer flows in the SVF Watershed.

Surface water in the SVF Watershed is not sufficient to support land uses in the watershed, resulting in a large proportion of imported water from other locations. Imported surface water supplies include the San Luis Canal/California Aqueduct System, Friant-Kern Canal, and the DMC. The State Water Project (SWP), through the San Luis Reservoir, delivers an average of 1,200,000 acre-feet of surface water annually to the Tulare Lake Basin. Reclamation delivers a combined 2,700,000 acre-feet to the Tulare Basin, during normal years, from the CVP via Mendota Pool, the Friant-Kern Canal, and San Luis Canal of the CVP/SWP San Luis Joint-Use Facilities (DWR 2005b). The majority of this water is used in the SVF Watershed.

Land Use Patterns

Figure 3-57 illustrates that agriculture is the largest land use type in the SVF Watershed, encompassing approximately 67 percent of the total land area. Native vegetation encompasses approximately 25 percent of the total acreage in the area. Urban-land uses represent about 6 percent. Table 3-58 shows land use acreage according to DWR and FRAP land use data for the SVF Watershed.

Table 3-58. Land Use Acreage according to DWR and FRAP Land Use Data for the South Valley Floor Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Citrus and Subtropical	218,174	4.1
Deciduous Fruits and Nuts	524,082	9.9
Field Crops	1,199,547	22.8
Grain and Hay	343,311	6.5

Land Use	Acres	Percent Total
Idle	43,986	0.8
Pasture	394,170	7.5
Rice	14	0.0
Semi agricultural and Incidental	65,585	1.2
Truck, Nursery, and Berry Crops	285,520	5.4
Vineyards	454,367	8.6
Subtotal	3,528,756	67.0
Urban		
Urban—Unclassified	175,777	3.3
Urban Landscape	13,718	0.3
Urban Residential	36,778	0.7
Commercial	10,602	0.2
Industrial	60,789	1.2
Vacant	47,990	0.9
Subtotal	345,654	6.6
Native		
Native Vegetation	1,082,402	20.5
Barren and Wasteland	56	0.0
Riparian Vegetation	41,848	0.8
Water Surface	59,292	1.1
Subtotal	1,183,598	22.5
FRAP Land Use Type		
Agriculture	821	0.0
Desert	29,424	0.6
Hardwood	1,183	0.0
Herbaceous	171,946	3.3
Shrub	1,224	0.0
Urban	7,490	0.1
Water	272	0.0
Subtotal	212,360	4.0
Total	**5,270,368**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004a) describes beneficial uses for waters in the SVF Watershed. Table 3-59 lists the beneficial uses of the Lower Kings River (Pine Flat Dam to Stinson and Empire Weirs), Lower Kaweah River (below Lake Kaweah), Lower Tule River (below Lake Success), Lower Kern River (below Southern California Edison's Kern River Powerhouse No. 1), west side streams, and valley floor waters.

Table 3-59. Beneficial Uses in the South Valley Floor Watershed

Beneficial Uses	Kings River (Pine Flat Dam to Stinson and Empire Weirs)	Kaweah River (below Lake Kaweah)	Tule River (below Lake Success)	Kern River (below KR-1)	West Side Streams	Valley Floor Waters
Municipal & Domestic	E	E	E	E		
Agriculture	E	E	E	E	E	E
Industrial Service		E	E	E	E	E
Industrial Process	E	E	E	E	E	E
Hydropower Generation	E			E		
Water Contact Recreation	E	E	E	E	E	E
Non-Contact Water Recreation	E	E	E	E	E	E
Freshwater Habitat—Warm	E	E	E	E	E	E
Freshwater Habitat—Cold	E					
Wildlife Habitat	E	E	E	E	E	E
Rare, Threatened, or Endangered Species				E	E	E
Spawning, Reproduction, and/or Early Development	E					
Groundwater Recharge	E	E	E	E	E	E
Freshwater Replenishment	E					
Preservation of Biological Habitats of Special Significance						

E=Existing. KR-1: Southern California Edison's Kern River Powerhouse No. 1.
Tulare Lake Basin Plan Beneficial Uses categories vary slightly from the Sacramento and San Joaquin Rivers Basin Plan Beneficial Uses categories.

The Kings River is further subdivided by the Tulare Lake Basin Plan, as follows:

- Reach I—above Kirch Flat,
- Reach II—Kirch Flat to Pine Flat Dam,
- Reach III—Pine Flat Reservoir to the Friant Kern Canal,
- Reach IV—Friant Kern Canal to Peoples Weir, and
- Reach V—Peoples Weir to Island Weir.

The Kings River Conservation District recognizes two additional reaches, as follows:

- Reach VI—Island Weir to Stinson Weir on the North Fork of the Kings River and to the Empire Weir No. 2 on the South Fork, and
- Reach VII—Stinson Weir to the James Weir on the North Fork of the Kings River (Kings River Conservation District 2000).

Hydrology

The dominant land use and industry in the SVF Watershed is irrigated agriculture. Fresno, Tulare, Kings, and Kern Counties are among the most productive agricultural counties in the world. Much of the water that once maintained historic Tulare and Buena Vista Lakes has been captured by reservoirs and is now used extensively to produce crops. Much of the water distribution system is comprised of historic river channels and sloughs and water is moved from one end of the valley to the next as needed.

On the west side of the valley, irrigation water is supplied through the San Luis Canal, which is the joint federal/state section of the California Aqueduct that delivers water from the Delta and San Luis Reservoir. On the east side of the valley, water is supplied from Millerton Lake through various turnouts on the Friant-Kern Canal. The Cross Valley Canal is a locally owned facility and is operated through a joint use agreement. The Friant-Kern Canal is operated by Reclamation and can deliver water to any number of contract and non-contract holders through various physical and institutional arrangements. Pine Flat Reservoir, Lake Kaweah, Lake Success, and Lake Isabella are operated by the Corps and likewise can deliver water to any number of contractors.

Many of the larger landholders in the basin have either contracts or agreements to use water from many of the reservoirs in the area and can take water through numerous facilities. An example is the Arvin-Edison Water Storage District that contracts for water from Millerton Reservoir but also has the capability through exchange agreements to store water from the California Aqueduct via the Cross Valley Canal. In another example, Fresno ID has contracts with Reclamation for Millerton Reservoir water and with the Corps for Kings River Water. Many of the irrigation districts and landholders also have agreements among themselves to exchange water in various year types and under certain circumstances. Because of the relatively dry conditions in the Tulare Lake Basin, most water in the basin is spoken for except in very wet conditions when there is not enough local surface storage to capture large flows. There also are numerous agreements between water storage districts and water agencies in the valley and State Water Contractors to store water in groundwater banks in the SVF Watershed for withdrawal or exchange during dry years.

While providing irrigation water, many of the reservoirs also were constructed to minimize flooding in the Tulare Lake Bed. This area has been intensively farmed for decades and very little water flows to the San Joaquin River through North Kings River. Because of the intensive water development that has occurred in the SVF Watershed, and in the watersheds directly to the east in the Sierra Nevada foothills, very few channels are not specifically maintained as water delivery features. While many of the historic channels provide recreation and fishing for some distance from the five main reservoirs in the foothills, flow in all of these channels is managed to provide irrigation and domestic supplies to water users in the SVF Watershed. This manipulation and commingling of many water sources has changed the hydrology and water quality characteristics of the basin. Because many of the once natural channels are maintained as water delivery features, little monitoring or characterization of the water quality has occurred—except by those who rely on these features for their livelihood.

The Friant-Kern Canal diverts water from the San Joaquin River below Friant Reservoir and travels south to deliver water to the southern portions of Kern County. The 151.8-mile Friant-Kern Canal stretches from Millerton Lake to the Kern River, 4 miles west of Bakersfield. Turnouts exist for Little Dry Creek, Kings River, Cottonwood Creek, St. Johns River, Porter Slough, Tule River, Deer Creek, White River, Poso Creek, and the Kern River. In wet years, the Friant-Kern Canal is used to transport flood flows out of the Basin via pumps/inlets from the Kings, Kaweah, St. Johns and Tule Rivers to the Kern River Intertie and the Cross Valley Canal into the California Aqueduct. Initial capacity of the canal is 5,000 cfs

and gradually decreases to 2,000 cfs as water is used for municipal, industrial, and irrigation supplies throughout the South Valley (Reclamation 2005).

Water from the California Aqueduct flows into O'Neill Forebay and water from the DMC can be pumped into O'Neill Forebay. From there, water is either pumped into San Luis Reservoir for storage or continues south in the San Luis Canal. When necessary, often during the irrigation months, stored water from San Luis Reservoir is released back to O'Neill Forebay and either flows south in San Luis Canal to both CVP and SWP contractors, including many in the SVF Watershed, or is released to the DMC for delivery to CVP Exchange Contractors (CALFED 2003). Water also can be moved between the Friant-Kern Canal and the San Luis Canal through the Cross Valley Canal.

Lower Kings River

The Lower Kings River originates in the southern Sierra Nevada and flows west toward the Tulare Basin (Figure 3-47). This analysis covers the lower portion of water delivery systems, following natural hydrology—such as the Kings River from Pine Flat Reservoir to the Tulare Lake Canal. Just below Pine Flat Reservoir, the river flows southwest in a single channel and passes near Centerville where it splits into multiple channels and then converges as a single channel downstream of Centerville Bottoms. Near Kingsburg, the river is confined by a continuous levee system that continues through the lower reaches of the river. Below Empire Weir No. 2, the Kings River travels approximately nine miles south, where it merges with the Tule River Canal. A portion of Kings River water is diverted from Empire Weir No. 2 pool to the Tulare Lake Canal.

Army Weir, located at the head of the Clarks and South Fork, is the main flow diversion in the Kings River System. The Crescent Bypass, when operated in conjunction with the Crescent Weir, provides a secondary diversion to the South Fork. However, the Crescent Weir also can relay water back and forth between the two forks. The Kings River system capacity progressively decreases downstream, from 50,000 cfs below Pine Flat Dam to 11,000 cfs at the head of Army Weir due to diversions into a large system of canals. Data indicate that flow does not typically exceed 5,000 cfs in high-flow months, and low-flow months can have no flow (see Appendix B, Table B-28) (Kings River Conservation District 2005). During extreme high flow conditions, the Kings River spills into the Fresno Slough and flows into the San Joaquin River. These flood flows represent the most significant outflows from the basin (Kings River Conservation District 2005).

Lower Kaweah River

The Kaweah River originates in the Sierra Nevada at an elevation of 12,000 feet, flowing generally westward toward the South Valley. The South Valley portion of the Kaweah River Watershed includes Lower Kaweah River below Terminus Reservoir and St. Johns River. The main tributaries to this segment of the Lower Kaweah River are Dry Creek and Yokohl Creek. Annual spring runoff from Dry Creek provides sufficient inflow to contribute to the Kaweah River's flow. The intermittent Yokohl Creek has adequate flow to reach Kaweah River only during years with above-normal precipitation (Kaweah and St. Johns Rivers Association 2005). The Lower Kaweah splits into several smaller channels; from north to south they are: Mill Creek, Packwood Creek, Cameron Creek, inside/outside CK and Elk Bayou.. Mill Creek discharges into Cross Creek; Packwood Creek discharges into Packwood Ditch, which in turn discharges into Bates Slough, Cameron Creek terminates into the Homeland Canal, and Elk Bayou formed by inside and outside creeks discharges into the Tule River. The City of Visalia discharges its treated effluent into Mill Creek, which ultimately flows into Cross Creek.

The Friant-Kern Canal plays a large role in the hydrology of the Kaweah River. Exeter, Ivanhoe, Stone Corral, and Tulare IDs have long-term water service contracts with Reclamation for CVP water. Water is delivered through turnouts, where the Friant-Kern Canal crosses the Tulare ID Main Canal, the St. Johns River channel, and the Lower Kaweah River channel. The principal diversions from the lower Kaweah River below McKay's Point are: Hamilton Ditch, Consolidated Peoples Ditch, Deep Creek, Crocker Cut, Tulare Irrigation Company Ditch, Fleming Ditch, Packwood Creek, Oakes Ditch, Evan's Ditch, Persian Ditch, and Watson Ditch.

St. Johns River

The St. Johns River originates from the Kaweah River downstream of Terminus Reservoir at McKay Point. The river flows southwest until it bends northwest of Visalia and becomes Cross Creek approximately two miles east of Highway 99 at its junction with Cottonwood Creek. Water from Cross Creek is diverted into Lakeside Ditch and into Lakeland Canal No. 2 where it is mingled with Kings River water and is delivered to Tulare Lake and Kings River water users. Cross Creek terminates into the Lakeland Canal and the Tule River Canal. Several agricultural irrigation diversions reduce the flow of the St. Johns River prior to its reaching Cross Creek. These diversions include Longs Canal, Sweeney Ditch, Ketchum Ditch, Packwood Canal, Tulare ID Main Canal, Mathews Ditch, Jennings Ditch, Uphill Ditch, Modoc Ditch, St. Johns Ditch, Goshen Ditch, Lakeside Ditch, and Lakelands Canal No. 2. Major public irrigation districts in the Kaweah River system include Tulare ID, Exeter ID, Ivanhoe ID, Lakeside Water District, a portion of Corcoran ID, and Stone Corral ID. Water is diverted from the St. Johns and Lower Kaweah Rivers and distributed through a complex system of natural channels and manmade canals owned and operated by numerous agencies and entitlement holders.

Other foothill watersheds have the potential to generate runoff that reaches the southern San Joaquin Valley floor but only in above-average precipitation conditions. These watersheds include Sand Creek, Stokes Mountain, Cottonwood Creek, and Lewis Creek (Kaweah and St. Johns Rivers Associations 2005).

Lower Tule River

The North, Middle, and South Forks of the upper portion of the Tule River flow out of the Sierra Nevada foothills into Lake Success. Below Lake Success, the Tule River enters the SVF Watershed, flowing through Porterville and across the southern San Joaquin Valley floor for about 40 miles to the Tulare Lakebed. Porter Slough, which begins at the Tule River downstream of Bartlett Park, is used for diverting flood and irrigation releases from Success Reservoir. The Tule River divides into South, Middle, and North Forks north of the community of Woodville; the river remains divided for several miles. The South and Middle Forks reunite east of SR 99, and the South and North Forks reunite west of SR 99.

There are numerous irrigation diversions along the Tule River and many connecting inflows from the Kaweah River that enter Tule River prior to reaching the Tulare Lakebed, including Elk Bayou and Cross Creek. Tule River water reaching the Tulare Lakebed is stored for future irrigation or evaporates (Tule River Association 2005). The main irrigation districts include the Terra Bella, Saucelito, Porterville, Lindmore, Lower Tule River, Delano-Earlimart, and Pixley IDs. Natural flow in the Lower Tule River is highly manipulated by these irrigation districts. During summer, the irrigation districts routinely take water from the natural channels, leaving the channels dry. The water is then run through canals and discharged back to the river channels, resulting in alternating wet and dry lengths of the river system. The Friant-Kern Canal also plays a large role in providing flow in Tule River during summer.

Deer Creek and White River

Deer Creek and the White River are both located south of the Tule River and flow west toward Tulare Lake Basin from the Sierra Nevada foothills. Deer Creek near Fountain Springs typically flows year-round, with reduced flows from August through October, and provides flow to the Pixley NWR. In dry years, there is no flow in August and September. The highest average flows occur in February (82 cfs). The month with the highest average flow for a single year was January 1997, with a flow of 440 cfs (see Appendix B, Table B-31). Further downstream, near Road 104, Dear Creek is channelized and flows into Homeland Canal.

White River, near Ducor, has a reduced flow during average years and no flow from June through November during dry years. In wet years, April has the most flow (165 cfs) and the lowest flow occurs during September (5 cfs) (Appendix B, Table B-31). Deer Creek and White River also are largely uncontrolled, and threats of flooding occur during locally heavy rainstorms.

Lower Kern River

While there are some minor streams in the Lower Kern River Watershed, such as Poso Creek and Caliente Creek, the Kern River is the only significant natural source of surface water. The Kern River originates in Sequoia National Park North of Mt. Whitney. Several creeks drain into the Kern River as traverses the Kern River Gorge on its way to Lake Isabella. The waters of the upper Kern River originate as snowmelt from feeder creeks on public lands in the national park or national forest. Since 1954, when Isabella Dam was completed, all of the Kern River flow has been diverted into conveyance canals below Kern River Canyon. The diverted water is either consumptively used or recharged to groundwater and does not reenter the Kern River. In some years, the Kern County Water Agency and the City of Bakersfield provide water in the Kern River Channel through the City of Bakersfield for recreation. However, this occurs only in years when there is adequate river flow above the major diversions.

At Kern River Canyon, average flows are lowest in November (153 cfs) and highest in June (812 cfs). The Lower Kern River merges into Bueno Vista Lake. From Bueno Vista Lake, a historical lake at the southern end of the San Joaquin Valley that is now mostly dry, the drainage is a flood channel that locals typically refer to as the “North Fork of the Kern River.” For much of its length, the river channel is bordered by major conveyance canals, including Cross Valley Canal to the north and Carrier Canal to the south.

Diversion canals also are located along the Lower Kern River. The Beardsley-Lerdo and Calloway Canals deliver Kern River water north to the Cawelo Water District, the North Kern Water Storage District, and the Shafter-Wasco Irrigation District. The Kern Island Canals deliver water to the Arvin-Edison Water Storage District and the Kern Delta Water District. The Buena Vista, Stine, and Farmers Canals deliver water to the Kern Delta and the Buena Vista Water Storage District (BVWSD). The Arvin-Edison Canal delivers water to the Arvin-Edison Water Storage District. The Alejandro Canal, a lined canal, proceeds south into the Buena Vista Aquatic Lakes. BVWSD diverts water from the lakes into the BVWSD’s Outlet Canal, which proceeds to the BVWSD’s intake facilities and to BVWSD’s canals that serve District landowners. Through urban Bakersfield, flood control levees protect the river’s water quality from discharges. When the river is dry, there are intentional surface water discharges from either the Friant-Kern Canal or Cross Valley Canal into the Kern River channel for groundwater recharge (Kern County Water Agency 2005).

In addition, Poso and Caliente Creeks are part of the Kern River Watershed. Both creeks are normally dry except for high water years, and both receive canal discharges in summer; this results in alternating wet and dry portions of the stream channel. The western end of the Kern River also supports the Kern Water Bank. However, the majority of the water that feeds the bank is supplied by the California Aqueduct.

West Side Drainages

A multitude of ephemeral streams originating in the Coast Ranges and Tehachapi and San Emigdio Mountains make up the west side drainages. These stream channels cut through and drain from marine sediments and are highly mineralized. Most of these streams consist of flashy pulse flows. Sustained flow is limited, occurring only after extended wet periods (Central Valley Water Board 2004b). For further information on these drainages, see the descriptions for the Coast Range, Sunflower, Temblor, and Fellows Watersheds.

Tulare Lake Bed

During high flow, the Tulare Lake Bed serves as the terminus for both east side and west side valley streams, including runoff from the Kings, Kaweah, Tule, and Kern Rivers. This lakebed, with a bottom elevation of 175 feet is effectively closed. The only natural outlet is the San Joaquin River to the north at an elevation of 207 feet. Water has not risen to this elevation and naturally flowed out of the basin since the 1870s. Development of intensive agriculture in the tributary basins, construction of reservoirs and other flood and water control measures, and land reclamation in the lakebed have greatly reduced the likelihood of future natural outflows (Kings River Conservation District 2004).

Water Quality

Based on evaluation of data available from multiple sampling locations in the SVF Watershed, water quality conditions in most water bodies of the SVF Watershed are highly influenced by agricultural operations. During the irrigation season, water bodies of the SVF Watershed are comprised of flows for irrigation purposes and a small percentage of agricultural return flows. In addition, pesticides are applied during the dormant spray season, which typically occurs between November and January, and can be transported from fields during rainfall events. Data indicate that chlorpyrifos, azinphos-methyl, dimethoate, malathion, thiobencarb, esfenvalerate, cypermethrin, toxaphene, DDE, DDT, and DDD have been detected in at least one of the SVF water bodies in which monitoring has occurred, and in concentrations that exceed water quality objectives (see Appendix C for water quality objectives) and are known to be associated with agricultural operations (Central Valley Water Board 2007a; USGS 2005b, 2005c). Copper also has been detected at multiple locations in the SVF Watershed. Copper is a naturally occurring metal that is also used as a pesticide. Other metals such as arsenic, cadmium, boron, lead, molybdenum, manganese, zinc, iron, and selenium have been detected at elevated levels and are likely mobilized and suspended in agricultural return flows throughout the SVF Watershed (Central Valley Water Board 2007a).

Many of the creeks and drainages located in the SVF Watershed contain low DO. Factors contributing to low DO are still under investigation in the SVF Watershed; however, nutrient loads from irrigated agriculture have been correlated with low DO in the San Joaquin River Basin (Kratzer et al. 2004). Many of the creeks in the SVF Watershed also have experienced fluctuating levels of pH and elevated levels of EC (Central Valley Water Board 2007a).

Table 3-60 summarizes the parameters with one or more concentrations that exceed the applicable water quality objective. The table cites the known source of the contaminants and whether there is a known connection to irrigated agriculture. The creeks and agriculture drains that this table represents are included in the notes at the bottom of the table.

Toxicity tests and TIEs were performed for ILRP monitoring in an attempt to identify the causes of water toxicity in the test organisms. TIEs generally were performed on the water samples that exceeded 50 percent mortality. The results indicated that non-polar organics such as chlorpyrifos, diazinon, dimethoate, disulfton, diuron, cyfluthrin, dioxathion, simazine, and atrazine are causing the large toxicity problem in the SVF Watershed (see Table 3-60) (Central Valley Water Board 2007a).

Table 3-60. Known Agricultural Contaminants and Conditions That Affect Water Quality in the South Valley Floor Watershed

Parameter	Potential Agricultural Source/Contribution to Water Quality Impairment	Sources
Chlorpyrifos	Pesticide used to protect agricultural crops	1
azinphos-methyl	Pesticide used to protect agricultural crops	1
Dimethoate	Pesticide used to protect agricultural crops	1
Malathion	Pesticide used to protect agricultural crops	1
Thiobencarb	Pesticide used to protect agricultural crops	1
Esfenvalerate	Pesticide used to protect agricultural crops	1
Cypermethrin	Pesticide used to protect agricultural crops	1
DDE	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDT	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
DDD	Legacy pesticide potentially mobilized by irrigated agricultural operations	1
Toxaphene	Most uses stopped in 1982 but can be used in limited circumstances; when used, is potentially mobilized by irrigated agricultural operations	2
Arsenic	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Molybdenum	Occurs naturally but is also used as a pesticide	2
Cadmium	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Manganese	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Zinc	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Iron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Copper	Occurs naturally but is also used as a pesticide	1
Lead	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Selenium	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Boron	Naturally occurring metal that is partly mobilized and concentrated by irrigated agriculture, causing toxic levels in receiving waters	1
Fecal coliform (*E. coli*)	Likely a result of land application of waste from animal confinement facilities	1

Parameter	Potential Agricultural Source/Contribution to Water Quality Impairment	Sources
DO	Factors contributing to low DO are under investigation. Nutrient loads from irrigated lands may be connected to low DO.	1
EC	Factors contributing to high EC may involve elevated levels of salt on irrigated land.	1
pH	Factors contributing to high pH are under investigation.	1
Toxicity (flea, minnow, algae)	Toxicity identification evaluations (TIEs) indicate that organophosphate insecticides (e.g., chlorpyrifos and diazinon) are linked to much of the observed water toxicity. In addition, cypermethrin, bifenthrin, and lambda-cyhalothrin are linked to much of the observed sediment toxicity.	1, 3

Sources:

[1] Central Valley Water Board 2007a.

[2] USGS 2005b, 2005c.

[3] Weston et al. In Press.

Note: Water bodies in the SVF Watershed for which monitoring data was readily available include Kings River at Manning Avenue, Kings River at Jackson Avenue, Kings River at Reed, Kings River at Lemoore Weir, Tule River at Poplar Avenue, Tule River at McCarthy, Tule River at North Fork, Tule River at Dam Outflow, Tule River at Woods, Goshen Ditch, Button Ditch, Calloway Canal, Cantua Creek, Drain to Wooten Creek, Elbow Creek, Elk Bayou, Fresno Slough, Melga Canal, St. Johns River, Stone Corral Discharge, Cross Creek at 99, Main Drain Canal at 46, I-5 at Panoche Silver Creek, Ditch South of Utica Avenue, King Ditch at 368, Kinestirc Ditch at 201, Mill Creek at 168, Stinson Ditch at Kamm, Turner Ditch at Marks, Outside Creek at Exeter, Packwood Creek, Porter Slough, and Deer Creek at 208.

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III.E Grapevine Watershed

General Description

The Grapevine Watershed borders the southernmost portion of the Central Valley (Figure 3-3). The Grapevine Watershed makes up the southern boundary of the Tulare Lake Basin and encompasses approximately 660,756 acres (about 1,032 square miles) (Figure 3-48). The Grapevine Watershed is bounded to the north by the Fellows, South Valley Floor, and Kern River Watersheds. To the south are Ventura and Kern Counties. On the west are San Luis Obispo and Santa Barbara Counties, and on the east is Kern County. The minimum elevation in the watershed is 610 feet, and the maximum elevation is 8,819 feet. There are no major water bodies in the Grapevine Watershed.

The climate of the Grapevine Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures are often higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. Snow accumulates in the higher elevations, above about 5,000 feet, and provides some flows in the watershed. However, much of this watershed is below 5,000 feet and most of the precipitation falls as rain. For this reason, most of the streams in the Grapevine Watershed are ephemeral, with higher flows occurring in winter.

Land Use Patterns

Native vegetation is the largest land use type of the Grapevine Watershed, occupying almost the entire watershed (Figure 3-58). Urban land uses occupy approximately 2 percent of the watershed. Irrigated agriculture, water, and barren land each occupy less than 1 percent of land in the watershed. Table 3-61 lists the land use acreage according to DWR and FRAP land use data for the Grapevine Watershed.

Table 3-61. Land Use Acreage according to DWR and FRAP Land Use Data for the Grapevine Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	643	0.1
Field Crops	986	0.1
Grain and Hay	1,021	0.2
Pasture	2,361	0.4
Semi agricultural and Incidental	209	0.0
Truck, Nursery, and Berry Crops	762	0.1
Vineyards	5	0.0
Subtotal	5,987	0.9
Urban		
Urban—Unclassified	1,124	0.2
Urban Landscape	182	0.0

Land Use	Acres	Percent Total
Urban Residential	9,506	1.4
Commercial	300	0.0
Industrial	28	0.0
Vacant	425	0.1
Subtotal	11,565	1.8
Native		
Native Vegetation	292,840	44.3
Water Surface	236	0.0
Subtotal	293,076	44.4
FRAP Land Use Type		
Agriculture	263	0.0
Barren/Other	875	0.1
Conifer	76,426	11.6
Desert	2,104	0.3
Hardwood	66,283	10.0
Herbaceous	128,249	19.4
Shrub	72,272	10.9
Urban	3,096	0.5
Water	348	0.1
Wetland	210	0.0
Subtotal	350,126	53.0
Total	**660,756**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Grapevine Watershed. For the purpose of beneficial use designations, all creeks in the Grapevine Watershed are categorized as part of the west side streams hydrologic unit. Table 3-62 lists beneficial uses for the west side streams.

Table 3-62. Beneficial Uses in the Grapevine Watershed

Beneficial Use	West Side Streams
Municipal & Domestic	
Irrigation	E
Industrial	E
Stock Watering	
Proc	E
Ind	
Power	

Beneficial Use	West Side Streams
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	
SPWN	
Wildlife Habitat	E
RARE	E
Groundwater Recharge	E
Fresh Water Replenishment	

E = Existing.

RARE = Rare, Threatened, or Endangered Species.

SPWN = Spawning, reproduction, and/or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2004b.

Hydrology

Creeks in this watershed include both west side and east side creeks. Creeks to the west and south in the Tehachapi Mountains flow east and north toward the South Valley Floor Watershed, and creeks in the east flow west from the Piute Mountains (Figure 3-48). Creeks from the west and south include Comanche Creek, Tecuya Creek, El Paso Creek, Pleito Creek, San Emigdio Creek, Bitterwood Creek, Sandy Creek, Salt Creek, Grapevine Creek, and Pastoria Creek. Creeks from the east include Caliente Creek and Walker Basin Creek, each with several tributaries. These creeks have intermittent ephemeral flows, with much of the water running off due to limited canalization. No flow data are available for these creeks on the USGS or CDEC websites.

Water Quality

There are few, if any, water quality concerns in the Grapevine Watershed. As stated above, there is little to no irrigated agriculture in the Grapevine Watershed; therefore, contaminants from agriculture are not expected to be found in the creeks of this watershed. The creeks of this watershed are dominated by flashy seasonal flows and are expected to contain high total suspended solids for short periods, along with the possibility of naturally occurring heavy metals due in part to settled solids on the first couple layers of soil from grazing and fires.

III.F Coast Range Watershed

General Description

The Coast Range Watershed is located in the northwestern portion of the Tulare Lake Basin (Figure 3-3). To the north are San Benito and Merced Counties and to the south are Kings and Kern Counties. On the west are San Benito and Monterey Counties, and on the east are Fresno and Kings Counties (Figure 3-49). The Coast Range Watershed is approximately 564,990 acres (approximately 883 square miles). The general topography of the Coast Range Watershed varies from small rolling hills to higher coastal mountains. The minimum elevation is 538 feet, the mean elevation is 2,051 feet, and the maximum elevation is 5,213 feet (DWR 2005c). The major water body is Panoche Creek.

The climate of the Coast Range Watershed is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures are often higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are marginally cooler and there is more precipitation at the higher elevations. Snow may occur in the higher elevations but does not accumulate in quantities that provide substantial source water to creeks in the Coast Range Watershed.

Land Use Patterns

Native vegetation makes up the largest land use in the Coast Range Watershed (approximately 95 percent) (Figure 3-59). Total irrigated land in the watershed accounts for only 1.5 percent of land use, and urban land use comprises less than 1 percent. Table 3-63 includes land use acreage according to DWR and FRAP land use data for the Coast Range Watershed.

Table 3-63. Land Use Acreage according to DWR and FRAP Land Use Data for the Coast Range Watershed

DWR Land Use	Acres	Percent Total
Agriculture		
Deciduous Fruits and Nuts	46	0.0
Field Crops	1	0.0
Grain and Hay Crops	8,343	1.5
Semi agricultural & Incidental to Agriculture	80	0.0
Truck, Nursery, and Berry Crops	9	0.0
Vineyards	27	0.0
Subtotal	8,506	1.5
Urban		
Urban—Unclassified	53	0.0
Industrial	2,453	0.4
Subtotal	2,506	0.4
Native		
Native Vegetation	450,328	78.6
Riparian Vegetation	128	0.0
Subtotal	450,456	78.6

DWR Land Use	Acres	Percent Total
FRAP Land Use Type		
Conifer	438	0.1
Hardwood	65,244	11.4
Herbaceous	12,901	2.3
Shrub	32,844	5.7
Urban	352	0.1
Subtotal	111,779	19.5
Total	**573,247**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Coast Range Watershed. Table 3-64 lists beneficial uses for west side streams.

Table 3-64. Beneficial Uses in the Coast Range Watershed

Beneficial Use	West Side Streams
Municipal & Domestic	
Irrigation	E
Industrial	E
Stock Watering	
Proc	E
Industry	
Power	
Rec-1*	E
Rec-2*	E
Freshwater Habitat—–Warm	E
Freshwater Habitat—Cold	
SPWN	
Wildlife Habitat	E
RARE	E
Groundwater Recharge	E
Fresh Water Replenishment	

E = Existing.
RARE = Rare, Threatened, or Endangered Species.
SPWN = Spawning, Reproduction and/or Early Development.
* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or

Beneficial Use	West Side Streams
any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.	

Source: Central Valley Water Board 2004b.

Hydrology

Panoche Creek drains a portion of the Coast Range Watershed into the southern San Joaquin Valley floor (Figure 3-49). Panoche Creek consists of many small tributaries that typically dry up during summer and have flashy seasonal pulse flows during the storm season. Upstream tributaries to Panoche Creek (upstream of the Silver Creek inflow) include Grisswald, Las Aguilas, Payne, and Antelope Creeks. One of the most important downstream tributaries is Silver Creek, which is the last primary inflow to Panoche Creek. The upstream portion of Silver Creek receives inflow from San Carlos Creek.

Much of the Panoche Creek Watershed does not contain irrigated agriculture until Panoche Creek reaches the southern San Joaquin Valley floor; this portion of the creek is discussed in the South Valley Floor Watershed section. The USGS website contained flow data for Panoche Creek but no data for any tributaries along Panoche Creek. Monthly average flows for Panoche Creek from 1998 to 2004 range from 0 to approximately 300 cfs, as shown in Table B-32 in Appendix B. The flow data for Panoche Creek near I-5 are from a station just outside the border of the Coast Range Watershed; however, it is the best representative flow station available for the watershed. The flow data validate the flashy storm-season pulse flows that occur in Panoche Creek. Only very rarely does runoff reach the San Joaquin River, and this requires extreme flood conditions.

Many small tributaries in the southern portion of the Coast Range Watershed contain seasonal pulse flows. The main creeks are Cantua Creek, Martinez Creek, Salt Creek, Domengine Creek, and Los Gatos Creek. The portions of these creeks that are in the Coast Range Watershed do not contain irrigated agriculture. However, during the storm season, flows from these seasonal creeks sometimes flow into the southern San Joaquin Valley where agriculture is present. The USGS website contained flow data for Los Gatos Creek and Cantua Creek. No flow data were available for other creeks. Monthly average flow data from 1995 to 2004 for Los Gatos Creek and Cantua Creek are included in Appendix B, Table B-32. Flow data represent the flashy storm-season pulse flows that occur in these west side drainages.

Water Quality

Many small ephemeral creeks drain occasionally into the southern San Joaquin Valley from the Coast Ranges. When this drainage occurs during the storm season, Panoche and San Carlos Creeks carry a high sediment and heavy metal load. Mercury impairments are a result of resource extraction from abandoned mines in the Coast Ranges. Sedimentation/siltation and elevated selenium concentrations are a result of agriculture, agriculture-grazing, and construction-related ground disturbance. A USGS Water Resources Investigations Report identifies Panoche Creek as having some of the world's largest natural deposits of selenium (Kratzer et al. 2003). This natural selenium, along with similar deposits of boron and other salts, contributes to the contamination of Panoche Creek. In addition, development of the lower watershed has

virtually eliminated the creek channel, promoting flooding and sediment deposition with its load of selenium, boron, and other salts into the downstream watershed (Kratzer et al. 2003).

As part of this evaluation, measurements exceeding a water quality objective were included. The objectives were generally the lowest criteria contained in Appendix C. Table 3-65 contains water quality data for selenium and sediment. Data indicate that Panoche Creek contains elevated levels of selenium and sedimentation (Central Valley Water Board 2007a, Kratzer et al. 2003, USGS 2005b, 2005c).

Table 3-65. Known Agricultural Contaminants and Conditions That Affect Water Quality in the Coast Range Watershed

Parameter	Potential Agricultural Sources/Contribution to Water Quality Impairment	Sources
Selenium	Naturally occurring metal that is mobilized and concentrated in the Panoche Creek Watershed from flashy intermittent flows. In the valley, where irrigated agriculture is more prevalent, selenium also may be mobilized and concentrated by agriculture return flows.	1, 2, 3
Sediment	Sediment is naturally occurring and can transport other hydrophobic contaminants. Sediment also can smother filter-feeding organisms.	1, 2, 3

Sources:
1 Central Valley Water Board 2007a.
2 Kratzer et al. 2003.
3 USGS 2005b, 2005c.
Note: This table applies to Panoche Creek.

The Arroyo Pasajero Watershed is located on the eastern slope of the Coast Ranges in southwestern Fresno County. Several creeks flow from the watershed into Pleasant Valley and form Arroyo Pasajero Creek east of Coalinga and west of the California Aqueduct. The largest of these creeks is Los Gatos Creek. There are several inactive or abandoned asbestos mines in the watershed. Two of these mines, the Coalinga Asbestos Mine and the Atlas Asbestos Mine, are Superfund cleanup sites. The Atlas Mine is located at the head of White Creek and the Coalinga Mine is located at the head of Pine Canyon Creek. Both White Creek and Pine Canyon Creek are tributaries of Los Gatos Creek. There is a possibility that asbestos fibers from the watershed migrate to the California Aqueduct through the Arroyo Pasajero Inlet. Waterborne asbestos fibers may be carcinogenic given a sufficient quantity and prolonged, constant exposure. DWR constructed a ponding basin to allow asbestos and sediment to settle out of the water before it is allowed to flow into the California Aqueduct, significantly decreasing the amount of asbestos entering the California Aqueduct.

III.G Fellows Watershed

General Description

The Fellows Watershed is located in the southern portion of the Central Valley on the west side (Figure 3-3). The Fellows Watershed is the smallest in the Tulare Lake Basin and accounts for approximately 34,398 acres (about 54 square miles). To the north is the Temblor Watershed, and to the south is the Grapevine Watershed. On the east is the South Valley Floor Watershed, and on the west is San Luis Obispo County. The general topography of the Fellows Watershed is typical of the Coast Ranges. The minimum elevation is 1,099 feet, and the maximum elevation is 3,944 feet (DWR 2005c). Figure 3-50 identifies the Fellows Watershed. Only small ephemeral creeks drain from the Fellows Watershed.

The climate of the Fellows Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures are often higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. Although snow may occur in the higher elevations on rare occasions, snow does not provide a substantial source of flow in the Fellows Watershed.

Land Use Patterns

Virtually all of the land use in the Fellows Watershed is native vegetation (Figure 3-60). Approximately 15 percent is desert, and 0.02 percent (6 acres) is defined as urban land use. The DWR land use data and FRAP vegetation data do not define any irrigated agriculture in the Fellows Watershed. Table 3-66 contains DWR and FRAP land use data for the Fellows Watershed.

Table 3-66. Land Use Acreage according to DWR and FRAP Land Use Data for the Fellows Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Native Vegetation	15,685	45.6
FRAP Land Use Type		
Desert	5,075	14.8
Hardwood	272	0.8
Herbaceous	13,359	38.8
Urban	6	0.0
Total	**34,398**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Fellows Watershed. The Tulare Lake Basin Plan combines all beneficial uses of the west side streams into one designation. Table 3-67 lists beneficial uses for the west side streams.

Table 3-67. Beneficial Uses in the Fellows Watershed

Beneficial Use	West Side Streams
Municipal & Domestic	
Irrigation	E
Industrial	E
Stock Watering	
Proc	E
Industry	
Power	
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	
SPWN	
Wildlife Habitat	E
RARE	E
Groundwater Recharge	E
Freshwater Replenishment	

E = Existing.
RARE = Rare, Threatened, or Endangered Species.
SPWN = Spawning, reproduction, and/or early development.
* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.
Source: Central Valley Water Board 2004b.

Hydrology

A few small ephemeral creeks drain into the Tulare Lake Bed from the Fellows Watershed (Figure 3-50). These coastal creeks tend to have flows only occasionally during the storm season. From north to south the creeks are Buena Vista Creek, Broad Creek, Sandy Creek, and Bitterwater Creek. There are no

available flow data for any of these creeks on the USGS or CDEC websites. However, the City of Taft discharges to Sandy Creek and has an NPDES permit with the Central Valley Water Board.

Water Quality

There are few, if any, water quality concerns in the Fellows Watershed. As stated above, there is no irrigated agriculture in the Fellows Watershed; therefore, contaminants from agriculture are not expected to be found in the creeks. Because the creeks within this watershed are dominated by flashy seasonal flows, they are expected to contain high total suspended solids for a short period, including the possibility of naturally occurring heavy metals. This watershed contains no 2006 Section 303(d) listings, and water quality is not analyzed further in this report.

III.H Temblor Watershed

General Description

The Temblor Watershed is part of the Coast Ranges on the west side of the Tulare Lake Basin (Figure 3-3). To the north is the Sunflower Valley Watershed, and to the south is the Fellows Watershed. On the east is the South Valley Floor Watershed, and on the west is San Luis Obispo County. The Temblor Watershed encompasses approximately 176,279 acres (about 275 square miles). Topography in the Temblor Watershed is typical of the Coast Ranges. The minimum elevation is 502 feet, the mean elevation is 3,783 feet, and the maximum elevation is 4,285 feet (DWR 2005c). Figure 3-51 shows the Temblor Watershed.

The climate of the Temblor Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures are often higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. It may snow in the upper elevations of the Temblor Watershed, but snow very rarely accumulates in large amounts and does not contribute substantially to stream flows in the Temblor Watershed.

Land Use Patterns

Like most other watersheds that are not in the southern San Joaquin Valley floor, native vegetation is the dominant land use in the Temblor Watershed (Figure 3-61). Total urban land use in the watershed is less than 1 percent. Total irrigated agriculture accounted for approximately 3.3 percent of the land use. Table 3-68 contains land use acreage according to DWR and FRAP land use data for the Temblor Watershed.

Table 3-68. Land Use Acreage according to DWR and FRAP Land Use Data for the Temblor Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Grain and Hay Crops	5,581	3.2
Industrial	2	0.0
Native Vegetation	101,763	57.7
Semi agricultural & Incidental to Agriculture	63	0.0
Vineyards	50	0.0
Water Surface	56	0.0
FRAP Land Use Type		
Agriculture	128	0.1
Barren/Other	96	0.1
Conifer	727	0.4
Desert	1,918	1.1
Hardwood	8,351	4.7

Land Use	Acres	Percent Total
Herbaceous	48,586	27.6
Shrub	8,369	4.7
Urban	584	0.3
Water	5	0.0
Total	**176,279**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Temblor Watershed. The Tulare Lake Basin Plan combines all west side streams beneficial uses into one designation. Table 3-69 lists beneficial uses for the west side streams.

Table 3-69. Beneficial Uses in the Temblor Watershed

Beneficial Use	West Side Streams
Municipal & Domestic	
Irrigation	E
Industrial	E
Stock Watering	
Proc	E
Ind	
Power	
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	
SPWN	
Wildlife Habitat	E
RARE	E
Groundwater Recharge	E
Fresh Water Replenishment	

E = Existing.
RARE = Rare, Threatened, or Endangered Species.
SPWN = Spawning, reproduction, and/or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment

Beneficial Use	West Side Streams
associated with the above activities.	

Source: Central Valley Water Board 2004b.

Hydrology

Many small creeks drain into the Tulare Lake Bed from the Temblor Watershed; however, most are ephemeral (Figure 3-51). From north to south these creeks include the Francisco Creek, Packwood Creek, Bitterwater Creek, Devilwater Creek, Media Agua Creek, Walnut Creek, Yeguas Creek, Santos Creek, Chico Martinez Creek, and Temblor Creek. No flow data are available for any of these creeks on the USGS or CDEC websites.

Water Quality

There are few, if any, water quality concerns in the Temblor Watershed. As stated above, irrigated agriculture accounts for only 3.3 percent of the land use in the watershed, and contaminants from agriculture have not been found in the creeks of this watershed. The creeks of this watershed are dominated by flashy seasonal flows and are expected to contain high total suspended solids for a short period, along with the possibility of naturally occurring heavy metals. There are no 2006 Section 303(d) listings for streams within this watershed, and water quality is not analyzed further in this report.

III.I Sunflower Valley Watershed

General Description

The Sunflower Valley Watershed is part of the Coast Ranges on the west side of the Tulare Lake Basin (Figure 3-3). North of the Sunflower Valley Watershed is the Coast Ranges; to the south is the Temblor Watershed. On the east is the South Valley Floor Watershed, and on the west are Monterey and San Luis Obispo Counties. The Sunflower Valley Watershed is approximately 93,042 acres (about 145 square miles). The general topography of the Sunflower Valley Watershed is typical of the Coast Ranges. The minimum elevation in the watershed is 453 feet, and the maximum elevation is 4,324 feet (DWR 2005c). Figure 3-52 shows the Sunflower Valley Watershed. Five main creeks make up the Sunflower Valley Watershed.

The climate of the Sunflower Valley Watershed is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures may be higher than 100°F, and winter temperatures are only occasionally below freezing. It may snow on occasion in the upper elevations of the Sunflower Valley Watershed, but snow very rarely accumulates due to the lower elevations and does not provide substantial flow to streams in the Sunflower Valley Watershed.

Land Use Patterns

Native vegetation makes up the majority of the Sunflower Valley Watershed (Figure 3-62). Total urban land use makes up less than 1 percent of the land in the watershed, and irrigated agriculture accounts for less than 1 percent. Table 3-70 includes land use acreage according to DWR and FRAP land use data for the Sunflower Valley Watershed.

Table 3-70. Land Use Acreage according to DWR and FRAP Land Use Data for the Sunflower Valley Watershed

DWR Land Use Type	Acres	Percent Total
Deciduous Fruits and Nuts	19	0.0
Field Crops	1	0.0
Grain and Hay Crops	76	0.1
Native Vegetation	85,445	91.8
Pasture	457	0.5
Semi agricultural and Incidental to Agriculture	3	0.0
Vineyards	55	0.1
Water Surface	2	0.0
FRAP Land Use Type		
Hardwood	400	0.4
Herbaceous	4,103	4.4
Shrub	2,411	2.6
Urban	70	0.1
Total	**93,042**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Sunflower Valley Watershed. The Tulare Lake Basin Plan combines all beneficial uses of the west side streams into one designation. Table 3-71 lists beneficial uses for the west side streams in the watershed.

Table 3-71. Beneficial Uses in the Sunflower Valley Watershed

Beneficial Use	West Side Streams
Municipal & Domestic	
Irrigation	E
Industrial	E
Stock Watering	
Proc	E
Ind	
Power	
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	
SPWN	
Wildlife Habitat	E
RARE	E
Groundwater Recharge	E
Fresh Water Replenishment	

E = Existing
RARE = Rare, Threatened, or Endangered Species.
SPWN = Spawning, reproduction, and/or early development.

* Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Source: Central Valley Water Board 2004b.

Hydrology

Like the Coast Range Watershed, flashy streams tend to dominate during the storm season and dry up during summer. Five main creeks make up the Sunflower Valley Watershed (Figure 3-52). From north to

south, they are Garza Creek, Baby King Creek, Big Tar Creek, Avenal Creek, and Cottonwood Creek. The USGS and CDEC websites contained flow data for only one of these creeks. Monthly minimum, mean, and maximum flows from 1975 to 1986 for Avenal Creek are included in Appendix B, Table B-33.

Water Quality

There are few, if any, water quality concerns in the Sunflower Valley Watershed. As stated above, irrigated agriculture accounts for less than 1 percent of the land use in the watershed, and contaminants for agriculture are not expected to be found in the creeks of this watershed. The creeks in this watershed are dominated by flashy flows and are expected to contain high total suspended solids for a short period, with the possibility of containing naturally occurring heavy metals. This watershed contains no 2006 Section 303(d)-listed water bodies, and water quality is not analyzed further in this report.

III.J Southern Sierra Watershed

General Description

The Southern Sierra Watershed is located south of the Kaweah River and north of the Kern River. On the east are the Kern River and the Sierra Nevada, and on the west is the Valley Floor (Figure 3-3). The Southern Sierra Watershed is bounded on the east and south by the Kern River Watershed, on the west by the South Valley Floor Watershed, and to the north by the Kaweah Watershed. The Tule River, Deer Creek, and White River are the main watersheds in the overall Southern Sierra Watershed. Together they occupy 665,472.83 acres of generally steep topography (DWR 2005c). Figure 3-53 shows the Southern Sierra Watershed. More than half of the mountainous portion of the watershed lies within Sequoia National Forest. The minimum elevation in the watershed is 518 feet, and the maximum elevation in the watershed is 10,226 feet.

The climate of the Southern Sierra Watershed is highly variable because of the large range in elevation. At the lower elevations, the climate is arid to semi-arid with dry, hot summers and mild winters. Summer temperatures are often higher than 100°F, and winter temperatures are only occasionally below freezing. Conditions are cooler and there is more precipitation at the higher elevations. The winter snowpack, which accumulates in the higher elevations, supplies much of the water in this watershed.

Land Use Patterns

Native vegetation is the dominant land use type in the Southern Sierra Watershed (Figure 3-63). Urban, irrigated agriculture, surface water, and barren land each make up less than 1 percent of land use in the region. These percentages can be attributed to the large Sequoia National Forest and Tule Indian Reservation land holdings. Table 3-72 lists land use acreage according to DWR and FRAP land use data for the Southern Sierra Watershed.

Table 3-72. Land Use Acreage according to DWR and FRAP Land Use Data for the Southern Sierra Watershed

Land Use	Acres	Percent Total
DWR Land Use Type		
Agriculture		
Deciduous Fruits and Nuts	119	0.0
Grain and Hay Crops	222	0.0
Idle	72	0.0
Pasture	910	0.1
Semi agricultural and Incidental to Agriculture	101	0.0
Vineyards	2	0.0
Subtotal	1,426	0.2
Urban		
Urban—Unclassified	762	0.1
Urban Landscape	159	0.0

Land Use	Acres	Percent Total
Commercial	55	0.0
Industrial	157	0.0
Residential	633	0.1
Vacant	22	0.0
Subtotal	1,788	0.3
Native		
Native Vegetation	142,278	21.4
Riparian Vegetation	715	0.1
Water Surface	2,644	0.4
Subtotal	145,637	21.9
FRAP Land Use Type		
Barren/Other	4,440	0.7
Conifer	104,322	15.7
Hardwood	239,054	35.9
Herbaceous	131,923	19.8
Shrub	36,011	5.4
Urban	674	0.1
Water	22	0.0
Wetland	175	0.0
Subtotal	516,621	77.6
Total	**665,473**	**100**

Basin Plan Status

The Tulare Lake Basin Plan (Central Valley Water Board 2004b) describes beneficial uses for waters in the Southern Sierra Watershed. Table 3-73 lists the beneficial uses of the Upper Tule River above Success Dam. The designated beneficial uses also apply to Dry Creek and the White River.

Table 3-73. Beneficial Uses in the Southern Sierra Watershed

Beneficial Use	Tule River above Lake Success
Municipal and Domestic	E
Agriculture	E
Industrial Service	
Industrial Process	
Hydropower Generation	E
Rec-1*	E
Rec-2*	E
Freshwater Habitat—Warm	E
Freshwater Habitat—Cold	E

Beneficial Use	Tule River above Lake Success
Wildlife Habitat	E
Rare, Threatened, or Endangered Species	E
Spawning, Reproduction, and/or Early Development	E
Groundwater Recharge	
Freshwater Replenishment	E
Preservation of Biological Habitats of Special Significance	

E = Existing.

*Rec-1 indicates recreational activities involving body contact with water, where ingestion of the water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs. Rec-2 indicates recreational activities involving proximity to water, but generally with no body contact with water or any likelihood of ingestion of water. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment associated with the above activities.

Beneficial use categories in the Tulare Lake Basin vary slightly from those in the Sacramento–San Joaquin Rivers Basin Plan.

Source: Central Valley Water Board 2004b.

Hydrology

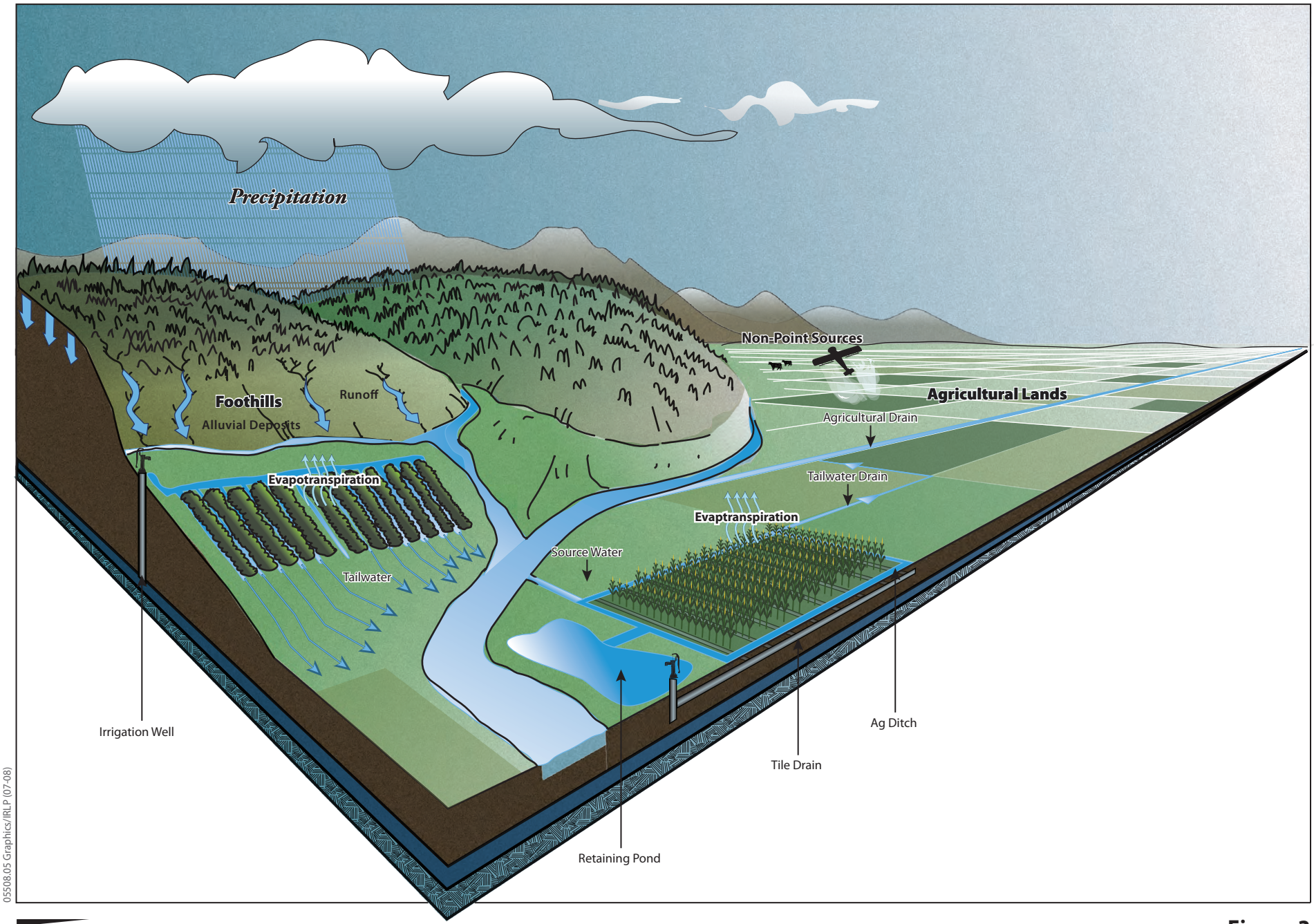
The southern portion of the Southern Sierra Watershed includes the Tule River Indian Reservation. The Upper Tule River's three forks—the North, Middle, and South—flow southwest or west into Success Reservoir (Figure 3-53). All three forks are fed by a multitude of small streams. The Upper Tule River flow varies seasonally, with the lowest flows (approximately 0 cfs) in late summer (August and September) and the highest flows (approximately 1,100 cfs) in spring (February through May) (see Table B-34 in Appendix B).

Deer Creek Watershed is located south of the Tule River Watershed and north of the White River Watershed. Steep mountainous terrain makes up the majority of the upper Deer Creek watershed; this watershed drains the western slope of the Greenhorn Mountains, which is part of the Sierra Nevada. The maximum elevation in the Deer Creek Watershed is 8,300 feet. Water generally flows west from this elevation through the foothills and crosses the South Valley. Flow data were not available for Deer Creek in the Southern Sierra Watershed. For more information on the lower portion of Deer Creek and its downstream flow, see the South Valley Floor Watershed section.

The White River Watershed, located south of Deer Creek Watershed and north of Poso Creek Watershed, drains a portion of the Greenhorn Mountains, flowing westward into the South Valley toward Tulare Lake Bed. For additional information on the lower reaches of White River, see the South Valley Floor Watershed section. Like the Deer Creek Watershed, the maximum elevation in the White River Watershed is 8,300 feet, with steep mountainous terrain in the upper watershed and foothills as the White River approaches the valley floor. Flow data were not available for White River in the Southern Sierra Watershed. For downstream flow data, see the South Valley Floor Watershed section.

Water Quality

There are few, if any, water quality concerns in the Southern Sierra Watershed. No 2006 Section 303(d)-listed pollutants are associated with the Upper Tule River. Generally, all physical parameters such as EC, pH, temperature, and turbidity are within Basin Plan standards.



05508.05 Graphics/IRLP (07-08)

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Figure 3
Conceptual Surface Water Model

PIT RIVER

SHASTA-TEHAMA

UPPER FEATHER
UPPER YUBA

BUTTE-
SUTTER-
YUBA

COLUSA
BASIN

LAKE-
NAPA

AMERICAN
RIVER

SOLANO-
YOLO

SISKIYOU
TRINITY
SHASTA
LASSEN
MODOC
TEHAMA
PLUMAS
BUTTE
GLENN
SIERRA
NEVADA
YUBA
PLACER
LAKE
COLUSA
SUTTER
YOLO
EL DORADO
ALPINE
NAPA
SACRAMENTO
AMADOR
SONOMA
SOLANO
CALAVERAS
MARIN
TUOLUMNE
Sacramento
Santa Rosa
Fairfield
Vallejo
Richmond
Concord
Stockton

Legend

- Cities
- US Highway
- Interstate
- Subwatershed Boundaries
- County Lines

0 25 50
Miles

Sacramento Valley Basin

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Figure 3-1
Sacramento Valley Basin

BUTTE
SUTTER
NEVADA
YUBA
COLUSA
PLACER
EL DORADO
SACRAMENTO
YOLO
ALPINE
SOLANO
AMADOR
CALAVERAS
SAN JOAQUIN
MONO
TUOLUMNE
CONTRA COSTA
MARIPOSA
ALAMEDA
SANTA CLARA
STANISLAUS
MADERA
INYO
SANTA CRUZ
MERCED
SAN BENITO
FRESNO
MONTEREY
KINGS
TULARE

Lake Tahoe
Mono Lake
Don Pedro Reservoir
San Luis Reservoir
Comanche Reservoir

Sacramento
Stockton
Modesto
San Jose
Salinas
Fresno

YUBA R
BEAR R
AMERICAN R
COSUMNES R
SACRAMENTO R
CALAVERAS R
MOKELUMNE R
SAN JOAQUIN R
STANISLAUS R
TUOLUMNE R
MERCED R
FRESNO R
CHOWCHILLA R
KINGS R
TULE R

COSUMNES RIVER

UPPER MOKELUMNE
UPPER CALAVERAS

STANISLAUS RIVER

NORTH VALLEY FLOOR

DELTA - CARBONA

TUOLUMNE RIVER

MERCED RIVER

SAN JOAQUIN VALLEY FLOOR

MARIPOSA

AHWAHNEE

SAN JOAQUIN RIVER

DELTA-MENDOTA CANAL

Legend

- Cities
- US Highway
- Interstate
- Subwatershed Boundaries
- County Lines

0 15 30
Miles

San Joaquin Valley Basin

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Figure 3-2
San Joaquin Valley Basin

STANISLAUS
MERCED
MARIPOSA
MADERA
MONO
INYO
FRESNO
KINGS
TULARE
KERN
SAN BENITO
MONTEREY
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
CHOWCHILLA R
FRESNO R
SAN JOAQUIN R
KINGS R
Fresno
Bakersfield
Lancaste
KINGS RIVER
KAWEAH RIVER
KERN RIVER
COAST RANGE
SOUTH VALLEY FLOOR
SUNFLOWER VALLEY
SOUTHERN SIERRA
TEMBLOR
FELLOWS
GRAPEVINE
5
101
395
6
39

Legend

- Cities
- US Highway
- Interstate
- Subwatershed Boundaries
- County Lines

0 15 30
Miles

Tulare Lake Basin

J:\GIS\PROJECTS\RWQCB1\06508_05\ARCMAP\TU_FIG3_3_SUBBASINSA.MXD JJ (10-25-05)

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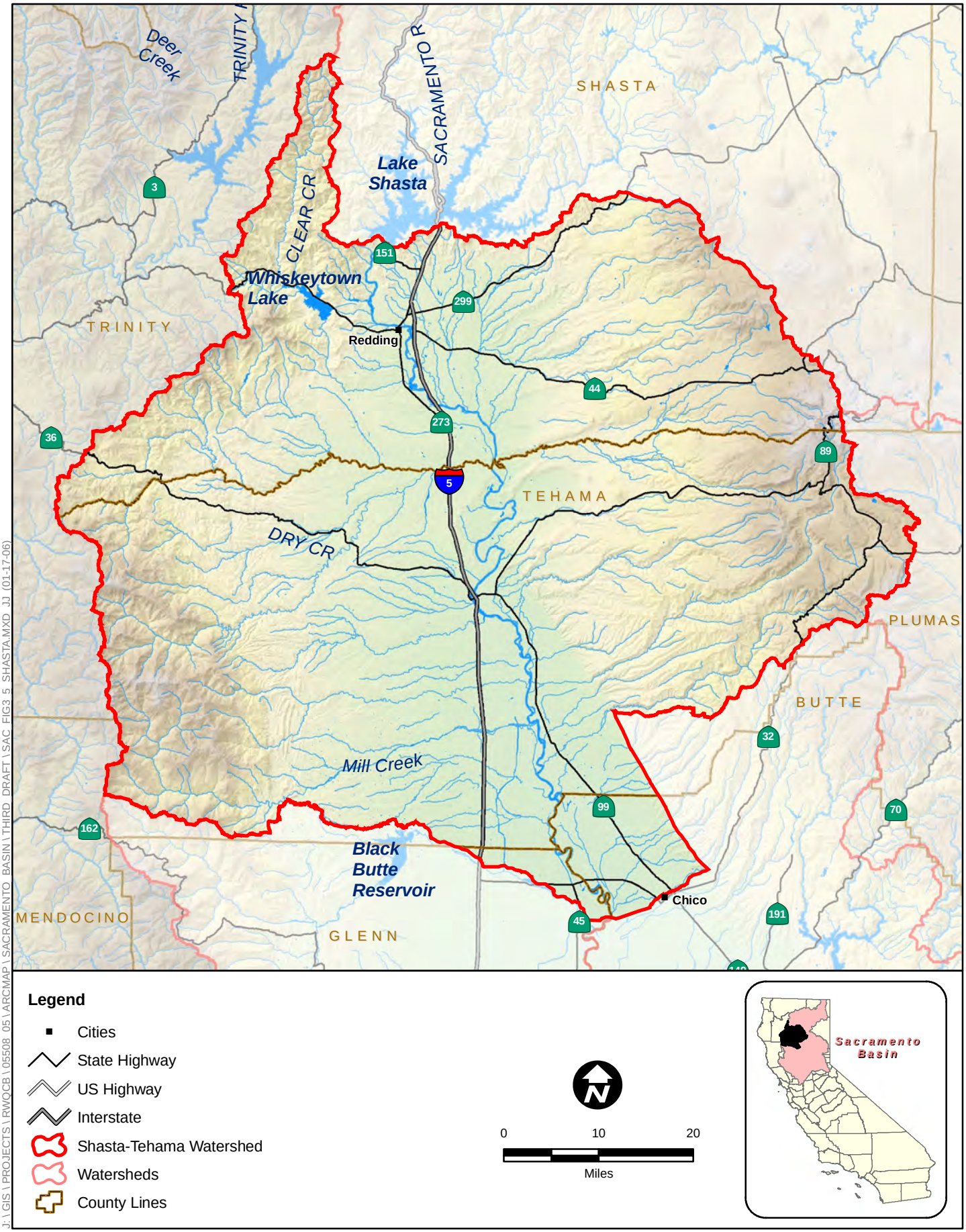
Figure 3-3
Tulare Lake Basin



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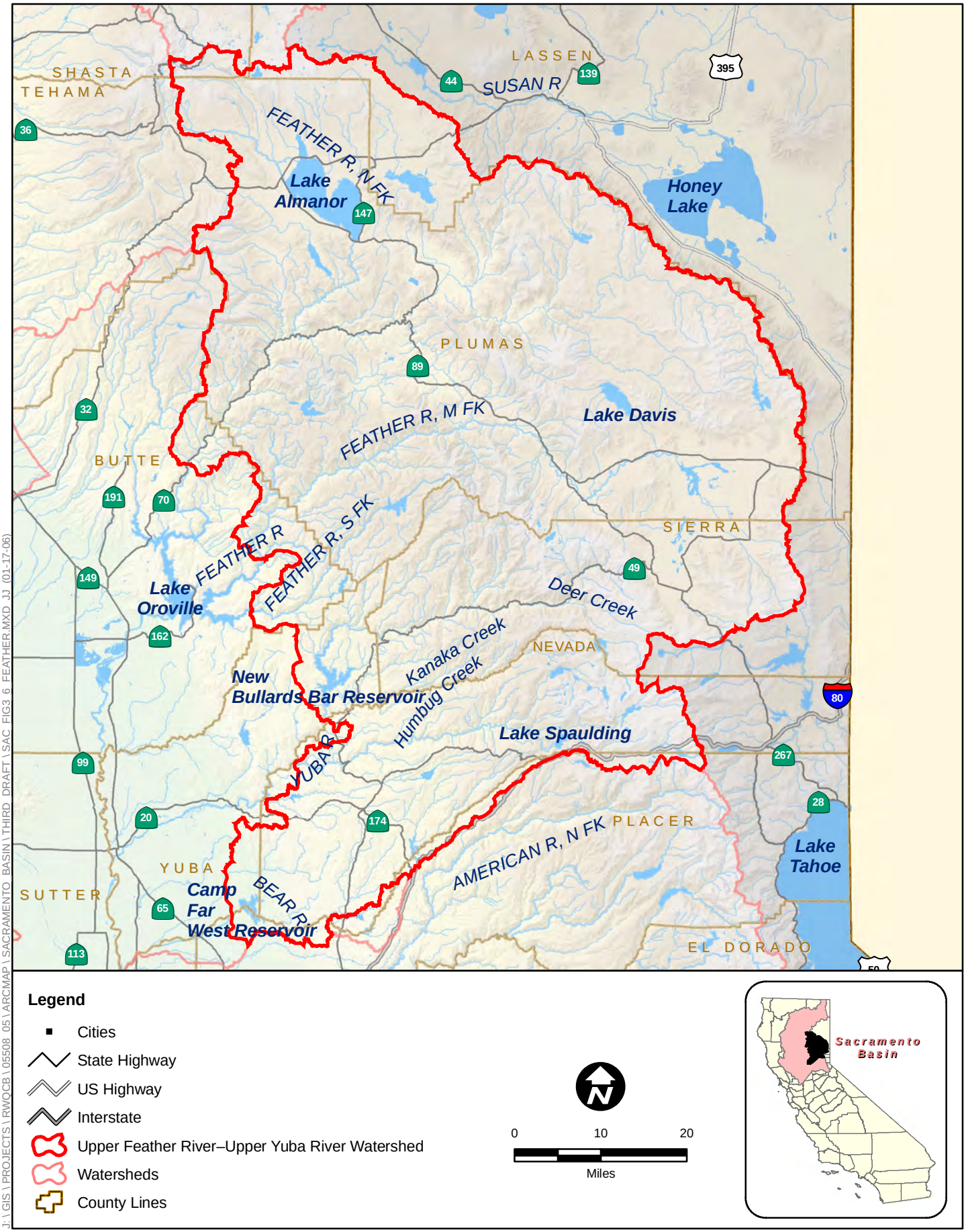
Figure 3-4
Pit River Watershed



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ICF Jones & Stokes

Figure 3-5
Shasta-Tehama Watershed



Legend

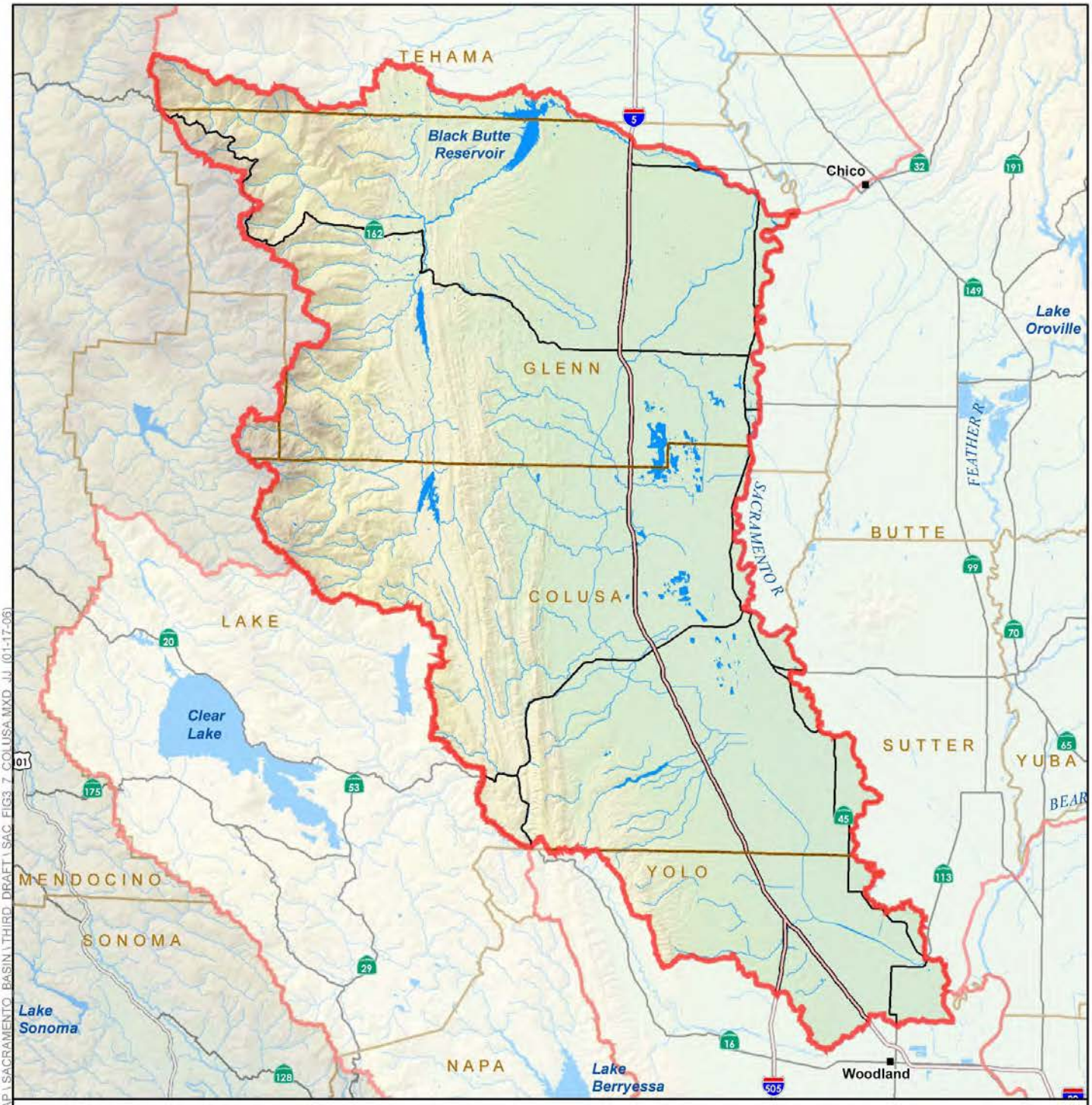
- Cities
- State Highway
- US Highway
- Interstate
- Upper Feather River–Upper Yuba River Watershed
- Watersheds
- County Lines

0 10 20
Miles

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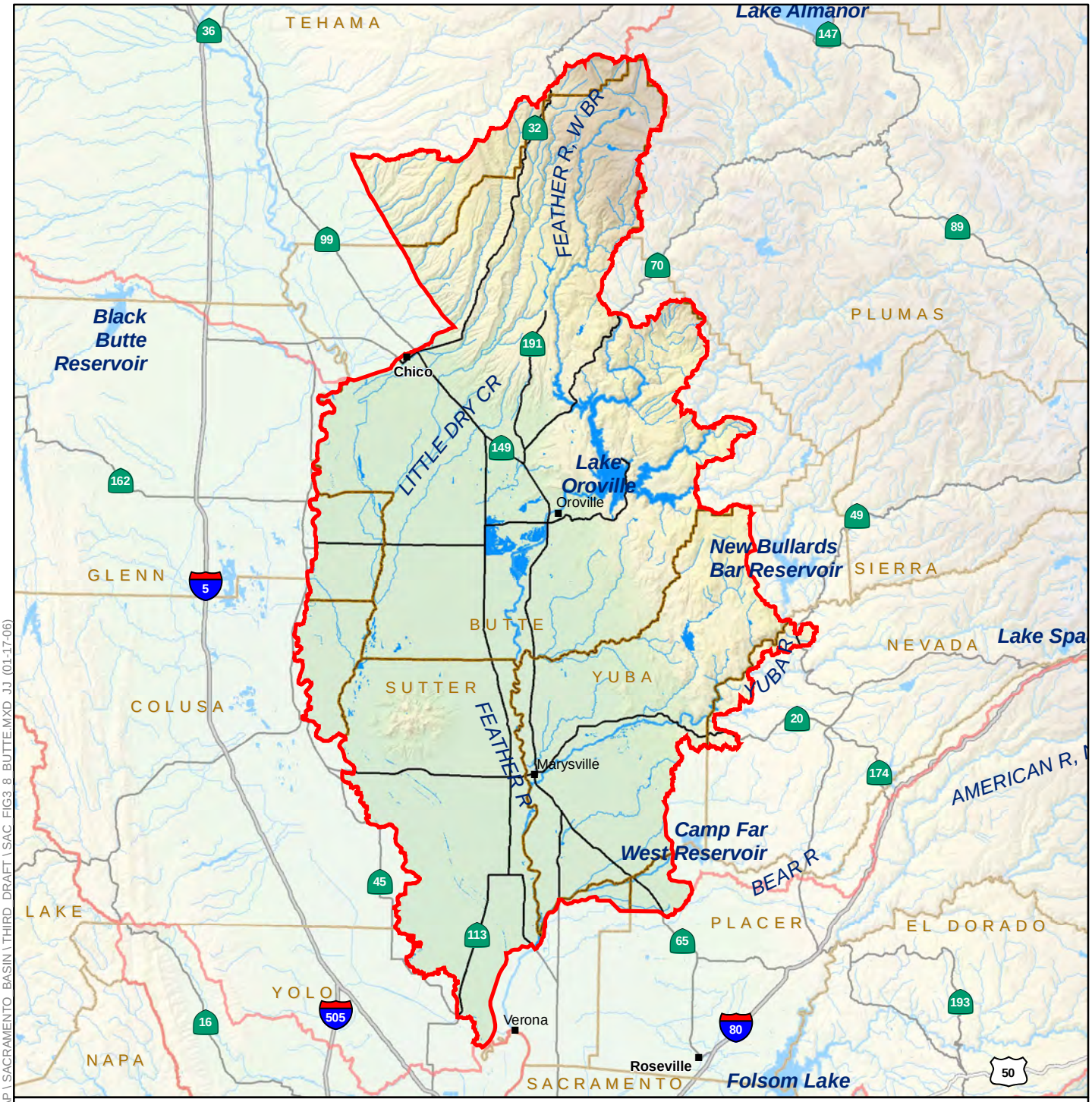
Figure 3-6
Upper Feather River–Upper Yuba River Watershed



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Figure 3-7
Colusa Basin Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Butte-Sutter-Yuba Watershed
- Watersheds
- County Lines

0 10 20

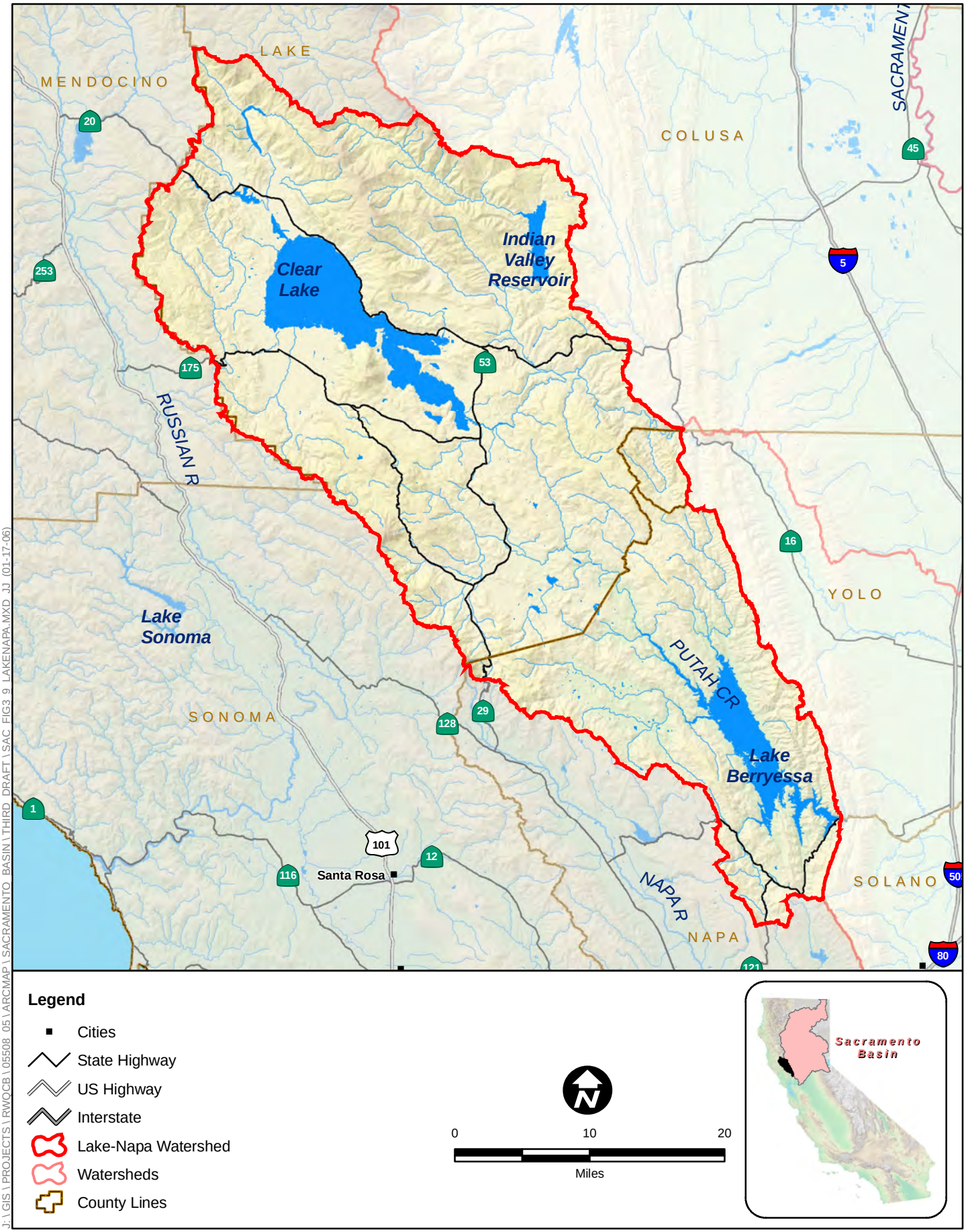
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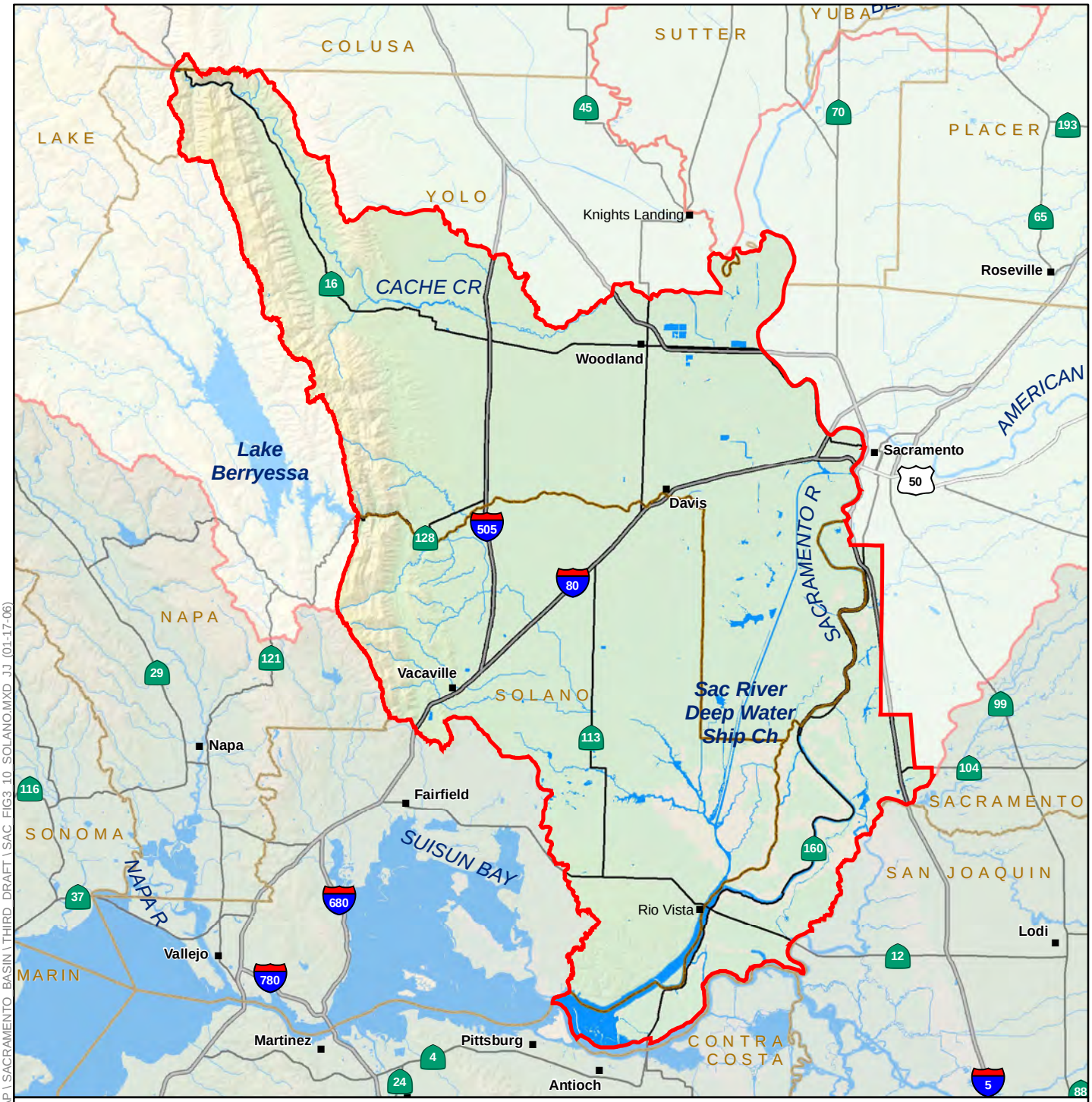
Figure 3-8
Butte-Sutter-Yuba Watershed



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Figure 3-9
Lake-Napa Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Solano-Yolo Watershed
- Watersheds
- County Lines

0 10 20

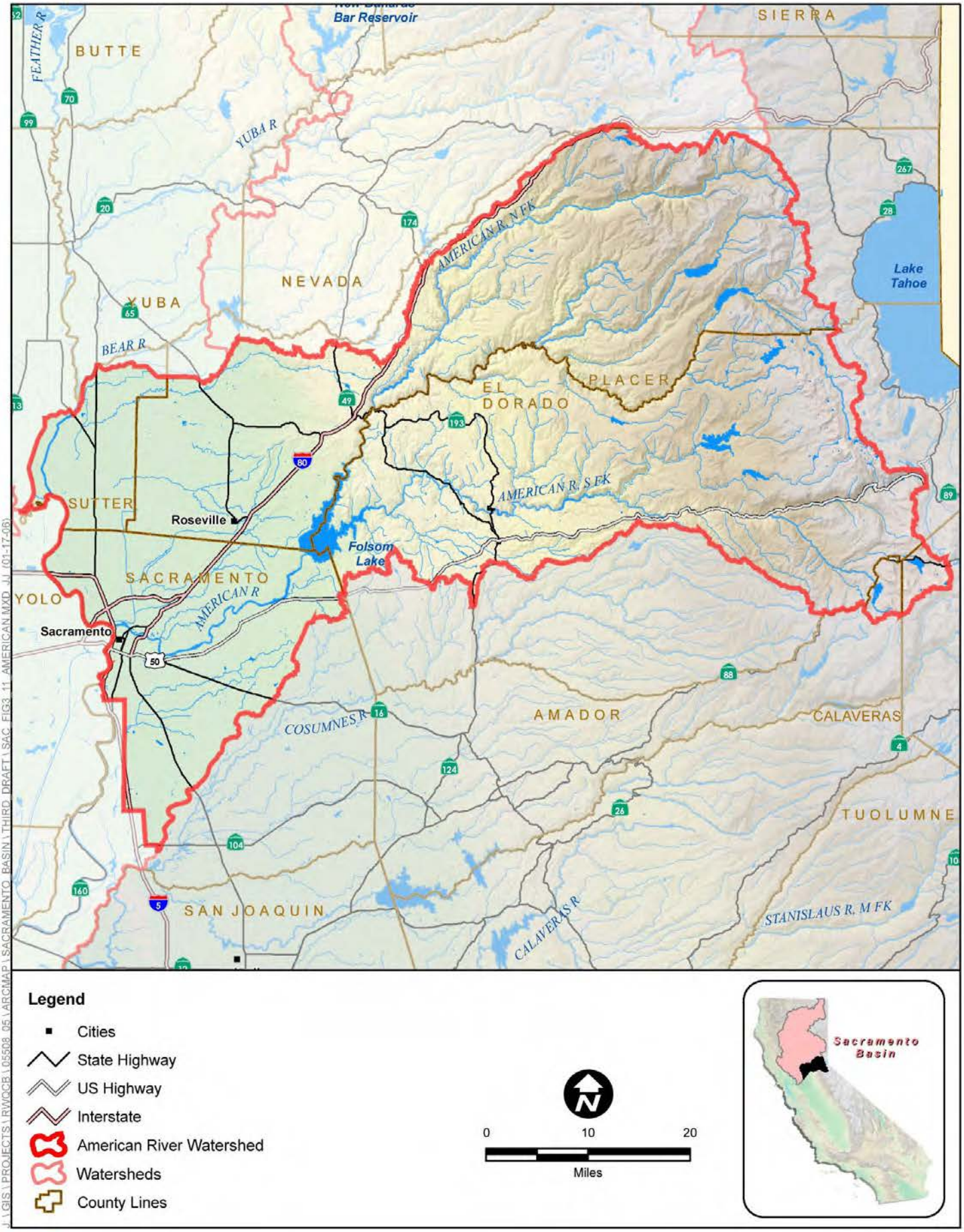
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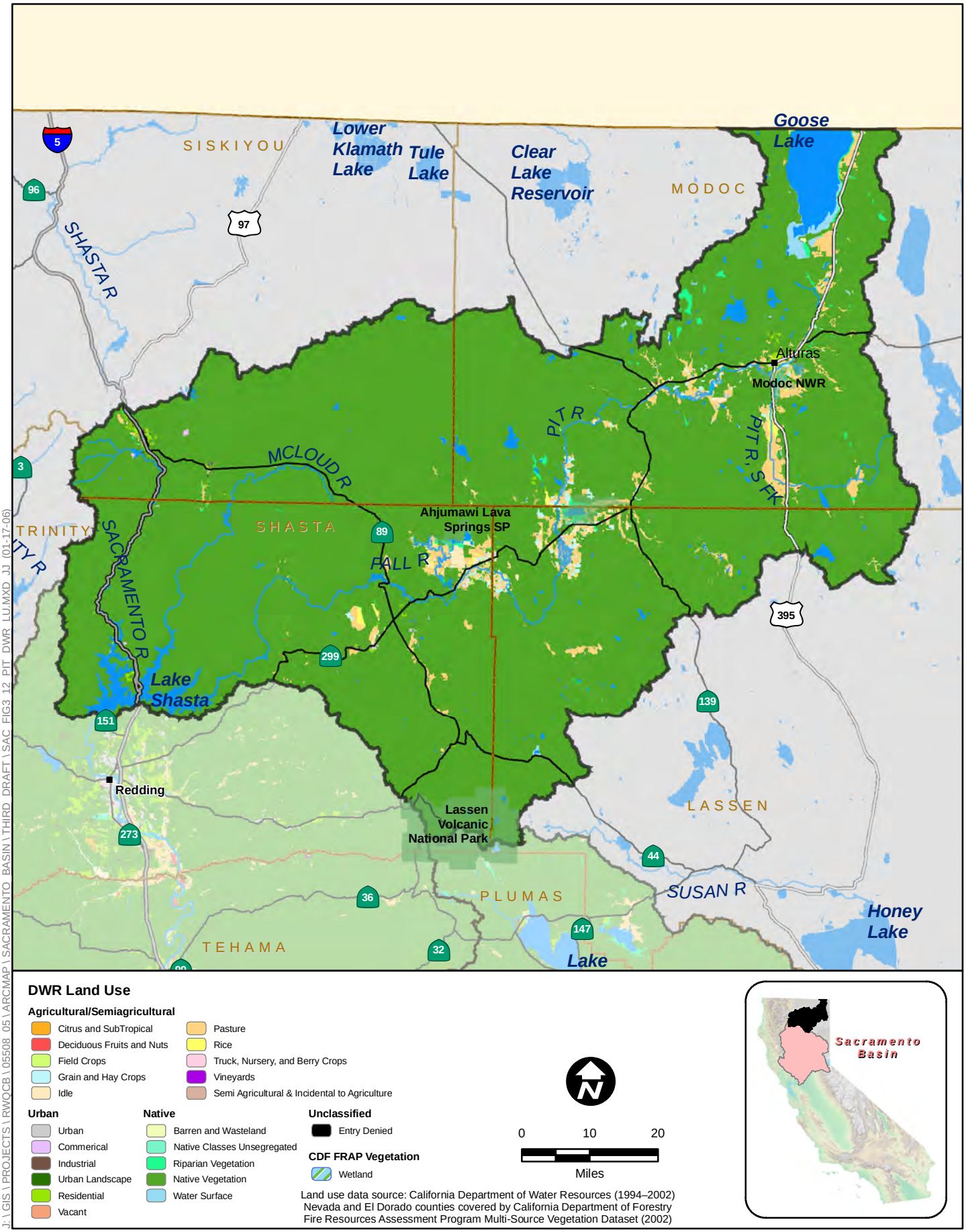
Figure 3-10
Solano-Yolo Watershed



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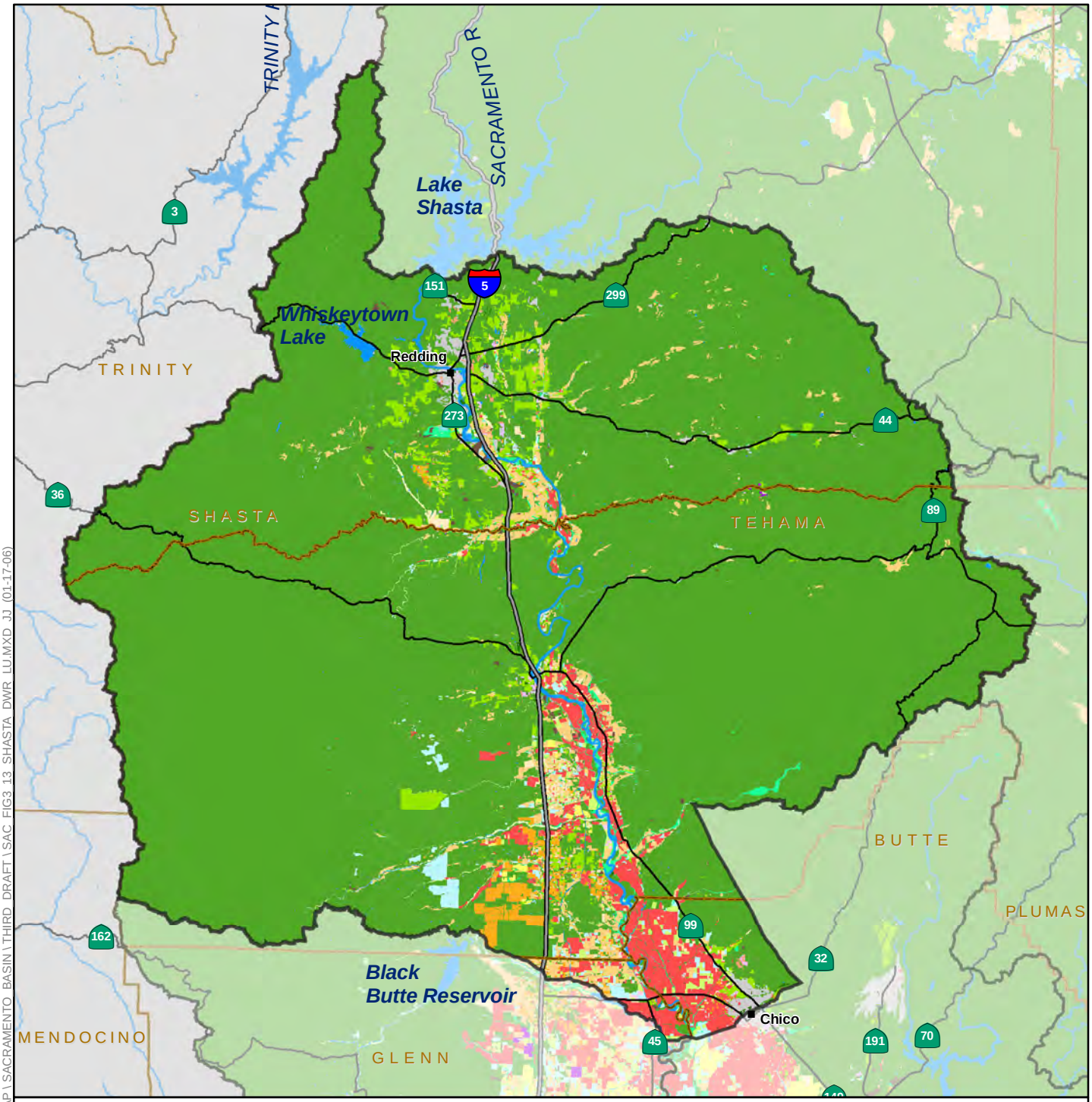
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Figure 3-11
American River Watershed



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an ICF International Company

Figure 3-12
California Department of Water Resources Land Use
Pit River Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

N

0 10 20

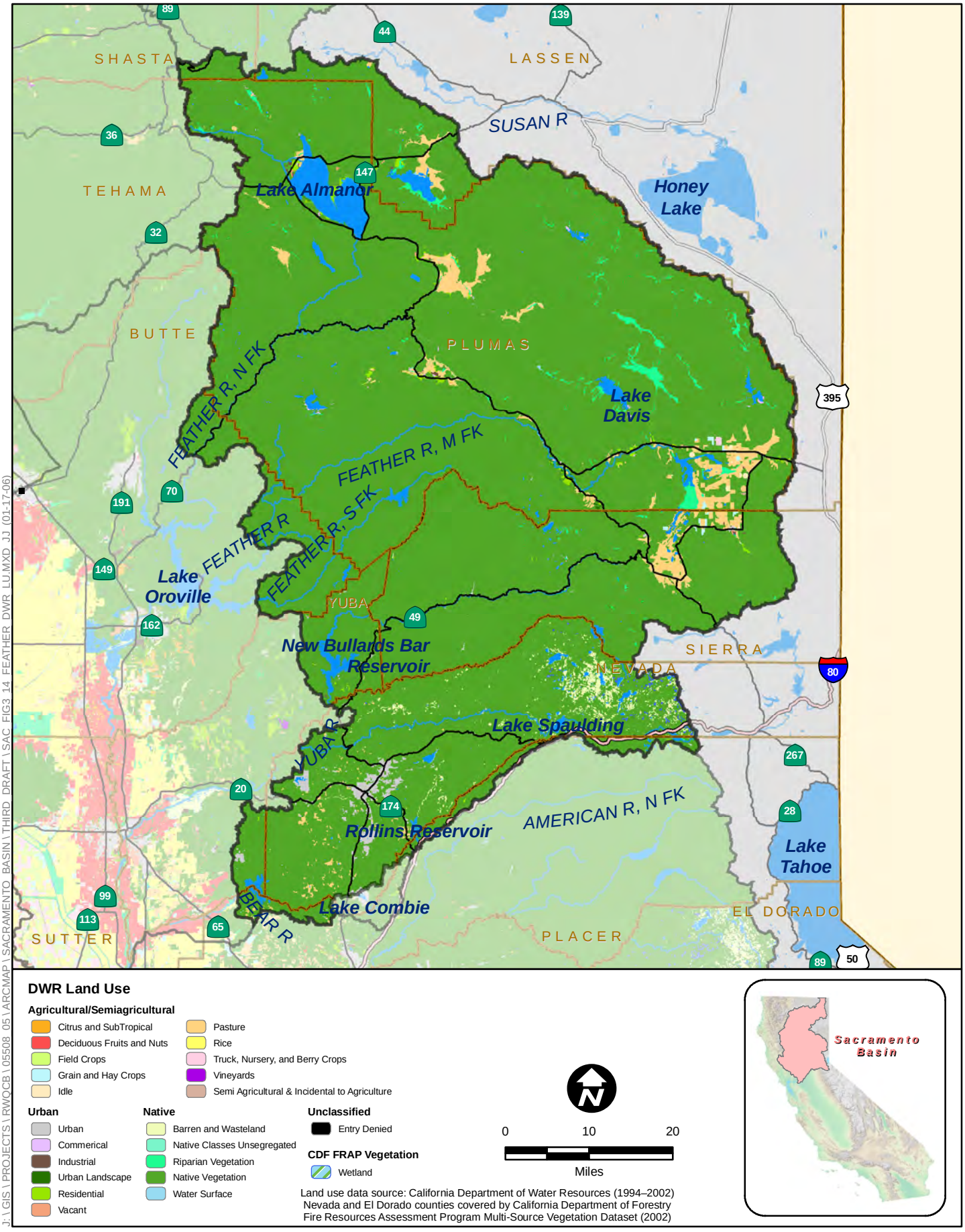
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Land use data source: California Department of Water Resources (1994–2002)
Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



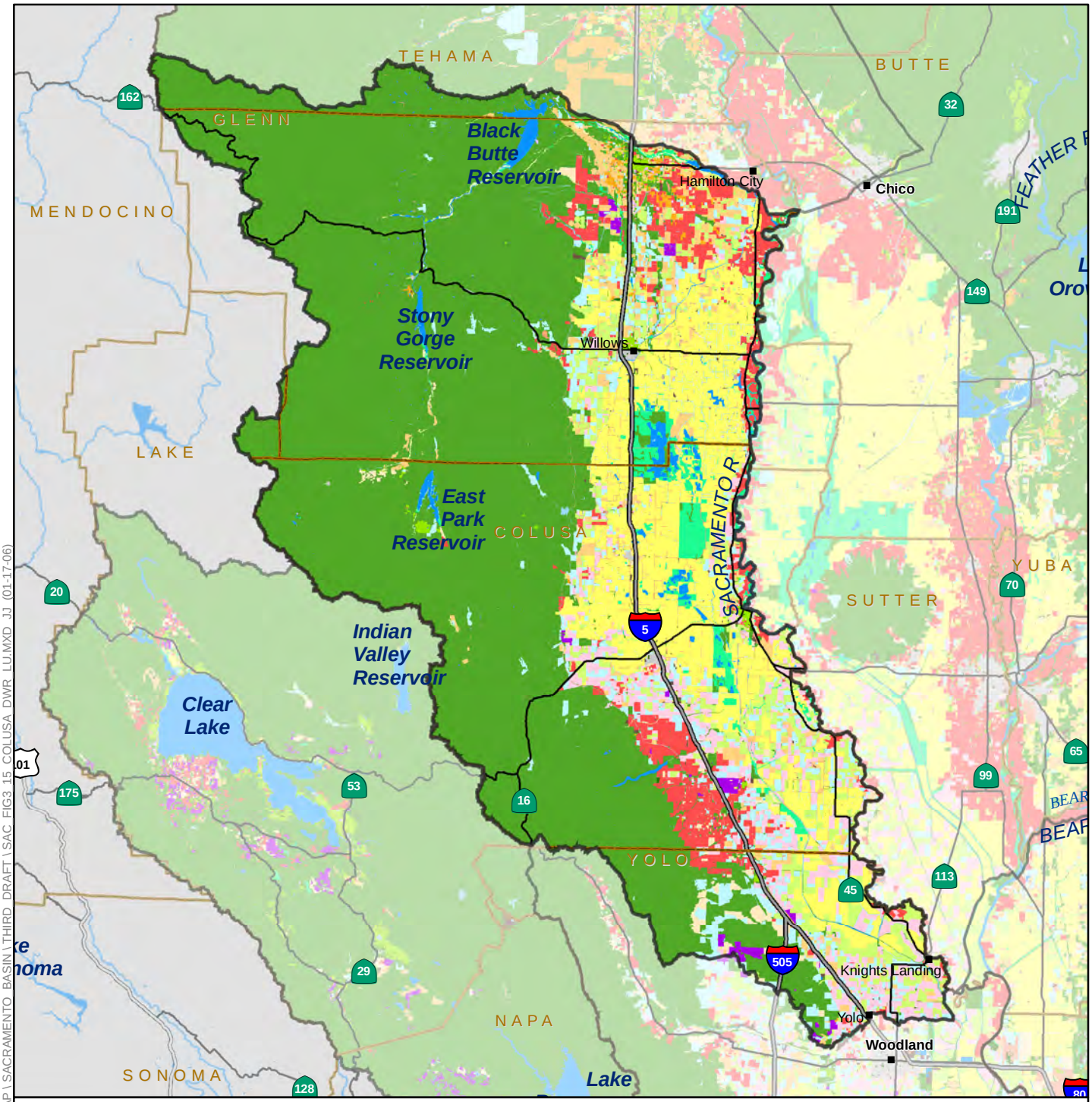
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Figure 3-13
California Department of Water Resources Land Use
Shasta-Tehama Watershed



ICF Jones & Stokes
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Figure 3-14
California Department of Water Resources Land Use
Upper Feather–Upper Yuba Subwatershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

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Miles

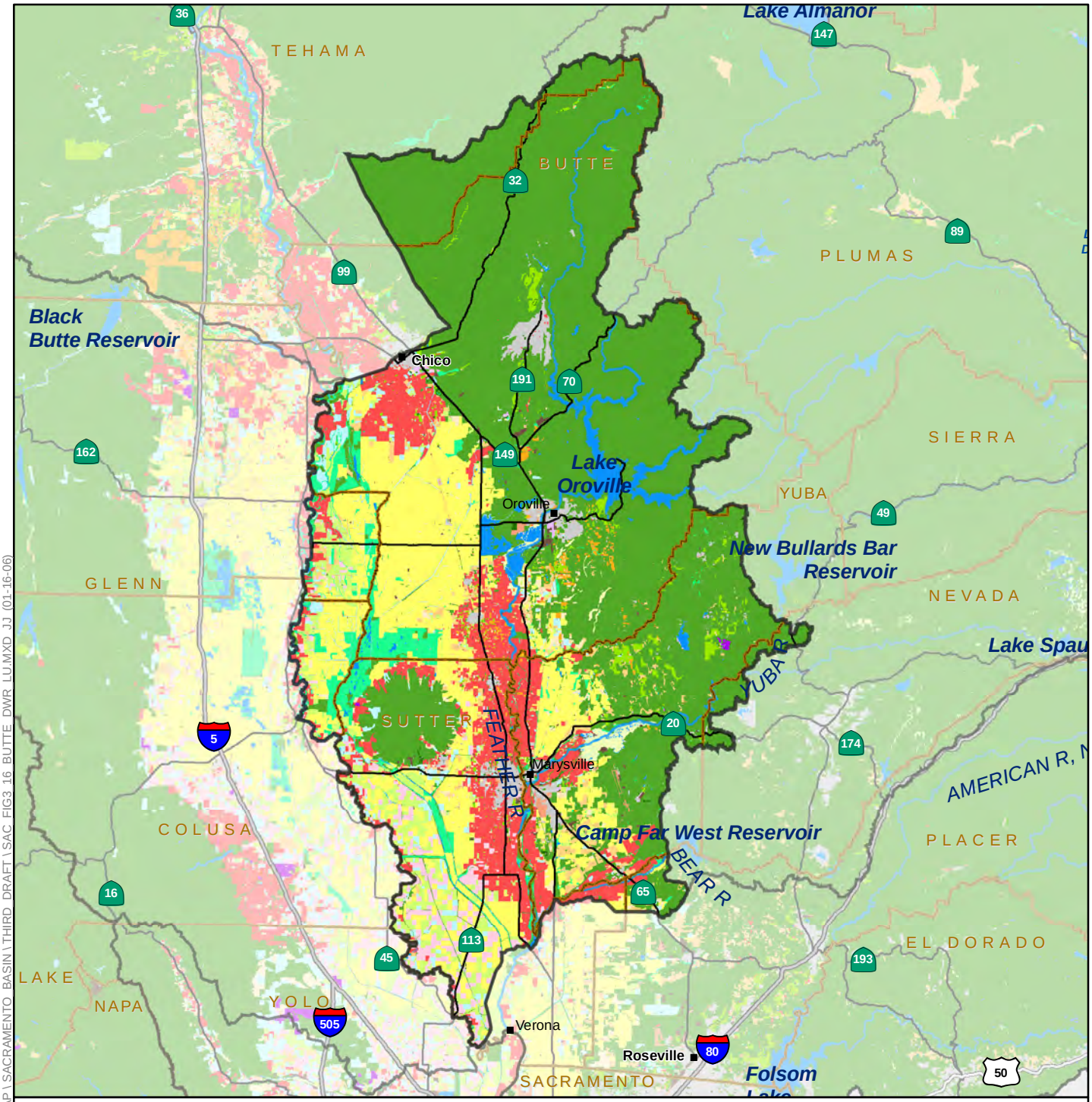
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Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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Figure 3-15
California Department of Water Resources Land Use
Colusa Basin Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

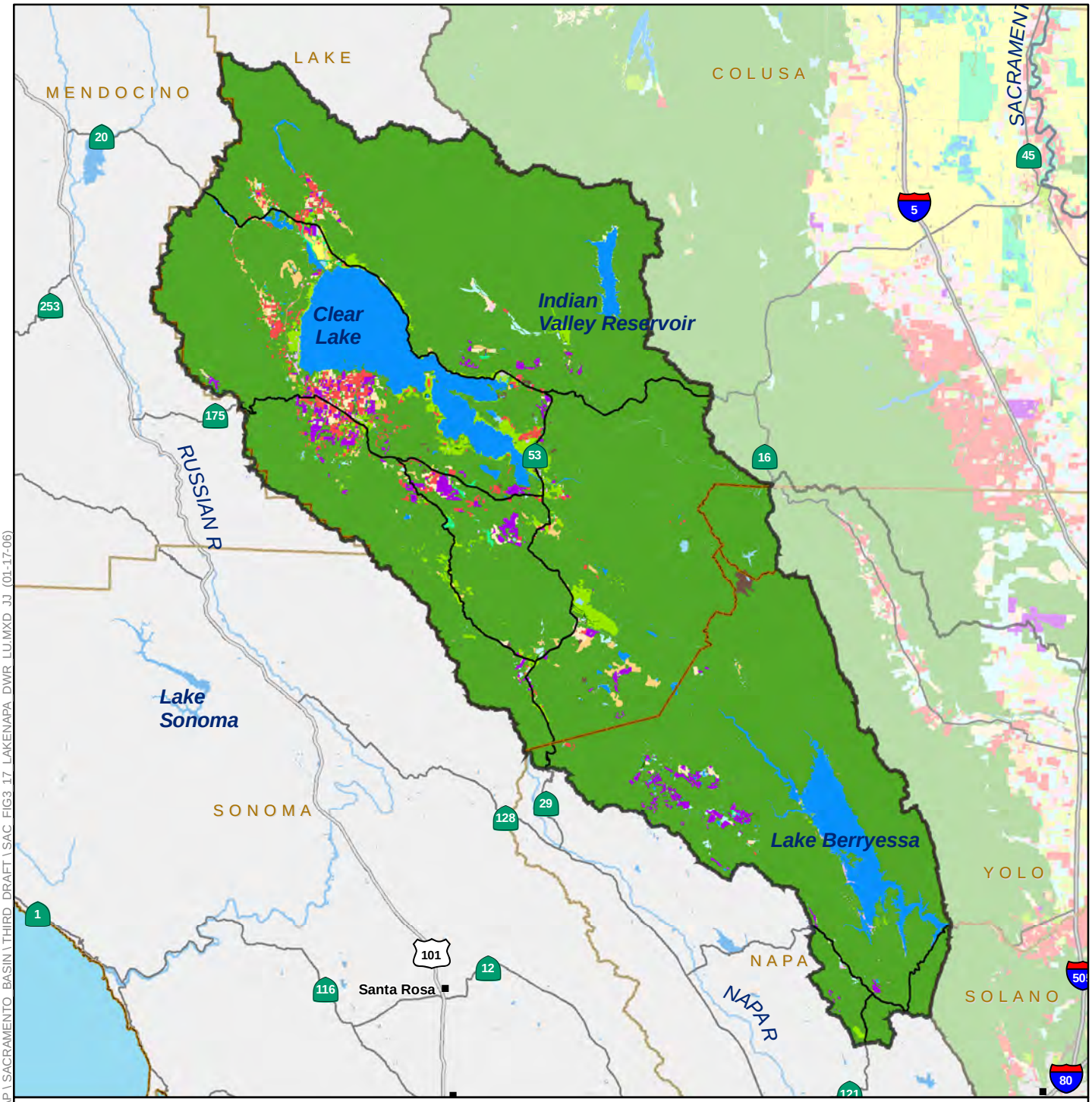
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Land use data source: California Department of Water Resources (1994–2002)
Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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Figure 3-16
California Department of Water Resources Land Use
Butte-Sutter-Yuba Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

N

0 10 20

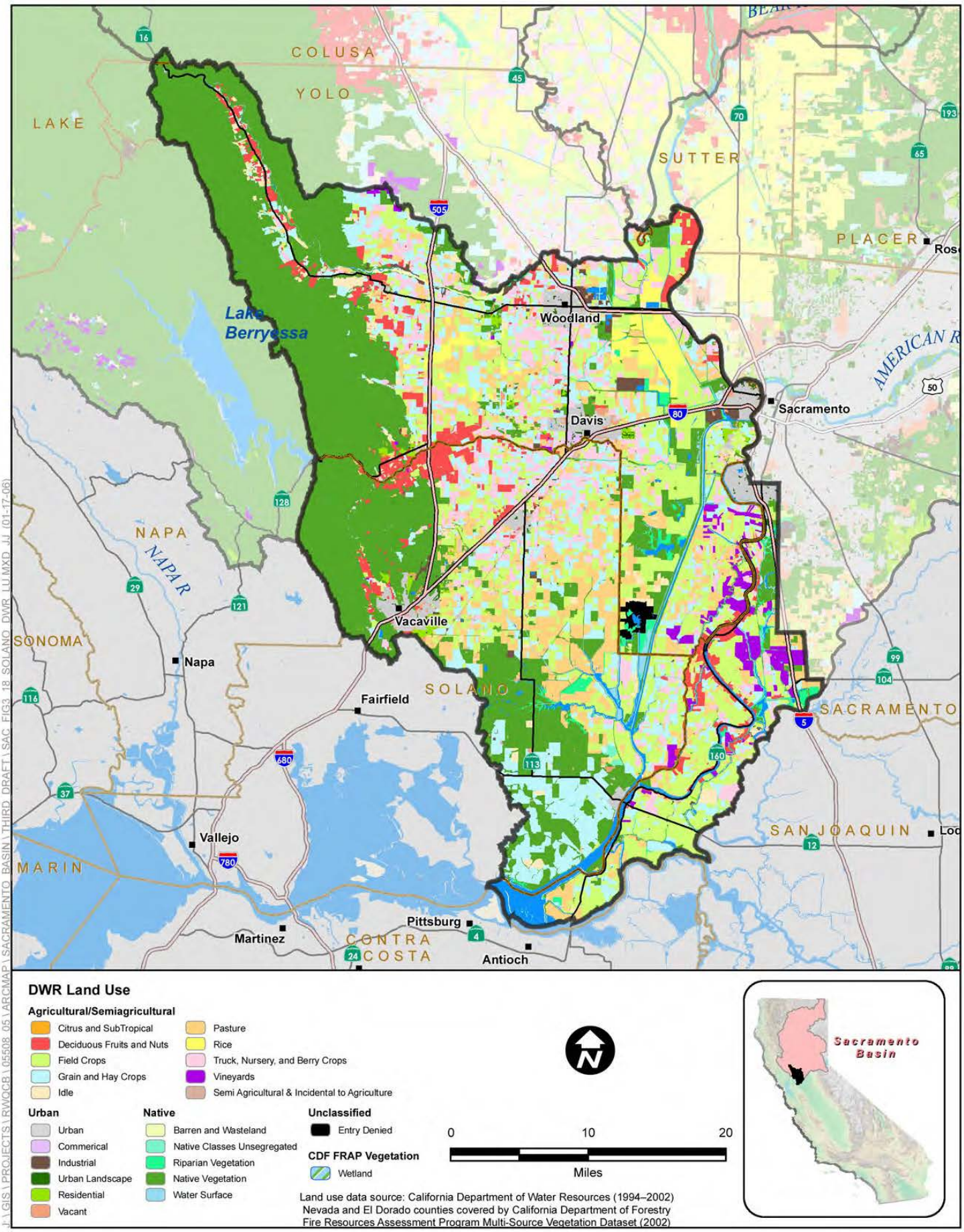
Miles

Land use data source: California Department of Water Resources (1994–2002)
Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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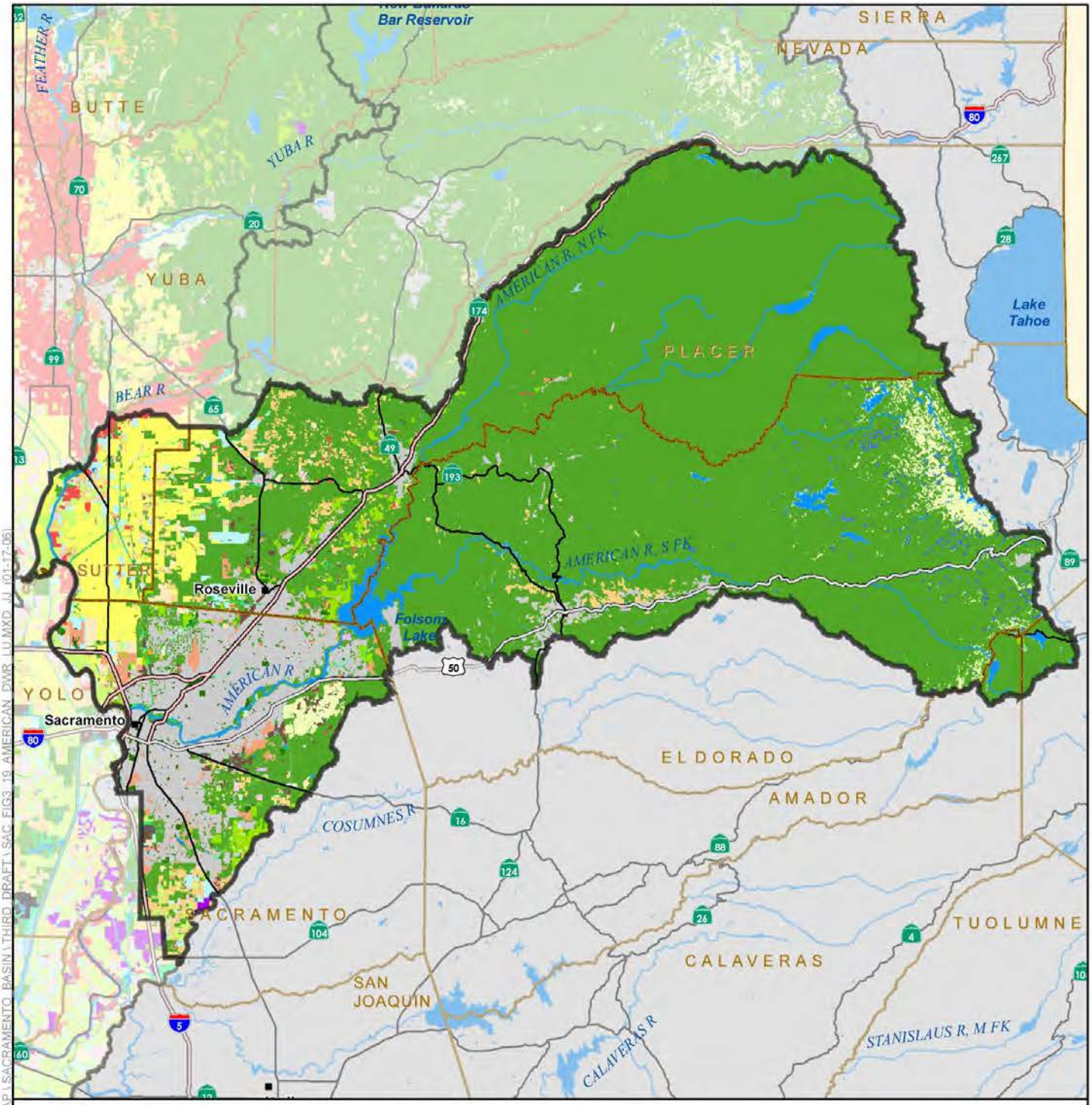
Figure 3-17
California Department of Water Resources Land Use
Lake-Napa Watershed



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Figure 3-18
California Department of Water Resources Land Use
Solano-Yolo Subwatershed

Adminsitrative Record
Page 30502



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles



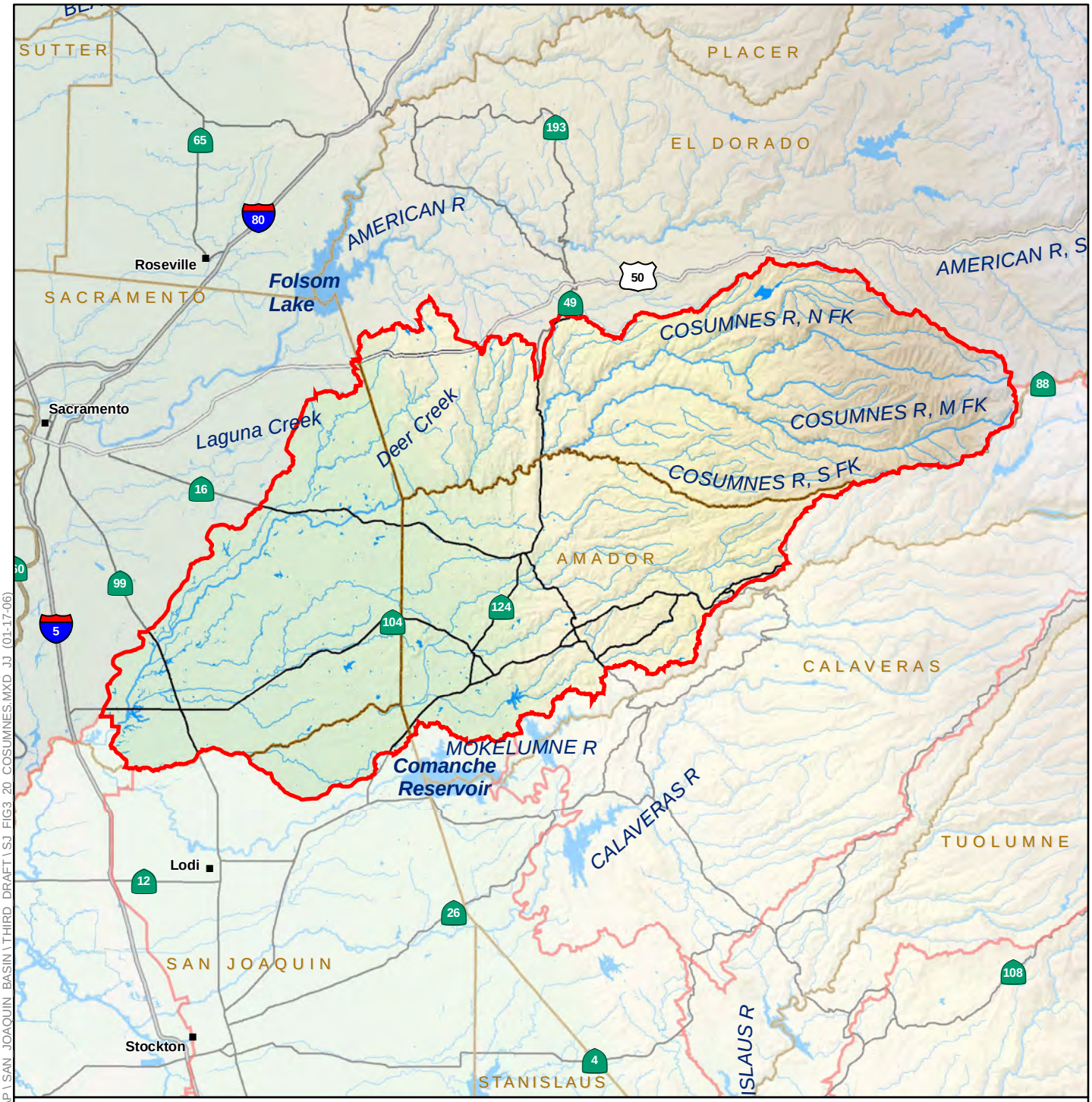
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Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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Figure 3-19
California Department of Water Resources Land Use
American River Subwatershed

Adminsitrative Record
Page 30503



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Cosumnes River Watershed
- Watersheds
- County Lines

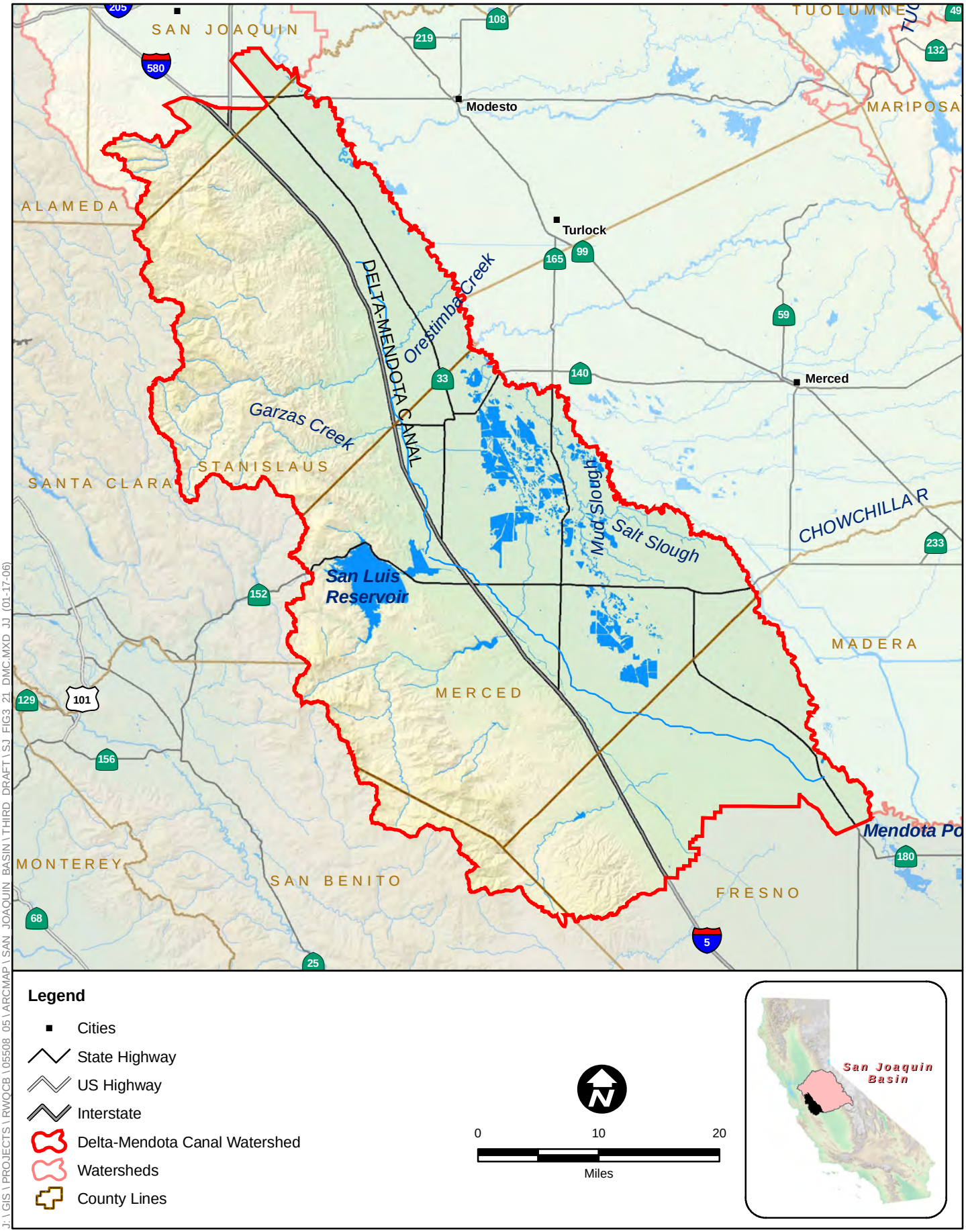
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Figure 3-20
Cosumnes River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Delta-Mendota Canal Watershed
- Watersheds
- County Lines

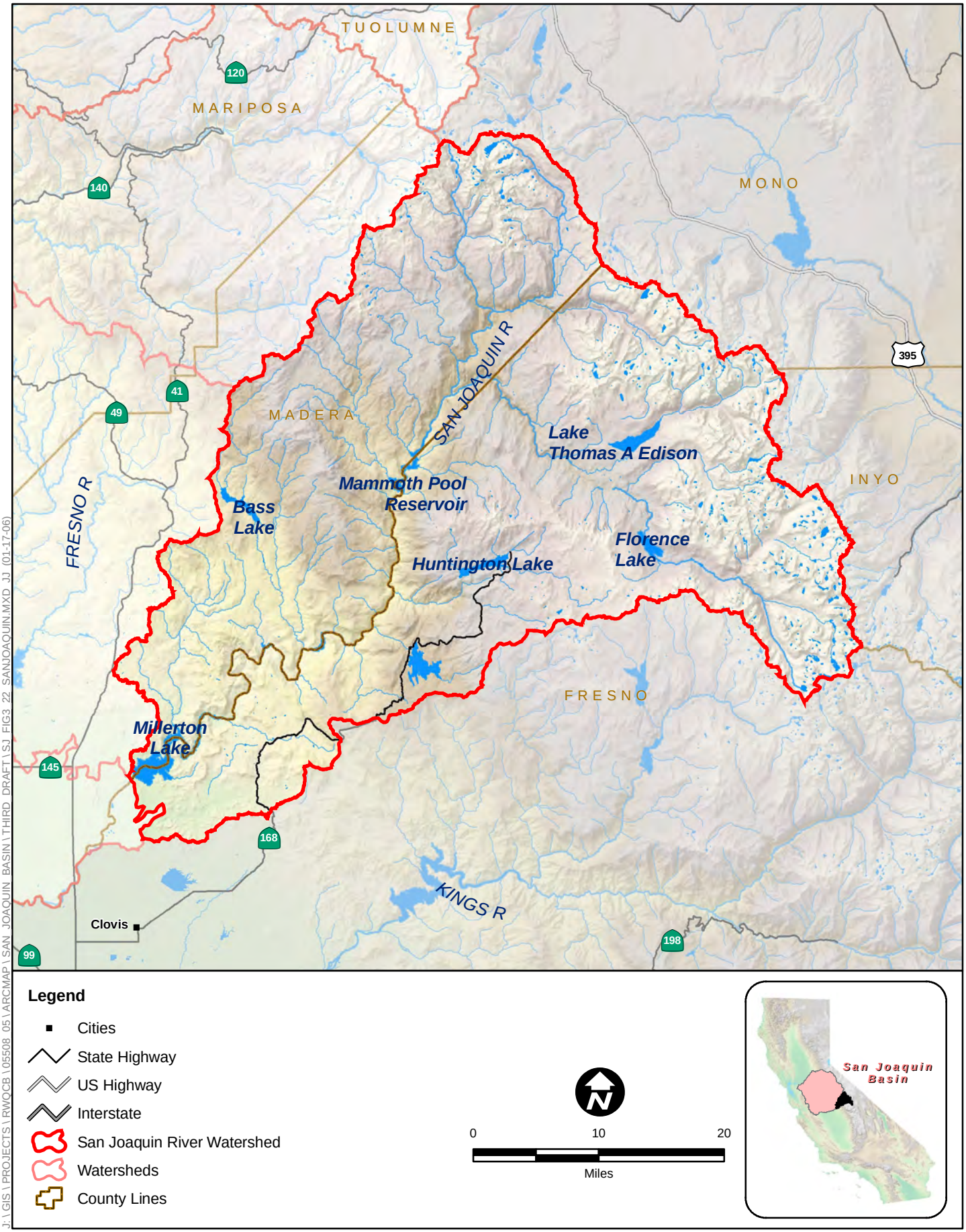
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Miles

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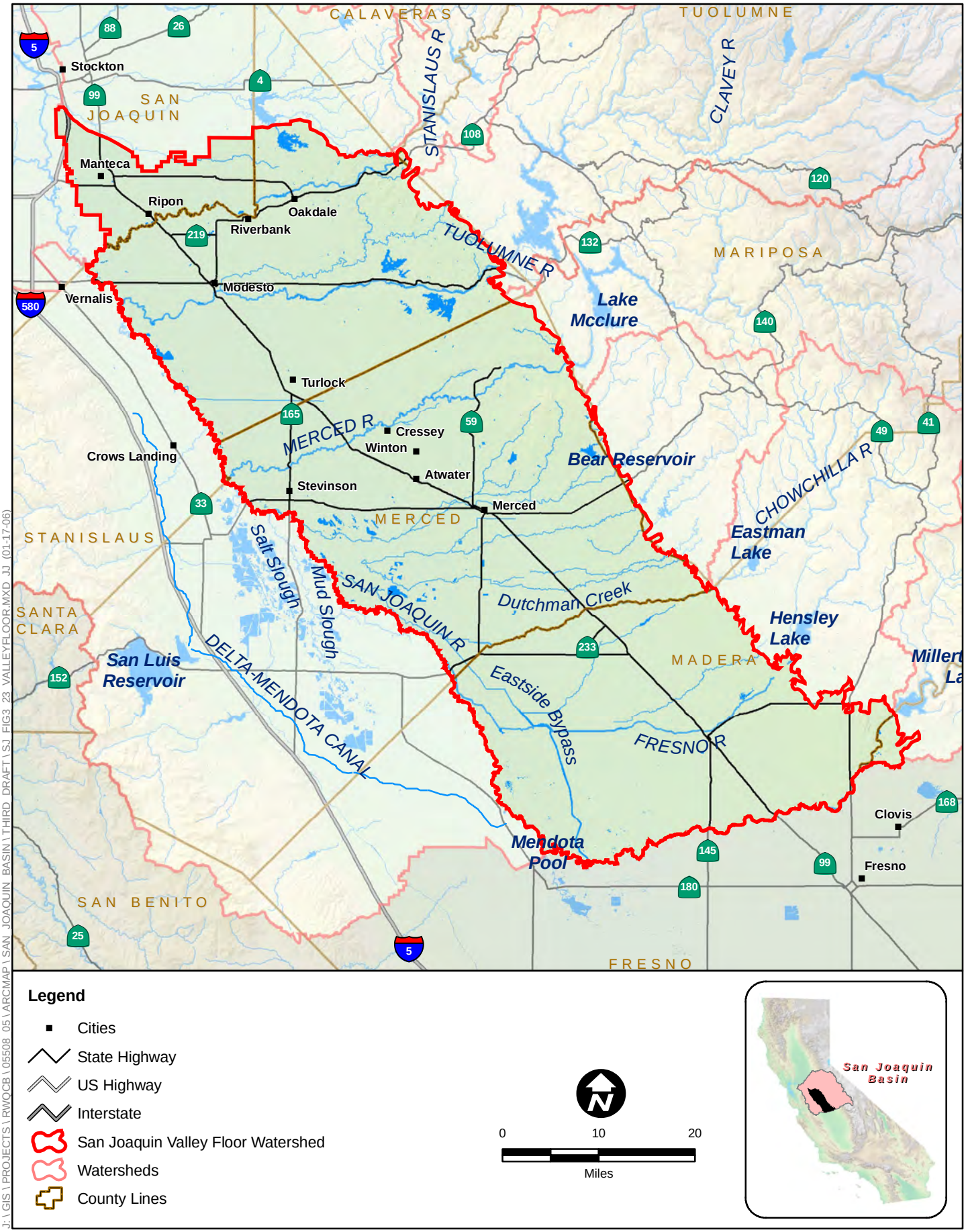
Figure 3-21
Delta-Mendota Canal Watershed



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Figure 3-22
San Joaquin River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- San Joaquin Valley Floor Watershed
- Watersheds
- County Lines

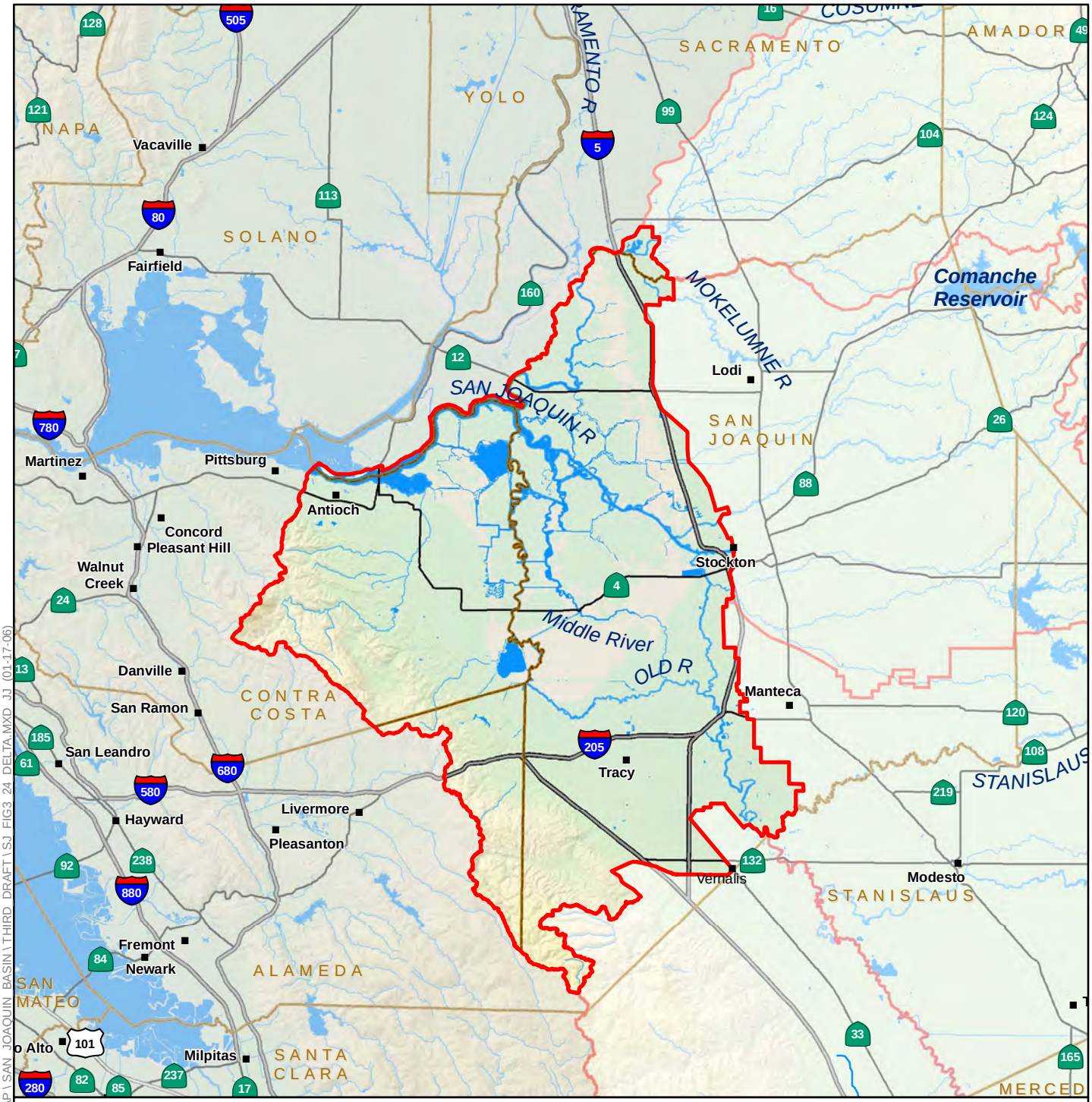
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Figure 3-23
San Joaquin Valley Floor Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Delta-Carbona Watershed
- Watersheds
- County Lines

0 10 20

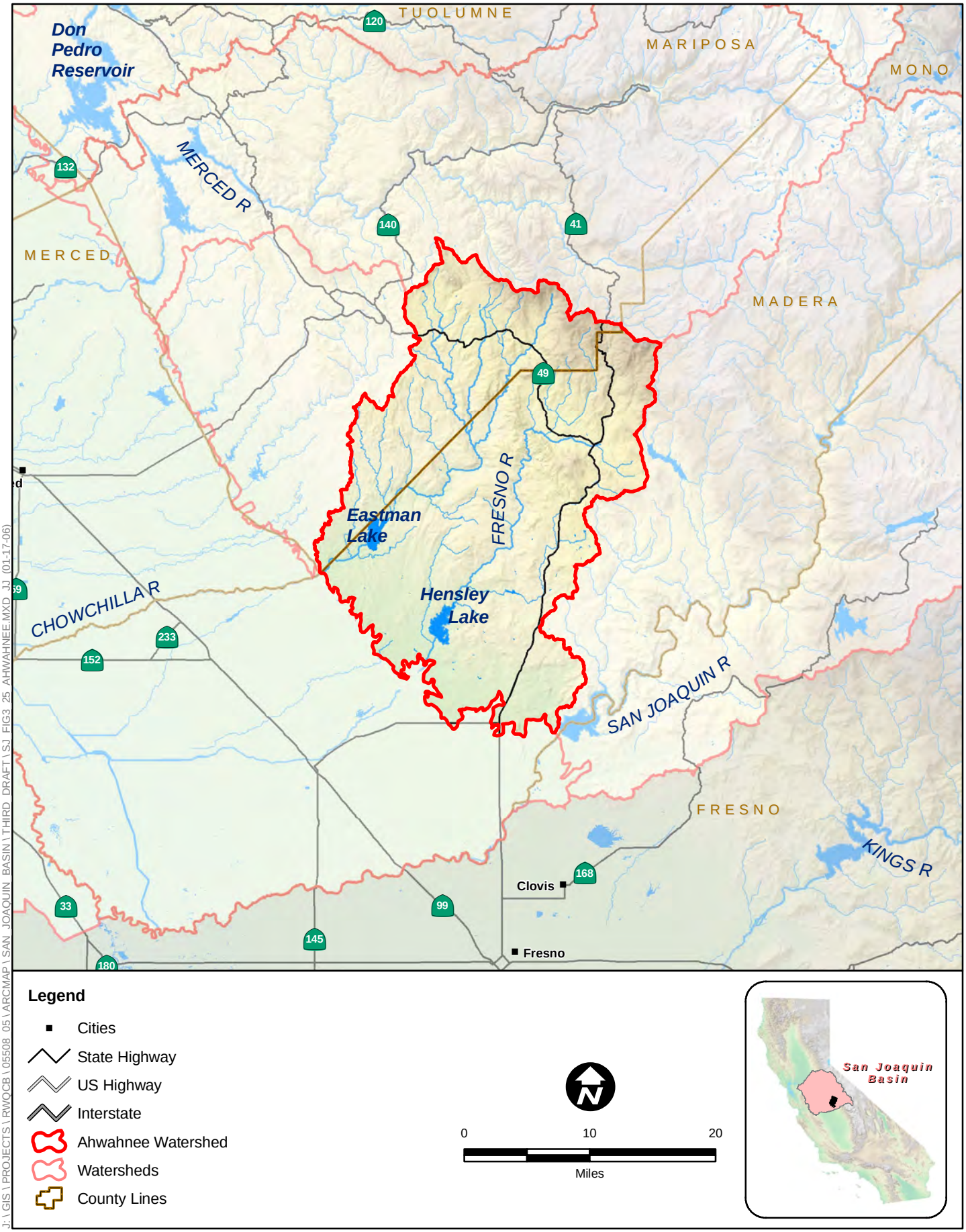
Miles



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ICF Jones & Stokes
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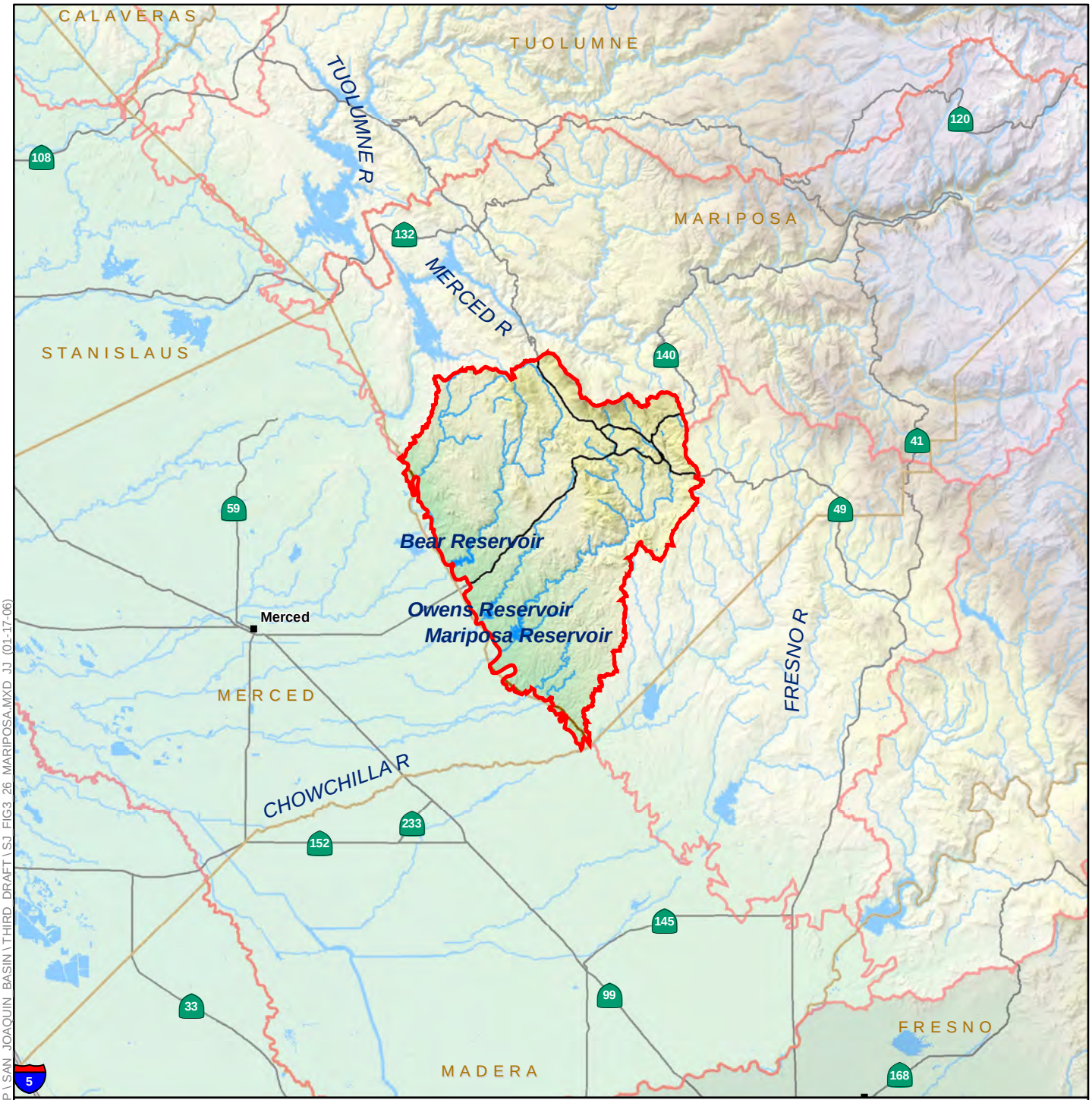
Figure 3-24
Delta-Carbona Watershed



J:\GIS\PROJECTS\RWQCB\05508_05\ARCMAP\SAN_JOAQUIN_BASIN\THIRD_DRAFT\SJ_FIG3_25_AHWAHNEE.MXD JJ (01-17-06)

ICF Jones & Stokes
an ICF International Company

Figure 3-25
Ahwahnee Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Mariposa Watershed
- Watersheds
- County Lines

0 10 20

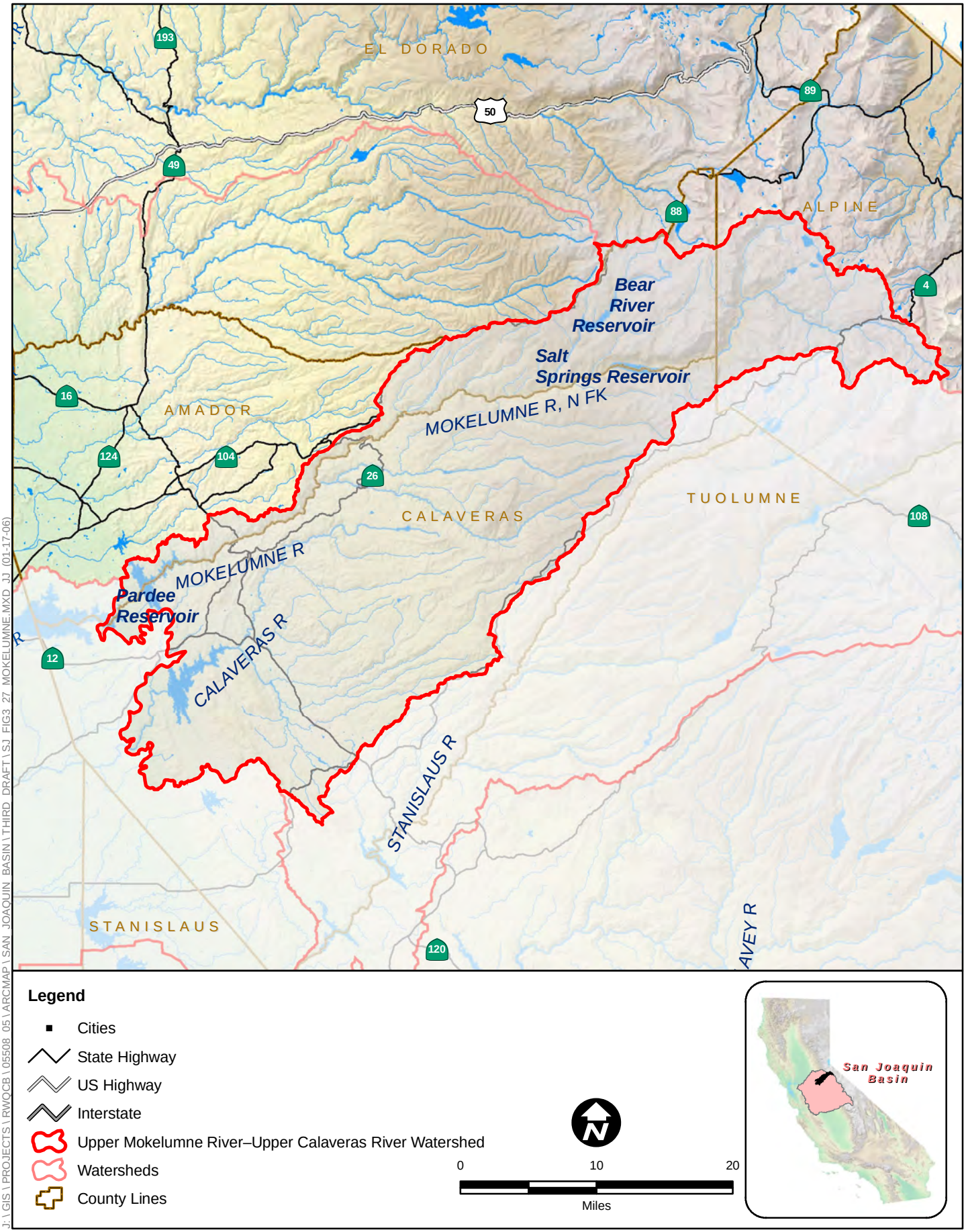
Miles



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ICF Jones & Stokes
an ICF International Company

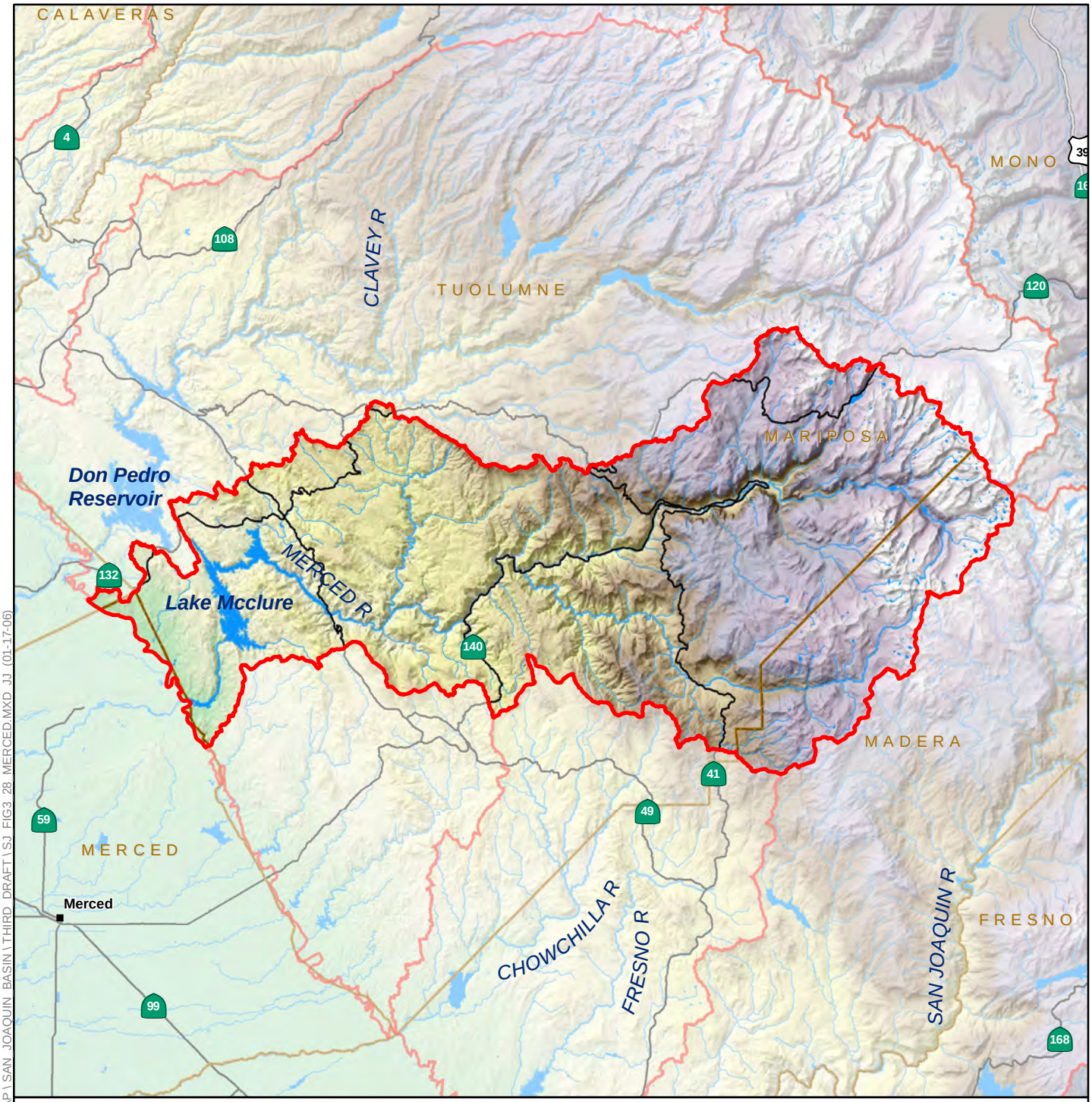
Figure 3-26
Mariposa Watershed



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ICF Jones & Stokes
an ICF International Company

Figure 3-27
Upper Mokelumne River–Upper Calaveras River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Merced River Watershed
- Watersheds
- County Lines

0 10 20

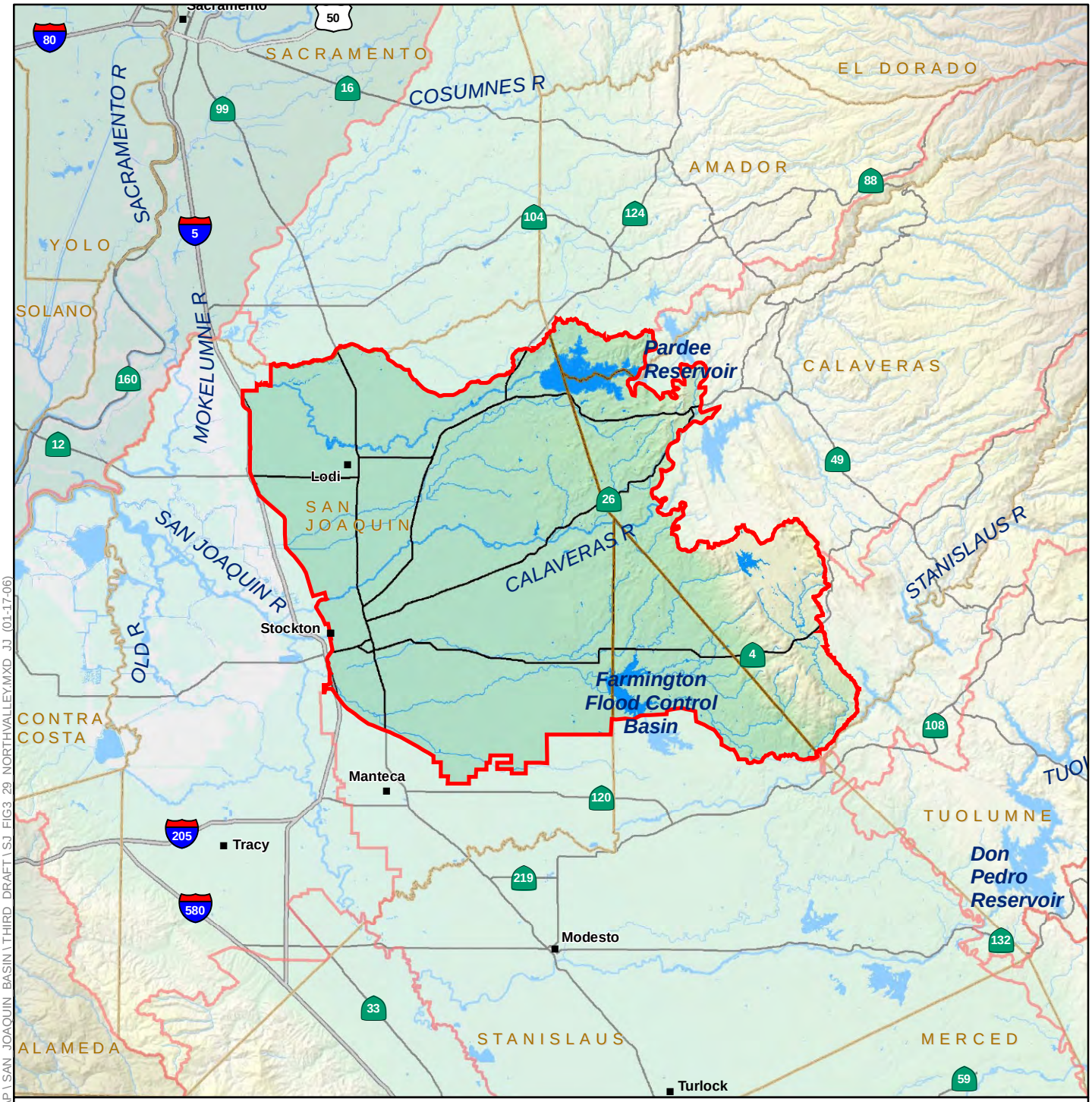
Miles



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an ICF International Company

Figure 3-28
Merced River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- North Valley Floor Watershed
- Watersheds
- County Lines

0 10 20

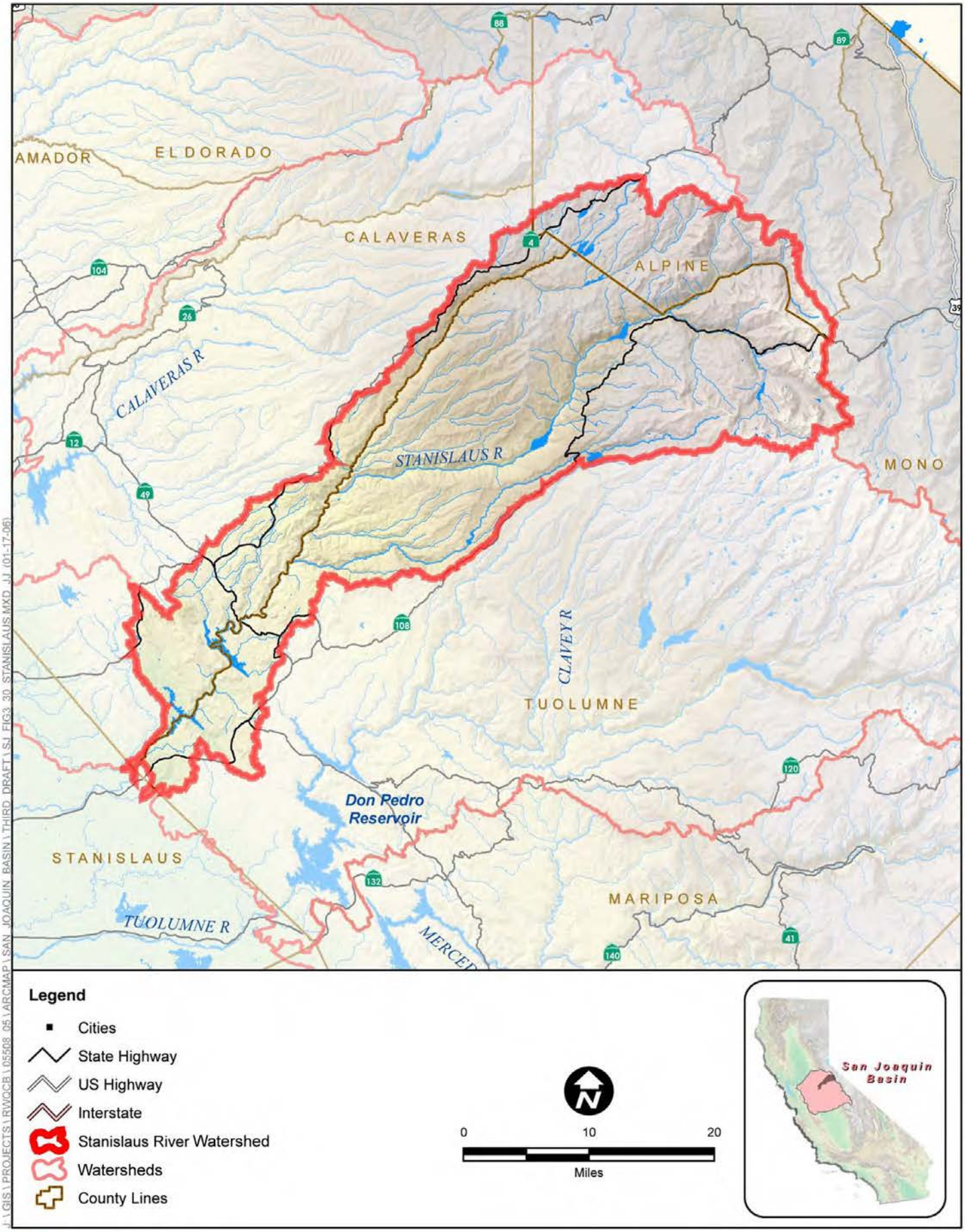
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ICF Jones & Stokes
an ICF International Company

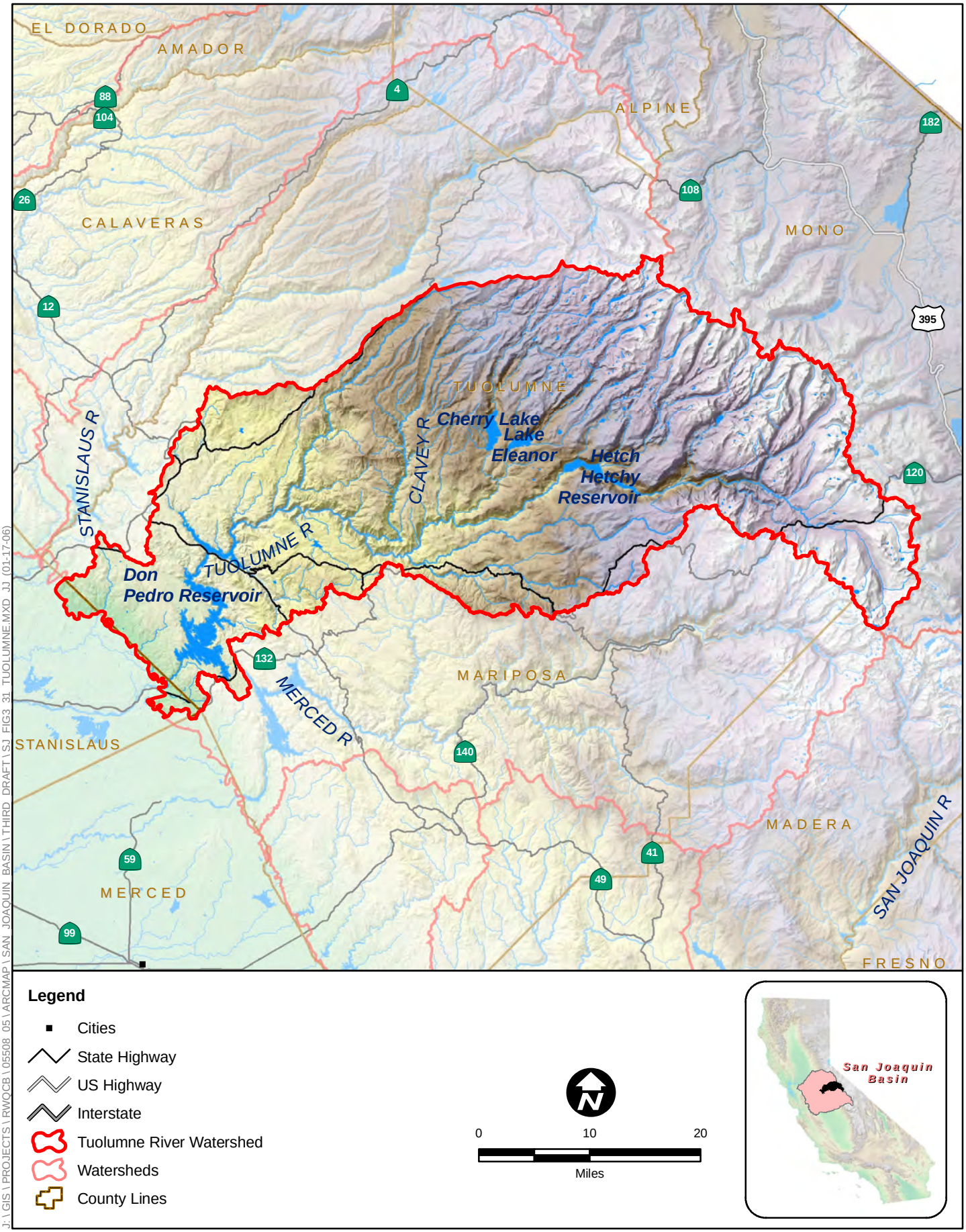
Figure 3-29
North Valley Floor Watershed



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ICF Jones & Stokes
an ICF International Company

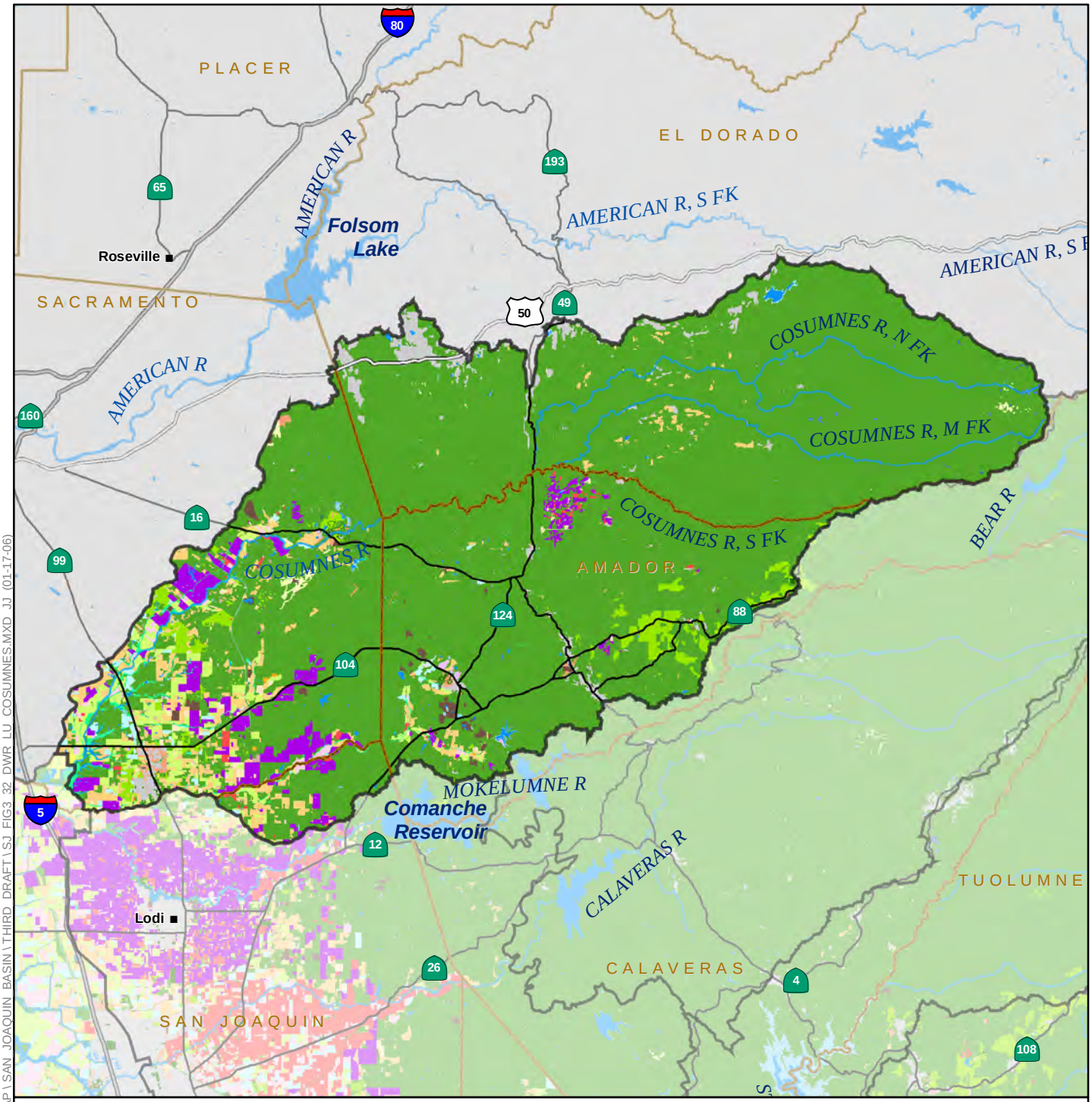
Figure 3-30
Stanislaus River Watershed



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an ICF International Company

Figure 3-31
Tuolumne River Watershed

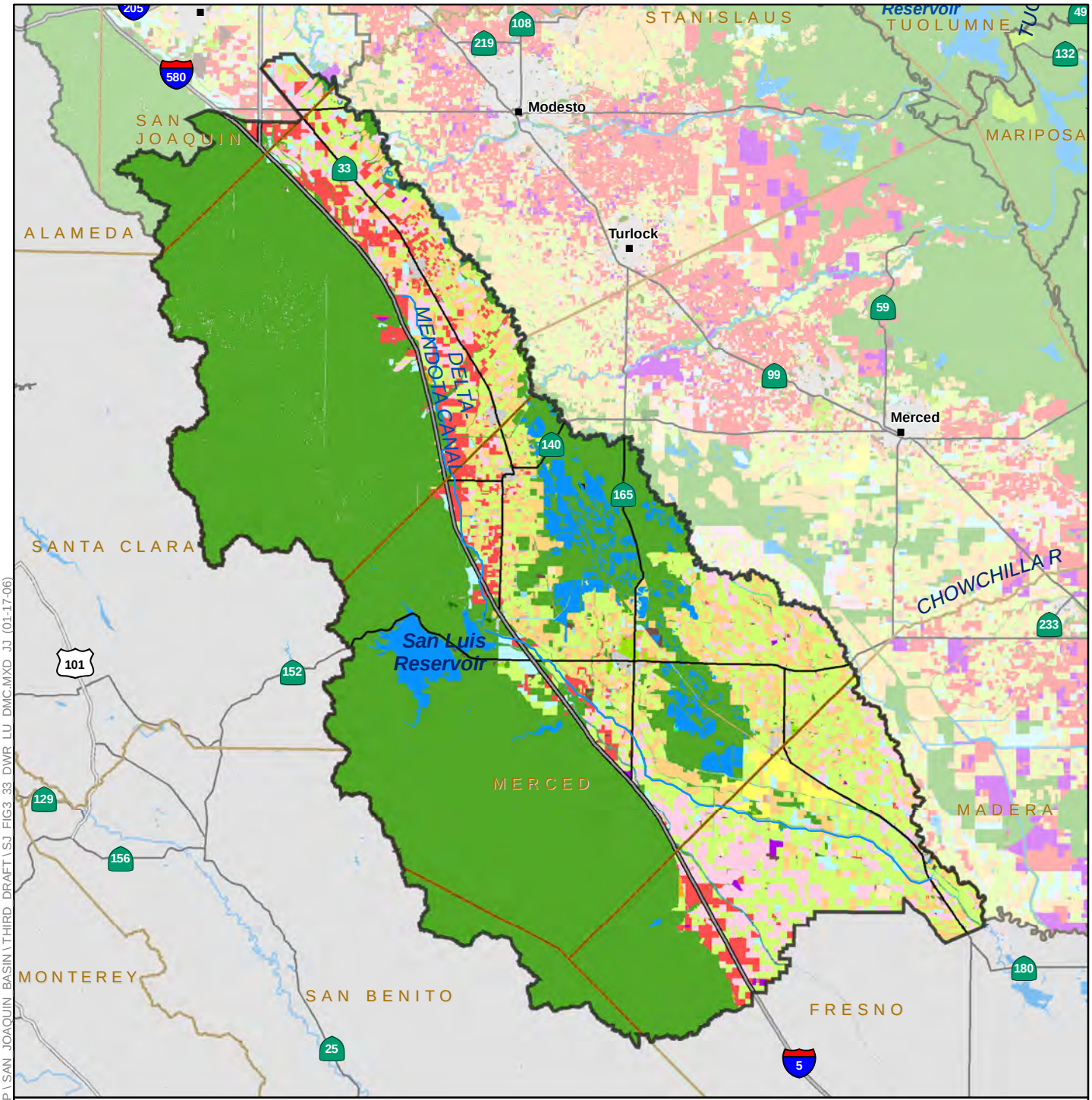


Land use data source: California Department of Water Resources (1994–2002)
Nevada and El Dorado counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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ICF Jones & Stokes
an ICF International Company

Figure 3-32
California Department of Water Resources Land Use
Cosumnes River Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

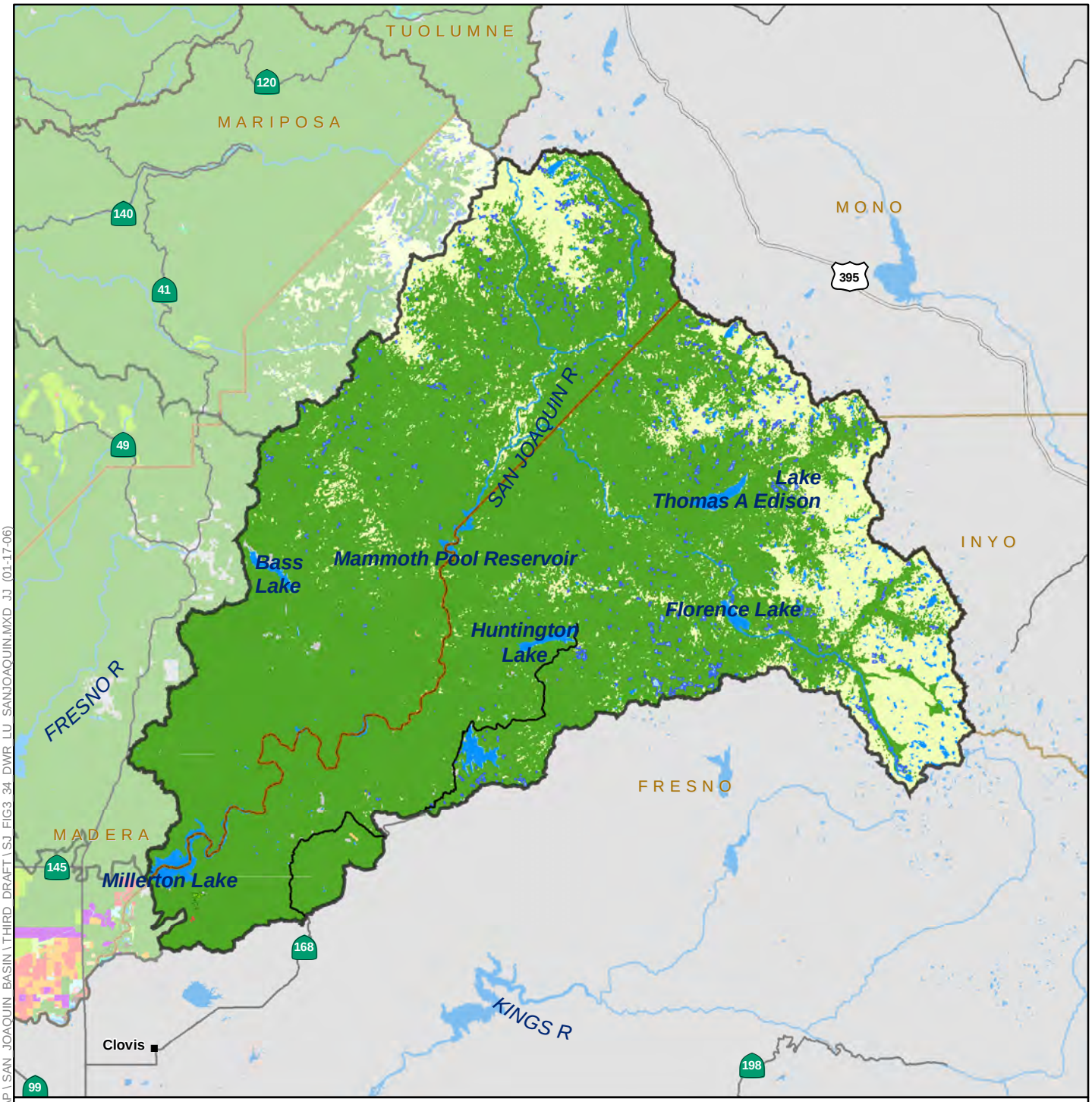


Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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ICF Jones & Stokes
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Figure 3-33
California Department of Water Resources Land Use
Delta-Mendota Canal Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

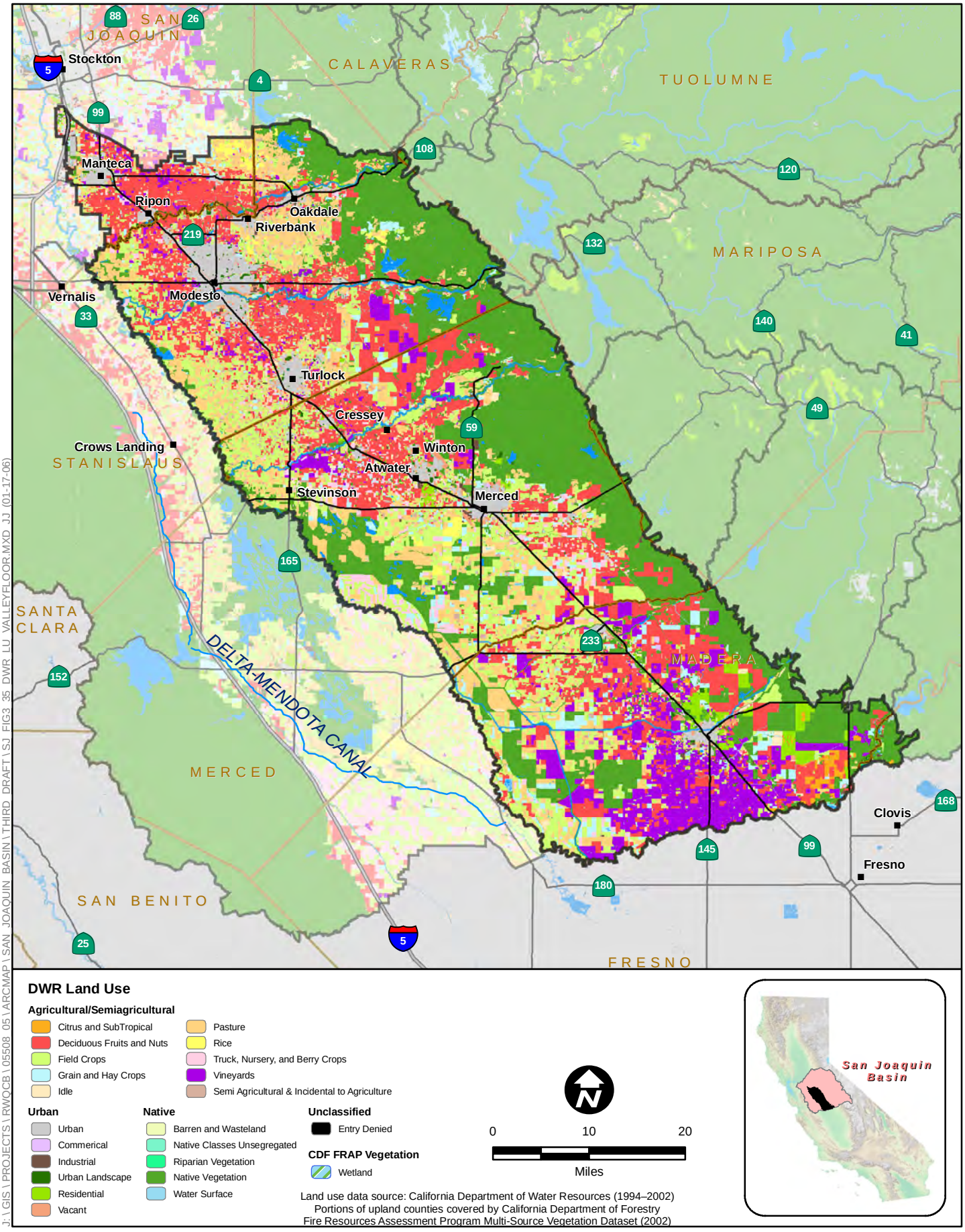
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Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

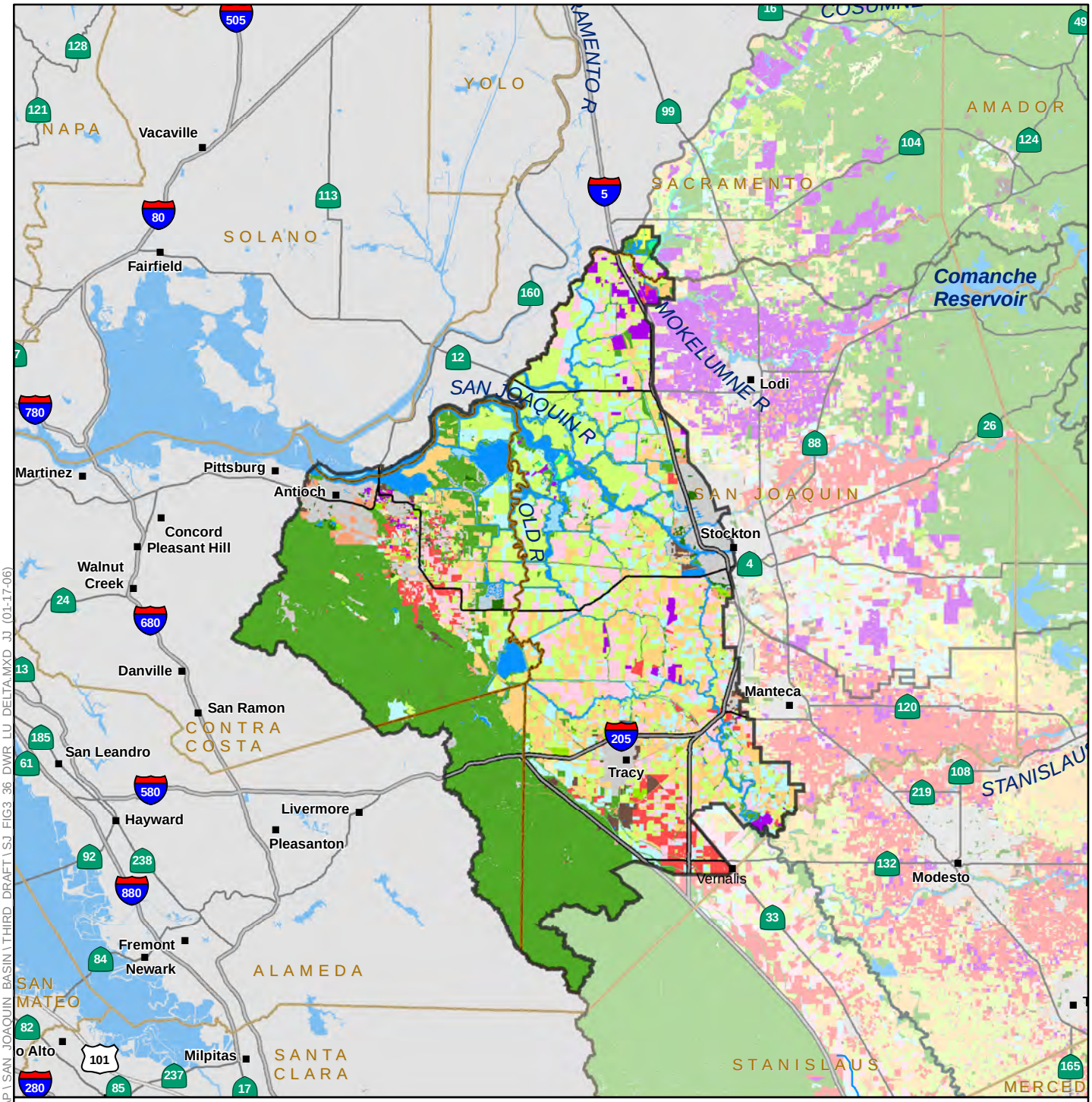
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an ICF International Company

Figure 3-34
California Department of Water Resources
San Joaquin River Watershed



ICF Jones & Stokes
an ICF International Company

Figure 3-35
California Department of Water Resources Land Use
San Joaquin Valley Floor Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

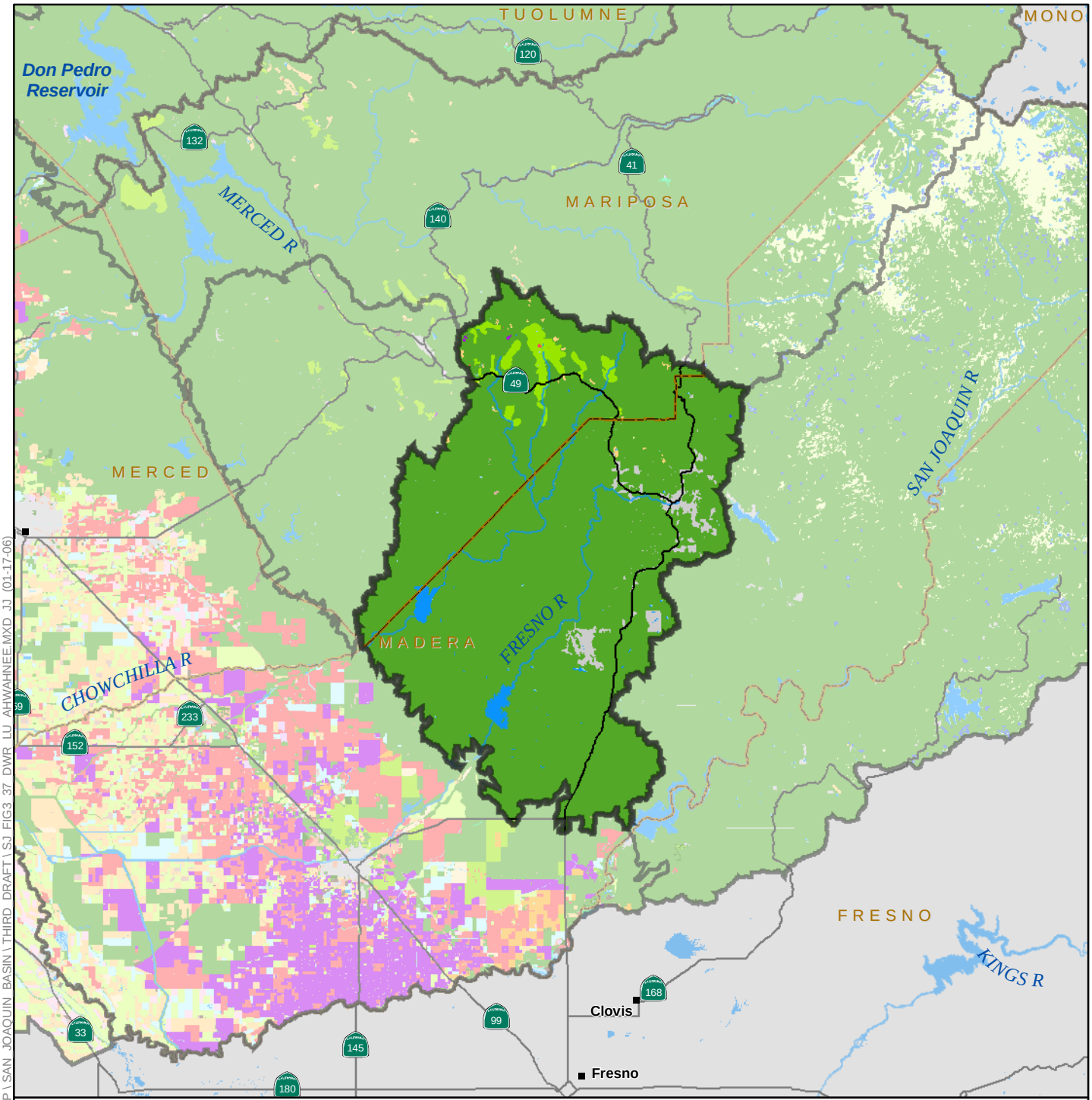


Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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ICF Jones & Stokes
an ICF International Company

Figure 3-36
California Department of Water Resources Land Use
Delta-Carbona Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

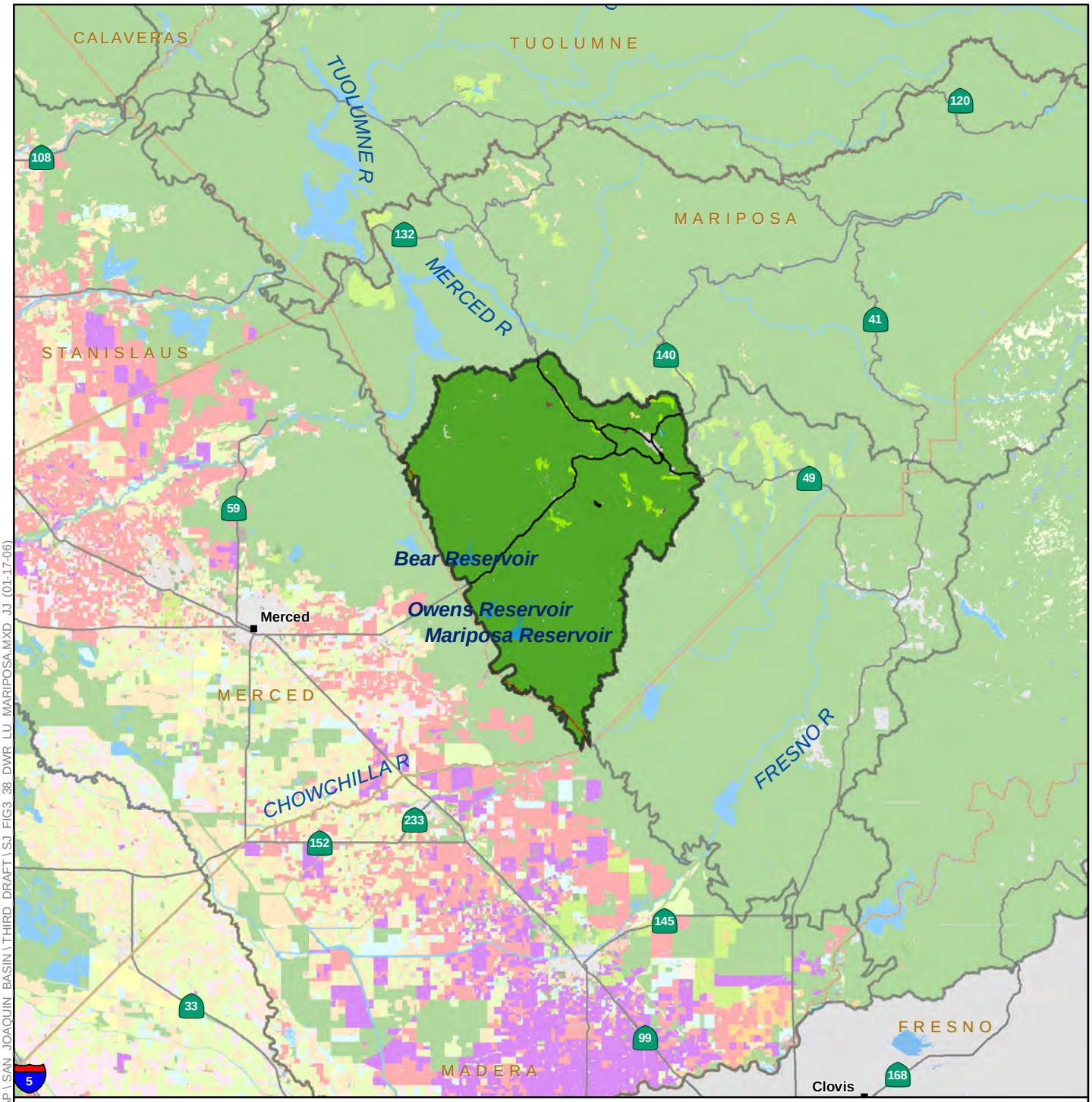
Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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Figure 3-37
California Department of Water Resources Land Use
Ahwahnee Subwatershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

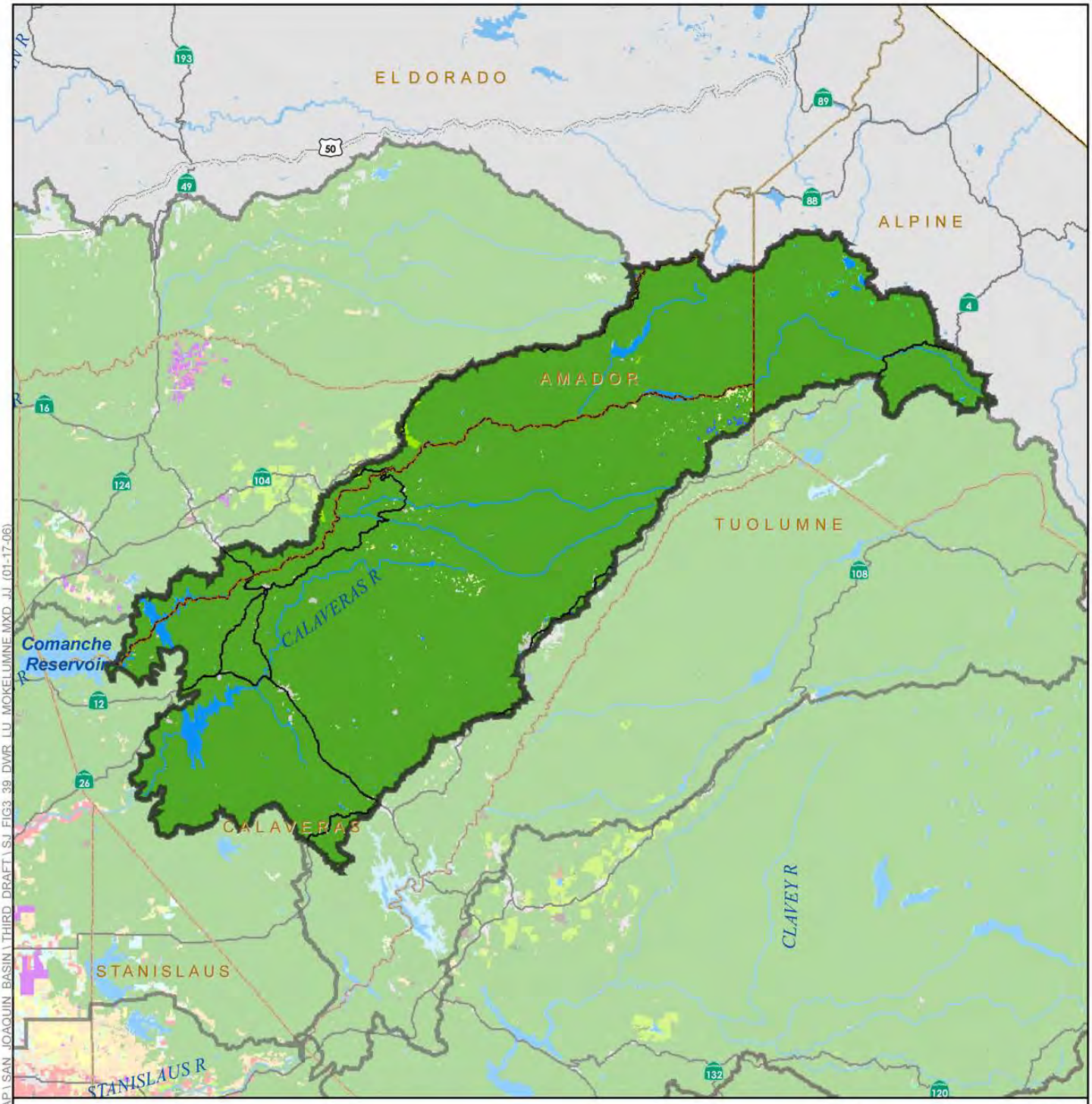
Miles



Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

ICF Jones & Stokes
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Figure 3-38
California Department of Water Resources Land Use
Mariposa Watershed



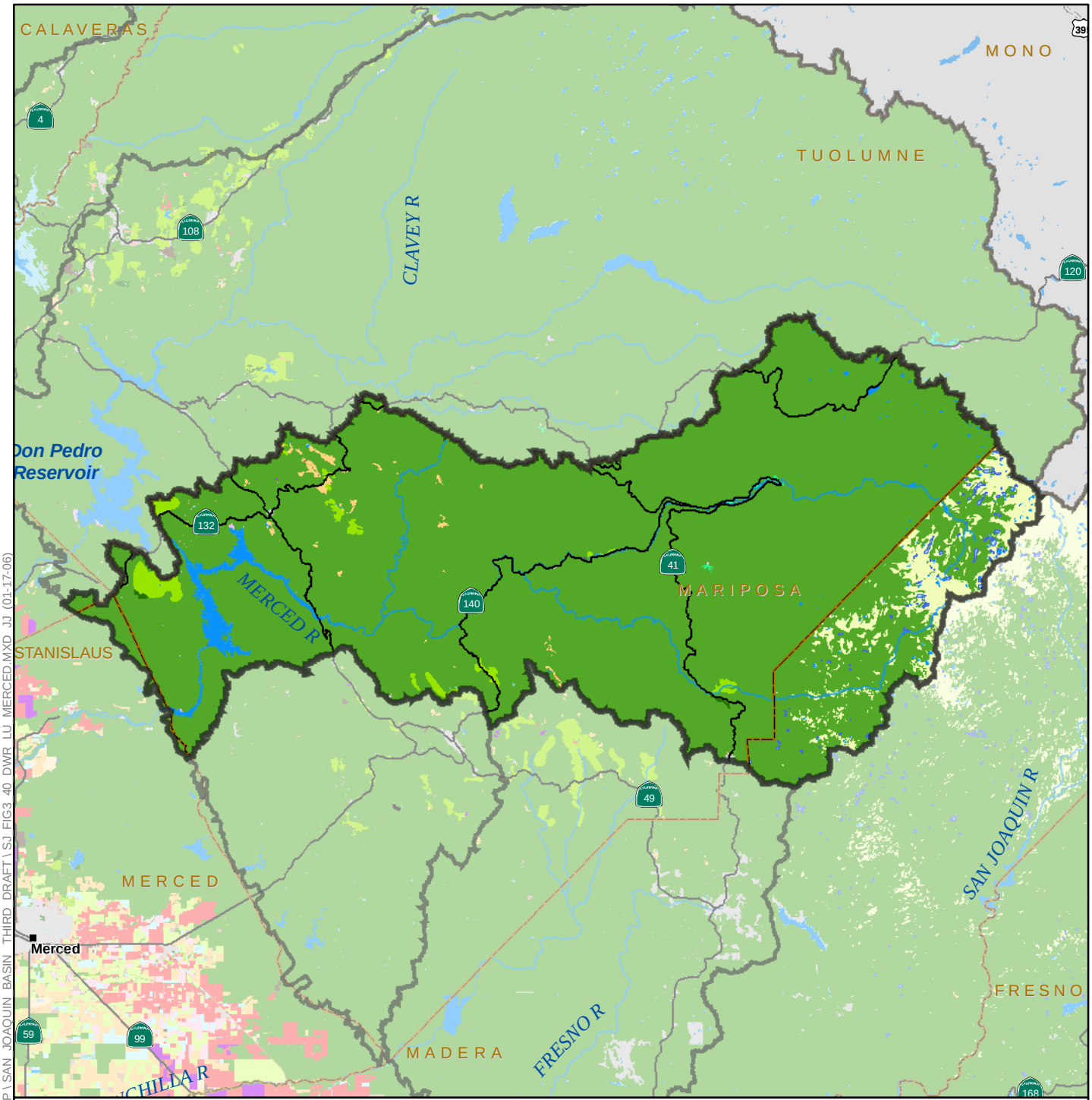
Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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Figure 3-39
California Department of Water Resources Land Use
Upper Mokelumne–Upper Calaveras Subwatershed

Administrative Record
Page 30523

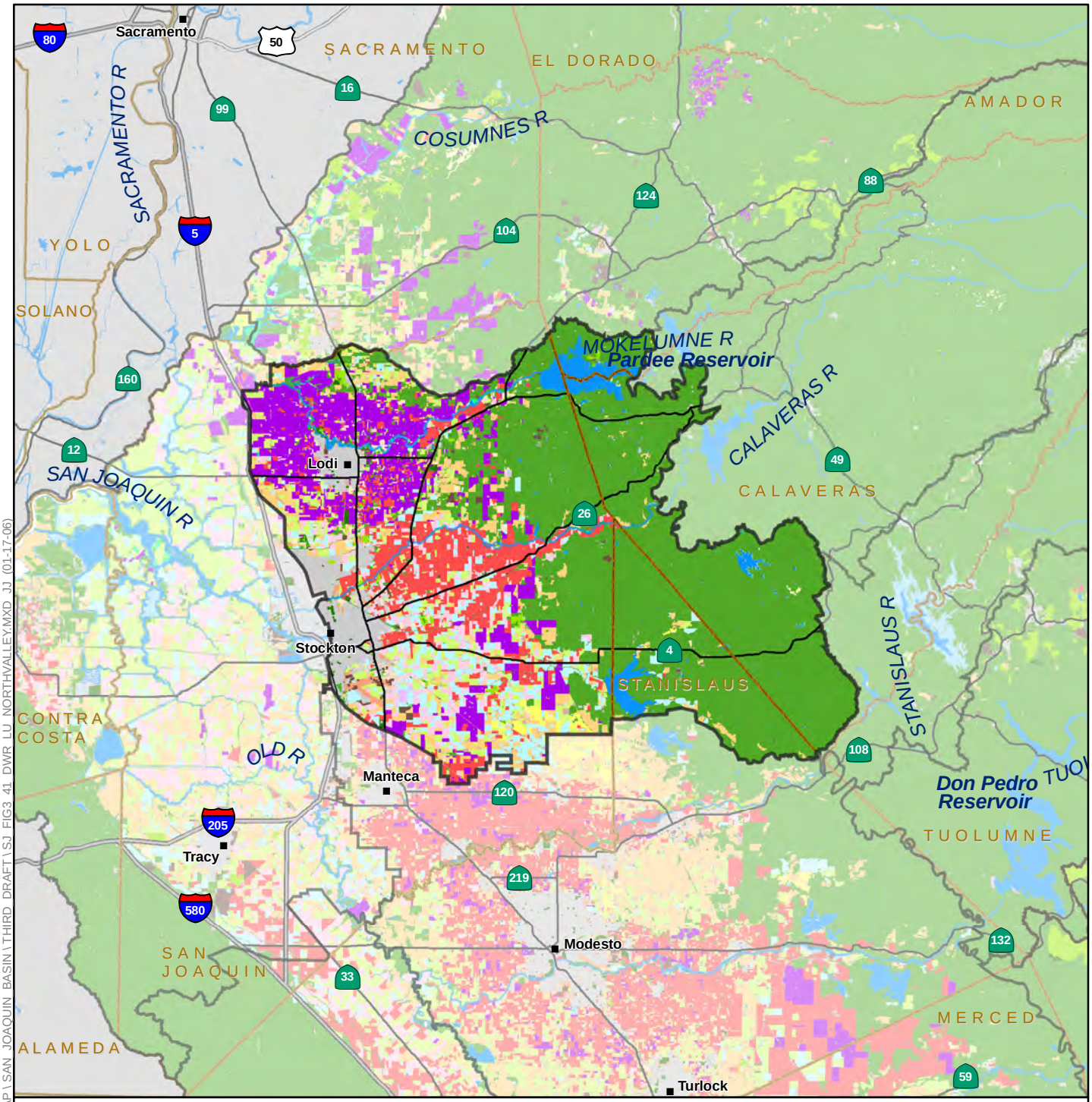


Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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ICF Jones & Stokes
an ICF International Company

Figure 3-40
California Department of Water Resources Land Use
Merced River Subwatershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

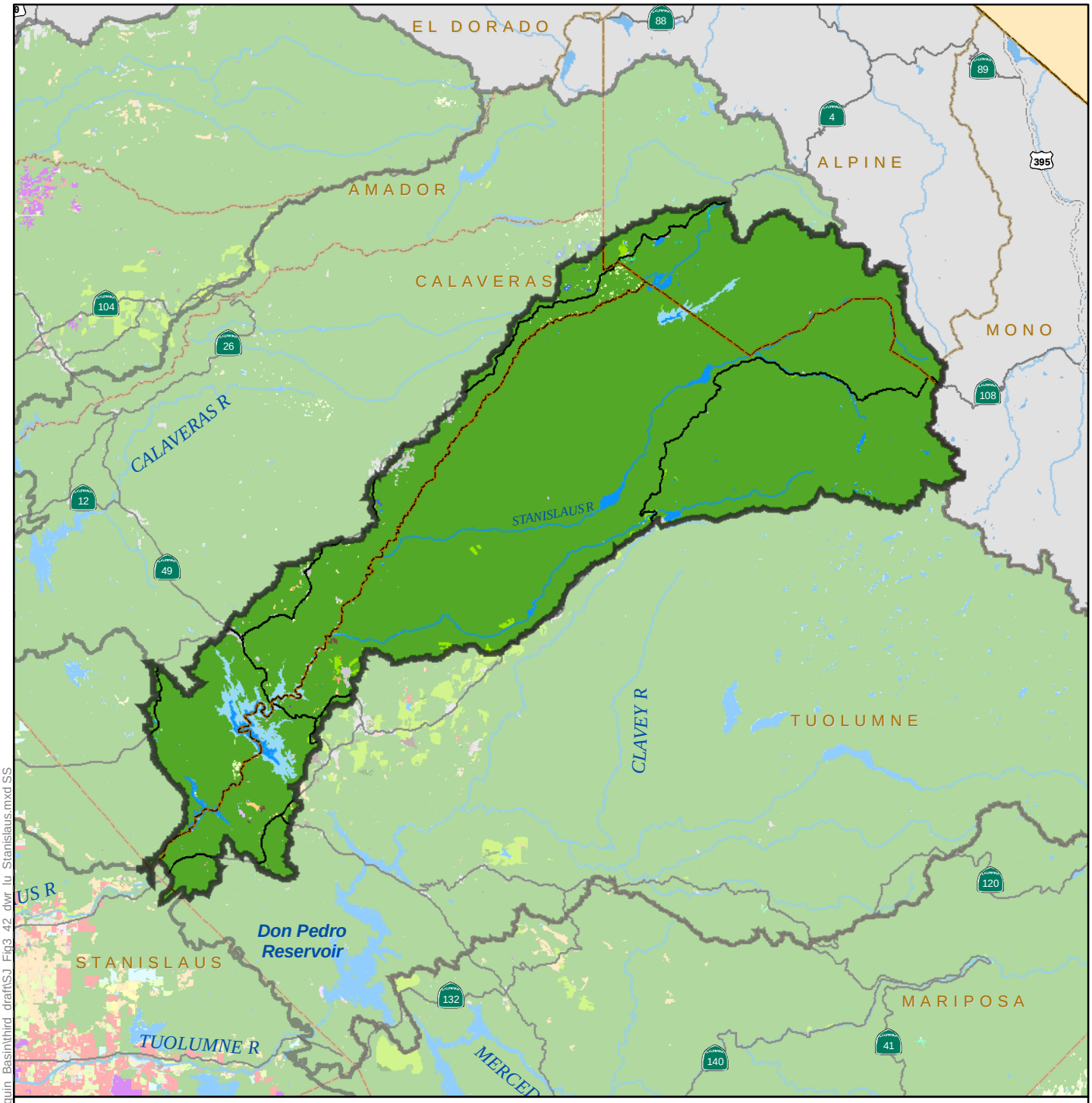
Miles



Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

ICF Jones & Stokes
an ICF International Company

Figure 3-41
California Department of Water Resources Land Use
North Valley Floor Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

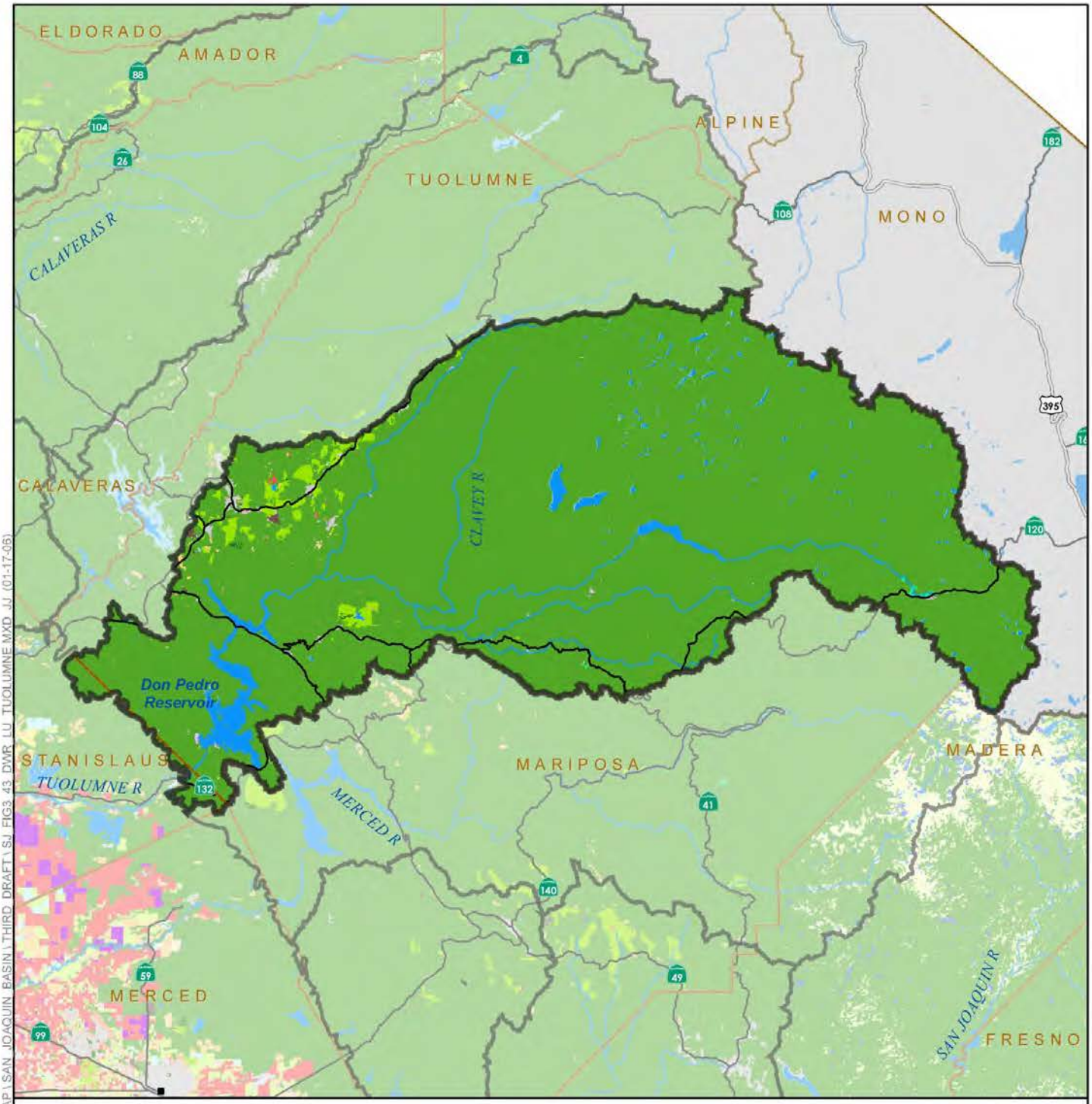
San Joaquin Basin

Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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Figure 3-42
California Department of Water Resources Land Use
Stanislaus River Subwatershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

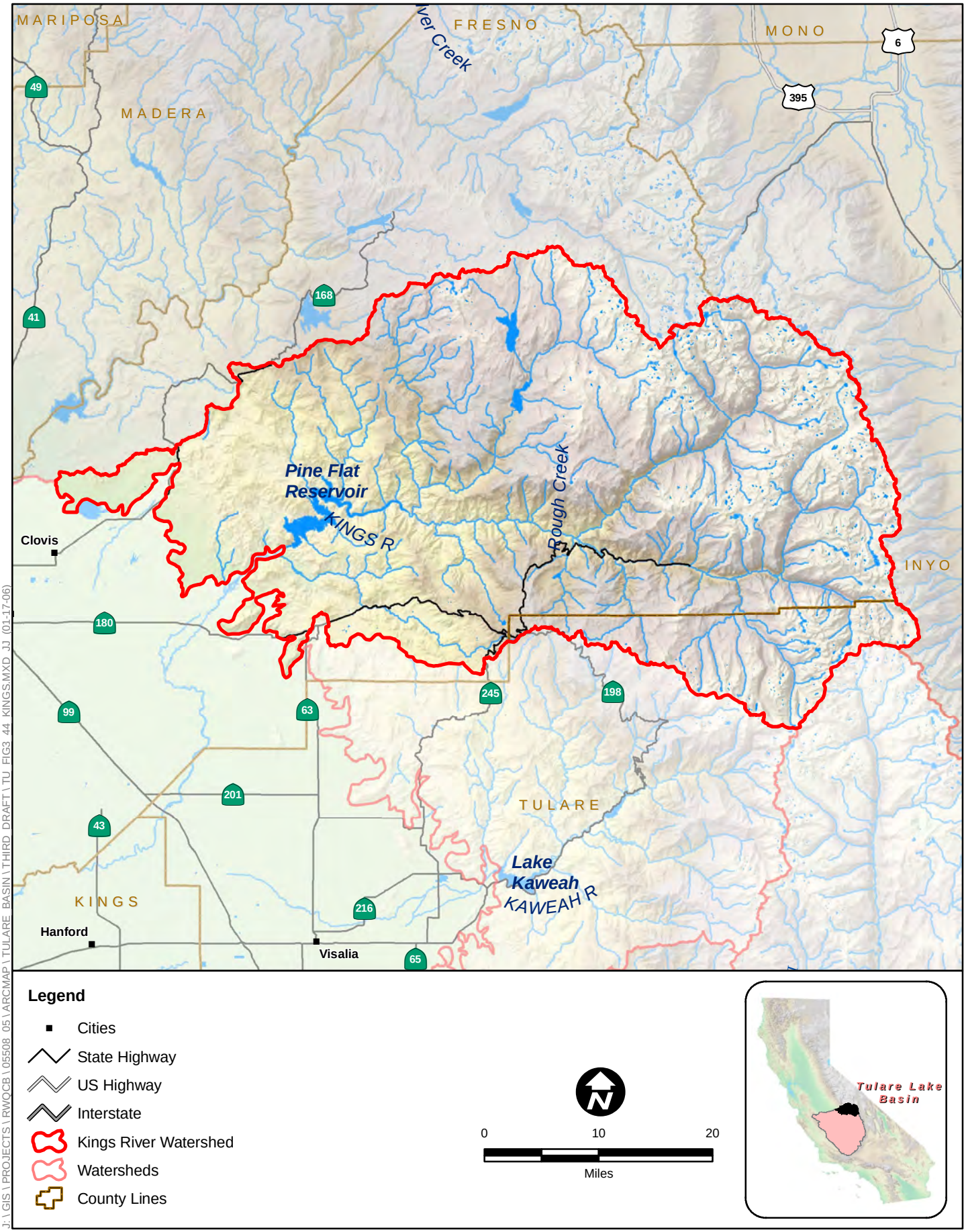
Miles

Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



ICF Jones & Stokes
an ICF International Company

Figure 3-43
California Department of Water Resources Land Use
Tuolumne River Subwatershed



Legend

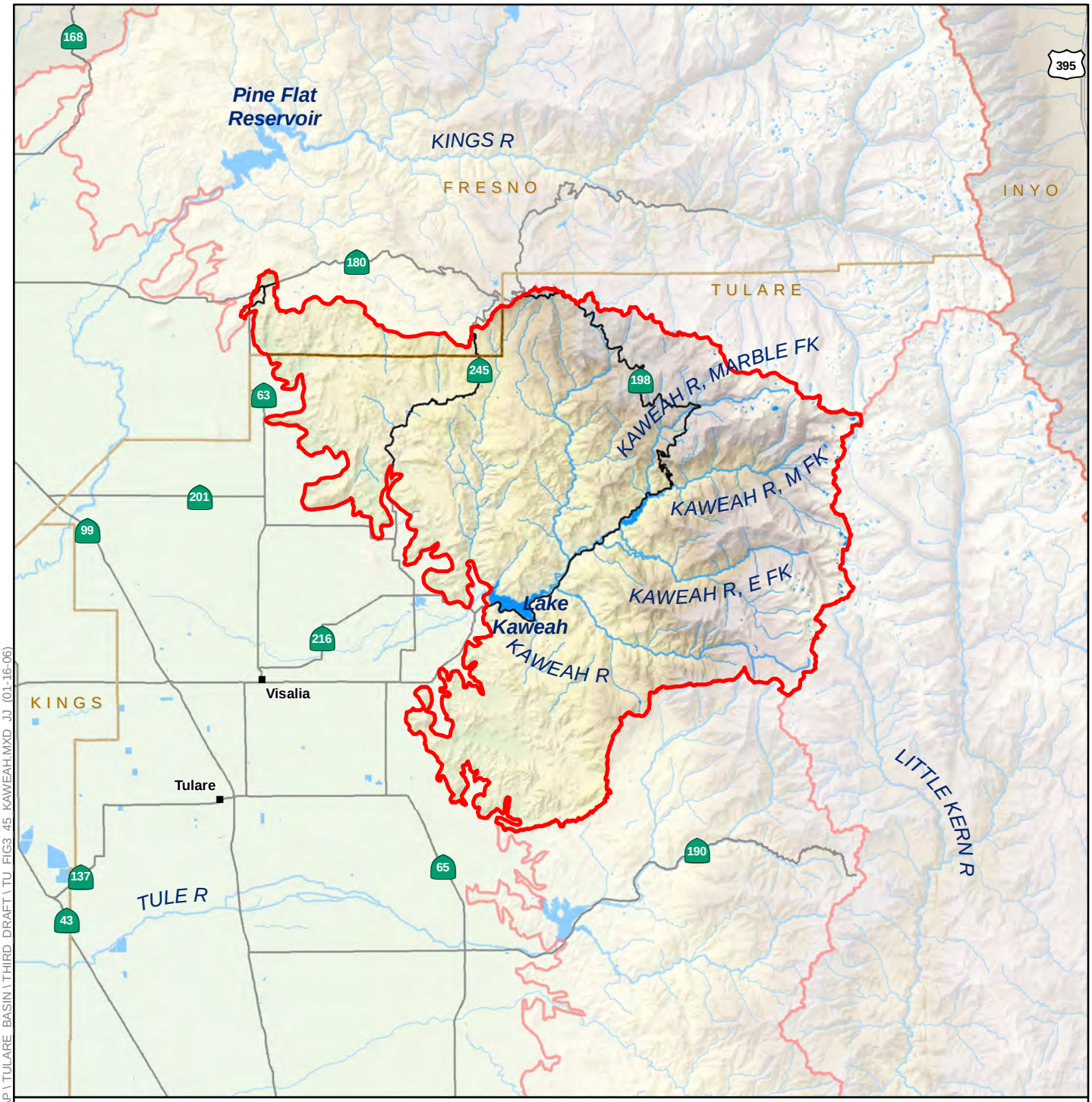
- Cities
- State Highway
- US Highway
- Interstate
- Kings River Watershed
- Watersheds
- County Lines

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Miles

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ICF Jones & Stokes
an ICF International Company

Figure 3-44
Kings River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Kaweah River Watershed
- Watersheds
- County Lines

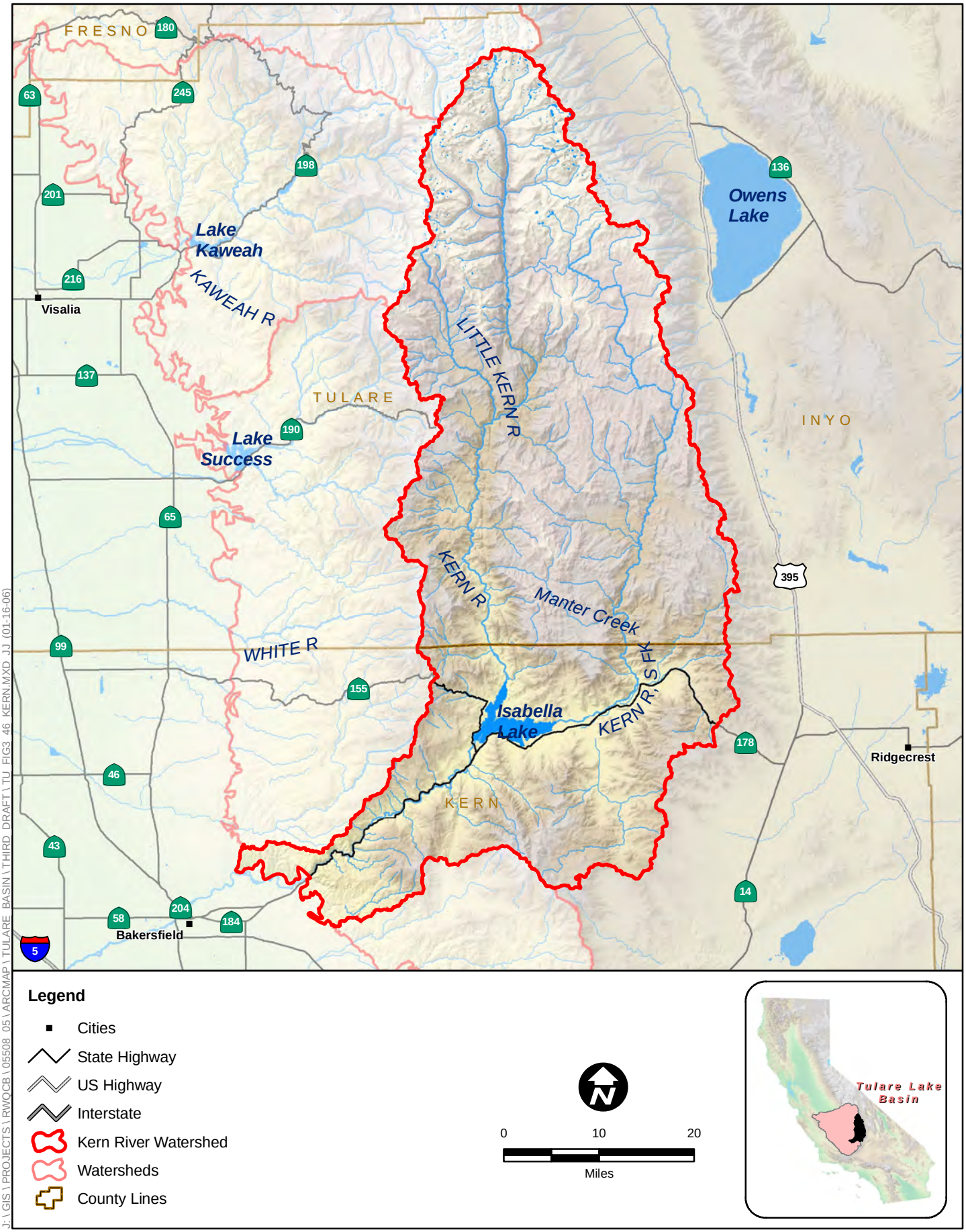
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Miles



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ICF Jones & Stokes
an ICF International Company

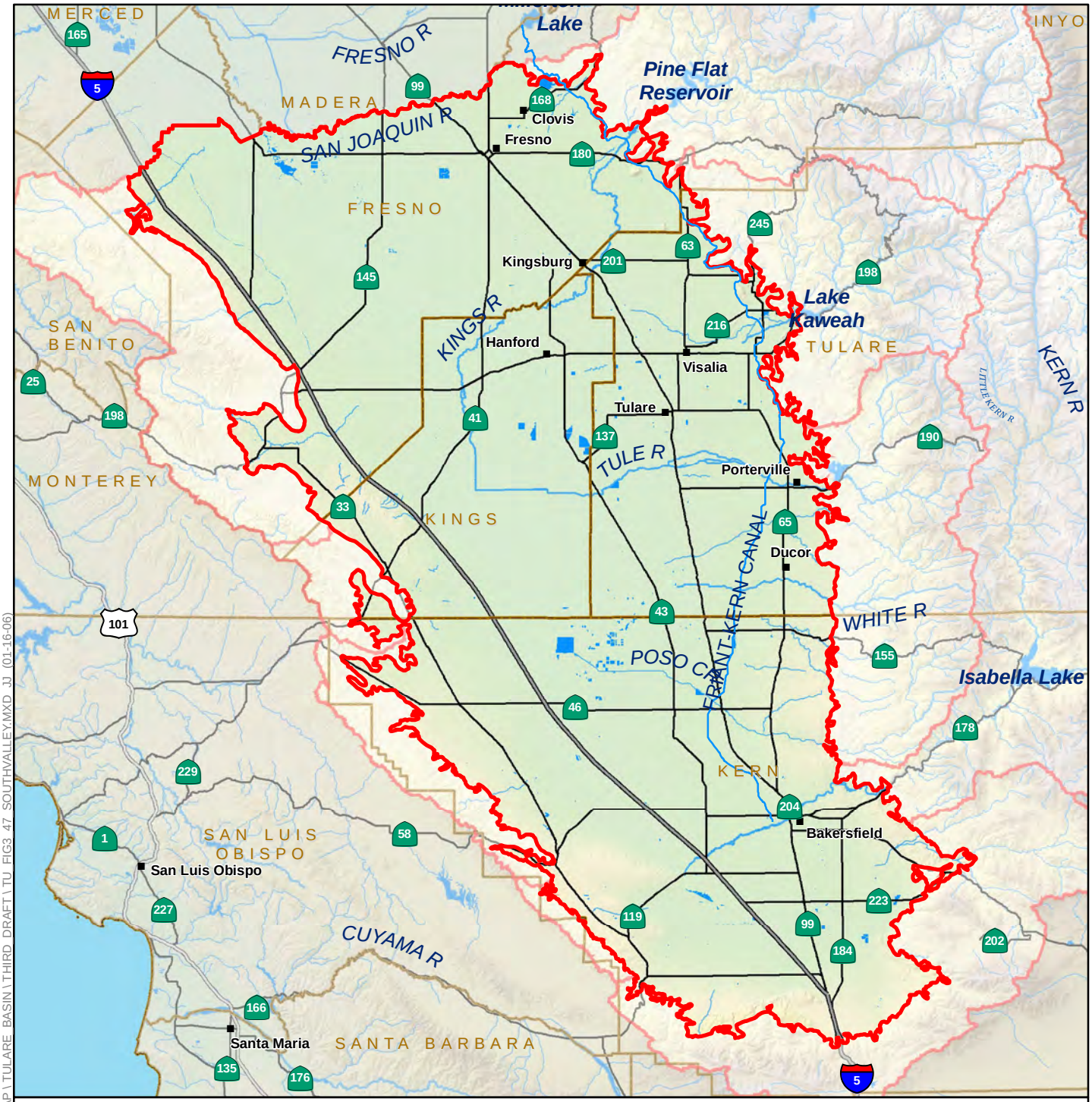
Figure 3-45
Kaweah River Watershed



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ICF Jones & Stokes
an ICF International Company

Figure 3-46
Kern River Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- South Valley Floor Watershed
- Watersheds
- County Lines

N

0 10 20

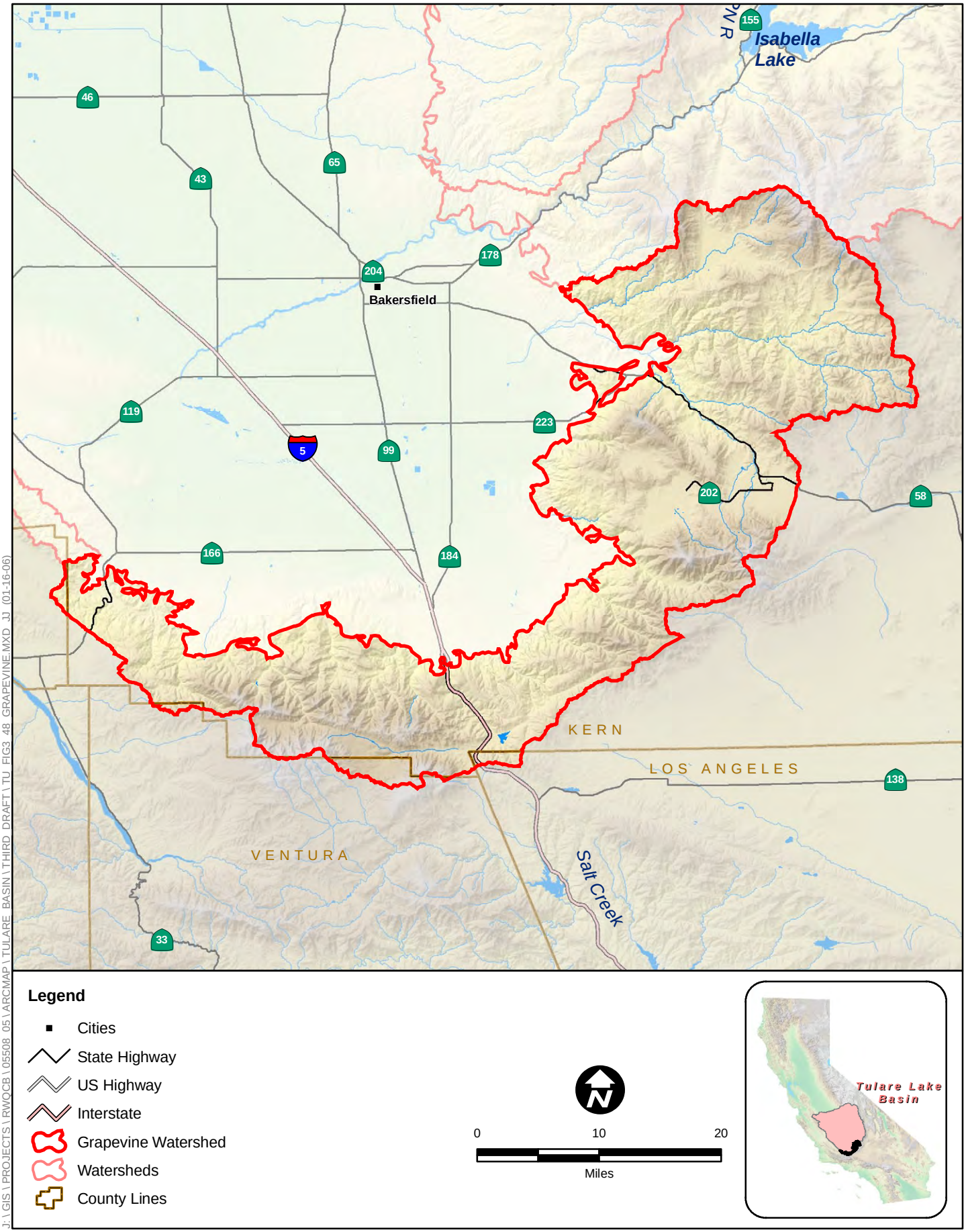
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ICF Jones & Stokes
an ICF International Company

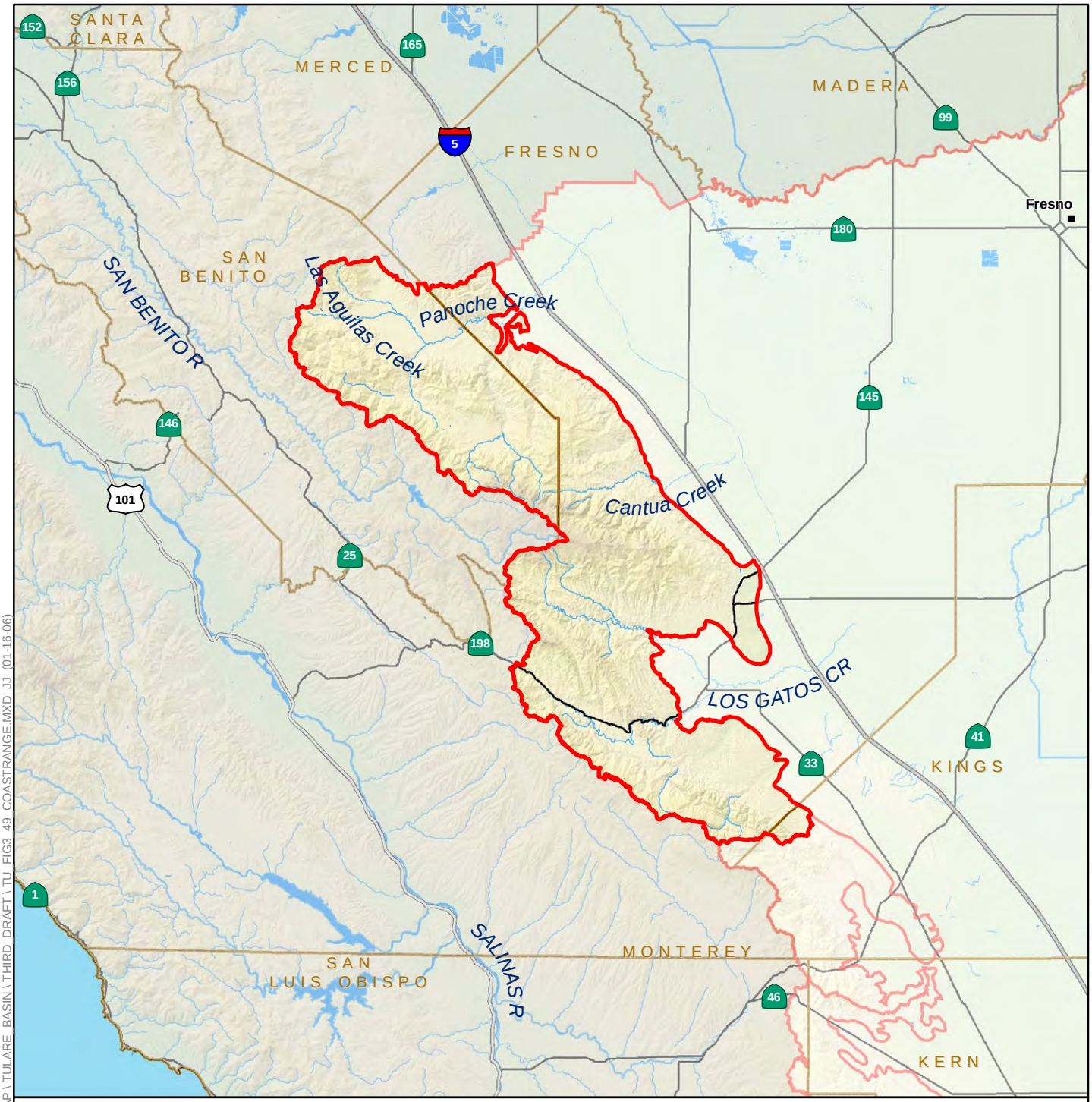
Figure 3-47
South Valley Floor Watershed



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ICF Jones & Stokes
an ICF International Company

Figure 3-48
Grapevine Watershed



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Legend

- Cities
- State Highway
- US Highway
- Interstate
- Coast Range Watershed
- Watersheds
- County Lines

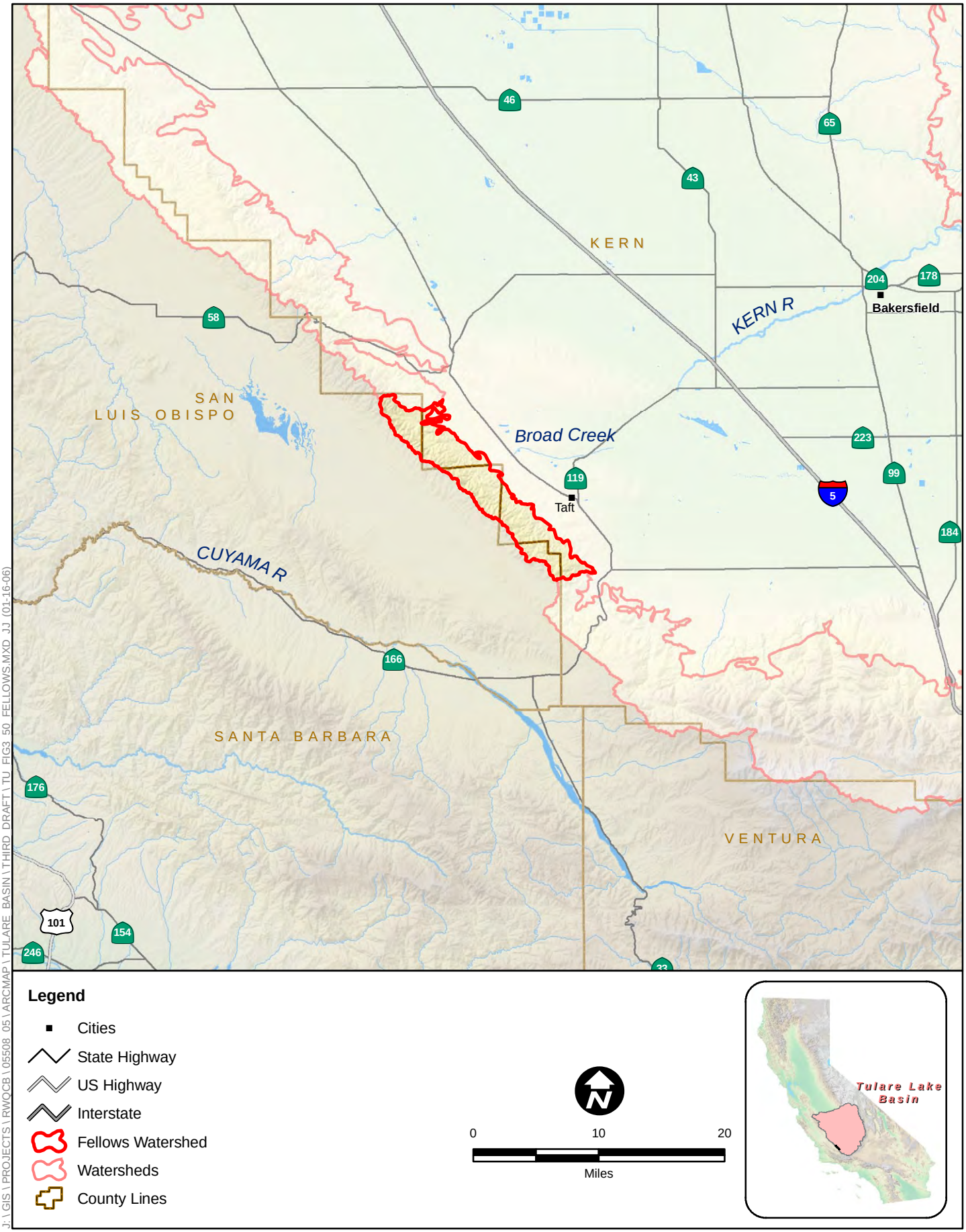
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an ICF International Company

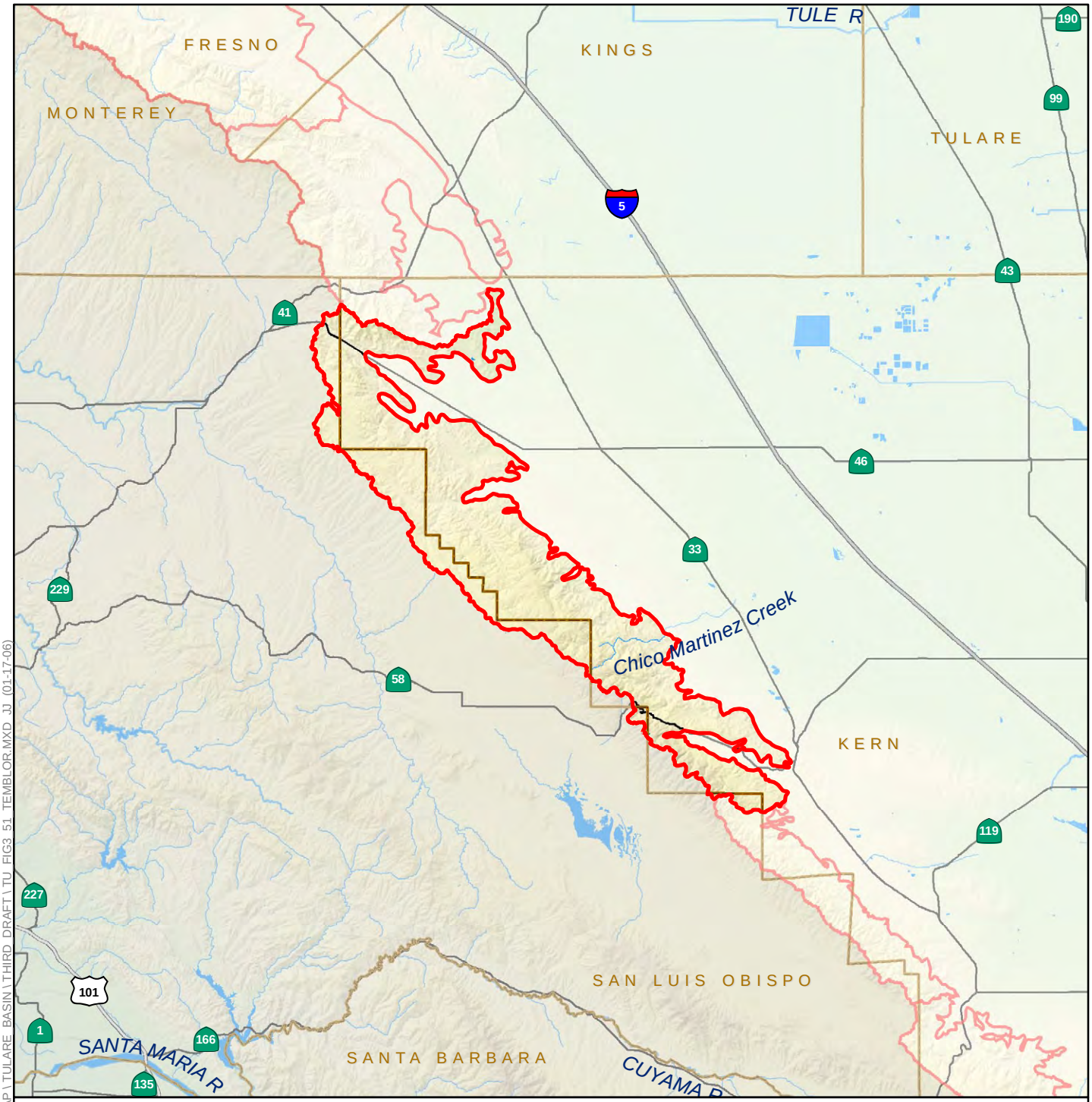
Figure 3-49
Coast Range Watershed



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Figure 3-50
Fellows Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Temblor Watershed
- Watersheds
- County Lines

0 10 20

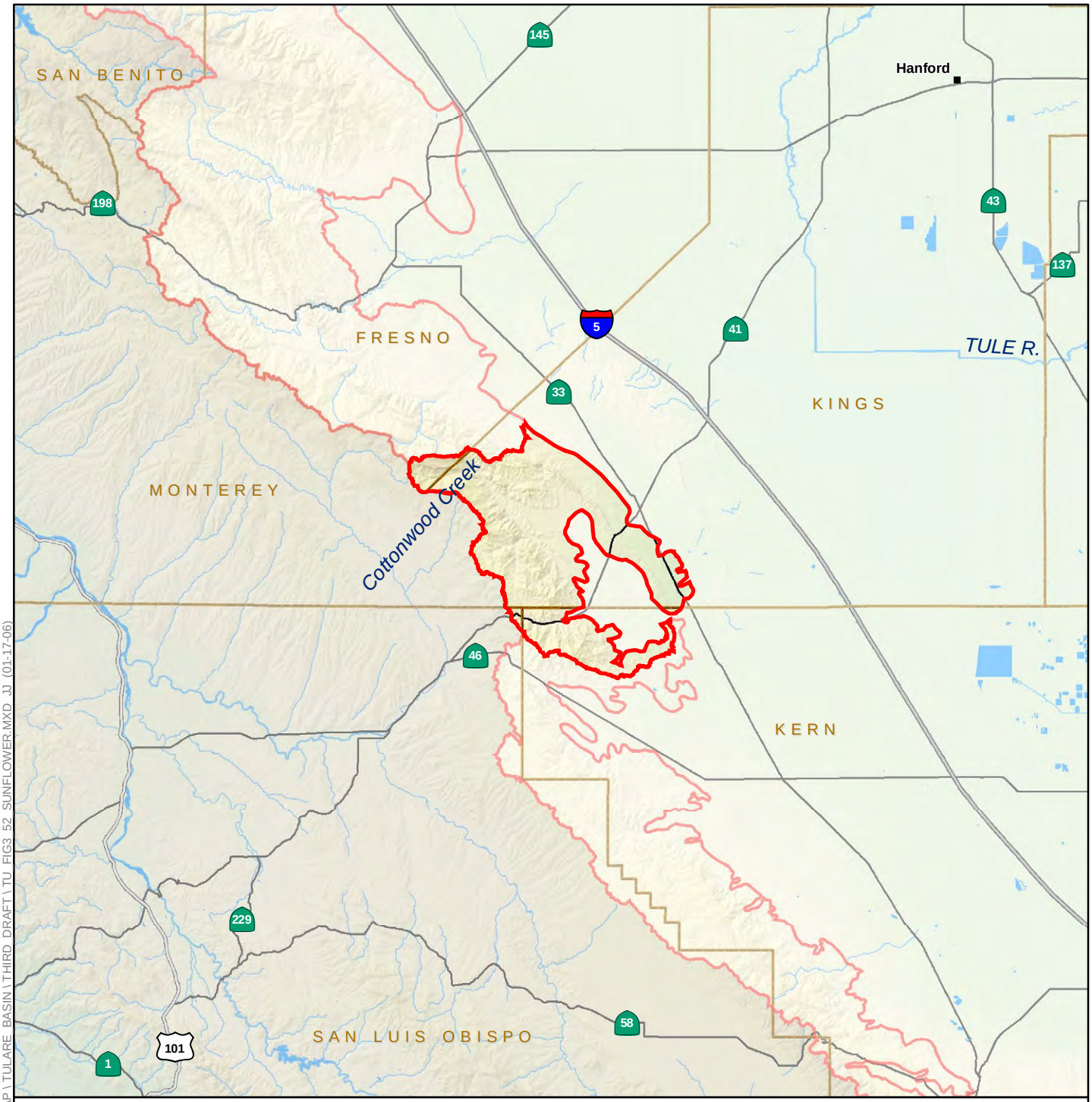
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Figure 3-51
Temblor Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Sunflower Valley Watershed
- Watersheds
- County Lines

0 10 20

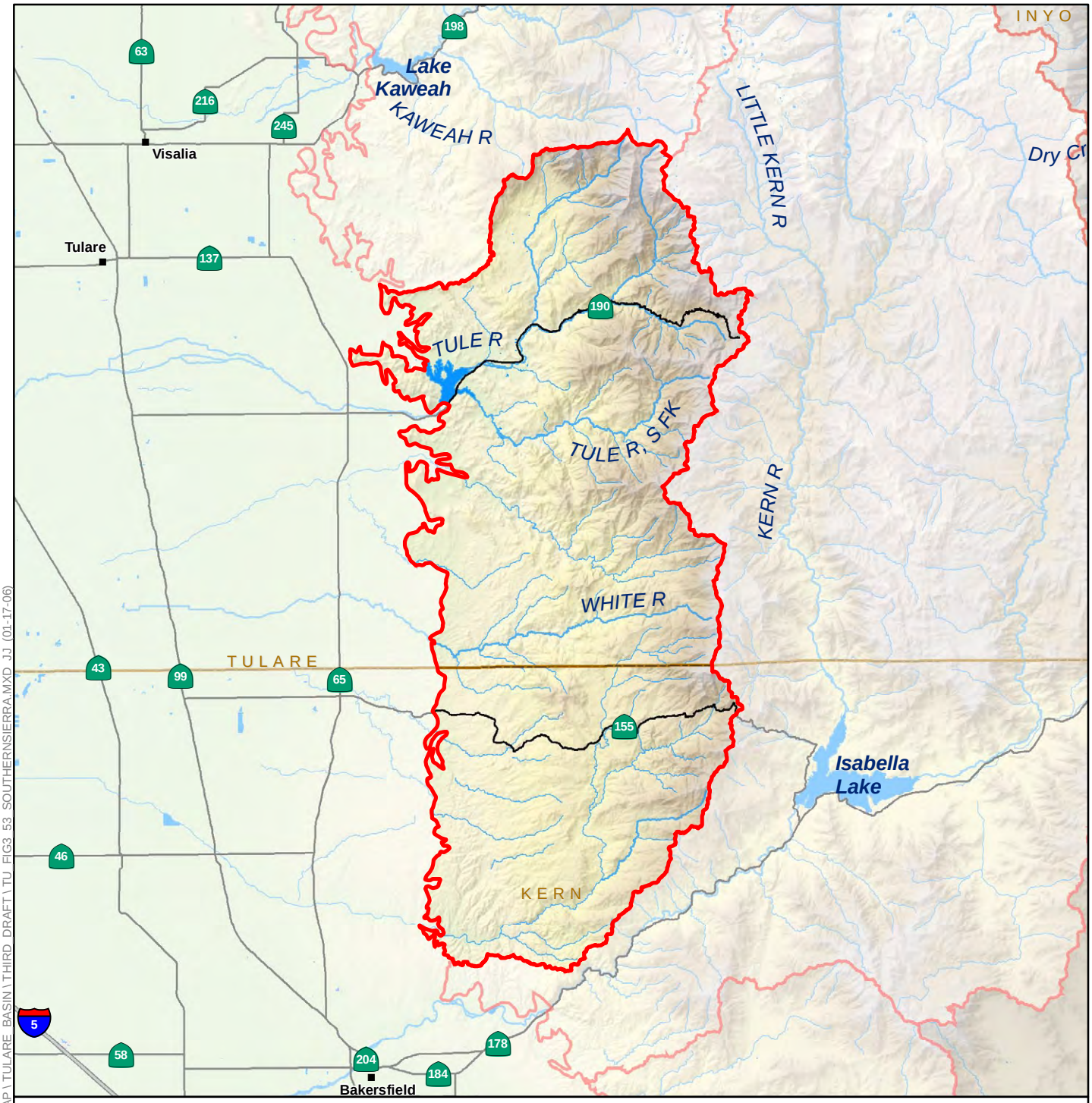
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Figure 3-52
Sunflower Valley Watershed



Legend

- Cities
- State Highway
- US Highway
- Interstate
- Southern Sierra Watershed
- Watersheds
- County Lines

0 10 20

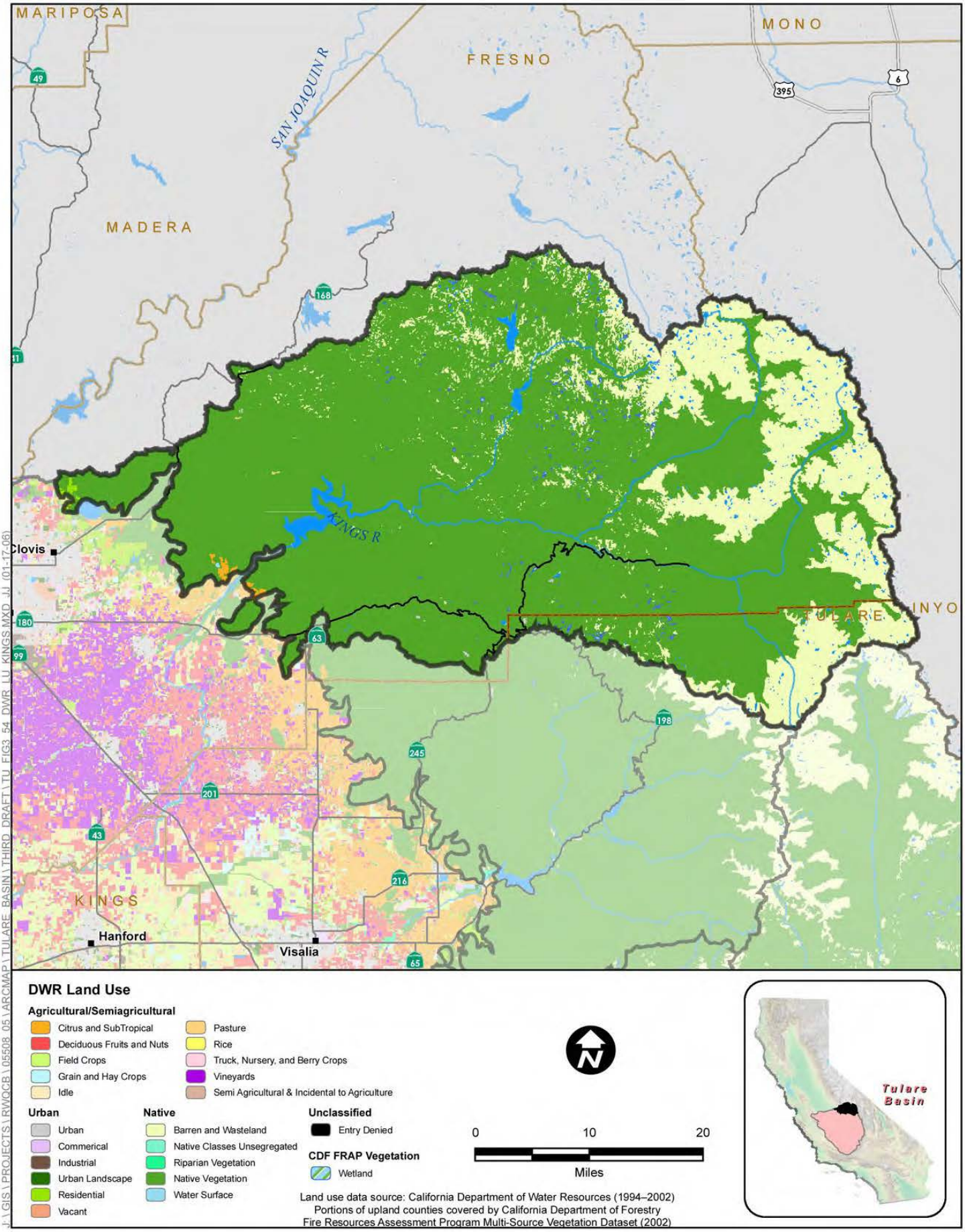
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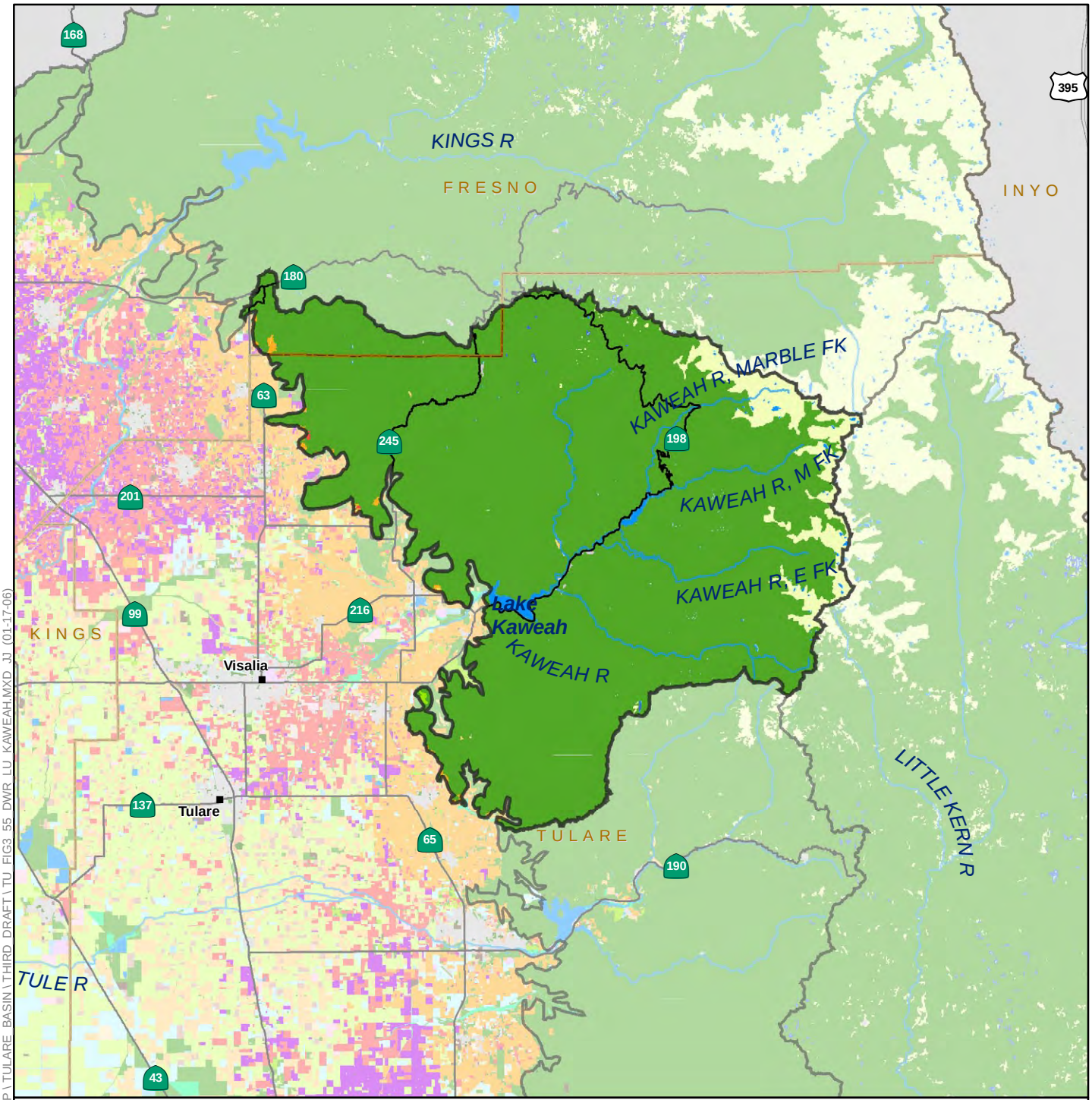
Figure 3-53
Southern Sierra Watershed



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Figure 3-54
California Department of Water Resources Land Use
Kings River Subwatershed

Adminsitrative Record
Page 30538



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

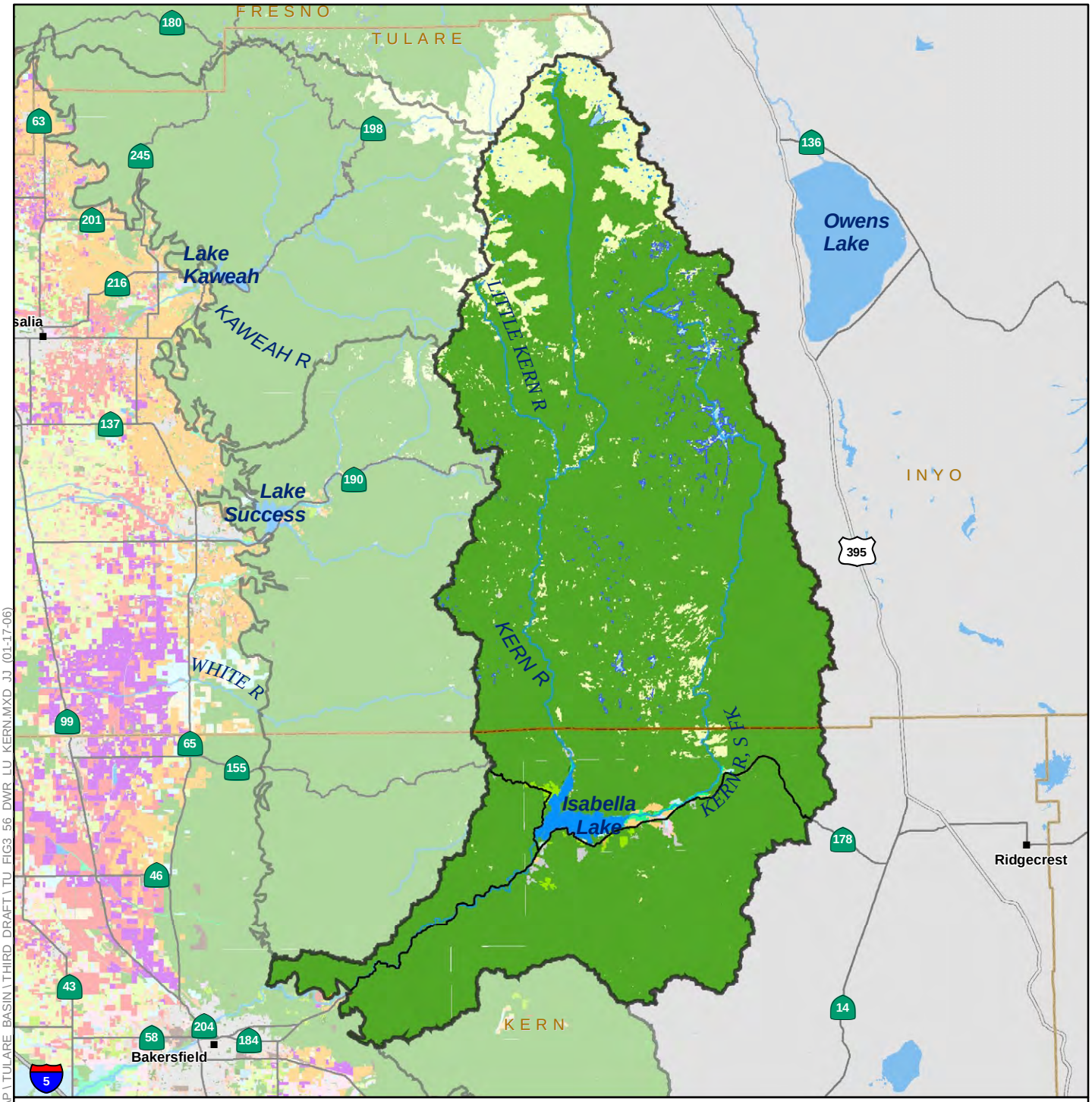


Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

ICF Jones & Stokes
an ICF International Company

Figure 3-55
California Department of Water Resources Land Use
Kaweah River Watershed

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J:\GIS\PROJECTS\RWQCB\05508_05\ARCMAP\TULARE_BASIN\THIRD_DRAFT\TU_FIG3_56_DWR_LU_KERN.MXD JJ (01-17-06)

DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

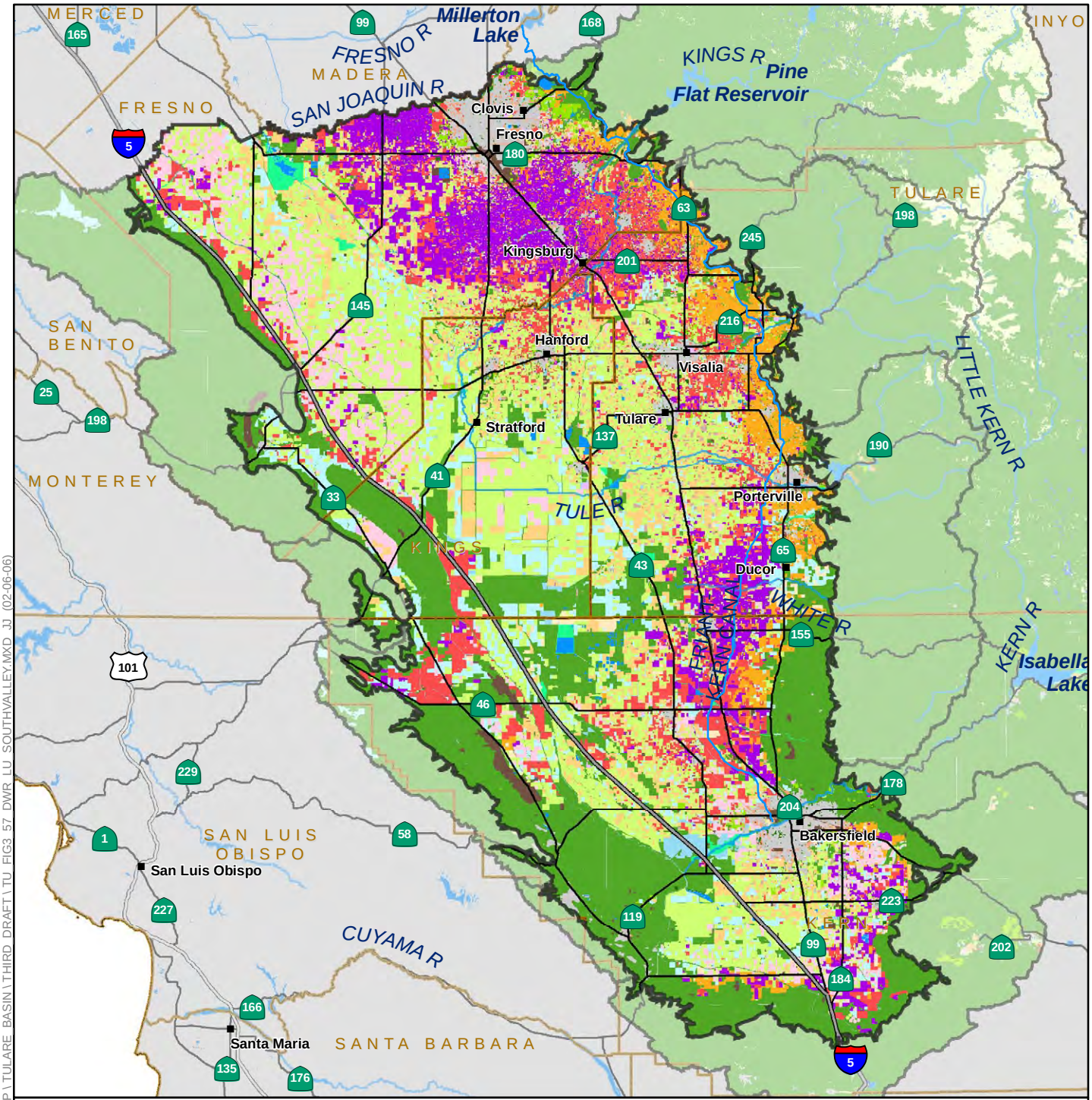
Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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Figure 3-56
California Department of Water Resources Land Use
Kern River Watershed

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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

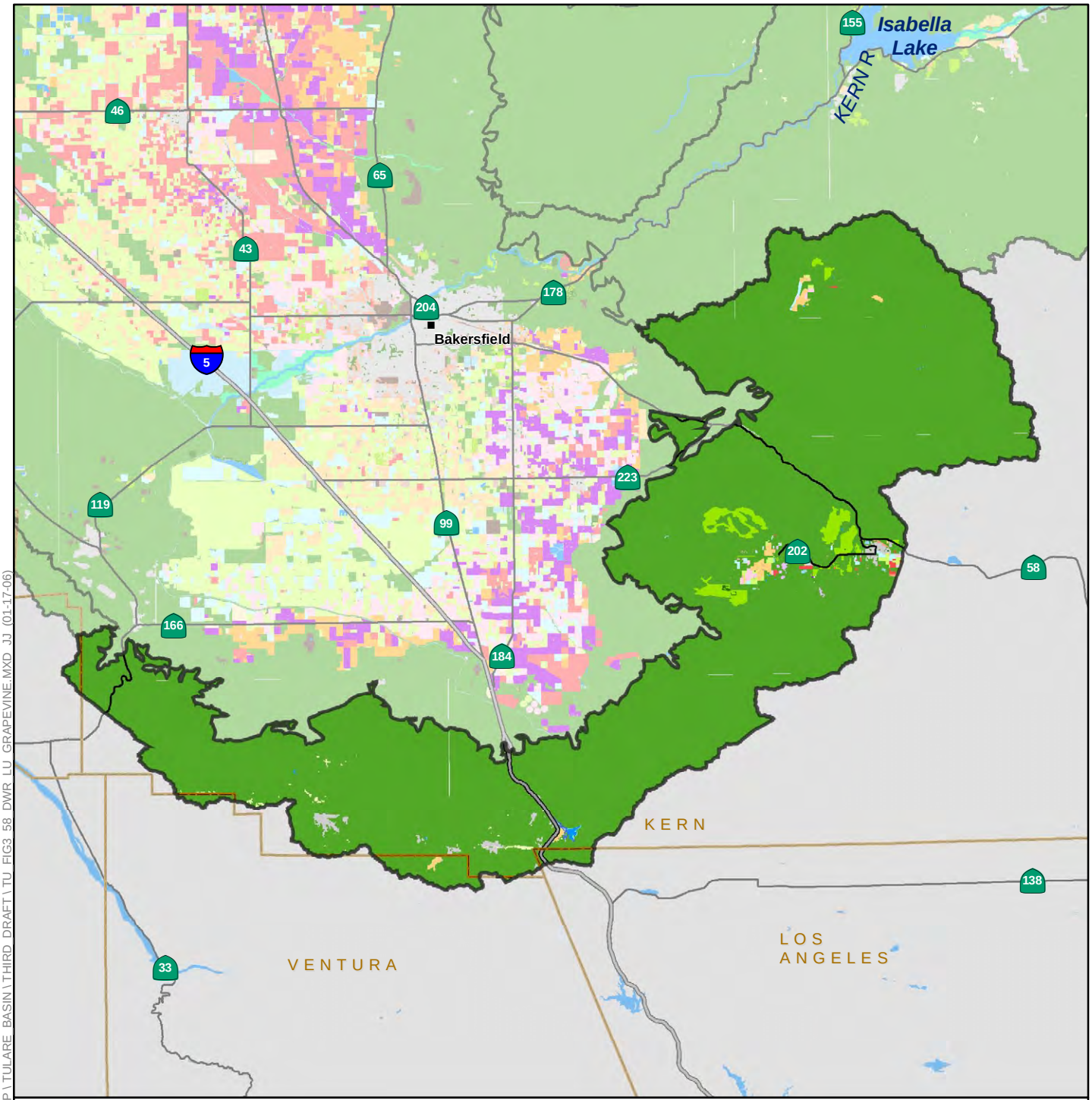
Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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ICF Jones & Stokes
an ICF International Company

Figure 3-57
California Department of Water Resources Land Use
South Valley Floor Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

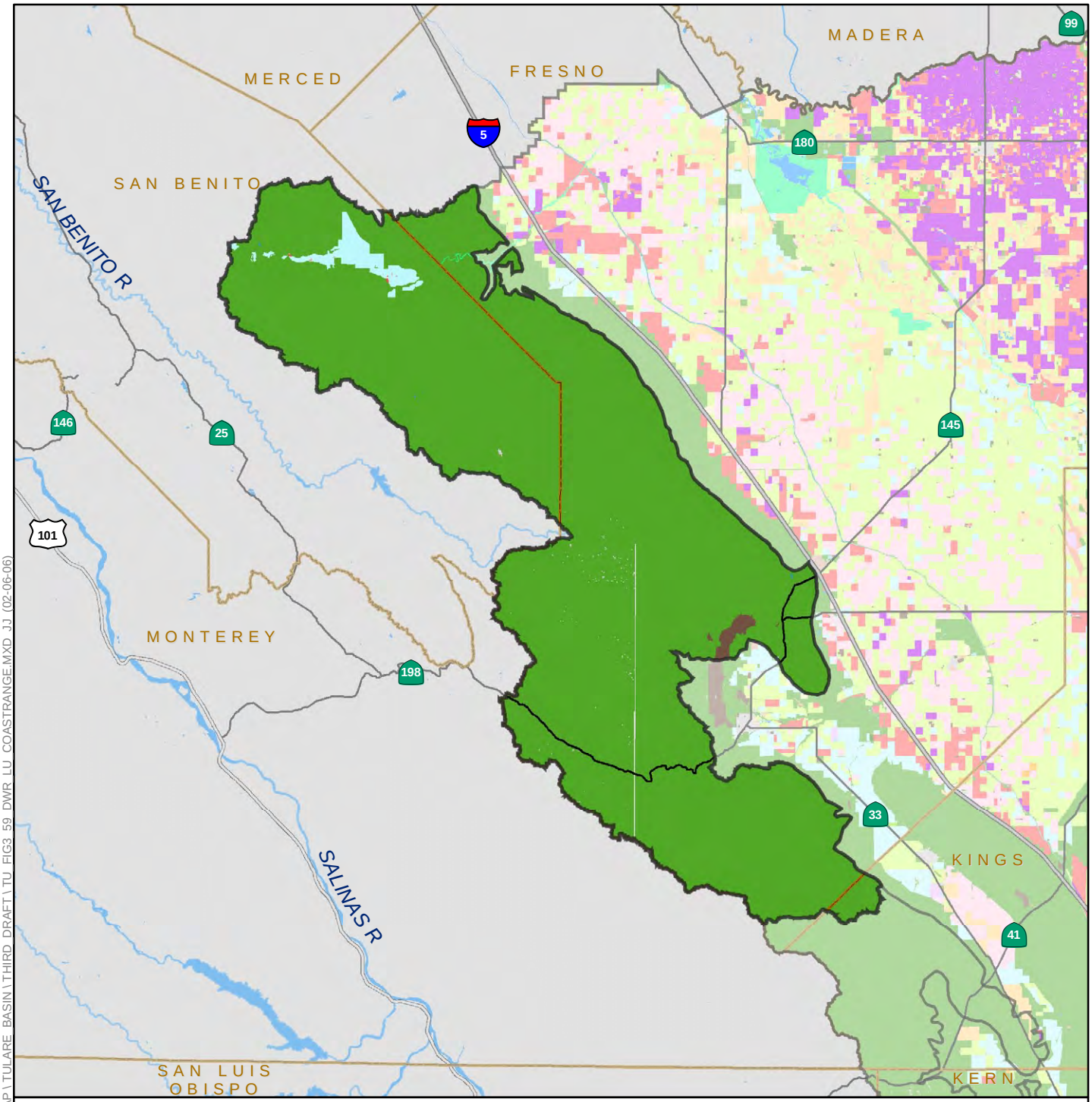
Miles



Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

ICF Jones & Stokes
an ICF International Company

Figure 3-58
California Department of Water Resources Land Use
Grapevine Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

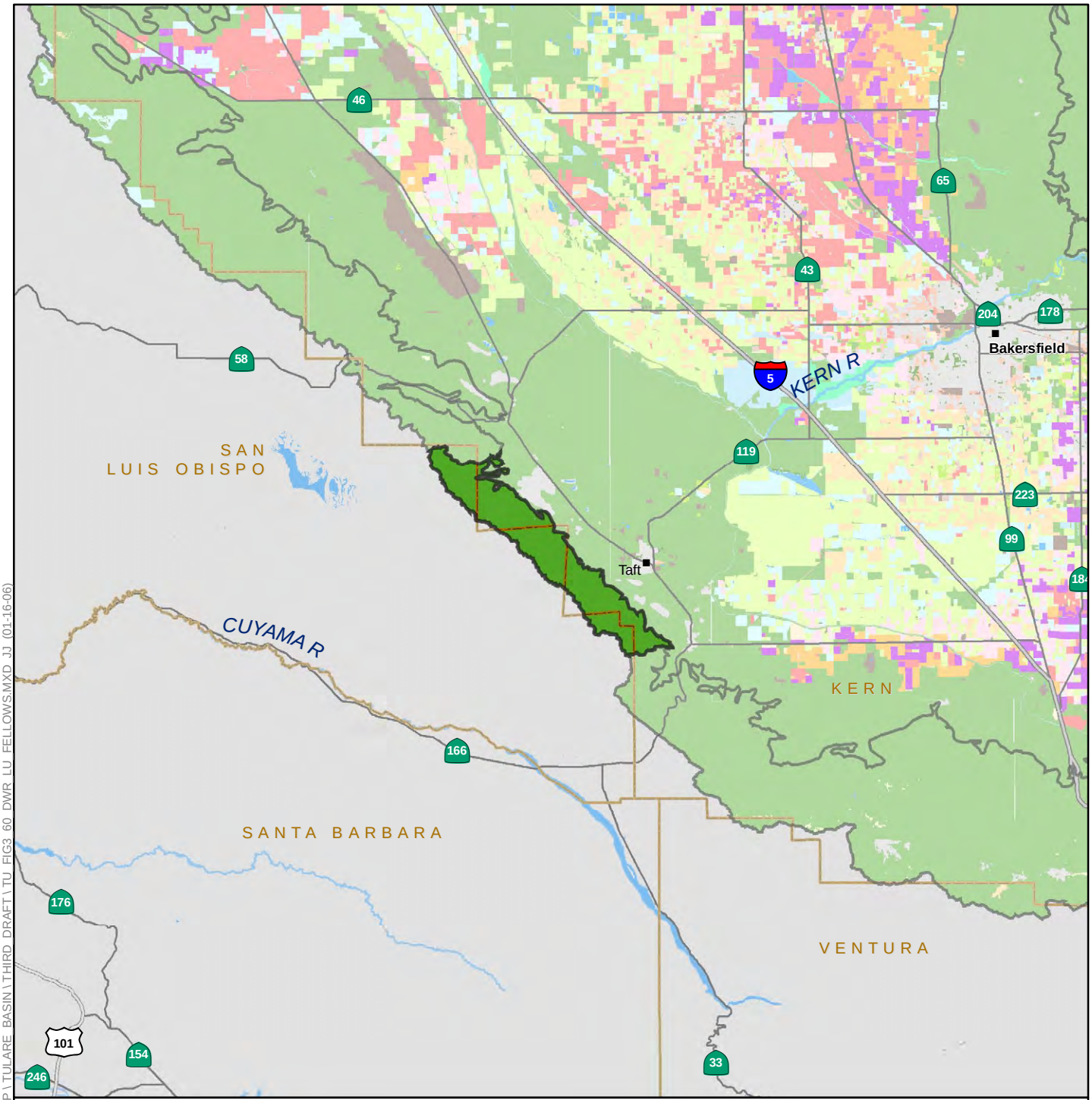
Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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ICF Jones & Stokes
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Figure 3-59
California Department of Water Resources Land Use
Coast Range Watershed



DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

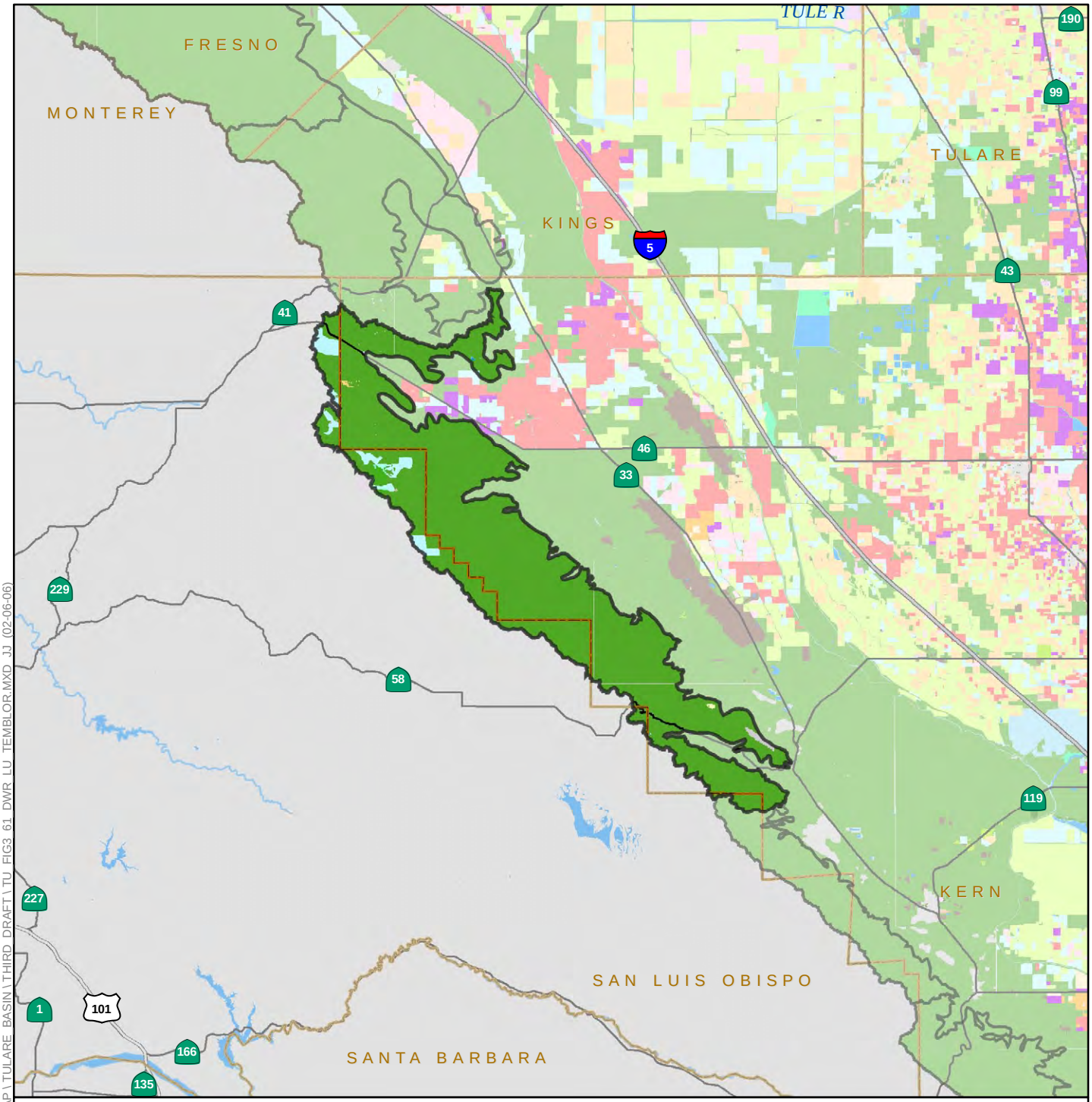


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Figure 3-60
California Department of Water Resources Land Use
Fellows Watershed

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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

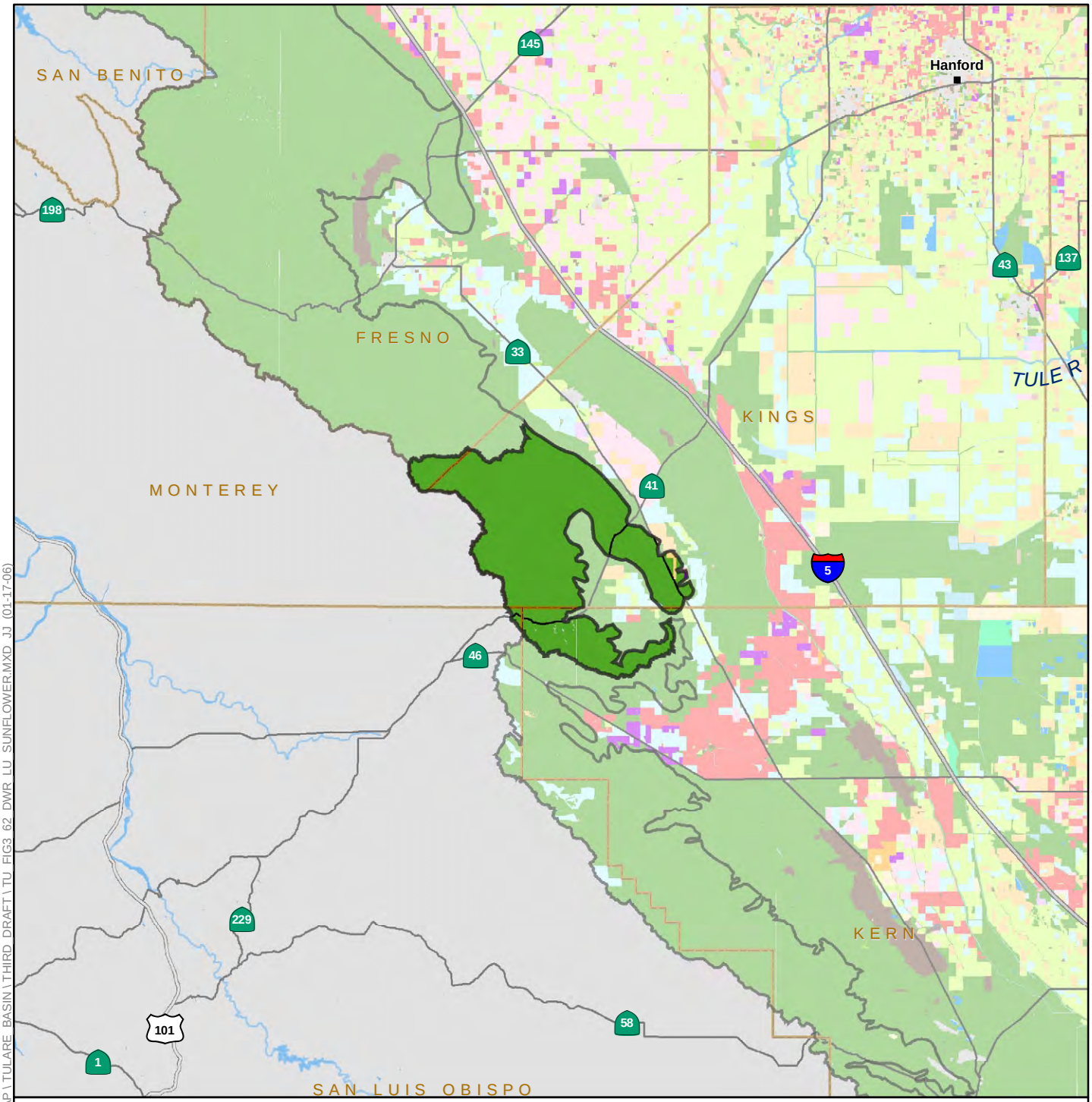


Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

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an ICF International Company

Figure 3-61
California Department of Water Resources Land Use
Temblor Watershed

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J:\GIS\PROJECTS\RWQCB\05508_05\ARCMAP\TULARE_BASIN\THIRD_DRAFT\TU_FIG3_62_DWR_LU_SUNFLOWER.MXD JJ (01-17-06)

DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

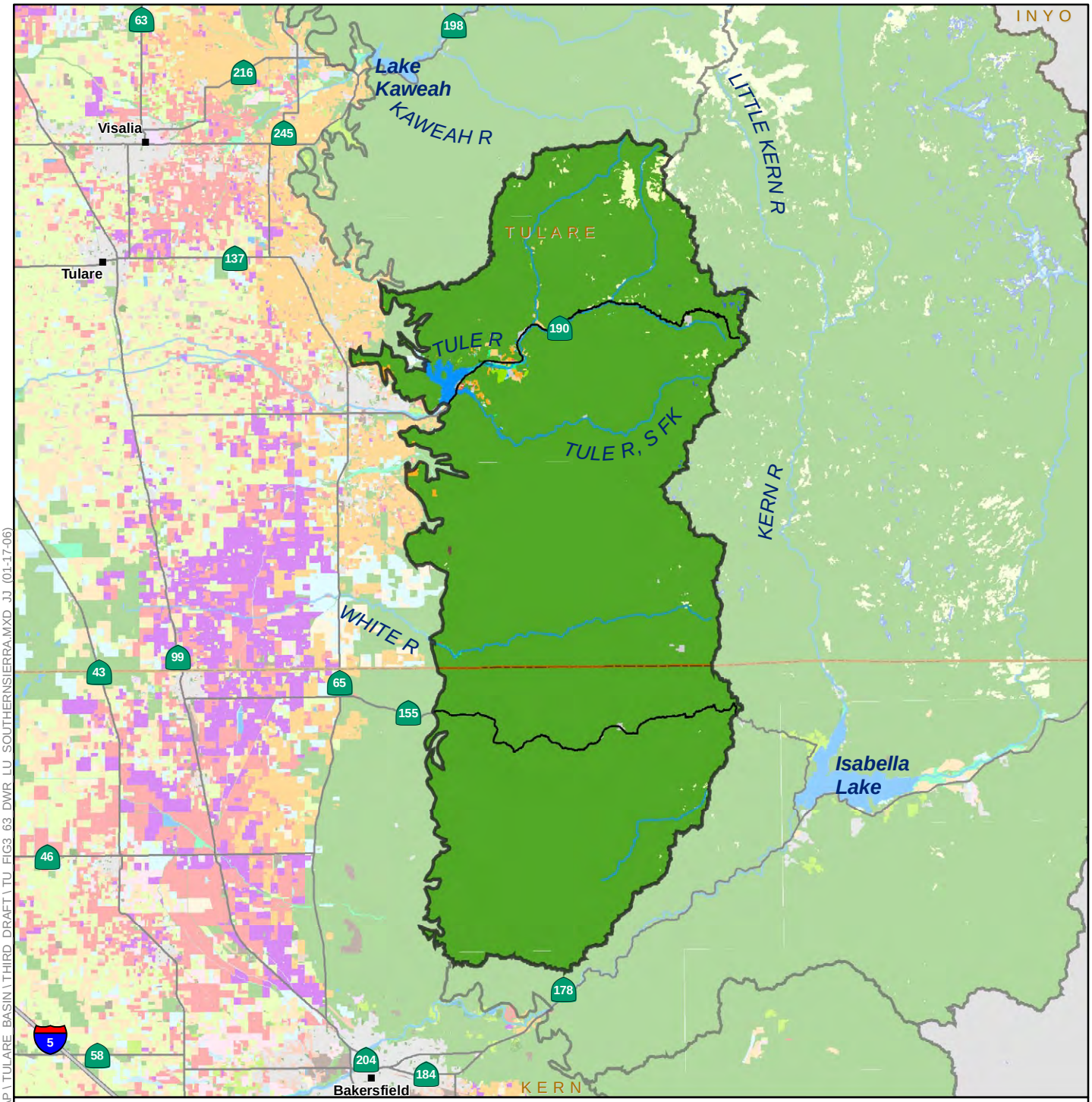
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Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)

ICF Jones & Stokes
an ICF International Company

Figure 3-62
California Department of Water Resources Land Use
Sunflower Valley Watershed



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DWR Land Use

Agricultural/Semiagricultural

- Citrus and SubTropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semi Agricultural & Incidental to Agriculture

Urban

- Urban
- Commerical
- Industrial
- Urban Landscape
- Residential
- Vacant

Native

- Barren and Wasteland
- Native Classes Unsegregated
- Riparian Vegetation
- Native Vegetation
- Water Surface

Unclassified

- Entry Denied

CDF FRAP Vegetation

- Wetland

0 10 20

Miles

Land use data source: California Department of Water Resources (1994–2002)
Portions of upland counties covered by California Department of Forestry
Fire Resources Assessment Program Multi-Source Vegetation Dataset (2002)



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Figure 3-63
California Department of Water Resources Land Use
Southern Sierra Watershed

Chapter 4
Groundwater Quality

INTRODUCTION

California's groundwater is described by DWR as a "hidden resource." Management of groundwater resources is more complex than management of surface water because groundwater is not visible (DWR 2003). It is thought that California could not have achieved its agricultural economy, the fifth largest in the world, if it were not for the groundwater supply. Approximately 43 percent of the entire population of California obtains their drinking water from groundwater aquifers (DWR 2003). In some areas, the use of groundwater is threatened by the high rates of extraction and inadequate recharge or contamination of the aquifer from poor management practices.

This chapter provides a general description of groundwater quality and conditions in the three major hydrologic regions (HRs) in the Central Valley:

- Sacramento River
- San Joaquin River
- Tulare Lake

The Sacramento River Basin consists of 90 basins and subbasins. The San Joaquin Valley Groundwater Basin, which includes the San Joaquin River Hydrologic Region, the Tulare Lake Region, and several Small Groundwater Basins, consists of 28 basins and subbasins.

Importance of Groundwater

Groundwater is one of California's most important natural resources, and our reliance on it continues to grow. Statewide, groundwater supplies account for approximately 30 percent of the total urban and agricultural water supply in average years, approximately 40 percent of the total water supply in dry years, and as much as 60 percent or more in some regions in dry years. Groundwater provides from 30 to 41 percent of the total water supply for urban and agricultural uses in the Sacramento River, San Joaquin River, and Tulare Lake HRs (see Table 4-1). More than 70 percent of the groundwater used in California is supplied from the Sacramento River, San Joaquin River, and Tulare Lake HRs. (DWR 2003.) With such a large amount of water coming from these hydrologic regions, protection of their water resources is critical to ensure that future needs are met.

Table 4-1. Average Annual Groundwater Supply for the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions

Hydrologic Region	Total Demand Volume in TAF	Demand Met by Groundwater (TAF)	Demand Met by Groundwater (%)
Sacramento River	8,720	2,672	31
San Joaquin River	7,361	2,195	30
Tulare Lake	10,556	4,340	41

TAF = thousand acre feet.
Source: DWR 2003.

Interconnection of Groundwater and Surface Water

The connection between groundwater and surface water is important to address in the development of any program designed to protect water resources because the movement of water from one hydrologic system to another can move pollutants between the two systems. Groundwater is recharged by seepage of water moving downward from the ground surface. Groundwater can receive seepage from precipitation; from applied water to agricultural fields and landscaping; and from rivers, lakes, and water delivery systems. Patterns of recharge are dependent on land uses, the amount of groundwater pumped, and the amount of surface water available in any given year. Recharge from irrigation during summer is more significant than recharge from precipitation in winter in the larger groundwater basins in California's Central Valley(UC Regents 2003a). Groundwater may also be discharged to surface waters as baseflow to streams, river, or lakes; as runoff of groundwater applied to cropland, or as subsurface drainage discharges. (UC Regents 2003b.)

Generally, groundwater basins become more dewatered from north (Sacramento hydrologic region) to south (San Joaquin and Tulare Lake HRs). This pattern of dewatering is heavily influenced by the availability of surface water. In the early 1900s, the state and federal governments realized that the lack of surface water available to grow crops in the San Joaquin Valley was causing subsidence and other problems, as irrigated agriculture pumped ever-increasing amounts of groundwater to grow more crops. The CVP was built to deliver surface water to areas in the San Joaquin River and Tulare Lake HRs as a response to the reliance on groundwater and the need to curtail pumping from these aquifers.

Today, many cities in the San Joaquin Valley that depend on groundwater for drinking water rely on surface water delivery facilities for groundwater recharge. In wet years, many agricultural water users are encouraged to forego pumping groundwater in exchange for applying surface water, and many irrigation districts and municipal water agencies recharge groundwater through spreading basins designed to enhance recharge. This recharged water can then be used in drier years when surface water supplies are less available. This interconnectedness both supports better utilization of water resources and provides pathways for contamination to occur.

Reflecting the importance of groundwater as a source of supply in California, a number of federal, state, and local agencies have some responsibility to monitor and regulate groundwater. Each agency at the state and federal level has a different responsibility and approach to monitoring groundwater issues, based on their respective mandate. State agencies that implement groundwater monitoring and assessment programs are presented in Table 4-2. Federal agencies that implement groundwater-related monitoring and assessment programs in California include EPA, Reclamation, and USGS.

Table 4-2. Summary of Monitoring Programs by State Agency

Agency	Groundwater Program	Groundwater Monitoring/Assessment Objectives
Department of Public Health (CDPH)	California Drinking Water Source Assessment and Protection Program	Ascertain quality of all public water supply sources for compliance with maximum contaminant levels (MCLs). Complete source water assessments of all sources by May 2003. A source water assessment is required for all new sources before receiving a CDPH permit.
Department of Pesticide Regulation (DPR)	Ground Water Protection Program	Groundwater contaminant identification; Determine potential for movement of pesticide residues to groundwater based on their physical/chemical properties. Conduct well sampling to identify new pesticide active ingredients in groundwater. Provide monitoring data to determine trends in pesticide concentrations in contaminated basins. Vulnerable area identification; Determine the spatial extent of contamination for residues already detected in groundwater. Use soil type, depth to groundwater, climate, and other geographic or agronomic factors to identify areas vulnerable to pesticide contamination of groundwater. Mitigation measure development and implementation; Identify and test mitigation measures to prevent movement of residues to groundwater. Implement mitigation measures to prevent continued movement of pesticides to groundwater. Backflow and chemigation education and training; Prevent the backflow of residues into groundwater when they are applied through injection into irrigation water.
Department of Water Resources (DWR)	Bulletin 118	Update of groundwater basin boundaries and basin characteristics.
	Water quality and quantity monitoring	Long-term water quality and well level data.
	Local and regional studies	Miscellaneous groundwater studies addressing local groundwater issues.
	Groundwater quantity for updating the State Water Plan	State's water supply and demand budget.
	State Water Project Conjunctive Use Program	Basin monitoring associated with State Water Project conjunctive use projects.
	Integrated Storage Investigations, Conjunctive Use, and Grants and Loans Programs	Data collection, monitoring, and evaluation; feasibility studies for groundwater recharge and storage.
	Water data management systems	Water Data Library: on-line access to hydrologic data.
	Subsidence monitoring	Monitoring along California Aqueduct; special studies as needed.
State Water Resources Control Board (State Water Board)	Groundwater Ambient Monitoring and Assessment (GAMA) Program	Assess statewide groundwater quality and aquifer susceptibility.

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Agency	Groundwater Program	Groundwater Monitoring/Assessment Objectives
State Water Board and Regional Water Quality Control Boards (Regional Water Boards)	Underground Storage Tank (UST) Program	Regulate USTs and provide cleanup oversight.
	Land Disposal Program	Impose statewide requirements for siting, operation, and closure of waste disposal sites through issuance of waste discharge requirements and compliance and enforcement efforts to ensure adequate protection of water quality.
	Site Cleanup	Oversee the investigation and remediation of sites associated with unauthorized releases that may impact water quality.
	Department of Defense (DOD) Program	Partner with DOD through the Defense and State Memorandum of Agreement (DSMOA) to oversee the investigation and remediation of water quality issues at over 200 military facilities.
Department of Toxic Substances Control (DTSC)	Hazardous Waste Management Program—Facility Permitting Division	Evaluate groundwater contamination at Resource Conservation and Recovery Act storage, treatment, and disposal facilities.
	Site Mitigation Program—Statewide Cleanup Operations Division	Evaluate groundwater contamination at Superfund, brownfield, and voluntary cleanup sites.
	Site Mitigation Program—Emergency Response and Statewide Operations Division	Evaluate groundwater contamination at Superfund, brownfield, and voluntary cleanup sites (technical support).
	Site Mitigation Program—Office of Military Facilities	Evaluate groundwater contamination at military sites.

Potential Agricultural Impacts to Groundwater Quality

Because irrigation is the primary source of recharge to the larger aquifers of the Central Valley, irrigation seepage can provide pathways for contamination in areas where groundwater aquifers underlie porous soils that receive heavy nutrient or chemical applications. While contamination of the aquifer can occur when water is applied to fields and landscaped areas, rainfall runoff also can carry agricultural pollutants that reach dry wells, ditches, sumps or ponds, and porous soils. Because many applications of pesticides to agricultural lands are from late fall to early spring, rainfall can transport pesticides to groundwater during this period (USGS 2004).

Figure 4-1 provides a conceptual model of the interconnection between groundwater and surface water, including possible sources of contaminants from irrigated agriculture. As shown in Figure 4-1, there are many potential pathways for irrigated agricultural pollutants to impact groundwater. Because of the many potential pathways and the existence of other pollutant sources (septic systems, dairies, etc.) it is difficult to determine where the pollutants originate from. Existing pollution could have been caused many years ago by practices no longer in use.

Numerous studies address the complex process of controlling the transport and fate of agricultural chemicals in surface water and groundwater. Not all of the applied agricultural chemicals remain in the soil or are taken up by the plant. A small percentage of the chemicals can move upward into the atmosphere, downward through the soil into shallow groundwater, or across the land into streams (USGS 2004). Chemicals that persist for long periods are more likely to be transported farther than short-lived

compounds. According to DPR, pesticides that move to groundwater under certain soil conditions are most frequently found in groundwater when the depth to groundwater is shallower than 70 feet (DPR 2007a, 2007b).

Constituents of Concern in Groundwater Related to Agriculture

Table 4-3 presents the main constituents of concern for potential groundwater contamination from agricultural practices in the Sacramento River, San Joaquin River, and Tulare Lake HRs.

Table 4-3. Constituents of Concern related to Agricultural Practices in the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions

Constituent of Concern	Agricultural Source
Nutrients—primarily nitrate but may include nitrites, ammonia, and phosphorous	Organic and chemical fertilizers, animal wastes, and natural sources
Pesticides (insecticides and herbicides) and degradation products	Crop applications
Salt—primarily measured as electrical conductivity and total dissolved solids	Evaporation from shallow water table and evapotranspiration of soil water, fertilizers, irrigation water, natural soil salinity, and animal wastes
Trace elements (cadmium, copper, lead, nickel, zinc, selenium, arsenic, and boron)	Fertilizers, irrigation water, and natural sources
Organic carbon and disinfection byproduct precursors	Mobilization of soil organic matter and plant residues due to cultivation and irrigation
Microorganisms	Animal wastes

Nutrients

Essential plant nutrients occur naturally in soil. To increase crop yield, growers supplement soil nutrients by adding chemical fertilizers and organic fertilizers such as animal manures and crop residues. Because excess nutrients can move below the root zone, managing plant nutrients is an important part of protecting groundwater quality. The three major nutrients for plants are nitrogen, phosphorous, and potassium.

The primary nutrient of concern in the Central Valley is nitrogen. In soil, both organic and inorganic nitrogen are converted to highly leachable nitrate. The risk of nitrate leaching and contaminating groundwater is highest when; nitrogen applications exceed crop needs, timing of nitrogen application does not coincide with crop needs, soils are well drained, and excess rainfall or irrigation increases leaching. Nitrogen in drinking water is of concern because it can interfere with the ability of red blood cells to carry oxygen to the tissues of the body, producing a condition called methemoglobinemia. It is of greatest concern in infants, whose immature stomach environment enables conversion of nitrate to nitrite, which is then absorbed into the blood stream. Throughout this chapter are references to primary and secondary inorganic. A primary inorganic is defined as an inorganic mineral that has not been altered chemically since its deposition and crystallization from molten lava. A secondary inorganic is defined as

an inorganic mineral resulting from the weathering of a primary mineral, either by an alteration in the structure or from reprecipitation of the products of weathering (dissolution) of a primary mineral.

Pesticides

Detection of pesticides in groundwater is related to physical and chemical properties of soils and the specific compounds, water management, and spatial and temporal variability of pesticide application and soil-water processes and properties. Factors that generally increase the degradation and soil adsorption of the pesticide reduce the probability of detection in groundwater. Throughout this chapter are references toverified and unverified pesticide detections. Verified pesticide detections are defined as those that are found at more than one sampling date resulting from legal or agricultural uses.

Water management practices also influence movement of pesticides in irrigated areas. Troiano et al. (1993) investigated different irrigation methods and found that “leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method.” For basin-flooding treatmentsa large amount of water application is required for each irrigation to provide application across the plot. Although irrigations are less frequent, the larger water volume may cause greater downward movement of water and associated pesticides.

Salinity

Irrigated agriculture can result in increasing groundwater salinity. Irrigation water containing varying levels of dissolved constituents or salts is partially evaporated as the result of crop transpiration and evaporation from the soil. These processes concentrate salts in the remaining water that percolates to groundwater. The extent of the effect on groundwater salinity depends on rainfall, volume of water applied, groundwater pumping and hydraulics, the salinity of the irrigation water, and chemical reactions in soils and aquifer materials.

Organic Carbon and Disinfection Byproducts

Disinfection byproducts form when disinfectants added to drinking water to kill germs react with naturally-occurring organic matter in surface water or groundwater. These disinfection byproducts have been a source of concern in recent years. While most groundwater does not contain elevated levels of organic material, increased scrutiny has been placed on monitoring for these precursors.

Microorganisms

All natural waters (rivers, lakes, wetlands) contain microorganisms. Groundwater usually has fewer microorganisms than surface water because of its long travel time in the subsurface environment. However, groundwater can become contaminated by domestic sewage, feedlots, and surface runoff, as well as other pollution sources. Where the subsurface geology permits rapid downward movement of water from the surface, or where the groundwater sources are tapped near the surface, aquifers may be vulnerable.

Groundwater Vulnerability to Pollution

Considerable effort has been expended in California to determine areas that are vulnerable to groundwater pollution from various sources. The California Drinking Water Source Assessment and Protection Program (DWSAP) prepared and administered by CDPH, and the Ground Water Protection Program developed and administered by DPR are two programs in California that were developed to determine areas where groundwater is vulnerable to pollution.

DPR's DWSAP Program was prepared in response to the 1996 reauthorization of the federal Safe Drinking Water Act (SDWA), which included an amendment requiring states to develop a program to assess sources of drinking water and encouraging states to establish protection programs. The drinking water source assessment is the first step in the development of a complete drinking water source protection program. The assessment includes a delineation of the area around a drinking water source through which contaminants might move and reach that drinking water supply. In addition, it includes an inventory of activities that might lead to the release of microbiological or chemical contaminants within the delineated area. This enables a determination to be made as to whether the drinking water source might be vulnerable to contamination. Finally, CDPH will work with the local drinking water providers to determine management practices in order to protect the drinking water from sources of contamination (CDPH 2000).

The Ground Water Protection Program determines where and how pesticides are contaminating groundwater, identifies areas sensitive to pesticide contamination, and develops mitigation measures to prevent further movement. DPR also adopts regulations and does outreach to carry out mitigation measures. The measures are designed to prevent continued movement to groundwater in contaminated areas and to prevent problems before they occur in other areas. DPR developed computer modeling that identified vulnerable areas of the state by using almost 20 years of well monitoring data compiled in DPR's well inventory database, as well as soil data from the NRCS and climate information. This model provides DPR with the tools to relate farming practices and soil conditions to the use of soil-applied herbicides that most often threaten groundwater. Vulnerable areas are classified as either "runoff" or "leaching." and management practices are written into regulation for each area type. Administration and enforcement of the program is carried out within the existing permit process and gives pesticide users flexibility to choose from a menu of regulatory options to apply the protection measure that best fits their situation. (DPR 2004a.)

Other programs also are actively working to identify vulnerable areas to various forms of pollution. Among them are the CDFA Fertilizer and Research Program (FREP) and the State Water Board and USGS Groundwater Ambient Monitoring Assessment (GAMA) Program. The FREP funds and coordinates research to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. FREP serves growers, agricultural supply and service professionals, extension personnel, public agencies, consultants, and other interested parties. The GAMA Program has evaluated the susceptibility of groundwater to contamination in several areas of the state. The California Aquifer Susceptibility assessment (CAS) was performed from 2000 to 2003 in collaboration with USGS and Lawrence Livermore National Laboratory. CAS was a study of the water quality and relative susceptibility of groundwater that serves as a source for public drinking water. GAMA also prepared a map showing areas of California with the potential to be more susceptible to groundwater contamination based on chemical analysis (see <http://www.waterboards.ca.gov/water_issues/programs/gama/>). (Moran et al. 2004.)

Organization and Elements

This discussion of groundwater quality in the Sacramento River, San Joaquin River, and Tulare Lake HRs is organized by groundwater basin and subbasin. The introduction for each groundwater basin includes an overview of agricultural impacts on groundwater, groundwater movement and solute transport, general hydrogeology, and groundwater development. Individual subbasin sections include discussions of general basin parameters (acreage, physiography, major sources of recharge, land uses, coalitions, water districts, major urban areas, and pertinent ordinances or regulations) and water quality data.

Figure 4-2 displays the locations of groundwater subbasins within the Sacramento River hydrologic region, Figure 4-3 displays the locations of groundwater subbasins within the San Joaquin River, and Figure 4-4 displays the locations of groundwater subbasins in the Tulare Lake hydrologic region. The groundwater quality descriptions are organized in alphabetical order by large subbasins in the Sacramento River HR and San Joaquin River and Tulare Lake HRs, followed by descriptions of the smaller basins peripheral to them.

General Sources of Information

Sources of information for each subbasin include reports and data from DWR, DPR, and USGS. Specifically, land use data came from the DWR land use surveys conducted periodically throughout California. DWR Bulletin 118 (DWR 2003) was the primary source of information for subbasin hydrogeologic and physiographic descriptions for the Sacramento Valley, San Joaquin Valley and Tulare Lake Groundwater Basins.

Water quality data were obtained from DPR (Schuette et al. 2003), DWR Bulletin 118, and other published documents. Several USGS reports provided information about concentrations of constituents in the Sacramento Valley Groundwater Basin. The DPR data are county-specific, not specific to the individual subbasins. Regulatory and groundwater management information was obtained from various DWR publications as well as from various county websites. Population information was obtained from county and individual city websites. Information regarding groundwater ordinances and regulation was obtained from DWR Bulletin 118 (DWR 2003) and by contacting individual counties.

DPR's Ground Water Protection Program provided information useful for determining where and how pesticides are contaminating groundwater, and identifying areas sensitive to pesticide contamination. Other literature was reviewed and cited that explains agriculture-related processes affecting groundwater quality in general and for specific subbasins. Included were peer-reviewed journal articles and preliminary data and reports from the GAMA Program funded by the State Water Board.

GROUNDWATER BASINS

The groundwater basins within the three major hydrologic regions of the Central Valley have been delineated using the boundaries in DWR Bulletin 118. Figures 4-2 through 4-4 show the boundaries of these basins.

Sacramento River Basin

- Sacramento Valley Basin
- Alturas Area Basin
- American Valley Basin
- Antelope Creek Basin
- Ash Valley Basin
- Bear Valley Basin
- Berryessa Valley Basin
- Big Valley Basin (No. 5-15)
- Big Valley Basin (No. 5-4)
- Blanchard Valley Basin
- Burney Creek Valley Basin
- Burns Valley Groundwater Basin
- Butte Creek Valley Basin
- Cayton Valley Basin
- Chrome Town Area Basin
- Clear Lake Cache Formation Basin
- Clover Valley Basin
- Collayomi Valley Groundwater Basin
- Coyote Valley Basin
- Dixie Valley Basin
- Dry Burney Creek Basin
- Egg Lake Valley Basin
- Elk Creek Area Basin
- Fairchild Swamp Area Basin
- Fall River Valley Basin
- Funks Creek Basin
- Goose Valley Basin
- Goose Lake Valley Basin
- Grays Valley Basin
- Grizzly Valley Basin
- High Valley Basin
- Hot Springs Valley Basin
- Humbug Valley Basin
- Indian Valley
- Jess Valley Basin
- Joseph Creek Basin
- Lake Almanor Valley Basin
- Lake Britton Area Basin
- Last Chance Creek Valley Basin
- Little Indian Valley Basin
- Long Valley Basin (No. 5-31)
- Long Valley Basin (No. 5-44)
- Lower Lake Basin
- McCloud Area Basin
- Meadow Valley Basin
- Middle Creek Basin
- Middle Fork Feather River Basin
- Mohawk Valley Basin
- Mountain Meadows Valley
- North Fork Battle Creek Basin
- North Fork Cache Creek Basin
- Pondosa Town Area Basin
- Pope Valley Basin
- Redding Area Basin
- Rock Prairie Valley Basin
- Round Valley Basin
- Scotts Valley Basin
- Sierra Valley Basin
- Squaw Flat Basin
- Stony Gorge Reservoir Basin
- Stonyford Town Area Basin
- Toad Well Basin
- Upper Lake Basin
- Yellow Creek Valley Basin

San Joaquin Valley Groundwater Basin

San Joaquin River Hydrologic Region

- Cosumnes Subbasin
- Eastern San Joaquin Subbasin
- Tracy Subbasin
- Modesto Subbasin
- Turlock Subbasin
- Merced Subbasin
- Delta-Mendota Subbasin
- Chowchilla Subbasin
- Madera Subbasin

Tulare Lake Hydrologic Region

- Westside Subbasin
- Kings Subbasin
- Tulare Lake Subbasin
- Kaweah Subbasin
- Tule Subbasin
- Pleasant Valley Subbasin
- Kern County Subbasin

Small Groundwater Basins

- Panoche Valley
- Kern River Valley
- Walker Basin Creek Valley
- Cummings Valley
- Tehachapi Valley West
- Castaic Lake Valley
- Vallecitos Creek Valley
- Brite Valley
- Cuddy Canyon Valley
- Cuddy Ranch Area
- Cuddy Valley
- Mil Portero Area

SACRAMENTO RIVER BASIN—INTRODUCTION

Overview of Agricultural Chemical Impacts to Groundwater

The information provided here focuses on the occurrence of groundwater contamination due to irrigated agriculture in the Sacramento River Basin. Table 4-4 summarizes the results of the review of the available information. Twenty-five percent of the basins or subbasins have insufficient data or available data indicate no groundwater quality problems. In a large number of the basins or subbasins (30%), irrigated agriculture occupies 5% or less of the area.

Table 4-4. Summary of Groundwater Quality Issues for the Sacramento River Hydrologic Region

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-21	Sacramento Valley		
5-21.54	Antelope	Nitrate concentrations of 20–45 mg/L observed in the west-central part of the subbasin.	44
5-21.53	Bend	No apparent problems.	3
5-21.52	Colusa	Elevated groundwater salinity and concentrations of nutrients and rice pesticides.	66
5-21.51	Corning	Possibly salinity.	35
5-21.55	Dye Creek	Possibly salinity.	20
5-21.59	East Butte	Pesticides and nitrates are the primary constituents of concern. There are also localized areas of high salinity.	60
5-21.56	Los Molinos	Possibly salinity. Insufficient data to determine effects of irrigated agriculture.	18
5-21.64	North American	Nitrates, pesticides, dissolved solids, and VOCs are the result of agricultural and urban land uses.	38
5-21.60	North Yuba	Nutrients (nitrogen, phosphorus), salinity, pesticides, and trace elements are the primary constituents of concern. Trace elements are thought to be naturally occurring but some are elevated to levels above the national limits. There is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides from irrigated agriculture in the North Yuba Subbasin.	71
5-21.50	Red Bluff	Salinity.	10
5-21.66	Solano	High levels of pesticides, nitrates, and salinity are possibly related to irrigated agriculture.	65
5-21.65	South American	High levels of pesticides, nitrates, and salinity are possibly related partially to irrigated agriculture and partially to urban land uses.	25

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Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-21.61	South Yuba	Pesticides and increasing salinity are the primary constituents of concern related to irrigated agricultural practices.	48
5-21.62	Sutter	Pesticides and increasing salinity are the primary constituents of concern related to irrigated agriculture. Localized high nitrogen concentrations may be caused by agricultural practices.	79
5-21.57	Vina	Groundwater quality problems include localized high calcium and high nitrate, TDS, and VOCs—primarily in the Chico area. It is uncertain whether these contaminants originate from agricultural practices. High nitrates are likely from septic systems. Dissolved solids may originate from irrigation practices, but it is uncertain.	36
5-21.58	West Butte	Dissolved solids are elevated in localized areas throughout the subbasin, and pesticides have been detected in groundwater beneath the rice growing areas. Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity and concentrations of nutrients and pesticides as the result of irrigated agriculture.	70
5-21.67	Yolo	High dissolved solids and nitrate are related to irrigated agriculture. Pesticides detected though insufficient dataare available to determine the effects of irrigated agriculture.	66
5-2	Alturas Area		
5-2.01	South Fork Pitt River	Salinity in localized areas	31
5-2.02	Warm Springs Valley	Salinity in localized areas	23
5-91	Antelope Creek	No groundwater quality data available.	5
5-54	Ash Valley	No water quality data available. All agricultural land is pasture.	37
5-64	Bear Valley	Insufficient water quality data.	5
5-20	Berryessa Valley	No irrigated agriculture in this basin.	0
5-15	Big Valley	Increasing levels of nitrate in individual wells may be the result of irrigated agriculture.TDS ranges from 270 to 790 mg/L, averaging 535 mg/L, which is above the EPA SMCL, may also be the result of irrigated agriculture. Elevated levels of iron and boron are caused by thermal waters.	37

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-4	Big Valley	Localized high levels of nitrates, manganese, fluoride, iron, sulfate, conductivity, calcium, adjusted sodium absorption ratio, ammonia, phosphorus, and TDS. Pastureland comprises 28% of the basin and may be the cause for nitrates, phosphorus, ammonia, and dissolved solids.	37
5-92	Blanchard Valley	No groundwater quality data available.	10
5-48	Burney Creek Valley	Insufficient water quality data available to determine effects of irrigated agriculture. All agricultural land is pasture.	41
5-17	Burns Valley	No indication that groundwater quality problems are due to agricultural irrigation.	19
5-51	Butte Creek Valley	No irrigated agriculture in this basin.	0
5-21.68	Capay Valley	Dissolved solids from six wells range from 300 to 500 mg/L, the EPA MCL is 500 mg/L.. Insufficient dataare available to determine the effects of irrigated agriculture.	31
5-45	Cayton Valley	No groundwater quality data available. All agricultural land is pasture.	69
5-61	Chrome Town Area	No irrigated agriculture in this basin.	0
5-66	Clear Lake Cache Formation	Insufficient water quality data.	1
5-58	Clover Valley	No irrigated agriculture in this basin.	0
5-19	Collayomi Valley	No apparent agriculturally related groundwater quality problems.	10
5-18	Coyote Valley	No apparent agriculturally-related groundwater quality problems.	28
5-53	Dixie Valley	No groundwater quality data available. All agricultural land is pasture.	51
5-49	Dry Burney Creek Valley	No irrigated agriculture in this basin.	0
5-41	Egg Lake Valley	No irrigated agriculture in this basin.	0
5-62	Elk Creek Area	No groundwater quality data available	6
5-5	Fall River Valley	Localized high concentrations of nitrate, manganese, ammonia, and phosphorus. Pastureland comprises 31% of the land use.	43
5-90	Funks Creek	Insufficient groundwater quality data.	17
5-47	Goose Valley	No groundwater quality data available.	92
5-1	Goose Lake Valley	Insufficient data.	
5-1.02	Fandango Valley	Insufficient data.	25
5-1.01	Lower Goose Lake Valley	Insufficient data.	26
5-52	Grays Valley	No irrigated agriculture in this basin.	0
5-59	Grizzly Valley	No irrigated agriculture in this basin.	0
5-16	High Valley	TDS ranges from 480 to 745 mg/L, averaging 598 mg/L, which is above the EPA SMCL. Locally high ammonia, boron, phosphorus, chloride, iron, and manganese.	8

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-40	Hot Springs Valley	No groundwater quality data available. All agricultural land is pasture.	10
5-60	Humbug Valley	Insufficient groundwater quality data.	4
5-3	Jess Valley	Insufficient data.	53
5-86	Joseph Creek	No groundwater quality data available.	20
5-46	Lake Britton Area	No irrigated agriculture in this basin.	0
5-57	Last Chance Creek Valley	No irrigated agriculture in this basin.	0
5-65	Little Indian Valley	Insufficient data.	24
5-31	Long Valley	Insufficient data	24
5-44	Long Valley	No irrigated agriculture in this basin.	0
5-30	Lower Lake Valley	High boron. Localized high iron, manganese, calcium, sodium, sulfate, and TDS. Insufficient data to determine effect of irrigated agriculture.	6
5-35	McCloud Area	No irrigated agriculture.	0
5-95	Meadow Valley	Insufficient groundwater quality data.	5
5-94	Middle Creek	No groundwater quality data available.	5
5-87	Middle Fork Feather River	Insufficient groundwater quality data.	4
5-50	North Fork Battle Creek	No groundwater quality data available.	6
5-93	North Fork Cache Creek	No irrigated agriculture.	0
5-38	Pondosa Town Area	No information available about the basin.	–
5-68	Pope Valley	No groundwater quality data available. Almost all agricultural land is vineyards.	28
5-6	Redding Area		
5-10	American Valley	Insufficient groundwater quality data.	42
5-6.03	Anderson	Localized high nitrate may be due to irrigated agriculture.	13
5-6.01	Bowman	No known groundwater quality problems due to agricultural land use.	3
5-6.04	Enterprise	. No known groundwater quality problems due to agricultural land use.	9
5-9	Indian Valley	Insufficient groundwater quality data.	39
5-7	Lake Almanor Valley	No apparent groundwater quality problems due to irrigated agriculture.	19
5-6.05	Millville	No known groundwater quality problems due to agricultural land use.	4
5-11	Mohawk Valley	No known groundwater quality problems due to agricultural land use..	7
5-8	Mountain Meadows Valley	Insufficient groundwater quality data.	46
5-6.02	Rosewood	No known groundwater quality problems.	4
5-6.06	South Battle Creek	No known groundwater quality problems.	6
5-43	Rock Prairie Valley	No irrigated agriculture.	0

Basin/Subbasin Number*	Basin Name Subbasin Name	Water Quality Issues That Are Potentially Related to Irrigated Agriculture	Percent Irrigated Agriculture
5-36	Round Valley	TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. Most agricultural land is pastureland. Insufficient information to determine effects of irrigated agriculture.	34
5-14	Scotts Valley	Nitrate, iron, manganese, and boron concentrations exceed EPA maximum acceptable concentrations for agricultural irrigation for selected wells. Insufficient information to determine effects of irrigated agriculture.	22
5-12	Sierra Valley	Insufficient data.	
5-12.02	Chilcoot	Localized high dissolved solids.	25
5-12.01	Sierra Valley	Localized high dissolved solids, boron, fluoride, iron, sodium, arsenic, manganese. Thermal groundwater intrusion is the most likely source for these constituents.	31
5-89	Squaw Flat	No irrigated agriculture in this basin.	0
5-88	Stony Gorge Reservoir	No groundwater quality data available.	4
5-63	Stonyford Town Area	Insufficient groundwater quality data.	12
5-37	Toad Well Area	No irrigated agriculture in this basin.	0
5-13	Upper Lake Valley	Localized high salinity likely due to irrigated agriculture.	42
5-56	Yellow Creek Valley	No water quality data available. All agricultural land is pasture.	61

Notes:
EPA = U.S. Environmental Protection Agency.
MCL = Maximum Contaminant Level (EPA 2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Limit (EPA 2005).
TDS = total dissolved solids.
VOCs = volatile organic compounds.
* Basin/Subbasin Number from California Department of Water Resources Bulletin 118.

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Results from monitoring that was performed as part of the DPR Ground Water Protection Program are summarized in Table 4-5.

Table 4-5. Pesticide Detections in Groundwater Wells for Counties in the Sacramento River Basin (1985–2003)

County	ACET	Atrazine	Bentazon	Bromocitl	DACT	DEA	Diuron	Norflurazon	Promoton	Simizine
Butte		6	8	1		1	1	2	1	1
Colusa	2		7			1			1	4
Glenn		23	21			4	2		5	11
Placer			1	1						
Sacramento		1	1							
Shasta	1				1					
Solano	6	13			3	9	4	1	1	1
Sutter			5							2
Tehama	1	3				2	1			2
Yolo		5	3							3
Yuba			8							
Total	**10**	**51**	**54**	**2**	**4**	**17**	**8**	**3**	**8**	**24**

Notes:
ACET = 2-amino-4-chloro-6-ethylamino-s-triazine.
DACT = 2,4-diamino-6-chloro-s-triazine.
DEA = deethyl-atrazine.
Source: DPR Ground Water Protection Program. 2003 Well Inventory Database, Cumulative Report 1986-2003

SACRAMENTO RIVER BASIN—SUBBASINS

Antelope Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Antelope subbasin is bounded on the west by the Sacramento River, on the north by the Red Bluff Arch, on the northeast by the Cascade Range, and the southeast by Antelope Creek. The Antelope subbasin is contiguous with the Dye Creek Subbasin to the south. The subbasin is 18,710 acres (29 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Antelope subbasin is taken from DWR Bulletin 118 (DWR 2004). The aquifer system in this subbasin is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation and the Tuscan Formation. The Tuscan Formation is the primary water-producing zone in the basin.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama, Tuscan, and Riverbank Formations. Well logs for wells drilled on the floodplain east of Red Bluff indicate that coarse-grained clean sand and gravel extend to a depth of approximately 50 feet below the surface. Below this depth, cemented gravel, sandstone, and hard clay of the Tehama and Tuscan Formations are encountered. The Modesto Formation yields limited groundwater due to its limited thickness.

The Pleistocene Riverbank Formation is observed in the far northern extents of the subbasin. The Riverbank Formation yields limited groundwater due to its limited thickness and areal extents.

The Pliocene Tuscan Formation is composed of volcanic breccia, tuff, tuff breccia, volcanic sandstone and conglomerate, basalt flows, and tuffaceous silt and clay. The formation is mostly consolidated tuff in the area of exposure east of the valley in the Cascade Range foothills. From there tuff breccias grade westerly into volcanic sands, gravels, and clay (DWR 1978). The Tuscan Formation is the major water-bearing aquifer in the northeastern portion of the Sacramento Valley. Thickness of the formation within the subbasin is approximately 1,500 feet.

The Pliocene Tehama Formation interfingers with the Tuscan Formation along the Sacramento River and is exposed in Westside Sacramento River banks. The formation consists of fluvial deposits of predominantly silt and clay with gravel and sand interbeds. The formation is identified within the subbasin at depths ranging from 100 to 150 feet.

Long-term groundwater levels indicate a decline of 5–10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation of approximately 2–15 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater storage capacity was estimated to be 269,200 acre-feet. This estimate was based on an average specific yield of 7.2% and an assumed thickness of 200 feet.

Estimate of groundwater extraction for agricultural use is estimated to be 17,000 acre-feet. The Antelope aquifer system appears to be leaky, allowing water from shallow aquifers to percolate into deeper water (DWR 1987).

Major Sources of Recharge

Recharge to the subbasin is from precipitation (23–27 inches/year), irrigation infiltration, stream infiltration, and infiltration from on-site domestic waste disposal systems.

Stream infiltration comes from the Sacramento River, Salt Creek, and Antelope Creek. In an investigation conducted by Reclamation, the upper and intermediate aquifer zones (located between the local groundwater elevation and 150 feet in depth) were found to intercept the Sacramento River. Diurnal fluctuations in river stage produce diurnal water level fluctuations in the deeper aquifer zone.

A 1987 study of the Antelope Groundwater Subbasin by DWR stated that seepage from Lake Red Bluff raised groundwater levels 5–10 feet in the southern part of the subbasin since 1966, when then diversion dam gates were first closed.

Municipal and industrial use is approximately 2,100 acre-feet. Deep percolation of applied water is estimated to be 3,800 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 49% of the subbasin, urban land use accounts for about 10% of the subbasin, and native land accounts for about 41% of the subbasin. The primary crop types in the region are orchards and pasture. Table 4-6 provides details of the land uses within the subbasin.

Table 4-6. Land Use in the Antelope Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	20	0.10
Deciduous Fruits and Nuts	5,730	30.60
Field Crops	180	1.00
Grain and Hay	490	2.60
Pasture	1,730	9.30
Truck, Nursery, and Berry Crops	20	0.10
Idle	880	4.70
Semiagricultural and Incidental	150	0.80
Subtotal	9,200	49.20
Urban		
Urban—unclassified	100	0.50

Land Use	Acreage of Land Use	Percent of Land Use
Urban Landscape	60	0.30
Urban Residential	1,190	6.40
Commercial	190	1.00
Industrial	80	0.40
Vacant	300	1.60
Subtotal	1,920	10.30
Native		
Native Vegetation	6,000	32.10
Barren and Wasteland	120	0.60
Riparian	990	5.30
Water	470	2.50
Subtotal	7,580	40.50
Total	**18,700**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Antelope groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the Antelope subbasin are the Tehama County Flood Control and Conservation District and the City of Red Bluff. Tehama County adopted a groundwater ordinance in 1994 and a countywide Assembly Bill 3030 (AB 3030) groundwater management plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use, and influence of well pumping restrictions. The city of Red Bluff is located partly within the subbasin. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L. High concentrations of boron, chloride, and TDS are found in groundwater in the vicinity of Salt Creek and Little Salt Creek. Nitrate concentrations of 20–45 mg/L have been observed within the west-central portion of the basin (DWR 2004).

A 1987 study by DWR stated that the quality of the groundwater in the subbasin is generally good. At that time it had a median concentration of dissolved solids of 296 mg/L. The current (2005) national secondary drinking water standard for dissolved solids is 500 mg/L. The median alkalinity, or hardness[1], of the water was 134 mg/L as $CaCO_3$.

[1] Water hardness is primarily the amount of calcium and magnesium in the water. Water hardness is measured by adding up the concentrations of calcium, magnesium and converting this value to an equivalent concentration of calcium carbonate ($CaCO_3$).

According to Tehama County (2003), a recent groundwater quality issue is related to increased levels of fecal coliform and nitrates in the Antelope area, which is just east of the city of Red Bluff. Fifty-two percent of the wells tested for nitrates in 2002 showed concentrations greater than 22.5 mg/L, including 20% that had concentrations greater than 45 mg/L. Forty-eight percent of the wells tested for coliform in 2002 showed a presence of the organism. Because the majority of wells with detections of nitrates and coliform were located in a developed area (previously agricultural land) with septic systems, DWR concluded that the most likely sources are the individual septic systems.

Dissolved Solids

The 1987 study by DWR found the concentration of dissolved solids in 75 groundwater wells to range from 140 to 558 mg/L with a median concentration of 296 mg/L. Electrical conductivity[2] from 72 wells ranged from 205 to 980 µohms/cm at 25 degrees C, with a median of 450 µohms/cm. These median values are within the acceptable range for domestic and irrigation use.

Nitrate

High nitrate concentrations (20–45 mg/L) were found throughout the west-central (north and west of State Highway 36 between Kaer and Trinity Avenues) portion of the subbasin. Concentrations above 3 mg/L are indicative of human induced contamination. The most probable sources of nitrogen in the subbasin are domestic wastes from septic systems and fertilizers. Another factor that may contribute to the movement of nitrate downward into the aquifer is the poor quality surface seals on some wells in the area (DWR 1987).

Boron

High boron concentrations were found in groundwater underlying Salt Creek and Little Salt Creek. This groundwater also contained high chloride and dissolved solids and a high adjusted sodium adsorption ratio (ASAR)[3], which indicates salt build-up in the sediments. Water is this area may harm sensitive crops. The boron in the groundwater in naturally occurring and is derived from marine rocks like those in the recharge areas for Salt Creek and Little Salt Creek (DWR 1987).

Pesticides

Antelope Valley subbasin contains 49% agricultural land uses. The DPR tests groundwater wells for pesticides on a regular basis. In Tehama County, in which Antelope Valley subbasin is located, DPR verified the detection of 5 different pesticides in the groundwater: ACET, bentazon, DEA, diuron, and simizine. These pesticides were detected 1, 7, 2, 1, and 3 times respectively.

[2] Electrical conductivity (EC) is a measure of how well the water accommodates the transport of electric charge. EC estimates the amount of total dissolved salts, or the total amount of dissolved ions in the water.
[3] Adjusted sodium adsorption ratio (ASAR) is calculated from the ratio of soluble sodium to calcium and magnesium, adjusted for the precipitation or dissolution of Ca^{2+} in waters containing significant amounts of bicarbonate.

Bend Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Sacramento River serves as the subbasin boundary to the west and the Cascade Range to the east. The subbasin is bounded on the north by the hydrologic divide between the Redding and Sacramento groundwater basins along the north side of Paynes Creek. The anticlinal structure above the projected trace of the Red Bluff fault serves as the subbasin boundary to the south. The subbasin is about 21,760 acres (34 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Bend subbasin is taken from DWR Bulletin 118 (DWR 2004).

The Bend subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include stream channel deposits, Holocene alluvium, and Pleistocene deposits of Modesto and Riverbank Formations. The Tertiary deposits include the Tuscan Formation.

Holocene Alluvial deposits in the subbasin consist of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. The thickness ranges up to 50 feet. The deposits are highly permeable and yield limited domestic water supplies.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates in the eastern and northern parts of mapped unit. The formation is approximately 430 feet thick.

Unit C is the primary surficial deposit and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165 to 265 feet. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30 to 160 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (23–31 inches/year), infiltration of applied water, and stream infiltration.

Estimate of groundwater extraction for agricultural use is estimated to be 220 acre-feet. Municipal and industrial use is approximately 120 acre-feet. Deep percolation of applied water is estimated to be 340 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 3% of the subbasin, urban land use accounts for about 2% of the subbasin, and native land accounts for about 95% of the subbasin. The primary crop types in the region are pasture, orchards, and grains. Table 4-7 provides details of the land uses within the subbasin.

Table 4-7. Land Use in the Bend Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	50	0.20
Field Crops	20	0.10
Grain and Hay	150	0.70
Pasture	360	1.70
Truck, Nursery, and Berry Crops	20	0.10
Idle	40	0.20
Semiagricultural and Incidental	10	0.05
Subtotal	650	3.00
Urban		
Urban Landscape	10	0.05
Urban Residential	220	1.00
Commercial	10	0.05
Industrial	10	0.05
Vacant	80	0.40
Subtotal	330	1.50
Native		
Native Vegetation	20,200	93.00
Barren and Wasteland	50	0.20
Riparian	150	0.70
Water	340	1.60
Subtotal	20,740	95.50
Total	**21,720**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Bend groundwater subbasin is within the Shasta-Tehama Watershed. The public agency operating within the subbasin is the Tehama County Flood Control and Water Conservation District. Tehama County adopted a groundwater ordinance in 1994 and a countywide AB 3030 groundwater management plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use, and influence of well pumping restrictions. No urban areas are located within the sub-area. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the subbasin is characterized as magnesium-calcium bicarbonate. TDS ranges from 334 to 360 mg/L. Localized high calcium concentrations occur in the basin.

Discharge Pathways and Sources of Contaminants

Specific discharge pathways or sources of contaminants could not be identified.

Capay Valley Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Capay Valley subbasin is 25,000 acres (39 square miles) in size and located within the Coast Ranges in the western portion of Yolo County. It is defined by depositional sediments within the northwest-southeast trending Capay Valley. The subbasin extends from the Yolo County boundary on the north end to the confluence of Salt Creek and Cache Creek on the south end. Structurally, the Capay Valley is a broad, elongated synclinal depression between the Blue Hills of the Vaca Mountains and the Rumsey Hills in the Coast Range Geomorphic Province (DWR 1961).

The following description of the hydrogeology in the Antelope subbasin is taken from DWR Bulletin 118 (DWR 2004).

Primary water bearing deposits within the Capay Valley subbasin include recent stream channel deposits and the Tehama Formation, which is underlain by older non-freshwater bearing Cretaceous Marine Rocks (DWR 1978; Wagner and Bortugno 1982).

Recent stream channel deposits consist of unconsolidated silt, fine- to medium-grained sand, gravel and occasionally cobbles deposited in and adjacent to Cache Creek and its tributaries. These deposits are moderately to highly permeable and range in thickness from approximately 0 to 150 feet (DWR 1978).

The Tehama Formation consists of moderately compacted silt, clay, and silty fine sand enclosing lenses of sand and gravel, silt and gravel, and cemented conglomerate. This formation can be seen outcropping

along the edges of the Capay Valley, and in other places within the western Yolo, Colusa, and Solano Counties. The Tehama Formation within the Capay Valley is generally less than a few hundred feet thick, however is found in much greater thickness to the east in the Sacramento Valley. The permeability of the Tehama Formation is variable, but generally less than the overlying recent stream channel deposits units.

Cretaceous Marine Rocks make up the basement rock beneath the fresh water bearing deposits of the Capay Valley Subbasin. Consisting of consolidated sandstone and shale of marine origin, these basement rocks generally contain saline connate water and are not considered useable water bearing formations.

Recharge for the Capay Valley Subbasin comes primarily from Cache Creek. Additional recharge comes from surrounding minor tributaries, including Bear Creek. Bear Creek is the source of waters high in boron, and has an influence on water quality within Cache Creek and on groundwater extracted from Cache Creek deposits within the Capay and Sacramento Valleys (DWR 1961).

Groundwater levels within most of the Capay Valley Subbasin vary from approximately 10 to 40 feet below ground surface and remain relatively stable, even through dry years. Wells located in the higher elevations along the edge of the valley show a greater variability, and appear to be more impacted by dry years.

Groundwater storage for the Capay Valley region was calculated in DWR Bulletin 90 (1961) based on estimated specific yield values for three discrete intervals between the depths of 20 and 200 feet. It was estimated that the groundwater storage capacity of the Capay Valley is approximately 99,800 acre-feet. It can be assumed that the groundwater in storage for the Capay Valley is roughly equal to the groundwater storage capacity, since water levels tend to remain at relatively shallow depths.

Groundwater is pumped from the Capay Valley subbasin for domestic, municipal and irrigation purposes and discharges to Cache Creek in lower reaches of the Valley. Specific agricultural sources of groundwater contamination could not be identified.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, and stream infiltration. Stream infiltration comes from the Cache Creek and its tributaries. Bear Creek is a tributary that is high in boron that influences the water quality in the Capay Valley groundwater subbasin. Annual precipitation is about 25 inches at ridge tops.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 38% of the subbasin, urban land use accounts for about 1% of the subbasin, and native land accounts for about 61% of the subbasin. Table 4-8 provides details of the land uses within the subbasin.

Table 4-8. Land Use in the Capay Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	10	0.04

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	3,920	15.66
Field Crops	220	0.88
Grain and Hay	2,550	10.19
Idle	1,670	6.67
Pasture	570	2.28
Semiagricultural and Incidental	130	0.52
Truck, Nursery, and Berry Crops	480	1.92
Vineyards	0	0.00
Subtotal	9,550	38.00
Urban		
Urban—unclassified	20	0.08
Commercial	0	0.00
Industrial	10	0.04
Urban Landscape	0	0.00
Urban Residential	120	0.48
Vacant	10	0.04
Subtotal	160	1.00
Native		
Native Vegetation	15,000	59.93
Water	320	1.28
Subtotal	15,320	61.00
Total	25,030	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Yolo County Flood Control and Water Conservation District is the only water agency in the basin. The towns of Rumsey, Guinea and Brooks are located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater quality within the Capay Valley Subbasin is primarily the result of infiltration of Cache Creek and its tributaries and is generally of good quality. It is a calcium-sodium-bicarbonate type with moderate to very high hardness. Highly mineralized water from Bear Creek and North Fork Cache Creek is a primary source of mineral constituents, especially boron, in groundwater in the Capay Valley Subbasin (DWR 1961). TDS measured in water taken from 6 wells in the Capay Valley ranged from approximately 300 to 500 mg/L, and was comparable to that found in water samples taken from Cache Creek (EPA 2001; DWR 1961).

Colusa Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Colusa subbasin aquifer is bound by Stony Creek in the north, Cache Creek in the south, the Coast Ranges on the west, and the Sacramento River on the east. The aquifer system is 1,434 square miles in size and is located in parts of Colusa, Glenn, Yolo, and Tehama Counties.

The following description of the hydrogeology in the Colusa subbasin is taken from DWR Bulletin 118 (2004). The Colusa Subbasin aquifer system is composed of continental deposits of late Tertiary to Quaternary age. Quaternary deposits include Holocene stream channel and basin deposits and Pleistocene Modesto and Riverbank formations. The Tertiary deposits consist of the Pliocene Tehama Formation and the Tuscan Formation. All Formations consist of varying amounts of gravel, sand, silt, and clay. The Holocene Stream Channel deposits are the upper part of the unconfined zone and are moderately-to-highly permeable. The Holocene basin deposits are interbedded with the Stream Channel deposits, have low permeability, and yield low quality and quantity of water.

The Modesto deposits consist of moderately to highly permeable gravels, sands, and silts. Thickness of the formation ranges from less than 10 feet to nearly 200 feet across the valley floor. The Riverbank deposits are the older terrace deposits that consist of poorly to highly pervious pebble and small cobble gravels interlensed with reddish clay, sand, and silt. Thickness of the formation ranges from less than 1 foot to over 200 feet depending on location. The formation yields moderate quantities of water to domestic and shallow irrigation wells and provides water to deeper irrigation wells that have multiple zones of perforation. Generally, the thickness of the formation limits the water-bearing capabilities.

The Tehama Formation is the predominant water-bearing unit within the Colusa Subbasin and reaches a thickness of 2,000 feet. The formation occurs at depths ranging from a few feet to several hundred feet from the surface. The formation consists of moderately compacted silt, clay, and fine silty sand enclosing lenses of sand and gravel; silt and gravel; and cemented conglomerate. Occasional deep sands and thin gravels constitute a poorly to moderately productive, deep, water-bearing zone.

The Tuscan Formation occurs in the northern portion of the subbasin at an approximate depth of 400 feet from the surface and may extend to the west to the Greenwood Anticline east of Interstate Highway 5. The formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin. Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

Groundwater levels in the Colusa subbasin tend to fluctuate by 5 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels. DWR (2004) estimated the specific yield to be 7.1% and the storage capacity (to a depth of 200 feet) to be 13 million acre-feet (maf).

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and to a lesser extent precipitation are also sources of recharge. The Sacramento River, Stony Creek, Cache Creek, and the Glenn-Colusa Canal recharge the aquifer. Annual precipitation ranges from 17 to 27 inches with higher precipitation occurring to the west (DWR 2004). Twenty-four percent of the Colusa subbasin is used for rice cultivation where the fields are typically flooded for six months each year. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage.

Land Uses

The Colusa subbasin is primarily utilized for irrigated farming, rice farming being the most prevalent. The second most prevalent land use in the subbasin is native vegetation. Both Glenn and Colusa Counties contain a wildlife refuge. Land use surveys were conducted within the basin by DWR from 1997 to 1999. Agricultural land use accounts for about 69% of the basin, urban land use accounts for less than 3% of the basin, and native land accounts for about 29% of the basin. Table 4-9 provides details on the distribution of land use throughout the Colusa subbasin.

Table 4-9. Land Use in the Colusa Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	5,057	0.55
Deciduous Fruits and Nuts	79,827	8.69
Field Crops	90,527	9.86
Grain and Hay	82,831	9.02
Vineyards	6,936	0.76
Pasture	47,494	5.17
Rice	217,573	23.69
Semiagricultural and Incidental	6,432	0.70
Truck, Nursery, and Berry Crops	76,603	8.34
Idle	17,863	1.94
Subtotal	631,143	68.72
Urban		
Urban—unclassified	2,699	0.29
Commercial	822	0.09
Industrial	4,135	0.45
Urban Landscape	528	0.06
Urban Residential	4,437	0.48
Vacant	12,036	1.31
Subtotal	24,657	2.68
Native		
Riparian	37,096	4.04
Native Vegetation	206,826	22.52
Water	15,755	1.72

Land Use	Acreage of Land Use	Percent of Land Use
Barren and Wasteland	2,950	0.32
Subtotal	262,627	28.60
Total	**918,427**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Colusa subbasin aquifer system are: Knights Landing WUA, Orland Unit WUA. Cortina Creek FC&WCD, Colusa County FC&WCD, and Yolo County FC&WCD Artois CSD, Butte City CSD, Hamilton City CSD, NE Willows CSD, Ord CSD, City of Colusa, City of Orland, City of Williams, 4-M WD, Chrome WD, Colusa County WD, Cortina WD, Davis WD, Dunnigan WD, Glenn Valley WD, Glide WD, Holthouse WD, Kanawha WD, La Grande WD, Orland-Artois WD, Princeton WD, Westside WD, and Yolo-Zamora WD, Glenn-Colusa ID, Maxwell ID, Princeton-Cordora-Glenn ID, Provident ID, Maxwell ID, Reclamation Districts (RDs) 108, 478, 730, 787, 1004, 2047, Arbuckle PUD, Maxwell PUD (DWR 2004).

The private entities within the Colusa subbasin aquifer system are: California Water Service Co., Colusa Drain Mutual Water Co., California Water Service Co., Roberts Ditch & Irrigation Co. Inc, Willow Creek Mutual Water Co. (DWR 2004).

Tehama County adopted a groundwater management ordinance in 1994. Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. Yolo County adopted a groundwater management ordinance in 1996 (DWR 2004). These ordinances affect primarily the volume of groundwater that can be pumped and/or exported from the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalition.

Water Quality

Groundwater quality issues in the Colusa subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the Colusa subbasin. Tables 4-10 and 4-11 summarize the available data.

Table 4-10. Water Quality in the Colusa Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for Colusa Subbasin
Nutrients	Median NO_3 concentration under rice fields was 2mg/L (Domagalski et al. 2000). High concentrations of nitrates found in groundwater near the Colusa, Arbuckle, Knights Landing, and Willows. Localized areas throughout the subbasin have high ammonia, and phosphorus concentrations (DWR 2004). Nitrate, ammonia, phosphorus measured in shallow groundwater in rice growing areas (Dawson 2001a).
Pesticides (insecticides and herbicides) and degradation products	Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells.
Salt—primarily as electrical conductivity and total dissolved solids.	High EC, TDS, adjusted sodium absorption ratio (ASAR) in groundwater near the City of Colusa and Knight's Landing. Localized areas throughout the subbasin have high TDS. High TDS concentrations measured in shallow groundwater in rice growing areas (Dawson 2001a). In the western half of the Sacramento Valley south of Willows, groundwater contains TDS frequently in excess of 500 mg/L (DWR 1978).
Trace elements	High boron concentrations found near Knights Landing. Localized areas throughout the subbasin have high manganese, fluoride, and iron. Dawson (2001a) found concentrations of inorganic constituents that exceeded primary state and federal drinking water standards at least once in 25% of the wells. The inorganic constituents detected above the primary limits were boron, barium, cadmium, molybdenum, or sulfate. Secondary drinking water standards were exceeded at least once in 79% of the wells. The constituents detected above secondary limits were chloride, iron, manganese, specific conductance (EC), or dissolved solids. Mercury from mining—Cache Creek/Putah Creek
Organic carbon and disinfection byproduct precursors	Dissolved organic carbon elevated relative to expected background in some areas (Dawson 2001a).
Microorganisms	No available data

Notes:
EC = electrical conductivity.
mg/L = milligrams per liter
TDS = total dissolved solids.

Table 4-11. Concentrations of Constituents of Concern Detected in the Colusa Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard
Nutrients	Nitrate	Median 2mg/L (Domagalski et al. 2000)	Nitrate was reported to exceed the MCL in two public supply wells in the Colusa subbasin (Moran et al. 2004).
	Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Ammonia + organic N as N	0.3–0.7 mg/L	30 (HAL)
	Nitrate+Nitrite, as N	0.08–6.2 mg/L	10 (MCL)
	Nitrate as N	0.08–6.2 mg/L	10 (MCL)
	Nitrite as N	0.01–0.01 mg/L	1 (MCL)
	Orthophosphate, as P	0.01–0.36 mg/L	

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard
	Phosphorus, as P	0.03–0.362 mg/L	
	Dissolved organic carbon, as C	0.3–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	*0.002*–0.026 µg/L	3 (MCL)
	Bentazon	0.06–*7.8* µg/L	18 (MCL)
	Bromacil	0.19 µg/L (one detection)	90 (HAL)
	Carbofuran	0.016–0.8 µg/L	18 (MCL)
	Desethyl atrazine	0.001–0.005 µg/L	
	Dichlorprop	*0.1* µg/L (one detection)	
	Diuron	0.04–0.09 µg/L	10 (HAL)
	Azinphos-methyl	*0.014* µg/L (one detection)	
	Molinate	*0.002*–0.056 µg/L	20 (MCL)
	Simazine	*0.002*–0.027 µg/L	4 (MCL)
	Tebuthiuron	*0.006* µg/L (one detection)	500 (HAL)
	Thiobencarb	0.006–0.025 µg/L	70 (MCL)
Salt—primarily as electrical conductivity and total dissolved solids.		120–1,220 mg/L, mean 391 mg/L (DWR 2004) 168–8,730 mg/L, median 532 (Dawson 2001a)	
Trace elements	Aluminum	0.002–0.010 mg/L	1 (MCL)
	Arsenic	0.001–0.015 mg/L	
	Barium	0.01–5.05 mg/L	1(MCL)
	Boron	0.02–1.8 mg/L	0.6 (HAL)
	Bromide	0.03–12 mg/L	
	Cadmium	0.006–0.007 mg/L	0.005 (MCL)
	Chromium	0.002–0.016 mg/L	0.05 (MCL)
	Cobalt	0.001–0.004 mg/L	
	Copper	0.001–0.003 mg/L	1.3 (MCL)
	Ferrous Iron Fe2+	Detected in 19/28 wells	
	Fluoride	0.1–1.8 mg/L	4 (MCL)
	Iron Fe	0.003–5.3 mg/L	0.3 (SMCL)
	Manganese	0.1–0.05 mg/L	0.05 (SMCL)
	Molybdenum	0.001–0.051 mg/L	0.04 (HAL)
	Nickel	0.001–0.009 mg/L	0.1 (HAL)
	Selenium	0.003–0.022 mg/L	0.05 (MCL)
	Sulfide	Detected in 14/28 wells	
	Uranium	0.001–0.023 mg/L	2000 (MCL)
	Zinc	0.001–0.017 mg/L	2 (HAL)

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Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standard

Notes:

* Numbers in *italics* are estimates.

MCL = Maximum Contaminant Level set by EPA (2005).

µg/L = micrograms per liter.

mg/L = milligrams per liter.

SMCL = Secondary Maximum Contaminant Level set by EPA (2005).

HAL = Health Advisory Level set by EPA (2005).

Nutrients

Dawson (2001b) presented evidence for movement of nitrate to shallow groundwater in the southeastern Sacramento Valley. Specifically, she demonstrated a significant correlation of nitrate concentrations to depth within the aquifer in oxygenated wells—higher nitrate concentrations were associated with shallower goundwater indicating movement of nitrate from land surface associated with agricultural activities (overlying land uses). There are naturally occurring nitrates in some formations of the Sacramento Valley, however, nitrate concentrations that occurred at concentrations above background levels are introduced into the groundwater via human activates (The NAQWA program set a threshold of 3mg/L of nitrate to indicate concentrations that are a at a level that is influenced by human activities) such as agriculture and urbanized development.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The predominant geochemical facies of the groundwater in the Colusa subbasin are calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. Two processes appear to primarily affect groundwater salinity in the Colusa subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Rice pesticides Molinate, Thiobencarb and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. Bentazon was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Detected pesticide concentrations were below state and federal drinking water standards in all occurrences.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1998. Dawson (2001a) found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward. Concentrations of bentazon showed a statistical relationship to

tritium concentrations. Since tritium is used for age-dating groundwater, this relationship suggests that bentazon concentrations may be related to recharge age of the groundwater in which it was found. Tritium concentrations in all wells except one indicate that groundwater in the rice growing areas of the Colusa subbasin were recharged after 1950. Using trition dating and pesticide use information Dawson (2001a) estimated groundwater recharge date to be sometime in the late 1970s.

Irrigation practices can have an effect on the amount of pesticides that reach groundwater. Troiano et al. (1993) investigated different irrigation methods and found that "leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method. For basin-flooding treatments, as those practiced on rice fields, a large amount of water application was required for each irrigation in order to provide application across the plot. Although irrigations were less frequent, the larger water volume caused greater downward movement of water and atrazine residues."

Trace Elements

The chemistry of geology formations in the Colusa subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of potassium were significantly lower in the western alluvial fans, which contain the Colusa subbasin. Concentrations of boron, chloride, fluoride, molybdenum, sulfate, and zinc were significantly higher in the western alluvial fans. Concentrations of arsenic were significantly higher in the central flood basins, which are also part of the Colusa subbasin. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

There is some evidence that recent changes in management practices in rice may result in higher dissolved organic carbon concentrations in deep percolation water (Dawson 2001a). High dissolved organic carbon content was confirmed in 43% of the wells studied by Dawson (2001a). The median concentration of which was 2.7 mg/L, much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Corning Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Corning Subbasin is bounded on the west by the Coast Ranges, on the north by Thomes Creek, on the east by the Sacramento River, and on the south by Stony Creek. Stony Creek is believed to be a hydrologic boundary throughout the year. The Corning Subbasin is likely contiguous with the Red Bluff Subbasin at depth. The subbasin is 205,600 acres (321 square miles) in size and is located in parts of Tehama and Glenn Counties.

The following description of the hydrogeology in the Corning subbasin is taken from DWR Bulletin 118 (DWR 2004).

The Corning Subbasin aquifer system is comprised of deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and the Pleistocene terrace deposits of the Modesto and Riverbank Formations. The Tertiary deposits consist of the Pliocene Tehama and Tuscan Formations.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tehama Formation and Quaternary stream terrace deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama and the Riverbank Formations. The deposit ranges from less than 10 feet to nearly 200 feet across the valley floor. These terrace deposits are observed along Thomes Creek, Burch Creek, and Stony Creek.

The Pleistocene Riverbank Formation consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The formation ranges from less than one foot to over 200 feet thick depending on location. Surficial deposits are observed over the eastern third of the subbasin and along Burch Creek and its tributaries.

The Pliocene Tehama Formation consists of sediments originating from the coastal mountains and is the primary source of groundwater for the subbasin. The formation ranges in thickness up to 2,000 feet, increasing in thickness from west to east, dipping 4 degrees to the east. The majority of the formation consists of fine-grained sediments indicative of deposition under floodplain conditions. The majority of both coarse and fine-grained sediments are unconsolidated or moderately consolidated.

The Pliocene Tuscan Formation is located within the eastern third of the subbasin. The formation occurs at a depth of approximately 200 feet from the surface and is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are believed to extend as far west as the Corning Canal.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

Sub-Areas of the Corning Subbasin

Sacramento Valley Floodplain

Pleistocene and Holocene silt, sand, and gravel deposits in the vicinity of the City of Corning extend to depths of 50–185 feet. The Tehama Formation near the City of Corning consists of yellow clay, poorly consolidated sandstone, and conglomerate.

Dissected Uplands

The surface of the upland area within the central third of the subbasin between Thomes Creek and Stony Creek includes a coarse-grained gravelly conglomerate locally capping the Tehama Formation. Wells drilled in this area encounter up to 60 feet of coarse deposits before reaching fine-grained Tehama deposits. The deposits are believed to be formed as a response to a fixed base level by impeded or enclosed drainages and have been referred to as the Red Bluff Formation. The shallow gravel is not a significant contributor to groundwater storage due to its position above the saturated zone.

Thomes Creek Floodplain

Bounding the northern extents of the subbasin, the Thomes Creek floodplain includes Holocene alluvium underlain by deposits of both the Modesto and Riverbank Formations. The floodplain averages about 1 mile in width and extends from the Coast Ranges to the Sacramento River floodplain.

Stony Creek Floodplain

The southern part of the subbasin, including the Capay plain, is alluviated by older floodplain deposits and channel deposits of Stony Creek. This area includes a moderately well-defined, highly productive, shallow water-bearing zone reaching a thickness of 150 feet along Stony Creek and 110 feet along the Sacramento River. Domestic and shallow irrigation wells along the west side of the Capay plain and south of the Tehama County line provide moderate-to-high yields from confined groundwater in 10–50-foot thicknesses of highly pervious pebble and cobble gravels. In the northwest part of Capay plain, older alluvium of the Riverbank Formation extends from the surface to 150 feet. Wells in this zone have low-to-moderate yields. This zone is underlain by a highly productive confined gravel averaging 40 feet in thickness.

Groundwater level data show seasonal fluctuations of approximately 3–15 feet for unconfined wells (5 feet near the Sacramento River), up to 30 feet for semi-confined wells away from the river, 5–20 feet for composite wells, and 10–30 feet for confined wells. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels. During the 1976–1977 and 1987–1994 droughts, there was a decline in groundwater levels of 5–12 feet, followed by a recovery to pre-drought conditions of the early 1970s and 1980s.

Groundwater storage capacity was estimated to be 2,753,000 acre-feet. This estimate was based on an average specific yield of 6.7% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (19-25 inches/year), irrigation infiltration, and stream infiltration. The Tehama-Colusa Canal and Corning Canals intersect the basin. These canals, which are part of the Central Valley Project, serve to provide irrigation water to the member water user associations, including the Corning WD, which has jurisdiction in the Colusa Basin.

Estimate of groundwater extraction for agricultural use is estimated to be 152,000 acre-feet. Municipal and industrial use is approximately 6,600 acre-feet. Deep percolation of applied water is estimated to be 54,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 37% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 59% of the subbasin. The primary crop types in the region are eucalyptus, olives, orchards, and pasture (Tehama County 2003). Table 4-12 provides details of the land uses within the subbasin.

Table 4-12. Land Use in the Corning Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	19,000	9.20
Deciduous Fruits and Nuts	19,500	9.50
Field Crops	2,900	1.40
Grain and Hay	10,500	5.10
Pasture	18,100	8.80
Rice	1,170	0.60
Truck, Nursery, and Berry Crops	750	0.40
Idle	1,950	0.90
Semiagricultural and Incidental	1,910	0.90
Subtotal	75,780	36.90
Urban		
Urban Landscape	40	0.02
Urban Residential	5,720	2.80
Commercial	390	0.20
Industrial	730	0.40
Vacant	1,970	1.00
Subtotal	8,850	4.30
Native		
Native Vegetation	108,900	53.00
Barren and Wasteland	2,580	2.60
Riparian	4,200	2.00
Water	5,250	2.60
Subtotal	120,930	58.80
Total	205,560	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Corning groundwater subbasin is within parts of the Shasta-Tehama and Colusa Watersheds. The public agencies within the Corning subbasin are: Tehama County Flood Control and Water Conservation District, Orland Unit Water Users' Association, Capay Rancho WD, City of Corning, Corning WD, Kirkwood WD, Richfield WD, Tehama WD, O'Connell MWD. City of Orland, Glenn Colusa ID,

Thomes Creek WD. Tehama County adopted a groundwater management ordinance in 1994 and a countywide AB 3030 plan in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance are off-parcel groundwater use, and influence of well pumping restrictions. The city of Corning is located within the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. The subbasin has localized areas of calcium-bicarbonate waters near Stony Creek. TDS concentrations range from 130-to 490-mg/L, averaging 286 mg/L. The Corning Subbasin has locally high calcium. Groundwater quality problems in the Corning Subbasin due to irrigated agriculture could not be identified.

Two groundwater supply wells have been shut down and are being monitored by the City of Corning because of methyl tertiary butyl ether (MTBE) and perchloroethylene (PCE) concerns. Monitoring for water quality also occurs twice weekly at seven locations for bacterial and fecal coliform.

Dye Creek Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dye Creek Subbasin is bounded on the southwest by the Sacramento River, on the northwest by Antelope Creek, on the east by the Chico Monocline, and on the south by Mill Creek. The subbasin is contiguous with the Antelope and Los Molinos subbasins at depth. The subbasin is 27,700 acres (43 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Holocene basin deposits and Pleistocene deposits of the Modesto and Riverbank Formations and Pleistocene fanglomerate. The Tertiary deposits include Pliocene Tehama and Tuscan formations.

Holocene basin deposits are exposed east of Highway 99, north and south of Dairyville, within the central portion of the subbasin. Basin deposits are the result of sediment-laden floodwaters rising above the natural levees of streams and rivers and spreading across low-lying areas. Thickness of the deposits has not been determined. The deposits generally have low permeability and yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation is observed along the western extents of the subbasin. The formation consists of undifferentiated terrace deposits of unconsolidated weathered and un-weathered gravel, sand, silt, and clay. Thickness of the unit can range from 0 to 150 feet.

The Pleistocene Riverbank Formation is exposed east of the Sacramento River north of Mill Creek. The formation is not a significant water-bearing formation due to its limited depth and areal extents.

Pleistocene Fanglomerate is observed along the eastern foothills and within the southern third of the subbasin. The formation is an alluvial fan deposit derived from erosion and deposition of volcanic mudflows of the Tuscan Formation and consists of polylithic volcanic clasts set in weathered tuffaceous matix. The fan deposits are poorly sorted and somewhat indurated to well cemented. Thickness of the fan deposits is up to 150 feet. The fanglomerate is not sufficiently thick to produce large quantities of groundwater.

The Pliocene Tuscan Formation is composed of a series of volcanic breccia, tuff, tuff breccia, volcanic sandstone and conglomerate, basalt flows, and tuffaceous silt and clay layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west to the Sacramento River. Surface exposures of Unit D appear along the east side of the subbasin and east of the subbasin boundary. The subsurface extent of Unit D is unknown.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. The Tuscan Formation reaches a thickness of 1,500 feet over older sedimentary deposits. The slope of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10 to 20 degrees southwestward towards the valley at the Chico Monocline (Olmsted and Davis 1961). The formation flattens beneath valley sediments.

The Pliocene Tehama Formation consists of fluvial deposits of predominantly silt and clay with gravel and sand interbeds and occurs in the subsurface along the western boundary of the subbasin.

Long-term comparison of groundwater levels indicate a decline of 2 to 5 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation ranging from 2 to 10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (17 inches/year), irrigation infiltration, stream infiltration, and subsurface flow. The main water source for irrigation is a mix of groundwater and surface water (Tehama County 2003). The Chico Monocline serves as a geographical boundary with some areas of recharge located east of the boundary.

Estimate of groundwater extraction for agricultural use is estimated to be 9,300 acre-feet. Municipal and industrial use is approximately 680 acre-feet. Deep percolation of applied water is estimated to be 3,200 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 23% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 74% of the subbasin. The primary crop types in the region are orchards and pasture (Tehama County 2003). Table 4-13 provides details of the land uses within the subbasin.

Table 4-13. Land Use in the Dye Creek Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	2,400	8.70
Field Crops	30	0.10
Grain and Hay	10	0.04
Pasture	3,160	11.40
Idle	530	1.90
Semiagricultural and Incidental	240	0.90
Subtotal	6,370	23.00
Urban		
Urban Landscape	20	0.04
Urban Residential	580	2.10
Commercial	10	0.04
Industrial	120	0.40
Vacant	180	0.70
Subtotal	910	3.30
Native		
Native Vegetation	18,900	68.30
Barren and Wasteland	80	0.30
Riparian	1,060	3.80
Water	360	1.30
Subtotal	20,400	73.70
Total	**27,680**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Dye Creek groundwater subbasin is within the Shasta-Tehama Watershed. The only public agencies within the subbasin are the Tehama County Flood Control and Water Conservation District. Tehama County adopted an AB 3030 groundwater management plan in 1996. There are no major urban areas within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the Dye Creek subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L. The DPR verified detections of five pesticides in Tehama County between 1985 and 2003. There were 14 detections total: 1 detection of ACET, 7 detections of atrazine, 2 detections of DEA, 1 detection of diuron, and 3 detections of simizine.

East Butte Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The East Butte Subbasin is bounded on the west and northwest by Butte Creek, on the northeast by the Cascade Ranges, on the southeast by the Feather River and the south by the Sutter Buttes. The subbasin is 265,400 acres (415 square miles) in size and is located in parts of Butte and Sutter Counties.

The following description of the hydrogeology in the East Butte subbasin is taken from DWR Bulletin 118 (DWR 2004).

The East Butte aquifer system is comprised of deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene stream channel deposits and basin deposits, Pleistocene deposits of the Modesto and Riverbank Formations, and Sutter Buttes Alluvium. The Tertiary deposits include the Tuscan and Laguna Formations.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. These deposits represent the upper part of the unconfined zone of the aquifer and are moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Holocene Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits. These deposits result from deposition from erosion from portions of the Cascade Ranges to the Sutter Buttes. Thicknesses of the deposits range to 150 feet (DWR 2000). These deposits have low permeability and generally yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation in this subbasin consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan Formation, Laguna Formation, and the Riverbank Formation. Surface exposure of the formation is west of the Feather River extending from south of the Thermalito Afterbay to the southern subbasin boundary. The formation may extend across the entire subbasin, underlying basin deposits, with thicknesses ranging from 50 to 150 feet.

The Pleistocene Riverbank Formation is older terrace deposits that consist of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. Surface exposure of the Riverbank Formation is primarily south and west of the Thermalito Afterbay. The formation may extend

across the entire subbasin, underlying basin and Modesto deposits, with thicknesses ranging from 50 to 200 feet.

In the southern portion of the subbasin, alluvium of the Sutter Buttes is observed in the subsurface and may range in thickness up to 600 feet. The fan deposits forming the apron around the buttes consist largely of gravel, sand, silt, and clay and may extend up to 15 miles north of the Sutter Buttes and westerly beyond the Sacramento River. Utility pump test records show the average well yield for that formation to be approximately 2,300 gallons per minute (gpm) with an average specific capacity of 64.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. Thickness of the formation is estimated to be 800 feet. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subsurface in the northern part of the subbasin and Units A and B are found in the southern part of the subbasin. Surface exposures of Units B and C are located in the foothills at the far eastern extents of the subbasin.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B.

The Pliocene Laguna Formation consists of interbedded alluvial sand, gravel, and silt deposits that are moderately consolidated and poorly-to-well cemented. The Laguna Formation is compacted and generally has a low-to-moderate permeability, except in scattered gravels in the upper portion. The formation yields moderate quantities of water to wells along the eastern margin of the valley. Wells of higher capacity generally tap underlying Tuscan deposits.

Surface exposures of the Laguna appear along the eastern margin of the subbasin in the vicinity of the Thermalito Afterbay and extend westerly in the subsurface. The lateral extent of the formation is unknown. The thickness of the formation is difficult to determine because the base of the unit is rarely exposed. Estimates of maximum thickness range from 180 to 1,000 feet. Geologic cross sections developed by DWR estimate the thickness to be approximately 500 feet. Wells completed in the formation yield only moderate quantities of water.

Wide seasonal fluctuations in groundwater levels exist in the northern part of the subbasin. Composite well fluctuations average about 15 feet during normal years and 30–40 feet during drought years. Annual groundwater fluctuations in the confined and semi-confined aquifer system range from 15 to 30 feet during normal years. In the part of the subbasin located within the southern part of Butte County, groundwater level fluctuations for composite wells average about 4 feet during normal years and up to 10 feet during drought years. The groundwater fluctuations for wells constructed in the confined and semiconfined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Groundwater flows primarily to the southwest towards the West Butte subbasin and the Sacramento River.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18–27 inches/year), subsurface flow, irrigation infiltration, and stream infiltration. The northeast boundary along the Cascade Ranges is primarily a geographic boundary with some groundwater recharge occurring beyond that boundary. Localized fluctuations in groundwater levels observed just south of the Thermalito Afterbay are due to the recharging of groundwater from this surface water system.

Estimates of groundwater extraction for agricultural; municipal and industrial; and environmental wetland uses are 104,000, 75,500, and 1,300 acre-feet respectively. Deep percolation of applied water is estimated to be 126,000 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1995 (Yuba County and 1999 (Butte County). Agricultural land use accounts for about 62% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 35% of the subbasin. Table 4-14 provides details of the land uses within the subbasin.

Table 4-14. Land Use in the East Butte Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	2,470	0.90
Deciduous Fruits and Nuts	35,400	13.30
Field Crops	3,130	1.20
Grain and Hay	1,660	0.60
Pasture	6,810	2.60
Rice	110,000	41.40
Truck, Nursery, and Berry Crops	480	0.20
Vineyards	97	0.04
Idle	3,000	1.10
Semiagricultural and Incidental	1,480	0.60
Subtotal	164,500	61.90
Urban		
Urban—unclassified	4,260	1.60
Urban Landscape	560	0.20
Urban Residential	1,690	0.60
Industrial	1,290	0.50
Vacant	1,400	0.50
Subtotal	9,520	3.60
Native		
Native Vegetation	59,500	22.40
Barren and Wasteland	3,130	1.20
Riparian	22,900	8.60
Water	6,350	2.40

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	91,880	34.60
Total	**265,900**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The East Butte groundwater subbasin is within the Butte-Sutter-Yuba Watershed. The public agencies within the East Butte subbasin are: Butte Basin Water Users Association, Biggs-West Gridley WD, Butte WD, Durham ID, City of Biggs, City of Gridley, Oroville-Wyandotte ID, Richvale ID, Thermalito ID, and Western Canal WD. The North Burbank Public Utility District is a private water agency in the East Butte subbasin. Butte County adopted a groundwater management ordinance in 1996. The Butte County ordinance requires export permits for groundwater extraction and substitute pumping, establishes the Water Commission and Technical Advisory Committee, and provides countywide groundwater monitoring programs. The city of Oroville is the largest urban area within the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate waters are the predominant groundwater water types in the subbasin. Magnesium bicarbonate waters occur locally near Biggs-Gridley, south and east to the Feather River. TDS ranges from 122 to 570 mg/L, averaging 235 mg/L. Localized high concentrations of manganese, iron, magnesium, TDS, conductivity, ASAR, and calcium occur within the subbasin. There is evidence of groundwater pesticide contamination in Butte County (DPR 2003); triazine herbicides and degradation productions, diuron, bromocil, norflurazon, and bentazon were detected in wells in Butte County. Data for the locations of detections could not be obtained.

Los Molinos Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Los Molinos Subbasin is bounded on the west by the Sacramento River, on the north by Mill Creek, on the east by the Chico Monocline, and on the south by Deer Creek. Mill Creek and Deer Creek serve as hydrologic boundaries in the near surface. The subbasin is hydrologically contiguous with Dye Creek and Vina subbasins at depth. The subbasin is 33,200 acres (52 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Los Molinos subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system of the subbasin is comprised of continental deposits of late Quaternary to Tertiary age. The Quaternary deposits include Holocene stream channel deposits, Pleistocene Modesto Formation terrace deposits located along most stream and river channels, and Pleistocene fanglomerate deposits from the Cascade Range. The Tertiary deposits include the Tuscan Formation.

The western edge of the subbasin is bounded by Holocene stream channel deposits of the Sacramento River. These deposits consist of moderately to highly permeable unconsolidated gravel, sand, silt and clay derived from the erosion, reworking, and deposition of the adjacent Tuscan and Tehama Formations. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Pleistocene Modesto Formation deposits extend from Mill Creek to Deer Creek on the west side of the subbasin and along the courses of Mill Creek, Deer Creek, and Thomes Creek. The formation consists of undifferentiated terrace deposits of unconsolidated weathered and un-weathered gravel, sand, silt, and clay. Thickness of the unit can range from 0 to 150 feet.

Along with the Modesto Formation, the Pleistocene Fanglomerate is a primary surficial deposit in the subbasin. The formation is an alluvial fan deposit derived from erosion and deposition of volcanic material from mudflows of the Tuscan Formation and consists of polylithic volcanic clasts set in a weathered tuffaceous matix. The fan deposits are poorly sorted and somewhat indurated to well cemented. The fanglomerate is being dissected by Mill Creek and Deer Creek. Thickness of the deposit is up to 150 feet. The fanglomerate is not sufficiently thick to produce large quantities of groundwater.

The Pliocene Tuscan Formation is the primary source of groundwater in the subbasin. The formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west of the Sacramento River.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick confining layers for groundwater contained in the more permeable sediments of Unit B.

The Tuscan Formation reaches a thickness of 1,500 feet over older sedimentary deposits. The dip of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10–20 degrees southwestward towards the valley at the Chico Monocline. The formation flattens beneath valley sediments.

Long-term comparison of groundwater levels indicates a slight decline associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show an average seasonal fluctuation of approximate 2 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

Groundwater storage capacity was estimated to be 397,700 acre-feet. This estimate was based on an average specific yield of 6.0% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18 inches/year), irrigation infiltration, stream infiltration, and subsurface flow. The major source for irrigation water is a mix of groundwater and surface water (Tehama County 2003). The Chico Monocline serves as a geographical boundary with some areas of recharge located east of the boundary.

Estimate of groundwater extraction for agricultural use is estimated to be 5,900 acre-feet. Municipal and industrial use is approximately 1,000 acre-feet. Deep percolation of applied water is estimated to be 3,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 62% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 35% of the subbasin. The primary crop types are orchards and pasture (Tehama County 2003). Table 4-15 provides details of the land uses within the subbasin.

Table 4-15. Land Use in the Los Molinos Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3,380	10.20
Field Crops	110	0.30
Grain and Hay	190	0.60
Pasture	2,180	6.60
Idle	180	0.50
Semiagricultural and Incidental	110	0.30
Subtotal	6,150	18.50
Urban		
Urban Landscape	40	0.10
Urban Residential	510	1.50
Commercial	60	0.20
Industrial	140	0.40
Vacant	140	0.40
Subtotal	890	2.70
Native		
Native Vegetation	23,400	70.50
Barren and Wasteland	460	1.40
Riparian	1,700	5.10
Water	600	1.80
Subtotal	26,160	78.80
Total	**33,200**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Los Molinos groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the subbasin are: Tehama County Flood Control and Water Conservation District, Stanford Vina Ranch ID, Los Molinos Mutual Water Co., Los Molinos Water Works. Tehama County Flood Control and Water Conservation District adopted an AB 3030 groundwater management plan in 1996. There are no major urban areas within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater in the Los Molinos subbasin is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate. TDS ranges from 119 to 558 mg/L, averaging 280 mg/L.

Los Molinos Community Service District (CSD) provides water to the town of Los Molinos. The primary water supply well (650 feet deep, open from 550 to 650 feet) produces water with about 10 parts per million (ppm) of arsenic (County of Tehama 2003). The current U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) for arsenic is 50 mg/L; however, lower MCL for arsenic (0.005 mg/L or 0.010 mg/L) have been proposed (Dawson 2001a, EPA 2005).

North American Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North American groundwater subbasin is bounded by the Sierra Nevada foothills on the east, the Feather and Sacramento Rivers on the west, the Sacramento and American Rivers on the south, and the Bear River on the north. The subbasin is about 548 square miles in size and is located in parts of Sutter, Placer, and Sacramento Counties.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The eastern boundary represents the approximate edge of the alluvial basin, where little or no groundwater flows into or out of the groundwater basin from the rock of the Sierra Nevada. The eastern portion of the study area is characterized by low rolling dissected uplands. The western portion is nearly a flat flood basin for the Bear, Feather, Sacramento, and American rivers, and several small east side tributaries.

The water-bearing materials of the North American subbasin are dominated by unconsolidated continental deposits of Late Tertiary and Quaternary age. Deposits include Miocene/Pliocene volcanics, older alluvium, and younger alluvium. The alluvium can be characterized as comprising the upper aquifer system, occupying the upper 200–300 feet below ground surface. The Mehrten and older geologic units

can be characterized as comprising the lower aquifer system, occurring generally deeper than 300 feet towards the west side of the subbasin. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,000 feet along the western margin of the subbasin. Most of the groundwater is produced in the northern portion of the subbasin. The aquifer zones in the upper 200–300 feet of this portion of the subbasin appear to be unconfined and behave similarly to stresses imposed on them. Conversely, deeper zones show a delayed response to stresses in the upper zone, indicating possibly limited interconnection with the shallower zones.

The younger alluvium deposits include flood basin deposits and recent stream channel deposits. The flood basin deposits occur along the western margin of the subbasin adjacent to the Sacramento River. The flood basin deposits consist primarily of silts and clays, although they may be locally interbedded with stream channel deposits of the Sacramento River. Thickness of the unit ranges from 0 to 100 feet. These fine-grained flood basin deposits have low permeability and generally yield low quantities of water to wells. Brackish water is often encountered in these deposits. The stream channel deposits include sediments deposited in the channels of active streams as well as overbank deposits of those streams, terraces, and local dredge tailings. These deposits occur predominantly along the Sacramento and American Rivers and their major tributaries, and consist primarily of unconsolidated silt, fine- to medium-grained sand, and gravel. Thickness of the unit ranges from 0 to about 100 feet. Sand and gravel zones in the younger alluvium are highly permeable and yield significant quantities of water to wells.

The older alluvium deposits consist of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. A number of formational names have been assigned to the older alluvium, including the Modesto, Riverbank, Turlock Lake, Victor, Laguna and Fair Oaks Formations, and the Arroyo Seco and South Fork Gravels. The older alluvial units are widely exposed between the Sierra Nevada foothills and overlying younger alluvial units near the axis of the Sacramento Valley. Thickness of the older alluvium ranges between 100 and 650 feet. It is moderately permeable.

The Miocene/Pliocene volcanic deposits consist of the Mehrten Formation, a sequence of fragmented volcanic rocks. The Mehrten Formation is exposed along the eastern margin of the subbasin between the towns of Lincoln and Folsom. It is composed of intervals of “black sands,” stream gravels, silt, and clay interbedded with intervals of dense tuff breccia. The sand and gravel intervals are highly permeable and wells completed in them have reported yields of over 1,000 gpm. The tuff breccia intervals act as confining layers. Thickness of the unit is between 200 and 1,200 feet.

Groundwater levels in southwestern Placer County and northern Sacramento County have generally decreased for the last 40 years or more. Groundwater levels in Sutter and northern Placer Counties generally have remained stable, although some wells in southern Sutter County have experienced declines.

DWR (2004) used and estimated specific yield of 7% and depth of 200 feet to calculate a storage capacity of 4.9 maf.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (18–20 inches/yr in the west, 20–24 inches/yr in the east), irrigation infiltration, and stream infiltration. Groundwater discharge likely occurs as evapotranspiration, subsurface flow, stream discharge, and pumpage. DWR estimated the groundwater budget components for a 1990 level of development. Estimated inflows include natural recharge at 83,800 acre-feet and

applied water recharge at 29,800 acre-feet. Estimated outflows include urban pumpage at 109,900 acre-feet and agricultural pumpage at 289,100 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1994 (Placer County), 1998 (Sutter County), and 2000 (Sacramento County). Agricultural land use accounts for about 42% of the subbasin, urban land use accounts for about 29% of the subbasin, and native land accounts for about 29% of the subbasin. Table 4-16 provides details of the land uses within the subbasin.

Table 4-16. Land Use in the North American Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	200	0.10
Deciduous Fruits and Nuts	9,680	2.80
Field Crops	12,400	3.60
Grain and Hay	15,200	4.50
Pasture	15,300	4.50
Rice	74,100	21.80
Truck, Nursery, and Berry Crops	1,230	0.40
Vineyards	50	0.01
Idle	11,900	3.50
Semiagricultural and Incidental	2,070	0.60
Subtotal	142,130	41.80
Urban		
Urban—unclassified	76,300	22.40
Urban Landscape	3,710	0.20
Urban Residential	5,210	1.50
Industrial	3,810	1.10
Commercial	660	0.20
Vacant	10,800	3.20
Subtotal	100,490	28.70
Native		
Native Vegetation	90,200	26.50
Barren and Wasteland	290	0.10
Riparian	4,360	1.30
Water	2,860	0.80
Subtotal	97,710	29.50
Total	**340,330**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North American groundwater subbasin is within the Placer North Sacramento Watershed.

The public agencies within the North American subbasin are: South Sutter WD, Camp Far West ID, Rio Linda/Elverta CWD, Citrus Heights WD, San Juan Suburban WD, Fair Oaks WD, Carmichael WD, Sacramento Suburban WD, Western Placer ID, Placer County WA, Del Paso Manor WD, City of Sacramento WSA, City of Roseville, Sacramento County Water Agency (DWR 2004).

The public agencies within the North American subbasin are Pleasant Grove—Verona MWC, Natomas Central MWC, California-American WC, Orangevale WC, Southern California WC.

The Sacramento Groundwater Authority (SGA) is a joint powers authority formed to manage the North Area Groundwater Basin, which is in the southern part of the North American subbasin. The Regional Water Authority (RWA) is a joint powers authority that serves and represents the interests of 21 water providers in the greater Sacramento, Placer, and El Dorado County region.

The Sacramento Groundwater Authority adopted a groundwater management plan on December 11, 2003. South Sutter WD adopted an AB 3030 plan in 1995. Placer County Water Agency adopted an AB 3030 plan in 1998. City of Lincoln adopted a groundwater management plan on November 12, 2003.

The Sacramento Metropolitan urban is partly located within the subbasin including the cities of Sacramento, Roseville, Citrus Heights, and Lincoln.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Many areas of good quality groundwater exist in the North American subbasin. However, in some parts of the basin groundwater quality is marginal. The three major groundwater types are: magnesium calcium bicarbonate or calcium magnesium bicarbonate; magnesium sodium bicarbonate or sodium magnesium bicarbonate; and sodium calcium bicarbonate or calcium sodium bicarbonate.

Comparison of groundwater quality data with applicable water quality standards and guidelines for drinking and irrigation indicate elevated levels of TDS, chloride, sodium, bicarbonate, boron, fluoride, nitrate, iron, manganese, and arsenic may be of concern in some locations within the subbasin.

High TDS levels exist in an area along the Sacramento River extending from Sacramento International Airport northward to the Bear River. The highest levels of TDS are found in an area extending just south of Nicholas to Verona, between RD 1001 and the Sutter Bypass. Some wells in this area have reported TDS exceeding 1,000 mg/L.

This same area along the Sacramento River extending from Sacramento International Airport northward to the Bear River also contains high levels of chloride, sodium, bicarbonate, manganese, and arsenic. The groundwater in the southern part of the basin is generally characterized as good quality, low in disinfection by-product precursor materials and moderate in mineral content, although some localized contamination issues do exist.

Nutrients

Dawson (2001b) presented evidence for movement of nitrate to shallow groundwater in the southeastern Sacramento Valley. Specifically, she demonstrated a significant correlation of nitrate concentrations to depth within the aquifer in oxygenated wells—higher nitrate concentrations were associated with shallower goundwater indicating movement of nitrate from land surface associated with agricultural activities (overlying land uses). There are naturally occurring nitrates in some formations of the Sacramento Valley, however, nitrate concentrations that occurred at concentrations above background levels are introduced into the groundwater via human activates (The NAQWA program set a threshold of 3mg/L of nitrate to indicate concentrations that are a at a level that is influenced by human activities) such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the North American subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L. The median concentration for nitrate in this study was 1.4 mg/L, which is higher than the national median (1.0 mg/L) for drinking water aquifers.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The groundwater in the North American subbasin was classified as multiple geochemical facies: magnesium calcium bicarbonate or calcium magnesium bicarbonate; magnesium sodium bicarbonate or sodium magnesium bicarbonate; and sodium calcium bicarbonate or calcium sodium bicarbonate.

Two processes appear to primarily affect groundwater salinity in the North American subbasin. The first is evaporation of irrigation water and shallow groundwater. The second is mixing of naturally occurring groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Pesticides were detected in four wells that affect the North American subbasin (Dawson 2001b). Three wells are located in the subbasin and one well is located in the South American subbasin but contamination is known to be moving across the American river to the North American subbasin. All concentrations were below the drinking water limits.

The most common pesticides detected in Dawson's (2001b) 1996 study of the Southeastern Sacramento Valley were bentazon, simazine, atrazine, bromacil, and tebuthiuron were detected. The major uses for atrazine, bromacil, and tebuthiuron are for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Trace Elements

The chemistry of geology formations in the North American subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and

zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the North American subbasin. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain. However she also presented evidence (Dawson 2001b) that, within the Southeastern Sacramento Valley, the concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. She found that as the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

Twenty-two percent of the North American subbasin is utilized as rice fields. Since 1983 rice farmers have been required to hold or recirculate irrigation water for up to 30 days after pesticide application to allow for the pesticides to degrade or volatilize out of the water (Dawson 2001a). There is evidence that this changes in management practice in rice cultivation may result in higher dissolved organic carbon concentrations in water that reaches the groundwater via deep percolation or irrigation water (Dawson 2001a). High dissolved organic carbon content was confirmed in 43% of the wells in rice growing areas studied by Dawson (2001a). The median concentration of which was 2.7 mg/L, much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in four of the ten wells in the North American subbasin in the 1996 study of the Southeastern Sacramento Valley by Dawson (2001b). The VOCs found in the wells are consistent with the land use surrounding each well. Those detected in agricultural areas were VOCs found in pesticides or gasoline while those detected in urban areas were VOCs associated with landscape maintenance, pet control, right-of-way weed control, gasoline, industrial chemicals and chlorinated drinking water.

North Yuba Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North Yuba subbasin is bounded on the north by Honcut Creek, the Feather River on the west, on the south by the Yuba River, and on the east by the Sierra Nevada. The subbasin is about 55,900 acres (87 square miles) and is located entirely within Yuba County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The North Yuba subbasin aquifer system is comprised of continental deposits of Quaternary to Late Tertiary (Pliocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 1,000 feet along the western margin of the basin.

Dredger tailing deposits occur along the Feather River in the northwest and the Yuba River in the southeast of subbasin. The coarse gravels and cobbles can be up to 125 feet thick and are highly permeable. Stream channel and floodplain materials occur as coarse sand and gravels along present stream channels of the Yuba River, Feather River, and Honcut Creek. Coarser grained materials occur near streams with thicknesses up to 110 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene Victor Formation lies unconformably above the Laguna Formation. The majority of the formation occurs as alluvium throughout the subbasin, but floodplain deposits are present along stream channels above the alluvium.

Pleistocene Floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits, and ranges in thickness from 5 to 15 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

Pleistocene Alluvium occurs over more than 50% of the basin surface and at least 60% of its irrigated agricultural lands. Its thickness is highly variable due to its lower contact with the Laguna Formation. The Older Alluvium is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation is the most extensive water-bearing unit within the subbasin. The formation is comprised of reddish to yellowish or brown silt to sandy silt with abundant clay and minor lenticular gravel beds. It overlies the Mehrten Formation and occurs at the surface intermittently at the east end of the basin. The continental deposits of the Laguna Formation dip to the west beneath the Victor Formation and range in thickness from 400 feet near the Yuba River up to 1,000 feet in the southwest portion of the county. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This, coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. Most of the groundwater produced from wells in the Laguna comes from overlying units.

The Miocene-Pliocene Mehrten Formation is a sequence of volcanic rocks of late Miocene through middle Pliocene age. Surficial exposures are limited to a few square miles in the northeast corner of the basin and thickness varies from 200 feet near the eastern margin of the basin to 500 feet near the Feather River. The Mehrten Formation is composed of two distinct units. One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals.

From 1950 through 1990, average basin groundwater levels remained relatively constant. Based on an analysis of hydrographs the Yuba River and Feather Rivers create a groundwater divide, which act as flow barriers in the shallow subsurface.

Groundwater storage capacity was estimated to be 620,000 acre-feet. This estimate was based on an area of 49,800 acres, an average specific yield of 6.9%, and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (20 inches/year in the southeast to 32 inches/yr in the northeast), irrigation infiltration, and stream infiltration. Stream channel and floodplain deposits present along the Yuba River, Feather River, and Honcut Creek are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Forty percent of the North Yuba subbasin is used for rice cultivation where the fields are typically flooded for 6 months each year, resulting in percolation of partially evaporated irrigation water.

Previous DWR unpublished studies have estimated natural and applied recharge. DWR has also estimated urban and agriculture extractions and subsurface outflow. Inflows include natural recharge of 51,100 acre-feet and applied recharge of 13,900 acre-feet. Groundwater discharge occurs as evapotranspiration, and pumpage. Outflows include urban extraction of 9,000 acre-feet, agricultural extraction of 65,800 acre-feet, and subsurface outflow of 21,800 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 75% of the subbasin, urban land use accounts for about 5% of the subbasin, and native land accounts for about 20% of the subbasin. Table 4-17 provides details of the land uses within the subbasin.

Table 4-17. Land Use in the North Yuba Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	390	0.70
Deciduous Fruits and Nuts	15,100	27.20
Field Crops	230	0.40
Grain and Hay	150	0.30
Pasture	1,760	3.20
Rice	22,000	39.60
Truck, Nursery, and Berry Crops	16	0.03
Idle	1,340	2.40
Semiagricultural and Incidental	410	0.70
Subtotal	41,400	74.50
Urban		
Urban—unclassified	1,900	3.40
Urban Landscape	88	0.20
Urban Residential	480	0.90
Industrial	120	0.20
Vacant	420	0.80
Subtotal	3,000	5.40

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	7,010	12.60
Barren and Wasteland	1,020	1.80
Riparian	2,150	3.90
Water	1,010	1.80
Subtotal	11,200	20.10
Total	**55,600**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North Yuba groundwater subbasin is within the Butte-Sutter-Yuba Watershed.

The public agencies within the North Yuba subbasin are: Yuba County Water Agency, Ramirez Water District, Cordua Irrigation District.

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. The Cordua Irrigation District and the Yuba County Water Agency have AB 3030 groundwater management plans.

The city of Marysville is located within the subbasin Yuba City is located at the southwestern boundary of the subbasin.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

The generally good water quality characteristics are apparent in the overall salinity of groundwater in the subbasin. In general, TDS concentrations in the subbasin are below 500 mg/L throughout the entire basin. DWR maintains data for 35 water quality wells in the North Yuba Subbasin. Data collected from these wells indicate a TDS range of 149 to 655 mg/L and a median of 277 mg/L. The primary water chemistry in the area indicates calcium magnesium bicarbonate or magnesium calcium bicarbonate groundwater. Some magnesium bicarbonate can be found in the northwest portion of the basin.

Groundwater Quality issues in the North Yuba subbasin include excess nutrients, trace elements, salinity and pesticides. Pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are elevated to levels above the national limits. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the North Yuba subbasin. Tables 4-18 and 4-19 summarize the available data.

Table 4-18. Water Quality in the North Yuba Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for North Yuba Subbasin
Nutrients	Median nitrate concentrations for the southeastern Sacramento Valley, including North Yuba subbasin was 1.4 mg/L. Only one well in the study area exceeded drinking water standards.
Pesticides (insecticides and herbicides) and degradation products	DPR verified bentazon detection in 10 wells with in Yuba County from 1996 to 2003 and one detection of benzol from July 2003 to June 2004. Pesticides detected in one domestic well in 1996 study, but concentration was below drinking water standards.
Salt—primarily as electrical conductivity and total dissolved solids.	
Trace elements	High concentration of arsenic (naturally occurring) in some areas.
Organic carbon and disinfection byproduct precursors	No available data.
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 3 of the 4 wells in or near North Yuba subbasin. Concentrations below drinking water standards.

Notes:
mg/L = milligrams per liter.
Sources: Dawson 2001b, DPR 2004b.

Table 4-19. Concentrations of Constituents of Concern Detected in the Southeastern Sacramento Valley Aquifers (Includes the North Yuba Subbasin)

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.11 mg/L	30 (HAL)
	Nitrate as N	0.06–12 mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.03–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.001 µg/L	3 (MCL[a])
	Bentazon	0.02–1.3 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		149 to 655 mg/L, median is 277 mg/L (DWR 2004) 134–1,750 mg/L, median is 258 mg/L	500 (SMCL)
Inorganic Constituents			EPA Standard, 2000
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–413 mg/L	

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–210 mg/L	
	Chloride	2.0–620 mg/L	250 (SMCL)
	Fluoride	0.1–0.3 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–100 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–4.1 mg/L	
	Silica	24–86 mg/L	
	Sodium	5.7–120 mg/L	
	Sulfate	1.0–130 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 (very hard) mg/L, median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	*0.06* µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Source: Dawson 2001b, unless otherwise indicated.

Natural and agricultural processes affect groundwater quality in the North Yuba basin. Natural processes include those that influence the chemistry of the recharge water. The chemistry of the recharge water, surface geology, and soils influence the major ion chemistry and concentrations. The groundwater oxidation state also influences the form and presence of constituents. Much of the groundwater in the

North Yuba subbasin is chemically oxidizing. This results in lower concentrations of manganese and iron and the presence of nitrate and sulfate. Agricultural processes include use of fertilizers and pesticides and the evaporation of irrigation water. Groundwater from the North Yuba subbasin discharges to wells and streams. Specific processes affecting constituents of concern are discussed in some detail below.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas that included the North Yuba Subbasin. Specifically, she demonstrated a significant correlation of nitrate concentrations with well depth—higher nitrate concentrations were associated with shallower well depths indicating movement of nitrate from land surface associated with agricultural activities. Dawson (2001b) also presented evidence suggesting that nitrate concentrations are being lowered by chemical reactions in the groundwater that reduce nitrate to nitrogen gas. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the North Yuba subbasin, show that shallow wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The eastern alluvial plains, in which North Yuba subbasin is located, contain magnesium-calcium-carbonate groundwater. Two processes appear to primarily affect groundwater salinity in the North Yuba subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring groundwater (Hull 1984; Olmsted and Davis 1961; Dawson 2001a).

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in wells sampled during the 1997 study by the USGS (Dawson 2001a) that included the North Yuba subbasin. The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in most wells in the rice growing areas of the Sacramento Valley in the 1997 study (Dawson 2001a), pesticides were only detected in one well in the North Yuba subbasin in the 1996 study (Dawson 2001b). This well was located just east of the Feather River near its confluence with the Yuba River. One pesticide was present in this domestic well at concentrations below the drinking water limits.

Other pesticides shown Table 4-19 include atrazine, bromacil, simizine, and tebuthiuron, which are used for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1997. She found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward.

Trace Elements

The chemistry of geology formations in the North Yuba subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the North Yuba subbasin. Elevated concentrations of potassium were also present. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain. Dawson (2001b) presented evidence that the presence and concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. As the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Organic Carbon and DPBs

Since 1983 rice farmers have been required to hold or recirculate irrigation water for up to 30 days after pesticide application to allow for the pesticides to degrade or volatilize out of the water (Dawson 2001a). In addition, some rice fields are flooded during the winter months to aid in rice straw decomposition and provide winter habitat for migrating birds (Dawson 2001a).There is some evidence that these changes in management practices in rice may result in higher dissolved organic carbon concentrations in deep percolation water (Dawson 2001a). Dawson (2001a) did a study of groundwater quality in rice-growing areas of the western Sacramento Valley. Findings showed high dissolved organic carbon content in 43% of the wells in that study area. The median concentration was 2.7 mg/L, which is much higher than the national median of 0.7 mg/L (Leenheer et al. 1974).

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in three of the four wells in or on the border of the North Yuba subbasin in the 1996 study by Dawson (2001b). The VOCs found in the wells are consistent with the agricultural land uses in the subbasin, in that they were VOCs found in pesticides or gasoline.

Red Bluff Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Red Bluff subbasin is bounded on the west by the Coast Ranges, on the north by the Red Bluff Arch, on the south by Thomes Creek and on the east by the Sacramento River. The Red Bluff Arch is a hydrologic divide between the Redding Basin to the north and the Sacramento Valley. The Red Bluff subbasin is likely contiguous with the Corning subbasin at depth. The subbasin is about 274,700 acres (429 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Red Bluff subbasin is taken from DWR Bulletin 118 (DWR 2004).

The subbasin aquifer system is composed of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene stream channel deposits and Pleistocene Modesto and Riverbank formations. The Tertiary deposits consist of Pliocene Tehama and Tuscan formations.

Holocene stream channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tehama Formation and Quaternary stream terrace deposits found at or near the surface along stream and river channels. The thickness varies from 1 to 80 feet. This unit represents the upper part of the unconfined zone of the aquifer. Although it is moderately to highly permeable it is not a significant contributor to groundwater because of its limited areal extent.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tehama and Riverbank Formations. The deposit ranges from less than 10 feet to nearly 200 feet across the valley floor. The terrace deposits are observed along Thomes, Elder, and Red Bank Creeks.

The Pleistocene Riverbank Formation consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The formation ranges from less than one foot to over 200 feet thick depending on location. Riverbank terrace deposits are observed along Thomes, Pine, Dibble, Reeds, Red Bank, Oat, and Elder Creeks.

The Pliocene Tehama Formation consists of sediments originating from the Coast Range and Klamath Mountains, and is the primary source of groundwater for the subbasin. The majority of the Tehama Formation consists of fine-grained sediments indicative of deposition under floodplain conditions. The thickness of coarse-grained beds of sand and gravel, as indicated by drill log data, are typically no more than 5 to 10 feet. The majority of both coarse and fine-grained sediments appear unconsolidated or moderately consolidated. The thickness of the formation is estimated to be up to 1,200 feet north of the City of Corning.

The Pliocene Tuscan Formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate and tuff, and tuffaceous silt and clay; derived predominantly from andesitic and basaltic sources of the Cascade Range. In the subsurface the Tuscan Formation is found juxtaposed with the Tehama Formation in the axis of the valley near the Sacramento River. Permeability is moderate to high with yields ranging from 100 to 1,000 gpm, excluding areas where beds of the impermeable tuff-breccia exist.

Long-term groundwater level data indicate a decline of 3–7 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater level data show a seasonal fluctuation ranging from 5 to 10 feet for unconfined, semiconfined, and composite wells. Wells constructed in confined aquifers can fluctuate up to 50 feet. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Groundwater storage capacity was estimated to be about 4,209,000 acre-feet. This estimate was based on an average specific yield of 7.9% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (19–27 inches/year), irrigation infiltration, and stream infiltration.

Estimate of groundwater extraction for agricultural use is estimated to be 81,000 acre-feet. Municipal and industrial use is approximately 8,900 acre-feet. Deep percolation of applied water is estimated to be 20,000 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 12% of the subbasin, urban land use accounts for about 5% of the subbasin, and native land accounts for about 83% of the subbasin. Table 4-20 provides details of the land uses within the subbasin.

Table 4-20. Land Use in the Red Bluff Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	620	0.20
Deciduous Fruits and Nuts	11,000	4.00
Field Crops	1,700	0.60
Grain and Hay	4,540	1.70
Pasture	8,870	3.20
Rice	1,530	0.60
Truck, Nursery, and Berry Crops	70	0.03
Idle	3,750	1.40
Semiagricultural and Incidental	860	0.30
Subtotal	32,910	12.00
Urban		
Urban—unclassified	310	0.10
Urban Landscape	340	0.10
Urban Residential	9,970	3.60
Commercial	680	0.20
Industrial	1,010	0.40
Vacant	2,240	0.80
Subtotal	14,550	5.30
Native		
Native Vegetation	219,000	79.70
Barren and Wasteland	2,300	0.80
Riparian	2,890	1.10
Water	3,030	1.10
Subtotal	227,220	82.70
Total	**274,380**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Red Bluff groundwater subbasin is within the Shasta-Tehama Watershed.

The public agencies within the subbasin are: Tehama County Flood Control and Water Conservation District. El Camino ID, Elder Creek WD, Gerber-Los Flores Community Service District, Gerber Water Works Inc., Tehama Ranch M.W.C., Proberta WD, Rawson WD, Thomes Creek WD, City of Red Bluff.

Tehama County adopted a groundwater ordinance in 1994 and a countywide AB 3030 groundwater management plan in 1996.

The city of Red Bluff is located within the subbasin.

Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance are off-parcel groundwater use, and influence of well pumping restrictions.

This subbasin falls within the area included in the Sacramento Valley and Rice Coalitions.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. TDS ranges from 120 to 500 mg/L and average 207 mg/L (DWR unpublished data). Impairments include high magnesium, TDS, calcium, ASAR, and phosphorus.

Solano Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Solano subbasin lies within the southwestern portion of the Sacramento Basin and the northern portion of the Sacramento-San Joaquin Delta. It is bounded by Putah Creek on the north, the Sacramento River on the east (from Sacramento to Walnut Grove), the North Mokelumne River on the southeast (from Walnut Grove to the San Joaquin River), the San Joaquin River on the south (from the North Mokelumne River to the Sacramento River) and a hydrologic divide between the San Francisco Bay and the Sacramento-San Joaquin River Delta on the west. The aquifer system is 664 square miles in size and lies in Solano, Sacramento, and Yolo Counties.

The following description of the hydrogeology in the Solano subbasin is taken from DWR Bulletin 118 (2004). The primary water-bearing formations comprising the Solano subbasin are sedimentary continental deposits of Late Tertiary to Quaternary age. Fresh water-bearing units include younger alluvium, older alluvium, and the Tehama Formation. The thickness of the units is nearly 3,000 feet near the eastern margin of the basin, thinning westward until they pinch out near the Coast Range. The Tehama Formation is underlain by saline water bearing sedimentary units that are generally considered the saline water boundary.

Flood basin deposits occur along the eastern margin of the subbasin and in the delta. Eastern flood basin deposits consist primarily of silts and clays, and may be locally interbedded with Sacramento River stream channel deposits. The flood basin deposits in the delta contain a significant percentage of organic material (peat). Thickness of the unit ranges from 0 to 150 feet. These deposits have low permeability and generally yield low quantities of water to wells.

Recent stream channel deposits occur along the Sacramento, Mokelumne and San Joaquin Rivers, and the upper reaches of Putah Creek, and consist of unconsolidated silt, fine- to medium-grained sand, and gravel with intermittent cobbles. The younger alluvium ranges in thickness from 0 to 40 feet but, with the exception of the Delta, generally lie above the saturated zone. The older alluvium ranges in thickness from 60 to 130 feet and has highly variable permeability. Deposits consist of loose to moderately compacted silt, silty clay, sand, and gravel from alluvial fan deposits. The coarser material usually occurs as lenses within the finer material. Well production within the unit can range from 50 to 4,000 gpm.

The Tehama Formation is the predominant water-bearing unit within the Solano subbasin, with thickness ranging from 1,500 to 2,500 feet. The formation consists of moderately compacted silt, clay, and fine silty sand enclosing lenses of sand and gravel; silt and gravel; and cemented conglomerate. Because of its large extent, wells completed in the Tehama Formation can yield up to several thousand gallons per minute, although its permeability is generally less than the overlying younger units.

Brackish to saline water-bearing sedimentary units of volcanic and marine origin underlie the Tehama Formation at depths ranging from a few hundred feet on the west to nearly 3,000 feet on the east of the subbasin. The contact between the Tehama Formation and these units is generally considered to coincide with the boundary between fresh and saline water.

According to DWR Bulletin 118 (2004), agricultural and urban development has resulted in significant decreases in groundwater elevations from historical levels. A large pumping depression has formed just north of the Delta. (DWR 1978.) Subsequent to the onset of surface water deliveries in 1959, however, water levels have recovered slightly or slowed their decline. Periods of drought in the 1970s and 1980s have significantly affected groundwater level trends, but these impacts have been offset by subsequent wet years. Average specific yield is estimated to be 0.07 for the Sacramento Valley and 0.08 for the Delta.

Major Sources of Recharge

The principal sources of stream recharge for the Solano subbasin are Putah Creek and the Sacramento River. Hydrochemical facies analysis indicates that the surface water from Putah Creek contributes to groundwater both near the creek and south into the center of Solano County (Evenson 1984). Deep percolation of water applied as crop irrigation is another source of recharge, but is secondary to the combination of streamflow and precipitation, as soils containing hardpan and clay in areas other than along streams impede vertical percolation in the Solano subbasin (DWR 1978).

Annual precipitation for the subbasin ranges from approximately 16 to 23 inches, with higher precipitation occurring to the west.

Adminsitrative Record
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Land Use

Land use surveys were conducted within the subbasin by DWR. Agricultural land use accounts for about 67% of the subbasin, urban land use accounts for about 4% of the subbasin, and native land accounts for about 28% of the subbasin. Table 4-21 provides details of the land uses within the Solano Subbasin.

Table 4-21. Land Use in the Solano Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	48	0.01
Deciduous Fruits and Nuts	10,738	2.52
Field Crops	98,892	23.23
Grain and Hay	73,196	17.19
Idle	5,739	1.35
Pasture	56,667	13.31
Semiagricultural and Incidental	3,154	0.74
Truck, Nursery, and Berry Crops	30,788	7.23
Vineyards	7,145	1.68
Subtotal	286,367	67.26
Urban		
Urban—unclassified	8,606	2.02
Commercial	468	0.11
Industrial	1,621	0.38
Urban Landscape	450	0.11
Urban Residential	2,104	0.49
Vacant	2,455	0.58
Subtotal	15,704	3.69
Native		
Native—unclassified	578	0.14
Native Vegetation	87,444	20.54
Barren and Wasteland	6	0.00
Riparian	7,983	1.87
Water	24,993	5.87
Subtotal	121,004	28.42
Unknown	**2,697**	**0.63**
Total	**425,772**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public water agencies included in the Solano Subbasin include City of Dixon, City of Rio Vista, California Water Service, City of Vacaville, and University of California, Davis. Private water agencies include Maine Prairie Water District, Solano Irrigation District, Solano County Water Agency, North

Delta Water Agency, and RDs 501, 536, 1607, 1667, 2060, 2068, 2084, 2093, 2098, 2104, and 2112 (DWR 2004).

AB 3030, a 1992 amendment to the Water Code, provides a systematic procedure for local agencies to develop a groundwater management plan for underlying groundwater basins as defined in DWR Bulletin 118-75 and updates. Agencies adopting a plan have authority, contingent on receiving a majority of votes in a local election, to collect revenues for implementation of groundwater management measures. An AB 3030 management plan for the Solano subbasin was adopted by the City of Vacaville and the Solano Irrigation District in February of 1995, and by the Maine Prairie Water District and RD 2068 in January of 1997 (DWR 2004).

This subbasin falls within the area included in the Sacramento Valley Coalition.

Water Quality

Groundwater within the Solano Subbasin is considered to be of generally good quality, and useable for both domestic and agricultural purposes. However, groundwater in some of the southwestern portion of the Sacramento Valley, which includes the Solano Subbasin, is not entirely suitable for human or agricultural use because of the presence of elevated levels of boron, fluoride, chloride, nitrate, and sulfate.

Chemical water types within the basin are variable and classified generally as magnesium bicarbonate in the central and northern areas, sodium bicarbonate in the southern and eastern areas, and calcium magnesium or magnesium calcium bicarbonate around and west of Dixon.

A USGS study (Evenson 1984) analyzed water quality in the Solano and Yolo Counties. Constituents that were measured include: dissolved solids, hardess, chloride, fluoride, sulfate, nitrogen, arsenic, boron, iron, and manganese. Unless otherwise noted, the following is a summary of the findings from that report, as they pertain to the Solano Subbasin.

Dissolved Solids

TDS ranges from 250 to 500 mg/L in the northwest and eastern portion of the basin and are found at levels higher than 500 mg/L in the central and southern areas. Data from the CDPH in 2000 (DWR 2004) shows the TDS minimum = 150 mg/L, maximum = 880 mg/L, average = 427 mg/L. Hardness, which is mainly a reflection of the amount of calcium and magnesium in water, is considered very high, with values generally greater than 180 mg/L. According to CDPH data (DWR 2004), about one half of drinking water well samples taken between 1970 and 2000 analyzed for overall hardness measured above 200 mg/L, but rarely over 400 mg/L. High concentrations of bicarbonate, which causes precipitation of Ca and Mg carbonates, is found in the southern portion of the basin (Hull 1984).

Boron

Boron concentrations are less than 0.75 ppm except in the southern and southeastern basin where concentrations average between 0.75 and 2.0 ppm (more than 1.0 ppm will affect sensitive tree crops). Concentrations are high along the Sacramento River and seem to increase in a southwesterly direction.

Iron

Iron concentrations are generally low with respect to federal standards (MCL = 0.3 ppm) in the Solano subbasin. Iron concentrations increase toward the eastern side of the subbasin, from less than 0.02 ppm to greater than 0.05 ppm along the Sacramento River.

Manganese

Manganese concentrations increase from west to east with concentrations from 0.01 ppm to over 0.1 ppm found north of Rio Vista and east of the Solano-Yolo County line. Manganese is found at concentrations above the MCL of 0.05 ppm (as a secondary constituent) along the Sacramento River along the eastern portion of the subbasin (DWR 2004).

Arsenic

Arsenic concentrations are typically between 0.02 and 0.05 ppm, with the highest concentrations found along the southeastern margin of the basin. Although this is currently not considered problematic, there could be impacts if the MCL is lowered. The current MCL (as set by the EPA [2005]) for arsenic is 0.05 ppm (DWR 2004).

Chloride

Chloride concentrations are highest in the southwestern part of the subbasin, with values greater than 100 mg/L. The lowest levels exist in the eastern central and northwestern sections, with values generally below 25 mg/L. The MCL for chloride is 600 ppm. The EPA secondary standard for chloride is 250 mg/L. According to a study in Sacramento County (DWR 1974), the average chloride ion concentration in the Delta region was measured at 132 mg/L, with a range of 6 mg/L to 904 mg/L.

Fluoride

Fluoride concentrations are generally greater than 0.5 mg/L in the southwestern portion of the basin and less than 0.5 mg/L in the east and north. EPA optimum fluoride concentration for this area is 0.8 mg/L.

Sulfate

Sulfate concentrations are low over the study area with respect to the recommended limits. The highest concentrations are in the southern areas, with values greater than 50 ppm. The MCL for sulfate is 600 ppm.

Nitrogen

There were several domestic wells with nitrogen as nitrate concentrations above the EPAMCL of 10 mg/L, ranging from 11 mg/L to 45 mg/L.

Pesticides

According to DPR (2004), there were 2 detections of DBCP (soil fumigant) and 1 detection of diquat dibromide (herbicide) in Sacramento County. For the period of 1985 to 2003 (DPR 2003), atrazine and bentazon were detected in Sacramento County, ACET, atrazine, DACT, DEA, diuron, norflurazon, prometon, and simazine were detected in Solano County, and atrazine, bentazon, and simazine were detected in Yolo County. The sampling locations and concentrations were not specified.

Summary of Significant Detections

Of the 71 public supply wells sampled by DWR, CDPH and their cooperators (DWR 2004), 1 well had primary inorganics concentrations above the MCL, 8 wells of 96 sampled had nitrate concentrations above the MCL, 3 wells out of 56 sampled had pesticide concentrations above the MCL, 1 well of 57 sampled had VOC/SVOC concentrations above the MCL, and 17 wells of 71 sampled had secondary inorganics concentrations above the MCL.

Discharge Pathways and Sources of Contaminants

Discharge occurs as flow to the Sacramento River and other streams and from evapotranspiration from vegetation. Irrigated agriculture appears to be a source of pesticide contamination.

South American Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South American groundwater subbasin is bound by the Sierra Nevada foothills on the east, the Sacramento River on the west, the American River on the north, and the Cosumnes and Mokelumne Rivers on the south. The subbasin is 388 square miles in size and is located entirely within Sacramento County.

The following description of the hydrogeology in the South American subbasin is taken from DWR Bulletin 118 (DWR 2004).

The South American subbasin aquifer system is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include younger alluvium (consisting of flood basin deposits, dredge tailings and Holocene stream channel deposits), older alluvium, and Miocene/Pliocene volcanics. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,500 feet along the western margin of the subbasin. The maximum combined thickness of all the younger alluvial units is about 100 feet. Calculated specific yield values range from about 5.4% in the flood basin deposits to 10% in the stream channel deposits.

The flood basin deposits occur along the western margin of the subbasin adjacent to the Sacramento River. They consist primarily of silts and clays, but along the western margin of the subbasin may be

locally interbedded with stream channel deposits of the Sacramento River. The flood basin deposits are generally fine-grained, have low permeability, and generally yield low quantities of water to wells.

Dredge tailings are exposed primarily along the American River in the northeastern corner of the subbasin. They consist of windows of gravel, cobbles, boulders, sand, and silt resulting from the activities of gold dredging operations. The tailings are highly permeable, but well construction is complicated by the presence of cobbles and boulders.

The stream channel deposits include sediments deposited in the channels of active streams as well as overbank deposits of those streams, terraces, and local dredger tailings. They occur along the Sacramento, American, and Cosumnes Rivers and their major tributaries and consist primarily of unconsolidated silt, fine- to medium-grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and yield significant quantities of water to wells.

The older alluvium deposits consist of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. A number of formational names have been assigned to the older alluvium, including the Modesto Formation, Riverbank Formation, Victor Formation, Laguna Formation, Arroyo Seco Gravels, South Fork Gravels, and Fair Oaks Formation. The older alluvial units are widely exposed between the Sierra Nevada foothills and overlying younger alluvial units near the axis of the Sacramento Valley. Thickness of the older alluvium is about 100–650 feet. It is moderately permeable. The calculated specific yield of these deposits is about 7%.

The Miocene/Pliocene volcanics consist of the Mehrten Formation, a sequence of fragmental volcanic rocks, which crops out in a discontinuous band along the eastern margin of the basin. It is composed of intervals of “black sands,” stream gravels, silt, and clay interbedded with intervals of dense tuff breccia. The sand and gravel intervals are highly permeable and wells completed in them can have high yields. The tuff breccia intervals act as confining layers. Thickness of the unit is between 200 and 1,200 feet.

Groundwater levels declined approximately 20 feet from the mid-1960s to about 1980. From 1980 through 1983 water levels recovered by about 10 feet and remained stable until the beginning of the 1987 through 1992 drought. From 1987 until 1995, water levels declined by about 15 feet. From 1995 to 2000 most water levels recovered by up to 20 feet leaving them generally higher than levels prior to the 1987 through 1992 drought. DWR (2004) estimated the specific yield to be 6.8% and the storage capacity (to a depth of 310 feet) to be 4.8 maf. The bounding rivers form groundwater flow divides in the shallow zone, but there is lateral groundwater flow between adjacent subbasins in the deeper zones.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (14-20 inches/year), irrigation infiltration, and stream infiltration. Average annual recharge for the period 1975-90 was estimated using a groundwater-flow model. The model estimated the recharge to be 357,000 acre-feet, subsurface outflow was 29,700 acre-feet, pumpage for irrigation was 163,000 acre-feet, and pumpage for public supply was 68,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 2000. Agricultural land use accounts for about 26% of the subbasin, urban land use accounts for about 37% of the subbasin, and native land accounts for about 37% of the subbasin. Table 4-22 provides details of the land uses within the subbasin.

Table 4-22. Land Use in the South American Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	60	0.02
Deciduous Fruits and Nuts	2,990	1.20
Field Crops	16,300	6.70
Grain and Hay	6,170	2.50
Pasture	17,500	7.20
Rice	250	0.10
Truck, Nursery, and Berry Crops	4,430	1.60
Vineyards	12,100	5.00
Idle	1,430	0.60
Semiagricultural and Incidental	1,500	0.60
Subtotal	62,730	25.70
Urban		
Urban—unclassified	62,200	25.40
Urban Landscape	3,210	1.30
Urban Residential	7,160	2.90
Industrial	6,790	2.80
Commercial	730	0.30
Vacant	10,500	2.90
Subtotal	90,590	37.10
Native		
Native Vegetation	73,700	30.20
Barren and Wasteland	8,180	3.30
Riparian	5,180	2.10
Water	4,030	1.60
Subtotal	91,090	37.30
Total	244,410	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The North American groundwater subbasin is within the Placer North Sacramento Watershed.

The public agencies within the South American subbasin are: Arden Cordova Water Service, City of Folsom, City of Sacramento, County of Sacramento, Elk Grove Water Works, Florin County WD, Fruitridge Vista, Mather Air Force Base, North Delta Water Agency, Omochumne-Hartnell WD, Rancho Murieta CSD, Tokay Park, Sacramento County WMD, and Sacramento County WMD- Zone 40 (DWR 2004).

The SGA is a joint powers authority formed to manage the North Area Groundwater Basin, which is north of the South American subbasin. The Regional Water Authority (RWA) is a joint powers authority

that serves and represents the interests of 21 water providers in the greater Sacramento, Placer, and El Dorado County region.

The Sacramento Metropolitan urban is partly located within the subbasin including the cities of Sacramento, Rancho Cordova, Folsom, and Elk Grove.

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater is typically a calcium magnesium bicarbonate or magnesium calcium bicarbonate. Other minor groundwater types include a sodium calcium bicarbonate or calcium sodium bicarbonate in the vicinity of Elk Grove and a magnesium sodium bicarbonate or sodium magnesium bicarbonate near the confluence of the Sacramento and American rivers (Bertoldi et al. 1991). TDS ranges from 24 to 581 mg/L and averages 221 mg/L based on 462 records (Montgomery Watson 1993).

Sites with significant groundwater contamination exist within the subbasin. These sites include Aerojet, Mather Field, and the Sacramento Army Depot, the Kiefer Boulevard Landfill, an abandoned Pacific Gas and Electric Company (PG&E) site near Old Sacramento, and the Southern Pacific and Union Pacific Rail Yards in downtown Sacramento.

Discharge Pathways and Sources of Contaminants

Natural, agricultural, and urban land use practices affect groundwater quality in the South American basin. Natural processes include those that influence the chemistry of the recharge water. The chemistry of the recharge water, surface geology, and soils influence the major ion chemistry and concentrations. The groundwater oxidation state also influences the form and presence of constituents. Much of the groundwater in the South American subbasin is chemically oxidizing. This results in lower concentrations of manganese and iron and the presence of nitrate and sulfate. Agricultural processes include use of fertilizers and pesticides and the evaporation of irrigation water. Specific processes affecting constituents of concern are discussed in some detail below.

Nutrients

The available data for the Southeastern Sacramento Valley, an area that includes the South American subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The groundwater in the South American subbasin is mostly calcium magnesium bicarbonate or magnesium calcium bicarbonate. Although some localized areas of sodium calcium bicarbonate or calcium sodium bicarbonate and magnesium sodium bicarbonate or sodium magnesium bicarbonate exist. The high amount of sodium and chloride in some wells may be due to natural or anthropogenic causes.

Two processes appear to primarily affect groundwater salinity in the North American subbasin. The first is evaporation of irrigation water and shallow groundwater. The second is mixing of naturally occurring groundwater with naturally occurring groundwater of a higher salinity. (Hull 1984; Olmsted and Davis 1961; Dawson 2001a.)

Pesticides

Pesticides were detected in three of the five wells in a study of the Southeast Sacramento Valley (Dawson 2001b). All concentrations were below the drinking water limits.

The most common pesticides detected in Dawson's (2001b) 1996 study of the Southeastern Sacramento Valley were bentazon, simazine, atrazine, bromacil, and tebuthiuron. The major uses for atrazine, bromacil, and tebuthiuron are for weed control in right-of-way areas and for landscape maintenance. Simazine is used for weed control in right-of-way areas and for landscape maintenance, and on many crops grown in the study area, including nut and fruit orchards.

Trace Elements

The chemistry of geology formations in the South American subbasin influences the concentrations of trace elements. In a study of the Southeastern Sacramento Valley (Dawson 2001b), which includes part of the South American subbasin, drinking water standards were exceeded for five inorganic constituents: chloride, boron, iron, manganese, and arsenic.

Dawson (2001b) presented evidence that, within the Southeastern Sacramento Valley, the concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. She found that as the concentration of dissolved oxygen increases, the arsenic concentrations decrease. The presence of trace constituents in groundwater in the South American Subbasin do not appear to be related to irrigated agriculture.

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in two of the five wells in the South American (Dawson 2001b). The VOCs found in the wells are consistent with the land use surrounding each well. Those detected in agricultural areas were VOCs found in pesticides or gasoline while those detected in urban areas were VOCs associated with landscape maintenance, pest control, right-of-way weed control, gasoline, industrial chemicals and chlorinated drinking water. Aerojet Superfund site is located in the South American basin and 8 VOCs were detected in the well on that particular site. The site is currently undergoing remediation.

South Yuba Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Yuba subbasin is bounded on the north by the Yuba River, on the west by the Feather River, on the south by the Bear River, and on the east by the Sierra Nevada foothills. The subbasin is 104,400 acres (163 square miles) in size and is located entirely within Yuba County.

The following description of the hydrogeology in the South Yuba subbasin is taken from DWR Bulletin 118 (DWR 2004).

The South Yuba Subbasin aquifer system is comprised of continental deposits of Quaternary (Recent) to Late Tertiary (Miocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 1,400 feet along the western margin of the basin. The base of the aquifer system overlies the Pre-Tertiary metamorphosed igneous and sedimentary rocks of the Sierra Nevada block.

Holocene Dredge deposits occur along the Yuba and Bear Rivers within the eastern region of the South Yuba Groundwater subbasin. The coarse gravels and cobbles can be up to 125 feet thick and are highly permeable.

Holocene Stream Channel and Floodplain deposits occur as coarse sand and gravels along present stream channels of the Yuba, Feather, and Bear Rivers. Coarser grained materials occur near streams with thicknesses up to 110 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene Victor Formation lies unconformably above the Laguna Formation. The majority of the formation occurs as alluvium throughout the North Yuba Groundwater subbasin, but floodplain deposits are present along stream channels above the alluvium.

Pleistocene Floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits, and ranges in thickness from 5 to 15 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

Pleistocene Alluvium occurs at over 50% of the basin surface and at least 60% of its irrigated agricultural lands. Its thickness is highly variable due to its lower contact with the Laguna Formation. The Older Alluvium is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation is the most extensive water-bearing unit within the South Yuba Groundwater subbasin. The formation is comprised of reddish to yellowish or brown silt to sandy silt with

abundant clay and minor lenticular gravel beds. It overlies the Mehrten Formation and occurs at the surface intermittently at the east end of the basin. The continental deposits of the Laguna dip to the west beneath the Victor Formation and range in thickness from 400 feet near the Yuba River up to 1,000 feet in the southwest portion of the county. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. Most of the groundwater produced from wells in the Laguna comes from overlying units.

The Miocene-Pliocene Mehrten Formation is a sequence of volcanic rocks of late Miocene through middle Pliocene age. Surficial exposures are limited to a few square miles in the northeast corner of the basin and thickness varies from 200 feet near the eastern margin of the basin to 500 feet near the Feather River. The Mehrten Formation is composed of two distinct units. One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals.

As early as 1960 groundwater levels showed a well-developed cone of depression beneath the South Yuba basin. Water levels in the center of the cone of depression were just below sea level. Nearly all water levels were well below adjacent river levels on the Bear, Feather, and Yuba Rivers. Groundwater conditions in 1984 reflect a continued reliance on groundwater pumping in the South Yuba Basin. Water levels in the center of the South Yuba cone of depression had fallen to 30 feet below sea level. The water level contours adjacent to the Bear and Yuba Rivers indicated a large gradient and seepage from the rivers. By 1990, water levels in the South Yuba Basin cone of depression rose to 10 feet above sea level. The rise in water levels was due to increasing surface water irrigation supplies and reduced groundwater pumping. Current DWR records indicate groundwater levels continue to increase.

Groundwater storage capacity was estimated to be 1,090,000 acre-feet. This estimate was based on an area of 88,700 acres, an average specific yield of 6.9%, and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (20–24 inches/year), irrigation infiltration, and stream infiltration. Stream channel and floodplain deposits present along the Yuba River, Feather River, and Honcut Creek are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Previous DWR unpublished studies have estimated natural and applied recharge. DWR has also estimated urban and agriculture extractions and subsurface outflow. Basin inflows include natural recharge of 53,700 acre-feet, and applied water recharge of 26,000 acre-feet. Outflows include urban extraction of 6,000 acre-feet, agricultural extraction of 93,400 acre-feet, and subsurface outflow of 4,900 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 50% of the subbasin, urban land use accounts for about 9% of the subbasin, and native land accounts for about 41% of the subbasin. Table 4-23 provides details of the land uses within the subbasin.

Table 4-23. Land Use in the South Yuba Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	140	0.10
Deciduous Fruits and Nuts	20,600	19.70
Field Crops	1,410	1.30
Grain and Hay	1,100	1.10
Pasture	9,140	8.70
Rice	16,900	16.20
Truck, Nursery, and Berry Crops	430	0.40
Idle	2,300	2.20
Semiagricultural and Incidental	720	0.70
Subtotal	52,740	50.40
Urban		
Urban—unclassified	4,100	25.40
Urban Landscape	420	1.30
Urban Residential	600	2.90
Industrial	1,230	2.80
Commercial	100	0.30
Vacant	2,540	2.90
Subtotal	8,990	8.60
Native		
Native Vegetation	35,400	30.20
Barren and Wasteland	3,900	3.30
Riparian	2,140	2.10
Water	1,140	1.60
Subtotal	42,580	41.00
Total	**104,310**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The South Yuba groundwater subbasin is within the Butte Sutter Yuba Watershed. The public agencies within the South Yuba subbasin are: Yuba County Water Agency, Brophy Water District, Linda County Water District, Wheatland Water District, South Yuba Water District, Plumas Water District, RD 794 (DWR 2004).

The South Yuba Water District completed an AB 3030 plan in 1998. No major urban areas exist within the subbasin. The cities of Marysville and Yuba City are located at the northwestern boundary of the subbasin. This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

. In general, TDS concentrations are below 500 mg/L throughout the entire subbasin. DWR maintains data for 27 water quality wells in the South Yuba Subbasin. Data collected from these wells indicate a TDS range of 141 to 686 mg/L and a median of 224mg/L. The primary water chemistry in the area indicates calcium magnesium bicarbonate or magnesium calcium bicarbonate groundwater. Some magnesium bicarbonate can be found in the northwest portion of the basin.

Groundwater quality issues in the South Yuba subbasin include excess nutrients, trace elements, salinity, and pesticides. Pesticides occur in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are found at levels above the MCL. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the South Yuba subbasin (Dawson 2001b). Tables 4-24 and 4-25 summarize the available data.

Table 4-24. Water Quality in the South Yuba Subbasin

Constituent of Concern	Available Information about Groundwater Concentrations for South Yuba Subbasin
Nutrients	Median nitrate concentrations for the southeastern Sacramento Valley, including South Yuba subbasin was 1.4 mg/L. Only one well in the study area exceeded drinking water standards.
Pesticides (insecticides and herbicides) and degradation products	DPR verified bentazon detection in 10 wells with in Yuba County from 1996 to 2003. Pesticides detected in one domestic well in 1996 study, but concentrations werebelow drinking water standards.
Salt—primarily as electrical conductivity and total dissolved solids.	141 to 686 mg/L, median is 224mg/L.
Trace elements	High concentration of arsenic (naturally occurring) in some areas.
Organic carbon and disinfection byproduct precursors	No available data.
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 2 wells in the South Yuba subbasin. Concentrations below drinking water standards.

Notes:
mg/L = milligrams per liter.
Sources: Dawson 2001b; DPR 2004b.

Table 4-25. Concentrations of Constituents of Concern Detected in the Southeastern Sacramento Valley Aquifers, including the South Yuba Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.11 mg/L	30 (HAL)
	Nitrate as N	0.06–12mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.03–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.001 µg/L	3 (MCL[a])
	Bentazon	0.02–1.3 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		141–686 mg/L, median is 224mg/L (DWR 2004) 134–1,750 mg/L, median is 258 mg/L	500 (SMCL)
Inorganic Constituents			
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–413 mg/L	
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–210 mg/L	
	Chloride	2.0–620 mg/L	250 (SMCL)
	Fluoride	0.1–0.3 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–100 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–4.1 mg/L	
	Silica	24–86 mg/L	
	Sodium	5.7–120 mg/L	
	Sulfate	1.0–130 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 (very hard) mg/L, median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])

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Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	0.06 µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Source: Dawson 2001b, unless otherwise indicated.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas. Specifically, she demonstrated a significant correlation of nitrate concentrations with well depth—higher nitrate concentrations were associated with shallower well depths indicating movement of nitrate from land surface associated with agricultural activities. There are naturally occurring nitrates in some formations of the Sacramento Valley. However, most nitrogen species that occur above 3 mg/L signify contamination introduced into the groundwater via human activates such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the South Yuba subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The eastern alluvial plains, in which the South Yuba subbasin is located, contain magnesium-calcium-carbonate groundwater. Two processes appear to primarily affect groundwater salinity in the South Yuba subbasin: evaporation of irrigation water followed by its percolation and shallow groundwater mixing with naturally occurring groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples. The South Yuba subbasin does not appear to be adversely affected by saline groundwater, the median concentration of dissolved solids is 224 mg/L.

Trace Elements

Concentrations of silica were significantly higher in the eastern alluvial plain, which contains the South Yuba subbasin. Elevated concentrations of potassium were also present. The eastern alluvial plains showed higher concentration of arsenic than in the western alluvial plain.

Volatile Organic Compounds

VOCs have many different uses including pesticides gasoline, degreasers, solvents, and refrigerants. Some VOCs are byproducts of the chlorination of drinking water. VOCs were detected in two wells in the South Yuba subbasin in the 1996 study by Dawson (2001b). The VOCs found in the wells were consistent with the agricultural land uses in the subbasin in that they were VOCs found in pesticides or gasoline.

Sutter Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Hydrogeology

The Sutter subbasin aquifer boundaries are the confluence of Butte Creek and the Sacramento River and Sutter Buttes on the north, the confluence of the Sacramento River and the Sutter Bypass on the south, the Sacramento River on the west, and the Feather River on the east. The aquifer system is 366 square miles in size and is located in Sutter County.

The following description of the hydrogeology in the Sutter subbasin is taken from DWR Bulletin 118 (2004). The geologic formations of the Sutter Subbasin include pre-Cretaceous metamorphic and igneous rocks of the Sierra Nevada block, which extends beneath the valley fill overlain principally by Tertiary sedimentary formations derived from these and other rocks that are exposed in the Sierra Nevada to the east. The sedimentary rocks are of both marine and continental origin and are frequently interbedded with tuff-breccias. Volcanic rocks are also represented in the area in and around Sutter Buttes, which are erosional remnants of an extinct Pliocene volcano. Only the sedimentary rocks can be considered as being water bearing to any appreciable degree.

The Sutter Subbasin aquifer system is comprised of continental deposits of Quaternary (Recent) to Late Tertiary (Miocene) age. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,000 feet along the western margin of the basin (DWR 1978).

The Holocene stream channel and floodplain deposits occur as coarse sand and gravel along present stream channels of the Yuba, Feather, and Sacramento Rivers. Coarser grained materials occur near streams with thicknesses up to about 100 feet. Both grain size and thickness decrease with increased distance from streams. These deposits are highly permeable and provide for large amounts of groundwater recharge within the subbasin. Well yields are reported in the range of 2,000 to 4,000 gpm.

The Pleistocene floodplain deposits occur as gravelly sand, silt, and clay from flood events along the Feather River and its tributaries. This unit overlies the Older Alluvium, underlies Quaternary Deposits,

and ranges in thickness up to about 100 feet. These deposits provide a good medium for groundwater recharge, provided the groundwater can pass the lower contact with the Older Alluvium.

The Pleistocene Victor Formation (Old Alluvium) ranges in thickness up to about 100 feet. This formation is comprised of Sierran alluvial fan deposits of loosely compacted silt, sand, and gravel with lesser amounts of clay deposits. The deposits occur as lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and the foothills. Hardpan and claypan soils have developed to form an impermeable surface, but below this the Older Alluvium is moderately permeable and provides for most of the groundwater from domestic and shallow irrigation wells. Wells in the older alluvium have yields up to 1,000 gpm.

The Pliocene Laguna Formation consists of compacted layers of sand, silt, and clay with hardpan in surface soils. In the subsurface, this formation has a thickness of about 300 feet but is estimated to be up to 1,000 feet along the valley axis. Although the occurrence of thin sand and gravel zones is common, many of them have reduced permeability due to cementation. This coupled with its fine-grained character, leads to an overall low permeability for the Laguna Formation. This formation is an important source of water for southeastern Sacramento Valley.

The Miocene - Pliocene Mehrten Formation is a sequence of volcanic and volcaniclastic rocks of late Miocene through middle Pliocene age. The formation ranges in thickness from about 200 feet to over 1,000 feet along the axis of the valley. The Mehrten Formation is composed of two distinct units: One unit occurs as intervals of gray to black, well-sorted fluvial andesitic sand (up to 20 feet thick), with andesitic stream gravel lenses and brown to blue clay and silt beds. These sand intervals are highly permeable and wells completed in them can produce high yields. The second unit is an andesitic tuff-breccia that acts as a confining layer between sand intervals. This formation is also an important source of water for southeastern Sacramento Valley.

The Oligocene - Miocene Valley Springs Formation consists of gravel, sand, silt, and clay, siltstone, and tuffaceous beds which all contain rhyolitic material. This unit is reported to have a maximum thickness of about 200 feet. The Valley Springs Formation deposits typically have low permeabilities and therefore, yield only small quantities of water to wells.

Groundwater levels in the Sutter subbasin tend to remain constant. In Bulletin 188-6 (DWR 1978), average annual groundwater recharge was documented to exceed average discharge in the Sutter subbasin. DWR (2004) estimated the storage capacity (200-foot depth) to be 5 maf. The depth to the aquifer in most locations is about 10 feet below ground surface.

Major Sources of Recharge

Stream infiltration, irrigation, and precipitation are the principal sources of recharge to the Sutter subbasin. The Sacramento and Feather Rivers provide recharge to the aquifer as well as irrigation from agricultural fields. Annual precipitation ranges from 17 to 21 inches with rainfall increasing across the valley from the southeast to the northwest (DWR 2004). Twenty-three percent of the Sutter subbasin is used for rice cultivation where the fields are typically flooded for 6 months each year. DWR (2004) estimated inflows to the subbasin from natural recharge to be 40,000 acre-feet and from applied water to be 22,100 acre-feet.

Groundwater discharge occurs as evapotranspiration, and pumpage. DWR (2004) estimated outflows include urban extraction at 3,900 acre-feet and agricultural extraction at 171,400 acre-feet.

Land Use

The Sutter subbasin is primarily utilized for fruit orchards, rice cultivation, and vegetable crops. There is a very little urban land use in the Sutter subbasin. Table 4-26 provides details on the distribution of land use throughout the subbasin.

Table 4-26. Land Uses in the Sutter Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	187	0.08
Deciduous Fruits and Nuts	45,556	19.44
Field Crops	38,226	16.31
Grain and Hay	11,676	4.98
Idle	3,400	1.45
Pasture	3,283	1.40
Rice	54,015	23.05
Semiagricultural and Incidental	1,744	0.74
Truck, Nursery, and Berry Crops	32,084	13.69
Vineyards	4	0.002
Subtotal	190,176	81.14
Urban		
Urban—unclassified	7,045	3.01
Commercial	209	0.09
Industrial	1,135	0.48
Urban Landscape	415	0.18
Urban Residential	1,412	0.60
Vacant	1,351	0.58
Subtotal	11,568	4.94
Native		
Riparian	8,507	3.63
Native Vegetation	19,570	8.35
Water	4,559	1.95
Subtotal	32,636	13.92
Total	**234,380**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Sutter subbasin aquifer system are: Sutter Mutual Water Company, Meridian Farms Water Company, Butte Slough Irrigation Company, Tisdale Irrigation District, Pelger Mutual Water Company, Sutter Extension Water District, Feather Water District, Oswald Water District, Tudor Mutual Water Company, Garden Highway Municipal Water Company (DWR 2004).

The private entities within the Sutter subbasin aquifer system are: Garden Highway Municipal Water Company, RD 70, RD 1660, RD 1500 (DWR 2004).

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. RD 1500, South Sutter Water District, and Sutter Extension Water District have adopted groundwater management plans in accordance with AB 3030.

This subbasin falls within the area included in the Sacramento Valley Water Quality and Rice Coalitions.

Water Quality

Groundwater Quality issues in the Sutter subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring but some are found at levels above the MCL's. Elevated nitrates are possibly due to on-site sewage systems (PMC 1996). However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the Sutter subbasin. Tables 4-27 and 4-28 summarize the available data.

Table 4-27. Water Quality in the Sutter Subbasin

Constituent of Concern	Available Information about groundwater concentrations for Sutter Subbasin
Nutrients	Nitrate concentrations greater than 45mg/L in localized areas (PMC 1996).
Pesticides (insecticides and herbicides) and degradation products	Bentazon and DBCP are present in groundwater (PMC 1996). Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells. Seven verified detections of simazine and 2 of bentazon in Sutter County from 1986 to 2003 (DPR 2004b).
Salt—primarily as electrical conductivity and total dissolved solids.	Dissolved solids exceed SMCL in 3 wells. Chloride exceeds 250 mg/L in a large area of the southeast section of the subbasin (PMC 1996). High TDS concentrations measured in shallow groundwater in rice growing areas. One well, south of Sutter Buttes, had a concentration of 8,730 mg/L of dissolved solids. (Dawson 2001a).
Trace elements	High concentrations of arsenic, boron, chloride, iron, and manganese. Manganese exceeds 50 µg/L in southern half and eastern boundary of Sutter County. Iron exceeds 300 µg/L in localized areas. Arsenic exceeds 10 µg/L to the south and east of Sutter Buttes and in other localized areas. Arsenic exceeds 50 µg/L in localized areas. (PMC 1996).
Microorganisms	No available data.
Volatile organic compounds	VOCs were detected in 12 of the 31 wells studied by Dawson (2001b).

Notes:
mg/L = milligrams per liter.
Sources: Dawson 2001b; Dawson 2001a; and PMC 1996.

Table 4-28. Concentrations of Constituents of Concern Detected in the Sutter Subbasin

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
Nutrients	Nitrate—Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Nitrate as N	0.06–12mg/L	10 (MCL[a])
	Nitrite as N	0.01–0.01 mg/L	1 (MCL[a])
	Orthophosphate, as P	0.01–0.4 mg/L	
	Phosphorus, as P	0.03–0.45 mg/L	
	Dissolved organic carbon, as C	0.2–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	0.001–0.026 µg/L	3 (MCL[a])
	Bentazon	0.02–7.8 µg/L	18 (MCL[b])
	Bromacil	0.34 µg/L (one detection)	90 (HAL)
	Desethyl atrazine	0.004–0.044 µg/L	
	Simazine	0.006–0.077 µg/L	4 (MCL[a])
	Tebuthiuron	0.32 µg/L (one detection)	500 (HAL)
Salt—primarily as electrical conductivity and total dissolved solids.		133–1,660 mg/L, (DWR 2004) 134–1,750 (Dawson 2001b)	500 (SMCL)
Inorganic Constituents			EPA Standard, 2000
	Arsenic	1–46 µg/L	50 (MCL[a])
	Bicarbonate	67–710 mg/L	
	Boron	12–110 µg/L	600 (HAL)
	Bromide	0.02–12 mg/L	
	Calcium	10–810 mg/L	
	Chloride	2.0–4,800 mg/L	250 (SMCL)
	Fluoride	0.1–1.8 µg/L	4 (MCL[a])
	Iron Fe	3–1,600 µg/L	300 (SMCL)
	Magnesium	5.0–480 mg/L	
	Manganese	1–870 µg/L	50 (SMCL)
	Potassium	0.40–9 mg/L	
	Silica	16–86 mg/L	
	Sodium	5.7–1,300 mg/L	
	Sulfate	1.0–1,500 mg/L	250 (SMCL)
	Total Hardness as $CaCO_3$	48 (soft)–940 mg/L (very hard), median is 135 mg/L	
Organic carbon and disinfection byproduct precursors	DOC	0.2–0.7 mg/L, median 0.3 mg/L	
Volatile organic compounds*	1,1-Dichloroethane	*0.02*–0.04 µg/L	
	1,2,4-Trimethylbenzene	*0.01*–0.02 µg/L	
	1,2-Dichloroethane	0.19 µg/L	0.5 (MCL[a])
	Bromodichloromethane	*0.03* µg/L	100 (MCL[a])
	cis-1,2-Dichloroethene	0.43 µg/L	6 (MCL[b])
	Dichlorodifluoromethane	*0.04*–0.29 µg/L	1000 (HAL)

Constituent Type	Constituent of Concern	Concentration Ranges	Drinking Water Standards
	Methyl tert-butyl ether	*0.06* µg/L	20 (HAL)
	Styrene	*0.06* µg/L	100 (MCL[a])
	Tetrachloroethene	0.58–0.97 µg/L	5 (MCL[a])
	Tetrachloromethane	1.2 µg/L	0.5 (MCL[b])
	Trichloroethene	*0.01*–5.5 µg/L	5 (MCL[a])
	Trichlorofluoromethane	*0.04* µg/L	150 (MCL[b])
	Trichloromethane	*0.03*–1.1 µg/L	100 (MCL[a])

Notes:
* Numbers in *italics* are estimates.
MCL[a] = Maximum Contaminant Level set by EPA (2005).
MCL[b] = Maximum Contaminant Level set by DWR.
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Sources: Dawson 2001a, 2001b, unless otherwise indicated.

Nutrients

Dawson (2001a) presented evidence for movement of nitrate to shallow groundwater in rice growing areas. Specifically, she demonstrated a significant correlation of nitrate concentrations with groundwater depth—higher nitrate concentrations were associated with shallower groundwater depths indicating movement of nitrate from land surface associated with agricultural activities. There are naturally occurring nitrates in some formations of the Sacramento Valley. However, most nitrogen species that occur above 3 mg/L signify contamination introduced into the groundwater via human activates such as agriculture and urbanized development. At this time, the data available for the Southeastern Sacramento Valley, an area that includes the Sutter subbasin, show that 8 of the 31 wells studied by Dawson (2001b) were impacted by nitrate concentrations above 3 mg/L.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The central flood plains, in which Sutter subbasin is located, contain a mixture of magnesium-calcium-carbonate groundwater (common in the eastern alluvial plain) and sodium-sulfate groundwater (common in the western alluvial plain. Two processes appear to primarily affect groundwater salinity in the Sutter subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001b). Using isotope data, Dawson (2001a) presented evidence that partial evaporation accounted for some of the measured increase in salinity among shallow groundwater samples.

One well located south of the Sutter Buttes yields groundwater of the sodium-calcium type. This same well had a concentration of 8,730 mg/L dissolved solids in the 1997 study by Dawson (2001a).

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in most wells in the rice growing areas of the Sacramento Valley in the 1997 Dawson study, pesticide concentrations were only detected in one well in the Sutter subbasin in the 1996 Dawson study (Dawson 2001b). This well was located adjacent to and southeast of the Sutter Buttes. Two different pesticides were present in this domestic well at concentrations below the drinking water limits.

Trace Elements

The chemistry of geology formations in the Sutter subbasin influences the concentrations of trace elements. Dawson (2001a) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of silica were significantly higher in the eastern alluvial plain, which contains part of the Sutter subbasin. Concentrations of arsenic and potassium were significantly higher in the central flood basins, which are also part of the Sutter subbasin. Dawson (2001b) presented evidence that the presence and concentration of arsenic is related to the dissolved oxygen concentration (or redox condition) of the groundwater. As the concentration of dissolved oxygen increases, the arsenic concentrations decrease. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Vina Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Vina Subbasin is bounded on the west by the Sacramento River, on the north by Deer Creek, on the east by the Chico Monocline and on the south by Big Chico Creek. Deer Creek and Big Chico Creek serve as hydrologic boundaries in the near surface. The subbasin is contiguous with the Los Molinos and West Butte subbasins at depth. The subbasin is 125,600 acres (195 square miles) in size and is located in parts of Butte and Tehama Counties.

The following description of the hydrogeology in the Vina subbasin is taken from DWR Bulletin 118 (DWR 2004).

The aquifer system is comprised of continental deposits of Tertiary to late Quaternary age. The Quaternary deposits include Holocene stream channel deposits and Pleistocene Modesto Formation deposits, located along most stream and river channels, and alluvial fan deposits. The Tertiary deposits include the Tuscan Formation.

Holocene Stream Channel deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Tuscan Formation and Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone

of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Holocene Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits along the Sacramento River. Thickness of these deposits can range up to 150 feet and they are observed primarily between Mud Creek and Rock Creek, west of Highway 99. These deposits have low permeability and generally yield low quantities of poor quality water to wells.

The Pleistocene Modesto Formation consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan Formation and Riverbank Formation. The Modesto Formation makes up the majority of the alluvial plain deposits except where older Riverbank Formation terrace deposits occur south of Pine Creek and the overlying basin deposits in the Nord area predominate. Thickness of the formation can range from less than 10 feet to nearly 200 feet across the valley floor.

The Pleistocene Riverbank Formation (older terrace deposits) consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. These deposits underlie the region between Pine Creek and Rock Creek. Thickness of the formation can range from less than 10 feet to nearly 200 feet across the valley floor.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subbasin and extend in the subsurface west of the Sacramento River.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. Unit C is exposed as alluvial upland deposits west of the Chico Monocline, largely north of Singer Creek. South of Singer Creek, the alluvial upland deposits merge with younger alluvial fan and plain deposits.

The Tuscan Formation reaches a thickness of 1,250 feet over older sedimentary deposits. The dip of the formation averages approximately 2.5 degrees, east of the valley, and steepens sharply to 10 to 20 degrees southwestward towards the valley at the Chico Monocline. The formation flattens beneath valley sediments.

Groundwater levels in the northern part of the Butte County show a decline because of the 1976–1977 and 1987–1994 droughts, followed by a recovery of groundwater levels to pre-drought conditions. Year-round extraction of groundwater for municipal use in the Chico area causes several small groundwater depressions that tend to alter the natural southwesterly movement of groundwater in the area. In the Chico area, groundwater level fluctuation in the unconfined portion of the aquifer system is about 5–7 feet during normal precipitation and up to approximately 16 feet during periods of drought. Annual fluctuation in the confined or semi-confined portion of the aquifer system is approximately 15–25 feet during normal years and up to approximately 30 feet during periods of drought. Groundwater levels for the confined or

semi-confined portions of the aquifer system indicate a 10–15-foot decline in groundwater levels since the 1950s.

Groundwater storage capacity was estimated to be 1,468,000 acre-feet. This estimate was based on an average specific yield of 5.9% and an assumed thickness of 200 feet.

Major Sources of Recharge

Recharge to the subbasin is from local precipitation (18–22.5 inches/year), subsurface flow from the Sierra Nevada and foothills, irrigation infiltration, and stream infiltration. Source water for irrigation is a mix of surface and groundwater. Natural recharge takes place along streams and outcrops of the Tuscan Formation to the east of the study area. Sources of non-natural uncontrolled recharge include leakage from pipelines, seepage through the boundaries of the groundwater basin, and most significantly, net irrigation return flows. The Chico Monocline forms a geographic boundary; however, a component of basin recharge is located east of the fault structure.

In an isotopic study of shallow monitoring wells on the east side of the Sacramento Valley, Moran et al. (2004) presented evidence of recent recharge of the Vina groundwater basin from flood irrigation. This study also found that Big Chico Creek significantly recharges the aquifer from the south and groundwater in the Chico area originates in the Sacramento Valley. Tritium concentrations in this same study indicate a pre-1950 recharge date for the groundwater located north of Big Chico Creek.

Estimate of groundwater extraction for agricultural use is estimated to be 130,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet. Deep percolation of applied water is estimated to be 30,000 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 37% of the subbasin, urban land use accounts for about 8% of the subbasin, and native land accounts for about 55% of the subbasin. Of the agricultural land uses, deciduous fruits and nuts make up 29%. Table 4-29 provides details of the land uses within the subbasin.

Table 4-29. Land Use in the Vina Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	400	0.30
Deciduous Fruits and Nuts	36,000	28.90
Field Crops	3,940	3.20
Grain and Hay	2,300	1.80
Pasture	1,900	1.50
Truck, Nursery, and Berry Crops	180	0.10
Idle	1,130	0.90
Semiagricultural and Incidental	570	0.50
Subtotal	46,420	37.20

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Urban—unclassified	5,100	4.10
Urban Landscape	390	0.30
Urban Residential	3,190	2.60
Commercial	300	0.20
Industrial	300	0.20
Vacant	650	0.50
Subtotal	9,930	8.00
Native		
Native Vegetation	64,300	51.50
Barren and Wasteland	230	0.20
Riparian	2,650	2.10
Water	1,220	1.00
Subtotal	68,400	54.80
Total	**124,750**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Vina groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies within the Vina subbasin are: Butte Basin Water User Association, Deer Creek ID, Stanford Vina Ranch ID, City of Chico, Tehama County Flood Control and Conservation District. Groundwater management ordinances were adopted in Butte County in 1996 and in Tehama County in 1994. The Butte County ordinance requires export permits for groundwater extraction and substitute pumping, establishes the Water Commission and Technical Advisory Committee, and provides countywide groundwater monitoring programs. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. Other key issues addressed in the ordinance include off-parcel groundwater use and influence of well pumping restrictions. The city of Chico is located partly within the subbasin, on the southern edge. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium-magnesium bicarbonate and magnesium-calcium bicarbonate are the predominant groundwater types in the subbasin. TDS ranges from 48 to 543 mg/L, averaging 285 mg/L. Groundwater quality issues include localized high calcium and nitrate, TDS and VOCs in the Chico area.

Nitrate

A common water quality problem in several of the subbasins, including Vina, is nitrate contamination by septic leachate and by agricultural activities. Nitrate exceeded the MCL in 4 public supply wells in the Vina subbasin. Nitrate contamination was more commonly found in shallow private wells rather than in the long-screened production wells included in the GAMA study by Moran et al. (2004).

Volatile Organic Compounds

According to the CDPH database, only 4 public wells had had detections of VOCs above MCLs from 1994 through 2000 and none have had MTBE concentrations above the detection limit for reporting for California Code of Regulations Title 22 water (5 parts per billion [ppb]).

More recently, tetrachloroethylene (also known as perchloroethylene, PCE) was detected in 47 public supply wells in the Chico area; all but 4 detections were at concentrations well below the MCL, which is 5,000 ng/L, and 16 were below the public health goal (PHG) of 56 ng/L. The Chico area also has a widespread contaminant plume of PCE. PCE is a solvent used in dry cleaning and metal cleaning operations. Nineteen of the Chico wells with PCE detections also had detections of trichloroethylene (TCE), which likely occurs as a breakdown product. MTBE co-occurred with PCE even more frequently, with 33 PCE-contaminated wells also having MTBE detections, suggesting a high degree of vulnerability to both recently introduced and decades-old contaminants at those wells. Groundwater contamination with VOCs does not appear to be related to irrigated agriculture. (Moran et al. 2004.)

West Butte Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The West Butte subbasin aquifer is part of the Sacramento Valley groundwater basin. It is bound by Big Chico Creek on the north, the Sacramento River on the south and west, by the Chico Monocline on the northeast and by Butte Creek on the east. The aquifer system is 284 square miles in size and is located in parts of Butte, Glenn, and Colusa Counties.

The following description of the hydrogeology in the West Butte subbasin is taken from DWR Bulletin 118 (2004).

The West Butte aquifer system is comprised of deposits of Late Tertiary to Quaternary age. The Quaternary deposits include the Holocene stream channel deposits and basin deposits, and the Pleistocene Modesto Formation, Riverbank Formation, and Sutter Buttes alluvium. The Tertiary deposits consist of the Pliocene Tehama Formation and the Tuscan Formation.

These deposits consist of unconsolidated gravel, sand, silt, and clay derived from the erosion, reworking, and deposition of adjacent Quaternary stream terrace alluvial deposits. The thickness varies from 1 to 80 feet. The unit represents the upper part of the unconfined zone of the aquifer and is moderately-to-highly permeable; however, the thickness and areal extent of the deposits limit the water-bearing capability.

Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread across low-lying areas. They consist primarily of silts and clays and may be locally interbedded with stream channel deposits along the Sacramento River. The deposits extend from south of Big Chico Creek to north of Angel Slough. Thickness of the unit can range from 10 to 100 feet (DWR 2001). The deposits have low permeability and generally yield low quantities of water to wells. The quality of groundwater produced from the unit is often poor (Reclamation 1960).

The Modesto Formation (deposited between 14,000 and 42,000 years ago) consists of poorly indurated gravel and cobbles with sand, silt, and clay derived from reworking and deposition of the Tuscan and Riverbank formations. Surface exposures extend south from Big Chico Creek to north of the city of Durham and extend south of Angel Slough to the Sacramento River. The unit varies in thickness from 50 to 150 feet (DWR 2000). In locations where gravel and sand predominate, groundwater yields are moderate.

The Riverbank Formation (deposited between 130,000 and 450,000 years ago) consists of poorly-to-highly permeable pebble and small cobble gravels interlensed with reddish clay sands and silt. The areal extent of the formation is limited more to the southern portion of the subbasin and underlies surface exposures of the Modesto Formation. The thickness of the formation is approximately 1–200 feet depending on location (DWR 2000). The formation is moderately to highly permeable and yields moderate quantities of water to domestic and shallow irrigation wells.

In the southern extents of the subbasin, Sutter Buttes alluvium is observed in the subsurface and may range in thickness up to 600 feet (DWR 2000). These alluvial fan deposits consist largely of gravel, sand, silt, and clay and may extend up to 15 miles north of the Sutter Buttes and westerly beyond the Sacramento River. Utility pump test records for wells located east of the subbasin, but believed to be in the same formation, show the average well yield for the formation to be approximately 2,300 gpm with an average specific capacity of 64 gpm/ft.

The Tehama Formation consists of sediments originating from the coastal mountains and interfingers with sediments of the Tuscan Formation in the vicinity of the Sacramento River at the far western extent of the subbasin (DWR 2000).

The Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers. Thickness of the formation is estimated to be 800 feet. The formation is described as four separate but lithologically similar units—A through D (with Unit A being the oldest)—which in some areas are separated by layers of thin tuff or ash units. Units A, B, and C are found within the subsurface in the northern part of the subbasin and Units A and B are found in the southern part of the subbasin. Surface exposures of Units A, B, and C are located in the foothills at the far eastern extents of the subbasin. The surface exposure of Unit B east of the subbasin boundary is a recharge area. Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Unit B is olcaniclastic and is the most transmissive portion of the volcanic aquifer system and is the primary aquifer at depth. The surface exposure of Unit B, east of the subbasin boundary, is a recharge area. Although the Tuscan Formation is unconfined where it is exposed near the valley margin, at depth, the formation is confined. Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable underlying sediments of Unit B.

Groundwater levels in the West Butte subbasin tend to fluctuate by 5 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels. DWR (2004) estimated the specific yield to by 7.1% and the storage capacity (to a depth of 200 feet) to be 13 maf.

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and, to a lesser extent precipitation, are also sources of recharge. Big Chico Creek, Little Chico Creek, and Butte Creek are major streams entering the subbasin. The Sacramento River drains the subbasin. Annual precipitation ranges from 17 to 27 inches with higher precipitation occurring to the west. Almost 30% of land is used for rice cultivation where the fields are typically flooded for 6 months each year. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage. Almost all the water used for irrigation in the West Butte subbasin is pumped from groundwater.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1998–1999. The West Butte subbasin is primarily utilized for agricultural purposes with rice fields and orchards covering the highest percentage of land. Table 4-30 provides details on the distribution of land use throughout the West Butte subbasin.

Table 4-30. Land Uses in the West Butte Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	131	0.07
Deciduous Fruits and Nuts	37,122	20.43
Field Crops	19,309	10.63
Grain and Hay	9,466	5.21
Idle	2,093	1.15
Pasture	4,817	2.65
Rice	52,971	29.16
Semiagricultural and Incidental	563	0.31
Truck, Nursery, and Berry Crops	2,564	1.41
Subtotal	129,036	71.03
Urban		
Urban—unclassified	2,065	1.14
Commercial	463	0.25
Industrial	529	0.29
Urban Landscape	160	0.09
Urban Residential	1,461	0.80
Vacant	951	0.52
Subtotal	5,629	3.10
Native		
Riparian	25,149	13.84
Native Vegetation	16,261	8.95
Water	5,062	2.79
Barren and Wasteland	532	0.29
Subtotal	47,004	25.87
Total	**181,669**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the West Butte subbasin aquifer system are: Butte Basin Water Users Association, Buzztail Community Service District, Durham ID, City of Chico, RD 1004, Western Canal WD, M&T Chico Ranch Inc., Sartain MWC (DWR 2004).

The private entities within the West Butte subbasin aquifer system are: Dayton Mutual Water Company, Del Oro Water Company, Durham Mutual Water Company, and California Water Service (DWR 2004).

Butte County adopted a groundwater management ordinance in 1996. Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998 (DWR 2004). These ordinances affect primarily the volume of groundwater that can be pumped in the subbasin. Additionally, the Butte County and Glenn County ordinances established Water Commissions and Technical Advisory Committees and countywide monitoring plans.

This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

Groundwater quality issues in the West Butte subbasin include excess nutrients, dissolved solids, trace elements, and pesticides. Dissolved solids are elevated in localized areas throughout the subbasin and pesticides are persistent in groundwater beneath the rice growing areas (Dawson 2001a). Trace elements are thought to be naturally occurring, as well as nitrates in some locations. However, there is evidence of elevated groundwater salinity (dissolved solids) and concentrations of nutrients and pesticides as the result of irrigated agriculture in the West Butte subbasin (Dawson 2001a). Tables 4-31 and 4-32 summarize the available data.

Table 4-31. Water Quality in the West Butte Subbasin

Constituent of Concern	Available Information about groundwater concentrations for West Butte Subbasin
Nutrients	Median NO_3 concentration under rice fields was 2 mg/L (Domagalski et al. 2000). Nitrate, ammonia, phosphorus measured in shallow groundwater in rice growing areas (Dawson 2001a).
Pesticides (insecticides and herbicides) and degradation products	Dawson (2001a) reported pesticides detections in 89% of the 28 wells sampled, 82% of which were pesticides used on rice fields: bentazon, carbofuran, molinate, and thiobencarb. Bentazon was found in 71% of the wells.
Salt—primarily as electrical conductivity and total dissolved solids.	Localized high EC, TDS, and adjusted sodium absorption ratio (ASAR) (DWR 2004). High TDS concentrations measured in shallow groundwater in rice growing areas (Dawson 2001a).

Constituent of Concern	Available Information about groundwater concentrations for West Butte Subbasin
Trace elements	Localized high calcium, EC, boron (DWR 2004). Dawson (2001a) found concentrations of inorganic constituents that exceeded primary state and federal drinking water standards at least once in 25% of the wells. The inorganic constituents detected above the primary limits were boron, barium, cadmium, molybdenum, or sulfate. Secondary drinking water standards were exceeded at least once in 79% of the wells. The constituents detected above secondary limits were chloride, iron, manganese, specific conductance (EC), or dissolved solids.
Organic carbon and disinfection byproduct precursors	Dissolved organic carbon elevated relative to expected background in some areas (Dawson 2001a).
Microorganisms	No available data.
Volatile organic compounds	One public supply well out of 26 sampled has concentrations above MCL (DWR 2004). According to the CDPH database, one public well had detections of VOCs above MCLs from 1994 to 2000 (Lawrence Livermore National Laboratory GAMA Study [Moran et al. 2004]).

Notes:
mg/L = milligrams per liter.

Table 4-32. Concentrations of Constituents of Concern Detected in the West Butte Subbasin

Constituent Type	Constituent of Concern	Concentration ranges	Drinking Water Standards
Nutrients	Nitrate	Median 2 mg/L (Domagalski et al. 2000)	Nitrate was reported to exceed the MCL in two public supply wells in the West Butte subbasin (Moran et al. 2004).
	Ammonia as N	0.02–0.46 mg/L	30 (HAL)
	Ammonia + organic N as N	0.3–0.7 mg/L	30 (HAL)
	Nitrate+Nitrite, as N	0.08–6.2 mg/L	10 (MCL)
	Nitrate as N	0.08–6.2 mg/L	10 (MCL)
	Nitrite as N	0.01–0.1 mg/L	1 (MCL)
	Orthophosphate, as P	0.01–0.36 mg/L	
	Phosphorus, as P	0.03–0.362 mg/L	
	Dissolved organic carbon, as C	0.3–6.8 mg/L	
Pesticides (insecticides and herbicides) and degradation products*	Atrazine	*0.002*–0.026 µg/L	3 (MCL)
	Bentazon	0.06–*7.8* µg/L	18 (MCL)
	Bromacil	0.19min µg/L	90 (HAL)
	Carbofuran	0.016–0.8 µg/L	18 (MCL)
	Desethyl atrazine	0.001–0.005 µg/L	
	Dichlorprop	0.1min µg/L	
	Diuron	0.04–0.09 µg/L	10 (HAL)

Constituent Type	Constituent of Concern	Concentration ranges	Drinking Water Standards
	Azinphos-methyl	0.014min µg/L	
	Molinate	*0.002*–0.056 µg/L	20 (MCL)
	Simazine	*0.002*–0.027 µg/L	4 (MCL)
	Tebuthiuron	0.006min µg/L	500 (HAL)
	Thiobencarb	0.006–0.025 µg/L	70 (MCL)
Salt—primarily as electrical conductivity and total dissolved solids.		120–1,220 mg/L, mean 391 mg/L (DWR 2004) 168–8,730 mg/L, median 532 mg/L (Dawson 2001a)	
Trace elements	Aluminum	0.002–0.010 mg/L	1 (MCL)
	Arsenic	0.001–0.015 mg/L	0.01 (MCL)
	Barium	0.01–5.05 mg/L	1(MCL)
	Boron	0.02–1.8 mg/L	0.6 (HAL)
	Bromide	0.03–12 mg/L	
	Cadmium	0.006–0.007 mg/L	0.005 (MCL)
	Chromium	0.002–0.016 mg/L	0.05 (MCL)
	Cobalt	0.001–0.004 mg/L	
	Copper	0.001–0.003 mg/L	1.3 (MCL)
	Ferrous Iron Fe^{2+}	Detected in 19/28 wells	
	Fluoride	0.1–1.8 mg/L	4 (MCL)
	Iron Fe	0.003–5.3 mg/L	0.3 (SMCL)
	Manganese	0.05–0.1 mg/L	0.05 (SMCL)
	Molybdenum	0.001–0.051 mg/L	0.04 (HAL)
	Nickel	0.001–0.009 mg/L	0.1 (HAL)
	Selenium	0.003–0.022 mg/L	0.05 (MCL)
	Sulfide	Detected in 14/28 wells	
	Uranium	0.001–0.023 mg/L	2000 (MCL)
	Zinc	0.001–0.017 mg/L	2 (HAL)

Notes:
* Numbers in *italics* are estimates.
MCL = Maximum Contaminant Level set by EPA (2005).
µg/l = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
HAL = Health Advisory Level set by EPA (2005).
Sources: Dawson 2001a, 2001b, unless otherwise indicated.

Nutrients

MCL exceedances of nitrate are reported in 4 public supply wells in the subbasin. Nitrate contamination is more commonly found in shallow private wells rather than in the long-screened production wells included in this study.

Salinity

The chemistry of the recharge waters strongly affects the chemistry of the groundwater in the Sacramento Valley. The geochemical facies of the groundwater in the West Butte subbasin in a mix of the calcium-magnesium bicarbonate waters in the western alluvial fan and the sodium sulfate waters in the eastern alluvial fan. Two processes appear to primarily affect groundwater salinity in the West Butte subbasin: evaporation of irrigation water and shallow groundwater and mixing of naturally occurring saline groundwater (Hull 1984, Olmsted and Davis 1961, Dawson 2001a). Using isotope data, Dawson (2001a) presented evidence that partial evaporation as indicated by the isotope data accounted for some of the measured increase in salinity among shallow groundwater samples.

Pesticides

Rice pesticides Molinate, Thiobencarb, and Carbofuran were detected in 7, 3, and 4 of the 28 wells sampled during the 1997 study by the USGS (Dawson 2001a). The most prevalent pesticide detected in groundwater was bentazon. This chemical was used in rice fields until it was suspended in 1989 and officially banned in 1992. Its presence in groundwater in studies completed in 1997 (Domagalski et al. 2000) suggests it is readily transported in groundwater and does not degrade quickly. Although present in many wells in the rice growing areas of the West Butte subbasin, pesticide concentrations were below state and federal 2000 drinking water standards in all occurrences.

Dawson (2001a) investigated the relationship between groundwater quality and rice cultivation land use practices in data collected during 1998. Dawson (2001a) found that shallower groundwater had more occurrences of pesticide contamination than deeper groundwater, indicating the movement of pesticides from the ground surface downward. Concentrations of bentazon showed a statistical relationship to tritium concentrations. Since tritium is used for age-dating groundwater, this relationship suggests that bentazon concentrations may be related to recharge age of the groundwater in which it was found. Tritium concentrations in all wells except one indicate that groundwater in the rice growing areas of the West Butte subbasin were recharged after 1950. To further identify the date at which the pesticides entered groundwater, the first application dates of the pesticides in the Sacramento Valley were studied. This resulted groundwater recharge dating in the late 1970s.

Irrigation practices can affect the amount of pesticides that reach groundwater. Troiano et al. (1993) investigated difference irrigation methods and found that “leaching of pesticides was less in sprinkler applications because water was applied more frequently in smaller applications than for the basin-flooding method. For basin-flooding treatments, as those practiced on rice fields, a large amount of water application was required for each irrigation in order to provide application across the plot. Although irrigations were less frequent, the larger water volume caused greater downward movement of water and atrazine residues.”

Trace Elements

The chemistry of geology formations in the West Butte subbasin influences the concentrations of trace elements. Dawson (2001a, 2001b) found that the geomorphic unit in which the groundwater resides influences the concentration of arsenic, boron, chloride, fluoride, molybdenum, potassium, sulfate, and zinc. Concentrations of arsenic and potassium were significantly higher in wells in the central flood basin, which contains the West Butte subbasin. Concentrations of nitrate were significantly lower in the central

flood basin. Trace element concentrations do not generally appear to be influenced by irrigated agriculture.

Volatile Organic Compounds

According to the CDPH database, only 4 public wells had had detections of VOCs above MCLs from 1994 to 2000 and none have had MTBE concentrations above the detection limit for reporting for Title 22 water (5 ppb).

Yolo Subbasin—Sacramento Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Yolo subbasin aquifer is bound by Cache Creek in the north, Putah Creek in the south, the Coast Ranges on the west, and the Sacramento River on the east. The aquifer system is 400 square miles in size and is located in parts of Yolo and Solano Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The primary water bearing formations comprising the Yolo subbasin are sedimentary continental deposits of Late Tertiary (Pliocene) to Quaternary (Holocene) age. Fresh water-bearing units include younger alluvium, older alluvium, and the Tehama Formation. The cumulative thickness of these units ranges from a few hundred feet near the Coast Ranges on the west to nearly 3,000 feet near the eastern margin of the basin. Saline water-bearing sedimentary units underlie the Tehama formation and are generally considered the boundary of fresh water.

Younger alluvium includes flood basin deposits and recent stream channel deposits. Flood basin deposits occur along the eastern margin of the subbasin in the Yolo Flood Basin. They consist primarily of silts and clays, but along the eastern margin of the subbasin may be locally interbedded with stream channel deposits of the Sacramento River. Thickness of the unit ranges from 0 to 150 feet. The flood basin deposits have low permeability and generally yield low quantities of water to wells. The quality of groundwater produced from the basin deposits is often poor.

Recent stream channel deposits consist of unconsolidated silt, fine- to medium-grained sand, gravel and occasionally cobbles deposited in and adjacent to active streams in the subbasin. They occur along the Sacramento River, Cache Creek, and Putah Creek. Thickness of the younger alluvium ranges from 0 to 150 feet.

The younger alluvium varies from moderately to highly permeable, but often lies above the saturated zone. Where saturated, the younger alluvium yields significant quantities of water to wells.

Older alluvium consists of loose to moderately compacted silt, silty clay, sand, and gravel deposited in alluvial fans during the Pliocene and Pleistocene. Thickness of the unit ranges from 60 to 130 feet, about one-quarter of which is coarse sand and gravel. Permeability of the older alluvium is highly variable. Wells penetrating sand and gravel lenses of the unit produce between 300 and 1,000 gpm. Adjacent to the Sacramento River, wells completed in ancestral Sacramento River stream channel deposits yield up to

4,000 gpm. Wells completed in the finer-grained portions of the older alluvium produce between 50 and 150 gpm.

The Tehama Formation is the thickest water-bearing unit underlying the Yolo subbasin, ranging in thickness from 1,500 to 2,500 feet. Surface exposures of the Tehama Formation are limited mainly to the Coast Range foothills along the western margin of the basin, as well as in the Plainfield Ridge. The Tehama consists of moderately compacted silt, clay, and silty fine sand enclosing lenses of sand and gravel, silt and gravel, and cemented conglomerate. Permeability of the Tehama Formation is variable, but generally less than the younger units. Because of its relatively greater thickness, however, wells completed in the unit can yield up to several thousand gallons per minute.

Underlying the Tehama Formation are brackish to saline water-bearing sedimentary units, including the somewhat brackish sedimentary rocks of volcanic origin (Pliocene to Oligocene?) underlain by marine sedimentary rocks (Oligocene? to Paleocene) which are typically of low permeability and contain connate water. The upper contact of these units generally coincides with the fresh/saline water boundary. The contact is found near the Coast Range at depths as shallow as a few hundred feet. Near the eastern margin of the basin it reaches depths of nearly 3,000 feet.

The geologic structure of the groundwater subbasin is dominated by an anticlinal ridge oriented northwest to southeast, which is expressed at the surface as the Dunnigan Hills and Plainfield Ridge. The anticlinal structure impedes subsurface flow from west to east. Subsurface groundwater outflow sometimes occurs from the Yolo subbasin into the Solano subbasin to the south. Subsurface outflow and inflow may also occur beneath the Sacramento River to the east with the South and North American subbasins. Subsurface groundwater inflow may occur from the west out of the Capay Valley Basin.

DWR (2004) estimated the specific yield to be 6.5 to 9.7% and the storage capacity (20–400 feet) to be approximately 6.5 maf.

Major Sources of Recharge

Irrigation is the primary source of groundwater recharge to the subbasin. Regionally, stream infiltration and to a lesser extent precipitation are also sources of recharge. Major streams above the Yolo subbasin are Cache Creek, Putah Creek, and the Sacramento River. Annual precipitation ranges from 18 to 24 inches with higher precipitation occurring to the west. Groundwater discharge occurs as evapotranspiration, loss to streams, and pumpage.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 69% of the subbasin, urban land use accounts for about 12% of the subbasin, and native land accounts for about 19% of the subbasin. Table 4-33 provides details on the distribution of land use throughout Yolo Subbasin.

Table 4-33. Land Use in the Yolo Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	226	0.10

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	11,359	5.03
Field Crops	41,426	18.34
Grain and Hay	33,421	14.80
Idle	4,807	2.13
Pasture	22,609	10.01
Rice	12,951	5.73
Semiagricultural and Incidental	1,714	0.76
Truck, Nursery, and Berry Crops	26,372	11.68
Vineyards	360	0.16
Subtotal	155,244	68.74
Urban		
Urban—unclassified	13,606	6.02
Commercial	1,216	0.54
Industrial	4,625	2.05
Urban Landscape	1,178	0.52
Urban Residential	2,546	1.13
Vacant	4,223	1.87
Subtotal	27,393	12.13
Native		
Barren and Wasteland	534	0.24
Riparian	2,702	1.20
Native Vegetation	37,251	16.49
Water	2,724	1.21
Subtotal	43,211	19.13
Total	**225,848**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The public entities within the Yolo subbasin aquifer system are: Yolo County Flood Control and Water Conservation District, City of Woodland, City of Davis, City of West Sacramento (DWR 2004). The private entities within the Yolo subbasin aquifer system are RDs 108, 900, 2035, and 2068 (DWR 2004).

In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. RD 108 adopted an AB 3030 plan in February 1995. RD 2035 adopted an AB 3030 plan in April 1995. RD 2068 adopted an AB 3030 plan in January 1997. Yolo County Flood Control and Water Conservation District is drafting a plan but it is not pursuant to AB 3030.

This subbasin falls within the area included in the Sacramento Valley and Rice Water Quality Coalitions.

Water Quality

Groundwater Quality issues in the Yolo subbasin include high dissolved solids, boron, selenium and nitrate. Hardness, which is mainly a reflection of the amount of calcium and magnesium in water, is considered very high, with values generally greater than 180 mg/L (Evenson 1984).

High average concentrations of dissolved solids, calcium, magnesium, sodium, chloride, and fluoride exist in the alluvial fans adjacent to the Coast Range in the southwestern margin of the Sacramento Valley. Boron and bicarbonate concentrations are very high. Silica concentrations are generally low. TDS measured in wells in this area show trends of significant increase in dissolved solids since the 1950s, while wells measured for nitrates showed no significant change over time (Hull 1984). Groundwater to the west of the Sacramento River in Yolo County is recharged by eastward flowing streams that drain the marine sediments to the west. This water is predominantly magnesium and magnesium-sodium bicarbonate and is of poorer quality than Sacramento Valley Basin water derived from the east (DWR 1974).

A USGS study (Evenson 1985) analyzed water quality in the Solano and Yolo Counties. Constituents that were measured include: dissolved solids, harness, chloride, fluoride, sulfate, nitrogen, arsenic, boron, iron, and manganese. Except where otherwise noted, the following is a summary of the findings as they pertain to the Yolo subbasin.

Using stable isotope data, Davisson and Criss (1993) elucidated the processes influencing increasing groundwater salinity in the Davis area. Specifically, their data supported the hypothesis of higher salinity groundwater within about 240 feet of land surface could be attributed to infiltration of irrigation water. The increased isotopic enrichment of this groundwater indicated soil evaporation associated with irrigated agriculture. This isotopic enrichment was also associated with high nitrate concentrations indicating fertilization influence.

Pesticides

According to DPR (2004), for the period of 1985 to 2003, atrazine, bentazon, and simazine were detected in Yolo County. Sampling locations and concentrations were not specified.

Nitrogen

Nitrogen concentrations varied over the subbasin, with some domestic wells sampled having concentrations above the EPA limit of 10 mg/L nitrate-nitrogen. The maximum concentration was 24 mg/L.

Boron

Boron concentrations were greater than 0.75 mg/L from Zamora to Knights Landing. High boron concentrations were generally found in water sampled from wells near Cache Creek; this indicates that surface water from the creek may be a source for high boron levels in the surrounding groundwater.

Arsenic

Arsenic concentrations are less than the EPA primary drinking water regulated limit of 0.05 ppm. The highest concentrations are along the northern and eastern margins of the Yolo subbasin.

Iron

Iron concentrations are generally low with respect to federal standards (MCL = 0.3 ppm) in the Yolo subbasin. Along the Cache Creek and in the eastern part of the study area, values ranged form 0.02 to 0.49 mg/L. In other areas, all wells sampled contained less than 0.02 mg/L.

Manganese

Groundwater sampled near the Sacramento River in the southeastern part of the subbasin had the highest concentrations of manganese (greater than 0.1 mg/L), with concentrations decreasing as a function of distance from the river. Wells sampled in the western half of the Yolo subbasin had levels generally below 0.01 mg/L. The MCL (as a secondary constituent) for manganese is 0.05 ppm.

South Fork Pit River Subbasin—Alturas Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Fork Pit River groundwater subbasin is located in Lassen and Modoc Counties and is 114,000 acres (178 square miles) in size. It is bounded on the east by Plio-Pleistocene basalt and Pleistocene Pyroclastic rocks of the Warner Mountains, to the north by Pleistocene basalt of Devils Garden, to the south by Plio-Pleistocene basalt, and to the west by Warm Springs tuff. The South Fork Pit River enters the subbasin near the community of Likely and flows north through the South Fork Pit River Valley to its confluence with the North Fork Pit at the town of Alturas.

The following description of the hydrogeology in the South Fork Pit River subbasin is taken from DWR Bulletin 118 (DWR 2004).

The principal water-bearing formations are Holocene sedimentary deposits (which include alluvial fan deposits, intermediate alluvium, and basin deposits), Pleistocene lava flows and near-shore deposits, and Plio-Pleistocene Alturas Formation and basalts.

The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits—each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water.

Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells.

Basin deposits consist of unconsolidated, interstratified clay, silt, and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

The Pleistocene near-shore deposits consist of slightly consolidated to cemented, poorly to well stratified pebble and cobble gravel with lenses of sand and silt to a thickness of 200 feet. The most extensive near-shore deposits occur in the northeast corner of the basin where the North Fork Pit River enters the valley. Other minor areas of these deposits occur but are not considered significant as water-bearing areas. These deposits have moderate permeability and may yield fair to moderate amounts of unconfined and confined water to wells.

The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone, and diatomite, and is widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the Alturas Formation are the principal water-yielding materials in the South Fork Pit River subbasin. These sediments have a moderate to high permeability and, where saturated, can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

Water levels generally declined up to 10 feet in the northern part of the subbasin during the period from the early 1980s through the early 1990s and have recovered to former levels since 1999.

The groundwater storage capacity to a depth of 800 feet is estimated to be approximately 7.5 maf for the entire Alturas Groundwater Basin (which includes the South Fork Pit River Subbasin and the Warm Springs Valley Subbasin) (DWR 1963).

DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 13,000 and 260 acre-feet respectively. These estimates are based on surveys conducted by the DWR during 1997.

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

The Alturas Groundwater Basin is utilized for irrigation. In 1979 DWR estimated pumpage of groundwater to be about 4,400 acre-feet (DWR 1986). The movement of groundwater through the Alturas Basin generally follows the topography.

The South Fork Pit River is the primary stream in the subbasin. It enters the subbasin from the south and continues north until is converges with the North Fork Pit River near Alturas in the northern portion of the subbasin. DWR (1986) states that the Pit River and its tributaries generally recharge the groundwater basin and therefore would not be a pathway for groundwater contaminant transport.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, and stream infiltration. Annual precipitation ranges from 13 to 19 inches. Deep percolation of applied water is estimated by DWR (2004) to be 9,600 acre-feet/year. The south and north forks of the Pit River influence groundwater in the subbasin.

Most recharge to the Alturas Groundwater Basin occurs in the upland areas of the western slope of the Warner Mountains (DWR 1986). The Pit River and other tributary streams recharge the groundwater in the subbasin as well.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. The South Fork Pit River subbasin is overlain with 31% agricultural land uses, 26% of which is rangeland. Table 4-34 provides details of the land uses within the subbasin.

Table 4-34. Land Use in the South Fork Pit River Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	2,446	2.14
Idle	632	0.55
Pasture	30,077	26.35
Rice	2,754	2.41
Semiagriculture and Incidental	480	0.42
Subtotal	36,389	31.88
Urban		
Commercial	172	0.15
Industrial	264	0.23
Urban Landscape	90	0.08
Urban Residential	2,671	2.34
Vacant	200	0.18
Subtotal	3,397	2.98
Native		
Riparian	2,542	2.23
Native Vegetation	69,372	60.78
Water	2,437	2.13
Subtotal	74,351	65.14
Total	**114,137**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). Alturas is the largest city in the subbasin. Public water agencies involved with the subbasin are the City of Alturas, California Pines Community Service District, and Hot Springs Valley Irrigation District. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate and sodium-calcium bicarbonate type waters are the predominant water types in the subbasin. TDS ranges from 180 to 800 mg/L, averaging 357 mg/L. Water quality concerns in the Alturas Basin are high concentrations of TDS, nitrate, iron, and boron (DWR 1963).

In 1986, DWR published a study of the Alturas Basin (which includes the South Fork Pit River subbasin) groundwater quality. The study concluded that the general water quality of the Alturas Basin was good but there were some localized problems that were limiting the groundwater's beneficial use. The water quality issues were high concentrations of salts, sulfate, boron, and chloride. Most of the problem wells were wells that draw from the groundwater in the Alturas Formation and groundwater that migrates along faults. Table 4-35 displays the results of this study.

Table 4-35. Data from DWR Study of the Alturas Basin in 1986

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate	0–38 mg/L, median is 4.2 mg/L (16 wells monitored)	10 (MCL)
Salt—as total dissolved solids.		100–1,600 mg/L, median is 260 mg/L	500 (SMCL)
	Adjusted sodium adsorption ratio (ASAR)	0–23.9 mg/L, 10 of 118 wells had values of 9 or greater	Ratio ≥ 9 can cause severe problems with sodium buildup in soils
Trace elements	Boron	0–4.6 mg/L, median is 0.03 mg/L	
	Chloride	0–271 mg/L, median is 8 mg/L	250 (SMCL)
	Sulfates	0–626 mg/L, median is 16 mg/L	250 (SMCL)
Hardness		2–506 mg/L (as $CaCO_3$), median is 76 mg/L	

Constituent Type	Constituent of Concern	Concentration ranges	Standards

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).

Warm Springs Valley Subbasin—Alturas Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Warm Springs Valley groundwater subbasin is located in Modoc County and is 68,000 acres (106 square miles) in size. It is bound on the east by a low mesa of the Plio-Pleistocene Alturas Formation (separating Warm Springs Valley from South Fork Pit River Valley); to the north by the Pleistocene basalt of Devils Garden; to the south by Plio-Pleistocene Warm Springs tuff and basalt and to the west by Pleistocene basalt (Gay 1968).

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage. From the confluence of the North and South Forks of the Pit River, just to the east at Alturas, the Pit River flows westerly through Warm Springs Valley.

The following description of the hydrogeology in the Warm Springs Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The principal water-bearing formations are Holocene sedimentary deposits, Pleistocene lava flows, and Plio-Pleistocene Alturas Formation and basalts. The following summary of water-bearing formations is from DWR (1963).

The Holocene sedimentary deposits include alluvial fan deposits, intermediate alluvium, and basin deposits—each up to a thickness of 75 feet. Alluvial fan deposits consist of unconsolidated to poorly consolidated, crudely stratified silt, sand and gravel with lenses of clay. These deposits generally have high permeability and are capable of yielding large amounts of water to wells. This unit may include confined as well as unconfined water.

Intermediate alluvium consists of unconsolidated poorly sorted silt and sand with some lenses of gravel. These deposits have moderate permeability and yield moderate amounts of water to shallow wells.

Basin deposits consist of unconsolidated, interstratified clay, silt, and fine sand. These deposits have moderate to low permeability and yield small amounts of water to wells.

The Pleistocene volcanic rocks consist of lava flows of layered, jointed basalt ranging in thickness from 50 to 250 feet. These basalt flows serve as recharge zones where exposed in the uplands surrounding the basin. Within the basin, where saturated, scoriaceous zones and joints in the basaltic flows can yield moderate amounts of water to wells. These flows occur interbedded with the upper member of the Alturas Formation in the valley areas.

The Plio-Pleistocene Alturas Formation consists of moderately consolidated, flat-lying beds of tuff, ashy sandstone, and diatomite, and is widespread both at the surface and at depth. The upper and lower sedimentary members of the formation are each about 400 feet thick, and are separated by a basalt member and the Warm Springs tuff. The sediments of the formation are the principal water-yielding materials in the Warm Springs Valley Subbasin. These sediments have a moderate to high permeability and where saturated can yield large amounts of groundwater to wells. The formation contains both confined and unconfined groundwater.

The groundwater regime between Warm Springs Valley and South Fork Pit River Valley is continuous through a north-to-northwest trending highland, west and south of Alturas, that forms two distinct valleys with separate surface drainage.

Exposures of Warm Springs tuff in Sections 10 and 15, Township 42 North, Range 11 East, act as a partial barrier to the westward movement of groundwater from South Fork Pit River Valley to Warm Springs Valley (DWR 1963).

The Alturas Groundwater Basin is utilized for irrigation. In 1979 DWR estimated pumpage of groundwater to be about 4,400 acre-feet (DWR 1986). The movement of groundwater through the Alturas Basin generally follows the topography.

From the confluence of the North and South Forks of the Pit River, just to the east at Alturas, the Pit River flows westerly through Warm Springs Valley. DWR (1986) states that the Pit River and its tributaries generally recharge the groundwater basin and therefore would not be a pathway for groundwater contaminant transport.

Water levels declined approximately 20 feet in the western part of the subbasin during the period between 1985 and the early 1990s and have recovered to approximately 5 feet elevation as of 1999.

The groundwater storage capacity to a depth of 800 feet is estimated to be approximately 7.5 maf for the entire Alturas Groundwater Basin (which includes the South Fork Pit River Subbasin and the Warm Springs Valley Subbasin) (DWR 1963).

DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 3,000 and 270 acre-feet, respectively. These estimates are based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the subbasin is from precipitation, irrigation infiltration, stream infiltration, and subsurface flow. Most recharge occurs in the upland areas of Devils Garden and Portuguese Ridge (DWR 1986). Upland recharge areas consist of permeable lava flows of Plio-Pleistocene and Pleistocene age. Precipitation falling on these areas infiltrates the lava flows and moves toward the valley floor (DWR 1963). The Pit River and other tributary streams recharge the groundwater in the subbasin as well. The average annual precipitation in the subbasin ranges from 13 to 19 inches increasing toward the west. Deep percolation of applied water is estimated by DWR (2004) to be 3,300 acre-feet.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1997. The Warm Springs Valley subbasin is overlain with 26% agricultural land uses, 21% of which is rangeland (pasture). Table 4-36 provides details of the land uses within the subbasin.

Table 4-36. Land Use in the Warm Springs Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	1,731	2.55
Idle	1,873	2.75
Pasture	14,089	20.72
Semiagricultural and Incidental	172	0.25
Subtotal	17,865	26.27
Urban		
Urban—unclassified	316	0.47
Commercial	21	0.03
Industrial	186	0.27
Urban Landscape	4	0.01
Urban Residential	162	0.24
Vacant	89	0.13
Subtotal	777	1.14
Native		
Native Vegetation	47,207	69.41
Water	1,352	1.99
Riparian	807	1.19
Subtotal	49,366	72.59
Total	**68,008**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the subbasin. A key element of the Modoc County ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004).

Public water agencies involved with the subbasin are the California Pines Community Service District, and Hot Springs Valley Irrigation District. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate and sodium-calcium bicarbonate type waters are the predominant water types in the Alturas Groundwater Basin. The concentration of TDS ranges from 180 to 800 mg/L, averaging 357 mg/L (DWR 2004).

Kelly Hot Springs has water high in concentrations of TDS, boron, and fluoride. There is also high conductivity; adjusted sodium absorption ratio; and sulfate, iron, nitrate, calcium, manganese, and boron in localized areas of the subbasin. (DWR 2004)

In 1986, DWR published a study of the Alturas Basin (which includes the Warm Springs subbasin) groundwater quality. The study concluded that the general water quality of the Alturas Basin was good, but some localized problems were limiting the groundwater's beneficial use. The water quality issues were high concentrations of salts, sulfate, boron, and chloride. Most of the problem wells were wells that draw from the groundwater in the Alturas Formation and groundwater that migrates along faults. Table 4-37 displays the results of this study.

Table 4-37. Data from DWR Study of the Alturas Basin in 1986

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate	0–38 mg/L, median is 4.2 mg/L (16 wells monitored)	10 (MCL)
Salt—as total dissolved solids.		100–1,600 mg/L, median is 260 mg/L	500 (SMCL)
	Adjusted sodium adsorption ratio (ASAR)	0–23.9, 10 of 118 wells had values of 9 or greater	Ratio ≥ 9 can cause severe problems with sodium buildup in soils
Trace elements	Boron	0–4.6 mg/L, median is 0.03 mg/L	
	Chloride	0–271 mg/L, median is 8 mg/L	250 (SMCL)
	Sulfates	0–626 mg/L, median is 16 mg/L	250 (SMCL)
Hardness		2–506 mg/L (as $CaCO_3$), median is 76 mg/L	

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).

American Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The American Valley Basin is 11 square miles in size and is located in Plumas County. The following information about the physiography and hydrogeology of the basin is taken from DWR Bulletin 118 (2004). The American Valley Groundwater Basin is bounded to the southwest and northeast by a northwest trending fault system. The basin is bounded to the northeast by Paleozoic metavolcanic rocks and is bounded on all other sides by Paleozoic marine sedimentary and meta-sedimentary rocks of the Sierra Nevada. Spanish Creek drains the valley and is tributary to the North Fork Feather River to the northwest.

Hydrogeologic information was not available for the Water-Bearing Formations and groundwater level Trends for the American Valley Basin. Storage capacity is estimated to be 50,000 acre-feet for a saturated depth interval of 10–210 feet.

Well yields for municipal/irrigation wells in the basin average 40 gal/min, based on 2 well completion reports. Total depths of domestic wells range from 20 to 561 feet, with an average of 127 feet, based on 286 well completion reports. Total depths of municipal/irrigation wells range from 44 to 250 feet, with an average of 125 feet, based on 15 well completion reports. According to a 1997 DWR survey of land use and sources of water, the estimated groundwater extraction for municipal and industrial uses in the American Valley Basin is estimated to be 1,400 acre-feet. Deep percolation of applied water is estimated to be 800 acre-feet. Groundwater generally discharges to Spanish Creek and groundwater wells (DWR 2004).

Major Sources of Recharge

The primary source of groundwater recharge is precipitation ranges from 43 to 49 inches per year, increasing to the southwest (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for over 42% of the subbasin, urban land use accounts for about 20% of the subbasin, and native land accounts for about 37% of the subbasin. Table 4-38 provides details on the distribution of land use throughout the American Valley Basin.

Table 4-38. Land Use in the American Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3	0.05
Pasture	2,857	42.02
Semiagricultural and Incidental	33	0.49

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	2,893	42.55
Urban		
Commercial	136	2.01
Industrial	235	3.45
Urban Residential	931	13.69
Vacant	63	0.93
Subtotal	1,365	20.08
Native		
Riparian	226	3.32
Native Vegetation	2,303	33.88
Water	12	0.17
Subtotal	2,541	37.37
Total	**6,799**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the American Valley Groundwater Basin. Public water agencies in the basin include Quincy Community SD and East Quincy Services District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Between 1994 and 2000, groundwater in the American Valley Basin was sampled for primary inorganics, radiologicals, nitrates, pesticides, VOCs and SVOCs, and secondary inorganics, as required under CDPH Title 22 program. VOCs/SVOCs were detected at concentrations above the MCL in 1 of 13 wells sampled, and secondary inorganics were detected above the MCL in 7 of 29 wells sampled. Primary inorganics, radiologicals, nitrates, and pesticides were not detected above the MCL in any of the wells sampled (DWR 2004).

Antelope Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Antelope Creek Groundwater Basin is 3 square miles (2,040 acres) and it is located in Colusa County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Antelope Creek Groundwater Basin is located east of Black Mountain in Antelope Valley. The basin consists of Quaternary alluvium and is bounded on all sides by Upper Cretaceous marine deposits. Several northeast trending faults may transect the valley. The basin is drained to the north by Antelope Creek.

Hydrologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use is estimated to be 2 acre-feet. Deep percolation of applied water is estimated to be 1 acre-foot.

Major Sources of Recharge

Annual precipitation is approximately 18 inches and is the primary source of recharge in the basin (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 3% of the basin, urban land use accounts for about 3% of the basin, and native land accounts for about 94% of the basin. Table 4-39 provides details on the distribution of land use throughout the Antelope Creek Basin.

Table 4-39. Land Use in the Antelope Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	97	4.77
Subtotal	97	4.77
Urban		
Urban Residential	30	1.48
Subtotal	30	1.48
Native		
Native Vegetation	1,912	93.69
Water	1	0.07
Subtotal	1,913	93.75
Total	**2,041**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County adopted a groundwater management ordinance for the Antelope Creek Basin in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramneto Valley Water Quality Coalition.

Water Quality

Water-quality information for this basin could not be found.

Ash Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Ash Valley Groundwater Basin is an alluvial filled valley located within a region of northwest trending faults. The basin is bounded to the east and west by Miocene basalt, to the north by Pliocene basalt, and to the north by Tertiary pyroclastic rocks and Pliocene basalt. The valley is drained to the northwest by Ash Creek. The area of the basin is 4,870 acres and is located in northeastern Lassen County.

DWR estimated the groundwater extraction for the Ash Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 3 acre-feet annually. Deep percolation of applied water was estimated to be 560 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and irrigation. Annual precipitation in the valley ranges from 17 to 21 inches, increasing to the north (DWR 2004). Deep percolation of applied water was estimated to be 560 acre-feet by DWR in 1997. The valley is drained to the northwest by Ash Creek.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 37% of the basin and native land accounts for about 63% of the basin. There is no urban land in the Ash Valley basin. Table 4-40 provides details of the land uses within the basin.

Table 4-40. Land Use in the Ash Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	2,250	37.40
Subtotal	2,250	37.40
Native		
Native Vegetation	3,750	62.40
Water	10	0.20
Subtotal	3,760	62.60
Total	**6,010**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Bear Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Bear Valley Groundwater Basin is an elongated north-south trending valley located adjacent to the Stony Creek Fault. The basin consists of Quaternary alluvium bounded by Mesozoic lower Cretaceous marine sedimentary rocks and the Knoxville Formation (Jennings 1960). The basin is located in Colusa County and is 9,110 acres (14 square miles) in size.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1993 survey. Groundwater extraction for municipal and industrial uses is estimated to be 5 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration. Annual precipitation ranges from 21 to 23 inches. Deep percolation of applied water is estimated by DWR (based on a 1993 survey) to be 12 acre-feet. The basin is drained to the south by Bear Creek. Other creeks in the basin are Mill Creek, Trout Creek, Rathbone Creek, Arrasatre Creek, Metcalf Creek, and Grout Creek.

Land Uses

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 6% of the basin and native land use accounts for about 94% of the basin. Table 4-41 provides details of the land uses within the Bear Valley basin.

Table 4-41. Land Use in the Bear Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	120	1.32
Pasture	380	4.17
Semiagricultural and Incidental	10	0.11
Subtotal	510	5.59
Native		
Native Vegetation	1,380	97.87
Barren and Wasteland	50	0.55
Subtotal	8,610	94.41
Total	**9,120**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County enacted a groundwater ordinance in 1998. This ordinance limits the amount of groundwater exported from the county. There are no cities or water agencies in the Bear Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Berryessa Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Berryessa Valley Basin aquifer system is 2 square miles in size and is located in Napa County. The following description of the hydrogeology in the Berryessa Valley Basin is taken from DWR Bulletin 118 (2004). The Berryessa Valley Basin is located on the eastern shores of Lake Berryessa in a sparsely populated region of Napa County along the western flanks of Rocky Ridge in the Coast Ranges, approximately 14 miles northwest of the town of Winters. Two narrow swaths of shallow alluvium along the banks of Lake Berryessa, each about 2.5 miles in length, define the basin. This alluvium extends into the lower elevations of the Berryessa Valley, which was flooded by Lake Berryessa after the construction of Monticello Dam in 1957.

Putah Creek, which flows into Lake Berryessa, is the primary surface water source for the Berryessa Valley, other than the lake. Additionally, several intermittent streams flow into Berryessa Valley Basin from the east. The basin is located within the Upper Putah Creek watershed.

Water Bearing Formations include Alluvium, described as poorly sorted stream and basin deposits. Beneath the alluvium lies the basement rock of the Lower Cretaceous Great Valley Sequence, comprised of marine mudstone, sandstone, and conglomerate. This basement rock is generally considered to be non-water bearing, but it does provide water through fractures.

No information related to groundwater level trends was available for this basin.

Major Sources of Recharge

The Berryessa Valley Basin receives approximately 18 inches to 24 inches of precipitation annually (DWR 2004) and this is the major source s of groundwater recharge. There is also stream recharge.

Land Use

Most of the lands in the Napa County area are low intensity brushlands, rangelands, and lands used in years past for quicksilver and gold mining (Sacramento Valley Water Quality Coalition 2004). Wine grape production encompasses the majority of intensive agricultural acreage in the county, with olive production providing the balance. The majority of land in wine grape and olive production is probably irrigated. Drip irrigation is almost exclusively the mode of water delivery to these crops, although a small percentage of lands utilize overhead sprinklers for early spring frost protection in wine grapes. Dryland pastures and oat hay acreages exist in the county as well. None of these lands are irrigated.

Land use surveys were conducted within the basin by DWR in 1999. Agricultural land use accounts for less than 1% of the basin, and native land use accounts for about 99% of the basin. Table 4-42 provides details on the distribution of land use throughout the Berryessa Valley Basin.

Table 4-42. Land Use in the Berryessa Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Semiagricultural and Incidental	11	0.80
Subtotal	11	0.80
Native		
Native Vegetation	1,159	84.30
Water	205	14.90
Subtotal	1,159	99.20
Total	**1,170**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There is currently no groundwater management plan in effect for the Berryessa Valley Basin. No public or private water agencies exist within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Information for groundwater quality in the Berryessa Groundwater Basin is unavailable.

Big Valley (5-15) Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Big Valley Basin (5-15) is bordered by Plio-Pleistocene extrusive rocks of Mt. Konocti and Camelback Ridge on the east and southeast, the Jurassic-Cretaceous Franciscan Formation to the west and south, and Clear Lake to the north. The basin shares a boundary with the Scott Valley Basin to the northwest and may be hydrologically contiguous. The basin area is 38 square miles and it is located in Lake County.

The following description of the hydrogeology in the Big Valley Basin is taken from DWR Bulletin 118 (2004). For the purpose of this basin summary, the valley has been divided into five subbasins based on geologic conditions, groundwater boundaries, and topography. These areas are referred to as the Western Upland, the Adobe Creek-Manning Creek Subbasin, the Kelseyville Subbasin, the Central Upland and Upper Big Valley Subbasin, and the Cole Creek Upland.

The Western Upland is a one-half to one-mile wide topographic bench located along the western margin of the basin. The Adobe Creek - Manning Creek Subbasin is located east of the Western Upland, extends north to the Big Valley Fault, and is hydrologically connected to the Kelseyville Subbasin. The Kelseyville Subbasin is located north of the Big Valley Fault and extends north to Clear Lake. The Central Upland and Upper Big Valley Subbasin includes the eastern half of the basin south of the Big Valley Fault and is geologically similar to the Western Upland but is separated topographically by the Adobe Creek—Manning Creek Subbasin and separated structurally by the Adobe Creek Fault system. The Cole Creek Upland is located east of the Central Upland and Upper Big Valley system and is bounded to the north by the Mt. Konocti volcanics and to the south by Camel Back Ridge.

The Big Valley Basin is comprised of extensive Quaternary to late Tertiary alluvial deposits, including fan deposits, lakebed and flood plain deposits, and terrace uplands. The primary water-bearing formations in the basin are Quaternary alluvium, lake, and terrace deposits and Upper Pliocene to Lower Pleistocene volcanic ash deposits.

Surface distribution of younger alluvium is observed throughout the Adobe Creek—Manning Creek and Kelseyville aquifer systems. The younger alluvium generally extends to depths of 40–90 feet and consists of alternating strata of gravel, sand, silt, and clay. Alluvial fan deposits extend from the eastern boundary to the northeast-southwest trending Adobe Creek Fault Zone.

Quaternary terrace deposits are observed south of the east-west trending Wight Way Fault system and along the western margin of the valley within the Western Upland. The deposits consist of red-brown, poorly stratified, sand, clay, and moderately well rounded gravels. Permeability of the formation is generally low. The deposits range in thickness from 50 to 100 feet.

Plio-Pleistocene lake deposits underlie all terrace deposits and younger alluvium in most places. The deposit consists of blue clay with alternating strata of shale and limestone. Permeability of the formation is generally low; however, groundwater flow through sedimentary strata and volcanic deposits can be significant. Thickness of the formation ranges up to 500 feet.

An unconsolidated coarse ash deposit ranging in depth from 70 to 240 feet has been encountered in a number of wells. The volcanic ash is a thin bed of lithic tuff confined within older semi-consolidated sediments and occupies the Western Upland, Adobe Creek-Manning Creek, and most of the Central Upland and Upper Big Valley aquifer system situated south of the Big Valley Fault. The ash layer is offset by the northeast/southwest trending Adobe fault system. Groundwater contained within the deposit is confined with pressure heads ranging from 100 to 150 feet. Thickness of the deposit averages 2 feet.

Groundwater levels in the Big Valley Basin tend to fluctuate from 5 to 15 feet in normal and dry years. There is no consistent decreasing trend in the aquifer levels; however, there are identified locations where overdraft conditions have occurred during drought years (Lake County Flood Control and Water Conservation District 1999). DWR (2004) estimated the storage capacity (to a depth of 100 feet) to be 105,000 acre-feet. Useable storage is estimated to be 60,000 acre-feet. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 24,000 and 410 acre-feet respectively. Deep percolation from applied water is estimated to be 5,600 acre-feet (DWR 2004).

Major Sources of Recharge

According to DWR (2004), recharge in the northern portion of the Big Valley Basin is primarily infiltration from Kelsey Creek and by underflow from the Adobe Creek-Manning Creek Subbasin. Underflow occurs mainly from more permeable zones at depths of 25–45 feet and 70–90 feet. A limited amount of underflow probably enters the basin from the Central Upland system and from Mt. Konocti. Some recharge by infiltration of rain, applied water, and creek water occurs in areas other than the Kelsey Creek flood plain; however, direct surface recharge is inhibited by clayey soil and the near surface clay layer. Recharge within the Adobe Creek-Manning Creek Subbasin is from percolation from the channels of Highland and Adobe Creeks and from underflow from the Western Upland and Central Upland areas. Precipitation in the basin ranges from 22 to 35 inches annually, decreasing to the northeast.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 43% of the basin, urban land use accounts for about 1% of the basin, and native land accounts for about 56% of the basin. Table 4-43 provides details on the distribution of land use throughout the Big Valley Basin.

Table 4-43. Land Use in the Big Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	7,501	8.15
Idle	4,648	5.05
Pasture	25,794	28.02
Rice	933	1.01

Land Use	Acreage of Land Use	Percent of Land Use
Semiagrcultural and Incidental	634	0.69
Truck, Nursery, and Berry Crops	45	0.05
Subtotal	39,555	42.96
Urban		
Urban—unclassified	302	0.33
Commercial	19	0.02
Industrial	266	0.29
Urban Landscape	28	0.03
Urban Residential	242	0.26
Vacant	16	0.02
Subtotal	873	0.95
Native		
Riparian	6,056	6.58
Native Vegetation	44,731	48.59
Water	853	0.93
Subtotal	51,640	56.09
Total	**92,067**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance and an AB 3030 groundwater management plan in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The County of Lake is the only public water agency within the Big Valley Basin (DWR 2004).

In 1992, Lake County adopted the Lake County Aggregate Resource Management Plan (ARMP), which updates and replaces the Creek Management Plan of 1981. The purpose of these plans is to limit in-channel gravel mining activities that compromise groundwater storage capacity and groundwater recharge to the aquifer (Lake County Flood Control and Water Conservation District 1999).

Lake County adopted County Ordinance No. 1823 in 1989 that sets minimum standards for the construction of water wells and requires destruction of unused wells in a manner that adequately protects the source aquifer.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The groundwater chemistry in the Big Valley Basin is predominantly magnesium bicarbonate. TDS ranges from 270 to 790 mg/L, averaging 535 mg/L. High levels of boron are present in groundwater along the eastern, southern, and northern perimeters of the valley, at concentrations that may be injurious to crops (DWR 1978, 2004). Elevated levels of iron and boron have been detected in groundwater adjacent

to faults that underlie the aquifer and are believed to be the result of intrusion of geothermal waters (Lake County Flood Control and Water Conservation District 1999). Boron and iron levels tend to be higher in the fall when groundwater levels are lower.

Contaminated groundwater has not been documented in the aquifer (Lake County Flood Control and Water Conservation District 1999), however, analysis in 1993 showed some increases in nitrate levels in individual wells. The nitrate source or contamination trends were not identified due to an insufficient number of wells analyzed.

Secondary inorganics were detected at concentrations above the MCL in 6 of 8 public supply wells sampled by DWR (2004). There were no detections above the MCL in the public supply wells sampled for primary inorganics, radiologicals, nitrates, pesticides, or VOCs/SVOCs.

Big Valley Basin (5-4)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Big Valley groundwater basin (5-4) is located in Modoc and Lassen Counties and encompasses 92,000 acres. It is a broad, flat plain extending about 13 miles north-to-south and 15 miles east-to-west consisting of a series of depressed fault blocks surrounded by tilted fault block ridges. The basin is bounded to the north and south by Pleistocene and Pliocene basalt and Tertiary pyroclastic rocks of the Turner Creek Formation, to the west by Tertiary rocks of the Big Valley Mountain volcanic series, and to the east by the Turner Creek Formation.

The following description of the hydrogeology in the Big Valley Basin is taken from DWR Bulletin 118 (DWR 2004). The primary water-bearing formations in Big Valley are Holocene sedimentary deposits, Pliocene and Pleistocene lava flows, and the Plio-Pleistocene Bieber Formation.

The Holocene sedimentary deposits include basin deposits, intermediate alluvium, and alluvial fans - each having a thickness of up to 150 feet. Basin deposits, located predominately in low-lying areas in the central part of the valley, consist of unconsolidated interbedded clay, silt, and organic muck, all having low permeability. These deposits are not considered a significant water-bearing formation. Intermediate alluvium, found along the perimeter of the valley, consists of unconsolidated silt and sand with some clay and gravel. These deposits are generally moderately permeable with gravel zones being highly permeable. Alluvial fans consist of unconsolidated poorly stratified silt, sand, and gravel with some clay lenses. Because the fans occur in only a few small areas, they are not considered a significant source of water. Locally they may yield moderate amounts of water to wells.

Pliocene volcanic rocks consist of jointed and fractured basalt flows occurring to the north and south of Big Valley. Deposits range in thickness to 1,000 feet. The lavas are moderately to highly permeable and serve as recharge areas in the uplands and contain unconfined and confined zones in the valley.

Pleistocene volcanic rocks consist of jointed and fractured basalt flows having moderate to high permeability. Deposits range from 50 to 150 feet thick. These flows serve as recharge areas and yield moderate to large amounts of confined and unconfined groundwater to wells in the southern part of the valley.

The Bieber Formation consists of lake deposited diatomite, clay, silt, sand, and gravel. These interbedded sediments are unconsolidated to semi-consolidated and are moderately permeable. The formation ranges in thickness from 1,000 to 2,000 feet and underlies all of Big Valley. The principal water-bearing zones consist of white pumiceous sand and black volcanic sand and yield large amounts of water to wells where there's sufficient thickness and continuity.

Water levels of the confined aquifer system declined 12–15 feet during the period between the mid-1980s and the early 1990s. Water levels through 1999 had recovered 10–12 feet.

Storage capacity for the Big Valley Groundwater Basin is estimated to be 3,750,000 acre-feet to a depth of 1,000 feet (DWR 1963). DWR (1963) notes that the quantity of useable water in storage is unknown. DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 29,000 and 300 acre-feet, respectively. This estimate is based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the Basin is from precipitation, irrigation infiltration, and surface water infiltration. The average annual precipitation ranges from 13 to 17 inches. Deep percolation of applied water is estimated by DWR (2004) to be 7,900 acre-feet. The Pit River is the major river passing through Big Valley. Big Swamp and several other reservoirs lie in the Valley.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Big Valley Basin is overlain with 43% agricultural land use, 28% of which is rangeland (pasture). Urban land uses make up about 1% and native land comprise 56% of the Basin. Table 4-44 provides details of the land uses within the basin.

Table 4-44. Land Use in the Big Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	7,501	8.15
Idle	4,648	5.05
Pasture	25,794	28.02
Rice	933	1.01
Semiagricultural and Incidental	634	0.69
Truck, Nursery, and Berry Crops	45	0.05
Subtotal	39,555	42.96
Urban		
Urban—unclassified	302	0.33
Commercial	19	0.02
Industrial	266	0.29
Urban Landscape	28	0.03
Urban Residential	242	0.26
Vacant	16	0.02

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	873	0.95
Native		
Riparian	6,056	6.58
Native Vegetation	44,731	48.59
Water	853	0.93
Subtotal	51,640	56.09
Total	**92,067**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). Public water agencies involved with the basin are the Lassen County WD No. 1 and Lassen-Modoc County Flood Control and Water Conservation District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium-magnesium bicarbonate and sodium bicarbonate type waters are present in the basin. The concentration of TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. (DWR 2004)

Two hot springs and one well with sodium sulfate type water have been identified in the basin east of Bieber. There are high concentrations of nitrates, manganese, fluoride, iron, sulfate, conductivity, calcium, adjusted sodium absorption ratio, and TDS in localized areas of the basin. Some groundwater has high concentrations of ammonia and phosphorus. (DWR 2004)

Blanchard Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Blanchard Valley Groundwater Basin is 3 square miles (2,200 acres) in size and is located in Colusa County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Blanchard Valley Groundwater Basin consists of two elongated north-south trending subbasins located in Antelope Valley. Both subbasins are bounded on all sides by Upper Cretaceous marine deposits.

Additional hydrologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use

and sources of water, groundwater extraction for municipal/industrial use in the Blanchard Valley Basin is estimated to be 2 acre-feet/year. Deep percolation of applied water is estimated to be 1 acre-foot/year.

Major Sources of Recharge

Annual precipitation is approximately 21 to 23 inches and is the primary source of groundwater recharge.

Land Uses

Land use surveys were conducted within the subbasin by DWR in 1998. Agricultural land use accounts for about 10% of the subbasin and native land accounts for about 90% of the subbasin. Table 4-45 provides details on the distribution of land use throughout the Blanchard Valley Basin.

Table 4-45. Land Use in the Blanchard Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	231	10.40
Subtotal	231	10.40
Native		
Native Vegetation	1,983	89.22
Water	8	0.38
Subtotal	1,992	89.60
Total	**2,223**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Information for groundwater quality for this basin could not be located.

Burney Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Burney Creek Valley Groundwater Basin is bounded to the west by north trending faults. The basin is bounded on all sides by Pleistocene basalt. Burney Creek drains the valley to the north. The area of the basin is 2,350 acres and is located in eastern Shasta County. The water-bearing formation in the basin consists of Quaternary lake deposits. Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 790 acre-feet.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater supply limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Burney Creek Valley aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation is about 27 inches. DWR (2004) estimated recharge by deep percolation of applied water at 490 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1999. The foothills situated in the Eastern Upland region of Shasta County, which contains Burney Creek Valley basin contain a high percent of rangelands. Of the 60% land uses that are agricultural in this basin, 41% is pasture. Fifteen percent of the basin is urban and 25% is native. Table 4-46 provides details of the land uses within the basin.

Table 4-46. Land Use in the Burney Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	430	18.30
Pasture	970	41.28
Semiagricultural and Incidental	10	0.43
Subtotal	1,410	60.00
Urban		
Urban—unclassified	320	13.62
Urban Residential	30	1.28
Vacant	10	0.43
Subtotal	360	15.32
Native		
Riparian	10	0.43
Native Vegetation	570	24.26
Subtotal	580	24.68

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,350**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. Along with Shasta County, the Burney Water District is the only water agency that manages the water in the Burney Creek Valley basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is insufficient water quality data available to determine the effects of irrigated agriculture.

Burns Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Burns Valley Basin is 4 square miles and it is located in Lake County. The following description of the physiography and hydrogeology in the Burns Valley Basin is taken from DWR Bulletin 118 (2004).

Burns Valley Basin is located along the southeastern edge of Clear Lake and consists of low-lying alluvial plains and upland terrace deposits. The basin is bounded by basalt flows to the northwest and the Plio-Pleistocene Cache Formation on all other sides with the exception of Olivine basalt to the southeast. The west side of the basin opens to Clear Lake. The Cache Formation underlies the majority of the basin. Assuming that there is hydraulic continuity between the alluvium and the Cache Formation, groundwater is in hydraulic continuity in all directions beyond the alluvial plain with the exception being to the northwest. Basement rock consists of the Jurassic-Cretaceous Franciscan Formation and volcanics.

Quaternary alluvium, upland terrace deposits, and the Plio-Pleistocene Cache Formation are the primary water-bearing deposits in the valley. Lowlands in the valley are composed of stream channel gravel and adjacent floodplain deposits of several unnamed creeks. The Quaternary alluvium of the lowland deposits is composed of silt, sand, and gravel. Its maximum thickness at the lower end of the valley is approximately 50 feet. Groundwater is essentially unconfined and yields water for domestic use.

On either side of the alluvial plain are remnants of a least two levels of terrace deposits. The deposits are approximately 15 feet above the valley floor and slope up the valley and merge with the Cache terrain. The deposits consist almost entirely of clastic debris from the Cache formation.

Plio-Pleistocene Cache formation deposits underlie all alluvial and terrace deposits. The formation is largely made up of lake deposits with the potential for included stream deposits. The formation consists of fine sands, silts, and thin interbeds of marl and limestone to a thickness of 200 feet. Near the top of the formation, water-laid tuffs and tuffaceous sands become dominant with intercalated clay, marl, limestone, and diatomite. The formation has low permeability and yields water to wells at rates up to a few hundred gallons per minute.

Storage capacity is estimated to be 4,000 acre-feet based on an area of 1,000 acres, a saturated thickness of 50 feet, and a specific yield of 8%. A 1960 estimate of useable storage capacity is 1,400 acre-feet. Estimates of groundwater extraction for the Burns Valley Basin are based on a survey conducted by the DWR in 1995 (DWR 2004). The survey included land use and sources of water. An estimate of groundwater extraction for agricultural use is 900 acre-feet. Deep percolation from applied water is estimated to be 210 acre-feet.

Major Sources of Recharge

Almost all of the groundwater of Burns Valley is derived from rain that falls within a 12.5 square mile drainage area. Annual precipitation in the basin is approximately 27 inches (DWR 2004).

Land Uses

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 20% of the basin, urban land use accounts for about 17% of the basin, and native land accounts for about 63% of the basin. Table 4-47 provides details on the distribution of land use throughout the Burns Valley Basin.

Table 4-47. Land Use in the Burns Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	382	13.30
Idle	31	1.08
Vineyards	169	5.88
Subtotal	582	20.26
Urban		
Commercial	48	1.68
Industrial	28	0.96
Urban Landscape	6	0.20
Urban Residential	401	13.96
Vacant	7	0.24
Subtotal	490	17.05
Native		
Native Vegetation	1,772	61.64
Water	30	1.05
Subtotal	1,802	62.69

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,875**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Groundwater management for the Burns Valley Basin is under Lake County. Highland Mutual Water Company is the sole (private) water agency in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

DWR monitors 5 wells biennially for various water quality parameters. Groundwater in the basin consists of magnesium-calcium type waters. TDS ranges from 280 to 455 mg/L, averaging 335 mg/L. Groundwater in the basin has high sodium and iron concentrations. Locally high manganese, magnesium, calcium, and phosphorus also occur. High boron concentrations may be an issue for groundwater for agricultural irrigation (DWR 2004, 1975).

Butte Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Butte Creek Valley groundwater basin is located in Lassen County and is 3,230 acres (5 square miles) in size. The basin is located to the west of Crater Lake Mountain and to the northwest of Project Peak in southwest Lassen County. The basin is an alluvium filled valley bounded on all sides by Pleistocene basalt. Highway 44 (Feather Lake Highway) traverses the valley.

Major Sources of Recharge

Recharge to the basin is from precipitation, intermittent lake and stream infiltration and surface runoff. The average annual precipitation in the basin ranges from 17 to 19 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Native vegetation comprises 99% of the basin, with industrial urban use occupying the remaining 1% of land. Table 4-48 provides details of the land uses within the basin.

Table 4-48. Land Use in the Butte Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Industrial	30	0.93
Subtotal	30	0.93
Native		
Native Vegetation	3,200	99.07
Subtotal	3,200	99.07
Total	**3,230**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. There are no water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Cayton Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cayton Valley groundwater basin is located in Shasta County and is 1,300 acres (2 square miles) in size. It is a northeast trending basin located west of Fall River Valley and north of Lake Britton. The basin is bounded to the east by several northwest trending faults and Pliocene andesitic rocks of Soldier and Fort Mountains. The basin is bounded to the north and west by Miocene basalt and to the south by Quaternary pyroclastic rocks.

DWR estimates groundwater extraction for municipal and industrial uses to be 1 acre-foot per year. These estimates are based on surveys conducted by the DWR during 1995.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation in the basin ranges from 35 to 41 inches, increasing toward the northwest. Deep percolation of applied water is estimated by DWR (2004) to be 210 acre-feet. Cayton Creek, which traverses the basin, is a tributary to the Pit River.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. The Cayton basin is overlain with 73% agricultural land uses, 69% of which is rangeland (pasture). Table 4-49 provides details of the land uses within the basin.

Table 4-49. Land Use in the Cayton Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	907	69.40
Semiagricultural and Incidental	8	0.58
Idle	45	3.45
Subtotal	959	73.42
Native		
Native Vegetation	347	26.52
Water	1	0.06
Subtotal	347	26.58
Total	**1,307**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. There are no water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Chrome Town Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Chrome Town Area Groundwater Basin is a north-south trending basin located near the eastern margin of the Coast Range consisting of Quaternary stream terrace deposits. The basin is bounded to the east by the Jurassic Knoxville Formation and lower Cretaceous marine sedimentary deposits. The basin is bounded on all other sides by the Jurassic Knoxville Formation (Jennings 1969). The basin is located in Glenn County and is 1,410 acres (2 square miles) in size.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1993 survey. Groundwater extraction for municipal and industrial uses is estimated to be 5 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration.

Annual precipitation is approximately 21 inches. Deep percolation of applied water is estimated to be 3 acre-feet. Chrome Creek drains the area in the north while Chrome creek, a tributary to Stony Creek, drains the area in the south.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 2% of the basin and native land use accounts for about 98% of the basin. Table 4-50 provides details of the land uses within the Chrome Town Area basin.

Table 4-50. Land Use in the Chrome Town Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Semiagricultural and Incidental	30	2.13
Subtotal	30	2.13
Native		
Native Vegetation	1,380	97.87
Subtotal	1,380	97.87
Total	**1,410**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County enacted a groundwater ordinance in 1990 and revised it in 2000. The key issues in the ordinance are the establishment of a Water Advisory Committee and Technical Advisory Committee, the establishment of basin management objectives, the establishment of a monitoring network and a requirement of permits for the exportation of groundwater outside the County. There are no cities and no water agencies in the Chrome Town Area Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data in this basin could not be identified.

Clear Lake Cache Formation Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Clear Lake Cache Formation Groundwater Basin is 47 square miles in size and is located in Lake County. The following description of the hydrogeology for the basin is taken from DWR Bulletin 118 (2004).

The Clear Lake Cache Formation Groundwater Basin is located east of Clear Lake and shares a basin boundary with the Burns Valley Groundwater Basin to the southwest. The basin is bounded to the south by lower Cretaceous marine and Knoxville Formation deposits and Mesozoic ultra-basic intrusive rocks. The basin is bounded on the east by lower Cretaceous marine deposits and to the north and west by rocks of the Franciscan Formation. The basin is drained by the North Fork Cache Creek and by Cache Creek. Faulting is observed along portions of the western and southern boundaries.

The primary water-bearing formation is the Cache Formation. The Cache Formation is largely made up of lake deposits. The formation consists of tuffaceous and diatomaceous sands and silts, limestone, gravel, and intercalated volcanic rocks. In some areas the general lithology includes up to 400 feet of blue clay and shale with alternating strata of shale and limestone below 400 feet. The permeability of the formation is generally low.

According to DWR (2004), there is no hydrogeologic information available concerning groundwater level trends and storage.

Well completion reports in the basin showed a yield range for 12 municipal/irrigation wells from 11 to 245 gal/min, with an average of 52 gal/min. The average total depth of domestic wells (113 wells reported) is 103 feet, with a range from 23 to 450 feet. The average total depth of municipal/irrigation wells (23 wells reported) is 162 feet, with a range from 58 to 380 feet (DWR 2004).

Based on a 1995 DWR survey of land use and sources of water, the estimate of groundwater extraction for municipal/industrial use is 55 acre-feet. Deep percolation from applied water is estimated to be 61 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and ranges from 25 to 29 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for less than 1% of the basin, urban land use accounts for about 6% of the basin, and native land use accounts for about 93% of the basin. Table 4-51 provides details on the distribution of land use throughout the Clear Lake Cache Formation Basin.

Table 4-51. Land Use in the Clear Lake Cache Formation Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	5	0.02
Idle	16	0.05
Semiagricultural and Incidental	8	0.03
Vineyards	154	0.52
Subtotal	182	0.61
Urban		
Commercial	71	0.24
Industrial	85	0.28
Urban Residential	1,715	5.77
Vacant	39	0.13
Subtotal	1,910	6.42
Native		
Native Vegetation	27,534	92.58
Water	114	0.38
Subtotal	27,648	92.96
Total	**29,740**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the sole public water agency in the basin. There are no private agencies reported. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. All three of the wells sampled for secondary inorganics showed concentrations above the MCLs for those constituents. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Clover Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Clover Valley Groundwater Basin is an irregular shaped basin that includes McReynolds Valley, Squaw Valley, Clover Valley, and Wakeynolds Valley. The valleys consist of deposits of alluvium and lake sediments. The basin is bounded by Miocene volcanic rocks on the north, east, and south and by recent volcanic and Mesozoic granitic rocks to the west. Dixie Creek and Red Clover Creek drain the southern two-thirds of the basin to the west and Squaw Queen Creek drains the northern third of the basin to the northeast. The basin is 16,780 acres (26 square miles) in size and is located in Plumas County. Dixie Creek and Red Clover Creek drain the southern two-thirds of the basin to the west and Squaw Queen Creek drains the northern third of the basin to the northeast.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation. Annual precipitation ranges from 19 to 27 inches, increasing to the south.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Clover Valley contains only native land (Table 4-52).

Table 4-52. Land Use in the Clover Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	10,440	62.20
Riparian	6,340	37.80
Total	16,780	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no groundwater management plans or ordinances, basin adjudications, water agencies, or urban areas within the Clover Valley Basin.This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Collayomi Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Collayomi Valley Basin aquifer system is 10 square miles in size and is located in Lake County. The following description of the hydrogeology in the Collayomi Valley Basin is taken from DWR Bulletin 118 (2004).

The Collayomi Basin includes both Collayomi Valley and Long Valley in the headwater area of Putah Creek. The two northwest-southeast trending valleys are considered a single groundwater basin due to their hydrologic continuity. The basin is bounded to the south by Jurassic-Cretaceous Franciscan, Knoxville, and volcanic rocks; to the west by undifferentiated Cretaceous rocks and Jurassic volcanic rock; to the north and northeast by Plio-Pleistocene Olivine basalt; and to the east by Jurassic volcanics. The basin is underlain by non-water-bearing sedimentary rocks of Jurassic-Cretaceous Franciscan and Knoxville formations that are capped locally by volcanic rocks. The basin boundary coincides with the edge of the valley floor except where water-bearing landslide debris and Quaternary basalt extend from beneath the valley floor into the uplands.

Nearly all groundwater throughout the Collayomi Basin occurs in Quaternary alluvium deposited as alluvial fans of shallow grade and in the gravel channels of Putah Creek, St. Helena Creek, and their tributaries. Groundwater occurs in a series of confined, semi-confined, and unconfined layers and lenses of permeable or semi-impermeable materials that are partially merged and interconnected. There is no evidence of any well-defined aquifer of any great areal extent within the basin. Pleistocene volcanics may also be a source of groundwater in the basin; however, no information is available on storage capacities and well yields within these units.

Quaternary alluvium in Collayomi Valley and Long Valley consists primarily of fine-grained deposits of clay and silt. However, alluvium in Collayomi Valley contains some coarse gravel channels and is more conducive to groundwater development in the basin. Along the channels of Putah and St. Helena Creeks, visible shallow deposits consist of fine sand to coarse cobbles and boulders with clean coarse gravel being dominant. In Long Valley, wells within the alluvial plain consist primarily of fine-grain material with low yields. A well log for Long Valley indicates that the alluvial fill is almost entirely clay from a depth of 64 to 230 feet. The maximum depths of alluvial fill in Collayomi and Long Valleys are approximately 350 feet and 475 feet respectively.

Storage capacity in the basin is estimated to be approximately 29,000 acre-feet. This is based on the assumptions that alluvium is 100 feet deep over an area of 4,000 acres with specific yield values of 6.5 and 4.5% for Collayomi and Long valleys respectively. Useable storage capacity is estimated at 7,000 acre-feet (DWR 2004). Maximum well yield is 1,200 gal/min, with an average yield of 500 gal/min (DWR 1975).

Major Sources of Recharge

The major source of recharge to the Collayomi Basin is from percolation of streamflow in Putah Creek, Dry Creek, and St. Helena Creek, although some recharge is derived from irrigation return flows and infiltration of rainfall. Annual precipitation in the basin ranges from 41 to 47 inches, decreasing to the

northeast. Only minor quantities of surface streamflow are available for recharge in the Long Valley portion of the basinwhich may be impeded by hardpan conditions near the ground surface (DWR 2004).

Land Use

Estimates of groundwater extraction are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 1,000 and 94 acre-feet respectively. Deep percolation from applied water is estimated to be 250 acre-feet (DWR 2004).

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 13% of the basin, urban land use accounts for about 9% of the basin, and native land accounts for about 78% of the basin. Table 4-53 provides details on the distribution of land use throughout the Collayomi Valley Basin.

Table 4-53. Land Use in the Collayomi Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	95	1.47
Grain and Hay	190	2.92
Idle	118	1.82
Pasture	88	1.35
Semiagricultural and Incidental	74	1.14
Vineyards	292	4.49
Subtotal	857	13.18
Urban		
Urban—unclassified	54	0.83
Commercial	26	0.40
Industrial	93	1.43
Urban Landscape	14	0.21
Urban Residential	395	6.07
Vacant	10	0.16
Subtotal	592	9.10
Native		
Native Vegetation	5,032	77.39
Water	21	0.33
Subtotal	5,053	77.72
Total	**6,502**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County has adopted a groundwater management ordinance in 1999 for the Collayomi Valley Basin. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The public water agencies within the basin include Hidden Valley Lake CSD and Middletown County Water District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin is characterized as magnesium bicarbonate type waters. TDS range from 150 to 255 mg/L, averaging 202 mg/L. Groundwater sampling shows locally high iron and manganese. Locally high boron may be an issue for agricultural uses (DWR 2004).

Coyote Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Coyote Valley Basin is 10 square miles in size and is located in Lake County. The following description of the physiography and hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

Coyote Valley is a northwest-southeast trending valley located within the southeastern portion of Lake County along Putah Creek about 4 miles northeast of Middletown. The valley is approximately 5 miles long and a maximum of 2.5 miles in width. The alluvial plain of the valley is bounded by sediments of the Jurassic-Cretaceous Franciscan-Knoxville groups and undifferentiated Cretaceous rocks on the west and northwest. The south and southeastern part of the valley is nearly isolated by low hills of basalt of Upper Jurassic age. The Plio-Pleistocene Cache Formation outcrops along the northern edge of the valley and Plio-Pleistocene basalt outcrops are observed at the northeastern valley edge. The aquifer system of Coyote Valley Basin is primarily comprised of Quaternary Holocene alluvial deposits and, to a much lesser extent, Plio-Pleistocene Cache Formation deposits.

Holocene alluvium within the valley overlies the Cache Formation and is the primary water-bearing unit in the basin. The alluvium is made up of floodplain and channel deposits of Putah Creek and gently sloping alluvial fan deposits in the southwestern lobe of the valley and at the valley margins. The deposits consist of poorly stratified sand, gravel, and fine-grained material. The most productive strata are gravels that occur in sheets and stringers between beds of silty and sandy clay. The alluvial fill may range in thickness from 100 to 300 feet.

Volcanic rocks and underlying tuffaceous deposits (Upper Cache Formation) exist along the north edge and in the southeastern part of the valley and may be water bearing. The tuffaceous deposits are poorly consolidated and apparently lie at considerable depth beneath the hills to the northeast, where they are overlain by, and possibly interbedded with, basaltic flows. The lithology of the sediments associated with lava flows along the north edge of Coyote Valley is like that of the Upper Cache near Clear Lake, except for the composition of the cobble gravels, which are composed largely of rounded cobbles of white

rhyolite. The Cache Formation outcrops on the northeast edge of Coyote Valley and probably underlies much of the Holocene alluvium. It is composed of gravel, silt, and sand, and near the top of the section, water–laid tuffs and tuffaceous sands become dominant. The permeability in the Cache formation is variable, but generally low. Most of the strata are too high in clay or silt for water movement to be great. Groundwater flow through a few coarse sedimentary strata and volcanic deposits may be appreciable.

Storage capacity of the basin is estimated to be 27,000 acre-feet. This estimate is based on the areal extent of alluvium within the basin (approximately 3,000 acres) for a saturated depth interval of 10 to 100 feet, having a specific yield of 10%. In 1960 DWR estimated the storage capacity to be 29,000 acre-feet with a useable storage capacity of 7,000 acre-feet.

Estimates of groundwater extraction for agricultural and municipal/industrial uses are 1,400 and 290 acre-feet respectively, based on a 1995 groundwater extraction survey conducted by the DWR. Deep percolation from applied water is estimated to be 1,100 acre-feet.

Major Sources of Recharge

The major source of groundwater recharge is from Putah Creek. Lesser amounts of recharge occur from precipitation upon the alluvial plain and from side-stream runoff. Annual precipitation in the valley ranges from 37 to 41 inches, increasing to the north (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 34% of the basin, urban land use accounts for about 14% of the basin, and native land accounts for about 52% of the basin. Table 4-54 provides details on the distribution of land use throughout the Coyote Valley Basin.

Table 4-54. Land Use in the Coyote Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	54	0.82
Grain and Hay	192	2.93
Idle	349	5.35
Pasture	1,039	15.90
Semiagricultural and Incidental	46	0.70
Vineyards	524	8.02
Subtotal	2,203	33.72
Urban		
Urban—unclassified	20	0.31
Commercial	48	0.74
Industrial	45	0.69
Urban Landscape	117	1.79
Urban Residential	691	10.58
Vacant	8	0.12

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	929	14.22
Native		
Native Vegetation	3,181	48.69
Water	220	3.36
Subtotal	3,401	52.06
Total	**6,533**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for the basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). No private or public water agencies are listed. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin consists of magnesium bicarbonate type waters. TDS ranges from 175 to 390 mg/L, averaging 288 mg/L. Water quality sampling shows locally high magnesium (DWR 2004).

Dixie Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dixie Valley Groundwater Basin is an elongated east/west trending alluvial basin located south of Bald Mountain and west of Madeline Plains in western Lassen County. The basin is bounded to the south by Pleistocene basalt and on all other sides by Pliocene basalt (Lydon 1960). Indian Creek flows into the valley from the east. The valley is drained by Horse Creek, which flows northwest to the Pit River. The basin is 4,870 acres (8 square miles) in size and is located in northeastern Lassen County.

There is no information about the hydrogeology of Dixie basin available.

DWR estimated the groundwater extraction for the Dixie Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 2 acre-feet annually. Deep percolation of applied water was estimated to be 420 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration.

Annual precipitation in the valley ranges from 17 to 19 inches, increasing to the north. Deep percolation of applied water was estimated to be 420 acre-feet by DWR in 1997. Indian Creek flows into the valley from the east. The valley is drained by Horse Creek, which flows northwest to the Pit River.

Land Uses

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 54% of the basin and native land use accounts for about 46% of the basin. There is no urban land in the Dixie Valley basin. Table 4-55 provides details of the land uses within the basin.

Table 4-55. Land Use in the Dixie Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	2,470	50.70
Semiagricultural and Incidental	10	0.20
Idle	140	2.90
Subtotal	2,620	53.80
Native		
Native Vegetation	2,180	44.80
Water	70	1.40
Subtotal	2,250	46.20
Total	**4,870**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Dry Burney Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Dry Burney Creek Valley Groundwater Basin is bounded to the northwest, west, and south by Pliocene andesite of Don Hurt Mountain, Stacher Butte, and Jacks Backbone. The basin is bounded to the east by Pleistocene basalt of Whittington Butte and Horse Heaven Buttes (Lydon 1960). The basin is 3,070 acres (5 square miles) in size and is located in eastern Shasta County.

The water-bearing formation in the basin is the Quaternary alluvium.

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation ranges from 49 to 55 inches, increasing to the southeast.

Land Uses

Land use surveys were conducted within the basin by DWR in 1999. Dry Burney Creek Valley basin is 100% native vegetation (Table 4-56).

Table 4-56. Land Use in the Dry Burney Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	3,080	100.00
Total	3,080	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. No water agencies are involved with the management of Dry Burney Creek Valley basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Egg Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Egg Lake Valley Basin is 6 square miles (4,100 acres) in size and is located in Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Egg Lake Valley Basin is bounded to the south by Tertiary volcanics of Egg Lake Butte, to the east by recent basalt, and on all other sides by Miocene basalt. The basin consists of Quaternary lake deposits.

The single municipal/irrigation well in the basin is reported to have a yield of 20 gal/min and a total depth of 440 feet. A domestic well in the basin is reported to have a total depth of 300 feet. No information is available on the yield of the domestic well. (DWR 2004.)

Major Sources of Recharge

Annual precipitation is the major source of recharge and ranges from 19 to 21 inches.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The entire basin consists of native vegetation and surface water features (rivers, lakes, etc.). Table 4-57 provides details on the distribution of land use throughout the Egg Lake Valley Basin.

Table 4-57. Land Use in the Egg Lake Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	1,617	39.41
Water	2,485	60.59
Total	4,102	100.00

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the Modoc County ordinance is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

As required under the CDPH Title 22 program, wells within the basin were sampled for the presence of primary and secondary inorganics, nitrates, pesticides, VOCs, and SVOCs. None of the wells sampled from 1994 through 2000 had detections above the respective MCLs (DWR 2004).

Elk Creek Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Elk Creek Groundwater Basin is located in east-central Glenn County and is 1,450 acres (2 square miles) in size. Stony Creek borders the basin on the southeast while Elk Creek flows down the center of the Valley. Stony Creek and Elk Creek converge in the basin. Elk Creek, Briscoe Creek, and Stony Creek drain the Valley. There is no hydrogeologic information available for Elk Creek Valley basin.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 6% of the basin, urban land use makes up about 6% of the basin and native land accounts for about 88% of the basin area. Table 4-58 provides details of the land uses within the Elk Creek Valley basin.

Table 4-58. Land Use in the Elk Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Citrus and Subtropical	60	4.14
Field Crops	30	2.07
Subtotal	90	6.21
Urban		
Urban	60	4.14
Commercial	10	0.69
Urban Landscape	10	0.69
Subtotal	80	5.52
Native		
Riparian	20	1.38
Native Vegetation	1,200	82.76
Water	60	4.14

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	1,280	88.28
Total	**1,450**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County enacted a groundwater ordinance in 1990 and revised it in 2000. The key issues in the ordinance are the establishment of a Water Advisory Committee and Technical Advisory Committee, the establishment of basin management objectives, the establishment of a monitoring network and a requirement of permits for the exportation of groundwater outside the County. There are no cities and no water agencies in the Elk Creek Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Fall River Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Fall River Valley groundwater basin is 54, 800 acres in size and is located in Lassen and Shasta Counties at 3,300 feet elevation. It is bounded on the east by Tertiary basalt of the Big Valley Mountains, and on the west by Pleistocene basalt and Pliocene andesite of Soldier and Saddle Mountains. Less distinct boundaries are to the north and south as low relief volcanic plateau areas of basalt. Fall River is the primary stream draining the northern and central-valley areas, and the Pit River is the primary stream in the easterly and southerly portion of the basin. These rivers converge at the southwestern corner of the valley near Fall River Mills and flow westward out of the valley.

The following description of the hydrogeology in the Fall River Valley basin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits, Holocene lava flows, Pleistocene lake and near-shore deposits, and Pleistocene to Pliocene volcanic rocks.

Holocene sedimentary deposits include intermediate alluvium and alluvial fans. The intermediate alluvium consists of unconsolidated silt, sand, and gravel up to 100 feet thick. These deposits occur along stream channels and on the floodplain. The permeability of these materials is moderate to high. However, with the exception of some areas along Bear Creek and the Pit River, the alluvial deposits are too thin to be of importance for groundwater development.

The alluvial fans consist of unconsolidated, poorly stratified silt, sand, and gravel to a thickness of 200 feet. These deposits are limited to the eastern margin of the valley and are primarily recharge areas but may yield moderate quantities of groundwater in places. These deposits are moderately permeable and contain confined and unconfined zones.

The Holocene volcanic rocks originate from the Medicine Lake Highlands and consist of highly jointed, vesicular basalt flows, scoria, cinder cones, and associated lenses of cinders ranging in thickness from 30 to 500 feet. These volcanic rocks are highly permeable. At the north end of the valley, where these deposits mantle the uplands, they serve as a major recharge area and feed numerous streams and springs.

Pleistocene near-shore deposits consist of partly consolidated clay, silt, and sand up to 300 feet thick. These deposits are moderately permeable and yield fair quantities of groundwater to wells.

Pleistocene volcanic rocks consist of partly consolidated, bedded cinders and highly jointed basalt flows ranging from 50 to 750 feet in thickness. The cinder beds are highly permeable but are of limited extent and are not significant valley wide. Overall, the basalt flows are moderately to highly permeable and can yield large amounts of confined water where interbedded with lake deposits. There is substantial variation in the water transmitting capabilities of these rocks. Some areas have basalt exposures that are essentially impermeable.

Pliocene volcanic rocks consist of basalt flows interbedded with pyroclastic rocks. Due to weathering and infilling of joints and fractures with fines, these rocks have low to moderate permeabilities and yield lesser amounts of groundwater to wells than the younger volcanic rocks.

Block faulting by northwestward-trending faults of late Pleistocene and possibly Holocene age is the dominant structural feature. At least three fault systems control the complex displacement structure. The basin is a fault trough in which a downthrown group of blocks is situated between two groups of elevated blocks. The volcanic rocks that underlie the valley have also been tilted and broken into several smaller blocks. Faulting has probably created shattered permeable zones for groundwater movement in the volcanic rocks. Within the sedimentary deposits faulting may have created barriers to groundwater movement.

Water levels in the basin are variable and are commonly dependent on the topographic elevation of a particular area, proximity to the Pit River, and localized pumping effects. In general, the northern portion of the basin consistently has the shallowest depths to groundwater (10 feet or less). Areas adjacent to the Pit River display more variable conditions.

The groundwater storage capacity to a depth of 400 feet is estimated to be 1,000,000 acre-feet (DWR 1963). DWR (1963) notes that the quantity of water that is useable is unknown.

Groundwater extraction, as estimated by DWR, is 19,000 acre-feet for municipal uses and 240 acre-feet for industrial uses.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater production limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Fall River Valley aquifer is mostly by subsurface flow and infiltration of precipitation into the alluvium. Average annual precipitation within the basin is estimated to be 17 to 27 inches in the valley and 29 to 43 inches in the upland areas to the west. DWR (2004) estimated recharge by deep percolation of applied water is estimated at 4,800 acre-feet.

The alluvial fans on the eastern margin of the valley are aquifer recharge areas. They consist of unconsolidated, poorly stratified silt, sand, and gravel to a thickness of 200 feet.

In the GAMA study, Moran et al. (2004) show evidence that subsurface flow also recharges the Fall River Valley basin. Two wells in Fall River Mills, in the distal portion of the groundwater flow field, have mantle helium components that show the effect of volcanic activity to the north indicating inflow into the basin from these areas.

At the north end of the Fall River Valley deposits from Holocene volcanic rocks serve as a major recharge area and feed numerous streams and springs. These springs have sustained flows measured at 1,400 to 2,000 cubic feet per second and provide the bulk of the base flow that sustains most of the streams, ponds, and lakes in the area. It has been speculated that the subsurface inflow for these springs originates 50 miles or more to the north at the Tule Lake/Klamath Lake basins and flows beneath and through the Medicine Lake Highlands. These springs have been extensively appropriated or diverted for irrigation and power development.

Land Use

Land use surveys were conducted within the basin by DWR in 1995. The foothills situated in the Eastern Upland region of Shasta County, which contains Fall River Valley basin contain a high percent of rangelands. The Fall River Valley basin is overlain with 57% agricultural land uses, 32% of which is rangeland. Table 4-60 provides details of the land uses within the basin.

Table 4-60. Land Use in the Fall River Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Field Crops	1,017	1.86
Grain and Hay	3,110	5.70
Pasture	17,422	31.94
Rice	1,321	2.42
Semiagricultural and Incidental	477	0.87
Truck, Nursery, and Berry Crops	822	1.51
Idle	6,679	12.24
Subtotal	30,847	56.55
Urban		
Urban—unclassified	417	0.76
Commercial	25	0.05
Industrial	79	0.15
Urban Landscape	9	0.02

Land Use	Acreage of Land Use	Percent of Land Use
Urban Residential	406	0.74
Vacant	79	0.15
Subtotal	1,015	1.86
Native		
Native Vegetation	17,421	31.94
Water	3,034	5.56
Riparian	2,233	4.09
Subtotal	22,689	41.59
Total	**54,551**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Although Shasta County has a groundwater ordinance, Fall River Valley itself, has no groundwater management plan. The largest extraction from the aquifer is for the paper mills and is 13 million gallons per day (mgd). There are also at least 470 wells (domestic and irrigation) drawing on the Fall River Valley aquifer (DWR 2004). The city of Fall River Mills relies solely on groundwater for its public water supply. Fall River Valley lies within the Pit River Watershed. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The mineral quality of groundwater in the basin ranges varies primarily as a function of recharge water. Water from wells in the unconfined volcanic rocks within and adjacent to this basin is quite good with a calcium/magnesium bicarbonate character and low to moderate TDS. In the central portion of the basin, where lake deposits are thick, a sodium bicarbonate character is prevalent. In the western portion of the basin numerous wells produce groundwater with elevated iron concentrations. The concentration of TDS ranges from 115 to 232 mg/L, averaging 174 mg/L. (DWR 2004)

There are high concentrations of nitrate, manganese, ammonia, and phosphorus in localized areas throughout the basin. Some well waters have high iron concentrations (DWR 2004).

Funks Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Funks Creek Groundwater Basin is 5 square miles (3,000 acres) in size and is located in Glenn and Colusa Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Funks Creek Groundwater Basin is located north of Antelope Valley and overlies the boundary of Glenn and Colusa Counties. The basin is north of a series of northeast trending faults and is bounded on all sides by Upper Cretaceous Marine deposits. The basin consists of Quaternary alluvial deposits and is drained to the east by Grapevine Creek and Funks Creek.

Major Sources of Recharge

Annual precipitation is approximately 18 inches and is the primary source of recharge for the basin.

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about 17% of the basin, and native land use accounts for about 83% of the basin. Table 4-61 provides details on the distribution of land use throughout the Funks Creek Basin.

Table 4-61. Land Use in the Funks Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	511	16.96
Semiagricultural and Incidental	6	0.21
Subtotal	518	17.18
Native		
Native Vegetation	2,464	81.73
Water	33	1.09
Subtotal	2,496	82.82
Total	**3,014**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

For the period of November 1, 1983 to June 30, 2003, the DPR reported 82 wells with verified pesticide detections and 27 wells with unverified pesticide detections in Glenn County. Funks Creek Basin is located within Glenn County. Three hundred and seventy-six wells were sampled for 117 pesticides (DPR 2003). The following compounds were detected and verified: atrazine (in 37 wells), bentazon (in 29 wells), DEA (in 4 wells), diuron (in 1 well), prometon (in 9 wells), and simazine (in 21 wells). The wells in the Funks Creek Basin that had pesticide detections could not be identified.

Goose Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Goose Valley groundwater basin is bounded to the west, north, and east by Pliocene basalt and to the south by Pleistocene basalt. It is located in a region of northwest trending faults in the mountains of eastern Shasta County. The basin is 4,210 acres (7 square miles) in size. The water-bearing formation in the basin consists of Quaternary lake deposits. Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 2 acre-feet.

Major Sources of Recharge

Recharge to the Goose Valley aquifer is mostly by infiltration precipitation into the alluvium. Annual precipitation ranges from 29–33 inches. DWR (2004) estimated recharge by deep percolation of applied water is estimated to be 1,100 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1999. The foothills situated in the Eastern Upland region of Shasta County, which contains Goose Valley basin are comprise of 54% of rangelands and 8% native land uses. This basin is sparsely populated. Table 4-62 provides details of the land uses within the basin.

Table 4-62. Land Use in the Goose Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	422	10.01
Pasture	2,273	53.98
Rice	1,180	28.02
Semiagricultural and Incidental	11	0.25
Subtotal	3,885	92.27
Native		
Riparian	43	1.03
Native Vegetation	282	6.70
Subtotal	326	7.73
Total	**4,210**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No water quality data are available for this basin.

Fandango Valley Subbasin—Goose Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Fandango Valley Groundwater subbasin is part of the Goose Lake Valley Groundwater Basin which is located in Modoc County and extends north into Lake County, Oregon. The valley is approximately 47 miles long and 12 miles wide. It lies at an elevation of about 4,700 feet. Two thirds of the Goose Lake Valley is in Oregon. The basin is a down-faulted block with numerous bounding faults on the west and east side of the valley. Goose Lake occupies 144 square miles of the southern portion of the basin. The Fandango Valley subbasin is 18,500 acres (27 square miles) in size. It is located in Modoc County. The subbasin is an irregularly shaped groundwater basin that includes Fandango Valley and the area previously identified as the Willow Ranch subbasin (DWR 1963).

The following description of the hydrogeology in the Fandango Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits (which include lake deposits, intermediate alluvium, and alluvial fan deposits) and Pleistocene near-shore deposits and lava flows. The following summary of water-bearing formations is from DWR (1963).

The lake deposits consist of unconsolidated interstratified clay and silty clay limited in extents to the Willow Ranch area. Water produced from these sediments may be of poor quality depending on the degree of alkalinity.

The intermediate alluvium consists of unconsolidated, poorly sorted silt and sand with lenses of gravel up to a thickness of 100 feet. The thickness of the deposits is considerably less for Fandango Valley. These zones are moderately permeable.

The alluvial fan deposits consist of unconsolidated to poorly consolidated, partially stratified sand, gravel, and silt with lenses of clay. These deposits are generally the most permeable of the valley sedimentary deposits. The eastside alluvial fans range up to 300 feet in thickness and are considered the most important groundwater source. The upper fan areas are moderately to highly permeable and, where saturated, can yield large amounts of water to wells. The mid- to lower fans are generally less permeable

but contain confined zones yielding moderate amounts of water to wells. The alluvial fan deposits in Fandango Valley are considerably less in thickness due to their limited areal extent.

Near-shore deposits occur at the south end of the subbasin. The deposits are moderately to highly permeable and may yield large quantities of water to wells.

The Pleistocene volcanic rocks consist of highly jointed flat lying basalt flows ranging from 50 to 200 feet in thickness with interbedded scoriaceous zones and pyroclastic rocks. These rocks serve as a recharge zone and interfinger with valley sediments. In general these rocks are highly permeable and can yield large amounts of water to wells.

In Goose Valley Basin (including Lower Goose Valley and Fandange subbasins) groundwater storage to a depth of 500 feet is estimated to be 1,000,000 acre-feet (DWR 1963).

Major Sources of Recharge

The Fandango Valley subbasin is bound on the west by Goose Lake and on the west by the Warner Mountains. Goose Lake is an intermittent lake that gains water from the Fandango Valley groundwater subbasin. The water level fluctuates and the lake has been completely dry several times since the early 1900s (DWR 1963). All surface drainage in the Goose Lake Valley basin is to Goose Lake. Intermittent streams characterize the flanks of the Warner Mountains, where streams commonly are lost to infiltration of the permeable alluvial-fan deposits that they traverse after leaving the canyons. Willow, Lassen, Davis, and New Pine Creeks are the major streams of the Fandango basin. Most streams in the basin have their peak discharge in April or May, when they are fed by snowmelt.

The major sources of recharge to the Fandango Valley subbasin are infiltration of surface water and precipitation. Upland recharge areas consist of the permeable basalt flows of Pliocene to Pleistocene age. Precipitation and surface runoff infiltrates the basalt flows and percolates towards the valley, and along Willow Creek, recharging valley sediments. Most of the recharge to deeper aquifers along the east side of the California portion of Goose Lake Valley is derived from infiltration of surface water, generally along the foothill portions of stream channels. DWR estimates Annual precipitation ranges from 17 to 19 inches in the Willow Ranch area and from 19 to 23 inches in Fandango Valley.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land uses made up 27% of the basin, native vegetation made up 73% of the basin and only 0.19% of the basin was urban. Land use details are displayed in Table 4-63.

Table 4-63. Land Use in the Fandango Subbasin*

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	32	0.18
Grain and Hay	290	1.57
Pasture	4,445	24.12
Semiagriculture and Incidental	129	0.70

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	4,896	26.57
Urban		
Urban Residential	35	0.19
Subtotal	35	0.19
Native		
Native Vegetation	10,048	54.52
Water	1,644	8.92
Riparian	1,807	9.81
Subtotal	13,500	73.25
Total	**18,431**	**100.00**

*The portion of Goose Valley that is in Oregon is heavily used for agricultural purposes and water is diverted from the tributary streams and pumped from groundwater in order to irrigate crops.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for transfers of water out of the basin (DWR 2004). Small communities exist on Deer Creek and New Pine Creek. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate type waters occur throughout the basin. Sodium bicarbonate waters are found below 200 feet in a three square mile area east of Goose Lake and south of New Pine Creek. The concentration of TDS averages 183 mg/L and ranges from 66 to 528 mg/L.

Lower Goose Lake Valley Subbasin—Goose Lake Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lower Goose Lake Valley Groundwater subbasin is part of the Goose Lake Valley Groundwater Basin which is located in Modoc County and extends north into Lake County, Oregon. The valley is approximately 47 miles long and 12 miles wide. It lies at an elevation of about 4,700 feet. Two thirds of the Goose Lake Valley is in Oregon. The basin is a down-faulted block with numerous bounding faults on the west and east side of the valley. Goose Lake occupies 144 square miles of the southern portion of the basin. The Lower Goose Lake Valley subbasin is 36,000 acres (56 square miles) in size. It is bounded on

the north by Goose Lake, on the east by Pliocene and Tertiary basalt and Tertiary intrusive rocks of the Warner Mountains, and on the west by Pliocene basalt of the Modoc Plateau.

The following description of the hydrogeology in the Lower Goose Lake Valley subbasin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations are Holocene sedimentary deposits (which include lake deposits, intermediate alluvium, and alluvial fan deposits), Pleistocene near-shore deposits, Pliocene to Pleistocene lava flows, and to a lesser extent, the Plio-Pleistocene Alturas Formation. The following summary of water-bearing formations is from DWR (1963).

The lake deposits consist of unconsolidated interstratified clay and silty clay. Water produced from these sediments may be of poor quality depending on the degree of alkalinity. Thickness of the deposits ranges up to 1,000 feet. The intermediate alluvium consists of unconsolidated, poorly sorted silt and sand with lenses of gravel up to a thickness of 100 feet. These zones are moderately permeable.

The alluvial fan deposits consist of unconsolidated to poorly consolidated, partially stratified sand, gravel, and silt with lenses of clay. These deposits are generally the most permeable of the valley sedimentary deposits. The eastside alluvial fans range up to 300 feet in thickness and are considered the most important groundwater source. The upper fan areas are moderately to highly permeable and, where saturated, can yield large amounts of water to wells. The mid- to lower fans are generally less permeable but contain confined zones yielding moderate amounts of water to wells. The west side fans, ranging in thickness to 100 feet, are less permeable resulting in low to moderate well yields.

Near-shore deposits occur at the south end of the subbasin and overlie the basin in the southwest trending towards the northeast subbasin boundary. The deposits are moderately to highly permeable and may yield large quantities of water to wells.

The Pleistocene volcanic rocks consist of highly jointed flat lying basalt flows ranging from 50 to 200 feet in thickness with interbedded scoriaceous zones and pyroclastic rocks. In the surrounding upland, these rocks serve as a recharge zone; in the valley they interfinger with valley sediments and act as a forebay to water-bearing deposits. In general these rocks are highly permeable and can yield large amounts of water to wells.

The Plio-Pleistocene volcanic rocks consist of highly jointed basalt flows with some zones of scoria and interbedded pyroclastic rocks. The deposits range up to 500 feet in thickness. These rocks are generally highly permeable and are areas of recharge where exposed at the ground surface. Flows from the west side of the basin contain numerous permeable zones that likely provide large quantities of water to wells. On the east side of the basin, multiple flows of fractured lava are interbedded within the valley sedimentary deposits. Wells penetrating these rocks yield moderate to high quantities of water.

The Alturas Formation consists of slightly consolidated, well-bedded, tuffaceous sandstone and occurs at depth in the basin separating younger and older lava flows. The deposits are moderately permeable and may provide moderate amounts of confined water to deep wells. Thickness of the formation ranges up to 500 feet. In the Goose Valley Basin (including Lower Goose Valley and Fandango subbasins) groundwater storage to a depth of 500 feet is estimated to be 1,000,000 acre-feet (DWR 1963).

Fall River is the primary stream draining the northern and central-valley areas, and the Pit River is the primary stream in the easterly and southerly portion of the basin. These rivers converge at the southwestern corner of the valley near Fall River Mills and flow westward out of the valley.

Estimates of groundwater extraction for the Goose Lake Basin (including Lower Goose Lake Valley and Fandango subbasins) are based on a survey conducted by the DWR during 1997. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal /industrial uses are 10,000, and 25 acre-feet respectively. Information about possible sources of contaminants could not be identified.

Major Sources of Recharge

Lower Goose Lake Valley is bounded on the north by Goose Lake, which is an intermittent lake. The lake gains water from the Lower Goose Lake Valley subbasin. The water level fluctuates and the lake has been completely dry several times since the early 1900s (DWR 1963). Davis Creek flows into the subbasin, toward Goose Lake, from the Warner Mountains. At the southern end of the subbasin, tributary streams flow south to the North Fork Pit River, exiting the subbasin.

The major sources of recharge to the Lower Goose Lake Valley subbasin are precipitation and surface runoff from the Warner Mountains. Upland recharge areas consist of permeable basalt flows of Pliocene to Pleistocene age. Precipitation and surface runoff infiltrates the basalt flows and percolates towards the valley recharging valley sediments. Most of the recharge to deeper aquifers along the east side of the California portion of Goose Lake Valley is derived from infiltration of surface water, generally along the foothill portions of stream channels. A relatively large portion of precipitation occurring along the west side of the valley infiltrates upland recharge areas (DWR 1963). Annual precipitation ranges from 15 to 17 inches. DWR estimates that recharge to Goose Lake Basin from deep percolation from applied water is 1,600 acre-feet per year.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. The majority (75%) of the land in Lower Goose Lake Valley is undeveloped. Twenty-five percent is agricultural and 0.28% is urban. Table 4-64 provides a more detailed description of the land use.

Table 4-64. Land Use in the Lower Goose Lake Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Deciduous Fruits and Nuts	0.28	0.001
Grain and Hay	355	0.99
Pasture	8,452	23.51
Semiagricultural and Incidental	111	0.31
Subtotal	8,918	24.80
Urban		
Industrial	26	0.07
Urban Landscape	3.5	0.01
Urban Residential	68	0.19
Vacant	2.6	0.01
Subtotal	100	0.28

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Riparian	1,350	3.75
Native Vegetation	18,924	52.63
Water	6,396	17.79
Barren and Wasteland	266	0.74
Subtotal	26,936	74.92
Total	**35,954**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate type waters occur throughout the basin. The concentration of TDS averages 183 mg/L and ranges from 66 to 528 mg/L (DWR 2004).

Grays Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Grays Valley groundwater basin is an alluvial valley located in southwest Lassen County. It resides at the western base of Crater Lake Mountain and is 5,440 acres (8 square miles) in size. The basin is bounded by basalt of Crater Lake Mountain to the east. The basin is bounded on all other sides by Pleistocene basalt of Bogard Buttes, Cal Mountain, and Cone Mountain. Highway 44 traverses the basin.

Major Sources of Recharge

Recharge to the basin is from precipitation, lake infiltration, and surface runoff. The average annual precipitation in the basin ranges from 19 to 21 inches. A lake resides in the northwest corner of the basin.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. Grays Valley is rather small and all of the land uses in are Native (Table 4-65).

Table 4-65. Land Use in the Long Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	4,750	87.30
Water	690	12.70
Total	**5,440**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications within Grays Valley Basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

No data are available for water quality.

Grizzly Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Grizzly Valley Groundwater Basin lies within a down-dropped graben bounded to the northeast by Grizzly Valley Fault and to the southwest by a series of northwest trending faults. Hot Springs Fault appears to transect the basin from the southeast to the northwest. The basin is bounded to the north by Miocene volcanic rocks and to the south by Paleozoic marine sediments, Mesozoic granitic rocks, recent volcanics, and Tertiary intrusive rocks. Grizzly Creek drains the valley and is tributary to the Middle Fork Feather River. Grizzly Creek drains the valley and is tributary to the Middle Fork Feather River. Other creeks in the basin are Freeman, Little Grizzly, Blakeless, Emigrant, Lovejoy, and Cow. The area of Grizzly Valley basin is 13,440 acres and is located in Plumas County.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 29 to 37 inches, increasing to the west.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Native land accounts for about 99.9% of the basin. Table 4-66 provides details of the land uses within the basin.

Table 4-66. Land Use in the Grizzly Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Urban Residential	10	0.10
Subtotal	10	0.10
Native		
Native Vegetation	8,390	62.40
Riparian	1,440	10.70
Water	3,600	26.80
Subtotal	13,430	99.90
Total	**13,440**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications, water agencies, or urban areas within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

High Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The High Valley Basin is 4 square miles in size and is located in Lake County. The following description of the physiography and hydrogeology in the High Valley Basin is taken from DWR Bulletin 118 (2004).

High Valley Basin is a small, poorly drained, isolated valley in the Coast Ranges. It is nearly a closed basin, with the only outlet being the narrow gorge of Schindler Creek in the southeast corner. The valley consists of a flat alluvial plain about 3 miles long and 1 mile wide, surrounded by a narrow band of high, steeply sloping hills. The north, west, and south boundary of the High Valley Basin is generally defined

as the contact between the Jurassic-Cretaceous Franciscan Formation and the valley alluvium. Baldy Mountain is located to the west, and High Valley Ridge borders the valley to the north. Quaternary Holocene volcanics border the basin to the east.

The aquifer system in High Valley Basin is comprised primarily of Quaternary alluvial deposits and Holocene volcanic deposits. The alluvium overlies a confined volcanic aquifer of Holocene age. Below the volcanic aquifer are older alluvial deposits about which there is little information.

The Quaternary alluvium consists of up to 100 feet of fine-grained lake deposits that confine an underlying volcanic aquifer. The permeability of the alluvium is generally low. The central part of the alluvial plain is bordered by alluvial fans containing coarser grained material.

Holocene volcanics likely originated from the vicinity of Round Mountain located to the east. These volcanics, which also dammed the ancestral valley, were later buried in the central portion of the valley by fine-grained alluvium reducing potential recharge on the valley floor. Most irrigation wells in the valley tap the fine-grained alluvium. Irrigation wells drilled in the volcanic aquifer system were initially productive, but after a few seasons of operation, production was reduced. One well was reported to yield about 1,000 gpm, reducing to a yield of only about 200 gpm after 4 years of production. Thickness of the formation is unknown.

Information with respect to the hydrogeology of the basin is limited. Little is known in regards to the lithology of the deeper alluvium and it's believed that the extents of the alluvium may be several miles to the east underneath the younger volcanics.

The storage capacity is estimated to be 9,000 acre-feet for a saturated depth interval of 10–100 feet. Usable storage capacity is estimated to be 900 acre-feet.

Estimates of groundwater extraction for the High Valley Basin are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 78 and 210 acre-feet, respectively. Deep percolation from applied water is estimated to be 33 acre-feet.

Major Sources of Recharge

The source of recharge in High Valley Basin is from precipitation within the drainage area. Infiltration likely occurs at the perimeter of the valley in the alluvial fans. Annual precipitation in the valley ranges from 27 to 35 inches, decreasing to the east.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 16% of the basin, urban land use accounts for less than 2% of the basin, and native land use accounts for about 82% of the basin. Table 4-67 provides details on the distribution of land use throughout the High Valley Basin.

Table 4-67. Land Use in the High Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	3	0.11
Idle	179	7.61
Pasture	119	5.05
Semiagricultural and Incidental	22	0.95
Vineyards	64	2.71
Subtotal	388	16.44
Urban		
Industrial	36	1.54
Subtotal	36	1.54
Native		
Riparian	38	1.59
Native Vegetation	1,883	79.86
Water	13	0.57
Subtotal	1,934	82.02
Total	**2,358**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). The only public water agency in the High Valley Basin is Clearlake Oaks CWD. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the basin consists of magnesium bicarbonate type waters. TDS ranges from 480 to 745 mg/L, averaging 598 mg/L. Impairments to water quality include locally high ammonia, phosphorus, chloride, iron, and manganese. High boron may be an issue for agricultural uses. (DWR 2004, 1975.)

Hot Springs Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Hot Springs Valley Basin is 4 square miles (2,400 acres) and it is located in Modoc and Shasta Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin

118 (2004). The Hot Springs Valley Groundwater Basin is a northwest trending valley of Quaternary alluvium. The basin is bounded to the north, northeast, and northwest by Tertiary basalt of Big Valley Mountain and to the east and west by Recent basalt.

Based on 1995 and 1997 DWR surveys of land use and sources of water, groundwater extraction for municipal and industrial uses in the basin is estimated to be 1 acre-foot. Deep percolation of applied water is estimated to be 41 acre-feet.

The total depth of domestic wells in the basin range from 55 to 380 feet, with an average of 164 feet, based on 7 well completion reports. The single municipal/irrigation well completed in the basin is reported to have a total depth of 230 feet. No yield information is available for these wells. (DWR 2004.)

Major Sources of Recharge

Precipitation is the major source of recharge. Annual precipitation ranges from 19 to 27 inches, increasing to the north.

Land Use

Land use surveys were conducted within the basin by DWR in 1995 and 1997. Agricultural land use accounts for about 23% of the basin and native land accounts for about 77% of the basin. Table 4-68 provides details on the distribution of land use throughout the Hot Springs Valley Basin.

Table 4-68. Land Use in the Hot Springs Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	332	13.79
Pasture	230	9.58
Subtotal	562	23.36
Native		
Native Vegetation	1,839	76.46
Water	4	0.18
Subtotal	1,843	76.64
Total	**2,405**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998 and Siskiyou County adopted a groundwater management ordinance in 1998. A key element of both of the county ordinances is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Humbug Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

Humbug Valley is a small down-dropped area within the Penman Peak-Beckwourth Peak northeast of Mohawk Valley. The valley is approximately 6 miles long and 3 miles wide. The valley is bounded to the north by Pliocene volcanic rocks of Penman Peak, to the southeast by Miocene volcanic rocks of Beckwourth Peak, and to the northeast by Mesozoic granitic rocks. The floor of the river canyon is composed of fairly flat alluvium and sloping lake deposits at the western end of the valley. Middle Fork Feather River flows southwesterly through the valley to Mohawk Valley. Humbug Creek and Willow Creek are major tributaries to Middle Fork Feather River. The basin is located in Plumas County and is 9,980 acres (16 square miles) in size.

The following information regarding the hydrogeology of Humbug Valley basin is taken from DWR Bulletin118 (2004). The water-bearing formations of Humbug Valley are probably similar to those of Mohawk Valley. The primary water-bearing formations of Mohawk Valley are Holocene sedimentary deposits and Pleistocene lake deposits.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. The fan deposits coalesce or interfinger with lake and alluvial deposits. Specific yield ranges from 8 to 17%. Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. Pleistocene Lake deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay. Specific yield ranges from 1 to 25%. DWR (1963) estimates storage capacity to be 76,000 acre-feet to a depth of 100 feet.

DWR (2004) estimated groundwater extraction and percolation of applied water based on a 1997 survey. Groundwater extraction for municipal and industrial uses is estimated to be 200 acre-feet. Deep percolation of applied water is estimated to be 200 acre-feet.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation, infiltration of irrigation water and stream infiltration. Annual precipitation in the valley ranges from 23 to 29 inches, increasing to the southwest. Middle Fork Feather River flows southwesterly through the Humbug Valley to Mohawk Valley. Humbug Creek and Willow Creek are major tributaries to Middle Fork Feather River. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 4% of the basin, urban land uses account for 8% of the basin and native land accounts for about 88% of the basin. Table 4-69 provides details of the land uses within the Humbug Valley Basin.

Table 4-69. Land Use in the Humbug Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	430	4.32
Subtotal	430	4.32
Urban		
Commercial	30	0.30
Industrial	70	0.70
Urban Landscape	10	0.10
Urban Residential	690	6.93
Subtotal	800	8.03
Native		
Riparian	120	1.20
Native Vegetation	8,590	86.24
Water	20	0.20
Subtotal	8,730	87.65
Total	**9,960**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for this basin. The cities of Portola and Delleker are located in the basin. The public water agencies in the basin are City of Portola WSA and Grizzly Lake Resort ID. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The CDPH sampled municipal wells as required by Title 22 from 1994 to 2000. Sampling was completed for inorganics (11 wells), nitrates (14 wells), pesticides (2 wells), volatile organic compounds (2 wells), and radioactive elements (4 wells). There were no confirmed detections above the MCLs.

Indian Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Indian Valley aquifer system is 46 square miles in size and is located in Plumas County. The following description of the hydrogeology of the basin is taken from DWR Bulletin 118 (2004).

The Indian Valley Groundwater Basin is an irregular shaped basin bounded by Paleozoic to Mesozoic marine, volcanic, and metavolcanic rocks. The basin includes Genessee Valley, Indian Valley, and Bucks Valley. Indian Creek flows south and drains the basin at the southwest corner.

Storage capacity is estimated to be 100,000 acre-feet for a saturated depth interval of 10–210 feet.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 100 acre-feet.

Major Sources of Recharge

Deep percolation of applied water is estimated to be 2,600 acre-feet. Annual precipitation ranges from 31 to 43 inches, increasing to the southwest. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 39% of the basin, urban land use accounts for about 4% of the basin, and native land use accounts for about 57% of the basin. Table 4-70 provides details on the distribution of land use throughout the Indian Valley Basin.

Table 4-70. Land Uses in the Indian Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	11,401	38.76
Semiagricultural and Incidental	106	0.36
Subtotal	11,507	39.12
Urban		
Commercial	103	0.35
Industrial	128	0.44
Urban Landscape	29	0.10
Urban Residential	778	2.64
Vacant	59	0.20
Subtotal	1,097	3.73

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Barren and Wasteland	185	0.63
Riparian	403	1.37
Native Vegetation	15,975	54.31
Water	246	0.84
Subtotal	16,809	57.15
Total	**29,413**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the Indian Valley Basin. No public or private water agencies exist within the basin (DWR 2004).

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater in the Indian Valley Basin is sampled for miscellaneous water quality parameters by DWR at 4 wells and by the CDPH at 9 wells. Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. One well of 14 sampled showed concentrations above the MCLs for secondary inorganics. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Jess Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Jess Valley groundwater basin is located in Modoc County and is 6,700 acres (10 square miles) in size. The west side of the basin is bounded by Miocene basalt and, to a much lesser extent, Tertiary pyroclastic rocks. The basin is bounded on all other sides by Tertiary pyroclastic rocks. Jess Valley Basin consists of Quaternary alluvium and lake deposits. It drains to the west.

No hydrogeologic information is available for this basin.

DWR estimates groundwater extraction for municipal and industrial uses to be 2 acre-feet. (DWR 2004)Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation is about 17 inches (DWR 2004). Deep percolation of applied water is estimated by DWR (2004) to be 830 acre-feet. East Creek and Mill River influence the groundwater in the Jess Valley Basin.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The Jess Valley Basin is overlain with 53% agricultural land use, almost all of which is rangeland (pasture). Table 4-71 provides details of the land uses within the basin.

Table 4-71. Land Use in the Jess Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	3,571	53.26
Semiagricultural and Incidental	16	0.24
Subtotal	3,587	53.49
Urban		
Urban Residential	38	0.57
Subtotal	38	0.57
Native		
Riparian	213	3.17
Native Vegetation	2,868	42.77
Subtotal	3,081	45.94
Total	**6,705**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally limit the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). Public water agencies involved with the basin are the California Pines Community Service District, and Hot Springs Valley Irrigation District. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Joseph Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Joseph Creek Basin is 7 square miles (4,450 acres) in size and is located in Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Joseph Creek Groundwater Basin is located south of Goose Lake Groundwater Basin and west of the Warner Mountains. The basin consists of Quaternary Pleistocene non-marine deposits and Holocene alluvial deposits. The alluvial deposits are located at the southern and western boundaries of the basin along North Fork Pit River and Parker Creek. Alluvial deposits are also located centrally and at the far eastern extents of the basin. The basin is bounded by Tertiary volcanic rocks of the Warner Mountains to the north, east, and south and Pleistocene pyroclastic rocks and basalt to the south and west respectively. Additional hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, or groundwater storage.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for agricultural use is estimated to be 1,300 acre-feet. Well completion reports in the basin showed the yield for 1 municipal/irrigation well as 400 gal/min. The total depth of the single municipal/irrigation well in the basin is 230 feet (DWR 2004).

Major Sources of Recharge

Deep percolation of applied irrigation water is estimated to be 140 acre-feet. Annual precipitation ranges from 15 to 19 inches, increasing to the east. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 21% of the basin, and native land accounts for about 79% of the basin. Table 4-72 provides details on the distribution of land use throughout the Joseph Creek Basin.

Table 4-72. Land Use in the Joseph Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	909	20.41
Semiagricultural and Incidental	12	0.27
Subtotal	921	20.67
Native		
Riparian	91	2.04
Native Vegetation	3,431	77.00
Water	13	0.29
Subtotal	3,535	79.33

Total	**4,456**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the ordinance requires an export permit for groundwater transfers out of the basin (DWR 2004). There are no public or private water agencies in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Lake Almanor Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lake Almanor Valley Basin is 11 square miles in size and is located in Plumas County. The basin is located along the northwest shore of Lake Almanor and consists of Quaternary lake deposits and Pleistocene non-marine sediments. The basin is bounded by Lake Almanor to the southeast and bounded on all other sides by Pliocene basalt (DWR 2004).

The storage capacity is estimated to be 45,000 acre-feet for a saturated depth interval of 10–210 feet (DWR 2004). According to DWR Bulletin 118 (2004), hydrologic information is not available for descriptions of the water-bearing formations or groundwater level trends in the basin.

Based on 18 well completion reports, the average total depth of domestic wells in the basin is 55 feet, with a range from 19 to 106 feet. The total depth of the 2 municipal/irrigation wells reported in the basin is 94 feet and 100 feet. (DWR 2004.)

A 1997 DWR survey of land use and sources of water indicates that groundwater extraction for municipal and industrial uses in the Lake Almanor Valley Basin is estimated at 740 acre-feet.

Major Sources of Recharge

Annual precipitation in the basin is the primary source of recharge and ranges from 31 to 37 inches, increasing to the northwest. Deep percolation of applied water is estimated at 690 acre-feet.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 19% of the basin, urban land use accounts for about 18% of the basin, and native land use accounts for about 62% of the basin. Table 4-73 provides details on the distribution of land use throughout the Lake Almanor Valley Basin.

Table 4-73. Land Use in the Lake Almanor Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,386	19.37
Semiagricultural and Incidental	3	0.04
Subtotal	1,389	19.41
Urban		
Urban	132	1.85
Commercial	56	0.78
Industrial	319	4.45
Urban Landscape	3	0.05
Urban Residential	625	8.74
Vacant	167	2.33
Subtotal	1,302	18.20
Native		
Riparian	399	5.58
Native Vegetation	3,458	48.34
Water	606	8.47
Subtotal	4,463	62.39
Total	**7,154**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for Lake Almanor Valley Groundwater Basin. Chester PUD is the sole public water agency in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium bicarbonate is the predominant groundwater type in the basin. TDS concentrations range from 53 to 260 mg/L, averaging 105 mg/L. Groundwater in the basin has locally high copper, iron, lead, manganese, calcium and boron. (DWR 2004.)

Lake Britton Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lake Britton Area groundwater basin is located within a west-northwest trending valley in a region of several northwest trending faults. The basin is bounded to the south by Pleistocene basalt, to the west by Tertiary andesite, and to the north by Miocene basalt and Pliocene andesite (Gay 1968; Lydon 1969). The valley is drained by the Pit River. The basin is 14,060 acres (22 square miles) in size and is located in eastern Shasta County.

Groundwater extraction for municipal and industrial uses is estimated by DWR (2004) to be 5 acre-feet.

The 1984 DWR study of the Eastern Upland area of Shasta County showed potential groundwater limitations in the area north of State Highway 299 in the Eastern Upland planning area.

Major Sources of Recharge

Recharge to the Lake Britton Area aquifer is mostly by infiltration of precipitation into the alluvium. Annual precipitation ranges from 21-43 inches, increasing to the east. Estimated recharge by deep percolation of applied water is 10 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1999. Almost all of the land uses in the Lake Britton basin are Native land uses. Only 0.9% is urban and 0.3% is agricultural. Table 4-74 provides details of the land uses.

Table 4-74. Land Use in the Lake Britton Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	44	0.32
Subtotal	44	0.32
Urban		
Urban—unclassified	29	0.21
Urban Landscape	93	0.66
Urban Residential	6	0.04
Subtotal	128	0.91
Native		
Native Vegetation	12,508	88.95
Water	1,381	9.82
Subtotal	13,889	98.78
Total	**14,061**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county.

Along with Shasta County, the Burney Water District is the only water agency that manages the water in the Lake Britton Area basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Last Chance Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Last Chance Valley Groundwater Basin is a narrow east/west trending basin located south of Honey Lake. The basin is bounded to the south by Tertiary pyroclastic rocks and to the north by Miocene volcanics, Mesozoic granitic rocks, and Tertiary pyroclastic rocks. Eocene basalt borders the basin in the west. Last Chance Creek drains the basin to the west. The basin is 4,660 acres (7 square miles) in size and is located in northeastern Plumas County.

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 17 to 23 inches, increasing to the west. Last Chance Creek drains the basin to the west.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. There is no agricultural land in this basin (Table 4-75).

Table 4-75. Land Use in the Last Chance Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	4,190	90.11
Riparian	460	9.89
Total	**4,650**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. There are no know water agenciesor urban areas within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Little Indian Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Little Indian Valley Basin is bounded to the northeast by the East Park Reservoir and on all other sides by Mesozoic lower Cretaceous marine sedimentary rocks and the Knoxville Formation. The basin consists of Quaternary stream terrace deposits. Faulting may transect the basin. The aquifer system is 2 square miles in size and is located in Lake County. Hydrogeologic information, groundwater level trends, and groundwater storage data are not available for the water bearing formations. Based on a 1993 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 34 acre-feet. (DWR 2004.)

Major Sources of Recharge

Annual precipitation is approximately 21 inches. Deep percolation of applied water is estimated to be 25 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 25% of the basin, urban land use accounts for about 38% of the basin, and native land use accounts for about 37% of the basin. Table 4-76 provides details on the distribution of land use throughout the Little Indian Valley Basin.

Table 4-76. Land Use in the Little Indian Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	305	24.06
Semiagricultural and Incidental	10	0.79
Subtotal	316	24.86
Urban		
Urban Residential	480	37.81
Subtotal	480	37.81
Native		
Riparian	6	0.51
Native Vegetation	466	36.71
Water	1	0.11
Subtotal	474	37.33
Total	**1,270**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). No public or private water agencies are located within the Little Indian Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is insufficient groundwater quality information available to characterize this basin (DWR 2004). CDPH sampled only one well for inorganic and one well for nitrates between the years of 1994 and 2000.

Long Valley Basin (5-31)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Long Valley Basin is 4 square miles in size and is located in Lake County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

Long Valley Groundwater Basin is located within a narrow elongated valley northeast of Clear Lake. The basin is bounded on most sides by the Franciscan Formation. A small portion of the southern boundary consists of Quaternary volcanic rocks. The valley is drained by Long Valley Creek, which is tributary to North Fork Cache Creek. Groundwater is developed in Quaternary alluvium and, to a limited extent, Quaternary terrace deposits.

Estimates of groundwater extraction are based on a survey conducted by the DWR in 1995. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 760 and 23 acre-feet respectively.

Major Sources of Recharge

Recharge to the basin is from precipitation with annual precipitation ranging from 27 to 33 inches, increasing to the west. Deep percolation from applied water is estimated to be 210 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 32% of the basin, urban land use accounts for about 6% of the basin, and native land use accounts for about 61% of the basin. Table 4-77 provides details on the distribution of land use throughout the Long Valley Basin.

Table 4-77. Land Use in the Long Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	44	1.56
Grain and Hay	523	18.68
Idle	206	7.36
Semiagricultural and Incidental	20	0.71
Truck, Nursery, and Berry Crops	117	4.16
Subtotal	910	32.46
Urban		
Urban Residential	175	6.25
Subtotal	175	6.25

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	1,715	61.23
Water	2	0.05
Subtotal	1,717	61.29
Total	**2,802**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Long Valley Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the only public water agency within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Long Valley Basin (5-44)

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The Long Valley groundwater basin (5-44) is an alluvial filled valley located in eastern Modoc and Lassen Counties. Total acreage is 1,090 acres (2 square miles). The basin is bounded on the west side by a north/south trending fault. The basin is bounded on the northern half of the west side of the valley by Tertiary pyroclastic rocks and on all other sides by Miocene basalt.

Major Sources of Recharge

The primary source of groundwater recharge is precipitation and surface runoff. The average annual precipitation in the basin ranges from 25 to 27 inches. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1997. According to the survey, native vegetation is the only category of land use in the Long Valley Basin 5-44.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally limit the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004).

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality datafor this basin could not be identified.

Lower Lake Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Lower Lake Basin is bounded on the south by Plio-Pleistocene Cache Formation, Tertiary bedrock, and rocks of the Great Valley Sequence; on the north by the Cache Formation and Quaternary volcanics; and on the east by Tertiary rock of the Martinez and Tejon formations. The area of the basin is 4 square miles and it is located in Lake County. (DWR 2004.)

The following description of the hydrogeology in the Lower Lake Basin is taken from DWR Bulletin 118 (2004). Lower Lake Basin is located at the southeast end of Clear Lake and includes the alluvial plains of Cache, Herndon, and Seigler Canyon Creeks. Copsey Creek also drains to Cache Creek from Excelsior Valley located to the south. The basin is Surficial Cache Formation and Martinez Formation deposits are located within the middle third of the basin north and northeast of the city of Lower Lake. The aquifer system of Lower Lake Basin is primarily composed of deposits of Quaternary alluvium and the Plio-Pleistocene Cache Formation.

Alluvial deposits in the basin are approximately 50–75 feet thick and consist of clay, silt, and sand, with some gravel. Irrigation wells constructed in the vicinity of alluvial deposits yield between 400 and 600 gpm with little drawdowns. The alluvial plain of Herndon Creek likely consists of clay, clay and gravel, and some interbedded gravel stringers or layers. Wells installed to depths of approximately 75 feet yield up to 250 gpm with about 40 feet of drawdown.

The Cache Formation is primarily composed of gravel, silt, and sand with the upper most sediments consisting of water-laid tuffs and tuffaceous sands intercalated with clay, marl, pebbly limestone, and diatomite. The formation underlies younger alluvial deposits over a region of approximately two-thirds of the basin. The permeability in the formation is variable but generally low. Most of the strata are too high in clay or silt. Depth of the formation is unknown. Well yields are reported to range between 150 and 240 gpm.

Storage capacity is estimated to range from 3,000 to 4,000 acre-feet. Additional storage capacity is available as part of the Cache Formation; however, thickness and specific yield of that formation is unknown.

Estimates of groundwater extraction for Lower Lake Basin are based on a survey conducted by the DWR in 2001. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 78 and 210 acre-feet respectively. Deep percolation from applied water is estimated to be 33 acre-feet.

Major Sources of Recharge

Groundwater recharge is derived from precipitation and from seepage from Herndon Creek and Clear Lake. Recharge also likely occurs from Copsey and Seigler Canyon Creeks. Recharge of groundwater in the Cache formation is likely derived from the infiltration of rain that falls on the outcrop area. Annual precipitation in the basin is approximately 27 inches. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 7% of the basin, urban land use accounts for about 27% of the basin, and native land accounts for about 66% of the basin. Table 4-78 provides details on the distribution of land use throughout the Lower Lake Basin.

Table 4-78. Land Use in the Lower Lake Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	91	3.76
Grain and Hay	18	0.76
Idle	19	0.80
Semiagricultural and Incidental	3	0.11
Vineyards	31	1.29
Subtotal	162	6.73
Urban		
Commercial	52	2.18
Industrial	6	0.25
Urban Landscape	5	0.20
Urban Residential	572	23.76
Vacant	11	0.44
Subtotal	645	26.83
Native		
Riparian	4	0.16
Native Vegetation	1,371	57.00
Water	223	9.28
Subtotal	1,598	66.44

Land Use	Acreage of Land Use	Percent of Land Use
Total	**2,406**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Lower Lake Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). Highlands Mutual Water Company is a private water agency within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Bicarbonate type waters with mixed cationic character are found in the basin. TDS concentrations range from 290 to 1,230 mg/L, averaging 568 mg/L. Groundwater in the basin has localized high iron, manganese, calcium, sodium, ASAR, sulfate, and TDS. High boron concentrations may be an issue for irrigation (DWR 2004). Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, and pesticides. Two wells of 3 showed concentrations above the MCLs for secondary inorganics. There were no detections above MCLs for other constituents.

McCloud Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The McCloud Area Groundwater Basin is located at the base of Mount Shasta on the southeast slope. It is in Siskiyou County and is 21,320 acres (33 square miles) in size. Elevation of the basin ranges from 3,060 feet mean sea level in the south to 6,000 feet mean sea level in the north. The basin is bounded to the west by Pleistocene volcanic rocks and glacial deposits of Mount Shasta. The basin is bounded to the north by Pliocene basalt, to the east by Pliocene basalt and Pleistocene volcanic rocks, and to the south by Paleozoic marine sedimentary and metasedimentary rocks (DWR 2004).

DWR estimated groundwater extraction for agriculture to be 3 acre-feet. Municipal and industrial use is approximately 420 acre-feet.

Major Sources of Recharge

Recharge to the subbasin is from precipitation (49 to 55 inches/year), irrigation infiltration, and stream infiltration.

Numerous creeks drain Mount Shasta and enter the basin, such as Squaw Valley Creek, Mud Creek, Ash Creek, and Pilgrim Creek. The McCloud River drains the basin to the south. These creeks provide groundwater recharge to the basin.

Deep percolation of applied water is estimated to be 280 acre-feet. These estimates were based on a survey conducted in 1991. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2000. Native land use accounts for about 98% of the basin. The City of McCloud is on the western basin boundary but does not lie entirely within the basin. The population of McCloud (as of 2000) is about 1,300. Table 4-79 provides details of the land uses within the basin.

Table 4-79. Land Use in the McCloud Area Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	77	0.36
Subtotal	77	0.36
Urban		
Commercial	42	0.19
Industrial	143	0.67
Urban Landscape	74	0.35
Urban Residential	118	0.55
Vacant	45	0.21
Subtotal	422	1.98
Native		
Native Vegetation	20,835	97.66
Subtotal	20,835	97.66
Total	**21,334**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Siskiyou County adopted a groundwater management ordinance in 1998. The City of McCloud is the only large town (population 1,300) in the basin; it is located on the western basin boundary. The McCloud CSD is the only public water agency within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is no groundwater quality information available for the McCloud Area Basin.

Meadow Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Meadow Valley Groundwater Basin is 9 square miles (5,730 acres) in size and is located in Plumas County. The following description of the hydrogeology in the Meadow Valley Basin is taken from DWR Bulletin 118 (2004).

The basin lies within the Melones Fault Zone of the Sierra Nevada Mountain Range. It is bounded on the west by Mesozoic ultrabasic intrusive rocks, to the north and south by Pliocene pyroclastic rocks, and to the east by ultrabasic intrusive rocks and Paleozoic marine sediments.

Hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses in the Meadow Valley Basin is estimated to be 27 acre-feet. Deep percolation of applied water is estimated to be 60 acre-feet.

The total depth of domestic wells (based on 151 well completion reports) in the basin ranged from 50 to 310 feet, with an average of 125 feet. There is no available data on well yields.

Major Sources of Recharge

The major source of groundwater recharge is precipitation, which ranges from 47 to 53 inches per year, increasing to the southwest (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 5% of the basin, urban land use accounts for about 6% of the basin, and native land accounts for almost 90% of the basin. Table 4-80 provides details on the distribution of land use throughout the Meadow Valley Basin.

Table 4-80. Land Use in the Meadow Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	274	4.78
Subtotal	274	4.78

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Commercial	18	0.31
Urban Landscape	3	0.05
Urban Residential	303	5.28
Subtotal	323	5.63
Native		
Native Vegetation	5,132	89.49
Water	5	0.10
Subtotal	5,138	89.58
Total	**5,735**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the Meadow Valley Basin. There are no public or private water agencies within the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater samples from one well were analyzed for primary inorganics, radiologicals, nitrates, and secondary inorganics as required under CDPH Title 22 program from 1994 to 2000. There were no detections of these constituents above the MCLs in the well sampled.

Middle Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Middle Creek Groundwater Basin is 1 square mile in size and is located in Lake County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Middle Creek Groundwater Basin is a north-trending basin located west of Pitney Ridge and east of Middle Mountain. The basin consists of Quaternary alluvium and is likely in hydraulic continuity with the Upper Lake Groundwater Basin. Faulting may extend the length of the western boundary. The basin is bounded to the north and east by the Franciscan Formation. Much of the western portion of the basin is bounded by Lower Cretaceous marine deposits.

According to DWR (2004), hydrogeologic information is not available for the water-bearing formations, groundwater level trends, or groundwater storage.

Well completion reports in the basin showed a yield for 1 municipal/irrigation well of 75 gal/min. The average total depth of domestic wells (31 wells reported) is 108 feet, with a range from 31 to 250 feet. The average total depth of municipal/irrigation wells (3 wells reported) is 70 feet, with a range from 54 to 100 feet (DWR 2004).

According to a 1995 DWR survey of land use and sources of water, groundwater extraction for agricultural use is estimated to be 28 acre-feet.

Major Sources of Recharge

Annual precipitation is the major source of recharge and ranges from 43 to 45- inches, increasing to the north. Deep percolation of applied water is estimated to be 6 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 5% of the basin, urban land use accounts for about 4% of the basin, and native land use accounts for about 91% of the basin. Table 4-81 provides details on the distribution of land use throughout the Middle Creek Basin.

Table 4-81. Land Use in the Middle Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	18	2.53
Pasture	18	2.51
Semiagricultural and Incidental	1	0.15
Subtotal	37	5.19
Urban		
Commercial	25	3.61
Industrial	1	0.12
Urban Residential	1	0.12
Subtotal	27	3.85
Native		
Barren and Wasteland	140	19.84
Native Vegetation	502	71.12
Subtotal	641	90.96
Total	**705**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

The CDPH monitors one well in the Middle Creek Basin for miscellaneous water quality parameters but there is no available groundwater quality data.

Middle Fork Feather River Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Middle Fork Feather River Groundwater Basin is 7 square miles (4,340 acres) in size and is located in Plumas County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Middle Fork Feather River Groundwater Basin consists of Quaternary lake and alluvial deposits. The basin is located within a region of northwest trending faults. A fault forms a basin boundary to the east. The basin is bounded to the north and south by Pliocene and Miocene volcanic rocks and to the east and west by Paleozoic marine deposits. The alluvial deposits in the basin are largely located along the North Fork Feather River, which drains the basin to the southwest.

Hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, and groundwater storage in the Middle Fork Feather River Basin.

Based on a 1997 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use is estimated to be 4 acre-feet.

Total depth of domestic wells in the basin ranges from 23 feet to 400 feet, with an average of 150 feet. There is no known data on well yields.

Major Sources of Recharge

Precipitation is the primary source of recharge with annual precipitation ranging from 39 to 47-inches, increasing to the west. Deep percolation of applied water is estimated to be 34 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 4% of the basin, urban land use accounts for about 2% of the basin, and native land use accounts for about 94% of the basin. Table 4-82 provides details on the distribution of land use throughout the Middle Fork Feather River Basin.

Table 4-82. Land Use in the Middle Fork Feather River Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	161	3.70
Semiagricultural and Incidental	7	0.15
Subtotal	167	3.86
Urban		
Commercial	82	1.88
Industrial	13	0.30
Urban Landscape	3	0.06
Urban Residential	4	0.10
Subtotal	102	2.34
Native		
Native Vegetation	4,027	92.77
Water	45	1.04
Subtotal	4,072	93.80
Total	**4,341**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications for the basin. There are no known public or private water agencies in the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater samples were analyzed for primary inorganics, nitrates, and secondary inorganics as required under CDPH Title 22 program from 1994 to 2000. Sampling results of these constituents were not above the MCLs. (DWR 2004.)

Mohawk Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mohawk Valley Groundwater Basin encompasses 30 square miles and is located in Plumas and Sierra Counties. The following description of the hydrogeology in the Mohawk Valley Basin is taken from DWR Bulletin 118 (2004).

The Mohawk Valley Groundwater Basin lies within an elongated valley occupying a portion of a long, narrow graben. The graben is bounded on the southwest side by the Mohawk Valley fault. The east side of the valley is bounded by a group of northwest trending faults that branch from the Mohawk Valley fault near Gattley. The floor of the valley consists of a narrow strip of nearly flat alluvial material overlying lake sediments. Lake sediments also underlie the upland areas of the valley. Depth to bedrock is estimated to range from 1,500 to 3,000 feet. The basin is bounded to the northeast by Pliocene volcanic rocks of Penman Peak, to the east by Miocene volcanic rocks of Beckwourth Peak, and to the west and southwest by Paleozoic metavolcanic rocks and Mesozoic granitic rocks of the Sierra Nevada. Sulphur Creek drains the southern half of the valley and enters Middle Fork Feather River near the midpoint of the valley and flows northwesterly.

The primary water-bearing formations in the basin are Holocene sedimentary deposits and Pleistocene lake and near-shore deposits. Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. Thickness of the deposits ranges to 200 feet. The fan deposits coalesce or interfinger with lake and alluvial deposits. Specific yield ranges from 8 to 17%.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater.

Lake and near-shore deposits underlie the majority of the valley and range in thickness to over 2,000 feet. These deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay. The sand beds usually yield large quantities of confined groundwater. The near-shore deposits are composed of moderately permeable sand and gravel and, where saturated, yield moderate amounts of groundwater. Specific yield ranges from 1 to 25%.

Storage capacity for the basin is estimated to be 90,000 acre-feet based on a specific yield of 5% for a depth interval of zero to 200 feet.

Based on a 1997 DWR survey of land use and sources of water, groundwater extraction for municipal and industrial uses is estimated to be 130 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and annually ranges from 27 to 39 inches in the valley and ranges to 51 inches in the upland areas. Deep percolation of applied water is estimated to be 330 acre-feet. (DWR 2004.)

Land Uses

Land use surveys were conducted within the basin by DWR in 1997. Agricultural and urban land use each account for about 7% of the basin, and native land use accounts for over 85% of the basin. Table 4-83 provides details on the distribution of land use throughout the Mohawk Valley Basin.

Table 4-83. Land Use in the Mohawk Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,337	7.04
Semiagricultural and Incidental	4	0.02
Subtotal	1,341	7.07
Urban		
Commercial	98	0.52
Urban Landscape	515	2.71
Urban Residential	809	4.26
Subtotal	1,422	7.49
Native		
Native Vegetation	16,122	84.93
Water	99	0.52
Subtotal	16,220	85.45
Total	**18,983**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications pertaining to the Mohawk Valley Basin. Public Water agencies within the basin include Plumas Eureka Community Services District and CLIO PUD.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Calcium-magnesium bicarbonate and sodium bicarbonate are the predominant groundwater types in the basin. TDS ranges from 210 to 285 mg/L, averaging 248 mg/L. Groundwater in the basin has locally high iron, manganese, ammonia, phosphorus, ASAR and boron levels. (DWR 2004.)

Groundwater sampling performed under the requirements of the CDPH Title 22 program from 1994 through 2000 tested for primary and secondary inorganics, radiologicals, nitrates, pesticides, VOCs, and SVOCs. Five wells of 11 sampled for secondary inorganics showed concentrations above the MCLs. Concentrations above the MCL for the other constituents were not detected (DWR 2004).

Mountain Meadows Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mountain Meadows Valley Groundwater Basin is located to the northeast of Lake Almanor. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004). The basin consists of Quaternary alluvium that encircles Mountain Meadow Reservoir. The basin is bounded to northeast by Jurassic to Triassic metavolcanic rocks and Tertiary non-marine sediments. The basin is bounded to the southeast by Miocene volcanic rocks and to the northwest by Pleistocene basalt. The area of the subbasin is 8,150 acres (13 square miles) and is located in Lassen County.

There is no available information about the hydrogeology of Mountain Meadows Valley Basin.

DWR estimated the groundwater extraction for the Mountain Meadows Valley Basin from a 1997 survey. The survey included land use and sources of water. Groundwater extraction for municipal and industrial uses was estimated to be 7 acre-feet annually.

Major Sources of Recharge

Recharge to the basin is from precipitation (18 inches/year), irrigation infiltration, and stream infiltration. Annual precipitation in the basin ranges from 35 to 39 inches. Deep percolation of applied water is estimated to be 350 acre-feet per year (DWR 2004). Streams in the basin are Roberts Creek, Deerheart Creek, Mountain Meadows Creek, and Greenville Creek.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 46% and undeveloped land accounts for about 54% of the basin. Table 4-84 provides details of the land uses within the basin.

Table 4-84. Land Use in the Mountain Meadows Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	3,740	45.89
Subtotal	3,740	45.89
Urban		
Industrial	10	0.12
Subtotal	10	0.12
Native		
Riparian	1,630	20.00
Native Vegetation	2,660	32.64
Water	110	1.35

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	4,400	53.99
Total	**8,150**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lassen County enacted a groundwater ordinance in 1999 that requires a permit for groundwater exported from the county. There are no known groundwater management plans or basin adjudications. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

North Fork Battle Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The North Fork Battle Creek basin is bounded to the north by Pliocene volcanic rock and on all other sides by Pleistocene volcanic basalt (Gay 1960). The basin consists of several east-west trending courses of alluvium located along North Fork Battle Creek and Bailey Creek. The areal extent of the basin is 12,760 acres (20 square miles) and is located in eastern Shasta County. (DWR 2004.)

The following description of the hydrogeology in the North Fork Battle Creek basin is taken from DWR Bulletin 118 (DWR 2004). Water-bearing formations in the basin include the Quaternary alluvium and underlying volcanic rocks. Driller reports for wells located in the area of Viola (along the eastern basin boundary) show uniform stratification of alluvium and volcanic rocks. The reports indicate that alluvium is approximately 32 feet thick overlying a succession of volcanic rocks (DWR 1984). The volcanic rocks are composed of two 10–40-foot thick flows that are separated by a 40–80-foot section of sand, gravel, ash, and cinders. DWR (1984) indicates that the interbedded sand-gravel-ash-cinder strata are the primary groundwater source in the area. DWR (1984) reports that groundwater in the area of Viola has a seasonal fluctuation of 1 foot with the lowest elevations occurring during periods of maximum evapotranspiration.

DWR (2004) estimated annual groundwater extraction for municipal and industrial use to be 190 acre-feet.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by infiltration of streamflows at the margins of the subbasin. Other sources of recharge are infiltration of applied water and direct infiltration of precipitation (43-49

inches/yr) into the alluvium. Inflow via deep percolation of applied water is estimated to be 220 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1999. North Fork Battle Creek basin contains 90% native land, 6% agricultural land, and 4% urban land. Table 4-85 provides details of the land uses within the basin.

Table 4-85. Land Use in the North Fork Battle Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	751	5.89
Subtotal	751	5.89
Urban		
Urban	6	0.05
Commercial	49	0.39
Urban Residential	426	3.34
Subtotal	482	3.78
Native		
Riparian	33	0.26
Native Vegetation	11,458	89.78
Water	38	0.29
Subtotal	11,529	90.34
Total	**12,762**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. No water agencies are involved with the management of North Fork Battle Creek basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

North Fork Cache Creek Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the North Fork Cache Creek Groundwater Basin is 5 square miles, located in Lake County. The following description of the North Fork Cache Creek Basin is taken from DWR Bulletin 118 (2004).

The North Fork Cache Creek Groundwater Basin is a north-south trending basin consisting of Quaternary alluvium and stream terrace deposits. The basin is bounded by Mesozoic ultrabasic intrusive rocks in the north. Other sides of the basin are bounded by Franciscan Formation metasediments and Franciscan volcanic and metavolcanic rocks. The valley is drained to the south by North Fork Cache Creek.

According to DWR (2004), hydrogeologic information was not available for the water-bearing formations, groundwater level trends, or storage in the basin.

Major Sources of Recharge

The primary source of recharge is precipitation which ranges from 23 to 25 inches per year, increasing to the south.

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Native land use accounts for 100% of the basin. Table 4-86 provides details on the distribution of land use throughout the North Fork Cache Creek Basin.

Table 4-86. Land Use in the North Fork Cache Creek Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Barren and Wasteland	545	15.69
Native Vegetation	107	3.08
Water	2,824	81.23
Total	**3,477**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). There are no public or private water agencies within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Pope Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The areal extent of the Pope Valley Basin aquifer system is 11 square miles and is located in Napa County. The following description of the hydrogeology is taken from DWR Bulletin 118 (2004).

The Pope Valley groundwater basin occupies a northwest trending structural depression in the central Coast Ranges, approximately 5 miles east of Lake Berryessa. The Pope Valley is approximately 9 miles in length from its northwestern boundary near the town of Aetna Springs to its southeastern margin near the confluence of Maxwell and Hardin Creeks. The basin ranges in width, up to 2 miles. Mountains of the Coast Ranges surround the Pope Valley Basin on all sides. The boundary between the water-bearing and nonwater- bearing materials roughly coincides with the edge of the valley floor. Pope and Maxwell Creeks drain the Pope Valley groundwater basin.

The Quaternary alluvium within the Pope Valley groundwater basin is considered the principal water bearing deposit.

Historically, stream development has been limited to small creeks. Since large stream flows were lacking, accumulations of alluvium seem to have been restricted to the range of 25 feet to 30 feet.

The alluvial material is principally composed of silty to clayey sands and gravels. With an assumed specific yield of 3% most wells yield less than 100 gpm.

Small outcrops of the Sonoma volcanics of Pliocene age occur in the vicinity of Aetna Springs. They are considered to be water bearing but their limited distribution restricts the quantity of groundwater that can be extracted from them to insignificant proportions.

Bedrock beneath the Pope Valley groundwater basin is comprised predominantly of Lower Cretaceous marine sedimentary rocks, which is also found cropping out in the surrounding hills.

According to DWR (2004), there is no published information found that is indicative of groundwater level trends, quantity of groundwater in storage, or groundwater extraction for the Pope Valley groundwater basin. Groundwater storage capacity for the Pope Valley groundwater basin is estimated to contain 7,000 acre-feet of water.

The average total depth of domestic wells in the Pope Valley Basin is 169 feet, with a range from 21 to 600 feet. The average total depth of municipal/irrigation wells is 194 feet, with a range from 60 to 300 feet (DWR 2004).

Major Sources of Recharge

Natural recharge occurs from infiltration of precipitation that falls on the basin floor and in the upland areas within the drainage basin of the valley. The annual precipitation ranges from less than 36 inches in the southeast to more than 40 inches in the northwest (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1999. Agricultural land use accounts for about 32% of the basin, urban land use accounts for about 1% of the basin, and undeveloped land accounts for almost 68% of the basin. Table 4-87 provides details on the distribution of land use throughout the Pope Valley Basin.

Table 4-87. Land Use in the Pope Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	16	0.23
Grain and Hay	197	2.74
Idle	226	3.15
Rice	3	0.04
Semiagricultural and Incidental	29	0.41
Vineyards	1,796	25.01
Subtotal	2,268	31.58
Urban		
Urban—unclassified	5	0.06
Commercial	12	0.16
Urban Landscape	34	0.47
Urban Residential	4	0.06
Vacant	9	0.12
Subtotal	63	0.88
Native		
Riparian	9	0.13
Native Vegetation	4,583	63.80
Water	259	3.60
Subtotal	4,851	67.54
Total	**7,182**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Napa County Flood Control and Water Conservation District is a public water agency within the Pope Valley Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

According to DWR (2004) there is no published data available to characterize the groundwater quality of the Pope Valley groundwater basin. The CDPH monitors 1 well in the basin for Title 22 water quality parameters.

Redding Basin—Introduction

The Redding Basin covers about 510 square miles in the northern part of the Central Valley of California and is surrounded by the Cascade Range, Klamath Mountains, and Coast Ranges. It is separated from the main part of the valley by the Red Bluff Arch, a subsurface geologic structure (Pierce 1983). The Basin is located in Tehama and Shasta Counties and contains six subbasins: Bowman, Rosewood, Anderson, Enterprise, Millville, and South Battle Creek.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by subsurface inflow, infiltration of streamflows at the margins of the subbasin, and infiltration of precipitation and irrigation water. Groundwater movement is generally from the periphery of the basin towards the Sacramento River and then southward, where at the Red Bluff Arch, the water in the sedimentary rocks of Tertiary and Quaternary age is probably discharging into the Sacramento River (Pierce 1983). Therefore, subsurface flow enters the subbasin from the west, and discharges to the east. The major sources of streamflow infiltration are Cottonwood Creek and Dry Creek. Annual precipitation ranges from 23 to 27 inches/yr. The average specific yield for the Redding basin reported to be 8.5%. Storage capacity for the entire Redding basin, assuming and average aquifer thickness of 200 feet, is 5.5 maf (Pierce 1983). Specific yield data for the subbasins is not available to estimate storage capacity for the individual subbasins.

Water Quality

Groundwater in the Redding Basin is characterized as magnesium-calcium bicarbonate and calcium-magnesium bicarbonate type waters. TDS ranges from 70 to 360 mg/L (DWR 2004). Groundwater quality problems include localized high boron concentrations. There is a potential to induce the saline water in the Chico Formation to move upward if pumpage from the Tuscan and Tehama Formations is increased significantly (Pierce 1983). Table 4-88 summarizes the results from Pierce (1983).

Table 4-88. Concentrations of Constituents of Concern Detected in the Redding Basin in 1979

Constituent Type	Constituent of Concern	Concentration ranges	Standards
Nutrients	Nitrate as N	0–10 mg/L, median is 0.59 mg/L	10 mg/L
Salt—primarily as electrical conductivity and total dissolved solids.	Dissolved Solids	95–424 mg/L, median is 166 mg/L	500 mg/L (SMCL)
Trace elements	Arsenic	1–48 µg/L, median 1 µg/L	10 µg/L (MCL as of January 23, 2006)
	Barium	10–100 µg/L, median 30 µg/L	2,000 µg/L (MCL)
	Cadmium	1–2 µg/L, median 1 µg/L	5 µg/L (MCL)
	Chromium	0–10 µg/L, median 0 µg/L	100 µg/L (MCL)
	Chloride	0–140 mg/L, median 3 mg/L	250 mg/L (SMCL)
	Copper	0–14 µg/L, median 1 µg/L	1,000 µg/L (SMCL)
	Fluoride	0–0.3 mg/L, median 0.1 µg/L	4 mg/L (MCL)
	Iron Fe	10–40 µg/L, median 10 µg/L	300 µg/L (SMCL)
	Lead	0–2 µg/L, median 0 µg/L	15 µg/L (MCL)
	Manganese	1–50 µg/L, median 3 µg/L	50 µg/L (SMCL)
	Mercury	0–0.1 µg/L	2 µg/L (MCL)
	Selenium	0–1 µg/L, median 0 µg/L	50 µg/L (MCL)
	Silver	0	0.10 mg/L (SMCL)
	Sulfate	0–170 mg/L, median 3 µg/L	250 mg/L (SMCL)

Notes:
MCL = Maximum Contaminant Level set by EPA (2005).
µg/L = micrograms per liter.
mg/L = milligrams per liter.
SMCL = Secondary Maximum Contaminant Level set by EPA (2005).
Source: Pierce 1983.

Groundwater quality samples were also collected by the USGS in the area surrounding Cottonwood Creek during October 1982 and May 1983 (Fogelman and Evenson 1984). Cottonwood Creek borders Bowman subbasin on the north. Groundwater quality in the Cottonwood Creek area at that time was considered good to excellent with respect to recommended standards. Chemical quality varied little both spatially and seasonally. Groundwater levels were higher in the spring and lower in the autumn, coinciding with precipitation patterns.

One well had high nitrate (as nitrogen) concentrations (12 mg/L during October 1982 and 9.2 mg/L during May 1983). The EPA primary drinking-water limit for nitrate (as nitrogen) is 10 mg/L. This well was a shallow domestic well located at a farmhouse surrounded by pasture. The shallow well depth, shallow water level, and locale of this well lead to the conclusion that the nitrate problem is probably a result of surface contamination through the well borehole.

Water samples from a test well drilled by the Corps exceeded the EPA primary drinking-water limit for arsenic at two of the three depth intervals sampled. Water samples from 246 feet had an arsenic concentration of 0.066 mg/L, and samples from 176 feet had an arsenic concentration of 0.06 mg/L.

Arsenic can be acutely or chronically toxic to humans and plants. The EPA has established 0.01 mg/L as the primary drinking water standard (as of 1/23/06).

Water from two wells exceeded the 0.05-mg/L secondary standard for manganese, with concentrations of 0.066 and 0.13 mg/L. Manganese is objectionable in public water supplies because it affects taste, stains plumbing fixtures, spots laundered clothes, and causes accumulation of oxide deposits in distribution systems.

One well was sampled at three intervals during October 25–26, 1982, for trace metals as well as the standard chemical analyses used in the semiannual groundwater samples. The sample depths were 246 feet, 176 feet, and 104 feet. These samples show that concentrations of calcium, magnesium, sulfate, manganese, cadmium, molybdenum, strontium, and vanadium decrease with increasing depth, and dissolved solids, sodium, alkalinity, chloride, arsenic, boron, lead, lithium, and zinc concentrations increase with increasing depth.

The DPR verified detections of five compounds in Shasta County between 1985 and 2003. There were 2 detections total: 1 detection of ACET and 1 detection of DACT. Verified detections are those that are found at more than one sampling date. These groundwater contaminants were the result of legal, agricultural uses. Access for specific locations for these water quality results was unavailable.

Bowman Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Bowman subbasin is bounded on the west by the Coast Ranges; on the north by Salt, Dry, and Cottonwood Creeks; on the east by the Sacramento River; and on the south by the Red Bluff Arch. The Red Bluff Arch is defined as the hydrologic divide between the drainages of Cottonwood Creek and Hooker Creek to the north and the drainages of Blue Tent Creek, Dibble Creek, and Reeds Creek to the south. The subbasin is 78,500 acres (123 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Bowman subbasin is taken from DWR Bulletin 118 (DWR 2004). The subbasin aquifer system consists of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include Pliocene Tehama and Tuscan formations.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek and Hooker Creek and along the Sacramento River. Riverbank Formation deposits are

observed along all major creeks. The thickness ranges up to 50 feet. These deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges and is the principal water-bearing formation in the subbasin. The formation is exposed over approximately 80% of the subbasin surface area. The thickness varies from 4,000 feet to the north to approximately 3,800 feet to the south along Interstate Highway 5. The thickness of the deposit thins to the west from Cottonwood and reaches a thickness of 2,500 feet at the Sacramento River. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is found interfingered with the Tehama Formation south of Cottonwood Creek. The overlapping thickness may reach up to 2,500 feet towards the Red Bluff Arch. The Tuscan Formation is the principal water-bearing formation at the eastern extents of the subbasin. The formation consists of volcanic gravel and tuff breccia, fine- to coarse-grained volcanic sandstone, conglomerate, tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia, which are essentially impermeable.

Long-term groundwater level data indicate a slight decline in groundwater levels associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Some wells increased in levels beyond the pre-drought conditions of the 1970s during the wet season of the early 1980s. Generally, the seasonal fluctuation is approximately 5- feet for normal and dry years. Overall, there do not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use at 350 acre-feet. Municipal and industrial use is approximately 9 acre-feet. Inflow via deep percolation of applied water is estimated to be 1,500 acre-feet.

Major Sources of Recharge

Recharge to the principal aquifer is mostly by infiltration of streamflows at the margins of the subbasin. (Pierce 1983). Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 3% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 94% of the subbasin. Table 4-89 provides details of the land uses within the subbasin.

Table 4-89. Land Use in the Bowman Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	660	0.80
Field Crops	20	0.03
Grain and Hay	80	0.10
Pasture	1,710	2.20
Truck, Nursery, and Berry Crops	10	0.01
Idle	160	0.20
Semiagricultural and Incidental	60	0.10
Subtotal	2,700	3.40
Urban		
Urban Landscape	30	0.04
Urban Residential	1,840	2.30
Commercial	50	0.10
Industrial	50	0.10
Vacant	270	0.30
Subtotal	2,240	2.90
Native		
Native Vegetation	71,800	91.40
Barren and Wasteland	660	0.80
Riparian	300	0.40
Water	850	1.10
Subtotal	73,610	93.70
Total	**78,550**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Bowman groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Tehama County Flood Control and Water Conservation District, Anderson-Cottonwood ID, and Rio Alto Water District.

Tehama County adopted a groundwater ordinance in 1994. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater

management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996. County ordinance 1617 prohibits extraction of groundwater for export outside the county.

No urban areas are located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Rosewood Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Rosewood subbasin is bounded on the west and northwest by the Coast Ranges, on the north by North Fork Cottonwood Creek, and on the southeast by Salt Creek, Dry Creek, and Cottonwood Creek. The subbasin is 46,500 acres (73 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the Rosewood subbasin is taken from DWR Bulletin 118 (DWR 2004). The Rosewood subbasin aquifer system west of the Sacramento River is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek. Riverbank Formation deposits are observed along all major creeks. The thickness ranges up to 50 feet. The deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. The formation is the principal water-bearing formation in the subbasin and is exposed over approximately 80% of the subbasin surface area. Thickness of the deposits is unknown but may reach up to 500 feet, thinning to the west where the Great Valley Sequence daylights at the subbasin boundary. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

Long-term groundwater level data indicate a slight decline in groundwater levels associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery to pre-drought conditions of the early 1970s and 1980s. Generally, groundwater levels have a seasonal fluctuation of approximately 5–10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in the groundwater levels.

Estimated groundwater extraction for agricultural use to be 680 acre-feet. Municipal and industrial use is estimated to be approximately 990 acre-feet. (DWR 2004.)

Major Sources of Recharge

Cottonwood and Dry Creeks recharge Rosewood subbasin on the north and southeast. Annual precipitation ranges from 23 to 27 inches per year. Deep percolation of applied water is estimated to be 1,200 acre-feet.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 4% of the subbasin, urban land use accounts for less than 1% of the subbasin, and native land accounts for about 96% of the subbasin. Table 4-90 provides details of the land uses within the subbasin.

Table 4-90. Land Use in the Rosewood Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	80	0.20
Field Crops	10	0.02
Grain and Hay	350	0.80
Pasture	1,220	2.60
Truck, Nursery, and Berry Crops	30	0.10
Vineyards	10	0.02
Idle	130	0.30
Semiagricultural and Incidental	60	0.10
Subtotal	1,890	4.10
Urban		
Urban Residential	170	0.40
Commercial	10	0.02
Vacant	20	0.04
Subtotal	200	0.40
Native		
Native Vegetation	43,200	92.80
Barren and Wasteland	800	1.70
Riparian	260	0.60
Water	190	0.40
Subtotal	44,450	95.50
Total	**46,540**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Rosewood groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Anderson-Cottonwood ID, and Igo-Ono Community Service District. Tehama County adopted a groundwater ordinance in 1994. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county.

No urban areas are located within the subbasin.

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Anderson Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Anderson subbasin is bounded on the west and northwest by bedrock of the Klamath Mountains, on the east by the Sacramento River, and on the south by Cottonwood Creek. The subbasin is 96,950 acres (151 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Anderson subbasin is taken from DWR Bulletin 118 (DWR 2004). The Anderson subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include Pliocene Tehama and Tuscan Formations. The Tehama Formation interfingers with the Tuscan Formation in the region between Interstate Highway 5 and the Sacramento River north of the city of Red Bluff.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. Modesto Formation deposits are observed along parts of Cottonwood Creek, Dry Creek, and along the Sacramento River. Riverbank terrace deposits are observed along all major creeks. The thickness ranges up to 50 feet. These deposits are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges and is the principal water-bearing formation west of the Sacramento River. The formation is exposed over approximately 60 to 70% of the

subbasin surface area. Thickness of the formation ranges from 1,000 to 4,000 feet from the northern subbasin boundary at the Sacramento River to Cottonwood Creek in the vicinity of Interstate Highway 5. Much of the deposit west of Anderson has a uniform thickness of approximately 500 feet which thins to the western subbasin boundary where the Great Valley Sequence daylights. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is thought to interfinger with the Tehama Formation between the Sacramento River to the east and Interstate 5. The formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate, tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia that are essentially impermeable.

Long-term groundwater level data indicates a slight decline in levels associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery to pre-drought conditions of the early 1970s and 1980s. Generally, the seasonal fluctuation ranges from 1 to 10 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use at 3,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet.

Major Sources of Recharge

Recharge to the subbasin is mostly from infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 5,700 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 15% of the subbasin, urban land use accounts for about 20% of the subbasin, and native land accounts for about 65% of the subbasin. Table 4-91 provides details of the land uses within the subbasin.

Table 4-91. Land Use in the Anderson Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	970	1.00

Land Use	Acreage of Land Use	Percent of Land Use
Deciduous Fruits and Nuts	1,300	1.30
Field Crops	340	0.40
Grain and Hay	420	0.40
Pasture	9,080	9.40
Truck, Nursery, and Berry Crops	230	0.20
Idle	1,540	1.60
Semiagricultural and Incidental	270	0.30
Subtotal	14,150	14.60
Urban		
Urban—unclassified	4,920	5.10
Urban Landscape	80	0.10
Urban Residential	11,000	11.30
Commercial	430	0.40
Industrial	2,150	2.20
Vacant	730	0.80
Subtotal	19,130	19.90
Native		
Native Vegetation	58,900	60.70
Barren and Wasteland	1,000	1.00
Riparian	2,260	2.30
Water	1,350	1.40
Subtotal	63,150	65.50
Total	**96,970**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Anderson groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Anderson-Cottonwood ID, Clear Creek ID, City of Anderson, Keswick Community Service District, City of Redding, Rio Alto WD, Shasta Community Service District and Shasta County Water Agency, IGO-ONO Community Service District.

Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. The cities of Redding and Anderson are urban areas located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Enterprise Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Enterprise subbasin is bounded on the west and southwest by the Sacramento River, on the north by the Klamath Mountains, and on the east by Little Cow Creek and Cow Creek. The subbasin is 60,900 acres (95 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Enterprise subbasin is taken from DWR Bulletin 118 (DWR 2004). The Enterprise subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene Stream Channel Deposits and terrace deposits of the Modesto and Riverbank Formations. The Tertiary deposits are the Pleistocene Tehama Formation and the Tuscan Formation.

The youngest alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These Holocene stream channel deposits are observed along the entire extents of the western boundary along the Sacramento River. These deposits are also observed along Stillwater Creek extending from the Klamath Mountains to the Sacramento River in the center of the subbasin and along Cow Creek on the eastern side. The thickness ranges to 50 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. They are usually found as terrace deposits near the surface along the Sacramento River and tributaries. The thickness ranges to 50 feet. They are moderately to highly permeable and yield limited domestic water supply from perched water tables.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. Thickness of the formation along the southern boundary ranges from 300 feet at the southwestern extents of the subbasin to 1,000 feet at the confluence of Cow Creek and the Sacramento River. From north to south along Cow Creek, the deposit uniformly increases in thickness from where the Chico Formation daylights near Bella Vista to a depth of 500 feet in the vicinity of Palo Cedro and to a depth of 1,000 feet at the Sacramento River. The permeability is moderate to high, with yields of 100–1,000 gpm. The formation interfingers with the Tuscan Formation along the eastern boundary; however, the extents are unknown.

The Pliocene Tuscan Formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate and tuff, tuffaceous silt and clay predominantly derived from andesitic and basaltic source rocks. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded

volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Permeability is moderate to high with yields of 100–1,000 gpm except for beds of tuff-breccia, which are essentially impermeable.

Long-term *groundwater* level data indicate a gradual decline of approximately 5–10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery to pre-drought conditions of the early 1970s and 1980s. Evaluation of groundwater level data shows a seasonal fluctuation of approximately 5–10 feet. Overall, there does not appear to be any increasing or decreasing trends in groundwater levels.

DWR (2004) estimated annual groundwater extraction for the subbasin for agricultural use to be 3,000 acre-feet. Municipal and industrial use is approximately 20,000 acre-feet.

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 3,788 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 12% of the subbasin, urban land use accounts for about 34% of the subbasin, and native land accounts for about 54% of the subbasin. Table 4-92 provides details of the land uses within the subbasin.

Table 4-92. Land Use in the Enterprise Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	40	0.10
Deciduous Fruits and Nuts	310	0.50
Field Crops	570	0.90
Grain and Hay	790	1.30
Idle	1,510	2.50
Pasture	3,920	6.40
Semiagriculture and Incidental	180	0.30
Truck, Nursery, and Berry Crops	120	0.20
Subtotal	7,440	12.20
Urban		
Urban—unclassified	2,720	4.50
Commercial	820	1.30
Industrial	240	0.40
Urban Landscape	290	0.50
Urban Residential	15,400	25.30

Land Use	Acreage of Land Use	Percent of Land Use
Vacant	1,410	2.30
Subtotal	20,880	34.30
Native		
Barren and Wasteland	120	0.20
Riparian	760	1.20
Native Vegetation	30,370	49.80
Water	1,380	2.30
Subtotal	32,630	53.50
Total	**60,950**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Enterprise groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Bella Vista WD, Shasta Co. Water Agency, Shasta Community Service District. Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Millville Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Millville Subbasin is bounded on the west by Cow Creek, Little Cow Creek, and the Sacramento River; on the north by the Klamath Mountains; on the east by the Cascade Range; and on the south by Battle Creek. The subbasin is 65,300 acres (102 square miles) in size and is located in Shasta County.

The following description of the hydrogeology in the Millville subbasin is taken from DWR Bulletin 118 (DWR 2004). The Millville subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation along the Sacramento River and the Tuscan Formation. The Tuscan Formation is the primary water-bearing unit in the subbasin.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These alluvial deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage due to its geomorphic distribution.

The Pleistocene Modesto and Riverbank Formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. The formations are usually found as terrace deposits near the surface along the Sacramento River and tributaries. The thickness ranges to 50 feet. They are moderately to highly permeable and can yield limited domestic water supplies.

The Pliocene Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. The permeability of the formation is moderate to high with yields of 100–1,000 gpm.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates the deposit in the eastern and northern parts of mapped unit. Unit C consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The unit has limited areal extents and may not occur within the Redding Basin. Unit C is the primary surficial deposit within the subbasin. Surficial deposits of Unit B are exposed over 15 to 20% of the subbasin to the north.

Deposits of the Tehama and Tuscan Formations interfinger along the western extents of the subbasin. Deposits of the Chico Formation outcrop in the northern most portion of the subbasin in the vicinity of Little Cow Creek and Cow Creek. Deposits of the Tehama and Tuscan formations begin at the northern extents of the subbasin and increase in thickness to approximately 1,000 feet at the confluence of Cow Creek and the Sacramento River. In the vicinity of Palo Cedro, the thickness of the sediments is approximately 500 feet. The thickness of the deposits decreases to the east and deposits of the Chico Formation between Cow Creek and Oak Run Creek in the northern half of the subbasin show that the Tuscan has been totally eroded in those areas.

Long-term groundwater level data indicate a slight decline of approximately 5 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a gradual recovery in levels to pre-drought conditions of the early 1970s and 1980s. Generally, seasonal fluctuations range from 2 to 8 feet for normal and dry years. Overall, there does not appear to be any increasing or decreasing trend in groundwater levels.

Land Use

Land use surveys were conducted within the subbasin by DWR in 1995. Agricultural land use accounts for about 4% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land accounts for about 93% of the subbasin. Table 4-93 provides details of the land uses within the subbasin.

Table 4-93. Land Use in Millville Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	150	0.20

Land Use	Acreage of Land Use	Percent of Land Use
Field Crops	220	0.30
Grain and Hay	60	0.10
Pasture	2,170	3.30
Rice	30	0.05
Idle	140	0.20
Semiagricultural and Incidental	80	0.10
Subtotal	2,850	4.40
Urban		
Urban—unclassified	20	0.03
Urban Landscape	20	0.03
Urban Residential	1,700	2.60
Commercial	80	0.10
Industrial	80	0.10
Vacant	10	0.02
Subtotal	1,910	2.90
Native		
Native Vegetation	59,900	91.80
Riparian	80	0.10
Water	510	0.80
Subtotal	60,490	92.70
Total	**65,250**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Millville groundwater subbasin is within the Shasta-Tehama Watershed. Public agencies operating within the subbasin: Redding Area Water Committee, Bella Vista WD, Shasta Co. Water Agency, Shasta Community Service District. Shasta County adopted a groundwater management ordinance in 1998. This ordinance requires a permit for groundwater exportation from the county. There are no urban areas located within the subbasin. This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

South Battle Creek Subbasin—Redding Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The South Battle Creek subbasin is bounded to the west by the Sacramento River, to the north by Battle Creek, to the east by the Cascade Range, and to the south by the drainage divide along the north rim of Paynes Creek. The subbasin is 33,860 acres (53 square miles) in size and is located in Tehama County.

The following description of the hydrogeology in the South Battle Creek subbasin is taken from DWR Bulletin 118 (DWR 2004). The South Battle Creek aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include younger alluvium and the Pleistocene Modesto Formation. The Tertiary deposits include the Tuscan Formation and possibly the Tehama Formation along the Sacramento River. The Tuscan Formation is the primary water-bearing unit in the subbasin. The Tehama Formation interfingers wit the Tuscan Formation in the region between Interstate Highway 5 and the Sacramento River north of the city of Red Bluff. The Tehama Formation may extend beyond the Sacramento River within the subbasin boundary; however, the deposit is not included here as a water-bearing formation.

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along the Sacramento River. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable it is not a significant contributor to groundwater usage due to its geomorphic distribution.

The Pleistocene Modesto Formation consists of terrace deposits containing poorly consolidated gravel with some sand and silt. These deposits are found along Inks Creek, Battle Creek, and the Sacramento River. The thickness varies up to 50 feet. The sediments are moderately to highly permeable and yield limited domestic water supplies.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers and is the principal water-bearing formation in the subbasin. Generally, the formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone. Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble to boulder conglomerate predominates in the eastern and northern parts of mapped unit. This portion of the formation is approximately 430 feet thick.

Unit C is the primary surficial deposit in the subbasin and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165 to 265 feet. Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30 to 160 feet. The total thickness of the Tuscan Formation ranges from approximately 750 feet in the northeastern extents of the subbasin to 2,400 feet at the Sacramento River.

Data is not available for groundwater levels for this subbasin.

Estimates of groundwater extraction are based on surveys conducted during 1994 and 1995 by the California Department of Water Resources. Annual groundwater extraction for agricultural uses is estimated to be 1,300 acre-feet. Municipal and Industrial uses are approximately 310 acre-feet (DWR 2004).

Major Sources of Recharge

Recharge to the aquifer is mostly by infiltration of streamflows. Infiltration of applied water and streamflows, and direct infiltration of precipitation are the main sources of recharge into the alluvium. Deep percolation of applied water is estimated to be 860 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the subbasin by DWR in 1999. Agricultural land use accounts for about 7% of the subbasin, urban land use accounts for less than 1% of the subbasin, and native land accounts for about 93% of the subbasin. Table 4-94 provides details of the land uses within the subbasin.

Table 4-94. Land Use within the South Battle Creek Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	10	0.03
Deciduous Fruits and Nuts	880	2.60
Grain and Hay	70	0.20
Pasture	1,120	3.30
Idle	100	0.30
Rice	20	0.06
Semiagricultural and Incidental	10	0.03
Subtotal	2,210	6.50
Urban		
Urban Residential	10	0.03
Industrial	40	0.10
Vacant	30	0.10
Subtotal	80	0.20
Native		
Native Vegetation	30,800	90.90
Barren and Wasteland	90	0.30
Riparian	420	1.20
Water	300	0.90
Subtotal	31,610	93.20
Total	**33,900**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The South Battle Creek groundwater subbasin is within the Shasta-Tehama Watershed. The public agencies operating within the subbasin is the Tehama County Flood Control and Water Conservation District.

In 1994 Tehama County adopted groundwater ordinance 1617. Key issues addressed in the ordinance are: mining groundwater for export, off-parcel groundwater use, and well pumping restrictions. In 1992, AB 3030 provided a systematic procedure for an existing local agency to develop a formal groundwater management plan. Tehama adopted a countywide groundwater management plan pursuant to AB 3030 in 1996.

No urban areas are located within the subbasin. Tehama County ordinance 1617 prohibits extraction of groundwater for export outside the county. This subbasin falls within the area included in the Sacramento Valley Water Quality.

Rock Prairie Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of Rock Prairie Valley Basin is 9 square miles (5,740 acres) it is located in southeastern Modoc County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Rock Prairie Valley Basin is an alluvial filled valley. It is bounded to the northeast by northwest trending faults. The basin is bounded to the northeast, southeast, and west by Pliocene basalt and to the southwest by Miocene basalt. The valley drains to the northeast. Graven and Bailey Reservoirs are located along the eastern boundary.

No hydrogeologic information was available from DWR for water-bearing formations, groundwater level trends, storage, budget, or groundwater quality.

Major Sources of Recharge

The primary source of recharge is annual precipitation which ranges from 19 to 21 inches (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. The entire basin is comprised of native vegetation and water. Table 4-95 provides details on the distribution of land use throughout the Rock Prairie Valley Basin.

Table 4-95. Land Use in the Rock Prairie Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	5,229	91.11
Water	510	8.89
Total	**5,739**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater management ordinance in 2000. A key element of the Modoc County ordinance is the requirement of an export permit for groundwater transferred out of the basin (DWR 2004). California Pines CSD is the sole public water agency in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Round Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Round Valley groundwater basin is located in Modoc County. The area of the basin is 7,270 acres (11 square miles). It is northeast of Big Valley and surrounded entirely by Mountains. The basin is bounded to the northwest by Tertiary basalt of Ryan and Barbar ridges, to the north and northeast by Tertiary pyroclastic rocks of Horsehead Mountain, and to the south and southwest by Tertiary pyroclastic rocks.

Ash Creek enters the valley from the southeast and continues to flow to the southwest entering Big Valley through a narrows in Barber Ridge. The following description of the hydrogeology in the Round Valley Basin is taken from DWR Bulletin 118 (DWR 2004).

The primary water-bearing formations in Round Valley are Holocene sedimentary deposits, Pliocene lava flows, and the Plio-Pleistocene Bieber Formation. The Holocene sedimentary deposits include basin deposits, intermediate alluvium, and alluvial fan deposits. Basin deposits, located predominately in low-lying areas in the southeast central part of the valley, consist of unconsolidated interbedded silt, clay, and organic muck having low permeability. These deposits are not considered a significant water-bearing formation.

Intermediate alluvium, found along the perimeter and the northwest central part of the valley, consists of unconsolidated silt and sand with some clay and gravel. These deposits are generally moderately permeable with gravel zones being highly permeable. Alluvial fan deposits consist of unconsolidated poorly stratified silt, sand, and gravel with some clay lenses. Because the fans occur in only a few small areas, they are not considered a significant source of water. Locally they may yield moderate amounts of water to wells.

The Bieber Formation consists of lake deposited diatomite, clay, silt, sand, and gravel. These interbedded sediments are unconsolidated to semi-consolidated and are moderately permeable. The principal water-bearing zones consist of white pumiceous sand and black volcanic sand, which yield large amounts of water to wells where there is sufficient thickness and continuity.

Pliocene lavas consisting of jointed and fractured basalt occur to the north and south of Round Valley on the surrounding ridges. The lavas are moderately permeable and serve primarily as recharge areas in the uplands. They may contain unconfined and confined zones near the margins of the valley.

Storage capacity for the Round Valley Basin is estimated to be 120,000 acre-feet to a depth of 200 feet (DWR 1963). DWR (1963) also notes that the quantity of useable water in storage is unknown. DWR estimates groundwater extraction for agricultural and municipal/industrial uses to be 400 and 4 acre-feet, respectively. This estimate is based on surveys conducted by the DWR during 1997.

Major Sources of Recharge

Recharge to the basin is from precipitation, irrigation infiltration, and stream infiltration. The average annual precipitation ranges from 15 to 19 inches (DWR 2004). Deep percolation of applied water is estimated by DWR (2004) to be 460 acre-feet. Ash Creek enters the valley from the southeast and continues to flow to the southwest entering Big Valley through a narrows in Barber Ridge. Dutch Flat Creek and Rush Creek also flow through the Round Valley.

Groundwater within the sediments of Round Valley is recharged primarily from the upland recharge areas of Pliocene basalt northwest of Round Valley (DWR 2004). The Turner Creek Formation of Ryan Ridge is a barrier between the Round Valley aquifer and the groundwater moving downslope through Barber Canyon.

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Round Valley Basin is 37% Agricultural and 63% undeveloped. Table 4-96 provides details of the land uses within the basin.

Table 4-96. Land Use in the Round Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Grain and Hay	430	5.91
Idle	160	2.20
Pasture	2,050	28.20
Semiagricultural and Incidental	50	0.69

Land Use	Acreage of Land Use	Percent of Land Use
Subtotal	2,690	37.00
Native		
Native Vegetation	4,510	62.04
Water	70	0.96
Subtotal	4,580	63.00
Total	**7,270**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Modoc County adopted a groundwater ordinance in 2000. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the basin. A key element of the Modoc County ordinance requires an export permit for groundwater transferred out of the basin (DWR 2004). The Adin Community Service District is the only public water agency involved with the basin. There are no major urban areas within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Sodium bicarbonate type waters are present in the basin. The concentration of TDS ranges from 141 to 633 mg/L, averaging 260 mg/L. There is no information about groundwater quality problems.

Scotts Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

Scotts Valley Basin is bordered to the east by the shoreline of Clear Lake and bounded on the west and the north by the Jurassic-Cretaceous Franciscan complex of metamorphic and sedimentary rocks that constitute the basement rock in the basin. The basin shares a boundary with the Big Valley Basin to the south and may be hydrologically contiguous. The area of the aquifer system is 11 square miles and is located in Lake County.

The following description of the hydrogeology in the Scotts Valley Basin is taken from DWR Bulletin 118 (2004). The Scotts Valley Basin lies adjacent to the west side of Clear Lake and extends northwesterly along Scotts Creek north to Hidden Lake. The aquifer system in Scotts Valley Basin is composed primarily of Quaternary alluvial and terrace deposits, and Plio-Pleistocene to Pleistocene lake and floodplain deposits. Plio-Pleistocene Cache Formation sediments overlie bedrock.

The channel deposits of Scotts Creek and the uppermost valley deposits in the southern portion of basin are composed of Quaternary alluvium. The active channel of Scotts Creek is underlain by uncemented gravel and sand, with silt and clay lenses. Sands and gravels within the alluvium have moderate to high

permeability while the silt and clay lenses have a relatively low permeability. In the southern part of the valley, gravels and clays are interbedded at shallower depths representing portions of former stream channels. Wells extract variable amounts of water from these zones. Wells installed in sand and gravel lenses yield an average of about 230 gpm. Surficial lake deposits of sandy and silty clay are located in the northern portion of the basin. Underlying these deposits is a fairly continuous gravel stratum in which water is under artesian pressure. Groundwater is confined in the northern portion of the valley and is essentially unconfined in the southern portion. The confined aquifer is 3 to 10 feet thick and underlies approximately 2.4 square miles of valley floor at depths ranging from 85 to 105 feet. The unconfined aquifer underlying the southern valley floor varies in thickness from 40 to 70 feet.

The northern part of Scotts Valley is underlain by lake deposits of sandy and silty clay ranging in thickness from 60 to 90 feet. Permeability in the fine-grained lake deposits is low with specific yields ranging from about 3 to 5%.

Terrace deposits lie directly on bedrock or on older lake and floodplain deposits. These deposits are a continuation of terrace deposits as seen in the Western Upland aquifer system of Big Valley Basin to the south. They consist of poorly consolidated clay, silt, and sand, with some gravel lenses. Thickness of the deposits ranges from 50 to 100 feet. These deposits generally have low permeability due to high clay content. Available well records indicate reddish brown clays with little potential for significant water yield.

Pre-terrace sediments that exist in Scotts Valley area are identified as the Cache Formation based on the stratigraphic position and the lithologic similarity to known beds of that formation. The Cache Formation is largely made up of lake deposits; however, some stream deposits and volcanic ash lenses are likely included. The Cache Formation is identified from water well driller reports as a blue clay layer containing some gravel lenses that is several hundred feet thick. Permeability of the Cache Formation is generally low due to its high clay content; however, yields of groundwater extracted from gravel or ash lenses within the Cache Formation may be appreciable.

Evaluation of the groundwater level data shows an average seasonal fluctuation ranging from 5 to 10 feet for normal and dry years for wells located in the vicinity of Scotts Creek and Clear Lake. For wells located closer to the Coast Ranges, the average seasonal fluctuation is approximately 20 to 40 feet for normal and dry years.

Long-term comparison of spring-spring groundwater levels indicates a slight decline in groundwater levels of up to 10 feet associated with the 1976–1977 and 1987–1994 droughts, followed by a recovery in levels to pre-drought conditions of early 1970s and 1980s. Overall there does not appear to be any increasing or decreasing trend in the groundwater levels.

Data indicates that lowering of groundwater levels accompanied by subsidence has occurred in Scotts Valley. Gravel has been extracted to average depths of 4 to 6 feet and up to 10 to 15 feet within Scotts Creek channel. This extraction has apparently resulted in the lowering of the stream channel and adjacent unconfined groundwater levels by about 3–4 feet in the southern portion of the valley.

The average specific yield for the depth interval of 0–100 feet is estimated to be 8% based on review and analysis of well logs. The storage capacity for the basin is estimated to be 5,900 acre-feet based on the above depth interval and estimate of specific yield. The useable storage capacity is estimated to be 4,500 acre-feet. Based on 1995 DWR surveys of land use and sources of water, groundwater extraction for agricultural use is estimated to be 4,200 acre-feet. Groundwater extraction for municipal/industrial

uses is estimated to be 520 acre-feet. Deep percolation of applied water is estimated to be 1,000 acre-feet (DWR 2004).

Major Sources of Recharge

Recharge to the confined aquifer takes place in the forebay or unconfined zone in the southern portion of the valley. Percolation from Scotts Creek is the principal source of recharge with minor amounts from precipitation and applied irrigation water. Annual precipitation in the basin ranges from 31 to 35 inches, increasing the northwest. (DWR 2004)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 27% of the basin, urban land use accounts for about 18% of the basin, and native land use accounts for about 55% of the basin. Table 4-97 provides details on the distribution of land use throughout the Scotts Valley Basin.

Table 4-97. Land Use in the Scotts Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Citrus and Subtropical	5	0.06
Deciduous Fruits and Nuts	1,231	16.80
Idle	337	4.59
Pasture	313	4.27
Semiagricultural and Incidental	34	0.46
Vineyards	41	0.56
Subtotal	1,960	26.75
Urban		
Commercial	272	3.72
Industrial	1	0.01
Urban Landscape	32	0.44
Urban Residential	933	12.73
Vacant	108	1.48
Subtotal	1,346	18.38
Native		
Riparian	12	0.17
Native Vegetation	3,936	53.72
Water	72	0.99
Subtotal	4,020	54.87
Total	**7,326**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Lake County adopted a groundwater management ordinance for Scotts Valley Basin in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). Public water agencies in the basin include County of Lake, City of Lakeport WSA, and Scotts Valley WCD.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater levels in the Scotts Valley Basin are monitored semi-annually by DWR at 3 wells and by Lake County at 6 wells. Miscellaneous water quality parameters are monitored by DWR biennially at one well. CDPH and its cooperators monitor for Title 22 water quality parameters in 9 wells.

Calcium-magnesium bicarbonate is the predominant groundwater type in the Scotts Valley Basin. TDS ranges from 140 to 175-mg/L, averaging 158 mg/L. Iron, manganese, and boron concentrations exceed EPA maximum acceptable concentrations for continuous irrigation for selected wells (DWR 2004). During the sampling period from 1994 to 2000 under the CDPH Title 22 program, there was 1 well out of 7 wells sampled with concentration of primary inorganics detected above the MCL. One well of 9 wells sampled showed nitrate concentrations above the MCL.

Chilcoot Subbasin—Sierra Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the Chilcoot subbasin is taken from DWR Bulletin 118 (2004). The Chilcoot subbasin aquifer is bounded to the north and east by Mesozoic granitic rocks and, to the south, by Tertiary Sierran basalt and pyroclastic rocks and Paleozoic metamorphic rocks. The basin is hydrologically connected to the Sierra Valley Subbasin to the west in the near surface but may be discontinuous at depth due to a bedrock sill. The aquifer system is 12 square miles in size and is located on the eastern side of the Sierra Valley Groundwater Basin in Plumas County.

The Chilcoot Subbasin is an irregularly shaped, complexly faulted valley. The surface drainage is a tributary to Little Last Chance Creek, which drains to the Middle Fork Feather River. The primary water-bearing formations in the Chilcoot Subbasin are the Holocene sedimentary deposits and silt and sand deposits, fractured and faulted Paleozoic to Mesozoic metamorphic and granitic rocks, and Tertiary volcanic rocks.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. These deposits are located at the perimeter of the valley to a thickness of 200 feet and are a major source of confined and unconfined groundwater. The fan deposits coalesce or interfinger with basin, lake, and alluvial deposits. Specific yield ranges from 8 to 17%. The fans also serve as important recharge areas.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent and is found along the margins of the basin. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater to shallow wells.

Sand and silt deposits are located in the northeast portion of the subbasin. The deposits are generally unconsolidated and have high permeability and porosity. Potentially large quantities of water may be extracted.

Volcanic rocks make up a portion of the bedrock outcrop north of Chilcoot along Frenchman Lake road. These rocks are fractured and faulted and produce between 5 and 10 gpm where wells encounter interconnected openings in the rock.

These rocks form the bedrock base of the subbasin and most of the surrounding mountain uplands. The metamorphic rocks underlie the eastern portion and the granitic rocks the western portion of the subbasin. Major north-south high angle faults form the contacts between these rocks. Several test wells drilled in a proposed subdivision in the area show that where wells encounter sufficient interconnected fractures, wells developed in these rocks can produce up to 20 gpm, but typically only produce 3–5 gpm (DWR 2004).

The estimated groundwater storage in the basin is 7,500,000 acre-feet to a depth of 1,000 feet (DWR 1963). The quantity of water that is useable is unknown. DWR (1973) estimates storage capacity to be between 1,000,000 and 1,800,000 acre-feet for the top 200 feet of sediments based on an estimated specific yield ranging from 5 to 8%. These estimates include the Sierra Valley Subbasin.

Estimates of groundwater extraction for the Chilcoot Subbasin are based on a survey conducted by the DWR during 1997. The survey included land use and sources of water. Estimates of groundwater extraction for agricultural and municipal/industrial uses are 64 and 72 acre-feet respectively.

Major Sources of Recharge

Annual precipitation ranges between 13 and 17 inches, increasing to the south (DWR 2004).

Most of the upland recharge areas are composed of permeable materials occurring along the upper portions of the alluvial fans that border the valley. Recharge to groundwater is primarily by way of infiltration of surface water from the streams that drain the mountains and flow across the fans. A minor amount of recharge may also be derived from some of the Sierran volcanic rocks located south of the valley. Most of these rocks appear to be of fairly low permeability and only small quantities of recharge can be derived from them (DWR 2004). Deep percolation from applied water is estimated to be 400 acre-feet (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for over 25% of the subbasin, urban land use accounts for about 3% of the subbasin, and native land use accounts for about 71% of the subbasin. Table 4-98 provides details on the distribution of land use throughout the Chilcoot subbasin.

Table 4-98. Land Use in the Chilcoot Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	1,899	25.20
Semiagricultural and Incidental	28	0.37
Subtotal	1,927	25.54
Urban		
Industrial	30	0.39
Urban Landscape	5	0.07
Urban Residential	205	2.71
Subtotal	239	3.17
Native		
Native Vegetation	5,379	71.28
Subtotal	5,379	71.28
Total	**7,546**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The Loyalton WD is included in this subbasin. Groundwater management is under the Sierra Valley Groundwater Management District (authorized by Senate Bill 1391, enacted in 1980).

This subbasin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

DWR monitors groundwater levels at 15 wells semi-annually, and samples for miscellaneous water quality parameters at 15 wells (including subbasin 5-12.01) biennially. CDPH and its cooperators sample for miscellaneous water quality parameters in 8 wells (frequency of sampling not specified) (DWR 2004).

Groundwater in the subbasin is bicarbonate type water with mixed cationic character. TDS concentrations for the Sierra Valley Groundwater Basin range from 110 to 1,620 mg/L, averaging 321 mg/L (DWR 2004).

Sierra Valley Subbasin—Sierra Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Sierra Valley groundwater subbasin is bounded to the north by Miocene pyroclastic rocks of Reconnaissance Peak, to the west by Miocene andesite of Beckwourth Peak, to the south and east by

Tertiary andesite, and to the east by Mesozoic granitic rocks. The aquifer system is 184 square miles in size and is located in eastern Plumas and Sierra Counties.

The following description of the hydrogeology in the Sierra Valley subbasin is taken from DWR Bulletin 118 (2004). Sierra Valley is an irregularly shaped, complexly faulted valley. The Middle Fork Feather River heads in Sierra Valley and is formed by the confluence of several streams draining the surrounding mountains. Most of the smaller tributaries flow north and northwest to join the Middle Fork Feather before it exits the valley at the northwest corner of the basin.

The primary water-bearing formations in Sierra Valley are Holocene sedimentary deposits, Pleistocene lake deposits, and Pleistocene lava flows. The aquifers of the valley are mainly alluvial fan and lake deposits. The alluvial fans grade laterally from the basin boundaries into coarse lake and stream deposits. The deposits of silt and clay act as aquitards or aquicludes in the formation. Aquiclude materials are predominantly fine-grained lake deposits. In the central part of the basin, alluvial, lake and basin deposits comprise the upper 30–200 feet of aquitard material that overlies a thick sequence of interstratified aquifers and aquicludes.

Holocene sedimentary deposits include alluvial fans and intermediate alluvium. Alluvial fans consist of unconsolidated gravel, sand, and silt with minor clay lenses. These deposits are located at the perimeter of the valley to a thickness of 200 feet. The fan deposits coalesce or interfinger with basin, lake, and alluvial deposits. Specific yield ranges from 8 to 17%. The fans are a major source of confined and unconfined groundwater and serve as important recharge areas.

Intermediate alluvium consists of unconsolidated silt and sand with lenses of clay and gravel. Specific yield is estimated to range from 5 to 25%. This unit is limited in extent and is found along streams and centrally in the basin. The deposits are up to 50 feet in thickness and yield moderate amounts of groundwater to shallow wells.

Lake deposits underlie the majority of the valley and range in thickness to 2,000 feet. These provide most of the groundwater developed in the valley. The deposits consist of slightly consolidated, bedded sand, silt, and diatomaceous clay with the sand beds yielding large amounts of groundwater to wells. Specific yield ranges from 1 to 25%. Well production reportedly ranges up to 3,200 gpm.

Pleistocene volcanic rocks consist of jointed and fractured basalt flows ranging in thickness from 50 to 300 feet. These rocks are moderately to highly permeable and yield large amounts of groundwater to wells. They also serve as a recharge area and, where buried by lake deposits, form confined zones with significant artesian pressures.

Increases in groundwater development in the mid-late 1970s resulted in the cessation of flow in many artesian wells and large pumping depressions formed over the areas where heavy pumping occurred. Water levels in a flowing artesian well in the northeast portion of the basin declined to more than 50 feet below ground surface by the early 1990s, when reductions in groundwater pumpage occurred. Through the 1990s groundwater levels in the basin have recovered to mid 1970s levels.

The estimated groundwater storage in the basin is 7,500,000 acre-feet to a depth of 1,000 feet. The quantity of water that is useable is unknown. Based on an estimated specific yield ranging from 5 to 8%, storage capacity is estimated to be between 1,000,000 and 1,800,000 acre-feet for the top 200 feet of sediments. These estimates include the Chilcoot Subbasin (5-12.02).

Based on a 1997 DWR survey of land use and sources of water, estimates of groundwater extraction for agricultural and municipal/industrial uses are 3,400 and 110 acre-feet per year respectively.

As of 1975, the average well yield was 300 gpm, with a max yield of 1,800 gpm. Groundwater pumpage, at the time of the 1975 report, was below safe yield (DWR 1978).

Major Sources of Recharge

Most of the upland recharge areas are composed of permeable materials occurring along the upper portions of the alluvial fans that border the valley. Recharge to groundwater is primarily by way of infiltration of surface water from the streams that drain the mountains and flow across the fans. Annual precipitation ranges from 13 inches in the valley to 29 inches in the upland areas to the south and west. Deep percolation from applied water is estimated to be 2,100 acre-feet per year. (DWR 2004.)

Land Use

Groundwater development, as of 1975, was limited to irrigation, domestic, and stock use, with a potential for moderate to high additional development (DWR 118-75).

Land use surveys were conducted within the subbasin by DWR in 1997. Agricultural land use accounts for about 33% of the subbasin, urban land use accounts for about 1% of the subbasin, and native land accounts for about 66% of the subbasin. Table 4-99 provides details on the distribution of land use throughout the Sierra Valley subbasin.

Table 4-99. Land Use in the Sierra Valley Subbasin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	2,014	1.71
Idle	1,313	1.12
Pasture	34,507	29.34
Semiagricultural and Incidental	469	0.40
Truck, Nursery, and Berry Crops	451	0.38
Subtotal	38,753	32.95
Urban		
Urban—unclassified	426	0.36
Commercial	37	0.03
Industrial	237	0.20
Urban Landscape	28	0.02
Urban Residential	420	0.36
Vacant	143	0.12
Subtotal	1,292	1.10
Native		
Riparian	7,765	6.60
Native Vegetation	69,631	59.20

Land Use	Acreage of Land Use	Percent of Land Use
Water	183	0.16
Subtotal	77,579	65.95
Total	**117,625**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Water agencies within the subbasin include Loyalton Water District (public agency), Sierra Valley PUD (public agency), and Sierra Brooks Subdivision (private). Groundwater management for this subbasin is under the Sierra Valley Groundwater Management District (authorized by Senate Bill 1391, enacted in 1980) (DWR 2004). This subbasin falls within the area included in the Upper Sacramento Valley Water Quality Coalition.

Water Quality

A wide range of mineral type waters exists throughout the basin. Sodium chloride and sodium bicarbonate type waters occur south of Highway 49 and north and west of Loyalton along fault lines. Two wells have waters that are sodium sulfate in character. In other parts of the valley the water is bicarbonate with mixed cationic character. Calcium bicarbonate type water is found around the rim of the basin and originates from surface water runoff. TDS in the basin range in concentration from 110 to 1,620 mg/L, averaging 312 mg/L.

The poorest quality groundwater is found in the central west side of the valley where fault-associated thermal waters and hot springs yield water with high concentrations of boron, fluoride, iron, and sodium (DWR 2004). Several wells in this area also have high arsenic and manganese concentrations.

Boron concentrations in thermal waters have been measured in excess of 8 mg/L. At the basin fringes, boron concentrations are usually less than 0.3 mg/L. There is also a sodium hazard associated with thermal waters and some potential for problems in the central portion of the basin (DWR 2003, 2004).

Squaw Flat Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Squaw Flat Groundwater Basin is 2 square miles (1,300 acres) and is located in Glenn County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Squaw Flat Basin is located due east of the Stony Gorge Reservoir Groundwater Basin. The basin is bounded on all sides by upper Cretaceous marine deposits. The basin consists of Quaternary alluvial deposits and is drained to the east by Logan Creek.

Hydrologic information was not available from DWR for the following: water-bearing formations, groundwater level trends, storage, budget, and groundwater quality.

Major Sources of Recharge

The primary source of recharge is precipitation which is approximately 18 inches per year (DWR 2004).

Land Use

Land use surveys were conducted in Glenn County by DWR in 1998. All acreage in the Squaw Flat Basin is designated as native vegetation.

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance for the Squaw Flat Basin in 2000. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

Stony Gorge Reservoir Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Stony Gorge Reservoir Groundwater Basin is 2 square miles (1,070 acres) in size and is located in Glenn County. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Stony Gorge Reservoir Basin is located due south of Stony Gorge Reservoir. It is bounded on the east and northwest by lower Cretaceous marine deposits and bounded on the west by rocks of the Knoxville Formation. The basin consists of Quaternary alluvial deposits.

Additional hydrogeologic information was not available from DWR for the water-bearing formations, groundwater level trends, or groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal/industrial use in the basin is estimated to be 8 acre-feet.

Major Sources of Recharge

Precipitation is the primary source of recharge and is approximately 18 inches per year. Deep percolation of applied water is estimated to be 38 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 1998. Agricultural land use accounts for about9% of the basinand native land use accounts for about 91% of the basin. Table 4-100 provides details on the distribution of land use throughout the Stony Gorge Reservoir Basin.

Table 4-100. Land Use in the Stony Gorge Reservoir Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Idle	43	4.00
Pasture	40	3.74
Semiagricultural and Incidental	9	0.88
Subtotal	92	8.63
Native		
Barren and Wasteland	91	8.55
Riparian	30	2.83
Native Vegetation	808	75.81
Water	45	4.19
Subtotal	974	91.37
Total	**1,066**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. There are no public or private water agencies in the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

There is no groundwater quality data for this basin.

Stonyford Town Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Stonyford Town Area Groundwater Basin is 10 square miles (6,440 acres) in size and is located in Glenn and Colusa Counties. The following description of the hydrogeology in the basin is taken from DWR Bulletin 118 (2004).

The Stonyford Town Area Basin consists of Quaternary stream terrace deposits and may be bounded on several sides by faulting of the Stony Creek Fault System. The basin is bounded to the west by Mesozoic Franciscan volcanic and metavolcanic rocks, to the north by metasedimentary rocks of the Franciscan Formation and Mesozoic ultrabasic intrusive rocks and the Knoxville Formation.

Additional hydrologic information was not available from DWR for water-bearing formations, groundwater level trends, and groundwater storage in the basin. Based on a 1993 DWR survey of land use and water sources, groundwater extraction for municipal and industrial uses is estimated to be 35 acre-feet.

Total depths of domestic wells completed in the basin range from 30 to 220 feet, with an average of 108 feet (based on 40 well completion reports). Total depth of the single irrigation well reported in the basin is 76 feet. No information on well yield was found.

Major Sources of Recharge

Precipitation is the primary source of recharge and ranges from 21 to 23 inches per year. Deep percolation of applied water is estimated to be 400 acre-feet. (DWR 2004.)

Land Use

Land use surveys were conducted in Glenn and Colusa Counties by DWR in 1998. Agricultural land use accounts for about 20% of the basin, urban land use accounts for about 2% of the basin, and undeveloped land accounts for more than 77% of the basin. Table 4-101 provides details on the distribution of land use throughout the basin.

Table 4-101. Land Use in the Stonyford Town Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Grain and Hay	43	0.67
Idle	486	7.54
Pasture	734	11.40
Semiagricultural and Incidental	34	0.52
Subtotal	1,297	20.13

Land Use	Acreage of Land Use	Percent of Land Use
Urban		
Commercial	4	0.07
Industrial	10	0.15
Urban Residential	135	2.09
Vacant	9	0.14
Subtotal	157	2.44
Native		
Barren and Wasteland	64	0.99
Riparian	5	0.07
Native Vegetation	4,879	75.74
Water	40	0.62
Subtotal	4,988	77.43
Total	**6,442**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Glenn County adopted a groundwater management ordinance in 2000. Colusa County adopted a groundwater management ordinance in 1998. There are no public or private water agencies in the basin. Both these ordinances limit groundwater exports from the basin.

This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Between 1994 and 2000, groundwater in the Stonyford Town Area Basin was sampled for primary inorganics, radiologicals, nitrates, pesticides, VOCs and SVOCs, and secondary inorganics, as required under CDPH Title 22 program. None of the constituents were detected at concentrations above MCL in either of the 2 wells sampled (DWR 2004).

Toad Well Area Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Toad Well Area groundwater basin is located in Siskiyou County and is 3,360 acres (5 square miles) in size. The Toad Well Area Groundwater Basin is a fault-bounded basin consisting of Quaternary alluvial deposits. Faults bound both the east and west sides of the basin. The basin is bounded to the west by Tertiary basalt of Buck Mountain and on all other sides by Pleistocene basalt.

Major Sources of Recharge

Recharge to the basin is from precipitation and stream infiltration. The average annual precipitation ranges from 55 to 57 inches. (DWR 2004.)

Land Uses

Land use surveys were conducted within the basin by DWR in 2000. The land use within the Toad Well Area Basin is entirely native (Table 4-102).

Table 4-102. Land Use in the Toad Well Area Basin

Land Use	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	3,360	100.00
Total	**3,360**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Siskiyou County adopted a groundwater management ordinance in 1998. Groundwater ordinances generally affect the volume of groundwater that can be pumped and/or exported from the basin. There are no major urban areas within the basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality datafor this basin could not be identified.

Upper Lake Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Upper Valley Basin is 11 square miles in size and is located in Lake County. The following description of the hydrogeology in the Upper Lake Basin is taken from DWR Bulletin 118 (2004).

The Upper Lake Basin is an irregularly shaped basin at the north end of Clear Lake that includes Middle Creek Valley, Clover Valley, and Bachelor Valley, all of which extend to a main central valley opening to the south to Clear Lake. Middle Creek Valley and Clover Valley are bounded by Middle Mountain to the west and Pitney and Hogback Ridges to the east.

Middle Mountain is a fault-bounded block underlain by sandstone and shale of the Great Valley Sequence. Pitney and Hogback Ridges consist mainly of graywacke sandstone and shale with minor interbedded basalt and chert of the Jurassic-Cretaceous Franciscan Formation. Similar rock types also underlie the mountain ridge south of Tule Lake located west of the basin.

The contact between the bedrock materials bounding the unconsolidated alluvium generally defines the basin boundary. Bedrock units in the area include the Franciscan Formation and the Great Valley Sequence.

The aquifer system in the Upper Lake Basin is composed primarily of Quaternary alluvial deposits and Pleistocene terrace, lake, and floodplain deposits. The alluvium, lake, and floodplain deposits fill the valleys and contain nearly all water yielded to wells. The older Cretaceous and Jurassic formations generally form the uplands surrounding the alluvial basin.

Groundwater within bedrock mainly occurs in near surface fractures along the lower hills. Generally, groundwater in bedrock has not been developed. Bedrock units and terrace deposits yield very little water to wells.

The Quaternary alluvial deposits include channel alluvium, fan deposits, and older alluvium consisting of gravel, sand, and fines. The active channels of Middle Creek, Alley Creek, and Clover Creek, and all other smaller creeks that drain the area around the Upper Lake Basin are underlain by uncemented gravel and sand, with silt and clay lenses. Fan and older alluvial deposits occur at the mouths of some ravines and small canyons that enter into the valley. These deposits consist of a mixture of gravel, sand, and fines and reach a thickness of 40–50 feet. The thickness of the deposits decreases downstream to just a few feet.

The Pleistocene terrace deposits border the west and northwest sides of Middle Creek Valley and exist as isolated remnants above the valley floor. The deposits consist of poorly consolidated clay, silt, and sand with some gravel lenses. The deposits generally have a low permeability due to their high clay content and are less important as a groundwater source.

Fine grained lacustrine sediments and coarser grained floodplain deposits underlie the valley floors of Middle, Clover, and Alley creeks. These deposits overlie bedrock and older unconsolidated sediments. These sediments generally range in thickness from about 60 to 110 feet and, in the Middle Creek Valley area, form a confining layer for an underlying artesian aquifer system. The fine-grained lake deposits also contain numerous sand and gravel lenses representing portions of former stream channels. Permeability of the fine-grained lake deposits is low with specific yields ranging from about 3 to 5%. Sand and gravel lenses yield an average of 230 gpm.

The Cache Creek formation is a pre-terrace alluvial deposit consisting of lacustrine clays, sands, and gravels that overly bedrock in some places along the borders of the valley. The permeability of the formation is generally low.

The average specific yield for the depth interval of 0–100 feet is estimated to be 8% based on review and analysis of well logs for the Upper Lake Basin. The storage capacity for the basin is 10,900 acre-feet. The useable storage capacity is estimated to be 5,000 acre-feet. According to a 1995 survey, estimates of groundwater extraction for agricultural and municipal/industrial uses are 4,100 and 190 acre-feet respectively.

Major Sources of Recharge

Recharge of the principal aquifer is from Middle Creek, Clover Creek, and Alley Creek, and precipitation in the basin ranges from 35 to 43 inches per year, increasing to the north. Deep percolation from applied water is estimated to be 2,100 acre-feet per year. (DWR 2004.)

Land Use

Land use surveys were conducted within the basin by DWR in 2001. Agricultural land use accounts for about 48% of the basin, urban land use accounts for about 10% of the basin, and native land use accounts for about 42% of the basin. Table 4-103 provides details on the distribution of land use throughout the Upper Lake Basin.

Table 4-103. Land Use in the Upper Lake Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	1,181	16.26
Grain and Hay	111	1.52
Idle	353	4.85
Pasture	727	10.01
Rice	580	7.98
Semiagricultural and Incidental	84	1.16
Truck, Nursery, and Berry Crops	29	0.39
Vineyards	414	5.70
Subtotal	3,479	47.88
Urban		
Urban—unclassified	11	0.15
Commercial	50	0.68
Industrial	7	0.10
Urban Landscape	46	0.64
Urban Residential	595	8.18
Vacant	24	0.33
Subtotal	732	10.08
Native		
Riparian	513	7.06
Native Vegetation	2,447	33.68
Water	95	1.31
Subtotal	3,055	42.04
Total	**7,266**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

A groundwater management ordinance for Upper Lake Basin was adopted by Lake County in 1999. A key element of the Lake County ordinance is the requirement of an export permit for groundwater extraction and substitute pumping (DWR 2004). County of Lake is the only public water agency in Upper Lake Basin. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Magnesium bicarbonate and calcium bicarbonate water are the predominant groundwater types in the basin. TDS ranges from 180 to 615 mg/L, averaging 500 mg/L.

Boron has been detected is some wells in the basin; however, high boron is not a prevalent condition. Water quality analyses show high iron, manganese, EC, calcium, ASAR, and TDS (DWR 2004).

Yellow Creek Valley Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The area of the Yellow Creek Groundwater Basin is 2,310 acres and it is located in Plumas County, to the southwest of Lake Almanor. It consists of Quaternary alluvium. The valley is bounded to the east by Mesozoic and Paleozoic marine sediments, bounded to the north and west by Tertiary volcanic rocks, and to the south by Recent volcanic and Paleozoic marine sediments. The valley is drained to the south by Yellow Creek. (DWR 2004.)

Major Sources of Recharge

Recharge to the basin is from infiltration of precipitation and stream infiltration. Annual precipitation ranges from 39 to 43 inches (DWR 2004).

Land Use

Land use surveys were conducted within the basin by DWR in 1997. Agricultural land use accounts for about 61% of the basin and native land use accounts for about 39% of the basin. There is no urban land in the Yellow Creek Valley basin. Table 4-104 provides details of the land uses within the basin.

Table 4-104. Land Use in the Yellow Creek Valley Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agricultural		
Pasture	1,410	61.04

Land Use	Acreage of Land Use	Percent of Land Use
Semiagricultural and Incidental	0	0.00
Subtotal	1,410	61.00
Native		
Native Vegetation	870	37.66
Riparian	30	1.30
Subtotal	900	39.00
Total	**2,310**	**100.00**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known groundwater management plans, groundwater ordinances, or basin adjudications. Therer are no know water agencies or urban areas. This basin falls within the area included in the Sacramento Valley Water Quality Coalition.

Water Quality

Groundwater quality data for this basin could not be identified.

SAN JOAQUIN VALLEY GROUNDWATER BASIN—INTRODUCTION

The San Joaquin Valley Groundwater Basin lies within the San Joaquin River and Tulare Lake HRs. The northern portion of the basin is within the San Joaquin River HR and consists of nine subbasins. These are the Cosumnes, Eastern San Joaquin, Tracy, Modesto, Turlock, Merced, Delta-Mendota, Chowchilla, and Madera Subbasins (Figure 4-3). The southern portion of the basin lies in the Tulare Lake HR and consists of seven groundwater subbasins. These are the Kings, Westside, Kaweah, Tulare Lake, Pleasant Valley, Tule, and Kern Subbasins (Figure 4-4). The subbasins are described in detail below.

The San Joaquin River HR portion of the basin covers approximately 3.73 million acres, and the Tulare Lake HR portion of the basin covers approximately 5.15 million acres. Groundwater is extensively used in the San Joaquin Valley Groundwater Basin by agricultural and urban entities and accounts for approximately 48% of the groundwater used in California (DWR 2003).

Overview of Agricultural Chemical Impacts to Groundwater

This section presents a discussion of data that are on a more regional scale than any one subbasin; it is intended to provide an overview of agricultural chemical impacts to groundwater in the San Joaquin Valley Groundwater Basin.

The National Water Quality Assessment (NAQWA) for the San Joaquin Valley Groundwater Basin concluded that groundwater within the eastern portion of the San Joaquin Valley that supplies drinking water to the majority of the population has been degraded by fertilizers and pesticides (Dubrovsky et al. 1998). This report concluded that nitrate concentrations frequently exceeded drinking water standards while pesticides, with the exception of DBCP, rarely exceeded drinking water standards. The specific conclusions are listed below.

- Nitrate concentrations in groundwater in the eastern San Joaquin Valley exceeded drinking water standards in approximately 25% of domestic water supply wells sampled.
- Nitrate concentrations in shallow groundwater were related to agricultural land use settings. Detected concentrations were related to fertilizer application, physical characteristics of the sediment, and groundwater biochemical processes and varied among different agricultural land use settings.
- Since the 1950s, nitrate concentrations in groundwater have increased. During the same period, nitrogen fertilizer applications have increased from 114 to 745 million pounds per year.
- Pesticides were detected in approximately 67% of the groundwater samples collected from domestic water supply wells. However, most concentrations were less than 0.1 microgram per liter (µg/L).
- Detected pesticide concentrations generally did not increase between 1986 and 1995.

The occurrence of pesticides and nitrates in groundwater were studied in three agricultural land use settings in the eastern San Joaquin Valley (Burow et al. 1998). The concentration and occurrence of nitrates and pesticides in groundwater was related to differences in chemical applications and physical

and biochemical processes at each of the three locations. Significant conclusions of the study are listed below.

- Groundwater beneath vineyard and almond land use settings is more vulnerable to non-point source contamination than groundwater beneath the corn, alfalfa, and vegetable (row crop) land use setting on the lower (more distal) part of the alluvial fan.
- Nitrate concentrations in groundwater beneath almond orchards are typically higher than nitrate concentrations in groundwater beneath vineyards because nitrate fertilizer application rates are typically higher in almonds than vineyards.
- Row crops on fine-grained sediments and low dissolved oxygen concentrations reflect processes that result in slow infiltration rates and longer groundwater residence times. Intermediate nitrate concentrations in groundwater are the result of these characteristics combined with typically high application rates.
- Nitrate concentrations in groundwater have increased with time.
- Twenty-three different pesticides were detected in 41 of 60 groundwater samples collected.
- At least one pesticide was detected in 80% of the groundwater samples collected from the vineyard land use setting, 70% of the groundwater samples collected from the almond land use setting, and 55% of the groundwater samples collected from the row crop land use setting.
- Simazine was the most commonly detected pesticide. Simazine was detected in 50% of the groundwater samples from the vineyard land use setting and in 30% of the groundwater samples from the almond and row crop land use setting,
- The occurrence of simazine, diuron, and DBCP was consistent with recent and historical use of these pesticides.
- The occurrence of atrazine was not directly related to crop use and may be related to applications on right-of-ways.

Domagalski and Dubrovsky (1991) completed a regional assessment of non-point source pesticide residues in groundwater of the San Joaquin Valley. Compounds detected in groundwater included atrazine, bromacil, 2,4-DP, diazinon, DBCP, prometon, prometryn, propazine, and simazine. Significant conclusions of this report are presented below.

- Pesticide leaching is dependent on application patterns, soil texture, total organic carbon in soil, pesticide half-life, and depth to groundwater.
- Leaching is enhanced by flood irrigation methods.
- Foliar-applied pesticides, such as diazinon, are not mobilized by flood irrigation and are less likely to be detected in groundwater.
- Shallower-occurring groundwater in the western San Joaquin Valley has fewer detected pesticides than groundwater in the eastern San Joaquin Valley. The finer-grained soils of the western San Joaquin Valley inhibit pesticide leaching due to either low vertical permeability or high surface area. Both properties enhance adsorption of pesticides in the soil.
- Soils in the eastern San Joaquin Valley are coarse-grained sediments derived from the Sierra Nevada Batholith. Unlike the fine-textured soils of the western San Joaquin Valley, these soils are susceptible to pesticide leaching and, particularly in areas where the water table is less than 100 feet, are vulnerable to groundwater degradation.

- The area that appears to be most susceptible to leaching is in eastern Fresno and Tulare Counties.
- Tritium was detected in samples where pesticides were detected. Tritium indicates recharge with water of recent origin (post 1952), indicating that the water recently interacted with soils. Tritium is a useful indicator of possible contamination of groundwater by pesticides.
- Nitrate concentrations were not significantly different in groundwater samples where atrazine was or was not detected. Nitrate is not a useful indicator of possible contamination of groundwater by pesticides.

Results from monitoring that was performed as part of the DPR Ground Water Protection Program are summarized in Table 4-105.

Table 4-105. Pesticide Detections in Groundwater Wells for Counties in the San Joaquin Valley Groundwater Basin (1985–2003)

County	ACET	Atrazine	Bentazon	Bromocitl	DACT	DEA	Diuron	Norflurazon	Promoton	Simizine
Amador										
Calaveras										
Contra Costa		1		1			1		2	1
Fresno	121	10		54	70	7	107	21	4	180
Kings		1					3		1	
Mariposa										
Madera	4	2		2	3	2	6			4
Merced	8	4	1	3	8	2	7	1	1	6
San Joaquin	19	7		5	15	10	7	1		7
Stanislaus	5	4	3	1	2	1	7		1	11
Tulare	70	24		145	30	10	250	14	8	282
Tuolumne										
Total	**227**	**53**	**4**	**211**	**128**	**32**	**388**	**37**	**17**	**491**

Notes:
ACET = 2-amino-4-chloro-6-ethylamino-s-triazine.
DACT = 2,4-diamino-6-chloro-s-triazine.
DEA = deethyl-atrazine.
Source: DPR Ground Water Protection Program. 2003 Well Inventory Database, Cumulative Report 1986-2003.

SAN JOAQUIN VALLEY GROUNDWATER BASIN— SAN JOAQUIN RIVER HYDROLOGIC REGION SUBBASINS

Cosumnes Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cosumnes Subbasin is within the San Joaquin River HR and comprises an area of approximately 281,000 acres (439 square miles), primarily in Sacramento and San Joaquin counties with a small portion of the subbasin in western Amador County (Figure 4-3). The subbasin is bounded on the south and southwest by the Eastern San Joaquin Subbasin and on the north by the South American Subbasin of the Sacramento Valley Groundwater Basin. Exposed bedrock of the Sierra Nevada comprises the eastern boundary of the subbasin.

Water-bearing units in the subbasin consist of continental deposits of the Miocene to Pliocene Mehrten Formation, older alluvium of Pliocene to Pleistocene age, and younger alluvium of Quaternary age. The cumulative thickness of these deposits ranges from a few hundred feet on the east near the Sierra Nevada foothills to over 2,500 feet along the western margin of the subbasin.

The Mehrten Formation crops out in a discontinuous band along the eastern margin of the subbasin and consists of gravels, sands, silt, and clay with interbedded tuff breccias. The sands and gravels are highly permeable with wells completed in these zones having high yields. The tuff breccias act as confining layers. Unit thickness ranges from 200 to 1,200 feet.

The older alluvium consists of loose to moderately compacted sand, silt, and gravel deposited in alluvial fans. Formation names assigned to these deposits include: Modesto Formation, Riverbank Formation, Victor Formation, Laguna Formation, Arroyo Seco Gravels, South Fork Gravels, and Fair Oaks Formation. These deposits crop out between the Sierra Nevada foothills and younger alluvium near the axis of the Valley. Unit thickness ranges from about 100 to 650 feet.

The younger alluvium consists of recent stream channel deposits and dredge tailings. The stream channel deposits include sediments laid down by active steams, terrace deposits, and overbank deposits. These deposits consist of silt, fine- to medium-grained sand, and gravels and occur primarily along the Sacramento, Cosumnes, and Mokelumne Rivers.

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. The estimated total annual natural and applied water recharge is approximately 270,000 acre-feet. Estimated groundwater extraction includes approximately 35,000 acre-feet annually for urban use and 94,000 acre-feet annually for agricultural use (DWR 2003).

Land Use

Land use within the approximately 281,000-acre subbasin is shown on Figure 4-5. Primary agricultural crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-106.

Table 4-106. Land Use in the Cosumnes Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	3,500
Field Crops	15,000
Grain and Hay	4,000
Pasture	23,000
Truck, Nursery, and Berry Crops	2,000
Vineyards	33,500
Total	**81,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public entities within the Cosumnes Groundwater Subbasin are: Galt ID, Jackson Valley ID, North Delta WA, North San Joaquin WCD, Omochumne-Hartnell WD, Clay WD, Amador WA, Calaveras County WD, City of Galt Service Area, Rancho Murieta CSD, Sacramento County WD, Sacramento County MUD, and North San Joaquin WCD.

Identified water quality coalitions in the Cosumes Groundwater Subbasin are the Sacramento Valley Water Quality Coalition in the Sacramento County portion of the subbasin and the San Joaquin County and Delta Coalition in the San Joaquin County portion of the subbasin.

There are no major urban areas in the Cosumnes Subbasin.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000 regarding extracting and exporting of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

Sacramento Metropolitan Water Authority adopted an AB 3030 groundwater management plan in 1994. Agencies within the subbasin that are part of the authority include Galt ID, Hartnell WD, Clay WD, City of Galt Service Area, and Rancho Murieta CSD.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County and 566 wells in Sacramento County for analysis of pesticides. Verified detections of pesticides were reported in 45 wells in San Joaquin County and 3 wells in Sacramento County. Unverified detections of pesticides were reported in 84 wells in San Joaquin County and 31 wells in Sacramento County. Detected pesticides include atrazine and bentazon in Sacramento County with ACET, atrazine, bromacil, DACT, DEA, diuron, norflurazon, and simazine detected in San Joaquin County (Schuette et al. 2003).

Groundwater samples collected from 1994 to 2000, from 22 public water supply wells to meet the requirements of Title 22 of the California Code of Regulations (Title 22) within the Cosumnes Subbasin were analyzed for pesticides. Pesticides were detected in groundwater from one well at a concentration that exceeded the applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater within the subbasin is typically a calcium-magnesium and calcium-sodium bicarbonate type water. Detected TDS concentrations range from 140 to 438 mg/L and average approximately 218 mg/L. Nitrate levels were below the MCL in 30 public supply wells sampled by CDPH (DWR 2003).

Eastern San Joaquin Subbasin

General subbasin parameters, water quality, and discharge pathways and sources of contaminants are discussed below.

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Eastern San Joaquin Subbasin is within the San Joaquin River HR and comprises an area of approximately 707,000 acres (1,110 square miles) in San Joaquin, Stanislaus, and Calaveras Counties (Figure 4-3). The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2004).The subbasin is bounded by the Modesto Subbasin on the south, Delta-Mendota Subbasin on the southwest, Tracy Subbasin on the west, and on the north and northwest by the Cosumnes, South Sacramento, and Solano Subbasins. The Solano and South American Subbasins are part of the Sacramento Valley Groundwater Basin.

Water-bearing units of the subbasin include undifferentiated deposits of alluvium and Modesto/Riverbank Formations, flood basin deposits, Laguna Formation, and Mehrten Formation.

The undifferentiated deposits of alluvium and the Modesto/Riverbank Formations are of Recent to Late Pleistocene in age and consist of sand and gravels deposited in alluvial fans and clay, silt, and sand deposited in interfan areas. These units range in thickness from a thin veneer along the eastern margin of the subbasin to 150 feet near the center of the valley.

The flood-basin deposits consist of Recent to Pliocene age sediments exposed in the delta area of the San Joaquin Valley. These sediments represent a finer-grained equivalent (more distal facies) of the alluvium and Modesto/Riverbank Formations as described above. These deposits consist primarily of fine-grained sand, silt, and clay with occasional gravel beds. Unit thickness ranges from 0 to 1,400 feet. This unit creates semi-confined to confined conditions when interfingered with coarser-grained deposits. This unit typically has low permeability and contains poor quality groundwater.

The Plio-Pleistocene Laguna Formation consists of discontinuous lenses of fluvial sand and silt with lesser amounts of clay and gravel. The unit thickens from approximately 400 feet near the Mokelumne River to 1,000 feet in the Stockton area.

The Miocene to Pliocene Mehrten Formation consists of moderately to well indurated andesitic sand interbedded with conglomerate, tuffaceous siltstone, and claystone. The unit is exposed along the eastern margin of the subbasin where it is approximately 400 feet thick. The unit appears to thicken westward in the subsurface with reported thicknesses of 600 feet near Stockton and 1,300 feet near McDonald Island.

Estimated groundwater extraction includes approximately 47,000 acre-feet annually for municipal and industrial use and 762,000 acre-feet annually for agricultural use (DWR 2003).

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. The estimated total annual recharge is 593,000 acre-feet from precipitation and applied water, 141,000 acre-feet from infiltration of surface water, and 3,500 acre-feet of net subsurface inflow.

Land Use

Land use within the approximately 707,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-107.

Table 4-107. Land Use in the Eastern San Joaquin Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	102,500
Field Crops	70,500
Grain and Hay	55,000
Pasture	65,500
Truck, Nursery, and Berry Crops	44,000
Vineyards	59,000
Total	**396,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

Public water entities within the Eastern San Joaquin Groundwater Subbasin include: Lockeford CSD, North Delta WA, North San Joaquin WCD, Oakdale ID, City of Lathrop WD, City of Lodi Service Area, City of Manteca WSA, Calaveras County WD, California Water Service Company, Central Delta WA, Central San Joaquin WCD, City of Escalon WSA, Reclamation District 828, River Junction Reclamation District 2064, Rock Creek WD, South Delta WA, South San Joaquin ID, Stockton East WD, Valley Springs PUD, Woodbridge ID, Woodbridge WUCD, San Joaquin County FC&WCD, and City of Stockton MUD.

Coalitions in the subbasin include the San Joaquin County & Delta Coalition in the San Joaquin County portion of the subbasin and the East San Joaquin River Water Quality Coalition in the Stanislaus County portion of the subbasin.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000, regarding extracting and exporting of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

Calaveras County adopted a groundwater management ordinance in 2002. The ordinance requires that a permit be obtained for extracting groundwater for use outside the County.

AB 3030 groundwater management plans have been adopted by Stanislaus County, Oakdale ID, San Joaquin County FC&WCD, South San Joaquin ID, Stockton East WD, and Woodbridge WD.

Major urban areas in the subbasin include the Cities of Stockton and Lodi.

Water Quality

Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County and 900 wells in Stanislaus County for analysis of pesticides. Groundwater samples from 45 wells in San Joaquin County and 45 wells in Stanislaus County had verified detections of pesticides. San Joaquin County had 84 unverified detections while Stanislaus had 171 unverified detections. Pesticides detected in both counties include: ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine. In addition, the pesticides bentazon and prometon were detected in Stanislaus County and norflurazon was detected in San Joaquin County (Schuette et al. 2003).

Inorganic Constituents

Most groundwater within the subbasin is calcium-magnesium bicarbonate or calcium-sodium bicarbonate type water. Along the western margin of the subbasin near the San Joaquin River, chloride becomes the dominant anion. Analysis of groundwater samples from 174 water supply wells in the subbasin detected

TDS concentrations from 30 to 1,632 mg/L with an average of 310 mg/L. Other studies have reported TDS concentrations of groundwater ranging from 463 mg/L to 3,520 mg/L with an average of 463 mg/L. (DWR 2003.)

Large areas of the subbasin southeast of Lodi and south of Stockton and east of Manteca (extending toward the Stanislaus-San Joaquin County line have elevated concentrations of nitrates (DWR 2003).

Intrusion of saline water has been occurring along a 16-mile front on the east side of the Delta. The front moved approximately 1 mile east from 1963 to 1996. It is believed that declining groundwater levels have allowed the intrusion of saline water (DWR 2003).

Tracy Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Tracy Subbasin is within the San Joaquin River HR and comprises an area of approximately 345,000 acres (539 square miles) in San Joaquin, Contra Costa, and Alameda Counties (Figure 4-3). The subbasin is bounded by the Solano subbasin of the Sacramento Groundwater Basin to the north, the Eastern San Joaquin Subbasin to the east, and the Delta-Mendota Subbasin to the south.

Water-bearing units of the Tracy Subbasin consist of Late Tertiary to Quaternary continental deposits of the Tulare Formation, older alluvium, flood basin deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet along the edge of the Coast Ranges to about 3,000 feet along the eastern margin of the subbasin.

The Tulare Formation is exposed in the Coast Ranges west of the subbasin and dips eastward towards the axis of the valley. This unit consists of discontinuous deposits of clay, silt, and gravel that are poorly sorted and semi-consolidated. The Corcoran clay (also referred to as the e-clay) occurs near the top of the formation and confines groundwater beneath. The eastern limit of the Corcoran clay is near the eastern subbasin boundary. Groundwater is produced both from the unconfined aquifer above the Corcoran clay and the confined aquifer below. However, poor quality water is often encountered above the Corcoran clay. Maximum thickness of the Tulare Formation is about 1,400 feet.

The older alluvium is commonly exposed between the Coast Ranges and the Delta. This unit consists of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Plio-Pleistocene. The older alluvium is about 150 feet thick.

The younger alluvium includes channel and overbank deposits of active streams and terrace deposits of those streams. These deposits are present primarily along Corral Hollow Creek and consist of unconsolidated silt, fine- to medium-grained sand, and gravel. This unit is less than 100 feet thick in the subbasin.

Flood basin deposits occur in the Delta portion of the subbasin. This unit consists primarily of silt and clay with occasional gravel interbeds and is the distal equivalent of the older and younger alluvium and

the Tulare Formation. Groundwater found within this unit, it is generally of poor quality. The maximum thickness of the flood basin deposits is about 1,400 feet.

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams and percolation of applied irrigation water.

Land Use

Land use within the approximately 345,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-108.

Table 4-108. Land Use in the Tracy Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	17,000
Field Crops	63,500
Grain and Hay	28,500
Pasture	47,500
Truck, Nursery, and Berry Crops	45,000
Vineyards	2,500
Total	**204,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The San Joaquin County and Delta Coalition is the only identified water quality coalition in the subbasin.

Identified public agencies within the Tracy Groundwater Subbasin are: Naglee Burk ID, North Delta WA, Contra Costa WD, Diablo WD, East Contra Costa WD, Alameda CFC&WCD, Banta-Carbona WD, Byron Bethany ID, Central Delta WA, City of Antioch WSA, City of Brentwood WSA, Pescadero RD 2058, Plain View WD, RD 2039, South Delta WA, Stockton-East WD, The West Side ID, and West Stanislaus ID.

San Joaquin County adopted a groundwater management ordinance in 1996 and an amendment in 2000, regarding extraction and exportation of groundwater from San Joaquin County. The ordinance requires that a permit be obtained for use of extracted groundwater outside the County boundaries.

The San Luis and Delta-Mendota Water Authority has adopted an AB 3030 groundwater management plan. The water authority is composed of the Banta-Carbona ID, City of Tracy, Del Puerto WD, Patterson WD, Plain View WD, San Joaquin County FC&WCD, West Side ID, and West Stanislaus ID.

The only identified major urban area is the City of Tracy.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in San Joaquin County for analysis of pesticides. Groundwater samples from 45 of the wells had verified detections of pesticides and 84 of the wells had unverified detections. Pesticides detected included: ACET, atrazine, bromacil, DACT, DEA, diuron, norflurazon, and simazine (Schuette et al. 2003). DPR also reported data for Alameda and Contra Costa Counties; however, it is not summarized here because only a minor portion of each county is within the Tracy Subbasin.

Inorganic Constituents

Groundwater beneath the northern part of the subbasin is a sodium bicarbonate, chloride, and mixed bicarbonate-chloride type water. The dominant cations in groundwater beneath the southern part of the subbasin are calcium and sodium while the anionic water type is sulfate to chloride and bicarbonate to chloride. TDS concentrations in San Joaquin and Contra Costa counties range from 50 to 3,520 mg/L with a mean of 463 mg/L. The highest TDS concentrations are found in the western and central parts of the subbasin. Analysis of groundwater samples from 36 water supply wells within the subbasin had TDS concentrations from 210 to 7,800 mg/L with an average of 1,190 mg/L (DWR 2003).

The northwestern part of the subbasin and around the city of Tracy has high nitrate levels. Boron is also elevated from the northwest side of the subbasin to just south of Tracy. Elevated chloride concentrations exist in several areas of the subbasin including: along the San Joaquin River, the northwestern part of the subbasin, and in the vicinity of the City of Tracy (DWR 2003).

Modesto Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Modesto Subbasin is within the San Joaquin River HR and comprises an area of approximately 247,000 acres (385 square miles) in Stanislaus County (Figure 4-3). The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The subbasin is bounded by the Stanislaus River to the north, San Joaquin River to the west, and Tuolumne River to the south. The Eastern San Joaquin Subbasin is to the north, Delta-Mendota Subbasin is to the west, Turlock Subbasin is to the south, and bedrock of the Sierra Nevada is to the east.

Water-bearing units of the subbasin include consolidated and unconsolidated sedimentary deposits. The consolidated deposits include the Tertiary age Ione, Valley Springs, and Mehrten Formations.

Unconsolidated deposits include Pliocene and younger deposits that from oldest to youngest have been identified as continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood basin deposits.

The consolidated deposits are exposed along the eastern edge of the subbasin and only the Mehrten is considered an important aquifer. The Ione and Valley Springs yield only limited quantities of water to wells. The Mehrten is composed of up to 300 feet sandstone, breccia, conglomerate, tuff siltstone, and claystone.

The continental deposits and the older alluvium are the primary water-bearing units of the unconsolidated deposits. The continental deposits consist primarily of poorly sorted gravel, sand, silt, and clay with a maximum thickness of about 450 feet.

The older alluvium consists of interstratified beds of gravel, sand, silt, and clay. This unit is up to 400 feet thick and is typically at or near the surface of the western half of the subbasin. This unit is equivalent of the Modesto and Riverbank Formations.

The Corcoran clay occurs within the lacustrine and marsh deposits. The Corcoran clay is the confining layer that separates the overlying unconfined aquifer from the underlying confined aquifer. The Corcoran clay underlies the southwestern portion of the subbasin at depths of 150 to 250 feet (DWR 2003).

Estimated annual groundwater extractions include 81,000 acre-feet for urban use and 145,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow downstream channels from the east. The lower to middle stretches of the Stanislaus and Tuolumne rivers are gaining streams with groundwater discharge supporting flow. Natural recharge to the subbasin is estimated at 86,000 acre-feet annually with an additional 92,000 acre-feet of recharge from applied water annually.

Land Use

Land use within the approximately 247,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-109.

Table 4-109. Land Use in the Modesto Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	2,000
Deciduous Fruits and Nuts	44,000
Field Crops	20,000
Grain and Hay	3,500
Pasture	37,000
Truck, Nursery, and Berry Crops	1,500
Vineyards	5,500
Total	**113,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition. Public water agencies within the Modesto Groundwater Subbasin are: Modesto ID, Oakdale ID, Stanislaus and Tuolumne Rivers Groundwater Subbasin Association, City of Modesto, City of Oakdale, and City of Riverbank.

The only major urban area in the subbasin is the City of Modesto.

There are no pertinent groundwater ordinances or regulations in Stanislaus County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County for analysis of pesticides. Groundwater samples from 45 of the wells had verified detections of pesticides and 171 of the wells had unverified detections. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, prometon, and simazine (Schuette et al. 2003). Groundwater samples collected from 117 water supply wells regulated by the CDPH within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater from 14 wells at concentrations greater than applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater beneath the eastern part of the subbasin is typically a calcium bicarbonate type water while groundwater beneath the western portion of the subbasin is typically a calcium-magnesium bicarbonate or

calcium-sodium bicarbonate type water. TDS concentrations range from 60 to 8,300 mg/L and typically fall between 200 and 500 mg/L. Analysis of 88 groundwater samples from wells regulated by CDPH had TDS concentrations ranging from 60 mg/L to 860 mg/L with an average concentration of 295 mg/L (DWR 2003).

There are localized areas of high chloride, boron, DBCP, nitrate, iron, and manganese. The eastern side of the subbasin has some areas with elevated sodium chloride and high TDS. 114 groundwater samples for analysis of nitrate were collected from water supply wells regulated by CDPH from 1994 through 2000. Three of these wells contained groundwater with nitrate concentrations greater than the MCL (DWR 2003).

Turlock Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Turlock Subbasin is within the San Joaquin River HR and covers approximately 347,000 acres (542 square miles) in Stanislaus and Merced Counties (Figure 4-3). The subbasin is bounded to the north by the Tuolumne River, to the south by the Merced River, and to the west by the San Joaquin River. The Modesto subbasin lies to the north, Delta-Mendota subbasin to the west, and Merced Subbasins to the south with bedrock of the Sierra Nevada to the east.

Water-bearing units of the subbasin include consolidated and unconsolidated sedimentary deposits. The consolidated deposits include the Tertiary age Ione, Valley Springs, and Mehrten Formations. Unconsolidated deposits include Pliocene and younger deposits that from oldest to youngest have been identified as continental deposits, older alluvium, younger alluvium, and flood basin deposits.

The consolidated units include the Ione, Valley Springs, and Mehrten Formations. Most of the consolidated material lies in the eastern portion of the subbasin and yield little water with the exception of the Mehrten Formation. The Mehrten Formation is composed of up to 800 feet of sandstone, breccia, conglomerate, tuff siltstone, and claystone.

Unconsolidated materials include continental, older, and younger alluvium, and flood basin deposits. In the western half of the subbasin the Corcoran or E-clay aquitard is composed of lacustrine and marsh deposits ranges at depths between about 50 and 200 feet. The lacustrine, flood-subbasin deposits and marsh deposits yield very little water. The younger alluvium yields only moderate quantities of water.

Given the stratigraphy of the Turlock Subbasin, there are three groundwater bodies: unconfined, semiconfined and confined in the consolidated material, and the confined water beneath the E-clay in the western portion of the subbasin.

Annual groundwater extraction is estimated at 65,000 acre-feet for urban use and 387,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow downstream channels from the east. Natural recharge is estimated at 33,000 acre-feet annually while recharge of applied water is estimated at 313,000 acre-feet annually.

Land Use

Land use within the approximate 347,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-110.

Table 4-110. Land Use in the Turlock Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	105,500
Field Crops	60,000
Grain and Hay	6,000
Pasture	42,500
Truck, Nursery, and Berry Crops	5,000
Vineyards	15,500
Total	**234,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Turlock Groundwater Subbasin include: Eastside WD, Turlock ID, Ballico-Cortez WD (inactive), and Merced ID.

The only identified major urban area in the subbasin is the City of Turlock.

There are no known groundwater ordinances or regulations in Merced or Stanislaus County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County and 1,230 in Merced County for analysis of pesticides. In Stanislaus County, groundwater samples from 45 of the wells had verified detections and 171 of the wells had unverified detections of pesticides. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detection of pesticides. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, prometon, and simazine (Schuette et al. 2003). Groundwater samples collected (1994-2000) from 117 public water supply wells within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater from 14 wells at concentrations greater than applicable MCLs (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a sodium-calcium bicarbonate type water with sodium bicarbonate and sodium chloride type waters at the western margin and in a small area of the north-central part of the subbasin. TDS ranges from 100 to 8,300 mg/L, but usually ranges from 200 to 500 mg/L. Analysis of groundwater samples collected from 71 wells regulated by CDPH had TDS concentrations from 100 to 930 mg/L, with an average of 335 mg/L. (DWR 2003)

Localized areas of the subbasin have groundwater with concentrations of nitrates, chlorides, boron, and DBCP that impair the beneficial uses. In eight of the 90 public supply wells between 1994 and 2000 nitrate levels exceeded the MCL. A supply well for the City of Turlock was closed because of nitrate concentrations (DWR 2003).

Merced Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Merced Subbasin is within the San Joaquin River HR and covers approximately 491,000 acres (767 square miles) in Merced County (Figure 4-3). Surrounding subbasins include: the Chowchilla Subbasin to the south, Turlock Subbasin to the north, and Delta-Mendota Subbasin to the west. Crystalline bedrock of the Sierra Nevada lies to the east.

Water-bearing units within the subbasin consist of consolidated rock and unconsolidated deposits. The consolidated units include the Tertiary-age Ione, Valley Springs, and Mehrten Formations. Most of the consolidated material lies in the eastern portion of the subbasin and yield little water with the exception of the Mehrten Formation. The Mehrten Formation is composed of sandstone, breccia, conglomerate, tuff siltstone, and claystone.

The unconsolidated deposits are Pliocene and younger in age and from oldest to youngest include: continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood basin deposits. Among the unconsolidated units, the main water yielding units are the continental and older

alluvium deposits. The lacustrine and marsh deposits, including the Corcoran Clay and the flood basin deposits yield little water while the younger alluvium generally yields moderate quantities of water.

An unconfined aquifer occurs in the unconsolidated materials above and to the east of the Corcoran Clay. The Corcoran Clay occurs in the western half of the subbasin at depths ranging from 50 to 200 feet, with the exception of the western and southern areas where clay lenses occur producing semiconfined conditions.

Annual groundwater extraction is estimated at 54,000 acre-feet for urban use and 492,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams, direct percolation of precipitation, and underflow channels from the east. Natural recharge is estimated at 47,000 acre-feet annually while recharge of applied water is estimated at 243,000 acre-feet annually. (DWR 2003.)

Land Use

Land use within the approximate 491,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-111.

Table 4-111. Land Use in the Merced Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	3,500
Deciduous Fruits and Nuts	67,500
Field Crops	66,000
Grain and Hay	17,000
Pasture	61,500
Truck, Nursery, and Berry Crops	28,000
Vineyards	7,500
Total	**251,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition in the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Merced Subbasin include: Merced ID, Merquin County WD, Turner Island WD, Le Grand-Athlone WD, Plainsburg ID, and Stevinson WD.

The only identified major urban area in the subbasin is the City of Merced.

There are no known groundwater ordinances or regulations in Merced County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 1,230 wells in Merced County for analysis of pesticides. Groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detection of pesticides. Detected pesticides included ACET, atrazine, bentazon, diuron, bromacil, DACT, DEA, norflurazon, prometon, and simazine (Schuette et al. 2003). In samples collected between 1994 and 2000 pesticides were detected in groundwater from eight of 62 public supply wells at concentrations greater than an applicable MCLs (DWR 2003).

Inorganic Constituents

Groundwater is typically of sodium bicarbonate type in western areas of the subbasin, calcium-magnesium bicarbonate type in interior areas of the subbasin, and calcium-sodium bicarbonate type in southern areas of the subbasin. Small areas of chloride type waters occur in the southwestern corner of the subbasin. TDS ranges from 100 to 3,600 mg/L, but usually ranges from 200 to 400 mg/L. Groundwater samples collected from 46 wells regulated by CDPH had TDS concentrations from 150 to 424 mg/L, with an average of 231 mg/L. (DWR 2003.)

Localized areas of the subbasin have groundwater with concentrations of iron, nitrates, and chlorides that impair the beneficial uses. Two of 64 public supply wells sampled from 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

Delta-Mendota Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Delta-Mendota Subbasin is within the San Joaquin River HR and covers approximately 747,000 acres (1,170 square miles) in Stanislaus, Merced, Madera, and Fresno counties (Figure 4-3). The Delta-Modesto Subbasin is bounded on the west by the Tertiary and older marine sediments of the Coast Ranges, on the north by the Tracy Subbasin, on the south by the Westside Subbasin, and on the east by the Modesto, Turlock, Merced, Chowchilla, Madera, and Kings subbasins.

The water-bearing units include: the Tulare Formation, terrace deposits, alluvium, and flood basin deposits. The Tulare Formation is comprised of interbedded tongues and lenses of clay, sand, and gravel that were deposited in alternating oxidizing and reducing environments. A member of the Tulare Formation, the Corcoran Clay, is an aquitard that occurs at a depth ranging from 100 to 500 feet and acts as the confining layer that separates the underlying confined from the overlying unconfined aquifers.

Pleistocene terrace deposits of yellow, tan, and light-to-dark brown silt, sand, and gravel are elevated above present day streambeds. These deposits typically occur above the water table, but their coarse grain size makes them potential recharge areas. The alluvium consists of poorly to well-sorted clay, silt, sand, and gravel. Capping the other units of the subbasin are flood basin deposits, which are dark to light brown and gray clay, silt, sand, and organic materials.

The water-bearing zones of the Delta-Mendota Subbasin have lower, upper, and shallow zones. The lower zone is the lower section of the Tulare Formation. The upper zone is generally confined, semiconfined, and unconfined water in the upper section of the Tulare Formation and some younger deposits. The shallow zone is unconfined within 25 feet of the land surface.

Annual groundwater extraction is estimated at 17,000 acre-feet for urban use and 491,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary sources of groundwater recharge in the subbasin are from deep percolation of applied irrigation water and from canals and water storage facilities. Lesser groundwater recharge occurs from percolation from small streams and direct percolation of precipitation. Natural recharge is estimated at 8,000 acre-feet annually while recharge of applied water is estimated at 74,000 acre-feet annually.

Land Use

Land use within the approximate 747,000-acre subbasin is shown on Figure 4-5. Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-112.

Table 4-112. Land Use in the Delta-Mendota Subbasin

Land Use	Approximate Acreage
Agriculture	
Rice	8,000
Deciduous Fruits and Nuts	52,500
Field Crops	207,500
Grain and Hay	18,500
Pasture	104,500
Truck, Nursery, and Berry Crops	81,500
Vineyards	2,500
Total	**475,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The identified water quality coalition within the subbasin is the Westside Water Quality Coalition.

Public water agencies within the Delta-Mendota Groundwater Subbasin include: Merced County, Fresno County, Broadview WD, Centinella WD, Central California ID, Davis WD, Del Puerto WD, Eagle Field WD, El Solyo WD, Farmers WD, Firebaugh Canal WD, Foothill WD, Fresno Slough WD, Grasslands WD, Hospital WD, Kern Canon WD, Laguna WD, Mercy Springs WD, Mustang WD, Oak Flat WD, Orestimba WD, Oro Loma WD, Pacheco WD, Panoche WD, Patterson WD, Romero WD, Salado WD, San Luis Canal Company, San Luis WD, Santa Nella CWD, Sunflower WD, Tranquility ID, West Stanislaus ID, Widren WD, and Quinto WD.

There are no identified major urban areas within the subbasin.

Pertinent ordinances and regulations affecting groundwater in the subbasin are listed below.

- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.
- A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.
- Madera County has a Groundwater Management Ordinance that regulates the importation of foreign water for groundwater banking and exportation of groundwater outside Madera County.

No known groundwater ordinances have been adopted by Stanislaus or Merced Counties.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 900 wells in Stanislaus County, 1,230 wells in Merced County, 391 wells in Madera County, and 4,032 wells in Fresno County for analysis of pesticides. In Stanislaus County, groundwater samples from 45 of the wells had verified detections and 171 of the wells had unverified detections. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detections. In Madera County, groundwater samples from 11 of the wells had verified detections and 89 of the wells had unverified detections. In Fresno County, groundwater samples from 224 of the wells had verified detections and 369 of the wells had unverified detections. ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine were detected in each of the counties. Norflurazon was detected in Fresno and Merced counties (Schuette et al. 2003). Groundwater samples collected from 47 public supply wells within the subbasin (1994-2000) were analyzed for pesticides. Pesticides were detected in groundwater from one well at concentrations greater than the MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a mixed sulfate to bicarbonate type water. In the central and southern portions of the subbasin, areas of sodium chloride and sodium sulfate type groundwater exist. TDS concentrations range from 400 to 1,600 mg/L in the northern part of the subbasin and 730 to 6,000 mg/L in the southern part. Analysis of groundwater samples collected from 44 wells regulated by CDPH had detected TDS concentrations from 210 to 1,750 mg/L, with an average of 770 mg/L (DWR 2003).

Localized areas of the subbasin have groundwater with concentrations of iron, fluoride, nitrate, and boron that impair the beneficial uses. Analysis of groundwater samples collected from 51 wells regulated by CDPH between 1994 and 2000, detected nitrate in groundwater from 4 of the wells at concentrations exceeding the MCL (DWR 2003).

Chowchilla Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Chowchilla Subbasin is within the San Joaquin River HR and covers approximately 159,000 acres (248 square miles) in Madera and Merced counties (Figure 4-3). The subbasin is bordered to the north by the Merced Subbasin, to the southeast by Madera Subbasin and to the west by Delta-Mendota Subbasin. Crystalline bedrock of the Sierra Nevada comprises the subbasin's eastern boundary.

The major water-bearing units within the Chowchilla Subbasin are unconsolidated continental deposits of Tertiary and Quaternary age. Quaternary age deposits include older alluvium, lacustrine and marsh deposits, and younger alluvium that crop out over most of the subbasin and yield 95% of the well water. The most important source of water is the older alluvium, which is characterized as being intercalated lenses of clay, silt, sand, and some gravel. The Corcoran Clay or E-Clay underlies most of the basin at depths between 50 and 250 feet and restricts the vertical movement of water.

Annual groundwater extraction is estimated at 6,000 acre-feet for urban use and 249,000 acre-feet for agricultural use (DWR 2003).

Major Sources of Recharge

The primary source of groundwater recharge in the subbasin is from deep percolation of applied irrigation water. Lesser groundwater recharge occurs from percolation from streams and direct percolation of precipitation. Natural recharge is estimated at 87,000 acre-feet annually while recharge of applied water is estimated at 179,000 acre-feet annually. (DWR 2003.)

Land Use

Land use within the approximate 159,000-acre subbasin is shown on Figure 4-5. Primary crops grown, and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-113.

Table 4-113. Land Use in the Chowchilla Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	29,000
Field Crops	40,500
Grain and Hay	8,000
Pasture	38,000
Truck, Nursery, and Berry Crops	1,000
Vineyards	12,500
Total	**129,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies include: Chowchilla WD, Clayton WD, El Nido ID, New Stone WD, and Sierra WD (inactive). California Water Service Company is the only identified private water agency in the subbasin.

Madera County has adopted an ordinance to provide regulatory control over the exporting groundwater, groundwater banking, and importing groundwater for groundwater banking. There are no known pertinent groundwater regulations in Merced County.

There are no identified urban areas within the subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 1,230 wells in Merced County and 391 wells in Madera County for analysis of pesticides. In Merced County, groundwater samples from 25 of the wells had verified detections and 72 of the wells had unverified detections. In Madera County, groundwater samples from 11 of the wells had verified detections and

89 of the wells had unverified detections. ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine were detected in both counties. Norflurazon was detected in Merced County (Schuette et al. 2003). Groundwater samples collected from 12 water supply wells regulated by CDPH within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were not detected in groundwater from any of these wells at a concentration greater than an applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a calcium-sodium bicarbonate type water in the eastern part of the subbasin and grades to a calcium bicarbonate, sodium-calcium bicarbonate, and sodium chloride type waters towards the western portion of the subbasin. TDS concentrations range from 120 to 6,400 mg/L, but are typically in a range from 200 to 500 mg/L. Analysis of groundwater samples collected from 8 wells regulated by CDPH had TDS concentrations from 120 to 390 mg/L, with an average TDS concentration of 228 mg/L. (DWR 2003.)

Localized areas of the subbasin have groundwater with concentrations of iron, nitrate, and chloride that impair the beneficial uses. None of the 10 public supply wells sampled between 1994 and 2000 had nitrate levels exceeding the MCL (DWR 2003).

Madera Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Madera Subbasin is within the San Joaquin River HR and covers approximately 394,000 acres (614 square miles) in Madera County (Figure 4-3). The Madera Subbasin is bounded to the east by crystalline bedrock of the Sierra Nevada, to the south by the Kings Subbasin, the Delta-Mendota Subbasin to the west, and the Chowchilla Subbasin to the north.

The water-bearing units in the Madera Subbasin consist of unconsolidated Pleistocene and Holocene age deposits. Quaternary continental deposits include older and younger alluvium, lacustrine, and marsh deposits that crop out over most of the Madera Subbasin and probably yield 95% of the well water. The most important part of the Quaternary deposits is the older alluvium. The older alluvium consists of intercalated lenses of clay, silt, sand, and some gravel. Within the older alluvium are lacustrine and marsh deposits that contain the E-Clay. The E-Clay does not crop out, but occurs at depths between 150 and 300 feet and restricts vertical movement of water.

Older Continental deposits of Tertiary and Quaternary, which include the Ione Formation, crop out along the subbasin's eastern margin and may yield small quantities of water.

Major Sources of Recharge

The primary source of groundwater recharge in the subbasin is from deep percolation of applied irrigation water. Lesser groundwater recharge occurs from percolation from streams and direct percolation of

precipitation. Natural recharge is estimated at 21,000 acre-feet annually while recharge of applied water is estimated at 404,000 acre-feet annually. Annual groundwater extraction is estimated at 15,000 acre-feet for urban use and 551,000 acre-feet for agricultural use (DWR 2003).

Land Use

Land use within the approximate 394,000-acre subbasin is shown on Figure 4-5. Primary crops grown, and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-114.

Table 4-114. Land Use in the Madera Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	7,000
Deciduous Fruits and Nuts	81,000
Field Crops	21,500
Grain and Hay	16,000
Pasture	16,500
Truck, Nursery, and Berry Crops	2,500
Vineyards	97,500
Total	**242,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the subbasin is the East San Joaquin River Water Quality Coalition.

Public water agencies within the Madera Groundwater Subbasin include: Gravelly Ford WD, Madera ID, and Root Creek WD. There are no known private water agencies within the subbasin.

The largest urban area within the subbasin is the City of Madera with a population of approximately 46,000 people.

Madera County has adopted an ordinance to provide regulatory control over exporting of groundwater, groundwater banking, and importing of groundwater for groundwater banking.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

DPR reported that between 1983 and 2003, groundwater samples were collected from 391 wells in Madera County for analysis of pesticides. Groundwater samples from 11 of the wells had verified detections and 89 of the wells had unverified detections. Detected pesticides include: ACET, atrazine, bromacil, DACT, DEA, diuron, and simazine (Schuette et al. 2003). Groundwater samples collected from 46 water supply wells within the subbasin from 1994 through 2000 were analyzed for pesticides. Pesticides were detected in groundwater samples from 3 of the wells at a concentration greater than an applicable MCL (DWR 2003).

Inorganic Constituents

Groundwater in the subbasin is typically a calcium-sodium bicarbonate type water with sodium bicarbonate and sodium chloride type waters along the western margin of the subbasin. TDS ranges from 100 to 6,400 mg/L, but are typically in a range from 200 to 400 mg/L. Analysis of groundwater samples collected from 40 wells regulated by CDPH had TDS concentrations from 100 to 400 mg/L, with an average TDS concentration of 251 mg/L (DWR 2003).

Localized areas of the subbasin have groundwater with concentrations of iron, nitrate, and chloride that impair the beneficial uses. One of 43 public supply wells sampled between 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

SAN JOAQUIN VALLEY GROUNDWATER BASIN—TULARE LAKE HYDROLOGIC REGION SUBBASINS

Westside Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Westside Subbasin is within the Tulare Lake HR and comprises an area of approximately 640,000 acres (1,000 square miles) located in the western portion of Fresno County and the northwestern portion of Kings County (Figure 4-4). The subbasin is bordered on the southwest by the Pleasant Valley Subbasin, the north and northeast by the Delta-Mendota Subbasin, the east by the Kings Subbasin, the southeast by the Tulare Lake Subbasin, and on the west by Tertiary marine sediments of the Coast Ranges.

The water-bearing units comprising the Westside Subbasin consist of unconsolidated continental deposits of Tertiary and Quaternary age. These deposits form an unconfined to semiconfined upper aquifer and a confined lower aquifer. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation . The depth to the top of the Corcoran Clay varies from approximately 500 to 850 feet (DWR 1981).

The unconfined to semiconfined aquifer (upper zone) above the Corcoran Clay includes younger alluvium, older alluvium, and the upper part of the Tulare Formation. These deposits consist of lenticular, poorly sorted clay, silt, and sand intercalated with occasional beds of well-sorted fine to medium grained sand.

The confined aquifer (lower zone) consists of the lower part of the Tulare Formation and possibly the uppermost part of the San Joaquin Formation. This unit is composed of lenticular beds of silty clay, clay, silt, and sand interbedded with occasional strata of well-sorted sand. Brackish or saline water underlies the usable groundwater in the lower zone.

Fine-grained flood basin deposits along the east side of the subbasin restrict the downward movement of percolating water. In certain areas this causes percolation of applied water to buildup as shallow water (perched) in the near surface zone. This shallow groundwater is typically of poor quality and is not a significant source of produced groundwater.

The Corcoran Clay is a lacustrine diatomaceous clay unit that underlies much of the sub basin. Within the subbasin it varies in thickness from 20 to 120 feet. Prior to groundwater development, the Corcoran Clay effectively separated the upper and lower zones. Numerous wells penetrate the clay and have allowed partial interaction between the zones.

Major Sources of Recharge

The main source of recharge to the subbasin aquifer system is from the seepage of Coast Range streams along the west side of the subbasin and deep percolation of surface irrigation. Recharge to the lower aquifer occurs by subsurface flow from areas to the east and northeast. (DWR 2003.)

Seepage from west side streams was estimated to amount to 30,000-40,000 acre-feet per year. For 1951, secondary recharge from the east into the upper aquifer was 20,000–30,000 acre-feet and was 150,000–200,000 acre-feet into the lower aquifer (DWR 2003).

Westlands WD (Westlands) estimated that the average deep percolation between 1978 and 1996 was 244,000 acre-feet per year. Westlands also estimated that the average applied groundwater between 1978 and 1997 was 193,000 acre-feet per year (DWR 2003).

Land Use

Land use within the approximate 744,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-115.

Table 4-115. Land Use in the Westside Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	1,000
Deciduous Fruits and Nuts	56,500
Field Crops	321,000
Grain and Hay	46,000
Pasture	31,000
Truck, Nursery, and Berry Crops	174,000
Vineyards	12,500
Total	**642,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The WestlandsWater Quality Coalition is the only identified water quality coalition within the subbasin.

Westlands WD is the only identified public water agency within the Westside Subbasin. There are no identified private water agencies within the subbasin.

There are no identified major urban areas in the subbasin.

Pertinent ordinances and regulations affecting the Westside Subbasin are as follows:

- AB 3030, California Groundwater Management Plan, adopted in 1992.

- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.
- A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.

No known pertinent groundwater ordinances have been adopted by Kings County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reports that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County and 229 wells were sampled in Kings County, both of which comprise portions of the Westside Subbasin. Fresno County had 224 wells with verified detections 369 wells with unverified detections while Kings County reported 4 wells with verified detections and 6 wells with unverified detections. Fresno County detections included ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Kings County had detections of atrizine, diuron, and prometon.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed to be the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the west side of the San Joaquin Valley is typically a sulfate or bicarbonate type water. Water quality of the upper aquifer is typically high in calcium and magnesium sulfate. Groundwater below 300 feet and above the Corcoran Clay shows a tendency of decreased dissolved solids with increased depth. Most of the groundwater in the lower aquifer is a sodium-sulfate type water (DWR 2003).

Based on the analysis of groundwater samples collected from six wells regulated by CDPH, the average TDS of the subbasin is 520 mg/L with a range from 220 mg/L to 1,300 mg/L. However, TDS concentrations in shallow groundwater can be greater than 10,000 mg/L at some locations in the lower fan areas of the subbasin with one sample having a TDS concentration of 35,000 mg/L. Groundwater in western Fresno County has an upper TDS concentration ranging from 2,000 to 3,000 mg/L. (DWR 2003.)

High TDS impairs groundwater use in the subbasin. Groundwater at certain locations also contains selenium and boron that may affect beneficial uses.

Bulletin 118 (DWR 2003) indicates that groundwater samples from 2 wells were analyzed for nitrates and detected concentrations were less than the MCL.

Kings Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Kings Subbasin is within the Tulare Lake HR and comprises an area of approximately 976,000 acres (1,530 square miles) primarily within Fresno County with the southern portion of the subbasin in Kings and Tulare Counties (Figure 4-4). The Kings Subbasin is bounded on the north by the Madera Subbasin, on the south by the Kaweah and Tulare Lake subbasins, and on the west by the Westside and Delta-Mendota Subbasins. Bedrock of the Sierra Nevada foothills bounds the subbasin on the east.

The water-bearing units of the Kings Subbasin consist of unconsolidated continental deposits. These deposits include an older series of Tertiary and Quaternary age sediments overlain by a younger series of Quaternary age sediments. The Quaternary age deposits are divided into older alluvium, lacustrine and marsh deposits, younger alluvium, and flood basin deposits.

The older alluvium consists of intercalated lenses of clay, silt, silty and sandy clay, clayey and silty sand, sand, gravel, cobbles, and boulders. It is, generally, fine grained near the trough of the valley. Lacustrine and marsh deposits are interbedded with the older alluvium in the western portion of the subbasin.

The younger alluvium consists of fluvial deposits of arkosic composition that overlie the older alluvium and are interbedded with the flood basin deposits. Its lithology is similar to the underlying older alluvium. Beneath river channels, the younger alluvium is highly permeable with lesser permeability beneath flood basin deposits. The flood basin deposits occur along the Fresno Slough and James Bypass. They consist of sand, silt, and clay.

The deposits of Quaternary age are exposed over most of the area and yield more than 90% of the water pumped from wells. The older continental deposits are exposed in the southeastern part of the subbasin and yield small amounts of water to wells.

Flood basin deposits provide minimal amounts of water to wells and typically restrict the flow of groundwater. The Corcoran Clay member of the Tulare Formation is the most extensive of these deposits. The Corcoran Clay lies at a depth 250 to 550 feet in the western one quarter to one third of the subbasin.

Major Sources of Recharge

Groundwater recharge occurs from river and stream seepage, deep percolation of irrigation water, canal seepage, and intentional recharge. The Cities of Fresno and Clovis, Fresno ID, and Fresno Metropolitan Flood Control District have a cooperative effort to utilize individually owned facilities to recharge surplus surface water in the greater urban area. Fresno ID, Consolidated ID, and others have similar groundwater recharge efforts in the subbasin. The Fresno-Clovis metropolitan area uses a regional sewage treatment facility that percolates treated wastewater in ponds southwest of Fresno (DWR 2003). The percolation of treated wastewater has created a significant groundwater mound beneath the facility.

Groundwater flow is generally to the southwest. The potential exists for subsurface flows to the south and west. Depending upon local groundwater conditions in the Westside Subbasin, subsurface flows may

occur in that direction. The potential exists for groundwater flow in either direction along the southern boundary of the subbasin. Groundwater depressions on either side of the subbasin boundary and groundwater mounding from recharge along the Kings River complicate flow patterns in the area (DWR 2003).

Land Use

Land use within the approximately 976,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-116.

Table 4-116. Land Use in the Kings Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	52,500
Deciduous Fruits and Nuts	168,500
Field Crops	133,500
Grain and Hay	24,000
Pasture	78,000
Vineyards	263,000
Total	**719,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kings Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water agencies within the Kings Subbasin include: City of Fresno, City of Clovis, Alta ID, Consolidated ID, Fresno ID, Hills Valley ID, James ID, Kings River Conservation District (KRCD), Kings River WD, Laguna ID, Liberty WD, Mid-Valley WD, Orange Cove ID, Raisin City ID, Riverdale ID, and Tri-Valley ID. Identified private water agencies within the subbasin are California Water Service Company and Bakman Water Company.

Major urban areas include the Fresno-Clovis metropolitan area with a population in excess of 500,000.

Pertinent ordinances and regulations affecting the Kings Subbasin are as follows:

- Alta ID, Consolidated ID, County of Fresno, Fresno ID, James ID, KRCD, Kings River WD, Liberty Canal Company, Liberty WD, Liberty Mill Race Company, Mid Valley WD, Orange Cove ID, Raisin City WD, and Riverdale ID have adopted AB 3030 Groundwater Management Plans.
- Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.

A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted.+ No known pertinent groundwater ordinances have been adopted by Kings or Tulare Counties.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reported that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County, 229 wells in Kings County, and 1,547 wells in Tulare County, all three of which comprise portions of the Kings subbasin. Fresno County had 224 wells with verified detections and 369 wells with unverified detections, Kings County reported 4 wells with verified detections and 6 wells with unverified detections, and Tulare County reported 365 wells with verified detections and 256 wells with unverified detections. Groundwater detections in Fresno and Tulare County included: ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Groundwater detections in Kings County included: atrizine, diuron, and prometon.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and were not reviewed by DPR (Schuette et al. 2003). DBCP, a soil fumigant (nematicide), has been detected in groundwater along the eastern side of the subbasin (DWR 2003).

Inorganic Constituents

The groundwater in the Kings Subbasin is predominantly a bicarbonate type water. The major cations are calcium, magnesium, and sodium. Sodium appears higher in the western portion of the subbasin where some chloride waters are also found (DWR 2003).

The TDS of groundwater in the Fresno area seldom exceeds 600 mg/L although 2,000 mg/L groundwater has been encountered at greater depths. A typical range of TDS concentrations in groundwater in the subbasin is 200 to 700 mg/L. CDPH data indicates an average TDS concentration of 240 mg/L in 414 samples collected from water supply wells subject to Title 22 regulations. The detected TDS concentrations of these samples ranged from 40 to 570 mg/L. (DWR 2003.)

Analysis of groundwater samples collected from 463 wells detected nitrates at concentrations greater than the MCL in 23 of the wells.

Shallow brackish groundwater can be found in localized areas along the western portion of the subbasin. This shallow water contains elevated concentrations of fluoride, boron, and sodium (DWR 2003).

Tulare Lake Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Tulare Lake Subbasin is within the Tulare Lake HR and comprises an area of 524,000 acres (818 square miles) primarily located in Kings County with a small portion along the eastern boundary of the subbasin within Tulare County (Figure 4-4). The Tulare Lake Subbasin is bordered on the north by the Kings Subbasin, on the northwest by the Westside Subbasin, to the east by the Kaweah and Tule Subbasins, and to the south by the Kern Subbasin. Tertiary marine sediments of the Kettleman Hills border the subbasin on the southwest.

Sediments comprising the Tulare Lake Subbasin include younger and older alluvium, flood basin deposits, lacustrine and marsh deposits, and continental deposits. Younger alluvium is a heterogeneous complex of interstratified discontinuous beds of unsorted to fairly well sorted clay, silt, sand, and gravel. This unit is very permeable but largely above the water table. Older alluvium consists of poorly sorted lenticular deposits of clay, silt, sand, and gravel, which may be loosely consolidated to cemented. Older alluvium is moderately to highly permeable and yields large quantities of water to wells. The unit is a major aquifer in the subbasin. Flood basin deposits are relatively impermeable silt and clay with some moderately to poorly permeable sand layers. This unit is not an important source of groundwater, but locally, may yield sufficient supplies for domestic and stock use. Lacustrine and marsh deposits are reduced deposits of silt, clay, and fine sand. In the subsurface, lacustrine clay interfingers with continental and alluvial deposits. The lacustrine and marsh deposits include the Corcoran Clay that underlies the sub basin at depths ranging between about 300 and 900 feet (DWR 1981). Continental deposits consist of poorly sorted lenticular deposits of clay, silt, sand, and gravel. These deposits are moderately to poorly permeable and yield low to large quantities of water to wells (DWR 2003).

Major Sources of Recharge

Groundwater recharge is primarily from percolation along stream channels and deep percolation of applied irrigation water. Natural recharge within the subbasin is estimated to be 89,200 acre-feet per year with recharge of applied water estimated to be 195,000 acre-feet per year. Annual urban and agricultural extractions are estimated at 24,000 and 648,000 acre-feet, respectively. (DWR 2003.)

Land Use

Land use within the approximate 524,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-117.

Table 4-117. Land Use in the Tulare Lake Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	35,500
Field Crops	214,000
Grain and Hay	64,000
Pasture	55,500
Truck, Nursery, and Berry Crops	16,000
Vineyards	5,000
Total	**390,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Tulare Lake Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water agencies in the Tulare Lake Groundwater Subbasin include: Alpaugh ID, Angiola WD, Atwell Island WD, Delano-Earlimart ID, Ducor ID, Kern-Tulare WD, Lower Tule River ID, Pixley ID, Porterville ID, Rag Gulch ID, Saucelito ID, Teapot Dome WD, Terra Bella ID, and Vandalia ID. California Water Service is the only identified private water agency within the subbasin.

The largest urban within the subbasin area is the City of Hanford with a population of approximately 46,350.

No known pertinent ordinances or regulations affect groundwater in the Tulare Lake Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that between 1986 and 2003, 229 wells were sampled for pesticide residues in Kings County. Four of those wells had verified detections and 6 of the wells had unverified detections of atrizine, diuron, and/or prometon (Schuette et al. 2003). DWR (2003) reported detection of pesticides at concentration greater than an applicable MCL in groundwater collected from 2 of 40 wells sampled.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater within the Tulare Lake Subbasin is generally a calcium bicarbonate type water in the northern portion that trends toward a sodium bicarbonate type water beneath Tulare Lakebed. Detected TDS concentrations typically range from 200 to 600 mg/L. TDS concentrations of shallow groundwater in areas of poor drainage are as high as 40,000 mg/L. CDPH reported that detected TDS concentrations in groundwater collected from 36 wells (subject to Title 22 water quality standards) ranged from 150 to 820 mg/L, with an average of 342 mg/L. The city of Hanford reported that EC values in groundwater from 14 wells ranged from 210 to 820 micromhos per centimeter (µmhos/cm), with an average value of 554 µmhos/cm. (DWR 2003.)

From 1994 to 2000, groundwater samples were collected from 38 wells within the subbasin for analysis of nitrates. Nitrates were not detected at a concentration above the MCL in any of the samples (DWR 2003).

There are areas of saline shallow groundwater in the southern portion of the subbasin and localized areas of high arsenic. The City of Hanford reported odors caused by the presence of hydrogen sulfide (DWR 2003).

Kaweah Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Kaweah Subbasin is within the Tulare Lake HR and comprises an area of approximately 446,000 acres (696 square miles) primarily in Tulare County with a small portion in Kings County (Figure 4-4). The Kaweah Subbasin is bounded on the north by the Kings Subbasin, on the south by the Tule Subbasin, and on the west by the Tulare Lake Subbasin, and on the east by crystalline bedrock of the Sierra Nevada foothills.

The Kaweah Subbasin aquifers are composed of unconsolidated sediments of Pliocene, Pleistocene, and Holocene age. On the east side of the subbasin, these deposits consist of arkosic material derived from the Sierra Nevada and are divided into three stratigraphic units: continental deposits, older alluvium, and younger alluvium. In the western portion of the subbasin unconsolidated deposits consisting of flood basin and lacustrine and marsh deposits interfinger with the eastside deposits.

The continental deposits of Pliocene and Pleistocene age are divided into oxidized and reduced deposits based on depositional environment. The oxidized deposits crop out along the eastern margin of the valley and consist of deeply weathered, poorly permeable, reddish-brown sandy silt and clay with well-developed soil profiles. The reduced deposits are moderately permeable and consist of micaceous sand, silt, and clay that extend to the west side of the valley in the subsurface.

Older alluvium, which overlies the continental deposits, is moderately to highly permeable and is the major aquifer in the subbasin. Younger alluvium consists of moderately to highly permeable arkosic sand and silty sand. Flood basin deposits consist of poorly permeable silt, clay, and fine sand. Groundwater in the flood basin deposits is often of poor quality. Lacustrine and marsh deposits consist of blue, green, or

gray silty clay and fine sand and underlie the flood basin deposits. Clay beds of the lacustrine and marsh deposits form aquitards that control the vertical and lateral movement of groundwater. The most prominent lacustrine deposit is the Corcoran Clay that underlies the western half of the Kaweah Subbasin at depths ranging from about 200 to 500 feet (DWR 1981). The Corcoran Clay separates the lower confined from the upper unconfined aquifers where present. In the eastern portion of the subbasin (areas where the Corcoran Clay is absent), groundwater occurs under unconfined and semi-confined conditions (DWR 2003).

Major Sources of Recharge

The primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada and percolation of applied irrigation water. Natural recharge is estimated to be 62,400 acre-feet per year. Lakeside Irrigation District has recharged about 7,000 acre-feet per year and in wet years may recharge up to 30,000 acre-feet. It is estimated that approximately 286,000 acre-feet of applied water is recharged annually in the subbasin. Annual urban and agricultural extraction is estimated to be 58,800 and 699,000 acre-feet, respectively. (DWR 2003.)

Groundwater flow is generally southwestward. Subsurface outflow may occur to the west and south towards the Tulare Lake Subbasin. DWR (2003) has not estimated the amount of inflow or outflow for the subbasin.

Land Use

Land use within the approximate 446,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-118.

Table 4-118. Land Use in the Kaweah Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	77,000
Deciduous Fruits and Nuts	60,000
Field Crops	160,000
Grain and Hay	19,000
Pasture	57,500
Truck, Nursery, and Berry Crops	6,500
Vineyards	13,000
Total	**393,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kaweah Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Kaweah Groundwater Subbasin include: Exeter ID, Ivanhoe ID, Kaweah-Delta WCD, Kings River Conservation District, Lakeside Irrigation Water District, Lindmore ID, Lindsay-Strathmore ID, St. Johns WD, Tulare ID, and Stone Corral WD. Private water entities within the subbasin include California Water Service, Melga Canal Company, Settlers Ditch Company, and Corcoran Irrigation Company.

Identified major urban areas are the City of Visalia with a population of approximately 92,500 and the City of Tulare with a population of approximately 49,500.

No known pertinent ordinances or regulations affect groundwater in the Kaweah Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, groundwater samples were collected from 1,547 wells in Tulare County and 229 wells in Kings County and analyzed for pesticide residues. Groundwater samples from 365 of the wells had verified detections of pesticides and groundwater samples from 256 of the wells had unverified detection of pesticides in Tulare County. In Kings County, verified detections of pesticides were reported in samples collected from 4 wells with unverified detections reported in samples collected from 6 wells. The detections in Tulare County were ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Detections in Tulare County included atrazine, diuron, and prometon (Schuette et al. 2003). DWR reported that from 1994 to 2000, groundwater samples were collected from 167 well regulated; by CDPH and analyzed for pesticides. Pesticides were detected at concentrations greater than applicable MCLs in 16 of the wells.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater in the Kaweah Subbasin is typically a calcium bicarbonate type water, with sodium-bicarbonate type water near the western margin of the subbasin. TDS ranges from 35 to 1,000 mg/L, with a typical range of 300 to 600 mg/L. The CDPH reported TDS concentrations in groundwater collected from 153 wellsranged from 35 to 580 mg/L, with an average concentration of 189 mg/L. (DWR 2003.)

DWR (2003) reports that there are localized areas of high nitrate concentrations in groundwater on the eastern side of the subbasin and an area of high salinity groundwater between Lindsay and Exeter.

Tule Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003). The Tule Subbasin is within the Tulare Lake HR and comprises an area of approximately 467,000 acres (733 square miles) in Tulare County (Figure 4-4). The subbasin is generally bordered on the north by the Kaweah Subbasin, on the south by the Kern Subbasin, on the west by the Tulare Lake Subbasin, and on the east by crystalline bedrock of the Sierra Nevada foothills.

The sediments that comprise the subbasin's aquifer are continental deposits of Tertiary and Quaternary age (Pliocene to Holocene). These deposits include flood basin deposits, younger alluvium, older alluvium, the Tulare Formation, and undifferentiated continental deposits. Flood basin deposits consist of relatively impermeable silt and clay interbedded with some moderately to poorly permeable sand layers that interfinger with the younger alluvium. These deposits are not an important source of water to wells, but may yield sufficient supplies for domestic and stock use. The younger alluvium consists of interstratified and discontinuous beds of unsorted to fairly well sorted clay, silt, sand, and gravel beneath the alluvial fans in the valley and stream channels. Where saturated, the younger alluvium is very permeable, but this unit is largely unsaturated and probably not important as a source of water. The older alluvium consists of poorly sorted deposits of clay, silt, sand, and gravel. This unit is moderately to highly permeable and is a major source of water to wells.

The Tulare Formation consists of poorly sorted deposits of clay, silt, sand, and gravel derived predominately from the Coast Ranges. It contains the Corcoran Clay Member, a major confining bed in the subbasin. The formation is moderately to highly permeable and yields moderate to large quantities of water to wells.

The undifferentiated continental deposits consist of poorly sorted lenticular deposits of clay, silt, sand, and gravel derived from the Sierra Nevada. The unit is moderately to highly permeable and is a major source of groundwater in the subbasin. (DWR 2003.)

Major Sources of Recharge

Groundwater recharge is primarily from stream recharge and from deep percolation of applied irrigation water (Hilton et al. 1963). The natural recharge into the subbasin is estimated at 34,400 acre-feet per year. Approximately 201,000 acre-feet of recharge from applied water occurs annually in the subbasin. Annual urban and agricultural extractions are estimated to be 19,300 and 641,000 acre-feet, respectively (DWR 2003). Groundwater flow is generally westward. Recharge to the confined aquifer below the Corcoran Clay occurs as subsurface flow from the east. (DWR 2003.)

Land Use

Land use within the approximate 467,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-119.

Table 4-119. Land Use in the Tule Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	36,500
Deciduous Fruits and Nuts	38,000
Field Crops	99,000
Grain and Hay	51,000
Pasture	60,500
Truck, Nursery, and Berry Crops	2,500
Vineyards	56,500
Total	**344,000**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Tule Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Tule Groundwater Sub basin include: Alpaugh ID, Angiloa WD, Atwell Island WD, Delano-Earlimart ID, Ducor ID, Kern-Tulare WD, Lower Tule River ID, Pixley ID, Porterville ID, Rag Gulch WD, Saucelito ID, Teapot Dome WD, Terra Bella ID, and Vandalia ID. California Water Service is the only identified private water entity within the subbasin.

The largest urban area in the subbasin is the City of Porterville with a population of approximately 44,500.

No known pertinent ordinances or regulations affect groundwater in the Tule Subbasin.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, that groundwater samples were collected from 1,547 wells in Tulare County for analysis of pesticide residues. Verified detections were reported in 365 of the wells sampled with unverified detections reported in samples from 256 of the wells. The detections included:

ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine (Schuette et al. 2003). DWR (2003) reported that from 1994 to 2000, groundwater samples were collected from 73 wells regulated by the CDPH. One of those wells contained groundwater with a verified pesticide concentration above an applicable MCL.

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the northern portion of the subbasin is a calcium-bicarbonate type water, while groundwater beneath the southern portion of the subbasin is typically a sodium-bicarbonate type water. Detected TDS concentrations typically range from 200 to 600 mg/L. TDS concentrations of shallow groundwater in areas of poor drainage can be as high as 30,000 mg/L. CDPH, which enforces` Title 22 water quality standards, reports TDS concentrations in groundwater (65 wells, sampled from 1994 to 2000) ranged from 20 to 490 mg/L, with an average concentration of 256 mg/L. Saline shallow groundwater occurs in the western portion of the subbasin (DWR 2003).

DWR (2003) reports that the eastern side of the subbasin has localized nitrate pollution. Six of 71 public supply wells sampled from 1994 and 2000, had nitrate levels exceeding the MCL (DWR 2003).

Kern County Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Kern County Subbasin is within the Tulare Lake HR and comprises an area of approximately 1,945,000 acres (3,040 square miles) in Kern County. The subbasin is bounded to the north by the Tulare Lake and Tule Subbasin, to the east and south by crystalline bedrock of the Sierra Nevada and San Emigdio Mountains, and to the west by the marine sediments of the San Emigdio Mountains and Coast Ranges.

The shallow to intermediate depth water-bearing units in the subbasin are primarily continental deposits of Tertiary and Quaternary age. From oldest to youngest the deposits include: the Olcese and Santa Margarita Formations, the Tulare Formation (western portion of the subbasin) and laterally equivalent Kern River Formation (eastern portion of the subbasin), older alluvium, and younger alluvium and laterally equivalent flood basin deposits (DWR 2003).

The origin of the Miocene Olcese and Santa Margarita Formations varies from continental to marine from east to west across the subbasin. The Olcese and Santa Margarita Formations are current sources of drinking water only in the northeastern portion of the sub basin where they occur as confined aquifers. The Olcese Formation is primarily sand, ranging in thickness from 100 to 450 feet. The Santa Margarita Formation is from 200 to 600 feet thick and consists of coarse-grained sand (DWR 2003).

The Tulare and Kern River Formations are both Plio-Pleistocene age and represent a west/east facies change across the subbasin. The Tulare Formation (western subbasin) contains up to 2,200 feet of interbedded, oxidized to reduced sands; gypsiferous clays and gravels derived primarily from Coast Range sources. The formation includes the Corcoran Clay, which is present in the subsurface from the Kern River Outlet Channel on the west through the central and much of the eastern subbasin at depths of 300 to 650 feet. Groundwater beneath the Corcoran Clay is confined. The Kern River Formation includes from 500 to 2,000 feet of poorly sorted, lenticular deposits of clay, silt, sand, and gravel derived from the Sierra Nevada. Both units are moderately to highly permeable and yield moderate to large quantities of water to wells (DWR 2003).

The older alluvium and Terrace Deposits are composed of up to 250 feet of Pleistocene-age lenticular deposits of clay, silt, sand, and gravel that are loosely consolidated to cemented and are exposed mainly at the subbasin margins. The unit is moderately to highly permeable and yields large quantities of water to wells. This sedimentary unit is often indistinguishable from the Tulare and Kern River Formations below and together with these underlying formations, forms the principal aquifer in the Kern County Subbasin (DWR 2003).

The Holocene-age younger alluvium and flood basin deposits vary in character and thickness in the subbasin. Along the eastern and southern subbasin margins, the unit consists of up to 150 feet of interstratified and discontinuous beds of clay, silt, sand, and gravel. In the southwestern portion of the subbasin the unit is finer grained and less permeable as it grades into fine-grained flood basin deposits underlying the historic lakebeds of Buena Vista and Kern Lakes in the southern portion of the subbasin. The flood basin deposits consist of silt, silty clay, sandy clay, and clay interbedded with poorly permeable sand layers. These flood basin deposits are difficult to distinguish from underlying fine-grained older alluvium and the total thickness of both units may be as much as 1,000 feet (DWR 2003).

Faults that affect groundwater movement include the Edison, Pond-Poso, and White Wolf faults. Other barriers to groundwater movement include anticlinal folds such as Elk Hills and Buena Vista Hills, angular unconformities, and contacts with crystalline and consolidated sedimentary rocks at the subbasin margins. The Corcoran Clay significantly impedes vertical groundwater movement where present (DWR 2003).

Major Sources of Recharge

Applied irrigation water is the largest source of recharge in the subbasin with natural recharge occurring primarily from stream seepage along the eastern margin of the subbasin and the Kern River (DWR 2003).

Water banking was initiated in the subbasin in 1978, and as of 2000, seven projects contain over 3 maf of banked water in a combined potential storage volume of 3.9 maf (KCWA 2001). Approximately two-thirds of this storage is in the Kern River Fan area west of Bakersfield with the remainder in the Arvin-Edison WSD in the southeastern portion of the subbasin and in the Semitropic WSD in the northwestern part of the subbasin.

Land Use

Land use within the approximately 1,945,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-120.

Table 4-120. Land Use in the Kern County Subbasin

Land Use	Approximate Acreage
Agriculture	
Citrus and Subtropical	56,000
Deciduous Fruits and Nuts	198,500
Field Crops	350,500
Grain and Hay	130,500
Pasture	125,000
Truck, Nursery, and Berry Crops	91,500
Vineyards	115,500
Total	**1,067,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

The only identified water quality coalition within the Kern Subbasin is the South San Joaquin Valley Water Quality Coalition.

Public water entities within the Kern County Groundwater Subbasin include: Kern County Water Agency, City of Bakersfield, West Kern Water Agency, and the Buena Vista Water agency. Private water entities within the subbasin include: California Water Service Company, McFarland Mutual Water Company, Stockdale Mutual Water Company, and numerous small community groups.

The City of Bakersfield is the only identified major urban area within the subbasin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a Conditional Use Permit (CUP) by Kern County to transport native groundwater outside of Kern County and its watersheds, including those through joint water conveyance facilities and sales to owners of water conveyance facilities. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR reports that from 1986 to 2003, groundwater samples were collected from 1,341 wells in Kern County for analysis of pesticide residues. Verified detections were reported in 22 of the wells sampled; however there were 206 unverified detections. The verified detections included ACET, atrizine, bromacil, DACT, DEA, diuron, and simazine (Schuette et al. 2003). From 1994 to 2000, 436 groundwater samples were collected from wells regulated by CDPH in Kern County. Analysis of groundwater from 23 of the wells detected at least one pesticide at a concentration greater than an applicable MCL (DWR 2003).

Various detections of selected compounds such as DBCP, xylenes, and ethyl dibromide were assumed the result of legal agricultural use prior to the Pesticide Contamination Prevention Act and therefore were not reviewed by the DPR.

Inorganic Constituents

Groundwater beneath the eastern portion of the Kern Subbasin contains primarily calcium bicarbonate type water in the shallow zones with the sodium content increasing with depth. In western parts of the subbasin bicarbonate is replaced by sulfate and lesser chloride. The average TDS concentration of groundwater is 400 to 450 mg/L with a range of 150 to 5,000 mg/L (DWR 2003).

Shallow groundwater near the trough of the valley has high TDS, sodium, chloride, and sulfate concentrations. Elevated arsenic concentrations exist in some areas associated with lakebed deposits. Nitrate, DBCP, and ethyl dibromide have been detected at concentrations exceeding MCLs in various areas of the basin. Groundwater samples for analysis of nitrates were collected between 1994 and 2000 from 475 wells in Kern County. Nitrates were detected at concentrations greater than the MCL in groundwater from 38 of the wells (DWR 2003).

Pleasant Valley Subbasin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The following description of the hydrogeology in the subbasin is taken from DWR Bulletin 118 (2003).The Pleasant Valley Groundwater Subbasin is within the Tulare Lake HR and comprises an area of approximately 146,000 acres (227 square miles) in the western portion of Kings and Fresno Counties (Figure 4-4). The subbasin lies on the western edge of the San Joaquin Valley and is mostly surrounded by uplifted areas of the Coast Ranges and Kettleman Hills. The subbasin is bounded by the Westside Subbasin to the northeast, Tulare Lake Subbasin to the east, and Kern County Subbasin to the south.

Water-bearing units within the subbasin include Holocene alluvium, the Plio-Pleistocene Tulare Formation, and the Pliocene San Joaquin Formation. Holocene alluvium consists of lenticular deposits of poorly sorted clay, silt, and sand. It is believed that the thickness of this unit does not exceed 300 feet (DWR 2003).

The Plio-Pleistocene Tulare Formation unconformably underlies Holocene alluvium. The Tulare Formation comprises the youngest folded sediments exposed in the Kettleman Hills. In the Kettleman Hills, where the unit is exposed, it consists primarily of continental deposits of sandstone and conglomerate. DWR (2003) reports that the Tulare Formation in the subbasin consists of highly lenticular deposits of poorly sorted clay, silt, and sand with occasional interbeds of well-sorted fine- to medium-grained sand.

The Pliocene San Joaquin Formation consists of alternating beds of clay, silt, sand, and conglomerate. The sand and conglomerate beds contain fossils indicative of deposition in marine to non-marine conditions.

Major Sources of Recharge

Groundwater recharge is primary from seepage from the various streams that cross the subbasin. The cities of Coalinga, in the northern portion of the subbasin, and Avenal, near the center import water for municipal purposes. The state prisons near Coalinga and Avenal also use imported water. Additional recharge may occur because of this water use. It is estimated that approximately 4,000 acre-feet per year of applied water is recharged within the subbasin (DWR 2003). No data were found concerning the amount of natural recharge within the subbasin.

Land Use

Land use within the approximately 146,000-acre subbasin is primarily agricultural (Figure 4-6). Primary crops grown and approximate acreages within the subbasin, as identified by the land use maps, are listed in Table 4-121.

Table 4-121. Land Use in the Pleasant Valley Subbasin

Land Use	Approximate Acreage
Agriculture	
Deciduous Fruits and Nuts	2,000
Field Crops	14,500
Grain and Hay	30,500
Pasture	5,000
Truck, Nursery, and Berry Crops	10,500
Total	**62,500**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no known water quality coalitions operating within the Pleasant Valley Subbasin.

Public water entities within the Pleasant Valley Groundwater Subbasin include: Pleasant Valley WD, City of Coalinga, Devil's Den WD, and Green Valley WD. There are no identified private water entities within the subbasin.

The largest developed area in the subbasin is Coalinga with a population of approximately 17,000.

Fresno County has a Groundwater Management Ordinance restricting the extraction and transfer of groundwater outside of the County.

A County-issued permit is required for groundwater transfer, directly or indirectly, outside of the County, unless the action is exempted or a permit first obtained.

No known pertinent groundwater ordinances have been adopted by Kings County.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

The DPR (Schuette et al. 2003) reported that between 1986 and 2003, 4,032 wells were sampled for pesticide residues in Fresno County and 229 wells in Kings County. Fresno County had 224 wells with verified detections and 369 wells with unverified detections while Kings County reported 4 wells with verified detections and 6 wells with unverified detections. Groundwater detections in Fresno County included: ACET, atrizine, bromacil, DACT, DEA, diuron, norflurazon, prometon, and simazine. Groundwater detections in Kings County included: atrizine, diuron, and prometon.

Inorganic Constituents

TDS concentrations of groundwater in Pleasant Valley WD ranged from 1,000 to 3,000 mg/L with an average of 1,500 mg/L. The constituents in groundwater include calcium, magnesium, sodium, bicarbonates, chlorides, sulfates, and boron. The high TDS concentrations limit the usability of groundwater in the subbasin for most uses (DWR 2003).

SMALL GROUNDWATER BASINS

Panoche Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Panoche Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 33,184 acres (52 square miles), in San Benito County (Figure 4-4). Panoche Valley is an elongate northwest-southeast trending basin in the Coast Range Mountains.

No specific published information on the water-bearing units of the basin was identified. Limited well log information indicates that drilling in the basin has encountered gravels, sands, silts, and clays. These deposits are believed to be recent alluvium, Quaternary nonmarine terrace deposits, and Plio-Pleistocene nonmarine sediments (DWR 2003).

Major Sources of Recharge

Information regarding recharge of groundwater was not identified. However, groundwater levels have generally risen over 40 feet throughout the basin since the 1970s. The rise in water levels is believed to be due to recovery from past periods of pumping for agricultural uses (DWR 2003). Groundwater recharge in the basin probably occurs from percolation of precipitation and infiltration from ephemeral streams in the area.

Land Uses

Land use within the approximately 33,084-acre basin is shown on Figure 4-6. According to land use data, approximately 44 acres are planted with deciduous fruits and nuts with an additional 62 acres being used for activities that are semiagricultural or incidental to agriculture (Table 4-122). Extensive areas of alfalfa and cotton were cultivated in the 1950s and 1960s however, reconnaissance of the basin in 2001 identified one vineyard of less than 20 acres and one walnut orchard of less than 20 acres as the only irrigated agriculture within the basin (DWR 2003).

Table 4-122. Land Use in the Panoche Valley Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	44	0.13
Grain and Hay	7,948	24.02
Vineyards	27	0.08
Truck, Nursery, and Berry Crops	9	0.03
Semiagricultural and Incidental	62	0.19
Subtotal	8,090	24.45
Native		
Native Vegetation	24,994	75.55
Subtotal	24,994	75.55
Total	**33,084**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or public water entities in the Panoche Valley Groundwater Basin. There are no major urban areas in the basin.

No ordinances or regulations regarding groundwater were identified in San Benito County.

Water Quality

Data were available for groundwater samples collected from 26 wells between 1954 and 1988. TDS values for these samples ranged from 394 to 3,530 mg/L (DWR 2003). No analytical data for analysis of pesticides or nitrates in groundwater were identified.

Kern River Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Kern River Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 79,432 acres (124 square miles) in Kern County (Figure 4-4). The basin is irregularly shaped reflecting the shape of the Kern River drainage in the southern Sierra Nevada.

Water-bearing units in the basin consist primarily of recent alluvium and to a lesser extent older alluvium. The alluvium is derived from surrounding granitic and metamorphic rocks. The highest producing wells are located near the valley axis and near Lake Isabella (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation along the valley margins and infiltration from flow in the north and south forks of the Kern River and their tributaries (DWR 2003).

Land Uses

Land use within the approximately 79,432-acre basin is shown on Figure 4-6. According to land use data, approximately 4,549 acres are agricultural with about 97 acres in semiagricultural or incidental to agriculture land uses (Table 4-123).

Table 4-123. Land Use in the Kern River Valley Groundwater Basin

DWR Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	7	0.01
Grain and Hay	777	0.98
Pasture	2,931	3.69
Truck, Nursery, and Berry Crops	693	0.87
Idle	44	0.06
Semiagricultural and Incidental	97	0.12
Subtotal	4,549	5.73
Urban		
Urban—unclassified	2,256	2.84
Urban Landscape	75	0.09
Urban Residential	2,342	2.95
Commercial	137	0.17
Industrial	57	0.07
Vacant	122	0.15
Subtotal	4,988	6.28
Native		
Native Vegetation	33,939	42.73
Riparian	3,008	3.79
Water	10,644	13.40
Subtotal	47,591	59.91
FRAP Land Use Type		
Barren	78	0.10
Conifer	247	0.31
Hardwood	1,770	2.23
Herbaceous	2,205	2.78
Shrub	7,527	9.48
Urban	375	0.47
Desert	10,103	12.72
Subtotal	22,304	28.08

DWR Land Use	Acreage of Land Use	Percent of Land Use
Total	**79,432**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Kern River Valley Groundwater Basin. There are no identified public water entities in the basin and private water entities include Kern River Valley Water Company, Erskine Creek Water Company, James Water System, and Mountain Mesa Water Company. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds, including those through joint water conveyance facilities and sales to owners of water conveyance facilities. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 58 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Based on samples from 11 wells, TDS values range from 253 to 480 mg/L with an average of 378 mg/L. Iron and manganese have been detected at concentrations above applicable secondary MCLs in samples collected from wells along the Kern Canyon Fault. Nitrates were detected at concentration exceeding the MCL in samples collected from 5 of 76 wells sampled from 1994 to 2000 (DWR 2003).

Walker Basin Creek Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Walker Basin Creek Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 7,644 acres (12 square miles), in Kern County (Figure 4-4). The basin is a shallow alluvial basin in the southern Sierra Nevada.

The basin fill consists of alluvial sediments up to 150 feet thick with an average thickness of approximately 70 feet. A limited number of well logs in the basin identify decomposed granitic rock, sand, clay, and minor gravel (DWR 2003).

Major Sources of Recharge

Groundwater recharge appears to occur by percolation of precipitation and infiltration from ephemeral and spring-fed perennial streams entering the basin (DWR 2003).

Land Uses

Land use within the approximately 7,644-acre basin is shown on Figure 4-6. According to land use data, approximately 1,347 acres are agricultural with another 17 acres in uses that are semiagricultural or incidental to agriculture (Table 4-124).

Table 4-124. Land Use in the Walker Basin Creek Valley Groundwater Basin

Land Use	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	39	0.51
Field Crops	111	1.46
Grain and Hay	214	2.80
Pasture	799	10.45
Truck, Nursery, and Berry Crops	168	2.19
Semiagricultural and Incidental	17	0.22
Subtotal	1,347	17.62
Urban		
Urban Residential	381	4.98
Subtotal	381	4.98
Native		
Native Vegetation	5,917	77.40
Water	23	0.30
Subtotal	5,917	77.40
Total	**7,644**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations,

There are no identified water quality coalitions, public water entities, or private water entities in the Walker Basin Creek Valley Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

No data were identified describing groundwater quality in the basin.

Cummings Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cummings Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 10,019 acres (16 square miles), in Kern County (Figure 4-4). The basin is bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains. Ridges on the east and west side of the basin connect the mountain ranges.

Water-bearing units in the basin consist of alluvium deposited in alluvial fans and on floodplains. The alluvial deposits are up to 450 feet thick with sands and gravels on the edge of the basin becoming finer grained towards the center of the basin (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from ephemeral streams along the margins of the basin. Thick clays in the center of the basin restrict infiltration on the valley floor (DWR 2003).

Land Uses

Land use within the approximately 10,019-acre basin is shown on Figure 4-6. According to land use data, approximately 2,667 acres are agricultural with about 119 acres in uses that are semiagricultural or incidental to agriculture (Table 4-125).

Table 4-125. Land Use in the Cummings Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	93	0.92
Grain and Hay Crops	334	3.33
Field Crops	508	5.07
Pasture	1,165	11.63
Semiagricultural and Incidental	119	1.19

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Truck, Nursery, and Berry Crops	448	4.48
Subtotal	2,667	26.62
Urban		
Urban—unclassified	25	0.25
Urban Residential	723	7.22
Commercial	214	2.13
Industrial	8	0.08
Vacant	4	0.04
Subtotal	974	9.72
Native		
Native Vegetation	6,333	63.21
Water Surface	46	0.46
Subtotal	6,379	63.66
Total	**10,019**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Cummings Valley Groundwater Basin. The groundwater basin is adjudicated and the Tehachapi-Cummings County Water District (TCCWD) is the watermaster. The only identified public water entity is the TCCWD with private water entities including the Stallion Springs Community Services District and the Bear Valley Community Services District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 15 wells in the basin from 1994 to 2000 for analysis of pesticides. There was one detection of a pesticide at a concentration above an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater in the basin is primarily a calcium-bicarbonate type with an average TDS of 344 mg/L. Analysis of groundwater samples collected from 15 wells from 1994 to 2000 did not detect nitrates at a concentration exceeding the MCL (DWR 2003).

Tehachapi Valley West Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Tehachapi Valley West Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 14,908 acres (23 square miles), in Kern County (Figure 4-4). The basin lies in the western half of Tehachapi Valley and is bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains.

Quaternary alluvium, up to 600 feet thick, is the primary water-bearing unit in the basin (DWR 2003). Lithologic descriptions of the Quaternary alluvium were not available.

Major Sources of Recharge

Groundwater recharge in the basin consists of percolation of stream flow within the basin and to a lesser extent percolation of precipitation (DWR 2003).

Land Uses

Land use within the approximately 14,908-acre basin is shown on Figure 4-6. According to land use data, approximately 1,143 acres are used for agricultural activities with about 36 acres in uses semiagricultural or incidental to agriculture (Table 4-126).

Table 4-126. Land Use in the Tehachapi Valley West Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	322	2.16
Grain and Hay Crops	403	2.70
Pasture	45	0.30
Field Crops	284	1.90
Semiagricultural and Incidental	36	0.24
Truck, Nursery, and Berry Crops	52	0.35
Subtotal	1,143	7.66
Urban		
Urban—unclassified	1,040	6.97

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Urban Residential	3,071	20.60
Urban Landscape	52	0.35
Vacant	212	1.42
Subtotal	4,375	29.35
Native		
Native Vegetation	9,194	61.67
Water Surface	92	0.62
Subtotal	9,286	62.29
Total	**14,908**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Tehachapi Valley West Groundwater Basin. The Tehachapi Valley West Groundwater Basin is an adjudicated basin. The TCCWD is the watermaster. Identified public water entities within the basin include TCCWD, City of Tehachapi, and Golden Hills Community Services District. The only identified private water entity in the basin is the Ashtown Mutual Water System. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 23 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Based on data from 3 wells, TDS values ranged from 280 to 365 mg/L. Groundwater samples were collected from 30 wells in the basin from 1994 to 2000 for analysis of nitrates. Nitrates were detected at concentrations exceeding the MCL in samples collected from two of the wells (DWR 2003).

Castaic Lake Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Castaic Lake Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,566 acres (6 square miles), in Kern County (Figure 4-4). Castaic Lake Valley is a "Y" shaped basin formed by the Garlock Fault and Grapevine Creek in the Tehachapi Mountains. Castaic Lake is a sag pond along the Garlock Fault (DWR 2003).

No data were found describing the water-bearing materials in the basin. Castaic Lake is a Quaternary playa where deposits typically consist of silts and clays that yield little water (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Cuddy Creek and other ephemeral and spring-fed perennial streams that flow into the basin (DWR 2003).

Land Uses

Land use within the approximately 3,566-acre basin is shown on Figure 4-6. According to land use data, approximately 232 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-127).

Table 4-127. Land Use in the Castaic Lake Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Urban		
Urban—unclassified	47	1.30
Vacant	2	0.07
Subtotal	49	1.37
Native		
Native Vegetation	60	1.68
Subtotal	60	1.68
FRAP Land Use Type		
Barren	26	0.72
Conifer	30	0.84
Hardwood	664	18.62
Herbaceous	1,012	28.38
Shrub	363	10.18
Urban	568	15.93
Pasture	232	6.51
Water	312	8.75

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Wetland	206	5.78
Desert	44	1.23
Subtotal	3,457	96.95
Total	**3,566**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or private water entities in the Castaic Lake Valley Groundwater Basin. The only identified public water entities within the basin are the Tejon-Castaic Water District and Lebec County Water District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 6 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Measured TDS values for samples collected from three wells ranged from 570 to 605 mg/L. Groundwater samples were collected from 8 wells in the basin from 1994 to 2000 for nitrate analyses. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed. The only reported impairment to water quality was a detection of fluoride above the MCL in one well (DWR 2003).

Vallecitos Creek Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Vallecitos Creek Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 15,107 acres (24 square miles), in San Benito County (Figure 4-4). The basin is a northwest-southeast trending synclinal valley within the Coast Range Mountains.

Very limited information was identified regarding the water-bearing units in the basin. The valley reportedly contains Quaternary alluvium surrounded by Plio-Pleistocene nonmarine sediments and Miocene to Paleocene marine sediments. It is likely that water-bearing materials are restricted to shallow alluvium in the center of the valley (DWR 2003).

Major Sources of Recharge

Information regarding recharge of groundwater was not identified. Groundwater recharge in the basin probably occurs from percolation of precipitation and infiltration from ephemeral streams in the area.

Land Uses

Land use within the approximately 15,107-acre basin is shown on Figure 4-6. According to land use data, there are no agricultural land uses in the basin (Table 4-128).

Table 4-128. Land Use in the Vallecitos Creek Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Native		
Native Vegetation	15,107	100
Total	**15,107**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or water entities in the Vallecitos Creek Valley Groundwater Basin. There are no major urban areas in the basin.

No ordinances or regulations regarding groundwater were identified in San Benito County.

Water Quality

No water quality data were identified within the basin.

Brite Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Brite Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,170 acres (5 square miles), in Kern County (Figure 4-4). The basin is a northwest to southeast trending valley bounded on the north by the Sierra Nevada and on the south by the Tehachapi Mountains. The basin is separated from Cummings Valley Groundwater Basin to the west and Tehachapi Valley West Groundwater Basin to the east by low lying ridges.

The primary water-bearing unit in the basin is alluvium deposited in alluvial fans on the edges of the valley and on floodplains in the center of the valley. The alluvium has a maximum thickness of approximately 500 feet (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Brite Creek and other ephemeral streams in the valley. The TCCWD owns and operates a storage and recharge facility for water received from the State Project Water (DWR 2003).

Land Uses

Land use within the approximately 3,170-acre basin is shown on Figure 4-6. According to land use data, approximately 282 acres in the basin are used for agricultural purposes with another 26 acres in uses semiagricultural or incidental to agriculture (Table 4-129).

Table 4-129. Land Use in the Brite Valley Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Deciduous Fruits and Nuts	174	5.49
Grain and Hay Crops	69	2.17
Pasture	19	0.60
Vineyards	5	0.17
Semiagricultural and Incidental	26	0.82
Truck, Nursery, and Berry Crops	14	0.46
Subtotal	308	9.70
Urban		
Urban Residential	132	4.18
Commercial	72	2.27
Subtotal	205	6.45
Native		
Native Vegetation	2,610	82.32

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Water Surface	48	1.53
Subtotal	2,658	83.84
Total	**3,170**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Brite Valley Groundwater Basin. Brite Valley Groundwater Basin is an adjudicated basin. The TCCWD is the watermaster. The only identified water entity within the basin is the TCCWD. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Groundwater within the basin appears to be a calcium-bicarbonate type water with an electrical conductivity ranging from 550 to 770 micromohs per centimeter (DWR 2003). No groundwater analytical data for pesticides or nitrates were identified from within the Brite Valley Groundwater Basin.

Cuddy Canyon Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Canyon Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,299 acres (5 square miles), in Kern County (Figure 4-4). The basin is within the San Emigdio Mountains in a series of valleys formed along the San Andreas Fault.

Water-bearing units in the basin consist of recent and older alluvium deposited in the Cuddy Creek drainage. These deposits consist of poorly sorted silty sand and gravel (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and infiltration from flow in Cuddy Creek and other ephemeral streams in the valley (DWR 2003).

Land Uses

Land use within the approximately 3,299-acre basin is shown on Figure 4-6. According to land use data, approximately 7 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-130).

Table 4-130. Land Use in the Cuddy Canyon Valley Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture	7.413	0.22
Barren	270	8.17
Conifer	427	12.94
Hardwood	51	1.54
Herbaceous	379.2	11.49
Shrub	1,564	47.39
Urban	602	18.24
Desert	0.091	0.003
Total	**3,299**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions in the Cuddy Canyon Valley Groundwater Basin. The only identified public entity within the basin is the Frazier Park Public Utility District. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watershedsFour exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater quality in the basin has not been characterized by DWR. Measured TDS values for samples collected from two wells ranged from 690 to 695 mg/L. Groundwater samples were collected from 5 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed. The only identified detections above an applicable MCL in the basin include fluoride and radiological constituents (DWR 2003).

Cuddy Ranch Area Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Ranch Area Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 4,186 acres (7 square miles), in Kern County (Figure 4-4). The basin is within the San Emigdio Mountains in a series of valleys formed along the San Andreas Fault.

Deposits in the basin include sandstone, conglomerate, siltstone, and claystone on the Tertiary Caliente Formation. The Tertiary deposits are overlain by Pleistocene and recent alluvium composed of unconsolidated gravels, sands, and silts. Abundant clays in the south end of the basin suggest the presence of lacustrine and/or marsh deposits that may indicate the basin was recently closed (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to occur by percolation of precipitation and infiltration from ephemeral streams in the area (DWR 2003).

Land Uses

Land use within the approximately 4,186-acre basin is shown on Figure 4-6. According to land use data, approximately 290 acres are used as pasture with no other identified agricultural uses in the basin (Table 4-131).

Table 4-131. Land Use in the Cuddy Ranch Area Groundwater Basin

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Agriculture		
Pasture	290	6.92
Subtotal	290	6.92
Urban		
Urban—unclassified	17	0.41
Subtotal	17	0.41
Native		
Native Vegetation	3,262	77.93

DWR Land Use Type	Acreage of Land Use	Percent of Land Use
Subtotal	3,262	77.93
FRAP Land Use Type		
Conifer	267	6.37
Herbaceous	30	0.72
Shrub	102	2.44
Urban	218	5.21
Subtotal	617	14.73
Total	**4,186**	**100**

Coalitions, Water Districts, Major Urban Areas — Pertinent Ordinances or Regulations

There are no identified water quality coalitions, public water entities, or private water entities in the Cuddy Ranch Area Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

The measured TDS of groundwater in the basin ranges from 690 to 695 mg/L. Groundwater samples were collected from 6 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).

Cuddy Valley Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Cuddy Valley Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 3,465 acres (5 square miles), in Kern County (Figure 4-4). The valley is an elongate east-west trending valley in the San Emigdio Mountains.

Water-bearing units in the basin consist of older alluvial and terrace deposits and younger alluvium. These deposits have a maximum thickness of approximately 450 feet and are underlain by crystalline bedrock or undifferentiated Tertiary sediments (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to occur primarily by percolation of precipitation. Recharge from septic systems in the Pinion Pines and Pineridge developments supplements the natural recharge (DWR 2003).

Land Uses

Land use within the approximately 3,465-acre basin is shown on Figure 4-6. According to land use data, there are no identified agricultural uses in the basin (Table 4-132).

Table 4-132. Land Use in the Cuddy Valley Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Conifer	1,615	46.62
Hardwood	10.3	0.30
Herbaceous	917	26.46
Shrub	714	20.61
Urban	199	5.73
Water	9.9	0.29
Total	**3,465**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions, public water entities, or private water entities in the Cuddy Valley Groundwater Basin. There are no major urban areas in the basin.

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

Water quality relating to pesticides and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 5 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Groundwater quality in the basin has not been characterized by DWR. TDS values in the basin range from 325 to 645 mg/L (DWR 2004). Groundwater quality appears to be better in the western portion of the basin with high levels of iron and manganese in samples collected from wells in the eastern portion of the basin. Groundwater samples were collected from 10 wells in the basin for nitrate analyses from 1994 to 2000. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).

Mil Portero Area Groundwater Basin

General Basin Parameters

Acreage, Physiography, and Water-Bearing Units

The Mil Portero Groundwater Basin is within the Tulare Lake HR and comprises an area of approximately 2,309 acres (4 square miles), in Kern County (Figure 4-4). The basin is irregularly shaped and within the San Emigdio Mountains.

The basin consists of stream-derived alluvium and mudflow debris with a maximum thickness estimated at 400 feet. This material is underlain by the Tertiary Caliente Formation that is composed of sandstone, conglomerate, siltstone, and claystone (DWR 2003).

Major Sources of Recharge

Groundwater recharge in the basin appears to be percolation of precipitation and springs emanating from canyon walls on the south side of the basin. Natural recharge is supplemented by over 1,900 septic systems in the basin (DWR 2003).

Land Uses

Land use within the approximately 2,309-acre basin is shown on Figure 4-6. According to land use data, there are no agricultural land uses within the basin (Table 4-133).

Table 4-133. Land Use in the Mil Portero Area Groundwater Basin

FRAP Land Use Type	Acreage of Land Use	Percent of Land Use
Conifer	1,325	57.37
Herbaceous	61	2.65
Shrub	98	4.26
Urban	825	35.72
Total	**2,309**	**100**

Coalitions, Water Districts, Major Urban Areas—Pertinent Ordinances or Regulations

There are no identified water quality coalitions or public water entities in the Mil Portero Groundwater Basin. The only identified private water entity within the basin is the Mil Portero Mutual Water Company. There are no major urban areas in the basin.

Pertinent Ordinances or Regulations

Kern County has adopted Ordinance number G-6502 requiring the issuance of a CUP by Kern County to transport native groundwater outside of Kern County and its watersheds. Four exemptions apply where a CUP is not required provided conditions of the Ordinance Code of Kern County are met.

Water Quality

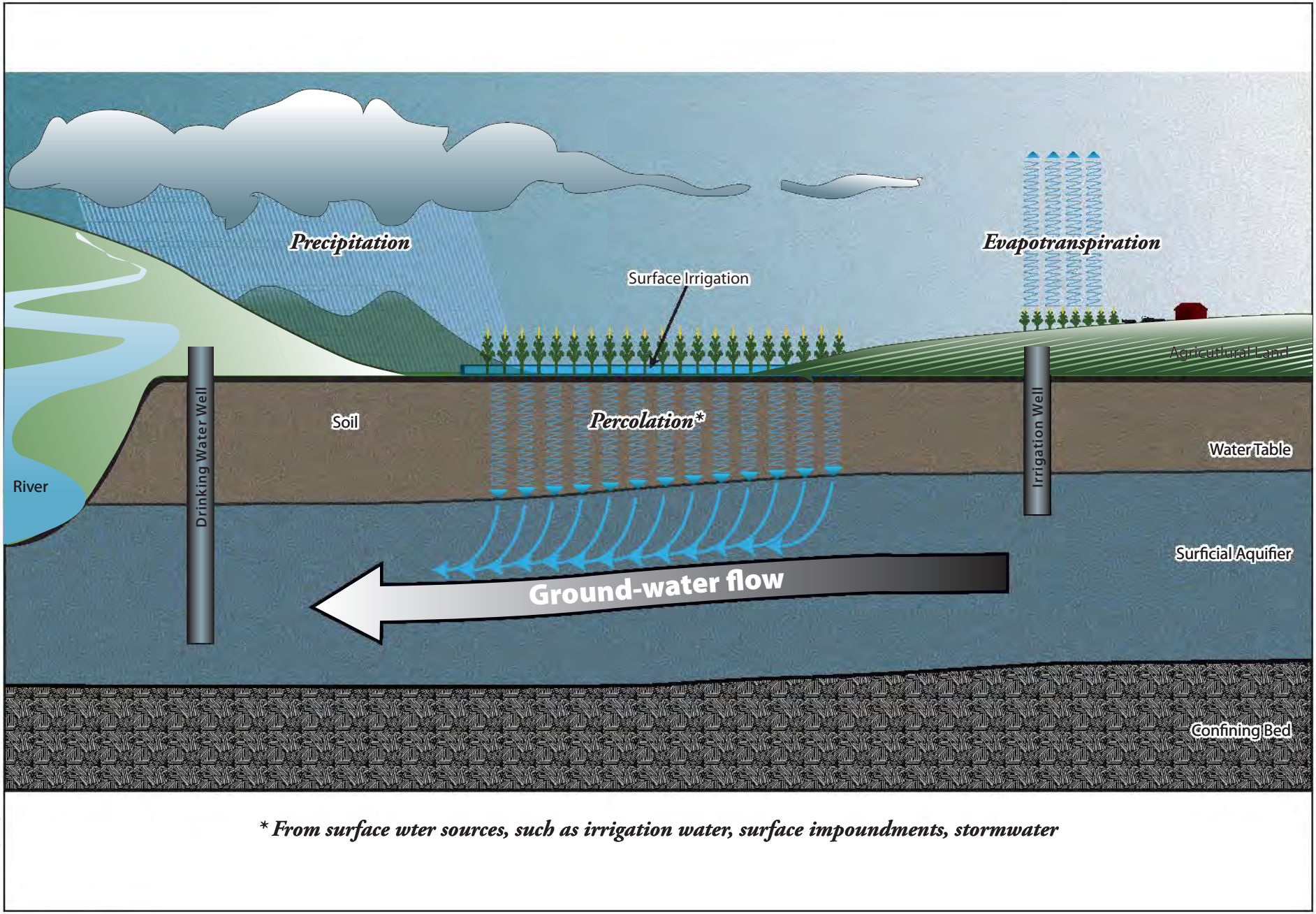
Water quality relating to pesticide and inorganic constituents is discussed below.

Pesticides

Groundwater samples were collected from 6 wells in the basin from 1994 to 2000 for analysis of pesticides. Pesticides were not detected at a concentration that exceeded an applicable MCL in the samples analyzed (DWR 2003).

Inorganic Constituents

Measured TDS values for samples collected from wells in the basin range from 372 to 657 mg/L. Secondary water standards for aluminum, iron, and manganese are exceeded in the water supply of the Mil Portero Mutual Water Company. Groundwater samples were collected from 7 wells for nitrate analyses in the basin. Nitrates were not detected at a concentration exceeding the MCL in the samples analyzed (DWR 2003).

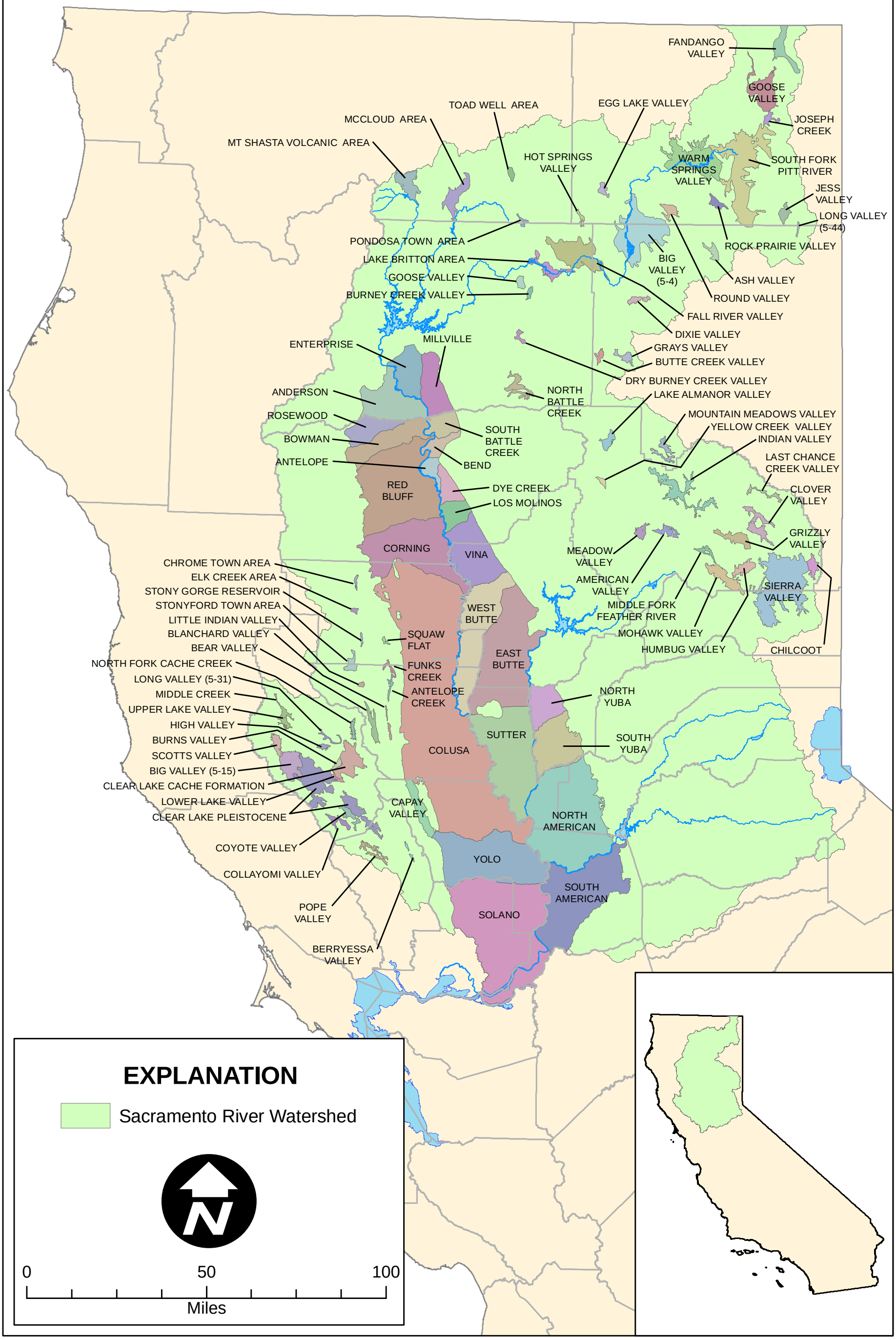


** From surface wter sources, such as irrigation water, surface impoundments, stormwater*

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an ICF International Company

Figure 4-1
Conceptual Groundwater Model



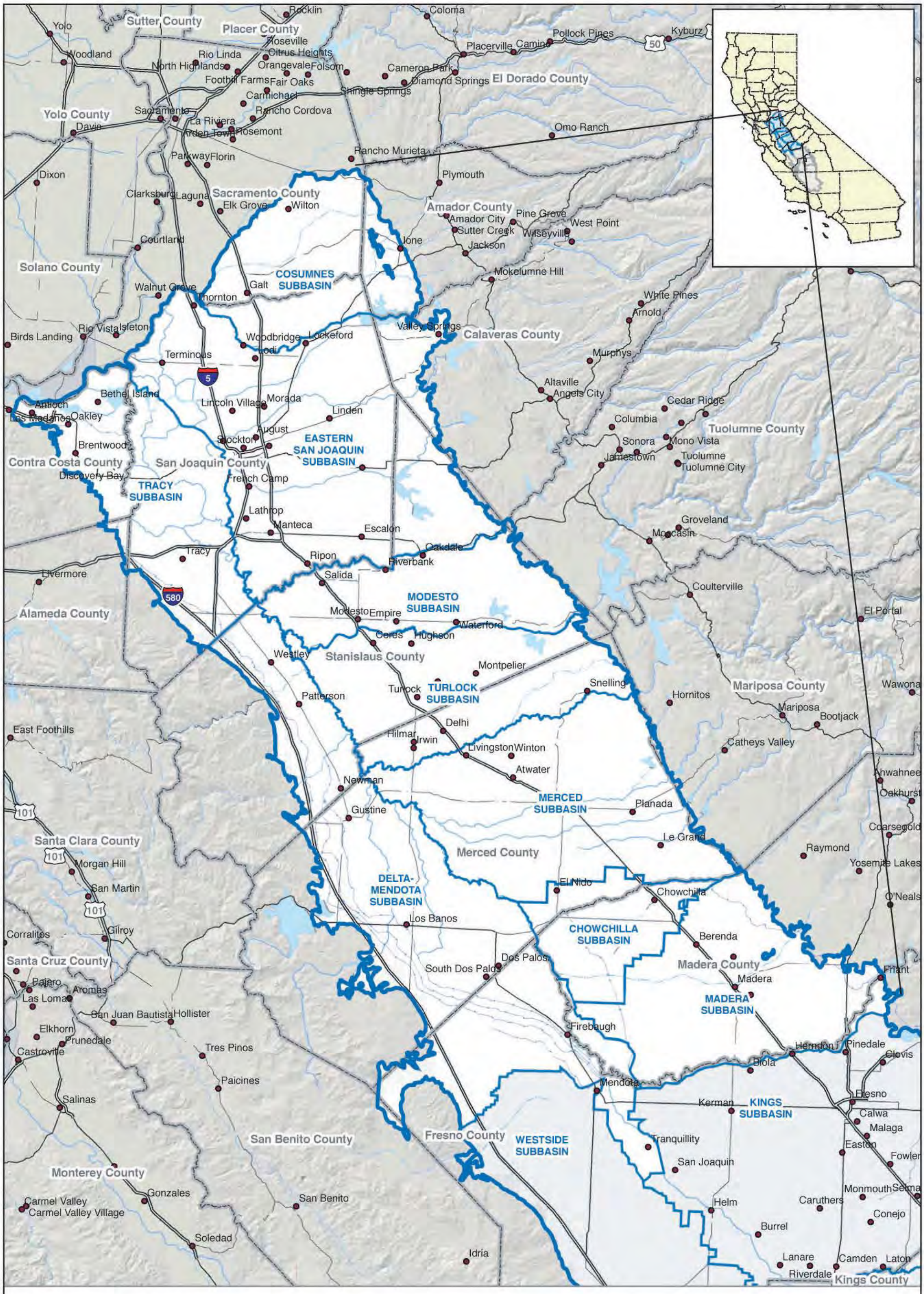
HYDROFOCUS INC.
Solutions for Land and Water Resources

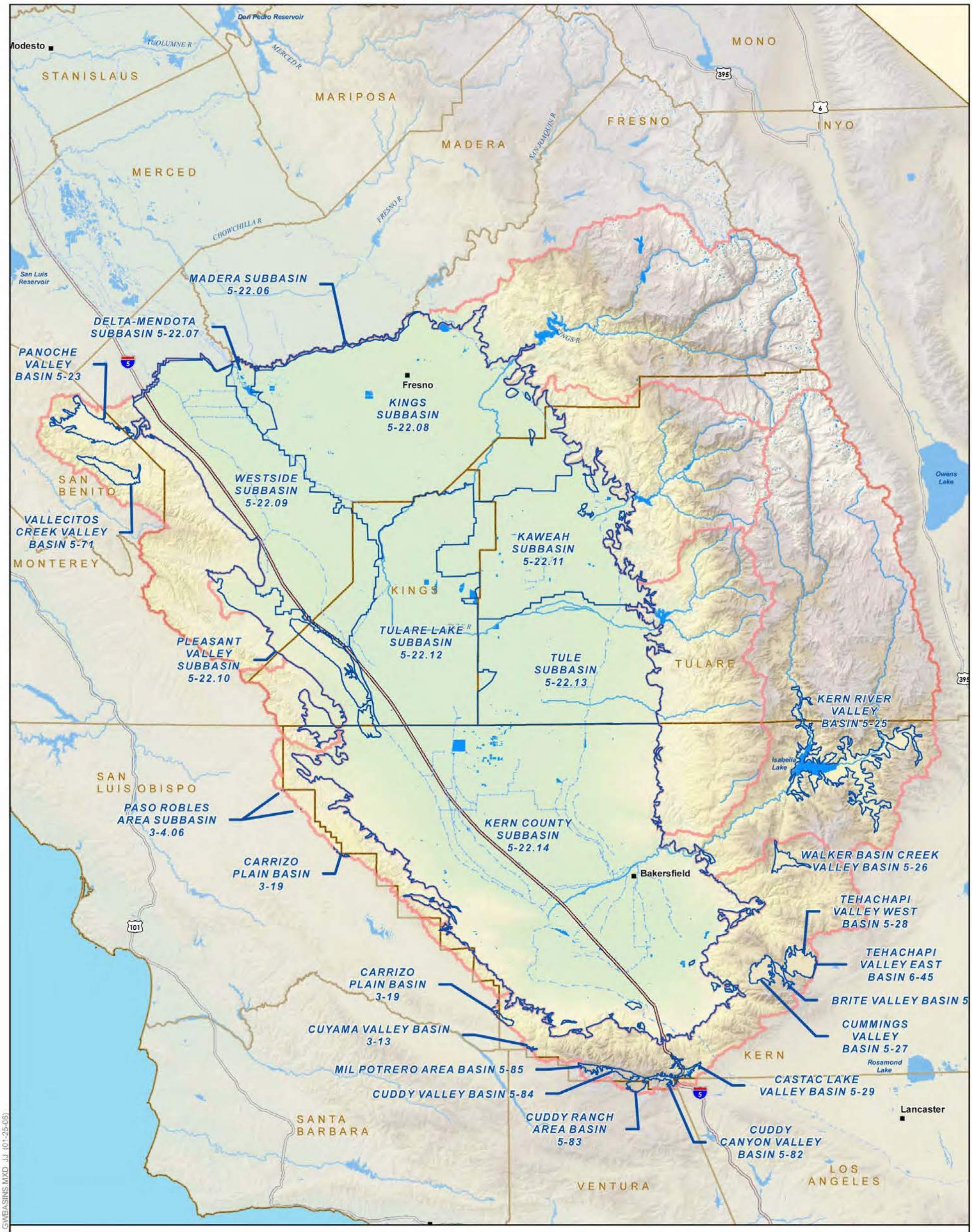
Sacramento River Groundwater Subbasins

Figure 4-2

PROJECT: 5538

DATE: 10/25/05


Rocklin
Coloma
Yolo
Sutter County
Placer County
Roseville
Pollock Pines
Kyburz
50
Placerville
Camino
Woodland
Rio Linda
Citrus Heights
North Highlands
Orangevale
Folsom
Cameron Park
Diamond Springs
El Dorado County
Foothill Farms
Fair Oaks
Shingle Springs
Carmichael
Yolo County
Sacramento
Rancho Cordova
La Riviera
Davis
Arden Town
Rosemont
Omo Ranch
Rancho Murieta
Parkway
Florin
Dixon
Plymouth
Clarksburg
Laguna
Sacramento County
Elk Grove
Wilton
Amador County
Amador City
Pine Grove
West Point
Sutter Creek
Wilseyville
Courtland
Ione
Jackson
Solano County
Mokelumne Hill
COSUMNES SUBBASIN
Walnut Grove
Galt
Thornton
White Pines
Arnold
Rio Vista
Isleton
Valley Springs
Calaveras County
Birds Landing
Woodbridge
Lockeford
Lodi
Terminous
Murphys
5
Altaville
Angels City
Bethel Island
Cedar Ridge
Antioch
Lincoln Village
Morada
Linden
Columbia
Los Medanos
Oakley
Tuolumne County
August
Sonora
Mono Vista
Brentwood
Stockton
EASTERN SAN JOAQUIN SUBBASIN
Jamestown
Tuolumne
Contra Costa County
San Joaquin County
Tuolumne City
Discovery Bay
French Camp
TRACY SUBBASIN
Lathrop
Manteca
Escalon
Groveland
Moccasin
Tracy
Oakdale
Ripon
Riverbank
Livermore
Salida
Coulterville
580
MODESTO SUBBASIN
Alameda County
Modesto
Empire
Waterford
El Portal
Ceres
Hughson
Westley
Stanislaus County
Montpelier
Snelling
Mariposa County
Wawona
Turlock
TURLOCK SUBBASIN
Patterson
Hornitos
Mariposa
Bootjack
Delhi
East Foothills
Hilmar
Irwin
Livingston
Winton
Catheys Valley
Atwater
Ahwahnee
Newman
Oakhurst
MERCED SUBBASIN
Planada
101
Gustine
Coarsegold
Le Grand
Santa Clara County
Raymond
Merced County
Morgan Hill
Yosemite Lakes
DELTA-MENDOTA SUBBASIN
El Nido
Chowchilla
San Martin
O'Neals
101
Los Banos
Gilroy
CHOWCHILLA SUBBASIN
Corralitos
Berenda
Santa Cruz County
Dos Palos
South Dos Palos
Madera County
Friant
Pajaro
Madera
Aromas
Las Loma
MADERA SUBBASIN
San Juan Bautista
Hollister
Firebaugh
Elkhorn
Prunedale
Herndon
Pinedale
Clovis
Castroville
Tres Pinos
Biola
Paicines
Mendota
Salinas
Fresno
Kerman
KINGS SUBBASIN
Calwa
Malaga
San Benito County
Fresno County
WESTSIDE SUBBASIN
Tranquillity
Easton
Fowler
Monterey County
San Joaquin
Monmouth
Selma
Carmel Valley
Carmel Valley Village
Gonzales
San Benito
Helm
Caruthers
Conejo
Burrel
Soledad
Idria
Lanare
Camden
Laton
Riverdale
Kings County
EXPLANATION
SUBBASIN BOUNDARY
COUNTY BOUNDARY
N
0
180
360
540
SCALE IN MILES
SOURCES: Environmental Systems Research Institute, Inc. (ESRI)- StreetMap, and California Department of Water Resources (DWR) website- Groundwater Basins.
NORTHERN PORTION OF
SAN JOAQUIN VALLEY GROUNDWATER BASIN
California
(San Joaquin Valley Basin)
GEOMATRIX
Project No.
9902
Figure
4-3
N:\9000s\009902\gis_fig_01_sjr.mxd

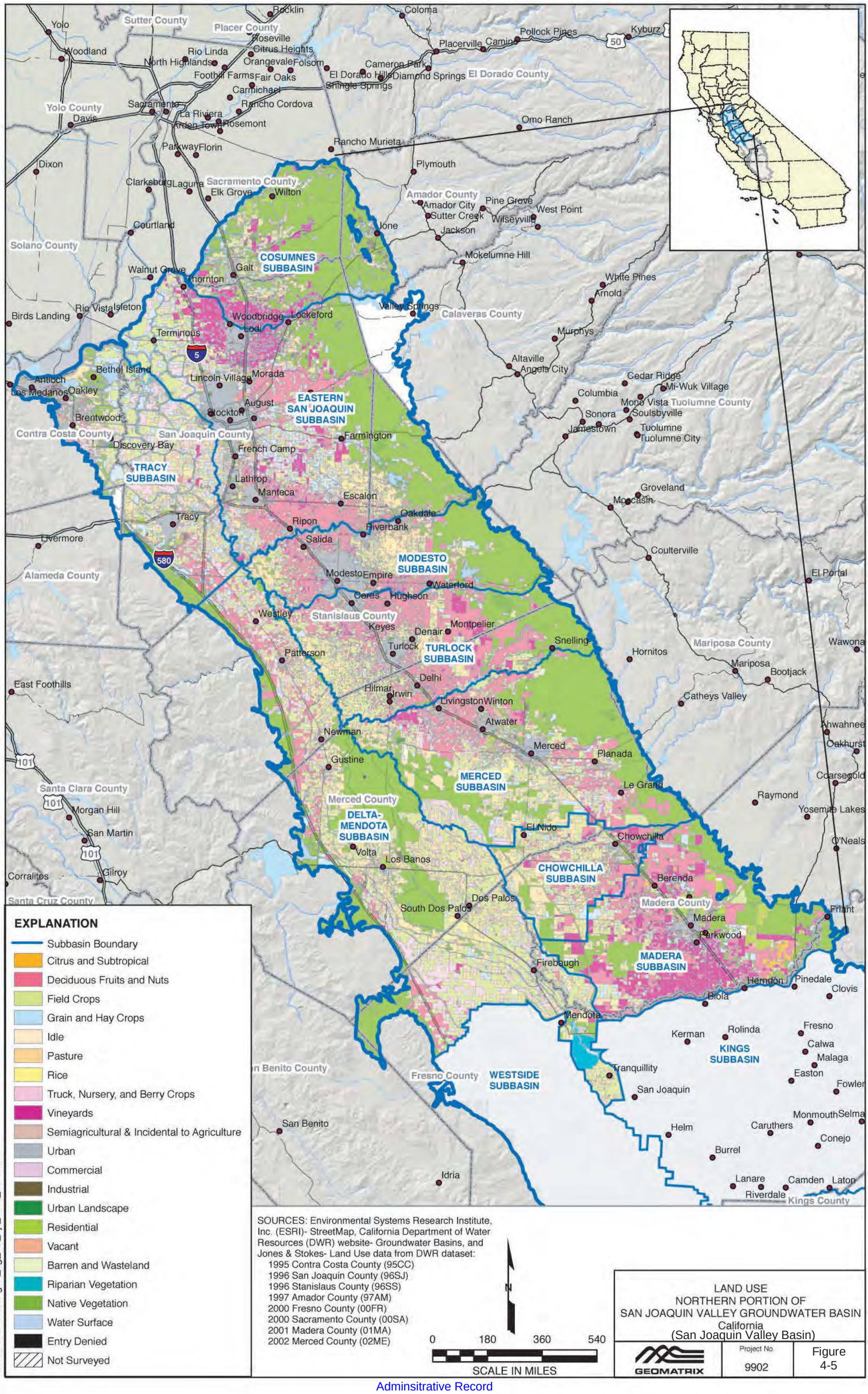


Groundwater basin data source: California Department of Water Resources (2004)

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ICF Jones & Stokes

Figure 4-4
Groundwater Basins



EXPLANATION

- Subbasin Boundary
- Citrus and Subtropical
- Deciduous Fruits and Nuts
- Field Crops
- Grain and Hay Crops
- Idle
- Pasture
- Rice
- Truck, Nursery, and Berry Crops
- Vineyards
- Semiagricultural & Incidental to Agriculture
- Urban
- Commercial
- Industrial
- Urban Landscape
- Residential
- Vacant
- Barren and Wasteland
- Riparian Vegetation
- Native Vegetation
- Water Surface
- Entry Denied
- Not Surveyed

SOURCES: Environmental Systems Research Institute, Inc. (ESRI)- StreetMap, California Department of Water Resources (DWR) website- Groundwater Basins, and Jones & Stokes- Land Use data from DWR dataset:
1995 Contra Costa County (95CC)
1996 San Joaquin County (96SJ)
1996 Stanislaus County (96SS)
1997 Amador County (97AM)
2000 Fresno County (00FR)
2000 Sacramento County (00SA)
2001 Madera County (01MA)
2002 Merced County (02ME)

N

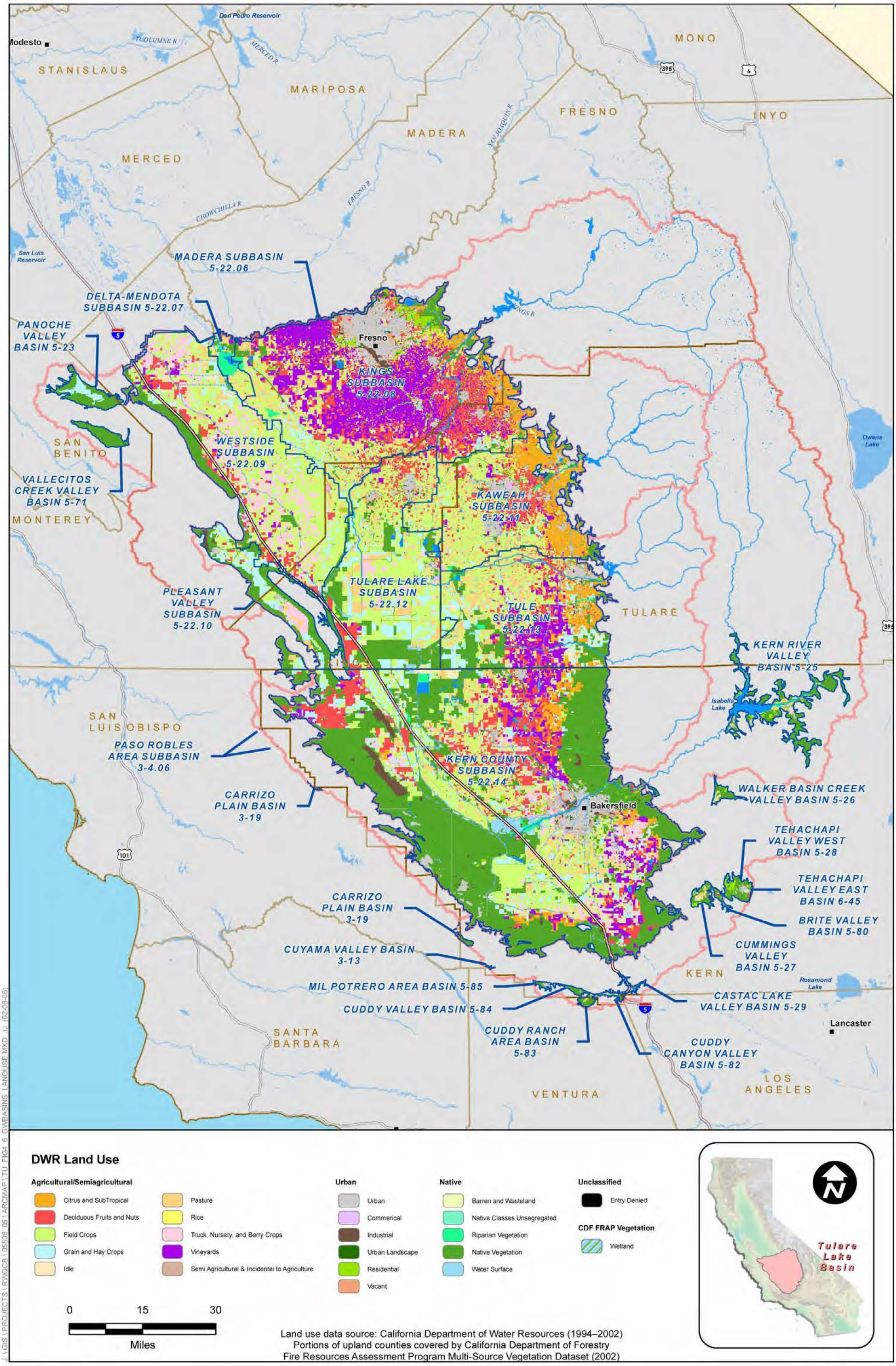
0 180 360 540

SCALE IN MILES

LAND USE
NORTHERN PORTION OF
SAN JOAQUIN VALLEY GROUNDWATER BASIN
California
(San Joaquin Valley Basin)

GEOMATRIX | Project No. 9902 | Figure 4-5

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ICF Jones & Stokes
an ICF International Company

Figure 4-6
California Department of Water Resources Land Use
Southern San Joaquin Valley Groundwater Basins

Chapter 5
MANAGEMENT PRACTICES

INTRODUCTION

This chapter is intended to provide an understanding of the quantitative and qualitative information that is readily available about the extent of management practices being implemented to reduce impacts on water quality resulting from irrigated agriculture and wetland management. The information in the chapter represents a snapshot of ongoing actions being conducted by irrigators and wetland managers to reduce impacts on water quality.

Organization

The chapter is organized as follows:

- The "Irrigated Lands Management Practices" section of this report provides information on the issues that would be addressed by various management practices, a discussion of various practices, and information on efforts to implement management practices.
- The "Wetland Management Practices" discussion is divided into three sections: the Sacramento Valley Subbasins, the San Joaquin Valley Subbasins, and the Tulare Lake Subbasins. These sections describe the managed wetlands and water supplies found in each subbasin; and provide information on water quality constituents of concern, current management practices, and the available water quality information for each subbasin. A general discussion of managed wetlands follows the subbasin information.

IRRIGATED LANDS MANAGEMENT PRACTICES

Sources of Information and Data

The approach used to prepare this section of the chapter was to conduct a phone survey to coalitions, commodity groups, and farm advisors to obtain quantitative and qualitative information about management practices being implemented. Questions also were asked about ongoing research and implementation barriers. Sources used to compile this information included the water quality coalitions, University of California (UC) Extension, and crop commodity groups that provide technical information to their members.

All of the individuals contacted for the phone survey were aware of the ILRP, and all but one contact was participating in the program at some level. Most of the individuals contacted were providing technical support to growers or working on the administration of coalition activities. Only one contact was directly involved in on-the-ground implementation of management practices. As noted, the information reported represents a snapshot of current efforts.

A recent noticeable change in implementing management measures is the availability of quantitative data and information. A few coalitions have begun to use geographic information systems (GIS) to monitor implementation of management practices, and the use of databases for organizing information has increased. Although these efforts are useful, it must be stressed that overall very little data concerning implementation of management practices are available. Other than an indicator such as the number of water quality violations, the effectiveness of the practices that have been implemented typically is not monitored. Although many state-funded projects contain monitoring components, there has been no review of that information to report.

Legal and Regulatory Requirements

Pursuant to the NPS Program Plan, the Regional Boards must implement programs to ensure that dischargers are following management measures. The management measures that apply to discharges from irrigated agriculture include specific steps for erosion and sediment control, nutrient management, pesticide management, and irrigation water management. Under this program, the manager of an irrigated field is expected to adhere to appropriate management practices designed to control potential releases of multiple pollutants. Individual landowners, or growers, are ultimately responsible for implementation of any Regional Quality Control Board Nonpoint Source Program requirements.

Water Quality Constituents

Improving water quality is based on reducing or eliminating waste constituents that could cause impairment to beneficial uses. The constituents that are addressed in this report vary by watershed but are categorized as follows:

- **Sediment**—Transported and deposited particles or aggregates derived from rocks, soil, or biological material. There are two primary concerns for sediment: its ability to bind chemicals, and the physical impacts caused by deposition.
- **Pesticides**—Natural or synthetic chemicals used to control pests and unwanted vegetation.
- **Nutrients**—Natural or synthetic elements or compounds that are essential materials for organism growth and development.
- **Native**—Compounds resulting from use of land and water resources. In the Central Valley, the primary native constituents of concern include boron, selenium, dissolved organic carbon (DOC), and salinity.
- **Pathogens**—Bacteria resulting from the application of animal waste to lands that are irrigated and from animals grazing on irrigated pastures.
- **Salts**---Salts are naturally occurring and move into the Central Valley through imported irrigation water & rivers. Evaporation of irrigation water and plant transpiration concentrates salts in the soil.

Each constituent has unique chemical and physical properties, and responds differently to biological activity; therefore, constituents can move and remain effective in different ways. These properties—solubility, adsorption, volatility, and persistence—are discussed below.

- **Solubility**—The amount of constituent that can dissolve in water. Highly soluble constituents dissolve in and flow with water, and are often referred to as "mobile" constituents.
- **Adsorption**—The attachment or adsorption of a constituent to a soil particle. The strength of attachment varies by constituent type. Constituents that are attached to soil particles will move with the particle.
- **Volatilization**—The process of a substance changing from a solid or liquid to a vapor. The volatilization of a constituent is a function of the constituents' chemical properties and its exposure to environmental factors such as relative humidity, temperature, and wind speed. For example, low relative humidity, high temperatures, and high wind speed favor volatilization.
- **Persistence**—The ability of the constituent to remain in the environment for long periods. Many constituents are stable in the environment and have particularly long half-lives while other constituents are more readily converted to breakdown products through microbial degradation, hydrolysis, or thermal processes.

Based on their properties, constituents can move from the place of application in three basic ways—moving with surface water runoff in solution or attached to soil particles, through percolation into the groundwater, and moving with air flow as drift. The following is a summary of the ways in which constituents move.

- **Moving with runoff in solution or attached to soil particles**—Soluble constituents will move with runoff and can affect the receiving water body. Constituents adsorbed to soil particles can be transported from the place of application on sediments and can affect the receiving water body.
- **Deep percolation**—Movement of constituents into the groundwater. Soluble constituents, in applied irrigation water and surface runoff, can percolate to groundwater. While adsorbed constituents do not move to groundwater, persistent adsorbed constituents can eventually move to groundwater and cause more serious long-term contamination issues. DDT is an example of a persistent legacy pesticide that adsorbs to soil particles and can be found in groundwater.

- **Drift**—Movement of a constituent as a vapor or as particles. The primary factor causing drift is the method of application and the environmental conditions when the constituent is applied.

Dissolved constituents and constituents adsorbed to sediment can affect receiving waters. Factors that affect the movement of constituents to surface waters include timing and intensity of rainfall, irrigation method, timing of chemical application, soil type, slope, and type of soil covering. Constituents can affect groundwater directly or indirectly. Direct or point source impacts occur from site-specific spills or preparation areas. Indirect or nonpoint-source impacts occur from deep percolation in areas where the constituent is applied or where surface water recharges groundwater.

MANAGEMENT PRACTICES

Management practices, best management practices, and management measures are all various ways of describing how growers and other responsible parties pursue stated objectives. In some cases, a practice or group of practices is pursued solely to lower production costs. In other cases, a practice is implemented to address a specific objective, such as a reduction in storm water discharge. For this discussion, it is assumed that the implemented management practices are intended to reduce or eliminate negative impacts on water quality.

Actions taken to prevent or reduce impacts on water quality include physical and operational changes (management and policies) as well as educational efforts. Physical changes include modification of irrigation and drainage systems at both the on-farm and district level. Typically, infrastructure improvements are accompanied by operational or management changes. At the district level, operational changes include implementation of delivery policies that enable more flexible on-farm use and restrictions on return flows and drainage. At the farm level, a great number of actions can be implemented to reduce impacts on water quality, as discussed in further detail in this section.

In irrigated agriculture, district operations and surface irrigation methods are the two primary actions that lead to surface runoff. Management practices implemented to improve district operations include investments in regulating reservoirs, canal automation, interceptor systems, and increased labor. These actions give a water supplier greater control over its operations and allow the end user to better match their crop water needs with the available supply. District improvements are not typically implemented to improve water quality, but they do directly affect the ability of the end user to manage their system to reduce impacts on water quality. Similarly, end users are investing in technologies that utilize district improvements and provide greater control over the use of water. These technologies generally result in higher uniformity of irrigation that in turn reduces the impacts on water quality from nutrients and pesticides. In addition, the higher level of management used with these systems typically results in less surface runoff.

Crop type, physical setting, and economics drive the selection and implementation of management practices used to support production systems. For a given crop rotation, the physical setting—particularly water availability and the slope of the land—is a primary determinant in selecting the type of on-farm irrigation and drainage system to use. The selection of other practices, such as cover cropping, nutrient and pesticide management, harvesting, and cultivation, is driven by economics and agronomic needs.

Proven Management Practices

This section provides a summary of the management and hardware actions that have been proven to provide a water quality benefit. The practices are presented under the management categories identified by the State Water Board: erosion and sediment control, nutrient management, pesticide management, irrigation water management, and education and outreach. The single most comprehensive reference for individual management practices is the NRCS (http://www.nrcs.usda.gov/technical/ECS/). This website lists over 100 proven practices that provide information for physical actions that apply to several of the management measure categories. Although the NRCS guides were developed for general use, they contain sufficient guidance for local implementation.

In nearly all cases, there is no quantified information regarding the amount of benefit received from implementing the action. However, where quantified information is available, it is provided. When reviewing this section, one is advised that the application of any action will be specific for the site and how the action is managed. Therefore the potential outcome of any action cannot be guaranteed.

A considerable amount of information exists concerning practices that have been proven to reduce impacts on water quality. In controlled studies, for example, the use of cover cropping has been shown to reduce the amount of sediment running off a production field. Although these practices have been proven effective in reducing impacts on water quality, it is not appropriate to assign a management practice to a particular situation without a comprehensive understanding of its applicability as well as the costs and benefits.

Guidance information regarding management practices is available in numerous formats from a multitude of sources. County-level agricultural extension offices (http://ucanr.org/ce.cfm) typically provide publications concerning crop-specific management practices, such as alternative strategies for the application of annual dormant spray on tree crops. Information also is available for such site-specific issues as reduction of erosion in the Yolo Basin through use of vegetated waterways.

Other guidance information is broad reaching, such as the recommendation to use pressurized irrigation systems over surface irrigation methods. The reader should note that, in some instances, management practices also could be considered a treatment process. A good example is the use of tailwater ponds to capture and reuse surface runoff. Properly managed, this practice can eliminate sediment in discharge waters; and the ponds can serve as holding basins for storm water runoff that may contain dormant spray residue. Another consideration concerning management practices is the potential for redirected impacts. For example, the use of cutback irrigation to reduce surface runoff may result in greater impacts on groundwater. The remainder of this section is a discussion of proven practices.

Erosion and Sediment Control

Management practices for erosion and sediment control are designed to prevent movement of soil aggregates into receiving waters. The basic strategy is to slow the water down to a point where soil aggregates settle out or to prevent soil aggregates from entering into irrigation water. Retaining soil aggregates through use of cover cropping or mulching prevents sediment movement into irrigation water. Increasing infiltration also reduces runoff and movement of soil aggregates. Another approach to reducing the offsite movement of soil aggregates is to physically stop the sediment through filter strips, laser leveling fields, sediment traps, vegetated waterways, windbreaks, and polyacrylimides. The Yolo Resource Conservation District (RCD) (Yolo Resource Conservation District 2002) found that use of

cover cropping reduced sediment loading by 46 percent compared to a fallow field. Another finding by the Yolo RCD was that sediment traps captured between 60 and almost 90 percent of suspended sediment. Specific practices related to erosion and sediment control that have been implemented at some level include:

- **Water and sediment control basins**—Constructed earth embankments or a combination ridge and channel that are constructed across slope and minor watercourses to form a sediment trap and water detention basin.
- **Temporary water checks**—Installed on the head or tail end of the field with the primary purpose of slowing down water.
- **PAM applications**—Polymers added to irrigation water at the head end of a field supply ditch or discharge point. Applications of 5–8 lbs/acre are typically metered with a gandy-type applicator. Several field trials have shown a 95-percent reduction in erosion from the use of PAM.
- **Tailwater return systems**—Essentially, large catchment ponds that prevent movement of sediment offsite. They are typically located at the low point in the field and must be maintained if used to trap sediment. These systems also can provide improved water management.
- **Tailend berms**—Constructed earthen berms that slow down water, allowing sediments to settle out. These can replace tail-end "V" ditches.
- **Sediment traps**—A variation on tailwater pond and berms. The traps are typically located on the tail end of a field and must be maintained.
- **Enhanced field drains**— A structural modification of the hydraulic performance of field drains. Changes to the hydraulic performance of field drains can decrease the velocity of runoff, allowing finer soil particles to settle out before discharge.
- **Cultural practices**—Practices used by growers to manage cropping systems. Cultural practices involve tillage operations, such as planting, weed control, plowing, ripping, disking, aerating, and harrowing, that are designed to loosen soil, direct water flow, and encourage vegetation growth. If properly conducted, tillage can dramatically reduce runoff and increase infiltration. The effects of tillage on offsite sediment movement largely depend on the specific tillage technique used, soil type, slope, soil organic matter, and a number of other site-specific factors. Improper tillage can compact soil, reduce soil organic matter, damage soil structure, and reduce the amount of infiltration during irrigation and storm events. Also, breaking up soil aggregates makes finer particles more available to move with the water.
- **Vegetated drainage systems**—Using vegetation in drainage systems that are a part of existing agricultural landscape features. Vegetated drainage ditches can be incorporated into a management program to help prevent offsite movement of sediments, nutrients, and pesticides with return flow and storm water runoff. Various vegetation management practices have the potential to slow the erosive speed of runoff thereby reducing pesticide runoff by increasing soil infiltration; accelerating pesticide degradation at the soil surface; and preventing the offsite movement of soil, nutrient, and pesticides during winter storm events.
- **Irrigation system hardware**—Hardware for three main types of irrigation systems: sprinkler, micro-irrigation, and surface. The type of irrigation system chosen is the result of many factors, including crop type and rotation, topography, water supply, soil type, delivery system capabilities, and cost. The type of irrigation system used, in combination with the implemented management, can determine the potential for surface runoff and the amount of sediment running off a field. Under proper management, little or no runoff usually is associated with sprinkler and micro-irrigation systems.

- **Windbreaks**—Often occurring as rows of trees, bushes, hay bales, or other obstruction, this practice reduces wind-driven erosion.
- **Filter Strips**—Land areas of either planted or indigenous vegetation, situated between a potential, pollutant-source area and a surface-water body that receives runoff that reduce the amount of sediment, organic matter, and some nutrients and pesticides, before the runoff enters the surface-water body. Filter strips also provide localized erosion protection since the vegetation covers an area of soil that otherwise might have a high erosion potential.

  Proper management of surface irrigation methods (basin, furrow, border) has the most potential for reducing the impacts on water quality through reduced runoff. Although some surface systems require runoff to achieve uniform distribution, structures (such as tailwater recovery systems) can be put in place to increase efficiency, reduce runoff, and trap sediments. Other surface irrigation practices that can reduce runoff include level basins, surge irrigation, and cutback irrigation, as summarized below:

  - **Level basins**—These are basins that are graded to zero slope (sometimes laser leveled) and have no outlet or drain and thus no runoff. For high irrigation uniformity, these systems require large flow rates. Although this method of irrigation is efficient, it would be difficult to convert existing systems to this method because of the high flow rates required.
  - **Surge irrigation**—These systems advance the wetting front down furrows by pulsing the water. The objective is to optimize the infiltration rate and thus to reduce surface runoff.
  - **Cutback irrigation**—After the irrigation water has progressed a pre-determined length of field, a cutback in flow rate is made. Although this method requires more field labor, the cutback step reduces the total volume of runoff and slows the water down, thus allowing sediment to fall out.

Nutrient Management

The basic management practice in this category is using a nutrient management plan to optimize the use of nutrients. The plan should identify the physical boundaries and features of the field, maintain records about the existing nutrient resources within the field, and identify the nutrient needs of the crop. When planning the use of nutrients, the timing of application must be considered to ensure that the rate of application meets the crop needs and does not lead to leaching losses or field runoff. A nutrient management plan should address the following:

- **Nutrient sampling in soil, tissue, and water**—Determine the amount of nutrients in soil and water for early season applications. Use plant tissue sampling for mid and late season nutrient decisions.
- **Timing of applications**—Base nutrient applications on existing nutrient levels and crop nutrient requirements. Optimize nitrogen applications to periods of crop uptake.
- **Fertilizer placement**—Place fertilizer material where maximum plant uptake occurs.
- **Water management**—Use micro-irrigation or sprinklers when applying fertilizers, practice cutback or surge irrigation or tailwater recovery when using surface methods.
- **Vegetation**—Plant grassed waterways and ditches to help remove sediments along with attached nutrients and pesticides. Increased vegetation, including cover crops, can uptake nutrients and prevent them from moving to surface water and groundwater.
- **Application practices**—Maintain equipment and calibration, use backflow prevention devices when applying through water, distribute wash water, and clean up spills.

Another promising management practice for nutrients is the implementation of precision farming. This practice utilizes various tools to tailor the nutrient, water, and cultural practices required for crop production. Precision farming requires that the lands be mapped and managed on a scale that provides an economic return. For example, if a field has both a sandy texture and a clay, the sandy soil will require more frequent, light irrigations than a heavy clay. Customizing the irrigation schedule will reduce the potential for nutrient leaching on the sandy texture.

Pesticide Management

The objective of pesticide management is to reduce the contamination of surface water and groundwater from pesticides. The basic approach is to determine pesticide needs based on pest control needs, crop type, and previous control approaches. Appropriate methods of use need to be followed for mixing, application, and clean up. In addition, proper irrigation water management and erosion control are needed to prevent constituents from moving to groundwater or surface water.

A major tool that is continually refined is integrated pest management (IPM). IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through monitoring and a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties of crops. Pesticides are used only after monitoring indicates that they are needed and according to established guidelines. Treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

DPR publishes a trend in pesticide use on an annual basis. Analyses of DPR data from 1997 to 2006 have shown that pesticide use varies from year to year, depending on pest problems, weather, acreage and types of crops planted, economics, and other factors. Of the different active ingredient types, insecticides evidenced the greatest increase by pounds; however, the vast majority of this increase was from use of oils. By acres treated, insecticide use increased only slightly. Herbicide use had the next largest increase by pounds and the largest increase by acres treated. Fungicide use (other than sulfur) decreased slightly by pounds but increased by acres treated. Similarly, pounds of fumigants decreased, but acres treated with fumigants increased. (DPR 2006)

Conventional pesticide application technologies such as sprayers are designed for ease of use, not for efficiency. According to the Central Valley Water Board, sprayer studies in orchards show that from 40 to 60 percent of the applied spray goes to the orchard floor, while only 9 to 16 percent ends up on the trees. Aerial pesticide application also can result in a direct drift to surface waters. Volatilization and atmospheric transport of pesticides are likely to affect surface water quality according to a USGS study (U.S. Geological Survey 2002) that documented atmospheric deposition as a transport mechanism during runoff events when precipitation and surface runoff are major sources of stream flow. Several studies by the Sacramento River Watershed Program report that the use of cover cropping reduced pesticide runoff. In one study (Ross et al. 1997) cited by Lee and Jones-Lee (2002), cover cropping in a peach orchard reduced pesticide runoff by 74 percent compared to an orchard with no cover cropping.

The UC Davis website <http://ipm.ucdavis.edu> provides extensive information on how to utilize IPM. In addition, the activities listed below are a component of IPM:

- **Monitoring**—Monitoring requires qualified field personnel to monitor the orchard or field for pests so that treatments are based on need rather than the calendar.

- **Labeling**—Users of pesticides should read and follow all labeling instructions. DPR provides guidance on how to interpret labels; in addition, registered pesticides contain full instructions on how to apply the chemicals.
- **Dormant spray**—Alternating the use of organophosphate (OP) and non-OP sprays helps to prevent resistance in the target pests. There is considerable information on this topic at <http://www.curesworks.org/bmp/almondDormant01.asp>. Other dormant spray practices for orchards include:
  - Restrict applications to ground based only.
  - Do not apply within 100 feet upslope of any sensitive aquatic habitat.
  - Maintain a 10-foot-wide vegetative buffer strip from the edge of field to aquatic sites.
  - Do not apply dormant spray when soil water content is at field capacity and rain is predicted within 48 hours.
  - Apply dormant spray when wind speed is 3–10 miles per hour (mph) at the application site.
  - When wind is >3 mph toward aquatic sites, begin spraying at the side nearest the aquatic site and then move upwind.
  - Shut off spray equipment near the end of rows.
  - Use a larger droplet size, lower pressure, and drift-retardant chemicals in the spray mix.
  - Spray the last three rows upwind of aquatic sites using nozzles on one side only and with the spray directed away from aquatic site.
- **Use of spray adjutants** – Adjutants are additives used in conjunction with a pesticide to increase biological activity and/or modify physical properties of a spray solution. Use of deposition aid and drift control agents as adjutants in pesticide sprays reduces the amount of fine spray particles that carry pesticides out of target areas. It also reduces evaporation of the spray droplets which makes it suitable for use during high temperature, low humidity and low spray volume situations. This can potentially reduce volatilization and atmospheric deposition of pesticides in surface water.
- **Vegetation**—As discussed under "Erosion and Sediment Control" and "Nutrient Management," vegetation management can result in several beneficial impacts related to pesticide management. Specific vegetation management practices include:
  - Cover crops can adsorb pesticides and prevent them from moving offsite; pesticides also break down faster when adsorbed to vegetation.
  - Spray only around the base of trees.
  - Leave a vegetated strip at the tail end of fields.
  - Roadways can be grassed or sod planted.
  - Filter ditches—areas filled with activated charcoal, peat or other organics—can adsorb pesticides.

Other specific actions that are known to reduce potential impacts on water quality from pesticide and nutrient applications are:

- **Mixing location**—Use an asphalt or concrete mixing pad that drains to a central sump. The mixing location should be at least 100 feet from all water bodies.

- **Equipment**—Continuously check all equipment for cracks and broken components. Spray nozzles should be adjusted for the crop and soil type for which they will be used.
- **Tank filling**—Partially fill the tank prior to the addition of chemical, use the air gap to prevent overfilling, and use a backflow device on the fill tube.
- **Personnel**—Ensure that qualified personnel are mixing and applying chemicals. Trained personnel must be present during tank filling and take corrective action when necessary.
- **Cleanup**—Triple rinse all equipment, apply the rinseate to the field, and clean all equipment at least 100 feet from water bodies.

DPR requires the implementation of specific management practices in Ground Water Protection Areas (GWPA's). GWPA's are those that have been identified as being vulnerable to pesticide movement to groundwater. These areas are designated as either leaching or runoff GWPA's with additional sections of land designated as GWPA's because they contain certain coarse or hardpan soils and have an average depth to groundwater of 70 feet or less. Of the 58 counties in California, 34 contain GWPA's. (DPR 2007)

Irrigation Water Management

Irrigation water management practices are designed to optimize the use of irrigation water for crop production by matching the timing and uniformity of irrigation to the soil water depletion. Over-application of irrigation water can lead to surface runoff and deep percolation. Farm-level practices that can reduce surface runoff include water budgeting, conversion of surface irrigation systems to pressurized systems, and increasing the uniformity of application to prevent excessive deep percolation. When growers use surface irrigation, measures that reduce erosion and surface runoff include tailwater ponds and cutback irrigation. District-level practices that allow a grower to better match supply with demand include increasing delivery flexibility through adjustments to rate, duration, and frequency. Effective irrigation water management practices incorporate the following items:

- **Backflow prevention**—When nutrients and pesticides are used in irrigation systems, proper backflow prevention devices are required to prevent contamination of source water. **Soil water monitoring**—Monitoring soil water depletion through field sensors, California Irrigation Management and Information System (CIMIS), or moisture by feel analysis is important for determining when to irrigate. If the soil water profile is too high when irrigating, deep percolation or surface water runoff may increase. If previous irrigations have sealed the soil surface, it may be necessary to cultivate the furrows to break up the surface skin so that the irrigation water can infiltrate.
- **Application depth**—Proper depth of application is important for preventing the movement of nitrates and other mobile constituents to groundwater. The depth of application is a function of the soil type, irrigation system, and existing soil water depletion.
- **Timing of irrigation**—Proper timing of irrigations reduces crop stress and susceptibility to disease and pest infestation. It also reduces the potential for runoff due to overwatering and thus the likelihood that nutrients or pesticides will be transported off site. Soil water content and the depth of application should be monitored to ensure that irrigations do not occur too early or too late.
- **Drainage management**—Subsurface tile drains can be used to convey deep percolation to a centralized collection point. The effluent of these systems should be monitored to ensure that the

irrigation system is being managed to achieve desired performance and that discharge from these drains does not impact water quality.

Education and Outreach

The objective of education and outreach is to provide end users with information for use in making decisions about which management practices to implement. Education must be tailored to the local conditions, crops, and economics. Outreach needs to be done by individuals who understand local conditions and the effect of the various management practices on the constituents of concern. Many of the commodity groups maintain outreach information regarding current practices for pesticide and nutrient management. Pesticide labeling informs growers on the safe use of pesticides and is considered a form of outreach (labeling is discussed under "Pesticide Management").

Known Management Practices

Known management practices are those currently being implemented to reduce impacts on water quality. For example, California rice growers prevent the discharge of water that has been treated with certain herbicides. This is a known practice because rice growers must follow product labels and are monitored by county agricultural commissioners. In some cases, such as with rice, the benefit of implementing a practice is known; in other cases, the benefit is unknown.

Water quality coalitions, University of California (UC) Extension, and members of crop commodity groups were contacted and asked to provide quantitative and qualitative information about ongoing management practices, and to discuss ongoing technical support and research. Questions also were asked about ongoing research and implementation barriers. The following six questions were asked of the participants:

1. Are data available that quantifies (or qualifies) the acreage under various practices and can we have it? Can data only on acreage, crop, and management practices be provided (without names, assessor parcel numbers, or any other information that identifies the grower)?
2. What is the benefit and effectiveness of the practice for improving water quality and how is it determined?
3. What practices are being recommended to improve discharge water quality?
4. What practices do you see growers using to improve discharge water quality? Can you estimate the percentage or acreage using a practice?
5. What are barriers to implementation?
6. Are you aware of any studies or research concerning management practices in place and their associated effectiveness? Where can we obtain the study or research results?

These questions were posed to all coalitions, commodity groups, and farm advisors. In addition, available final reports from grants that were funded to provide technical support and research on agricultural water quality issues were reviewed. In most cases, the grants were specific to coalitions and are discussed under the appropriate coalition.

All individuals contacted stated that crop producers in their area are implementing multiple management practices designed to reduce impacts on water quality; however, the extent and performance of the implementation of those practices is not known.

Coalitions

Currently, coalitions conduct monitoring, provide outreach, and develop management plans where agriculture-related water quality problems exist. Coalitions are the Regional Water Board's primary contact to relay information to the growers. Under the current program, the Regional Water Board relies on the coalitions to provide the local oversight.

Association in a particular coalition is primarily based on geography and political boundaries. Coalitions in the Sacramento Valley, the Delta, and the upper east and west sides of the San Joaquin have return flow to natural water bodies. Return flow to natural water bodies generally is not associated with coalitions in the lower San Joaquin Valley and in the Tulare Lake region. In all regions, however, there is deep percolation that—over time—will reach groundwater.

In general, the coalitions understand the types of management practices being implemented to reduce impacts on water quality. Some coalitions have surveyed their growers to determine the types of management practices being implemented. Coalitions also provide support to their members regarding management practices, research, and program requirements. The remainder of this section discusses information that was provided by each coalition.

Sacramento Valley Water Quality Coalition

The Sacramento Valley Water Quality Coalition has compiled a comprehensive report on the evaluation of commodities and appropriate management practices for each commodity. This assessment assigns a priority to the drainage areas that should be targeted in order to promote management practices that reduce impacts on water quality. The coalition is currently conducting surveys about management practices within areas with exceedances of water quality constituents. To remain in the coalition, landowners must complete the survey. Based on the survey results, the coalition expects to compile a database of practices. This information may be available in the future.

California Rice Commission

In November 2004, the California Rice Commission (CRC) provided the Central Valley Water Board with its quality assurance project plan (QAPP) to meet the requirements of Central Valley Water Board resolution R5-2003-0105, conditional waiver of waste discharge requirements. The QAPP describes in detail the steps taken by rice growers to manage constituents. The document provides an inventory of the acreage under monitoring but does not provide an analysis of the acreage participating in management practices.

State mandates and pesticide labeling requirements require rice growers to hold herbicide-treated waters on their fields to allow dissipation or breakdown of herbicides into nontoxic products. The water-holding requirements make it necessary for farmers to carefully control water flow. The three main water management systems that were historically used by rice growers include conventional, recirculating, and static systems. In the past, almost all rice farms were irrigated with conventional flow-through systems

where water flows into one "check" or basin and then to the next check. Finally, the water flows out of the bottom check and into a drain. Due to the difficulties in meeting water quality mandates with this type of system, it is not currently used.

Closed systems, such as the recirculating and static systems, are considered the best management practices for holding treated water because they can reduce pesticide residue mass discharge by up to 97 percent over conventional systems. In recirculating systems, water is pumped from the bottom check back to an uphill field, usually on the same farm. Some of these systems have been implemented at the irrigation district level, but most were built by individual farming operations. A static system independently controls inflow into each basin and limits it to the amount required to replenish applied water lost to evapotranspiration and percolation. It also eliminates the possibility of spillage of field tailwater into public drains.

On an annual basis, the CRC maintains information on the amount of chemicals used that have required water-holding time. In an effort to improve the water quality of rice field drain water, growers are adopting closed systems. According to the CRC, the four major rice growing counties (Colusa, Glenn, Yolo, and Butte) show an increase in the use of closed systems from 74,600 acres in 1991 to 136,200 acres in 1994. However, the total number of acres in rice production also increased during the same period. Of the total acreage, closed systems increased from 31.8 to 36.5 percent between 1991 and 1994, while conventional systems decreased from 68.2 to 63.5 percent. The CRC supports all rice growers through technical outreach.

Butte County

As part of a contract, the Agricultural Commissioner of Butte County agreed to provide services to the Central Valley Water Board to support the ILRP. Specifically, the contract was to evaluate a number of agricultural sites and operations, including the coalition's water quality monitoring sites, and carry out other activities to identify and document management practices that are specific and appropriate to the agricultural operations within the Butte-Yuba-Sutter watershed. The contract also entails an assessment of management practices and their effectiveness to protect water quality.

Many of the current management practices were instituted for economic reasons related to the cost of irrigation; and many of the practices were instituted for soil conservation reasons, not specifically to address water quality issues. However, the identified management practices suggest water quality improvement benefits.

The following summary identifies the key components of the agricultural sites and operations that were surveyed:

- A 14.1-mile length of the creek was surveyed.
- Fifty-four parcels were surveyed.
- Fifty parcels are under an agricultural permit.
- Twenty-three agricultural operations have restricted materials permits.
- A total of 12,332 acres were surveyed.
- A total of 7,944 acres are under cultivation.
- Thirty-nine discharge points were documented.

- Thirteen agricultural operations had discharge points directly to the channel, and all had some form of discharge control device.
- Eight agricultural operations had no observable discharge points directly to the channel.
- Heavy vegetation growth was present at all potential discharge areas.
- One irrigation discharge to Pine Creek was observed.

Walker Creek Watershed Coalition

The Central Valley Water Board contracted with the Walker Creek Watershed Coalition to collect management practices information and to prepare a report on its findings. This watershed was chosen because it is fully contained in Glenn County, and county staff has access to all pesticide use and permitting information that can be used to acquire a grower list and contact information. Results show 140 growers covering 26,755 acres of diversified cropping are present in the watershed. Tillage and vegetation management practices were identified on 98 percent of the acreage surveyed. As part of the information collection process, a pesticide use query was performed to coincide with visual inspection of the agricultural discharger parcels. A total of 228,695 pounds of active ingredients of all pesticides and herbicides were applied within the watershed boundaries from September 2006 through September 2007.

Based on the survey, the coalition concluded the following:

- Although water quality exceedances occurred in the watershed during the study period, an examination of the number of the exceedances reveals that the management practices in place are working to protect water quality. Narrowing the scope for a water quality concern within a watershed is more effective than searching the entire county for a possible cause.
- Visual field assessment surveys can be used as a tool for a subwatershed group if water quality standards are not being met. The survey information can be used to help formulate a management plan or to suggest management practices that can be implemented to alleviate water quality issues. Conducting a watershed evaluation is a more relevant and practical way to determine water quality impacts. When sampling is conducted near the end of the watershed, it provides a good characterization of the watershed. Watersheds also can evaluate management practices for effectiveness or determine whether additional management practices for specific growers need to be encouraged.

Goose Lake Coalition

The Goose Lake Coalition, in Modoc County, is primarily comprised of livestock-forage operations. Although is irrigated pasture is present, they report essentially no pesticide use. They do utilize tailwater ponds, buffer strips, and fencing to reduce the movement of pathogens to water bodies. The coalition received grant funding to restore a river channel and prevent grazing impacts. Organic alfalfa operations are supplying hay to dairies in Humboldt, which appears to be an increasing trend. A barrier to additional implementation of management practices is a lack of available funding.

Delta Water Quality Coalition

The Delta Water Quality coalition is in the process of documenting management measures being implemented to reduce impacts on water quality; consequently, there is no information available concerning the benefits of various management practices to water quality improvements. One of the biggest challenges is to anticipate land use changes and how new cropping patterns need to be managed to reduce impacts on water quality. The use of tailwater return systems and filter strips in the area has increased. Adding Landguard™ OP-A (an enzyme) to water has been shown to dramatically reduce chlorpyrifos runoff (see discussion below under "Westside Coalition"); however, whether the manufacturer will continue to provide the product is questionable. Some areas apply polyacrylimide (PAM) to reduce sediment loading. The coalition is currently considering the use of a farm-assist program, in which growers would work through a workbook that comprehensively reviews the farm operation and seeks to identify where management practices can be implemented to improve operations. The model for this program is being used by the Lodi-Woodbridge Winegrape Growers Association. Target crops include walnuts, alfalfa, tomatoes, and winegrapes. Water quality practices are a component of this effort.

Westside Coalition

As part of their outreach effort, the Westside Coalition supplements traditional grower and Pest Control Advisors (PCA) educational meetings. Called "tailgate meetings," these informal sessions are held with individual large-acreage growers at their farm offices and are facilitated by the Coalition for Urban/Rural Environmental Stewardship (CURES) and either Del Puerto Water District or Central California Irrigation District field staff. Discussed at the meetings are the results of Westside Coalition water and sediment monitoring in Orestimba Creek and Del Puerto Creek, and the requirements for management plans and Westside Coalition members under the ILRP. Also discussed are potential BMPs to address runoff, including results for vegetated ditch and PAM studies performed under this project. Growers are provided literature on several management practices (vegetated ditches; sediment ponds, including a spreadsheet developed by the Westside Coalition to determine holding pond size and dimensions; and pesticide management practices) that are used in the area and show the best potential for affecting runoff.

Management practices that have been quantified for the Westside Coalition include:

- Full operation throughout the 2007 irrigation season of a regional tailwater return system that prevents surface runoff from entering the San Joaquin River and improves water quality and supplies within Patterson ID. This return system intercepts water from the Marshall Road Drain and diverts it into a 65± acre-foot reservoir, where it is returned to the district's irrigation system. Annually, the reservoir collects approximately 2,000 cubic yards of sediment that settled out of the diverted water.
- Construction continued in summer 2007 on a second tailwater return project in Patterson ID, with an expected completion date of 2008. The project consists of a 50± acre-foot reservoir that will collect tailwater and operational spills from five canal laterals that would otherwise discharge into Del Puerto Creek. The project could affect up to 4,500 acres by intercepting tailwater and settling out suspended solids. The project is expected to be operational by the 2008 irrigation season.
- The Westside Coalition distributed a spreadsheet to numerous growers in order to help design tailwater sedimentation ponds that would match field irrigation and cropping practices. As of the current reporting period, at least two ponds have been constructed with assistance from this spreadsheet and a number of others are planned. The spreadsheet is now being distributed by member districts for use by landowners.

- A single farm sedimentation pond was completed in late summer 2007 that will divert irrigation drainage water from approximately 700 acres of orchards and row crops before it enters Ingram Creek. The facility will capture drainage water that will be recirculated to other fields nearby.
- A BMP handbook continues to be distributed to landowners in the Westside Coalition region. The handbook was developed as part of a project to identify and design BMPs for reduction of discharge in the Orestimba Creek watershed.
- Landowners are continuing to install drip and micro-spray irrigation systems. These systems reduce or eliminate irrigation drainage water and subsequent discharges.
- Enzyme treatments of irrigation drain water were made by numerous growers in the Orestimba and Del Puerto Creek Watersheds, according to representatives of Orica Australia Pty, Ltd. Landguard™ OP-A is the enzyme-based technology currently under development for treatment of water contaminated with OP insecticides. In summer 2007, the enzyme was applied into irrigation drainage water after applications of chlorpyrifos in walnut and alfalfa fields. Field trials performed in 2006 demonstrated that Landguard™ OP-A may be an effective BMP for reducing the contamination of agriculture tailwaters following the use of OP insecticides. Further work will continue by Orica in 2008 to better define the optimum dosing rate of Landguard™ OP-A with different crops and developing improved methods for product delivery into drainage water.

Research and BMP evaluations on the Westside include the following three projects.

(1) Use of Vegetated Ditches for Mitigation of Pyrethoid Runoff from Alfalfa

The objective of this study performed in August 2007 was to evaluate the effects of two management practices on concentrations of the pyrethroid, lambda cyhalothrin, in irrigation runoff in alfalfa. The management practices included (1) a standard irrigation return ditch dredged to remove vegetation just prior to the irrigation event; and (2) a specially constructed ditch with resident grasses to provide a dense cover of vegetation for the irrigation event. The study site was a 35-acre commercial alfalfa field near the cities of Crows Landing and Patterson. The concentrations of pesticide were lower in the vegetated ditch than at the inflow or in the conventional ditch, with the mean concentrations for each irrigation event being lower than the inflow concentrations. On average, the median concentration reduction at the end of the vegetated ditch was about 25 percent. The median concentration of lambda cyhalothrin in the vegetated ditch sediment was approximately eight times higher than in the conventional ditch sediment. The concentrations in the vegetated ditch sediment also increased as the water traveled further down the ditch. This indicates that the pesticide drops out of the water (with the sediment) in the vegetated ditch more readily than in the conventional ditch, hence the reason for low detections in the whole water samples. The complete results of this study were submitted to the Regional Water Board in November 2007 as part of the draft final report for the "Western San Joaquin Valley Pesticide BMP Implementation Program" by the San Luis and Delta Mendota Water Authority.

(2) Use of Polyacrylamide (PAM) and Calcium to Mitigate Chlorpyrifos Runoff from Row Crops

This study evaluates the use of PAM in irrigation water after a field is sprayed with chlorpyrifos. Although the study showed that reductions in chlorpyrifos runoff were not significantly different when using PAM and calcium in irrigation water, it did show PAM to be effective in reducing sediment runoff based on visual observation. PAM causes soil particles to aggregate and thereby reduce soil particle movement offsite. Reduced movement of soil particles is quite evident *in vitro* and from observations during the study of irrigation water *in situ*. For pesticides of low water solubility and with a

correspondingly high propensity to bind to soil particles, one would expect to see a decrease in the amount of those pesticides moving offsite from fields treated with PAM due to the lack of sediment movement. For pesticides like chlorpyrifos (which is moderately water soluble and has only a moderate tendency to bind to soil), however, the presence or absence of PAM in irrigation water would not be expected to dramatically reduce chlorpyrifos offsite movement under typical conditions.

Work continued in 2007 in a study entitled "Evaluation of Vegetated Ditches, Ponds, and Wetlands as BMPs for Mitigating the Water Quality Impact of Irrigated Agriculture in the San Joaquin Valley," led by William Stringfellow at the University of the Pacific. This project is examining and evaluating three BMPs currently being applied in western Stanislaus County: drainage retention ponds, constructed wetlands, and vegetated ditches. Ponds and wetlands are constructed for the purpose of water recycling, and vegetated ditches are being used as a method to reduce the runoff of sediments and pesticides from fields and farms. The objective of the project is to evaluate the efficacy of these current BMPs for sediment and pesticide control, and to determine the potential effect of the BMPs on other water quality constituents—particularly dissolved organic carbon and nutrients. The overall objective is to determine how these BMPs and similar structures could serve as components of a regional BMP strategy. Also examined are the water quality benefits of vegetated ditches as an end-of-field practice and vegetated drainages as a multi-field mitigation strategy.

A preliminary report on the project stated that, although vegetated ditches and vegetated drainages were effective at removing sediments, end-of-field vegetated ditches presented hydraulic control problems in areas characterized by very little slope. Irrigation return flow conveyed through vegetated drainages showed improvement in water quality compared to return flow conveyed through conventional (dirt-lined) ditches. Although vegetated drainages offer demonstrable water quality benefits, the placement of vegetated drainages throughout the region may not be practical, in part due to land availability and maintenance requirements.

The water quality benefits of ponds and wetlands also were investigated in summer 2007 as part of the project. The study examined whether these recycling facilities have collateral benefits on water quality and if similar structures should be part of a regional BMP strategy. Ponds with and without vegetation were compared to determine whether vegetated systems offer greater water quality benefits than ponds where vegetation is closely controlled. In one study performed in summer 2007, a 12-acre settling pond managed by Patterson ID was evaluated. Drain water from 2000± acres of irrigated cropland flows into the facility. The reservoir is deep (greater than 10 feet) and was designed for sediment removal but is not managed as a biologically active system. Plant growth on pond edges is controlled with herbicides, so vegetation and biological activity are minimal. Water analysis over a 4-month period showed that the pond reduced suspended sediments by an average of 71 percent between the inlet and the outlet. Soluble phosphate also was reduced by 40 percent in outlet flows. The pond, which is drained and excavated each year, traps approximately 2,000 cubic-yards of sediment annually from drainage water. Phosphate is removed by physical processes (settling with sediments) in this pond.

The preliminary report states that the evaluation of constructed BMPs suggests that a regional approach to drainage mitigation would be more effective than a farm-by-farm approach in western Stanislaus County. Vegetated ditches and drainages offer water quality benefits, but will be difficult to implement on scale sufficient to significantly alter the regional environmental impact of irrigated agricultural. Ponds and wetlands have an important role in regional water- recycling and have the potential to serve a water quality control function as well. The efficacy of ponds and wetlands for improving water quality in the region is being further investigated.

(3) Efficacy of Sediment Ponds and PAM for Removal of Pyrethroid Insecticides

A study performed in July 2007 was designed to investigate the effectiveness of sediment basins (with and without PAM) for reducing pyrethroid loading in irrigation drainage water from processing tomatoes in the Orestimba Creek watershed.

A study is planned to evaluate the impact of resident vegetation on pesticide runoff from dormant almonds. The study was scheduled for January 2008, depending on orchard conditions. The study will evaluate the benefits of cultivating native vegetation in almond orchards during the rainy season as a means of reducing pesticide concentrations in runoff. However, low rainfall amounts in fall and early winter 2007 has slowed development of vegetation on the orchard floor, which may inhibit the ability to perform the study.

Grassland Bypass Project

On the westside of the San Joaquin Valley is the Grasslands Drainage Area. The Grassland Bypass Project utilizes a highly coordinated and monitored system to optimize discharge of drainage water with elevated levels of salinity and selenium. There is considerable documentation of the efforts of the Grasslands Bypass Project that is available at <http://www.usbr.gov/mp/grassland/>. This effort is regulated through use of a waste discharge requirements, and lands included in this project are not subject to the current conditional waiver.

The Project prevents discharge of subsurface agricultural drainage water into wildlife refuges and wetlands in central California. The drainage water is conveyed instead through a segment of the San Luis Drain to Mud Slough, a tributary of the San Joaquin River. The Project includes drainage from 97,000 acres of farmland on the west side of the San Joaquin Valley. The California Regional Water Quality Control Board, Central Valley Region, issued Waste Discharge Requirements (WDRs) that specified the maximum monthly and annual loads of selenium that the Project may discharge into Mud Slough and the San Joaquin River. The WDR includes monthly monitoring for molybdenum and nutrients (nitrate, ammonia, total Kjedahl nitrogen, total phosphate, and ortho-phosphate); weekly analyses of salinity, selenium, boron, and other parameters, and chronic toxicity testing. The WDR also outlines a program to monitor storm water releases from the Grassland Drainage Area into the Grassland wetland supply channels should they occur.

Since implementation of the Project, all discharges of drainage water from the Grassland Drainage Area into wetlands and refuges have been eliminated. The Project has reduced the load of selenium discharged from the Grassland Drainage Area, drainage that eventually ends up in the San Joaquin River, by 61percent (from 9,600 lbs to 3,700 lbs). The load of salts has been reduced by 39 percent (from 187,300 tons to 113,600 tons). These efforts have been funded by the farmers that discharge to the San Luis Drain, and the project has been successful largely because of the individual efforts of these farmers. This program was developed around the principal of voluntary actions to meet a regulatory requirement. Intensive monitoring enabled the Grassland Area Farmers to identify where the impairments were originating and the flexibility of the WDR provided a framework where specific management measures could be implemented to control discharges (Reclamation 2005)

Westlands Water District

Westlands Water District does not have a reporting mechanism for agricultural practices information. Westlands works with growers when runoff occurs. They have an active on-farm loan program that provides $4 million annually for the installation of drip and micro-irrigation systems. These systems are primarily being installed on the hilly western area of the district. The loan funding and privately financed installations cover about 8,000 acres per year.

Root Creek Water District

This district is small, and the overhead to operate is greater than the available funding. Although the coalition did survey its members regarding their management practices, the data have not been analyzed. At this point, some of the growers are signing up with the Eastside San Joaquin Coalition. Although nearly all growers are on micro-irrigation systems, a water quality exceedance was recorded in February 2005, resulting from storm water runoff, from an unknown compound.

East San Joaquin Water Quality Coalition

The East San Joaquin Water Quality Coalition provided a limited amount of information on management practices to the Agricultural Commissioner's office; however, they do not maintain the information in an organized manner. The coalition has completed creek walks to identify discharge locations in the region and has met with growers to discuss applicable BMPs. Because the coalition has had some exceedances for chlorpyrifos, they have held meetings with growers to discuss wait times prior to irrigation.

The coalition is trying to document more information with surveys and is working with CURES to obtain BMP information. They distributed 5,052 management practices surveys to selected growers in the coalition region (both coalition members and non-members). The surveys were sent to landowners whose fields were identified by the coalition as being adjacent to or near a waterway monitored by the coalition and where exceedances occurred in 2006. Of the distributed surveys, 200 were returned to the coalition marked as undeliverable, 1,161 were completed and returned, and 3,691 were not returned. While the February 2007 membership stood at 2,486 landowners, more surveys were sent out. One reason is because multiple fields of a single farmer were located near several waterways; these farmers were asked to fill out multiple surveys (not all fields are managed the same due to cropping patterns and irrigation type). Surveys also were sent to non-members whose addresses were obtained through county records. The majority of surveys were completed by coalition members, with a small percentage returned by non-members. The acreage reported on the surveys was approximately 296,162, indicating that approximately 47 percent of the coalition growers returned surveys covering approximately 48 percent of the total enrolled acres in the coalition region.

Of the returned surveys, 995 responses indicated that there was no discharge from their property during either the storm or irrigation season. A large portion of the responses (48 percent) said there was simply no runoff from their property during either season because of local conditions or proximity to waterways. By those who indicated that discharge was a possibility, a variety of management practices are employed to minimize drainage. Each completed survey can contain several management practices; therefore, the number of responses is greater than the number of surveys. Drainage management systems included holding basins, bermed fields, recirculating systems, and sediment settling basins. In addition, 651 respondents indicated that they allowed vegetation growth in drainage ditches in either winter or summer, or both as a means of trapping sediment. When asked about practices used to lessen storm or

irrigation runoff from fields to ditches, canals, or streams, 1,269 responses indicated using a variety of practices—including grass row centers in orchards, grass waterways, gravity tailwater recapture systems, and vegetative filter strips—or irrigation management systems such as drip, microspray, sprinkler, or careful water management. A total of 3,456 responses indicated that various management practices were employed to protect surface water quality, including attending commodity-specific training sessions, obtaining a soil nutrient analysis, following a crop nutrient management plan, seeking an agronomist's advice on practices, laser leveling fields, obtaining PCA recommendations, obtaining Certified Crop Advisor recommendations, and performing sprayer calibrations. Only one respondent indicated that no management practices were employed. Over one-quarter of the growers (321) indicated that they had employed a new management practice in 2006, reflecting that growers are making a substantial effort to protect water quality.

Southern San Joaquin Valley Water Quality Coalition

The Kings River Conservation District supports this coalition. They have not collected any quantitative information. There is very little runoff in this region, and much of the runoff that does occur may not reach a water body. Due to the minimal surface drainage, growers feel that less than 10 percent of the acreage is potentially an issue. An existing concern is sediment runoff from furrow-irrigated citrus groves. Growers are responding to that issue by implementing management practices to capture sediments. Growers recognize the potential for pesticides to move to groundwater and are working with DPR to manage the situation. They have requested UC Cooperative Extension to provide field seminars on the use of smart sprayers. These sprayers use technology to sense where the crop canopy is and to spray chemicals at the appropriate locations.

Technical Assistance

Environmental Quality Incentive Program (EQIP)

EQIP provides technical, educational, and financial assistance to eligible farmers and ranchers in order to address soil, water, and related natural resource concerns on their land in an environmentally beneficial and cost-effective manner. The program assists farmers and ranchers in complying with federal, state, and tribal environmental laws and encourages environmental enhancement. The purposes of the program are achieved through implementation of a conservation plan that includes structural, vegetative, and land management practices on eligible land. Contracts from 5 to 10 years are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practice, such as irrigation improvements, filter strips, cover crops, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices, such as nutrient management, integrated pest management, and grazing land management.

Because EQIP expenditures are reported at the county level and consequently cannot be assigned to a specific water coalition. The data provided for each practice report the number of projects funded and the sum of the units implemented. For example, conservation cover (the establishment and maintenance of permanent vegetative cover to protect soil and water resources), included five separate actions covering 13 acres, all in the Sacramento Valley in 2002.

County-level detail is available only for 2002. Practice-level data for prior years are unavailable, and data for subsequent years have not been analyzed or posted to the NRCS website. What is known for other years is the level of EQIP effort (Table 5-1). The EQIP funding priorities change annually; therefore, it is

not possible to estimate the types of practices implemented in other years. Although the NRCS provides guidance for implementation and estimation of the benefits of each practice, no repository of information reports the benefit.

Table 5-1. EQIP Funding Categories with Potential to Benefit Water Quality

	NRCS EQIP Funding Allocations ($ million)						Local	
Program Category	2000	2001	2002	2003[1]	2004[1]	2005[1]	Share [2]	Total
Statewide Ground and Surface Water Conservation Initiative				9.9	9.2	9.1	112.4	140.5
Other EQIP Expenditures				17.2	26.0	29.7	291.3	364.1
Subtotal	5.8	22.7	16.0	27.0	35.1	38.8	403.6	504.5
Coalition area funding based on 2002 analysis[3]	2.3	9.2	6.5	11.0	14.3	15.7	164.0	205.0

[1] These data are projected from initial allocation ratios, actual data may change.
[2] Local share is assumed at 75 percent of total project cost.
[3] 2002 data were used to determine funding to coalition areas.

Integrated Pest Management

The University of California Statewide Integrated Pest Management Program recently completed a series of seasonal IPM guidelines for almonds, peaches, and plums. The guidelines were created to inform growers and pest control advisors about environmentally responsible pest management. Some of the updated practices include use of pest thresholds to determine when to treat and what type of chemical to use, the promotion of "soft" chemicals over ones that are more toxic, and the promotion of mating disrupters. Not all growers are proactive on pest management issues, and this is a significant barrier to implementing the IPM program. For example, with the increase in almond prices, growers were concerned about maximizing yield and chose to continue with traditional dormant spray routines rather than implementing IPM techniques. In addition, the higher cost of the soft chemicals compared to traditional ones limits their use.

Commodity Groups

Commodity groups are designed as a clearinghouse for technical, research, marketing, and regulatory information for specific crops. Typically, a commodity group only handles one crop—such as the California Almond Board. Phone interviews were conducted with the commodity groups discussed below, using the same set of questions asked to the coalitions. Neither the Dry Bean Board nor the Cherry Board provides outreach materials on water quality issues to their members. The Dry Bean Board stated that they have never provided technical information to their members. The Cherry Board stated that there are no issues such as dormant spray or return flow with this crop. The Dried Plum Board, Pear Board, Specialty Crops Council, Almond Board, Citrus Mutual, CRC, and California Forage and Alfalfa Association all provide significant technical support to their members regarding management practices that are designed to reduce impacts on water quality. The CRC's support is discussed under "Coalitions." In addition, many of the commodity groups work with CURES in the East Side San Joaquin Valley Coalition.

California Alfalfa and Forage Association

The California Alfalfa and Forage Association estimates that approximately 400,000 acres of alfalfa in the Sacramento to Modesto region have the potential for runoff with OP pesticides leaving the farm. They feel that growers in the region should switch to pyrethroids because, after the initial year of production, there is generally very little sediment runoff. Another recommended practice is to avoid spraying pesticides in the tail end of surface irrigated fields and in any conveyance ditches. The Association would like to prepare statewide guidelines and was awarded a grant in 2003 for that effort but did not sign a contract because of issues regarding grower confidentiality.

Almond Board

The Almond Board provides outreach to their members through the press and an annual meeting. They are currently updating their online materials in an effort to be more effective. One outreach issue is that the members are on average from 55 to 60 years old and are not frequent users of the internet. The Board is planning on a grower self-assessment similar to what the Lodi-Woodbridge Winegrape Growers have implemented. In part, this assessment helps growers identify management practices that they can implement to reduce impacts on water quality. This effort is about 2 years out.

Dried Plum Board

The Dried Plum Board provides outreach to it members through newsletters and grower meetings. Based on findings from a state-funded grant, they are recommending that growers implement cover crops and filter strips to reduce OP impacts on water quality. One study that was supported by CURES looked at the use of smart sprayers. The results indicate that 50 percent less chemical can be applied if the sprayer is turned off between plants and that only the optimum sections of the plants are treated. Another study that looked at dormant spray timing and intensity found that these sprays could be applied at a lower rate in fall when the soil is dry and before rains begin. This approach has a positive impact because the pesticide is not as susceptible to moving offsite. The Dried Plum Board needs better information concerning aphid monitoring so that IPM could be more effective.

California Citrus Mutual

The California Citrus Mutual provides outreach to its members and to coalitions on management practices that are intended to reduce impacts on water quality. Citrus growers are adopting many of the recommended practices such as greater use of IPM and conversion to micro-spray irrigation. The movement to IPM is partially because of customers' demands for products to be grown with less pesticide use. In Tulare County, where the most acreage is planted, an ordinance to prevent storm water runoff forces growers to implement practices to prevent runoff from their fields.

Cooperative Extension and County Farm Advisors

The UC Cooperative Extension provides crop and water management specialists throughout the Central Valley. These advisors distribute technical information to growers and commodity groups and conduct research on specific issues such as management practices to reduce impacts on water quality. The support ranges from newsletters and field seminars to research into specific areas of concern. Advisors participate in water quality research projects and are aware of the ILRP.

Most advisors report an increase in the amount of drip irrigation and in the use of IPM. New almond plantings in the Sacramento Valley are almost exclusively on drip, whereas drip irrigation accounts for 25 to 30 percent of tomato acreage. Also, many more tailwater recovery ponds, filter strips, and sediment traps are being installed. Growers are utilizing IPM to a greater extent, mainly due to economics. The UC IPM group considers water quality concerns when recommending pesticides. A grant study that was targeted at herbicide management in rice production found that significantly less chemical is needed if the fields were drained and the chemical was applied as a contact herbicide. Another aspect of the study was to look at achieving weed control prior to planting the rice. A barrier that was commonly cited by farm advisors is the financial difficulty for small operations to implement many practices that would reduce impacts on water quality.

Land Use Survey

DWR updates land use information, by county, on a 5-year basis. The land use figures in Chapter 3 present a sample of the land use coverage that is generated by the survey. Included in the update is a description of the type of irrigation method used on the land, any type of water body or conveyance channel, and the source of irrigation water.

Irrigation methods include:

- Sprinkler irrigation—center pivot, linear move, side roll, hand move, permanent, and solid set;
- Surface irrigation—furrow, border strip, basin, and wild flooding;
- Subirrigation;
- Trickle irrigation—surface drip, buried drip, and micro sprinkler; and
- Low Energy Precision Application (LEPA).

In some cases, there are multiple methods of irrigation. For example, it is common to sprinkler germinate field crops and then switch to a surface irrigation method. What is not reported in the database is the presence of tailwater recovery systems or the type of irrigation system used with rice. When the type of irrigation system is specified, there is no indication of the level of management or performance of the system. This is significant because the level of management is a factor in impacts on water quality. For example, a poorly managed sprinkler irrigation system may result in a greater adverse impact to water quality than a well-managed furrow irrigation system. A land use type in the database that would be a direct quantification of a management practice are fields with a cover crop that indicates where grain, field, or pasture type crops have been planted for soil stabilization. However it should be noted that there is no assurance of the performance of the cover crop.

The DWR land use classes that contain a water surface are subdivided into seven categories—three of these categories are significant to the understanding of the connection between irrigated agriculture and water bodies: land use for river or stream channels, channels that are used to convey irrigation water, and channels that are used to remove on-farm drainage water. Connecting irrigation water return flows to drainage could be accomplished by the use of this information set. The information would provide a very good indication of the lands with a surface water connection to drainage or natural water channels.

FUNDING RESOURCES

Statewide Grant Programs

Several statewide grant programs are available to address impacts on water quality. Funding was made available for research, demonstration, monitoring, and implementation projects. Table 5-2 lists recent grants awarded from various sources for implementation projects, education, demonstration and outreach efforts, and applied research.

Table 5-2. Recent Water Quality Grants by Various Funding Agencies

Applicant	Project Title
Education, Demonstration, and Outreach	
Agriculture and Land Based Training Association	Agricultural NPS Reduction: Demonstration, Outreach and Education
Protected Harvest	Common Goals Towards Conservation: Creating a CA Sustainable Processing Workbook
Yolo County Resource Conservation District (RCD)	Yolo-Solano Ag Water Quality Management Support Program
Glenn County Department of Agriculture	Glenn County Surface Water Stewardship
Coalition for Urban Rural Environmental Stewardship	Promotion of Farming Best Management Practices and Calibration Technology to Mitigate Organophosphate Pesticide Runoff into the Sacramento River Watershed
California Prune Board	Implementation of BMP to Mitigate Organophosphate Pesticide Runoff
Implementation	
Sonoma Ecology Center	Plymouth Area Vineyard Erosion Control
California Avocado Commission	Implementation of On Grove Reverse Osmosis to Reduce TDS and Chlorine Impairments
Contra Costa RCD	Application of Beneficial Management Practices to Reduce Runoff from Irrigated Agriculture
El Dorado County RCD	Agricultural Stewardship Project for the South Fork American River Watershed
Grasslands Water District	Adaptive, coordinated real-time management of wetland drainage
Panoche Drainage District	San Joaquin River Water Quality Improvement Project- Reuse Development Project
Patterson Irrigation District (ID)	Real-Time, Salt and Nutrient Drainage Load Reduction Strategies - Patterson & West Stanislaus ID
Reclamation District 800	Lower Kellogg Creek Bio-Filter/Retention Pond Implementation Project
Stevinson Water District	Agricultural Drainage Control Project
Sutter County RCD	Implementation of Feather River TMDL for Orchards
Monterey County RCD	Conversion of Agricultural Drainage Ditches into Treatment Wetlands
Western Shasta RCD	Williams Ranch Tailwater Collection Pond

Applicant	Project Title
The Regents of the University of California, Cooperative Extension (UC Extension)	Upper Feather River Watershed (UFRW) Irrigation Discharge Management Program
Research	
U.S. Environmental Protection Agency, Region 9	Benefits of Vegetated Agricultural Drainage Ditches (VADD) as a Best Management Practice in Yolo County, California
UC Extension	Irrigation Management Measures to Improve the Quality of Surface Runoff Water
California Certified Organic Farmers Foundation	Going Organic Project
Central Coast Vineyard Team	Vineyard Ag Waiver Compliance & Comprehensive Evaluation of Cover Crops to Protect Water Quality
Coalition for Urban Rural Environmental Stewardship	Westside San Joaquin Watershed Irrigated Agricultural Water Quality
Regents of the University of California	Management Practices for Mitigating Off-Site Transport of Soil-Adsorbed Pesticides
San Joaquin County RCD	Measuring the Effectiveness of Agricultural Management Practices
Sustainable Cotton Project	Improving Surface Water Quality in San Joaquin River Basin through Sustainable Cotton Production
UC Extension	Effective Management Practices to Treat and Reuse Agricultural Drainage Waters
UC Davis	Alternative Agricultural Management Strategies to Reduce Runoff and Improve Water Quality
UC Davis	Developing a Water Quality Stewardship for Alfalfa
University of California	Reducing sediment and nutrient loss from commercial vegetable fields
UC Davis	Pheromone Mating Disruption as an Alternative to Organophosphate Use in Walnuts: A Cost Analysis
University of Redlands	Spatial Data Infrastructure to Implement and Monitor NPS Pollution

Proposition 84

The State Water Board is administering a nonpoint source grant program to improve agricultural water quality. The Central Valley Water Board received $8 million of the Proposition 84 bond funds to aid Central Valley farmers in the implementation of management practices necessary to reduce the discharge of pollutants from agricultural operations into surface waters. A public workshop on this funding opportunity was held on September 17, 2008.

Total available grant funds is $8,027,158. The grant distribution is as follows:

- No more than 10 percent of the total grant will be used by the grantee for direct project costs associated with administration and project management of the grant.

- At least 83 percent of the total grant will be spent on individual projects (growers and water districts) that will implement management practices that result in improvement of surface water quality.
- No more than 7 percent of the total grant may be budgeted for technical and consulting services through subcontracts to assist growers and farmers in designing and implementing management practices.

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WETLAND MANAGEMENT PRACTICES—SACRAMENTO VALLEY SUBBASINS

Pit River Subbasin

Managed Wetlands

Modoc National Wildlife Refuge

Modoc National Wildlife Refuge (NWR) is located in Modoc County just south of the city of Alturas. The refuge was authorized in 1959 by the Migratory Bird Conservation Commission and presently totals 7,020 acres. The refuge is managed for waterfowl production and migration, and is a major production area for the greater sandhill crane. Approximately 2,000 acres of wetlands are managed on the refuge. Also 2,180 acres of wet meadows are managed for sandhill cranes and Canada goose forage.

Ash Creek Department of Fish and Game Wildlife Area

The Ash Creek Wildlife Area (WA) is located 4 miles northeast of the town of Bieber and consists of 14,754 acres in the heart of Big Valley. The area contains 3,000 acres of natural wetlands and is managed for waterfowl and sandhill crane production and migration. The refuge manages 710 acres of wetlands on seasonal flow from six streams.

Private Wetlands

There are few managed private wetlands in this subbasin. Most private wetlands are maintained as flow-through areas or are re-flooded agricultural fields utilized for waterfowl hunting in fall and winter.

Water Supplies

Modoc National Wildlife Refuge

Modoc NWR utilizes water under diversion and storage licenses from tributaries of the North Fork Pit River (Parker Creek and Stockdill Slough) and Pine Creek, as well as water rights from the South Fork Pit River. USFWS purchased the Dorris Reservoir Unit in 1960. When at full legal capacity, Dorris Reservoir covers 1,080 surface acres and stores about 11,100 acre-feet of water. The refuge has the right to use all of the storage capacity of the reservoir.

The South Fork Pit River supplies are diverted to the adjacent floodplain wetland units when flows are adequate. Diversions are usually possible year-round except at lowest flow periods in July and August. In addition, the refuge has water rights to divert directly from Pine Creek for irrigation and stock water on the south and east management units of the refuge. Total annual water use on the refuge is approximately 11,000 acre-feet.

Ash Creek Wildlife Area

The water supply for the Ash Creek WA is provided by seasonal flows from Ash Creek and five other streams. These flows maintain natural and managed refuge wetlands. The water supply is managed by a flow-through system on an available flow basis, with water returning to Ash Creek downstream of refuge wetlands.

Private Wetlands

Water supplies for private wetlands are not certain for this area. Most rely on spring runoff and additional flows to maintain year-round wetlands. Others may utilize return flows from irrigated pastures and/or wild rice units when available.

Constituents of Concern

Constituents of concern for the Pit River as identified by the CWA 2002 section 303(d) and Central Valley Water Board are nutrients, organic enrichment/low DO, and temperature. The primary potential sources of these constituents are agriculture and grazing.

Current Management Practices

All management practices utilized at the Modoc NWR and Ash Creek WA are intended to maintain and enhance wetland habitat for the benefit of the fish and wildlife resources that occur on each area. However, no management practices are specifically directed to address water quality concerns of discharged water. The current practices include:

- Water levels in wetland units are manipulated to encourage desirable wetland vegetation that will provide food and cover for waterfowl and other migratory water birds.
- Wet meadows at the Modoc NWR are irrigated from April through July annually and then allowed to dry to encourage maximum grass production.
- When mature in late August, the wet meadow grasses are mowed and baled by cooperators who remove the hay from the fields. The grasses are then ready to provide desirable habitat and food for Canada geese and sandhill cranes.
- Water diversion and distribution facilities are maintained to assure proper water flows and depths.

Available Water Quality Information

No direct water quality information for the wetlands supplies or return flows is currently known to be available. A water quality survey for baseline information on alkalinity, CO_2, hardness, DO, pH, and temperature was conducted at eight locations on Modoc NWR in 1996. However the results of this survey are not available from the refuge and will require further research if needed.

The Ash Creek WA does not conduct water quality-related activities. Management activities on both Modoc NWR and Ash Creek WA, as stated above, are intended to manage wetland habitat for the

benefits of utilizing wildlife populations; any improvement to water quality would be considered an ancillary benefit.

Colusa Subbasin

Managed Wetlands

Sacramento National Wildlife Refuge

Sacramento NWR is located in Glenn and Colusa Counties, 6 miles south of the city of Willows. The refuge was authorized in 1937 and presently totals 10,783 acres. The refuge is managed as a waterfowl wintering area. Seasonal, semi-permanent, and permanent wetlands are managed for waterfowl and other wetlands-dependent wildlife that utilize the refuge.

Delevan National Wildlife Refuge

Delevan NWR was authorized in 1962; it is located east of the town of Maxwell, in Colusa County. The refuge totals 5,797 acres of uplands, semi-permanent wetlands, and seasonal wetlands. The refuge wetlands are managed for migrating and wintering waterfowl and other wetlands-dependent birds.

Colusa National Wildlife Refuge

Colusa NWR was authorized in 1944 and currently totals 4,956 acres just west of the city of Colusa in Colusa County. The refuge manages seasonal and semi-permanent wetlands for migrating and wintering waterfowl and for several listed threatened and endangered species, such as the giant garter snake.

Sacramento River National Wildlife Refuge

Sacramento River NWR was authorized in 1986; it entails several units along 77 miles of the Sacramento River between the Cities of Tehama to Colusa. The refuge currently consists of 10,000 acres of riparian and floodplain wetlands, as well as walnut, prune, and almond orchards. The orchards are managed by the previous land owner or co-operator and will be until the trees are removed and replaced with native riparian vegetation. The Llano Seco unit contains the only managed wetlands of the refuge. These seasonal wetlands are managed for migrating and wintering waterfowl and shorebirds.

Private Wetlands

The major private wetlands areas in the Colusa Subbasin are located in the Willow Creek and Lurline areas in Colusa County. These areas consist of seasonal wetlands flooded from October through February for wintering waterfowl and recreational hunting. The Willow Creek area is located east of the Sacramento NWR, and the Lurline area is located south of Delevan NWR. USFWS holds conservation easements on 6,000 acres of these private wetlands. The Department of Fish and Game (DFG) also has an active conservation easement program in this basin and has acquired easements on 358 acres to date.

Water Supplies

National Wildlife Refuges

The Sacramento, Delevan, and Colusa NWRs are authorized to receive Central Valley Project (CVP) water supplies per the 1992 Central Valley Project Improvement Act (CVPIA). These water supplies are used to manage refuge wetland units and enhance riparian habitat.

Sacramento River National Wildlife Refuge

The Llano Seco unit contains the only managed wetlands in the Sacramento NWR. Water supplies for this area are provided by the Parrot Ranch under its Butte Creek water right.

Constituents of Concern

Constituents of concern for the Colusa Subbasin as identified by the Central Valley Water Board for the Colusa Basin Drain include the following:

- Azinphos-methyl,
- Carbofuran/Furadan,
- Diazinon,
- Group A pesticides,
- Malathion,
- Methyl Parathion,
- Molinate/Odram, and
- Unknown toxicity.

The primary source of these constituents is agriculture and/or irrigation tailwater.

Current Management Practices

National Wildlife Refuges

Management practices utilized on each of the NWRs in the Colusa Basin are intended to flood and/or maintain several types of wetland habitats and, more recently, to irrigate riparian forest restorations at the Sacramento River NWR. None of the management practices are undertaken to specifically address potential water quality concerns. Management practices that may provide ancillary benefits to water quality include the following:

- Irrigation of seasonal wetland units for waterfowl food production through application of water to encourage plant growth in a unit and allowing water to dissipate through evapotranspiration. This practice is utilized primarily for the production of swamp timothy.

- Manipulation of water levels in wetland units to maximize habitat benefits and encourage desirable vegetation that will provide cover for waterfowl and other migratory water birds. This management practice is utilized on seasonal semi-permanent and permanent wetlands.
- Control of undesirable vegetation and densities is generally conducted through mechanical and controlled fire practices.
- Use of herbicides/pesticides is limited to upland areas, and all chemical use requires completion and approval of pesticide use proposals (PUPs) in accordance with USFWS and Department of Interior requirements. In 2004–2005, 99 acres were treated within the refuge complex. When use of aquatic herbicides in deemed necessary, it is strictly controlled by an extensive list of procedures to ensure that application is conducted only when it is certain that no treated water will leave the confines of the refuge.
- Mosquito abatement is conducted by the appropriate abatement district and is subject to PUP application and approvals.
- Flood-up for fall and winter waterfowl use begins August 1st and continues on a stage basis until full habitat availability is reached, usually by October 1st. Once all desired habitat is flooded, it is maintained on a flow-through basis until draw down is initiated beginning in early March.
- Irrigation for food production is initiated in late April. Swamp timothy units receive a single irrigation each spring, except in dry years. Watergrass and mixed marsh units generally receive two to three irrigations, after which plants are allowed to mature, and then flooded in accordance with a schedule developed each year.

Available Water Quality Information

Water quality information for the NWRs in the Colusa Subbasin is limited. Most of the information is contained in investigations or conducted research associated with waterfowl disease and mosquito abatement activities. The USGS conducted an investigation, *Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex, California* (Investigation Report 92-4036).

In addition, from 1986 to1989, the USFWS National Wildlife Health Laboratory and Northern Prairie Research Center conducted research on avian botulism in waterfowl on the complex. This research involved several environmental quality aspects of the disease cycle; water quality, both supply and wetland water, was included. A number of reports were generated and are available in refuge files.

In cooperation with mosquito abatement districts, the refuge recently has conducted abatement activities research that has targeted impacts on non-target organisms (both single application and cumulative affects) and has involved a number of quality parameter tests. No formal reports have been published.

A wastewater treatment plant is operated at the Sacramento NWR headquarters. The facility is a class 3B and subject to State Water Board regulations and requirements related to water quality and containment. The system is designed to be self-contained; no water is released from the plant into any stream, wetland, or upland. Over the past 5 years, major improvements to the overall system have been implemented, including a 1-acre second evaporation pond.

No water quality information is known to exist specifically addressing the privately owned and managed wetlands in the Willow Creek-Lurline areas.

Butte-Yuba-Sutter Subbasin

Managed Wetlands

Sutter National Wildlife Refuge

Sutter NWR was authorized in 1944 and totals 2,591 acres. The refuge is located in the Sutter Flood Bypass south of Highway 20 and west of Yuba City. The refuge was established to assist in the alleviation of crop damage caused by wintering waterfowl. The refuge is presently managed for this purpose and to provide habitat for wintering waterfowl and other wetlands-dependent migratory birds.

Butte Sink National Wildlife Refuge

Butte Sink NWR was authorized in 1976 and consists of 10,254 acres of conservation easements on privately owned wetlands and 733 acres of fee title wetlands. The fee title area is managed as seasonal wetlands for wintering waterfowl and migratory shorebirds.

Gray Lodge Wildlife Area

Gray Lodge WA, managed by DFG, totals 9,200 acres; 6,300 acres are managed wetlands. The refuge is one of the first wildlife areas established in the Central Valley. It is managed for migratory waterfowl as a wintering area and public hunting and fishing in accordance with State regulations.

Upper Butte Basin Wildlife Area

Upper Butte Basin WA is located west of Gridley, adjacent to Butte Creek. The area totals 9,376 acres of which 6,800 acres are managed wetlands. The WA is composed of three management units: Howard Slough, Little Dry Creek, and Llano Seco. Providing waterfowl and upland game habitat and providing public hunting opportunities are the primary objectives of the WA.

Spenceville Wildlife Area

Spencerville WA is located in Nevada and Yuba Counties, 15 miles east of Marysville. The WA totals 11,448 acres; of these, 81 acres are managed wetlands. The remainder of the area contains foothill oak and grassland habitat. The wetlands are managed to provide water for upland game and habitat for waterfowl.

Private Wetlands (Butte Sink)

Discussion of the Butte Sink NWR occurs above. In addition to the USFWS conservation easements, 8,000 acres of privately owned wetlands are found adjacent to and within the Butte Sink. DFG also has an active easement program in this basin, currently protecting 3,416 acres of the private wetlands. These wetlands are primarily managed as waterfowl hunting clubs. Water in the private Butte Sink wetlands is

managed on a flow-through basis to maintain water quality and to minimize effects on salmonids that migrate up and down Butte Creek.

Water Supplies

Sutter National Wildlife Refuge

Sutter NWR is authorized to receive waters supplies from the CVP in accordance with the CVPIA. However, the refuge is awaiting a final conveyance agreement and is currently utilizing the same water supplies available prior to enactment of CVPIA.

The water supply for the 500 acres located outside the Flood Bypass is provided by the Sutter Extension Water District and by groundwater. The Sutter Extension supplies are a firm reliable Feather River supply that is expected to continue. Groundwater is utilized to supplement needs, primarily in late winter.

The water supply for the wetlands inside the Flood Bypass consists of diversions from the East Borrow Channel under USFWS water rights and winter flood flows. Sufficient water flows are diverted to the East Borrow Channel by water managers to meet the needs of diverters from that channel, including the refuge.

Butte Sink National Wildlife Refuge

Water supplies for the 733 acres of fee title lands within Butte Sink NWR are diverted from Butte Creek, the primary water course through the Sink. This water is diverted upstream of the NWR and flows through adjacent private hunting clubs before reaching the NWR. These lands and other wetlands within the Butte Sink are entitled to water supplies in fall and winter in accordance with a 1925 agreement with agricultural and other users upstream of the managed wetlands. In addition, the Butte Sink area is frequently flooded during winter, when high water flows in the Sacramento River and Butte Creek are diverted into the area at the Colusa Weir. These flows continue through the Sink to the Sutter Flood Bypass before co-mingling with Feather River flows and back to the Sacramento River.

Gray Lodge Wildlife Area

Gray Lodge WA is authorized to receive water supplies from the CVP in accordance with CVPIA. Reclamation recently entered into an agreement with the Biggs West Gridley Water District (BWGWD) to convey CVPIA supplies to the refuge. The agreement allows for a 6- to 7-year facility upgrade period before full CVPIA supplies can be delivered on a reliable basis. Therefore, the WA continues to utilize water rights and BWGWD entitlements for primary and secondary lands supplemented by groundwater from refuge wells.

Upper Butte Basin Wildlife Area

The Upper Butte Basin WA water supplies include the Sacramento River and Butte Creek water purchased from the Parrot Ranch, Feather River water purchased from Western Canal Water District and Richvale Irrigation District, and groundwater from WA wells.

Spenceville Wildlife Area

Managed wetlands on the Spenceville WA are provided with water purchased from Nevada Irrigation District.

Private Wetlands (Butte Sink)

The water supply for the private wetlands in the Butte Sink is primarily derived from the 1925 agreement mentioned above in the NWR discussion. This water is diverted from Butte Creek. In addition, groundwater is utilized to meet wetland needs.

Private wetlands adjacent to the Butte Sink rely on agricultural and other wetland return flows to meet water supply needs.

Constituents of Concern

The major constituent of concern for Butte Creek and the Sutter Bypass, as identified in the Central Valley Water Board 2002 section 303(d) list, is diazinon. The potential source for this constituent is crop-related runoff and agriculture.

Current Management Practices

Management practices utilized on the managed wetlands in the Butte-Yuba-Sutter Subbasin are intended to flood and/or maintain several types of wetland habitats and, more recently, to irrigate riparian restorations. Management practices that may provide ancillary benefits to water quality include the following:

- Seasonal wetland units are irrigated in spring for waterfowl food production through application of water to encourage plant growth in a unit and allowing water to dissipate through evapotranspiration. This practice is utilized primarily for the production of swamp timothy.
- Water levels in wetland units are manipulated in fall and winter to maximize habitat benefits and encourage desirable vegetation that will provide cover for waterfowl and other migratory water birds.
- Undesirable vegetation and densities is controlled through mechanical and controlled fire practices.
- Use of herbicides/pesticides is limited to upland areas. All chemical use on USFWS NWRs requires completion and approval of a PUP in accordance with USFWS and Department of Interior requirements.
- Mosquito abatement is conducted by the appropriate abatement districts. The districts conducting abatement activities on NWRs are also subject to PUP application and approvals.
- Flood-up for fall and winter waterfowl use begins August 1st and continues on a staged basis until full habitat availability is reached, usually by October 1st. Once all desired habitat is flooded, it is maintained on a flow-through basis until draw down is initiated beginning in late February and early March.

- Irrigation for food production is initiated in late April. Swamp timothy units receive one irrigation except in dry years. Watergrass and mixed marsh units generally receive two to three irrigations, after which plants are allowed to mature, and then flooded in accordance with a pre-developed schedule.

Available Water Quality Information

Available information for the Sutter and Butte Sink NWRs is found in USGS Investigation Report No. 92-4036, as discussed above for the Colusa Subbasin. The reports developed from the avian disease research discussed for the Colusa Basin also may contain water quality information on the Sutter NWR.

Groundwater currently provides a portion of wetland water supplies at the Gray Lodge WA. DFG measures groundwater levels for both active and inactive wells on a monthly basis and provides the information to Reclamation. Reclamation collects monthly EC, pH, and DO samples from each well used to provide surface supply. In addition, Reclamation tests (1) groundwater for specific conductance, arsenic, chromium, iron, and manganese; and (2) surface water for DO, specific conductance, chromium, hardness, and pH—prior to pumping groundwater and 1 month after pumping stops.

Reclamation is proposing to expand surface water monitoring at major inflow and outflow points for temperature and EC.

WDRs (Order No. 5-01-088) have been issued to DFG for the closed Spenceville Mine at the Spenceville WA. Monitoring is required as part of the Monitoring and Reporting Program for the unsaturated zone; reclaimed pit; and groundwater specific conductance, pH, TDS, TSS, turbidity, alkalinity, hardness, manganese, sodium, potassium, calcium, magnesium, chloride, sulfate, and 11 metals.

DFG purchases approximately 25 miners inches of water per year from Nevada Irrigation District to augment flow in Wellman Creek during the April–October period. This added flow improves water quality below the Farm Ditch in the “1,000 Acre” parcel.

At the Upper Butte Basin WA, Reclamation recently initiated monitoring of groundwater quality at two wells. Specific information on the type of monitoring is lacking at this time.

Solano-Yolo Subbasin

Managed Wetlands

Yolo Bypass Wildlife Area

The Yolo Basin WA is located in the Yolo Flood Bypass east of the City of Davis. The WA manages over 15,830 acres for fish, wildlife, and recreational benefits and includes 4,066 acres of managed wetlands.

Private Wetlands (Conaway Ranch)

Private wetlands in the Solano-Yolo Subbasin are primarily located within the Yolo Flood Bypass. The total amount of private wetlands is estimated at over 17,000 acres. USFWS has a perpetual conservation easement on 4,531 acres of private wetlands. DFG also has an active conservation easement program in

the Yolo Bypass, with a total of 1,763 acres under easement. In addition, NRCS has a wetland easement and restoration program under the WRP that has restored and protected over 2,000 acres of former agricultural lands in the Bypass. Several tracts owned and managed by other governmental agencies or non-profit organizations, such as Liberty Island, are areas that have reverted to wetlands due to levee breaches and are subject to tidal fluctuations.

Stone Lakes National Wildlife Refuge

Stone Lakes NWR was established in 1994 and currently manages 4,065 acres within the approved 18,000-acre boundary. A total of 1,400 acres of wetlands are currently managed, with additional wetland restoration planned for the near future. The NWR is in an active acquisition program aimed at meeting the land and habitat protection goals as approved in 1992.

Cosumnes River Preserve

Cosumnes River Preserve was established in 1987. This unique cooperative effort between local, state, and federal agencies and private conservation organizations has acquired over 40,000 acres of habitat, through fee and easement purchases, within the Cosumnes River watershed. The primary goal of the preserve is protection and restoration of the floodplain and associated riparian habitats along the only remaining free-flowing river in the Central Valley. The preserve has created over 1,500 acres of new wetlands, of which 1,080 are managed.

Water Supplies

Yolo Bypass Wildlife Area

The water supply for the Yolo Basin includes water diverted from Putah Creek and the Yolo Bypass toe drain.

Private Wetlands

Water supplies for the private wetlands within the Yolo Basin Flood Bypass are diverted from the toe drain, from the Sacramento River, and through pumped groundwater.

Stone Lakes National Wildlife Refuge

Water sources for Stone Lakes NWR include Morrison Creek, agricultural drainage, North and South Stone Lakes, and groundwater. The refuge also has many small waterways that originate in urban and agricultural areas and empty into refuge wetlands.

Cosumnes River Preserve

Water supplies for the Cosumnes River are dependent on tidal flows. The preserve has a secondary right to pump tidal water for management of the various habitat types on the area, including wetlands.

Constituents of Concern

The constituents of concern for the Solano-Yolo Subbasin are those identified for the Delta Waterways in the CWA 2002 section 303(d) list as identified by the Central Valley Water Board and include the following:

- Chlorpyrifos,
- DDT,
- Diazinon,
- Group A pesticides,
- Mercury, and
- Unknown toxicity.

The potential sources for these constituents are agriculture, urban runoff/storm sewers, and resource extractions (mining).

Current Management Practices

The Yolo Bypass WA does not undertake any wetland management practices that are designed to specifically address water quality concerns for return flows. Water management practices utilized for WA wetlands are similar to those discussed above for the other subbasin wetlands. These management practices may have ancillary benefits to water quality. As with the practices discussed above, habitat maintenance and enhancement are the primary focus of water management on the area.

Water management practices at Stone Lakes NWR are limited by available water supplies. Wetland units are flooded in early fall and maintained through winter. Some wetland units are influenced by tidal fluctuations in North and South Stone Lakes and in Snodgrass Slough.

The Cosumnes River Preserve water management practices depend on available river flows and are utilized in a manner similar to other managed wetlands in the Sacramento Valley. The primary focus of water management practices is the maintenance of wetlands for fall and winter, and restoration of riparian habitat.

Private wetlands are managed as waterfowl hunting areas and are flooded during fall and winter. The area routinely floods each year, inundating wetlands until flows recede in spring.

Available Water Quality Information

Yolo Basin Wildlife Area

The City of Woodland CALFED Bay-Delta Program Watershed Grant Agreement 4600001691 monitored bacteria, boron, metals, organic carbon, pesticides/herbicides, salinity, and total suspended solids throughout the Yolo Bypass, including one site on the Yolo Basin WA. The monitoring occurred over a 1-year period, and the agreement is proposing to produce a water quality management plan to address degradation of surface water.

The Sacramento River Watershed Program Mercury Methylation Study, Proposition 50 Grant, from the State Water Board proposes that water quality monitoring will provide an indication of the extent to which mercury transformation processes in wetlands may affect downstream water quality with regard to methylmercury. Water quality sampling will include selected inflow and outflow sites from the Yolo Basin WA wetlands. Water quality analyses will include filtered and unfiltered total mercury and methylmercury, total suspended solids, major cations, anions, trace metals, nutrients, and dissolved particulate carbon.

Stone Lakes National Wildlife Refuge

Various studies by the Sacramento Regional Wastewater Treatment Plant and USFWS have been completed to date on the refuge and in the surrounding area.

The contaminant assessment was conducted on Refuge waters by USFWS in 1997. The assessment provided known sources of contamination and a survey of potential contaminant sources, pathways, and problems.

Additional USFWS studies conducted in Morrison Creek during 1999 and 2000 found that levels of diazinon were sufficient to kill fish and affect other wildlife after a rainfall greater that 1 inch. The potential source of these pesticides is storm water runoff drainage, flushed through urban stormwater drains.

The Sacramento Regional Wastewater Treatment Plant conducts ongoing quarterly water sampling for certain trace elements from several sites along Morrison Creek, Laguna Creek, Meadowlark Lake, and Black Crown Lake. The USACE sampled water from the Morrison Creek Watershed from 1982 to 1984. Concentrations of cadmium, copper, and lead exceeded the EPA acute toxicity criterion for aquatic life in all samples. DFG and the State Water Board collected and analyzed large mouth bass from Meadowlark Lake from 1985 to 1987 and analyzed for heavy metals and organochlorine pesticides. Elevated levels of mercury, copper, chlordane, dacthal, total DDT, and total PCBs were detected.

Cosumnes River Preserve

University of California, Davis is conducting a remote monitoring program on the Cosumnes River. The overall goal of the monitoring program is to ascertain hydrogeomorphic and ecologic responses to the floodplain restoration program. The program uses levee breaches to reinstate natural processes on former agricultural lands for the purpose of recreating functioning floodplains that also reduce financial losses from floods. The supporting objectives include methodological concerns regarding how to address

geomorphic problems with multi-temporal scaling issues, as well as fundamental processes of water, sediment, and contaminant transport on floodplains.

In addition the USGS is monitoring mercury at one sample site on the Preserve as part of a nationwide program. A monitoring site has been established at Twin Cities Road to sample River flows as part of the subbasin compliance with the current Irrigated Lands Waiver Program.

WETLAND MANAGEMENT PRACTICES— SAN JOAQUIN VALLEY SUBBASINS

West Side San Joaquin Valley Subbasin

Managed Wetlands

San Luis National Wildlife Refuge Complex

The San Luis NWR Complex is composed of the San Luis NWR (San Luis, Kesterson, and West and East Gallo units), San Joaquin River NWR, and Merced NWR (Merced and Arena Plains units). Although the Merced NWR is located east of the San Joaquin River, it is included here to maintain the continuity of discussion of the overall NWR complex. The refuge complex totals approximately 43,000 acres. These refuges manage over 150 separate wetland units totaling 9,000 acres. The balance of the lands consists of native uplands, floodplains, vernal pools, riparian forest, and 1,974 acres of cropland.

Los Banos Wildlife Area

Los Banos WA was established in 1929 as the first of a series of waterfowl refuges established throughout the state for wintering waterfowl. The WA currently totals 6,217 acres of wetland habitat composed of lakes, sloughs and managed marsh. The refuge is located 4 miles northeast of the City of Los Banos in Merced County.

Volta Wildlife Area

Volta WA is located 0.75 mile north of the town of Volta in Merced County. The area totals 2,891 acres of managed marsh and valley alkali shrub. The area is managed as a wintering area for waterfowl and shorebirds.

North Grasslands Wildlife Area

The North Grasslands WA is comprised of the China Island Unit, the Salt Slough Unit, and the Gadwall Unit. The three units are close to the Cities of Los Banos and Gustine. The WA totals 7,069 acres of wetlands, riparian habitat, and uplands that are managed for wintering waterfowl, Swainson's hawk, and sandhill cranes.

Grassland Resource Conservation District

The Grassland RCD is comprised of the Grassland Water District (GWD); San Luis NWR; and Los Banos, Volta, and North Grassland WAs. The private lands within the Grassland Water District and RCD are hunting clubs totaling approximately 70,000 acres, of which about 39,000 are managed wetlands.

USFWS has an active conservation easement program in the RCD and has acquired easements on over 50,000 acres to date. DFG also has an active easement program within the San Joaquin River Subbasin and has acquired 994 acres of easements to date.

Water Supplies

The water supplies for the San Luis and Merced NWRs, Los Banos and Volta WAs, and the Grassland RCD are authorized by the CVPIA and provided by Reclamation from the CVP. However, the Merced NWR receives water supplies from the Merced Irrigation District as mitigation for the New Exchequer Dam and also utilizes groundwater supplies.

Constituents of Concern

Constituents of concern for the Westside drainages as identified by CWA 2002 section 303(d) and the Central Valley Water Board include:

- Chlorypyrifos,
- Diazinon,
- EC,
- Selenium,
- Boron,
- Azimphos-methyl,
- DDE,
- Group A pesticides,
- Mercury,
- Sediment, and
- Unknown toxicity.

Table 5-3. CWA 303d List of Impaired Water Bodies near the West Side San Joaquin Valley

Waterbody	Constituent	Potential Sources
Del Puerto Creek	Chlorpyrifos, diazinon	Agriculture
Grassland Marshes	Electrical conductivy (EC)	Agriculture
Ingram Hospital Creek	Chlorpyrifos, diazinon	Ag return flows
Mendota Pool	Selenium	Agriculture, agricultural return flows, groundwater withdrawal, other
Mud Slough	EC, selenium, boron, unknown toxicity, pesticides	Agriculture
Newman Wasteway	Chlorpyrifos, diazinon	Agriculture
Orestimba Creek	Unknown toxicity, chlorpyrifos, diazinon, azinphos-methyl, DDE	Agriculture
Panoche Creek	Selenium, mercury, sediment	Agriculture, grazing, roads, mining
Salt Slough	EC, boron, unknown toxicity, chlorpyrifos, diazinon	Agriculture
San Joaquin River		
Bear Creek to Mud Slough	EC, boron, unknown toxicity, chlorpyrifos, diazinon, Group A pesticides, DDT, mercury	Agriculture, mining
Mendota Pool to Bear Creek	EC, boron, unknown toxicity, chlorpyrifos, diazinon, Group A pesticides, DDT	Agriculture
Merced River to South Delta Boundary	EC, boron, unknown toxicity, chlorpyrifos, diazinon, Group A pesticides, DDT, mercury	Agriculture, mining
Mud Slough to Merced River	EC, selenium, boron, unknown toxicity, chlorpyrifos, diazinon, Group A pesticides, DDT, mercury	Agriculture, mining

Current Management Practices

Existing Water Quality Monitoring

San Luis National Wildlife Refuge

Hourly flow and salinity data were collected throughout 2002 and 2003. Only one inlet and three outlets were instrumented in the San Luis Unit of the refuge complex. Of these, adequate data were obtained at only two of the outlets.

Grassland Water District

A more comprehensive monitoring network has been operational in GWD for the past 4 years. The monitoring network comprises both inlet and outlet sensors measuring flows and salinity, data are transmitted hourly to a satellite and made available to water managers on a district website.

Participation in the SJV Westside Coalition

The Grasslands wetland entities have chosen to become part of the San Joaquin Valley Westside Coalition in order to comply with monitoring guidelines developed for the Agricultural Waiver Program. A watershed conditions document that describes the unique characteristics of the wetlands and a monitoring program plan document that justifies the selection and monitoring frequency of the sites chosen for the program were filed by wetland signatories to the coalition.

Water Management Plans (5 year and yearly updates)

Focus on methods to improve water use efficiency and water quality on refuge water management plans should be revised as more data become available to characterize current conditions on the various wetland areas that make up the Grassland Ecological area. The water management plan updates should strive to document what constitutes a BMP relevant to each major wetland function and allow these practices to be refined, together with quantitative measures of water use, irrigation timing, and drainage management. Each updated water management plan also should include updates on quantitative measures of habitat quality to provide a baseline against which improved management practices and the result of their application can be compared.

Groundwater Wells

Groundwater wells were installed in the refuges as a hedge against water shortages. Wells yielding water of acceptable quality (typically below 1,500 ppm TDS) are used conjunctively in refuges such as the San Luis NWR to supplement existing water supply. Wells in the State-managed wetlands are less frequently used owing to the added cost of groundwater pumping. There are no District-owned production wells in the GWD. Domestic wells within the District service local duck clubs.

Grasslands Drainage Pilot Study

The State Water Board has provided funding for a pilot implementation study of real-time water quality management in the Grasslands Ecological area. The study will comprise three paired sites in the GWD and State WMAs. These paired sites include a control site that will be managed using traditional techniques for a period of 3 years and a treatment site that will be managed traditionally in year 1 and practice delayed wetland drawdown (between April 15 and May 15) in years 2 and 3. Inlets and outlets of each pair of sites will be instrumented, and the telemetric data sent to the water master's office. Water monitoring will occur within each wetland to develop relationships between ambient wetland salinity and outlet salinity. Habitat assessment methodologies will be refined and implemented during each year of the study to provide a quantitative measure of the impacts of real-time water quality management implementation.

Available Water Quality Information

Recent studies and monitoring of water quality in the area west of the San Joaquin River include:

- USFWS studies of selenium contaminant levels in migratory birds (1989 and 1994).
- Operational USFWS Selenium Monitoring of Mud Slough and Salt Slough (1989–1995).
- "Selenium in the Ecosystem of the Grassland Area of the San Joaquin Valley: Has the Problem Been Fixed?" (2004).

- "Salinity, Boron, and Nutrient Monitoring of Wetland Source Waters and Discharges at the San Luis National Wildlife Refuge Complex" (2002).
- "Evaluation of the Effects of Management of the San Luis National Wildlife Refuge Complex Wetlands on the Dissolved Oxygen Problem in the San Joaquin River Deep Water Ship Channel" (2004).
- Grassland Bypass Project (1996–present).
- The Grassland Bypass Project is an innovative program that was designed to improve water quality in the channels used to deliver water to wetland areas. Prior to the project, subsurface drainage water was conveyed through those channels in route to the San Joaquin River (see previous discussion on page 5-18).
- Westside Drainage Coalition (2003–present)

California Department of Fish and Game—Los Banos Wildlife Area

Electrical conductivity measurements have been taken by DFG staff at eight major intake locations and two major drainage locations along Mud Slough periodically between January 2001 and November 2004.

Beginning in March 2005, monitoring resumed on a bi-weekly basis. As part of the Conditional Waiver, several sites are monitored near the Los Banos WA. Salt Slough at Sand Dam is monitored by the Westside Coalition, sampling for general physical characteristics, water column toxicity, sediment toxicity, drinking water constituents, and pesticides. Boundary Drain is monitored by the San Luis Canal Company upstream from the WA boundary. This site is a real-time monitoring station collecting data on EC and stage. USFWS maintains a real-time monitoring station on Salt Slough at Wolfsen Road that collects continuous data on temperature, flow, and EC.

Volta Wildlife Area

In March 2005, DFG staff began measuring EC at two major intake locations, a major drainage into the Volta Wasteway and the two major drainage locations at the WA boundary. A real-time monitoring station along the Volta Wasteway has been maintained by GWD since 2002 and continues to be monitored as part of the Conditional Waiver. GWD also conducts monthly grab sampling at this location for boron and selenium.

North Grasslands Wildlife Area—Salt Slough Unit

DFG staff have taken EC measurements at seven major drainage locations periodically since 2001. As part of the Conditional Waiver, several sites are monitored near the Salt Slough Unit. USFWS maintains four sites nearby that monitor general physical parameters, organic carbon, and several other constituents.

North Grasslands Wildlife Area—China Island Unit

Currently, only one monitoring location (near China Island) is maintained by the Westside Coalition as part of the Conditional Waiver. The site is located in the Newman Wasteway; however, the WA does not receive or discharge water into the Wasteway.

U.S. Fish and Wildlife Service—San Luis National Wildlife Refuge

Hourly flow and salinity data were collected throughout 2002 and 2003. Only one inlet and three outlets were instrumented in the San Luis Unit of the refuge complex. Similar monitoring systems will need to be installed at the inlet and outlets of the other management units of the San Luis NWR complex as well as in the state WA complex. Adequate resources need to be devoted to station maintenance in order to ensure data quality.

Grassland Water District

A more comprehensive monitoring network has been operational in the Grassland Water District (GWD) for the past 4 years. The monitoring network comprises both inlet and outlet sensors measuring flow and salinity. Data are transmitted hourly to satellite and made available to water managers on a district website.

GWD also has the following information on file:

- Grassland Water Task Force—Water Quality Analysis/Monitoring Reports 1985–1995; required by the Central Valley Water Board Program Nos. SJR001-SJR016.
- "Water Quality Impact of Wetlands on San Joaquin River, California," L. Grober, J. Karkoski, and T. Poole; 1994.
- Grassland Water District Drainage Operation Plans, 1989–c.1994; required by Central Valley Water Board.
- Inland Surface Water Plans, 1992–c.1994; required by Central Valley Water Board.
- "Real Time Water Quality Management in the Grassland Water District," Nigel Quinn et.al, December 2004 (covers the period from 2001 to 2004).
- Grassland Bypass Project, Monthly water quality monitoring and reporting 1996–current; data compiled by San Francisco Estuary Institute.

East Side San Joaquin Valley Subbasin

Managed Wetlands

Merced National Wildlife Refuge

Merced NWR was authorized under the Lea Act in 1944 and currently totals 8,358 acres. The Merced Unit of the refuge manages 1,550 acres of seasonal wetlands, 88 acres of semi-permanent wetlands, and 41 acres of permanent wetlands. In addition, the unit manages 40 acres of irrigated pasture and 453 acres of cropland.

The Arena Plains Unit totals 2,460 acres, which includes 222 acres of non-irrigated seasonal wetlands and 275 acres of semi-permanent wetlands.

Private Wetlands

Private wetlands east of the San Joaquin River are found on several private hunting clubs and large ranches south of Highway 140, north of Sandy Mush Road, and west of Highway 59. USFWS has conservation easements on approximately 12,000 acres, and recently acquired 2,000 acres that will be managed by the Merced NWR as the Sno-bird unit.

Water Supplies

The Merced NWR unit is authorized water supplies in accordance with the CVPIA. Because there are no facilities for delivery of CVP water, refuge supplies are provided by the Merced Irrigation District (MID), water rights on Duck and Deadman Sloughs, and groundwater. MID water is available only during the irrigation season (April–October). Fall and winter supplies rely on groundwater and water right diversions to maintain flooded wetlands.

The Arena Plains Unit water supplies are diverted under water right permits from the Atwater Drain and Bear Creek.

Private wetland water supplies are provided by groundwater, various water rights held by the landowners, and purchased water from neighboring water districts.

Constituents of Concern

Constituents of concern as identified under the CWA 2002 Section 303(d) for Bear Creek and the San Joaquin River from Bear Creek to Mud Slough are listed as follows:

- Boron,
- Chlorpyrifos,
- DDT,
- Diazinon,
- EC,
- Group A pesticides,
- Mercury, and
- Unknown toxicity.

Potential sources for these constituents are agriculture, resource extraction, and unknown.

Current Management Practices

Management practices for this area are essentially the same as those discussed above for the managed wetlands west of the San Joaquin River.

Available Water Quality Information

There is no information on water quality that is specific to the Merced NWR and private wetlands east of the San Joaquin River. Some of the studies discussed for the San Luis NWR may have data relative to Merced NWR.

Wetland Management Practices—Tulare Lake Subbasin

Managed Wetlands

Kern-Pixley National Wildlife Refuge Complex

Kern NWR was established in 1960 and consists of 10,618 acres of managed wetlands, riparian, and upland habitat. A total of 6,185 acres are managed as seasonal wetlands.

Pixley NWR was established in 1959 and consists of 6,192 acres. A total of 4,392 acres is set aside as endangered species habitat. Currently, approximately 400 acres of seasonal wetlands are managed on the refuge. The remaining 1,400 acres are managed as non-irrigated uplands and dry wetlands.

Mendota Wildlife Area

Mendota WA, located in Fresno County, consists of 11,800 acres of floodplain and managed wetlands habitat. The area is managed as a wintering area for migratory birds and for public hunting.

Private Wetlands

Private wetlands in the Tulare Lake Basin currently consist of approximately 3,000 acres of private hunting clubs primarily located north and east of the Kern NWR. In addition, NRCS has restored approximately 2,000 acres of former agricultural lands under the WRP. These wetlands are protected by conservation easements held by the USDA.

Water Supplies

Water supplies for the Kern NWR are authorized under the CVPIA and conveyed to the refuge by the Buena Vista Water Storage District.

Water supplies for Pixley NWR also are authorized under the CVPIA. Pending completion of a conveyance agreement and construction of facilities, the refuge is utilizing groundwater for the management of wetland units.

Water supplies for the Mendota WA are authorized by the CVPIA and are delivered by Reclamation through the Mendota Pool to Fresno Slough, where the water is then diverted onto the WA.

Water supplies for the private wetlands depend almost entirely on groundwater. During above-normal and wet hydrologic years, surface supplies may be available from local water storage districts such as the Semi-Tropic Water Storage District.

Constituents of Concern

No CWA Section 303(d) constituents have been identified for the Tulare Basin waters adjacent to the Kern and Pixley NWRs or private wetlands.

Selenium is a recognized constituent of concern at the Mendota WA, along with TDS and EC.

Current Management Practices

When Kern NWR has sufficient or excess water and permission from downstream landowners, the refuge utilizes a flow-through management practice to reduce the level of salts in impounded water. These flows are then released and utilized downstream on agricultural lands.

Inflow water is monitored to ensure that it is not excessively high in salts and other organic or inorganic compounds. Monitoring is conducted to ensure that water utilized on the refuge is the highest quality possible.

With the increase in reliable water supplies through the CVPIA, Kern has reduced the level of water recycling due to improved water quality. This should somewhat reduce the salt load in the water that may be released from the refuge.

The majority of water utilized on Kern NWR evaporates or percolates into the soil. The relatively small amount of water that is discharged is utilized on adjacent farmland or seeps into the soil in the Goose Lake Canal.

On Pixley NWR, the wetland units are also used for groundwater recharge; thus no waters are discharged off the refuge. On the private wetlands, water is applied in early fall and winter for waterfowl hunting. Following the close of the hunting season, water is allowed to evaporate and percolate into the soil.

Management practices at the Mendota WA are directed toward maintaining quality wetland habitat for migrating and wintering migratory birds, primarily waterfowl and shorebirds. These management practices are similar to those of other managed wetlands in the Valley.

Available Water Quality Information

Kern NWR monitors twice yearly for the following constituents: DO, EC, molybdenum phosphorus, pH, TDS, boron, sodium, arsenic, and selenium. Reports are available in the refuge files.

DISCUSSION

The total acreage of managed wetlands in the Central Valley Watershed from Modoc NWR in the north to Kern NWR in the south is about 144,000 acres. These wetlands are principally located in the lower elevations of the various subbasins in which they occur. These low areas have traditionally served as the receiving lands for return flows from upland water users. This is especially true following the major alteration to historical flows for flood control and agriculture.

Water quality has been a concern of wetland managers for more than 50 years. This concern, however, was focused on water being used to manage wetlands rather than waters being discharged to downstream rivers. As a result, limited information is available about the water quality of wetland discharges. The majority of the available information is for wetlands in the Westside San Joaquin River Subbasin; San Luis NWR; Grassland RCD and Volta, Los Banos, and North Grassland WAs.

The CVPIA has resulted in a beneficial effect on water reliability, quality, and management for a major portion of Central Valley wetlands. For the most part, the quality of water available for wetland management has improved. Wetlands nationwide have been known as natural filtering systems for many constituents; it is anticipated that, over time, the wetlands' authorized supplies for the CVPIA also will result in improved quality of return flows.

The management practices that are utilized by wetland managers are essentially uniform throughout the Central Valley. The primary management objective is to provide quality wetland habitat for migrating and wintering populations of migratory birds, primarily waterfowl and shorebirds. Therefore, management practices are focused on meeting that objective. The principle type of wetlands managed are seasonal wetlands, either irrigated for waterfowl food production (swamp timothy/watergrass) or non-irrigated. Irrigated seasonal wetlands receive water one to three times between April and June each year, depending on the food plants desired and geographic location of the area. These wetlands, along with non-irrigated seasonal wetlands, are then flooded in early fall and maintained through the winter until February or March, when they are gradually drawn down to achieve desired soil temperatures for germination of desired food plants.

Other wetland types being managed include permanent year-round marsh units and semi-permanent wetlands. The semi-permanent wetlands, also known as brood ponds, are usually dewatered for 2–3 months around July of each year and may be re-flooded for the fall and winter waterfowl migrations. These two wetland types comprise about 10% of the total wetlands in the Central Valley Watershed.

Typical management of wetlands in past years did not consider the quality of return flows as a principle focus of any of the standard management practices. With a few minor exceptions, this is still the existing condition today. To better understand the water quality of return flows and whether wetlands and wetland management practices are impacting that quality, monitoring of inflow and outflow waters may be desirable. However, some wetland managers feel that, due to the location of wetlands throughout the Valley and the public trust responsibilities for the resources that utilize them, wetlands should be considered receiving waters of the State. Thus, water supplies that flow to and through wetlands and are used for their management should be held to the same standards as other receiving waters within the subbasin in which the wetlands are located.

Overall, the primary finding of the current existing conditions for Central Valley managed wetlands is that the information on water quality can be found where concerns have existed for many years. The information is primarily found for wetlands in the Westside San Joaquin River Subbasin. All the other

subbasins have very limited information, if any, and management practices are not focused on improving the quality of discharged waters. Nevertheless, some management practices may result in ancillary benefits to wetland return flows. A more in-depth review, as the Water Quality Program moves forward and the expected EIR is developed, may help in determining the overall role of wetlands in the larger-scale management of water supplies throughout the entire Central Valley Watershed.

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Appendix A

Surface Water Quality Data

[Data files are on a separate compact disc.]

Appendix B
Flow Data Tables

Appendix B

Flow Data Tables

Introduction

The Central Valley is divided into three major surface water basins: (I) Sacramento River Watershed, (II) San Joaquin River Watershed, and (III) Tulare Lake Basin Watershed. Each of these three basins is divided into subwatersheds delineated by California Department of Water Resources (DWR) CalWater boundaries, or a hybrid of these boundaries if the hybrid was determined to be more accurate in defining the watershed. This appendix provides flow data for these three basins and their subwatersheds.

Sources of Data and Information

Flow data was obtained from the California Data Exchange Center (CDEC) and the U.S. Geological Survey (USGS) websites (<http://cdec.water.ca.gov>; <http://water/usgs.gov/data.html>).

California Data Exchange Center

The CDEC is maintained by the DWR Division of Flood Management. It contains current and historical flow for all of California. Users locate individual stations through a user-friendly map interface. Once the desired stations are located, a user may download one parameter from one station at a time, and the same limitations apply to downloading 3 or 4 years of hourly or 15-minute data at a time. After the data sequence is displayed on the screen, the user may select to save it to a file, or select a spreadsheet program to open it directly.

U.S. Geological Survey

The USGS maintains a database of current and historical flow from many flow stations in California. These data are available through the USGS website, as well as on a CD database product that is updated annually by a commercial vendor (Hydrosphere Data Products). It is important to note that sometimes data between stations do not cross over between the website and the Hydrosphere product.

Hourly or 15-minute flow data are available in the real-time portion of the USGS database. Stations can be selected by state, station name, identification number, period of record, etc. Once a station is selected, individual parameters can be saved in a tab-separated file and then opened in a spreadsheet and error-checked. This USGS website is one of the more user-friendly database interface and retrieval systems available.

I. Sacramento River Basin Watershed

A. Pit River Watershed

B. Shasta-Tehama Watershed

C. Upper Feather–Upper Yuba River Watershed

D. Colusa Basin Watershed

E. Butte-Sutter-Yuba Watershed

F. Lake-Napa Watershed

G. Solano-Yolo Watershed

H. American River Watershed

I.A. Pit River Watershed

Table B-1. Monthly Average Flows in the Pit River Watershed (1995–2004)

	Pit River at Canby			McCloud River above Lake Shasta			Sacramento River at Delta Ca		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	71	443	1,625	342	2,054	5,093	430	3,105	7,188
Feb	75	527	1,686	725	2,064	4,777	1,421	3,257	7,116
Mar	67	519	1,276	763	1,688	4,847	1,189	2,881	6,639
Apr	78	400	842	543	1,076	2,231	1,356	2,332	3,386
May	10	695	2,188	359	806	2,050	912	1,926	3,718
Jun	8	321	1,624	270	521	1,514	409	1,068	3,672
Jul	1	59	193	225	357	565	235	440	1,145
Aug	3	45	103	200	306	538	205	309	548
Sep	11	71	209	220	301	547	203	287	602
Oct	15	98	247	231	303	549	206	303	613
Nov	48	123	388	232	433	1,020	265	640	1,340
Dec	69	198	416	311	1,131	3,533	307	1,850	5,754

Flows are in cubic feet per second (cfs).

Sources: Data for the Pit River at Canby were obtained from the USGS website at <http://waterdata.usgs.gov/>.
Data for McCloud and Sacramento River were obtained from the CDEC website at <http://cdec.water.ca.gov/>.

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I.B. Shasta-Tehama Watershed

Table B-2. Monthly Average Flows in the Shasta-Tehama Watershed (1995–2004)

	Clear Creek near Igo			Cow Creek near Millerville			Mill Creek near Los Molinos			Deer Creek near Vina			Cottonwood Creek near Cottonwood			Elder Creek near Paskenta			Sacramento River at Red Bluff		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	190	490	1,132	645	2,286	4,625	184	646	1,592	177	847	2,326	614	2,912	8,831	7	176	1,208	6,968	22,604	56,787
Feb	211	492	1,569	723	2,220	5,491	247	614	1,069	270	862	1,800	1,170	4,254	12,140	2	109	366	8,456	28,543	68,396
Mar	186	359	797	501	1,494	4,519	310	535	1,200	368	746	2,066	852	2,907	7,092	4	104	892	8,103	23,290	55,449
Apr	167	267	578	324	920	1,926	259	460	655	252	565	1,238	509	1,311	2,496	2	38	250	7,446	12,264	24,973
May	99	215	499	129	729	2,406	276	507	830	150	469	1,057	297	947	2,425	2	31	203	10,334	14,731	22,923
Jun	66	127	172	36	304	1,336	142	389	790	102	239	651	122	494	2,082	1	8	65	12,650	14,808	21,153
Jul	58	81	150	18	90	313	110	228	510	82	141	251	67	173	495	1	4	21	13,603	15,186	16,765
Aug	53	85	151	12	50	145	93	142	226	75	112	170	60	86	178	2	3	9	10,589	12,388	15,787
Sep	51	113	227	17	53	121	89	119	163	78	105	147	53	72	122	1	3	7	7,936	9,249	11,901
Oct	128	171	210	22	86	149	88	118	153	80	110	141	61	85	140	1	5	17	5,788	7,074	8,110
Nov	128	208	282	94	411	1,307	123	177	329	117	180	390	62	259	991	2	15	31	6,115	7,766	14,090
Dec	170	326	580	226	1,315	2,473	133	393	755	124	497	1,424	153	1,238	3,645	0	48	107	6,501	13,199	23,625

Flows are in cfs.

Source: USGS website.

I.C. Upper Feather River–Upper Yuba River Watershed

Table B-3. Monthly Average Flows in the Upper Feather River–Upper Yuba River Watershed (1995–2004)

	Feather River at Oroville			North Yuba River below New Bullards Bar Dam*			Middle Yuba River below Our House Dam*			South Yuba River at Jones Bar			Bear River below Camp Far West Reservoir		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	618	3,338	26,748	10	18	38	31	64	144	93	447	838	12	14	22
Feb	619	2,312	7,477	34	322	1,002	36	157	531	219	738	1,657	11	14	19
Mar	617	2,684	18,873	16	475	786	32	50	65	197	531	851	11	14	22
Apr	615	813	2,490	9	328	1,227	43	47	49	220	446	721	24	27	32
May	620	1,481	7,916	9	19	37	53	64	104	112	611	1,323	26	28	30
Jun	617	634	668	30	98	224	42	47	58	52	602	2,281	26	27	30
Jul	621	658	718	11	33	56	29	33	36	43	93	284	10	11	13
Aug	618	665	799	9	20	47	22	30	36	33	48	74	10	11	13
Sep	623	636	659	9	14	20	22	28	35	14	34	53	10	11	13
Oct	627	807	1,580	8	14	26	22	28	33	34	50	70	11	13	14
Nov	626	884	1,633	9	48	94	30	32	34	62	102	181	12	13	18
Dec	620	1,337	5,764	8	28	85	34	64	153	72	307	586	12	14	16

Flows are in cfs.

* North Fork River flows are for 1998–2001 and Middle Fork Yuba River flows are for 2000–2004.

Source: USGS website.

I.D. Colusa Basin Watershed

Table B-4. Monthly Average Flows in the Colusa Basin Watershed (1995–2004)

	Sacramento River at Verona			Cache Creek at Yolo			Bear Creek above Holsten Chimney near Rumsey*			Sulphur Creek at Wilbur Springs*			Harley Gulch near Wilbur Springs*			Colusa Basin Drain*		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	15,416	37,717	71,035	81	2,322	7,177	14	104	252	3	9	17	0.27	1.02	2.32	1,289	1,477	1,678
Feb	16,034	44,100	69,817	181	3,081	12,617	35	287	1,029	3	14	35	0.34	2.79	7.25	2,249	2,463	2,703
Mar	17,752	38,249	62,248	108	2,391	7,003	21	103	180	2	7	13	0.23	1.19	1.95	732	808	896
Apr	10,397	24,617	52,577	23	796	2,843	10	45	126	1	2	4	0.16	0.3	0.41	300	456	519
May	7,802	22,375	49,810	15	267	812	5	31	124	1	1	3	0.07	0.13	0.23	403	473	552
Jun	10,532	18,907	44,507	5	73	418	3	13	57	0	0	1	0.02	0.03	0.05	423	478	534
Jul	13,384	18,024	21,681	3	38	141	1	4	14	0	0	0	0	0.01	0.02	495	532	577
Aug	12,132	16,525	21,255	3	38	139	1	2	6	0	0	0	0	0.01	0.02	872	904	942
Sep	11,175	14,593	20,997	2	37	106	1	2	5	0	0	0	0	0.01	0.02	649	684	728
Oct	7,360	9,809	12,881	1	40	73	1	3	5	0	0	0	0	0.02	0.07	225	257	307
Nov	10,201	11,923	18,437	5	41	82	3	12	32	0	1	4	0.02	0.21	0.52	620	667	775
Dec	11,658	25,271	44,855	17	537	1,622	3	103	259	1	13	26	0.14	3.28	6.9	1,079	1,167	1,267

Flows are in cfs.

* Bear Creek flows are for 1997–2004, Sulphur Creek flows are for 1999–2004, Harley Gulch flows are for 2000–2004, and Colusa Basin Drain flows are for 1998–2004.

Source: USGS website.

I.E. Butte-Sutter-Yuba Watershed

Table B-5. Monthly Average Flows in the Butte-Sutter-Yuba Watershed (1995–2004)

	Feather River near Oroville			Yuba River near Marysville			Bear River below Camp Far West Reservoir			Sacramento River near Verona			Sutter Bypass			Butte Creek near Chico		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	618	3,338	26,748	828	5,522	26,180	12	14	22	15,416	37,717	71,035	34	4,117	35,080	175	1,033	2,847
Feb	619	2,256	7,241	1,024	5,470	11,056	11	14	19	16,034	44,100	69,817	0	4,389	35,110	424	1,068	2,266
Mar	617	2,684	18,873	864	5,000	14,119	11	14	22	17,752	38,249	62,248	0	4,409	35,140	318	935	2,601
Apr	615	907	3,429	780	3,193	6,542	24	27	32	10,397	24,617	52,577	20	323	855	285	715	1,510
May	620	1,390	7,007	302	3,667	9,230	26	28	30	7,802	22,375	49,810	877	1,359	1,641	208	620	1,314
Jun	617	635	668	263	2,526	7,289	26	27	30	10,532	18,907	44,507	1,190	1,444	1,626	178	355	773
Jul	621	659	719	845	1,554	2,747	10	11	13	13,384	18,024	21,681	1,456	1,548	1,649	125	192	356
Aug	618	665	798	939	1,548	2,242	10	11	13	12,132	16,525	21,255	746	1,303	1,456	115	151	211
Sep	623	637	658	463	796	1,398	10	11	13	11,175	14,593	20,997	558	775	893	100	132	183
Oct	627	814	1,594	431	785	1,145	11	13	14	7,360	9,809	12,881	395	672	1,365	83	128	186
Nov	626	883	1,624	443	823	1,620	12	13	18	10,201	11,923	18,437	506	611	880	114	201	367
Dec	619	1,555	7,728	696	2,206	8,036	12	14	16	11,658	25,271	44,855	367	513	690	135	557	1,809

Flows are in cfs.

Source: USGS website.

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I.F. Lake-Napa Watershed

Table B-6. Monthly Average Flows in the Lake-Napa Watershed (1995–2004)

	Cache Creek near Yolo			Cache Creek near Lower Lake			Putah Creek near Guenoc		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	81	2,322	7,177	4	987	3,047	133	432	676
Feb	181	3,081	12,617	4	1,459	4,988	132	764	1,295
Mar	108	2,391	7,003	7	1,325	3,957	137	332	557
Apr	23	796	2,843	11	616	2,187	47	166	352
May	15	267	812	180	541	761	20	97	264
Jun	5	73	418	180	483	702	4	36	145
Jul	3	38	141	153	482	641	1	9	37
Aug	3	38	139	250	390	505	0	3	11
Sep	2	37	106	5	228	326	0	1	7
Oct	1	40	73	5	86	182	0	2	8
Nov	5	41	82	2	4	6	10	79	201
Dec	17	537	1,622	3	71	255	21	564	1,444

Flows are in cfs.

Source: USGS website.

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I.G. Solano-Yolo Watershed

Table B-7. Monthly Average Flows in the Solano-Yolo Watershed (1995–2004)

	Sacramento River at Freeport			Putah Creek near Winters		
	Min	Mean	Max	Min	Mean	Max
Jan	17,251	43,997	87,116	66	116	438
Feb	18,232	52,203	80,867	67	274	607
Mar	21,316	44,644	74,782	81	292	629
Apr	12,178	29,311	61,315	180	383	529
May	9,194	27,865	63,350	322	506	654
Jun	12,422	22,777	53,557	561	645	726
Jul	14,840	21,753	30,452	589	662	725
Aug	13,067	18,593	24,007	502	570	657
Sep	12,303	16,575	24,742	356	409	448
Oct	8,214	12,004	15,679	169	218	267
Nov	11,501	14,299	22,405	68	86	110
Dec	13,752	29,479	68,604	61	80	102

Flows are in cfs.

Sources: USGS website. Sacramento River and Putah Creek flows were from the CDEC website.

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I.H. American River Watershed

Table B-8. Monthly Average Flows for the American River Watershed (1995–2004)

	Sacramento River at Freeport			American River at Fair Oaks			Arcade Creek at Del Paso			Morrison Creek near Sacramento*			South Fork American River at Chili Bar		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	17,251	43,997	87,116	1,470	6,698	31,245	7	61	181	11	40	93	627	1,351	2,476
Feb	18,232	52,203	80,867	1,507	7,298	14,656	2	80	232	11	98	281	455	1,813	3,600
Mar	21,316	44,644	74,782	1,507	5,513	18,157	4	17	27	11	19	27	693	1,857	3,273
Apr	12,178	29,311	61,315	1,594	4,472	8,408	2	15	35	7	12	21	942	1,928	3,332
May	9,194	27,865	63,350	1,805	5,499	13,816	2	11	28	5	9	17	1,075	2,392	3,709
Jun	12,422	22,777	53,557	2,230	4,083	7,601	1	2	4	3	5	7	323	1,425	2,513
Jul	14,840	21,753	30,452	2,110	3,941	10,562	1	2	3	4	6	7	309	856	1,211
Aug	13,067	18,593	24,007	1,558	2,369	4,007	2	3	9	4	6	9	285	1,043	1,717
Sep	12,303	16,575	24,742	1,558	2,369	4,007	1	2	7	3	5	9	200	912	1,367
Oct	8,214	12,004	15,679	1,268	2,130	2,765	1	5	17	4	7	11	127	469	698
Nov	11,501	14,299	22,405	964	2,236	3,483	2	17	31	6	13	17	274	589	1,064
Dec	13,752	29,479	68,604	1,454	3,515	14,008	0	47	101	3	25	52	497	862	1,254

Flows are in cfs.

* Morrison Creek flows are 1998–2004.

Relevant data were not available for the Auburn Ravine, Coon Creek, or the Markham Ravine.

Sources: USGS website. SFAR monthly average flows are from 1997 to 2004. Data for SFAR obtained from CDEC website.

II. San Joaquin River Watershed

A. Cosumnes River Watershed

B. Delta-Mendota Canal Watershed

C. San Joaquin River Watershed

D. San Joaquin Valley Floor Watershed

E. Delta-Carbona Watershed

F. Ahwahnee Watershed

G. Mariposa Watershed

H. Upper Mokelumne–Upper Calaveras Watershed

I. Merced River Watershed

J. North Valley Floor Watershed

K. Stanislaus River Watershed

L. Tuolumne River Watershed

II.A. Cosumnes River Watershed

Table B-9. Monthly Average Flows in the Cosumnes River Watershed (1995–2004)

	Laguna Creek (Station 11336585)			Cosumnes River (Station 11335000)		
	Min	Mean	Max	Min	Mean	Max
Jan	4	46	206	140	1,516	7,129
Feb	2	75	254	255	1,520	3,490
Mar	0	9	22	346	1,431	4,515
Apr	0	3	9	403	996	2,182
May	0	1	2	171	831	2,202
Jun	0	1	3	43	305	1,084
Jul	0	1	2	14	86	263
Aug	0	1	2	6	32	87
Sep	0	1	2	5	24	67
Oct	0	0	1	9	32	65
Nov	0	2	4	32	82	188
Dec	0	19	92	70	448	2,599

Flows are in cfs.

Source: USGS website.

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II.B. Delta-Mendota Canal Watershed

Table B-10. Monthly Average Flows in the Delta-Mendota Canal Watershed (1995–2004)

	Del Puerto Creek near Patterson			Orestimba Creek at River Road			Mud Slough near Gustine			San Luis Drain (Site B)			Salt Slough at Highway 165		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	2	28	130	15	98	574	98	225	545	22	30	60	118	205	426
Feb	2	53	333	17	149	698	126	303	956	48	67	126	180	340	632
Mar	2	30	132	5	84	318	137	252	545	53	65	115	275	380	512
Apr	1	10	28	8	60	185	47	92	200	35	50	91	146	211	305
May	0	4	18	9	62	243	44	79	123	40	51	80	120	172	275
Jun	0	2	9	11	29	97	23	69	98	47	56	61	124	182	284
Jul	0	1	3	15	32	104	10	68	114	51	58	74	146	198	293
Aug	0	0	1	9	22	62	7	58	90	45	56	64	135	194	336
Sep	0	0	1	3	15	43	17	52	108	23	31	53	59	122	217
Oct	0	0	2	12	38	121	23	134	190	18	24	33	100	129	175
Nov	0	2	3	10	38	101	74	159	195	19	24	29	144	166	211
Dec	0	12	53	9	36	78	119	176	305	20	24	32	103	136	214

Flows are in cfs.

Source: USGS website.

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II.C. San Joaquin River Watershed

Table B-11. Monthly Average Flows in the San Joaquin River Watershed

	San Joaquin River near Auberry (CDEC Station SJA)		
	Min	Mean	Max
Jan	604	2,277	9,058
Feb	604	2,317	4,303
Mar	1,375	3,117	6,277
Apr	2,294	3,488	5,911
May	2,425	4,781	8,418
Jun	2,192	5,661	11,874
Jul	1,287	3,849	11,300
Aug	1,335	2,260	4,241
Sep	1,300	1,785	2,944
Oct	712	1,166	1,789
Nov	456	1,077	1,927
Dec	511	1,292	3,540

Flows are in cfs.

Source: CDEC website.

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II.D. San Joaquin Valley Floor Watershed

Table B-12. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Stanislaus River (1995–2004)

	Stanislaus River at New Melones Powerhouse			Stanislaus River below Goodwin Dam			Stanislaus River at Ripon		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	82	998	5,984	236	1,100	6,005	309	1,211	6,273
Feb	199	1,696	6,683	263	1,801	6,036	367	1,940	6,499
Mar	100	1,600	3,446	213	1,315	3,180	337	1,539	3,473
Apr	1,002	2,097	2,935	601	1,145	1,936	607	1,182	1,976
May	1,939	2,580	2,988	772	1,268	2,046	834	1,356	2,067
Jun	1,970	2,460	3,137	480	934	1,798	550	1,024	1,867
Jul	1,676	2,200	3,575	264	572	1,861	414	674	1,875
Aug	1,634	2,051	3,592	226	472	1,791	318	562	1,792
Sep	1,053	1,476	2,844	184	414	1,634	278	514	1,702
Oct	–*	825	2,579	339	603	1,738	332	668	1,951
Nov	–*	373	909	253	364	530	311	460	962
Dec	–*	671	3,152	252	676	3,300	308	706	3,194

Flows are in cfs.

* No data at New Melones Powerhouse or below Goodwin Dam for October 1, 2004–December 31, 2004.

Source: USGS website.

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Table B-13. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Tuolumne River (1995–2004)

	Tuolumne River at Modesto Canal Diversion[a]			Tuolumne River at Turlock Canal Diversion[a]			Tuolumne River below La Grange[a]			Tuolumne River at Dry Creek Inflow[b]			Tuolumne River at Modesto[a]		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	6	83	237	0	181	544	176	1,932	13,074	18	114	441	298	2,393	15,498
Feb	44	83	168	0	274	599	171	3,193	8,116	4	276	974	262	3,620	8,782
Mar	121	292	642	454	764	1,457	165	2,733	5,407	9	80	179	299	3,103	5,665
Apr	250	541	720	699	1,111	1,304	558	2,298	6,920	28	56	156	718	2,507	7,163
May	310	640	872	800	1,227	1,710	412	2,117	7,935	35	56	80	582	2,273	7,862
Jun	655	785	954	1,243	1,539	1,725	54	1,136	4,918	48	100	400	240	1,334	5,481
Jul	781	892	1,041	1,805	1,893	2,081	88	764	3,104	57	71	93	238	924	3,291
Aug	703	807	927	1,489	1,607	1,796	86	409	1,107	69	85	105	241	612	1,437
Sep	461	555	719	617	824	1,063	68	537	2,067	44	77	103	227	753	2,365
Oct	268	382	609	358	573	883	189	474	1,460	16	41	110	334	703	1,794
Nov	0	88	195	0	16	59	184	288	392	4	9	20	248	403	520
Dec	0	50	86	0	89	301	177	800	4,625	1	29	141	299	941	4,996

Flows are in cfs.

[a] Source: Data obtained from USGS website. No data for Turlock Canal for October 1, 2004–December 31, 2004. Measurements at Modesto are taken 0.2 miles downstream of Dry Creek.

[b] Source: Data obtained from CDEC website. No measurements until April 1997.

Table B-14. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Merced River (1995–2004)

	Merced River below Merced Falls[a]			Merced River at Dry Creek near Snelling[b]			Merced River at Cressy[c]			Merced River near Stevinson[d]		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	201	1,064	7,368	8	48	209	194	269	346	233	434	762
Feb	214	1,763	6,686	0	108	336	208	573	1,784	217	1,182	4,878
Mar	443	1,554	3,043	5	47	160	206	649	2,196	235	1,161	2,742
Apr	1,087	1,936	3,904	0	14	66	324	666	1,171	364	1,272	3,291
May	1,688	2,423	4,781	0	4	14	497	679	886	403	1,240	3,755
Jun	1,650	2,314	4,847	0	1	9	164	197	242	117	798	3,232
Jul	1,746	2,343	4,804	0	0	3	110	120	143	83	582	2,497
Aug	1,343	1,682	2,484	0	0	0	76	94	118	74	217	568
Sep	748	1,244	2,424	0	1	4	84	147	348	65	292	970
Oct	711	1,255	2,601	0	2	8	277	349	578	175	486	1,111
Nov	236	363	551	0	3	13	226	305	478	215	345	580
Dec	209	543	2,180	2	38	182	211	294	435	223	311	471

Flows are in cfs.

[a] Missing October 2004–December 2004. Source: Data from USGS website.

[b] Missing January 1995–April 1997. Source: Data from CDEC website.

[c] Missing January 1995–March 1999. Source: Data from CDEC website.

[d] Missing November 1995–April 1997. Source: Data from CDEC website.

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Table B-15. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Bear Creek (1995–2004)

	Bear Creek at Bear Reservoir Release			Bear Creek near McKee Road*		
	Min	Mean	Max	Min	Mean	Max
Jan	0	125	428	1	240	1,035
Feb	0	116	473	11	357	1,306
Mar	0	80	370	9	158	457
Apr	0	32	135	24	87	137
May	0	12	35	20	143	255
Jun	0	5	18	27	181	306
Jul	0	3	12	39	181	267
Aug	0	2	12	33	144	215
Sep	0	2	10	10	65	128
Oct	0	3	13	6	50	120
Nov	0	5	15	0	34	114
Dec	0	22	59	0	68	208

Flows are in cfs.

* No data from McKee Road gage for 1995 and 1996.

Source: CDEC website.

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Table B-16. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Chowchilla River (1995–2004)

	Chowchilla River Downstream of Eastman Lake Release		
	Min	Mean	Max
Jan	0	188	1,852
Feb	0	188	1,107
Mar	0	131	334
Apr	0	77	525
May	0	43	183
Jun	26	163	323
Jul	114	214	340
Aug	7	173	503
Sep	0	66	168
Oct	0	819	7,459
Nov	0	10	104
Dec	0	67	633

Flows are in cfs.

Source: CDEC website.

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Table B-17. Monthly Average Flows in the San Joaquin Valley Floor Watershed, Fresno River (1995–2004)

	Fresno River Downstream if Hensley Lake Release		
	Min	Mean	Max
Jan	0	158	1,487
Feb	0	238	1,020
Mar	0	162	823
Apr	0	77	331
May	0	109	193
Jun	41	167	287
Jul	118	193	272
Aug	73	144	221
Sep	0	64	145
Oct	0	73	291
Nov	0	23	169
Dec	0	95	746

Flows are in cfs.

Source: CDEC website.

Table B-18. Monthly Average Flows in the San Joaquin Valley Floor Watershed, San Joaquin River (1995–2004)

	San Joaquin River below Friant Dam[a]			San Joaquin River near Mendota[b]			San Joaquin River at Fremont Ford Bridge[c]			San Joaquin River near Crows Landing[d]			San Joaquin River near Vernalis[e]		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	73	1,021	9,144	14	95	144	263	5,538	25,603	888	3,930	25,603	1,792	5,911	30,377
Feb	95	1,195	6,514	185	288	341	233	5,730	23,389	804	6,219	23,389	1,879	10,954	35,057
Mar	86	1,099	4,203	209	248	329	329	2,404	6,034	870	3,547	10,134	2,134	9,362	19,352
Apr	97	1,297	6,074	179	222	259	182	787	1,991	706	2,735	13,983	2,598	7,657	21,937
May	131	1,460	7,637	257	305	359	149	898	2,800	937	2,564	12,094	2,625	7,524	22,187
Jun	189	1,162	6,535	496	528	556	144	441	1,132	454	1,895	11,887	1,404	5,034	17,760
Jul	201	1,185	5,322	546	579	601	158	373	800	403	1,401	8,176	1,147	3,613	13,193
Aug	191	274	464	397	405	421	145	376	812	408	692	1,757	1,116	2,227	5,442
Sep	181	237	383	183	227	292	83	316	797	326	640	1,842	1,121	2,407	5,758
Oct	133	195	357	103	185	247	103	723	2,338	631	1,115	2,338	1,705	3,145	6,153
Nov	87	158	378	66	148	186	165	553	1,027	731	955	1,228	1,647	2,284	3,290
Dec	82	278	1,147	1	73	158	145	1,153	4,364	687	1,338	4,364	1,503	3,374	12,192

Flows are in cfs.

[a] data from January 1995–September 2004.

[b] data from December 1999–September 2004.

[c] data from October 2001–September 2004.

[d] data from October 1995–September 2004.

[e] data from January 1995–September 2004.

Source: USGS website.

II.E. Delta-Carbona Watershed

Table B-19. Monthly Average Flows in the Delta-Carbona Watershed, San Joaquin River (1995–2004)

	San Joaquin River near Vernalis			Grant Line Canal at Tracy Boulevard[a]			Middle River at Middle River			Old River at Bacon Island			San Joaquin River at Jersey Point		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	1,792	5,911	30,377	1,456	1,519	1,603	-5,059	-1,075	11,992	-3,934	-1,226	10,550	6,086	20,788	81,847
Feb	1,879	10,954	35,057	1,254	1,898	3,338	-4,713	177	11,359	-3,890	22	9,304	2,025	26,079	69,726
Mar	2,134	9,362	19,352	1,364	2,635	5,184	-4,878	-869	4,294	-2,823	357	3,895	492	15,664	35,201
Apr	2,598	7,657	21,937	1,020	1,096	1,172	-2,590	-984	5,269	-1,649	190	4,667	-1,008	9,261	33,464
May	2,625	7,524	22,187	413	769	1,125	-2,333	-708	2,969	-785	351	3,503	2,821	9,085	26,572
Jun	1,404	5,034	17,760	139	139	139	-5,715	-2,927	1,877	-2,802	-1,405	2,075	1,491	7,319	24,083
Jul	1,147	3,613	13,193	70	275	481	-5,755	-4,754	-848	-4,438	-3,234	-18	-517	3,060	11,638
Aug	1,116	2,227	5,442	-37	231	500	-5,808	-4,951	-3,556	-4,682	-3,661	-2,321	-1,579	2,099	7,143
Sep	1,121	2,407	5,758	-48	-48	-48	-5,580	-4,716	-3,318	-3,933	-3,018	-1,558	1,342	2,937	5,403
Oct	1,705	3,145	6,153	-33	279	590	-4,731	-3,508	-2,620	-3,438	-2,375	-1,473	222	3,796	8,054
Nov	1,647	2,284	3,290	696	919	1,142	-4,522	-3,223	-1,467	-3,291	-2,301	-864	2,554	4,256	5,612
Dec	1,503	3,374	12,192	1,328	1,375	1,412	-4,779	-2,936	-80	-3,686	-1,903	152	37	6,894	21,292

Flows are in cfs.

Data for all locations except Vernalis had gaps.

[a] Data collected 2000–2004. For April–November there were only 1–2 years with flow measurements.

Source: USGS website.

II.F. Ahwahnee Watershed

Table B-20. Monthly Average Flows in the Ahwahnee Watershed (1995–2004)

	Eastman Lake			Hensley Lake		
	Min	Mean	Max	Min	Mean	Max
Jan	32	309	1,623	38	311	1,689
Feb	34	347	1,242	57	332	991
Mar	47	259	793	69	294	815
Apr	14	158	609	38	204	639
May	13	85	262	29	133	385
Jun	4	51	191	7	62	256
Jul	4	27	46	4	26	69
Aug	2	11	33	7	13	17
Sep	2	8	30	3	14	27
Oct	2	11	21	2	16	34
Nov	5	36	133	5	37	156
Dec	6	159	1,004	15	128	781

Flows are in cfs.

Source: CDEC website.

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II.G. Mariposa Watershed

Table B-21. Monthly Average Flows in the Mariposa Watershed (1995–2004)

	Bear Creek			Owens Creek			Mariposa Creek		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	12.06	100.77	427.30	1	26	110	9	214	815
Feb	5.80	131.05	444.41	1	29	93	6	197	725
Mar	5.00	83.68	319.00	0	27	76	7	145	422
Apr	1.57	35.38	126.75	1	16	34	3	73	181
May	0.00	12.96	32.63	0	12	22	4	49	100
Jun	0.00	6.14	17.23	0	8	21	1	24	83
Jul	0.00	3.49	12.00	0	5	15	1	4	7
Aug	0.00	2.67	12.00	0	3	14	0	0	0
Sep	0.00	2.06	9.13	0	4	15	0	0	0
Oct	0.00	2.97	13.06	0	4	14	0	2	17
Nov	0.00	8.06	26.78	0	5	19	0	14	73
Dec	2.00	56.02	322.71	0	10	50	0	83	505

Flows are in cfs.

Source: CDEC website.

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II.H. Upper Mokelumne River–Upper Calaveras River Watershed

Table B-22. Monthly Average Flows in the Upper Mokelumne River–Upper Calaveras River Watershed (1995–2004)

	Mokelumne River near Mokelumne Hill			Calaveras River below New Hogan Reservoir*		
	Min	Mean	Max	Min	Mean	Max
Jan	308	1,400	5,659	2	257	1,223
Feb	314	1,371	2,189	1	469	1,933
Mar	617	1,579	3,338	2	520	2,843
Apr	781	1,504	2,936	1	228	1,397
May	443	2,052	4,031	61	149	234
Jun	521	2,115	5,014	67	191	251
Jul	498	1,007	2,821	67	202	271
Aug	483	639	929	77	203	265
Sep	454	592	813	3	128	197
Oct	397	579	825	3	58	122
Nov	327	608	880	2	293	1,559
Dec	451	802	2,286	2	441	1,755

Flows are in cfs.

* Calaveras River flows are from 1988 to 1992.

Source: USGS website.

II.I. Merced River Watershed

Table B-23. Monthly Average Flows in the Merced River Watershed (1995–2004)

	Merced River		
	Min	Mean	Max
Jan	247.7	1,962.3	8,106.2
Feb	542.2	1,686.3	4,258.1
Mar	928.9	1,907.8	4,393.3
Apr	1,304.8	2,517.3	3,489.7
May	2,178.3	4,054.3	6,301.3
Jun	500.1	3,172.5	8,030.6
Jul	110.3	900.2	4,538.9
Aug	3.5	226.1	1,146.9
Sep	0.4	88.2	465.5
Oct	6.9	85.6	287.3
Nov	40.4	288.5	944.9
Dec	56.7	745.2	3,740.4

Flows are in cfs.
Source: USGS website.

II.J. North Valley Floor Watershed

Table B-24. Monthly Average Flows in the North Valley Floor Watershed, Mokelumne River (1995–2004)

	Mokelumne River below Comanche Reservoir*			Mokelumne River at Woodbridge*		
	Min	Mean	Max	Min	Mean	Max
Jan	242	861	4,978	194	906	4,746
Feb	239	1,552	4,315	183	1,466	4,285
Mar	258	1,372	2,725	181	1,019	2,262
Apr	283	978	2,923	173	547	1,490
May	423	1,075	3,155	166	572	1,660
Jun	378	1,242	3,847	39	619	2,085
Jul	321	1,011	2,932	41	518	2,561
Aug	258	674	1,770	34	298	1,462
Sep	220	436	1,447	30	86	149
Oct	243	350	639	96	141	199
Nov	230	317	372	195	280	320
Dec	235	546	1,991	199	517	1,861

Flows are in cfs.

* Both sites are missing data for October–December 2004. Woodbridge site also is missing January 1995–September 1996.

Source: USGS website.

Table B-25. Monthly Average Flows in the North Valley Floor Watershed, New Hogan Reservoir (1995–2004)

	New Hogan Reservoir		
	Min	Mean	Max
Jan	29	468	3,105
Feb	22	744	3,093
Mar	13	213	669
Apr	59	181	538
May	130	214	517
Jun	175	221	347
Jul	181	235	334
Aug	172	219	337
Sep	133	179	308
Oct	44	95	255
Nov	24	94	402
Dec	26	189	1,278

Flows are in cfs.
Data were not continuous.
Source: CDEC station NHG.

II.K. Stanislaus River Watershed

Table B-26. Monthly Average Flows in the Stanislaus River Watershed (1995–2004)

	Stanislaus River		
	Min	Mean	Max
Jan	471	2,310	9,759
Feb	624	2,140	3,606
Mar	921	2,400	5,084
Apr	1,305	2,309	3,968
May	1,109	3,109	6,335
Jun	588	2,836	6,950
Jul	482	1,549	4,406
Aug	592	968	1,471
Sep	478	927	1,255
Oct	396	834	1,228
Nov	448	681	1,053
Dec	640	1,210	3,659

Flows are in cfs.
Source: CDEC website.

II.L. Tuolumne River Watershed

Table B-27. Monthly Average Flows in the Tuolumne River Watershed (1995–2004)

	Don Pedro Reservoir		
	Min	Mean	Max
Jan	707	4,444	14,315
Feb	1,512	4,255	7,601
Mar	1,646	4,345	6,477
Apr	2,109	4,061	5,696
May	2,371	5,476	10,366
Jun	315	5,164	10,264
Jul	292	3,092	9,880
Aug	250	1,006	2,368
Sep	152	580	1,010
Oct	292	498	848
Nov	194	575	1,266
Dec	225	1,510	6,517

Flows are in cfs.
Data were not continuous.
Source: CDEC station DNP

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III. Tulare River Watershed

A. Kings River Watershed

B. Kaweah River Watershed

C. Kern River Watershed

D. South Valley Floor Watershed

E. Grapevine Watershed

F. Coast Range Watershed

G. Fellows Watershed

H. Temblor Watershed

I. Sunflower Valley Watershed

J. Southern Sierra Watershed

III.A. Kings River Watershed

Table B-28. Monthly Average Flows in the Kings River Watershed (1997–2004)

	North Fork Kings River below Dinkey Creek*			Kings River at Meadowbrook		
	Min	Mean	Max	Min	Mean	Max
Jan	59	201	470	0	9	15
Feb	71	205	398	0	10	18
Mar	227	350	451	0	27	85
Apr	402	512	700	0	69	155
May	350	665	1,006	0	188	346
Jun	94	235	464	0	163	506
Jul	45	55	73	0	77	503
Aug	38	42	47	0	11	67
Sep	37	41	47	0	4	18
Oct	32	51	99	0	2	6
Nov	44	82	143	0	6	17
Dec	40	83	122	0	6	15

Flows are in cfs.

* Data on the North Fork Kings River are from 1999 to 2004.

Source: USGS website.

III.B. Kaweah River Watershed

Table B-29. Monthly Average Flows in the Kaweah River Watershed (1985–1990)

	Kaweah River (11208600)		
	Min	Mean	Max
Jan	27	186	1,250
Feb	32	170	439
Mar	82	275	529
Apr	234	442	633
May	382	795	1,051
Jun	134	667	2,039
Jul	13	312	1,512
Aug	14	66	244
Sep	8	23	87
Oct	12	24	60
Nov	11	78	335
Dec	16	66	271

Flows are in cfs.
Source: USGS website.

III.C. Kern River Watershed

Table B-30. Monthly Average Flows in the Kern River Watershed (1994–2004)

	Kern River near Democrat Springs (11192501)			South Fork Kern River near Onyx California (11189500)		
	Min	Mean	Max	Min	Mean	Max
Jan	220	453	921	26	101	500
Feb	300	715	2,467	35	108	240
Mar	379	811	2,441	64	198	493
Apr	409	988	2,046	84	328	923
May	551	1,436	3,693	52	340	1,465
Jun	911	1,961	4,593	18	154	915
Jul	943	1,824	3,735	2	48	279
Aug	576	1,508	3,315	1	21	84
Sep	281	842	1,805	1	16	57
Oct	216	634	1,451	8	22	51
Nov	190	574	1,497	22	66	293
Dec	254	465	1,336	23	49	117

Flows are in cfs.

Source: USGS website.

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III.D. South Valley Floor Watershed

Table B-31. Monthly Average Flows in the South Valley Floor Watershed (1994–2004)

	Deer Creek near Fountain Springs[a]			Kaweah River below Terminus Dam[b]			Kern River below Kern Canyon Diversion Dam[a]			Kings River (CMS)[c]		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	10	68	440	53	213	444	21	176	630	0	699	4,715
Feb	16	82	364	65	425	1494	23	316	1,234	0	563	3,796
Mar	21	68	213	25	529	2569	29	344	1,634	0	164	910
Apr	13	64	318	50	349	1775	26	274	1,543	0	543	3,496
May	6	51	211	52	472	1654	18	479	3,378	0	613	4,113
Jun	2	28	153	599	1,216	1,784	16	812	4,191	0	661	4,477
Jul	0.27	11	67	632	1,008	1,801	16	791	3,375	0	669	3,790
Aug	0	5	29	59	313	909	15	528	2,667	0	179	976
Sep	0	4	20	20	61	210	16	201	1,442	0	120	669
Oct	2	5	19	8	19	33	16	155	1,134	0	22	83
Nov	7	18	46	14	32	83	21	153	1,093	0	20	71
Dec	9	30	145	48	200	519	21	160	1,278	0	81	430

Flows are in cfs.

[a] Kern River, Deer Creek, and White River—USGS data from January 1994 to September 2004.

[b] Kaweah River and Tule River—USGS data January 1985 to September 1990.

[c] Kings River—CDEC data from January 1997 to June 2003.

[d] Panoche Creek—USGS data from December 1997 to June 2004 (January–June, and December for all years).

Sources: USGS and CDEC websites.

Table B-31 is continued on the next page.

Table B-31. Continued

	Panoche Creek at I-5 near Silver Springs[d]			Tule River below Success Dam[b]			White River near Ducor[a]		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	0	0.4	3	20	94	209	1.95	20	97
Feb	0	46	316	0.27	150	560	3.38	31	155
Mar	0	4	23	10	214	1,096	3.75	30	107
Apr	0	2	11	44	104	368	2.89	28	165
May	0	0.65	4	20	59	95	0.42	18	88
Jun	0	0.63	2	34	122	244	0	8	59
Jul				84	230	382	0	2	21
Aug				46	139	431	0	0.66	7
Sep	No Flow Available			22	69	196	0	0.49	5
Oct				8	63	226	0	0.77	8
Nov				0.52	29	79	0	4	12
Dec	0	0.29	2	3	62	201	0.3	11	29

Flows are in cfs.

[a] Kern River, Deer Creek, and White River—USGS data from January 1994 to September 2004.

[b] Kaweah River and Tule River—USGS data January 1985 to September 1990.

[c] Kings River—CDEC data from January 1997 to June 2003.

[d] Panoche Creek—USGS data from December 1997 to June 2004 (January–June, and December for all years).

Sources: USGS and CDEC websites.

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III.E. Grapevine Watershed

No flow data are available for the Grapevine Watershed on the USGS or CDEC websites.

III.F. Coast Range Watershed

Table B-32. Monthly Average Flows in the Coast Range Watershed (1995–2004)

	Panoche Creek near I-5 (11255575)*			Los Gatos Creek near Coalinga California (11224500)			Cantua Creek near Cantua Creek California (11253310)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Jan	0	0.5	3	0	17	111	0	7	31
Feb	0	53	316	0.25	25	160	0.1	11	64
Mar	0	5	23	0.04	36	237	0.1	17	102
Apr	0	2	11	0	9	35	0.2	5	21
May	0	0.8	4	0	7	43	0	3	14
Jun	0.1	0.7	2	0	2	13	0	1	7
Jul				0	0.6	4	0	0.5	3
Aug				0	0.2	2	0	0.1	1
Sep		No Data		0	0.2	1	0	0.1	1
Oct				0	0.3	1	0	0.1	1
Nov				0	0.5	2	0	0.2	2
Dec	0	0.4	2	0	2.5	12	0	1.1	5

Flows are in cfs.

* Panoche Creek data are from 1998 to 2004

Source: USGS website.

III.G. Fellows Watershed

No flow data are available for the Fellows Watershed on the USGS or CDEC websites.

III.H. Temblor Watershed

No flow data are available for the Temblor Watershed on the USGS or CDEC websites.

III.I. Sunflower Valley Watershed

Table B-33. Monthly Average Flows in the Sunflower Valley Watershed (1995–2004)

	Avenal Creek near Avenal, California (11197250)		
	Min	Mean	Max
January	0	5.7	28.9
February	0	23.8	111.8
March	0	14.4	44.6
April	0	4.7	17.0
May	0	1.5	9.2
June	0	0.6	4.7
July	0	0.3	2.0
August	0	0.2	1.2
September	0	0.2	1.4
October	0	0.2	0.7
November	0	0.3	1.6
December	0	2.9	11.9

Flows are in cfs.
Source: USGS website.

III.J. Southern Sierra Watershed

Table B-34. Monthly Average Flows in the Southern Sierra Watershed (1995–2004)

	Tule River		
	Min	Mean	Max
Jan	13	163	666
Feb	9	278	954
Mar	82	342	1130
Apr	67	322	989
May	51	262	948
Jun	23	153	902
Jul	1	59	361
Aug	0	22	144
Sep	0	20	80
Oct	3	38	105
Nov	4	86	274
Dec	10	157	582

Flows are in cfs.
Source: USGS website.

Appendix C
Water Quality Objectives

Appendix C
Water Quality Objectives

Table C-1. Water Quality Objectives

Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
GENERAL				
pH	6.5–8.5 units 7.5–9.5 (Goose Lake)	Numeric	Basin Plan Objective (multiple);	1, 2, 3
	6.5-8.3	Numeric	Tulare Basin Plan, page III-3 (multiple)	4
Electrical Conductivity	700 µmhos/cm	Numeric or Narrative	1995 Bay Delta Plan and *Water Quality for Agriculture*, Ayers and Westcot, 1985 (agriculture)	1, 2, 3
	Not to exceed 50th percentile or 90th percentile at Knights Landing above Colusa Drain or at I Street Bridge, based on previous 10 years of record	Numeric	Basin Plan Objective, page III-7.00, Table III-3, Sacramento River (multiple)	1
	Not to exceed 150 µmhos/cm in well-mixed waters of the Feather River	Numeric	Basin Plan Objective, page III-7.00, Table III-3, Designated reaches of the Feather River system (multiple)	1
	Not to exceed 150 µmhos/cm from Friant Dam to Gravelly Ford	Numeric	Basin Plan Objective, page III-7.00, Table III-3, San Joaquin River, Friant Dam to Mendota Pool (multiple)	3
	Variable, depends on water body	Numeric	Tulare Basin Plan, page III-5 (MUN, agriculture)	4
Dissolved Oxygen (minimum)	7.0 mg/L	Numeric	Basin Plan Objective, page III-5.00 (aquatic life)	1, 2, 3
	5.0 mg/L	Numeric	Basin Plan Objective, page III-5.00: for waters designated WARM (aquatic life)	1, 3

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Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
	6.0 mg/L	Numeric	Basin Plan Objective, page III-5.00: San Joaquin River between Turner Cut and Stockton from September through November 30.	2
	9.0 mg/L	Numeric	Basin Plan Objective, page III-5.00, Sacramento River from Keswick Dam to Hamilton City, 1 June to 31 August (aquatic life)	1
	8.0 mg/L (September 1–May 31)	Numeric	Basin Plan Objective, page III-5.00, Table III-2, Specific DO Water Quality Objectives, Feather River from Fish Barrier Dam at Oroville to Honcut Creek (aquatic life)	1
	8.0 mg/L	Numeric	Basin Plan Objective, page III-5.00, Table III-2, Specific DO Water Quality Objectives, Merced River from Cressy to New Exchequer Dam (aquatic life)	3
	8.0 mg/L (October 15–June 15)	Numeric	Basin Plan Objective, page III-5.00, Table III-2, Specific DO Water Quality Objectives, Tuolumne River from Waterford to La Grange (aquatic life)	3
	Variable, depends on water body and aquatic life designation	Numeric	Tulare Basin Plan, page III-3 and Table III-1 (aquatic life)	4
Turbidity	Variable	Numeric	Basin Plan Objective (varies based on natural turbidity) (multiple)	1, 2, 3, 4
Total Dissolved Solids	450 mg/L	Narrative	*Water Quality for Agriculture*, Ayers and Westcot, 1985 (agriculture)	1, 2, 3, 4
	125 mg/L	Numeric	Basin Plan Objective, page III-7.00, Table III-3, American River above and below Folsom Lake (multiple)	1
	100 mg/L	Numeric	Basin Plan Objective, page III-7.00, Table III-3, Folsom Lake (multiple)	1
	Not to exceed 1,300,000 tons	Numeric	Basin Plan Objective, page III-7.00, Table III-3, Goose Lake (multiple)	1
E. coli	235 MPN/ 100 mL	Narrative	USEPA Ambient Water Quality Criteria for Bacteria—1986 (contact recreation)	1, 2, 3, 4
PESTICIDES—CARBAMATES				
Aldicarb	3.0 µg/L	Narrative	Basin Plan Chemical Constituents Objective, USEPA Primary MCL (MUN, human health)	1, 2, 3, 4
Carbaryl	2.53 µg/L	Narrative	Basin Plan Toxicity Objective: Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (California Department of Fish and Game) (aquatic life)	1, 2, 3, 4

Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
Carbofuran	0.40 or ND	Numeric: Performance Goal or Pesticide Prohibition	Basin Plan Performance Goal if under Management Plan; Basin Plan Prohibition, page IV-25.00 (MUN, human health)	1, 2, 3
	0.5 µg/L	Narrative	Basin Plan Toxicity objective, USEPA National Ambient Water Quality Criteria for Aquatic Life Protection, instantaneous maximum (aquatic life)	4
Methomyl	0.52 µg/L	Narrative	Basin Plan Toxicity Objective, Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (California Department of Fish and Game) (aquatic life)	1, 2, 3, 4
PESTICIDES—ORGANOCHLORINES				
DDD (p,p')	0.00083µg/L	Numeric	CTR (human health)	1, 2, 3, 4
DDE (p,p')	0.00059 µg/L	Numeric	CTR (human health)	1, 2, 3, 4
DDT (p,p')	0.00059 µg/L	Numeric	CTR (human health)	1, 2, 3, 4
Dieldrin	0.00014 µg/L	Numeric	CTR (human health)	1, 2, 3, 4
Endrin	0.01 µg/L	Numeric	Basin Plan Pesticides Objective prohibition of detectable persistent chlorinated hydrocarbon pesticides, SIP Minimum Level (MUN, aquatic life)	1, 2, 3
	0.036 µg/L	Numeric	CTR, Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (aquatic life)	4
Methoxychlor	0.03 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA National Ambient Water Quality Criteria—Freshwater Aquatic Life Protection—instantaneous maximum (aquatic life)	1, 2, 3, 4
PESTICIDES—ORGANOPHOSPHATES				
Azinphos methyl	0.01 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA National Ambient Water Quality Criteria—Freshwater Aquatic Life Protection (aquatic life)	1, 2, 3, 4
Chlorpyrifos	0.015 µg/L	Numeric	Basin Plan, page III-6.01; San Joaquin River and Delta, pending Sacramento and Feather Rivers (aquatic life)	1, 2, 3
	0.015 µg/L	Narrative	Sacramento San Joaquin Basin Plan, San Joaquin River & Delta numeric standard pending Sacramento & Feather Rivers numeric standard	4

Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
Demeton	0.1 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection, Instantaneous (human health, aquatic life)	1, 2, 3, 4
Diazinon	0.1 µg/L	Numeric	Basin Plan, page III-6.01; San Joaquin River and Delta, pending Sacramento and Feather Rivers (aquatic life)	1, 2, 3
	0.1 µg/L	Narrative	Sacramento San Joaquin Basin Plan, San Joaquin River & Delta numeric standard pending Sacramento & Feather Rivers numeric standard	4
Dichlorvos	0.085 µg/L	Narrative	Basin Plan Toxicity Objective, Cal/EPA Cancer Potency Factor (MUN, human health)	1, 2, 3, 4
Dimethoate	1.0 µg/L	Narrative	Basin Plan Toxicity Objective, Notification Level—DHS (MUN, human health)	1, 2, 3, 4
Disulfoton	0.05 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA National Ambient Water Quality Criteria—Freshwater Aquatic Life Protection—instantaneous maximum (aquatic life)	1, 2, 3, 4
Malathion	0.1 or ND	Numeric: Performance Goal or Pesticide Prohibition	Basin Plan Performance Goal if under a Management Plan; Basin Plan, page IV-25.00 (human health, aquatic life)	1, 2, 3
	0.43 µg/L	Narrative	Basin Plan Toxicity Objective, Water Quality Criteria, 1-hour average, California Department of Fish & Game (aquatic life)	4
Methidathion	0.7 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA IRIS Reference Dose (MUN, human health)	1, 2, 3, 4
Parathion, Methyl	0.13 or ND	Numeric: Performance Goal or Pesticide Prohibition	Basin Plan Performance Goal if under a Management Plan; Basin Plan Prohibition, page IV-25.00 (aquatic life, human health)	1, 2, 3
	0.08 µg/L	Narrative	Basin Plan Toxicity Objective, Water Quality Criteria, instantaneous maximum, California Department of Fish & Game (aquatic life)	4
PESTICIDES—PYRETHROIDS				
Biphenthrin	110 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA IRIS Reference Dose (human health)	1, 2, 3, 4
Cypermethrin, total	0.002 µg/L	Narrative	Basin Plan Toxicity Objective, Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (California Department of Fish and Game) (aquatic life)	1, 2, 3, 4
Cyhalothrin, lambda, total	35 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA IRIS Reference Dose (MUN, human health)	1, 2, 3, 4

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Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
Permethrin, total	0.03 µg/L	Narrative	Basin Plan Toxicity Objective, Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (California Department of Fish and Game (aquatic life)	1, 2, 3, 4
PESTICIDES—HERBICIDES				
Atrazine	0.15 µg/L	Narrative	Basin Plan Toxicity Objective, California Public Health Goal (MUN, human health)	1, 2, 3, 4
Cyanazine	1.0 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA Health Advisory (human health)	1, 2, 3, 4
Diuron	2 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA Health Advisory—Cancer Risk (MUN, human health)	1, 2, 3
	14 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA Health Advisory (MUN, human health)	4
Glyphosate	700 µg/L	Numeric	Basin Plan Chemical Constituents Objective, page III-3.00, California Primary MCL (MUN, human health)	1, 2, 3, 4
Linuron	1.4 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA IRIS Reference Dose as a drinking water level (human health)	1, 2, 3, 4
Molinate	10 µg/L	Numeric: Performance Goal	Basin Plan Performance Goal if under a Management Plan; Basin Plan Prohibition, page IV-25.00 (MUN, human health, aquatic life)	1, 2, 3
Oryzalin	35 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA IRIS Reference Dose as a drinking water level (human health)	1, 2, 3, 4
Simazine	4.0 µg/L	Numeric	Basin Plan Chemical Constituents Objective, page III-3.00, California Primary MCL (MUN, human health)	1, 2, 3, 4
Thiobencarb	1.0 µg/L	Numeric: Secondary MCL	Basin Plan Pesticides Objective if under a Management Plan; Basin Plan Prohibition, page IV-25.00 (MUN, human health)	1, 2, 3
	1.0 µg/L	Numeric	Basin Plan Chemical Constituents Objective, California Secondary MCL (MUN)	4
METALS				
Aluminum	87 µg/L	Narrative	Basin Plan Toxicity Objective, USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection, 4-Day Average (aquatic life)	1, 2, 3, 4
Antimony	6 µg/L	Numeric	Basin Plan Chemical Constituents Objective, page III-3.00, California Primary MCL (MUN, human health)	1, 2, 3, 4

Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
Arsenic	10 µg/L	Narrative	Basin Plan Chemical Constituents Objective, USEPA Primary MCL (MUN, human health)	1, 2, 3, 4
Boron	700 µg/L	Narrative	Basin Plan Chemical Constituents Objective, *Water Quality for Agriculture*, Ayers and Westcot, 1985 (agriculture)	1, 2, 3
	2,000 ug/L (March 15–September 15) 800 ug/L (monthly mean, March 15–September 15) 2,600 ug/L (September 16–March 14) 1,000 ug/L (September 16–March 14)	Numeric	Basin Plan Objective, page III-3.00, Table III-1, Trace Element Water Quality Objectives, San Joaquin River, mouth of the Merced River to Vernalis (multiple)	3
	1,000 µg/L	Numeric	Tulare Basin Plan, page IV-3	4
Cadmium	0.07 µg/L	Narrative or Numeric	Basin Plan California Public Health Goal (MUN, human health)	1, 2, 3, 4
	Variable, depends on hardness	Numeric	Basin Plan Objective, page III-3.00, Table III-1, Trace Element Water Quality Objectives, Sacramento River and its tributaries above State Hwy 32 bridge at Hamilton City (aquatic life)	1
Chromium	50 µg/L	Numeric	Basin Plan Chemical Constituents Objective, page III-3.00, California Primary MCL (MUN, human health)	1, 2, 3, 4
Chromium VI	11 µg/L	Numeric	CTR (aquatic life)	1, 2, 3, 4
Copper	Variable, depends on hardness	Numeric	CTR Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (aquatic life)	1, 2, 3, 4
	Variable, depends on hardness	Numeric	Basin Plan Objective, page III-3.00, Table III-1, Trace Element Water Quality Objectives, Sacramento River and its tributaries above State Hwy 32 bridge at Hamilton City (aquatic life)	1
Lead	2 µg/L or variable, depends on hardness	Narrative or Numeric	Basin Plan narrative toxicity Objective, California Public Health Goal; CTR Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average—varies with water hardness (MUN, aquatic life)	1, 2, 3, 4
Mercury	0.05 µg/L	Numeric	CTR Criteria, Human Health Protection—Sources of Drinking Water 30-day Average (MUN, human health)	1, 2, 3, 4

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Parameter	Water Quality Objective	Standard Type	Reference (Beneficial Use)[1]	Zone[2]
Nickel	12 µg/L or variable, depends on hardness	Narrative or Numeric	Basin Plan Toxicity Objective, California Public Health Goal; CTR Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average—varies with water hardness (MUN, aquatic life)	1, 2, 3, 4
Selenium	5.0 µg/L	Numeric	CTR, Freshwater Aquatic Life Protection, 4-Day Average (aquatic life)	1, 2, 3, 4
	2.0 ug/L	Numeric	Basin Plan Objectives, page III-4.0, Table III-1, Salt Slough and constructed and re-constructed water supply channels in the Grassland watershed (aquatic life)	3
Zinc	Variable, depends on hardness	Numeric	Basin Plan Objectives, page III-4.0; CTR Freshwater Aquatic Life Protection—Continuous Concentration, 4-Day Average (MUN, aquatic life, agriculture, human health)	1, 2, 3, 4

Notes:

CTR = California Toxics Rule
ILP = Irrigated Lands Program.
IRIS = Integrated Risk Information System.
µg/L = micrograms per liter.
mg/L = milligrams per liter.
MCL = Maximum Contaminant Limit.
MPN = Most Probable Number.
MUN = Municipal and Domestic Supply Beneficial Use.
ND = Non Detection.
USEPA = U.S. Environmental Protection Agency.

[1] The "Reference" column includes, in parentheses, the beneficial use intended to be addressed by the standard or most affected by the particular parameter.

[2] Zone 1 Sacramento River Basin.

Zone 2 Delta Carbon Subwatershed, North Valley Floor Subwatershed, Cosumnes River Subwatershed, and Upper Mokelumne/Upper Calaveras River Subwatershed.

Zone 3 Delta Mendota Canal Subwatershed, San Joaquin Valley Floor Subwatershed, Stanislaus River Subwatershed, Tuolumne River Subwatershed, Merced River Subwatershed, Mariposa Subwatershed, Ahwahnee Subwatershed, and the San Joaquin River Subwatershed.

Zone 4 Tulare Lake Basin.

Source: California Regional Water Quality Control Board, Central Valley Region. 2007. Trigger Limits Used for Zone Data Review. July 16. Attachment A to Revised Draft 2007 Review of Monitoring Data Irrigated Lands Conditional Waiver Program. July 13, 2007. Rancho Cordova, CA.