SAN JOAQUIN COUNTY & DELTA
WATER QUALITY COALITION

February 16, 2016

Pamela Creedon, Executive Officer
Irrigated Lands Regulatory Program
Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670-6114

Dear Ms. Creedon,

The San Joaquin County and Delta Water Quality Coalition (SJCDWQC) is submitting the 2016 Comprehensive Groundwater Quality Management Plan (GQMP) for review by the Central Valley Regional Water Quality Control Board (CVRWQCB) as required by the Waste Discharge Requirements General Order for Growers within the San Joaquin County and Delta Area that are members of the SJCDWQC (WDR Order R5-2014-0029-R1).

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for knowingly submitting false information, including the possibility of fine and imprisonment for violations."

This letter is being mailed with an original signature to the CVRWQCB.

Submitted respectfully,

Michael L. Johnson
SJCDWQC Technical Program Manager
Michael L. Johnson, LLC

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Comprehensive Groundwater Quality Management Plan

San Joaquin County and Delta Water Quality Coalition

Irrigated Lands Regulatory Program
Central Valley Regional Control Board

February 16, 2016

MICHAEL L. JOHNSON LLC
ECOSYSTEMS • CONSULTING

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AB	Assembly Bill
BLS	Below Land Surface
BOD	Board of Directors
CASGEM	California Statewide Groundwater Elevation Monitoring
CCWD	Calaveras County Water District
CDPH	California Department of Public Health
GQMP	Comprehensive Groundwater Quality Management Plan
COC	Constituent of Concern
CTR	California Toxics Rule
CURES	Coalition for Urban Rural Environmental Stewardship
CVHM	Central Valley Hydrologic Model
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
DAC	Disadvantaged Community
DBCP	1,2-dibromo-3-chloropropane
DEM	Digital Elevation Model
DOI	United States Department of the Interior
DPR	California Department of Pesticide Regulation
DUC	Disadvantaged Unincorporated Community
DWR	California Department of Water Resources
EC	Electrical Conductivity
EDB	Ethylene dibromide (also known as 1,2-Dibromoethane)
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FE	Farm Evaluation
GAR	Groundwater Assessment Report
GAMA	Groundwater Ambient Monitoring and Assessment
GBA	Northeastern San Joaquin County Groundwater Banking Authority
GIS	Geographic Information System
HHVA	Hydrogeological High Vulnerability Area
ILP	Irrigated Lands Program
ILRP	Irrigated Land and Regulatory Program
IPNI	International Plan Nutrition Institute
IRWM	Integrated Regional Water Management Plan
MCL	Maximum Contaminant Level
MLJ-LLC	Michael L. Johnson, LLC
MPEP	Management Practice Evaluation Program
MSL	Mean Sea Level

NA	Not Applicable
NI	Non-irrigated
NOA	Notice of Applicability
NMP	Nitrogen Management Plan
NRCS	Natural Resource Conservation Service
NWIS	National Water Information System
PAM	Polyacrylamide
PCA	Pesticide Control Adviser
pH	Power of Hydrogen
PLSS	Public Land Survey System
SC	Specific Conductance
SJCDWQC	San Joaquin County and Delta Water Quality Coalition
SJR	San Joaquin River
SNMP	Salt and Nitrate Management Plan
SWRCB	State Water Resources Control Board
TAF	Thousand Acre Feet
TDS	Total Dissolved Solids
TRS	Township Range Section, Public Land Survey System
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WDL	Water Data Library
WDR	Waste Discharge Requirements General Order R5-2014-0029-R1
WQO	Water Quality Objective
WQTL	Water Quality Trigger Limit

LIST OF DEFINITIONS

DRASTIC settings	An EPA standardized system for evaluating groundwater pollution using hydrogeological

LIST OF UNITS

af	acre feet
°C	degrees Celcius
cm	centimeter
ft	foot (feet)
L	Liter
mg	milligram
µg	microgram
µmhos	microsiemens

INTRODUCTION AND BACKGROUND

The Comprehensive Groundwater Quality Management Plan outlined in this document, addresses the requirements of the Waste Discharge Requirements General Order for Growers within the San Joaquin County and Delta Area (No. R5-2014-0029-R1). The Comprehensive Groundwater Quality Management Plan (from now on referred to as the Comprehensive GQMP or simply GQMP) presents the Coalition's approach to eliminating/reducing impairments of beneficial uses of groundwater. The Management Plan approach involves three parts: 1) a broad spectrum method for identification of whether or not constituents of concern are related to agricultural practices, 2) outreach to all members whose parcels lay above groundwater identified as having constituents that exceed water quality objectives, providing recommendations of management practices with the potential to be effective in managing discharges, and 3) monitoring to evaluate the efficacy of those implemented management practices.

BACKGROUND

The Central Valley Regional Water Quality Control Board (the Regional Water Board or CVRWQCB) initiated the Irrigated Lands Program (ILP) in 2003 (and renewed in 2006) with the adoption of a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands. The ILP, later the Irrigated Lands Regulatory program (ILRP), was developed to regulate discharges from irrigated agriculture to surface waters. On March 12, 2014, the Regional Water Board adopted the Waste Discharge Requirements General Order (revised April 16, 2015) for Growers within the San Joaquin County and Delta Area (WDR or the Order; No. R5-2014-0029-R1) (CVRWQCB, 2015a). The WDR, along with other orders to be adopted for the irrigated lands within the Central Valley, constitute the long-term ILRP.

On April 25, 2014, the Regional Water Board approved the Notice of Applicability (NOA) for the San Joaquin County Resource Conservation District (RCD) to act as the third-party group representing members of the San Joaquin County and Delta Water Quality Coalition (SJCDWQC or Coalition) in the San Joaquin County and Delta Area. The RCD oversees and operates the Coalition, which in turn represents the concerns of its members and works to fulfill the requirements of the Order. SJCDWQC members are those landowners and/or operators of irrigated lands who have enrolled an irrigated land parcel(s) under the Order within the area represented by the SJCDWQC. By enrolling an irrigated land parcel under the Order, members obtain regulatory coverage for operational discharges and agree to comply with the terms and conditions of the Order.

The approval date associated with the NOA started the timeline for several requirements, including submittal of a Notice of Intent from entities wishing to join the Coalition and for the Coalition to submit an outline of the Groundwater Assessment Report (GAR) for the Coalition region. The GAR (SJCDWQC, 2015) was submitted on April 25, 2015 and provides an understanding of current groundwater quality conditions within the Coalition region and therefore is instrumental in the development of the Groundwater Quality Management Plan, the Groundwater Quality Trend Monitoring Program, and the Management Practices Evaluation Program defined in the Order.

The Coalition's GAR was 'conditionally' approved by the Regional Water Board on December 18, 2015, with the requirement that CVRWQCB staff recommendations be addressed in the 2020 GAR update and in the Groundwater Trend Monitoring Work Plan (due December 18, 2016). The CVRWQCB's conditional approval of the GAR established the Comprehensive Groundwater Quality Management Plan's (GQMP) required submittal date to be February 16, 2016 (60 days after the conditional approval of the GAR).

PURPOSE OF THE GROUNDWATER QUALITY MANAGEMENT PLAN

The GQMP was developed following the requirements listed in the Order, using existing groundwater data and includes a review of current regional groundwater management plans. The goal of the GQMP is to protect groundwater quality, with regards to agricultural practices, within the designated region of the Coalition in as timely a manner as possible and within the limitations set forth by the Order. Requirements of the Order and where they can be found within the GQMP are listed in Table 1.

Historical data (1969-2013) were reviewed for exceedances of water quality trigger limits (WQTLs) in the GAR and are summarized in the SJCDWQC GQMP. Areas with exceedances of groundwater WQTLs for constituents of concern (COCs) and/or areas determined as high vulnerability by the GAR must be addressed in a management plan.

The SJCDWQC GQMP does the following:

1. Evaluates the magnitude and extent of water quality impairments using existing groundwater quality data (based on data provided in the GAR) as well as annual monitoring data,
2. Identifies current agricultural management practices (based on Farm Evaluation Plans submitted by landowners/growers),
3. Identifies management practices that are effective in reducing impact of irrigated agriculture (based on MPEP studies),
4. Establishes the Performance Goals and Measures that will be assessed in the Annual Report, and
5. Develops management plan compliance timetables for reporting to the Regional Water Board on the effectiveness of the GQMP.

Although the Coalition will begin with the development of a management plan for COC's within the high vulnerability areas (HVAs), the strategy employed by the Coalition is to address COCs across the entire Coalition region in as timely a manner as practicable. Exceedances of COCs will be categorized into one of several categories as enumerated below. The four categories of exceedances all require significant effort to remove from management plans; however, the management of exceedances moves from relatively easier at the top of the list to more difficult at the bottom of the list:

1. Chemicals applied by irrigated agriculture that are traceable to a source(s) (e.g. pesticides, toxicity)

2. Chemicals applied by irrigated agriculture that are also applied by other entities (e.g. herbicides, pyrethroids)
3. Chemicals applied by irrigated agriculture that are not traceable to a single source (e.g. nitrate in fertilizers)
4. Constituents with unknown/multiple sources that are difficult to identify (e.g. *E. coli*)
5. Measured parameters with no direct sources whose concentration can be the result of many processes (e.g. dissolved oxygen, pH, TDS)

This GQMP presents the Coalition's approach to eliminating impairments of beneficial uses for groundwater in the Coalition region within the 10-year compliance schedule as stated in the Order. The GQMP approach involves determining whether COCs are related to agricultural practices, identifying best management practices that effectively manage discharge to groundwater, conducting outreach to members identified as having the potential to discharge COCs to groundwater to notify them of water quality impairments, providing recommendations about potential management practices that are known to be effective in managing discharges, and monitoring to evaluate the efficacy of implemented management practices.

The Coalition will submit a Management Plan Progress Report annually as part of the Annual Report. The Management Plan Progress Report will include an evaluation of monitoring results, information on the practices being implemented, an assessment of management practice effectiveness, and a review of any new or removed site/constituent specific management plans for those areas requiring management plans.

COALITION BOUNDARIES

The SJCDWQC region encompasses an area of approximately 2 million acres (3,099 square miles). Under the current Order (dated April 16, 2015), the boundary of the Coalition region is defined by the San Joaquin Delta subbasin to the west, the Sacramento and San Joaquin County line until the intersection of Sacramento and San Joaquin and Amador County lines, the Lower Mokelumne River watershed, the Upper Mokelumne subwatershed, the Lower North Fork Mokelumne River watershed, the Lower North Fork Mokelumne River watershed to the Alpine County line to the north, to the crest of the Sierra Nevada Mountain Range to the east, to the Stanislaus River in the south between the San Joaquin River and the Alpine County line. The SJCDWQC region does not include portions of Del Puerto Water District, West Stanislaus Irrigation District, and the San Joaquin River National Wildlife Refuge that are within the general boundary described above (Figure 1).

Groundwater Subbasins within the GQMP

Groundwater subbasins within the SJCDWQC region lie within the greater San Joaquin Valley Groundwater Basin of the San Joaquin River Hydrologic Region as defined in Bulletin 118 from the Department of Water Resources (DWR) (Table 2, Figure 2). The areal extent of the unconsolidated and semi-consolidated sedimentary deposits of the groundwater subbasins within the Coalition is bounded by the base of the consolidated bedrock of the Sierra Nevada Mountains to the east and the Diablo Range to the west. The Coalition's eastern and western boundaries extend beyond the eastern and western limits of the groundwater subbasins within the region. The northern borders of the Tracy and Eastern San Joaquin subbasins as defined by Bulletin 118 are the Mokelumne and San Joaquin Rivers for the Tracy subbasin and the Mokelumne River for the Eastern San Joaquin subbasin, and parallel with that section of the northern boundary of the Coalition. Continuing east from the Eastern San Joaquin subbasin, the Coalition's northern boundary follows the San Joaquin County line as it passes through the Cosumnes subbasin, crossing the subbasin from west to east, to the intersection of Sacramento, San Joaquin, and Amador County lines. The southern boundary of the Coalition encompasses the entire Tracy subbasin with the exception of the footprint below the Del Puerto Water District and the West Stanislaus Irrigation District. The southern boundary of the Coalition and the Eastern San Joaquin subbasin follow the Stanislaus River until the termination of the subbasin's eastern boundary at the consolidated rock of the Sierra Nevada Mountains.

Table 1. WDR requirements for GQMPs and their corresponding sections within the SJCDWQC GQMP.

Required Element (Appendix MRP-1)	Comprehensive Groundwater Quality Management Plan Sections
A. Introduction and Background	**Introduction and Background**
Coalition geographic boundaries	Coalition Boundaries
Groundwater subbasin boundaries within the Coalition	Coalition Boundaries
Discussion of COCs and Water Quality Objectives or triggers requiring preparation of the GQMP	Existing Groundwater Quality Data - Summary
Previous groundwater monitoring within the Coalition	Existing Groundwater Quality Data – Summary Existing Groundwater Quality Data - Expanded
B. Physical Setting and Information	**Physical Setting and Geographical Characteristics**
B.1.a. Land use maps	Land Use
B.1.b. Identification of potential agricultural sources of COCs	Constituents of Concern
B.1.c. Beneficial uses	Beneficial Uses
B.1.d. Baseline of management practices	Existing Agricultural Management Practices
B.1.e. Summary, discussion, and compilation of surface water quality data	Existing Groundwater Quality Data - Summary Existing Groundwater Quality Data - Expanded
B.3. a. Soil information	Soils and Geology
B.3.b. Geology and hydrology	Hydrogeology
B.3.b.i. Regional geology	Soils and Geology
B.3.b.ii. Groundwater basins and sub-basins in area	Hydrogeology
B.3.b.iii. Known water bearing zones	Hydrogeology
B.3.b.iv. Identify water bearing zones used for domestic, irrigation, and municipal water	Hydrogeology Land Use
B.3.b.v. Aquifer characteristics	Hydrogeology
B.3.c. Identification of water chemistry	Hydrogeology
B.3.c. Identification of irrigation water sources	Land Use
C. Management Plan Strategy	**Management Plan Strategy**
C.1. Description of approach	Description of Approach
C.2. Actions to meet goals and objectives	Management Plan Effectiveness
C.2.a. Compliance with receiving water limitations	Management Plan Effectiveness
C.2.b. Educate members	Description of Approach Actions to Meet Goals and Objectives
C.2.c. Identify, validate and implement management practices	Description of Approach Actions to Meet Goals and Objectives
C.3 Duties and responsibilities of individuals	Duties and Responsibilities
C.4. Strategies to implement the management plan tasks	Strategies to Implement Management Plan Tasks
C.4.a. ID entities or agencies	Strategies to Implement Management Plan Tasks
C.4.b. ID management practices	Strategies to Implement Management Plan Tasks
C.4.c. ID outreach	Strategies to Implement Management Plan Tasks
C.4.d. Specific schedule and milestones	Strategies to Implement Management Plan Tasks
C.4.e. Measurable performance goals with specific targets	Strategies to Implement Management Plan Tasks
D. Monitoring Methods	**Monitoring Methods**
D.3 Management Practice Evaluation Program and Groundwater Quality Trend Monitoring	Monitoring Methods
E. Data Evaluation	**Data Evaluation**
F. Records and Reporting	**Records and Reporting**
G. Source Identification Study Requirements	**Strategies to Implement Management Plan Tasks**

Figure 1. San Joaquin County and Delta Water Quality Coalition boundary within California (CVRWQCB, 2015a).

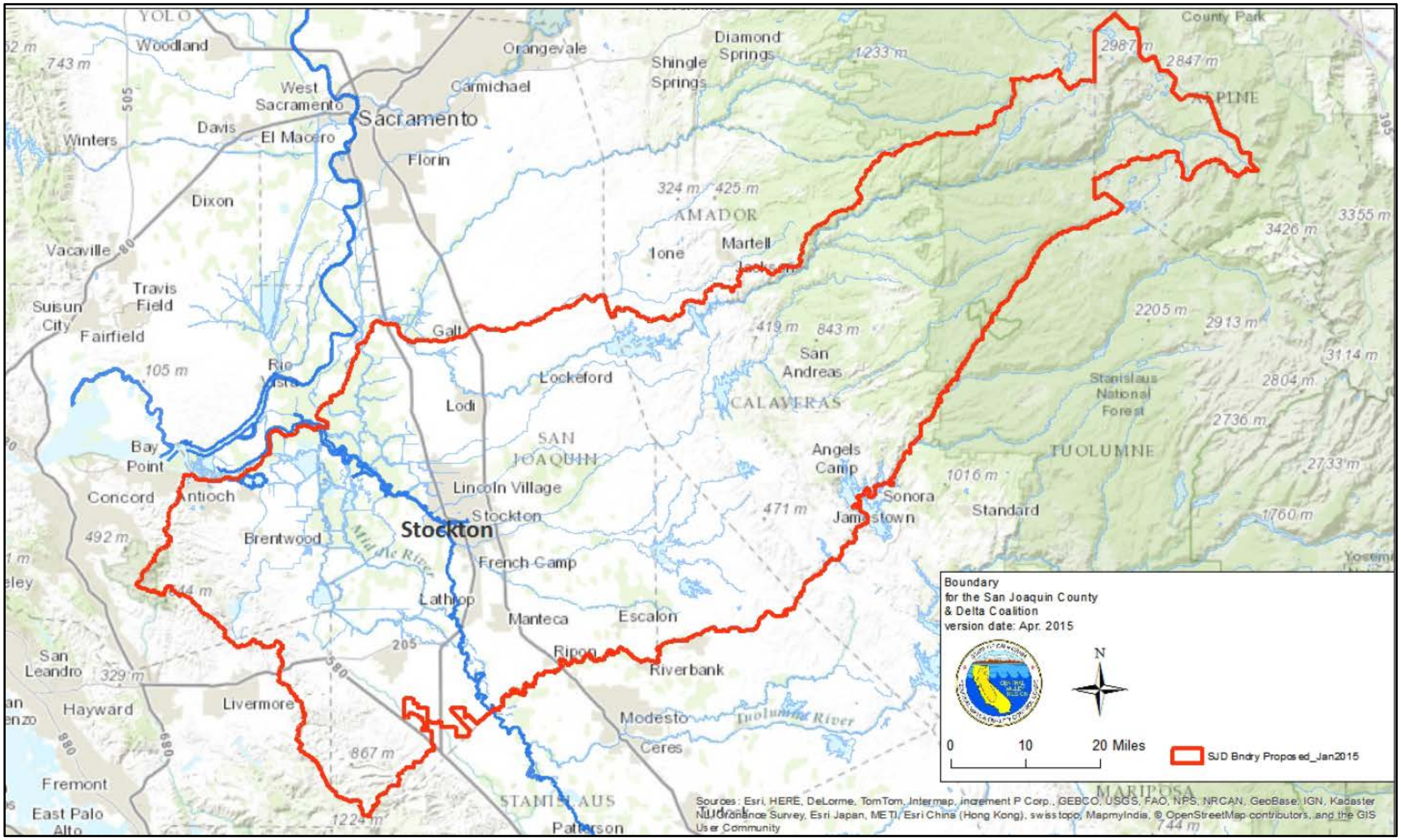
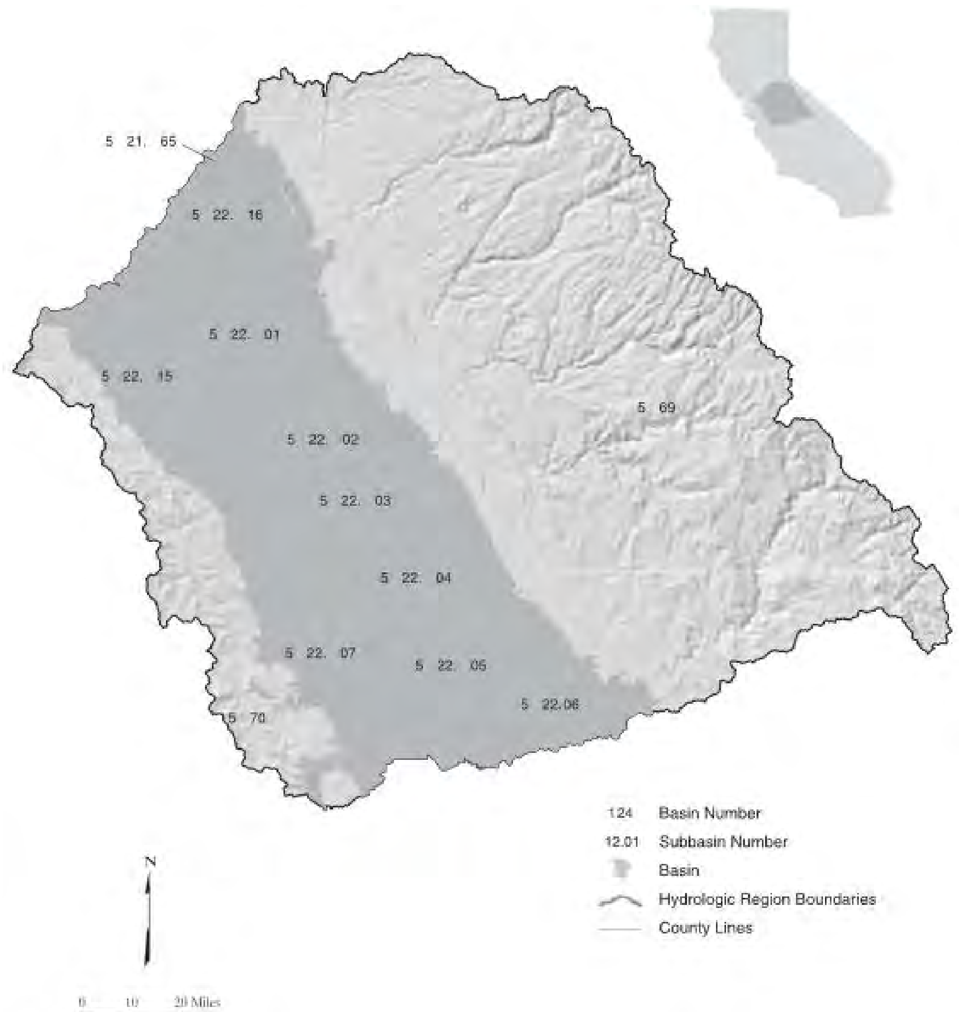


Table 2. Basins and subbasins within the San Joaquin River Hydrologic Region.

Basin	Basin-Subbasin Number	Subbasin Name
San Joaquin Valley	5-21.65	South American
San Joaquin Valley	**5-22.01**	**Eastern San Joaquin**
San Joaquin Valley	5-22.02	Modesto
San Joaquin Valley	5-22.03	Turlock
San Joaquin Valley	5-22.04	Merced
San Joaquin Valley	5-22.05	Chowchilla
San Joaquin Valley	5-22.06	Madera
San Joaquin Valley	5-22.07	Delta-Mendota
San Joaquin Valley	**5-22.15**	**Tracy**
San Joaquin Valley	**5-22.16**	**Cosumnes**
Yosemite Valley	5-69	NA
Los Banos Creek Valley	5-70	NA

NA – Not applicable
Bold Text - Illustrates subbasins within the Coalition

Figure 2. DWR Designated Groundwater Basins and Subbasins within the Coalition region (Figure 35, DWR 2003).



Existing Groundwater Management Plans within the SJCDWQC Region

Numerous entities (other than agricultural landowners/operators) whose water management practices could affect groundwater quality are located within the Coalition area boundaries including portions of several public and private irrigation districts, numerous federal and state water districts, municipal water companies, and metropolitan water service areas. Jackson Valley, East Contra Costa, Oakdale, South San Joaquin, Woodbridge, Banta-Carbona, Byron Bethany, Naglee Burk, and West Side Irrigation Districts are now members of the SJCDWQC.

In 1992, the State Legislature provided structure for more formal groundwater management with the passage of Assembly Bill (AB) 3030, the Groundwater Management Act (Water Code §10750 et seq.). Groundwater management, as defined in DWR's Bulletin 118 Update 2003, is the planned and coordinated monitoring, operation, and administration of a groundwater basin, or portion of a basin, with the goal of long-term groundwater resource sustainability. Assembly Bill 359 was signed into water code in 2011, and required local agencies to provide a copy of their groundwater management plan to DWR and for DWR to provide public access to those plans. Table 3 lists the water agencies within the GQMP area, the subbasin(s) they overlie, and whether there is an existing groundwater management plan associated with the agency.

Table 3. Water agencies and associated groundwater subbasins (partial or entire) within the GQMP area*. Subbasins are listed as they appear from the northeast to west according the DWR's Bulletin 118.

WATER AGENCIES	GROUNDWATER SUBBASINS				PARTICIPATING IN AN EXISTING GROUNDWATER MANAGEMENT PLAN
	Cosumnes	*Eastern San Joaquin*	*Tracy*	*No Associated Groundwater Subbasin*	
North Delta Water Agency	X	X	X		
Calaveras County Water District	X	X			X
North San Joaquin Water Conservation District	X	X			X
Amador Water Agency	X				X
Jackson Valley Irrigation District	X				
Pine Acres Community Services District	X				
Central Delta Water Agency		X	X		
San Joaquin County Flood Control & Water Conservation District		X	X		X
South Delta Water Agency		X	X		
Stockton-East Water District		X	X		X
California Water Service Company		X			
Central San Joaquin Water Conservation District		X			
City of Escalon Water Service Area		X			
City of Lathrop Water District		X			

Water Agencies	Groundwater Subbasins				Participating in an Existing Groundwater Management Plan
City of Lodi Service Area		X			
City of Manteca Water Service Area		X			
City of Stockton Municipal Utility District		X			X
County of Stanislaus		X			X
Lockeford Community Services District		X			
Northeastern San Joaquin County Groundwater Banking Authority		X			X
Oakdale Irrigation District		X			X
Reclamation District 828		X			
River Junction Reclamation District 2064		X			
Rock Creek Water District		X			X
South San Joaquin Irrigation District		X			X
Stanislaus & Tuolumne Rivers Groundwater Basin Association		X			X
Valley Springs Public Utility District		X			
Woodbridge Irrigation District		X			X
Woodbridge WUCD		X			
Alameda County Flood Control & Water Conservation District			X		X
Banta-Carbona Irrigation District			X		X
Byron-Bethany Irrigation District			X		X
City of Antioch Water Service Area			X		
City of Brentwood Water Service Area			X		
City of Tracy			X		X
Contra Costa Water District			X		
Diablo Water District			X		X
East Contra Costa Irrigation District			X		
Ironhouse Sanitary District			X		X
Naglee Burk Irrigation District			X		
Patterson Water District			X		X
Pescadero Reclamation District 2058			X		
Plain View Water District			X		X
Reclamation District 2039			X		
San Luis & Delta Mendota Water Authority - North			X		X
The West Side Irrigation District			X		X
West Stanislaus Irrigation District			X		X
Calaveras Public Utilities District				X	
City of Angels Camp WSA				X	

*According to California Water Plan Update 2013 (Draft), DWR; Status of Groundwater Management in California, 2004, DWR (http://www.water.ca.gov/pubs/groundwater/bulletin_118/california's_groundwater__bulletin_118_-_update_2003_/cagwmgmt10jan05-final.pdf); DWR, Bulletin 118, updates; and DWR http://www.water.ca.gov/groundwater/groundwater_management/GWM_Plans_inCA.cfm; and CVRWQCB, Irrigated Lands Discharge Program Draft Existing Conditions Report, 2008. (http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/new_waste_discharge_requirements/exist_cond_rpt/draft_existing_conditions_rpt/ch04_pt3.pdf).

The impact of urban areas on groundwater is an additional stressor to water quality, especially considering the rapid and ongoing growth of urban centers. The rapid growth of cities such as Lodi, Stockton, Lathrop, and Manteca on the east side of the Delta and Antioch, Sand Hill, Knightsen, and Brentwood on the west side of the Delta results in the conversion of large amounts of irrigated agricultural land to urban land. Land designated as agricultural only a few years ago, is now covered by urban development.

With so many public and private entities influencing groundwater quality and quantity, the state recognized the importance of generating water management plans for entire regions, rather than for individual interests. In 2002, the Integrated Regional Water Management Act was created when Senate Bill 1672 was passed. With the passing of Proposition 50 in 2002 (the Water Security, Clean Drinking Water, Coastal and Beach Protection Act), funding for the preparation of Integrated Regional Water Management Plans (IRWMPs) was in place. IRWMPs define planning regions and identify strategies that allow for the regional management of water resources (supply, quality, management, and ecosystem restoration). The IRWMP program is currently administered by DWR. IRWMPs in the GQMP area and their associated, approximate acreages and the acreages associated with the groundwater subbasins are listed in Table 4.

Table 4. Approximate acreages* associated with IRWMPs and underlying subbasins (none, partial, or entire) within the SJCDWQC area.

IRWMPs within the Coalition Area	Cosumnes Subbasin	Eastern San Joaquin Subbasin	Tracy Subbasin	Total Acreage in IRWMPs within the Coalition
(19) Mokelumne/Amador/Calaveras (MAC)	13,708	47,994		61,702
(36) Tuolumne-Stanislaus		4,184		4,184
(44) Westside - San Joaquin			43,293	43,293
(7) East Contra Costa County			96,615	96,615
(8) Eastern San Joaquin	70,861	545,919		616,781
Grand Total	**84,569**	**598,098**	**139,907**	**822,575**

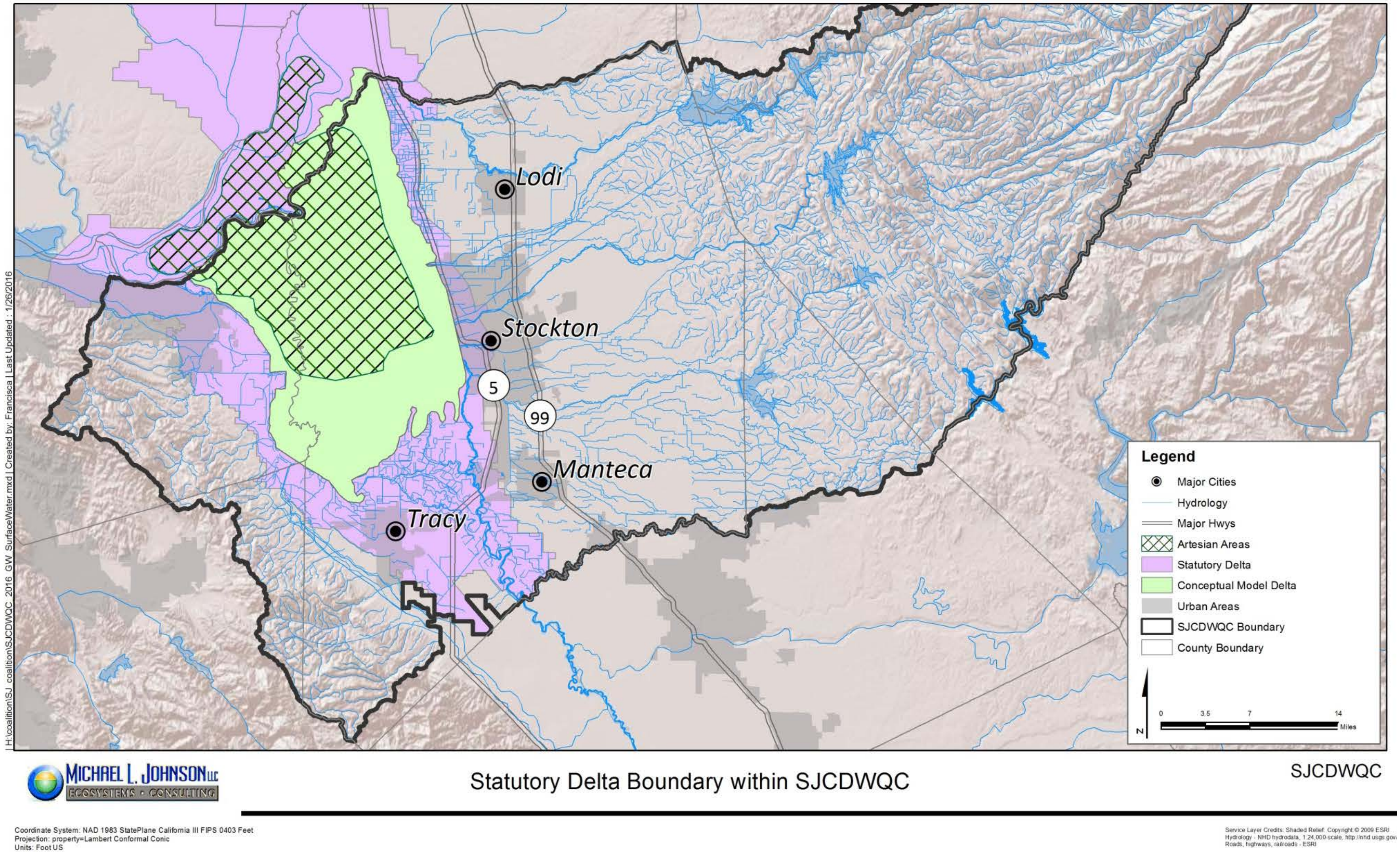
*Acreage values from Arc GIS data.

EXISTING GROUNDWATER QUALITY DATA - SUMMARY

The Coalition's GAR summarizes current and historic groundwater quality data in the Coalition region watershed area using data from local, state, and federal agencies (see Constituents of Concern section of this document for an expanded discussion). The GAR discusses groundwater quality data, highlights COCs relevant to irrigated agricultural practices, provides a spatial and temporal assessment of constituents in the groundwater, and serves as a survey of current, available groundwater quality data necessary to develop an effective comprehensive GQMP for the Coalition region.

Within the GAR, water quality data are described as either pertaining to the Delta or non-Delta areas within the Coalition region. Water quality data attained from the GAR are also described in terms of the Delta and non-Delta areas in the sections below. The boundary defining the Statutory or Legal Delta is discussed in the Hydrogeology section of this report and shown in Figure 3.

Figure 3. Statutory Delta, conceptual model Delta, and artesian area boundaries within the SJCDWQC Coalition.



Delta

Within the GAR, a distinction is made between what is referred to as the "conceptual model Delta" and the rest of the statutory Delta, including the artesian areas of the Delta (Figure 3). The conceptual model Delta boundary as well as the statutory Delta can be seen in Figure 3, Figure 4, and in Figure 44 in the Physical Setting and Geographical Characteristics section. As described in the Hydrogeology section of this report, the conceptual model Delta is that smaller portion of the statutory Delta where artesian groundwater conditions are predicted to exist based on a model developed by the authors of the GAR but where there are currently no water quality data to confirm this prediction. Per the GAR, the area delineated within Figure 3 as the artesian area, was identified using land-surface elevations, subsurface lithology, the bottom elevations of organic deposits, groundwater levels, and channel stage and isotope data for groundwater and surface water samples. The artesian area is where artesian groundwater conditions exist and where, essentially, surface water is predicted to be representative of groundwater. According to authors of the GAR, there are little groundwater quality data available for the artesian area or for the area covered by the "conceptual model Delta". Hydrofocus (authors of the SJCDWQC GAR) identified no groundwater quality concerns in either the artesian or the "conceptual model Delta" areas of the statutory Delta. It is unclear from the text of the GAR, whether or not there have been exceedances of constituents relative to their maximum contamination levels (MCLs) for drinking water within the statutory Delta in the south; within the statutory Delta but outside of the conceptual model Delta portion of the Delta.

For additional data on the COCs in the statutory Delta, the Coalition included the data analysis from USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) for the area within the Delta's statutory boundary. Approximate locations of exceedances for constituents were based on visual inspection of the maps provided in the USGS study (Bennett et al., 2010a). The following constituents are identified by Bennett et al. (2010a) as having exceeded an MCL for a water quality benchmark for drinking water in the Coalition region: arsenic, nitrate, chloride, iron, manganese, sulfate, and TDS, and boron.

Non-Delta

According to the GAR, wells within the non-Delta portion of the Coalition region indicate the frequency of nitrate concentrations exceeding the MCL generally increased with time from the 1970s to 2013, were more prevalent immediately east of the Delta, and were predominantly in wells shallower than 250 feet (ft). Levels of TDS exceeded the secondary MCL for drinking water and three pesticides were detected in wells in the non-Delta areas of the Coalition region: di-bromo-chloro-propane (DBCP), ethylene dibromide (EDB), and simazine, with instances of DBCP and EDB concentrations in groundwater exceeding their respective MCLs. The following constituents are identified by USGS (Bennett et al., 2010a) as having exceeded the MCL for drinking water quality benchmark for drinking water: arsenic, nitrate, DBCP, EDB, iron, manganese, and boron.

PHYSICAL SETTING AND GEOGRAPHICAL CHARACTERISTICS

The approximate acreage of the SJCDWQC area, according to the 2015 WDR, is 2,126,684 acres. Using an Arc GIS map overlay, the calculated acreage within the Coalition that is part of the statutory Delta is 419,629 acres. The remaining non-Delta acres within the Coalition amount to 1,707,055 acres.

The boundaries of the Coalition region are a combination of county lines (Alameda, Alpine, Amador, Calaveras, Contra Costa, and Stanislaus) and hydrological units of surface water subbasins and watersheds. The SJCDWQC area includes nearly the entirety of Calaveras and San Joaquin Counties and portions of Alameda, Alpine, Amador, Contra Costa, and Stanislaus Counties (Table 5). The Delta portion of the Coalition region includes portions of Alameda, Contra Costa, and San Joaquin Counties. The non-Delta portion of the Coalition region includes portions of San Joaquin, Stanislaus, Alpine and Amador Counties and nearly the entire (99.9%) County of Calaveras. The Coalition area receives drainage from four major rivers: the San Joaquin River, Stanislaus River, Calaveras River, and the Mokelumne River, all of which flow into the Delta. The eastern tributaries of the Delta drain the Sierra Nevada range from east to west.

Table 5. Approximate acreage of Counties within the SJCDWQC region.

Delta vs. Non-Delta Areas	Alameda	Alpine	Amador	Calaveras	Contra Costa	San Joaquin	Stanislaus
Legal Delta Boundary	4,659	-	-	-	98,790	315,974	-
Non-Delta	41,772	95,240	135,915	662,844	87,687	573,091	108,818
Grand Total of Acres within Coalition[1]	46,431	95,240	135,915	662,844	186,477	889,065	108,818
Percent acreage of County within Coalition[2]	8.8%	20.0%	35.1%	99.9%	36.3%	97.4%	11.2%

[1]Acres of the legal Delta vs. non-Delta areas of the Coalition was determined using Arc GIS in comparison to total acre values obtained from USDA/NRCS, State Plane Coordinate System 1983.

[2]Total County acreage values from USDA/NRCS - National Geospatial Center of Excellence, "Processed TIGER 2002 Counties plus NRCS additions."

Elevations in the Coalition region range from below mean sea level in the Sacramento-San Joaquin Delta to over 10,000 ft along the Sierra crest. Figure 4 illustrates that for the majority of the Coalition, the slope is between 0 and 2%, within the trough of the Central Valley, with slopes increasing to over 18% within the western and eastern portions of the region, along the margins of the Central Valley and into the adjacent mountain ranges.

Soil type and factors such as slope (Figure 4), soil saturation, rainfall/irrigation water amount, and drainage patterns determine runoff. Local topography influences water flow and recharge as runoff occurs more readily in locations with steep slopes, whereas low slopes cause water to stay in place and infiltrate towards groundwater. During the winter, surface water runoff is moved through the myriad of creeks, rivers, and drains, generally moving from the margins on the east and west of the Central Valley towards the trough and the San Joaquin River. Runoff to streams and rivers can also occur during the irrigation season if irrigation water entering the field is greater than the amount that can infiltrate the soil. In Delta islands, water is pumped in and out of supply and drainage canals. For a large number of islands, water is continually entering the islands through groundwater recharge (essentially seepage from the Delta channels which are greater in elevation than the Delta islands) thus requiring off-island draining.

Figure 4. Slope percentages illustrated with DRASTIC ratings for the Coalition region (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

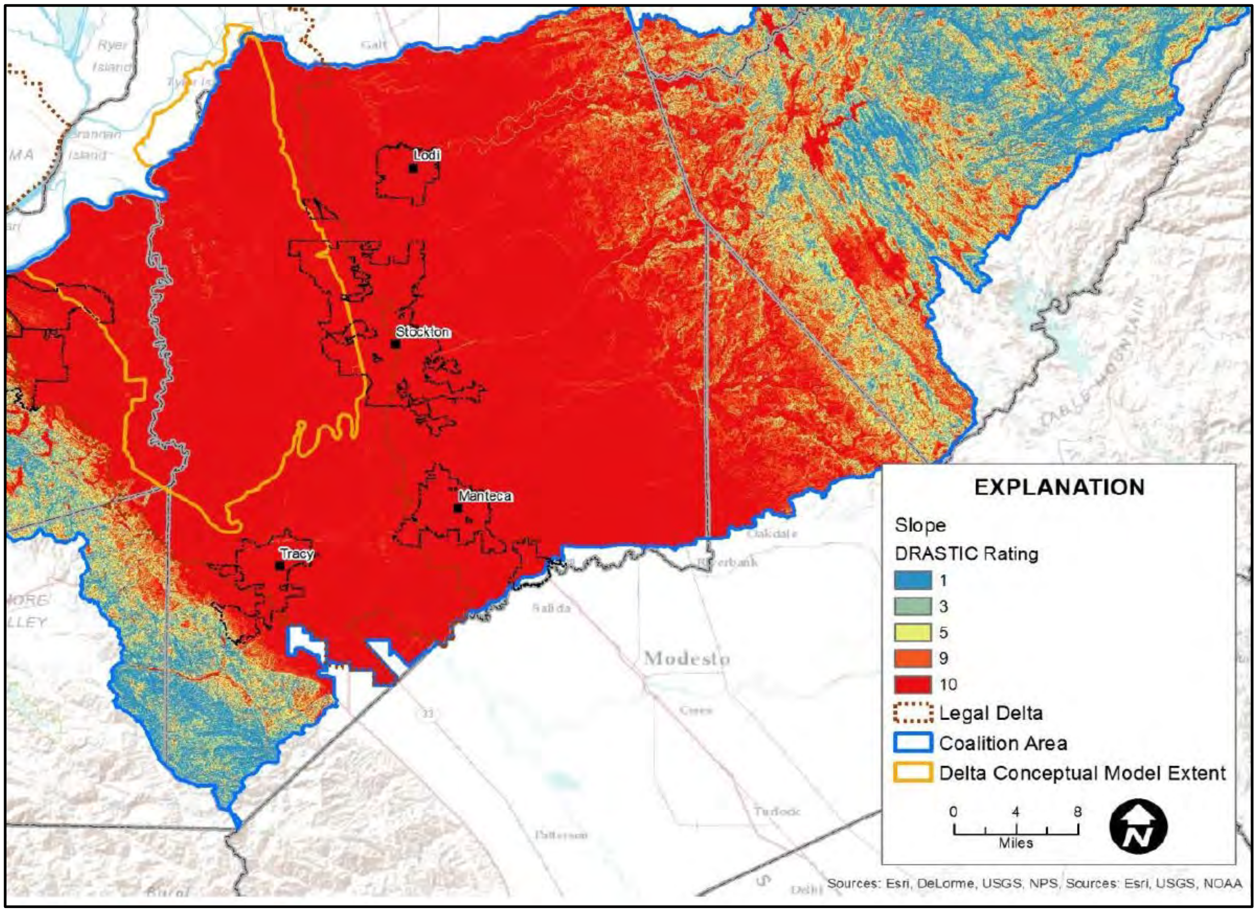


Table 6. DRASTIC rating scores for topography as illustrated in Figure 4.

Range (% Slope)	Rating
0-2	10
2-6	9
6-12	5
12-18	3
>18	1

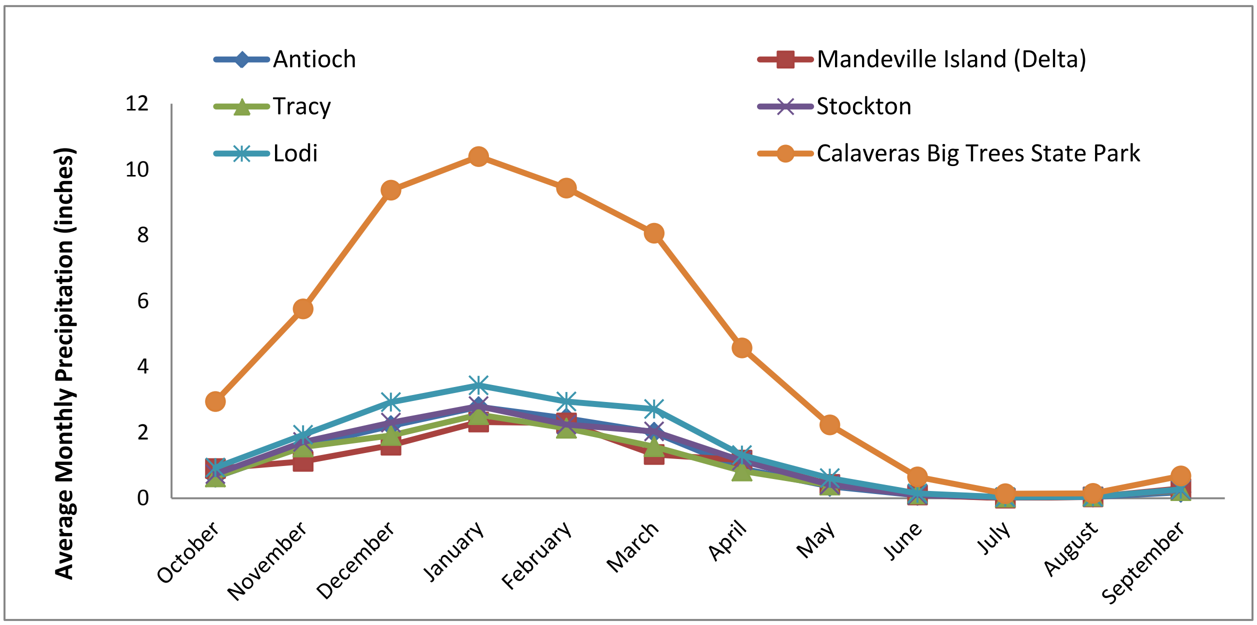
The climate of the Coalition region ranges greatly from the Central Valley Floor to the higher elevations. Annual precipitation ranges from less than 12 inches in areas of the Central Valley Floor to more than 54 inches at high elevations (Table 7, Figure 5).

Table 7. Average climate parameters* for selected locations within the Coalition area from west to east.

Locations	Average Annual Minimum Temperature (˚F)	Average Annual Maximum Temperature (˚F)	Average Annual Total Precipitation (inches)
Antioch	48	73.3	13.22
Mandeville Island (Delta)	47.1	71.4	11.58
Tracy	49.9	74.3	12.03
Stockton	48.5	74.5	13.76
Lodi	46	73.6	17.24
Calaveras Big Trees State Park	38.1	62.1	54.36

*Climate summary data retrieved from the Western Regional Climate Center (http://www.wrcc.dri.edu/summary/Climsmcca.html).

Figure 5. Average monthly precipitation values by Water Year (October through September) in the cities of Antioch, Mandeville Island (Delta), Tracy, Stockton, Lodi, and Calavaras Big Trees State Park, CA, from west to east.



*Climate summary data retrieved from the Western Regional Climate Center (http://www.wrcc.dri.edu/summary/Climsmcca.html).

SURFACE WATER HYDROLOGY IN THE COALITION REGION

Within the Coalition region, the terminus of the San Joaquin River flows into the Delta and drains the California Central Valley. San Joaquin River effluent is either exported to the San Francisco Bay through the Delta, or conveyed southward via the State Water Project (California Aqueduct) and the Federal Delta Mendota Canal. The remaining three major rivers in the Coalition area other than the San Joaquin River, are the Stanislaus, Calaveras, and Mokelumne Rivers. The watershed of the Coalition region is bounded by the crest of the Sierra Nevada in the east with the drainage area bounded by the San Joaquin River in the west, the Stanislaus River in the south, and the Mokelumne River in the north.

Intermediate sized water bodies in the Coalition region (Littlejohns Creek, Duck Creek, Lone Tree Creek, Bear Creek, French Camp Slough, Dry Creek, Marsh Creek, Mormon Slough, Mosher Creek, and Pixley Slough) are tributaries to either one of the major rivers or discharge to the San Joaquin Delta. Smaller water bodies found in the Coalition area are primarily canals and ditches that convey water to one of the larger rivers or intermediate creeks/sloughs, or are used to drain Delta islands. Within the Coalition area, the lower reaches of the San Joaquin River drain the eastern and western parts of the California Central Valley (Valley). The eastern tributaries of the Delta drain the Sierra Nevada range from east to west. Much of the Delta is below sea level and consequently relies on a series of levee systems for protection against flooding.

Delta

The main source rivers include the Sacramento River from the north, the San Joaquin from the southeast, and the Calaveras and Mokelumne Rivers from the east. The Calaveras and Mokelumne are both tributaries of the San Joaquin River. The Sacramento and San Joaquin Rivers are linked at the western end of the Delta near Pittsburg, at the head of Suisun Bay, and upstream by the Georgiana Slough. Even though the City of Pittsburg and the confluence of the Sacramento and San Joaquin Rivers at the head of Suisun Bay are outside of the Coalition region, these geographical points provide a frame of reference. The southwestern part of the Delta is transected by Middle River and Old River, former channels of the San Joaquin. Freshwater from the Sacramento, San Joaquin, Calaveras, and Mokelumne Rivers mingle with saltwater from the Pacific Ocean, and along with their tributaries, carry about half of the state's total annual runoff (Ingebritsen, 2000). The Delta is composed of 57 leveed island tracts and 700 miles of sloughs and winding channels. Many of the islands are 10 to 25 ft below sea level. About two-thirds of all Californians and millions of acres of irrigated farmland rely on the Delta for water from the State Water Project and federal Central Valley Project (DWR, 2015).

Non-Delta

The eastern portion of the Coalition receives drainage flowing westward from the crest of the Sierra Nevada Mountains, along the Stanislaus, Calaveras, and Mokelumne Rivers; these watersheds eventually flow into the San Joaquin River and further, into the Delta. The western boundary of the Coalition has been expanded and now lies along the western CVRWQCB Region 5 boundary in Contra Costa County and Alameda County. There are several small subwatersheds in this portion of the Coalition region including the Kellogg Creek, Marsh Creek, Sand Creek, and Brushy Creek subwatersheds that drain the northern hills of Mount Diablo; these waterbodies flow east through urban areas on the western edge of the statutory Delta.

SOILS AND GEOLOGY

Surface and Shallow Subsurface Sediments Characterization

Soil Chemistry

pH

Soil pH is a measurement of the concentration of hydrogen ions present in soil with acidic soils having a pH below 7, alkaline soils having pH values above 7, and neutral soils with a pH at 7. Crop success is affected by soil pH, with most crops growing best when soils are at or slightly below pH neutral. Soil pH also affects soil chemistry, the persistence of herbicides and pesticides in the soil, and whether or not those chemical compounds become bound to the soil surface or pass through the soil matrix.

Based on the maps of soil pH provided in the GAR, soils with pH values below 6 primarily exist in the eastern areas of the Coalition, along the Sierra foothills, with another lens in the area adjacent to the City of Stockton. Scattered soils with lower pH values also appear within the northern half of the statutory Delta. Neutral pH soils appear throughout the Coalition with a large area east of the San Joaquin River, within the southern half of the statutory Delta, and along the Coastal Range in the western portion of the Coalition. Alkaline soils with pH greater than 8 primarily occur along the eastern edge of, and scattered within the southern half of the statutory Delta (Figure 6).

Salinity

Soil salinity is generally measured by determining electrical conductivity (EC) of a soil solution. TDS and EC levels in soils are closely related. Potential TDS in soils include the following principal cations: sodium (Na), calcium (Ca), potassium (K), magnesium (Mg), and anions: chloride (Cl), sulfate (SO4), carbonate (CO3), bicarbonate (HCO3), and to a lesser extent, nitrate (NO_3), boron (B), iron (Fe), manganese (Mn) and fluoride (F). Levels of TDS, in turn, can be estimated by measuring the EC of an aqueous solution. For water containing less than 5,000 milligrams per liter (mg/l) TDS, the ratio of EC:TDS generally ranges from about 1.04:1 to 1.85:1 and averages about 1.56:1 (Sonon, 2012). Figure 7 illustrates a range of soil salinity from an EC of less than 500 µmhos/cm throughout the majority of the Coalition region, to greater than 2000 µhos/cm along the northern reaches of the San Joaquin River as it enters the statutory Delta.

The concentration of salts in water is determined by many natural factors including those reactions with minerals in the soil and rock formations across and through which the water moves. Human activities also can add salts to natural waters, e.g., groundwater, used as irrigation water containing mineral constituents leached from the soil and deeper geologic formations. The minerals in the irrigation water are in turn deposited as salts on the land surface through evaporation.

Figure 6. Soil pH values within the Coalition based on the NRCS soil surveys of San Joaquin and northern Stanislaus Counties (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

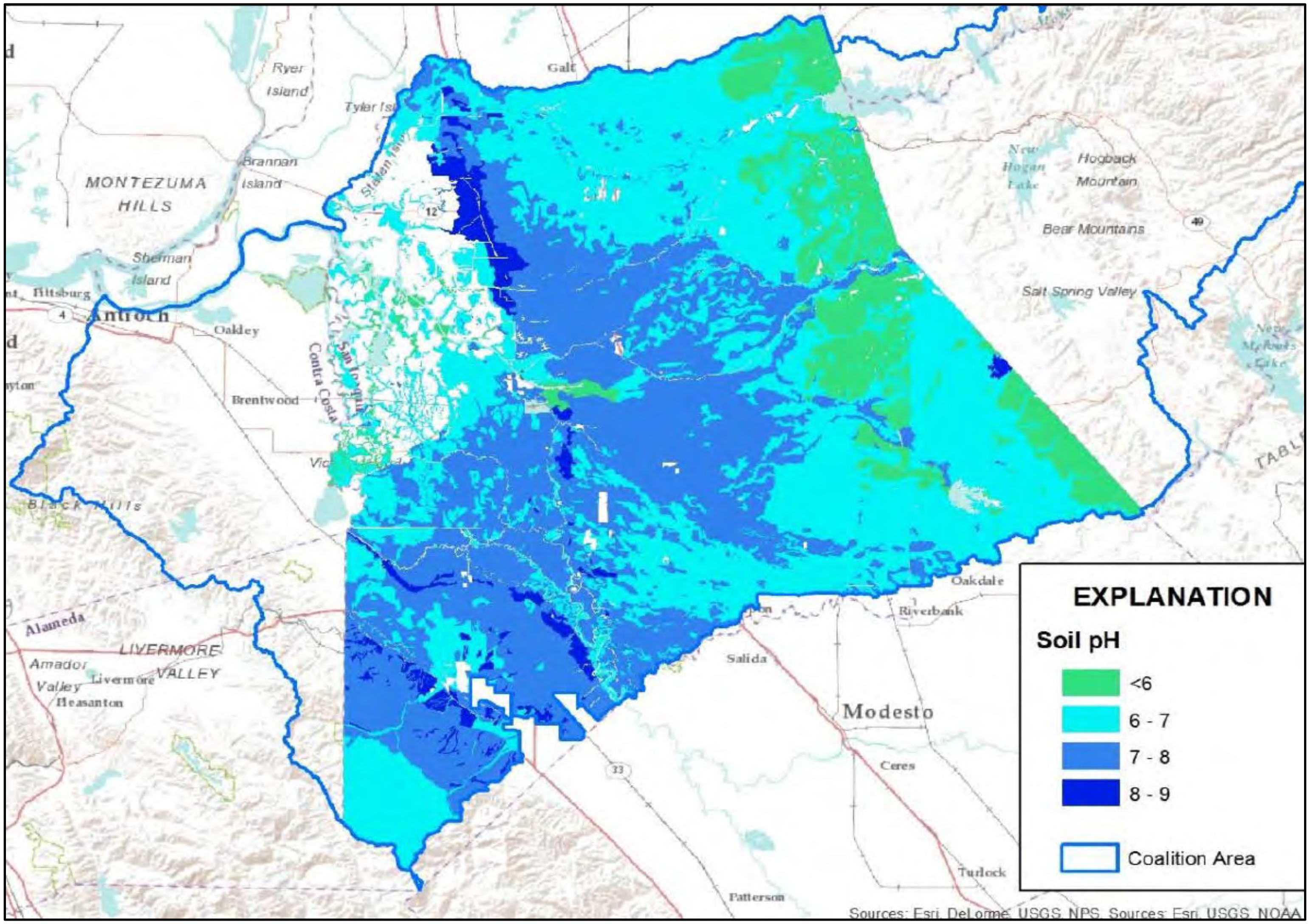
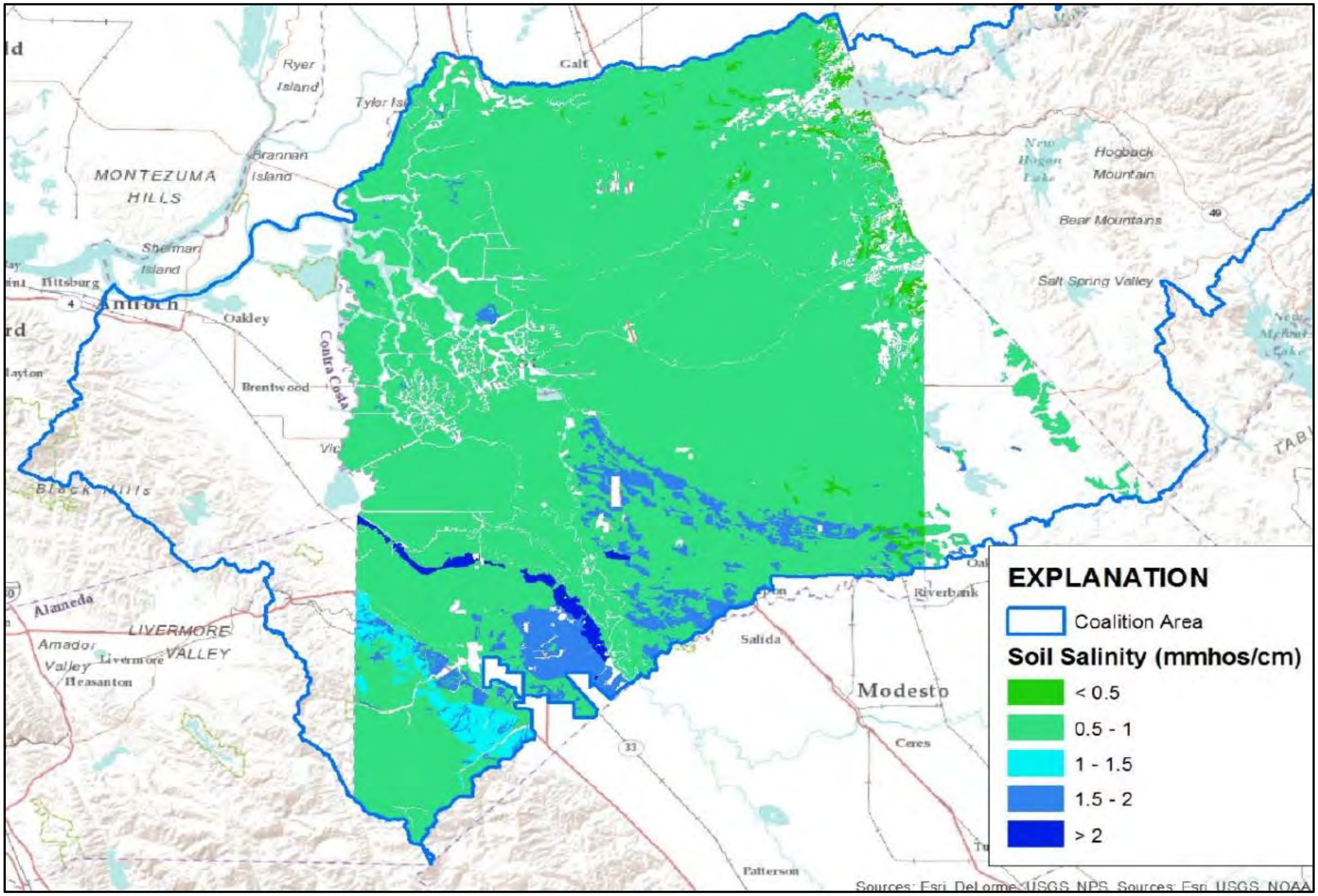


Figure 7. Soil salinity values (EC) within the Coalition based on the NRCS soil surveys of San Joaquin and northern Stanislaus Counties (SJCDWQC, 2015). Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



Mining activities can release dissolved mineral constituents to local streams and groundwater. Storm runoff from urban areas and municipal wastewater also can contribute salts and chemicals (Cordy, 1999).

Salinity in soils reduces water availability for plant use. High salt levels hinder water absorption, inducing physiological drought in the plant. The soil may contain adequate water, but plant roots are unable to absorb the water due to unfavorable osmotic pressure. The second effect of salinity is shown when excessive amounts of salt enter the plant in the transpiration stream and injure leaf cells, which further reduces growth. Symptoms may include restricted root growth, marginal or leaf tip burning/ browning, inhibited flowering, reduced vigor and reduced crop yields.

The issue of salinity management within the Central Valley is currently being addressed by the Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS) program. CV-SALTS is a collaborative stakeholder driven and managed program between the Central Valley Salinity Coalition, Central Valley Water Board, and the State Waters Resource Control Board. The CV-SALTS program is tasked with developing sustainable salinity and nitrate management planning for the Central Valley. Management of the salinity of groundwater or soils within the SJCDWQC is outside the purview of this GQMP.

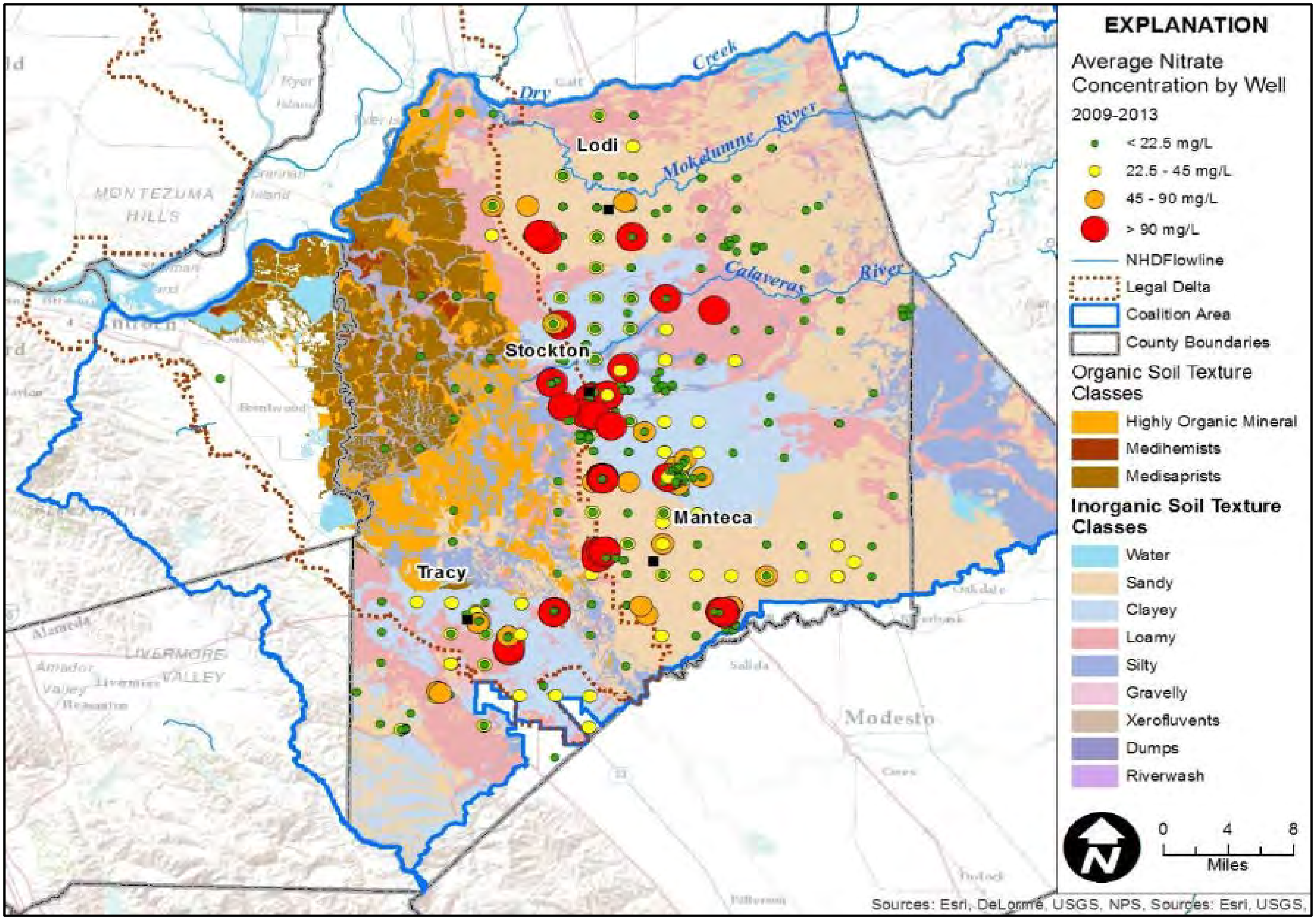
Texture

For the purposes of completing the GAR for the SJCDWC region, sources of data used to characterize soils in the Coalition area consisted primarily of geo-referenced soil data obtained from the USDA Natural Resource Conservation Service (NRCS) soil surveys of San Joaquin and northern Stanislaus counties. The following description of the soils within the Coalition area comes almost exclusively from the GAR for the SJCDWQC area. Figure 8 shows the distribution of soil texture within the Coalition based in the NRCS Soil Survey (SJCDWQC, 2015).

Within the non-Delta area, sandy and loamy soils predominate throughout the central eastern, northern and southern areas of the Coalition region. There are large areas of clayey soils in the central and southeastern parts of the Coalition region north and northeast and south and southeast of Stockton. The eastern part of the non-Delta Coalition region contains intermixed loamy, clayey, sandy and silty soils. In Stanislaus County, silt-textured soils (silty clay loams, silty loams and silt) predominate (Figure 8).

In the Delta, true surface organic soils or highly organic mineral soils or histosols predominate in the central, eastern and southern Delta (Figure 8). These are predominantly medisaprists and include the Rindge, Kingile, Webile, Shinkee, and Shima soil series. A small portion of less decomposed medihemist histosols is present in the central Delta (Figure 8).

Figure 8. Distribution of soil types and textures in the Coalition area and average groundwater nitrate concentrations for 2009-2013 (SJCDWQC, 2015). Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



Subsurface Lithology

Figure 9 and Figure 10 illustrate the spatial layout of the various geologic formations within the Coalition region. Figure 10 is taken from USGS' Status and Understanding report on the Northern San Joaquin Basin GAMA study unit (Bennett et al., 2010a). Subsurface sediment texture model data from the USGS Central Valley Hydrologic Model (CVHM) and thickness and depth characteristics of the Corcoran Clay layer, where it exists, are represented in Figure 10 and Figure 12 to Figure 14 (Faunt, 2009). The texture data of the CVHM was estimated using lithologic data from numerous well drillers' logs and other available date, in 50-foot-thick vertical increments. The model layers (1-10) range from 50-400 ft thick with the thickness of each layer 50 ft thicker than the layer above (Table 8, Figure 11) to a total depth of 1,800 ft.

Figure 12 depicts the groupings of basins and subbasins within the Central Valley used for the textural soils analysis in the CVHM. Layers 1-3 of the texture model are provided below (Figure 13 and Figure 14) to represent the texture of soils surrounding wells typically defined as shallow (less than 200 ft deep). The Delta of the GQMP is located partially in the northern half of the Tracy/Delta-Mendota spatial province and domain (20) and partially within the northwestern part of the Northern San Joaquin spatial province and domain (22). The non-Delta areas of the GQMP are primarily located in the northern portion of the Northern San Joaquin spatial province and domain (22) with the westernmost sliver located in the northwestern portion of the Tracy/Delta-Mendota spatial province and domain (20).

Hydraulic Conductivity

Hydraulic conductivity is a measure of the ability of a material to transmit water; the greater a material's hydraulic conductivity, the faster water moves through the matrix. In general, coarser grained material, or soils with a higher percentage of coarse grained material, will allow water to move through the matrix faster than finely grained soil.

Figure 15 through Figure 20 from the SJCDWQC GAR provide a closer look at soil conductivity by analyzing for percent coarse grained material within the Coalition. Figure 15 through Figure 20 show the distribution of percent coarse grain (sand and gravel) in 50 foot intervals in the subsurface for the mile-square grid of the CVHM. These distributions were developed from the analysis of Well Completion Reports by the USGS from throughout the Coalition region. Included within the GAR are interpretations of CVHM data extending up to 300-ft depth; this is the approximate depth of municipal water-supply wells in the Coalition region.

In the first 50 feet (Figure 15), darker areas representing over 40 percent coarse-grained materials within soils tend to predominate near the Stanislaus River and at the eastern edge of the Coalition near the foothills. There is also an area with greater coarse-grained percentages south of the Mokelumne River in the eastern part of the Coalition. The pattern of relatively greater abundance of coarse-grained deposits in these areas is evident in the deeper depth intervals as well. However, the percent coarse-grained decreased with depth in in the south-central area of the Coalition, adjacent to the Stanislaus River.

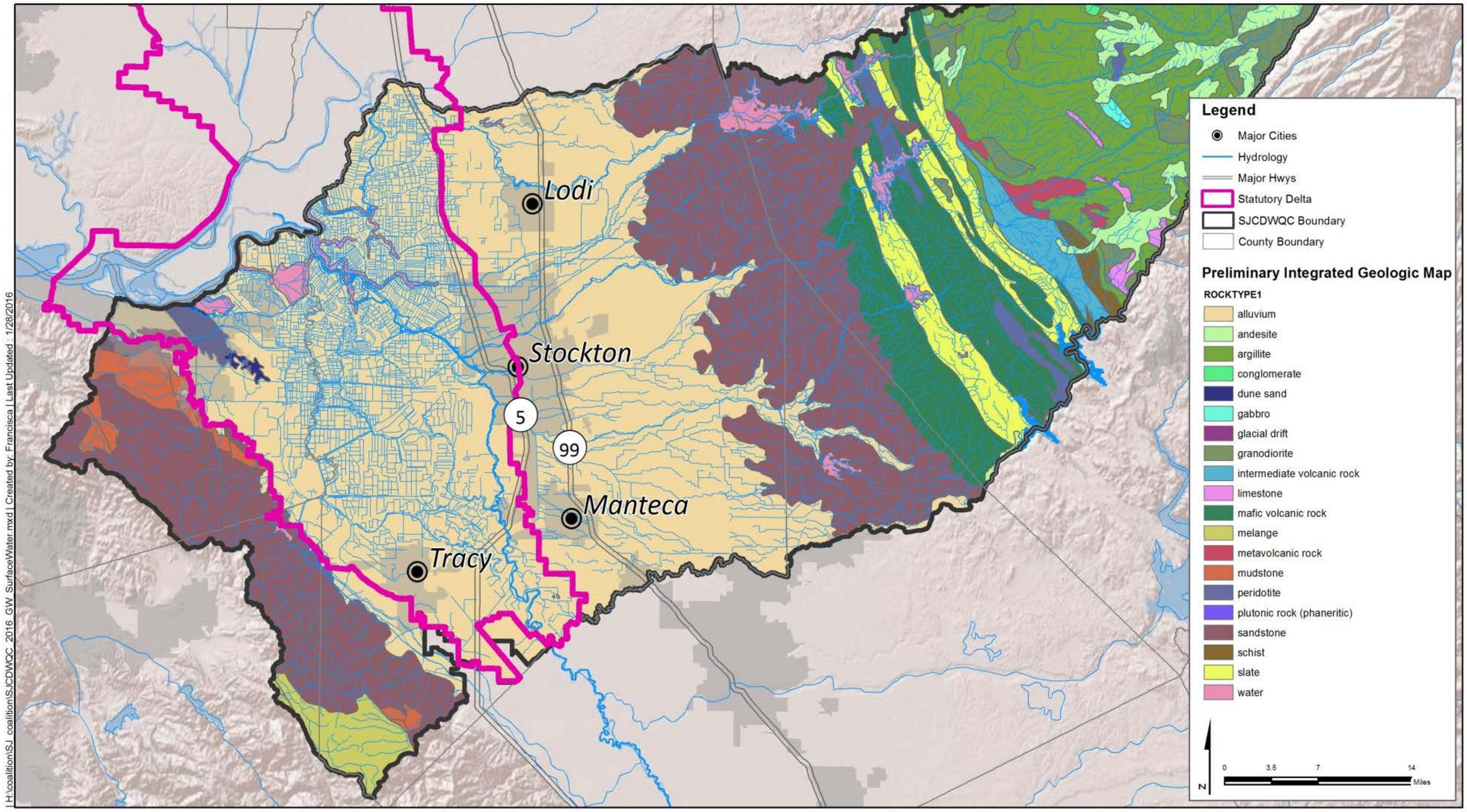
Based on soil data from USDA soil surveys, Figure 21 and Table 9 represent the DRASTIC ratings for horizontal hydraulic conductivity and Figure 22 and Table 10 represent the DRASTIC ratings for vertical hydraulic conductivity presented in the GAR for the Coalition region. The percent of coarse-grain sediments in the first 50 feet below land surface (Figure 15) and those areas with a high DRASTIC rating for hydraulic conductivity in Figure 21 generally correspond with one another. Lenses of soil with high hydraulic conductivity occur within the southern portion of the statutory Delta surrounding Tracy, between Tracy and Manteca, and south of Manteca. Within the non-Delta portion of the Coalition, lenses of soil with high hydraulic conductivity are scattered along the eastern portion of the Coalition and within the western portion of the Coalition, north of Brentwood and east of Oakley.

Corcoran Clay

The Corcoran Clay is a prominent stratigraphic layer of diatomaceous clay in parts of the Central Valley. Due to its low hydraulic conductivity, where it exists, the Corcoran Clay layer is generally believed to divide deeper groundwater zones from shallow groundwater zones. The spatial extent of the Corcoran Clay, as depicted in the CVHM, is shown in Figure 10, Figure 23, and Figure 24. The Corcoran Clay is generally present only in the western portion of the Central Valley Floor area, approximately west of Highway 99. Depth to the top of the Corcoran Clay generally increases towards the center of the valley and ranges from less than 50 feet along its borders to more than 300 feet below ground in the southwest portion of the Central Valley Floor.

The northern extent of the Corcoran Clay member is not known due to the absence of data north of Stockton, particularly in the Delta area (Williamson, 1989). Within the Coalition, the Corcoran Clay is either known to extend or inferred to extend north of the Stanislaus River to the City of Tracy, west to the Delta Mendota Canal and east beyond the San Joaquin River to the City of Manteca (Bennett et al., 2010a; DWR, 2003) (Figure 10, Figure 24).

Figure 9. General geologic formations within the Coalition region.



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Geologic Map of SJCDWQC

SJCDWQC

Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet
Projection: property=Lambert Conformal Conic
Units: Foot US

Service Layer Credits: Shaded Relief: Copyright:© 2009 ESRI
Hydrology - NHD hydrodata, 1:24,000-scale, http://nhd.usgs.gov/
Roads, highways, railroads - ESRI
Preliminary Integrated Geologic Map - USGS

Figure 10. Geologic formations, and areal distribution of grid and understanding wells, in the USGS' Northern San Joaquin Basin GAMA study unit (Bennett et al., 2010a).

The Northern San Joaquin study unit spans the Tracy, Eastern San Joaquin, and Cosumnes groundwater subbasins from west to east.

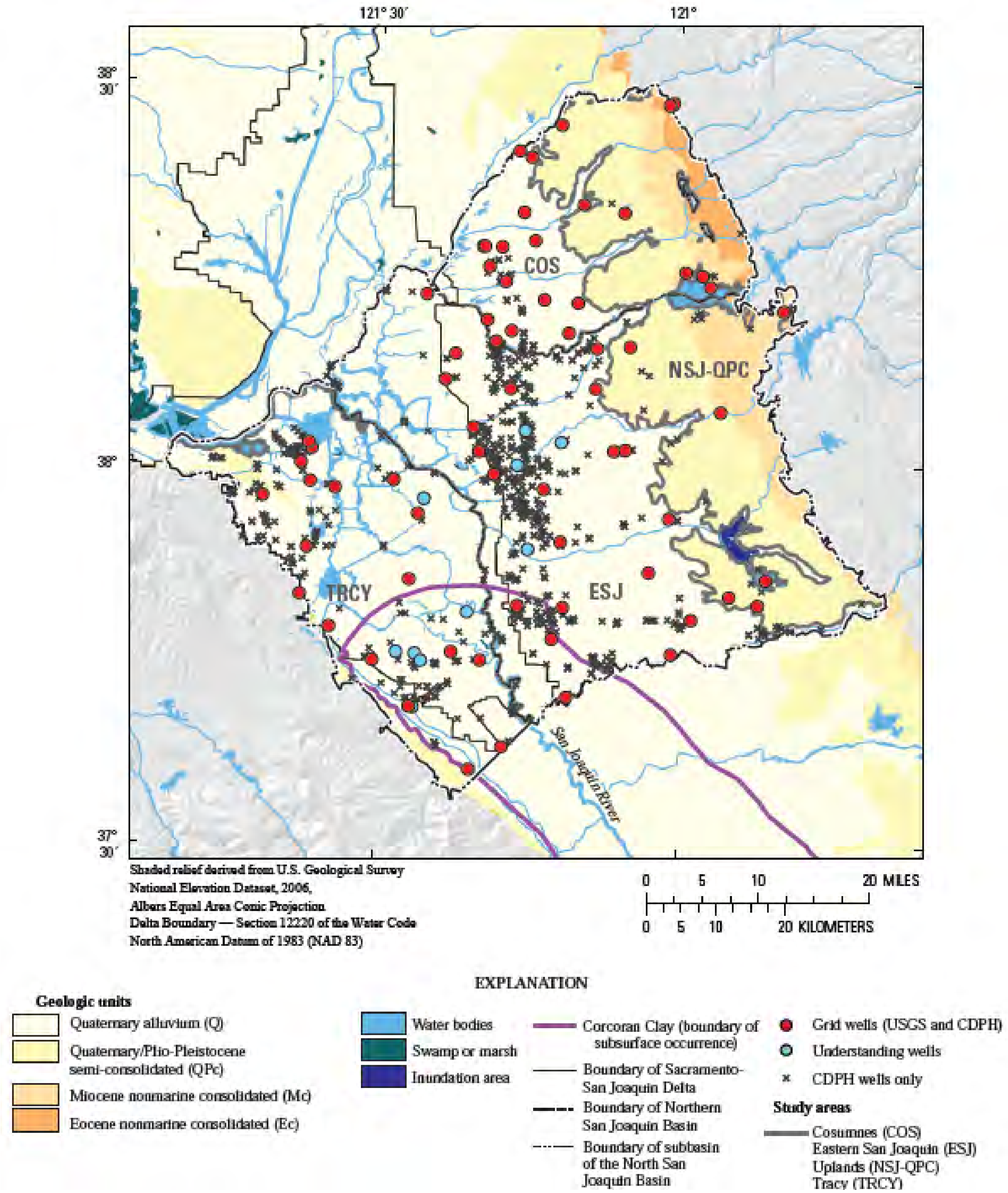


Table 8. Central Valley, California groundwater flow model layer thicknesses and depths listed by layers (Faunt, 2009).

Layers 4 and 5 represent Corcoran Clay where it exists; elsewhere a 1 foot thick phantom layer; they are kept only to keep track of layer numbers.

Layer	Thickness (ft)	Depth to Base Outside Corcoran Clay (ft)
1	50	50
2	100	150
3	150	300
4	Variable	301
5	Variable	302
6	198	500
7	250	750
8	300	1050
9	350	1400
10	400	1800

Figure 11. Generalized hydrogeological section of the Central Valley according the CVHM. Layers 1-10 indicate the discreet vertical layers described in the CVHM (Faunt, 2009).

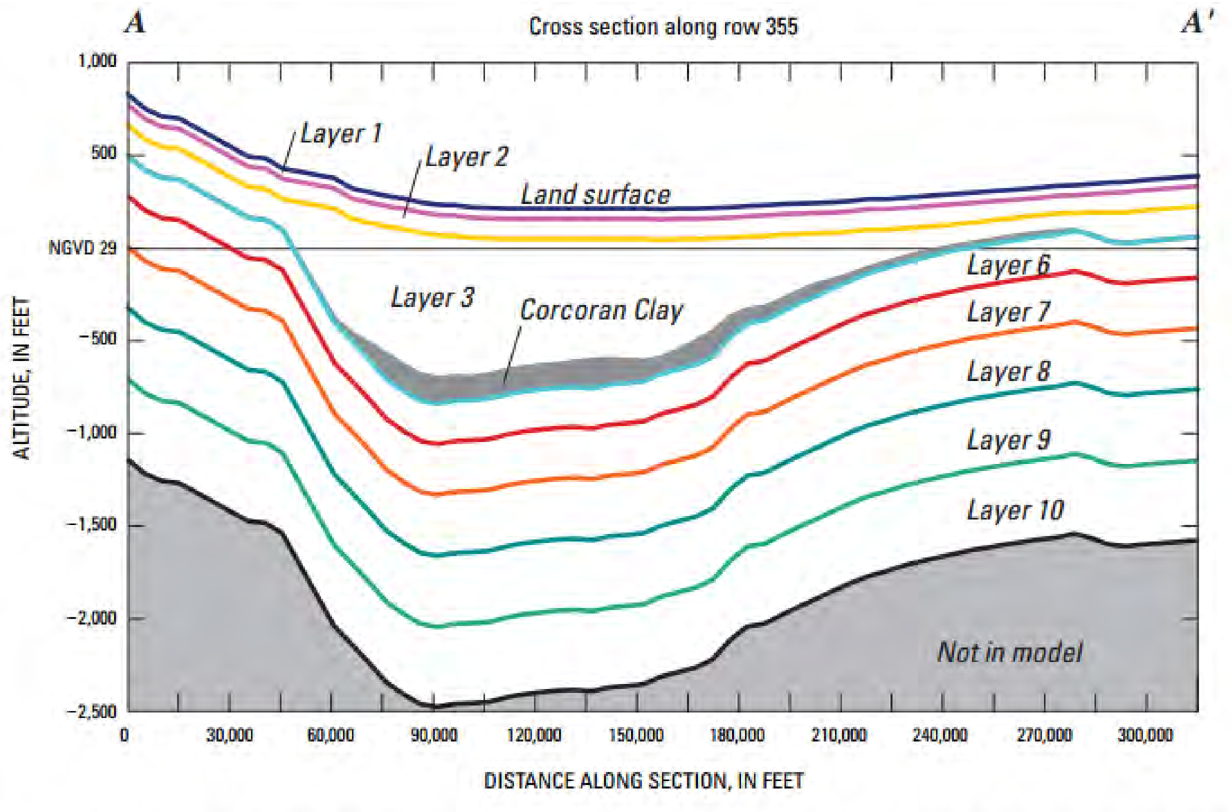


Figure A11. Generalized hydrogeologic section (*A–A'*) indicating the vertical discretization of the numerical model of the groundwater-flow system in the Central Valley, California. Line of section shown on *figure A1* (altitudes are along row 355; layer numbers indicate model layer).

Figure 12. Groupings of basins and subbasins within the Central Valley used for textural soils analysis in the CVHM (Faunt, 2009).

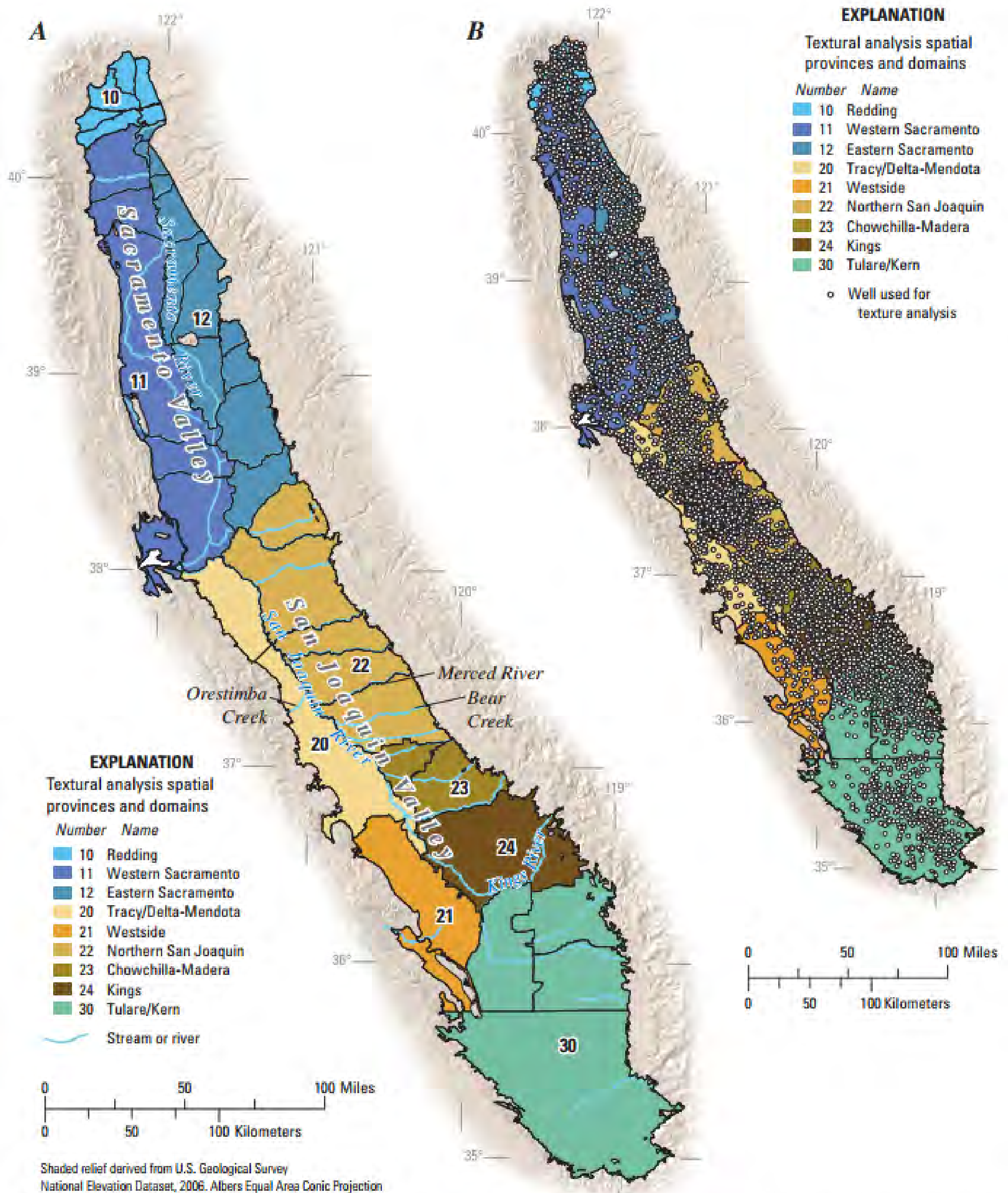


Figure A10. *A*, Central Valley showing groundwater basins and subbasins, groupings of basins and subbasins into spatial provinces and domains for textural analysis. *B*, Distribution of wells used for mapping texture. *C*, Count of wells for each depth increment by domains through 1,200 feet. Because less than 1 percent of the logs extend past 1,200 feet, increments below 1,200 feet were not shown. Detailed description of the spatial provinces and domains are in *table A2*.

Figure 13. Layer 1 of the CVHM depicting the percentage of coarse-grained material within the top 50 ft of the Central Valley (Faunt, 2009).

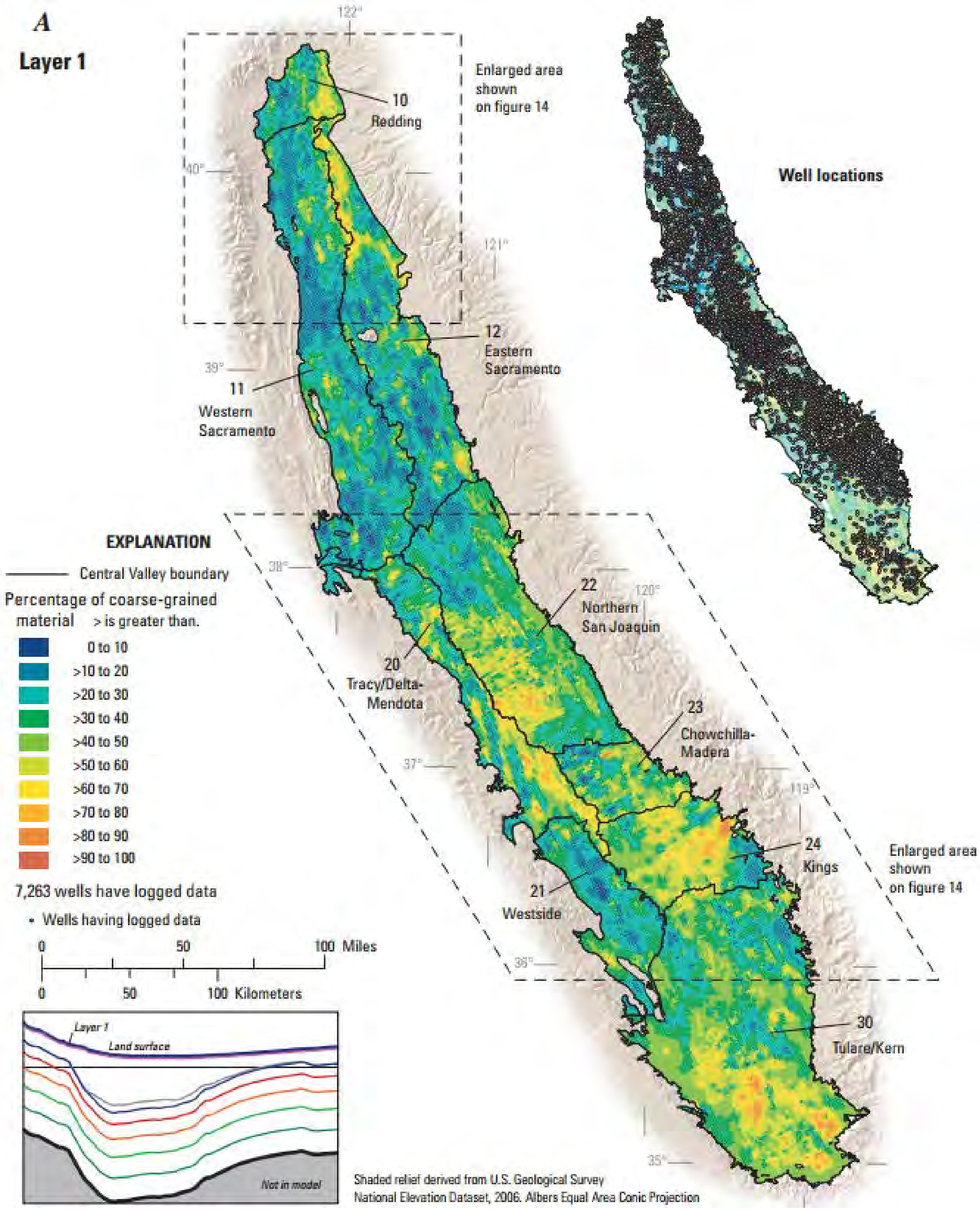


Figure 14. Layer 3 of the CVHM depicting the percentage of coarse-grained material within the top 150 ft of the Central Valley (Faunt, 2009).

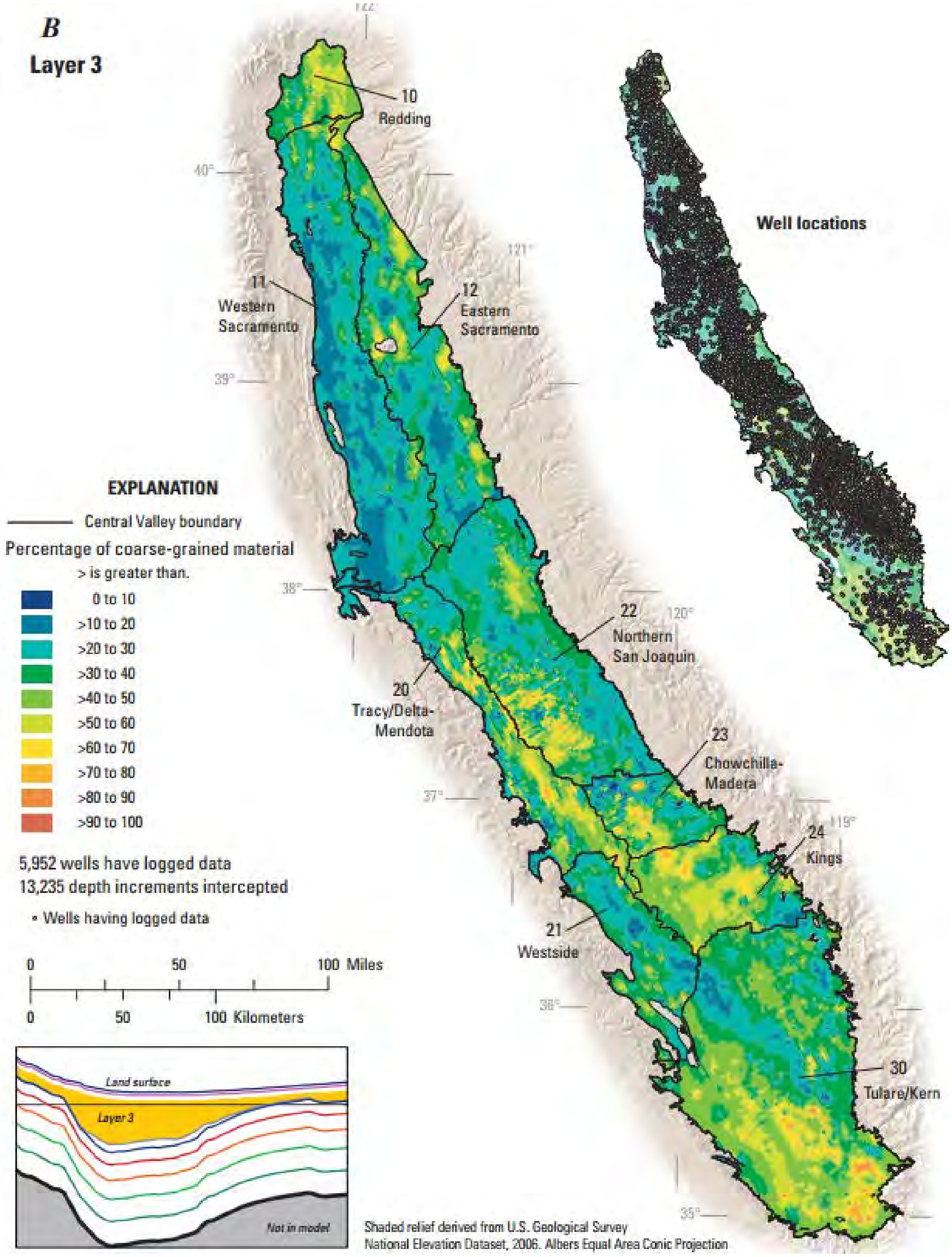


Figure 15. Percent coarse grain sediments, 0-50-ft below land surface with average nitrate concentrations by well (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

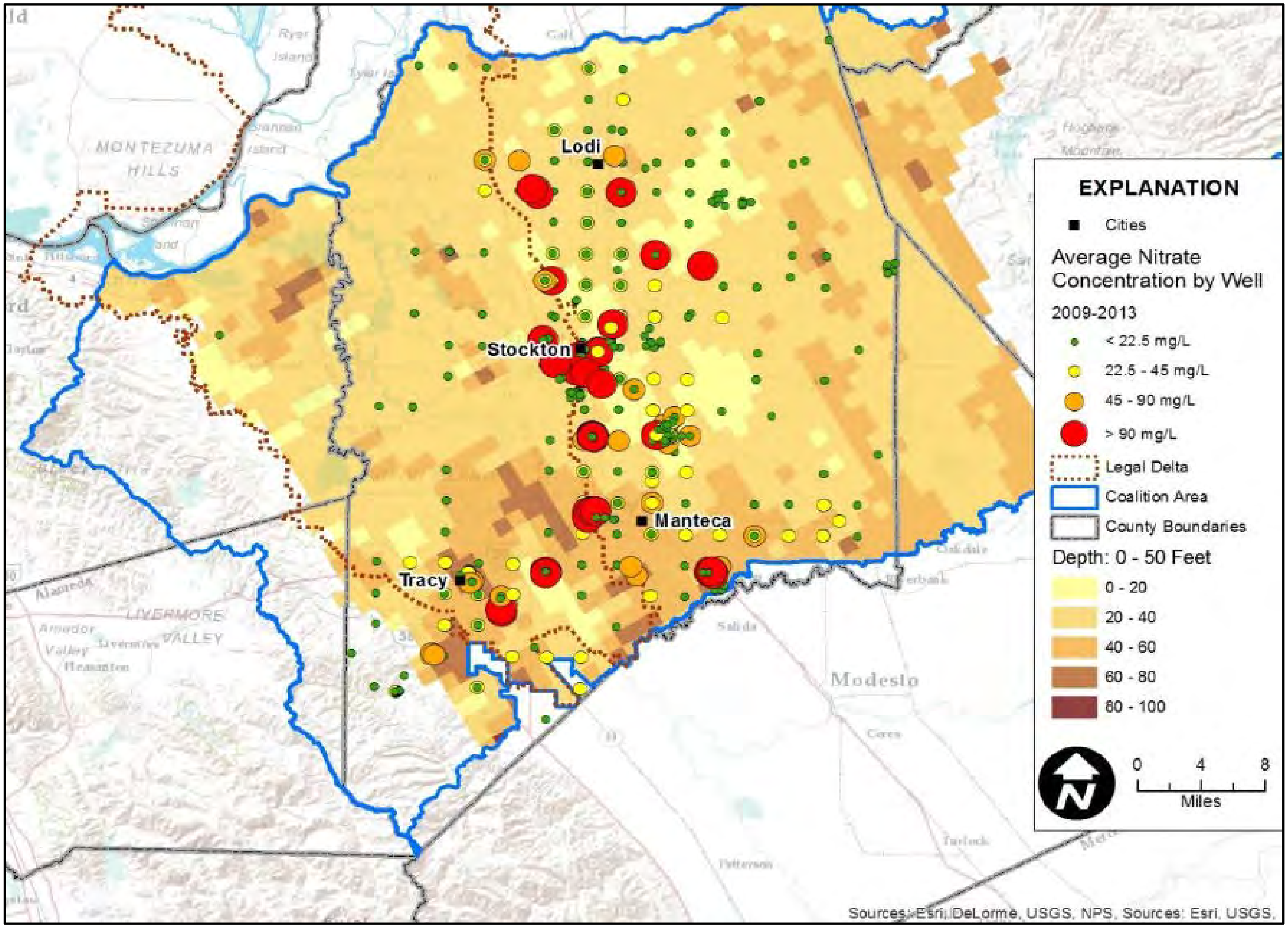


Figure 16. Percent coarse grain sediments, 50-100 ft below land surface (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line. CVHM = Central Valley Hydrologic Model; Pct = Percent.

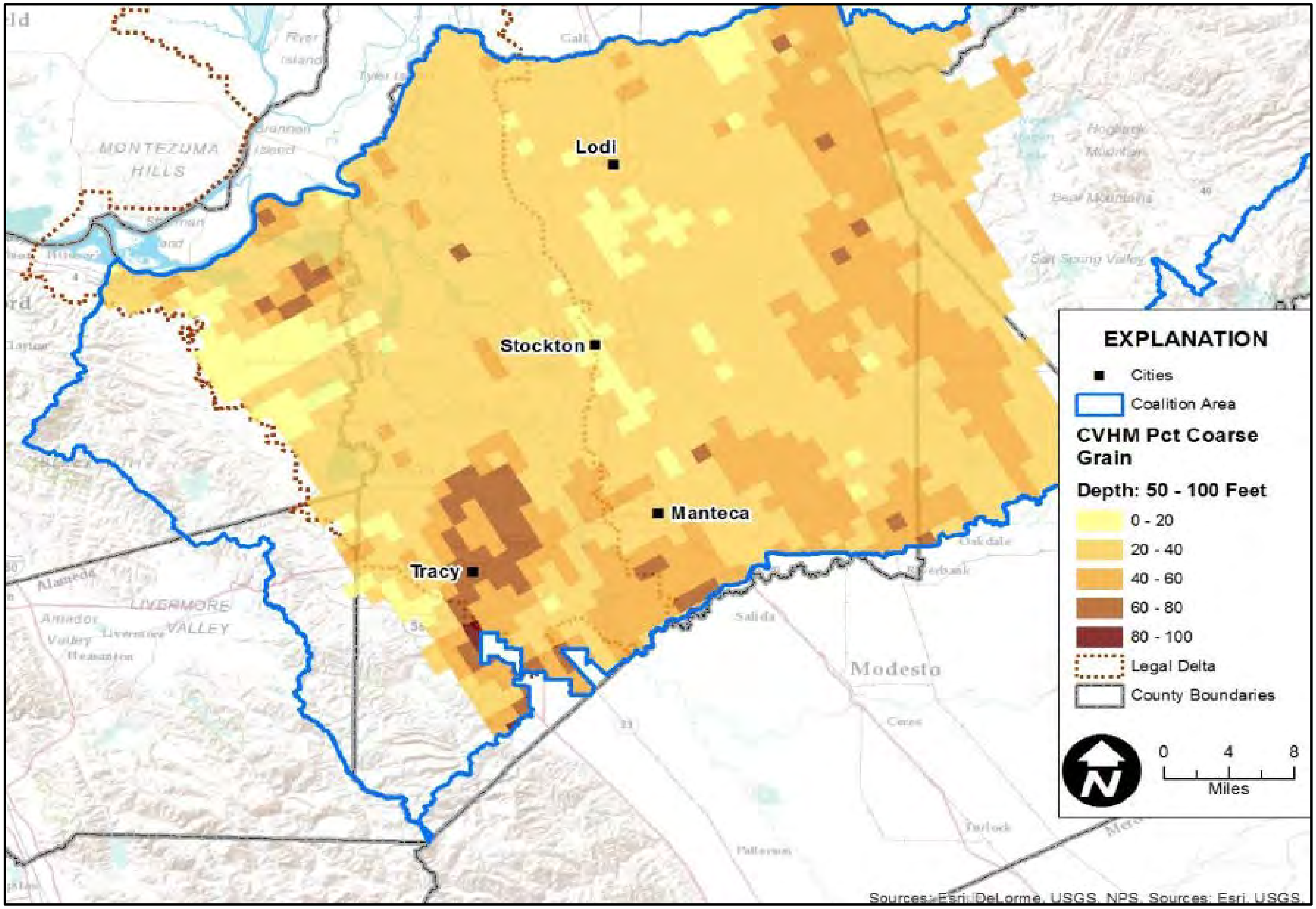


Figure 17. Percent coarse grain sediments, 100-150 ft below land surface (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line. CVHM = Central Valley Hydrologic Model; Pct = Percent.

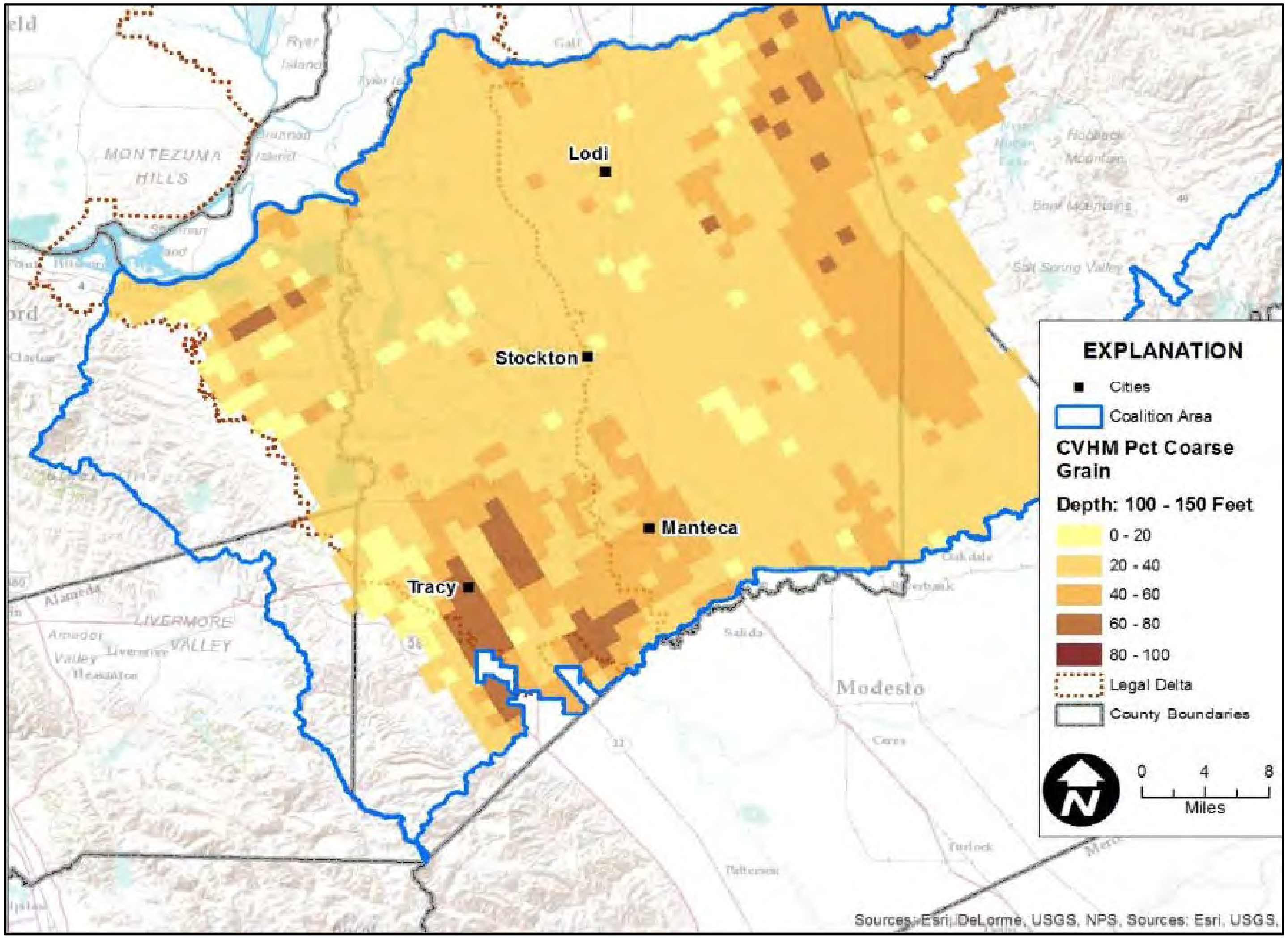


Figure 18. Percent coarse grain sediments, 150-200 ft below land surface (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line. CVHM = Central Valley Hydrologic Model; Pct = Percent.

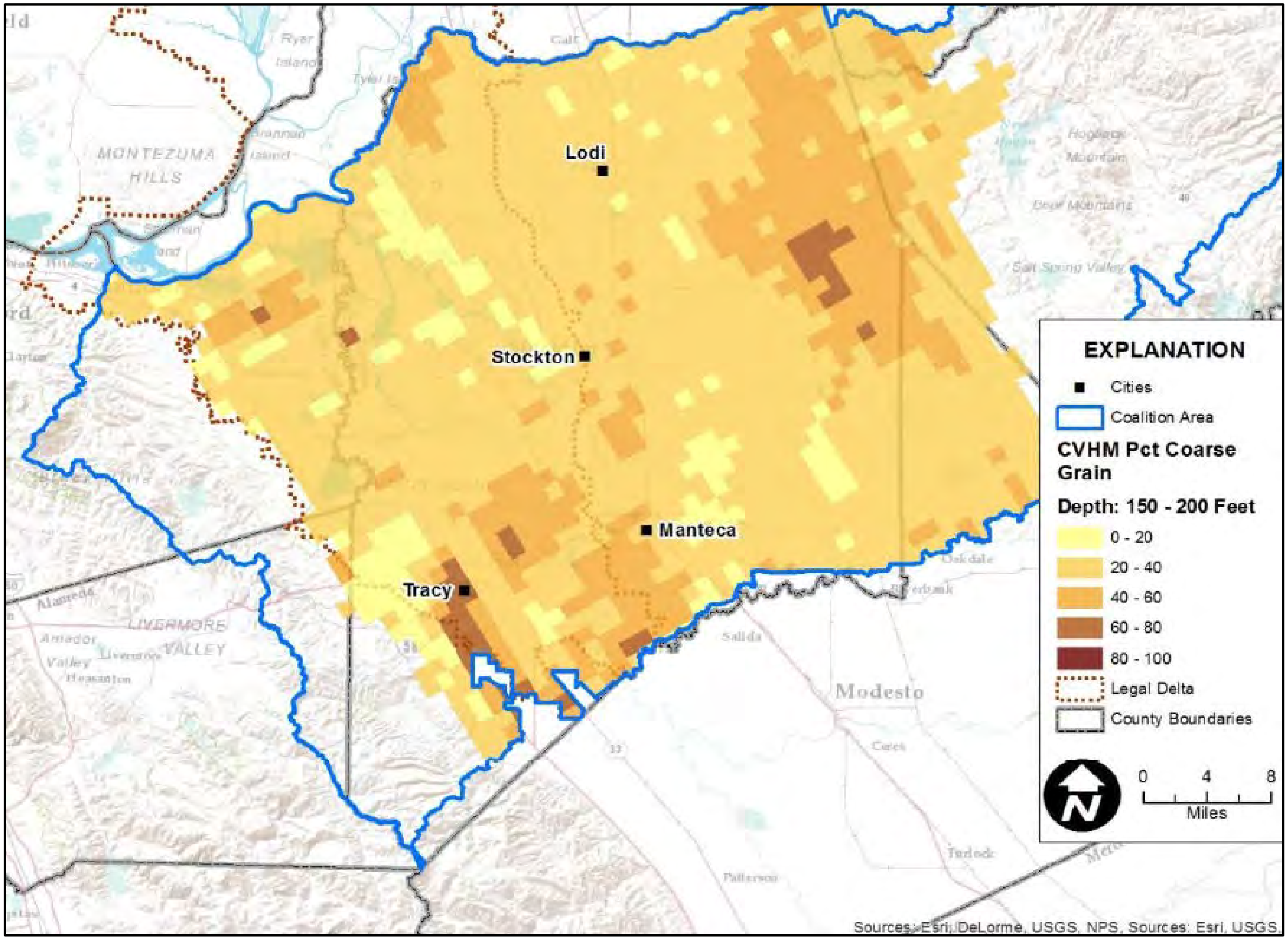


Figure 19. Percent coarse grain sediments, 200-250 ft below land surface (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line. CVHM = Central Valley Hydrologic Model; Pct = Percent.

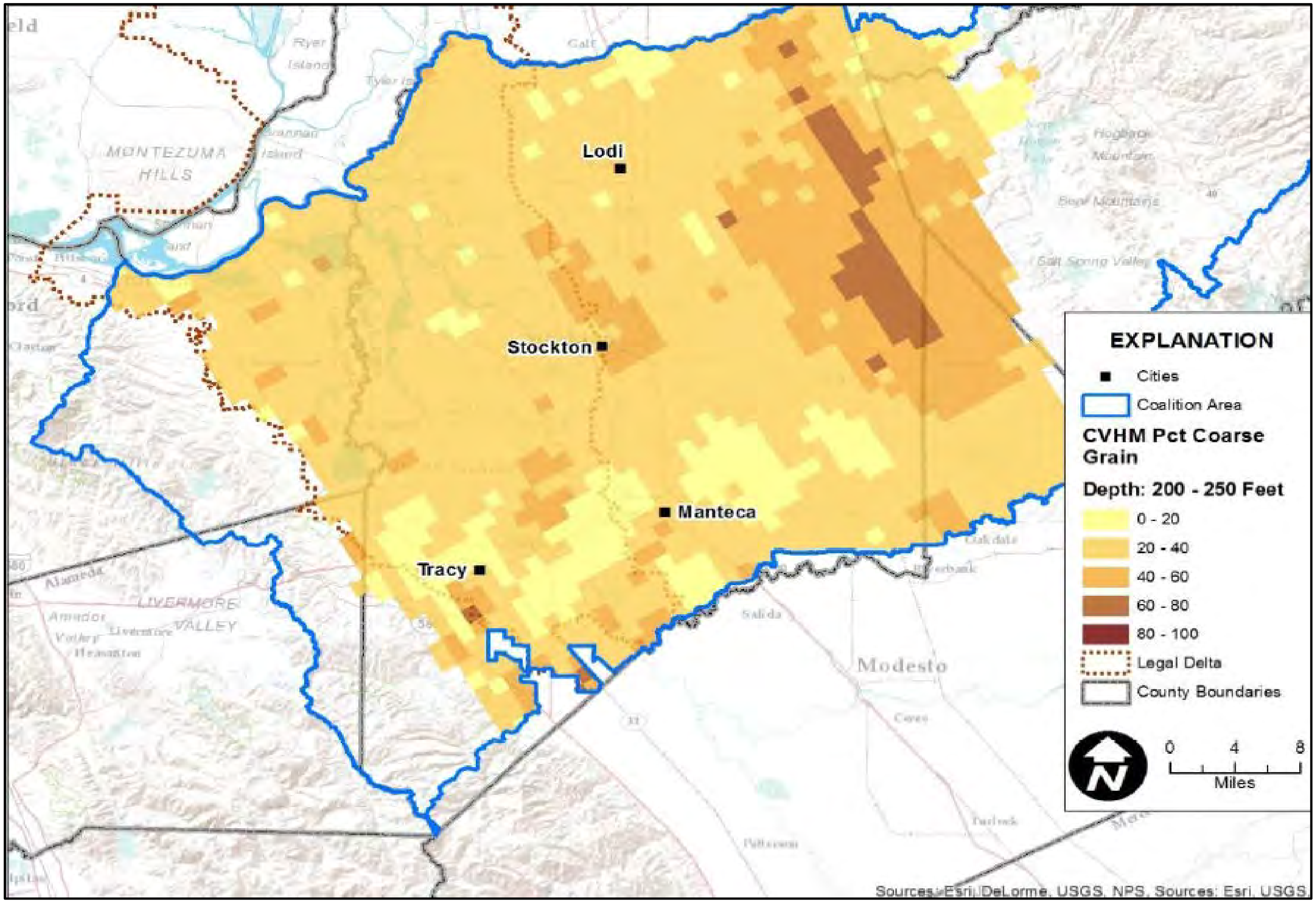


Figure 20. Percent coarse grain sediments, 250- 300 ft below land surface (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line. CVHM = Central Valley Hydrologic Model; Pct = Percent.

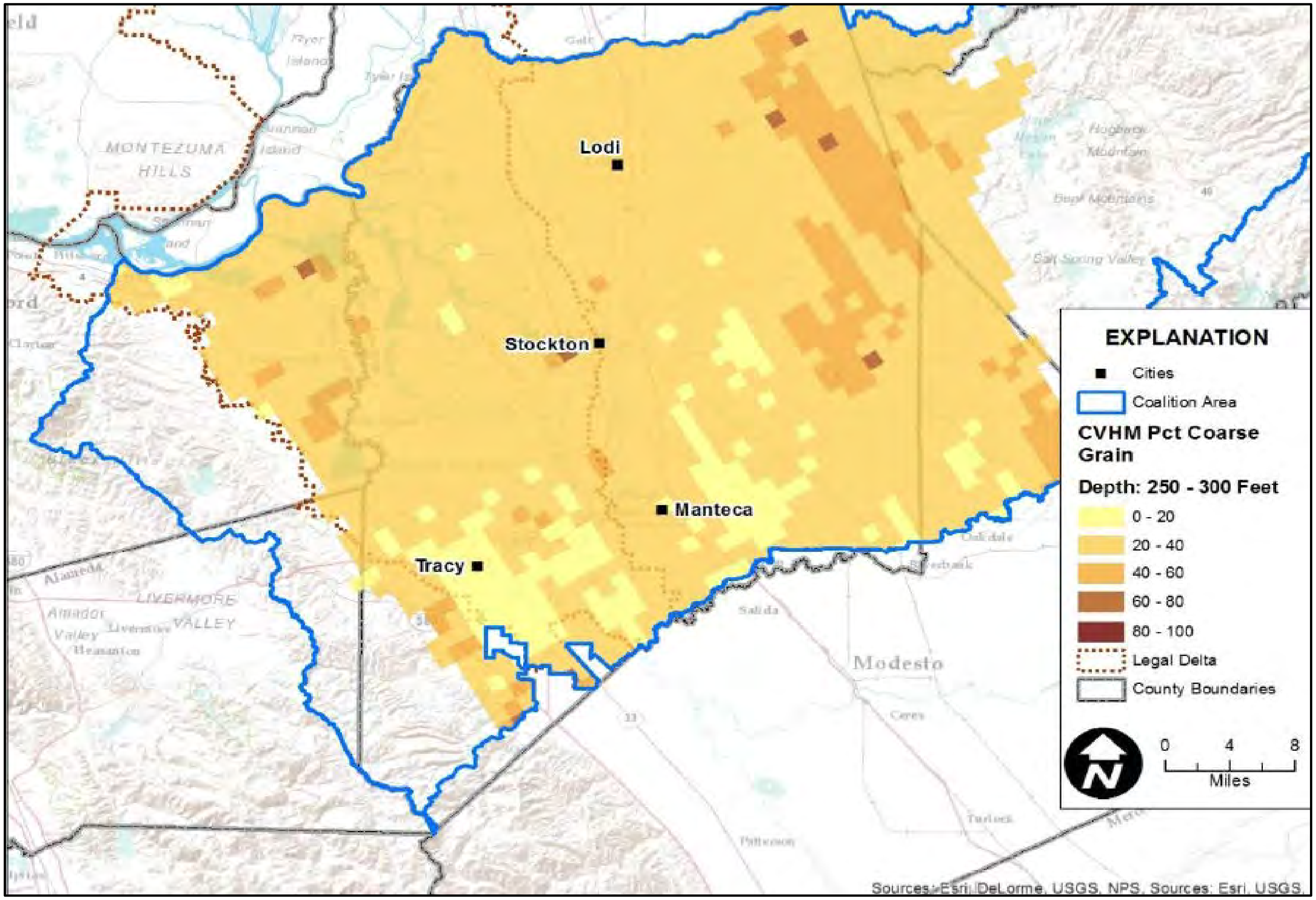


Figure 21. DRASTIC input ratings for horizontal hydraulic conductivity (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

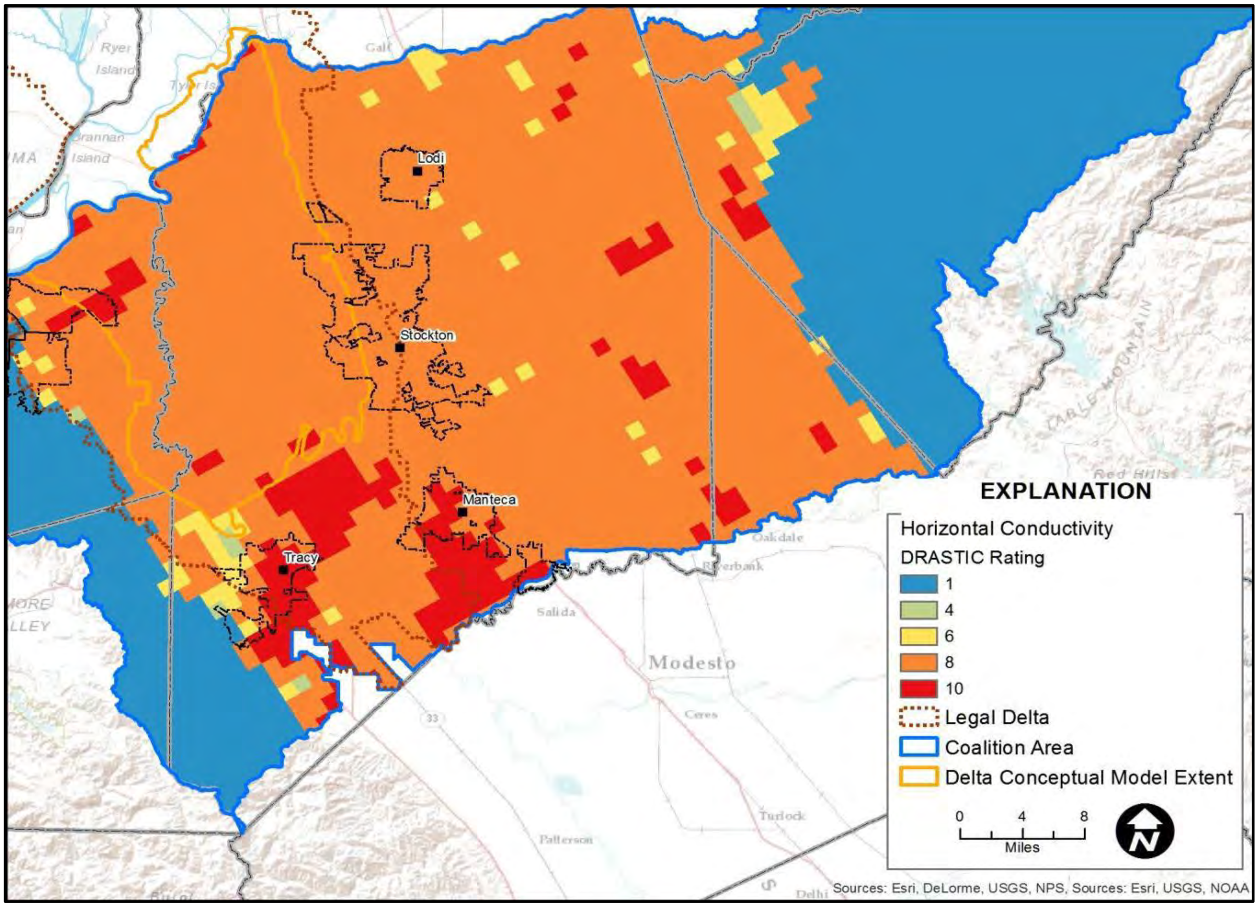


Table 9. Aquifer hydraulic conductivity DRASTIC ratings

Range (gpd/ft^2)	Rating
1 – 100	1
100 – 300	2
300 – 700	4
700 – 1,000	6
1,000 – 2,000	8
>2,000	10

gpd/ft^2– gallons per day per square foot

Figure 22. DRASTIC input ratings for vertical hydraulic conductivity(SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

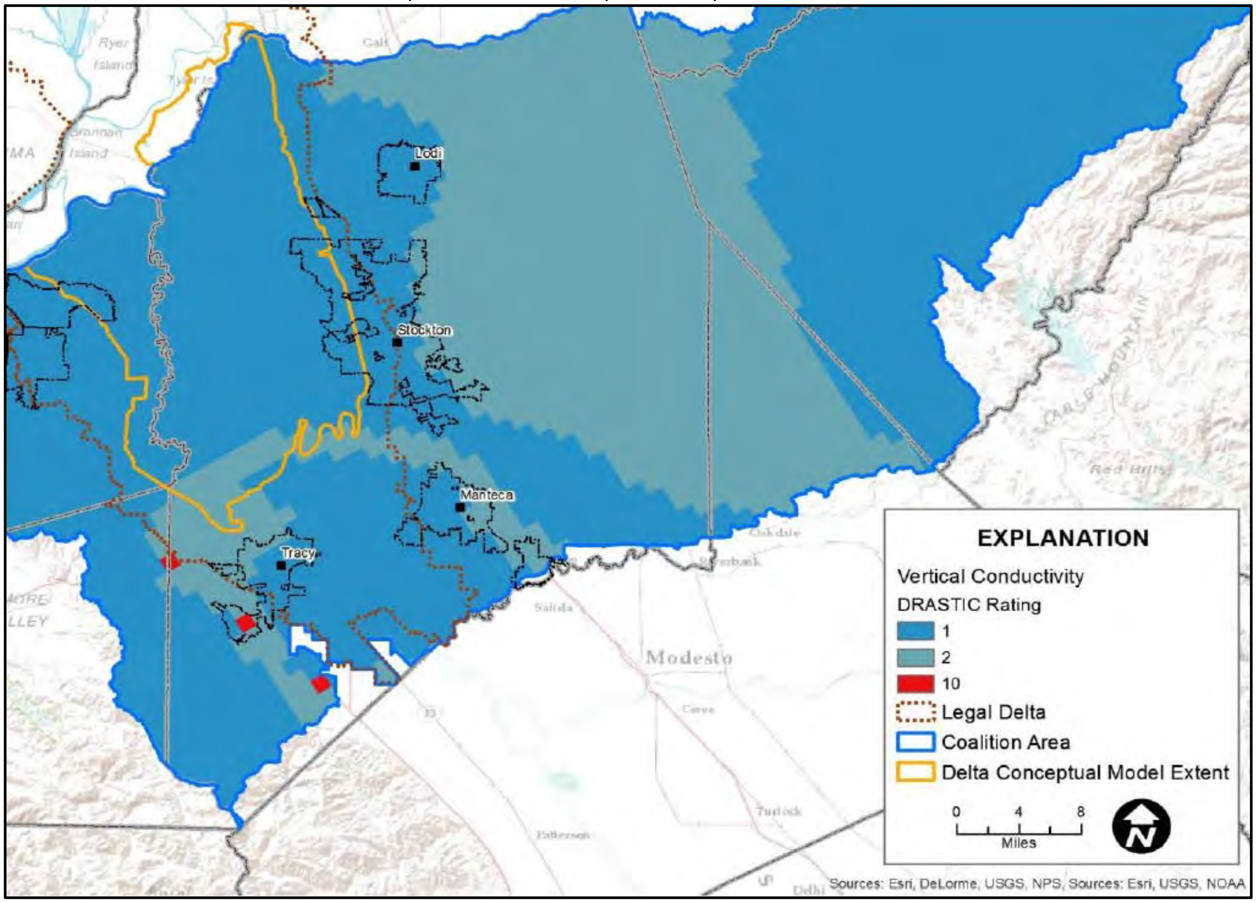
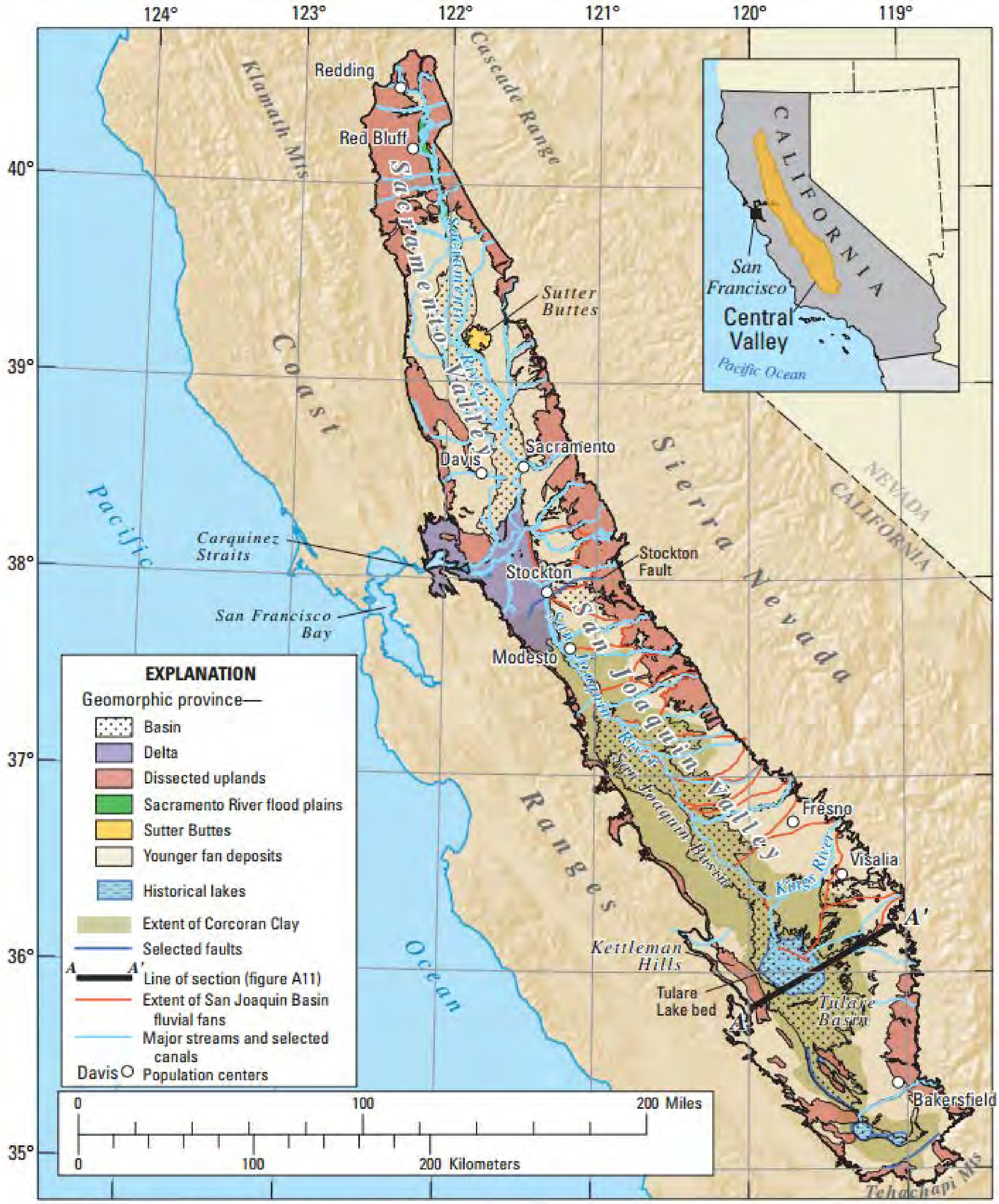


Table 10. Aquifer hydraulic conductivity DRASTIC ratings

RANGE (GPD/FT^2)	RATING
1 – 100	1
100 – 300	2
300 – 700	4
700 – 1,000	6
1,000 – 2,000	8
>2,000	10

gpd/ft^2– gallons per day per square foot

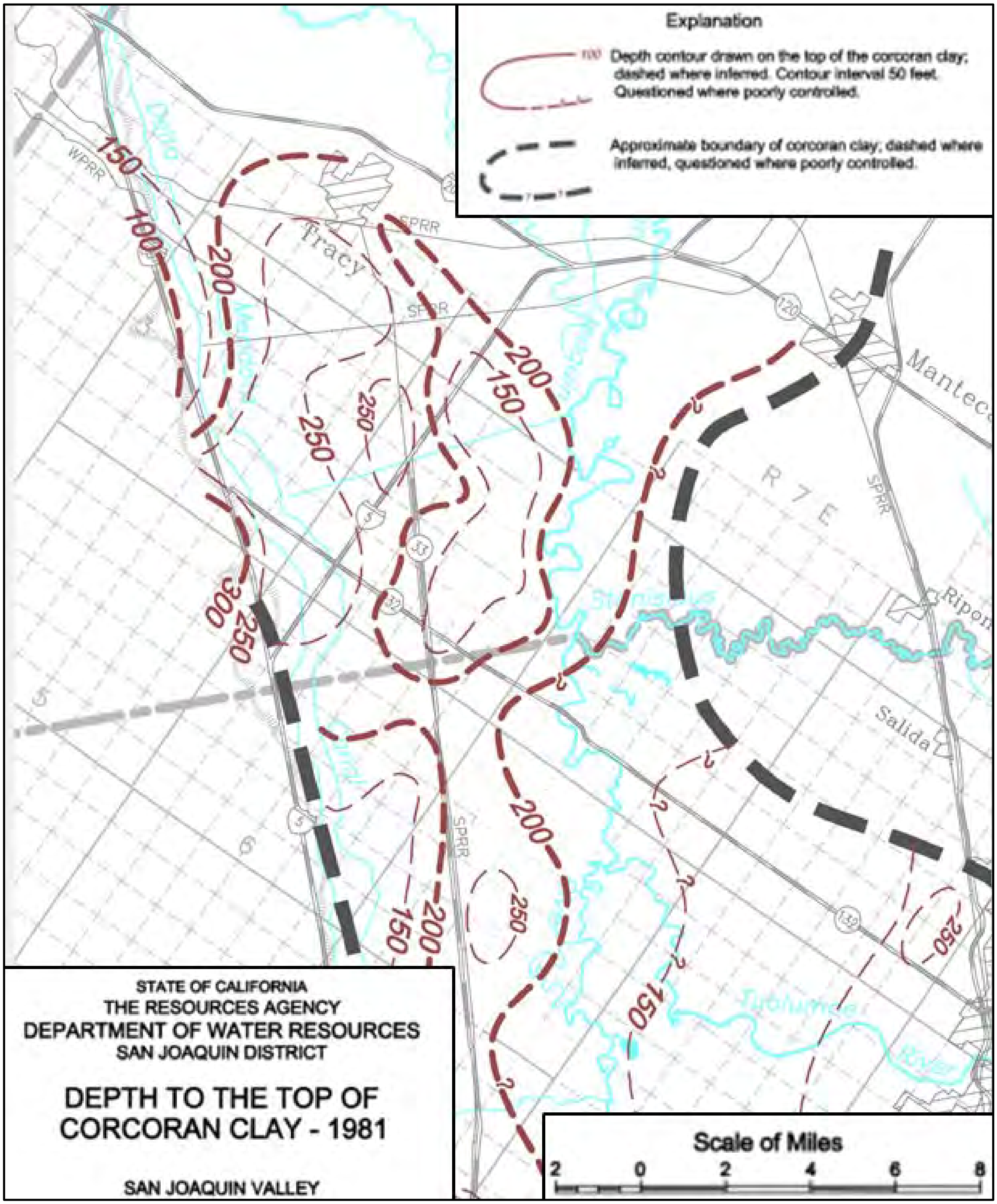
Figure 23. Central Valley major geomorphic provinces, alluvial fans of the San Joaquin Basin, and extent of the Corcoran Clay layer (Faunt, 2009).



Shaded relief derived from U.S. Geological Survey National Elevation Dataset, 2006.
Albers Equal Area Conic Projection

Figure 24. Depth contours of the northern extent of the Corcoran Clay layer within the Coalition region (DWR, 1981).

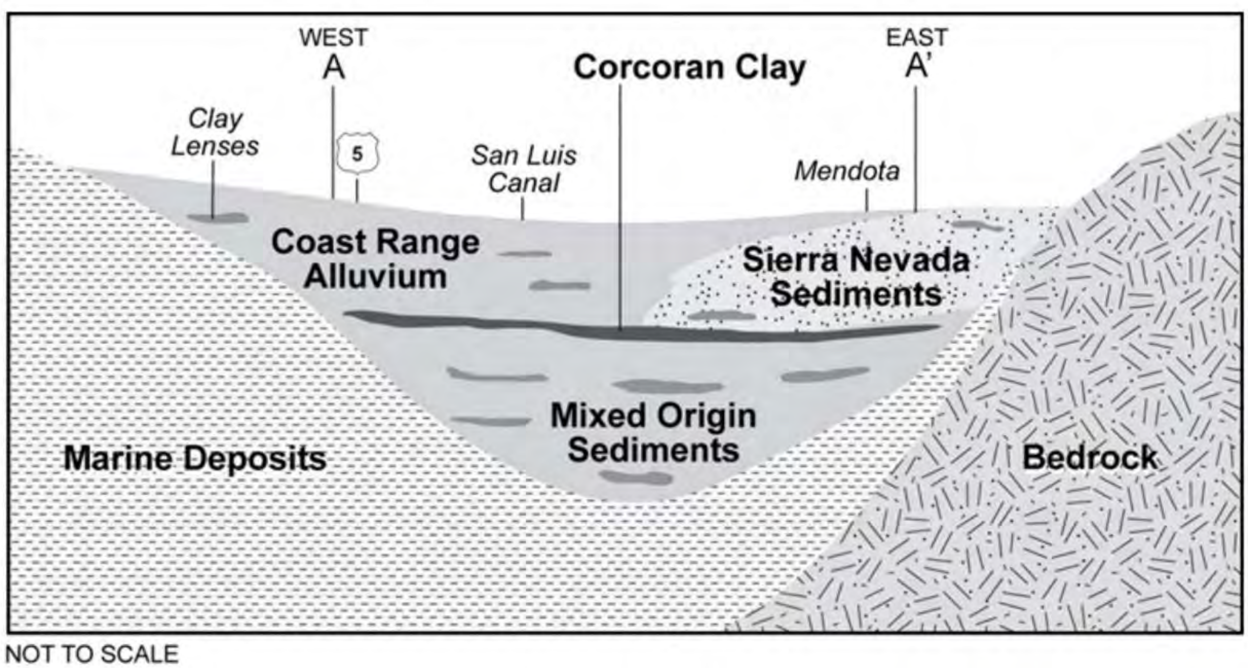
Corcoran Clay layer extends north of the Stanislaus River, south of the City of Tracy, east of Interstate 5, and west of the City of Manteca.



HYDROGEOLOGY

Hydrogeological conditions differ dramatically from the eastern edge of the Coalition with the exposed bedrock of the Sierra Nevada Mountains, to the western region of the Coalition with the flood basin deposits of the Delta, and finally further west to the alluvium deposits of the Coast Ranges. The Coast Range alluvial deposits are derived largely from the erosion of marine rocks from the Coast Range. These deposits are up to 850 ft thick along the western edge of the valley and taper off to the east as they approach the center of the valley floor. The alluvial deposits contain a large proportion of silt and clay, are high in salts, and also contain elevated concentrations of selenium and other trace elements. The Sierra Nevada sediments on the eastern side of the region are derived primarily from granitic rock and consist of predominantly well-sorted micaceous sand. These deposits make up most of the total thickness of sediments along the valley axis and gradually thin to the west until pinching out near the western boundary. The Sierra Nevada sediments are relatively permeable with hydraulic conductivities three times the conductivities of the Coast Range deposits. The flood-basin deposits are relatively thin and were derived in recent time from sediments of the Coast Ranges to the west and from sediments of the Sierra Nevada to the east. These deposits occur along the center of the valley floor and consist primarily of moderately to densely compacted clays ranging between 5 and 35 feet thick (Figure 25) (USBR, 2011).

Figure 25. Generalized hydrogeological cross-section in the San Joaquin River Hydrologic Region (USBR, 2011).



Groundwater Subbasin(s)

The study area for the GQMP includes the entire Coalition region but focuses on the part of the Coalition overlaying the three groundwater subbasins, in large part because irrigated agriculture is primarily located above these groundwater subbasins. From east to west, portions or all of three groundwater subbasins lie within the Coalition region: Cosumnes, Eastern San Joaquin, and Tracy (Table 11). A generalized layout of the aquifer system and associated direction of groundwater flow in the subbasins underlying the Coalition region is illustrated in Figure 26. All three subbasins (Figure 27) are located within the aquifer system studied within the USGS' Northern San Joaquin GAMA study unit (Bennett et al., 2010a).

Table 11. Percent acreage of groundwater subbasins within the SJCDWQC region.

Basin-Subbasin Number	Subbasin Name	Percent Acreage* of Subbasin in Delta vs. non-Delta Areas of Coalition		Percent Acreage* of Subbasin in Coalition
		Delta	Non-Delta	
5-22.01	Eastern San Joaquin	18%	82%	99%
5-22.15	Tracy	85%	10%	95%
5-22.16	Cosumnes	0.4%	30%	30%

*Acres of subbasins, and Delta and non-Delta areas determined by Arc GIS as compared to acreages listed in Bulletin 118 (DWR, 2003).

Figure 26. The aquifer system for USGS' Northern San Joaquin GAMA study unit (Bennett et al., 2010a). The Northern San Joaquin study unit spans the Tracy, Eastern San Joaquin, and Cosumnes groundwater subbasins from west to east.

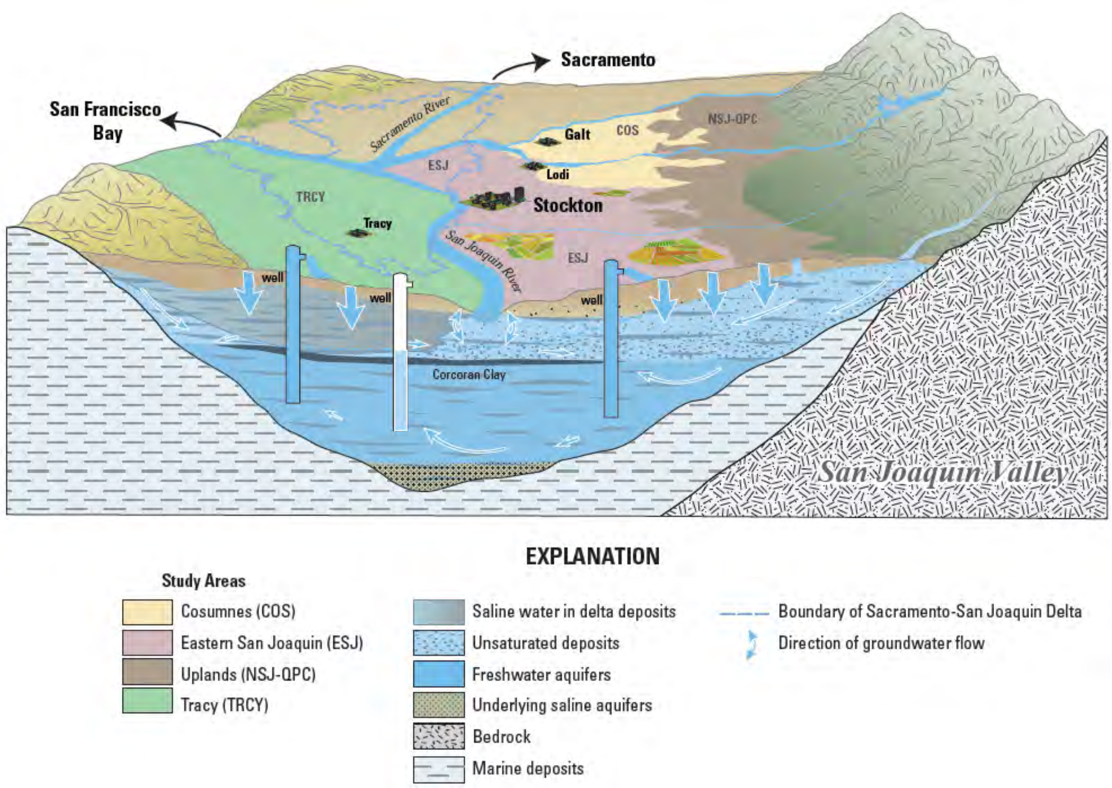
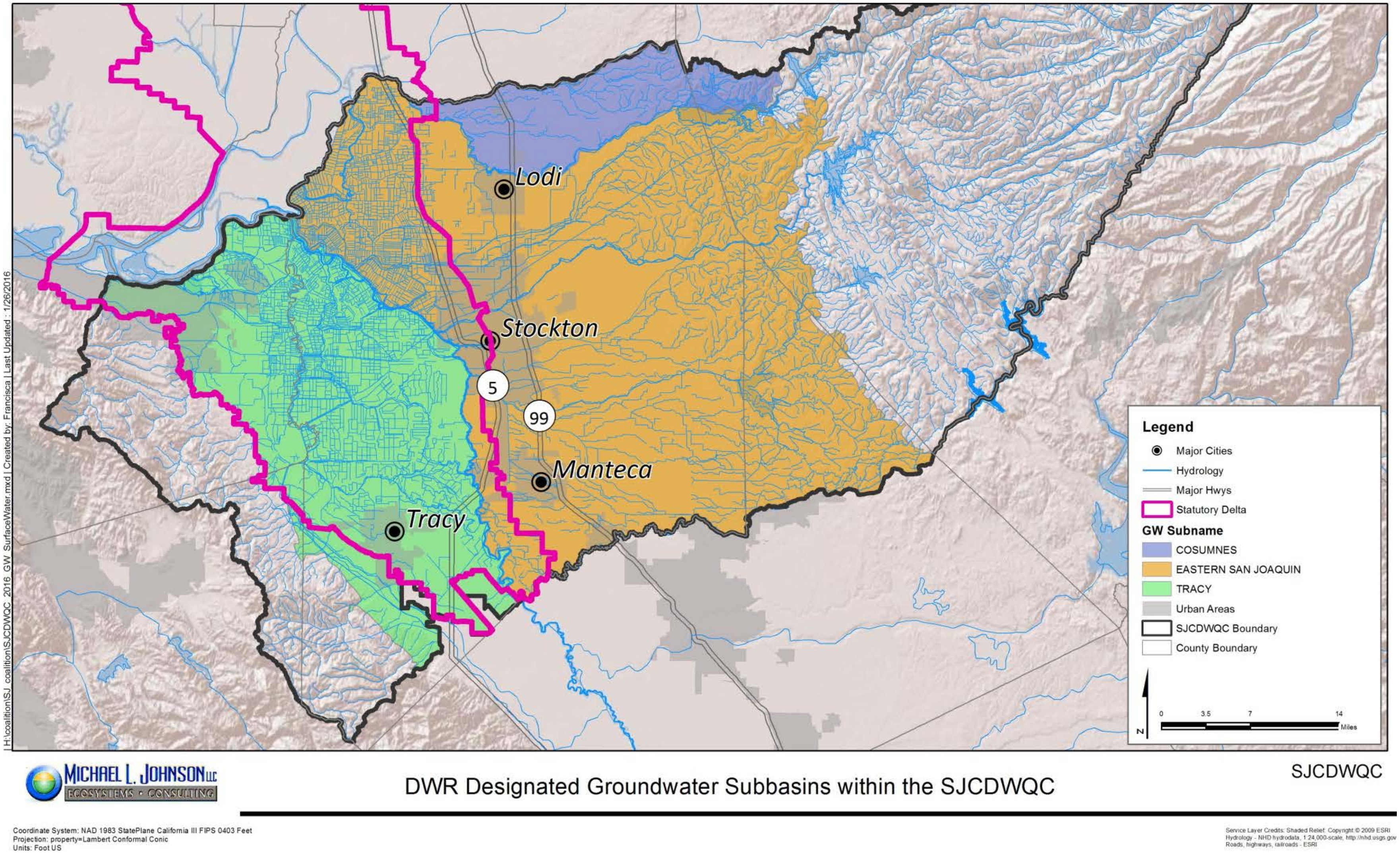


Figure 27. Groundwater subbasins within the SJCDWQC Coalition as designated in DWR's Bulletin 118 (updated 2003).



The Northern San Joaquin study unit spans the Tracy, Eastern San Joaquin, and Cosumnes groundwater subbasins from west to east. Almost the entire Tracy subbasin is included within the Coalition region with the exception of an excised portion underlying the Del Puerto Water District and the West Stanislaus Irrigation District, which are members of the Westside San Joaquin River Watershed Coalition. The entire Eastern San Joaquin subbasin and the southern portion of the Cosumnes subbasin, south of the Sacramento County line, are included within the Coalition region.

Water Bearing Geologic Formations by Subbasin

The following description of hydrogeological conditions within the subbasins of the Coalition was taken from DWR's Bulletin 118 (2003). A visual layout of the hydrogeological formations within the region described below may be found in the generalized illustrations of Figure 9 and Figure 10.

Tracy Subbasin

The Tracy Subbasin is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, Older Alluvium, Flood Basin Deposits, and Younger Alluvium. The cumulative thickness of these deposits increases from a few hundred ft near the Coast Range foothills on the west to about 3,000 ft along the eastern margin of the basin.

Tulare Formation. The Tulare is exposed in the Coast Range foothills along the western margin of the basin and dips eastward toward the axis of the valley. It consists of semi-consolidated, poorly sorted, discontinuous deposits of clay, silt, and gravel. The Corcoran clay occurs near the top of the Tulare Formation and confines the underlying fresh water deposits. The eastern limit of the Corcoran clay is near the eastern boundary of the basin. The Tulare formation is moderately permeable, with most of the larger agricultural, municipal and industrial extractions coming from below the Corcoran clay. Wells completed in this zone produce up to 3,000 gallons per minute. Small domestic wells often obtain their supply from above the Corcoran clay. However, groundwater above the Corcoran clay is often of poor quality. The total thickness of the Tulare Formation is about 1,400 ft. Specific yield values for water bearing deposits in the San Joaquin Valley and Delta area range from about 7 to 10 percent.

Older Alluvium. Older alluvium consists of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is about 150 feet. It is moderately to locally highly permeable.

Flood Basin Deposits. Flood basin deposits occur in the Delta portion of the subbasin, in the northern two-thirds of the basin. They are the distal equivalents of the Tulare Formation and older and younger alluvial units and consist primarily of silts and clays. Occasional interbeds of gravel occur along the present waterways. Because of their fine-grained nature, the flood basin deposits have low permeability and generally yield low quantities of water to wells. Occasional zones of fresh water are found in the basin deposits, but they generally contain poor quality groundwater. The maximum thickness of the unit is about 1,400 ft.

Younger Alluvium. Younger alluvium includes those deposits that are accumulating or would be accumulating under natural conditions. It includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They are present along the channel of Corral Hollow Creek and consist of unconsolidated silt, fine- to medium grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. The thickness of the younger alluvium in the Tracy Subbasin is less than 100 ft.

Eastern San Joaquin Subbasin

Water bearing formations of significance in the Eastern San Joaquin Subbasin consist of the Alluvium and Modesto/Riverbank Formations, Flood Basin Deposits, Laguna Formation, and Mehrten Formation. The Mehrten Formation is considered to be the oldest fresh water-bearing formation on the east side of the basin, even though the underlying Valley Springs Formation produces minor quantities.

Alluvium and Modesto/Riverbank Formations (Undifferentiated). These units are exposed within the subbasin along a band approximately 15 miles wide that extends from about Stockton eastward. These units are Recent to Late Pleistocene in age and consist primarily of sand and gravel in the fan areas while clay, silt, and sand are dominant in the interfan areas. These units range in thickness from a thin veneer on the east side of the basin to over 150 feet near the center of the basin. Groundwater occurs unconfined within these units. Well yields to 650 ± gpm are reported. Because these units are limited in thickness, most wells penetrate them in order to tap deeper aquifers in the area. Average specific yields in the 10- to 200-foot depth range vary from about 7 to 15 percent within the boundaries of the Tuolumne River Storage Unit (Davis et al. 1959). The average specific yield for fresh water bearing units in the San Joaquin County Groundwater Investigation area as defined in (DWR 1967) is 7.3 percent. The Victor Formation as defined in (DWR 1967) is correlative with these units.

Flood Basin Deposits. This unit is exposed in the Delta area of the San Joaquin Valley. These deposits are basinward, fine-grained forms of the Laguna, Riverbank, Modesto, and Recent formations and, therefore, range in age from Pliocene to Recent. They are generally much finer grained with a higher percentage of fine sand and clays than their depositional equivalents to the east and west. Occasional gravel beds occur along the present waterways and are probably representative of the type of underlying lithology distribution. This unit ranges in thickness from 0 to 1,400 ± ft. Groundwater in this unit occurs under unconfined to confined conditions. The unit, in general, has low permeabilities and may create semi-confined to confined conditions when interfingered with the Alluvium and Modesto/Riverbank Formations. Occasional pockets of fresh water are found in the Delta deposits, but generally speaking the formation contains poor quality water. This unit is designated as Dos Palos Alluvium by (Wagner et al. 1990).

Laguna Formation. The Laguna Formation is Plio-Pleistocene in age and consists of discontinuous lenses of stream laid sand and silt with lesser amounts of clay and gravel. There are no regionally significant fine-grained intervals that could cause water pressure conditions, although the heterogeneous nature of the sediments causes local confinement. From the Mokelumne River area, the formation thickens from approximately 400 feet to approximately 1,000 feet in the Stockton area. Regionally, yields of 1,500 gpm have been reported from highly permeable beds, but average yields are about 900 ± gpm. Groundwater occurs under unconfined to locally semiconfined conditions within this unit. Occasional minor perched water zones are encountered in this formation, particularly in the Mokelumne River area.

Mehrten Formation. This formation is exposed in the easternmost part of the subbasin where it forms readily identifiable, nearly flat-topped hills. The formation is late Miocene to Pliocene in age and is composed of moderately to well indurated andesitic sand to sandstone interbedded with conglomerate, tuffaceous siltstone, and claystone. The Mehrten Formation is approximately 400 ft thick in eastern surface outcrops to over 600 t thick in the subsurface near Stockton. It is reported to be 1,300 ± ft thick at McDonald Island. The top of the Mehrten Formation occurs at depths of approximately 800 to 1,000 ft in the Stockton area. Regional studies indicate that Mehrten Formation sands commonly yield on the order of 1,000 gpm from wells. The formation appears to be semiconfined at least locally in the Stockton area, due to the inferred extensive fine-grained beds in its upper part. The average specific yield for fresh water bearing units in the San Joaquin County Groundwater Investigation area as defined in (DWR 1967) is 7.3 percent.

Cosumnes Subbasin

The Cosumnes subbasin aquifer system is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include Younger Alluvium, 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 ft along the western margin of the subbasin.

Younger Alluvium: This unit includes recent stream channel deposits and dredge tailings. The maximum combined thickness of all the younger alluvial units is about 100 ft. Minor exposures of dredge tailings are present along the Cosumnes and Mokelumne Rivers at the eastern margin of the subbasin. They consist of windrows of gravel, cobbles, boulders, sand, and silt resulting from 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 and terraces of those streams. They occur along the Sacramento, Cosumnes, and Mokelumne 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.

Older Alluvium: This unit consists 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 and Riverbank Formations, Victor Formation and Laguna Formation, and 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 to 650 feet. It is moderately permeable.

Miocene/Pliocene Volcanics: This unit consists 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 Level Trends by Subbasin

Tracy

Review of hydrographs for the Tracy Subbasin indicate that except for seasonal variation resulting from recharge and pumping, the majority of water levels in wells have remained relatively stable over at least the last 10 years (DWR unpublished data; San Joaquin County Flood Control unpublished data) (DWR, 2003).

Eastern San Joaquin

Measurements over the past 40 years show a fairly continuous decline in groundwater levels in Eastern San Joaquin County. Groundwater levels have declined at an average rate of 1.7 ft per year and have dropped as much as 100 ft in some areas. It is estimated that groundwater overdraft during the past 40 years has reduced storage in the basin by as much as 2 million acre ft (DWR, 2003).

Cosumnes

Wells outside the influence of the Cosumnes River declined from the mid- 1960s to about 1980 on the order of 20 to 30 ft. From 1980 through 1986, water levels recovered on the order of 5 to 10 ft. During the 1987 through 1992 drought, water levels once again declined by 10 to 15 ft. From 1993 through 2000, much of the basin recovered by 15 to 20 ft, leaving water levels at the about the same elevation or slightly higher than they were in the mid-1980s. One exception is along the eastern subbasin margin where water levels remained fairly constant during the 1993 through 2000 recovery period. Prior to that, those eastern wells behaved similarly to other wells in the subbasin (DWR, 2003).

Depth to Groundwater and Groundwater Elevations

In an effort to provide a picture of available groundwater level data for the Coalition region, a search of published reports on depth to groundwater and groundwater elevations in the Coalition region during the spring and fall seasons was performed; results of the literature search are provided below. Spring and fall groundwater level measurements generally occur before and after most of the irrigation season, respectively, in order to have some indication of the amount of draw-down of the local aquifer during the growing season. Springtime measurements indicate the extent that the storage in the aquifer systems has recharged from winter precipitation. Fall groundwater levels give insight about the amount of groundwater removed from local aquifer storage during the irrigation season.

Depth to Groundwater

Knowing the local depth to groundwater can provide a better understanding of the interaction between the groundwater table, the surface water systems, and the contribution of groundwater aquifers to the local ecosystem. Figure 28 through Figure 31 illustrate depths to groundwater levels in spring and fall of 2000 and 2005 for the San Joaquin County within the Central Valley floor, the largest county in the Coalition region (Table 5) (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008). The contour lines within the depth to groundwater maps are in 10-foot increments and represent areas having similar spring or fall depth to groundwater values in the years 2000 and 2005, respectively.

Figure 32 is a spring 2010 depth to groundwater contour map for the entire San Joaquin Hydrologic Region of California from DWR's Water Plan 2013 Update. Again, the contour lines in the figure represent areas having similar spring 2010 depth to groundwater. Contour lines were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined groundwater conditions. Figure 32 illustrates that the depth to groundwater in the western half of the region is shallowest along the valley floor adjacent to the San Joaquin River and its associated tributaries, and deepest along the eastern side of the valley where it abuts the lower foothills of the Sierra Nevada.

Groundwater levels were analyzed for the Coalition region and presented in the GAR. An interpolation of data of groundwater levels from 1989-2013 for the Delta, and 2009-2013 for the non-Delta areas, was performed to obtain a raster representation (Figure 33 and Table 12). In a following section referring to nitrate levels in groundwater, Figure 72 also illustrates depth to groundwater and includes contour lines of equal depth in 10 foot intervals.

Figure 28. Lines of equal depth to groundwater spring 2000 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

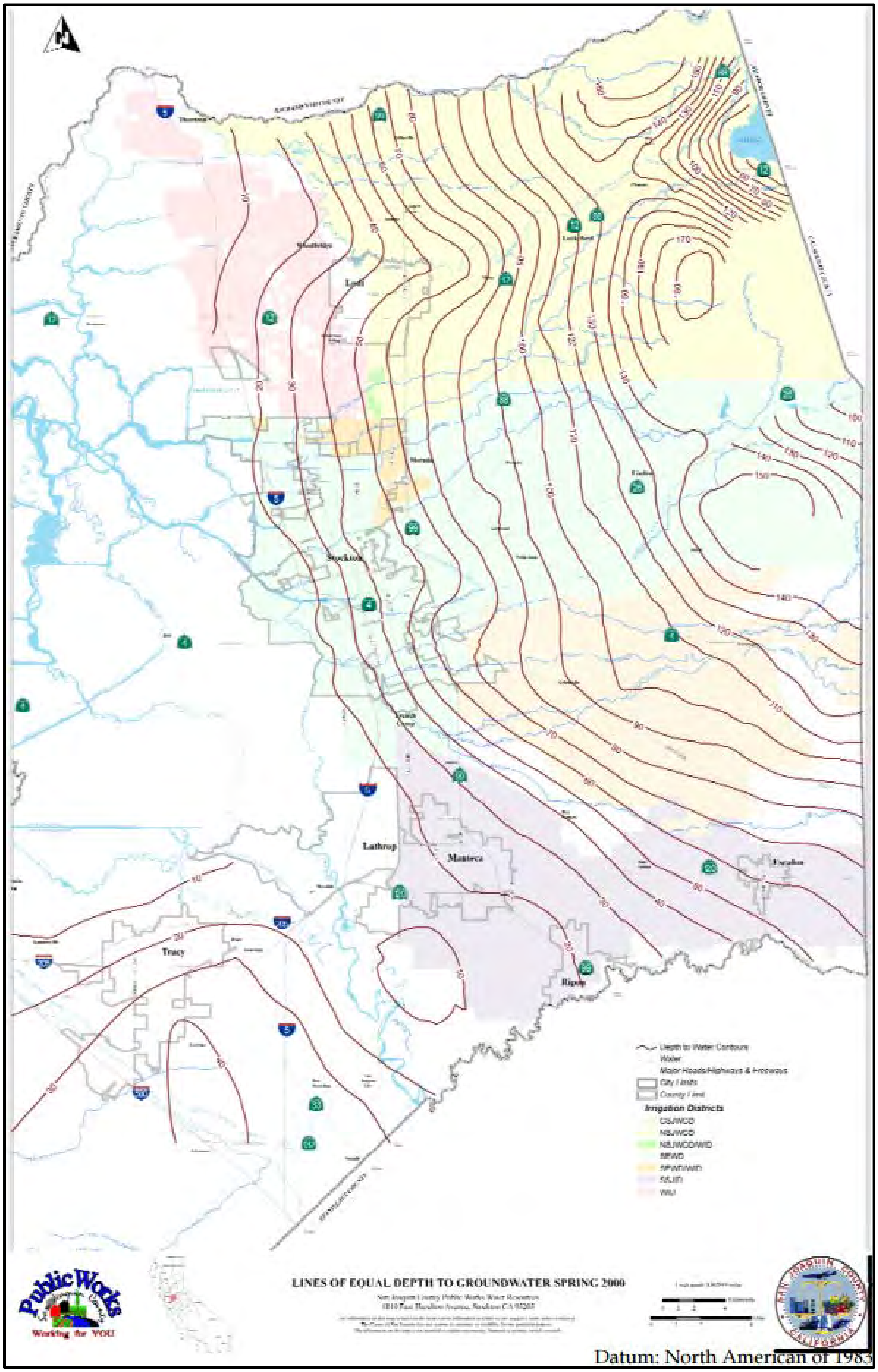


Figure 29. Lines of equal depth to groundwater fall 2000 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

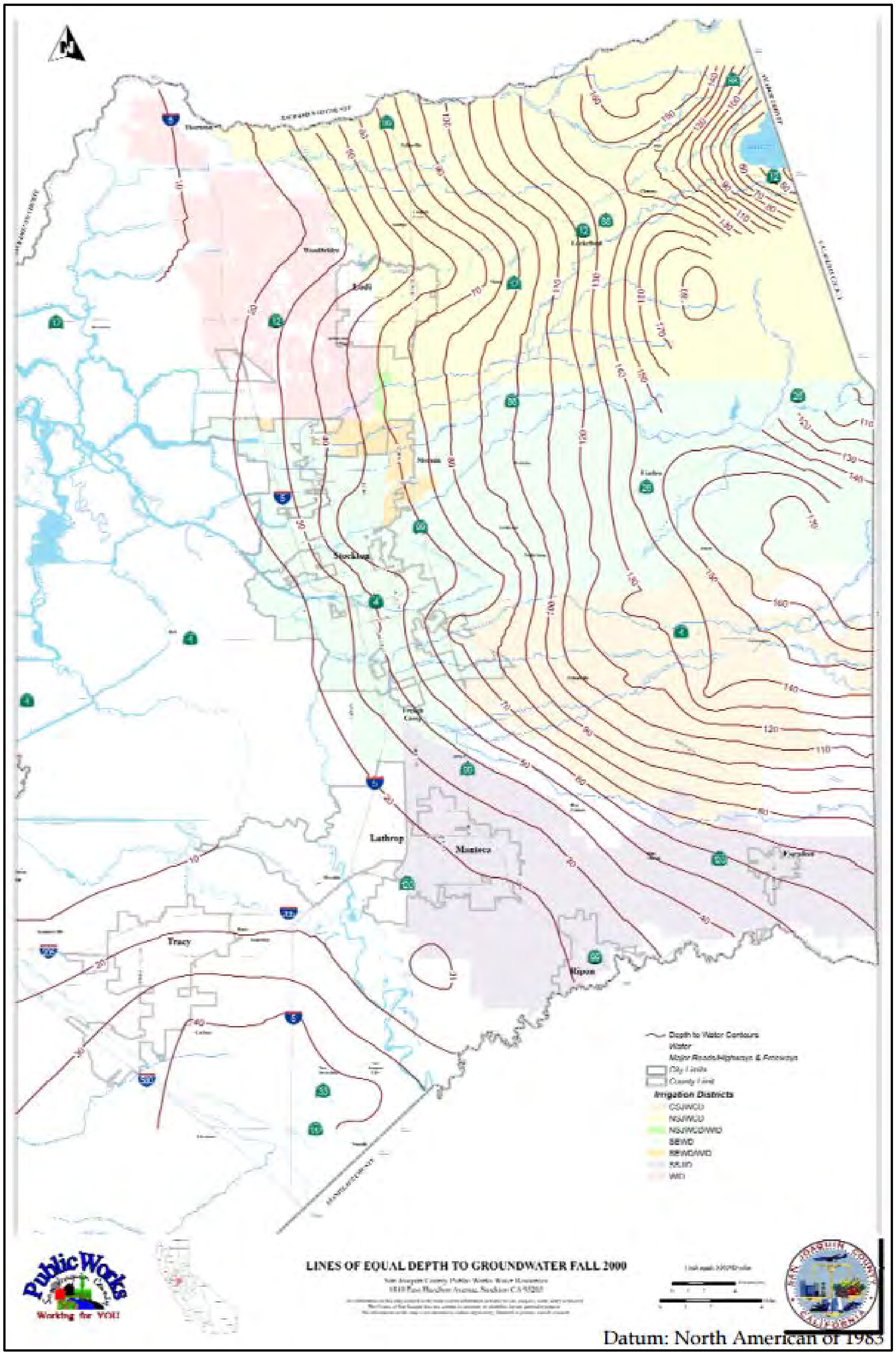


Figure 30. Lines of equal depth to groundwater spring 2005 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

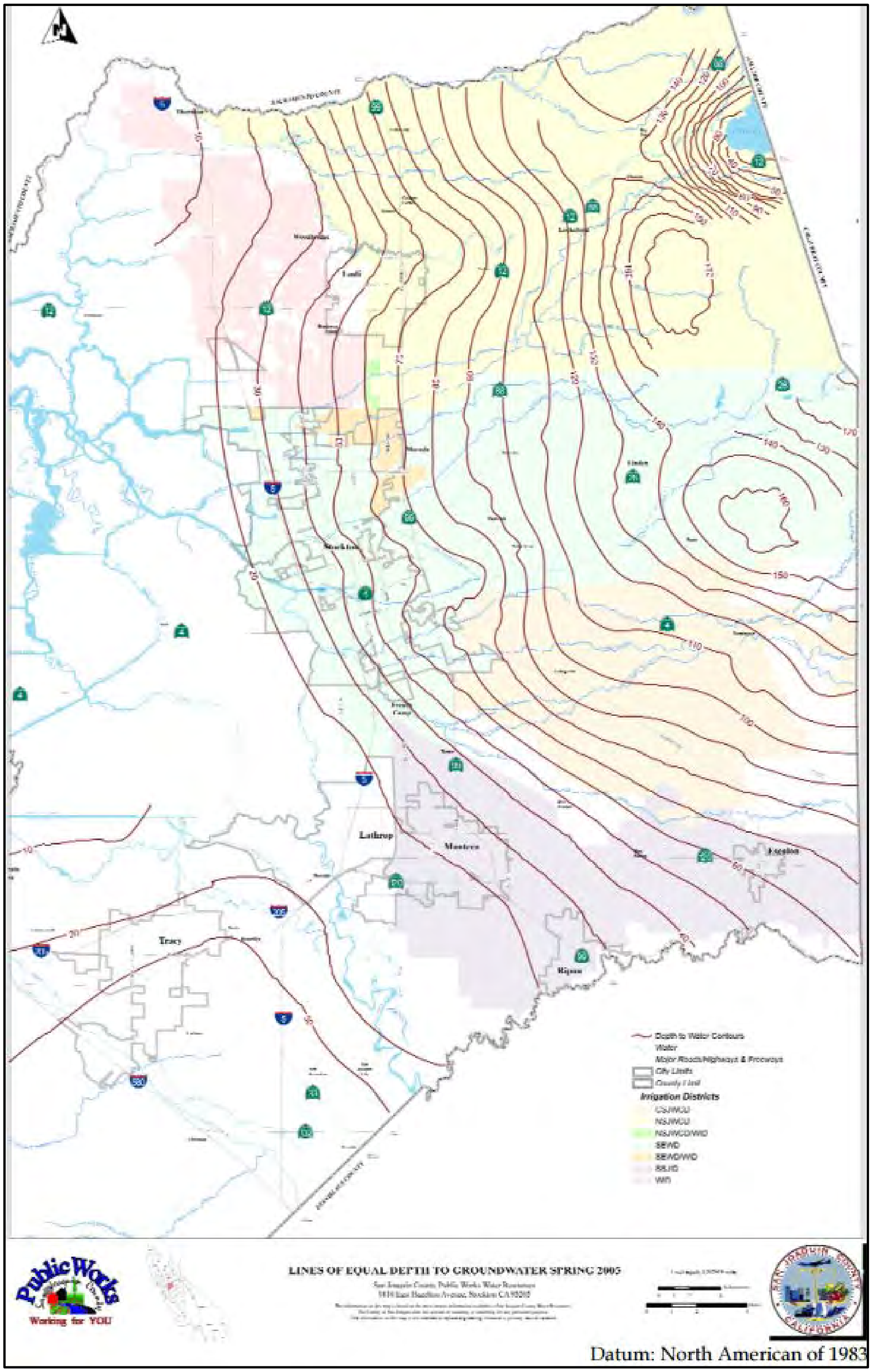


Figure 31. Lines of equal depth to groundwater fall 2005 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

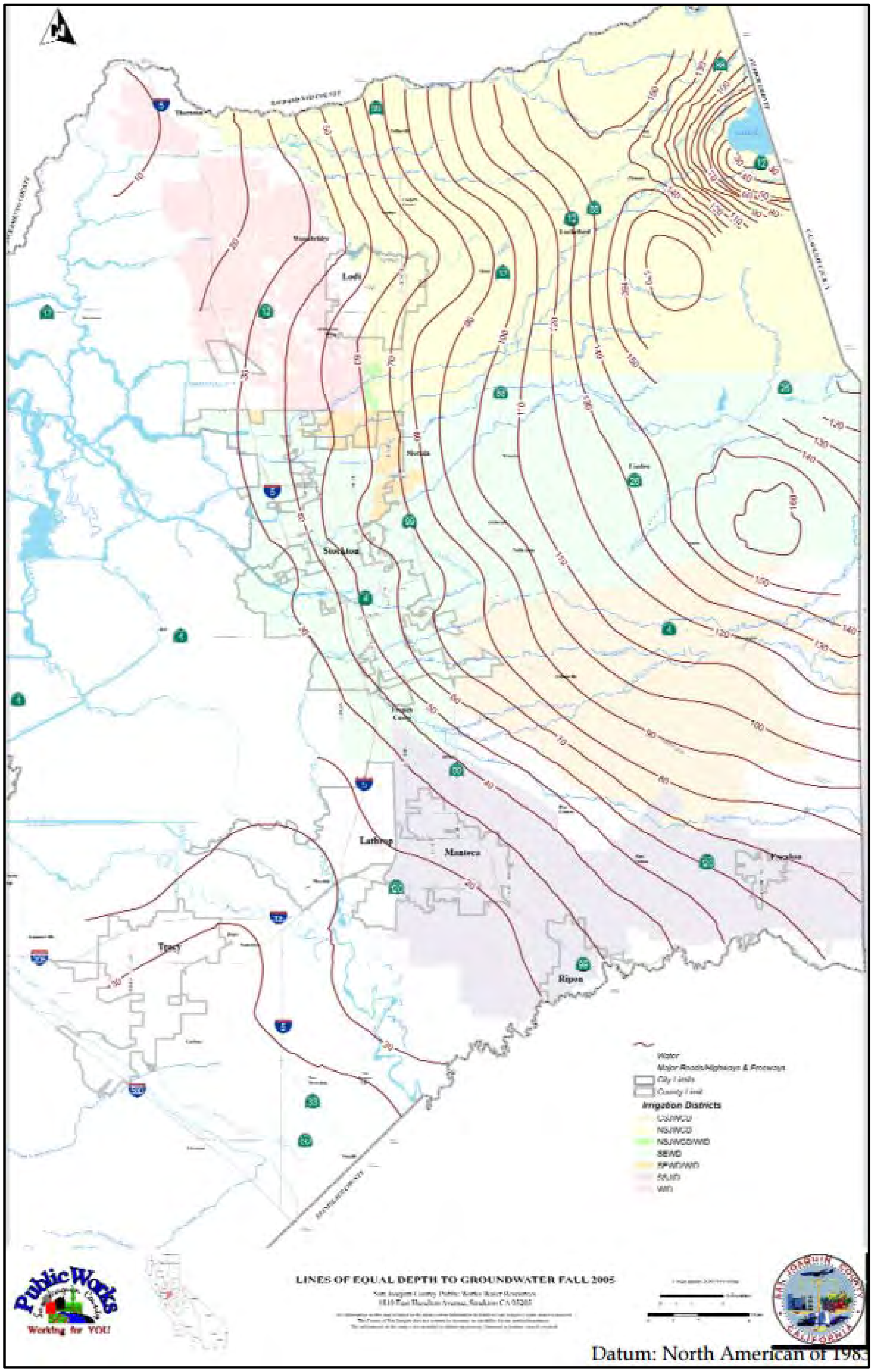


Figure 32. Spring 2010 depth to groundwater contours for the San Joaquin River Hydrologic Region (DWR, 2013).

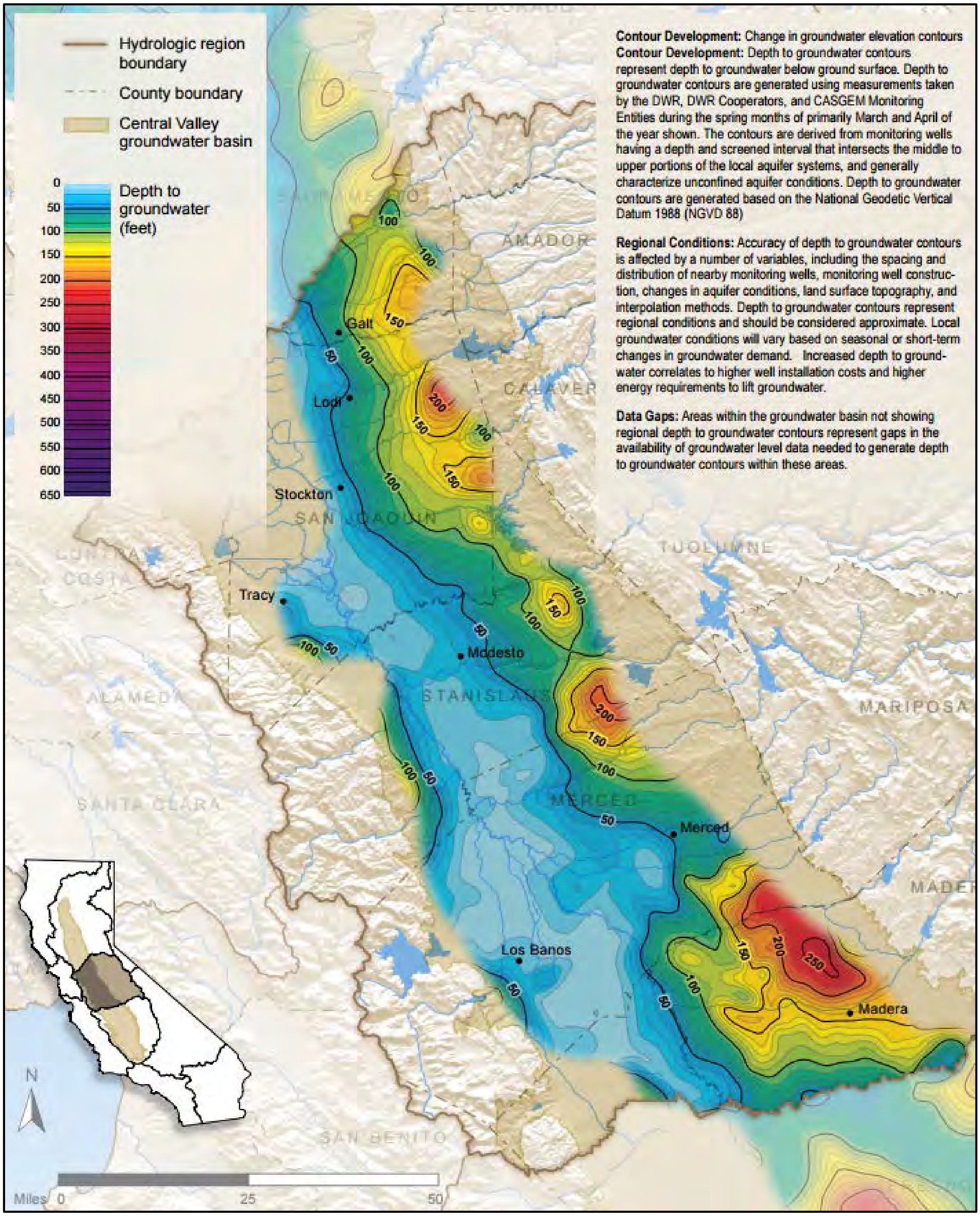


Figure 33. Drastic input ratings for depth to groundwater (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

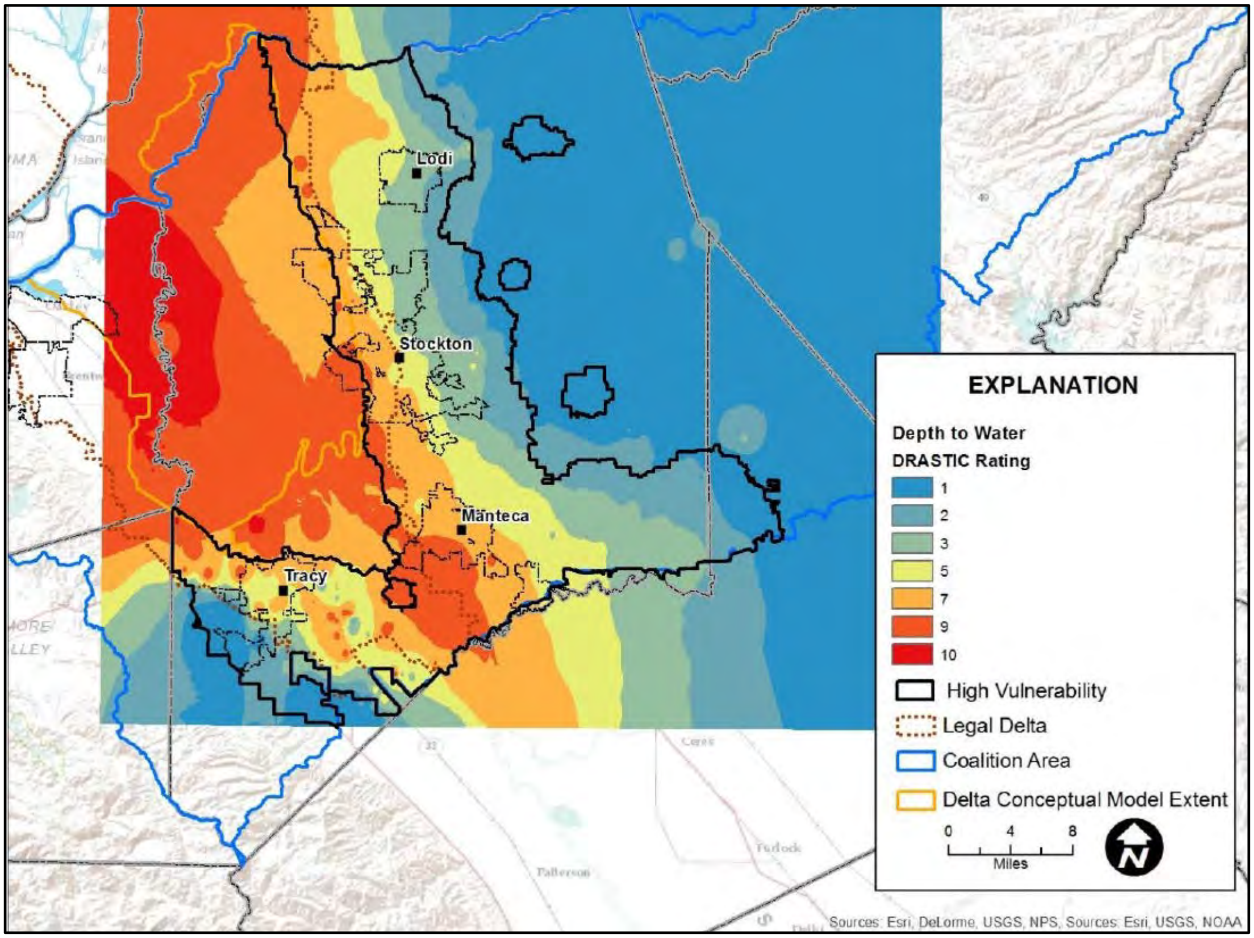


Table 12. Depth to groundwater DRASTIC ratings (SJCDWQC, 2015).

RANGE (FT)	RATING
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
>100	1

Groundwater Elevations and Flow

Measuring the depth to groundwater below the ground surface is more informative if the elevation of the ground surface is known as well. If the land elevation is known, the elevation of the groundwater surface can be calculated by subtracting the depth to groundwater from the land surface elevation. The movement of groundwater is from areas of higher hydraulic potential to areas of lower hydraulic potential, typically from higher elevations to lower elevations. Once the elevation of the groundwater surface is calculated, comparisons of groundwater elevations can be made between monitoring well locations and the direction and gradient of groundwater flow can be estimated.

Under predevelopment conditions, the occurrence and movement of groundwater in the region was largely controlled by the surface and the subsurface geology, the size and distribution of the natural surface water systems, the average annual hydrology, and the regional topography. However, decades of high-volume groundwater extraction for agricultural and urban water uses has impacted the natural occurrence and movement of groundwater. Areas of high groundwater extraction tend to redirect and capture groundwater underflow that may otherwise have contributed to nearby surface water systems. Thousands of high-capacity wells screened over multiple aquifer zones also lend themselves to vertical aquifer mixing, which can result in further deviation from natural groundwater flow conditions (DWR, 2013); see discussion of areas around Stockton and Lodi below. In addition, due to groundwater pumping, groundwater in the San Joaquin Valley has generally been depleted and redistributed from the deeper aquifer system to the shallow aquifer system through irrigation infiltration (Galloway, 1999) and vertical aquifer mixing.

Figure 34 through Figure 41 illustrate groundwater elevation levels in spring and fall of 2000 and 2005 for San Joaquin County, the largest county in the Coalition region (Table 5) (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008). The contour lines within the depth to groundwater maps are in 10 foot increments and represent areas having similar spring or fall depth to groundwater in the years 2000 and 2005, respectively. Figure 34 and Figure 41 illustrate groundwater elevation levels during very wet year (1986) and during a historic drought year (1992). All of the groundwater elevation contour maps show a significant groundwater depression east of Stockton and another northeast of Lodi, east of Galt.

Figure 42 is a spring 2010 groundwater elevation contour map for the region from DWR’s 2013 Water Plan Update. Horizontal direction of groundwater flow is shown as a series of arrows along the groundwater flow path. Per the DWR’s Water Plan Update, groundwater elevation contours were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined aquifer conditions. Figure 42 illustrates that groundwater movement during spring 2010 was generally from the eastern and western edges of the basins towards the axis of the valley. In some areas large pumping centers have developed cones-of-depression, reducing water levels to near sea level (DWR, 2013). Due to the continued overdraft of groundwater within the eastern San Joaquin subbasin, significant groundwater depressions are present below the City of Stockton, east of Stockton, and east of Lodi. Several of these groundwater depressions extend to depths of about 100 feet below ground surface (or more than 40 feet below mean sea level [MSL]) (DWR, 2006). For the groundwater depression east of Stockton, instead of groundwater flowing from the east towards the axis of the valley, regional groundwater flow now converges on this low point, with relatively steep groundwater gradients (0.0018 ft/ft) westwards towards the cone of depression, and eastward gradients from the Delta area on the order of 0.0008 ft/ft (GBA, 2007).

Figure 34. Lines of equal elevation of groundwater showing color gradation, spring 1986, a year of historically wet conditions (GBA, 2007).

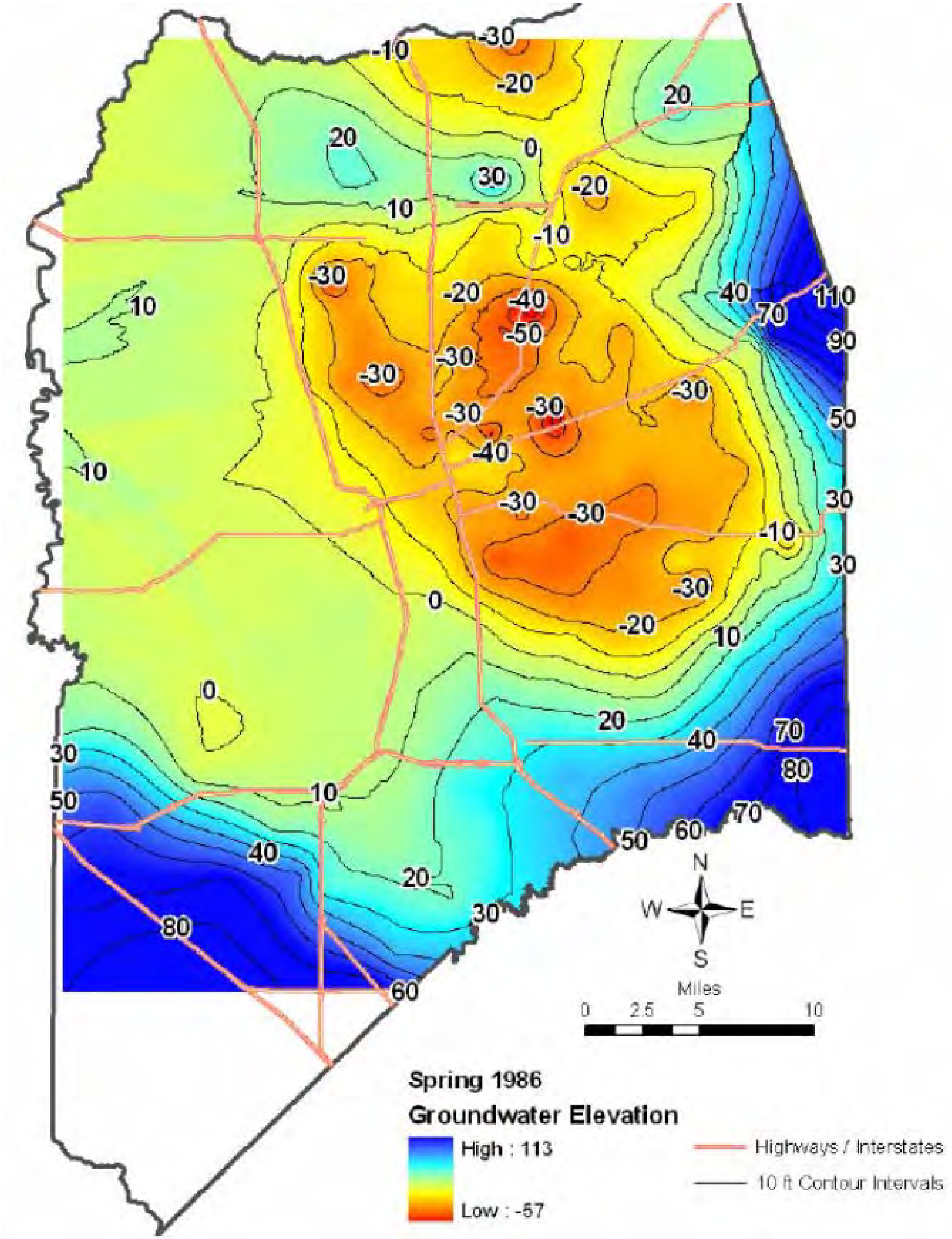


Figure 35. Lines of equal elevation of groundwater showing color gradation, fall 1992, a year of historic drought (GBA, 2007).

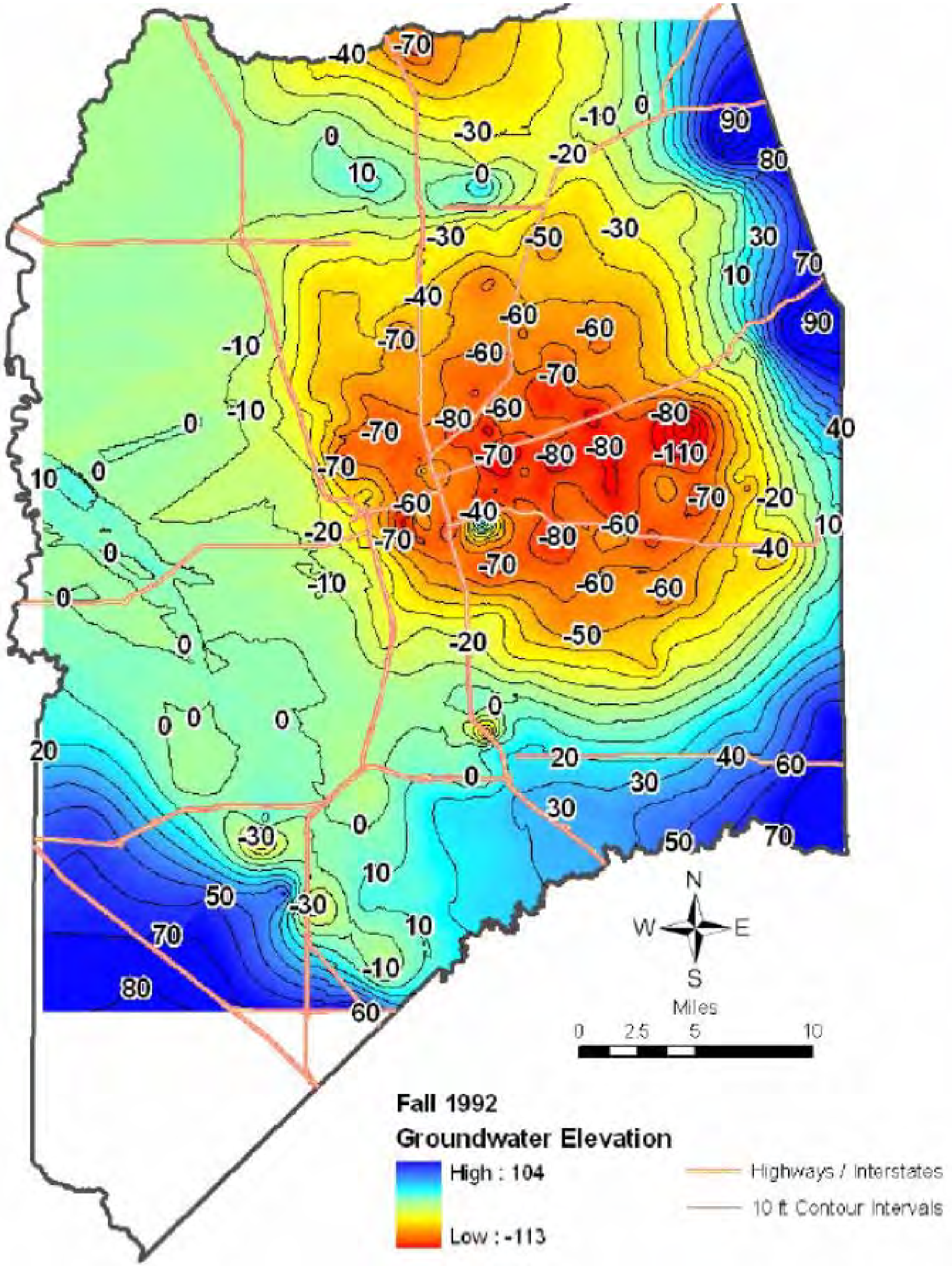


Figure 36. Lines of equal elevation of groundwater spring 2000 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

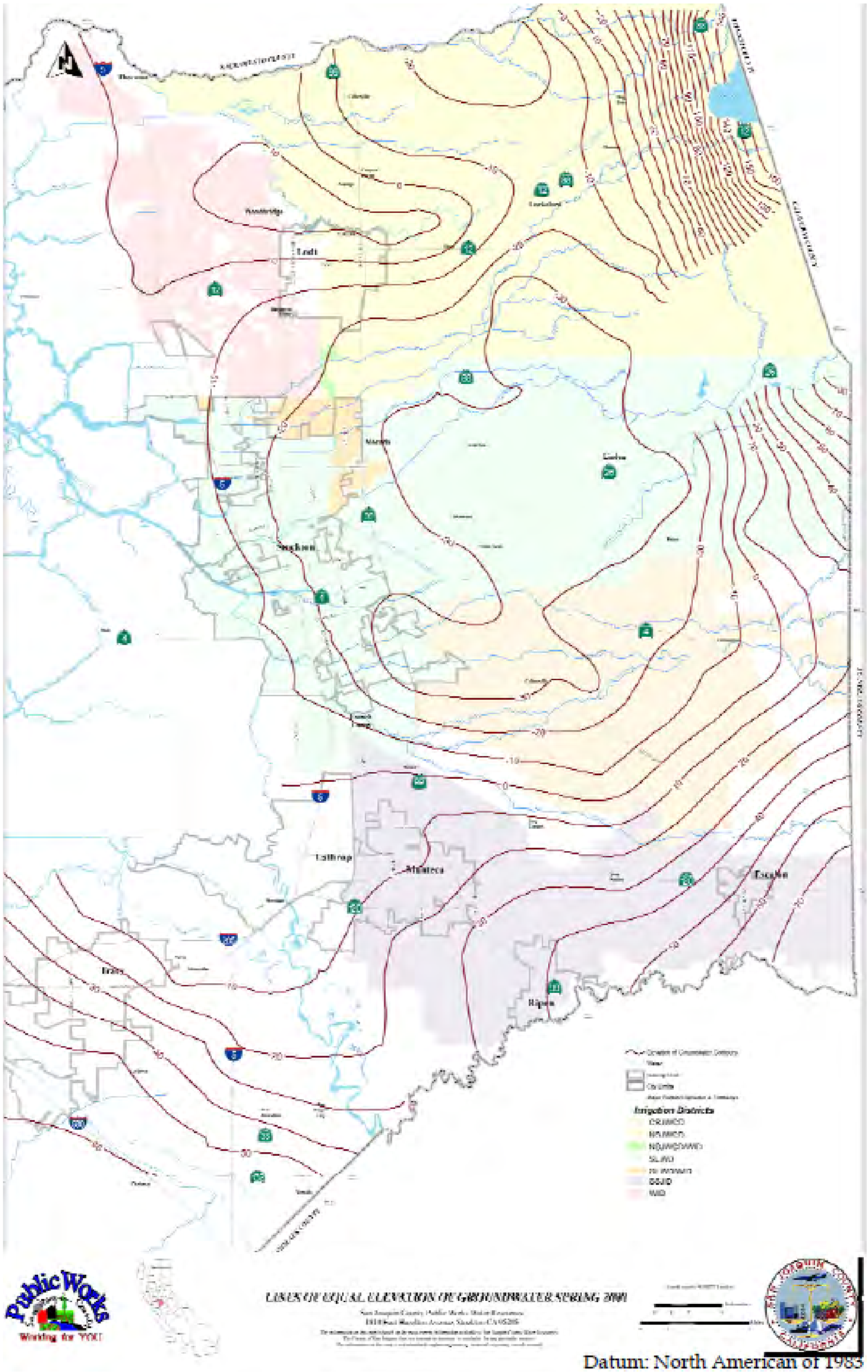


Figure 37. Lines of equal elevation of groundwater fall 2000 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

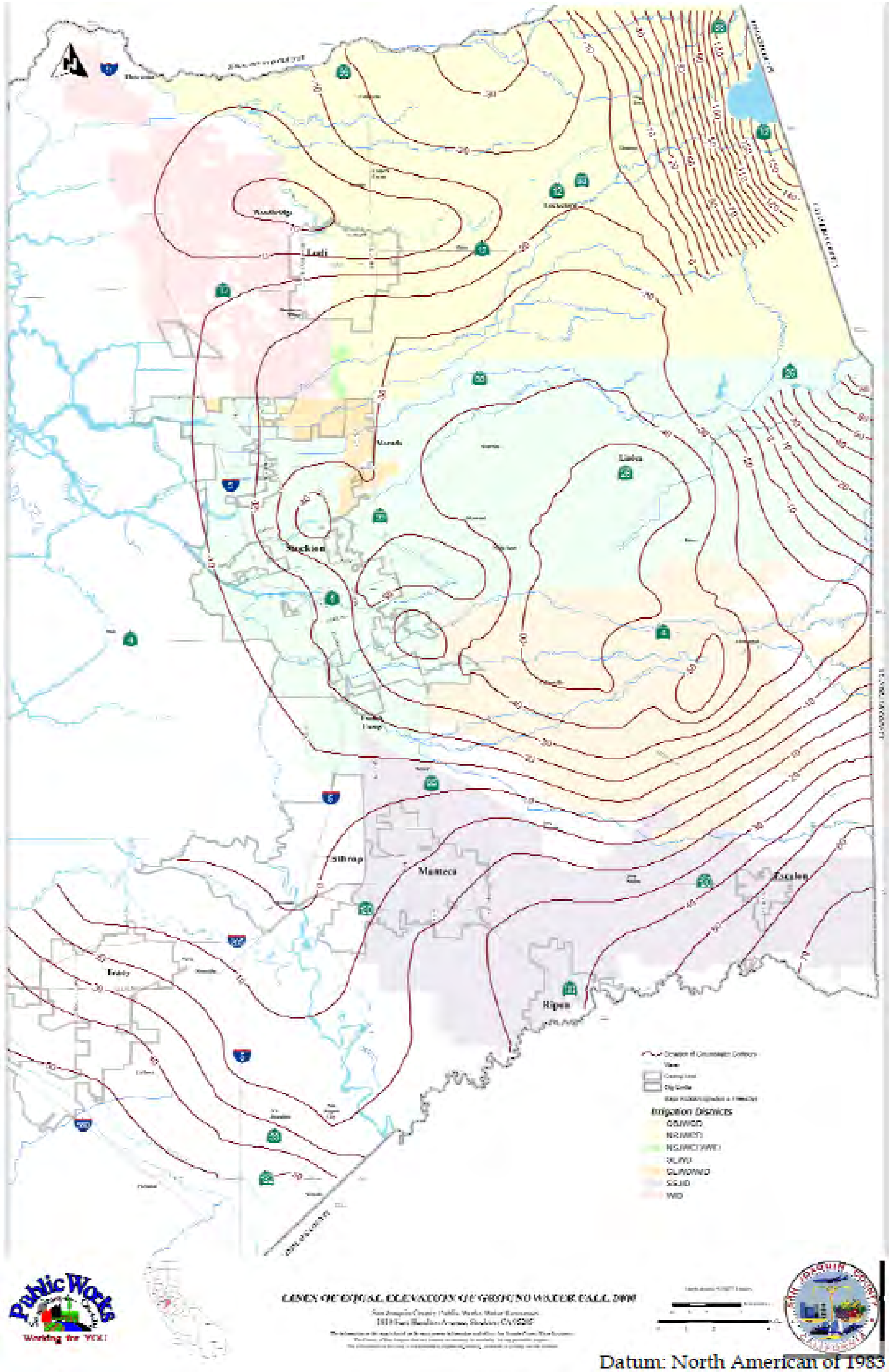


Figure 38. Lines of equal elevation of groundwater spring 2005 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

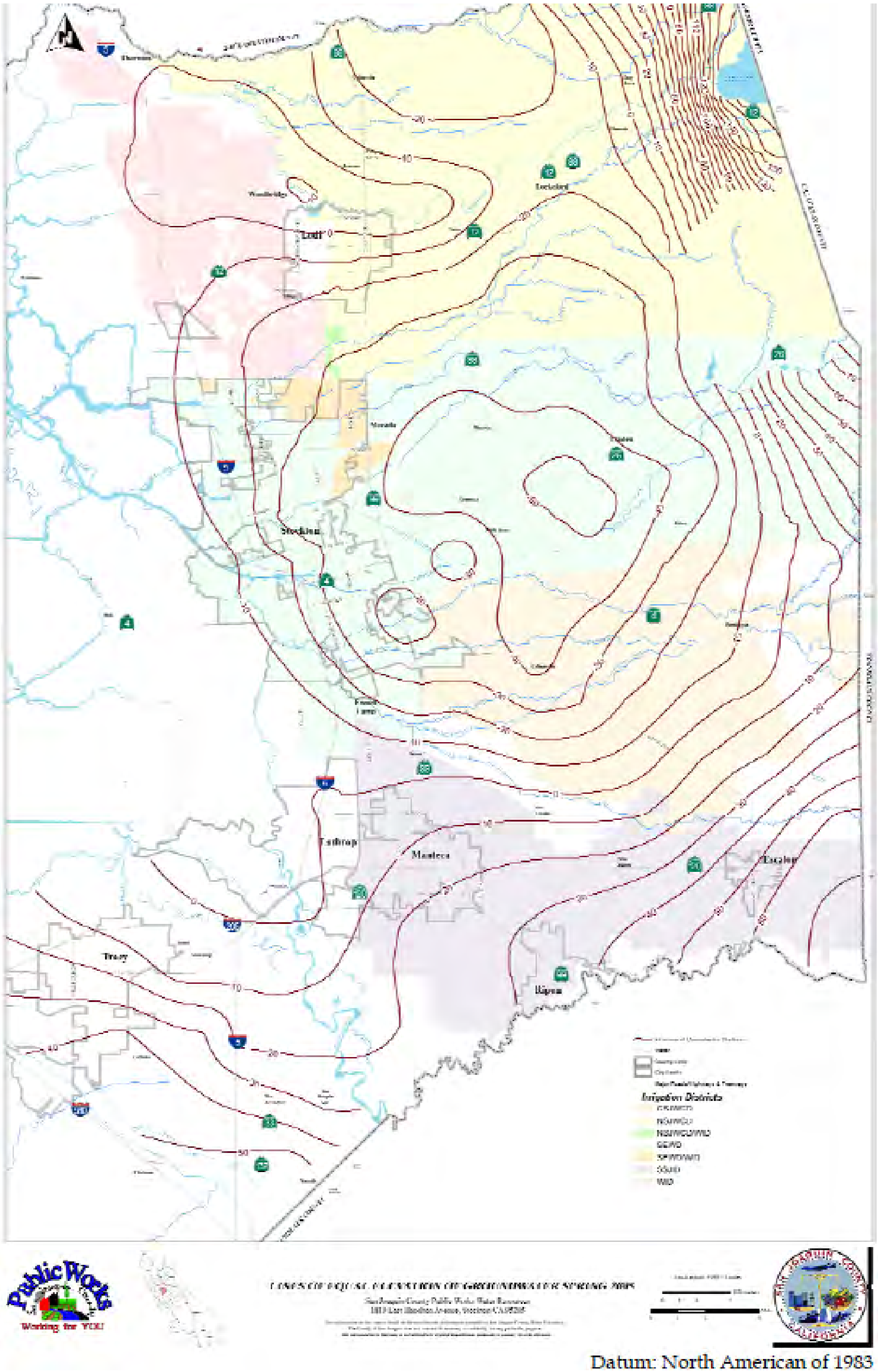


Figure 39. Lines of equal elevation of groundwater showing color gradation, spring 2005 (GBA, 2007).

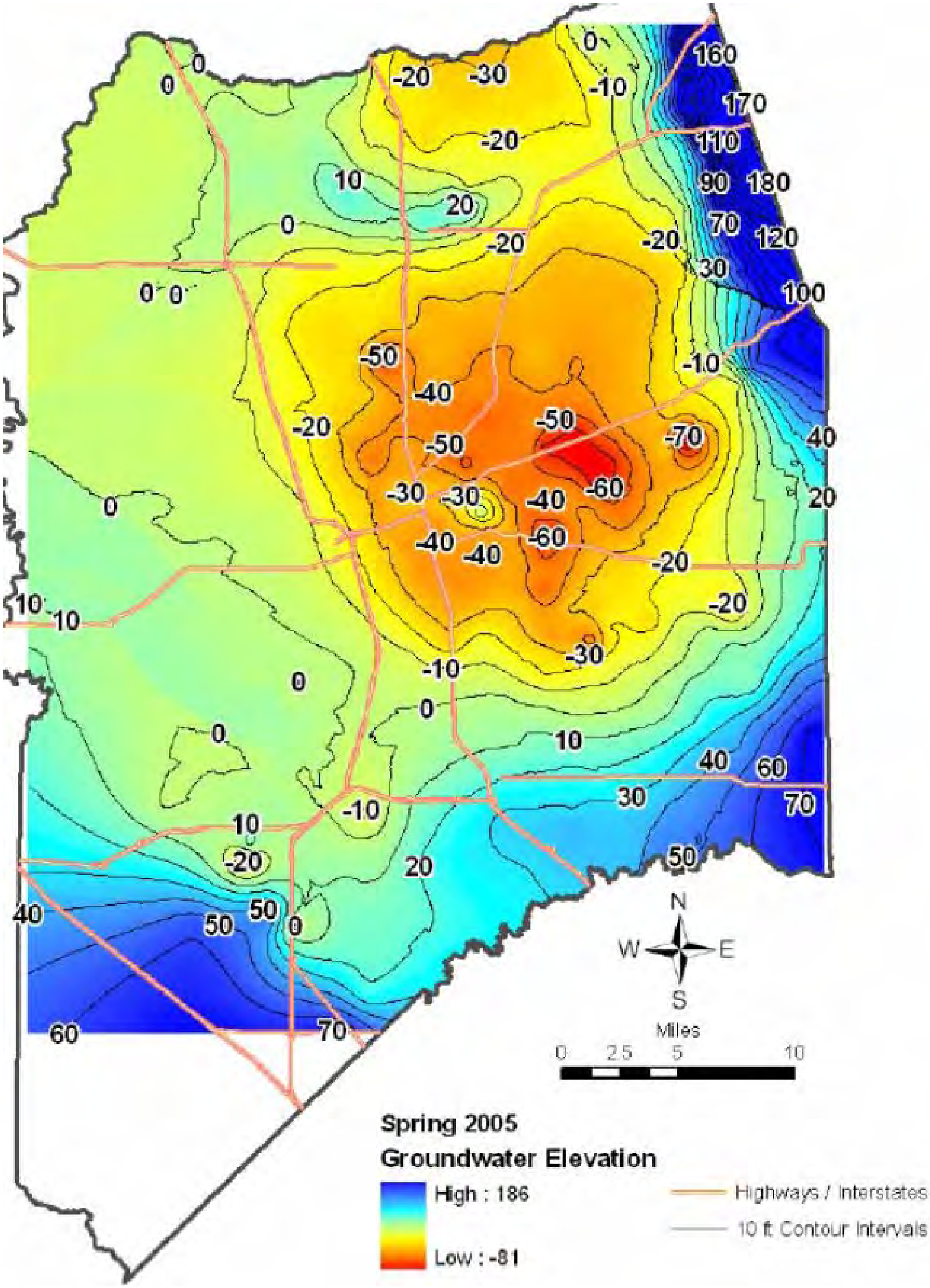


Figure 40. Lines of equal elevation of groundwater fall 2005 (San Joaquin County Flood Control and Water Conservation District, Department of Public Works, 2008).

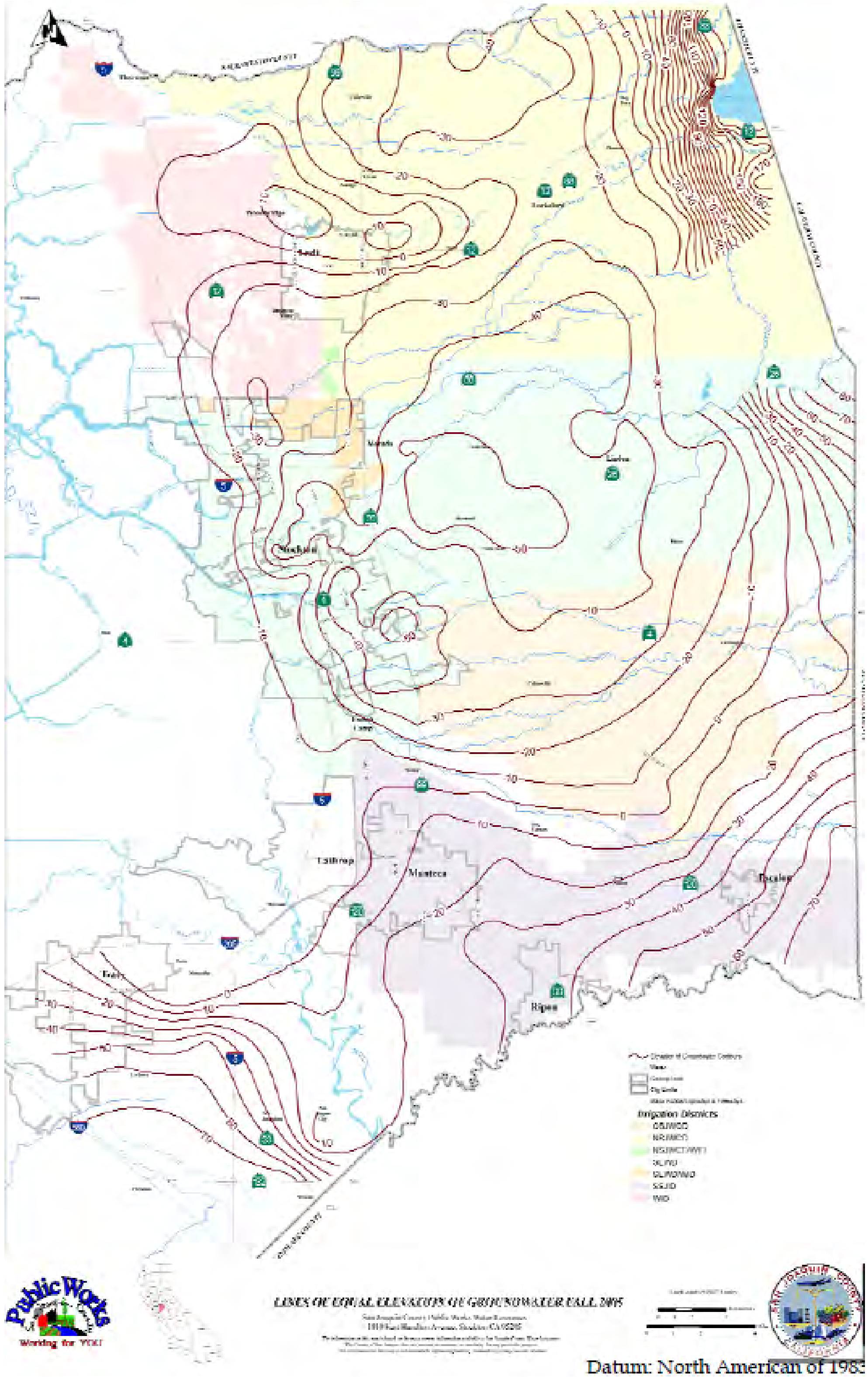


Figure 41. Lines of equal elevation of groundwater showing color gradation, fall 2005 (GBA, 2007).

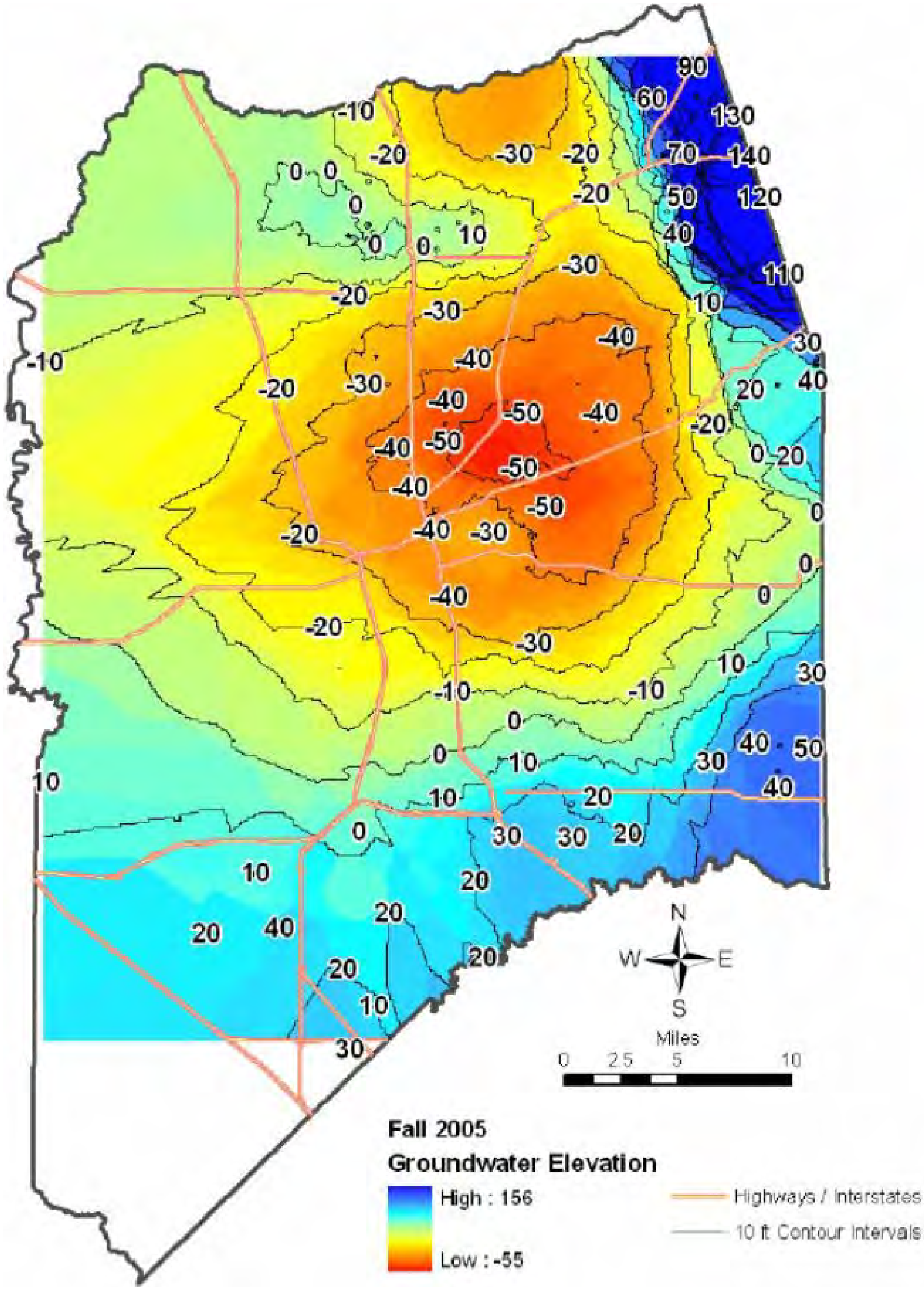
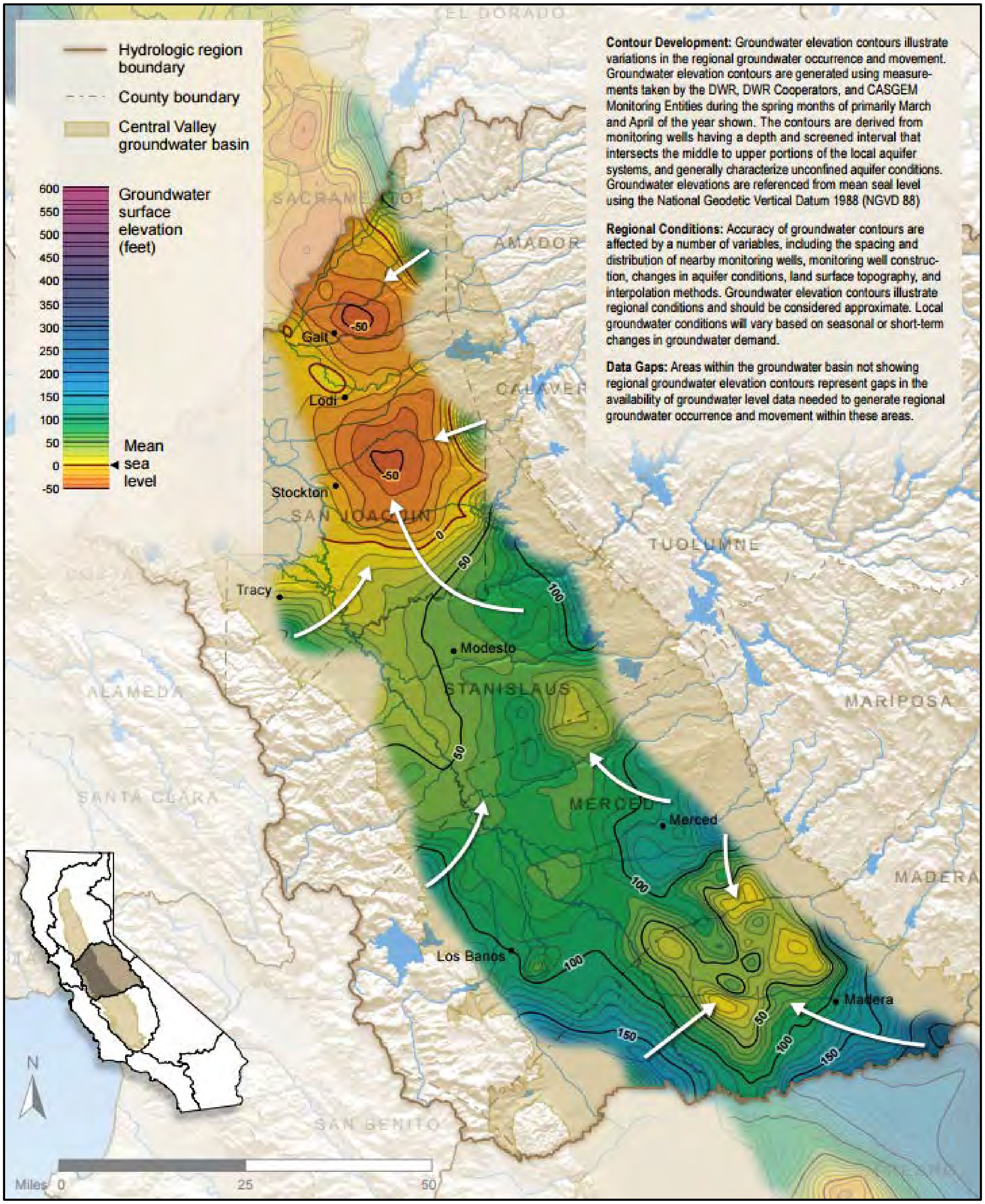


Figure 42. Spring 2010 groundwater elevation contours of the San Joaquin River Hydrologic Region (DWR, 2013).



Delta vs. Non-Delta

A highly recognizable hydrological feature within the SJCDWQC, is the Sacramento-San Joaquin Delta (Figure 43). Hydrological conditions within the Sacramento-San Joaquin Delta differ greatly from those in the surrounding non-Delta areas within the Coalition and are discussed below. In general, within the Delta, depth-to-groundwater levels are just at or in some cases above land surface. Within the non-Delta areas, depth-to-groundwater levels, relative to land surface, increase in both easterly and westerly directions, away from the statutory Delta limits.

Delta

(Upwelling Groundwater vs. non-Upwelling Groundwater)

The Delta was formally defined in the Delta Protection Act of 1959 (California Water Code Section 12220). The statutory Delta boundary that defines the Legal Delta is shown in Figure 43.

Authors of the GAR analyzed land-surface elevations, subsurface lithology, organic deposit bottom elevations groundwater levels, channel stage and isotope data for groundwater and surface water samples and delineated the area where artesian groundwater conditions exist (Figure 3). An artesian condition is defined by groundwater levels in wells screened in the aquifer underlying the organic deposits that rise above the bottom of the organic deposits. According to the GAR, artesian conditions in the Delta demonstrate the influence of adjacent channels on island groundwater levels and upward flowing groundwater.

Outside the area delineated as artesian within the Delta, where groundwater elevations are below sea level, there is also upward flowing groundwater, i.e. the additional area delineated by Hydrofocus' conceptual model Delta (Figure 44). Hydrofocus' conceptual model predicts that, where land-surface elevations are about 5 feet above sea level or less, groundwater flows upward towards drainage ditches from tens of feet below land surface. The area delineated by Hydrofocus' conceptual model Delta, which includes the artesian areas, where groundwater generally does not flow downward to wells, measures approximately 240,000 acres or 55 % of the legal Delta within the Coalition region.

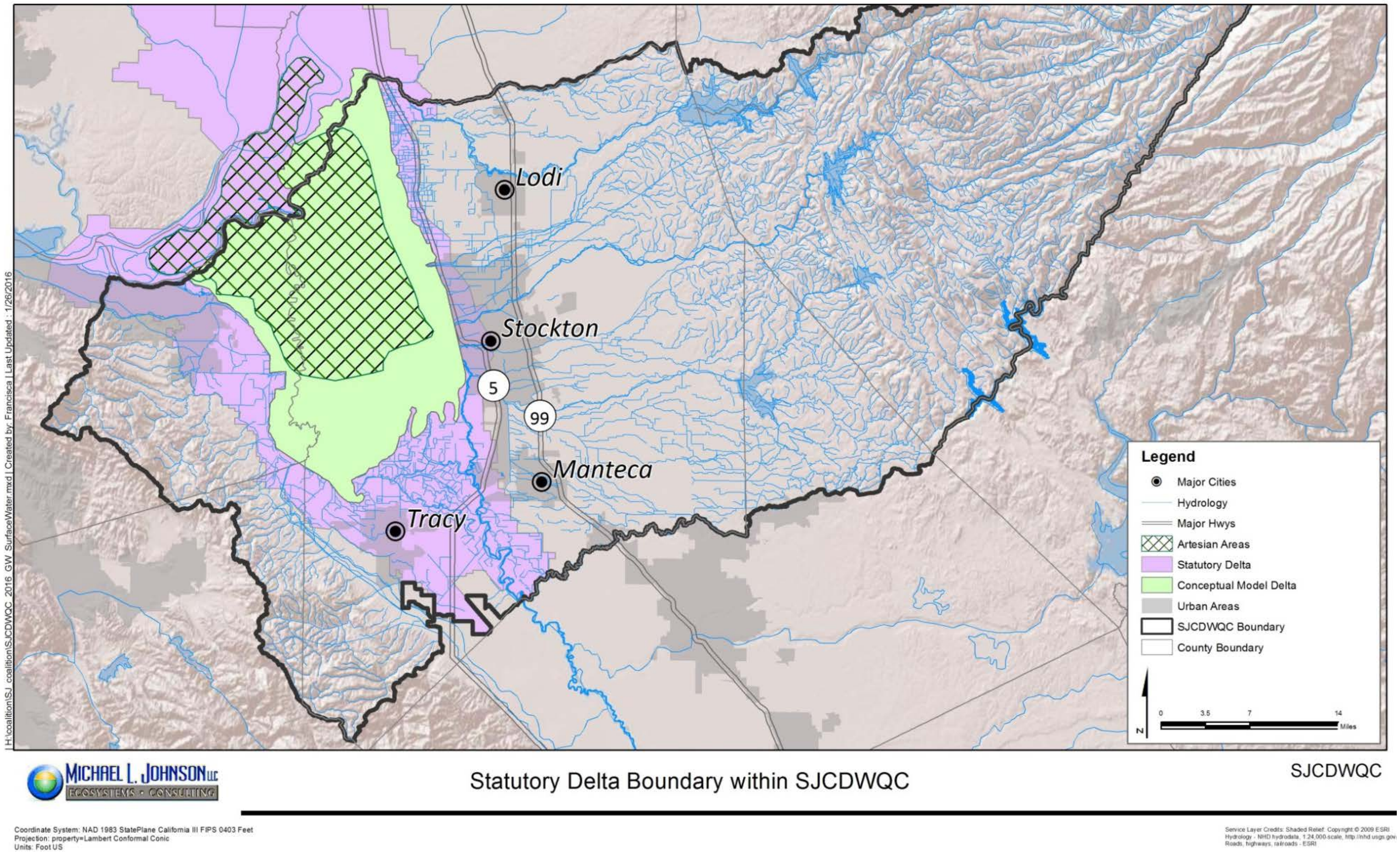
For the purposes of this GQMP, the two different hydrogeological conditions, i.e. upwelling groundwater vs. non-upwelling groundwater, delineate sub-areas within the Delta and will most likely require differing monitoring methodology. According to the GAR shallow groundwater, in areas experiencing upwelling, could be monitored by sampling adjacent drain-water vs. well water.

Non-Delta

The non-Delta is that area within the Coalition that lies to the west, south, and east of the statutory Delta boundaries and that has the potential to be influenced by irrigated agricultural land use practices (irrigated lands).

Figure 43. Expanded view of the Legal Delta within the Coalition (SJCDWQC, 2015).

Figure 44. Boundaries of the statutory Delta, Hydrofocus' conceptual model Delta, and areas with artesian groundwater conditions.



Areas of Recharge / Discharge to Groundwater

Within the Central Valley, prior to development, ground water in the alluvial sediments was replenished primarily by infiltration through stream channels near the valley margins. The eastern-valley streams carrying runoff from the Sierra Nevada provided most of the recharge for valley aquifers. Some recharge also occurred from precipitation falling directly on the valley floor (diffuse recharge) and from stream and lake seepage (localized recharge) occurring there. Over the long term, natural replenishment was dynamically balanced by natural depletion through ground-water discharge, which occurred primarily through evapotranspiration and contributions to streams flowing into the Delta. The areas of natural discharge in the valley generally corresponded with the areas of flowing, artesian wells (Galloway, 1999).

Current intensive development of groundwater resources has drastically altered the valley's water budget. The amount of surface-water outflow from the valley through the Delta has been reduced compared to predevelopment conditions due to a redirection of surface water resources. Even though less water is flowing out from the Central Valley to the Delta, several aquifers in the Central Valley are in a state of overdraft due to pumping more groundwater than is able to be recharged to the aquifers, including the Eastern San Joaquin subbasin within the Coalition region (DWR, 1980). The groundwater water deficit may have amounted to as much as 800,000 acre-ft per year during the late 1960s.

In general, the importance of diffuse recharge decreases as the aridity of a region increases (Reilly, 2008), as in the Central Valley. However, precipitation in the mountainous region of Calaveras County in the eastern portion of the Coalition, feeds rivers and streams which then flow to the west and into the Valley floor or provide water for storage within surface water reservoirs. The topography in Calaveras County varies greatly, from near sea level in the Central Valley (western portion of the County) to elevations around 8,100 ft in the mountainous Sierra Nevadas (eastern portion of the County). Due to the pronounced difference in elevation from west to east, precipitation varies throughout the Calaveras County. Precipitation increases with altitude with average precipitation being 20 inches per year in the western region and 60 inches per year in the northeastern region of Calaveras County (Figure 5) (Raney, 2012).

Three major rivers within Calaveras County that feed Central Valley rivers and streams and recharge groundwater aquifers include the Mokelumne, Calavaras, and Stanislaus Rivers. Additional significant sources of recharge within the Central Valley portion of the Coalition, include the San Joaquin River, and seepage from the State Water Project (California Aqueduct), the Federal Delta Mendota Canal, and the various forms of irrigation through agricultural practices.

Primary sources of groundwater recharge across the three subbasins within the Coalition (Tracy, Eastern San Joaquin, and Cosumnes) are percolation of precipitation, irrigation and urban return flows, reservoirs, and rivers. Surface water draining from the Sierra Nevada, which is stored in reservoirs and diverted for irrigation and water supply, is the largest source of groundwater recharge to the study unit of the USGS' GAMA Program Priority Basin Project for the Northern San Joaquin Basin.

Primary sources of discharge are pumping withdrawals for irrigation and municipal water supply, discharge to streams, and the combination of evaporation from areas with a shallow depth to water and transpiration of water from plants (evapotranspiration) (Bennett et al., 2010a).

Within the Tracy subbasin, the primary source of recharge to the area is seepage from streams and percolation of applied irrigation water. According to DWR's Bulletin 118 (2003), there are no published data available on the amount of groundwater in storage for the Tracy subbasin. Also, there are insufficient published data available to estimate recharge values for this subbasin (CVRWQCB, 2008).

For the Eastern San Joaquin subbasin, the primary source of recharge to the area is seepage from streams flowing from the Sierra Nevada Mountains and percolation of applied irrigation water. The estimated total annual recharge from precipitation and applied water is approximately 593 thousand acre-ft (TAF), 141 TAF from infiltration of surface water, and 3.5 TAF of net subsurface inflow. Estimated groundwater extraction includes approximately 47 TAF annually for municipal and industrial use and 762 TAF annually for agricultural use (CVRWQCB, 2008).

The primary source of recharge to the Cosumnes subbasin area is seepage from streams flowing from the Sierra Nevada Mountains and percolation of applied irrigation water. The estimated total annual natural and applied water recharge is approximately 270 TAF. Estimated groundwater extraction includes approximately 35 TAF annually for urban use and 94 TAF for agricultural use (CVRWQCB, 2008).

Net recharge (R) values refer to the net amount of water (i.e., deep percolation minus pumping) that travels downward from the surface to the saturated zone (SJCDWQC, 2015), i.e. R represents the amount of water per unit area of land which penetrates the ground surface and reaches the aquifer (Klug, 2009). Annual R figures for the Coalition region were obtained from the CVHM output files and provided in Figure 45 through Figure 47 for years 1994, 1995, and 2002, the most recent estimates provided in the CVHM (SJCDWQC, 2015). Negative R values indicate a net loss of groundwater moving from the surface to the saturated zone. Negative net recharge values are generally in areas where groundwater is shallow, resulting in greater evapotranspiration of water within the root zone and a greater potential for direct groundwater discharge to the surface through seeps, springs, streams, rivers, etc.(Szilagyi, 2012).

The R values for the non-Delta areas vary between the years 1994, 1995, and 2002. In 1994 the majority of the R values for the non-Delta area within San Joaquin County are between -1.6 and -0.2 ft per year, with several areas north and east of Lodi and Manteca and east of Stockton with R values between -2.9 to -1.6 ft per year. The area surrounding Manteca and along the eastern boarder of San Joaquin County showed higher R values of -0.2 to 1.1 ft per year in 1994. In 1995, the majority of R values in the non-Delta area are above -0.2 ft per year, with an area to the east of and between Stockton and Manteca with R values between -1.6 and -0.2 ft per year and the areas south of Manteca and along the northeastern boarder of the San Joaquin County boarder above 1.1 ft per year. In general, in 2002 R values for the Coalition in the non-Delta area range from -1.6 to 1.1 ft per year, with isolated locations northeast of Manteca, east of Stockton, and surrounding Lodi with R values of -2.9 to -1.6 ft per year. The depth to groundwater in the majority of the non-Delta area is 15 ft or greater, well below the root zone of most crops (USDA, 1997) and the effects of evapotranspiration or groundwater to surface discharge. Rather, the calculated negative R values are most likely the result of loss of groundwater through pumping beyond the ability of the system to be recharged naturally, i.e. negative R values are due to overdraft of the aquifer.

The R values within the statutory Delta as shown in Figure 45 through Figure 47 vary widely not only within the Delta but also across years. In 1994, 1995, and 2002, there is a ribbon of R values between -4.6 and -2.9 ft per year along the San Joaquin River. In 1994 the majority of the R values for the Delta are between -1.6 and -0.2 ft per year. In 1995, the majority of R values in the Delta are between -0.2 and 1.1 ft per year. In 2002 there is a fairly even distribution of R values between -0.2 and 1.1 per year interspersed with R values between -1.6 to -0.2 ft per year throughout the remainder of the Delta. The depth to groundwater in the Delta ranges from above ground level in some Delta islands to less than 30 ft, with the majority of the depth to groundwater values less than 15 ft below ground level (SJCDWQC, 2015). Because groundwater is so shallow within much of the Delta, the negative R values could be explained by direct groundwater discharge to the surface or through evapotranspiration from the root zone.

Areas of Discharge - Artesian Conditions in the Delta

Groundwater in aquifers between layers of rock with low permeability, such as clay or shale, may be confined under pressure. If such a confined aquifer is tapped by a well, water will rise above the top of the aquifer and may even flow from the well onto the land surface.

According to the GAR, artesian conditions in the Delta are defined by groundwater elevation above the top of a confined aquifer and underneath the tidal peat and muds. In other words, for a well installed and screened in the aquifer underlying the peat, the measured water level would be above the top of that aquifer. In the Delta, the upper elevation of the aquifer is defined as the bottom of the peat which was in turn delineated using methods described in the GAR.

The available groundwater level data indicate that artesian conditions prevail below land-surface elevations of about -7.5 ft below mean sea level (MSL) and are present in areas where land-surface elevations range from -2.5 to -5 ft MSL. Artesian areas demonstrate the effect of pressure transmitted from the adjacent channels to the aquifer below the tidal deposits. Available data indicate that where artesian conditions exist, they exist near levees and on the interior of islands (SJCDWQC, 2015).

Figure 45. Estimated net recharge for 1994 and average groundwater nitrate concentrations for 2009-2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line

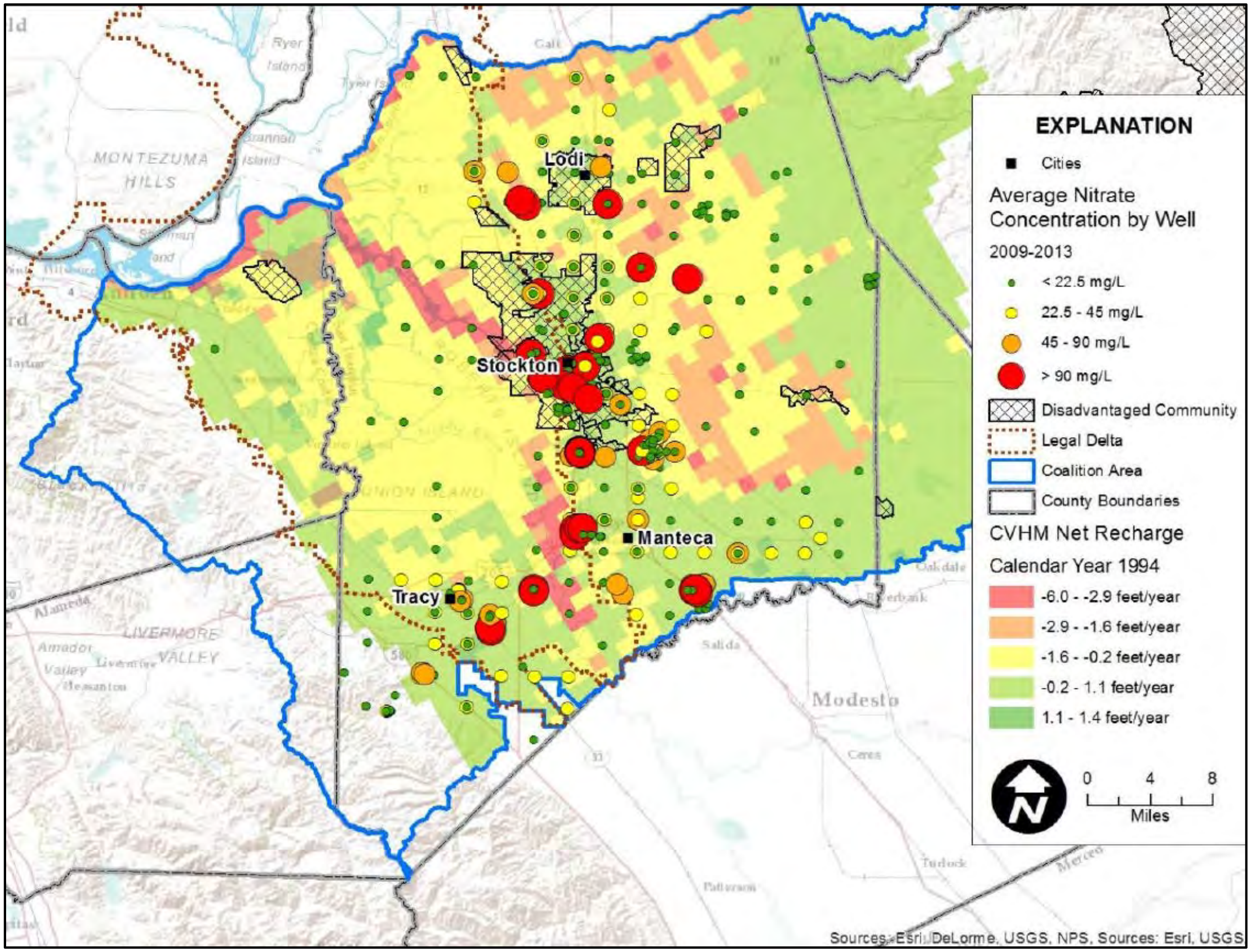


Figure 46. Estimated net recharge for 1995 and average groundwater nitrate concentrations for 2009-2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

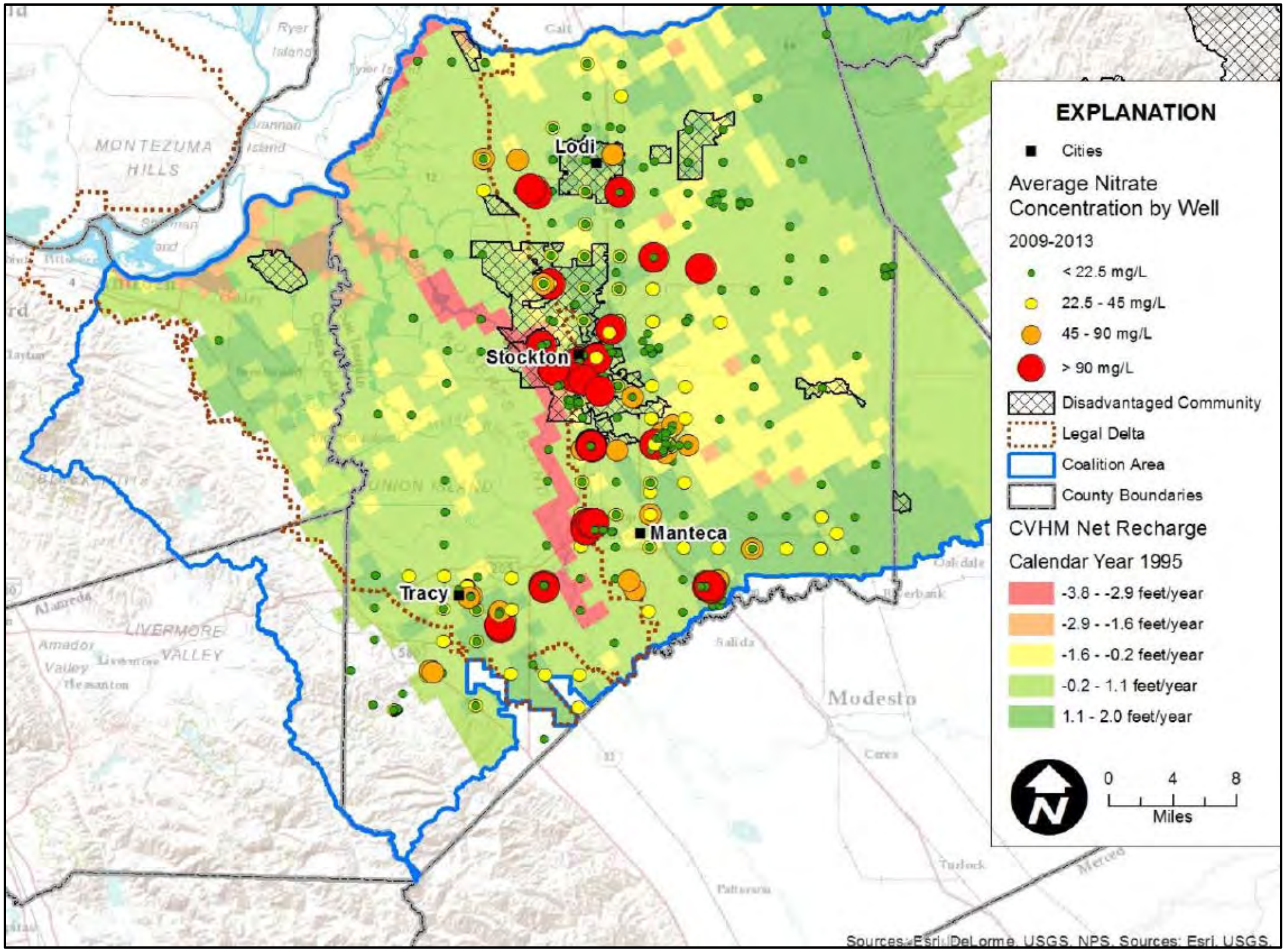
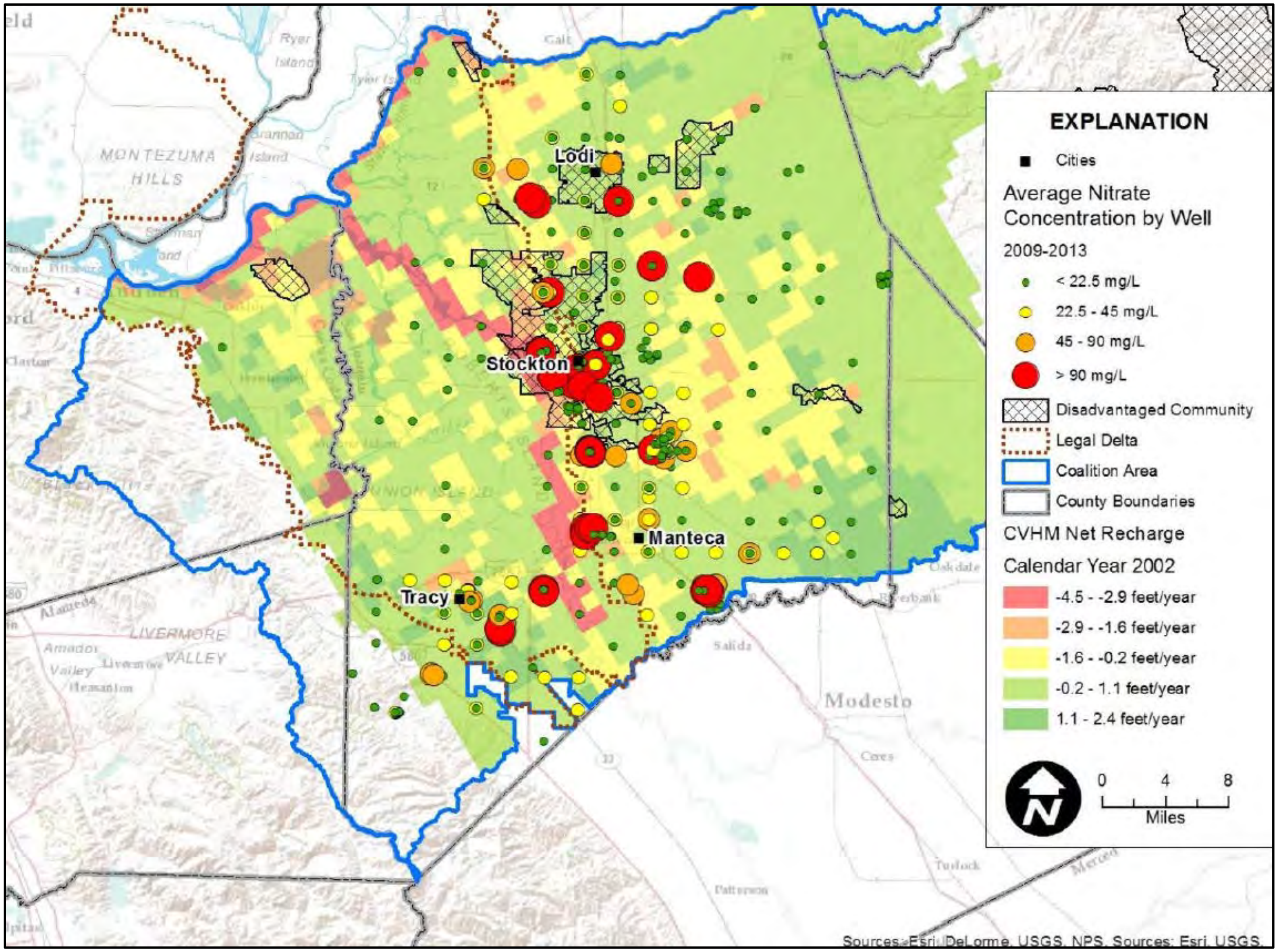


Figure 47. Estimated net recharge for 2002 and average groundwater nitrate concentrations for 2009-2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



General Water Chemistry of Coalition Region

The following description of hydrogeological conditions across the Coalition region was taken from USGS' California GAMA Program Priority Basin Project for the Northern San Joaquin Basin (Bennett et al., 2010a) (Figure 48) and the GAR for the SJCDWQC. Descriptions of groundwater chemistry within the subbasins of the Coalition were taken from DWR's Bulletin 118 (2003).

The study area for the USGS' California GAMA Program Priority Basin Project for the Northern San Joaquin Basin includes all three subbasins with the Coalition (Tracy, Eastern San Joaquin, and Cosumnes). A randomized grid-based approach was used within the USGS study area (grid wells), and 10 of the wells were sampled to increase spatial density and provide additional information for the evaluation of water chemistry in the study unit (understanding/flowpath wells) (Bennett et al., 2010a). Grid wells within the USGS' California GAMA Program Priority Basin Project for the Northern San Joaquin Basin have well depths ranging from 83 to 930 ft below land surface (BLS), with a median of 360 ft BLS, and are used primarily for drinking-water supply. Depths to the top-of-perforation in grid wells ranged from 23 to 750 ft BLS, with a median of 180 ft BLS, and with perforation lengths measuring was as much as 470 ft, with a median of 177 ft. The understanding wells in the Northern San Joaquin Basin study unit generally were deeper (although not statistically significantly deeper) and screens were longer than the depths and screens in the grid wells. The median well depth, median depth to top-of-perforation, and median perforation length for understanding wells were 460, 200, and 268 ft, respectively.

Oxic vs. Anoxic Conditions

Groundwater samples from the wells in the USGS' California GAMA Program Priority Basin Project for the Northern San Joaquin Basin study unit were classified as oxic or anoxic (Figure 49). Groundwater in the Northern San Joaquin Basin study unit primarily was classified as oxic (54 percent of wells). Anoxic conditions occurred in 20 of the 61 wells evaluated (33 percent). Anoxic conditions primarily occurred in the central and western parts of the study unit (valley trough and Delta locations) (Tracy subbasin). Previous investigations have noted that groundwater typically becomes more reducing towards the trough of the San Joaquin Valley. Analysis of the relation between redox conditions and normalized lateral position of the wells indicates that waters classified as anoxic tend to occur closer to the valley trough, and wells classified as oxic tend to occur closer to the valley margin; however, the relation was not statistically significant (Bennett et al., 2010a). According to Figure 49, oxic conditions primarily occurred within the Eastern San Joaquin subbasin. Groundwater within and along the margin of the Delta generally is anoxic, thus providing conditions for the dissolution of arsenic into groundwater and reduction and removal of nitrate from groundwater (Bennett et al., 2010b). Bennett et al. (2010a) also reported high nitrate concentrations associated with oxygenated groundwater conditions, with higher concentrations associated with orchards and vineyards. However, Bennett and others indicated that there is uncertainty as to whether the observed high nitrate levels were an artifact of well selection or land-management practices.

Figure 48. Geographic features and study areas of the Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment (GAMA) study unit (Bennett et al., 2010a).

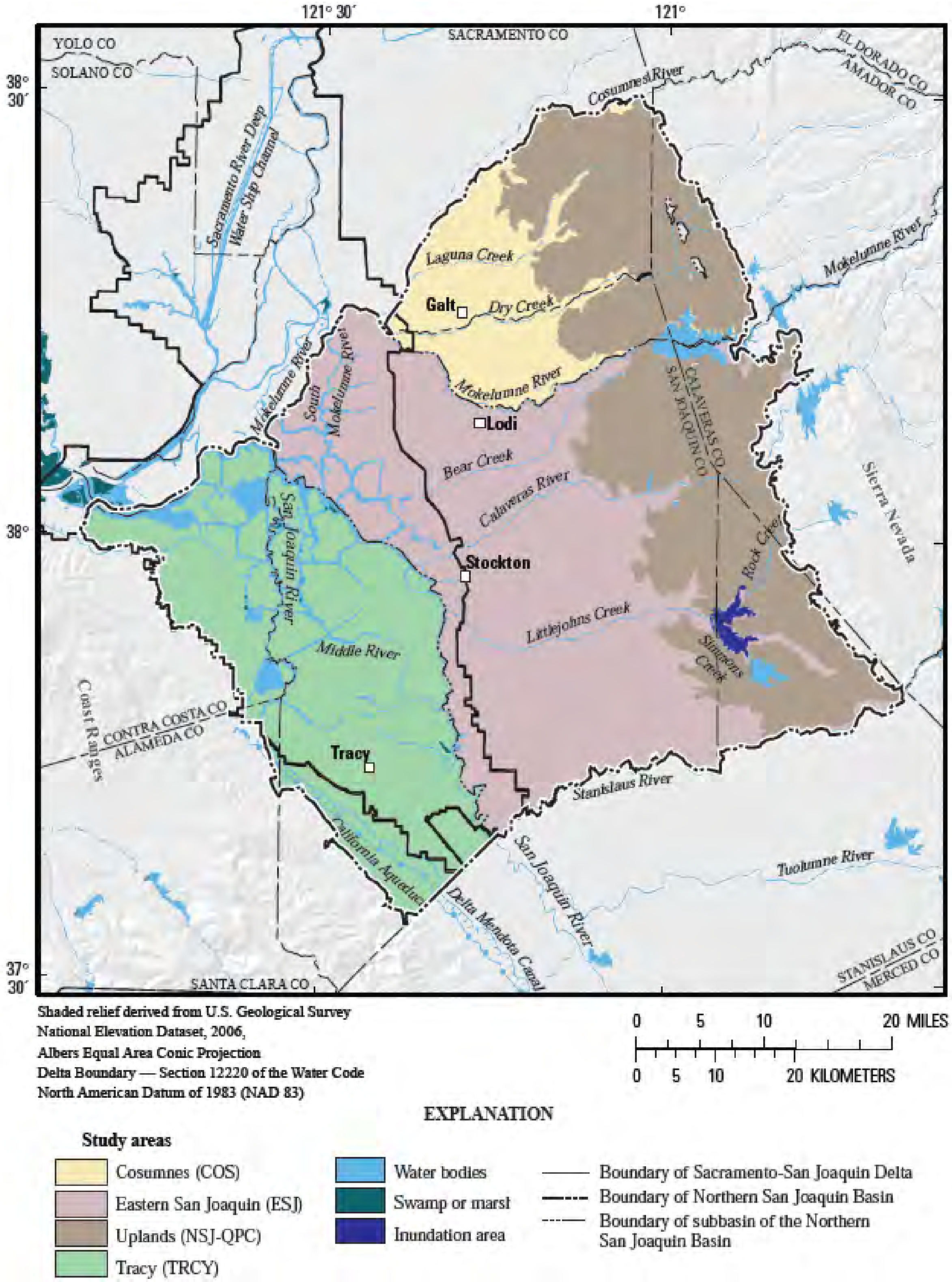
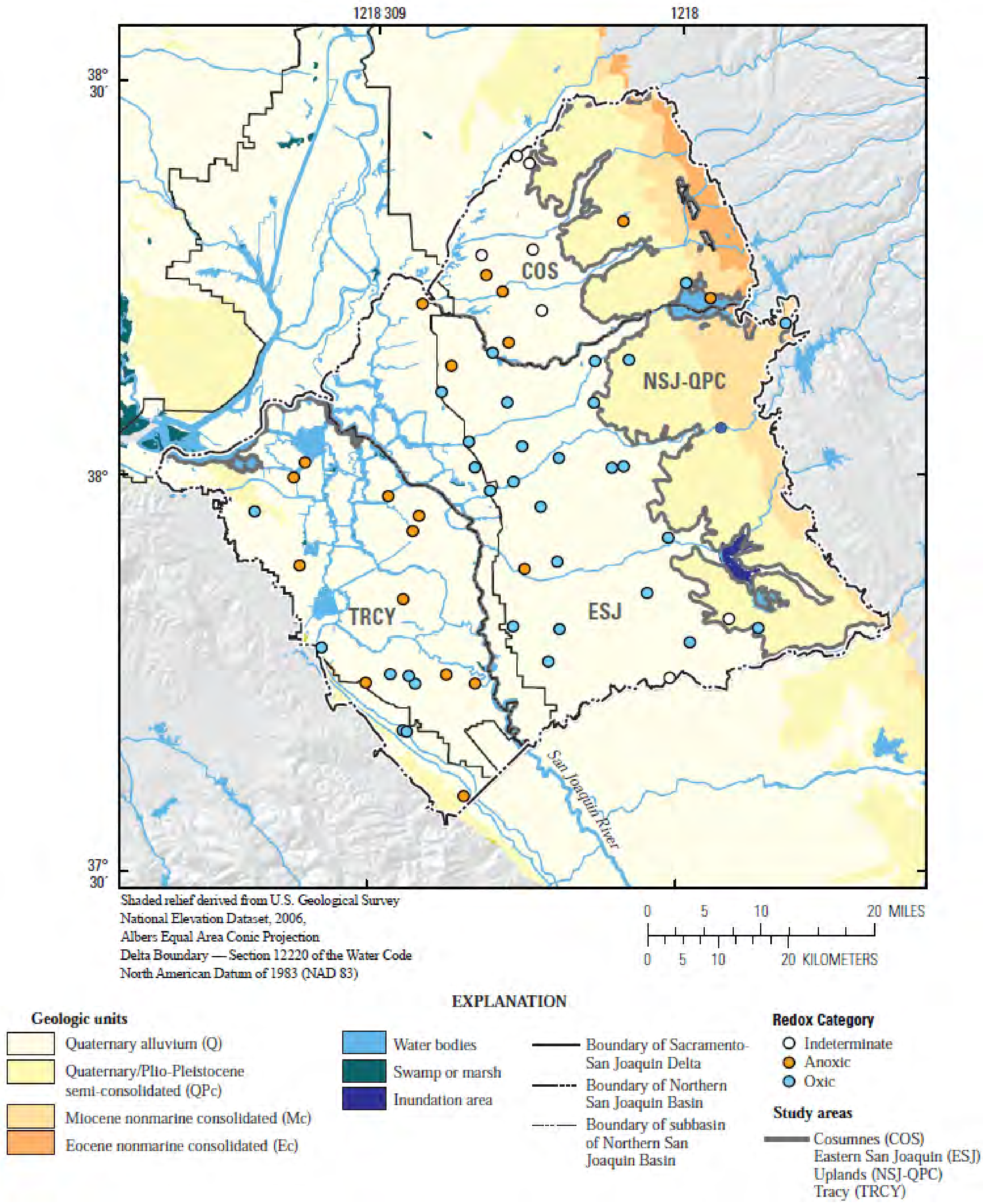


Figure 49. **Redox conditions in grid and understanding wells of the Northern San Joaquin Basin GAMA study unit. Wells labeled as indeterminate had insufficient data for classification (Bennett et al., 2010a).**



Cation/Anion Composition

Trilinear diagrams illustrate the relative contributions of major cations and anions (on a charge-equivalent basis) as a percentage of the total ion content of the water. Major cations (calcium, magnesium, sodium and potassium) are plotted on the lower left triangle, and major ions (chloride, sulfate and bicarbonate) are plotted on the lower left triangle, and the central diamond integrates the data (Figure 50). Bennett et al., (2010a) used USGS-GAMA and CDPH major ion data for grid wells and all CDPH major ion data to determine whether the groundwater types observed in grid wells within the Northern San Joaquin Basin GAMA study unit were similar to groundwater types observed historically in the study unit (Figure 51) (Bennett et al., 2010a). The similarity of the range of relative abundance of major cations and anions in grid wells to those in the set of all CDPH wells described below and in Figure 51 indicates that the grid wells represent the distribution and diversity of water types present in the Northern San Joaquin Basin study unit.

Data from grid wells and recent CDPH data indicate that a similar range of water types was sampled. At most wells, no single cation accounted for more than 60 percent of the total cations, and bicarbonate accounted for more than 60 percent of the total anions; these samples are described as mixed cation-bicarbonate type waters. At many other wells, no single cation and no single anion accounted for more than 60 percent of the total; these samples are described as mixed cation-mixed anion type waters. In a minority of wells, sodium and chloride accounted for more than 60 percent of the total cations and anions, respectively; these samples are classified as sodium-chloride type waters (Bennett et al., 2010a).

TDS

The recommended EPA Secondary MCL for taste and odor or welfare for TDS is 500 mg/L. TDS levels in the primary aquifers (between 100 and 500 below land surface) studied in the USGS' Northern San Joaquin Study Unit (Tracy, Eastern San Joaquin, and Cosumnes subbasins), were present at high concentrations (greater than the EPA Secondary MCL) in about 6% of the primary aquifers, and at moderate concentrations in about 16%. Chloride and sulfate occurred at high concentrations in the primary aquifers and contributed to high concentrations of TDS. Anoxic conditions in groundwater may result in the release of manganese and iron from minerals into groundwater. Manganese with or without iron was present at high or moderate concentrations in about 34 and 5% of the primary aquifers, respectively (Bennett et al., 2010b).

According to the GAR, TDS levels within the Coalition region, including within the designated High Vulnerability Areas (HVAs), are illustrated in Figure 52. TDS concentrations in 386 of 423 wells in the HVAs, were greater than 500 mg/L. Many wells with TDS concentrations above the recommended limit are located in the Stockton and Lathrop urban areas. There are also wells with TDS concentrations above the recommended limit on the eastern edge of San Joaquin County and in the Delta on Staten and Roberts islands. Temporal trends from ten wells with extensive history of TDS concentrations were analyzed and results presented in the GAR. Five wells showed a significant increasing trend, one well showed a significant decreasing trend, and three wells did not show a significant trend. Figure 53 shows the well locations with their trends. All wells with increasing TDS trends are within the HVAs.

Figure 50. An example of chemical characteristics and areas of ionic dominance represented within a trilinear diagram.

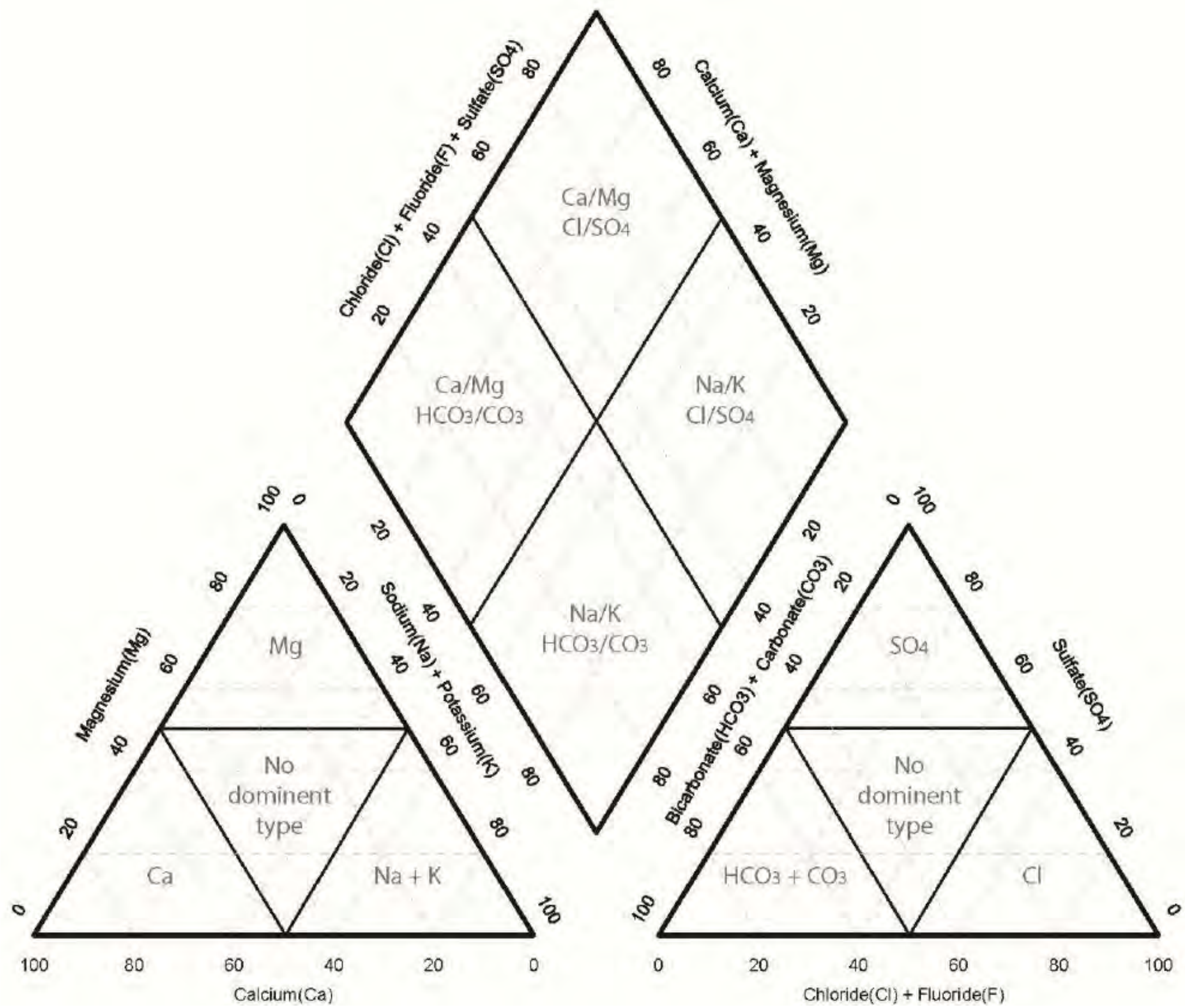


Figure 51. **Trilinear diagram comparing water types in grid wells and all wells in the CDPH database that have a charge imbalance of less than 10 percent, within the Northern San Joaquin Basin GAMA study unit.**

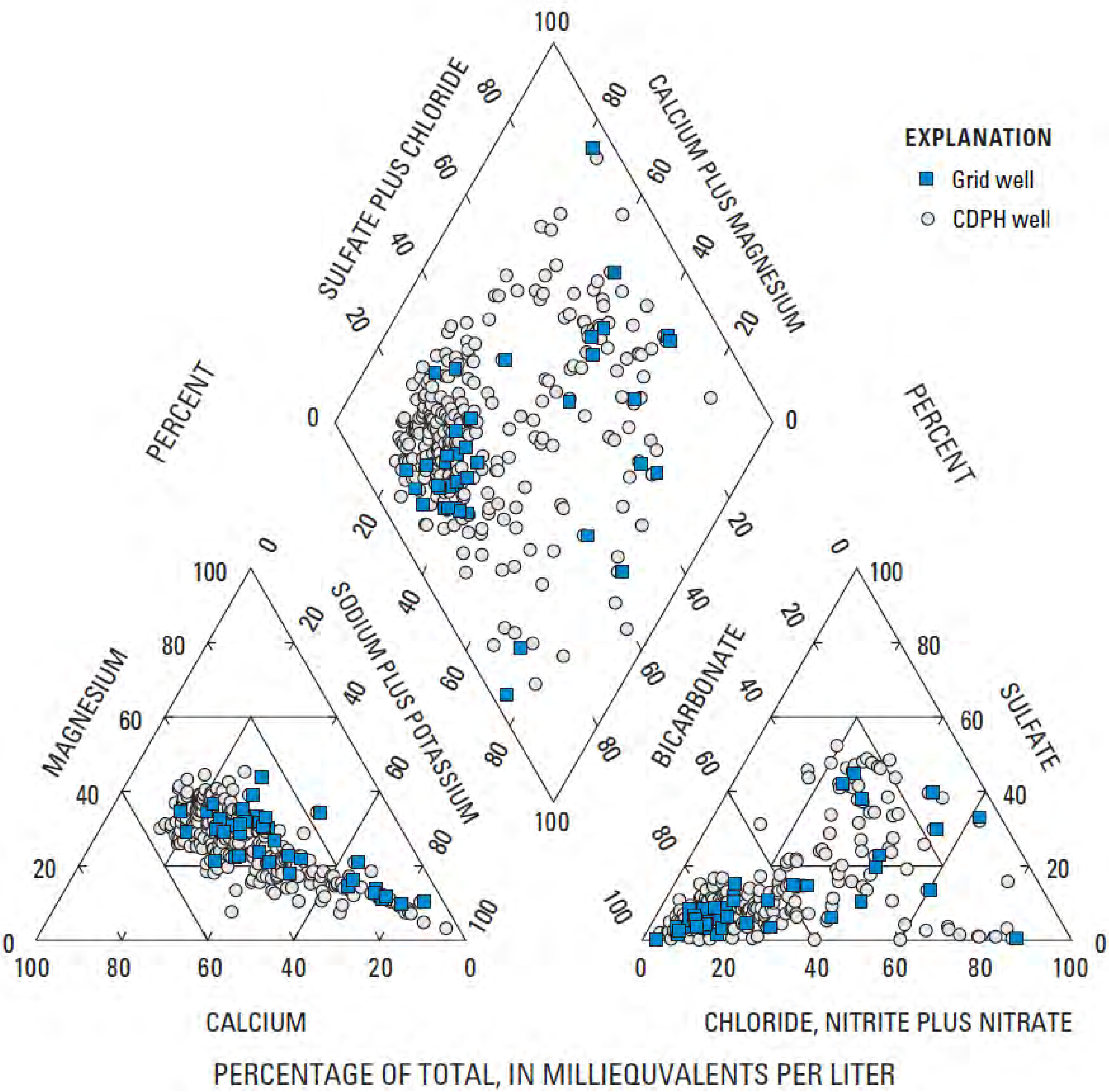


Figure 52. TDS concentrations from data spanning 2009-2013 in the Coalition region (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

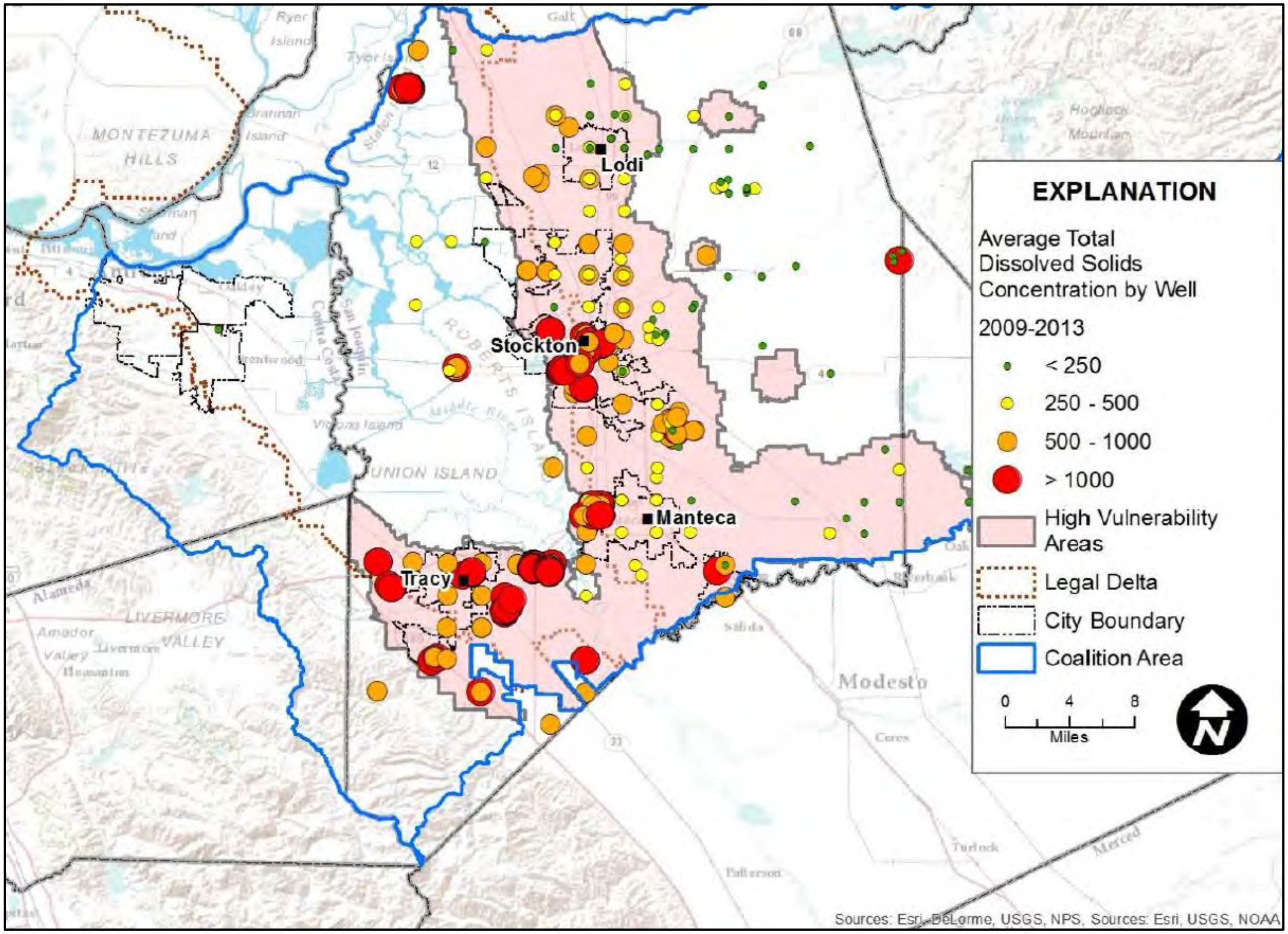
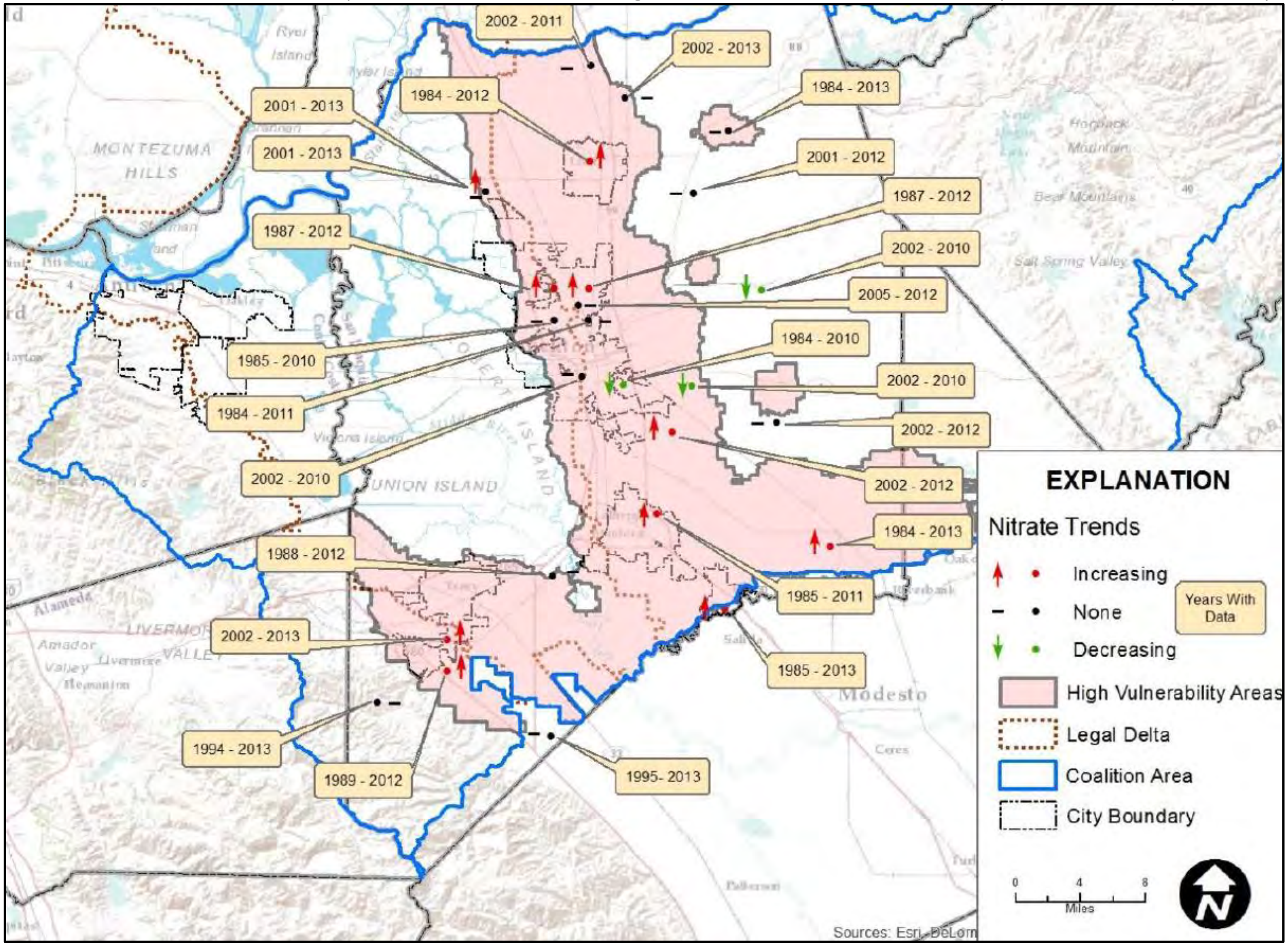


Figure 53. TDS trends at 10 wells within the HVAs in the Coalition region (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



General Water Chemistry by Subbasin

Tracy

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).

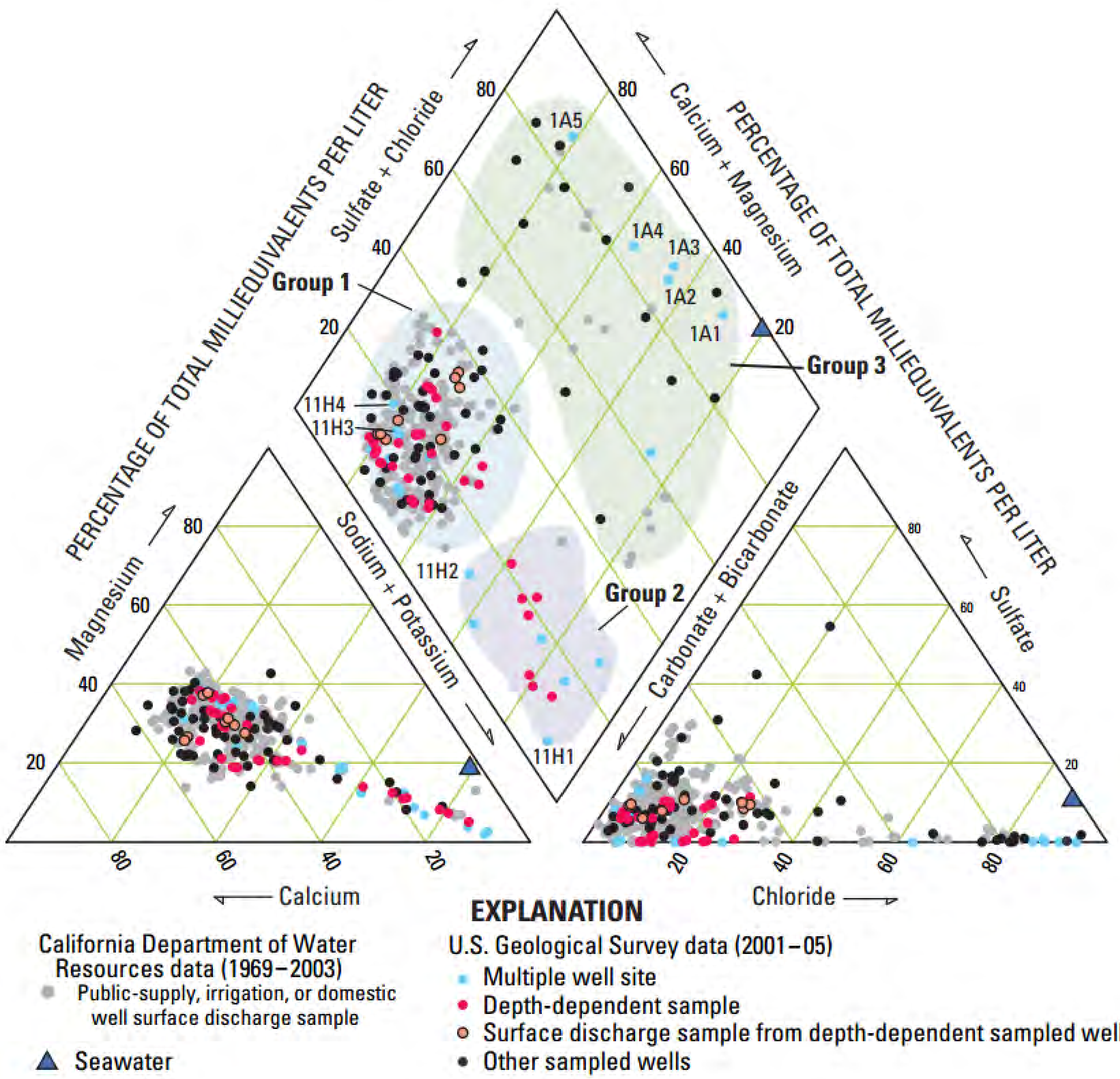
Eastern San Joaquin

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).

In a study by Izbicki, et al. (2006), water samples taken from 76 public supply, irrigation, domestic, and observation wells and 245 historical samples from within the Eastern San Joaquin subbasin were plotted on a trilinear diagram (Figure 54). On the basis of their distribution within the trilinear diagram, data were separated into three groups having different chemical compositions. Group 1 represents the majority of sampled wells. Group 2 consists of depth-dependent samples from deeper depths. All samples within Groups 1 and 2 had chloride concentrations of less than 100 mg/L. In contrast, all but two samples within Group 3 were from wells that had chloride concentrations greater than 100 mg/L. Group 3 included several public-supply wells that are no longer in use due to chloride concentrations that were greater than EPA's Secondary Maximum Contaminant Level (SMCL) of 250 mg/L. The major ion composition of water from wells did not trend consistently toward the composition of seawater as chloride concentrations increased.

Intrusion of saline water has been occurring along a 16-mile-long 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).

Figure 54. Trilinear diagram illustrating major-ion chemistry of water from selected wells in the Eastern San Joaquin Ground-Water Subbasin, California, 2004–2005 (Izbicki, 2006).



Calaveras County Water District (CCWD) analyzed water samples from 2012 within the portion of the county overlaying the footprint of the Eastern San Joaquin subbasin. Data from the 2012 study, along with data from the June and July 2010 USGS sampling efforts, were plotted in a Piper diagram (Figure 55). Analysis of the data by CCWD revealed three general water types in the Calaveras County portion of the Eastern San Joaquin subbasin: a mixed anion-mixed cation (Group 1), a sodium-chloride type (Group 2), and a sodium-bicarbonate type (Group 3). The mixed anion-mixed cation (Group 1) water types are usually represent mixing of fresh water and more saline water sources. The sodium-chloride type (Group 2) represents saline water from deeper formations of water that has moved from a saline marine source like the San Joaquin Delta, or of water that has experienced mixing with irrigation water.

The sodium-bicarbonate water type (Group 3) is typical of deeper groundwater that has been influenced by ion exchange.

The water chemistry in the eastern San Joaquin subbasin which underlies the Calaveras County footprint is illustrated in Figure 55. Figure 56 illustrates the locations of the wells sampled within Calaveras County by the Calaveras County Water District (CCWD). Grouping of the major cations and anions using Piper diagrams confirmed groundwater is divided into three main types: sodium–chloride type, sodium–bicarbonate, and mixed water type. TDS concentrations were typically below 300 mg/L, with the exception of well CCWD 001. Arsenic exceeds the California primary drinking water Maximum Contaminant Level (MCL) only at well CCWD 001. The Secondary MCL for electrical conductivity at 25˚C, manganese, sulfate, and TDS was also exceeded at CCWD 001, with the secondary MCL for manganese also being exceeded at CCWD 014 and 015.

Cosumnes

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).

Figure 55. Piper (trilinear) diagram depicting major anion and cation water types of the Eastern San Joaquin subbasin underlying a portion of the footprint of Calaveras County. Samples taken during CCWD and USGS sampling efforts in 2012 and 2010 respectively (CCWD, 2013).

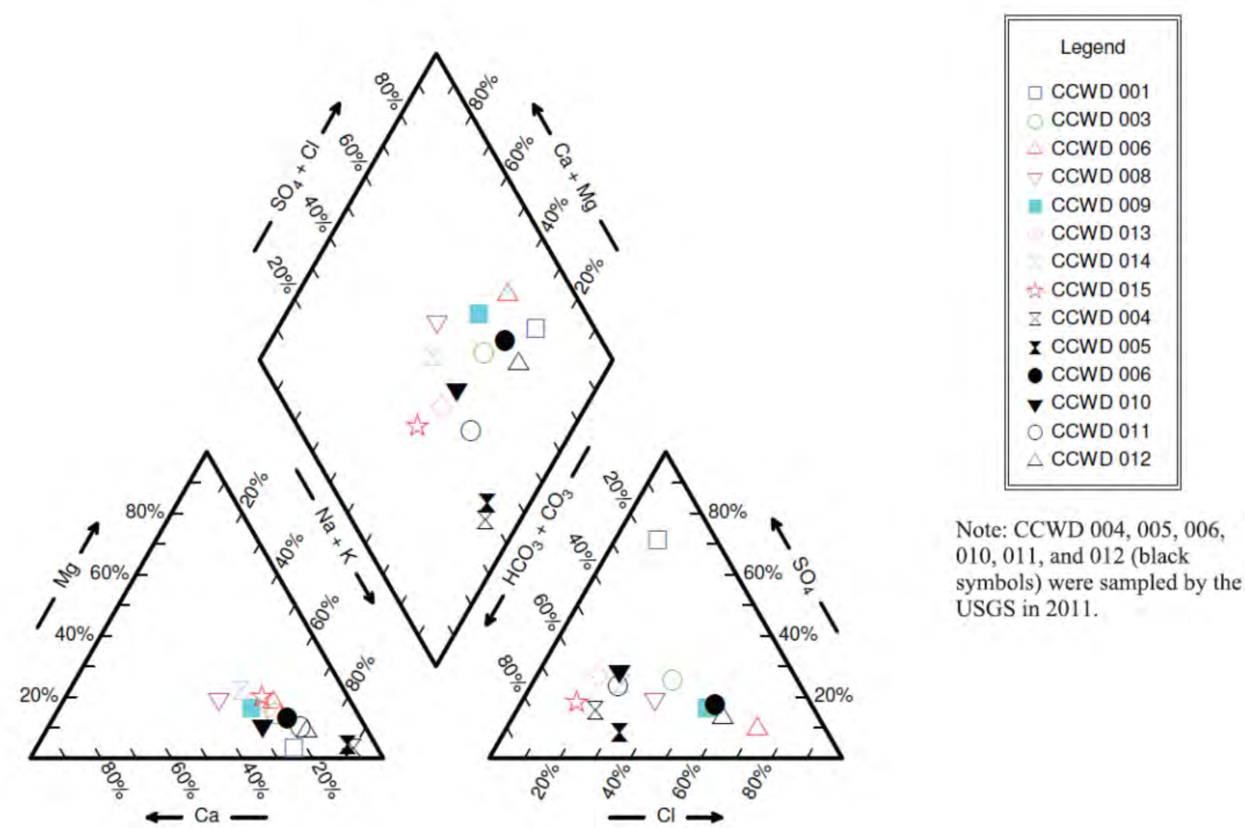
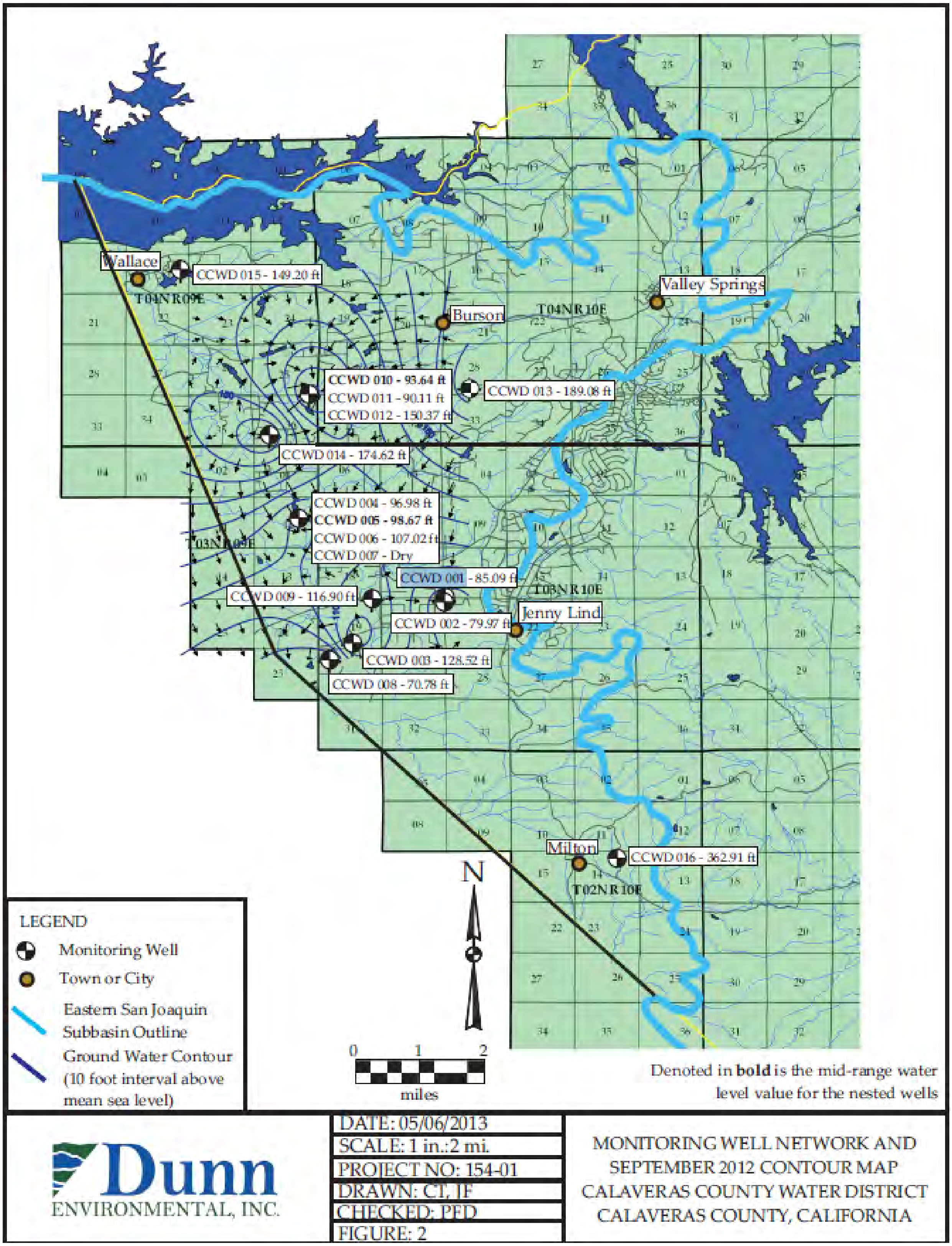


Figure 56. Monitoring Well Network and September 2012 contour map, Calaveras County Water District (CCWD), Calaveras County, California (CCWD, 2013).



LAND USE

Using DWR land use survey data for counties within the Coalition, and including the entire Coalition region (i.e. the areas outside of the Central Valley), land use within the Coalition as a whole is about 31% irrigated agriculture, 62% natural vegetation, and 6% urban (Figure 57).

Irrigated Land

Because land use within a given region is constantly changing, the exact acreage within a region used by agriculture is difficult to attain. However, based on available data from the California Department of Water Resources (DWR), out of the Coalition region's approximately 2,123,069 acres, approximately 29% (617,257 acres) are considered used for irrigated agriculture (Table 13). Irrigated acreages were calculated using data from two DWR sources: 1) DWR Agricultural Land and Water Use data and 2) DWR Land Use Survey. According to the Order, there are approximately 618,000 acres of cropland under irrigation within the Coalition, including non-member acres; acreage data in the Order from the California Department of Conservation's Farmland Mapping and Monitoring Program Geographic Information System. Approximately 29% of the Coalition is considered irrigated land.

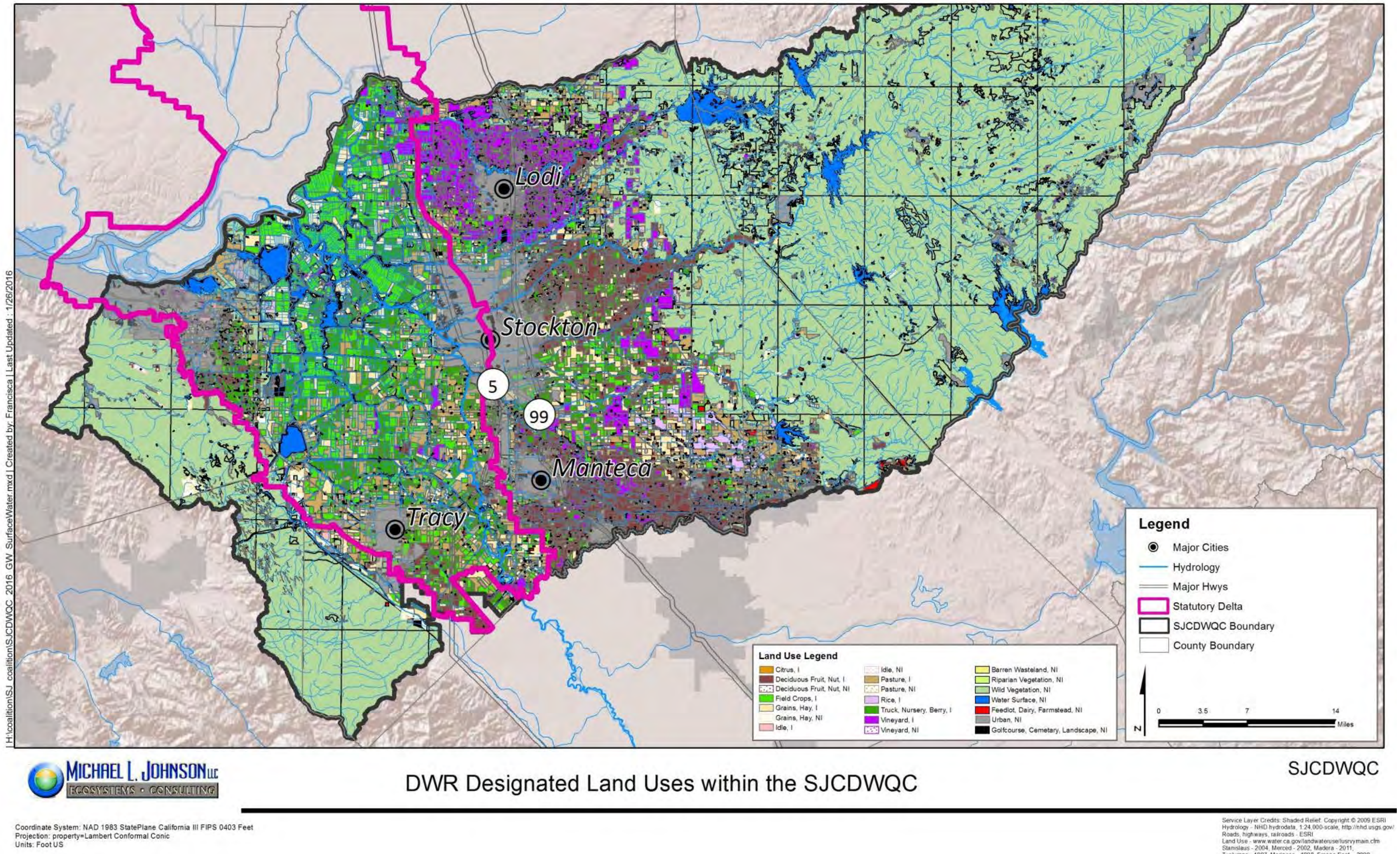
Agricultural Land and Water Use data (DWR, http://www.water.ca.gov/landwateruse/anaglwu.cfm) were used to estimate the acreage of irrigated crops for the entirety of each county. Land Use Survey data (DWR, http://www.water.ca.gov/landwateruse/lusrvymain.cfm) included more detailed information regarding specific crop uses (both irrigated and non-irrigated) than the Agricultural Land and Water Use data, but was updated less often. Because Land Use Survey data were available in GIS shape files, the information was mapped to the Coalition area and used for estimates of irrigated crop acreage. The data source depended on: 1) whether or not the entire county was within the Coalition boundary, and 2) which data were developed most recently. For Alameda, Alpine, Amador, Contra Costa, and Stanislaus Counties, the Coalition utilized DWR Land Use Survey data to determine irrigated land area because only sections of these counties were included in the Coalition boundary. For San Joaquin and Calaveras Counties, data from Agricultural Land and Water Use were used as all of San Joaquin County was encompassed in the Coalition boundary (Table 13).

Table 13. Acreage of irrigated land in SJCDWQC counties, and available DWR data.

County	Acreage of County within Coalition (DWR Land Use)	Acreage within County/Coalition Designated as Irrigated Land[1]	Data Source Year
Alameda	46,563	1,063	2006
Alpine	95,585	0	2013
Amador	135,309	39	1997
Calaveras	663,313	4,300	2000
Contra Costa	184,548	48,456	1995
San Joaquin	889,505	541,310	1996
Stanislaus	108,246	22,089	2004
Total	**2,123,069**	**617,257**	

[1]Source data from DWR Land Use Survey* (Alameda, Alpine, Amador, Contra Costa, Stanislaus Counties) or Land and Water Use Data, 2010** (Calaveras and San Joaquin Counties)
*DWR Land Use Survey: http://www.water.ca.gov/landwateruse/lusrvymain.cfm
**DWR Agricultural Land Use: http://www.water.ca.gov/landwateruse/anaglwu.cfm

Figure 57. DWR designated land uses within the SJCDWQC Coalition.



According to the GAR, the top five crop classes based on DWR land use survey data for the Delta (2007), San Joaquin County (1996) and Stanislaus County (2004), are deciduous fruits and nuts (18.4%), field crops (13.5%), pasture (12.7%), vineyards (12.3%), and truck, nursery, berry crops (6.6%). Comparing these DWR land use survey data with USDA (2012) cropland data for the entire Coalition region, the top five crop classes remain the same but vary in hierarchy: deciduous fruits and nuts (22.9%), field crops (19.9%), vineyards (14.7%), pasture (14.7%), and truck, nursery, berry (7.4%).

Irrigation Water from Groundwater Sources

Data presented in DWR's Water Plan 2013 Update regarding the amount of groundwater used for agricultural, urban, or managed wetlands is categorized by county (Table 14). Calaveras and San Joaquin Counties are almost entirely encompassed by the Coalition; the remaining counties are only partially within Coalition boundaries (Table 5). Review of groundwater usage listed in Table 14 should be with county percentages in mind, i.e. only approximately 9% of Alameda, 20% of Alpine, 35% Amador, 36% of Contra Costa, and 11% of Stanislaus Counties are within the Coalition, however, approximately 100% of Calaveras and 97% of San Joaquin Counties are within the Coalition. The TAFs water usage reported for Calaveras and San Joaquin Counties in DWR Water Plan 2013 Update and listed in Table 14 would be almost entirely accounted for within the Coalition footprint. Table 15 presents how many acres from each county are included within the SJCDWQC footprint by Delta and non-Delta areas, and groundwater subbasins.

Table 14. Average annual groundwater supply by entire county[1] and by type of use (2005-2010).[2]

Hydrologic Region	County	Water Use Type Met by Groundwater							
		Agriculture		Urban		Managed Wetlands		Total Water	
		TAF	%	TAF	%	TAF	%	TAF	%
San Francisco Bay	Alameda	5.8	51%	35.9	15%	0.0	0%	41.7	17%
San Joaquin River	Amador	3.5	23%	1.6	15%	0.0	0%	5.1	20%
NA	Alpine[3]	-	-	-	-	-	-	0.3	2%
San Joaquin River	Calaveras	1.3	16%	1.6	13%	0.0	0%	2.8	14%
San Joaquin River	Contra Costa	0.8	1%	24.9	9%	0.0	0%	25.7	6%
San Joaquin River	San Joaquin	354.1	22%	81.8	44%	0.0	0%	435.8	25%
San Joaquin River	Stanislaus	512.4	29%	162.8	85%	1.4	13%	676.6	35%
Total Annual Average for Counties[3] within GQMP Area (2005-2010)		877.9	24%	308.6	30%	1.4	2%	1,188.0	17%

[1] County data is for entire the county. However, most of the counties are only partially within the Coalition. Refer to Table 5 for proportion of a given county in the Coalition.
[2] Table contents from DWR's Water Plan, 2013 Update.
[3] Table contents for Alpine County from Groundwater Management Plan, 2007.
TAF – Thousand acre foot
Percent (%) use is the percentage of the total water supply (for the county) that is met by groundwater, by type of use

Table 15. Approximate acreages* associated with the Delta and non-Delta areas, underlying subbasins (none, partial, or entire), and overlaying counties (partial, or entire) within SJCDWQC.

Delta vs. Non-Delta and Subbasins	Alameda	Alpine	Amador	Calaveras	Contra Costa	San Joaquin	Stanislaus	Grand Total
Delta	**4,659**	**-**	**-**	**-**	**98,790**	**315,974**	**-**	**419,424**
Cosumnes	-	-	-	-	-	1,211	-	1,211
Eastern San Joaquin	-	-	-	-	-	125,686	-	125,686

Delta vs. non-Delta and Subbasins	Alameda	Alpine	Amador	Calaveras	Contra Costa	San Joaquin	Stanislaus	Grand Total
Tracy	4,659	-	-	-	98,541	188,847	-	292,048
Non-Delta	**41,772**	**9,5240**	**135,915**	**662,844**	**87,687**	**573,091**	**108,818**	**1,705,365**
Cosumnes	-	-	13,166	347	-	70,117	-	83,629
Eastern San Joaquin	-	-	-	51,803	-	421,861	102,591	576,255
Tracy	1,966	-	-	-	-	32,263	-	34,229
Grand Total	**46,431**	**95,240**	**135,915**	**662,844**	**186,477**	**889,065**	**108,818**	**2,124,789**

*Acreage values calculated from Arc GIS data.

Agricultural Crop Land Use Data

Table 16 presents all of the land use data from DWR in the Coalition, including non-agriculturally related land use. Analysis of DWR's land use data for the GQMP area indicate that less than a third of the land within the Coalition is designated as irrigated. In addition, most of the land use classes for crops are irrigated rather than non-irrigated (Table 16). Land use crop data within the GQMP area from two different data sets, USDA (2012) and DWR (early 2000s), respectively, are presented in Table 17 and Table 18. The GAR provided land use analyses based on DWR land use data, ranging from the mid-1990s to the mid-2000s. DWR data is verified in the field by DWR department staff in over 95 percent of the developed agricultural areas and provides irrigated vs. non-irrigated data, but is not as recent as USDA cropland data (2012), which is based on satellite imagery and not ground proofed. Both DWR and USDA data analyses are presented below to give a broader view of the land use data available for the Coalition region. USDA data (Table 17) indicate grapes, alfalfa, corn, walnuts and almonds, tomato, winter wheat, fallow /idle cropland and other hay/non-alfalfa as capturing over 80% of the agriculturally related land use in the GQMP area, regardless of irrigated or non-irrigated status. DWR data were also separated into only those irrigated land use subclasses (crops), listed in descending percentage of irrigated land use, and presented in Table 18. The irrigated crops totaling more than 80% of DWR's designated irrigated land use subclasses are: corn, grapes, miscellaneous grain and hay, alfalfa, mixed pasture, almonds, tomatoes, walnuts, asparagus, and safflower.

The crops which make up to 80% of those grown in the irrigated lands of the GQMP area and which are listed in both the USDA (not including fallow cropland) and DWR data sets are: grapes, alfalfa, corn, walnuts, almonds, tomatoes, and miscellaneous grains and hay (including oats and winter wheat) (Table 17 and Table 18). In descending order the top three crops identified in the USDA dataset are grapes, alfalfa, and corn (42%) (Table 17). In the DWR dataset, the top three crops are corn, grapes, and miscellaneous grain and hay (37%) (Table 18).

Table 16. DWR Land use data by acreage as associated with irrigation data[1] and acreage within the entire GQMP area.

Land uses derived from DWR data in order to incorporate irrigation data; numbers are rounded to nearest whole number.

Land Use Category	Irrigated (Acres)	Non-Irrigated (Acres)	Grand Total	Percent of "Irrigated" Land Use Data Category	Percent of "Non-Irrigated" Land Use Data Category
Barren	0	822	822	0.00%	0.04%
Citrus & Sub-Tropical	569	51	620	0.03%	0.00%

Land Use Category	Irrigated (Acres)	Non-Irrigated (Acres)	Grand Total	Percent of "Irrigated" Land Use Data Category	Percent of "Non-Irrigated" Land Use Data Category
Deciduous Fruits & Nuts	114,669	662	115,331	5.40%	0.03%
Field Crops	135,670	206	135,876	6.39%	0.01%
Grain & Hay	77,870	6,666	84,536	3.67%	0.31%
Idle	12,738	454	13,192	0.60%	0.02%
Native Riparian	0	9,645	9,645	0.00%	0.45%
Native Vegetation	0	1,261,650	1,261,650	0.00%	59.39%
Open Water	0	59,446	59,446	0.00%	2.80%
Pasture	122,444	289	122,733	5.76%	0.01%
Rice	7,020	0	7,020	0.33%	0.00%
Semi-agricultural	0	12,875	12,875	0.00%	0.61%
Truck, Nursery, Berry	87,839	0	87,839	4.13%	0.00%
Urban[2]	79	133,991	134,070	0.00%	3.60%
Vineyard	78,511	115	78,626	0.00%	0.12%
Grand Total	**637,409**	**1,486,872**	**2,124,281**	**30.01%**	**69.99%**

[1] Land use information obtained from data provided by DWR, http://www.water.ca.gov/landwateruse/anaglwu.cfm. Data compiled in 2006 (Alameda), 1995 (Contra Costa), and 1996 (San Joaquin). Land use in some areas of the SJCDWQC may have changed since that time.
[2] "Urban" land use subcategories categories were combined into the "urban" category and associated with the appropriate I/NI status where applicable.

Table 17. USDA land use data[1] by acreage within the entire GQMP area.
The crops listed above the bold line (within the middle of the table) are those crops making up to 80% of the crops grown on irrigated land in the GQMP area.

USDA Land Use Category by Crop	DWR Land Use Class	Acreage	Percentage of Crops in GQMP[2] Area	Cumulative Percentages
Grapes	Vineyard	93,108	14.72%	14.72%
Alfalfa	Pasture	88,255	13.96%	28.68%
Corn	Field Crops	86,626	13.70%	42.38%
Walnuts	Deciduous Fruits & Nuts	68,735	10.87%	53.25%
Almonds	Deciduous Fruits & Nuts	54,247	8.58%	61.83%
Tomatoes	Truck, Nursery, Berry	38,737	6.13%	67.96%
Winter Wheat	Grain & Hay	34,226	5.41%	73.37%
Fallow/Idle Cropland	Fallow Lands	27,333	4.32%	77.69%
Other Hay/Non Alfalfa	Grain & Hay	26,080	4.12%	81.82%
Oats	Grain & Hay	23,643	3.74%	85.56%
Cherries	Deciduous Fruits & Nuts	200,734	3.17%	88.73%
Dbl Crop Oats/Corn	Field Crops	16,481	2.61%	91.34%
Herbaceous Wetlands	Water Surface	9,649	1.53%	92.86%
Safflower	Field Crops	7,609	1.20%	94.07%
Triticale	Field Crops	6,461	1.02%	95.09%
Grand Total for Land Use Category		**601,263**	**95.09%**	

[1]Land use information obtained from data provided by USDA, 2012 California Cropland Data Layer: http://www.nass.usda.gov/research/Cropland/SARS1a.htm. Land use in some areas of the SJCDWQC may have changed since that time.
[2]Percent of cropped area includes all agricultural fields, whether fallow or active. Land use categories such as barren, developed, grassland, forest, shrubland, wetland, ice, snow, or open water were not included in acreage totals. Crops contributing 1% or more of the overall land use within the GQMP area were included.

Table 18. DWR land use subclass (crop) data by acreage as associated only with irrigated land use[1] within the GQMP area.

The crops listed above the bold line (within the middle of the table) are those crops making up to 80% of the crops grown on irrigated land in the GQMP area.

DWR's Irrigated Land Use Subclass (Crop)	DWR's Associated Land Use Class	Irrigated Acres	Percent of Overall Irrigated Acres[2]	Cumulative Percentages
Corn	Field Crops	83,186	13.05%	13.05%
Grapes	Vineyard	78,483	12.31%	25.36%
Miscellaneous Grain and Hay	Grain & Hay	75,396	11.83%	37.19%
Alfalfa	Pasture	65,550	10.28%	47.48%
Mixed Pasture	Pasture	51,555	8.09%	55.56%
Almonds	Deciduous Fruits & Nuts	42,517	6.67%	62.23%
Tomatoes	Truck, Nursery, Berry	42,279	6.63%	68.87%
Walnuts	Deciduous Fruits & Nuts	41,213	6.47%	75.33%
Asparagus	Truck, Nursery, Berry	24,063	3.78%	79.11%
Safflower	Field Crops	21,787	3.42%	82.53%
Beans	Field Crops	16,088	2.52%	85.05%
Idle (within past three years)	Idle	12,483	1.96%	87.01%
Cherries	Deciduous Fruits & Nuts	11,095	1.74%	88.75%
Melons, Squash, and Cucumbers	Truck, Nursery, Berry	8,022	1.26%	90.01%
Rice (not classified)	Rice	7,020	1.10%	91.11%
Apples	Deciduous Fruits & Nuts	6,956	1.09%	92.20%
Sugar Beets	Field Crops	6,646	1.04%	93.24%
Grand Total		**594,339**	**93.24%**	

[1]Land use information obtained from data provided by DWR, http://www.water.ca.gov/landwateruse/anaglwu.cfm. Data compiled in 2006 (Alameda), 1995 (Contra Costa), and 1996 (San Joaquin). Land use in some areas of the SJCDWQC may have changed since that time.
[2]Crops contributing 1% or more of the overall land use within the GQMP were included.

EXISTING AGRICULTURAL MANAGEMENT PRACTICES

The SJCDWQC WDR requires that all Coalition members within low and high vulnerability areas (surface and groundwater) complete a Farm Evaluation (FE) by June 15, 2015 and submit it to the third-party (Coalition). Per the Order, those Coalition members within a high vulnerability area are required to submit an updated FE annually by the 15th of June while those in low vulnerability areas must submit an updated FE to the third-party every 5 years. The FE is intended to gather information on general site conditions and management practices that members currently have in place to protect surface and groundwater quality.

The Coalition includes an assessment of member management practices from the previous year in its Annual Report (submitted May 1 of each year). Data presented below are from the 2014 Farm Evaluations which were submitted to the third party by June 15, 2015. Table 19 and Figure 58 through Figure 62 are based on FEs submitted to the Coalition summarize the management practices implemented by members in 2014 to protect surface and groundwater quality and represent 406,993 acres of the Coalition region. Approximately 75% of the required FEs were submitted by October 2015 to the Coalition.

Table 19. SJCDWQC member management practices implemented in 2014 WY; listed by Management Practice Category.

Management Practice Category		Management Practices
Irrigation Management Practices	Irrigation Efficiency Practices	Laser Leveling
		Pressure Bomb
		Soil Moisture Neutron Probe
		Use of ET in scheduling irrigations
		Use of moisture probe
		Water application scheduled to need
	Primary (and/or secondary) Irrigation Practices	Border Strip
		Drip
		Flood
		Furrow
		Sprinkler
		Micro Sprinkler
Sediment Management Practices	Cultural Practices to Manage Sediment and Erosion	Berms are constructed at low ends of fields to capture runoff and trap sediment.
		No storm drainage due to field or soil conditions.
		Cover crops or native vegetation are used to reduce erosion.
		Creek banks and stream banks have been stabilized.
		Crop rows are graded, directed and at a length that will optimize the use of rain and irrigation water.
		Field is lower than surrounding terrain.
		Hedgerows or trees are used to help stabilize soils and trap sediment movement.
		Minimum tillage incorporated to minimize erosion.
		Sediment basins / holding ponds are used to settle out sediment and hydrophobic pesticides such as pyrethroids from irrigation and storm runoff.
		Soil water penetration has been increased through the use of amendments, deep ripping and/or aeration.

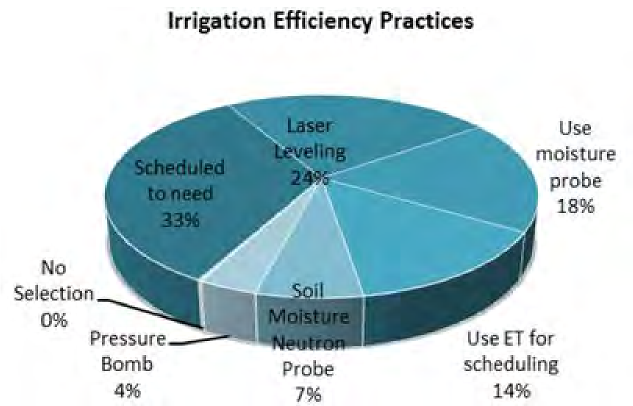
Management Practice Category		Management Practices
		Storm water is captured using field borders.
		Subsurface pipelines are used to channel runoff water.
		Vegetated ditches are used to remove sediment as well as water soluble pesticides, phosphate fertilizers and some forms of nitrogen.
		Vegetative filter strips and buffers are used to capture flows.
	Irrigation Practices for Managing Sediment and Erosion	In-furrow dams are used to increase infiltration and settling out of sediment prior to entering the tail ditch.
		Catchment Basin.
		No irrigation drainage due to field or soil conditions.
		PAM (polyacrylamide) used in furrow and flood irrigated fields to help bind sediment and increase infiltration.
		Shorter irrigation runs are used with checks to manage and capture flows.
		Tailwater Return System.
		The time between pesticide applications and the next irrigation is lengthened as much as possible to mitigate runoff of pesticide residue.
		Use drip or micro-irrigation to eliminate irrigation drainage.
		Use of flow dissipaters to minimize erosion at discharge point.
Pesticide & Nutrient Management	Pesticide Application Practices	Avoid Surface Water When Spraying
		Chemigation
		End of Row Shutoff When Spraying
		Follow County Permit
		Follow Label Restrictions
		Monitor Rain Forecasts
		Monitor Wind Conditions
		Reapply Rinsate to Treated Field
		Sensitive Areas Mapped
		Target Sensing Sprayer used
		Use Appropriate Buffer Zones
		Use Drift Control Agents
		Use PCA Recommendations
		Attend Trainings
		Use Vegetated Drain Ditches
	Nitrogen Management Methods to Minimize Leaching Past the Root Zone	Cover Crops
		Fertigation
		Foliar N Application
		Irrigation Water N Testing
		Soil Testing
		Split Fertilizer Applications
		Tissue/Petiole Testing
		Variable Rate Applications using GPS
Well Management Practices	Wellhead Protection Practices	Air Gap (for non-pressurized systems
		Backflow Preventive / Check Valve
		Good "Housekeeping" Practices*
		Ground Sloped Away from Wellhead
		Standing water avoided around wellhead
	Abandoned Wells Practices (if abandoned well is known to be present on site)	Destroyed – certified by county
		Destroyed - Unknown method
		Destroyed by licensed professional

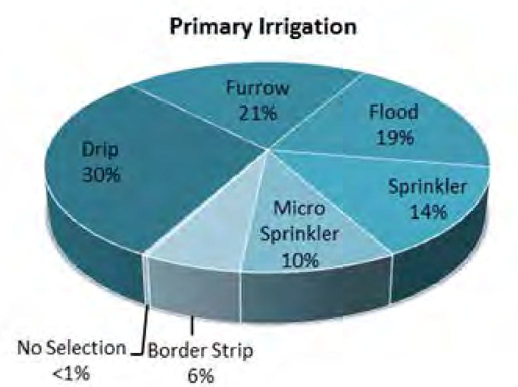
*Good housekeeping practices include keeping the area surrounding the wellhead clean of trash, debris and any empty containers

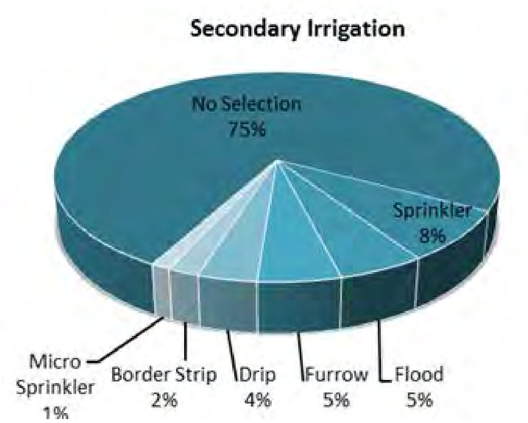
Irrigation Management Practices

The methods of irrigation water delivery and irrigation efficiency are intertwined within the irrigation management practices employed by parcel owner/operators. Just over half of the irrigated acres within the Coalition are associated with pressurized irrigation (drip, sprinkler, and microsprinkler), with the largest percentage of irrigated acres on a drip system. Most members utilize only one irrigation method (no selection for Secondary Irrigation) (Figure 58).

Figure 58. Percent of acreage with irrigation management practices.







Nutrient management practices target measures designed to achieve the desired crop yield, but also to prevent excess nutrients from passing through the root zone and entering groundwater. Pesticide management practices apply to groundwater by targeting the minimum amount of pesticide required to achieve the desired crop yield, preventing overspray from entering recharge areas, and by timing the application of the pesticide far enough in advance of irrigation to prevent pesticides from travelling beyond the targeted area through irrigation waters to recharge areas and entering the groundwater (Figure 59 and Figure 60).

Figure 59. Acreage associated with nitrogen management methods.

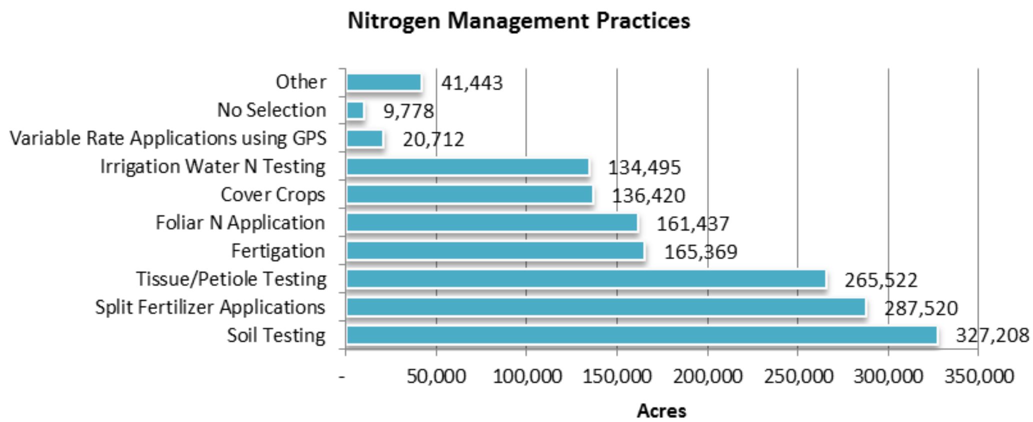
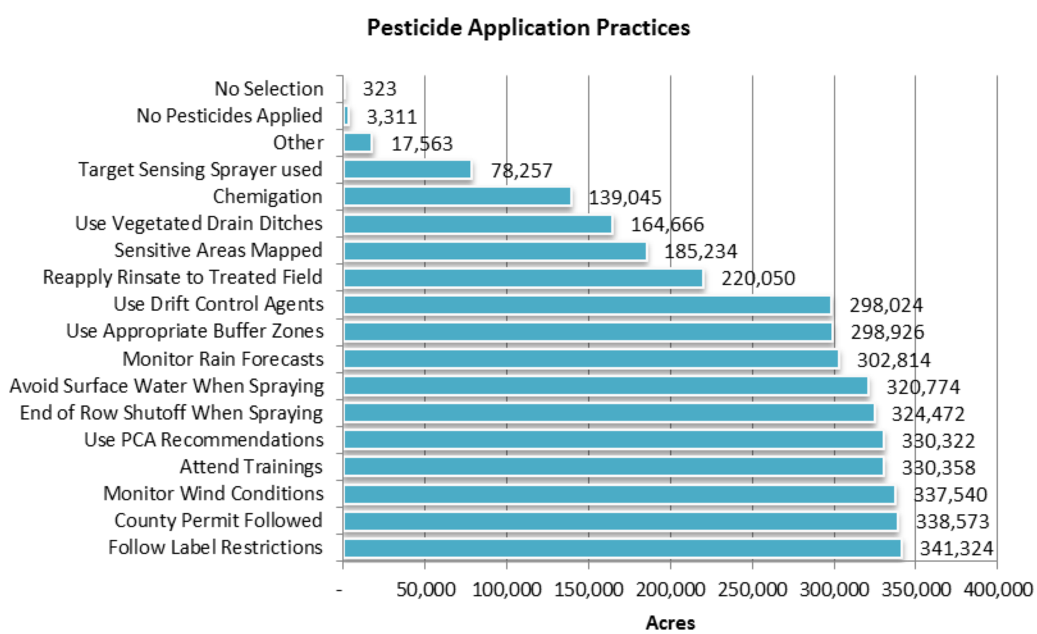


Figure 60. Acreage associated with pesticide application practices.



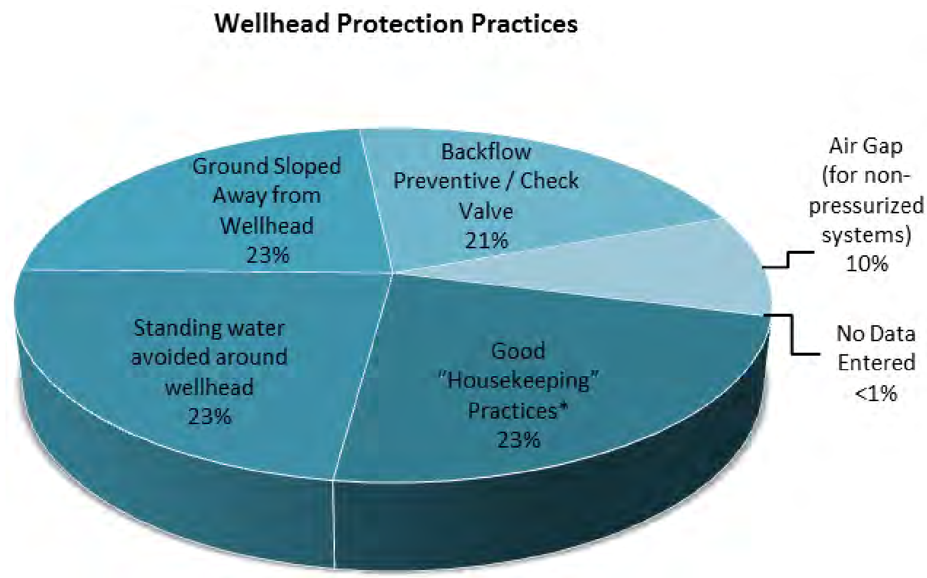
Well Management Practices

Irrigation Wells

Fifty five percent of those owners/operators who returned a Farm Evaluation Survey indicated there was an irrigation well on the agricultural parcel(s). Of those owners/operators utilizing the irrigation well, various wellhead protection practices were employed (Figure 61).

Figure 61. Percent acreage associated with members who have irrigation wells and members implementing wellhead protection practices.

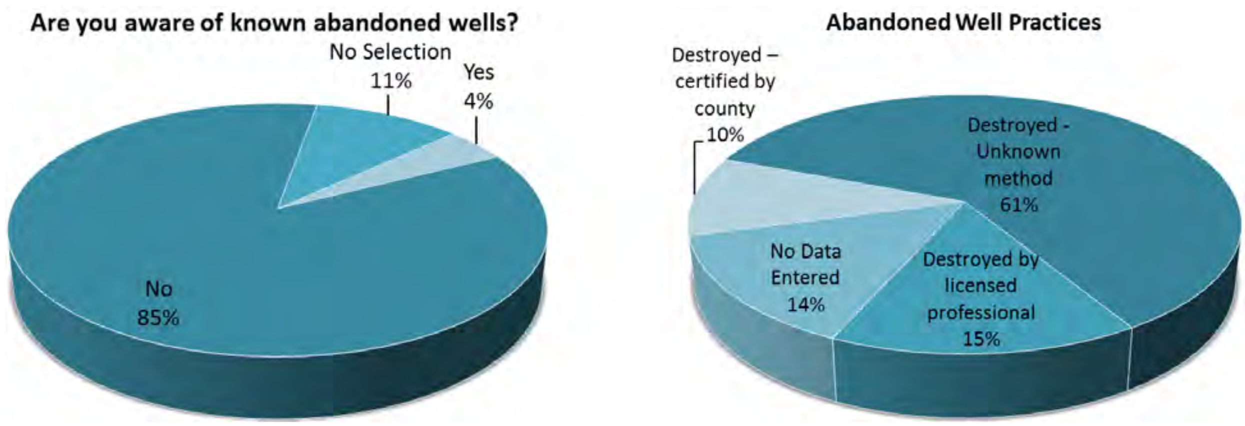
*Good housekeeping practices include keeping the area surrounding the wellhead clean of trash, debris and any empty containers.



Abandoned Wells

According to the Farm Evaluations, only a small percentage of acreage within the Coalition region is associated with known abandoned wells. A large portion of these abandoned wells have been destroyed by unknown methods while approximately 25 percent of known abandoned wells have been destroyed by a licensed professional or were certified by the County (Figure 62).

Figure 62. Percentage of acreage with known abandoned wells and practices associated with those wells.



CONSTITUENTS OF CONCERN

In the identification of existing water quality data and COCs for the GQMP area, the Coalition relied on the findings of the GAR as well as other existing relevant, regional literature as sources of groundwater quality and environmental conditions for this GQMP. Those constituents identified as having exceeded an MCL were then evaluated to determine if they were a COC in relation to agricultural management practices and/or a potential source of degradation to a beneficial use as described below.

Constituents of concern in groundwater are those materials that could impact beneficial uses and that have been applied during agricultural operations, including constituents in irrigation supply water (e.g., pesticides, fertilizers, soil amendments, etc.). Typically, shallow groundwater is that water most recently entering the groundwater recharge cycle and is representative of more recent overlaying land use activities. Due to the extended transport time of downward-moving irrigation return water (years) to even shallow groundwater aquifers, any management practice applied to land during a given year could take years to result in improvements in groundwater quality. Because groundwater samples taken currently will, in most cases, include constituents applied several years in the past and potentially in a different overlaying location, identifying the exact source and location of application of a constituent in groundwater is often times impractical. Agricultural management practices recommended by this GQMP are designed to prevent future degradation of groundwater quality by agricultural operations.

In general, the Groundwater Monitoring Advisory Workgroup for the Regional Water Board determined "that the most important constituents of concern related to agriculture's impacts to the beneficial uses of groundwater are nitrate (NO_3-N) and salinity" (WDR, Attachment A, page 24).

According to Bulletin 118 (DWR, 2003), the primary constituents present in the San Joaquin River Hydrologic Region with the potential to impact or cause degradation to state waters are salts (TDS), nitrate, boron, chloride and organic compounds such as pesticides. High salts can be attributed to marine sediments in the Coast Range in the west side of the San Joaquin Valley and a culmination of evaporation and poor drainage resulting in increased salt concentrations within the Valley floor. Nitrates may occur naturally or as a result of anthropogenic sources such as human/animal waste or fertilizers. Boron and chloride occur naturally in existing sediments and aquifers of the region, with increased concentrations a result of evapotranspiration from the root zone, crops, and surface waters whose source of irrigation waters is groundwater. As described in Bulletin 118, agricultural pesticides and herbicides have been detected in groundwater throughout the San Joaquin River Hydrologic Region especially where soil permeability is higher and depth to groundwater is shallower.

BENEFICIAL USES

The WDR identifies shallow groundwater COCs as "…any material applied as part of the agricultural operation, including constituents in irrigation supply water (e.g., pesticides, fertilizers, soil amendments, etc.) that could impact beneficial uses or cause degradation" (WDR, Attachment B, pg. 14).

According to the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan), "unless otherwise designated by the Regional Water Board, all ground waters in the Region are considered as suitable or potentially suitable, at a minimum, for municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply" (CVRWQCB, 2015b). These beneficial uses are described as:

- Municipal and Domestic Supply (MUN) – Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
- Agricultural Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- Industrial Service Supply (IND) – Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
- Industrial Process Supply (PRO) – Uses of water for industrial activities that depend primarily on water quality.

Groundwater provides a substantial portion of the water required for agricultural practices in the counties within the Coalition (partial or entire) and east of the regulatory Delta: Amador (23%), Calaveras (16%), San Joaquin (22%), and Stanislaus (29%) (DWR, 2013) (Table 14). Percent of urban use requirements met by groundwater in those counties east of the Delta are as follows: Amador (15%), Calaveras (13%), San Joaquin (44%), and Stanislaus (85%) (DWR, 2013). By contrast, groundwater is scarcely used within the Delta in the equation outlined in DWR's 2013 Water Plan Update for total water usage within DWR's Planning Area 602 (San Joaquin Delta). Planning Area 602 covers the majority of the Tracy subbasin and the northwestern tip of the Eastern San Joaquin subbasin, a large portion of the western half of the Coalition region. Planning Area 602 has an estimated total water use of 899 TAF, with only 4% of that water use met by groundwater and of that groundwater, none (0%) is estimated to be used to meet agricultural management practices (DWR, 2013). A consideration should be made when thinking about the numbers provided for Planning Area 602 regarding agricultural use of groundwater, e.g. if groundwater is only being measured from wells or if, in the case of the Delta, also being measured from ditches whose source water is groundwater.

EXISTING GROUNDWATER QUALITY DATA - EXPANDED

In the identification and analysis of existing water quality data for the GQMP area, the Coalition relied on the findings of the GAR which summarized previous work, studies, and monitoring programs conducted throughout GQMP area. Several sources were cited in the GAR for water quality data including: San Joaquin County Flood Control and Water Conservation District, California Department of Public Health's (CDPH) Water Quality Analyses Database Files, Department of Water Resources' (DWR) Water Data Library (WDL), United States Geological Survey (USGS) National Water Information System (NWIS), SWRCB's Geotracker database, USGS' Groundwater Ambient Monitoring and Assessment Program (GAMA), the Dairy Cares Representative Monitoring Program, and the DPR pesticide sampling database. In addition to the GAR, the Coalition referred to USGS' reports of the Northern San Joaquin Basin for the California GAMA Priority Project (Bennett et al., 2010a) and other existing relevant, regional literature as sources of groundwater quality and environmental conditions for this GQMP.

Selection of the threshold value used to indicate an exceedance of an MCL, and identification of potential COCs, within the GAR appears to coincide with the CDPH Drinking Water Standards Primary MCL and the United States Environmental Protection Agency (EPA's) Federal Primary MCL and the CDPH's Secondary MCL for TDS. Additional analysis of TDS concentrations above the Agricultural Water Quality Goals of 450 mg/L threshold published by the Food and Agriculture Organization of the United Nations in the Constituents of Concern in High Vulnerability Areas section below. Analysis of TDS data at the 450 mg/L threshold is present for discussion purposes as it is considered to be of particular relevance for the agricultural industry, rather than as a threshold that would trigger a management plan.

The most recent data indicate TDS concentrations in many shallow wells are below 500 mg/L, which represents the recommended Secondary MCL for Drinking Water Standards; upper and short term secondary MCLs for TDS are set at 1,000 mg/L and 1,500 mg/L, respectively. Secondary Drinking Water Standards are established for aesthetic reasons such as taste, odor, and color and are not based on public health concerns. Some areas of locally high TDS concentrations exist in shallow wells in the vicinity of Modesto and also in some locations west of Turlock as shown in Figure 5-7. A number of wells with higher TDS concentrations are apparent in close proximity to the San Joaquin River along the western edge of the Coalition region where groundwater is generally very shallow. Elevated TDS concentrations can be a result of natural processes and the presence of high TDS concentrations does not necessarily indicate impacts from overlying land use activities.

The following constituents are identified in the GAR as having exceeded a threshold for the Drinking Water Standards MCLs at well locations within the Coalition and are of concern with regards to agricultural management practices: nitrate and TDS, and the pesticides DBCP and EDB. According to groundwater quality data compiled from a variety of well depths throughout the Coalition, nitrate concentrations were reported to be above the 22.5 mg/L levels (Figure 70) (2009 to 2013) and TDS concentrations exceeded the 500 and 1,000 mg/L levels (Figure 74). There are no actively applied pesticides containing EDB and DCBP currently registered with the DPR. The use of DBCP in California stopped in California in 1977 and nationally in 1979, and the EPA cancelled the registrations for all DBCP-containing products in 1985. The US EPA banned the use of EDB as a soil fumigant in 1983. Only those constituents currently used by the agriculture industry, with concentrations above the MCLs or notification level, or concentration of TDS above 450 mg/L were retained as potential COCs.

Delta

The GAR did not list any groundwater constituents of concern as present within the Delta. It is unclear from the GAR, whether or not COCs have been identified within the statutory Delta but outside of the artesian portion of the Delta.

For additional data on the COCs in the Delta, the Coalition included the data analysis from USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) for the Tracy subbasin and western edge of the eastern San Joaquin subbasin, within the statutory boundary. Approximate locations of exceedances for the following constituents were based on the maps provided in the USGS' study (Bennett et al., 2010a). The following constituents are identified by Bennett et al. (2010a) as having exceeded an MCL for a water quality benchmark for drinking water in the Coalition region: arsenic and nitrate (U.S. Environmental Protection Agency [USEPA] MCL), chloride, iron, manganese, sulfate, and TDS (CDPH Secondary Maximum Contaminant Level [SMCL]), and boron (CDPH NL). The USGS not only analyzed samples but also compared data from CDPH analyses. Of the previously listed constituents, only nitrate (nitrate exceedances only found in the CDPH data) and TDS levels are considered COCs as current agricultural practices, while not necessarily the sole source, have been shown to contribute to elevated levels of both TDS and nitrate. All the other previously listed constituents are either not used in agricultural practices (arsenic, iron, manganese, and sulfate) and/or are commonly found naturally in soils of the area (chloride and boron).

Non-Delta

According to the GAR, exceedances of the MCL for nitrate and the fumigants DBCP and EDB, and a detection of simazine (below the MCL) were detected in wells in the Coalition region. Only DBCP and EDB concentrations were detected to be greater than the MCL within the non-Delta portion of the Coalition region. As stated previously, neither DBCP nor EDB are currently used in agricultural practices and are therefore not to be considered COCs. Simazine has not been detected above the MCL and therefore is not considered a COC.

Data analysis from the USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) indicates the following constituents as having exceeded an MCL for a water quality benchmark for drinking water: arsenic, nitrate, DBCP, EDB (USEPA MCL), iron, manganese (CDPH SMCL), and boron (CDPH NL). Of the previously listed constituents, only nitrate (nitrate exceedances only found in the CDPH data) levels are considered constituents of concern as current agricultural practices, while not necessarily the sole source, have been shown to contribute to elevated levels. All the other previously listed constituents are either not used in agricultural practices (arsenic, iron, and manganese), are no longer used as soil fumigants (EDB and DBCP), and/or are commonly found naturally in soils of the area (chloride and boron).

USGS' GAMA Project Research for the Northern San Joaquin Basin Study Unit: Relative-concentrations of constituents within the Delta and non-Delta Areas

Relative concentrations were used as the primary metric for comparing concentrations of constituents in the USGS' study (Relative concentration = sample concentration/benchmark concentration) (Figure 63). Inorganic constituents with a health-based benchmark and with high relative concentrations (exceeded the MCLs for their respective benchmarks with a relative concentration value greater than or equal to 1) for the grid wells were arsenic and boron. Inorganic constituents with moderate relative concentrations (relative concentration values for inorganic constituents = 0.5) for the grid wells were arsenic, barium, boron, nitrate, strontium, and vanadium. The inorganic constituents with a non-health-based benchmark and with high relative-concentrations were manganese, iron, TDS, chloride, and sulfate.

Of the organic constituents with a health-based benchmark, a high relative-concentration for the soil fumigant, DBCP, was detected in the study unit; the highest primary-aquifer proportion of any organic constituent, even though its use was discontinued in California in 1977. The primary aquifer was that aquifer between 100 and 500 below land surface. According to Bennett et al. (2010), DBCP remains one of the most frequently detected fumigants in groundwater due to its use as a soil fumigant on orchards and vineyards throughout the San Joaquin Valley up until the late 1970s, and due to its physical and chemical properties (low vapor pressure and moderate solubility) that contribute to its persistence in groundwater.

Maximum relative-concentrations of the individual constituents and constituent groups from USGS grid well samples were compared to each other in Figure 64 (Bennett, 2010). All constituents shown have health-based benchmarks, except for those in the group inorganic-SMCL, which have non-health-based aesthetic benchmarks. Most of the detected organic and special-interest constituents (32 of 40; 80%) have some type of health-based benchmark. Three of the detected constituents (deethylatrazine, 2,6-diethylaniline, 3,4-dichloroanaline) on the pesticide schedules and for which no health-based benchmarks exist are degradates of pesticides that do have health-based benchmarks (atrazine, alachlor, and propanil, respectively.

Trace Elements and Nutrients

Relative-concentrations of trace elements and nutrients by study unit (throughout the three groundwater subbasins and uplands) are illustrated in Figure 65 (Bennett, 2010). According to the analysis by Bennett, et.al, of samples from USGS grid wells, high relative-concentrations of inorganic constituents with health-based benchmarks primarily resulted from high relative-concentrations of trace elements (13% of the primary aquifer [between 100 and 500 ft BLS]), and to a lesser extent from high relative-concentrations of radioactive constituents (2.1% of the primary aquifer) and nutrients (2.1% of the primary aquifer). High relative-concentrations of inorganic constituents with non-health-based benchmarks primarily resulted from high relative-concentrations of manganese (34% of the primary aquifer), and to a lesser extent iron (11% of the primary aquifer), TDS (5.8% of the primary aquifer), chloride (3.9% of the primary aquifer), and sulfate (2.0% of the primary aquifer).

Nitrate – Spatial Distribution and Temporal Trends

According to the GAR, nitrate concentration is positively and significantly correlated with salinity (total dissolved solids, conductivity) and salinity-related variables. These include (correlation coefficients are in parentheses): conductivity (0.42), hardness (0.93), total dissolved solids (0.64), calcium (0.69), magnesium (0.66), sodium (0.43), chloride (0.50) and sulfate (0.60). Groundwater salinity tends to increase with proximity to the San Joaquin River, where groundwater levels are shallowest. Authors of the GAR suggest that the higher nitrate concentrations are likely the result of the shallow groundwater levels which are spatially associated with the higher salinities. Authors of the GAR did not find any association between oxidation-reduction potential, dissolved oxygen, or pH and nitrate levels. Typically, in an anoxic environment, such as the majority of the Delta, nitrate levels would be lower than in oxic areas, due to nitrate being reduced to nitrogen gas. According to the USGS' study (Bennett et al., 2010a), nitrate concentrations were significantly different when comparing samples in oxic vs. anoxic geochemical conditions, with concentrations significantly higher in oxic samples in the Northern San Joaquin study unit.

Figure 66 through Figure 70 show the progression of nitrate concentrations at various sampling locations from 1979 to 2013. Authors of the GAR examined 28 wells throughout the Coalition region with extensive history of nitrate concentrations to determine any significant trends (Figure 71). Nine wells showed a significant increasing trend, three wells showed a significant decreasing trend, and 16 wells did not show a significant trend.

Figure 63. Table listing benchmark types and values for constituents used in relative-concentration analyses in USGS' Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment Study Unit (Bennett et al., 2010a).

18 **Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project**

Table 5. Benchmark type and value for constituents included in the assessment of status of groundwater quality in the Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment (GAMA) study unit.

[**Benchmark type:** MCL-US, U.S. Environmental Protection Agency (USEPA) maximum contaminant level; MCL-CA, California Department of Public Health (CDPH) maximum contaminant level; HAL-US, USEPA lifetime health advisory level; NL-CA, CDPH notification level. **Benchmark units:** mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter; pCi/L, picocuries per liter]

Constituent	Typical use or source	Benchmarks		
		Type	Concentration/activity	Units
	Inorganic constituents			
Trace elements with health-based benchmarks				
Aluminum [1]	naturally occurring	MCL-CA	1,000	µg/L
Antimony [1]	naturally occurring	MCL-US	6	µg/L
Arsenic	naturally occurring	MCL-US	10	µg/L
Barium	naturally occurring	MCL-CA	1,000	µg/L
Boron	naturally occurring	NL-CA	1,000	µg/L
Fluoride [1]	naturally occurring	MCL-CA	2,000	µg/L
Lead [1]	naturally occurring	MCL-US	15	µg/L
Mercury [1]	naturally occurring	MCL-US	2	µg/L
Strontium	naturally occurring	HAL-US	4,000	µg/L
Vanadium	naturally occurring	NL-CA	50	µg/L
Radioactive constituents				
Gross alpha radioactivity [1]	naturally occurring	MCL-US	15	pCi/L
Uranium [1]	naturally occurring	MCL-CA	20	pCi/L
Nutrients				
Nitrate plus nitrite, as nitrogen	natural, fertilizer, sewage	MCL-US	10	mg/L
Nitrite, as nitrogen	natural, fertilizer, sewage	MCL-US	1	mg/L
Major and minor ions, and trace elements with SMCLs				
Chloride	naturally occurring	SMCL-CA	500	mg/L
Iron	naturally occurring	SMCL-CA	300	µg/L
Manganese	naturally occurring	SMCL-CA	50	µg/L
Specific conductance	naturally occurring	SMCL-CA	1,600	µS/cm
Sulfate	naturally occurring	SMCL-CA	500	mg/L
Total dissolved solids (TDS)	naturally occurring	SMCL-CA	1,000	mg/L
	Organic and special-interest constituents			
Volatile organic compounds (VOCs)				
Chloroform	disinfection by-product	MCL-US	80	µg/L
1,1-Dichloroethene [1]	solvent	MCL-CA	6	µg/L
1,2-Dichloroethane [2]	solvent, fumigant, plastics	MCL-CA	0.5	µg/L
cis-1,2-Dichloroethene [1]	solvent	MCL-CA	6	µg/L
Methyl-*tert*-butyl-ether (MTBE)	gasoline oxygenate	MCL-CA	13	µg/L
Tetrachloroethene (PCE)	dry-cleaning, metal degreasing	MCL-US	5	µg/L
Trichloroethene (TCE) [1]	dry-cleaning, metal degreasing	MCL-US	5	µg/L
Vinyl chloride [2]	organic systhesis	MCL-CA	0.5	µg/L
Fumigants				
1,2-Dibromo-3-chloropropane (DBCP)	fumigant	MCL-US	0.2	µg/L
1,2-Dibromoethane (EDB) [1]	fumigant	MCL-US	0.05	µg/L
1,2-Dichloropropane (1,2-DCP) [1]	industrial, fumigant	MCL-US	5	µg/L
1,4-Dichlorobenzene [2]	fumigant	MCL-CA	5	µg/L
Pesticides				
Simazine	herbicide	MCL-US	4	µg/L
Special-interest constituents				
Perchlorate	natural, rocket fuel, flares	MCL-CA	6	µg/L

[1] Included on the basis of concentrations reported in CDPH database. Constituent also detected by USGS-GAMA at low relative-concentrations.

[2] Included on the basis of concentrations reported in CDPH database. Constituent not detected by USGS-GAMA

Figure 64. Maximum relative-concentration in grid wells for constituents detected by type of constituent in the Northern San Joaquin Basin GAMA study unit (Bennett et al., 2010a).

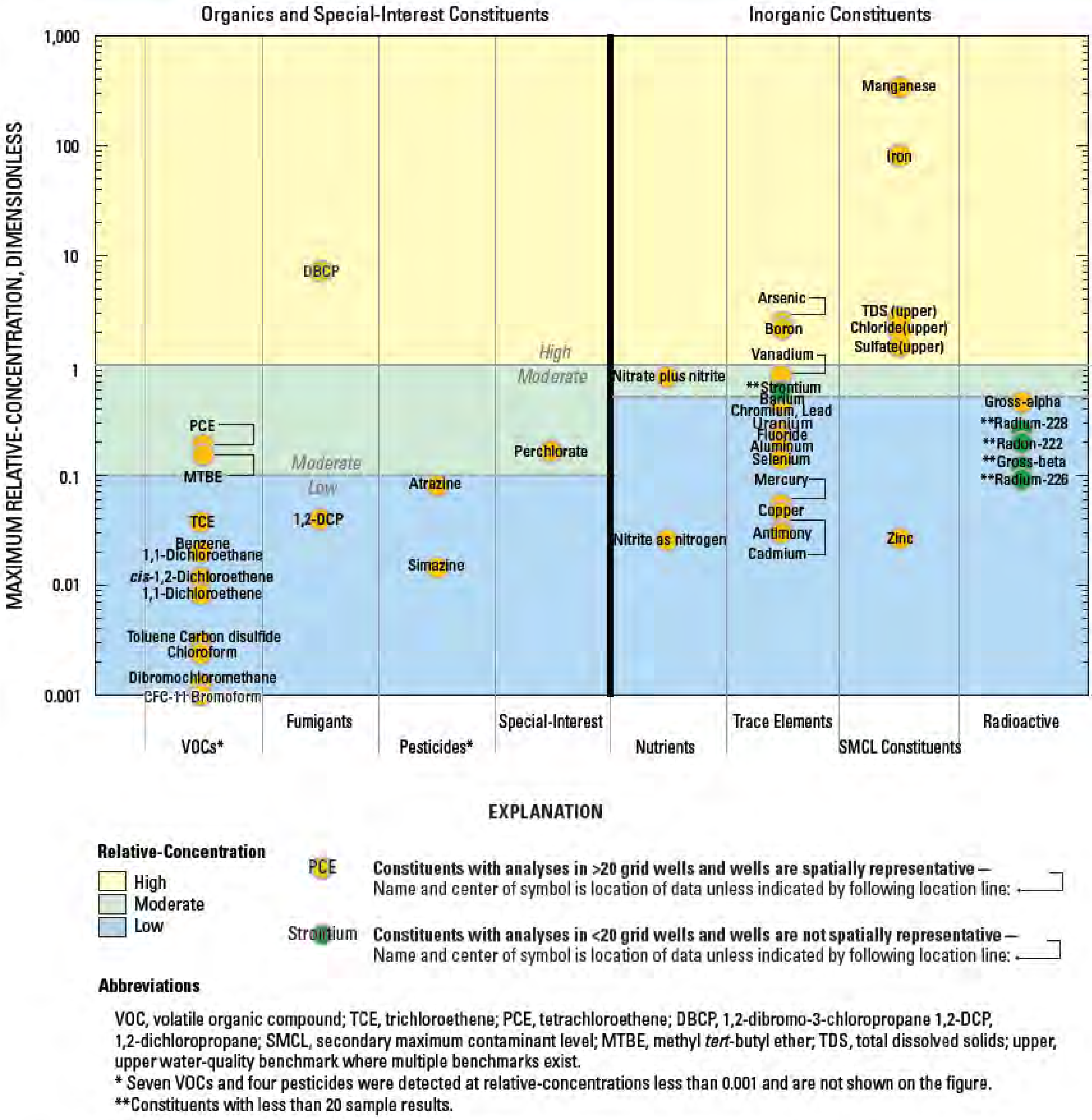
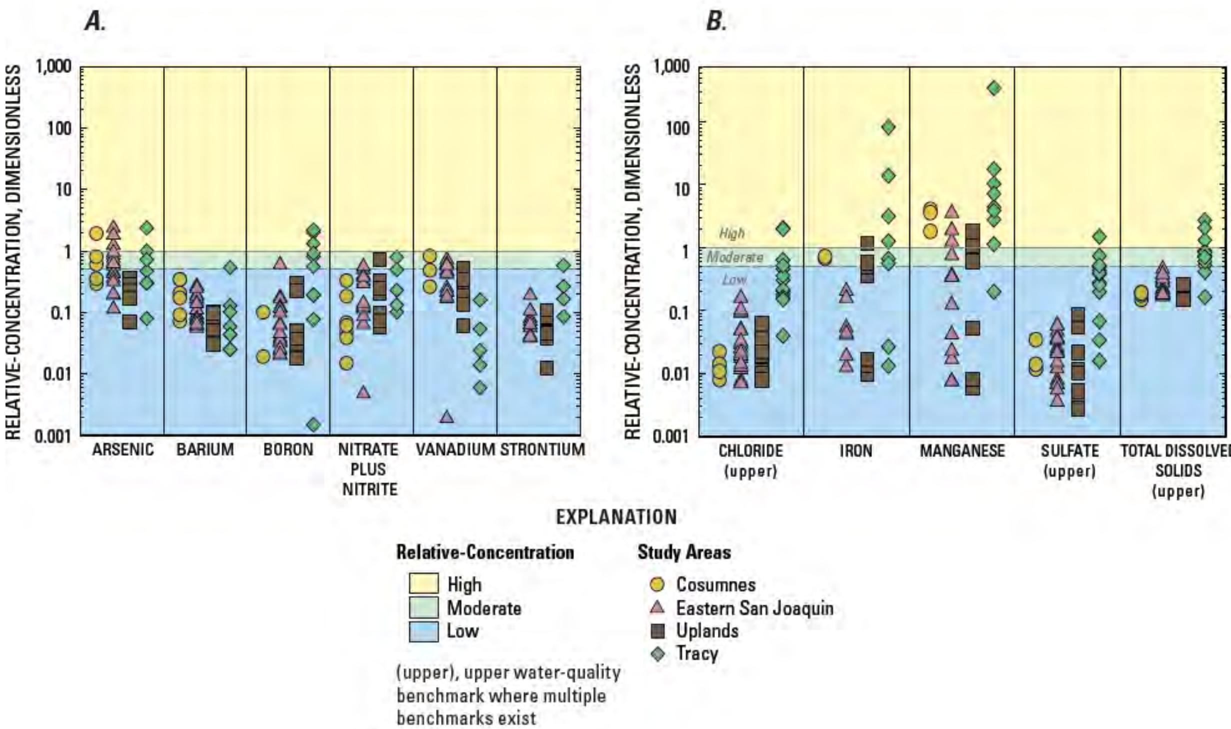


Figure 65. (A) Relative-concentrations of trace elements and nutrients with health-based benchmarks and maximum relative-concentrations greater than 0.5 in grid wells and (B) Major and minor elements with aesthetic benchmarks and maximum relative-concentrations greater than 0.5 in grid wells in the Northern San Joaquin GAMA study unit (Bennett et al., 2010a).



Delta

According to the GAR, historical water quality data indicate concentrations of nitrate in groundwater exceeded the MCL of 45 mg/L in the areas south of the City of Oakley, southwest of the City of Brentwood, and in a slice of the Delta following the Delta's western boundary, south and west of the City of Tracy (from 1979 to 1983); northwest of Tracy (from 1984 and 1988); and with increasing frequency from 1999 to 2013 south and east of Tracy (Figure 66 to Figure 70). The GAR also noted that the increased observed frequency of nitrate levels exceeding the MCL may also be as a result of the increased number of sampling events after 2000. The vast majority of samples with concentrations of nitrate exceeding the MCL were found in shallow (less than 250 ft BLS) groundwater wells (Figure 72).

According to the USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) nitrate levels tended to decrease towards the center of the Central Valley basin. No samples from the USGS study exceeded the MCL for nitrate. CDPH sample data presented in USGS' Status and Understanding study included nitrate levels above the MCL in agricultural areas south and east of Tracy and north of Brentwood within the Delta (Figure 73) and in general, correspond spatially with the locations presented in the GAR.

Non-Delta

Large areas of the eastern San Joaquin 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).

According to the GAR, the frequency of nitrate concentrations exceeding the MCL generally increased with time from the 1970s to 2013, with high concentrations of nitrate most frequently found in shallow groundwater and in groundwater immediately east of the Delta and with increasing nitrate concentrations in the area surrounding Manteca and northward extending to and surrounding Lodi (Figure 72).

According to the USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) nitrate levels tended to decrease towards the center of the Central Valley basin. No samples from the USGS study exceeded the MCL for nitrate. CDPH sample data presented in USGS' Status and Understanding study included nitrate levels above the MCL in agricultural and urban areas surrounding Lodi, Stockton, and Manteca, as well as in agricultural areas south of Tracy and west of the statutory Delta (Figure 73). These areas of elevated nitrate levels presented in the USGS Status and Understanding study generally correspond spatially with the locations presented in the GAR.

Figure 66. Distribution of average nitrate concentrations in the Coalition region, 1979 to 1983 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

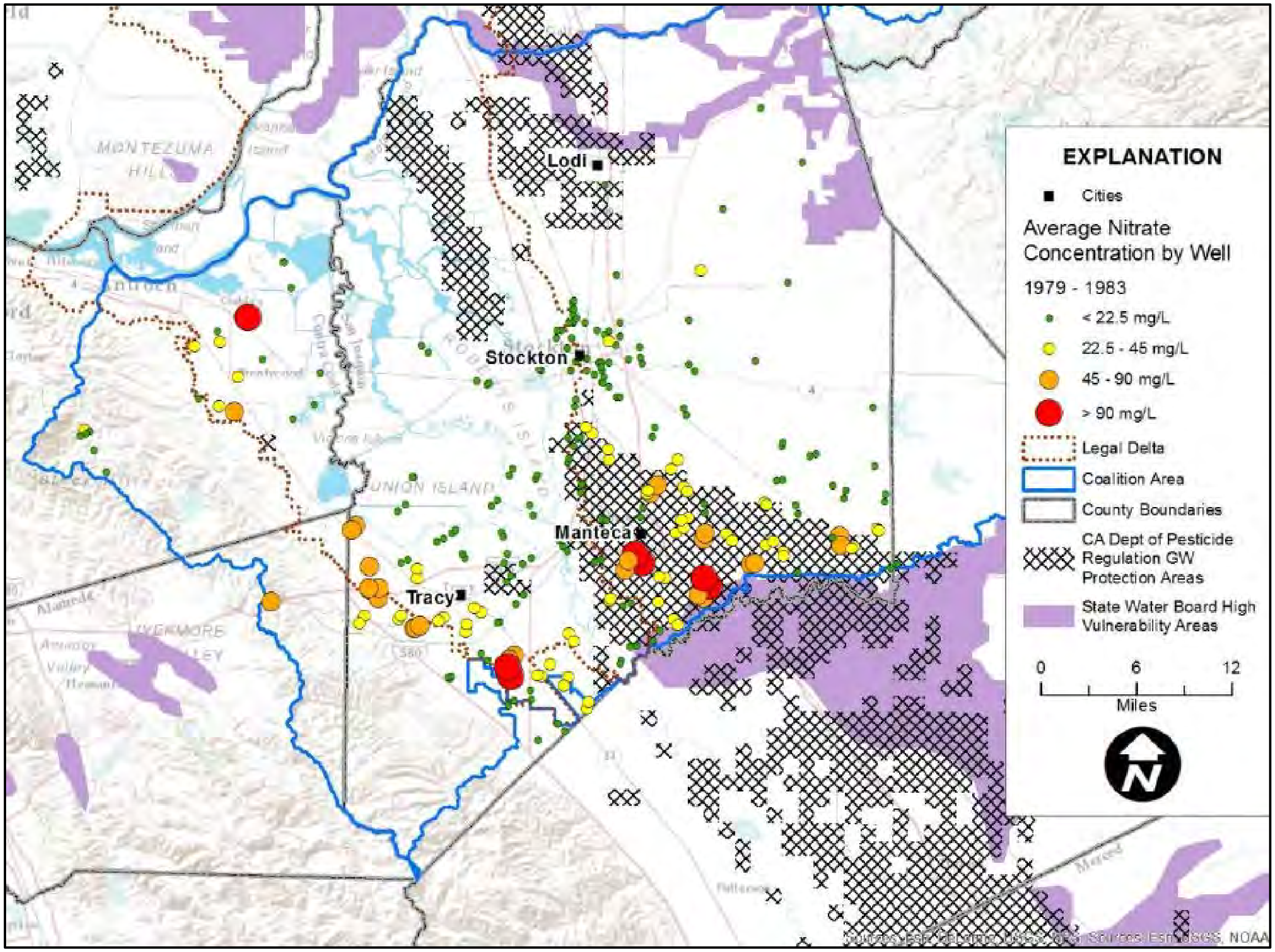


Figure 67. Distribution of average nitrate concentrations in the Coalition region, 1984 to 1988 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

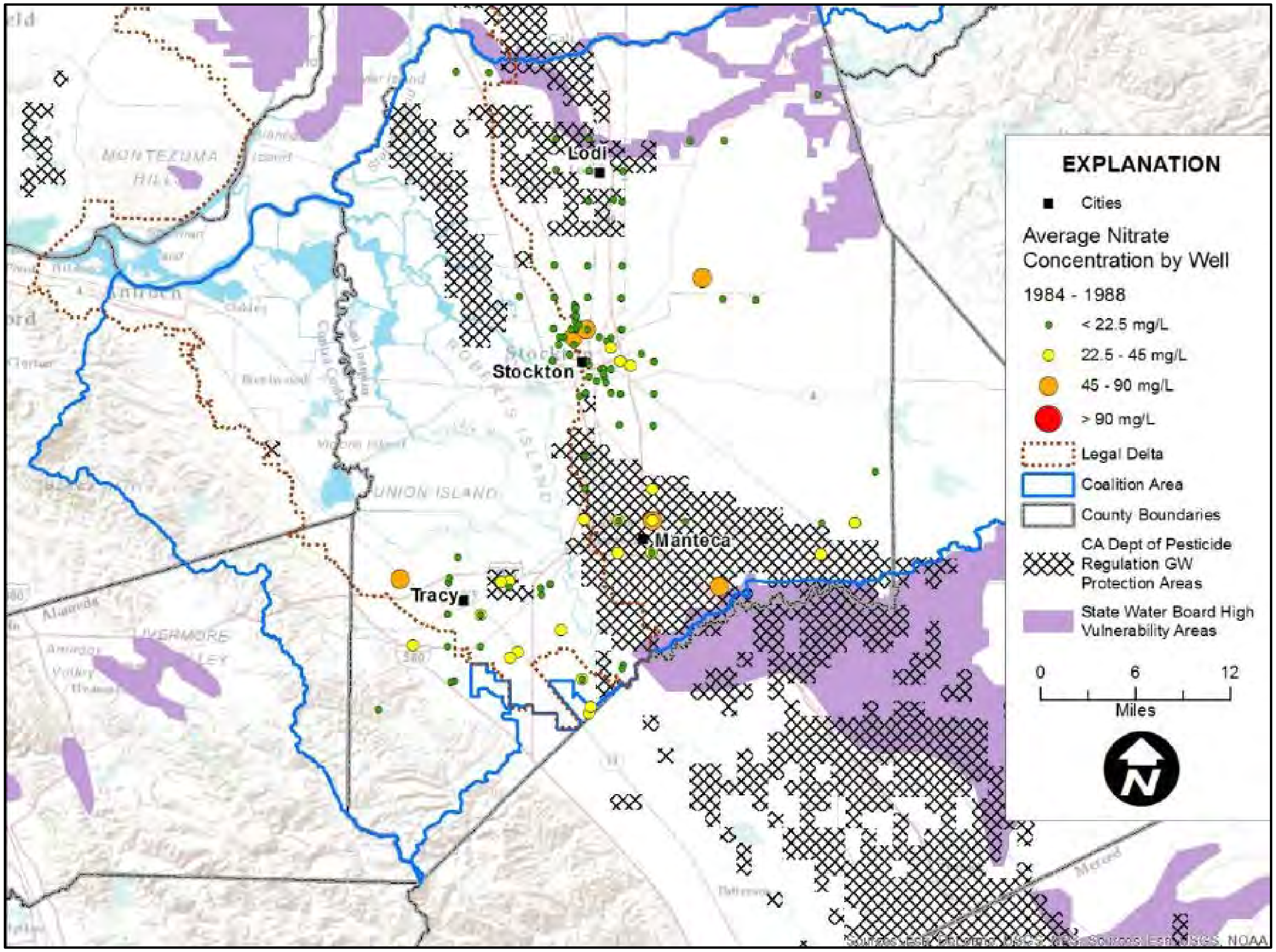


Figure 68. Distribution of average nitrate concentrations in the Coalition region, 1999 to 2003 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

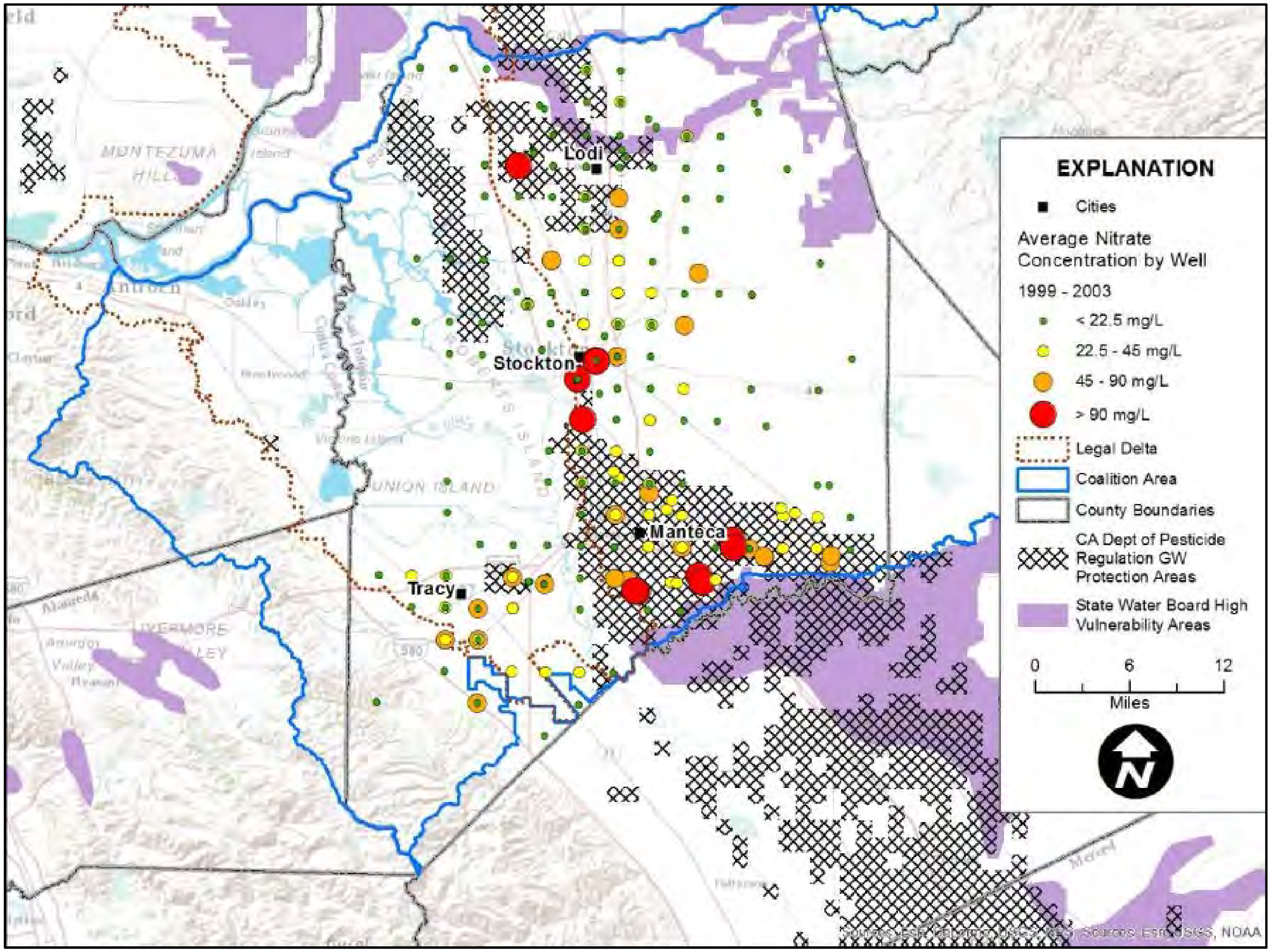


Figure 69. Distribution of average nitrate concentrations in the Coalition region, 2004 to 2008 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

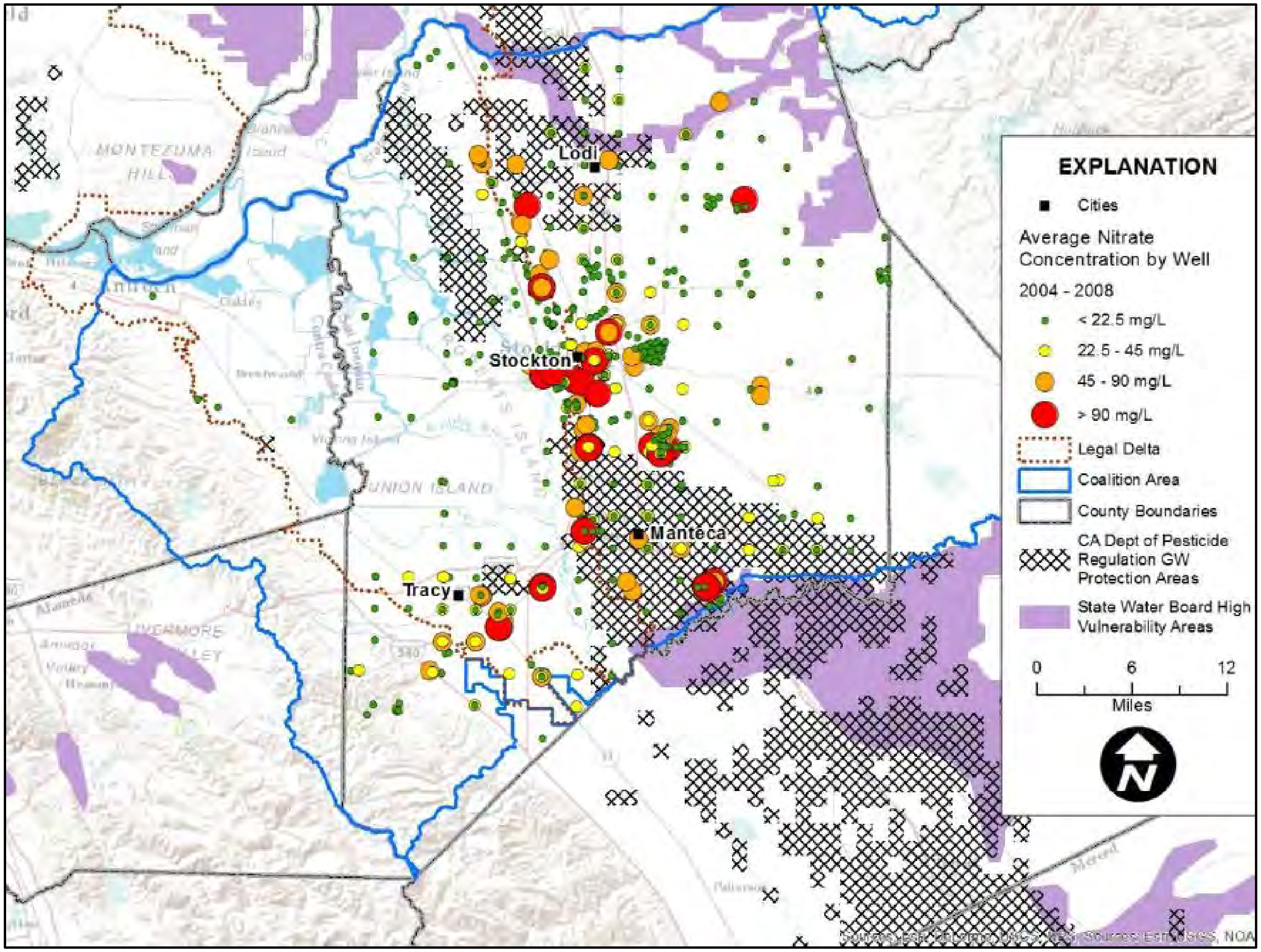


Figure 70. Distribution of average nitrate concentrations in the Coalition region, 2009 to 2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

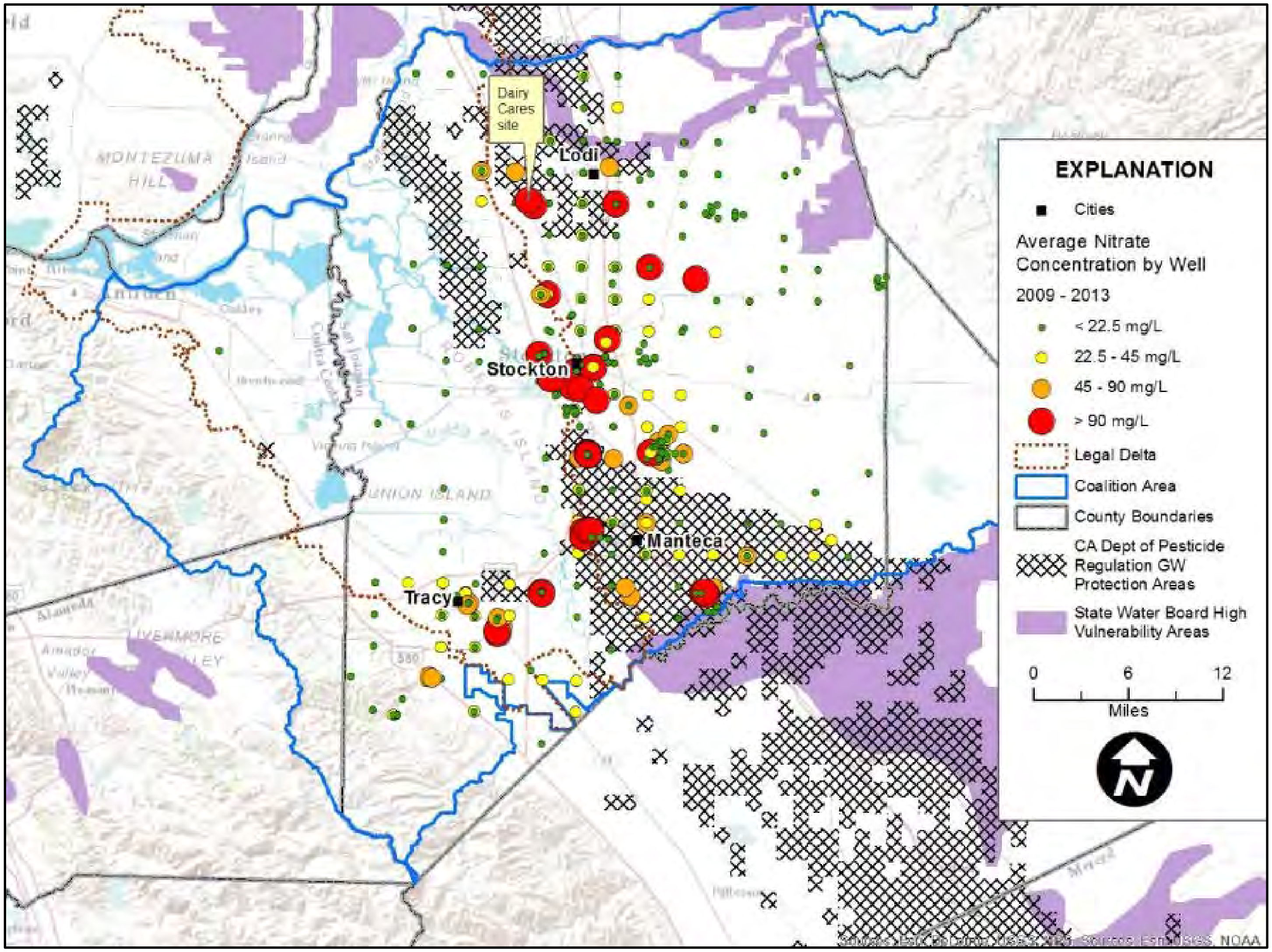


Figure 71. Location of wells used in trend analysis for nitrate in the Coalition region (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

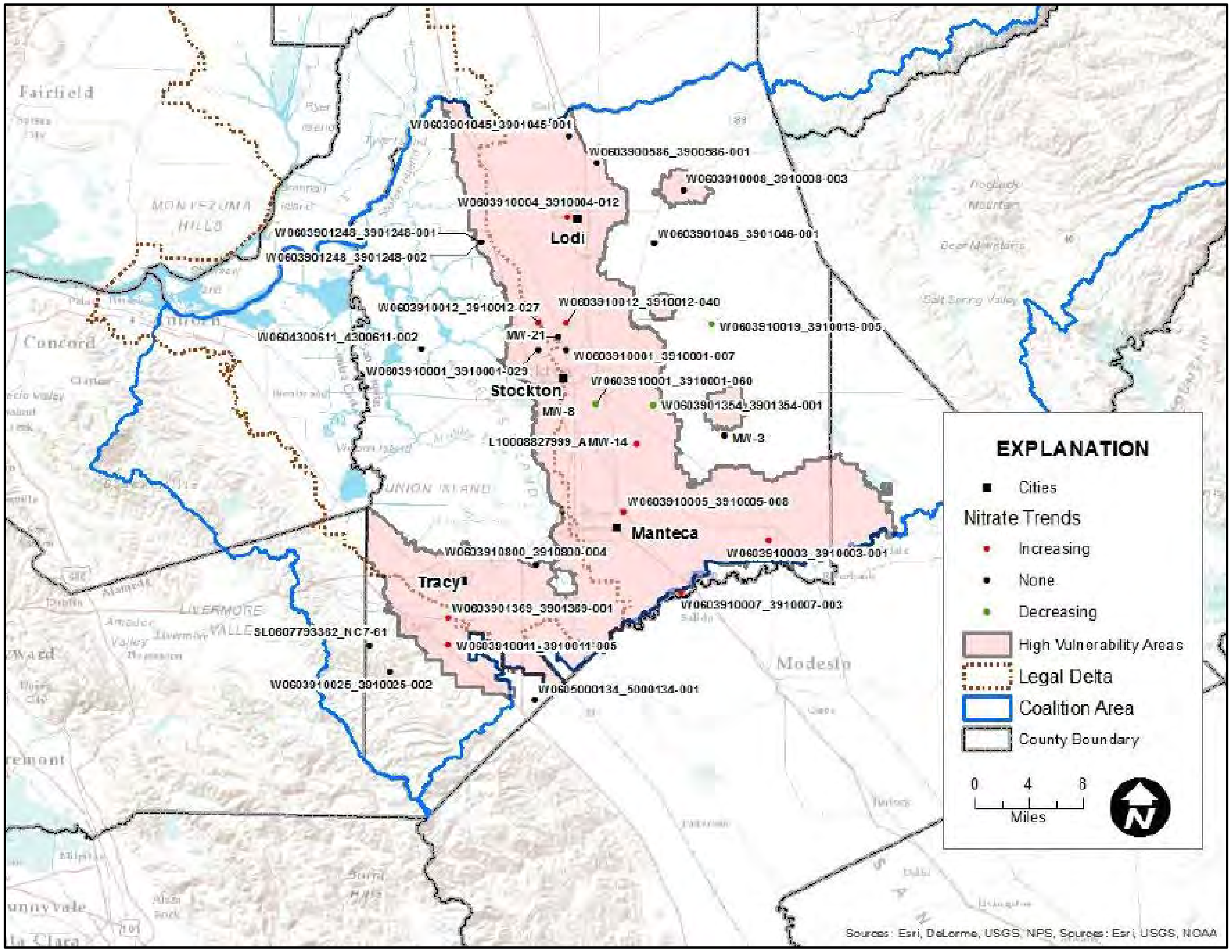


Figure 72. Distribution of average depth to groundwater and average 2009-2013 groundwater nitrate concentrations (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

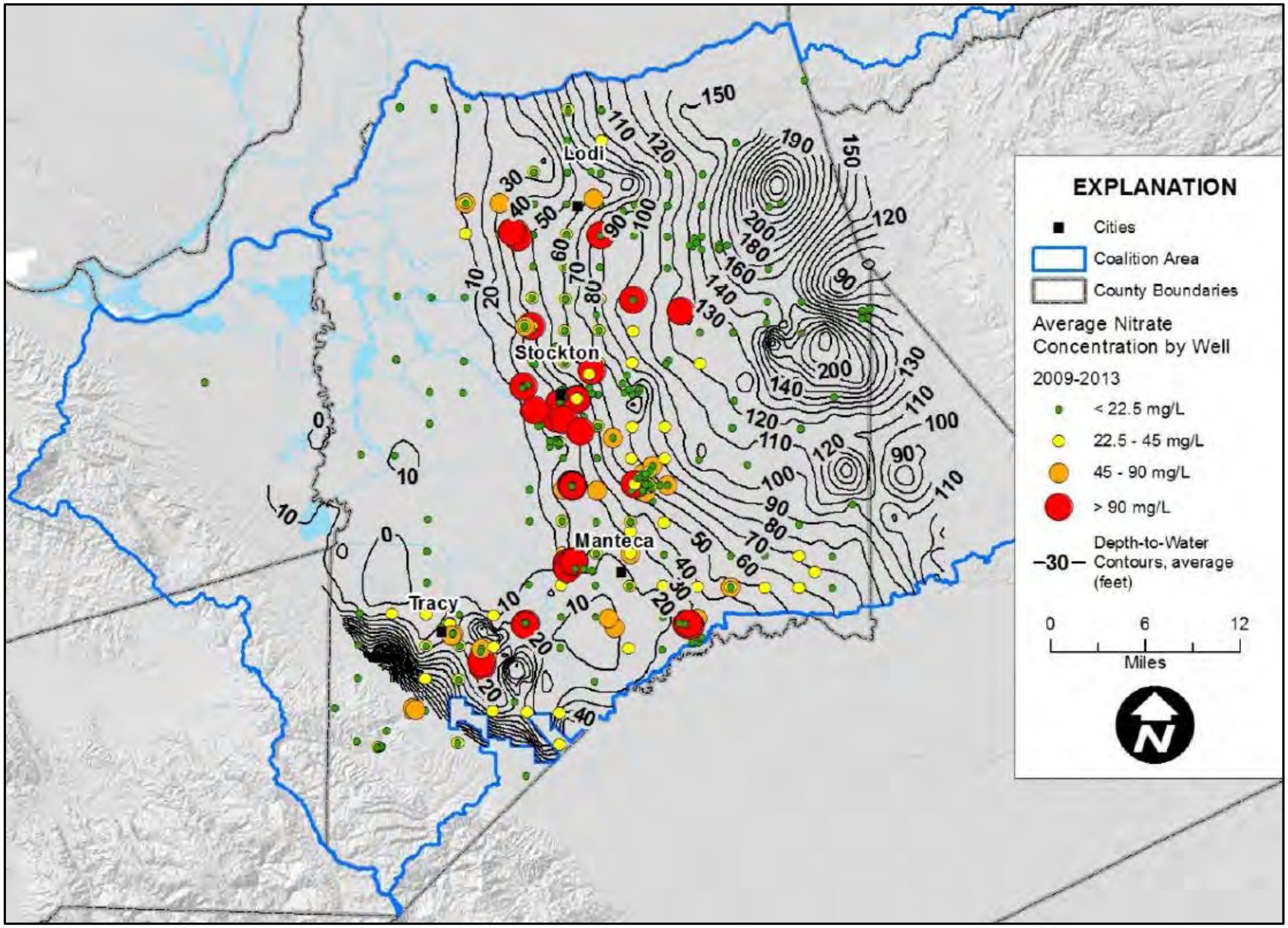
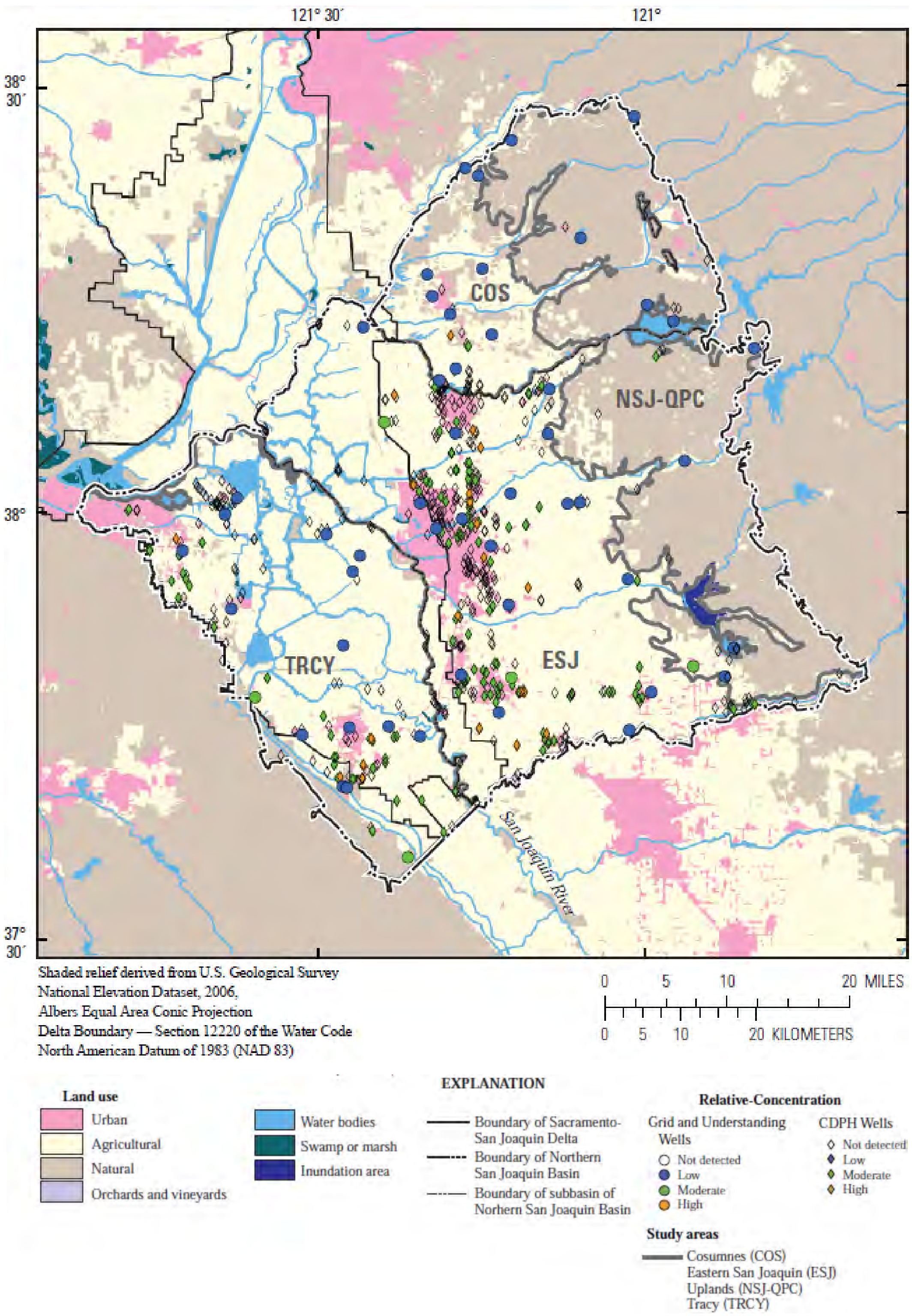


Figure 73. Locations of relative-concentrations of nitrate from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)



TDS – Spatial Distribution and Temporal Trends

Figure 74 shows the spatial distribution of TDS sampling locations as well as average TDS concentrations throughout the Coalition. Authors of the GAR also examined 10 wells with sufficient history of total dissolved solids (TDS) concentrations to assess statistically significant trends. Five wells showed significant increasing trends, two wells showed a significant decreasing trend, and three wells did not show a significant trend (Figure 75).

Delta

High TDS concentrations (>1,000 mg/L) exist within the statutory Delta boundary west of Stockton, on Roberts Island, Staten Island, west of Manteca, and east and west of Tracy (Figure 74). TDS concentrations above the secondary MCL of 500 mg/L occur concurrent with the locations described above as well as within the Delta between Lodi and Stockton and between Stockton and Lathrop. Figure 75 illustrates the trends in TDS concentrations in the Delta near Tracy as increasing or for those southwest of Manteca to be level, neither increasing nor decreasing.

According to the USGS' GAMA Project (Bennett et al., 2010a) TDS levels were significantly correlated with normalized lateral position within the valley trough, with concentrations increasing moving away from the valley trough, contrary to the spatial pattern within the non-Delta areas of the Coalition. Concentrations of TDS for wells in the Tracy study area (subbasin) are significantly elevated relative to concentrations for wells in the other study areas (Eastern San Joaquin and Cosumnes subbasins and uplands). According to Bennett et al. (2010a), sources of TDS in the Tracy study area are primarily associated with the proximity of the study area to the Sacramento-San Joaquin Delta, and regional groundwater-flow patterns of the San Joaquin Valley. Per the USGS study, historically, the Sacramento-San Joaquin Delta was periodically inundated by saline water, which saturated delta deposits and increased TDS concentrations. Also, the Coast Ranges along the western boundary of the Tracy subbasin are composed of easily weathered marine deposits, which results in an elevated TDS in recharge water on the western side of the valley. Based on a visual analysis of Figure 76, the following well locations (either CDPH or USGS) displayed TDS concentrations above the 500 mg/L secondary MCL in the statutory Delta: within Bethel, Union, McDonald, and Roberts Islands; within Fabian and Stewart Tracts; west of Orwood Tract and south of Brentwood; and northeast of Vernalis.

Non-Delta

According to the GAR, some areas of particularly high TDS concentrations (>1,000 mg/L) exist in the vicinity of Stockton. Concentrations above the MCL of 500 mg/L occur along the eastern boundary of the statutory Delta, from just north of Lodi to just north of Manteca, east of Linden along the San Joaquin County boundary, and west of the statutory Delta's boundary, south of Tracy (Figure 74). Figure 75 illustrates the trends in TDS concentrations in the non-Delta areas near Lodi, north of Manteca and south of Tracy, as increasing while well locations south of Lockeford and near Stockton with decreasing trends in TDS concentrations. According to the USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) TDS levels outside of the Tracy subbasin (in the non-Delta areas predominantly) were significantly

Figure 74. The High Vulnerability Areas and TDS concentrations within the Coalition (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

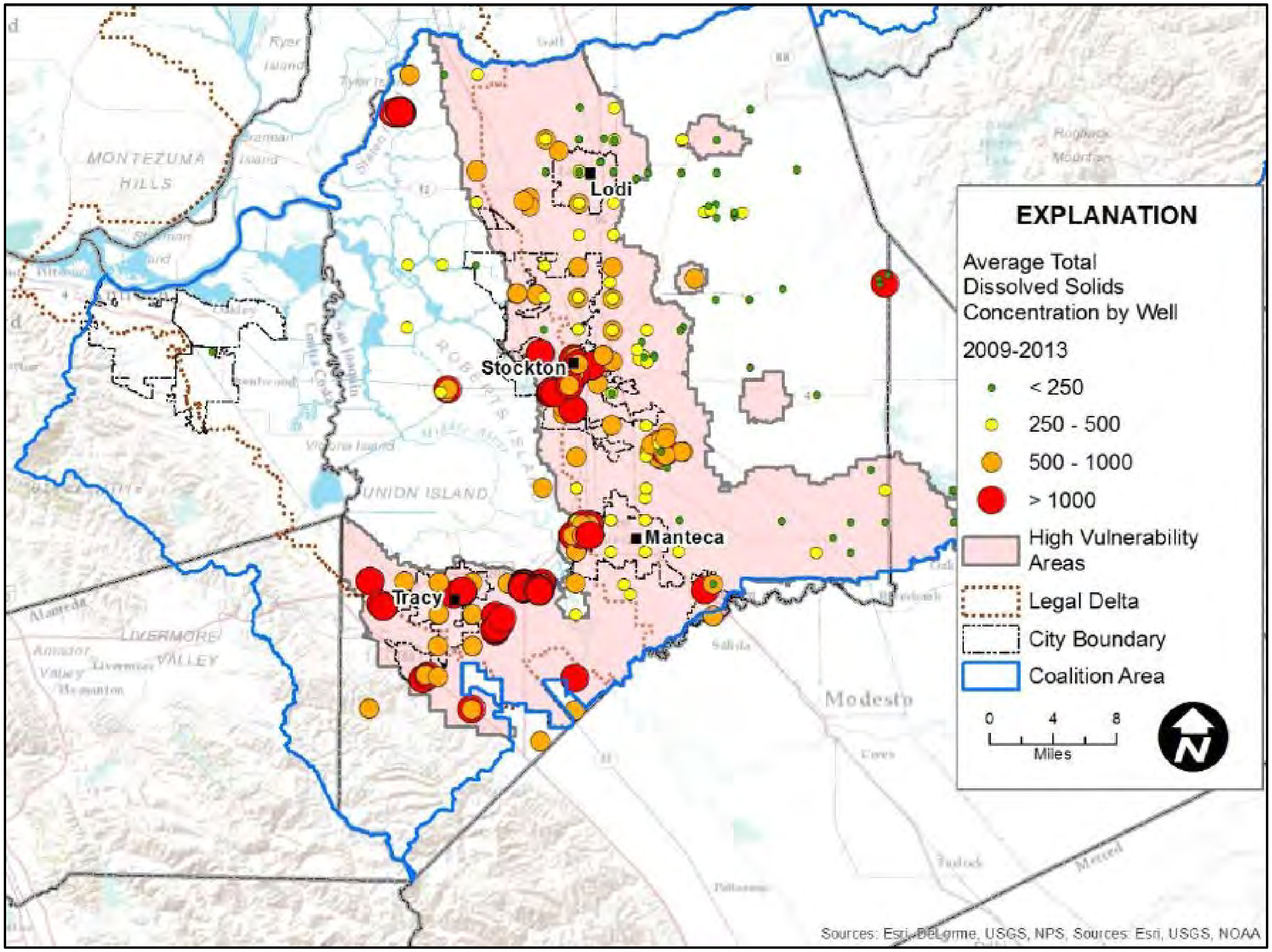
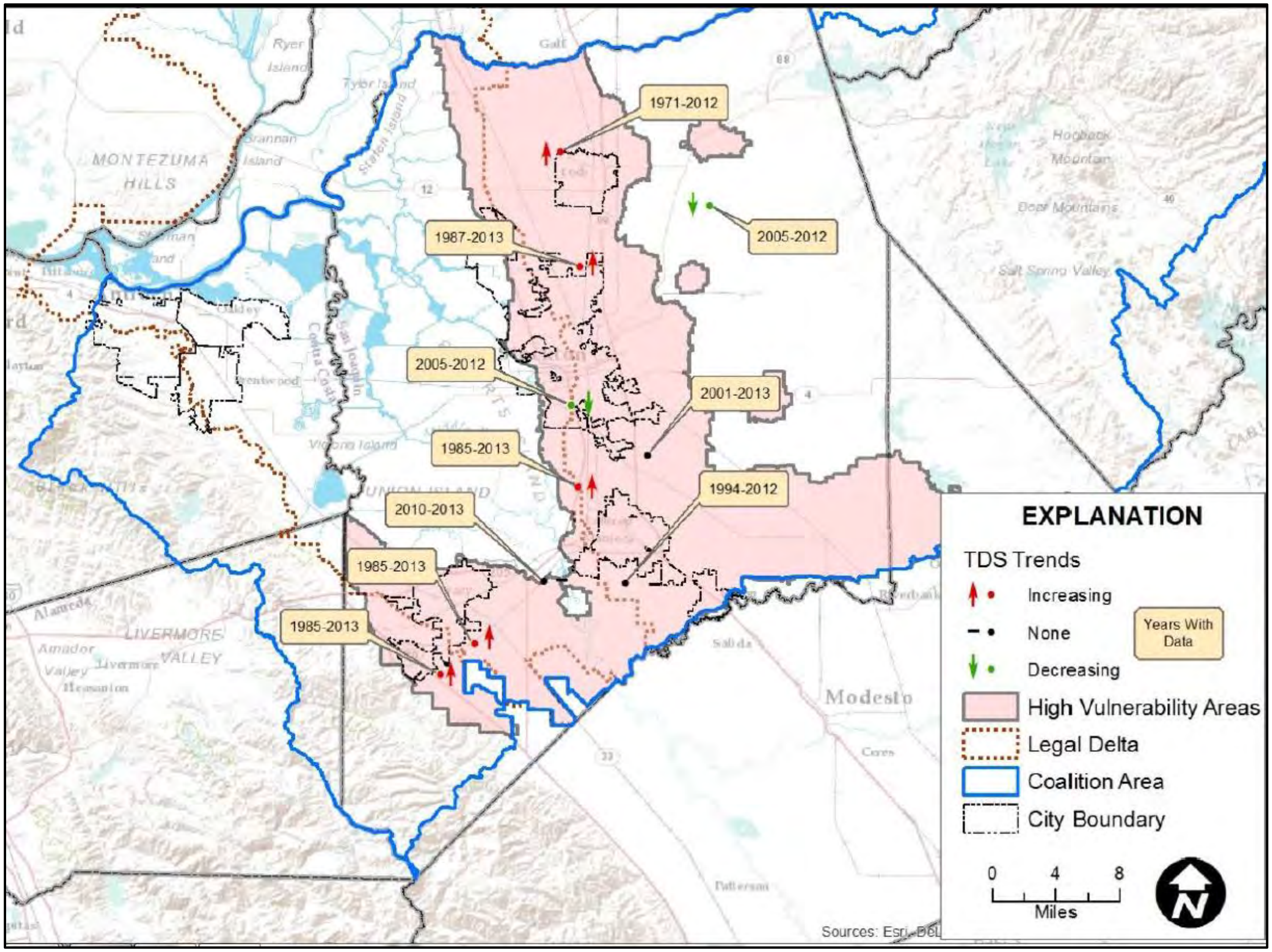


Figure 75. TDS concentration trends from 10 well locations within the High Vulnerability Areas of the Coalition region (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



correlated positively with pH and negatively with lateral position within the valley trough, i.e. TDS concentrations tend to increase towards the center of the Central Valley basin. This trend of increasing TDS concentrations from east to west has been ascribed to the low-TDS recharge water infiltrating from the Sierra Nevadas along and the increase of TDS in the water as the residence time of the water in the soil increases as it travels from east to west, due to the interactions between the groundwater and the aquifer sediments. Based on a visual analysis of Figure 76, no well locations in the non-Delta areas from the USGS study, neither CDPH nor USGS grid wells, displayed TDS concentrations above the 500 mg/L secondary MCL.

OTHER CONSTITUENTS

The constituents discussed below are not considered constituents of concern in relation to current agricultural practices or at the levels detected. Some of the constituents maybe connected to agricultural practices, i.e. DBCP, EDB, simazine, and atrazine, but are either are no longer in use (DCBP and EDB) or have not been detected at concentrations above their respective MCLs (simazine and atrazine). Discussion of water quality data on these constituents is provided here to provide a better understanding of the environment currently existing within the primary aquifer of the Coalition region.

Arsenic – Spatial Distribution

Analyses presented in the GAR and in USGS' study for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) are consistent with regards to the sources affecting the relative concentrationsof arsenic in groundwater in the Coalition region, i.e. the resultant concentrations are from resident environmental factors rather than from agricultural related inputs to the system. The USGS' study discusses how arsenic concentrations within the region are related to geochemical conditions in the primary aquifer, vary with depth, groundwater age, and normalized lateral position within the Central Valley. Arsenic concentrations in samples with a groundwater age classified as young and collected from wells with a depth to the top-of-perforation of less than 200 ft were significantly higher than samples with a groundwater age classified as old based on tritium concentrations or samples from wells with a depth to top-of-perforation of greater than 200 ft. Arsenic concentrations also were negatively correlated with normalized lateral position and percentage of natural land use, indicating an increase in arsenic concentrations with increased proximity to the valley trough. Locations of high concentrations (above MCL) of arsenic as presented in the GAR generally coincide with those presented in the USGS' study, with an increase of concentrations from the margins of the valley to the eastern edge of the Delta (Figure 77 and Figure 78). Data presented in the GAR illustrate a few more locations of high concentrations of arsenic (exceedances of the 10 µg/L MCL) in the statutory Delta west and northwest of Stockton and north of Tracy and within the non-Delta areas, south of Tracy. According to the analysis presented in the GAR and the USGS study (Bennett et al., 2010a), elevated arsenic levels in groundwater in the eastern San Joaquin Valley have been attributed primarily to two mechanisms: the release of arsenic resulting from reductive dissolution of iron or manganese oxyhydroxides under iron-or manganese-reducing conditions and from pH-dependent desorption of arsenic from aquifer sediments under oxic conditions.

Figure 76. Locations of relative-concentrations of TDS from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)

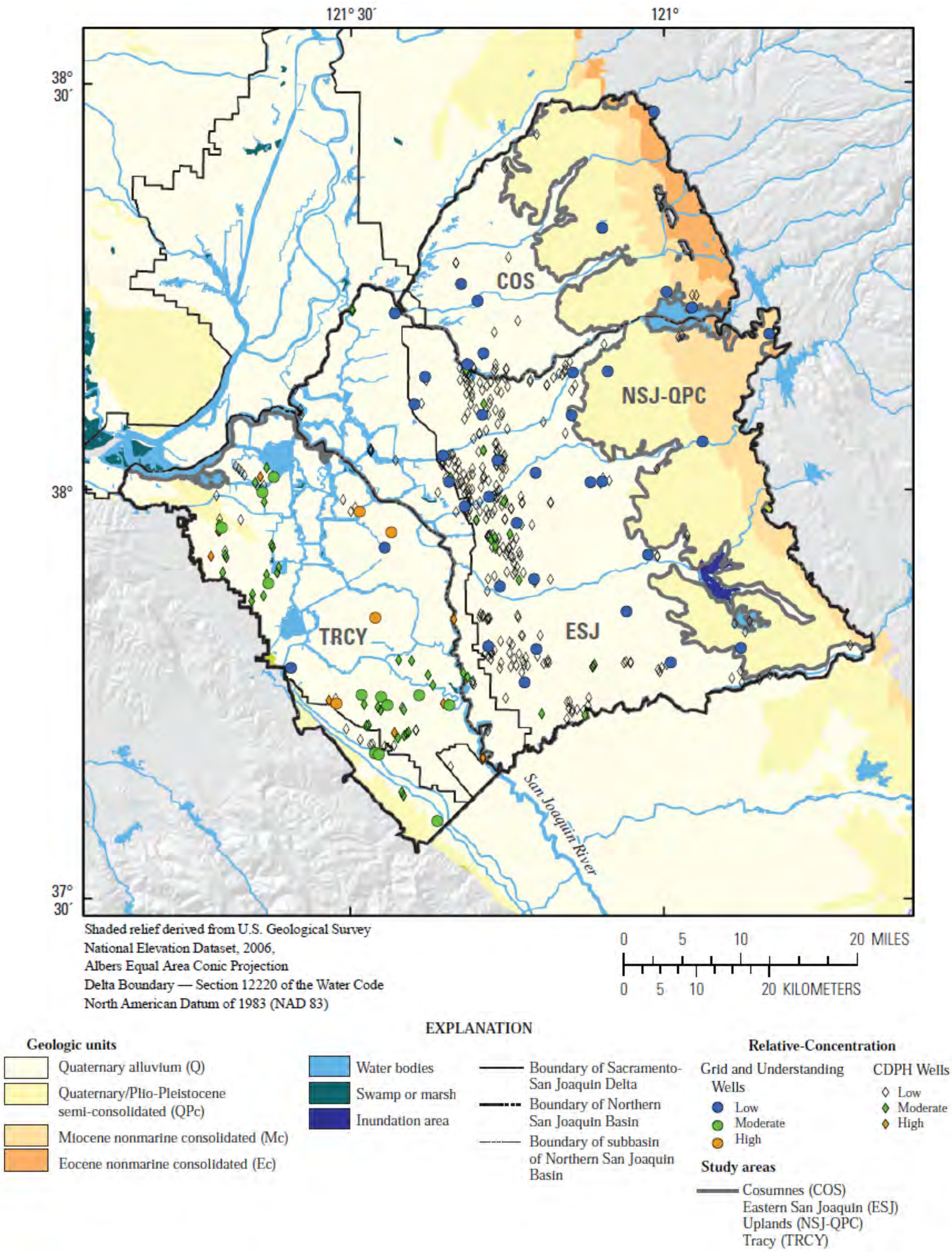


Figure 77. Arsenic concentrations within Coalition (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

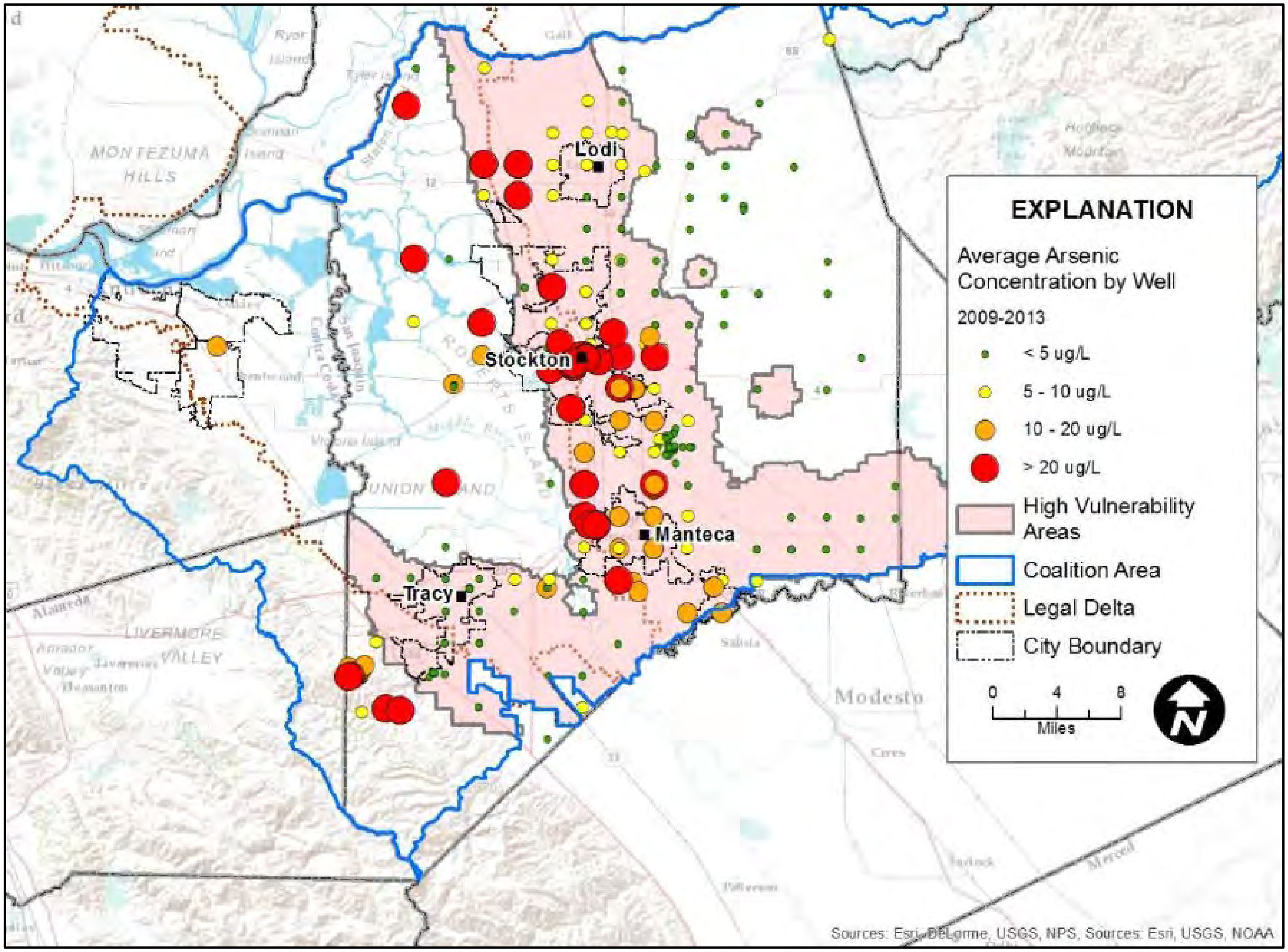
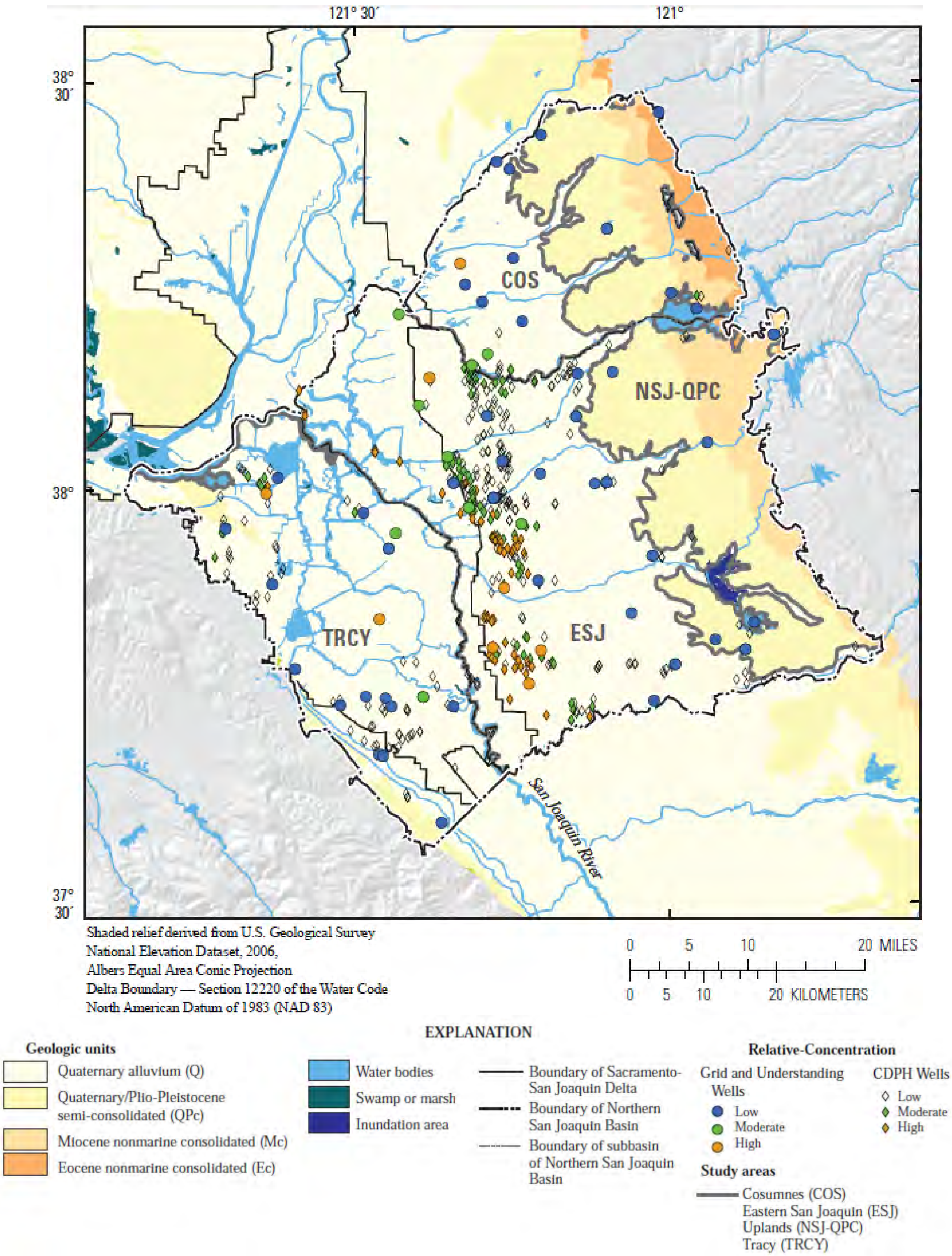


Figure 78. Locations of relative-concentrations of arsenic from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)



Boron

According to the analysis presented by the USGS (Bennett et al., 2010a), high concentrations of boron are not significantly correlated with any of the following potential explanatory factors: well depth, water age or redox categories, normalized lateral position within the Central Valley, or land use. Authors of the GAR cited a study by Deverel and Millard (1988) shallowing groundwater samples collected in San Joaquin Valley as having boron concentrations highly correlated with shallow ground water salinity. Deverel and Millard reported that boron is present as a geochemically mobile oxyanion in the generally alkaline San Joaquin Valley soils and groundwater. High boron concentrations are a water-quality concern for agriculture, primarily due to plant sensitivity to concentrations over about 1 mg/L in irrigation water.

According to the GAR, concentrations of boron are highest (above the MCL of 1 mg/L) south and west of the city of Tracy, with a couple of locations east of Stockton as well (Figure 79). The locations of high relative-concentrations of boron according to the USGS study are similar to those presented in the GAR within the inclusion of additional locations west of Brentwood and Oakley (Figure 80). Because high and moderate relative-concentrations of boron were limited to the western part of the Central Valley, within the Delta, vs. areas east of the Delta, elevated concentrations of boron appear to be associated with sediments in the aquifer derived from marine deposits, which are naturally high in boron, and which are contained within the Coast Ranges on the western edge of the Coalition. Saline waters, which also contain relatively high concentrations of boron and which once permeated the marine sediments within the Tracy subbasin, near the San Joaquin River, have migrated into adjacent and overlying continental deposits.

Manganese and Iron

Manganese and iron concentrations were correlated with redox conditions, with higher concentrations of each in anoxic conditions than in oxic conditions (Bennett et al., 2010a). Like nitrate, manganese and iron are redox sensitive constituents. Manganese and iron were not significantly correlated with any of the following potential explanatory factors: well depth, water age or redox categories, normalized lateral position within the Central Valley, or land use.

Because manganese and iron are redox-sensitive constituents, geochemical conditions appear to be the primary control affecting manganese and iron concentrations in the USGS Northern San Joaquin Basin study unit (Bennett et al., 2010a). Generally, oxic conditions can result in the precipitation of manganese as a mineral coating, or encrustation, on aquifer sediments. Conversely, under anoxic conditions, these mineral coatings tend to dissolve, releasing manganese back into the water. Similar reactions also are exhibited by arsenic and iron, which tend to co-precipitate with manganese under oxic conditions. As a result, there is a strong positive correlation ($p < 0.05$) between concentrations of arsenic and manganese and between iron and manganese. Manganese and iron concentrations (as well as all other major ions and TDS) were highest in the Tracy study area (primarily the Delta) (Figure 81 and Figure 82), which contains a large part of the Sacramento-San Joaquin Delta, where much of the groundwater is anoxic.

Figure 79. Boron concentrations (mg/L) within Coalition (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

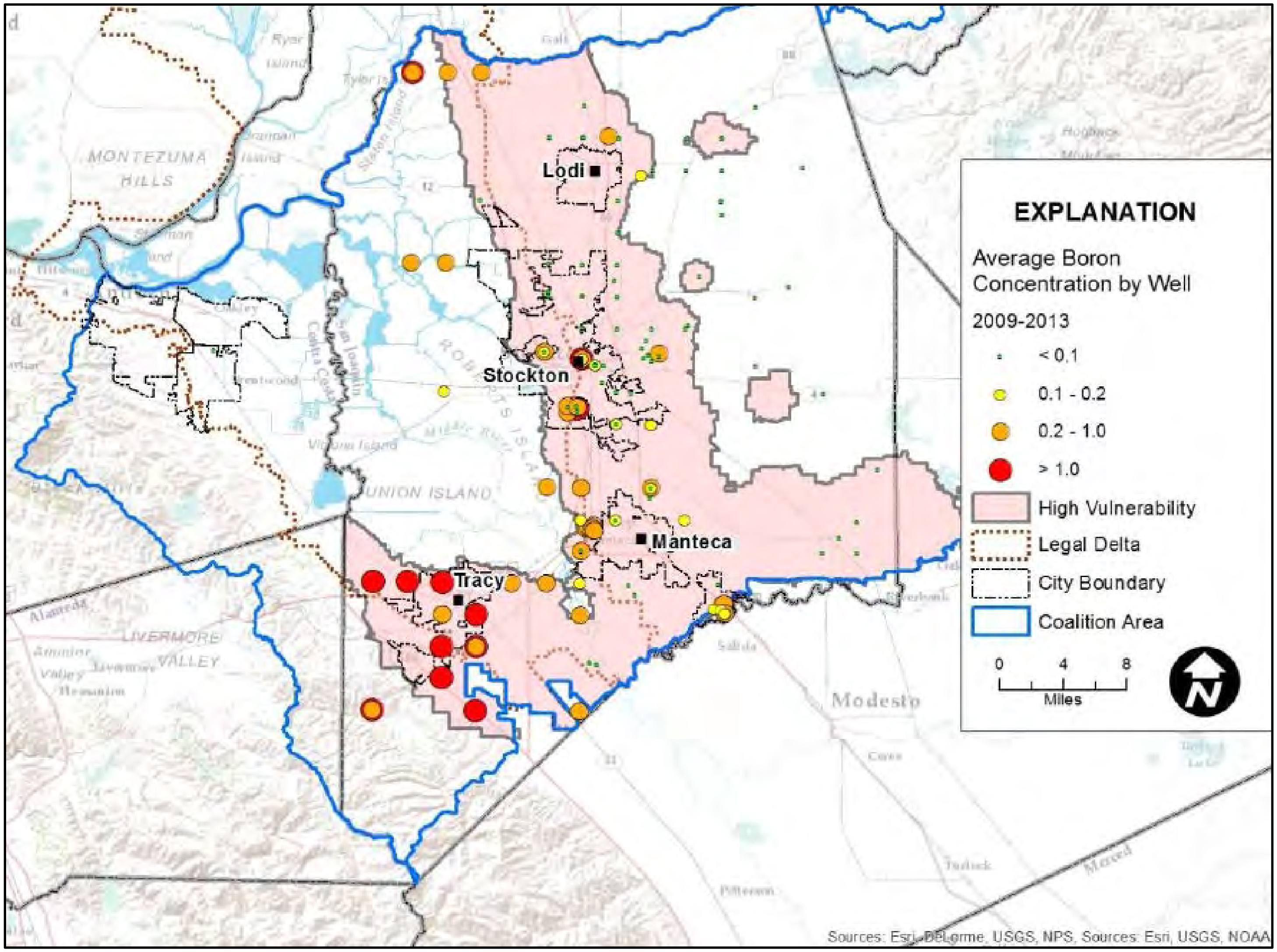


Figure 80. Locations of relative-concentrations of boron from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)

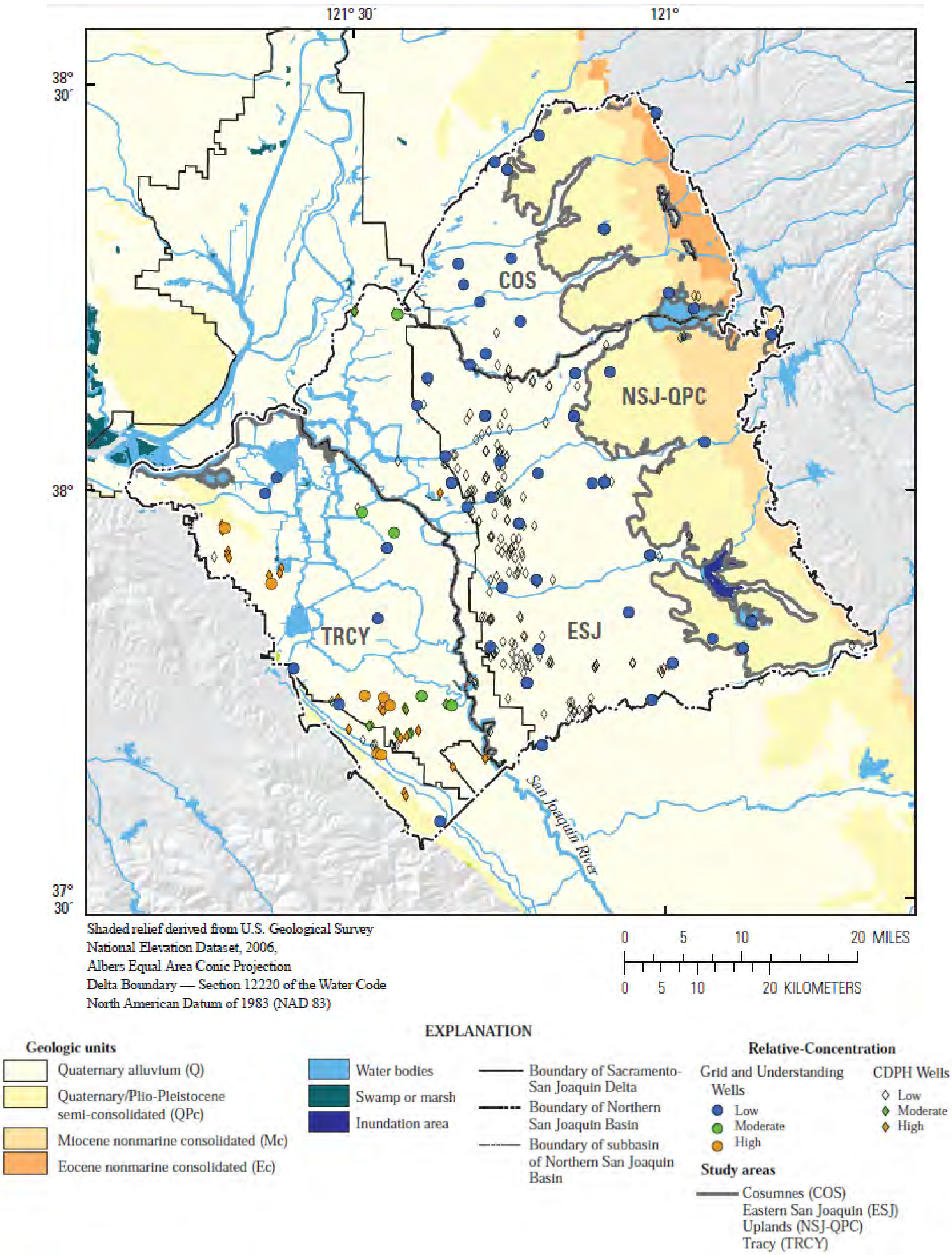


Figure 81. Locations of relative-concentrations of manganese from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)

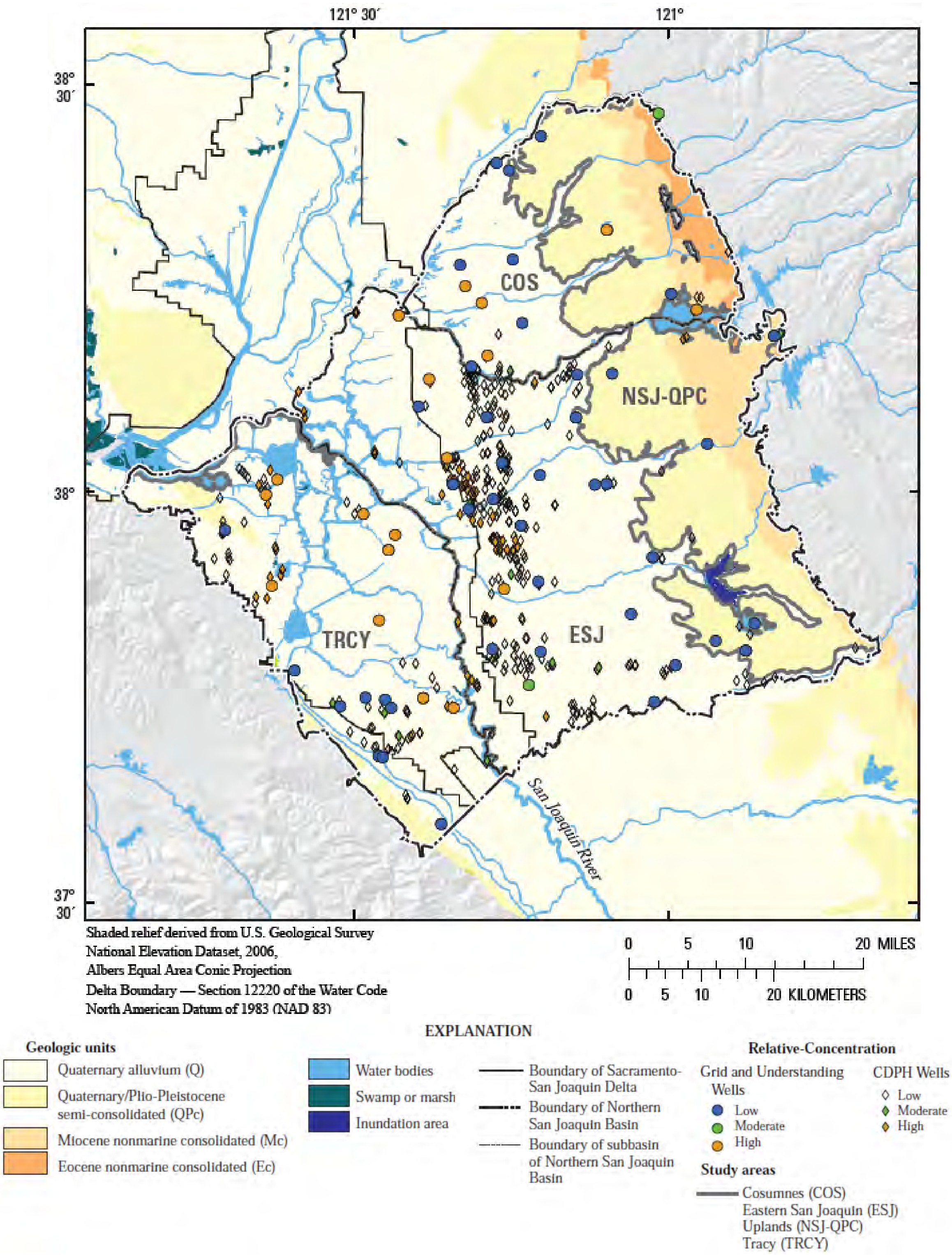
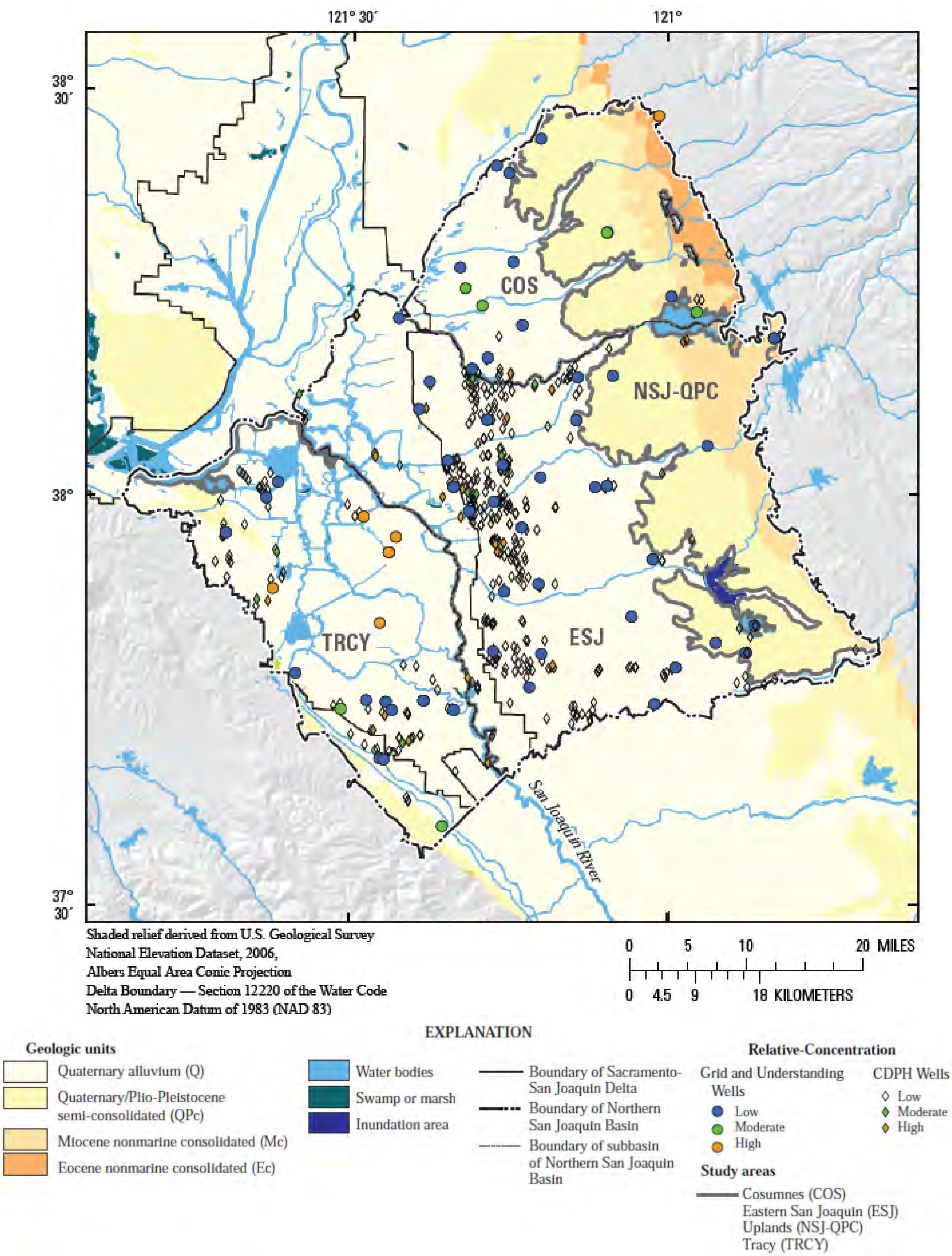


Figure 82. Locations of relative-concentrations of iron from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)



Pesticides

According to both the USGS study (Bennett et al., 2010a) and the GAR, all detections of currently, actively applied pesticides in samples from the Coalition region were below their respective MCLs. The authors of the GAR examined all GeoTracker (RWRCB) sites within the Coalition for exceedances of the MCLs for pesticide concentrations. According to the GAR, two pesticides are listed in Geotracker as having exceeded their respective MCLs within the Coalition region, mostly within urban areas: the soil fumigants DBCP and EDB (Figure 83). Simazine was detected in groundwater in samples collected from 2009 to 2013 but concentrations did not exceed the MCL. USGS' Northern San Joaquin Basin study unit Figure 84 illustrates the locations of all the pesticide detections (excluding fumigants); most sites also fall within urban areas (Bennett et. al., 2010a). DBCP and EDB are soil fumigants and were discussed separately from other pesticides in the USGS study.

Table 20. Summary of pesticide detections (below MCL threshold) and exceedances (at or above MCL threshold) for the GQMP area by individual well.

Well and pesticide data are those data compiled from 2009-2013 by Hydrofocus for completion of the SJCDWQC GAR. Data were retrieved from Hydrofocus on October 13, 2015 and include well and sample data within the April 2015 Coalition boundary.

Pesticide	Individual Wells with Detections	Individual Wells with Exceedances*	Concentration in Samples with Detections (µg/L)		Exceedance Threshold Used (µg/L)	Basis for Exceedance Threshold**
			Minimum	Maximum		
DBCP	274	92	0.001	50	0.2	CA Primary MCL
EDB	262	221	0.0017	2,500	0.05	CA Primary MCL
Simazine	36	0	0.06	1	4	CA Primary MCL

*Sample results from the same well on the same sample date were treated as one exceedance for that well on that date.
**Exceedance thresholds used are based on values reported in the SWRCB Water Quality Goals Online Database (http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml), when available. Selection of the threshold value for use to indicate an exceedance is based on a hierarchy consisting of the following order of preference: CA Primary MCL = California Primary MCL; EPA Primary MCL = EPA's Federal Primary MCL.

Pesticides (non-fumigant)

Atrazine (MCL of 1 µg/L) was the pesticide detected with the highest relative-concentration (0.08) of any pesticide detected within the USGS study. The only pesticide detected in more than 10 percent of the USGS grid wells was the herbicide simazine (MCL of 4 µg/L). Simazine had a detection frequency of 16 percent in the USGS study and was only detected in the western portion of the East San Joaquin subbasin and southwestern portion of the Cosumnes subbasin near Lodi. Figure 85 illustrates the distribution of the maximum concentrations of simazine in 2010 as found in the GAR.

Figure 83. Hazardous waste sites within the Coalition region contaminated with DBCP, EDB, or simazine (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

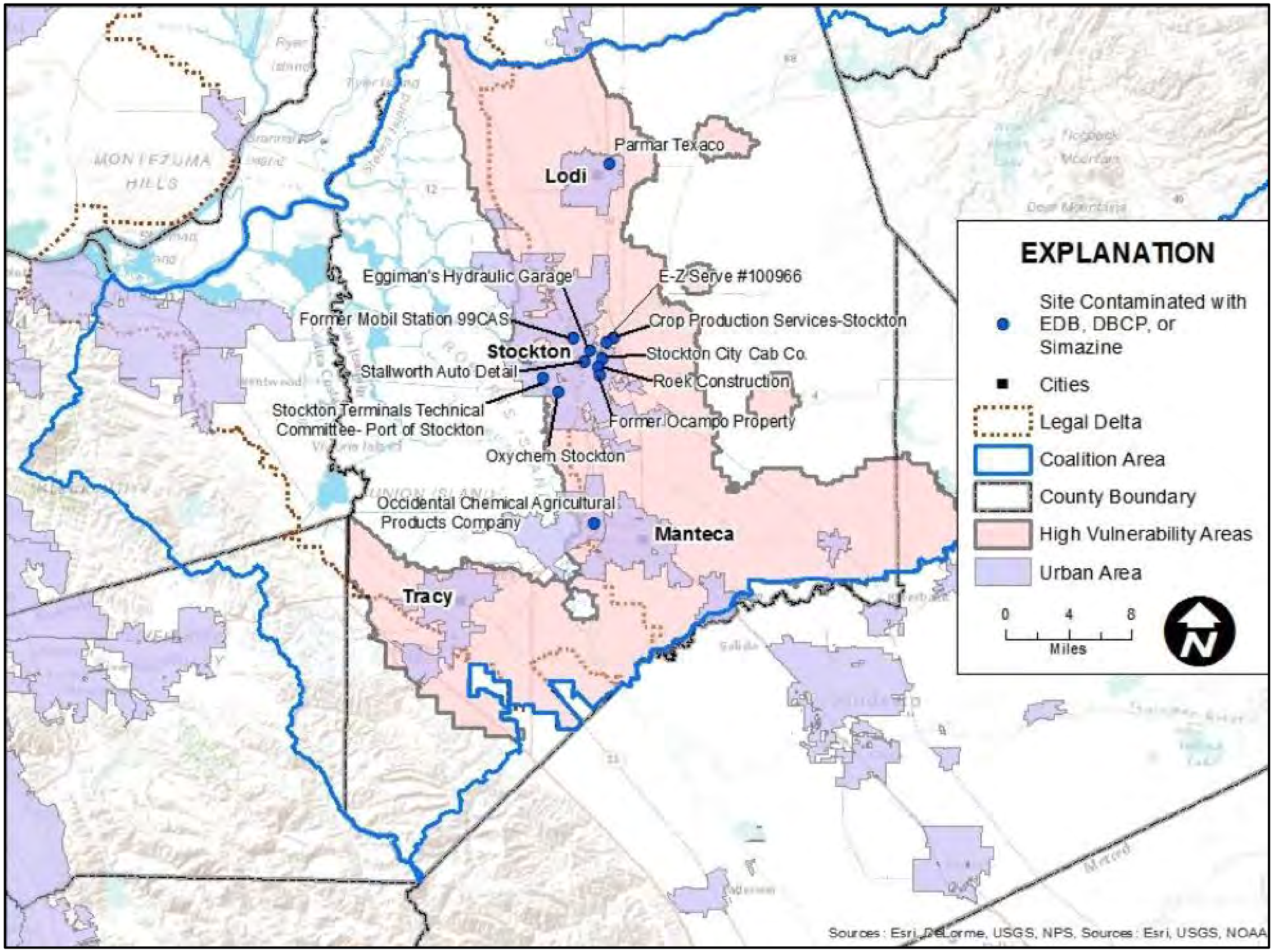


Figure 84. Locations of pesticide (all observed) relative-concentrations from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)

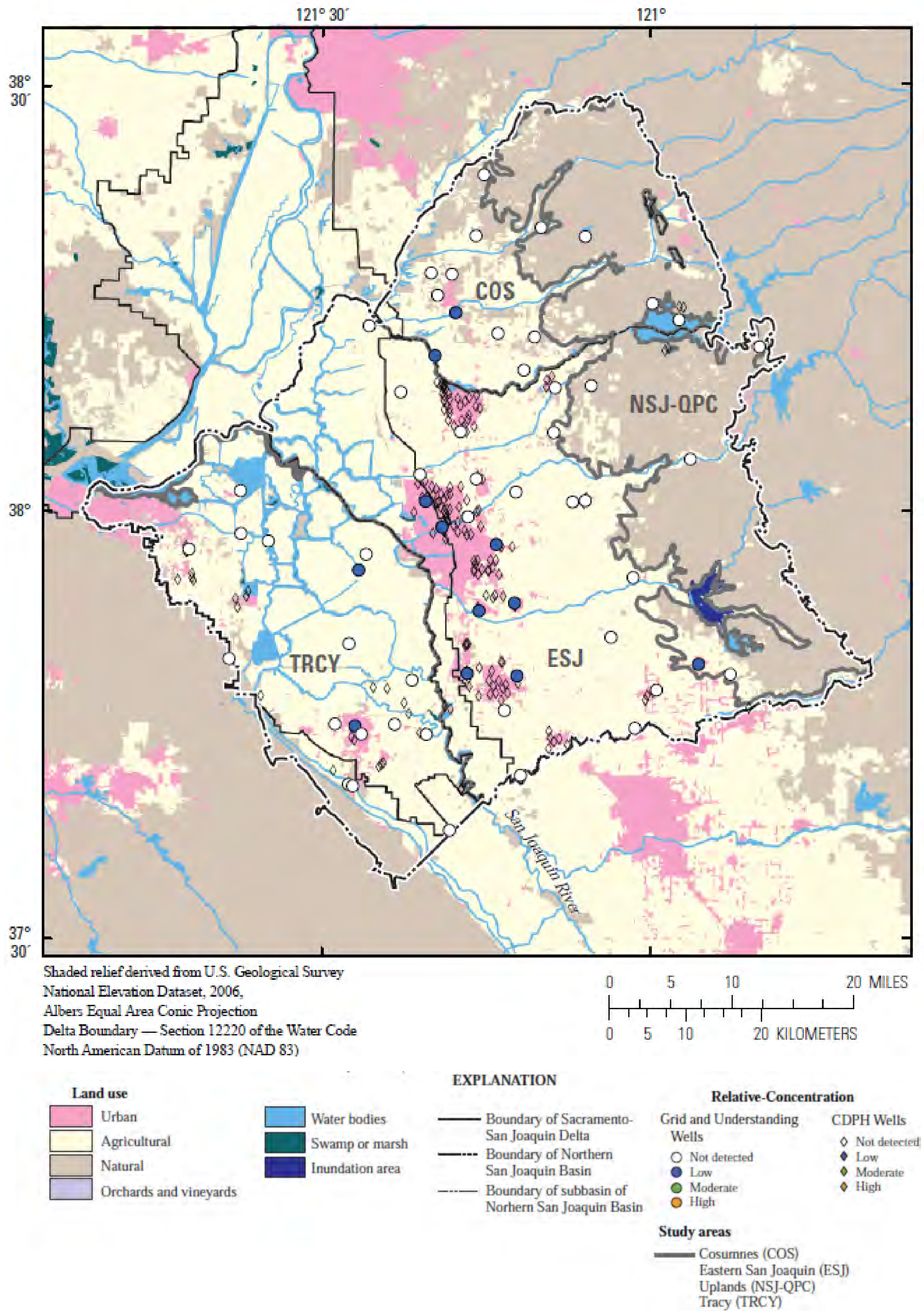
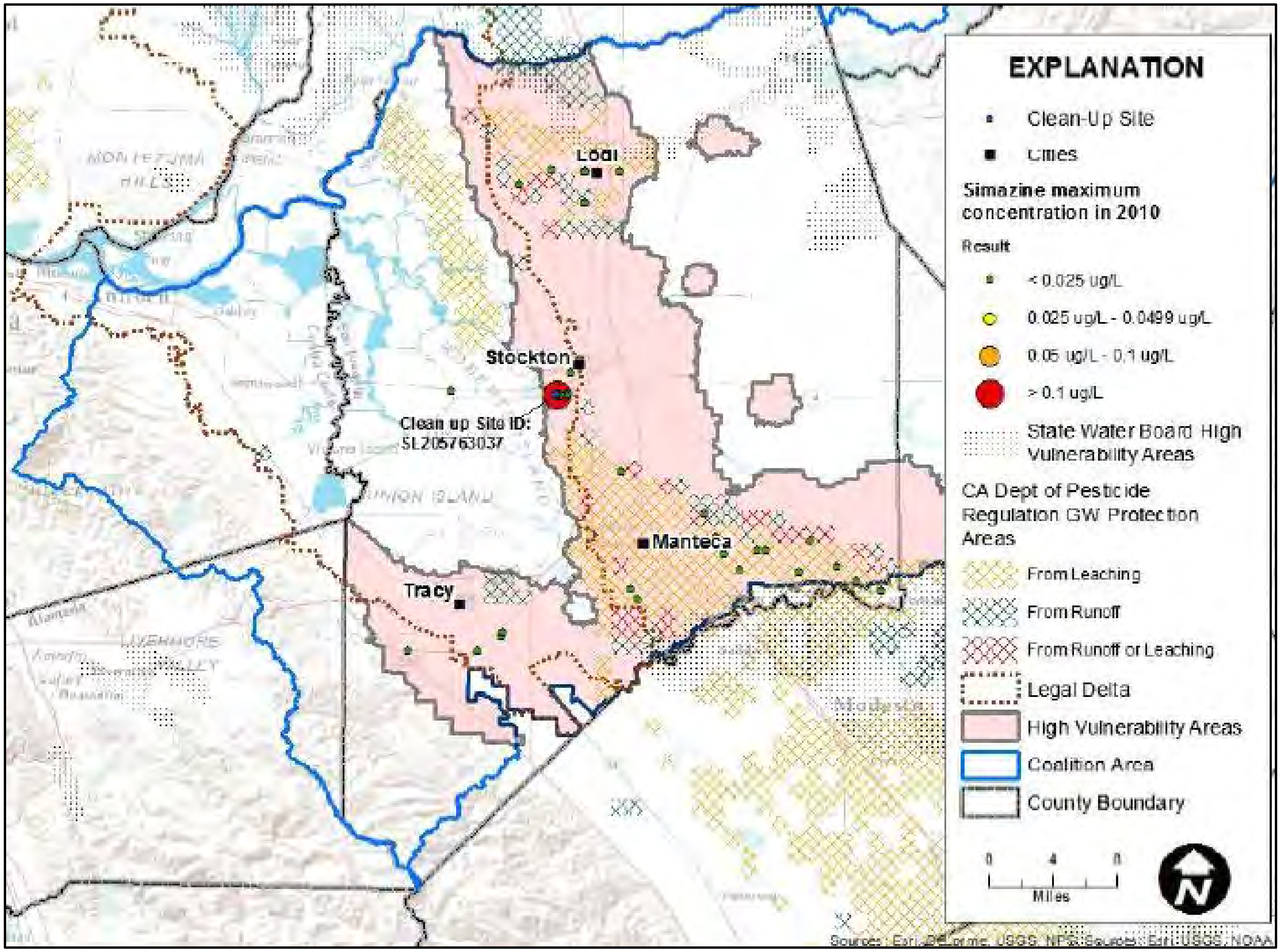


Figure 85. Distribution of maximum simazine concentrations in 2010 in the Coalition region (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



In addition to atrazine and simazine, the following pesticides (non-fumigants) and pesticide degradates with health-based benchmarks were detected in USGS grid wells: deethylatrazine (a degradate of atrazine), 3,4-dichloroanaline (a degradate of diuron), 2,6-diethylaniline (a degradate of alachlor), hexazinone, metolachlor, tebuthiuron, and trifluralin. All detections were below their respective MCL thresholds. Most of the detections of the previously stated pesticides were located in the Eastern San Joaquin subbasin (Figure 84). In addition to those pesticides listed in the GAR and the USGS study, review of DPR's "*Sampling for Pesticide Residues in California Well Water, 2014 Update,*" a detection of the herbicide diquat dibromide was listed by the CDPH at a concentration of 4.5 µg/L (MCL of 20 µg /L) in San Joaquin County. According to the DPR report, CDPH resampled the detection site and failed to find diquat dibromide in subsequent samples. As levels of diquat dibromide in the initial sample did not exceed the MCL, diquat dibromide is not considered a COC in the Coalition region.

Fumigants

Fumigants are gaseous forms of pesticides applied to soils, grain, produce, and structures for the purpose of pest control. Those fumigants used primarily to control pests in agriculture, households and in by-product synthesis for fumigant mixtures were grouped into their own constituent class (fumigants) in the USGS study (Bennett et al., 2010a).

DBCP

According to the GAR and USGS studies, DBCP is the primary pesticide and fumigant detected in the Coalition region. DBCP was used as a soil fumigant to control nematodes, primarily on orchards and vineyards but also on some row crops, between about 1955 and 1977 in California. Use of DBCP was discontinued by the California Department of Food and Agriculture in 1977 and banned in the United States in 1979 (excluding Hawaii where it was used until 1985) because of its detection in groundwater and its toxicity. Detection frequencies of DBCP in groundwater in the Central Valley have persisted due to its widespread use as an agricultural fumigant and because of its long half-life in groundwater of over 100 years (Bennett et al., 2010a). In the dataset analyzed by the authors of the GAR, the number of wells with DBCP exceedances decreased from 49 wells in 2009 to nine wells in 2013 (Figure 86 and Figure 87). Figure 88 illustrates DBCP detections and exceedances in the USGS' Northern San Joaquin Basin study unit.

EDB

Ethylene dibromide was used as a fumigant to protect against insects and nematodes in citrus, vegetable, and grain crops, and as a fumigant for turf, particularly on golf courses. In 1984, EPA banned its use as a soil and grain fumigant. According to the GAR, maximum EDB concentrations observed in wells decreased significantly between 2009 and 2013; 15 wells in 2009 had EDB exceedances of the 0.05 µg/L MCL whereas no wells in 2013 exceeded the MCL. Figures illustrating the yearly maximum and average EDB concentrations from wells sampled between 2009 and 2013 can be found in the GAR Appendix. Figure 89 and Figure 90 illustrate the maximum concentrations of EDB found in the Coalition region in 2009 versus 2013 (SJCDWQC, 2015).

Figure 86. Locations of maximum concentrations of DBCP in the Coalition region in 2009 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

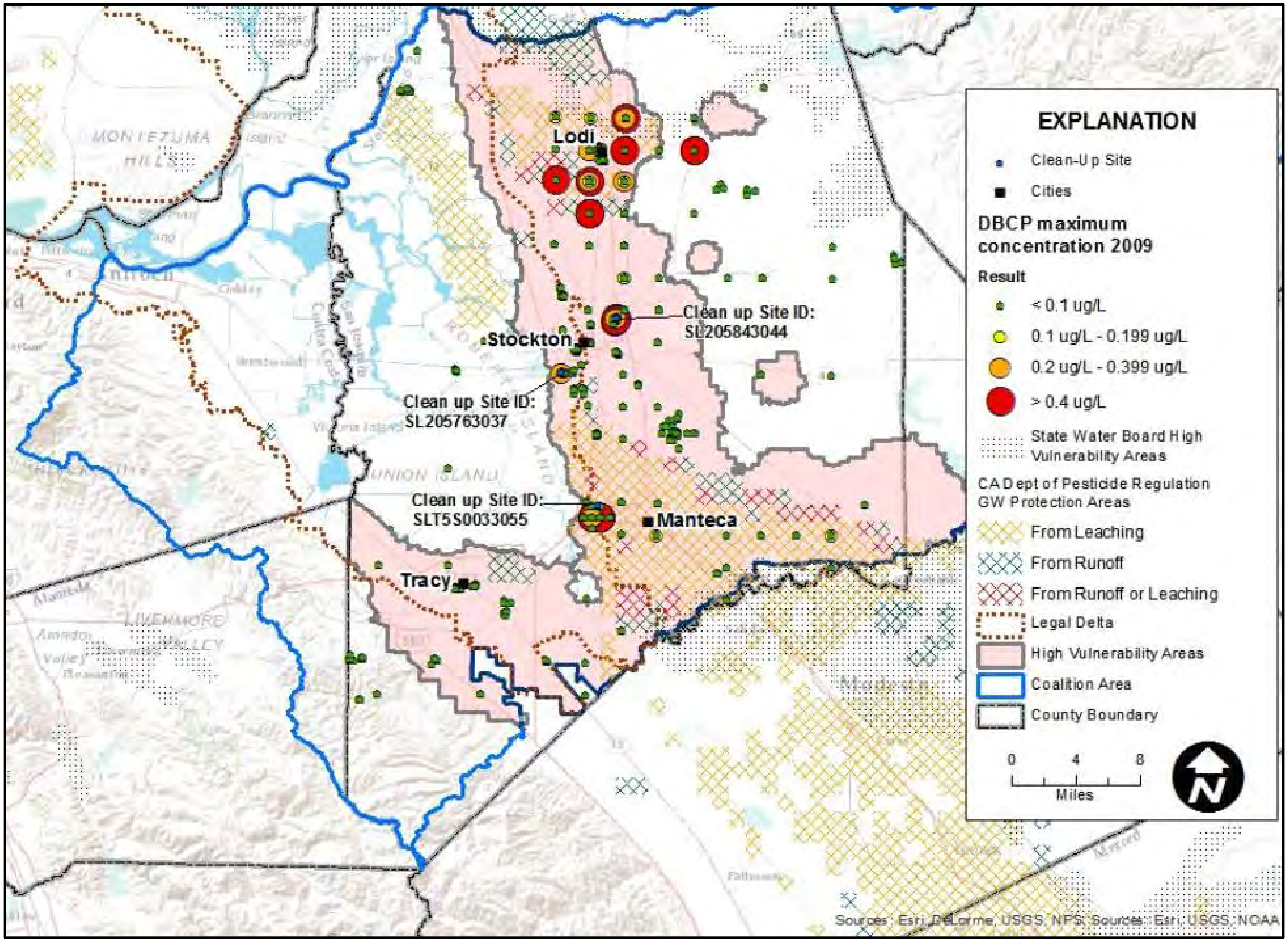


Figure 87. Locations of maximum concentrations of DBCP in the Coalition region in 2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

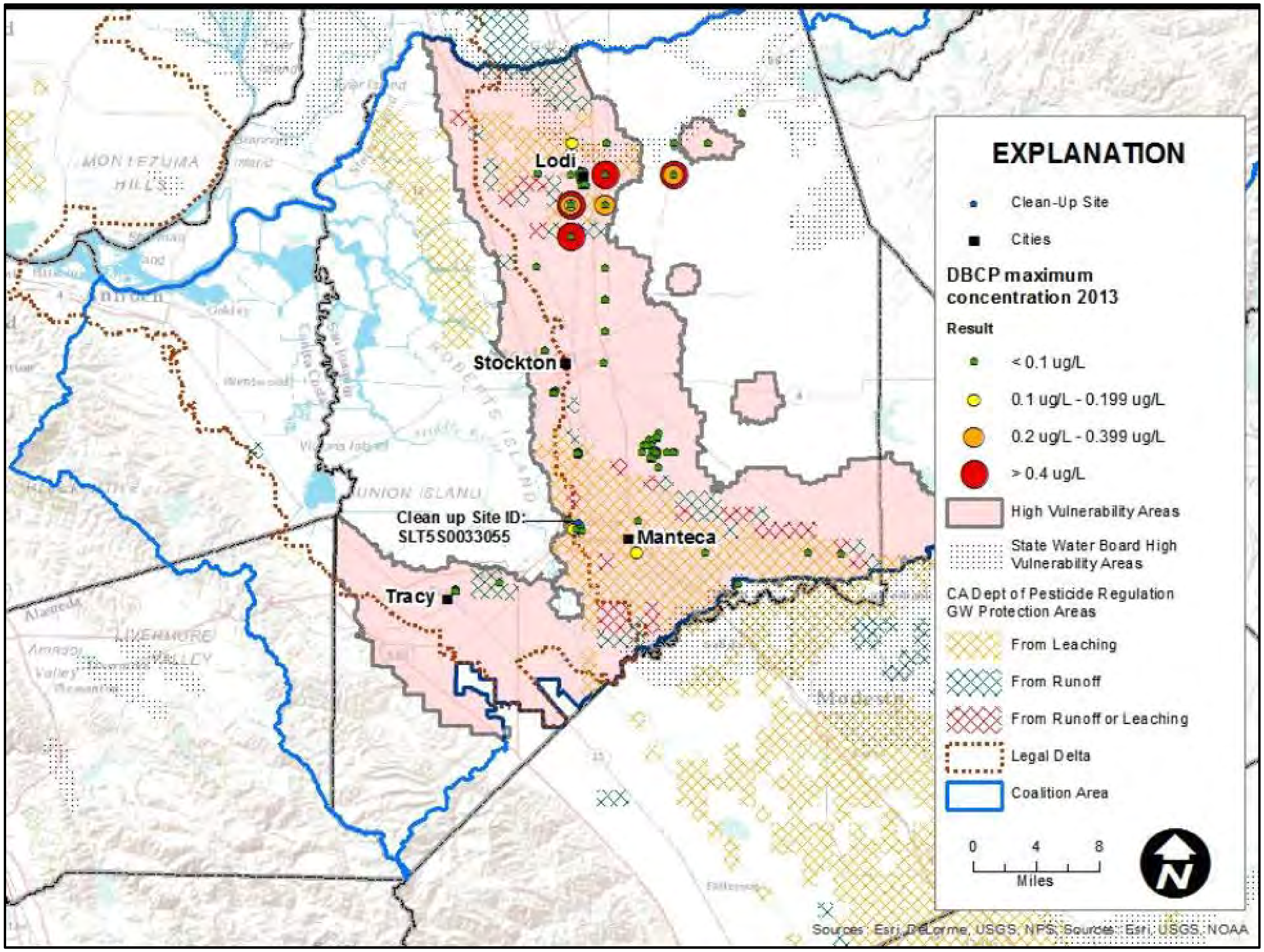


Figure 88. Locations of relative-concentrations of DBCP from both USGS grid wells and CDPH understanding wells as presented in the Status and Understanding of Groundwater Quality, Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project (Bennett et al., 2010a).

Relative-concentration = (sample concentration/benchmark concentration)

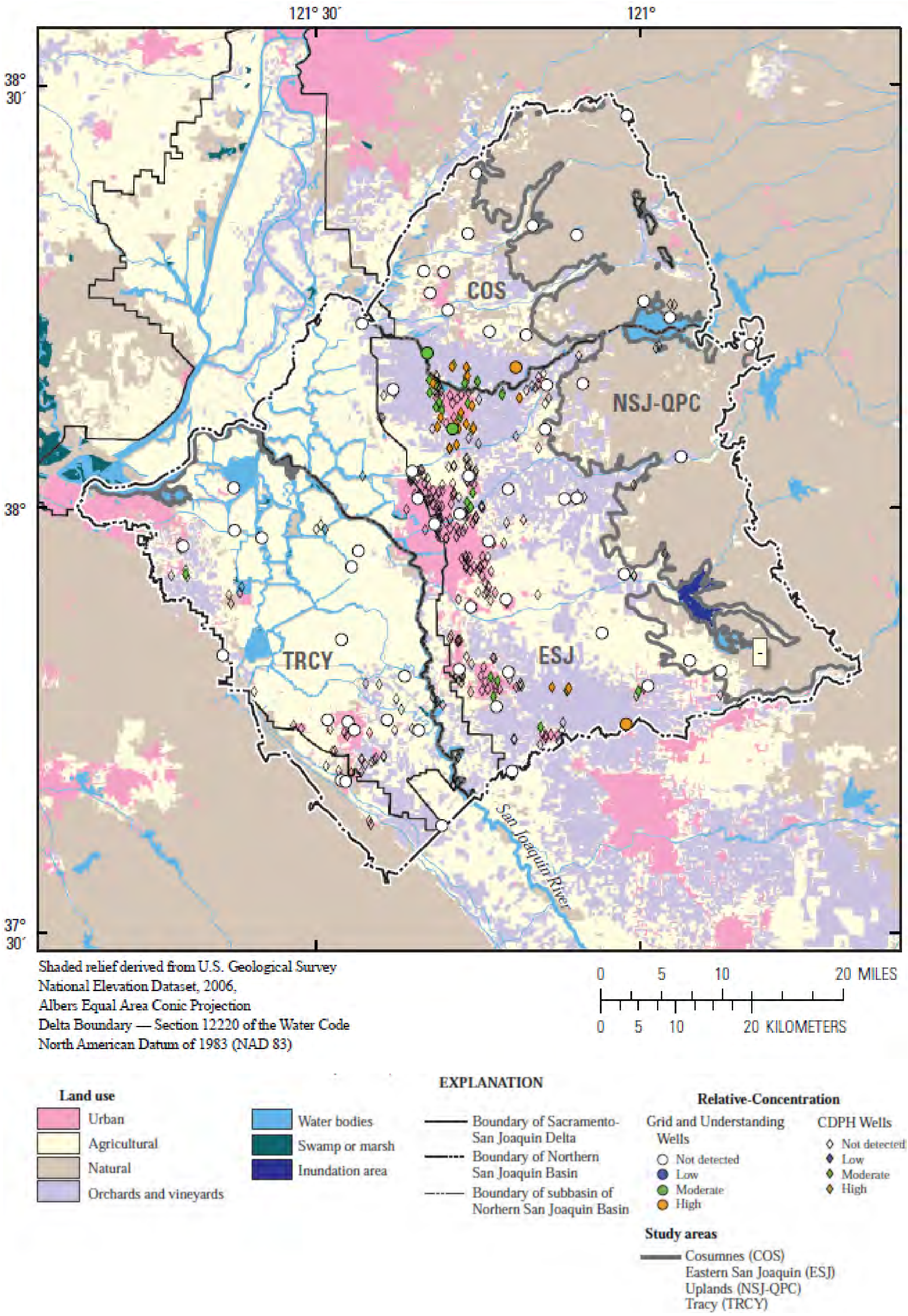


Figure 89. Locations of maximum concentrations of EDB in the Coalition region in 2009 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

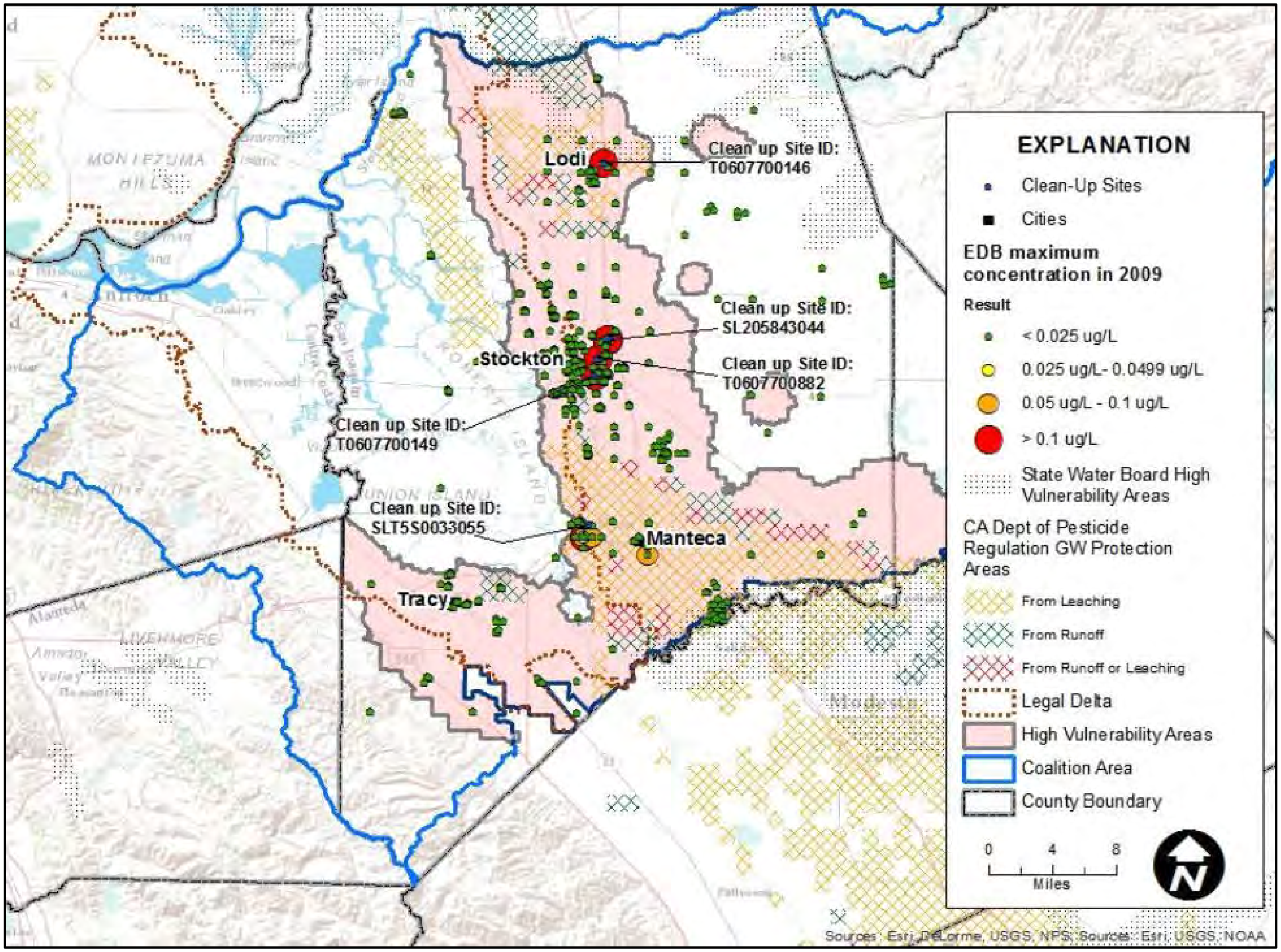
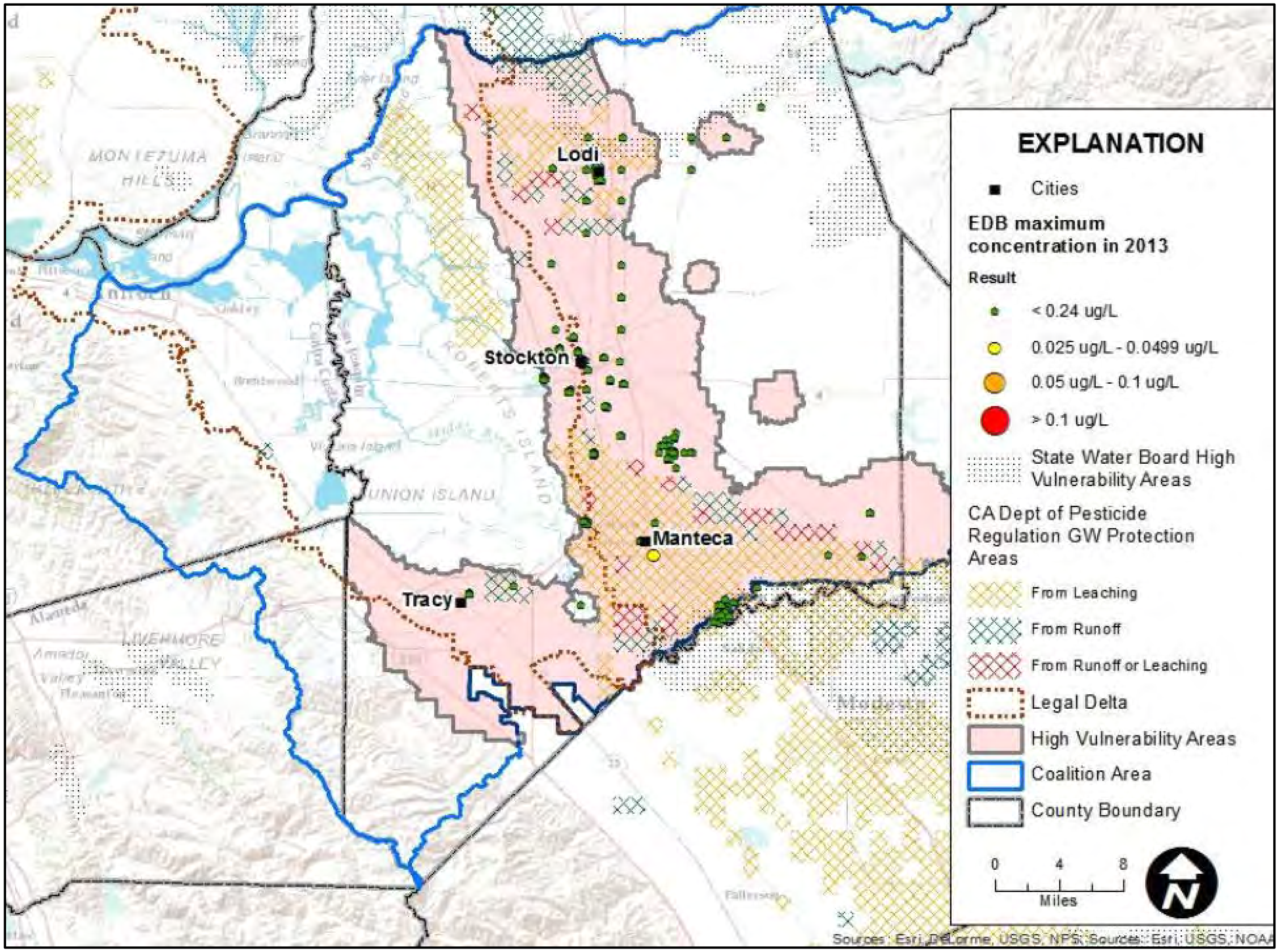


Figure 90. Locations of maximum concentrations of EDB in the Coalition region in 2013 (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



FACTORS AFFECTING WATER QUALITY IN GROUNDWATER

The USGS' GAMA Project research for the Northern San Joaquin Basin study unit (Bennett et al., 2010a) statistically evaluated the relationships between water quality and five explanatory factors (land use, depth, normalized lateral position, groundwater age, and geochemical conditions). Wells (grid wells) were chosen to span the range of normalized lateral positions in the study unit, i.e. well positions normalized with respect to distance from the valley trough and normalized to the distance between the valley margin and the trough. Land use represented by the wells (defined as the percentages of urban, agricultural, and natural land use within a 500-meter buffer surrounding the well) was more urban than was land use for the study unit as a whole, likely a result of the tendency to locate drinking-water wells near population centers. Well depths ranged from 83 to 930 feet with a median depth of 360 feet. Groundwater ages in 61 wells were classified as young (36 wells) or old (25 wells) based on 3H (tritium) concentrations. Redox conditions were assigned based on relative-concentrations of redox-sensitive constituents for the wells sampled that had redox information; groundwater in the Northern San Joaquin Basin study unit primarily was oxic (33 of 61 wells; 54 percent).

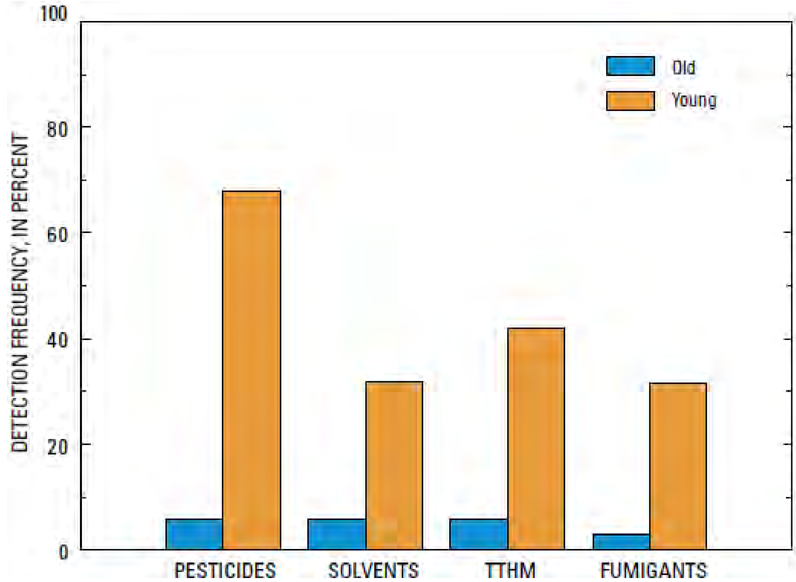
Inorganic Constituents

According to the USGS' study, "groundwater age, normalized lateral position, and redox conditions were the most significant explanatory factors related to inorganic constituent concentrations. Groundwater age was shown to be associated with concentrations of arsenic, gross alpha radioactivity, and TDS. High and moderate relative-concentrations of arsenic, iron, and manganese primarily were associated with geochemical conditions. Arsenic relative-concentrations were high in oxic, high-pH waters and in anoxic waters. High relative-concentrations of iron and manganese were most commonly associated with anoxic waters. Normalized lateral position was shown to be associated with arsenic, nitrate, and TDS concentrations. High and moderate relative-concentrations of arsenic and total dissolved solids were more often closer to the basin center (valley trough), whereas concentrations of nitrate tended to decrease towards the basin center." (Bennett et al., 2010a)

Organic Constituents

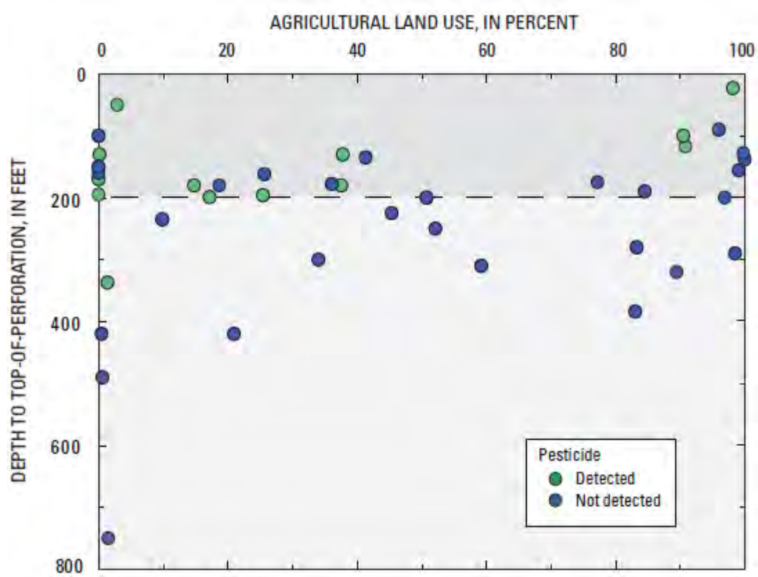
According to the USGS' study, "groundwater age, well depth, and land use within 500 meters of each sampled well were the most significant factors affecting organic constituent concentrations. Trihalomethanes, fumigants, pesticides, and solvents were all shown to have higher concentrations in young groundwater than in old groundwater (Figure 91). Fumigant and pesticide concentrations were related to well perforation depth, with shallower perforation depths having higher constituent concentrations. Detections of trihalomethanes and solvents were positively associated with urban land use and negatively associated with agricultural land use. Fumigant detections were strongly correlated with a specific agricultural land use (orchards and vineyards). Young groundwater, shallow well depths, and urban land use are commonly related to the occurrence of organic constituents in the Northern San Joaquin Basin study unit." (Bennett et al., 2010a).

Figure 91. Pesticide, solvent, total trihalomethane (TTHM), and fumigant detection frequencies grouped by groundwater-age classification, Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment (GAMA) study unit (Bennett et al., 2010a).



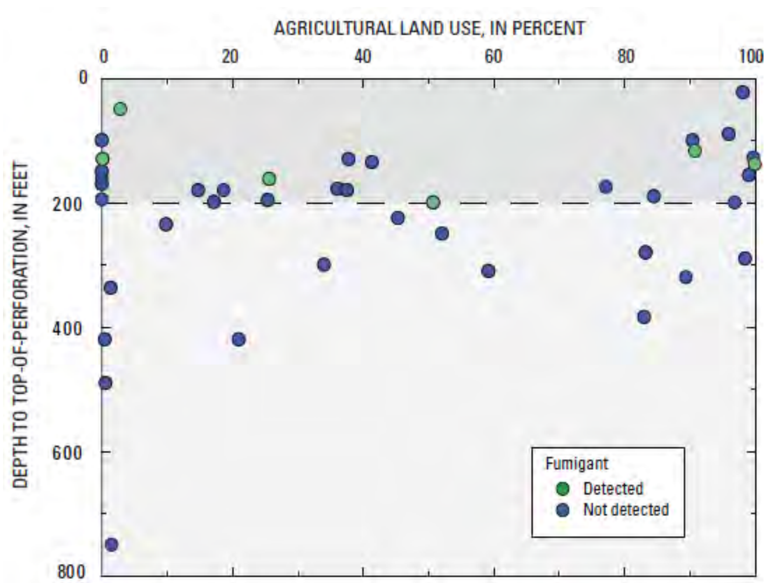
As stated previously, according to the USGS' study, pesticide concentrations were significantly related to groundwater age and depth to top-of-perforation (Figure 92), and normalized lateral position within the Central Valley. Groundwater classified as young had a significantly higher detection frequency of pesticides as a class and contained significantly higher pesticide concentrations than groundwater classified as old. With the exception of one well screened at 337 ft below land surface, all pesticides were detected in wells with a depth to top-of-perforation of less than 200 ft in the USGS' study. The correlation with water age and depth suggests that pesticides in the primary aquifer of USGS' Northern San Joaquin Basin study unit are related to young groundwater and that this young groundwater has infiltrated to depths of as much as 200 ft below land surface. Locations of pesticide concentrations indicate increasing pesticide concentrations the closer they are to the basin, as opposed to the margin, of the Central Valley. Most pesticides were detected in wells along the western side of the Eastern San Joaquin (study area) (subbasin). Pesticide concentrations were not correlated with any of the land-use categories. Bennett et al. (2010a), suggest this might be the case because simazine and some of the other pesticides detected have both agricultural and non-agricultural uses. Pesticides commonly are used on rights-of-way and in landscaping, and thus may be associated with urban land use.

Figure 92. Relation between detection of pesticides and depth to top-of-perforation and percentage of agricultural land use in 500-m buffer areas surrounding wells for USGS-grid and USGS-understanding well samples, Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment (GAMA) study unit (Bennett et al., 2010a).



According to USGS' study, fumigant concentrations were significantly negatively correlated with depths to top-of-perforation (Figure 93), significantly lower in those water samples categorized as old as compared to those categorized as young, and significantly positively correlated with percentage of orchard/vineyard land use.

Figure 93. Relation between detection of fumigants and depth to top-of-perforation and percentage of agricultural land use within 500-m buffer areas surrounding wells for USGS-grid and USGS-understanding well samples, Northern San Joaquin Basin Groundwater Ambient Monitoring and Assessment (GAMA) study unit (Bennett et al., 2010a).



SURFACE WATER DATA INDICATING CONSTITUENTS OF CONCERN IN GROUNDWATER

The Coalition first identified surface water locations and constituents that would require a management plan for surface water in 2007, and developed the SJCDWQC Management Plan in 2008. Currently, the Coalition submits Annual Monitoring Reports of surface water quality monitoring and management for its Members to the Regional Water Board. In general terms, data collected from surface water monitoring will be used to evaluate current constituent applications in agricultural operations and to better advise specific management practices to protect future groundwater quality. It is beyond the scope of this GQMP to identify surface water sources of constituents of concern identified in groundwater samples collected over previous decades.

SJCDWQC HIGH VULNERABILITY AREAS

"The GAR shall designate high/low vulnerability areas for groundwater in consideration of high and low vulnerability definitions provided in Attachment E of the Order" (WDR, 2015).

One of the objectives of the GAR was to "provide a basis for establishing groundwater quality management plans in high vulnerability areas and priorities for implementation of those plans" (WDR, 2015). As part of the focus on protection of regional groundwater quality, the relative vulnerability of groundwater to irrigated land practices was assessed in the GAR based on hydrogeologic sensitivity, overlying land uses and practices and groundwater quality data, historic and recent.

DETERMINATION OF HIGH VULNERABILITY AREAS

The GAR designates High-Vulnerability Areas (HVAs) and Low-Vulnerability Areas within the Coalition based on a combination of EPA DRASTIC scores, indicator kriging results, and groundwater particle tracking results (SJCDWQC, 2015). The resulting surface area designated as an HVA is 392,400 acres within the Coalition, both Delta and non-Delta.

According to the GAR, delineation of the High Vulnerability Areas (HVAs) in the SJCDWQC region was primarily based on the footprint of nitrate exceedances of the MCL in the SJCDWQC region. Using known locations for nitrate exceedances, the authors of the GAR utilized indicator kriging and select hydrogeologic characteristics identified in the DRASTIC model (Aller, 1987) to determine areas within the Coalition where groundwater may be more vulnerable to contamination of constituents of concern associated with agricultural management practices in surface waters.

Using a nitrate regression model, the authors of the GAR preliminarily delineated HVAs as those areas where there is a 40% or greater probability that the nitrate concentration will exceed 22.5 mg/L (half the MCL for nitrate). These areas included 92% of the wells where measured nitrate concentrations have exceeded 22.5 mg/L. HVAs were expanded to include all areas where nitrate concentrations have exceeded the MCL and those areas identified as recharge capture zones for the public water systems and disadvantaged communities using particle tracking analysis. Finally, the initial distribution of vulnerability areas was further modified based on the results of the DRASTIC analysis (Table 21).

Table 21. Characteristics used in the four methods for delineating HVAs in the SJCDWQC region.

Characteristics used to Evaluate Vulnerability	Nitrate Regression Model	Kriging	Particle Tracking	DRASTIC Model
Existing NO_3 Data	X	X		
Land Use	X			
Groundwater Flow			X	
Soil and Vadose-zone Characteristics	X		X	X
Depth to Groundwater	X			X
Recharge	X		X	X
Topography				X
Hydraulic Conductivity			X	X

DETERMINATION OF PRIORITIZATION OF HIGH VULNERABILITY AREAS

The HVA is further subdivided into Priority 1 -3 areas (Figure 94). Several considerations were suggested within the Order for the authors of the GAR to use when establishing relative priorities for HVAs:

- Identified exceedances of water quality objectives
- Proximity to areas contributing recharge to urban and rural communities that rely on groundwater as a source of supply
- Existing field and operational practices identified to be associated with irrigated agricultural waste discharges that are the cause or source of groundwater quality degradation
- The largest acreage commodity types comprising up to at least 80 percent of irrigated agriculture in the high vulnerability areas
- Legacy or ambient groundwater conditions
- Groundwater basins currently proposed to be under review by Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)
- Identified constituents of concern

Additional information such as models, studies, and information collected as part of the Order's requirements were also suggested in the Order to be considered when designating and prioritizing vulnerability areas for groundwater. Priority areas within the HVA were designated based on three primary criteria in the GAR:

- Extent and spatial frequency of nitrate exceedances
- DRASTIC scores, presence of disadvantaged and disadvantaged unincorporated communities (DACs and DUCs respectively)
- Land use

HVA - Priority 1

HVA Priority Area 1 includes all identified DUCs within the HVA except one DUC near Tracy and the majority of the DAC area (Figure 94). According to the GAR, the HVA Priority 1 area contains the largest number and greatest spatial frequency of nitrate exceedances and the largest area of high and medium DRASTIC scores (Figure 95). Priority Area 1 also includes the largest contiguous DPR groundwater protection areas within the Coalition and the largest area of groundwater-dependent communities (Stockton, Lathrop, and Manteca) and their respective recharge areas, as determined through particle tracking analysis. Analysis of DWR land use data indicates the primary non-urban land use within Priority Area 1 is deciduous fruits and nuts (Figure 96) (SJCDWQC, 2015).

HVA - Priority 2

HVA Priority Area 2 contains a large area of DRASTIC high and medium vulnerability areas (Figure 95), a DUC north of Tracy, which is a groundwater-dependent community, and a small area of DACs (Figure 94). Grain and hay production is the primary non-urban land use (Figure 96) (SJCDWQC, 2015).

HVA - Priority 3

Priority Area 3 includes the groundwater-dependent communities of Lodi and Lockeford and a relatively small area of medium and high DRASTIC scores and low number of nitrate exceedances (Figure 95). DACs are identified near the Delta but no DUCS have been identified (Figure 94). This priority area includes a relatively small DPR groundwater protection area. Vineyards are the primary non-urban land use (Figure 96) (SJCDWQC, 2015).

According to the GAR, acreages of agricultural land use classes in Figure 96 are shown in Table 22. The two agricultural land use classes with the largest area within the HVAs are grain and hay crops (78,200 acres) and deciduous fruits and nuts (77,000 acres). Over 88% of the HVAs are composed of five agricultural land use classes; grain and hay crops (27.6%), deciduous fruits and nuts (27.2%), vineyards (15.9%), pasture (11.1%), and truck, nursery, and berry crops (6.4%).

Table 22. Agricultural land use acreages for the area of the Coalition within the HVAs, based on DWR land use data for irrigated lands (SJCDWQC, 2015).

Land Use Class	Acres	Percent	Cumulative Percent
Grain and Hay Crops	78,200	27.6%	27.6%
Deciduous Fruits and Nuts	77,000	27.2%	54.9%
Vineyards	44,900	15.9%	70.8%
Pasture	31,300	11.1%	81.8%
Truck, Nursery & Berry Crops	18,100	6.4%	88.2%
Idle	16,700	5.9%	94.1%
Field Crops	13,800	4.9%	99.0%
Rice	2,150	0.8%	99.8%
Citrus and Subtropical	635	0.2%	100.0%
Grand Total for Agricultural Crops	**282,800**		

Figure 94. Delineation of priority areas within the HVA and DACS and DUCs (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

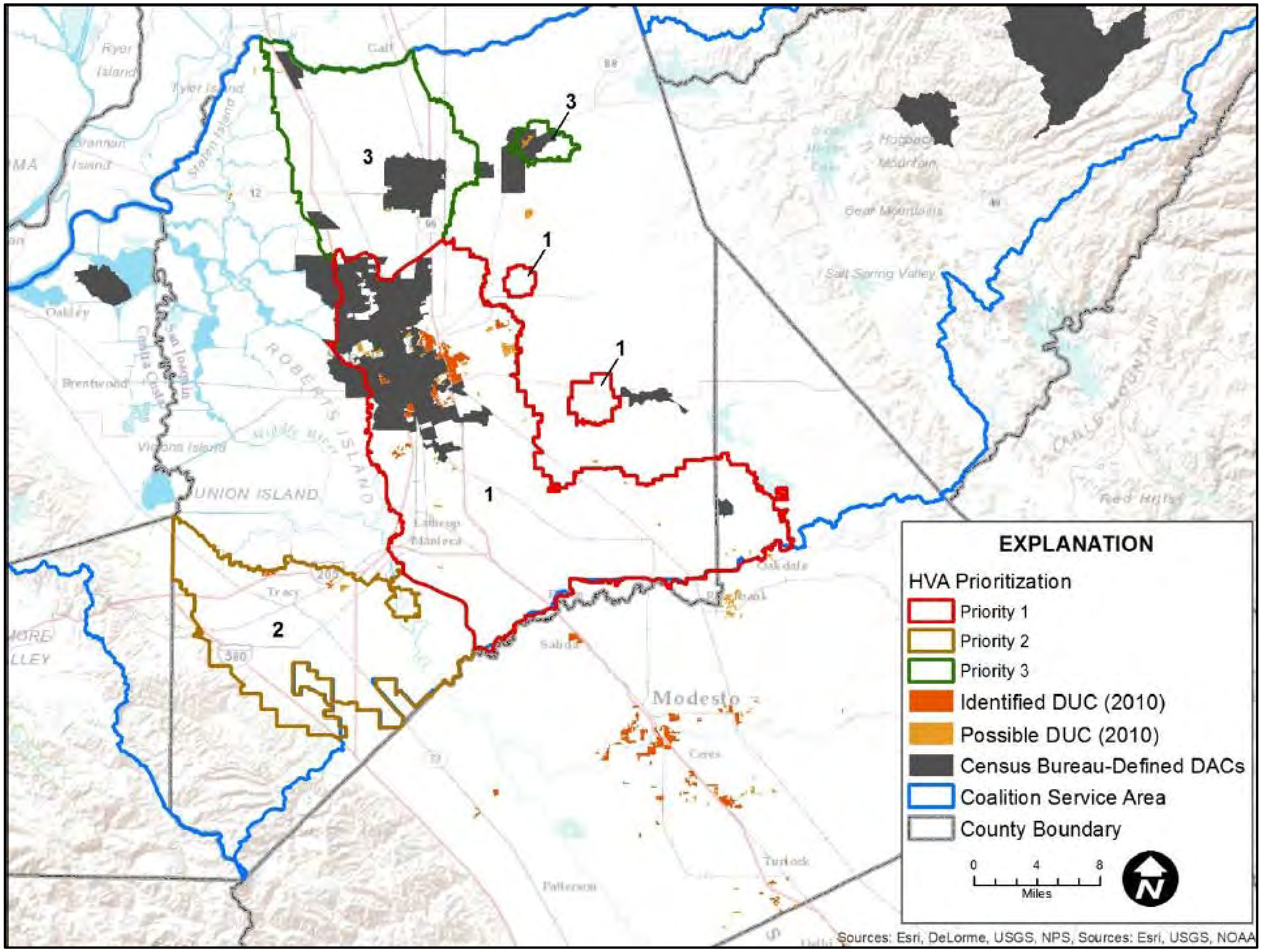


Figure 95. Delineation of the HVA, the HVA Priority Areas, DRASTIC scores, and nitrate concentrations and the Coalition region (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

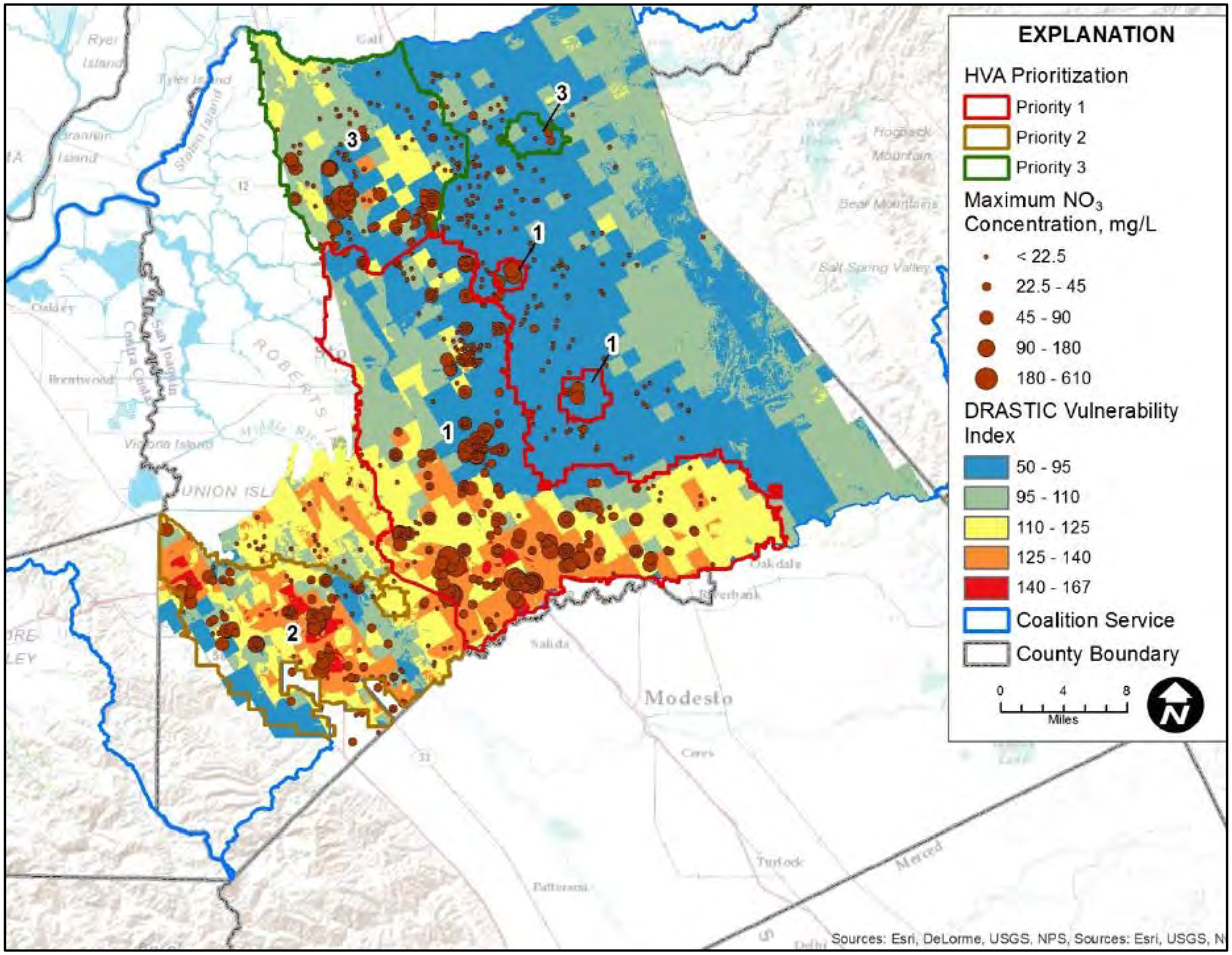
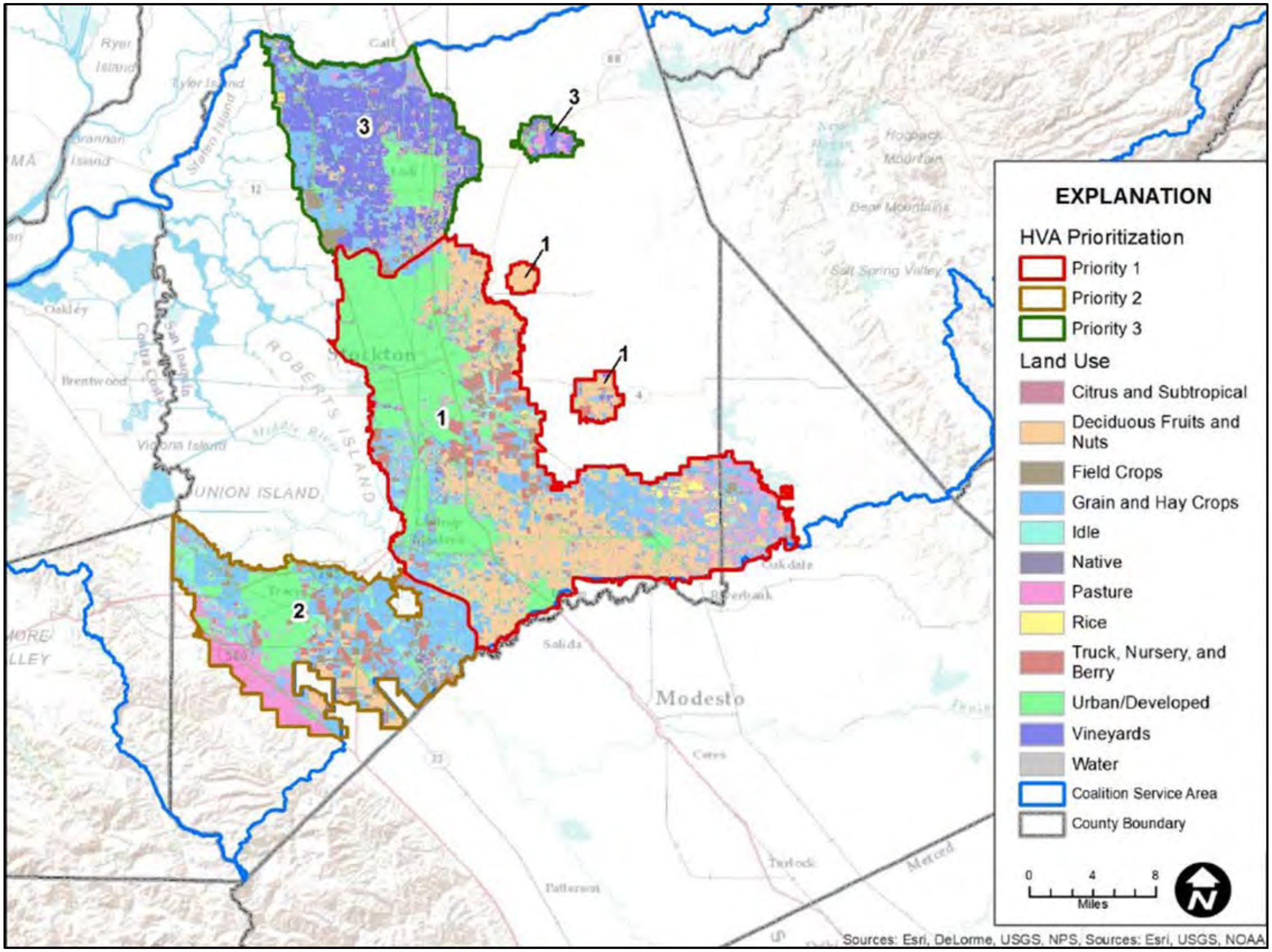


Figure 96. Delineation of HVAs, the HVA priority areas, and the overlaying land use (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



LAND USE IN HIGH VULNERABILITY AREAS

According to the GAR, the most prevalent crop classes based on DWR land use survey data are deciduous fruits and nuts (18.4%), field crops (13.5%), pasture (12.7%), vineyards (12.3%), and truck crops (6.6%). Analysis of land use data relative to the HVA, and the individual designated HVA Priority areas are provided below.

Table 23. Land use acreage associated with DWR land use data within the Coalition according to HVA Priority 1-3 areas.

Land uses derived from DWR data in order to incorporate irrigation data designated as irrigated/non-irrigated (I/NI); numbers are rounded to nearest whole number.

Land Use Class Name	I/NI	HVA Priority 1	HVA Priority 2	HVA Priority 3	Outside SJCDWQC HVA	Grand Total
Barren	N	31	-	-	790	821
Citrus & Sub-Tropical	I	175	-	26	368	570
Citrus & Sub-Tropical	N	-	-	-	51	51
Deciduous Fruits & Nuts	I	60,519	6,923	4,764	42,389	114,594
Deciduous Fruits & Nuts	N	-	-	-	664	664
Field Crops	I	15,535	14,590	8,302	97,153	135,580
Field Crops	N	-	-	-	206	206
Grain & Hay	I	18,431	11,096	2,565	45,784	77,877
Grain & Hay	N	181	1,107	19	5,356	6,663
Idle	I	3,303	362	1,701	7,367	12,733
Idle	N	-	-	15	439	454
Native Riparian	N	211	159	510	8,590	9,469
Native Vegetation	N	7,202	13,371	6,747	1,233,697	1,261,017
Open Water	N	1,607	1,339	864	55,470	59,280
Pasture	I	31,247	16,250	9,004	65,767	122,268
Pasture	N	-	-	-	290	290
Rice	I	4,306	-	-	2,714	7,020
Semiagricultural	N	3,855	1,337	1,243	6,455	12,890
Truck, Nursery, Berry	I	14,418	8,565	4,335	60,487	87,806
Urban (combined)	N	56,316	13,021	10,850	53,906	134,092
Urban (Landscape)	I	-	-	-	79	79
Vineyard	I	9,068	697	35,426	33,197	78,388
Vineyard	N	-	-	-	115	115
Subtotal	I	157,003	58,483	66,124	355,304	636,914
Subtotal	N	69,402	30,334	20,248	1,366,029	1,486,013
Grand Total	I/N	452,810	177,634	172,743	3,442,667	4,245,854

[1] Land use information obtained from data provided by DWR, http://www.water.ca.gov/landwateruse/anaglwu.cfm. Data compiled in 2006 (Alameda), 1995 (Contra Costa), and 1996 (San Joaquin). Land use in some areas of the SJCDWQC may have changed since that time.
*Urban Combined - Urban, Urban Commercial, Urban Industrial, Urban Landscape, Urban residential, Urban Vacant.

CONSTITUENTS OF CONCERN IN HIGH VULNERABILITY AREAS

Nitrate

Figure 95 illustrates the HVA Priority 1-3 areas along with approximate nitrate sampling locations and maximum observed sample concentrations. Figure 97 and Figure 98 display the locations of nitrate concentrations, their observed range of concentrations in groundwater and temporal trends relative to the HVA within the Coalition. According to the GAR, all except two wells from the 2009-13 dataset with average nitrate concentrations over 22.5 mg/L are located within the HVA. All wells with increasing nitrate concentrations are located within or on the border of the HVA (Figure 98).

Table 24 and Table 25 describe nitrogen as nitrate maximum concentrations sampled and well counts within the GQMP area. Table 24 indicates that of those wells sampled in the GQMP area between 2009 and 2013, approximately 16% exceeded the MCL for nitrate of (>45 mg/L). Table 25 indicates that from 2009-2013, of those wells with nitrate exceedances (based on maximum concentrations sampled), the majority (73%) are located in the Priority 1 area of the SJCDWQC HVA.

Table 24. Count of maximum nitrate (NO_3) concentrations by well, from 2009-2013 for the GQMP area.
Well and nitrate data are those data compiled in the GAR. Maximum sample concentrations were analyzed. NO_3 detections that are not exceedances (>0 and ≤45 mg/L) or detections that are exceedances (>45 mg/L). Numbers associated with exceedances are **BOLD**. "Percent of Wells" calculation equal detections / detections + nondetections. "Total Wells Sampled" equals nondetections + detections.

Location	Count of Individual Wells			Percent of Wells (Detections vs. Total Wells Sampled)			Total Wells Sampled
	NO_3 (>0 and <22.5 mg/L)	NO_3 (≥22.5 and ≤45 mg/L)	NO_3 (>45 mg/L)	NO_3 (>0 and <22.5 mg/L)	NO_3 (≥22.5 and ≤45 mg/L)	NO_3 (>45 mg/L)	
GQMP Area	747	303	**226**	53%	21%	**16%**	1,415

Table 25. Count of individual wells associated with nitrate exceedances (based on maximum concentrations sampled) from 2009-2013 for the GQMP area relative to SJCDWQC HVA Priority Areas: 1, 2, or 3.
Well, nitrate, and SJCDWQC HVAs priority designation data used here are the same as those data compiled in the GAR. Maximum sample concentrations were analyzed. Exceedances (>45 mg/L). Numbers associated with exceedances are **BOLD.**

Location	Count of Individual Wells within HVA Priority Areas			
	Priority 1	Priority 2	Priority 3	Outside SJCDWQC HVA
GQMP Area	**164**	**17**	**9**	**50**

Figure 97. The High Vulnerability Areas and 2009-2013 nitrate concentrations in the Coalition (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

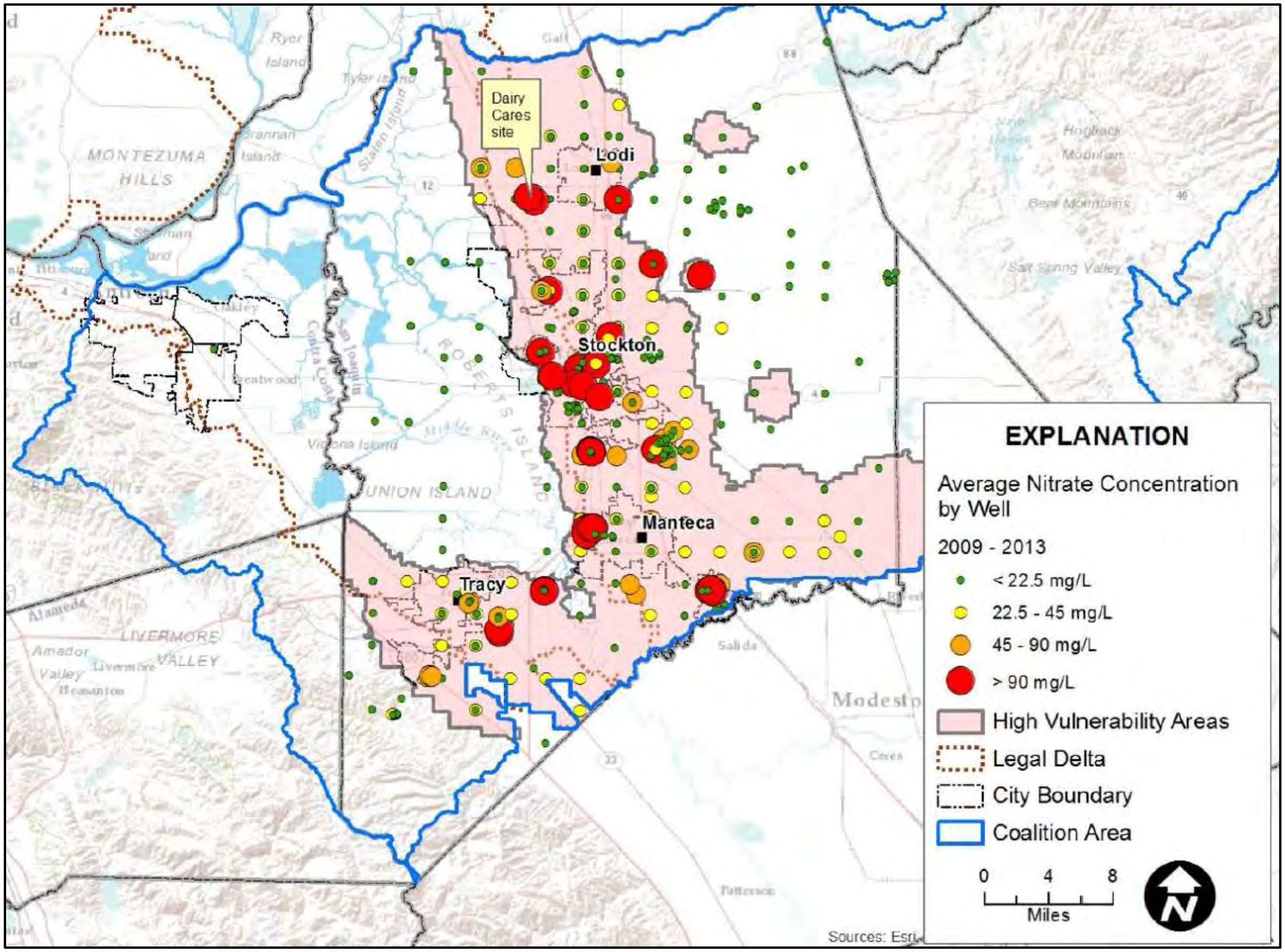
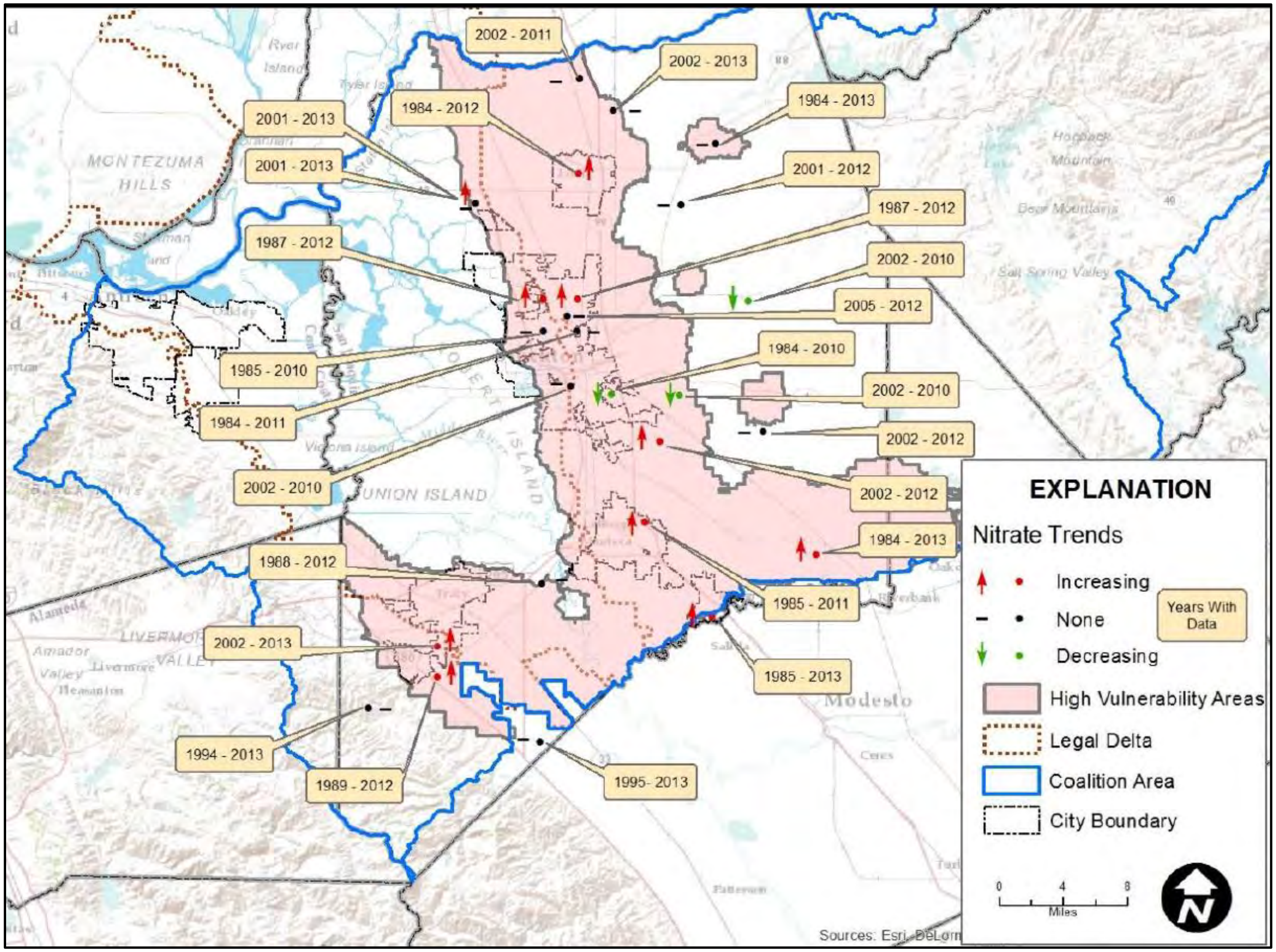


Figure 98. The High Vulnerability Areas and nitrate concentration trends in the Coalition.

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



TDS

Figure 99 and Figure 100 display the locations of TDS concentrations, their observed range of concentrations in groundwater, and temporal trends within the Coalition. The recommended secondary drinking water standard for TDS is 500 mg/L and the upper limit is 1,000 mg/L. According to the GAR, 386 of 423 wells with TDS > 500 mg/L are located in the HVAs, based on average concentrations per well. Per the GAR, many wells with average TDS concentrations above the recommended limit are located in Stockton and Lathrop urban areas, similar to nitrate. There are also wells with average TDS concentrations above the recommended limit on the eastern edge of San Joaquin County and in the Delta on Staten and Roberts islands. All wells with increasing TDS trends are included within the HVAs.

Table 26 and Table 27 describe maximum TDS sample concentrations per well within the GQMP area as compared to the agricultural MCL of 450 mg/L. The analysis below can be considered conservative relative to the secondary MCL for TDS in drinking water of 500 mg/L and more relevant to the needs of agriculture. Table 26 indicates that of those wells sampled in the GQMP area, approximately 61% of sample concentrations exceeded the agricultural MCL of 450 mg/L. Table 27 indicates that of those wells with TDS concentrations exceeding 450 mg/L from 2009-2013, the majority (51%) are located in the Priority 1 area of the SJCDWQC HVA.

Table 26. Count of individual wells associated with (maximum) detections levels of TDS and exceedances of TDS based on the agricultural MCL, from 2009-2013 within the GQMP area.

Well and TDS data used here are the same as those data compiled in the GAR. TDS detections (>0 and ≤450 mg/L) or exceedances of agricultural MCL (>450 mg/L). Maximum sample concentrations were analyzed. Numbers associated with exceedances are **BOLD**. "Percent of wells" calculation equal detections/detections+nondetections.

Location	Count of Wells			Percent of wells sampled with TDS >450 mg/L
	TDS≤450	TDS>450	Total wells	
GQMP Area	274	**431**	705	61%

Table 27. Count of individual wells associated with exceedances of the agricultural MCL for TDS from 2009-2013 for the GQMP area, relative to SJCDWQC HVA Priority Areas 1, 2, or 3.

Well, TDS, and SJCDWQC HVA priority designation data used here are the same as those data compiled in the GAR. Maximum sample concentrations were analyzed. Exceedances of agricultural MCL (>450 mg/L). Numbers associated with exceedances are **BOLD**.

Location	Count of Individual Wells within SJCDWQC HVA Priority Areas			
	Priority 1	Priority 2	Priority 3	Outside HVAs
GQMP Area	**218**	**169**	**9**	**35**

Figure 99. The High Vulnerability Areas and 2009-2013 TDS concentrations in the Coalition (SJCDWQC, 2015).

Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.

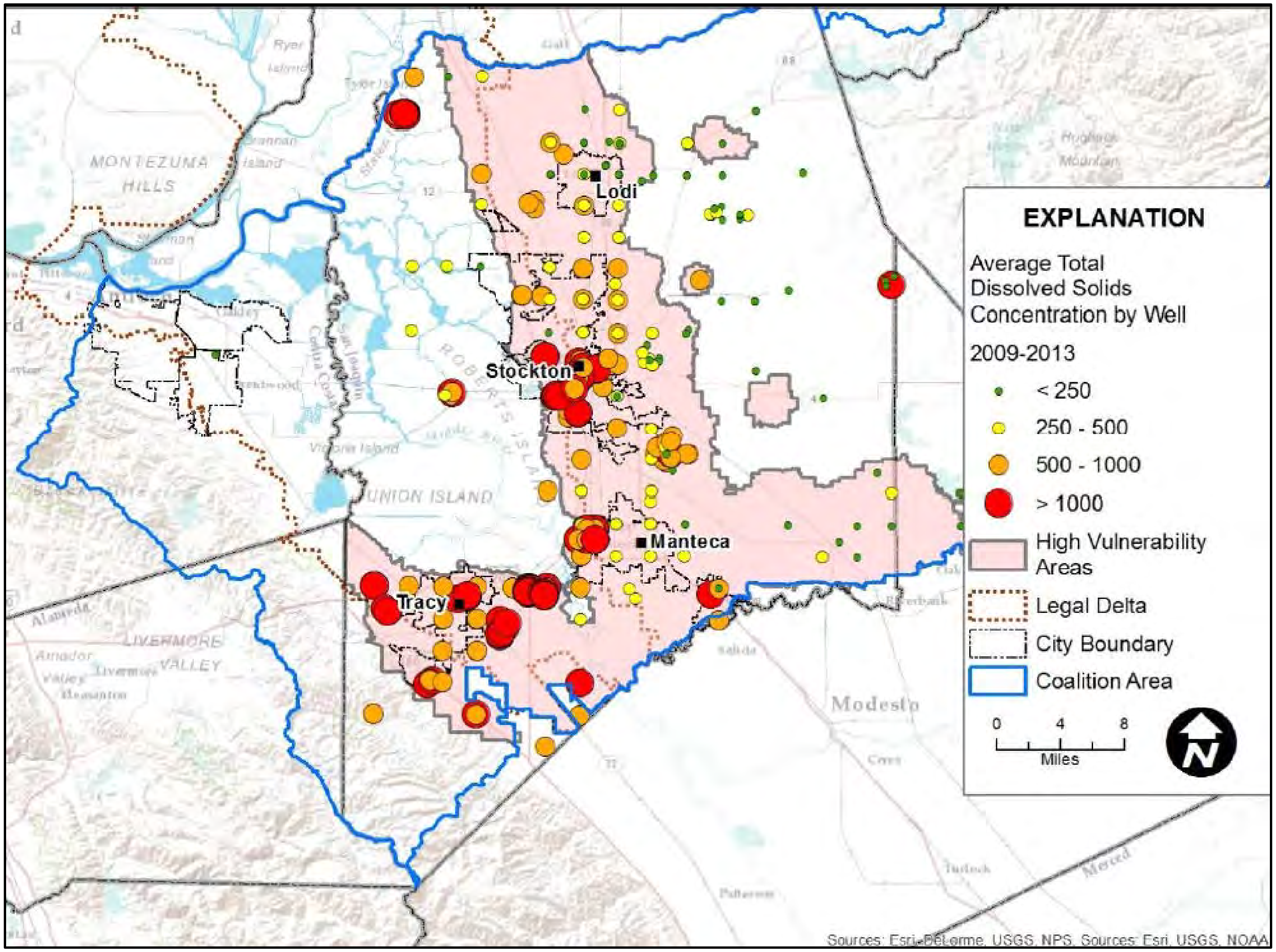
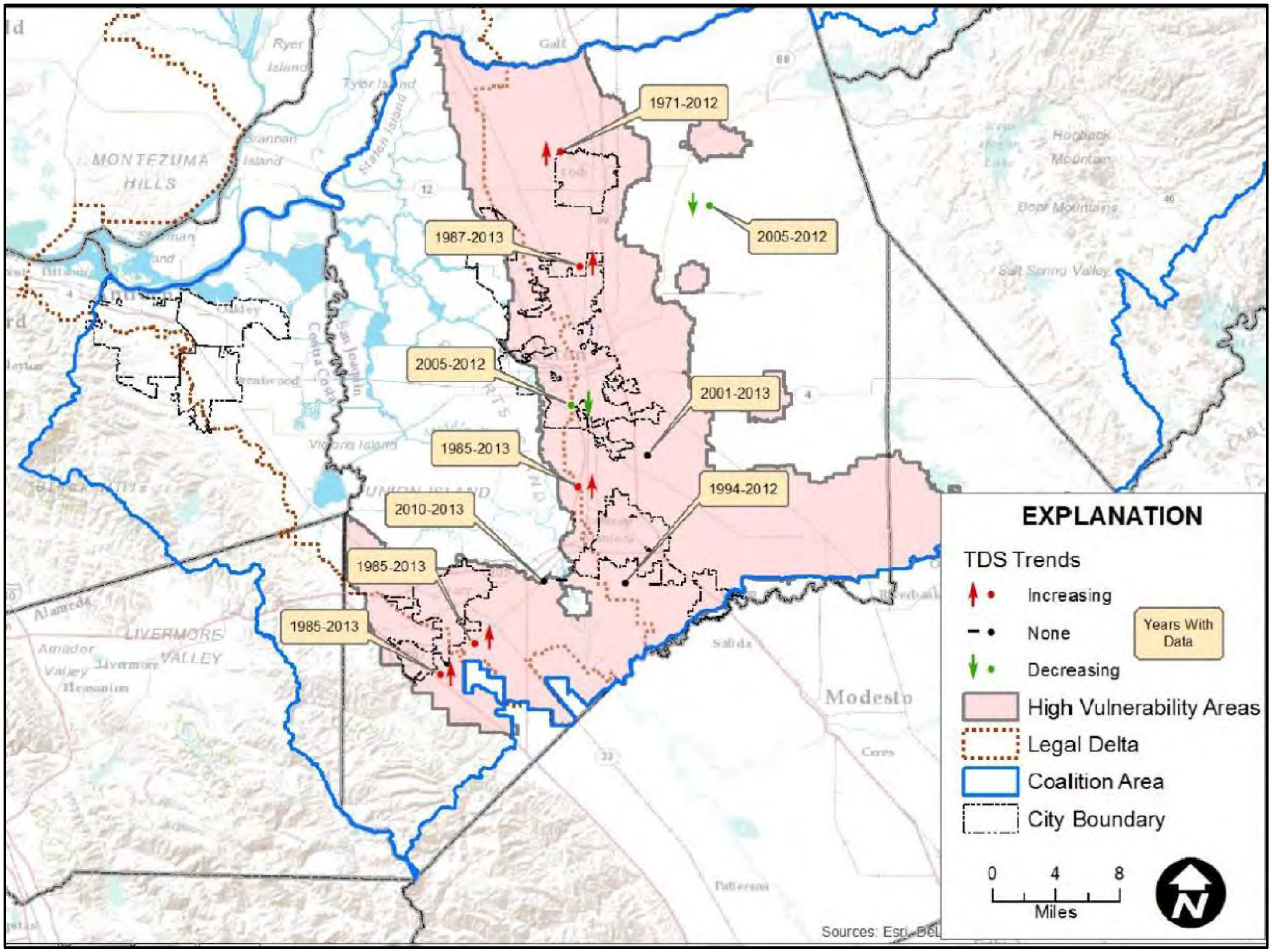


Figure 100. The High Vulnerability Areas and TDS concentration trends from 10 well locations within the Coalition (SJCDWQC, 2015).
Maps provided from the GAR utilized SJCDWQC boundaries from the March 2014 Order, prior to the April 2015 revision. The boundaries of the Coalition listed within the April 2015 Revision of the Order include an expanded southern border, matching the Stanislaus River between the San Joaquin River and the Alpine County line.



Pesticides

Groundwater quality data for wells within the GQMP area indicate there are no elevated levels of currently registered pesticides, i.e. groundwater samples do not contain concentrations of currently registered pesticides which exceed their respective MCLs. Only atrazine and simazine are currently registered for application and use with the DPR, however, these pesticides were found at concentrations below the MCLs. Neither atrazine nor simazine are to be considered COCs for current groundwater quality management purposes as neither detected concentrations exceeded their respective MCLs. Table 28 lists the number of wells with pesticide detections within the GQMP. Atrazine is not included within Table 28 as no data associated with atrazine was included in the data analyzed in the GAR. Atrazine detections are discussed within the USGS analysis of the region (Bennett et al., 2010a). Table 29 illustrates the number of pesticide exceedances per well within the SJCDWQC HVA Priority areas.

Table 28. Count of individual wells with detections of pesticides by well from 2009-2013 within the GQMP area. Well and pesticide data used here are the same as those data compiled in the GAR. Maximum sample concentrations per well were analyzed to determine MCL exceedance. Numbers associated with exceedances are **BOLD**.

Pesticide	Individual Wells					Concentration in Samples with Detections (µg/L)		MCL Used (µg/L)	Basis for MCL
	Detections (>0 µg/L)	Exceedances (> MCL))	Number Sampled	Percent with Detections	Percent with Exceedances	Minimum	Maximum		
DBCP	336	**92**	1,006	33%	**9%**	0.001	50	0.2	CA Primary MCL
EDB	483	**221**	2,339	21%	**9%**	0.0017	2,500	0.05	CA Primary MCL
Simazine	37	0	163	23%	0%	0.006	1	4	CA Primary MCL

Table 29. Count of individual wells with pesticide exceedances relative to SJCDWQC HVA Priority Areas 1, 2, or 3. Well, pesticide, and SJCDWQC HVA priority designation data used here are the same as those data compiled in the GAR. Maximum sample concentrations were analyzed. Numbers associated with exceedances are **BOLD**.

Pesticide	Count of Individual Wells within SJCDWQC HVA Priority Areas			
	Priority 1	Priority 2	Priority 3	Outside HVA
DBCP	**53**	0	**17**	**22**
EDB	**207**	0	**8**	**6**

MANAGEMENT PLAN STRATEGY

DESCRIPTION OF APPROACH

The goal of the SJCDWQC GQMP is to develop a process by which growers are educated about management practices that are protective of groundwater quality, and encourage the implementation of those management practices. To achieve the goal, the SJCDWQC developed four objectives: 1) identify the specific constituents (constituents of concern or COCs) applied by agriculture that impair groundwater quality, 2) identify management practices to prevent/reduce leaching and improve groundwater quality, and 3) document the implementation of those practices, and 4) develop management practice performance goals with a schedule (10 year compliance schedule).

Objective 1: Identify COCs in the GQMP

The SJCDWQC identified COCs based on the analyses of groundwater quality in the Coalition region presented in the GAR and Bennett et al. (2010a). As identified in the GAR and Bennett et al. (2010a), there have been exceedances of water quality objectives for nitrate, TDS, pesticides (DBCP [dibromochloropropane] and ethylene dibromide [EDB]), arsenic, boron, manganese, and iron. Because DBCP and EDB are no longer registered for use in California, these compounds are not included as COCs. Arsenic, boron, manganese, and iron were identified as coming from natural sources (Bennett et al., 2010a) and therefore are not considered COCs. COCs that are related to agriculture for the SJCDWQC region include nitrate and TDS. Table 30 lists the WQTLs for the GQMP COCs.

Table 30. GQMP COC WQTLs.

Constituent	Water Quality Trigger Limit (WQTL)	Standard Type	Beneficial Use (BU) with most protective limit	Reference for the Trigger Limit	Category (see footnotes)
Total Dissolved Solids	450 mg/L	Narrative	Agricultural Supply	Water Quality for Agriculture (Ayers & Westcott)	3
Nitrate as NO_3 Nitrate as N	45 mg/L as NO_3 10 mg/L as N	Numeric	Municipal and Domestic Supply	Sacramento/San Joaquin Basin Plan Chemical Constituents Objective: California Primary MCL	1

Category 1: Constituents that have numeric water quality objectives in the Sac-SJR Basin Plan or other WQO listed by reference such as MCLs (Page III-3.0)*, CTRs (Page III-10.00)*,
Category 3: Constituent does not have numeric WQO, and does not have a primary MCL. WQTL exceedance is based on implementation of narrative objective. All detections should be tracked. None are default exceedances.
MUN-Municipal and Domestic Supply
(*)-Water Quality Control Plan for the Sacramento and San Joaquin River Basins. Revised June 2015.

Objective 2: Identify Management Practices that are Protective of Groundwater

The COCs identified are soluble chemicals that are transported to groundwater with the downward movement of water. Rainfall, irrigation water, unlined irrigation canals, rivers, and streams can result in the movement of nitrate and TDS to groundwater. Other conduits that facilitate the transport of nitrate and TDS to groundwater include direct injection to operational wells lacking a proper backflow device, and improperly abandoned or cased wells. Consequently the Coalition will focus on management practices that address all of these pathways to groundwater. Some of these transport pathways can be addressed immediately (transport through wells lacking backflow prevention, improperly abandoned wells); others will require additional research conducted through the MPEP to fully understand which management practices are most effective in eliminating the movement of nitrate to groundwater.

The Coalition's approach includes outreach about practices that can be implemented immediately and, through the MPEP, conducting studies that will provide crop-specific information on management practices. In the short term, the Coalition will initiate outreach on management practices that the Coalition knows can reduce the movement of nitrates and pesticides to groundwater through wells. The Coalition will focus outreach initially on commodities with large acreage in the HVAs. The Coalition is currently providing members with information about wellhead protection and practices to manage nitrogen applications. In the longer term, the emphasis in the Coalition's outreach will be expanded to include the outcome of the MPEP studies which will provide information on management practices that is specific to crops, soils, and climatic regions within the Coalition region.

Practices involving wellhead protection and prevention of contaminants moving down active or abandoned wells to groundwater include:

- Installation of proper backflow prevention devices
- Maintenance of the area around the wellhead including grading ground away from well
- Good housekeeping practices around wellhead
- Properly abandoning/destroying wells

To guide the outreach to reduce the potential for leaching of nitrate, the Coalition will utilize the 4Rs, right product, right, rate, right time, and right place, to guide its general approach for managing nitrogen. The 4Rs (see below) were developed in the late 1980's at the Potash and Phosphate Institute, which is the predecessor of the International Plant Nutrition Institute (IPNI). Although developed specifically for fertilizers, the 4Rs are also applicable to the management of other soluble constituents.

The 4Rs include right time, right place, right rate, and right source (product):

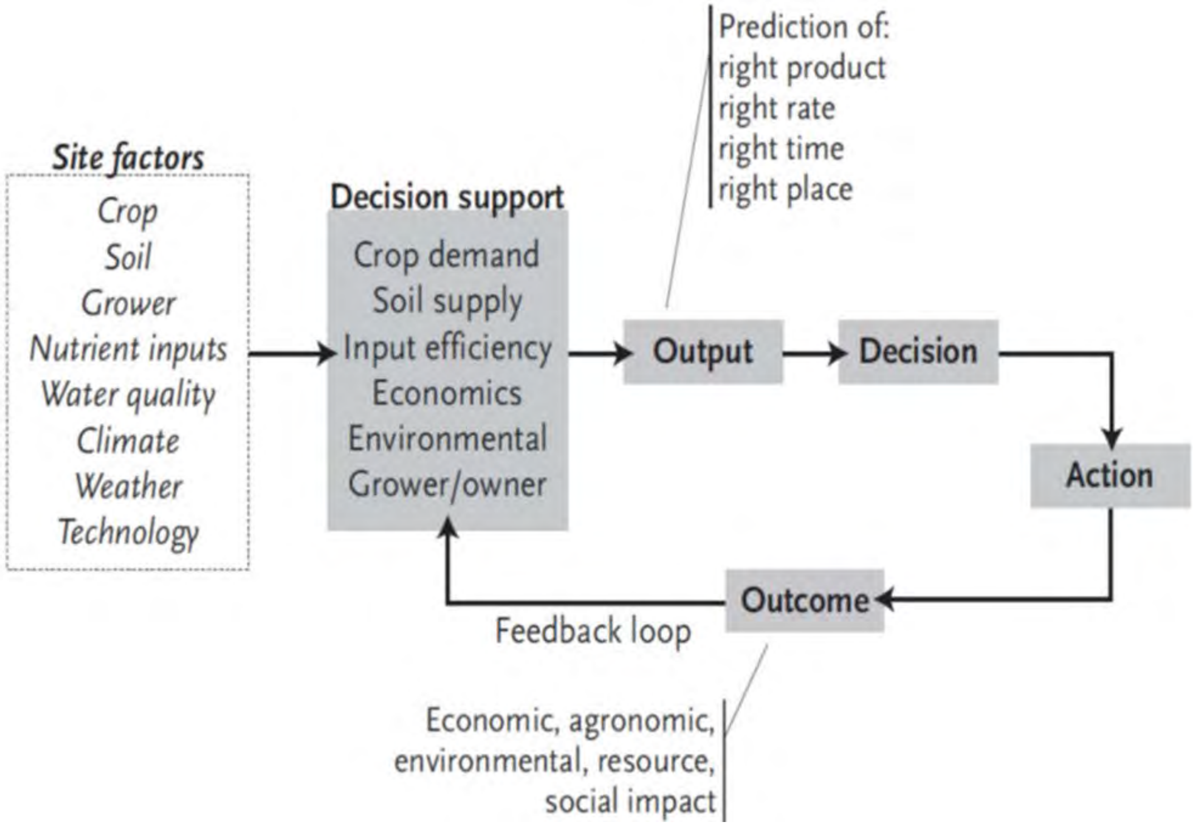
- Right time – nutrients are made available when the plant needs them, can be accomplished by providing when the plant needs them by synchronizing their application with crop demand, properly managing applications e.g. pre-plant or split applications, controlled release technologies, and product stabilizers
- Right rate – match the amount of fertilizer applied to the crop need to reduce losses to leaching or surface water runoff; BMPs include realistic yield goals, soil testing, crop nutrient budgets, tissue testing, plant analysis, applicator calibration, good record keeping and nutrient management plans
- Right place – keep nutrients where the crop can use them. Incorporation or fertigation are usually the best methods of doing this
- Right source (product) – match the fertilizer source and product to crop need and soil properties. Be aware of nutrient interactions and balance nitrogen, phosphorus, potassium, and other nutrients

Many of the basic properties of the 4Rs can be implemented without specific information about the individual crop including actions such as soil testing for residual N, tissue testing, testing of the concentration of nitrate in irrigation water, and developing a nitrogen management plan. However, for more specific management practices associated with the 4Rs, including the right timing of applications, right place (side dress), and right rate (100 lbs/acre vs. 200 lbs/acre), additional studies need to be conducted before the most efficient management practices, including the most optimal nitrogen fertilizer rate, are known for each crop. Developing this information is the purpose of the MPEP.

The Coalition uses the information provided by different state and federal agencies when making recommendations to growers about how to eliminate discharges from their farming operation. Recommended practices include a range of actions from reducing the amount of pesticide applied to installation of pressurized irrigation systems. Some of the management practices are not technically feasible on some crops. Some practices may be technically feasible but for some members, the practices may not be economically feasible. For these members, the Coalition provides information about programs that provide a cost share of the purchase and installation improving the affordability of these systems.

By definition, BMPs are site and crop-specific and vary depending on soils, climate, cropping history, and management expertise. The utility of BMPs depends on a variety of controllable and uncontrollable factors. Uncontrollable factors include light, temperature, moisture, and soil type. Controllable factors include fertilizer, other soil amendments, pesticide applications, tillage, and other cultural practices. Uncontrollable factors introduce uncertainty into the system which can make management of nutrients difficult. Only when controllable factors are truly controlled and uncontrollable factors are measured can reliable information on the efficacy of management practices be generated. Once the information is developed, it can be used as part of a larger decision support system (DSS) to guide the selection and implementation of appropriate management practices. An example of a DSS developed by IPNI is provided in Figure 101. The Coalition will use this general framework for communicating with growers about implementing fertilizer BMPs.

Figure 101. Decision support system for adaptive management of nutrient inputs to irrigated crops. Adapted from Fixen (2005).



Objective 3: Document the Implementation of Management Practices

The Coalition will utilize Farm Evaluation Plans returned annually by growers within HVAs to determine changes in management practices that are relevant to groundwater protection. The practices include wellhead protection, irrigation management, and nitrogen management. The SJCDWQC will first focus on changes in practices within the prioritized HVAs where additional management practices will be encouraged during crop specific meetings focused on nitrogen management.

Growers within HVAs will be prioritized for additional outreach based on crop and information obtained on their Nitrogen Management Plan (NMP) Summary Report. Members growing crops with the largest amount of nitrogen applications (pounds applied per acre compared to other crops) as well as crops with the greatest acreage within the HVAs will be the highest priority. Members will be identified after the first NMP Summary Reports are returned to the Coalition in June 2016. The Coalition will review the information on applied nitrogen from the NMP Summary Reports and determine statistical outliers of the reported Applied N / Yield and Applied N / Removed (when it is possible to calculate N removed) ratios for the same crop grown on similar soils. Growers in HVAs with high priority crops that appear as A/Y outliers will be the first to receive outreach regarding nitrogen management practices specific to their crop. These grower meetings will be planned with crop experts and discuss current knowledge regarding the 4Rs with the goal of implementing additional practices to reduce the risk of nitrogen leaching to groundwater. Crop specific nitrogen removed information will also be discussed.

The most recent Farm Evaluation Surveys will be used to determine current irrigation and nitrogen management practices used by these growers. At the end of these meetings, the growers will be surveyed to determine which additional practices will be implemented based on the information presented at the meeting. Additional practices may be crop specific and not necessarily on the Farm Evaluation Survey template. In the following years, the amount of nitrogen and the A/Y ratio will be tracked by the Coalition to determine if the amount of nitrogen applied is reduced for these high priority crops.

Objective 4: Develop Management Practice Performance Goals and Compliance Schedule

The Coalition's Performance Goals are built on actions essential for successful completion of the Management Plan strategy. The Performance Goals reflect the steps necessary to guarantee that the objectives of the Management Plan program are met and that groundwater quality improves in the SJCDWQC region.

The following section describes the Performance Measures associated with each Performance Goal (Table 31). These Performance Measures are the actions the Coalition will perform to meet the Performance Goals. Included in the table of Performance Goals and Performance Measures are the parties responsible for performing the actions described by the Performance Measures.

Performance Goal 1. Identify member parcels in HVAs.

Performance Measures

1.1 Map parcels of members in HVAs.

The SJCDWQC will review member parcels in relation to the most recent groundwater high vulnerability areas and trend monitoring results (if applicable). This information will be used to identify member acreage within the SJCDWQC GQMP area and will be reported on in the annual Management Plan Progress Report.

Performance Goal 2. Review the members' Farm Evaluations (FEs) to determine number/type of well management practices in place.

Performance Measures

2.1 Review FEs from 100% of member parcels in HVAs to identify management practices associated with wells.

2.2 Identify well management practices not currently used by members that can be recommended to prevent discharges to groundwater.

The FE is completed by all members in high vulnerability regions annually. The Coalition will review these submissions to determine what practices are in place on member farming operations in regards to well management practices. The Coalition will review well management practice responses and conduct outreach and education about additional practices that should be implemented to prevent discharges to groundwater through wells. The Coalition will report on well management practices and additional recommended practices in the Management Plan Progress Report.

Performance Goal 3. Review the members' Farm Evaluations (FEs) to determine number/type of irrigation and nitrogen management practices in place.

Performance Measures

3.1 Review FE from 100% of member parcels in GQMP for irrigation, pesticide and nitrate management practices.

3.2 Identify management practices not currently used by members that can be recommended to prevent discharges to groundwater based on MPEP study results.

Irrigation, pesticide and nitrate management practices will be recorded annually in an Access database to track changes in member management practices over time. As the MPEP studies are conducted, the results will be communicated to members within the Coalition as effective management practices to reduce the potential for discharging nitrogen to the groundwater. The Management Plan Progress Report will identify management practices that have been identified by the Coalition (either through the MPEP or other resources) to be effective in reducing the potential for leaching of pesticides, nitrates and salts.

Performance Goal 4. Conduct outreach to inform members of water quality problems and recommend additional practices.

Performance Measures

4.1 Provide groundwater monitoring results at meetings with members and discuss practices that can be used to reduce leaching of COCs to groundwater.

4.2 When available and appropriate, provide information to members on the results of the MPEP.

4.3 Track attendance at meetings attended by the targeted members.

The Coalition conducts a series of Annual Meetings in addition to various meetings throughout the year. Results of groundwater monitoring will be discussed with members at Coalition meetings as well as the various management practices that can be implemented to reduce the leaching of COCs to groundwater. As results of the MPEP studies become available, the Coalition will present this information to its members in addition to having the information available on its website. Attendance will be tracked at meetings to ensure that members within groundwater high vulnerability zones attend these meetings and are informed of current groundwater quality conditions.

Performance Goal 5. Improve understanding of effective management practices to reduce potential for leaching of COCs.

Performance Measures

5.1 Identify high priority crops.

5.2 Conduct studies through the MPEP to help fill data gaps regarding management practice effectiveness.

5.3 Create online resources regarding MPEP study results and information regarding the 4Rs.

The Coalition will identify high priority crops and use NMP TAWG work products to help close the data gaps that will improve the understanding the effectiveness of nitrogen management practices. This information will be summarized in the Management Plan Progress Report and disseminated to members. The MPEP studies will further assist with filling in data gaps identified through the NMP

Technical Advisory Work Group as well as better understand the efficacy of many of the practices currently being implemented by SJCDWQC members. The Coalition will participate in the MPEP planning process including study design implementation and working with participating members to conduct the studies. The Coalition anticipates that online resources will be necessary to disseminate the results of the MPEP studies, and other nitrogen management studies. The SJCDWQC will post resources on the SJCDWQC website including links to existing webpages with pertinent information regarding nitrogen and irrigation management.

Performance Goal 6. Improve understanding of effective management practices to reduce potential for leaching of COCs.

Performance Measure

6.1 Evaluate monitoring results from the Groundwater Trend Monitoring Program.

Once the Groundwater Trend Monitoring Program is initiated, the Coalition will review the results annually in its Management Plan Progress Report and adjust the COCs in HVAs as needed. The results will be reviewed in relation to changes in management practices as documented in the FEs as well as changes in nitrogen applications as recorded in the NMP Summary Reports.

Table 31. Performance Goals for the SJCDWQC GQMP.

Performance Goal/Performance Measure	Outputs	Who
Performance Goal 1: Identify member parcels in areas requiring a GQMP.		
Performance Measure 1.1. – Map parcels of members in HVAs.	Report in Management Plan Progress Report the acreage represented by members in HVAs.	MLJ-LLC
Performance Goal 2: Review the member's Farm Evaluation (FE) to determine number/type of well management practices in place.		
Performance Measure 2.1 – Review FE from 100% of member parcels in a GWMP for well management practices.	Completed individual management practice evaluations recorded in an Access database.	MLJ-LLC
Performance Measure 2.2 – Identify well management practices not currently used by members that can be recommended to prevent discharges to groundwater.	Summary in the Management Plan Progress Report of management practices recommended to members.	Mike Wackman/MLJ-LLC
Performance Goal 3: Review the member's Farm Evaluation (FE) to determine number/type of irrigation, pesticide and nitrate management practices in place.		
Performance Measure 3.1 – Review FE from 100% of member parcels in a GWMP for irrigation, pesticide and nitrate management practices.	Completed individual management practice evaluations recorded in an Access database.	MLJ-LLC
Performance Measure 3.2 – Identify management practices not currently used by members that can be recommended to prevent discharges to groundwater based on MPEP study results.	Summary in the Management Plan Progress Report of management practices identified as reducing the potential for leaching pesticides, nitrates and salts.	Mike Wackman/MLJ-LLC
Performance Goal 4: Conduct outreach to inform members of water quality problems and recommend additional practices.		
Performance Measure 4.1 – Provide groundwater monitoring results at meetings with members, and discuss practices that can be used to reduce leaching of COCs to groundwater.	Agendas and/or reports of all meetings with members.	Mike Wackman/MLJ-LLC
Performance Measure 4.2 – When available and appropriate, provide information to members on the results of the MPEP.	Provide reports from studies through meetings and the SJCDWQC website.	Mike Wackman
Performance Measure 4.3 - Track attendance at meetings	Report of members attending meetings provided in	Mike

Performance Goal/Performance Measure	Outputs	Who
attended by the targeted members.	Management Plan Progress Report.	Wackman/MLJ-LLC
Performance Goal 5: Improve understanding of effective management practices to reduce potential for leaching of COCs.		
Performance Measure 5.1 – Identify high priority crops in HVAs.	Include conclusions from NMP TAC in Management Plan Progress Report.	MLJ-LLC
Performance Measure 5.2 – Conduct studies through the MPEP to help fill data gaps regarding management practice effectiveness.	Participate in the MPEP including study design implementation.	MLJ-LLC
Performance Measure 5.3 – Create online resources regarding MPEP study results and information regarding the 4Rs.	Post resources on the SJCDWQC website.	Mike Wackman/MLJ-LLC
Performance Goal 6: Evaluate effectiveness of new management practices.		
Performance Measure 6.1 – Evaluate monitoring results from the Groundwater Trend Monitoring Program for COCs.	Assess results in Management Plan Progress Report.	MLJ-LLC
Performance Measure 6.2 – Compare annually changes in well, irrigation, pesticide and nitrate management practices recorded on FEs.	Evaluate changes in Management Plan Progress Report.	MLJ-LLC
Performance Measure 6.3 – Evaluate trends in groundwater quality every 5 years in the GAR.	Trend analysis of COCs in GAR.	HydroFocus, Inc.

Specific Schedule and Milestones for Implementing Management Practices

Each year the Coalition will evaluate and report on the management practices implemented the previous year by members within GQMP. During the year the Coalition will conduct outreach and education to members regarding effective management practices that can be implemented to reduce the transport of COCs to groundwater. As data gaps regarding the 4Rs for specific crops are decreased, this information will be included in the Coalition's outreach and education efforts. The following milestones were developed based on this strategy and supplemented with target dates based on the objectives of this GQMP.

Milestone 1: Within 2 years of the approved GQMP, additional management practices will be implemented by members in high vulnerability areas especially regarding well management and nitrogen management (Target Date – 2018).

Milestone 2: Within 5 years of the initiation of the MPEP studies, identify a schedule for implementation of practices identified as effective by the MPEP (Target Date – 2020).

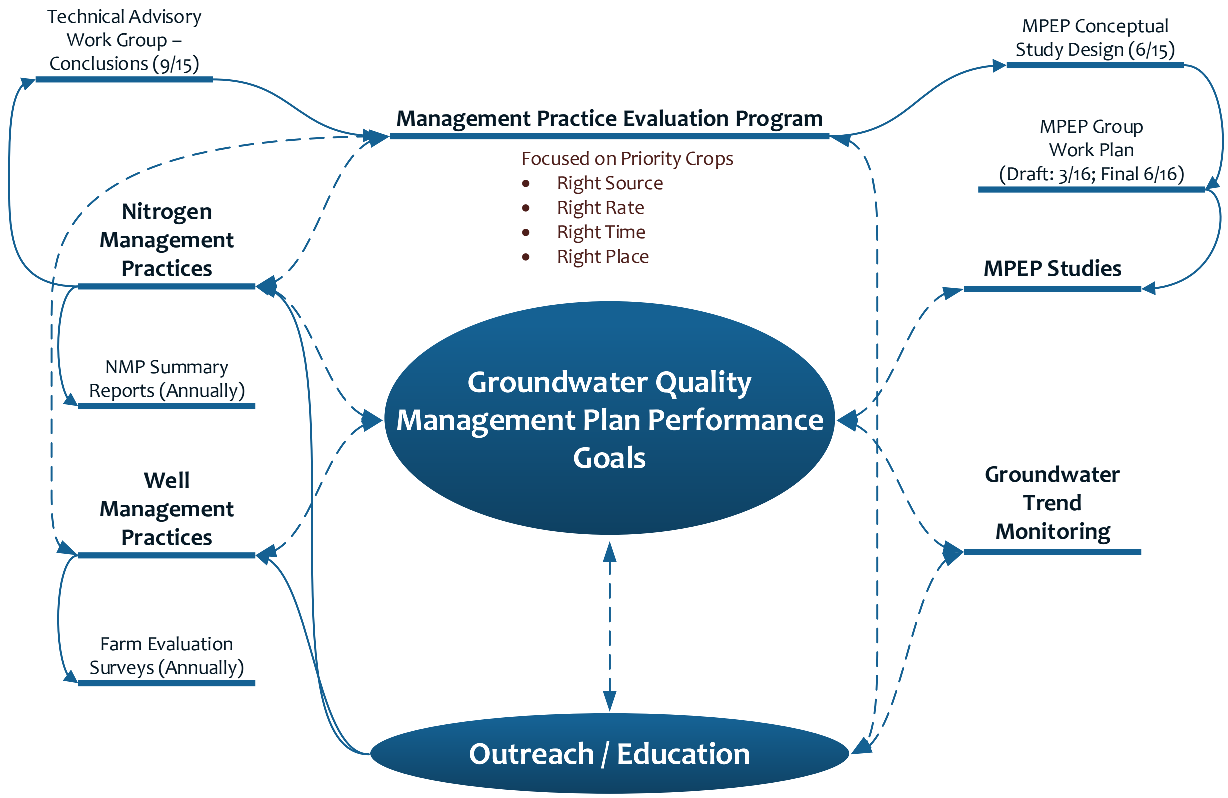
Milestone 3: Within 5 years, demonstrate a reduction in the amount of nitrogen applied per irrigated acre in the Coalition region.

Milestone 4: Within 10 years of conducting Groundwater Quality Trend Monitoring, show a reduction of the amount of nitrate being discharged to groundwater by irrigated agriculture.

MANAGEMENT PLAN EFFECTIVENESS

The Coalition will evaluate the effectiveness of the GQMP strategy by 1) documenting management practices implemented by members, and 2) assessing groundwater quality improvements using monitoring data (Figure 102).

Figure 102. Conceptual diagram of the GQMP strategy to evaluation effectiveness. MPEP refers to the due dates of the Northern Coalitions MPEP Group.



Tracking of Management Practices

Completion and submission of Farm Evaluations (FEs) is required of members. The purpose of the FEs is to report the management practices implemented on their farming operation. For practices relevant to groundwater, the FE provides information on wellhead protection, irrigation practices, and nitrogen applications. Growers in HVAs will submit a NMP Summary Report annually starting in 2016 which will include crop, amount of nitrogen applied and a ratio of the amount applied divided by the crop yield (A/Y) for the previous crop harvest year.

The Coalition will evaluate changes in practices that protect groundwater quality from the FEs, practices recorded after additional outreach, amount of nitrogen applied and A/Y for crops within HVAs. It is expected that with each year additional practices will be implemented especially among members who attend crop specific nitrogen management outreach events. As a result of implemented practices, it is expected that over time the average amount of nitrogen applied (by crop) and the A/Y ratios (by crop) will decrease.

Tracking of Groundwater Quality

Changes in groundwater quality, even first encountered groundwater which may be shallow, are very difficult to affect for several reasons including infiltration rate, depth to groundwater, seasonal variation in groundwater quality and depth, yearly variation in recharge due to changes in weather (drought years vs. above normal rainfall years), volume of the aquifer, flow rate and path, and the spatial and temporal sample sizes (potentially years) needed to demonstrate a trend. However, the Coalition's Trend Monitoring Program will generate groundwater quality data that can be used to evaluate groundwater quality for COCs over an extended period of time. Even in shallow groundwater, reductions in nitrate concentration may not be measureable for many years. The nitrate in the vadose zone may take several years to reach groundwater, and the volume of groundwater and concentration of nitrate in that groundwater may make any improvement difficult to document. Consequently, the first few years of monitoring will establish a baseline from which future trends can be determined. Future improvement can be linked to implementation of management practices as reported in the FEs and NMPs. The time needed to demonstrate improvements in groundwater quality is expected to vary across the Coalition region and therefore it is not known how long it will take to detect trends in groundwater quality.

ACTIONS TO MEET GOALS AND OBJECTIVES

The Coalition conducts outreach meetings regularly throughout the year in the Coalition region. At these meetings, Coalition monitoring results including exceedances of water quality objectives are discussed as well as management practices that can be implemented to reduce surface water runoff, sediment discharge, and leaching of COCs to groundwater. These practices include but are not limited to wellhead protection, irrigation system maintenance and calibration, and nitrogen management planning.

In addition to the outreach meetings, the Coalition will organize crop specific meetings lead by nitrogen management crop experts to discuss the 4R strategy, recent research and current understanding of N removed.

The MPEP will provide substantial information that can be provided to growers about crop-specific management practices. The Coalition will provide information to growers of specific commodities at meetings in the Coalition region focused on conclusions from the MPEP studies. The Coalition will work with the MPEP Group to secure funding for studies on priority crops in HVAs as well as funds for creating additional outreach materials and tools that can be utilized by members to assist with nitrogen application planning relative to the 4Rs.

DUTIES AND RESPONSIBILITIES

The responsible parties are provided in organizational chart provided below (Figure 103).

SJCDWQC policy is determined by the San Joaquin County Resource Conservation District Board of Directors (SJC RCD). The SJC RCD Board of Directors (BOD) also oversees all Coalition business. The BOD works closely with the Executive Director to ensure effective management of Coalition activities. Mike Wackman is the Executive Director of the SJCDWQC and the project lead for management plan activities. Mr. Wackman is responsible for implementing policy as directed by the BOD including budgeting and financial management, management of the Coalition's membership, member outreach, oversight of consultant contracts, and management of consultant work products. Technical consultants are contracted by the Coalition as needed to complete tasks and activities required by the Regional Water Board. Currently, the technical consultants to the SJCDWQC are Michael L. Johnson, LLC and HydroFocus, Inc. Michael L. Johnson, LLC (MLJ-LLC) will be responsible for conducting the groundwater monitoring and reporting program. It is anticipated that HydroFocus, Inc. will be responsible for developing the Groundwater Trend Monitoring Report, updating the GAR every 5 years and providing technical support for groundwater issues.

Coalition Contact Information

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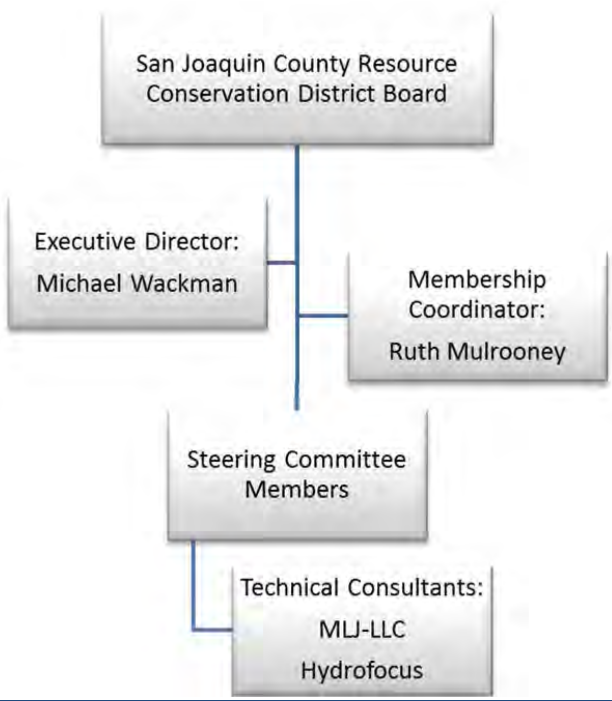
Figure 103. Identification key of responsible parties involved in major aspects of the comprehensive GQMP.



STRATEGIES TO IMPLEMENT MANAGEMENT PLAN

Agencies Contacted for Data and/or Assistance

The Coalition receives input from the NRCS in Stockton regarding county wide NRCS assistance to growers to implement new management practices. The Coalition encourages members to apply for NRCS funds to implement structural BMPs.

The Coalition is participating in a joint effort with four other coalitions to conduct MPEP studies. Other coalitions participating are the Sacramento Valley Water Quality Coalition, the East San Joaquin Water Quality Coalition, the Westside San Joaquin River Watershed Coalition, and the Westlands Water Quality Coalition. The Coalitions have met and developed an administrative structure to manage the MPEP studies, and have convened a technical advisory group consisting of several representatives from UC Cooperative Extension (UCCE), the fertilizer industry, and commodity groups. The Coalitions selected CURES as the administrative contractor and are proceeding with developing a work plan for MPEP studies.

In addition, several Coalitions obtained a grant from CDFA to develop a nitrogen/irrigation management curriculum that will allow members who successfully complete the course and certify their Nitrogen Management Plans. The curriculum received input from UCCE and CDFA, and has been approved by CDFA and the Executive Officer. Classes are currently being provided to growers in the Coalition region.

The Central Valley Salinity Alternatives for Long Term Solutions (CV-SALTS) process and the Central Valley Salinity Coalition are in the process of developing a Salt and Nutrient Management Plan (SNMP) for salt and nitrate. This SNMP will include implementation options that may result in the use of specific management practices in some or the entire Coalition region. The CV SALTS process is anticipated to be completed by 2017 and when that BPA is finalized, the Coalition will re-evaluate its GQMP to determine its compatibility with the requirements of the BPA and the SNMP(s) developed for the Coalition region.

Outreach Methods

Meetings in the Coalition region are typically held each year in conjunction with meetings of the Agricultural Commissioners. Additional meetings can be called at any time during the year if circumstances warrant. At these meetings, the Coalition discusses the water quality results for the year, new management plans that are developed to improve water quality, and any changes in member reporting requirements due to updates of the WDR by the Regional Water Board.

Meetings targeting growers of specific commodities in a smaller geographic area are held periodically. These meetings are arranged as needed and can involve the participation of individuals with specialized training, e.g. NRCS or UC Extension personnel. If the Coalition determines that meeting with a subgroup of members within the HVAs will provide information that can lead to increased implementation of practices known to be protective of groundwater quality, the Coalition will organize a meeting with the appropriate members.

The Coalition hosts a website (http://www.sjdeltawatershed.org/), which serves as a clearing house for Coalition activities and outreach on management practices. Information provided through the website is utilized as a supplement to regular grower contacts and meetings. All outreach and education activities are reported in the SJCDWQC Annual Report submitted by May 1 of each year.

MONITORING METHODS

MONITORING DESIGN

The Coalition's groundwater monitoring strategy is currently being developed through the Groundwater Trend Monitoring Program and the Management Practices Evaluation Program. The Groundwater Trend Monitoring Program Work Plan will be submitted on December 18, 2016, one year after the approval of the SJCDWQC by the Regional Water Board, and will include a comprehensive monitoring program for groundwater quality. In addition, the MPEP will develop several studies of management practices to determine if they are protective of groundwater. The SJCDWQC submitted a conceptual work plan on June 4, 2015 as part of the MPEP Group Coordination Committee (MPEP GCC). The Coalition will submit the final work plan either on June 4, 2016, as part of the MPEP GCC plan or independently by December 18, 2016, as stipulated by the conditional approval of the GAR on December 18, 2015.

Minimum Groundwater Monitoring Requirements

According to the WDR, "Trend monitoring wells will be sampled, at a minimum, annually at the same time of the year for the indicator parameters identified in (Table 32) below."

Table 32. Groundwater monitoring parameters (Order R5-2014-0029-R1, Attachment B, pg. 21).

Constituents, Parameters, and Tests	
Annual Monitoring	
Dissolved Oxygen* (mg/L)	Physical Parameters and General Chemistry
Electrical Conductivity* (μmhos/cm)	
pH* (in pH units)	
Temperature* (˚C)	
Nitrate* as nitrogen (mg/L)	
Trend Monitoring	
Total Dissolved Solids (SC, field measure)	Physical Parameters and General Chemistry
Carbonate	Anions
Bicarbonate	
Chloride	
Sulfate	
Boron	Cations
Calcium	
Sodium	
Magnesium	
Potassium	

*Field parameters

DATA EVALUATION

INFORMATION NEEDED TO QUANTIFY PROGRAM EFFECTIVENESS

To quantify management plan program effectiveness, there are several types of data that will be collected by the Coalition over the next year including:

- Management practices used by members in high vulnerability regions,
- Management practices recommended to growers for implementation in the future, and
- Recommended management practices actually implemented by members.

RECORDS AND REPORTING

The Coalition will submit an annual Groundwater Management Plan Progress Report as part of the Annual Monitoring Report (submitted May 1 annually). The Groundwater Management Plan Progress Report will contain the 13 components listed in Appendix MRP-1 of the WDR:

1) Title page
2) Table of contents
3) Executive summary
4) Location map(s) and a brief summary of management plans covered by the report
5) Updated table that tallies all exceedances for the management plans
6) A list of new management plans triggered since the previous report
7) Progress update on preparation of new management plan monitoring data collected during the reporting period
8) A summary of management plan grower outreach conducted
9) A summary of the degree of implementation of management practices
10) Results from evaluation of management practice goals and schedules
11) Any recommendations for changes to the management plan

All reports are submitted electronically and shapefiles are either submitted with the reports, or available upon request.

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