Western San Joaquin River Watershed
Groundwater Quality Management Plan

September 2016

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

in conjunction with

SEI
Summers Engineering, Inc
Since 1962

Western San Joaquin River Watershed

Comprehensive Groundwater Quality Management Plan

September 2016

Prepared for

SAN JOAQUIN VALLEY DRAINAGE AUTHORITY

On Behalf of

Westside San Joaquin River Watershed Coalition

Prepared by

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

in conjunction with

SEI Summers Engineering, Inc Since 1962

Vicki Kretsinger
Senior Principal Hydrologist

Nicholas Watterson, P.G.
Senior Hydrogeologist

Sept. 8, 2016

Debra Cannon, P.G.
Senior Hydrogeologist

Sept. 8, 2016

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LIST OF ABBREVIATIONS AND ACRONYMS

Coalition	Westside San Joaquin River Watershed Coalition
COC	Constituents of concern
DWR	California Department of Water Resources
EC	electrical conductivity
FE	Farm evaluation
GAMA	Groundwater Ambient Monitoring Assessment program
GAR	Groundwater Quality Assessment Report
ILRP	Irrigated Lands Regulatory Program
Lower Aquifer	Lower confined zone
LSCE	Luhdorff & Scalmanini, Consulting Engineers, Inc.
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MRP	Monitoring and Reporting Program
NMP	Nitrogen Management Plan
NRCS	Natural Resource Conservation Service
PLSS	Public Land Survey System
QA/QC	Quality Assurance/Quality Control
Regional Board	Central Valley Regional Water Quality Control Board
RWQCB	Central Valley Regional Water Quality Control Board
SMCL	Secondary MCL
SJVDA	San Joaquin Valley Drainage Authority
TDS	total dissolved solids
Upper Aquifer	Upper semi-confined zone
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
Watershed	Western San Joaquin River Watershed
WDRs	Waste Discharge Requirements under General Order R5-2014-0002
Westside Coalition	Westside San Joaquin River Watershed Coalition

1 INTRODUCTION

This Comprehensive Groundwater Quality Management Plan (GQMP) has been prepared on behalf of the Westside San Joaquin River Watershed Coalition (Westside Coalition, or Coalition). The Westside Coalition serves as the third-party group for the growers within the Western San Joaquin River Watershed. The Waste Discharge Requirements (WDRs) under General Order R5-2014-0002, which apply to growers within the Western San Joaquin River Watershed, were adopted by the Central Valley Regional Water Quality Control Board (RWQCB, or Regional Board) on January 9, 2014. The extent of the Westside Coalition region is the same as the boundary of the Western San Joaquin River Watershed, as identified in the WDRs and provided in spatial data available from the RWQCB.

1.1 Background

California is known for the wide range of agricultural commodities the state produces and distributes worldwide. In 2003, the Irrigated Lands Program (ILP) was initiated to regulate discharges from irrigated agriculture to surface waters. Upon the adoption of the Conditional Waiver of Waste Discharge Requirements for discharges from irrigated lands, the ILP became known as the Irrigated Lands Regulatory Program (ILRP). An expansion of the ILRP, the Long-Term Irrigated Lands Regulatory Program has been developed to protect both surface water and groundwater.

The RWQCB has coordinated with growers to encourage them to combine resources by forming water quality coalitions. Currently, there are 14[1] coalition groups that work directly with their member growers to assist in complying with RWQCB requirements. Of the estimated 35,000 growers in the Central Valley, there are about 25,000 landowners / operators[2] who are part of one of these 14 coalition groups. The Westside Coalition is one of the 14 coalition groups.

1.1.1 Westside San Joaquin River Watershed Coalition

The Westside Coalition (**Figure 1-1**) serves as the third-party group for the growers within the Western San Joaquin River Watershed (Watershed) (**Figure 1-1**), although some growers in the area may elect to be regulated as individuals. The Watershed area covers a total area of 1,270,835 acres, including approximately 389,692 acres of irrigated cropland, 20,652 acres of idle cropland, and 881,143 acres of non-irrigated or non-agricultural land. Managed wetlands are also located in the Watershed area, including a combination of State wildlife areas and Federal wildlife refuges, as well as privately owned wetlands. These lands are managed to provide important habitat for waterfowl and shorebirds and provide recreational opportunities for bird enthusiasts, hunters, and other activities.

[1] There are 14 Coalition groups shown for the Central Valley, Region 5; http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/app_approval/index.shtml, accessed October 13, 2015.

[2] This number is included in the RWQCB ILRP Frequently Asked Questions as of November 2013; the number of enrolled growers has increased since that time.

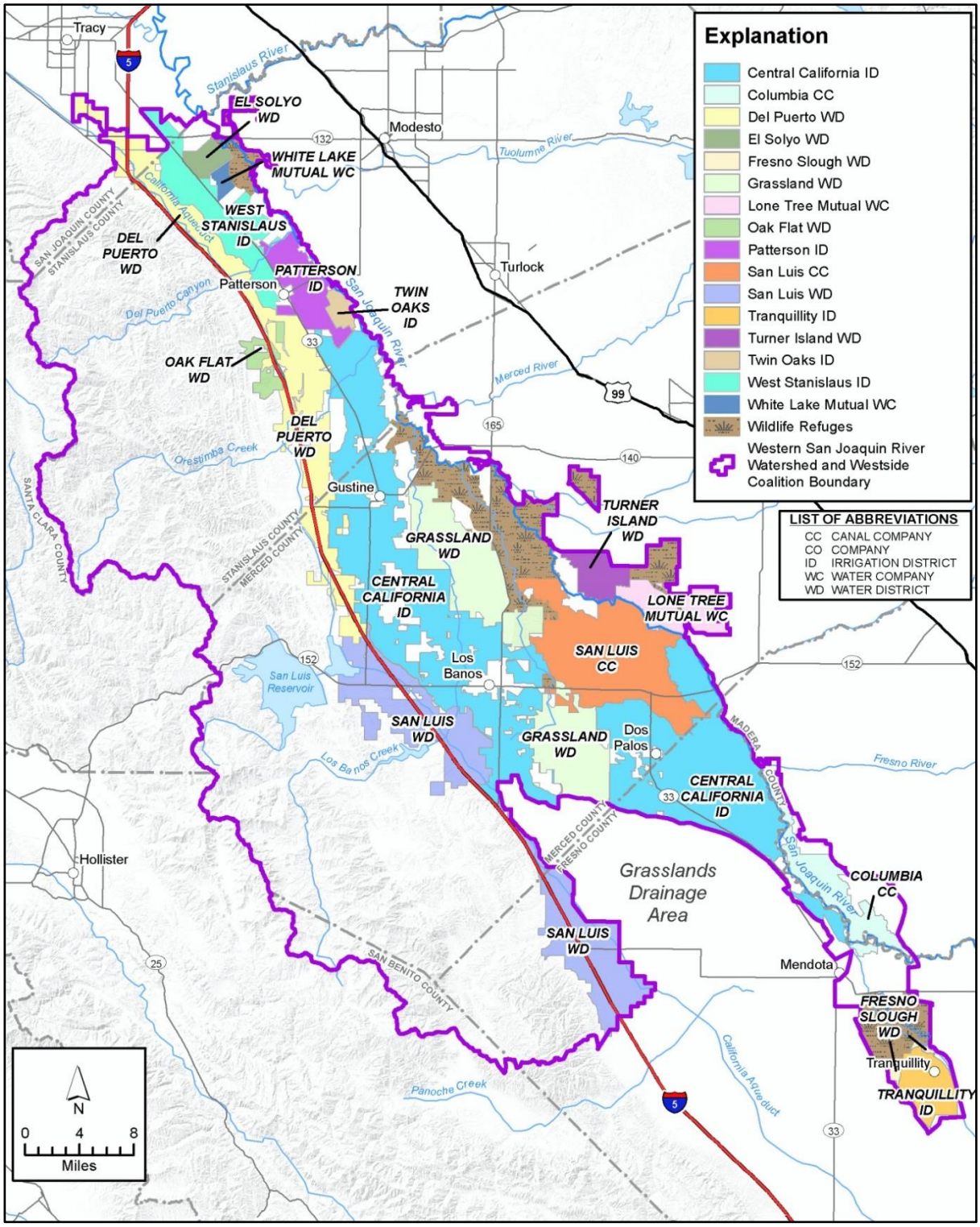


Figure 1-1 Westside San Joaquin River Watershed Coalition member entities

The Westside Coalition WDRs indicate that nearly all of the irrigated acreage is currently regulated under the Coalition Group Conditional Waiver; however, it is anticipated that some additional irrigated

acres will require regulatory coverage under Order R5-2014-0002 or other WDRs or waivers. The WDRs define Small Farming Operations as those growers with a total farming operation of fewer than 60 acres of irrigated land. In counties within the Watershed, Small Farming Operations represent approximately 63 percent of the growers, but account for approximately 6 percent of the total irrigated lands.

1.1.2 Waste Discharge Requirements and Monitoring and Reporting Program

The WDR concluded that available information indicates irrigated lands could cause or contribute to an exceedance of water quality objectives or degradation of groundwater quality that may threaten applicable beneficial uses (WDR, Attachment A, pg. 10). Following the Regional Board's adoption of the WDRs on January 9, 2014, the Notice of Applicability (NOA) was approved on March 17, 2014. The approval date associated with the NOA started the timeline for several requirements, including the Groundwater Quality Assessment Report (GAR). The due date for the GAR was set at one calendar year after approval of the NOA, which for the Westside Coalition was March 17, 2015. The Westside Coalition submitted the GAR outline to the Regional Board on June 13, 2014 and received approval on September 19, 2014. The GAR was submitted on March 16, 2015 and received final approval from the Regional Board Executive Officer on September 16, 2015. The GAR identifies high vulnerability groundwater areas where a Groundwater Quality Management Plan must be developed and implemented.

1.2 Purpose of Groundwater Quality Management Plan (GQMP)

The GQMP is triggered when water quality objectives are exceeded, where there is a trend of degradation that threatens a beneficial use, or for "high vulnerability groundwater areas" designated by the GAR (WDRs, Attachment A, pg. 22). Its purpose is to determine if irrigated agriculture is the cause or has contributed to the "water quality problem" and to define a method for determining compliance with receiving water limitations in the area (WDRs, Attachment A, p. 23). It outlines an approach to addressing influences from irrigated agriculture on groundwater quality.

This GQMP follows the requirements listed in the Monitoring and Reporting Program (MRP) under Order R5-2014-0002 using existing groundwater quality data. The GQMP relies greatly on elements of the Management Practices Evaluation Program (MPEP) and Groundwater Quality Trend Monitoring (GQTM) which are still in the process of being developed. **Table 1-1** summarizes major requirements of the GQMP as identified in the WDRs and where they are addressed within this GQMP document, in the GAR, and/or in coordination with future documents and ILRP regulatory requirements. The emphasis of the GAR was on characterizing past and present groundwater quality and evaluating impacts to groundwater quality from irrigated agricultural practices within the Coalition region. One primary objective of the GAR was to identify high vulnerability areas for more focused management. The GAR involved an extensive effort to assemble readily available groundwater quality data. The data collection effort focused on nitrate, salinity (TDS and EC), and pesticides and the identification of high vulnerability areas where intrinsic physical properties represent conditions more vulnerable to groundwater quality impacts from irrigated agriculture. Additionally, locations where exceedances of groundwater quality drinking water standards for these constituents occur were identified as high vulnerability. Nitrate is the primary constituent of concern (COC) relating to irrigated agriculture and pesticides represent additional COCs, although very few pesticides have been detected in groundwater within the Coalition region.

Table 1-1 Cross-reference between GQMP requirements in WDR, section of GQMP, information contained in GAR, and coordination with future ILRP documents

GQMP Items Identified in Monitoring and Reporting Program (Appendix MRP-1) of the Western San Joaquin River Watershed WDR General Order		Where Addressed in		
		GQMP Section	GAR	Coordination with Future Documents
Introduction				
A.	Discuss the COCs that are the subject of the plan and the water quality objective(s) or trigger(s) requiring preparation of the management plan	1		
B.	Identify (narrative and map) boundaries (geographic and groundwater basin[s] or portion of a basin) to be covered by the management plan including how the boundaries were delineated	1		
C.	Summarize previous work related to identifying the occurrence of the COCs (e.g., studies, monitoring conducted) for the GQMP area	1		
Physical Setting and General Information				
A.	Land use maps which identify the crops being grown in the SQMP watershed or GQMP area. For groundwater, these maps may already be presented in the Groundwater Quality Assessment Report (GAR) and may be referenced and/or updated as appropriate.	2	GAR; Figure 4-4 Map of USDA 2013 Coalition Region Land Use	
B.	Identification of the potential irrigated agricultural sources of the COC(s) for which the management plan is being developed.	2	GAR; Section 6.2.8 (Figure 6-28 and Table 6-4)	
C.	List of the designated beneficial uses as identified in the applicable Basin Plan.	2		
D.	Baseline inventory of identified existing management practices in use within the management plan area that could be affecting the concentrations of the COCs in groundwater and locations of the various practices.	2	GAR; Section 4.7. (Nitrogen management practices)	MPEP
E.	Summary of available groundwater quality data for the parameters addressed by the management plan. Available data from existing water quality programs may be used, including but not limited to: GAMA Program, USGS, DPH, DPR, DWR, and local groundwater management programs. The GAR developed for the third-party's geographic area, and groundwater quality data compiled in that document, may serve as a reference for these data.	2	GAR; Section 5.1 Groundwater Quality Dataset. Tables 5-1A, 5-1B, 5-2, and 5-3	
F.	Soil types and other relevant soils data as described by the appropriate NRCS soil survey or other applicable studies. The soil unit descriptions and a map of their areal extent within the study area must be included. The GAR developed for the third-party's geographic area, and the soils mapping contained in that document, may satisfy this requirement.	2	GAR; Surficial Soils Section 2.3.1	
G.	Regional and area specific geology, including stratigraphy and existing published geologic cross-sections.	2	GAR; Section 2.2.1 General Hydrogeologic Setting	
H.	Groundwater basin(s) and sub-basins contained within the GQMP area, including a discussion of general water chemistry as known from existing publications, including the GAR (range of electrical conductivity [conductivity at 25°C, EC], concentrations of major anions and cations, nutrients, total dissolved solids [TDS], pH, dissolved oxygen and hardness). The discussion should reference and provide figures of existing Piper (tri-linear) diagrams, Stiff diagrams and/or Durov Diagrams for the GQMP area.	2	GAR; Section 1.3.1 Focus: Central Valley Floor (extent of DWR Bulletin 118 groundwater basins/subbasins); Figure 1-3 map of DWR-Designated Groundwater Basins and Subbasins	
I.	Known water-bearing zones, areas of shallow and/or perched groundwater, as well as areas of discharge and recharge to the basin/sub-basin in the GQMP area (rivers, unlined canals, lakes, and recharge or percolation basins).	2	GAR; Figures 2-5 and 2-8. Section 3.1.3.2, Figure 3-19	
J.	Identification of which water-bearing zones within the GQMP area are being utilized for domestic, irrigation, and municipal water production.	2	GAR; Table 3-1, Table 7-1	
K.	Aquifer characteristics such as depth to groundwater, groundwater flow direction, hydraulic gradient, and hydraulic conductivity, as known or estimated based on existing information.	2	GAR; 3.1.2.1 (Depth to Groundwater); 3.1.3 (Groundwater Flow and gradient); 2.3.1.1 (Soil Hydraulic Conductivity); 2.3.2 (Hydraulic Properties of Subsurface Sediments)	
L.	Identification, where possible, of irrigation water sources (surface water origin and/or groundwater) and their available general water chemistry (range of EC, concentrations of major anions and cations, nutrients, TDS, pH, dissolved oxygen and hardness).	2	GAR; Table 3-1	
Management Plan Strategy				
A.	Describe approach to be used in the GQMP (e.g., multiple COCs addressed in a scheduled priority fashion, multiple areas covered by the plan with a single area chosen for initial study, or all areas addressed simultaneously [area-wide]). Any prioritization must be consistent with the requirements of the Order.	3		MPEP
B.	**Actions to meet the following goals and objectives:**	3		MPEP
	a. Compliance with the Order's receiving water (groundwater) limitations.			
	b. Educate Members about the sources of the water quality exceedances to promote prevention, protection, and remediation efforts that can maintain and improve water quality.			
	c. Identify, substantiate, and implement management practices to reduce loading of COCs to groundwater.			
C.	**A description of duties and responsibilities of the individuals or groups implementing the management plan, including:**	3		
	a. Identification of key individuals involved in major aspects of the project (e.g., project lead, data manager, sample collection lead, lead for stakeholder involvement, quality assurance manager).			
	b. Discussion of each individual's responsibilities.			
	c. An organizational chart with identified lines of authority.			
D.	**Strategies to implement the management plan tasks. This element must:**	3		
	a. Identify the entities or agencies that will be contacted to obtain data and assistance.			
	b. Identify management practices used to control sources of COCs from irrigated lands that are 1) technically feasible; 2) economically feasible; 3) proven to be effective at protecting water quality, and 4) comply with sections III.A and B of the Order. Discuss practices growers will implement, including estimated effectiveness or any known limitations on the effectiveness of the chosen practice(s). Practices identified may include those that are required by local, state, or federal law. Where an identified constituent of concern is a pesticide that is subject to DPR's Groundwater Protection Program, the GQMP may refer to DPR's regulatory program for that pesticide and any associated requirements.			MPEP
	c. Identify outreach to disseminate information to participating growers, including: the strategy for informing growers of the water quality problems that need to be addressed, method for disseminating information on relevant management practices to be implemented, and a description of how the effectiveness of the outreach efforts will be evaluated.			MPEP
	d. Include specific schedule and milestones for implementation of management practices and tasks outlined in the GQMP. Schedule must include: time estimated to identify new management practices as necessary to meet the Order's groundwater receiving water limitations and a timetable for implementation of identified management practices.			MPEP
	e. Establish measureable performance goals that are aligned with the elements of the GQMP strategy. Performance goals include specific targets that identify the expected progress towards meeting a desired outcome.			MPEP
Monitoring Design				
A.	Coordinate with MPEP and Groundwater Quality Trend Monitoring to determine whether additional monitoring is needed in conjunction with the proposed management strategy(ies) to evaluate the effectiveness of the strategy(ies).	4		GQTM, MPEP
Data Evaluation				
A.	Methods to present data and perform data analysis (graphical, statistics, modeling, index computation, or some combination thereof)	5		
B.	Information necessary to assess program effectiveness of the implemented management practices, including the process tracking of management practice implementation, how the information will be collected from growers, the type of information being collected, how the information will be verified, and how the information will be reported. The approach for determining the effectiveness of the management practices implemented must be described. Acceptable approaches include field studies of management practices at representative sites and modeling or assessment to associate the degree of management practice implementation to changes in water quality.	4		MPEP, GQTM
Records and Reporting				
A.	Management Plan Status Report submitted with the semi-annual monitoring report summarizing progress for the reporting period and will include the 13 components listed in WDR Appendix MRP-1	5		

1.3 Coalition Boundaries

1.3.1 Boundaries

The extent of the Westside Coalition region and study area for the GQMP is the same as the Watershed boundary (**Figure 1-1**). **Figure 1-2** illustrates a key distinction between what is hydrogeologically referred to as the Central Valley Floor and areas peripheral to the Central Valley Floor in the Coalition region. The Central Valley Floor, as referred to in the GAR, is defined by the extent of the San Joaquin Valley Groundwater Basin as designated by the California Department of Water Resources (DWR) and presented in Bulletin 118 (DWR, 2003). The basins and subbasins located within the Central Valley Floor (**Figure 1-2**) include the Delta-Mendota Groundwater Subbasin (5-22.07), a small part of the Tracy Groundwater Subbasin (5-22.15), and a small part of the Merced Groundwater Subbasin (5-22.04). Greater than 99 percent of the DWR-designated groundwater basins and subbasins within the Watershed area are located within the Central Valley Floor, and these basins represent the area that is the focus of most of the work for the GAR and for this GQMP, although the geology of Los Banos Creek Valley Groundwater Basin and peripheral areas outside the Central Valley Floor were also considered with respect to vulnerability.

1.3.1.1 High vulnerability areas

The GAR identified high vulnerability areas, where irrigated agriculture operations may have impacted or are more likely to impact groundwater quality, within the Coalition based on the combination of intrinsic physical properties with additional consideration and incorporation of areas with elevated concentrations of nitrate. Natural sources of nitrogen have also been noted as referenced in the GAR; these may warrant further consideration. To determine the high vulnerability areas, select statistical analyses and index overlay approaches were used based on observed groundwater quality, soil parameters, and hydrogeologic characteristics of the aquifer system beneath the Central Valley portion of the Coalition area. The results from the groundwater vulnerability assessment were evaluated with respect to locations of observed exceedances of groundwater quality drinking water standards for nitrate, total dissolved solids, and pesticide detections. The method of determining groundwater vulnerability also accounts for differences in land use among the observations in order to decipher differences in groundwater quality that are related to hydrogeologic variables as opposed to differences in groundwater quality that are related to land use using land use snapshots from the mid-1980s to 1990s, mid-1990s to mid-2000s, and 2013.

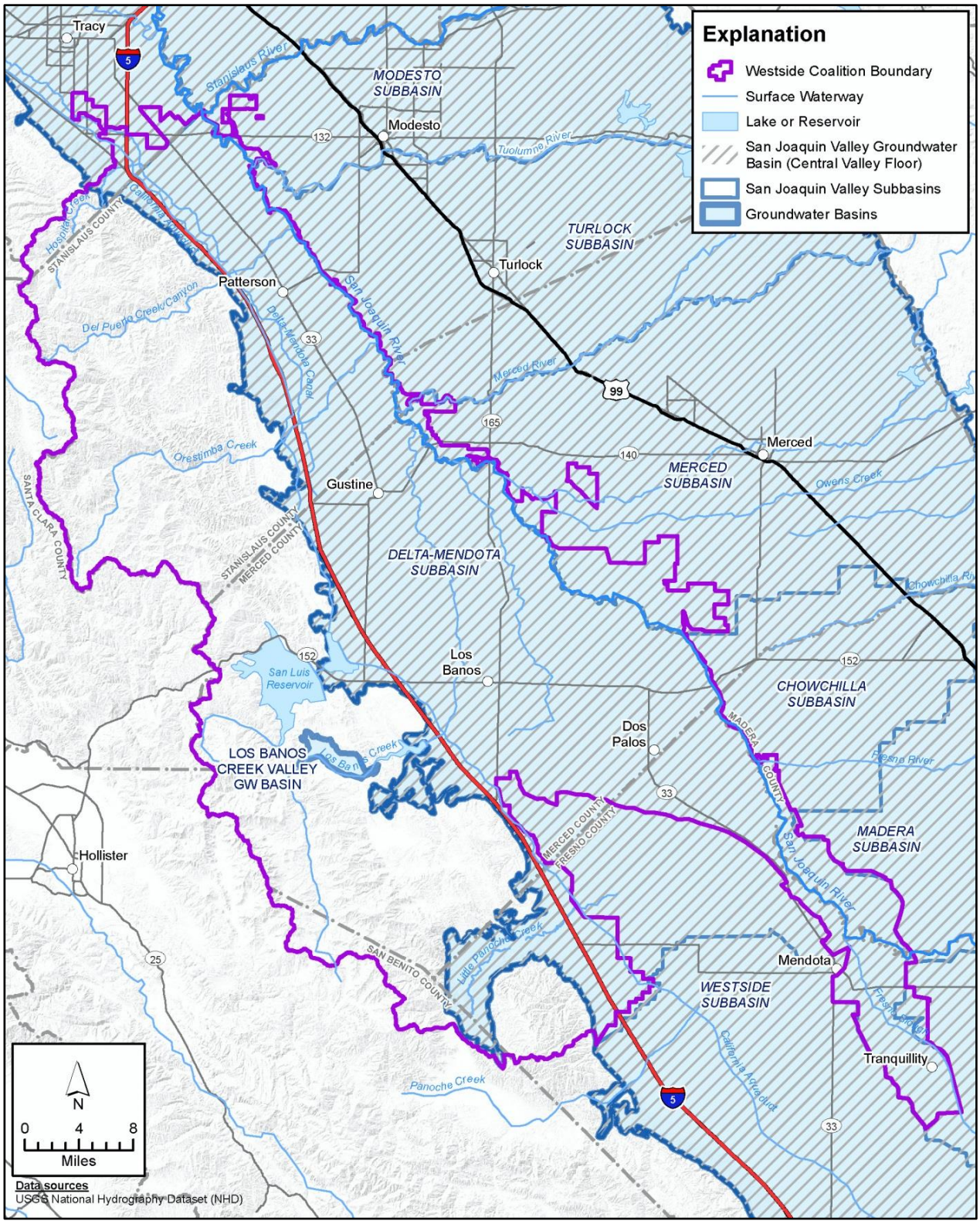


Figure 1-2 Map of DWR-designated groundwater basins and subbasins and surface water features

A Hydrogeologic High Vulnerability Area (HHVA) was defined based on hydrogeologic characteristics and represented largely by soils with relatively well draining characteristics. The HHVA encompasses most wells with elevated nitrate concentrations. The locations of wells with maximum historical nitrate concentrations of 10 milligrams per liter (mg/L) as nitrogen (as N) or greater and also wells with maximum concentrations greater than or equal to 5 mg/L that exhibit statistically significant increasing trends in concentrations were incorporated through delineation of High Well Vulnerability Areas (HWVAs) through inclusion of a 0.5-mile radius around outlier wells when they are located away from the HHVA. **Figure 1-3** illustrates HHVA and HWVAs identified in the GAR in relation to wells with an historical nitrate exceedance and wells with an historical nitrate concentration greater than 5 mg/L with a statistically significant increasing trend. The high vulnerability area defined for the Coalition region (Westside HVA) includes the combined HHVA and HWVAs and totals 292,171 acres, of which 207,567 acres are irrigated land.

Figure 1-4 presents all of the Westside HVA within the Coalition region, and its components, as identified in the GAR and shows those areas that are irrigated. Irrigated lands within the Westside HVA are the focus of this GQMP. **Table 1-2** summarizes the acreages associated with the Westside HVA.

Table 1-2 Summary of acreages for the Westside High Vulnerability Area

Vulnerability Area Description	Total Coalition Region (Acres)	Irrigated Area[1] (Acres)
Hydrogeologic High Vulnerability Area	**285,159**	**202,139**
High Well Vulnerability Area	**7,012**	**5,428**
High Vulnerability Area (Total)	**292,171**	**207,567**

[1] Includes irrigated land as identified from 2012 California Department of Conservation Farmland Mapping and Monitoring Program (FMMP) data

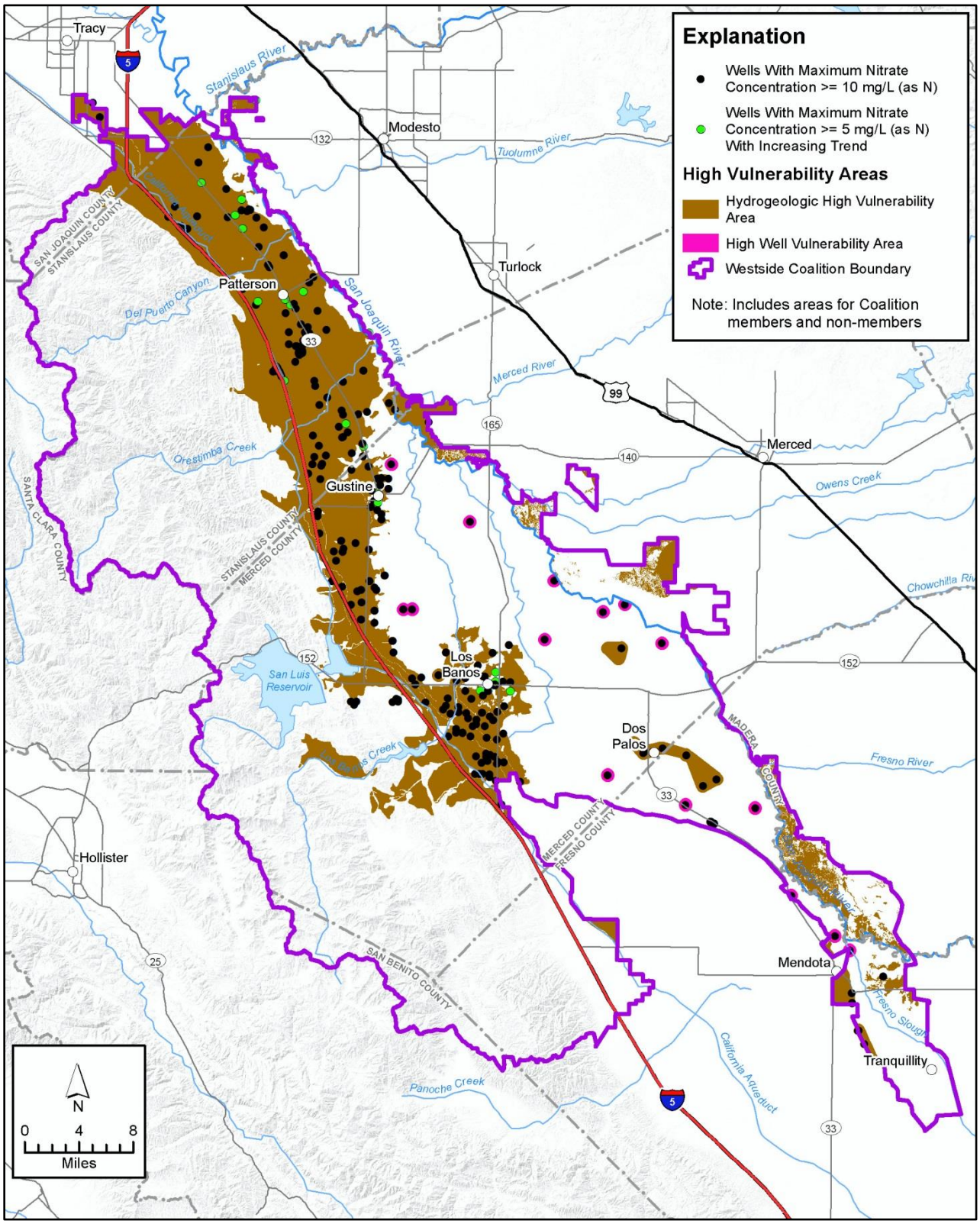


Figure 1-3 Map of High Vulnerability Area relative to wells having historical nitrate concentrations exceeding the MCL or greater than 5 mg/L with a statistically significant increasing trend

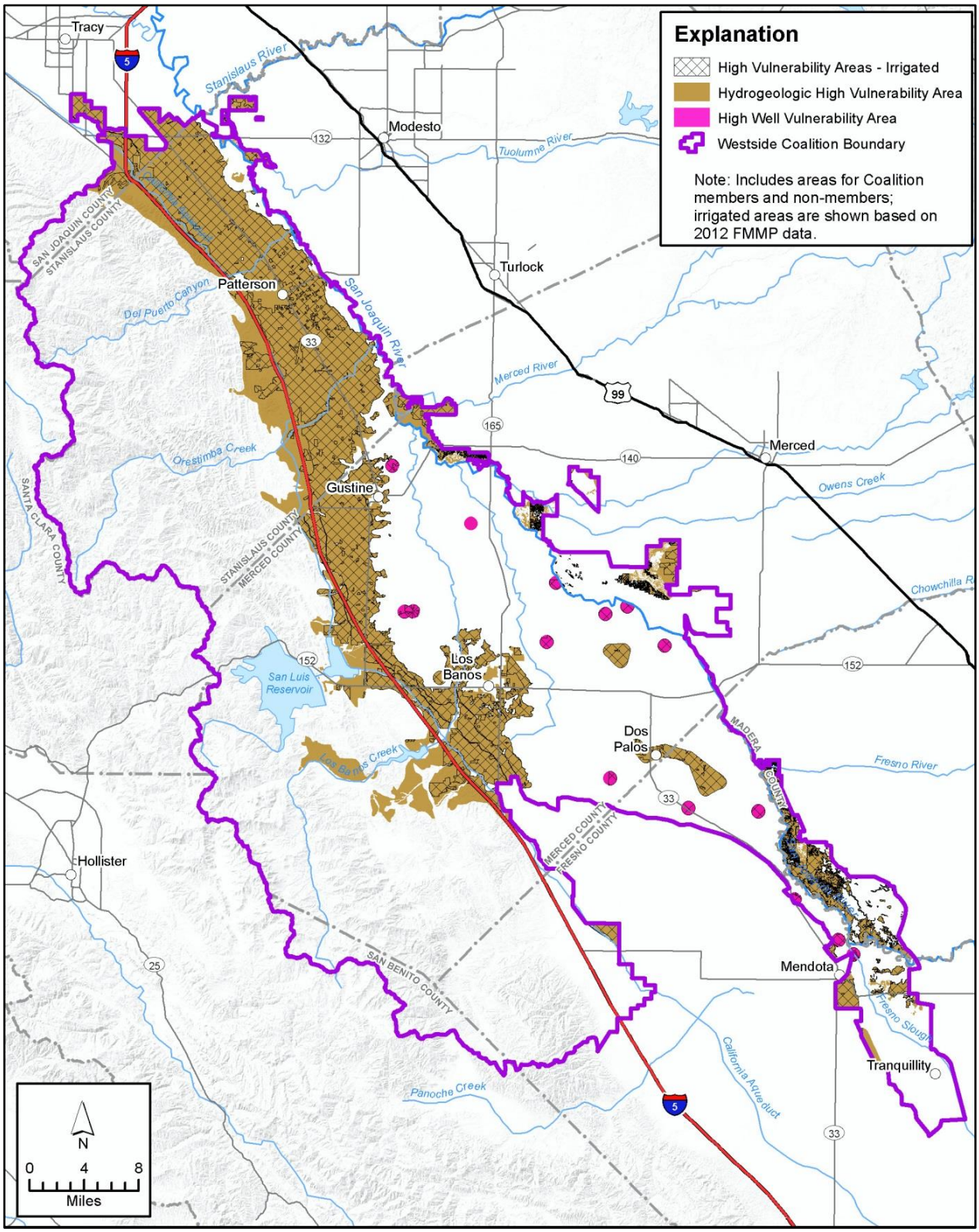


Figure 1-4 Map of High Vulnerability Area within irrigated lands

2 GENERAL INFORMATION AND PHYSICAL SETTING

2.1 General Information

2.1.1 Location, topography, climate

The Watershed lies on the western side of the Central Valley and extends from the San Joaquin River in the east, along the axis of the Valley, to the Coast Range divide on the west side. The Watershed has ground surface elevations ranging from less than 100 feet along parts of the eastern edge to greater than 1,600 feet in the Coast Range mountains (see **GAR Figure 2-1**[3]). Most of the lower elevation areas occur east of Interstate 5, in the eastern parts of the Coalition region, although some lower elevation areas also extend westward into the Coast Range such as in Los Banos Creek Valley. Low elevation areas generally coincide with the extent of the San Joaquin Valley Groundwater Basin which defines the Central Valley Floor portion of the Coalition region. Topography within the Coalition region consists largely of flat areas across the Central Valley Floor, where slopes are generally less than 2 percent, with steepening slopes to the west. The topography outside of the Central Valley Floor in the Coast Range mountains is characterized by steeper slopes, generally greater than 6 percent (**GAR Figure 2-2**).

The climate of the Watershed region is relatively arid with average annual precipitation generally totaling between 9 and 12 inches on the Valley Floor, although greater annual precipitation amounts exceed 15 inches across much of the higher elevation areas within the Coast Range mountains. The considerably higher elevations in the Coast Ranges along the western edge of the Watershed create a rainfall shadow along the eastern slope of the mountains and the adjacent Valley Floor. **GAR Figure 2-3** shows the spatial distribution of average annual precipitation in the area based on data from the PRISM model (PRISM Climate Group, 2014). Most precipitation occurs during winter and spring with very little precipitation occurring during summer and fall. **GAR Figure 2-4** illustrates seasonal trends in average annual precipitation at two locations within the Valley Floor.

2.2 Surface Water

The San Joaquin River is the primary surface water feature within the Westside Coalition region, flowing from south to north along the eastern edge of the Coalition region. During the 1960s, the San Joaquin River exhibited gaining flow conditions through much of the Westside Coalition region (Hotchkiss and Balding, 1971). Numerous intermittent streams from the Coast Range enter the Coalition region from the west; however, none of these maintain perennial flow and only Orestimba Creek and Del Puerto Creek have channels that extend eastward to a junction with the San Joaquin River. Most of the flow in other notable west-side creeks, including Quinto Creek, San Luis Creek, and Los Banos Creek, is lost to infiltration (Hotchkiss and Balding, 1971). The San Luis Reservoir on San Luis Creek, which is located within the Watershed area, is an artificial water storage facility for the Central Valley Project and California State Water Project and has no notable natural surface water inflows. Outflows from the reservoir go into the system of federal and state operated canals and aqueducts comprising the Central

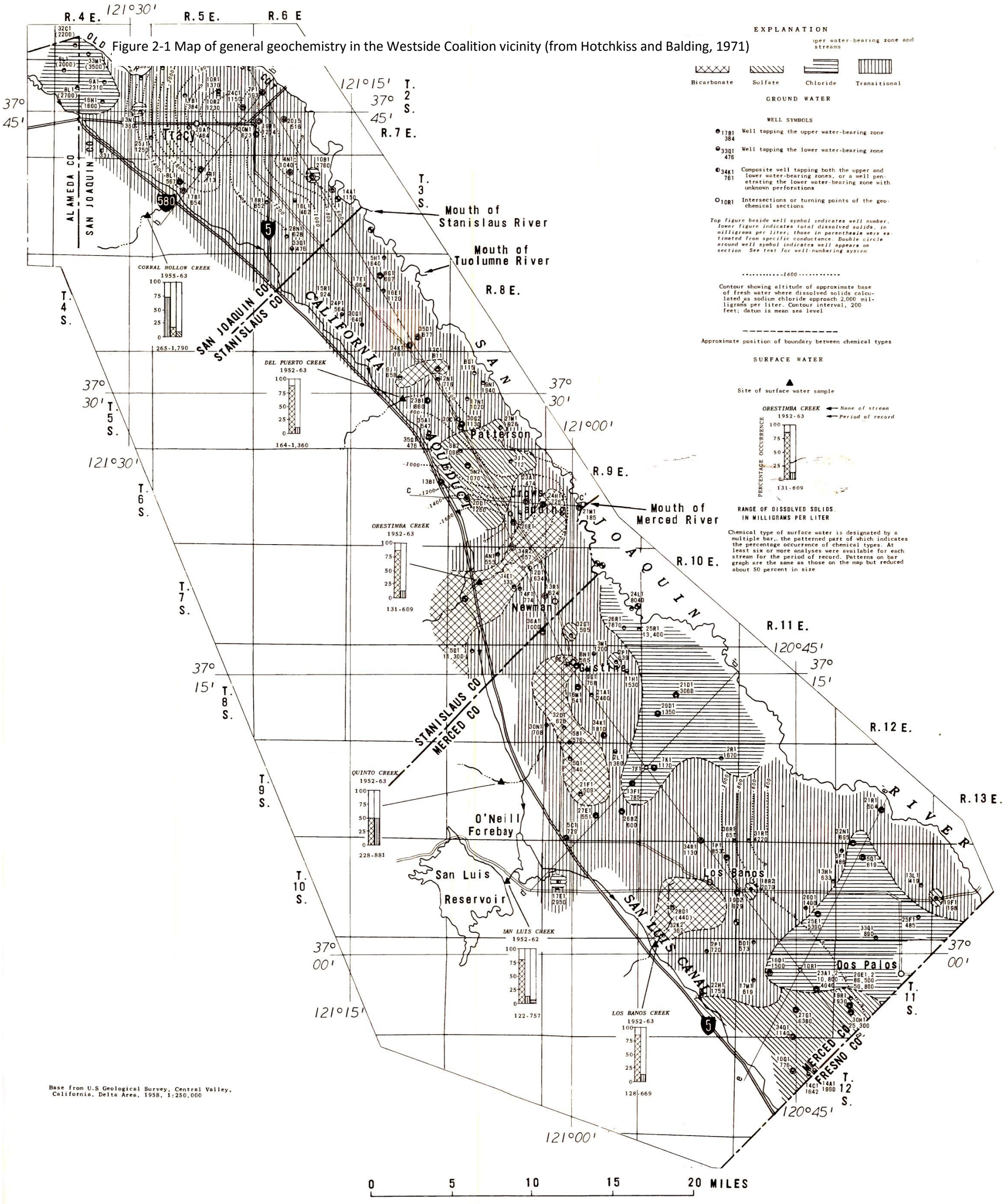
[3] In depth background information relating to the Coalition region physical setting, land use, groundwater quality conditions, and groundwater vulnerability determination are provided in the Westside GAR (http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/monitoring_plans_reports_reviews/assessment_reports/coalitions/westside_sjr_watershed/2015_0316_westside_gar.pdf).

Valley and California State Water Projects. Surface water use within the Coalition is derived largely from water deliveries provided by these projects, including from the California Aqueduct (sometimes referred to as San Luis Canal) and Delta-Mendota Canal, and also from the San Joaquin River (**Figure 1-2**).

2.2.1 Chemistry of surface water

In contrast with the siliceous mineralogy of the alluvial sands and gravels on the eastern side of the Central Valley that are derived from the Sierra granitic rocks, which are coarser and more resistant to chemical dissolution, the sulfate and carbonate shales and sandstones of Coast Range sediments on the western side are more susceptible to dissolution processes. The chemical quality of waters in the Coast Range streams can be closely correlated with the geologic units within their respective catchments. Groundwater flows discharging from these marine and non-marine rocks into streams introduce a variety of dissolved constituents, resulting in variable groundwater types. The water quality and chemical makeup in west-side streams can be highly saline, especially in more northern streams, including Corral Hollow and Del Puerto Creeks, where historical base flow TDS concentrations have typically exceeded 1,000 mg/L with measured concentrations as high as 1,790 mg/L (Hotchkiss and Balding, 1971). This is in contrast with TDS concentrations typically below 175 mg/L in streams draining from the Sierras. The contribution of water associated with these Coast Range sediments has resulted in naturally high salinity in the groundwater within and around the Westside Coalition, which has long been recognized, including documentation of these conditions since the early 1900s (Mendenhall et al., 1916). Groundwater in some areas within the immediate vicinity of the San Joaquin River is influenced by lower salinity surface water discharging from the east side of the San Joaquin Valley Groundwater Basin (Davis et al., 1959. A general characterization of water quality in surface waterways within the Coalition region during the period 1952-1963 are illustrated by Hotchkiss and Balding (1971) as shown in **Figure 2-1**.

Figure 2-1 Map of general geochemistry in the Westside Coalition vicinity (from Hotchkiss and Balding, 1971)



2.3 Hydrogeology

2.3.1 Geologic setting

The San Joaquin Valley is at the southern end of the Central Valley of California in the Great Valley Geomorphic Province. The Central Valley is a large structural trough that has been filled with interlayered sediments of sand, gravel, silt, and clay derived from erosion of the Sierra Nevada and Coast Range mountains. **Figure 2-2** shows the geology within the Coalition region as generalized by the U.S. Geological Survey (USGS) and published as digital data by Ludington et al. (2007). Detailed discussion of the hydrogeology of the Coalition region is contained in the GAR. Approximately three million years ago, tectonic movement of the oceanic and continental plates associated with the San Andreas Fault system gave rise to the Coast Range, which sealed off the Central Valley from the Pacific Ocean. As this occurred, the floor of the San Joaquin Valley began to transition from a marine depositional environment to a freshwater system, where ancestral rivers brought alluvium to saltwater bodies (Mendenhall et al., 1916).

The Coast Ranges on the western side of the San Joaquin Valley consist mostly of complexly folded and faulted consolidated marine and nonmarine sedimentary and crystalline rocks ranging from Jurassic to Tertiary age (**GAR Figure 2-7**), which dip eastward and overlie the basement complex in the region (Croft, 1972; Hotchkiss and Balding, 1971). The Central Valley Floor within the Coalition region consists of Tertiary and Quaternary-aged alluvial and basin fill deposits (**Figure 2-2 and GAR Figure 2-7**). The fill deposits mapped throughout much of the valley extend vertically for thousands of feet, and the texture of sediments varies in the east-west direction across the valley. Coalescing alluvial fans have formed along the sides of the valley created by the continuous shifting of distributary stream channels over time. This process has led to the development of thick fans of generally coarse texture along the margins of the valley and a generally fining texture towards the axis of the valley (Faunt et al., 2009 and 2010). Deposits of Coast Range and Sierra Nevadan sources interfinger within the Coalition region. Steeper fan surfaces, with slopes as high as 80 feet per mile, exist proximal to the Coast Range whereas more distal fan surfaces consist of more gentle slopes of 20 feet per mile (Hotchkiss and Balding, 1971). In contrast to the east side of the valley, the more irregular and ephemeral streams on the western periphery of the Central Valley Floor have less energy and transport smaller volumes of sediment resulting in less-developed alluvial features, including alluvial fans, which are less extensive, although steeper, than alluvial fan features on the east side of the valley (Bertoldi et al., 1991). Lacustrine and floodplain deposits also exist closer to the valley axis as thick silt and clay layers. Lakes present during the Pleistocene epoch in parts of the San Joaquin Valley deposited great thicknesses of clay sediments.

Subsurface sediment texture data from the U.S. Geological Survey's Central Valley Hydrologic Model indicate a shallow interval of coarse materials at depths less than 200 to 250 feet exists across large areas of the Coalition region corresponding with the Upper Aquifer. The presence of generally fine-grained sediments (<25 percent coarse) are apparent between depths of about 250 to 400 feet, consistent with the depths at which the Corcoran Clay occurs within the Coalition region. Deeper sediment textural data suggest relatively finer-grained sediments below the Corcoran Clay within much of the Lower Aquifer, although localized areas of coarse material exist in association with alluvial fan

deposits of both Sierra and Coast Range origin. Areas and intervals with the highest percentages of coarse sediments are largely zones of Sierra-sourced alluvial fan materials.

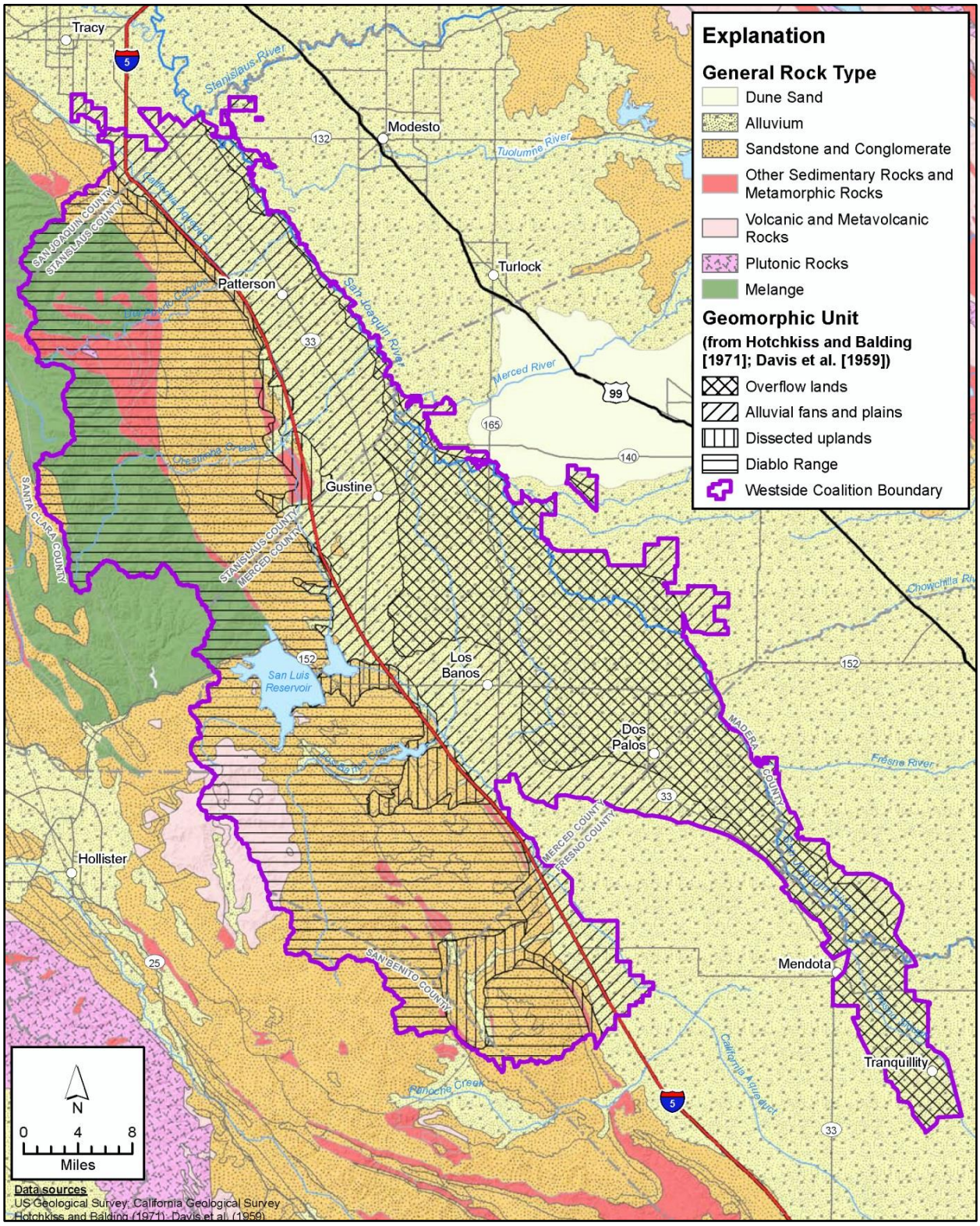
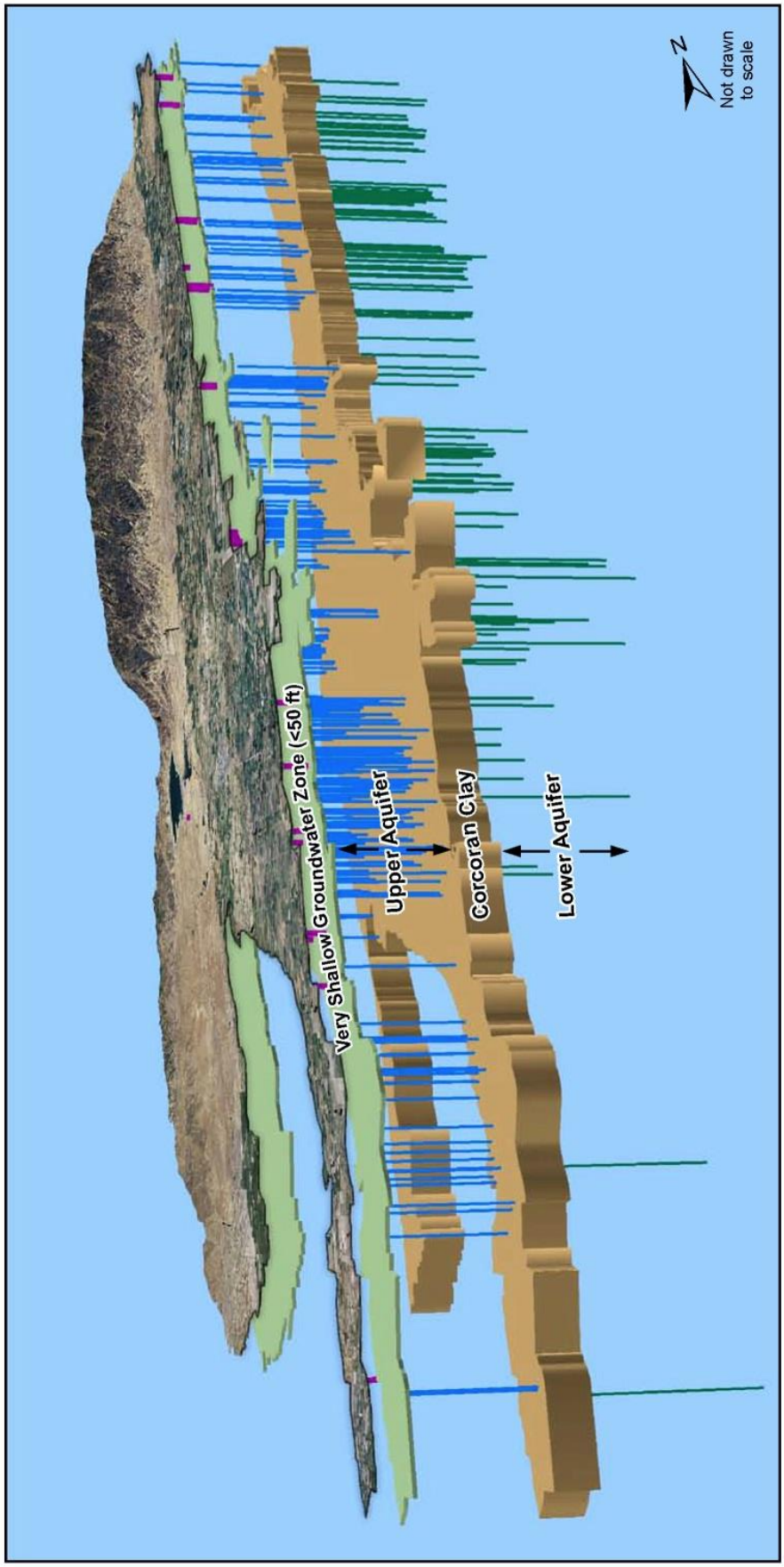


Figure 2-2 Generalized geologic map

2.3.2 Hydrogeologic characterization and groundwater occurrence

A hydrogeologic characterization of the Coalition region is described in detail in Section 2 of the GAR and a brief summary is included here. Within the Central Valley Floor of the Coalition region, the primary groundwater bearing units consist of Tertiary and Quaternary-aged unconsolidated continental deposits and older alluvium, including geologic units of the Tulare Formation. The continental and alluvial deposits consist of layers of sand, gravel, silt, and clay that increase in thickness away from the margins of the valley. The hydrogeologic system in the Coalition region is characterized by the presence of three distinct groundwater zones (**Figure 2-3**), including a very shallow groundwater zone, an upper semi-confined zone (Upper Aquifer), and a lower confined zone (Lower Aquifer). The Tulare Formation is hydrologically the most important geologic formation in the Westside Coalition region because it contains many fresh water-bearing deposits. The Tulare Formation extends to the base of freshwater throughout most of the area and is comprised of stratigraphic layers of clays, silts, sands, and gravels and includes the Corcoran Clay (E-Clay) member, a diatomaceous clay or silty clay of lake bed origin which is a prominent aquitard in the region that separates the upper zone from the lower zone and distinguishes the Upper Aquifer from the Lower Aquifer.

Because of the generally shallow nature and high salinity in some areas, Very Shallow Groundwater, which is considered to be the zone within 50 feet of the ground surface in this report, is not believed to provide a major supply of water for agricultural or drinking uses within the Coalition region. The Upper Aquifer includes geologic units of younger and older alluvium and upper parts of the Tulare Formation. The Corcoran Clay is a notable hydrogeologic feature throughout most of the Coalition region that acts as an aquitard and impediment to vertical hydraulic communication between the Upper and Lower Aquifers. The Corcoran Clay is present at depths ranging between approximately 150 and 300 feet below the ground surface across much of the Central Valley Floor portion of the Coalition region with a general spatial pattern of deepening and thickening to the south. The thickness of the Corcoran Clay, which is greater than 50 feet in most areas of the Coalition region, but ranges from less than 25 feet to more than 100 feet thick, is believed to provide some degree of hydraulic separation between the Upper and Lower Aquifers. The Lower Aquifer is the portion of the Tulare Formation that is confined beneath the Corcoran Clay extending downward to the underlying San Joaquin Formation and the interface of salty water of marine origin. The Upper and Lower Aquifers represent the primary sources of supply for groundwater used for agricultural and drinking water purposes within the Coalition region.



Very Shallow Groundwater Zone: Ground surface to 50 feet deep
thickness range = 50 feet

Upper Aquifer: From 50 feet to top of Corcoran Clay
thickness range = less than 50 feet to greater than 500 feet

Corcoran Clay: E Clay member of the Tulare Formation, from Faunt et al. (2009)
depth range = 25 feet to greater than 500 feet
thickness range = 20 feet to greater than 125 feet

Lower Aquifer: Below Corcoran Clay
depth range = less than 200 feet to greater than 600 feet

Figure 2-3 Conceptual illustration of the hydrogeologic system in the Western San Joaquin River Watershed

2.3.3 Surficial geologic conditions

Soil characteristics are described in detail in the GAR Section 2 and a brief summary is included here. Soils of low hydraulic conductivity, corresponding with extensive floodplain deposits, blanket much of the Central Valley Floor area of the Coalition region, although higher hydraulic conductivity soils occur along modern and ancient surface watercourses and in association with alluvial fan features. The drainage characteristics of soils within the Coalition region are shown in **GAR Figure 2-25** by drainage class. Soil drainage classes are closely related to the hydraulic conductivity of soils, but also account for the frequency and duration of wet periods under conditions similar to those under which the soil developed. Soil drainage classes range from excessively drained soils to very poorly drained soils. Excessively drained soils tend be coarse-textured soils of high hydraulic conductivity in which water is removed rapidly and the occurrence of internal water is uncommon (Natural Resource Conservation Service [NRCS], 2015). In contrast, poorly drained soils tend to have low hydraulic conductivity which limits the ability of water to drain vertically and results in frequent saturation of soils, although the zone of saturated soil is limited to very shallow and shallow depths and does not extend to deeper soils.

Areas of highest soil salinity are located across areas of the eastern and southern portion of the Coalition region where soil hydraulic conductivity is generally lower and which are also characterized by poor drainage conditions. These areas of highest soil salinity, where values exceed 4 dS/m, occur mainly north of Los Banos and east of Gustine and also in the vicinity west of Dos Palos (**GAR Figure 2-26**). The hydrologic properties of these soils inhibit the ability of salts to flush from these soils resulting in concentration of salts. Finer-textured soils with low hydraulic conductivity are also capable of holding more water by capillarity, which can increase bare soil evaporation resulting in shallow salt accumulation over time. Soil map units with relatively lower soil salinity are exhibited across much of the western and northern portion of the Coalition region and also in large areas in the vicinity and north of Dos Palos, associated with the current and ancient alignment of the San Joaquin River where a greater density of soils of higher hydraulic conductivity occur.

Soils within the Coalition region are mainly neutral to alkaline (higher pH) with several areas of especially highly alkaline soils (pH > 8.5) located southeast of Gustine and extending south past Los Banos. Another area of particularly high pH soils exists in the far southeast part of the Coalition region between Tranquillity and Mendota (**GAR Figure 2-27**). Areas of alkaline soils coincide with areas of high soil salinity, with many alkaline soils located where carbonates and hydroxides exist within near surface soils derived from Coast Range rock formations (**GAR Figure 2-27**). Neutral soils cover most of the far western part of the peripheral areas of the Coalition region and in the north within the Central Valley Floor.

2.4 Groundwater Conditions

2.4.1 Groundwater levels, flow, gradient, and recharge to groundwater

Regionally, depth to the water table decreases from the valley perimeter to the valley axis – in the Coalition region this translates to a west-to-east decrease in depth to water. Water levels range from very close to the ground surface to approximately 50 feet, with generally deeper water tables in the western side of the valley portion of the Coalition region.

Depth to water in wells designated as Upper Aquifer wells ranged from 10 to 80 feet below ground surface throughout the Coalition region, with generally higher water levels in the spring. The potentiometric surface interpolated from these wells in both spring and fall indicates that groundwater in this aquifer flows generally from west to east throughout most of the region. The Lower Aquifer exhibits some variation between spring and fall, with most of the aquifer presenting reduced piezometric heads in the fall. In the northern portion of the Coalition region the hydraulic flow gradient in the Lower Aquifer trends eastward.

Most of the natural recharge that occurs in the Westside Coalition region is in the alluvial fan apex areas along the intermittent Coast Range streams, although deep percolation of applied irrigation water is also a source of recharge. Changing irrigation technologies are reducing deep percolation from irrigation water. Secondary recharge to areas near the valley axis occurs from subsurface flow from the east (DWR, 2003).

2.4.2 Groundwater quality

Naturally high concentrations of total dissolved solids (TDS) in groundwater are known to have existed historically within parts of the Westside Coalition region due to the geochemistry of the Coast Range rocks, the resulting naturally high TDS of recharge derived from Coast Range streams, the dissolvable materials within the alluvial fan complexes, and the naturally poor draining conditions which tend to concentrate salts in the system. Areas of historical high salinity groundwater documented by Mendenhall et al. (1916) are displayed in **GAR Figure 2-9**, which shows somewhat high TDS concentrations approaching or greater than 1,000 mg/L in wells sampled throughout many parts of the Coalition region. Some soils and sediments within the western San Joaquin Valley, that are derived from marine rocks of the Coast Range, have notably high concentrations of naturally occurring nitrogen, with particularly higher nitrate concentrations in younger alluvial sediments (Strathouse and Sposito, 1980; Sullivan et al., 1979). These naturally occurring nitrogen sources may contribute to nitrate concentrations in groundwater within the Coalition region, although it is not well known where this may occur and to what degree.

Groundwater quality characterizations completed by Hotchkiss and Balding (1971), Dubrovsky (1991), and Mathany et al. (2013) provide the basis for understanding groundwater chemistry in the Coalition region. The general chemical composition of groundwater in the Westside Coalition region is variable based on location and depth. Groundwater within the Upper Aquifer is largely characterized as transitional type with fewer areas which are predominantly of chloride, bicarbonate, and sulfate water types. Transitional water types, in which no single anion represents more than 50 percent of the reactive anions, occurs in many different combinations with greatly ranging TDS concentrations. Chloride type waters occur generally in grasslands areas east of Gustine and around Dos Palos with sodium chloride water present in northern areas near Tracy and also extending south from Dos Palos. These waters also exhibit greatly varying salinity with typical TDS concentrations ranging from less than 500 mg/L to greater than 10,000 mg/L and of high sodium makeup (50-75 percent of cations present) (Hotchkiss and Balding, 1971). Areas of bicarbonate groundwater within the Upper Aquifer of relatively lower TDS concentrations are directly associated with intermittent streams of the Coast Range near Del Puerto, Orestimba, San Luis, and Los Banos Creeks. Sulfate water in the central and southern areas has

TDS concentrations decreasing from west (1,200 mg/L) to east (700 mg/L) towards the San Joaquin River, similar to the bicarbonate water areas, although areas of sulfate water south of Dos Palos have much higher TDS concentrations (1,900 to 86,500 mg/L)(Hotchkiss and Balding, 1971). Data relating to the general chemical composition of groundwater in 1985 in the Upper Aquifer from Dubrovsky et al. (1991) are shown in **Figure 2-4a**.

Groundwater in the Lower Aquifer below the Corcoran Clay is also spatially variable, consisting of mostly transitional sulfate waters in the northern part of the Coalition region to more sodium-rich water further south in the grasslands areas. In the northern part of the Coalition region, the Lower Aquifer exhibits relatively lower TDS concentrations ranging from 400 to 1,600 mg/L with a sulfate-chloride type makeup near the valley margin trending to sulfate-bicarbonate type near the valley axis. Farther south TDS concentrations in the Lower Aquifer increase with values ranging as high as 6,000 mg/L of high sodium content (Hotchkiss and Balding, 1971). **Figure 2-4b** shows the general water quality composition of groundwater in 1985 in the Lower Aquifer as presented by Dubrovsky et al. (1991).

The most recent groundwater quality investigation conducted as part of the California State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring Assessment (GAMA) Program's Priority Basin Project is summarized by Mathany et al. (2013). Results from water quality analyses conducted on samples from 45 wells as part of this investigation indicate that most inorganic constituents in groundwater within the Coalition region are present at concentrations below primary and secondary maximum contaminant level. The primary maximum contaminant level (either set by the U.S. Environmental Protection Agency or the SWRCB) is designed to protect public health by limiting the levels of contaminants in public drinking water systems.

Table 2-1 summarizes the notable water quality results for the 45 wells within the Coalition region sampled as part of the USGS GAMA study and reported by Mathany et al. (2013). As shown in **Table 2-1**, a few wells sampled as part of this study had concentrations above the primary maximum contaminant level (MCL) for the respective inorganic constituents. However, more commonly, wells sampled had groundwater exceeding secondary MCL (SMCL) thresholds, which are not health-based standards and are applied to constituents that affect the aesthetic qualities of drinking water, such as taste, odor, and color, or the physical qualities of drinking water, such as scaling and staining. The most common constituents detected above the SMCL included sulfate, manganese, and chloride. Also shown on **Table 2-1** are results from a study of the Northern Part of the Western San Joaquin Valley (Dubrovsky, 1991). Areas that are poorly drained are generally more susceptible to the accumulation of trace elements such as arsenic, boron, and selenium in the shallow subsurface (Randolph, 2003) and a few exceedances of arsenic and boron were reported in the Dubrovsky study. Historically in the Coalition area southeast of Gustine at the Kesterson Reservoir, high amounts of selenium concentrated in wetlands.

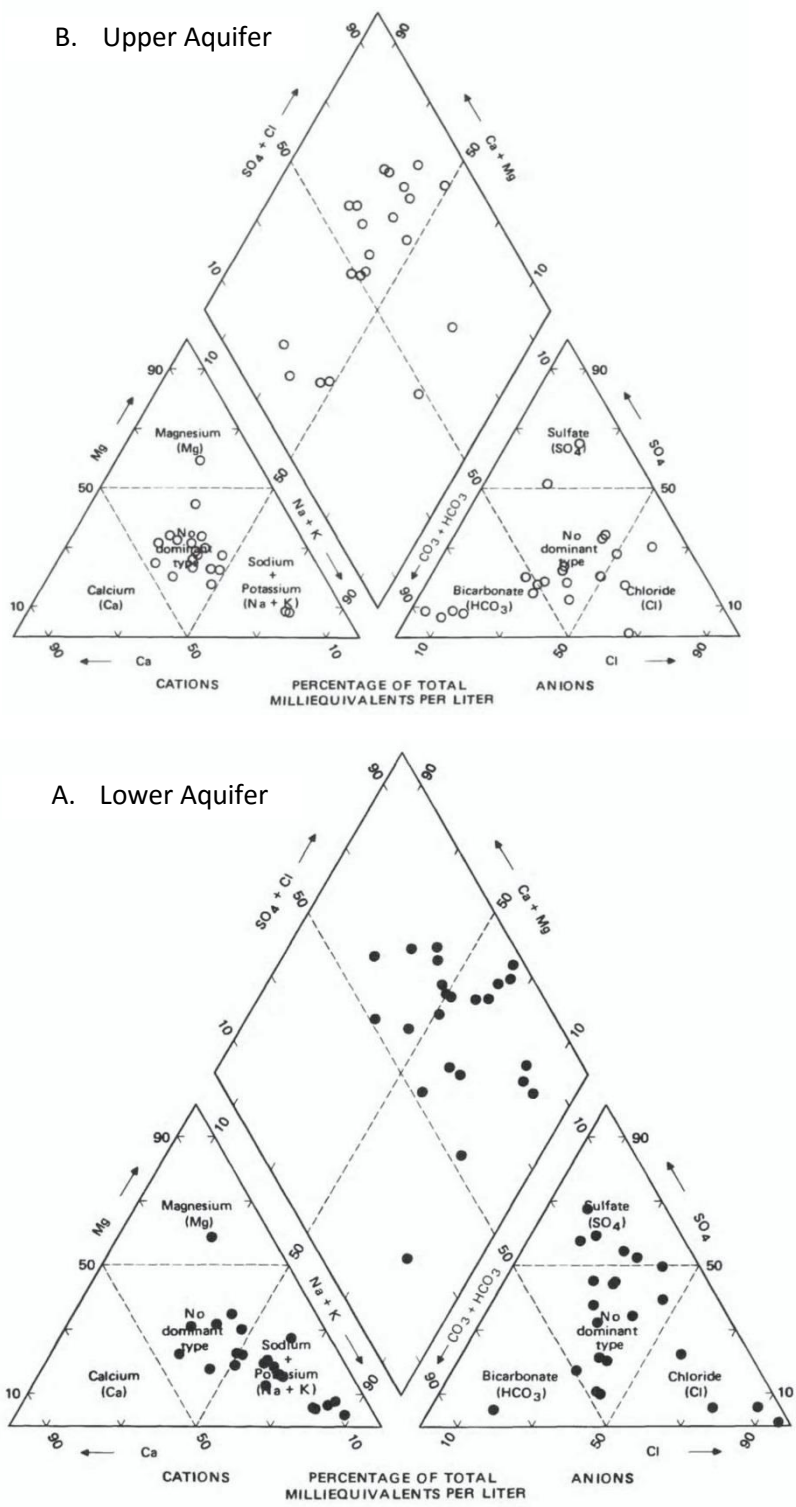


Figure 2-4 Chemical composition of groundwater in the Coalition vicinity (from Dubrovsky et al., 1991)

Table 2-1 Summary of general groundwater quality results from Mathaney et al. (2013) and Dubrovsky et al. (1991)

Delta-Mendota Subbasin USGS GAMA Study from Mathany et al. (2013) (Total wells sampled in 2010 = 45)				
Water Quality Constituent	**Detections**	**Exceedances**	**Exceedance Threshold** (µg/L)	**Threshold Type**
Arsenic	--	5	10	Primary MCL
Molybdenum	--	3	40	Primary MCL
Nitrite plus Nitrate (as Nitrogen)	--	9	10*	Primary MCL
Perchlorate	19	0	6	Primary MCL
Selenium	--	1	50	Primary MCL
Uranium	43	2	30	Primary MCL
Pesticides	19	0	Various	Various
Volatile Organic Compounds	16	0	Various	Various
Chloride	--	19	250*	Secondary MCL
Iron	--	5	300	Secondary MCL
Manganese	--	19	50	Secondary MCL
Sulfate	--	26	250*	Secondary MCL
Strontium	--	3	4,000	USEPA lifetime health advisory level
1,2,3-Trichloropropane	1	19	40	USEPA lifetime health advisory level
Boron	--	22	1,000	CDPH Notification level

Northern Part of the Western San Joaquin Valley from Dubrovsky et al. (1991) (Wells sampled by zone in 1985: semi-confined [upper] = 21, confined [lower]= 23)				
Water Quality Constituent	**Exceedances**		**Exceedance Threshold** (µg/L)	**Threshold Type**
	Semi-Confined Zone	**Confined Zone**		
Arsenic	3	2	10	Primary MCL
Molybdenum	0	0	40	Primary MCL
Nitrite plus Nitrate (as Nitrogen)	6	3	10*	Primary MCL
Selenium	0	0	50	Primary MCL
Chloride	8	7	250*	Secondary MCL
Iron	2	0	300	Secondary MCL
Manganese	7	9	50	Secondary MCL
Sulfate	7	10	250*	Secondary MCL
Boron	5	11	1,000	CDPH Notification level

* Units are expressed in mg/L.

1. CDPH Notification (Action) Level; Health-based notification level established by CDPH for some constituents in drinking water that lack MCLs. If the constituent is detected in drinking water at concentrations greater than the action level local governing bodies must be notified.

2.4.2.1 Summary of available groundwater quality data for parameters addressed by GQMP

The Westside Coalition's GAR summarizes current and historical groundwater quality dating back to the 1930s. Public sources of data included the California Department of Public Health Water Quality Analyses Data Files (now maintained by Division of Drinking Water), DWR's Water Data Library, USGS's National Water Information System, SWRCB's Geotracker database GAMA, data from the RWQCB for wells located on dairies, and the Department of Pesticide Regulation (DPR) pesticide sampling database. The GAR lists groundwater quality data relevant to irrigated agricultural practices (**GAR Tables 5-1a, 5-1b, and 5-2**) and what is necessary to develop a GQMP for the Westside Coalition region. The presence of natural salinity conditions in groundwater throughout much of the Coalition region has existed historically as a result of the natural hydrogeologic setting. Natural conditions of groundwater salinity exist throughout all zones of the groundwater system in some areas of the Coalition region as a result of the contribution of salts from recharge off of the Coast Range mountains. Areas of the Coalition region are underlain by low-permeability, fine-grained floodplain sediments and clays which impede vertical movement of groundwater, often resulting in poor drainage conditions, shallow groundwater stagnation, and associated accumulation of salts, particularly in the Very Shallow Groundwater zone.

2.4.2.1.1 *Nitrate*

A map of the maximum observed nitrate concentration for all wells in the Coalition region is presented in **Figure 2-5**. Extensive display and discussion of nitrate concentration data is available in the GAR. Limited data are available for the Very Shallow Groundwater, but the majority of nitrate concentrations are below the nitrate MCL of 10 mg/L; however, it is difficult to draw conclusions based on this limited information. In contrast to the Very Shallow Groundwater, many more wells from the Upper Aquifer have nitrate results with some concentrations exceeding the MCL. The majority of these exceedances are located in the northwestern portion of the study area on the Central Valley Floor. Wells in the Upper Aquifer in more southeastern parts of the Coalition region tend to have lower concentrations of nitrate, typically below 5 mg/L. Nitrate data available for the Lower Aquifer are limited in comparison to the Upper Aquifer data. Data that are available are concentrated in the area north of Los Banos. Most wells northwest of Gustine in the Lower Aquifer have a maximum nitrate concentration above 5 mg/L with only eight wells classified as Lower Aquifer having maximum nitrate concentrations exceeding 10 mg/L. Furthermore, in the most recent nitrate data, a fewer number of the Lower Aquifer wells have concentrations exceeding 10 mg/L. In contrast to data in the Very Shallow Groundwater and Upper Aquifer zones, much of the nitrate data in the Lower Aquifer are more recent, since 2005. The few occurrences of high concentrations of nitrate in the Lower Aquifer wells near Los Banos suggest the continued role of the Corcoran Clay as an impediment to vertical migration of constituents into the Lower Aquifer. Clusters of higher nitrate concentrations in the Lower Aquifer are generally concentrated in areas where the Corcoran Clay is less than 50 feet thick, most notably to the northwest of Gustine.

Time-series data were used to identify trends in nitrate. Very shallow wells with three or more nitrate sampling events are sparse but most data show relatively low and stable values in the northern Coalition area with slightly increasing values in two wells near Los Banos though both are below the MCL of 10 mg/L. Despite data limitations, wells in the Upper and Lower Aquifers appear to indicate relatively low nitrate concentrations exhibiting overall stable long-term trends with a few exceptions.

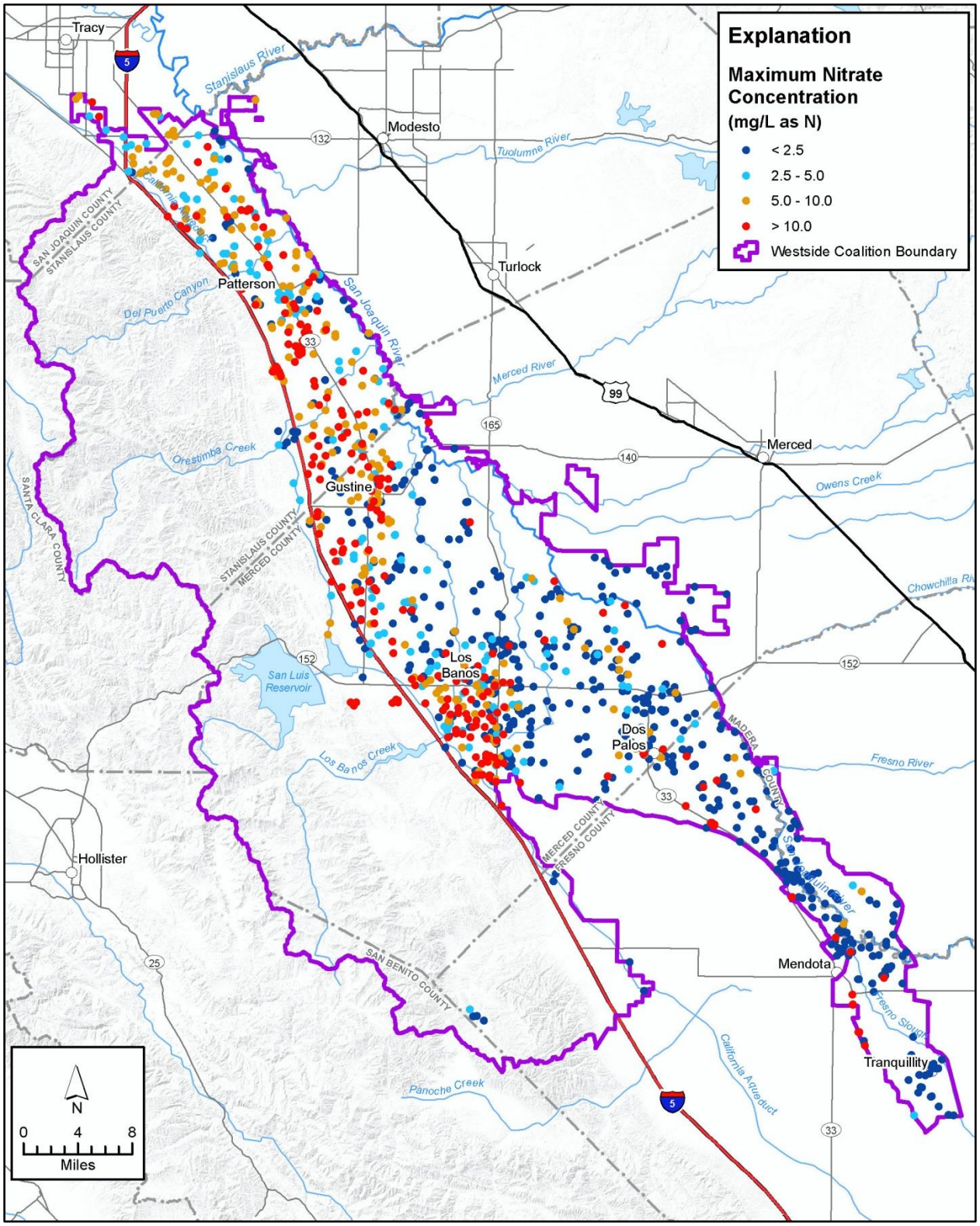


Figure 2-5 Map of maximum nitrate concentrations for all wells

2.4.2.1.2 *Pesticides*

Pesticide concentration data for the GAR were limited to data obtained from DPR. Pesticide data available from DPR are for wells, but locations are only provided at the spatial resolution of the Public Land Survey System (PLSS) section in which the well is located. Data for a total of 452 wells (in 240 PLSS sections) tested for pesticides in the study area were available from DPR. There were 272 instances of pesticide detections recorded within the Coalition region; however, some wells had detectable concentrations of multiple pesticides. The detections are summarized in the GAR along with pesticides exceeding water quality objectives, exceedance thresholds, and the basis for the exceedance thresholds (see **GAR Table 5-2**). Of the 240 sections that had wells tested, 59 sections had wells with detectable concentrations of a pesticide and 5 sections had wells with exceedances. The wells with exceedances are shown on a map and table included in **Appendix A**. The exceedances included: one well with ethylene dibromide (EDB; MCL is 0.05 ug/L) with concentrations reported in 1992 that ranged from 0.19 to 0.48 ug/L; two other wells with EDB concentrations reported in 1985 of 0.08 and 0.198 ug/L; one well with two exceedances of DBCP (MCL is 0.2 ug/L) at 6.1 and 10.1 ug/L reported in 1985; and one well with one exceedance of simazine at 6.8 ug/L reported in 1992. A higher density of pesticide detections and exceedances has occurred in the northern part of the Coalition region, from south of Gustine to north of Patterson.

2.4.2.1.3 *TDS*

The numbers of wells with TDS concentrations in the Very Shallow Groundwater are limited but the majority of these wells have TDS levels below 1,500 mg/L. The few wells that do exceed 1,500 mg/L TDS are located along or near the San Joaquin River in areas of poor soil drainage. TDS concentration data for wells in the Upper Aquifer are greater than for the Very Shallow Groundwater, with most data scattered over the Coalition area on the Central Valley Floor. Higher TDS concentrations (>1,500 mg/L) in the Upper Aquifer are observed in a band stretching from Los Banos northward along the San Joaquin River, where poor drainage conditions exist resulting in high salinity in the Very Shallow Groundwater. A notable area occurs in the southeast where TDS concentrations are largely below 1,000 mg/L, likely indicative of higher-quality groundwater in sediments derived from Sierran sources.

Time-series data were also used to identify trends in TDS. Two out of 13 wells with graphs of TDS concentrations in the Very Shallow Groundwater show data from mid-1980s through the present with a stable trend near or below 1,000 mg/L. Wells in the Upper Aquifer tend to have longer periods of record for TDS than those wells in other depth zones and most of these wells indicate slightly increasing TDS concentrations for the 1990s to the present, though concentrations remain below 1,500 mg/L. Wells in the Lower Aquifer exhibit largely stable TDS concentrations since sampling began in 1990 with most concentrations below 1,500 mg/L, although fewer data for Lower Aquifer wells exist in the southern part of the Coalition region.

2.4.2.2 Groundwater beneficial uses

The San Joaquin River Basin Plan (revised 2011) states that beneficial uses of groundwaters of the basins are "…suitable or potentially suitable, at a minimum for municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply". The Tulare Lake Basin Plan (2004) lists groundwater beneficial uses as the same unless otherwise designated by the Regional Board.

2.5 Land Use

2.5.1 Land use

Characterizing changes in land use, irrigation, and fertilization practices over time supports understanding of past, current, and potential future groundwater quality, as these practices have the potential to affect groundwater quality. Quantitative and qualitative assessment of the spatial distribution of agricultural cropping and practices and assessing the intensity of effects on groundwater quality support the development of effective groundwater quality monitoring and management strategies. Additionally, documenting past and present land use and practices is critical in assessing groundwater vulnerability. In 2013 (**GAR Figure 4-4**), the irrigated crop area was approximately 390,000 acres based on data from U.S. Department of Agriculture (USDA). Alfalfa was the top crop by acreage in 2013 with nearly 85,000 acres estimated for the Central Valley Floor, closely followed by almonds with an estimated 76,000 acres. Cotton, corn (including a winter grain crop in many cases), tomatoes, wheat, and irrigated pasture are the next most common crops by acreage. These crops represent nearly 94 percent of the irrigated crop area. From the 2013 USDA data, the Valley Floor includes approximately 383,000 acres (greater than 98 percent) of the irrigated land within the Coalition region. Primary changes in agricultural cropping between 1990 and 2013, based on DWR and USDA data, include a decrease in field crops by 66,000 acres (43 percent), an increase in nut trees by 59,000 acres (201 percent), and a decrease in seed and bean crops by 35,000 acres (91 percent).

DWR and USDA data suggest a decrease in cropland of approximately 20,000 acres between 2000 and 2013. Managed wetlands within the region include a combination of State wildlife areas and Federal wildlife refuges, as well as privately owned wetlands. These lands are managed to provide important habitat for waterfowl and shorebirds and provide recreational opportunities for bird enthusiasts, hunters, and other activities. Primary habitat types include seasonal wetlands (46 percent), upland habitat (35 percent), and riparian (8 percent). Other habitat includes irrigated pasture, permanent wetlands, and semi-permanent wetlands. Cropland including irrigated pasture and grain crops is a relatively small land use in these areas and typically farmed for wildlife feed and shelter, rather than as a commercial crop.

2.5.2 Irrigated land and potential sources of COCs

The presence of natural salinity conditions in groundwater throughout much of the Coalition region has existed historically as a result of the natural hydrogeologic setting. Natural conditions of groundwater salinity exist throughout all zones of the groundwater system in same areas of the Coalition region as a result of the contribution of salts from recharge off of the Coast Range. Areas of the Coalition region are underlain by low-permeability, fine-grained floodplain sediments and clays which impede vertical movement of groundwater, often resulting in poor drainage conditions, shallow groundwater stagnation, and associated accumulation of salts, particularly in the Very Shallow Groundwater.

The HVA shown in the GAR encompasses all known nitrate exceedances within the Coalition region for which irrigated agriculture is potentially the cause (see GAR, Section 6.2.8). The Westside HVA also overlaps all of the sections within which a historical pesticide exceedance has occurred; of the 272 wells reported to have pesticide detections, five wells have been identified as having an exceedance (see also above Section 2.4.2.1.2).

2.5.3 Existing agricultural management practices

Growers within the Coalition region have already implemented many management practices that are known to or likely to improve groundwater quality and reduce impacts from irrigated agriculture. The GAR outlined some of the changes in management practices. In 2014, Farm Evaluation (FE) surveys and Managed Wetland Evaluation surveys, which describe existing management practices already being actively used, were completed by Coalition members in accordance with the WDRs. These surveys were conducted for all lands irrigated to produce crops or pasture for commercial purposes, nurseries and private/public managed wetlands and results illustrate many changes occurring in the agricultural management practices of Coalition members. The Westside Coalition's 2014 membership total acreage was 459,440 acres as of December of 2014. FEs were returned for a total of 394,433 acres (86% of total acreages) and of these 295,855 acres were irrigated, 64,127 acres are wetland and 26,250 acres are fallow or not irrigated. The purpose of the surveys is to provide the Westside Coalition and the Regional Board with information on how and where management practices intended to protect water quality are being used. This information collected through the FE surveys will be used in conjunction with surface water and groundwater quality information to determine the effects that irrigated agricultural practices have on water quality. Categories of information collected through the FE include:

- Farm Information
- Irrigation
- Pesticide and nitrogen practices
- Well information
- Managed wetland practices

Specific management practices surveyed in the FE are listed in **Table 2-2**. The results from the FE surveys of management practices are discussed and summarized in the following sections. The location of current management practices as updated in the 2016 Farm Evaluations will be reported by township and range by 6 months from GQMP approval. In addition, maps will be created that in the high vulnerability areas identify well management practices, irrigation efficiency practices, and pesticide application practices by 6 months from GQMP approval.

Table 2-2 Management practices implemented in 2014 to protect surface and groundwater quality

Management Practice Category		Management Practice
Irrigation	Primary and Secondary Methods	Drip
		Furrow
		Micro sprinkler
		Flood
		Border strip
		Sprinkler
	Irrigation Efficiency	Water application scheduled to need
		Use of moisture probe
		Laser leveling
		Use of ET in scheduling irrigations
		Pressure bomb
		Soil moisture neutron probe
Pesticide and Nutrient	Pesticide Application	County permit followed
		Follow label restrictions
		Monitor wind conditions
		Avoid surface water when spraying
		Use pest control advisor recommendations
		Attend trainings
		Use drift control agents
		End of row shutoff when spraying
		Use appropriate buffer zones
		Monitor rain forecasts
		Reapply rinsate to treated field
		Sensitive areas mapped
		Chemigation
		Target sensing sprayer used
		Use vegetated drain ditches
	Nitrogen Management Methods to Minimize Leaching Past The Root Zone	Soil resting
		Split fertilizer applications
		Tissue/petiole testing
		Foliar N application
		Fertigation
		Irrigation water N testing
		Cover crops
		Other (e.g., side-dressing, nitrogen fixing crops, time-releasing fertilizers)
		Variable rate applications using GPS
Wellhead Protection	Practices	Good “housekeeping” practices
		Standing water avoided around wellhead
		Ground sloped away from wellhead
		Air gap (for non-pressurized systems
		Backflow preventive / check valve
	Abandoned Wells	Destroyed by licensed professional
		Destroyed - unknown method
		Destroyed – certified by county
Managed Wetland	Pesticide Application	Follow label restrictions
		Monitor wind conditions
		County permit followed
		Monitor rain forecasts
		Avoid surface water when spraying
		Attend trainings
		Sensitive areas mapped
		Use pest control advisor recommendations

2.5.3.1 Irrigation management practices

In the 2014, FE the majority of the Coalition region reports implementing irrigation management practices. Coalition irrigation practices in 2014 are summarized in **Figures 2-6** (primary irrigation methods) and **Figure 2-7** (secondary irrigation methods). The data suggest that about half of the surveyed acreage is irrigated using high-efficiency irrigation systems (drip and micro sprinkler) and the other half utilizes conventional irrigation methods.

Figure 2-8 characterize changes in irrigation technology over time using the available irrigation method data from the circa-2000 DWR land use surveys and additional data obtained from Coalition members. Between approximately 2000 and 2010, the use of microirrigation increased more than three-fold from 11 percent to 36 percent of the irrigated crop area and to about 49 percent (151,000 acres) in 2014. This reflects a combination of a shift to microirrigation for crops traditionally irrigated using gravity techniques (e.g., tomatoes) and a shift of crops commonly irrigated via gravity (e.g., field crop) to crops typically irrigated using microirrigation (e.g., almond orchards). A combination of furrow, flood, border strip, and sprinkler irrigation was used on about 51 percent (157,000 acres) of the lands that specified an irrigation type. **Figure 2-9** illustrates the wide-spread use of a variety of additional practices used to increase irrigation efficiency.

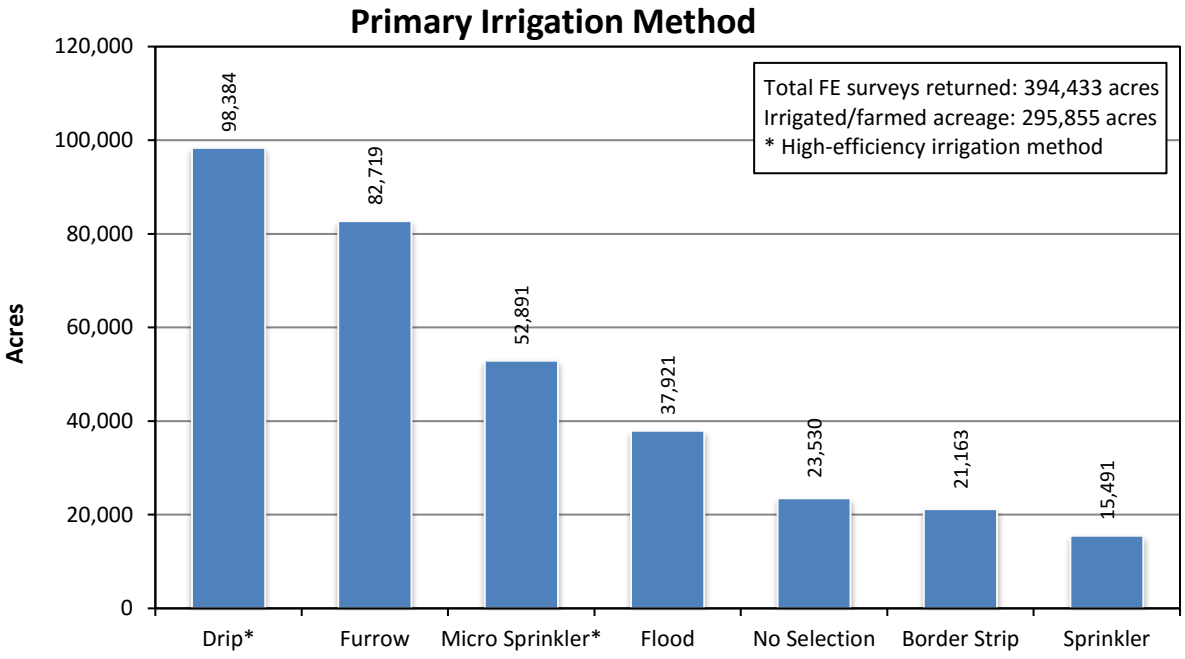


Figure 2-6 Primary irrigation method from 2014 FE

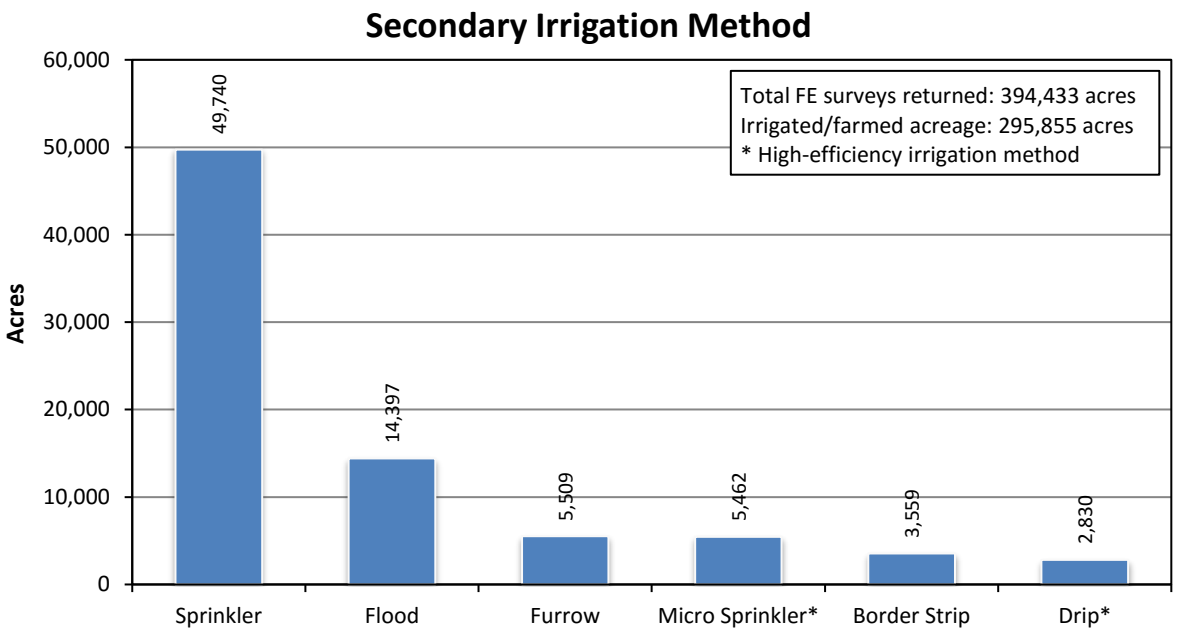


Figure 2-7 Secondary irrigation method from 2014 FE

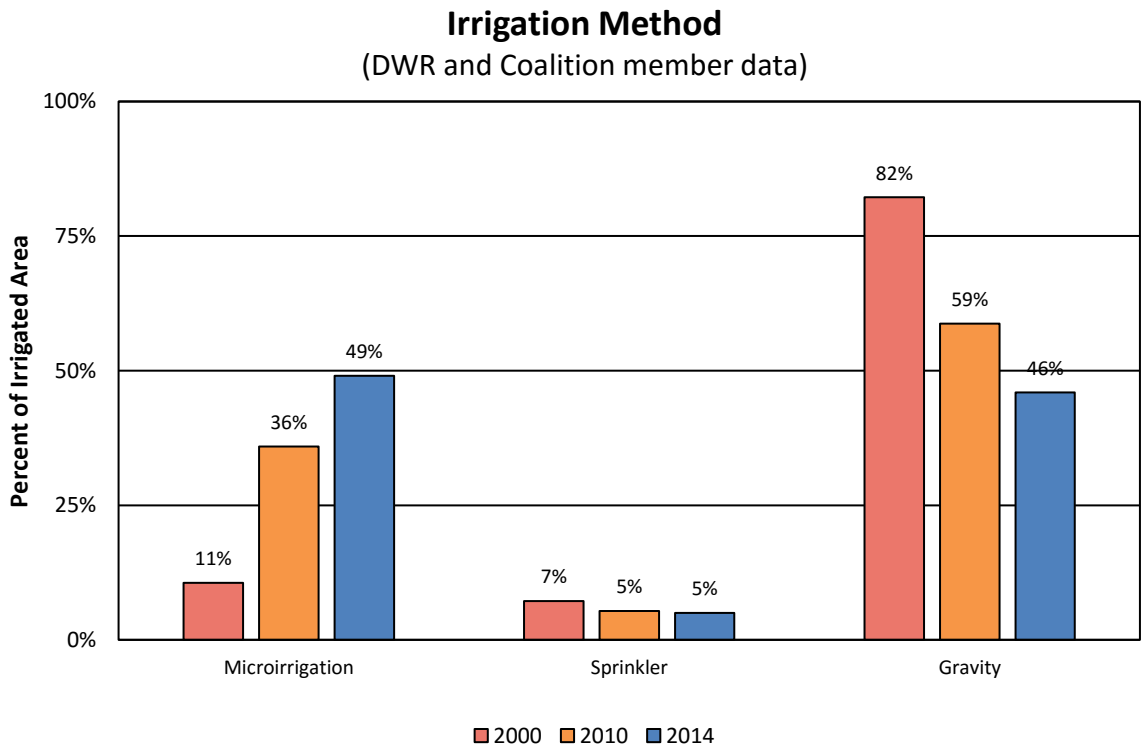


Figure 2-8 Change in irrigation method (circa-2000 from DWR; 2010 and 2014 from Coalition members)

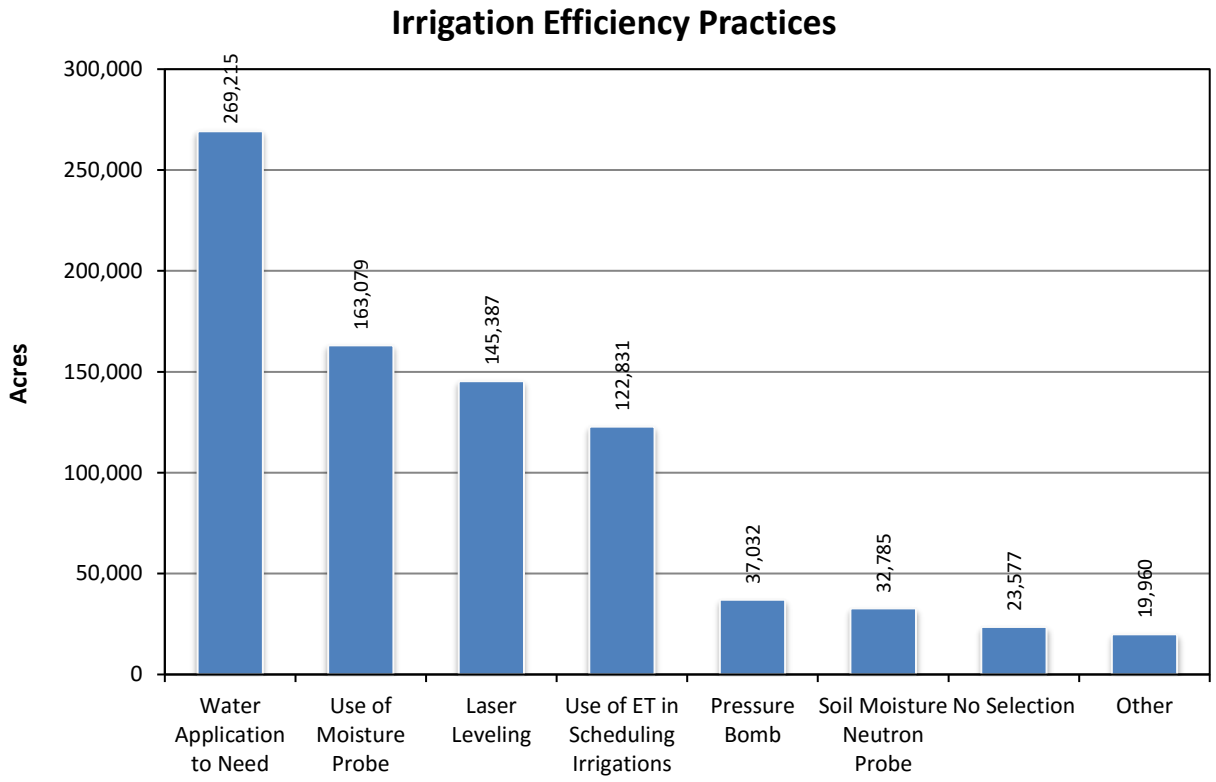


Figure 2-9 Irrigation efficiency management practices

2.5.3.2 Fertilization management practices

Nitrogen fertilization application methods have several associated management practices intended to reduce the movement to groundwater. Nitrogen application amounts differ depending on crop type, irrigation method, soil characteristics, and other factors. Nitrogen management practices for the Coalition region are summarized in **Figure 2-10**. **Figure 2-11** illustrates results for who assists growers in developing their crop fertility plan.

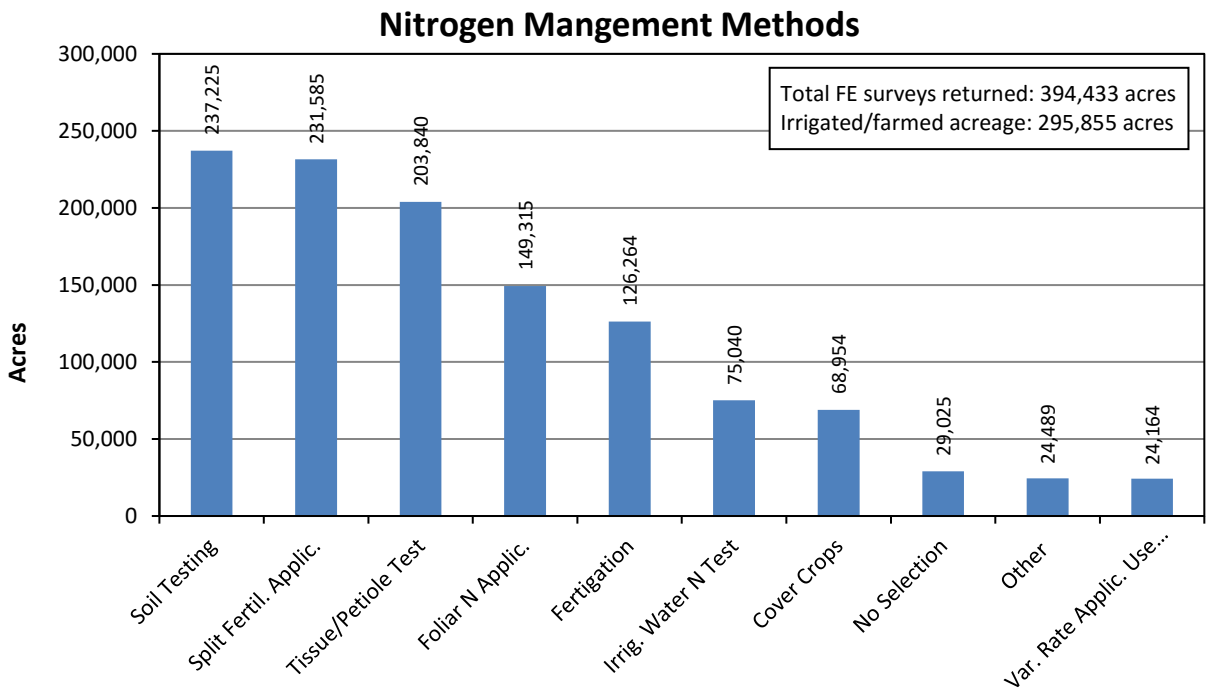


Figure 2-10 Nitrogen application management practices

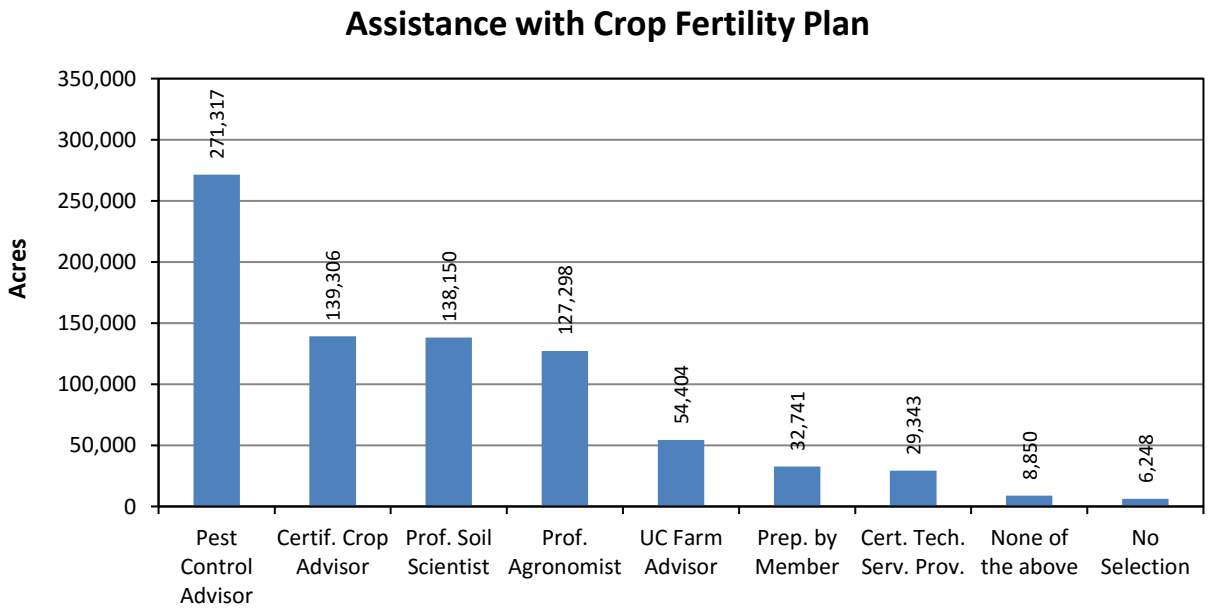


Figure 2-11 Assistance with development of crop fertility plan

2.5.3.3 Well management practices

2.5.3.3.1 *Wellhead protection*

The 2014 FE survey reported 1,062 production wells and of these 1,042 were irrigation wells and most of these reported wellhead protection practices. Over 91 percent reported using good "housekeeping practices" in addition to other well management practices (**Figure 2-12**).

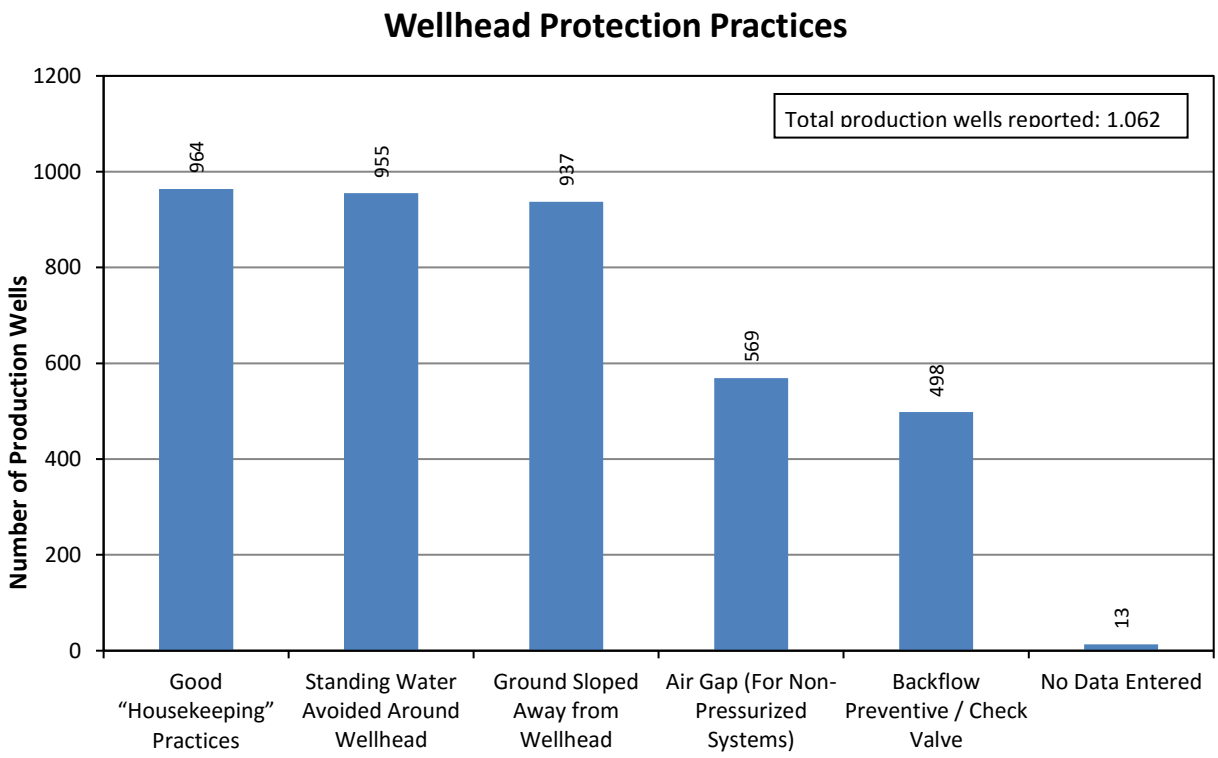


Figure 2-12 Production wells with wellhead protection practices

2.5.3.3.2 *Abandoned wells*

The Westside Coalition region in the 2014 FE survey reports 83 abandoned wells. These wells were mostly abandoned in the 1990s and destroyed by a licensed professional.

2.5.3.4 Pesticide management practices

Several management practices are intended to reduce the potential for movement of pesticides to groundwater. Numerous pesticide management practices were used by Coalition growers in 2014 as summarized in **Figure 2-13**.

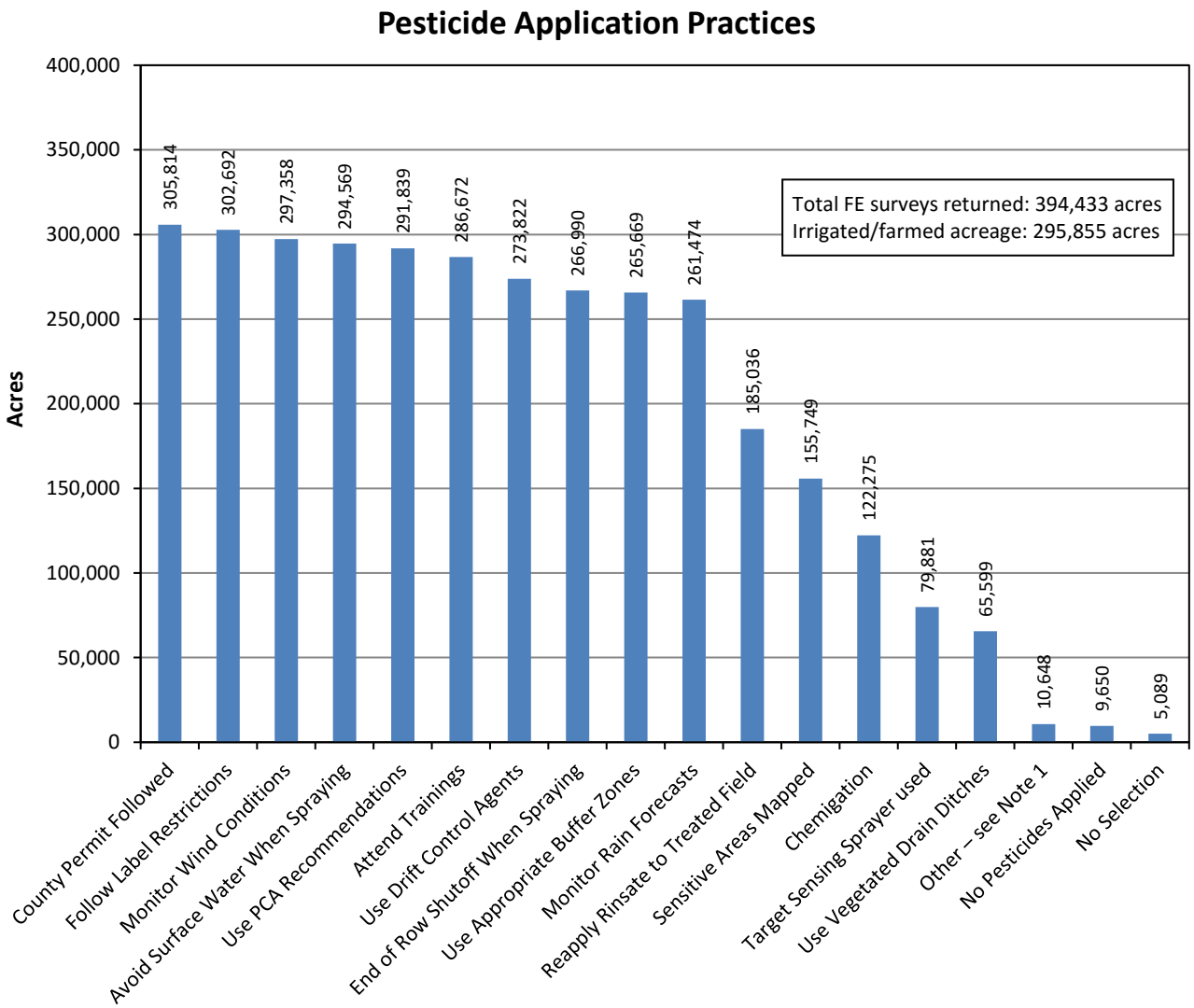


Figure 2-13 Pesticide application management practices

3 MANAGEMENT PLAN STRATEGY

3.1 Description of Approach

Nitrate is the primary COC for the Westside Coalition region and is the focus of the GQMP. Although very few pesticide exceedances have been observed within the Coalition region, pesticides are an additional COC to be addressed by the GQMP and associated ILRP activities. The GQMP will focus on ensuring that appropriate agricultural management practices are implemented by Coalition growers to address these COCs. Specific management practices demonstrated to be effective at reducing movement of COCs into groundwater under various conditions (e.g., commodity, physical setting) will be identified as part of the Management Practices Evaluation Program (MPEP).

3.1.1 Prioritization of Areas

As part of the GAR, the Westside HVA (over 207,000 acres) was prioritized using four priority levels (**Figure 3-1**). The HVAs were prioritized for planning of future monitoring and management efforts, including this GQMP. In accordance with factors identified in the WDRs, the prioritization incorporated many considerations including, but not limited to, the following:

- Identified exceedances of water quality objectives,
- Proximity to communities reliant on groundwater,
- Existing land uses,
- Legacy or ambient groundwater conditions, and
- Hydrogeologic vulnerability factors.

To objectively incorporate the many factors to be considered, a prioritization system was developed with which to calculate priority values across the HVA. From these priority calculations, priority areas ranging from priority 1 (high priority) to priority 4 (low priority) were identified to inform groundwater monitoring and management efforts. The priority areas for lands within the HVA are presented in **Figure 3-1** and summarized in **Table 3-1. Table 3-1** also presents the agricultural land use categories making up each of the different priority areas. The specific commodities that are most common within the Coalition region (based on USDA 2013 land use data), and their spatial distribution relative to the Westside HVA, are presented in **Figure 3-2**. Understanding the land uses within the HVA and each of the priority levels will further serve to guide focused monitoring and management as part of this GQMP and future ILRP activities. A better understanding of agricultural management practices for specific commodities will be developed through compilation and evaluation of results from the Coalition FEs and Nitrogen Management Plans.

Table 3-1 Summary of Westside HVA priority areas and land uses

Description	Priority 1 (Acres)	Priority 2 (Acres)	Priority 3 (Acres)	Priority 4 (Acres)	Total (Acres)
High Vulnerability Area	54,978	58,853	54,816	123,525	292,172
Irrigated Lands Within HVA* (from 2012 FMMP)	51,382	51,663	53,188	51,333	207,566
Land Use Category Within HVA* (2013 USDA land use data)					
Agricultural Land Use Categories	*49,506*	*49,601*	*50,358*	*43,105*	*192,570*
Field Crops	*12,924*	*8,620*	*4,451*	*1,580*	*27,574*
Pasture and Alfalfa	*10,954*	*11,856*	*13,670*	*14,932*	*51,412*
Nut Trees	*9,814*	*12,141*	*19,308*	*13,972*	*55,235*
Grain	*7,828*	*8,110*	*4,620*	*1,848*	*22,406*
Vegetables	*6,118*	*6,375*	*4,881*	*1,580*	*18,954*
Seeds/Beans	*825*	*647*	*1,051*	*668*	*3,191*
Idle	*688*	*1,170*	*945*	*4,747*	*7,549*
Vineyards	*216*	*310*	*454*	*2,063*	*3,042*
Fruit Trees	*113*	*306*	*745*	*1,177*	*2,342*
Citrus/Subtropical	*24*	*66*	*214*	*488*	*791*
Rice	*2*	*1*	*20*	*51*	*75*
Non Agricultural	*5,472*	*9,252*	*4,458*	*80,419*	*99,601*

* Irrigated lands area calculations are based on FMMP 2012 data; land use category calculations are based on USDA 2013 cropscape data. Due to differences between FMMP and USDA datasets, total crop acres from USDA are different than irrigated acres from FMMP.

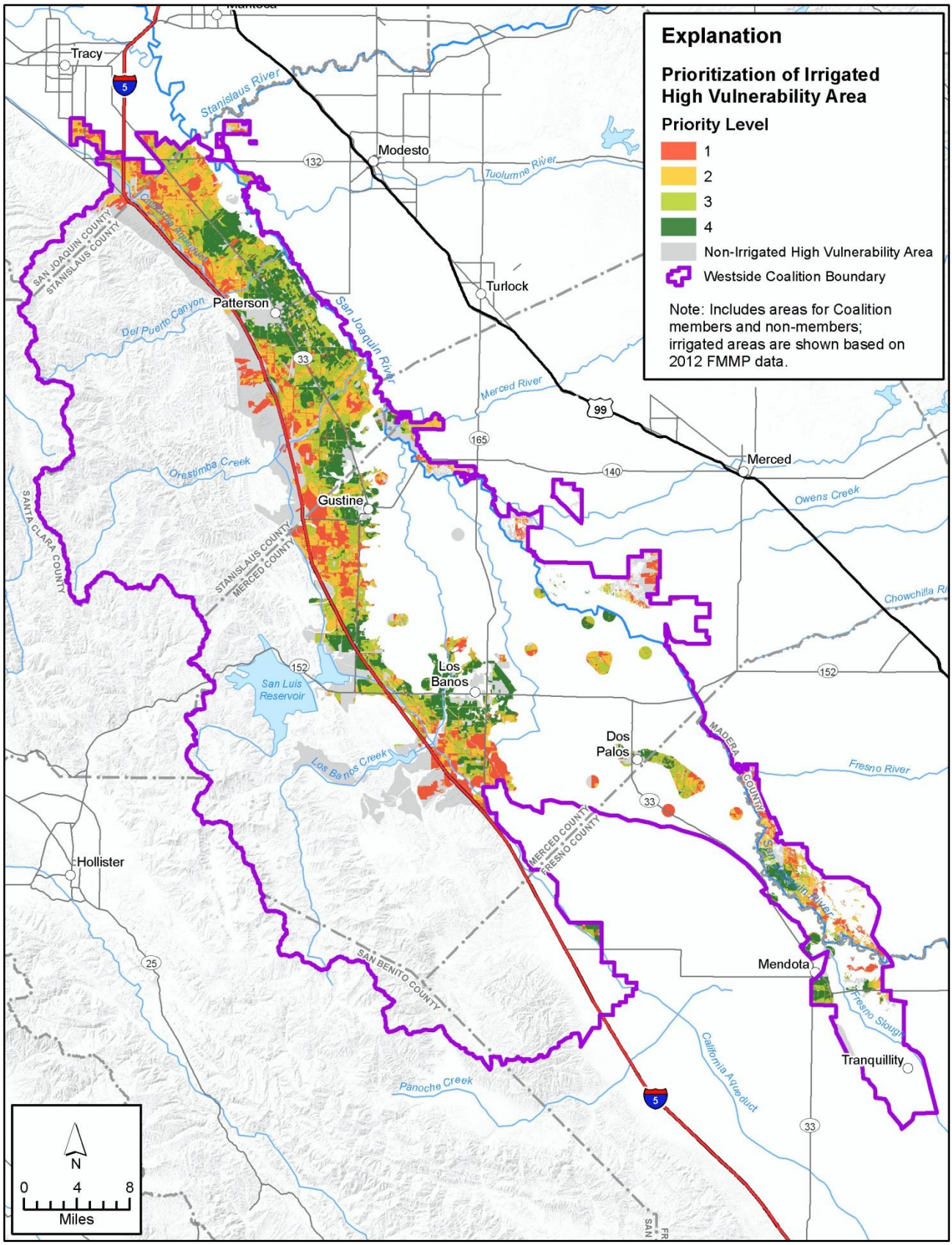


Figure 3-1 Map of priority levels for Westside High Vulnerability Area within irrigated lands

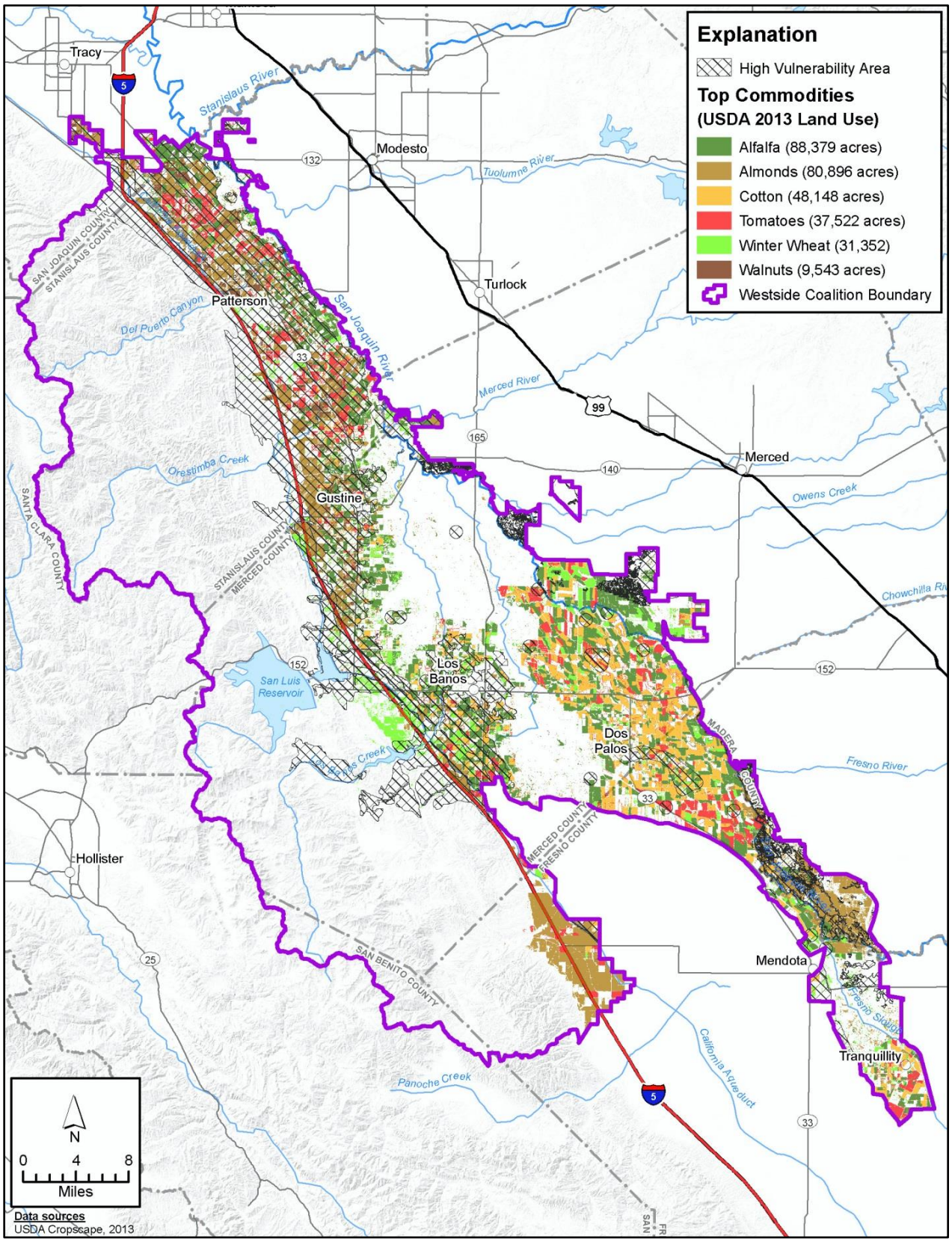


Figure 3-2 Map of top commodities within the Westside HVA

3.2 Actions to Meet the GQMP Goals and Objectives

3.2.1 Compliance with the WDRs receiving (groundwater) water limitations (WDRs Section III)

As described later in this section, the Coalition will be conducting Farm Evaluation surveys, reviewing current management practices, identifying additional effective management practices, and tracking effectiveness related to achieving goals and objectives of the GQMP to comply with the WDRs. More specifically, this section presents performance goals, measures, and milestones implemented to reduce the transport of COCs to groundwater.

3.2.2 Education of members

Throughout the year, the Coalition conducts outreach meetings at various locations in the Coalition region. Discussions at these meetings include Coalition monitoring results (e.g., exceedances of water quality objectives) as well as management practices that can be implemented to reduce surface water runoff, sediment discharge, and leaching of COCs to groundwater.

The Coalition also performs individual outreach to follow up on surface water exceedances and at those meetings will provide information on groundwater management practices. The Coalition distributed to all farmers the first FE survey. The reason it was distributed to all members is that the GAR and high vulnerability areas had not yet been identified. These FEs were received by the Coalition by December 14, 2014 and summarized in the June 15, 2015 Semi-Annual Monitoring Report. Nitrogen Management Plans (NMP) were also provided to all farmers to complete by April 15, 2015; these are maintained on individual farms. The NMP was provided to all farmers because the GAR had not yet been completed.

By March 1, 2016, growers for large farms in high vulnerability areas are to report to the Coalition their NMP Summary Report. This information will be tabulated by the Coalition. Growers with outliers will be contacted, similar to the one-on-one outreach for surface water exceedances, to review the results and provide a list of management practices.

In the fall and winter of 2015, the Coalition will distribute to farmers in large farm-high vulnerability areas the NMP with the requirement to complete, certify and retain on-farm by April 15, 2016. Completion of this form with the certificate requirement will provide farmers an education component.

3.2.3 Identification and Tracking of Management Practices

In addition to the outreach meetings, the Coalition presents information about management practices at individual one-on-one meetings. Information regarding crop-specific management practices will be provided to growers as results are developed through the MPEP. In coordination with the MPEP, the Coalition will work 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.

<u>Nitrogen Management</u>

The implementation of nitrogen management methods will be tracked through responses provided to the FE surveys. Nitrogen management methods were received in the 2014 FE and the status of these

practices will be tracked through results from future FEs and evaluated with respect to GQMP objectives and milestones.

Irrigation Management

The current trend in use of irrigation methods is towards more efficient systems as noted in **Figure 2-7**. Funding assistance programs are provided by districts within the Coalition, NRCS, and other sources to encourage adoption of efficient irrigation technology. Changes in irrigation methods with be tracked and documented through the FEs. Data relating to irrigation management practices were received in the 2014 FE. The status of irrigation management practices will be tracked through results from future FEs and evaluated with respect to the GQMP objectives and milestones.

3.3 Duties and Responsibilities

The Westside Coalition operates under the umbrella organization: the San Joaquin Valley Drainage Authority (SJVDA). The SJVDA is a Joint Powers Authority comprised of member Water and Irrigation Districts (**Figure 1-1**). Consistent with Regional Board regulations, guidelines, and policies, the SJVDA establishes Coalition policy, adopts budgets, and provides guidance and direction to the Watershed Coordinator.

The Watershed Coordinator is responsible for the overall management and day to day operation of the Westside Coalition's activities. He is responsible for field activities including monitoring, production and administration of the field coordinator, implementation and monitoring of Best Management Practices (BMP) projects, and grower outreach. The coordinator insures all data are collected and analyzed in accordance with the QAPP, and manages the database of monitoring results. The coordinator is also responsible for all data analysis and reporting requirements. The Watershed Coordinator provides guidance and direction for the Westside Coalition's day to day operations and administration through the Program Manager and the Quality Assurance/Quality Control (QA/QC) Officer.

The Program Manager (PM) is responsible for the production of the semi-annual and other various reports required under the ILRP. The PM oversees database management, the Coalition's membership list, administers the Coalition's data collection through the various reports the growers provide to the Coalition. The PM also provides technical support to member districts and growers in the Coalition. The PM is the liaison to the Regional Board staff and SJVDA staff. The PM directs field outreach, stakeholder involvement, and BMP recommendations. The PM will also serve as data manager. Outreach to growers and stakeholder involvement is achieved at the field level through dedicated field staff (**Figure 3-2**).

The QA/QC Officer is responsible for all field monitoring and laboratory analysis; ensures that all QAPP procedures, protocols, and policies are adhered to; and ensures all data are collected and analyzed in the laboratory in accordance with the QAPP. The QA/QC Officer is responsible for the training and continuing education of the Westside Coalition's field sampling crews (**Figure 3-2**). The QA/QC Officer is the Coalition's liaison, and provides technical support to, the Westside Coalition's contract laboratories.

Coalition Contact Information:

Joseph McGahan
Watershed Coordinator
San Joaquin Valley Drainage Authority
Phone: 559-582-9237
Email: jmcgahan@summerseng.com

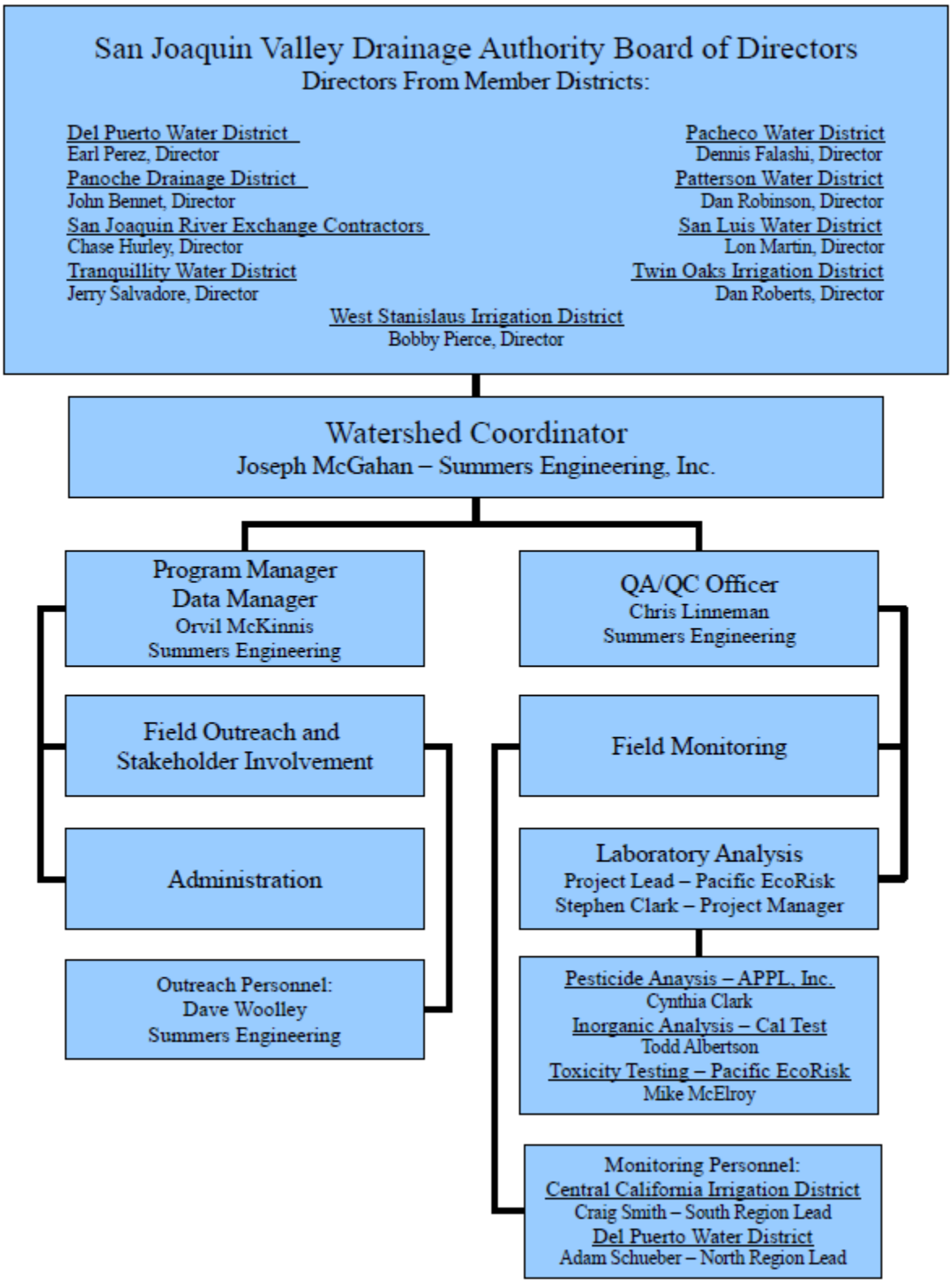


Figure 3-3 San Joaquin Valley Drainage Authority organizational chart

3.4 Strategies to Implement Management Plan Tasks

3.4.1 Agencies contacted for data and assistance

Various entities, including those listed below, will be used as resources for data and other assistance during the implementation of the GQMP.

- County Agriculture Commissioners
- West Stanislaus Resource Conservation District
- USDA Natural Resources Conservation Service

3.4.2 Management practices to control sources of COCs

3.4.2.1 Management practices description and effectiveness

Tables 3-2 through 3-5 summarize management practices that may be appropriate for controlling sources of COCs. These tables describe each management practice and provide an indication of its potential effectiveness. It is important to recognize that not all management practices will be technically and/or economically feasible under all circumstances. Various factors, physical and otherwise, may limit the technical and/or economic feasibility of implementing some MPs (see WDR MRP Att. B, App. 1, Sec. I.C.4.b). Technical and economic exceptions have been noted, and a priority level has been assigned to each practice.

Table 3-2 Irrigation efficiency management practices

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
1	Laser grading	Time-tested MP to produce precise slopes on irrigated farm land. Improved compact and portable electronics automates the process.	Allows for calculation of minimum amounts of irrigation water for a particular crop's needs. Grower sees a return on investment on an annual basis through water savings. Initial cost to grower is limiting factor.	Technically feasible, not applicable for all parcels, i.e., parcels with drip or micro irrigation	3
2	High efficiency irrigation methods	Drip/micro sprinkler systems used to precisely deliver water to each plant.	Minimizes or eliminate irrigation water runoff. This multi-year investment provides grower with a return on investment on an annual basis through water savings. Initial cost to grower is limiting factor.	Technically feasible, high cost, not applicable for all parcels	3
3	Use of ET in scheduling irrigations	The ET, or evapotranspiration, rate equals the total loss of water by evaporation from the soil surface, plus the transpiration from a reference plant, over a given area.	Grower can calculate the evaporation and transpiration losses, which, in turn, helps the grower to efficiently apply water to a field.	Technically and economically feasible	1
4	Water application scheduled to need	The basics of growing a crop dictate that water should be available for plant uptake (or use) when, biologically, the plant is ready to accept moisture. There are many variables, such as plant type, atmospheric temperature, soil temperature, etc., which must be considered when scheduling crop irrigation.	This MP can be effective as there are multiple reputable sources available to a grower that provide guidance when, and how much water a plant needs. This allows a grower to adopt an appropriate irrigation schedule.	Technically and economically feasible	1

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
5	Use of moisture probe	Sensors are employed which report soil moisture levels at a plant's root zone.	By measuring the amount of moisture available to the plant, over-watering can be reduced, thereby reducing the potential for COC migration past the root zone.	Technically feasible, usually requires farmer hire consultant	3

*Specific circumstances and physical factors may limit the technical and/or economic feasibility of implementing some MPs (see WDR MRP Att. B, App. 1, Sec. I.C.4.b).

**Priority:

1 Recommend to all growers in outreach materials and meetings
2 Identify to growers as a useful tool if applicable to growers operation
3 Identify to growers at outreach meetings as good practices if feasible for grower

Table 3-3 Nitrogen management practices

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
1	Irrigation water N testing	Determine the amount of N being added to the soil nutrient profile via the applied irrigation water. An irrigation water sample is collected and sent to a laboratory for analysis. That result is used to calculate the amount of N that is being added by the irrigation source water throughout the crop growing season.	Allows the grower to incorporate that value into the total N required and calculate the crop's need more precisely. The MP can be highly effective in areas where surface or groundwater contain high levels of nitrate that can be incorporated into an overall on-farm nitrogen use strategy.	Technically and economically feasible	1
2	Soil testing	Measures the potential amount of N residing in the soil profile that might be available for plant uptake. Soil samples are taken at various depths in the profile where the plant is likely to encounter nutrients and at multiple locations throughout the crop fields. The samples are taken to a laboratory for analysis and the results are used to calculate the amount of N in the soil available for plant uptake.	Allows the grower to incorporate that value into the total N required and calculate the crop's need more precisely. While the MP can be useful, its effectiveness is blunted by the need for multiple samples which begin to make it cost prohibitive.	Technically feasible, usually requires farmer hire consultant	2
3	Tissue/petiole testing	Measures the amount of N residing in the plant at the time of the test. Nutrient management can be made more efficient by plant analysis and plant tissue/petiole nitrate testing is a way of monitoring the nitrogen condition of the crop during the growing season.	Effectiveness of the testing is limited by the amount of time required in getting results back to the grower to allow for real-time use in nutrient management.	Technically feasible, usually requires farmer hire consultant	2

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
4	Foliar N application	Widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots. Allows grower to apply the nutrient directly on the plant instead of introducing more fertilizer to the soil.	Advantage is that the nitrate in the soil profile is less likely to impact groundwater due to less N being introduced in the soil. The disadvantage is that not all plants react favorably to foliar N application.	Technically and economically feasible. Foliar N usually very minor percentage of total N applied	2
5	Split fertilizer application	Divides the total N application into two or more applications during the plant's growing cycle. Postponing a portion of the N application until the crop is better able to utilize the nutrient allows plants to take up N more quickly and efficiently.	Benefit of this MP is that the potential for N loss is minimized and thereby, less total N is used.	Technically and economically feasible	3
6	Fertigation	Injecting fertilizer directly into high efficiency irrigation systems.	Nutrients can be applied directly to plants in the correct amount and at the right time for each specific stage of plant growth. In turn, this lessens the amount of total N applied which lessens the potential to impact groundwater. The MP is highly effective, but can be cost prohibitive to growers.	Technically feasible, high cost (required drip or micro irrigation system), not applicable for all parcels	3
7	Variable rate applications using GPS	Variable rate application is used to minimize the amount of N used in each part of a field by adjusting applications to site-specific needs. The global positioning system directs the spraying implement to each of those site-specific locations in the field.	The MP is highly effective, but when compared to conventional methods, it can be cost prohibitive to growers.	Technically feasible, high cost (requires GPS equipment), not applicable for all parcels	3

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
8	Employ cover crops	Depending on whether a grass or legume is planted, the MP is designed to trap and recover unused N in the soil and/or provide atmospheric N from their plant tissues when they are tilled back into the soil.	Somewhat effective. It can be difficult to calculate the amount of N available to a crop without additional soil sampling and analysis. This MP is more suited to the organic farmer.	Technically and economically feasible, not applicable to all crops	3
9	Nitrogen Management Plan and Summary Report	Tool for farmers to properly plan and report nitrogen application.	Effective in providing tools for applying the right amount of synthetic fertilizer. Allows for accounting of nitrogen in water and other sources. Coalition reporting back to farmers a comparison of their application rates compared to other farmers will be useful information.	Technically and economically feasible	1

*Specific circumstances and physical factors may limit the technical and/or economic feasibility of implementing some MPs (see WDR MRP Att. B, App. 1, Sec. I.C.4.b).

**Priority:

1 Recommend to all growers in outreach materials and meetings
2 Identify to growers as a useful tool if applicable to growers operation
3 Identify to growers at outreach meetings as good practices if feasible for grower

Table 3-4 Wellhead protection management practices

Management Practice		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
1	Ground sloped away from wellhead	A wellhead may provide a conduit for surface water to migrate to groundwater and thereby the potential for COCs to impact groundwater. This MP requires the ground at, and directly adjacent to, a wellhead to be sloped away from the wellhead in such a manner so as to not allow water to contact the wellhead or its standpipe.	An effective MP as it requires minimal investment and minimal maintenance.	Technically and economically feasible	1
2	Standing water avoided around wellhead	Standing water near a wellhead could potentially enter the well casing and move to groundwater. The MP requires a grower to monitor the area near the wellhead and not allow surface water to pond.	An effective MP as it requires minimal investment and minimal maintenance.	Technically and economically feasible	1
3	Good housekeeping practices	If debris is allowed to collect at or near a wellhead, there is the possibility for materials with pesticide or nutrient residue to contaminate the wellhead. If water were to come in contact with the contamination, contaminated water could potentially impact groundwater. The MP requires the grower to monitor well sites and remove debris at regular intervals.	An effective MP as it requires minimal investment and minimal maintenance.	Technically and economically feasible	1

Management Practice		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
4	Air gap used on non-pressurized systems	When a well is powered-down a pressure differential can be created that can cause any water in the well system to be drawn back down the well casing. If that water has come into contact with COCs, the contaminated water would be drawn down the well and potentially impact groundwater. Some types of irrigation systems require the well to be connected directly to the system; this creates a closed and pressurized system. The MP requires the grower to create a mechanical separation between the well discharge piping and the remaining irrigation piping.	An effective MP. The disadvantage is, that in some scenarios, it requires the grower to install a booster pump to account for the pressure loss the air gap creates. Growers may not be able to afford the cost of the booster pump and the energy for operation.	Technically and economically feasible	1
5	Backflow prevention valve for pressurized systems	When a well is powered-down a pressure differential can be created that can cause any water in the well system to be drawn back down the well casing. If that water has come into contact with COCs, the contaminated water would be drawn down the well and potentially impact groundwater. Some types of irrigation systems require the well to be connected directly to the system; this creates a closed and pressurized system. The MP requires the grower to install a special check valve between the wellhead and the pressurized irrigation system to stop any reverse flow back to the wellhead.	An effective MP. The disadvantage is that the special check valve requires the grower to perform regular maintenance and testing of the valve.	Technically and economically feasible	1

*Specific circumstances and physical factors may limit the technical and/or economic feasibility of implementing some MPs (see WDR MRP Att. B, App. 1, Sec. I.C.4.b).

**Priority:

1 Recommend to all growers in outreach materials and meetings

Table 3-5 Pesticide handling management practices

Management Practice (MP)		Description	Effectiveness*	Technical/Economic Exceptions	Priority**
1	Good Housekeeping	Follow county permit requirements, label restrictions, and attend training.	This is a basic requirement	Technically and economically feasible	1
2	Avoid surface water when spraying	See notes 1 and 2.	See note 3	Technically and economically feasible	1
3	Use appropriate buffer zones	A buffer zone is a given distance for a given sprayed constituent away from a water body. See notes 1 and 2.	See note 3	Technically and economically feasible	1
4	Monitor wind conditions	Wind conditions play an important part of when chemical spraying can or cannot be performed as it can cause chemicals to drift into unwanted areas. There are multiple free sources available to an applicator to know wind velocity at the application site. See notes 1 and 2.	See note 3	Technically and economically feasible	1
5	Use drift control agents	Drift control agents are chemical additives that help the main constituent bond to its intended target. By minimizing drift and improving plant targeting, drifting of the chemical into unwanted areas is minimized.	Using drift control agents reduces the amount of chemical used because of the increased targeting efficiency which lessens the opportunity for impact to surface waters. The MP has proven to be effective and is widely used throughout the Coalition's service area.	Technically and economically feasible	1

Management Practice (MP)	Description	Effectiveness*	Technical/Economic Exceptions	Priority**	Management Practice (MP)
6	Use vegetated drain ditches	Vegetated ditches are wide, often shallow, low velocity channels used to transport irrigation or storm water drainage from fields to sumps or downstream waterways. The purpose is to slow movement of irrigation and storm water to help reduce erosion and sediment transport as well as filter input residues.	This MP is somewhat effective but its implementation presents challenges. It requires annual maintenance; takes acreage out of production; can harbor pests; and noxious seeds can be spread to farm fields.	Technically and economically feasible, not applicable to all crops	2
7	Chemigation	Applying chemicals to cropland using a pressurized irrigation system to distribute both the water and chemical.	This practice is very effective as precise amounts of pesticides and nutrients can be applied directly to the plants, thereby reducing the overall amount that may have been used otherwise. Initial investment of a pressurized irrigation system can be cost prohibitive to growers.	Technically feasible, high cost (required drip or micro irrigation system), not applicable for all parcels	3
8	Reapply rinsate to treated field	In the process of mixing chemicals and cleaning/rinsing pesticide application equipment, a rinsate remains and must be disposed of in an environmentally safe manner. The rinsate is spread across the recently treated farm field and becomes part of the total chemical applied. See note 2.	See note 3	Technically and economically feasible	1

Management Practice (MP)	Description	Effectiveness*	Technical/Economic Exceptions	Priority**	Management Practice (MP)
9	Target sensing sprayer used	Use of technologically advanced pesticide application equipment (e.g., special spray nozzles, controlled droplet application technology, electrostatic charging of spray droplets, real-time operator controlled spray rates, and sensors to adjust spray nozzles to the foliage profiles).	Highly effective MP. The technology allows the applicator to target the pesticide more directly and accurately on the affected plant. Compared to conventional methods, it can be cost prohibitive to growers.	Technically feasible, high cost (requires special equipment), not applicable for all parcels	3
10	End of row shutoff when spraying	Lateral drainage ditches and surface water canals are often located perpendicular to tree rows, shutting off sprayer nozzles when approaching the end rows can reduce drift of pesticides into these non-target surface water bodies. See notes 1 and 2.	See note 3	Technically and economically feasible	1

Notes:

1. Applicator to be familiar with the location of potential surface water and surface water vectors (i.e. drain ditches, field discharge points).
2. The MP is a standard practice and is included in all labeled instructions.
3. While the MP can be effective, it is not a “stand-alone” practice and must be used in conjunction with other MPs or its effectiveness is negated.

*Specific circumstances and physical factors may limit the technical and/or economic feasibility of implementing some MPs (see WDR MRP Att. B, App. 1, Sec. I.C.4.b).

**Priority:

1 Recommend to all growers in outreach materials and meetings
2 Identify to growers as a useful tool if applicable to growers operation
3 Identify to growers at outreach meetings as good practices if feasible for grower

3.4.2.2 Practices required by local, state, or federal law

1. Backflow prevention:

DPR requires that equipment drawing water from an outside source, such as a well, to be equipped with an air-gap separation, reduced pressure principle backflow prevention device, or double check valve assembly. Backflow protection must be acceptable to both the water purveyor and the local health department (see 3CCR § 6610). Further, in 2001, DPR issued two enforcement letters, ENF 01-12 and ENF 01-28, to clarify that the EPA label language is appropriate protection for chemigation systems connected to stand alone domestic and irrigation wells. These letters affirm DPR's adoption of the EPA label language and include a list of alternative components.

2. Wellhead protection:

DPR requires a 100 foot buffer zone around any well for anyone mixing, loading, and storing pesticides; rinsing spray equipment or pesticide containers; performing maintenance on spray equipment that could result in spillage of pesticide residues on the soil; or the application of pre-emergent herbicides. (see 3CCR § 6609).

3.4.2.3 DPR Groundwater Protection Program requirements

1. Runoff ground water protection areas:

DPR requires anyone who uses pesticides, in “runoff” groundwater protection areas, that are registered for agricultural use containing chemicals listed in section CCR § 6800(a) to adhere to the management practices listed in CCR § 6487.4. For a fuller reading of the regulation and the attending management practices see: http://www.cdpr.ca.gov/docs/emon/grndwtr/regs/pesticide_use.htm.

2. Leaching groundwater protection areas:

DPR requires anyone who uses pesticides, in “leaching” groundwater protection areas, that are registered for agricultural use containing chemicals listed in section CCR § 6800(a) to adhere to the management practices listed in CCR § 6487.5. For a fuller reading of the regulation and the attending management practices see: http://www.cdpr.ca.gov/docs/emon/grndwtr/regs/pesticide_use.htm.

3.4.2.4 Summary and cross reference to MPEP

The intent of the MPEP is to evaluate the effectiveness of specific irrigated agricultural management practices on improving or protecting groundwater and identify practices for implementation. The design of the MPEP has not been completed; however, as results from the MPEP are available to inform and draw conclusions relating to management practices, such information will be incorporated into Coalition outreach efforts.

3.4.3 Grower Outreach

3.4.3.1 Methods of outreach

As the need arises, outreach to growers will be initiated to inform them of on-farm management practices they can employ in their general areas to minimize impacts to groundwater from COCs. The

Coalition is currently conducting outreach to growers and will continue while exploring any other available avenues of outreach. Currently, the Coalition performs outreach to growers on an annual basis, in large venues in the southern, central, and northern sectors of the Coalition's service area. The Coalition also meets with growers in smaller groups in targeted areas where COCs are an issue as well as one-on-one grower visits if the situation warrants it. The Coalition utilizes its member Water District's outreach by supplying relevant material and articles for the Districts to distribute on the Coalition's behalf. An annual Coalition newsletter is also published and sent to all Coalition growers as well as targeted and specialized announcements when the need arises. The Coalition maintains a website and posts all relevant news and information for the growers' benefit and use.

Specific outreach will be made to growers regarding the information reported in their Nitrogen Management Plan Summary Reports (NMP Summary Reports). Information provided in the NMP Summary Reports will be checked, converted to A/R (applied/removal) and summarized for specific crops and areas. Feedback will be provided to growers on the A/R that was reported and how their numbers compare to similar growers. This feedback will be provided prior to the next crop year so there is time to take into account this information prior to the next NMP submittal. For example NMP Summary A/R grower information from the 2015 crop year will be provided to growers prior to their 2017 year planning. Outliers will be identified and specific outreach will be made to outliers per **Table 3-6**, Performance Goals.

Outreach is also made via the Westside San Joaquin River Watershed Coalition website at: http://www.westsidesjr.org/.

3.4.3.2 Evaluation of effectiveness

The Coalition currently tracks all attendees at all meetings and will continue to do so. Membership mailing lists are regularly updated to ensure that mailed material is arriving to the proper people at the correct address. Annual farm plans in high vulnerability areas will also be analyzed to mark the year-to-year changes in management practices implementation as a gauge of outreach effectiveness. Effectiveness will also be evaluated by tracking the percent Farm Evaluation and NMP Summary Reports received from year-to-year. Attendance at annual and special meetings will be evaluated through percent attendance.

3.4.3.3 Coordination of outreach

The Coalition will coordinate with MPEP activities to make the best use of outreach efforts. The way outreach is conducted, and to whom it is directed, will be informed by the efforts of the MPEP. The Coalition recognizes that its current outreach direction may need to be modified as the MPEP begins to generate crop-specific data and management practice effectiveness related to specific crops in specific areas of the Coalition. Additionally, opportunities to coordinate outreach with other Coalition-related activities, including but not limited to other ILRP activities, will be explored and considered.

Table 3-6. Performance Goals

Performance Goal	Milestone/Action	Metric	Goal	Completion Date	Deliverable
1. Provide Outreach and Education to members in HVA					
	Develop list of parcels in HVA areas	List of parcels and completion of map	100%	90 days after GQMP approval	List and map of parcels
	Develop GW specific outreach material		NA	90 days after GQMP approval	Copy of outreach material
	Outreach to parcels in HVAs	# Growers reached	100%	4 years from GQMP approval (1)	Outreach materials
	Outreach to all growers at Annual Meetings	# of growers attended	100%	Annually.	Annual Meeting attendance count
2. Properly destroy abandoned wells					
	Locate parcels with abandoned wells in all areas	Completion of map	100%	120 days after GQMP approval	Map of parcels with abandoned wells
	Outreach to well owners to Identify abandoned wells that need to be destroyed/confirm destruction method of destroyed wells	Abandonment status of wells	100%	180 days after GQMP approval	List of wells that require destruction
	Proper destruction of identified wells	# of wells destroyed	100%	To be determined (2)	List of wells destroyed
3. Implement Well Head Protection Practices					
	Locate parcels that have wells w/o any well head protection MPs in all areas	Completion of map	100%	120 days after GQMP approval	Map of parcels with unprotected wells
	Outreach to well owners	# of well owners reached	100%	210 days after GQMP approval	
	Implement well head protection measures	Inventory of MPs implemented	100%	1 year after GQMP approval	FE data summaries, updated well map, outreach

Performance Goal	Milestone/Action	Metric	Goal	Completion Date	Deliverable
4. Implement Pesticide Management Practices for Groundwater					
	Identify and locate wells with past pesticide exceedances in all areas	# of wells identified and located	100%	120 days after GQMP approval	
	Resample wells with past exceedances	# of wells resampled	100%	210 days after GQMP approval	resample results
	Outreach to well owners w/ confirmed pesticide exceedance. Recommend MPs	# of MPs implemented	100% of wells with exceedances	To be determined (3)	Outreach materials
	Review results from trend monitoring program	inventory of exceedances w/ details	100%	Reporting date in Trend Monitoring Program	Trend monitoring report
	Implement pesticide MPs	Inventory of MPs implemented	25% per year	2 years after Reporting date in Trend Monitoring Program	FE data summaries, updated well map, trend monitoring results
5. Outreach to Nitrogen Outliers					
	Identify outliers from NMP Summary Reports in HV areas	List of outliers	100%	November 30 Annual Monitoring Report	Summary of outlier data in AMR
	Outreach to outlier growers	# of growers reached	100%	4 years from GQMP approval (1)	Outreach materials, documentation of outreach
	Track outlier trends	Report of trends from NMP Summary Reports	100%	Annually in Annual Monitoring Report November 30 each year	Outlier data summary and trend comparison

Notes:
(1) Outreach activities expected to reach one-quarter of the relevant growers annually
(2) Completion date is dependent on actual number of wells that need to be destroyed
(3) Dependent on the number of exceedances detected

3.4.4 Performance goals and measures

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 ensure that the objectives of the Management Plan program are met and that groundwater quality improves in the Coalition region.

The following section describes the Performance Measures associated with each Performance Goal. These Performance Measures are the actions the Coalition will perform to meet the Performance Goals. Performance Measures will be implemented across the Coalition region although some areas may receive greater emphasis and evaluation in accordance with monitoring subareas identified as part of the Groundwater Quality Trend Monitoring (GQTM) development. **Table 3-6** shows the Performance Goals and corresponding milestone/action, metric, goal, completion date, and deliverable.

Performance Goal 1.
Provide Outreach and Education to members in HVA.

Performance Measure

The Coalition will develop a list and map of parcels within the high vulnerability areas. Outreach materials will be developed and used for outreach to parcels and for presentation at grower meetings. Member parcels will be reviewed in relation to the most recent groundwater high vulnerability areas. This information will be used to identify member acreage within the Coalition GQMP area.

Performance Goal 2.
Properly destroy inactive/chronically unused wells

Performance Measure

Parcels with abandoned well will be identified in all areas of the Coalition. Although a well may be referred to as abandoned, this does not mean it has been destroyed per the requirements of DWR Bulletin 74-90 and 74-81 Water Well Standards. Nor does it mean that the owner intends to destroy the well. Outreach will be made to well owners to identify abandoned wells that need to be destroyed and/or to confirm the destruction method of destroyed wells.

Performance Goal 3.
Implement Well Head Protection Practices

Performance Measure

Parcels will be located without any well head protection in all areas of the Coalition. Outreach will be made to well owners, and well head protection measures will be recommended.

Performance Goal 4.
Implement Pesticide Management Practices for Groundwater

Performance Measure

The pesticide exceedances identified in the GQMP are several decades old. The Coalition will attempt to locate and identify the wells where exceedances occurred for follow up. Going forward results from the trend monitoring program will be reviewed and actions implemented if wells are identified with pesticide exceedances. The Coalition will follow up on implementation of pesticide management practices.

Performance Goal 5.
Outreach to Nitrogen Outliers

Performance Measure

The Coalition will identify outliers from the NMP Summary Reports in high vulnerability areas. Outreach will be made to growers that have identified outliers, and outlier trends will be tracked.

3.4.4.1 Evaluating progress and milestones

Each year the Coalition will evaluate and report on the management practices implemented the previous year by members within GQMP areas in the November 30 annual monitoring report. Each year, the Coalition will conduct outreach and education of members regarding effective management practices that can be implemented to reduce the transport of COCs to groundwater.

3.4.4.2 Schedule

The overall schedule associated with the GQMP and relevant ILRP requirements will be in accordance with timelines specified in the WDRs. The schedule of ILRP activities is provided in **Table 3-7**.

Table 3-7 Irrigated Lands Regulatory Program schedule and GQMP milestones

	2014	2015	2016	2017	2018	2019	2020	2020+
	Q1 ---------- Q4	Q1 ---------- Q4	Q1 ---------- Q4	Q1 ---------- Q4	Q1 ---------- Q4			
Key Irrigated Lands Regulatory Program (ILRP) Activities								
Adoption of Waste Discharge Requirements (WDR) General Order R5-2014-0002 (January 9, 2014)	●							
Approval of Notice of Applicability (NOA) for Coalition as Third-Party Representative (March 17, 2014)	●							
Groundwater Quality Assessment Report (GAR)								
GAR Outline Submittal (June 13, 2014)	●							
GAR Submittal (March 16, 2015)		●						
RWQCB GAR Approval (September 16, 2015)		●						
GAR Update (September 16, 2020 and subsequently at five-year intervals)								●
Comprehensive Groundwater Quality Management Plan (GQMP) (November 16, 2015)		●						
Management Practices Evaluation Program (MPEP)								
Workplan Completion - Individual Option (September 16, 2016)			●					
Workplan Completion - Group Option (June 4, 2016)			●					
Groundwater QAPP for MPEP (September 16, 2016)			●					
Annual MPEP Reporting (November 30 Annually)				●				
Management Practices Evaluation Report (MPER) (Six years after implementation of each phase of MPEP)								●
Groundwater Quality Trend Monitoring (GQTM)								
Workplan Completion (September 16, 2016)			●					
Groundwater QAPP for GQTM (September 16, 2016)			●					
Annual GQTM Reporting (November 30 Annually)				●	●	●	●	●
Groundwater Monitoring Reporting								
Groundwater Monitoring Reports (November 30 Annually)			●	●	●	●	●	●
Annual Groundwater Monitoring Results Submittal (June 15 Annually)			●	●	●	●	●	●

4 MONITORING DESIGN: COORDINATION WITH MPEP AND GQTM

The Coalition's groundwater monitoring will be accomplished through monitoring conducted as part of the GQTM and MPEP. The Coalition is participating in a group MPEP for which the workplan was submitted on June 4, 2016. Ongoing efforts are being made to coordinate the MPEP with other coalition groups. The GQTM Workplan is due on September 16, 2016, one year after GAR approval. A general overview of some of the anticipated monitoring components of the MPEP and GQTM is summarized below. Results from the MPEP and GQTM will be evaluated to determine if additional monitoring is needed in conjunction with proposed management strategies to meet GQMP objectives. Required updates to the GAR at five-year intervals will also assemble and evaluate additional groundwater quality data to characterize groundwater quality conditions and trends.

4.1 Management Practices Evaluation Program (MPEP)

The MPEP evaluates the effectiveness of specific irrigated agricultural management practices on improving or protecting groundwater under different conditions (e.g., soil type, depth to groundwater, irrigation practice, crop type, and nutrient management practice). The MPEP Workplan was submitted on June 4, 2016); an outline of some of the components and considerations is provided below.

- Study Design: Conduct studies to determine whether management practices are protective of groundwater and determine the processes that influence the availability of nitrate for leaching
    - Literature search for information used to supplant the need for studies on certain crops
        - Modeling may be performed as part of studies if the literature search produces adequate information to begin model development and initial modeling
    - Select region and individual fields for study
        - Prioritized by vulnerability status, crop type, and management practice to be evaluated
    - Management practices selected will initially focus on those assumed to reduce nitrate leaching to groundwater
    - Develop experimental design with multiple sampling grids within each plot
        - Characterize initial soil physical and chemical conditions at each test site
- Extrapolation of Result:
    - Evaluate potential for model development and where applicable, conduct initial modeling to extend the results of the studies to other crops and management practices
    - Develop conceptual model based on initial evaluation, where applicable, potential methods involve physical based modeling (e.g., Hydrus, ENVIRO-GRO) or statistical modeling
    - Synthesis of the information obtained from the studies and literature search to identify generalities about management practices and what additional studies may be needed
- Potential additional modeling of crops and management practices

4.2 Groundwater Quality Trend Monitoring (GQTM)

The GQTM Workplan will evaluate current water quality conditions and will develop a groundwater monitoring network in both high and low vulnerability areas used to evaluate long-term regional effects of agricultural management practices on groundwater quality. The design of the GQTM has not been completed (due date is September 16, 2016), but an outline of some of the anticipated components and considerations is provided below. It is anticipated that the GQTM will include a proposal for a regional monitoring program to take advantage of other programs that may have similar requirements as well as a process to select candidate wells in the Westside Coalition area for initial monitoring.

- GQTM Concept: Establish monitoring program for collecting groundwater quality data for evaluation of long-term changes in regional groundwater quality and responses to agricultural management practices
- Delineation of distinct monitoring areas considering various factors including groundwater vulnerability, land use, physical characteristics, and prioritization
- Establishing criteria to use in selection of wells to include as part of GQTM network incorporating conceptual hydrogeologic understanding and GQTM objectives for monitoring of long-term regional groundwater quality and assessment of effectiveness of agricultural management practices at a regional scale
- Identifying wells (in accordance with the established GQTM well criteria) for inclusion in GQTM network
    - Consider well construction and potential capture zone
    - Consider historical record of water quality data
    - Site-specific considerations
    - Coordinate agreement with well owners or other monitoring entity
- Conducting groundwater quality monitoring of GQTM network wells (in accordance with monitoring constituents and schedule in WDR)
- Annual evaluation and reporting of results of GQTM in accordance with WDR
- Consider analyses, where applicable, to determine if the nitrogen in the groundwater is from naturally occurring nitrogen or applied fertilizer

5 DATA EVALUATION AND REPORTING

To determine the effectiveness of management practices, the following data will be collected:

- Management practices used by growers reported through the FE Reports
- Pesticide use information from the County Agricultural commissioners
- Update of water quality database in conjunction with updating of the GAR and GQTM (every five years) to acquire data from SWRCB Division of Drinking Water (DDW), Geotracker, USGS, and pesticide data from DPR
- Recommended management practices to growers through meetings and written material
- Consideration of all factors of elevated constituents, including natural causes and groundwater migration (direction of groundwater flow)

These data will be assessed to associate implemented management practices with changes in water quality. Results will be reported as part of the semi-annual monitoring reporting. Data collection and evaluation will be coordinated and conducted in accordance with the procedures developed as part of the MPEP and GQTM.

The intent of the GQTM is to evaluate long-term changes in groundwater quality conditions at a regional scale as they relate to aggregated effects of irrigated agriculture and changes in agricultural practices. The GQTM will include analysis and reporting of trend monitoring results.

5.1 GQTM Analysis

Annual reports will likely include a map or maps of the wells sampled and monitored as part of the GQTM network. Results from sampling will likely be provided as a summary of the results using statistics such as recent, minimum, maximum, and mean result, in addition to providing all field and analytical results. Some visual presentation of results with limited interpretation may be provided in the form of maps of patterns in groundwater quality within the aquifer system.

Time-series groundwater quality data for wells in the GQTM network will be included in the annual reports. Time-series data will include available historical water quality data relevant to potential influences from irrigated agriculture for network wells, including data that pre-date the GQTM. Groundwater level contours and other representations of groundwater levels within select areas of the Coalition region, as applicable and appropriate relative to the regional monitoring network design, will be generated. Groundwater level data will be presented to inform hydrogeologic understanding of areas with respect to depth to groundwater and regional groundwater flow directions.

It is anticipated that analysis of groundwater quality trends will be conducted at five-year intervals and reported accordingly. Trends will likely be analyzed using statistical methods to evaluate the presence and magnitude of groundwater quality trends and investigate relationships with land use conditions and practices. Statistical analyses may include non-parametric (e.g., Mann-Kendall test) and parametric statistical analyses (e.g., linear regression) of temporal trends in constituent concentrations to compare and contrast any patterns in trends indicated by the different statistical analyses. The results from trend

analyses will likely be presented in the form of maps and evaluated for regional spatial patterns in trends.

5.2 GQMP Reporting

The Westside Coalition will submit a Management Plan Status Report with each annual monitoring report due November 30 of each year. It will summarize the progress for the reporting period and will include the required report components (WDR, Appendix MRP-1; modified to apply to this comprehensive GQMP rather than many GQMPs), including:

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) Status update on preparation of new management plans
8) A summary and assessment of management plan monitoring data collected during the reporting period
9) A summary of management plan grower outreach conducted
10) A summary of the degree of implementation of management practices
11) Results from evaluation of management practice effectiveness
12) An evaluation of progress in meeting performance goals and schedules

6 REFERENCES

Bertoldi, G.L., R.H. Johnston, and K. D. Evenson. 1991. Ground water in the Central Valley, California – A Summary Report. U.S. Geological Survey Professional Paper 1401-A.

California Department of Water Resources. 1991. California Well Standards. Bulletin 74-90. (Supplement to Bulletin 74-81)

California Regional Water Quality Control Board Central Valley Region. 2011. The water quality control plan (basin plan), The Sacramento River Basin and the San Joaquin River basin. Fourth Edition, revised October 2011.

California Regional Water Quality Control Board Central Valley Region. 2004. Water quality control plan for the Tulare Lake Basin. Second Edition. Revised January 2004.California Department of Water Resources (DWR). 2003. California's groundwater. DWR Bulletin 118, update 2003. http://www.water.ca.gov/groundwater/bulletin118/index.cfm

Central Valley Regional Water Quality Control Board. Revised 2011. The water quality control plan (basin plan), for the Sacramento River Basin and the San Joaquin River Basin.

Central Valley Regional Water Quality Control Board. Revised 2004. Water quality control plan for the Tulare Lake Basin, second edition.

Central Valley Regional Water Quality Control Board. 2014. Order R5-2014-0002. Waste discharge requirements for General Order for growers within the Western San Joaquin River Watershed that are members of a third-party group.

Central Valley Regional Water Quality Control Board. 2014. Notice of applicability issued to San Joaquin Valley Drainage Authority to serve as a third-party under General Order R5-2014-0002.

Croft, M. G. 1972. Subsurface geology of the Late Tertiary and Quarternary water-bearing deposits of the southern part of the San Joaquin Valley, California: U.S. Geological Survey Water-Supply Paper 1999-H.

Davis, G. H., J.H. Green, S.H. Olmstead, and D.W. Brown. 1959. Ground water conditions and storage capacity in the San Joaquin Valley, California. U.S. Geological Survey Water Supply Paper No. 1469, 287 p.

Dubrovsky, N.M., J.M. Neil, M.C. Welker, K.D. Evenson. 1991. Geochemical relations and distribution of selected trace elements in ground water of the northern part of the western San Joaquin Valley, California. U.S. Geological Survey Water-Supply Paper 2380, 51 p.

East San Joaquin Water Quality Coalition. 2015. Groundwater quality management plan, irrigated lands regulatory program. For the Central Valley Regional Water Quality Control Board.

Faunt, C., R.T. Hanson, K. Belitz, W. Schmid, S. Predmore, D. L. Rewis, and K. McPherson. 2009. Groundwater availability of the Central Valley Aquifer, California. U.S. Geological Survey Professional Paper 1766. http://pubs.usgs.gov/pp/1766/

Hotchkiss, W.R. and G.O. Balding. 1971.Geology, hydrology, and water quality of the Tracy-Dos Palo area, San Joaquin Valley, California. U.S. Geological Survey Open-File Report 72-169. 107 p.

Landon, M.K., Belitz, Kenneth, Jurgens, B.C., Kulongoski, J.T., and Johnson, T.D, 2010, Status and understanding of groundwater quality in the Central-Eastside San Joaquin Basin, 2006: California GAMA Program Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2009-5266, 97 p.

Ludington, S., B.C. Moring, R.J. Miller, K.S. Flynn, P.A. Stone, D.R. Bedford. 2007. Preliminary integrated databases for the United States – Western States: California, Nevada, Arizona, Washington, Oregon, Idaho, and Utah, Version 1.3, Updated December 2007. U.S. Geological Survey Open-File Report 2005-1305, available online at http://pubs.usgs.gov/of/2005/1305.

Mathany, T.M., M.K. Landon, J.L. Shelton, and K. Belitz. 2013. Groundwater-quality data in the Western San Joaquin Valley study unit, 2010: Results from the California GAMA program. U.S. Geological Survey Data Series 706.

Mendenhall, W.C., R.B. Dole, and H. Stabler. 1916. Ground water in the San Joaquin Valley, California. U.S. Geological Survey Water-Supply Paper 398, 310 p.

Natural Resources Conservation Service (NRCS). 2015. Soil Survey Manual, http://www.nrcs.usda.gov/wps/portal/nrcs/detail//?cid=nrcs142p2_054253.

PRISM Climate Group. 2014. Annual mean precipitation 1980-2010 data, PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu.

Randolph, B.F. 2003. Managing groundwater quality and quantity in the San Joaquin Valley, California: integrated strategies for protecting groundwater in arid regions. University of California, Berkeley M.S. Environmental Science, Policy and Management Thesis Paper Professor T.N. Narasimhan, Chair.

San Joaquin Valley Drainage Authority. 2015. Western San Joaquin River Watershed Comprehensive Summary of management Practice Information Collected from Farm Evaluations and Managed Wetland Evaluations for 2014 growing season. June 2015.

Shelton, J.L., Fram, M.S., Belitz, K., and Jurgens, B.C., 2013, Status and understanding of groundwater quality in the Madera-Chowchilla study unit, 2008: U.S. Geological Survey Scientific Investigations Report 2012-5094, 86 p. Available at: http://pubs.usgs.gov/sir/2012/5094.

Strathouse, S. M. and Sposito, G., 1980, Geologic nitrogen may pose hazard, California Agriculture, August-September 1980.

Sullivan, P.J., G. Sposito, S.M. Strathouse, and C.L. Hansen. 1979. Geologic nitrogen and the occurrence of high nitrate soils in western San Joaquin Valley, California. Hilgardia, Vol. 47, No. 2, 15-49 p.

APPENDIX A

Table A-1
Wells with Exceedances for Select Pesticides

Well Township/ Range/ Section	Well Depth (feet)	Agency Name	Sample Date	Reported Date	Pesticide	Concen-tration (ug/L)	MDL (ug/L)	MCL (ug/L)
07S09E19		CALIF. DEPT. OF PUBLIC HEALTH	10/20/1989	1992	ETHYLENE DIBROMIDE	**0.19**	0.02	0.05
07S09E19		CALIF. DEPT. OF PUBLIC HEALTH	9/15/1989	1992	ETHYLENE DIBROMIDE	**0.26**	0.02	0.05
07S09E19		CALIF. DEPT. OF PUBLIC HEALTH	4/30/1990	1992	ETHYLENE DIBROMIDE	**0.39**	0.02	0.05
07S09E19		CALIF. DEPT. OF PUBLIC HEALTH	3/23/1990	1992	ETHYLENE DIBROMIDE	**0.48**	0.02	0.05
04S06E13	126	CALIF. DEPARTMENT OF PESTICIDE REGULATION		1985	ETHYLENE DIBROMIDE	**0.198**	0.05	0.05
04S06E12	130	CALIF. DEPARTMENT OF PESTICIDE REGULATION		1985	ETHYLENE DIBROMIDE	**0.08**	0.05	0.05
10S10E16		U S GEOLOGICAL SURVEY		1992	SIMAZINE	1.4	0.1	4
10S10E16		U S GEOLOGICAL SURVEY		1992	SIMAZINE	**6.8**	1	4
08S08E25		CALIF. DEPT. OF PUBLIC HEALTH		1985	DBCP	**6.1**	0	0.2
08S08E25		CALIF. DEPT. OF PUBLIC HEALTH		1985	DBCP	**10.1**	0	0.2

Bold=concentratons that exceed the Maximum Contaminant Level (MCL)

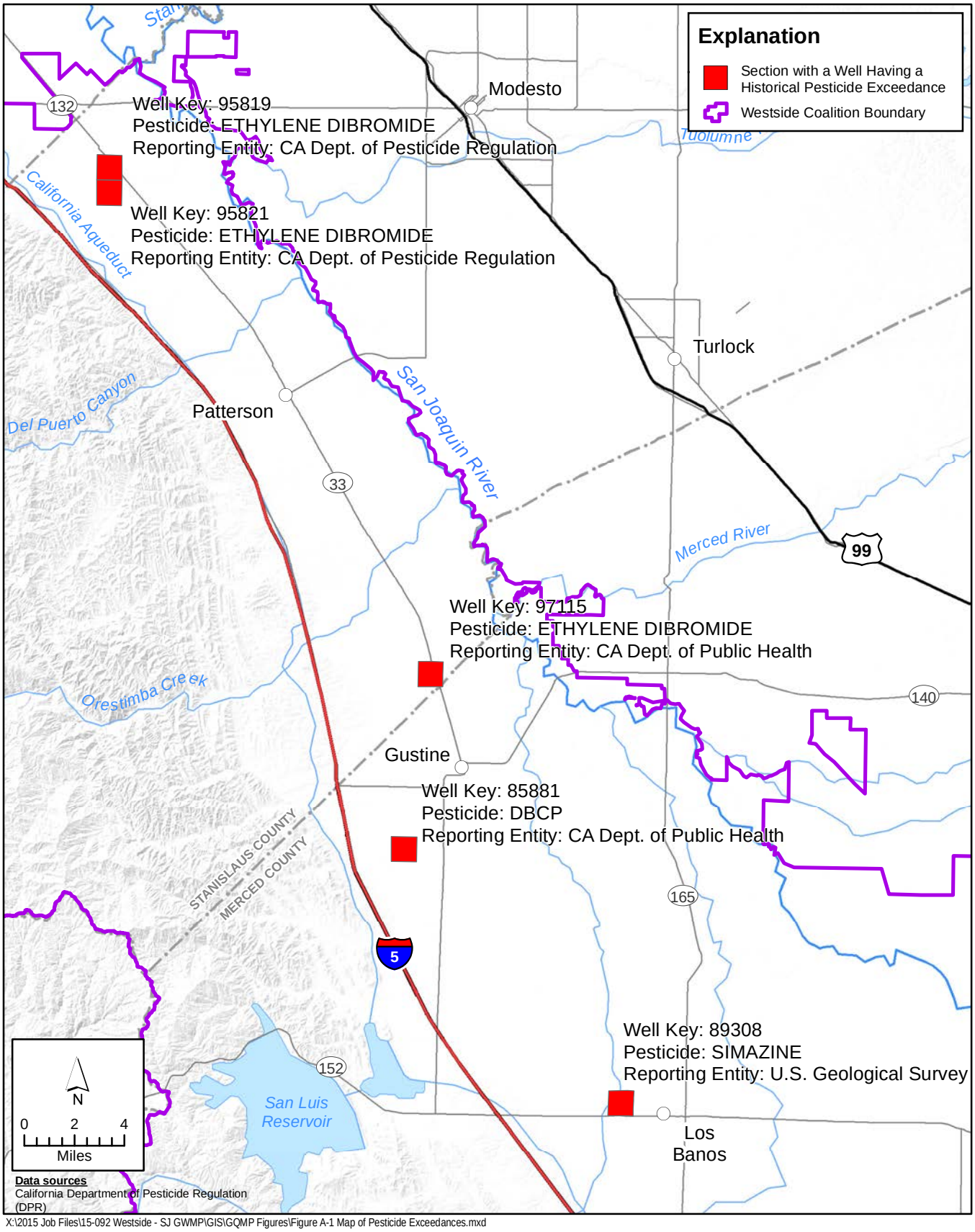


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FIGURE A-1
Map of Wells
with Pesticide Exceedances

Westside San Joaquin River Watershed Coalition