Kaweah Basin Water Quality Association

Revised Comprehensive Groundwater Quality Management Plan

Tulare County, California • September 2016

Prepared for:

Kaweah Basin Water Quality Association

Prepared by:

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company

KAWEAH BASIN WATER QUALITY ASSOCIATION

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Post Office Box 2840 • Visalia, California 93279

Prepared by:
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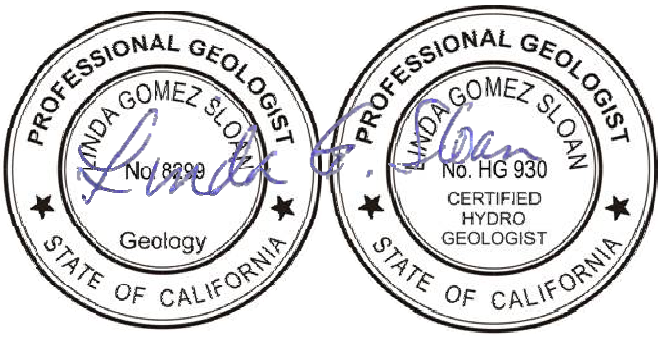

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Abbreviations

A/R ..... Applied/Removed

AGR ..... Agricultural

ASA-CCAs ..... American Society of Agronomy Certified Crop Advisors

CASGEM ..... California Statewide Groundwater Elevation Monitoring

CDFA ..... California Department of Food and Agriculture

CDPH ..... California Department of Public Health

CGQMP ..... Comprehensive Groundwater Quality Management Plan

CIMIS ..... California Irrigation Management Information Systems

Coalition ..... Kaweah Basin Water Quality Association

COC ..... Constituent of Concern

CTCL ..... Carbon Tetrachloride

CVHM ..... Central Valley Hydrologic Model

CVRWQCB ..... Central Valley Regional Water Quality Control Board

DAC ..... Disadvantaged Community

Dairy General Order ..... RWQCB Order R5-2013-0122 Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies

DBCP 1,2-Dibromo-3-chloropropane

DCA12 ..... 1,2-Dichloroethane

DPR ..... California Department of Pesticide Regulation

DWR ..... California Department of Water Resources

EC ..... Electrical Conductivity

EDB ..... Dibromoethane

EDF ..... Clean Up Sites

ET ..... Evapotranspiration

FREP ..... Fertilizer Research and Education Program

GAMA ..... Groundwater Ambient Monitoring & Assessment Program

GAR ..... Groundwater Quality Assessment Report

General Order ..... General Order R5-2013-0120

GIS ..... Geographic Information Systems

GQMP ..... Groundwater Quality Management Plans

GQTMP ..... Groundwater Quality Trend Monitoring Program

HVAs ..... High Vulnerability Areas
ILRP ..... Irrigated Lands Regulatory Program
IND ..... Industrial
ITRC ..... Cal Poly Irrigation Training and Research Center
KBWQA ..... Kaweah Basin Water Quality Association
KDWCD ..... Kaweah Delta Water Conservation District
Ksat ..... Hydraulic Conductivity
LUST ..... Leaking Underground Storage Tank
MCL ..... Maximum Contaminant Level
Mg/L ..... Milligrams Per Liter
MPEP ..... Management Practices Evaluation Program
MRP ..... Monitoring and Reporting Program
MUN ..... Municipal
NRCS ..... Natural Resources Conservation Service
NWIS ..... National Water Information System
Order No. R5-2007-0035 ..... Waste Discharge Requirements General Order for Existing Milk Cow Dairies
SAR ..... Sodium Absorption Ratio
SSJV ..... Southern San Joaquin Valley
SWRCB-AEP ..... State Water Resources Control Board Agricultural Expert Panel
SWRCB-DDW ..... State Water Resources Control Board Division of Drinking Water
TDS ..... Total Dissolved Solids
Tulare Lake Basin Plan ..... CVRWQCB Water Quality Control Plan for the Tulare Lake Basin
UCCE ..... University of California Cooperative Extension
UCD ..... University of California, Davis
USDA ..... United States Department of Agriculture
USEPA ..... United States Environmental Protection Agency
USGS ..... United States Geological Survey
VK ..... Vertical conductivity
WDRs ..... Waste Discharge Requirements

1 INTRODUCTION

This Revised Comprehensive Groundwater Quality Management Plan (**CGQMP**) has been prepared on behalf of the Kaweah Basin Water Quality Association (**KBWQA** or **Coalition**) in response to Waste Discharge Requirements General Order for Growers in the Tulare Lake Basin that are Members of a Third Party Group, Order No. R5-2013-0120 (**General Order**). Groundwater Quality Management Plans are required in areas where groundwater quality does not meet receiving water limitations described in the General Order: "member operations shall not cause or contribute to an exceedance of applicable water quality objectives in the underlying groundwater, unreasonably affect applicable beneficial uses, or cause or contribute to a condition of pollution or nuisance."

On 7 February 2015 the KBWQA submitted a CGQMP to the Central Valley Regional Water Quality Control Board (**CVRWQCB**) in coordination with the submittal of the Groundwater Assessment Report (GAR). Comments were received from the CVRWQCB on 28 June 2016 requesting the KBWQA to revise the CGQMP. In accordance with requirements outlined in section VIII.I. of the General Order, and Appendix MRP-1 of Attachment B, Monitoring and Reporting Program (**MRP**), to the General Order, the CGQMP shall;

- Investigate potential irrigated agricultural sources of waste discharge to groundwater;
- Review physical setting information for the plan area such as geologic factors and existing water quality data;
- Develop a strategy with schedules and milestones to implement practices to ensure discharge from irrigated lands are meeting Groundwater Receiving Water Limitations;
- Develop a monitoring strategy to provide feedback on CGQMP progress;
- Develop methods to evaluate data collected under the CGQMP; and,
- Provide reports to the CVRWQCB on progress.

To address the requirements of the General Order the KBWQA has elected to submit a single comprehensive groundwater management plan, rather than submitting separate management plans for documented exceedances. This CGQMP outlines a strategy to work with growers to implement protective management practices and a monitoring program which will provide feedback on CGQMP progress.

To determine areas potentially impacted by irrigated agriculture the KBWQA reviewed publicly available groundwater quality data. Pesticides, elevated nitrates and elevated salinity were identified as constituents which do not currently meet applicable groundwater quality objectives defined for basins underlying the KBWQA. Areas to be addressed by the CGQMP include all areas identified in the KBWQA's GAR as high vulnerability areas (**HVAs**). This CGQMP also outlines the limitations of available data, the physical barriers to representative groundwater monitoring, and the complex dynamics of decreasing the potential to leach nitrate from irrigated agriculture.

Implementation of the CGQMP will occur in coordination with ongoing South San Joaquin Valley Management Practices Evaluation Program (SSJV MPEP) activities and other ILRP program elements to address documented impacts to groundwater quality. The CGQMP's objective is to ensure progress in reducing impacts to groundwater from COC's within the KBWQA's boundary. Fulfillment of the CGQMP will be validated by using grower feedback, Farm Evaluations and Nitrogen Management Plan Summary Reports. As required by the General Order the Groundwater Management Plan Status Report will be submitted annually and contain an evaluation of Farm Evaluation Surveys and Nitrogen Management Plan Summary Report results. In each report, the KBWQA will use appropriate data analyses (statistics, Soil & Water Assessment Tool **(SWAT)** modeling, numerical modeling, index computation, or some

combination thereof) and analytical results will be reported using narrative description, mapping and data graphics.

1.1 Geographic Boundaries of the Comprehensive Groundwater Quality Management Plan

The Kaweah sub-basin is located on the east side of the south-central portion of the San Joaquin Valley within the Tulare Lake Basin (**Figure 1**). The San Joaquin Valley, which is the southerly part of the great Central Valley of California, extends about 250 miles from the Sacramento-San Joaquin Delta area at the north end to the Tehachapi Mountains at the south end. In the vicinity of the KBWQA, the Valley is approximately 65 miles wide. The Valley is bordered on the east by the Sierra Nevada mountains which range in elevation from about 1,000 feet to more than 14,000 feet above sea level. The Coast Range, which borders the Valley on the west, rises to about 6,000 feet above sea level. The southern end of the San Joaquin Valley, also known as the Tulare Lake Basin, is a closed feature separated from the Sacramento-San Joaquin Bay-Delta system and without external surface drainage.

The KBWQA covers the watershed from the Sierra Nevada Mountains to the valley floor in northern Tulare County within the Tulare Lake Basin. The KBWQA is comprised of the valley floor area as its Primary Area with a majority of the irrigated agricultural activity, while the foothill and mountain regions have been defined as the Supplemental Area due to significantly reduced irrigated agricultural activity (**Figure 2**).

The northern boundary roughly follows the Kaweah Delta Water Conservation District (**KDWCD**) northern border, and has been extended further north to include Stone Corral Irrigation District and portions of Cottonwood Creek. The western boundary generally follows the Kings County Water District and Tulare Irrigation District borders. The southern boundary generally follows the KDWCD southern border, but approximately follows the Avenue 212 alignment as it heads towards the foothills. In total, the KBWQA's service area approximately encompasses 958,000 acres.

There are approximately 356,000 total acres in the Primary Area (valley floor) and 602,000 total acres in the Supplemental Area (foothill and mountain areas) as illustrated in **Figure 3**.

2 PHYSICAL SETTING & BACKGROUND

2.1 Land and Hydrology Characteristics

Potential sources of contaminants and transport mechanisms within the soil and groundwater are dependent on land use and hydrologic characteristics within the KBWQA. Identification of the various land uses within the Coalition area can provide possible explanations for sources of contaminants. Transport and persistence of contaminants in groundwater is partially controlled by the hydrologic properties of the underlying geology. Areas of recharge, general water chemistry, hydrogeology, soil types, aquifer characteristics, and water bearing zones further define areas of potential groundwater contamination related to irrigated agriculture.

2.1.1 Land Use

Information on land use within the KWBQA area was obtained from the Tulare County Agriculture Commissioner, U.S. Department of Agriculture (**USDA**) and the California Department of Water Resources (**DWR**). In general, there is very limited irrigated agriculture in the Supplemental Area, the limited portions which are commercially farmed are typically citrus crops, which are located on the border between the Primary and Supplemental Areas.

Figure 4 illustrates crop types within the KBWQA, using information as reported in returned grower Farm Evaluations for large farms (defined by the General Order as greater than 60 acres) within HVAs, during the 2015 calendar year. Parcels were generalized to represent the majority crop for all fields within a single parcel. The KBWQA will continue to collect cropping information from growers in future Farm Evaluation submittals, allowing the Coalition to track changes in land use over time.

Irrigated agriculture and dairies are the dominate land use within the KBWQA's Primary Area. Citrus, alfalfa, hay and forage, fruit and nuts, stone fruit, and vegetables make up 85 percent of the crops grown within the KBWQA. In the eastern portion citrus crops are primarily grown. Within the central portions of the KBWQA are deciduous fruit and nut crops are predominately grown. In the western half of the KBWQA, dairy facilities are the predominate land use. Dairies are regulated under the Waste Discharge Requirements General Order for Existing Milk Cow Dairies (**Order No. R5-2007-0035**) and RWQCB Order R5-2013-0122, Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (**Dairy General Order**). Forage crops are also grown in the western portion of the KBWQA, many of the forage crops grown in this area are associated with manure waste applications and are also regulated by the Dairy General Order. Urban areas are generally located in the central area of the KBWQA.

2.1.2 Soils

Soil information for the Primary Area is well documented. However, information on soils for the Supplemental Area is limited, with the eastern portion of the area unmapped in soil surveys. A generalized depiction of the soil textures within the KBWQA are provided as **Figure 5**.

Loam is the predominant soil texture in the Primary KBWQA area, encompassing 52 percent of the soils in that region. Stream channels; however, are dominated by sandier soils based on the presence of water providing the required energy to transport the larger particle size. In general, the areas to the

east are more subject to hardpan with coarser soils along the riverbeds atop the alluvial fan and clay deposits off to either side of the fan.

Soils in the Supplemental Area are generally coarser than the soils found in the Primary study area, due to the main parent material and source of the sediment being newly weathered Sierra Nevada and Sierra Foothills materials. The majority of the soils are sandy loam and coarse sandy loam. Rock outcroppings are also found in this area with most of the areas lying near the eastern border of the available information.

Areas of higher permeability are located within the study area near ancient and modern stream channels, consistent with the Central Valley Hydrologic Model **(CVHM)** well log texture analysis (**Figure 5**). Areas of higher runoff potential are located predominantly in the northeastern area and along the eastern border, due to the increased slope in the mountainous regions (**Figure 6**). The steepest portion of the KBWQA is in the Supplemental Area, generally with slopes 20 to 50 percent. The land surface becomes more level as the foothills transition to the valley floor with the Primary Area having little slope and topographic distinctions.

There are limited soils within the KBWQA range with high electrolytic conductivity and/or sodium absorption ratio (**SAR**). They are located primarily along the central north and central south borders of the area. These soils are located coincident to highly alkaline soils and mostly coincident to silty clay textures in the same areas (**Figure 7**).

Soils within the KBWQA range from extremely acidic to moderately alkaline with the majority of the soil being slightly alkaline in the Primary Area and acidic in the Supplemental study area. In general soils become more acidic in the eastern portion of the study area, near the base of the Sierras. Though pH amendments exist; most of the agriculture near the eastern region includes crops that can tolerate the slightly lower pH, such as citrus.

2.1.3 Geology

2.1.3.1 Regional Stratigraphy

The KDWCD area comprises approximately 71% of the Primary Area within the KBWQA. Studies completed by the KDWCD indicate most of the fresh groundwater pumped within the KDWCD is from unconsolidated deposits of Pliocene, Pleistocene, and Recent Age (Fugro West, Inc., 2007). Consolidated marine rocks of Pliocene age and older which contain brackish or salty water constitute the effective base of fresh water (or permeable sediments).

Research completed for the development of the KBWQA's GAR utilized additional information collected by the KDWCD which described geologic units that affect the occurrence and movement of groundwater (Fugro West, Inc., 2007). Geologic units within the KDWCD are generally classified and described as;

a. Basement Rocks of pre-Tertiary age consisting of non-water-bearing granitic and metamorphic rocks. In the subsurface, they slope steeply westward from the Sierra Nevada beneath the deposits of Cretaceous age and younger rocks that compose the valley fill.

b. Marine Rock of Tertiary age consisting of non-water-bearing marine sediments including the San Joaquin Formation which overlap the basement complex and underlie the unconsolidated deposits.

c. Unconsolidated Deposits of older and younger alluvium consisting of non-marine, water-bearing material comprised of the Tulare Formation and equivalent units which thicken from zero along the western front of the Sierra Nevada to a maximum of about 10,000 feet at the west boundary of the KDWCD.

d. Alluvial Deposits consisting of coarse-grained, water-bearing alluvial fan and stream deposits including older oxidized and reduced units, and younger alluvium which underlie the older alluvium. The 200 to 500 feet thick oxidized deposits are red, yellow, and brown, consist of gravel, sand, silt and clay, and generally have well-developed soil profiles. Reduced deposits which extend to about 3,000 feet below land surface are blue, green, or gray, calcareous, and generally are finer grained than oxidized deposits, and commonly have a higher organic content than the oxidized deposits.

e. Lacustrine and Marsh Deposits consisting of fine-grained sediments representing a lake and marsh phase of equivalent continental and alluvial fan deposition. Only the "E" Clay (or Corcoran Clay member) of the Tulare Formation, one of the laterally continuous clay zones in the southern San Joaquin Valley, is found within the KDWCD, extending from Tulare Lake Bed to U.S. Highway 99 with vertical bifurcation near Goshen. It is about 140 feet thick near Corcoran and the average thickness is about 75 feet.

Soils developed on younger alluvium show little or no profile development and are generally free of underlying clay subsoil or hardpan. Very coarse soils can be found beneath the channels of the Kaweah, Tule and Kings Rivers, with fine-grained deposits occurring in the channel of Cross Creek. In the eastern portion of the KDWCD the Rocky Hill fault disrupts pre-Eocene deposits and may locally penetrate older alluvial deposits, potentially restricting the hydrologic connection of aquifers. A thickening section of unconsolidated deposits is indicated moving west across the KDWCD with modest warping of the Tulare Formation's surface, suggesting regional folding during and after deposition, but having little effect on the patterns of groundwater flow within or at the perimeter boundaries of the KDWCD.

Other local irrigation districts include Alta, Stone Corral, Ivanhoe, Exeter and Lindmore. These districts surround the KDWCD along the north and east borders. Most of the districts are sloped ranging from 1 to 30 percent and have some form of shallow hardpan. Adobe clay is commonly found on the smooth valley plain near the foothills with coarser materials along current or old streambeds.

The Sierra Nevada Mountain range, partially located within the KBWQA Supplemental Area, is the result of initial and continued uplifting of the Pacific and North American tectonic plates. As illustrated in **Figure 8**, the area is predominately plutonic rocks of the Mesozoic era, interspersed with outcrops of mixed rocks of pre-Cambrian to Mesozoic era. Portions of the Sequoia and Kings Canyon National Parks are located in the uppermost elevations of the area.

Lake Kaweah is centrally located near the eastern border. Small areas of Quaternary alluvium are located up and down stream of the lake, with larger areas along the foothill borders.

Cross sections are attached as **Appendix A: Geologic Cross Sections** (Croft, M.G., G.V. Gordon. 1968.; Croft, M.G. 1972.*;* Fugro West, Inc.. 2007). Publically available geologic cross sections that extend across portions of the Coalition's area will be utilized in future work plans and reports to present data in a graphical format.

2.1.4 Hydrogeology

2.1.4.1 Groundwater Basins and Subbasins

The Kaweah sub-basin is located on the east side of the south-central portion of the San Joaquin Valley within the Tulare Lake Basin (**Figure 1**). As defined in the Tulare Lake Basin Plan, the Tulare Lake Basin is bounded by the crest of the Sierra Nevada Mountain Range to the east, the San Joaquin River to the north, the Westlands Water District and the crest of the Southern Coast Ranges to the west, and the crest of the San Emigdio and Tehachapi Mountains to the south (CVRWQCB, 2015). Tributary streams drain to depressions, the largest of which is the Tulare Lake bed located to the west of the KBWQA boundary. The Kings, Kaweah, and Tule Rivers and, on occasion, the Kern River, discharge into the Tulare Lake bed, as well as the Kern discharges into the beds of the former Buena Vista, and Kern Lakes at times when flows exceed the capacity of foothill reservoirs and of the irrigation diversion systems.

The Kaweah sub-basin lies between the Kings Groundwater sub-basin on the north and west, the Tule Groundwater sub-basin on the south, and crystalline bedrock of the Sierra Nevada foothills on the east. The sub-basin generally comprises lands in the Kaweah Delta Water Conservation District and is the approximate extent of the Primary KBWQA area. The sub-basin's watershed is to the east and is the approximate extent of the Supplemental KBWQA area. The major river in the sub-basin is the Kaweah River which is supported by Dry Creek, Yokohl River, Cottonwood Creek, and Sand Creek with a distributary of the St. Johns Rivers and Cross Creek, illustrated in **Figure 9**. The Kaweah River is the primary source of recharge to the area.

2.1.4.2 General Groundwater Chemistry

The KBWQA Primary Area includes the majority of the Kaweah Subbasin of the San Joaquin Groundwater Basin, which is an inland groundwater basin with no significant outflow. The Kaweah subbasin lies primarily on the valley floor with crystalline bedrock of the Sierra Nevada foothills on the east.

In the Tulare Lake Basin and areas immediately adjacent to it, there is a tendency for salts to accumulate, due to almost no percolation (frequently upward groundwater gradients) and evapoconcentration. Localized areas of elevated salinity can occur upgradient where inadequate leaching, flushing, and outflow occur due to local drainage impairments such as poorly drained soil or limited surface drainage toward the historic Tulare Lake. The Kaweah River is the primary source of recharge to the area, allowing for some dilution of concentrated salts in groundwater.

The groundwater in this basin is generally of a calcium bicarbonate type, with sodium bicarbonate waters near the western margin. Bulletin 118 describes the Kaweah Subbasin aquifers as unconsolidated deposits with the east side behind made up of Sierra Nevada derived sediments and the western portion of the subbasin, near the Tulare Lake bed, consists of flood-subbasin, lacustrine and marsh deposits that interfinger with the east side deposits. The groundwater in the KBWQA area is primarily of a calcium bicarbonate type and the western margin contains sodium bicarbonate groundwater (Bulletin 118, 2004). The KBWQA area groundwater chemistry is expressed in **Table 1**.

Table 1. General Groundwater Chemistry

General Groundwater Chemistry			
Analyte	**Range of Detected Values**	**Average Detected Value**	**Units**
Specific Conductivity[1]	146-2670	520.49	mS/cm
Dissolved Oxygen[1]	5-8.4	6.17	mg/L
pH[1]	6.1-9.2	7.59	
TDS[1]	0.17-964	194.72	mg/L
Calcium[2,3]	7.92-169	27	mg/L
Magnesium[2,3]	0.42-93.3	2	mg/L
Total Hardness[1]	9.01-620	161.4	mg/L
Ammonia[3]	0.23-8.10		mg/L
TKN[1]	0.05-0.07	0.0575	mg/L
Nitrite[1]	0.001-.085	0.0172	mg/L
Nitrate[1]	0.063-182	29.25	mg/L
Total N[2]	0.07-32.5		mg/L
Orthophosphate[1]	0.006-1.20	0.2503	mg/L
Chloride[1]	0.77-231	34.7	mg/L
Sodium[2,3]	230-296	13	mg/L
Sulfate[1]	0.59-195	38.88	mg/L

[1] National Water Information System. USGS. http://waterdata.usgs.gov/nwis Accessed 22 July 2016.
[2] Fugro West, Inc. *Water Resources Investigation of the Kaweah Delta Water Conservation District*. Prepared for Kaweah Delta Water Conservation District, December 2003, Revised July 2007.
[3] California Water Resources Control Board. 2013. Domestic Well Project, Groundwater Quality Data Report, Tulare County Focus Area (GAMA). p. 18.

Groundwater can vary greatly from one well to another, depending on aquifer characteristics and soil type, creating varying ranges of groundwater chemistry and other water quality parameters. Localized areas of groundwater quality impairments, including elevated levels of nitrate, salinity and pesticides can be found throughout the KBWQA area, and are discussed throughout this CGQMP.

As required by the General Order, the GAR will be revised in the next five year cycle, scheduled for February 2020. Revisions to the GAR will include a detailed description of all readily available public groundwater data (range of EC, concentrations of major anions and cations, nutrients, TDS, pH, dissolved oxygen and hardness). As required by the General Order (Appendix MRP-1 3.b.ii, Stiff Diagrams are provided in this CGQMP to visually represent groundwater chemistry within the KBWQA area (**Figure 10**). Stiff Diagrams graphically illustrate water quality by plotting the major cations and anions; the resulting shape of the diagram allows visual comparison of differences in water quality (Fugro West, Inc., 2007).

2.1.4.3 General Surface Water Chemistry

To characterize surface water quality data within the KBWQA boundary multiple publicly accessible databases were queried. Many databases referenced surface water quality data collected by the KBWQA in fulfillment of requirements described in the General Order. Results of queried databases are described below.

The Kaweah Delta Water Conservation District's, Agricultural Water Management Plan (Kaweah Delta Conservation District, 2010) identifies surface water inputs to the districts' agricultural conveyance system, as illustrated in **Figure 11**. Water from the Friant-Kern Canal enters at multiple turnouts, other features and generalized surface water distributary systems are also illustrated in **Figure 11**.

The California Environmental Data Exchange Network **(CEDEN)** was queried for surface water quality monitoring data. The search included data collected by the former Southern San Joaquin Valley Water Quality Coalition at all sites located within the KBWQA boundaries, returning nine sites in total. Data was selected for EC, nutrients, TDS, pH, dissolved oxygen, and hardness. Major cation and anion balance is not reported as part of the ILRP. Additionally chloride, carbonate, sulfate, and sodium are not data collected by the IRLP. Surface water chemistry characteristic ranges can be found **Table 2**, **Table 3** and **Table 4**.

Table 2. CEDEN, Surface Water Quality: Nutrients

CEDEN, Surface Water Quality: Nutrients					
Station	Ammonia (mg/L)	TKN (mg/L)	OrthoPhosphate (mg/L)	Phosphorous as P (total) (mg/L)	Total N (Nitrate = Nitrite as N) (mg/L)
Cross Creek at Highway 99	0.05-0.10	0.471-0.6	0.0256-0.04	0.01-0.55	0.05-0.5
Elk Bayou	0.03-0.16	0.18-0.85	0.02-0.26	0.01-0.30	0.1-1.8
Foothill Ditch	0.07-0.15	0.14-1.09	0.01-0.66	0.01-0.88	0.1-5.4
Kaweah River	0.08-0.25	0.3-0.9	0.01-0.7	0.01-0.07	0.1-0.6
Lewis Creek (SSJ)	0.1-0.15	0.2-0.8	0.02-0.38	0.03-0.11	0.04-2.00
St. Johns River	0.07-0.47	0.23-2.21	0.01-0.08	0.009-0.194	0.03-1.40
Stone Corral Irrigation Discharge	0.05-2.14	0.16-1.00	0.06-0.38	0.034-0.595	1.0-16.9
Wutchumna Spill	0.07-0.18	0.3-0.5	0.049-0.144	0.03-0.07	0.03-15.10

Table 3. CEDEN, Surface Water Quality: Minerals

CEDEN, Surface Water Quality: Minerals			
Station	Calcium (mg/L)	Hardness (mg/L)	Magnesium (mg/L)
Cross Creek at Highway 99	4.9-13.7	15.0 - 46.2	0.80 - 2.92
Elk Bayou	4.6-23.2	14.8-89.6	0.768-7.72
Foothill Ditch	6.1-50.7	19-194	0.9-16.3
Kaweah River	4.5-13.0	13.8-40.7	0.59-2.44
Lewis Creek (SSJ)	5.5-40.2	18-178	0.91-18.9
St. Johns River	4.34-18.9	13.6 – 47.2	0.67 – 4.01
Stone Corral Irrigation Discharge	12.0-92.0	38-388	0.2-38.6
Wutchumna Spill	6.6-68.1	17-288	0.8-28.6

Table 4. CEDEN, Surface Water Quality: Field Parameters

CEDEN, Surface Water Quality: Field Parameters				
Station	**Dissolved Oxygen (mg/L)**	**pH**	**Specific Conductivity (uS/cm)**	**Total Dissolved Solids (mg/L)**
Cross Creek at Highway 99	7.4-16-8	7.32-7.92	47.7-117.7	24-77
Elk Bayou	7.37-10.96	7.13-8.26	39-231	24-157
Foothill Ditch	6.09-9.85	7.19-8.63	49-415	27-310
Kaweah River	7.5-14.3	7.04-8.62	41.5-109.9	21-78
Lewis Creek (SSJ)	7.53-11.77	7.92-9.36	46-642	25-315
St. Johns River	4.97-13.75	6.69-9.16	38-177	26.6-96.4
Stone Corral Irrigation Discharge	6.48-16.82	7.61-9.62	114-854	81-591
Wutchumna Spill	8.12-9.94	7.71-8.22	44-726	25-505

The DPR surface water database **(SURF)** was queried for Kings and Tulare Counties and returned results housed in STORET and CEDEN. Results were filtered to remove results retrieved from CEDEN, remaining results were filtered to remove non-detects. Only 7 records of 1,029 were above the detection limit. All detections (total of 7) were detections for DEET and all sites were located within Sequoia National Park, outside of the KBWQA's primary boundary and are managed by the National Parks Service.

The USGS National Water Information System **(NWIS)** database was searched for all station locations with surface water samples between 2000 and 2016. No records within the coalition boundary were found.

The USEPA National Aquatic Resource Survey database was queried for rivers and streams, results returned two data sets 2005 and 2008-2009. However, locations of monitoring sites are not publicly disclosed in these data sets. Both data sets use unique site code identifiers and don't include any geospatial information.

In the Kaweah Integrated Regional Water Management Plan **(IRWMP),** surface water quality is described citing efforts made by the ILRP and characterizes surface water quality within the Kaweah IRWMP area as "very high quality." The plan does not include data or other validation of the characterization, only references to SWRCB database for ILRP. Data retained in the SWRCB's database (CEDEN) is described above.

The DWRs surface water database, the California Data Exchange Center (**CDEC**), was queried for information within the KBWQA Primary Area. Monitored CDEC stations within the KBWQA do not collect water quality data. Stations and associated collected data are limited to those listed in **Table 5**.

Table 5. Monitored CDEC Stations

Monitored CDEC Stations	
EBY – Elk Bayou	River Stage/Flow
CRH – Cross Creek at Huston	River Stage
VSL – Visalia	Rain
LND – Lindsay	Rain
DRK – Deer Creek	River Stage
LMC – Lemon Cove	Rain
KRM – Kaweah River below McKay Point	River Stage
JRM – St Johns River below McKay Point	River Stage
FTH – Foothill Ditch	River Stage

2.1.4.4 Water Bearing and Discharge/Recharge Zones

Depth to groundwater was determined based on a combination of data from the KDWCD (Fugro West, Inc., 2007; Kaweah Delta Water Conservation District, 2010) and California Statewide Groundwater Elevation Monitoring (**CASGEM**) information. In general, the depth to groundwater is shallowest in the northeast and southeast portions of the basin with an overwhelmingly southwest regional direction of flow. A groundwater ridge occurs along the Kaweah River footprint with troughs on either side. The deepest groundwater is found in the eastern area between the cities of Exeter and Lindsay. The affects of pumping are apparent in groundwater contours. The Supplemental Area has limited data available, but it can be assumed that, other than within fractured bedrock, groundwater will generally follow the topography.

The Terminus Dam was constructed in 1962, coinciding with a regional drop in groundwater levels of 40 feet or more. Recent high water years can be noted in the mid- to late-1980s with water levels generally not reaching those elevations in the years following. The State of California is currently in a drought state of emergency and the Central Valley, in particular, is in a severe overdraft condition, as is apparent in the hydrographs for the valley floor wells. Groundwater levels have generally been in decline since 1999 with a recent decline of up to 100 feet in some wells since approximately year 2008.

Recharge areas within the Primary valley floor area were identified and mapped using a combination of publicly available resources. To determine relative recharge rates, identified recharge areas were layered over CVHM vertical conductivity (**VK**) layers of varying thicknesses (**Figure 12**). The fastest VK values are found in the areas near the mouths of the Kaweah River and Yokohl Creek and extending northwestward. The slowest VK values include the areas to the north and south of the two alluvial fans (Kaweah and Yokohl creek locations) and the better part of the south-central and southeast areas.

The most significant recharge area is at and near the mouth of the Kaweah River due to the shallowest groundwater at less than 50 feet and the upgradient position to the majority of the KBWQA area. The second most significant recharge area is the northwest-southeast trending belt of relatively high VK values and multiple surface waterways and impoundments. Depth-to-water in this area ranges from 50 to 150 feet and less of the KBWQA area is downgradient.

Based on information presented in the *California Groundwater Bulletin 118 for the Kaweah Subbasin*, total depths of municipal/irrigation wells in the Kaweah Subbasin range from 100 to 500 feet; however, the data was last updated in 2004. Similarly, information provided in the *Groundwater Ambient*

Monitoring and Assessment (GAMA), Domestic Well Project, Groundwater Quality Data Report, Tulare County Focus Area (California State Water Resources Control Board, 2013) indicate that domestic wells in the Kaweah Subbasin tend to be completed to total depths of 100 to 300 feet, although some wells are completed to depths as great as 450 feet. Both of these general depth ranges are reasonably corroborated with the Fugro Report's cross sections included as **Appendix B: Furgo Cross Sections** in this report. In general, deeper wells are to the west and shallower wells are to the east.

Based on the Fugro Report's cross sections, most wells completed shallower than approximately 400 feet are completed within the oxidized older alluvium (Qooo) and are unconfined. Towards the foothills, the Qooo decreases in thickness and eventually pinches out however most wells are completed correspondingly shallower. Some wells to the west are landed in the E-Clay (QTl – lacustrine or marsh deposits, while some deeper wells throughout and most easterly wells are partially or completely screened in the older reduced alluvium (Qoar). While well identifications are clear in the Fugro Report's cross sections, the well types are not specified. According to the GAMA and Bulletin 118 information, most wells are likely completed within the Qooo formation (Fugro West, Inc., 2007).

2.1.4.5 Water Sources and Water Chemistry

Water bearing zones, providing groundwater for domestic, irrigation, and municipal users, vary throughout the KBWQA region. Typically, domestic wells use shallower aquifers due to the greater cost of drilling deeper wells, but there is no comprehensive record for domestic well depth ranges. Due to their shallower depths, domestic wells are typically disproportionally affected by groundwater quality issues associated with surface level activities.

Municipal and agricultural wells, within the KBWQA, have been estimated by the DWR to be drilled to depths that range to depths exceeding 2,000 feet. Currently, agricultural irrigation wells are being drilled through all usable water bearing zones.

To evaluate irrigation water quality, the KBWQA area was split between east and west based on hydrogeologic changes provided by the E clay unit, as seen in **Figure 13**. The western portion of the boundary tends to have deeper wells that are likely screened in both shallow and deep aquifers; whereas the eastern portion of the boundary contains more wells in shallow aquifers. The respective irrigation water quality from both regions can be found in **Table 6** and **Table 7**. The data were obtained through the NWIS database, which is managed by USGS. The NWIS data were the only accessible data that contained well depth data; however, the data did not clarify information related to screened intervals and well usage and ownership (public/private). To accommodate for the unknown screened interval depths, geologic cross sections containing well depth information was compared to note the correlation between greater hydraulic head and deeper well depth.

Table 6. Irrigation Water General Chemistry - West KBWQA

West KBWQA					
Chemical Name	Detection Range	Median (total)	Mean (total)	Units	# of wells sampled
Chloride	0.77-231	23.2	31.8436	mg/L	65
Kjeldahl Nitrogen	0.05-0.07	ND	0.02	mg/L	14

West KBWQA					
Chemical Name	Detection Range	Median (total)	Mean (total)	Units	# of wells sampled
Nitrate	0.431-152	16.05	27.845	mg/L	43
Nitrite	0.001-0.085	ND	0.01527	mg/L	43
pH	6.1-9.8	7.6	7.64	std. units	39
Specific Conductance	146-1680	462	518.4695	uS/cm	51
TDS	119-964	304.5	327.261	mg/L	43
Hardness	9.01-1050	159	198.688	mg/L CaCO3	43

Table 7. Irrigation Water General Chemistry - East KBWQA

East KBWQA					
Chemical Name	Detection Range	Median (total)	Mean (total)	Units	# of wells sampled
Chloride	1.73-517	25.8	46.836	mg/L	39
Kjeldahl Nitrogen	No Detection	No Detection	No Detection	mg/L	2
Nitrate	0.078-182	9.3	21.5299	mg/L	38
Nitrite	0.001-0.055	ND	0.019625	mg/L	39
pH	6.1-8.2	7.3	7.239	std. units	42
Specific Conductance	175-2570	576	633.257	uS/cm	50
TDS	122-1550	359	385.5	mg/L	39
Hardness	3.11-444	117	156.453	mg/L CaCO3	39

2.1.4.6 Aquifer Characteristics

Depth to groundwater was measured by the DWR in the fall of 2013. Groundwater elevation contours were created using these data (**Figure 14**). Depth to groundwater is shallowest to the northeast and southeast portions of the KBWQA, with typical depth to groundwater ranging from approximately 16 to 45 feet. A groundwater ridge occurs along the Kaweah River footprint with troughs apparent to either side. The deepest groundwater in the eastern area is approximately 127 feet located between the cities of Exeter and Lindsay. Depth to groundwater was reported by the DWR in spring of 2016, and is illustrated in **Figure 15**. Comparison of both maps indicates that depth to groundwater has increased throughout the KBWQA Primary Area. Decreased surface water supplies due to recent drought conditions have increased groundwater pumping, as demonstrated by these data.

The topography to the east is the steepest in the Primary Area. Combined with the Kaweah River ridge, steep declines in groundwater levels can be noted within the eastern regions. Topography through the central and western portions is relatively flat with groundwater levels exhibiting an apparent greater reaction to pumping activities.

The deepest groundwater is located in the western portions of the KBWQA, with depth to ground water typically ranging from approximately 140 to 180 feet, with a maximum of 270 feet. Pockets of deeper

groundwater depths are throughout the western portion, but these points are evidence of cones of depression resulting from groundwater pumping.

Depth to groundwater data indicates that groundwater within the KBWQA flows from northeast to southwest. Water levels are influenced by several factors, including elevation, water elevation, and media in which the groundwater flows. Saturated hydraulic conductivity (Ksat) refers to the ability of a soil to transmit water or air and estimates the rate of water movement, in micrometers per second, when the soil is saturated. The higher the Ksat, the faster the water will move through the material. The vertical hydraulic conductivity and potential recharge areas are demonstrated in **Figure 12**. The hydraulic gradient, rate of change of pressure head to unit distance of groundwater flow, is depicted in **Figure 12**, as the dynamic average Ksat experiences horizontally spatial changes.

3 GROUNDWATER ASSESSMENT

3.1 Available Groundwater Data

A comprehensive evaluation of readily available groundwater quality data were used to determine current and past conditions of groundwater within the KBWQA. These data were then assessed and evaluated to determine areas of groundwater contamination and areas considered to be more vulnerable to groundwater contamination. As required by the General Order, the KBWQA's GAR was used as a primary reference to identify areas where protection of groundwater quality is most critical. Evaluated data, previously conducted studies, and general process of HVA assessment are outlined below.

3.1.1 Data Sources

For the purpose of the GAR and the CGQMP, data for groundwater quality exceedances were collected and compiled into a comprehensive groundwater quality database. The sources of groundwater quality data available included water quality data gathered from the State Water Resources Control Board's GeoTracker and Groundwater Ambient Monitoring and Assessment (**GAMA**) databases which provided the most comprehensive dataset of water quality information, and others as listed below;

- State Water Resources Control Board Department of Drinking Water (**SWRCB-DDW**) (formerly California Department of Public Health (**CDPH**);
- CDPH Archived Data;
- DWR;
- Cleanup Sites (**EDF**) (through the GAMA program);
- California Department of Pesticides Regulation (**DPR**, through the GAMA program);
- United States Geological Survey (**USGS**) (through the GAMA program);
- NWIS;
- CEDEN;
- University of California, Davis (UCD); and
- CVRWQCB dairy regulatory program.

3.2 Previous Studies and Monitoring

3.2.1 Regional Data Resources

3.2.1.1 Kaweah Delta Water Conservation District, Agricultural Water Management Plan

In 2010 the Kaweah Delta Water Conservation District (KDWCD), developed an Agricultural Water Management Plan, describing soils, geology, surface water and groundwater management, as well as an inventory of water supplies and water usage by the District. The Agricultural Water Management Plan is

an update to the KDWCD's 2005 plan and reflects data collected through 2010. The KDWCD covers approximately 71 percent of the Primary KBWQA area. Work conducted by the KDWCD is considered to be an accurate description of the KBWQA due to this significant area of overlap of groundwater basins.

3.2.1.2 Department of Water Resources, California Groundwater: Bulletin 118

Bulletin 118 is a comprehensive groundwater report prepared by the Department of Water Resources (DWR) for groundwater basins within the State outlining dependence on groundwater resources, groundwater management, groundwater regulations, and characterization of California's hydrologic regions. Bulletin 118 also provides information geology, groundwater quantity and quality. The bulletin has been updated several times; the most recent revision was completed in 2003. Bulletin 118 contains information regarding the Tulare Lake Basin which has been used to provide general aquifer characteristics of the KBWQA area.

3.2.1.3 Final Report of Water Resources Investigation (Fugro Report)

Fugro West, Inc. (revised 2007) provides a Final Report of Water Resources Investigation for the KDWCD. The report describes hydrogeologic characteristics within the KDWCD including: usable groundwater basins, groundwater flow directions, confining unit locations, water budget and general water quality of surface and groundwater. The Fugro Report provided cross sections that have been used to better analyze the underlying geology of the KBWQA area.

3.2.2 Kaweah Basin Water Quality Association's Groundwater Assessment Report

The Groundwater Assessment Report (GAR) was prepared by the KBWQA to fulfill the requirements of the General Order. The GAR identified regional water quality, existing groundwater monitoring programs, areas of high vulnerability, hydrogeologic characteristics and land use within the KBWQA area.

The 2015 KBWQA GAR was a primary reference tool in the development of the CGQMP and much of the data described in previous sections were collected and compiled into a comprehensive groundwater quality database for the KBWQA area to fulfill the requirements of the GAR. This water quality data included available groundwater quality analysis results from 1909 through 2014. Some of the available groundwater quality data was associated with wells for which location information was not available; these data were not included in the analyses presented below. Of the 950 GAMA system wells with available data for the KBWQA area, 819 are located in the 356,000 acre Primary Area, and 131 in the 602,000 acre Supplemental Area. Well construction information is not generally available for the wells for which groundwater quality data are available. As a result, the analyses presented in the CGQMP and GAR does not include any evaluation of depth or aquifer material associated with water quality results. As noted, it is assumed for this evaluation that all groundwater quality results represent first encountered groundwater. Some of the available groundwater quality data was associated with wells for which location information was not available; these data were not included in the analyses to determine areas of high vulnerability.

The maximum contaminant level **(MCL)** of 45 mg/L for nitrate as nitrate was used to identify nitrate impacted groundwater in the KBWQA area for the GAR and used in the CGQMP. For this analysis, it was assumed that all groundwater quality results represent first encountered groundwater; however, most

samples were retrieved from production wells and, overall, construction information is unavailable for most wells. Future monitoring programs should include the collection of well construction data to provide additional information on the vertical distribution of these constituents over time.

Well locations for water quality data are imprecise. Some agencies use approximate locations of monitoring wells, preventing association of groundwater quality data with a specific well. Data reported by CDPH gives the vaguest location of monitoring wells, resulting in significant spatial distortion of groundwater quality data. Additionally, data reported by other agencies gives imprecise monitoring well locations by using smaller grids to report any water quality data within that grid. Mapping buffers based on well location inaccuracies are dependent on the monitoring program, or regulatory agency, and are described as follows:

- 100 foot radius for data from the Tulare County dataset, UCD and GAMA data not derived from the SWRCB-DDW;
- 1 mile section squares for DPR data; and
- 2 mile squares for DDW data derived from the GAMA database.

Once the buffers were determined, the GIS layer is underlain by the CVHM 1-mile grid. Where a buffer lies within a CVHM grid cell, the cell is considered to be within the sphere of influence of that groundwater quality detection. With this approach, the extent of groundwater quality exceedances and uptrending impacts are considered to be conservative and err on the side of groundwater quality protection.

Analytical chemistry results, collected within the last 10 years, for constituent of concerns were mapped independently to determine where detections within of CVHM cells. Areas identified with elevated electrical conductivity/total dissolved solids (**EC/TDS**) and pesticides were overlapped by identified areas of elevated nitrates. Areas without nitrate exceedances are primarily located along the Kaweah River footprint, and to the southeast of the City of Visalia. A limited set of statistically uptrending wells are scattered throughout the area and mostly coincide with CVHM sections already noted to be in exceedances for nitrates. Limited groundwater nitrate exceedances of the MCL are located within the Supplemental Area, mostly along the border to the Primary Area, and near Three Rivers. Nitrate exceedances in the Three Rivers area do not correlate with membership grower properties.

To determine the appropriate data for assessment of HVA designation the KBWQA prioritized data which would have a comparable timeframe with other relevant data sets such as crop type, irrigation methods, farming practices, land management practices, and water quality. Sufficient water quality data appropriate for analysis was available by using data publicly available from 2003 through the time of GAR development. The KBWQA worked to reduce the effect of additive margins of error in cross comparison of data sets, as well as data used for prioritization of HVAs (identified in **Table 8**, by selecting data that was no more than 10 years old at the time of GAR development. The resultant data set is considered to be the baseline water quality of the KBWQA. It is anticipated that as new data becomes publicly available, it will be evaluated and incorporated every five years in revisions to the GAR, as required by the General Order. Over time this data will continue to be cross referenced with other data sets (pesticide use records, irrigations methods, crop type etc.), creating a matrix of water quality data and associated land use and management practices to increase accuracy of areas defined as high vulnerability. This combined data set will be critical in future submittals to further identify areas where water quality may have been impacted by irrigated agriculture, aiding in the development of work plans and management plans. This combined data set will also aide the KBWQA in properly identifying

growers in the greatest need of improved management practices in order to most effectively execute management plans.

Table 8. Prioritization Matrix

Prioritization Matrix	
	Score
Critical (Score 0-75)	
Nitrate or Pesticide Water Quality over MCL	75 points
Upgradient of a DAC or Small Water System	0.25 miles away – 75 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Nitrate Water Quality Trends	Upward – 50 points Stable – 0 points Downward – minus 25 points
Secondary (Score 0-50)	
NRCS Hydraulic Conductivity	Sand, Loamy Sand, Riverwash – 50 points Sandy Loam, Gravelly Clay Loam, Fine Sandy Loam, Course Sandy Loam, Loam, Silt Loam – 25 points Clay, Clay Loam, Cobbly Clay, Silty Clay – 10 points
CVHM Vertical Hydraulic Conductivity	75-100% – 50 points 50-75% – 30 points 25-50% – 15 points 0-25% – 0 points
Upgradient of Recharge Area	0.25 miles away – 50 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Depth to Groundwater	<50 feet – 50 points 50-100 feet – 25 points >100 feet – 0 points
Groundwater Gradient	Steep – 25 points Moderate – 15 points Fairly Flat – 5 points
Contributing (Score 0-25)	
Irrigation Method	Flood – 25 points Sprinkler – 15 points Efficient – 0 points
Crop	Onion/Cilantro/Cabbage – 25 points Melons/Tomatoes – 14 points Citrus/Alfalfa/Corn/Stone Fruit/Grain & Hay/Walnuts – 7 points Grapes/Olives/Fallow – 0 points
Proximity to Permitted Discharger	0.25 miles away – minus 10 points 0.5 miles away – minus 5 points >0.75 miles away – 0 points
Farm Size	Large – 10 points Small – 0 points

Data collected from existing monitoring well networks (dairies, landfills, etc.) are targeted to address impacts from known issues associated with point source pollution and were not used to determine HVAs. These data may not be representative of irrigated agricultural impacts and were not considered to be an appropriate data source for HVA analysis. Use of these additional data was not anticipated to have any impact on HVA designation.

Water quality data, used for the analysis in the GAR, did not include information regarding depth to groundwater or the monitored water bearing zone of the collected samples. At the time of GAR completion this associated information was not publicly available. The KBWQA understands that legislation has since been enacted, which allows public access to well logs upon request from the DWR. This information will help in determining areas where first encountered groundwater quality is potentially impacted by irrigated agriculture. Well logs and associated groundwater quality data will be included in future updates to the CGQMP and GAR.

Section 7 "Vulnerability Assessment" of the GAR describes the general additive and overlay methodology based on a weighted matrix, as identified in GAR Tables 7.1. and 7.2., which were used to designate HVAs. The weighted overlays were compiled using GIS, creating an assessment that accounts for the cumulative effects rather than by evaluation of individual systems.

Specifically, recharge areas were delineated by using areas of known surface water recharge basins and soil type and heavily weighted in the prioritization matrix. Other factors including soil type, hydraulic conductivity, recharge areas, and depth to groundwater were correlated to assess the cumulative effects to vertical hydro-conductivity. Within the weighted matrix, additional points were also assessed for areas of identified groundwater contamination which were upgradient of DACS, small DACs, and small or unincorporated water systems.

CVHM grid cells with identified impairments to water quality and were classified as an HVA. If at least 50 percent of a commercially irrigated parcel was within a designated that parcel was determined to be within an HVA. Groundwater quality attributes of each well are assigned to the entire individual 1-mile CVHM grid cell. Additionally, areas within identified groundwater impact cells that are located directly upgradient of a DAC or small water system that is reliant on groundwater are specifically included in the HVA designation.

3.2.3 GAR – Groundwater Trend Analysis

Water quality data were analyzed to determine areas of statistically significant uptrending nitrate concentrations. Publicly available data, from 1909 through 2014, were analyzed for all nitrate results reported at the detection limit or higher. To calculate statistically significant up-trends in the water quality data, a Theil-Sen analysis was performed using the U.S. Environmental Protection Agency (**USEPA**) ProUCL software program with a 95 percent confidence interval. The Theil-Sen analysis does not require normally-distributed data, can deal with some non-detect data points and is a recommended method of determining if statistically significant trends are found in a dataset.

To ensure that all of the available nitrogen concentration data were captured, and not duplicated, the UCD dataset was used for calculations. The UCD dataset included wells from GAMA, in addition to other wells not included in the GAMA system. Because both the GAMA and UCD dataset did not provide exact well locations and used different well naming conventions, it was impossible to correlate well specific water quality data from the two datasets. To be of sufficient quantity for analysis, only wells with at least eight detections, at or above the reporting limit, within the monitoring record period were used.

The datasets were entered in the ProUCL software program and tested for trends using the Theil-Sen slope calculations.

Wells identified with a statistically significant increasing nitrate trend appear as red-hashed squares in **Figure 16**. The remaining cells are either of known good groundwater quality or did not have available groundwater quality data. All areas determined to have statistically significant upward trending values for nitrate were incorporated into HVAs, as illustrated in **Figure 17**.

3.2.4 HVA Data Gap Resolution

Spatial gaps, where water quality exceedances were not found, were assessed to determine if they should be included or excluded from the HVAs based on the following criteria:

- Groundwater quality testing over the most recent 10 year time frame indicating a lack of groundwater impacts from nitrate or pesticides;
- Endangered species critical habitat;
- Residential or industrial; and
- Other incompatible land use areas such as gravel mining, landfills, wetlands, and water storage or waterways.

If not excluded from the HVA due to the above criteria, the remaining cropped or potentially cropped areas in both the Primary and Supplemental Areas are assessed for inclusion in or exclusion from the HVAs using several factors including geologic, hydrologic, soil, cropping, irrigation and proximity to a DAC reliant on groundwater. Where data were insufficient to make a determination regarding HVA designation, onsite visits were completed by a professional geologist and an agricultural specialist to determine appropriate HVA designation.

3.2.5 HVA Designation

Final determination of HVA designation, within the KBWQA, is illustrated in **Figure 18**. DACs and small water systems that are reliant on groundwater are illustrated as black-hashed polygons with high vulnerability areas in red and low vulnerability areas in green. These are overlain by the groundwater elevation contour lines from spring 2014 (which are reasonably consistent with historical groundwater contour maps). Cropped or potentially cropped areas with nitrate or pesticide groundwater quality impacts (both exceedances and uptrending), that are located upgradient of a DAC or small water system that is reliant on groundwater, are included as HVA properties. To augment this designation, these particular HVA properties are designated as the highest priority. A map showing the locations of enrolled member parcels (October 2014) with applied HVA designation is included as **Figure 19**.

3.3 Constituents of Concern (COCs)

Constituents of concern (COCs) were identified using data collected for the development of the GAR, as well as recent evaluation of groundwater wells impacted by pesticides. Nitrates, pesticides and elevated salinity are referred to collectively as constituents of concern and abbreviated as COCs throughout the CGQMP. This section describes COCs within the KBWQA, potential sources, and the environmental fate of identified COCs in groundwater.

3.3.1 Nitrates

Other than nitrogen fertilizers, there are several natural sources of soil nitrogen. Soil nitrogen is essential to plants and soil organisms that cannot capture nitrogen directly from the atmoshphere. Free-living and symbiotic soil microbiota fix atmospheric nitrogen into plant and microbial biomass, which becomes soil organic matter when it dies and decomposes. Ammonium (an inorganic form of nitrogen) is produced when that organic matter is mineralized (converted to basic inorganic components), and deposited from the atmosphere. This is the main natural source of non-gaseous, inorganic soil nitrogen.

Nitrate is a naturally occurring form of nitrogen that can be formed from nitrification (a microbially-mediated process common in soils) of ammonium. Geologic sources of nitrate also exist in some locales. Nitrate and ammonium are taken up by microbes and plants to form amino acids. Nitrate from fertilizers can also be found in soils and groundwater. Groundwater contamination most likely results from excessive application of nitrogen fertilizers in to irrigated agricultural and landscaped areas, as well as contributions from percolation from feedlots or dairies, wastewater and food processing waste percolation, and leachate from septic system drainfields (Harter T., et al. 2012). To address nitrate contamination of groundwater the KBWQA proposes a dynamic process that is described in greater detail in **Section 5**.

The MCL for Nitrate as nitrate is 45 mg/L. Exceedances of the MCL for nitrate as nitrate were used to identify areas of groundwater impairment. MCL exceedances are illustrated as red-hashed squares in **Figure 16**. Nitrate exceedances are located almost entirely within the Primary Area.

3.3.2 Pesticides

Agricultural pesticides are chemicals used to control organisms which can be harmful to crops, including bacteria, fungi, weeds, insects and vertebrates, as well as other vectors of disease. Pesticides are generally synthetic and do not occur naturally in the environment. In addition to agricultural applications, pesticides are used in residential lawn and garden areas, as well as golf courses and roadside weed control. Pesticides contain active and inert ingredients that may be environmental pollutants depending on their labile or recalcitrant behavior, solubility, bioavailability, and the direct and indirect impacts to organisms. Chemicals categorized as pesticides can be found in a variety of non-agricultural products. The respective uses of detected pesticides are described in **Section 4.1.1**. To address pesticides present in groundwater, the KBWQA proposes to use the approach further described in **Section 5**, which includes developing grower outreach and education to emphasize proper irrigation wellhead protection and closure of abandoned wells. Prevention of potential impacts from pesticides will further be addressed by the DPR's Groundwater Protection Program.

Only those pesticides with designated MCLs were included in the CGQMP. Data from 2000 to 2015 was accessed from the DPR and GAMA records. Pesticides reviewed for potential inclusion in the CGQMP are listed in **Table 9**. Evaluation of exceedances of a MCL included pesticides that are currently registered for use in California, as well as those that are no longer permitted. Recent groundwater samples indicate Xylenes, 1,2-Dibromo-3-chloropropane (**DBCP**), 1,2-Dichloroethane (**DCA12**), 1,2-Dibromoethane (**EDB**) and Carbon Tetrachloride (**CTCL**) exceeded their respective MCLs. Information regarding the number of exceedances and wells, as well as MCL values for the noted pesticides can be found in **Table 10**. The spatial extent of the various pesticide exceedances is illustrated in **Figure 20**.

Table 9. Comprehensive List of Analyzed Pesticides within the GAMA Data Set

GAMA Data - List of Pesticides			
Pesticide	**Chemical Name**	**MCL**	**Units**
PCA	1,1,2,2 Tetrachloroethane (PCA)	1	µg/L
TCA112	1,1,2-Trichloroethane	5	µg/L
EDB	1,2 Dibromoethane (EDB)	0.05	µg/L
DCBZ12	1,2 Dichlorobenzene (1,2-DCB)	600	µg/L
DCA12	1,2 Dichloroethane (1,2 DCA)	0.5	µg/L
TCB124	1,2,4- Trichlorobenzene (1,2,4 TCB)	5	µg/L
DBCP	1,2-Dibromo-3-chloropropane (DBCP)	0.2	µg/L
DCP13	1,3 Dichloropropene	0.5	µg/L
DCBZ14	1,4-Dichlorobenzene (p-DCB)	5	µg/L
TCDD2378	2,3,7,8-Tetrachlorodibenzodioxin (Dioxin)	0.00003	µg/L
SILVEX	2,4,5-TP (Silvex)	50	µg/L
24D	2,4-Dichlorophenoxyacetic acid (2,4 D)	70	µg/L
ALACL	Alachlor	2	µg/L
ATRAZINE	Atrazine	1	µg/L
BTZ	Bentazon	18	µg/L
CRBFN	Carbofuran	18	µg/L
CTCL	Carbon Tetrachloride	0.5	µg/L
CHLORDANE	Chlordane	0.1	µg/L
DALAPON	Dalapon	200	µg/L
DINOSEB	Dinoseb	7	µg/L
ENDOTHAL	Endothall	100	µg/L
ENDRIN	Endrin	2	µg/L
GLYP	Glyphosate (Round-up)	700	µg/L
HEPTACHLOR	Heptachlor	0.01	µg/L
HEPT-EPOX	Heptachlor Epoxide	0.01	µg/L
HCLBZ	Hexachlorobenzene (HCB)	1	µg/L
BHCGAMMA	Lindane (Gamma-BHC)	0.2	µg/L
MTXYCL	Methoxychlor	30	µg/L
MOLINATE	Molinate	20	µg/L
OXAMYL	Oxamyl	50	µg/L
PICLORAM	Picloram	0.5	mg/L
SIMAZINE	Simazine	4	µg/L
TOXAP	Toxaphene	3	µg/L
XYLENES	Xylenes (total)	1750	µg/L

Table 10. Pesticide Exceedances in GAMA Data Set in the KBWQA

Pesticide Exceedances in KBWQA Groundwater					
Pesticide	Number of Exceedances	Range of Exceedance Values (µg/L)	Number of Wells Exceeded	Percent of Exceedance Wells	MCL (µg/L)
CTCL	56	0.5-45	4	1.0%	0.5
DBCP	142	0.2-1.2	61	16.1%	0.2
DCA12	50	0.54-420	7	1.8%	0.5
EDB	5	3.3-8.4	1	0.3%	0.05
Xylene	62	1,800-23,000	6	2.2%	1750

3.3.3 Salinity

Salinity in groundwater can originate from natural sources, sewage, runoff and deep percolation from urban and agricultural areas, industrial wastewater, and oilfield produced water. Complex hydrogeologic processes often dissolve, transport, dilute, concentrate, and/or precipitate salts. Variations in surface water availability affect recharge with higher quality surface water and subsequent salt dilution of salts. The sources of applied irrigation water, and the leaching fraction applied, determine the steady-state salinity of percolating water. Salinity is commonly measured as Electrical conductivity (**EC**) micro mhos per centimeter (µmhos/cm; often dS/m in soils literature, which is 1000 µmhos/cm) or Total Dissolved Solids (**TDS**) in mg/L during routine water quality sampling. Both sample analyses represent numerous individual constituents that together make up bulk salinity. EC is the measure of dissolved material in an aqueous solution and is directly related to the ability of the material to conduct electrical current through it, whereas TDS is generally inorganic and organic suspended solids under 2 microns.

The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is an initiative to identify salinity management strategies that will achieve a salt balance and keep agriculture economically viable. The KBWQA has contributed to the Central Valley Salinity Coalition and the CV-SALTS process since 2013 and will remain actively involved in this important stakeholder process.

4 Physical Setting & Information for CGQMP Area

4.1 Identification of Constituent of Concern (COC) Sources and Fate in the Environment

Potential constituents of concern (COCs) were evaluated by the KBWQA for impairments to groundwater quality throughout the Primary and Secondary Areas. These COCs, their intended uses, and potential environmental fate in groundwater are described below.

4.1.1 Irrigated Agriculture

4.1.1.1 Sources of Nitrogen

4.1.1.1.1 Nitrates

Migration of nitrates to groundwater occurs when water travels beyond the root zone and through the unsaturated zone. In irrigated agriculture the application of water and the method of irrigation are key factors influencing percolation of nitrates to groundwater. In order to sustain agricultural production, a leaching fraction is required to prevent excessive salt accumulation in the rootzone. Irrigation efficiency, distribution uniformity and nutrient management can help to minimize nitrate impacts to groundwater.

4.1.1.1.2 Nitrite

Nitrite is readily converted to nitrate and is often considered a transient and minority state of nitrogen. HVAs were identified using any one of three criteria:

- An up trending nitrate trend in ag land,
- Two or more exceedances of the nitrate MCL, or
- All DACs and small DACs at the request of the CVRWQCB.

GAMA data were used to evaluate nitrite concentrations in the KBWQA area's groundwater. Analysis of nitrite in groundwater from two separate wells indicated exceedances of the 1 mg/L MCL for nitrite; however, these wells were not sampled subsequently. Therefore, readily available data does not alter previously identified HVAs using the criteria defined in the GAR. A trend analysis of nitrite could not be completed, because only a single data point for nitrite was available for analysis time period. Further, all DACs were previously identified and included in previously defined HVAs. Isolated detections of elevated nitrite levels will not result in an alteration of previously defined HVAs, therefore nitrite is not required to be addressed independently of nitrate.

4.1.1.2 Pesticides

4.1.1.2.1 Xylenes

Xylene is used as a solvent in a variety of substances, including the manufacturing of agricultural sprays, chemicals, adhesives and coatings. Most notably, Xylene is the solvent base for the pesticide "parathion" (Munnecke & Hsieh, 1975). Parathion is a broad spectrum pesticide, intended to control many insects and mites. Parathion is toxic by all possible forms of exposure. In 1992, EPA cancelled all uses of parathion on fruit, nut and vegetable crops; however, alfalfa, barley, corn, cotton, sorghum, soybeans, sunflowers and wheat were granted continued use (EXTONET: Parathion, 2016). Parathion readily binds to soil particles and is degraded quickly by biological and chemical processes. This minimizes potential for parathion to be transported making groundwater contamination unlikely (EXTONET: Parathion, 2016).

Xylene's fate in the environment is determined by its high vapor pressure, resulting in the frequent volatilization of the chemical. Xylene can also be biodegraded in the vadose zone of soils, under aerobic conditions. Despite Xylene's quick degradation within the vadose zone, ability to easily adsorb to sediment and volatilize, exceedances of Xylene were recorded within the KBWQA boundary. This may be attributed to improperly abandoned wells or inadequate wellhead protection, and runoff containing Xylene being transported directly into groundwater. Groundwater is characterized as being low in dissolved oxygen content; therefore, the degradation of Xylene in a groundwater environment would be slowed.

4.1.1.2.2 DBCP

DBCP is a fumigant pesticide that was commonly used to kill nematodes in soil prior to planting. During the period of 1957 to 1977, approximately 32 million pounds of DBCP were applied in California, primarily for soybeans (County of Fresno, 2016). DBCP was used on over 40 crops in the United States (County of Fresno, 2016). In 1977 DBCP was no longer permitted for use in irrigated agriculture within California, and is considered to be a legacy issue.

DBCP was expected to adsorb to the soil or be broken down via chemical or biological degradation pathways prior to leaching into the groundwater table; however, extensive contamination of DBCP has been found in groundwater throughout the agriculturally rich San Joaquin Valley (County of Fresno, 2016). This may also be attributed to improperly abandoned wells or inadequate wellhead protection that provided an opportunity for DBCP to transport directly to the groundwater. Once in groundwater, DBCP becomes highly mobile and lingers with the medium half life of 20 years (County of Fresno, 2016).

4.1.1.2.3 DCA12

DCA12 is a manufactured chemical used in the production of a variety of products, including plastics, furniture, polyvinyl chloride pipes, automobile parts and as a solvent in pesticides. DCA is no longer listed as a pesticide in California, and became regulated as a toxic substance in 1989 with an MCL of 0.5 µg/L (Agency for Toxic Substances & Disease Registry: 1,2-Dichloroethane, 2016).

DCA12 has a high vapor pressure, resulting in quick evaporation. However, DCA12 has the capacity to leach into groundwater rapidly and has a long residence time. The long residence time can be attributed to its halogenated structure. This makes it recalcitrant to break down, leading to limited biodegradation.

4.1.1.2.4 EDB

EDB was used extensively as a fumigant for crops and as a quarantine fumigant for citrus and tropical fruits and vegetables. Beginning in 1983 use of EDB for agriculture was suspended after it was detected in groundwater. EDB is still registered today for termite, Japanese beetle, and beehive control/fumigation (EXTONET: EDB, 2016).

The majority of EDB degradation occurs in the topsoil; however, it is stable in aqueous conditions, aiding its ability to leach easily into groundwater. The reducing conditions in groundwater slow microbial degradation. As a result, EDB can persist in groundwater longer than in aerobic or semi-aerobic environments.

4.1.1.2.5 Carbon Tetrachloride

Carbon tetrachloride, or CTCL, was used as a pesticide fumigant for grain storage, milling distribution and processing phases. It is no longer registered as a pesticide in California and its use as a fumigant was prohibited in 1986 (Agency for Toxic Substances & Disease Registry: Carbon Tetrachloride, 2016), and is considered to be a legacy issue.

Although most of CTCL in the environment evaporates due to its high vapor pressure, if it leaches into groundwater, it can persist for long periods of time. Much like DCA12, CTCL's halogenated structure slows degradation, further contributing to an extensive residence time.

4.1.1.2.6 Additional Detected Pesticides

Various thresholds exist to demonstrate unhealthy concentrations of pesticides. These include: Notification Limits, Public Health Goals (**PHG**), Health-Based Screening Levels, and Maximum Contaminant Levels (MCLs). Exceedances of regulatory and non-regulatory thresholds reported for areas within the KBWQA area and occurred since 2010 are summarized in **Table 11**. Only those pesticides which exceeded an MCL are addressed by the CGQMP.

Table 11. Pesticide Detections Above of Any Health Threshold in the KBWQA Area

Pesticide Detections Above Any Health Threshold in the KBWQA Area						
Chemical Name	**Total Tests from Wells above a Threshold**	**Wells above a Threshold**	**Tests Total**	**Wells Total**	**% Tests above a Threshold**	**% Wells above a Threshold**
Xylenes (total)	136	6	2859	276	4.8%	2.2%
1,2,3-Trichloropropane (1,2,3 TCP)	263	48	3864	398	6.8%	12.1%
1,2 Dibromoethane (EDB)	16	1	3242	384	0.5%	0.3%
1,2 Dichloropropane (1,2 DCP)	181	1	2752	383	6.6%	0.3%
Deethylatrazine (DEATZ)	71	5	305	79	23.3%	6.3%
1,2 Dichloroethane (1,2 DCA)	70	7	2847	395	2.5%	1.8%
1,2-Dibromo-3-chloropropane (DBCP)	2160	61	3437	378	62.8%	16.1%
Carbon Tetrachloride	236	4	2836	384	8.3%	1.0%

4.1.1.3 Salinity

The application of water to support agriculture leads to the uptake of water and an increase in concentration of solutes in excess water of the rootzone. It is critical to apply sufficient water to leach salts from the rootzone to maintain soil and agronomic viability; as such discharges of potentially elevated salinity can only be partially mitigated. Generally, improper drainage can result in elevated levels of EC leaching into groundwater. However, the extent of elevated salinity throughout the KBWQA is not only characteristic of irrigated agriculture and can be likely attributed to the natural geology.

Many permanent crops have converted to drip or micro irrigation systems and application rates are being more closely matched to a crop's water usage, reducing the amount of water that can potentially be lost to runoff or below the root zone as deep percolation. However, this efficiency comes at risk with soil salinity concentrations increasing as less water is applied to leach these salts below the root zone.

4.1.2 Alternative Sources

Pesticide contamination prevention will further be addressed under DPR's Groundwater Protection Program. Nitrate can also be found in groundwater as a result of percolation from feedlots, dairies, food processing facility discharges, or wastewater. Information on dairy facilities and land application areas was obtained from the CVRWQCB. In 2012 there were approximately 71,000 acres of dairy associated land located within the Primary KBWQA area. Dairies are currently regulated under the Dairy General Order.

It is unknown how many acres within the KBWQA boundary are under the regulatory jurisdiction of other Waste Discharge Requirements (WDR's) or conditional waivers of WDR's (i.e. effluent wastewater, food processing, recycled water, etc). Locations monitoring wells, regulated by the CVRWQCB, within the KBWQA were mapped and are illustrated in **Figure 21** and listed in **Table 12**. These programs include leaking underground storage tank (**LUST**) and other cleanup sites, solid waste and wastewater treatment plant facilities, and food processor and dairy sites, updated in 2015.

Table 12. CVRWQCB-Supervised Sites with Monitoring Well Networks (2015)

CVRWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
Open Sites – Primary				
SL205194270	15	Sprague Electric Co. (Former)	Visalia	Cleanup Program Site
T0610700157	12	Elderwood Market	Woodlake	LUST Cleanup Site
T0610700193	12	El Rancho Market	Woodlake	LUST Cleanup Site
T0610700279	28	Jack Griggs Inc.-Bulk Plant	Exeter	LUST Cleanup Site
T0610700290	34	Sub Station	Woodlake	LUST Cleanup Site
T0610700327	20	Valley Convenience Store #9	Exeter	LUST Cleanup Site
T0610700407	12	Villicana's Gasoline Alley	Woodlake	LUST Cleanup Site
T0610700464	6	Banti Market	Tulare	LUST Cleanup Site
T0610779138	3	Caltrans Right-of-Way	Exeter	LUST Cleanup Site

CVRWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
T0610793750	13	Chief Enterprises	Lindsay	LUST Cleanup Site
T10000001159	10	Union Pacific Railroad	Tulare	Cleanup Program Site
L10008919544	52	Visalia Landfill	Visalia	Solid Waste Facility
L10001207790	11	Woodlake Landfill - Closed	Woodlake	Solid Waste Facility
L10001505773	21	Exeter Landfill - Closed	Exeter	Solid Waste Facility
L10001873737	37	Woodville Landfill - just south of boundary	Woodville	Solid Waste Facility
	14	Visalia WWTP	Visalia	Wastewater Treatment Plant
	29	Tulare WWTP	Tulare	Wastewater Treatment Plant
	19	City of Lindsay (Lindsay Brine Ponds East)	Lindsay	Food Processors
	25	Sierra Cattle (Lindsay Brine Ponds West)	Lindsay	Food Processors
	6	The Wine Group	Tulare	Food Processors
	3	Aukeman Dairy	Tulare	Dairy Facility
	3 - 6	De Jong Heifer Feed Lot	Visalia	Dairy Facility
	3 - 6	Dykstra Dairy	Tulare	Dairy Facility
	3 - 6	Edwin Brasil Dairy	Visalia	Dairy Facility
	3 - 6	Elkhorn Dairy	Visalia	Dairy Facility
	3	FM Ranch #4 Dairy	Visalia	Dairy Facility
	3	Friesian Farms	Tulare	Dairy Facility
	3 - 6	Highstreet Dairy	Tulare	Dairy Facility
	3	Holstein Farms	Tulare	Dairy Facility
	3 - 6	Homestead Dairy	Visalia	Dairy Facility
	3 - 6	Hynes Dairy	Tulare	Dairy Facility
	3 - 6	Rancho Sierra Vista	Visalia	Dairy Facility
	3	Mineral King Dairy	Vislia	Dairy Facility
	3 - 6	Moonlight Dairy	Visalia	Dairy Facility
	3 - 6	Shirk Dairy	Visalia	Dairy Facility
	3 - 6	Sierra View Dairy	Tulare	Dairy Facility
	3	Triple H Dairy	Tulare	Dairy Facility
	3 - 6	Vanderham Dairy	Visalia	Dairy Facility
Open Sites – Supplemental				
T0610700237	35	Sequoia Grocery	Exeter	LUST Cleanup Site
Closed Sites – Primary				
T0610700014	15	Time Oil Co./Mooney Mart	Visalia	LUST Cleanup Site
T0610700028	17	Caltrans Lemon Cove	Lemon Cove	LUST Cleanup Site

CVRWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
T0610700035	21	R. E. Havens Lease Property	Lindsay	LUST Cleanup Site
T0610700038	18	Value & Convenience (Exeter Mini Mart)	Exeter	LUST Cleanup Site
T0610700043	12	Sierra Citrus Packing	Lindsay	LUST Cleanup Site
T0610700108	7	City of Lindsay	Lindsay	LUST Cleanup Site
T0610700170	7	Private Residence	Tulare	LUST Cleanup Site
T0610700175	5	Gong's Market	Farmersville	LUST Cleanup Site
T0610700244	4	Souza Property	Tulare	LUST Cleanup Site
T0610700245	6	J. A. Fischer Inc.	Visalia	LUST Cleanup Site
T0610700248	11	Tosco - Facility #4318	Visalia	LUST Cleanup Site
T0610700288	7	Lonestar Canteen	Exeter	LUST Cleanup Site
T0610700331	15	Roche Oil	Tulare	LUST Cleanup Site
T0610700332	8	Felix's Chevron	Woodlake	LUST Cleanup Site
T0610700363	35	Gas Ranch	Woodlake	LUST Cleanup Site
T0610700381	6	Visalia Unified School District	Visalia	LUST Cleanup Site
T0610700399	4	Tosco - Facility #5389	Visalia	LUST Cleanup Site
T0610700402	11	Quality Mart	Lindsay	LUST Cleanup Site
T0610700426	4	Shell Service Station	Visalia	LUST Cleanup Site
T0610700433	13	Tosco - Facility #2177	Visalia	LUST Cleanup Site
T0610700435	8	Double D Mini Mart	Visalia	LUST Cleanup Site
T0610700436	24	Quick Stop Food Market	Woodlake	LUST Cleanup Site
T0610700453	6	C. P. Phelps	Tulare	LUST Cleanup Site
T0610709906	3	Tri Mart Chevron	Exeter	LUST Cleanup Site
T0610741247	3	AA Gas-N-Grub #2	Farmersville	LUST Cleanup Site
T0610752851	12	Shell Service Station	Visalia	LUST Cleanup Site
T0610799010	11	Farmersville Chevron	Farmersville	LUST Cleanup Site
Closed Sites – Supplemental				
T0610700234	3	Private Residence	Three Rivers	LUST Cleanup Site
T0610793753	3	Badger Forest Fire Station	Badger	LUST Cleanup Site

4.1.3 Source Identification Study

The KBWQA has elected to use a comprehensive approach to address exceedances of groundwater quality thresholds. Previous efforts to define the relative contribution of various nitrate producing activities to groundwater impacts have yielded inconclusive results, especially in defining or explaining legacy impacts. As such, the cost and effort required to thoroughly conduct a source identification study is considered to have little benefit and would be duplicative of other efforts previously made by the CVRWQCB and others (Harter T., et al. 2012).

4.2 Beneficial Uses

The Tulare Lake Basin Plan designates groundwater aquifer beneficial uses to be protected, water quality objectives to protect those beneficial uses, and a program of implementation needed for achieving or sustaining these objectives. The four DWR groundwater basins included in the area of the KBWQA, noted previously, are designated for municipal (**MUN**), agricultural (**AGR**) industrial process supply (**PRO**), water contact recreation (**REC-1**), and contact water recreation (**REC-2**), and industrial (**IND**) beneficial uses (CVRWQCB, 2015).

4.3 Management Practices Baseline

Factors that influence nitrogen impacts from irrigated agriculture have been studied by numerous entities. Continued research is underway to help aid in understanding the factors that affect nitrate leaching from farmland. The main contributors to nitrate leaching potential that interact within land management decisions at the surface are soil type, crop type, and irrigation type (Letey et al., 1979; Plant Nutrient Management Technical Advisory Committee, 1994; and Wu et al., 2005). Management decisions, such as fertilizer application methods, influence how farming affects groundwater. These elements provide a framework for introducing nitrate leaching potential to members throughout the KBWQA area regarding protective management practices. The currently implemented practices are a baseline to evaluate the relative influence of future management practices to reduce nitrate leaching risk.

4.3.1 Existing Practices

Figure 22 illustrates general irrigation methods, within the KBWQA, as reported in returned grower Farm Evaluations for large farms (defined by the General Order as greater than 60 acres) within HVAs, during the 2015 calendar year. Parcels were generalized to represent the primary irrigation type for all fields within a single parcel. The KBWQA will continue to collect irrigation method information from growers in future Farm Evaluation submittals, allowing the Coalition to track changes over time.

Farm Evaluation Surveys and Nitrogen Management Plans (**NMPs**) are required to be completed by all members in the High Vulnerability Areas as identified by the GAR. Farm Evaluations were required by the General Order to be submitted to the third-party coalition in spring 2016 by large farms (those greater than 60 acres) in HVAs. The Farm Evaluation catalogues field specific crop and irrigation practices, including the implementation of protective practices relevant to irrigation efficiency, nitrogen application efficiency, and sediment and erosion control. The NMP Summary Reports are required to be submitted in spring of 2017 for growers of large farms in HVAs.

5 MANAGEMENT PLAN STRATEGY

Fulfillment of CGQMP requirements outlined in the General Order relies on the implementation of multiple co-dependent elements of the ILRP Program. These elements include the GAR, required member reports such as the Farm Evaluation Survey, NMP Summary Reports, the Management Practices Evaluation Program (**MPEP**), and Groundwater Quality Trend Monitoring Program **(GQTMP)**. The implementation timelines for these elements vary and resulting data will be incorporated into the CGQMP as required by the General Order. The following section highlights the significance and application of each of these elements in the ongoing management plan strategy.

The implementation of the CGQMP is linked with the MPEP throughout the General Order. The General Order requires CGQMPs to address HVAs as identified in the GAR through the implementation of protective practices. The MPEP identifies, promotes implementation of, and monitors implementation and benefits of protective practices. As specified in the General Order, the purpose of the MPEP is to determine the effects, if any, of irrigated agricultural practices on first encountered groundwater under varied conditions (e.g., soil type, depth to groundwater, irrigation practice, crop type, nutrient management practices). Some MPEP Workplan elements and their relevance to the CGQMP are described in the following sections.

To effectively address the surface-level decisions that influence nitrate leaching, a clear understanding of the relationship of these decisions to nitrate transport, the constraints in a range of agricultural management systems, and the factors that influence grower management choices is required. Management plan implementation will rely on education and outreach to address irrigation and nutrient management practices which have already been demonstrated to be protective in current research or will be demonstrated to be protective in MPEP evaluation. Outreach will also incorporate surface level metrics, such as nitrogen applied and removed values (**A/R Ratios**), to provide direct grower feedback mechanisms on currently and potentially implemented practices. See **Section 6** for a further description of monitoring methods.

Additional collaborative research is required to fill data gaps to support the reporting of A/R ratios, a critical grower feedback metric. The Nitrogen Technical Advisory Workgroup (**NTAWG**) convened in 2015 to coordinate applicable research to support the reporting of nitrogen A/R ratios.

5.1 CGQMP Strategy and MPEP Implementation

The CGQMP strategy and MPEP implementation is outlined in **Appendix C: MPEP GQMP Management Practices** "Identification, Extension, and Implementation of Management Practices to Minimize Nitrate Leaching from Crop Root Zones to Satisfy Groundwater Quality Management Plan Requirements." The following is an excerpt from **Appendix C: MPEP GQMP Management Practices** with minor edits.

The KBWQA has joined with six other coalitions to form the South San Joaquin Valley **(SSJV)** MPEP Committee, and collaborates actively with a technical team (SSJV MPEP Team) to develop and implement a Workplan. This process and the Discussion Draft Workplan (2016; Workplan) further advanced the understanding of what the MPEP entails and the timeline to complete program requirements and produce results.

It is understood that GQMPs are intended to address high priority areas where a prompt response is required of the coalitions. The Workplan outlines how the MPEP will interface with individual coalitions and GQMPs. Section 2.1.3 of the SSJV MPEP Workplan ("Exchanging Data with Coalitions and Informing Groundwater Quality Analyses") reads as follows:

"As mentioned previously, individual ILRP coalitions are engaged in complementary activities that can inform the MPEP and allow for more rapid, effective work. Examples of data and work products from the coalitions that are potentially relevant to the MPEP include the following:

- Coalitions' data about the type and location of practices are fundamental to assessing the effects of irrigated agriculture on underlying groundwater. These data might arise from the following sources:
- Farm Evaluations
- Nitrogen Summary Reports
- GARs
- Trend Monitoring Reports
- Methodology and results (e.g., surface loading, loading to groundwater) from the MPEP can inform Groundwater Quality Management Plans (GQMPs) and other groundwater analyses undertaken by coalitions."

The SSJV MPEP was developed to be an efficient, collective effort to identify and increase implementation of protective practices to address requirements that pertain to both the MPEP and CGQMP. **Appendix C: MPEP GQMP Management Practices** outlines the sections of the CGQMP and the SSJV MPEP Workplan which jointly address CGQMP requirements. **Figure 23** and **Figure 24** provides the SSJV MPEP Workplan master schedule.

Table 13. MPEP vs. CGQMP Requirements

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	**SSJV MPEP Workplan**
I.A. Introduction and Background Section			
	The introduction portion of the management plan shall include a discussion of the COCs that are the subject of the plan and the water quality objective(s) or trigger(s) requiring preparation of the management plan. The introduction shall also include an identification (both narrative and in map form) of the boundaries (geographic and surface water/ groundwater basin[s] or portion of a basin) to be covered by the management plan including how the boundaries were delineated	Section 1. Introduction, Section 1.1 Geographic Boundaries of Comprehensive Groundwater Quality Management Plan, Section 3.3 Constituents of Concern	N/A
I.B.1. Physical Setting and Information			

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	**SSJV MPEP Workplan**
I.B.1.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 Assessment Report (GAR) and may be referenced and/or updated as appropriate. Map(s) must be in electronic format using standard Arc-geographic information system (ArcGIS shapefiles).	Section 2.1.1 Land Use	Section 3.5.1.1, Cropping
I.B.1.b	Identification of the potential irrigated agricultural sources of the COC(s) for which the management plan is being developed. If the potential sources are not known, a study may be designed and implemented to determine the source(s) or to eliminate irrigated lands as a potential source.	Section 4.1 Identification of Constituent of Concern (COC) Sources and Fate in the Environment, Section	Section 3.6, Source Quantification
I.B.1.c	A list of the designated beneficial uses as identified in the applicable Basin Plan.	Section 4.2 Beneficial Uses	N/A
I.B.1.d	A baseline inventory of identified existing management practices in use within the management plan area that could be affecting the concentrations of the COCs in surface water and/or groundwater (as applicable) and locations of the various practices.	Section 4.3 Management Practices Baseline	Section 3.6.3, Benchmark Existing Level of BMP Adoption
I.B.1.e	A summary, discussion, and compilation of available surface water and/or groundwater quality data (as applicable) for the parameters addressed by the management plan. Available data from existing water quality programs may be used…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.	Section 3.1 Available Groundwater Data, Section 3.2 Previous Studies and Monitoring	Section 3.5.2.2, Groundwater Conditions
I.B.3. Groundwater – Additional Requirements			
I.B.3.a	Soil types and other relevant soils data as described by the appropriate Natural Resources Conservation Service (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.	Section 2.1.2 Soils	3.5.1.2, Soil Characteristics
I.B.3.b	A description of the geology and hydrogeology for the area covered by the GQMP.	Section 2.1.3 Geology, Section 2.1.4 Hydrogology	Section 3.5.2 Characterizations of Sub-Root Zone Process Factors
I.C. Management Plan Strategy			
I.C.1	A description of the approach to be utilized by the	Section 5.1	Section 3.1, Master

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		KBWQA CGQMP	**SSJV MPEP Workplan**
	management plan (e.g., multiple COC's 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 included in the management plan must be consistent with the requirements in section XII of the Order, Time Schedule for Compliance.	Approach and Prioritization	Schedule; Section 3.7, Initial Prioritization of Investigations; and Section 3.13, Regulatory Deliverables
I.C.2	The plan must include actions to meet the following goals and objectives: • Compliance with the Order's receiving water limitations (section III of the Order). • Educate Members about the sources of the water quality exceedances in order to promote prevention, protection, and remediation efforts that can maintain and improve water quality. • Identify, validate, and implement management practices to reduce loading of COC's to surface water or groundwater, as applicable, thereby improving water quality.	Section 5.1 CGQMP Strategy and MPEP Implementation, 5.3.2 Protective Management Practices, 5.3.3 Outreach Strategy, Section, 5.3.5 Performance Goals	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach), Section 3.6.3, Benchmark Existing Levels of BMP Adoption; 3.8, Focused Field Studies; Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality; Section 3.10, Landscape-level Performance Assessment; Section 3.12, Assessing Adoption, Data Exchange with Coalitions , Section 3.9.4, Summary Rationale for a Multi-Pronged Approach
I.C.3	Identify the duties and responsibilities of the individuals or groups implementing the management plan. This section should include: • 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). • Discussion of each individual's responsibilities • An organizational chart with identified lines of	Section 5.3.1 Partner Agencies and Entities, Section 8.1 Identification of Project Administration, Section 8.2 Individual Responsibilities, Section 8.3	Section 2.2, Institutional Approach

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	**SSJV MPEP Workplan**
	authority.	Organizational Chart	
I.C.4	Strategies to implement the management plan tasks.		Entire Management Practices Evaluation Workplan
I.C.4.a	Identify the entities or agencies that will be contacted to obtain data and assistance.	Section 5.3.1 Partner Agencies and Entities	Section 2.2, Institutional Approach
I.C.4.b	Identify management practices used to control sources of COCs from irrigated lands that are: • Technically feasible; • Economically feasible; • Proven to be effective at protecting water quality, and • Will comply with Sections III.A and B of the Order. Practices that growers will implement must be discussed, along with an estimate of their effectiveness or any known limitations on the effectiveness of the chosen practice(s).	Section 5.3.2 Protective Management Practices	Section 2.1.4, Demonstrating **Progress (partial);** Section 3.8, Focused Field Studies; and Section 3.10, Landscape-level Performance Assessment
I.C.4.c	Identify outreach that will be used to disseminate information to participating growers. This discussion shall include: 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. The third-party may conduct outreach efforts or work with the assistance of the County Agricultural Commissioner's, U.C. Cooperative Extension, Natural Resources Conservation Service, Resource Conservation District, California Department of Food and Agriculture, or other appropriate groups or agencies.	Section 5.3.3 Outreach Strategy, Section 5.3.5 Performance Goals, Section 6.3 Validate KBWQA Approach	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach)
I.C.4.d	A specific schedule and milestones for the implementation of management practices and tasks outlined in the management plan. Items to be included in the schedule include: time estimated to identify new management practices as necessary to meet the Order's surface and groundwater receiving water limitations (section III of the Order); a timetable for implementation of identified management practices (e.g., at least 25% of growers identified must implement management practices by year 1; at least 50% by year 2).	Section 5.3.4 Management Practices Implementation Schedule, Section 5.3.5 Performance Goals	Section 3.1, Master Schedule

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	**SSJV MPEP Workplan**
I.C.4.e	Establish measureable performance goals that are aligned with the elements of the management plan strategy. Performance goals include specific targets that identify the expected progress towards meeting a desired outcome.	Section 5.3.5 Performance Goals	Section 3.1, Master Schedule and Section 3.12, Assessing Adoption, Data Exchange with Coalitions
I.D. Monitoring Methods			
I.D.1	The monitoring system must be designed to measure effectiveness at achieving the goals and objectives of the SQMP or GQMP and capable of determining whether management practice changes made in response to the management plan are effective and can comply with the terms of the Order. Management practice-specific or commodity-specific field studies may be used to approximate the contribution of irrigated lands operations. Where the third-party determines that field studies are appropriate or the Executive Officer requires a technical report under CWC 13267 for a field study, the third-party must identify a reasonable number and variety of field study sites that are representative of the particular management practice being evaluated.	Section 6.1 Measure Achievement of CGQMP Goals, Section 6.2 Measure Effectiveness of CGQMP Practices	Section 3.8, Field Studies and Section 3.10, Landscape-level Performance Assessment
I.D.3	The third-party's Management Practice Evaluation Program and Groundwater Quality Trend Monitoring shall be evaluated to determine whether additional monitoring is needed in conjunction with the proposed management strategy(ies) to evaluate the effectiveness of the strategy(ies). This may include commodity-based representative monitoring that is conducted to determine the effectiveness of management practices implemented under the GQMP. Refer to section IV of the MRP for groundwater monitoring requirements.	Section 5.1 CGQMP Strategy and MPEP Implementation, Section 6.3 Additional Monitoring Required, Section 6.3.1 Validate KBWQA Outreach Results	Section 3.7, Initial Prioritization of Events and Section 3.9, A Multi-pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality
I.E. Data Evaluation			
I.E.1	Methods to be used to evaluate the data generated by SQMP/GQMP monitoring and to evaluate the effectiveness of the implemented management practices must be described. The discussion should include at a minimum, the following: • Methods to be utilized to perform data analysis (graphical, statistics, modeling, index computation, or some combination thereof). • Identify the information necessary to quantify program effectiveness going forward, including the tracking of management practice implementation. The approach for determining the effectiveness of the	Section 5.3.5 Performance Goals, Section 7 Data Evaluation & Reporting	Section 3.7, Initial Prioritization of Events; Section 3.8, Focused Field Studies; Section 3.9, A Multi-pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality; Section 3.10, Landscape-

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	**SSJV MPEP Workplan**
	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. The process for tracking implementation of management practices must also be described. The process must include a description of 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.		level Performance Assessment; Section 3.11, Sharing Findings with Coalition Members (Outreach); and Section 3.12, Assessing Adoption, Data Exchange with Coalitions
I.E.2	The plan must include actions to meet the following goals and objectives: • Compliance with the Order's receiving water limitations (section III of the Order). • Educate Members about the sources of the water quality exceedances in order to promote prevention, protection, and remediation efforts that can maintain and improve water quality. • Identify, validate, and implement management practices to reduce loading of COC's to surface water or groundwater, as applicable, thereby improving water quality.	Section 5.1 CGQMP Strategy and MPEP Implementation, 5.3.2 Protective Management Practices, 5.3.3 Outreach Strategy, Section, 5.3.5 Performance Goals	Section 2.4, Outreach Approach and Section 3.11, Sharing Findings with Coalition Members (Outreach), Section 3.6.3, Benchmark Existing Levels of BMP Adoption; 3.8, Focused Field Studies; Section 3.9, A Multi-Pronged Approach to Assessing the Influence of Irrigated Lands on Groundwater Quality; Section 3.10, Landscape-level Performance Assessment; Section 3.12, Assessing Adoption, Data Exchange with Coalitions , Section 3.9.4, Summary Rationale for a Multi-Pronged Approach
I.E.3	Identify the duties and responsibilities of the individuals or groups implementing the management plan. This section should include: • Identification of key individuals involved in major aspects of the project (e.g., project lead, data manager, sample collection lead, lead for	Section 5.3.1 Partner Agencies and Entities, Section 8.1 Identification of Project Administration, Section 8.2	Section 2.2, Institutional Approach

MPEP vs. CGQMP Requirements			
		KBWQA CGQMP	SSJV MPEP Workplan
	stakeholder involvement, quality assurance manager). • Discussion of each individual's responsibilities • An organizational chart with identified lines of authority.	Individual Responsibilities, Section 8.3 Organizational Chart	
I.E.4	Strategies to implement the management plan tasks.		Entire Management Practices Evaluation Workplan
I.E.4.a	Identify the entities or agencies that will be contacted to obtain data and assistance.	Section 5.3.1 Partner Agencies and Entities	Section 2.2, Institutional Approach

5.2 Approach and Prioritization

Within the KBWQA's Primary Area, known exceedances of the groundwater quality objective for nitrate are well documented. Through the process of GAR development these exceedances were demonstrated to be the most prevalent groundwater impact within the KBWQA. Other COC's will be addressed concurrently throughout the management plan area. To facilitate and focus groundwater quality monitoring and agricultural system management efforts, the KBWQA has prioritized all identified HVAs within the KBWQA.

5.2.1 Actions Taken to Fulfill the CGQMP

This CGQMP specifies the actions that will be taken to address groundwater impacts through the implementation and validation of protective practices. This includes outreach and education, implementation of the SSJV MPEP Workplan to identify and validate protective practices, and ongoing monitoring to demonstrate progress in protecting receiving water. Monitoring will include tracking responses to required member reports, analysis of trends in proxy metrics (A/R ratio's), and long term groundwater trend monitoring. Groundwater quality data from required monitoring will be analyzed by the SSJV MPEP Team alongside regional and site specific Soil & Water Assessment Tool **(SWAT)** model estimates of potential groundwater impacts to support the objectives of the MPEP and the CGQMP.

5.2.2 Prioritization of HVAs and Crop types within HVAs

5.2.2.1 KBWQA's HVA Prioritization

Prioritization of the land within HVAs for the GAR was based on a matrix of factors that may influence the potential for COC impacts from irrigated crops. Priority values were calculated throughout the identified HVA to define a three tier system with priorities being classified as Tiers 1(highest), 2, and 3 (lowest).

The HVAs of the KBWQA GAR were prioritized for the members located within Primary and Supplemental Areas using a combination of critical, secondary, and contributing parameters. Critical parameters include properties with groundwater quality issues and properties with groundwater quality issues that are upgradient of a DAC or small water system that is reliant on groundwater. Secondary parameters include physical properties of the soil and hydrogeology that are not expected to change significantly in the foreseeable future. Contributing parameters include factors that are generally expected to experience temporal variations. These factors include crop type, irrigation type, and other management decisions. **Table 8** provides a summary of the factors used for prioritization. The prioritization results are shown in **Figure 25**.

Parameters of the index are weighted relatively to contribute varying point values. Therefore, the point values assigned to the parameters and associated sub-categories vary. For instance, land located adjacent to a DAC and reliant on groundwater with nitrate exceedances, is more likely to be a higher priority than an area with shallow groundwater and nitrate exceedances that are not located near a DAC.

5.2.2.2 SSJV MPEP Crop Type Prioritization

In addition to prioritization of HVAs within the KBWQA boundaries, the SSJV MPEP Team developed a prioritization scheme for the SSJV to guide MPEP implementation. This is described in Section 3.7 of the SSJV MPEP Workplan.

"The following criteria are proposed as the basis for selection of in-depth sampling and field studies:

1. *Crops that represent the largest land area and economic value.*
2. *Crops and cropping systems with the largest N surplus and/or largest depth of leaching water applied.*
3. *Crops and cropping systems preferentially grown on coarse soils (e.g. sweet potatoes).*
4. *Crops and cropping systems in areas with shallow depth to groundwater (i.e., hydrogeologic sensitivity).*
5. *Regions of the MPEP area classified as disadvantaged communities (i.e., proximity to public groundwater supply wells).*

Initial modeling results, along with assessments of soil, vadose zone, and groundwater properties, as well as crop area distribution, will provide a basis for prioritizing effort relative to these criteria. Magnitudes of crop production area and value of the major commodities (presented in Section 3.5.1.1) will inform decisions about crop selection for more detailed study and data collection. Included among the most important crops in terms of area and value are fruit and nut crops (almond, citrus, pistachios), field crops (cotton, alfalfa, silage corn [exclusive of dairy], wheat), and vegetable crops."

5.3 Implementation Strategy

CGQMP implementation will be integrated with SSJV MPEP activities and other ILRP program elements to address groundwater quality impacts. The KBWQA will leverage the ongoing efforts of the SSJV MPEP to compile background information for management practices, facilitate training programs, and produce outreach and educational materials appropriate to protective management practices.

5.3.1 Partner Agencies and Entities

Section 2.2 of the SSJV MPEP Workplan, "Institutional Approach", describes efforts to maximize existing resources and knowledge regarding nitrogen and irrigation management. This includes the SSJV MPEP, technical support by agronomists, horticulturalists, plant nutritionists, soil scientists (specialists in management, soil fertility, soil chemistry, soil physics, plant physiology, plant nutrition, agro-meteorology, and modeling), and hydrogeologists (specialists in groundwater systems, as well as their management and modeling). Additional support can be found with technical partners, including public sector expertise, industry and commodity groups, and partner programs. Additional discussion of the role of partners can be found in the MPEP Workplan, but specific resources include:

- California Department of Food and Agriculture (**CDFA**);
- Fertilizer Research and Education Program (**FREP**);
- Tulare County Agricultural Commissioner;
- NRCS;
- Cal Poly Irrigation Training and Research Center (**ITRC**);
- UCCE; and
- Central Valley water quality coalitions.

The missions of institutions and programs such as the UCCE, ITRC, and FREP make them ideal partner organizations to help accomplish the objectives of the CGQMP. Existing training programs and outreach materials developed by these partners will be employed to the greatest extent possible. This will allow KBWQA to benefit from the knowledge and expertise of existing programs, while contributing to expansion of the knowledge base through the SSJV MPEP.

Additional research objectives for specific cropping systems will likely be achieved in partnership with commodity groups that are dedicated to providing access to information on effective field level management practices to improve production and efficiency. Resources and consultation provided by American Society of Agronomy (ASA) Certified Crop Advisers (**CCAs**) will also be employed throughout regional implementation of nutrient management plans and evaluation of irrigation management.

5.3.2 Protective Management Practices

5.3.2.1 Practices to Reduce Percolation of Nitrate to Groundwater

There has been extensive research on agricultural management practices in California, particularly relative to irrigation and nutrient management, including publications such as Nitrogen Source Reduction to Protect Groundwater Quality (Dzurella et al., 2012). The SSJV MPEP identifies protective practices. These practices limit deep percolation of COC's. Where there is uncertainty about management practice performance, where new knowledge is needed, the SSJV MPEP initiates investigations to close these knowledge gaps or develops needed tools.

As part of early outreach, the SSJV MPEP Team is working with CDFA, UCCE, and other partners to inventory known protective management practices. The SSJV MPEP will promote expanded practice implementation, and continue to work to develop and validate protective practices. In particular, the early outreach component of the workplan is designed to boost implementation of protective practices

where they are most needed in the shortest possible time (beginning in the next planting season). A selection of practices that may reduce deep percolation of nitrate can be found on Table 3-3 beginning on page 3-28 of the MPEP workplan, referencing Dzurella et al., 2012 (reproduced as **Table 14**).

The KBWQA will continue to communicate additional findings relevant to protective practices as they become available through annual monitoring and coordination with SSJV MPEP.

Table 14. Management Practices Documented to Improve Nitrogen Fertilizer Efficiency and Barriers (Dzurella et al., 2012)

Management Practices Documented to Improve Nitrogen Fertilizer Efficiency and Barriers		
	Management Practice	**Barriers to Adoption**
Irrigation and Drainage Design and Operation		
Irrigation System Evaluation and Monitoring		
1	Conduct irrigation system performance evaluation	Operational cost, land tenure, training
2	Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	Capital cost, operational cost, training
3	Conduct pump performance tests	Operational cost, training
Irrigation Scheduling		
4	Use weather-based irrigation scheduling	Operational cost, logistics, training, technology
5	Use plant-based irrigation scheduling	Operational cost, logistics, training
6	Use soil moisture content to guide irrigation timing and amount	Operational cost, logistics, training
7	Avoid heavy pre-plant or fallow irrigations for annual crops	Risk to yield or quality, logistics, training
Surface Gravity System Design and Operation		
8	Convert to surge irrigation	Capital cost, operational cost, logistics, training
9	Use high flow rates initially, then cut back to finish off the irrigation	Operational cost, logistics, training
10	Reduce irrigation run distances and decrease set times	Risk to yield or quality, capital cost, operational cost, land tenure, training
11	Increase flow uniformity among furrows (e.g. by compacting furrows)	Operational cost
12	Grade fields as uniformly as possible	Operational cost, training
13	Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	Capital cost, operational cost, land tenure, training
Sprinkler System Design and Operation		

Management Practices Documented to Improve Nitrogen Fertilizer Efficiency and Barriers		
Management Practice		**Barriers to Adoption**
14	Monitor flow and pressure variation throughout the system	Operational cost
15	Repair leaks and malfunctioning sprinklers; follow manufacturer recommended replacement intervals	Capital cost, operational cost, training
16	Operate sprinklers during the least windy periods, when possible	Logistics
17	Use offset lateral moves	Operational cost, logistics, technology
18	Use flow-control nozzles when pressure variation is excessive	Capital cost, land tenure, training
Drip and Micro-sprinkler System Design and Operation		
19	Use appropriate lateral hose lengths to improve uniformity	Training, capital cost
20	Check for clogging; prevent or correct clogging	Operational cost, capital cost, training
Other Irrigation Infrastructure Improvements		
21	Installation of sub-surface drains in poorly drained soils[1]	Capital cost, technology
22	Backflow prevention	Capital cost, training
Crop Management		
Change Crops to Use Those with Smaller N Requirements and Greater N Efficiency		
23	Cover crops to recover residual soil nitrate and immobilize it in soil organic matter	Risk to yield or quality of cash crop, capital cost, operational cost, logistics, training, technology, increased irrigation requirements for the cash crop
24	Include deep-rooted or N-scavenger crop species in annual crop rotations	Risk to yield or quality, capital cost, operational cost, logistics
25	Include perennial crop in rotation, e.g. alfalfa or perennial grasses	Capital cost, logistics, land tenure
Nitrogen Fertilizer Management		
Improve Rate, Timing and Placement of N Fertilizers		
26	Adjust N-fertilizer rates based on soil nitrate testing	Operational cost, training
27	Adjust timing of N fertilization based on plant tissue analysis	Risk to yield or quality, operational cost, training, lack of robust relationships between tissue test and amount of N fertilizer required
28	Apply N fertilizer in small multiple doses, rather than one or two large doses, to meet crop demand during the growing season without deficiency or excess	Operational cost, training
29	Know N content of irrigation water and adjust fertilizer rates accordingly	Operational costs, logistics, training

Management Practices Documented to Improve Nitrogen Fertilizer Efficiency and Barriers		
	Management Practice	**Barriers to Adoption**
30	Reduce total N-fertilizer rates by replacing low-uptake-efficiency N-fertilizer applications to soil with high-uptake-efficiency foliar-N applications	Operational costs, training, technology
31	Vary N-application rates within large fields according to site-specific needs based on heterogeneity in soil N supply and/or crop growth	Operational costs, capital costs, training, technology
32	Use delayed injection procedure when fertigating in surface gravity systems	Operational costs, logistics, training
34	Develop an N budget that includes crop N harvest removal, supply of N from soil and other inputs to guide decisions on N-fertilizer rates and timing	Operational costs, training, technology
35	Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	Risk to yield quantity or quality, capital cost, training, technology, benefits depend on soil types and N-fertilizer management practices
Improve Rate, Timing, and Placement of Animal Manure and Organic Amendment Applications		
36	Apply appropriate rates of manure and compost, taking N mineralization characteristics of these organic N sources into account	Risk to yield quantity or quality, operational cost, logistics, training, technology
37	Incorporate solid manure immediately to decrease ammonia volatilization loss	Operational costs, training
38	Use delayed injection to improve application uniformity when applying liquid manure in surface-gravity irrigation systems	Operational cost, logistics, training, technology
39	Use quick-test methods to monitor dairy lagoon water N content immediately before and during application, and adjust application rate accordingly	Operational costs, training, technology
40	Calibrate solid manure and compost spreaders	Operational cost, logistics, training
Promote Overall Healthier Soil		
41	Promote healthy soil to augment water and nutrient holding capacity and reduce nutrient loss[1]	Time and knowledge required to integrate organic amendments and other healthy soil promotion (e.g., reduced tillage) into cropping system.

[1]Presumably beneficial to N management primarily by promoting more uniform crop growth and N uptake across the field.

5.3.2.2 Additional Practices to Address COC's

Additional practices to address transport of COC's to groundwater include appropriate irrigation well maintenance and destruction of abandoned wells. As discussed previously, unsealed wells or abandoned wells may provide a direct conduit of surface level constituents to groundwater. This may be evidenced by the presence of currently un-used, highly labile pesticides in groundwater. The KBWQA will continue to work with growers to direct them to county resources for appropriate well destructions in the case of

abandonment. Additionally the KBWQA will provide information on proper well destruction at outreach events, and feedback from Farm Evaluations on well management.

Additionally, COC pesticides considered subject to the DPR's Groundwater Protection Program will be considered to be under the purview of the DPR's regulatory program.

5.3.2.3 Technically and Economically Feasible Practices

Protective practices advocated by the KBWQA to growers must be demonstrated to be to be technically and economically feasible for growers to implement. For example, practices which increase irrigation efficiency and nitrogen consumption may be economically advantageous to growers if barriers to adoption can be mitigated. The barriers to adoption for practices outlined in **Table 14** are a preliminary identification of the relative technical and economic feasibility of implementing the selected protective practices. **Appendix C: MPEP GQMP Management Practices** defines the methodology to address barriers to adoption, a revised excerpt is provided as follows.

"Barriers to adoption will be investigated by discussing individual practices with key resource persons, including growers and those who work closely with them (CCAs, Farm Advisors, and NRCS staff). Once a barrier is identified, means will be sought to lower this barrier to allow beneficial implementation of protective practices. Some examples of barriers and actions that may be taken to alleviate them include the following:

- *Outreach to supplement training and available information to growers or farmworkers*
- *Simplify complex practices or develop tools to manage complexity*
- *Promote efforts to offset costs of practices with high material resources needs through funding and volume pricing*
- *Produce workable alternatives when practices are ill adapted to certain types of operations or soil/topographic/management settings*
- *Practices will need to be fed back into field research performed by MPEP research partners"*

Site specific and operational conditions will require different combinations of management practices to protect groundwater quality. The success of the CGQMP is dependent on member growers tailoring the implementation of practices to site conditions. The KBWQA will continue to support grower efforts to implement protective practices through outreach and support in conjunction with the SSJV MPEP.

5.3.2.4 Practice Effectiveness and Limitations

The agricultural practices defined in **Table 14** have been demonstrated to improve nitrogen fertilizer crop consumption and, thereby minimizing deep percolation of nitrates. The relationship of these performance changes to underlying groundwater quality will be established by methods spelled out clearly in the MPEP Workplan. Site specific and regional analysis of cropping systems within the MPEP, long term groundwater monitoring, and the metrics defined in subsequent sections will validate effectiveness of protective practices.

5.3.3 Outreach Strategy

5.3.3.1 KBWQA General Outreach Approach

Since the establishment of the Coalition, the KBWQA has worked to support growers in meeting requirements of the ILRP. This includes the completion of required third-party reports and associated

research such as Annual Monitoring Reports, the GAR, the development of the SSJV MPEP Workplan, and the GQTM Workplan. The KBWQA has also worked diligently to develop a strong relationship of trust with growers through extensive outreach and hands-on support for required member reports. The KBWQA maintains office hours and an open door policy to serve and inform members, ensuring full engagement in the program.

KBWQA conducted numerous member outreach meetings to discuss the findings of the GAR and the development of the HVAs. This outreach provided growers with a foundational understanding of the extent of groundwater impacts from COCs. Outreach focusing on ongoing groundwater quality and trends will continue to be conducted as additional data are collected and interpreted.

The KBWQA also devoted significant effort in training growers and consultants in how to correctly complete Farm Evaluation Surveys and NMPs throughout 2015 and in early 2016. For example, during the spring 2016 reporting period, the KBWQA office assisted at least 250 members to complete their Farm Evaluation Surveys during one-on-one sessions. The remaining 850 growers completed their Farm Evaluations with assistance through phone calls, electronic communications, and mailings. The KBWQA also organizes and facilitates NMP self-certification training.

5.3.3.2 KBWQA CGQMP & SSJV MPEP Outreach Approach

Ongoing education will provide feedback on analysis of member surveys including relevant performance metrics (such as A/R and Farm Evaluations), and the findings of the SSJV MPEP regarding protective practices. The KBWQA will coordinate with the SSJV MPEP to define outreach curricula reflecting protective management practices throughout the CGQMP area. See **Appendix C: MPEP GQMP Management Practices** for additional description of the CGQMP & MPEP outreach strategy.

As discussed in the SSJV MPEP Workplan Section 2.4, "Outreach Approach", a multi-pronged effort will leverage current resources to reduce duplication of effort and to effectively support growers.

"The main themes of information that the SSJV MPEP will focus on include the following:

- *Early outreach to rapidly expand implementation of known, protective practices.*
- *Program and process information, explaining regulatory obligations and how to meet them, schedules, meetings, and where to find information on protective practices.*
- *Referrals to technical advisors who can assist growers in fitting suites of protective practices to growers' specific settings and needs.*
- *New and highly relevant information on protective practices and environmental performance, as it is collected and generated.*
- *Information from growers regarding crop selection, location, and management, mainly obtained through coalitions.*

Growers have historically obtained information to guide management decisions from a variety of sources, including the following:

- *Information from public-sector experts housed within UCCE, USDA-NRCS, United States Department of Agriculture Agricultural Research Service, CDFA, CSU Fresno, California Polytechnic State University San Luis Obispo, out-of-state cooperative extension services, irrigation and drainage districts, and occasionally other public agencies (e.g., county*

departments, DWR, California Departments of Fish and Wildlife and Pesticide Regulation, County Agricultural Commissioners, State and Regional Water Boards, Bureau of Reclamation, and the United States Geological Survey (USGS) and Fish and Wildlife Service.

- *Private-sector experts housed within commodities groups, Certified Crop Advisers (CCAs), Pest Control Advisers, private institutes (e.g., International Plant Nutrition Institute, Western Growers Association), input manufacturers and vendors, and production cooperatives.*
- *Social networks including other growers, friends, neighbors, and family members.*
- *Growers' experiential knowledge bases, which tend to be the most site-specific and best informed about field and management history.*

The formats of information exchange among growers vary widely, and include the following:

- *One-on-one, word of mouth, or written communication.*
- *Presentations at grower (often winter) meetings, technical workshops, and training sessions.*
- *Online tools and databases, including a Grower/Advisor Webpage, to promote and accelerate understanding and implementation of protective management practices.*
- *Targeted mailings to memberships of various groups.*
- *Online and printed newsletters, and online repositories of scientific literature, extension circulars, handbooks, soil surveys, and other references.*
- *GARs, trend monitoring programs, groundwater quality management plans, and annual reports produced by member coalitions.*
- *Surveys relating to growers' crop selections, practices, needs, and preferences (e.g., surveys conducted by coalitions to meet Farm Evaluation and Nitrogen Summary Report requirements of the General Order).*

… The success of outreach will therefore depend on prioritizing *practices that growers can use and that have potential to increase levels of groundwater quality protection, and on leveraging the broad range of existing outreach resources through collaboration and partnership."*

5.3.3.3 Outreach Activities and Tools

CGQMP outreach activities will include the efforts ongoing outreach programs conducted by partner groups (UCCE, USDA/NRCS, CSU, CDFA, and commodity groups), Central Valley coalitions, in coordination with the SSJV MPEP. This network of cooperating partners will assist in the development and delivery of CGQMP relevant curricula, resulting in the optimal use of resources. KBWQA outreach events will include presentations of applicable grower feedback, and early implementation curricula from the SSJV MPEP.

KBWQA growers currently participate in the many agricultural outreach programs conducted by CGQMP implementation partners, which provide growers information on protective practices. The SSJV MPEP will help to coordinate partner meetings where Information on protective practices will be provided The KBWQA will seek to document growers' participation in these events. The SSJV MPEP maintains a database of outreach and outreach-related activities. Events may be hosted by coalitions and/or cooperating partners. This allows the MPEP and member coalitions to track grower participation in

outreach activities. Additional description of these tools is provided in **Appendix C: MPEP GQMP Management Practices.**

A timetable for outreach events associated with the SSJV MPEP is provided in the Workplan master schedule (**Figure 23** and **Figure 24**). The SSJV MPEP Team will develop the outreach curricula pertaining to the initial inventory of management practices, including relevant meeting materials, videos, fliers, and online tools. Resources will be organized into a Grower/Advisor webpage to increase accessibility to coalition members and consultants.

Additional tools to support outreach are described in Sec 3.11 of the SSJV MPEP Workplan.

- Helpful information for growers and their advisors to efficiently derive maximum benefit from required Nitrogen Management Planning processes can be provided.
- Tools to facilitate second-language growers to understand and comply with LTILRP requirements and derive maximum water quality and production advantages.
- Query-able management practice databases to assist growers in evaluating the potential cost and benefits (production, water quality, labor) benefits of various suites of management practices, applied at their specific management block locations and planting dates.

The KBWQA considers grower outreach and education to be a critical component of the ILRP. As required by the General Order, outreach products and activities will be summarized and reported to the CVRWQCB annually as part of the Groundwater Quality Management Report and Annual Monitoring Report.

5.3.4 Management Practices Implementation Schedule

Many of the practices listed in **Table 14** are currently implemented by growers to minimize fertilizer loss and maximize irrigation water application efficiency. Currently, the Farm Evaluation Survey tracks the implementation of nitrogen efficiency, irrigation efficiency, and sediment and erosion control practices. Seventeen of the practices described by Dzurella et al., (2012) are included in the Farm Evaluation Surveys. The initial Farm Evaluation Surveys were completed by members in the CGQMP area during spring 2016. Analysis of the Farm Evaluation Surveys will provide a management practice baseline for KBWQA members throughout HVAs.

5.3.4.1 Timetable to Identify & Implement Management Practices

An initial identification of protective practices for the early outreach component of the SSJV MPEP is currently under development to inform fall 2016 – winter 2017 grower choices. Additional practices will be evaluated throughout the timeline of the MPEP Workplan. The SSJV MPEP Workplan master schedule provides a timetable for program milestones (**Figure 23** and **Figure 24**).

The outline below specifies the sequence of KBWQA activities and deliverables for implementation of the CGQMP.

- Year 1 (2016)
    - Define baseline of protective practices currently implemented throughout the HVA and high priority areas. Develop summary statistics by soil, crop, and associated practices (March 2016 Farm Evaluations).

  - Coordinate with SSJV MPEP Team on research of known protective practices and schedule winter outreach curriculum.

- Year 2 (2017)
  - Begin tracking trends in the implementation of protective practices over time throughout the HVAs. Develop summary statistics by soil, crop, and associated practices (2016-2017 Farm Evaluations).
  - Define baseline analysis for reported nitrogen applied versus crop yield (A/Y), calculate nitrogen removed values for crops with available coefficients (to convert A/Y to A/R Ratios, see Sec 6.1.2.1). Develop summary statistics, box and whisker plots by soil, crop, and associated practices. Identify potential outliers in reported nitrogen use or practice implementation (March 2017 NMP Summary Report)
  - Provide feedback to growers on their NMP Summary Report data and Farm Evaluation Surveys relative to other growers within similar cropping systems. Initiate outreach to provide additional resources to growers demonstrated to be an outlier in member submission data.
  - SSJV MPEP Team begins investigation of prioritized crops and site conditions with ongoing refinement of SWAT modeling to evaluate effects of management practice application (See SSJV MPEP Workplan Schedule, **Figure 23** and **Figure 24**).
- Year 3 (2018)
  - Continue tracking trends and progress in implementation of protective practices over time throughout the HVA and high priority areas. Develop summary statistics by soil, crop, and associated practices (2016-2018 Farm Evaluations).
  - Begin tracking trends reported in A/Y ratios, calculate n removed for crops with available nitrogen removed coefficients to develop A/R ratios. Develop summary statistics, box and whisker plots by soil, crop, and associated practices. Identify potential outliers in reported nitrogen use or practice implementation. (2017 NMP Report)
  - Provide feedback to growers on their relative performance within similar cropping systems based on provided Nitrogen application data and on farm practices. Initiate outreach specific to outliers to provide additional resources to satisfy the requirements of the ILRP program.
  - Coordinate outreach and education to growers incorporating SSJV MPEP Team resources and findings of site specific modeling results demonstrating impact of implemented practices.
  - Integrate grower reported data as modeling parameter inputs for the SSJV MPEP to analyze landscape-level trends and demonstrate progress. Assess landscape level modeling alongside long term groundwater monitoring data.

The third year of CGQMP implementation can be considered the steady state of the CGQMP implementation. Member submittals, SSJV MPEP progress, and annual monitoring continue to inform CGQMP implementation and support grower outreach efforts. Progress in implementing protective practices will be demonstrated by the findings of the SSJV MPEP and feedback provided by growers on the efficacy of outreach, described in **Section 6**.

5.3.5 Performance Goals

KBWQA will work to ensure enrolled HVA growers defined under this CGQMP provide member submittals as required in the timeline of the order. Successful completion of Farm Evaluation Surveys and NMP Summary Reports are a foundational indicator of performance. Grower participation in the ILRP Program is a demonstration of the success of the Coalition and an ongoing relationship with members.

Growers will be provided with feedback on their reporting with respect to trends over time and relative to other growers as soon as data are available. This feedback will be expanded to define the effectiveness of practices to mitigate COC's on varying site conditions as defined via the SSJV MPEP. The KBWQA will conduct specialized outreach to members that appear to be outliers with respect to nitrogen reporting and/or practice implementation.

Performance goals for the implementation of protective practices to limit deep percolation of nitrate are based on baselines of currently adopted protective practices. For example, in Section 3.6.3 of the SSJV MPEP Workplan, "Benchmark Existing Level of BMP Adoption":

"Another important MPEP objective is to provide a quantitative framework to predict how adoption of BMPs can reduce nitrate losses to groundwater. Achieving this objective will require characterizing the current N balances and net N surpluses for the most vulnerable regions, crops, and cropping systems (Section 3.6.2), as well as benchmarking the current degree of adoption of BMPs across the MPEP area. These benchmarks provide a baseline against which increases in BMP adoption levels can be evaluated for their impact on reducing nitrate losses using models and targeted field studies."

As mentioned previously, certain practices identified as protective are already included in Farm Evaluations. Additional protective practice implementation above the established baseline will be defined through the timetable of practice identification above (**Section 5.3.4.1**), including review of member submittals, SSJV MPEP findings, and scheduled monitoring. As additional protective management practices are identified by work completed by the SSJV MPEP and other independent studies. The KBWQA will work with growers to receive feedback on implementation progress.

Reported member data will also inform the SSJV MPEP demonstration of program performance. Management parameters will be included among model management parameters to assess landscape level performance changes over time, and MPEP modeling will demonstrate the influence on underlying groundwater. The following SSJV MPEP Workplan sections highlight this process.

"As these data become available, trends in implementation of protective practices can be characterized in greater detail and with greater accuracy. These characterizations will be combined with performance data to illustrate progress in protecting groundwater quality from degradation by irrigated agriculture. Results will be provided to coalitions for inclusion in annual reports, and included in MPEP deliverables, as appropriate (SSJV MPEP Workplan, 2016. Section 3.12 Assessing Adoption, Data Exchange with Coalitions, pg 3-69)."

"The Committee will document and demonstrate progress in protecting groundwater from nitrate emanating from irrigated agriculture. Once protective practices for specific irrigated lands settings (unique crop, soil, and management combinations) are identified and implemented under the MPEP, the increasing frequency of those practices on the landscape will be the main evidence of MPEP progress…

Assessment of landscape-level impact of program. This includes the following:

- *Development of a verification monitoring framework for landscape-level nitrate loading as a function of management and other factors.*
- *Refinements to the framework, including refined model inputs characterizing management and driving the landscape-level assessment of pre-MPEP and a series of post-MPEP conditions. These will be based on the following:*
    - *Comparisons with results of verification monitoring.*
    - *Results of management practice field monitoring and evaluation.*
- *Comparison of landscape-level performance trends over time.*

*Collaborative work with coalitions to assess the impact of changing performance on underlying groundwater. (*SSJV MPEP Workplan, 2016. Section 2.1.4 pg 2-4/2-5)*"*

The performance of the CGQMP strategy will also be assessed with respect to the effectiveness of KBWQA and SSJV MPEP outreach efforts in impacting grower decisions. Grower receptivity and comprehension to outreach topics will be assessed by taking sample groups of participating growers and surveying the benefit of outreach. Results will be employed to adjust and/or supplement outreach curricula and to follow up with participants. Performance will be evaluated by the proportion of members reporting improved understanding and reduced barriers to implementation as a result of outreach activities.

6 MONITORING METHODS

6.1 Measure Achievement of CGQMP Goals

The CGQMP's objective is to ensure progress to reducing impacts from COC's within the CGQMP area. Fulfillment of the CGQMP will be validated by the following reporting and monitoring.

6.1.1 Farm Evaluation Surveys

Farm Evaluation Surveys provide the KBWQA with information on grower practices that are protective of water quality. The KBWQA will summarize these practices in an annual CGQMP update. Farm Evaluation Surveys are required to be submitted to the KBWQA by March 1, 2016 for all farms in the HVA's, and by March 1, 2017 for all other farms.

Farm Evaluations also serve as education for growers, drawing attention to management practices that may not have been previously considered or evaluated. Management practice implementation will be tracked through Farm Evaluation Survey data from the first submission forward. As additional practices are defined as protective in the MPEP, components may be added to the surveys to determine the implementation of these practices.

6.1.2 Nitrogen Management Plans

The NMP template is to be completed by large growers in HVA's by March 1, 2016, and all small HVA growers by March 1, 2017. The Nitrogen Summary Report, (reported from growers to the coalition) is required to be submitted by March 1, 2017 for all large HVA growers, and on or before March 1, 2018 for all small HVA growers. The KBWQA began an outreach and education program for growers in 2015 to provide information necessary to complete the NMP. The KBWQA also provided 3 opportunities for grower self-certification of NMPs. The KBWQA will continue to provide education and outreach to growers regarding the requirements of the NMP and NMP Summary Report.

The KBWQA considers the NMP Summary Report to be a critical component of the ILRP and the information provided will be summarized and submitted to the CVRWQCB annually as part of the Groundwater Quality Management Report and Annual Monitoring Report. Nitrogen Summary Reports provide nitrogen applied/crop yield information, from which nitrogen removed values will be calculated and shared back with growers. To evaluate the trends in nitrogen use reported in the NMP Summary Report, the KBWQA will report the ratio of applied nitrogen (A) to nitrogen removed (R), the A/R metric recommended by the SWRCB-AEP.

$$\frac{A}{R} = \frac{Nitrogen\ Applied}{(Nitrogen\ removed\ at\ harvest)+(Nitrogen\ sequestered\ in\ the\ permanent\ wood\ of\ perennial\ crops)}$$

Nitrogen summary data will help to guide outreach and education. Feedback about nitrogen use in the context of grower peers will allow growers to assess their own nitrogen use and make appropriate adjustments where needed. Additionally, NMP Summary Reports will aid the KBWQA in identifying nitrogen use trends.

6.1.2.1 Researched and Development of A/R Ratio Data

The Central Valley Water Quality Coalitions (excluding the California Rice Commission) convened a Nitrogen Management Plan Technical Advisory Workgroup (NMP TAWG) in March 2015 to develop guidelines to identify knowledge gaps that exist in the understanding of nitrogen removal values that are required in the annual NMP template and NMP Summary Report. The NMP TAWG consists of experts from the University of California, state and federal agencies such as the NRCS, and private industry. A "Crop Nitrogen Knowledge Gap Study Plan and Guidance Documents" report was submitted to the CVRWQCB on December 18, 2015 and a follow-up memo was submitted in response to CVRWQCB comments on February 19, 2016.

As a result, the Central Valley Coalitions submitted a request to the CVRWQCB on November 19, 2015 to report nitrogen applied and the ratio of nitrogen applied to yield (A/Y) in the annual NMP Summary Report template rather than A/R. This reporting option allows for more consistent and reliable data from growers because it only requires information that all growers already collect with no additional calculations based on uncertain nitrogen removal information.

$$\frac{A}{Y} = \frac{Nitrogen\ Applied}{Actual\ Yield}$$

The CV Coalitions have contracted with Dr. Daniel Geisseler, University of California Department of Land, Air, and Water Resources CE Nutrient Management Specialist, to develop yield-to-removal (Y-to-R) conversion calculations for 99% of the crops grown in the Central Valley. This work should address most of the knowledge gaps that were identified by the NMP TAWG, as described in the "Work Plan for Crop Nitrogen Knowledge Gap Study Plan and Guidance Documents" that was submitted by the CV Coalitions to the CVRWQCB on July 29, 2016. As Y-to-R conversions become available, the coalition will calculate A/R ratios from grower reported A/Y ratios. In addition to reporting A/R to the CVRWQCB, they will be shared with growers as feedback. The sequence of Dr. Geisseler's activities is as follows: posed by Dr. Daniel Geisseler on behalf of the Central Valley Water Quality Coalitions is as follows:

- Task 1: Development of Y-to-R conversions for the 17 crops in the CDFA FREP database;
- Task 2: Identification of crops not included in the CDFA database that are grown on major Central Valley acreage. Ultimately, this work will develop Y-to-R values for 99% of the crop acreage in the Central Valley (not including non-alfalfa hay and silage);
- Task 3: Development of Y-to-R conversions for the additional crops that are not currently in the CDFA FREP database; and,
- Task 4: Assessment of the quality of the data as well as a description of additional work that will be needed to develop usable Y-to-R conversions for 99% of the crops grown in the Central Valley.

6.2 Measure Effectiveness of CGQMP Practices

6.2.1 Monitoring Grower Trends

The cornerstone of the ILRP program is reconciling and tracking information provided in Farm Evaluations and Nitrogen Summary Reports. The Coalition will track this information over the long term to attempt to establish a relationship between implemented practices and reported nitrogen applications for similar site conditions. For individual growers this is feedback that enables them to review and/or demonstrate progress on an on-farm basis. On the Coalition scale these data will be analyzed further with respect to the MPEP and GQTMP.

6.2.2 SSJV MPEP Analysis

The SSJV MPEP anticipates using Coalition data to characterize the extent and locations of implemented practices. On the basis of these and other data characterizing crops, soils, climate, and management systems, performance will be assessed for all fields, and aggregated at a landscape scale (since this is the scale that influences groundwater quality). This assessment will occur along with priority investigations to define performance on specific sites. The modeled output will be employed to gauge the performance of implemented practices throughout the Coalition. The end product will be successively more refined versions of calibrated SWAT model output, along with analysis of the influence of land-surface conditions and activities on groundwater.

This process is described in Sec 3.10 of the SSJV MPEP Workplan, "Landscape-Level Performance Assessment."

"Because the interactions between water, soil, plants, nitrogen, and the atmosphere are very complex and highly variable over time and space, attempts to quantify nitrate fluxes require a modeling framework that simulates water and N balances across the soil-plant-water-atmosphere continuum. In addition, the modeling framework must also incorporate spatial factors to quantify nitrate fluxes at scales ranging from field to watershed. SWAT (Neitsch et al., 2009) is a modeling framework that integrates crop production and physical data, producing output for the entire landscape, but specific down to relatively small spatial units of analysis (field or sub-field). For these and other reasons, SWAT has been selected as the central analysis tool to evaluate the influence of management practices on N losses and crop production. The use of SWAT does not, however, preclude use of other tools and models for focused investigations and to check SWAT results, as appropriate.

The landscape-level performance assessment will be conducted in three primary steps (Figure 2-2):

1. *Initial SWAT models will be developed to characterize the potential ranges of N loading based upon readily available information.*
2. *SWAT models will be refined by comparison with the results of field studies and benchmark N balance and N surplus data.*
3. *Updated SWAT models will be used to evaluate the effects of actual and hypothetical levels of BMP implementation across the MPEP area."*

6.2.3 Groundwater Quality Trend Monitoring Program

Long term groundwater monitoring data collection will be standardized through the KBWQA's Groundwater Quality Trend Monitoring **(GQTM)** Workplan, to be submitted in February 3, 2017. Data collected will define long term, regional groundwater quality trends. Groundwater quality trends will be evaluated over multiple years to account for the temporal lag in the effects of surface activities on groundwater quality.

The KBWQA is working to develop a groundwater monitoring network which will be implemented in high and low vulnerability areas, employing existing shallow wells. Well construction information was not available for existing wells, which were used to develop the GAR. This complicates determination of representativeness of shallow groundwater. However, legislation allowing public access to additional well construction information upon request from DWR has been enacted since the of GAR was completed. Well classification will be included with future updates to the GAR. The General Order requires annual groundwater monitoring of conductivity, pH, dissolved oxygen, temperature, and nitrate as nitrogen. Initial samples and those collected every five years thereafter will also be analyzed for total dissolved solids and general minerals analysis.

The MPEP will also rely on data acquired through the GQTM programs for regional analysis. Sec 3.9.1 "Goals and Objectives Pertaining to Groundwater" on the SSJV MPEP Workplan defines the specific overlap in the MPEP and the GQTMP objectives.

"The MPEP and GQTMP are very closely linked. Specifically, the MPEP supports the GQTMP by providing calculated constituent fluxes (e.g., volume and mass) through the vadose zone and into groundwater to assess ongoing impacts from agricultural operations, residual (vadose zone) impact, and legacy contamination issues. In turn, the monitoring data generated under the GQTMP supports the MPEP by providing feedback in the form of regional groundwater constituent concentrations to assess groundwater quality changes on a regional scale, and their response to changing management practices and other contributing factors.

Both programs include groundwater monitoring activities. The MPEP, as developed herein, will include monitoring of first-encountered groundwater at a few select sites, and will maximize use of existing wells to the greatest extent feasible (Section 3.8). It is expected that the emphasis of GQTMP monitoring will be on a mix of domestic, municipal, and agricultural water supply wells that do not target first-encountered groundwater."

6.3 Validate KBWQA Outreach Approach

Grower receptivity to, and comprehension of outreach will be assessed to refine outreach so that it can become increasingly effective in informing and affecting grower behavior, and in expanding implementation of protective practices that are suitable to each crop, soil, climate, and hydrographic setting. This work is expected to include surveys of growers at outreach events, and through the mail, to gauge and refine outreach. Surveys may include questions regarding:

- Historical changes in management practices which growers recognized as producing a significant change in operation (e.g. cost reductions, increased yields, efficiency, etc);
- Management practices implemented recently (e.g. those practices implemented in the last 12 months);

- Plans to adjust management practices in the future (e.g. those practices planned to be implemented in the next 12 months);
- Barriers to implementing management practices (e.g. logistical, conflicting interests, production, financial, etc.); and,
- Information and educational items that were useful for the grower in making informed management decisions.

7 Data Evaluation & Reporting

After implementation of NMPs, A/R ratios will be calculated and reported annually. They will also form a long-term data set for summary and interpretation. Results will be shared with growers through outreach events to educate members regarding their own practices in the context of their peers. This information will be included in the Management Plan Status Report for the review of the CVRWQCB.

Annually, the Management Plan Status Report will summarize results of the Farm Evaluation Survey and NMP Summary Report results, as required by the General Order. The results will be summarized in box and whisker plots and grouped by similar crop and soil types within townships (or larger areas if a township contains too few fields to provide meaningful context). Spatial mapping at a township level resolution will also be presented to assist in the analysis of implemented management practices. Grower reported data will be used as input parameters in the SSJV MPEP SWAT modeling to provide a landscape-level performance assessment, as it is affected by practices as they evolve over time.

The GQTMP, as required by the General Order, will be implemented to determine current groundwater quality conditions relevant to irrigated agriculture, and to develop long-term groundwater quality data that can be used to evaluate the regional effects of irrigated agriculture in high and low vulnerability areas. The GQTMP monitoring information will be determined and submitted to the CVRWQCB on or before February 3, 2017.

In each report, the KBWQA will select appropriate analyses and presentation (statistics, SWAT modeling, numerical modeling, index computation, graphical presentation, narrative, mapping, or some combination thereof) so that results can be understood.

8 DUTIES & RESPONSIBILITIES

Donald Ikemiya, PE is the Executive Director of the KBWQA and will be responsible for administering the Comprehensive Groundwater Quality Management Plan under the direction of the KBWQA Board. The KBWQA Board may change project administration duties from time to time.

Responsibilities of individuals managing, staffing and supporting the implementation of the CGQMP are outlined on **Figure 26**, The Comprehensive Groundwater Quality Management Plan Organizational Chart

Additional support is outlined in **Section 5.1** and **Section 5.3.1**. As discussed, The KBWQA has joined with six other coalitions to form the South San Joaquin Valley **(SSJV)** MPEP Committee, and hired a technical team (SSJV MPEP Team) to support CGQMP and MPEP implementation. An initial evaluation of potential KBWQA partners includes organizations and programs that have missions which prioritize implementation of effective nutrient and irrigation management. Although these organizations are well suited to working in conjunction with the KBWQA and the SSJV MPEP Team and have been actively involved in aspects of the ILRP, there have been no formal agreements to collaborate in implementation efforts. However, planning of joint and coordinated work with these technical partners is ongoing.

9 Conclusion

The KBWQA is committed to protecting water quality conditions throughout the Kaweah sub-watershed, particularly impacts from irrigated lands. Grower outreach and education will continue to be provided by the Coalition. Continued compliance with the General Order will strengthen the understanding of the water quality in the KBWQA area, and promote improved management practices.

The KBWQA will submit annual reports of groundwater quality conditions and irrigated agriculture activities. The KBWQA will continue to promote the transparent and trustworthy culture with its members, and intends to continue to use the active participation among growers for improved communication, and practice implementation and documentation to achieve KBWQA goals.

Figures

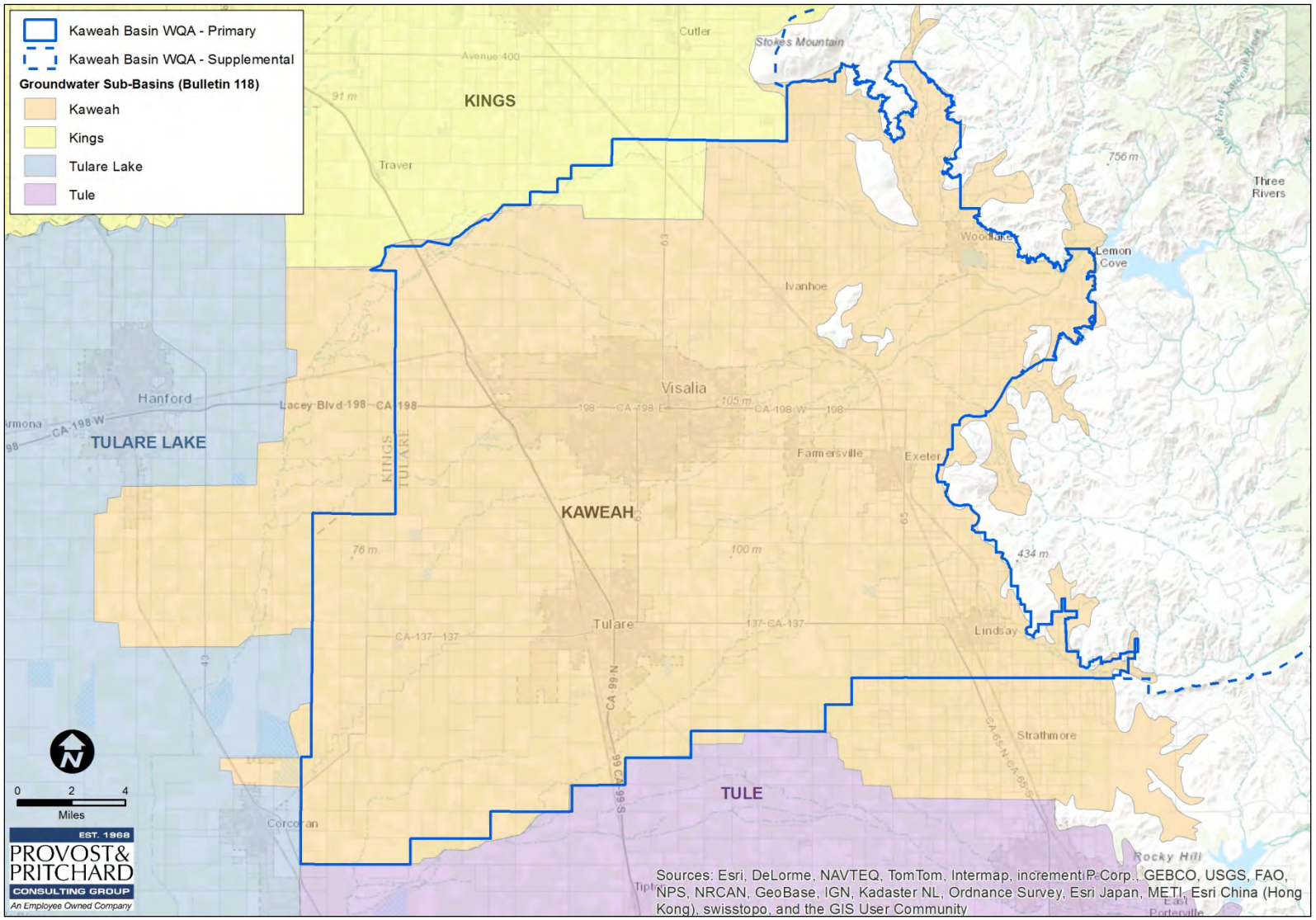


Figure 1. Groundwater Basins

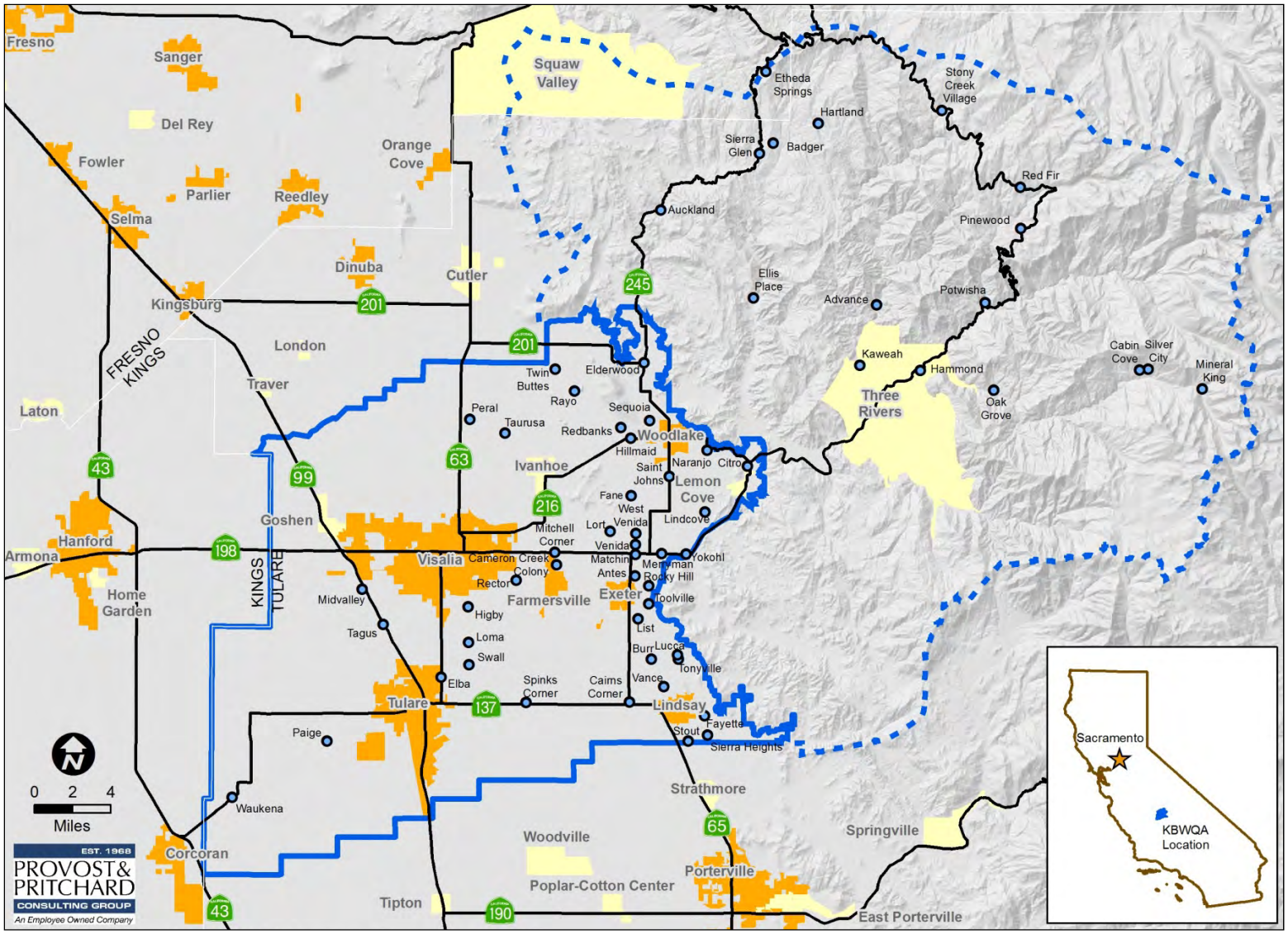


Figure 2. KBWQA Vicinity Map

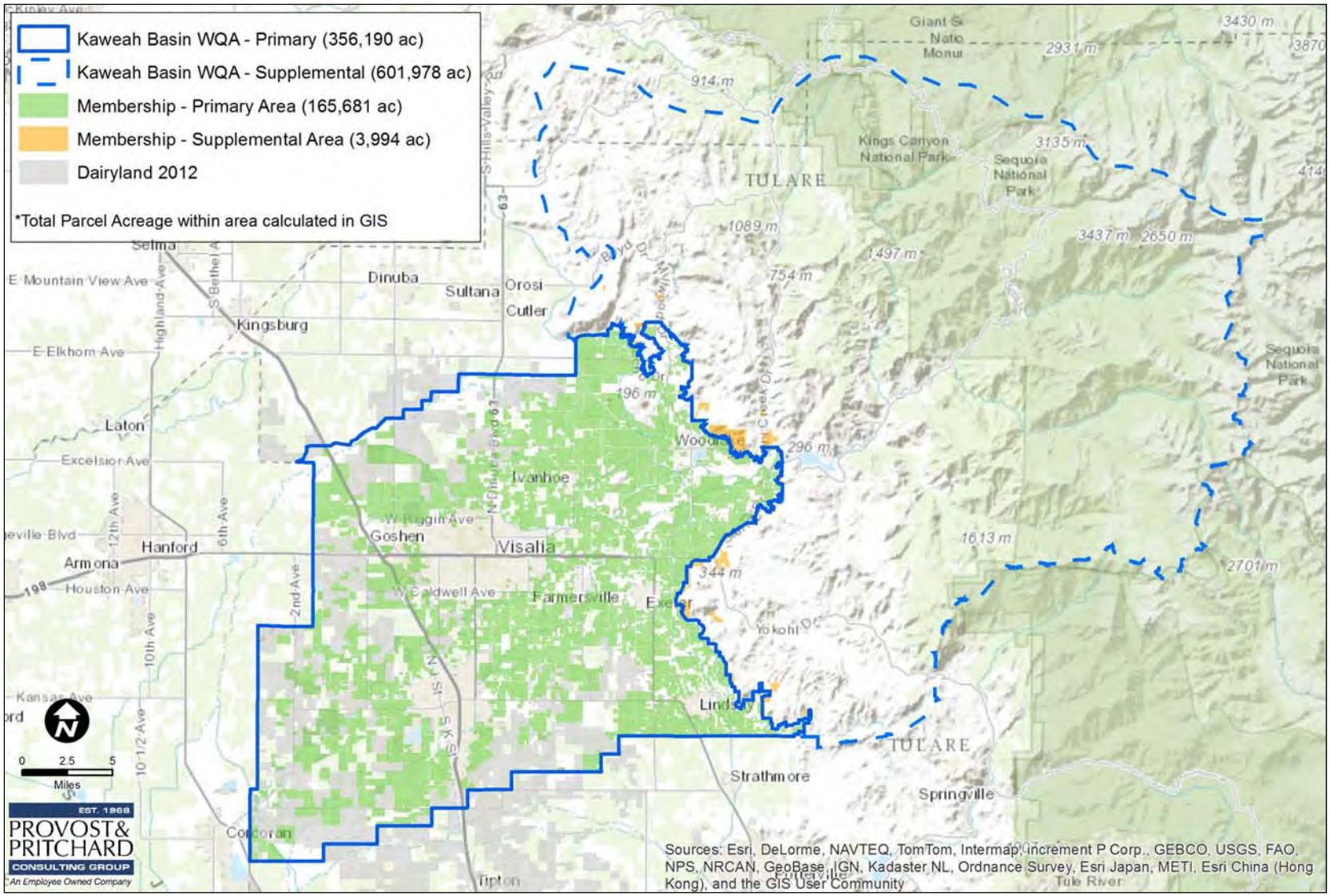


Figure 3. KBWQA Boundary Map

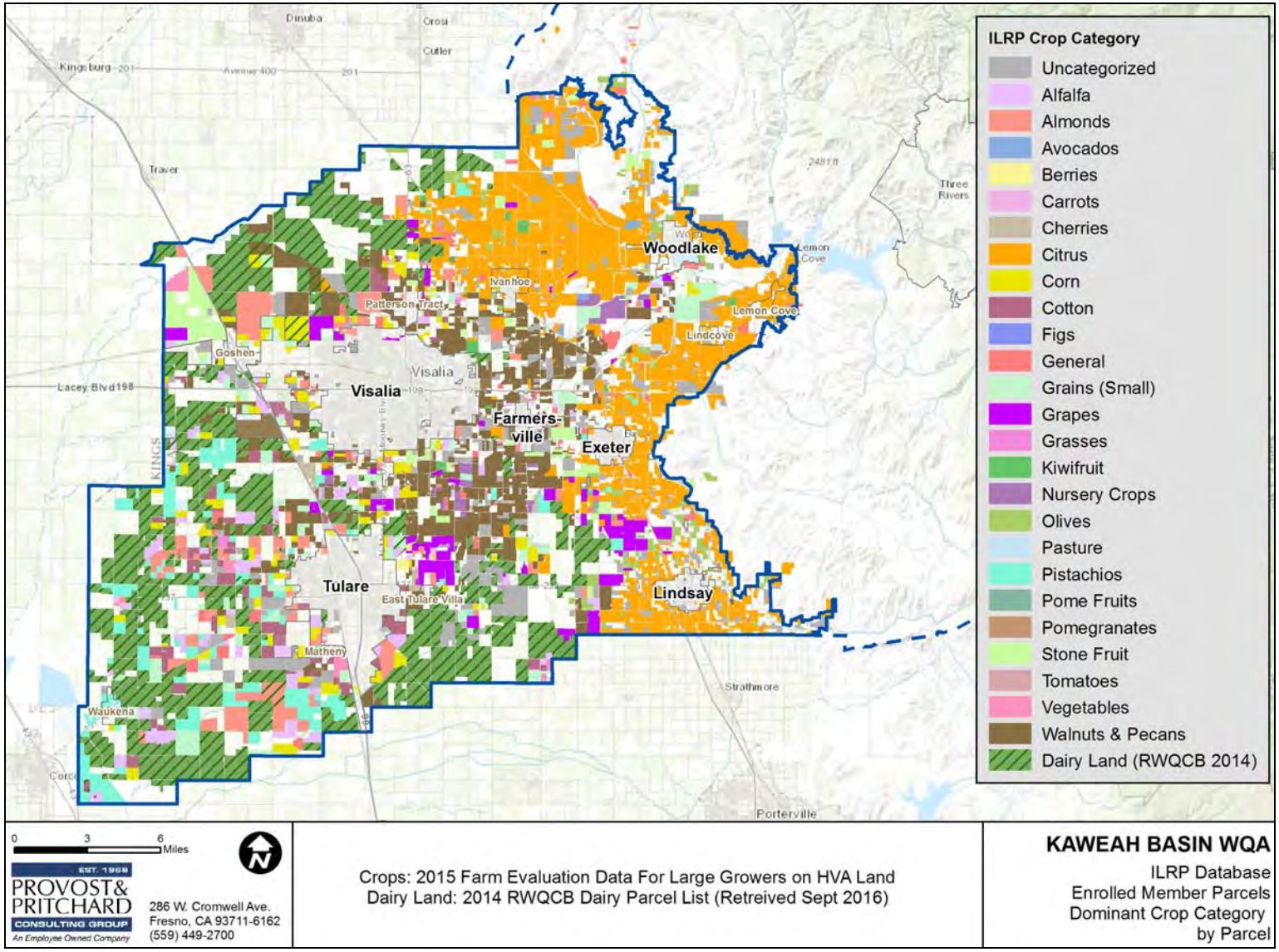


Figure 4. 2015 Crop Type

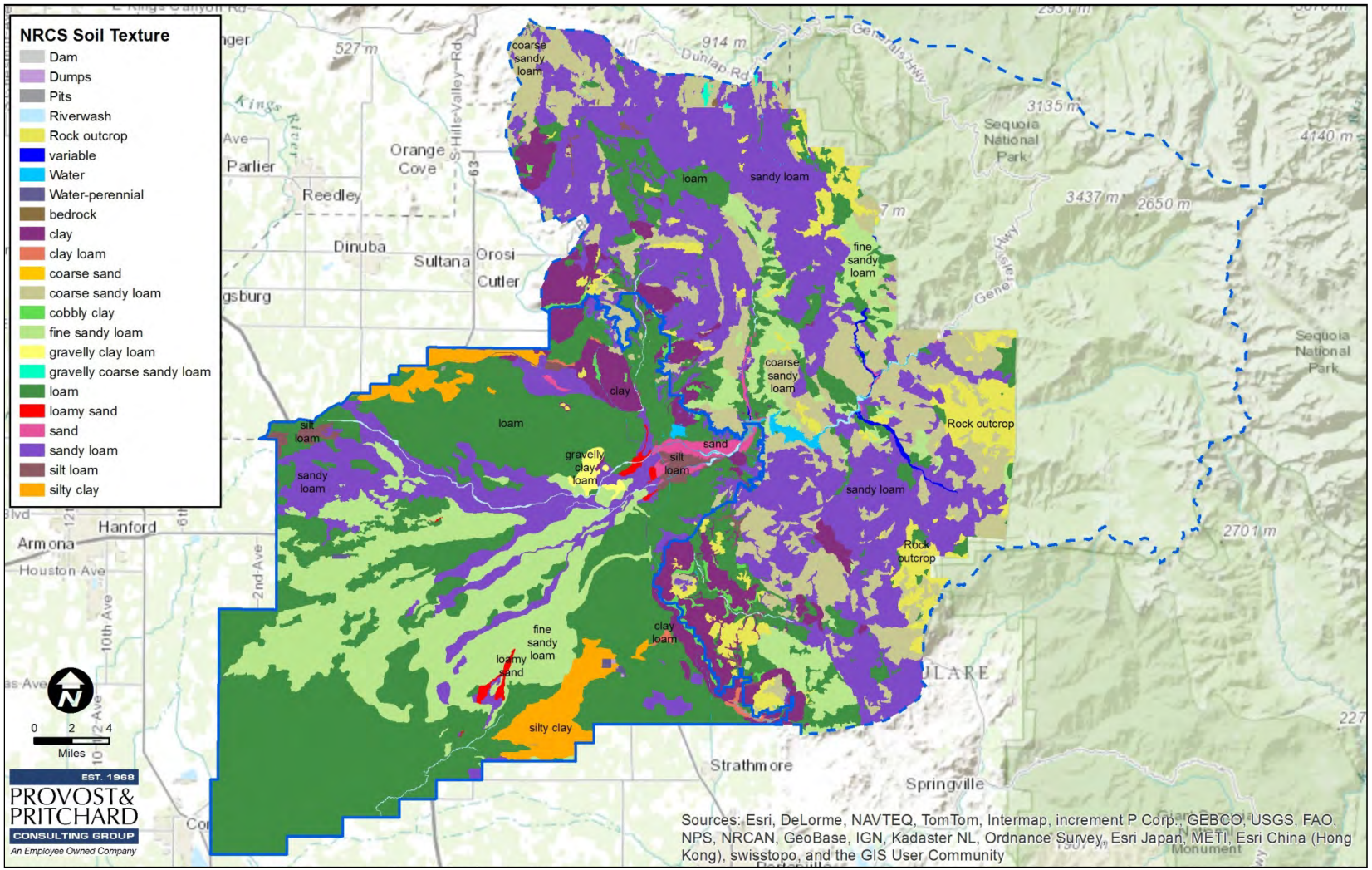


Figure 5. Soil Texture

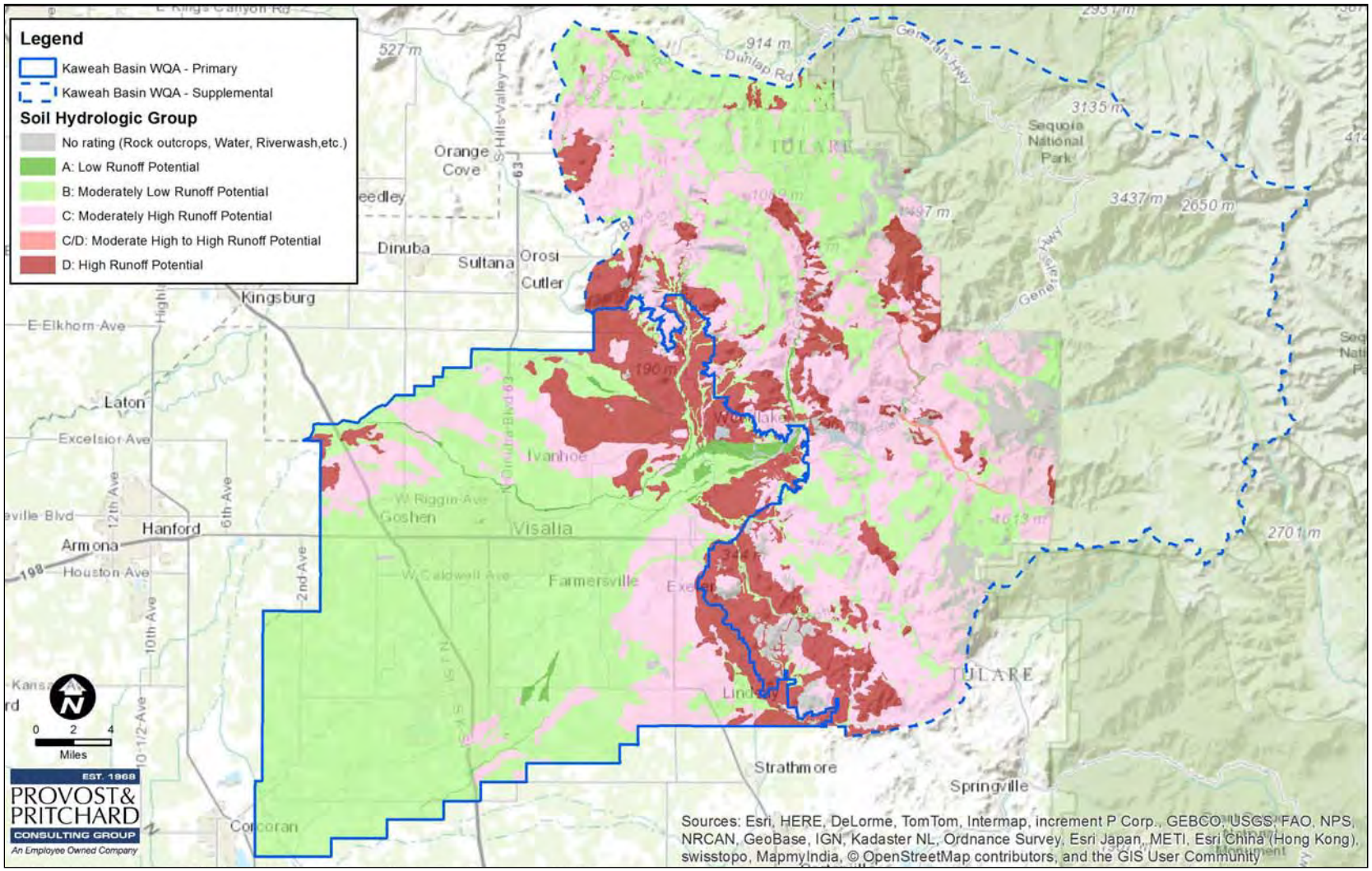


Figure 6. Runoff Potential

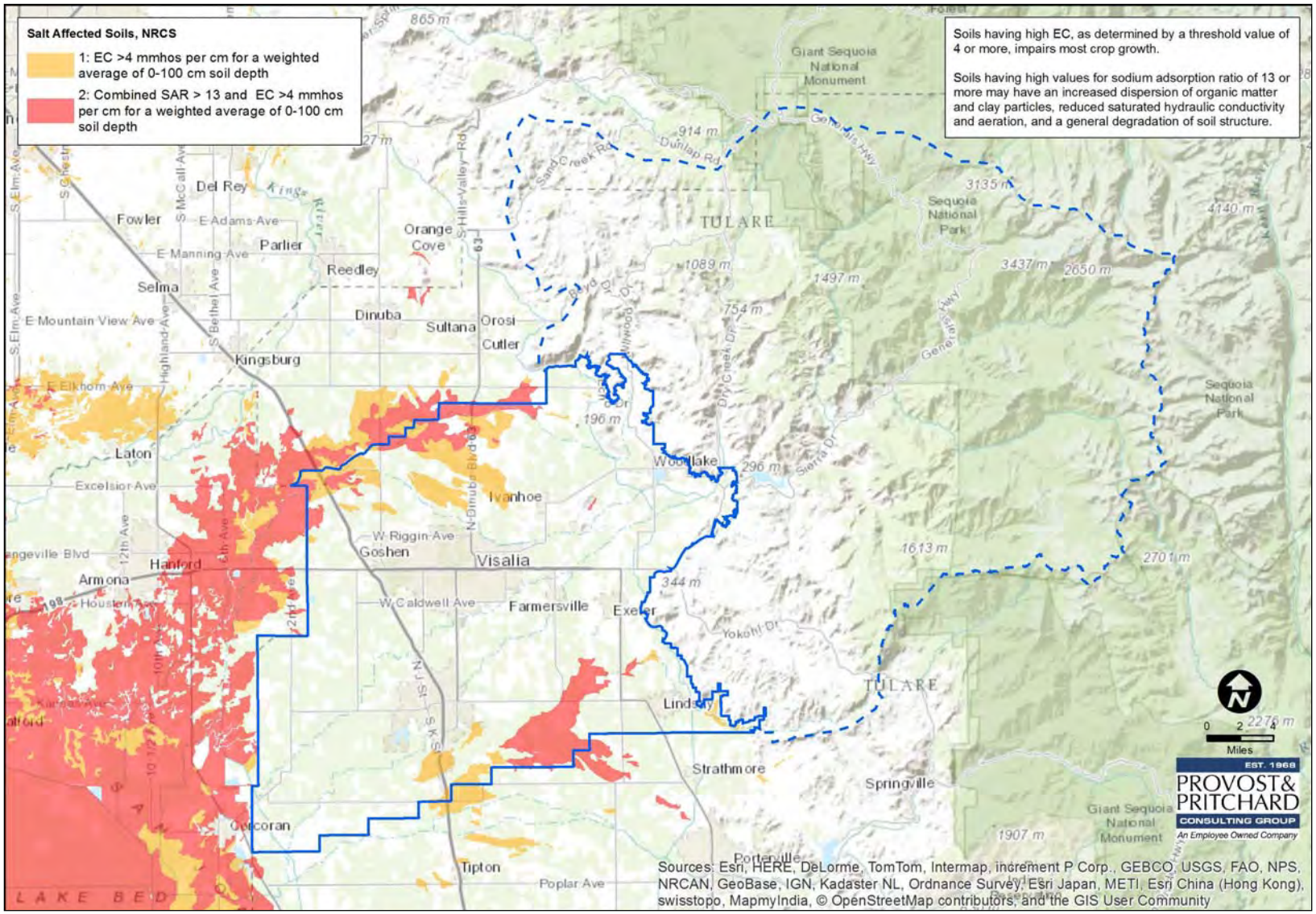


Figure 7. Soil Salinity

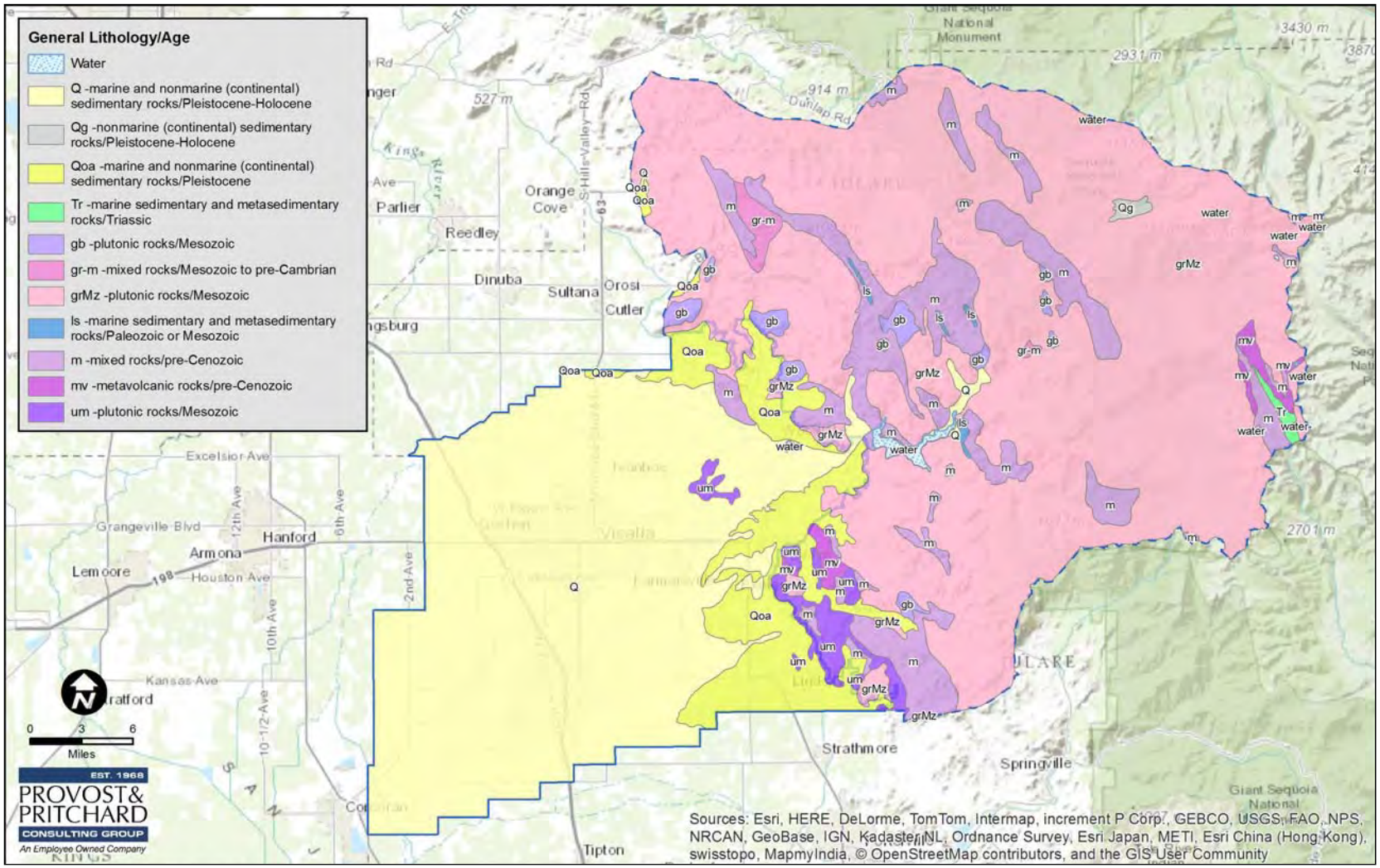


Figure 8. Geology Map

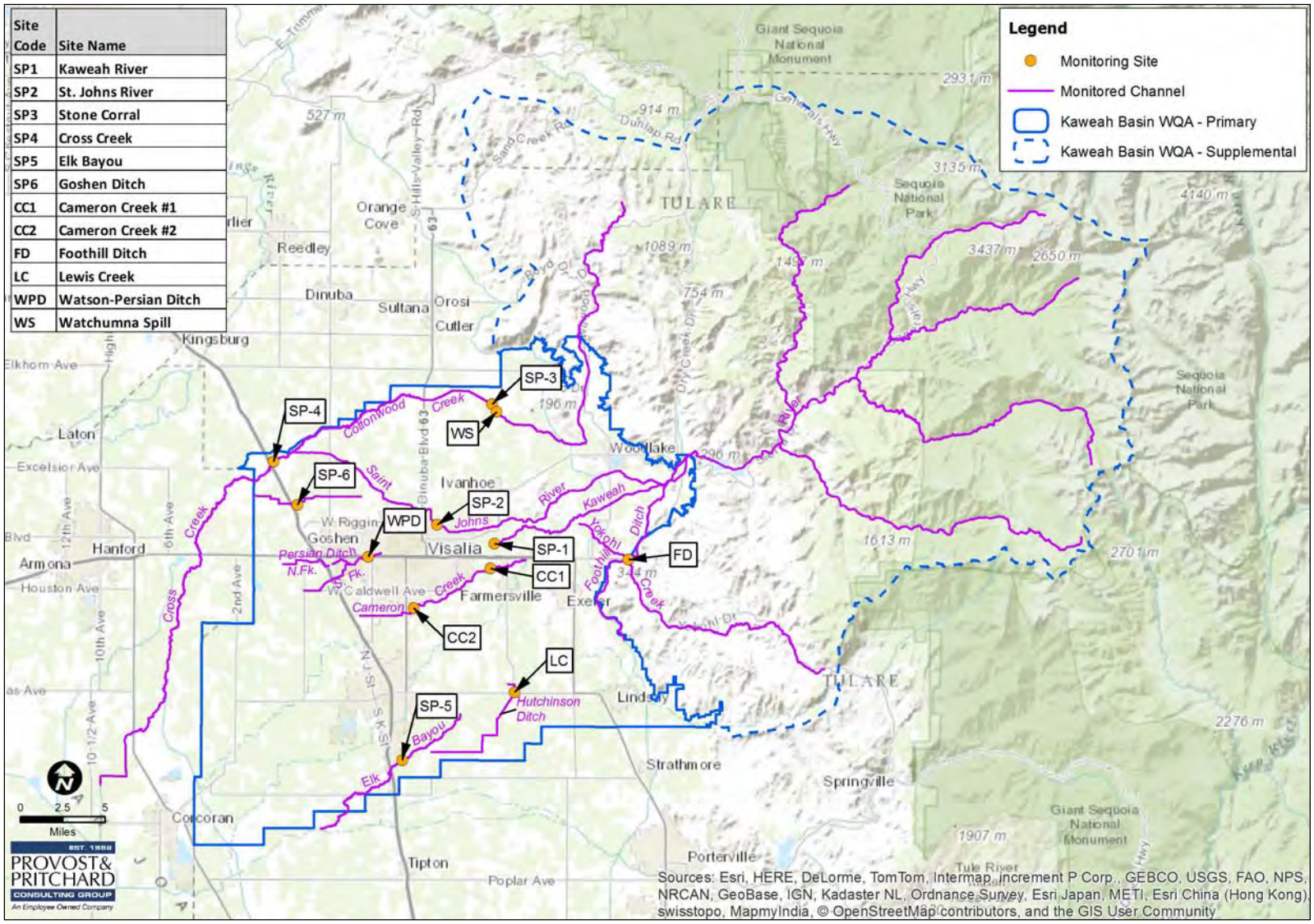


Figure 9. Surface Water Monitoring

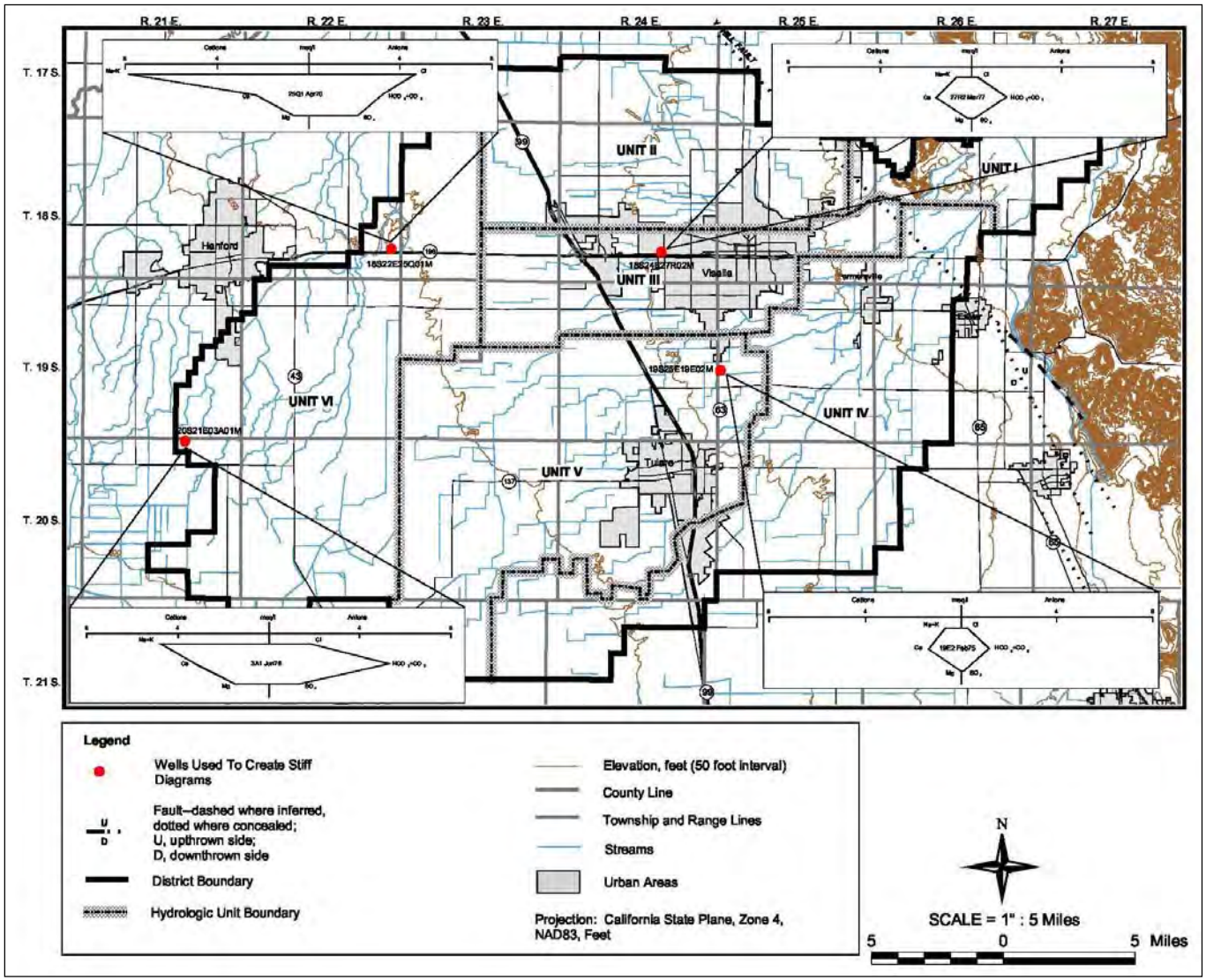


Figure 10. Fugro Stiff Diagrams

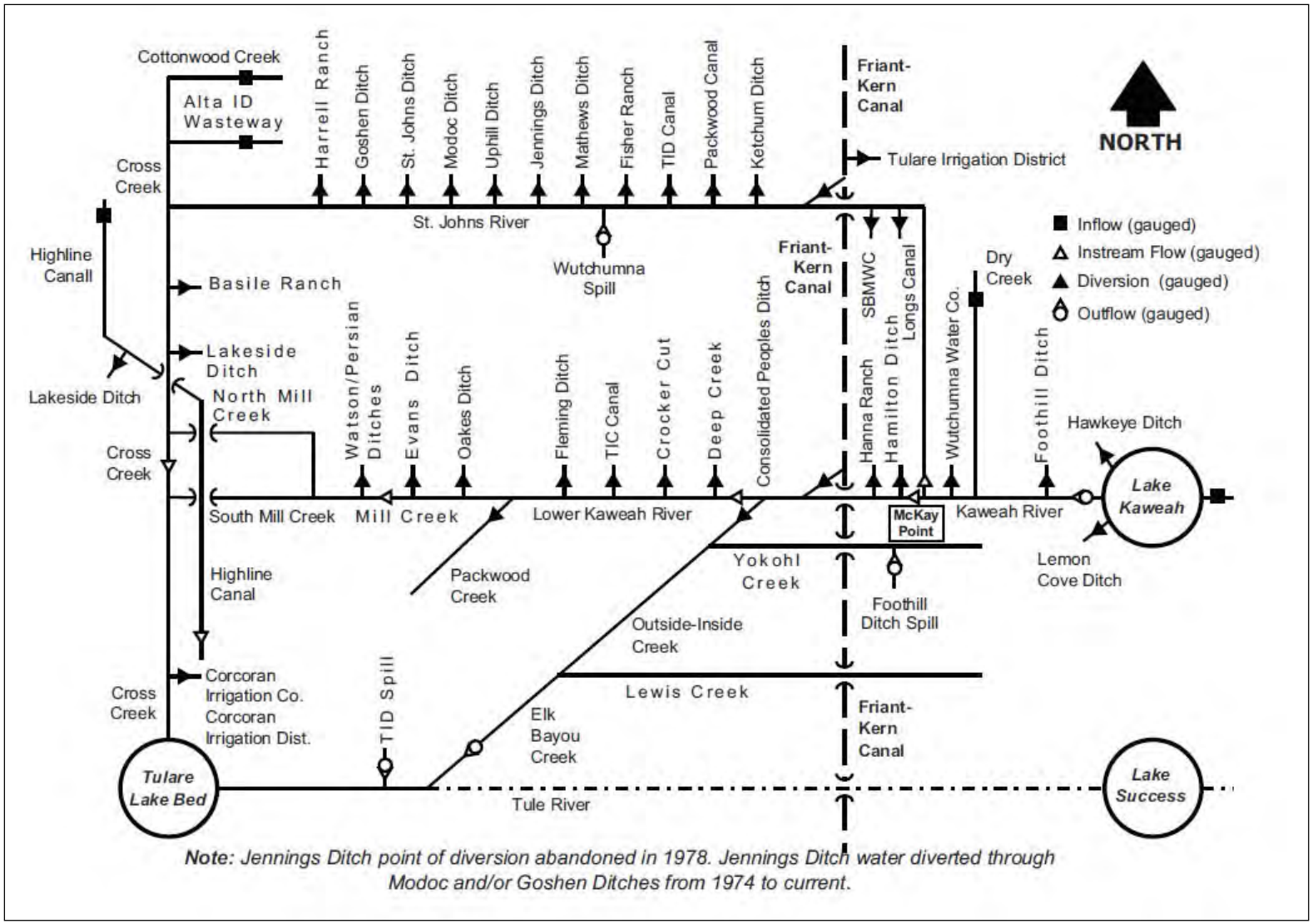


Figure 11. Kaweah River System Schematic

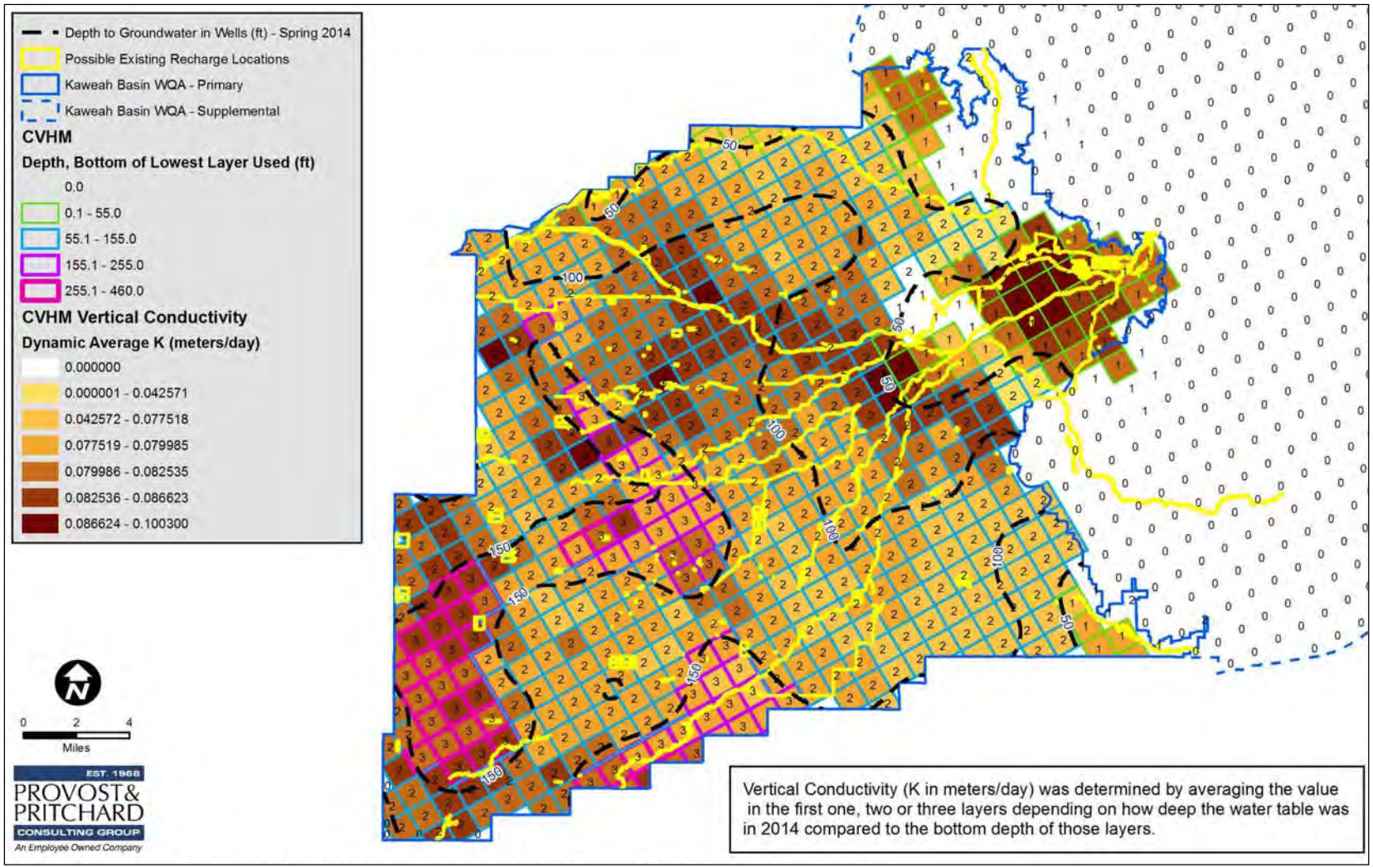


Figure 12. Vertical Conductivity and Potential Recharge Areas

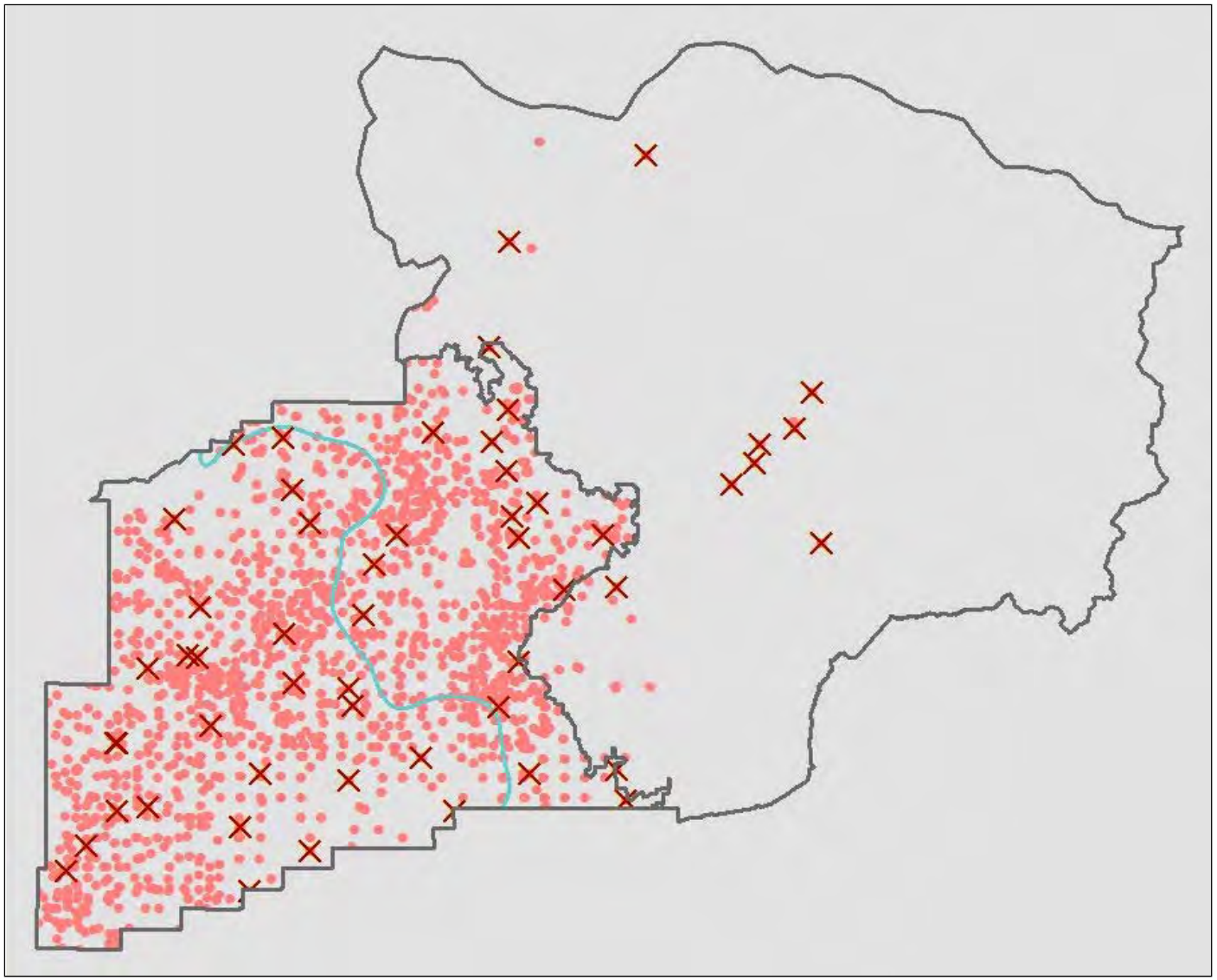


Figure 13. Irrigated Water Quality, East and West Division (NWIS)

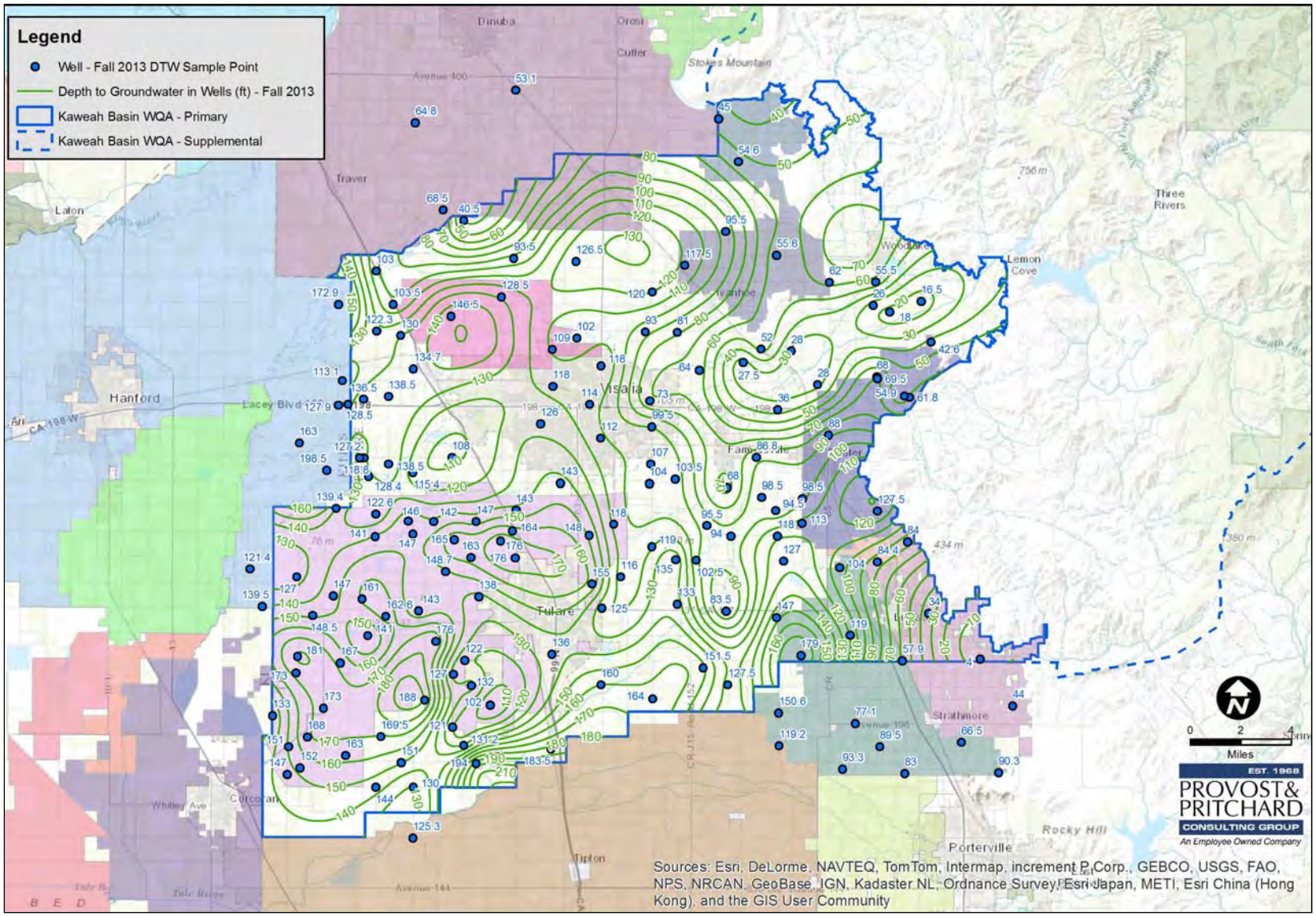


Figure 14. Fall 2013 - Depth to Water

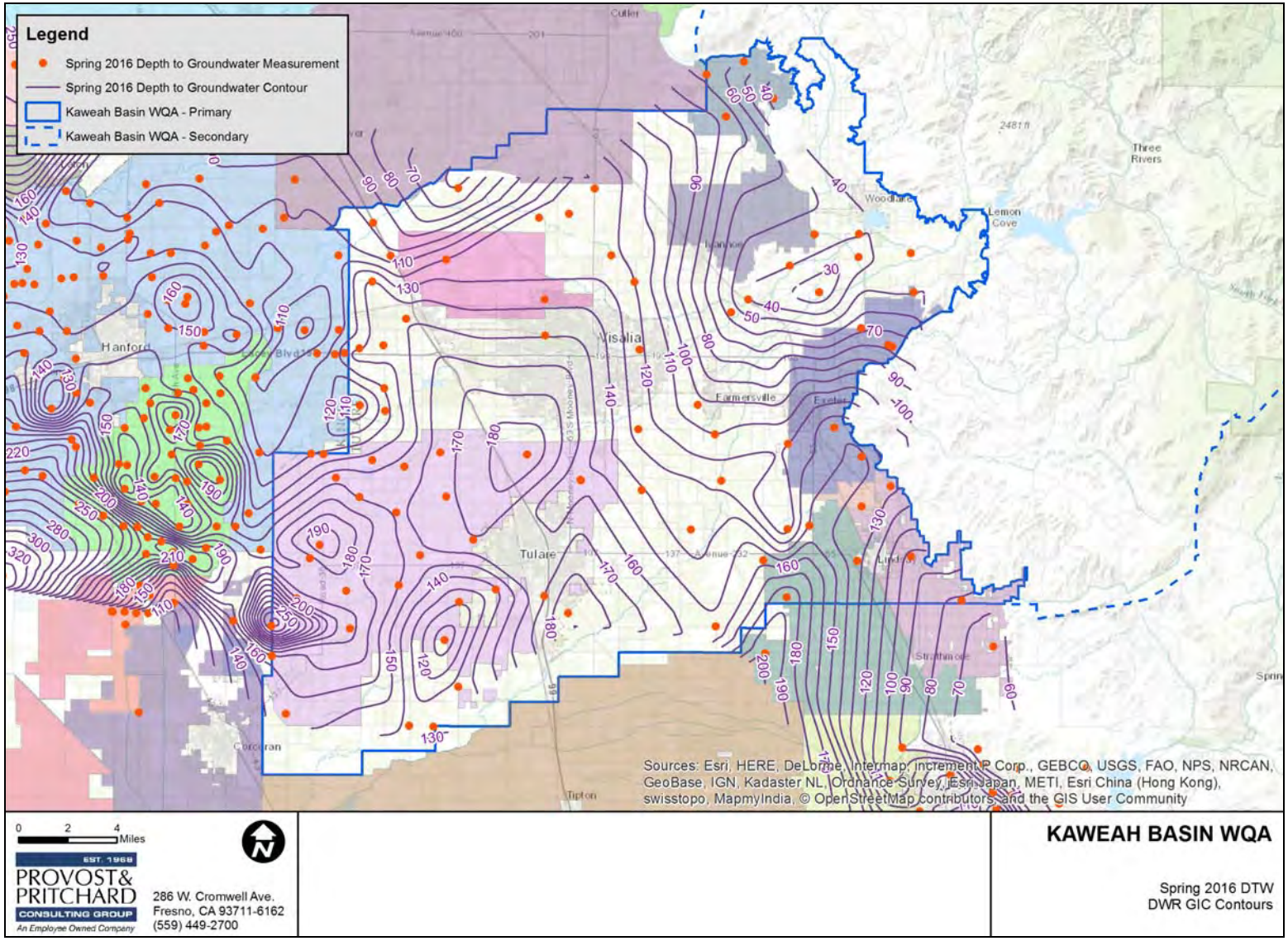


Figure 15. Spring 2016 - Depth to Water

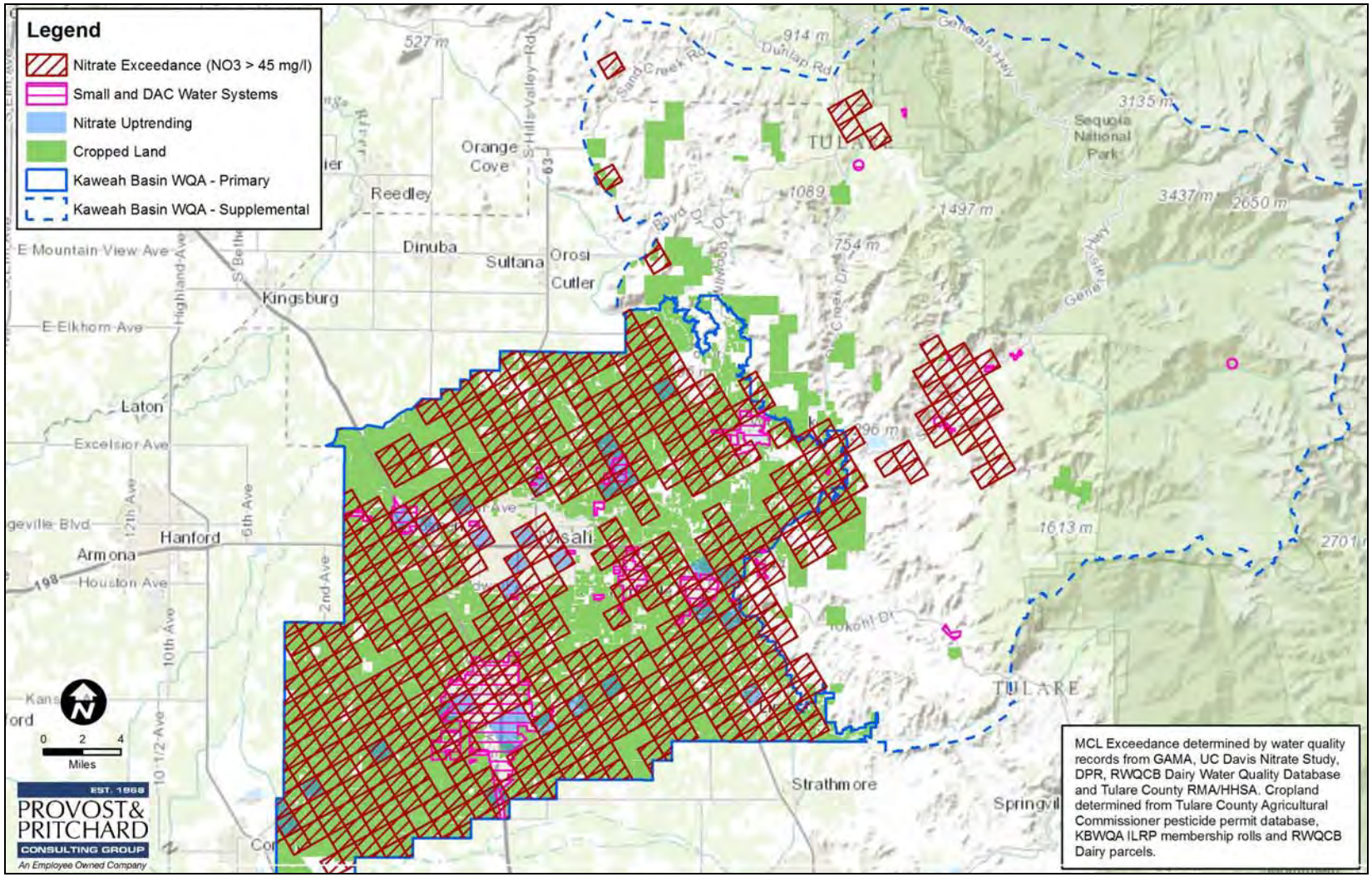


Figure 16. Nitrate Exceedance and Uptrending

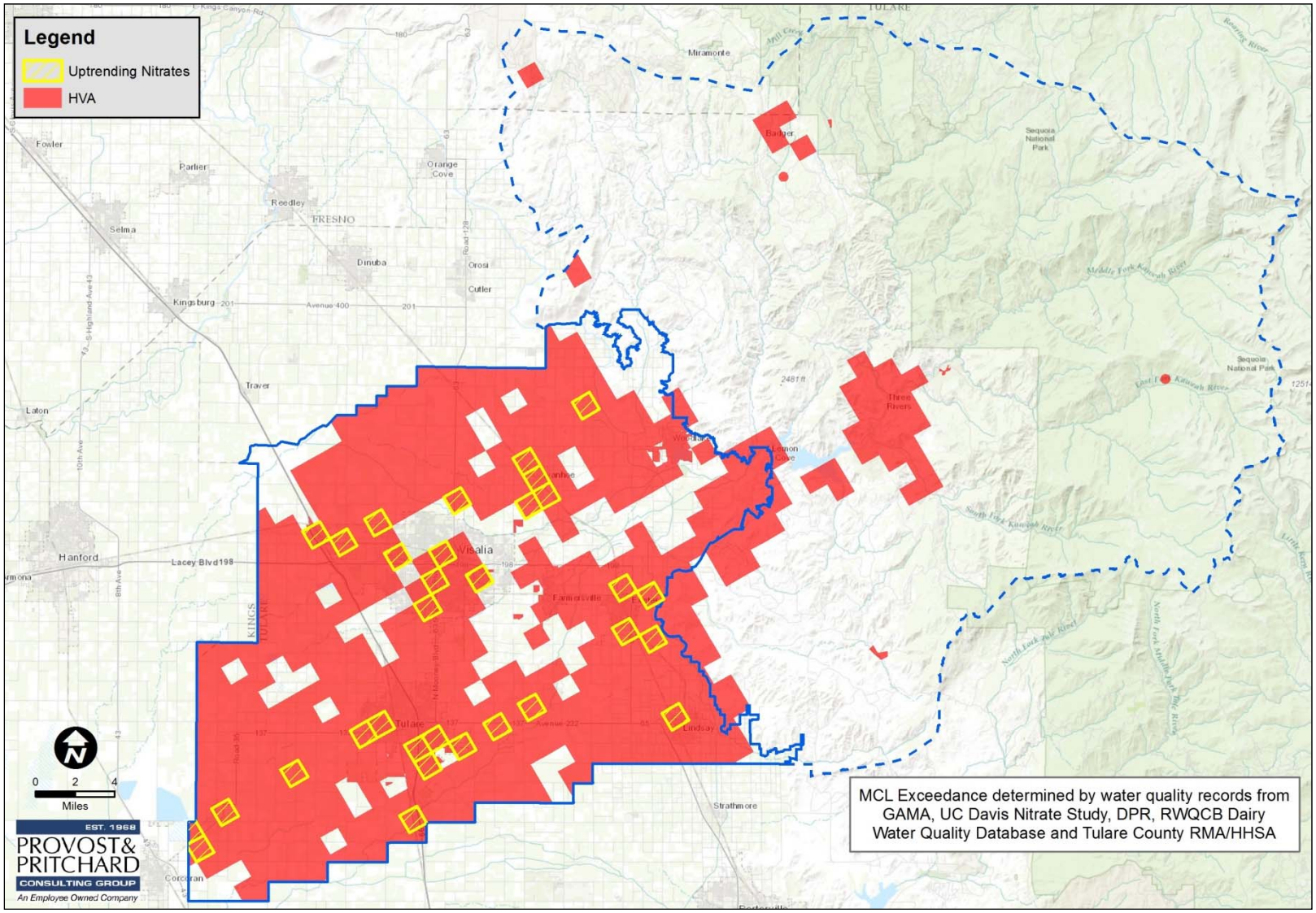


Figure 17. KBWQA Uptrending Nitrate

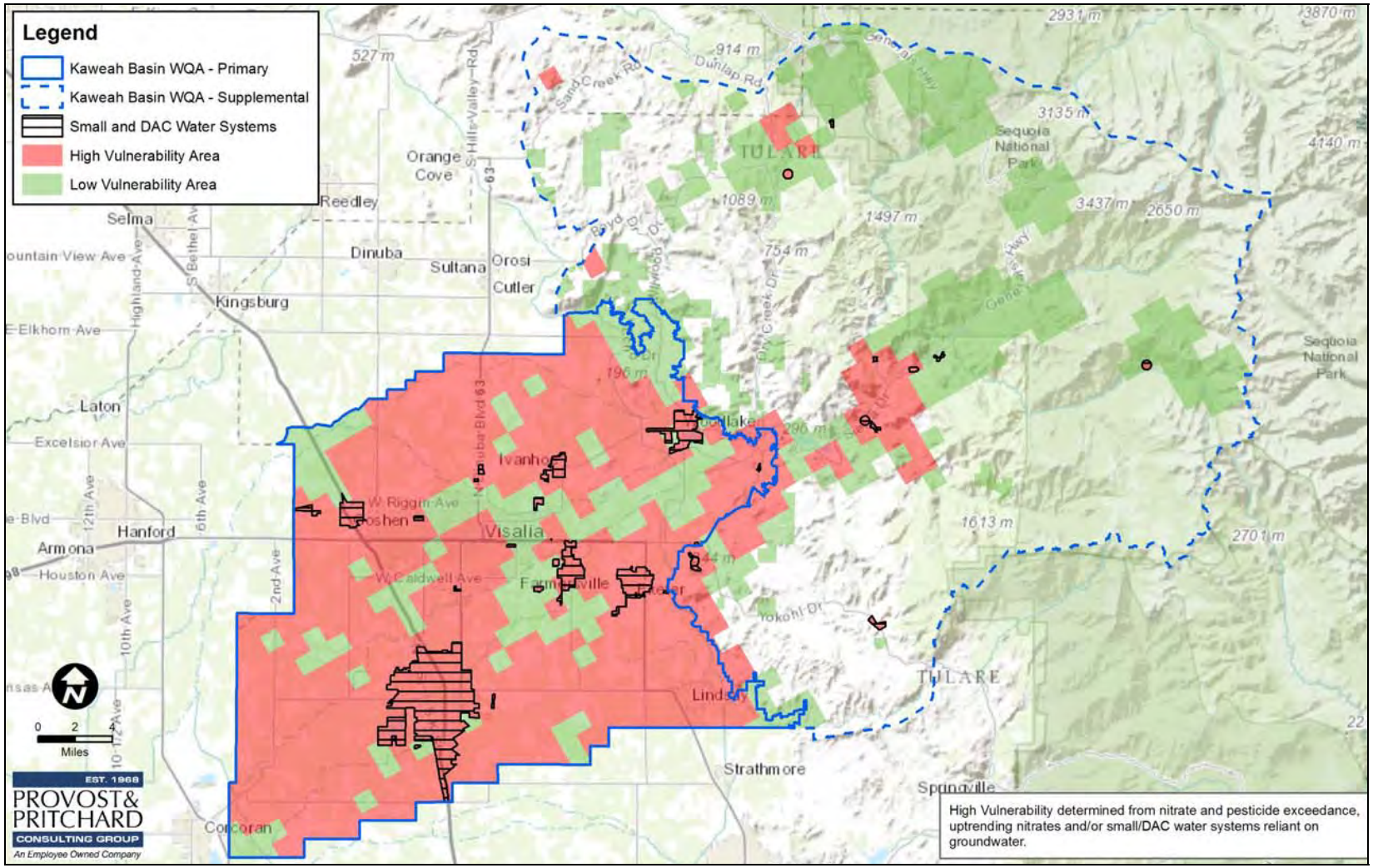


Figure 18. High Vulnerability Area

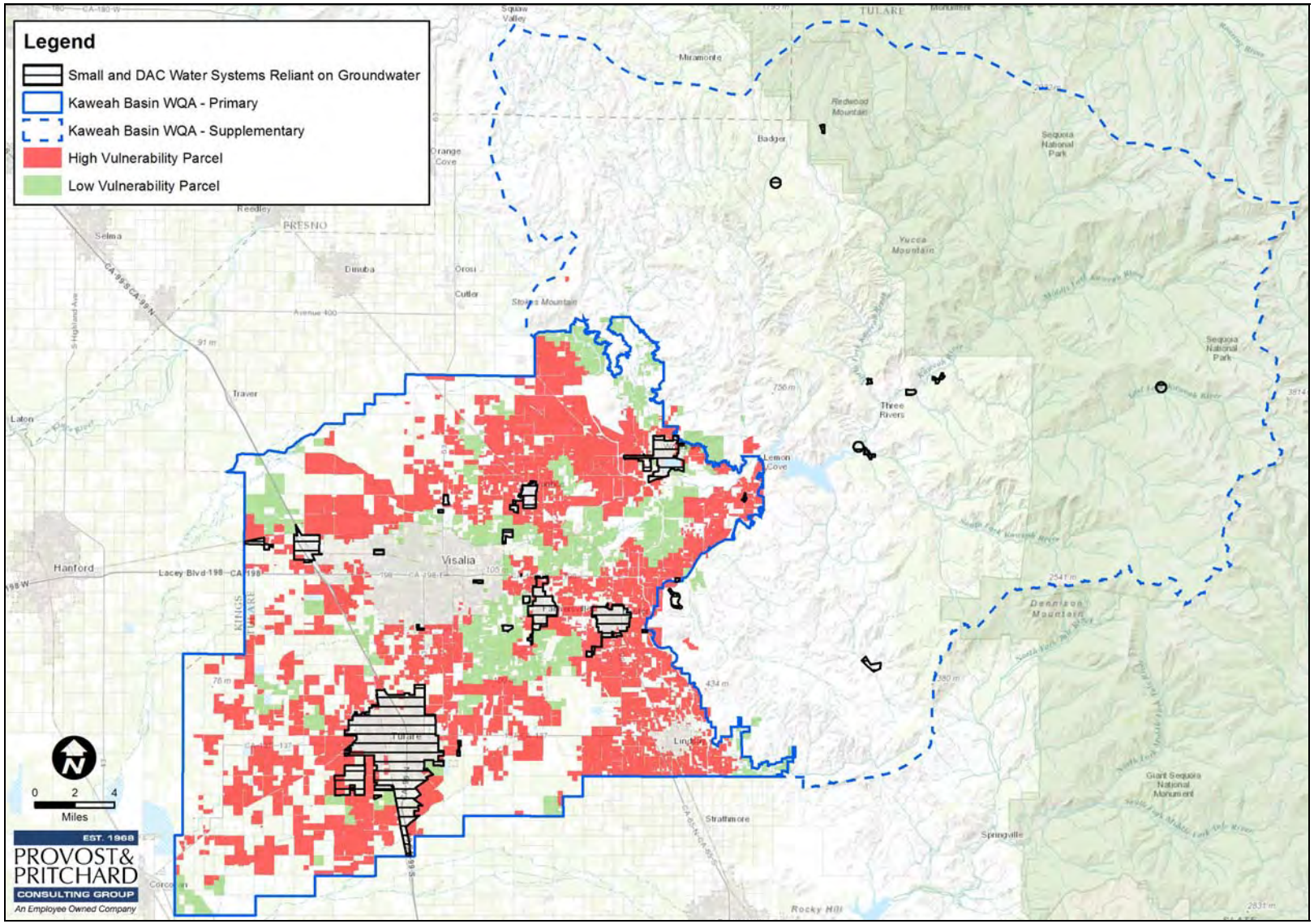


Figure 19. High Vulnerability Area - Membership Area

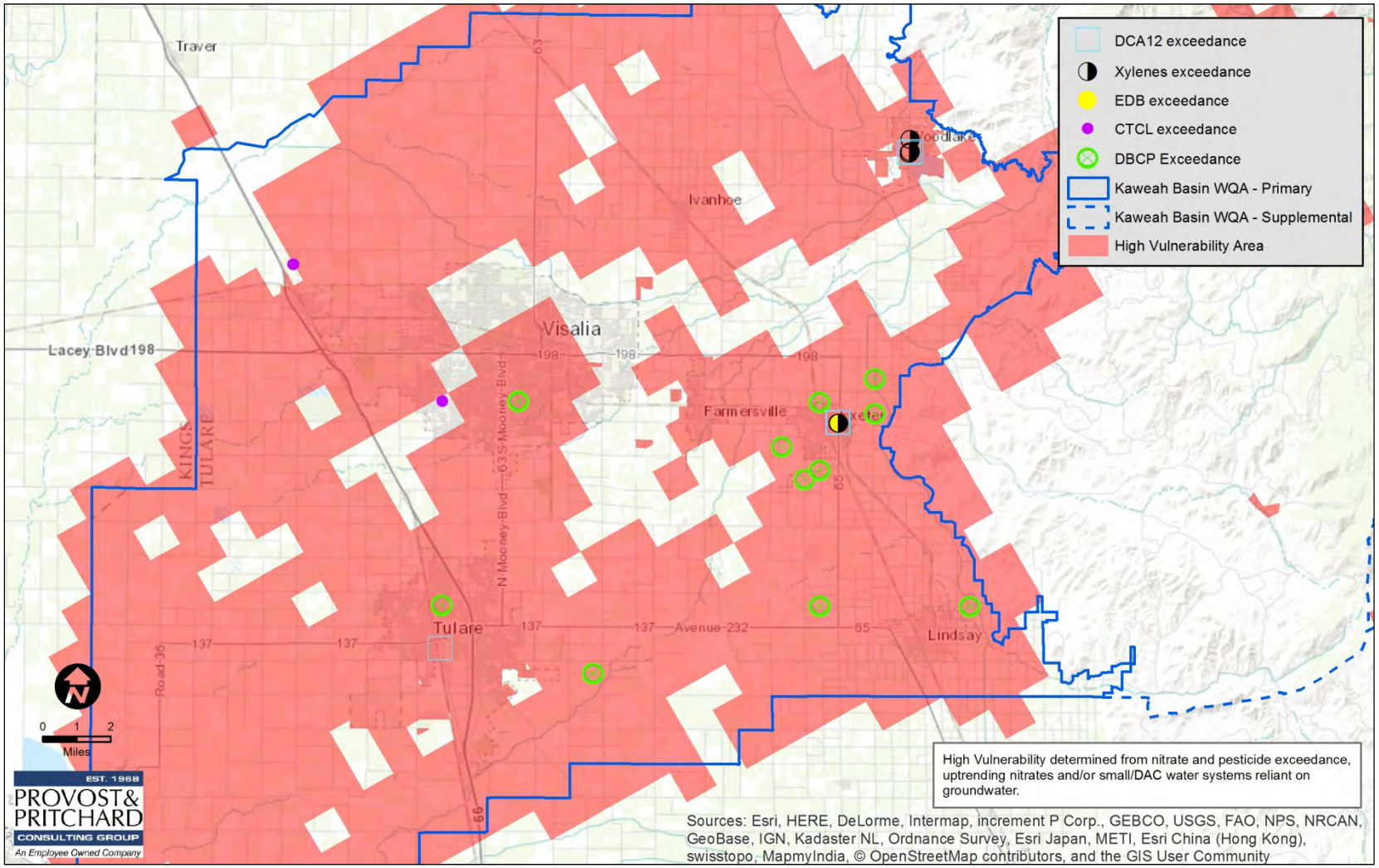


Figure 20. KBWQA Pesticide MCL Exceedances

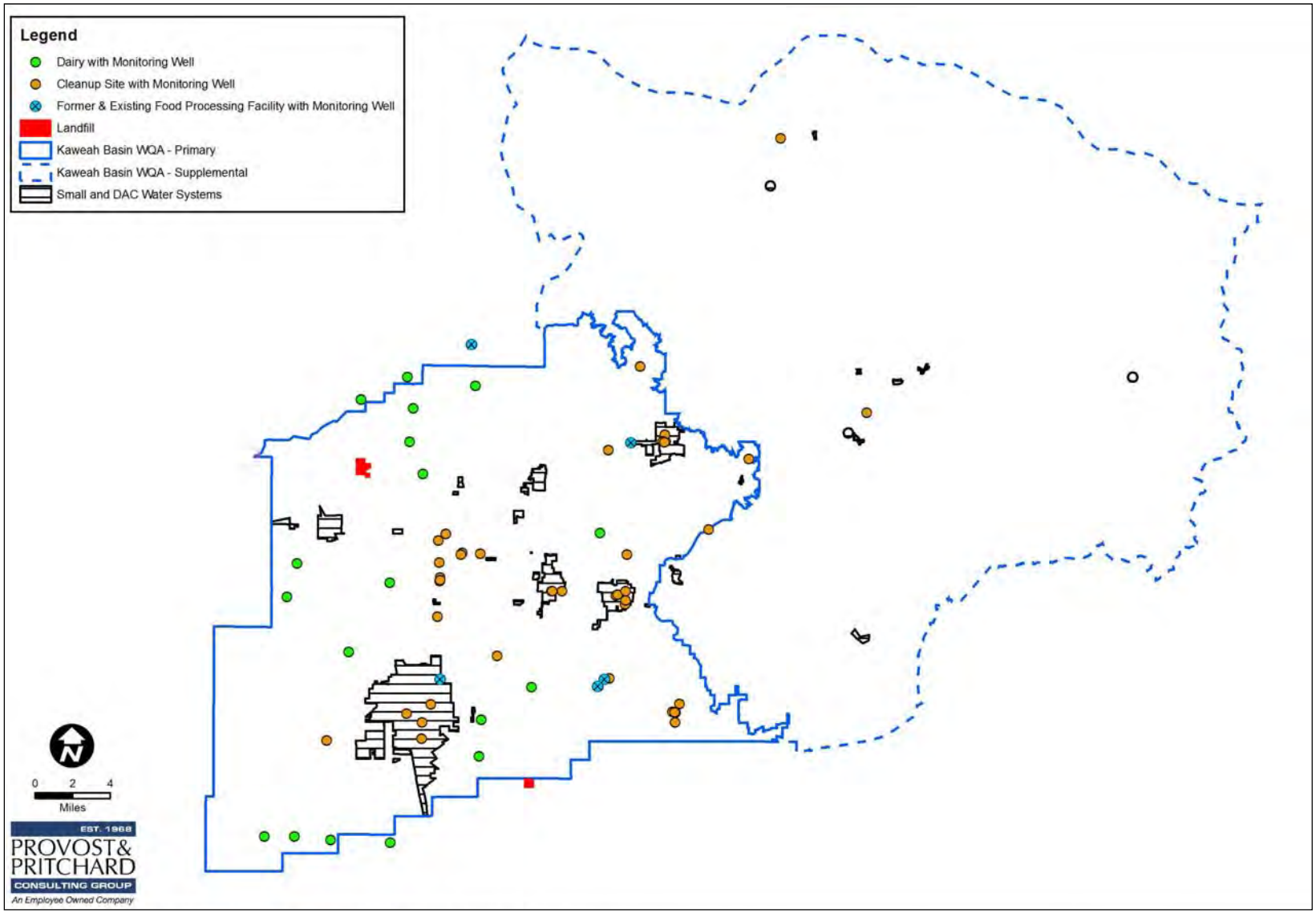


Figure 21. Monitored Dischargers

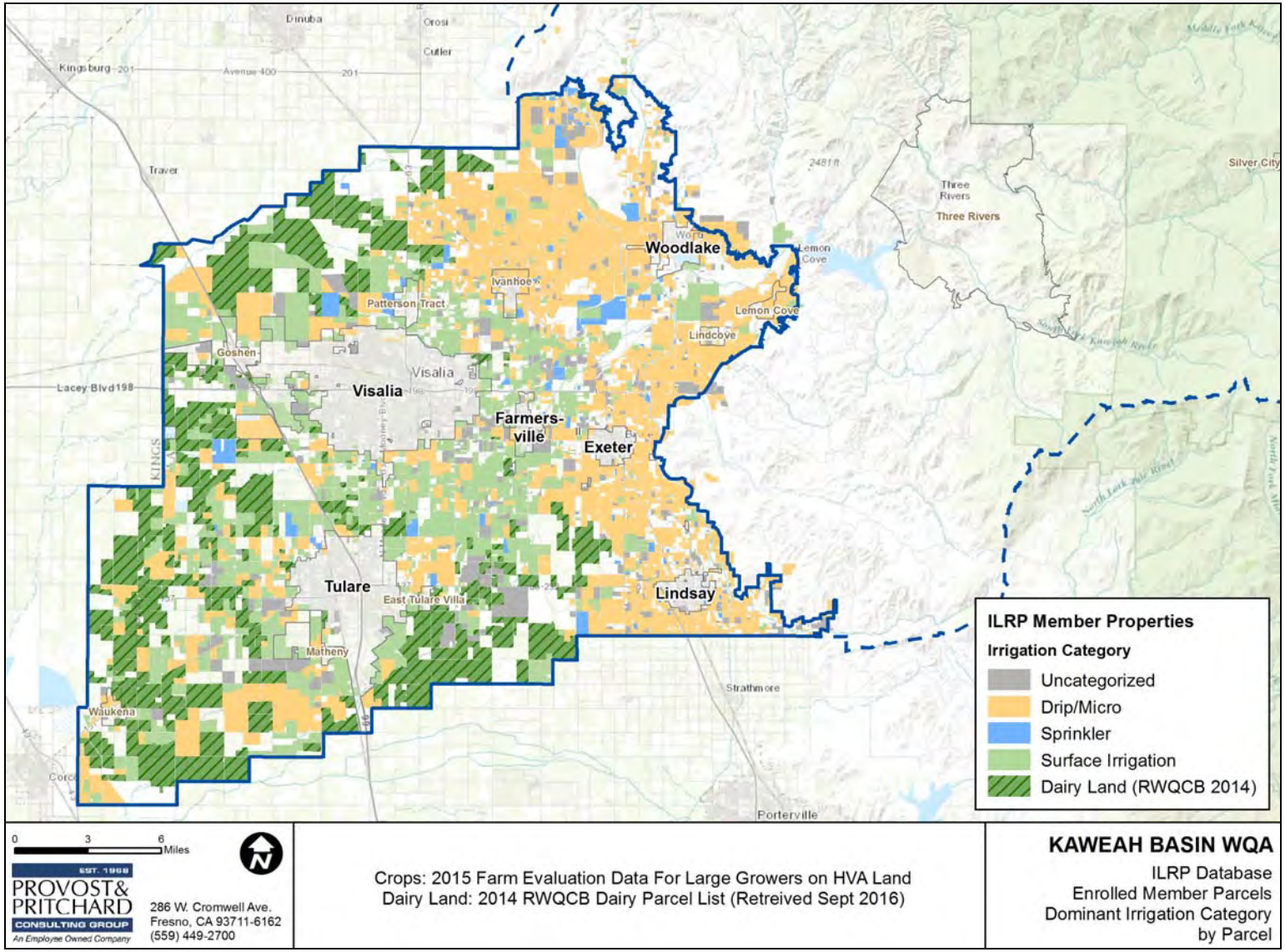
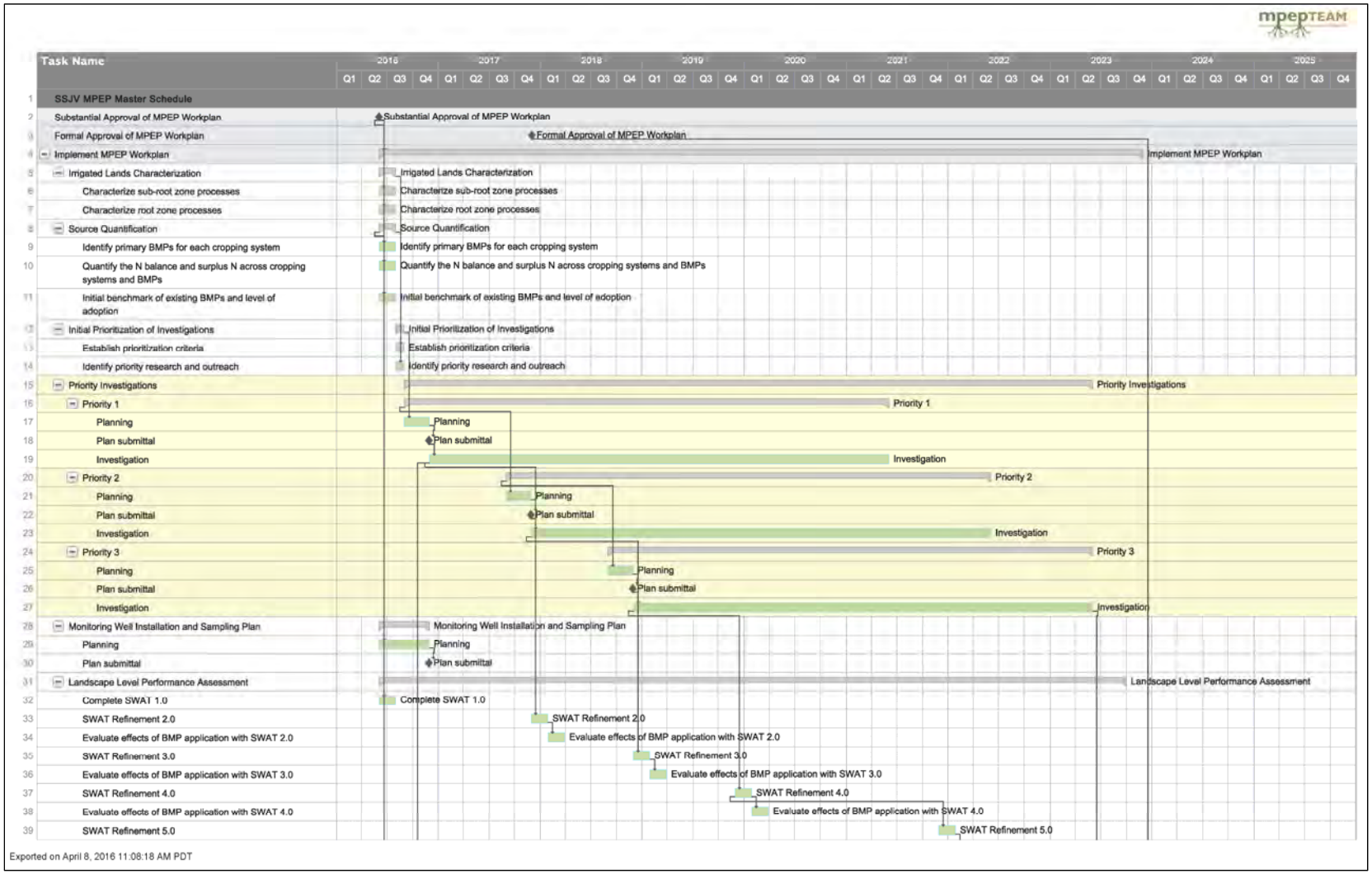
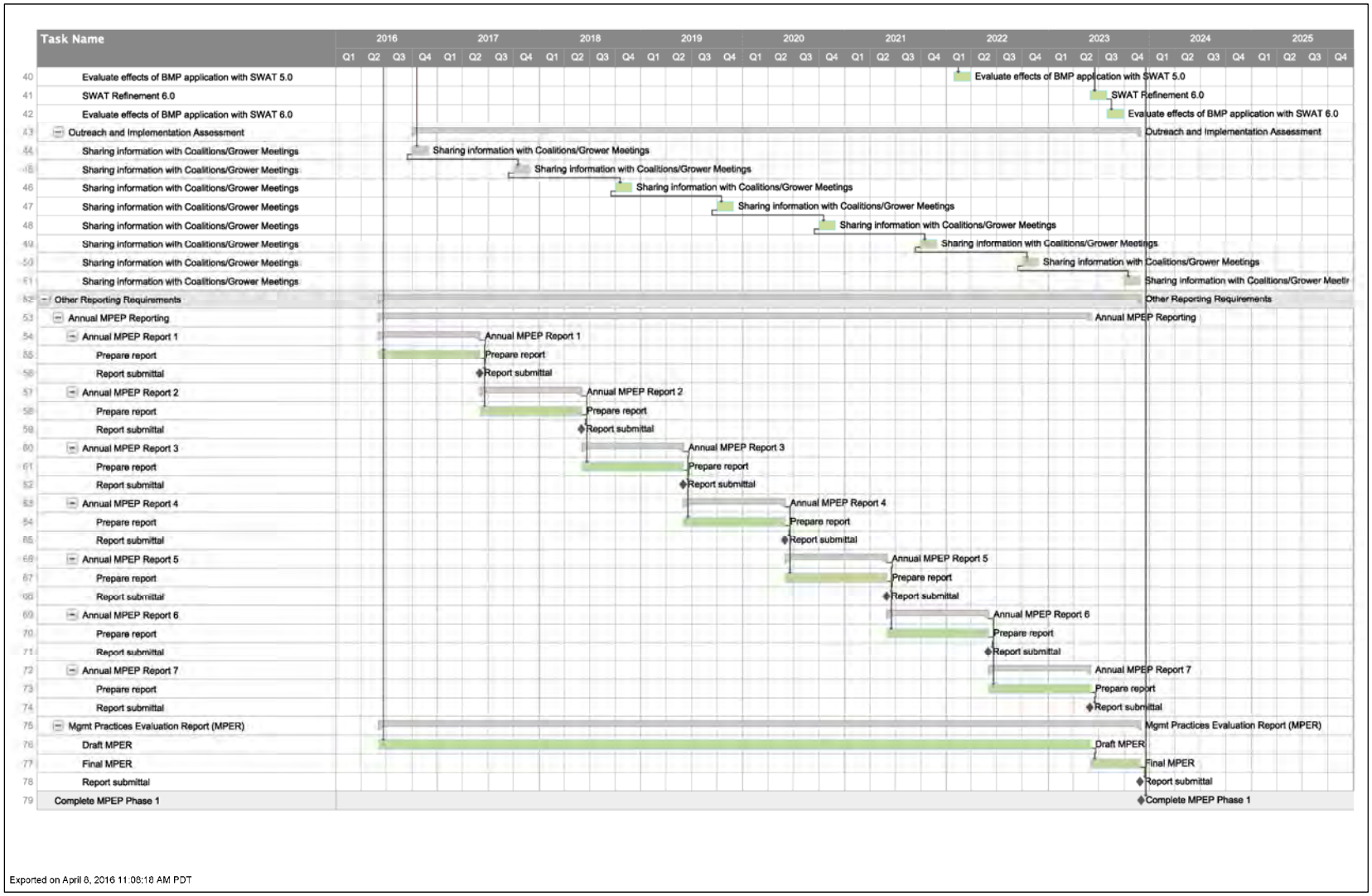


Figure 22. 2015 Irrigation Type



Source: MPEP Team for the SSJV MPEP Committee. May 2016. Discussion Draft Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee

Figure 23. SSJV MPEP Workplan Master Schedule (Page 1)



Source: MPEP Team for the SSJV MPEP Committee. May 2016. Discussion Draft Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee

Figure 24. SSJV MPEP Workplan Master Schedule (Page 2)

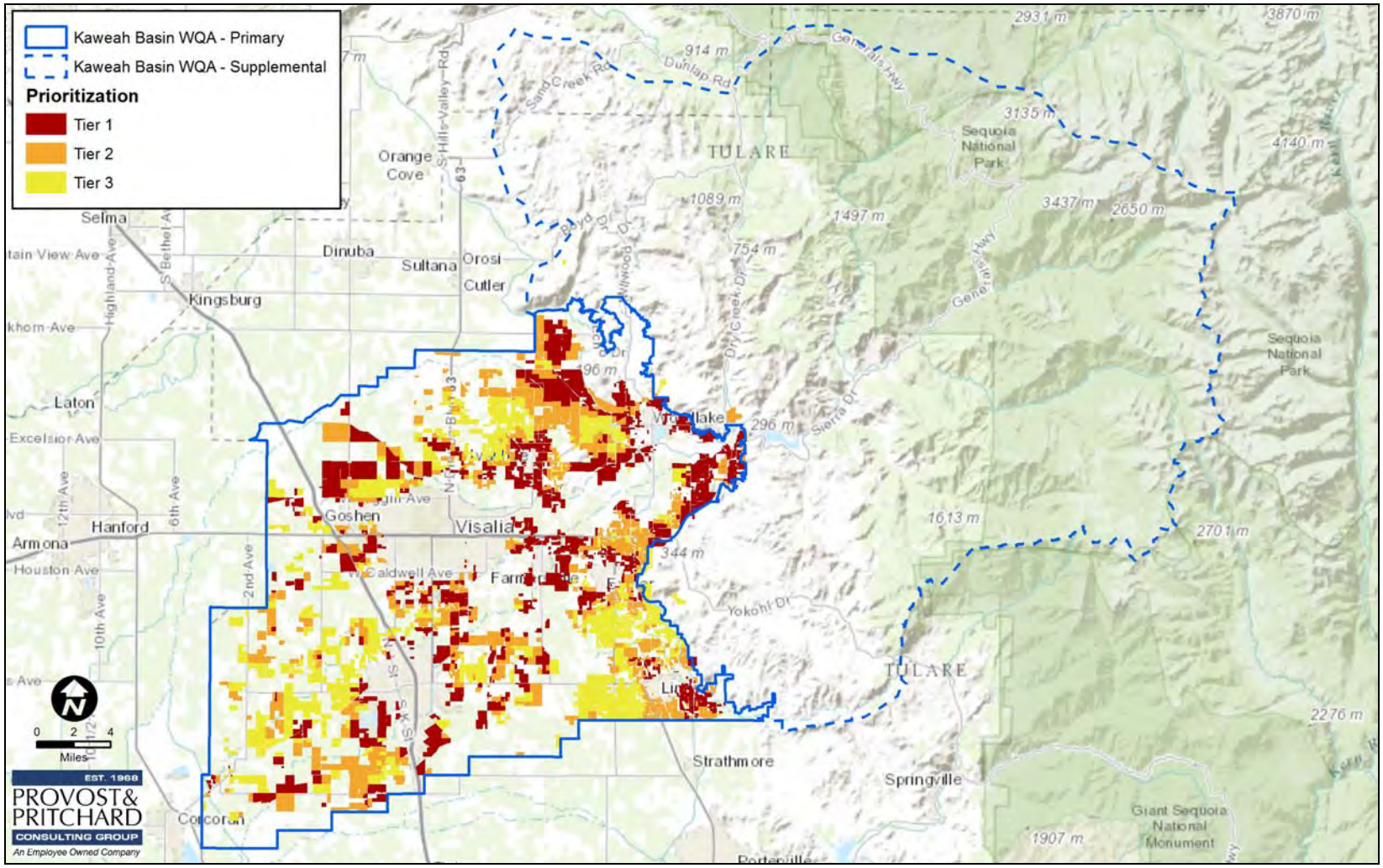


Figure 25. Final Prioritization

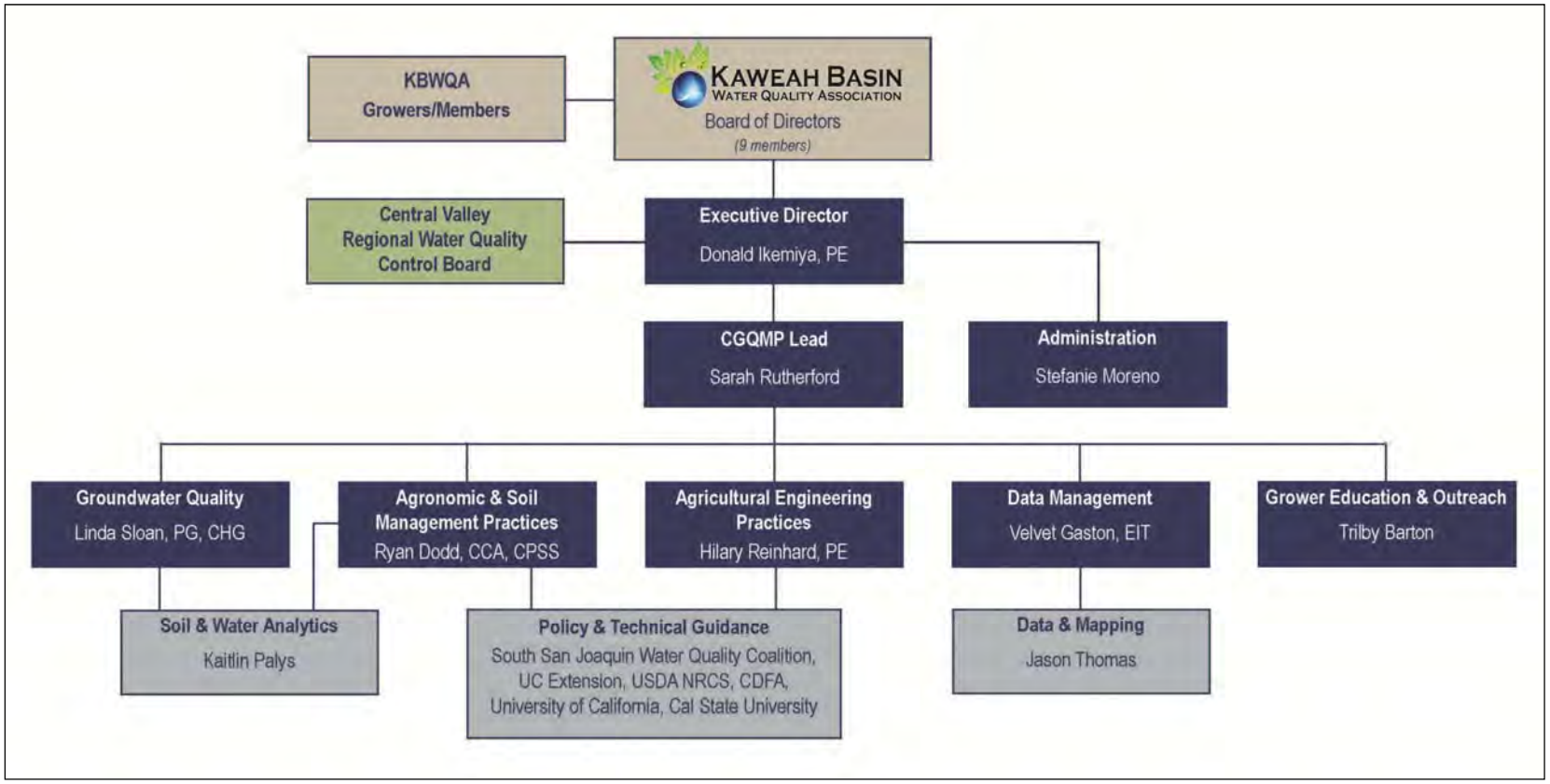


Figure 26. KBWQA Organizational Chart

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EXTONET. Parathion. http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/parathion-ext.html Accessed 15 July 2016.

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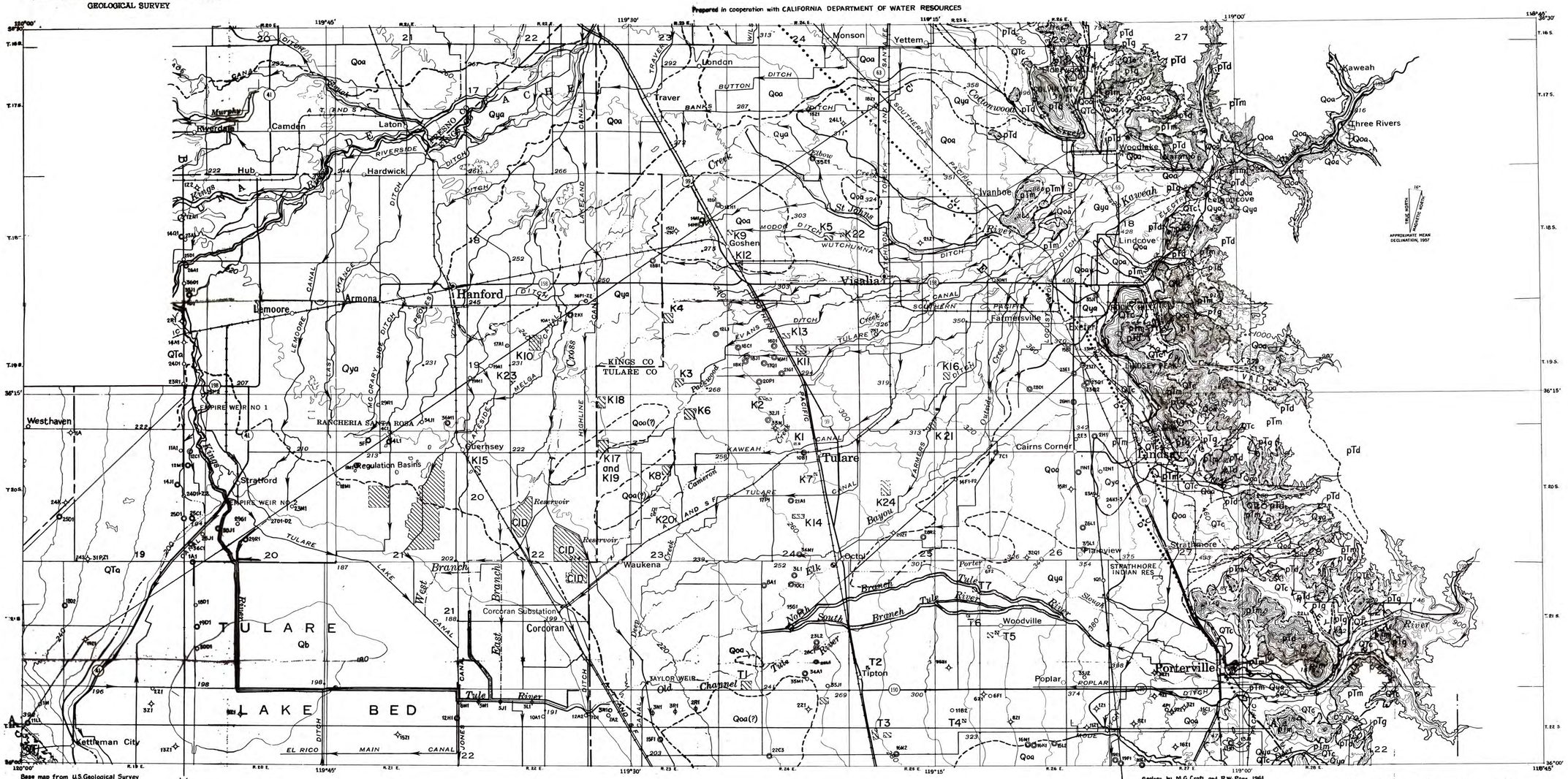
Appendix A: Geologic Cross Sections

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with CALIFORNIA DEPARTMENT OF WATER RESOURCES



Base map from U.S. Geological Survey topographic map, Central Valley, Calif., South area, 1959. 1:250000 -

Geology by M.G. Croft and R.W. Page, 1964
Modified from Soil maps in some areas

5 4 3 2 1 0 5 10 MILES

CONTOUR INTERVAL 100 FEET
Contours at 20 feet intervals are shown in valley area where space permits
DATUM IS MEAN SEA LEVEL

GEOLOGIC MAP OF THE HANFORD-VISALIA AREA, SAN JOAQUIN VALLEY, CALIFORNIA

EXPLANATION

UNCONSOLIDATED DEPOSITS

WEST SIDE *Coast Ranges Provenance*

- Pliocene to Recent — QTa — Alluvium, undifferentiated
- Pliocene and Pleistocene — QTl — Lacustrine and marsh deposits
- Recent — Qb — Flood basin deposits

EAST SIDE *Sierra Nevada Provenance*

- Recent — Qya — Younger alluvium
- Pleistocene — Qoa — Older alluvium
- Pliocene and Pleistocene(?) — QTc — Continental deposits

QUATERNARY

TERTIARY and QUATERNARY(?)

CONSOLIDATED ROCKS

pTg, pTd, pTm

Basement complex
pTg, *gabbro*
pTd, *diorite and granodiorite*
pTm, *metamorphic rocks*

PRE-TERTIARY

Lithologic contact
Dashed where indefinite or inferred

Fault
Dashed where inferred; dotted where concealed; U, upthrown side; D, downthrown side

A — A' Line of section

Domestic, stock, or unused well

Public supply or irrigation well

Destroyed well

Oil test well

Recharge basin
K = *Kaweah Delta Water Conservation District*
T = *Lower Tule River Irrigation District*
CID = *Corcoran Irrigation District*

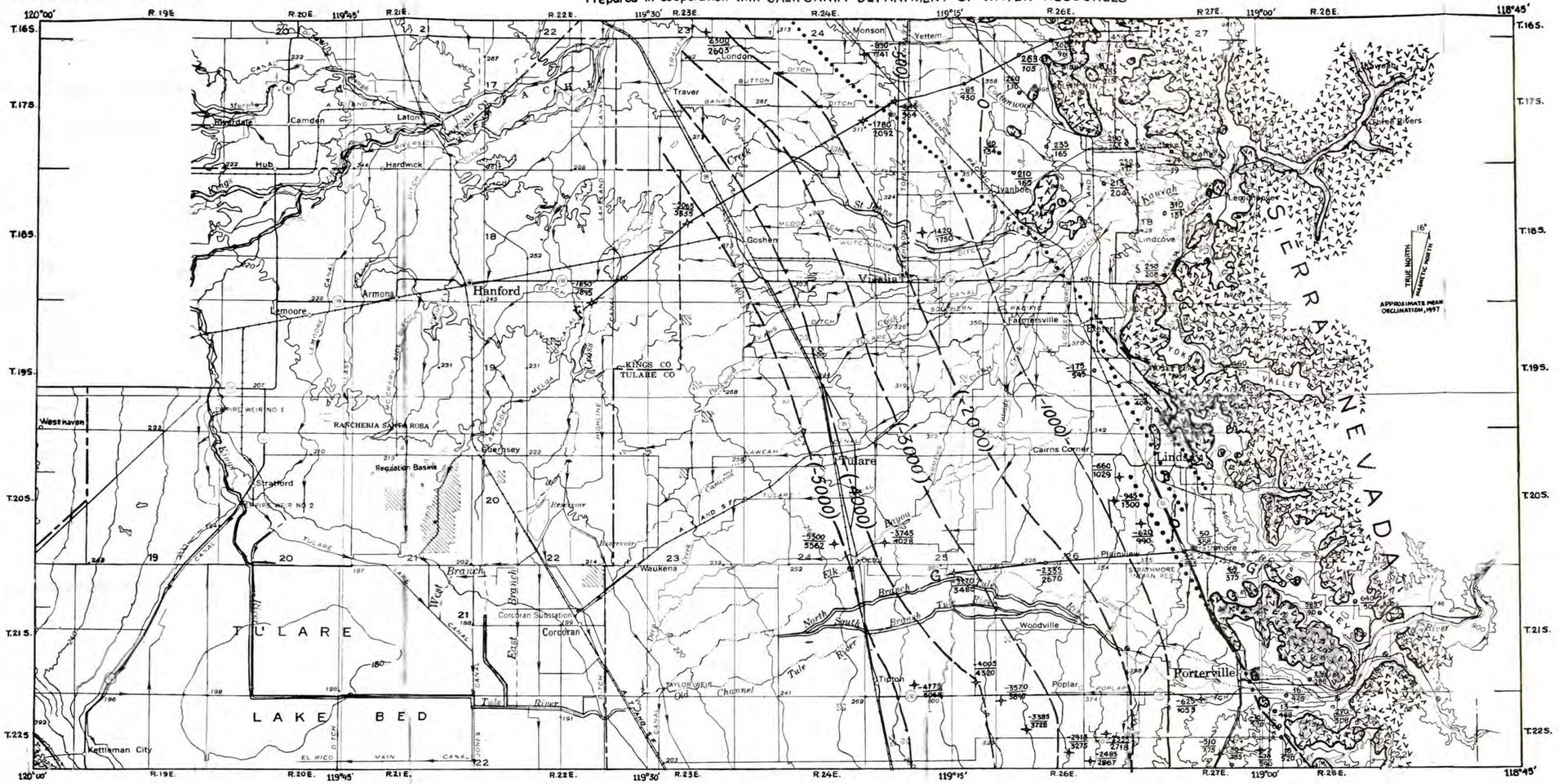
INDEX TO TOPOGRAPHIC QUADRANGLE MAPS

68-67

U.S. GEOLOGICAL SURVEY

Prepared in cooperation with CALIFORNIA DEPARTMENT OF WATER RESOURCES

PLATE 3



4 0 4 8 12 16 Miles

Contour interval 100 feet
Contours at 20 foot interval are shown in valley area where space permits
Datum is mean sea level

EXPLANATION

Structure contour

Drawn on top of basement complex: Contour interval 500 or 1000 feet as shown. Datum is mean sea level

Fault

Dashed where inferred; dotted where concealed

F ——— F'

Line of section

100/300

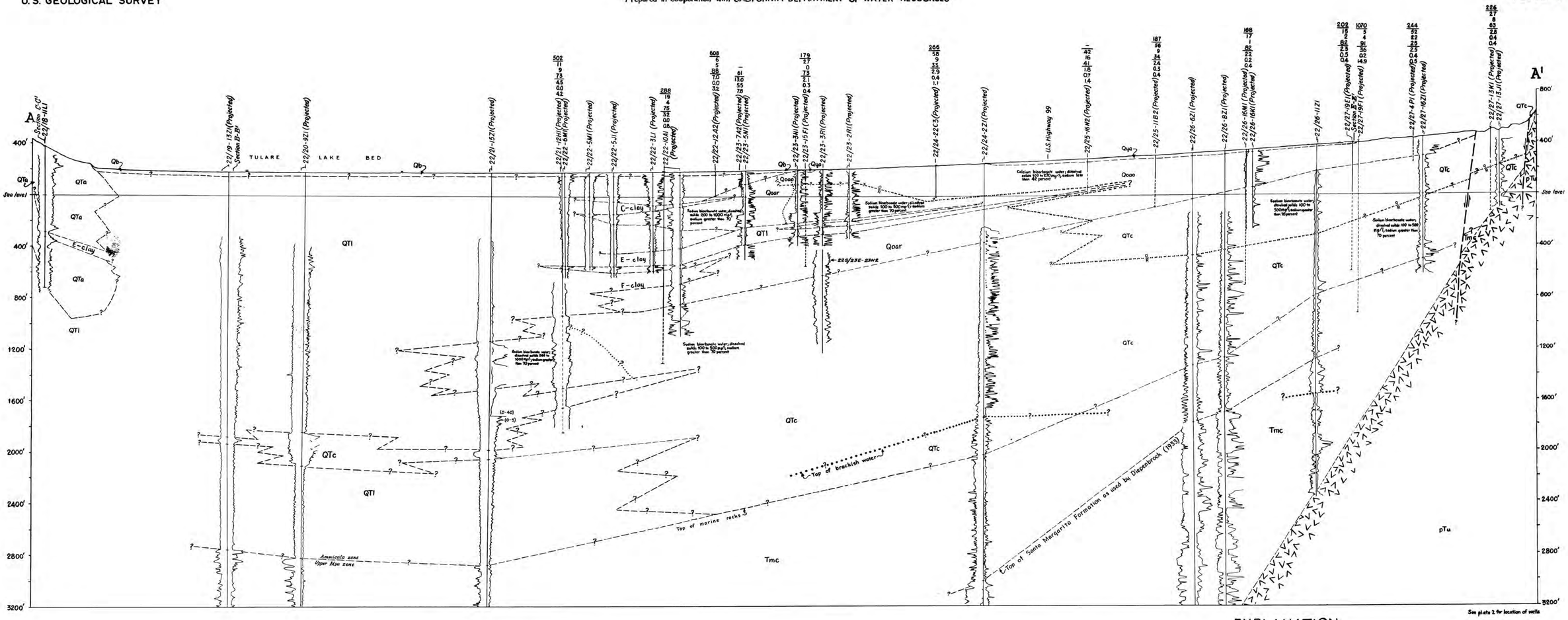
Water well

150/400

Oil test well

Number above line is altitude, in feet, of basement complex above or (-) below sea level

Number below line is depth, in feet, to basement complex below land surface



5 4 3 2 1 0 5 Miles

Vertical scale is approximately 26½ times horizontal scale

GEOLOGIC SECTION A-A'

EXPLANATION

UNCONSOLIDATED DEPOSITS

WEST SIDE (Coast Ranges Provenance)		EAST SIDE (Sierra Nevada Provenance)	
Pliocene to Recent	Recent: Qb, Flood-basin deposits	Qya, Younger alluvium	QUATERNARY
	Pleistocene and Recent(?): Qoao, Qoar, Older alluvium; Qoao_oxidized; Qoar_reduced		QUATERNARY
Pliocene to Recent	QTa, Alluvium, undifferentiated		
Pliocene and Pleistocene	QTI, Lacustrine and marsh deposits		
Pliocene and Pleistocene(?)	QTc, Continental deposits		TERTIARY and QUATERNARY(?)

CONSOLIDATED ROCKS

Tmc, Marine and continental rocks	PRE-TERTIARY TERTIARY
pTu, Basement complex	PRE-TERTIARY TERTIARY

Lithologic contact
Queried where evidence is not conclusive

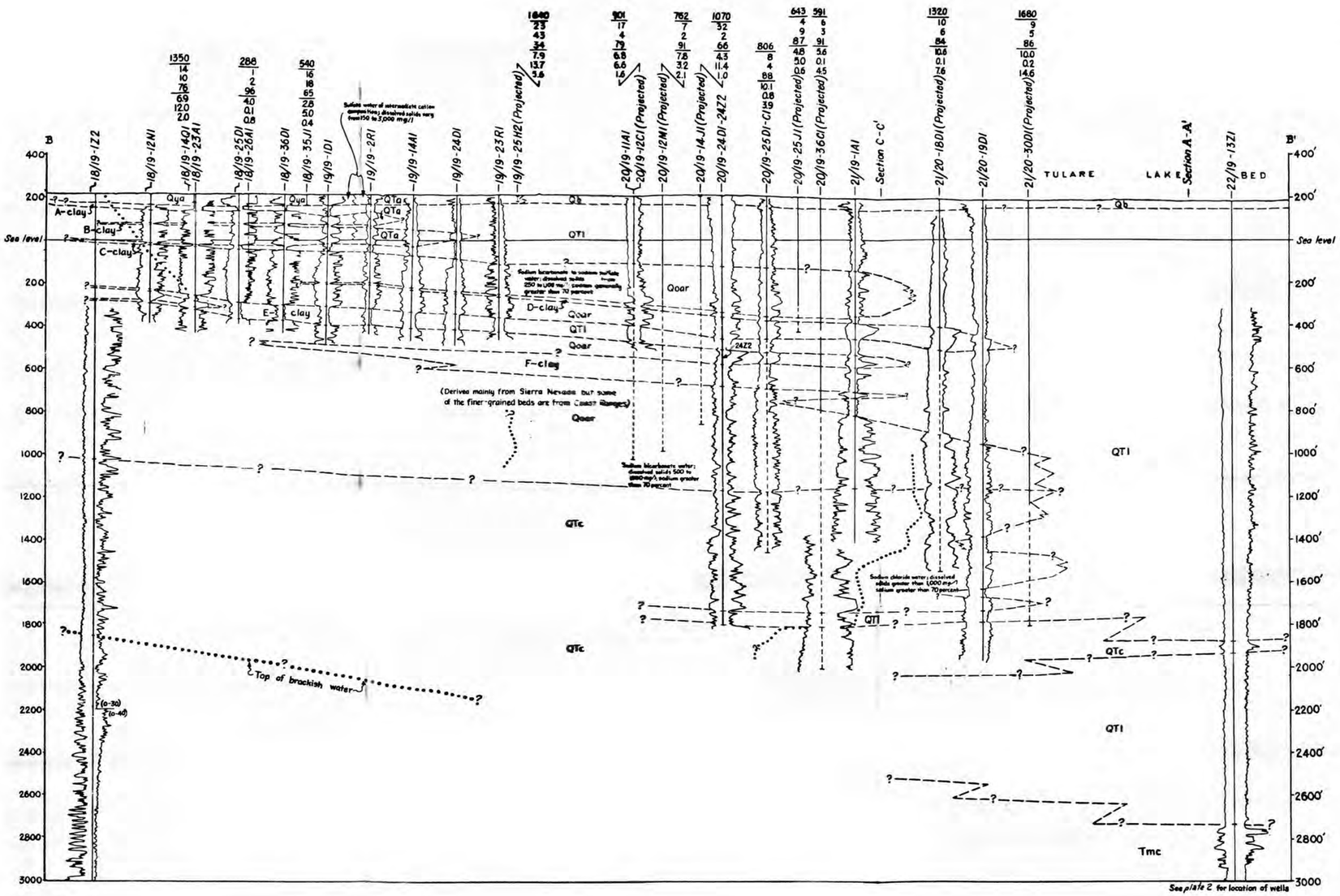
Inferred Fault
Arrows indicate direction of movement

Contact between oxidized (O) and reduced (R) deposits

Water-quality boundary
Queried where data are lacking or evidence is not conclusive

Well
Dashed line indicates perforated interval

202 dissolved solids (mg/l)
15 percent calcium
2 percent magnesium
82 percent sodium
2.3 carbonate and bicarbonate (epm)
0.5 sulfate (epm)
0.4 chloride (epm)



EXPLANATION

UNCONSOLIDATED DEPOSITS

WEST SIDE		EAST SIDE	
Coast Ranges Provenance		Sierra Nevada Provenance	
Pliocene to Recent	Recent: Qb, Flood-basin deposits	Qya, Younger alluvium	QUATERNARY
		Pleistocene and Recent(?): Qoao, Qoar, Older alluvium; Qoao_oxidized; Qoar_reduced	QUATERNARY
QTa, Alluvium, undifferentiated	Pliocene and Pleistocene: QTl, Lacustrine and marsh deposits	Pliocene and Pleistocene(?): QTc, Continental deposits	TERTIARY and QUATERNARY(?)

CONSOLIDATED ROCKS

Tmc — Marine and continental rocks — TERTIARY

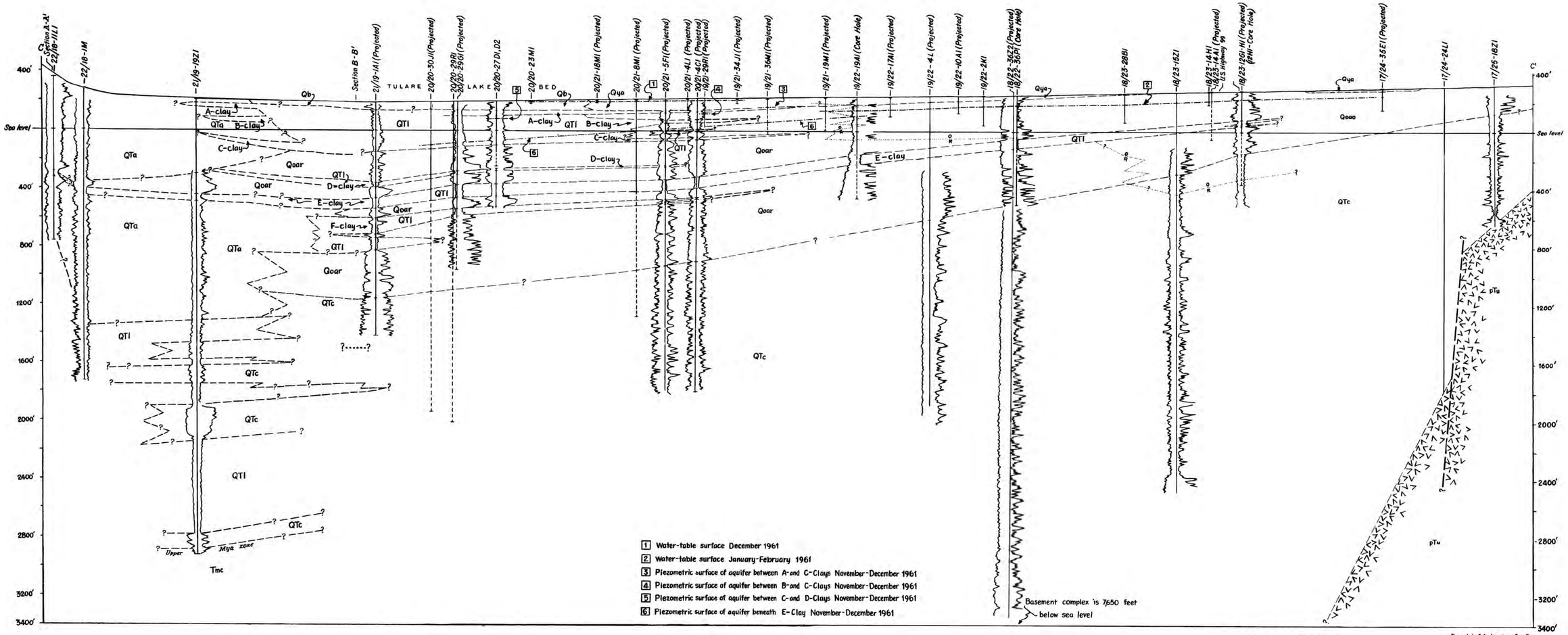
Lithologic contact
Queried where evidence is not conclusive

Well
Dashed line indicates perforated interval

Water quality boundary
Queries indicate data are lacking or evidence is not conclusive

202 dissolved solids (mg/l)
15 percent calcium
2 percent magnesium
82 percent sodium
2.3 carbonate and bicarbonate (epm)
0.5 sulfate (epm)
0.4 chloride (epm)

GEOLOGIC SECTION B–B'



1 Water-table surface December 1961
2 Water-table surface January-February 1961
3 Piezometric surface of aquifer between A- and C-Clays November-December 1961
4 Piezometric surface of aquifer between B- and C-Clays November-December 1961
5 Piezometric surface of aquifer between C- and D-Clays November-December 1961
6 Piezometric surface of aquifer beneath E-Clay November-December 1961

5 4 3 2 1 0 5 MILES

Vertical scale is approximately 26⅔ times horizontal scale

GEOLOGIC SECTION C-C'

EXPLANATION

UNCONSOLIDATED DEPOSITS

WEST SIDE — *Coast Ranges Provenance*

EAST SIDE — *Sierra Nevada Provenance*

Pliocene to Recent

Recent

- **Qb** — Flood-basin deposits
- **Qya** — Younger alluvium

Pleistocene and Recent(?)

- **Qoao / Qoar** — Older alluvium
  - Qoao - *oxidized*
  - Qoar - *reduced*

Pliocene and Pleistocene

- **QTa** — Alluvium, undifferentiated
- **QTl** — Lacustrine and marsh deposits

Pliocene and Pleistocene(?)

- **QTc** — Continental deposits

QUATERNARY

TERTIARY and QUATERNARY(?)

CONSOLIDATED ROCKS

- **Tmc** — Marine and continental rocks (TERTIARY)
- **pTu** — Basement complex (PRE-TERTIARY)

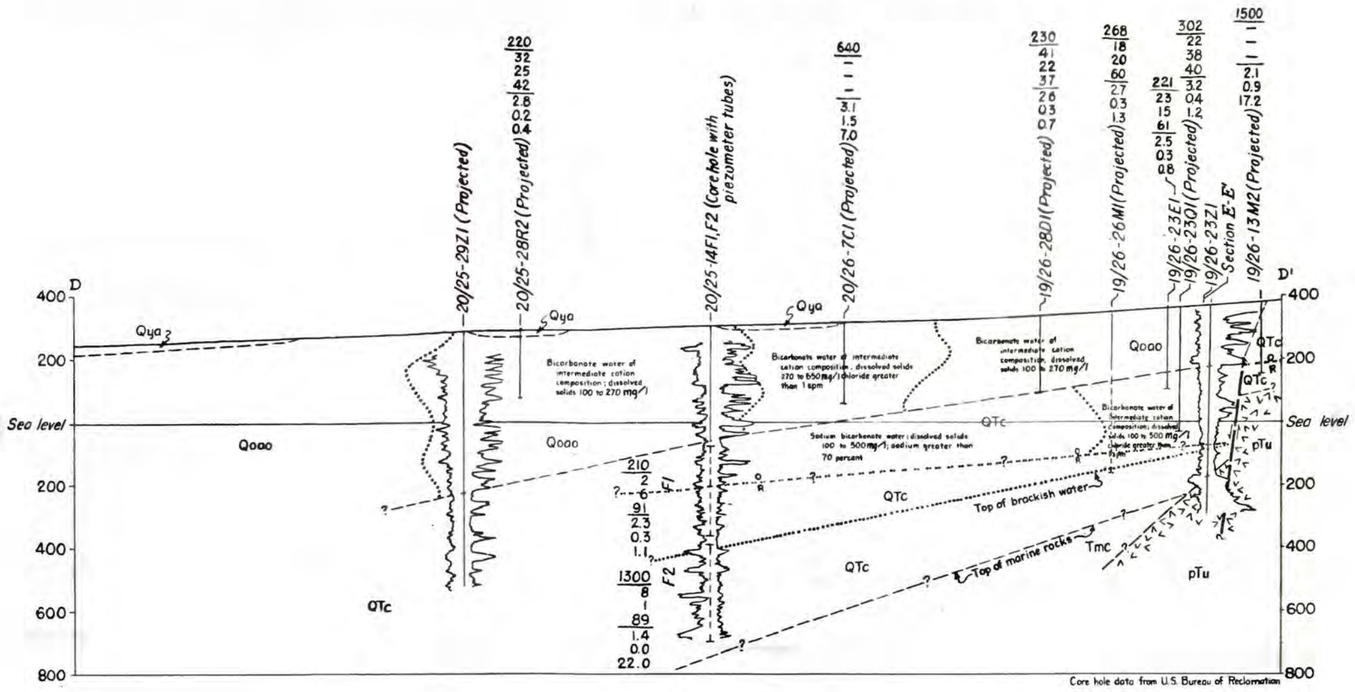
Lithologic contact
Queried where evidence is not conclusive

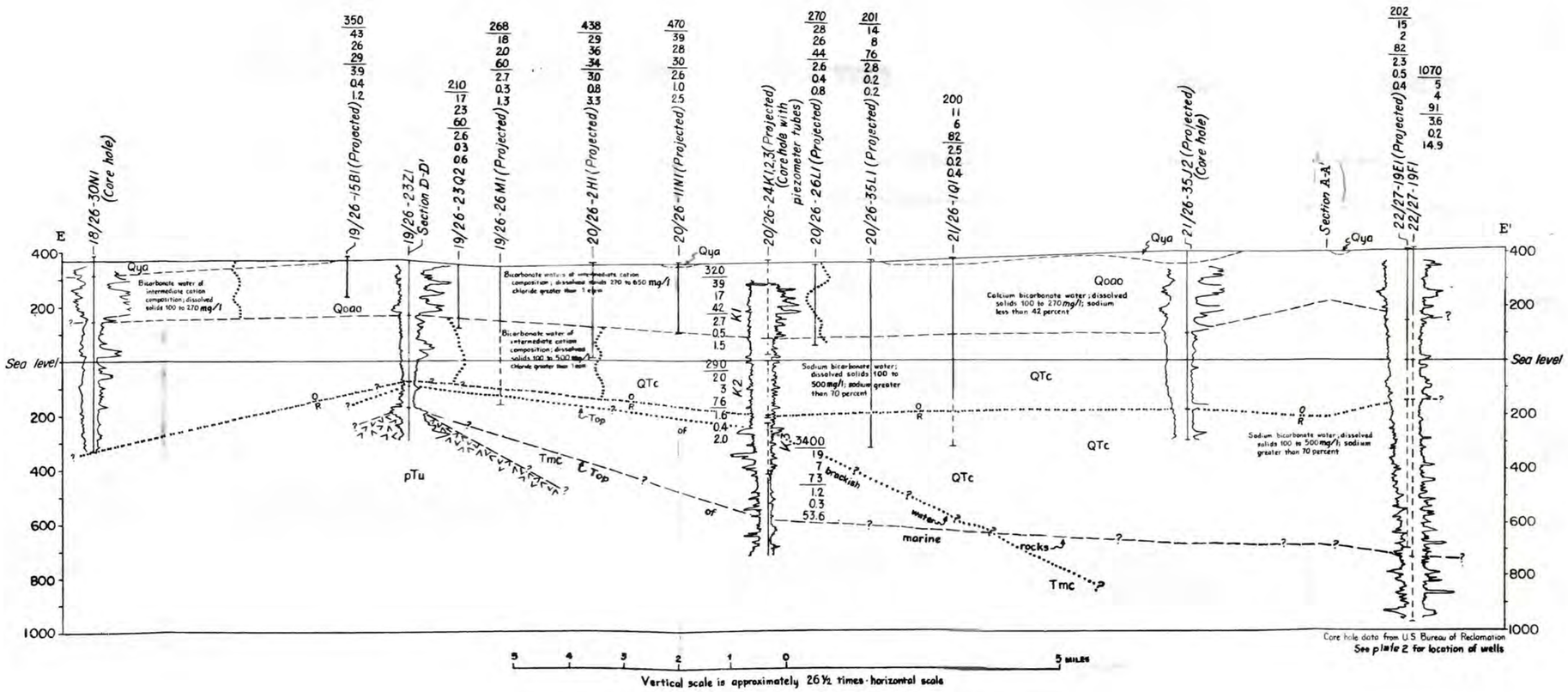
Inferred Fault
Arrows indicate direction of movement

Contact between oxidized (O) and reduced (R) deposits

Well
Dashed line indicates perforated interval

Water-quality boundary
Queried where data are lacking or evidence is not conclusive





GEOLOGIC SECTIONS D-D' AND E-E'

EXPLANATION

UNCONSOLIDATED DEPOSITS

EAST SIDE

Sierra Nevada Provenance

- **Qya** — Younger alluvium (*Recent*; QUATERNARY)
- **Qoao** — Older alluvium, *Oxidized* (*Pleistocene and Recent(?)*; QUATERNARY)
- **QTc** — Continental deposits (*Pliocene and Pleistocene(?)*; TERTIARY QUATERNARY(?))

CONSOLIDATED DEPOSITS

- **Tmc** — Marine and continental rocks (TERTIARY)
- **pTu** — Basement complex (PRE-TERTIARY)

Lithologic contact

Contact between oxidized (O) and reduced (R) deposits

Inferred fault

Arrows indicate direction of movement

Water quality boundary

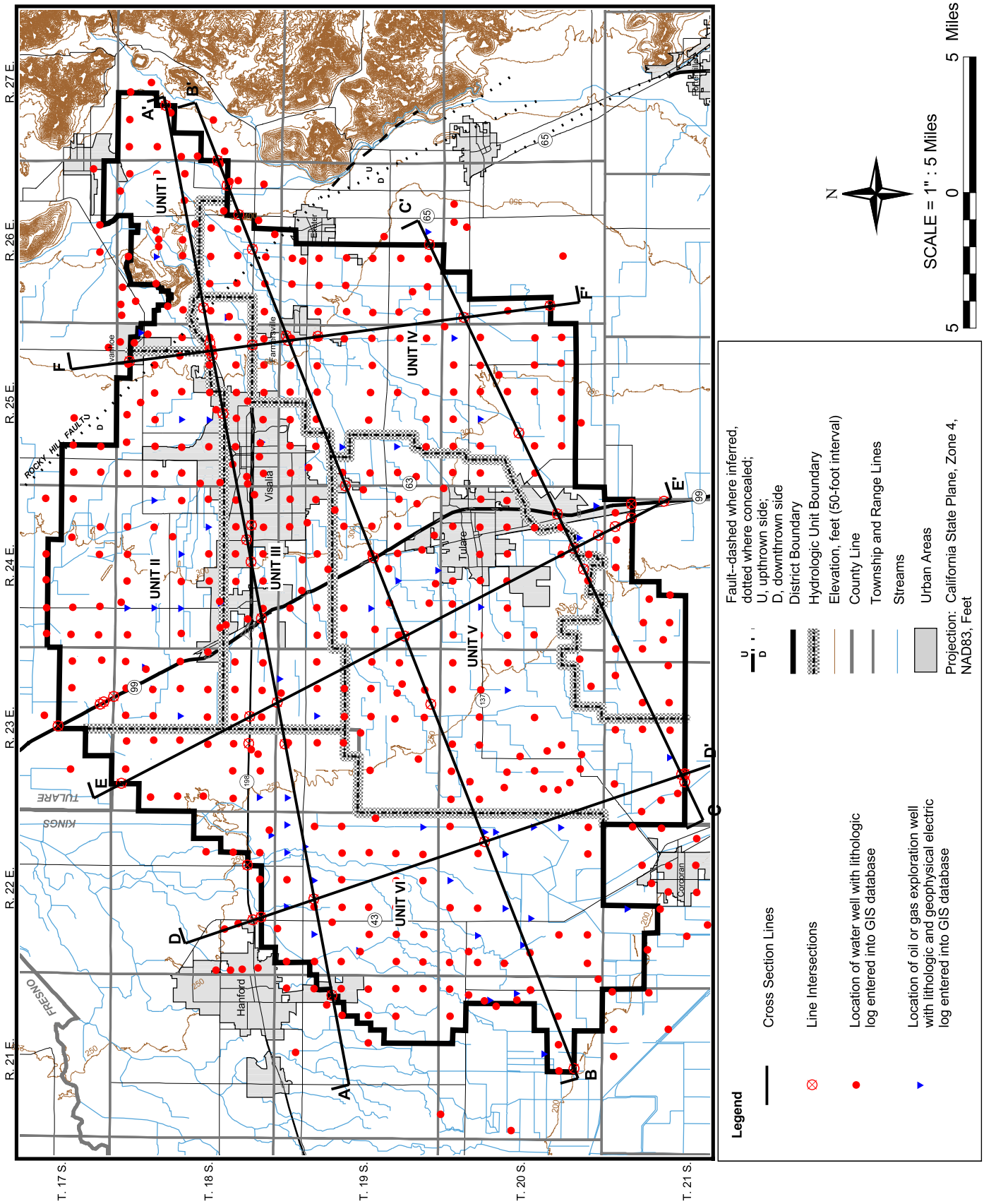
Queries indicate data are lacking or evidence is not conclusive

Well

Dashed line indicates perforated interval

202	dissolved solids (mg/l)
15	percent calcium
2	percent magnesium
82	percent sodium
2.3	carbonate and bicarbonate (epm)
0.5	sulfate (epm)
0.4	chloride (epm)

Appendix B: Furgo Cross Sections

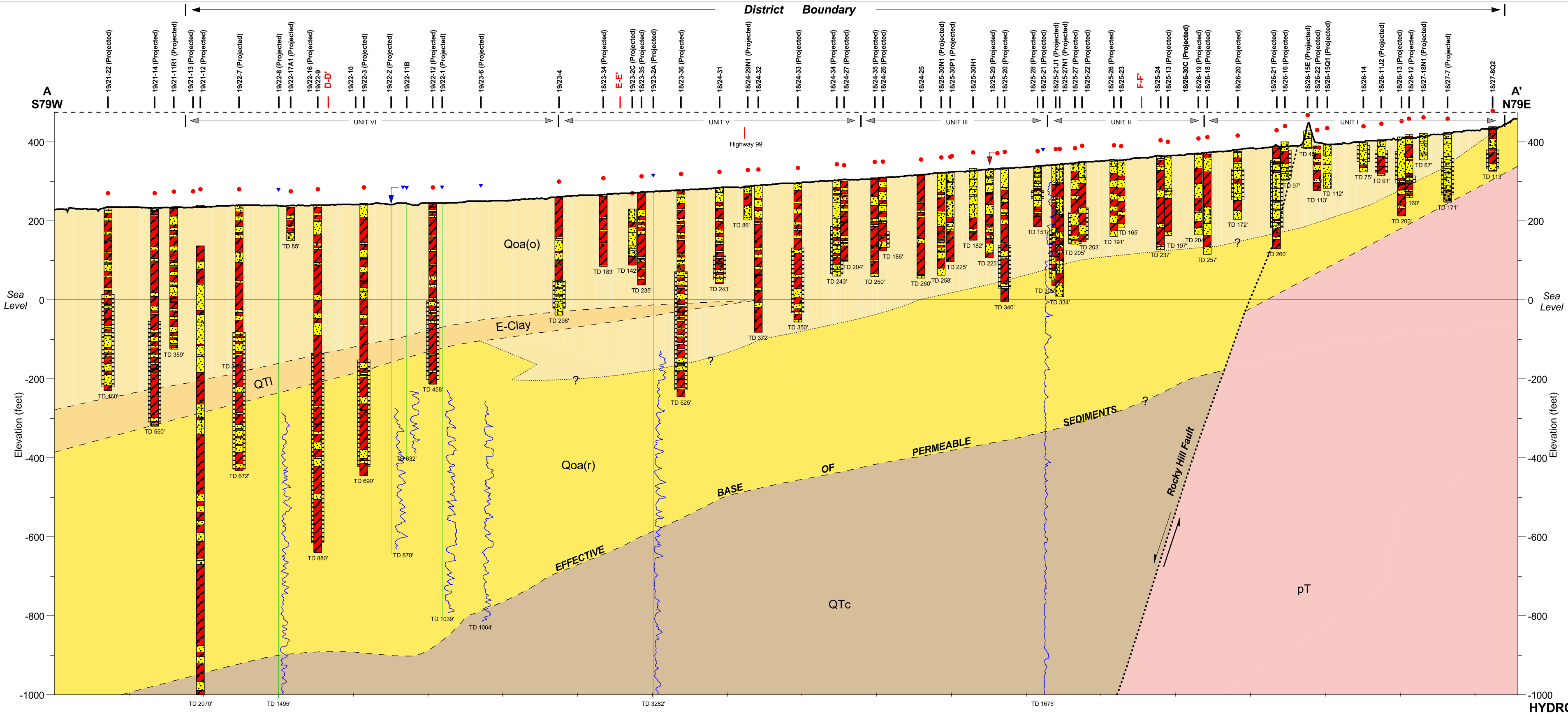


WELL DATABASE AND CROSS SECTION LOCATION MAP

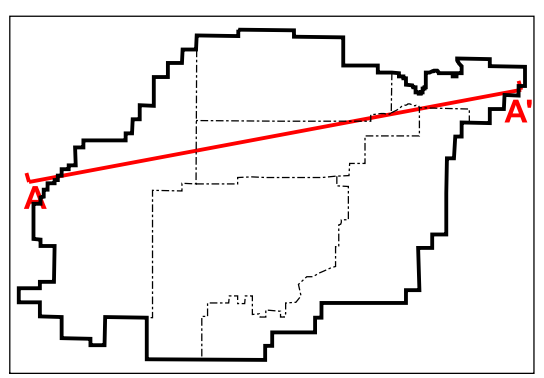
Kaweah Delta Water Conservation District

PLATE 12

December 2003 (Revised July 2007)
Project No. 3087.004.07



Section Location



GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from well and electric logs. Conditions vary both along and perpendicular to the section line.

2) Refer to Key to Cross Sections for descriptions of wells and electric log data shown above.

3) Wells and electric logs are projected to a distance of one mile onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

4) Legend on Plate 16

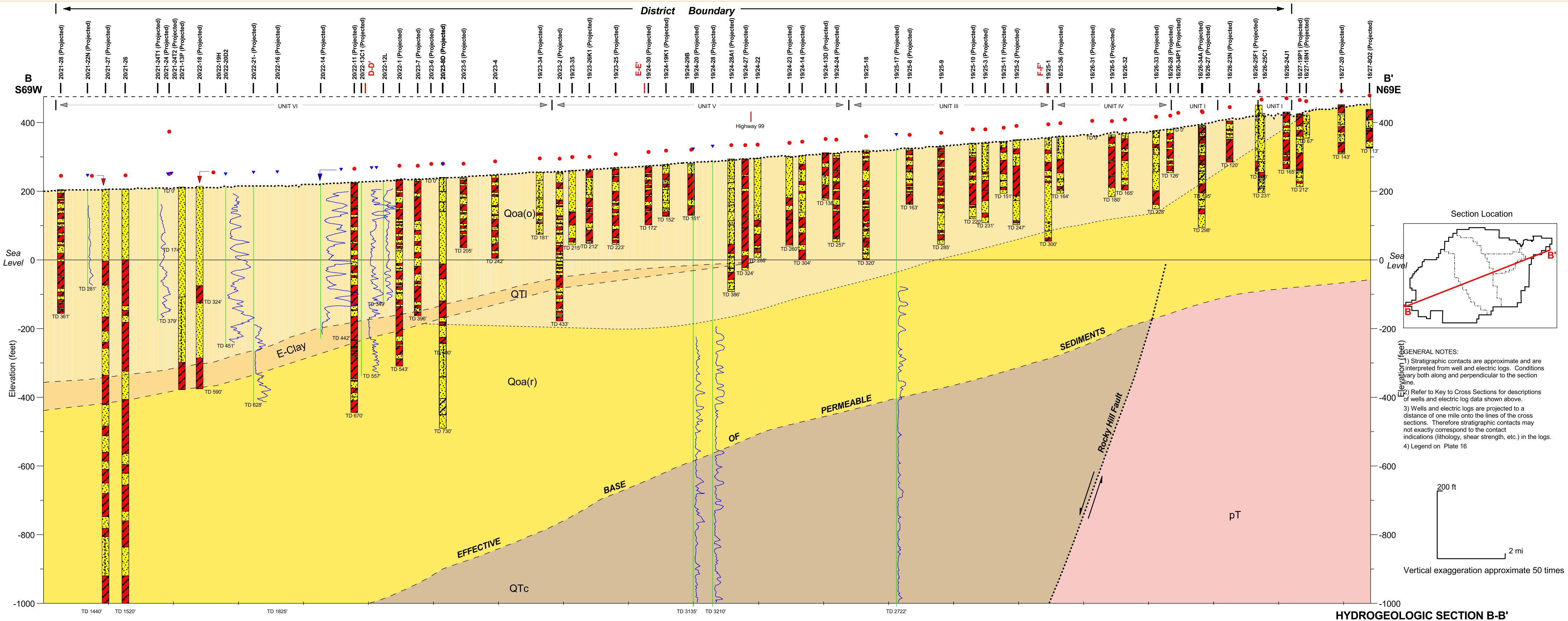
200 ft

2 mi

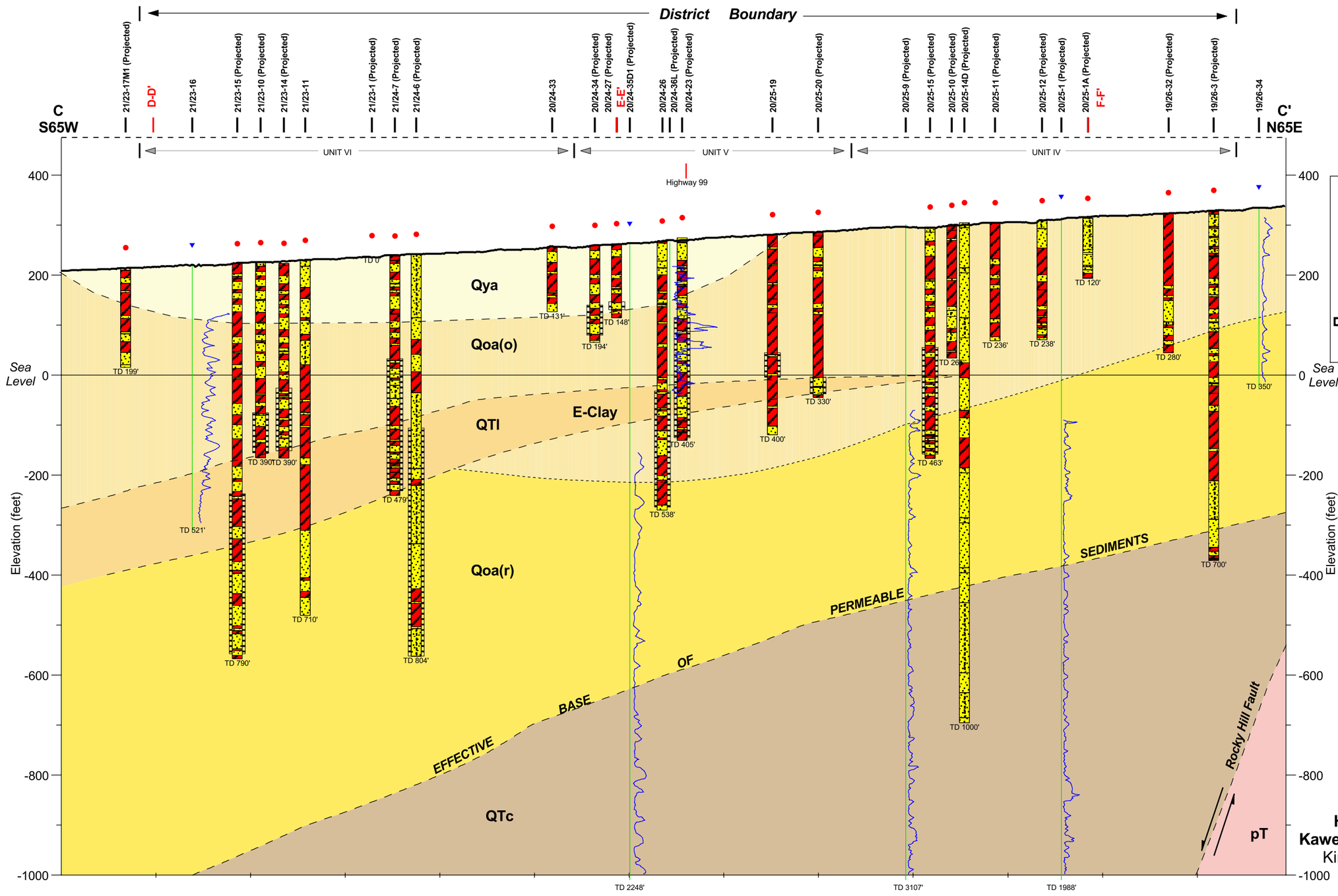
Vertical exaggeration approximate 50 times

HYDROGEOLOGIC SECTION A-A'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California

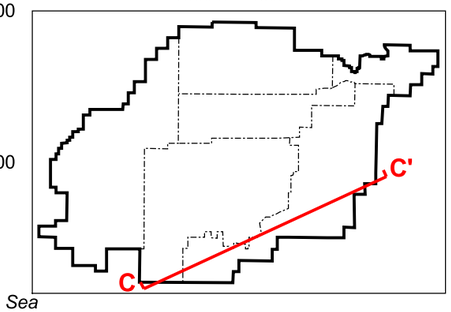
December 2003 (Revised July 2007)
Project No. 3087.004.07



HYDROGEOLOGIC SECTION B-B'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California



Section Location



GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from well and electric logs. Conditions vary both along and perpendicular to the section line.

2) Refer to Key to Cross Sections for descriptions of wells and electric log data shown above.

3) Wells and electric logs are projected onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

4) Legend on Plate 16

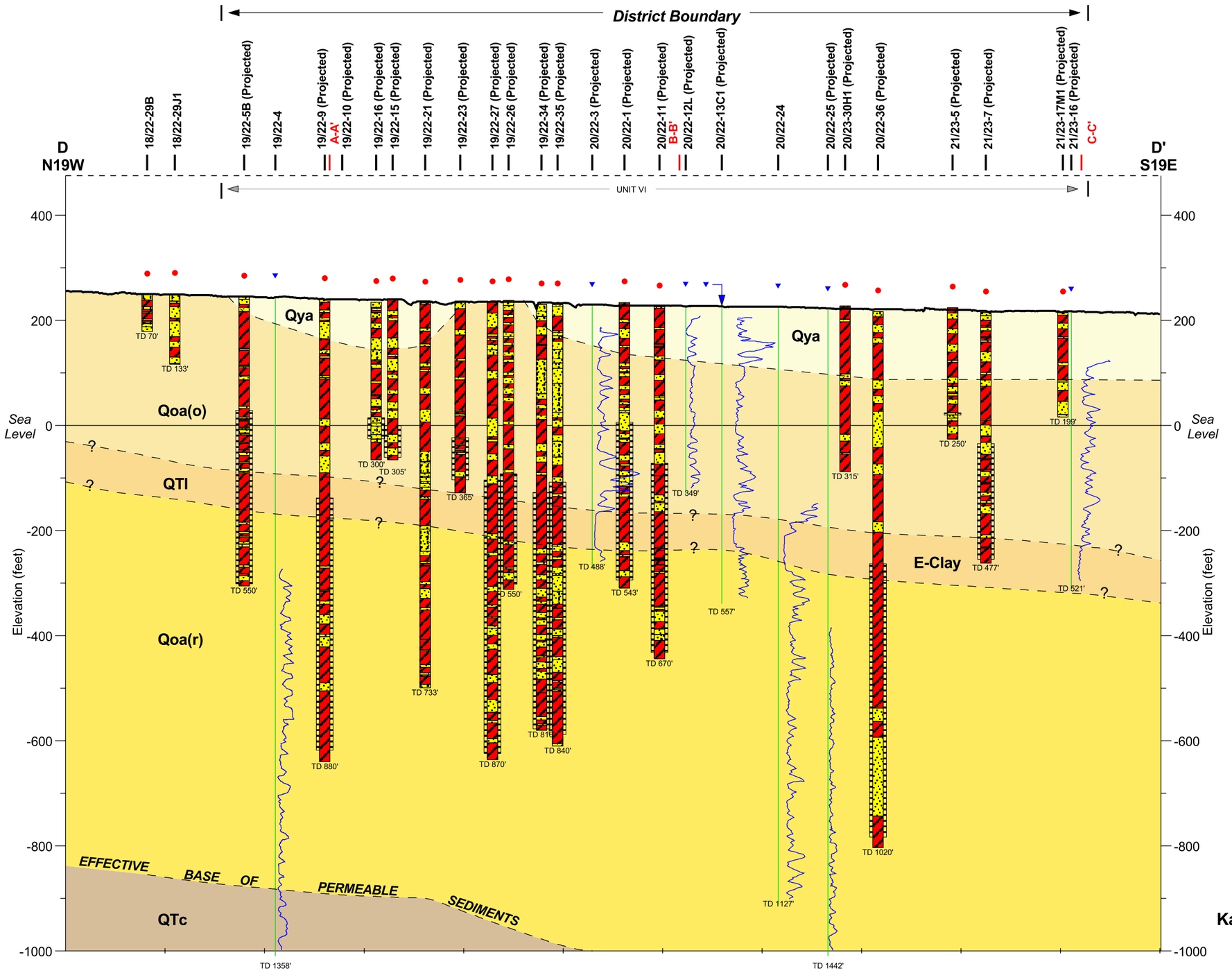
200 ft

2 mi

Vertical exaggeration approximate 50 times

HYDROGEOLOGIC SECTION C-C'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California

PLATE 16



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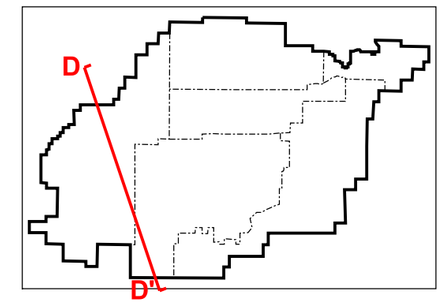

GENERAL NOTES:

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2) Refer to Key to Cross Sections for descriptions of wells and electric log data shown above.

3) Wells and electric logs are projected to a distance of one mile onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

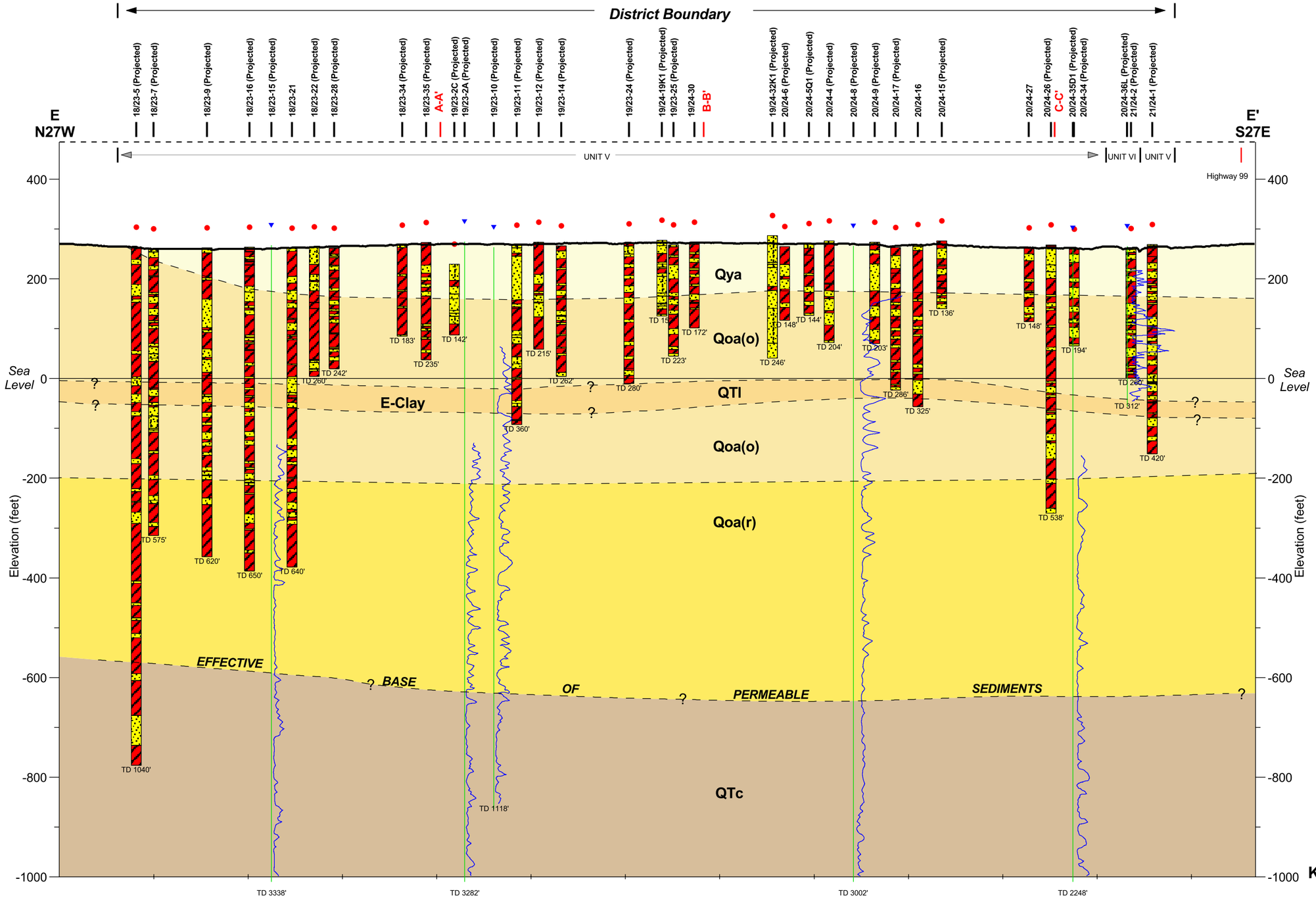
4) Legend on Plate 16

200 ft

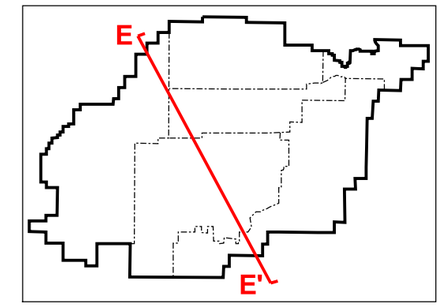
2 mi

Vertical exaggeration approximate 50 times

HYDROGEOLOGIC SECTION D-D'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California



Section Location



GENERAL NOTES:

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3) Wells and electric logs are projected to a distance of one mile onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

4) Legend on Plate 16

200 ft

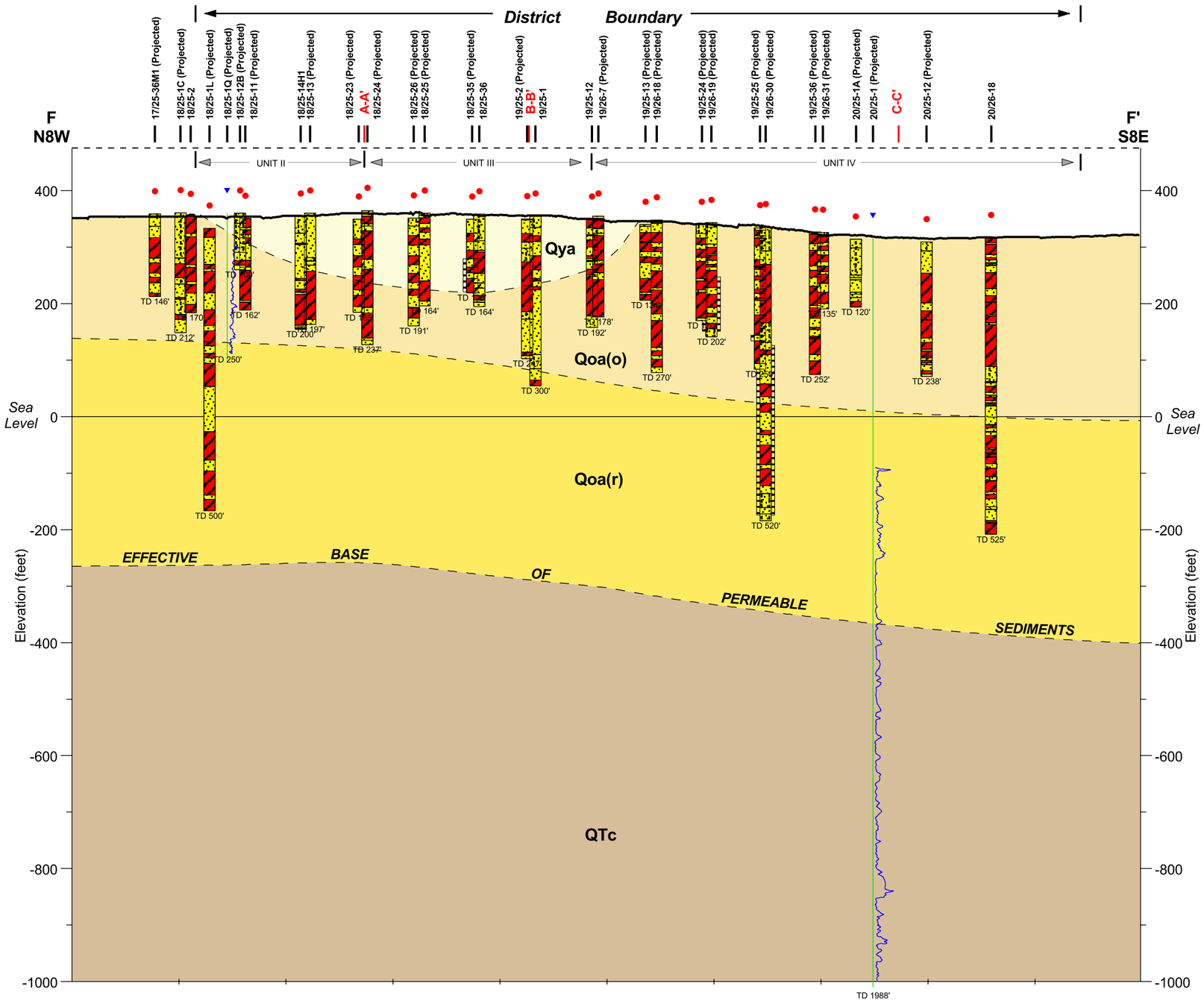
2 mi

Vertical exaggeration approximate 50 times

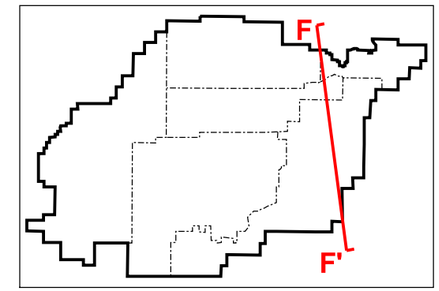
HYDROGEOLOGIC SECTION E-E'

Kaweah Delta Water Conservation District

Kings and Tulare Counties, California



Section Location



GENERAL NOTES:

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3) Wells and electric logs are projected to a distance of one mile onto the lines of the cross sections. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

4) Legend on Plate 16

200 ft

2 mi

Vertical exaggeration approximate 50 times

HYDROGEOLOGIC SECTION F-F'
Kaweah Delta Water Conservation District
Kings and Tulare Counties, California

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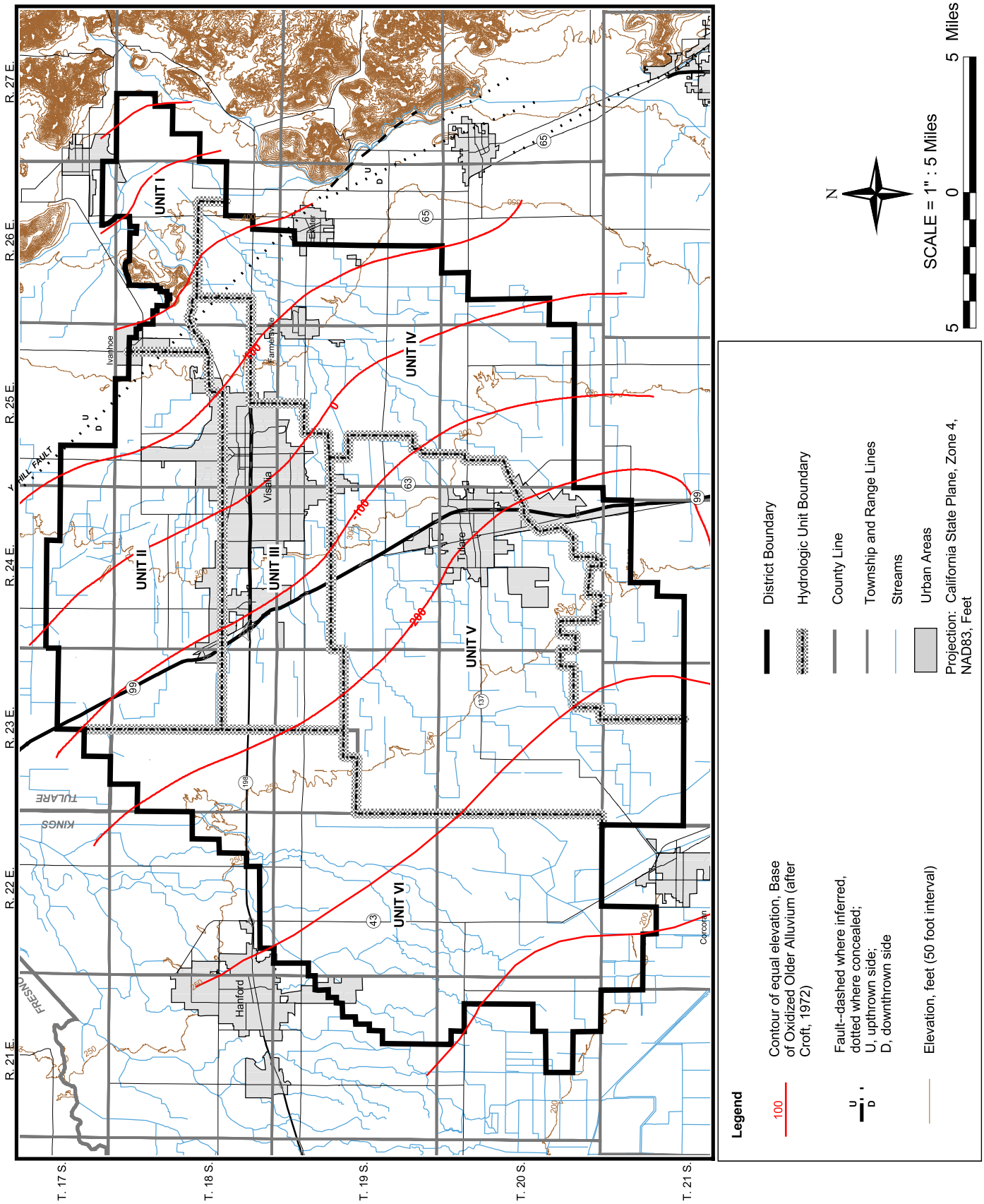

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BASE OF OXIDIZED OLDER ALLUVIUM CONTOUR MAP

Kaweah Delta Water Conservation District

Appendix C: MPEP GQMP Management Practices

TECHNICAL MEMORANDUM

IDENTIFICATION, EXTENSION, AND IMPLEMENTATION OF MANAGEMENT PRACTICES TO MINIMIZE NITRATE LEACHING FROM CROP ROOT ZONES TO SATISFY GROUNDWATER QUALITY MANAGEMENT PLAN REQUIREMENTS

PREPARED FOR: South San Joaquin Valley Management Practices Evaluation Plan Committee

PREPARED BY: MPEP Team

DATE: August 25, 2016

It is anticipated that versions of this document, when appended to a GQMP deliverable by a South San Joaquin Valley (SSJV) Management Practices Evaluation Program (MPEP) member coalition, will serve to inform the Central Valley Regional Water Quality Control Board (Central Valley Water Board) about the management practices component of the coalition's GQMP.

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LIST OF ABBREVIATIONS

CCA	Certified Crop Adviser
CDFA	California Department of Food and Agriculture
COC	constituent of concern
Committee	SSJV MPEP Committee

CSU	California State University
DWR	California Department of Water Resources
General Order	Waste Discharge Requirement General Order for the Growers within the Tulare Lake Basin Area that are members of a Third-Party Group, General Order No. R5-2013-0120, as modified by General Order No. R5-2013-0143.
GQMP	Groundwater Quality Management Plan
LTILRP	Long-term Irrigated Lands Regulatory Program
MPEP	Management Practices Evaluation Program
N	Nitrogen
NH_4	Ammonium
NMP	Nitrogen Management Plan
NO_3	Nitrate
NUE	nutrient use efficiency
SSJV	Southern San Joaquin Valley
SWAT	Soil and Water Assessment Tool
TDS	total dissolved solids
UCCE	University of California Cooperative Extension
USDA	United States Department of Agriculture
USDA-NRCS	United States Department of Agriculture Natural Resources Conservation Service
USGS	United States Geological Survey
Central Valley Water Board	Central Valley Regional Water Quality Control Board
WDR	Waste Discharge Requirement
Workplan	SSJV MPEP Workplan

1 BACKGROUND AND PURPOSE

The Kaweah Coalition's GQMP was submitted in February 2015, and comments received from the Central Valley Water Board at the end of June 2016. During this 16-month interval, a great deal transpired as the LTILRP developed. Among these developments, the Kaweah Coalition joined with six others to form the SSJV MPEP Committee (Committee), and hired the MPEP Team to develop a workplan. This process and the Discussion Draft Workplan (2016; Workplan) advanced everyone's understanding of what the MPEP would entail, and when it would begin to produce results. Kaweah can

now draw on this work to more clearly articulate how management practices will be identified, communicated to growers, implemented, and assessed, as requested in comments received from the Central Valley Water Board.

The Workplan deals explicitly with how that program will interface with individual coalitions, including their GQMPs. Section 2.1.3 (Exchanging Data with Coalitions and Informing Groundwater Quality Analyses) reads as follows:

As mentioned previously, individual LTILRP coalitions are engaged in complementary activities that can inform the MPEP and allow for more rapid, effective work. Examples of data and work products from the coalitions that are potentially relevant to the MPEP include the following:

- *Coalitions' data about the type and location of practices are fundamental to assessing the effects of irrigated agriculture on underlying groundwater. These data might arise from the following sources:*
    - *Farm Evaluations*
    - *Nitrogen Summary Reports*
    - *GARs*
    - *Trend Monitoring Reports*
- *Methodology and results (e.g., surface loading, loading to groundwater) from the MPEP can inform Groundwater Quality Management Plans (GQMPs) and other groundwater analyses undertaken by coalitions.*

Since the General Order provides for GQMPs to identify priority/urgent areas, and requires an MPEP to develop practices for such areas, it follows that the output of the MPEP should satisfy GQMP requirements related to management practices. The purpose of this memo is to fulfil this requirement for member coalition GQMPs related to nitrate.

The MPEP can satisfy management practice related requirements for any constituent of concern (COC), as evidenced by the following passage from Section 1 of the Workplan:

The current General Orders focus on controlling nitrate (NO_3) contamination of groundwater by irrigated agriculture, but the overall program also pertains to other constituents that could be construed as pollutants (e.g., sediment in runoff, salts). Nitrate movement through irrigated lands is therefore the main focus of this Workplan. If at some point other constituents need to be addressed by growers, the MPEP would likely serve the same functions for those constituents. At that time, addenda to this Workplan might be required to supplement and update the general approach with specific considerations relative to those constituents. However, the general approach described here, if successful, would otherwise remain intact.

Thus, for the Kaweah GQMP, where salinity and pesticides must be addressed, the MPEP will expand to incorporate practices that are protective relative to these COCs, in addition to practices deemed protective relative to nitrate.

The Workplan describes early outreach and assessment components:

- *…the initial inventory of management practices will result in a list of known, protective practices that will move immediately into this outreach process. It will be discussed with advisors and growers during 2016-17 meetings. Information on these practices will also be featured in an organized, accessible fashion on the Grower/Advisor Webpage, which water quality coalition membership will be encouraged to consult.* (p. 3-69)
- *…outreach products and activities will be documented and shared with the Central Valley Water Board in regular communications such as quarterly meetings and as part of required reporting.* (p. 3-69)
- …benchmarking the current degree of adoption of BMPs across the MPEP area. (p. 3-36)… Studies of management practice and production data from Farm Evaluations and Nitrogen Summary Reports, as supported and sanctioned by member coalitions, as well as similar data from packers who may gather such data from growers with whom they work. If these data are of sufficient quality, they could provide extremely powerful information about grower practices. (p. 3-38)
- *…a Grower/Advisor Webpage on its website, which includes an organized collection of many useful tools and references that already exist. This site will be updated as additional information becomes available from the Committee, member coalitions, partners (including the Central Valley Water Board), and other sources. This handy collection of resources for minimizing loss of applied nitrogen to groundwater will be available not only to member growers, but to growers and grower advisors anywhere. The Committee hopes that such a grower-oriented collection, focused on means to address this problem through sound management, will help growers actually apply these solutions in their practices on their fields, which must be done for actual benefits to be realized. Additional online tools, information, and applications will be developed to meet specific needs. For example:*
    - *Helpful information for growers and their advisors to efficiently derive maximum benefit from required Nitrogen Management Planning processes can be provided.*
    - *Tools to facilitate second-language growers to understand and comply with LTILRP requirements and derive maximum water quality and production advantages.*
    - *Query-able management practice databases to assist growers in evaluating the potential cost and benefits (production, water quality, labor) benefits of various suites of management practices, applied at their specific management block locations and planting dates. (p. 3-68)*

One purpose and feature of the SSJV MPEP is an efficient, collective effort to identify and increase implementation of protective practices, mainly by working with member coalitions to understand grower needs and to help them with resources to achieve this goal. As stated on page 2-6 of the Workplan:

- *Member coalitions are linked directly to the MPEP by their participation in the Committee. Growers are linked to the MPEP through their membership in their coalitions, meetings, communications, and data gathering. Growers will also participate in commodity, other winter, and special-purpose meetings where MPEP findings will be discussed during outreach sessions. Presenters primarily will*

be technical collaborators from public-sector research and extension, as well as private-sector production and grower experts.

Therefore, it is natural and appropriate that when information and outreach to promote implementation of protective practices is identified as part of a Groundwater Quality Management Plan developed by one of the member coalitions, work of this sort being done as part of the MPEP should be incorporated. It is understood that GQMPs signify high priority areas where a prompt response is required of the coalitions. At this time, as evidenced in excerpts from the Workplan, the corresponding elements of the MPEP are scheduled for the coming months and therefore constitute a timely component of the GQMP. For example, the soonest that growers can be convened to discuss practices for the next (2017) season is fall 2016/winter 2017, the very period targeted in the MPEP for early outreach.

The purpose of this document is to summarize the following:

- Protective management practices identified to for application as part of GQMPs
- Use of outreach to expand implementation of protective practices, including assessment of barriers to adoption and grower response to outreach
- Assessment of barriers to adoption, the impact of outreach, and the extent of practice implementation

2 MANAGEMENT PRACTICE OVERVIEW FROM WORKPLAN AND EXPANDED MANAGEMENT PRACTICE INVENTORY

Table 3-3, beginning on page 3-28 of the workplan contains a summary of the range of protective management practice types. That table is reproduced here for convenient reference, and will be used to frame more specific and expanded descriptions of practices that will be shared with growers.

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
Irrigation and Drainage Design and Operation		
Irrigation System Evaluation and Monitoring		
1	Conduct irrigation system performance evaluation	Operational cost, land tenure, training
2	Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	Capital cost, operational cost, training
3	Conduct pump performance tests	Operational cost, training
Irrigation Scheduling		
4	Use weather-based irrigation scheduling	Operational cost, logistics, training, technology
5	Use plant-based irrigation scheduling	Operational cost, logistics, training

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
6	Use soil moisture content to guide irrigation timing and amount	Operational cost, logistics, training
7	Avoid heavy pre-plant or fallow irrigations for annual crops	Risk to yield or quality, logistics, training
Surface Gravity System Design and Operation		
8	Convert to surge irrigation	Capital cost, operational cost, logistics, training
9	Use high flow rates initially, then cut back to finish off the irrigation	Operational cost, logistics, training
10	Reduce irrigation run distances and decrease set times	Risk to yield or quality, capital cost, operational cost, land tenure, training
11	Increase flow uniformity among furrows (e.g. by compacting furrows)	Operational cost
12	Grade fields as uniformly as possible	Operational cost, training
13	Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	Capital cost, operational cost, land tenure, training
Sprinkler System Design and Operation		
14	Monitor flow and pressure variation throughout the system	Operational cost
15	Repair leaks and malfunctioning sprinklers; follow manufacturer recommended replacement intervals	Capital cost, operational cost, training
16	Operate sprinklers during the least windy periods, when possible	Logistics
17	Use offset lateral moves	Operational cost, logistics, technology
18	Use flow-control nozzles when pressure variation is excessive	Capital cost, land tenure, training
Drip and Micro-sprinkler System Design and Operation		
19	Use appropriate lateral hose lengths to improve uniformity	Training, capital cost
20	Check for clogging; prevent or correct clogging	Operational cost, capital cost, training
Other Irrigation Infrastructure Improvements		
21	Installation of sub-surface drains in poorly drained soils[1]	Capital cost, technology
22	Backflow prevention	Capital cost, training
Crop Management		

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

Management Practice		Barriers to Adoption
Change Crops to Use Those with Smaller N Requirements and Greater N Efficiency		
23	Cover crops to recover residual soil nitrate and immobilize it in soil organic matter	Risk to yield or quality of cash crop, capital cost, operational cost, logistics, training, technology, increased irrigation requirements for the cash crop
24	Include deep-rooted or N-scavenger crop species in annual crop rotations	Risk to yield or quality, capital cost, operational cost, logistics
25	Include perennial crop in rotation, e.g. alfalfa or perennial grasses	Capital cost, logistics, land tenure
Nitrogen Fertilizer Management		
Improve Rate, Timing and Placement of N Fertilizers		
26	Adjust N-fertilizer rates based on soil nitrate testing	Operational cost, training
27	Adjust timing of N fertilization based on plant tissue analysis	Risk to yield or quality, operational cost, training, lack of robust relationships between tissue test and amount of N fertilizer required
28	Apply N fertilizer in small multiple doses, rather than one or two large doses, to meet crop demand during the growing season without deficiency or excess	Operational cost, training
29	Know N content of irrigation water and adjust fertilizer rates accordingly	Operational costs, logistics, training
30	Reduce total N-fertilizer rates by replacing low-uptake-efficiency N-fertilizer applications to soil with high-uptake-efficiency foliar-N applications	Operational costs, training, technology
31	Vary N-application rates within large fields according to site-specific needs based on heterogeneity in soil N supply and/or crop growth	Operational costs, capital costs, training, technology
32	Use delayed injection procedure when fertigating in surface gravity systems	Operational costs, logistics, training
34	Develop an N budget that includes crop N harvest removal, supply of N from soil and other inputs to guide decisions on N-fertilizer rates and timing	Operational costs, training, technology

TABLE 2-3. MANAGEMENT PRACTICES DOCUMENTED TO IMPROVE NITROGEN FERTILIZER EFFICIENCY AND BARRIERS TO THEIR ADOPTION AS MODIFIED FROM DZURELLA ET AL. (2012). *TABLE REPRODUCED FROM WORKPLAN.*

	Management Practice	Barriers to Adoption
35	Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	Risk to yield quantity or quality, capital cost, training, technology, benefits depend on soil types and N-fertilizer management practices
Improve Rate, Timing, and Placement of Animal Manure and Organic Amendment Applications		
36	Apply appropriate rates of manure and compost, taking N mineralization characteristics of these organic N sources into account	Risk to yield quantity or quality, operational cost, logistics, training, technology
37	Incorporate solid manure immediately to decrease ammonia volatilization loss	Operational costs, training
38	Use delayed injection to improve application uniformity when applying liquid manure in surface-gravity irrigation systems	Operational cost, logistics, training, technology
39	Use quick-test methods to monitor dairy lagoon water N content immediately before and during application, and adjust application rate accordingly	Operational costs, training, technology
40	Calibrate solid manure and compost spreaders	Operational cost, logistics, training

[1]Presumably beneficial to N management primarily by promoting more uniform crop growth and N uptake across the field.

This brief list of practices captures most of the categories of practices available to growers to retain mobile nutrients (like nitrogen) in their root zone so that the largest practicable proportion of it is used by the plant, and the least practicable amount percolates downward. Many practices are usable as they are stated (e.g., item 40, calibration of solid manure and compost spreaders could be implemented by any grower using these implements). Some require crop-specific information (e.g., item 27, adjusting timing of N fertilization based on plant tissue analysis requires that reference values for specific tissues be established, along with sampling and analysis protocols that produce consistent results). Not all practices apply to all crops. For example, tissue tests have not been found to be useful when assessing almond N status.

As part of early outreach, the SSJV MPEP is working with CDFA, UCCE, and other partners to inventory known protective management practices. This inventory is informed by the rather substantial knowledge base (literature, scientific and grower expertise) regarding practices that help growers to retain N for crop use and avoid excessive percolation losses. The inventory is being developed in database format so that it can be deployed in prioritizing and developing outreach curriculum, working with coalitions to assess implementation through Farm Evaluations, and to serve as an online resource to help growers explore and develop their management options. Practices tie into MPEP modeling/performance assessments too, since most can be quantitatively captured in model parameters and results. The inventory currently contains over 150 practices associated with various crops and crop classes, has identified 23 high-priority documents for review, posted 22 references in an online collection of grower resources (http://www.ssjwqc.org/_pdf/MPEP%20Tables.pdf), and identified

another 29 to be posted. The inventory is being further augmented and will be posted during the coming months.

GQMP

3 METHODOLOGY

This section describes methods used for outreach, and for the assessment of how well outreach is working so that it can be improved.

3.1 OUTREACH

Coalitions and partners (UCCE, USDA/NRCS, CSU, CDFA, commodity groups) all have ongoing outreach programs that are partly or wholly devoted to sharing protective management practices with growers with the goal of broader implementation. The MPEP/GQMP outreach program aims to harness and supplement these programs to ensure that ILRP commitments are met, and to document these activities. To this end, MPEP/GQMP outreach will entail the following:

- A database of outreach and outreach-related activities and products, including dates, format (live presentation, video, online tools, or hardcopy literature [mailings, fliers]), practices covered, and number of grower/members participating. To the extent practicable, this will include events that occurred before the inception of the database. This database will periodically be shared with the Water Board so that staff can assess outreach.

- Curricula developed in the form of meeting materials (agendas and presentations), video, fliers, and online tools and informational resources.

- A network of cooperating partners, including other water quality coalitions, CDFA, UCCE, private-sector experts (e.g., CCAs), CSU, NRCS, and commodity groups will be tapped to assist with development and delivery of curricula. The video and online options will help to extend these scarce resources to meet what is a growing need. CDFA staff are currently working with the MPEP Team to expand the practices inventory. One or more protective practices workshops are planned with UCCE in the September/October timeframe, specifically to finalize curricula for the early-outreach period. All of these groups have been involved in developing the Workplan.

- Growers already attend many meetings where protective practices to achieve good environmental performance are discussed. The Workplan specifies that, to make the best use of grower's and partner's time, curricula will be delivered at these meetings whenever practicable. The MPEP Team is identifying candidate meetings and working with organizers to include on their agendas protective practice sessions where the curricula can be delivered to growers. Many of the partners listed previously are responsible for convening these meetings and are the focus of these contacts.

3.2 ASSESSMENT

While outreach is crucial for reaching growers, follow up and assessment are essential to understanding how effective outreach is. Assessment results will guide refinement of outreach so that it can become increasingly effective at informing and affecting grower behavior, and in expanding implementation of protective practices that are suitable to each crop, soil, climate, and hydrographic setting. Assessment methods are discussed in this section.

The means and methods for assessing outreach consist of the following:

- A database of outreach activities (including sponsor, subject matter, locale, number of participants, and curricula) has been developed to capture past, ongoing, and future activities. All relevant activities will be included, whether sponsored by water quality coalitions or not. This is appropriate since the MPEP strategy is to multiply effort through collaboration with a wide range of partners.
- Barriers to adoption will be investigated by discussing individual practices with key resource persons, including growers and those who work closely with them (CCAs, Farm Advisors, and NRCS staff). Once a barrier is identified, means will be sought to lower this barrier. Some examples of barriers and actions that may be taken to alleviate them include the following:
    - When growers or farmworkers lack information or training, this can be supplemented through outreach.
    - When practices are exceedingly complex, simplified versions, or tools that enable growers to cope with complexity, can be developed.
    - When material resources are lacking, funding and volume pricing can be sought to offset costs.
    - When practices are ill adapted to certain types of operations or soil/topographic/management settings, more workable alternatives will be sought, and the “recommendation domain” (the conditions under which the practice is applicable and necessary) will be adjusted. Ideally, each practice should be associated with a defined recommendation domain. In some cases, questions of applicability and alternative practices will need to be fed back into field research performed by MPEP research partners.
- Grower receptivity and comprehension to outreach topics will be assessed by discussing practices with groups of growers participating in outreach events. Results will be employed to adjust and/or supplement outreach curricula, and to follow up with participants, so that practices as communicated are acceptable and understood by participants.
- Management practice implementation will be tracked through Farm Evaluation data. As mentioned previously, certain practices are already included in Farm Evaluations. As other priority practices are identified, these will be added so that the extent and pace of implementation can be tracked. This information will also inform landscape-level modeling that demonstrates program performance. Many management parameters, when known, can be included among model management parameters, so that model output will reflect performance changes over time that result from management shifts.

4 SCHEDULE

[This section to be developed separately by each coalition, depending on their individual order, GQMP, and program.]

5 REFERENCES

MPEP Team for the SSJV MPEP Committee. May 2016. Discussion Draft Management Practices Evaluation Workplan, Southern San Joaquin Valley MPEP Committee.

Kaweah Basin
Water Quality Association

www.kaweahbasin.org