

### 3. Initial Assessment of Groundwater Conditions

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The initial assessment of nitrate groundwater conditions for the Preliminary Management Zone Proposal is based on readily available existing data and information. Where possible, information from the Central Valley SNMP (CV-SALTS 2016a) was used and updated with more recent groundwater quality data from publicly available sources. Key data sources for this assessment included:

- Supplemental information on groundwater within the proposed KRE/AID Management Zone was obtained via DWR's Bulletin 118 (DWR 2003). This document provides an overview of groundwater conditions (both groundwater levels and groundwater quality) in specific subbasins. Bulletin 118 also contains descriptions of groundwater basins and subbasins in California, with many descriptions updated from their 2003 descriptions in 2016 (DWR 2016). DWR also released their statewide Groundwater Basin Prioritization in 2014 and 2015,<sup>1</sup> which contains basic information on each groundwater basin including population, population growth, total number of public supply wells, groundwater volume, percent of total water supply supplied by groundwater, irrigated acreage, and other comments on groundwater levels or quality specific to aquifers within the basin.
- The KRE GSA, which overlays most of this proposed Management Zone is actively working on the development of its GSP,<sup>2</sup> which is due to DWR on or before January 31, 2020. The GSP will contain additional hydrogeological information including cross sections, description of the distribution of groundwater pumping (spatially and vertically), groundwater flow directions (possibly with more information on the northeastern and southeastern portions of the Management Zone where DWR does not currently have groundwater elevation contour data), and any additional non-public groundwater quality data.
- CV-SALTS technical findings, which included projects from areas within this proposed Management Zone:
  - High-resolution mapping analysis of nitrate and total dissolved solids (TDS) groundwater quality in the Central Valley Region (CV-SALTS 2016c). The high resolution mapping of salt and nitrate was completed for the Upper, Lower, and Production Zones of the groundwater system, which are defined in the documentation. Ambient TDS and nitrate conditions are provided, as well as assimilative capacity, groundwater quality trends, and predicted conditions (after 10, 20, and 50 years). The CV-SALTS high resolution dataset utilizes groundwater quality data from 2000-2016.
  - Conceptual management zone study (AID Management Zone Archetype Study), which was developed and implemented in a collaborative setting with local stakeholders, served as an example and “proof of concept” to help test, on a spatially refined basis, the

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<sup>1</sup> [https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel\\_BasinRank\\_by\\_HR\\_5-18-15.pdf](https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf)

<sup>2</sup> The KREGSA GSP outline is available on the Kings River East GSA's website: <https://kingsrivereast.org/wp-content/uploads/2019/01/kregsa-gsp-outline.pdf>, accessed June 2019.

application of selected policies, data analysis methods, and salt and nitrate management approaches under consideration by CV-SALTS (CV-SALTS 2016b).

- Through CV-SALTS a Nitrate Implementation Measures Study was conducted to identify potential nitrate management controls (e.g., pump, treat, and serve, or pump, treat, and re-inject) that could be deployed to improve water quality (CV-SALTS 2016d). At the same time the AID Management Zone Archetype Study (CV-SALTS 2016b) evaluated a number of management scenarios and the potential benefits to water quality within the AID area. To better understand the types of nitrate control measures that would be necessary to meet implement a management aquifer restoration program (i.e., improve water quality so that it meets the 10 mg/L nitrate MCL), the Aggressive Restoration Modeling Scenario Study was completed within a portion of the proposed Management Zone area to link nitrate management scenarios with selected nitrate management controls and on-farm winter recharge to determine how groundwater quality was affected (CV-SALTS 2016e).

**Table 3-1** summarizes sources of data reviewed and accessed to complete this Initial Assessment of Groundwater Conditions.

### **3.1 Hydrogeology**

The proposed Management Zone is located in the eastern part of the Kings Subbasin of the San Joaquin Groundwater Basin. DWR's Bulletin 118 describes the Kings Subbasin as lying between the San Joaquin River to the north; the eastern contact of the alluvium with the metasedimentary, metavolcanics, and granitic rocks of the Sierra Nevada foothills; and jurisdictional boundaries to the south and west, including the Tulare/Kings County line, the Kings River, and the Westlands Water District. According to the Bulletin 118 description, the Kings Subbasin receives 7 to 10 inches of average annual precipitation, increasing eastward (DWR 2006).

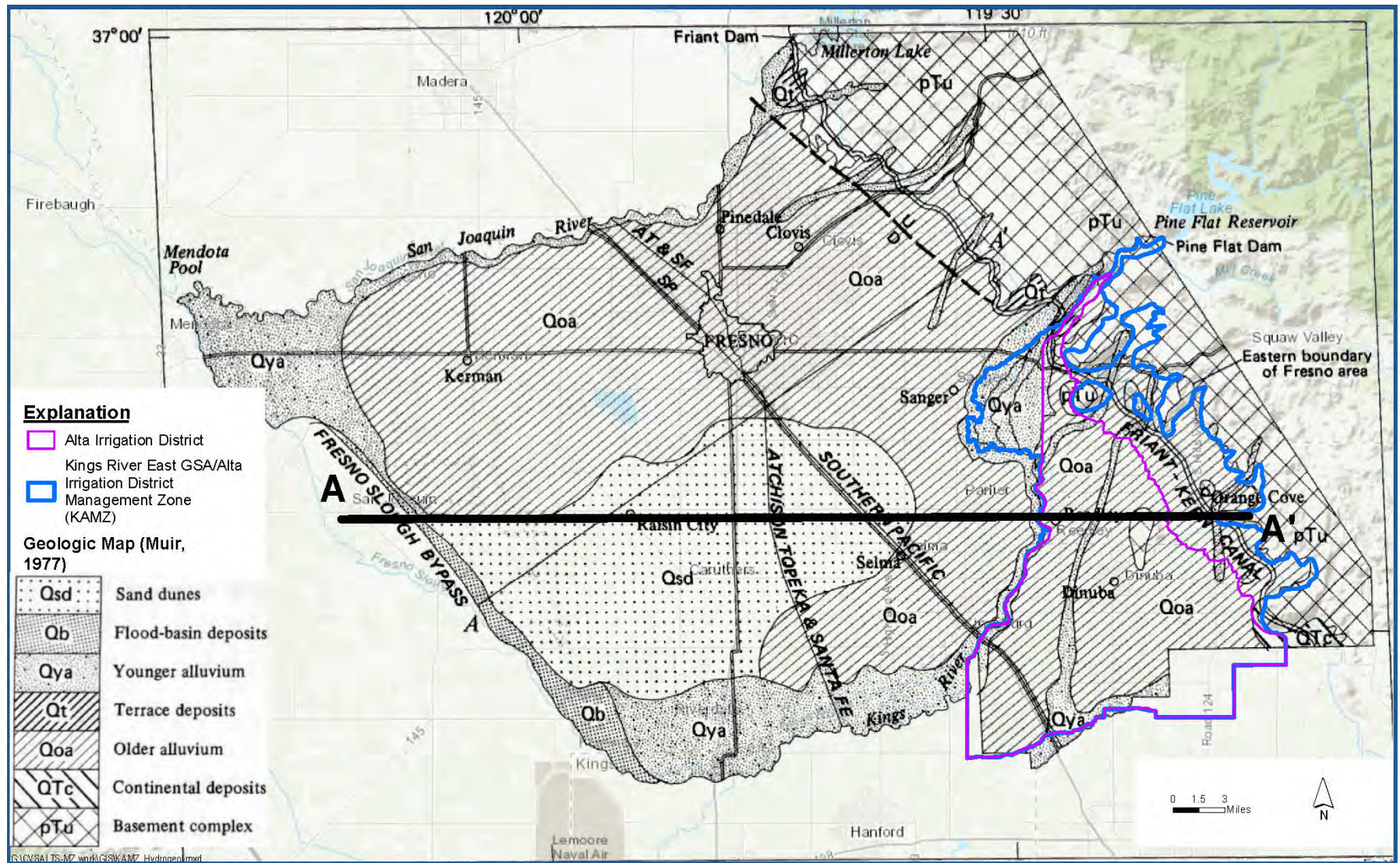
The primary hydrogeologic units in the Kings Subbasin consist of unconsolidated continental deposits of Tertiary and Quaternary age, overlain by a younger series of deposits of Quaternary age. In the Management Zone area, most of the surface geology consists of continental deposits and younger alluvium, whose thickness pinches out steeply to the east toward the Sierra Nevada foothills where the basement complex forms a border between the alluvium.

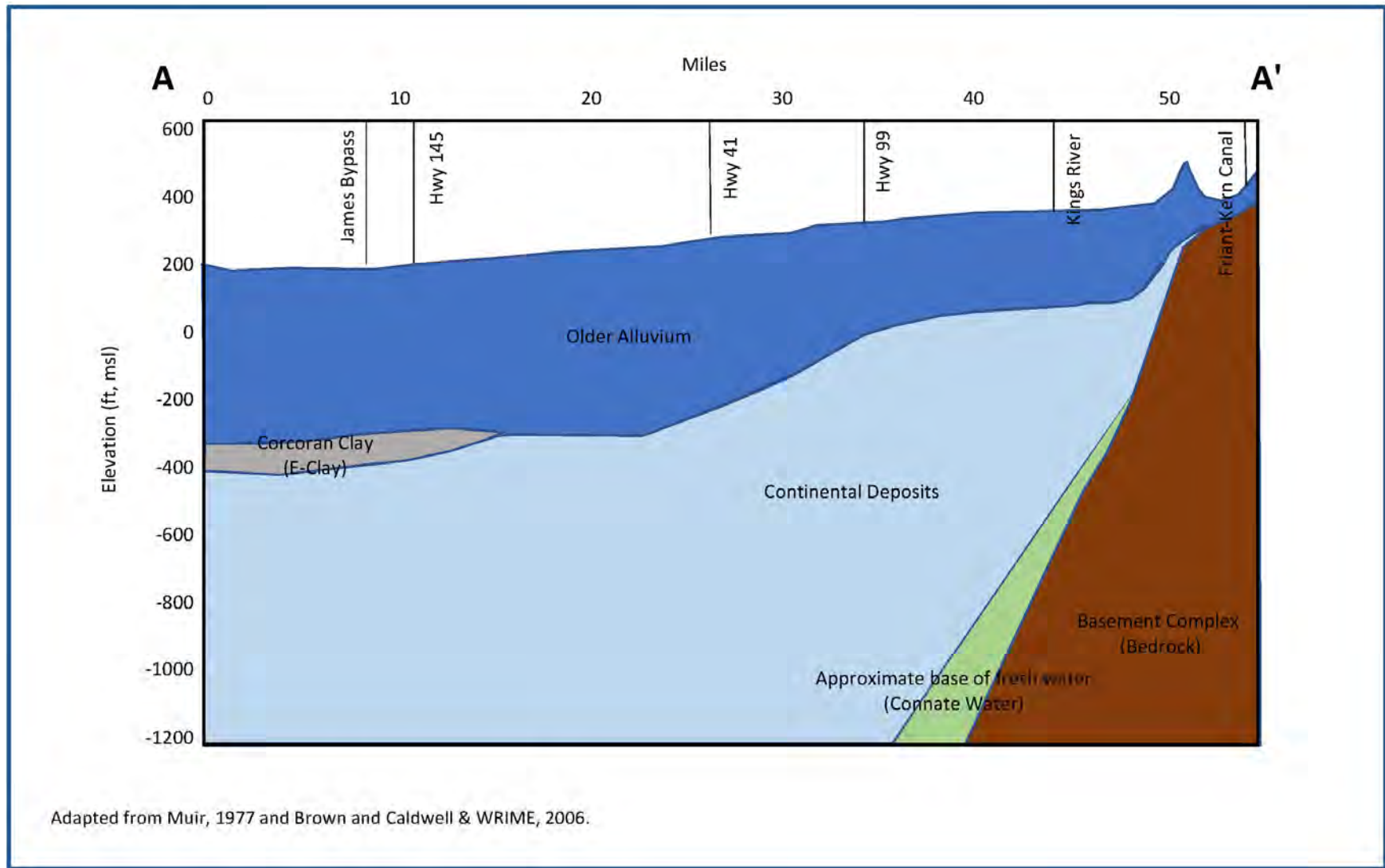
**Figure 3-1** shows the surficial geology and cross section location map; **Figure 3-2** illustrates a general depiction of the hydrogeologic units in map and cross-sectional forms for the eastern portion of the Kings Subbasin (adapted from Muir 1977; Brown and Caldwell & WRIME 2006). The Corcoran Clay (E-Clay) is also an important feature in the Kings Subbasin, and is generally present on the west side of the subbasin, west of the Management Zone area.

**Table 3-1. Data Sources Accessed to Develop Initial Assessment of Groundwater Conditions**

Data Source	Link
<b>General Groundwater Conditions</b>	
DWR Bulletin 118 overview of basin/subbasin conditions (groundwater levels and groundwater quality)	<a href="https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118">https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118</a>
DWR's Groundwater Sustainability Basin Prioritization	<a href="https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf">https://water.ca.gov/LegacyFiles/groundwater/casgem/pdfs/lists/PubRel_BasinRank_by_HR_5-18-15.pdf</a>
Individual GSA's Hydrogeologic Conceptual Model, via request to the GSA Point of Contact	<a href="https://sgma.water.ca.gov/portal/gsa/all">https://sgma.water.ca.gov/portal/gsa/all</a>
CV-SALTS High Resolution Salt and Nitrate Mapping for Region 5	<a href="https://www.cvsalinity.org/committees/technical-advisory/conceptual-model-developments/171-updated-groundwater-quality-analysis-for-central-valley.html">https://www.cvsalinity.org/committees/technical-advisory/conceptual-model-developments/171-updated-groundwater-quality-analysis-for-central-valley.html</a>
Other CV-SALTS Studies within the proposed Management Zone area	<ul style="list-style-type: none"> <li>Nitrate Implementation Measures Study: <a href="https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/implementation-planning/3275-20160331-nims-report-rev1/file.html">https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/implementation-planning/3275-20160331-nims-report-rev1/file.html</a></li> <li>AID Management Zone Archetype Study: <a href="https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/conceptual-model-development/3335-aid-management-zone-report-final-may-2016-072916/file.html">https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/conceptual-model-development/3335-aid-management-zone-report-final-may-2016-072916/file.html</a></li> <li>Aggressive Restoration Scenario Study: <a href="https://www.cvsalinity.org/docs/ceqa/ceqa-documents/3525-final-tm-aggressive-restoration-scenario-09292016.html">https://www.cvsalinity.org/docs/ceqa/ceqa-documents/3525-final-tm-aggressive-restoration-scenario-09292016.html</a></li> </ul>
<b>Publicly Available Groundwater Quality Data Sources</b>	
GeoTracker GAMA	<a href="http://geotracker.waterboards.ca.gov/gama/gamamap/public/">http://geotracker.waterboards.ca.gov/gama/gamamap/public/</a>
DWR Water Data Library	<a href="http://wdl.water.ca.gov/waterdatalibrary/waterquality/index.cfm">http://wdl.water.ca.gov/waterdatalibrary/waterquality/index.cfm</a>
USGS National Water Information System	<a href="https://waterdata.usgs.gov/nwis/gw">https://waterdata.usgs.gov/nwis/gw</a> )
GeoTracker Regulated Facilities	<a href="http://geotracker.waterboards.ca.gov/">http://geotracker.waterboards.ca.gov/</a> and <a href="http://geotracker.waterboards.ca.gov/datadownload">http://geotracker.waterboards.ca.gov/datadownload</a>
Division of Drinking Water	<a href="https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html">https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html</a> )
<b>County-Specific Data Available by Request</b>	
Fresno County state small water systems and domestic/local small water systems (water quality data)	<a href="https://www.co.fresno.ca.us/departments/public-health/environmental-health">https://www.co.fresno.ca.us/departments/public-health/environmental-health</a>
Kings County state small water systems (water quality data)	<a href="https://www.countyofkings.com/departments/health-welfare/environmental-health-services-1">https://www.countyofkings.com/departments/health-welfare/environmental-health-services-1</a> <a href="https://www.countyofkings.com/departments/community-development-agency">https://www.countyofkings.com/departments/community-development-agency</a>
Tulare County state small water systems (water quality data)	<a href="https://tularecountyeh.org/eh/">https://tularecountyeh.org/eh/</a> <a href="https://tularecounty.ca.gov/tcict/index.cfm/information-services/geographic-information-system-gis/">https://tularecounty.ca.gov/tcict/index.cfm/information-services/geographic-information-system-gis/</a>







**Figure 3-2. Conceptual Hydrogeologic West-East Cross Section of the Kings Subbasin**



### 3.1 Groundwater Elevations and Flow

Regional groundwater flows generally from the Sierra Nevada foothills to the west and south, following the regional dip of basement rock and sedimentary units. Contours of equal groundwater elevation are available from DWR for Spring 2018 (**Figure 3-3**).<sup>3</sup> This map shows groundwater entering the proposed Management Zone from the eastern border and flowing mostly southwest. Groundwater levels are highest in the east and lowest in the southwest. The Kings River East GSA is in the process of developing their own description of groundwater levels in the Management Zone area of the Kings Subbasin, which could be used to supplement this section.

### 3.2 Upper Zone Delineation

The Upper Zone refers to the upper portion of the groundwater aquifer system used for determining ambient nitrate conditions in the Management Zone. The depth of the Upper Zone includes the depth from the bottom of the vadose zone to the top of the Lower Zone. The depth of the Upper Zone is based on well construction information, as possible, and other comparable information that provide the best available indication of well depth. The determination of the Upper Zone depth gives the highest weight to domestic well depths (**Table 3-2** for more explanation). Where the Corcoran Clay (or E-Clay) is present, the Upper Zone does not extend below the Corcoran Clay.

**Table 3-2. Basis for Determining Depth of the Upper Zone**

Date Layer	Weights for Establishing Bottom of Upper Zone
Domestic Wells Bottom Perforations	40%
Farm Virtual Wells Top Perforations	10%
Urban PWS Top Perforations	20%
Rural PWS Top Perforations	20%
DDW Systems Top Perforations	10%
<b>Total</b>	<b>100%</b>

CV-SALTS (2016c) determined the boundaries of the Upper and Lower Zones throughout the Central Valley Floor through high resolution nitrate and TDS mapping using GIS spatial analyses of several layers of data. Well construction data were used in combination with depth to water contours and characteristics of the Corcoran Clay, including the extent, depth, and thickness of this significant clay member. Data for the development of the Upper and Lower Zones originated from:

- DWR depth to groundwater contours;
- Depth to groundwater from Groundwater Quality Assessment Reports;
- State Water Board's DDW database of location and construction information for public water systems;

<sup>3</sup> Groundwater contour data is available through DWR's Groundwater Information Center Interactive Map Application (GICIMA) website: <https://gis.water.ca.gov/app/gicima/>

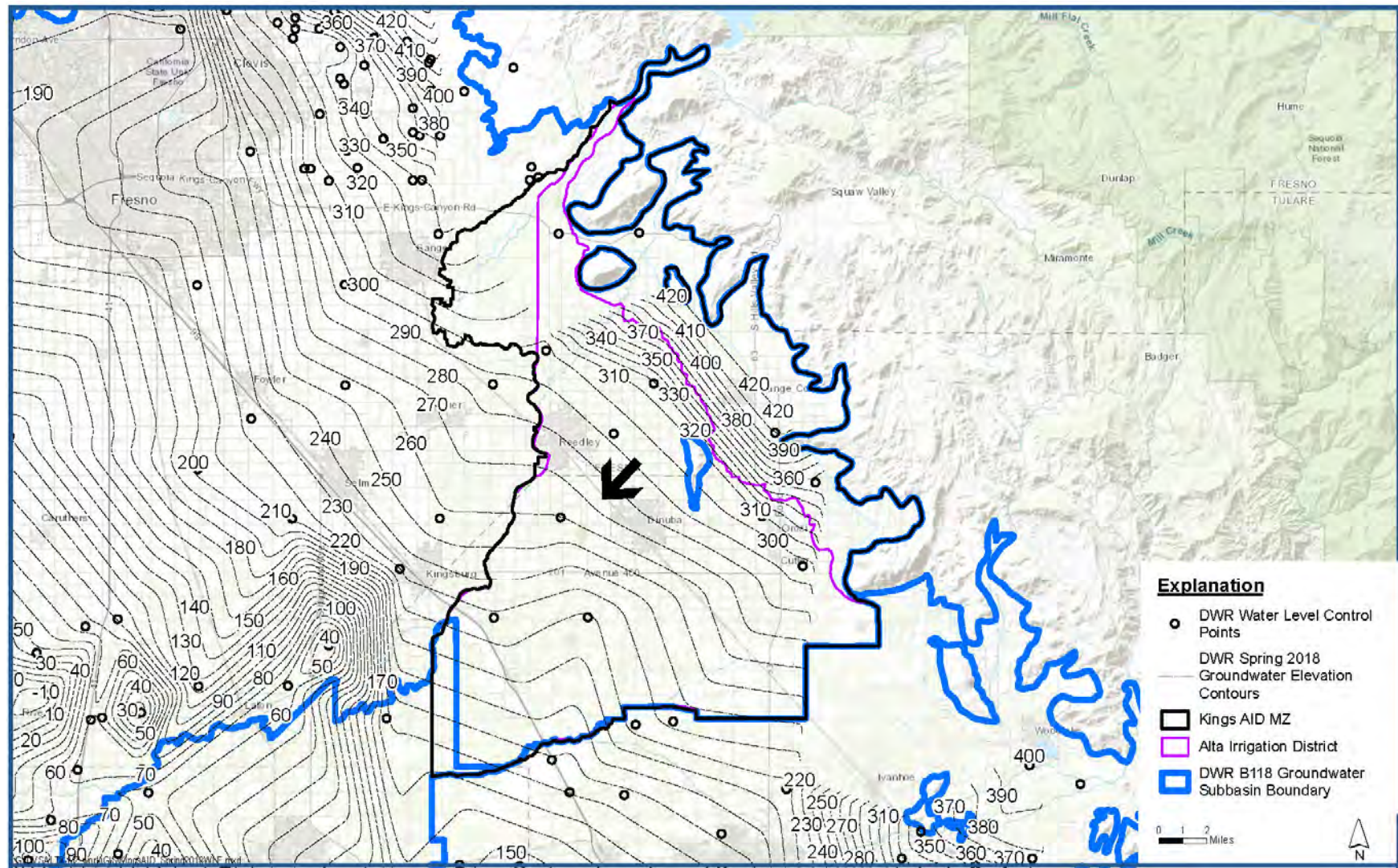


Figure 3-3. Spring 2018 Groundwater Elevation Contours for the for proposed Management Zone and Adjacent Areas.

- US Geological Survey (USGS) California Central Valley Hydrologic Model 2.0 (CVHM2; in progress):
  - Modeled virtual farm well construction for agricultural pumping
  - Actual rural public well water system well construction information
  - Actual urban public well water system well construction information
  - Texture database of driller's logs, including domestic well construction information
  - Corcoran Clay depth, thickness, and extent

The above data were used to create interpolated layers over the Central Valley Floor of different well types and their perforation depths. The well construction layers were then combined in a weighting process to estimate where pumping occurs for the predominant well types. The weights provided in Table 3-2 were then used for calculating the depth to the bottom of the Upper Zone. **Figure 3-4** shows the depth to the bottom of the Upper Zone in the proposed Management Zone, as delineated in previous CV-SALTS efforts. Generally, the depth to the bottom of the Upper Zone is between 84 and 230 feet below ground surface in the Management Zone.

### **3.3 Nitrate Water Quality**

**Table 3-3** summarizes the groundwater quality data that were readily available for use to develop this Preliminary Management Zone Proposal. These data included data previously developed for CV-SALTS and additional data obtained in 2019. Nitrate measurements and well data were compiled for the Management Zone from the data sources listed in Table 3-3. Nitrate data were summarized by data source, depth, and recent nitrate exceedances.

**Table 3-4** provides a summary of wells with nitrate measurements in the proposed Management Zone by well source. A total of 645 wells have nitrate data in the Management Zone, most of them (488 wells, or about 76%) have nitrate measurements since January 2000, and slightly more than half of those wells with recent (post-2000) nitrate measurements have nitrate concentrations that exceed the MCL of 10 mg/L as N.

New wells added to the database since the original database was established through CV-SALTS (2016c) were categorized into an appropriate depth category (Upper Zone, Lower Zone, Upper/Lower, Below Lower, and Unknown). CV-SALTS (2016c) produced GIS coverages of the depths to the bottom of the Upper and Lower Zones (e.g., see Figure 3-4). Depth information (well depth or top of screen depth and screen length) from the new dataset were used to categorize individual wells into their appropriate depth category. Wells without construction or depth information were categorized based on their well type:



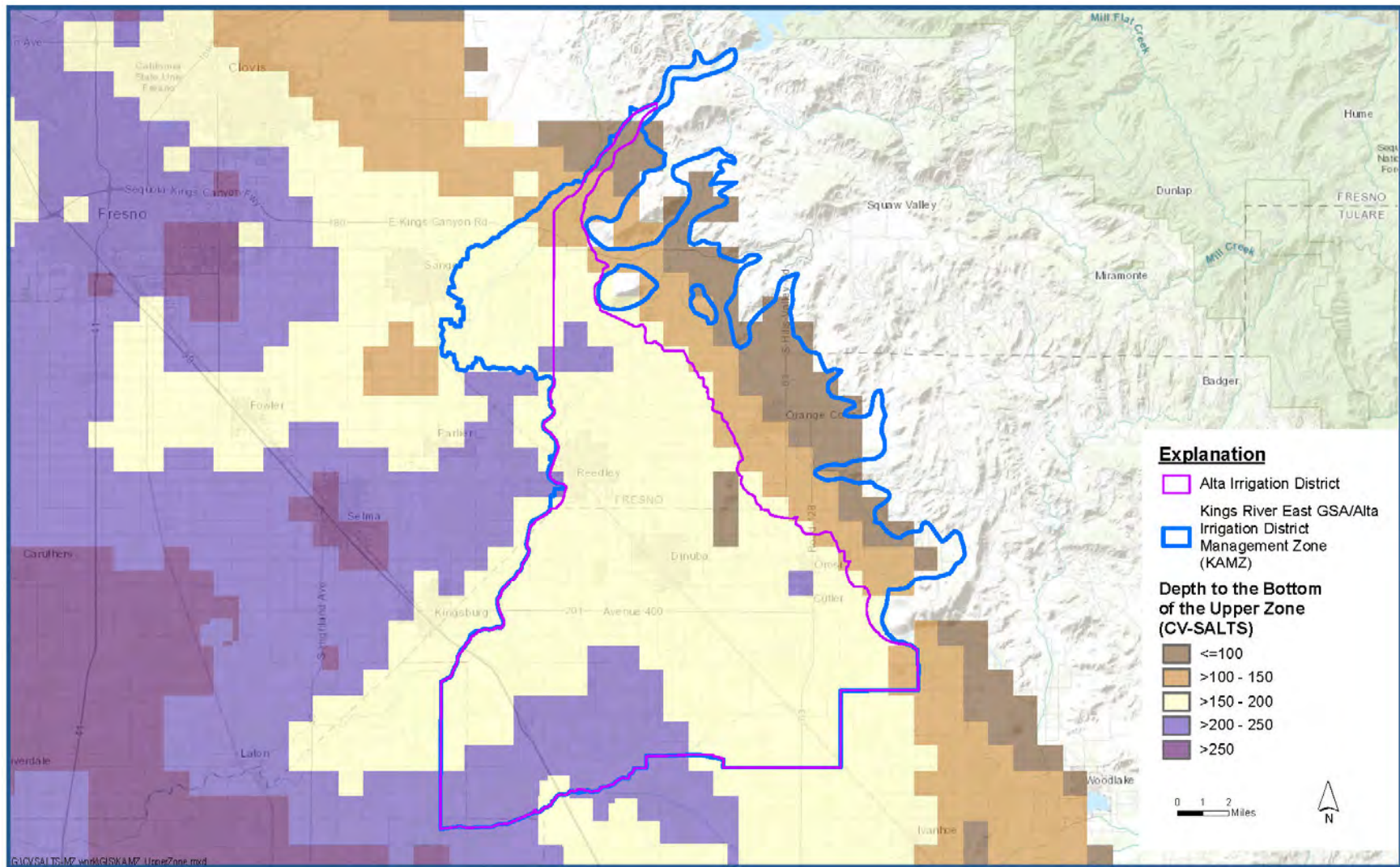


Figure 3-4. Depth to the Bottom of the Upper Zone of the Groundwater Underlying the Proposed Management Zone

**Table 3-3. Groundwater Quality Data Sources**

Data Category	Data Sources
The Phase II CV-SALTS Conceptual Model nitrate groundwater database developed for the High Resolution Mapping project (CVSALTS 2016c)	<ul style="list-style-type: none"> <li>Former California Department of Public Health (CDPH), now DDW</li> <li>DWR</li> <li>Central Valley Water Board Waste Discharge Requirements (WDR) data per the Dairy General Order</li> <li>Central Valley Water Board Regulated Sites</li> <li>State Water Board/USGS Groundwater Ambient Monitoring and Assessment Program (GAMA)</li> <li>USGS</li> </ul>
Geotracker GAMA <sup>4</sup> (Note: Not all entities had nitrate data from within the proposed Management Zone)	<ul style="list-style-type: none"> <li>Department of Pesticide Regulation</li> <li>DWR</li> <li>GAMA – Domestic Wells; Special Studies, and Priority Basin Projects</li> <li>Local Groundwater Projects</li> <li>Monitoring Wells (Central Valley Water Board Regulated Sites)</li> <li>DDW Public Water System Wells (Actual Locations)</li> <li>USGS National Water Information System (NWIS)</li> </ul>
State Small Water Systems	Fresno and Tulare Counties
Domestic Well Permit Sample Data	Fresno County
Tulare County Regional Geodatabase	Geodatabase received from GIS Analyst Mike Hickey at the County of Tulare office in February 2019; contains domestic and dairy (domestic/animal/irrigation) well data in the proposed Management Zone

**Table 3-4. Summary of Wells with Nitrate Data by Source (All Well Depths)**

Source	All Well Depth Categories		
	Wells with Nitrate Data	Wells with Post-2000 Nitrate Data	Wells with Post-2000 Nitrate MCL Exceedance
DDW	210	198	63
Dairy	75	75	59
DWR	124	0	0
GeoTracker Regulated Facilities	18	18	12
Fresno County Domestic	46	46	20
GAMA	54	54	38
Tulare County Domestic/Dairy	75	75	49
State Smalls	1	1	1
USGS	42	21	8
<b>Total</b>	<b>645</b>	<b>488</b>	<b>250</b>

<sup>4</sup> <https://geotracker.waterboards.ca.gov/gama/gamamap/public/>, accessed in February 2019)

- Municipal wells were categorized using the DWR GIS coverage of well completion report statistics, which identifies the mean total depth of municipal wells in each township/range-section. The mean municipal well depth was assigned to the municipal well with no depth information posted in Geotracker GAMA and compared to the CV-SALTS depth to the bottom of the Upper and Lower Zones in order to estimate its depth category.
- Domestic wells were placed in the Upper Zone;
- State Water Board Regulated Site monitoring wells were placed in the Upper Zone; and
- Wells with an Unknown well type were placed in the “Unknown” depth category.

Of the entire dataset of 645 available wells in the proposed Management Zone with a nitrate measurement, many of the wells (250 wells, or about 39%) are completed in the Upper Zone (**Figure 3-5**). There are more Upper Zone wells in the central and southern part of the Management Zone, with fewer Upper Zone wells located in the northeastern and southwestern parts of the Management Zone. Deeper wells are prevalent closer to the communities of Reedley, Dinuba, Cutler, and Orosi.

There are fewer wells with nitrate data available and more wells without well types and well depth/construction information in the northern portion of the MZ. **Table 3-5** identifies the number of wells in each depth category with nitrate data, with recent data (post-2000) and with recent nitrate concentrations that exceed 10 mg/L as N. Wells categorized into the Upper Zone constitute about 39% of the total wells with nitrate data (250 wells out of 645), with most (238 wells, or 95%) of those Upper Zone wells having post-2000 nitrate measurements, and slightly more than half (140 wells, or 59%) of those Upper Zone wells with recent data that have nitrate above the MCL.

**Figure 3-6** shows Upper Zone wells with recent (post-2000) nitrate measurements divided into two categories: (1) wells with all post-2000 nitrate measurements at or below the MCL of 10 mg/L as N; and (2) wells with at least one nitrate measurement exceeding the MCL of 10 mg/L as N. Upper Zone wells with recent nitrate data are sparse in the northeastern portion of the Management Zone. Upper Zone wells with measured nitrate above the MCL are scattered throughout the Management Zone, with most located in the central and southern portions of the area.

The high resolution CV-SALTS spatial analysis (CVSALTS 2016c) of nitrate in the Upper Zone was updated for this Preliminary Management Zone Proposal using the updated Upper Zone post-2000 nitrate dataset developed and described above. This update included the following steps:

- Temporal declustering: Annual average nitrate concentrations were calculated for each well for the years 2000-2018; those annual averages were then averaged to yield one average nitrate concentration representing recent conditions.



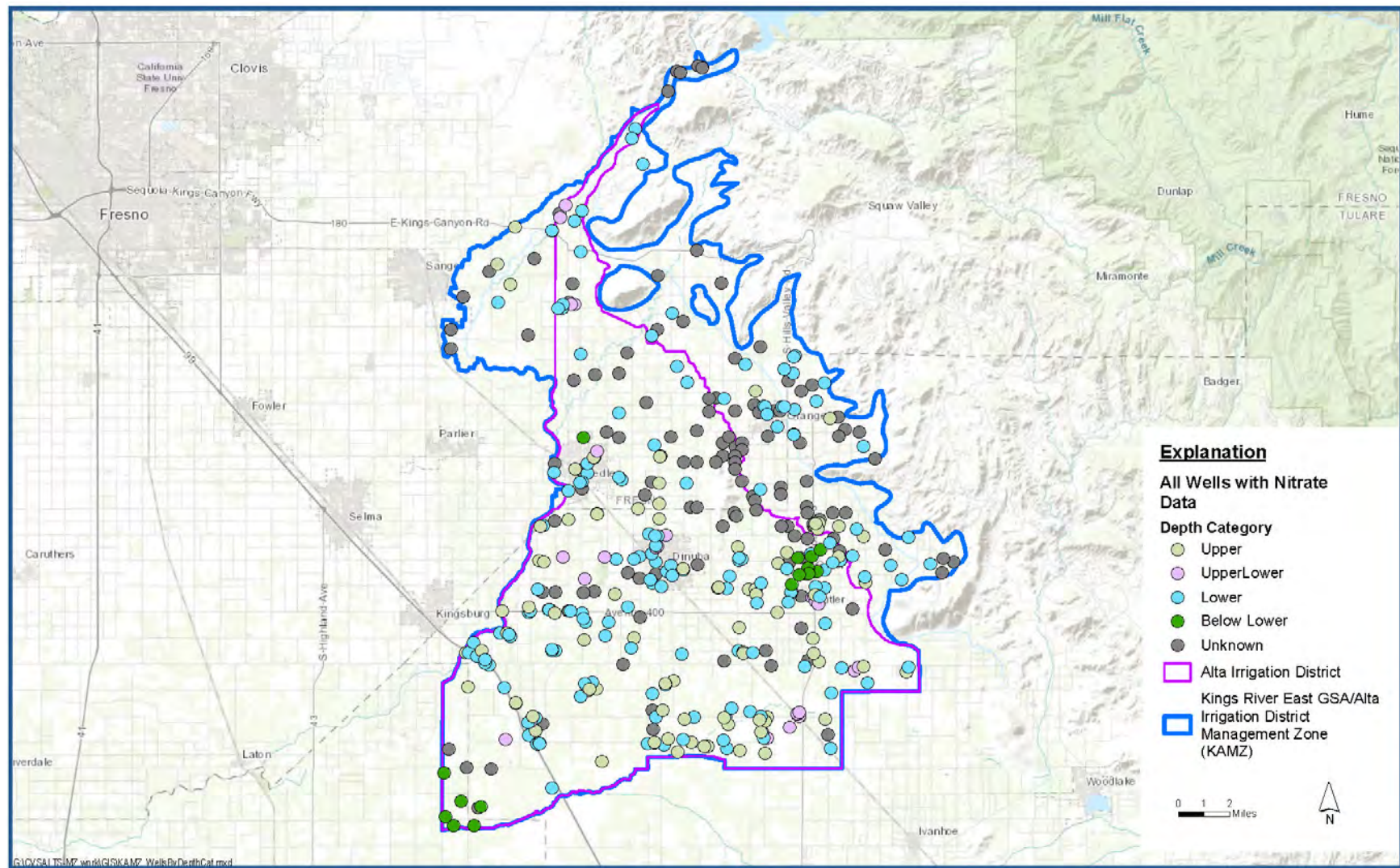


Figure 3-5. Wells with Nitrate Data within the Proposed Management Zone by Depth Category



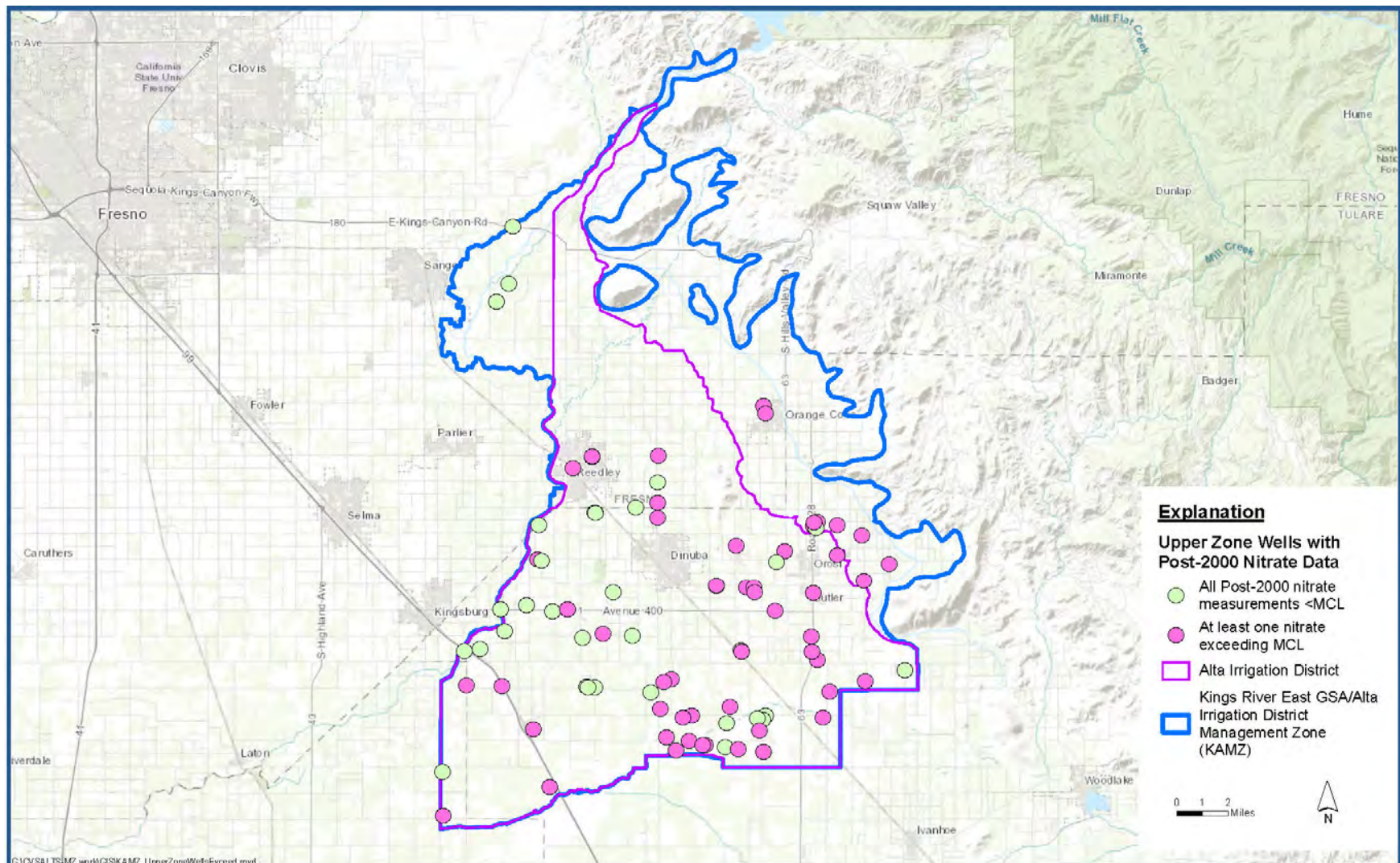


Figure 3-6. Upper Zone Wells with Nitrate Data and Nitrate MCL Exceedances

**Table 3-5. Wells with Nitrate Measurements by Depth Category**

Depth Category	All Wells with Nitrate Data	Wells with Post-2000 Nitrate Data	Wells with Post-2000 Nitrate $\geq 10$ mg/L as N	Percent of Wells with Post-2000 Nitrate Data > MCL
Upper	250 (39%)	238	140	59%
Lower	199 (31%)	182	79	43%
Upper and Lower	45 (7%)	42	16	38%
Below Lower	16 (2%)	14	9	64%
Unknown	135 (21%)	12	6	50%
<b>Total</b>	<b>645 (100%)</b>	<b>488</b>	<b>250</b>	<b>-</b>

- Upper Zone wells outside the Management Zone and within a buffer zone of three miles around the Management Zone boundary were compiled and used in the updated high resolution analysis because nitrate occurrence does not cease at the border of the Management Zone.
- Geospatial interpolation of the well point data was performed (kriging) using a search radius of 1.5 miles.<sup>5</sup>
- Gap areas were shown to exist where post-2000 Upper Zone nitrate well data were insufficient to produce the spatial interpolation using the 1.5 mile search criterion.

**Figure 3-7** illustrates the average post-2000 nitrate concentrations for all Upper Zone wells in the proposed Management Zone and control points in the three-mile buffer. This figure also shows the interpolated ambient Upper Zone post-2000 nitrate as well as the gap areas where insufficient Upper Zone nitrate data exist. High nitrate concentrations exist throughout the Management Zone, particularly in the central and southeastern portions. Insufficient recent Upper Zone nitrate data are available in the northeastern and southwestern areas of the proposed Management Zone.

<sup>5</sup> The 1.5 mile search radius was selected to refine the local ambient nitrate mapping for the proposed Management Zone and recognize the potential variability inherent in groundwater nitrate concentrations spatially. This search radius reduces the reliance on well data from farther away that may not represent local nitrate conditions.



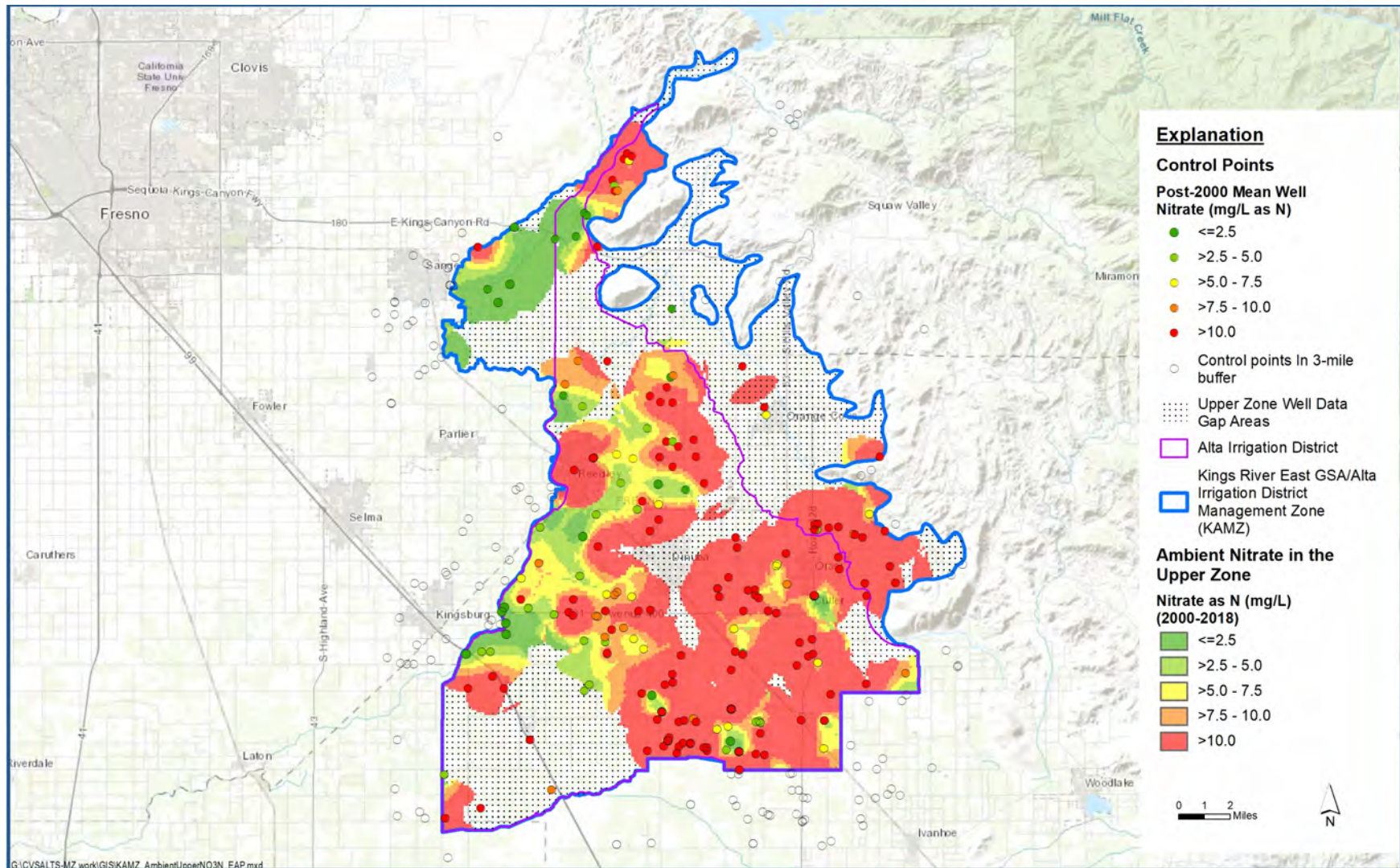


Figure 3-7. Ambient Post-2000 Nitrate Concentrations in the Upper Zone of Groundwater Underlying the Proposed Management Zone