Mr. J.J. Westra  
Assistant Manager  
Tulare Lake Basin WSD  
1001 Chase Avenue  
Corcoran, CA 93212  

Re: Hydrogeologic Evaluation of  
Tulare Lakebed Area  

Dear J.J.:  

Submitted herewith is our revised report on the results of the  
Hydrologic Evaluation of Delisting Part of the Tulare Lakebed  
Area. I appreciate the cooperation of the District personnel in  
providing data for this evaluation.  

Sincerely yours,  

Kenneth D. Schmidt  
Geologist No. 1578  
Certified Hydrogeologist  
No. 176  

KDS/td
Technical and Regulatory Evaluation of MUN and AGR Beneficial Uses in the Tulare Lake Bed Area

December 4, 2015

Prepared by
Hydrogeology by Kenneth D. Schmidt & Associates
Regulatory and Technical Analysis by CDM Smith and Summers Engineering

Submitted by
Tulare Lake Drainage District and Tulare Lake Basin Water Storage District
Table of Contents

Section 1 Executive Summary.............................................................................................................. 1-1
  1.1 Overview .................................................................................................................................. 1-1
  1.2 Technical Findings .................................................................................................................... 1-1
  1.3 Regulatory Basis ....................................................................................................................... 1-3

Section 2 Project Purpose and Background ....................................................................................... 2-1
  2.1 Project Purpose ....................................................................................................................... 2-1
  2.2 Project Background .................................................................................................................. 2-1
  2.3 Existing Regulatory Framework ............................................................................................... 2-2
    2.3.1 Sources of Drinking Water Policy ..................................................................................... 2-2
    2.3.2 Tulare Lake Basin Plan .................................................................................................... 2-3
  2.4 Proposed Changes to the Tulare Lake Basin Plan ................................................................. 2-3
    2.4.1 Evaluation of MUN .................................................................................................... 2-3
    2.4.2 Evaluation of AGR .................................................................................................... 2-4
  2.5 Project Approach .................................................................................................................... 2-4
  2.6 Data Sources .......................................................................................................................... 2-6

Section 3 Project Study Area .............................................................................................................. 3-1
  3.1 Preliminary Project Area Delineation ..................................................................................... 3-1
    3.1.1 Horizontal Extent of Project Area .................................................................................... 3-1
    3.1.2 Vertical Extent of Project Area ....................................................................................... 3-2
  3.2 Project Study Area Description ............................................................................................... 3-2
    3.2.1 Historical Development ................................................................................................ 3-2
    3.2.2 Topography .................................................................................................................. 3-2
    3.2.3 Soil Conditions ............................................................................................................. 3-3
    3.2.4 Groundwater Conditions ............................................................................................... 3-3
    3.2.5 Water Quality ............................................................................................................... 3-4
    3.2.6 Regional Subsurface Geology ....................................................................................... 3-4
    3.2.7 Surface Features ........................................................................................................... 3-4
    3.2.8 Cities and Local Communities ....................................................................................... 3-5
    3.2.9 Political Boundaries ..................................................................................................... 3-5

Section 4 Technical Analysis .............................................................................................................. 4-1
  4.1 Introduction ............................................................................................................................ 4-1
  4.2 Subsurface Geologic Conditions .............................................................................................. 4-1
    4.2.1 Hydrologic Evaluation .................................................................................................... 4-1
      4.2.1.1 North Subarea ......................................................................................................... 4-2
      4.2.1.2 West Subarea ......................................................................................................... 4-3
      4.2.1.3 South Subarea ....................................................................................................... 4-4
      4.2.1.4 East Subarea ......................................................................................................... 4-5
      4.2.1.5 Central Subarea .................................................................................................... 4-6
    4.2.2 Evaluation of Stratigraphy above the E-Clay ................................................................. 4-7
      4.2.2.1 Lacustrine Clay Units ............................................................................................ 4-7
      4.2.2.2 Occurrence of Sands above the E-Clay ................................................................. 4-7
# Table of Contents

- **4.2.2.3** Evaluation of "V" Sequence .................................................. 4-7
- **4.2.2.4** Extent of "V" Sequence Facies ................................................. 4-10
- **4.2.2.5** Above "V" Sequence ................................................................. 4-10

- **4.3** Historical Water Supply Wells ......................................................... 4-10
  - **4.3.1** North Subarea ........................................................................... 4-11
  - **4.3.2** West Subarea ........................................................................... 4-12
  - **4.3.3** South Subarea .......................................................................... 4-12
  - **4.3.4** East Subarea ............................................................................ 4-12
  - **4.3.5** Central Subarea ....................................................................... 4-13

- **4.4** Groundwater Characteristics ......................................................... 4-13
  - **4.4.1** Depth to Water ......................................................................... 4-14
  - **4.4.2** Direction of Groundwater Flow Near Urban Areas .................. 4-14

- **4.5** Groundwater Quality ...................................................................... 4-16
  - **4.5.1** Water Quality Data .................................................................. 4-17
    - **4.5.1.1** North Subarea ..................................................................... 4-17
    - **4.5.1.2** West Subarea ..................................................................... 4-18
    - **4.5.1.3** South Subarea .................................................................... 4-18
    - **4.5.1.4** East Subarea ...................................................................... 4-19
    - **4.5.1.5** Central Subarea .................................................................. 4-20
  - **4.5.2** Electric Log Data ........................................................................ 4-20

- **4.6** Supply Well Pumpage and Downward Head Gradients .................. 4-21

- **4.7** Proposed Horizontal and Vertical MUN De-Designation Boundaries .... 4-22
  - **4.7.1** Horizontal Boundary ............................................................... 4-22
  - **4.7.2** Vertical Boundary .................................................................... 4-23

- **4.8** Proposed Horizontal and Vertical AGR De-Designation Boundaries .... 4-26
  - **4.8.1** Horizontal Boundary ............................................................... 4-26
  - **4.8.2** Vertical Boundary .................................................................... 4-26

## Section 5 Regulatory Analysis .................................................................... 5-1

- **5.1** Applicability of MUN Beneficial Use ............................................. 5-1
  - **5.1.1** Applicability of Sources of Drinking Water Policy Exception Criterion 1a. ........... 5-1
  - **5.1.2** Applicability of Sources of Drinking Water Policy Exception Criterion 1b. ........... 5-4

- **5.2** Applicability of AGR Beneficial Use ............................................. 5-7
  - **5.2.1** Water Quality ........................................................................... 5-8
  - **5.2.2** Existing and Probable Future Use .............................................. 5-8

## Section 6 References .................................................................................. 6-1

## Attachments

- **Attachment A** Electric Logs Used for Subsurface Geologic Cross Sections
- **Attachment B** Drillers Logs Used in Subsurface Geologic Cross Sections (Confidential)
- **Attachment C** Evaluation of Stratigraphy above the E-Clay Tulare Lake Bed MUN/AGR De-designation Area
- **Attachment D** Construction Data and Chemical Analyses for Public Supply Wells
- **Attachment E** Summary of Domestic Wells in Originally Proposed De-Designation Area
- **Attachment F** Active Irrigation Wells - Annular Seal Intervals
Table of Contents

Attachment G  Well Logs for Active Irrigation Wells
Attachment H  Water Quality - Local Data & USGS Reports
Attachment I  Water Quality - Backhoe Excavation Data & Methodology
Attachment J  Electric Logs Evaluated for Vertical Extent of High Salinity Groundwater
Attachment K  Electric Logs - Wells 16L and 20A
Attachment L  Comment Letters Regarding Proposed MUN De-designation

List of Figures

Figure 1-1  Location of Tulare Lake Bed and Subareas Evaluated ............................................. 1-6
Figure 1-2  Proposed Boundary for De-Designation of MUN ....................................................... 1-7
Figure 1-3  Proposed Boundary for De-Designation of AGR - Crop Irrigation ................................. 1-8
Figure 1-4  Proposed Boundary for De-Designation of AGR - Stock Watering ............................... 1-9

Figure 3-1  Original Project Study Area Boundary ............................................................................ 3-6
Figure 3-2  Location of Tulare Lake Bed and Subareas Evaluated .................................................. 3-7
Figure 3-3  Topographic Map of Tulare Lake Bed ............................................................................ 3-8
Figure 3-4  Zones of Alluvial Fan and Basin Soils ......................................................................... 3-9
Figure 3-5  Location of Geologic Cross Sections ............................................................................. 3-10
Figure 3-6  Tulare Lake Cross-section (North - South) ................................................................. 3-11
Figure 3-7  Highway 198 Cross-section (East - West) ................................................................... 3-12
Figure 3-8  Extent of Flooded Cropland in the Tulare Lake Bed During 1969, 1983, 1997, and 1998 .......................................................... 3-13
Figure 3-9  Depth to First Encountered Groundwater ..................................................................... 3-14
Figure 3-10 Salinity Distribution for all Subzones in the Tulare Basin ............................................ 3-15

Figure 4-1  Generalized Subsurface Geologic Cross Section for Tulare Lake Bed Area .............. 4-28
Figure 4-2  Location of Subsurface Geologic Cross Sections in North Subarea ............................ 4-29
Figure 4-3  Subsurface Geologic Cross Section A-A’ ..................................................................... 4-30
Figure 4-4  Subsurface Geologic Cross Section B-B’ ................................................................. 4-31
Figure 4-5  Subsurface Geologic Cross Section C-C’ ..................................................................... 4-32
Figure 4-6  Subsurface Geologic Cross Section D-D’ ..................................................................... 4-33
Figure 4-7  Location of Subsurface Geologic Cross Sections in West Subarea ............................ 4-34
Figure 4-8  Subsurface Geologic Cross Section E-E’ ..................................................................... 4-35
Figure 4-9  Subsurface Geologic Cross Section F-F’ ..................................................................... 4-36
Figure 4-10 Subsurface Geologic Cross Section G-G’ ................................................................. 4-37
Figure 4-11 Location of Subsurface Geologic Cross Sections in South Subarea .......................... 4-38
Figure 4-12 Subsurface Geologic Cross Section H-H’ ..................................................................... 4-39
Figure 4-13 Subsurface Geologic Cross Section I-I’ ..................................................................... 4-40
Figure 4-14 Location of Subsurface Geologic Cross Sections in East Subarea ............................ 4-41
Figure 4-15 Subsurface Geologic Cross Section J-J’ ..................................................................... 4-42
Figure 4-16 Subsurface Geologic Cross Section K-K’ ..................................................................... 4-43
Figure 4-17 Subsurface Geologic Cross Section L-L’ ..................................................................... 4-44
Figure 4-18 Subsurface Geologic Cross Section M-M’ ..................................................................... 4-45
Figure 4-19 Location of Subsurface Geologic Cross Sections in Central Subarea .................... 4-46
Figure 4-20 Subsurface Geologic Cross Section N-N’ ..................................................................... 4-47
Figure 4-21 Subsurface Geologic Cross Section O-O’ ..................................................................... 4-48
List of Tables

Table 4-1 Summary of facies characteristics identified in North and East Subareas............................4-8
Table 4-2 Conductivity data from monitor wells at Site T20S/R21E-4F.............................................4-18
Table 4-3 Conductivity data from monitor wells at Site T19S/R20E-29E..............................................4-18
Table 4-4 Conductivity data from monitor wells at Site T21S/R21E-4R (NEB-3 Series)......................4-24
Table 4-5 Conductivity data from monitor wells at Site T25S/R21E-1N.............................................4-24
Table 4-6 Conductivity data from monitor wells at Site T24S/R23E-5B.............................................4-25
Table 4-7 Conductivity data from monitor wells at TLDD SEB 6-2.....................................................4-25
Table 5-1 Water quality data from drain water in Tulare Lake Bed area .............................................5-6
Table 5-2 Backhoe excavation electrical conductivity (μS/cm) water quality data within the analysis area shown in Figure 5-4.................................................................5-10
Table 5-3 Landowner information on use of groundwater for stock watering in the Project Study Area.............................................................................................................5-12
Section 1

Executive Summary

1.1 Overview

Portions of the historical Tulare Lake Bed have been proposed for de-designation of MUN (Municipal and Domestic Supply Beneficial Use) and AGR (Agricultural Supply) beneficial uses. The purpose of this Tulare Lake Bed Beneficial Use Evaluation Report is to present the technical and regulatory basis for recommending areas for de-designation of these beneficial uses from the groundwater within horizontally and vertically delineated areas under the Tulare Lake Bed. Information regarding geologic subsurface conditions, the location of existing water supply wells, groundwater movement and water quality are presented in this report to provide a basis for recommending a vertical and horizontal boundary for de-designation of beneficial uses.

1.2 Technical Findings

The following text summarizes the key technical findings contained within this report as described in detail in Sections 3 and 4. These findings coupled with the regulatory basis for de-designation summarized below provide the basis for the recommendation to de-designate MUN and AGR from areas within proposed horizontal and vertical boundaries within the Tulare Lake Bed area:

- A Central Subarea and four other subareas along the fringes of the Tulare Lake Bed were selected for evaluation (Figure 1-1). The overall horizontal boundary served as the Project Study Area for beneficial use evaluation. The subareas provided a framework for more focused analysis.

- The subareas along the fringes are adjacent to cities and/or communities (Corcoran, Alpaugh, Kettleman City, and Stratford) which rely entirely on groundwater for their water supply. Subsurface geologic conditions, records on water supply wells, the directions of groundwater flow, and shallow groundwater quality were the major factors considered in the evaluation of each of the subareas.

- Of particular importance are clay and other fine-grained deposits within the uppermost several hundred feet of the subsurface. The United States Geological Survey (USGS) has identified three relatively shallow clay tongues around the margins of the Tulare Lake Bed. Clay layers are predominant in the central part of the lakebed; groundwater above the Corcoran Clay is not a source of water supply in that area.

- Two approaches were used to characterize subsurface geologic conditions within the project study area: (a) an evaluation of the hydrologic characteristics within the Project Study Area; and (b) an evaluation of the stratigraphy above the E-Clay, particularly in the eastern and northern subareas of the Project Study Area. Findings from these analyses supported the technical basis for the proposed horizontal and vertical boundaries for MUN and AGR de-designations.

- There are records for a number of historical water supply wells along the north fringe of the lakebed, including a number of private domestic wells southeast of Stratford (Figure 4-28).
Such wells may not be sealed off opposite all of the higher salinity shallow groundwater (generally above a depth of about 200 feet). There are also records for a number of other domestic wells in the north part of the East Subarea, between Corcoran and Alpaugh. In addition, there are public supply wells at Stratford, Kettleman City, Alpaugh, and northeast of Corcoran. To address MUN concerns, the proposed de-designation boundary was placed to exclude the area within the vicinities of these wells.

- High salinity groundwater is present beneath most of the lakebed area above the shallowest of these clay layers (the A and B-Clays). In contrast, lower salinity groundwater is often present below the deepest of these clay layers (the C-Clay). Shallow clay and other fine-grained layers are effective confining beds that limit the downward flow of shallow high salinity groundwater to greater depths.

- While electrical conductivity levels are generally very high (above 7,500 microsiemens/centimeter [μS/cm]) in shallow groundwater throughout the study area, exceptions can be found, particularly in portions of the East Subarea. A review of these data show that lower conductivity levels are associated with samples collected from locations near or adjacent to major irrigation canals. These exceptions are temporary, e.g., during periods of irrigation, and not considered representative of the area as a whole.

The originally proposed horizontal de-designation boundary was largely validated along most of the west and south parts of the lakebed. However, this boundary was moved to the south in parts of the North Subarea (Figure 4-28), primarily due to the presence of numerous water supply wells. The largest change in the de-designation boundary from that originally proposed de-designation boundary for the Project Study Area was in the East Subarea. The de-designation boundary was moved to the west in part of this subarea due to:

- The proposal to use one or more wells in the Angiola W.D. west field for public supply in Alpaugh.
- The presence of a number of domestic wells in this area.
- Lower salinity shallow groundwater apparently associated with recharge from Tule River streamflow.

The originally proposed horizontal de-designation boundary was revised to establish a proposed boundary for de-designation of the MUN beneficial use (Figure 1-2) based on an electrical conductivity threshold of 5,000 μS/cm. This recommendation is based on the technical findings summarized above and described in detail in Section 4.

The originally proposed horizontal de-designation boundary was revised to establish a proposed boundary for de-designation of the AGR beneficial use for crop irrigation (proposed electrical conductivity threshold of 3,000 μS/cm) (Figure 1-3) and stock watering (proposed electrical conductivity threshold of 7,500 μS/cm) (Figure 1-4). These proposed horizontal boundaries are based on the technical findings summarized above and described in detail in Section 4.

Based on the technical findings discussed in Section 4, the vertical extent of proposed MUN and AGR de-designations within their respective horizontal boundaries is as follows:
- The top of the A-clay or a minimum depth of 75 feet, in the northern fringe areas (see yellow areas in northern part of the study area, e.g., Figure 1-2);

- The A-clay or a minimum depth of 110 feet in the eastern fringe areas (see blue areas in eastern part of the study area, e.g., Figure 1-2);

- The C-Clay or a minimum depth of 200 feet in the north and northwest parts of the study area, e.g., as shown in Figure 1-2 (orange area); and

- Top of Corcoran Clay in the remainder of the project study area (e.g., Figure 1-2, green area).

### 1.3 Regulatory Basis

The following text summarizes the regulatory basis for the proposed MUN and AGR de-designation boundaries.

**MUN De-Designation Proposal**

The MUN threshold is based on the State Water Resources Control Board’s (State Water Board) Sources of Drinking Water Policy (Resolution No. 88-63). The area within the proposed de-designation boundary meets the Policy’s MUN Exception Criteria 1a and 1b:

- **Exception Criterion 1a:** The total dissolved solids (TDS) exceeds 3,000 milligrams/liter (mg/L) (5,000 μS/cm electrical conductivity) and it is not reasonably expected by Regional Boards to supply a public water system:
  - With only a few exceptions the electrical conductivity is above 5,000 μS/cm; many areas have conductivities that exceed 10,000 μS/cm. The exceptions are considered anomalous given that other water quality data from the areas adjacent to the anomalous readings have electrical conductivity values that exceed 5,000 μS/cm. These exceptions are logically due to recent irrigation or tile drains systems collecting perched saline water effectively leaching out salts from recently irrigated fields.
  - Technical evaluation demonstrates that not only will the public water supply systems for each of the four communities near the area proposed for MUN de-designation not be impacted by the de-designation but that no public entities view the area proposed for MUN de-designation as a viable source of future water supply.

- **Exception Criterion 1b:** There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices.
  - The shallow groundwater in the Tulare Lake Bed has numerous contaminants which would have to be removed for it to be usable as an acceptable potable water supply. The operation and ongoing maintenance for a required water treatment facility would be complex to manage. For example, this complexity is illustrated by the U.S. Bureau of Reclamation project to construct a 200 gallons per minute $22.7 million pilot water treatment facility on the west side of the San Joaquin Valley to test and verify the suitability and feasibility of different treatment options for treating agricultural drainage water. This pilot facility will include options for reverse osmosis, microfiltration, or ultrafiltration treatment.
While treatment may be technologically possible, as illustrated by the U.S. Bureau of Reclamation project, the feasibility of implementing such technology to treat drain water to potable standards within the Tulare Lake Bed would not be practical because of the potential for flooding in the Tulare Lake Bed. The potential for flooding has greatly influenced where development occurs relative to the Tulare Lake Bed area.

**AGR De-Designation**

Two salinity-related criteria were used to evaluate the protection of the AGR beneficial use within the areas proposed for de-designation:

- **Agricultural Irrigation**: Use of water for agricultural irrigation is not generally suitable for irrigating all but the most salt-tolerant crops, except as a temporary, short-term alternative when higher water quality water supplies are not readily available at electrical conductivities greater than 3,000 μS/cm (TDS > 2,000 mg/L). The basis for this threshold is ongoing discussions by Central Valley Salinity Alternatives for Long Term Sustainability (CV-SALTS), which is developing the Salt and Nitrate Management Plan for the Central Valley.

- **Stock Watering**: Use of water for stock watering is severely impacted when electrical conductivities exceed 7,500 μS/cm (TDS > 5,000 mg/L). The basis for this threshold is a recently completed CV-SALTS literature review (CV-SALTS 2013) and technical and regulatory findings from the Royal King Mine Basin Plan Amendment recently approved by the Central Valley Water Quality Control Board (Central Valley Water Board) (Resolution No. R5-2014-0047) and State Water Board (Resolution No. SB-2015-003).

Using these water quality thresholds, Figures 1-3 and 1-4 illustrate proposed boundaries for AGR de-designation for crop irrigation and stock watering, respectively. A few exceptions to these conductivity thresholds exist within the proposed boundaries; however, these exceptions are associated with data from very shallow monitoring wells which are influenced by irrigation activity. Accordingly, these exceptions are not considered representative of normal conditions.
Page intentionally left blank
Section 2

Project Purpose and Background

2.1 Project Purpose

The Tulare Lake Bed is located within the Tulare Lake Basin in the southern portion of the San Joaquin Valley. The Tulare Lake Basin, comprising approximately 10.5 million acres, is a mixture of federally owned land, agricultural land, and municipalities. The Basin is essentially a closed system, draining only into the San Joaquin River in extreme wet years (Central Valley Water Board 2004, as amended). Given this natural geography coupled with ongoing surface water irrigation activities to support agriculture, salts accumulate in the basin.

Under the existing Water Quality Control Plan for the Tulare Lake Basin (Basin Plan) (Central Valley Water Board 2004, as amended), the groundwater basin under the Tulare Lake Bed is designated with the following beneficial uses: Municipal and domestic water supply (MUN); Agricultural Supply (AGR), and Industrial Service Supply (IND). The groundwater under a portion of the Tulare Lake Bed is also designated as an Industrial Process Supply (PRO).

The Basin Plan states that the beneficial uses listed for groundwater in the Tulare Lake Bed area may not apply to the entire area currently designated with these uses. This may be the case for the MUN and AGR beneficial uses; however, per the State Water Board Sources of Drinking Water Policy the applicability of specific exemption criteria must be demonstrated before a groundwater body may be exempted from designation as MUN.

The purpose of this project is to evaluate the applicability of the MUN and AGR beneficial uses for a portion of the groundwater basin underlying the historical Tulare Lake Bed. This report provides the technical and regulatory findings.

2.2 Project Background

Previously collected data and studies indicated that removing MUN as a beneficial use in the underlying groundwater for at least a portion of the Tulare Lake Bed was warranted. This information included:

- A study done for the original Tulare Lake Basin Plan that showed high saline groundwater in Tulare Lake Bed;
- USGS 1982-1989 data that delineates various high saline zones;
- Tulare Lake Drainage District (TLDD) data from 2009 confirms the high salinity levels in the first waters encountered in the Tulare Lake Bed;
- Information that groundwater generally flows toward the lake bottom; and

---

1 As documented in November 18, 2011 letter from Central Valley Water Board to Tulare Lake Drainage District.
section 2 • Project Purpose and Background

- Well information including (1) location data showing the lack of wells on the lake bottom, but several around the upslope periphery; and (2) that some wells on the periphery may act as conduits by penetrating both the upper ‘poor’ or "perched" groundwater layer and the deeper ‘good’ quality groundwater near the perimeter of the lake bottom.

Based on this preliminary information and input from Central Valley Water Board staff (per November 18, 2011 letter from Central Valley Water Board to TLDD), it was agreed that a formal proposal to de-designate MUN as a beneficial use within a specific area would require the development of the following technical information, including:

- Delineation of the specific area (horizontal and vertical) to be considered for de-designation of the MUN beneficial use (Project Study Area);

- Summary and analysis of data within the proposed de-designation area, including identifying the portions of the aquifer that are above 3,000 mg/L TDS (or equivalent electrical conductivity, i.e., 5,000 μS/cm);

- Study of the proposed de-designation area equivalent to a use attainability analysis for surface water, where any use of water in the area for MUN would be identified, including:
  - Map showing the specific locations of all known wells within the project area and highlighting those that serve as domestic water supply sources; and
  - Water quality data, where available, from wells identified above.

During the development of technical information to support the MUN evaluation, the data evaluation was expanded to determine the applicability of the AGR beneficial use (for agricultural irrigation and stock watering) within the same Project Study Area.

2.3 Existing Regulatory Framework

This section describes the existing state and regional regulatory framework that governs water quality control activities in the Tulare Lake Bed area.

2.3.1 Sources of Drinking Water Policy

In 1988 the State Water Board adopted the Sources of Drinking Water Policy (Resolution 88-63). This policy states that all waters are considered suitable or potentially suitable to support the MUN beneficial use, with certain exceptions. The Basin Plan implements this policy by generally assigning the MUN beneficial use to all surface waters and groundwaters in the Central Valley unless those waters have already been identified as not supporting the MUN use. Exemptions to the MUN beneficial use can only be made in the Basin Plans themselves. For surface and ground waters an exemption may be allowed for one of the following reasons:

- 1a - The TDS exceeds 3,000 mg/L (5,000 μS/cm, electrical conductivity) and it is not reasonably expected by Regional Boards to supply a public water system, or

- 1b - There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices, or
1c - The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day.

2.3.2 Tulare Lake Basin Plan

Basin Plan Table II-2 (Tulare Lake Basin Ground Water Beneficial Uses) identifies three Detailed Analysis Units (DAU) applicable to the Tulare Lake Bed. DAUs 241 and 246 have three designated beneficial uses: MUN, AGR, and IND. DAU 238 has these same three uses and one additional use: PRO. The Basin Plan states, "Existing beneficial uses generally apply within the listed... DAU. Due to the size of the DAUs, however, the listed uses may not exist throughout the DAU." The water quality objectives and implementation measures to protect the MUN, AGR, IND and PRO beneficial uses are described in Sections III and IV of the Basin Plan.

2.4 Proposed Changes to the Tulare Lake Basin Plan

This study evaluated the applicability of the MUN and AGR beneficial uses applied to groundwater under a portion of the Tulare Lake Bed. The basis for these evaluations is described in the following sections.

2.4.1 Evaluation of MUN

The Basin Plan defines MUN as: *Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply.* As noted in Section 2.3.1 above, the Sources of Drinking Water Policy establishes the basis for excepting MUN as a beneficial use in a groundwater body. Two of these exceptions (1a and 1b) provide the basis for the analysis conducted by this study, with Exception 1a being the primary focus of this analysis. To evaluate the applicability of Exception 1a, the investigation involved two key elements:

- **Water Quality** – Groundwater quality data will be analyzed for the Project Study Area. This analysis will include horizontal and vertical components to identify where groundwater quality exceeds the thresholds contained within the Sources of Drinking Water Policy.
- **Use of the Groundwater as a Public Water Supply** – Information regarding the potential use of the water in the Project Study Area as a public water supply will be developed. In addition, information regarding sources of drinking water for nearby communities will be assessed to determine their potential to use groundwater in the Project Study Area as a future water supply.

The study also evaluated the applicability of Exception 1b. The investigation of this exception involved the following activities:

- **Evaluation of Water Quality Treatment Requirements** – Information will be provided regarding water quality-related concerns and requirements to treat shallow groundwater for use as a municipal or domestic water supply.
- **Tulare Lake Bed Flood Risk** – Historical information will be provided to demonstrate the impracticality of well construction in the Tulare Lake Bed because it is prone to flooding.
2.4.2 Evaluation of AGR

The Basin Plan defines the AGR beneficial use as: Uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing. This definition includes AGR-related uses to protect irrigation of crops and protection of stock watering.

The Basin Plan designates AGR as a beneficial use in the Project Study Area. The Basin Plan does not establish salinity water quality objectives specific to the protection of this beneficial use. For the purposes of this report, the following salinity thresholds were used to develop proposed boundaries for de-designation of the AGR beneficial use:

- **Agricultural Irrigation:** Based on ongoing policy discussions by CV-SALTS, when electrical conductivities in the irrigation water supply are greater than 3,000 μS/cm (TDS > 2,000 mg/L) the water is not generally suitable for irrigating all but the most salt-tolerant crops, except as a temporary, short-term alternative when higher water quality water supplies are not readily available. The original basis for this threshold is Ayers and Westcot (1985); however, CV-SALTS is currently considering affirming this electrical conductivity value as a critical threshold for general use of a water supply for crop irrigation.

- **Stock Watering:** Use of water for stock watering is severely limited when TDS levels exceed 5,000 mg/L (electrical conductivity > 7,500 μS/cm). This threshold is based on a National Academy of Sciences (NAS) report (A Guide to the Use of Saline Waters for Livestock and Poultry; NAS 1974). CV-SALTS recently reaffirmed this threshold in its review of the literature (CV-SALTS 2013; see Table 21) and in ongoing AGR policy discussions. The 7,500 μS/cm EC threshold is also consistent with a recent approved Central Valley Water Board Basin Plan Amendment that removed the AGR (stock watering) beneficial use in a specific area to support the Closure of Mining Waste Management Units at the Royal Mountain King Mine (RMKM) Site in Calaveras County (Central Valley Water Board Resolution No. R5-2014-0047; State Water Board Resolution No. SB-2015-003). To support the approval of the removal of AGR for stock watering at the RMKM site peer review was requested on use of the 7,500 μS/cm electrical conductivity threshold for stock watering protection. The peer reviewer affirmed this threshold.

2.5 Project Approach

The beneficial use evaluation contained in this report focused on the development of both technical and regulatory findings. The following project approach was used to develop these findings:

- **Establish Preliminary De-Designation Boundary** – The preliminary de-designation boundary served as the Project Study Area. The delineation of this boundary was based on a multitude of factors. Initially, the location and extent of high electrical conductivity of first encountered waters was determined. The extent of the impermeable clay soils and flood vulnerability further reduced the Project Study Area boundary. The towns and, communities that rely on groundwater as a potable water source further shaped the boundary as they include municipal

---

2 External Peer Review of a Proposed Basin Plan Amendment to Address Beneficial Uses for Groundwater at the Royal Mountain Mine Site, Calaveras County. Memorandum from Kerry Rood (Utah State University) to Gerald Bowes (Manager Cal/EPA Scientific Peer Review Program). November 23, 2012.
uses and the municipal designation would remain. The surface features allowed the horizontal boundary to be physically defined and make it more readily identifiable. Lastly, the boundaries of the local water agricultural water purveyor (Tulare Lake Basin Water Storage District [TLBWSD]) and the entity tasked with reducing the salt load (TLDD) were included.

- **Subdivide Project Study Area into Subareas for Focused Analysis** – The Project Study Area was divided into a Central Subarea and Fringe Subareas. This was done to facilitate the analysis of the horizontal boundary area between where MUN and AGR could be removed and where these beneficial uses should remain designated.

- **Characterize Subareas** – For each of the subareas defined, the following information was developed:
  - Characterize subsurface geologic conditions.
  - Identify known water supply wells - Information on water supply well locations and types was taken primarily from USGS Well Data reports, Department of Water Resources (DWR) well completion reports, and City or Department of Health Services records. Construction data for active public supply wells was gathered where available.
  - Characterize water levels - Shallow groundwater level data were developed for each subarea. In addition, because of the importance of urban areas to this evaluation, the direction of shallow groundwater flow in and near these areas was evaluated.
  - Characterize groundwater quality.

- **Develop Final Horizontal and Vertical Delineation of Area Proposed for MUN and AGR De-Designation** – Based on the findings from the focused analyses conducted within each of the subareas, a final horizontal and vertical delineation of the area proposed for removal of MUN and AGR beneficial uses was developed.

- **Conduct Regulatory Analysis** - Using the criteria described above in Sections 2.3 and 2.4, proposed changes to the MUN and AGR beneficial uses within the proposed area for de-designation were evaluated. Specifically:
  - Evaluate water quality of area proposed for MUN and AGR de-designation to demonstrate that water quality in the proposed area meets the exception criteria for these beneficial uses.
  - Evaluate potential use of groundwater in the delineated area for MUN and AGR beneficial use.
  - Evaluate treatment practices that could be applied to the delineated area to treat groundwater for domestic use to demonstrate that the water cannot reasonably be treated for domestic use using either BMPs or best economically achievable treatment practices.
2.6 Data Sources

At the beginning of this project a data source list was developed and provided to area stakeholders for review. Based on this review a final list was developed. The following sections summarize the final list of data sources used for this project. Specific references are provided in Section 6.

Groundwater Conditions

- USGS Reports
  - Hanford-Visalia Area Open-File
  - Terra Bella-Lost Hills Open-File
  - Avenal-McKittrick Area-Water Supply Paper 1457
  - Subsurface Geology of Late Tertiary Quaternary Water-Bearing Deposits, South San Joaquin Valley Water Supply Paper 1999H

- Groundwater Reports by Kenneth D. Schmidt & Associates (KDSA)
  - City of Corcoran (December 1992)
  - Angiola Water District (July 2011)
  - City of Lemoore WWTF (March 2002)

- Other Reports
  - Westlake Farms Subsurface Drainage System, Phase 1 Master Plan Report (May 1985)

Subsurface Geologic Conditions

- Well completion reports and electric logs (E-logs) from California DWR, San Joaquin District. Lithologic logs and E-logs from California Division of Oil, Gas, & Geothermal Resources.
- Previously listed reports.

Well Construction Data

- DWR well completion reports and USGS Data for Wells reports for Dos Palos-Kettleman City Area and Hanford-Visalia Area, Water Supply Paper 1457, and KDSA reports.

Water Levels

- DWR water-level data base website, referenced reports, and evaporation pond groundwater monitoring reports.
- DWR spring water-level elevation contour maps for San Joaquin Valley.
Shallow Groundwater Quality


- More recent analyses by the USGS, as available.

- Laboratory electrical conductivity measurements for monitor wells on a quarter section spacing in much of lake bed for recent years.


- North and South Evaporation Basins, Westlake Farms, Kings County, California.

- Tulare Lake Drainage District Monitoring Reports for North Evaporation Basins, Hacienda Evaporation Basins, and South Evaporation Basins, updated through 2012 and provided by John Minney.

- Central Valley Water Board files on groundwater monitoring at dairies and other sites in and near the Tulare Lake Bed.

Urban Area Deeper Groundwater Quality

- California Department of Public Health records for water systems in Stratford, Kettleman City, Alpaugh, and Corcoran.

- KDSA City of Corcoran Report (December 1992) and updated files.

- KDSA Alpaugh and Angiola W.D. files.
Section 3
Project Study Area

3.1 Preliminary Project Area Delineation

Beneficial use evaluations for groundwater must consider both horizontal and vertical dimensions. The following sections describe how these dimensions were defined at the beginning of the project.

3.1.1 Horizontal Extent of Project Area

Prior to the initiation of technical data collection, a originally proposed horizontal de-designation boundary was developed. Figure 3-1 illustrates this preliminary delineated area. During data development, the preliminary delineated area was further evaluated and divided into a Central Subarea and four Fringe Subareas. Figure 3-2 shows the Central Subarea, which represents the portion of the Project Study Area between the four fringe subareas and is in the lakebed proper. This area is evaluated even though it is more distant from public supply and drinking water wells; it has extensive clay deposits and very high salinity shallow groundwater. The fringe of the area proposed for de-designation was divided into four subareas (see Figure 3-2). The boundaries of each subarea were generally delineated to extend several miles in both directions from the originally proposed de-designation boundary. These subareas and their general descriptions include:

- The North Subarea is located between Kent Avenue and Orange Avenue. This subarea generally covers the north part of the lakebed and adjoining areas, including Stratford. The Westlake Farms North Evaporation basins are located just north of this subarea. The south branch of the Kings River and several branches of the Kaweah River pass through this subarea.

- The West Subarea generally extends to the west to near Kettleman City, and extends from Orange Avenue on the north to the Garces Highway on the south. The Westlake Farms South Evaporation Basins are in this subarea. No large streams pass through this subarea.

- The South Subarea extends from 22nd Avenue on the west to Road 32 on the east, and is primarily south of Virginia Avenue. The TLDD Hacienda and South Evaporation Basins are in this subarea. No urban areas are located in the subarea. The Kern River overflow channel passes through the south part of this subarea.

- The East Subarea extends from Orange Avenue on the north to one mile south of Virginia Avenue on the south. This subarea includes the City of Corcoran and Alpaugh, and the Tule River passes through the central part of the subarea. The east boundary of this subarea is west of part of the original de-designation boundary. This is because of a recent proposal to supply water from one or more Angiola W. D. wells that are located between Roads 32 and 40 for public supply in Alpaugh. This project is to mitigate high arsenic concentrations in the Alpaugh public supply. Thus the proposed de-designation boundary in this area would be moved to the west from that originally proposed (e.g., as shown in Figure 3-2), to west of these wells. Because of this, the eastern boundary of the East Subarea was selected to be at Road 40.
3.1.2 Vertical Extent of Project Area

As noted above, de-designation of beneficial uses from groundwater requires consideration of both horizontal and vertical dimensions. However, for the purposes of this study the preliminary project area only included a horizontal boundary to provide a basis for technical data collection. The preliminary project area did not include a vertical delineation because all data regardless of vertical depth was included in the technical data analysis. The evaluation of these data, which is reported in subsequent sections, was used as the basis for establishing a final recommended proposed vertical delineation to correspond with the final recommended proposed horizontal delineation.

3.2 Project Study Area Description

The historical development, topography, soil, groundwater and flooding conditions of the Tulare Lake Bed region truly make this area very unique. The following background information describes the uniqueness of the Tulare Lake Bed area.

3.2.1 Historical Development

This unique area, located in the southern part of the Central Valley of California, is a closed basin from which there has been no runoff to the sea for more than 100 years. A combination of alkaline heavy clay soils, extremes of climate and a continuing flood hazard make the area unsuitable for crops such as orchards, vineyards and most fresh vegetable crops. The area has been quite successful in the production of cotton, wheat, safflower, alfalfa hay, processing tomatoes, and other field crops.

Before dams were constructed on the major tributary streams, the boundaries of the Tulare Lake were historically in flux because of the wide variation of inflow in various years. The maximum reported area of Tulare Lake was about 800 square miles in 1862 and again in 1868. The most recent time in which water flowed naturally from Tulare Lake to San Francisco Bay was 1878. At that time, the flooded lands covered an area of about 600 square miles, with a maximum depth of only about thirty feet. During the latter part of the 19th Century, Tulare Lake was considered to be a permanent part of the State’s geography. There are records indicating that the Lake was navigated with docks and commercial fishing. The first record of agricultural activity was the 1880’s. The Lake was first dry in historical times in 1898 or 1899.

Under conditions of subsequent development of irrigated agriculture in both the Tulare Lake Bed and the Tulare Lake Basin as well as construction of foothill flood control reservoirs, uncontrolled stream flows that historically fed into the Lake Bed have been significantly reduced and the flood hazard has been largely removed from the fringe portions of this land. Some of the fringe portions as defined by the 1876 map now have relatively dependable water supplies, so that they have lost much of their former Tulare Lake character. Hence the 400,000 acres of the maximum historical Lake Bed has shrunk to slightly less than 200,000 acres.

3.2.2 Topography

The topography of the Tulare Lake Bed is a gradually sloping trough from the former lake outer boundary toward the lowest region in the Tulare Lake Bed. The lowest region of the Tulare Lake Bed is approximately 175 feet above mean sea level (MSL) as shown in Figure 3-3. The generally flat terrain has an average slope of about one-foot per every mile from the lowest area towards the boundary. The Tulare Lake Bed is a “closed” basin with no natural outlet. It is important to note that no natural outflow from the historic Tulare Lake Bed has occurred since the late 1870’s. This is a result of upstream diversions on the eastside of the San Joaquin Valley from the four major river
tributaries, Kings, Kaweah, Tule and Kern, to the area, and the U.S Army Corps of Engineers flood control projects on the tributaries. However, periodic floodwaters occurring in above-normal runoff years can inundate highly productive farmland within the Tulare Lake Bed approximately 1 out of every 7 years (see additional discussion below and in Section 5.1.2).

3.2.3 Soil Conditions

**Figure 3-4** is a Map of Kings River Service Area, showing zones of Alluvial Fan and Basin Soils. This map was prepared by overlaying the Kings River Service Area upon Plate 3 of USGS Water Supply Paper 1618. As is evident from the map, the Tulare Lake area is largely underlain by relatively impermeable basin soils. The predominant soil is Tulare Clay, a deep and very finely textured soil.

The alluvial deposits of the western part of the valley are derived from the marine sedimentary deposits that comprise the Coast Ranges and tend to be of finer texture relative to those of the eastern part of the valley and have higher clay content. Lacustrine and marsh deposits exist beneath the Tulare Lake Bed. These deposits are composed primarily of silts and clays. Several cross sections were prepared of which the locations are shown in **Figure 3-5**. The Tulare Lake Bed clay can be seen for hundreds of feet deep in **Figure 3-6**.

The most laterally continuous of these units have been designated from the youngest to oldest by the letters A through F (Figures 3-6 and 3-7). The most prominent of these clay units is the E-Clay or Corcoran Clay Member of the Tulare Formation (Corcoran Clay) which extends throughout the majority of western and southern Tulare Lake Basin (absent along the eastern boundary and in the Bakersfield area). The Corcoran Clay generally separates unconfined groundwater conditions above the clay to confined conditions below the clay. The Corcoran Clay is an impermeable hydrologic barrier that ranges from 400 to 600 feet below the surface. The Corcoran Clay layer ranges in thickness from 50 to more than 200 feet. As a result of the clay strata, any economically feasible attempt to directly recharge the aquifer below the Corcoran Clay is impractical within the Tulare Lake Bed. The very dense clays above and below the Corcoran Clay layer extend several thousand feet from the surface down to the unknown.

The nearly impervious nature of the Tulare Lake clay soils is rather dramatically demonstrated by the fact that the 1969 flood runoff was impounded to an average depth of only about eleven feet at its peak level in June 1969 as shown in **Figure 3-8**. It was not completely dissipated until August 1971, more than two years after the inflow had ceased and the impounded flood water was used for irrigation. Engineering calculations indicate that about half of the total disposal was from evaporation, about half from withdrawals for irrigation of surrounding lands. After making allowance for absorption upon initial wetting, the vertical percolation was calculated to be less than one-half foot per year that contributed to the very shallow perched water conditions. In 1983, large scale flooding again happened with similar results.

3.2.4 Groundwater Conditions

Groundwater conditions in and around the Tulare Lake area are described in a number of reports and studies of the USGS, the California DWR and others, and are substantiated from records of actual development and attempted development of groundwater resources. What is unique about the lakebed is the lack of usable groundwater resources within the lakebed.

First groundwater encountered is typically only a few feet deep, as indicated by DWR in **Figure 3-9**. There has been, and will continue to be, a substantial amount of time, effort and resources expended
within the area to keep the poor quality first encountered groundwater from getting into the root zone which reduces the crop yields. This was the reason for the formation of the TLDD. TLDD manages and disposes of subsurface tile drainage waters that are received from its landowners.

With the exception of a few old deep wells, there are no wells in the Lake Bed proper. Wells must be drilled below the clay formations to a depth of about 1,500 to 2,000 feet to find any useable groundwater. Care must be given not to perforate the wells closer than about 600 feet to the land surface in order to avoid marsh gas and the highly saline and alkaline waters in sand lenses in the upper strata. The USGS and documents water quality problems natural to the Tulare Lake area in **Figure 3-10.** Tulare Lake operators own water wells, located on the outside fringe of the Tulare Lake Bed. The Tulare Lake Groundwater Basin (TLGB) is described in studies conducted by the DWR and the USGS. In a simplistic view, the TLGB consists essentially of a shallow saline aquifer and a deep aquifer separated by the Corcoran Clay hydrogeologic barrier. The Corcoran Clay is located about 400 feet to 600 feet below the surface and ranges in thickness from about 50 to over 200 feet. The underlying soils are primarily low water-bearing, fine-textured clay materials, with interspersed silty sand lenses. The relatively impermeable heavy clay soils prevent any feasible attempt to directly recharge either the shallow or lower aquifers.

### 3.2.5 Water Quality

The first subsurface waters encountered in the interior portion of the Tulare Lake Bed region have high concentrations of salts. Historical data from farm operators indicate that the electrical conductivity is in the range of 5,000 to greater than 35,000 μS/cm, which is clearly unusable for municipal and agricultural use. Thus, there is no shallow water suitable for these purposes. Extending outward from the proposed Project Study Area, the first encountered groundwater improves in quality. The Project Study Area encompasses the area where the electrical conductivity is documented to be 5,000 μS/cm or greater.

### 3.2.6 Regional Subsurface Geology

The soils in the historic Tulare Lake Bed are primarily impermeable clays. Soils along the rim of the historic Lake Bed are primarily fine grained, silty alluvium which was deposited along the shoreline. Older Continental alluvium deposits have noticeably finer texture than the younger Sierra Nevada deposits. The Project Study Area boundary surrounds the relatively impermeable heavy clay soils that are several thousand feet deep with the Corcoran Clay separating the confined from the unconfined aquifers. The clay layers rise and thin out near the fringe of the Project Study Area.

### 3.2.7 Surface Features

To geographically define and make the Project Study Area boundary more visually definable, several surface features were used. Major roads in the area are often easily identifiable on maps. The Project Study Area is bounded to the north by Laurel Avenue, on the west by Highway 41 and Interstate 5, and on the east by Highway 43. Where no roads existed, canals and ground surface contour lines were also used to delineate the boundary.

There are no natural waterways or bodies in the Project Study Area. All of the canals in the Lake Bed are man-made and are not naturally occurring. It is a closed basin and there are no outlets to any natural waterways or bodies. Since the area is also prone to periodic flooding, there are no residential areas, permanent plantings or public supply wells located in the interior portion of the Tulare Lake Bed.
3.2.8 Cities and Local Communities
There are no towns or communities in the Project Study Area. The local towns and communities in the fringe area all draw on groundwater resources that are upslope from the Lake Bed and Project Study Area. Areas where groundwater is used as a potable water source were avoided. The community of Stratford is north of the Project Study Area, Kettleman City is west of the Project Study Area, the City of Corcoran is on the northeast corner of the Project Study Area and the Community of Alpaugh is southeast. The growth of these communities is away from the proposed Project Study Area, principally due to the flood risks. Groundwater on the fringe of the Project Study Area flows away from the domestic well fields and towards the center of the Project Study Area.

3.2.9 Political Boundaries
The political boundaries of the TLBWSD and the TLDD were also considered in the development of the proposed Project Study Area boundary. The boundaries of these two entities generally overlap in the interior portion of the Project Study Area. TLBWSD is the major water supplier to the area and TLDD services the drainage needs of the landowners. While there are additional areas south and west of the Project Study Area that have similar elevated saline shallow groundwater, these areas have not been included in the Project Study Area for funding and lack of data reasons.
Page intentionally left blank
Section 4
Technical Analysis

4.1 Introduction
This section provides technical analyses completed to evaluate the Project Study Area for potential MUN and AGR de-designation. The types of information developed and their relevance to this study include:

- **Subsurface Geologic Conditions** – Describes the geology underlying the Tulare Lake Bed Project Study Area to provide basis for evaluating relevant groundwater characteristics.
- **Known Water Supply Wells** – Identifies locations and uses of wells for municipal and domestic water supply, including where water is being drawn to support public water systems.
- **Groundwater Characteristics** – Describes the characteristics of shallow groundwater in the study area including depth to groundwater and the direction of flow.
- **Groundwater Quality** – Provides information regarding the salinity-related water quality at varying depths to evaluate potential use of water for MUN and AGR beneficial uses relevant to critical salinity thresholds.
- **Supply Well Pumpage and Downward Head Gradients** – Evaluates the influence of water supply well pumpage on groundwater flow.

The findings from the technical evaluations completed for each of the above technical areas provides the basis for a proposed horizontal and vertical MUN and AGR de-designation boundary. The regulatory context of this proposed boundary is discussed in Section 5.

4.2 Subsurface Geologic Conditions
Section 3.1 described preliminary horizontal and vertical boundaries within the Project Study Area for de-designation of MUN and AGR uses. As described above, a number of technical analyses were conducted to evaluate the appropriateness of the proposed boundaries. A key step in this analysis is the evaluation of subsurface geologic conditions within the proposed boundaries. Two approaches were used to characterize subsurface conditions: (a) an evaluation of the hydrologic characteristics of the Proposed Study Areas; and (b) an evaluation of the stratigraphy above the E-Clay. The following subsections provide the findings from each of these evaluations.

4.2.1 Hydrologic Evaluation
Croft (1972) of the USGS prepared several subsurface geologic cross sections extending through the Tulare Lake Bed. Croft’s sections were based entirely on E-logs or geologic logs from coreholes. He identified six “clayey or silty clay tongues”, designated by letter symbols A to F, beneath the fringes of part of the lakebed. The most widespread of these are the A, C, and E Clays. The E-Clay is also known as the Corcoran Clay, and is the most laterally extensive confining bed in the San Joaquin Valley.
Of particular interest in this de-designation evaluation are the A-Clay, the B-Clay, and the C-Clay. The average depths of these clays in the Tulare Lake Bed area, where they can be identified, are about 60, 130, and 230 feet, respectively. High salinity groundwater is common above the uppermost of these clays and sometimes as deep as below the B-Clay. Lower salinity groundwater is usually present beneath the C-Clay and in some areas also below the A-Clay. The shallowest public supply wells in or near the lakebed are for the City of Corcoran, and some of these tap sands above the C-Clay. However, most of the production from these wells is from below the C-Clay. Kettleman City wells tap strata above the Corcoran Clay. Other public supply wells (in Corcoran and elsewhere) tap sand below the Corcoran Clay. In the lakebed proper, clay is predominant to several thousand feet in depth, and these tongues are usually not distinguishable from the other clay that is present (Figure 4-1). Figure 4-1 extends from the northwest to the southeast through the Tulare Lake Bed, from northwest of Stratford extending to the Kings/Kern County line just southwest of Alpaugh.

KDSA previously prepared several subsurface cross sections for the west part of the North Subarea, the north part of the West Subarea, and for the east part of the East Subarea. As part of this evaluation, some of the previous KDSA subsurface geologic sections were supplemented and a number of new cross sections were developed. These sections include data from E-logs, drillers logs and other relevant reports, and thus are based on data from many more wells than were Croft's cross sections (see Attachment A and B3 for copies of the E-logs and drillers logs, respectively, used for the cross sections). Because the most important confining beds relative to the high salinity shallow groundwater are above a depth of about 250 feet, most of the sections were prepared to only show strata above this depth. However, some deeper cross sections that were prepared prior to this evaluation were used near urban areas, where deeper groundwater is tapped. Deeper cross sections were also prepared in the Central Subarea. A recent technical memorandum provides additional information on subsurface geologic conditions above the Corcoran Clay, particularly in the northeast part of the lakebed (Luhdorff & Scalmanini 2014, Attachment C). This information is summarized below in Section 4.2.2.

4.2.1.1 North Subarea

Figure 4-2 shows the locations of four subsurface geologic cross sections in the North Subarea. Because the originally proposed de-designation boundary in this subarea is primarily oriented in the east-west direction, most of these sections are oriented from north to south. Cross Section A-A' extends from the north-northeast near Stratford, to the southwest to near Nevada Avenue and 23rd Avenue (Figure 4-3). This section is generally parallel to the originally proposed de-designation boundary, and is generally near the northwest edge of the lakebed in this area. This section indicates the predominance of clay in this area, as no large streams apparently passed through this area during most of the past when the upper 250 feet of deposits were laid down. Clay is so predominant, that none of the "tongues" identified by Croft (1972) can be identified.

Cross Section B-B' extends from near Kansas Avenue and 18th Avenue on the north, to the south to near Manteca Avenue and 19th Avenue (Figure 4-4). The historic Kings River is indicted to have

---

3 Attachment B contains confidential information not publicly available; provided to regulators only for purpose of supporting regulatory decisions proposed by this report.

4 On Figure 4-2, Well 17L has a shallow sand layer from 4 to 11 feet in depth, and well 17G has shallow sand layers from 0 to 10 feet in depth, and 15 to 20 feet in depth. Both wells are consistent with each other by having shallow thin sand layers and predominately clay textured deep deposits immediately below the shallow sand. Both well have similar characteristics, therefore only one well was used.
passed through part of this area at some times, and sand layers are more predominant along the part of the section north of Madison Avenue. Clay becomes predominant toward the south (at Wells 21A, 27D, and 33A). The A-Clay (several layers) can be identified at Wells 10R and 21J. Sands below the A-Clay are particularly discontinuous along this section. The other two clays (B-Clay and C-Clay) can't be readily distinguished because of the preponderance of clay.

Cross Section C-C' extends from north of Kansas Avenue near 16th Avenue to the south, to near Manteca Avenue and 16th Avenue (Figure 4-5). This section generally shows similar subsurface geologic conditions as does Section B-B' (see Figure 4-4). Some sands are present to the north, but these are thin and pinch out to the south. Clay is predominant south of Laurel Avenue along this section. Near the north end of the section, the A-Clay, the B-Clay, and the C-Clay can be identified. The A-Clay appears to be in the interval between about 30 to 100 feet in depth. The B-Clay appears to be in the interval between about 135 to 170 feet in depth. The top of the C-Clay was indicated to be near sea level, or at a depth of about 210 to 215 feet. South of Lincoln Avenue along this section, the three clay tongues are indistinguishable, due to the predominance of clay. Some shallow sands within the upper 50 feet or so are fairly continuous along the north part of this section. At least two sands between the A-Clay and B-Clay are apparently continuous in this area. At least one sand layer just above the C-Clay is apparently continuous along the part of the section north of Lincoln Avenue.

Cross Section D-D' extends from between Kansas and Lansing Avenues near 14th Avenue on the north, to the south to the TLDD North Evaporation Basins (Figure 4-6). This section is far enough east that former branches of the Kaweah River likely passed through the area. The A-Clay, B-Clay, and C-Clay appear to be distinguishable along the section. Near the north end of the section, the A-Clay is present between above 60 and 95 feet in depth. This clay deepens to the south, and near the south end of the section is about 75 to 120 feet deep. The B-Clay is distinguishable along the part of the section north of Manteca Avenue. The top of this clay averages about 130 feet deep, and the bottom averages about 170 feet deep along the section. The upper part of the C-Clay is distinguishable along all of the section. The top of this clay is an average of about 210 feet deep along the section. A fairly continuous sand layer is present above the A-Clay along the part of the section north of Manteca Avenue. Another sand layer between the A-Clay and B-Clay is also fairly continuous along this part of the section. One or more sand layers between the B-Clay and C-Clay appear to be continuous along most of this section.

The subsurface geologic cross sections indicate that the originally proposed de-designation boundary does not need to be moved on the basis of subsurface geologic conditions. This is because of the abundance of clay in the subsurface at and near the boundary.

4.2.1.2 West Subarea

Figure 4-7 shows locations of subsurface geologic cross sections in the West Subarea. Cross Section E-E' and part of Section F-F' were previously developed by KDSA (2002) for a City of Lemoore WWTF evaluation and extend deep enough to include the Corcoran Clay.

---

5 In Figure 4-6, the A-Clay was interpreted to be present below the bottom of NEB-1A by correlation between deeper wells 33E and NEB-3A
Cross Section E-E’ extends from near Orange Avenue and east of the 26th Avenue to the south, to near Redding Avenue and 26th Avenue (Figure 4-8)⁶. The south end of this section is about one and a half miles northeast of Kettleman City. The A-Clay is distinguishable along the north part of this section, in the interval between 60 and 90 feet in depth. Below this clay and to the south, clay is predominant along the section. Several laterally discontinuous sand layers are present between the A-Clay and a depth of about 250 feet.

Cross Section F-F’ extends from Kettleman City to the north-east, near Quebec Avenue and 4th Avenue (Figure 4-9). This section extends downward to the Corcoran Clay, because Kettleman City public supply wells tap strata below 250 feet in depth and above the Corcoran Clay. All of the Kettleman City wells are outside of the originally proposed de-designation boundary. Laterally extensive clays are predominant, and the A-Clay and C-Clay are distinguishable along the section. The top of the Corcoran Clay is about 600 to 700 feet deep along the section. Sand strata thin and pinch out to the east along the section.

Cross Section G-G’ extends through the south part of the West Subarea, from near Utica Avenue and I-5 on the west to the east, to near Tucson Avenue and east of the 22nd Avenue (Figure 4-10). A sand layer was found within the upper 60 feet at Well 10P. This sand layer pinches out to the east and clay is predominant beneath the east part of the section.

The subsurface geologic cross sections indicate that the originally proposed de-designation boundary is supported by subsurface geologic conditions. This is because of the abundance of clay in the subsurface at and near the boundary.

4.2.1.3 South Subarea

Figure 4-11 shows the locations of subsurface geologic cross sections in the South Subarea and the TLDD Hacienda and South Evaporation Basins. Subsurface Section H-H’ extends from the north between 18th and 19th Avenues, about one mile south of Virginia Avenue, to the south to about one mile south of the Kings County-Kern County line, and east of the alignment of 16th Avenue (Figure 4-12). Clay is predominant above a depth of about 250 feet along the part of this section south of 16th Avenue. Several sand layers are present at Well 11P, but are not present at Well 10N. At Well 30N a review of drillers logs and the spontaneous potential curve indicate three relatively thin sand layers above a depth of 100 feet. The long normal resistivity curve indicates the presence of salty groundwater above a depth of about 180 feet at this site. The A and B-Clays can be delineated at Well 7B1. The deepest of the three clays (C-Clay) can be identified along part of the section. The top of this clay is indicated to be at an elevation of about 25 feet below sea level, or at a depth of about 230 feet, at Well 11P.

Cross section I-I’ extends from about a mile east of I-5 and the extension of Cecil Avenue to the east, past the TLDD South Evaporation Basins, to near Corcoran Road and Avenue 4 (Figure 4-13). The A-Clay can apparently be distinguished along parts of the section, between about 30 and 65 feet in depth. The top of the C-Clay is indicated to be at an elevation of about 10 feet below sea level, or a depth of about 220 feet at Well 2P1. The ancestral Kern River is indicated to have passed through at least part of this section, and several sand layers are present at Well 1N4. Clay is predominant below a

---

⁶ In Figure 4-8 the A-Clay at wells 16L and 20A was extrapolated to be present from logs for other wells to the north and south, because of the uniform depth and thickness that was apparent. E-logs for wells 16L and 20A were reviewed and used to supplement Section E-E’ to the extent possible (see Attachment K).
depth of about 150 feet along most of the cross section, except near the east edge. A fairly laterally continuous sand is indicated to be present beneath the central part of the section at a depth of about 40 to 60 feet. Another fairly continuous sand is indicated along the eastern part of the section below the C-Clay at a depth of about 240 feet.

The subsurface geologic cross sections indicate that the originally proposed de-designation boundary does not need to be moved on the basis of subsurface geologic conditions. This is because of the abundance of clay in the subsurface at and near the boundary. In addition, high salinity shallow groundwater and a lack of public supply and drinking water wells indicate that this boundary could be moved farther to the southwest and south in part of the area. The proposed de-designation boundary has been moved as shown in Figure 4-11, and is discussed further in a subsequent section of this report. A one mile buffer was provided around the TLDD South Evaporation Basins.

4.2.1.4 East Subarea

Figure 4-14 shows the locations of subsurface geologic cross sections in the East Subarea. Two of the cross sections (J-J' and K-K') were previously developed for the Angiola W.D. Two additional cross sections (L-L' and M-M') were developed for this evaluation, both extending approximately in the east-west direction.

Cross Section J-J' extends from the north near Avenues 112 and Road 36 to the south to Alpaugh (Figure 4-15). The A-Clay was delineated in Alpaugh at a depth of about 110 feet, and along the central part of the section, between Avenues 76 and 108. The C-Clay was delineated along most of the section south of Avenue 112. The top of this clay averaged about 200 to 250 feet deep. The top of the Corcoran Clay is shown, and productive sands are present between the C-Clay and Corcoran Clay along the part of the section north of Avenue 76. Numerous sand layers are present along much of this section, most of which is east of the lakebed proper. These sands were likely deposited by the ancestral Tule River. This section passes through the west well field of the Angiola W.D., where highly productive sands are present both above and below the Corcoran Clay.

Cross Section K-K' extends from the west near Avenue 56 and Road 11 to the east to near Avenue 88 and Road 44 (Figure 4-16). The east part of this section passes through the west well field of the Angiola W.D. This section extends to a depth of about 2,000 feet and shows the Corcoran Clay. The clay was distinguishable at several wells, and is about 150 feet deeper than the A-Clay. This section indicates that many sands become thinner or pinch out toward the lakebed proper. Clay becomes predominant below the Corcoran Clay along the part of the section west of Road 32.

Cross Section L-L' extends from the west near Seattle Avenue and 5th Avenue to the east to north of Avenue 112 near Road 36 (Figure 4-17). Clay is predominant along the part of the section west of Road 24. The A-Clay is distinguishable along the section below a depth of about 30 feet and above a depth of about 60 feet. The B-Clay may be present at an average depth of about 120 feet along parts of the section. The C-Clay is also distinguishable, and generally the top of this clay is near sea level, or at an average depth of about 200 feet. Sand layers are generally discontinuous along this section.

Cross Section M-M' extends from the west near Quail Avenue and 8th Avenue to the east to near Avenue 144 and 4th Avenue (Figure 4-18). Clay is predominant along the west part of this section. The A-Clay is distinguishable along the east part of the section between about 25 and 70 feet in depth. The C-Clay is distinguishable along the west and east parts of the section, below a depth of about 220 to 230 feet. There are a number of sand layers present in the area east of 5th Avenue.
The subsurface geologic cross sections indicate that the originally proposed de-designation boundary does not need to be moved to the west on the basis of subsurface geologic conditions, except south of the Tule River. This is because of the abundance of clay in the subsurface in the rest of the area.

4.2.1.5 Central Subarea

Figure 4-19 shows the locations of four subsurface geologic cross sections that were developed in the Central Subarea as well as Croft’s cross section G-G’ (Croft 1972). Two of these cross sections (N-N’ and O-O’) are oriented from west to east, and the other two (P-P’ and Q-Q’) are oriented from north to south. Each of these sections was extended to a depth of about 500 feet.

Cross Section N-N’ (Figure 4-20) extends from near 26th Avenue and Pueblo Avenue on the west to the northeast, and generally along Orange Avenue to the east near 10th Avenue. Clay layers are so predominant along much of the section, that most of the clay tongues that are present near the fringes of the lakebed can’t be identified. The thickest sand layers along the section were indicated at Well 18D above a depth of about 300 feet. Two or less sand layers were indicated at the other holes along the cross section, except at 28D, near the west edge of the section. None of the sand layers are indicated to be laterally continuous along the section, and most of them are less than 20 feet thick.

Cross Section O-O’ (Figure 4-21) extends from near the Westlake Farms South Evaporation Basins (north of Utica Avenue and west of 22nd Avenue) to the east, generally along Utica Avenue, to near Tucson Avenue and 4th Avenue. Clay is also predominant along this section. However, several sand layers were identified at Holes 15G, 13N, 18D, 10H, and 7D. The westerly sand layers are east of Dudley Ridge and are present at average depths of about 100 feet, 250 feet, and 400 feet and are of limited horizontal extent. The sand layers near the eastern edge of the section are at approximately comparable depths, and are also indicated to be discontinuous.

Cross Section P-P’ (Figure 4-22) extends from Nevada Avenue east of 20th Avenue to the near Virginia Avenue and east of 19th Avenue. Clay is also predominant along this section. Two thin sand layers were indicated at Hole 34L, below a depth of about 400 feet. One thin sand layer was indicated at Hole 21R, at a depth of about 60 feet. Another localized sand layer was present at Hole 5B at a depth of about 70 feet. Another localized sand layer was present at Hole 20A at a depth of about 250 feet. Another localized sand layer was present at Hole 34L, at an average depth about 200 feet.

Cross Section Q-Q’ (Figure 4-23) extends from near Orange and 10th Avenues to the south, to near Utica and 10th Avenues, thence on to the south-southeast to near the Kern River Channel, east of 13th Avenue. Clay is also predominant along this cross section. Near the north end of the section at Hole 13A, a localized sand layer is present at a depth of about 100 feet, and another at a depth of about 300 feet. At Hole 36A, four relatively thin localized sand layers are present above a depth of about 150 feet. At Holes 1J and 14J1, a thin sand layer is present at an average depth about 20 feet. At Wells 36A and 6D, several sands are present above a depth of about 200 feet. No coarse-grained deposits were indicated within the upper 350 feet in depth along the part of the section south of Tucson Avenue.

In summary, clay is predominant within the upper 500 feet in depth in the Central Subarea. Sand layers are generally uncommon, and where present are discontinuous. However, two relatively thick sand layers are present between Tucson and Utica Avenues, east of 7th Avenue, and near Utica Avenue between 19th Avenue and 16th Avenue. These are generally in several layers below a depth of about 50 feet and above a depth of 300 feet, and are interbedded with laterally extensive clay layers.
4.2.2 Evaluation of Stratigraphy above the E-Clay

To support the technical evaluation of the preliminary horizontal and vertical boundaries of the Project Study Area proposed for de-designation of MUN and AGR uses, an evaluation of the stratigraphy above the E-Clay in the Tulare Lake Bed Area was conducted. This information was developed in particular to support the evaluation of boundaries in the North and East Subareas where the A-Clay is not always present or cannot be easily distinguished from other clays (Figure 4-24).

The stratigraphic evaluation included data developed for the hydrologic evaluation described in Section 4.2.1 and additional information developed for this analysis. The evaluation focuses on the occurrence and distribution of sand units above the E-Clay as a basis for defining the limits of potential water supply sources. The following subsections provide a high level summary of the findings of the stratigraphic evaluation completed for this study. The detailed analysis is in Attachment C, which includes a CD with additional E-log data.

4.2.2.1 Lacustrine Clay Units

The presence of lacustrine clay units in the San Joaquin Valley has been known since the early 1900s. Previous studies have defined the lacustrine/marsh beds in a descending sequence of A to F clays. Various studies have also where these clays are present in areas of the southern San Joaquin Valley, including the Tulare Lake Bed area. Consistent with previous studies, the current stratigraphic evaluation found that the more distant from the Tulare Lake Bed margins, the more difficult it is to distinguish stratigraphic horizons using geophysical logs. Within the thick, very low resistivity lacustrine clay sequence, only the E-Clay unit (Corcoran Clay) could reliably be identified and correlated.

4.2.2.2 Occurrence of Sands above the E-Clay

To support this analysis, recent E-logs from boreholes located mainly in the south half of T21N (within R21E and R22E) and T22N/R22E were examined for stratigraphic markers and correlations. This area includes the North and East Subareas as described above. These E-logs were supplemented with older geophysical logs and drillers reports from water wells and oil and gas boreholes. Figure 4-25 shows the location of wells where data were analyzed for the purpose of this evaluation. Wells referenced in Section 4.2.1 were considered here as well. Based on a review of these data, the central portion of the Tulare Lake Bed is characterized by up to 3,000 feet of clay formation with indistinguishable features on E-logs. Sands were identified in the North and East Subareas from recent geophysical logs, which are informally termed as the ‘V’ Sequence or ‘V’ Sands, to delineate their interpreted stratigraphic relationship. These sands are interbedded with the lacustrine clay units.

4.2.2.3 Evaluation of “V” Sequence

The evaluation of the ‘V’ Sequence consisted of detailed review of recent E-logs and selected older E-logs to construct structure maps and geologic cross sections. A representative cross section extends over eight miles into the North and East Subareas as defined in Section 3.1.1 (see Figure 3-2). The east-west cross section reflects geophysical characteristics of geologic beds to a depth of about 800 feet, or -600 feet elevation. The alignment of the representative cross section was selected to reflect the depositional environments from the northern and eastern fringes into the central part of the Lake Bed.

Stratigraphic correlations were determined from e-logs based on the nature, character and variation of geophysical signatures for geologic beds encountered in boreholes. Observations were made on the
thickness and number of beds. The representative Cross Section X-X’ is shown on Figure 4-26. The location and well control for this cross section is shown on Figure 4-27. For each well on the cross section, the 16-inch normal resistivity curve (short normal) from the geophysical log is reproduced based on a normalization to an original drawing scale of 0.10 inch to 10 ohm-meter²/meter (the shorthand “ohms” is used to express resistivity values). In general, higher resistivity values represent coarse-grained, sedimentary geologic material of sands and gravels, with the lowest resistivity values representing fine-grained, sedimentary material of silts and clays. In the southern San Joaquin Valley and elsewhere, water wells are screened in the higher resistivity beds of sand and gravel beds, which have characteristics conducive to successful water supply development. Observations of resistivity values for individual beds, or the range of values for a series of beds, were also made.

From observations on the number, thickness, and nature of the geologic beds, and their resistivity values, available well log control was examined for patterns in these parameters to construct and interpret work sections and the representative cross section (X-X’, Figure 4-26). Four areas are distinguishable from this evaluation based on consistent characteristics (i.e., thickness, nature, resistivity values) which define a sedimentary facies (i.e., general nature and characteristics). From east to west on Section X-X’ (Figure 4-26): Alluvial Plain; Sandflat; Lake Margin; and Lake Bed. Each facies is a reflection of the depositional environment in which the beds were formed, such as stream channels, alluvial fans/plains or lakes. The following subsections describe each identified facies; Table 4-1 summarizes the findings from this analysis.

**Table 4-1. Summary of facies characteristics identified in North and East Subareas**

<table>
<thead>
<tr>
<th>Facies Type</th>
<th>Resistivity Characteristics</th>
<th>Depositional Environment</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial Plain</td>
<td>Resistivity values range from low 20s up to 50 ohms; interbedded with some thin, low resistivity fine grained beds.</td>
<td>Distal alluvial plain where streams and flood flows spread out, laying down lobes of sand as the gradient decreased towards the base level of the lake to the west</td>
<td>Figure 4-26; E-log for Well 25H in Attachment C</td>
</tr>
<tr>
<td>Sandflat</td>
<td>Short normal resistivity sand beds which interbed and interfinger with low resistivity lake clays. Resistivity values range from low 20s to the east decreasing westward to less than 15 ohms</td>
<td>Thin beds of sand deposited as flow velocities decreased near lake base level and the ability to transport sand was diminished. Possibly small alluvial, delta-like lobes may have developed and built out into the lake in this area.</td>
<td>Figure 4-26; E-log for Well 27N in Attachment C</td>
</tr>
<tr>
<td>Lake Margin</td>
<td>Short normal resistivity values range from less than 5 ohms to 8 ohms. Interbedded with the lake clays are a few, thin sandy or silty clay beds with resistivity values of less than 10 ohms to less than 15 ohms</td>
<td>Standing water of the lake where fine-grained sediments of silt and clay settled. The few thin, slightly higher resistivity beds are believed to be sandy or silty clays formed by high sediment influx of flood flows or possibly density currents</td>
<td>Figure 4-26; E-log for Well 30N in Attachment C</td>
</tr>
<tr>
<td>Lake Bed</td>
<td>Short, normal resistivity values less than 5 ohms</td>
<td>Deeper lake waters where fine-grained, silt and clay sized sediments settled. Thin, slightly higher resistivity beds represent periods of high sediment inflow and/or turbid density flows into the lake</td>
<td>Figure 4-26; E-log for Well 27A in Attachment C</td>
</tr>
</tbody>
</table>
**Alluvial Plain Facies** - At the east end of Cross Section X-X' (see Figure 4-26), the Alluvial Plain facies consists of numerous, thick sand beds with relatively high short normal resistivity. Resistivity values for these beds range from low 20s up to 50 ohms and are interbedded with some thin, low resistivity fine grained beds. A typical log for this facies is from T21S/R22E, Well 25H on Cross Section X-X' (see Figure 4-26 and E-logs in Attachment C). The interpreted depositional environment is a distal alluvial plain where streams and flood flows spread out, laying down lobes of sand as the gradient decreased towards the base level of the lake to the west. About three miles further east outside the study area, available well control indicates that the Alluvial Plain facies exhibits even higher resistivity and is interbedded with lower resistivity beds. These characteristics possibly reflect a more fluvial or stream dominated alluvial plain with floodplain or soil horizons.

**Sandflat Facies** - To the west of the Alluvial Plain facies, the Sandflat facies is characterized by numerous, thin to thick, medium short normal resistivity sand beds which inter-bed and inter-finger with low resistivity lake clays, (see Figure 4-26). The short normal resistivity values of the sand beds range from the low 20s to the east decreasing westward to less than 15 ohms. The sands are divisible into four sand sequences separated by clay beds associated with high lake stands. A typical log for this facies is from Well 27N on Cross Section X-X' (see Figure 4-26 and E-logs in Attachment C).

The interpreted depositional environment of the Sandflat facies is where thin beds of sand were deposited as flow velocities decreased near lake base level and the ability to transport sand diminished. Possibly small alluvial, delta-like lobes may have developed and built out into the lake in this area. The sand beds can be seen to decrease westward with thickening interbeds of lake clays (see Figure 4-26). The western edge of the Sandflat facies is believed to mark the western extent of 'V' Sands that are of sufficient thickness and resistivity to be potential targets for low to modest yields of groundwater to wells. The western edge of the Sandflat facies is interpreted as the demarcation point where lake or lacustrine deposition became dominant in standing waters.

**Lake Margin Facies** - The Lake Margin facies is characterized by thick, low resistivity, fine-grained lake clays. Short normal resistivity values are very low ranging from less than 5 ohms to 8 ohms. Interbedded with the lake clays are a few, thin sandy or silty clay beds with resistivity values of less than 10 ohms to less than 15 ohms. A typical log for this facies is from Well 30N on Cross Section X-X' (see Figure 4-26 and E-logs in Attachment CA). Notably, these low resistivity beds can be stratigraphically correlated eastward to the sandy sequences of the Sandflat facies consistent with the interpreted depositional processes described for the Sandflat facies.

The depositional environment of the Lake Margin facies is standing water of the lake where fine-grained sediments of silt and clay settled. The few thin, slightly higher resistivity beds are believed to be sandy or silty clays formed by high sediment influx of flood flows or possibly density currents. The thin-bedded nature, fine-grained character, and low resistivity of the stratigraphic marker beds in the lake margin facies are not water supply targets and no water supply wells are known to be completed above the E-Clay in this area.

**Lake Bed Facies** - At the west end of Cross Section X-X' (see Figure 4-26), the Lake Bed facies is characterized by thick, very low resistivity beds of clay and silty clays. Short normal resistivity
values of these beds are generally less than 5 ohms. Thin, stratigraphic markers occur with slightly higher resistivity, but are generally less than 2 to 4 ohms greater than the adjacent clay beds and may be difficult to discern on logs using scales typical of water well surveys (e.g., 0 to 50 ohms or 0 to 100 ohms). A typical log for this facies is from Well 27A shown on Cross Section X-X’ (Figure 4-26 and E-logs in Attachment C).

The depositional environment for the Lake Bed facies is the deeper lake waters where fine-grained, silt and clay sized sediments settled. The thin, slightly higher resistivity beds represent periods of high sediment inflow and/or turbid density flows into the lake. The thin, very low resistivity stratigraphic markers in the lake bed facies are not water supply targets and no water supply wells are known to be completed above the E-Clay in this area West of Cross Section X-X’ for 4 miles, geophysical surveys from four recent boreholes included a natural gamma ray log (see X”-X on Figure 4-27). Five distinct gamma ray spikes, or cluster of spikes, were found to correlate between these boreholes. Two of these occurred above and below the E-Clay. The uppermost three gamma ray features appear to correlate to the thin resistivity zones on the westernmost borehole on Cross Section X-X’ and may represent volcanic ash that fell into the lake, or was carried into the lake by streams. The spikes may provide a means to correlate the thick lake clay beds where other stratigraphic markers are not discernable; however, most geophysical logs do not include the curve.

4.2.2.4 Extent of “V” Sequence Facies

From the detailed examination and stratigraphic correlations, including those presented on representative Cross Section X-X’ (Figure 4-26), and development of a depositional facies model (as described above), the areal extent of the ‘V’ Sequence facies were mapped in the North and East Subareas of the Project Study Area. The resistivity values and bedding characteristics (thickness, number, and nature) on the cross-section wells were used to determine facies trends and then evaluated more broadly with geophysical logs from other wells, including other water wells and oil and gas test holes.

Figure 4-27 illustrates the depositional facies of the ‘V’ Sequence in the Tulare Lake Bed area. The delineated facies form an arcuate (curved or bowed) pattern around the north to northeast lake bed region. Available geophysical log control in the west and south areas is more limited because of a lack of wells. The Sandflat facies boundary indicates the interpreted extent of sand beds in the ‘V’ Sequence with the potential to be used as water supply sources. In the northernmost area it appears that only a lower ‘V’ sequence sandflat beds occur below a depth of 250 feet overlain by lake-margin to lake-bed facies clay beds. As indicated on Figure 4-27, Upper ‘V’ Sequence sandflat beds appear to occur only to the east.

4.2.2.5 Above “V” Sequence

As shown on Cross Section X-X’ on Figure 4-27, overlying the ‘V’ Sequence is the interpreted A-Clay unit, as described by Croft and Gordon (1968) and Croft (1972) (see additional discussion of Croft (1972) in Section 4.2.1). At the surface, the Tulare Clay basin soil unit is encountered throughout the Tulare Lake Bed area (see Section 3.2.3 for additional discussion of soil conditions).

4.3 Historical Water Supply Wells

Information on water supply well locations and types was taken primarily from USGS Well Data reports, DWR well completion reports, and City or Department of Health Services records.
Construction data for active public supply wells are provided in **Attachment D. Attachment E** contains an inventory of the status of domestic wells in the originally proposed de-designation area. **Attachment F** provides an inventory and a map of active irrigation wells within the study area. Where available, annular seal information is provided in the table and associated well log data are provided in **Attachment G**.

### 4.3.1 North Subarea

#### Public or Domestic Supply Wells

**Figure 4-28** shows locations of historical supply wells in part of the North Subarea; however, not all wells shown in this figure remain in existence. There are records for five public supply wells in Stratford. These are outside of the originally proposed de-designation boundary, and are discussed in a later section of this report (see Section 4.4.2). There are a number of private domestic wells located in part of the originally proposed de-designation area. Because many of these wells may not be sealed off from the area to be de-designated (four of these domestic wells, south or southwest of Stratford and originally opposite the high salinity (electrical conductivity) shallow groundwater) it is advisable to not include them in the area to be de-designated. Additional wells were reviewed further to evaluate their current status: (a) well T20S/19E-25 is destroyed7 and the landowner is trucking in drinking water; (b) wells T21S/R19E-11 and T21S/R19E-01 are completed below the Corcoran Clay (see Attachment E, page 4; email communication from C. Howe, March 31, 2015 regarding information on this well); and (c) T20S/R20E-29 is screened from 500-520 feet. (see Attachment E, page 3 for information regarding this well). There are several other private domestic or small water system wells close to the originally proposed de-designation boundary (Figure 4-28), and the boundary was moved slightly to exclude them from the de-designation area. The distance moved was based on the estimated lateral influence of these wells (less than half a mile).

#### Irrigation Supply or Stock Wells

In the rest of this subarea proposed for de-designation, the only known water supply wells were used for irrigation. **Figure 4-28** identifies locations of historical irrigation supply wells. **Table F-1 in Attachment F** provides more detailed information showing which wells are known to be active. **Figure F-1 in Attachment F** provides the annular seal interval for active wells (see Attachment G for well logs, where available). Within the North Subarea, wells can be seen to typically have a “deep” annular seal meaning that the seal extends from the land surface to at least 500 feet (approximate average depth to the top of the Corcoran Clay). One exception is Well 10D (T21S-R21E-10) with a shallow annular seal of 50 feet. However, this well is screened at a depth beginning at 702 feet. As discussed in Section 4.6, the presence of gravel packs opposite of blank casings are not conducive to vertical movement of groundwater and therefore the shallow annular seal is not a concern with regards to downward flow of groundwater.

Supply wells identified as stock wells within the North Subarea have all been found to be abandoned8 (See Section 5.2.2 for additional discussion of the use of wells for stock watering in the area proposed for AGR de-designation).

---

7 The term “abandoned” means that the well is physically in existence but is not used. When the well is “destroyed” it means the well is no longer in existence; well destruction logs for destroyed wells could not be located.

8 See previous footnote.
4.3.2 **West Subarea**

*Public or Domestic Supply Wells*

Figure 4-29 shows locations of historical supply wells in the West Subarea; however, not all wells shown in this figure remain in existence. Several of these wells were abandoned due to poor water quality. Records are available for four public supply wells in Kettleman City. Three of these wells are still active. Records are available for two old private domestic wells near Salem Avenue and 27th Avenue, but they may no longer be active. These public supply and domestic wells are indicated to tap strata above the Corcoran Clay. Records are also available for five industrial wells located near Highway 41 between Quebec Avenue and Redding Avenue, and four other industrial wells west of 27th Avenue between Racine Avenue and Salem Avenue. Most of these industrial wells no longer exist. The northerly industrial wells range in depth from about 1,350 to 1,700 feet and primarily tap strata below the Corcoran Clay. The southerly industrial wells tap strata above the Corcoran Clay. The proposed de-designation boundary has been moved to the east to exclude these wells.

*Irrigation Supply or Stock Wells*

Records are available for four irrigation wells north of Quebec Avenue and four other irrigation wells north of Salem Avenue, between 26th and 27th Avenues. These wells are indicated to primarily tap strata below the Corcoran Clay and are no longer used (inactive).

Records are also available for five stock wells south of Tucson Avenue. These are indicated to be shallow, likely tapping strata above the Corcoran Clay. Four of these wells (see Figure 4-29; wells 11D1, 11D2, 30Q1 and 31Q1) have been abandoned; per the landowners, where cattle require water this water is either hauled in or obtained from ditches (See Section 5.2.2 for additional discussion of the use of wells for stock watering in the area proposed for AGR de-designation). The remaining stock well (36J1) is located outside the area proposed for de-designation.

4.3.3 **South Subarea**

*Public or Domestic Supply Wells*

Figure 4-30 shows locations of historical water supply wells in the South Subarea; however, not all wells shown in this figure remain in existence. There are records for only three private domestic wells and all of these are east of Corcoran Road and outside of the proposed de-designation area; all are abandoned.

*Irrigation Supply or Stock Wells*

There are records for a number of irrigation wells in the southeast part of the subarea, and all of them are outside of the proposed de-designation area. There are records for four stock wells in the west part of the subarea. Two of these wells (19N1 and 31Q1) are within the proposed de-designation area but are abandoned.

4.3.4 **East Subarea**

*Public or Domestic Supply Wells*

Figure 4-31 shows the locations of historical water supply wells in the originally proposed area for de-designation in the East Subarea; however, not all wells shown in this figure remain in existence. Only wells west of Road 40 are shown in the east part of the subarea. City of Corcoran supply wells are all in the area northeast of Highway 43 and well out of the area proposed for de-designation. The primary Alpaugh public supply well is also located outside of the area proposed for de-designation.
There were several drinking water wells near Road 21 and south of Avenue 136, but these are no longer present.

There are records for two private domestic wells in the east part of Section 21 and the west part of Section 22, T21S/R22E. These are west of Corcoran and inside the area originally proposed for de-designation. The Section 21 private domestic well is only used for toilet flushing; not for drinking. The Section 22 private domestic well is abandoned; the residence that was using this well is now connected to City of Corcoran water. There are records for a number of other private domestic wells in the area south of Avenue 144, north of Avenue 120, and east of 5th Avenue. The proposed de-designation boundary was moved to the west from that originally proposed to exclude the areas where private domestic wells are or were present. There are no known records of other private domestic wells in the remaining part of the subarea proposed for de-designation.

Irrigation Supply or Stock Wells

There are a number of irrigation wells west of Corcoran and south of Corcoran and north of Avenue 120 in the subarea. South of Avenue 104, almost all of the irrigation wells in the subarea are near Road 40 or farther east. Attachment F summarizes information regarding the active irrigation wells in the area. For example, for the clusters of wells in T21S/R21E, T21S/R22E and T22S/R22E available logs for these wells indicate annular seals extending to depths ranging from 500 to 860 feet (see Attachment G). Three wells (T21S/R22E-35C, T22S/R22E-4H, T22S/R22-3H) had shallow (50-foot) annular seals; however, these wells are screened at a depth beginning at 898, 510 and 500 feet, respectively. As previously mentioned well screens are not conducive to vertical movement of groundwater (see Section 4.6 discussion). There is one record of a stock well (19A1) that is on the boundary of the area proposed for de-designation. A field visit found that this well no longer exists.

4.3.5 Central Subarea

Public or Domestic Supply Wells

Figure 4-32 shows the locations of historical water supply wells in the Central Subarea; however, not all wells shown in this figure remain in existence. A record was found for only one domestic well (T22S/R22E-17L2) in the subarea; however, the landowner stated that the well is abandoned (see Domestic Well Table).

Irrigation Supply or Stock Wells

In the area south of Salem Avenue, there are records for only a few stock and irrigation wells (Figure 4-32). The two stock wells (11D1 and 11D2) identified in the subarea are abandoned. Cows use either water hauled in via tanker or ditch water for drinking (See Section 5.2.2 for additional discussion of the use of wells for stock watering in the area proposed for AGR de-designation). The irrigation wells have since been destroyed. Records are available for numerous irrigation wells in the part of the subarea north of Quebec Avenue and east of the 2nd Avenue, and in the area between the Tule River and Salem Avenue, east of 9th Avenue. Most of these wells have been destroyed. The active irrigation wells are shown in Attachment F.

4.4 Groundwater Characteristics

Shallow groundwater levels are discussed in this section. Because of the importance of urban areas to this evaluation, the direction of shallow groundwater flow in and near these areas is also discussed.
4.4.1 Depth to Water

The shallowest groundwater in most of the lakebed area is less than 20 feet deep. Detailed maps showing the water-level elevations and direction of shallow groundwater flow are generally unavailable except in specific areas, such as at and near the Westlake Farms Evaporation Basins. Available data indicate that the direction of shallow groundwater flow in most of the lakebed area generally follows the topography, flowing from the exterior part of the subareas toward the center of the lake bed (see Figure 3-1). Thus near the fringes of the lakebed, the direction of groundwater flow is toward the interior of the lakebed.

Information on vertical differences in water levels for the shallow groundwater is available from U.S. Geologic Survey multiple completion monitor well sites and at or near some of the evaporation basins. Beard, Fujii, and Shanks (1994) provided water-level data for four cluster monitor wells sites in the Tulare Lake Bed area. At Site T19S/R20E-29E, north of Stratford, there was little difference in water levels for two monitor wells that were 50 feet deep or shallower. However, the water level at a depth of 80 feet was about 12 feet lower than in the shallower strata. At a depth of 190 feet, the water level was about 65 feet lower than a depth of 80 feet (Figure 4-33).

At Site T20S/R21E-4F, located east of Stratford, the water level at a depth of 51 feet was about five feet lower than at a depth of 15 feet. At a depth of 98 feet, the water level was about 14 feet lower than at a depth of 51 feet. At a depth of 195 feet, the water level was about 20 feet lower than at a depth of 98 feet.

At Site 24S/R26E-5B, located southwest of Alpaugh, there was little difference in water level between 15 and 95 feet in depth. However, between 95 and 180 feet in depth, there was a difference of about 51 feet. At Site T25S/R21E-1N, located near the southwest edge of the lakebed in Kern County, there was very little difference in water levels above a depth of 194 feet. At this particular location, the water level at a depth of 194 feet was actually several feet shallower than at a depth of 95 feet, indicating an upward direction of groundwater flow. This is probably due to the lack of groundwater pumping in the vicinity.

The most important conclusion from the water-level data for the shallow groundwater is that the significant vertical water-level differences in the absence of pumping are an indication of the extremely low hydraulic conductivities of clay layers, in particular, the A and B-clays. Considering the low vertical conductivities of the clay layers, this means that there is very little if any downward flow of groundwater.

4.4.2 Direction of Groundwater Flow near Urban Areas

This section provides a review of the direction of groundwater flow relevant to the four urban areas surrounding the Project Study Area.

Stratford

Data for the primary public supply well (Attachment D) in Stratford indicates that it is perforated from 660 to 1,170 feet in depth and taps strata below the Corcoran Clay. The deposits above the Corcoran Clay are sealed off in this well. The direction of shallow groundwater flow is indicated to be to the south, based primarily on monitoring at the Westlake Farms North Evaporation Basins and on the topography. Shallow groundwater would not influence the quality of groundwater pumped from the
Stratford supply wells because of the intervening clay above the top of the perforations. In addition, all of these public supply wells are located outside of the proposed de-designation.

**Kettleman City**

There are three active public supply wells in Kettleman City. Two of these well are about 400 feet deep and the other is 630 feet deep (Attachment D). All of these wells are indicated to tap strata above the Corcoran Clay, which is indicated to be below a depth of about 800 feet near Kettleman City. The direction of shallow groundwater flow is indicated to be to the east, based primarily on the topography and the direction of groundwater flow at the Westlake Farms South Evaporation Basins. All of these public supply wells are located outside of the proposed de-designation boundary.

**Alpaugh**

The primary supply well in Alpaugh is perforated from 1,025 to 1,210 feet in depth and taps strata below the Corcoran Clay. This well is sealed off opposite all strata above a depth of 900 feet (Attachment D). The direction of shallow groundwater flow near Alpaugh is indicated to be to the west, based on topography. The two Angiola W.D. wells (G-3 and G-5), which could be used for Alpaugh, are perforated from about 200 to 500 feet in depth and tap strata above the Corcoran Clay. The direction of shallow groundwater flow in that area (between Avenues 104 and 112 and Roads 32 and 40) is indicated to be to the west, based on topography. Shallow groundwater within the proposed de-designation area would not influence the quality of water pumped from the Angiola W.D. well or wells, because of the intervening clay layers above the top of the perforations.

**City of Corcoran**

Active City of Corcoran public supply wells are located east of 5th Avenue and north of Orange Avenue. All of these wells are located more than two miles outside of the proposed de-designation boundary. Two of these wells (No. 8 and No. 9) tap strata above the C-Clay and have perforations extending up to 120 and 116 feet in depth, respectively. These two wells are located between Orange and Niles Avenues and 4½ and 5th Avenues. The remaining active City wells (Attachment D) have perforations below a depth of 194 feet and are located farther to the north or northeast of City Wells No. 8 and 9 (farther from the proposed de-designation area). Four active City of Corcoran wells tap strata below the Corcoran Clay.

Water-level maps from the KDSA (1992) report on groundwater conditions in the vicinity of the City of Corcoran and annual water-level maps prepared by the California DWR, San Joaquin District, were reviewed. Maps for the lower aquifer (below the Corcoran Clay) have consistently indicated a southwesterly direction of groundwater flow, toward the central part of the lakebed. This is primarily due to the pumping of numerous deep irrigation wells in the area southwest of Corcoran.

Water-level maps for the upper aquifer (above the Corcoran Clay) have shown an influence from pumping at the Corcoran Irrigation District (CID) well field, which is located north of Avenue 192 and east of 6th Avenue (north-northeast of the City). When wells in this well field are heavily pumped, there is a significant cone of depression in the upper aquifer in the area northwest of the Corcoran-Tulare Highway; however, this well field is located more than two miles northeast from the proposed de-designation boundary and are indicated to produce groundwater primarily from inflow from the northeast. Water-level maps for the period 1997-2003 were generally based on more measurements near Corcoran, and are thus considered more representative. These maps consistently indicate a
southwesterly direction of groundwater flow, toward the central part of the lakebed, except within the CID cone of depression.

The direction of shallow groundwater flow above a depth of about 50 feet in Corcoran is indicated to be to the west, based on topography. High salinity shallow groundwater in the area proposed for de-designation would not influence the quality of water pumped from City of Corcoran wells, due to the presence of the A-Clay, the annular seals in these wells, the direction of groundwater below the A-clay, and the distance of the wells from the proposed de-designation boundary.

### 4.5 Groundwater Quality

As used in this report, the "shallowest groundwater" is that closest to the water table, primarily above a depth of about 50 feet. This can also be termed the "first encountered groundwater". "Deeper shallow groundwater" is generally between about 50 feet and 200 feet in depth. The chemical quality of groundwater below the C-Clay is generally discussed only in the vicinity of the four urban areas in the study area. Information on the chemical quality of groundwater above a depth of about 200 feet was obtained from several sources:

2. Monitoring reports for shallow groundwater at and near the Westlake Farms and TLDD evaporation basins.
5. Recent monitoring results for dairies and other sites in the study area.
6. Available E-logs from wells within the study area.

The backhoe excavation data consist of electrical conductivity measurements on water samples collected from backhoe pits during post-harvest periods. Pits are excavated for agronomic purposes in which depth-to-water, soil properties, water salinity, and other information are used to determine crop rotation and soil amendment needs. The various tests are implemented to mitigate shallow water table and high soil salinity present in the lakebed. Attachment I provides a general water sampling methodology and results for the backhoe excavations in the entire Project Study Area. The methodology is summarized below.

Backhoe pits are systematically located on a quarter-section basis and typically target a depth of 10 feet and terminate below first-encountered water. Groundwater is permitted to stabilize in the pit for 24 hours after which a water sample is collected by submerging a sample bottle below the water surface. Sample bottles are collected at the backhoe sites and transported to a laboratory for analysis. Electrical conductivity analysis is performed within 24 hours of sample collection. Testing oversight was performed by a laboratory manager with an advanced chemistry degree and 25 years of experience. Electrical conductivity was measured with a YSI 3100 meter calibrated daily. The laboratory is noncommercial, but is presently undergoing certification for certain water quality parameters including electrical conductivity.
Figure 4-35 shows electrical conductivities of the shallowest groundwater for the composite lakebed area, including the subareas on the fringes of the lakebed and in the central part of the Tulare Lake Bed. This illustration documents the high salinities of the shallowest groundwater beneath most of the lakebed. The following sections provide additional information regarding each subarea.

4.5.1 Water Quality Data

4.5.1.1 North Subarea

Figure 4-36 shows electrical conductivities of shallow groundwater in the North Subarea.

Shallowest Groundwater

Data available in or near this subarea are from the Westlake Farms North Evaporation Basins monitoring, from the previously referenced USGS reports, backhoe excavations, and for other monitoring programs, such as at dairies. The shallowest groundwater samples are primarily for wells or excavations less than about 30 feet deep. The highest electrical conductivities exceeding 10,000 μS/cm have been found in the west part of the subarea, primarily near or northwest and west of Highway 41. In most of the rest of the subarea north of the originally proposed de-designation boundary, electrical conductivities of the shallowest groundwater have exceeded 5,000 μS/cm and have generally been highest to the west and south. The electrical conductivities in this subarea were less than 5,000 μS/cm at a few locations, all in the northeast part. These records are from very shallow monitoring wells near or inside the north evaporation basins. Data from these wells are not representative of typical well data in the area since they are influenced by the lower EC waters in the evaporation basins owned and operated by the Tulare Lake Drainage District.

In part of the area south of Nevada Avenue and east of 20½ Avenue, Tulare Lake Bed land owners have measured electrical conductivities of the shallow groundwater in numerous backhoe excavations. The results are provided for such holes north of Newton Avenue. All of these electric conductivities exceeded 10,000 μS/cm.

In summary, the high electrical conductivities of the shallowest groundwater support the originally proposed de-designation boundary in this subarea, except for a small area south of Nevada Avenue and east of 12th Avenue. The proposed de-designation boundary was moved from that originally proposed to exclude this area. This boundary was also moved in certain areas to exclude domestic wells, as previously discussed. This distance moved was about half a mile beyond the wells, to account for well drawdown.

Deeper Groundwater

There are data for a deep monitor well near the TLDD North Evaporation Basins. Well NEB-A tapped groundwater at a depth of about 95 feet. The electrical conductivities of water from this well ranged from about 3,200 to 3,600 μS/cm when monitoring first began in 1975-76. The electrical conductivities of water from this well ranged from 3,000 to 3,400 μS/cm in 2010-2012. Additional data are available for three cluster monitor wells at Site T20S/R21E-4F from 1990-1991) (Table 4-2). Electrical conductivities were much lower in samples from below a depth of 93 feet.

Similar information is available for four cluster monitor wells at Site T19S/R20E-29E (Table 4-3). At this site, high salinity groundwater was still present to a depth of almost 200 feet. This well is about a mile and a half north of the North Subarea and about half a mile northeast of the Westlake Farms North Evaporation Basins.
4.5.1.2 West Subarea

Figure 4-37 shows electrical conductivities of the shallowest and deeper groundwater in the West Subarea.

<table>
<thead>
<tr>
<th>Depth Interval (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 20</td>
<td>5,490</td>
</tr>
<tr>
<td>93 - 103</td>
<td>928</td>
</tr>
<tr>
<td>190 - 200</td>
<td>1,530</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth Interval (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 20</td>
<td>21,500</td>
</tr>
<tr>
<td>45 - 55</td>
<td>41,700</td>
</tr>
<tr>
<td>75 - 85</td>
<td>39,200</td>
</tr>
<tr>
<td>185 - 195</td>
<td>15,200</td>
</tr>
</tbody>
</table>

Shallowest Groundwater

Electrical conductivities are available for 14 wells, all of which are about 20 feet deep, in this subarea. Some of these wells are near the Westlake Farms South Evaporation Basins. Electrical conductivities of water from all of these wells exceeded 10,000 μS/cm. Values ranged from 12,600 to 59,200 μS/cm and were generally lowest in the central part of the subarea, east of Kettleman City. For the part of the area east of 22nd Avenue, backhoe excavations were dug by landowners and electrical conductivities measured (Attachment I). Electrical conductivities for all of this shallow groundwater exceeded 10,000 μS/cm. These values were similar to those for shallow groundwater in USGS monitor wells to the west and within about three miles of the excavations.

Deeper Groundwater

Information on the chemical quality of groundwater between 30 feet and 250 feet in depth is not known to be available in this subarea.

4.5.1.3 South Subarea

Figure 4-38 shows electrical conductivities of shallow groundwater in the South Subarea.

Shallowest Groundwater

Electrical conductivities of the shallowest groundwater have been measured at many sites in the part of this subarea east of 12th Avenue. Included are data from monitor wells for the Tulare Lake D.D. Hacienda and South Evaporation Basins. There are two USGS cluster monitor well sites (T24S/R23E-5B and T25S/R21E-1N) where additional data are available. In the part of the subarea east of 10th Avenue and north of the extension of Avenue 36, Tulare Lake Bed landowners collected samples of shallow groundwater in a number of backhoe excavations for electrical conductivity measurements (Attachment I).
Most of the monitor wells tapping the shallow groundwater range from about 10 to 50 feet deep. Electrical conductivities in water from these wells and the backhoe excavations exceeded 10,000 μS/cm in much of the subarea. One well west of the TLDD South Evaporation Basins had water with an electrical conductivity of only 1,750 μS/cm. This well (T25S/R21E-1N1) is perforated from 10 to 20 feet in depth and is adjacent to a local ditch. The electrical conductivity is indicated to not be representative of other areas. Groundwater at that site between 52 and 62 feet in depth had an electrical conductivity of 12,000 μS/cm, which is considered representative of the shallowest groundwater in the vicinity. Electrical conductivities in water from four excavations north of the Hacienda evaporations basins ranged from 1,600 to 3,400 μS/cm. These lower electrical conductivities are from very shallow monitoring wells in a small, isolated area in and near the evaporation basins. Only one other shallow well (HEB-13-1A) near the Hacienda Evaporation Basins had an electrical conductivity of less than 10,000 μS/cm (9,300 μS/cm) in 2009-10. Thus the representative electrical conductivity of shallow groundwater in this subarea substantially exceeds 10,000 μS/cm, with some values exceeding 40,000 μS/cm. Data indicate that the south boundary of the originally proposed designation area in Kern County could be moved farther south, because high salinity shallow groundwater extends at least several miles south of the Kern County line in this area.

**Deeper Groundwater**

There are five monitor wells at or near the TLDD Hacienda Evaporation Basins that range in depth from about 80 to 100 feet. Electrical conductivities in water from those wells ranged from about 4,600 to 25,000 μS/cm. Overall, the salinity of the deeper groundwater was less than that of the shallowest ground-water in this subarea, but was still relatively high. There are five monitor wells at or near the TLDD South Evaporation Basins that are about 100 feet deep. The electrical conductivities of water from these wells ranged from 2,900 to 47,000 μS/cm. There was only one well (SEB6-2) with an electrical conductivity of less than 4,500 μS/cm. At the other three sites, electrical conductivities exceeded 40,000 μS/cm. There is a monitor well that is perforated from 90 to 100 feet in depth northeast of the Trico Gas Field. The electrical conductivity of water from Well T24S/R23E-5B5 was 8,900 μS/cm. There are two USGS monitor wells in the subarea that tap strata in the interval between 175 and 200 feet in depth. The electrical conductivity of water from Well T25S/R21E-1N4 was 4,540 μS/cm and the electrical conductivity of water from Well T24S/R23E-5B6 was 2,380 μS/cm. This relatively lower salinity deeper groundwater is separated from the overlying high salinity groundwater by significant clay layers.

**4.5.1.4 East Subarea**

Figure 4-39 shows electrical conductivities of the shallowest groundwater in the East Subarea. There is a substantial amount of data from landowner backhoe excavations and monitor wells.

**Shallowest Groundwater**

Electrical conductivities for the shallowest groundwater are primarily from samples above a depth of about 20 feet. A distinct geographical distribution of electrical conductivities is apparent in the East Subarea. Electrical conductivities of the shallowest groundwater exceeded 50,000 μS/cm in the area south of Avenue 96 and southwest of a line extending from near Quebec Avenue and 9th Avenue to the southeast, to near Avenue 96 and Road 40. Electrical conductivities were less than 5,000 μS/cm in an area primarily south of Avenue 144 and east of 6 ½ Avenue. The south boundary of this area was near Avenue 120 between 5th Avenue and Road 32. In the area south of Avenue 136, the transition from
lower salinity (less than 5,000 μS/cm) to higher salinity (more than 10,000 μS/cm) shallowest groundwater occurred in a relatively short distance (less than a mile) (see Figure 4-39).

**Deeper Groundwater**

There is little information on the salinity of groundwater between a depth of about 30 feet and 250 feet in this subarea. However, sampling of water for a test well in Alpaugh adjacent to the recommended subarea boundary indicated an electrical conductivity of 1,330 μS/cm at a depth near 250 feet. Thus groundwater below the C-Clay in this area is of much lower electrical conductivity than that of the shallowest groundwater (indicated to range from about 30,000 to 57,000 μS/cm) in the vicinity.

**4.5.1.5 Central Subarea**

Figure 4-40 shows electrical conductivity of the shallowest groundwater in the Central Subarea. The subarea boundary for this evaluation was made smaller in part of the subarea because the salinity of shallow groundwater was previously discussed under some of the precious subareas. For example, in the area north of Avenue 16 and east of Avenue 11, electrical conductivities were shown in Figure 4-37 and were previously discussed. Electrical conductivities for the shallowest groundwater in this subarea are primarily from samples above a depth of about 20 feet. Data for this subarea are primarily from shallow excavations and from shallow USGS monitor wells. As expected, electrical conductivities exceeded 5,000 μS/cm beneath almost all of the study area for this subarea. There were three shallow monitoring wells with anomalously low electrical conductivities (T21S/R21E-29 NE, and T22S/R21E-12SW and 27SE). Electrical conductivity was found to be low due to nearby ditch systems and summer irrigation. As a consequence, these conductivity values are not considered representative of the Central Subarea.

**4.5.2 Electric Log Data**

To supplement available water quality data from the Project Study Area, a number of E-log from the Tulare Lake Bed area that extend up to shallow depths were evaluated. Table J-1 in Attachment J summarizes the wells where E-log data were available (see Attachment J for E-logs). The log normal resistivity curves for these logs indicate that high salinity groundwater (electrical conductivity greater than about 5,000 μS/cm @ 25°C) is often present above a depth of several hundred feet, and is consistently present above a depth of about 70 feet. Figure 4-34 summarizes the well information by showing locations of the evaluated wells, the depth to the top of the E-log and the vertical extent of the high salinity groundwater. This information is consistent with that found in E-logs and other information in the north part of Kern County south of the county line and in the Stratford area.

The reason that high salinity groundwater extends to various depths in different parts of the lakebed area is attributed to natural factors, as opposed to the downward movement of shallow groundwater to greater depths. One reason for this finding is that a number of the wells for which E-log data are available are at least 40 to 50 years old, indicating the presence of deeper high salinity groundwater in parts of the lakebed for an extended period (see Table J-1 in Attachment J). Where groundwater in deeper strata is of high salinity (i.e., to depths of several hundred feet), downward flow below the A-clay or its equivalent is not a concern, because the underlying groundwater is already of high salinity. In areas where that underlying groundwater is of low salinity, the absence of groundwater quality degradation due to downward flow in the past is the best evidence that this will not occur in the future.
4.6 Supply Well Pumpage and Downward Head Gradients

Diamond and Williamson (1983) reported on estimated pumpage from wells in the Central Valley for 1961-77. Information in that report was provided for townships and ranges in the Tulare Lake Bed and vicinity. Maximum annual pumpage in the range of about 3,000 to 11,000 acre feet per year was reported for the following townships and ranges: T21S/R20E, T21S/R21E, T22S/R22E, and T24S/R22E. Pumpage in the remaining townships and ranges in the Tulare Lake Bed was generally insignificant.

Figure 4-32 shows locations of irrigation wells with records in the north part of the Central Subarea. T21S/R20E and T21S/R21E are covered by this map, and records are available for numerous irrigation wells in these townships and ranges. The greatest pumpage in these townships and ranges during the period was generally prior to 1965, and during 1977 in T21S/R21E. Figure 4-32 also shows the locations of a number of irrigation wells with records in T22S/R22E, southwest of Corcoran. The greatest pumpage in this township and range was prior to 1966 and during 1976-77. Figure 4-31 shows the location of irrigation wells with records in the south part of the East Subarea. This map includes T24S/R22E, and indicates a number of irrigation wells near the south edge of this subarea. Pumpage in this area was relatively high during 1962-1971 and 1976-77.

The downward head gradients previously described at the closest shallow monitor well sites (primarily within the upper 100 to 200 feet in depth) may reflect an influence of this pumping. The pumping from irrigation wells has been present since at least the early 1960’s and likely since at least the 1950’s. Despite the downward head gradient for many decades, the electrical conductivities in the groundwater below one or more of the clay tongues (A-Clay, B-Clay, and C-Clay) has remained low. This is attributed to the lower vertical hydraulic conductivity of these clay layers and the interbedded deposits. There is no indication that high salinity shallow groundwater has moved to greater depths, even after about 60 years of such pumping.

The potential for downward flow of shallow poor quality groundwater through well gravel packs as a result of irrigation well pumping was evaluated for wells in the area. Gravel packs are comprised of coarser material than the native fine-grained layers (i.e., clay). Thus, one can envision these gravel packs as being a possible conduit for downward flow of shallow poor quality groundwater. However, there are several other factors to consider. First, is that most of the older irrigation wells (pre-1970’s) were drilled by the direct rotary method. This method involves the use of substantial amounts of bentonite or other clay to make up the drilling fluid. When the gravel packs were originally placed in the wells in an area such as the lakebed, they contained a substantial amount of this drilling fluid. Subsequently, the gravel packs opposite the coarse-grained strata were developed and should have been relatively permeable. However, opposite sections of blank casing and/or clay layers, the gravel packs could not be developed, due to a lack of water production from such zones. The overall effect of this is that the vertical permeability of the gravel packs would be expected to be low opposite sections of blank casing and clay layers. Numerous clay layers are normally present and are often predominant in the lakebed area. This would normally preclude the gravel packs from functioning as significant conduits for the downward flow of poor quality shallow groundwater.

In recent decades, the reverse rotary method has been widely used to construct new deep wells in the lakebed area. Although water is used as the main drilling fluid, a substantial amount of clay is introduced to this fluid from native deposits encountered during drilling. Bentonite and other materials are also added to prevent hole collapse, particularly for clay layers such as the Corcoran...
Clay. The same principal applies for the gravel pack development as described above for the direct rotary method. Because of these factors, gravel packs in wells in the lakebed area have a very low potential to function as conduits for the downward flow of groundwater from one zone to another.

4.7 Proposed Horizontal and Vertical MUN De-Designation Boundaries

Based on the findings from the technical analyses provided above, this section provides the final proposed horizontal and vertical boundaries of the area originally proposed for MUN de-designation.

4.7.1 Horizontal Boundary

Figure 1-2 shows the proposed de-designation boundary in the Tulare Lake Bed area as the result of the technical evaluation provided in the previous sections. This figure illustrates the recommended boundary of the area proposed for de-designation of MUN and the originally proposed boundary as described in Section 3.1. Modifications were made where needed to take into account findings from the technical analysis, primarily findings that indicated the presence of domestic or industrial wells, which may be used as a drinking water source, or water quality characteristics that did not support the Sources of Drinking Water Policy exemption criteria. Based on the technical evaluations described above, changes were made to the originally proposed de-designation boundary (see Figure 3-1) to create a final horizontal proposed MUN de-designation boundary within each of the fringe areas. These changes are discussed below.

**North Subarea**

The primary revision in the North Subarea is for an area southeast of Stratford, where records are available indicating a large number of private domestic wells (see Figure 4-28). Therefore, the de-designation boundary was moved several miles to the south, primarily between 17th Avenue and 20½ Avenue. A second part of this subarea where the boundary was moved south was south of Nevada Avenue between 10th Avenue and 12th Avenue. The subsurface geologic conditions, supply well locations, and shallowest groundwater quality data support the originally proposed de-designation boundary in the rest of this subarea.

**West Subarea**

The originally proposed de-designation boundary near Kettleman City was moved about half a mile to the east to exclude the industrial wells north of and near Kettleman City (see Figure 4-29). Most of these wells were abandoned due to water quality problems. The rest of the originally proposed boundary is supported by subsurface geologic conditions, supply well data, the direction of groundwater flow, and shallowest groundwater quality data.

**South Subarea**

The original westerly de-designation boundary in T24S was moved to the southwest, because of the presence of shallow clay layers, the lack of domestic wells, and the relatively high electrical conductivity of the shallowest groundwater (see Figure 4-30). Clay strata are indicated to be predominant and the electrical conductivities of the shallowest groundwater in this part of the lakebed exceed 4,500 μS/cm. The proposed de-designation boundary was also moved from that originally proposed near the TLDD South Evaporation Basins. South of the South Evaporation Basins, clay is predominant in the subsurface and information in Kern County indicates electrical conductivities exceeding 10,000 μS/cm in the shallowest groundwater (see Figure 4-30). There are also no records...
of domestic wells in the area south of these basins and within a distance of one mile. Thus this boundary was moved south over a width of three miles in this part of the subarea.

East Subarea
The originally proposed de-designation boundary was moved to the west in part of this subarea south of Corcoran and north of Alpaugh, primarily because of the presence of lower electrical conductivities in the shallowest groundwater south of the Tule River, and also because of supply well locations. Recent backhoe excavations by landowners in a large part of this subarea (see Figure 4-39) indicated electrical conductivities in the shallow groundwater exceeded 5,000 μS/cm. The direction of shallow groundwater flow in this area is to the west, based on the topography. The top of the A-Clay is present at variable depths below ground surface (see discussion in Section 4.2.2) and provides a barrier between the shallow groundwater and the uppermost usable groundwater (see Figures 4-16, 4-17 and 4-18).

The supply well information (see Figure 4-31) indicates there are or were several drinking water wells in the area south of the Tule River and north of Racine Avenue (Avenue 120), between Highway 43 and 6th Avenue. For this reason, the proposed de-designation boundary has been shifted to the southwest in this area. In addition, the boundary was moved westerly generally between Avenue 80 and Avenue 120 because of the proposed use of one or more Angiola W.D. wells for public supply in Alpaugh. These changes were the largest changes from the originally proposed boundary for the lakebed area. Also, considering the location of the City of Corcoran public supply wells northeast of Corcoran, well beyond the Project Study Area boundary, de-designation of the shallow groundwater within the proposed boundary in the East Subarea is reasonable. This is based on the subsurface geologic conditions, shallow groundwater quality, and the location of public supply and drinking water wells.

4.7.2 Vertical Boundary
Figure 1-2 illustrates the vertical boundaries for de-designation of MUN within the horizontal boundary. The proposed vertical boundary is the top of the E-Clay in much of the Project Study Area (see green highlighted area in Figure 1-2). However, based on the hydrologic and stratigraphic evaluations completed in the North and East Subareas (see Sections 4.2.1 and 4.2.2), the proposed vertical boundary varies within these areas – either to the top of the A-Clay (yellow and blue highlighted areas – or a minimum of 75 and 110 foot depths, respectively) or to the top of the C-Clay or a minimum depth of 200 feet (orange highlighted area). While the basis for these boundaries is based on all the technical findings provided in Section 4, the following subsections highlight the key bases for these proposed boundaries.

Hydrologic Evaluation Findings
Information on vertical trends in electrical conductivity is available at a number of sites where multiple completion monitor wells have been installed and sampled. Most of these wells were installed by the USGS or for the TLDD near evaporation basins. Two such sites are in or near the North Subarea: T20S/R21E-4F and T21S/R21E-4R. The latter of these sites is the TLDD North Evaporation Basins NEB-3 series. Table 4-2 summarized the electrical conductivities observed at the 4F site. A geologic log by Beard, Fujii, and Shanks (1994) indicated that the A-Clay was present in several layers between 82 and 95 feet in depth at this site. The A-Clay thus separates the higher electrical conductivity (exceeding 5,000 μS/cm) groundwater above a depth of about 80 feet from the
groundwater below a depth of about 90 feet, which had an electrical conductivity of less than 1,000 μS/cm.

Table 4-4 summarizes electrical conductivities at the NEB-3 site. The geologic log for TLDD NEB-3 indicates that the A-Clay is present from 59 to 80 feet in depth. The higher electrical conductivities (exceeding 12,000 μS/cm) are in groundwater above a depth of 75 feet (above the lower part of the A-Clay). This is separated from lower electrical conductivity groundwater below a depth about 95 feet (below the A-Clay).

Table 4-4. Conductivity data from monitor wells at Site T21S/R21E-4R (NEB-3 series)

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>13,000</td>
</tr>
<tr>
<td>74</td>
<td>22,000</td>
</tr>
<tr>
<td>96</td>
<td>3,100</td>
</tr>
</tbody>
</table>

There are three cluster monitor well sites of interest in the South Subarea: T25S/R21E-1N, T24S/R22E-6R (SEB 6-2), and T24S/R23E-5B. Table 4-5 summarizes electrical conductivities at Well 1N. With regards to this USGS monitor well, the upper part of the whole (to a depth of 100 feet) was augured. A geologic log was not provided from 50 to 60 feet in depth, and the log between 62 and 100 feet in depth is not precise. An electrical conductivity of 12,000 μS/cm was reported in the interval from 52 to 62 feet in depth. This material was logged primarily as “mostly clean sand.” Strata from 60 to 62 feet and probably deeper were logged as “very clayey sand.” An electrical conductivity of 6,250 μS/cm was reported in the interval from 90 to 100 feet (apparently near the base of this clayey sand). Thus there appeared to be enough fine grained strata below a depth of 50 feet to preclude downward flow of the higher salinity groundwater. Whether or not these deposits are the A-Clay has not been determined. Clay was indicated by Beard, Fuji and Shanks (1994) from 120 to 162 feet in depth at this site. Subsurface Geologic Cross Section 1-1’ (see Figure 4-13) extends through Well 1N and indicates that this is the B-Clay. The B-Clay thus separates groundwater with an electrical conductivity exceeding 6,200 μS/cm from the underlying groundwater with a lower electrical conductivity (4,540 μS/cm).

Table 4-5. Conductivity data from monitor wells at T25S/R21E-1N

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>1,750</td>
</tr>
<tr>
<td>52-62</td>
<td>12,000</td>
</tr>
<tr>
<td>90-100</td>
<td>6,250</td>
</tr>
<tr>
<td>187-199</td>
<td>4,540</td>
</tr>
</tbody>
</table>

Table 4-6 summarizes electrical conductivities observed at Well 5B. The geologic log from Beard, Fuji and Shanks (1994) indicates that the A-Clay is present from 81 to 91 feet in depth at this site. This clay separates groundwater above the clay with an electrical conductivity of 20,300 μS/cm from groundwater beneath the clay with an electrical conductivity of 8,990 μS/cm. A clay to clayey silt layer was indicated from 97 to 104 feet in depth, and a clay layer was present from 160 to 167 feet in depth. One or both of these fine-grained layers separates groundwater above a depth of 100 feet (electrical conductivity of 8,900 μS/cm) from the groundwater below a depth of 175 feet (electrical conductivity
of 3,100 μS/cm). Subsurface Geologic Cross Section J-J’ (see Figure 4-15), the south end of which is about one mile north of Well 5B, indicates that the deepest of these fine-grained layers may be the C-Clay.

### Table 4-6. Conductivity data from monitor wells at Site T24S/ R23E-5B

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 – 20</td>
<td>43,800</td>
</tr>
<tr>
<td>53 - 63</td>
<td>20,300</td>
</tr>
<tr>
<td>90 – 100</td>
<td>8,990</td>
</tr>
<tr>
<td>175 - 185</td>
<td>2,380</td>
</tr>
</tbody>
</table>

### Table 4-7. Conductivity data from monitor wells at TLDD SEB 6-2

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Electrical Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>36,000</td>
</tr>
<tr>
<td>101</td>
<td>2,900</td>
</tr>
</tbody>
</table>

Table 4-7 provides the electrical conductivities at two cluster monitor wells at TLDD SEB 6-2. The geologic log for SEB 6-2 indicates that the A-Clay is present from about 63 to 86 feet in depth at this site. The A-Clay thus separates the high salinity shallow groundwater (electrical conductivity of 36,000 μS/cm) above a depth of about 60 feet from groundwater below a depth of 100 feet (electrical conductivity less than 3,000 μS/cm).

In summary, the A-Clay is indicated to be overlain by groundwater with electrical conductivities ranging from about 5,400 to 44,000 μS/cm at the cluster monitor well sites. This clay is normally present somewhere in the interval between about 6 and 100 feet in depth in the Tulare Lake Bed area. At four of the sites, the electrical conductivities of groundwater below the A-Clay ranged from about 930 to 3,100 μS/cm. At the fifth site, high salinity groundwater was indicated to also be present between the A-Clay and B-Clay. For purposes of this evaluation, the requested vertical de-designation would be for groundwater above the A-Clay (yellow and blue highlighted areas – or a minimum of 75 and 110 foot depths, respectively), to the top of the C-Clay or a minimum depth of 200 feet (orange highlighted area), and to the top of the E-Clay in the remainder of the Project Study Area (see green highlighted area).

### Stratigraphic Evaluation

**Figure 4-41** presents the extent of stratigraphic facies where sands may be encountered that potentially support MUN uses below the A-Clay vertical de-designation boundary recommended based on the hydrologic evaluation above. In this fringe area, 'V' Sequence sands inter-finger within the lakebed clays and are overlain by the A-Clay. Within the fringe areas proposed for de-designation to the top of the A-Clay, there are no widespread or continuous lacustrine or other fine-grained facies (i.e., similar to the A – F Corcoran Clay units) separating soils or shallow geologic materials investigated through backhoe excavations. The surficial geology is mapped as Quaternary alluvium sourced from the Sierra Nevada and the depositional setting is interpreted as Sandflat to Lake Margin facies. There is no continuous fine-grained bed or beds that isolate or confine water-bearing facies in
the interval between the saline water encountered in the backhoe excavations to the top of the A-Clay. As a result, the saline water encountered near the surface would be hydraulically connected throughout the interval to the A-Clay.

In the area between the proposed horizontal boundary and the secondary, stratigraphic demarcation in Figure 4-41, it is recommended that the interpreted top of A-Clay be the vertical boundary. This is where first encountered water above that boundary exceeds MUN beneficial use criteria. Groundwater electrical conductivity was estimated for 'V' Sands using the Spontaneous Potential (SP) curve from the recent well logs (see Attachment C). Calculations from the SP deflections indicated that these interbedded sands below the interpreted A-Clay in the fringe area have conductivity values from just under 3,000 μS/cm to greater than 5,000 μS/cm. While these values may explain the lack of water supply wells completed between the A-Clay and E-Clay in this area, some groundwater in these units may not satisfy MUN de-designation criteria based on the Sources of Drinking Water Policy. Thus, the top of the A-Clay is a conservative vertical boundary in this area.

In areas outside the north and northeast fringe where thick lacustrine clay units of the Lake Bed facies are predominant and no known wells support the MUN use, the vertical boundary is recommended at the top of the E-Clay. Figure 4-42 shows well control and top of the E-Clay depths. Other than the northern and eastern fringe areas where numerous water well logs were available, much of the contour map for the E-Clay boundary was constructed using oil and gas well logs obtained from the California Division of Oil, Gas and Geothermal Resources website. Both resistivity and gamma ray (when available) curves were used to determine the E-Clay depth.

4.8 Proposed Horizontal and Vertical AGR De-Designation Boundaries

4.8.1 Horizontal Boundary

Figure 1-3 shows the proposed horizontal boundary for de-designation of the AGR beneficial use for crop irrigation, based on an electrical conductivity threshold of 3,000 μS/cm (TDS > 2,000 mg/L). Figure 1-4 provides the proposed horizontal boundary for de-designation of the AGR beneficial use for stock watering, based on an electrical conductivity threshold of 7,500 μS/cm (TDS > 5,000 mg/L). These boundaries are based on existing groundwater quality within the boundary area as described in Section 4.5 of this report.

4.8.2 Vertical Boundary

The vertical boundary for de-designation of the AGR beneficial use (crop irrigation and stock watering) is the same as the boundary proposed for de-designation of the MUN beneficial use (see Figures 1-3 and 1-4 and compare color-coded depths with Figure 1-2). See section 4.7.2 for discussion of the basis for the vertical boundaries.
Page intentionally left blank
Page intentionally left blank
Section 5

Regulatory Analysis

This section discusses the technical information provided in Section 4 within the context of regulatory requirements for de-designation of MUN or AGR beneficial use. Each of these beneficial uses is discussed independently below.

5.1 Applicability of MUN Beneficial Use

The Sources of Drinking Water Policy establishes criteria for evaluating the applicability of the MUN beneficial use to a waterbody. As described in Section 2, two exception criteria are being evaluated for applicability to the area proposed for MUN de-designation:

- The TDS > 3,000 mg/L (electrical conductivity > 5,000 μS/cm) and it is not reasonably expected by Regional Boards to supply a public water system, or
- There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices

The following sections discuss the applicability of these exception criteria within the context of the technical information developed in Section 4.

5.1.1 Applicability of Sources of Drinking Water Policy Exception Criterion 1a

Section 4.7 describes the horizontal and vertical boundaries of the area proposed for de-designation of MUN. These final proposed boundaries take into account any technical findings inconsistent with Exception Criterion 1a (see Figure 1-2). The applicability of this criterion to the area within the final proposed boundaries is described below.

Water Quality

Figure 1-2 illustrates the horizontal boundary of the proposed area for MUN de-designation for the Tulare Lake Bed area. This boundary was adjusted as needed to take into account: (a) areas with electrical conductivity less than 5,000 μS/cm (except where such readings are anomalous, as discussed below); and (b) proximity to known wells that serve as a source of water supply, including the need to provide a sufficient buffer between the proposed de-designation boundary and groundwater under the potential area of influence of a pumping supply well.

Figure 4-35 illustrates the overall quality of groundwater within the proposed horizontal boundary for MUN de-designation for the North, West, South and East Subareas (Figures 4-36 through 4-39, respectively) and Central Subarea (Figure 4-40). Within this proposed horizontal boundary, MUN is proposed for de-designation above the A-Clay layer at variable depths in the north, northwest and east areas. Per Section 4.2.1, this clay layer occurs at an average depth of about 60 feet below ground level in the Tulare Lake Bed area, but this layer can be present as much as 100 feet below the ground surface (e.g., see discussion in Section 4.7.2).
With very few exceptions, above the A-Clay layer the electrical conductivity is above the 5,000 $\mu$S/cm criterion at all well locations within the proposed horizontal boundary. These exceptions are limited to (a) a few data results in the South Subarea, where lower electrical conductivities are the likely the result of tile drains collecting irrigation from recently irrigated fields (e.g., a few samples from an area north of the Hacienda evaporation basins in the South Subarea (see Section 4.5.1.3); and (b) three anomalous conductivity values in the Central Subarea (see Section 4.5.1.5). Other water quality data from these same areas show that typical electrical conductivity values in this area are typically above 10,000 $\mu$S/cm (see Figure 4-38, South Subarea; Figure 4-40, Central Subarea). Thus, conductivities that do not meet the Exception 1a criterion within these areas are the exception rather than the rule. Accordingly, it is not practical to consider these anomalous areas as potential sources of drinking water.

Water quality between the A-Clay and B-Clay layers can exceed the Exception 1a criteria, as noted in Section 4.7.2. However, given the known variability in water quality in this area below the A-Clay layer, it is proposed that MUN only be de-designated in the area above the A-Clay layer.

Protection of Existing Public Water Supply Sources

Figure 5-1 provides a summary of the locations of all municipal wells in the Tulare Lake Bed area and the active domestic water and irrigation supply wells within the area proposed for de-designation of the MUN beneficial use. All municipal wells are outside the proposed horizontal de-designation boundary and drill from depths well below the proposed vertical boundaries. Only three active domestic wells are within the proposed horizontal de-designation boundary (southwest of Stratford). Two of these wells are completed below the Corcoran Clay and one well draws water from a 500-520 foot depth – all three wells are completed well-below the proposed vertical de-designation boundary. Numerous active irrigation supply wells have been identified within the proposed horizontal de-designation boundary; however, all are completed below the Corcoran Clay, well-below the proposed vertical de-designation boundary.

Potential to Supply a Public Water System

Exception 1a includes a requirement that water with electrical conductivity greater than 5,000 $\mu$S/cm is not reasonably expected to supply water to a public water system. There are four such systems within the four urban areas that are near the project study area: Stratford, Kettleman City, Alpaugh and Corcoran (see Figure 3-1). The potential for the area proposed for de-designation to serve as a supply for these public water systems is as follows:

- **Stratford** – Section 4.3.1 provides information regarding the public supply wells that serve the Stratford area. All of these wells are located outside of the horizontal boundary proposed for MUN de-designation (Figure 4-29). In addition, as discussed in Section 4.4.2, these wells only draw water from below the Corcoran Clay at depths of 660 to 1,170 feet, well below the vertical boundary proposed for MUN de-designation. The City of Stratford Public Utilities District has indicated that the area above the A-Clay layer is a nonviable water supply source for municipal and domestic water supply wells now and in the future (Letter to Central Valley Water Board, December 11, 2013, see Attachment L).

- **Kettleman City** - Section 4.3.2 provides information regarding the public supply wells that serve the Kettleman City area. All of these wells are located outside of the horizontal boundary proposed for MUN de-designation (Figure 4-30). The City's three active public water supply
wells draw water from 400 (two wells) and 630 feet (one well). These depths are above the Corcoran Clay (which lies at about 800 feet in that area), but well below the bottom of the A-Clay Layer. The Kettleman City Community Services District has indicated by letter that the area proposed for MUN de-designation is a nonviable water supply source for municipal and domestic water supply wells now and in the future (Letter to Central Valley Water Board, September 17, 2013, see Attachment L).

- **Alpaugh** – Section 4.3.4 notes that the primary public water supply well for Alpaugh is located outside of the horizontal boundary of the area proposed for MUN de-designation. As noted in Section 4.4.2, this well draws water from 1,025 to 1,210 feet in strata below the Corcoran Clay. This section also notes that the City of Alpaugh may develop two wells in the future to provide a public water supply (see Figure 4-32, wells G-3 and G-5). These wells, which are located outside of the horizontal boundary of the area proposed for MUN de-designation, are perforated between about 200 and 500 feet, above the Corcoran Clay, but well below the A-Clay layer. The City is considering development of these wells to address arsenic concerns in its existing public water system wells (see discussion regarding the East Subarea in Section 3.1.1). In response to the proposed MUN de-designation, the Alpaugh Community Services District (ACSD) stated that the “ACSD views the Recommended Delisting areas a nonviable water supply source for municipal water supply wells now and in the future. All of ACSD’s municipal water supply wells are located outside of this area to the East. Furthermore, the ACSD does not intend on installing new wells within the Recommended Delisting Boundary. Any potential wells would be located up gradient and further away from the Recommended Delisting area; which is consistent with past trends” (Letter to Central Valley Water Board, January 22, 2014, see Attachment L).

- **Corcoran** – As noted in Section 4.3.4, the City of Corcoran’s public supply wells are all in the area northeast of Highway 43. Section 4.4.2 indicates that these wells are located more than two miles outside (east/northeast) of the proposed horizontal boundary for MUN de-designation. Two of the City of Corcoran’s wells draw water from relatively shallow depths (120 and 116 feet), but below the A-Clay layer. The remaining City wells draw water from deeper depths; four of the City’s well tap strata below the Corcoran Clay. The City of Corcoran’s Public Works Department has stated that it views the area proposed for MUN de-designation as a nonviable water supply source for municipal water supply wells now and in the future (Letter to Central Valley Water Board, September 3, 2013, see Attachment L). Moreover, the City states that MUN de-designation in the proposed area does not pose any risk to its source of water supply.

The above discussion regarding protection of the public water supply systems for each of the four communities near the area proposed for MUN de-designation documents that not only will existing public water systems not be impacted by the proposed MUN de-designation, all of these communities do not view the area as a viable source of future water supply. The Kings County Board of Supervisors has also submitted a letter indicating it does not have any concerns with the proposed MUN de-designation, noting that not only is the groundwater in area unsuitable for municipal use, but the area proposed for de-listing is also prone to flooding (see additional discussion regarding the flooding issue below) (Letter to Central Valley Water Board, September 10, 2013, see Attachment L).
Although Sources of Drinking Water Policy Exception Criterion 1a only addresses the potential for water to be used as a source of water for a public water system, Section 4 of this document also provides information on the potential for the proposed MUN de-designation to impact private domestic wells or industrial wells which may still be used as local water sources. Sections 4.3 and 4.7 document how the proposed horizontal boundary for MUN de-designation was modified to ensure these wells were not located within the area proposed for de-designation.

5.1.2 Applicability of Sources of Drinking Water Policy Exception Criterion 1b

The Sources of Drinking Water Policy states that the MUN beneficial use may be exempted from ground waters where, “…there is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices” (Exception Criterion 1b).

The area proposed for de-designation of the MUN beneficial use in the Tulare Lake Bed is located above what is called the A-Clay. As previously noted, Croft (1972) identified six ‘clayey or silty clay tongues’ designated by letter symbols A to F, beneath the fringes of parts of the lakebed. The most widespread of these clays are the A, C, and E Clays. The E-Clay is also known as the Corcoran Clay, and is the most laterally extensive confining bed in the San Joaquin Valley. As discussed in Section 4.2, the A-Clay is normally present at a depth varying from 60 to 100 feet beneath the Tulare Lake bed.

The groundwater above the A-Clay is shallow groundwater which, as detailed, has high values of electrical conductivity throughout the Tulare Lake Bed varying from approximately 5,000 up to areas greater than 50,000 μS/cm. The high salinity values in the shallow groundwater and its impact on productive agriculture explains why numerous lands in the Tulare Lake Bed have installed subsurface drainage systems to allow the surface soils to be leached and to drain the high saline drainage water.

Table 5-1 summarizes results from tests on drainage water quality by TLDD. TLDD has a Main Pipeline which pumps collected subsurface drainage water from the north portion of the Tulare Lake Bed to the south where it eventually is discharged into evaporation basins for disposal. The water quality analyses represent average subsurface groundwater quality for drainage water which has been discharged into the pipeline. As shown on Figure 5-2, the water quality testing occurred at two locations: (1) the Tule River crossing of the Main Pipeline; and (2) at the Main Pipeline Outlet Structure. Listed in Table 5-1 are the MUN de-designation criteria (per the Sources of Drinking Water Policy), California Maximum Contaminant Levels (MCLs), Secondary MCLs, and the Public Health Goals.

Per Exception Criterion 1b and these water quality findings, the question is whether the shallow groundwater in the Tulare Lake Bed can reasonably be treated for domestic use. More specifically, with water of this quality what will be required for water to be treated for domestic use and what is

---

9 Per California Code §116275 (h), “public water system” means a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. A public water system includes the following: (1) Any collection, treatment, storage, and distribution facilities under control of the operator of the system that are used primarily in connection with the system; (2) Any collection or pretreatment storage facilities not under the control of the operator that are used primarily in connection with the system; (3) Any water system that treats water on behalf of one or more public water systems for the purpose of rendering it safe for human consumption.
the likelihood there would be a need to treat water for domestic or industrial use in this area? Table 5-1 shows that the subsurface drainage water exceeds the California MCLs for nitrate, sulfate, arsenic, radiological uranium, and while not shown there is evidence some of the shallow groundwater in the Tulare Lake Bed also exceeds the MCL for selenium. The groundwater also exceeds the Secondary MCL for conductivity, TDS, chloride, sulfate, and aluminum.

The technology and treatment process that would be required to ensure that the groundwater above the A-Clay meets California potable water quality requirements would not be a simple off-the-shelf treatment plant for an individual landowner or for a commercial or industrial business interested in operating in the Tulare Lake Bed. At a minimum, water treatment options for wells installed in the shallow groundwater above the A-Clay would have to be capable of treating the groundwater exceeding the MCLs for nitrate, sulfate, arsenic, radiological uranium, and also for the California Secondary MCLs for conductivity, TDS, chlorides and for sodium which exceed what would be acceptable. Per Table 5-1, the nitrate (as nitrate) levels in the drain water (comparable to the shallow groundwater in the Tulare Lake Bed area) are above 100 mg/L (more than two times the MCL), the sulfate levels are approximately four times the MCL, the arsenic levels are approximately 10 times the MCL, the radiological uranium varies from nearly three times to 13 times the MCL, and the conductivity, TDS, and chlorides are also significantly above the Secondary MCLs.

Individual treatment options can more easily be implemented if you are dealing with removal of only one contaminant. The shallow groundwater in the Tulare Lake Bed, however, as described above, has numerous contaminants which would have to be removed for it to be usable as an acceptable potable water supply. The operation and ongoing maintenance for a required water treatment facility would be complicated and time consuming. For example, at this time the U.S. Bureau of Reclamation is constructing a 200 gallons per minute $22.7 million pilot water treatment facility on the west side of the San Joaquin Valley to test and verify the suitability and feasibility of different treatment options for treating agricultural drainage water. This facility will include options for reverse osmosis, microfiltration, or ultrafiltration treatment.

While treatment may be technologically possible, as illustrated by the U.S. Bureau of Reclamation project, the feasibility of implementing such technology to treat drain water to potable standards within the Tulare Lake Bed would not be cost effective (e.g., a reverse osmosis water treatment plant which be required to remove the contaminants of concern) or, more importantly, practical because of the potential for flooding in the Tulare Lake Bed. The potential for flooding has influenced where development occurs relative to the Tulare Lake Bed area.

The Tulare Lake Bed area has been intensively farmed since the early 1920's. Landowners typically have their offices in or near Corcoran. Businesses in the area are usually related in one manner or another to agricultural production. A primary reason that only agriculturally oriented businesses work in and around the Tulare Lake Bed is the ongoing risk from historic flooding.

Prior to the construction of dams in the lower foothills of the Sierra Nevada, during each spring’s annual snowmelt runoff, water which could no longer be diverted by upstream farmers would flow into Tulare Lake. Nearly every year the lake was recreated, enlarging outward into the fringe areas of the lake as the runoff volume increased. The lake would rise and fall depending on the total quantity of runoff each year, often varying from year to year. Land was purchased within the center and fringe areas of Tulare Lake and levees were constructed to protect farm land and to divert water to certain
areas. Each year farmers would gamble on the estimated runoff and choose how close to the center of the lake they could plant their crops without being flooded.

Table 5-1. Water quality data from drain water in Tulare Lake Bed area

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Drains Water Sample Locations</th>
<th>California Regulatory Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main Pipeline @ Tule River</td>
<td>Main Pipeline @ Outlet Structure</td>
</tr>
<tr>
<td>Analytes</td>
<td>Units</td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>μS/cm</td>
<td>7,200</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>5,000</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>690</td>
</tr>
<tr>
<td>Nitrate as NO₃</td>
<td>mg/L</td>
<td>100</td>
</tr>
<tr>
<td>Hexavalent Chromium</td>
<td>μg/L</td>
<td>ND</td>
</tr>
<tr>
<td>Sulfate as SO₄</td>
<td>mg/L</td>
<td>2,400</td>
</tr>
</tbody>
</table>

| Metals       |                      |                              |                              |      |              |                  |
| Aluminum     | mg/L                 | 1.9                         | 0.88                         |      | 1            | 0.2              | 0.6              |
| Arsenic      | μg/L                 | 110                         | 110                          |      | 10           | 0.004            |
| Cadmium      | μg/L                 | ND                          | 1.7                          |      | 5            | 0.04             |
| Calcium      | mg/L                 | 150                         | 200                          |      |              |                  |
| Copper       | mg/L                 | ND                          | ND                           |      | 1.3<sup>c</sup> | 1.0              | 0.3              |
| Hardness as CaCO₃ | mg/L | 920                        | 1,200                        |      |              |                  |
| Lead         | μg/L                 | ND                          | ND                           |      | 15<sup>c</sup> | 0.2              |
| Magnesium    | mg/L                 | 130                         | 170                          |      |              |                  |
| Manganese    | mg/L                 | 0.27                        | 0.22                         |      | 0.05         |
| Potassium    | mg/L                 | 12                          | 18                           |      |              |                  |
| Selenium     | μg/L                 | 15                          | 37                           |      | 50           | 30               |
| Silver       | mg/L                 | ND                          | ND                           |      |              |                  |
| Sodium       | mg/L                 | 1,600                       | 2,000                        |      |              | 0.1              |
| Uranium      | μg/L                 | 84                          | 390                          |      |              | 0.5              |
| Uranium, Radiological | pCi/L | 57                        | 260                          |      | 20           | 0.43             |
| Zinc         | mg/L                 | ND                          | ND                           |      |              | 5                |

<sup>a</sup> MUN De-Designation Criteria
<sup>b</sup> California Secondary Standards - Short Term Consumer Acceptance Contaminant Level
<sup>c</sup> Regulatory Action Level

When dams were constructed in the upper watershed during the last 60 years it provided Tulare Lake farmers with a better ability to farm without being impacted by flooding. Nevertheless, even with dams constructed on the Kings, Kaweah, Tule, and Kern Rivers there continue to be years when floods still impact the low lying lands in the Tulare Lake Bed, particularly in peak flood or snowmelt years when the dams do not have the capacity to store all the runoff. During these years water has to be released to provide storage in the dams for the anticipated peak runoff and to minimize flood impacts adjacent to the river channels. The water is often diverted by upstream farmers for recharge, but if the
water cannot be used it flows down the river channels and into the Tulare Lake Bed, once again creating the historic Tulare Lake.

**Figure 5-3** shows for illustrative purposes drought years when runoff was limited, flood years in which some flood water flowed into Tulare Lake, and years which were not impacted by flood or drought. This figure shows there was some flood water or residual flood water remaining in Tulare Lake for 19 of the 59 years listed. Since construction of Pine Flat Dam on the Kings River, these data show that just over 30 percent of the time flood water has impacted farming and some of the lands within the Tulare Lake Bed. In Section 3 an aerial photograph was provided that illustrates the extent of flooded cropland in the Tulare Lake Bed during the years 1969, 1983, 1997 and 1998 (see Figure 3-8). This depiction of flooding in the Tulare Lake Bed since 1969 also shows which lands are flooded can vary from one flood year to the next.

This risk of flooding through the years has created a situation where it is not financially feasible to consider constructing a large business or even an office or home within the Tulare Lake Bed. Add this risk to the cost of constructing a well and a treatment plant to provide a usable water supply also impacts the financial feasibility. For example, one ranch office in the southern Tulare Lake area, just outside of the historic Tulare Lake Bed area, flooded during the last 60 years. It does not have a domestic well to provide a water supply for its office. The groundwater quality is comparable to what is outlined above. To obtain water, rather than considering construction of a treatment plant, they have their own water tank and haul water to the ranch office, as needed. Given the conditions described above, it is not anticipated that a commercial or industrial business not involved in agricultural production would seek to locate within the Tulare Lake Bed.

In addition to industrial and commercial businesses relying on the Tulare Lake Bed as a potential location to construct a domestic well, the four communities that surround the lakebed (Kettleman City, Corcoran, Alpaugh, and Stratford) and the Kings County Board of Supervisors have indicated that they have no plans to construct water production wells in the Tulare Lake Bed (see Appendix E). Each of these jurisdictions does not consider the area proposed for MUN de-designation as a viable source for municipal water supplies now or in the future.

### 5.2 Applicability of AGR Beneficial Use

Section 2.4.2 defines the salinity-related requirements for the protection of the AGR beneficial use, consistent with recent Central Valley Water Board decisions and CV-SALTS policy discussions. Specifically:

- **Agricultural Irrigation:** Use of water for agricultural irrigation is not generally suitable for irrigating all but the most salt-tolerant crops, *except* as a temporary, short-term alternative when higher water quality water supplies are not readily available, when electrical conductivities are greater than 3,000 μS/cm (TDS > 2,000 mg/L). This either precludes or greatly limits the use of groundwater within the proposed vertical and horizontal AGR crop irrigation de-designation boundaries for crop production.

- **Stock Watering:** Water is not suitable for stock watering (or crop irrigation) where electrical conductivities are greater than 7,500 μS/cm (TDS levels > 5,000 mg/L).

These electrical conductivity thresholds coupled with the Section 4 technical findings provide the basis for the regulatory analyses provided below.
5.2.1 Water Quality

Section 5.1.1 summarizes typical electrical conductivity values associated with groundwater within the area proposed for AGR de-designation (See Figures 1-3 and 1-4; also see Figures 4-36 through 4-40). With only a few exceptions electrical conductivities exceed 5,000 μS/cm and range as high as 50,000 μS/cm. For the few exceptions where electrical conductivity is less than 5,000 μS/cm, most of these values are above 3,000 μS/cm. Accordingly, use of the groundwater for agricultural irrigation within the area proposed AGR de-designation is limited at best.

With regards to stock watering salinity threshold (electrical conductivity > 7,500 μS/cm), with only a few exceptions, primarily in the northern part of the East Subarea, the electrical conductivity of water in the area proposed for AGR de-designation exceeds the 7,500 μS/cm threshold. The exceptions are typically associated with shallow monitoring wells located near or in evaporation basins (e.g., North Evaporation Ponds in the North Subarea; and Hacienda and South Evaporation Ponds in the South Subarea).

In the East Subarea the exceptions to the 7,500 μS/cm threshold are generally located within small, isolated pockets which are surrounded by water with very high electrical conductivity values. These isolated results are likely the result of the seasonal influence of irrigation water with much lower conductivity values. Figure 5-4 highlights the water quality data a portion of this Subarea. As can be seen a number of the exceptions (electrical conductivity < 7,500 μS/cm) are located near or next to the Tule Canal, West Branch Cross Creek, East Branch Cross Creek and Bean Ditch conveyance facilities. Given these exceptions several areas were not included within the proposed horizontal de-designation boundary for AGR stock watering: (a) along Quebec Avenue generally between 7th and 9th Avenues; (b) south of Pueblo Avenue west of 7th Avenue; and (c) three land sections south of Redding Avenue and generally between 5th and 7th Avenues. However, even with these exceptions the average electrical conductivity of all data within the red outlined area on Figure 5-4 is 11,641 μS/cm (median = 10,500 μS/cm) (Table 5-2). If only the area proposed for de-designation of the AGR stock watering beneficial use is evaluated (light brown areas in Figure 5-4), then the average electrical conductivity value is 15,571 μS/cm (median = 13,300 μS/cm). While the proposed AGR stock watering de-designation boundary is more conservative, the average and median conductivity values with or without the exceptions included are well above the 7,500 μS/cm conductivity threshold.

5.2.2 Existing and Probable Future Use

Irrigation Supply Wells

Section 4.3 identifies the known water supply wells in the project study area. There are active irrigation wells in the northeast fringe of the Central Area and records indicate that these wells are completed below the vertical de-designation boundary. Where irrigation wells were identified in a fringe area, these wells are not located within the horizontal boundary proposed for de-designation of AGR.

Stock Water Supply Wells

Any wells that were historically recorded as stock wells (e.g., as noted in Section 4) have been abandoned due to high electrical conductivity of the water. Table 5-3 identifies landowners within the area proposed for de-designation of AGR (stock watering) and the source of water for those with stock operations within the proposed de-designation boundary. Conversations with landowners within the area proposed for de-designation in December 2013 identified where stock watering
activity was occurring within the Project Study Area and determined that any existing stock watering needs within the area were being met by either hauling water into the area or use of local surface ditch water. These sources of water are adequate and landowners would not install wells within the area proposed for AGR (stock water) de-designation in the future to meet stock watering needs. This finding applies to the potential for future landowner sales and leases as all lands within the TLBWSD have surface water supplies allocated to them. Additionally a vast network of ditches throughout the Project Study Area allows surface water to be conveyed to all lands within area proposed for de-designation.

Follow-up conversations occurred in March 2015 to verify previous findings and determine if any landowners were utilizing groundwater given that the area is currently experiencing some of the most severe drought on record. Even under these severe conditions, stock operators within the proposed de-designation area have not turned to groundwater within the area proposed for de-designation of AGR (stock water).
Table 5-2. Backhoe excavation electrical conductivity (μS/cm) water quality data within the analysis area shown in Figure 5-4

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Electrical Conductivity (μS/cm) of Sample Locations within Area of Analysis in Figure 5-4</th>
<th>Sample Locations within Proposed MUN De-designation Boundary</th>
<th>Sample Locations within Proposed AGR (Stock Watering) De-designation Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Township Range</td>
<td>Section</td>
<td>All Sample Locations</td>
<td>Sample Locations within Proposed MUN De-designation Boundary</td>
</tr>
<tr>
<td>T21S R22E 22</td>
<td></td>
<td>5100</td>
<td>5100</td>
</tr>
<tr>
<td>T21S R22E 26</td>
<td></td>
<td>7300</td>
<td>--</td>
</tr>
<tr>
<td>T21S R22E 27</td>
<td></td>
<td>9400</td>
<td>9400</td>
</tr>
<tr>
<td>T21S R22E 27</td>
<td></td>
<td>11000</td>
<td>11000</td>
</tr>
<tr>
<td>T21S R22E 27</td>
<td></td>
<td>11400</td>
<td>11400</td>
</tr>
<tr>
<td>T21S R22E 28</td>
<td></td>
<td>3500</td>
<td>3500</td>
</tr>
<tr>
<td>T21S R22E 28</td>
<td></td>
<td>7700</td>
<td>7700</td>
</tr>
<tr>
<td>T21S R22E 28</td>
<td></td>
<td>9200</td>
<td>9200</td>
</tr>
<tr>
<td>T21S R22E 28</td>
<td></td>
<td>19100</td>
<td>19100</td>
</tr>
<tr>
<td>T21S R22E 29</td>
<td></td>
<td>5500</td>
<td>5500</td>
</tr>
<tr>
<td>T21S R22E 29</td>
<td></td>
<td>10500</td>
<td>10500</td>
</tr>
<tr>
<td>T21S R22E 29</td>
<td></td>
<td>10500</td>
<td>10500</td>
</tr>
<tr>
<td>T21S R22E 29</td>
<td></td>
<td>25600</td>
<td>25600</td>
</tr>
<tr>
<td>T21S R22E 30</td>
<td></td>
<td>4800</td>
<td>4800</td>
</tr>
<tr>
<td>T21S R22E 30</td>
<td></td>
<td>7700</td>
<td>7700</td>
</tr>
<tr>
<td>T21S R22E 30</td>
<td></td>
<td>7800</td>
<td>7800</td>
</tr>
<tr>
<td>T21S R22E 30</td>
<td></td>
<td>11200</td>
<td>11200</td>
</tr>
<tr>
<td>T21S R22E 31</td>
<td></td>
<td>12600</td>
<td>12600</td>
</tr>
<tr>
<td>T21S R22E 31</td>
<td></td>
<td>15700</td>
<td>15700</td>
</tr>
<tr>
<td>T21S R22E 31</td>
<td></td>
<td>16100</td>
<td>16100</td>
</tr>
<tr>
<td>T21S R22E 31</td>
<td></td>
<td>17400</td>
<td>17400</td>
</tr>
<tr>
<td>T21S R22E 32</td>
<td></td>
<td>5100</td>
<td>5100</td>
</tr>
<tr>
<td>T21S R22E 32</td>
<td></td>
<td>5500</td>
<td>5500</td>
</tr>
<tr>
<td>T21S R22E 32</td>
<td></td>
<td>8100</td>
<td>8100</td>
</tr>
<tr>
<td>T21S R22E 33</td>
<td></td>
<td>5100</td>
<td>5100</td>
</tr>
<tr>
<td>T21S R22E 33</td>
<td></td>
<td>6900</td>
<td>6900</td>
</tr>
<tr>
<td>T21S R22E 33</td>
<td></td>
<td>10700</td>
<td>10700</td>
</tr>
<tr>
<td>T21S R22E 33</td>
<td></td>
<td>12000</td>
<td>12000</td>
</tr>
<tr>
<td>T21S R22E 34</td>
<td></td>
<td>6700</td>
<td>6700</td>
</tr>
<tr>
<td>T21S R22E 34</td>
<td></td>
<td>10600</td>
<td>10600</td>
</tr>
<tr>
<td>T21S R22E 34</td>
<td></td>
<td>12900</td>
<td>12900</td>
</tr>
<tr>
<td>T21S R22E 34</td>
<td></td>
<td>28200</td>
<td>28200</td>
</tr>
<tr>
<td>T21S R22E 35</td>
<td></td>
<td>7000</td>
<td>7000</td>
</tr>
<tr>
<td>T21S R22E 35</td>
<td></td>
<td>16500</td>
<td>16500</td>
</tr>
</tbody>
</table>
Table 5-2. Backhoe excavation electrical conductivity (μS/cm) water quality data within the analysis area shown in Figure 5-4

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Electrical Conductivity (μS/cm) of Sample Locations within Area of Analysis in Figure 5-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Township Range</td>
<td>All Sample Locations</td>
</tr>
<tr>
<td>T22S R22E 2</td>
<td>2200</td>
</tr>
<tr>
<td>T22S R22E 2</td>
<td>21200</td>
</tr>
<tr>
<td>T22S R22E 2</td>
<td>27600</td>
</tr>
<tr>
<td>T22S R22E 2</td>
<td>43400</td>
</tr>
<tr>
<td>T22S R22E 3</td>
<td>3600</td>
</tr>
<tr>
<td>T22S R22E 3</td>
<td>13300</td>
</tr>
<tr>
<td>T22S R22E 4</td>
<td>5000</td>
</tr>
<tr>
<td>T22S R22E 4</td>
<td>9000</td>
</tr>
<tr>
<td>T22S R22E 4</td>
<td>18300</td>
</tr>
<tr>
<td>T22S R22E 5</td>
<td>2700</td>
</tr>
<tr>
<td>T22S R22E 5</td>
<td>3700</td>
</tr>
<tr>
<td>T22S R22E 5</td>
<td>4700</td>
</tr>
<tr>
<td>T22S R22E 6</td>
<td>13700</td>
</tr>
<tr>
<td>T22S R22E 6</td>
<td>19300</td>
</tr>
<tr>
<td>T22S R22E 9</td>
<td>29600</td>
</tr>
<tr>
<td>T22S R22E 12</td>
<td>2900</td>
</tr>
<tr>
<td>T22S R22E 14</td>
<td>2900</td>
</tr>
<tr>
<td>T22S R22E 15</td>
<td>5900</td>
</tr>
<tr>
<td>T22S R22E 17</td>
<td>21700</td>
</tr>
<tr>
<td>T22S R22E 18</td>
<td>13200</td>
</tr>
<tr>
<td>T22S R22E 18</td>
<td>13600</td>
</tr>
<tr>
<td>T22S R22E 18</td>
<td>14600</td>
</tr>
<tr>
<td>T22S R22E 18</td>
<td>15000</td>
</tr>
<tr>
<td>T22S R22E 23</td>
<td>5900</td>
</tr>
</tbody>
</table>

|  | Count | 59 | 57 | 35 |
|  | Average | 11,641 | 11,870 | 15,571 |
|  | Median | 10,500 | 10,500 | 13,300 |
### Table 5-3. Landowner information on use of groundwater for stock watering in the Project Study Area

<table>
<thead>
<tr>
<th>Landowner</th>
<th>Date of Conversation</th>
<th>Water Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westlake Farms</td>
<td>December 2013, March 2015</td>
<td>• Ditch water, truck in water; • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Ceil Howe Jr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23311 Newton Avenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratford, CA 93266</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandridge Partners</td>
<td>December 2013, March 2015</td>
<td>• Ditch water, truck in water; • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Stephen Vidovich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>960 N. San Antonio Rd.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Altos, CA 94022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Island Cattle / Triple H Farms</td>
<td>December 2013, March 2015</td>
<td>• Pipes in water from outside the originally proposed de-designation boundary; • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Tim Sellers / Phil Hansen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4600 South K Street / P.O. Box 398</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tulare, CA 93274 / Corcoran, CA 93212</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newton Farms</td>
<td>December 2013, March 2015</td>
<td>• No stock operations on lands • Groundwater could not be used due to diarrhea issues with cattle • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Paul Newton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.O. Box 117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratford, CA 93266</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J.G. Boswell Company</td>
<td>December 2013, March 2015</td>
<td>• No stock operations on lands • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Walter Bricker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. O. Box 877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corcoran, CA 93212-0877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hansen Ranches</td>
<td>December 2013, March 2015</td>
<td>• No stock operations on lands • No intention to use groundwater from within the proposed de-designation boundaries in the future</td>
</tr>
<tr>
<td>Phil Hansen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.O. Box 398</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corcoran, CA 93212</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Page intentionally left blank
Section 6

References


