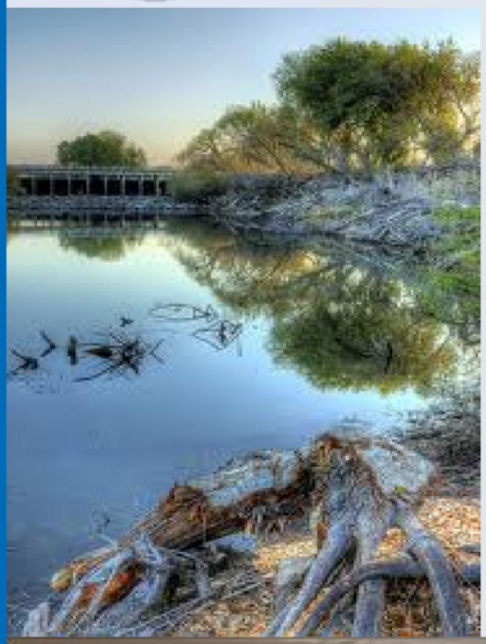

Final

Groundwater Management Plan Update

Kern Delta Water District

October 11, 2013

Todd Engineers

Groundwater Management Plan Update

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TODD ENGINEERS

SIGNATURE PAGE

Phyllis Stanin
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FINAL

Groundwater Management Plan (GWMP) Update
Kern Delta Water District

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List of Acronyms

AFY – acre feet per year
AEWSD – Arvin-Edison Water Storage District
BVWSD – Buena Vista Water Storage District
Cal Water – California Water Service Company
CEQA – California Environmental Quality Act
cfs – cubic feet per second
COB – City of Bakersfield
District – Kern Delta Water District
DWR – (California) Department of Water Resources
ET - evapotranspiration
ft/day - feet per day
gpm – gallons per minute
GWMP – Groundwater Management Plan
ID4 –Improvement District No. 4 of the Kern County Water Agency
IRWMP – Integrated Regional Water Management Plan
KDWD – Kern Delta Water District
KCWA – Kern County Water Agency
KWB – Kern Water Bank
Metropolitan – The Metropolitan Water District of Southern California
mgd – million gallons per day
msl – mean sea level
NKWSD – North Kern Water Storage District
PAC – Project Advisory Committee for the Groundwater Management Plan Update – designated as the Kern Delta Water District Board of Directors
RWQCB – Central Valley Regional Water Quality Control Board (also Water Board)
SBVMWD - San Bernardino Valley Municipal Water District, also referred to as Valley MWD
SWP – State Water Project
SWRCB – State Water Resources Control Board
UWMP – Urban Water Management Plan
Valley MWD – San Bernardino Valley Municipal Water District
WAP – Kern River Water Allocation Plan, Kern Delta Water District
Water Board – Central Valley Regional Water Quality Control Board (also RWQCB)
WWTP – wastewater treatment plant

1 Introduction

For more than 130 years, groundwater and surface water have been used conjunctively in the Kern Delta Water District (KDWD or District) service areas. Canal companies dating back to the late 1800s have provided conveyance of Kern River water for agricultural irrigation. Significant quantities of conveyed water seep into the permeable bottoms of the unlined canals, providing recharge to the groundwater basin. Additional recharge occurs through irrigation in excess of crop consumptive use (referred to as return flows). Beginning in the early 1900s, groundwater has been developed to supplement surface water supply; groundwater demand has increased over time and currently represents more than one-half to about two-thirds (in dry years) of the District's total irrigation supply. Municipal groundwater demand has also increased within KDWD as the City of Bakersfield has expanded into the northern portions of the District.

This increasing reliance on groundwater highlights the need for continued and improved groundwater monitoring and management. This Groundwater Management Plan (GWMP) update is being prepared to assess current groundwater conditions and to coordinate the various groundwater and surface water management programs being implemented by KDWD.

The GWMP follows guidelines set forth in the Groundwater Management Planning Act (Assembly Bill AB 3030) promulgated in 1992, which allows local agencies to prepare and adopt GWMPs (California Water Code Sections 10750 through 10756). The GWMP is also in compliance with the 2002 Water Code amendments by Senate Bill (SB) 1938, which identified additional components to be included in a GWMP. Such a plan allows KDWD to address issues of groundwater recharge and storage, critical components for effective management of the District's water supply.

On June 19, 2012, the KDWD Board of Directors held a public hearing and adopted Resolution No. 2012-05, *Intention of the Kern Delta Water District to Update Its Groundwater Management Plan* (Appendix A). A draft GWMP Update was presented in a second public hearing on September 17, 2013. Comments from the District and Project Advisory Committee on the draft GWMP Update were incorporated into the Final GWMP Update. On October 15, 2013, the KDWD Board of Directors adopted the Final GWMP Update, including GWMP monitoring protocols (Appendix C), by Resolution 2013-05 in accordance with AB 3030 timelines. A copy of Resolution 2013-05, *Adoption and Implementation of the Kern Delta Water District Groundwater Management Plan Update*, is included with this document in Appendix B; the original executed resolution is on file at the District office.

1.1 Background

Since its formation in 1965, KDWD has conducted numerous groundwater management activities within its approximate 200-square mile boundary (Figure 1). Activities have been formalized in numerous water supply planning documents including its original GWMP (KDWD, 1996) and a 2010 amended GWMP and Agricultural Water Management Plan (KDWD, December2010). These plans are summarized in the following section.

1.1.1 Previous KDWD Groundwater Management Plans

KDWD first prepared a GWMP under AB3030 in 1996 to formalize ongoing groundwater management practices and support the continuation of local management. Specifically the plan provided the District with the information and tools needed to maintain and improve its overall water supply through conjunctive management. The primary Basin Management Objective was to preserve the utility of the local groundwater resources, both in quantity and quality, for beneficial uses in the District. Plan elements included groundwater replenishment through incidental recharge (in unlined canals) and in-lieu recharge through delivery of imported water. The plan also documented the District's groundwater monitoring program (KDWD, 1996).

In 2010, KDWD updated and amended its GWMP in combination with an Agricultural Water Management Plan (AWMP). The 2010 plan recognized the need to optimize monitoring in compliance with new legislation including SB 6, which contained certain requirements for water level monitoring, and SB 7, which contained requirements for agricultural water conservation/management. The overall goal of the 2010 plan was to assist with long-term, sustained productive and profitable agriculture within KDWD. Combined GWMP/AWMP objectives to achieve that goal included:

- Increase water use efficiency
- Increase water supply to the extent feasible given available surface supply
- Maintain the quality of groundwater and
- Encourage and support water management techniques that minimize salt and mineral build up in soils and groundwater.

The plan contained strategies to meet these objectives, which are reviewed and incorporated into this GWMP update as applicable. Key strategies involved specific actions for optimized monitoring of groundwater levels, water demand/use, and water quality; facilitation of basic water management strategies under SB 7; consideration of pricing incentives for water management; coordination and cooperation of water use efficiency and water conservation measures; and increasing importation, recharge and storage of available water. The amended plan also noted the need for a GWMP update to include a more detailed groundwater analysis and meet requirements of recent amendments to the California Water Code, which are included in this GWMP Update.

1.1.2 Current Update

This GWMP update is being developed to document ongoing management actions, address more fully the requirements of SB 1938, consider integration with regional water management plans (including the Tulare Lake Integrated Regional Water Management Plan (IRWMP)), and incorporate additional legislative requirements since the completion of the 2010 plan (including AB 359 regarding identification of recharge zones). Current groundwater conditions beneath the District are analyzed to provide context for the plan. The GWMP also includes a more detailed assessment of water demand/use in accordance with a specific management strategy identified in the 2010 GWMP.

1.2 Project Goal, Objectives, and Management Area

The goal of the project is to develop an updated GWMP that complies with recent legislation and recommends groundwater management and monitoring activities including documentation of those already being conducted by the District. To accomplish this goal, the following project objectives have been identified:

- Update the GWMP with requirements from SB 1938 and other legislative requirements
- Re-evaluate groundwater basin conditions and update Basin Management Objectives (BMOs)
- Coordinate groundwater management with other KDWD management plans and activities for surface water (local and imported) supply
- Coordinate groundwater management with regional water management conducted by others
- Cooperate with state and local agencies on management
- Update and adopt GWMP monitoring protocols.

The GWMP update establishes the Management Area as the 129,000 acres (approximately 200 square miles) within the KDWD boundary (Figure 1). This area is located within the Kern County subbasin of the larger San Joaquin Valley Groundwater Basin as defined by the California Department of Water Resources (DWR) (Figure 2). The GWMP recognizes that the Management Area covers only a portion of the contiguous groundwater basin and represents a shared resource also managed by other agencies, which also have prepared GWMPs. Through this GWMP update, KDWD meets its responsibilities for providing local groundwater management and monitoring for its portion of the underlying groundwater resource.

1.3 Public Participation

The KDWD Board of Directors (Board) has served an active role in preparation, oversight, and adoption of GWMPs and other management activities in the District. As users of the local water resources and representatives of the various service areas across the District, the Board has the responsibility for developing sustainable groundwater management policies for all beneficial uses. As such, they are serving as the GWMP Project Advisory Committee (PAC) for the GWMP update.

The public has been invited to participate in GWMP development. The Board formally invited public participation and included contact information on how to participate in the planning process at their June 2012 public meeting. At that meeting, the Board adopted Resolution 2012-05 providing a Notice of Intention to update its GWMP. The resolution included the contact information for public participation. The public was notified of the date, time, location, and subject of the meeting through publication of the meeting date and topic in the local newspaper. The Notice of Public Hearing and the adopted resolution of Notice of Intent are provided in Appendix A. The resolution was also provided to DWR for publication on their GWMP website.

The Draft GWMP Update was provided to the PAC/Board on June 13, 2013 for review and presented in a public hearing on September 17, 2013 for public comment and consideration. The Final GWMP Update was adopted by the Board on October 15, 2013 by Resolution 2013-05. As part of the GWMP Update,

the monitoring plan and protocols, provided in Appendix C, were also adopted by the Board. The resolution and Notice of the Public Hearing are included in this document as Appendix B[1].

1.4 GWMP Organization

This document begins by presenting the purpose, goals, objectives, management area, and public participation process of the GWMP Update (Section 1). Section 2 provides a review of regional water management activities including adjacent GWMPs prepared by others and other planning documents potentially relevant to KDWD groundwater management objectives. Section 3 provides a description of current District operations and facilities and its ongoing water management activities, including conjunctive use. Section 4 provides an update of local groundwater conditions within the Management Area, including a detailed analysis of recent irrigation demand and estimated quantities of groundwater pumping. The ongoing programs in Section 3 and the groundwater evaluation in Section 4 provide the foundation for updated BMOs in Section 5. An assessment of various management strategies that could be used to achieve BMOs are discussed in Section 6, including a checklist of potential applicable strategies originally provided in AB 3030 and updated in SB 1938. Section 7 provides the components of the GWMP and presents an implementation schedule.

The KDWD monitoring program has been updated to better achieve BMOs and to monitor performance of the GWMP activities. Monitoring program details and protocols are provided in Appendix C. Resolutions, Notices of Public Hearings, and Proof of Publications are in Appendices A and B. An index to DWR required and recommended components of a GWMP is provided as Appendix D.

[1] A copy of the unsigned final resolution is provided in Appendix B. The original signed resolution was executed after the production of this document; the original is on file with the District and a copy is available on request.

2 Local Groundwater Management

Kern County is an area of both current and historical active groundwater management. In response, in part, to declining groundwater levels and regional overdraft, numerous water districts were formed in the 1960s to consolidate surface water rights and provide imported water supplies. During the next few decades, groundwater recharge and storage projects were developed across the region. In the 1990s, larger and more formalized banking projects were developed along the Kern River north and northwest of the District. Further, many local water districts engaged in groundwater replenishment activities for the benefit of in-district customers. Both banking and in-district replenishment projects have involved numerous participants and cooperation among local water districts and other water purveyors in the region.

Recently local water districts, including KDWD, have engaged in formal banking agreements with outside partners to recharge water in-district for later recovery. These arrangements have provided needed revenue for groundwater management infrastructure such as recharge basins. Because groundwater management activities by others have the potential to impact groundwater resources beneath the District, a summary is provided below of local and regional groundwater management activities adjacent or applicable to KDWD.

2.1 Neighboring GWMPs

Numerous Kern County water districts have prepared GWMPs, including two neighboring water districts, Arvin-Edison Water Storage District and Wheeler Ridge-Maricopa Water Storage District. These two plans have been reviewed to better understand groundwater conditions and management adjacent to KDWD and to ensure complementary management of the shared groundwater resource. GWMPs from adjoining districts are summarized below.

2.1.1 Arvin-Edison Water Storage District (AEWSD)

Arvin-Edison Water Storage District (AEWSD) is located east and south of KDWD and is about the same size in area (132,000 acres) and irrigated acreage (about 113,000 acres) (Figure 1). It was formed in the mid-1960s to provide imported water from the Federal Central Valley Project (CVP) to supplement groundwater for agricultural irrigation and to alleviate groundwater overdraft (estimated at about -126,000 AFY in 1964). Due to the variable nature of CVP water availability, AEWSD initiated recharge operations as early as 1966 to store excess imported water in the groundwater basin. Groundwater storage and conjunctive use activities were expanded in 1995 and 1997 through more formalized banking projects with Rosedale-Rio Bravo Water Storage District (RRBWSD) and The Metropolitan Water District of Southern California (Metropolitan), respectively.

In 2003, AEWSD prepared a GWMP to develop a coordinated and comprehensive approach to future groundwater evaluation and management (Provost & Pritchard, 2003). The GWMP identified 24 BMOs to be used as guiding principles for groundwater management actions. Most of the BMOs consisted of

general guidelines such as maximizing surface water supplies in an economical manner, increasing conjunctive use, consideration of economical exchanges or banking arrangements with other agencies, avoidance of overdraft and subsidence, protection of groundwater quality, cooperation with local agencies, and continuation of groundwater monitoring. Components of the AEWSD GWMP are organized around the 12 elements provided in AB 3030 as potential items for inclusion in a GWMP. Key plan elements are summarized below:

- Minimize groundwater degradation (salinity) and limit migration of saline water through continued importation of high quality surface water for direct or in lieu recharge, management of groundwater extractions, and improved monitoring programs.
- Cooperate with the Wellhead Protection programs of other agencies with public water supply wells.
- Report groundwater contamination issues to the appropriate agency and cooperate and assist according to AEWSD's jurisdiction and authority.
- Comply with the Kern County Department of Health Services well ordinance by applying for well permits and properly abandoning AEWSD wells. Encourage landowners to convert usable wells to monitoring wells. Continue to maintain DWR Well Completion Reports for wells in AEWSD to facilitate evaluation of groundwater monitoring data.
- Work towards reduction and elimination of overdraft conditions by monitoring levels, subsurface inflow, and pumping; look for opportunities to reduce overdraft by participating in projects or activities that positively affect groundwater balance and are cost effective to implement.
- Continue to operate and manage existing groundwater replenishment facilities. Look for and evaluate opportunities to participate in projects or activities that further replenish groundwater.
- Continue current groundwater levels, storage and quality monitoring program. Update hydrographs annually and present to AEWSD Board of Directors. Update water quality mapping every 5 years.
- Manage extractions from AEWSD wells to balance groundwater on a district-wide basis. Manage indirectly extractions by landowners by providing surface water supplies and continuing the AEWSD conjunctive use program.
- Continue to participate in water transfers, water exchanges, water banking, and other water management arrangements that are mutually beneficial to the parties involved and are consistent with the BMOs in the GWMP. Evaluate potential projects that would involve the construction and operation of additional groundwater management facilities.
- Cooperate with various Federal, State, and local agencies with jurisdiction over various aspects of surface water and groundwater and participate in cooperative management of the Kern groundwater basin, while maintaining local control of AEWSD's groundwater resources.
- Review and comment on environmental documents related to land use plans affecting BMOs or AEWSD.
- Cooperate with agency studies on subsidence. Update elevations of critical benchmarks and structures when available as part of projects that require land surveying.

- Continue to work with agencies for mitigation of potential impacts on groundwater from changes in surface water flow, if any, as environmental documents are prepared. Monitor land use activities in ephemeral streams tributary to AEWSD. Report illegal discharges to the Regional Water Quality Control Board. Identify and oppose land uses or activities with potential to negatively impact groundwater quality.
- Continue relationships with other agencies in the basin involved in groundwater management including basin-wide planning efforts. Propose periodic meeting with overlapping and adjacent agencies for the purposes of coordinating groundwater management activities.
- Establish the Board of Directors as the GWMP Stakeholder Advisory Committee.
- Prepare annual Water Management Reports for the Board of Directors (presented on May 31st of each year).
- Conduct a re-evaluation every five years unless the Advisory Committee elects to forgo a re-evaluation.

In addition to these elements, the GWMP contains a 20-year planning horizon list of potential projects to improve surface water facilities, many of which also support groundwater replenishment and management (Table 8, Provost & Pritchard, 2003).

2.1.2 Wheeler Ridge-Maricopa Water Storage District (WRMWSD)

Wheeler Ridge-Maricopa Water Storage District (WRMWSD) borders KDWD on the south and consists of approximately 147,000 acres in the southernmost portion of the Kern County Groundwater Subbasin (Figure 1). WRMWSD prepared an AB 3030 GWMP in 2007, documenting their portfolio of water sources including private and District groundwater wells, State Water Project (SWP) water, and storage accounts in the Kern Water Bank, Berrenda Mesa Project, and Pioneer Project (Todd Engineers, 2007). The goal of the GWMP was to determine how best to integrate groundwater use with the other sources of water available to WRMWSD. To accomplish this goal, groundwater levels, flow and quality in the various subareas of the district were evaluated, including groundwater response to localized groundwater use across the area. BMOs identified in the plan are listed below:

- Prevent a return to historical overdraft
- Maintain groundwater quality
- Monitor water levels, water quality, and groundwater storage
- Estimate groundwater use and future demand
- Update progress on achieving BMOs

Strategies for groundwater management included the following actions:

- Optimize the integration of WRMWSD water sources
- Secure additional water sources, as necessary, to supplement current supplies
- Prepare a Groundwater Development Program
    - Evaluate perennial yield of the subareas
    - Implement a Well Maintenance Program for WRMWSD wells
    - Determine the need for additional wells
    - Operate the basin to support BMOs

- Improve coordination with Kern County well ordinances
    - Obtain copies of permits from County for new wells drilled in WRMWSD
    - Coordinate well abandonment activities in WRMWSD with the County
- Continue and improve groundwater monitoring
- Coordinate monitoring activities with other agencies
- Report progress on the GWMP annually and update the GWMP periodically
- Prepare an Integrated Water Resources Plan with neighboring agencies in the southern portion of the subbasin.

WRMWSD also conducts a water level monitoring program and coordinates with AEWSD on its monitoring programs (Provost & Pritchard, 2003).

2.2 Urban Water Management Plans (UWMPs)

Several water purveyors supplying municipal water are located adjacent to and within portions of KDWD as shown on Figure 3. Two of the larger municipal water suppliers, California Water Service Company (Cal Water) and the City of Bakersfield, have service areas that extend into the northern portion of KDWD. These purveyors have prepared Urban Water Management Plans (UWMPs) that compare current and future water supply sources and water demands as described below.

Cal Water serves a large portion of eastern Bakersfield and unincorporated lands adjacent to the City (encompassing about 49 square miles and a population of about 225,000 persons). Groundwater has historically supplied up to 80 percent of Cal Water's demands supplemented by surface and imported water. In 2011, Cal Water operated about 115 active wells, four of which are located within KDWD, with a total design capacity of 142,000 AFY. As per Cal Water's 2010 UWMP, their service area population is expected to increase by about 55 percent between 2010 and 2040 (Cal Water, 2011). Cal Water plans on reducing groundwater pumping during normal hydrologic years and replacing this supply with treated surface water. Cal Water now has additional treatment plant capacity to treat surface water and can expand these plants in the future when needed. Pumping is anticipated to be reduced from 44,000 AFY in 2010 to about 11,400 AFY in 2025 and then increase to 32,800 in 2040 (Cal Water, 2011).

The City of Bakersfield's Water System service area covers about 35 percent of the western portion of the Bakersfield (about 38 square miles) and provides water to a population of about 118,600 persons. Water sources include groundwater, Kern River water, and imported SWP water. The City has contracted with Cal Water to operate its water distribution system. Groundwater supply is pumped from approximately 50 active groundwater wells within City boundaries with about 12 active wells within KDWD boundaries. The City Water System population is estimated to increase from 130,600 in 2010 to about 183,900 by 2030 (City of Bakersfield, June 2012). The most recent UWMP for the City Water System is a 2007 Update to the 2005 UWMP (Stetson, 2007). Like Cal Water, the City anticipates using more treated surface water and less groundwater in the future due to new and expanded water treatment plants. The 2007 UWMP Update estimated that groundwater production would decrease from around 33,700 AFY in 2006 to 15,800 AFY in 2015 then slowly increase to 31,700 AFY by 2035 (Stetson, 2007). A 2010 UWMP is currently being prepared but not yet available.

2.3 General Plans

In addition to other GWMPs and UWMPs, additional planning documents for the area were reviewed. Cooperative and complementary actions relating to groundwater were identified for consideration in this GWMP update as discussed below.

2.3.1 City of Bakersfield

City's General Plan. The City's current general plan was adopted in 2002 (City of Bakersfield, December 2002). The plan estimates growth through 2022 and establishes a maximum extent of development. The City's 2002 General Plan update identified nine policies to address fundamental water resources issues:

1. Develop and maintain facilities for groundwater recharge in the planning area.
2. Minimize the loss of water to locations outside the planning area when water could otherwise be used for groundwater recharge to benefit local groundwater aquifers.
3. Support programs to convey imported water into the planning area (sources outside of the San Joaquin Valley basin).
4. Support programs and policies that assure continuance or augmentation of Kern River surface water supplies.
5. Work towards resolving the problem of groundwater resource deficiencies in the upland portions of the planning area.
6. Protect planning area groundwater resources from further quality degradation.
7. Provide substitute or supplemental water resources to areas already impacted by groundwater quality degradation by supporting facilities construction for surface water diversions.
8. Consider each proposal for water resource usage within the context of total planning area needs and priorities including water transport, groundwater recharge, flood control, recreational needs, riparian habitat preservation and conservation.
9. Encourage and implement water conservation measures and programs.

Kern River Flow and Municipal Water Program. The City has been developing a project to allow for more sustained flows in certain reaches of the Kern River, a project referred to as the Kern River Flow and Municipal Water Program (KRFMWP). The City recently prepared a Draft Environmental Impact Report (DEIR) for the project (City of Bakersfield, June 2012).The goal of the project is to increase Kern River channel flows to protect, increase, and enhance the City's water supply to meet current and future water demands (City of Bakersfield, June 2012). The proposed program would use existing facilities and infrastructure and would not require new construction. Under the program, water flow in the river could potentially increase downstream of the Calloway Weir in amounts up to approximately 160,000 AFY, depending upon hydrologic conditions (City of Bakersfield, June 2012).

According to the City, the increased flows would be from two potential sources:

- Up to 70,000 AFY, on average, of water from the City's pre-1914 appropriative Kern River water rights. This water has been used by local agricultural districts under long-term water supply agreements, which are expiring.

- An estimated average of up to 87,000 AFY of water, if available, through the City's application for unappropriated Kern River water with the State Water Resources Control Board (SWRCB).

2.3.2 Kern County Planning Commission

The Kern County General Plan (Kern County, 2009) also contains policies and implementation measures related to surface water and groundwater. Relevant policies include:

- Provide water related infrastructure in an efficient and cost effective manner.
- Ensure that water quality standards are met for existing users and future development.
- Ensure that adequate water storage, treatment, and transmission facilities are constructed concurrently with planned growth.
- Ensure that appropriate funding mechanisms for water are in place to fund the needed improvements resulting from growth and subsequent development.
- Encourage utilization of wastewater treatment facilities which provide for the reuse of wastewater.
- Encourage the development of the County's groundwater supply to sustain and ensure water quality and quantity for existing users, planned growth, and maintenance of the natural environment.
- Encourage utilization of community water systems rather than the reliance on individual wells.
- Review development proposals to ensure adequate water is available to accommodate projected growth.
- Discretionary projects shall analyze watershed impacts and mitigate for construction-related and urban pollutants, as well as alterations of flow patterns and introduction of impervious surfaces as required by the CEQA, to prevent the degradation of the watershed to the extent practical.
- New high consumptive water uses, such as lakes and golf courses, should require evidence of additional verified sources of water other than local groundwater. Other sources may include recycled stormwater or wastewater.

Implementation measures were developed for the various stated policies, several of which are included below:

- Develop guidelines for the protection of groundwater quality which will include comprehensive well construction standards and the promotion of groundwater protection for identified degraded watersheds (to be conducted by the County Health Services Department).
- Ensure maintenance and repair of existing water systems.
- Encourage effective groundwater resource management for the long-term benefit of the County through the following:
    - Promote groundwater recharge activities in various zone districts.
    - Support the development of Urban Water Management Plans and promote Department of Water Resources grant funding for all water providers.
    - Support the development of Groundwater Management Plans.

- Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water, and groundwater and desalination.

2.4 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County

KDWD participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County prepared by Kern County Water Agency (KCWA) (Kennedy/Jenks Consultants, 2011). As a member of the Regional Water Management Group (RWMG), KDWD executed a Participation Agreement and sponsored a joint project with AEWSD. That project involved improvements to the Arvin-Edison Intake Canal check structures and KDWD interties, which would increase operational efficiency.

The IRWMP Executive Committee ranked the project 13th among more than 135 separate projects and incorporated it into the IRWMP. Although IRWMP funding was not available, KDWD and AEWSD constructed the project in 2012.

The project improves conveyance of water into and out of KDWD, facilitating water exchanges between the two districts. This efficiency increases the overall water supply including water available for recharge and banking. Additional project benefits include water quality improvements and floodplain management.

2.5 Agricultural Water Management

KDWD is currently working with regulators on improvements in management of agricultural water runoff. Some of these management strategies, including Best Management Practices (BMPs), were addressed in the previous GWMP (KDWD, December 2010). Future management strategies are focused on enhancing water for recharge while preserving groundwater quality and are consistent with goals and objectives of this GWMP Update, including Basin Management Objectives discussed in Section 5.

2.6 Groundwater Banking Areas

Several formal banking projects have been developed along the Kern River for groundwater recharge, storage, and subsequent recovery on behalf of others. Most of these projects are located within a few miles northwest of KDWD as shown on Figure 1 and listed below:

- Berrenda Mesa – KCWA
- Pioneer Project – KCWA
- COB 2800 – City of Bakersfield
- Kern Water Bank – Kern Water Bank Authority

An additional banking project is also planned for the McAllister Ranch ID area (Figure 1).

Also shown on Figure 1 are numerous additional recharge basins that have been constructed in water districts (e.g., Rosedale-Rio Bravo Water Storage District (RRBWSD), North Kern WSD, and AEWSD) that are not part of the four Kern River banking projects. These recharge facilities are used primarily for in-district groundwater replenishment, although several districts, including RRBWSD, AEWSD and KDWD, have also established formal in-district banking programs to store water for out-of-district parties. In addition to their in-district banking program, KDWD also participates in several of the Kern River banking projects by releasing river water to be conveyed to banking areas or through purchase of SWP water for banking. For example, KDWD is a participant in the Pioneer Project banking program through an agreement with KCWA. Additional information on KDWD water sources and water management programs is summarized in Section 3.

3 KDWD Operations and Management Programs

KDWD was formed in 1965 to provide a contracting agency for importing State Water Project (SWP) water through the Kern County Water Agency (KCWA) and to protect the existing Kern River water rights of the landowners within its boundaries. To provide context for the GWMP, a brief description of the District and its current operations, facilities, and management programs are summarized below.

3.1 Kern Delta Water District

KDWD boundaries encompass approximately 129,000 acres, about 107,635 of which contain irrigated agriculture (ESA, 2012). The area within the KDWD boundaries includes 89,212 acres within the historical utility service areas of five former canal companies and about 35,615 acres in non-utility areas. Figure 4 shows KDWD boundaries and the canal service areas. Lands within the KDWD boundary but outside of a service area are the non-utility lands. As shown on Figure 4, the canal service areas extend to the north beyond the KDWD boundary. Major roads and rights-of-way cover approximately 4,133 acres within KDWD, leaving about 124,867 acres (typically rounded to 125,000 acres) available for agriculture or other development. These areas are summarized in the following table.

Table 1
In-District Areas
Kern Delta Water District

Land Description	Area (acres)
Service Areas	
Kern Island	40,359
Buena Vista	14,408
Stine	19,817
Farmers	9,789
Eastside	4,839
Service Area Total	89,212
Non-Utility Areas	35,615
Rights-of-Way	4,133
Total	128,960

Reference: Boyle, 2000

3.2 Water Sources

KDWD manages three primary water sources – local surface water, groundwater, and imported water – conjunctively for beneficial uses in the District. Surface water rights on the Kern River are provided to agricultural customers to supplement groundwater pumping by individual landowners. The District also pumps groundwater for supplemental supply through District wells. In addition, KDWD has secured

imported SWP water rights and obtains other water sources as available through various contracts and exchanges. These sources are described below.

3.2.1 Kern River Water

KDWD acquired Kern River water rights (and related facilities) of the Kern Island Water Company in 1976 through a series of transactions. Tenneco West, Inc. (successor-in-interest to the Kern County Land Company) sold its Kern River water rights, Isabella storage rights, water transportation and distribution facilities, and other assets to the City of Bakersfield. Bakersfield, concurrently, sold the portion of these assets that served the Kern Island Water Company to KDWD. In January 1977, KDWD assumed control of these assets and facilities and began delivery of Kern River water to landowners (City of Bakersfield, et al, 1976).

In KDWD, specific diversion rights on the Kern River are associated with the service areas. Diversions are based on the river stage and the diversion priority of each water right holder as summarized in Table 2.

Table 2
Kern River Water Rights - Kern Delta Water District

Service Area	Right (cfs)	River Stage (cfs)	Diversion Priority	Appropriation Date
Kern Island	300	0-300	1	12/1/1869
	56	3,106-3,162	26	
Buena Vista	80	330-410	4	7/19/1870
	90	2,416-2,526	22	
Stine	150	550-700	7	12/12/1872
Farmers	150	730-880	9	4/28/1873
Eastside	83/300th of Kern Island		-	6/30/1921

Diversions of river flow occur on a daily basis through a cooperative effort and are recorded at measurement stations along rivers and canals. The First Point of measurement lies upstream of the diversion points for the "First Point diverters", which include KDWD, City of Bakersfield, and North Kern Water Storage District (NKWSD). The First Point measurement station upstream on the Kern River is shown on Figure 1. Allocated water not used by any First Point diverter can be used by others with downstream water rights (BVWSD, 2007).

In 1995, NKWSD initiated water rights litigation against KDWD over how Kern River water was allocated among the First Point diverters (NKWSD v. KDWD, Tulare County Supreme Court Case No. 96-172919). The final determination, after appeal, was a forfeiture of a portion of the Kern Island water rights during January, October, November, and December and a portion of junior water rights for other service areas during January, August, September, October, November and December (Vartabedian Appeal Opinion, 2007). Although KDWD water rights have always had maximum monthly volume caps, the judgments

resulted in further reductions for certain months. Current entitlement monthly caps for the service areas are summarized below.

Table 3
Entitlement Caps Resulting from Court Decisions
Kern Delta Water District

Service Areas	January (acre-feet)	August (acre-feet)	September (acre-feet)	October (acre-feet)	November (acre-feet)	December (acre-feet)
Kern Island	8,493	-	-	6,989	3,375	2,050
Buena Vista	347	-	-	-	236	191
Stine	-	-	583	1,380	22	12
Farmers	-	610	268	-	-	207

The cap restrictions reduced KDWD's long-term average Kern River water supply from about 251,775 acre-feet per year (AFY) to about 201,943 AFY, based on average river conditions recorded from 1997 through 2007. In its 2012 Kern River Water Allocation Plan (WAP), KDWD identified a series of prioritized management actions for use of the full Kern River entitlement including moving water among service areas, providing water to meet underserved demand, and increasing the amount of groundwater recharge (Todd Engineers, September 2011).

3.2.2 Groundwater

Landowners in both utility and non-utility areas within KDWD augment surface water supplies with groundwater: more than 1,000 wells have been drilled within the District boundary (KCWA, 2011). Wells are used primarily for irrigation where surface water deliveries are limited. Groundwater is also used for non-irrigation agriculture, including dairies, and for municipal and industrial (M&I) uses. In addition, KDWD pumps a relatively small amount of groundwater from District-owned wells to supplement surface water deliveries. The total amount of pumping within the District is unknown, but is estimated to range between about 200,000 AFY and 300,000 AFY. Pumping is especially critical in service areas with more limited Kern River diversion rights, such as Buena Vista, Stine, Farmers, and Eastside, or the non-utility areas without any diversion rights (Figure 4) (Boyle, 2001). Additional analyses of groundwater pumping locations and amounts are provided in Section 4 of this GWMP update.

3.2.3 State Water Project (SWP) Water

In 1972, KDWD contracted with KCWA to receive 30,000 AFY of SWP water imported into the county via the California Aqueduct (KDWD, 1974). KDWD's SWP contract included a buildup schedule that reached the maximum amount in 1990, consisting of 25,500 AF of firm supply and 4,500 AF of unregulated surplus supply to be delivered during four winter months on an as-available basis (AECOM, 2004). In 1994, the surplus water was eliminated as part of the Monterey Agreement, revising the District's SWP maximum amount to 25,500 AFY. The SWP water supply is used to balance the area's groundwater overdraft and provide supplemental surface water deliveries to the various portions of the District.

In the absence of a readily-available means to convey SWP water into the District, KDWD executed exchange agreements with Buena Vista Water Storage District (BVWSD) to allow BVWSD access to KDWD's SWP allotment for an equal amount of BVWSD rights on the Kern River. This arrangement allowed KDWD to divert its SWP allotment from the Kern River using existing facilities while BVWSD accessed the SWP water directly from the California Aqueduct.

Since the early 1990s, the availability of SWP water has declined. Recent restrictions on the importation of SWP water by the courts have resulted in greater uncertainty for future supplies (AECOM, 2009). For the 14-year period of 1998 through 2011, the District's full allotment of SWP water was available during only one year. Given the uncertainties associated with ongoing court restrictions and other conditions, the District estimates that 50 percent of its SWP contract amount, on average, will be available.

3.2.4 Other Sources of Water

Although KDWD is not a long-term contractor for the Central Valley Project (CVP), it is eligible for excess non-storable CVP water (Section 215 flood water) during wet years (typically about two out of every ten years). If capacity is available, this surplus CVP water is delivered to KDWD via the Friant-Kern Canal (ESA, September 2012).

In addition, certain lands within the District also receive treated municipal effluent (recycled water) from the City of Bakersfield Wastewater Treatment Plants (WWTP) and Lamont Public Utility District (LPUD) WWTP (see WWTP and Lamont PUD locations on Figure 3). These lands, referred to as sewer farm lands, use recycled water for irrigation. In 2000, these lands covered approximately 6,000 acres and were estimated to use approximately 18,000 AFY of recycled water for irrigation (ESA, September 2012).

3.3 Operations and Facilities

The District owns, operates, and/or maintains physical infrastructure to support conjunctive management of surface water and groundwater. Facilities and operations are summarized below.

3.3.1 Canals and Surface Water Conveyance

KDWD operates gravity conveyance systems consisting of five main canals and laterals covering about 150 miles and associated with the five service areas. These canals are shown on Figure 4 and, from west to east, include the Buena Vista Canal, Stine Canal, Farmers Canal, Kern Island Canal (including the main canal and the Central Branch), and Eastside Canal. These canals connect to regional facilities via the Kern River Canal, the Carrier Canal, and the Arvin-Edison Intake Canal (all shared with other users), allowing diversion of Kern River water and other water sources into the District (KDWD, 2002). Canals are mostly unlined; small reaches through some urban areas consist of either concrete-lined canals or pipelines (Boyle, November 1975).

Seepage of surface water through the bottoms of the unlined canals (associated with the conveyance of surface water) represents a significant portion of groundwater recharge and is considered part of the District's water supply. KDWD recognizes this benefit to groundwater resources and has maintained the canals without installing concrete liners. The District measures and manages operational canal losses in certain areas for the benefit of specific groundwater users.

Annual canal losses in each of the KDWD service areas have been estimated for 1998 – 2011, a time period representing average hydrologic conditions for Kern River flows. These operational losses are based on data presented in the Kern River annual operations reports, although the estimates differ slightly (typically within 1 to about 10 percent) from those summarized specifically as canal loss[2]. Average canal losses are estimated at about 55,880 AFY as shown in Table 4.

Table 4
Operational Loss/Groundwater Recharge from Canals

Service Area	Average Canal Loss (1998 - 2011)		2011 Canal Loss % of Total Supply
	(AFY)	(%)	
Buena Vista	7,389	13%	41%
Stine	3,957	7%	37%
Farmers	8,278	15%	44%
Kern Island	33,411	60%	31%
Eastside	2,845	5%	24%
TOTAL	55,880	100%	

In general, the amount of canal loss is commensurate with the diversion rights associated with each service area. As shown in Table 4, Kern Island receives more than one-half (60%) of the total recharge because of the higher diversions amounts into that large service area. Loss along the Farmers Canal also contributes to recharge in the Stine service area where the canal crosses service area boundaries (Figure 4).

Overall, the average annual canal loss (groundwater recharge) of 55,880 AFY represents between 30 and 40 percent of the total surface water diverted on a district-wide basis. That percentage varies across the District as shown on the right side of Table 4, where 2011 canal loss is represented as a percentage of total water supply. As shown in the table, a higher loss rate is associated with deliveries in the western service areas (Buena Vista, Stine, and Farmers) compared to the central (Kern Island) and eastern (Eastside) service areas. Numerous factors affect these losses including antecedent soil moisture content, local subsurface conditions (e.g., soil/sediment permeability and storage), and duration and amounts of water in each canal. Actual seepage and percolation rates also vary significantly with time. Canal loss is less in the summer months when more water is running in the canals and channel bottoms are continuously wetted.

[2] *The annual summary of canal loss presented in the Kern River Operations report is a simple subtraction of delivered supplies from entitlement diversions and does not always account for all water coming into the District.*

3.3.2 Recharge Basins

KDWD owns and operates approximately 814 acres[3] of spreading basins throughout the District to allow for groundwater replenishment. These basins have been constructed since 2003 as part of a joint project with The Metropolitan Water District of Southern California (Metropolitan), described in Section 3.4 of this GWMP Update. Although these facilities were constructed to support the KDWD banking arrangement with Metropolitan, the District also operates these facilities for local groundwater replenishment and storage of excess surface water when available. Basins have been constructed or are under construction at seven locations in Kern Island, Buena Vista, Stine, Farmers, and Eastside service areas as shown in Figure 4 and summarized in Table 5.

Table 5
KDWD Recharge Basins for Groundwater Replenishment and Banking

Recharge Basins	Service Area	Size (acres)	Average Infiltration Rate (ft/day)[1]	Average Annual Recharge Capacity (AFY)
Destefani	Buena Vista	215	0.43	34,000
Pit	Stine	72	0.20	5,000
Dairy	Stine	40	0.45	6,500
Ramero	Farmers	169	0.45	28,000
Stonefield	Stine	80	0.45	13,000
Kern Island	Kern Island	160	0.45	26,000
Di Giorgio[2]	Eastside	78	0.30	8,500
TOTAL		**814**	**0.41**	**121,000**

[1] *Average infiltration rate based on estimates of average annual recharge capacity provided by KDWD*
[2] *Di Giorgio recharge basins under construction*

As shown in Table 5, infiltration rates average about 0.41 feet per day, but vary by basin and with time. The lower infiltration rate associated with the Pit spreading basin is likely the result of finer-grained soils in that area, as discussed in more detail in Section 4.

The total annual recharge capacity of 121,000 AFY is theoretical and assumes basins are full and recharge continuously at average infiltration rates. Nonetheless, this amount illustrates that large volumes of water can be recharged when water is available. Significant amounts of additional groundwater recharge can also be achieved through release of water into the unlined canals, especially during winter months when both recharge water and canal capacity are available. An examination of seepage losses during these time periods indicates that more than 4,000 AF/month could be recharged along the existing in-district conveyance systems (Todd Engineers, September 2011).

3.3.3 District Wells

As part of the banking project with Metropolitan, the District has constructed or purchased 18 wells to recover banked groundwater. About one-half of these wells were installed adjacent to two of the larger

[3] *Basins on 736 acres are in operation; basins on 78 acres are currently under construction.*

spreading basins in Kern Island and Buena Vista service areas. Additional wells have been drilled along the northern portion of the District. KDWD well locations are shown on Figure 4. Up to 32 wells may be incorporated into the banking program at project build-out (KDWD, 2002).

The total annual average capacity of the wells is estimated at 94,000 AFY. Wells have been tested or operated at rates ranging from about 1,800 gallons per minute (gpm) to about 4,500 gpm. KDWD can use these wells for recovery of banked water or to pump groundwater for in-District use.

3.3.4 Isabella Reservoir Storage Rights

KDWD also has access to storage space in Isabella Reservoir and can store Kern River water accruing to its water rights. Available storage is based on an agreement that sets individual month-by-month storage limits. In addition, KDWD can store SWP exchange water using BVWSD's storage space with a carryover limit of 6,000 AFY that must be used prior to March 15 of the following year (Boyle, 2000). End-of-month storage and carryover limits under normal operating conditions are shown in Table 6.

Table 6
Isabella Reservoir Storage Limits
Kern Delta Water District

Service Area	End-of-Month Storage (AF)	Carryover (AF)
Kern Island	18,000	2,500
Buena Vista	11,000	1,500
Stine	9,000	1,500
Farmers	6,000	1,500
TOTAL	44,000	7,000

Ref: Boyle, August 2000

3.4 Management Programs

KDWD's ongoing surface water and groundwater management programs are complementary and provide flexibility for the effective use of the various water sources available to the District. Key programs are described below.

3.4.1 Water Allocation Plan (WAP)

To provide operational flexibility and to prevent forfeiture of surface water rights, KDWD has implemented a Kern River Water Allocation Plan (WAP) (Todd Engineers, September 2011). The plan prioritizes management actions to allow full use of the District's entitlement of Kern River water to beneficially manage water sources and preserve groundwater resources. The Kern River WAP identified five primary objectives for management of Kern River water:

- Meet existing underserved irrigation demand within KDWD boundaries
- Maintain sustainable groundwater resources and a sustainable water balance

- Provide equitable distribution of water among the historical utility service areas
- Serve the growing demand for water and emerging needs of customers in KDWD
- Preserve KDWD's water rights assets.

The WAP prioritized management actions as listed in Table 7. Proposed actions include meeting demands in each service area (Priority 1), movement of water between service areas to meet all in-district irrigation demands (including non-utility lands that currently rely on SWP water and groundwater) (Priority 2), provision of water for meeting in-district municipal and industrial demands (Priority 3) and groundwater replenishment and storage for both in-district and out-of-district areas (Priorities 4, 5, and 6).

Table 7
KDWD Allocation of Kern River Water

Priority	Management Action	Average[1] (acre-feet/year)
1	Deliver Water for Irrigation within Service Areas According to Service Area Water Rights	168,895
2	Deliver Available Water for Irrigation within District	10,488
3	Meet In-District M&I Demands	6,281
4	Perform In-District Groundwater Recharge	15,281
5	Store Water in Pioneer Project	226
6	Other Uses (meeting addtl surface demands, ground-water recharge, transfers to out-of-district agencies)	772
Average Annual Adjusted Entitlement		**201,943**

1. Annual averages 1997-2007; amounts vary significantly on a monthly and annual basis.
From Todd, September 2011

With more effective use of available surface water, the WAP decreases groundwater demand for in-district supplies and also increases recharge water available for groundwater replenishment.

3.4.2 Banking Programs with Metropolitan and Valley Water Districts

A key KDWD groundwater management program is an in-district banking partnership with two out-of-district water agencies, The Metropolitan Water District of Southern California (Metropolitan) and San Bernardino Valley Municipal Water District (Valley). The banking agreement allows for the agencies to store up to 50,000 AFY beneath KDWD, with a maximum storage amount of 250,000 AF. KDWD has significant flexibility for delivery and recovery options and can choose to credit the banking account if the project water can be put to beneficial use within the District (replacing groundwater use as in-lieu recharge). Water delivered for banking is subject to operational losses of 11 percent as measured at the point of KDWD delivery. This water is left in the groundwater basin for the benefit of basin users and

adds to the total groundwater in storage. Stored water (less loss) can be returned to Metropolitan and/or Valley via direct extraction or through water exchanges.

This banking program funded the construction of recharge basins and groundwater extraction wells that can be shared with in-district groundwater replenishment and recovery activities. Since the banking agreement was implemented in 2003, all of the project recharge basins and most of the project extraction wells have been purchased or constructed.

From 2003 through 2011, about 213,277 AF have been either recharged or credited (in-lieu) by KDWD for banking. Accounting for operational losses (11 percent by agreement), about 189,817 AF have been stored in the basin. Of that amount, 29,722 AF have been returned to the banking partner (in this case, Metropolitan), leaving 160,095 AF stored in the groundwater basin for subsequent recovery. Details of the banking program are summarized in the table below.

Table 8
Water Banking Program Summary 2003 - 2011
Kern Delta Water District

Service Area / Banking Partner	Recharge	In-Lieu	Total Deliveries	Operational Loss (11%)	Stored Water	Returned Water	Current Water in Storage
Buena Vista Service Area	44,672	16,516	61,188	6,731	54,457	8,527	45,930
Eastside Canal Service Area	0	16,022	16,022	1,762	14,260	2,233	12,027
Farmers Service Area	10,508	5,878	16,385	1,802	14,583	2,283	12,300
Kern Island Service Area	36,412	27,253	63,665	7,003	56,662	8,872	47,790
Stine Service Area	22,259	33,757	56,016	6,162	49,854	7,806	42,048
TOTALS:	**113,851**	**99,426**	**213,277**	**23,460**	**189,817**	**29,722**	**160,095**
Metropolitan Water District			183,277	20,160	163,117	29,722	133,395
Valley Municipal Water District			30,000	3,300	26,700	0	26,700

All values in AF

As shown on the table, most of the banked water has been recharged in the Buena Vista, Kern Island, and Stine service areas. Almost one-half of the deliveries involve a credit for in-lieu recharge. Again, operational losses represent an increase in the total groundwater in storage that is not returned to the banking partner. The available storage capacity in the subsurface is more than sufficient for these volumes of banked water. For example, assuming an average storage coefficient of 20 percent, the current stored water for banking (160,095 AF) represents an average water level rise of about six feet beneath the District. Even if the storage is less in certain areas of low permeability, the example illustrates the ability to store even larger volumes of water.

3.4.3 State Water Project (SWP) Water Allocation Plan

KDWD allocates its allotment of 25,500 AFY of SWP water among the service areas in accordance with a SWP Allocation Plan, developed in 1974 and amended in 1981 and 2009 (KDWD, 1974, 1981, and 2009). Based on underserved irrigation demand from surface water, declining groundwater levels, existing facilities, and other factors, a firm supply of SWP exchange water was allocated first to two zones of benefit:

1. Eastside Service Area (up to 0.5 AF/acre)

2. Non-utility areas (up to 0.3 AF/acre)

If additional water is available, equal amounts of SWP water are provided to other service areas as requested.

3.4.4 Out-of-District Banking

KDWD participates in several of the formal banking projects along the Kern River to optimize its use of water sources and provide overdraft protection of the groundwater system. From 1995 through 2006, KDWD banked approximately 63,660 AF of excess SWP water, CVP water, and high-flow Kern River water in Berrenda Mesa, Pioneer Project, COB 2800, and Kern Water Bank. Of that amount, approximately 23,670 AF was banked for subsequent recovery and approximately 39,990 AF was banked for overdraft protection.

3.5 GWMP Management Area

The planning and management area covered by this GWMP Update includes the approximate 129,000 acres within the District boundaries. A description of the physical conditions within the Management Area are summarized below, including topography, climate, surface water, soils, and land use.

3.5.1 Physical Setting

The management area is located in the southern San Joaquin Valley. This area of the valley floor is relatively flat to gently sloping and is surrounded by uplands including the Sierra Nevada to the east, the Coast Ranges to the west, and the San Emigdio/Tehachapi Mountains to the south (Figure 2). The Kern River, with headwaters in the Sierra Nevada, cuts across the valley floor to the west and provides surface water supply for the region. The river is located an average of about five miles north of KDWD (Figure 1).

Within KDWD, the ground surface elevation slopes at an average of about 10 feet per mile to the southwest. The highest ground surface elevations are in the northeast at approximately 420 feet above mean sea level (msl). The lower surface elevations of about 290 feet msl are in the south and southwest coincident with paleo-lakebeds that have been drained and placed into agricultural production. Most of the District has a ground surface elevation between 300 and 350 feet msl.

3.5.2 Hydrologic Setting

Long-term average annual rainfall in Bakersfield is approximately 6.03 inches per year (NOAA, 2011). Data from 1998-2011 are shown on Figure 5. Because most of the rain occurs outside of the primary irrigation season and varies significantly from year to year, precipitation is not a main source of agricultural supply. In addition, high intensity/short duration storms are typical of the region; such conditions are not conducive for efficient use of the water by crops. Nonetheless, a small portion of rainfall is available in most years to supplement other irrigation supplies. Todd Engineers conducted an assessment of daily crop consumptive use in KDWD service areas from 1998 to 2011 along with daily precipitation records to estimate the amount of rainfall that could contribute to irrigation demand. That analysis suggested that an average of approximately 20 percent of total rainfall could be used effectively

by crops. This estimate is generally consistent with amounts used in a calibrated groundwater model developed for KDWD (Boyle, 2001).

Kern River flow is a better indicator of hydrologic conditions than rainfall because the river is the primary surface water supply for the region. Because Kern River headwaters are located in the Sierra Nevada more than 50 miles east of KDWD, precipitation patterns that control river flow are not always consistent with rainfall patterns on the valley floor. Kern River flows are typically represented by the *river index*, a calculated value that relates annual flow to the long-term average. Annual river indices for 1998 – 2011 are provided on the bottom of Figure 5. As shown, annual flows during this 14-year period exhibit high variability ranging from 35 percent (2007) to 232 percent (1998) of the long-term average. Dry conditions from 1999 through 2004 and 2007 through 2009 averaged about 60 percent. Indices from the relatively wet years of 1998, 2005, 2006, 2010 and 2011 were all above 100 percent of the long-term average.

There are no significant, un-managed surface water drainageways that cross the District. Due to the conveyance of surface water along canals and the predominance of agricultural lands, surface water is highly managed. As such, surface water-groundwater interaction occurs primarily through operational canal loss, seasonal irrigation return flows, and managed recharge associated with groundwater banking.

3.5.3 Soils

The depositional history of the Kern River has influenced the shallow subsurface sediments and soil profile beneath the District. Historically, the terminus of the Kern River has been at large inland lakes. The ancestral river flowed from east to west across the valley before turning north toward the large Tulare Lake Bed some 40 miles away. During flood stage in the main east-west channel, flows spilled to the south across KDWD and terminated into two smaller inland lakes, Kern and Buena Vista lakes, portions of which lie within the KDWD southern boundary. These two now-dry lakebeds historically received thick deposits of fine-grained sediments as flood flows diminished and dropped their bed load[4].

These depositional patterns have resulted in the thick sequences of coarse-grain sediments (sand) in northern and central KDWD and fine-grained deposits (silt and clay) in the paleo-lakebeds as indicated by the soil texture map shown on Figure 6. Here soil textures are color-coded and listed in the legend by decreasing grain size (texture). Loamy sands to fine sandy loams, shown by yellow and light orange, are the dominant soil textures in the north central portions of the District with an additional patch of loamy sand in the eastern-most area near Lamont (Figure 6). Loams to clay, shown in dark orange, green, brown, and dark red, are the primary soil textures along the southern boundary of KDWD. An additional north-south band of fine-grain textures also occurs in east-central KDWD (Figure 6).

The correlation of these textures to soil permeability is shown on Figure 7 by the mapping of saturated hydraulic conductivity (K) values (a parameter controlled by permeability). Areas of silt and clay contain

[4] *Since the regulation of river flows with the construction of Isabella Dam in the early 1950s, the lakebeds no longer receive regular surface water inflow and have been converted to agriculture.*

lower K values (red and orange) and sandy soils correlate to higher K values (yellow and blue) of 6 feet per day (ft/day) to more than 30 ft/day. This map allows for more discrete differentiation of permeability zones and provides an indication of areas of higher drainage (recharge). District recharge basins are also shown on the map and allow a comparison to infiltration rates and relative K values. As shown on Figure 7, most of the recharge basins occur in higher permeability zones with the exception of one small basin (Pit) in the southwest, which occurs in an area of lower permeability soils. This basin has a lower infiltration rate than other basins, likely as a result of lower permeability conditions in the shallow subsurface. Although these permeability values pertain to shallow soils (about 10 to 30 feet deep), the depositional pattern is also mirrored in the sub-soil sediments, suggesting that the K zones are good indicators of relative recharge areas across the District.

3.5.4 Land Use

The primary land use beneath KDWD is irrigated agriculture. Over the last few decades, urban areas have increased as the City of Bakersfield has expanded to the south into northern KDWD. In 1975, urban areas only covered about one percent of the District lands (about 949 acres). But by 2010, urbanization covered more than 13 percent of the area (16,880 acres) (AECOM, 2010). The 2012 aerial photograph on Figure 8 shows the areas of current urban and agricultural land use as well as the Bakersfield city limits and sphere of influence.

The increase in urbanized lands is not expected to result in a decrease in water demands on KDWD supplies. Through an agreement with the City of Bakersfield, KDWD may provide municipal and industrial (M&I) supply when lands formerly supplied by KDWD become urbanized. An analysis in the District's Kern River WAP indicated that KDWD may be required to supply an additional 6,281 AFY for M&I demand (see Table 7, Priority 3) (Todd Engineers, September 2011).

The total number of acres irrigated within KDWD has been estimated at about 99,000 acres. However, with double cropping and multiple crops grown throughout the year on the same parcel, the number of permitted agriculture acres is likely higher than historically reported. For example, KDWD estimated that irrigated lands represented the equivalent of about 130,000 acres for their 2011 crop survey. In addition, even with an increase in urbanized areas, the amount of irrigation water demand has increased over time. A variety of factors may have contributed to this condition including changes in cropping patterns and fewer acres fallowed.

Figure 9 shows the pattern of agriculture and primary crops grown in 2011 in KDWD. As indicated by the 2011 data, five crops – alfalfa, wheat/oats, corn, and cotton – cover more than about 70 percent of the irrigated areas. Alfalfa, wheat/oats, and corn are grown throughout the District. Cotton and tomatoes are the primary crops in the south, in particular on the Kern Dry Lake bed. Grapes (represented by *vines* on the map) are grown primarily in the east (Figure 9).

4 State of the Groundwater Basin

KDWD and the Management Area for this GWMP are located in the Kern County Subbasin, a portion of the larger San Joaquin Valley Groundwater Basin as designated by the California Department of Water Resources (DWR) (Figure 2) (DWR, 2006). The Kern County Subbasin (DWR Basin No. 5-22.14) is defined by the Kern County line on the north, the granitic bedrock of the Sierra Nevada and Tehachapi Mountains on the east and southeast, and the marine sediments of the Coast Ranges and San Emigdio Mountains on the west and southwest. The subbasin covers more than 3,000 square miles of the southern end of the valley. The Management Area (KDWD boundary) is shown on Figure 2 and covers about 200 square miles of the south central portion of the subbasin, approximately 7 percent of the total subbasin area.

Current groundwater conditions in the Management Area have been reviewed to identify any new issues of concern and provide a basis for updating the Basin Management Objectives (BMOs). The review includes a description of local aquifers, evaluation of groundwater occurrence and flow, documentation of groundwater quality, and a re-assessment of groundwater use. Groundwater issues of concern are summarized at the end of Section 4.

4.1 Aquifers and Hydrostratigraphy

The aquifers beneath the Management Area are comprised primarily of Tertiary- and Quaternary-age continental sediments extending to depths below 1,000 feet in the subsurface. The base of fresh water has been mapped to depths of more than 3,000 feet locally (Page, 1973). The deeper deposits are composed of older coalescing alluvial fans from the Coast Ranges in the west and the Sierra Nevada in the east and have been designated the Tulare Formation and Kern River Formation, respectively. The overlying younger sediments consist of alluvial fan, fluvial, and flood basin deposits.

A geologic map provided on Figure 10 shows the surficial geologic units in the region and the KDWD boundaries. As shown on the map, the north and central portions of KDWD are underlain by Tertiary to Quaternary-age valley fill deposits, composed locally of sands and gravels deposited on the Kern River alluvial fan. Flood basin and lacustrine deposits of the Kern and Buena Vista dry lake beds rim the southern boundary and correspond to the fine-grain textures noted previously (Figure 6).

The depths and thickness of the various units have not been differentiated previously beneath KDWD and have been considered one continuous aquifer system by other investigators (Boyle, 2001). Nonetheless, the changes in depositional patterns with depth are reflected in the subsurface geology, and several zones can be generally delineated with the incorporation of geophysical logs recorded in various District wells.

In general, log data indicate more permeable layers of sand and gravel inter-bedded with less permeable layers of silt and clay extending to depths of about 700 to 1,000 feet (the bottom of most water wells in

the District[5]). An analysis of the upper 1,000 feet of the alluvial aquifers was conducted using about 50 geophysical logs recorded in wells within KDWD and immediately adjacent to District boundaries. Although textures and thickness of the aquifer units vary over the area, the geologic section can be delineated generally into three hydrostratigraphic packages, consistent with previous interpretations by the DWR beneath the Kern Water Bank northwest of KDWD. These packages are referred to herein as the Upper, Middle, and Lower zones of the alluvial aquifer.

Figure 11 shows five geophysical logs across the District arranged on cross section A-A' to illustrate the aquifer zone delineation. The middle log is from one of the District's recovery wells near the Kern Island recharge basin. The northwest-southeast location of the cross section across the District is shown on the inset map on Figure 11.

In general, the Upper Zone refers to the alluvial deposits from the ground surface to a depth between 200 and 300 feet. The Middle Zone extends from the base of the Upper Zone to between about 600 and 800 feet, and the Lower Zone is defined by the alluvial deposits below the Middle Zone. The 2010 water table is also presented on Figure 11 to illustrate the location of the water table in the Upper Zone. As shown on the figure, the Upper Zone is mostly unsaturated in the northwest and central areas. Saturation in the Upper Zone increases to the southeast.

The resistivity readings presented on the right side of each log were used to interpret general aquifer characteristics and textures, with higher resistivity readings indicating relatively higher-permeability units of sand and gravel[6]. Note that the resistivity scale shown at the bottom of each log is consistent for the three logs in the west (0 to 100 ohm meters), but changes for the two southeastern logs (e.g., 0 to 80 ohm meters and 0 to 50 ohm meters). These two wells contain relatively fine-grained, lower permeability sediments as indicated by the lower resistivity measurements. None of the geologic units in these two wells have resistivity readings above 50 ohm meters (typical of sands in this area). By comparison, numerous units have resistivity measurements above 50 ohm meters in the other wells (Figure 11).

Using the resistivity logs on Cross Section A-A', characteristics of the three zones of the alluvial aquifer can be estimated. The Upper Zone contains thick sands and gravels in the western and central portions of the District as indicated by the higher resistivity zones on the three western-most logs. Upper Zone resistivity readings were much lower in the southeast, indicating silts and clays. This is the area that corresponds to lower permeability soils discussed previously (Figure 7). As indicated by the label on the cross section, perched water has been identified close to the surface in nearby shallow wells.

The Middle Zone consists of a relatively thick section of inter-beds with more permeable intervals occurring in the central District wells. Although only a few wells have penetrated more than 100 to 150

[5] According to well records, less than three percent of the water supply wells in KDWD are drilled below 900 feet. In general, wells have been drilled deeper over time with almost one-half of the deeper wells drilled after 1990.

[6] Resistivity readings are also influenced by changes in groundwater quality, degree of saturation, and other factors, but a check between driller log descriptions and resistivity logs in some wells indicate that the correlation of higher resistivity to zones of higher permeability is adequate for the purposes of this characterization.

feet of the Lower Zone, the unit appears to be composed of mostly sand in the west with lower permeability sediments in the southeast. These descriptions provide a general framework for groundwater conditions beneath the District, recognizing that alluvial deposits are heterogeneous and local conditions vary.

4.2 Groundwater Occurrence and Flow

Groundwater has been characterized as unconfined to semi-confined beneath KDWD. The Upper Aquifer contains a water table that fluctuates seasonally with local recharge and temporally in response to drought and wet hydrologic conditions. Groundwater pumping is likely the largest controlling factor on water levels with depth, although exact pumping depths are generally unavailable.

In general, groundwater flows from north to south across the District, influenced by recharge along the Kern River and subsurface inflow into the District from the north. Pumping centers also influence the direction of groundwater flow. Data and analyses used to further examine groundwater occurrence and flow in the Management Area are described below.

4.2.1 Water Levels

Water level data have been compiled from DWR, KCWA, and KDWD in support of this study. Hydrographs have been generated from more than 300 wells to view trends and fluctuations in water levels over time. Figure 12 presents 12 representative hydrographs prepared for wells with sufficiently long records to include the drought conditions of the early 1990s. This is a time when many areas experienced record declines in water levels. Horizontal and vertical scales are consistent on the graphs (except Hydrograph 8) to facilitate viewing.

Although there is some variability among the hydrographs on Figure 12, many water level records are consistent with the general observations listed below (e.g., Hydrographs 1, 2, 6, and lower graphs on 10 and 12):

- relatively low water levels in the early 1990s,
- rising water levels in the late 1990s (especially 1998),
- declining water levels through about 2004
- rising water levels from 2005 and 2006
- rising water levels in 2005/2006
- declining water levels 2007 through 2010 with minor recovery in late 2010 and 2011.

In general, these observations are consistent with years of above-average rainfall and higher flows on the Kern River including 1998, 2005/2006 and 2010/2011 (Figure 5). Most wells have fluctuated only about 40 to 80 feet over the entire time period. However, some wells indicate significant declines with minimal recovery (e.g., Hydrograph 7 on Figure 12). Notwithstanding the variation in patterns, most water levels are close to the early 1990s levels.

Several hydrographs show relatively consistent water levels over time with no significant trend and only minimal fluctuations (e.g., Hydrograph 8, 9, and shallow graphs in red on Hydrographs 10 and 12). These wells coincide with areas of low-permeability soils and subsurface sediments described previously

(Sections 3.5.3 and 4.1). These deposits are also characterized by low percolation rates. Water recharged at the surface (including infiltration of precipitation and agricultural return flows) drains slowly and builds up in the shallow subsurface. Shallow wells in these areas have documented consistently high water levels for decades. Nearby wells indicate large vertical gradients between these perched zones and the underlying water levels as measured in and near pumping wells (see water level differences between the red and blue graphs on Hydrographs 10 and 12).

The zone where perched water accumulates has been delineated by KCWA as shown on Figure 13. These zones are areas of high recharge and slow drainage that appear to be in equilibrium in the shallow subsurface. In the southern portion of KDWD, the perched zone overlies the low permeability clays associated with the paleo dry lakes. Perched water here likely represents return flows from irrigation. The north-trending arm of the perched layer corresponds with low permeability soils and basin deposits shown previously on Figures 7 and 10. Perched water here likely originates from both return flows and losses along the Central Branch canal. As noted previously, Kern Island has a larger supply of surface water than other service areas and is associated with the largest amount of recharge from canal loss.

4.2.2 Groundwater Flow

Groundwater elevation contour maps prepared by DWR and KCWA have been used to examine groundwater flow patterns in the Management Area. KCWA prepares annual contour maps from water levels measured prior to the summer irrigation season when numerous cones of depression complicate local groundwater flow. Two annual spring contour maps, 2010 and 1998, have been selected for illustration of groundwater flow patterns in the Management Area during relatively low (2010) and high (1998) water levels.

The water level contour map shown on Figure 14 presents water levels from Spring 2010 in feet msl. During this period, water levels were generally below 200 feet msl across most of the District and below 150 feet msl in the southwest and east. An isolated area above 200 feet msl occurs along Highway 99, south of the Kern Island recharge basin. Here, lower permeability soils hold recharge from canals and return flows, creating areas of higher water levels in a perched system and at the water table.

As shown by the contours and generalized flow arrows on Figure 14, groundwater flows from the Kern River to the south and southeast into KDWD. Beneath the District, groundwater generally flows southwest and southeast, influenced by local groundwater pumping. There is also a component of groundwater inflow into southern KDWD as indicated by the north-northeast flow arrow in the south-central portion of the District. In this area, low permeability soils are recharged by agricultural return flows; this recharge creates a hydraulic gradient to the north.

These groundwater flow patterns are altered somewhat when water levels are higher. Figure 15 presents a groundwater elevation contour map during Spring 1998 when water levels were typically about 50 feet higher than in 2010. During this time period, water levels are above 200 feet msl beneath most of the District. Recharge along the Kern River creates subsurface inflow from the north and northwest, a pattern similar to Spring 2010 conditions. But with higher water levels beneath central KDWD, hydraulic gradients create more complicated patterns of flow in western KDWD. Subsurface outflow appears to occur in the southwest, although most of the flow is likely captured by pumping

wells either within or just south of the boundary (Figure 15). Subsurface outflow occurs to the east, similar to the flow pattern indicated on Figure 14.

4.3 Groundwater Quality

Groundwater quality beneath KDWD has been designated for both agricultural and municipal beneficial uses (among others). Groundwater constituents/parameters that may limit irrigation use include salinity (represented as chloride, electrical conductivity, or total dissolved solids - TDS), sodicity (represented as sodium or sodium adsorption ratio), boron, and others. Previous evaluations have described groundwater as suitable for irrigation with no significant constituents of concern. Municipal beneficial use is governed by drinking water quality standards.

Groundwater quality data collected from 1986 through 2006 were provided by KDWD in support of this study. The most comprehensive data set was collected in the early 1990s and contained inorganic analyses for general minerals from 20 wells across the District. Although these data are relatively old, they are capable of monitoring potential impacts from agriculture, which has been the predominant land use overlying the basin since the late 1800s. The 1990s data represent any potential cumulative impacts from decades of similar cropping patterns and practices. To supplement the older data, KDWD sampled four of the District's wells in July 2013. To evaluate groundwater quality, three selected constituents from the early 1990s and 2013 data – TDS, nitrate, and sodium – have been posted on District maps on Figures 16a and 16b, respectively. In addition, a smaller data set from a few wells sampled in 2005 and 2006 are included on Figure 16a for completeness. These two figures illustrate the geographical distribution of general inorganic water quality across the Management Area and provide some information on changes in quality from the 1990s to 2013. Data posted on the two maps (Figures 16a and 16b) are discussed in more detail below.

4.3.1 Total Dissolved Solids (TDS)

As shown by the TDS values on Figures 16a and 16b, groundwater is not highly mineralized in most areas as indicated by relatively low concentrations; most values meet the TDS secondary maximum contaminant level (MCL) of 500 mg/L for drinking water. TDS values range from 144 mg/L (north-central KDWD) to 1,623 mg/L (southwest KDWD in the paleo-lakebed of Buena Vista Dry Lake). The average TDS value posted on Figure 16a is 418 mg/L. In general, values average about 315 mg/L in northwestern KDWD, about 200 mg/L in north-central KDWD, and about 530 mg/L along the western boundary. Wells in southwestern KDWD have highly variable TDS values ranging up to 1,623 mg/L and are likely being influenced by the high salt content of the paleo-dry lake bed sediments. The 2013 data (Figure 16b) indicate TDS values from 160 mg/L to 200 mg/L in the four north-central District wells, values generally consistent with the older data.

The relatively low values of TDS in northern KDWD are likely influenced by the decades of surface water recharge through canal loss and irrigation return flows from relatively low-TDS surface water. Kern River water concentrations averaged approximately 110 mg/L in 1986 (when the most surface water quality data were available). The lowest TDS concentrations in groundwater were recorded in the northern Kern Island Service Area (144 mg/L to 199 mg/L) where most of the canal loss and surface water return flows

occur. However, canal loss along the Eastside Canal does not appear to correlate to lower TDS values; concentrations in wells along that canal average about 530 mg/L (Figure 16a).

To further examine the potential changes in TDS values with depth, more recent TDS data from a shallow/deep well pair were reviewed (see data boxes on Figure 16a labeled Shallow and Deep in northwest KDWD). Although the actual construction data are not available for these wells, well information indicates that these monitoring points target shallow aquifers at about 200 to 300 feet deep and deeper aquifers below about 400 feet. Recent data from this well pair suggest that TDS in deeper aquifers (132 mg/L) is lower than in the shallow aquifers (280 mg/L). Additional data would be needed to confirm this relationship or determine if a similar relationship occurs in other areas.

4.3.2 Nitrate

Nitrate concentrations from the 1990s samples did not indicate any wells or areas of concern. The average nitrate concentration shown on Figure 16a is 8 mg/L. All concentrations were below the primary MCL of 45 mg/L. To examine the vertical nature of nitrate concentrations, more recent data from the shallow/deep well pair in northwest KDWD were reviewed (Figure 16a). Although only one sampling event is available, these data indicate that the shallow nitrate concentration (16 mg/L) is higher than nitrate in the deeper zone (0.7 mg/L). Nitrate concentrations measured in 2013 (Figure 16b) were generally consistent with the 1990s data and range from 7.9 mg/L to 13 mg/L. Again, all concentrations are within the drinking water standards.

4.3.3 Sodium and Boron

As shown on Figure 16a, sodium concentrations are elevated above the irrigation water quality standard of 69 mg/L in some areas. The average concentration of data on Figure 16a is 58 mg/L with a median of 47 mg/L. Higher sodium concentrations occur generally in the southeastern and southwestern portions of the District and may be associated with the low permeability silts and clays documented in this area. Sodium concentrations in the northern wells in 2013 (Figure 16b) are relatively low at 25 to 29 mg/L and are consistent with the older data in this area.

Although not posted on Figures 16a and 16b, boron concentrations were also reviewed for irrigation suitability. All boron concentrations were below 0.6 mg/L, an acceptable range for crops grown in KDWD. A typical irrigation standard for most crops is 7 mg/L.

Additional inorganic groundwater constituents were evaluated with time by comparing data from the 1990s, 2001 through 2006, and the 2013 samples with a focus on the northern wells where most of the data were available. In general, no significant water quality changes were identified.

Observations from data posted on Figures 16a and 16b and discussed in this section are constrained by the limited number of sampling events and the absence of data within the central and southern portions of KDWD. Most wells in the program contained only one or two samples from 1990 to 2013. Further, very few wells have been sampled since the 1990s; all of the 2006 and 2013 data were concentrated in a small area involving only a few wells. Local groundwater quality conditions likely vary and current conditions may be different than in the 1990s. Nonetheless, there are no areas or constituents of concern indicated by the available groundwater data.

4.4 Groundwater Use

Groundwater has been used in KDWD for more than 100 years to supplement surface water supplies. According to drillers' logs, more than 1,700 wells have been drilled within District boundaries (KCWA, 2011b). About 1,000 of these wells were drilled between the 1950s and the late 1970s prior to the availability of imported water supplies. Over the last 30 years, about 500 additional wells have been drilled. The number of active, inactive, or abandoned wells in the District is unknown.

Most wells in KDWD have been drilled to a total depth of about 400 to 600 feet and were screened primarily in the Upper and Middle aquifer zones. Since the 1990s, an increasing number of wells have been drilled to depths of about 800 to 1,000 feet with screens typically in the Middle and Lower aquifers. Even though the recent trend is toward deeper wells, only about seven percent of all wells extend below 800 feet.

Although most of the wells were drilled for agricultural irrigation, numerous wells in the northern portion of the District provide municipal supply, including wells operated by the City of Bakersfield, Cal Water, and Greenfield County Water District. Information on municipal demand within the District boundary is further documented in Section 4.4.2. Given the depth to groundwater, pumping beneath the District does not appear to significantly change surface water flows.

Previous analyses of agricultural water demand have been updated for this GWMP to provide a more detailed assessment of groundwater use. For this analysis, groundwater use is estimated by subtracting surface water deliveries (including local water and imported water) from total irrigation demand in KDWD over the last 14 years (1998 – 2011), a time period representing average hydrologic conditions. This analysis and results are described in more detail below.

4.4.1 Agricultural Irrigation

Total irrigation demand for the KDWD service areas has been developed from the crop permit database compiled by the Kern County Agricultural Commissioner's Office. This database contains the crop type and associated parcels in a spatial Geographical Informational System (GIS) format (for example, see the 2011 crop data presented on Figure 9). Although KDWD crop surveys were also reviewed for the analysis, the County database allowed for a more detailed and spatial compilation of crops over time including double cropping. In addition, more detailed crop categories are contained in the County data than in many of the District surveys.

One potential inaccuracy in the County data involves the assignment of multiple crops to an entire parcel when the crop may actually be planted on only a portion of the parcel (referred to as multiple plantings by the County). Although this process may over-estimate irrigated acreage in some areas, it was noted to occur most often on smaller parcels. Total estimated irrigated acreage is also slightly over-estimated in the analysis because it includes the entire service areas of the District, including acreage north of KDWD boundaries. However, groundwater use in this area is immediately adjacent to the District and is considered relevant to the total demand on groundwater in the vicinity.

4.4.1.1 Primary Crops in KDWD

Over the last 14 years, the total number of annual irrigated acres in the KDWD service areas has averaged about 118,000 acres. That amount has increased about 14 percent over the last six years from about 112,000 acres to more than 127,000 acres.

County maps indicate that approximately 42 different crops[7] were grown on this acreage. Of these, 12 crops (or groups of crops) represent 80 percent or more of the total irrigated acreage. These crops are listed on Table 9. As shown on the table, each of the 12 crop groups covers more than 1,000 acres in most years of the study period. In addition, the first four crops (alfalfa, cotton, wheat/oats, and corn) have been planted on at least 10,000 acres annually and represent an average of 72 percent of the total irrigated area. The 2011 distribution of these and other crops are also shown on Figure 9.

Table 9
Primary Crops Grown in Kern Delta Water District

CROP, ACRES	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Alfalfa	26,559	26,774	19,960	27,679	30,545	27,026	28,183	29,850	29,869	30,076	32,259	32,186	28,338	27,263
Cotton	23,160	28,403	33,383	30,468	21,607	23,818	26,006	24,954	18,837	17,631	11,746	11,968	11,640	15,253
Wheat / Oats	NA	19,838	14,312	16,197	20,142	22,246	18,475	16,511	19,516	20,308	26,320	25,652	26,589	25,554
Corn	16,187	12,643	10,968	14,087	18,082	16,521	15,494	16,690	16,095	14,063	15,227	17,114	16,745	20,035
Misc. Field	9,545	488	685	1,017	240	1,865	2,237	4,287	5,412	9,676	14,908	7,541	7,209	10,092
Carrots	1,895	6,553	5,515	5,169	5,185	4,568	3,608	4,479	4,659	5,231	4,665	3,905	3,866	3,455
Grapevines	5,761	5,626	4,673	5,651	5,245	4,868	4,622	4,595	4,569	5,059	5,052	5,074	5,069	5,408
Vegetables	339	676	738	395	628	649	756	1,654	1,269	1,455	1,226	1,780	2,366	3,697
Tomato	37	298	1,053	968	1,402	1,330	1,588	1,548	1,625	2,633	3,044	3,790	4,218	2,206
Potato	1,673	2,914	2,707	2,277	2,559	2,186	1,756	1,412	1,944	1,968	1,547	1,706	1,632	1,965
Onion (dry)	2,269	3,883	3,376	1,927	1,956	2,347	1,705	963	1,081	972	1,050	1,901	2,150	2,611
Almonds	743	703	3,315	782	793	771	834	1,028	1,323	1,645	1,948	2,041	2,225	3,782
TOTAL ACRES	**88,170**	**108,798**	**100,686**	**106,617**	**108,384**	**108,194**	**105,264**	**107,971**	**106,198**	**110,715**	**118,992**	**114,659**	**112,046**	**121,321**
% DISTRICT TOTAL	**81%**	**94%**	**90%**	**96%**	**95%**	**97%**	**97%**	**97%**	**86%**	**85%**	**88%**	**95%**	**97%**	**88%**

An examination of Table 9 indicates changes in cropping patterns over time. Acres for selected crops are plotted with time on Figure 17 to illustrate major crop trends. As shown on the figure, cotton and alfalfa represent the largest plantings in the District from 1998 through 2005 (more than 20,000 acres each). However, in 2006, cotton experienced a sharp decline in response to a drop in price and has not recovered to pre-2005 levels. During the decline in cotton acreage, increases in acreage occurred for alfalfa, wheat/oats, and miscellaneous field crops. Smaller increases were also noted for corn, almonds, tomatoes, and other vegetables. Many of these increases were associated with an overall increase in irrigation demand.

4.4.1.2 Total Irrigation Demand

Total irrigation demand for 1998 through 2011 has been estimated using daily crop coefficients from DWR and local climate data. The evapotranspiration (ET) demand of the crop was calculated by multiplying the reference monthly evapotranspiration rate (from the local Shafter CIMIS station) by the crop coefficient for each crop type (or group of crops). Daily crop coefficients and growing seasons for

[7] *The number of crops reflects some grouping of related crops with similar water demands.*

over 40 crops were derived from the DWR irrigation estimation tool *CPU M+*. Daily precipitation was compared to crop ET and applied to meet a portion of crop demand.

An irrigation efficiency of 80 percent was assumed for the analysis (20 percent return flows). This estimate was based on reported irrigation methods and associated efficiencies in numerous District crop reports (most recently in 2000). Reported efficiency values ranged from 76 percent to 92 percent across the District with the lower values covering most of the District and higher efficiencies in areas of low permeability soils in the south.

This analysis produced an estimated applied water rate required for each crop grown in the District. The applied water rate was multiplied by the crop acreage to produce an overall irrigation demand for each year. Applying this methodology to hydrologic data from 1998 through 2011 provided the irrigation demand values shown on Figure 18. As shown on the chart, irrigation demand has ranged from about 348,000 AFY (2003) to 436,000 AFY (2008). In general, demand has risen over the last five years (since 2006), with the four highest annual irrigation demand estimates occurring in 2007, 2008, 2009, and 2011.

4.4.1.3 Irrigation by Surface Water and Groundwater

The portion of the total irrigation demand that is met by surface water deliveries[8] is shown on Figure 18. The remaining demand is assumed to be met with groundwater. For the 14-year period shown on Figure 18, surface water averages about 141,000 AFY and groundwater pumping averages about 245,000 AFY. In general, the use of surface water has increased somewhat over time as the District has become more efficient in diverting and storing surface water when available. For example, the four largest annual surface water deliveries have occurred within the last seven years.

As shown on Figure 18, the portion of irrigation supplied by groundwater varies significantly from year to year based on the amount of surface water available. In years of relatively low surface water availability (e.g., low flows in the Kern River in 2007), pumping accounts for almost 75 percent of the irrigation demand. In relatively wet years (e.g., 2005 and 2006), surface water can supply up to about one-half of the demand, reducing the need for additional groundwater pumping. On an average basis, groundwater provides about two-thirds of the total irrigation water supply.

Most of the groundwater pumping occurs in areas where surface water rights are limited or unavailable. Figure 19 divides groundwater pumping the estimates in Figure 18 into the corresponding service areas. As shown, almost one-half of the KDWD groundwater pumping occurs in the Non-utility areas where the only surface water available is a portion of the limited supply of SWP allocated to the District on an annual basis. Groundwater pumping represents about 20 percent of the irrigation supply in the Stine Service Area. Although Stine has a Kern River water right, the amount is typically not sufficient to accommodate demands within the 20,000-acre service area (the second largest in KDWD). The Eastside Service Area is associated with the lowest amount of groundwater pumping due to its small size (Figure 4).

[8] *Surface water deliveries are less than actual diversions due to seepage and other losses.*

4.4.2 Municipal Water Supply

Urban areas that serve municipal and industrial (M&I) water supply have expanded into KDWD over time (mostly from the north) and currently cover about 16,880 acres within KDWD boundaries, or 13 percent of the area. Urban areas within or adjacent to KDWD include a portion of the City of Bakersfield, the City of Greenfield, the communities of Lamont and Weedpatch, and other unincorporated areas and communities such as the small community of Pumpkin Center. Service areas of the City overlap District areas while the KDWD boundary circumnavigates around some of the smaller communities (e.g., Greenfield and Lamont, see Figure 3). Some private domestic wells also pump within District boundaries but net consumption of this water is judged small compared to agricultural and municipal consumption; it has not been estimated for this GWMP update.

Groundwater provides most of the municipal supply, which is replenished locally from natural recharge, canal seepage, spreading basins, and recycled water. In addition, KDWD recharges water on behalf of small community water systems including Greenfield County Water District (CWD) to maintain groundwater levels and support municipal pumping. In this capacity, KDWD has served as an M&I wholesaler for groundwater replenishment (Todd Engineers, September 2011). Recent pumping and future estimates for the main municipal suppliers are summarized in the following sections.

4.4.2.1 City of Bakersfield

The City of Bakersfield is served by two municipal suppliers: Cal Water and the City of Bakersfield Water System (Figure 3). Water supply is a combination of groundwater, river water, and SWP water (from KCWA, ID-4). The use of treated imported SWP water has increased in recent years with the expansion of local water treatment plants.

Cal Water is the largest municipal water supplier in Bakersfield. Groundwater has historically supplied up to 80 percent of Cal Water's demands supplemented by surface and imported water. Its groundwater system includes about 115 active wells with a design capacity of 142,000 AFY. Total 2010 pumping was 44,000 AFY (Cal Water, 2011). Cal Water has four active wells within KDWD. Annual production from these wells has ranged from 23 AFY to 2,619 AFY and averaged 1,563 AFY from 1998 to 2011. Data are summarized on Table 10. Cal Water production within KDWD has decreased significantly since 2007 when two high production in-District wells were no longer being pumped. Future system-wide pumping is predicted to decrease below 35,000 AFY when additional proposed surface water projects are completed (Cal Water, 2011).

Table 10
Annual Municipal Pumping within District Boundaries (AFY)

YEAR	Cal Water	Bakersfield	Greenfield CWD	Lamont	TOTAL
1998	1,975	5,572	1,120	4,922	13,589
1999	2,139	6,228	1,114	5,966	15,447
2000	2,347	5,368	1,329	5,269	14,313
2001	2,365	6,093	1,360	5,278	15,096
2002	2,619	6,176	1,507	5,524	15,826
2003	2,479	5,088	1,653	5,763	14,983
2004	2,298	4,836	2,026	4,640	13,799
2005	2,415	4,345	2,169	5,226	14,155
2006	1,518	4,717	2,486	3,683	12,404
2007	34	5,144	2,574	4,450	12,202
2008	41	5,216	2,554	4,220	12,031
2009	23	6,100	2,445	3,235	11,802
2010	62	5,904	2,282	3,649	11,897
2011	not available	6,936	2,258	3,879	13,073
14-Year AVG	1,563	5,552	1,920	4,693	13,616
2020	system-wide pumping predicted to decrease	system-wide pumping predicted to decrease	2,651	4,555	NA

Greenfield 1998-2001 data from KCWA annual reports. 2003-2011 data from Greenfield.
2002 pumping estimated as halfway between 2001 and 2003.
COB and Cal Water pumping derived from monthly pumping records
Lamont 1998-2001 data from KCWA annual reports. 2002-2011 data from AECOM (2013).
2020 based on 1.8% annual increase from Kern COG (2010)

Bakersfield's City Water System service area covers about 35 percent of the western portion of the Bakersfield (about 38 square miles) and provides surface water and groundwater to a population of 118,600. Cal Water operates the City's water distribution system including 50 active groundwater wells within City boundaries, 12 of which are in KDWD. Between 1998 and 2011, system-wide pumping ranged between 24,361 AF (1998) and 45,517 AF (2008). Pumping in 2011 was 35,520 AF. Pumping from wells within District boundaries for the 1998 to 2011 period is summarized in Table 10. As shown in the table, City pumping has ranged from 4,345 AFY to 6,936 AFY and averaged 5,552 AFY.

Some of this pumped water is treated and reused for irrigation. Wastewater treatment occurs at the City's WWTP #2 in northern KDWD (Figure 3). A portion of the effluent is used for irrigation of non-human consumption crops within KDWD boundaries and irrigation return flows provide recharge to the groundwater system. Wastewater is stored in reservoirs on City-owned land just south of the WWTP. Biosolids from the City's WWTP #2 and #3 are also spread on this land. Between 2000 and 2010, effluent flow ranged from 15,300 AFY to 18,200 AFY.

4.4.2.2 Greenfield County Water District

Greenfield CWD supplies groundwater to a population of about 8,500 in Greenfield from five wells. Greenfield CWD's average annual pumping from 1998 to 2011 was 1,920 AFY. Annual pumping totals

are shown on Table 10. Pumping increased from 1,114 AFY in 1998 to 2,574 AFY in 2007. Since 2007 it has remained within the 2,260 to 2,560 AFY range.

4.4.2.3 Lamont Public Utilities District

The Lamont Public Utilities District (PUD) is located on the eastern edge of KDWD and supplies water to the communities of Lamont, Weedpatch and other surrounding areas. It currently serves a population of about 13,900 through 4,200 service connections (AECOM, January 2013). It has three service areas and nine wells but four of the wells are inactive due to water quality problems (arsenic, perchlorate, and nitrate) and aging infrastructure (CDPH, June and October 2012). Lamont PUD is seeking affordable financing to either construct new wells or water treatment plants (Kennedy/Jenks, 2011). Between 1998 and 2011, pumping has ranged from 3,649 AFY (2010) to 5,966 AFY (1999) (Table 10).

Lamont PUD also has a wastewater treatment plant south of Lamont that has two aeration ponds, two lined facultative ponds, two lined storage ponds, and six older unlined storage ponds. Current flows average 1.4 mgd (1,570 AFY) (CRWQCB, June 2012). The plant has disposal capacity problems and effluent discharge quality violations. Currently, all effluent goes to Community Recycling and Resource Recovery, Inc. for composting manufacturing (on 190 acres of Lamont PUD land adjacent to and south of the WWTP) and to irrigate 130 acres of nearby non-human consumptive crops.

4.4.2.4 Future KDWD Municipal Groundwater Use

In an agreement with the City, KDWD may serve water to those urban lands that have received KDWD water deliveries in the past (prior to urbanization) including the 4,775 acres currently served by the City. This responsibility would be linked to the average amount of water that KDWD has delivered historically to a certain area (Todd Engineers, September 2011).

Based on this agreement, urbanized lands historically served by the District but currently served by the City represent a potential un-met demand for KDWD. The urbanized lands within the Greenfield CWD and Lamont PUD also represent an increasing demand for either KDWD wholesale water delivery or the KDWD sale of water for groundwater recharge (Todd Engineers, September 2011).

4.5 Groundwater Issues of Concern

The evaluation of current groundwater conditions highlights several groundwater issues to address in the GWMP Update, as discussed in more detail below.

4.5.1 Water Levels and Groundwater Storage

Although water levels have varied over time in response to wet and dry hydrologic conditions, current water levels appear to be at or near water levels in the early 1990s drought. This occurs at a time when approximately 160,000 AF is in groundwater storage associated with out-of-district banking (Table 8). Without this stored water, water levels would be even lower.

Current water levels do not appear to be sufficiently low to create district-wide issues with groundwater pumping and wells. Well screens and likely associated pump settings appear to be sufficiently deep to

continue normal operation. However, if water levels continue to decline, well operation could be impacted. Further, the decline in water levels increases lift costs for pumpers.

4.5.2 Change in Groundwater Storage and Potential Overdraft Conditions

The evaluation of current groundwater conditions provide estimates for the primary components of inflows and outflows to the groundwater system as summarized on Table 11.

Table 11
Groundwater Budget Components

INFLOW	AFY
Irrigation Return Flows (Surface Water)	28,200
Irrigation Return Flows (Groundwater)	49,000
Irrigation Return Flows (Municipal Effluent)	3,600
SWP for Irrigation	12,750
Canal Loss	55,880
Banking Recharge (less loss)	101,327
Banking In lieu (reduces pumping below)	88,489
Banking Loss (credited to KDWD)	23,460
Urban Return Flows	1,000
Subtotal Inflows	**363,707**
OUTFLOW	
Irrigation Pumping	245,000
Municipal Pumping	13,616
Banking recovery	29,722
Subtotal Outflows	288,338
ESTIMATED CHANGE IN STORAGE	75,369

Note: Subsurface inflows and outflows are not included in the analysis.

This list is generally based on average conditions from 1998 through 2011, but also combines some estimates for future operation, such as the estimate of 12,750 AFY of SWP (estimated to be available at one-half of the District's full allotment of 25,500 AFY, on an average basis over time). Further, the groundwater budget analysis is incomplete. Two key components, subsurface inflow and outflow, are not included on Table 11. These amounts are complex and variable over space and time; accurate estimates cannot be made without a quantitative tool such as a groundwater model. Currently the District's groundwater model is not sufficient for this analysis.

In consideration of these limitations, the groundwater budget cannot be used to generate an accurate estimate of changes in groundwater storage or to determine if the entire Management Area should be characterized as in overdraft. Nonetheless, it highlights the importance of two key management activities – maximizing the District's use of Kern River water as described in the WAP and continuation of the banking program. As reflected in the groundwater budget components in Table 11, use of Kern River water produces significant irrigation return flow and recharge through canal loss. In addition, its use for irrigation directly offsets groundwater pumping. The groundwater banking program has generated the most significant components of inflow through direct recharge, in lieu pumping, and groundwater storage credit to KDWD. Without the banking program, the net change in groundwater storage in Table 11 would be negative.

To more accurately develop an ongoing groundwater budget for the Management Area, the District intends to update and/or modify existing numerical groundwater models to allow tracking of subsurface inflows and outflows, as well as provide more detailed assessments of groundwater storage over time. The District is currently participating in the development of a regional numerical model for the Kern Fan Monitoring Committee. A modified portion of that model may be employed for future groundwater assessments in the Management Area.

4.5.3 Protection of Primary Recharge Zones

The protection of groundwater recharge across the District is an important component for the continued use and sustainability of the groundwater resource. Recent legislation (AB 359) recognizes the importance of identifying primary groundwater recharge areas and requires that a GWMP include a map of the primary recharge zones in the Management Area.

For KDWD, the primary source of recharge includes banking in recharge basins, seepage through unlined canals, and return flows from surface water irrigation. Return flows from groundwater irrigation also represent a large recharge volume but do not result in a net increase in groundwater storage because more groundwater is removed through crop ET. As such, recharge from groundwater return flows is judged less important than for surface water return flows. In addition to the application areas of these recharge sources, the permeability of soils and subsurface sediments also influence recharge. Lower permeability zones restrict the rate and volume of recharge from return flows and canal loss. Although return flows provide some recharge in urban areas, the amounts are small compared to the irrigation return flows.

Using these observations, a map illustrating the primary areas of recharge in the GWMP Management Area is provided as Figure 20. As seen on the figure, the primary areas of recharge are highlighted in blue and represent the recharge basins and canals associated with significant amounts of groundwater recharge. More than 100,000 AF has been recharged in the recharge basins over time and average annual operational canal losses are estimated at more than 55,000 AFY. Even in areas where canals overlie lower permeability soils (light yellow), some losses (and associated recharge) occur. The light orange areas of the map identify where irrigation return flows are being recharged through the more permeable soils. The amount of recharge represented by this exact area is unknown, but an average of at least 30,000 AFY of irrigation return flows from surface water has been estimated on a District-wide basis. The darker orange areas on the map represent permeable soils that are associated with a 2011 land use other than irrigated agriculture (including temporary fallowing). Note that Figure 20 is based on 2011 cropping patterns and land use, both of which change from year to year. Although Figure 20 identifies the primary areas of recharge in the basin, specific locations and amounts of recharge will vary over time.

The light orange areas that are not covered by a Service Area (hatched areas) represent recharge from return flows that originate from groundwater. These areas are underlain by permeable soils conducive to high recharge rates, but in areas where surface water is generally unavailable for irrigation. Although recharge occurs in this area, it is the remainder of a net loss to groundwater. Urban areas (gray) and

areas with low permeability soils (light yellow) are associated with less recharge than other defined areas on Figure 20.

These primary recharge areas represent current conditions and are subject to change. Over time, the distribution and amount of surface water deliveries, urban development, and other land use issues may change. Nonetheless, this map is a useful planning tool for developing future groundwater management strategies and zones of wellhead protection.

4.5.4 Groundwater Quality

Although the review of groundwater quality did not indicate specific areas or constituents of concern, data are sparse and may not represent current conditions. The lack of groundwater quality data represents a data gap that can be addressed in the GWMP process over time, focusing initially on key areas of recharge and pumping.

4.5.5 Subsidence

Declining water levels are associated with increased potential of inelastic land subsidence. Subsidence in the Management Area was first documented in 1953 following an assessment related to the 1952 Arvin-Tehachapi earthquake. A more detailed evaluation was conducted by the USGS in 1975 that documented land subsidence due to groundwater withdrawal (Lofgren, 1975). That evaluation indicated subsidence of about 0.5 feet up to about 9 feet just outside of the southern and eastern KDWD boundary from 1957 through 1970; the largest impact within KDWD (about five feet) had occurred along the southern boundary coincident with the paleo-Kern bed. During that time period, water levels had fallen up to 100 feet, especially in northern KDWD as a result of overdraft conditions in the 1960s.

Since that time, groundwater levels have fluctuated with wet and dry cycles, but have not fallen significantly below 1975 levels. A recent water level assessment associated with the KDWD Environmental Impact Report (EIR) for the Kern River WAP compiled data back to the 1950s. Although only a few wells had complete records since that time, data indicate that current water levels are within about 10 feet of 1975 levels over most of the Management Area. One possible exception is in southwestern KDWD where declines in pumping wells were more significant over time.

A key mitigation measure to slow or arrest land subsidence is to allow water levels to recover to pre-subsidence conditions. Maintaining water levels at 1975 levels or higher would mitigate any further risk of subsidence.

To provide ongoing monitoring of potential land subsidence in the District, data from a nearby monitoring station should be incorporated into the KDWD monitoring program. The National Geodetic Survey manages a network of continuously operating reference stations (CORS) that provide satellite data for government, academic, and private use. One CORS, BKR1, is located within about 1,500 feet of the southern KDWD boundary on Old River Road. Data could be accessed and downloaded from this station on a periodic basis to evaluate changes in benchmark elevations over time.

5 Basin Management Objectives

Based on the evaluation of groundwater conditions beneath the Management Area, the following Basin Management Objectives (BMOs) have been identified for this GWMP Update.

5.1 Mitigate Overdraft

Since 1990, water levels beneath the District have recovered and declined in response to wet and dry years without an overall rising or falling trend in most areas. Exceptions to this observation are declining water levels in areas where surface water is limited or unavailable including localized areas in the southwest and southeast KDWD.

This BMO identifies the 2011 water levels as a maintenance level for future groundwater conditions in the basin. By this designation, the BMO is considered quantitative. Actions to implement should water levels fall will depend on the timing and duration of the declines. Localized areas may continue to decline in the short term, but ongoing management strategies are expected to result in overall water level recovery for the basin in the future.

5.2 Preserve Groundwater Quality

Groundwater quality supports current beneficial uses within the District including agriculture, municipal supply and other uses. Degradation of groundwater quality is recognized as a potential threat to both agriculture and drinking water. By incorporating metrics such as drinking water quality standards and irrigation suitability standards, this BMO is considered quantitative. KDWD is committed to preserving the high quality groundwater in the Management Area; a fundamental aspect is monitoring. Improvements to the District's groundwater quality monitoring program are incorporated into this GWMP Update and are documented in Appendix C.

5.3 Manage Groundwater Storage

To ensure a sustainable groundwater supply, KDWD will manage groundwater in storage and storage capacity. Management will seek to maximize the amount of groundwater in storage while maintaining areas in which to recharge excess surface water when available. Groundwater in storage and storage capacity will be evaluated from data collected in the water level monitoring program. The groundwater banking program already contains accounting requirements for managing banked water in storage; this is an example of how the BMO is quantitative. Also embedded in this BMO is the recognition that areas of primary groundwater recharge must be identified and preserved. Section 4 provides quantitative analyses of the primary recharge components.

An additional component of this BMO is the ongoing evaluation of surface water-groundwater interaction. As described in Section 4, operational loss along canals and return flows from irrigation of surface water are the primary seasonal sources of recharge to the groundwater system. In all areas of

the District, there is a sufficient vadose zone to receive the recharge. Even in areas of low permeability with relatively shallow water levels, the sediments drain sufficiently to allow for the seasonal infiltration. Monitoring wells around the recharge basins allow for the tracking of managed recharge in those areas.

To develop a more accurate estimate of groundwater storage changes and groundwater/surface water interaction, KDWD is considering an update and/or modification of a numerical groundwater model capable of analyzing and tracking groundwater conditions beneath the Management Area.

5.4 Avoid Further Inelastic Land Subsidence

As previously discussed, subsidence up to about nine feet has occurred near the southern KDWD boundary with lesser amounts occurring to the north within the District boundary. Subsidence of that magnitude occurred in response to water level declines of up to 100 feet beneath KDWD from the 1950s to the 1970s. Since that time, water levels have not fallen significantly below 1970s levels, indicating that any additional subsidence would have been minimal. If water level maintenance is achieved as stated above, further subsidence would be prevented. For this GWMP Update, 2011 water levels are designated as target levels for avoidance of inelastic land subsidence. Further, monitoring of land subsidence will be incorporated into the GWMP monitoring program through the download and review of geodetic data from the nearby CORS monitoring station. Data from the CORS station along with documentation of water level changes make this BMO quantitative.

5.5 Update District Monitoring Programs

The ongoing groundwater level and quality monitoring program will be reviewed and modified as necessary to document groundwater conditions on an annual basis and demonstrate the ability to achieve BMOs. Although the evaluation of groundwater quality did not indicate significant areas or constituents of concern, existing data are sparse and limited to certain areas within the District. Surface water quality monitoring is also key to ensure that recharge along canals and in recharge basins do not adversely impact groundwater quality. To date, surface water data indicate lower salinity and mineralization than local groundwater and has likely improved groundwater quality in areas of primary recharge (Figure 20).

One management strategy for evaluation is a more systematic District-wide groundwater quality monitoring plan to be implemented and updated over time. In addition, the monitoring program will be updated to allow ongoing assessments of groundwater storage and inelastic land subsidence. The KDWD monitoring program and protocols that incorporate plans for improved monitoring are provided in Appendix C.

5.6 Coordinate Groundwater Management Activities with Other Agencies

KDWD has already developed mutually-beneficial management programs with several neighboring water districts and local agencies. In addition, KDWD continues to cooperate with local, state, and federal regulatory agencies. Examples of these cooperative programs are described in this GWMP Update and include the following:

- CASGEM Monitoring Cooperative Group with BVWSD and RRBWSD
- Resolution with AEWSD to cooperatively pursue mutually beneficial groundwater management activities
- Joint project with AEWSD to construct infrastructure to allow water to be conveyed across district boundaries more efficiently
- Groundwater banking agreements with Metropolitan Water District of Southern California and San Bernardino Valley Municipal Water District (Valley)
- Agreements with the City of Bakersfield and Greenfield County Water District (and others) to enhance groundwater recharge for the benefit of municipal pumpers
- Provision of SWP water via KCWA through exchange agreements with BVWSD
- Participation in regional out-of-district banking projects including the Pioneer Project operated by KCWA
- Cooperating with KDWD customers and the Central Valley Water Board to develop steps for compliance with recent regulations on the management of agricultural water, including Best Management Practices (BMPs).

In support of this BMO, KDWD documents these efforts as part of the GWMP Update and intends to pursue additional opportunities for coordinated groundwater management.

6 DWR-Suggested Components and Groundwater Management Strategies

Numerous management strategies have been identified and considered for inclusion in this GWMP update. These strategies have been developed using the DWR checklist of management components from AB3030 as a framework (Water Code Section 10753.7). Application of each DWR component to the KDWD Management Area is discussed below. Strategies for groundwater basin management of each component are summarized in Table 12. When applicable, ongoing KDWD management activities are also included. There is significant overlap for many components and many strategies are applicable for more than one component. To minimize duplication in Table 12, applicable strategies may be listed with only the more relevant components.

6.1 Saline Water Control

For KDWD, this component relates to management of sources that contribute to the overall salinity or TDS of groundwater. A review of groundwater quality has identified local areas of mineralized groundwater in southwest and southeast KDWD. These areas correspond to low-permeability flood-basin sediments and are likely indicative of natural processes rather than human activities. Nonetheless, groundwater quality data are sparse and additional evaluation would be helpful to assess current and future conditions.

Key management strategies involve a more detailed identification of TDS values across the area and the continued use of lower TDS Kern River water for delivery and recharge. Specific action items for consideration are provided in Table 12.

6.2 Identification and Management of Wellhead Protection Areas and Recharge Areas

The municipal water purveyors within and adjacent to KDWD are responsible for delineating and managing wellhead protection areas around the water supply wells. KDWD can assist in this process through identification of municipal wellhead areas within KDWD and survey of activities in those areas. General areas of municipal wells have been identified in this GWMP Update through a discussion of water purveyors in Sections 2.2 and 4.4.2 and on Figure 3.

KDWD is familiar with the Kern County Well Ordinance (Chapter 14) that provides for the design, construction, repair, and reconstruction of agricultural and domestic wells (and other wells) to protect groundwater quality. Through this GWMP, KDWD encourages compliance with both County and State well construction standards for all wells in the District.

In addition, the primary areas of recharge have been discussed and identified on a map to assist the District with groundwater management and provide for compliance under AB 359. This map will be updated as conditions for groundwater recharge change across the District. These and other management strategies are listed in Table 12.

Table 12
DWR GWMP Components and Management Strategies

Management Component	Applicable BMO(s)	Potential KDWD Management Strategies
Saline Water Control	**Preserve Groundwater Quality**	• Identify areas of elevated TDS or highly mineralized water • Expand monitoring of groundwater quality • Maximize Kern River water for delivery and recharge (WAP) • Provide education on fertilizer management
Identification and Management of Wellhead Protection Areas and Recharge Areas	**Preserve Groundwater Quality; Manage Groundwater Storage; Coordinate with Other Agencies**	• Identify and update primary recharge areas (provided as Figure 20) • Identify areas of water supply wells • Encourage compliance with County/State well construction standards and surface seals • Provide education on managing agricultural runoff away from wells
Regulation of Migration of Contaminated Groundwater	**Preserve Groundwater Quality; Coordinate with Other Agencies**	• Identify areas and constituents of concern • Improve groundwater quality monitoring program • Coordinate with Regional Water Boards and other local agencies on water quality issues
Administration of Well Abandonment and Destruction Program	**Preserve Groundwater Quality; Coordinate with Other Agencies**	• Encourage compliance with Kern County Department of Health Services Well Ordinance • Obtain and review DWR Well Driller's Reports for well locations, construction, and destruction
Mitigate Overdraft	**Mitigate Overdraft; Manage Groundwater Storage; Avoid Further Inelastic Land Subsidence**	• Optimize local river water and imported water sources for use and recharge (WAP) • Monitor water levels and identify areas of declines • Monitor groundwater storage capacity • Develop and maintain an in-district groundwater budget using an updated groundwater model
Conduct Groundwater Replenishment and Facilitate Conjunctive Use Operations	**Mitigate Overdraft; Manage Groundwater Storage; Coordinate with Other Agencies; Avoid Further Inelastic Land Subsidence**	• Continue banking programs with outside partners • Estimate Kern River water recharge from irrigation • Continue to recharge excess surface water • Preserve unlined canals • Continue to document canal loss (including intentional recharge in canals)
Groundwater Monitoring of Levels and Storage	**Update District Monitoring Programs**	• Monitor water levels (for in-district evaluations and CASGEM) • Update estimates of groundwater in storage and storage capacity • Develop and adopt monitoring protocols (Appendix C of this document)
Management of Groundwater Extractions	**Mitigate Overdraft; Manage Groundwater Storage; Avoid Further Inelastic Land Subsidence**	• Maximize Kern River and imported water deliveries (WAP) • Develop more detailed estimates of groundwater extractions on a spatial and temporal basis • Manage District wells to minimize pumping impacts to others
Identification of Well Construction Polices	**Preserve Groundwater Quality; Manage Groundwater Storage; Coordinate with Other Agencies**	• Adopt well standards in the Kern County Well Ordinance • Identify in-district well issues, if any • Adopt DWR well construction standards
Construction and Operation of Groundwater Management Facilities	**Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality; Coordinate with other Agencies**	• Operate recharge basins and District wells for efficient recharge and recovery • Construct additional proposed recharge basins associated with the Banking Program • Manage Banking Program recharge to balance in lieu use and rechage in spreading basins • Optimize in-district recharge and deliveries • Preserve unlined canals • Manage surface water storage capacity in Isabella Reservoir • Use in-county banking facilities in accordance with the WAP
Monitoring and Management of Inelastic Land Surface Subsidence	**Avoid Further Inelastic Land Subsidence; Update District Monitoring Programs**	• Maintain water levels above historical low levels • Document subsidence to date • Periodically download and monitor the CORS geodetic data
Development of Relationships with Federal, State, and Local Regulatory Agencies	**Coordinate with Other Agencies; Manage Groundwater Storage; Preserve Groundwater Quality; Update District Monitoring Programs;**	• Continue to participate in the cooperative monitoring group for CASGEM compliance • Continue to work with the Central Valley Water Board on agricultural water management • Continue coordination with KCWA and BVWSD for imported water deliveries and exchange
Review Land Use Plans and Coordination with Land Use Planning Agencies	**Coordinate with Other Agencies; Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality;**	• Coordinate activities with Kern County Planning Commission • Address mutual Kern County goals such as the preservation of agricultural lands • Coordinate with Bakersfield on urban growth and build-out
Plan to Involve Local Agencies	**Coordinate with Other Agencies; Mitigate Overdraft; Manage Groundwater Storage; Preserve Groundwater Quality**	• Conduct public hearings on the GWMP process • Continue coordination with KCWA and BVWSD for imported water deliveries and exchange • Provide urban water to the City of Bakersfield per agreement • Continue coordinated groundwater management with AEWSD as per the Resolution 01-25 • Continue participation in the IRWMP process • Notify local agencies on GWMP activities

6.3 Regulation of Migration of Contaminated Groundwater

No areas of contaminated groundwater have been identified from the groundwater quality data reviewed for this GWMP Update. Additional monitoring is recommended and will provide more information on groundwater quality potential issues or areas of concern. Key management strategies include the improvement of the groundwater quality monitoring program and analysis of monitoring data. Many of the strategies listed under the wellhead protection component above are applicable to this component as well. Management strategies are listed in Table 12.

6.4 Administration of Well Abandonment and Destruction Program

The Kern County Ordinance Code Chapter 14 provides requirements for abandonment and destruction of agricultural, domestic, and other water supply wells. The District is aware of the ordinance and encourages compliance from local drillers and well owners for the protection of groundwater quality. State construction standards are also incorporated into the strategies. In addition, drillers' logs are available from KCWA on a confidential basis to review the location and construction of wells in the Management Area. Available drillers' logs through 2011 have been compiled for this GWMP Update as discussed in Section 4. These management strategies are summarized in Table 12.

6.5 Mitigate Overdraft

Most water level hydrographs do not indicate a long-term decline in water levels. In addition, an examination of inflows and outflows over average hydrologic conditions suggests a positive change in groundwater storage, primarily due to current banking operations. Using these two observations, the occurrence or level of overdraft, if present, is difficult to define for the Management Area. Further, components of subsurface inflow and outflow have not been evaluated; these are complex and transient and are best estimated with a calibrated groundwater model. KDWD plans to consider the incorporation of groundwater modeling into a more detailed assessment of overdraft for periodic updates to the GWMP.

Additional strategies to mitigate overdraft conditions are also incorporated into this GWMP Update. Many of these involve ongoing programs such as the in-district banking project and the Kern River WAP. These and other strategies are listed in Table 12.

6.6 Conduct Groundwater Replenishment and Facilitate Conjunctive Use Operations

This management component relates directly to the previous component and is addressed through similar management strategies. The initiation of the banking program with outside partners allowed the District to develop key infrastructure of conjunctive use facilities to optimize all water sources. With more than 800 acres of recharge basins and 150 miles of canals, KDWD is well-suited to continue and expand conjunctive use for replenishing and sustaining groundwater resources. These facilities offer a recharge capacity of 121,000 AFY and a recovery capacity of 94,000 AFY. In addition, KDWD participates in the Pioneer Project, an out-of-district banking project where it has approximately 24,000 AF in

groundwater storage. Finally, KDWD uses available surface water storage in Isabella Reservoir, which can provide, on average, approximately 44,000 AF of additional capacity to the District's infrastructure. A portfolio of management activities involving conjunctive use operations is listed in Table 12.

6.7 Groundwater Monitoring of Levels and Storage

KDWD has monitored water levels for decades and has coordinated monitoring with other agencies including KCWA and DWR. Currently KDWD is participating in a cooperative group of monitoring entities to fulfill requirements of the California State Groundwater Elevation Monitoring (CASGEM) program. In addition, KDWD monitors additional wells to support ongoing evaluations of local groundwater conditions. Details of the District's current monitoring program, including monitoring protocols, are provided in Appendix C. A summary of management strategies is provided in Table 12.

6.8 Management of Groundwater Extractions

Estimates of groundwater extractions for planning purposes can guide groundwater management activities. Although these amounts are not available on a well-by-well basis, KDWD estimates from cropping patterns and in-district knowledge are judged sufficient in guiding most management activities. Pumping from District wells is monitored and managed through the groundwater banking program.

More detailed pumping estimates could be developed by comparing surface water deliveries to estimated irrigation demand on a spatial and temporal basis. Further, this knowledge could assist in developing more detailed plans of in-lieu recharge and the timing needs of surface water and groundwater. Finally, these estimates could support better management of water levels to minimize well interference among growers. Several management strategies focused on groundwater extractions are provided in Table 12.

6.9 Identification of Well Construction Policies

For this GWMP Update, KDWD adopts the well construction policies developed by the Kern County Well Ordinance and the DWR well construction standards. These local and state standards provide guidance for the proper installation and abandonment activities to protect groundwater quality. In addition, KDWD invites the PAC to provide information on any issues that well owners have identified that may affect groundwater management activities. These activities are listed in Table 12.

6.10 Construction and Operation of Groundwater Management Facilities

As envisioned by DWR, this component could involve numerous types of facilities operated for contamination cleanup, recharge, storage, conservation, water recycling, and/or groundwater extraction projects. Groundwater management facilities in KDWD have been discussed previously in Section 4 and summarized in Section 6.6. These facilities consist of recharge basins, recovery wells, and conveyance canals that facilitate the optimal use of water sources for the benefit of basin users and the groundwater resource. Applicable strategies for the groundwater management facilities are summarized in Table 12.

6.11 Monitoring and Management of Inelastic Land Surface Subsidence

A detailed evaluation of inelastic subsidence in the Management Area was published in 1975. Since that time, water levels have remained close to or above 1975 levels and further significant subsidence is not anticipated. However, a nearby CORS monitoring site with geodetic data exists within about 1,500 feet of the southern boundary of the Management Area where the greatest amount of subsidence in KDWD has been recorded. KDWD will consider incorporating data from this monitoring station as part of its ongoing land subsidence monitoring. These strategies are summarized in Table 12.

6.12 Development of Relationships with Federal, State, and Local Regulatory Agencies

KDWD has developed numerous cooperative relationships with regulatory agencies. The District is working with the Central Valley Water Board on behalf of local growers to meet requirements of the agricultural water management program. In addition, KDWD, BVWSD, and RRBWSD have formed a cooperative group to serve as the monitoring entity for compliance with the state's CASGEM program. As a participant in the SWP, KDWD also works with KCWA and BVWSD on requirements for allocation, exchange, and use of SWP water.

6.13 Review Land Use Plans and Coordination with Land Use Planning Agencies

As part of this GWMP Update, KDWD has reviewed planning documents by local land use agencies as described in Section 2. Numerous goals and objectives from those plans are relevant to and support KDWD groundwater management activities. Some of those mutual goals involve the preservation of agricultural lands and the provision of supplemental municipal water supply for the City of Bakersfield to support build-out (as per existing agreement). These land use coordination activities are summarized in Table 12.

6.14 Plan to Involve Local Agencies

KDWD already participates with other water districts and local agencies to manage the shared groundwater resource. Some of those activities include participation in the IRWMP planning process, cooperative CASGEM monitoring with BVWSD and RRBWSD, and a resolution with AEWSD to conduct mutually beneficial groundwater management activities. The resolution passed by the KDWD Board of Directors of the intent to develop a GWMP was broadcast to the public. Local agencies have also been made aware of the District's ongoing GWMP efforts. Specific activities to coordinate with local agencies are listed in Table 12.

7 GWMP Implementation and Schedule

KDWD has been conducting groundwater management activities since its inception and has been documenting those activities in GWMPs since 1996. As an update to these plans, this GWMP Update includes numerous programs that are already in place, more recent programs that have been implemented in the past few years, and additional activities planned for implementation in the future.

7.1 GWMP Strategies and Implementation Schedule

Table 13 lists the key ongoing programs and additional selected strategies that are incorporated into this GWMP Update. Most of the additional strategies involve more coordination with local agencies and improvements to the District's monitoring program. Also included on Table 13 is the status and implementation schedule for each program or strategy.

7.2 Monitoring and Reporting

Current monitoring programs, including recommended improvements, are documented in Appendix C. Monitoring protocols for the various media are also included. Results from GWMP monitoring will be incorporated into monitoring reports provided annually to the PAC as described below.

7.3 Annual Reporting and Five-Year GWMP Updates

KDWD intends to prepare a report on the progress of its GWMP on an annual basis. Annual reports will be provided to the PAC and will document ongoing programs and important changes that occurred in the prior year. Monitoring data can be attached as an appendix for PAC review. It is envisioned that future annual reports will consist of a concise document for the PAC's internal use and will not contain the detail provided herein. This GWMP Update has been expanded to include legislative requirements that had not been included in previous plans. In addition, an updated hydrogeologic assessment of the groundwater basin was conducted to provide a basis for ongoing strategies and monitoring protocols.

In addition to the annual reports, the GWMP and management programs will be re-evaluated in a more detailed assessment every five years to provide the level of analysis needed to modify groundwater management strategies.

Table 13
Selected Groundwater Management Strategies and Implementation Schedule

Selected GWMP Strategies	Description	Status and Schedule
Kern River Water Allocation Plan (WAP)	Recently-developed program to optimize the use of Kern River water throughout the District. Program will enhance groundwater recharge and reduce groundwater pumping. Surface water return flows, canal loss, and intentional recharge also contribute to improved groundwater quality. Project-level EIR was certified September 2012. No infrastructure modifications or other construction is needed.	Ongoing
In-District Banking Program with Outside Partners	Agreements with Metropolitan and Valley water districts to store water up to 50,000 AFY in the basin for future recovery. Program increases groundwater in storage, includes a credit of 11 percent to KDWD, and funds conjunctive use factilities including recharge basins and recovery wells.	Ongoing; improvements including additional recharge basins and recovery wells are scheduled for 2014.
In-District Conjunctive Use Program	Elements of this program are incorporated into the Kern River WAP, but the strategy is listed separately to highlight the ongoing use of District-owned recharge basins and recovery wells for groundwater management activities on an as-needed basis. KDWD has the ability to select recharge areas, use of recovered water, and timing of activities to best manage water levels and groundwater storage in the basin.	Ongoing
Out-of-District Banking Program	Agreement with Pioneer Project to store excess water in the banking project for groundwater replenishment and/or future recovery. Supports groundwater replenishment in an area upgradient of the District that contributes some subsurface inflow to the Management Area. Currently, KDWD has 24,000 AF in storage for subsequent recovery.	Ongoing
SWP Water Allocation Plan	SWP water is allocated on a higher priority basis to non-utility areas that have no access to Kern River water. Secondary priority SWP water is delivered to areas with only limited Kern River water rights. This SWP water reduces groundwater pumping. If allocation is not needed for irrigation, KDWD uses it to recharge groundwater in areas of high pumping to manage storage and levels.	Ongoing
Coordinate Well Construction Policies	KDWD will compile and maintain well construction standards in the District's office including the Kern County Well Ordinance and work with landowners to ensure compliance.	To be implemented in 2013 with the adoption of this GWMP Update.
Coordinate with Land Use Policies	KDWD will provide the GWMP Update to Kern County land use planners to ensure consistent policies are implemented.	To be implemented in 2013 with the adoption of this GWMP Update.
Water Level Monitoring Program	KDWD will continue to cooperate with BVWSD and RRBWSD to monitor and report water levels through the CASGEM program coordinated by DWR. In addition, KDWD may expand or modify its in-district water level monitoring to better manage water levels and respond to potential future groundwater management issues.	Ongoing
Monitor Groundwater Storage	KDWD compiles water level data to support estimates for groundwater in storage. KDWD intends to update and/or modify an existing groundwater model as a tool for periodic assessments of groundwater storage changes and tracking groundwater budgets over time.	Implementation by 2014.
Groundwater Quality Monitoring Program Improvements	KDWD will continue to monitor groundwater quality and make improvements to its monitoring program over time. In particular, representative wells will be added to allow for better spatial distribution of data. A selected group of constituents will be identified for monitoring on more-frequent and less-frequent schedules. A more complete water quality monitoring event will be conducted every five years.	Ongoing; improvements to be incorporated over the next two years and coordinated with the Agricultural Water Management Program
Land Subsidence Monitoring Program	KDWD will continue to track water levels across the Management Area with a focus on areas in the southern District that may be more suceptible to land subsidence. KDWD will periodically obtain and review data from nearby CORS geodetic station.	To be implemented in 2013 with the adoption of this GWMP Update.

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FIGURES

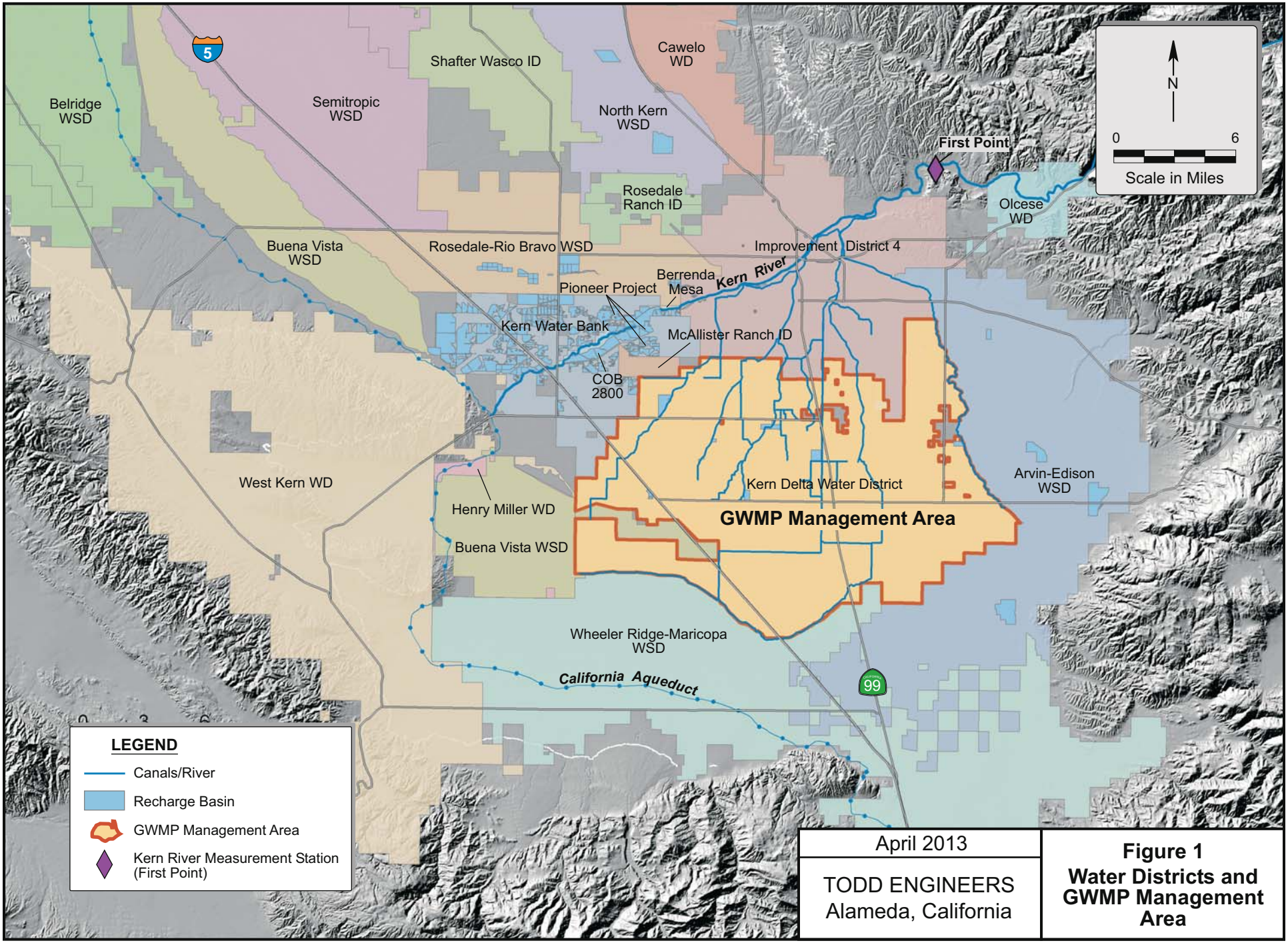

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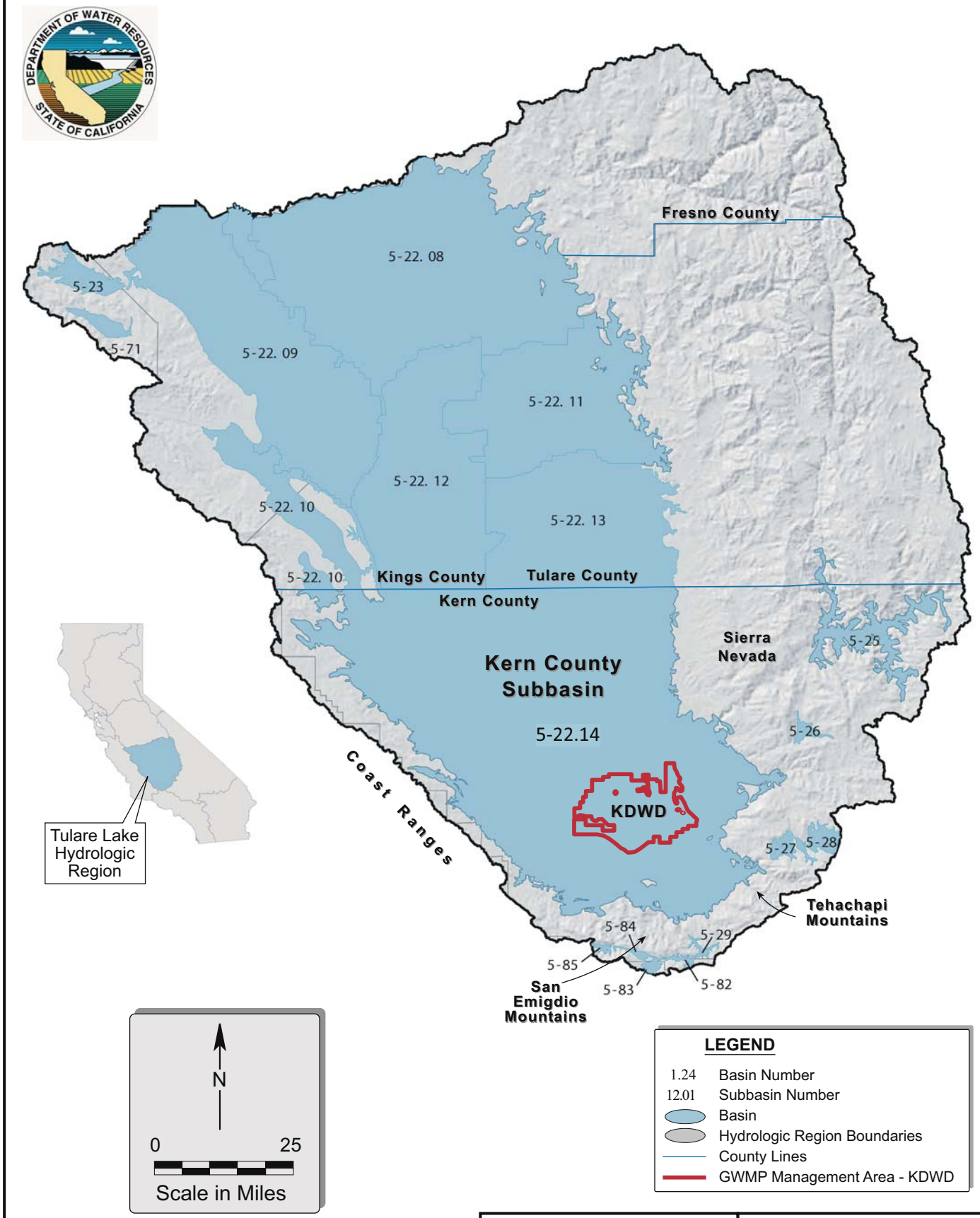
Figure 1
Water Districts and GWMP Management Area



Source: DWR, 2006.

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Figure 2
Groundwater Subbasins and Management Area

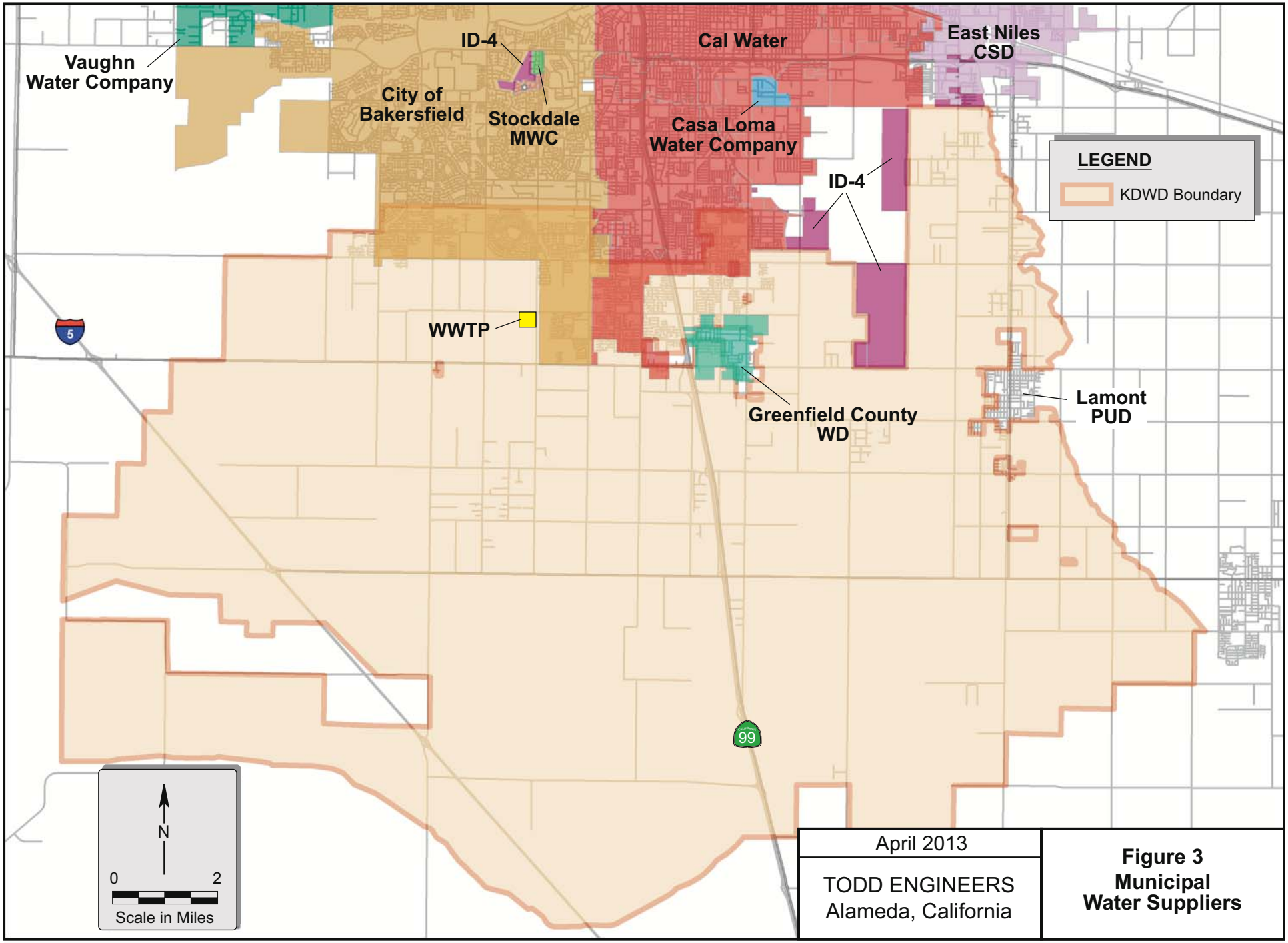
Vaughn Water Company
ID-4
City of Bakersfield
Stockdale MWC
Cal Water
East Niles CSD
Casa Loma Water Company
ID-4
LEGEND
KDWD Boundary
WWTP
5
Greenfield County WD
Lamont PUD
99
N
0
2
Scale in Miles
April 2013
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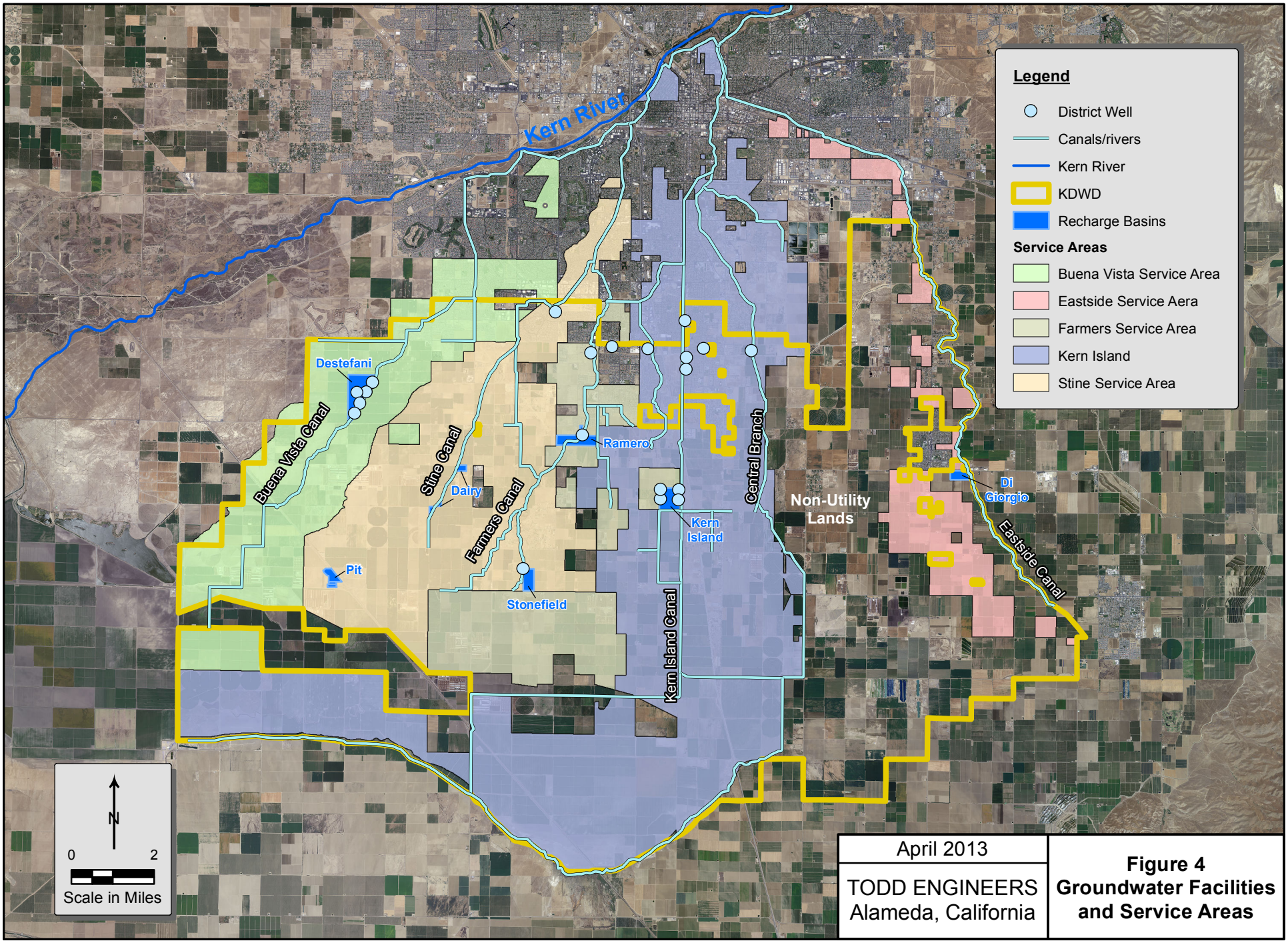
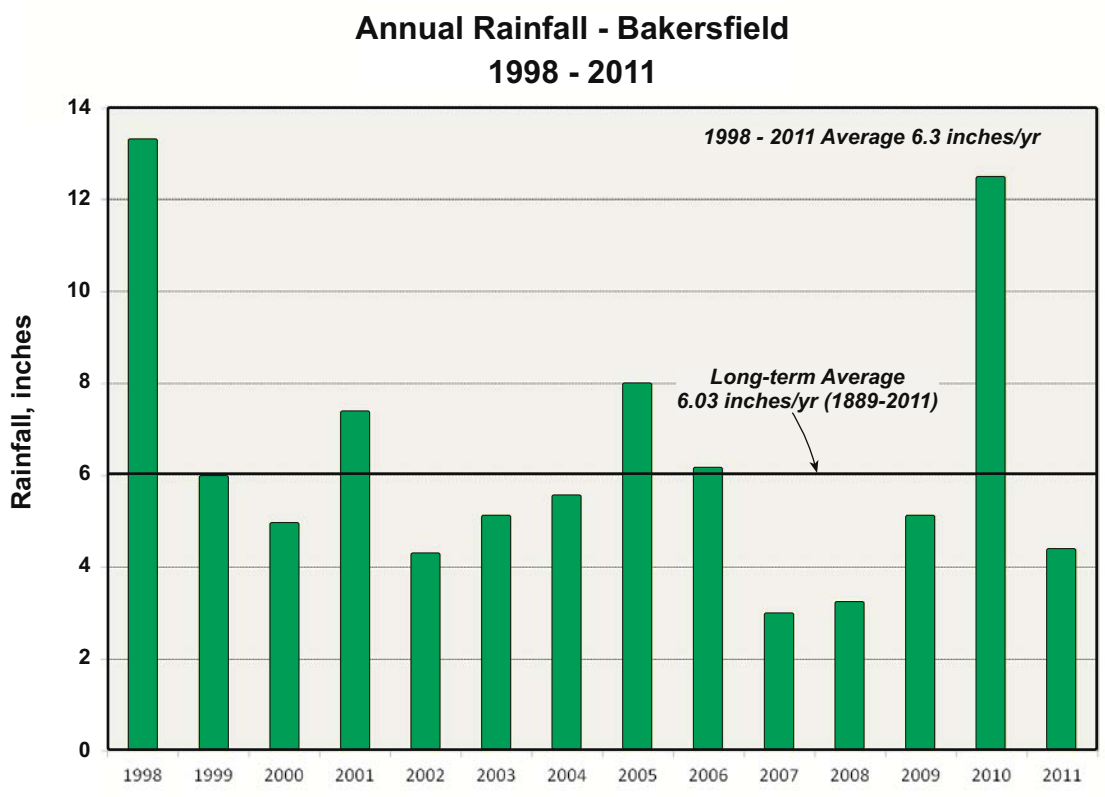
Figure 3
Municipal
Water Suppliers


Legend
District Well
Canals/rivers
Kern River
KDWD
Recharge Basins
Service Areas
Buena Vista Service Area
Eastside Service Aera
Farmers Service Area
Kern Island
Stine Service Area
Kern River
Destefani
Buena Vista Canal
Stine Canal
Dairy
Farmers Canal
Ramero
Central Branch
Non-Utility Lands
Kern Island
Di Giorgio
Eastside Canal
Pit
Stonefield
Kern Island Canal
N
0
2
Scale in Miles
April 2013
TODD ENGINEERS
Alameda, California
Figure 4
Groundwater Facilities and Service Areas



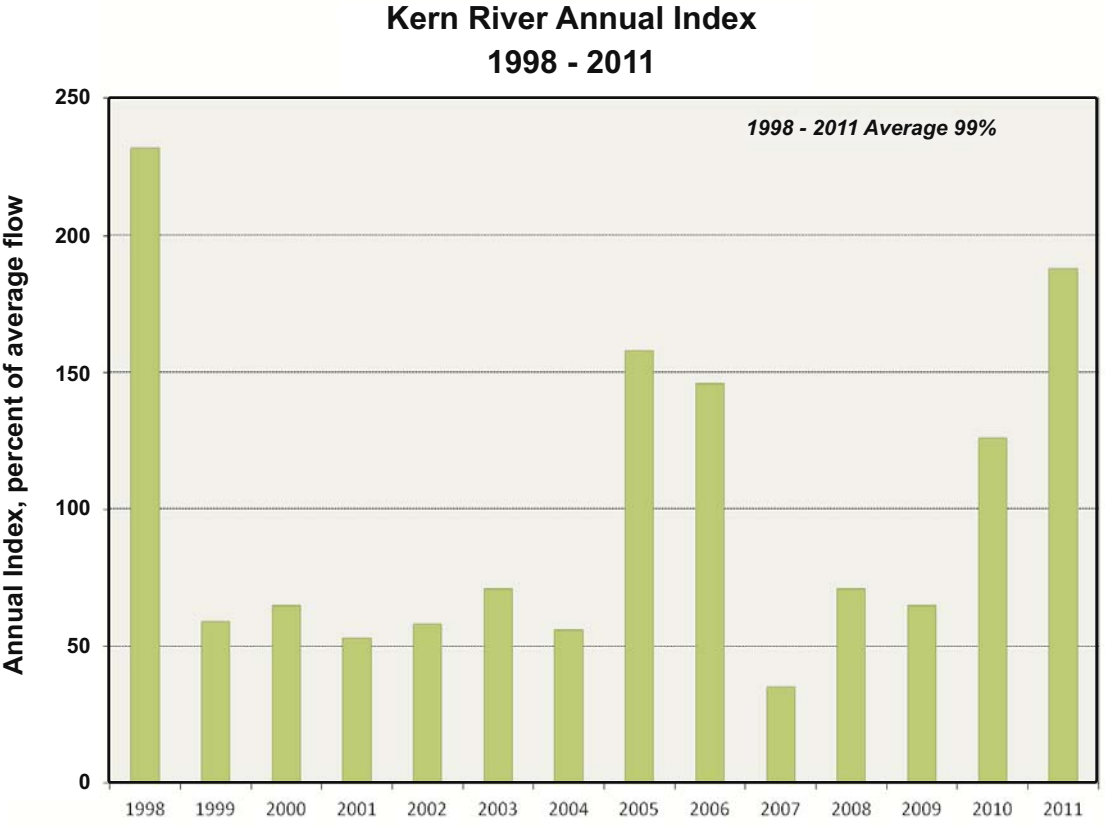


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Figure 5
Rainfall and Kern River Index

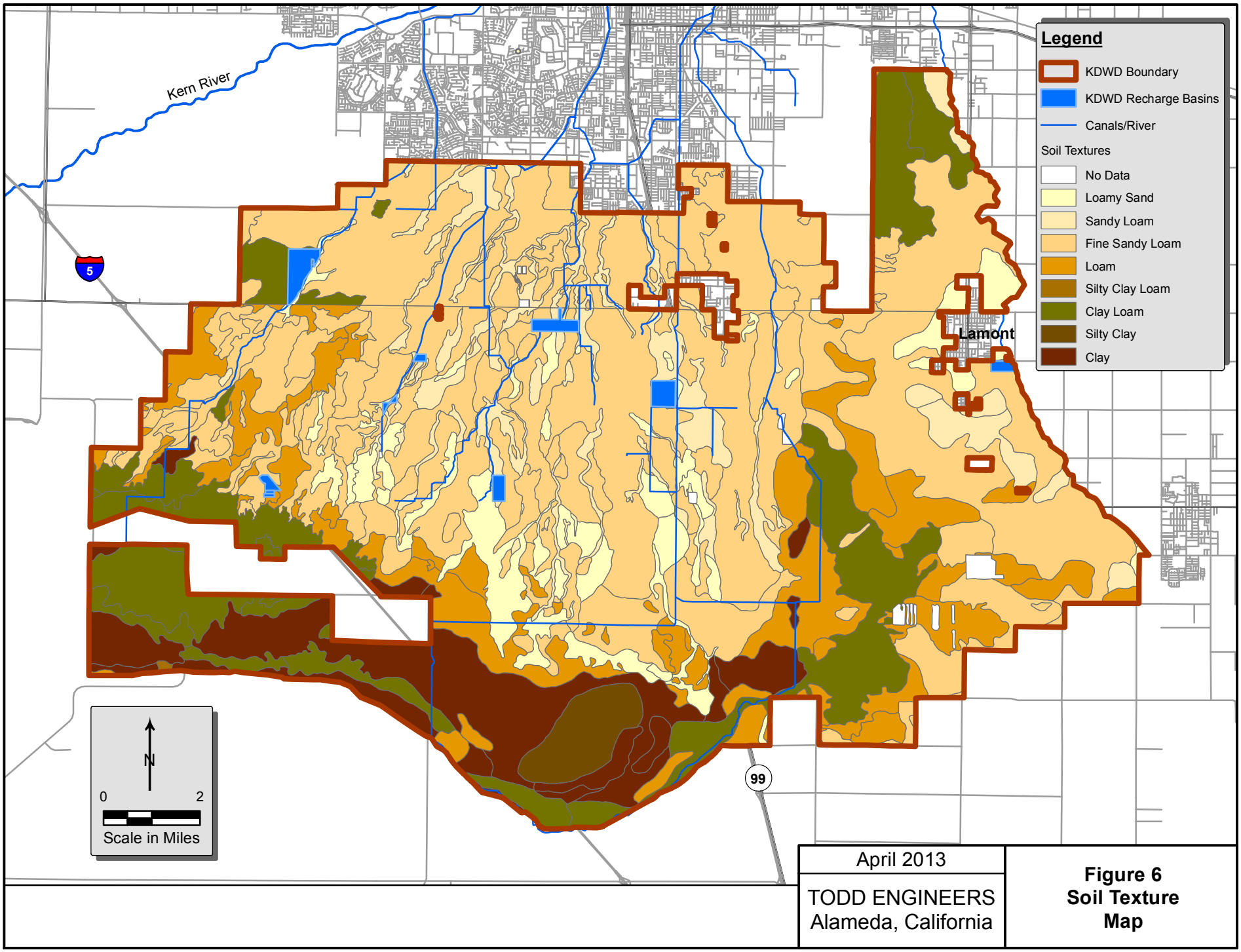

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Figure 6
Soil Texture Map

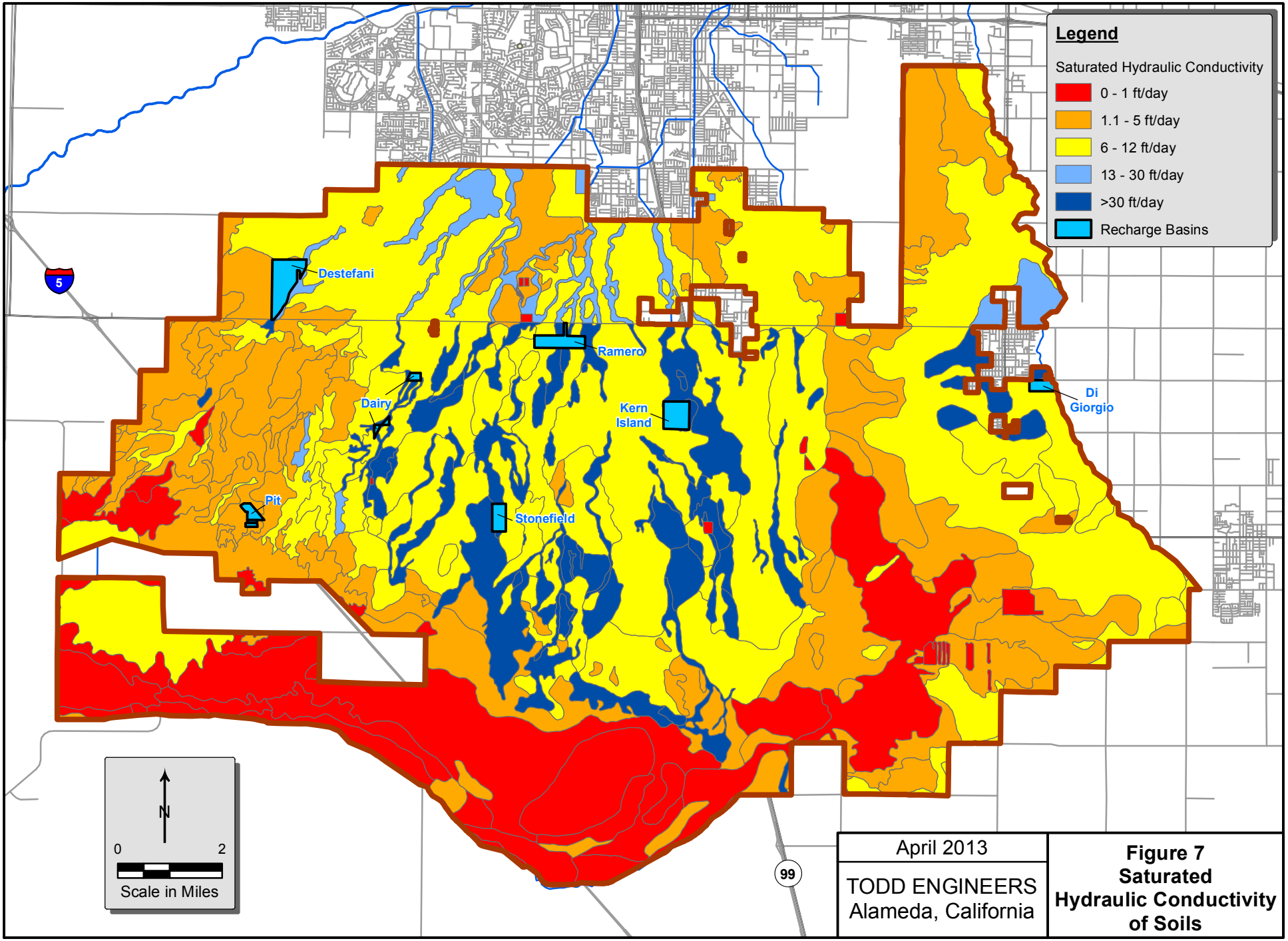
Legend
Saturated Hydraulic Conductivity
0 - 1 ft/day
1.1 - 5 ft/day
6 - 12 ft/day
13 - 30 ft/day
>30 ft/day
Recharge Basins
Destefani
Ramero
Dairy
Kern Island
Di Giorgio
Pit
Stonefield
5
99
N
0
2
Scale in Miles
April 2013
TODD ENGINEERS
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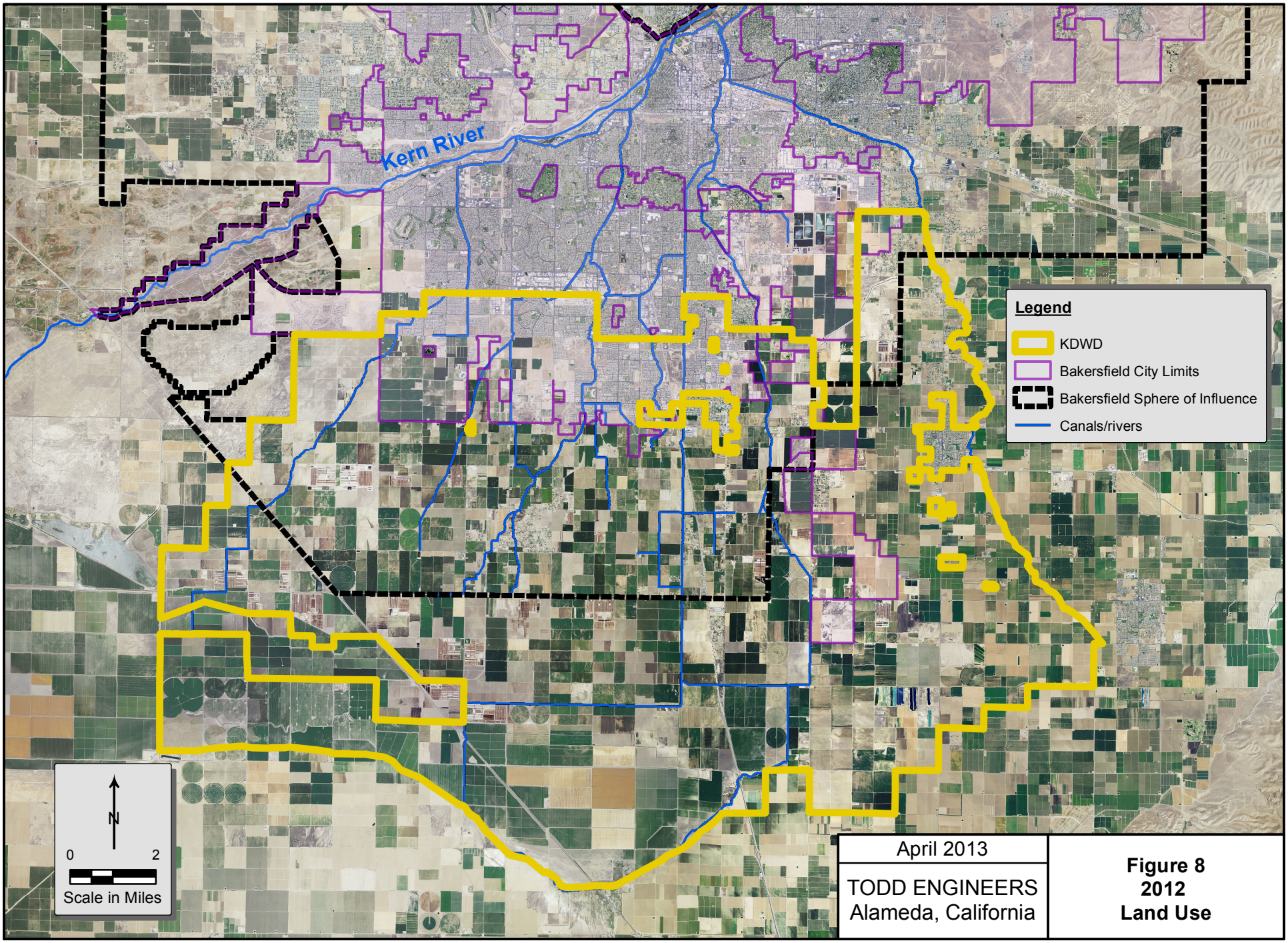
Figure 7
Saturated Hydraulic Conductivity of Soils


Kern River
Legend
KDWD
Bakersfield City Limits
Bakersfield Sphere of Influence
Canals/rivers
N
0
2
Scale in Miles
April 2013
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Alameda, California
Figure 8
2012
Land Use

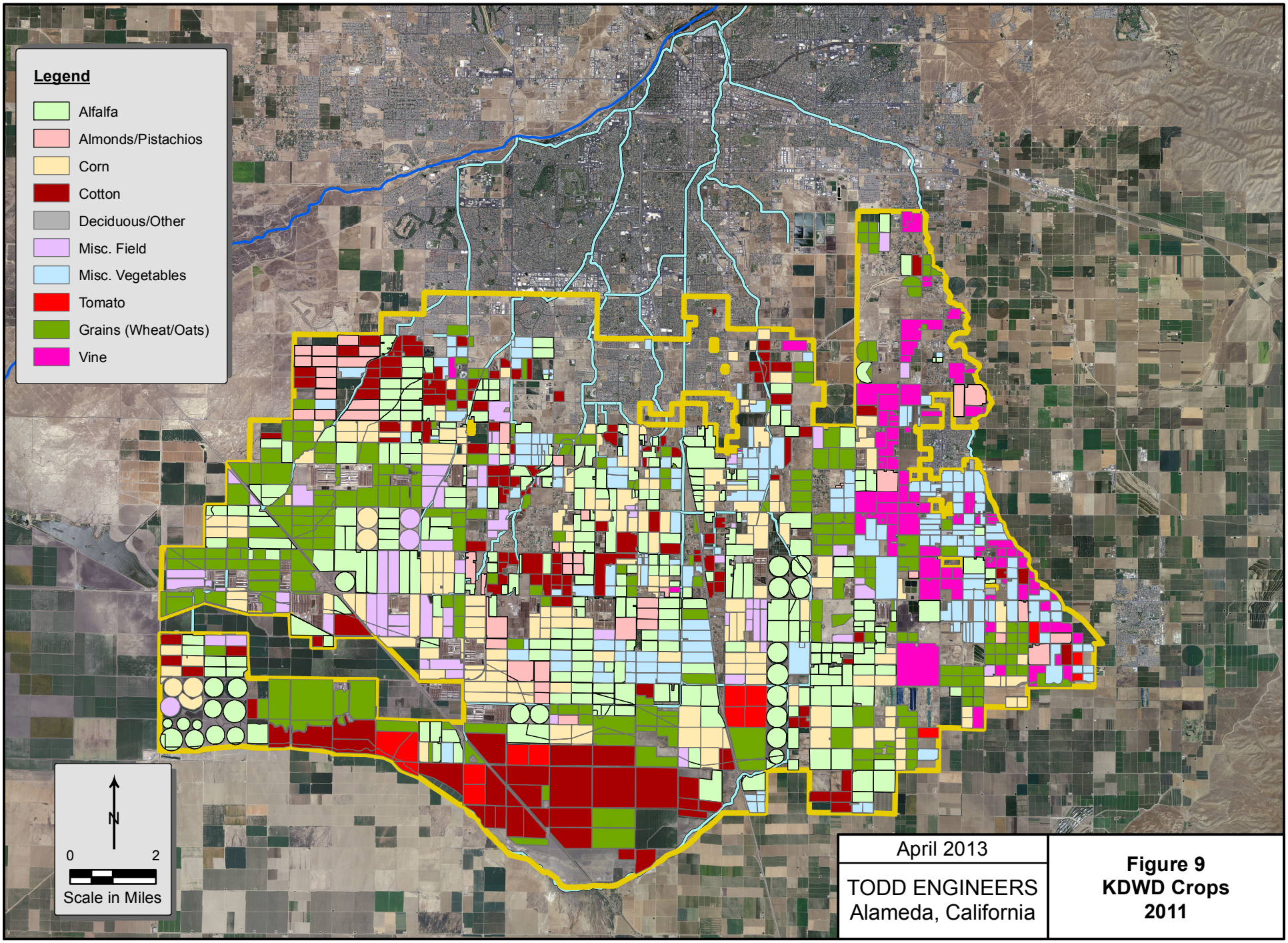
Legend
Alfalfa
Almonds/Pistachios
Corn
Cotton
Deciduous/Other
Misc. Field
Misc. Vegetables
Tomato
Grains (Wheat/Oats)
Vine
N
0
2
Scale in Miles
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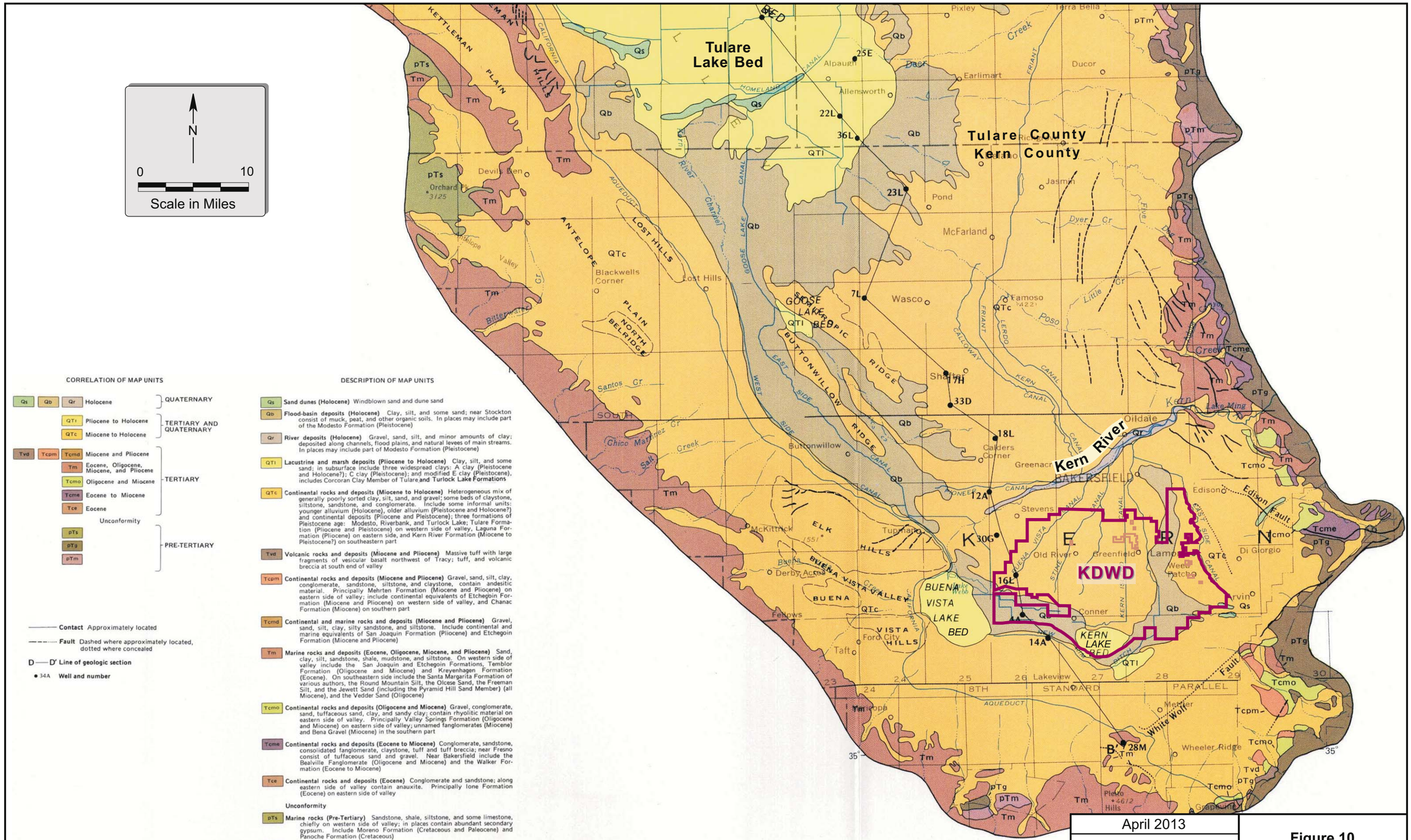
Figure 9
KDWD Crops
2011



CORRELATION OF MAP UNITS

Qs Qb Qr	Holocene	QUATERNARY
QTl	Pliocene to Holocene	TERTIARY AND QUATERNARY
QTc	Miocene to Holocene	
Tvd Tcpm Tcmd	Miocene and Pliocene	TERTIARY
Tm	Eocene, Oligocene, Miocene, and Pliocene	
Tcmo	Oligocene and Miocene	
Tcme	Eocene to Miocene	
Tce	Eocene	
	Unconformity	
pTs		PRE-TERTIARY
pTg		
pTm		

Contact Approximately located

Fault Dashed where approximately located, dotted where concealed

D—D' Line of geologic section

• 34A Well and number

DESCRIPTION OF MAP UNITS

Qs Sand dunes (Holocene) Windblown sand and dune sand

Qb Flood-basin deposits (Holocene) Clay, silt, and some sand; near Stockton consist of muck, peat, and other organic soils. In places may include part of the Modesto Formation (Pleistocene)

Qr River deposits (Holocene) Gravel, sand, silt, and minor amounts of clay; deposited along channels, flood plains, and natural levees of main streams. In places may include part of Modesto Formation (Pleistocene)

QTl Lacustrine and marsh deposits (Pliocene to Holocene) Clay, silt, and some sand; in subsurface include three widespread clays: A clay (Pleistocene and Holocene?); C clay (Pleistocene); and modified E clay (Pleistocene), includes Corcoran Clay Member of Tulare and Turlock Lake Formations

QTc Continental rocks and deposits (Miocene to Holocene) Heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel; some beds of claystone, siltstone, sandstone, and conglomerate. Include some informal units: younger alluvium (Holocene), older alluvium (Pleistocene and Holocene?) and continental deposits (Pliocene and Pleistocene); three formations of Pleistocene age: Modesto, Riverbank, and Turlock Lake; Tulare Formation (Pliocene and Pleistocene) on western side of valley, Laguna Formation (Pliocene) on eastern side, and Kern River Formation (Miocene to Pleistocene?) on southeastern part

Tvd Volcanic rocks and deposits (Miocene and Pliocene) Massive tuff with large fragments of vesicular basalt northwest of Tracy; tuff, and volcanic breccia at south end of valley

Tcpm Continental rocks and deposits (Miocene and Pliocene) Gravel, sand, silt, clay, conglomerate, sandstone, siltstone, and claystone, contain andesitic material. Principally Mehrten Formation (Miocene and Pliocene) on eastern side of valley; include continental equivalents of Etchegoin Formation (Miocene and Pliocene) on western side of valley, and Chanac Formation (Miocene) on southern part

Tcmd Continental and marine rocks and deposits (Miocene and Pliocene) Gravel, sand, silt, clay, silty sandstone, and siltstone. Include continental and marine equivalents of San Joaquin Formation (Pliocene) and Etchegoin Formation (Miocene and Pliocene)

Tm Marine rocks and deposits (Eocene, Oligocene, Miocene, and Pliocene) Sand, clay, silt, sandstone, shale, mudstone, and siltstone. On western side of valley include the San Joaquin and Etchegoin Formations, Temblor Formation (Oligocene and Miocene) and Kreyenhagen Formation (Eocene). On southeastern side include the Santa Margarita Formation of various authors, the Round Mountain Silt, the Olcese Sand, the Freeman Silt, and the Jewett Sand (including the Pyramid Hill Sand Member) (all Miocene), and the Vedder Sand (Oligocene)

Tcmo Continental rocks and deposits (Oligocene and Miocene) Gravel, conglomerate, sand, tuffaceous sand, clay, and sandy clay; contain rhyolitic material on eastern side of valley. Principally Valley Springs Formation (Oligocene and Miocene) on eastern side of valley; unnamed fanglomerates (Miocene) and Bena Gravel (Miocene) in the southern part

Tcme Continental rocks and deposits (Eocene to Miocene) Conglomerate, sandstone, consolidated fanglomerate, claystone, tuff and tuff breccia; near Fresno consist of tuffaceous sand and gravel. Near Bakersfield include the Bealville Fanglomerate (Oligocene and Miocene) and the Walker Formation (Eocene to Miocene)

Tce Continental rocks and deposits (Eocene) Conglomerate and sandstone; along eastern side of valley contain anauxite. Principally Ione Formation (Eocene) on eastern side of valley

Unconformity

pTs Marine rocks (Pre-Tertiary) Sandstone, shale, siltstone, and some limestone, chiefly on western side of valley; in places contain abundant secondary gypsum. Include Moreno Formation (Cretaceous and Paleocene) and Panoche Formation (Cretaceous)

pTg Granitic rocks (Pre-Tertiary) Chiefly granitic rocks on eastern side of valley, in places consists of mafic intrusive rocks

pTm Metamorphic rocks (Pre-Tertiary) Metasedimentary, metavolcanic and other metamorphic rocks on eastern side of valley

Source: Page, 1986.

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Figure 10
Geologic Map

A
Northwest

A'
Southeast

31S/26E-28J

31S/27E-7A

31S/27E-12

31S/28E-31N1

32S/28E-9B

Upper Zone

Middle Zone

Lower Zone

2010 Water Level

? Perched Water

Elevation GSE (feet)

300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Distance (Miles)

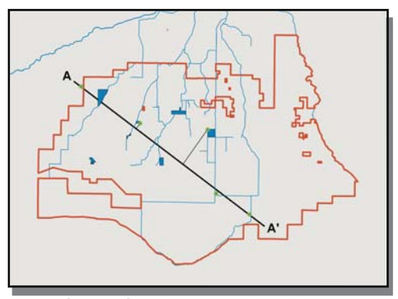
0 100

0 100

0 100

0 80

0 50



Cross Section Location Map

LEGEND

Mostly sands and gravels

Mostly silts and clays

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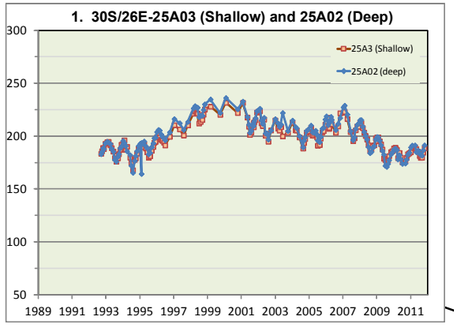
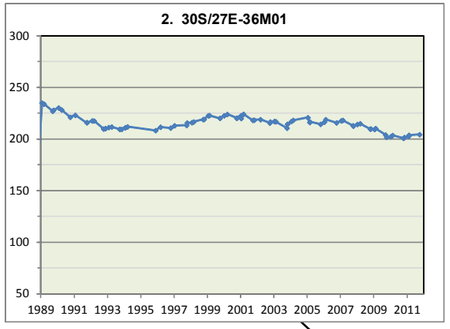
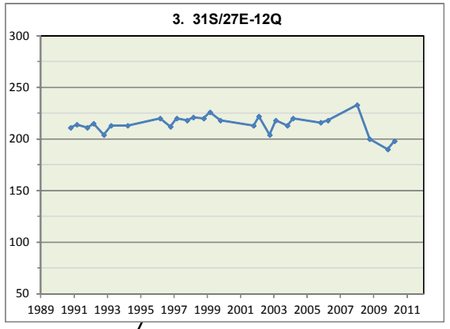
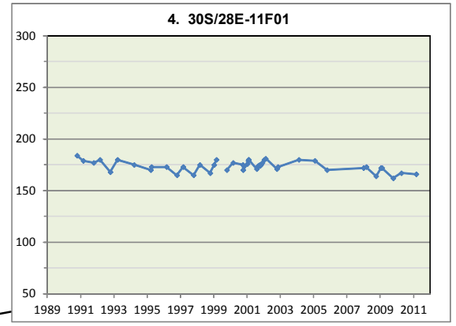
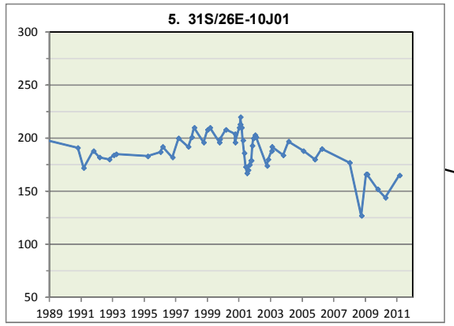
Figure 11
Cross Section
A - A'

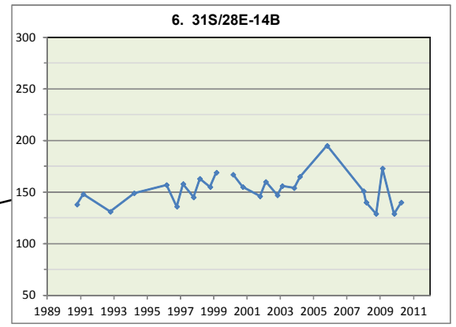


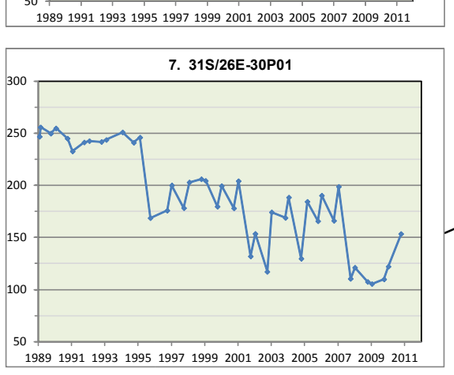


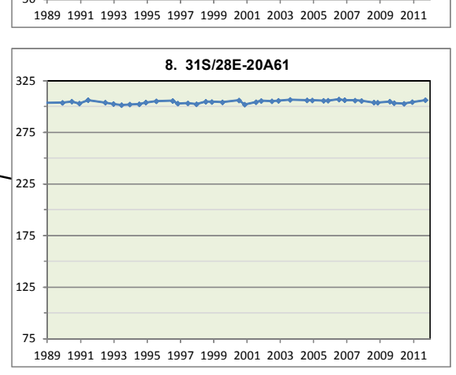


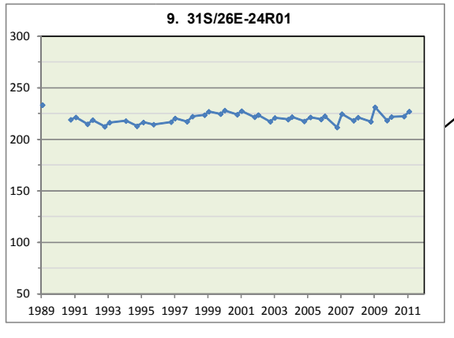


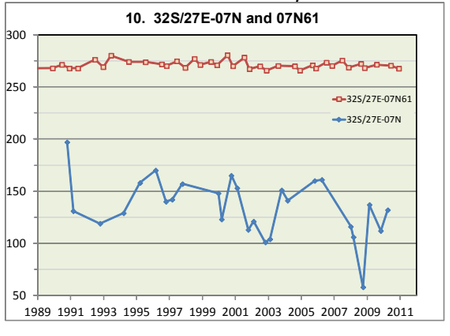


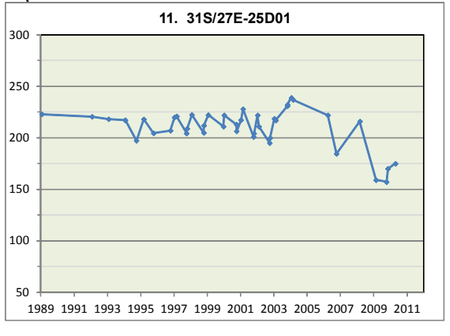


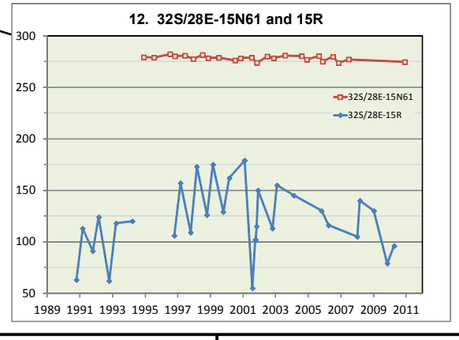


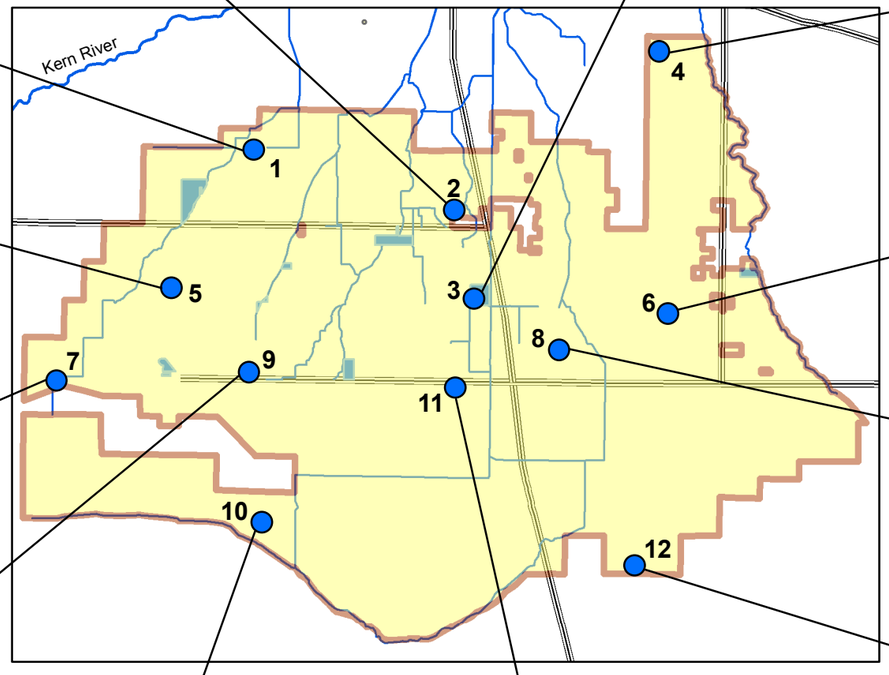












Water level elevations in feet, MSL

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Figure 12
Selected KDWD Hydrographs 1989 - 2011

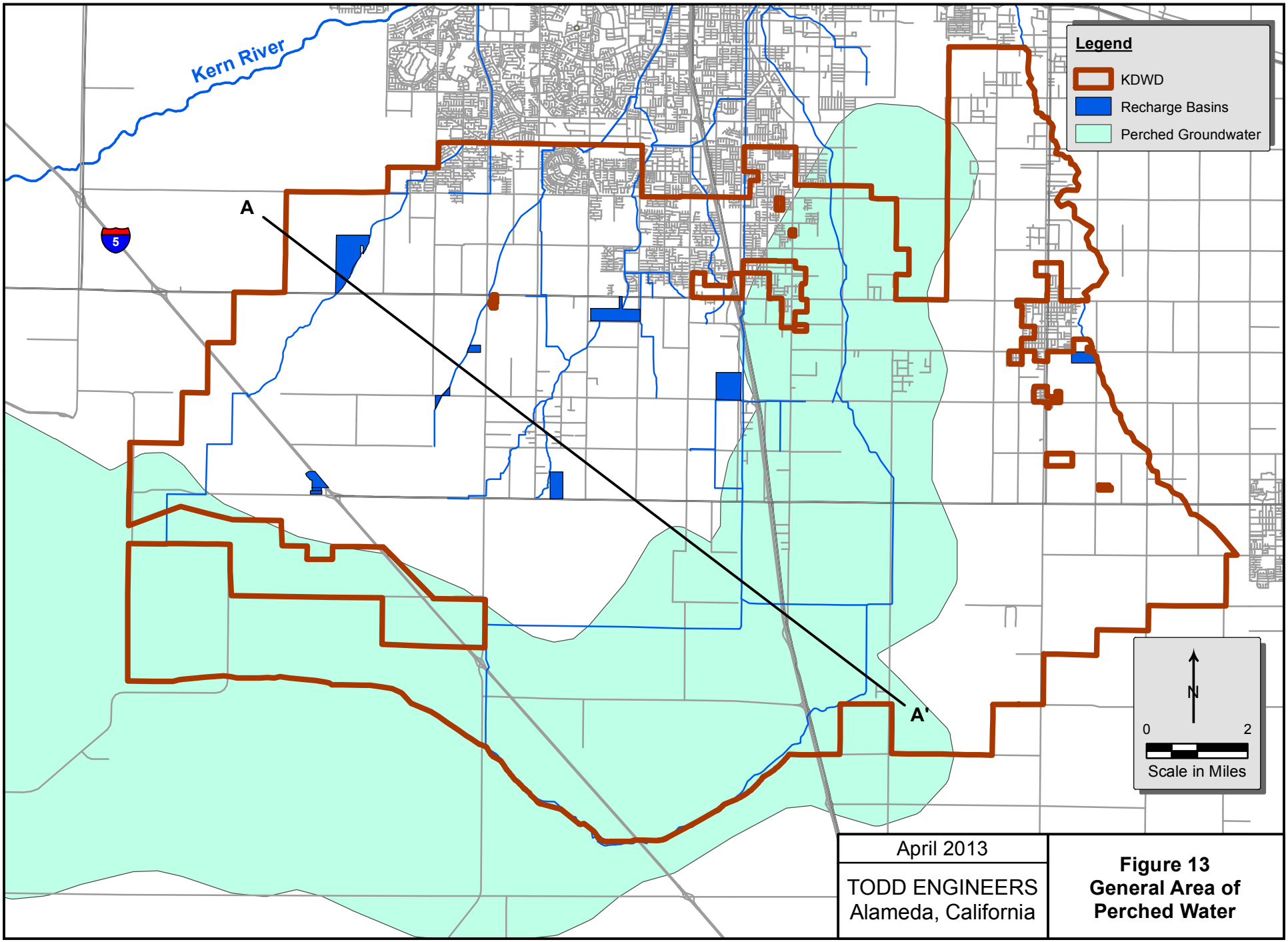

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Figure 13
General Area of Perched Water

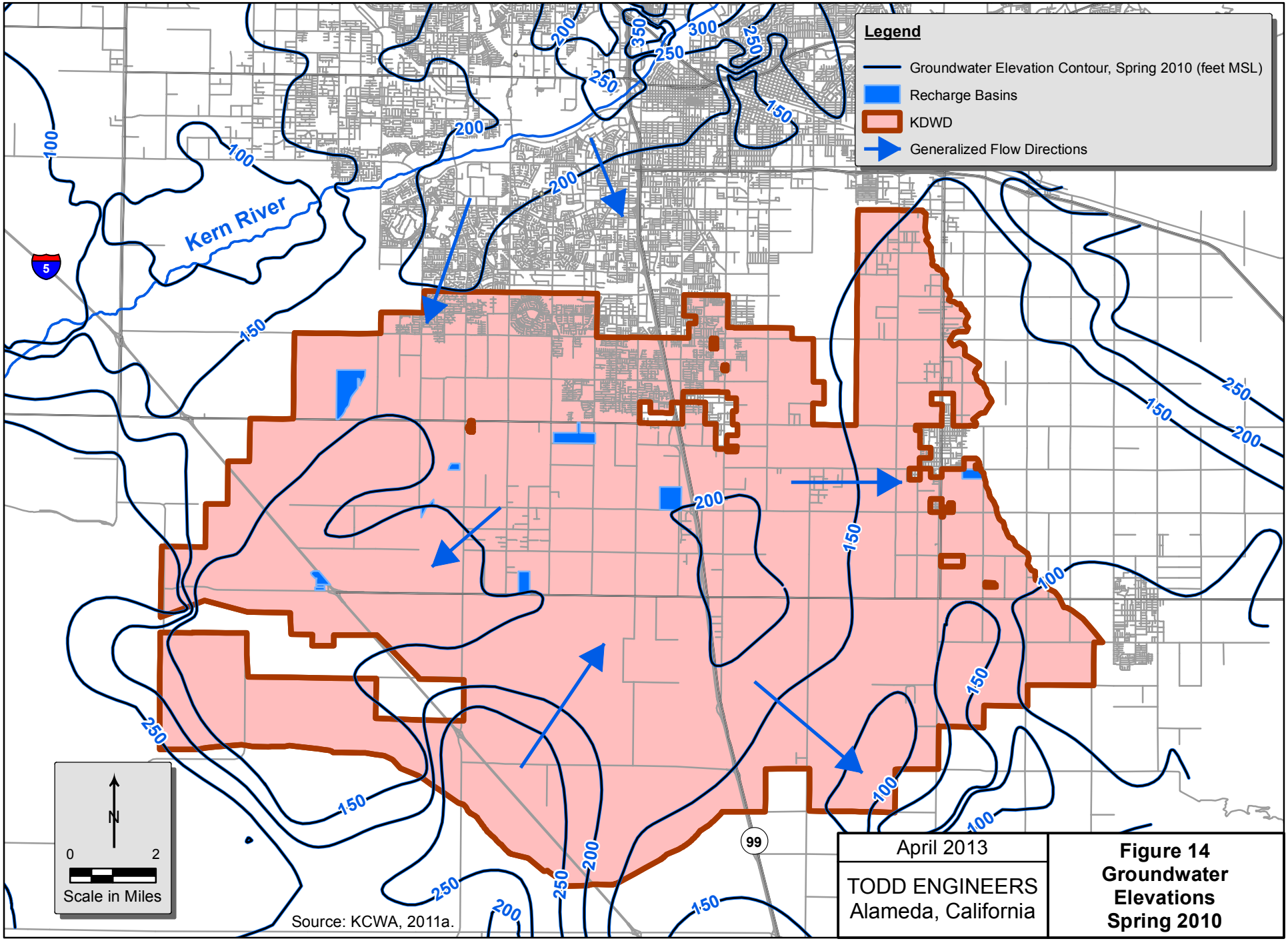
Legend
Groundwater Elevation Contour, Spring 2010 (feet MSL)
Recharge Basins
KDWD
Generalized Flow Directions
Kern River
5
99
100
150
200
250
300
350
N
0
2
Scale in Miles
Source: KCWA, 2011a.
April 2013
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Figure 14
Groundwater
Elevations
Spring 2010

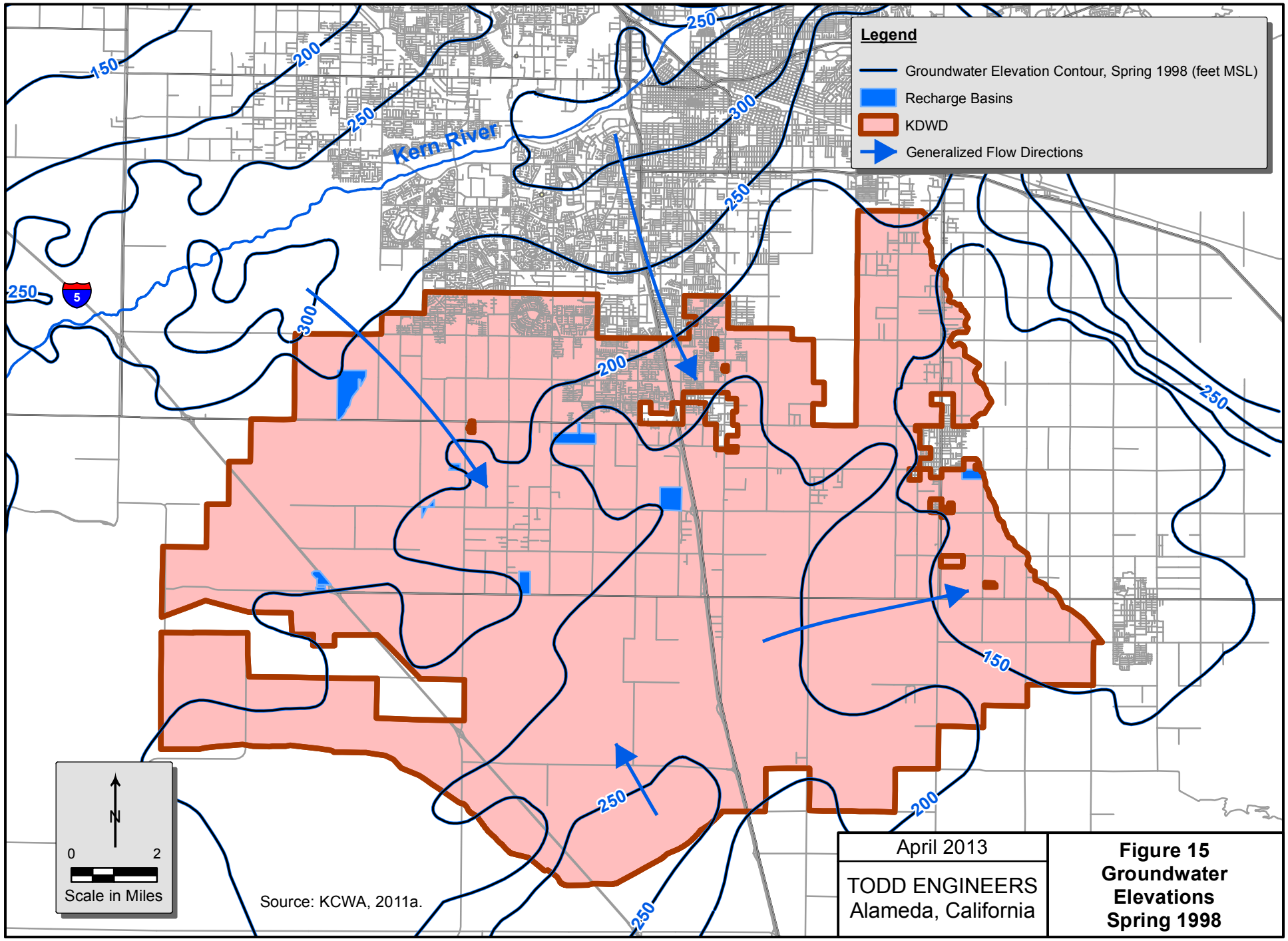
Legend
Groundwater Elevation Contour, Spring 1998 (feet MSL)
Recharge Basins
KDWD
Generalized Flow Directions
Kern River
150
200
250
300
5
N
0
2
Scale in Miles
Source: KCWA, 2011a.
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Figure 15
Groundwater
Elevations
Spring 1998

Kern River

5

99

TDS: 322
NO3: 23
Na: 47

TDS: 374
NO3: 13
Na: 38

TDS: 371
NO3: 21
Na: 31

TDS: 168
NO3: 5
Na: 22

TDS: 295
NO3: 2
Na: 47

TDS: 199
NO3: 5
Na: 38

TDS: 302
NO3: 20
Na: 47

Shallow -
TDS: 280
NO3: 16
Na: 28

TDS: 347
NO3: 22
Na: 47
(2001 data)

Deep -
TDS: 132
NO3: 0.7
Na: 31
(2005 - 2006 data)

TDS: 275
NO3: 6
Na: 53

TDS: 223
NO3: 4
Na: 30

TDS: 579
NO3: 12
Na: 60

TDS: 144
NO3: <0.4
Na: 18

TDS: 247
NO3: <0.4
Na: 69

TDS: 512
NO3: 19
Na: 62

TDS: 299
NO3: <0.4
Na: 79

TDS: 480
NO3: 16
Na: 88

TDS: 586
NO3: <0.4
Na: 118

TDS: 514
NO3: <0.4
Na: 129

TDS: 553
NO3: 26
Na: 113

TDS: 1623
NO3: <0.4
Na: 154

Legend

- Water Quality Monitoring Program
- KDWD Recharge Basins
- KDWD
- Canals/River

TDS: Total Dissolved Solids
NO3: Nitrate
Na: Sodium

All Concentrations in mg/L

N

0 2

Scale in Miles

Note: All data from 1990 - 1994 analyses except as noted

October 2013

TODD ENGINEERS
Alameda, California

Figure 16a
Groundwater Quality
1990 - 1994

Kern River

5

99

TDS: 210
NO_3: 13
Na: 29

TDS: 200
NO_3: 10
Na: 25

TDS: 200
NO_3: 10
Na: 25

TDS: 160
NO_3: 7.9
Na: 26

Legend

- 2013 Water Quality Monitoring Program
- KDWD Recharge Basins
- KDWD
- Canals/River

TDS: Total Dissolved Solids
NO_3: Nitrate
Na: Sodium

All Concentrations in mg/L

N

0 2

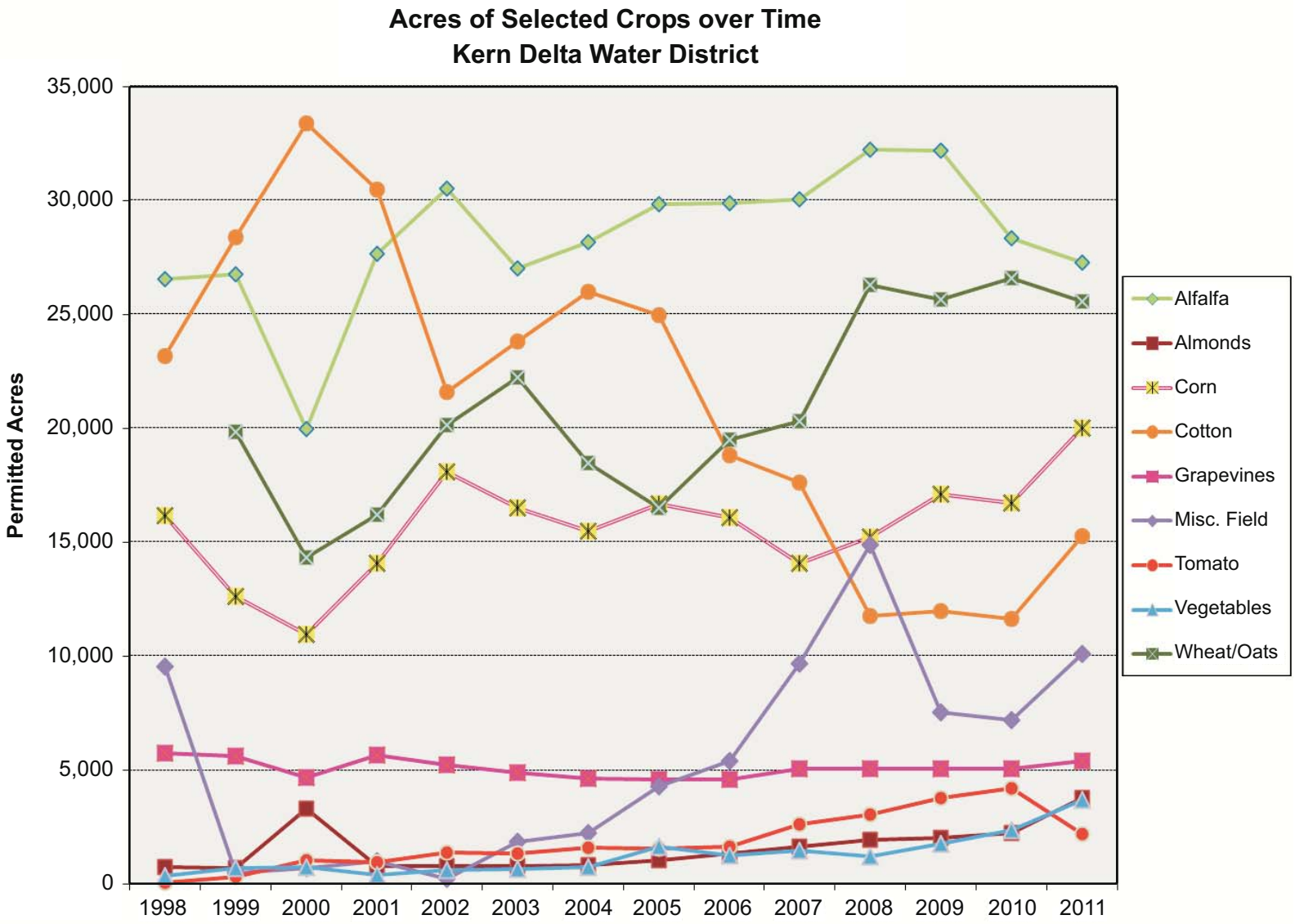
Scale in Miles

Note: All data from July 2013 samples

October 2013

TODD ENGINEERS
Alameda, California

Figure 16b
Groundwater Quality 2013

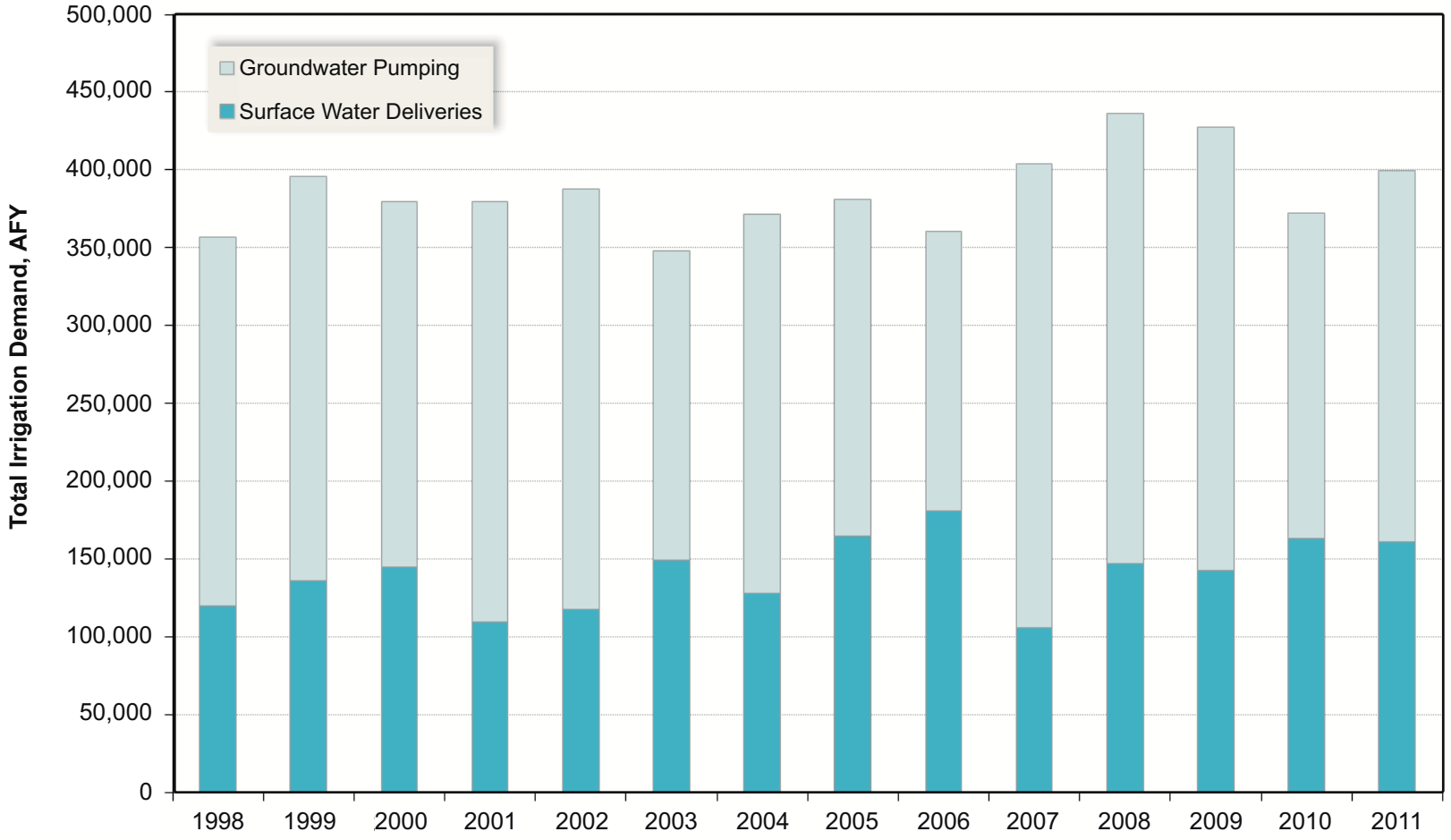


April 2013

TODD ENGINEERS
Alameda, California

Figure 17
Changing Patterns of Selected Crops

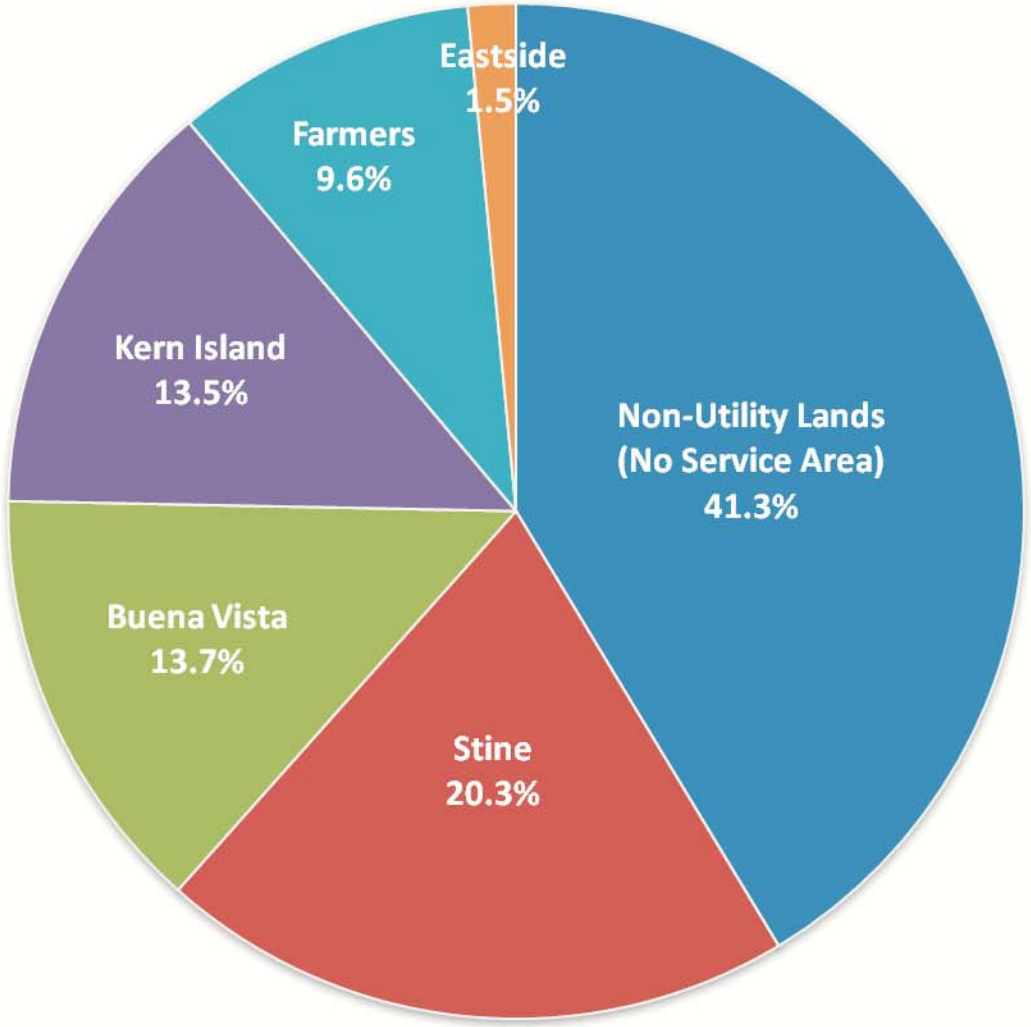
Surface Water and Groundwater Use - Total Irrigation Demand
Kern Delta Water District



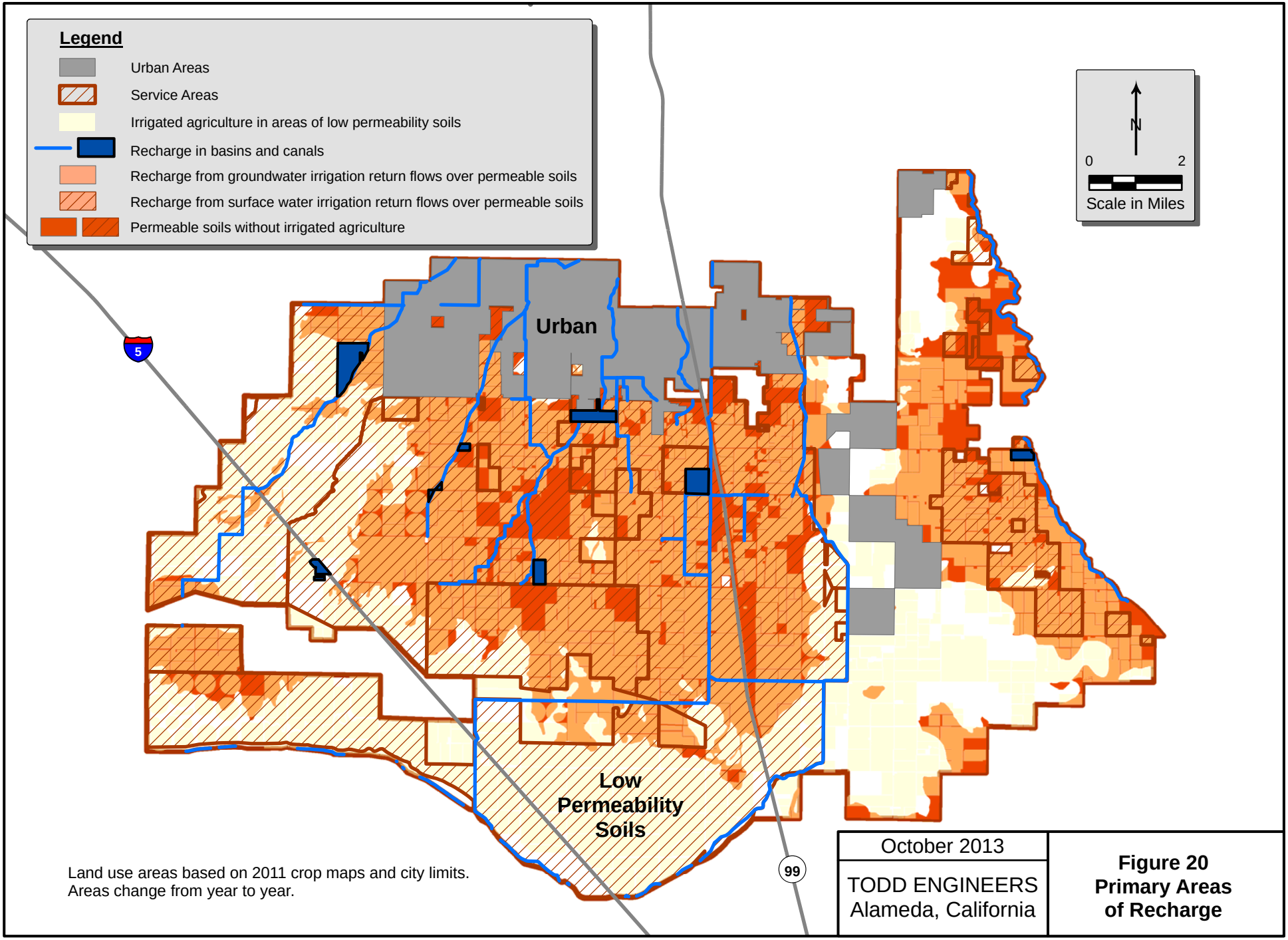
NOTES: Surface Water Deliveries include Kern River, SWP, and other water obtained through exchange agreements. Amounts shown are actual deliveries that do not include canal seepage and other losses. Total irrigation demand accounts for the effective precipitation available to offset irrigation, evaluated on a daily basis. An average irrigation efficiency of 80 percent is assumed.

April 2013	**Figure 18**
TODD ENGINEERS Alameda, California	**Surface Water and Groundwater Agricultural Use**

Average Annual Percentage of Irrigation Pumping by Service Area



April 2013	**Figure 19**
TODD ENGINEERS Alameda, California	**Percentage of Irrigation Pumping in Each Service Area**


Legend
Urban Areas
Service Areas
Irrigated agriculture in areas of low permeability soils
Recharge in basins and canals
Recharge from groundwater irrigation return flows over permeable soils
Recharge from surface water irrigation return flows over permeable soils
Permeable soils without irrigated agriculture
N
0
2
Scale in Miles
Urban
Low Permeability Soils
5
99
Land use areas based on 2011 crop maps and city limits.
Areas change from year to year.
October 2013
TODD ENGINEERS
Alameda, California
Figure 20
Primary Areas of Recharge

Appendices

GWMP Update

Kern Delta Water District

FINAL

TODD ENGINEERS

APPENDIX A

Resolution No. 2012-05

Intention of the Kern Delta Water District to Update its Groundwater Management Plan

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2012-05**

INTENTION OF THE KERN DELTA WATER DISTRICT
TO UPDATE ITS GROUNDWATER MANAGEMENT PLAN

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 in order to preserve local management and enhance existing groundwater management programs; and

WHEREAS, in 2002, Water Code 10750 et seq. was amended by SB 1938, providing recommendations and requirements for agencies that elected to develop a groundwater management plan; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) in compliance with the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern Fan Authority through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County, which contains groundwater management activities of local agencies in the region; and

WHEREAS, the District has recently prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that will involve the conjunctive management of surface water and groundwater; and

WHEREAS, the Board thinks that the adoption of a groundwater management plan will be in the best interests of the District's landowners and water users; and

WHEREAS, the Board would like to update its groundwater management plan to document and integrate various legislative requirements with ongoing and planned groundwater management activities; and

WHEREAS, notice of a public hearing to consider and adopt this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" was published pursuant to Water Code §10753.2; and

WHEREAS, a public hearing was held on June 19, 2012 to consider the adoption of this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" pursuant to Water Code §10753.2;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. This Board of Directors hereby declares its intention to prepare an updated Groundwater Management Plan that integrates ongoing and future groundwater management activities and recent legislative amendments to the Water Code.

2. The General Manager is authorized and directed to take such steps as are necessary to update the Groundwater Management Plan for Board consideration, and to publish a copy of this Resolution as required by law.

3. Upon completion of the updated Groundwater Management Plan, the Board of Directors will consider adopting and implementing the plan in accordance with the process required by law.

4. If adopted, the plan would be submitted in electronic form to DWR in compliance with the law and copies of the plan would be made available to the public.

5. The General Manager shall take such steps as are necessary to ensure active public participation in the groundwater management planning process. To support the process, the General Manager shall develop a plan for public involvement that includes a Public Outreach List of stakeholders and interested parties for provision of public review and comment periods, and public hearings pursuant to Water Code Section 10753 et seq.

6. Any member of the public or other interested party is invited to participate in the development of the plan and can do so by contacting the General Manager and being placed on the Public Outreach List.

All the foregoing being on motion of Director Cerro, seconded by Director Collins, and authorized by the following vote, namely:

AYES: Frick, Tillema, Antongiovanni, Cerro, Garone, Cosyns, Collins, Palla

NOES: None

ABSENT: Kaiser

ABSTENTIONS: None

I HEREBY CERTIFY that the foregoing Resolution is the Resolution of said District as duly passed and adopted by said Board of Directors at a legally convened meeting held June 19, 2012.

WITNESS my hand and the Seal of said Board of Directors this 19th day of June, 2012.

David Cosyns, Secretary

[SEAL]

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	12816584	**PO #:**	Groundwater
Edition:	TBC	**Run Times**	2
Class Code	Legal Notices		
Start Date	6/5/2012	**Stop Date**	6/12/2012
Billing Lines	37	**Inches**	222.95
Total Cost	$ 135.46	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER
AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 6/5/12
6/12/12

ALL IN YEAR 2012

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

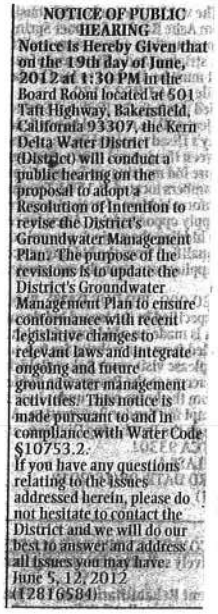
Terri Brice

DATED AT BAKERSFIELD CALIFORNIA
6/12/12

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARINGNotice is Hereby

Ad Number 12816584



NOTICE OF PUBLIC HEARING

Notice is Hereby Given that on the 19th day of June, 2012 at 1:30 PM in the Board Room located at 501 Taft Highway, Bakersfield, California 93307, the Kern Delta Water District (District) will conduct a public hearing on the proposal to adopt a Resolution of Intention to revise the District's Groundwater Management Plan. The purpose of the revisions is to update the District's Groundwater Management Plan to ensure conformance with recent legislative changes to relevant laws and integrate ongoing and future groundwater management activities. This notice is made pursuant to and in compliance with Water Code §10753.2.

If you have any questions relating to the issues addressed herein, please do not hesitate to contact the District and we will do our best to answer and address all issues you may have.

June 5, 12, 2012
(12816584)

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	13306899	**PO #:**	Revised Res 2012-05
Edition:	TBC	**Run Times**	2
Class Code	Legal Notices		
Start Date	9/30/2013	**Stop Date**	10/7/2013
Billing Lines	97	**Inches**	8.10
Total Cost	$ 1,045.08	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

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STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER
AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 10/7/13
9/30/13

ALL IN YEAR 2013

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Jessi Brice

DATED AT BAKERSFIELD CALIFORNIA

10/7/13

Printed on 10/6/2013 at 11:23:19AM

Solicitor I.D.: 0

First Text
BEFORE THE BOARD OF DRIECTORSOF THEKERI

Ad Number 13306899

(over)

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: RESOLUTION NO. 2012-05

INTENTION OF THE KERN DELTA WATER DISTRICT
TO UPDATE ITS GROUNDWATER MANAGEMENT PLAN

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 in order to preserve local management and enhance existing groundwater management programs; and

WHEREAS, in 2002, Water Code 10750 et seq. was amended by SB 1938, providing recommendations and requirements for agencies that elected to develop a groundwater management plan; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) in compliance with the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern Fan Authority through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County, which contains groundwater management activities of local agencies in the region; and

WHEREAS, the District has recently prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that will involve the conjunctive management of surface water and groundwater; and

WHEREAS, the Board thinks that the adoption of a groundwater management plan will be in the best interests of the District's landowners and water users; and

WHEREAS, the Board would like to update its groundwater management plan to document and integrate various legislative requirements with ongoing and planned groundwater management activities; and

WHEREAS, notice of a public hearing to consider and adopt this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" was published pursuant to Water Code §10753.2; and

WHEREAS, a public hearing was held on June 19, 2012 to consider the adoption of this "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan" pursuant to Water Code §10753.2;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. This Board of Directors hereby declares its intention to prepare an updated Groundwater Management Plan that integrates ongoing and future groundwater management activities and recent legislative amendments to the Water Code.
2. The General Manager is authorized and directed to take such steps as are necessary to update the Groundwater Management Plan for Board consideration, and to publish a copy of this Resolution as required by law.
3. Upon completion of the updated Groundwater Management Plan, the Board of Directors will consider adopting and implementing the plan in accordance with the process required by law.
4. If adopted, the plan would be submitted in electronic form to DWR in compliance with the law and copies of the plan would be made available to the public.
5. The General Manager shall take such steps as are necessary to ensure active public participation in the groundwater management planning process. To support the process, the General Manager shall develop a plan for public involvement that includes a Public Outreach List of stakeholders and interested parties for provision of public review and comment periods, and public hearings pursuant to Water Code Section 10753 et seq.
6. Any member of the public or other interested party is invited to participate in the development of the plan and can do so by contacting the General Manager and being placed on the Public Outreach List.

All the foregoing being on motion of Director Cerro, seconded by Director Collins, and authorized by the following vote, namely:

AYES:	Frick, Tillema, Antongiovanni, Cerro, Garone, Cosyns, Collins, Palla
NOES	None
ABSENT:	Kaiser
ABSTENTIONS:	None

I HEREBY CERTIFY that the foregoing Resolution is the Resolution of said District as duly passed and adopted by said Board of Directors at a legally convened meeting held June 19, 2012.

WITNESS my hand and the Seal of said Board of Directors this 19th day of June, 2012.

/s/ David Cosyns
David Cosyns, Secretary

"Pursuant to this Resolution a Groundwater Management Plan has been prepared. That Plan was reviewed at a duly noticed public hearing held September 17, 2013 and will be considered for adoption by the board of directors of the Kern Delta Water District at the regular board meeting to be held October 15, 2013."

September 30, October 7, 2013 (13306899)

APPENDIX B

Resolution No. 2013-05

Adoption and Implementation of the Kern Delta Water District Groundwater Management Plan Update

BEFORE THE BOARD OF DRIECTORS
OF THE
KERN DELTA WATER DISTRICT

IN THE MATTER OF: **RESOLUTION NO. 2013-05**

ADOPTION AND IMPLEMENTAION OF THE KERN DELTA WATER DISTRICT GROUNDWATER MANAGEMENT PLAN UPDATE

WHEREAS, Part 2.75 (commencing with Section 10750) of Division 6 of the California Water Code, otherwise known as the Groundwater Management Act of 1992 (AB 3030), authorizes this District to adopt and implement a Groundwater Management Plan; and

WHEREAS, on October 15, 1996, pursuant to Resolution No. 96-03 the District adopted a Groundwater Management Plan pursuant to the Groundwater Management Act of 1992 for the purposes of implementing the plan and establishing a Groundwater Management Program within the District; and

WHEREAS, in 2002, the Groundwater Management Act was amended by SB 1938; and

WHEREAS, in 2003, the District signed an agreement with Metropolitan Water District of Southern California for a water banking program that significantly increased its groundwater management infrastructure, and

WHEREAS, in 2010, the District amended its Groundwater Management Plan and Agricultural Water Management Plan, noting the District's intent to comply with Water Code amendments; and

WHEREAS, in 2011, the District submitted a groundwater level monitoring plan to the California Department of Water Resources (DWR) pursuant to the California Statewide Elevation Monitoring (CASGEM) Program (SB 6) and is participating in the CASGEM program as part of the Kern River Fan Group through an agreement with Buena Vista Water Storage District, Rosedale Rio Bravo Water Storage District, and Henry Miller Water District with BVWSD; and

WHEREAS, in 2011, amendments to the Water Code pertaining to groundwater management plans were made by AB 359, which requires, among other things, that recharge areas be mapped and included in a groundwater management plan; and

WHEREAS, the District has participated in the 2011 Integrated Regional Water Management Plan (IRWMP) for the Tulare Lake Basin Portion of Kern County; and

WHEREAS, the District prepared a Water Allocation Plan to optimize its use of Kern River water among District service areas that involves the conjunctive management of surface water and groundwater; and

WHEREAS, on June 19, 2012 the Board of Directors held a public hearing in accordance with Water Code §10753.2 and thereafter adopted Resolution 2012-05 "Resolution of Intention of the Kern Delta Water District to Update its Groundwater Management Plan"; and

WHEREAS, a draft Groundwater Management Plan Update has been prepared; and

WHEREAS, notice of a public hearing to consider the adoption of the Groundwater Management Plan Update" was published pursuant to Water Code §10753.2 and a public hearing was held pursuant thereto on September 17, 2013;

NOW, THEREFORE, BE IT RESOLVED, and ordered by the Board of Directors as follows:

1. The foregoing are true and correct.

2. The Board of Directors hereby adopts the Groundwater Management Plan Update and the Monitoring Protocols contained therein dated October 11, 2013 in accordance with Part 2.75 of Division 6 of the California Water Code.

3. The Board of Directors hereby authorizes the General Manager to execute all documents, and take any other action necessary or advisable to carry out the purpose of this resolution.

All the foregoing being on the motion of Director Garone, seconded by Director Cerro and authorized by the following vote, namely:

AYES: Antongiovanni, Cerro, Collins, Cosyns, Frick, Garone, Kaiser, Tillema

NOES: None

ABSENT: Palla

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of October, 2013.

WITNESS my hand and the official seal of said Board of Directors this 15th day of October, 2013.

_____
President of the Board of Directors
KERN DELTA WATER DISTRICT

ATTEST:

_____
Secretary of the Board of Directors
KERN DELTA WATER DISTRICT

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P. O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	13269849	**PO #:**	GWMP 2nd Hear
Edition:	TBC	**Run Times**	2
Class Code	Public Notices		
Start Date	9/2/2013	**Stop Date**	9/9/2013
Billing Lines	39	**Inches**	3.26
Total Cost	$ 142.62	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

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STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER
AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 9/9/13
9/2/13

ALL IN YEAR 2013

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Jessi Brice

DATED AT BAKERSFIELD CALIFORNIA
9/9/13

Printed on 9/9/2013 at 8:48:46AM

Solicitor I.D.: 0

First Text
Notice of Kern Delta Water District to C

Ad Number 13269849

Notice of Kern Delta Water District to Consider Adoption of its Groundwater Management Plan Update:

On September 17, 2013, at 1:30 pm, Kern Delta Water District will hold a public hearing at its office at 501 Taft Highway in Bakersfield to consider adoption of its *Groundwater Management Plan Update*, prepared in compliance with California Water Code Sections 10750 to 10756. The plan summarizes the groundwater basin, updates Basin Management Objectives (BMOs), and evaluates groundwater management strategies. It describes management strategies selected for implementation including ongoing groundwater management and monitoring activities being conducted by the District. Copies of the draft plan may be obtained for the cost of reproduction at Kern Delta Water District, 501 Taft Highway, Bakersfield, CA 93307-6247.

September 2, 9, 2013
(13269849)

APPENDIX C

Monitoring Program and Protocols

C. Monitoring Program and Protocols

KDWD conducts numerous monitoring activities to support groundwater and surface water management programs. Monitoring objectives are described below followed by protocols of the current program and future monitoring refinements for the various media being monitored.

C.1 Monitoring Objectives and Programs

KDWD monitors surface water flows, groundwater levels and quality, groundwater storage, and subsidence to meet a variety of District objectives including:

- Fulfillment of California Ambient Groundwater Elevation Monitoring (CASGEM) Program
- Compliance with Kern River Surface Water Rights
- Execution of groundwater banking agreements with Metropolitan Water District of Southern California and San Bernardino Valley Municipal Water District
- Understanding and tracking of groundwater levels and quality for overall groundwater management
- Evaluation of adverse impacts from potential land subsidence

C.2 Surface Water Flows and Quality

As a First Point diverter and water rights holder on the Kern River, KDWD measures surface water diversions and deliveries.

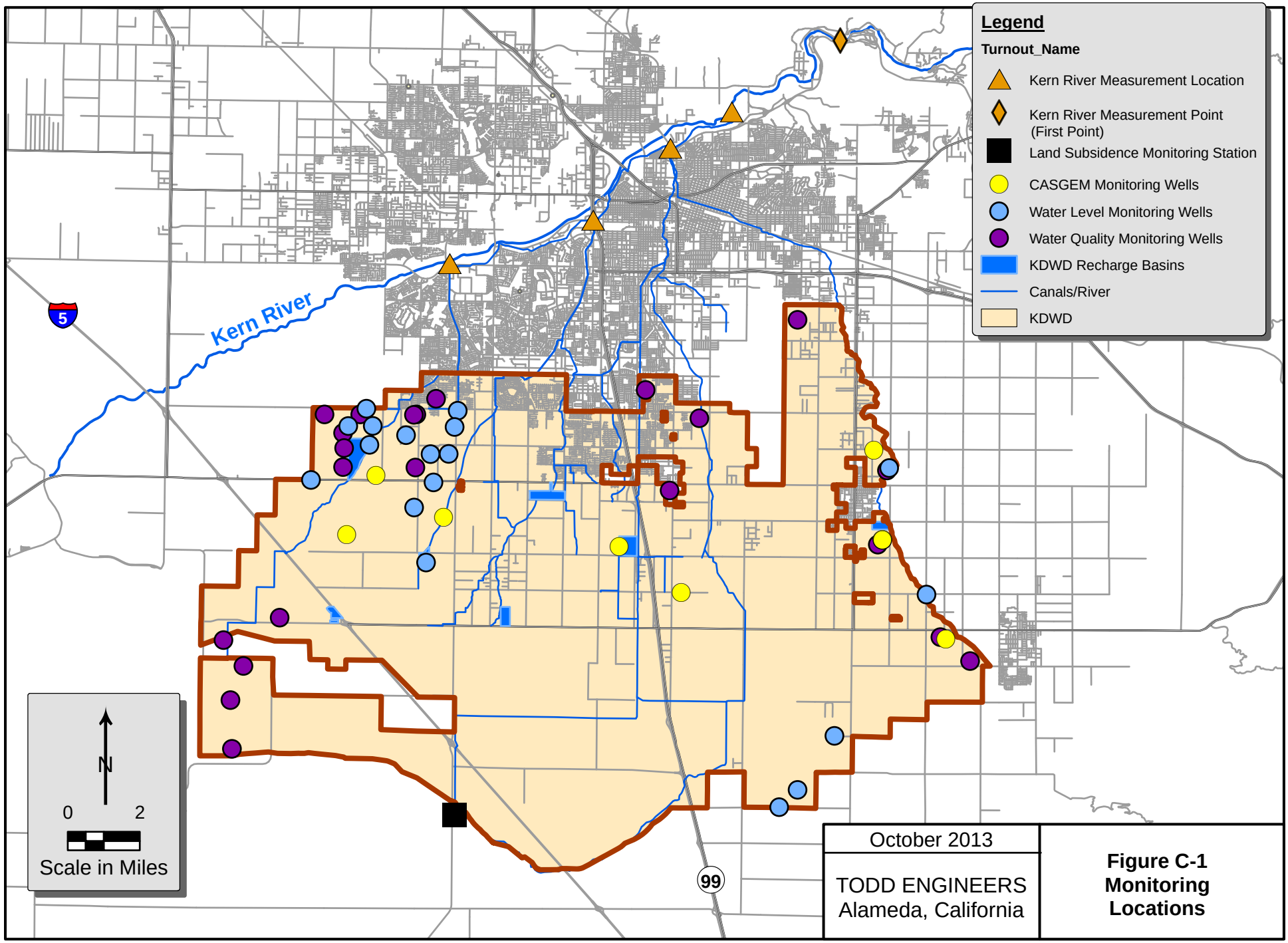
C.2.1 Methods

Kern River flows are measured at First Point and routed into regional canals for conveyance into the District. KDWD monitors Kern River diversions at four monitoring points as listed below and shown on Figure C-1:

- Rocky Point Weir as water is diverted into the Carrier Canal
- Kern Island – Eastside Weir at the Arvin Edison Intake Canal
- Stine-Farmers Weir at the Stine Headgate
- Buena Vista Canal Weir on the River Canal.

Deliveries from the KDWD main canals and laterals are also monitored, allowing estimates of groundwater recharge along the unlined canals. Data are summarized on a daily basis.

The City of Bakersfield and Improvement District No. 4 (ID-4) monitors surface water quality at various locations along the Carrier and River canals. As part of these monitoring protocols, KDWD will compile key relevant water quality data as available and incorporate them into its monitoring reports.


Legend
Turnout_Name
Kern River Measurement Location
Kern River Measurement Point (First Point)
Land Subsidence Monitoring Station
CASGEM Monitoring Wells
Water Level Monitoring Wells
Water Quality Monitoring Wells
KDWD Recharge Basins
Canals/River
KDWD
Kern River
5
99
N
0
2
Scale in Miles
October 2013
TODD ENGINEERS
Alameda, California
Figure C-1
Monitoring
Locations

C.2.3 Data Management

Surface water flow and diversion monitoring data are provided to the City of Bakersfield, where it is compiled into the annual hydrographic reports. These reports provide accounting of monthly diversions, deliveries, and loss along the canals among all First Point diverters. In addition, KDWD maintains records for internal accounting.

C.3 Water Levels

Since 1989, KDWD has conducted a groundwater level monitoring program involving approximately 100 to 150 wells. Typically, semi-annual measurements are made in Spring and Fall representing the annual high and low water levels, respectively. Almost all of the wells are active or inactive agricultural wells that have been made available for District monitoring. Although construction data are limited, most wells are screened in various aquifer zones and measurements represent average water levels beneath the District. Data are used to track changes in water levels and estimate trends and fluctuations. Over time, the number and location of wells has varied with changes in well availability and changes in program objectives.

In addition to the ongoing water level monitoring program, eight key wells have been selected for more systematic water level monitoring as part of the CASGEM program. Water level monitoring locations are shown on Figure C-1.

C.3.1 Methods

For active wells, measurements are made after the well pump has been turned off for at least 24 hours, when possible. In addition, data are compared to inactive wells to assess the reliability of the readings.

Reference point elevations are measured by field personnel with handheld global positioning system (GPS) devices. Water level measurements are made with an acoustic sounder. Field personnel follow the procedure recommended by the sounder manufacturer as reproduced below:

1. Place sensor inside well or in contact with the wellhead at the reference point.
2. Plug the sensor cable into the Speaker jack on the unit.
3. Turn selector knob to Auto and turn the power on.
4. Note the pulsing sound from the sensor and the 4 dashes on the unit display; within seconds, the distance to the water surface will appear on the display. It is normal for the unit to transmit 6 or 7 pulses before the reading is displayed.
5. Readings are saved electronically and noted manually on field forms.

C.3.2 Monitoring Points

The 2012 water level monitoring program consisted of 23 wells, including eight key wells that have been identified for the CASGEM program. The locations of the water level monitoring points are provided on Figure C-1 with the CASGEM wells highlighted. Construction data are not available for most wells in the larger District water level program. Available data for the CASGEM wells are provided on Table C-1.

Table C-1
CASGEM Monitoring Wells
Kern Delta Water District

Well Designation		Year Drilled	Location		Reference Elevation (ft, msl)	Total Depth (ft, bgs)	Screen Interval	
No.	State Well Number		Latitude	Longitude			Top (ft, bgs)	Bottom (ft, bgs)
1	30S/26E-35C01	2008	35.16.143	119.08.998	333	630	230	600
2	31S/26E-10J	1977	35.14.705	119.09.842	332	709	400	709
3	31S/27E-7B	1955	35.15.150	119.06.990	335	641	156	630
4	31S/27E-12Q	2008	35.14.486	119.01.805	327	720	200	697
5	31S/28E-20D	1961	35.13.379	118.59.968	317	200	100	200
6	30S/29E-31C	NA	35.16.878	118.54.325	417	NA	NA	NA
7	31S/29E-7K	1991	35.14.705	118.54.051	412	780	330	780
8	31S/29E-28C	1963	35.12.317	118.52.157	412	530	280	530

C.3.3 Frequency

Water levels are recorded in Spring and Fall to capture annual fluctuations from seasonal groundwater pumping. Typically, wells are measured in April and November, representing the annual high and low water levels, respectively. Some of these wells may be monitored more frequently (e.g., quarterly) to address specific groundwater management issues.

C.3.4 Data Management

All water level data are maintained in the District's hydrography division. Field measurements for the CASGEM wells are compiled, checked, recorded on the DWR Form 1213, and uploaded to the CASGEM website. Field measurements will be kept onsite for one year for reference.

C.4 Groundwater Quality

Groundwater quality issues identified previously within KDWD have focused on salts and nutrients. The City of Bakersfield, Cal Water and other purveyors monitor wells in and near KDWD for drinking water quality – no issues of concern have been identified (Stetson, 2007). Although significant amounts of high quality water are recharged in the District, the combination of increased groundwater pumping and high salinity sediments to the south represent a potential for deteriorating water quality. The primary discharge of groundwater beneath the District is to wells. As groundwater is reused for irrigation, salts and nutrients can become concentrated in the soils and groundwater over time. A review of groundwater quality data from the early 1990s and a few additional monitoring points from 2005-2006 indicate that problematic levels of salts and nutrients have not occurred. However, more recent monitoring is needed to confirm and track this issue.

C.4.1 Methods

Clean laboratory containers will be obtained for sample collection and transport to the laboratory. Chain-of-custody forms will be completed to track the sample from collection through analysis. California-certified laboratories will be used for the analysis.

To the extent practical, the well will be pumped (purged) prior to sample collection. Field personnel will note the time that the pump was turned on and the amount of water purged prior to sampling. Water samples will be collected at a sampling port if available to minimize volatilization or air entrainment.

C.4.2 Monitoring Points

The final groundwater quality monitoring program will be developed over time. As an initial program, the eight wells included in the CASGEM program will be considered for groundwater quality analysis. These wells were selected because well construction data are generally available and a long-term water level record will be developed to inform future interpretation of groundwater quality data. Because most of these wells are privately owned, permission to sample for water quality must be obtained. Additional wells owned by the District will also be considered for the program unless determined to be duplicative with other wells.

C.4.3 Frequency

Groundwater quality monitoring will be conducted annually each fall. Although the actual timing is yet to be determined, September or October will be considered after the irrigation season is complete and water in the vadose zone has had some time for percolation.

C.4.4 Analytes

Major anions and cations, along with general physical parameters, are the focus of the KDWD groundwater quality monitoring program. These analyses are relatively inexpensive and provide specific concentrations on salts (TDS) and nutrients (NO_3) as well as valuable data on overall groundwater chemistry. As a quality control measure, an anion-cation balance will be requested to ensure the analytical integrity of the sample.

Additional analytes may be incorporated from time to time to address specific issues as they arise. Drinking water quality data (Title 22) may be available from municipal wells within the District and can be incorporated as available.

C.4.5 Data Management

All laboratory data are filed in the District's hydrography division. Data are transferred into an electronic database as needed for comparison and analysis. Electronic software for storing and analyzing groundwater quality data includes Microsoft Excel or Access database formats. Well locations will be entered in the project GIS for spatial analysis of the data.

C.5 Groundwater Storage

KDWD examines changes in groundwater levels from their ongoing monitoring program. As water levels rise and decline annually, changes are noted and reported to the KDWD Board of Directors in an internal groundwater monitoring report. In addition, KCWA prepares annual water level contour maps that cover the Management Area. These maps are reviewed and compared to changes indicated in ongoing water level monitoring.

The District intends to update or modify an existing groundwater model to allow for a more rigorous evaluation of changes in groundwater storage. Water level contour maps will continue to be generated annually; these can be coupled to the groundwater model to provide a more quantitative approach to changes in groundwater budgets and storage.

C.5.1 Methods

In 2001, the District retained Boyle Engineering to construct a MODFLOW groundwater model across the Management Area. That model has not been updated and is not available for a quantitative assessment of groundwater storage. A more regional MODFLOW model is currently being developed by the Kern Fan Monitoring Committee, a project in which KDWD is participating. That model contains more updated information and covers most of KDWD. Model completion is currently scheduled for late 2013. The District may elect to modify and use one of the existing models to conduct ongoing assessments of groundwater storage in the Management Area. After review of the model water budgets over several decades, simplifying assumptions and a streamlined analytical method may be developed to quickly monitor changes in groundwater storage outside of the numerical model.

C.5.2 Data Management

The groundwater model will be based on a detailed database that incorporates groundwater recharge and discharge within and beyond the Management Area. Changes in water levels and the groundwater budgets will be the primary output from model simulations, including quantitative assessments of subsurface inflow and outflow.

C.6 Groundwater Extractions

The analysis of groundwater use provided in Section 4.4 provides an estimate of groundwater extractions for irrigation based on a systematic assessment of irrigation demand. This methodology is judged sufficient for ongoing groundwater management activities. In the future, a more detailed accounting of groundwater use would allow for better planning and a more quantitative assessment of groundwater conditions.

For future activities, KDWD staff will work with the PAC and District customers to develop more accurate methods of determining groundwater extractions. This will allow for better management of water levels and storage and help identify areas in which to focus future recharge and conjunctive use strategies.

C.7 Land Subsidence

Prior to this GWMP Update, monitoring of land subsidence has been conducted indirectly only through the use of water level monitoring data. To improve land subsidence monitoring, a more direct monitoring approach will be implemented. This approach will incorporate currently available geodetic data near KDWD into the monitoring program as described in more detail below.

An additional improvement will include the tabulation of vertical datum from key benchmarks throughout the District. As new infrastructure is added, survey elevations will be updated at these locations as an additional check on potential land subsidence.

C.7.1 Methods and Data Management

Two continuously operating reference stations (CORS) are monitored by the National Geodetic Survey. The stations provide global navigation satellite system data in support of three dimensional positioning for a variety of applications throughout the United States. CORS-enhanced post processed coordinates are within a few centimeters relative to the National Spatial Reference System both horizontally and vertically. Data can be downloaded for each station free of charge.

Two stations are maintained in Bakersfield and one station, Bakersfield 1 (BKR1), is located on Old River Road at the Kern Dry Lake Bed about 1,500 feet south of the KDWD boundary as shown on Figure C-1. The current latitude/longitude of the station is 350756.63N; -1190634.19E with a vertical datum of 56.745 meters (186.2 feet). The other station, BKR2, is located north of KDWD, and will serve as a reference point for changes at BKR1. Vertical and horizontal data from the CORS BKR1 and BKR2 will be downloaded and reviewed on an annual basis.

C.7.2 Data Management

Data from BKR1 and BKR2 will be tabulated over time including horizontal and vertical coordinates. Changes in vertical datum at BKR1 will be compared to BKR2 for potential changes beneath KDWD. Significant changes at BKR1 that do not occur at BKR2 will be identified for further evaluation.

APPENDIX D

Index to Recommended and Required Components of a Groundwater Management Plan

D. Index to Recommended and Required Components of a Groundwater Management Plan

To facilitate the review and use of this GWMP Update, an index of key GWMP components is provided on Table D-1. These GWMP components have been compiled from the Water Code and various lists by DWR and others. Most of these components are incorporated throughout the structure of the GWMP Update, and not all appearances are referenced. However, the table lists representative sections of the document and demonstrates inclusion of the recommended and required components in this GWMP Update.

Table D-1
Index to Required and Recommended Components of a Groundwater Management Plan

GWMP Component	Location in This GWMP Update*
A. CWC § 10753.7 *et seq*. Required Components (SB 1938)	
1 Develop Quantitative Basin Management Objectives	Section 5
2 Involve and Cooperate with Other Agencies	Sections 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6. Sections 3.4.2, and 3.4.4. Section 4.4.2. Section 5.6. Sections 6.2, 6.4, 6.6, 6.9, 6.12, 6.13, 6.14. Section 7.1 and Table 13.
3 Prepare Map of DWR Bulletin 118 Groundwater Basin and Management Area. Show Map of Other Agencies	Figures 1, 2, and 3
4 Provide Map of Primary Recharge Areas	Figure 20, Section 6.5.3.
5 Develop and Adopt Monitoring Protocols for Groundwater Levels, Storage, Quality, and Inelastic Land Subsidence	Appendix C, Section 5.5, Sections 4.5.4 and 4.5.5, 6.7, and 6.11. Section 7 and Table 13
6 Document Public Involvement Plan	Section 1.3, Appendix A
7 Monitor and Describe Changes in Surface Water Flows/Quality affecting levels or caused by pumping	Sections 3.5.2 (last paragraph), 4.3 (4.3.1), 4.4 (3rd paragraph), 4.5.2., and 5.5, and Appendix C, especially Section C.2.
B. CWC § 10753.7 *et seq*. Voluntary Components (AB3030)	
1 Control Saline Intrusion	Table 12, Section 6.1.
2 Manage Wellhead Protection and Recharge Areas	Table 12, Section 6.2.
3 Prevent Migration of Groundwater Contamination	Table 12, Section 6.3.
4 Administer Well Abandonment and Destruction Program	Table 12, Section 6.4.
5 Mitigate Overdraft Conditions	Table 12, Section 6.5.
6 Manage Groundwater Extraction and Replenishment	Table 12, Section 6.6, and 6.8.
7 Monitor Groundwater Levels and Storage	Table 12, Section 6.7.
8 Facilitate Conjunctive Use Operations	Table 12, Section 6.6.
9 Identify Well Construction Policies	Table 12, Section 6.9.
10 Operate Contaminant Remediation, Recharge, Conservation, Recycling, or Extraction Projects	Table 12, Section 6.10.
11 Develop Relationships with Regulatory Agencies	Table 12, Section 6.12.
12 Coordinate with Land Use Planning Agencies	Table 12, Section 6.13.
C. DWR Suggested Components	
1 Assemble Project Advisory Committee	Section 1.3.
2 Describe GWMP Management Area	Section 1.2. Section 3, especially 3.5. Section 4 (all).
3 Link BMOs with Best Management Practices	Table 12, Chapter 6, Section 2.5, Section 5.6 (last bullet item)
4 Describe GWMP Monitoring Program	Appendix C. Sections 4.2, 4.4, 4.5 (especially 4.5.5). Section 5.5. Sections 6.3, 6.7, and 6.11, Section 7.2.
5 Describe Integrated Water Management Planning Efforts	Section 2.4. Sections 3.4, especially 3.4.2, and 3.4.4.
6 Provide GWMP Implementation Schedule	Section 7. Table 13.
7 Describe Ongoing Reporting of Management Activities	Section 7.3.

* Numerous aspects of each component are incorporated throughout this GWMP Update; specific references to all related text are too numerous to provide a comprehensive list. Rather, primary sections of the GWMP dedicated to each of the components are provided in this table.