Deep Groundwater Conditions Report

December 2015

Westlands Water District
April 2016

Introduction

Westlands Water District (District) located on the west side of the San Joaquin Valley in Fresno and Kings Counties. The District receives water for irrigation from surface sources delivered through the Delta-Mendota Canal and the San Luis Canal (SLC) and from groundwater.

Agricultural production in the District area was originally developed and sustained with groundwater for irrigation. Surface water deliveries from the San Luis Unit of the Central Valley Project (CVP) began in 1968 with the goal to reduce historical groundwater pumping. However, the District's contractual entitlements for CVP water are not sufficient to supply the agricultural demands of the District, thus some groundwater pumping is still required. Since 1990, CVP water supplies have been due to drought and regulatory actions resulting from the Central Valley Project Improvement Act (CVPIA), the Endangered Species Act (ESA), Bay/Delta water quality requirements and Court orders. As a result, groundwater pumping has increased to meet crop water demands.

This increased reliance on groundwater resources to supplement surface water resulted in the development of the District's Groundwater Management Plan in 1996, which includes continuation of this groundwater monitoring and reporting program.

Geology

The San Joaquin Valley is a wide bedrock basin filled with thousands of feet of alluvial sediment deposited by streams and rivers flowing out of the adjacent mountains on both the east and the west. Westlands is located near the centerline of this basin, bordered on the east by the Fresno Slough and on the west by the Diablo Range of the California Coast Ranges.

The Diablo Range consists of complex, folded, and uplifted mountains, which are composed predominantly of sandstone and shale of marine origin. Eroded by creeks flowing from the Diablo Range, sediments form gentle sloping alluvial fans. The texture of the Diablo Range deposits depends on the relative position on the alluvial fan and ranges from coarse sand and gravel to fine silt and clay. Generally, those portions of Westlands lying high on the alluvial fans have permeable, medium-textured soils. With decreasing elevation from the west to east, soil textures become finer. These fine textured soils are characterized by low permeability and increased concentrations of water-soluble solids, primarily salts and trace elements.

The Sierra Nevada on the east side of the Valley is predominately comprised of uplifted granite rock overlaid in areas by sedimentary and metamorphic rock. Sierran alluvial deposits in the District consist primarily of well-sorted sands, with minor amounts of clay. The Sierran alluvium decreases in thickness and increases in depth below the surface toward the west. These coarse-textured sediments are characterized by high permeability and a low concentration of water-soluble solids.

One of the principal subsurface geological features of the San Joaquin Valley is the Corcoran Clay formation. Formed as a lakebed about 600,000 years ago, this clay layer ranges in thickness from 20 to 200 feet and underlies most of the District. Varying depths from 200 to 500 feet in the Valley through to 850 feet along the Diablo Range, the Corcoran Clay divides the groundwater system into two major aquifers—a confined aquifer below and a semi-confined system above.

Westside Groundwater Basin

The groundwater basin underlying the District is comprised generally of two water-bearing zones: (1) an upper zone above a nearly impervious Corcoran Clay layer containing the Coastal and Sierran aquifers and (2) a lower zone below the Corcoran Clay containing the Sub-Corcoran aquifer. These water-bearing zones are recharged by subsurface inflow from the west, east, and northeast, and by percolation of applied surface water. A generalized cross section of the District showing the Corcoran Clay and these water-bearing zones is shown in Figure 1.

The Corcoran Clay separates the upper and lower water bearing zones in the majority of the District; however, it is not continuous and diminishes near the San Luis Canal. The United States Geological Survey (USGS) lines of equal elevation for the base of the Corcoran Clay are shown in Figure 2.

Groundwater quality, measured as electrical conductivity, in the lower water-bearing zone (Sub-Corcoran aquifer) varies throughout the District as shown in Figure 3. Typically, water quality varies with depth, with poorer quality present at the upper and lower limits of the aquifer and with the optimum quality somewhere between. The upper limit of the lower aquifer is the base of the Corcoran Clay and the USGS identifies the lower limit as the base of the fresh groundwater. The quality of the groundwater below the base of fresh water exceeds 2,000 parts per million total dissolved solids (TDS) which is too high for irrigating crops. The elevation for the base of the fresh groundwater is shown in Figure 4.

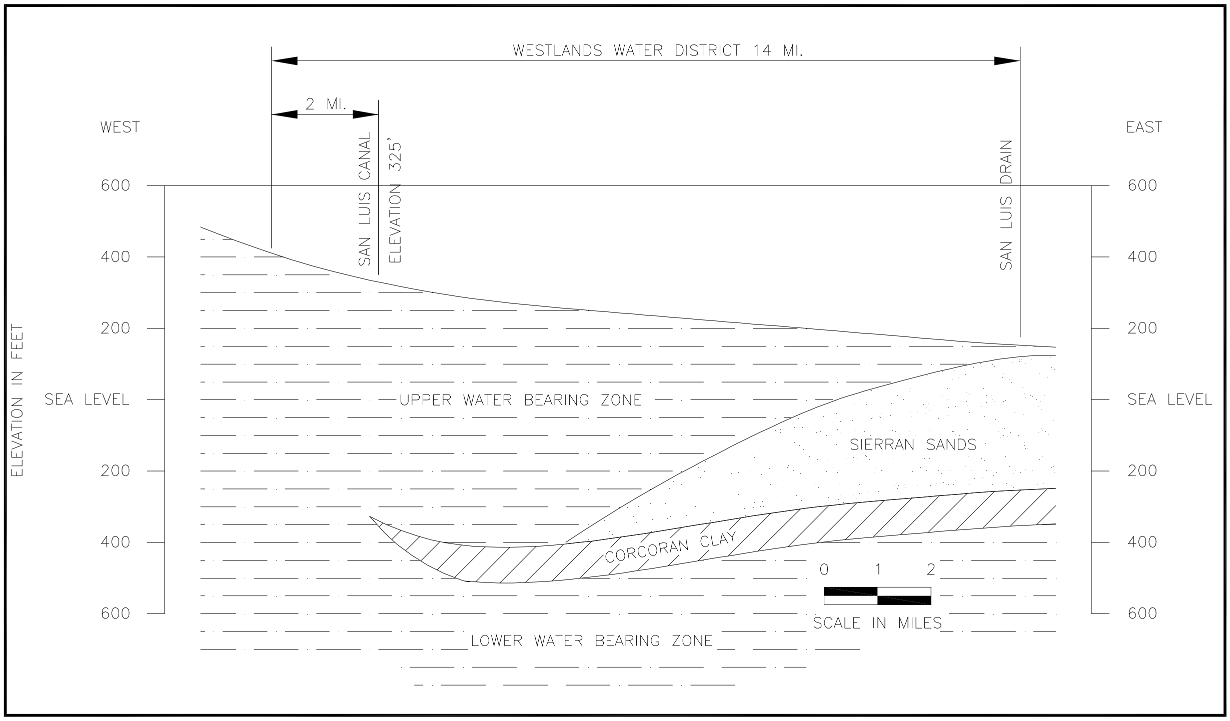
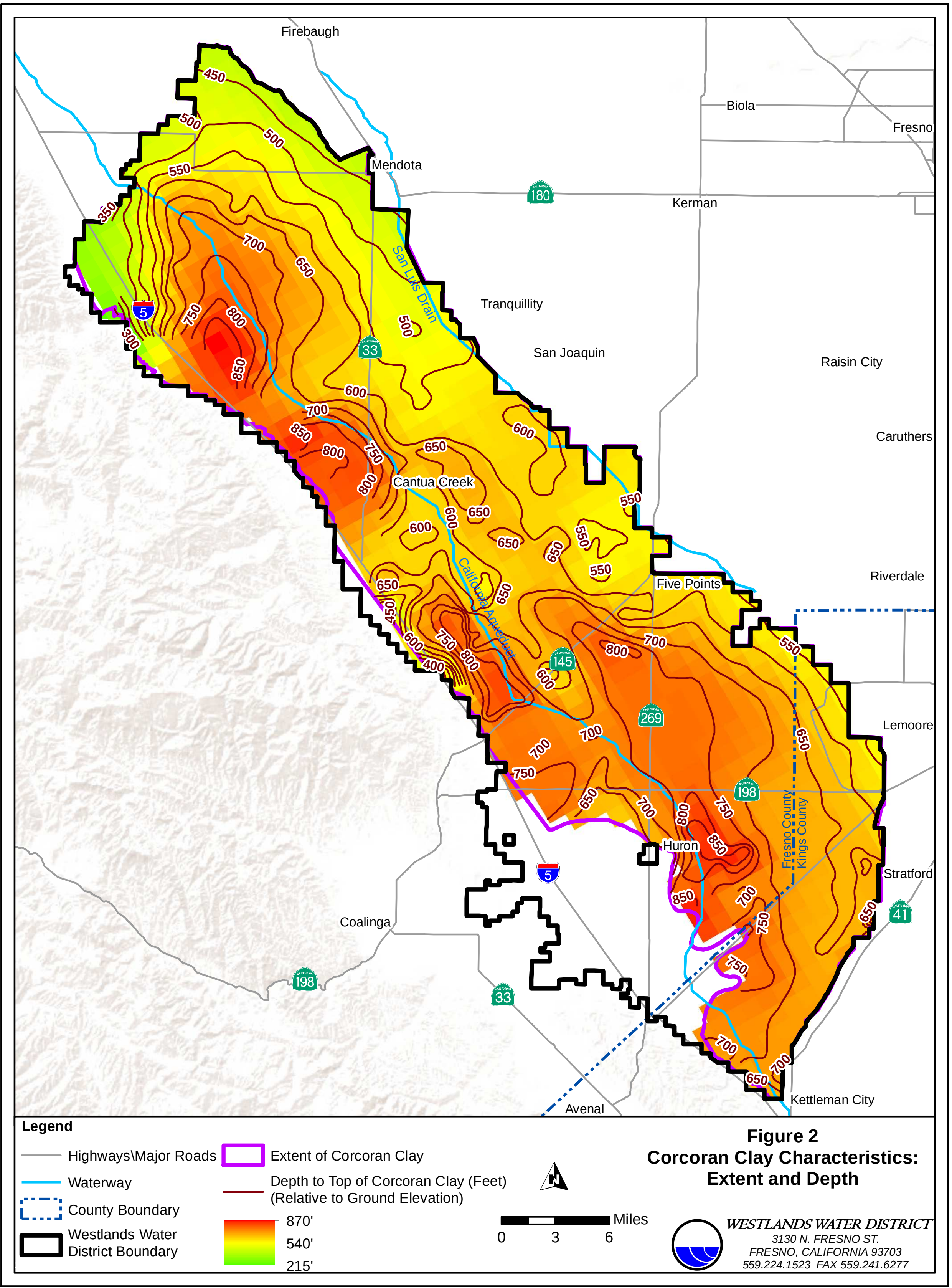


Figure 1: A generalized Hydro-geological Cross Section of the District.



C:\WWD_Data\2016-W-0019\Figure 2 Corcoran Clay Extent and Depth.mxd

Data Source: Central Valley Hydrologic Model
Ground Surface Elevation Datums: Horizontal Datum of NAD83 and Vertical Datum of NAVD 88
Date: 4/7/2016

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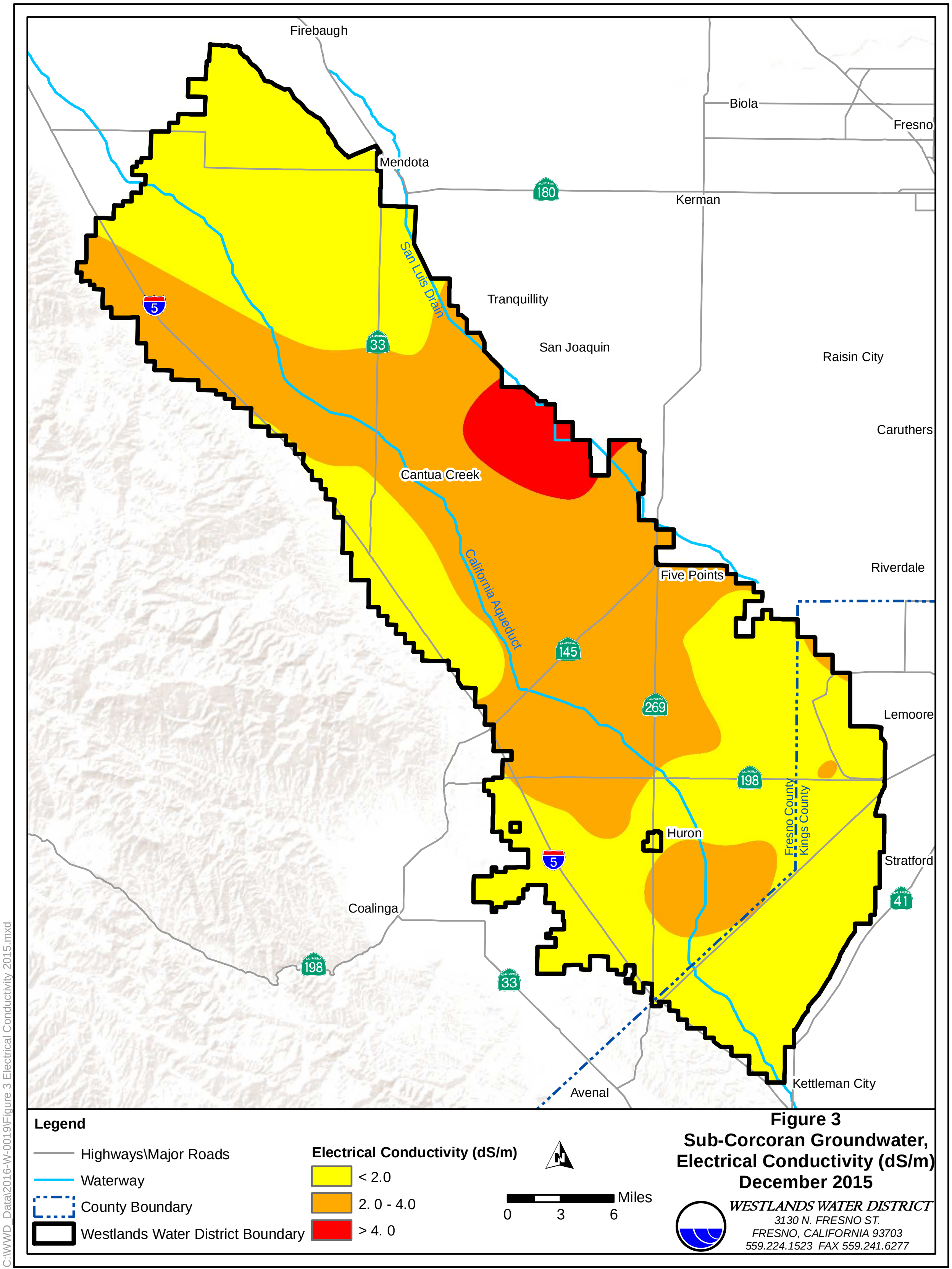
Figure 2: Elevation of the Base of the Corcoran Clay (USGS Lines of Equal Elevation)

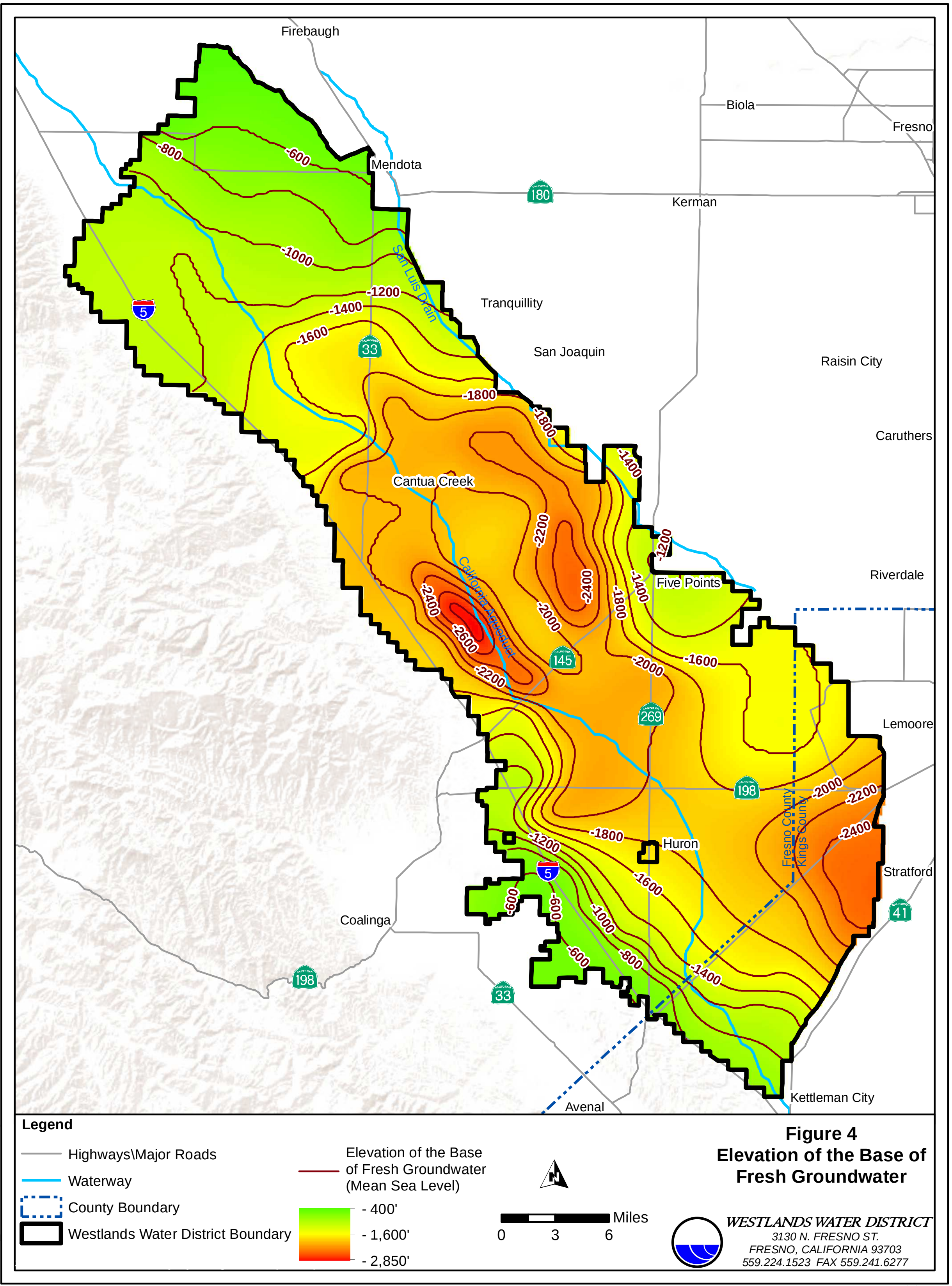


C:\WWD_Data\2016-W-0019\Figure 3 Electrical Conductivity 2015.mxd

Ground Surface Elevation Datums: Horizontal Datum of NAD83 and Vertical Datum of NAVD 88

Date: 4/7/2016

Figure 3: The Sub-Corcoran Groundwater, Electrical Conductivity (dS/m), December 2015.



C:\WWD_Data\2016-W-0019\Figure 4 Elevation of the Base of Fresh Groundwater.mxd

Vertical Datum of Mean Sea Level (MSL)

Date: 4/7/2016

Figure 4: The elevation of the Base of Fresh Groundwater (USGS Lines of Equal Elevation).

Groundwater Monitoring Program

CVP Project water and other surface water supplies are carefully allocated and all deliveries are metered, resulting in accurate water use data to manage the supplies and determine water delivery costs. Surface water quality is monitored by state and federal agencies.

Groundwater measurements and quality testing have proved useful to water users in helping them manage water supplies, facilitate accurate irrigation-scheduling, monitor pump efficiency and participate in District groundwater programs. It also enables the District to better monitor groundwater supplies, calculate drought impacts, and determine long-term water needs.

Groundwater monitoring is an essential part of managing any conjunctive use program. This information is vital to determine the effect of groundwater pumping on the aquifer, aquifer water quality, pumping costs, and subsidence. Without effective monitoring, the short and long-term impacts of conjunctive use cannot be determined.

Annually, District wells are monitored by sounding each well while in a static condition for depth or by measuring the electrical conductivity of the water while the pump is operating. Results from the annual survey are stored in a groundwater database and used to formulate District reports and maps. The survey information enables the District to monitor groundwater trends, provide reports to water users, estimate District-wide pumped groundwater quantities, and calculate seasonal application efficiency more accurately.

Many of the District water users participated in the Canal Integration Program (CIP) and the Groundwater Distribution Integration Program (DIP) from 1990-1994, which allowed groundwater to be pumped into the SLC and into the District’s distribution system. The water users received surface water credits for the volume of groundwater pumped into the system, which was then used to meet their crop demand schedule. However, in 1995, the California Department of Water Resources (DWR) suspended the discharge of groundwater into the SLC, due to concerns that groundwater could degrade the water quality. The DIP program has continued throughout this period except in years when the District received 100 percent allocation. Briefly, in 2008, DWR allowed the District to pump groundwater into the SLC for the period June through September because of restricted pumping from the Delta. In 2014, the District was again allowed to pump groundwater into the SLC for the period July through November and a small amount in February 2015. CIP pumping was again allowed from August to October 2015.

District staff conducted the Annual Deep Groundwater Survey for 2015 and visited 1,210 well locations. The total number of operational wells within the District was 792 of which 97.1% have meters and 124 non-operational wells of which 56.5% have meters. Additionally, the District visited 32 wells outside its boundaries finding 25 operational wells of which 68.0% have meters and 7 non-operational wells with one having a meter. The majority of the non-District wells monitored are located along the District's eastern boundary.

The reduction of CVP water and other surface water supplies has resulted in the construction of many new wells. There have been 605 new wells constructed within the District since 2000, to make up for the shortfall in surface irrigation water.

Historic Conditions

Prior to the delivery of CVP water into the District, the annual groundwater pumping ranged from 800,000 to 1,000,000 acre-feet (AF) during the period of 1950-1968. The majority of this pumping was from the aquifer below the Corcoran Clay causing the sub-Corcoran piezometric groundwater surface (groundwater surface) to reach the lowest recorded average elevation of 156 feet below mean sea level in 1967. The USGS concluded that extraction of large quantities of groundwater prior to CVP deliveries resulted in compaction of water bearing sediments and caused land subsidence ranging from 1 to 24 feet between 1926 and 1972 (U.S. Geological Survey, 1988).

After CVP water deliveries began in 1968, the groundwater surface rose steadily until reaching 89 feet above mean sea level in 1987, the highest average elevation on record dating back to the early 1940's. The only exception during this period was in 1977 when a drought and drastic reduction of CVP deliveries resulted in groundwater pumping of approximately 472,000 AF and an accompanying drop in the groundwater surface elevation of approximately 97 feet.

During the early 1990's, groundwater pumping increased due to reduced CVP water supplies due to drought, regulatory actions related to the Central Valley Project Improvement Act, the Endangered Species Act, and Bay/Delta water quality requirements. Groundwater pumping reached an estimated 600,000 AF annually during 1991 and 1992 when the District received only 25 percent of its contractual entitlement of CVP water. This increased pumping caused the groundwater surface to decline to 62 feet below mean sea level, the lowest elevation since 1977. The Department of Water Resources estimated the amount of subsidence since 1983 to be almost two feet in some areas of the District, with most of that subsidence occurring since 1989.

Recent Conditions

Over the last five years, 2011 to 2015, CVP allocations averaged 28% (319,693 acre-feet), total groundwater pumped was 2,353,000 acre-feet and the groundwater surface elevation decreased 169 feet. The CVP allocation for the 2015/16 water year was 0% (0 acre-feet) and with the accompanying increase in groundwater pumped (660,000 acre-feet), the groundwater surface decreased 44 feet from 2014/15 to 2015/16 to an average elevation of 120 feet below mean sea level. With the 2016/17 water year CVP allocation again at 0%, the District anticipates groundwater pumping will range from 650,000 – 700,000 AF. The water elevation could drop between 20 and 50 feet to levels not seen since the 1960's.

Groundwater elevations and the estimated amount of groundwater pumped for the last sixty years are shown in Table 2. This table shows the average elevation of the groundwater in the lower water bearing zone and the change in elevation for each year.

Crop[1] Year	Pumped AF	Elevation FT	Elevation Change FT	Crop Year	Pumped AF	Elevation FT	Elevation Change FT
1956	964,000	-65	-13	1986	145,000	71	8
1957	928,000	-56	9	1987	159,000	89	18
1958	884,000	-29	27	1988	160,000	64	-25
1959	912,000	-77	-48	1989	175,000	63	-1
1960	872,000	-81	-4	1990	300,000	9	-54
1961	824,000	-96	-15	1991	600,000	-32	-41
1962	920,000			1992	600,000	-62	-30
1963	883,000			1993	225,000	1	63
1964	913,000			1994	325,000	-51	-52
1965	822,000			1995	150,000	27	78
1966	924,000	-134		1996	50,000	49	22
1967	875,000	-156	-22	1997	30,000	63	14
1968	596,000	-135	21	1998	15,000	63	0
1969	592,000	-120	15	1999	20,000	65	2
1970	460,000	-100	20	2000	225,000	43	-22
1971	377,000	-93	7	2001	215,000	25	-18
1972		-54	39	2002	205,000	22	-3
1973		-37	17	2003	160,000	30	8
1974	96,000	-22	15	2004	210,000	24	-6
1975	111,000	-11	11	2005	75,000	56	32
1976	97,000	-2	9	2006	15,000	77	21
1977	472,000	-99	-97	2007	310,000	35	-42
1978	159,000	-4	95	2008	460,000	-11	-46
1979	140,000	-13	-9	2009	480,000	-31	-20
1980	106,000	4	17	2010	140,000	9	40
1981	99,000	11	7	2011	45,000	49	40
1982	105,000	32	21	2012[2]	355,000	1	-48
1983	31,000	56	24	2013	638,000	-58	-59
1984	73,000	61	5	2014	655,000	-76	-18
1985	228,000	63	2	2015	660,000	-120	-44

Table 2: 60-years of estimated groundwater pumpage.[3]

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[1] Crop year is from 1 October (previous year) to 30 September (current year) for the year in question.

[2] Starting with 2012 the amount of groundwater pumped is for Water Year (March 1 through February 28).

[3] Data compiled from PG&E power records by USBR through 1971 and USGS 1974-1987, District estimates 1988-present. Elevation data for 1943-1961 and 1977 from Bill Coor, USBR (requested by the District and received on 4/20/1978) and elevation for 1966-1976 from Plate 5 of "Project Effects on Sub-Corcoran Water Layers" (April 1977).

Figure 5 shows in graphical format the historical average elevation of the Sub-Corcoran piezometric groundwater surface and the estimated amount of groundwater pumped in the District for the last 30 years. Figures 6 and 7 shows the depth to the piezometric groundwater surface in the lower water-bearing zone during December 2011 and during December 2015, respectively. Change in depth to the piezometric groundwater surface from December 2011 to December 2015 is shown in Figure 8.

In addition to monitoring the water levels of wells pumping from the lower aquifer, the wells pumping from the upper aquifer are also monitored. The majority of the wells pumping from the upper aquifer had groundwater surface levels 100 to 300 feet below ground surface during December 2015 as shown in Figure 9.

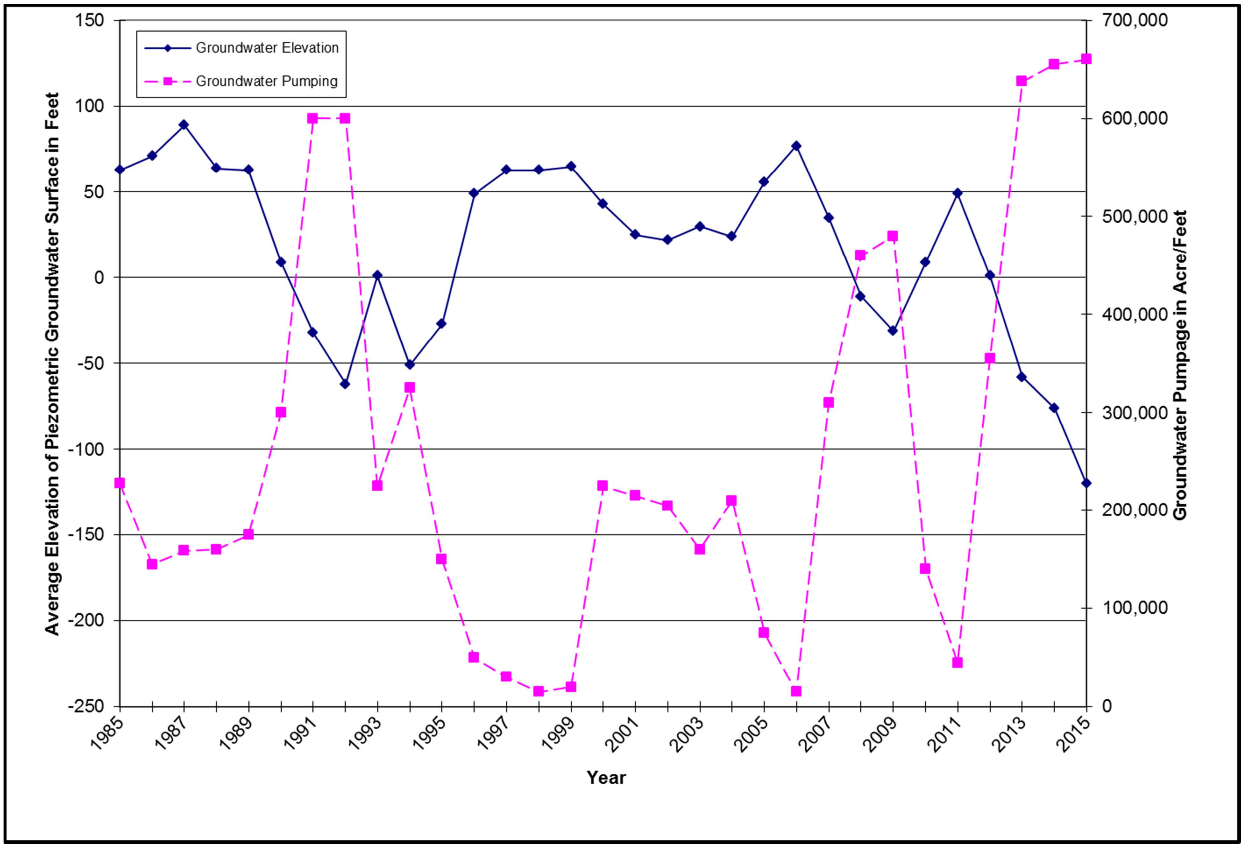
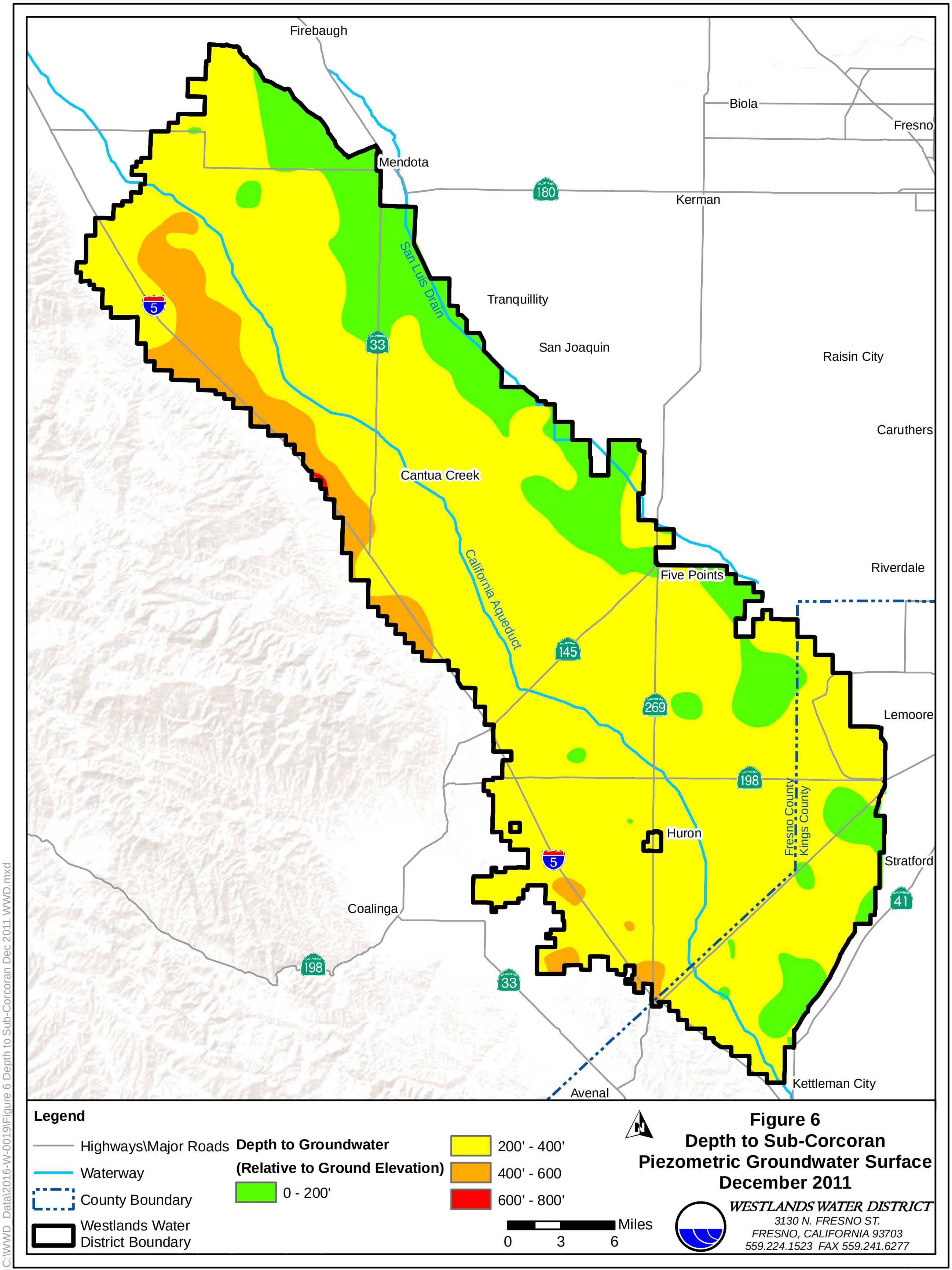


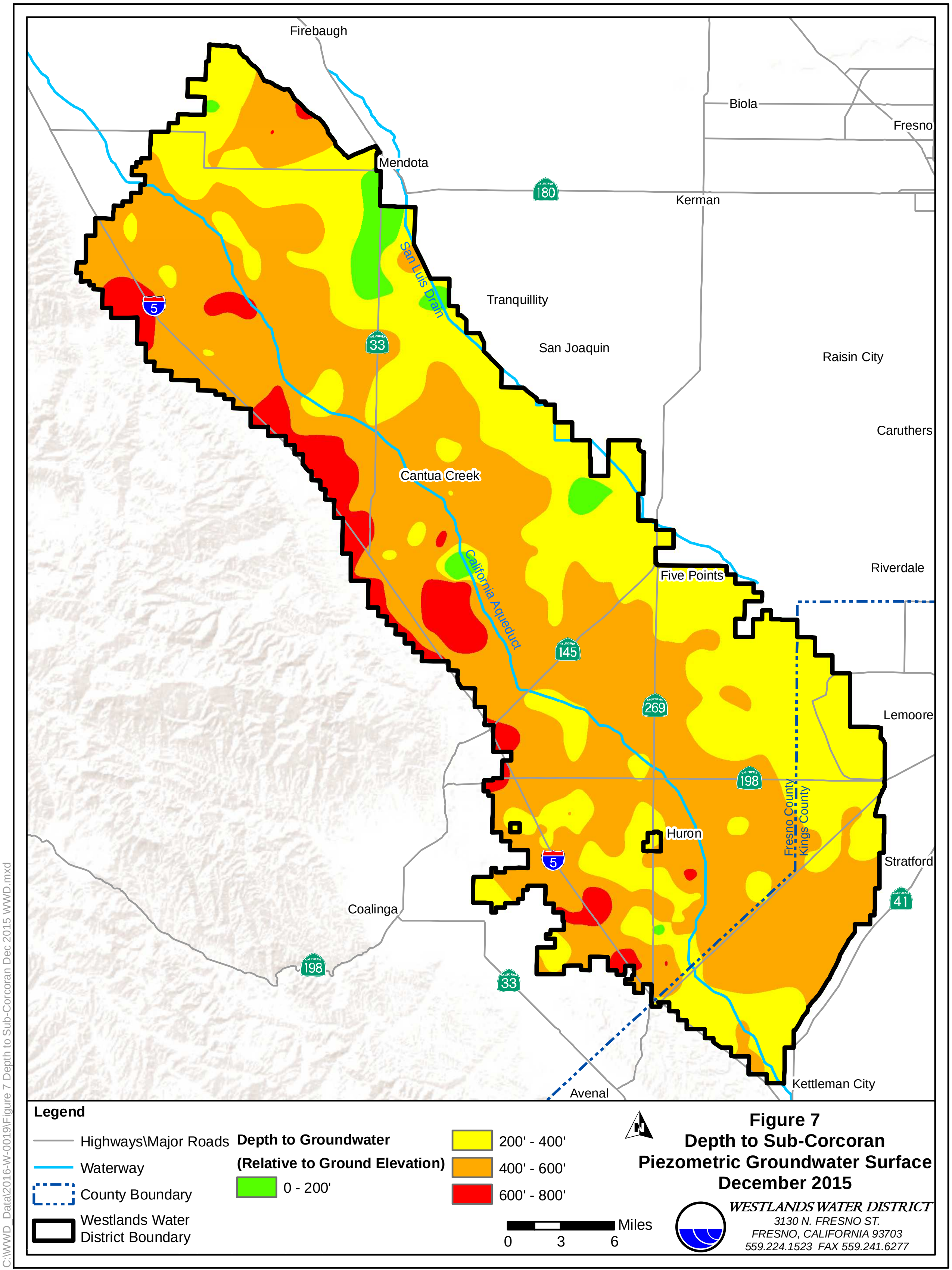
Figure 5: The Historical Average Elevation of Sub-Corcoran Piezometric Groundwater Surface and Groundwater Pumpage.



Ground Surface Elevation Datums: Horizontal Datum of NAD83 and Vertical Datum of NGVD 29

Date: 4/7/2016

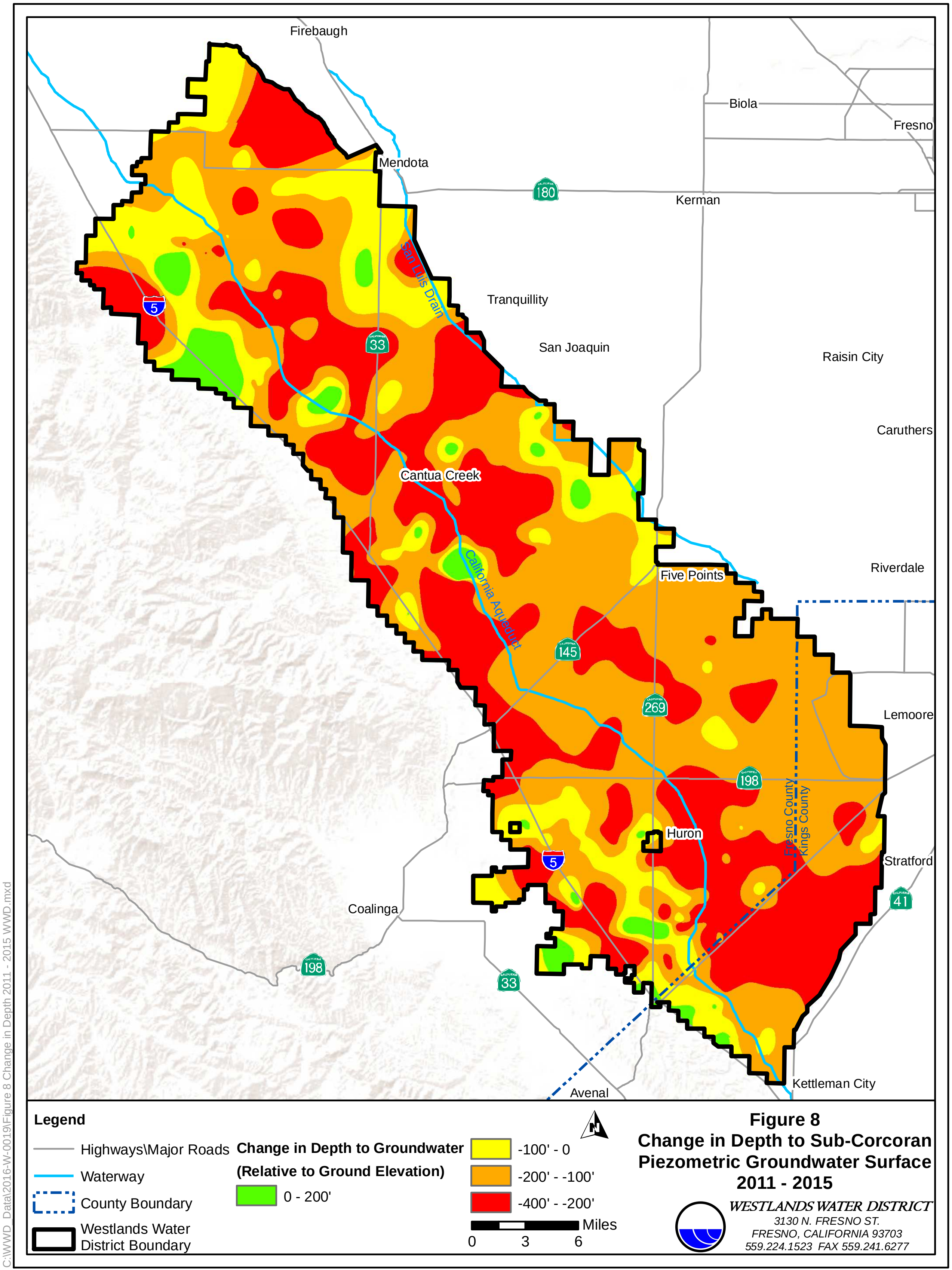
Figure 6: Depth to Sub-Corcoran Piezometric Groundwater Surface, December 2011.



Ground Surface Elevation Datums: Horizontal Datum of NAD83 and Vertical Datum of NAVD 88

Date: 4/7/2016

Figure 7: Depth to Sub-Corcoran Piezometric Groundwater Surface December 2015.



C:\WWD_Data\2016-W-0019\Figure 8 Change in Depth 2011 - 2015 WWD.mxd

Ground Surface Elevation Datums: Horizontal Datum of NAD83 and Vertical Datum of NAVD 88

Date: 4/7/2016

Figure 8: Change in Depth to the Sub-Corcoran Piezometric Groundwater Surface 2011-2015.

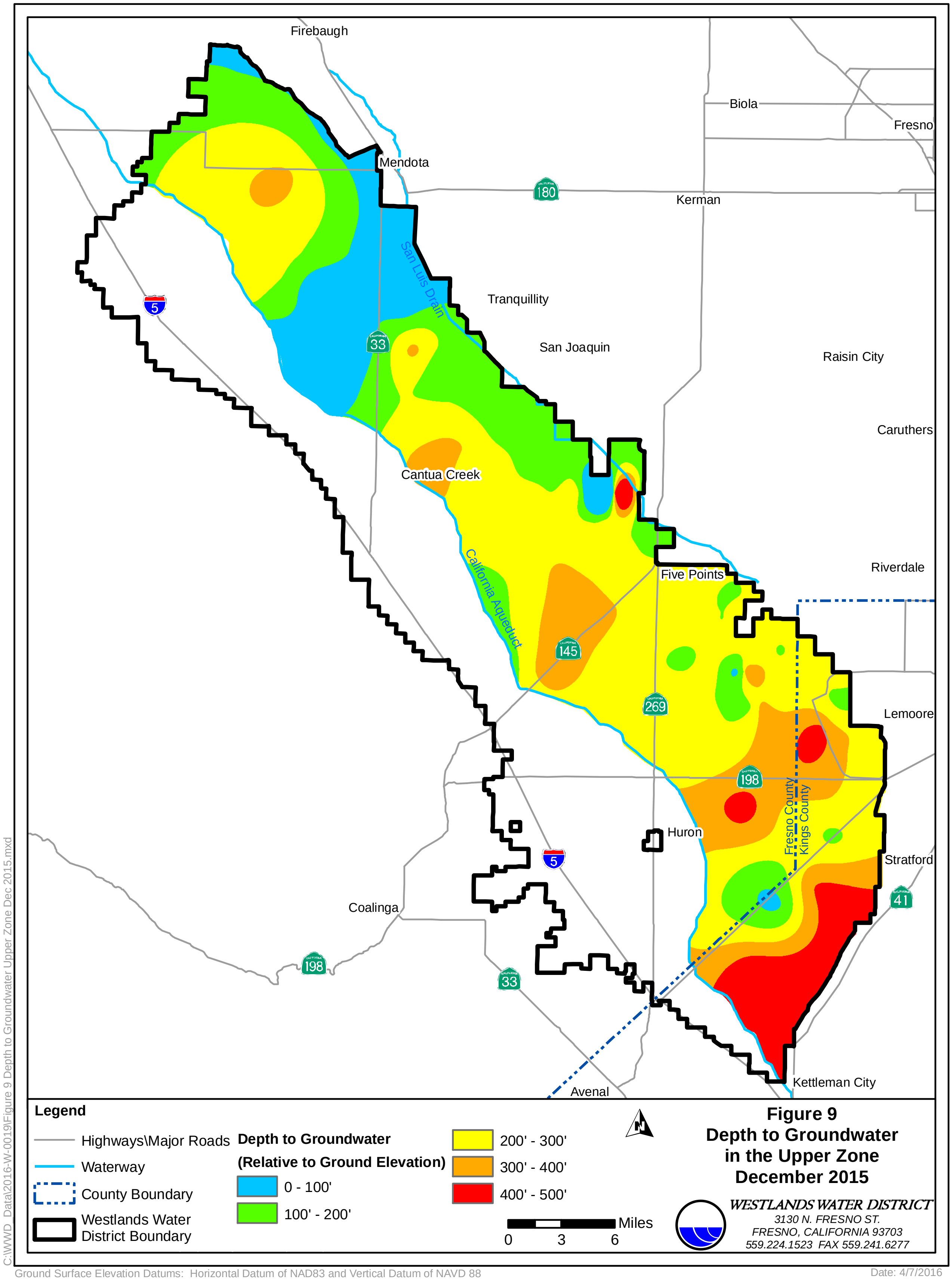


Figure 9: Depth to Groundwater in the Upper Zone, December 2015.

Safe Yield

Safe yield or current perennial yield is the amount of groundwater that can be extracted without lowering groundwater levels over the long term. Current perennial yield can be determined by plotting the amount of groundwater pumped in one year versus the average change in groundwater level in the basin for that year. Data for 1976 to present were plotted and a "best fit" was drawn. The intersection of the best fit with the line showing zero groundwater level change as shown in Figure 10 indicates the current perennial yield of groundwater could range from 200,000 – 225,000 AF.

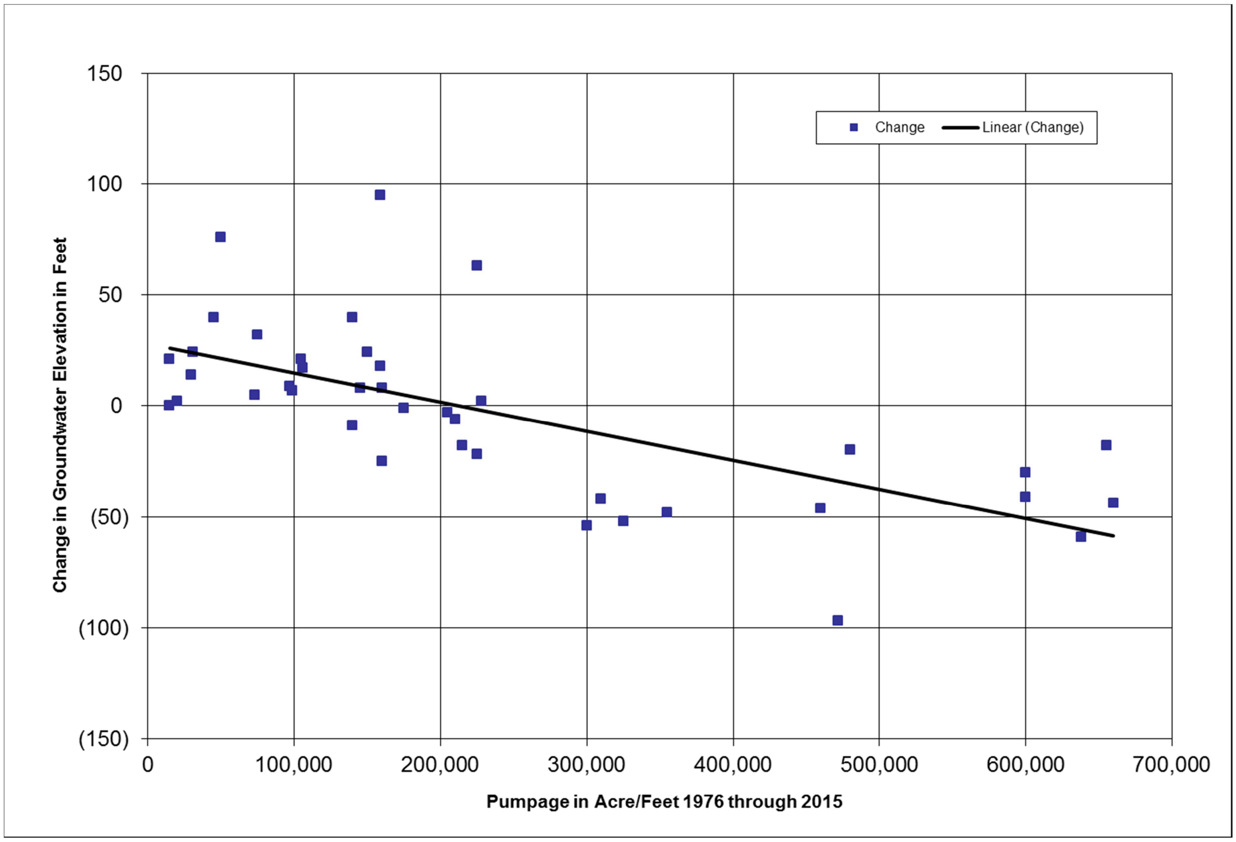


Figure 10: Change in Groundwater Elevation versus Pumping.