Groundwater-Related Land Subsidence

Land subsidence has not been monitored in the Redding Area Groundwater Basin. However, there would be potential for subsidence in some areas of the basin if groundwater levels decline below historic low levels. The groundwater basin west of the Sacramento River is composed of the Tehama Formation; this formation has exhibited subsidence in Yolo County and the similar hydrogeologic characteristics in the Redding Area Groundwater Basin could be conducive to land subsidence.

Groundwater Quality

Groundwater in the Redding Area Groundwater Basin is typically of good quality, as evidenced by its low total dissolved solids (TDS) concentrations, which range from 70 to 360 milligrams per liter (mg/L). Areas of high salinity (poor water quality), are generally found on the western basin margins, where the groundwater is derived from marine sedimentary rock. Elevated levels of iron, manganese, nitrate, and high TDS have been detected in some areas. Localized high concentrations of boron have been detected in the southern portion of the basin (DWR Northern District 2002).

3.3.1.3.2 Sacramento Valley Groundwater Basin

The Sacramento Valley Groundwater Basin includes portions of Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Solano, Tehama, Yuba and Yolo counties. The Sacramento Valley Groundwater Basin is bordered by the Red Bluff Arch to the north, the Coast Range to the west, the Sierra Nevada to the east, and the San Joaquin Valley to the south. Bulletin 118 further divides the Sacramento Valley Groundwater Basin into subbasins (DWR 2003). Figure 3.3-5 shows the Sacramento Valley Groundwater Basin and subbasins. The following section provides information on geology, hydrogeology, hydrology, groundwater production, groundwater levels and storage, land subsidence, and groundwater quality.

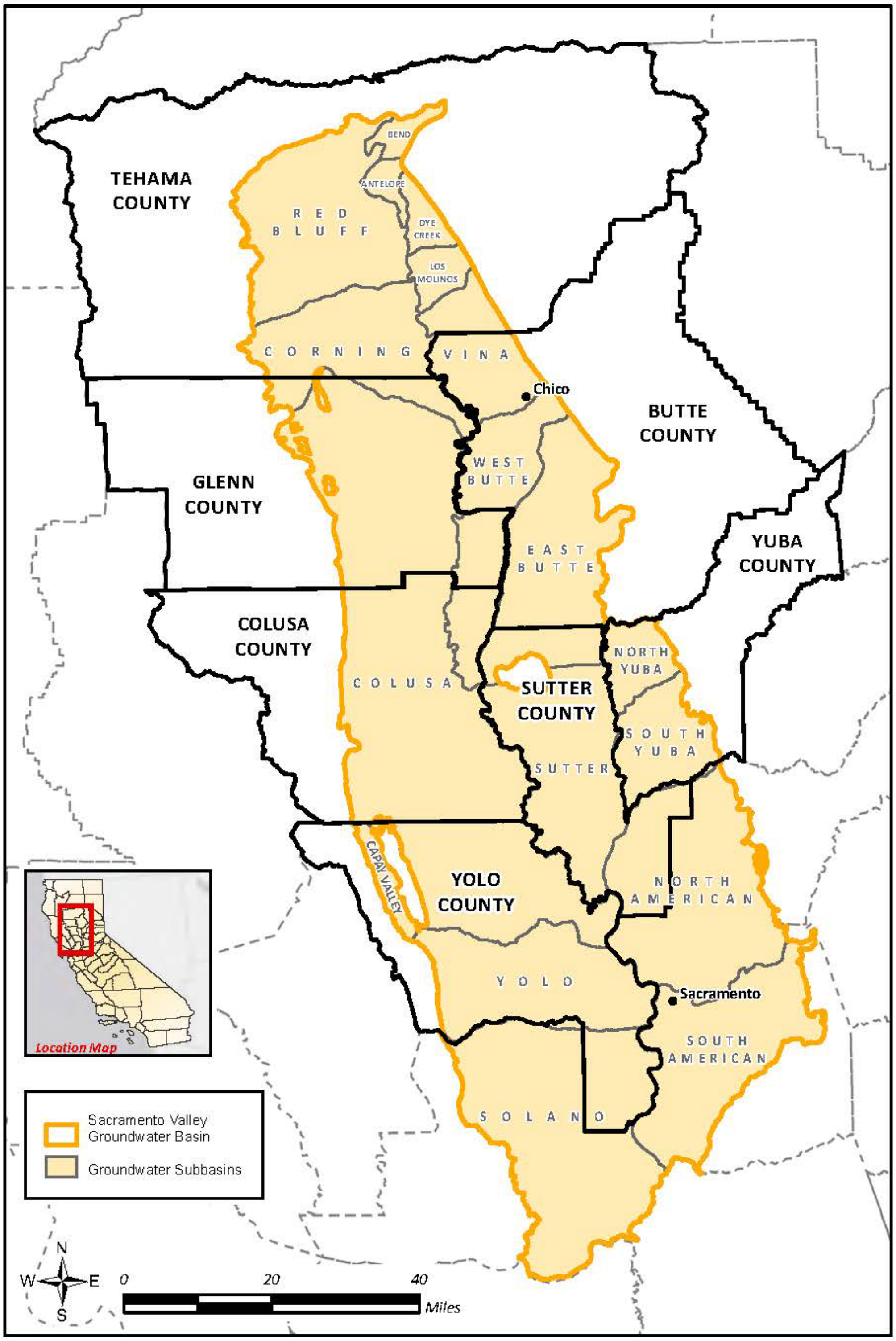


Figure 3.3-5. Sacramento Valley Groundwater Basin

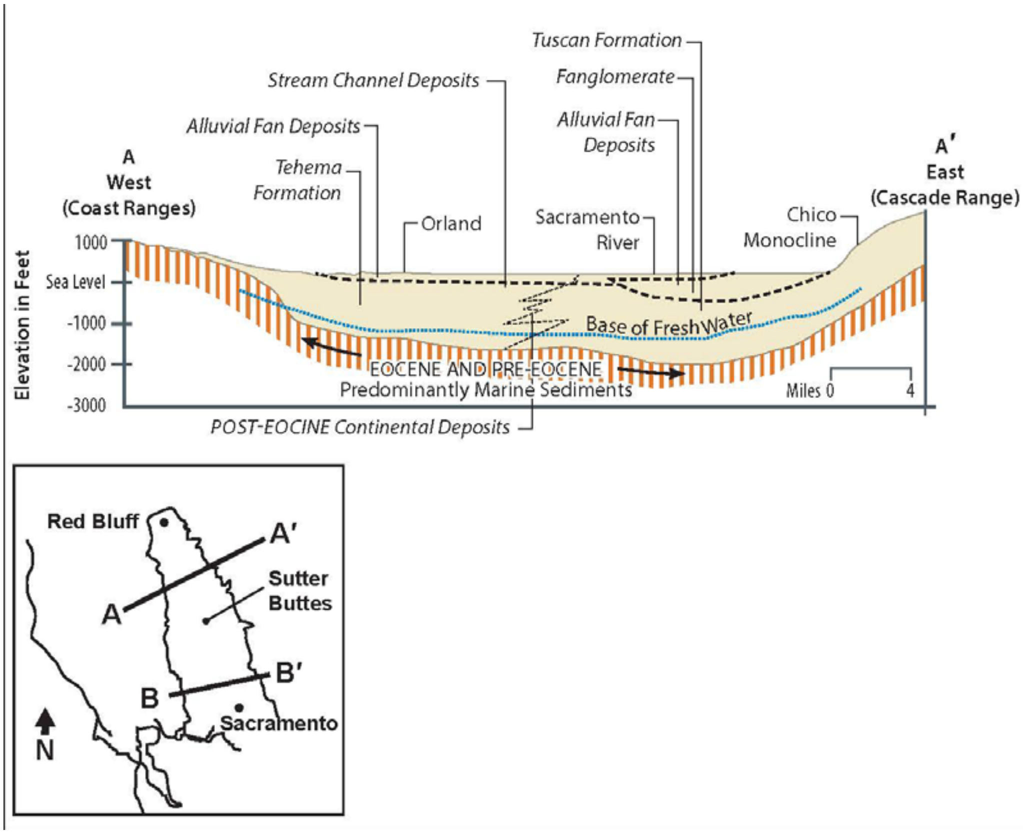
Geology, Hydrogeology, and Hydrology

The Sacramento Valley Groundwater Basin is a north-northwest trending asymmetrical trough filled with both marine and continental rocks and sediment. On the eastern side, the basin overlies basement rock that rises relatively gently to the Sierra Nevada, while on the western side the underlying basement rock rises more steeply to form the Coast Range. Overlying the basement rock are marine sandstone, shale, and conglomerate rocks, which generally contain brackish or saline water (DWR 1978). The freshwater-bearing formation in the valley comprises of sedimentary and volcanic rocks that have the ability to absorb, transmit and yield fresh water. The depth below ground surface (bgs) to the base of freshwater is approximately 1,150 feet in the northern portion of the Sacramento Valley and approximately 1,600 feet in the southern portion of the Sacramento valley (DWR 1978).

Along the eastern and northeastern portion of the basin are the Tuscan and Mehrten formations, derived from the Cascade and Sierra Nevada ranges. The Tehama Formation in the western portion of the basin is derived from Coast Range sediments. In most of the Sacramento Valley Groundwater Basin, the Tuscan, Mehrten, and Tehama formations are overlain by relatively thin alluvial deposits.

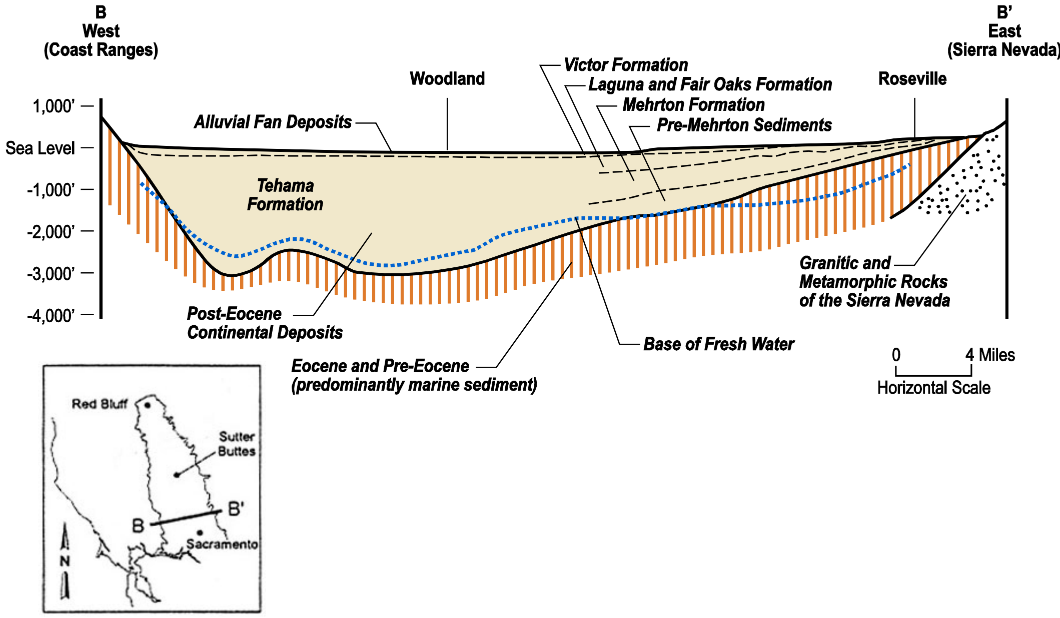
Freshwater is present primarily in the heterogeneous gravel and sand layers of the Laguna, Mehrten, Tehama, and Tuscan formations and in shallower alluvial deposits of the Riverbank and Modesto formations and the Stony Creek fan alluvium that overly the deeper Eocene and Pre-Eocene marine deposits (DWR Northern District 2014). Figures 3.3-6 and ~~Figure~~ 3.3-7 are generalized cross sections for the northern and southern portions of the Sacramento Valley Groundwater Basin, respectively. Groundwater users in the basin pump primarily from aquifers above the marine deposits.

Groundwater is recharged by deep percolation from rainfall infiltration, leakage from streambeds, lateral inflow along the basin boundaries, and landscape processes, including irrigation. The primary source of recharge has become deep percolation of irrigation water past crop roots, sometimes referred to as recharge from excess applied irrigation water. Of the average 13.3 million AF of groundwater recharged annually from 1962 to 2003, the USGS's Central Valley Hydrologic Model (CVHM) estimates that approximately 19 percent was from streamflow leakage and 79 percent was from the landscape processes, including recharge from excess applied irrigation water and from precipitation (Faunt 2009). Average annual precipitation in the Sacramento Valley Groundwater Basin ranges from 13 to 26 inches, with the higher precipitation of 46 inches occurring along the eastern and northern edges of the basin. Typically, 85 percent of the basin's precipitation occurs from November to April, half of it during December through February in average years (Faunt 2009).



Source: DWR 1978

Figure 3.3-6. North Geologic Cross Section of the Sacramento Valley Groundwater Basin



Source: DWR 1978

Figure 3.3-7. South Geologic Cross Section of the Sacramento Valley Groundwater Basin

The main surface water feature in the Sacramento Valley Groundwater Basin is the Sacramento River which flows from north to south through the basin. The Sacramento River has several major tributaries draining the Sierra Nevada, including the Feather River, Yuba River, and American River. Stony Creek, Cache Creek, and Putah Creek drain the Coast Range and are the main west side tributaries of the Sacramento River. Surface water and groundwater interact on a regional basis, and gains and losses to groundwater vary spatially and temporally.

Groundwater Production, Levels, and Storage

Groundwater pumping can be generally grouped into agricultural and urban, which includes M&I sources. Agricultural groundwater pumping supplies water for the crops grown in the basin. Truck, field, orchard, and rice crops are grown on approximately 2.1 million acres; rice represents about 23 percent of the total acreage (DWR 2003 as cited in Faunt 2009). The water supply for growing rice relies on a combination of surface water and groundwater. Groundwater accounts for less than 30 percent of the annual supply used for agricultural and urban purposes in the Sacramento Valley (Faunt 2009). Urban pumping in the Sacramento Valley increased from approximately 250,000 AF annually in 1961 to more than 800,000 AF annually in 2003 (Faunt 2009).

DWR and other monitoring entities, as defined by SB X7 6 extensively monitors groundwater levels in the basin. The total depth of monitoring wells range from 18 to 1,380 feet bgs within the Sacramento Valley Groundwater Basin.

Figures 3.3-8a, 3.3.-8b, and Figure 3.3-9 8c show the location and groundwater elevation of select monitoring wells across the Sacramento Valley that portray show the local groundwater elevations in the shallow, intermediate, and deep portions of the aquifer, respectively.within the Sacramento Valley Groundwater Basin. The dotted blue line in these figures is the measured groundwater level data. Each graph in these figures represents the period of available data for that well between 1970 and 2014. Appendix L shows a larger format version of each hydrograph in Figures 3.3-8a, 3.3-8b and 3.3-8c. The shallow wells in Figure 3.3-8a show long term trends that are either increasing, stable, or decreasing, depending on the well. Several wells also show the recovery of groundwater levels following drought periods. For example, well 09N02E16N001M (shallow well) shows declines in water levels during drought periods (1976 to 1977; and 1987 to 1992). Groundwater levels at this well recovered to levels observed before each drought during subsequent wet periods. This response following drought periods can also be seen at other shallow wells (06N02E19J001M, 08N06E09Q004M). The groundwater level at 09N02E16N001M has declined since 2013. However, the levels at this well have not reached the historic low levels recorded during the 1970s.

Water levels at well 21N03W33A004M generally declined during the 1970s and prior to import of surface water conveyed by the Tehama-Colusa Canal. During the 1980s, groundwater levels recovered due to import and use of surface water supply and because of the 1982 to 1984 wet water years (DWR 2014a). Groundwater levels in well 15N03W01N001M (which is surrounded by agricultural lands) declined until 1978 and then recovered during the 1982-1984 wet years. After the 2008-2009 drought, water levels declined to historical lows. Water levels recovered quickly during 2010 and 2011, then after returned to the trend of long-term decline (DWR 2014a). Even though groundwater levels at wells 21N03W33A004M and 15N03W01N001M are generally showing a declining trend, groundwater levels in other wells in the basin have remained steady, declining moderately during extended droughts and recovering to pre-drought levels after subsequent wet periods (See Figure 3.3-8 and Figure 3.3-9 for Groundwater Elevations within the Sacramento Valley Groundwater Basin).

The hydrographs shown in Figure 3.3-8b show similar long term trends as the shallow wells (i.e., increasing, stable, or decreasing). Similar to the shallow wells, several intermediate wells show recovery of groundwater levels in wetter periods following drought conditions (17N02E31A001M, 18N04W23F001M, 22N02W09L003M). Several of A number of the wells in Figure 3.3-8b show recent groundwater levels at or below historic low levels. However, some of these wells also show levels above historic low levels.

Of the hydrographs shown in Figure 3.3-8c, several ofa number these wells show long-term declining water level trends. Most of the wells shown in this figure have a shorter measurement record. The recovery of water levels following drought periods can be seen in the hydrograph for well 06N01E02B001M.

Figure 3.3-4 shows Spring 2013 groundwater elevation contours within the Redding Area and Sacramento Valley Groundwater Basins. Figures 3.3-9a, 3.3-9b, and 3.3-9c show the change in groundwater elevation from Spring 2013 to Spring 2014 within the Sacramento Valley. Figures 3.3-10a, 3.3-10b, and 3.3-10c show the change in groundwater elevation from Spring 2004 to Spring 2014 within the Sacramento Valley. Figure 3.3-11 shows the change in groundwater levels between Spring 2010 and Spring 2014. All the aforementioned figures indicate a general decreasing trend in groundwater levels in the Sacramento Valley. As shown in Figure 3.3-12, WY 2014 was one of driest years on record since 1977 and was preceded by two consecutive dry years (WY 2013 and WY 2012). Groundwater levels in the spring of 2014 changed between +5 to -20 feet within the Sacramento Valley in comparison to Spring 2013. Comparisons of spring groundwater levels in the last decade (Spring 2004 to Spring 2014) indicate steep declines in groundwater levels up to 40 feet.

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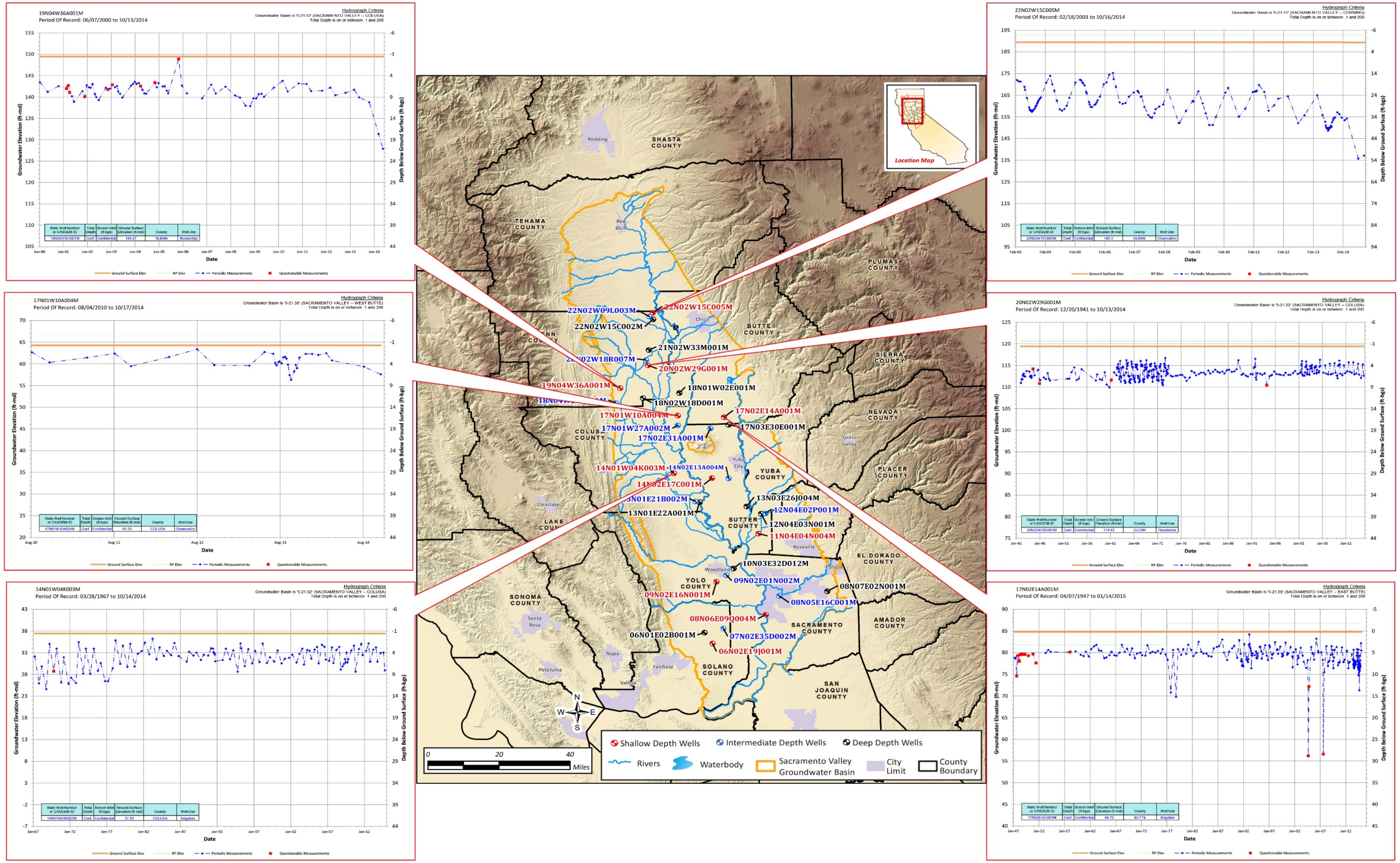

Source: DWR 2015b

Figure 3.3-8a. Sacramento Valley Groundwater Basin Historic Groundwater Elevations in Shallow Wells (less than 200 feet bgs)

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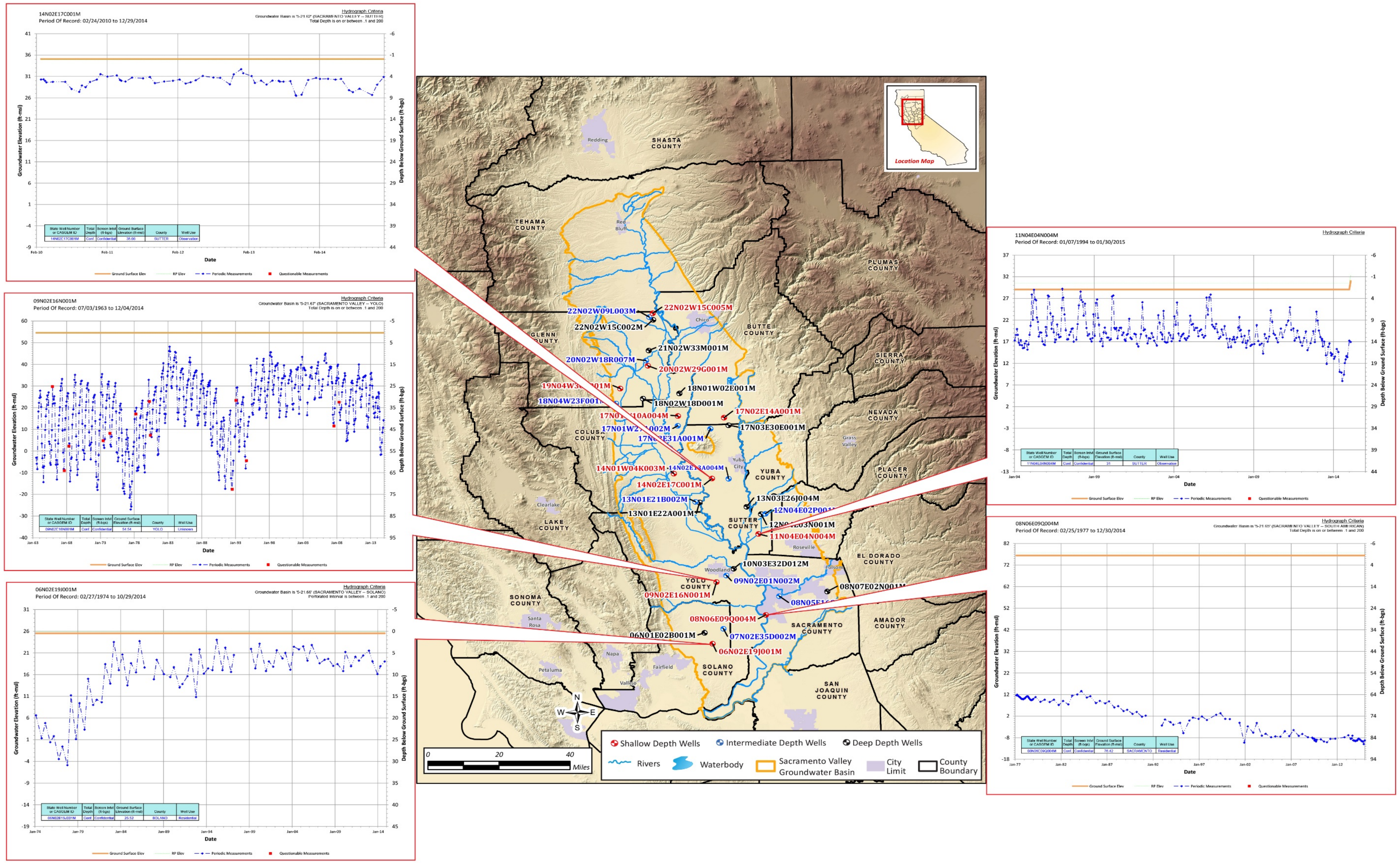

Source: DWR 2015b

Figure 3.3-8a continued. Sacramento Valley Groundwater Basin Historic Groundwater Elevations in Shallow Wells (less than 200 feet bgs)

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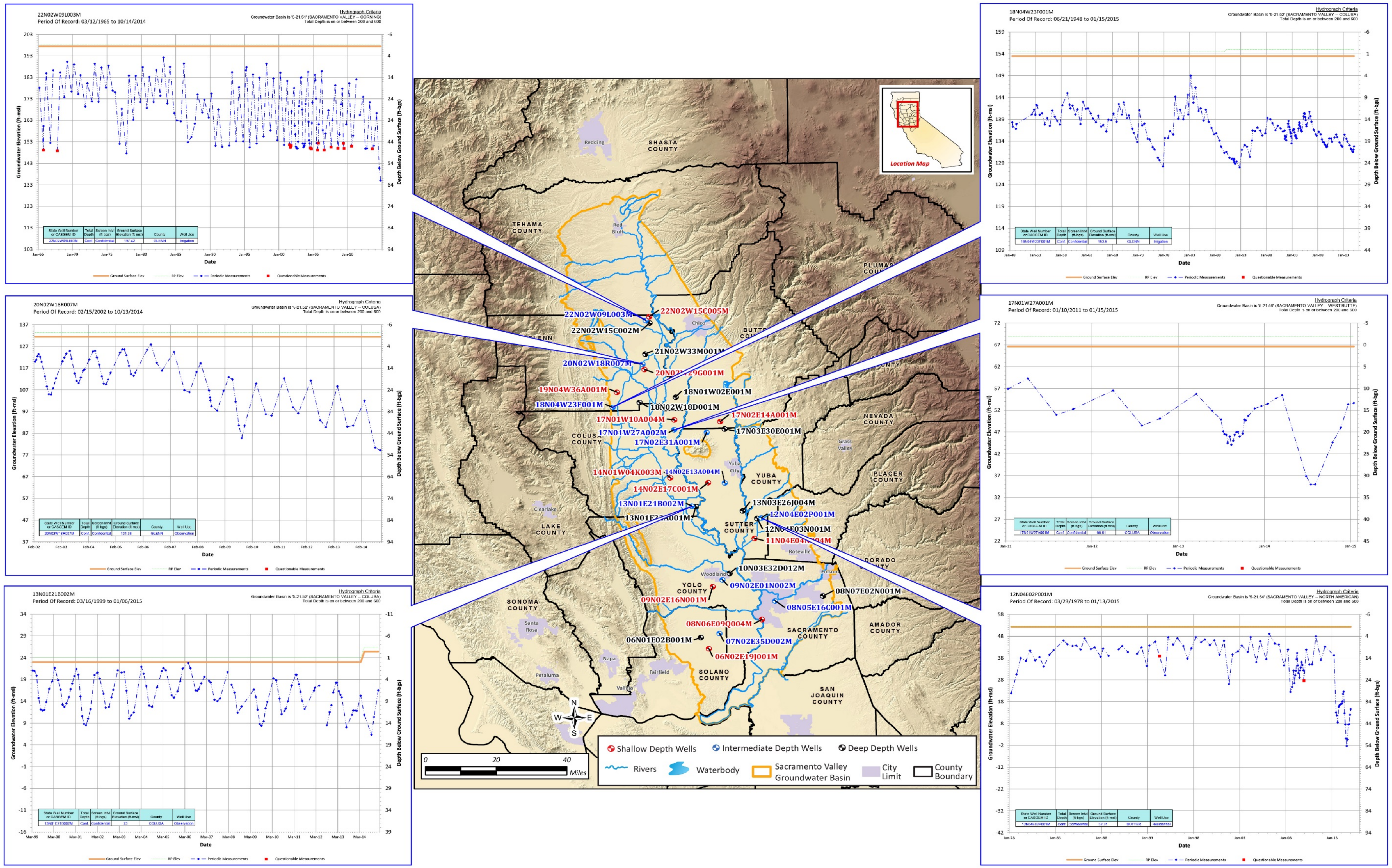

Source: DWR 2015b

Figure 3.3-8b. Sacramento Valley Groundwater Basin Historic Groundwater Elevations in Intermediate Depth Wells (between 200 feet to 600 feet bgs)

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