CHAPTER 2
BASIN SETTING

2.1 INTRODUCTION TO BASIN SETTING

Physical Setting and Characteristics

The Las Posas Valley Basin (LPVB) is located near the western edge of the Transverse Ranges Geomorphic Province, which extends from the San Bernardino Mountains in the east to San Miguel, Santa Rosa, and Santa Cruz Islands in the west (CGS 2002). The Transverse Ranges Geomorphic Province is characterized by a series of east-to-west-trending mountain ranges and valleys that are formed by north–south compression across a restraining bend in the San Andreas Fault (Hadley and Kanamori 1977; Bohannon and Howell 1982; Eberhart-Phillips et al. 1990; Nicholson et al. 1994; DeVecchio et al. 2012a). Compression across this restraining bend is responsible for rapid, ongoing uplift of the mountain ranges (Yeats 1988; Feigl et al. 1993; Marshall et al. 2008) and extensive folding and faulting of the Pleistocene and older geologic formations in the province (Rockwell et al. 1988; Huftile and Yeats 1995).

The LPVB, which underlies the east-to-northeast-trending Las Posas Valley in southern Ventura County, is bounded by the Camarillo and Las Posas Hills to the south, South Mountain and Oak Ridge to the north, the Santa Susana Mountains to the east, and the Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin to the west (SWRCB 1956; DWR 2003). The Oak Ridge/South Mountain uplift is an anticlinal structure associated with deformation in the hanging wall of the southward-dipping Oak Ridge Fault (Yeats 1988; DeVecchio et al. 2012a). To the south, the Las Posas Hills are part of the Camarillo fold belt, which consists of several active anticlinal folds (DeVecchio et al. 2012a). Between these two uplifts, the LPVB is bisected by the Las Posas syncline, an east-to-northeast-trending fold that plunges to the west.

The primary water-bearing formations from top to bottom in the LPVB are alluvium, the San Pedro Formation, and the Santa Barbara Formation. The Santa Barbara Formation is a lower Pleistocene marine sand, and the San Pedro Formation is a lower to middle Pleistocene shallow marine deposit that grades upward from a white gray sand and gravel basal layer into an overlying series of interbedded silts, clays, and gravels (SWRCB 1956; Weber and Kiessling 1976; Turner 1975; Jakes 1979). The lower San Pedro Formation hosts the Fox Canyon Aquifer (FCA), the primary aquifer from which the majority of the water in the LPVB is produced. An additional localized aquifer, the Epworth Gravels Aquifer, is located in the Saugus Formation. The Epworth Gravels Aquifer covers an area of approximately 1,600 acres (2.5 square miles) located 2 to 3 miles north-northwest of Moorpark. This aquifer is not believed to be in hydraulic communication with the underlying FCA (Turner 1975).

The majority of the LPVB lies within the jurisdiction of the Fox Canyon Groundwater Management Agency (FCGMA), with two notable exceptions (Figure 2-1, Map of the Las Posas Valley Basin). These exceptions are the easternmost area of the LPVB, in the foothills of the Santa Susana Mountains, and the southern part of the LPVB, in the Las Posas Hills. The reason for this discrepancy is that the FCGMA boundary was established based on a vertical projection of the FCA as defined by the Fox Canyon Groundwater Management Agency Act in 1982, whereas the LPVB boundary is based on the surface extent of the alluvium in the Las Posas Valley and the location of geologic structures that impede flow between the LPVB and neighboring groundwater basins (DWR 2003). The geologic and hydrologic descriptions of the LPVB in this Groundwater Sustainability Plan (GSP) are based on the boundaries of the LPVB, including the areas to the east and south that are outside the FCGMA jurisdictional boundaries.

2.2 HYDROGEOLOGIC CONCEPTUAL MODEL

The California Department of Water Resources (DWR) defines three water-bearing formations in the LPVB: alluvium, the San Pedro Formation, and the Santa Barbara Formation (DWR 2003). These formations are similar to, but not the same as, the five principal hydrostratigraphic units defined by local investigators in the LPVB (Table 2-1; CMWD 2016a). The five principal hydrostratigraphic units are the Shallow Alluvial Aquifer, the Upper San Pedro Formation (USP), the Epworth Gravels Aquifer, the FCA, and the Grimes Canyon Aquifer (GCA; CMWD 2016a). The Shallow Alluvial Aquifer hydrostratigraphic unit corresponds to the alluvium as described by DWR (2003). In this GSP, the term *Shallow Alluvial Aquifer* applies to the alluvium adjacent to Arroyo Simi–Las Posas, while in the western part of the LPVB, the undifferentiated alluvium is referred to as the *shallow aquifer system*. The USP, the Epworth Gravels Aquifer, and the FCA correspond to the San Pedro Formation as described by DWR. The GCA corresponds to the Santa Barbara Formation as described by DWR (2003). Together, the Epworth Gravels, USP, FCA, and GCA are referred to as the Lower Aquifer System (LAS) in the LPVB, although the USP is not considered an aquifer throughout much of the LPVB.

Although DWR does not recognize any subbasins within the LPVB, local investigators have historically divided the LPVB into three groundwater subbasins based on the location of geologic structures that were thought to affect flow in the LAS (Figure 2-1). These subbasins are referred to as *basins* by both FCGMA and the Ventura County Watershed Protection District (VCWPD); therefore, we will refer to them as such in this document. These local basins are named the West, East, and South Las Posas Basins (WLP, ELP, and SLP, respectively). The Somis Fault, which trends north-northeast across the LPVB in the vicinity of Somis, defines the boundary between the WLP and ELP. Groundwater elevation differences in excess of 200 feet across the Somis Fault are evidence that it acts as a barrier to groundwater flow in the principal water-bearing units of the LAS (CMWD 2016a). The northeastern-trending axis of the Moorpark anticline has historically been used as the boundary between the ELP and the SLP. Groundwater quality data collected during recent investigations, however, suggest that the Moorpark anticline does not act as a barrier to groundwater movement between the ELP and the SLP (CMWD 2016b, 2016a).

Because the Moorpark anticline does not appear to restrict groundwater flow, local investigators now divide the LPVB into two management areas rather than three basins (CMWD 2016a). The area of the West Las Posas Management Area (WLPMA) is the same area as the WLP: west of the Somis Fault to the western boundary of the LPVB with the Oxnard Subbasin. The East Las Posas Management Area (ELPMA) comprises the entire eastern portion of the LPVB east of the Somis Fault and includes both the ELP and the SLP (Figure 2-1).

In addition to the WLPMA and ELPMA, a third management area has been proposed in a localized area of the ELPMA for the Epworth Gravels Aquifer (Figure 2-1; CMWD 2016a). The Epworth Gravels Aquifer occurs in an area limited to approximately 1,600 acres (2.5 square miles) located 2 to 3 miles north-northwest of Moorpark (Turner 1975; CMWD 2016a). A separate management area was proposed for this aquifer because it is a locally significant source of water but is not believed to be in hydraulic communication with the other aquifers of the LAS (Turner 1975).

Both the lithologic units and geologic structures present in the LPVB affect the hydrology of the basin. These features are discussed in more detail in the following sections.

2.2.1 Geology

Geologic Units and Variation

The nomenclature of the lower Pleistocene and younger stratigraphic units exposed in outcrop and drilled in the subsurface within the LPVB has evolved through time since the first regional scale mapping was conducted by Kew in 1924 (Table 2-1; Kew 1924; Weber and Kiessling 1976; Jakes 1979; DeVecchio et al. 2012b). Kew (1924) identified the lower Pleistocene stratigraphic unit, which marks the base of the freshwater aquifer in the LPVB, as the *Saugus Formation*. Subsequent investigators identified this unit as either the Las Posas Sand (Pressler 1929, as cited in DeVecchio et al. 2012a; Dibblee 1992a, 1992b; DeVecchio et al. 2012b) or the Santa Barbara Formation (Weber and Kiessling 1976; DWR 2003; CMWD 2016a). To remain consistent with DWR nomenclature, this GSP refers to the lowermost Pleistocene lithologic unit as the *Santa Barbara Formation*.

Similarly, the lithologic unit overlying the Santa Barbara Formation is referred to as the *San Pedro Formation* in this GSP in order to remain consistent with DWR nomenclature. The USP has been referred to in the literature as both the *Las Posas Sand* (Pressler 1929, as cited in DeVecchio et al. 2012a; Dibblee 1992a, 1992b; DeVecchio et al. 2012b) and the *Saugus Formation* (Kew 1924; Jakes 1979). The Saugus Formation is primarily a terrestrial fluvial deposit, whereas the San Pedro Formation is primarily a marine deposit. Weber and Kiessling

(1976) and DeVecchio et al. (2012b) identify the Saugus Formation as unconformably overlying the San Pedro Formation, whereas DWR (2003) and CMWD (2016a) include the Saugus Formation as part of the upper San Pedro Formation.

Older alluvial deposits unconformably overlie the San Pedro Formation (Weber and Kiessling 1976; Jakes 1979; Dibblee 1992a, 1992b; DeVecchio et al. 2012b). These older alluvial deposits correspond to the terrace deposits of Kew (1924) and are distinguished from the younger, active alluvial deposits by evidence of deformation from ongoing tectonic compression in the region.

The youngest unit, exposed at the surface throughout much of the east Las Posas Valley, is an active alluvial unit that lacks evidence for structural deformation and is called either *recent alluvium* (Kew 1924; Weber and Kiessling 1976; Jakes 1979) or *alluvium* (DeVecchio et al. 2012b). This unit is referred to as *recent alluvium* in this GSP in order to distinguish it from the underlying, deformed older alluvium.

Tertiary Sedimentary and Igneous Formations

Tertiary sedimentary and igneous rocks that underlie the LPVB are generally considered semi-permeable or non-water-bearing (Turner 1975; DeVecchio et al. 2012b; CMWD 2016a). These tertiary formations include the Oligocene/Eocene-age Sespe Formation, the lower Miocene Conejo Volcanics, the upper Miocene Modelo and Monterey Formations, and the Pliocene Pico Formation (Weber and Kiessling 1976; Dibblee 1992a, 1992b; Jakes 1979; DeVecchio et al. 2012b; CMWD 2016a). These formations are exposed in outcrop to the north, east, and south of the LPVB boundary and have been encountered in deep wells drilled throughout the LPVB (Figure 2-2, Geology of the Las Posas Valley Basin; Weber and Kiessling 1976; Jakes 1979; DeVecchio et al. 2012b). Because these formations typically contain poor-quality water, they are not considered an important source of groundwater in the LPVB (Turner 1975).

Quaternary Sedimentary Formations

The Quaternary sedimentary formations are listed in Table 2-1 and are described below. The lithologic nomenclature used in this GSP is per Weber and Kiessling (1976).

Santa Barbara Formation (Lower Pleistocene; Marine)

The Santa Barbara Formation is typically composed of laminated, poorly indurated blue-gray marine mud- and siltstone with sand and gravel (Turner and Mukae 1975). The clay-rich sediments act as an aquitard between the Santa Barbara Formation and the overlying USP (Weber and Kiessling 1976). The localized basal conglomerate within the upper member of the Santa Barbara Formation hosts the GCA (Weber and Kiessling 1976). The lower member of the Santa Barbara Formation, which underlies the GCA, is fine-grained sandstone, siltstone, and mudstone (Weber and Kiessling 1976).

San Pedro Formation (Lower to Middle Pleistocene; Marine and Nonmarine)

The San Pedro Formation is an interbedded, poorly lithified fine marine, silty sandstone, shale, and mudstone with local pebble conglomerate and an extensive basal sand unit that thickens to the west (Weber and Kiessling 1976; DeVecchio et al. 2012b). In the LPVB, the San Pedro Formation unconformably overlies the Santa Barbara Formation. The pebbles are plutonic, metamorphic, and metavolcanic clasts. A ubiquitous bivalve hash is found in exposures of the USP, which are typically poorly consolidated to poorly cemented (DeVecchio et al. 2012b).

The lower part of the San Pedro Formation is separated from the upper part of the San Pedro Formation by a regionally extensive clay marker bed (Turner 1975). Overlying the clay marker bed are lenticular layers of sand, gravel, and silt (CMWD 2016a). Below this marker bed, the basal unit of the San Pedro Formation comprises a 100- to 600-foot-thick continuous white or gray marine sand and gravel with local silt and clay lenses (Turner 1975).[1] The lower part of the San Pedro Formation hosts the FCA, which is the most important source of groundwater supply in the LPVB (Turner 1975; CMWD 2016a).

Saugus Formation (Middle to Upper Pleistocene; Terrestrial)

In the LPVB, the Saugus Formation is characterized by poorly consolidated fluvial deposits of pebbly, coarse sandstone and conglomerate deposited in a nonmarine environment (Weber and Kiessling 1976). Conglomerate clasts are predominantly composed of Miocene Monterey shale and Conejo Volcanics (DeVecchio et al. 2012b). In some locations, the coarse-grained upper fluvial deposits grade downward into a fine-grained estuarine sandstone and siltstone (Weber and Kiessling 1976). The upper part of the Saugus Formation hosts the Epworth Gravels (Table 2-1).

Older Alluvium (Upper Pleistocene; Terrestrial)

Unconformably overlying the Saugus Formation is the older alluvium, which is composed of gravel, sand, silt, and clay. The older alluvium was deposited in river, floodplain, beach, and terrace environments. These deposits lack marine fossils and have evidence of soil “B” horizon development (Jakes 1979). The older alluvium has been incised and slightly folded (DeVecchio et al. 2012b).

Recent Alluvium (Holocene; Terrestrial)

Recent alluvium comprises surficial deposits of loose sand, silt, clay, gravel, and boulders (Weber and Kiessling 1976; Jakes 1979). The recent alluvium includes colluvium and slopewash, stream channel, valley fill and floodplain, and alluvial fan deposits. These deposits are distinguished from the older

[1] This marine sand has been identified as both the Saugus Formation (Kew 1924; Jakes 1979) and the Las Posas Sand (Pressler 1929, as cited in DeVecchio et al. 2012a; Dibblee 1992a, 1992b; DeVecchio et al. 2012b). The term *USP* is used here for consistency with DWR nomenclature (DWR 2003).

alluvium by the lack of soil horizon development and lack of deformation. The recent alluvium is an aquifer beneath the floodplain of Arroyo Simi–Las Posas. The alluvium is also present in the WLPMA in Beardsley Wash and Ferro Ditch, although it is not an aquifer in these locations (Figure 2-2).

Geologic Structure

Boundary Faults

Wright Road Fault

The Wright Road Fault is an active oblique right reverse fault. The western boundary of the LPVB, separating the Oxnard Subbasin to the west from the LPVB to the east, generally parallels the Wright Road Fault (Figure 2-2; DeVecchio et al. 2007). The fault trace is characterized by a 20-meter-high topographic scarp with up-to-the-east displacement along the north-northwest-trending fault (DeVecchio et al. 2007). There is no evidence that the Wright Road Fault impacts groundwater flow between the LPVB and the Oxnard Subbasin.

Springville Fault Zone

The Springville Fault Zone trends east-northeast along the southern base of the Camarillo Hills. The Springville Fault Zone is divided into two structural domains that together form the boundary between the WLPMA to the north and the Pleasant Valley Basin (PVB) to the south (Figure 2-2; DeVecchio et al. 2012a). The southern Springville Domain extends from the Wright Road Fault on the west to the inferred Spanish Hills Fault (Figure 2-2; DeVecchio et al. 2012a). The northern Springville Domain extends from the Spanish Hills Fault to the Somis Fault. The Spanish Hills Fault offsets the northern section of the Springville Fault to the north of the southern section of the Springville Fault (Figure 2-2; DeVecchio et al. 2012a).

In both structural domains, the Springville Fault is a high-angle reverse fault with up-to-the-north displacement that juxtaposes the Saugus Formation on the north side of the fault and older alluvium on the southern side of the fault (DeVecchio et al. 2012a). In the southern Springville Domain, deformation in the hanging wall has resulted in the formation of the Springville anticline. In the northern Springville Domain, deformation in the hanging wall has resulted in the formation of the Camarillo Hills anticline. In both domains, the Springville Fault restricts groundwater flow between the WLPMA and the PVB to the south.

Simi–Santa Rosa Fault Zone

The Simi–Santa Rosa Fault Zone trends east-northeast along the southern base of the Las Posas Hills (Figure 2-2). This fault is a high-angle reverse fault that dips to the north. Deformation in the hanging wall of the fault has resulted in uplift of the Las Posas Hills (DeVecchio et al. 2012a). Displacement on the fault juxtaposes outcrops of the Saugus Formation in the Las Posas Hills and active alluvial fan deposits to the south. The Simi–Santa Rosa Fault Zone restricts groundwater flow between the ELPMA and the PVB to the south.

Internal Faults

<u>Somis Fault (Central Las Posas Fault)</u>

The Somis Fault is a high-angle oblique right-reverse fault that strikes north-northeast across the LPVB in the vicinity of the Somis gap between the Las Posas Hills to the east and the Camarillo Hills to the west (Figure 2-2; DeVecchio et al. 2012a; CMWD 2016a). The surface trace of the fault is concealed by Arroyo Las Posas alluvium, which has resulted in several interpretations of the fault trace, sense of motion, and nomenclature, depending on the investigator (Bailey 1951, as cited in DeVecchio et al. 2012a; Weber and Kiessling 1976; Jakes 1979; USGS 2003; DeVecchio et al. 2012a). The Somis Fault discussed in this GSP is that of DeVecchio et al. (2012a), which is the same as the Central Las Posas Fault in U.S. Geological Survey (USGS 2003), but differs from the Somis Fault of Weber and Kiessling (1976) and USGS (2003) (Figure 2-2).

The presence of the Somis Fault in the subsurface is apparent from differences in groundwater elevations measured in the LAS east and west of the fault (CMWD 2016a). Since the early 1980s, groundwater elevations to the west of the fault have consistently been several hundred feet lower than those to the east of the fault (CMWD 2016b). The Somis Fault impedes groundwater movement in the LAS; therefore, the trace of the Somis Fault is generally coincidental with the boundary between the WLPMA and the ELPMA.

<u>Additional Internal Faults</u>

In addition to the Somis Fault, several other faults have been identified within the LPVB (Figure 2-2). These faults include the La Loma and Fox Canyon Faults on the northern edge of the WLPMA; the Berylwood Fault on the northern edge of the WLPMA and the ELPMA; the Conejo NE2 Fault in the west-central ELPMA; the Fairview Fault in the northeastern ELPMA (USGS 2003); and the Little Simi Valley Fault on the southern boundary of the ELPMA. These faults were all modeled as flow barriers with varying degrees of resistance to flow across them (USGS 2003). However, additional data are needed to further refine the influence of these faults on groundwater flow within the LPVB.

Folds

The LPVB is located within the Camarillo fold belt, an area characterized by south-verging anticlinal folds (DeVecchio et al. 2012a). Within the LPVB, there are two primary east-to-northeast-trending anticlines and three primary east-to-northeast-trending synclines (Turner 1975). These are, from north to south, the Long Canyon syncline, Long Canyon anticline, Las Posas syncline, Moorpark anticline, and Moorpark syncline (Figure 2-2). In general, the Long Canyon anticline is associated with lower transmissivity in the USP, and the Las Posas syncline is associated with higher transmissivity in the USP (CMWD 2016a). Along the axis of the Las Posas syncline in the center of the LPVB, the USP thickens, and the depth to the FCA at the base of the USP can approach 2,000 feet bgs (Turner 1975; CMWD 2016a).

The Moorpark anticline causes thinning and disruption of the San Pedro Formation and the underlying Santa Barbara Formation. The USP thins along the axis of the anticline, and the Santa Barbara Formation pinches out along the axis of the anticline (CMWD 2016a). The Santa Barbara Formation is present to the north of the Moorpark anticline and thin to absent to the south (CMWD 2016a). The thinning and disruption to the LAS units were previously thought to affect groundwater flow across the anticline during periods of low water levels (Las Posas Users Group 2012; CMWD 2016a). Recent water quality data, however, suggest that the Moorpark anticline is not a barrier to groundwater flow (CMWD 2016a, 2016b).

2.2.2 Boundaries

The southern boundary of the LPVB is defined by the Springville and Simi–Santa Rosa Fault Zones. These faults are associated with uplift of the Camarillo and Las Posas Hills (SWRCB 1956; DWR 2003).

The western boundary of the LPVB is associated with the topographic change in slope along the trace of the Wright Road Fault and separates the LPVB from the Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin to the west. The Wright Road Fault is not known to impede groundwater movement between the LPVB and the Oxnard Subbasin. Because the LPVB and Oxnard Subbasin are in hydraulic communication, a jurisdictional boundary, which generally follows the trace of the Wright Road Fault, serves as the boundary between the LPVB and Oxnard Subbasin. The recent jurisdictional boundary change allows the water produced from wells along the western boundary to be associated with the same basin from which it is pumped and used.

The northern and eastern boundaries of the LPVB are delineated by the contact between the alluvial deposits and surface exposures of bedrock. The northern boundary follows the contact between the alluvium and the base of the Oak Ridge/South Mountain uplift, coinciding with outcrops of the upper San Pedro Formation in the WLPMA. To the east, the water-bearing strata of the LPVB pinch out against the uplift of the Santa Susana Mountains (SWRCB 1956; DWR 2003).

2.2.3 Basin Bottom

The bottom of the LPVB is defined by the contact between the upper member of the Santa Barbara and the underlying Pliocene and older formations, where the upper member of the Santa Barbara Formation is present (Figure 2-2 and Figure 2-3, Conceptual Cross Section A–A′). Where the upper member of the Santa Barbara Formation is absent, the bottom of the LPVB is defined by the contact between the USP and the underlying Pliocene and older formations. This contact coincides with the base of the freshwater aquifer (Turner 1975). In the western part of the LPVB, and in the eastern part of the LPVB north of the Moorpark anticline, the base of the freshwater aquifer occurs at the base of the upper member of the Santa Barbara Formation (Figure 2-4, Conceptual Cross Section B–B′). South of the Moorpark anticline, however, the base of the freshwater aquifer coincides with the base of the USP.

In general, the depth to the bottom of the LPVB increases from east to west and toward the axis of the Las Posas syncline. At the eastern end of the LPVB, adjacent to the Santa Susana Mountains, the depth of the LPVB is less than 500 feet (CMWD 2016a). To the west, the depth can exceed 2,000 feet (CMWD 2016a).

2.2.4 Principal Aquifers and Aquitards

Shallow Alluvial Aquifer

The alluvial deposits that compose the Shallow Alluvial Aquifer include loose sand and gravel adjacent to Arroyo Simi–Las Posas in the ELPMA (SWRCB 1956; Weber and Kiessling 1976; Jakes 1979; CMWD 2016a). This aquifer coincides with the Holocene-age recent alluvium and upper Pleistocene-age older alluvium lithologic units defined in Section 2.2.1, Geology, of this GSP. The thickness of these units ranges from less than 50 feet at the boundary of the LPVB with the Santa Susana Mountains to approximately 200 feet adjacent to Arroyo Simi–Las Posas (Turner 1975; CMWD 2016a).

Adjacent to Arroyo Simi–Las Posas and near Moorpark, the sediments of the Shallow Alluvial Aquifer are saturated, and the aquifer is unconfined (Las Posas Users Group 2012; CMWD 2016a). Recharge to the Shallow Alluvial Aquifer is typically from native and non-native flows within Arroyo Simi–Las Posas (Las Posas Users Group 2012; CMWD 2016a). The non-native flows consist of discharges from the Simi Valley Water Quality Control Plant (SVWQCP), dewatering wells operated by the City of Simi Valley, and discharges from the Moorpark Wastewater Treatment Plant (MWTP) percolation ponds adjacent to Arroyo Simi–Las Posas (Las Posas Users Group 2012; CMWD 2016a).

A qualitative evaluation of relative transmissivity from well log data suggests that the transmissivity of the Shallow Alluvial Aquifer typically ranges from 34.1 to 149.9 feet per day

(CMWD 2016a). In general, the aquifer has higher transmissivities to the east and lower transmissivities to the west where Arroyo Simi–Las Posas bends to the southwest (CMWD 2016a). Well yields within the Shallow Alluvial Aquifer average approximately 400 gallons per minute (gpm; Turner 1975).

Recharge from non-native flows in Arroyo Simi–Las Posas has resulted in a mound of poor-quality water, characterized by concentrations of total dissolved solids (TDS), chloride, and sulfate that exceed concentrations in native flows. The effect of this recharge is evident on the south flank of the ELPMA west of Moorpark (CMWD 2016b).

Currently, relative to the total groundwater production in the ELPMA, there are few wells that produce water from the Shallow Alluvial Aquifer, which is likely a result of the marginal-quality water and low well yields compared to the FCA (Las Posas Users Group 2012). The Shallow Alluvial Aquifer is hydraulically connected to the LAS and is a conduit for recharge to the deeper aquifers via vertical leakage.

Epworth Gravels Aquifer

The Epworth Gravels Aquifer is a localized aquifer that is only present within an approximately 1,600 acres (2.5 square miles) area of the ELPMA, near Broadway Road (Figure 2-1; Las Posas Users Group 2012). This aquifer occurs near the top of the USP and is composed of up to 400 feet of upper Pleistocene-age gravels, gravelly clays, and silts that are likely remnants of an ancient alluvial fan (Turner 1975; CMWD 2016a). The Epworth Gravels Aquifer is exposed at the surface adjacent to the northern and eastern boundaries of the ELPMA. To the south and west, the Epworth Gravels Aquifer grades into silt and clay (Turner 1975). The Epworth Gravels Aquifer is separated from the underlying FCA by several hundred feet of the USP and therefore is not in hydraulic communication with the FCA.

The Epworth Gravels Aquifer is adjacent to, and may be in hydraulic communication with, the Fairview Area Unconfined Aquifer (Turner 1975; Las Posas Users Group 2012). The Fairview Area Unconfined Aquifer comprises both recent and upper Pleistocene alluvial sediments that were a locally important source of water prior to the mid-1970s (Turner 1975; Las Posas Users Group 2012). Wells completed within the Fairview Area Unconfined Aquifer had average yields of about 500 gpm; however, declining water levels in this Shallow Alluvial Aquifer likely resulted in construction of replacement wells in deeper water-bearing zones (Turner 1975; CMWD 2016a). Because the Fairview Area Unconfined Aquifer cannot be easily distinguished from the Epworth Gravels Aquifer in electronic well logs (CMWD 2016a), it is included as part of the Epworth Gravels Aquifer in this GSP.

Well yields in the Epworth Gravels Aquifer average approximately 300 gpm and range from 250 to 750 gpm (SWRCB 1956; Turner 1975; DWR 2003). The average specific yield of the water-bearing gravels in the Epworth Gravels Aquifer is 15% to 20% (SWRCB 1956; DWR 2003). Water produced from this aquifer has been used for agricultural and domestic consumption (Turner 1975).

Upper San Pedro/Saugus Formation

The sediments that compose the upper San Pedro/Saugus Formations (USP) are primarily interbedded silts, clays, and gravels with minor sand layers (SWRCB 1956; Weber and Kiessling 1976; Turner 1975; Jakes 1979; CMWD 2016a). The base of the USP is typically marked by a laterally continuous clay bed that varies in thickness and separates this hydrostratigraphic unit from the underlying FCA (CMWD 2016a). The thickness of the USP ranges from less than 50 feet on the northern and eastern margins of the LPVB to over 1,000 feet in the WLPMA and in the vicinity of the Fairview Fault in the ELPMA (CMWD 2016a).

Throughout much of the LPVB, the USP is confined, especially at depth (CMWD 2016a). Although several wells in the WLPMA produce water from lenses of permeable sediments within the USP, these lenses are laterally discontinuous and not well connected throughout the LPVB (Las Posas Users Group 2012). As a result, the USP is not considered an aquifer, but rather, likely functions as a leaky aquitard providing additional water to the underlying FCA.

Fox Canyon Aquifer

The FCA, which is the primary aquifer in the LPVB, occurs below the base of the USP in the lower portion of the San Pedro Formation and is laterally continuous within the boundaries of the LPVB. The water produced from the FCA is used for agricultural, domestic, industrial, and municipal purposes.

The sediments that compose the FCA are white or gray sand and gravel with some clay and silt lenses (SWRCB 1956; Turner 1975). These sediments were deposited under shallow marine conditions and were extensively folded post-deposition (Turner 1975). Along the axis of synclinal structures in the central portion of the LPVB, the depth to the upper surface of the FCA can exceed 1,000 feet below ground surface (bgs), and the thickness of the aquifer can exceed 800 feet (Turner 1975; CMWD 2016a). To the east, the FCA shallows and thins, pinching out in the vicinity of Happy Camp Canyon (SWRCB 1956). To the south, the FCA thins along the axis of the Moorpark anticline in the ELPMA and is exposed at the surface locally in the Las Posas and Camarillo Hills (Figure 2-2; DeVecchio et al. 2012b). The FCA is also exposed in a continuous band of outcrop in the South Mountain and Oak Ridge uplift to the north of the LPVB boundary (DeVecchio et al. 2012b).[2]

The primary structural restriction to flow in the FCA is the north-to-northeast-trending Somis Fault (DeVecchio et al. 2012a; CMWD 2016a). Groundwater elevations on the eastern side of the Somis

[2] For more detail on the LPVB boundary and the Fox Canyon Groundwater Management Agency boundary, see Section 1.3.1, Description, of this GSP.

Fault are over 200 feet higher than those on the western side of the Somis Fault (CMWD 2016b). The restriction of flow across the inferred trace of the Somis Fault is the basis for separating the LPVB into two management areas: the ELPMA and the WLPMA.

The FCA occurs under confined conditions at most locations in the LPVB (CMWD 2016a). The average specific yield of the FCA is 15% to 20%, and the average yield of wells that are at least partially completed in the FCA is 900 to 1,000 gpm (SWRCB 1956; Turner 1975; DWR 2003). Typical well yields range from 500 to 2,000 gpm (Turner 1975; Las Posas Users Group 2012). In the ELPMA, the estimated hydraulic conductivity of the FCA, based primarily on conversion from specific capacity measurements, was generally higher within structural synclines, ranging from approximately 30 to greater than 150 feet per day (CMWD 2016a). In the WLPMA and in areas north of the Fairview Fault and along the eastern limb of the Long Canyon anticline in the ELPMA, the hydraulic conductivity of the FCA, also estimated from specific capacity, is typically less than 30 feet per day (CMWD 2016a).

In the ELPMA, water quality in the FCA has been affected by the percolation of wastewater treatment plant and shallow dewatering well discharges from Simi Valley that compose the base flow in Arroyo Simi–Las Posas (CMWD 2016b). Chloride concentrations in wells adjacent to Arroyo Simi–Las Posas increased from between 50 and 150 milligrams per liter (mg/L) in the early 1960s to between 150 and 250 mg/L in the mid-1980s (CMWD 2016b). Since the mid-1980s, chloride concentrations in these wells decreased to between 150 and 200 mg/L. Chloride concentrations in wells to the north of Arroyo Simi–Las Posas, however, have generally increased since the mid-1980s from less than 50 mg/L to 150 mg/L currently (CMWD 2016b). Based on the timing of the observed increases in chloride concentration, the rate of northward migration of poor-quality water has been estimated to average between 100 and 250 feet per year (CMWD 2014). Chloride concentration in the FCA north of the Moorpark anticline in the ELPMA and throughout the WLPMA is generally less than 125 mg/L.

In the WLPMA, water quality in the FCA is variable. Adjacent to the Camarillo Hills, in the southeastern WLPMA, TDS concentrations in groundwater range from 300 to 700 mg/L. TDS concentrations are higher in the central and western parts of the WLPMA, ranging from 900 to 5,000 mg/L.

Grimes Canyon Aquifer

The GCA comprises up to 300 feet of coarse to fine-grained gravel and sand deposits, with lenses of clay and silt within the upper Santa Barbara Formation (DWR 2003; CMWD 2016a). Throughout much of the WLPMA and along the northern part of the ELPMA, the GCA is separated from the overlying FCA by a clay-rich aquitard that is between 25 and 200 feet thick

(CMWD 2016a). East of Stockton Road in the ELPMA, the GCA and FCA are difficult to distinguish from one another and are likely in direct contact with each other (CMWD 2016a).

Similar to the FCA, the GCA is exposed in a continuous band of outcrop in the South Mountain and Oak Ridge uplift to the north of the LPVB boundary (DeVecchio et al. 2012b). From the exposures in the South Mountain and Oak Ridge uplift, the GCA dips to the south and is generally thickest in the central portion of the LPVB. In the ELPMA, this unit thins and pinches out to the south of the Moorpark anticline. The GCA is not present near the Las Posas Hills (CMWD 2016a). In the WLPMA, the GCA deepens and thins to the west.

There are relatively few wells fully screened in the GCA, but this aquifer is thought to be an important source of water in areas of the LPVB where the FCA is thin or unsaturated (Las Posas Users Group 2012). The average specific yield of the GCA is 10% to 20% (SWRCB 1956; DWR 2003). The average hydraulic conductivity of the GCA, estimated from specific capacity, is approximately 7 feet per day (CMWD 2016a). Water quality data from the GCA in the LPVB have not been published.

2.2.5 Data Gaps and Uncertainty

The primary data gaps in the hydrogeologic conceptual model are as follows:

- Distributed measurements of aquifer properties from wells screened solely in a single aquifer.
- Distributed measurements of groundwater quality from wells screened solely in a single aquifer.
- Measurements of aquifer properties are limited in all aquifers in the LPVB.
- The volume of leakage between the USP and the underlying FCA has been estimated to be approximately 14,600 AFY from the numerical model (Appendix C). This estimate and the effects of the leakage on the underlying FCA will need revision as additional data become available.
- The connectivity and vertical flow between the multiple distinct water-bearing zones within the USP has not been quantified.

The data gaps listed in this section create uncertainty in the understanding of the impacts of water level changes on change in storage in the aquifer. Additional aquifer tests and future groundwater quality sampling would help reduce the uncertainty associated with these data gaps.

2.3 GROUNDWATER CONDITIONS

2.3.1 Groundwater Elevation Data

Groundwater elevations in the LPVB were first measured in agricultural wells in the 1930s, and an annual groundwater monitoring program was initiated in the LPVB by the County of Ventura, United Water Conservation District (UWCD), and USGS in the 1990s (FCGMA 2007). Additionally, Calleguas Municipal Water District (CMWD) has monitored groundwater elevations in the LPVB since 2011. The Ventura County annual groundwater monitoring program includes production wells and multiple-completion nested monitoring wells. Many of the production wells included in the monitoring program are screened across multiple aquifers. Historically, the FCGMA annual reports have included water elevations for the LPVB in its potentiometric surface maps for wells screened in the LAS (FCGMA 2016).

To conform with Title 23 of the California Code of Regulations, Section 354.14, the following discussion of groundwater elevation is limited to production and monitoring wells screened in a single aquifer. Water level measurements collected between March 2 and March 29, 2015, are used to represent groundwater elevations in spring 2015. Water level measurements collected between October 2 and 29, 2015, are used to represent groundwater elevations in fall 2015.

Because many production wells within the LPVB are screened across multiple aquifers and there are a limited number of dedicated monitoring wells, the depiction of representative regional potentiometric surfaces in each aquifer is limited. Groundwater pumping data for the year 2015 were mapped to provide context for interpreting the potentiometric surfaces presented in this section (see Figure 2-5, Groundwater Extraction [acre-feet] in 2015 in the Las Posas Valley Basin). The majority of the production in the LPVB comes from the FCA in both the WLPMA and the ELPMA (Figure 2-5).

Non-native surface water flows in Arroyo Simi–Las Posas, groundwater production, climate cycles, groundwater storage, and surface water delivery programs have impacted groundwater elevations in the LPVB. Non-native surface water flows in Arroyo Simi–Las Posas caused groundwater elevations to rise beginning in the 1970s as these flows provided additional recharge to the Shallow Alluvial Aquifer, the USP, and the FCA. Groundwater production from the LPVB has caused water level declines, particularly during periods of drought. Groundwater storage and surface water delivery programs in the LPVB have affected local groundwater elevations in different ways. These activities include: (1) deliveries of in-lieu surface water to groundwater producers in the WLPMA (1995–2008) and ELPMA (1995–2016) by CMWD and (2) injection and recovery from the CMWD Aquifer Storage and Recovery Project (ASR) in the ELPMA.

Groundwater elevation data for the WLPMA and ELPMA are discussed in the subsections that follow. Within each management area, discussion of the groundwater elevation is divided by aquifer. Not all aquifers have sufficient data to analyze groundwater elevation trends and gradients.

2.3.1.1 West Las Posas Management Area

2.3.1.1.1 Upper San Pedro Formation

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the USP in the WLPMA ranged from −23.8 feet above mean sea level (msl) to 244.4 feet msl (Figure 2-6, Groundwater Elevation Contours in the Upper San Pedro Formation, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −53.6 feet msl to 242.7 feet msl (Figure 2-7, Groundwater Elevation Contours in the Upper San Pedro Formation, October 2–29, 2015).

The highest groundwater elevations in the USP are measured in Well 02N21W16J01S in both the spring and fall of 2015 (Figures 2-6 and 2-7). This well is screened from 182 to 295 feet bgs. The lowest groundwater elevations in the USP are measured in Well 02N21W15M03S, which is approximately 1,100 feet east of Well 02N21W16J01S, but is screened from 406 to 1,030 feet bgs. The difference in groundwater elevations between these wells reflects the large vertical gradient within the USP. Additionally, the data suggest that there are multiple, distinct water-bearing zones within the USP. The heterogeneity of the sediments that compose the USP, the variation in well screen intervals, and the high vertical hydraulic gradient in the USP prohibit a determination of a lateral hydraulic gradient for the spring and fall of 2015.

Vertical Gradients

Groundwater elevations in the USP vary with depth (Figures 2-6 and 2-7; Table 2-2). The vertical gradient within the USP was determined from groundwater elevations measured in Wells 02N21W11J04S, 02N21W11J05S, and 02N21W11J06S, which are located in a multiple-depth nested monitoring well cluster installed by the USGS in the central WLPMA. In the spring of 2015, the vertical gradient between Wells 02N21W11J06S and 02N21W11J05S was 0.19 feet/feet, directed downward, and the vertical gradient between Wells 02N21W11J05S and 02N21W11J04S was 0.66 feet/feet, also directed downwards. In the fall of 2015, the gradient between Wells 02N21W11J06S and 02N21W11J05S was 0.21 feet/feet and the vertical gradient between Wells 02N21W11J05S and 02N21W11J04S was 0.68 feet/feet, directed downwards (Table 2-2).

Historical Groundwater Elevation Trends

Groundwater elevation trends vary with depth and geographic location within the WLPMA. Wells 02N21W16J01S, 02N21W11J05S, and 02N21W11J06S are screened within the San Pedro

Formation, and had groundwater elevations consistently above sea level for the length of the historical observations (Figures 2-6 and 2-7 and Figure 2-8, Upper San Pedro Formation Groundwater Elevation Hydrographs: WLPMA). Groundwater elevations in Well 02N21W16J01S rose approximately 58 feet between 1972 and 2011, with no observed response to climatic cycles of precipitation (Figure 2-8). Between 2011 and 2015, groundwater elevations declined approximately 5 feet. This decline is coincident with the 2011 to 2015 drought, but it is likely also influenced by management actions in the basin. Groundwater elevations in this well remain approximately 50 feet higher than they were in 1972 (Figure 2-8).

Groundwater elevations in Wells 02N21W11J05S and 02N21W11J06S also rose, independent of climatic influence, from 1991 through 2015. Groundwater elevations in these wells did not decline during the drought from 2011 to 2015, although declines of approximately 5 feet were observed in both wells during 2016 (Figure 2-8). The trends observed in these wells are similar to those observed in Wells 02N21W01L01S and 02N21W11J04S, which were measured less frequently (Figure 2-8).

In contrast, groundwater elevations in Wells 02N21W15M03S and 02N21W11J04S show muted responses to climatic trends and management actions taken in the WLPMA over time. The groundwater elevation in Well 02N21W15M03S declined from approximately 7 feet msl to approximately −78 feet msl between 1983 and 1991 (Figure 2-8). Groundwater elevations in this well recovered between 1991 and 2009, reaching 5 feet msl in 2009. However, with reduced surface water spreading in the Oxnard Subbasin and the effects of the 2011 to 2015 drought, the groundwater elevation in this well declined approximately 60 feet between 2009 and 2015.

The response to climatic cycles is more muted in Well 03N21W36Q01S than it is in Well 02N21W15M03S; however, overall it shows similar trends, with groundwater elevations rising through the 1990s, reaching a maximum in the late 2000s, and declining between 2009 and 2015. The groundwater elevation in this well was −16.3 feet msl in October 2015 (Figure 2-8).

2.3.1.1.2 Fox Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the FCA in the WLPMA ranged from −138.7 feet msl to 65.6 feet msl (Figure 2-9, Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −154 feet msl to 46 feet msl (Figure 2-10, Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015).

The highest groundwater elevation in the FCA is found in Well 03N21W35P02S on the northern margin of the LPVB (Figure 2-9). Groundwater elevations measured in Well 03N21W35P02S in the spring and fall were 65.6 and 46.2 feet msl, respectively. This well is hydrologically separated from the majority of the basin by the La Loma and Berylwood Faults, which parallel the southern boundary of the South Mountain uplift (Figure 2-9). Groundwater elevations to the south of the La Loma and Berylwood Fault Zones ranged from −8.1 to −138.7 feet msl in the spring of 2015 and from −51 to −154 feet msl in the fall of 2015 (Figures 2-9 and 2-10). Groundwater elevations south of these fault zones are highest adjacent to the Oxnard Subbasin and lowest near the Somis Fault.

The hydraulic gradient in the FCA in the spring and fall of 2015, is directed toward the southeastern corner of the management area (Figures 2-9 and 2-10). In the spring of 2015, the hydraulic gradient was approximately 0.008 feet/feet. In the fall of 2015 the hydraulic gradient ranged from approximately 0.007 to 0.022 feet/feet depending on location within the aquifer. These gradients may not fully depict the direction and magnitude of flow within the FCA because additional production wells are screened across multiple aquifers in the WLPMA. Groundwater elevations from these wells are not included in the calculation of gradients within the FCA. Additionally, there are limited data between the western boundary of the LPVB and the central portion of the WLPMA. Installation of monitoring wells in this area would provide additional information on the direction and magnitude of groundwater flow in the FCA in the WLPMA.

Vertical Gradients

Groundwater elevations in the FCA are lower than those in the overlying USP (Figures 2-7 and 2-10; Table 2-2). The vertical gradient between the USP and FCA was determined from groundwater elevations measured in Wells 02N21W11J03S and 02N21W11J04S, which are wells within a multiple-depth nested monitoring well installed in the central WLPMA by USGS. In the spring of 2015, the downward vertical gradient from the USP to the FCA was 0.10 feet/feet (Table 2-2). In the fall of 2015, the downward vertical gradient from the USP to the FCA was 0.13 feet/feet (Table 2-2).

Historical Groundwater Elevation Trends

Groundwater elevation trends in the FCA vary with geographic location in the WLPMA. In the western part of the WLPMA, adjacent to the Oxnard Subbasin water levels in the FCA have declined and recovered over climatic cycles (Figure 2-11, Fox Canyon Aquifer Groundwater Elevation Hydrographs: Western WLPMA). In addition to climate, the groundwater elevations in these wells have also been impacted by the construction and operation of water recharge facilities in the Oxnard Subbasin, to the west of the LPVB boundary (see Section 2.3.1, Groundwater Elevation Data). Full hydrographs for LPVB wells with five or more water elevation measurements are included in Appendix D.

Declines in groundwater elevation occurred between 1984 and 1990 and between 2011 and 2016, coincident with periods of drought shown in the declining limb of the cumulative departure from the mean precipitation curve (Figure 2-11). Groundwater elevations recovered after the 1984 to

1990 drought period. In 1999, water levels exceeded the previous maximum in 1983 (Figure 2-11), likely due to several wet years during the 1990s and the influence of management actions taken and water conservation facilities constructed in the 1980s and 1990s (see Section 2.3.1).

Unlike the area of the WLPMA adjacent to the Oxnard Subbasin, groundwater elevations in the WLPMA closer to the Somis Fault are not correlated with the cumulative departure from the mean rainfall (Figure 2-12, Fox Canyon Aquifer Groundwater Elevation Hydrographs: Eastern WLPMA). Between 1950 and 1991, groundwater elevations in the eastern WLPMA declined by as much as 335 feet (Figure 2-12), despite a prolonged period of above-average precipitation between 1976 and 1982. Between 1995 and 2008 groundwater elevations recovered by as much as 80 feet (Figure 2-12). This recovery resulted from deliveries of in-lieu surface water by CMWD that reduced groundwater pumping by approximately 1,800 acre-feet per year (AFY) in this area. In-lieu water deliveries ceased in 2008. Since the in-lieu deliveries stopped, groundwater elevations have declined by up to 80 feet, approaching previously measured low groundwater elevations in 1994 and 1995.

2.3.1.1.3 Grimes Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

There are only eight wells currently screened solely within the GCA in the WLPMA. Of these wells, only two have recorded groundwater elevations in the spring and fall of 2015 (Figure 2-13, Groundwater Elevation Contours in the Grimes Canyon Aquifer, March 2–29, 2015, and Figure 2-14, Groundwater Elevation Contours in the Grimes Canyon Aquifer, October 2–29, 2015). In the spring of 2015, the groundwater elevation in Well 02N21W28A02S was −78.3 feet msl and the groundwater elevation in Well 02N21W22G01S was −83.2 feet msl (Figure 2-13). In the fall of 2015, the groundwater elevation in Well 02N21W28A02S was −90.4 feet msl and the groundwater elevation in Well 02N21W22G01S was −90.1 feet msl (Figure 2-14).

Both Well 02N21W28A02S and Well 02N21W22G01S are located in the Camarillo Hills in the southwestern area of the WLPMA. Because these were the only two wells screened solely within the GCA with recorded groundwater elevations, a hydraulic gradient could not be determined for the GCA in 2015.

Vertical Gradients

There are no wells screened in the FCA or USP with recorded groundwater elevations in 2015 in the vicinity of Wells 02N21W28A02S and 02N21W22G01S. Therefore, vertical gradients between the overlying aquifers and the GCA could not be determined in 2015. Additionally, the vertical gradient within the GCA could not be determined because Wells 02N21W28A02S and 02N21W22G01S are not separated geographically and are not screened within a multiple-completion nested monitoring well cluster.

Historical Groundwater Elevation Trends

Groundwater elevation trends in the GCA vary with location in the WLPMA. Groundwater elevations in Well 02N21W08G01S rose during periods of above-average precipitation from 1977 to 1983 and again from 1991 to 2002 (Figure 2-15, Grimes Canyon Aquifer Groundwater Elevation Hydrographs). In the intervening period, they declined, coincident with a period of drought from 1986 to 1991. This well is also located close to the boundary between the LPVB and the Oxnard Subbasin, and water level responses in this well are likely influenced by surface water spreading in the Forebay area of the Oxnard Subbasin.

In contrast to Well 02N21W08G01S, groundwater elevations in Wells 02N21W16J01S, 02N21W22A01S, and 02N21W28A02S were below sea level throughout the period of observation from 1999 to 2016 (Figure 2-15). Between 1999 and 2010, the groundwater elevation in Well 02N21W22A01S rose approximately 50 feet, but with the onset of drought in 2011, the groundwater elevation in this well declined to −63 feet msl by September 2015 (Figure 2-15). This elevation is higher than the groundwater elevation at the start of the record in 1999.

The groundwater elevation trends in Wells 02N21W16J01S and 02N21W28A02S are similar to those observed in Well 02N21W22A01S, although the groundwater elevations in these wells were relatively stable, and did not increase, between 2000 and 2011. Between 2011 and 2015, the groundwater elevation in these wells declined approximately 35 feet. In October 2015 the groundwater elevation in these wells was approximately −90 feet msl, the lowest recorded elevation since the start of the records in 1999 and 2005 for Wells 02N21W22A01S and 02N21W28A02S, respectively (Figure 2-15). The low groundwater elevation measured in October 2015 reflects the effects of the drought from 2011 to 2015.

2.3.1.2 East Las Posas Management Area

2.3.1.2.1 Shallow Alluvial Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the Shallow Alluvial Aquifer in the ELPMA ranged from 186.1 to 485.9 feet msl (Figure 2-16, Groundwater Elevation Contours in the Shallow Alluvial Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from 160.8 to 435.8 feet msl (Figure 2-17, Groundwater Elevation Contours in the Shallow Alluvial Aquifer, October 2–29, 2015). The large gap in the maximum elevation contours is caused by lack of data at the most upgradient monitoring location in fall of 2015.

The highest groundwater elevation in the Shallow Alluvial Aquifer was measured in Well 02N19W09E01S in the spring of 2015 (Figure 2-16). This well is the easternmost well with recorded groundwater elevations in the Shallow Alluvial Aquifer. The groundwater elevation in this well was not measured in the fall of 2015. In the fall of 2015, the highest groundwater elevation was measured in Well 02N19W07G01S, which is west of Well 02N19W09E01S. Groundwater elevations decline to the west in this aquifer, and the lowest groundwater elevations were measured in Well 02N20W17J06S, which is adjacent to the boundary with the PVB (Figures 2-16 and 2-17).

The observed gradient in the Shallow Alluvial Aquifer ranged from 0.007 feet/feet in the eastern part of the aquifer to 0.016 feet/feet in the western part of the aquifer in the spring of 2015. In the fall of 2015, the gradient ranged from 0.011 feet/feet in the eastern part of the aquifer to 0.021 feet/feet in the western part of the aquifer. This gradient drives lateral groundwater flow from east to west, generally following the trend of Arroyo Simi–Las Posas (Figures 2-16 and 2-17).

Vertical Gradients

Groundwater elevations in the Shallow Alluvial Aquifer were lower than those in the underlying USP, as measured in nested monitoring wells 02N19W07K03 and 02N19W07K04 (Table 2-2). The lower groundwater elevations in the Shallow Alluvial Aquifer produced an upward vertical gradient. In the fall of 2015, the gradient was approximately 0.03 feet/feet. This gradient indicates the potential for flow from the USP to the Shallow Alluvial Aquifer in this area, although the sediments of the USP have a low hydraulic conductivity that may limit flow into the Shallow Alluvial Aquifer.

Historical Groundwater Elevation Trends

Well 02N20W12G02S is the only well with a long-term record of groundwater elevations in the Shallow Alluvial Aquifer (Figures 2-16 and 2-17 and Figure 2-18, Shallow Alluvial Aquifer Groundwater Elevation Hydrographs). Groundwater elevations declined approximately 25 feet in this well from 1927, when the first measurements were collected, to 1940 (Figure 2-18). Between 1940 and 1954, groundwater elevations were relatively stable. Beginning in 1977, groundwater elevations rose as a result of increased urban runoff, discharges from dewatering wells in Simi Valley, and wastewater discharges to Arroyo Simi–Las Posas from the Simi Valley Water Quality Control Plant and MWTP (Las Posas Users Group 2012; CMWD 2016a). Between 1977 and 1995, groundwater elevations rose approximately 45 feet, as non-native perennial stream flows recharged the aquifer (Figure 2-18). The groundwater elevation record for Well 02N20W12G02S ends in 2002. Groundwater elevations in this well were relatively stable between 1995 and 2002. Although it is screened in the USP, below the base of the Shallow Alluvial Aquifer, groundwater elevations from Well 02N19W05K01S are also plotted on Figure 2-18 to bridge the gap in data between 2002 and 2014, when transducers were installed in several wells in the Shallow Alluvial Aquifer. The groundwater elevations in this well are used only as representative of the trends and conditions in the Shallow Alluvial Aquifer from 2002 to 2014.

These groundwater elevations indicate that elevations in the Shallow Alluvial Aquifer were likely stable during this period. In the western part of the Shallow Alluvial Aquifer, and in areas adjacent to the PVB, groundwater elevations have declined in recent years as the non-native perennial surface water flow in Arroyo Simi–Las Posas less frequently reaches the boundary between the LPVB and the PVB (CMWD 2016c). The decreased surface flows may reflect the decrease in wastewater discharge to Arroyo Simi–Las Posas from the MWTP percolation ponds since the late 1990s (CMWD 2016c).

2.3.1.2.2 Epworth Gravels Aquifer

Spring and Fall 2015 Groundwater Elevations

Five currently active wells are screened solely within the Epworth Gravels Aquifer (Figure 2-19, Groundwater Elevation Contours in the Epworth Gravels Aquifer, March 2–29, 2015). Of these, Wells 03N19W30M02S and 03N19W29F06S have recorded groundwater elevation measurements for spring and fall 2015 (Figure 2-19 and Figure 2-20, Groundwater Elevation Contours in the Epworth Gravels Aquifer, October 2–29, 2015). The remaining wells have only one recorded groundwater elevation, from January 2015. In the spring of 2015, the groundwater elevation in Well 03N19W30M02S was 619.5 feet msl and the groundwater elevation in Well 03N19W29F06S was 601.5 feet msl. In the fall, the groundwater elevation was 622 feet msl in Well 03N19W30M02S and 598.6 feet msl in Well 03N19W29F06S.

Vertical Gradients

There are no multiple-depth nested monitoring wells with screen intervals in the Epworth Gravels Aquifer, so vertical gradients cannot be calculated for this aquifer. Groundwater elevations in the Epworth Gravels Aquifer are, however, several hundred feet higher than in the underlying FCA, resulting in a downward potential vertical hydraulic gradient. As discussed above, the Epworth Gravels Aquifer is separated from the FCA by the USP. Therefore, although there is a downward gradient, flow from the Epworth Gravels Aquifer to the FCA is impeded by the low-permeability sediments of the USP.

Historical Groundwater Elevation Trends

Groundwater elevations in the Epworth Gravels Aquifer were as high as 712 feet msl in 1932, and declined steadily until 1980, when groundwater elevations were approximately 575 feet msl (Figure 2-21, Epworth Gravels Aquifer Groundwater Elevation Hydrographs). These declines were independent of climatic cycles in the basin. Groundwater elevations continued to decline, although at a slower rate, between 1980 and 1992, when the groundwater elevation was approximately 565 feet msl (Figure 2-21). Between 1992 and 2010, groundwater elevations recovered by 70 feet in Well 03N19W29F06S, partly in response to decreased production from the Epworth Gravels Aquifer as water levels declined and production wells were drilled in the FCA instead. After recovering between 1992 and 2010, groundwater levels declined by 20 feet between 2010 and 2015 (Figure 2-21). Groundwater elevations in the Epworth Gravels Aquifer remain approximately 100 feet below the highest recorded elevations in 1932 (Figure 2-21).

2.3.1.2.3 Upper San Pedro Formation

Spring and Fall 2015 Groundwater Elevations

There are nine currently active wells screened within the USP in the ELPMA (Figure 2-6). In the spring of 2015, recorded groundwater elevations in the USP ranged from 272.6 to 371.2 feet msl (Figure 2-6). In the fall of 2015, recorded groundwater elevations ranged from 272.8 to 437.6 feet msl (Figure 2-7).

In the spring, the highest groundwater elevation in the USP was measured in Well 02N19W06F01S, and in the fall, the highest groundwater elevation was measured in Well 02N19W07K03S, because no water level measurement was recorded for this well between March 2 and March 29, 2015 (Figures 2-6 and 2-7). Well 02N19W07K03S is screened from 240 to 300 feet bgs and is adjacent to Arroyo Simi–Las Posas. Groundwater elevations in this well are influenced by non-native surface water recharge from Arroyo Simi–Las Posas. The lowest recorded groundwater elevation in the USP was measured in Well 03N20W35R04S, which is screened from 490 to 530 feet bgs and is located approximately 2.5 miles northwest of Well 02N19W07K03S. The difference in groundwater elevations between these wells reflects the influence of recharge from non-native surface water flows in Arroyo Simi–Las Posas.

Vertical Gradients

The vertical gradient between the USP and the underlying FCA was determined from elevations measured in Wells 02N19W07K03S, 02N19W07K02S, 03N30W35R04S, and 03N30W35R03S. These wells are located in two separate multiple-depth nested monitoring well clusters. Wells 02N19W07K03S and 02N19W07K02S are located adjacent to Arroyo Simi–Las Posas, while Wells 03N20W35R04S and 03N20W35R03S are located in the central part of the ELPMA (Figures 2-6 and 2-9). In the fall of 2015, the vertical gradient between Wells 02N19W07K03S and 02N19W07K02S was 0.16 feet/feet, directed downward (Table 2-2). Groundwater elevations were not measured in these wells in the spring of 2015. In the spring of 2015, the vertical gradient between Wells 03N20W35R04S and 03N20W35R03S was 0.34 feet/feet, directed downward (Table 2-2). In the fall of 2015, the vertical gradient between these wells was 0.40 feet/feet directed downward (Table 2-2). The vertical gradient between the USP and the FCA is approximately 2.5 times greater in the vicinity of Wells 02N30W35R04S and 02N30W35R03S, in the central ELPMA, than it is in the vicinity of Arroyo Simi–Las Posas.

Historical Groundwater Elevation Trends

Groundwater elevation trends in the USP vary with screen interval depth and geographic location within the ELPMA. The groundwater elevation in Well 02N20W01M01S, the well with the longest historical record, declined approximately 30 feet between 1968 and 1977, after which the groundwater elevation remained stable until 2004 (Figure 2-22, Upper San Pedro Formation Groundwater Elevation Hydrographs: ELPMA). Between 2005 and 2010, the groundwater elevation declined an additional 60 feet, likely in response to production from the CMWD ASR well field between 2007 and 2010.

In contrast, the groundwater elevations in Wells 03N20W35R04S and 02N19W06F01S do not exhibit the same trends as those observed in Well 02N20W01M01S (Figure 2-22). Between 1991 and 2015, the groundwater elevation in Well 03N20W35R04S declined approximately 30 feet, independent of climatic cycles. The rate of decline slowed between 2002 and 2007, when CMWD was injecting water in its ASR wells between 2002 and 2007. When CMWD extracted water from the ASR wells between 2007 and 2011, groundwater levels in the well declined, though at a similar rate to the decline observed between 1991 and 2002. The groundwater elevation record in Well 02N19W06F01S has several gaps that limit the comparison between water levels and climate cycles. However, groundwater elevations in this well were approximately 150 feet higher in 2015 than they were in 1974 (Figure 2-22).

2.3.1.2.4 Fox Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, groundwater elevations in the FCA ranged from 142.8 to 285.8 feet msl (Figure 2-9). In the fall the groundwater elevations ranged from 127.8 to 279.3 feet msl (Figure 2-10). The highest groundwater elevations in the FCA were measured in Well 02N20W07K02S, adjacent to Arroyo Simi–Las Posas, and the lowest groundwater elevations were measured in wells located in the central part of the ELPMA (Figure 2-10).

The observed gradient in the FCA drives lateral groundwater flow toward the central part of the ELPMA. In the vicinity of Arroyo Simi–Las Posas, the lateral hydraulic gradient was approximately 0.031 feet/feet to the north-northwest in the spring of 2015 and 0.034 feet/feet to the north-northwest in the fall of 2015 (Figures 2-9 and 2-10). Additionally, recharge along the flanks of South Mountain produces a lateral gradient to the southeast, toward the central area of the ELPMA (Figures 2-9 and 2-10). This southeastern gradient was 0.011 feet/feet in the spring of 2015 and 0.007 feet/feet in the fall of 2015.

Vertical Gradients

Groundwater elevations in the FCA are lower than those in the overlying USP and Shallow Alluvial Aquifer, as measured in nested monitoring wells 02N19W07K02 and 02N19W07K03 in the vicinity of Arroyo Simi–Las Posas and Wells 03N20W35R03S and 03N20W35R04S in the central part of the ELPMA (Table 2-2). Groundwater elevations were not recorded for Wells 02N19W07K02 and 02N19W07K03 in the spring of 2015. The vertical gradient in Wells 03N20W35R03S and 03N20W35R04S was 0.34 feet/feet directed downward in the spring of 2015. The higher groundwater elevations in the Shallow Alluvial Aquifer and USP produced a downward vertical gradient of 0.16 feet/feet in the fall of 2015 in Wells 02N19W07K02 and 02N19W07K03 and 0.40 feet/feet in Wells 03N20W35R03S and 03N20W35R04S. In areas where the USP directly underlies the Shallow Alluvial Aquifer, direct downward transport of water is limited. However, in areas where the Shallow Alluvial Aquifer directly overlies the FCA, the downward gradient has resulted in transport of water from the Shallow Alluvial Aquifer to the FCA, as evidenced by increasing groundwater elevations and decreasing water quality in the FCA underlying the Shallow Alluvial Aquifer (Las Posas Users Group 2012; CMWD 2016a).

Within the FCA, there was an upward vertical gradient in the spring of 2015 and a downward vertical gradient in the fall of 2015 (Table 2-2). The vertical gradient within the FCA is one to two orders of magnitude smaller than the vertical gradient between the USP and the FCA. In the spring of 2015, the upward-directed gradient within the FCA was 0.004 feet/feet, and in the fall of 2015 the downward-directed gradient was 0.03 feet/feet.

Historical Groundwater Elevation Trends

Historical groundwater elevations and trends in the FCA vary geographically within the ELPMA. Groundwater elevation trends in the western, central, and eastern areas of the ELPMA are discussed below.

Southwestern East Las Posas Management Area

In the southwestern part of the ELPMA, groundwater elevations declined by approximately 80 feet in Well 02N20W10G01S between 1950 and 1975 (Figure 2-23, Fox Canyon Aquifer Groundwater Elevation Hydrographs: Southwestern ELPMA). Between 1975 and 1998, groundwater elevations in Well 02N20W10G01S recovered approximately 180 feet, in response to recharge from urban runoff, wastewater discharges, and shallow groundwater dewatering discharges that resulted in perennial surface water flows in Arroyo Simi–Las Posas (CMWD 2012a). These surface water flows percolated into the Shallow Alluvial Aquifer and eventually into the FCA. Since 1998, groundwater elevations in Well 02N20W10G01S have declined approximately 40 feet. These declines may reflect the decrease in wastewater discharge to Arroyo Simi–Las Posas from the MWTP percolation ponds since the late 1990s (CMWD 2016c).

Wells that are farther from Arroyo Simi–Las Posas (e.g., Wells 02N20W09F01S and 02N20W10D02S) tend to have lower groundwater elevations than Well 02N20W10G01S, and water levels in these wells have declined by approximately 60 feet since 1998. However, the overall trend in recovery and decline is similar to that observed in Well 02N20W10G01S (Figure 2-23). The change in groundwater elevation observed throughout the southwestern part of the ELPMA is primarily driven by the effects of groundwater recharge through Arroyo Simi–Las Posas, rather than by climatic cycles.

Central East Las Posas Management Area

In the central part of the ELPMA, groundwater elevations in Well 02N20W02D02S declined approximately 89 feet between 1955 and 1977 (Figure 2-24, Fox Canyon Aquifer Groundwater Elevation Hydrographs: Central ELPMA). Similarly, groundwater elevations in Well 03N20W36G01S declined approximately 92 feet between 1950 and 1969. Beginning in 1978, groundwater elevations began to recover in Well 02N20W02D02S. Between 1977 and 1998, groundwater elevations rose approximately 109 feet and were higher than the measured groundwater elevation in 1955 (Figure 2-24). Groundwater elevation was not measured in Well 03N20W36G01S during this period. However, in 1999, the groundwater elevation in Well 03N20W36G01S was approximately 150 feet below the measured groundwater elevation in this well in 1950 (Figure 2-24). The different groundwater elevation trends in these wells are likely caused by the proximity of Well 02N20W02D02S to Arroyo Simi–Las Posas. Recharge from non-native surface water flows in Arroyo Simi–Las Posas produced the groundwater elevation recovery observed in Well 02N20W02D02S. In contrast, groundwater levels did not recover in Well 03N20W36G01S, which is farther from Arroyo Simi–Las Posas, suggesting that there may be a geologic structure limiting the hydraulic connection between this well and the wells closer to Arroyo Simi–Las Posas.

From 1998 to 2007, groundwater elevations in the central ELPMA were stable (Wells 03N20W36G01S and 03N20W35J01S) to declining (Wells 02N20W02D02 and 02N20W03H01S). The overall rate of decline in Wells 02N20W02D02 and 02N20W03H01S was approximately 1.6 feet per year (Figure 2-24). It is noted that water levels in this area were stable or declining slightly despite considerable groundwater storage via in-lieu deliveries and injection by CMWD during this period. Water levels continued to decline at a rate of approximately 1 to 1.9 feet per year in Wells 02N20W02D02 and 02N20W03H01S between 2007 and 2015. Over the same period, groundwater elevations declined at a rate of approximately 9 feet per year in Well 03N20W36G01S, although the primary decline occurred between 2007 and 2010. This well is close to the CMWD ASR project well field, and water level declines measured in Well 03N20W36G01S between 2007 and 2010 are the result of groundwater extractions from the ASR well field during that period. Groundwater elevations recovered approximately 45 feet in Well 03N20W36G01S between 2010 and 2012, after extraction from the ASR well field ceased.

Groundwater elevations in this well have remained stable since 2012. It is noted that water levels in this area have been stable since 2012 despite considerable groundwater injection by CMWD. In the fall of 2015, the groundwater elevation in Well 03N20W36G01S was 127.8 feet msl, which is approximately 215 feet below the groundwater elevations in this well measured in the 1950s.

Eastern East Las Posas Management Area

The groundwater elevation in Well 03N19W29K04S, which has historical groundwater elevations dating back to 1972 (CMWD 2016c), declined approximately 200 feet during the 1970s, 1980s, and 1990s (Figure 2-25, Fox Canyon Aquifer Groundwater Elevation Hydrographs: Eastern ELPMA). The groundwater elevation decline measured in this well is larger than that observed in Well 03N19W19P02S, which declined approximately 30 feet over a similar period (Figure 2-25). From the early 1990s to 2007, groundwater elevations were stable in the eastern ELPMA (Figure 2-25). During this time, CMWD stored approximately 29,000 AF of groundwater in the ELPMA through in-lieu deliveries of surface water and direct injection of water in the ASR well field. Between 2007 and 2010, groundwater production from the CMWD ASR well field caused water level declines of between 40 and 100 feet (Figure 2-25). Groundwater elevations in Well 03N19W31B01 recovered approximately 40 feet between 2010 and 2012, and have remained stable since 2012 as a result of approximately 5,000 AF of water injected into the CMWD ASR well field during this time. Groundwater elevation has not been measured in Well 03N19W29K04S since 2012 (Figure 2-25). Groundwater elevations in the eastern ELPMA are primarily influenced by groundwater production and ASR activities in the ELPMA and are independent of climatic cycles.

2.3.1.2.5 Grimes Canyon Aquifer

There are no wells screened solely within the GCA in the ELPMA (Figures 2-13 and 2-14). Future groundwater monitoring efforts should include monitoring wells screened solely within the GCA to assess groundwater conditions in this aquifer.

2.3.2 Estimated Change in Storage

Estimated monthly change in storage values for the WLPMA and ELPMA were generated using numerical groundwater flow models. Values in the WLPMA came from the groundwater model prepared by UWCD (Appendix E). Change in storage estimates for the ELPMA came from the groundwater model prepared by CMWD (Appendix C). Monthly data reported from the model were summed to reflect the annual change in storage for water year 1986 through water year 2015 for the WLPMA and water year 1985 through water year 2015 for the ELPMA. Change in storage results for each management area are summarized in Figures 2-26 through 2-29, showing annual and cumulative changes in storage (by management area), and in the sections below.

2.3.2.1 West Las Posas Management Area

Change in storage in the WLPMA was calculated for the shallow aquifer system and the LAS. The water year average annual change in storage in the shallow aquifer system was a decrease in storage of approximately 230 AFY, with a maximum decrease in storage of approximately 3,150 AF in 2007 and a maximum increase in storage of approximately 5,000 AF in 2005 (Figure 2-26, West Las Posas Management Area Annual Change in Storage). In the LAS, the water year average annual change in storage was a decrease of approximately 2,100 AFY, with a maximum decrease in storage of approximately 15,900 AF in 1990 and a maximum increase in storage of approximately 14,900 AF in 1998 (Figure 2-26). The total average annual change in storage was a loss of approximately 2,300 AFY, with a maximum decrease in storage of approximately 18,400 AF in 1990 and a maximum increase in storage of approximately 18,500 AF in 1998 (Figure 2-26). The cumulative change in storage over the model period for the shallow aquifer system and the LAS was a loss of approximately 6,800 AF and a loss of approximately 63,400 AF, respectively, for a total cumulative loss in storage for the WLPMA of approximately 70,200 AF (Figure 2-27, West Las Posas Management Area Cumulative Change in Storage). Pumping within FCGMA jurisdiction is reported on a calendar-year basis, so pumping shown in the figures is per calendar year, while change in storage is per water year.

2.3.2.2 East Las Posas Management Area

Model calculated change in storage values for the ELPMA were obtained from the CMWD numerical model (Appendix C). Change in storage values were calculated for the Shallow Alluvial Aquifer, Epworth Gravels Aquifer, USP, FCA, and GCA (Figure 2-28, East Las Posas Management Area Annual Change in Storage). Average change in storage values for each aquifer, along with maximum and minimum change in storage values, are presented in Table 2-3. The total average annual change in storage was an increase in storage of approximately 3,600 AFY, with a maximum increase in storage in the basin of approximately 14,000 AF in 1986 and a maximum decrease in storage of approximately 8,300 AF in 2010. The cumulative change in storage from water year 1985 through water year 2015 for the Shallow Alluvial Aquifer, Epworth Gravels Aquifer, USP, FCA, and GCA were increases of approximately 7,600 AF, 2,700 AF, 53,700 AF, 44,700 AF, and 3,800 AF, respectively, for a total cumulative storage increase in the basin of approximately 112,500 AF (Figure 2-29, East Las Posas Management Area Cumulative Change in Storage). The cumulative increase in storage has leveled off since 2010 (Figure 2-19). As noted previously, pumping in FCGMA jurisdiction is reported on a calendar-year basis, so pumping shown in the figures is per calendar year.

2.3.3 Seawater Intrusion

The western boundary of the LPVB is approximately 9 miles east of the Pacific Ocean. The western LPVB is in hydraulic communication with the Oxnard Subbasin, the western boundary of which is the Pacific Ocean and has experienced seawater intrusion in both the Upper Aquifer System (UAS) and the LAS. The UAS of the Oxnard Subbasin does not extend into the WLPMA. Additionally, the eastward extent of seawater intrusion in the Oxnard Subbasin is approximately 6 to 7 miles southwest of the boundary between the Oxnard Subbasin and the LPVB. Therefore, seawater intrusion is not currently a problem for the LPVB. Furthermore, the LPVB and Oxnard Subbasin are both managed by FCGMA, which has set targets and specified measurable objectives to attain control over seawater intrusion in the GSP for the Oxnard Subbasin. Therefore, seawater intrusion is not anticipated to occur within the LPVB in the future. However, groundwater pumping in the LAS in the WLPMA can directly affect seawater intrusion in the Oxnard Subbasin by lowering the groundwater elevations in the WLPMA thereby increasing groundwater flow from the Oxnard Subbasin into the WLPMA. There is no potential for seawater intrusion in the ELPMA and pumping there does not impact the ability of other basins to address seawater intrusion.

2.3.4 Groundwater Quality

FCGMA adopted Basin Management Objectives (BMOs) for chloride (Cl) and total dissolved solids (TDS) in the LPVB (FCGMA 2007; Table 2-4). The Water Quality Control Plan: Los Angeles Region (Basin Plan) also specifies Water Quality Objectives (WQOs) for total dissolved solids (TDS), chloride, nitrate (mg/L as nitrate, or NO_3), sulfate (SO_4), and boron (B) (LARWQCB 2014; Table 2-4). The current and historical distribution of these five constituents are discussed below, based on management area rather than individual aquifer. There are too few measurements of water quality in wells screened solely within a single aquifer to allow for meaningful discussion of water quality by aquifer.

Groundwater quality monitoring within the LPVB occurs on different schedules for different wells. In order to assess the current groundwater quality conditions within the LPVB, the most recent concentration of each of the five constituents listed above was mapped for samples collected between 2011 and 2015. Historical groundwater quality hydrographs are presented in Appendix F. Statistics on the most recent sample date, the maximum and minimum concentrations measured, the number of times sampled, and the number of samples whose concentration exceeded the relevant water quality threshold are presented in Appendix G.

2.3.4.1 Total Dissolved Solids

The WQO for TDS is 700 mg/L for the eastern part of the WLPMA and 500 mg/L for the western part of the WLPMA (Figures 2-30A and 2-30B, Most Recent Total Dissolved Solids [mg/L]

Measured 2011–2015; Table 2-4; LARWQCB 2014). The FCGMA BMO for TDS is 600 mg/L in the WLPMA (Table 2-4; FCGMA 2007).

In the ELPMA, the WQO for TDS ranges from 250 mg/L in the area near Grimes Canyon Road and Broadway to 2,500 mg/L east of Grimes Canyon Road and Hitch Boulevard (Table 2-4; Figures 2-30A and 2-30B). The FCGMA BMOs for TDS in the ELPMA range from 500 mg/L to 1,500 mg/L, depending on location and aquifer depth (Table 2-4). Sources of high-TDS water in the LPVB include upstream discharges to Arroyo Simi–Las Posas from dewatering wells in Simi Valley (see Section 1.3.2, Geography, of this GSP).

West Las Posas Management Area

The concentration of TDS in groundwater in the WLPMA ranged from 300 to 1,910 mg/L (Figures 2-30A and 2-30B). The highest concentration of TDS was measured in Well 02N21W18H01S, which is adjacent to the boundary between the LPVB and the Oxnard Subbasin and is screened across multiple aquifers (Figures 2-30A and 2-30B). Other wells in this area, screened solely within the FCA, have concentrations of TDS ranging from 1,050 to 1,400 mg/L. These concentrations are similar to those in the adjacent Oxnard Basin.

Groundwater sampled from Well 02N21W18H01S also has the highest concentration of chloride, nitrate, sulfate, and boron measured between 2011 and 2015 in the WLPMA (Figures 2-31 through 2-34). The consistently high concentrations in this well relative to nearby wells suggests that the water quality in this well may be influenced by shallow groundwater with higher concentrations of TDS, chloride, nitrate, sulfate, and boron.

The lowest concentrations of TDS are found in the eastern part of the WLPMA, near the Somis Fault (Figures 2-30A and 2-30B). With the exception of Well 03N20W32H03, which has a TDS concentration of 1,200 mg/L, wells screened in the FCA in this area have TDS concentrations of between 300 and 650 mg/L.

East Las Posas Management Area

The concentration of TDS in groundwater in the ELPMA ranged from 261 mg/L to 1,540 mg/L (Figures 2-30A and 2-30B). The highest concentration was measured in Well 02N20W09Q07S, which is adjacent to Arroyo Simi–Las Posas and is screened within the FCA (Figures 2-30A and 2-30B). Wells adjacent to Arroyo Simi–Las Posas have TDS concentrations that are higher than the majority of wells within the ELPMA, with concentrations between approximately 1,200 and 1,500 mg/L. The higher concentration of TDS along Arroyo Simi–Las Posas likely results from discharges of high-TDS water to the Arroyo Simi–Las Posas from shallow dewatering wells in Simi Valley, SVWQCP discharges, and discharges from the MWTP percolation ponds (Todd Groundwater 2016). In general, TDS concentrations in the ELPMA decrease to the north (Figures

2-30A and 2-30B). The lowest concentration of TDS was measured in Well 03N19W30E06S, screened in the FCA to the north of the Fairview Fault (Figures 2-30A and 2-30B). In the hills along the northern edge of the LPVB, outcrops of the FCA are recharged directly by infiltration of precipitation, which results in lower concentrations of TDS in the groundwater in these areas.

2.3.4.2 Chloride

The WQO for chloride is 100 mg/L for the eastern part of the WLPMA and 150 mg/L for the western part of the WLPMA (Figures 2-31A and 2-31B, Most Recent Chloride [mg/L] Measured 2011–2015; Table 2-4; LARWQCB 2014). The FCGMA BMO for chloride is 100 mg/L in the WLPMA (Table 2-4; FCGMA 2007).

In the ELPMA, the WQO for chloride ranges from 30 mg/L in the area near Grimes Canyon Road and Broadway to 400 mg/L east of Grimes Canyon Road and Hitch Boulevard (Table 2-4; Figures 2-31A and 2-31B). The FCGMA BMOs for chloride in the ELPMA range from 100 mg/L to 160 mg/L, depending on location and aquifer depth (Table 2-4). Sources of high-TDS water in the LPVB include upstream discharges to Arroyo Simi–Las Posas from dewatering wells in Simi Valley (see Section 1.3.2).

West Las Posas Management Area

The concentration of chloride in groundwater in the WLPMA ranges from 10 to 160 mg/L (Figures 2-31A and 2-31B). The highest concentration of chloride was measured in Well 02N21W18H01S, which is adjacent to the boundary between the LPVB and the Oxnard Subbasin and is screened across multiple aquifers (Figures 2-31A and 2-31B). Other wells in this area, screened solely within the FCA, have concentrations of chloride ranging from 51 to 84 mg/L.

Groundwater sampled from Well 02N21W18H01S also had the highest concentration of TDS, sulfate, and boron measured between 2011 and 2015 in the WLPMA. The consistently high concentrations in this well relative to nearby wells suggests that the water quality in this well may be influenced by shallow groundwater with higher concentrations of TDS, chloride, nitrate, sulfate, and boron.

The lowest concentrations of chloride are found in the eastern part of the WLPMA, near the Somis Fault (Figures 2-31A and 2-31B). Wells screened in the FCA in this area have chloride concentrations between 10 and 61 mg/L.

East Las Posas Management Area

The concentration of chloride in groundwater in the ELPMA ranges from 11 to 220 mg/L (Figures 2-31A and 2-31B). The highest concentration was measured in Well 02N20W09Q04S, which is adjacent to Arroyo Simi–Las Posas and screened in multiple aquifers (Figures 2-31A and 2-31B). Wells adjacent to Arroyo Simi–Las Posas have chloride concentrations that are higher than the majority of wells within the ELPMA, with concentrations ranging from 153 to 220 mg/L. The higher concentration of chloride along Arroyo Simi–Las Posas likely results from the combined discharges of water to the Arroyo from shallow dewatering wells in Simi Valley, SVWQCP discharges, and discharges from the MWTP percolation ponds (Todd Groundwater 2016). In general, chloride concentrations in the ELPMA decrease to the north (Figures 2-31A and 2-31B). The lowest concentration of chloride was measured in Well 03N20W36A02S, screened in the FCA to the south of the Fairview Fault (Figures 2-31A and 2-31B). In the hills along the northern edge of the LPVB, outcrops of the FCA are recharged directly by infiltration of precipitation, which results in lower concentrations of chloride in the groundwater in these areas.

2.3.4.3 Nitrate

The WQO for nitrate is 45 mg/L for both the WLPMA and ELPMA within the LPVB. There are no BMOs for nitrate in the LPVB.

West Las Posas Management Area

The concentration of nitrate as NO_3 in groundwater in the WLPMA ranged from 1 to 208 mg/L (Figures 2-32A and 2-32B, Most Recent Nitrate [mg/L as Nitrate] Measured 2011–2015). The highest concentration of nitrate was measured in Well 02N21W11A03S, which is located between Price Road and Aggen Road in the central WLPMA and is screened in the USP (Figures 2-32A and 2-32B). Only three wells exceeded 45 mg/L nitrate in the WLPMA between 2011 and 2015 (Figure 2-31a).

Groundwater sampled from Well 02N21W18H01S also had a nitrate concentration of 130 mg/L. Well 02N21W18H01S is located adjacent to the Oxnard Subbasin and is screened across multiple aquifers. Other wells in this area, screened solely within the FCA, have concentrations of nitrate ranging from 0.9 to 43 mg/L. Well 02N21W18H01S had the highest concentration of TDS, chloride, sulfate, and boron measured between 2011 and 2015 in the WLPMA. The consistently high concentrations in this well relative to nearby wells suggests that the water quality in this well may be influenced by shallow groundwater with higher concentrations of TDS, chloride, nitrate, sulfate, and boron.

The lowest concentrations of nitrate are found in the eastern part of the WLPMA, near the Somis Fault (Figures 2-32A and 2-32B). Wells screened in the FCA in this area have detectable nitrate concentrations between 0.5 and 12 mg/L.

East Las Posas Management Area

The detectable concentration of nitrate in groundwater in the ELPMA ranged from 0.6 to 89 mg/L (Figures 2-32A and 2-32B). The highest concentration was measured in Well 03N20W34K01S, which is adjacent to Balcom Canyon Road in the central ELPMA and is screened solely in the FCA (Figures 2-32A and 2-32B).

Groundwater concentrations of nitrate as NO_3 greater than 45 mg/L are found in four wells in the ELPMA. These wells are located in the central and northern parts of the ELPMA and do not follow a clear geographic trend. Two of the four wells are screened solely within the FCA, one is screened solely within the GCA, and one is screened across multiple aquifers. The majority of the wells in the ELPMA have nitrate as NO_3 concentrations below 10 mg/L.

2.3.4.4 Sulfate

The WQO for sulfate is 300 mg/L for the eastern part of the WLPMA and 250 mg/L for the western part of the WLPMA (Figures 2-33A and 2-33B, Most Recent Sulfate [mg/L] Measured 2011–2015; Table 2-4; LARWQCB 2014). In the ELPMA, the WQO for sulfate ranges from 30 mg/L in the area near Grimes Canyon Road and Broadway to 1,200 mg/L east of Grimes Canyon Road and Hitch Boulevard (Table 2-4; Figures 2-33A and 2-33B). There are no BMOs for sulfate in the LPVB.

West Las Posas Management Area

The concentration of sulfate in groundwater in the WLPMA ranges from 76 to 790 mg/L (Figures 2-33A and 2-33B). The highest concentration of sulfate was measured in Well 02N21W18H01S, which is adjacent to the boundary between the LPVB and the Oxnard Subbasin and is screened across multiple aquifers (Figures 2-33A and 2-33B). Other wells in this area that are screened solely within the FCA have concentrations of sulfate ranging from 320 to 534 mg/L. In the WLPMA, 13 wells exceeded 300 mg/L sulfate between 2011 and 2015 (Figure 2-33A).

Groundwater sampled from Well 02N21W18H01S also had the highest concentration of TDS, chloride, and boron measured between 2011 and 2015 in the WLPMA. The consistently high concentrations in this well relative to nearby wells suggests that the water quality in this well may be influenced by shallow groundwater with higher concentrations of TDS, chloride, nitrate, sulfate, and boron.

The lowest concentrations of sulfate are found in the eastern part of the WLPMA, near the Somis Fault (Figures 2-33A and 2-33B). With the exception of Well 03N20W32H03, which has a sulfate concentration of 490 mg/L, wells screened in the FCA in this area have sulfate concentrations between 85 and 290 mg/L.

East Las Posas Management Area

The concentration of sulfate in groundwater in the ELPMA ranges from 26 to 850 mg/L (Figures 2-33A and 2-33B). The highest concentration was measured in Well 02N20W09Q04S, which is adjacent to Arroyo Simi–Las Posas and is screened in multiple aquifers (Figures 2-33A and 2-33B). Wells adjacent to Arroyo Simi–Las Posas have sulfate concentrations that are higher than the majority of wells within the ELPMA, with concentrations ranging from 430 to 850 mg/L. The higher concentration of sulfate along Arroyo Simi–Las Posas likely results from discharges of water to the Arroyo Simi–Las Posas from shallow dewatering wells in Simi Valley, SVWQCP discharges, and discharges from the MWTP percolation ponds (Todd Groundwater 2016). In the ELPMA, five wells exceeded 300 mg/L sulfate between 2011 and 2015 (Figure 2-33B)

In general, sulfate concentrations in the ELPMA decrease to the north (Figures 2-33A and 2-33B). The lowest concentration of sulfate was measured in Well 03N19W29K06S, screened in the FCA, to the north of the Fairview Fault (Figures 2-33A and 2-33B). In the hills along the northern edge of the LPVB, outcrops of the FCA are recharged directly by infiltration of precipitation, which results in lower concentrations of sulfate in the groundwater in these areas.

2.3.4.5 Boron

The WQO for boron is 0.5 mg/L for the eastern part of the WLPMA and 1 mg/L for the western part of the WLPMA (Figures 2-34A and 2-34B, Most Recent Boron [mg/L] Measured 2011–2015; Table 2-4; LARWQCB 2014). In the ELPMA, the WQO for boron ranges from 0.2 mg/L in the area near Grimes Canyon Road and Broadway to 3 mg/L east of Grimes Canyon Road and Hitch Boulevard (Table 2-4; Figures 2-34A and 2-34B). There are no BMOs for boron in the LPVB.

West Las Posas Management Area

The concentrations of boron in groundwater in the WLPMA ranged from less than the detection limit to 0.9 mg/L (Figures 2-34A and 2-34B). The highest concentration of boron was measured in Well 02N21W22A01S, which is screened in the GCA (Figures 2-34A and 2-34B). Other wells in the GCA have concentrations of boron ranging from 0.6 to 0.8 mg/L.

The lowest concentrations of boron are found in the eastern part of the WLPMA, near the Somis Fault (Figures 2-34A and 2-34B). Several wells in this area did not have detectable concentrations of boron. The highest detectable concentration of boron was 0.1 mg/L for wells screened in the FCA in this area.

East Las Posas Management Area

The concentration of boron in groundwater in the ELPMA ranged from less than the detection limit to 0.9 mg/L (Figures 2-34A and 2-34B). The highest concentration was measured in Wells

02N20W09Q04S and 02N19W07B02S, which are adjacent to Arroyo Simi–Las Posas. The aquifer in which Well 02N20W09Q04S is screened is not known. Well 02N19W07B02S is screened in the FCA (Figures 2-34A and 2-34B). Wells adjacent to Arroyo Simi–Las Posas have boron concentrations that are higher than the majority of wells within the ELPMA, with concentrations ranging from 0.6 to 0.9 mg/L. In general, boron concentrations in the ELPMA decrease to the north (Figures 2-34A and 2-34B). The higher concentration of boron along Arroyo Simi–Las Posas likely results from discharges of water to the Arroyo Simi–Las Posas from shallow dewatering wells in Simi Valley, SVWQCP discharges, and discharges from the MWTP percolation ponds (Todd Groundwater 2016).

2.3.4.6 Maps of Features That Could Impact Groundwater Quality

Map of Oil and Gas Deposits

In the database maintained by the County of Ventura, six oil fields entirely or partially fall within the LPVB: Las Posas, Somis, South Mountain, Moorpark West, Moorpark, and Oak Park (Figure 2-35, Oil Fields in the Vicinity of FCGMA Groundwater Basins).

Map of Locations of Impacted Surface Water

Impaired surface waters (i.e., 303[d] Listed Reaches) that overlie the LPVB include Beardsley Wash, Fox Barranca, and Arroyo Simi–Las Posas (Figure 2-36, Impaired Surface Waters in the Vicinity of FCGMA Groundwater Basins; Appendix H [LPVB 303(d) List Reaches]; SWRCB 2004).

Map of Locations of Impacted Soil and Groundwater

Locations of impacted soil and groundwater were assessed on a basin-wide scale by reviewing information available on the California State Water Resources Control Board GeoTracker website and the California Department of Toxic Substances Control EnviroStor website. Cases that were closed by the supervisory agency were not considered.

No open cases with impacted groundwater were identified in the LPVB. Consequently, it does not appear that existing groundwater contamination poses a substantial threat to beneficial use of groundwater in the LPVB.

2.3.5 Subsidence

Inelastic, or irrecoverable, land subsidence (subsidence) is a concern in areas of active groundwater extraction, including the LPVB. Active causes of land subsidence in LPVB include tectonic forces, petroleum reservoir compaction, and aquifer compaction (USGS 2003). Significant water level declines in the FCGMA groundwater basins since the early 1900s suggest that fluid extraction, in addition to tectonic forces, is a cause of land subsidence in the LPVB (USGS 2003). Subsidence resulting from any of these sources can cause infrastructure damage, increased flood risk, well casing collapse, and a permanent reduction in specific storage.

Direct measurement of historic subsidence in the LPVB is limited geographically and historically. Two subsidence survey monuments exist in the LPVD. UNAVCO monument MPWD is located in the foothills north of Moorpark, in the ELPMA, and monument P729 is located near Los Angeles Avenue on the western boundary of the LPVB (Figure 2-37, Subsidence Monuments in the Las Posas Valley Basin). UNAVCO is a non-profit university-governed consortium that facilitates geoscience research and education using geodesy (UNAVCO 2017). Each geo-located UNAVCO land surface monument is given a four-character identifier (e.g., MPWD).

There has been no measurable subsidence at monument MPWD since it was installed in 2000 (Figure 2-37). Monument P729 has experienced approximately 8 centimeters (3 inches) of subsidence since it was installed in 2007 (Figure 2-37). The subsidence measured at this monument reflects the combined effects of tectonic activity, groundwater withdrawals, and oil and gas withdrawals. Although these effects cannot be separated in the recorded subsidence at this monument, the majority of the subsidence at monument P729 has occurred since 2012, coincident with a period of drought, and with reduced surface water spreading in the Forebay area of the Oxnard Subbasin to the northwest of this monument.

DWR designated the LPVB as an area that has a medium to low potential for future subsidence. The amount of future subsidence will depend on whether future water levels decline below previous maximum declines for a sufficient time to cause compaction, or remain above these previous low levels (USGS 2003).

From March 2015 to June 2016, the Jet Propulsion Laboratory (JPL) analyzed interferometric synthetic aperture radar (InSAR) data from the European Space Agency's satellite-borne Sentinel-1A and NASA's airborne UAVSAR along with similar previous studies from 2006 to 2015 to examine subsidence in areas of California. The study included the south-central coast of California areas of Ventura and Oxnard (Farr et al. 2017). The map generated from this study for the south-central coast of California area (Farr et al. 2017, Figure 23) showed less than 1 foot of subsidence for the LPVB area.

2.3.6 Groundwater–Surface Water Connections

2.3.6.1 West Las Posas Management Area

There are no surface water bodies that are considered to be major contributors to groundwater in the WLPMA.

2.3.6.2 East Las Posas Management Area

Arroyo Simi and Arroyo Las Posas have been identified as surface water bodies that may have a connection to groundwater in the ELPMA. Dry weather flows in Arroyo Simi–Las Posas are the result of discharge from the SVWQCP, dewatering wells operated by the City of Simi Valley, and discharges from the MWTP percolation ponds adjacent to Arroyo Simi–Las Posas. During a study conducted in 2011 and 2012, gauges along Arroyo Simi–Las Posas were used to identify gaining and losing sections along the stream (CMWD 2012, 2013; Figure 2-16). Overall, the study identified an average yearly net loss from Arroyo Simi–Las Posas to groundwater of approximately 10,187 AFY.

2.3.7 Groundwater-Dependent Ecosystems

Arroyo Simi–Las Posas is the dominant surface water body in the LPVB. The watershed for Arroyo Simi–Las Posas extends beyond the boundaries of the LPVB. Examination of available County's air photos indicated that Arroyo Simi–Las Posas in the LPVB was dry without adjacent vegetation before the 1970s. Within LPVB, flow in Arroyo Simi–Las Posas has been perennial since the 1970s. Flow in Arroyo Simi–Las Posas is from both native and non-native flow sources (Bachman 2016; Las Posas Users Group 2012). The non-native flows consist of discharges from the SVWQCP, dewatering wells operated by the City of Simi Valley, and discharges from the MWTP percolation ponds adjacent to Arroyo Simi–Las Posas (Bachman 2016; Las Posas Users Group 2012). Irrigation water from agriculture and/or landscaping may also serve as a source of flow in the channel during some parts of the year.

Arroyo Simi–Las Posas was identified as a potential groundwater-dependent ecosystem (GDE) on the statewide potential GDE map (Figure 2-38, Potential Groundwater-Dependent Ecosystems for the Las Posas Valley Basin; Appendix I, The Nature Conservancy GDE Tech Memo). The connection between Arroyo Simi–Las Posas and the underlying Shallow Alluvial Aquifer varies with location in the ELPMA (CMWD 2012, 2013). Arroyo Simi–Las Posas is a losing stream from upstream of the basin boundary to approximately Leta Yancy Road in Moorpark, at which point it becomes a gaining stream to approximately a mile downstream of the MWTP (CMWD 2012, 2013). Downstream from this point, Arroyo Simi–Las Posas is a losing stream again, extending into the PVB to the south (Figure 2-16). Currently, perennial flow in Arroyo Simi–Las Posas ends upstream of the boundary between the LPVB and PVB, although in the past, perennial flow has reached the PVB. During 2014 and 2015, which were both drought years, the terminus of perennial flow retreated upstream (CMWD 2015, 2016d).

The Arroyo Simi–Las Posas potential GDE ranges from natural channel consisting of riparian woodland/wetland habitat (Caltrans 1987) to a confined channel with riprap on the sides and a soft bottom that is maintained in a largely vegetation-free state by the VCWPD (Appendix I). In the natural areas of the stream channels, the active channel generally supports a dense canopy of vegetation, although winter storm events can scour the active channel and mid- to lower terraces, leaving some areas free of vegetation for extended periods of time (VCWPD and Aspen Environmental Group 2013a).

The Basin Plan (LARWQCB 2014) for Arroyo Simi–Las Posas lists the following beneficial uses: groundwater recharge, warm freshwater habitat, cold freshwater habitat (potential), wildlife habitat, and freshwater replenishment. Arroyo Simi–Las Posas provides habitat for the state- and federally listed endangered least Bell's vireo (*Vireo bellii pusillus*) and supports the native arroyo chub (*Gila orcuttii*), southwestern pond turtle (*Actinemys pallida*), and the San Diego desert woodrat (*Neotoma lepida intermedia)* (CDFW 2017). Additionally, in the Virginia Colony Area, which is outside the FCGMA jurisdictional boundary but within the LPVB boundary, the GDE supports the federally threatened California gnatcatcher (*Polioptila californica californica*) (VCWPD and Aspen Environmental Group 2013b).

The depth to groundwater in Shallow Alluvial Aquifer wells adjacent to Arroyo Simi–Las Posas varies from less than 5 feet in Well 02N19W07K04S to more than 80 feet in Well 02N20W17J06S (Figure 2-39, Depth to Water in the Shallow Alluvial Aquifer). The depth to groundwater reported is what was measured in the wells. However, few of the wells screened in the Shallow Alluvial Aquifer lie within the boundaries of the potential GDE, and the measuring point for these wells is at a higher elevation than it would be if the well were located closer to Arroyo Simi–Las Posas. For instance, the ground surface elevation at Well 02N20W17J06S is approximately 274 feet msl. The elevation of the land surface in Arroyo Simi–Las Posas, approximately 300 feet to the southeast of Well 02N20W17J06S, is 30 feet lower than it is at the well. Therefore, the depth to groundwater within the potential GDE may be as much as 30 feet less than it is at Well 02N20W17J06S. Accounting for this difference in elevation, an approximate depth to water within the potential GDE is also shown on Figure 2-39. Using the approximate depth to water, Wells 02N19W07K04S, 02N20W17J06S, and 02N20W09Q08S may have groundwater elevations in the potential GDE that are less than 15 feet bgs (Figure 2-39). Therefore, the vegetation in the potential GDE may be supported by what is now shallow groundwater but was formerly surface water, which infiltrated through the sediments underlying Arroyo Simi–Las Posas. As described above, this process, which elevated groundwater levels in in the Shallow Alluvial Aquifer, is primarily the result of non-native surface water flows that have recharged the Shallow Alluvial Aquifer over time.

Wastewater recycling at the SVWQCP, which is one of the primary sources of surface water flow to Arroyo Simi–Las Posas, is anticipated to decrease surface water flows and recharge to the aquifer in the future. This potential change may negatively impact the potential GDE. Such a change, however, is unrelated to groundwater production from the Shallow Alluvial Aquifer, and is outside the jurisdictional powers of FCGMA to prevent. Better understanding of the hydrology along Arroyo Simi–Las Posas would aid in determining the impacts of decreasing groundwater levels on the riparian habitat and the potential for groundwater production to contribute to decreasing groundwater levels. The future monitoring network should include wells dedicated to monitoring water levels in the potential GDE to assess the degree to which existing habitat is reliant on groundwater under native flow conditions.

2.3.8 Potential Recharge Areas

To evaluate potential future recharge areas within the LPVB, soil types were obtained from the Web Soil Survey (USDA 2019). Soil Ksat rates (saturated hydraulic conductivity rates) for soils of 92 micrometers per second or greater were plotted. Figure 2-40, Las Posas Valley Potential Recharge Areas, shows the results of this evaluation and areas with the most favorable soil recharge rates. The most favorable areas are along Arroyo Simi–Las Posas, along the north–south drainage at the eastern FCGMA boundary, and along small drainages north of Moorpark (Figure 2-40).

2.4 WATER BUDGET

This section presents the water budgets that have been prepared for the aquifer systems in the LPVB. These water budgets were completed in accordance with the DWR GSP Regulations. Separate water budgets were prepared for the WLPMA and ELPMA. The WLPMA and ELPMA water budgets were prepared for the 31-year period from 1985 through 2015, and are described in units of AF or AFY.

CMWD (Appendix C) developed the Groundwater Flow Model of the East and South Las Posas Sub-Basins, a MODFLOW numerical groundwater flow model, for the ELPMA of the LPVB. The groundwater budget analysis for the ELPMA is based on the 2016 modifications to the DWR Bulletin 118 basin boundary for the LPVB east of the Somis Fault (Central Las Posas Fault) as shown on Figure 2-2. As with all groundwater flow models, the CMWD model has undergone revisions and will continue to be revised as additional data are collected and the understanding of the hydrogeologic interactions in the model domain improves. This GSP uses the version of the model finalized in September 2018, which was developed to support the GSP process. This version of the model was used for the ELPMA current and historical water budget analysis as well as for the future projected groundwater scenarios discussed in Section 2.4.5, Projected Water Budget and Sustainable Yield.

UWCD (Appendix E) developed the Ventura Regional Groundwater Flow Model, a MODFLOW numerical groundwater flow model, for the Oxnard Subbasin, the Mound Basin, the WLPMA, and the PVB. The groundwater budget analysis for the WLPMA are based on the 2016 modifications to the DWR Bulletin 118 basin boundary for the LPVB west of the Somis Fault (Central Las Posas Fault), as shown on Figure 2-2. The UWCD model has undergone several revisions and will continue to be revised as additional data are collected and the understanding of the hydrogeologic interactions in the model domain improves. This GSP uses the version of the model finalized in June 2018, which was developed to support the GSP process. This version of the model was used for the current and historical WLPMA water budget analysis as well as for the future projected groundwater scenarios discussed in Section 2.4.5.

2.4.1 Sources of Water

The LPVB receives water from several water sources. Native sources consist predominantly of rainfall infiltration within the LPVB and along its margins (mountain-front recharge), including stormwater runoff from tributary canyons, subsurface inflows to the ELPMA from adjacent Simi Valley, and groundwater inflow to the WLPMA from the Oxnard Subbasin.

Water sources from human activities provide additional sources of water to the LPVB. These consist of deep percolation of a portion of the irrigation water that is applied to both agricultural and landscaped lands (i.e., irrigation return flows), leakage from water distribution systems, periodic direct injection of imported water at CMWD’s ASR wellfield, percolation of treated wastewater from the MWTP, septic system discharges, percolation of treated wastewater from the SVWQCP discharged to Arroyo Simi, and percolation of pumping groundwater from Simi Valley dewatering discharged to Arroyo Simi.

Imported water supplies consist of imported Metropolitan Water District of Southern California water provided by the CMWD and a blend of CMWD-supplied water (State Water Project or Colorado River water), Conejo Creek water, and/or pumped groundwater supplied by the Camrosa Water District from the PVB and Arroyo Santa Rosa Valley Basin.

Twenty-three water purveyors have service areas located wholly or partially within the LPVB (Figure 1-8). Eight of these water purveyors import some portion of their water through CMWD, while the rest of their water supply for service areas within the LPVB comes from pumped groundwater and, in the case of one purveyor, Ventura County Waterworks District (VCWD) No. 1, recycled water. The remaining 15 water purveyors provide exclusively groundwater to their service areas. The sources of water supplied by each water purveyor are summarized in Table 2-5.

2.4.1.1 Surface Water Flows

The Arroyo Simi–Las Posas is the lone perennial stream in the ELPMA. There are no permitted surface water diversions in the LPVB. In addition to storm flows, Arroyo Simi–Las Posas receives inflow from discharges in Simi Valley, which is located immediately upstream (east) of the LPVB (Figure 2-41, Las Posas Valley Basin Stream Gauges and Water Infrastructure). These dry-weather flows occur as discharges from the SVWQCP, dewatering wells, minor amounts of urban runoff, and natural groundwater discharges at the west end of Simi Valley. SVWQCP discharges and Simi Valley dewatering amounts are listed in Table 2-6. Discharge from the SVWQCP are estimated to have averaged 9,936 AFY from 1985 to 2015, and ranged from 8,506 to 11,171 AFY (Table 2-6). Discharge from Simi Valley dewatering operations are estimated to have averaged 1,618 AFY from 1985 to 2015, ranging between 0 to 1,949 AFY (Table 2-6).

In addition to the dry-weather SVWQCP and Simi Valley dewatering inflows, this creek system receives dry-weather (non-storm) inflows from seepage percolation of treated wastewater from the MWTP infiltration ponds. These percolation ponds have been active since at least 1960, and in 2015 they percolated 1,635 AF of secondary-treated wastewater into the ELPMA. Table 2-6 shows the amounts of secondary-treated wastewater percolated in these ponds since 1985. In 2001 and 2002, the MWTP also released 1,647 and 1,613 AF of tertiary-treated wastewater into Arroyo Simi–Las Posas. Figure 2-42, Wastewater Treatment Plant Discharges and Flows from Simi Valley, shows the amounts of MWTP discharges and Simi Valley inflows from 1985 to 2015.

Recharge from Surface Water

West Las Posas Management Area

Beardsley Wash in the WLPMA was discussed in the UWCD model (Appendix E) as a channel that could convey stormwater and agricultural return flows from the WLPMA to the Mugu Lagoon area in the Oxnard Subbasin. The UWCD model report states that Beardsley Wash in the western part of the WLPMA is likely to have had some sort of drainage system in place to reduce soil alkalinity and prevent waterlogging of the root zone for crops. Thus, no recharge from Beardsley Wash was calculated in the UWCD model in the WLPMA.

East Las Posas Management Area

In 2011 and 2012, Larry Walker & Associates (LWA) conducted dry-weather gauging along Arroyo Simi–Las Posas to evaluate streambed percolation for CMWD (CMWD 2012, 2013). The gauging locations (G1 to G11) used in the study are shown on Figure 2-41. LWA generally observed losing conditions from G1 to G4 and from G7 to G11, and gaining conditions from G4 to G7. Field studies have observed that the dry-weather discharge in Arroyo Simi–Las Posas during the current drought years ends before the stream exits the ELPMA; therefore, effluent discharge was observed to percolate, evaporate, or be transpired within the extent of the ELPMA.

The CMWD groundwater model (Appendix C) used these LWA reaches to estimate focused recharge from percolation of streamflow in Arroyo Simi–Las Posas for baseflow conditions. The baseflow focused recharge was estimated by scaling reach-specific streamflow differences measured by LWA to either (1) annual SVWQCP discharge to Arroyo Simi–Las Posas or (2) annual discharge to the Moorpark percolation ponds, depending on the location of the reach (Appendix C). Recharge from stormflow conditions when runoff and tributary inflows reach Arroyo Simi–Las Posas, which typically only occurs during the winter or during heavy periods of rain was not estimated because of the lack of stream gauging information and that the previous geochemical study by Izbicki and Martin (USGS 1997) reported that the tritium composition of groundwater in wells in the LPVB (the absence of tritium), that recharge from infiltration of runoff from intermittent streams was not an important source of recharge to the LAS (Appendix C).

Additionally, much of the tributary inflows to Arroyo Simi–Las Posas is expected to leave the ELPMA as streamflow. Bachman (2016) analyzed baseflow and stormflow at the VCWPD Hitch gauge (Figure 2-41; 841 and 841A) from 1994 through 2010 and determined that about half the flow in the arroyo was baseflow and half was stormflow.

The CMWD groundwater model (Appendix C) estimated that the average inflow to the ELPMA from the percolation of Arroyo Simi–Las Posas from 1985 to 2015 was 13,966 AFY and ranged from 11,406 AFY to 19,241 AFY (Table 2-7).

2.4.1.2 CMWD Imported Water Supplies

CMWD sells imported water to eight water purveyors (Table 2-5) located within their service area. CMWD has also provided imported water to purveyors located within the LPVB for use in lieu of groundwater pumping (Section 2.4.1.4, CMWD ASR Project and In-Lieu Storage Program). Table 2-8 indicates the volume of CMWD imported water delivered to water purveyors and used in the WLPMA and ELPMA. Figure 2-43, Imported Water Deliveries, indicates the amounts of imported water provided from 1985 to 2015. In addition, CMWD uses some imported water for their ASR project where imported water is injected into the aquifer system in the ELPMA (Section 2.4.1.4).

2.4.1.3 Other Water Supplies

Table 2-9 indicates the volume of recycled water that MWTP provides for municipal and industrial (M&I) use, and the volume of groundwater that Camrosa Water District provides that was extracted from the PVB and Arroyo Santa Rosa Valley Basin for agricultural and M&I uses in the LPVB. Additionally, since 2008, Camrosa Water District has provided some nonpotable surface water (Conejo Creek Project) for agricultural use to the ELPMA. Figure 2-44, Other Water Sources, shows the volume of other water supplies from 1985 to 2015.

Recharge from Imported and Other Water Supplies

Return flows from imported and other water supplies were calculated for both the WLPMA and ELPMA by the UWCD and CMWD models respectively. In urban settings, outdoor water use may percolate to groundwater if water remains after ET and runoff losses. In the model areas, M&I outdoor water use is predominantly used for irrigation of landscape vegetation, but may also include car washing, the filling of swimming pools and other uses. Recharge from M&I return flows are presented here with imported water and other water supplies for the LPVB, but some of this M&I return flow water is from urban use of pumped groundwater as noted by the water purveyors that use groundwater (Table 2-5).

West Las Posas Management Area

Table 2-10a and Table 2-10b provide the estimated recharge for the WLPMA shallow aquifer system and LAS, respectively. The recharge shown in Tables 2-10a and 2-10b includes recharge from precipitation, M&I return flows, and agricultural return flows. Table 2-11 shows the estimated recharge from M&I uses in the WLPMA from the UWCD model. The average calendar-year recharge from M&I from 1985 to 2015 was 1,225 AFY, which is about 18.6% of the total average recharge (6,597 AFY) shown in Table 2-11.

East Las Posas Management Area

In the ELPMA, most of the M&I water use is derived from imported water (Appendix C). Of the M&I water use, 65% was assumed to occur outdoors for irrigation and 10.5% of the outdoor use was assumed to percolate to groundwater. For the water budget period of 1985 to 2015, the average annual M&I return flow was 666 AF (Appendix C, p. 39).

As noted in the CMWD report (Appendix C) the question of whether return flows from the irrigation of agricultural lands (or M&I return flows here) have arrived at the water table should be considered. These return flow arrivals are based on the depth to the groundwater table and the permeability of the sediments between the land surface and the groundwater table. Isotopic groundwater studies by Izbicki and Martin (USGS 1997) suggest that return flows occurring above the Shallow Alluvial Aquifer and the Epworth Gravels Aquifer could have arrived at the water table based on estimated travel time. However, return flows occurring above the USP may not have reached the water table in areas where the water table is deep (more than 200 feet bgs) and overlain by clay confining beds.

2.4.1.4 CMWD ASR Project and In-Lieu Storage Program

CMWD has injected imported water into the ELPMA since 1993 through their ASR program. Table 2-12 shows the net annual injected amounts reported by the CMWD for the wells shown on Figure 2-41, and Table 2-7 provides the amounts of ASR water injected per year. The CMWD ASR project has also included delivery of imported water to LPVB users in lieu of groundwater pumping in both the WLPMA and the ELPMA. Under this FCGMA-approved program, CMWD is credited an acre-foot of storage for every acre-foot of water that is delivered in lieu of pumping. Table 2-12 also shows the cumulative amount of CMWD water in storage in 2015 for their ASR project and in-lieu storage program. As of 2015, the CMWD had 25,192 AF stored in the WLPMA and 11,398 AF in the ELPMA, largely from in-lieu credits, for a total of 36,590 AF in the LPVB. Figure 2-45, CMWD ASR and In-Lieu Water, shows the amounts of ASR and in-lieu water provided to the LPVB from 1985 to 2015.

2.4.1.5 Percolation of Precipitation

Much of the rain that falls in the LPVB quickly returns to the atmosphere via evaporation, or runs off to creeks; the remainder percolates into the soil, where it is subject to ET, soil absorption, or plant use. However, some precipitation can percolate into the soil and downward past the plant root zone and reach an underlying aquifer. This recharge process is referred to as deep infiltration (or percolation) of precipitation.

Deep percolation of precipitation depends on many factors, including precipitation rate and duration, evaporation rate, ambient temperature, texture and slope of land surface, soil type and texture, antecedent soil moisture, vegetation cover, seasonal plant activity, and others, and is highly variable over time and location. Thus, estimates of the percolation of precipitation are subject to substantial uncertainty.

West Las Posas Valley Management Area

UWCD downloaded monthly precipitation data for 180 rainfall gauge stations across the model domain from VCWPD (at http://www.vcwatershed.net/hydrodata/) (Appendix E, p. 80). UWCD used the Kriging method of geostatistical analysis to generate monthly precipitation distributions across model area, and the areal recharge from deep infiltration of precipitation was input to the model using the recharge package, and was calculated as follows:

- If monthly precipitation is less than 0.75 inches, the precipitation is lost to ET.
- If monthly precipitation is 0.75 to 1 inch, then recharge is assigned from 0% to 10% of precipitation (on a sliding scale).
- If monthly precipitation is 1 to 3 inches, then recharge is assigned from 10% to 30% of precipitation.
- If monthly precipitation is greater than 3 inches, then recharge is assigned as 30% of precipitation.
- Urban (non-agricultural) land use, including residential, commercial, and industrial areas: 5% of the total water precipitation.
- Undeveloped land: 10% of the total water precipitation.

Precipitation Recharge

Recharge from the percolation of precipitation is included with recharge in Table 2-10a and Table 2-10b, but identified individually in Table 2-11. Of the average annual recharge shown in Table 2-11 (6,597 AFY), percolation of precipitation accounts for 3,875 AFY, or 58.7%.

East Las Posas Valley Management Area

For the ELPMA, the CMWD model (Appendix C) calculated recharge using a two-step approach with two datasets. The first dataset was the Basin Characterization Model (BCM), a publicly available dataset for California. The BCM calculates the groundwater water balance for grid cells that simulate physical processes like snow accumulation, snowmelt, sublimation, and potential evaporation. CMWD did not use precipitation gauge data in the BCM model; instead, recharge was scaled by using precipitation data and the BCM dataset to produce estimates of recharge for the water budget. The Somis-Bard gauge (Station 190 on Figure 1-3) in the eastern portion of the WLPMA was used to linearly scale the average precipitation and average recharge from the BCM to provide a time series of recharge in the model area.

Precipitation Recharge

Groundwater recharge from precipitation was found to be highly variable over time, and the average annual recharge from precipitation between 1985 and 2015 was 5,119 AF (Appendix C, p. 40). Recharge from precipitation is included with "recharge except Arroyo Simi–Las Posas (includes MWTP)" in Table 2-7.

2.4.1.6 Basin Groundwater Subsurface Inflow and Outflow

Subsurface groundwater flow between the WLPMA and the adjacent Oxnard Subbasin and the PVB were provided by the UWCD groundwater numerical model, and are included in Table 2-10a and Table 2-10b. Groundwater flows occur between the WLPMA and the PVB in the shallow layers mostly because of mounding in the Camarillo area since about 1992 (Table 2-10a), and in the deep layers of the model east of the fault barrier between the basins near Highway 101. The UWCD model did not have subsurface flow between the ELPMA and the WLPMA. However, the CMWD model has subsurface flows from 104 AFY to 146 AFY from the ELPMA to the WLPMA (Table 2-7).

The CMWD model has subsurface inflows from the Simi Valley Basin, which were not estimated separately from total subsurface inflows into the ELPMA shown in Table 2-7. However, the groundwater subsurface inflows from the Simi Basin were estimated by Todd Groundwater (2016), and are considered to be minor and were assumed to be 100 AFY, as cited in the Simi Valley groundwater resources study (Todd Groundwater 2016). The CWMD model report found that this amount is consistent with the State Water Resources Control Board (SWRCB) finding of 100 AFY, but more than the 5 AFY calculated based on a hydraulic gradient of 0.005 feet/feet, the 1,000-foot width of the floodplain, a saturated alluvium thickness of 5 feet, and a hydraulic conductivity of 25 feet/day (Appendix C, p. 45).

Groundwater outflows to the PVB from the ELPMA were estimated from the CMWD model. These values are generally close to the initial values provided UWCD for inflows to the PVB from the ELPMA during model development, but are generally about 130 AFY or 8% higher.

2.4.1.7 Mountain-Front Recharge

West Las Posas Management Area

In the UWCD model, the mountain-front recharge is calculated based on the upstream watershed area, the precipitation intensity, and a fixed recharge ratio of 10%. Mountain-front recharge from the UWCD model is shown as recharge from USP outcrops in Table 2-10b for the WLPMA LAS. The mountain-front recharge averaged 1,734 AFY, with a range from 103 to 4,066 AFY from 1985–2015.

East Las Posas Management Area

In the CMWD model mountain-front recharge is included with inflow at basin boundary in Table 2-7. The inflow at the ELPMA basin boundary averaged 2,052 AFY from 1985 to 2015 and ranged from 1,795 AFY to 2,581 AFY (Table 2-7).

2.4.1.8 Septic Systems Recharge

The number and location of septic systems in the LPVB were estimated by DBS&A (2017) based on the Ventura County septic database (Ventura County Environmental Health Division 2017). If septic systems were present within any parcel within a tract, it was assumed that all parcels in the tract contained septic systems.

Household water use and annual disposal were estimated to decrease from 0.21 AFY per system for 1985 to 1997, to 0.20 AFY per system for 1988 to 2010, and to 0.16 AFY per system from 1998 to 2015 based on DeOreo and Mayer (2012, as cited in DBS&A 2017).

West Las Posas Management Area

The resulting percolation for the WLPMA from all septic systems was estimated to decrease from 463 AFY in 1985 to 341 AFY in 2015 (DBS&A, 2017). The UWCD groundwater model (Appendix E) assumed that septic system recharge was widespread and small relative to other recharge sources and incorporated septic system return flows implicitly as a component of agricultural and municipal return flows.

East Las Posas Management Area

The CMWD model used the following assumptions to estimate septic system return flows for the ELPMA (Appendix C, p. 40):

- In the VCWD No. 1 (Moorpark) area, it was assumed that only the residences outside of the city limits use septic systems, and for VCWD No. 19 (Somis), it was assumed that 100% of the residences use septic systems, and none of the residences are connected to sewers. It was further assumed that only 30% of the septic usage in VCWD No. 19 occurs within the ELPMA.
- The estimated value for the residential water demand (146.4 gallons per capita per day) and household size (3.31 people) were used to produce an average household water use of 0.54 AFY. Assuming 35% of the water demand is for indoor use and 100% of the indoor use returns to the groundwater system, then 0.19 AFY per septic system would be available for percolation.

The result was that the water budget estimated septic system return flow was 385 AF in 1985 and decreased to 317 AF in 2015. The average annual septic system return flow was estimated as 374 AF over the water budget period. For comparison, the resulting percolation for the ELPMA from all septic system was estimated to decrease from 210 AFY in 1985 to 155 AFY in 2015 by DBS&A (2017).

2.4.1.9 Recharge from Water System Losses

West Las Posas Management Area

Recharge from leakage of water delivery systems was assumed to be 5% of all deliveries (Sharp 2010, as cited in DBS&A 2017). Using 5% of the total average water delivery values in Table 2-8, the estimated leakage of water delivery systems for the WLPMA is 61 AFY (1,212 AFY × 0.05). The UWCD groundwater model (Appendix E) did not consider water system losses as a distinct source of water separate from other urban return flows.

East Las Posas Management Area

For the CMWD model, over the water budget period of 1985 to 2015, the average annual percolation from distribution systems was estimated as 498 AF. Using 5% of the total average water delivery values in Tables 2-8 and 2-9, the estimated leakage of water delivery systems for the ELPMA is 480 AFY ([9,300 AFY + 300 AFY] × 0.05).

2.4.1.10 Percolation of Agricultural Irrigation Water (Agricultural Return Flows)

Groundwater pumping is discussed in Section 2.4.2.1; only recharge from agricultural return flow is discussed in this section. Water applied to the cropland surface may percolate below the root zone and reach the groundwater if the applied water is not consumed by vegetation. The source of agricultural return flows may include both pumped groundwater and imported water from outside of the basin.

West Las Posas Management Area

The UWCD groundwater model used extracted groundwater from wells, which was applied to irrigated land, and assumed an agricultural return flow of 14%. If the precipitation was more than 1 inch per month, the agricultural return flow ratio was compared with the precipitation recharge ratio. If the precipitation recharge ratio was larger than 14%, the agricultural return flow ratio was replaced by the precipitation recharge ratio.

Recharge from the agricultural return flow is included with recharge in Tables 2-10a and 2-10b, and identified individually in Table 2-11. Of the average annual recharge shown in Table 2-11 (6,597 AFY), agricultural return flow accounts for 1,497 AFY, or 22.7%.

East Las Posas Management Area

The CMWD model used the preliminary draft LPVB GSP water budget prepared for FCGMA (Dudek 2017), and the results of the DBS&A (2017) Distributed Parameter Watershed Model, which is run with daily time steps, to estimate the groundwater budget the ELPMA. From the Distributed Parameter Watershed Model, the average agriculture return flows was 10.5% of the average applied water for agriculture uses in the ELPMA during the period from 1985 to 2015 (DBS&A 2017). The CMWD model applied this return flow rate to the annual applied water for agricultural uses tabulated by Dudek (2017) and estimates average annual agricultural return flows of 2,117 AFY in the ELPMA over the water budget period of 1985 to 2015 (Appendix C, p. 39). An average annual agricultural return flow of 2,117 AFY is about 8% of the estimated total of 27,276 AFY shown in Table 2-7.

As noted in Section 2.4.1.3, Other Water Supplies, there is some question as to whether return flows from M&I and the irrigation of agricultural lands have arrived at the groundwater table. These return flow rates are based on the depth to the groundwater table and the permeability of the sediments between the land surface and the groundwater table. Isotopic groundwater studies by Izbicki and Martin (USGS 1997) suggest that return flows occurring above the USP may not have reached the groundwater table in areas where the groundwater table is deep (more than 200 feet bgs) and overlain by clay confining beds.

2.4.2 Sources of Water Discharge

Sources of groundwater discharge predominantly include groundwater pumping and ET. Groundwater pumped and used for agricultural, M&I, and domestic purposes can produce return flows, and subsurface groundwater flows (interbasin flows) can discharge groundwater from the LPVB to the adjacent groundwater (Section 2.4.1.6, Basin Groundwater Subsurface Inflow and Outflow).

2.4.2.1 Groundwater Pumping

Tables 2-13 and 2-14 summarize the estimated historical volumes of groundwater pumped during the 31-year period for the WLPMA and ELPMA for agricultural, M&I, and domestic use, by aquifer. The estimated pumping type percentages (agricultural, M&I, and domestic) were determined from semi-annual groundwater extraction reports to the FCGMA, and the groundwater amounts extracted by aquifer are from the UWCD model results (Appendix E for the WLPMA) and the CMWD (Appendix C for the ELPMA) model results. Figures 2-46 through 2-49 indicate the volume of agricultural, M&I, domestic, and total groundwater pumping in the ELPMA. Figure 2-50, WLPMA Total Groundwater Pumping, indicates the total volumes of agricultural, M&I, and domestic groundwater pumped and the total groundwater pumping by the shallow aquifer system and LAS in the WLPMA. Additional wells are present within the basin yet outside the FCGMA boundary, for which no pumping is reported. However, only a few wells are located outside the FCGMA boundary, so the volume of groundwater pumping from these wells should be minor. The pumping spike in 2007–2010 is due to CMWD ASR M&I pumping (Figure 2-17).

West Las Posas Management Area

The WLPMA contains 100 known wells, of which, 70 are in active use, 20 are destroyed, and 10 are inactive. During calendar year 2015, the UWCD model groundwater pumping totaled 16,383 AF, 85% of which was for agricultural use (13,887 AF), about 15% for municipal and industrial use (2,496 AF), and less than 1% for domestic use (1 AF) (Table 2-14).

East Las Posas Management Area

The ELPMA contains 248 known wells, of which 161 are in active use, 30 are destroyed, 50 are inactive, and 7 cannot be located. During calendar year 2015, the CMWD model pumping totaled 23,858 AF, 91% of which was for agricultural use (21,810 AF), about 8% for municipal and industrial use (2,025 AF), and less than 1% for domestic use (23 AF) (Table 2-14).

2.4.2.2 Riparian Evapotranspiration Losses

Riparian ET of groundwater by vegetation occurs when the water table is near the land surface and roots can penetrate the saturated zone below the water table allowing vegetation to directly transpire water from the groundwater system.

West Las Posas Management Area

As noted in Section 2.3.6.1 (see Section 2.3.6, Groundwater–Surface Water Connections), there are no surface water bodies that are considered to be major contributors to groundwater in the WLPMA, and the UWCD model (Appendix E) did not simulate any ET for the WLPMA.

East Las Posas Management Area

ET losses from deep-rooted vegetation (phreatophytes) occur near Arroyo Simi–Las Posas in riparian areas where groundwater is near land surface. In Arroyo Simi–Las Posas riparian areas, a common non-native phreatophyte is *Arundo donax* (Arundo; also known as giant reed, giant cane), which has a high rate of water use as well as other native phreatophytes (Appendix C; Appendix I). Arundo and other phreatophytes are common in many coastal watersheds in Southern California. The CMWD model (Appendix C) estimated the loss by ET from Arroyo Simi–Las Posas riparian areas. Because Arundo may annually consume about 6 times as much water as other phreatophytes and detailed mapping of Arundo is available in the basin, the CMWD model assumed that all riparian vegetation was Arundo to simplify estimates of groundwater ET for the water budget.

Because the consumptive use of water by phreatophytes varies over time in response to factors like air temperature, precipitation, and wind speed, the water consumption use was estimated using an annual average reference ET (ETo) value from the California Irrigation Management Information System (CIMIS) and the average crop coefficient of 1.26 for Arundo (Appendix C). Table 2-7 shows the CMWD results for riparian ET. The average for calendar years 1985 to 2015 is 1,062 AFY with a range from 693 AFY to 1,236 AFY.

2.4.3 Current and Historical Water Budget Analysis

2.4.3.1 Water Year Types

Water year type is based on the percentage of the water year precipitation compared to the 31- year precipitation average. Types are defined in this GSP as wet (≥ 150% of average), above normal (≥ 100% to <150% of average), below normal (> 75% to <100% of average), dry (> 50% to <75% of average), and critical (<50% of average). Figure 2-26 shows the water year type from 1985 to 2015. The water year type for 2015 is dry.

2.4.3.2 Historical Conditions

DWR has designated the LPVB as a high-priority basin. DWR GSP Regulations, Section 354.18, Water Budget, states: “If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.” Bulletin 118 Interim Update 2016 (DWR 2016) does not list the LPVB as being in critical overdraft. Although Bulletin 118 does not list the LPVB as being in critical overdraft, and GSP Regulations Section 354.18(b)(5) does not require a quantification of the overdraft over a period of years during which water years and water supply conditions approximated average conditions, this type of analysis for the WLPMA and ELPMA is useful in evaluating historical conditions for the WLPMA and ELPMA.

West Las Posas Management Area

Using the water year types discussed in Section 2.4.3.1, Water Year Types, and the above normal (> 100% to <150% of average) and the below normal (> 75% to <100% of average) water year types to bracket water supply conditions approximating average conditions, the following years have near average conditions in the WLPMA: 1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011 (see Figure 2-26).

The average change in groundwater storage for these calendar years in the shallow aquifer system was an increase of 292 AFY. Groundwater pumping averaged 1,346 AFY and the recharge was 5,652 AFY. The average change in groundwater storage for these calendar years in the LAS was a decrease of 263 AFY. Groundwater pumping averaged 13,274 AFY and the recharge was 1,372 AFY. The LAS received 8,852 AFY of water from the shallow aquifer system during these years. However, the WLPMA also received 25,192 AF of in-lieu water from the CMWD between 1995 and 2011, or an average of 1,023 AFY for the near average condition years (Table 2-12). This would suggest that the total change in storage during these years was actually a decrease of 994 AFY.

East Las Posas Management Area

Using the water year types discussed in Section 2.4.3.1, and the above normal (> 100% to <150% of average) and the below normal (> 75% to <100% of average) water year types to bracket water supply conditions approximating average conditions, the following years have near average conditions in the ELPMA: 1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011 (the same as for the WLPMA; see Figure 2-28). It should be noted here again that as discussed in Section 2.3, Groundwater Conditions; Section 2.4.1.3, Other Water Supplies; and Section 2.4.1.10, Percolation of Agricultural Irrigation Water (Agricultural Return Flows), the USP is unsaturated over a significant thickness and many of the wells in the ELPMA do not show groundwater levels that correlate with recharge and that are independent of climatic cycles (Section 2.3). Most of the wells in the WLPMA do show at least some correlation with recharge and the climatic cycles.

The average change in groundwater storage for these calendar years in the ELPMA and Epworth Gravels Management Area combined was an increase of 4,959 AFY. Groundwater pumping for both the ELPMA and Epworth Gravels Management Area averaged 18,487 AFY and the recharge was a total of 24,932 AFY. During average conditions, the net change in groundwater storage for the ELPMA alone was an increase of 4,638 AFY and groundwater pumping averaged 17,283 AFY during these calendar years. However, the ELPMA also received an average of 1,023 AFY of in-lieu water from the CMWD during these years and an average of 559 AFY of ASR water (Table 2-7 and Table 2-12). This would suggest that the total change in storage during these years was an increase of 3,377 AFY.

East Las Posas Management Area

Using the water year types discussed in Section 2.4.3.1, and the above-normal (> 100% to <150% of average) and below-normal (> 75% to <100% of average) water year types to bracket water supply conditions approximating average conditions, the following years have near average conditions in the Epworth Gravels Management Area: 1988, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011. The average change in groundwater storage for these calendar years in the Epworth Gravels Management Area was an increase of 184 AFY. Groundwater pumping during these years averaged 1,203 AFY.

2.4.3.3 Current (2015) Las Posas Valley Basin Conditions

Current (2015) condition of the LPVB indicates that total groundwater outflows were larger than total groundwater inflows for both the WLPMA and ELPMA, which show an imbalance of 11,966 AF and 3,171 AF, respectively (Tables 2-7, 2-10a, and 2-10b). According to groundwater inflow and outflow estimates (Table 2-7), the ELPMA has shown groundwater outflows greater than groundwater inflow since about 2012, a period that corresponds to the current drought as shown on Figure 1-6. The major source of groundwater recharge to the ELPMA is recycled water from the SVWQCP, which has increased the TDS (Section 2.3.4, Groundwater Quality) in portions of the ELPMA.

Groundwater inflow and outflow estimates (Tables 2-10a and 2-10b) for the WLPMA have shown a groundwater outflow greater than groundwater inflow since about 2011, a period that corresponds to the current drought shown on Figure 1-6. Figure 2-27 shows that groundwater storage has declined since about 2011.

Since 1995, both the WLPMA (until 2007) and the ELPMA had in-lieu water deliveries, and the ELPMA has had ASR injection water, which may have kept groundwater levels and storage from declining. As of 2015, the CMWD has 36,590 AF in cumulative storage in the LPVB, of which, 25,192 AF is in the WLPMA, and 11,398 AF in the ELPMA (Table 2-12). Groundwater levels and storage would be lower if CMWD cumulative storage were removed.

2.4.3.4 Estimates of Sustainable Yield

GSP Regulations Section 354.18(b)(7) states that an estimate of the historical sustainable yield for the basin shall be quantified in the water budget for the basin GSP.

The Final Draft Las Posas Basin-Specific Groundwater Management Plan (Las Posas Users Group 2012, pp. 39–40) put the total operational yield of the WLPMA at 11,000 AFY, and 18,000 to 19,000 AFY for the ELPMA.

For this GSP, the water budget estimate for the historical sustainable yield was based on the average groundwater inflows from 1985 to 2015 in Tables 2-10a and 2-10b, excluded the CMWD in-lieu deliveries (Table 2-12), and was adjusted for the storage changes (Tables 2-10a and 2-10b). This water budget analysis produced an estimated historical sustainable yield for the WLPMA from about 10,000 AFY to 11,000 AFY.

Using a similar approach to the ELPMA is more difficult. Using the average groundwater inflows from Arroyo Simi–Las Posas is reasonable, but estimating the recharge from the rest of the basin is problematic due to the time delay in the USP (see Sections 2.3, 2.4.1.3, and 2.4.1.10). Assuming all of the Arroyo Simi–Las Posas recharge (Table 2-7), and half of the total reported recharge except Arroyo Simi–Las Posas (Table 2-7) from 1985 to 2015, and excluding the CMWD in-lieu and ASR deliveries (Table 2-12), and then adjusting for the change in storage (Table 2-7), the estimated sustainable yield for the ELPMA would be about 17,000 AFY to 19,000 AFY. Half of the reported recharge except Arroyo Simi–Las Posas was used because about half of the area can be recharged through outcrops of the Fox Canyon, Grimes Canyon, and Shallow Aquifer System. The other half is covered by the San Pedro Formation that limits direct recharge.

An evaluation of historical hydrographs for Epworth Gravels Aquifer Wells 03N19W29F06S and 03N19W30M02S from 1984 and 1990, respectively, suggests that the historical average Epworth Gravels Aquifer pumping rate of 1,290 AFY (Table 2-14) is sustainable. The uncertainty of this historical evaluation suggests that the sustainable yield of the Epworth Gravels is 1,290 AFY plus or minus approximately 200 AFY.

2.4.4 General Uncertainties in the Water Budget

There are several limitations and uncertainties associated with other water budget terms used for both the historical and future conditions due to necessary simplifying of assumptions and data gaps. Uncertainties about the groundwater models used are discussed in Sections 2.4.5.1.8 and 2.4.5.2.6, Uncertainty Analysis. Some of the general water budget limitations and/or uncertainties include the following:

1. The reporting of groundwater pumping outside the FCGMA boundaries is limited and there is a possibility of underreporting of pumping within the FCGMA boundaries due

to non-reporting, inaccurate reporting and equipment problems. Additional future data collection is needed to verify the existence and extent of and to eliminate this potential data gap. However, the amount of pumping outside the FCGMA boundary is expected to be minor given the limited number of wells (estimated at fewer than 12).

2. The hydrologic base period (calendar years 1985–2015, DWR's 31-year base period) may not necessarily be representative of long-term average or representative conditions. As shown on Figure 1-6, Long-Term Precipitation Trends in the LPVB, this was a generally wetter-than-average period. This could suggest that the estimated sustainable yield for the WLPMA in Section 2.4.3.4, Estimates of Sustainable Yield, is too high. Because much of the ELPMA is unaffected by climate cycles due to the long time delay from precipitation and agricultural and M&I return flows (Section 2.4.1.3), the wetter-than-average period for 1985 to 2015 may not have much effect on the estimated sustainable yield for the ELPMA in Section 2.4.3.4.

3. Conclusions regarding uncertainties in the UWCD model are discussed in Section 2.4.5.1.8.

4. Subsurface inflows and outflows across basin boundaries are not measurable. The groundwater level data in these areas by themselves do not provide a clear indication of groundwater flow directions because of the limited water level measurements and the variation in time between measurements. The UWCD model provides a significantly improved understanding of these boundary fluxes and their variability under different pumping and recharge conditions in the region, but checking model values with observations and calculating the gradient with three-point groundwater flow problems should be considered to verify model estimates. Attempts to estimate inflows and outflows across basin boundaries using well groundwater level data was attempted for this GSP, but data gaps and limited well locations screened in one aquifer made the results unreliable.

5. Some shallow groundwater in the southwestern portion of the WLPMA is potentially captured by tile drains, rather than recharging the UAS. Attempts to estimate inflows and outflows across basin boundaries using well groundwater level data was attempted for this GSP, but data gaps and limited well locations screened in one aquifer made the results unreliable. This uncertainty could be reduced through installation of instrumentation and measurement of discharges from the tile drains.

6. Currently, aquifer-specific water level maps are not reliable to estimate aquifer change in groundwater storage due to the limited number and distribution of aquifer-specific water wells. Aquifer-specific water-level maps could be used to check groundwater model change in storage calculations. Dedicated monitoring wells could installed and equipped with water-level measuring data loggers in all of the

aquifers. This would help decrease uncertainty in estimates of future changes in groundwater storage by enabling use of aquifer-specific water-level maps to check groundwater model change in storage calculations.

2.4.5 Projected Water Budget and Sustainable Yield

2.4.5.1 West Las Posas Management Area

Several UWCD model scenarios were developed to assess the future sustainable yield of the WLPMA, the PVB, and the Oxnard Subbasin. Each future scenario covered a 50-year time frame, from 2020 to 2069, which is referred to as the *model period*. In this GSP, the period from 2020 to 2039 is referred to as the *implementation period* and the period from 2040 to 2069 is referred to as the *sustaining period*. The sustainable yield for the WLPMA was determined from the model scenarios that did not contribute to a net flux of seawater into either the UAS or the LAS in the Oxnard Subbasin, within the level of the model uncertainty, during the 30-year sustaining period (Figure 2-51, Coastal Flux from the UWCD Model Scenarios). Because groundwater production in the WLPMA has the potential to adversely affect the ability of the Oxnard Subbasin to achieve its GSP sustainability goals, groundwater production from the WLPMA was evaluated in the context of the modeled net flux of seawater into either the UAS or the LAS in the Oxnard Subbasin.

Because the WLPMA is hydraulically connected to the Oxnard Subbasin, the sustainable yield of the WLPMA is influenced by groundwater production and projects in the Oxnard Subbasin. The UWCD model used to assess the sustainable yield of the WLPMA, the Oxnard Subbasin, and the PVB in the model domain, and the modeling assumptions associated with each scenario discussed below include the assumptions made for these adjacent basins.

The model scenarios developed for Oxnard Subbasin, the PVB, and the WLPMA all included existing projects and the 2070 DWR climate-change factor applied to the 1930–1970 historical precipitation and hydrology base period. The model scenarios are the following:

- Future Baseline Simulation (2015–2017 average production rates adjusted for surface water deliveries). Future surface water deliveries were estimated by UWCD using Santa Clara River flows for historical periods, the 1930–1979 climate period adjusted for future DWR climate-change factors, and estimated diversions based on similar historical Santa Clara River flows. UWCD also considered current allowable diversions, which account for current environmental restraints and diversion operating conditions, and optimization of water deliveries for the Pleasant Valley Pipeline and spreading basins. Additional details about the UWCD future model scenarios are included in Appendix L.

- Future Baseline Simulation With Projects (2015–2017 average production rates adjusted for surface water deliveries; potential future projects that met the DWR conditions for incorporation in the GSP)
- Reduction With Projects (35% reduction of 2015–2017 average production rates adjusted for surface water deliveries for the UAS and LAS in the Oxnard Subbasin, 20% reduction for the UAS and LAS in PVB; and 20% in the LAS in the WLPMA; potential future projects that met the DWR conditions for incorporation in the GSP)
- Reduction Without Projects 1 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 25% in the UAS, 60% in the LAS, and 45% for wells screened in both aquifer systems in the Oxnard Subbasin; 25% reduction for the UAS and the LAS in the PVB; and 25% in the LAS in the WLPMA)
- Reduction Without Projects 2 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 20% reduction for the UAS and the LAS in the PVB; and 20% in the LAS in the WLPMA)
- Reduction Without Projects 3 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 0% reduction for the UAS and the LAS in the PVB; and 0% in the LAS in the WLPMA)

Two of the model scenarios listed above, the Future Baseline Simulation With Projects scenario and the Reduction With Projects scenario, incorporated projects that were approved for inclusion in the GSP model scenarios by the FCGMA Board. The Board's approval of these projects only indicates that they were sufficiently defined by the project proponent to be analyzed as part of the GSP. It does not indicate that these specific projects will necessarily be constructed or, conversely, that other projects will not be developed in the future. The projects included are discussed in more detail with the description of each scenario below.

An initial set of four modeling simulations were conducted using the future baseline conditions with two 50-year average climate cycles (1930–1979 and 1940–1989), and two DWR climate-change factors (2030 and 2070) applied to each of the 50-year periods. The 1930–1979 50-year period with the 2070 DWR climate-change factor was found to be the most conservative and was used for the comparison for the other modeling simulations conducted. Additional details about the selection of the two 50-year average climate cycles is provided in Section 2.4.5.1.7, Alternative Climate and Rainfall Patterns.

In addition to the initial set of four modeling simulations and the six model scenarios listed above, the Reduction Without Projects Scenario 1 was simulated with the DWR 2030 climate-change factor and with a historical precipitation and hydrology base period from 1940 to 1989. These simulations were conducted to better understand the potential impact of precipitation patterns and climate-change factors on the model results.

Over the next 5 years, as additional projects are developed, the model assumptions discussed below will need to be altered and incorporated into the 5-year GSP evaluation.

2.4.5.1.1 Future Baseline Model Simulation

DWR regulations require that the GSP include an assessment of the future baseline conditions. In the Future Baseline scenario, in order to assess whether or not groundwater extractions from the WLPMA, PVB and the Oxnard Subbasin were sustainable at their current rates, the average 2015–2017 production rates were simulated. For the WLPMA, this rate is approximately 13,000 AFY for the LAS and 1,000 for the shallow aquifer system.

Future Baseline Scenario Model Assumptions

The Future Baseline model simulation included the following:

- Constant pumping at the 2015–2017 average rate adjusted for surface water deliveries of approximately 14,000 AFY in the PVB, 68,000 AFY in the Oxnard Subbasin (39,000 AFY in the UAS; 29,000 AFY in the LAS), and 13,000 AFY in the WLPMA LAS and 1,000 AFY from the shallow aquifer system.
- Starting water levels equal to the final 2015 water levels from the historical simulations
- Precipitation and streamflow for two 50-year periods (1930–1979 and 1940–1989), with an average precipitation that equaled the average precipitation for the entire historical record
- Estimates of Santa Clara River surface water available for diversion prepared by UWCD staff using climate-change factors provided by DWR and historical measured flow in the river for the 50-year periods
- East Las Posas Management Area outflows to Arroyo Las Posas to the PVB from the CMWD model
- Projects that are currently operating in the model area or currently under development

The historical measurements of precipitation for the two 50-year periods were modified using the DWR 2030 and 2070 climate-change factors. Stream flows were estimated using the adjusted rainfall. UWCD estimated Santa Clara River flow and the volume of water diverted to direct delivery and spreading. Pumping was decreased where the water is delivered to account for the surface water delivered. Future streamflow in Conejo and Calleguas Creeks in the PVB were estimated by regression.

No projects currently under development were identified in the WLPMA or the Oxnard Subbasin, but two projects under development in the PVB were incorporated into the future baseline simulation because these projects affect inflows to the Oxnard Subbasin. The two projects in PVB are the Camarillo North Pleasant Valley Desalter (desalination) project and Conejo Creek Diversion deliveries to Pleasant Valley. The North Pleasant Valley Desalter project was simulated by dividing the total project pumping of 4,500 AFY between project extraction wells 02N20W19L05 and 02N20W19F04. Additionally, pumping from Well 02N21W34C01 increased by 1,300 AFY to reflect a shift in areas of production.

Conejo Creek diversions will increase deliveries to agriculture by an additional 2,200 AFY to make the total deliveries in the PVB 4,500 AFY starting in 2020. Camrosa Water District will increase pumping by potentially 4,500 AFY based on credits for surface water delivered. In running the future simulations, it became apparent the cells identified for production from the Camrosa Water District wells were not able to extract the full amount. The amount of simulated pumping that was achievable in the future baseline simulation was 2,816 AFY.

It is important to remember that groundwater extractions are not the only source of water to the PVB. Surface water deliveries vary between the model scenarios because the model adjusts the deliveries of Santa Clara River water based on simulated groundwater elevations in the Oxnard Forebay. Additionally, although the model calculates the groundwater extractions and surface water deliveries with precision, the values reported in Table 2-15 have been rounded to the nearest 1,000 AFY to reflect the uncertainty in the model calculations.

Future Baseline Scenario Model Results

Both the modeled flux of seawater (Figure 2-51) and the particle tracks from the Future Baseline scenario indicate that continuing the 2015–2017 extraction rate for the WLPMA, PVB, and the Oxnard Subbasin over the next 50 years would allow net seawater intrusion in both the UAS and the LAS, as well as ongoing inland migration of the 2015 saline water impact front (FCGMA, 2019). Because the model showed the saline water impact front continuing to migrate landward throughout the sustaining period, even during wetter-than-average climate periods, the distribution of groundwater production at the extraction rates in the WLPMA, PVB, and the Oxnard Subbasin was determined not to be sustainable.

2.4.5.1.2 Future Baseline With Projects Model Simulation

Future Baseline With Projects Scenario Model Assumptions

Modeling of future conditions included all of the assumptions incorporated into the Future Baseline simulation, and also incorporated potential future projects approved for inclusion by the FCGMA Board. Incorporation of the potential future projects in the Future Baseline With Projects scenario neither represents a commitment by FCGMA to actually reduce pumping by the amounts specified at the wells specified nor a commitment to move forward with each project included in the future model scenarios. Assumptions about projects and project implementation may have changed since the modeling was conducted and will continue to change over the next 5 years. These changes should be incorporated into the modeling for the 5-year GSP evaluation.

In the WLPMA, future projects included the purchase of 1,762 AFY of water to be delivered to the eastern portion of WLPMA in lieu of groundwater extraction. Simulated pumping was reduced in Zone Mutual Water Company Wells 02N20W07R03, 02N20W07R02, 02N20W08M01, 02N20W08E01, and 02N20W08F01, as well as VCWD No. 19 Wells 02N20W06R01 and 02N20W08B01. The pumping reductions of 1,762 AFY were applied uniformly and proportionally across the wells. This projects is discussed in detail in Chapter 5, Projects and Management Actions, of this GSP.

In the PVB, a proposed temporary fallowing project was simulated near the pumping trough. This project would generate a 2,407 AFY reduction in pumping; however, actual simulated fallowing totaled 2,234 AFY due to considerations of existing contracts for the delivery of surface water from the Santa Clara River. Pumping was preferentially reduced in wells in the LAS within the PVB to the extent possible.

In the Oxnard Subbasin, simulated future projects included delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, expansion of the Groundwater Recovery Enhancement and Treatment (GREAT) Program to increase spreading by 4,500 AFY in the Saticoy Spreading Grounds, and a 504 AFY reduction of pumping through fallowing.

To simulate the delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, pumping from wells near the coast in the pumping depression area was reduced uniformly and proportionally by 4,600 AFY. Additionally, pumping from Wells 02N22W23C05S and 02N22W23C07S in the Forebay was adjusted to allow the City of Oxnard to pump up to 8,000 AFY of accumulated credits for 2,600 AF recycled agricultural water delivered annually from the GREAT Program.

To simulate the expansion of the GREAT Program, spreading recharge was increased by 4,500 AFY starting in 2025. To simulate the 504 AFY reduction of pumping through fallowing, pumping from Wells 01N22W26K04S, 01N22W27H02S, 01N22W26M03S, 01N22W26K03S, 01N22W26P02S, 01N22W26Q03S, and 01N22W26D05S was reduced uniformly and proportionally by 504 AFY. It should be noted that these wells were selected for modeling purposes only and use of these wells in the model simulations was not intended to represent any planned pumping restrictions or limitations on these wells.

After incorporating the potential future projects, the average groundwater production rate for the WLPMA LAS was 11,000 AFY and 1,000 AFY in the shallow aquifer system for a total of 12,000 AFY, with about 2,000 AFY of additional in lieu of groundwater extraction (Table 2-15). In the PVB, the average was 4,300 AFY in the UAS and 7,600 AFY in the LAS. The average pumping rate for the UAS in the Oxnard Subbasin was 41,000 AFY and the average groundwater production rate for the LAS in the Oxnard Subbasin was 24,000 AFY for the Future Baseline With Projects scenario.

Future Baseline With Projects Scenario Model Results

Although the shift in groundwater extractions from the LAS to the UAS in the Oxnard Subbasin and the reduction in the total extractions helped reduce the flux of seawater into the Oxnard Subbasin, overall the Future Baseline With Projects scenario resulted in approximately 3,000 AFY of seawater flux into the UAS and 2,700 AFY into the LAS during the sustaining period (Figure 2-51). Particle tracks for the Future Baseline With Projects scenario also showed net landward migration of the saline water impact front during the sustaining period (FCGMA 2019). Based on these factors, the distribution of groundwater production at the extraction rates modeled in the Future Baseline With Projects scenario was determined not to be sustainable.

2.4.5.1.3 Reduction With Projects Scenario

Reduction With Projects Scenario Model Assumptions

The Reduction With Projects scenario included all of the assumptions incorporated into both the Future Baseline simulation and the Future Baseline With Projects scenario. The Reduction With Projects scenario also included a 35% reduction of 2015–2017 average production rates for the UAS and the LAS in the Oxnard Subbasin, 20% reduction for the UAS and the LAS in the PVB, and 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period. In the WLPMA, the shallow aquifer system simulated groundwater production rate in model year 2020, at the beginning of the implementation period, was 900 AFY. The production rate in model year 2040, at the beginning of the sustaining period, was 740 AFY.[3] The average production from the shallow aquifer system for the sustaining period was 750 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 11,000 AFY and the simulated groundwater production rate in model year 2040 was 8,600 AFY. The average production rate from the LAS for the sustaining period was 8,600 AFY. Additionally, approximately 2,000 AFY of water was delivered in lieu of groundwater extraction (Table 2-15).

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[3] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the WLPMA and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the shallow aquifer system in 2040 is 82% of the extraction rate in 2020, rather than the 35% reduction specified in the model scenario description.

Reduction With Projects Model Scenario Results

Reducing groundwater production in the UAS and the LAS, and shifting some groundwater extractions from the LAS to the UAS via the potential future projects in the Reduction With Projects scenario, resulted in an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,300 AFY during the sustaining period. In the LAS, the Reduction With Projects scenario resulted in an average flux of approximately 1,200 AFY of seawater into the LAS during the sustaining period (Figure 2-51). Particle tracks for the Reduction With Projects model scenario indicate that the location of the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations, while it would experience some landward migration in the LAS (FCGMA 2019). The continued landward migration of the saline water impact front in the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in this model scenario, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.1.4 Reduction Without Projects Scenario 1

Reduction Without Projects Scenario 1 Model Assumptions

The Reduction Without Projects Scenario 1 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 1 also included a 25% reduction of 2015–2017 average production rates for wells screened solely in the UAS, a 60% reduction of the 2015–2017 average production rates for wells screened solely in the LAS, and a 45% reduction of the 2015–2017 average production rates for wells screened in both aquifer systems. The 2015–2017 average pumping rate was reduced by 25% in the UAS and the LAS in the PVB, and 25% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

In the WLPMA shallow aquifer system, the simulated groundwater production rate in model year 2020, at the beginning of the implementation period, was 1,800 AFY. The production rate in model year 2040, at the beginning of the sustaining period, was 1,000 AFY.[4] The average production from the shallow aquifer system for the sustaining period was 1,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 13,000 AFY and the simulated groundwater

[4] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the WLPMA and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the shallow aquifer system in 2040 is 56% of the extraction rate in 2020, rather than the 25% reduction specified in the model scenario description.

production rate in model year 2040 was 10,000 AFY. The average production rate from the LAS for the sustaining period was 9,700 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 10,000 AFY for the 30-year sustaining period (Table 2-15).

Reduction Without Projects Scenario 1 Model Results

The fluxes in the UAS and the LAS in the Reduction Without Projects Scenario 1 were similar to those simulated in the Reduction With Projects Scenario. There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 2,800 AFY during the sustaining period in the Reduction Without Projects Scenario 1 (Figure 2-51). In the LAS, the Reduction Without Projects Scenario 1 resulted in an average flux of approximately 1,300 AFY of seawater into the LAS during the sustaining period. Particle tracks for this scenario indicate that the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations in the UAS, while it would migrate farther landward in the LAS than in the Reduction With Projects scenario (FCGMA 2019). As in the Reduction With Projects scenario, the continued landward migration of the saline water impact front in the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 1, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.1.5 Reduction Without Projects Scenario 2

Reduction Without Projects Scenario 2 Model Assumptions

The Reduction Without Projects Scenario 2 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 2 also included a 55% reduction of 2015–2017 average production rates for the UAS and the LAS. The 2015–2017 average pumping rate was reduced by 20% in the UAS and the LAS in the PVB, and by 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

In the WLPMA, the shallow aquifer system simulated groundwater production rate in model year 2020 (at the beginning of the implementation period) was 920 AFY. The production rate in model year 2040 (at the beginning of the sustaining period) was 740 AFY.[5] The average production from

[5] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the WLPMA and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the shallow aquifer system in 2040 is 80% of the extraction rate in 2020, rather than the 55% reduction specified in the model scenario description.

the shallow for the sustaining period was 1,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 11,000 AFY and the simulated groundwater production rate in model year 2040 was 8,600 AFY. The average production rate from the LAS for the sustaining period was 10,000 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 11,000 AFY for the 30-year sustaining period (Table 2-15).

Reduction Without Projects Scenario 2 Model Results

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 4,700 AFY during the sustaining period in the Reduction Without Projects Scenario 2 and an average flux of approximately 900 AFY of seawater into the LAS (Figure 2-51). As in the Reduction Without Projects Scenario 1, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 2, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.1.6 Reduction Without Projects Scenario 3

Reduction Without Projects Scenario 3 Model Assumptions

The Reduction Without Projects Scenario 3 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 3 also included a 55% reduction of 2015–2017 average production rates for the UAS and the LAS. The 2015–2017 average pumping rate was not reduced in the UAS and the LAS in the PVB, and was not reduced in the LAS in the WLPMA. Groundwater production rates were reduced in the Oxnard Subbasin linearly over the implementation period and held constant during the sustaining period.

In the WLPMA, the shallow aquifer system simulated groundwater production rate in model year 2020 (at the beginning of the implementation period) was 930 AFY. The production rate in model year 2040 (at the beginning of the sustaining period) was 920 AFY. The average production from the shallow aquifer system for the sustaining period was 940 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 11,000 AFY and the simulated groundwater production rate in model year 2040 was 11,000 AFY. The average production rate from the LAS for the sustaining period was 13,000 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 14,000 AFY for the 30-year sustaining period (Table 2-15).

Reduction Without Projects Scenario 3 Model Results

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,700 AFY during the sustaining period in the Reduction Without Projects Scenario 3, and an average flux of approximately 1,400 AFY of seawater into the LAS (Figure 2-51). As in the Reduction Without Projects Scenarios 1 and 2, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 3, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.1.7 Alternative Climate and Rainfall Patterns

In order to begin to assess the potential impacts on the model predictions from alternate climate change assumptions and precipitation patterns, two additional simulations were conducted using the Reduction Without Projects Scenario 1. These additional simulations changed the scenario assumptions in two ways. First, the Reduction Without Projects Scenario 1 was simulated using the DWR 2030 climate-change factor, rather than the more conservative 2070 climate-change factors. This revised scenario is referred to as the Reduction Without Projects Scenario 1a. Second, the Reduction Without Projects Scenario 1 was simulated with the DWR 2030 climate-change factor applied to the historical precipitation and hydrology period from 1940 to 1989, rather than the original period from 1930 to 1979. This revised scenario is referred to as the Reduction Without Projects Scenario 1b.

The 50-year periods from 1930 to 1979 and 1940 to 1989 were selected because they were the two periods from the entire historical record with the closest mean, or average, precipitation to the mean precipitation for the entire historical record of 14.4 inches. The mean precipitation for the historical period from 1930 to 1979 is also 14.4 inches and the mean precipitation from the historical period from 1940 to 1989 is 14.6 inches. These periods also have a similar distribution of precipitation years to the historical record and a similar average drought length to the average drought length in the historical record. The primary difference between the two periods is the timing of the dry periods in the records. The period from 1930 to 1979 begins with a 7-year dry period from 1930 to 1936 (model years 2020–2026), while the period from 1940 to 1989 begins with a 5-year wetter-than-average period (model years 2020–2024). The differences between these scenarios are discussed below.

Reduction Without Projects Scenario 1a

The Reduction Without Projects Scenario 1a had approximately 2,200 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 1,500 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction Without Projects Scenario 1, there was approximately 600 AFY less flow out of the UAS and approximately 200 AFY more flow into the LAS from the Pacific Ocean (Figure 2-51). This is the result of lower water levels in the UAS and the LAS under this scenario than the Reduction Without Projects Scenario 1. The 2030 climate-change factor showed lower potential water levels and more seawater intrusion than the 2070 climate-change factor; however, the difference between the simulated fluxes in the two scenarios is within the uncertainty of the model predictions and is not significant compared to other uncertainties in the future simulations, including the actual precipitation pattern that will prevail over the period from 2020 to 2069.

Reduction Without Projects Scenario 1b

The Reduction Without Projects Scenario 1b had approximately 4,300 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 760 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction Without Projects Scenario 1a discussed above, the Reduction Without Projects Scenario 1b had 2,100 AFY more freshwater leaving the UAS and 800 AFY less seawater intrusion in the LAS during the sustaining period (Figure 2-44). The reduced seawater intrusion and increased freshwater outflow are the result of higher simulated groundwater levels during the sustaining period than in the Reduction Without Projects Scenario 1a. The groundwater elevations in the Reduction Without Projects Scenario 1b rise faster in response to the wetter-than-average precipitation pattern that occurs at the beginning of the model period (model years 2020–2024) and remain higher during the sustaining period (model years 2040–2069) than they do in the Reduction Without Projects Scenario 1a. The differences in seawater intrusion and water levels between the Reduction Without Projects Scenarios 1a and 1b show that the model is more sensitive to actual precipitation patterns than it is to the predicted relative changes in climate between 2030 and 2070. The actual climate and precipitation patterns over the next 5 years should be used to revise the model simulations and refine the estimated potential for net seawater intrusion during the sustaining period.

2.4.5.1.8 Uncertainty Analysis

A peer review of the UWCD model was conducted to provide an independent evaluation of the model for use in the context of developing a GSP and to quantify the uncertainty associated with the modeling estimates of the sustainable yield for the basins in the model domain (Appendix J, UWCD Model Peer Review Report). UWCD conducted a *local* sensitivity analysis of its model prior to this review, in order to evaluate how the model input parameters obtained via the model calibration affect the model outputs. The peer review conducted an additional *global* sensitivity analysis that keys off their local sensitivity analysis and allows for a quantitative assessment of uncertainty in seawater flux and sustainable yield.

General Results

Results of the model scenarios discussed above indicate that changes to groundwater production rates and/or to extraction locations for the Oxnard Subbasin are needed to avoid seawater intrusion in the LAS during the sustaining period. Understanding the uncertainties in the model predictions underscores the desirability of making gradual changes in production rates while additional monitoring and studies help to reduce these uncertainties.

The largest potential sources of uncertainty in the model were found to be hydraulic properties for a given precipitation pattern. As discussed in Section 2.4.3, precipitation and surface water availability are a critical input parameter for predictive simulations. Critical areas of hydraulic properties were constrained in the historical simulations by aquifer testing. In particular, the model parameters that accounted for the most variance (approximately 37% of total variance) in minimizing error between observed groundwater levels and model simulated heads throughout the model were the horizontal hydraulic conductivities assigned to the Oxnard and Mugu Aquifers in the Forebay. The values assigned in the model were consistent with horizontal hydraulic conductivities determined from aquifer testing in that area. The fact that the most sensitive parameter assignments were well constrained by observations reduces uncertainty and provides good confidence in model predictions of groundwater levels overall.

Additionally and importantly, these same zones of horizontal hydraulic conductivity accounted for approximately 24% of total variance in model calculations of seawater flux across the ocean boundary. In contrast, the conductance of the ocean general head boundaries only accounted for approximately 3% of the variance in seawater flux. This indicates that the movement of artificially recharged groundwater from the Forebay to the coast is key in seawater flux. Additionally, the amount of Forebay recharge that enters the WLPMA rather than moving toward the coast was found to affect the seawater flux more than the conductance of the general head boundaries representing the ocean outcrops at the model boundary.

Stream infiltration, a parameter that was estimated based on the correlation between predicted and observed water levels, accounted for approximately 5% of the variance in seawater flux. Horizontal and vertical hydraulic conductivity of the aquitard separating Layer 5 (Mugu Aquifer) from Layer 7 (the Hueneme Aquifer) in the PVB accounted for approximately 3% of the variance in seawater flux. This sensitivity is associated with the flux across the basin boundary and the flow between the UAS and the LAS. Again, these parameters in the PVB accounted for more seawater flux than that accounted for by the conductance of the aquifer outcrops beneath the ocean.

Quantifying Uncertainty

For the Oxnard Subbasin, the uncertainty associated with model simulations of seawater flux was calculated by determining the relationship between simulated groundwater levels in wells near the coast and simulated seawater flux at the ocean boundary for the six model scenarios described in Section 2.4.5. The relationship was established by calculating the mean errors between observed and simulated groundwater levels at the coastal wells and applying the relationship between simulated groundwater levels and seawater flux to determine what the flux would have been had the model exactly reproduced observed groundwater levels. The analysis was conducted for both the entire model period (from 2020 to 2069) and the sustaining period (from 2040 to 2060).

The Oxnard Subbasin uncertainty analysis indicated that the uncertainty estimate for groundwater pumping in the Oxnard Subbasin was plus or minus 6,000 AFY in the UAS and 3,000 AFY in the LAS, for a total of plus or minus 9,000 AFY. The Oxnard Subbasin uncertainty analysis was used to interpolate the uncertainty for the WLPMA. This was done by using the uncertainty estimate for the Oxnard Subbasin and the ratio of model pumping in the WLPMA to the total model pumping for the three model basins: the Oxnard Subbasin, the PVB, and the WLPMA. This produced an uncertainty in the WLPMA pumping of plus or minus 1,200 AFY for both the shallow aquifer system and the LAS.

The relationship between seawater flux and water levels will continue to be refined through data collection and analysis over successive 5-year periods for the GSP evaluations, and these uncertainty estimates are anticipated to contract accordingly.

2.4.5.1.9 Estimates of Future Sustainable Yield

Because the WLPMA cannot adversely affect the Oxnard Subbasin's ability to achieve the GSP sustainability goal of no net flux of seawater into either the UAS or the LAS, the sustainable yield for WLPMA was assessed by examining the modeled flux of seawater into the UWCD future water scenarios over the 30-year sustaining period predicted for the UWCD model for the Oxnard Subbasin, the PVB, and the WLPMA. Only the sustaining period was assessed because SGMA recognizes that undesirable results may occur during the 20-year implementation period, as basins move toward sustainable groundwater management. Scenarios that minimize the net flux of seawater into the Oxnard Subbasin and the landward migration of the saline water impact front over the 30-year sustaining period are sustainable for the Oxnard Subbasin, while those that allow for net seawater intrusion and landward migration of the saline water impact front are not.

None of the model scenarios described in Section 2.4.5 successfully eliminated seawater intrusion in the LAS of the Oxnard Subbasin during the 50-year model period, or the 30-year sustaining period, while the majority of the model scenarios resulted in net freshwater loss from the UAS to the Pacific Ocean. Therefore, none of the direct model scenarios was used to determine the sustainable yield of the WLPMA. Instead, the relationship between seawater flux and groundwater production of the model scenarios for both the 50-year period and the 30-year period were plotted graphically and the linear relationship between the seawater flux and groundwater production was used to predict the quantity of groundwater production that would result in no net seawater intrusion over the periods in either the UAS or the LAS. This method is also discussed in Appendix J, Section 2.3.2.2, and the seawater flux and groundwater production plots are provided in Appendix J as Figures 4 and 5. In order to provide separate estimates for the two aquifer systems, independent relationships between groundwater production and seawater intrusion were developed for the UAS and the LAS. It was possible to develop relationships for each aquifer within the UAS and the LAS, but in general wells in the Oxnard Subbasin are screened in multiple aquifers in each aquifer system. Therefore, for management purposes, the sustainable yield estimates were developed for the aquifer systems rather than for independent aquifers.

Based on the scenarios presented in Section 2.4.5 and the uncertainty analysis discussed in Section 2.4.5.8, the WLPMA sustainable yield for the shallow aquifer system and the LAS was estimated to be 12,500 AFY plus or minus 1,200 AFY. Using the ratio of shallow aquifer system pumping to LAS pumping, this produces an estimate of 1,000 AFY for the shallow aquifer system and 11,500 AFY for the LAS.

It is anticipated that the analysis for the 5-year update to the GSP will focus on differential extractions on the coast and inland, particularly in the LAS. Additional modeling is recommended for the 5-year update process to understand how changes in pumping patterns can increase the overall sustainable yield of the WLPMA. As this understanding improves, projects to support increases in the overall sustainable yield can be developed.

2.4.5.2 East Las Posas Management Area

The sustainable yield for the ELPMA was assessed using the CMWD model (Appendix C) to examine the simulated future groundwater elevations under differing groundwater extraction and project scenarios. Scenarios that resulted in chronic lowering of groundwater levels and a loss of groundwater storage over the 30-year sustaining period were found not to be sustainable. Scenarios in which groundwater elevations were stable, or increased were analyzed further to assess the potential impacts of the predicted elevations on users of groundwater in the ELPMA. Based on these combined analyses, the sustainable yield was found to equal a groundwater production rate that did not result in chronic lowering of groundwater levels and a loss of groundwater storage during the 30-year sustaining period. This rate differs between model scenarios. Therefore, the model was run multiple times to examine the potential range of sustainable yields depending on which projects, if any, may be implemented in the ELPMA and the production rates that would result in stable groundwater elevations in the absence of projects.

The model scenarios developed for the ELPMA included the following:

- Future Baseline Simulation (2015–2017 average production rates; existing projects; 2070 DWR climate change)

- Future Baseline Simulation With Projects (2015–2017 average production rates; existing projects; 2070 DWR climate change; potential future projects that met the conditions for incorporation in the GSP)
- Reduced Production With Projects (15% reduction of 2015–2017 average pumping rates in the Epworth Gravels; 10% reduction in the FCA and GCA, existing projects; 2070 DWR climate change; potential future projects)
- Reduced Production Without Projects
  - 10% reduction of 2015–2017 average pumping rates in the Epworth Gravels; 25% reduction in the FCA and GCA; existing projects; 2070 DWR climate change
  - 12% reduction of 2015–2017 average pumping rates in the Epworth Gravels; 15% reduction in the FCA and GCA; existing projects; 2070 DWR climate change

Two model scenarios for the ELPMA incorporated projects that were approved for analysis in the GSP by the FCGMA Board. These projects are removal of Arundo along Arroyo Simi–Las Posas, to decrease losses from ET, and purchase of wastewater from the SVWQCP in order to maintain flow in Arroyo Simi–Las Posas. No projects were simulated for the Epworth Gravels Aquifer.

In addition to the initial set of modeling simulations listed above, the Reduction Without Projects Scenario 1 (10% Epworth Gravels Aquifer, 25% FCA and GCA reduction) was simulated with the DWR 2030 climate-change factors and applied to a historical precipitation and hydrology base period from 1940 to 1989. These simulations were conducted to better understand the potential impact of precipitation patterns and climate change factors on the model results.

The average annual production rate from each of the scenarios listed above and how these scenarios were used to assess the sustainable yield of the basins is discussed in further detail below.

2.4.5.2.1 Future Baseline Scenario

DWR regulations require that the GSP include an assessment of the future baseline conditions in each basin. In the case of ELPMA, discharge from dewatering by the City of Simi Valley was assumed to be zero AFY after 2022 based on the City of Simi Valley's plan to desalt and reuse the dewatering water. The discharges from the SVWQCP were reduced stepwise by 1,340, 4,340, 4,500, 5,000, 5,200 AFY in 2020, 2025, 2030, 2035, and 2040, respectively, based on the City of Simi Valley's intention to use the recycled water (VCWD No. 1 2016).

In ELPMA the existing projects include 850 AFY discharged to infiltration ponds from VCWD. The CMWD (Appendix C) model designates the reach downstream of the VCWD as a losing stream so this water ends up recharging the groundwater.

Chronic groundwater elevation declines were observed in all the groundwater elevation hydrographs analyzed from the future baseline model scenario. The primary cause of the simulated groundwater elevation declines in the FCA and GCA is the combination of groundwater production and reduced flow in Arroyo Simi-Las Posas. In the Epworth Gravels Aquifer, chronic lowering of groundwater levels are attributed to groundwater production in excess of the sustainable yield of the aquifer, and are not linked with reduced flow in Arroyo Simi–Las Posas, because there is no hydraulic connection between Arroyo Simi–Las Posas and the Epworth Gravels Aquifer. Under the conditions modeled in the future baseline scenario, the extraction rates were found to be unsustainable in the ELPMA.

2.4.5.2.2 Future Baseline With Projects Scenario

Several projects were proposed to enhance the yield of the ELPMA. Proposed projects included Arundo removal and purchase of SVWQCP effluent discharge to maintain flow in Arroyo Simi–Las Posas. The Nature Conservancy estimates that Arundo removal will result in a reduction in evapotranspiration (ET) losses and an increase in Arroyo Simi–Las Posas flow by up to 2,680 AFY (see Appendix I). Not all of the reduction in ET will be within the model domain, some will be upstream. The CMWD model incorporates approximately 1,900 AFY of ET losses attributed to Arundo. All of these losses were eliminated to simulate Arundo removal. The difference between The Nature Conservancy's estimate of 2,860 AFY losses from Arundo and the ET loss in the model was assumed to occur upstream of the model, and the surface water inflow was increased by this amount. These projects are discussed in detail in Chapter 5 of this GSP.

A project proposed by The Nature Conservancy to purchase 4,691 AFY of SVWQCP effluent to maintain flow in Arroyo Simi–Las Posas and resulting recharge to the LPVB was also incorporated into the future simulations with projects scenarios. This project was designed to maintain flow in Arroyo Simi–Las Posas that Simi Valley has indicated it would divert for other use.

The second model scenario incorporated these projects without reducing the average groundwater extraction rate from the future baseline scenario. The addition of the projects eliminated chronic lowering of groundwater levels in the Shallow Alluvial Aquifer and in wells screened in the FCA adjacent to Arroyo Simi–Las Posas. Chronic lowering of groundwater levels was simulated in the Epworth Gravels Aquifer, and in the FCA and GCA in the central and northern parts of the ELPMA. Because chronic lowering of groundwater levels persisted in the majority of the ELPMA, additional scenarios were developed to examine how changing groundwater production rates would impact groundwater level declines and loss of groundwater in storage.

2.4.5.2.3 Reduction With Projects Scenario

Subsequent model scenarios incorporated reductions in groundwater extractions from the Epworth Gravels, FCA, and GCA, in addition to the projects, and reductions in groundwater extractions without projects. Groundwater extraction reductions for the Epworth Gravels Aquifer were adjusted independently from the extraction reductions in the FCA and GCA, because the Epworth Gravels Aquifer is hydraulically separated from the underlying FCA by several hundred feet of the USP. All reductions in groundwater extractions are relative to the 2015–2017 average groundwater extraction rate, and the reductions were simulated to occur gradually over the 20-year implementation period. The groundwater extraction rate at the end of the 20-year implementation period was held constant for the 30-year sustaining period.

The scenario with projects and reduced extractions included a 15% reduction in the Epworth Gravels Aquifer and 10% reduction in the FCA and GCA, which translates to an average groundwater extraction rate of 20,000 AFY over the sustaining period (Table 2-16). This scenario is called the Reduction With Projects scenario. In the Reduction With Projects scenario, groundwater elevations in the Epworth Gravels Aquifer declined for the first 15 years of the implementation period, and then recovered throughout the sustaining period. In the Shallow Alluvial Aquifer, FCA, and GCA, the Reduction With Projects scenario resulted in stable groundwater elevations throughout the sustaining period. Therefore, the Reduction With Projects scenario was found to be sustainable for all aquifers in the ELPMA.

2.4.5.2.4 Reduction Without Projects Scenarios

Two scenarios were analyzed with reduced groundwater production and no projects. The first scenario included a 10% reduction in extractions from the Epworth Gravels Aquifer and 25% reduction in extractions from the FCA and GCA. This scenario is called the Reduction Without Projects Scenario 1. The average groundwater extraction rate for the sustaining period in the Reduction Without Projects Scenario 1 is 17,000 AFY (Table 2-16). In the Reduction Without Projects Scenario 1, groundwater elevations in the Epworth Gravels Aquifer declined during both the implementation period and the sustaining period. Therefore, a 10% reduction relative to 2015–2017 rates is not sustainable in the Epworth Gravels Aquifer. In the Shallow Alluvial Aquifer, FCA and GCA, the Reduction Without Projects Scenario 1 resulted in stable groundwater elevations throughout the sustaining period. Simulated groundwater elevations were lower in wells adjacent to Arroyo Simi–Las Posas than they were in the Reduction With Projects scenario. For wells in the central and northern portion of the ELPMA, the simulated groundwater elevations were higher in the Reduction Without Projects Scenario 1 than they were in the Reduction With Projects scenario, reflecting the reduced influence of recharge along Arroyo Simi–Las Posas in these areas. Because groundwater elevations in the Shallow Alluvial Aquifer, FCA, and GCA were stable, or recovered during the sustaining period in the Reduction Without Projects Scenario 1, the groundwater extraction rate was found to be sustainable for these aquifers in the ELPMA.

The second scenario with reduced groundwater extractions and no projects included a 12% reduction in groundwater extractions from the Epworth Gravels Aquifer and 15% reduction in extractions from the FCA and GCA. This scenario is called the Reduction Without Projects Scenario 2. The average groundwater extraction rate for the sustaining period in the Reduction Without Projects Scenario 2 is 19,000 AFY (Table 2-16). In this scenario, groundwater elevations were stable during the sustaining period in the Epworth Gravels Aquifer. However, chronic lowering of groundwater levels was simulated throughout the Shallow Alluvial Aquifer, FCA and GCA. Therefore, the simulated production rates in the Reduction Without Projects Scenario 2 are only sustainable for the Epworth Gravels Aquifer, and are not sustainable for the Shallow Alluvial Aquifer, FCA, and GCA.

2.4.5.2.5 Evaluating the Impact of Chronic Lowering of Water Levels on Storage, Recharge, and Well Yields in the ELPMA

Dudek evaluated potential undesirable results associated with chronic lowering of groundwater levels in the ELPMA (see memo included as Appendix K to this GSP). The evaluation used the CMWD numerical model's 50-year simulation of future baseline conditions for the ELPMA to estimate potential changes in the amount of the groundwater in storage, potential changes in the production capacity of the FCA, and potential impacts on recharge due to conversion of the FCA from confined to unconfined conditions (see Appendix C).

The model predicts that continued production at 22,000 AFY throughout the ELPMA (the average 2015–2017 rate) would result in an ELPMA-wide loss of more than 209,000 AF of groundwater in storage. This is equivalent to approximately 8% of groundwater in storage in 2015. Approximately 90,000 AF of this loss occurs in the USP, which is the reservoir containing accumulated recharge from past centuries that leaks downward to replenish the FCA. However, along the northern and southern basin margins and in the center of the basin along the Moorpark and Long Canyon Anticlines, the FCA would experience reductions in storage ranging from 25% to 36%. Additionally, there is a 45% reduction in groundwater in storage in the Epworth Gravels aquifer (Appendix K).

ELPMA-wide 50-year declines in water levels would reduce the production capacity of the FCA by 3%, areas along the northern and southern basin margin and in the center of the basin along the Moorpark Anticline would experience production decreases of 56% to 78%.

As water levels decline in the FCA, the top of the FCA becomes unsaturated in some areas. Leakage from the overlying USP is slightly impeded by unsaturated flow conditions and is reduced locally by approximately 10%. ELPMA-wide, this reduction is estimated to amount to approximately 650 AFY (Appendix K).

2.4.5.2.6 Uncertainty Analysis

A quantitative review of the CMWD model (included as Appendix M to this GSP) is an independent evaluation of the uncertainty associated with modeling estimates of the sustainable yield for the ELPMA. The review complements a local sensitivity analysis performed by CMWD that evaluated how the model parameterization affected predictions of historical groundwater elevations. The peer review presented in Appendix M employed a global sensitivity analysis that keys off the local sensitivity analysis and allows for a quantitative assessment of uncertainty in predictions of key mechanisms, such as annual change in storage, recharge into the FCA, and infiltration from Arroyo Las Posas, that are linked to sustainable yield estimates.

Quantifying Uncertainty

Analysis of uncertainty in model calculations of historical annual change in storage, recharge into the FCA, and infiltration from Arroyo Las Posas yielded confidence intervals of 1,700 AFY, 1,300 AFY, and 2,500 AFY, respectively (Appendix M, Section 3). Annual average change in storage broadly reflects the effects of all stresses in the model and incorporates uncertainty embedded in the other two mechanisms. The relative magnitude of the uncertainty in recharge to the FCA and infiltration from the arroyo indicates that Arroyo Las Posas remains a critical component of the overall uncertainty in storage changes in the ELPMA.

Avoiding long-term loss of storage is proposed to determine the sustainable yield of the ELPMA; applying the annual change in storage confidence interval to the estimated groundwater production that induces no long-term change in groundwater storage under future conditions without projects produces a sustainable yield of 17,800 AFY ±2,300 AFY for the ELPMA.

2.4.5.2.7 Estimates of Future Sustainable Yield

Analysis of the model scenarios, impacts of the chronic lowering of water levels on storage, recharge, and well yields, and the well screen analysis for the ELPMA indicates that the sustainable yield is dependent on the combined effects of projects and groundwater extraction rates. If projects are implemented, the sustainable yield for the total ELPMA may be as high as 20,800 AFY. In the absence of projects, the total sustainable yield for the ELPMA may be closer to 17,800 AFY. As with all models, there is uncertainty in the predicted sustainable yield. Additional work will be done to reduce the uncertainty over the next 5 years, and the sustainable yield may be better defined based on the implementation of any projects or management actions in the ELPMA.

The estimated sustainable yield for just the Epworth Gravels was determined from the Future Baseline scenario, Reduction With Projects scenario, Reduction Without Projects Scenario 1, and Reduction Without Projects Scenario 2, where results from 0%, 15%, 10%, and 12% reductions respectively, in the 2015 to 2017 average pumping in the Epworth Gravels could be evaluated relative to groundwater level hydrographs, (Table 2-16). The Epworth Gravels pumping rate in the Future Baseline scenario was 1,497 AFY, in the Reduction With Projects scenario it was 1,273 AFY, in the Reduction Without Projects Scenario 1 it was 1,348 AFY, and in the Reduction Without Projects Scenario 2 it was 1,318 AFY. The hydrographs suggest that an Epworth Gravels Aquifer pumping rate of about 1,320 AFY, plus or minus 20 AFY, would be sustainable. This is close to the 1,290 AFY estimated for the historical sustainable yield of the Epworth Gravels Aquifer discussed in Section 2.4.3.4.

2.5 MANAGEMENT AREAS

As discussed in Section 2.2, Hydrogeologic Conceptual Model, and Section 2.3, Groundwater Conditions, sustainable management of the LPVB requires dividing the LPVB into three management areas: the WLPMA, the ELPMA, and the Epworth Gravels Management Area. The WLPMA and ELPMA are separated by the Somis Fault, which limits the hydraulic communication between these management areas, and results in an over 300-foot difference in the groundwater elevation across the fault in the FCA (Figures 2-9 and 2-10; Section 2.2.4, Principal Aquifers and Aquitards). Additionally, the water budget indicates that the primary sources of recharge differ between the WLPMA and ELPMA (Section 2.4, Water Budget). Recharge in the WLPMA is dominated by percolation from precipitation and agricultural irrigation infiltration, along with subsurface flows from the Oxnard Subbasin (Section 2.4). In contrast, recharge to the ELPMA has been dominated by recharge from non-native surface water flows in Arroyo Simi–Las Posas (Sections 2.2, 2.3, and 2.4). As a result of both the geologic separation and differing controls on recharge to the WLPMA and ELPMA, these management areas require separate minimum thresholds and management objectives to achieve sustainability. These thresholds and objectives are addressed in Chapter 3, Sustainable Management Criteria, according to management area.

In addition to the WLPMA and ELPMA, the Epworth Gravels Management Area is the third management area defined in the LPVB. Geologically, the Epworth Gravels Aquifer is a localized aquifer that is only present within an approximately 1,600-acre (2.5-square-mile) area of the ELPMA (Section 2.2). A separate management area is defined for this aquifer because it is a locally significant source of water but is not believed to be in hydraulic communication with the other aquifers of the LAS (Section 2.2; Turner 1975). Production from this aquifer caused groundwater elevation declines in the past that did not impact groundwater elevations in the underlying FCA. These aquifers are separated by the USP, which is less transmissive, thereby isolating the effects of drawdown in the Epworth Gravels Aquifer from the FCA. In the fall of 2015, groundwater elevations in the Epworth Gravels Aquifer were several hundred feet higher than they were in the FCA (Figures 2-10 and 2-20). The primary source of recharge to the Epworth Gravels Aquifer is precipitation (Section 2.4). As a result of the geologic separation and isolation of the Epworth Gravels Aquifer from the underlying FCA and the other sources of recharge to the ELPMA, this management area requires separate minimum thresholds and management in order to achieve sustainability. These thresholds and objectives are addressed in Chapter 3.

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Table 2-1
Las Posas Valley Basin Lithologic and Hydrostratigraphic Nomenclature

Geologic Period	Geologic Epoch	Kew (1924); Bailey (1951)[a]	Jakes (1979)	Weber and Kiessling (1976)	Dibblee (1992a, 1992b)	DeVecchio et al. 2012b	CMWD 2016a	CMWD 2016a	Units Used in This GSP	DWR (2003)	USGS 2003; CMWD 2016a	USGS 2003; CMWD 2016a
		Lithologic Units and Formations					*Stratigraphic Column*	*Hydrostratigraphic Units*	*Hydrostratigraphic Unit or Formation*	*Water-Bearing Formations*	*Regional Aquifer Designations*	*Regional Aquifer Systems*
Quaternary	**Holocene**	**Recent Alluvium:** active lagoonal, beach, river, and floodplain, and alluvial deposits				**Alluvium**: active alluvium	**Undifferentiated Alluvium**	**Shallow Alluvial Aquifer**	**Shallow Alluvial Aquifer (ELPMA)** **Shallow aquifer system (WLPMA)**	**Alluvium**	**Recent alluvial and semi-perched**	**Upper Aquifer System**
	Upper Pleistocene	**Terrace deposits:** Deformed river deposits	**Older Alluvium:** Deformed beach, river, floodplain and terrace deposits			**Older Alluvium**: Incised and gently folded fluvial deposits					**Oxnard** **Mugu**	
						Saugus Formation						
		Saugus Formation: Terrestrial and marine sand and gravel		**Saugus Formation:** Terrestrial fluvial	**Saugus Formation:** Terrestrial		**Epworth Gravels (where present)**	**Epworth Gravels (where present)**	**Epworth Gravels (where present)**	**San Pedro Formation**	**Hueneme**	**Lower Aquifer System**
				San Pedro Formation: Marine clays and sand and terrestrial sediment		**Las Posas Sand:** Shallow marine sand thickening westward	**Upper San Pedro / Saugus Formation**	**Upper San Pedro Formation**	**Upper San Pedro Formation**			
	Lower Pleistocene				**Las Posas Sand:** Shallow marine sand		**Clay Marker Bed** **Fox Canyon Aquifer**	**Fox Canyon Aquifer**	**Fox Canyon Aquifer**		**Fox Canyon Aquifer**	
				Santa Barbara Formation: Shallow marine sand			**Upper Santa Barbara Formation (clay-rich)** **Grimes Canyon Aquifer**	**Grimes Canyon**	**Grimes Canyon Aquifer**	**Santa Barbara Formation**	**Grimes Canyon Aquifer**	
Tertiary	**Pliocene**	**Fernando Group**	**Pico Formation**			**Absent**	**Undifferentiated Tertiary Formation (effective Base of Fresh Water)**		**Undifferentiated Tertiary Formation (effective Base of Fresh Water)**	**Non-water-bearing**	**No water-bearing units of regional significance/non-freshwater-bearing**	**Not included in regional flow system**
	Miocene	**Modelo Formation:** Marine mudstones			**Monterey Formation**							
		Conejo Volcanics: Terrestrial and marine extrusive and intrusive igneous rocks										
	Oligocene/ Eocene	**Sespe Formation:** Sandstone and cobble conglomerate										

Notes: CMWD = Calleguas Municipal Water District; DWR = California Department of Water Resources; GSP = Groundwater Sustainability Plan; USGS = U.S. Geological Survey.
[a] As cited in DeVecchio et al. 2012a.

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Table 2-2
Vertical Gradient

Location	Nested Group (First 9 Digits of SWN)	Well (Penultimate 2 Digits of SWN)	Screen Interval		Spring 2015 Elevation (ft msl)	Spring 2015 Gradient (ft/ft)[a]	Fall 2015 Elevation (ft msl)	Fall 2015 Gradient (ft/ft)[a]	Aquifer
			Top	*Bottom*					
WLPMA	02N21W11J	06	190	230	201.5	—	201.0	—	USP
		05	340	380	172.7	−0.192	169.5	−0.21	USP
		04	615	655	−8.6	−0.659	−16.3	−0.675	USP
		03	1,020	1,080	−51	−0.102	−69	−0.130	FCA
ELPMA	02N19W07K	04	90	150	—	—	433.1	—	Alluvium
		03	240	300	—	—	437.6	0.030	USP
		02	680	730	—	—	368.5	-0.159	FCA
	03N20W35R	04	490	530	272.6	—	272.8	—	USP
		03	800	900	155.6	−0.344	136.6	−0.401	FCA
		02	1050	1110	156.6	0.004	128.7	−0.034	FCA

Notes: ELPMA = East Las Posas Management Area; FCA = Fox Canyon Aquifer; ft/ft = feet per feet; ft msl = feet above mean sea level; SWN = State Well Number; USP = Upper San Pedro Formation; WLPMA = West Las Posas Management Area.

[a] Negative gradients are directed downward.

Table 2-3
Average, Maximum, and Minimum Annual Change in Storage in ELPMA Aquifers

Aquifer	Average Annual Change in Storage (AFY)[a]	Maximum Annual Decrease In Storage (AF),[a] *Year*	Minimum Annual Increase in Storage (AF),[a] *Year*
Shallow Alluvial	247	−441, *2013*	1,686, *1990*
Epworth Gravels	86	−805, *1985*	727, *1998*
USP	1,730	−830, *2014*	4,611, *1986*
FCA	1,441	−7,763, *2010*	7,912, *1986*
GCA	122	−1,520, *2010*	973, *1995*

Notes: AF = acre-feet; AFY = acre-feet per year; ELPMA = East Las Posas Management Area; FCA = Fox Canyon Aquifer; GCA = Grimes Canyon Aquifer; USP = Upper San Pedro Formation.
[a] Negative numbers represent a loss in groundwater storage in the aquifer.

Table 2-4
Basin Plan and FCGMA Water Quality Thresholds for Groundwater in the LPVB

Basin/ Subbasin	Threshold Source	Sub-Area/Zone Description	Basin Plan Zone	Threshold Concentration (mg/L)				
				TDS	*Chloride*	*Nitrate*	*Sulfate*	*Boron*
Las Posas Valley	LARWQCB Basin Plan WQO	NW of Grimes Cyn Rd & LA Ave & Somis Rd	1	700	100	45	300	0.5
		E of Grimes Cyn Rd & Hitch Blvd	2	2,500	400	45	1,200	3
		S of LA Ave between Somis Rd & Hitch Blvd	3	1,500	250	45	700	1
		Grimes Cyn Rd & Broadway Area	4	250	30	45	30	0.2
		North Las Posas Area	5	500	150	45	250	1
	FCGMA 2007 BMO	East Las Posas		<500	<100	—	—	—
		West Las Posas		<600	<100	—	—	—
		South Las Posas		<1,500	<160	—	—	—

Sources: LARWQCB 2014; FCGMA 2007; Las Posas Users Group 2012.
Notes: BMO = Basin Management Objective; CMWD = Calleguas Municipal Water District; FCGMA = Fox Canyon Groundwater Management Agency; LARWQCB = Los Angeles Regional Water Quality Control Board; LPVB = Las Posas Valley Basin; mg/L = milligrams per liter; TDS = total dissolved solids; WQO = Water Quality Objective.

Table 2-5
Las Posas Valley Basin Water Purveyors

Water Purveyor	Water Supplied by CMWD	Recycled Water	Water Supplied by Groundwater
Arroyo Las Posas MWC			X
Balcom Bixby Water Association			X
Balcom Canyon Water Well Association			X
Berylwood Heights MWC	X		X

Table 2-5
Las Posas Valley Basin Water Purveyors

Water Purveyor	Water Supplied by CMWD	Recycled Water	Water Supplied by Groundwater
Camrosa Water District[a]	X		
Crestview MWC	X		X
California American Water Co.	X		
Del Norte MWC			X
Epworth MWC			X
Fairview Ranch MWC			X
Fuller Falls MWC			X
La Loma Ranch MWC			X
Las Lomas Water System			X
Lloyd-Butler MWC			X
Rancho Canada Water Co.			X
Rancho de Courtesy			X
City of San Buenaventura (Ventura)			X
Solano Verde MWC	X		
Thermic MWC			X
Waters Road Users Group			X
VCWD No. 1 (MWTP)	X	X	X
VCWD No. 19	X		X
Zone MWC	X		X

Notes: CMWD = Calleguas Municipal Water District; MWC = Mutual Water Company; MWTP = Moorpark Wastewater Treatment Plant; VCWD = Ventura County Waterworks District.

[a] Camrosa Water District also uses pumped groundwater from the Pleasant Valley and Arroyo Santa Rosa Valley Basins.

Table 2-6
Moorpark Wastewater Treatment Plant Discharges and Simi Valley Flows (AF)

Calendar Year	MWTP Flows to Percolation Ponds	MWTP Creek Discharge	Simi Valley Dewatering[a]	Simi Valley Water Quality Control Plant[b]	Subsurface Inflow from Simi Valley[c]
1985	1,559	0	0	8,933	100
1986	1,639	0	0	9,957	100
1987	1,892	0	1,740	10,313	100
1988	2,190	0	1,740	10,235	100
1989	2,155	0	1,740	9,743	100
1990	2,041	0	1,740	9,651	100
1991	1,903	0	1,740	9,264	100
1992	2,041	0	1,740	10,114	100

Table 2-6
Moorpark Wastewater Treatment Plant Discharges and Simi Valley Flows (AF)

Calendar Year	MWTP Flows to Percolation Ponds	MWTP Creek Discharge	Simi Valley Dewatering[a]	Simi Valley Water Quality Control Plant[b]	Subsurface Inflow from Simi Valley[c]
1993	2,201	0	1,740	10,472	100
1994	2,236	0	1,740	9,557	100
1995	2,281	0	1,740	9,436	100
1996	2,224	0	1,740	9,315	100
1997	2,362	0	1,740	9,771	100
1998	2,534	0	1,740	10,602	100
1999	2,339	0	1,740	10,093	100
2000	2,362	0	1,740	10,215	100
2001	2,430	1,647	1,740	10,399	100
2002	2,488	1,613	1,740	10,193	100
2003	2,522	0	1,740	10,263	100
2004	2,247	0	1,740	10,011	100
2005	2,270	0	1,740	11,171	100
2006	2,247	0	1,740	9,914	100
2007	2,201	0	1,949	9,912	100
2008	2,178	0	1,882	10,794	100
2009	2,127	0	1,867	10,725	100
2010	2,096	0	1,782	10,457	100
2011	2,010	0	1,828	9,884	100
2012	1,879	0	1,522	9,574	100
2013	1,747	0	1,569	9,501	100
2014	1,627	0	1,523	9,051	100
2015	1,635	0	1,428	8,506	100
Maximum	**2,534**	**1,647**	**1,949**	**11,171**	**100**
Minimum	**1,559**	**0**	**0**	**8,506**	**100**
Average	**2,118**	**105**	**1,618**	**9,936**	**100**

Sources: DBS&A 2017; Todd Groundwater 2016. See lettered notes below for specifics.
Notes: AF = acre-feet; MWTP = Moorpark Wastewater Treatment Plant.

[a] DBS&A 2017, p. 22, Table 12; Todd 2016, Table 5, for Simi Valley dewatering data. For the years from 1987 (estimates start of dewatering) to 1997 it was assumed that average pumping from 2007 through 2014 (1,740 AFY) was discharged from 1987 to 2006 to fill in historical record.

[b] DBS&A 2017, p. 22, Table 12; Calleguas Creek HSPF Model for discharge from SVWQCP from 1/1/1985 to 5/31/2010 (as cited in DBS&A 2017); City of Simi Valley annual reports for data from 6/1/2010 to 12/31/2015 (as cited in DBS&A 2017).

[c] Todd Groundwater 2016.

Table 2-7
Water Balance for the ELPMA from the CMWD Model

Calendar Year	Model Calculated Inflows				Model Calculated Outflows					Total Groundwater Inflow	Total Groundwater Outflow	Yearly Change
	Reported Recharge Except Arroyo Simi–Las Posas (Includes MWTP)	*Injected ASR Water*	*Inflow at Basin Boundary*	*Inflow from Arroyo Simi–Las Posas Percolation*	*Subsurface Outflow to PVB*[a]	*Riparian ET*	*Extraction*[b]	*Outflow to WLPMA*	*Outflow at Basin Boundary*			*Storage*[3]
1985	9,620	0	1,846	12,648	209	693	17,696	104	1,160	24,114	19,861	-4,252
1986	9,682	0	1,795	18,824	620	720	16,260	105	1,017	30,301	18,722	-11,579
1987	10,002	0	1,935	16,697	519	747	19,038	105	988	28,634	21,397	-7,237
1988	10,197	0	1,950	17,668	806	776	20,593	107	977	29,815	23,258	-6,557
1989	10,262	0	1,932	13,658	662	801	23,252	107	1,028	25,852	25,850	-1
1990	10,014	0	1,886	14,449	774	828	22,629	108	967	26,348	25,306	-1,042
1991	9,906	0	1,853	16,679	986	855	18,498	109	977	28,438	21,425	-7,014
1992	10,016	0	1,843	19,241	1,418	884	15,064	111	869	31,100	18,347	-12,754
1993	10,362	105	1,875	17,317	1,719	909	16,105	112	886	29,659	19,731	-9,928
1994	10,517	326	1,908	15,163	1,706	936	18,305	113	946	27,914	22,006	-5,908
1995	10,812	379	1,883	16,340	1,962	963	15,386	115	928	29,414	19,354	-10,060
1996	10,687	250	1,924	14,494	1,976	993	11,935	117	999	27,355	16,020	-11,335
1997	10,902	257	1,910	13,532	1,949	1,017	16,892	118	1,009	26,601	20,986	-5,615
1998	11,306	1	1,918	14,426	2,220	1,044	15,499	121	962	27,651	19,845	-7,806
1999	11,059	112	1,959	13,366	2,101	1,064	19,965	123	1,010	26,495	24,262	-2,233
2000	11,125	1	2,060	13,306	2,091	1,234	18,612	125	1,052	26,493	23,114	-3,379
2001	11,181	0	2,045	13,658	2,222	1,230	14,013	126	1,022	26,884	18,614	-8,269
2002	11,292	436	1,978	12,961	2,060	1,230	19,909	128	1,109	26,668	24,436	-2,232
2003	11,207	1,229	1,955	12,565	2,308	1,230	16,544	130	1,038	26,956	21,250	-5,705
2004	10,936	961	1,980	12,491	2,268	1,234	18,344	132	1,089	26,368	23,067	-3,301
2005	11,224	1,785	1,907	12,386	2,396	1,230	13,941	133	1,015	27,301	18,715	-8,586
2006	11,405	4,285	1,906	11,406	2,378	1,230	18,624	135	979	29,001	23,347	-5,655
2007	11,327	198	1,997	12,031	2,310	1,230	23,745	137	944	25,553	28,366	2,812
2008	11,173	64	2,161	11,973	2,284	1,234	24,565	138	1,011	25,371	29,232	3,861
2009	10,946	600	2,344	12,060	2,275	1,230	30,315	140	1,054	25,949	35,013	9,064
2010	10,800	84	2,546	12,374	2,327	1,230	26,954	141	954	25,804	31,607	5,803
2011	10,800	765	2,581	12,141	2,339	1,230	19,729	142	912	26,287	24,352	-1,935
2012	10,718	1,577	2,536	12,063	2,253	1,234	23,122	144	884	26,894	27,636	742
2013	10,244	1,461	2,543	11,701	2,027	1,236	27,434	144	867	25,950	31,708	5,758
2014	9,970	3,838	2,412	13,462	1,970	1,230	26,064	145	846	29,682	30,256	574
2015	9,891	703	2,251	11,870	1,832	1,230	23,858	146	820	24,715	27,886	3,171
Maximum	**11,405**	**4,285**	**2,581**	**19,241**	**2,396**	**1,236**	**30,315**	**146**	**1,160**	**31,100**	**35,013**	**9,064**
Minimum	**9,620**	**0**	**1,795**	**11,406**	**209**	**693**	**11,935**	**104**	**820**	**24,114**	**16,020**	**-12,754**
Average	**10,632**	**626**	**2,052**	**13,966**	**1,773**	**1,062**	**19,771**	**125**	**978**	**27,276**	**23,709**	**-3,568**

Sources: CMWD Model; FCGMA/CMWD.
Notes: AF = acre-feet; CMWD = Calleguas Municipal Water District; FCGMA = Fox Canyon Groundwater Management Agency.
[a] These numbers are updated, and are different from those used by UWCD for subsurface inflow into the PVB for the GSP.
[b] Adjusted to account for ASR Injection and extraction starting in 1993.
[c] A negative number indicates that water entered storage.

Table 2-8
Sales and Usage of CMWD Imported Water Supplied (AF)

	Berylwood Heights MWC	CA-American Water Co.[b]	CWD[c]			Crestview MWC	Solano Verde MWC[d]			VCWD No. 1[e]			VCWD No.19[f]							Zone MWC			Total Imported Water Delivered						
	ELPMA	*WLPMA*	*ELPMA*			*WLPMA*	*WLPMA*			*ELPMA*			*WLPMA*			*ELPMA*				*WLPMA*	*ELPMA*	*Total*	*WLPMA*			*ELPMA*			
Year[a]	*Ag*	*M&I*	*Ag*	*M&I*	*Total*	*M&I*	*Ag*	*M&I*	*Total*	*Ag*	*M&I*	*Total*	*Ag*	*M&I*	*Total*	*Ag*	*M&I*	*Total*	*Total*	*Ag*			*Ag*	*M&I*	*Total*	*Ag*	*M&I*	*Total*	*Total*
1985	0	538	86	64	150	31	0	0	0	1,873	5,620	7,494	282	117	398	188	78	266	664	146	97	243	427	686	1,113	2,244	5,762	8,006	9,120
1986	2	538	81	60	141	49	0	0	0	1,786	5,359	7,145	238	99	336	159	66	224	561	90	60	150	328	686	1,013	2,088	5,484	7,572	8,585
1987	7	538	95	70	165	4	0	0	0	2,039	6,118	8,157	337	139	476	224	93	317	793	48	32	80	385	682	1,067	2,397	6,281	8,678	9,745
1988	19	538	121	90	211	63	0	0	0	2,266	6,798	9,065	197	82	278	131	54	186	464	173	116	289	370	683	1,053	2,652	6,943	9,595	10,648
1989	28	538	141	104	245	313	0	0	0	2,384	7,152	9,535	287	119	407	192	79	271	678	186	124	310	473	971	1,444	2,868	7,335	10,203	11,648
1990	13	538	141	105	246	245	0	0	0	2,418	7,254	9,672	726	301	1,027	484	201	684	1,711	8	6	14	734	1,084	1,818	3,062	7,559	10,621	12,439
1991	0	538	85	63	148	219	0	0	0	1,943	5,830	7,773	319	132	451	213	88	301	752	6	4	11	325	889	1,215	2,245	5,981	8,226	9,440
1992	4	538	80	60	140	354	0	0	0	2,016	6,047	8,063	339	141	480	226	94	320	800	25	17	42	365	1,033	1,398	2,343	6,201	8,544	9,942
1993	1	538	76	57	133	446	0	0	0	2,137	6,412	8,550	158	66	224	105	44	149	373	11	7	18	169	1,050	1,219	2,327	6,512	8,839	10,058
1994	0	538	79	59	137	321	0	0	0	1,974	5,921	7,895	131	54	186	87	36	124	309	0	0	0	131	914	1,045	2,140	6,016	8,156	9,201
1995	1	538	81	60	140	140	1	0	0	1,784	5,351	7,135	144	60	203	96	40	135	339	0	0	0	145	737	882	1,961	5,451	7,412	8,294
1996	0	538	82	61	143	0	0	0	0	1,921	5,764	7,685	59	25	84	39	16	56	140	0	0	0	59	563	622	2,043	5,841	7,884	8,506
1997	0	538	97	72	170	140	0	0	0	2,121	6,364	8,486	103	43	146	69	28	97	243	6	4	10	109	721	830	2,291	6,465	8,757	9,587
1998	0	538	42	31	72	1	0	0	0	1,704	5,111	6,815	132	55	187	88	37	125	312	0	0	0	133	595	727	1,834	5,178	7,012	7,739
1999	0	538	58	43	101	75	0	0	0	2,178	6,534	8,711	162	67	229	108	45	152	381	0	0	0	162	680	842	2,344	6,621	8,965	9,807
2000	0	538	67	50	117	306	0	0	0	2,274	6,822	9,096	70	29	100	47	19	66	166	0	0	0	70	873	944	2,388	6,891	9,279	10,223
2001	0	538	70	52	122	363	0	0	0	2,246	6,739	8,986	51	21	72	34	14	48	121	0	0	0	51	923	974	2,351	6,806	9,156	10,131
2002	0	538	92	68	159	14	0	0	0	2,798	8,395	11,194	411	170	581	274	113	387	968	0	0	0	411	723	1,133	3,164	8,577	11,741	12,874
2003	0	538	96	71	167	258	0	0	0	2,595	7,784	10,378	74	31	104	49	20	70	174	0	0	0	74	827	901	2,740	7,875	10,615	11,516
2004	0	538	116	86	202	289	0	0	0	2,716	8,149	10,866	388	161	549	259	107	366	915	0	0	0	388	988	1,376	3,091	8,342	11,433	12,810
2005	0	538	87	64	151	269	0	0	0	2,320	6,959	9,279	128	53	181	85	35	121	302	0	0	0	128	861	989	2,492	7,059	9,550	10,539
2006	0	577	99	73	172	249	127	7	134	2,507	7,521	10,029	365	151	516	243	101	344	860	0	0	0	492	984	1,476	2,849	7,696	10,545	12,021
2007	0	621	120	89	209	266	287	15	302	2,942	8,826	11,768	171	71	242	114	47	162	404	0	0	0	458	973	1,431	3,176	8,962	12,138	13,569
2008	0	647	111	88	200	272	285	15	301	2,801	8,404	11,205	498	206	704	332	137	469	1,173	0	0	0	783	1,140	1,923	3,245	8,630	11,874	13,797
2009	3	579	104	83	187	176	290	15	306	2,567	7,700	10,267	428	178	606	286	118	404	1,010	0	0	0	719	948	1,667	2,960	7,901	10,861	12,528
2010	0	445	88	70	158	233	209	11	220	2,119	6,358	8,478	260	108	368	174	72	246	614	0	0	0	470	797	1,267	2,381	6,500	8,881	10,148
2011	2	471	82	65	147	197	243	13	256	1,996	5,987	7,982	81	34	115	54	22	76	191	0	0	0	324	714	1,038	2,133	6,074	8,207	9,245
2012	3	483	92	73	165	205	309	16	325	2,131	6,393	8,524	41	17	58	27	11	39	97	0	0	0	350	721	1,072	2,254	6,478	8,731	9,803
2013	0	592	106	85	190	280	336	18	354	2,158	6,473	8,631	350	145	495	233	97	330	825	0	0	0	686	1,035	1,721	2,497	6,654	9,151	10,872
2014	0	569	115	93	208	282	396	21	417	2,219	6,656	8,875	423	175	598	282	117	399	997	0	0	0	819	1,047	1,866	2,616	6,866	9,481	11,347
2015	16	400	90	58	148	299	329	17	346	1,929	5,788	7,717	324	134	459	216	90	306	765	0	0	0	653	851	1,504	2,252	5,936	8,188	9,691
Maximum	**28**	**647**	**141**	**105**	**246**	**446**	**396**	**21**	**417**	**2,942**	**8,826**	**11,768**	**726**	**301**	**1,027**	**484**	**201**	**684**	**1,711**	**186**	**124**	**310**	**819**	**1,140**	**1,923**	**3,245**	**8,962**	**12,138**	**13,797**
Minimum	**0**	**400**	**42**	**31**	**72**	**0**	**0**	**0**	**0**	**1,704**	**5,111**	**6,815**	**41**	**17**	**58**	**27**	**11**	**39**	**97**	**0**	**0**	**0**	**51**	**563**	**622**	**1,834**	**5,178**	**7,012**	**7,739**
Average	**3**	**538**	**93**	**70**	**163**	**205**	**91**	**5**	**95**	**2,221**	**6,664**	**8,886**	**248**	**103**	**350**	**165**	**68**	**234**	**584**	**23**	**15**	**38**	**361**	**851**	**1,212**	**2,498**	**6,802**	**9,300**	**10,512**

Sources: Bondy, pers. comm. 2017; CWD 2017; VCWD pers. comm. 2016. See lettered notes below for specifics.

Notes: AF = acre-feet; Ag = agricultural; CA-American Water Co. = California-American Water Company; CMWD = Calleguas Municipal Water District; CWD = Camrosa Water District; ELPMA = East Las Posas Management Area; M&I = municipal and industrial; MWC = Mutual Water Company; VCWD = Ventura County Waterworks District; WLPMA = West Las Posas Management Area.

[a] "Year" refers to calendar year.
[b] Data for 2006 to 2015 from Bondy, pers. comm. 2017; 1985 to 2005 is the average of 2006 to 2015.
[c] Data from CWD, pers. comm. 2017.
[d] Large-lot estates with both domestic and agricultural water usage; assumes 95% outdoor usage.
[e] 75% M&I and 25% Ag in 2015 (Ventura County Public Works Agency, Waterworks District email on 04-19-2016).
[f] 29.3% M&I and 70.7% Ag in 2015 (Ventura Public County Works Agency, Waterworks District email on 04-19-2016).

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Table 2-9
Other Imported Water (AF)

Calendar Year	MWTP[a]	Camrosa Water District Deliveries Used in ELPMA[b]					Total M&I	Total Ag	Total
	Recycled Water for M&I	*PVB Groundwater Used for M&I*	*PVB Groundwater Used for Ag*	*ASRVB Pumped Groundwater for M&I*	*ASRVB Pumped Groundwater for Ag*	*Nonpotable Water Delivered by CWD for Ag*			
1985	0	0	0	6	8	0	6	8	14
1986	0	0	0	5	7	0	5	7	13
1987	0	0	0	6	9	0	6	9	15
1988	0	0	0	8	11	0	8	11	19
1989	0	0	0	9	13	0	9	13	22
1990	0	0	0	9	13	0	9	13	22
1991	0	0	0	18	24	0	18	24	42
1992	0	0	0	17	23	0	17	23	40
1993	0	0	0	16	22	0	16	22	38
1994	0	0	0	17	23	0	17	23	39
1995	0	0	0	21	29	0	21	29	50
1996	0	9	12	13	17	0	22	30	52
1997	0	7	10	23	31	0	30	41	71
1998	0	2	3	12	17	0	14	19	33
1999	0	4	6	15	20	0	19	26	45
2000	0	4	5	18	25	0	22	30	52
2001	0	5	7	19	25	0	24	32	57
2002	0	7	9	25	34	0	32	43	75
2003	291	9	12	24	33	0	325	45	370
2004	571	13	17	27	36	0	611	54	665
2005	526	8	10	22	29	0	556	40	595
2006	493	5	6	27	36	0	524	43	567
2007	515	9	12	31	42	0	556	54	610
2008	482	9	11	31	39	16	521	66	587

Table 2-9
Other Imported Water (AF)

Calendar Year	MWTP[a]	Camrosa Water District Deliveries Used in ELPMA[b]					Total M&I	Total Ag	Total
	Recycled Water for M&I	*PVB Groundwater Used for M&I*	*PVB Groundwater Used for Ag*	*ASRVB Pumped Groundwater for M&I*	*ASRVB Pumped Groundwater for Ag*	*Nonpotable Water Delivered by CWD for Ag*			
2009	403	10	12	27	34	60	440	107	547
2010	381	11	14	19	24	104	411	142	554
2011	426	9	12	18	23	148	453	183	637
2012	549	6	8	26	33	163	581	204	785
2013	616	0	0	38	48	178	654	226	880
2014	616	10	12	32	40	193	658	245	904
2015	616	7	11	21	32	207	644	251	895
Maximum	**616**	**13**	**17**	**38**	**48**	**207**	**658**	**251**	**904**
Minimum	**0**	**0**	**0**	**5**	**7**	**0**	**5**	**7**	**13**
Average	**209**	**5**	**6**	**19**	**26**	**34**	**233**	**66**	**300**

Sources: MWTP pers. comm. 2016; CWD pers. comm. 2017.
Notes: AF = acre-feet; Ag = agriculture; ASRVB = Arroyo Santa Rosa Valley Basin; CWD = Camrosa Water District; ELPMA = East Las Posas Management Area; M&I = Municipal and Industrial; MWTP = Moorpark Wastewater Treatment Plant; PVB = Pleasant Valley Basin.
[a] Data from MWTP on August 22, 2016.
[b] Data from Camrosa Water District on August 21, 2017.

Table 2-10a
Water Balance for the WLPMA Shallow Aquifer from the UWCD Model (AF)

Calendar Year	Inflows			Outflows			Total Inflows	Total Outflows	Model Change in Groundwater Storage[a]
	Recharge	*Subsurface Flow from Oxnard Subbasin*	*Subsurface Flow from PVB*	*Outflow to LAS*	*Pumping*	*Subsurface Flow to Oxnard Subbasin*			
1985	3,663	0	0	−5,915	−667	−589	3,663	−7,170	3,507
1986	6,611	2,695	1	−8,184	−973	0	9,307	−9,157	−150
1987	4,482	472	0	−5,808	−1,439	0	4,954	−7,247	2,294
1988	4,857	2,125	11	−6,424	−1,237	0	6,994	−7,661	667

Table 2-10a
Water Balance for the WLPMA Shallow Aquifer from the UWCD Model (AF)

Calendar Year	Inflows			Outflows			Total Inflows	Total Outflows	Model Change in Groundwater Storage[a]
	Recharge	*Subsurface Flow from Oxnard Subbasin*	*Subsurface Flow from PVB*	*Outflow to LAS*	*Pumping*	*Subsurface Flow to Oxnard Subbasin*			
1989	3,574	787	1	−5,136	−1,693	0	4,363	−6,828	2,466
1990	3,937	109	0	−5,657	−823	0	4,046	−6,480	2,434
1991	6,346	2,707	1	−7,834	−612	0	9,054	−8,446	−608
1992	7,392	7,198	68	−9,795	−677	0	14,658	−10,473	−4,186
1993	7,541	8,452	198	−12,095	−915	0	16,191	−13,011	−3,180
1994	4,202	4,505	166	−8,390	−1,431	0	8,872	−9,821	949
1995	8,245	7,544	237	−11,939	−1,245	0	16,025	−13,184	−2,841
1996	6,097	4,677	233	−10,008	−1,313	0	11,007	−11,321	314
1997	5,748	3,825	308	−9,366	−1,511	0	9,881	−10,877	997
1998	9,132	7,690	994	−12,825	−392	0	17,816	−13,216	−4,599
1999	3,685	2,240	800	−7,788	−1,247	0	6,725	−9,036	2,310
2000	5,013	3,085	715	−7,788	−1,544	0	8,813	−9,332	519
2001	6,905	4,630	921	−9,810	−1,453	0	12,456	−11,263	−1,193
2002	4,280	1,874	731	−6,980	−2,237	0	6,886	−9,217	2,332
2003	4,476	2,717	833	−6,817	−1,665	0	8,026	−8,482	456
2004	5,788	2,456	728	−7,711	−1,952	0	8,971	−9,663	692
2005	7,710	9,803	1,194	−12,004	−1,805	0	18,707	−13,808	−4,898
2006	4,969	6,418	994	−9,878	−1,899	0	12,381	−11,777	−603
2007	3,340	1,748	906	−6,725	−2,334	0	5,994	−9,059	3,065
2008	5,538	4,397	843	−9,299	−1,900	0	10,779	−11,199	421
2009	4,637	1,891	786	−7,752	−1,481	0	7,314	−9,233	1,920
2010	7,171	3,092	1,082	−10,105	−1,003	0	11,345	−11,108	−237
2011	4,762	6,146	1,196	−9,560	−1,250	0	12,104	−10,810	−1,294
2012	4,271	2,540	870	−8,256	−1,863	0	7,682	−10,119	2,438

Table 2-10a
Water Balance for the WLPMA Shallow Aquifer from the UWCD Model (AF)

Calendar Year	Inflows			Outflows			Total Inflows	Total Outflows	Model Change in Groundwater Storage[a]
	Recharge	*Subsurface Flow from Oxnard Subbasin*	*Subsurface Flow from PVB*	*Outflow to LAS*	*Pumping*	*Subsurface Flow to Oxnard Subbasin*			
2013	3,005	1,405	493	−5,602	−2,028	0	4,902	−7,630	2,728
2014	4,611	1,603	265	−6,649	−1,690	0	6,478	−8,339	1,862
2015	2,975	1,304	240	−5,114	−1,033	0	4,519	−6,147	1,628
Maximum	**9,132**	**9,803**	**1,196**	**−5,114**	**−392**	**0**	**18,707**	**−6,147**	**3,507**
Minimum	**2,975**	**0**	**0**	**−12,825**	**−2,334**	**−589**	**3,663**	**−13,808**	**−4,898**
Average	**5,321**	**3,553**	**510**	**−8,297**	**−1,397**	**−19**	**9,384**	**−9,713**	**329**

Notes: AF = acre-feet; LAS = Lower Aquifer System; PVB = Pleasant Valley Basin; UWCD = United Water Conservation District; WLPMA = West Las Posas Management Area.
Components are from the UWCD model.
[a] A negative number indicates that water entered storage.

Table 2-10b
Water Balance for the WLPMA LAS from the UWCD Model (AF)

Calendar Year	Inflows					Outflows			Inflows	Outflows	Model Change in Storage[a]
	Recharge from USP Outcrops	*Recharge*	*From Alluvium*	*Subsurface Flow from Oxnard Subbasin*	*Subsurface Flow from PVB*	*Subsurface Flow to Oxnard Subbasin*	*Pumping*	*Subsurface Flow to PVB*			
1985	823	899	5,915	0	0	−292	−13,940	−1,425	7,636	−15,657	8,021
1986	2,440	1,625	8,184	292	0	0	−13,226	−686	12,541	−13,912	1,371
1987	1,098	1,049	5,808	0	0	−1,091	−15,416	−1,343	7,955	−17,851	9,895
1988	1,412	1,113	6,424	0	0	−470	−16,397	−678	8,949	−17,546	8,596
1989	419	703	5,136	0	0	−1,569	−17,505	−961	6,257	−20,035	13,778
1990	466	748	5,657	0	0	−1,838	−20,321	−1,259	6,871	−23,417	16,546
1991	2,314	1,453	7,834	0	0	−911	−15,268	−830	11,601	−17,008	5,407
1992	3,067	1,844	9,795	1,474	407	0	−13,551	0	16,588	−13,551	−3,037
1993	3,040	1,879	12,095	2,170	879	0	−14,263	0	20,064	−14,263	−5,801
1994	1,090	1,025	8,390	719	466	0	−13,849	0	11,690	−13,849	2,159
1995	3,856	2,119	11,939	1,393	811	0	−11,383	0	20,117	−11,383	−8,735
1996	2,485	1,492	10,008	866	420	0	−11,617	0	15,271	−11,617	−3,655
1997	1,872	1,376	9,366	557	314	0	−14,392	0	13,485	−14,392	907
1998	4,066	2,303	12,825	2,093	1,085	0	−10,670	0	22,372	−10,670	−11,702
1999	896	866	7,788	834	259	0	−13,098	0	10,643	−13,098	2,455
2000	1,654	1,215	7,788	450	39	0	−12,989	0	11,146	−12,989	1,844
2001	3,103	1,725	9,810	620	219	0	−9,455	0	15,477	−9,455	−6,021
2002	1,153	1,020	6,980	0	0	−470	−13,139	−303	9,153	−13,911	4,759
2003	1,378	1,111	6,817	0	125	−36	−10,751	0	9,431	−10,786	1,356
2004	2,074	1,412	7,711	0	0	−529	−11,596	−54	11,198	−12,179	981
2005	3,285	1,903	12,004	1,799	614	0	−10,678	0	19,604	−10,678	−8,927
2006	1,780	1,210	9,878	999	693	0	−9,375	0	14,560	−9,375	−5,185
2007	595	776	6,725	55	383	0	−13,974	0	8,533	−13,974	5,441
2008	1,846	1,363	9,299	0	621	−195	−14,957	0	13,129	−15,152	2,023
2009	1,297	1,069	7,752	0	853	−772	−15,318	0	10,971	−16,090	5,119
2010	2,710	1,755	10,105	136	1,438	0	−14,243	0	16,144	−14,243	−1,902
2011	1,259	1,157	9,560	1,115	1,701	0	−15,720	0	14,792	−15,720	927
2012	905	996	8,256	0	1,429	−463	−18,183	0	11,586	−18,646	7,061
2013	103	643	5,602	0	381	−1,061	−17,262	0	6,728	−18,323	11,595
2014	1,020	1,056	6,649	0	0	−1,681	−15,410	−73	8,726	−17,164	8,438
2015	263	630	5,114	0	269	−1,264	−15,350	0	6,276	−16,614	10,338
Maximum	**4,066**	**2,303**	**12,825**	**2,170**	**5,796**	**0**	**−9,375**	**0**	**22,372**	**−9,375**	**16,546**
Minimum	**103**	**630**	**5,114**	**0**	**0**	**−1,838**	**−20,321**	**−1,425**	**6,257**	**−23,417**	**−11,702**
Average	**1,734**	**1,275**	**8,297**	**502**	**432**	**−408**	**−13,977**	**−246**	**12,242**	**−14,631**	**2,389**

Notes: AF = acre-feet; LAS = Lower Aquifer System; USP = Upper San Pedro Formation; UWCD = United Water Conservation District; WLPMA = West Las Posas Management Area.
Components are from the UWCD model.
[a] A negative number indicates that water entered storage.

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Table 2-11
Recharge Type (AF)

Calendar Year	Precipitation Recharge	M&I Recharge	Ag Recharge	Total
1985	2,044	1,189	1,329	4,561
1986	5,808	1,064	1,363	8,236
1987	2,548	1,397	1,586	5,531
1988	2,976	1,423	1,572	5,971
1989	986	1,449	1,842	4,277
1990	953	1,642	2,090	4,685
1991	4,921	1,307	1,572	7,800
1992	6,700	1,227	1,310	9,236
1993	6,799	1,220	1,401	9,420
1994	2,600	1,265	1,361	5,226
1995	8,142	1,019	1,202	10,363
1996	5,327	817	1,445	7,589
1997	4,310	1,049	1,764	7,124
1998	9,416	745	1,275	11,435
1999	2,047	1,013	1,491	4,551
2000	3,675	1,113	1,439	6,227
2001	6,578	867	1,185	8,630
2002	2,433	1,298	1,568	5,300
2003	3,400	915	1,273	5,587
2004	4,701	1,101	1,398	7,200
2005	7,382	980	1,251	9,613
2006	3,906	1,098	1,175	6,179
2007	1,227	1,389	1,499	4,116
2008	3,877	1,577	1,447	6,901
2009	2,836	1,457	1,413	5,706
2010	6,242	1,256	1,427	8,926
2011	3,053	1,225	1,641	5,919
2012	1,870	1,425	1,972	5,267
2013	218	1,626	1,803	3,647
2014	2,517	1,468	1,683	5,667
2015	634	1,352	1,618	3,605
Maximum	**9,416**	**1,642**	**2,090**	**11,435**
Minimum	**218**	**745**	**1,175**	**3,605**
Average	**3,875**	**1,225**	**1,497**	**6,597**

Notes: AF = acre-feet; Ag = agricultural; M&I = municipal and industrial.

Table 2-12
Calleguas Municipal Water District Aquifer Storage and Recovery Program (AF)

Calendar Year	In-Lieu Water Deliveries		Net ASR System Injection in ELPMA	Pumping Allocation in ELPMA	Cumulative Storage		
	WLPMA	*ELPMA*			*WLPMA*	*ELPMA*	*Total*
1985	0	0	0	0.0	0	0	0
1986	0	0	0	0.0	0	0	0
1987	0	0	0	0.0	0	0	0
1988	0	0	0	0.0	0	0	0
1989	0	0	0	0.0	0	0	0
1990	0	0	0	0.0	0	0	0
1991	0	0	0	0.0	0	0	0
1992	0	0	0	0.0	0	0	0
1993	0	0	65	2.5	0	67	67
1994	0	0	248	2.5	0	318	318
1995	380	276	371	2.3	380	967	1,347
1996	2,088	5,501	−11	2.3	2,468	6,460	8,928
1997	1,933	3,047	87	2.3	4,401	9,596	13,997
1998	914	628	−61	2.3	5,315	10,165	15,480
1999	2,000	0	6	2.3	7,315	10,174	17,489
2000	2,279	1,871	1	2.2	9,594	12,046	21,640
2001	2,125	140	0	2.2	11,719	12,186	23,905
2002	2,000	0	225	2.2	13,719	12,414	26,133
2003	2,498	1,374	1,157	2.2	16,217	14,947	31,164
2004	2,171	2,307	919	2.2	18,388	18,175	36,563
2005	1,956	2,118	1,690	2.2	20,344	21,985	42,329
2006	1,975	2,446	4,227	2.2	22,319	28,660	50,979
2007	2,472	551	−2,167	2.2	24,791	27,047	51,838
2008	401	0	−5,110	2.2	25,192	21,939	47,131
2009	0	0	−9,770	2.1	25,192	12,171	37,363
2010	0	946	−9,035	1.9	25,192	4,084	29,276
2011	0	724	−422	1.9	25,192	4,388	29,580
2012	0	437	1,171	1.9	25,192	5,998	31,190
2013	0	491	419	1.9	25,192	6,910	32,102
2014	0	510	2,938	1.9	25,192	10,360	35,552
2015	0	433	604	1.7	25,192	11,398	36,590
Maximum	**2,498**	**5,501**	**4,227**	**2**	**25,192**	**28,660**	**51,838**
Minimum	**0**	**0**	**−9,770**	**0**	**0**	**0**	**0**
Average	**813**	**768**	**−402**	**2**	**11,565**	**8,466**	**20,031**

Source: FCGMA email November 11, 2017.
Notes: AF = acre-feet; ELPMA = East Las Posas Management Area; WLPMA = West Las Posas Management Area.
Net ASR System Injection in ELPMA negative numbers indicate net pumping during the year.

Table 2-13
WLPMA UWCD Model Pumping by FCGMA Types (AF)

Calendar Year	Agricultural Pumpage			M&I Pumpage			Domestic Pumpage			Totals		
	Pumping Shallow	*Pumping LAS*	*Total Agricultural Pumping*	*Pumping Shallow*	*Pumping LAS*	*Total M&I Pumping*	*Pumping Shallow*	*Pumping LAS*	*Total Domestic Pumping*	*Total Pumping Shallow*	*Total Pumping LAS*	*Total Groundwater Pumping*
1985	667	13,303	13,969	0	638	638	0	0	0	667	13,940	14,607
1986	973	12,321	13,294	0	905	905	0	0	0	973	13,226	14,199
1987	1,439	13,447	14,886	0	1,970	1,970	0	0	0	1,439	15,416	16,855
1988	1,237	14,700	15,937	0	1,697	1,697	0	0	0	1,237	16,397	17,634
1989	1,693	16,593	18,286	0	912	912	0	0	0	1,693	17,505	19,198
1990	823	18,515	19,338	0	1,806	1,806	0	0	0	823	20,321	21,144
1991	611	14,272	14,883	0	996	996	1	0	1	612	15,268	15,880
1992	675	12,328	13,003	0	1,223	1,223	2	0	2	677	13,551	14,228
1993	907	12,802	13,709	6	1,462	1,468	2	0	2	915	14,263	15,179
1994	1,429	12,431	13,859	0	1,418	1,418	2	0	2	1,431	13,849	15,280
1995	1,243	9,947	11,190	0	1,436	1,436	2	0	2	1,245	11,383	12,628
1996	1,310	9,595	10,904	0	2,022	2,022	3	0	3	1,313	11,617	12,929
1997	1,508	12,298	13,806	0	2,094	2,094	3	0	3	1,511	14,392	15,903
1998	383	9,049	9,433	0	1,620	1,620	8	0	8	392	10,670	11,062
1999	1,245	10,897	12,143	0	2,201	2,201	2	0	2	1,247	13,098	14,345
2000	1,542	10,432	11,974	0	2,557	2,557	3	0	3	1,544	12,989	14,533
2001	1,450	7,406	8,856	0	2,049	2,049	3	0	3	1,453	9,455	10,908
2002	2,235	10,202	12,436	0	2,937	2,937	2	0	2	2,237	13,139	15,376
2003	1,662	8,368	10,030	0	2,383	2,383	3	0	3	1,665	10,751	12,416
2004	1,950	9,097	11,046	0	2,499	2,499	2	0	2	1,952	11,596	13,548
2005	1,801	8,546	10,347	0	2,132	2,132	4	0	4	1,805	10,678	12,483
2006	1,895	7,478	9,374	0	1,896	1,896	4	0	4	1,899	9,375	11,274
2007	2,331	11,420	13,751	0	2,554	2,554	4	0	4	2,334	13,974	16,308
2008	1,898	12,219	14,117	0	2,738	2,738	3	0	3	1,900	14,957	16,858
2009	1,480	12,598	14,078	0	2,720	2,720	1	0	1	1,481	15,318	16,799
2010	1,001	12,343	13,344	0	1,900	1,900	2	0	2	1,003	14,243	15,246
2011	1,242	13,112	14,354	0	2,608	2,608	8	0	8	1,250	15,720	16,970
2012	1,856	15,031	16,887	0	3,152	3,152	7	0	7	1,863	18,183	20,047
2013	2,025	14,368	16,393	0	2,894	2,894	3	0	3	2,028	17,262	19,290
2014	1,689	12,714	14,402	0	2,696	2,696	2	0	2	1,690	15,410	17,100
2015	1,033	12,854	13,887	0	2,496	2,496	1	0	1	1,033	15,350	16,383
Maximum	**2,331**	**18,515**	**19,338**	**6**	**3,152**	**3,152**	**8**	**0**	**8**	**2,334**	**20,321**	**21,144**
Minimum	**383**	**7,406**	**8,856**	**0**	**638**	**638**	**0**	**0**	**0**	**392**	**9,375**	**10,908**
Average	**1,395**	**11,958**	**13,352**	**0**	**2,020**	**2,020**	**2**	**0**	**2**	**1,397**	**13,977**	**15,374**

Sources: UWCD model (pumping amounts); FCGMA well database (usage type).
Notes: AF = acre-feet; FCGMA = Fox Canyon Groundwater Management Agency; LAS = Lower Aquifer System; M&I = municipal and industrial; UWCD = United Water Conservation District; WLPMA = West Las Posas Management Area.

Table 2-14
ELPMA CMWD Model Groundwater Pumping by FCGMA Type (AF)

Calendar Year	Ag Pumping						M&I Pumping						Domestic Pumping						Total Reported GWP					
	EGA	*SAA*	*USP*	*FCA*	*GCA*	*Total Ag*	*EGA*	*SAA*	*USP*	*FCA*	*GCA*	*Total M&I*	*EGA*	*SAA*	*USP*	*FCA*	*GCA*	*Total Domestic*	*EGA*	*SAA*	*USP*	*FCA*	*GCA*	*Total GWP*
1985	1,444	346	991	11,350	652	14,784	251	60	172	1,973	113	2,570	33	8	23	262	15	342	1,729	414	1,187	13,586	780	17,696
1986	1,222	277	1,046	9,880	641	13,066	282	64	241	2,279	148	3,015	17	4	14	136	9	180	1,521	345	1,302	12,295	797	16,260
1987	1,078	305	1,384	11,550	825	15,143	276	78	355	2,961	212	3,882	1	0	1	9	1	12	1,356	384	1,740	14,520	1,038	19,038
1988	1,019	265	1,454	12,996	1,122	16,855	224	58	320	2,857	247	3,706	2	0	3	25	2	32	1,245	323	1,776	15,878	1,370	20,593
1989	1,303	333	1,444	15,023	1,306	19,409	254	65	282	2,930	255	3,785	4	1	4	45	4	58	1,561	398	1,730	17,998	1,565	23,252
1990	1,628	271	1,341	13,587	1,437	18,264	385	64	317	3,211	340	4,317	4	1	4	36	4	49	2,017	336	1,661	16,835	1,780	22,629
1991	1,422	281	1,207	11,766	1,274	15,951	224	44	190	1,854	201	2,514	3	1	3	25	3	33	1,649	326	1,400	13,645	1,477	18,498
1992	1,082	234	745	9,913	1,114	13,088	160	35	110	1,464	165	1,933	4	1	2	32	4	43	1,246	269	857	11,410	1,282	15,064
1993	1,260	242	856	10,899	1,220	14,477	138	26	94	1,193	134	1,584	4	1	3	33	4	44	1,402	269	952	12,124	1,357	16,105
1994	1,377	270	1,072	11,485	1,289	15,493	246	48	191	2,050	230	2,766	4	1	3	34	4	46	1,627	319	1,267	13,570	1,523	18,305
1995	1,032	219	1,233	9,455	938	12,876	197	42	236	1,806	179	2,460	4	1	5	36	4	49	1,233	262	1,473	11,297	1,121	15,386
1996	1,278	209	1,133	7,594	1,127	11,341	62	10	55	367	54	548	5	1	5	31	5	46	1,345	220	1,192	7,992	1,186	11,935
1997	1,233	284	1,323	11,878	1,349	16,066	59	14	63	567	64	768	4	1	5	43	5	58	1,296	299	1,391	12,488	1,418	16,892
1998	574	909	1,199	10,767	1,037	14,486	39	61	81	723	70	973	2	2	3	30	3	40	614	972	1,283	11,520	1,109	15,499
1999	898	305	1,428	14,053	1,514	18,197	85	29	135	1,327	143	1,719	2	1	4	38	4	49	985	335	1,566	15,418	1,661	19,965
2000	911	419	1,475	13,992	1,371	18,167	20	9	32	306	30	397	2	1	4	37	4	47	933	429	1,511	14,335	1,404	18,612
2001	755	383	1,064	9,688	1,150	13,040	54	27	76	692	82	932	2	1	3	30	4	41	811	411	1,144	10,411	1,236	14,013
2002	1,094	859	1,622	13,056	1,421	18,052	110	86	163	1,313	143	1,816	3	2	4	30	3	42	1,207	947	1,789	14,399	1,567	19,909
2003	1,227	310	1,384	11,309	1,279	15,510	79	20	89	726	82	995	3	1	3	28	3	39	1,308	331	1,476	12,063	1,365	16,544
2004	1,403	488	1,474	13,138	1,510	18,014	20	7	21	187	22	257	6	2	6	54	6	73	1,429	497	1,501	13,379	1,538	18,344
2005	654	385	1,125	10,154	1,141	13,459	21	13	37	333	37	441	2	1	3	31	3	41	677	399	1,166	10,517	1,182	13,941
2006	1,251	327	1,362	14,158	1,103	18,200	28	7	31	317	25	408	1	0	1	12	1	16	1,280	334	1,393	14,488	1,128	18,624
2007	1,149	480	1,314	15,798	1,482	20,223	199	83	228	2,740	257	3,508	1	0	1	11	1	14	1,349	563	1,543	18,549	1,741	23,745
2008	616	350	1,035	14,709	1,484	18,195	215	122	362	5,140	519	6,358	0	0	1	10	1	12	832	473	1,398	19,859	2,003	24,565
2009	712	285	1,023	15,434	1,403	18,858	432	173	621	9,367	852	11,445	0	0	1	10	1	12	1,145	458	1,645	24,811	2,256	30,315
2010	657	136	690	14,063	1,288	16,834	394	81	414	8,440	773	10,103	1	0	1	14	1	17	1,051	217	1,105	22,517	2,063	26,954
2011	873	182	993	13,233	1,396	16,677	159	33	181	2,410	254	3,038	1	0	1	11	1	14	1,033	216	1,175	15,654	1,652	19,729
2012	1,148	252	1,304	16,358	1,614	20,676	135	30	153	1,924	190	2,432	1	0	1	12	1	15	1,284	282	1,458	18,293	1,805	23,122
2013	1,278	240	1,654	18,870	2,367	24,409	157	29	203	2,321	291	3,002	1	0	2	17	2	23	1,436	269	1,859	21,209	2,661	27,434
2014	1,615	319	1,349	17,690	2,103	23,076	208	41	174	2,277	271	2,970	1	0	1	14	2	18	1,824	360	1,524	19,980	2,376	26,064
2015	1,432	186	1,523	16,879	1,790	21,810	133	17	141	1,567	166	2,025	1	0	2	18	2	23	1,567	203	1,665	18,464	1,959	23,858
Maximum	1,628	909	1,654	18,870	2,367	24,409	432	173	621	9,367	852	11,445	33	8	23	262	15	342	2,017	972	1,859	24,811	2,661	30,315
Minimum	574	136	690	7,594	641	11,341	20	7	21	187	22	257	0	0	1	9	1	12	614	203	857	7,992	780	11,935
Average	1,117	334	1,234	12,927	1,314	16,926	169	48	186	2,182	211	2,796	4	1	4	37	3	49	1,290	383	1,424	15,145	1,529	19,771

Notes: AF = acre-feet; Ag = agricultural; CMWD = Calleguas Municipal Water District; EGA = Epworth Gravels Aquifer; ELPMA = East Las Posas Management Area; FCA = Fox Canyon Aquifer; FCGMA = Fox Canyon Groundwater Management Agency; GCA = Grimes Canyon Aquifer; GWP = groundwater pumping; M&I = municipal and industrial; SAA = Shallow Alluvial Aquifer; USP = Upper San Pedro Formation.

Table 2-15
UWCD Model Scenario Extraction Rates for the WLPMA (AFY)

UWCD Model Scenario	Shallow Aquifer Groundwater Extractions	LAS Groundwater Extractions	Total Groundwater Extractions	Project Water	Total Scenario
Future Baseline	1,000	13,000	14,000	0	14,000
Future Baseline With Projects	1,000	11,000	12,000	2,000	14,000
Reduction With Projects	1,000	9,000	10,000	2,000	12,000
Reduction Without Projects Scenario 1	1,000	10,000	11,000	0	11,000
Reduction Without Projects Scenario 2	1,000	10,000	11,000	0	11,000
Reduction Without Projects Scenario 3	1,000	13,000	14,000	0	14,000

Notes: AFY = acre-feet per year; LAS = Lower Aquifer System; UWCD = United Water Conservation District; WLPMA = West Las Posas Management Area.

Table 2-16
Modeled 2040–2069 Groundwater Extraction Rates for the ELPMA

CMWD Model Scenario	Model Extraction Rates (AFY)
Future Baseline	22,000
Future Baseline With Projects	22,000
Reduction With Projects (15% Epworth Gravels Aquifer; 10% FCA and GCA)	20,000
Reduction Without Projects (1) (10% Epworth Gravels Aquifer; 25% FCA and GCA)	17,000
Reduction Without Projects (2) (12% Epworth Gravels Aquifer; 15% FCA and GCA)	19,000

Notes: AFY = acre-feet per year; CMWD = Calleguas Municipal Water District; ELPMA = East Las Posas Management Area; FCA = Fox Canyon Aquifer; GCA = Grimes Canyon Aquifer.

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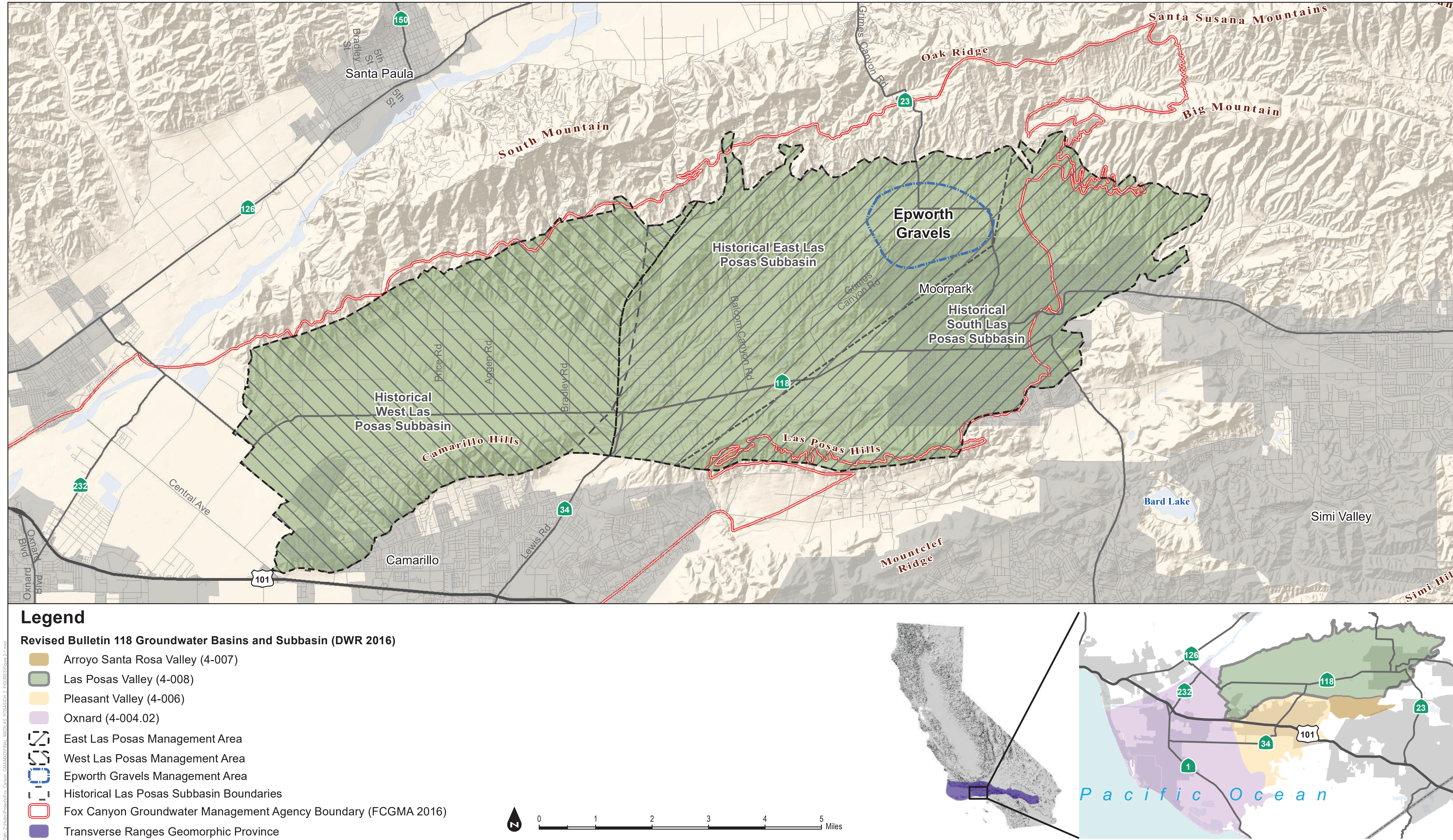

SOURCE: CGS 2002; DWR 2016; FCGMA 2016

DUDEK

FIGURE 2-1

Map of the Las Posas Valley Basin

Groundwater Sustainability Plan for the Las Posas Valley Basin

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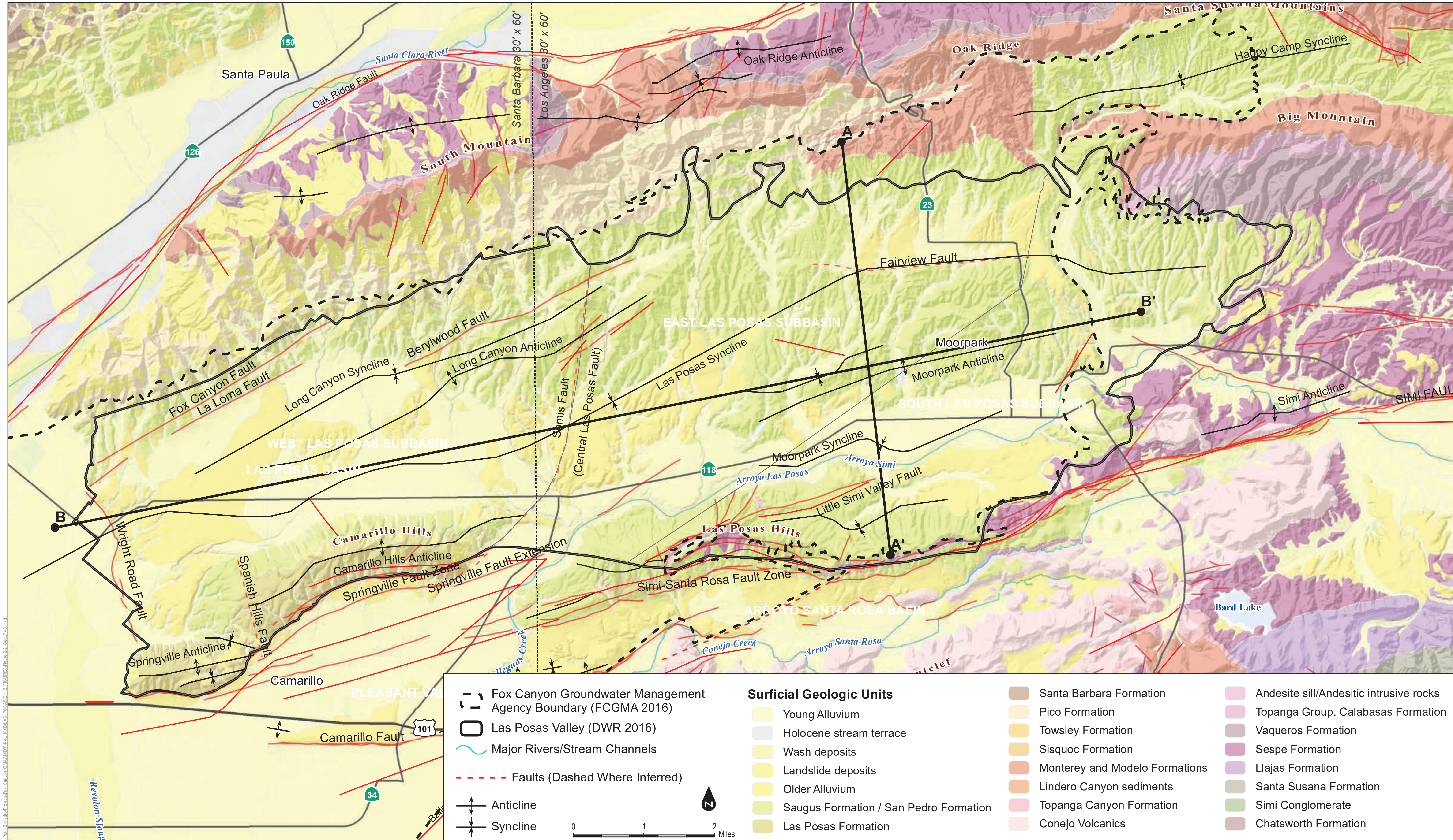

SOURCE: DWR; FCGMA; surficial geology after California Geological Survey; folds after Dibblee 1992a and 1992b, Devecchio 2012a, Turner 1975; faults after DeVecchio et al. 2012a

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FIGURE 2-2

Geology of the Las Posas Valley Basin

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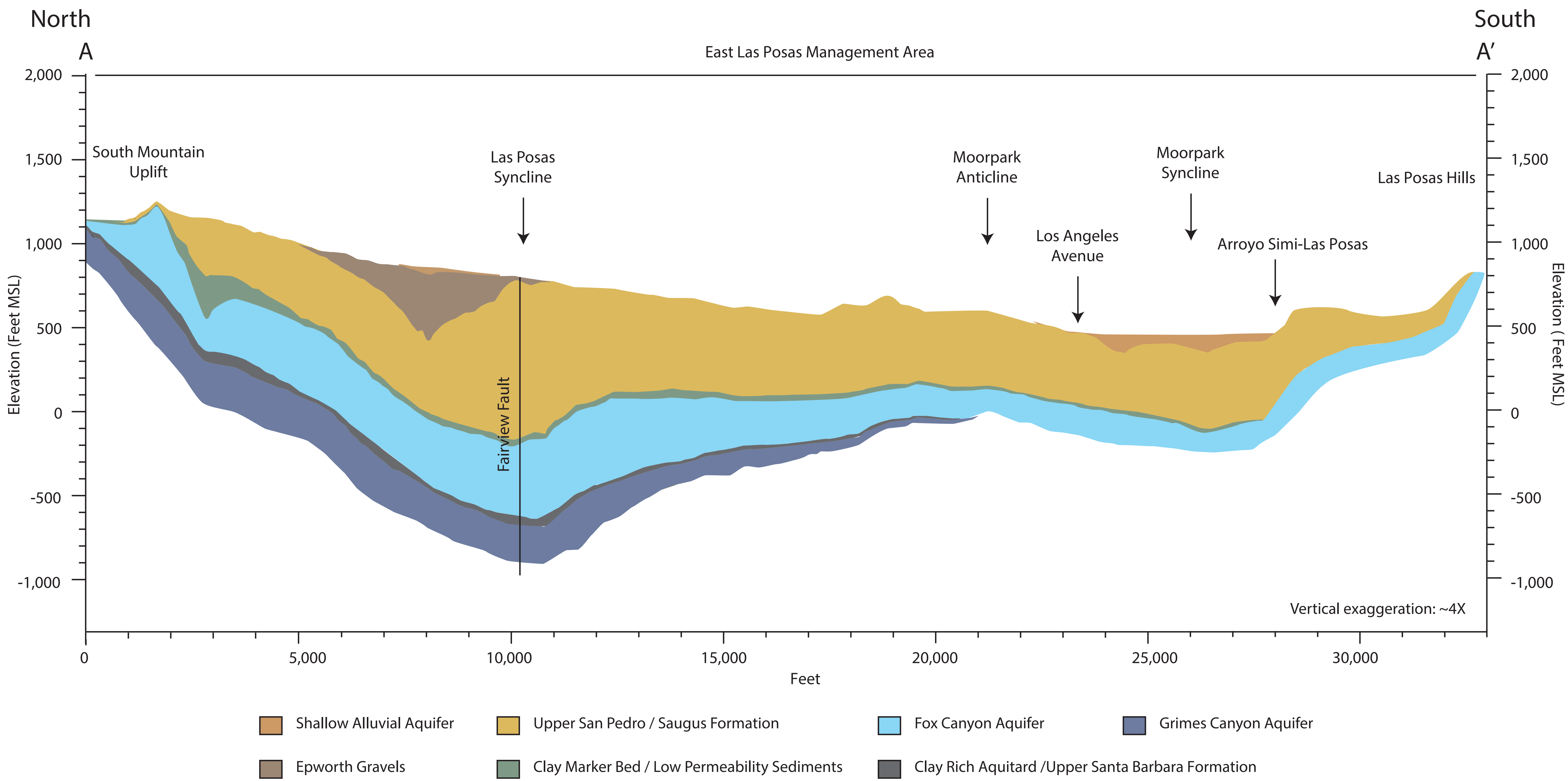

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SOURCE: CMWD 2016a

FIGURE 2-3
Conceptual Cross Section A-A'

Groundwater Sustainability Plan for the Las Posas Valley Basin

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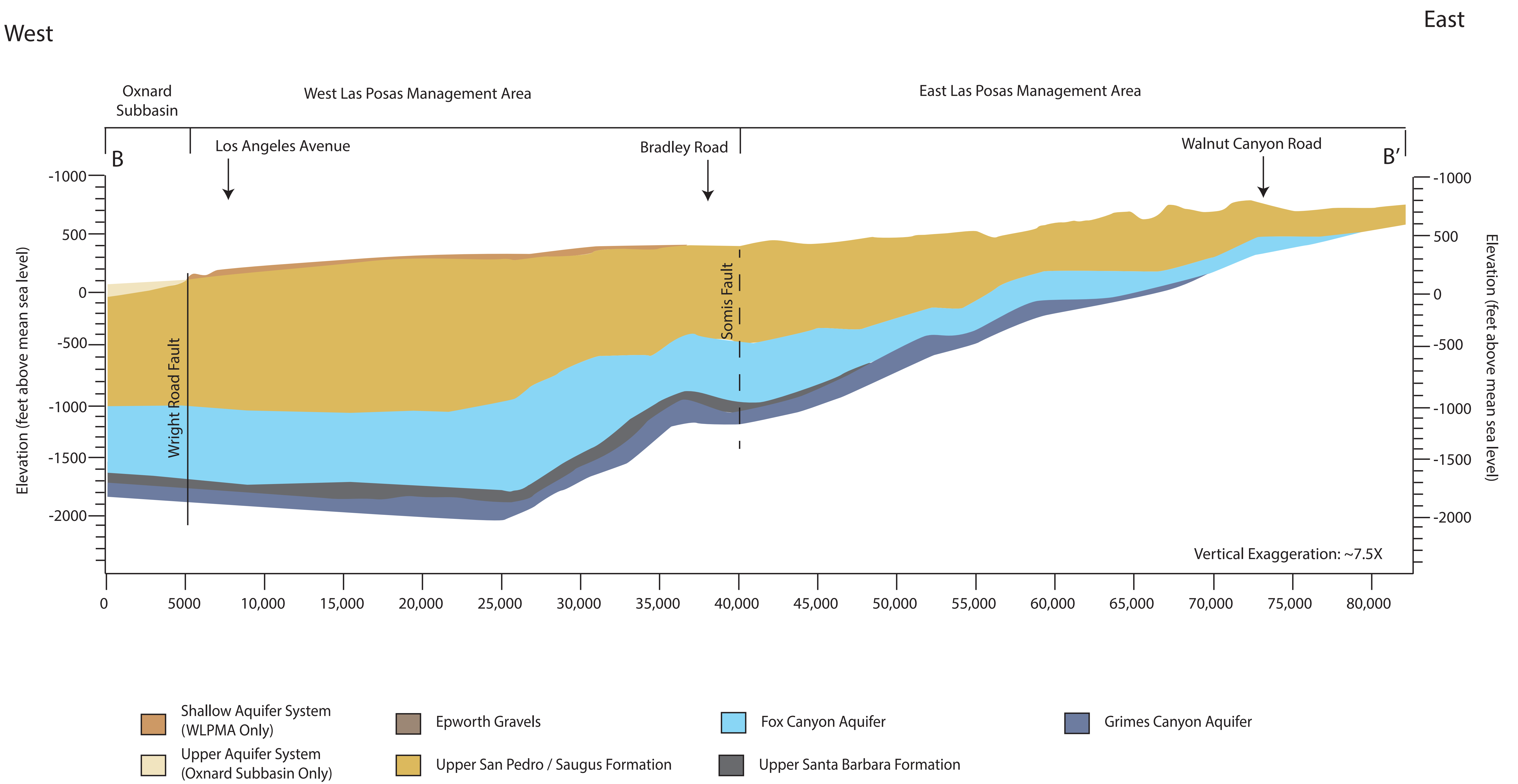

SOURCE: Turner 1975; Calleguas 2012; Calleguas 2016a

FIGURE 2-4
Cross Section B-B’

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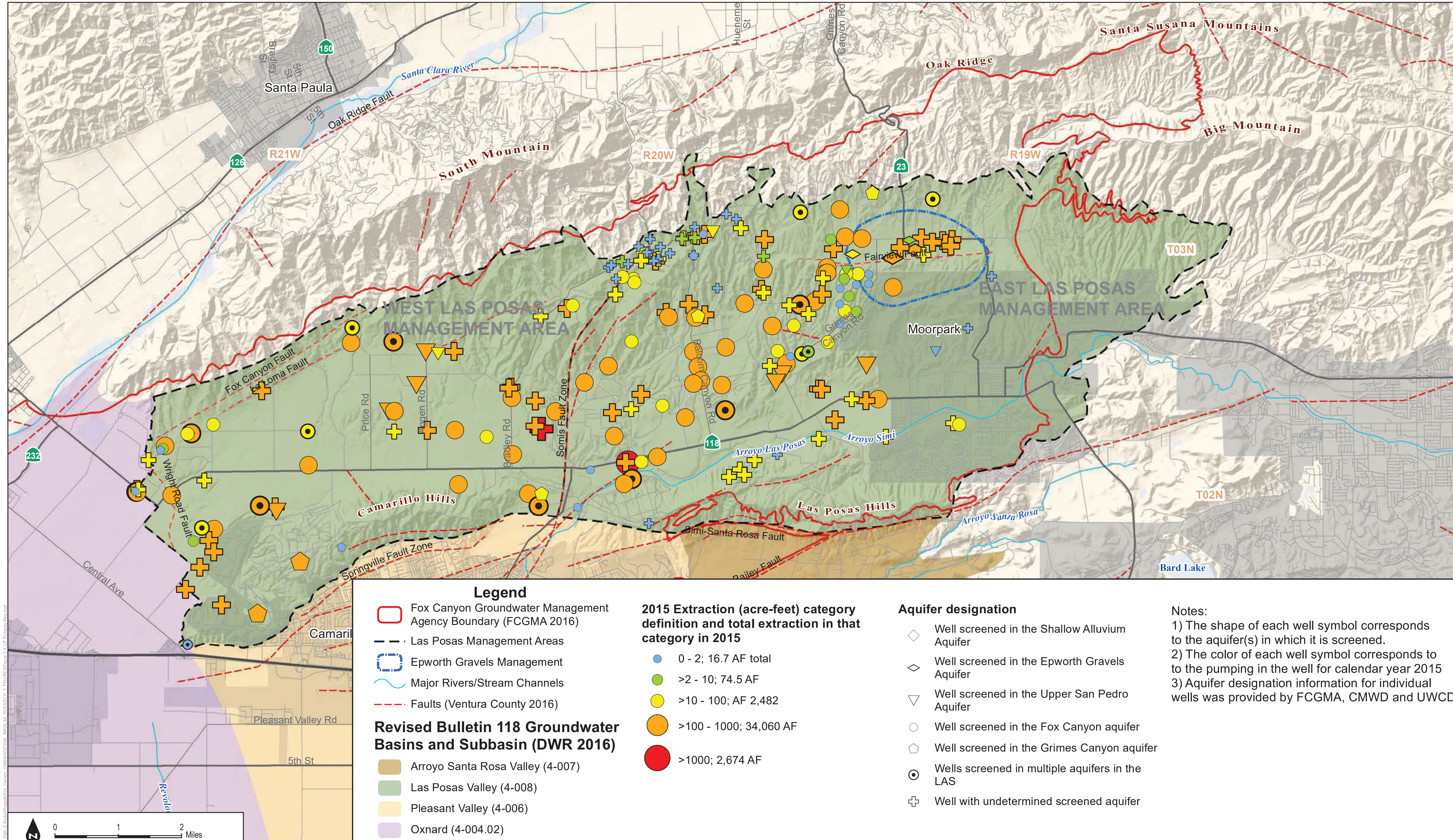

Notes:
1) The shape of each well symbol corresponds to the aquifer(s) in which it is screened.
2) The color of each well symbol corresponds to to the pumping in the well for calendar year 2015
3) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-5

Groundwater Extraction (acre-feet) in 2015 in the Las Posas Valley Basin

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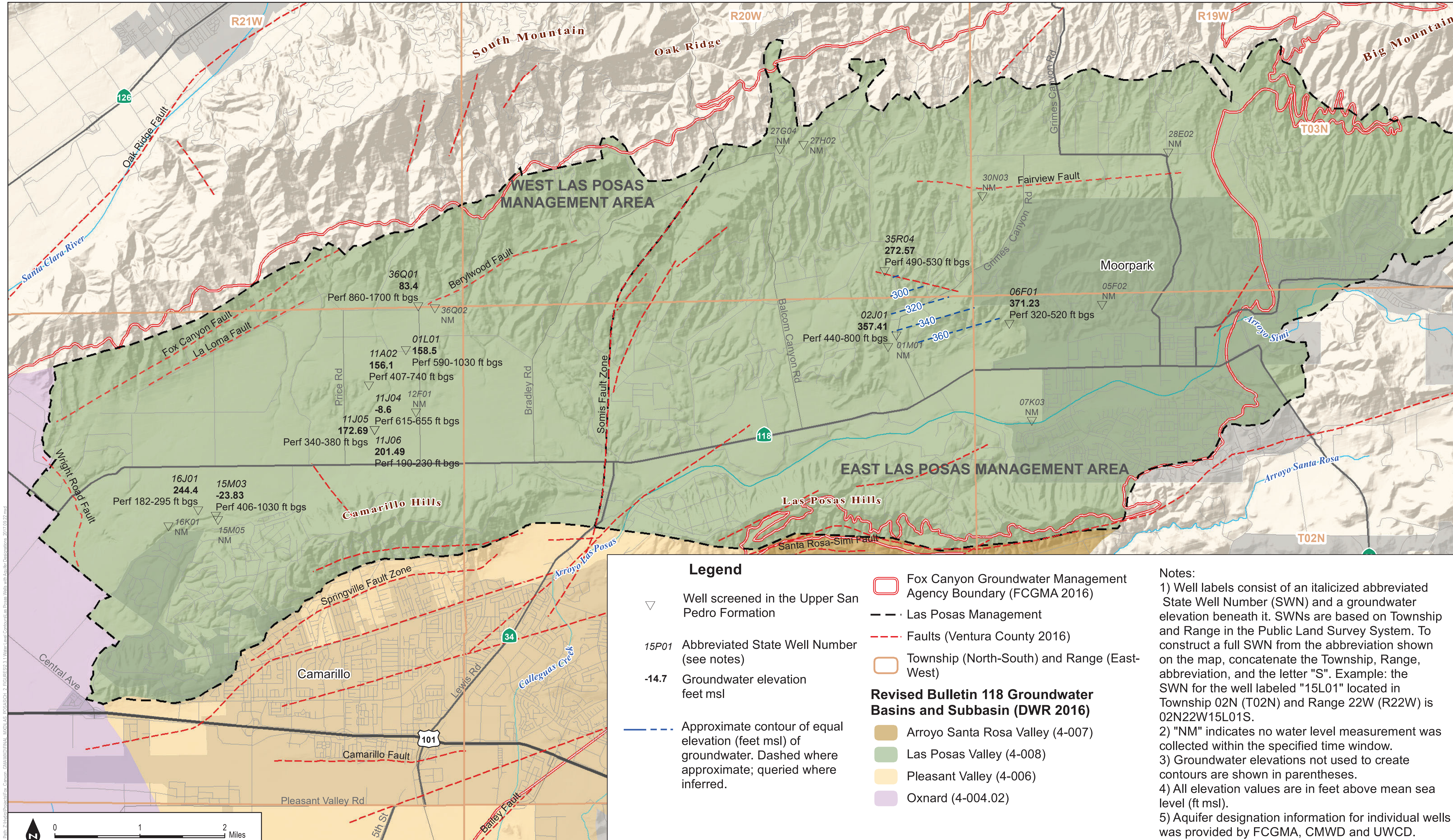

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-6

Groundwater Elevation Contours in the Upper San Pedro Formation, March 2-29, 2015

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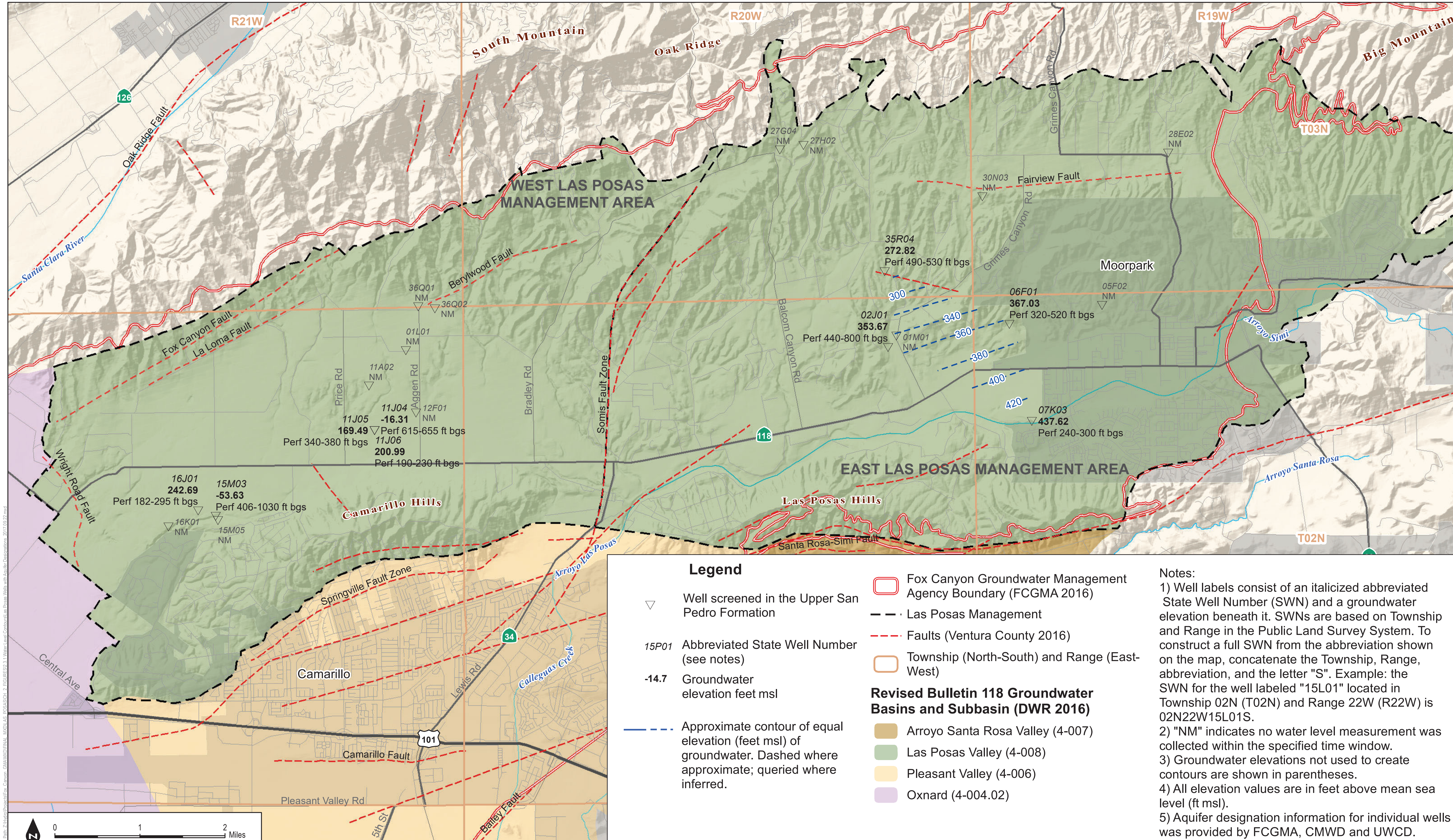

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-7

Groundwater Elevation Contours in the Upper San Pedro Formation, October 2-29, 2015

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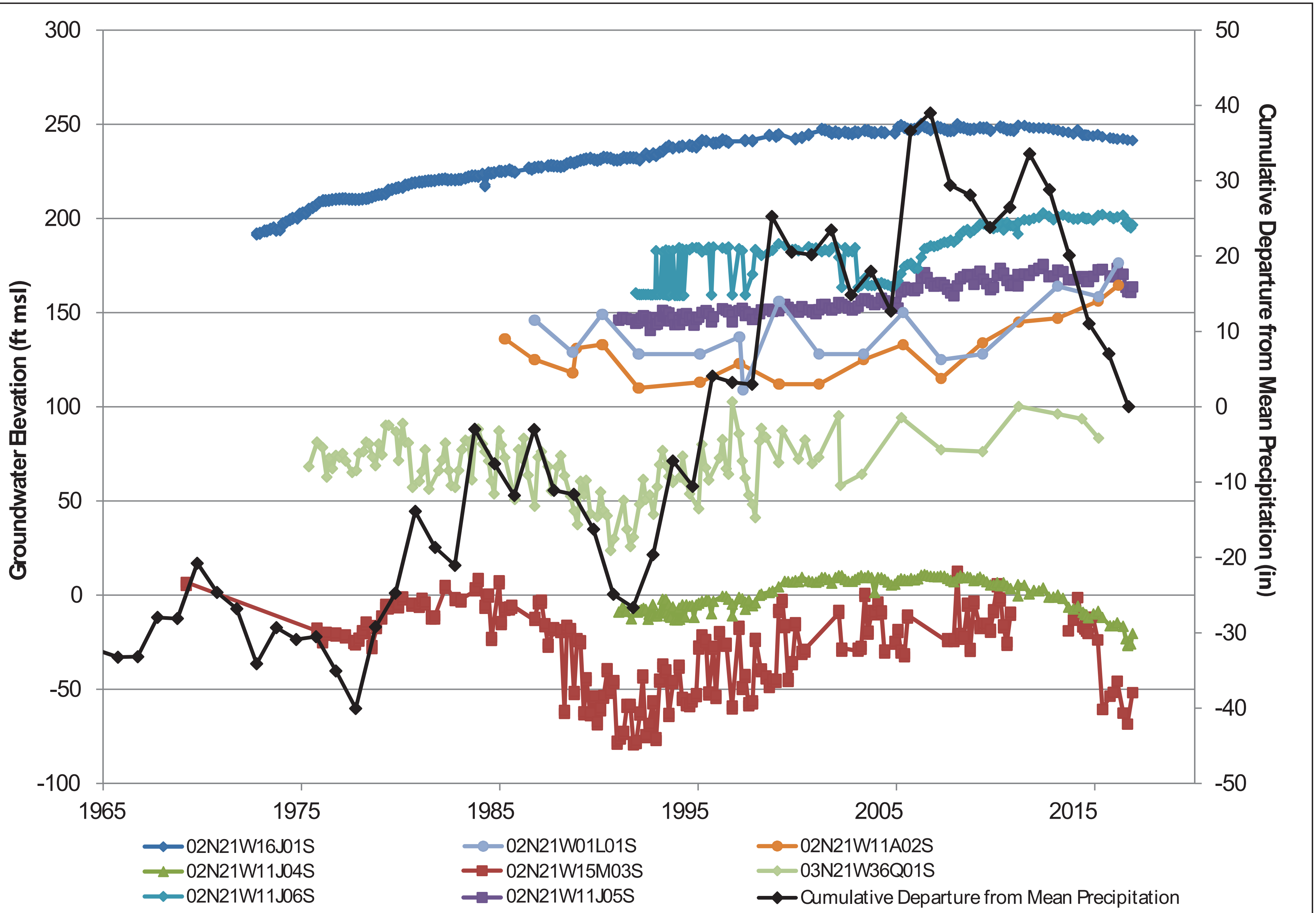

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FIGURE 2-8

Upper San Pedro Formation Groundwater Elevation Hydrographs: WLPMA

Groundwater Sustainability Plan for the Las Posas Valley Basin

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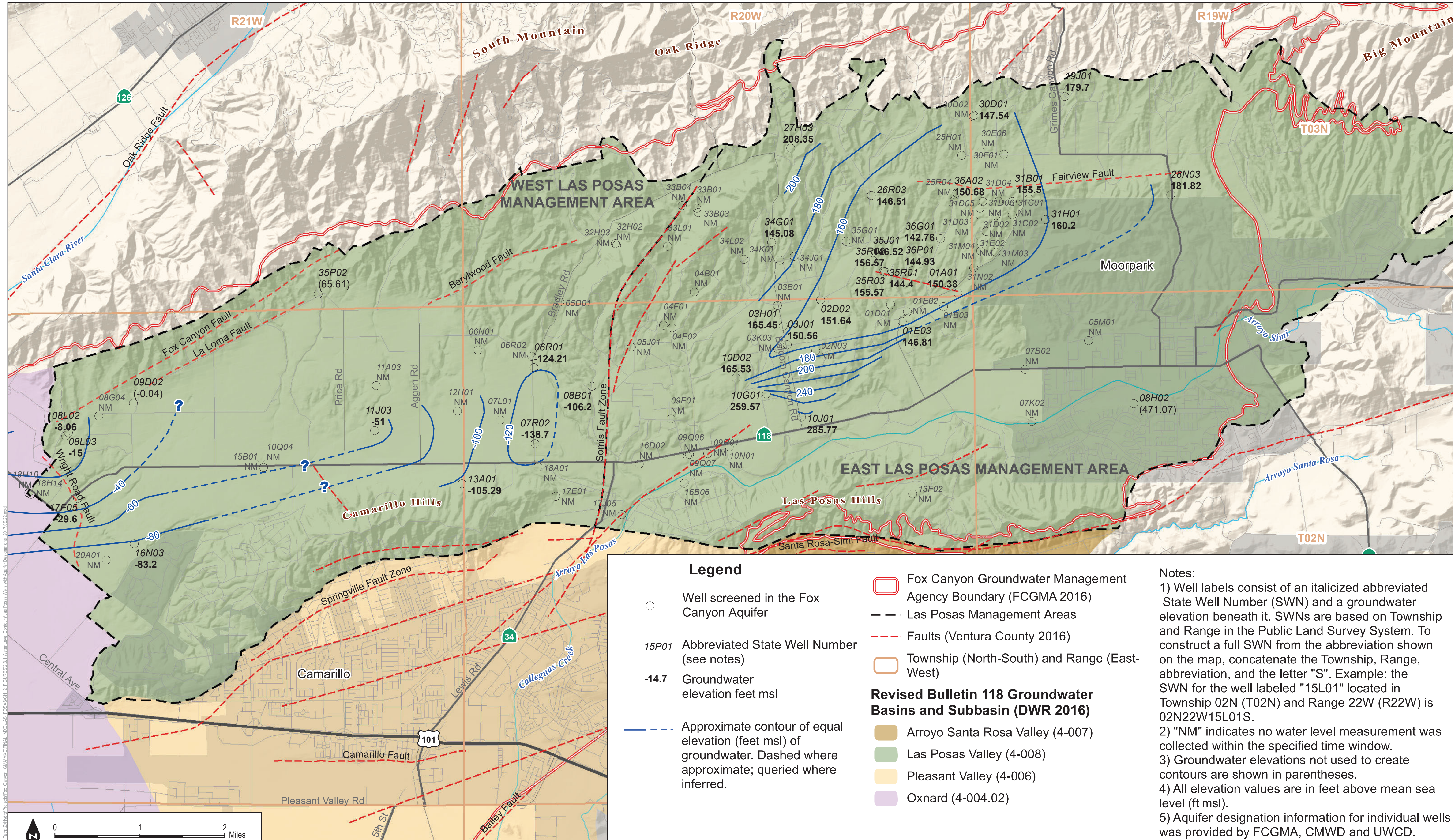

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-9

Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2-29, 2015

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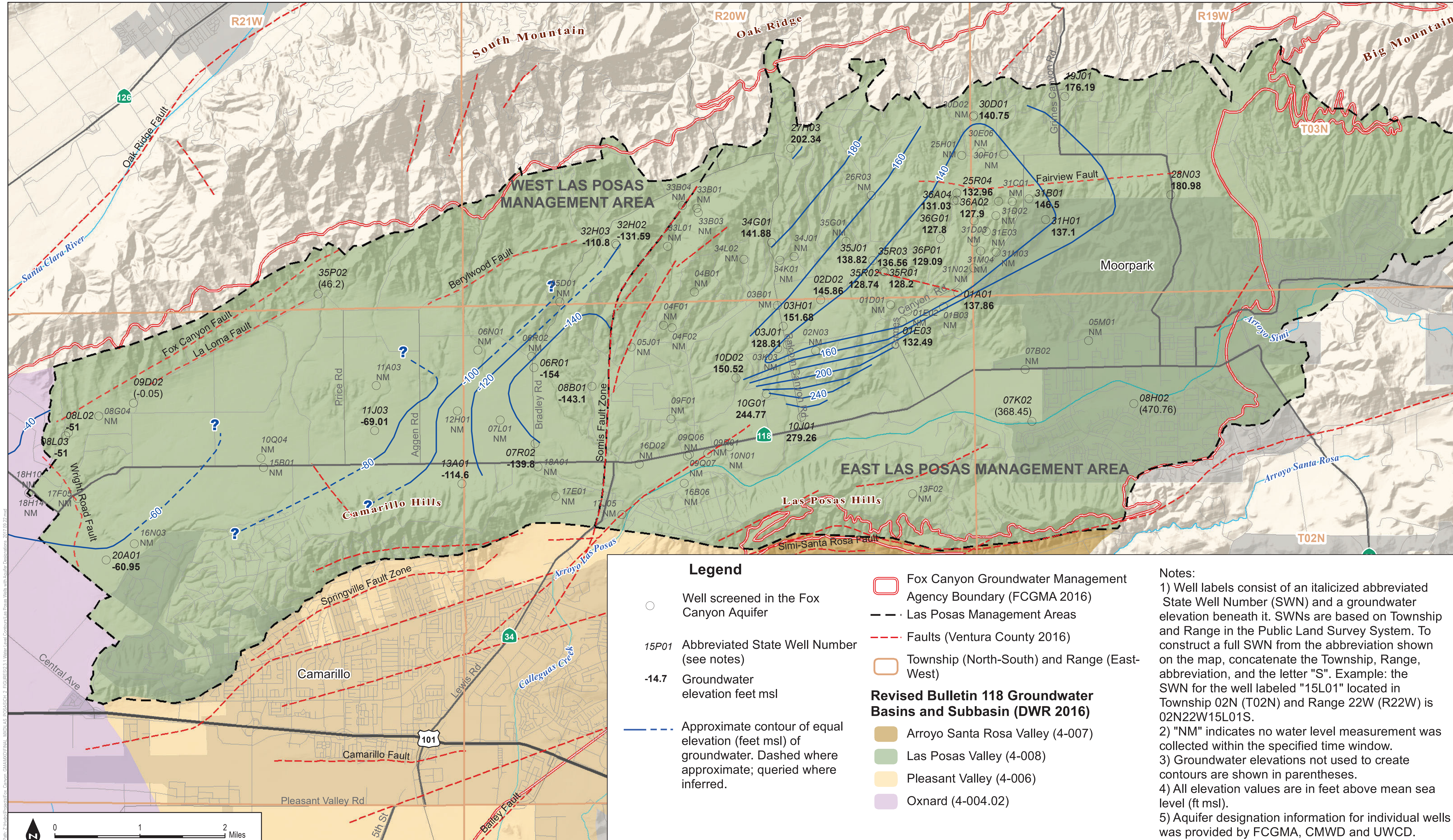

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-10

Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2-29, 2015

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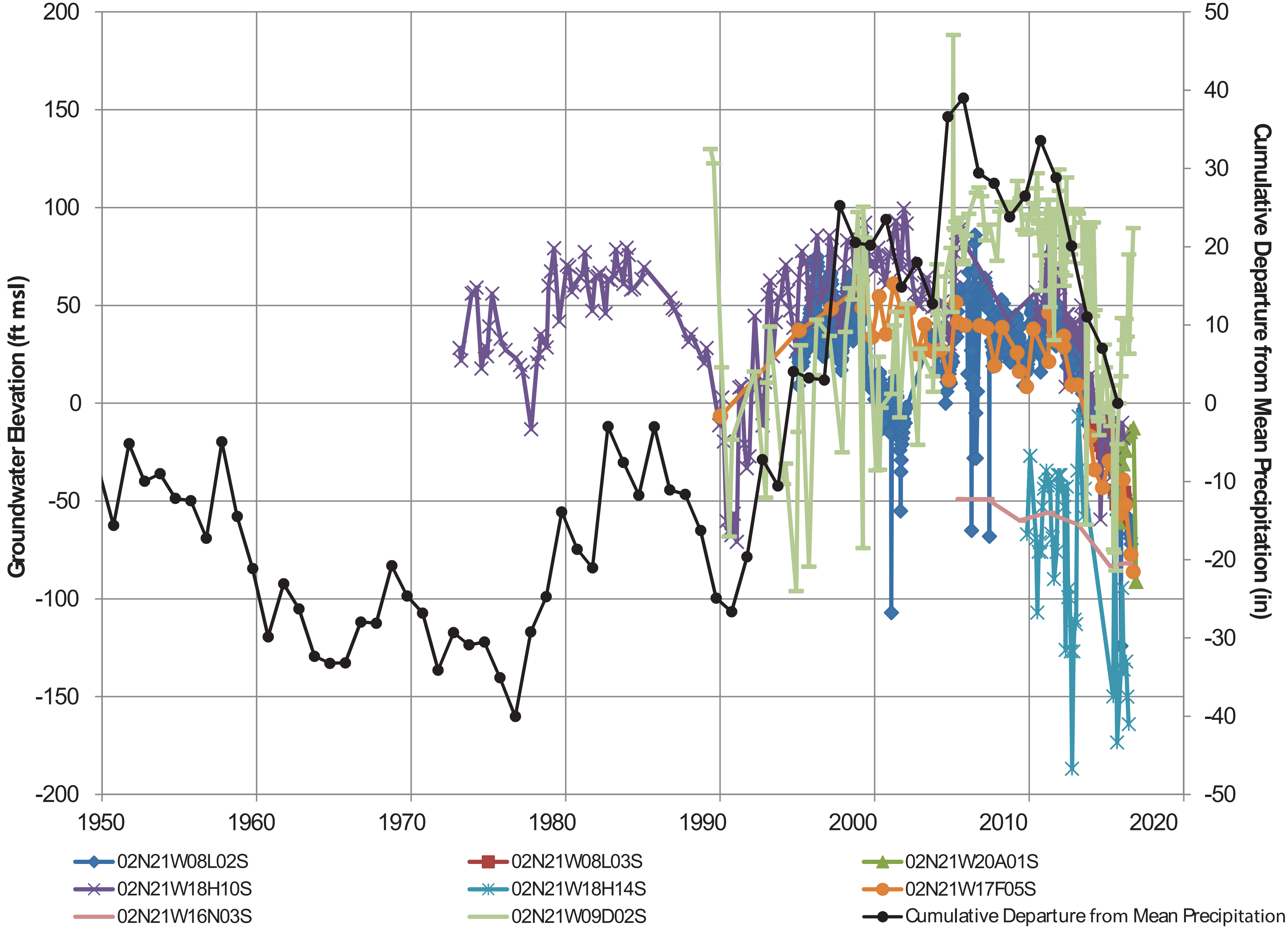

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FIGURE 2-11

Fox Canyon Aquifer Groundwater Elevation Hydrographs: Western WLPMA

Groundwater Sustainability Plan for the Las Posas Valley Basin

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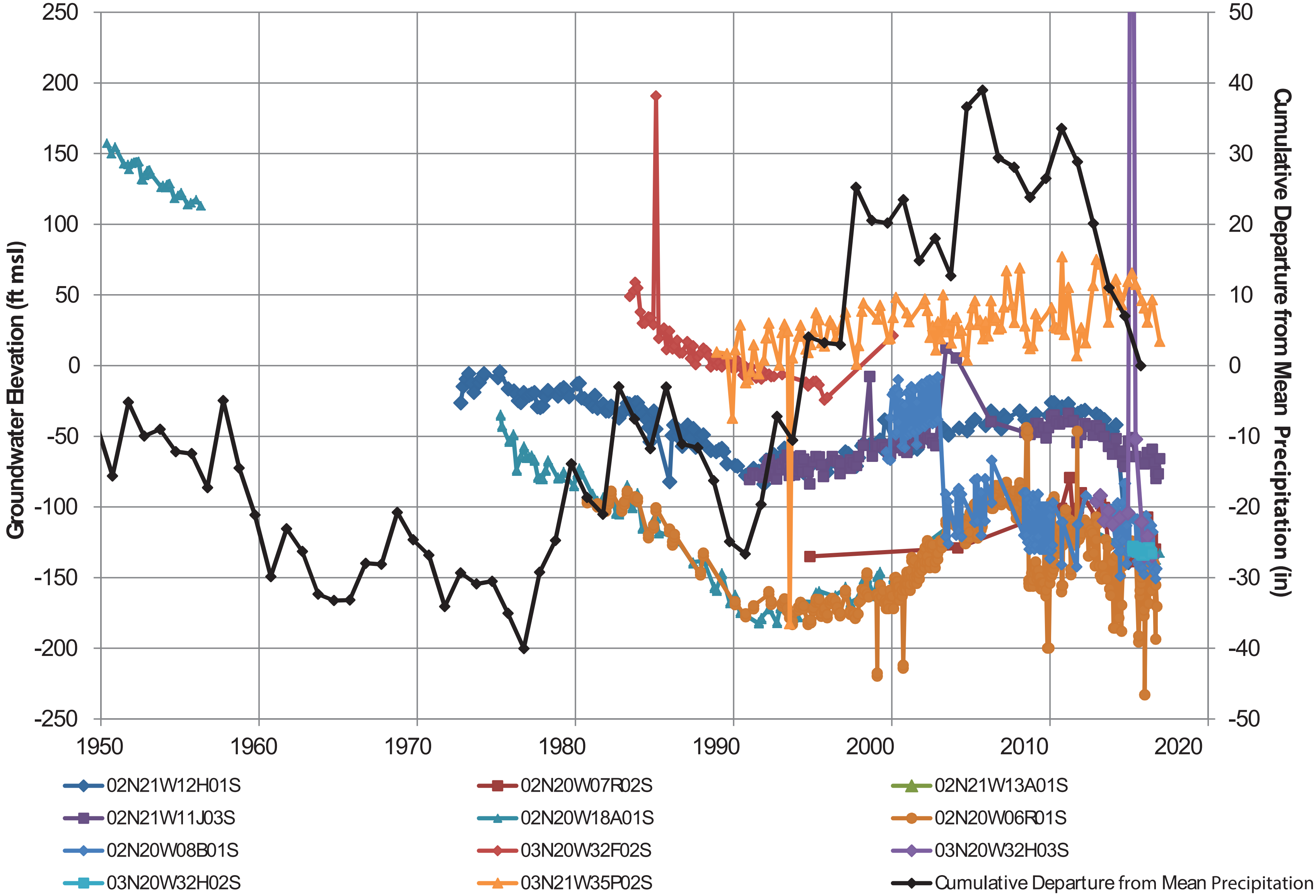

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FIGURE 2-12

Fox Canyon Aquifer Groundwater Elevation Hydrographs: Eastern WLPMA

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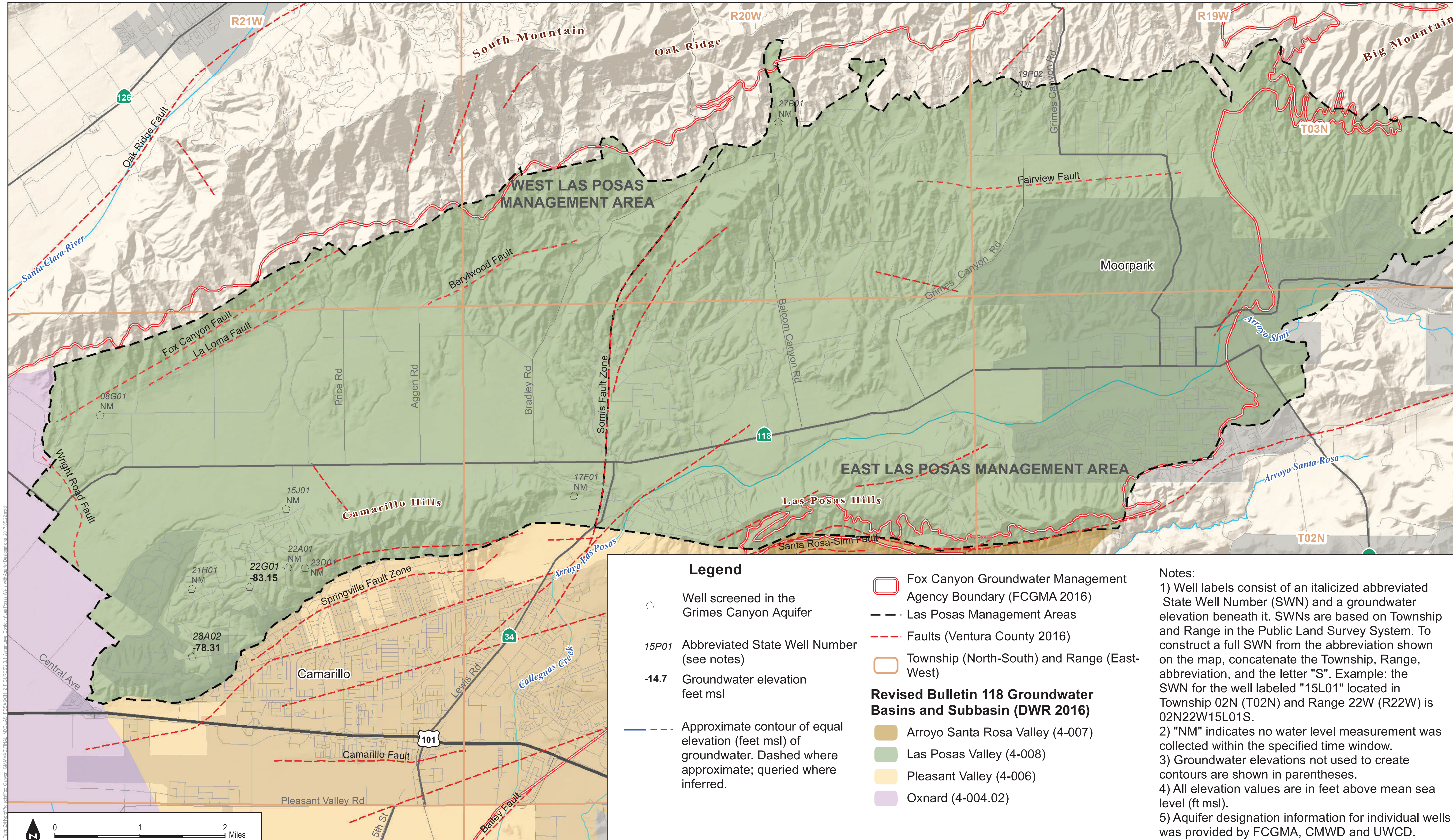

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SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-13

Groundwater Elevation Contours in the Grimes Canyon Aquifer, March 2-29, 2015

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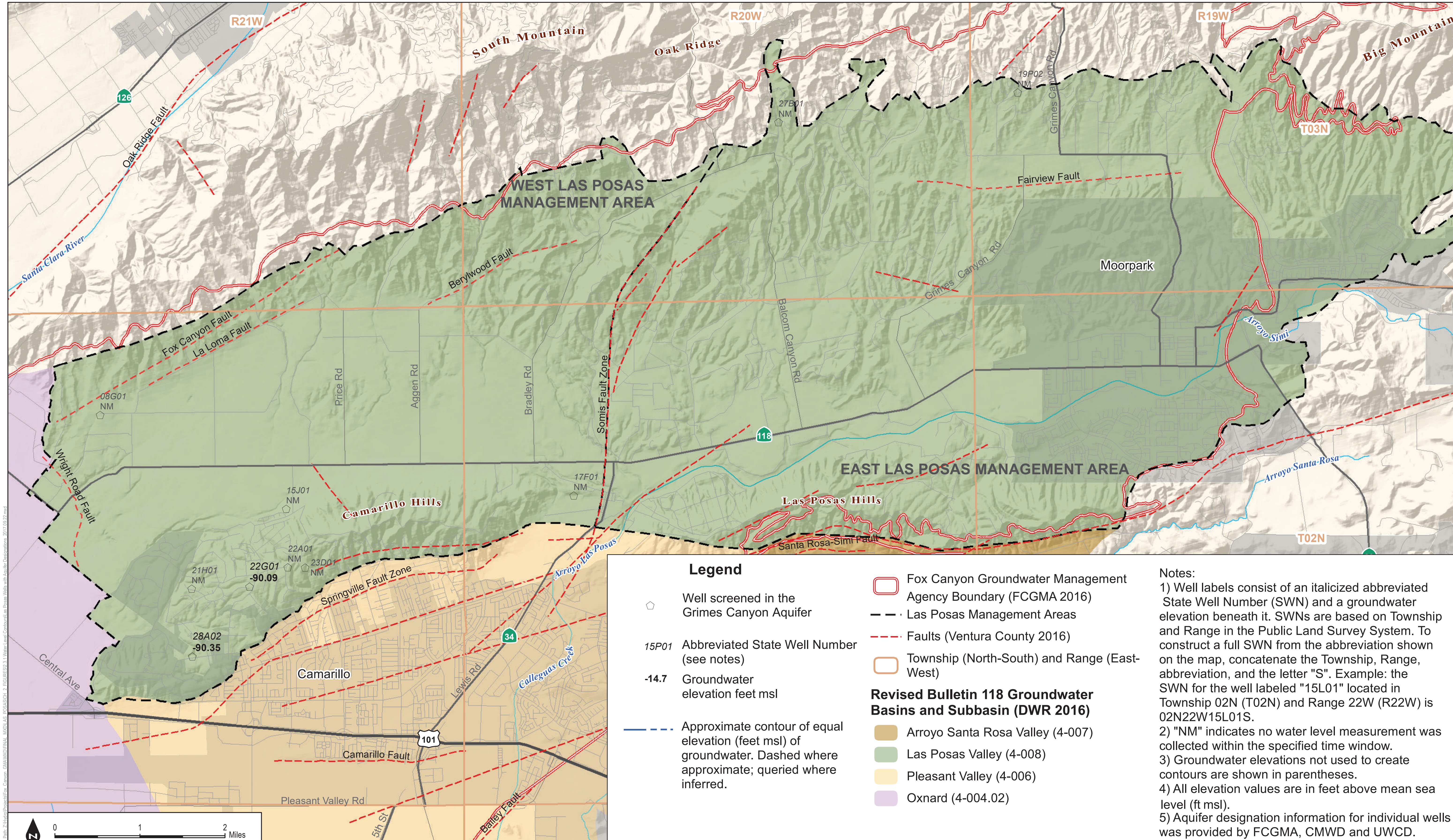

Legend

- Well screened in the Grimes Canyon Aquifer
- *15P01* Abbreviated State Well Number (see notes)
- -14.7 Groundwater elevation feet msl
- Approximate contour of equal elevation (feet msl) of groundwater. Dashed where approximate; queried where inferred.
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Las Posas Management Areas
- Faults (Ventura County 2016)
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a groundwater elevation beneath it. SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
2) "NM" indicates no water level measurement was collected within the specified time window.
3) Groundwater elevations not used to create contours are shown in parentheses.
4) All elevation values are in feet above mean sea level (ft msl).
5) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-14

Groundwater Elevation Contours in the Grimes Canyon Aquifer, October 2-29, 2015

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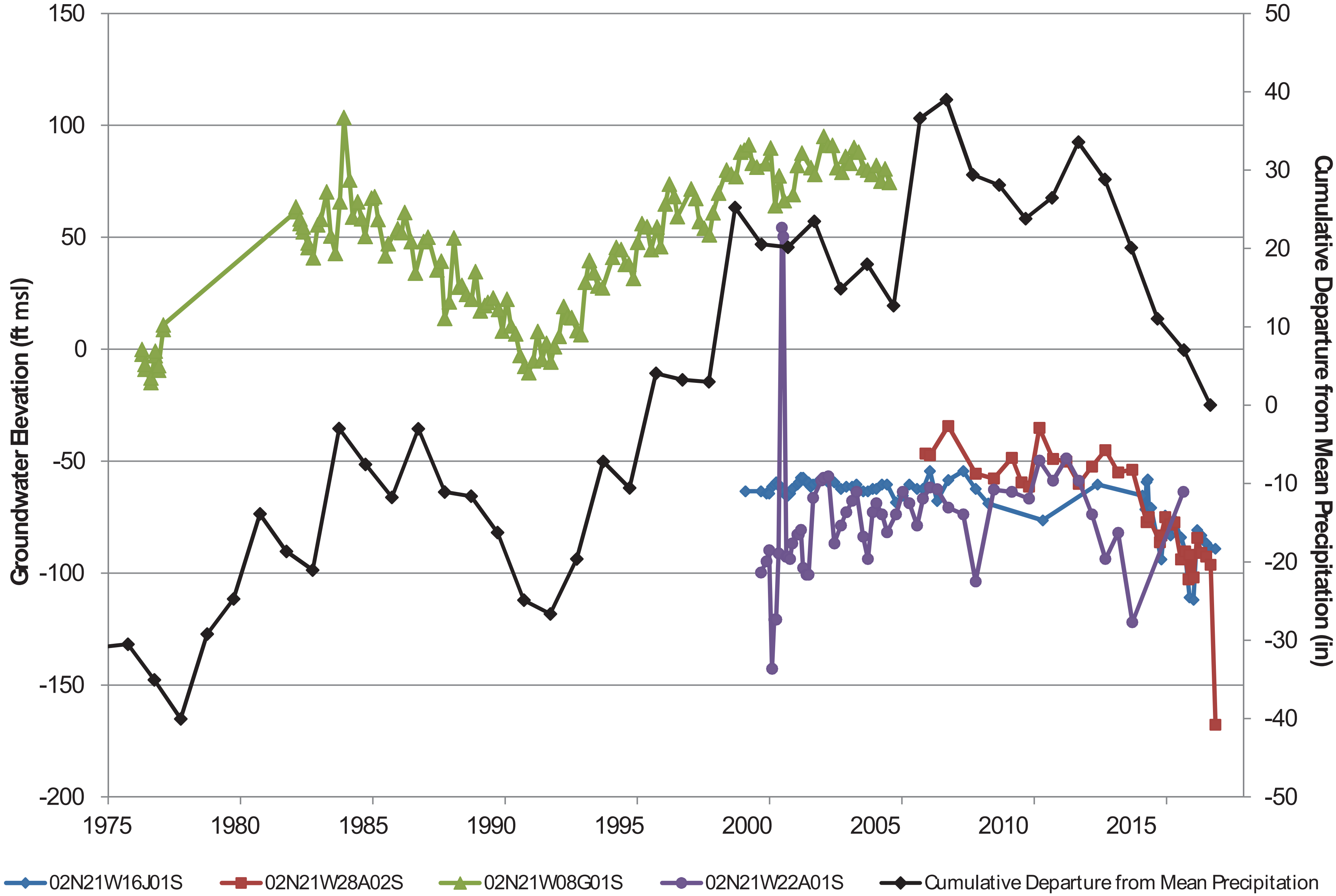

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FIGURE 2-15
Grimes Canyon Aquifer Groundwater Elevation Hydrographs

Groundwater Sustainability Plan for the Las Posas Valley Basin

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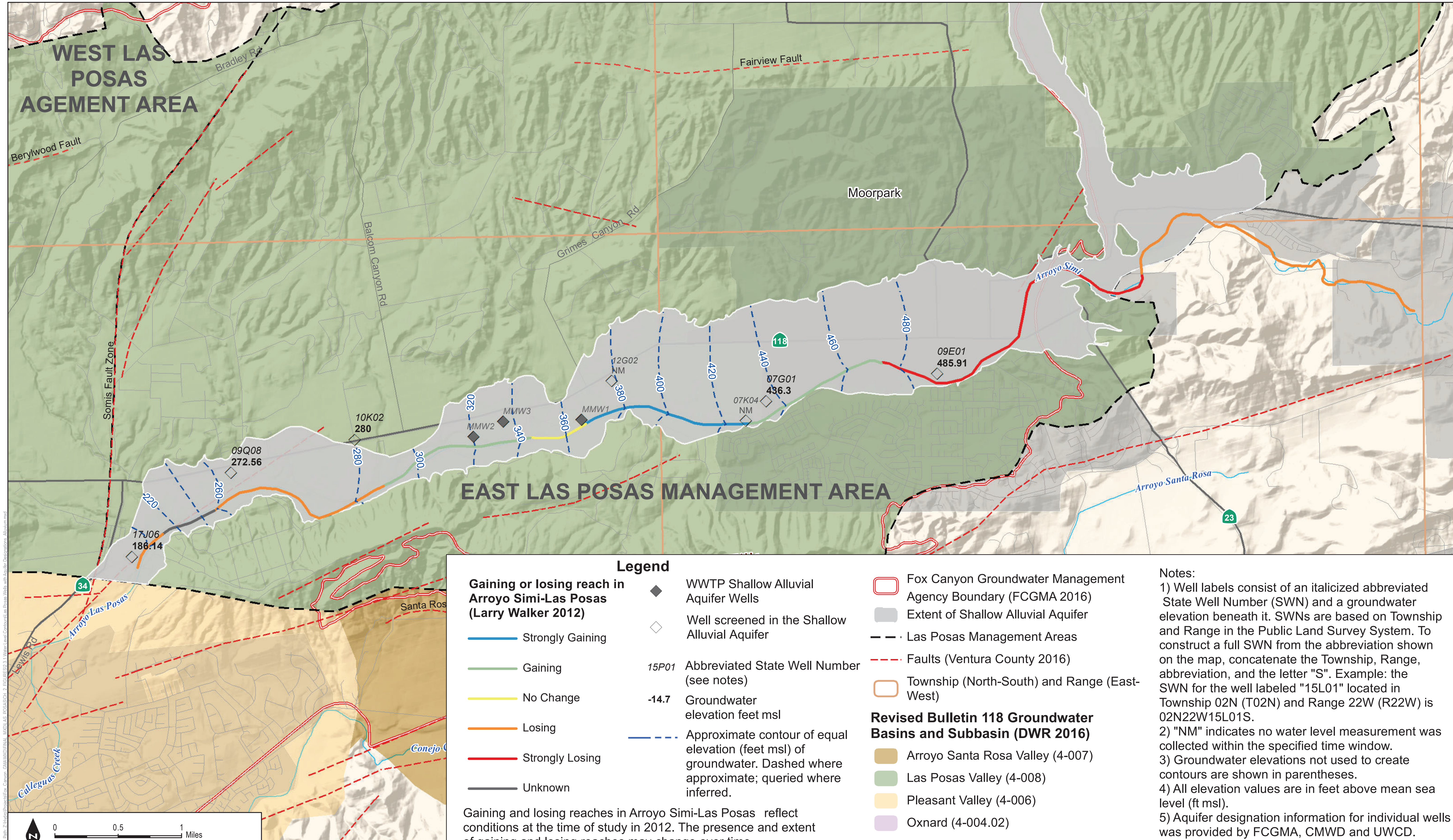

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-16

Groundwater Elevation Contours in the Shallow Alluvial Aquifer, March 2-29, 2015

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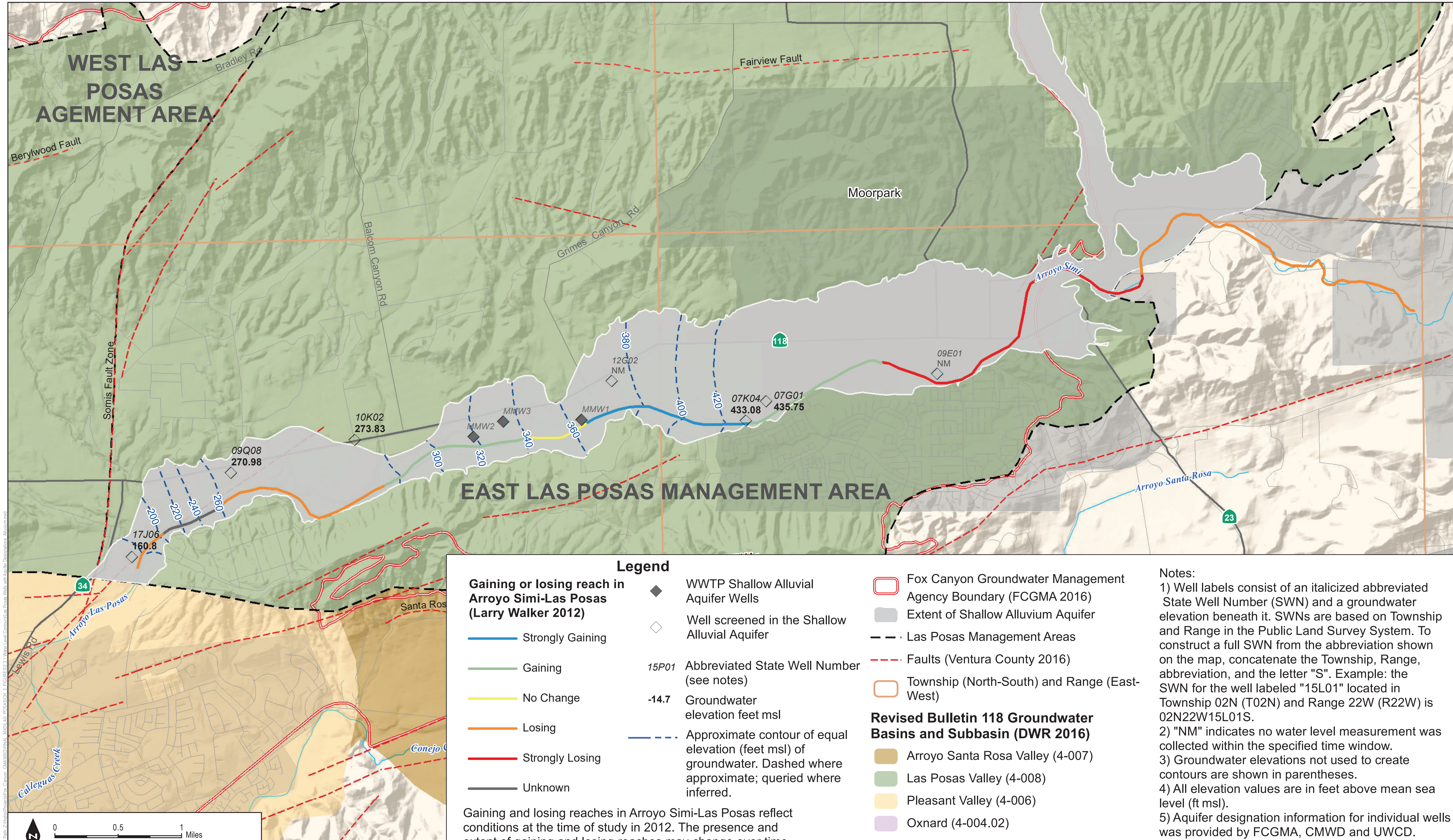

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SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-17

Groundwater Elevation Contours in the Shallow Alluvial Aquifer, October 2-29, 2015

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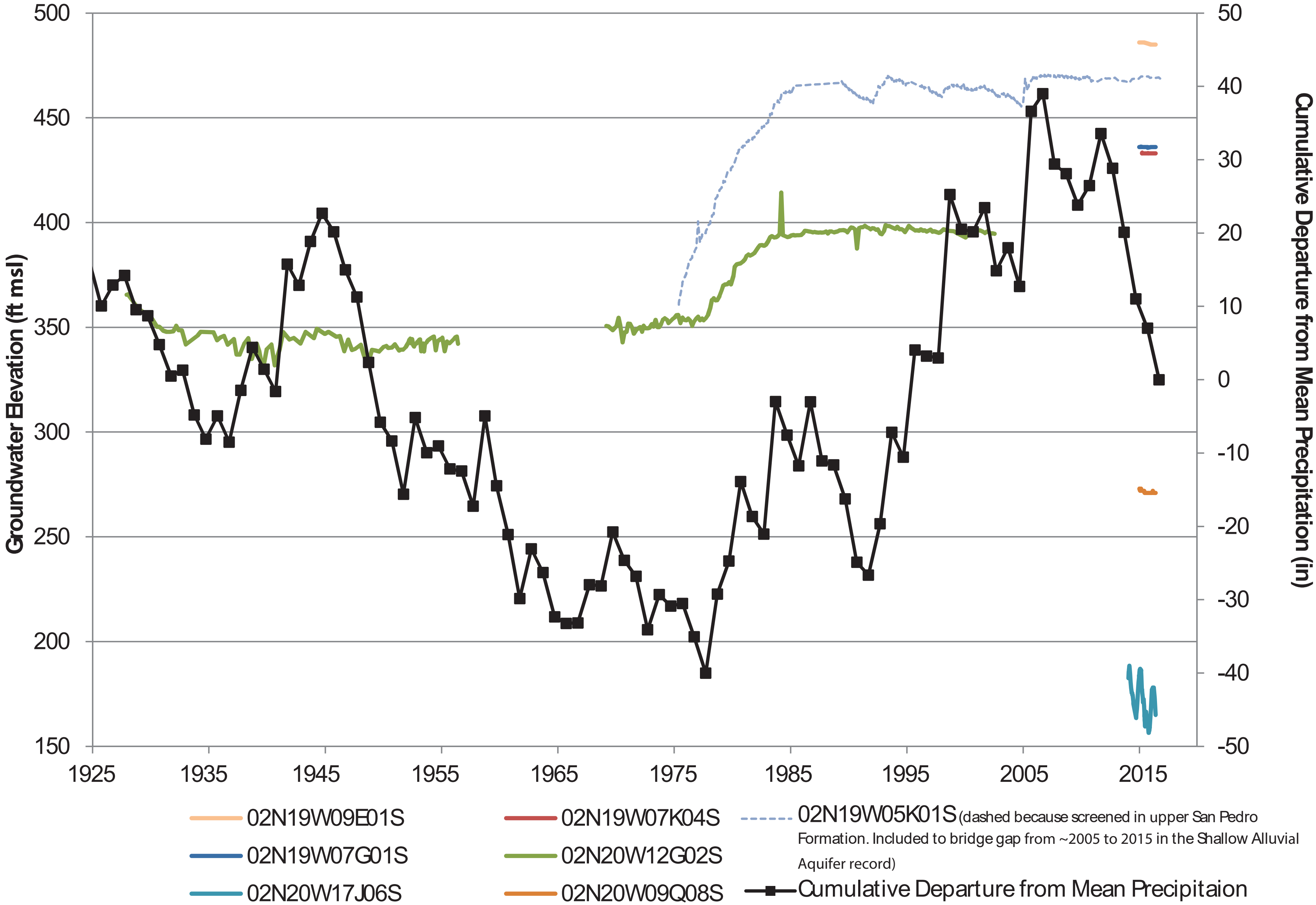

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FIGURE 2-18

Shallow Alluvial Aquifer Groundwater Elevation Hydrographs

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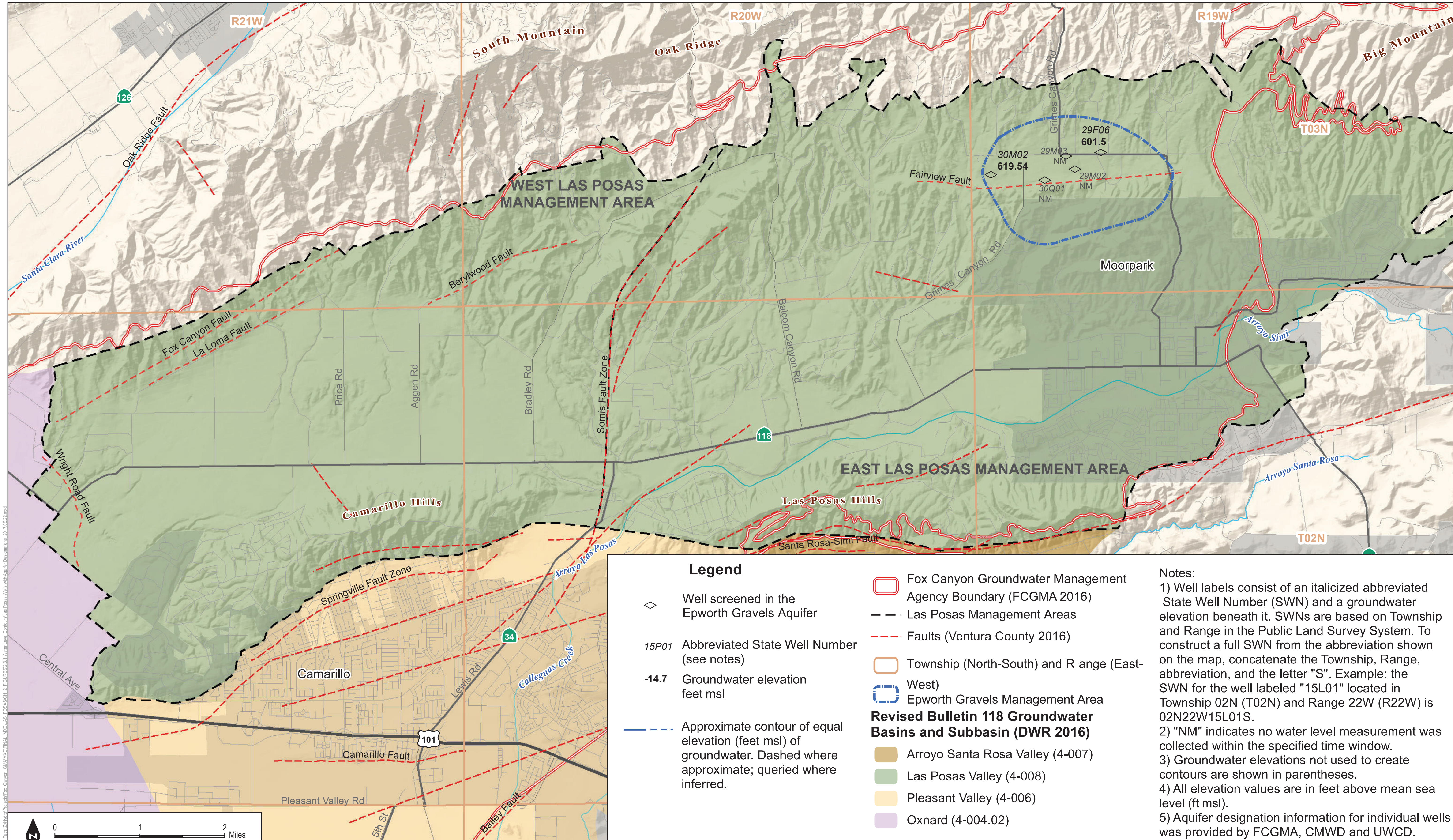

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-19

Groundwater Elevation Contours in the Epworth Gravels Aquifer, March 2-29, 2015

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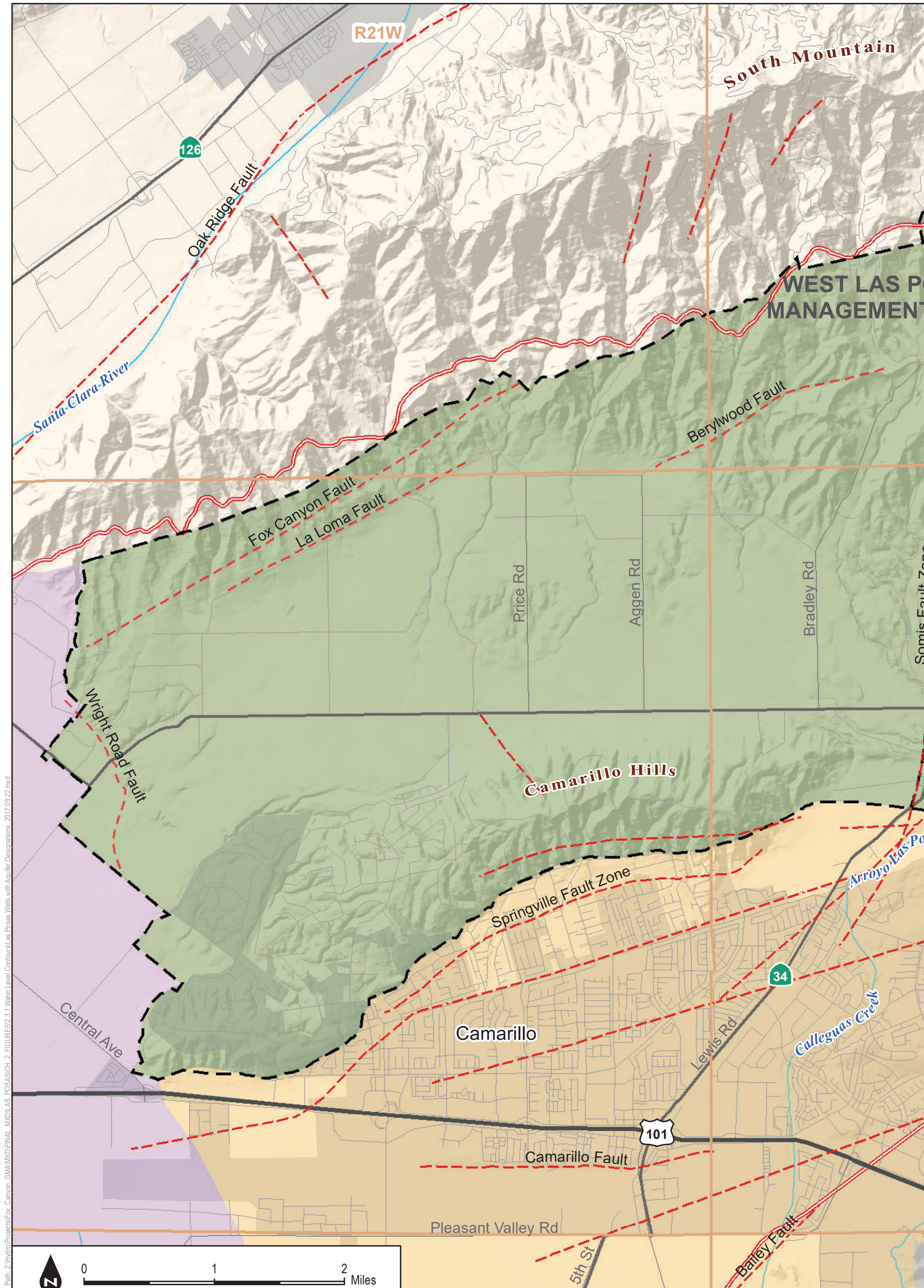

Legend

- Well screened in the Epworth Gravels Aquifer
- *15P01* Abbreviated State Well Number (see notes)
- **-14.7** Groundwater elevation feet msl
- Approximate contour of equal elevation (feet msl) of groundwater. Dashed where approximate; queried where inferred.
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Las Posas Management Areas
- Faults (Ventura County 2016)
- Township (North-South) and R ange (East-West)
- Epworth Gravels Management Area

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a groundwater elevation beneath it. SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
2) "NM" indicates no water level measurement was collected within the specified time window.
3) Groundwater elevations not used to create contours are shown in parentheses.
4) All elevation values are in feet above mean sea level (ft msl).
5) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-20

Groundwater Elevation Contours in the Epworth Gravels Aquifer, October 2-29, 2015

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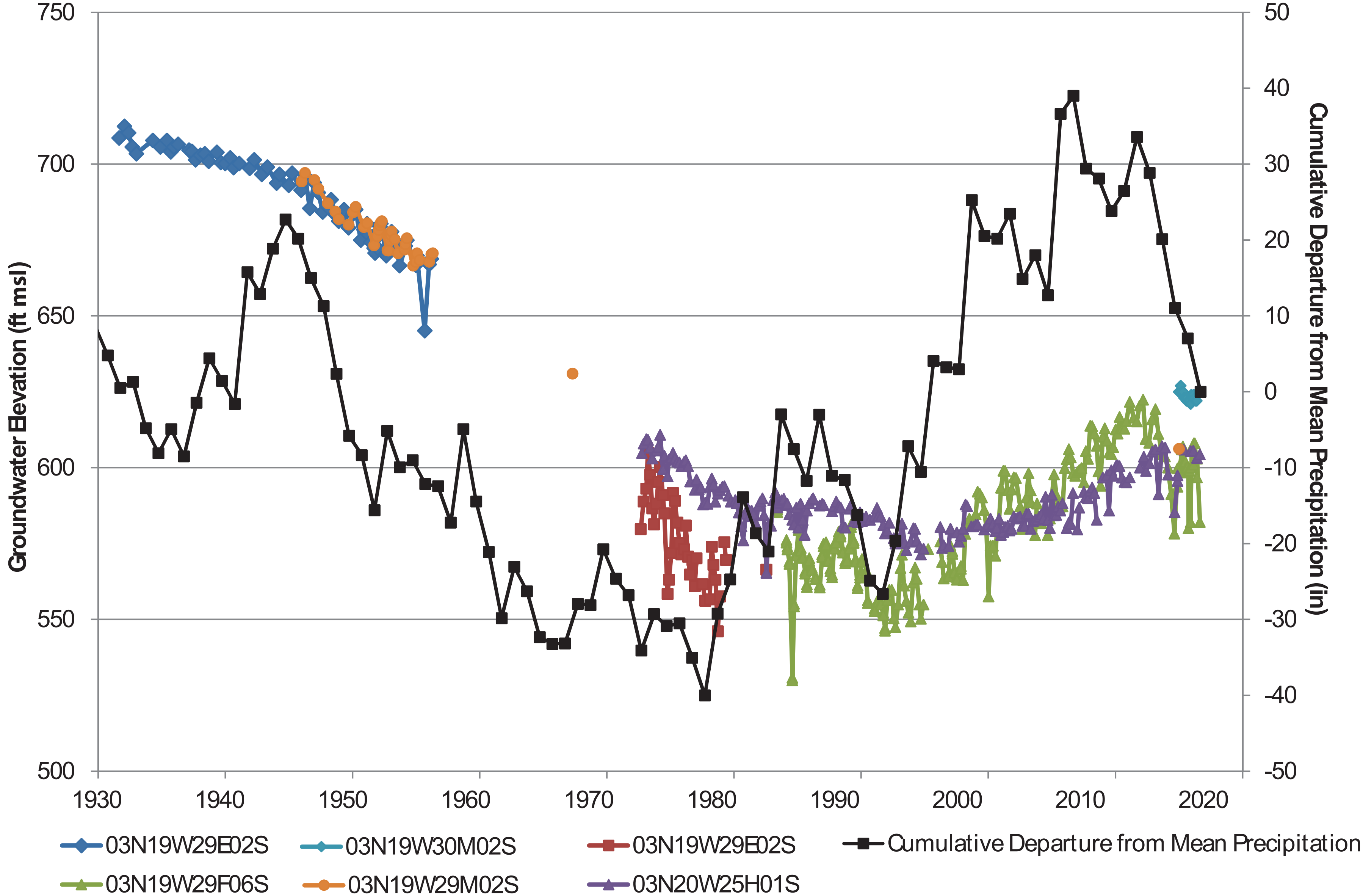

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FIGURE 2-21

Epworth Gravels Aquifer Groundwater Elevation Hydrographs

Groundwater Sustainability Plan for the Las Posas Valley Basin

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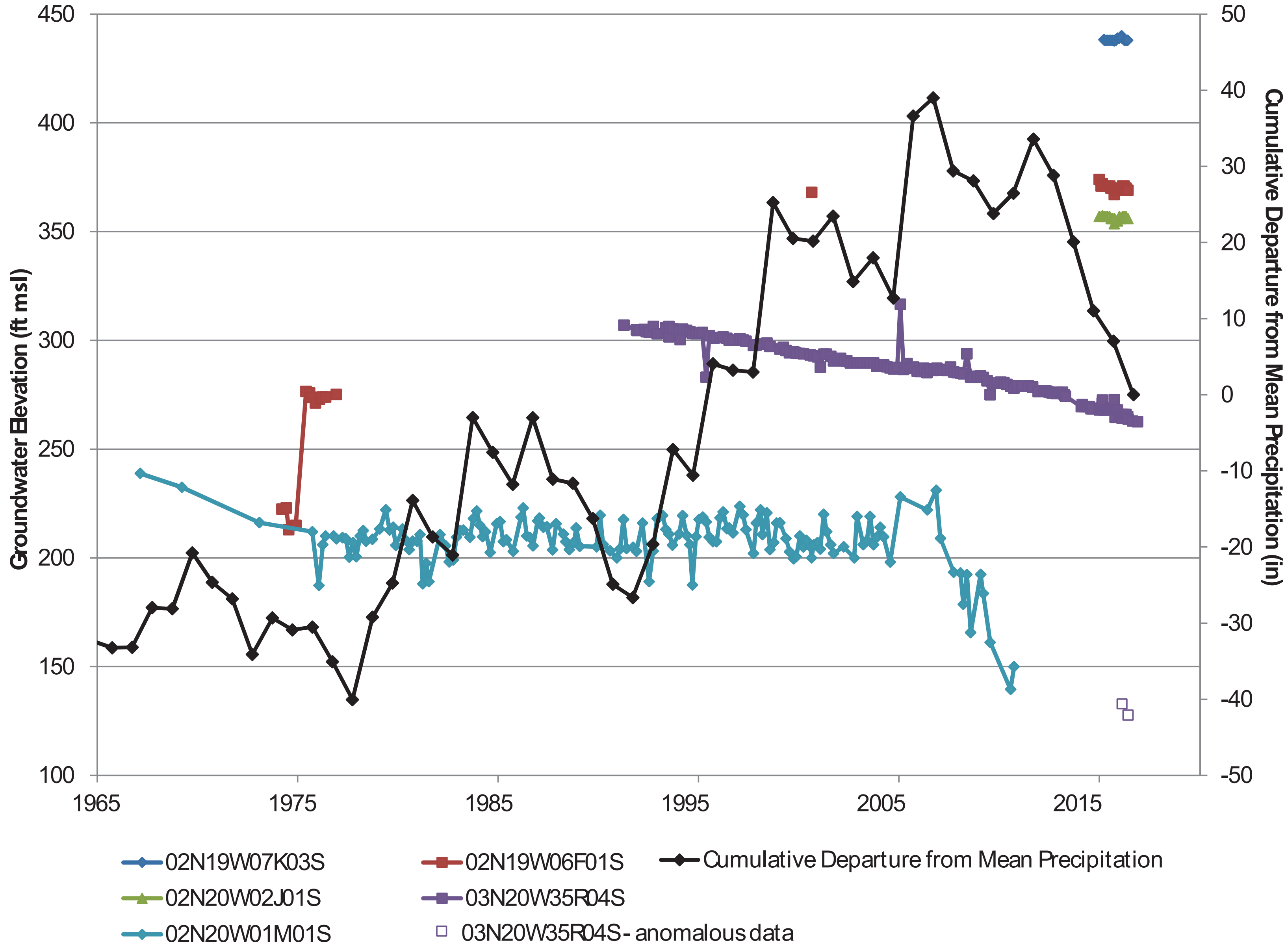

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FIGURE 2-22

Upper San Pedro Formation Groundwater Elevation Hydrographs: ELPMA

Groundwater Sustainability Plan for the Las Posas Valley Basin

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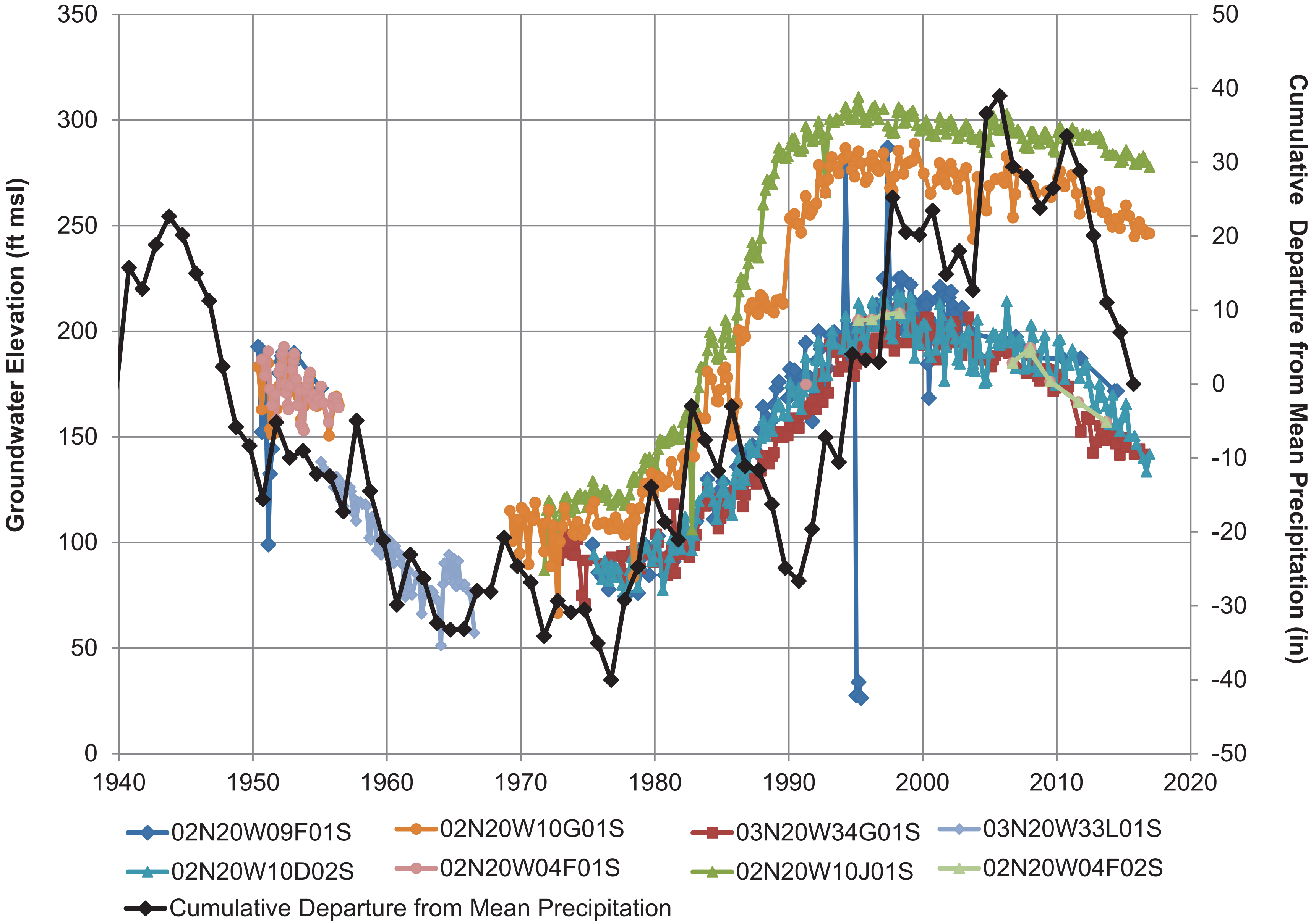

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FIGURE 2-23

Fox Canyon Aquifer Groundwater Elevation Hydrographs: Southwestern ELPMA

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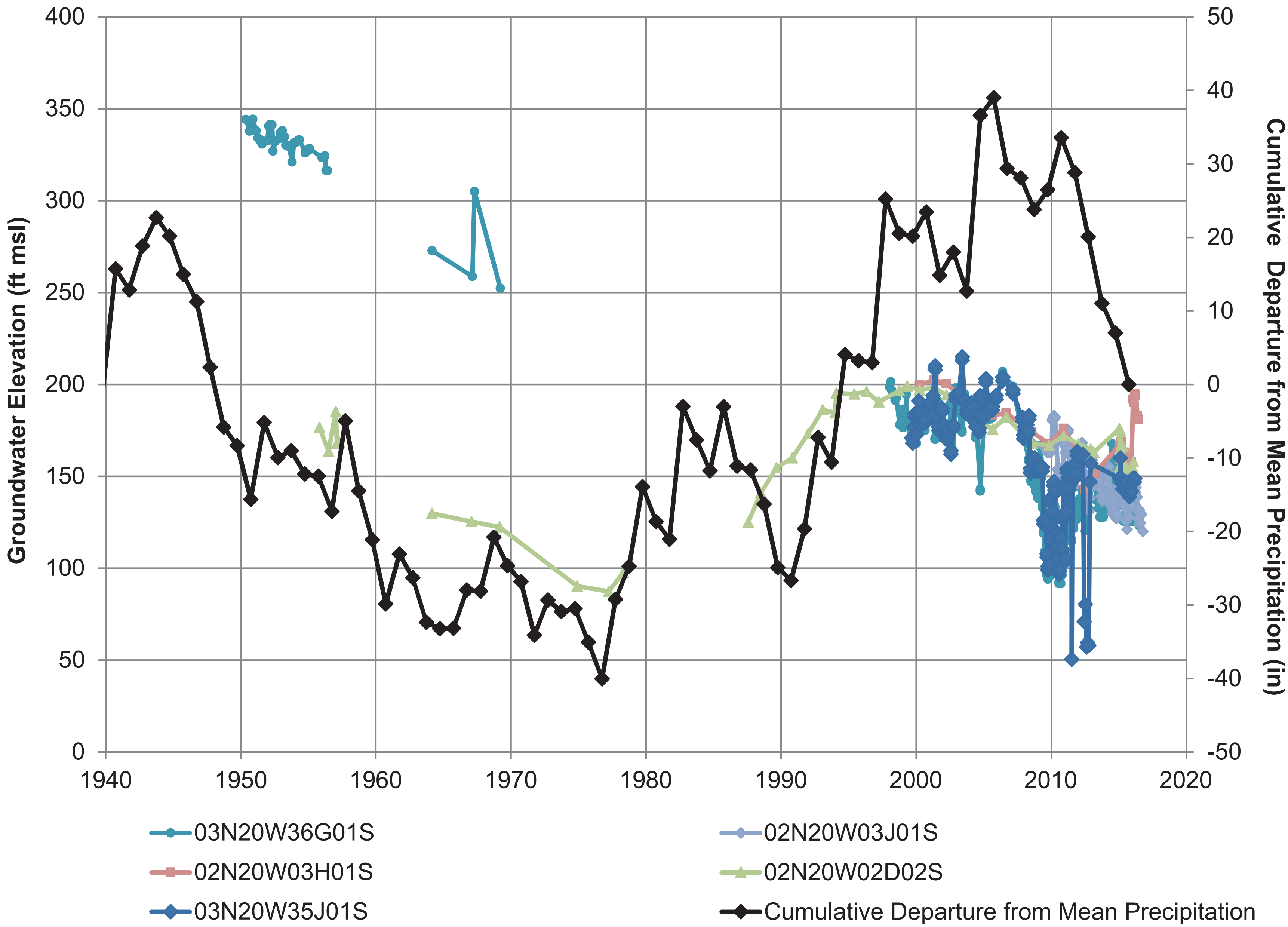

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FIGURE 2-24

Fox Canyon Aquifer Groundwater Elevation Hydrographs: Central ELPMA

Groundwater Sustainability Plan for the Las Posas Valley Basin

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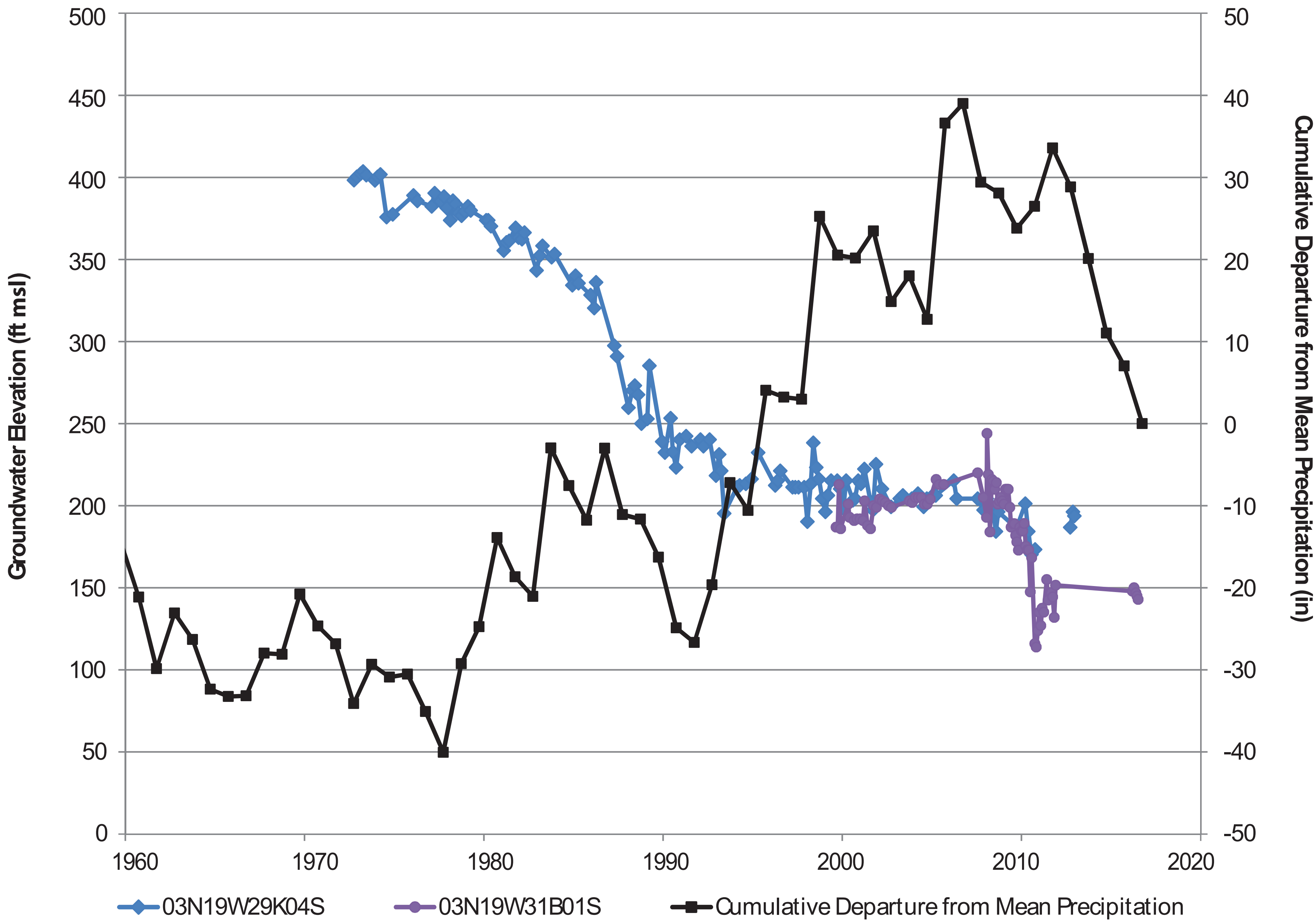

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FIGURE 2-25

Fox Canyon Aquifer Groundwater Elevation Hydrographs: Eastern ELPMA

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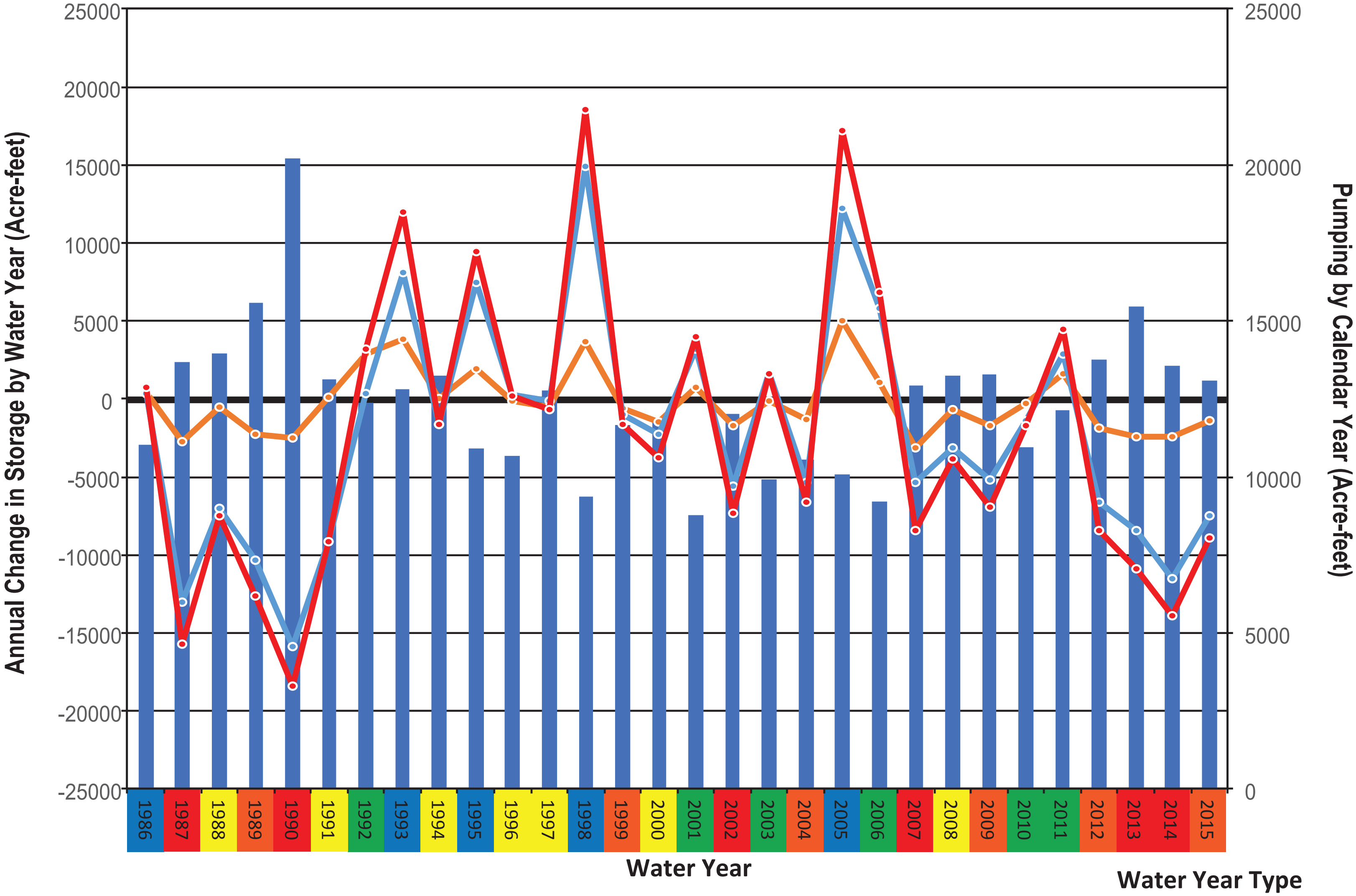

Notes:

1) Estimated Annual Change in Storage is from the United Water Conservation District (UWCD) numerical groundwater model report from Appendix D. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the UWCD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

3) Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined as Wet (≥150% of average), Above Normal (≥100% to <150% of average), Below Normal (≥75% to <100% of average), Dry (≥50% to <75% of average), and Critical (<50% of average).

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FIGURE 2-26

West Las Posas Management Area Annual Change in Storage

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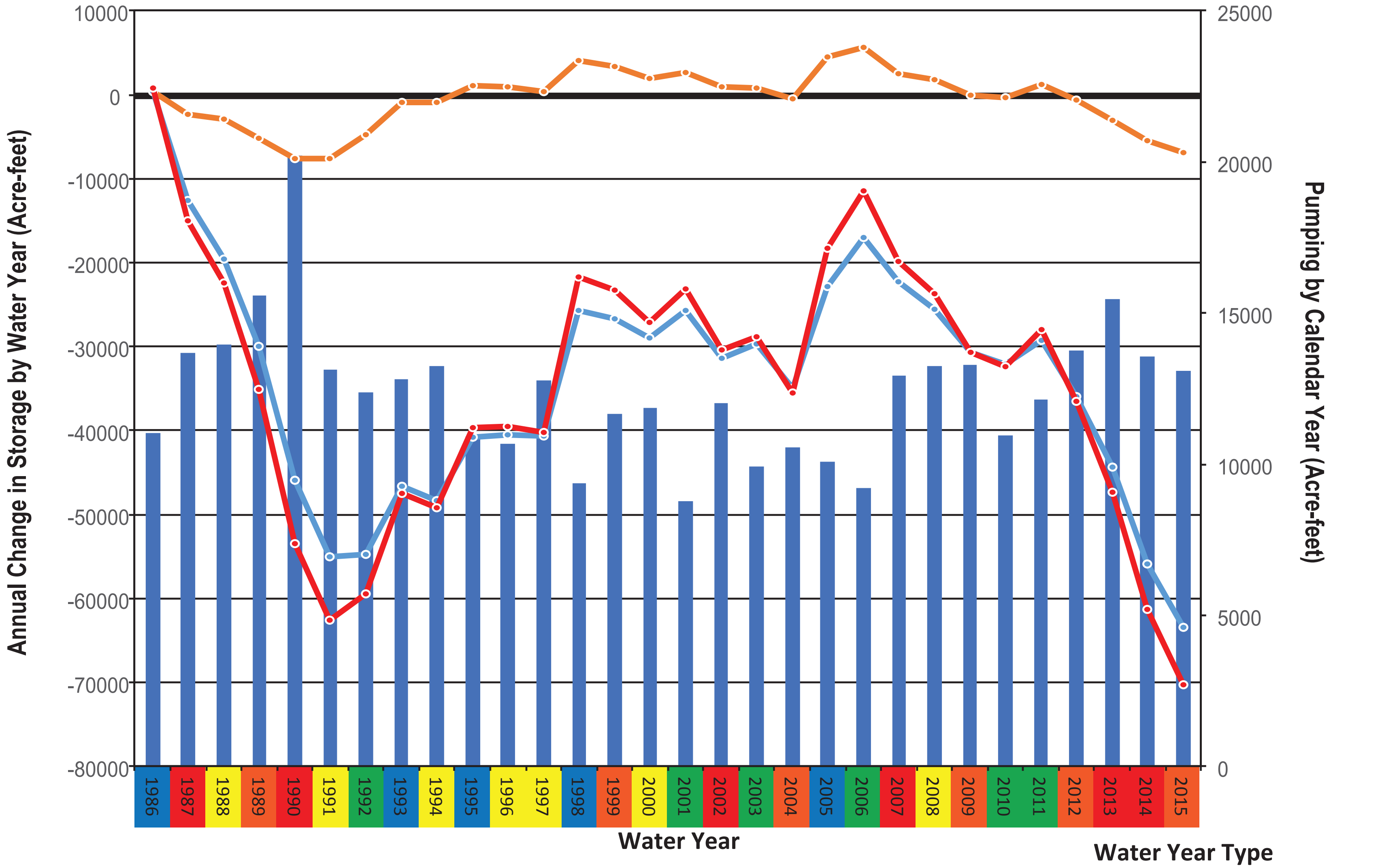

Notes:

1) Estimated Annual Change in Storage is from the United Water Conservation District (UWCD) numerical groundwater model report from Appendix C. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the UWCD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

3) Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined as Wet (≥150% of average), Above Normal (≥100% to <150% of average), Below Normal (≥75% to <100% of average), Dry (≥50% to <75% of average), and Critical (<50% of average).

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FIGURE 2-27

West Las Posas Management Area Cumulative Change in Storage

Groundwater Sustainability Plan for the Las Posas Valley Basin

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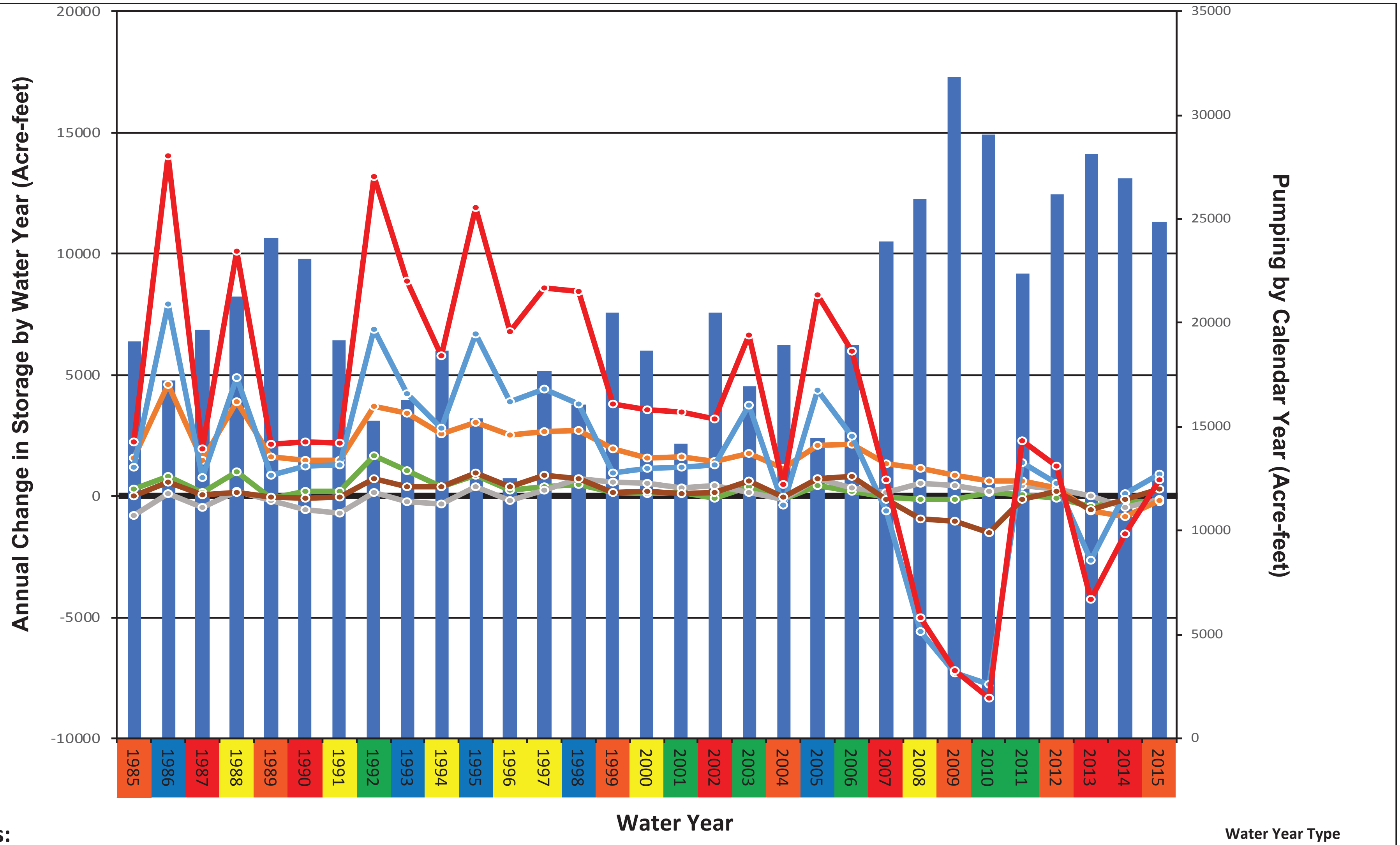

Notes:

1) Estimated Annual Change in Storage is from the Calleguas Municipal Water District (CMWD) numerical groundwater model report from September 2018. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the CMWD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

3) Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined as Wet (≥150% of average), Above Normal (≥100% to <150% of average), Below Normal (≥75% to <100% of average), Dry (≥50% to <75% of average), and Critical (<50% of average).

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FIGURE 2-28

East Las Posas Management Area Annual Change in Storage

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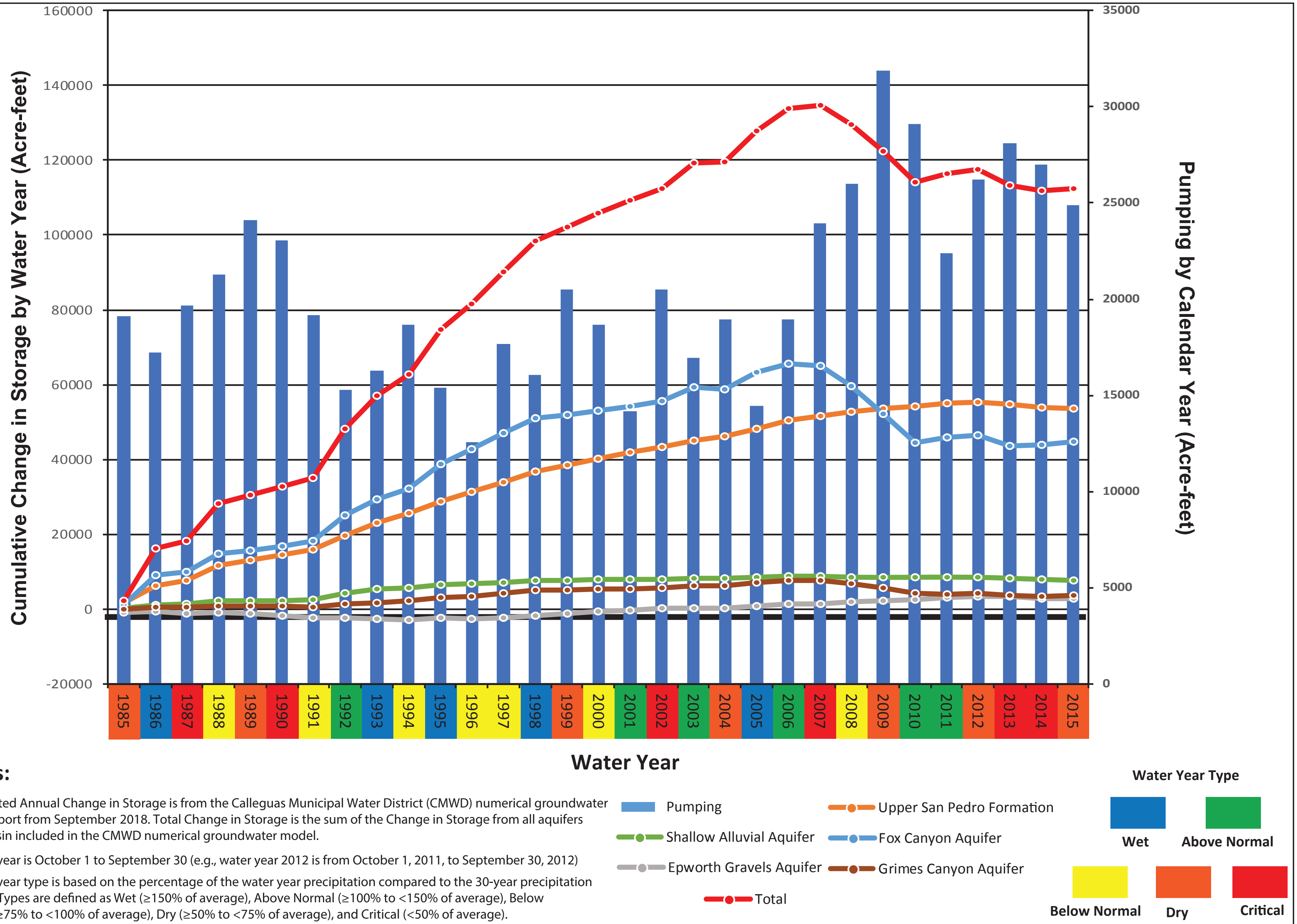

Notes:

1) Estimated Annual Change in Storage is from the Calleguas Municipal Water District (CMWD) numerical groundwater model report from September 2018. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the CMWD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

3) Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined as Wet (≥150% of average), Above Normal (≥100% to <150% of average), Below Normal (≥75% to <100% of average), Dry (≥50% to <75% of average), and Critical (<50% of average).

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FIGURE 2-29

East Las Posas Management Area Cumulative Change in Storage

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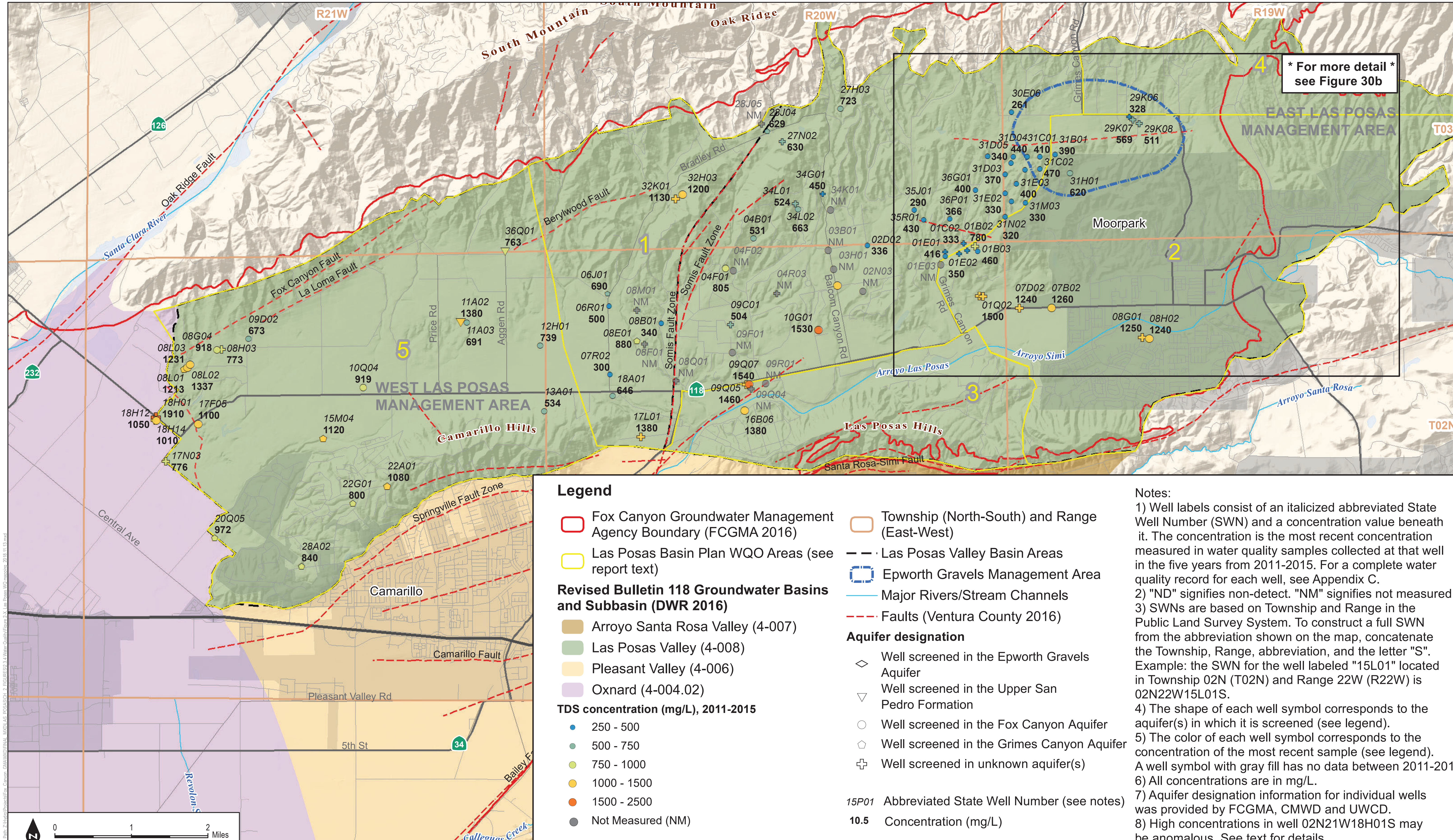

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-30A

Most Recent Total Dissolved Solids (mg/L) Measured 2011-2015

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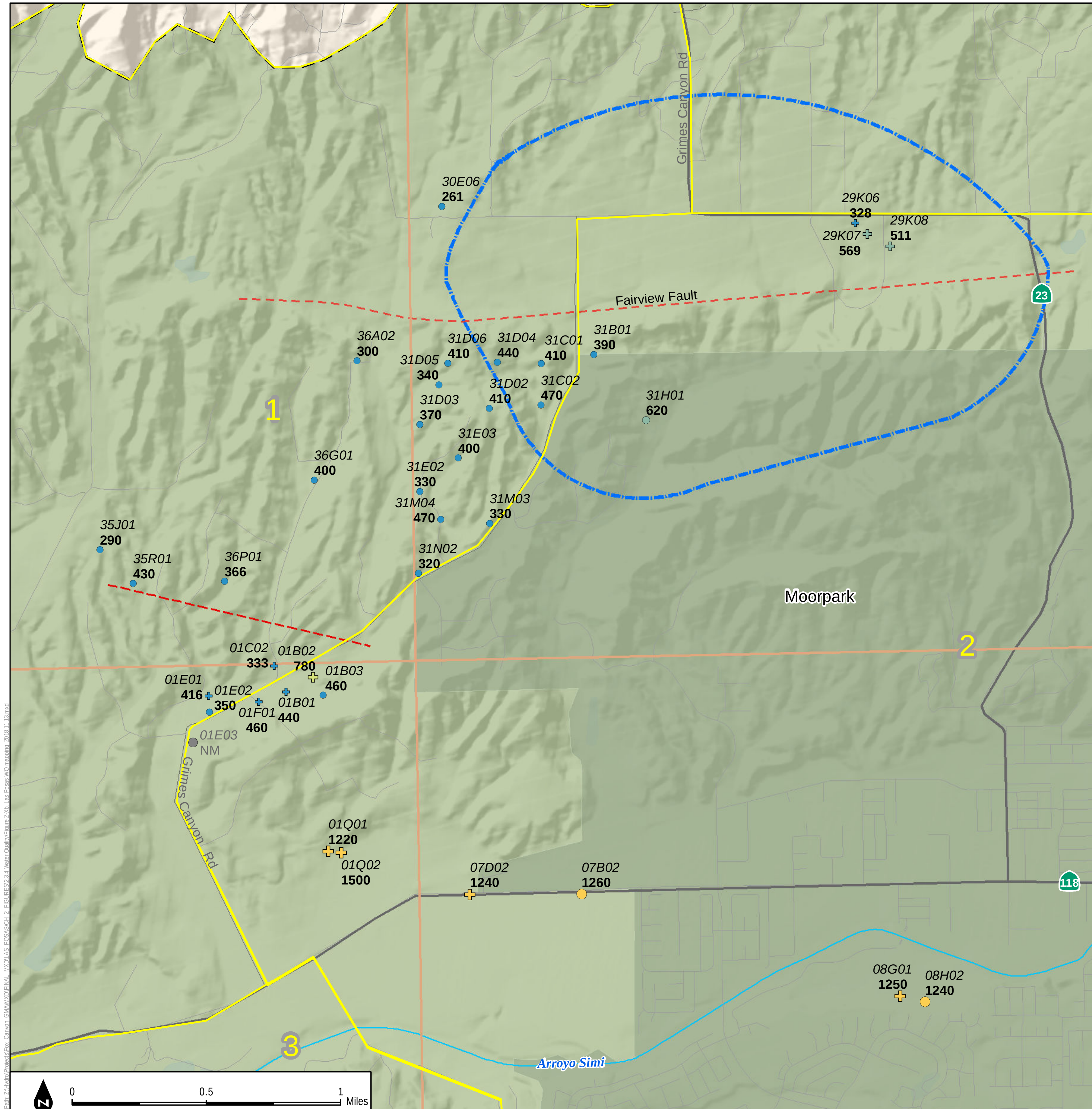

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Las Posas Basin Plan WQO Areas (see report text)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Las Posas Valley (4-008)
- Township (North-South) and Range (East-West)
- Las Posas Management Areas
- Epworth Gravels Management Area
- Major Rivers/Stream Channels
- Faults (Ventura County 2016)

TDS concentration (mg/L), 2011-2015

- 250 - 500
- 500 - 750
- 750 - 1000
- 1000 - 1500
- 1500 - 2500
- Not Measured (NM)

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Aquifer designation

- Well screened in the Epworth Gravels Aquifer
- Well screened in the Upper San Pedro Formation
- Well screened in the Fox Canyon Aquifer
- Well screened in the Grimes Canyon Aquifer
- Well screened in undetermined aquifer(s)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it. The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix C.
2) "ND" signifies non-detect. "NM" signifies not measured.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol corresponds to the aquifer(s) in which it is screened (see legend).
5) The color of each well symbol corresponds to the concentration of the most recent sample (see legend). A well symbol with gray fill has no data between 2011-2015.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.
8) High concentrations in well 02N21W18H01S may be anomalous. See text for details.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-30B

Most Recent Total Dissolved Solids (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Las Posas Valley Basin

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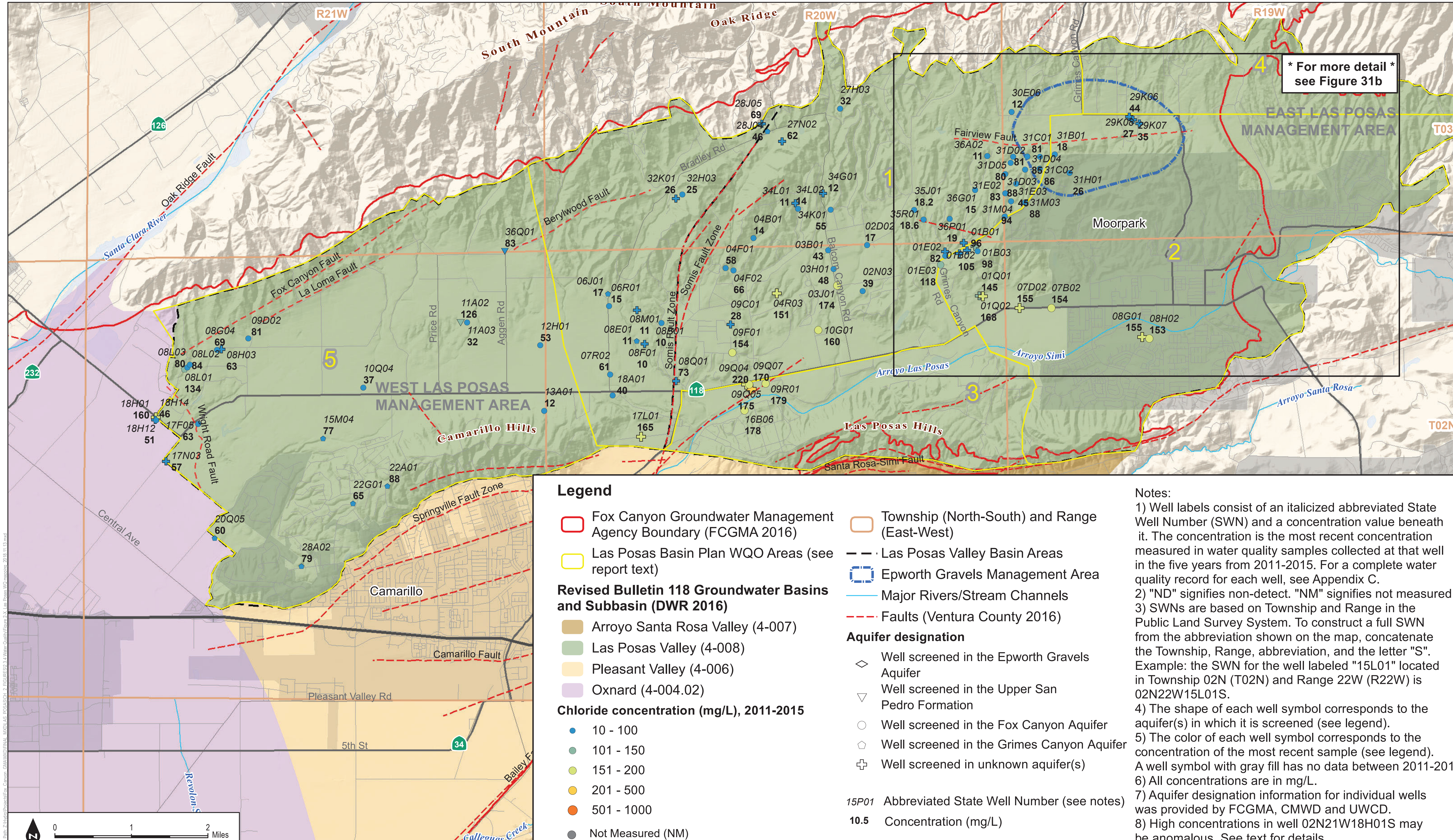

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it. The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix C.
2) "ND" signifies non-detect. "NM" signifies not measured.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol corresponds to the aquifer(s) in which it is screened (see legend).
5) The color of each well symbol corresponds to the concentration of the most recent sample (see legend). A well symbol with gray fill has no data between 2011-2015.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.
8) High concentrations in well 02N21W18H01S may be anomalous. See text for details.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-31A

Most Recent Chloride (mg/L) Measured 2011-2015

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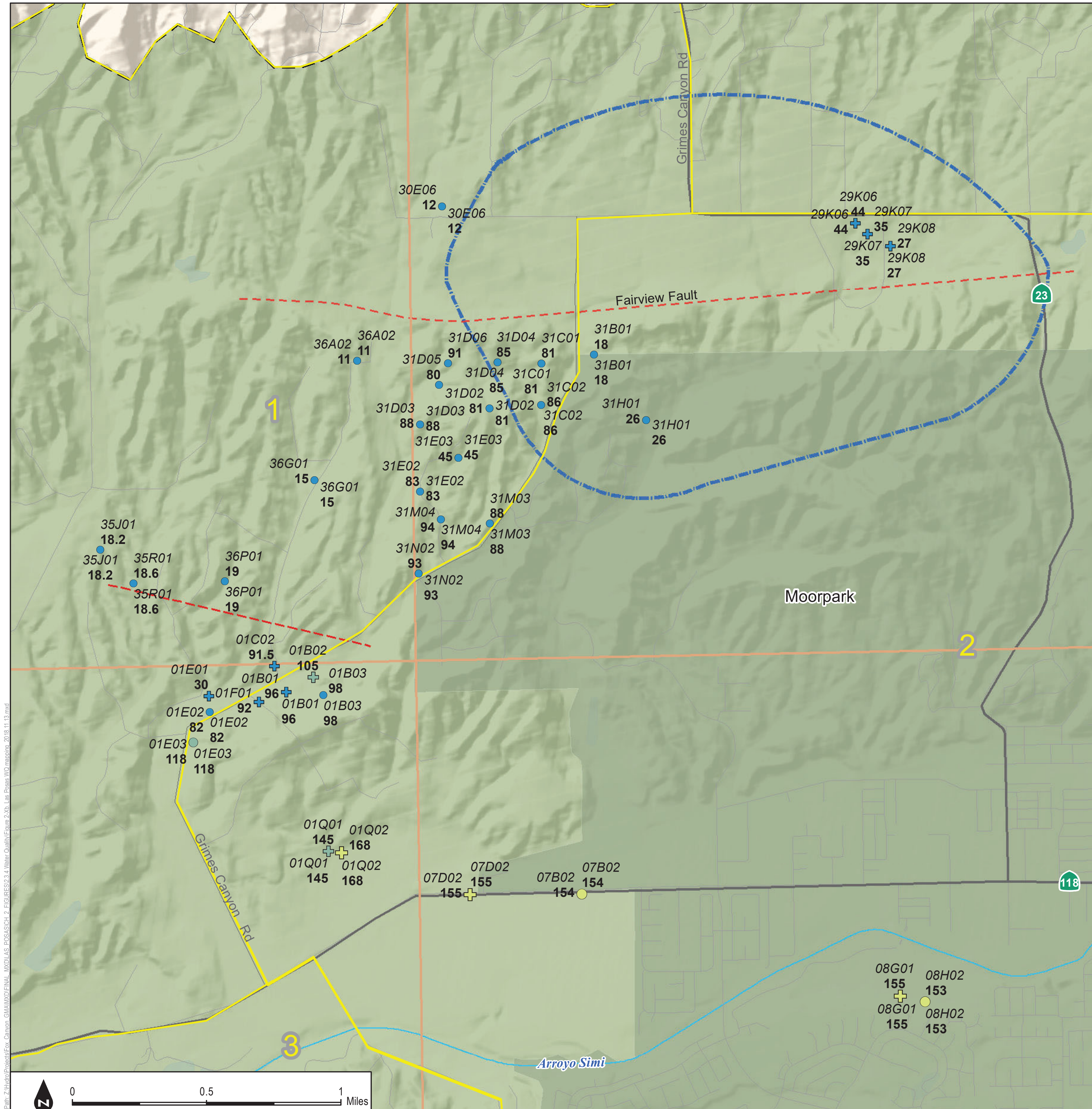

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Las Posas Basin Plan WQO Areas (see report text)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Las Posas Valley (4-008)
- Township (North-South) and Range (East-West)
- Las Posas Management Areas
- Epworth Gravels Management Area
- Major Rivers/Stream Channels
- Faults (Ventura County 2016)

Chloride concentration (mg/L), 2011-2015

- 10 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- 501 - 1000
- Not Measured (NM)
- *15P01* Abbreviated State Well Number (see notes)
- **10.5** Concentration (mg/L)

Aquifer designation

- Well screened in the Epworth Gravels Aquifer
- Well screened in the Upper San Pedro Formation
- Well screened in the Fox Canyon Aquifer
- Well screened in the Grimes Canyon Aquifer
- Well screened in undetermined aquifer(s)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it. The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix E.
2) "ND" signifies non-detect. "NM" signifies not measured.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol corresponds to the aquifer(s) in which it is screened (see legend).
5) The color of each well symbol corresponds to the concentration of the most recent sample (see legend). A well symbol with gray fill has no data between 2011-2015.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.
8) High concentrations in well 02N21W18H01S may be anomalous. See text for details.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-31B

Most Recent Chloride (mg/L) Measured 2011-2015

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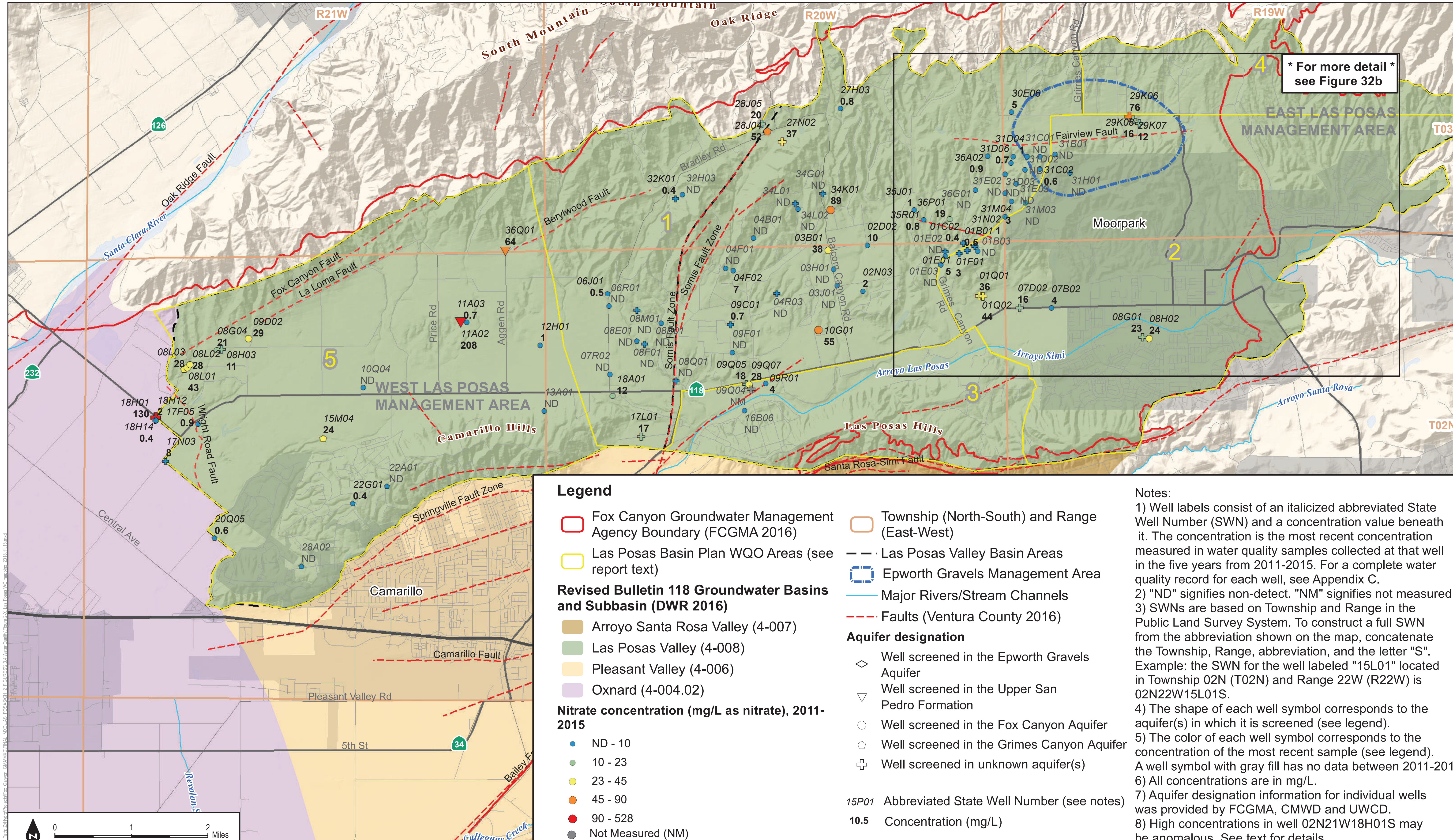

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-32A

Most Recent Nitrate (mg/L as Nitrate) Measured 2011-2015

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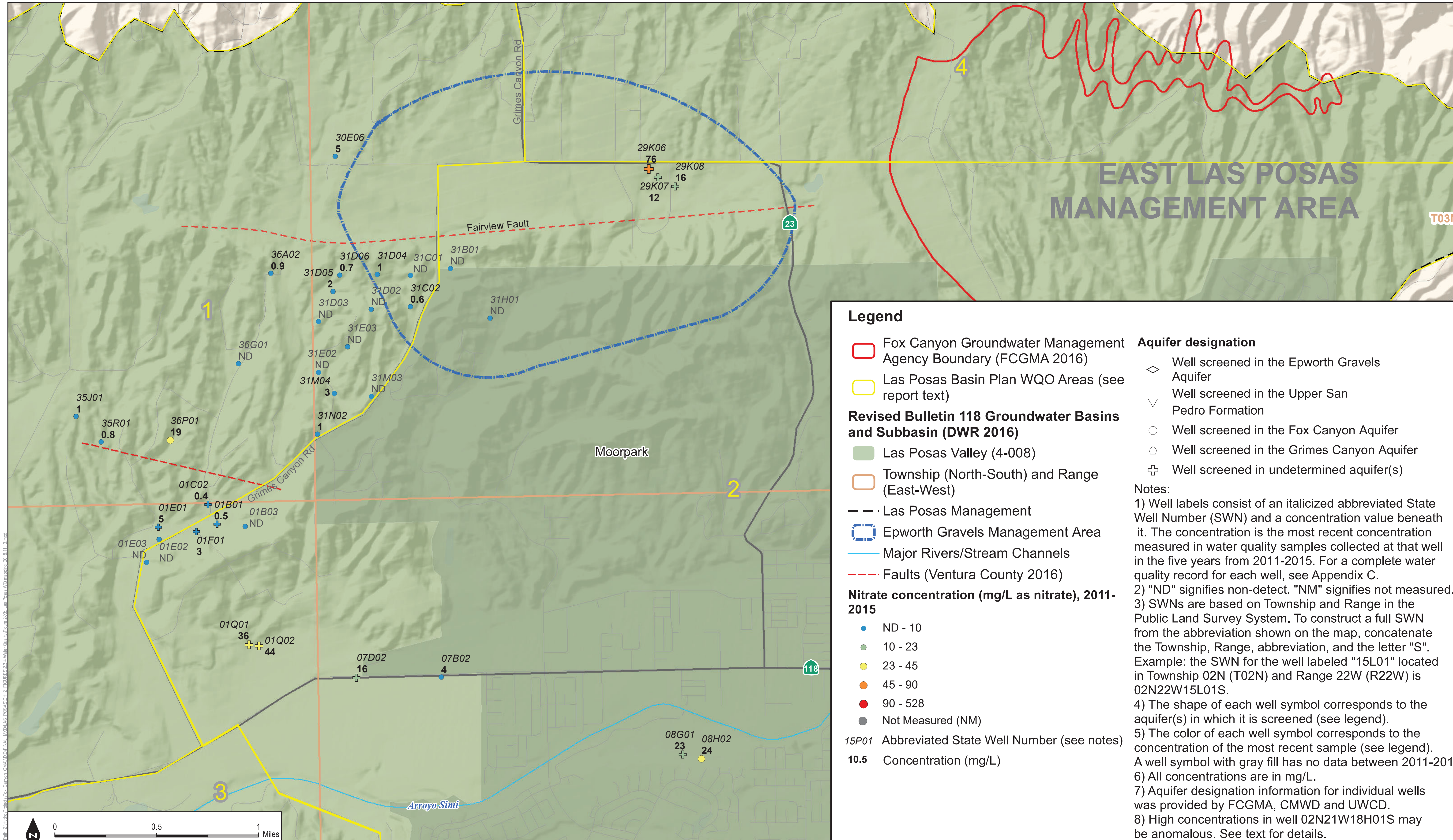

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-32B

Most Recent Nitrate (mg/L as Nitrate) Measured 2011-2015

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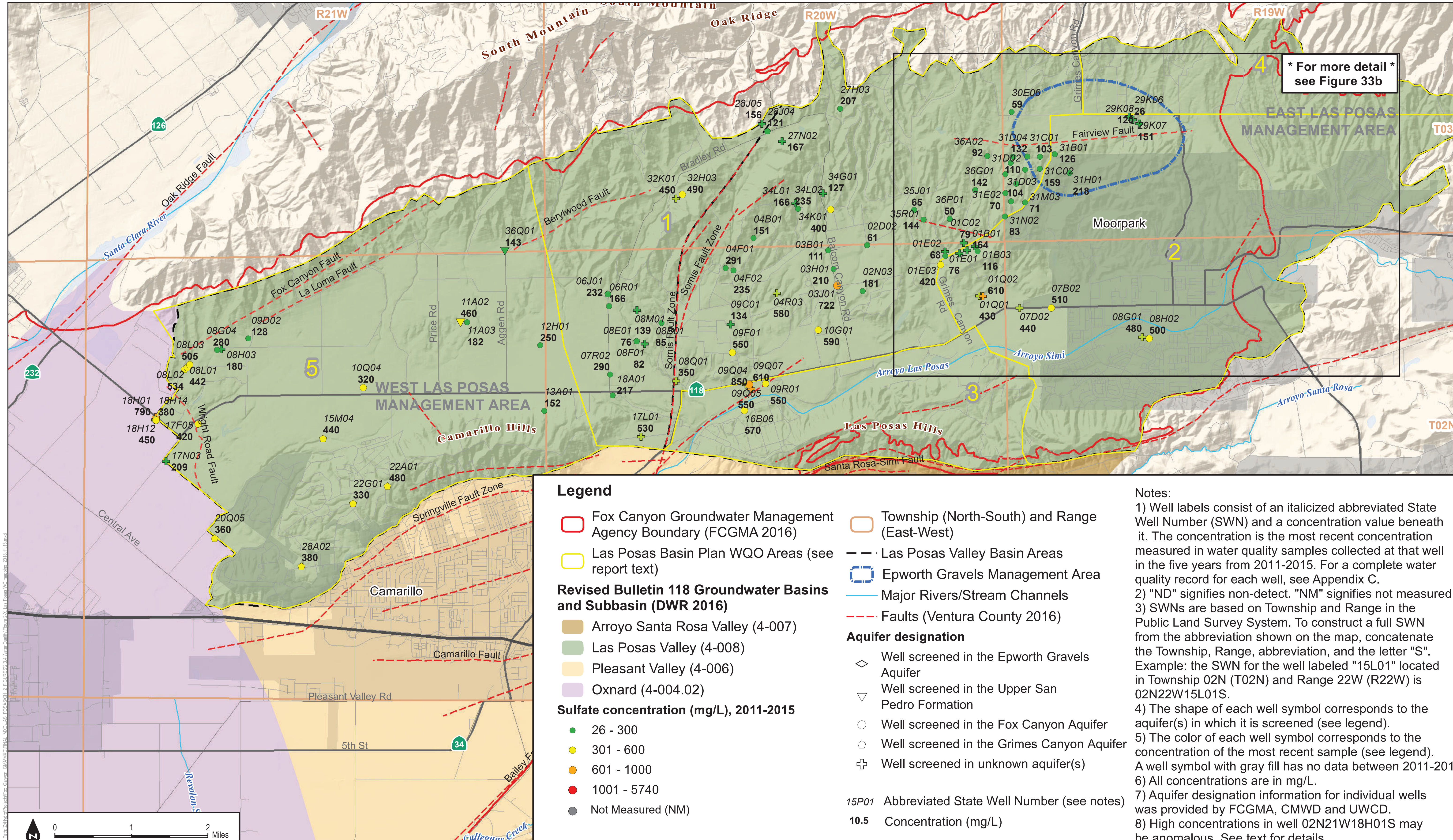

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-33A

Most Recent Sulfate (mg/L) Measured 2011-2015

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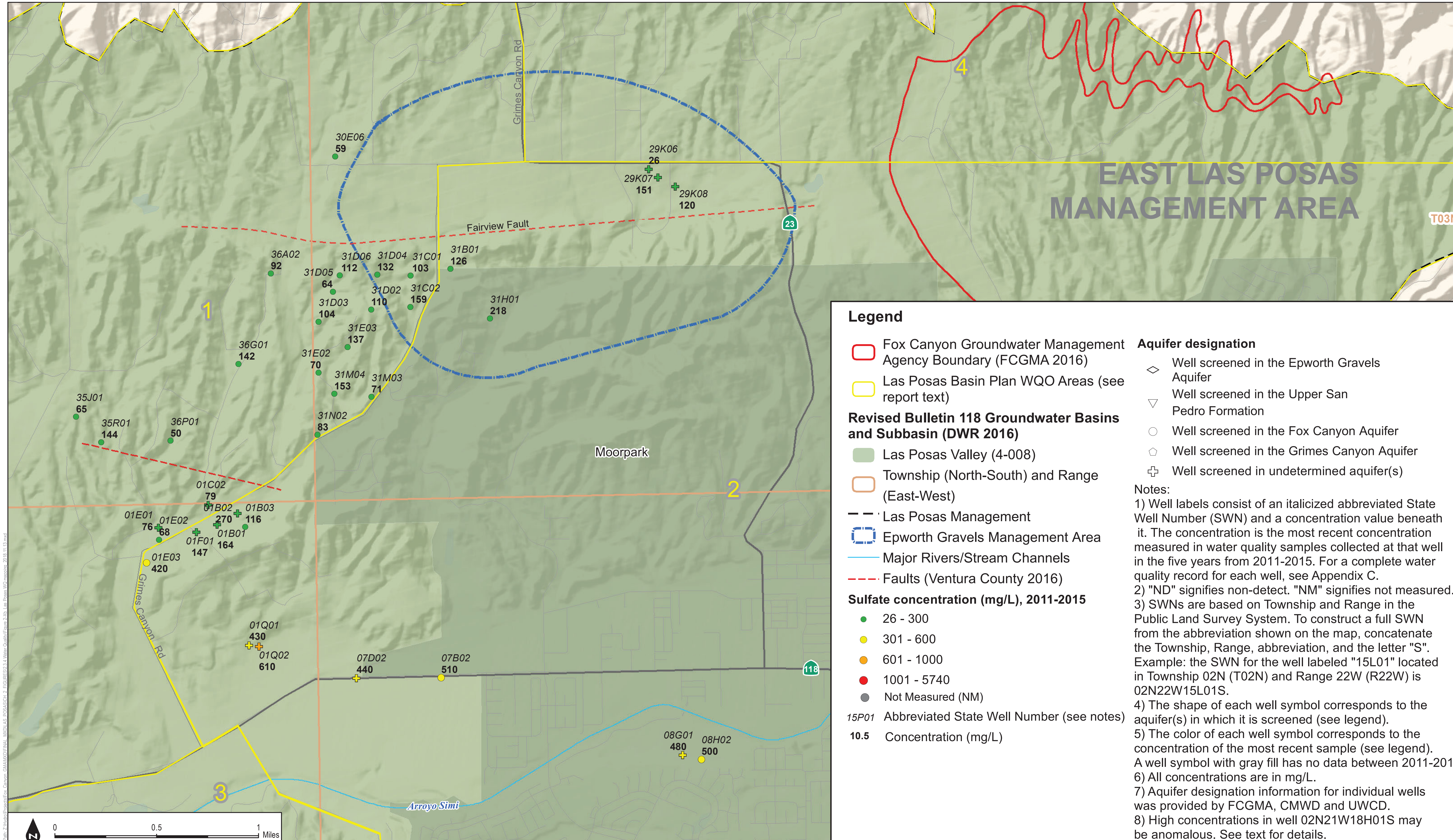

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-33B

Most Recent Sulfate (mg/L) Measured 2011-2015

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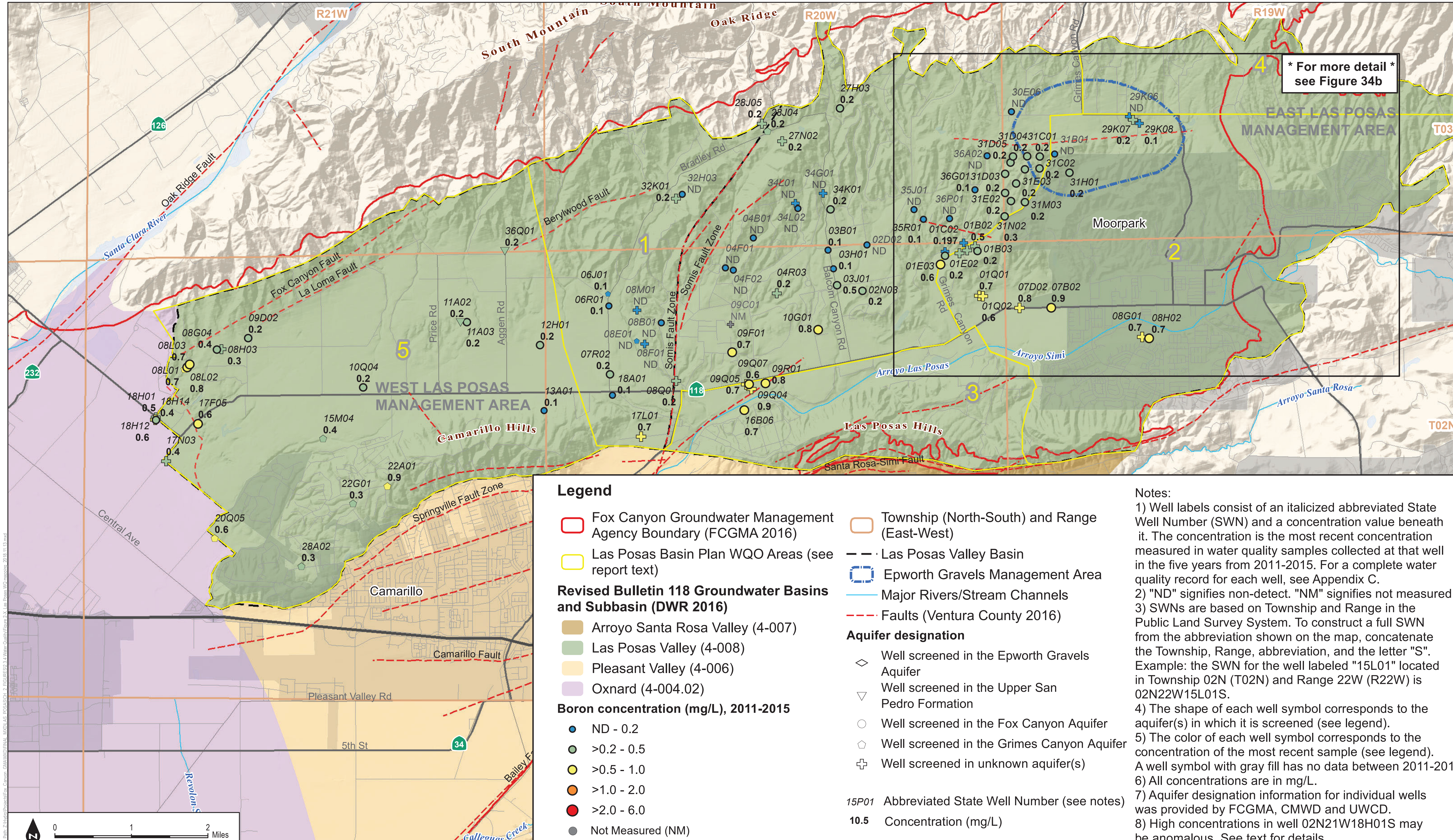

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Las Posas Basin Plan WQO Areas (see report text)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)

Boron concentration (mg/L), 2011-2015

- ND - 0.2
- >0.2 - 0.5
- >0.5 - 1.0
- >1.0 - 2.0
- >2.0 - 6.0
- Not Measured (NM)

- Township (North-South) and Range (East-West)
- Las Posas Valley Basin
- Epworth Gravels Management Area
- Major Rivers/Stream Channels
- Faults (Ventura County 2016)

Aquifer designation

- Well screened in the Epworth Gravels Aquifer
- Well screened in the Upper San Pedro Formation
- Well screened in the Fox Canyon Aquifer
- Well screened in the Grimes Canyon Aquifer
- Well screened in unknown aquifer(s)

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Notes:

1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it. The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix C.
2) "ND" signifies non-detect. "NM" signifies not measured.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol corresponds to the aquifer(s) in which it is screened (see legend).
5) The color of each well symbol corresponds to the concentration of the most recent sample (see legend). A well symbol with gray fill has no data between 2011-2015.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.
8) High concentrations in well 02N21W18H01S may be anomalous. See text for details.

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

DUDEK

FIGURE 2-34A

Most Recent Boron (mg/L) Measured 2011-2015

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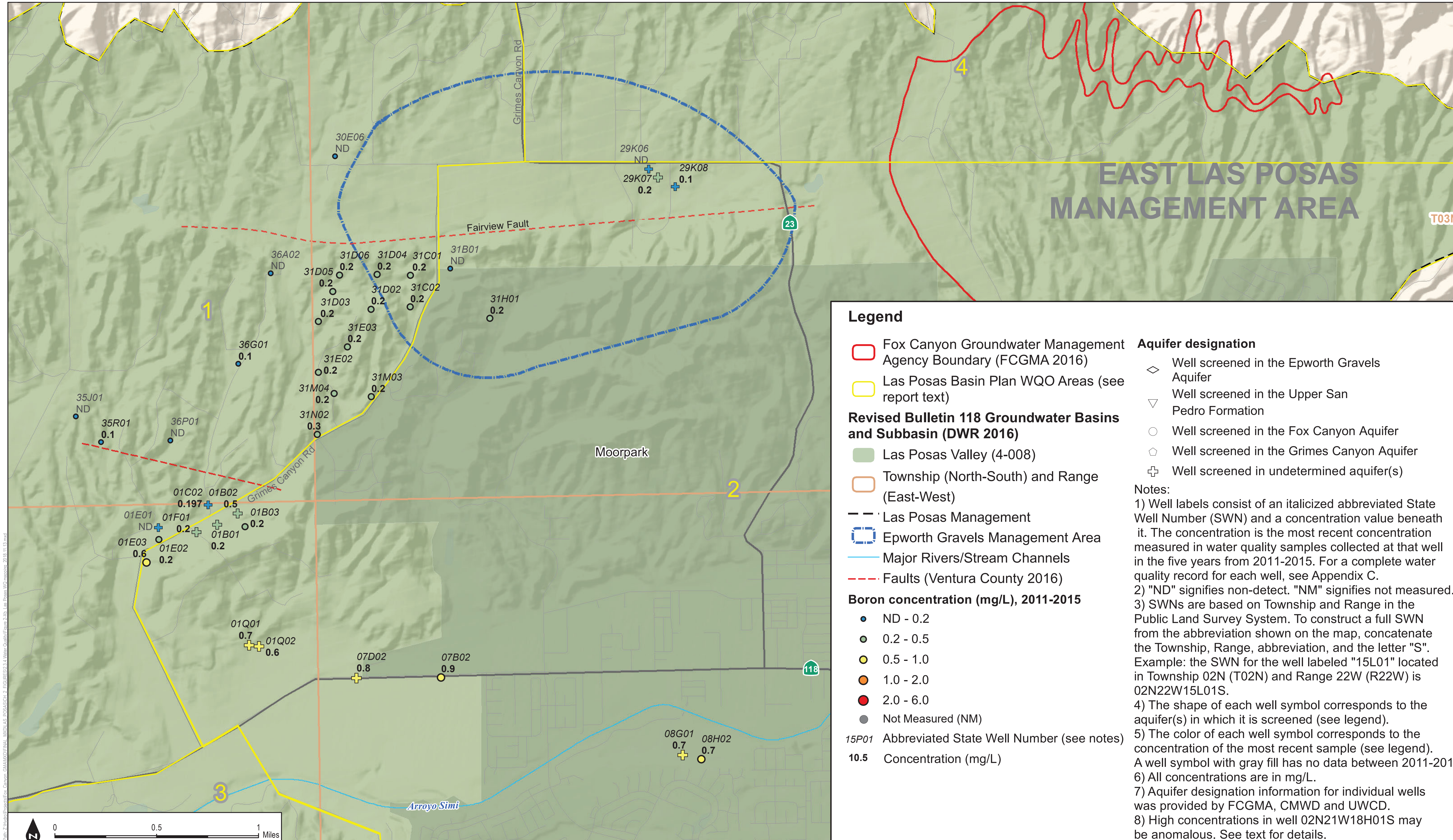

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-34B

Most Recent Boron (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Las Posas Valley Basin

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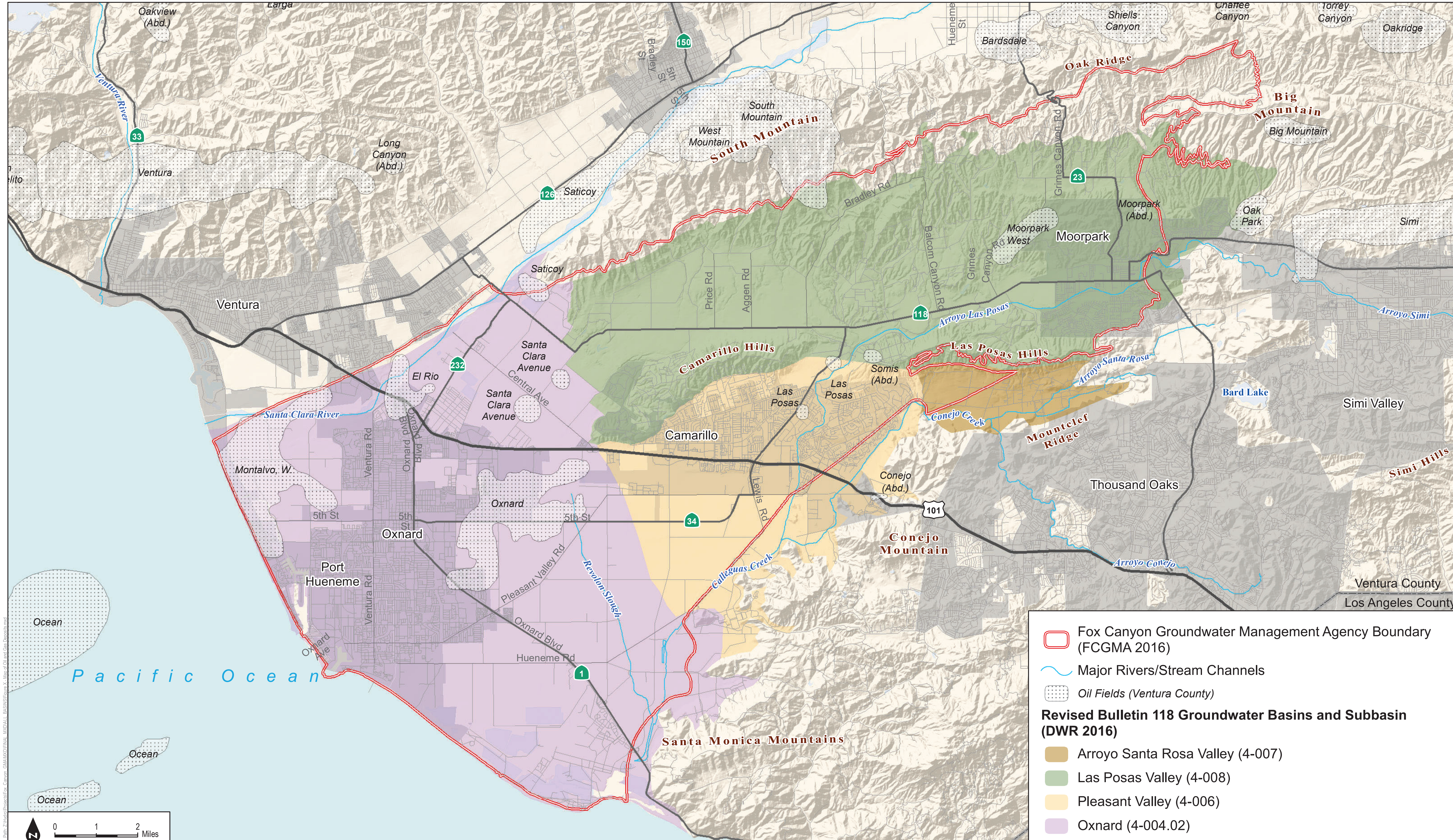

SOURCE: DWR; Ventura County

FIGURE 2-35

Oil Fields in the Vicinity of FCGMA Groundwater Basins

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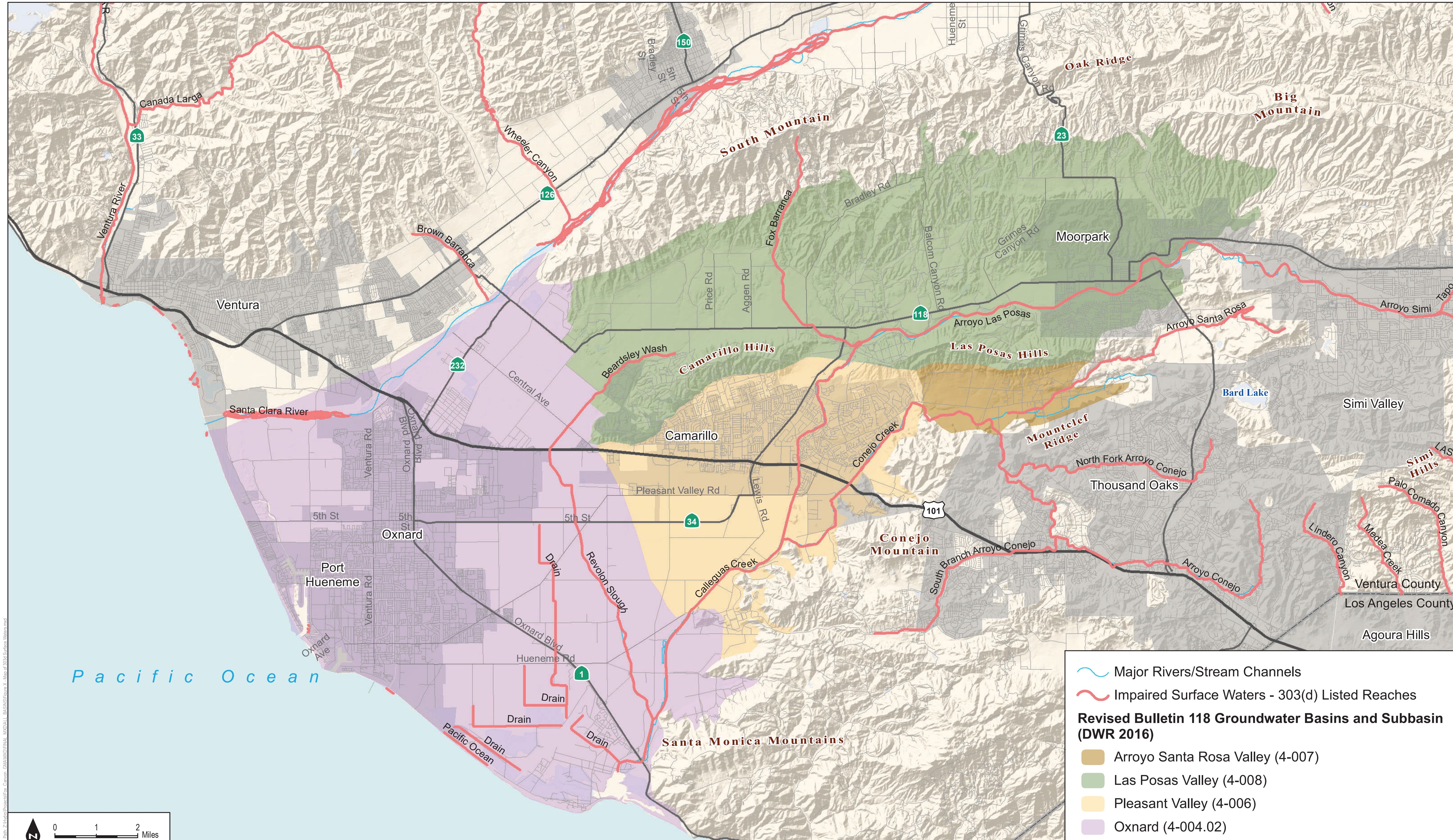

SOURCE: DWR; Ventura County

DUDEK

FIGURE 2-36

Impaired Surface Waters in the Vicinity of FCGMA Groundwater Basins

Groundwater Sustainability Plan for the Las Posas Valley Basin

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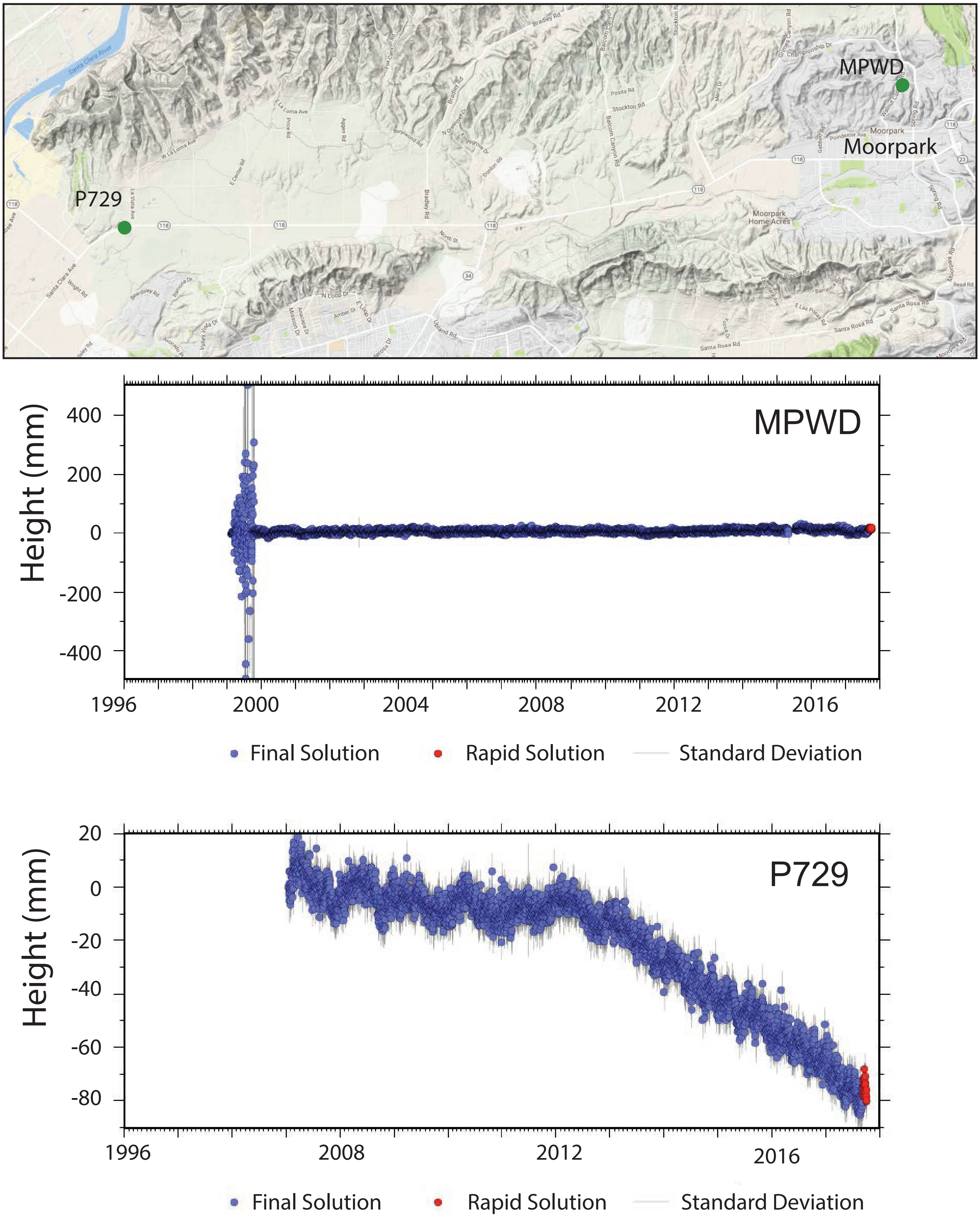

DUDEK

SOURCE: UNAVCO (accessed October 2017)
www.unavco.org/instrumentation/networks/map/map.html

FIGURE 2-37
Subsidence Monuments in the Las Posas Valley Basin

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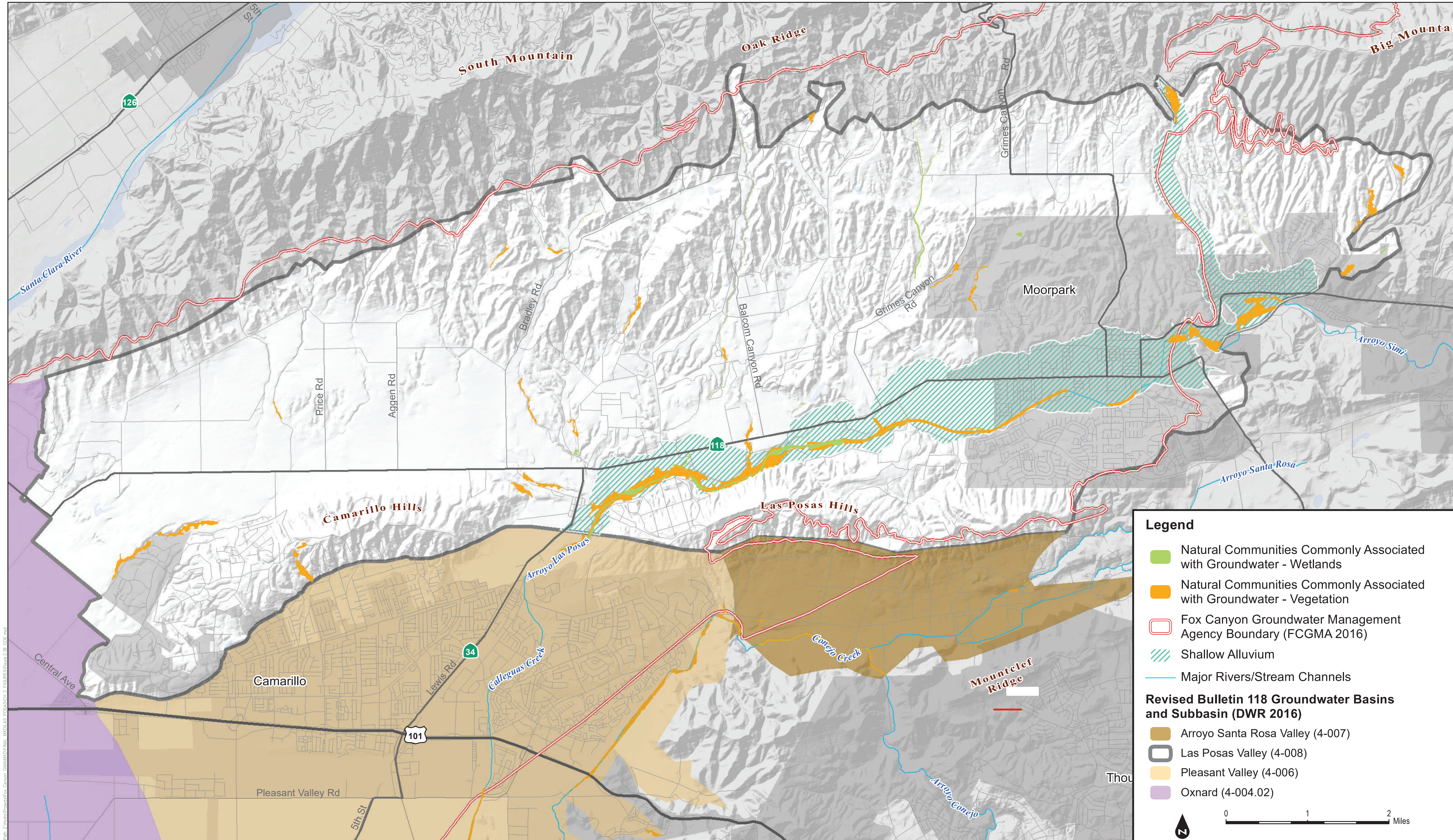

SOURCE: DWR; Santa Barbara County; FCGMA

DUDEK

FIGURE 2-38

Potential Groundwater-Dependent Ecosystems for the Las Posas Valley Basin

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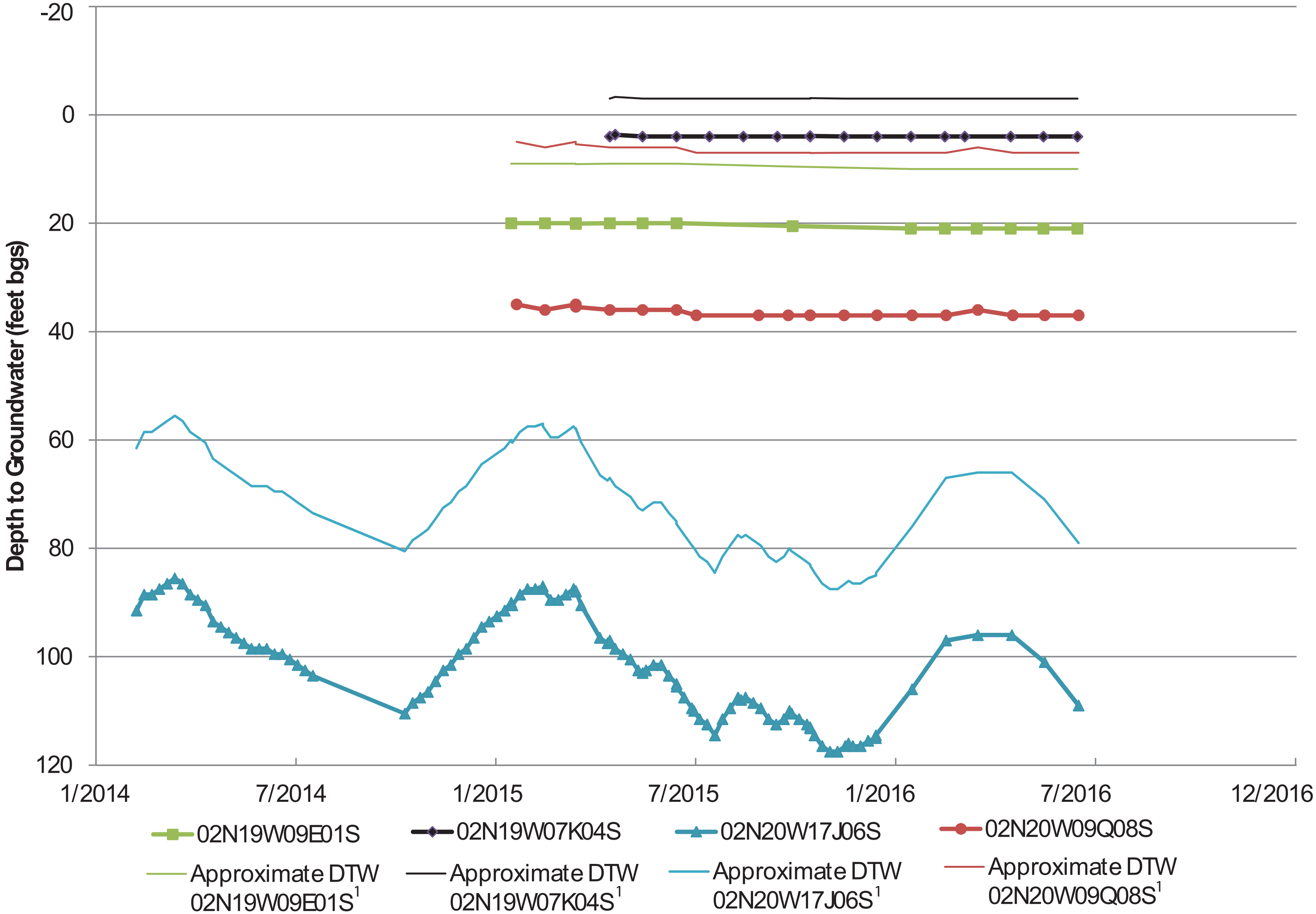

1) Approximate DTW is based on the DTW measured at the well projected to the potential DTW that may occur in Arroyo Las Posas, which is 5 to 30 feet lower than the land surface elevation at the well. The approximate DTW is *NOT* a measured groundwater level. See the text for additional detail.

DUDEK

FIGURE 2-39

Depth to Water in the Shallow Alluvial Aquifer

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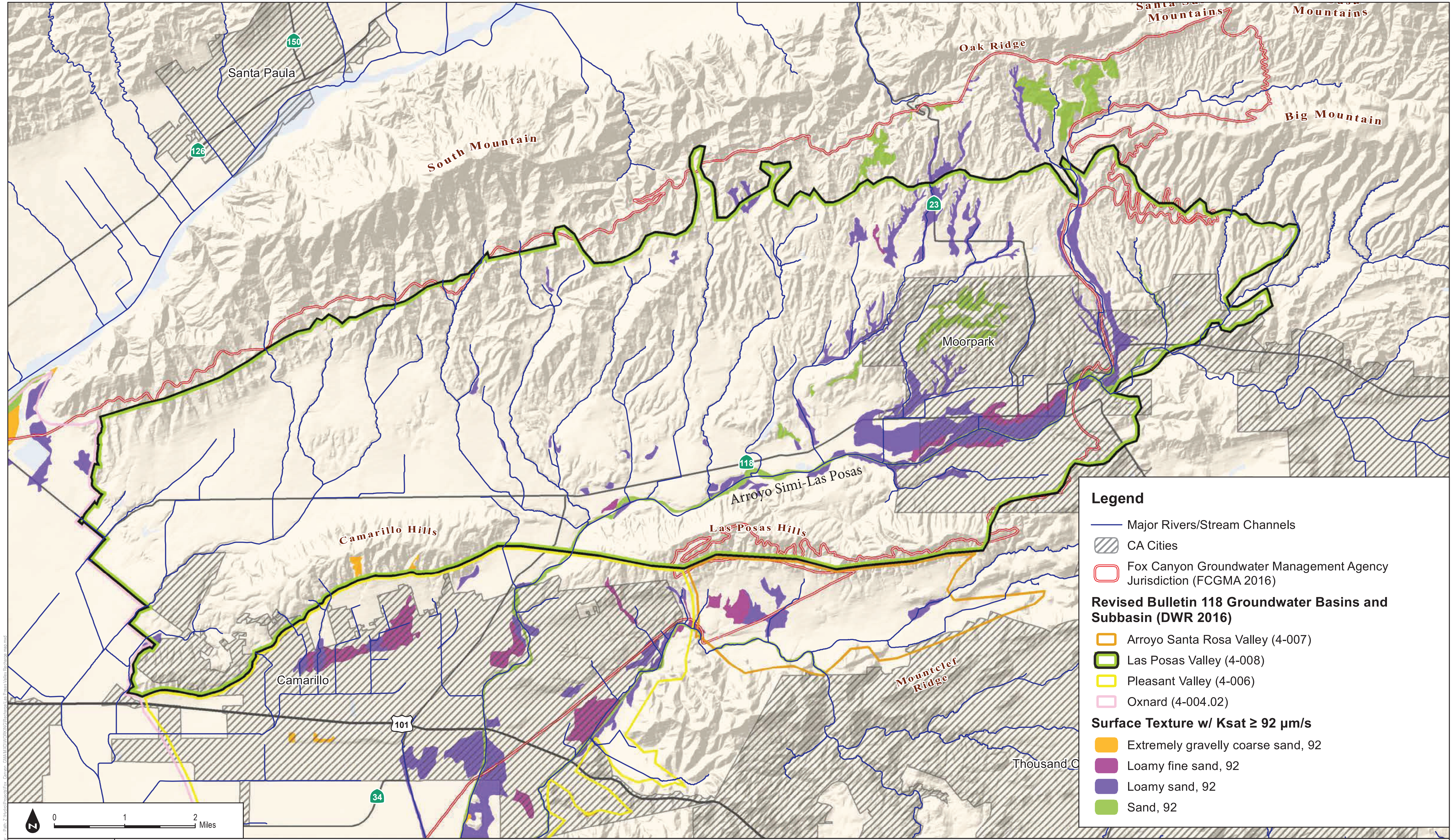

SOURCE: DWR, USGS, NRCS

DUDEK

Figure 2-40

Las Posas Valley Potential Recharge Areas

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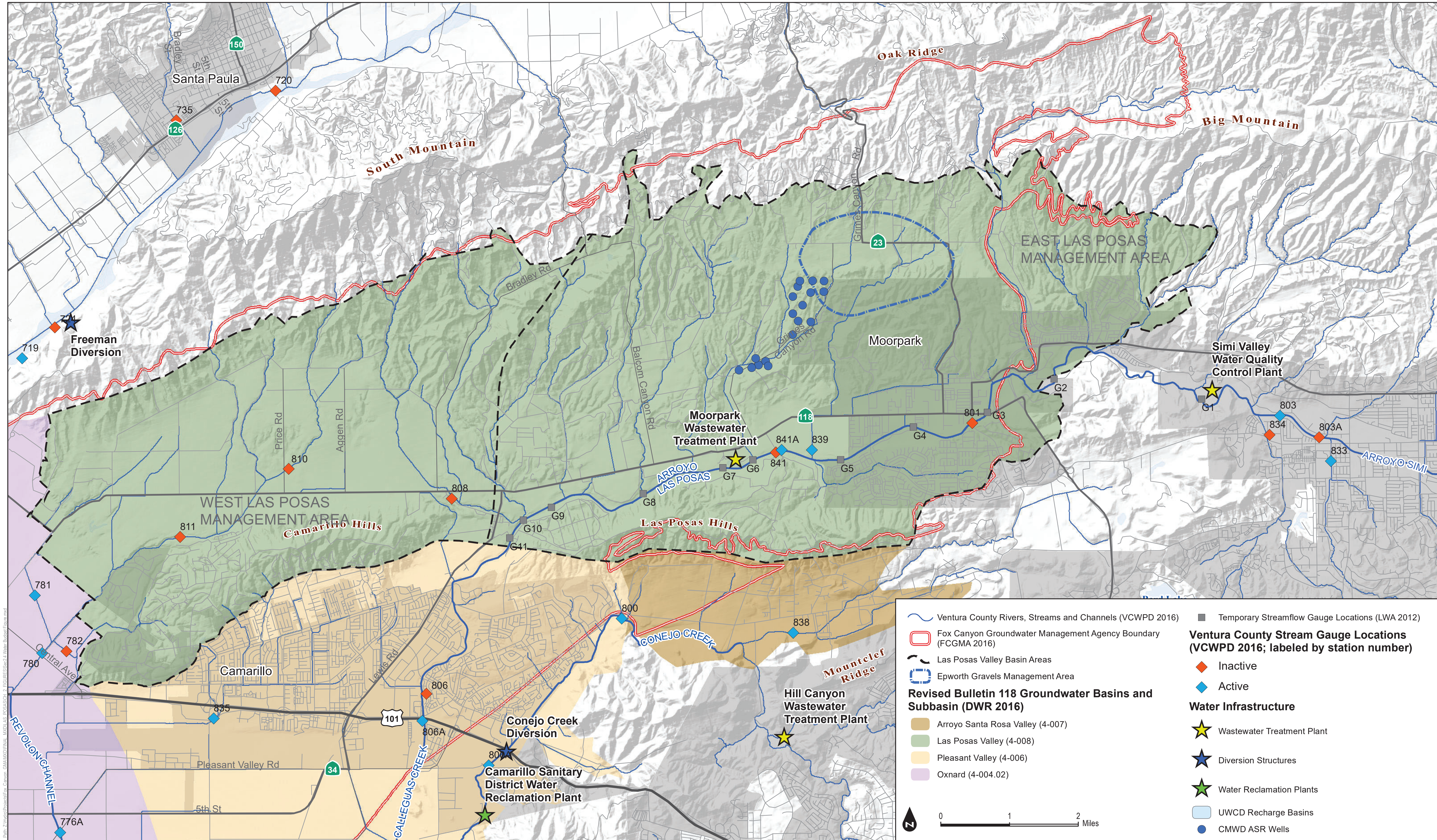

SOURCE: DWR; Ventura County; VCWPD

DUDEK

FIGURE 2-41

Las Posas Valley Basin Stream Gauges and Water Infrastructure

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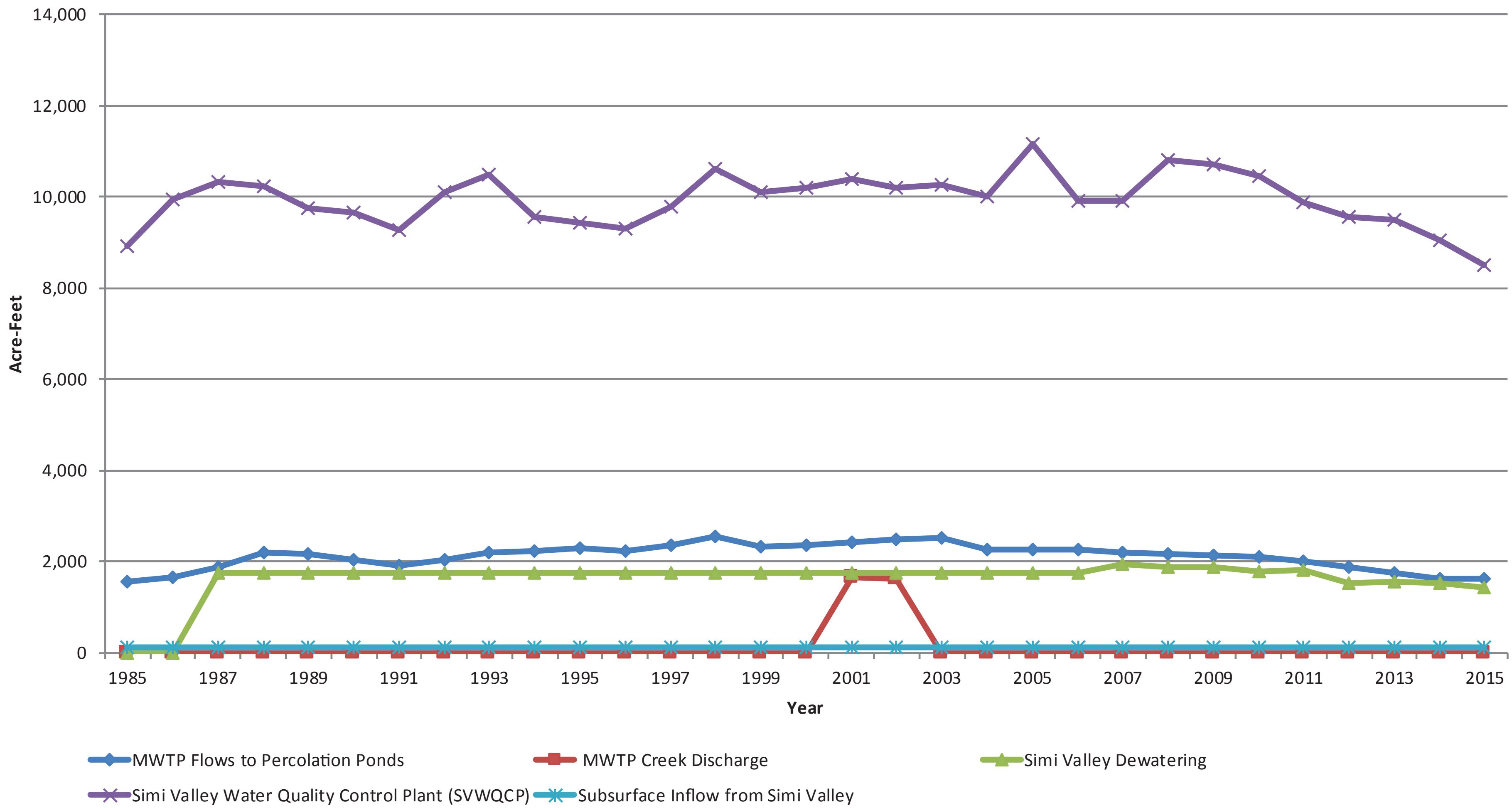

DUDEK

FIGURE 2-42

Wastewater Treatment Plant Discharges and Flows from Simi Valley

Groundwater Sustainability Plan for the Las Posas Valley Basin

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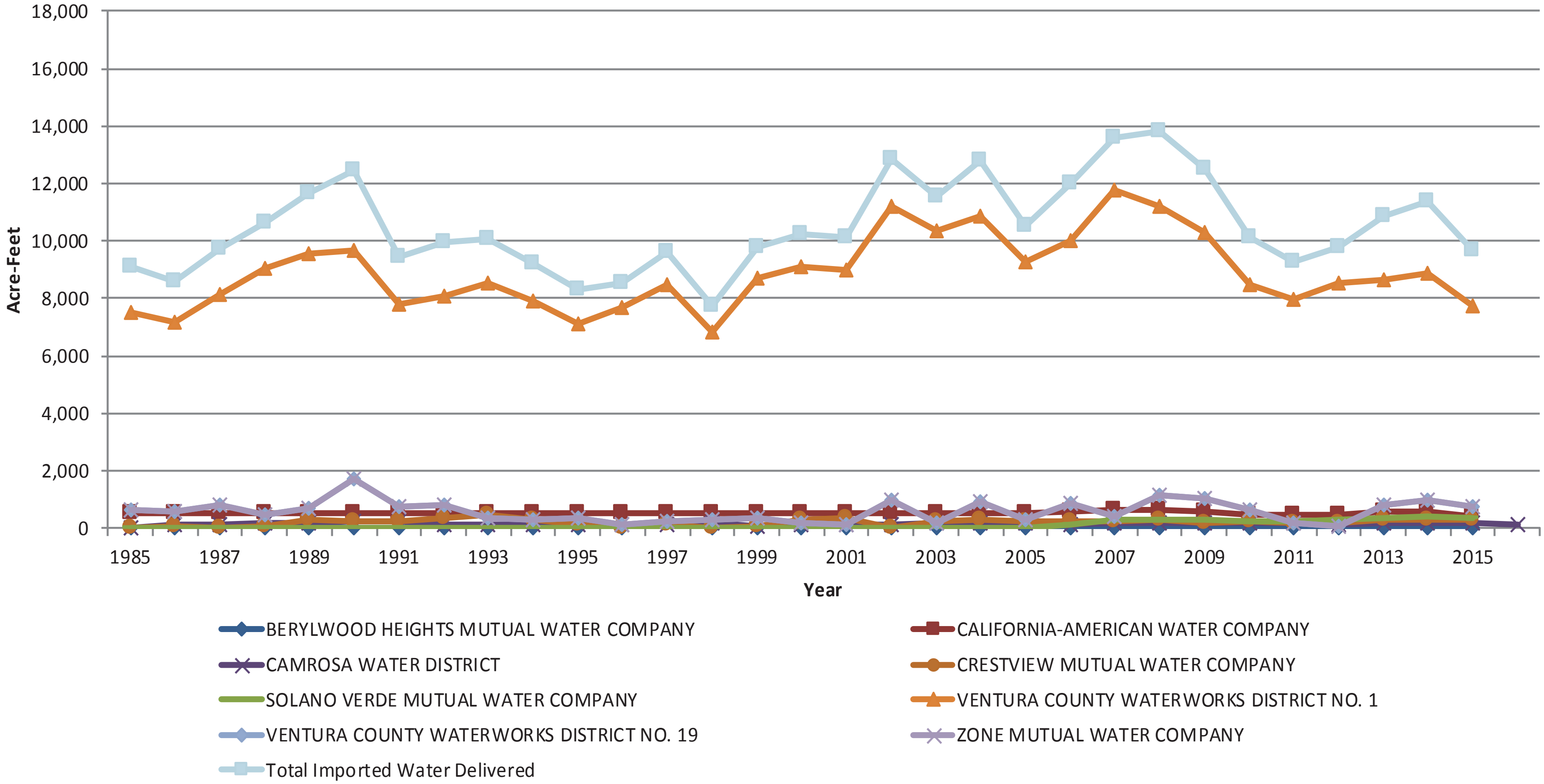

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FIGURE 2-43
Imported Water Deliveries

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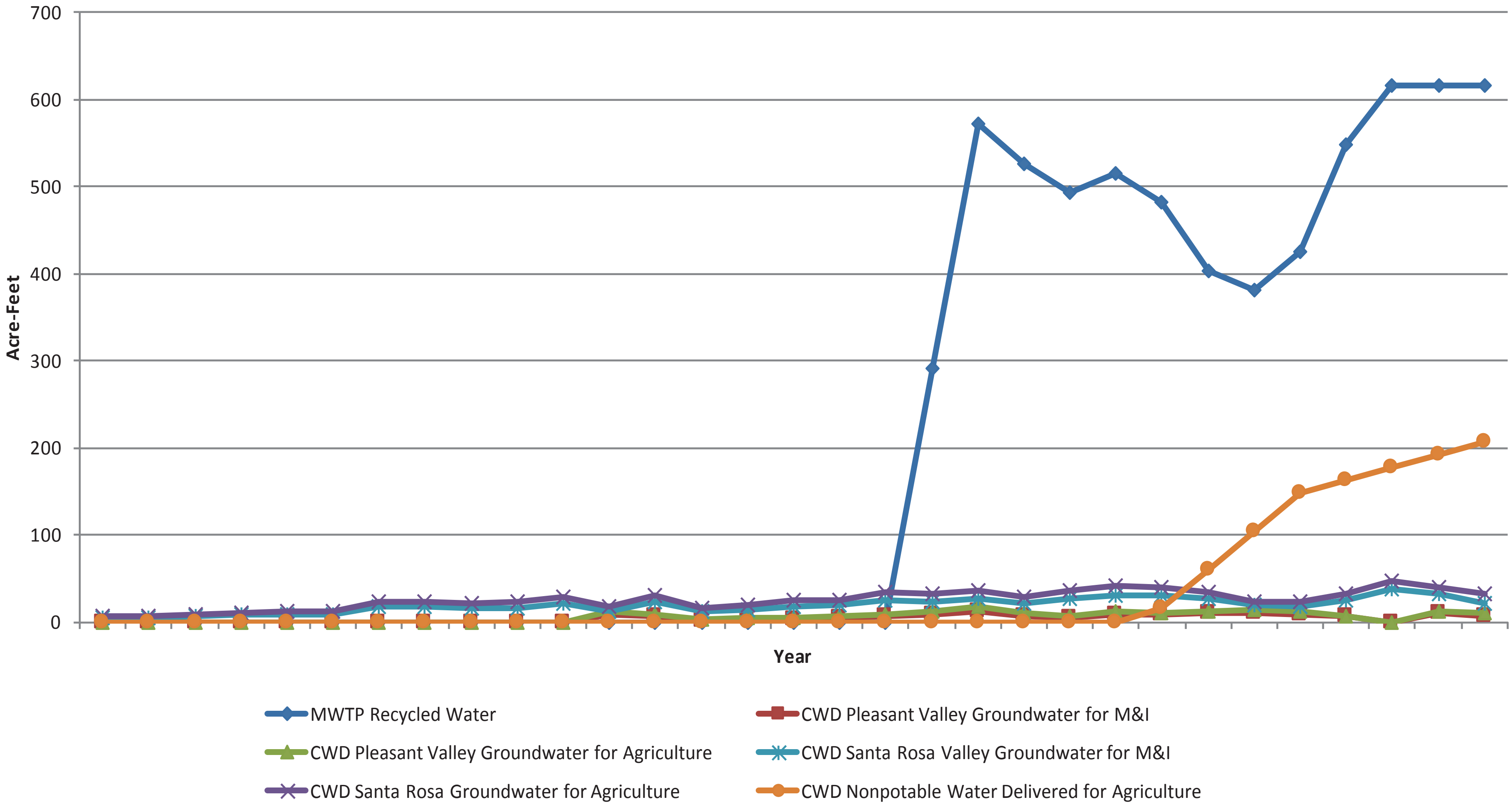

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FIGURE 2-44
Other Water Sources

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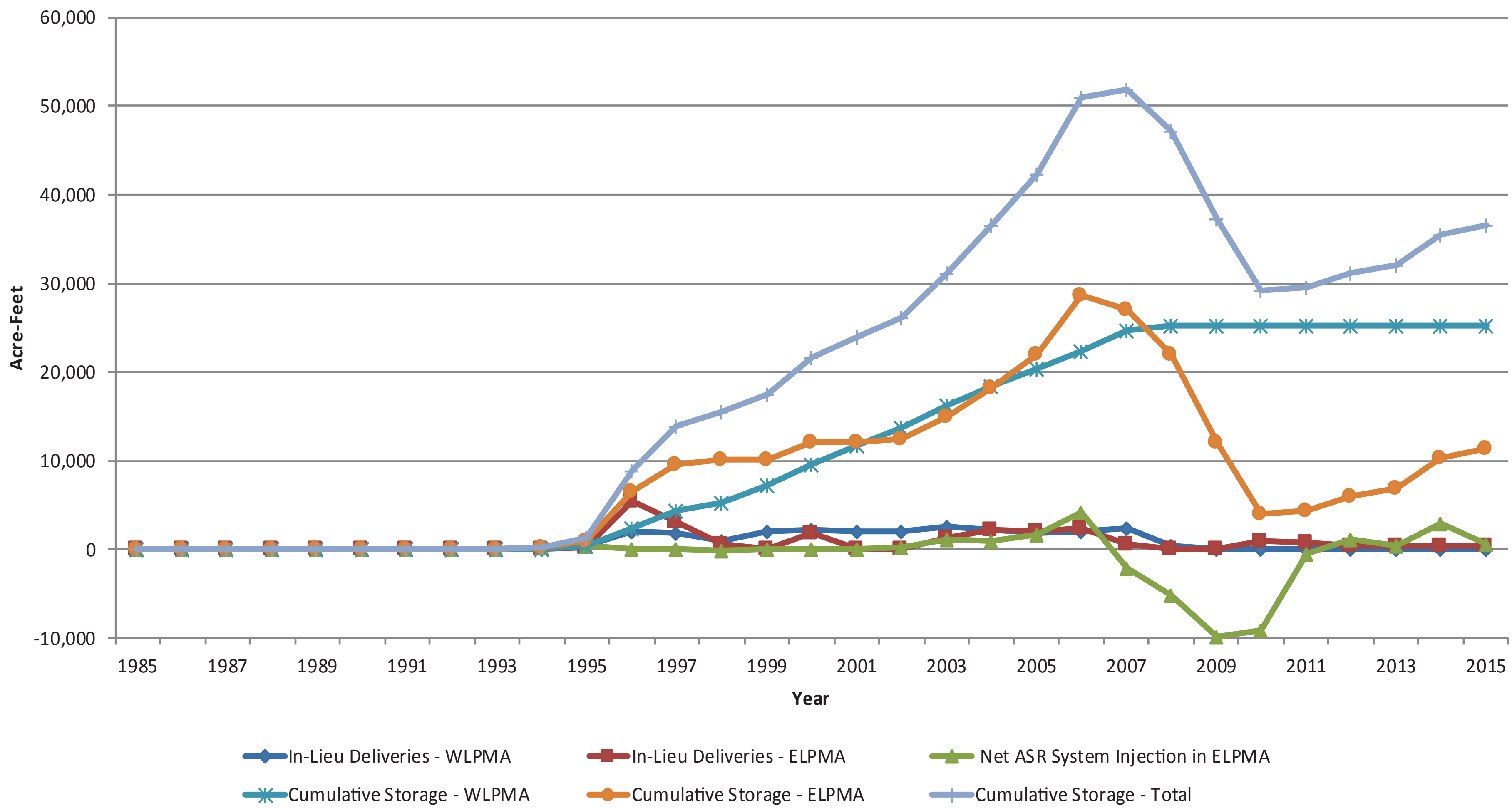

DUDEK

FIGURE 2-45
CMWD ASR and In-Lieu Water

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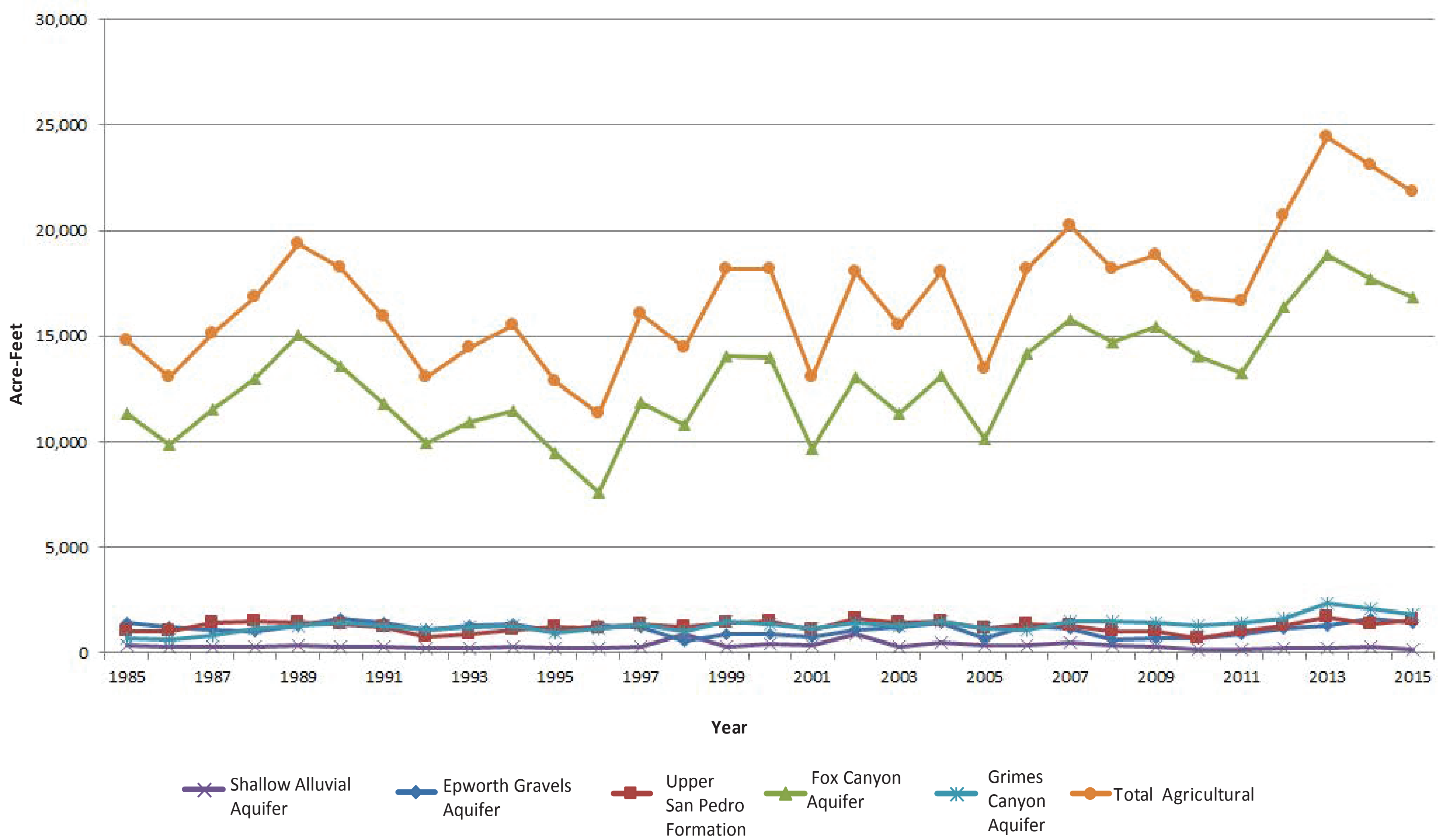

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FIGURE 2-46
ELPMA Agricultural Groundwater Pumping

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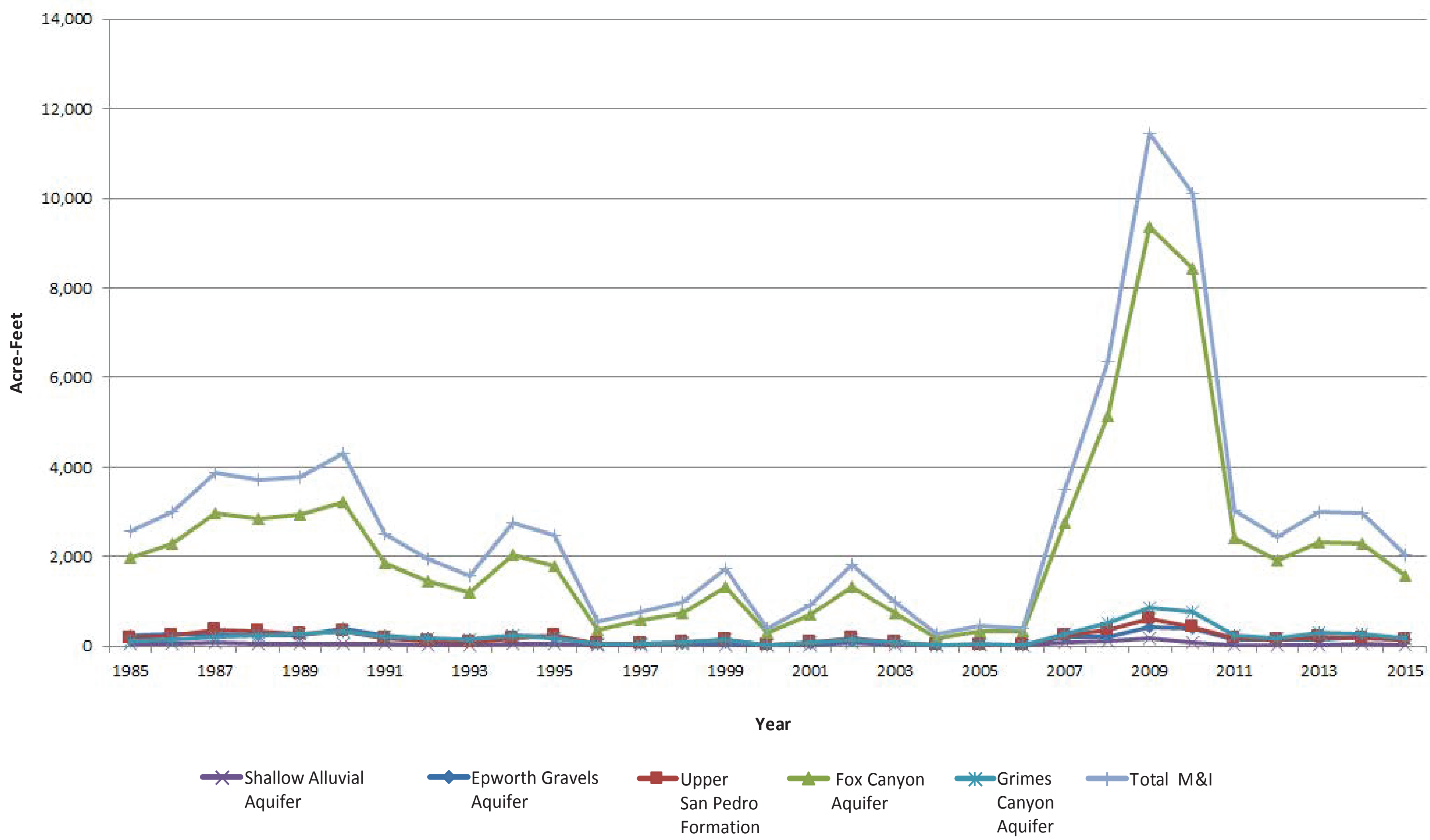

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FIGURE 2-47

ELPMA M&I Groundwater Pumping

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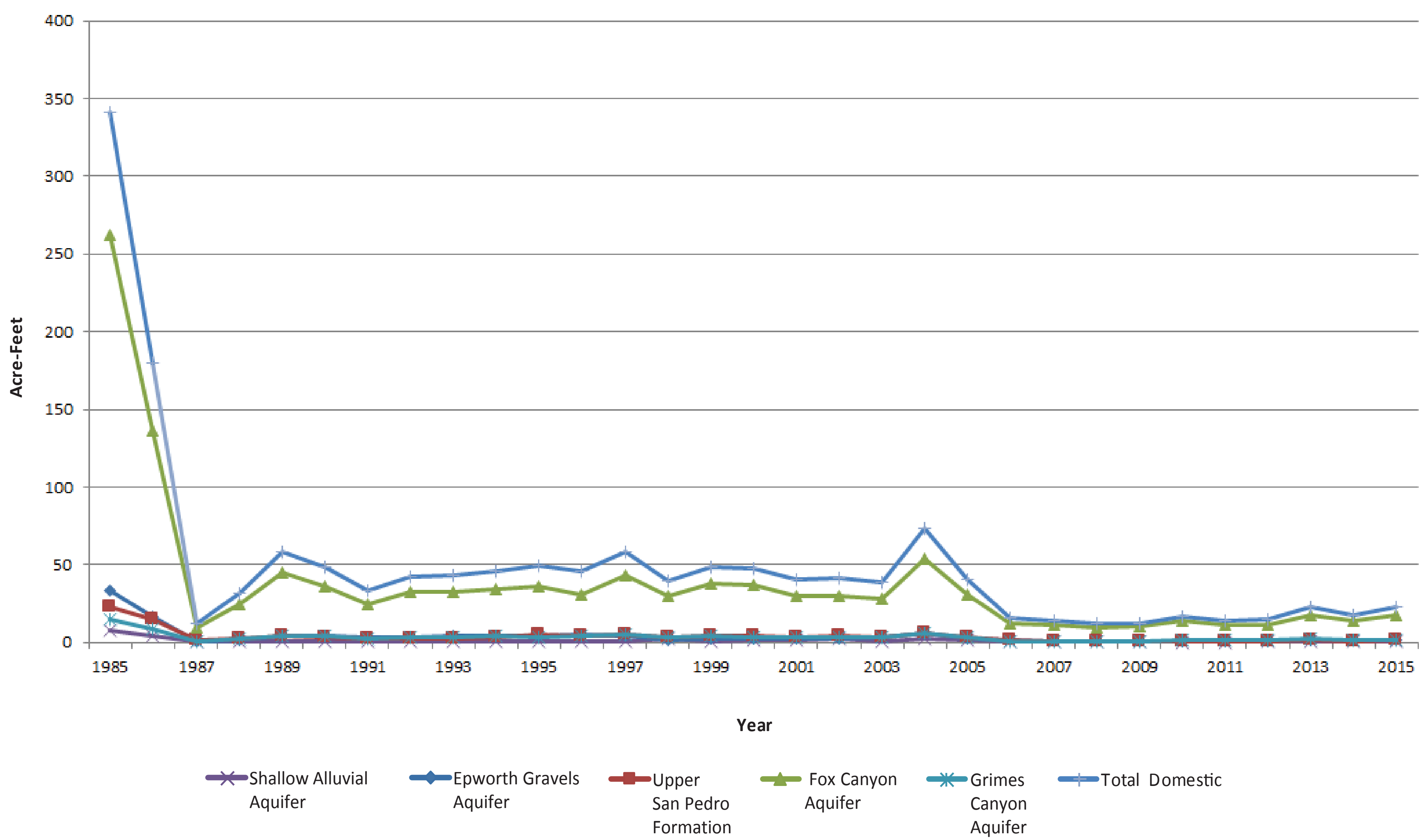

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FIGURE 2-48
ELPMA Domestic Groundwater Pumping

Groundwater Sustainability Plan for the Las Posas Valley Basin

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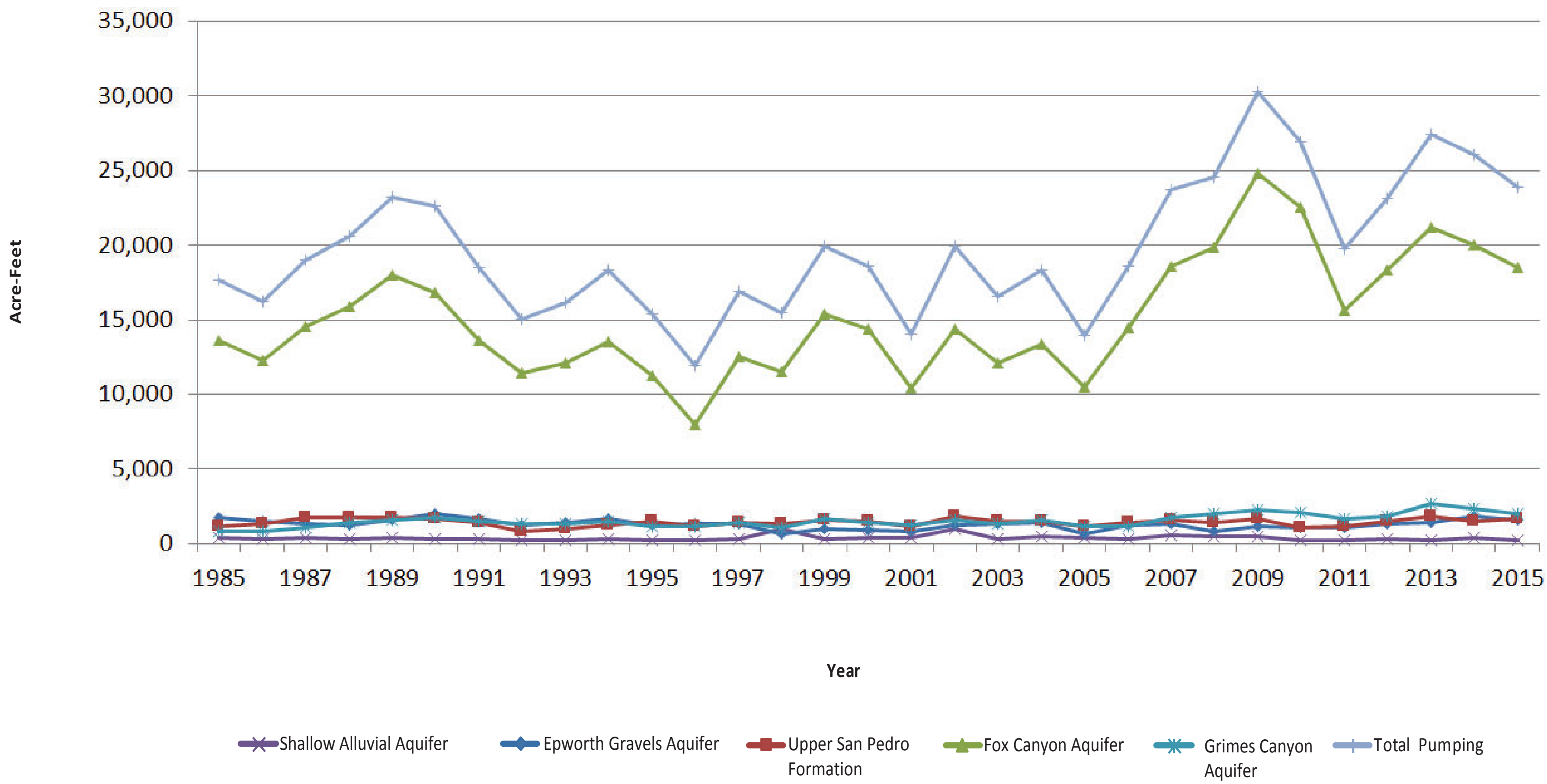

DUDEK

FIGURE 2-49
ELPMA Total Groundwater Pumping

Groundwater Sustainability Plan for the Las Posas Valley Basin

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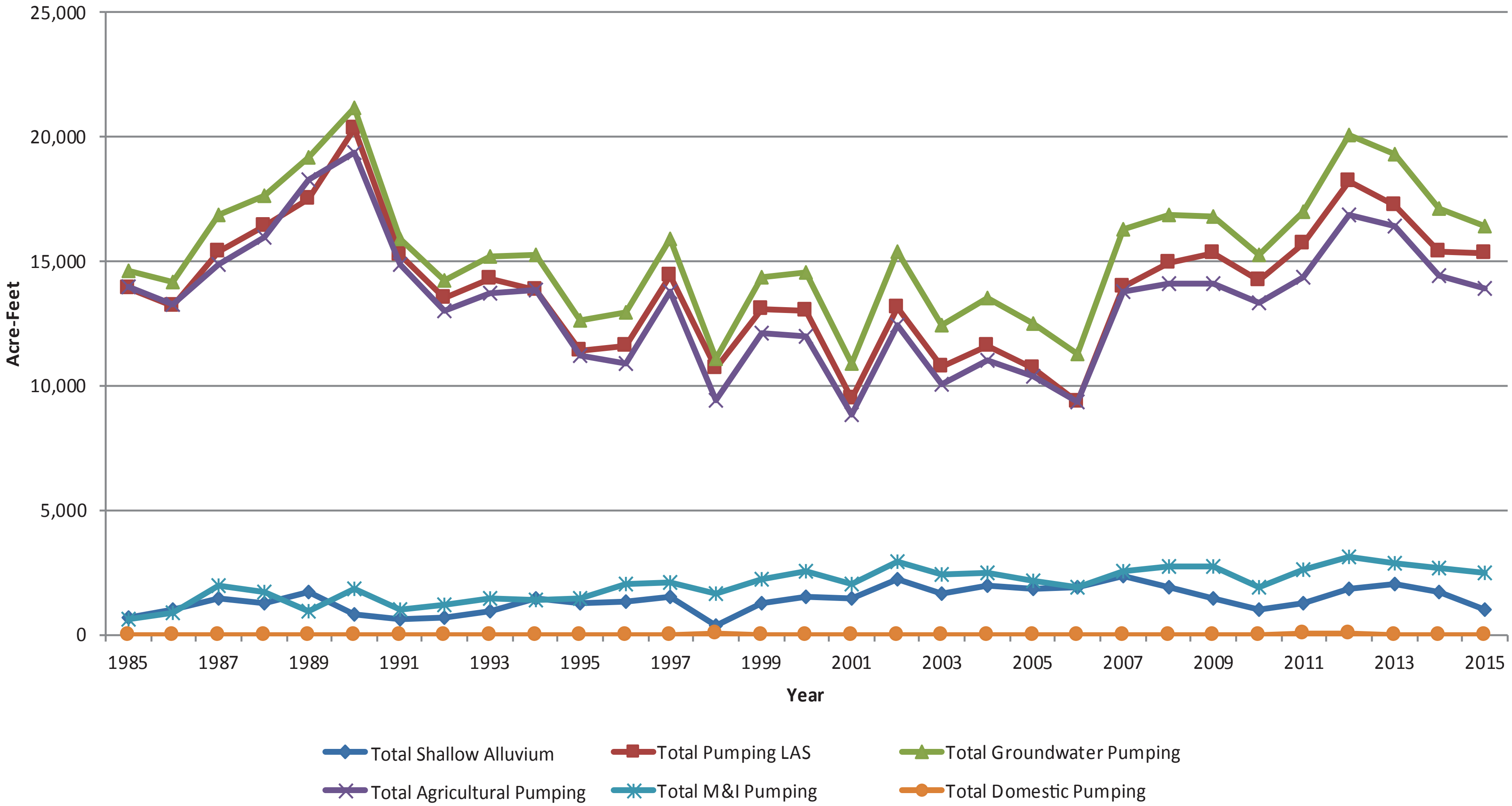

DUDEK

FIGURE 2-50

WLPMA Total Groundwater Pumping

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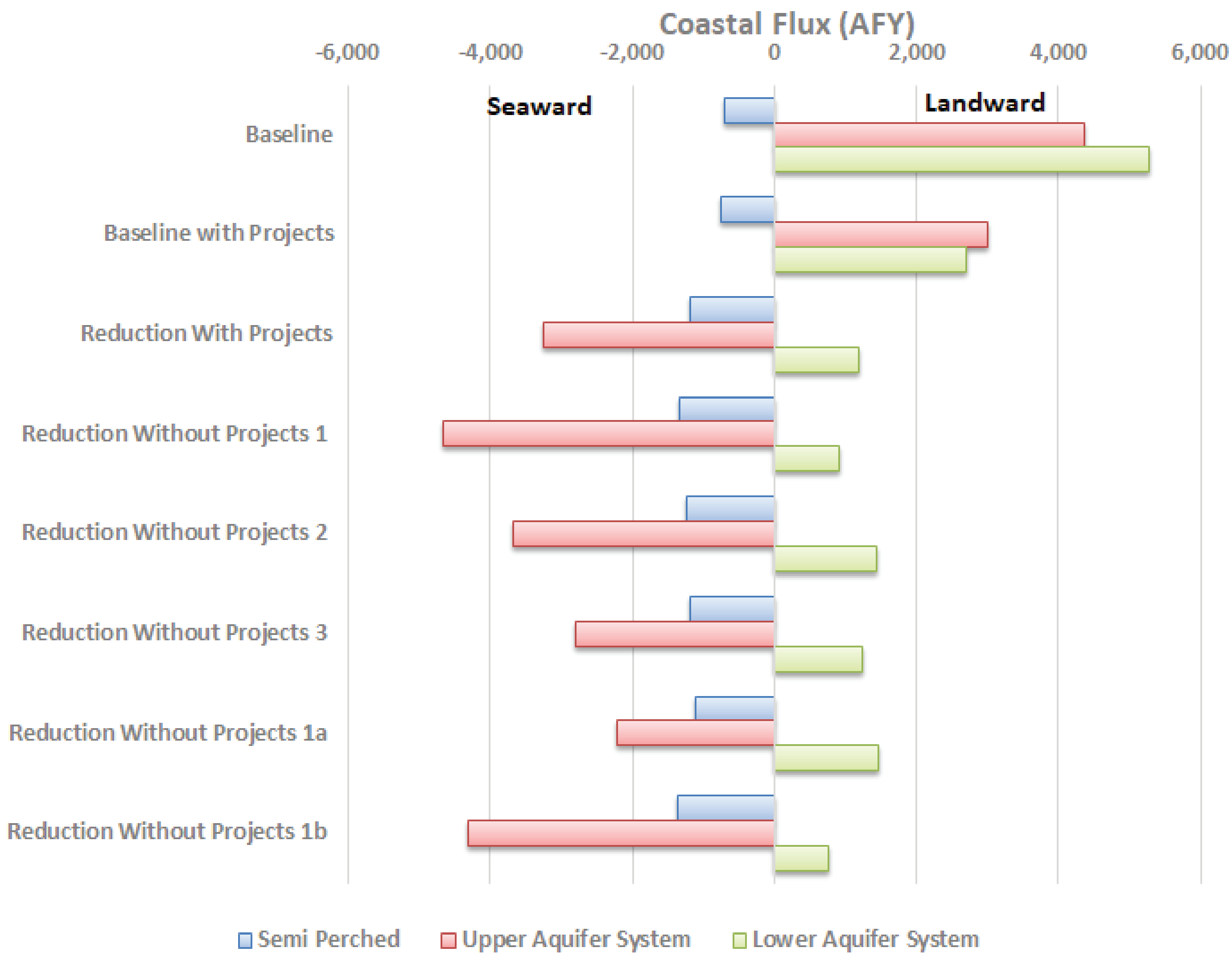

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FIGURE 2-51

Coastal Flux From the UWCD Model Scenarios

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