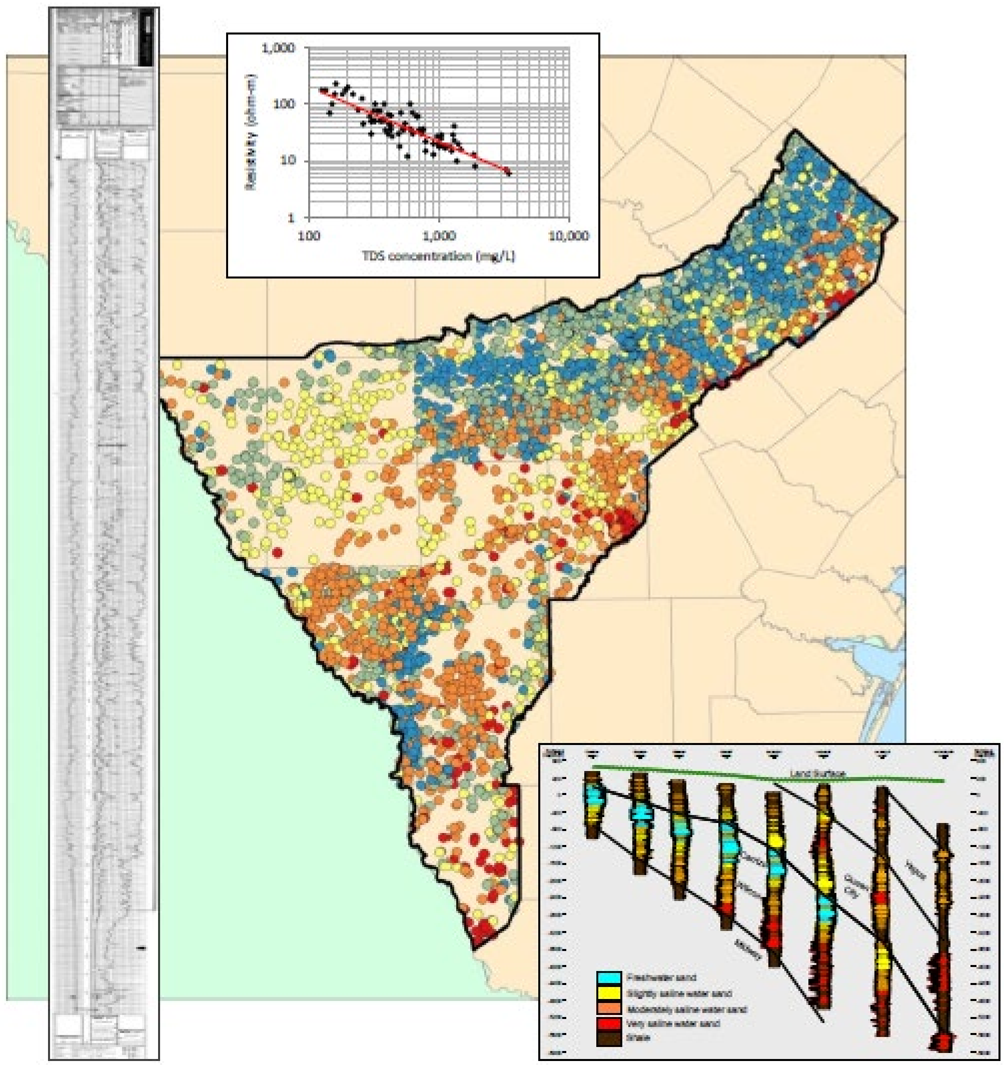
# Fresh, Brackish, and Saline Groundwater Resources in the Carrizo-Wilcox Aquifer in Groundwater Management Area 13—Location, Quantification, Producibility, and Impacts





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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| °F | degrees Fahrenheit |
| amsl | above mean sea level |
| BEG | Bureau of Economic Geology |
| cm/s | centimeters per second |
| $C_w$ | specific conductivity |
| $C_t$ | proportionality constant |
| Ft | feet |
| ft/day | feet per day |
| GAM | groundwater availability model |
| GCD | groundwater conservation district |
| GHB | general head boundary |
| GHS | geohydrostratigraphic |
| GHSM | geohydrostratigraphic model |
| GMA | groundwater management area |
| gpm | gallons per minute |
| Kh | horizontal hydraulic conductivity |
| Kz | vertical hydraulic conductivity |
| mg/L | milligrams per liter |
| PPA | Potential Production Area |
| R | potential recharge |
| $R_t$ | formation resistivity |
| $R_w$ | water resistivity |
| SP | spontaneous potential |
| Ss | specific storage |
| STEER | South Texas Energy and Economic Roundtable |
| TDS | total dissolved solids |
| TERS | Total Estimated Recoverable Storage |
| TWDB | Texas Water Development Board |
| USGS | United States Geological Survey |

# 1 Introduction

Brackish groundwater is becoming increasingly important as fresh groundwater resources diminish. Brackish groundwater is defined as water containing between 1000 milligrams per liter (mg/L) and 10,000 mg/L total dissolved solids (TDS) (LBG-Guyton Associates, 2003). The Texas Water Development Board (TWDB) divides groundwater salinity into five categories: fresh (<1000 mg/L TDS), slightly saline (1000–3000 mg/L TDS), moderately saline (3000–10,000 mg/L TDS), very saline (10,000-35,000 mg/L TDS), and brine (>35,000 mg/L TDS) (Winslow and Kister, 1956). Reliable maps and models of brackish and saline groundwater resources are needed for planning purposes to meet rising water demands. Brackish groundwater is usable with minimal treatment for many purposes in agricultural and oil field operations and may be better suited than sea water (35,000 mg/L TDS) for desalination. For example, in Groundwater Management Area (GMA) 13 in South Texas, brackish groundwater in the Carrizo–Wilcox aquifer is a potential source of water for hydraulic fracturing in the Eagle Ford Shale play (Scanlon et al., 2014).

Brackish groundwater is difficult to distinguish and quantify because few direct salinity measurements are available. Most chemical analyses of formation water samples are either from freshwater aquifers or from oil field brines. Geophysical logs can help fill the gap between fresh groundwater and formation brine. Geophysical log interpretation spans the entire groundwater flow regime from outcrop to deep subsurface and from fresh groundwater to brine. Geophysical logs provide continuous vertical records of the electrical properties of both rocks and fluids in wells, whereas groundwater sample analysis provides only point-sourced data. However, hydrochemistry data from groundwater sampling are needed to calibrate geophysical log interpretations. This study characterizes brackish groundwater distribution and quantification using four integrated approaches: (1) groundwater quality and hydrochemistry as context for salinity mapping and to better understand salinity sources, (2) geophysical log (electric log) interpretation of groundwater salinity to map brackish groundwater, (3) calculation of volumes of fresh, brackish, and saline groundwater to quantify the resource, and (4) groundwater modeling to help predict the impacts of brackish groundwater production. This report covers the first half of our study of brackish groundwater resources in GMA 13—the Carrizo–Wilcox Aquifer. The second half of the study will cover the Queen City–Sparta Aquifer.

# 2 Hydrogeologic Setting

The Wilcox Group is a thick succession of fluvial-deltaic sandstone and shale that was deposited during the Late Paleocene and Early Eocene in the first major Cenozoic progradational episode into the Gulf of Mexico Basin (Fisher and McGowen, 1967; Galloway et al., 2000, 2011). The onshore Texas Wilcox Group is divided into three intervals. Lower and middle Wilcox sandstones are thickest along the upper Texas coast (Houston Embayment), whereas upper Wilcox sandstones are thickest in South Texas (Rio Grande Embayment) (Bebout and others, 1982; Xue and Galloway, 1993, 1995). In South Texas the Carrizo Formation is the updip equivalent of the upper Wilcox interval (Hargis, 1985, 1986, 2009). Carrizo fluvial facies updip are contiguous with upper Wilcox deltaic facies downdip (Hamlin, 1988). The middle and lower

Wilcox intervals were deposited in a variety of coastal plain and marine environments and are generally less sandy than the Carrizo–upper Wilcox interval. The study area covers the Rio Grande Embayment and the southern flank of the San Marcos Arch. The study area includes most of GMA 13 except Maverick and Zapata counties. The Wilcox Group ranges in thickness for a few hundred feet (ft) at outcrop to 5000 ft along the southeastern boundary of GMA 13. The Wilcox Group dips gently to the southeast at 50 to 150 feet per mile, and the top of the Carrizo–Wilcox Aquifer is 4,000 to 6,000 ft deep along the southeastern boundary of GMA 13.

Carrizo–Wilcox sands form one of the most extensive and productive aquifers in Texas. In South Texas almost the entire fresh groundwater resource is located in Carrizo–upper Wilcox sands. Fresh groundwater extends as far as 50 mile downdip from the outcrop to as deep as 5000 ft below sea level (Klemt, et al., 1976; Hamlin, 1988). Middle and lower Wilcox sands contain primarily brackish and saline groundwater. The middle Wilcox interval is shale-dominated and generally forms an aquitard between the lower Wilcox interval and the Carrizo–upper Wilcox interval. The Carrizo–Wilcox aquifer is variably consolidated and includes sands and sandstones, both of which are referred to as sands in this report.

# 3 Groundwater Quality

## 3.1 Previous Studies

Understanding groundwater quality is important for interpreting geophysical logs and understanding the evolution of the groundwater chemistry to assess potential sources of salinity. Many factors may influence groundwater quality, including recharge rates (current and paleo-recharge rates), composition of recharge water, lithology, interconnectedness of different lithologies, mineralogy, geochemical processes (mixing, cation exchange), residence time of groundwater, cross-formational flow, faulting, and relationship between geopressure and hydropressure systems. We quantified spatial variability in recharge rates for the Carrizo-Wilcox aquifer for the GAM study (Reedy et al., 2009). Previous studies have noted a distinct band of relatively dilute, low chloride, sodium, and sulfate water downdip from the outcrop zone that has been attributed to paleo-recharge of Pleistocene water (Green et al., 2008). Hamlin (1988) characterized the regional hydrochemistry of this region, describing the evolution of water from predominantly calcium-bicarbonate to sodium-bicarbonate water, attributed to cation exchange. Kreitler et al. (2013) noted the evolution of groundwater from mixed cation mixed anion (chloride, sulfate) type water near the outcrop zone to sodium bicarbonate water further down dip, confirming the findings of Hamlin (1988). Increases in down dip salinity were attributed mostly to increases in bicarbonate concentrations, rather than large increases in chloride concentrations. The importance of open and closed systems relative to CO2 and down dip coalification of organic material forming methane and CO2 are considered important in controlling bicarbonate concentrations. Hamlin et al. (1988) also noted a relationship between bicarbonate and pH up to pH of 8.6 with increases with distance along flow paths. Carbonic acid is believed to be derived from methane fermentation at depth (Hamlin, 1988). Studies by Kreitler et al. (2013) suggested limited cross formational flow impacting water quality. Large variations in water quality were identified in some regions where faults are mapped. Two vertical cross sections with detailed sampling and analyses along with data from multiple depths in wells from the San Antonio Water Systems provide valuable data in assessing vertical stratification of groundwater quality. Isotopic age dating from many studies can help determine variations in groundwater residence time and relationship to groundwater chemistry (Pearson and White, 1967; Castro and Goblet, 2003; Kreitler et al., 2013). This proposed study builds on a previous study conducted by the Bureau to assess the availability of fresh and brackish groundwater to support hydraulic fracturing in the region where we mapped groundwater TDS in the various aquifer units in the study region (Scanlon et al., 2014).

## 3.2 Groundwater Quality Data Sources

We developed a geochemical database that include groundwater quality data ±5% charge balance. The database includes data 1462 groundwater samples from the TWDB database in the Carrizo Wilcox aquifer (**Table 3-1**, **Figure 3-1**). Data on produced water quality were obtained from the United States Geological Survey (USGS) produced water quality database (205 wells). Operators in the Eagle Ford play report drilling and using brackish water with TDS up to 36,000 mg/L in Dewitt County (6,000 ft deep wells) (Scanlon et al., 2014). We obtained data on groundwater quality for 430 wells from the South Texas Energy and Economic Roundtable (STEER) through the TWDB BRACS group (John Meyer, pers. comm.) (**Figure 3-2**). A study on brackish water conducted at Texas A&M did not include any data (McVay et al., 2015).

## 3.3 Characterization of Groundwater Quality

The primary purpose of this characterization effort was to map hydrochemical facies to delineate areas of relatively uniform chemical composition for application of the empirical approach of TDS mapping from well logs. Additional benefits include a deeper understanding of salinity sources and distributions that will be important for development of brackish groundwater.

We evaluated the distribution of TDS and assessed variations in TDS in the Carrizo Wilcox aquifer using groundwater data predominantly from the TWDB. TDS in and adjacent to the outcrop zone in the Carrizo Wilcox aquifer generally ranges from 500 – 3,000 mg/L (**Figure 3-3**). There is generally a band of lower TDS water (mostly ≤500 mg/L) further downdip. This zone of fresher groundwater has been attributed to paleo-recharge of Pleistocene age water (Green et al., 2008). Slightly higher TDS (500 – 3,000 mg/L) is found further downdip, mostly in the southwest region (Webb, McMullen, and LaSalle counties). The generally higher in the southwest relative to the northeast was attributed to finer grained sediments in the southwest in a previous analysis (Hamlin et al., 1988). TDS exceeding 3,000 mg/L is found in localized areas throughout the aquifer. Chloride concentrations are also shown, with highest concentrations near the outcrop zone (250 – 7,500 mg/L), and fresher water downdip, with chloride ranging mostly from 25 – 50 mg/L. High chloride concentrations are also found further downdip (100 – 7,500 mg/L), particularly in the southwest region, consistent with the TDS distribution.

TDS of produced waters from oil and gas wells provide an upper bound on TDS in groundwater in the region (**Figure 3-4**). Sampling of produced waters is limited with clusters of wells in different regions, e.g. Karnes, Atascosa, and Frio counties. The limited data suggest that the TDS of produced waters generally increase downdip from 10,000 – 30,000 furthest updip to 30,000 – 320,000 furthest downdip. These produced waters are based on analyses from conventional wells mostly sampled prior to 1980. The USGS recently collected samples of produced water from the Eagle Ford shale wells; however, the results are not yet available in the USGS website.

The distribution and depths of injection wells used for disposal (Underground Injection Control Class II wells) were mapped in case water disposal impacts groundwater quality in the vicinity of these wells (**Figure 3-5**). Disposal wells near the outcrop zone range from < 1000 ft to 4,000 ft. The depths of disposal wells generally increase downdip with wells ranging from 4,000 – 8,000 ft and some exceeding 8,000 ft (particularly in the southwest in Webb and Zapata counties).

Because of the importance of ionic composition of groundwater on the relationship between resistivity from electric logs and TDS (Estepp, 1998, 2010), we examined the ionic makeup of the water and characterized the dominant composition of the water in the Carrizo Wilcox aquifer. Hydrochemical facies were mapped relative to the Carrizo Wilcox aquifer (**Figure 3-6**). The hydrochemical facies in the Carrizo-Wilcox aquifer vary from predominantly Ca HCO3 and Ca Cl near the outcrop zone. In the central region of the aquifer Ca HCO3 water is generally further downdip than Ca HCO3 water, mostly in Atascosa and Frio counties. High TDS downdip in the Carrizo-Wilcox aquifer is generally associated with sodium-bicarbonate type water, rather than sodium-chloride type water (Figure 3-6). Localized zones of Na-HCO3 and Na-Cl water are found mostly in Dimmit County and scattered throughout the aquifer. Major cation and anion water types that make up the water types are also shown (**Figures 3-7 and 3-8**).

## 3.4 Water Quality Relative to Suitability for Desalination or Hydraulic Fracturing

The suitability of the brackish groundwater for desalination and hydraulic fracturing was examined by evaluating the distribution of relevant elements. Parameters of concern for desalination using reverse osmosis (RO) are described in Greenlee et al. (2009) and Meyer et al. (2012). High concentrations of hydrated silica can foul RO membranes. Hydrated silica concentrations are generally low, mostly ≤30 mg/L (**Figure 3-9**). Highest Si concentrations are found in the outcrop zone in the central and norther portions of the aquifer. Isolated zones of high Si are also found in western Dimmit county and furthest downdip in McMullen, Atascosa and Karnes counties (30 – 50 mg/L). Elevated levels of iron are also a concern because of the potential for iron precipitation and fouling of membranes; therefore, high iron concentrations generally require pretreatment. Iron concentrations are generally highest near the outcrop zone in the central and northern regions, collocated with high TDS (500 – 68,000 ug/L, Figure 10). Iron concentrations through the remainder of the aquifer are generally low, mostly ≤500 ug/L. The presence of radionuclides was evaluated because high levels of Naturally Occurring Radioactive Materials are a problem for concentrate disposal. The number of analyses of radionuclides is limited. Levels of radium-226 are generally low, mostly ≤5 pCi/L with slightly higher levels in localized zones in the central region near the border between Frio and Medina counties (**Figure 3-11**). Uranium concentrations are also generally low, mostly < 2 ug/L with slightly higher concentrations (3 – 43 ug/L) in the southwest in Zavala county (**Figure 3-12**).

While hydraulic fracturing technologies are continually evolving to allow use of more brackish and saline groundwater (Lebas et al., 2013), certain constituents in water may interfere with hydraulic fracturing fluids. Some elements create problems with scaling, including barium sulfate and hardness (Ca, Mg). Sulfate may also interfere with hydraulic fracturing fluids because of microbial reduction of sulfate, requiring higher levels of biocides. Boron is also a problem for hydraulic fracturing fluids that use cross link gels that contain boron. Areal maps of these ions were developed to assess suitability of brackish groundwater for hydraulic fracturing. The areal map of sulfate shows highest concentrations near the outcrop zone, mostly ranging from 100 – 1,900 mg/L (**Figure 3-13**). Further downdip sulfate concentrations range from 50 – 100 mg/L in the southwest (Zavala, Frio, and La Salle counties). Downdip sulfate concentrations further north are even lower, generally ranging from < 25 – 50 mg/L. Analyses of barium are limited, making it difficult to determine any systematic trends (**Figure 3-14**). In much of the region lower barium concentrations (≤75 ug/L) are generally found further downdip of higher concentrations, mostly ranging from 100 – 200 ug/L. Boron concentrations are ≤200 ug/L throughout much of the aquifer, with slightly higher concentrations in the southwest (200 - 26,500 ug/L, Dimmit, La Salle and Webb counties) (**Figure 3-15**).

In summary, the water chemistry is generally considered suitable for desalination with generally low silica and iron concentrations. Low levels of radionuclides should reduce their impact on concentrate disposal. Water quality issues related to use for hydraulic fracturing may be problematic near the outcrop zone where sulfate levels and barium concentrations and lower levels further downdip. Limited sampling of boron underscores the need for more intensive sampling to increase the reliability of the areal maps.

**Table 3-1. Well depth ranges and numbers of samples for various water constituent analyses of for samples from the Carrizo-Wilcox aquifer (TWDB) and from producing oil and gas wells (USGS) in the study area.**

| Source | Minimum Depth (ft) | Maximum Depth (ft) | TDS | Major Ions | SiO2 | Fe | Ra-226 | U | Ba | B |
|---|---|---|---|---|---|---|---|---|---|---|
| TWDB | 18 | 6,211 | 1,462 | 1,462 | 1,345 | 634 | 81 | 154 | 408 | 570 |
| USGS | 1,494 | 12,388 | 205 | | | | | | | |

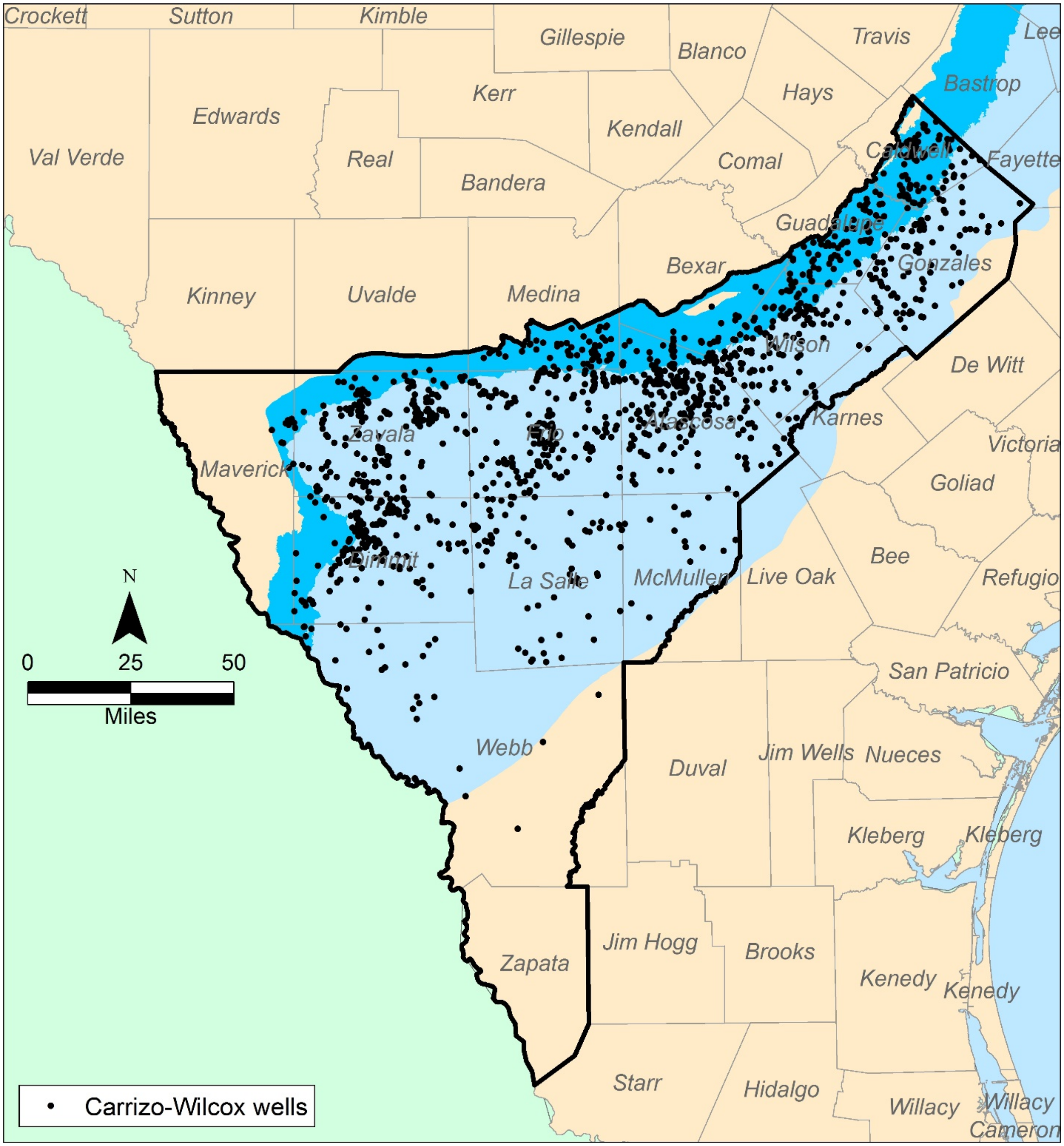


**Figure 3-1. Location of wells with groundwater chemical analyses in the Carrizo-Wilcox aquifer from the TWDB database.**

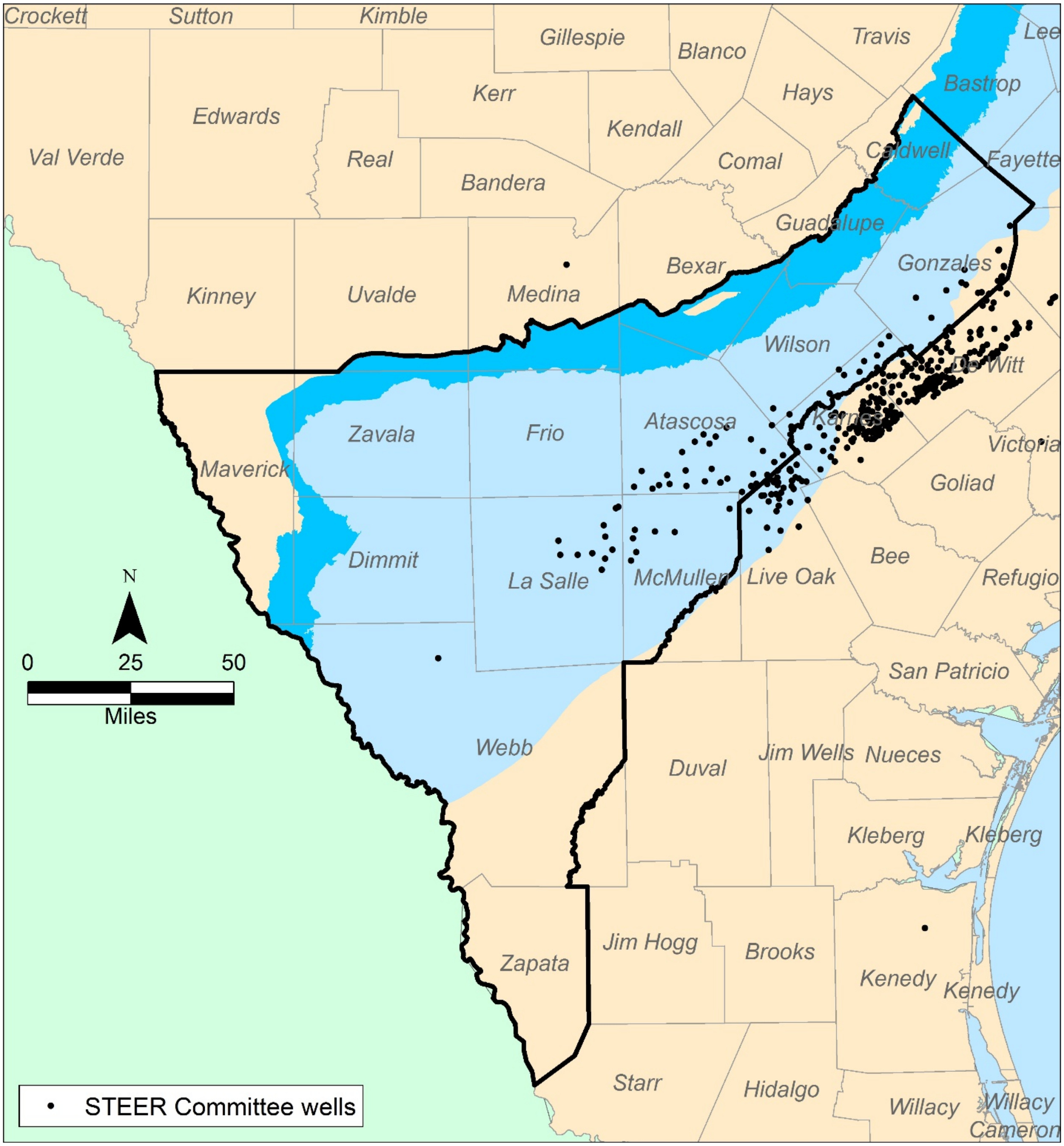


**Figure 3-2.** **Location of wells with groundwater chemical analyses obtained from STEER. These wells provide information on water quality in the Queen City, Sparta, and Gulf Coast aquifers.**

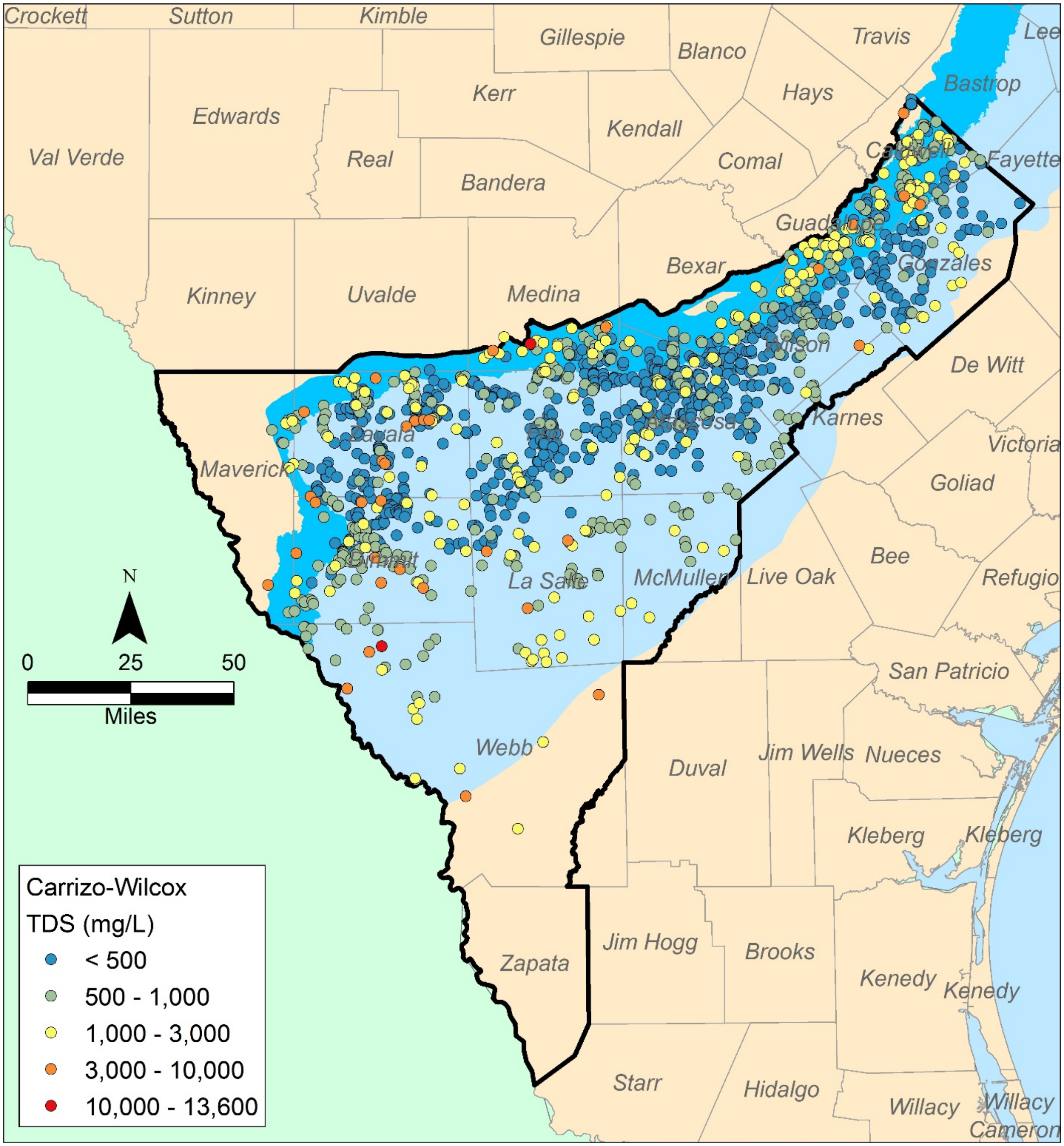


**Figure 3-3.** **Distribution of groundwater total dissolved solids (TDS) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

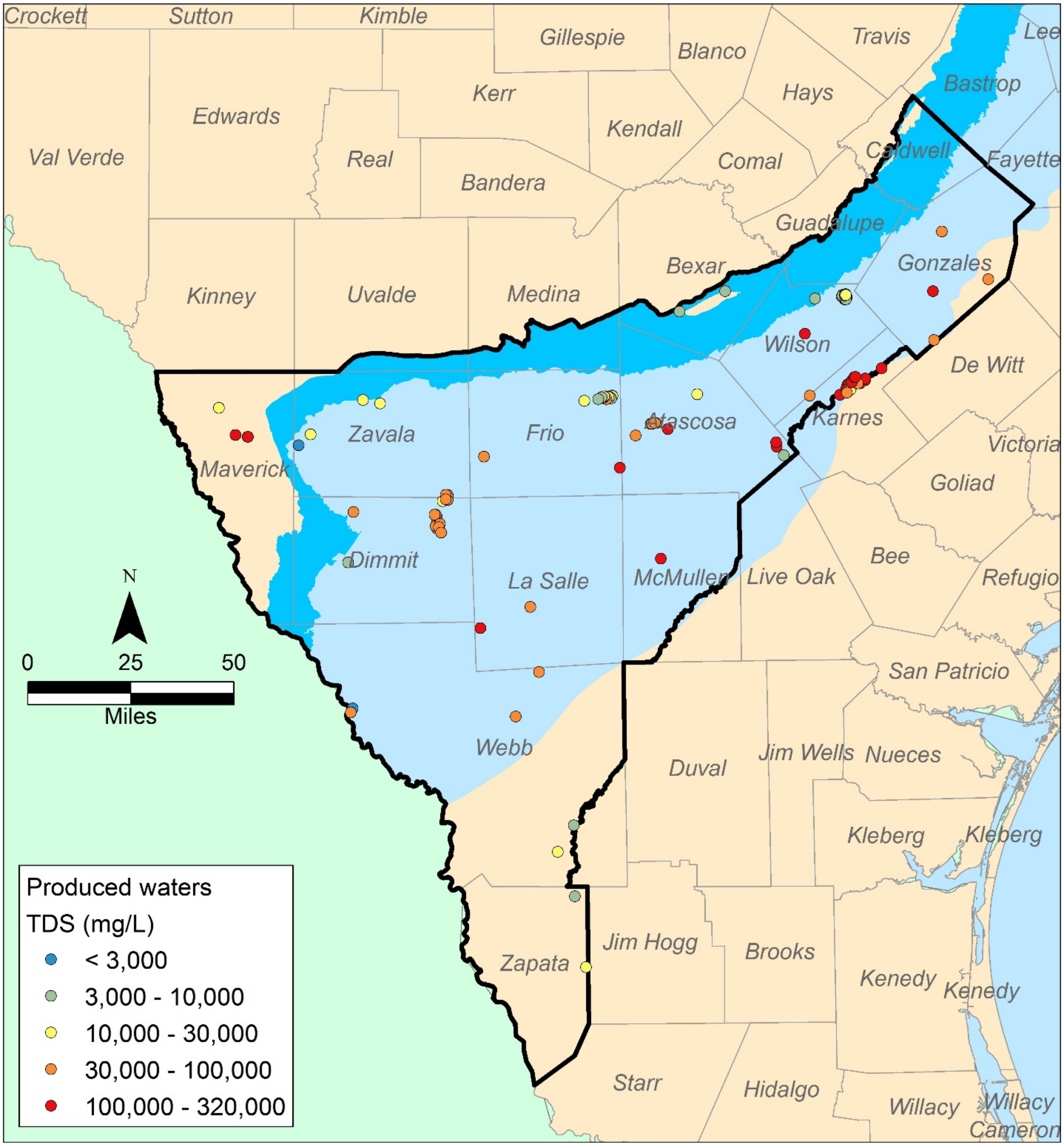


**Figure 3-4.** **Location and TDS concentrations of wells with water samples from the USGS Produced Waters database (http://energy.usgs.gov/EnvironmentalAspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx#3822349-data)**

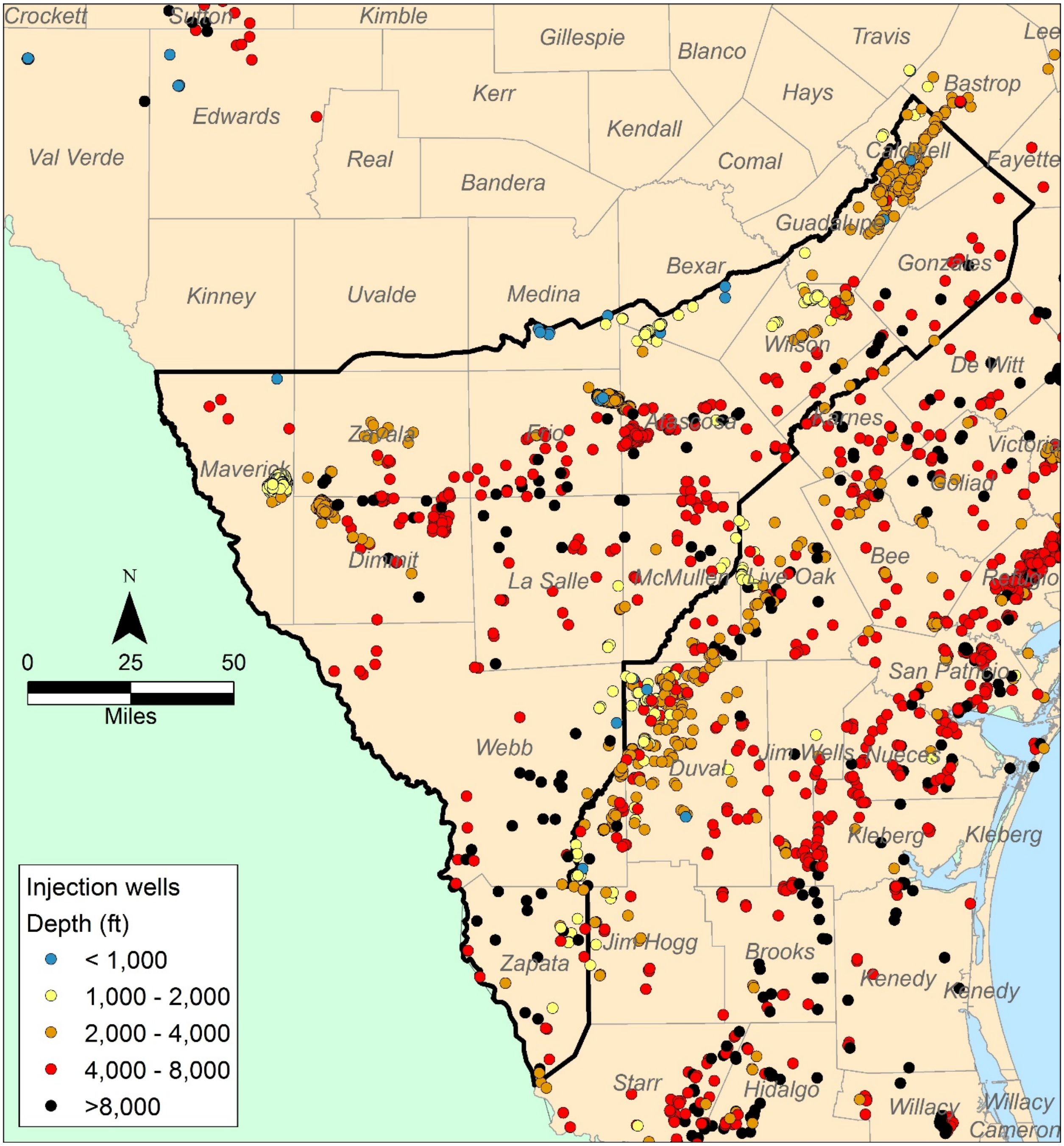


**Figure 3-5. Location and depths of injection wells in the region. Injection wells include Salt Water Disposal wells and wells with injection into producing horizons.**

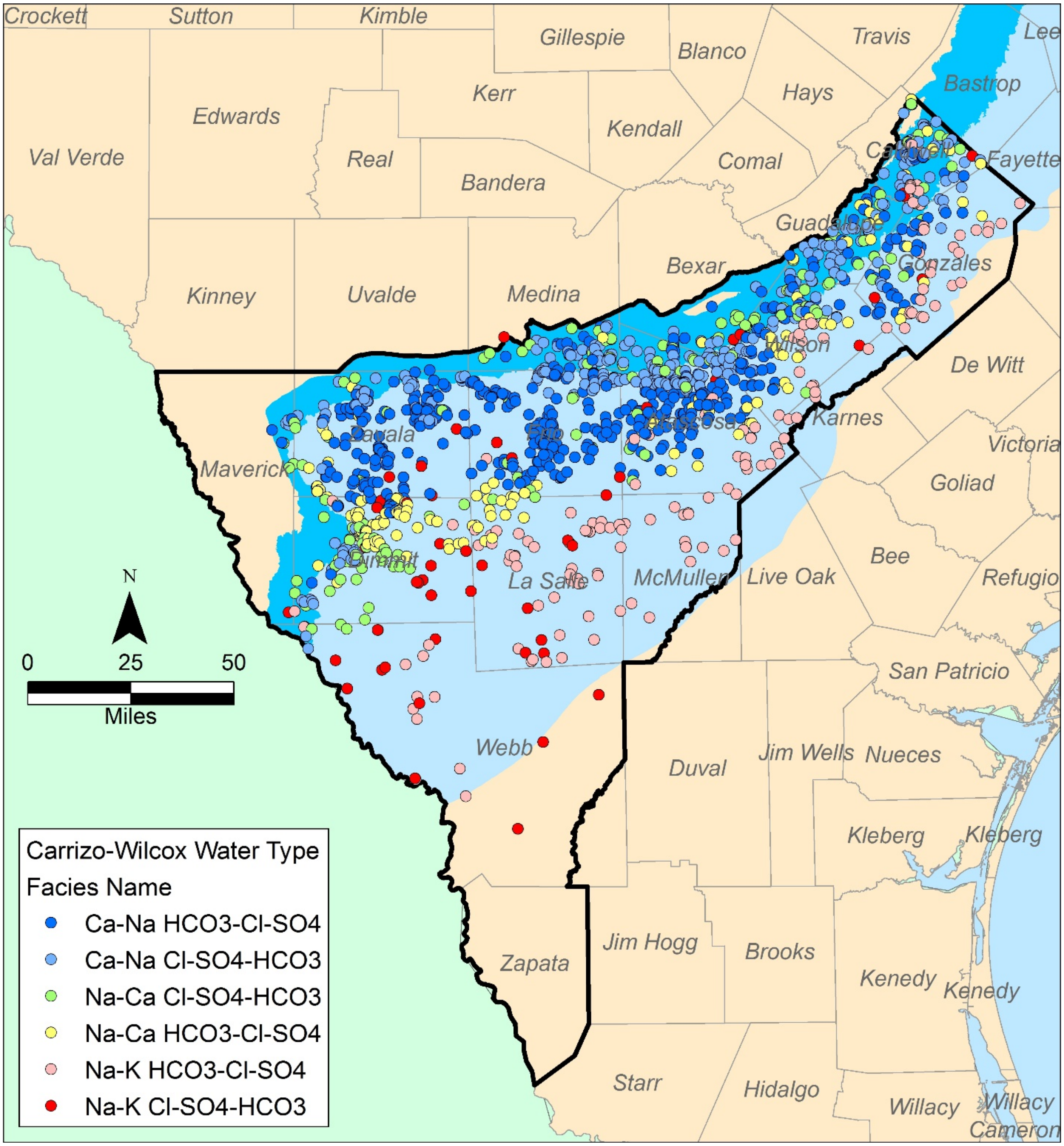


**Figure 3-6.** **Distribution of dominant hydrochemical facies in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

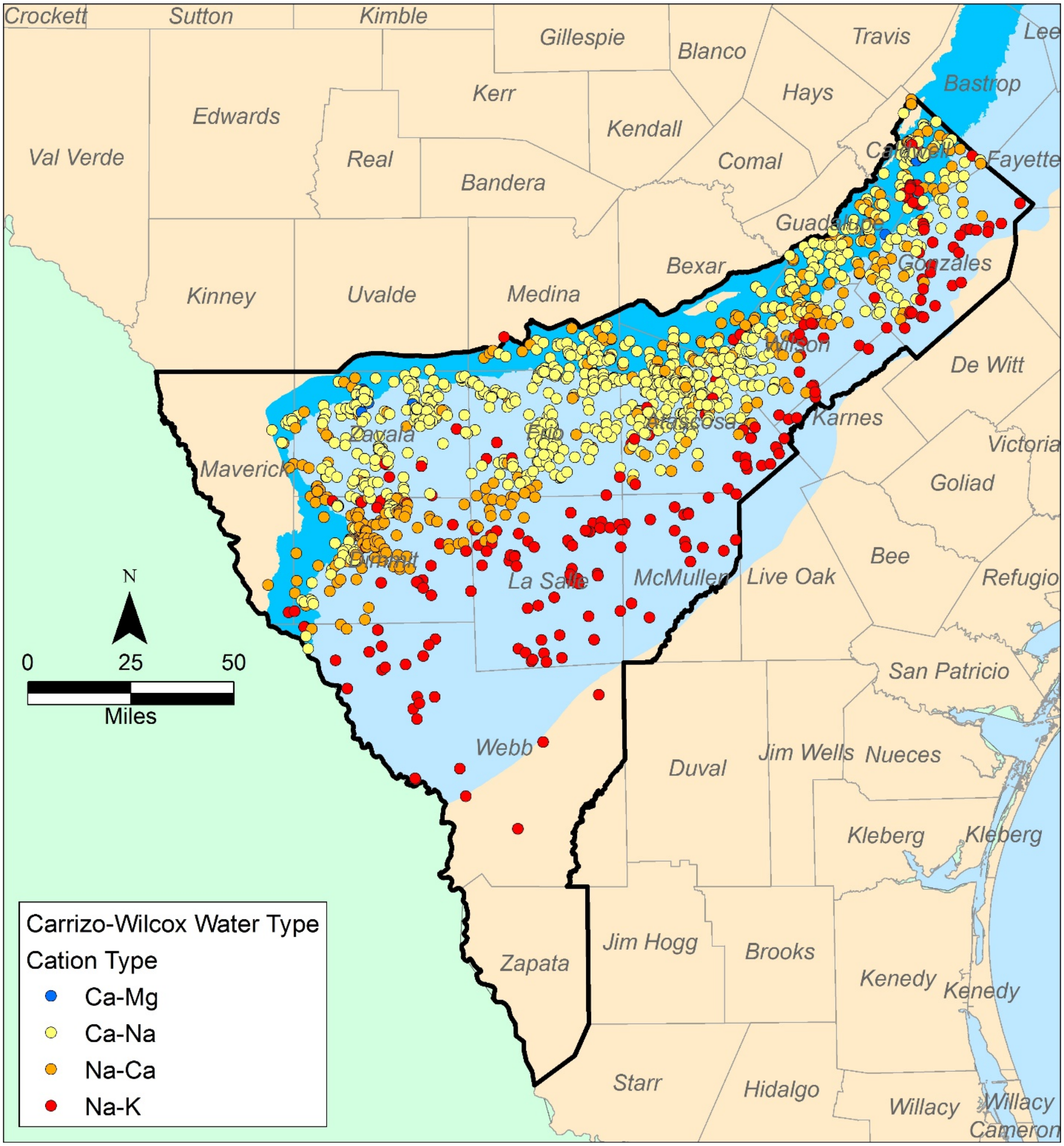


**Figure 3-7.** **Distribution of dominant cation hydrochemical facies in the Carrizo-Wilcox aquifer based on the most recent chemical analyses. End members (Ca-Mg and Na-K) represent waters with those constituents representing at least 90% of all cations. Ca-Na represents waters with Ca representing between 50% and 90% of all cations and Na-Ca represents waters with Na representing between 50% and 90% of all cations.**

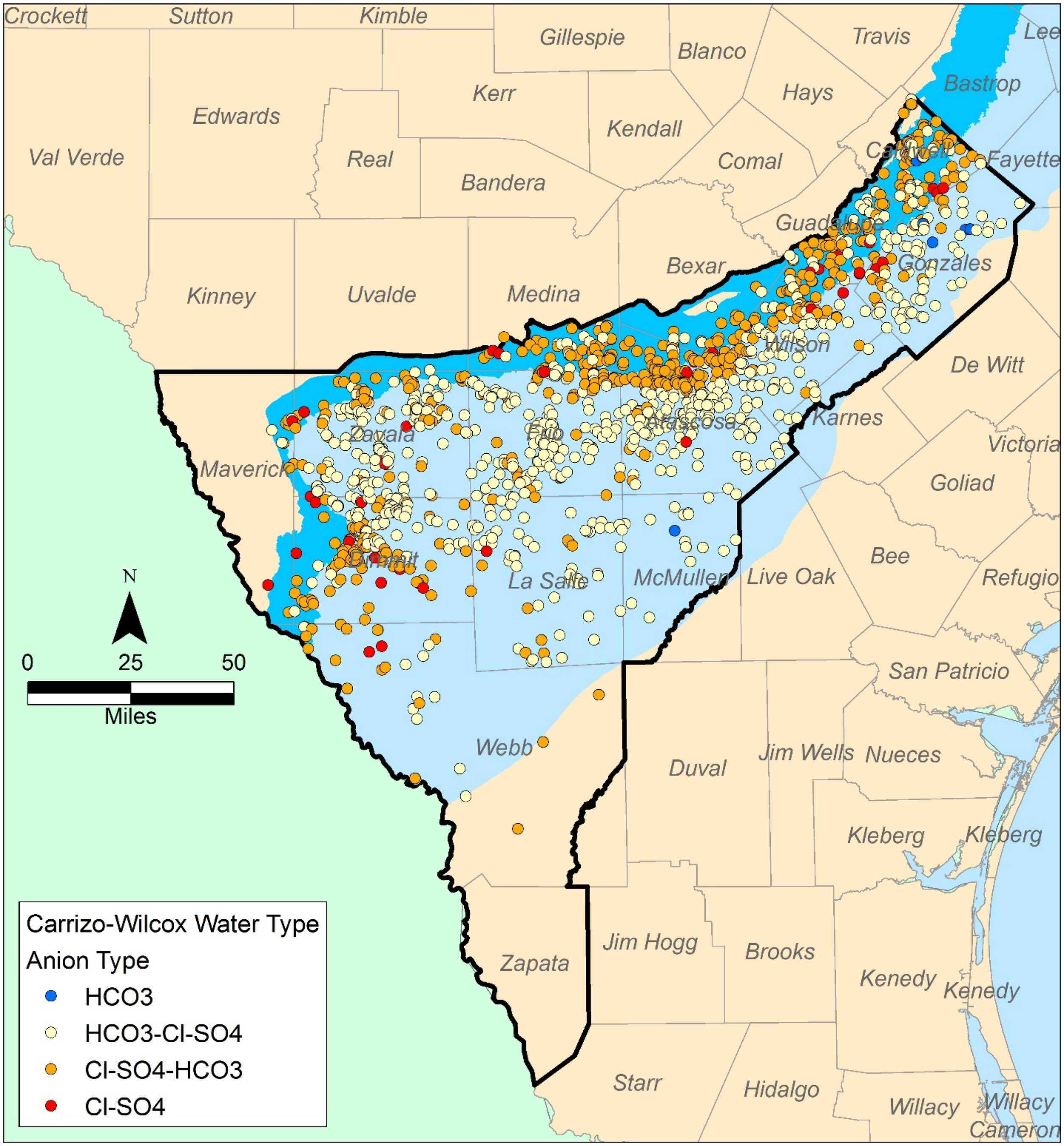


**Figure 3-8. Distribution of dominant anion hydrochemical facies in the Carrizo-Wilcox aquifer based on the most recent chemical analyses. End members (HCO3 and Cl-SO4) represent waters with those constituents representing at least 90% of all anions. HCO3-Cl-SO4 represents waters with HCO3 representing between 50% and 90% of all anions and Cl-SO4-HCO3 represents waters with Cl-SO4 representing between 50% and 90% of all anions.**

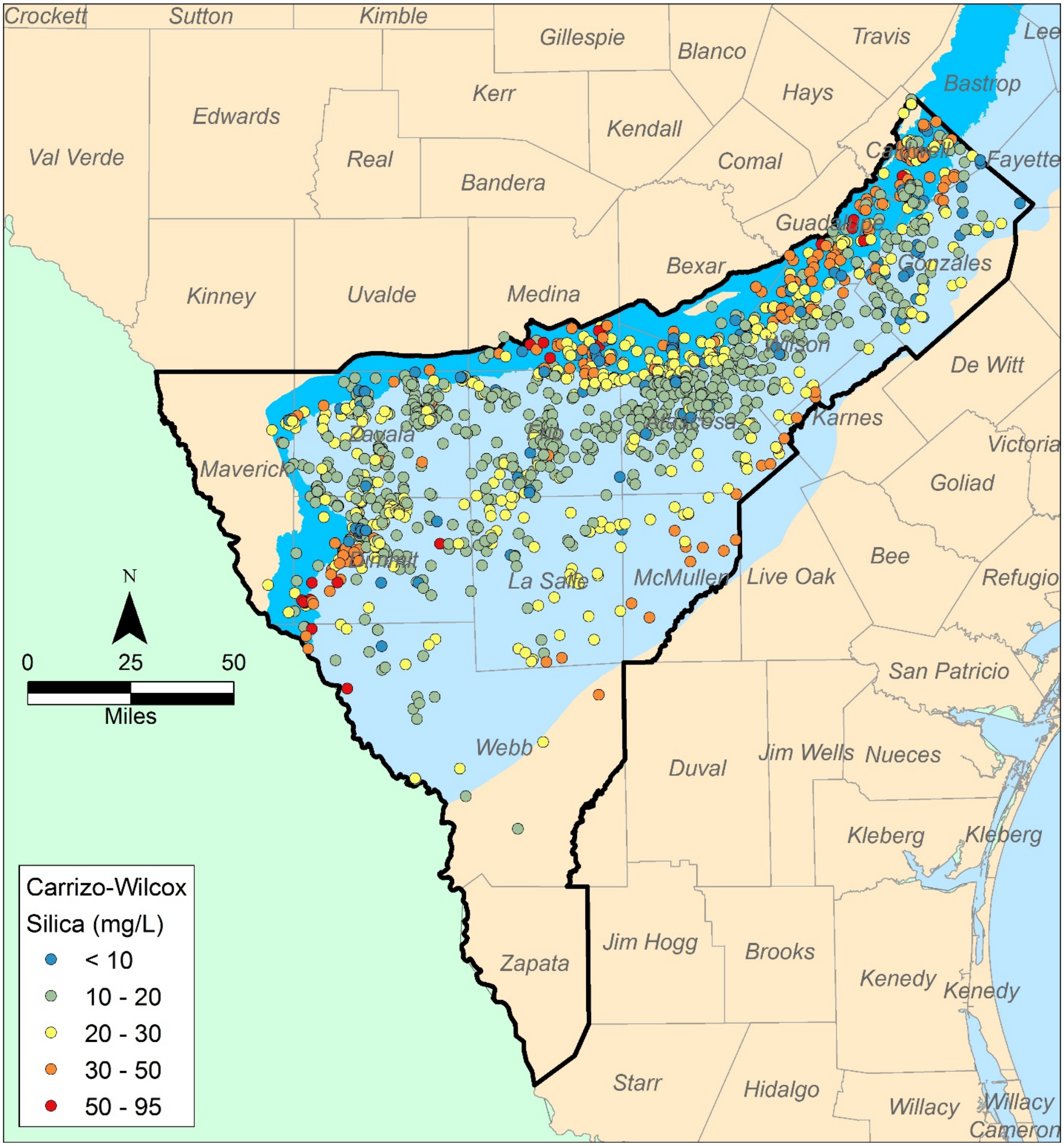


**Figure 3-9.** **Distribution of groundwater silica (SiO2) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

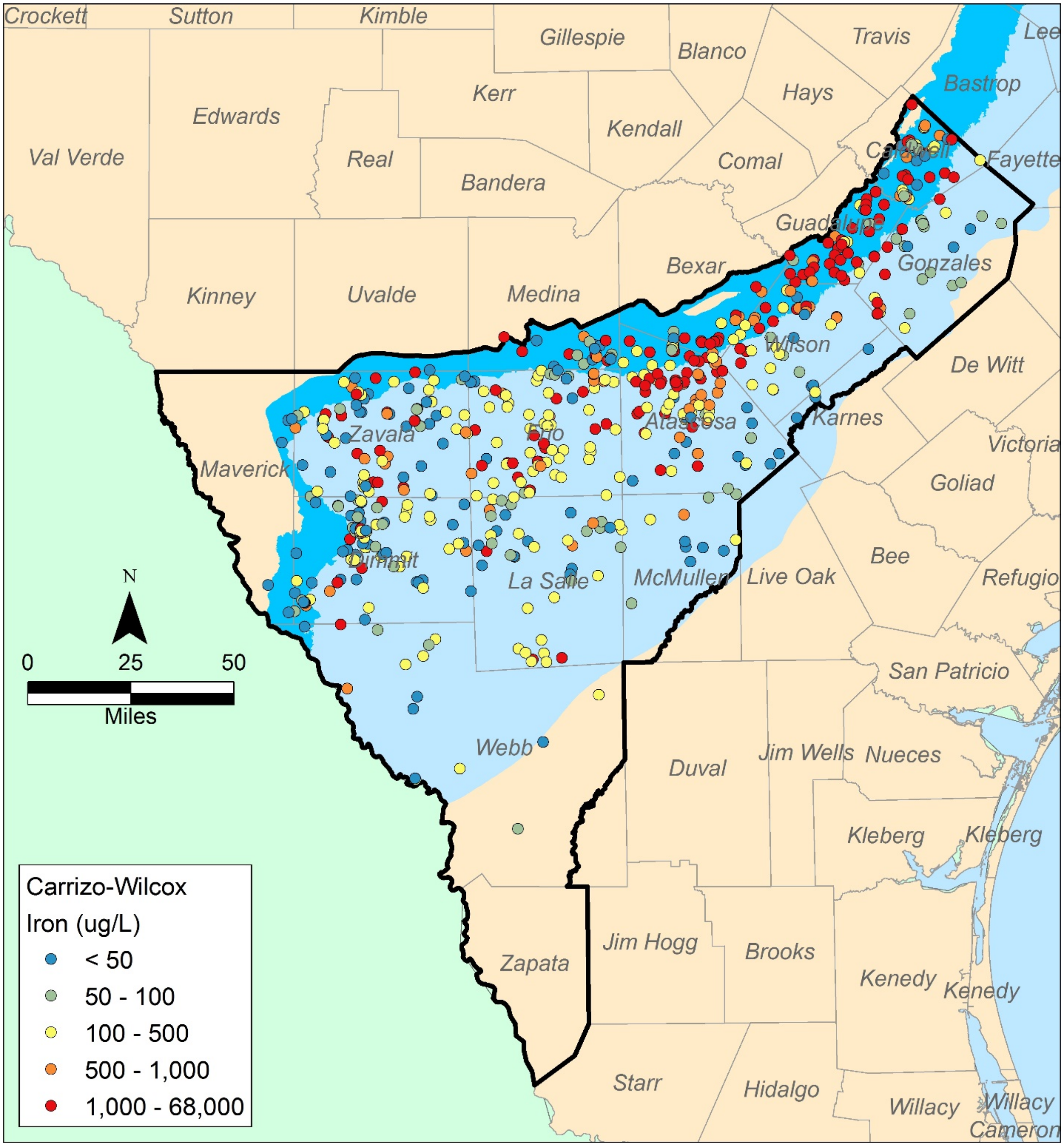


**Figure 3-10.** **Distribution of groundwater iron (Fe) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

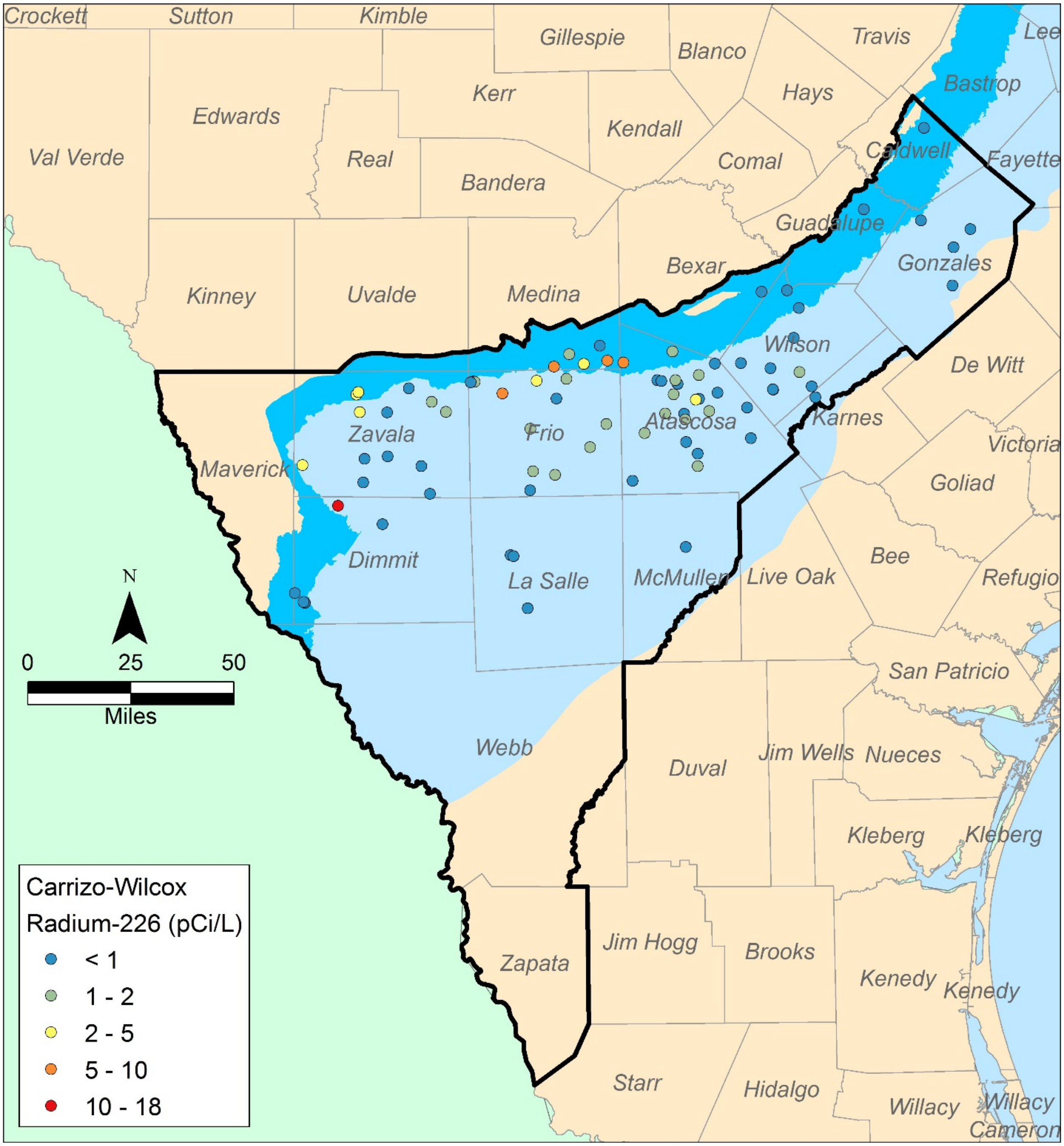


**Figure 3-11.** **Distribution of groundwater radium-226 (Ra-226) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

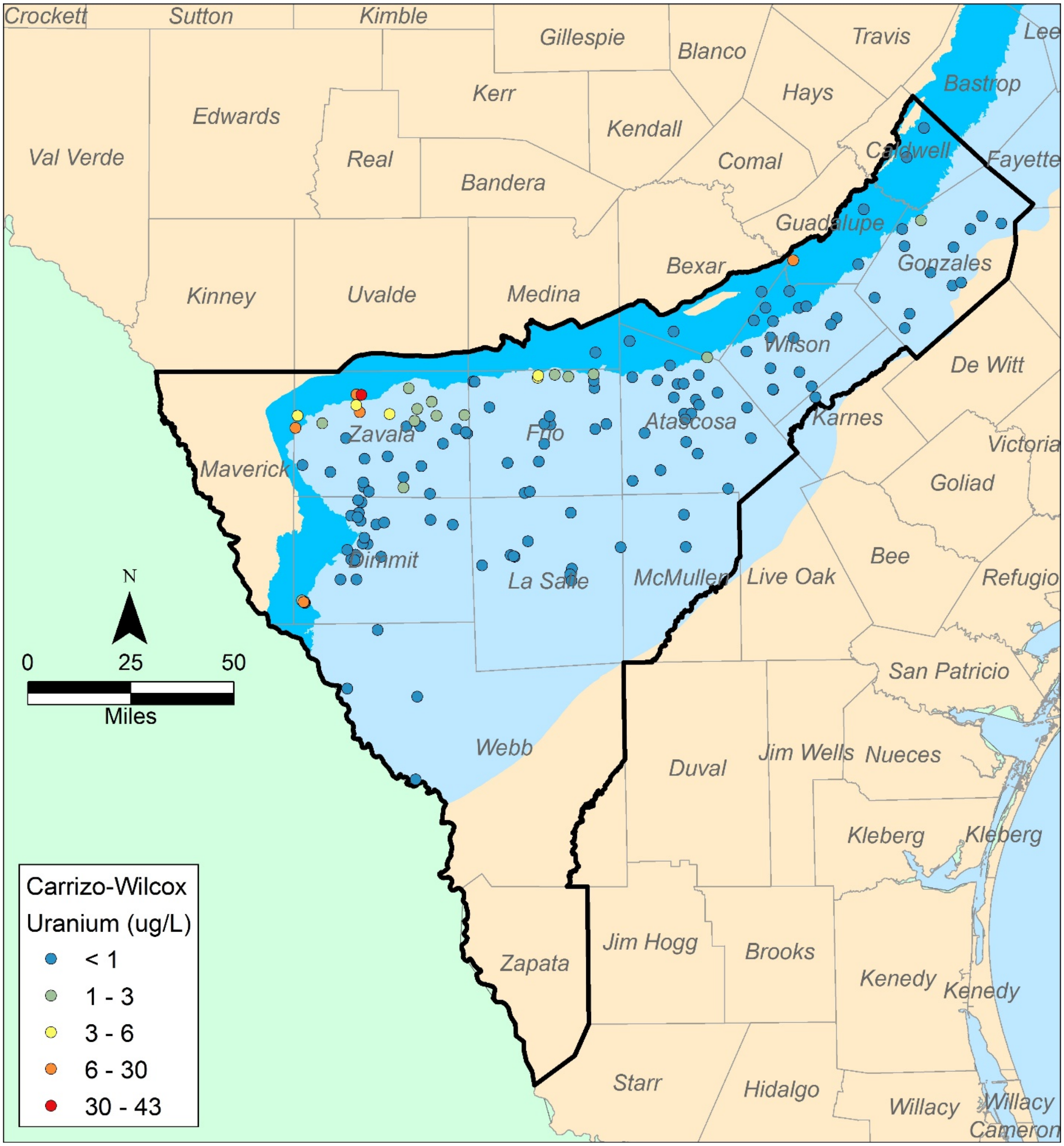


**Figure 3-12. Distribution of groundwater uranium (U) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

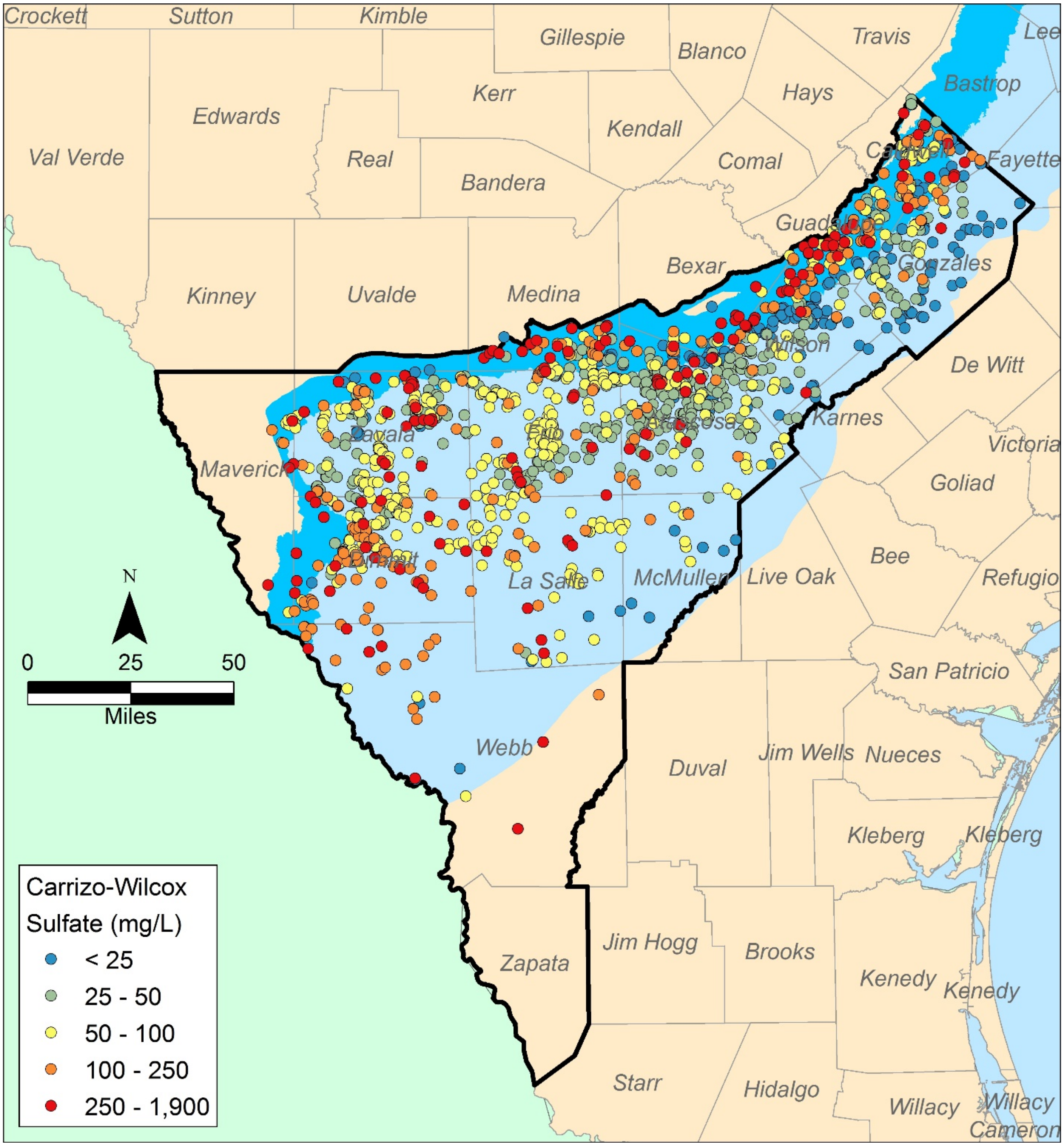


**Figure 3-13. Distribution of groundwater sulfate (SO4) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

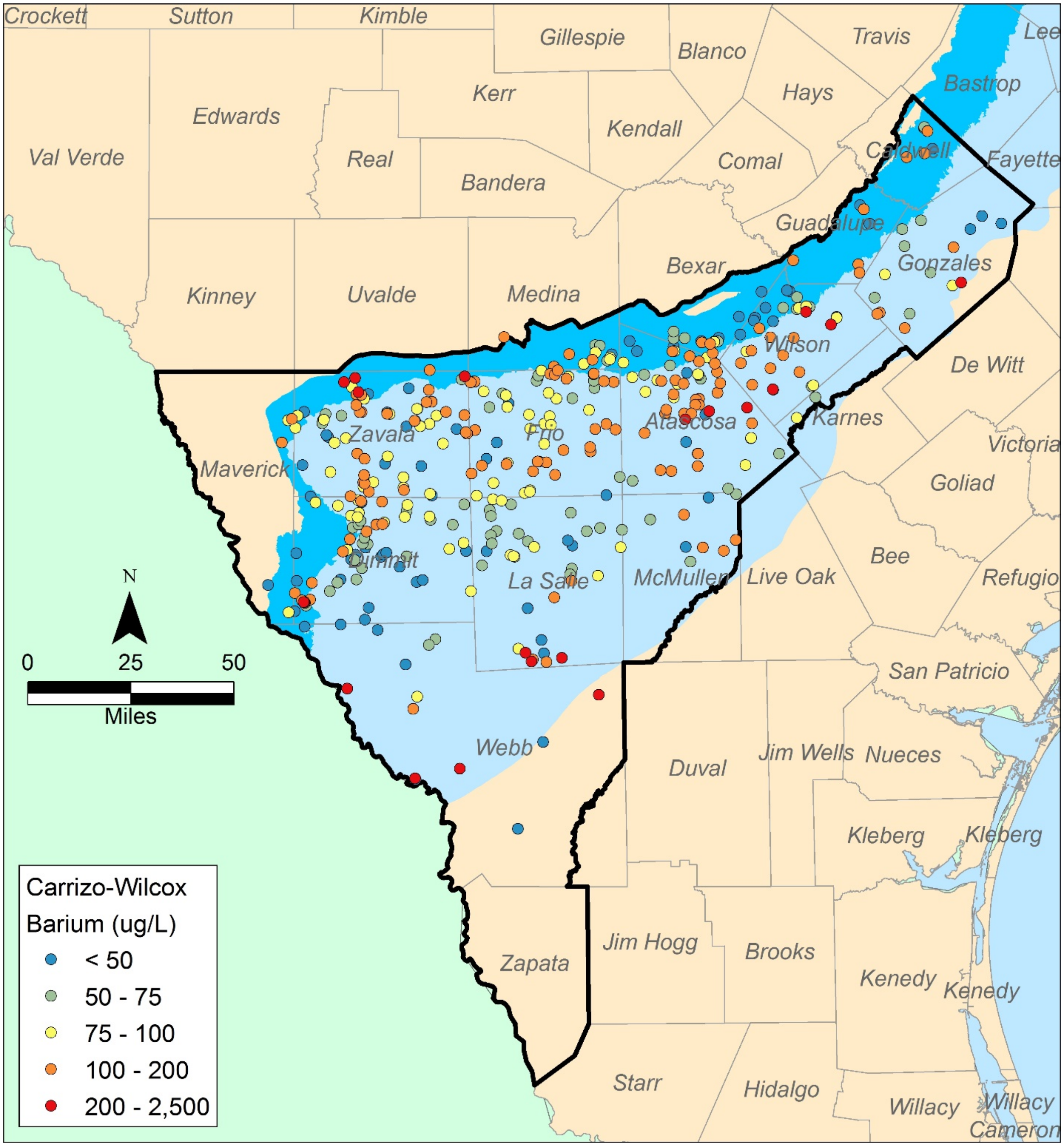


**Figure 3-14.** **Distribution of groundwater barium (Ba) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

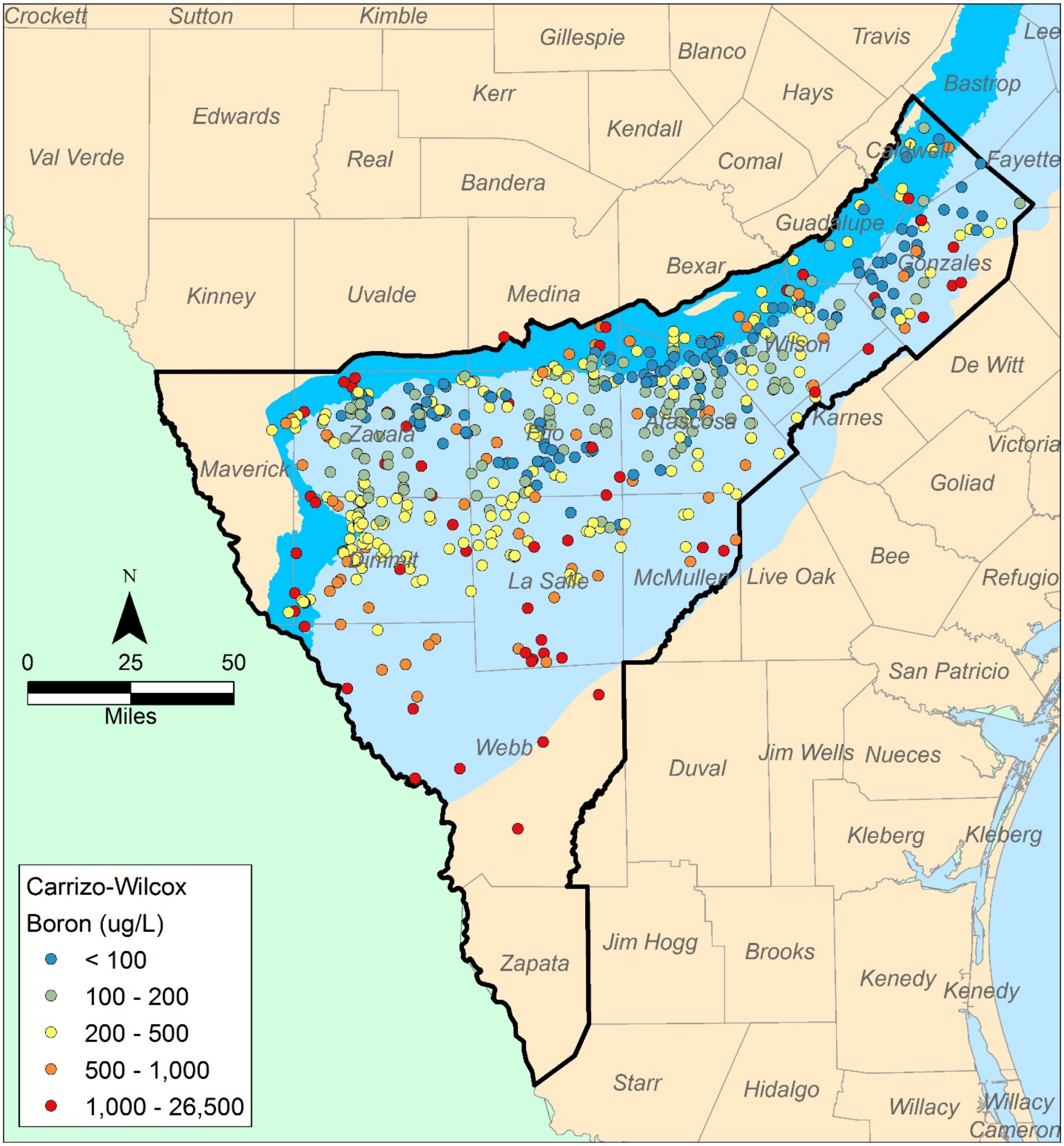


**Figure 3-15. Distribution of groundwater boron (B) concentrations in the Carrizo-Wilcox aquifer based on the most recent chemical analyses.**

# 4 Geophysical Log Interpretation

## 4.1 Methods

### *4.1.1 Geophysical Log Database*

Geophysical logs (electric logs) from 382 wells were used to correlate and map stratigraphy and to estimate groundwater salinity (**Figure 4-1**). Digital logs from 191 wells were used to automate calculations and to display lithology and groundwater salinity on cross sections. Petra software (IHS, Inc.) was used for data management, interpretation, and visualization. All geophysical logs used in this study are from one or more of these publically available sources: TWDB BRACS database, Bureau of Economic Geology (BEG) Geophysical Log Facility, Railroad Commission of Texas.

### *4.1.2 Stratigraphic Correlations*

Stratigraphic correlations were guided by type logs published in regional studies (Bebout et al., 1982; Hargis, 1986, 2009; Hamlin, 1988). The depositional framework is also based on previous regional studies (Hargis, 1985, 1986, 2009; Fisher and McGowen, 1967; Bebout et al., 1982; Hamlin, 1988; Xue and Galloway, 1993, 1995). In Gulf Coast Tertiary sand/shale sequences, lithologies can be distinguished with confidence on electric logs (SP and resistivity curves) (**Figure 4-2**). Standard subsurface mapping techniques were applied to construct net sand thickness maps separately for sands containing fresh groundwater and those containing brackish groundwater. Depth maps to important salinity boundaries were also constructed. Stratigraphic and structural cross sections were constructed to show depth-related variations in lithology and groundwater quality.

### *4.1.3 Groundwater Salinity Using $R_0$ Method*

Groundwater salinity estimations are based on two methods: (1) empirical relationship between the resistivity of a water-filled formation ($R_0$) and formation water salinity; and (2) calculation of formation water resistivity ($R_w$) using a modified version of the Archie equation (Jones and Buford, 1951; Estepp, 1998). The $R_0$ method involves correlating deep resistivity (long normal or deep induction) with chemical analyses of groundwater samples from the same zone (Fogg and Blanchard, 1986; Hamlin et al., 1988; Collier, 1993; Estepp, 1998). The deep resistivity curve is used to minimize the effects of mud filtrate invasion. Deep $R_0$ is assumed to be approximately equal to true formation resistivity ($R_t$). Bed thickness also affects $R_0$. For beds thinner than about twice the electrode spacing, $R_0$ does not equal $R_t$ (Jones and Buford, 1951). Therefore, only sand layers greater than 10 ft thick are included on thickness maps and in volume calculations. Where water saturation is 100 percent (no hydrocarbons), $R_0$ is affected primarily by formation water salinity and hydrochemical composition, temperature, porosity, and lithology (Jones and Buford, 1951; Turcan, 1962; Alger, 1966). Hydraulic conductivity (permeability) also affects resistivity, and resistivity has been used to map recharge and groundwater flow paths (Fogg et al., 1983; Ayers and Lewis, 1985; Ayers et al., 1986). $R_0$ is most closely related to groundwater salinity in thick, clay-free sands having similar porosities, depositional facies, geographic area, and depth range. The $R_0$ method works best in unconsolidated to semi-consolidated, sand/shale sequences such as the Gulf Coast Tertiary.

To develop TDS/$R_0$ regressions, TDS values from water well chemical analyses from 166 wells were paired with $R_0$ measurements in nearby petroleum wells, taking care to identify the same zone in both wells. Median distance between wells in the pairs is 8,835 ft (**Figure 4-3**). Most of the water wells produce low TDS groundwater from the Carrizo–upper Wilcox interval; the lower Wilcox interval is poorly represented. A small set of lower Wilcox data (9 wells) was obtained from analyses of high TDS formation water produced in petroleum wells. Graphing TDS versus $R_0$ for the entire data set yielded a correlation coefficient of 0.87 (**Figure 4-4**). This relatively good correlation suggests that groundwater salinity is the dominant control on $R_0$ in shallow (<6000 ft) Carrizo–Wilcox sands in South Texas.

TDS/$R_0$ correlations were refined by dividing the study area into three smaller regions, and developing separate TDS/$R_0$ regressions for each region (**Figure 4-5**). The regions coincide with Carrizo–upper Wilcox hydrogeologic zones that have distinct lithologies, depositional facies, dissolved-ion abundances, and other aquifer properties (Hamlin, 1988) (Figure 4-1, **Table 4-1**). Hydrochemical variations, especially, can affect TDS/$R_0$ correlations. High bicarbonate concentration, for example, increases resistivity independently of TDS (Jones and Buford, 1951; Alger, 1966; Meyer et al., 2014). Dissolved ions abundances shown in Table 4-1 are not the same as hydrochemical facies discussed in Section 3. All three hydrogeologic regions have bicarbonate hydrochemical facies, but bicarbonate concentrations are highest in the southwest region (Hamlin, 1988).

TDS/$R_0$ correlations were used to define $R_0$ cutoff values in each region for freshwater (<1000 mg/L TDS), slightly saline water (1000–3000 mg/L TDS), moderately saline water (3000–10,000 mg/L TDS), and very saline water (10,000–35,000 mg/L TDS) (**Table 4-2**). Brackish water includes both slightly saline and moderately saline waters. The TDS/$R_0$ relationship was not used to map brine (>35,000 mg/L TDS) (**Section 4.1.7**).

### *4.1.4 Groundwater Salinity Using $R_w$ Method*

The $R_w$ method was used to supplement and corroborate the $R_0$ method, especially in deeper intervals where water well chemical analyses are scarce. Parameters for the $R_w$ equation are porosity ($\Phi$) and the cementation exponent (m), which is an empirical parameter related to compaction, cementation, and grain size (Jones and Buford, 1951; Asquith et al., 2004).

$$R_w = \Phi^m \times R_0 \qquad \text{(Equation 4-1)}$$

Values for $\Phi$ and m are based primarily on previous studies of Wilcox porosity and petrography (Loucks et al., 1986; McBride et al., 1991; Dutton and Loucks, 2014) supported by water sample measurements of $R_w$ from petroleum wells (Gaither, 1986). Ranges of $\Phi$ and m were tested for sensitivity and reasonable outcome. $R_w$ from equation (4-1) was corrected to a standard surface temperature (75° F) and then converted to TDS through a conductivity relationship that is specific to formation and region (Turcan, 1966; Estepp, 1998).

$$C_w = 10{,}000/R_w \qquad \text{(Equation 4-2)}$$

$$TDS = ct \times C_w \qquad \text{(Equation 4-3)}$$

where $C_w$ is specific conductivity, and ct is a proportionality constant that was determined by graphing TDS versus $C_w$, both of which were measured in groundwater samples from the Carrizo–Wilcox aquifer in South Texas (**Figure 4-6**). The $R_w$ method allows $R_0$/TDS cutoffs to be determined independently from water sample analysis (**Table 4-3**).

### *4.1.5 Resistivity Cutoffs*

Resistivity cutoffs from the $R_0$ method (Table 4-2) were used to estimate groundwater salinity mainly in Carrizo–upper Wilcox sands, whereas cutoffs from the $R_w$ method (Table 4-3) were used mainly in lower Wilcox sands. For similar groundwater salinities, resistivities in Carrizo–Wilcox sands increase from northeast to southwest (Figure 4-5). Reasons for southwest-increasing resistivities have not been documented, but increasing bicarbonate concentration and decreasing porosity and permeability are probably important factors. Similar resistivity increases are present in the lower Wilcox interval relative to the Carrizo–upper Wilcox interval. In the Southwest region, however, lithologies and aquifer properties are similar for both the Carrizo–upper Wilcox and the lower Wilcox, and $R_0$ cutoffs are similar there as well (compare Tables 4-2 and 4-3).

### *4.1.6 Discussion of Resistivity Methods*

The empirical TDS/$R_0$ method is a quick and effective way to map regional resources of fresh and brackish groundwater in some aquifers. Cutoff values of $R_0$ can be determined that distinguish broad categories of groundwater salinity: fresh, slightly saline, moderately saline, and very saline. Where TDS data are scarce, the computational $R_w$ method can be used to calculate $R_0$ cutoff values independently. Although the correlation between TDS and $R_0$ is commonly fair to good ($R^2 > 0.7$), other parameters significantly affecting $R_0$ are hydrochemistry, porosity, lithology, grain size, diagenesis, temperature, pressure, and borehole conditions. Variations in well logging instrumentation and practice, especially between old and new wells, also affect measured $R_0$. Therefore, the methods described in this report do not precisely calculate TDS from $R_0$. More quantitative methods are available for calculating TDS from electric logs, but they are less amenable to regional reconnaissance. Instead, the $R_0$ and $R_w$ methods provide rough estimates of groundwater in-place, which can be used in calculations of producible groundwater. In addition, these methods provide mappable parameters, such as net thickness of brackish groundwater sands, which can be used to locate and rank the resource.

### *4.1.7 Determination of Brine Distribution*

Separate methods were used to map brine (>35,000 mg/L TDS) in the Carrizo–Wilcox Aquifer in GMA 13. Empirical TDS/$R_0$ methods do not work well at very high salinities, where large salinity changes typically correlate to tiny $R_0$ differences. We inferred from the distribution of very saline groundwater and TDS measurements that brine is a minor component of the Carrizo–Wilcox flow system updip from the Wilcox growth-fault zone. To test this hypothesis, we collected high TDS measurements from oil and gas wells and plotted their distribution relative to the GMA 13 boundaries (**Figure 4-7**). These data suggest that brine is restricted to the Wilcox growth-fault zone. TDS values updip from the growth-fault zone are all in the very saline or moderately saline categories and agree well with TDS estimated from $R_0$. TDS values in the growth-fault zone are highly variable and include very saline and brine groundwaters. TDS variation in the growth-fault zone reflects fault-compartmentalized flow systems and release of connate waters from compacting shales (Bebout et al., 1982). However, the growth-fault zone impinges upon GMA 13 in Webb and Zapata counties (Zapata County is not part of the Carrizo–Wilcox Aquifer analysis). The southeast part of Webb County includes brine in thin isolated sands in the lower and middle Wilcox (Figure 4-7).

The Carrizo–Wilcox Aquifer in GMA 13 is underlain by shale intervals that are typically several thousand feet thick. Below the thick shales, Cretaceous sandstones and limestones commonly contain brine, and the brine wells shown in Figure 3-4 are all screened in Cretaceous intervals. The thick shale aquitards, however, preclude any possibility of a salinity interface between the Wilcox Group and underlying Cretaceous formations.

## 4.2 Results

Sand distribution and geometry are important aquifer properties, and mapping sand thicknesses is the first step in quantifying groundwater volumes. Using lithology and groundwater salinity interpretations from electric logs, we constructed a series of maps (**Figures 4-8** to **4-23**) and cross sections (**Figures 4-24** to **4-29**) to display locations and thickness of Carrizo–Wilcox sands having fresh, slightly saline, moderately saline, and very saline groundwater.

### *4.2.1 Carrizo-Upper Wilcox*

The Carrizo–upper Wilcox interval ranges from greater than 90 percent sand near outcrop in the northeast to about 50 percent sand along the Rio Grande in the southwest (Hamlin, 1988). Carrizo–upper Wilcox sand thickens into a large depocenter located south of San Antonio (Figure 4-8). Coarse-grained, bed-load fluvial channel systems dominate the Carrizo updip from the sand depocenter (Hamlin, 1988). Along the downdip margin of the study area and in the Wilcox growth-fault zone, the upper Wilcox was deposited in wave-dominated delta and associated barrier/strandplain systems (Fisher, 1969; Edwards, 1980, 1981). Specific depositional environments within the sand depocenter are not well documented but probably comprise bed-load fluvial channel facies interfingering with coalesced delta front and shoreface facies.

The Carrizo–upper Wilcox interval contains fresh or brackish groundwater across most of the study area. The thickest freshwater zones are located in fluvial sands in the north and northeast parts of the study area (Figures 4-9, 4-24 to 4-27). Sands containing fresh groundwater are thinner in the west and southwest (Figures 4-9, 4-28 to 4-29). Thickness of freshwater sands decreases abruptly along the downdip margin of the study area, coinciding locally with regional fault zones (Figure 4-9). These normal faults are located updip from the Wilcox growth-fault zone (Figure 4-1). In Gulf Coast Tertiary aquifers, groundwater salinity changes commonly occur near faults and result from the interaction between descending low-TDS meteoric water and expulsing high-TDS deep-basin formation water (Kreitler, 1979; Galloway, 1984; Hamlin, 1988).

In Carrizo–upper Wilcox sands, fresh groundwater grades downdip into brackish groundwater. Sands containing slightly saline groundwater form a discontinuous belt of maximum thickness near the downdip margin of the study area (Figure 4-9). Carrizo–upper Wilcox sands containing slightly saline groundwater are also widespread across the western part of the study area (Figure 4-9). Thick Carrizo–upper Wilcox sands containing slightly saline groundwater are well developed locally in Webb, La Salle, McMullen, Live Oak, and Karnes counties (Figures 4-24 to 4-28).

Carrizo–upper Wilcox sands containing moderately saline groundwater display locations and thickness patterns similar to those of slightly saline groundwater sands, although the thickest moderately saline groundwater sands are located farther downdip (compare Figures 4-10 and 4-11). Thick Carrizo–upper Wilcox sands containing moderately saline groundwater are well developed locally in Webb, McMullen, and Karnes counties (Figures 4-25, 4-27, 4-29). In the northeast, where the transition between fresh groundwater and saline groundwater occurs across a relatively short distance, both slightly and moderately saline groundwater zones form narrow, discontinuous belts (Figures 4-10, 4-11, 4-24, 4-25).

In the Carrizo–upper Wilcox, sands containing very saline groundwater are located along the southeast boundary of GMA 13. Very saline groundwater in the Carrizo–upper Wilcox lies mostly outside of GMA 13 except in Webb County (Figure 4-12). Very saline groundwater sands are thickest in the northeast (Figures 4-24 and 4-25). No brine is present in the Carrizo–upper Wilcox interval in GMA 13 (Figure 4-7).

### *4.2.2 Middle Wilcox*

The middle Wilcox interval is shale-dominated in GMA 13. Net sand thickness is mostly less than 300 feet (Figure 4-13). The middle Wilcox is composed primarily of thin sands and thick shales that were deposited in a marine transgressive environment (Xue and Galloway, 1995; Hargis, 2009). The middle Wilcox potentially forms aquitards in places where shales are especially thick (Figures 4-24 to 4-26). We constructed a percent sand map of the middle Wilcox to highlight areas where flow barriers may exist between the lower Wilcox and the Carrizo–upper Wilcox. Areas where sand percentages are less than about 30 (shale > 70%), have the greatest potential to form flow barriers (Figure 4-14). In the far northeast, the middle Wilcox thickens greatly into a feature called the Yoakum Canyon (Figure 4-24). During the time of middle Wilcox deposition, the Yoakum Canyon was a large submarine channel that eroded into the underlying lower Wilcox and subsequently filled with middle Wilcox shale (Hoyt, 1959; Dingus and Galloway, 1990).

The middle Wilcox interval is dominated by brackish and saline groundwater, although minor fresh groundwater is present locally in outcrop and the shallow subsurface. Middle Wilcox sands containing fresh groundwater are thickest (up to about 100 ft) in Zavala and Frio counties (Figure 4-15). The cross sections show that middle Wilcox sands containing fresh groundwater are rare (Figures 4-27, 4-28). Slightly saline groundwater in the middle Wilcox is more widespread than is fresh groundwater (Figure 4-16). Middle Wilcox sands containing slightly saline groundwater are thickest in Frio and Atascosa counties (Figures 4-26, 4-27). Moderately saline groundwater in the middle Wilcox is also widespread but thin (Figure 4-17). Middle Wilcox sands containing moderately saline groundwater are shifted downdip compared to sands containing slightly saline groundwater (compare Figures 4-16 and 4-17), although the two brackish groundwater salinity types are commonly interbedded in the middle Wilcox (Figures 4-26 to 4-28). Sands containing very saline groundwater in the middle Wilcox are located along the southeast boundary of GMA 13 in the northeast but are more widespread in the southwest (Figure 4-18). Sands containing brine in the middle Wilcox are restricted to southeast Webb County (Figure 4-7) in thin sands enclosed in thick shales (southeast end of cross section F, Figure 4-29).

### *4.2.3 Lower Wilcox*

In South Texas the lower Wilcox interval is less sandy than the Carrizo–upper Wilcox but more sandy than the middle Wilcox. Percent sand in the lower Wilcox interval generally decreases from 60 percent sand near the outcrop and in the northeast to less than 10 percent sand locally in the southwest and downdip. The thickest sands in the lower Wilcox interval are in the northeast on the San Marcos Arch (Figure 4-19). In the Rio Grande Embayment, lower Wilcox net sand patterns are strike aligned and decrease updip and downdip from an elongated depocenter (Figure 4-19). Fisher and McGowen (1967) interpreted these sand thickness patterns to represent a delta system in the northeast flanked by a barrier-strandplain system to the southwest. The Yoakum Canyon is expressed on the lower Wilcox net sand map as a sand-poor, dip-oriented trend in Gonzales County (Figure 4-19).

Similar to the middle Wilcox, the lower Wilcox interval is dominated by brackish and saline groundwater. Minor fresh groundwater is present locally in outcrop and the shallow subsurface especially in Zavala, Frio, and Gonzales counties (Figure 4-20). None of the cross sections shows fresh groundwater in the lower Wilcox. Lower Wilcox sands containing slightly saline or moderately saline groundwater are mainly restricted to the north and northeast (Figures 4-21, 4-22). Thus, maximum brackish groundwater in the lower Wilcox underlies maximum fresh groundwater in the Carrizo–upper Wilcox interval (compare Figures 4-9 with 4-21 and 4-22). Sands containing slightly and moderately saline groundwater in the lower Wilcox are well developed in Frio, Atascosa, and Wilson counties (Figures 4-25 to 4-27). The lower Wilcox interval contains mostly very saline groundwater in the southwest (Webb County), in the northeast (Gonzales County), and along the downdip margin of the study area (Figure 4-23). Fault-related groundwater mixing probably controls distribution of brackish groundwater in the lower Wilcox interval in the northeast. In the southwest poor sand development and low rainfall recharge in outcrop are probably the main controls on brackish groundwater distribution (Hamlin, 1988). Sands containing brine in the lower Wilcox are restricted to southeast Webb County (Figure 4-7) in thin sands enclosed in thick shales (southeast end of cross section F, Figure 4-29).

### *4.2.4 Structural Depths*

Fresh and brackish groundwater intervals extend to greater depths in the Carrizo–Wilcox aquifer in South Texas than they do in other Texas aquifers (LBG-Guyton Associates, 2003). To show depth distribution of groundwater salinity, we constructed depth maps to the bases of fresh and brackish groundwater as well as selected structural cross sections (**Figures 4-30** to **4-36**). The base (deepest occurrence) of fresh groundwater ranges from 500 ft below land surface near the outcrop to greater than 5,000 ft below surface downdip mainly in Live Oak County (Figures 4-30, 4-34). In the northeast base of fresh groundwater is mostly less than 3000 ft below surface (Figures 4-30, 4-33). In parts of Webb County, base of freshwater is less than 1500 ft below surface (Figure 4-36).

The base of slightly saline groundwater ranges from 500 ft below surface near outcrop to greater than 6,000 ft below surface downdip (Figures 4-31, 4-34). The base of moderately saline groundwater ranges from about 500 ft below surface at outcrop to greater than 6,500 ft below surface downdip (Figure 4-32). The deepest occurrences of both fresh and brackish groundwater are in the Carrizo–upper Wilcox interval. In the lower Wilcox interval, depth to base of brackish water ranges from 5,000 ft in the northeast to 1,200 ft in the southwest (Figures 4-33, 4-36). In GMA 13 the base of very saline groundwater coincides with the base of the Wilcox Group except for a small area in southeast Webb County that is in the Wilcox growth-fault zone (Figure 4-7).

### *4.2.5 Faults*

Structural faults are common in the Carrizo–Wilcox Aquifer in GMA 13. Faults are vertically oriented zones of slippage and deformation that disrupt sedimentary layers. Large faults may have vertical displacements that completely separate aquifer layers and thus form flow barriers. Most of the faults in the Carrizo–Wilcox Aquifer are small and have displacements of 100 ft or less. These small faults offset aquifer layers but generally do not completely separate the layers. Most faults in the Carrizo–Wilcox probably affect groundwater flow by inhibiting horizontal flow and increasing vertical flow and groundwater mixing (Kreitler, 1979; Galloway, 1984). Ewing (1991) and Hargis (2009) mapped faults in GMA 13, and we show their larger faults on the groundwater salinity sand thickness maps (Figures 4-9 to 4-12, 4-15 to 4-18, 4-20 to 4-23). As mentioned in the section on freshwater in the Carrizo–upper Wilcox (**Section 4.2.1**), abrupt groundwater salinity changes are apparent across many faults especially those in the northeast (for example, Figures 4-9, 4-22).

### *4.2.6 Brackish Groundwater Production Areas*

We mapped four potential brackish groundwater production areas (PPAs) within the Carrizo–Wilcox Aquifer in GMA 13. Initial selection of PPAs was based mainly on thickness of sands containing slightly saline or moderately saline groundwater. Once the areas were selected, we investigated potential hydrogeologic barriers that would be sufficient to separate the production areas from the rest of the aquifer and that might prevent significant impact to groundwater availability or quality in layers containing fresh groundwater. Hydraulic connectivity between brackish groundwater production areas and freshwater areas of the Carrizo–Wilcox Aquifer might be accomplished in fault zones or across leaky aquitards. A sand-dominated, hydraulically conductive interval that separates overlying fresh groundwater from underlying brackish groundwater might act as a leaky aquitard. We also conducted three dimensional flow modeling to estimate impacts of brackish groundwater production on fresh groundwater resources (**Section 6**).

In the Carrizo–Wilcox Aquifer in GMA 13, PPAs are mostly in the lower Wilcox interval where it underlies fresh groundwater in the Carrizo–upper Wilcox interval. Approximate locations of the PPAs are shown as ellipses on the map (**Figure 4-37**). These ellipses are generalized boundaries and not meant to encompass final areas where brackish groundwater can be produced without impacting fresh groundwater resources. The structural cross sections show more focused PPA boundaries in relation to faults and aquifer layering (Figures 4-33 to 4-36). Across the north and northeast from Frio to Gonzales counties, abundant brackish groundwater in present so that PPAs 1 – 3 could be merged into one area. However, differences between these three areas are gradational but real (**Table 4-4**), and we concluded that it would be more effective to analyze them separately. The impact of producing brackish groundwater from these PPAs is considered in more detail in **Section 6**.

The properties of the PPAs are summarized in Table 4-4. PPA 1 is located in the northeast and is bounded updip and downdip by fault zones (Figure 4-33). The potential production zone is in the lower Wilcox. The middle Wilcox, which is 70-80% shale in this area, separates lower Wilcox brackish groundwater from fresh to slightly saline groundwater in the Carrizo–upper Wilcox. PPA 2 is located south of San Antonio (Figure 4-37). PPA 2 is not associated with faults (Figure 4-34). The shale-dominated (75-90% shale) middle Wilcox also forms a potential hydrogeologic barrier in PPA 2. PPA 3 is located mainly in Frio County and is bounded on the updip side by a fault (Figures 4-37, 4-35). The middle Wilcox is sandier in this area (50-60% shale), decreasing its effectiveness as a hydrogeologic barrier. PPA 4 is located in Webb County and is the only potential brackish groundwater production area in the Carrizo–upper Wilcox interval (Figures 4-37, 4-36). PPA 4 includes faults, but the main potential hydrogeologic barrier is distance from updip fresh groundwater (Figure 4-36).

#### *4.2.7 Injection Wells in Brackish Groundwater Production Areas*

The PPAs include 100 Class II injections wells within their current generalized boundary ellipses. Almost all of these wells (93) inject below the base of brackish groundwater (**Figure 4-38**). Vertical distance from the PPA to these deeper injection zones ranges from a few feet to over 6,000 ft. In PPA 2, two closely spaced injection wells inject into the Queen City Aquifer about 2,000 ft above the top of brackish groundwater in the Carrizo-Wilcox Aquifer. In PPA 1, four injection wells have injection intervals that overlap with the base of brackish groundwater, and in PPA 4, one injection well has an injection intervals that overlaps with the base of brackish groundwater (Figure 4-38). In these five wells, injection zone overlaps range from 4 ft to 174 ft.

**Table 4-1. Hydrogeologic properties of the Carrizo-upper Wilcox interval in the TDS/$R_0$ regions shown on Figure 4-1. All properties except sandstone percent from Hamlin (1988).**

| Region | Hydraulic Conductivity Mean (ft/day) | Transmissivity Mean ($ft^2$/day) | Sandstone Mean Percent | Most Abundant Dissolved Ions |
|---|---|---|---|---|
| Southwest | 24.7 | 4,815 | 53 | $HCO_3$, Na, Cl |
| Central | 35.7 | 14,845 | 65 | Ca, $HCO_3$ |
| Northeast | 35.6 | 21,933 | 78 | Na, $HCO_3$ |

**Table 4-2. $R_0$ cutoff values based on the TDS/$R_0$ empirical relationships (Figure 4-5).**

| Region | Freshwater | Slightly Saline Water | Moderately Saline Water | Very Saline Water |
|---|---|---|---|---|
| Southwest | > 34 | 16 – 34 | 7 – 16 | < 7 |
| Central | > 29 | 13 – 29 | 5 – 13 | < 5 |
| Northeast | > 25 | 10 – 25 | 4 – 10 | < 4 |

**Table 4-3. $R_0$ cutoff values calculated using the $R_w$ method.**

| TDS (mg/L) | Depth range (ft) | Temperature (ºF) | Porosity (%) | m | ct | $R_w$ | $R_0$ |
|---|---|---|---|---|---|---|---|
| 1,000 | < 3,000 | 110 | 30 | 1.8 | 0.56 | 3.78 | 33 |
| 3,000 | 3,000 – 6,000 | 158 | 25 | 2.1 | 0.56 | 0.87 | 16 |
| 10,000 | 4,000 – 7,000 | 177 | 20 | 2.4 | 0.56 | 0.23 | 11 |

**Table 4-4. Potential Brackish Groundwater Production Areas in the Carrizo–Wilcox aquifer in GMA 13 (Figure 4-36).**

| Area Number | Counties | Aquifer Layer | Brackish Groundwater Type | Depths (ft) | Hydrogeologic Barriers |
|---|---|---|---|---|---|
| 1 | Gonzales Wilson | Lower Wilcox | mostly moderately saline | 1500 – 5500 | Middle Wilcox layer 70-80% shale |
| 2 | Wilson Atascosa | Lower Wilcox | mostly moderately saline | 1500 – 5500 | Middle Wilcox layer 75-90% shale |
| 3 | Frio Zavala | Lower Wilcox | mostly slightly saline | 1500 – 4500 | Middle Wilcox layer 50-60% shale |
| 4 | Webb | Carrizo–upper Wilcox | mixed slightly and moderately saline | 2500 – 4500 | horizontal distance 25 miles from fresh groundwater |

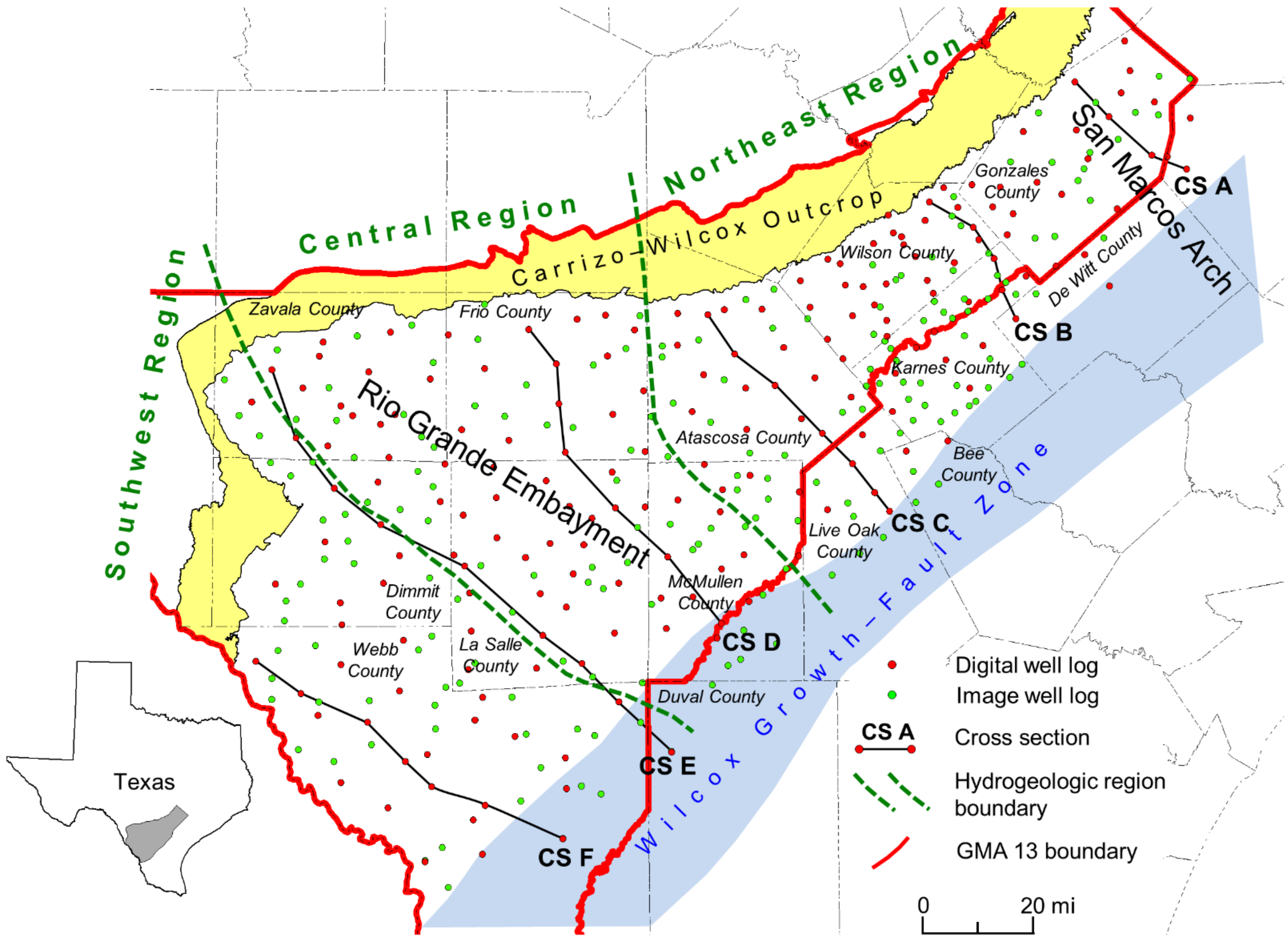


**Figure 4-1.** **Location of study area in GMA 13 showing electric log well control, cross section lines, and Carrizo–Wilcox outcrop. The Wilcox growth-fault zone and selected updip fault zones are also shown (Ewing, 1990). The area was divided into hydrogeologic regions (Hamlin, 1988) for separate TDS/$R_0$ regressions.**

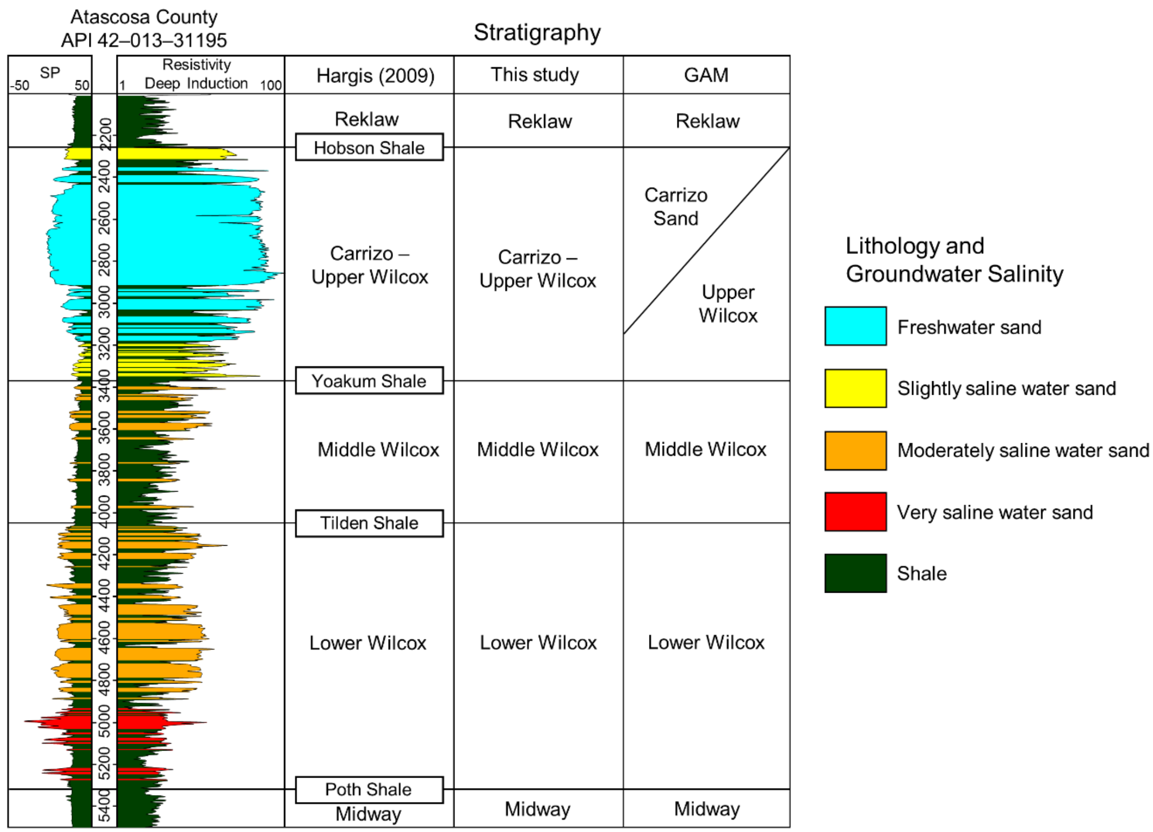


**Figure 4-2.** **Typical electric log showing SP (spontaneous potential) and resistivity curves through the Carrizo–Wilcox Aquifer. Both lithology (sand/shale) and groundwater salinity were interpreted from the electric log (see text for details). Aquifer stratigraphy follows well established subdivision of the Wilcox Group in South Texas. Prominent shales identified by Hargis (2009) were used to help correlate the three layers. Layering from the Groundwater Availability Model (GAM) is also shown (Kelley et al., 2004).**

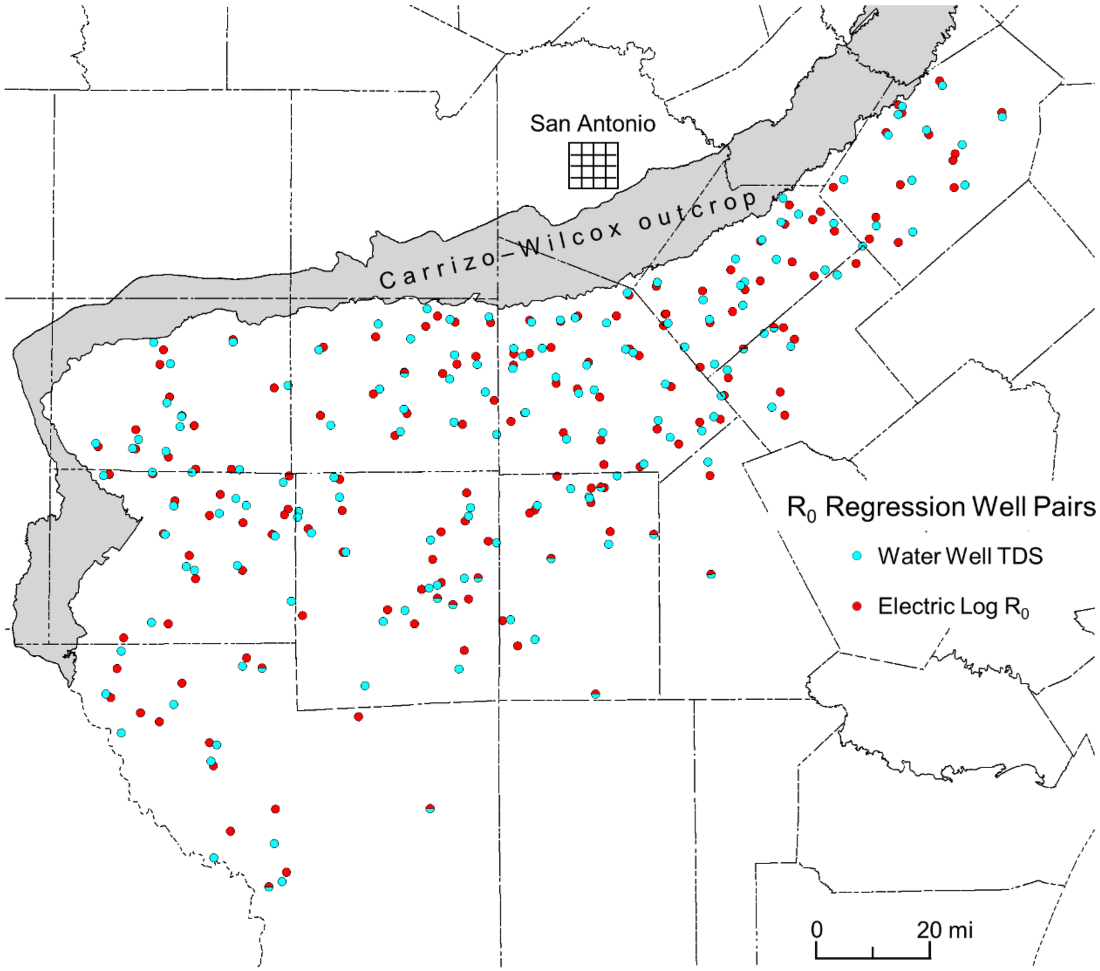


**Figure 4-3. Wells used to develop TDS/$R_0$ regressions. Most TDS data (blue dots) come from water wells, whereas most resistivity data (red dots) come from petroleum wells. A few wells have both data types (red and blue dots).**

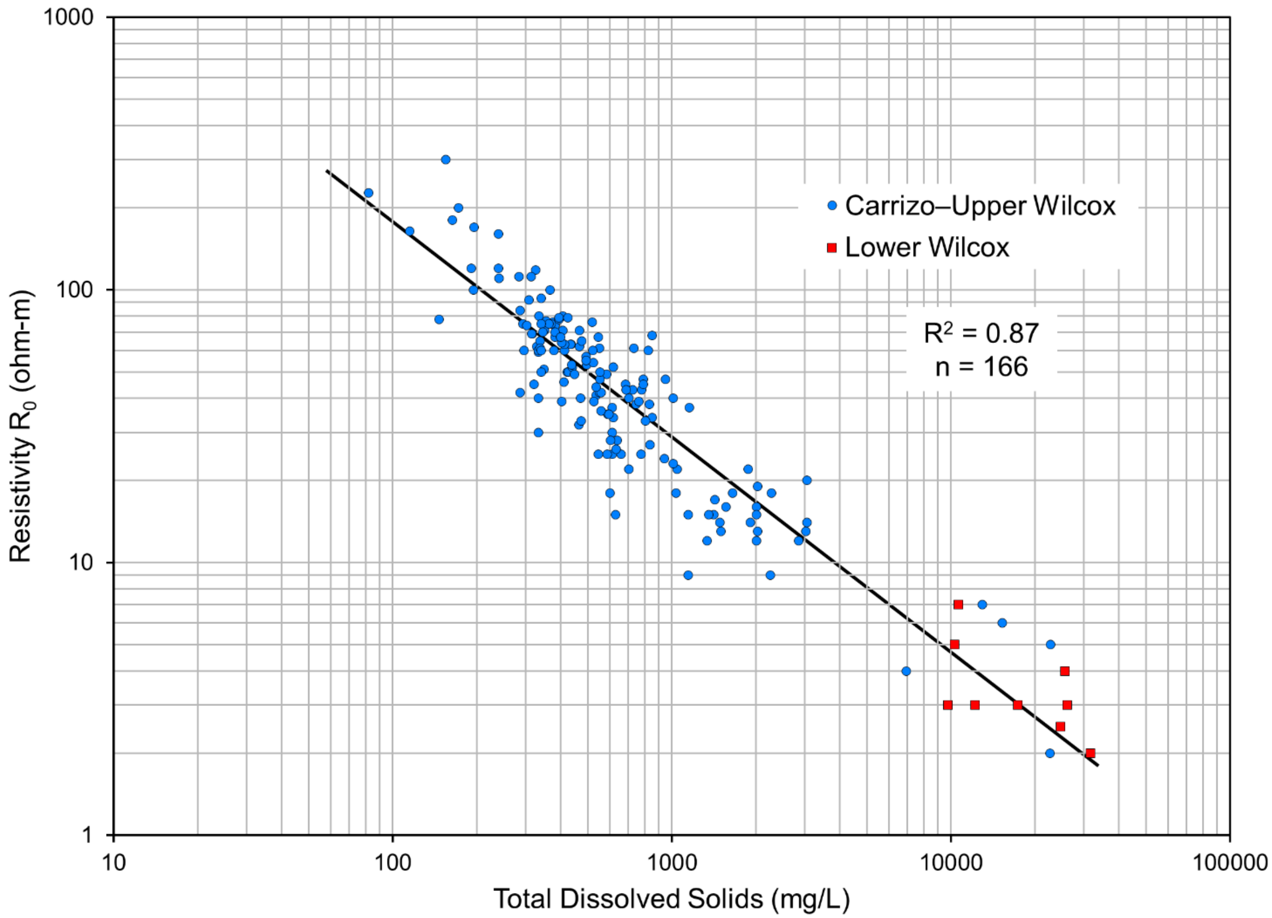


**Figure 4-4. Total dissolved solids (TDS) versus deep resistivity ($R_0$) for all well pairs in the study area.**

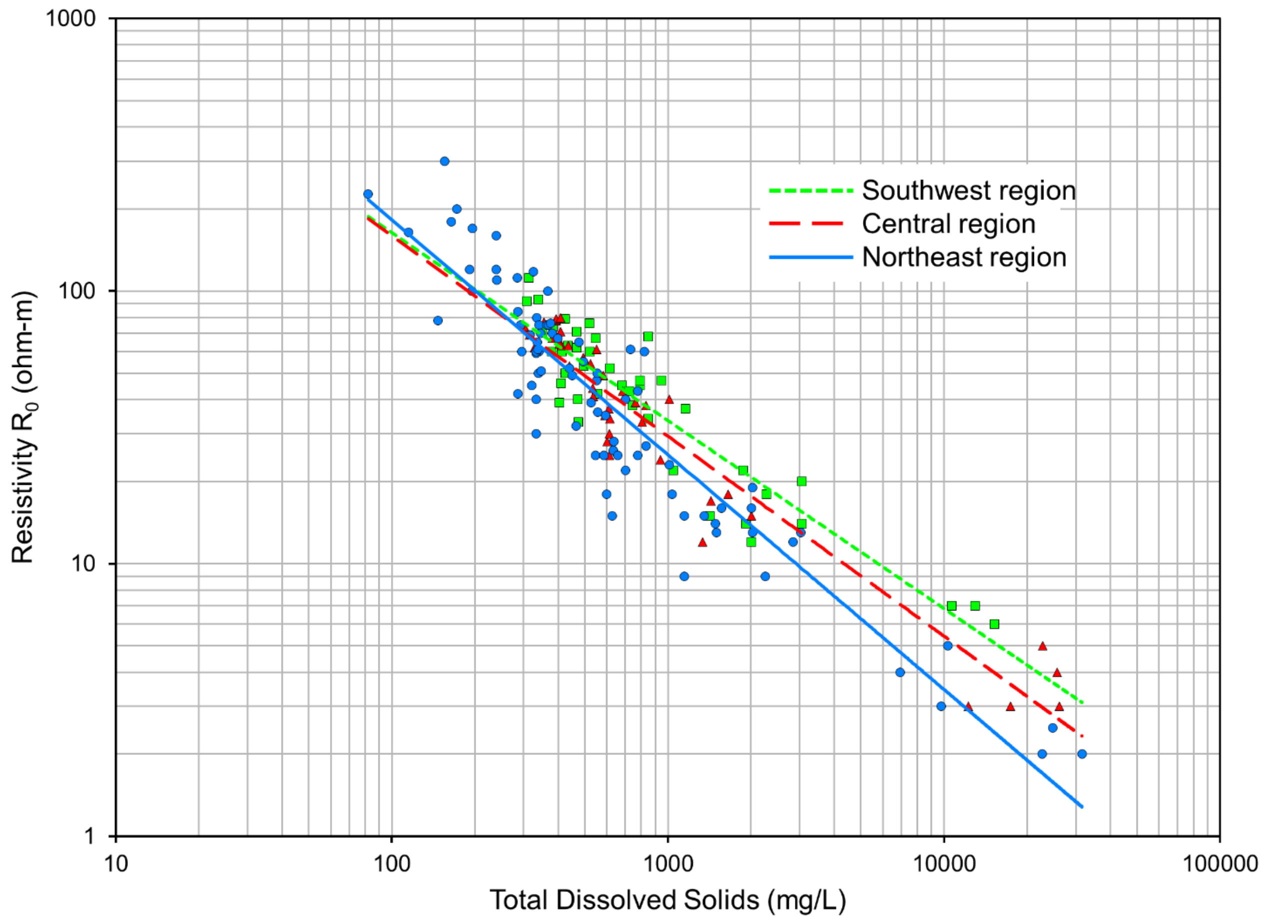


**Figure 4-5.** **TDS versus deep resistivity ($R_0$) showing separate regressions for each of the three hydrogeologic regions (Figure 4-1).**

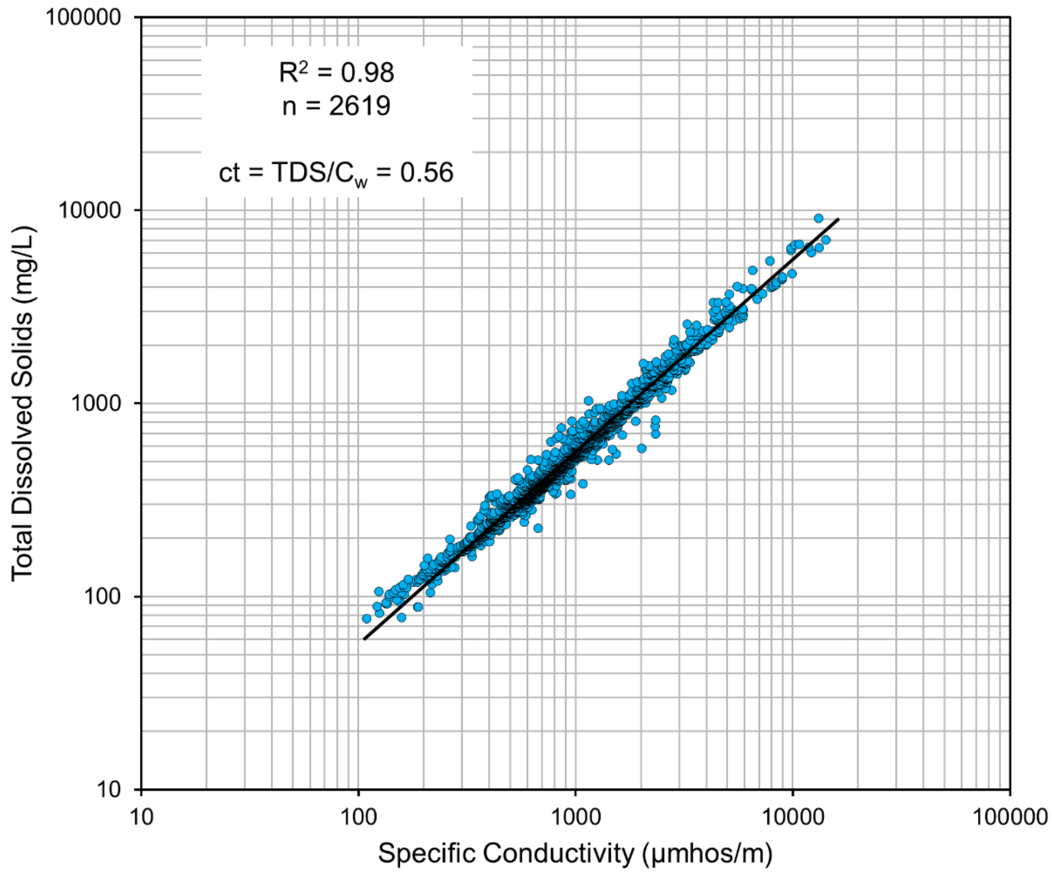


**Figure 4-6. Graph of specific conductivity ($C_w$) versus TDS for the study area. Both $C_w$ and TDS were measured in water well samples. $C_w$ and TDS are related by a proportionality constant (ct), which is specific to area and formation. In the South Texas, however, a single value of ct is valid for the entire Carrizo–Wilcox aquifer.**

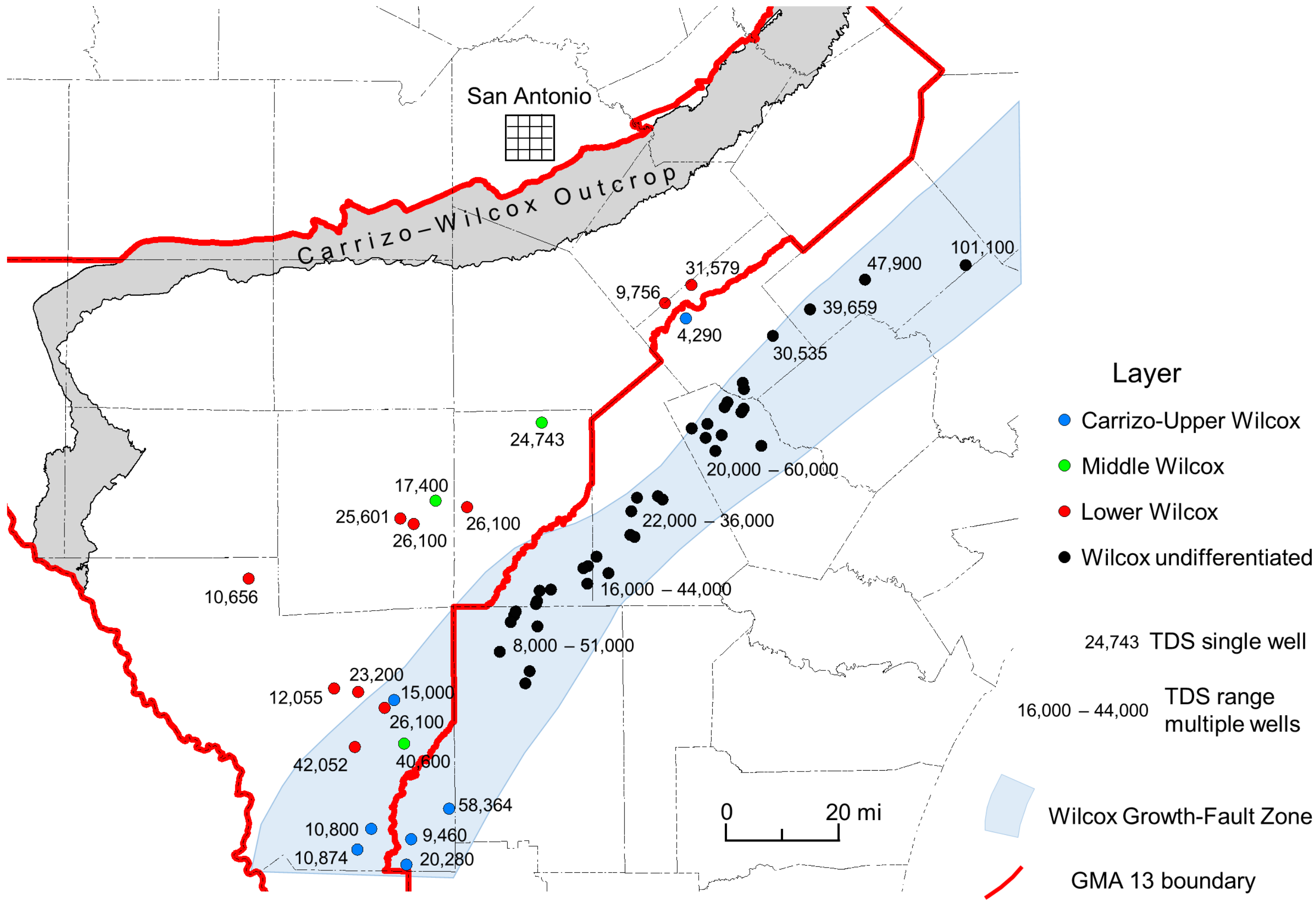


**Figure 4-7. High groundwater salinities from oil and gas wells. Data from Taylor (1975) and Gaither (1986).**

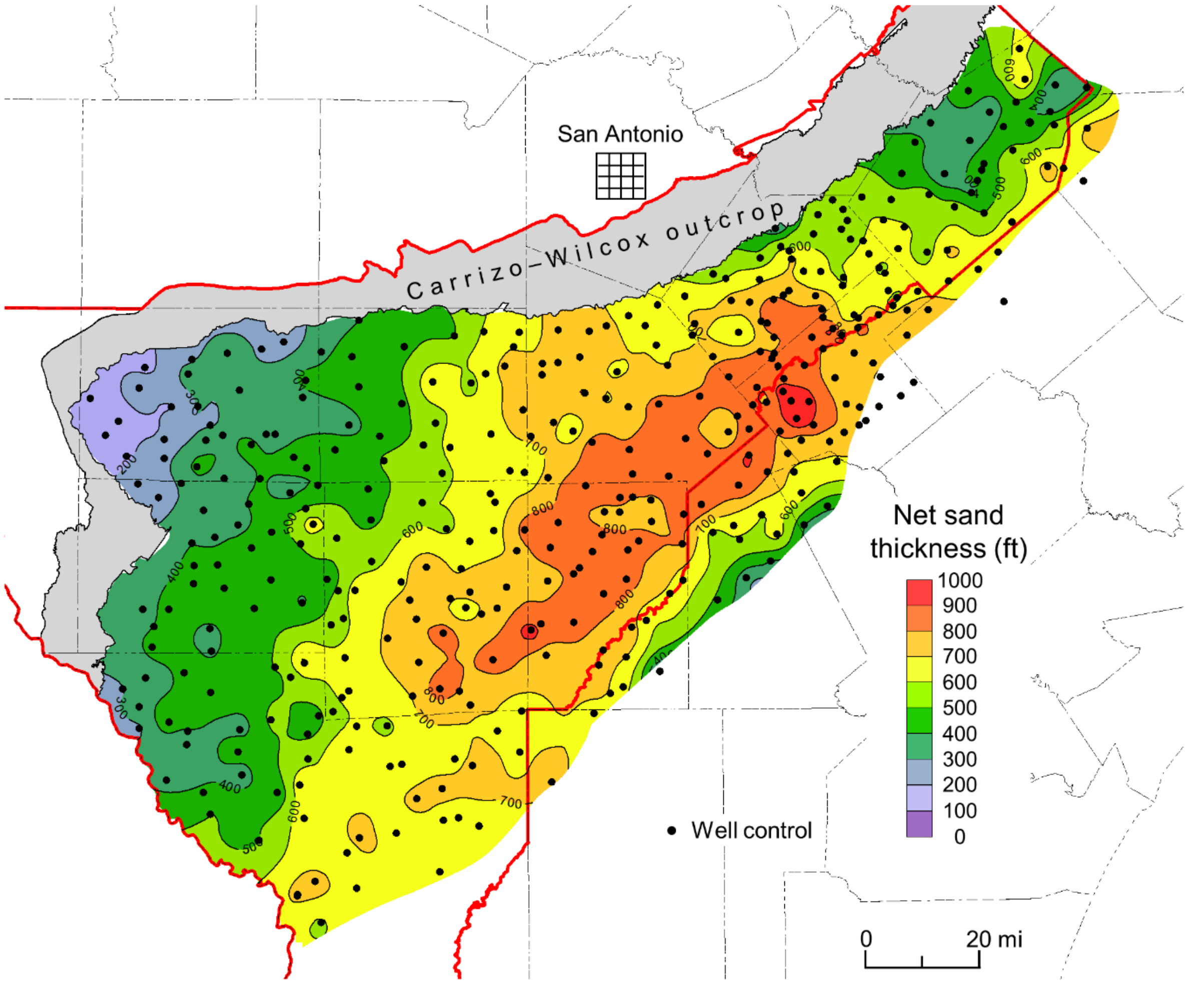


**Figure 4-8.** **Carrizo–upper Wilcox net sand thickness. Maximum sand thicknesses in the Carrizo–upper Wilcox form a depocenter south of San Antonio.**

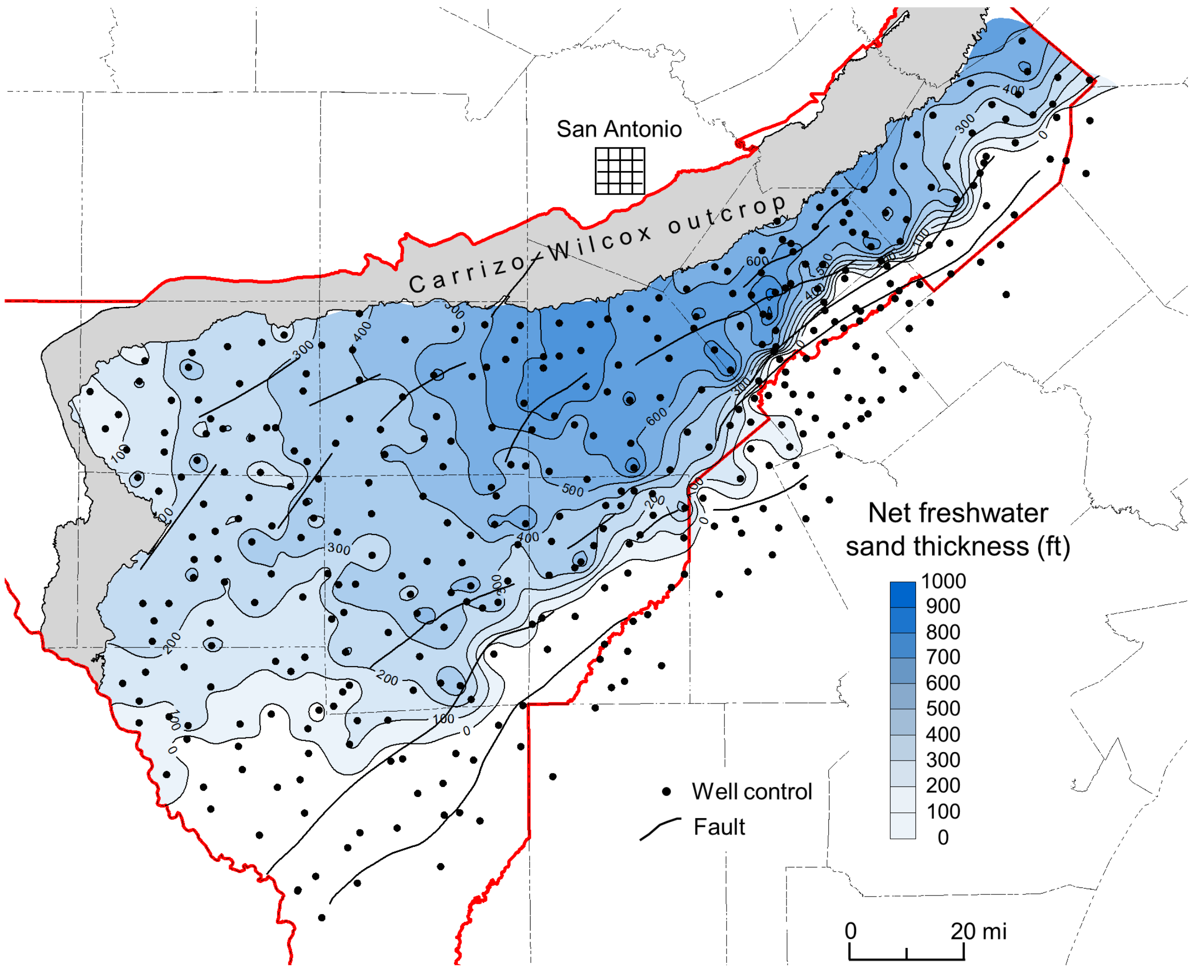


**Figure 4-9.** **Net thickness of sand containing fresh groundwater in the Carrizo–upper Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009). Groundwater salinities increase abruptly across some of these regional faults.**

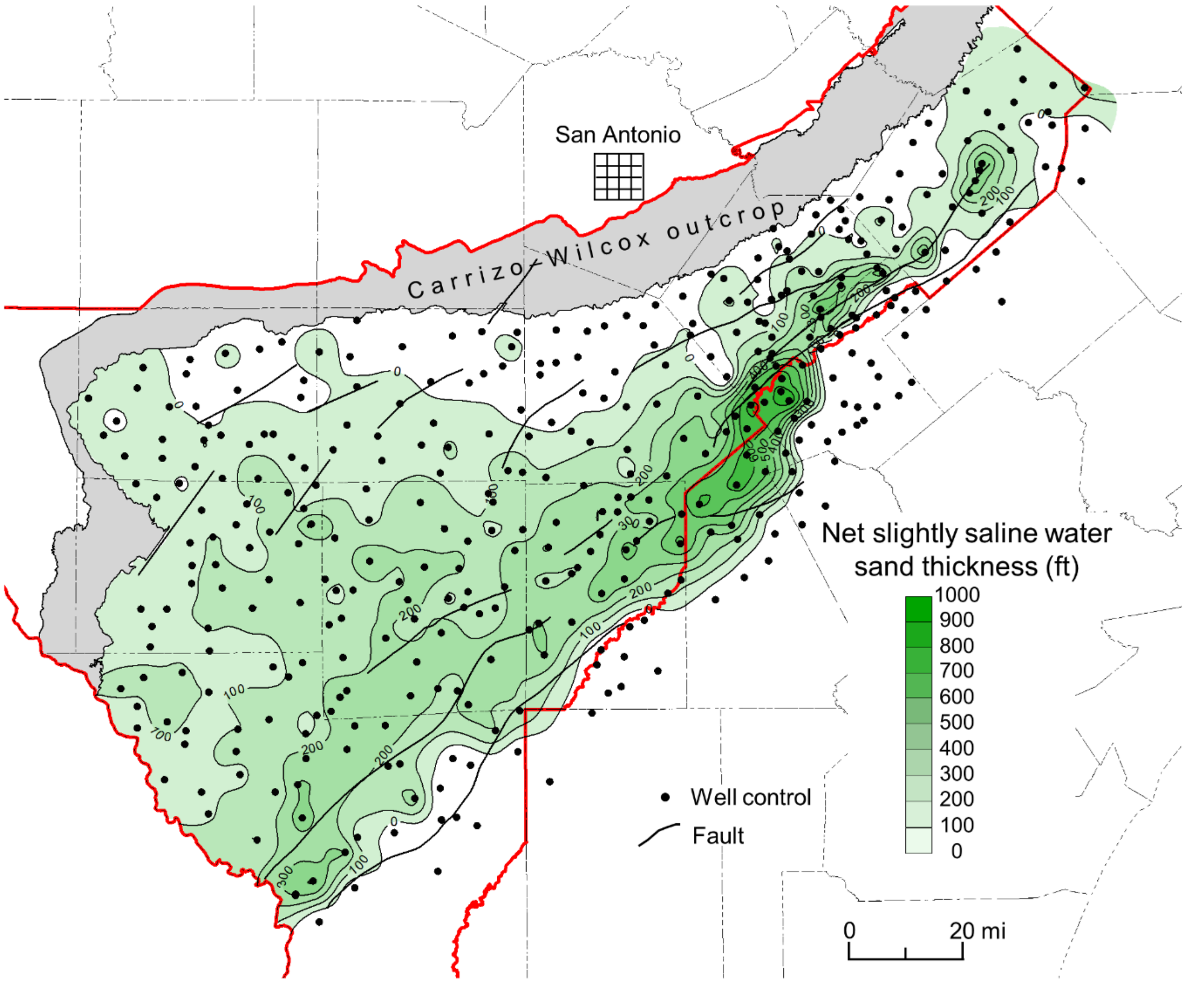


**Figure 4-10. Net thickness of sand containing slightly saline groundwater in the Carrizo–upper Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

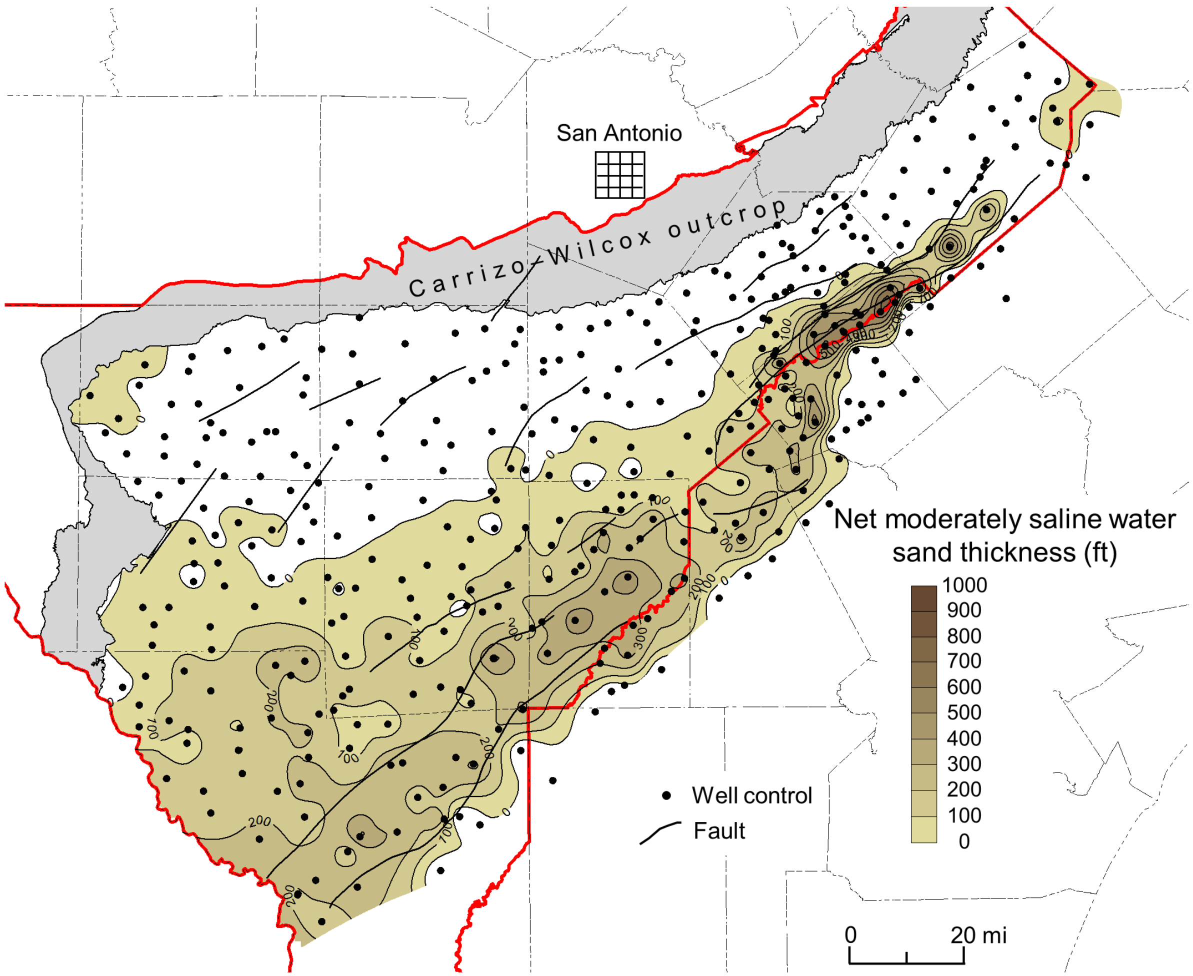


**Figure 4-11. Net thickness of sand containing moderately saline groundwater in the Carrizo–upper Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

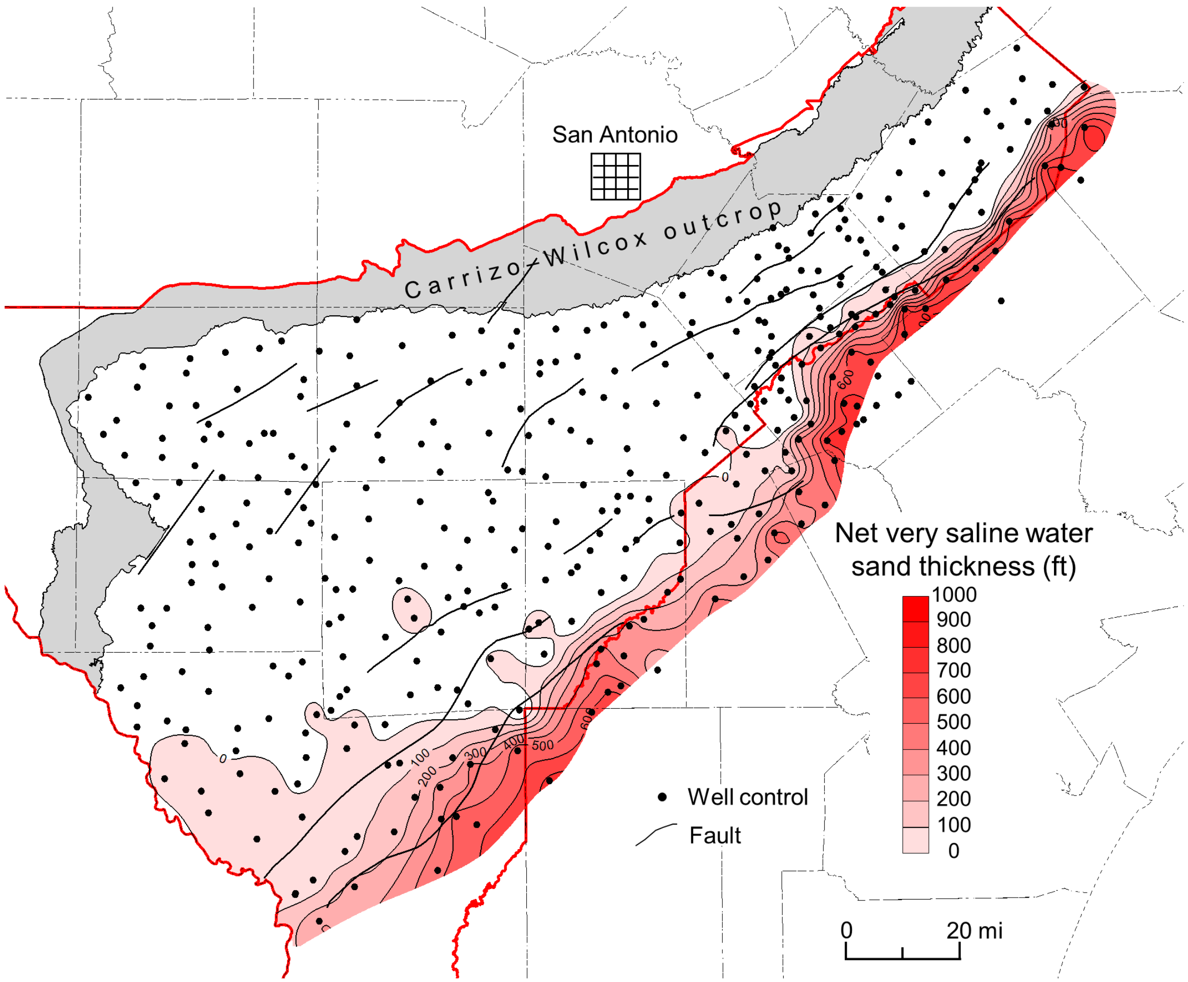


**Figure 4-12. Net thickness of sand containing very saline groundwater in the Carrizo–upper Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

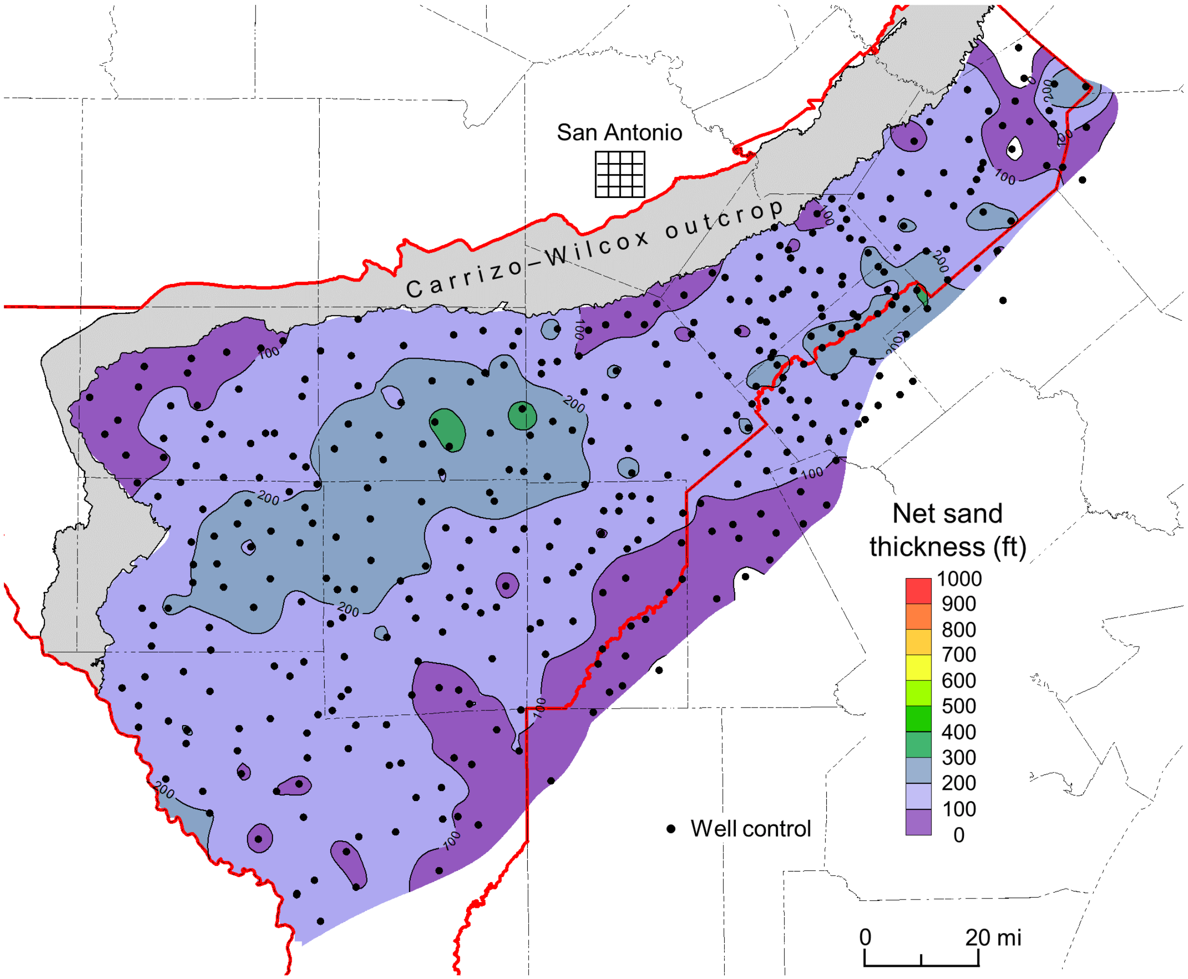


**Figure 4-13.** **Middle Wilcox net sand thickness. The middle Wilcox is typically a low-sand, high-shale interval.**

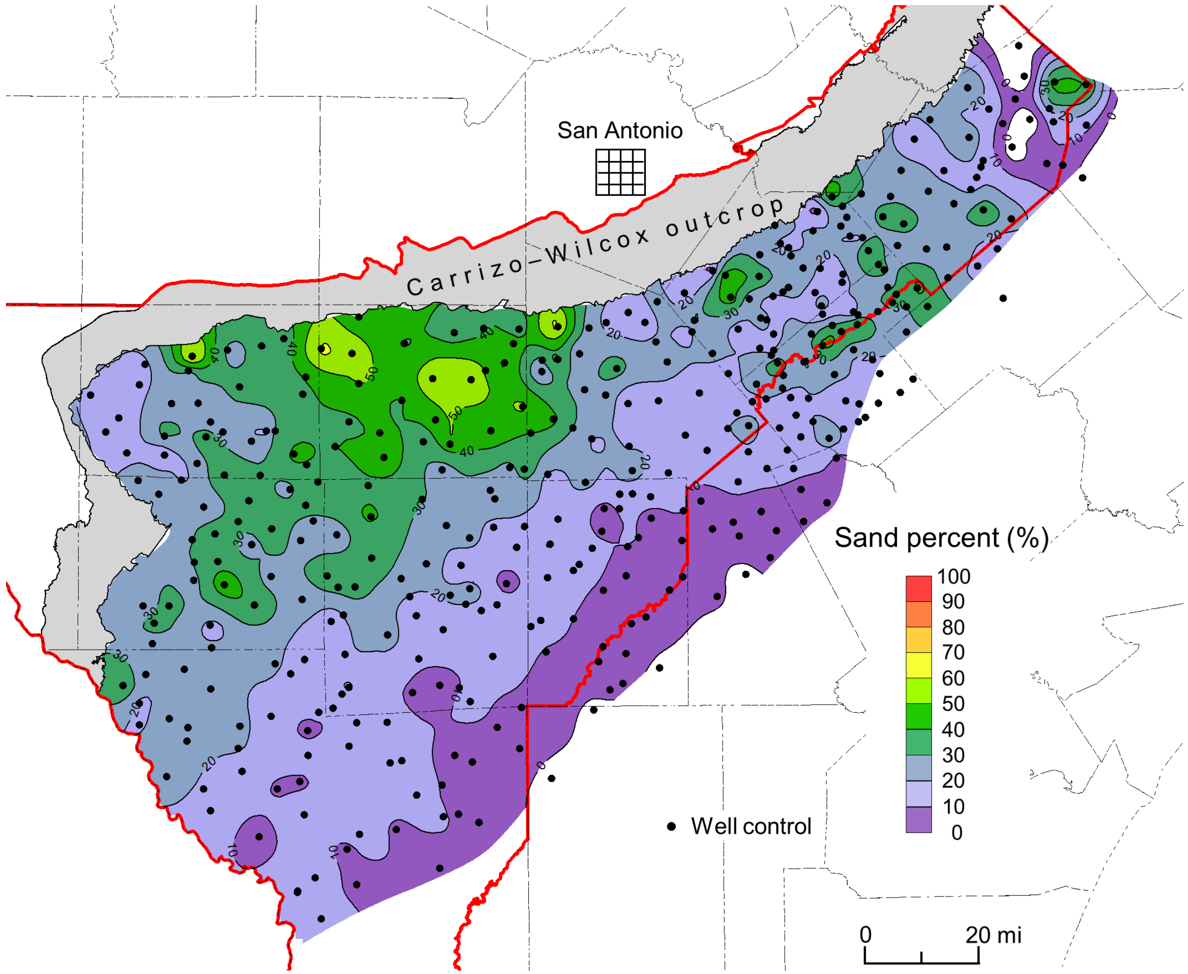


**Figure 4-14. Middle Wilcox percent sand (net sand thickness / total interval thickness). The middle Wilcox is typically >50% shale (<50% sand), but in large parts of GMA 13, the middle Wilcox is >70% shale.**

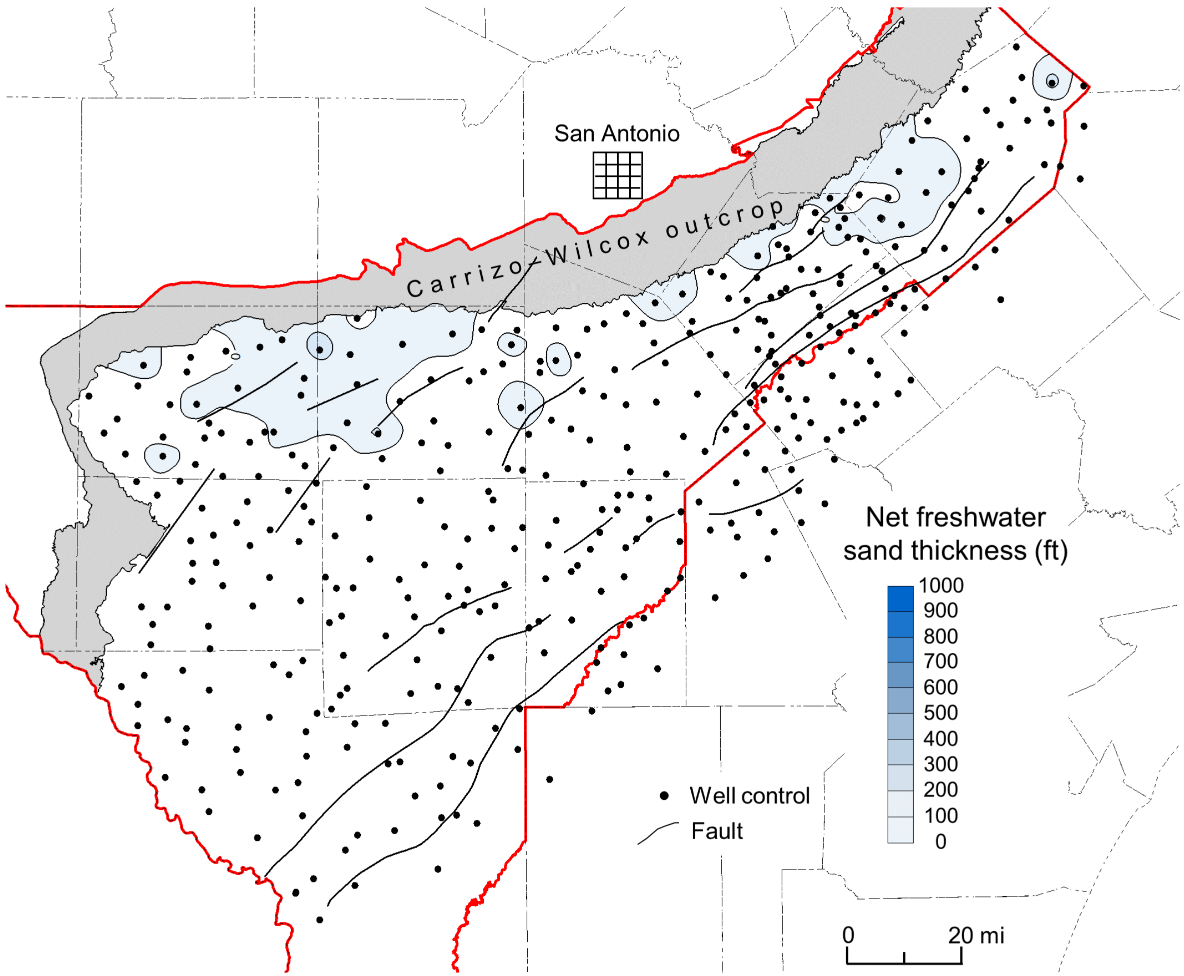


**Figure 4-15. Net thickness of sand containing fresh groundwater in the middle Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

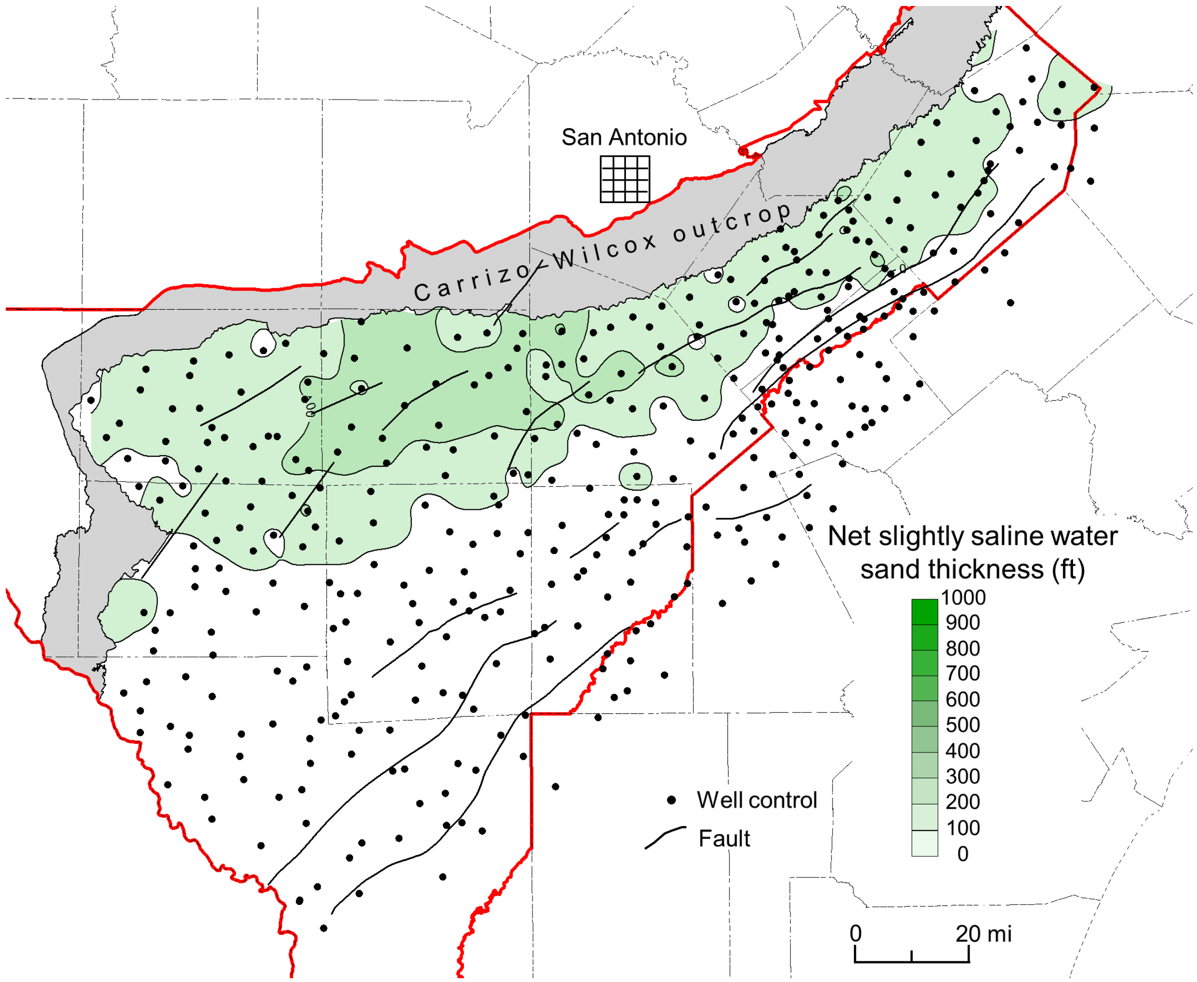


**Figure 4-16.** **Net thickness of sand containing slightly saline groundwater in the middle Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

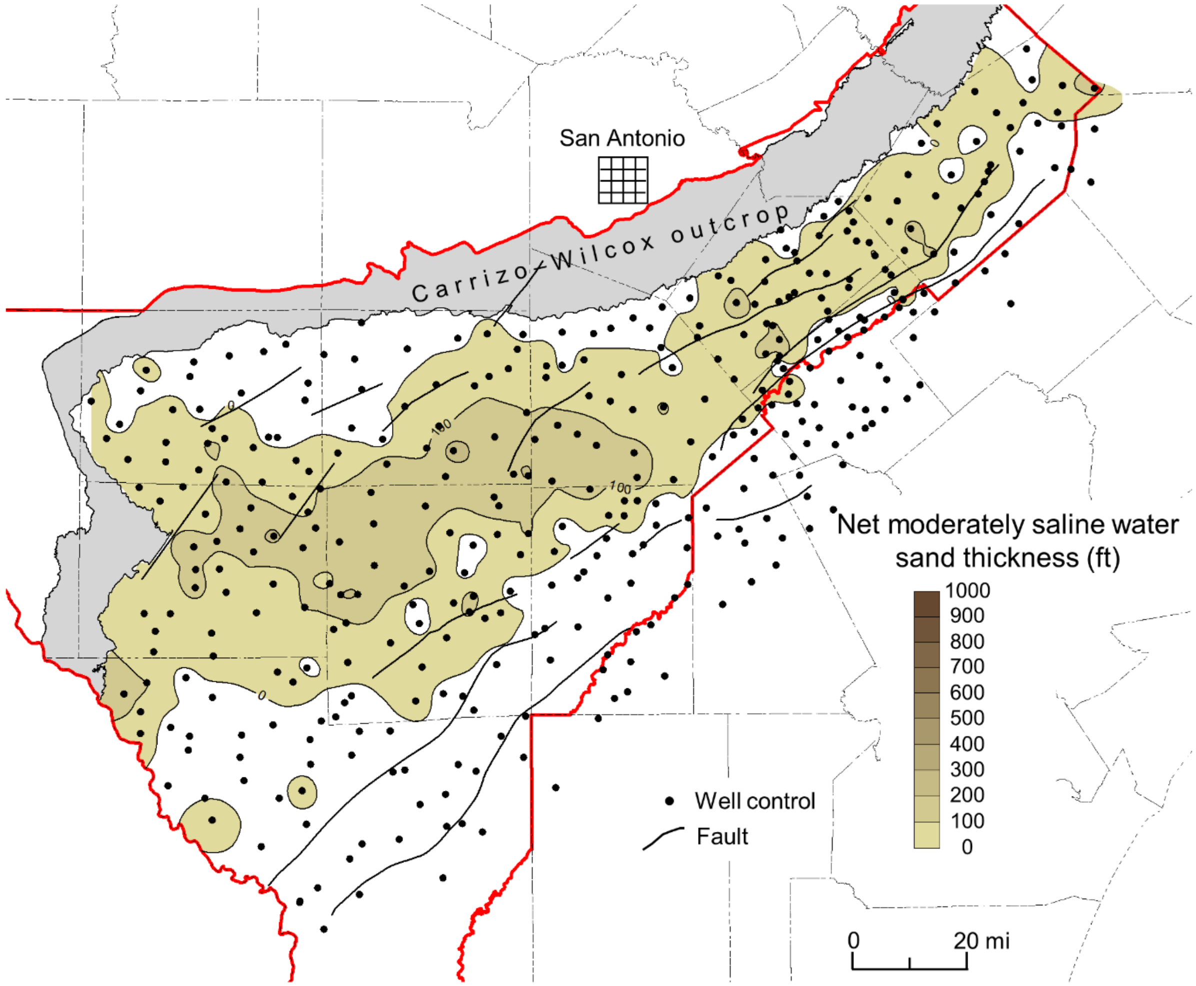


**Figure 4-17. Net thickness of sand containing moderately saline groundwater in the middle Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

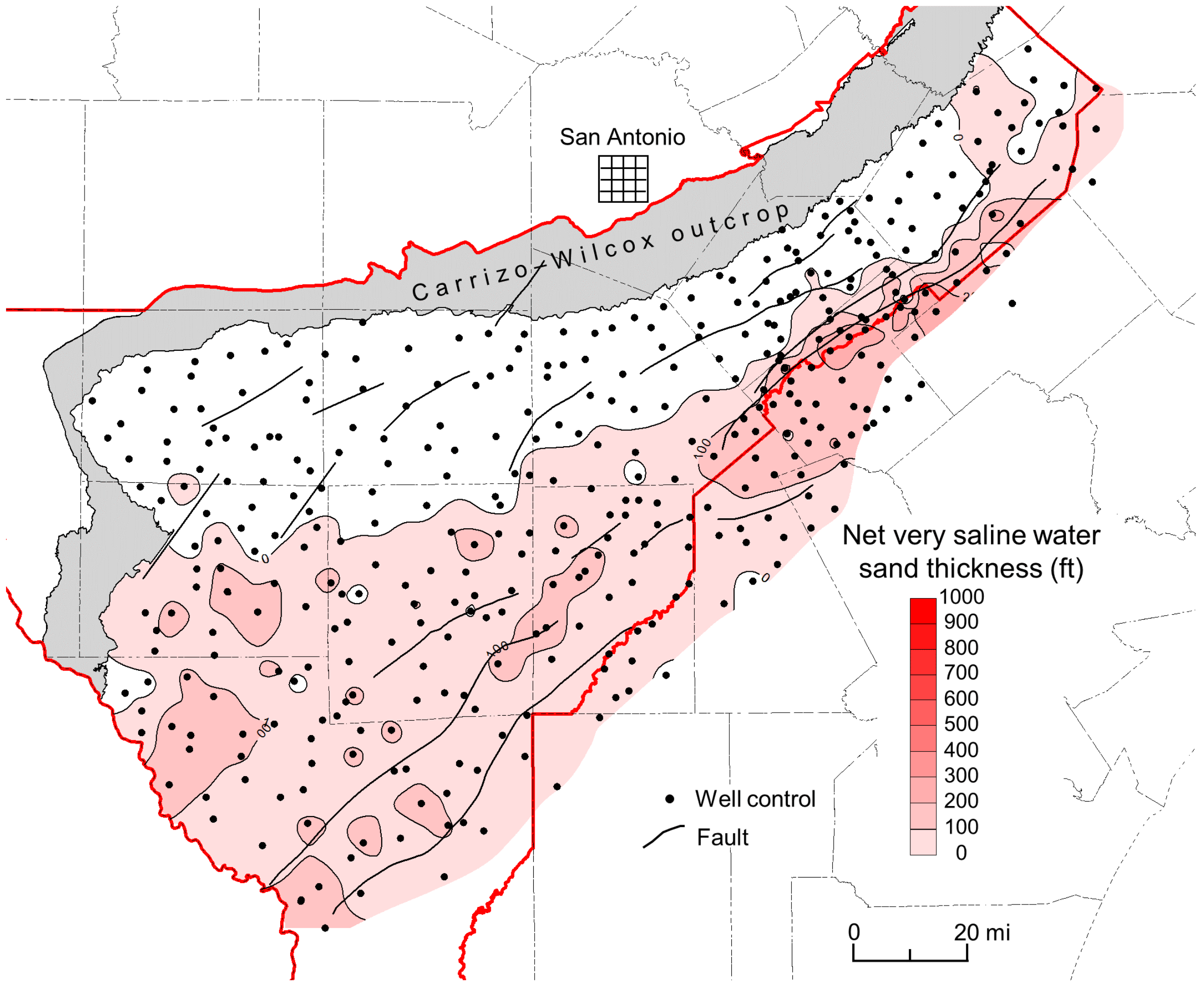


**Figure 4-18. Net thickness of sand containing very saline groundwater in the middle Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

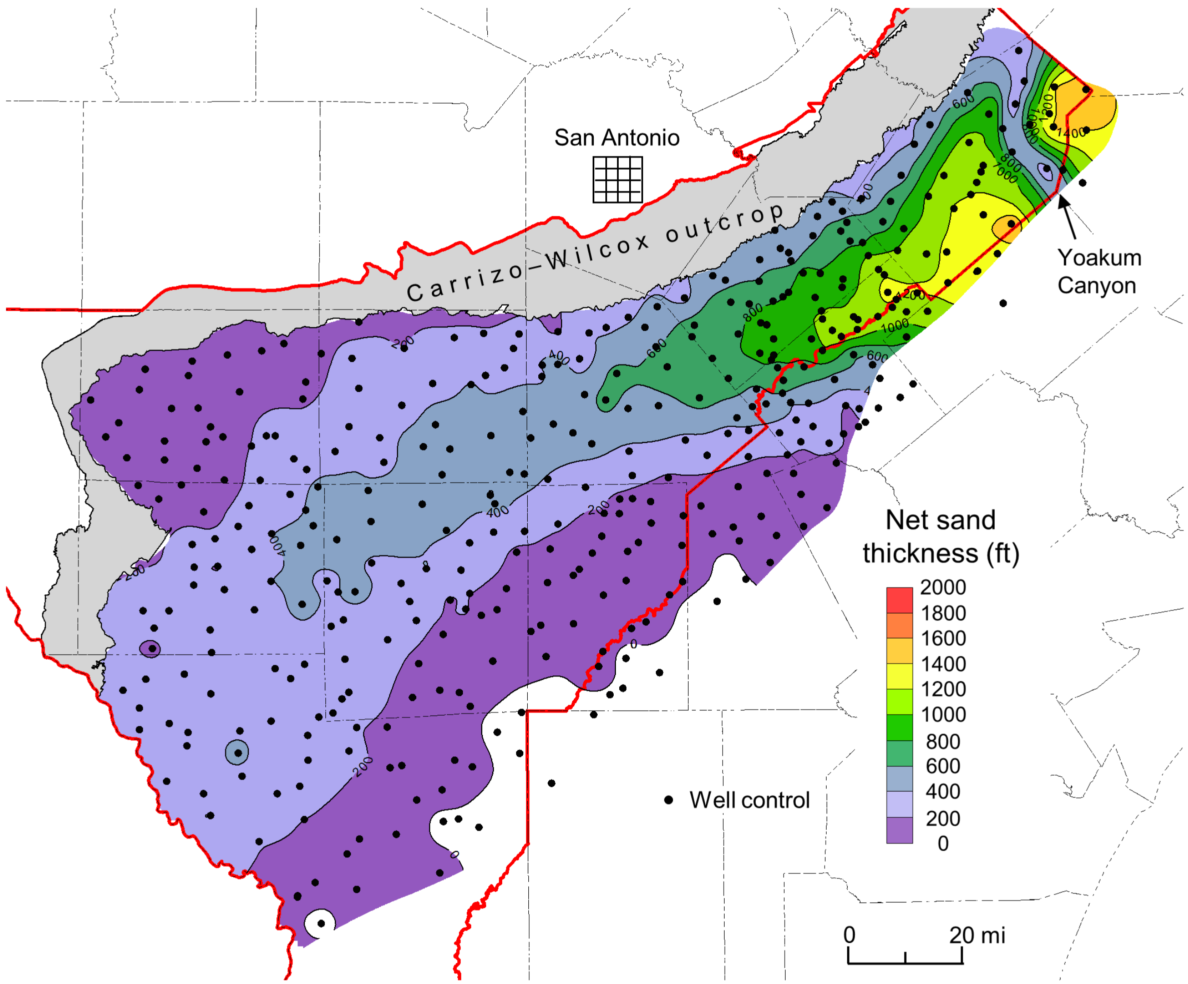


**Figure 4-19.** **Lower Wilcox net sand thickness. Maximum sand thicknesses in the lower Wilcox are located in the northeast part of the study area. The shale-filled Yoakum Canyon erosionally truncates lower Wilcox sands.**

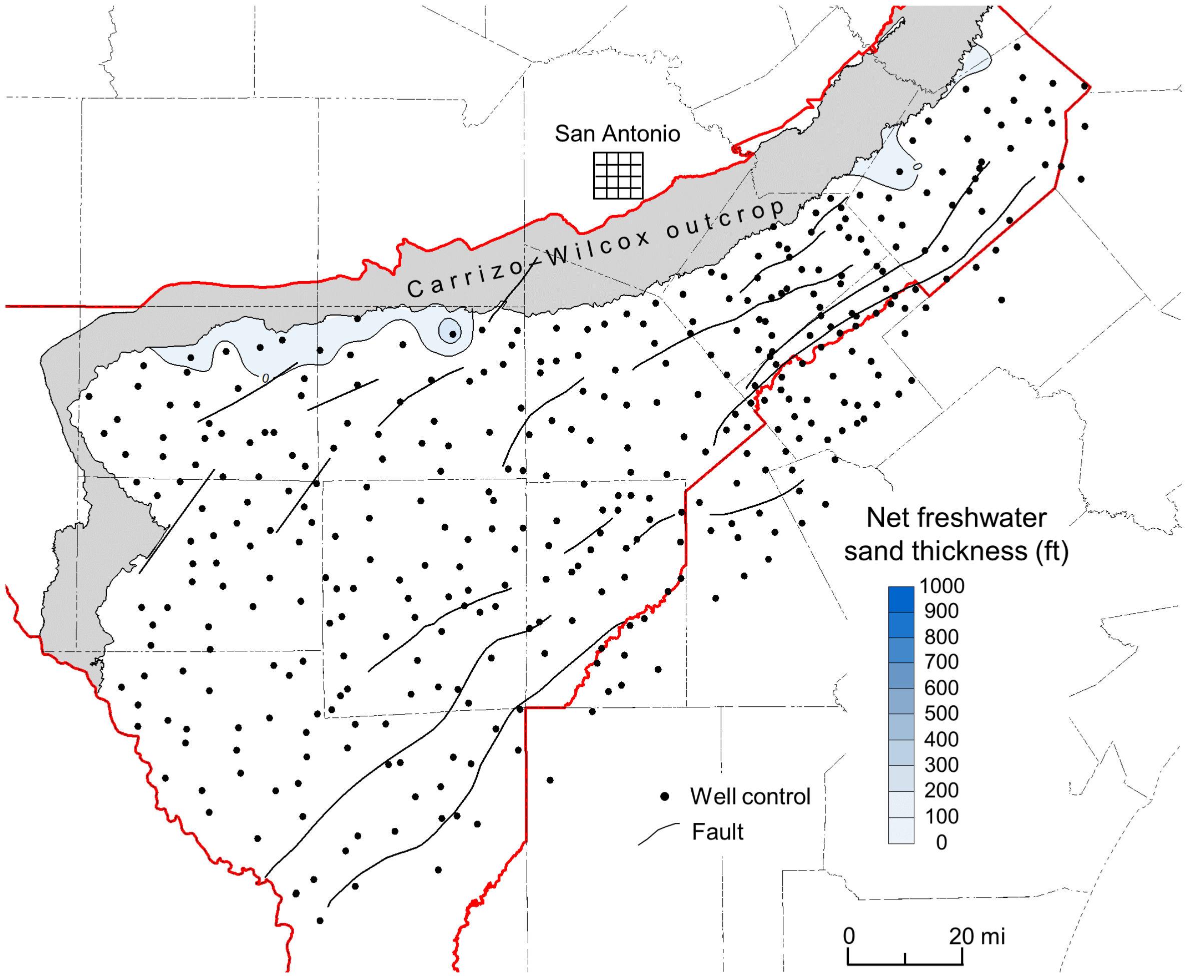


**Figure 4-20.** **Net thickness of sand containing fresh groundwater in the lower Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

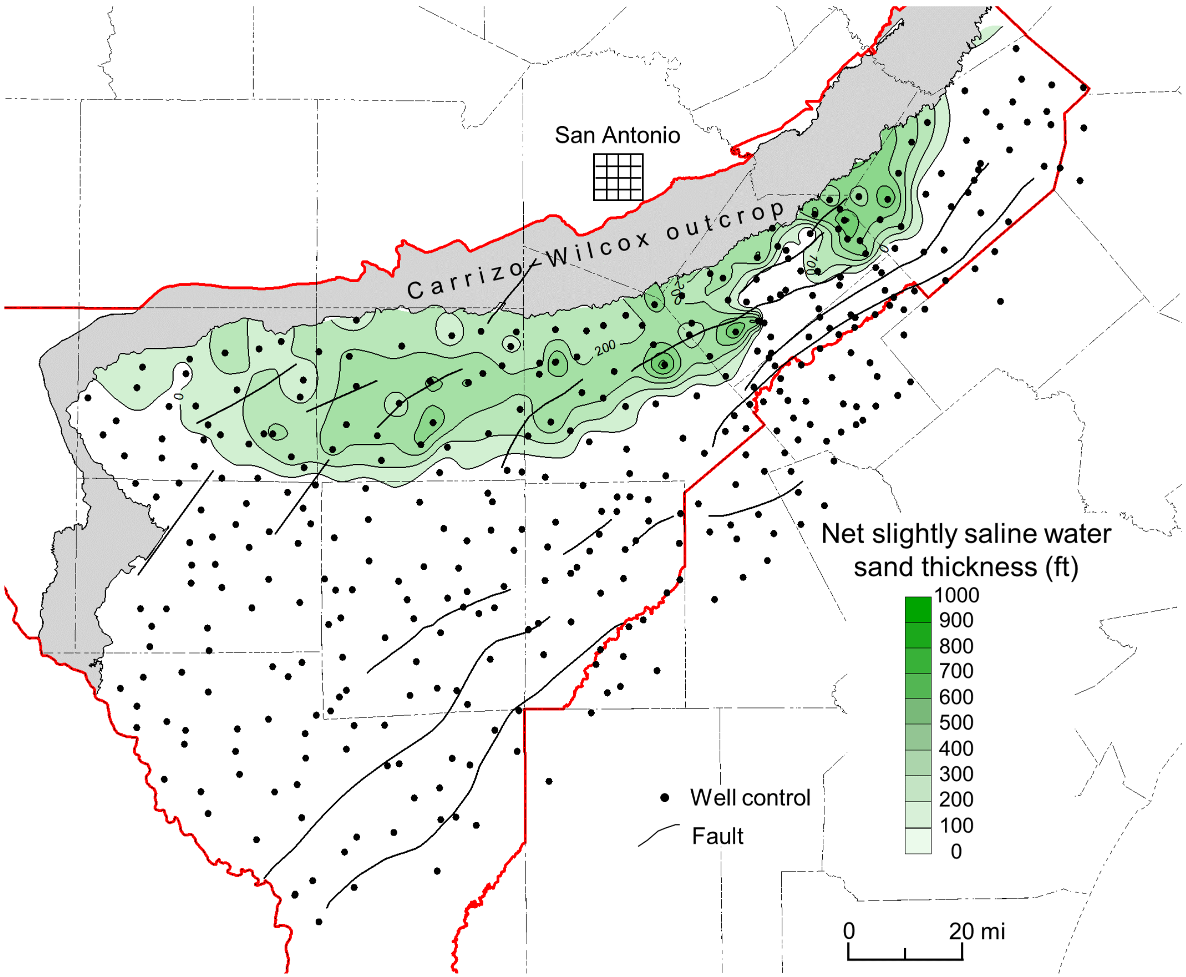


**Figure 4-21. Net thickness of sand containing slightly saline groundwater in the lower Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

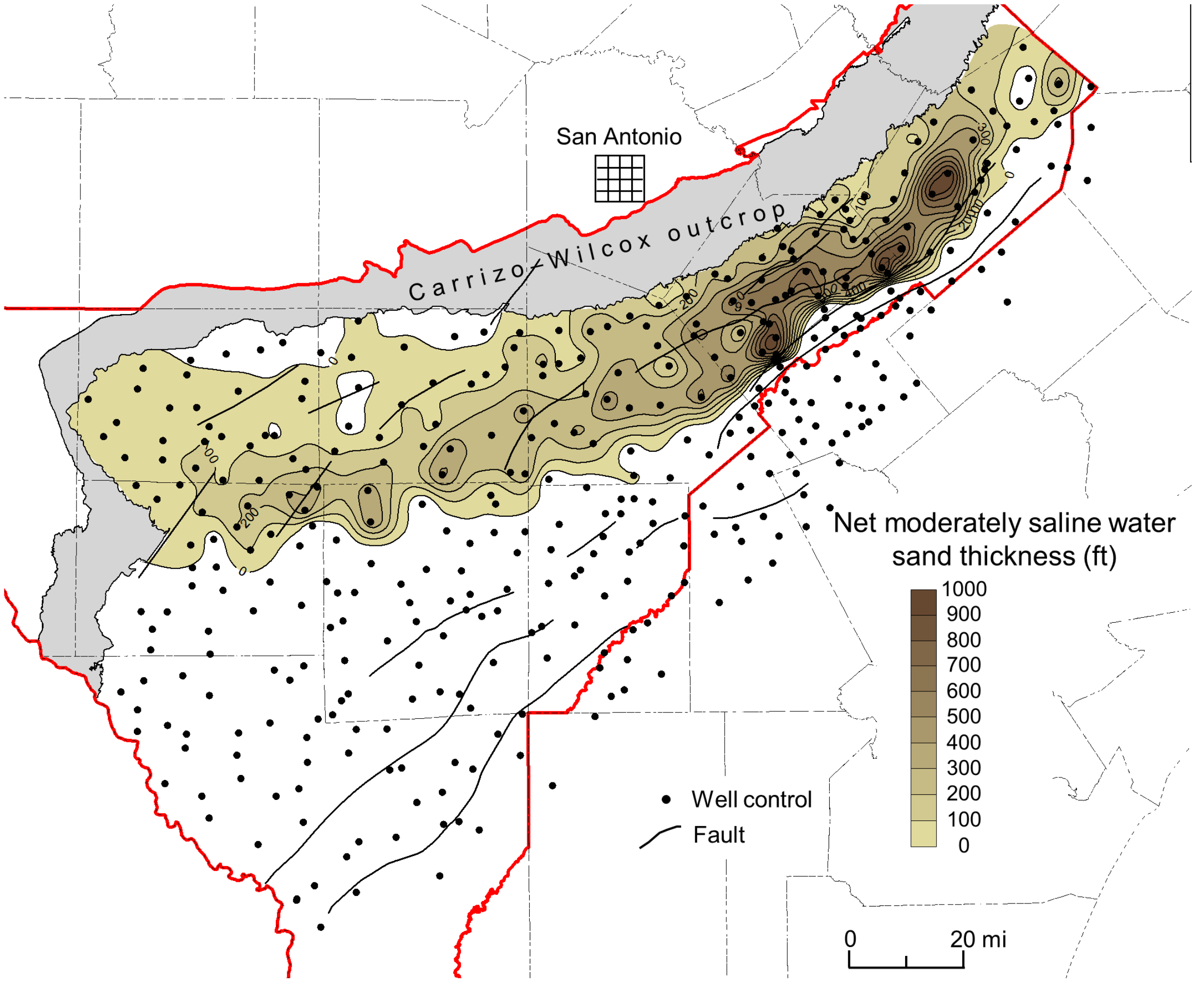


**Figure 4-22. Net thickness of sand containing moderately saline groundwater in the lower Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

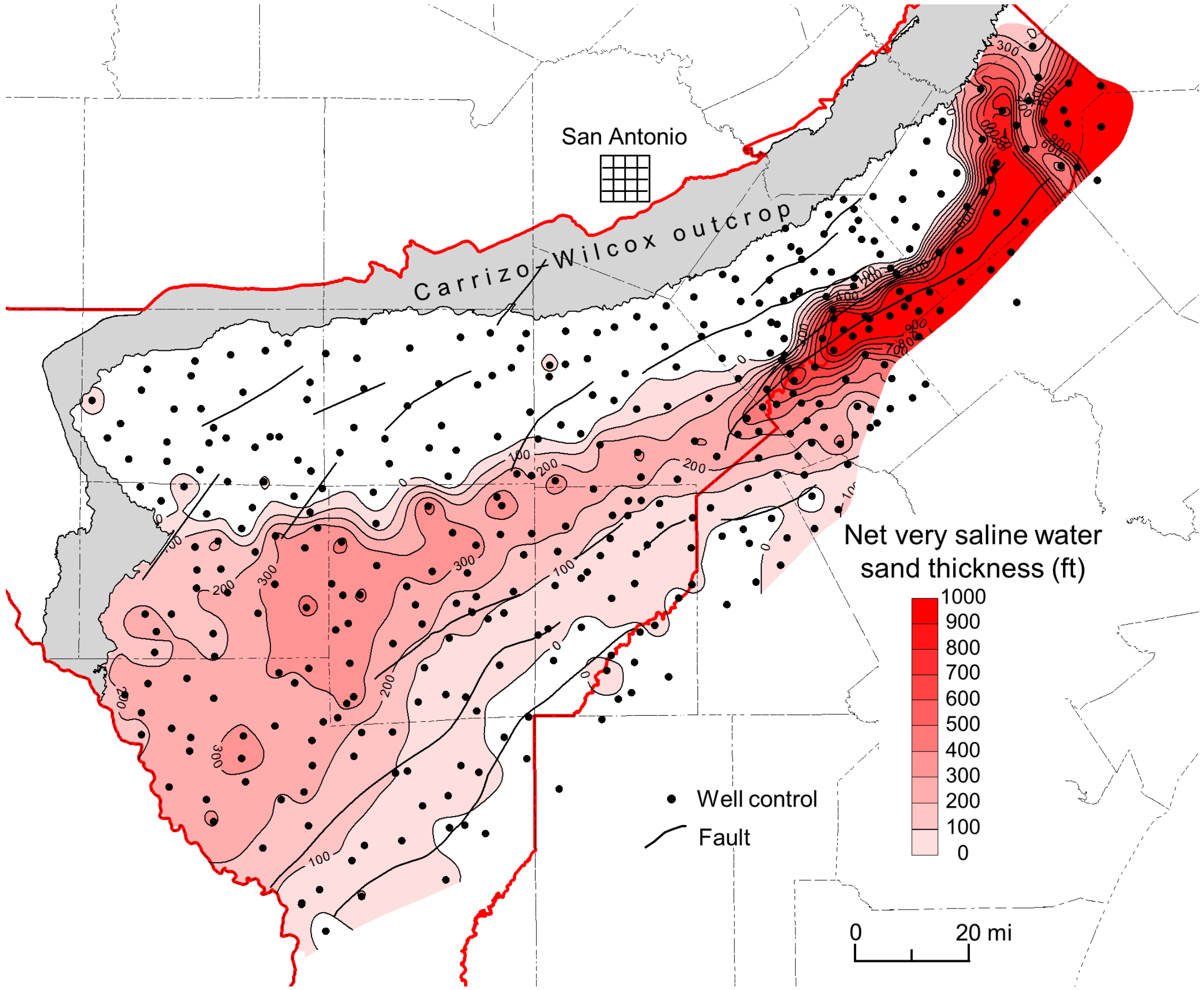


**Figure 4-23. Net thickness of sand containing very saline groundwater in the lower Wilcox interval. Fault zones modified from Ewing (1990) and Hargis (2009).**

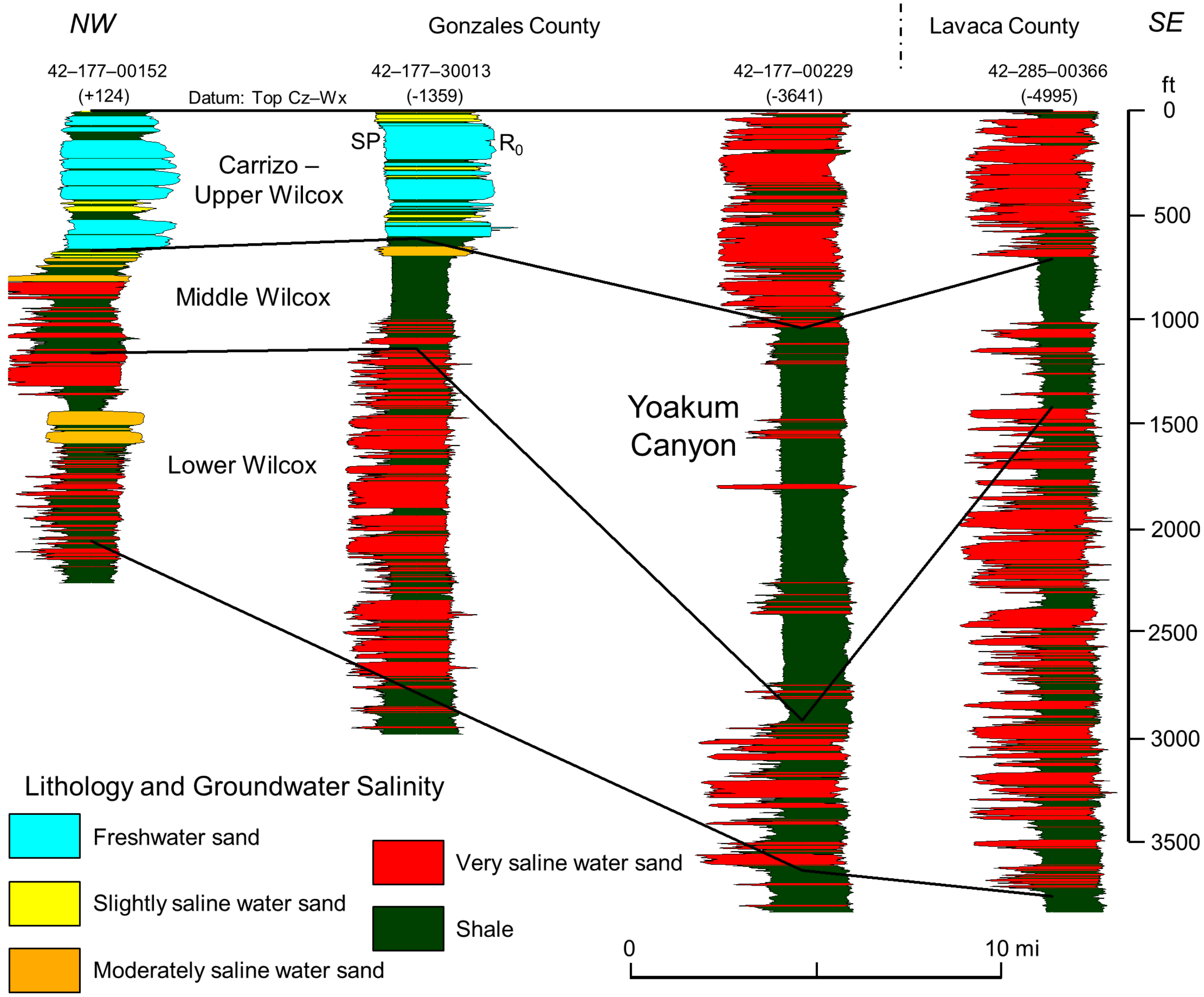


**Figure 4-24.** **Stratigraphic cross section A showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

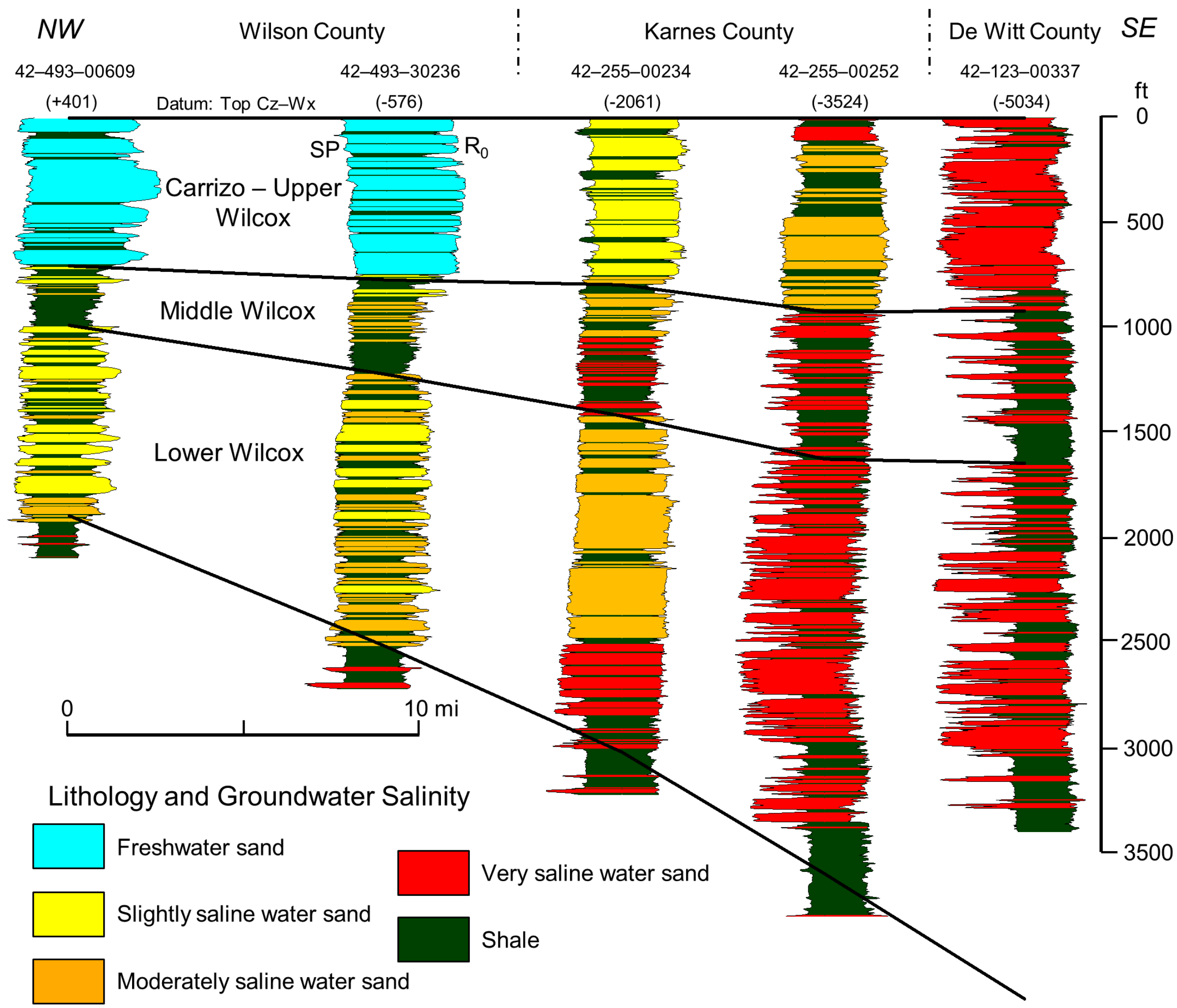


**Figure 4-25.** **Stratigraphic cross section B showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

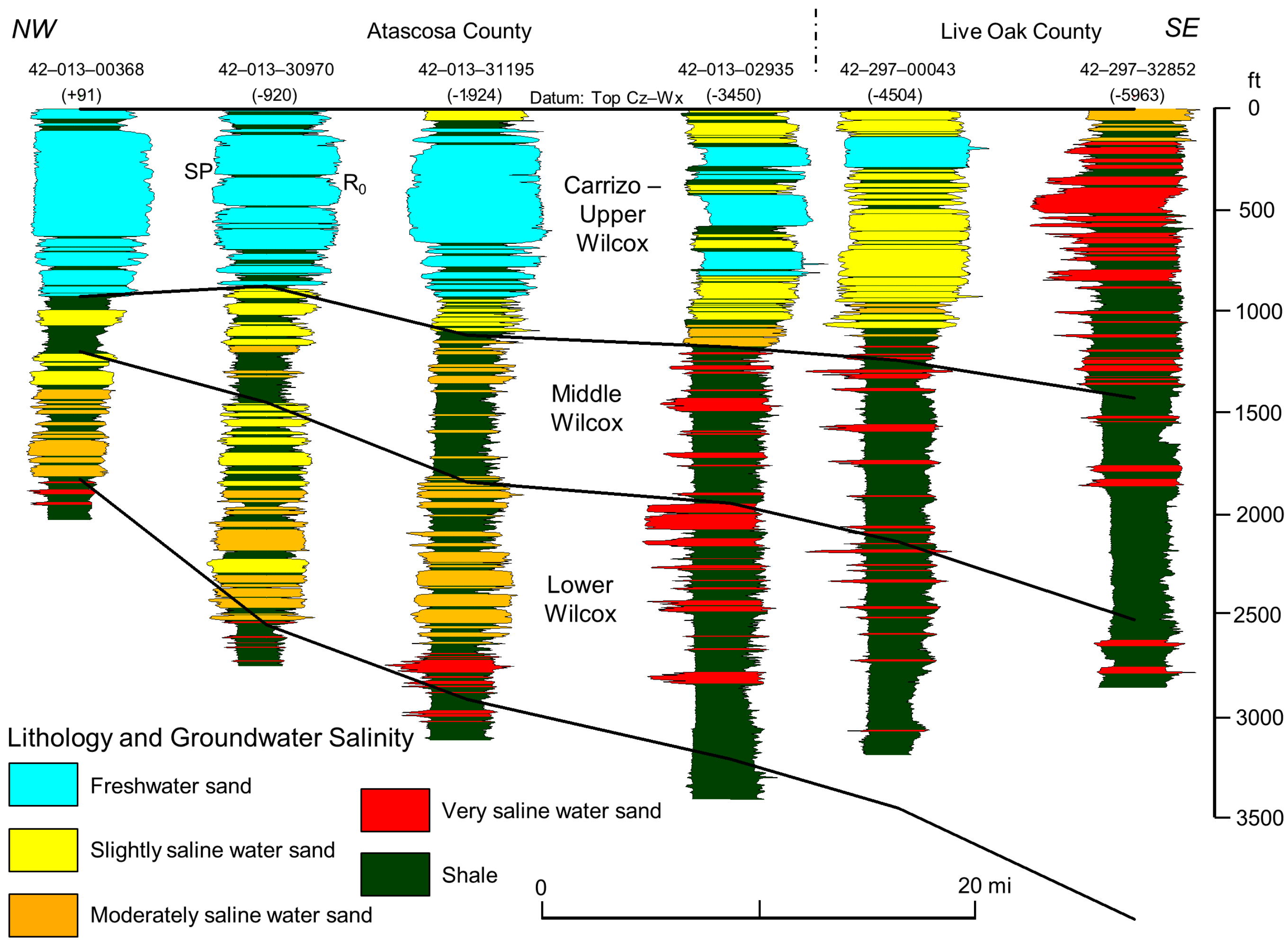


**Figure 4-26.** **Stratigraphic cross section C showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

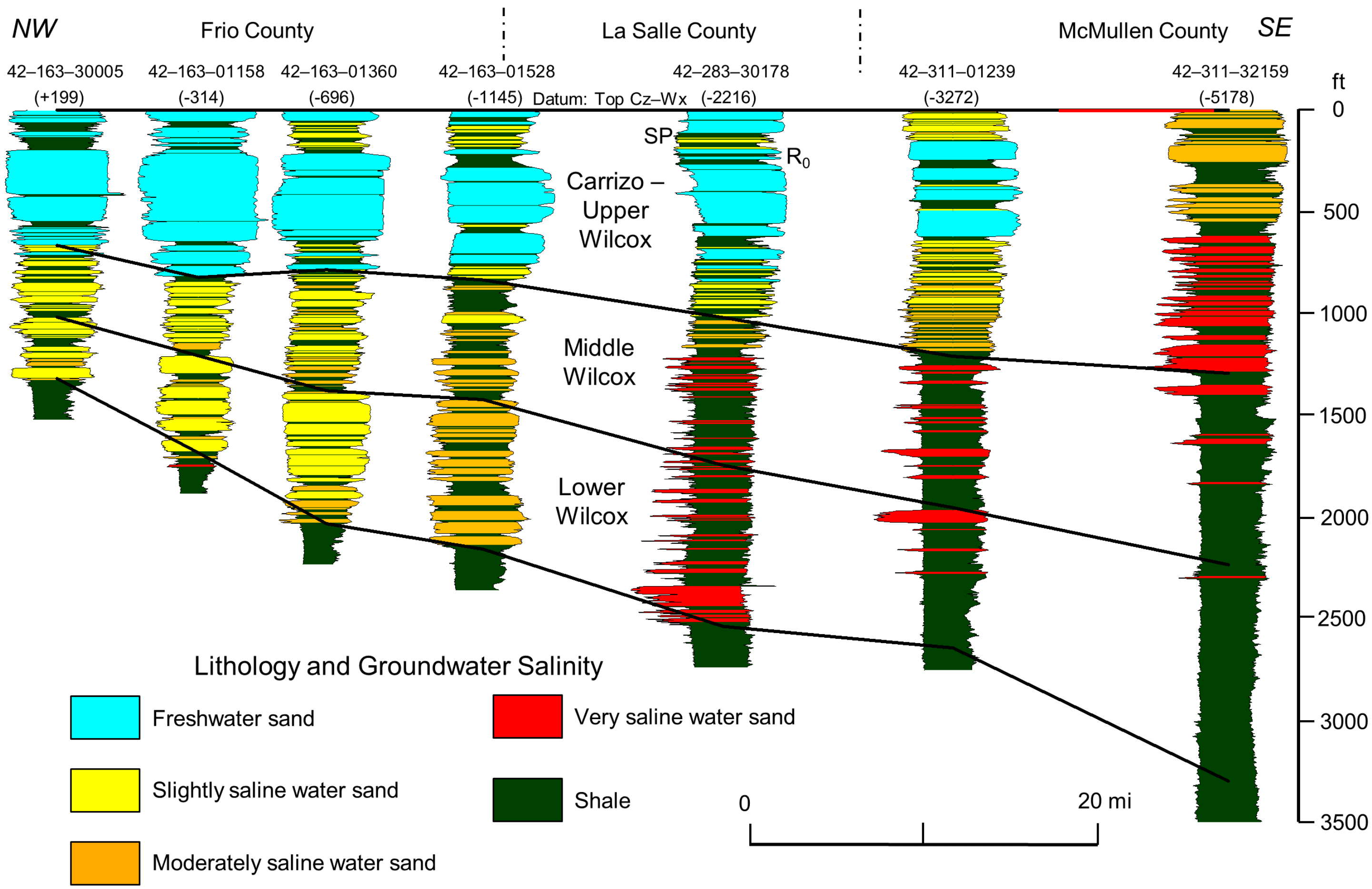


**Figure 4-27.** **Stratigraphic cross section D showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

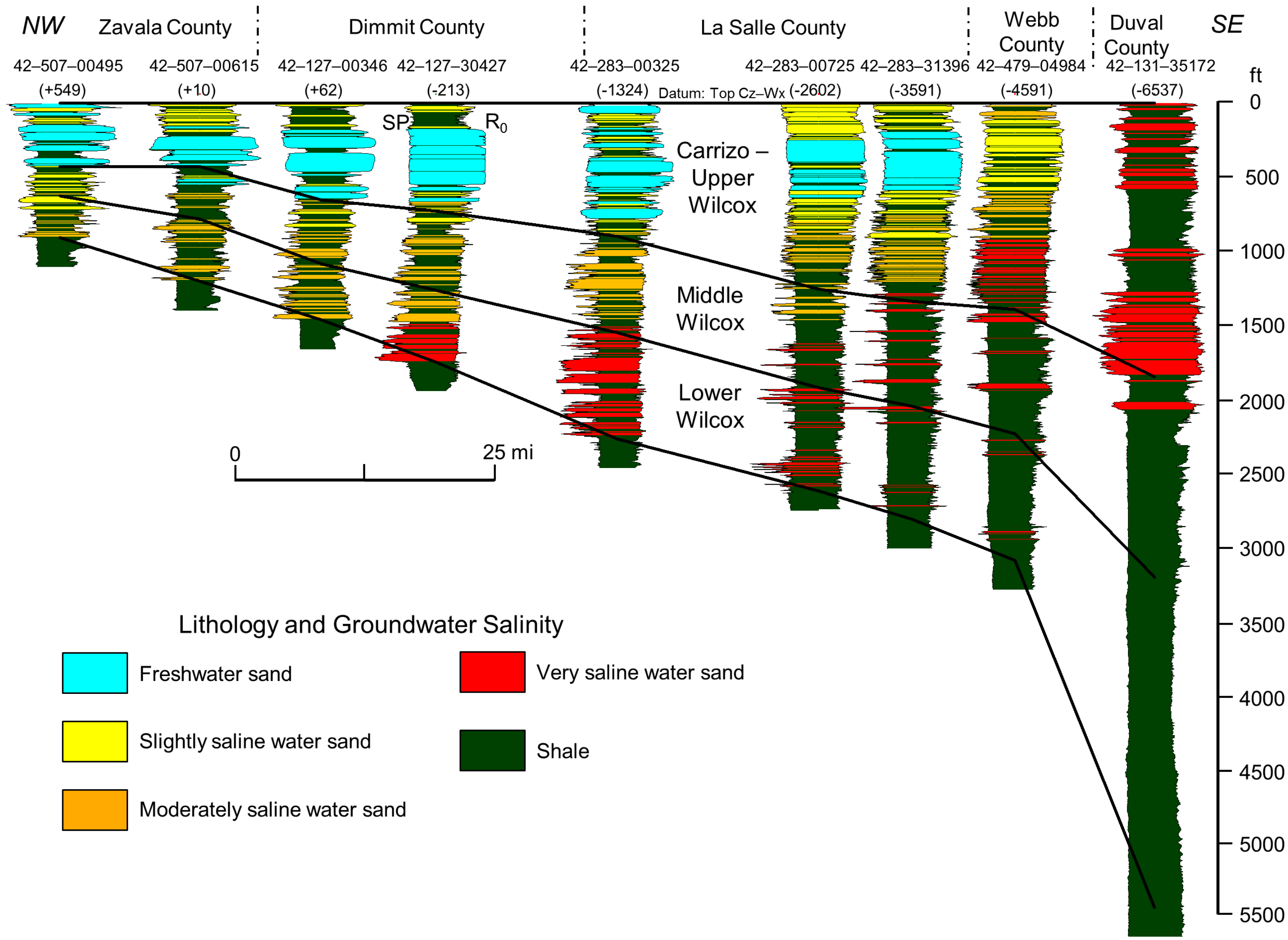


**Figure 4-28.** **Stratigraphic cross section E showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

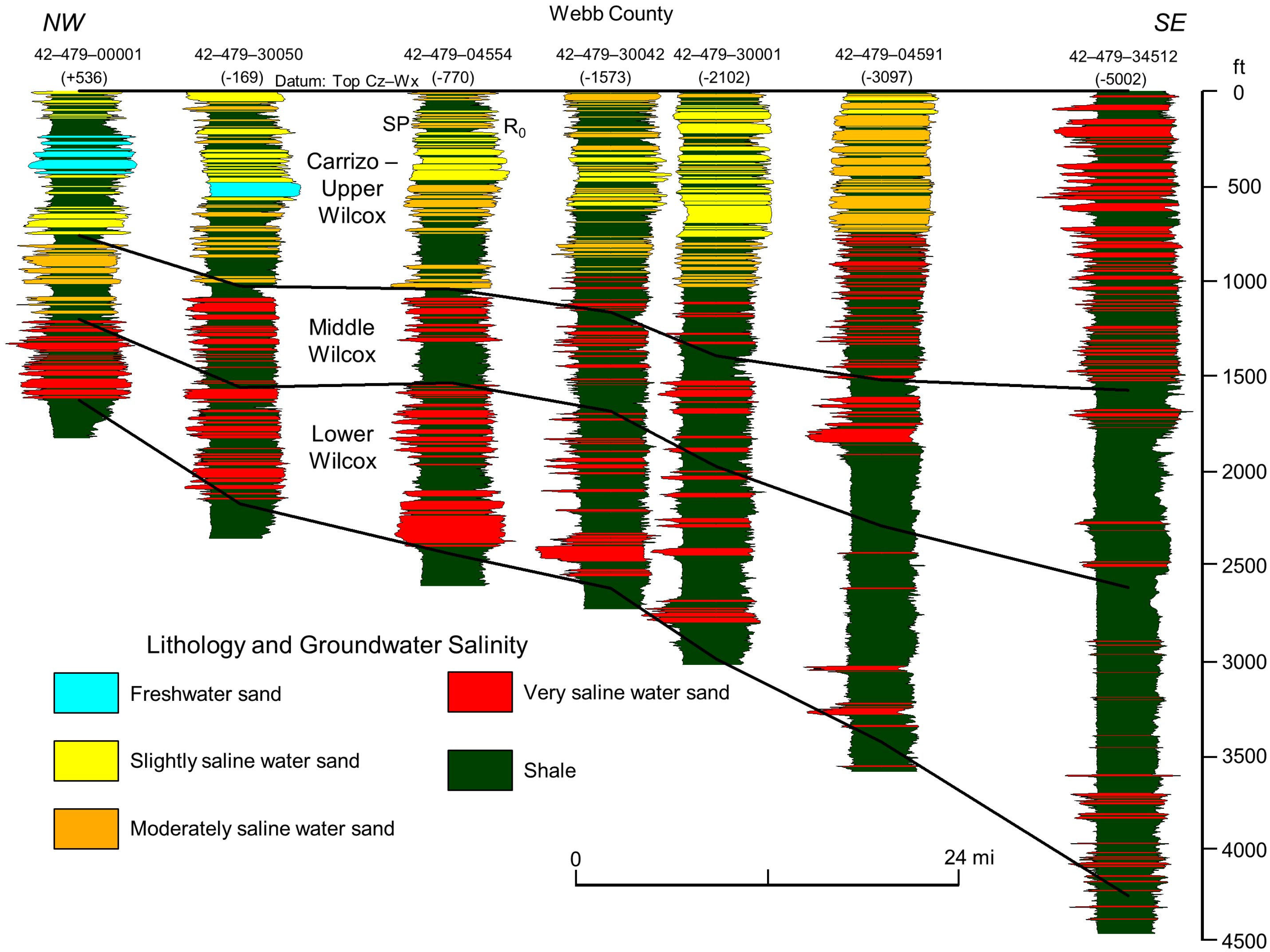


**Figure 4-29.** **Stratigraphic cross section F showing lithologies and groundwater salinities. See Figure 4-1 for location. Well API numbers are shown at top. SP (left side) and resistivity (right side) logs are shown for each well. Subsea elevation of the datum (top Carrizo–Wilcox Aquifer) is also shown for each well.**

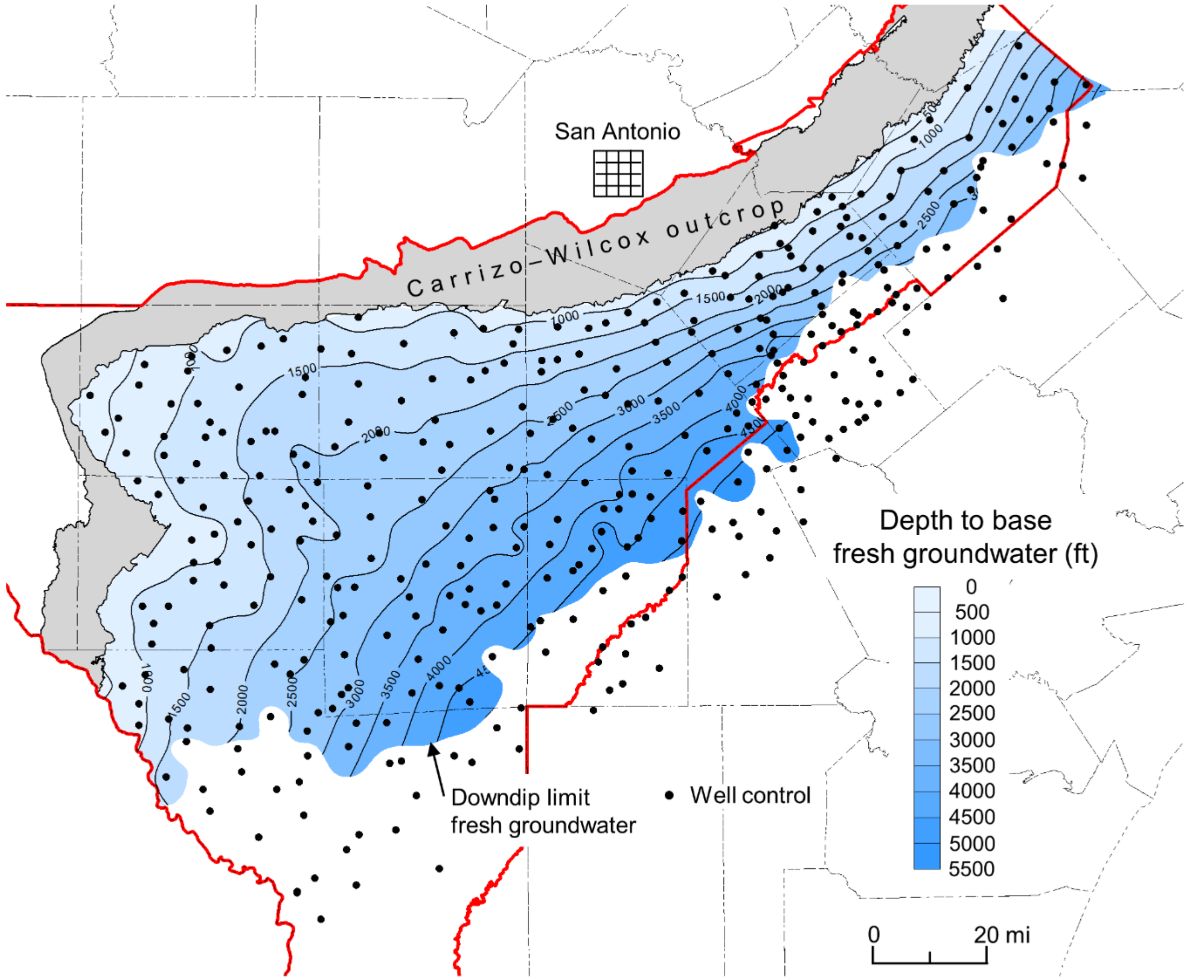


**Figure 4-30.** **Depth from surface to base (deepest occurrence) of fresh groundwater in the Carrizo–Wilcox aquifer. Almost all fresh groundwater is in the Carrizo–upper Wilcox interval.**

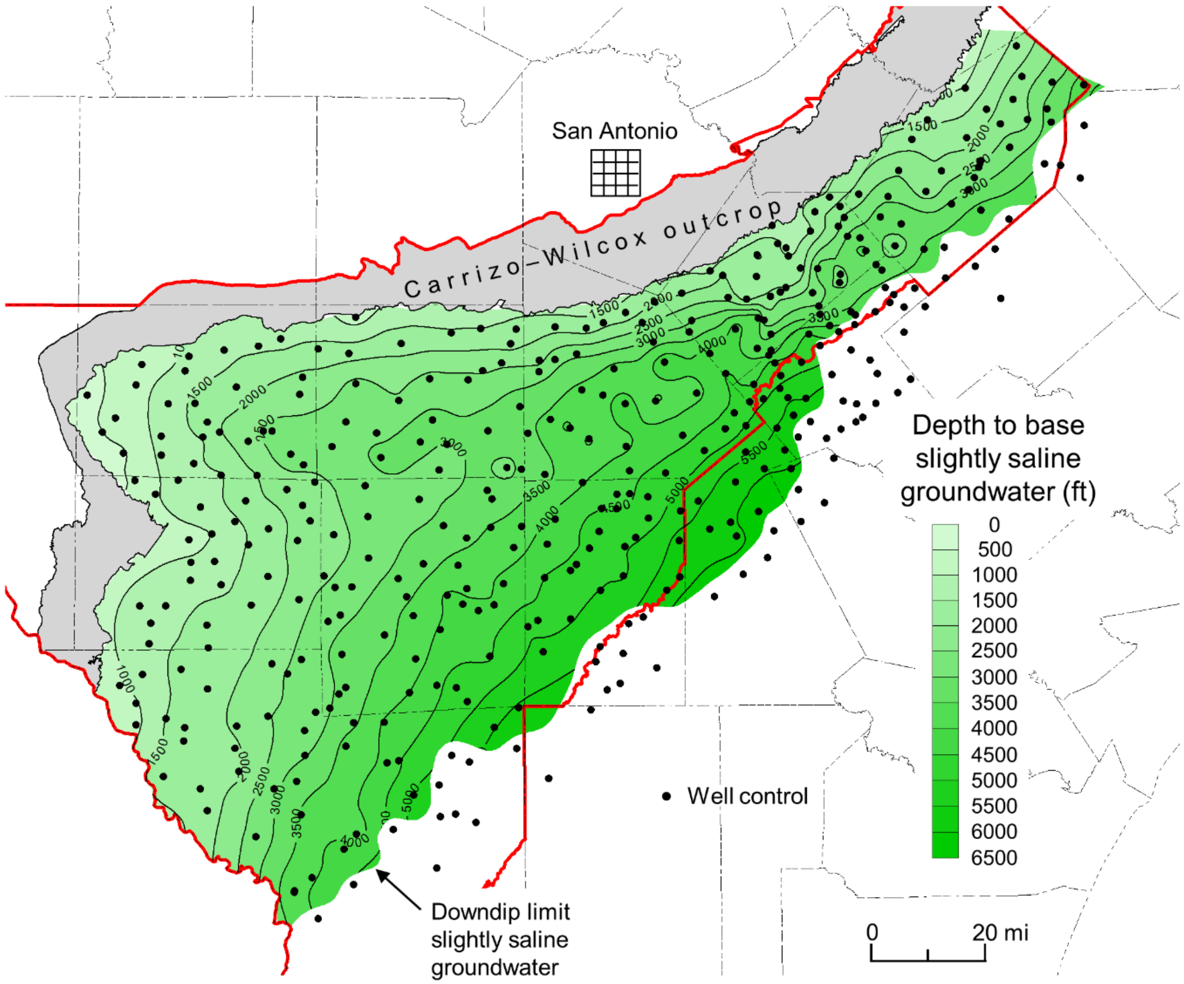


**Figure 4-31.** **Depth from surface to base (deepest occurrence) of slightly saline groundwater in the Carrizo–Wilcox aquifer.**

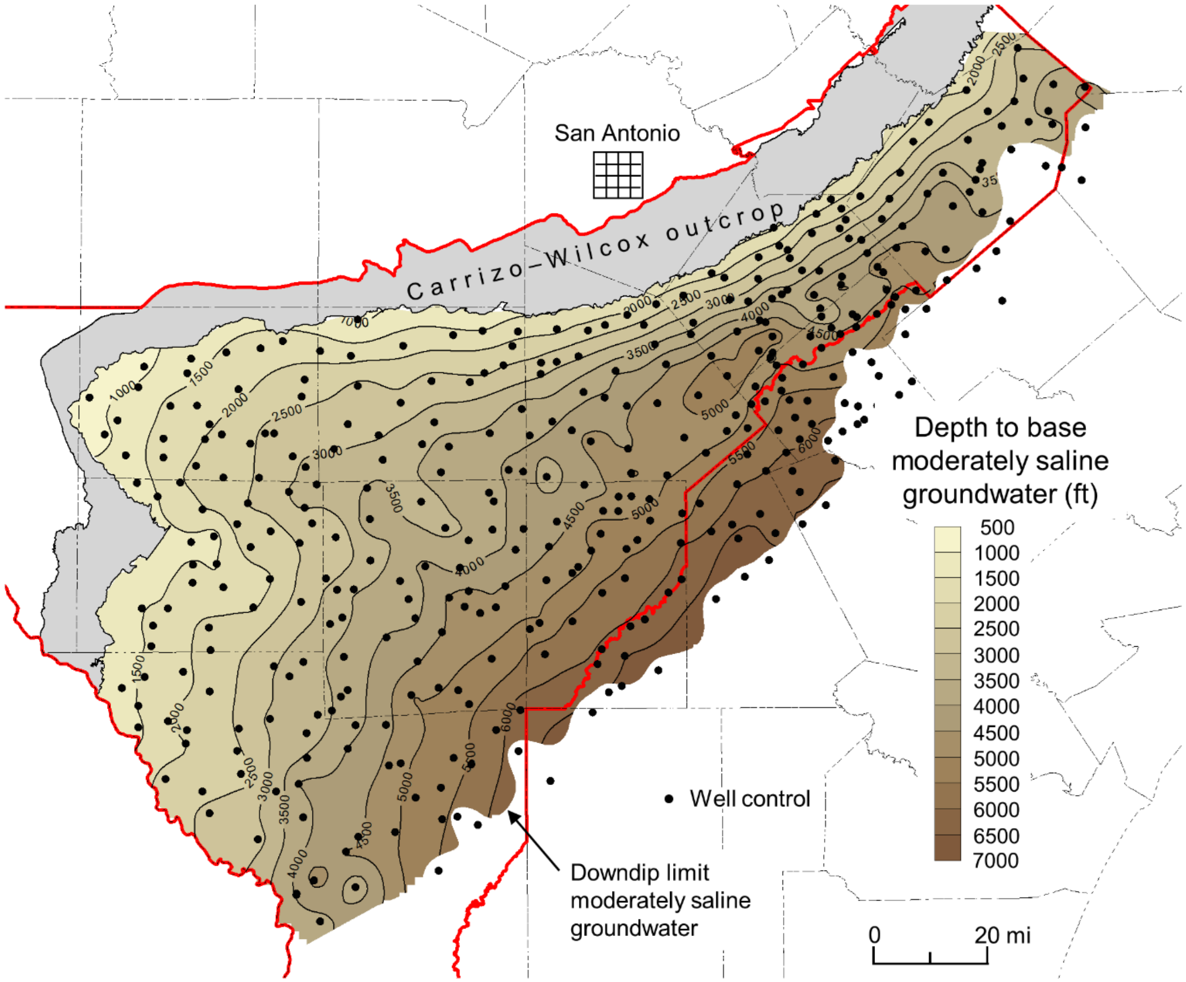


**Figure 4-32.** **Depth from surface to base (deepest occurrence) of moderately saline groundwater in the Carrizo–Wilcox aquifer.**

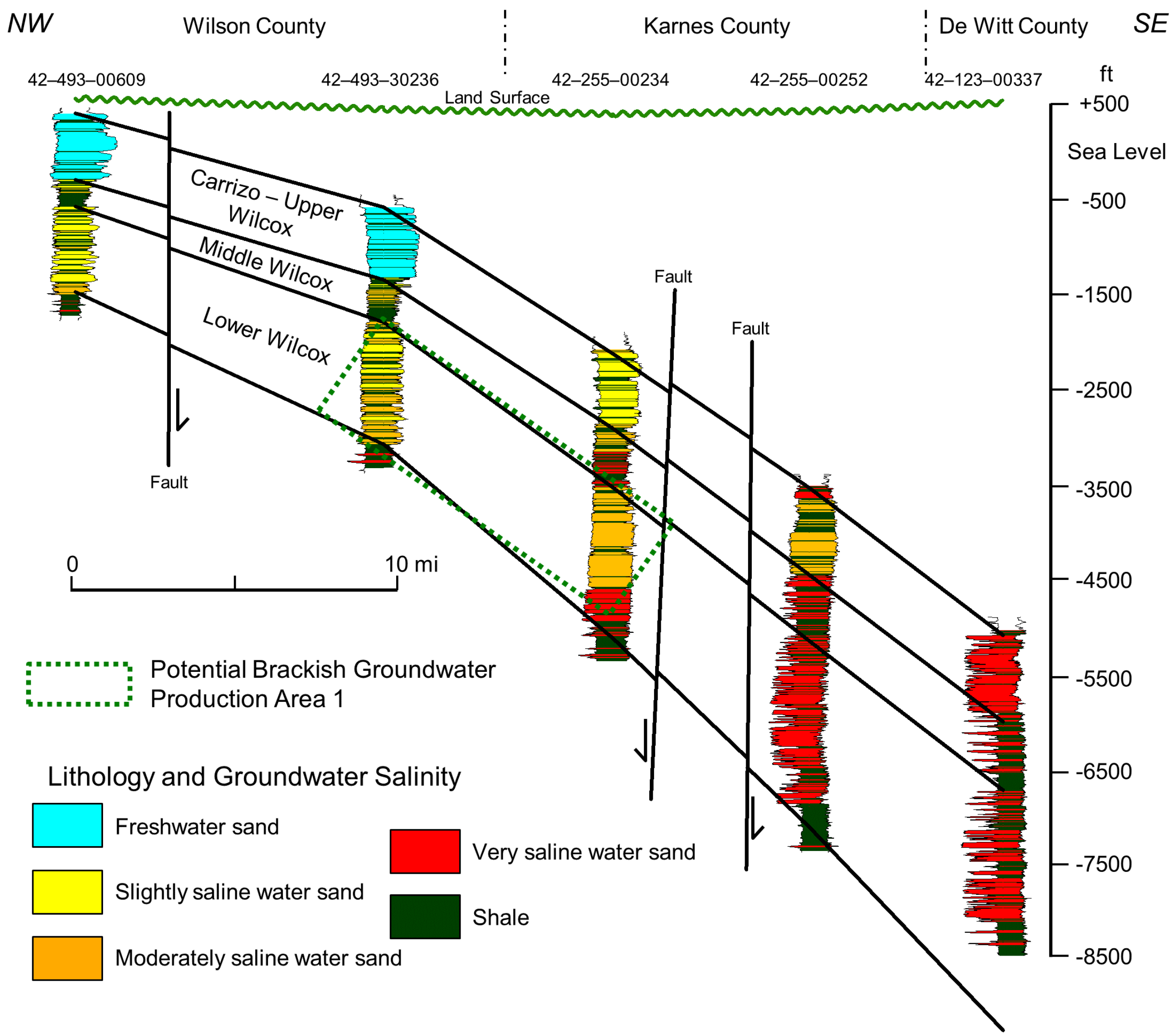


**Figure 4-33.** **Structural cross section B (sea-level datum) showing lithologies and groundwater salinities. Faults and potential brackish groundwater production areas are also shown. See Figure 4-1 for location.**

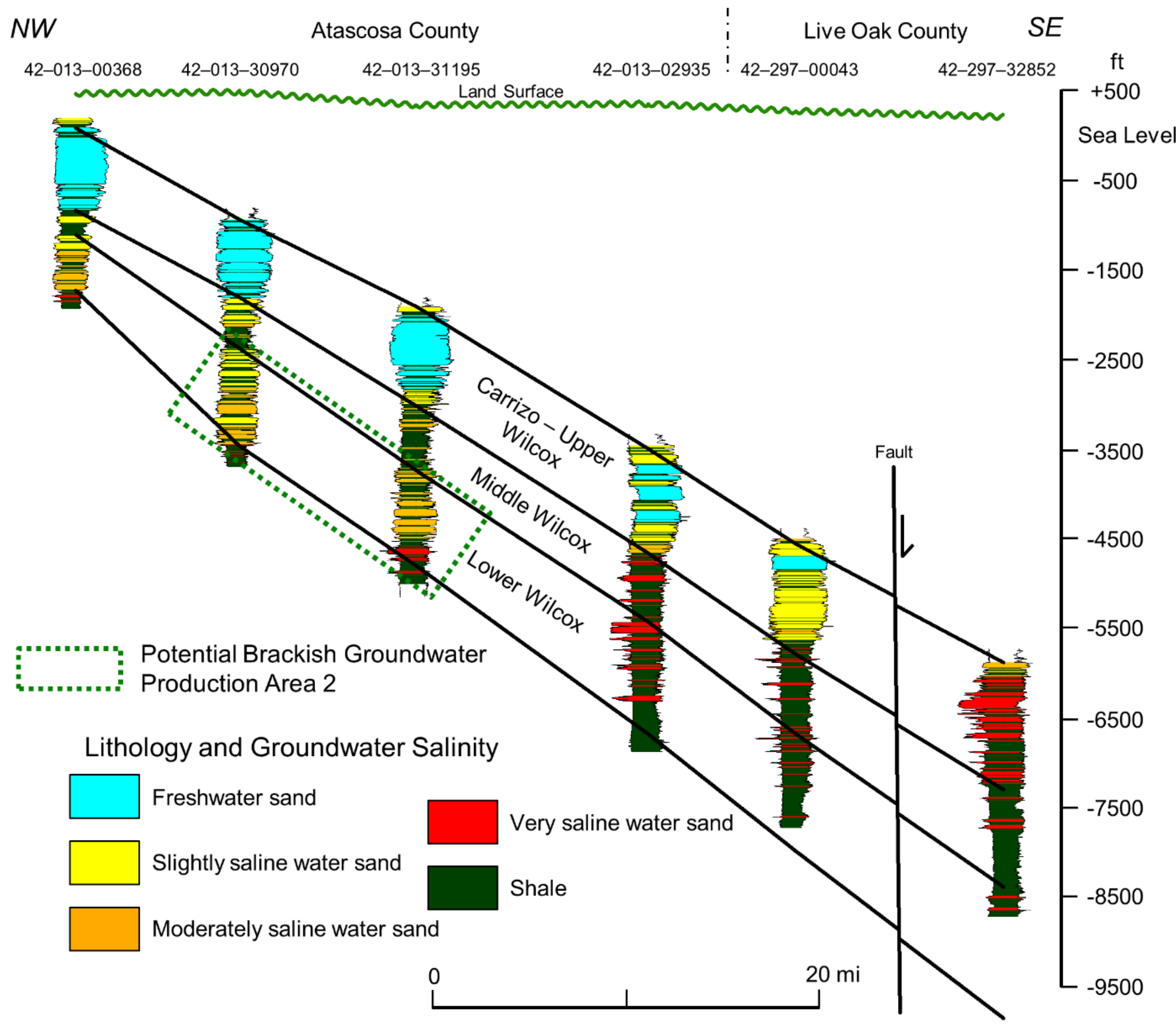


**Figure 4-34.** **Structural cross section C (sea-level datum) showing lithologies and groundwater salinities. Faults and potential brackish groundwater production areas are also shown. See Figure 4-1 for location.**

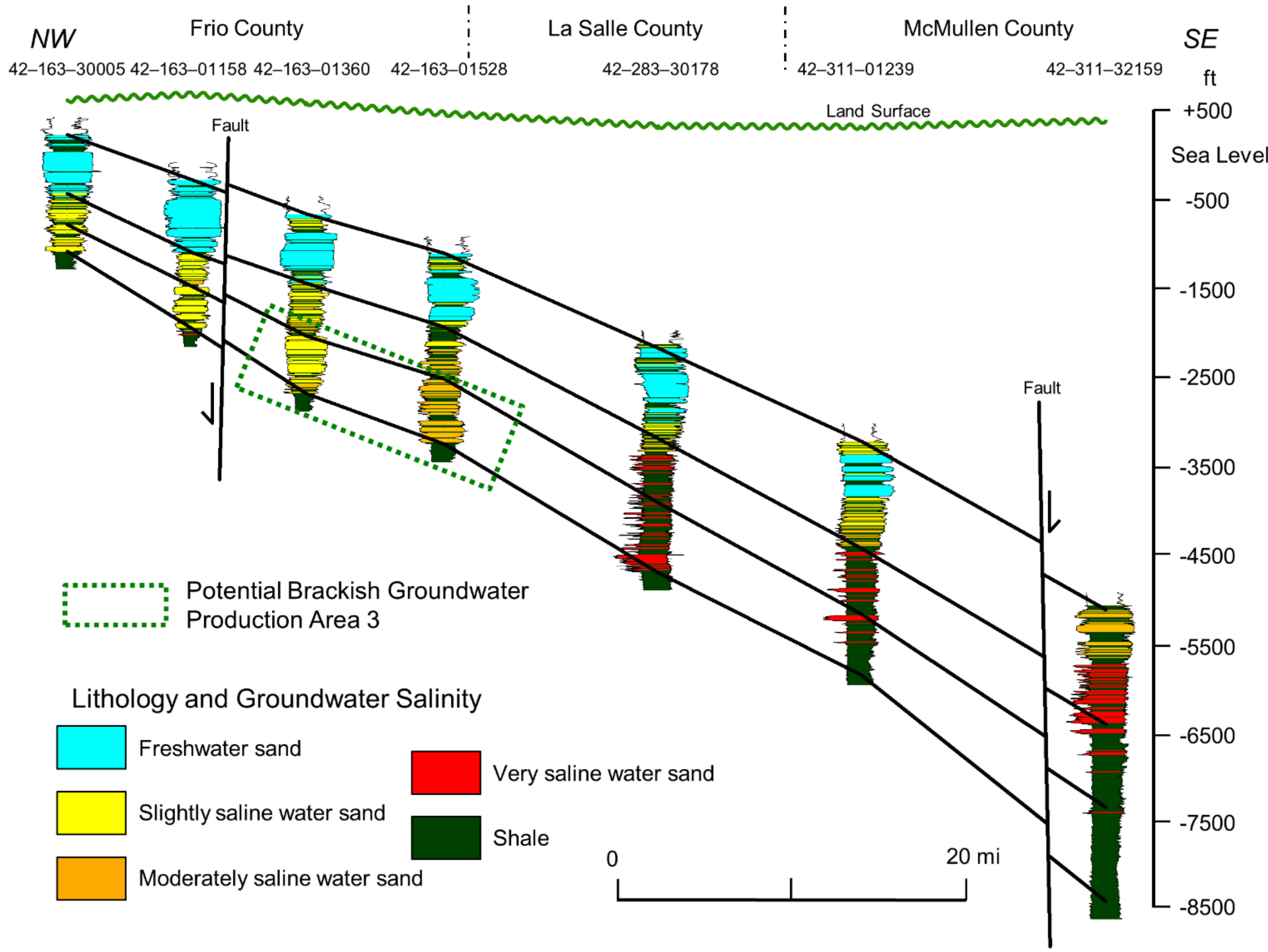


**Figure 4-35.** **Structural cross section D (sea-level datum) showing lithologies and groundwater salinities. Faults and potential brackish groundwater production areas are also shown. See Figure 4-1 for location.**

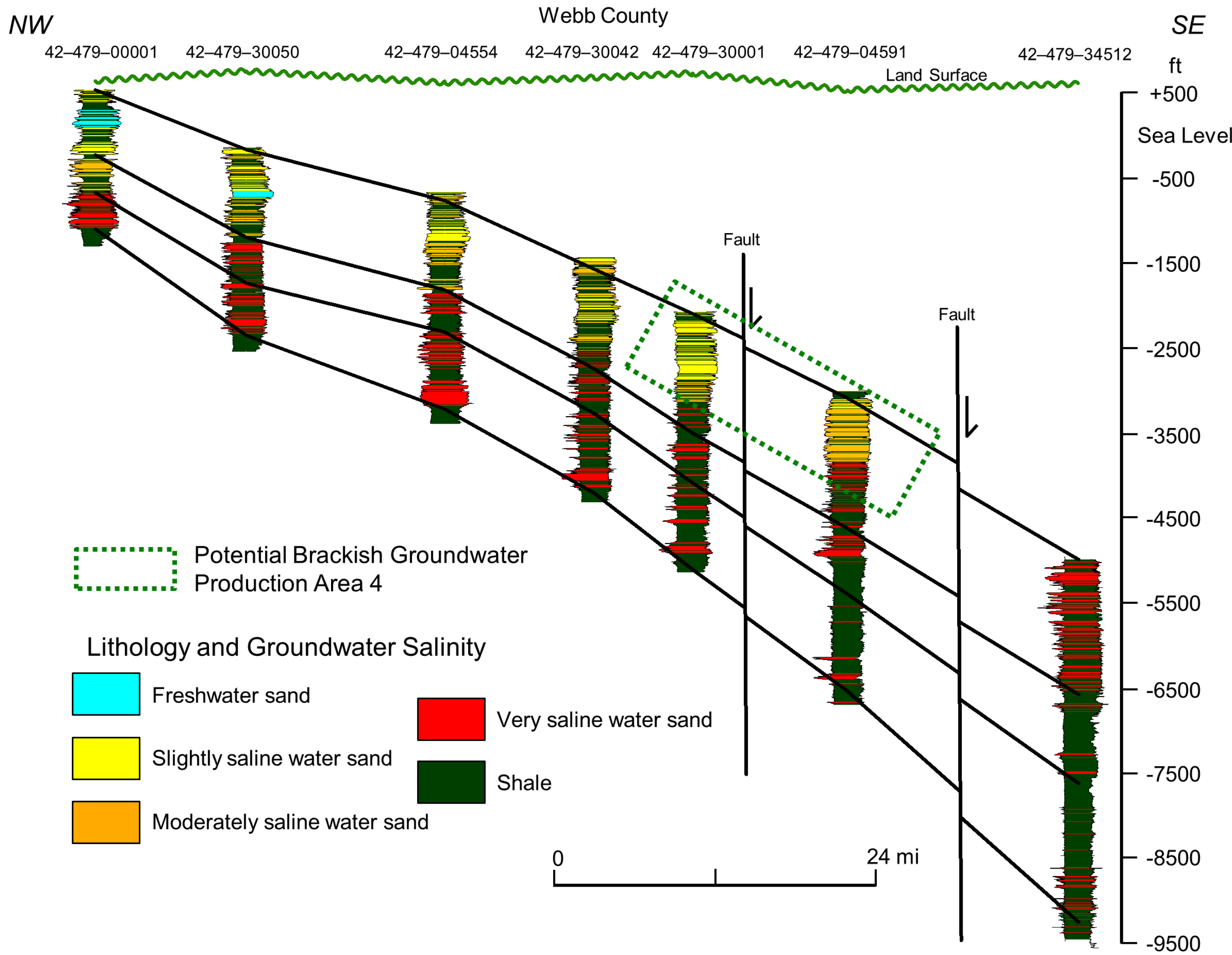


**Figure 4-36. Structural cross section F (sea-level datum) showing lithologies and groundwater salinities. Faults and potential brackish groundwater production areas are also shown. See Figure 4-1 for location.**

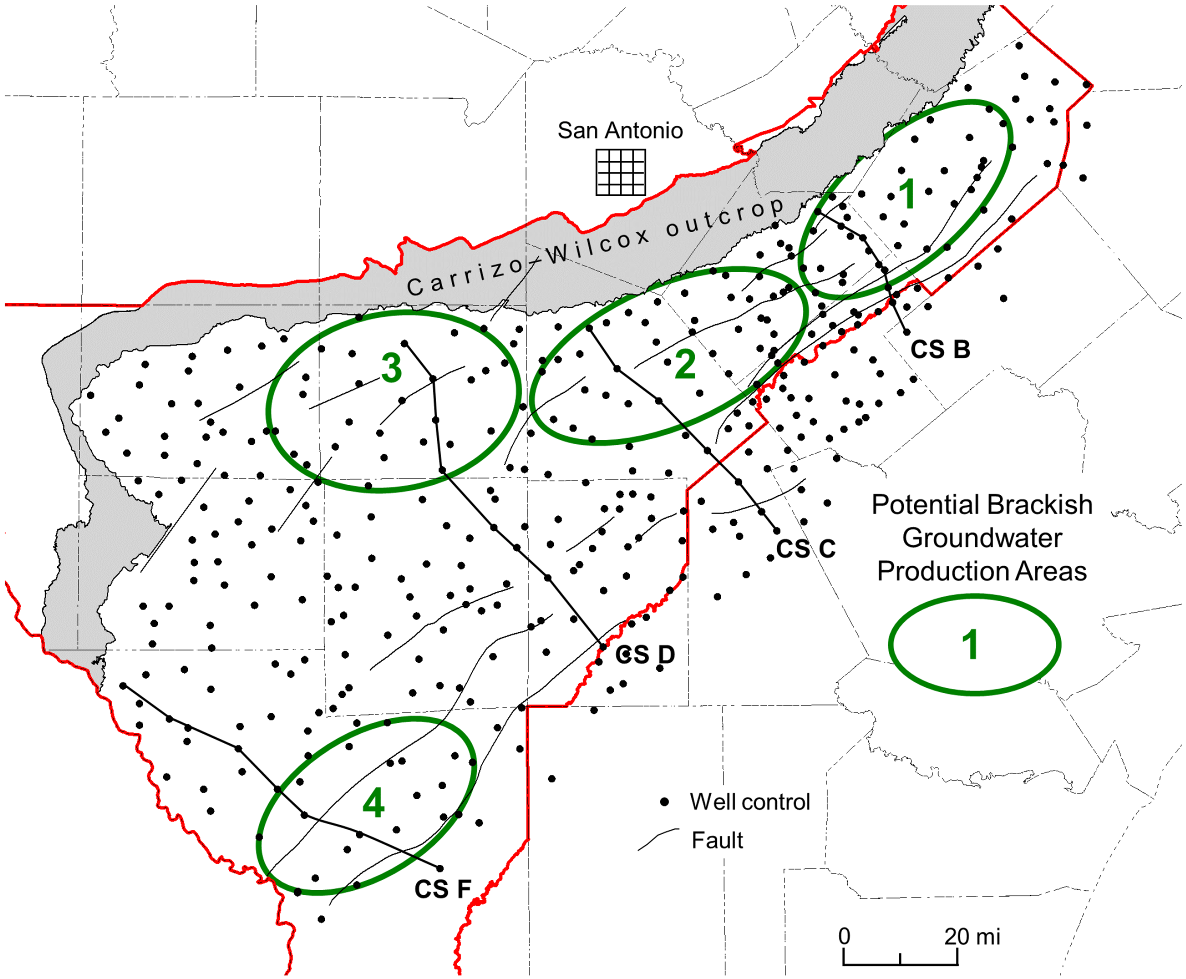


**Figure 4-37. Potential brackish groundwater production areas in the Carrizo–Wilcox Aquifer in GMA 13. Structural cross sections show the vertical location and stratigraphic setting of each production area (Figures 4-32 – 4-35).**

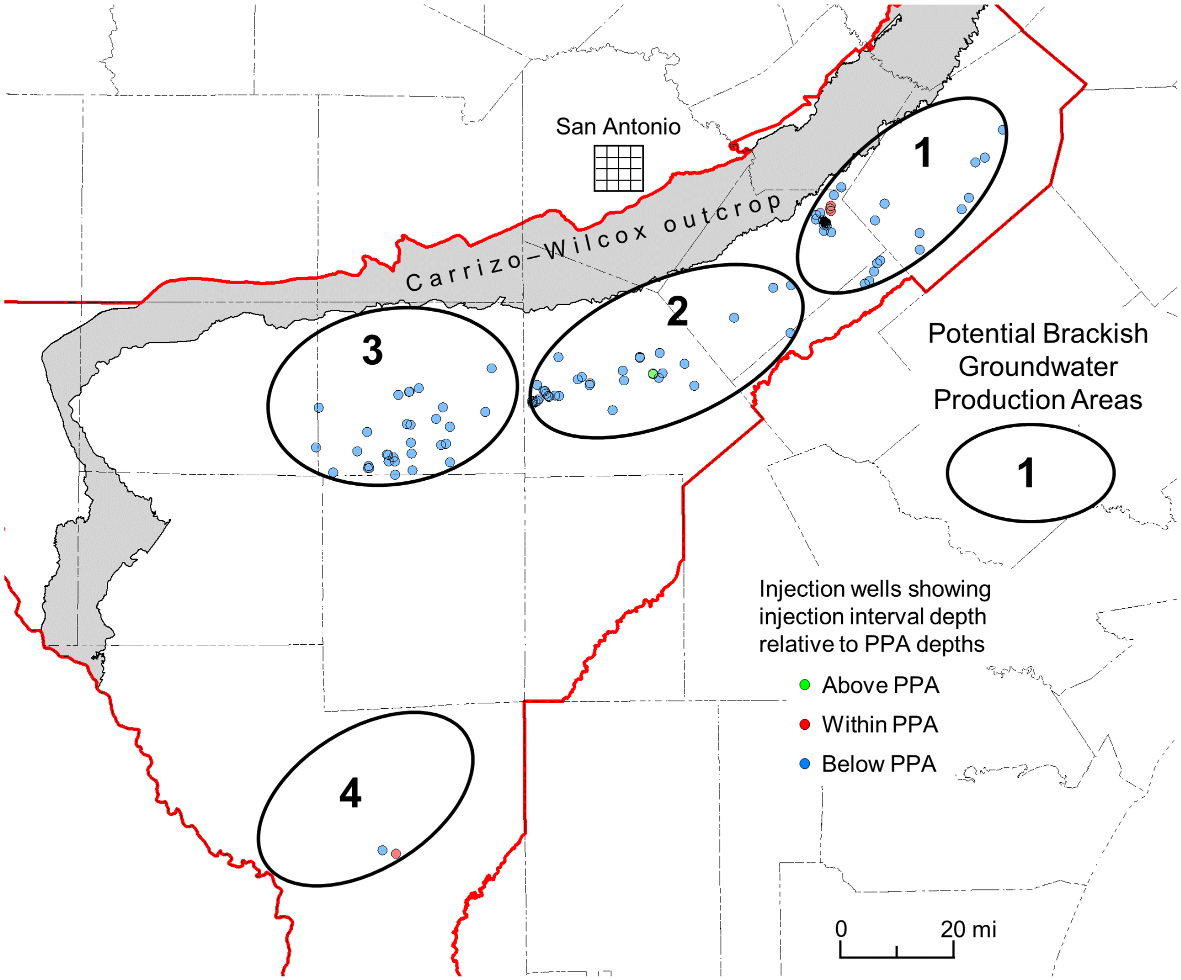


**Figure 4-38. Location of Class II injection wells within the potential brackish groundwater production areas. Injection intervals relative to the PPAs are also shown.**

# 5 Volumes of Fresh, Brackish and Saline Groundwater

In this section, estimates of groundwater volumes are generated for different classifications of groundwater quality for the Carrizo-Wilcox Aquifer based on the interpolation and extrapolation of the results of the geophysical logs presented in Section 4.

## 5.1 Mechanics of Calculating Groundwater Volumes

Wade and Bradley (2013) provide a good overview of an approach for calculating the volume of groundwater in storage as part their calculation of Total Estimated Recoverable Storage (TERS) for different aquifers in GMA 13. As part of this study, we will perform the same type of calculation that Wade and Bradley (2013) performed to calculate TERS but we will go into more detail. That level of detail will include partitioning the groundwater into different water quality classifications developed by the United States Geological Survey (Winslow and Kister, 1956) and presented in **Table 5-1**.

**Table 5-1. Groundwater classification based on the Criteria Establish by Winslow and Kister (1956).**

| Water Classification Description | TDS Range |
|---|---|
| Fresh | Less than 1,000 mg/L |
| Slightly Saline | 1,000 to 3,000 mg/L |
| Moderately Saline | 3,000 to 10,000 mg/L |
| Very Saline | 10,000 to 35,000 mg/L |

The method used by Wade and Bradley to calculate groundwater volume is dependent on whether or not the aquifer is confined or unconfined. In the Carrizo-Wilcox Aquifer, a portion of the aquifer is confined and a portion of the aquifer is unconfined. Before describing the mathematical equations that will be used to calculate the groundwater volumes, a general discussion of the confined and unconfined aquifer is presented in order to prepare the reader for the terminology used to describe the volume calculations. Because our mathematical calculations will be similar to those to calculate TERS, the much of the text in **Section 5.1.1** mimics the discussions from Wade and Bradley (2013).

### *5.1.1 Confined and Unconfined Aquifer*

**Figure 5-1** provides a schematic of a confined and unconfined aquifer. Like most dipping aquifers in the eastern part of Texas, the Carrizo-Wilcox Aquifer includes both unconfined and confined regions. **Figure 5-2** shows a schematic of a dipping aquifer that is unconfined up dip and is confined down dip.

For an unconfined aquifer, the total storage is equal to the volume of groundwater removed by pumping that makes the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer by pumping causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part, similar to unconfined aquifers, is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level decline, the amount of water released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity related to the confined aquifer and specific yield related to the unconfined aquifer. For example, storativity values range from $10^{-5}$ to $10^{-3}$ for most confined aquifers, while the specific yield values typically range from 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total groundwater volume are presented below:

For unconfined aquifers:

$$\text{Total Volume} = V_{drainable} = \text{Area} * S_y * (\text{Water Level} - \text{Bottom}) \quad \text{(Equation 5-1a)}$$

$$\text{Total Volume} = V_{in\ place} = \text{Area} * \theta * (\text{Water Level} - \text{Bottom}) \quad \text{(Equation 5-1b)}$$

For confined aquifers:

$$\text{Total Volume} = V_{confined} + V_{drainable} \quad \text{(Equation 5-1c)}$$

- Volume for confined part

$$V_{confined} = \text{Area} * [S *(\text{Water level-Top})] \quad \text{(Equation 5-2)}$$

Or

$$V_{confined} = \text{Area} * [S_s *(\text{Top-Bottom})*(\text{Water level-Top})] \quad \text{(Equation 5-3)}$$

- Volume for unconfined part

$$V_{drainable} = \text{Area} * [S_y *(\text{Top-Bottom})] \quad \text{(Equation 5-4a)}$$

$$V_{in\ place} = \text{Area} * [\theta *(\text{Top-Bottom})] \quad \text{(Equation 5-4b)}$$

where

| | | |
|---|---|---|
| $V_{drainable}$ | = | storage volume due to water draining from the formation (acre-feet) |
| $V_{confined}$ | = | storage volume due to elastic properties of the aquifer and water (acre-feet) |
| $V_{in\ place}$ | = | storage volume due void spaces in the aquifer occupied by water (acre-feet) |
| *Area* | = | area of aquifer (acre) |
| *Water Level* | = | groundwater elevation (feet above mean sea level) |
| *Top* | = | elevation of aquifer top (feet above mean sea level) |
| *Bottom* | = | elevation of aquifer bottom (feet above mean sea level) |
| *Sy* | = | specific yield (unitless) |
| *Ss* | = | specific storage (1/feet) |
| *S* | = | storativity or storage coefficient (unitless) |
| θ | = | porosity (unitless) |

In the above equations, two options are provided to calculate the volume in the unconfined aquifer. Equations 5-1a and 5-4a use specific yield whereas Equation 5-1b and Equation 5-4b use total porosity. Wade and Bradley (2013) use Equations 5-1a and 5-4a to calculate TERS. The use of specific yield in Equations 5-1a and 5-4a implies that the unconfined aquifer has not fully drained because specific yield is less than the porosity of an unconfined aquifer. The selection of specific yield or porosity is dependent on the purpose of the calculation. If one is interested more in the volume of drainable groundwater than the actual volume of groundwater in place, than the use of specific yield rather than total porosity would be appropriate. If the reverse is desired, and one would therefore be more interested in the total groundwater in place rather than the drainable groundwater, than porosity would be appropriate to use in Equation 5-4.

### *5.1.2 Hydraulic and Physical Properties for the Carrizo-Wilcox Aquifer*

The equations for calculating groundwater volumes involve aquifer properties that need to be defined. For the purpose of this study, most of these aquifer properties will be obtained from the Southern QCSP GAM (Deeds and others, 2004). **Table 5-2** lists the model layers that represent the Carrizo-Wilcox Aquifer in the Southern QSCP GAM. Also included in Table 5-2 are the specific yields assigned to the model layers. Several of the equations in Section 5.1.1 require a water level. The water level that will be used in the calculations of groundwater volumes will be those produced by the GAM for 1999, which is the last year of the model calibration period.

**Table 5-2. Model layers that comprise the Carrizo-Wilcox Aquifer in the QCSP GAM (Deeds and others, 2004)**

| Model Layer | Aquifer | Specific Yield |
|---|---|---|
| 5 | Carrizo | 0.15 |
| 6 | Upper Wilcox | 0.15 |
| 7 | Middle Wilcox | 0.1 |
| 8 | Lower Wilcox | 0.1 |

### *5.1.3 Process for Calculating Groundwater Volumes Based on Water Quality*

The groundwater volume calculations for TERS (Wade and Bradley, 2013) are implemented for each grid cell in the Southern QCSP GAM and then are summed together. This process was also used for this study with a few modifications. The key modification is to transfer information from the geophysical logs to the grid cell location prior to calculating the groundwater volumes. The process of transferring the data from the geophysical logs to the grid cells was effected using the following four-step process.

<u>Step 1. Assign sand layers to Aquifer Units.</u> Intersect the surfaces for the Carrizo, upper Wilcox, middle Wilcox, and lower Wilcox from the Southern QCSP GAM onto every geophysical log within the model domain of the GAM. Assign the sand layers and its associated groundwater to an aquifer unit.

<u>Step 2. Generate sand percentages for each grid cell.</u> Use kriging to interpolate the point measurements of sand thickness to create a continuous map of sand percentages for each aquifer unit and assign a sand percent to each grid cell. Where the geophysical logs do not provide adequate coverage to estimate sand percentages in the shallow regions of the aquifer unit, use the lithology profiles from the driller logs shown in **Figure 5-3** to complete the data gap.

Step 3. Determine water quality percentages for each grid cell. Create maps for each aquifer unit that distribute the groundwater associated with the sands into fresh, slightly saline, moderately saline, and very saline water for every grid cell based on interpolating data generated from the geophysical well analyses. Assign water quality to the sands in the driller logs used in Step 3, based on water quality data from the closest water wells with measured TDS concentrations. **Figure 5-4** shows the distribution of water well data were assembled for these analyses.

Step 4. Add up the groundwater volumes in each grid cell. Assume that the clay layers in a grid cell has the same water quality distribution as does the sand. Add up the groundwater volumes in each grid cell. For the unconfined aquifers, use either the specific yield assigned to the grid cell by the Southern QCSP GAM or use a porosity value calculated from the porosity versus depth relationship in Equation 5-5, which was developed from porosity measurements shown in Figure 5-5 that generated as part of this study. The porosity measurements were estimated for sand beds identified on neutron and density logs.

$$\theta = 37.2 - 0.0022 * d \qquad \text{(Equation 5-5)}$$

where:

$\theta$ = porosity (unitless)
d = depth below ground surface (ft)

## 5.2 Calculated Groundwater Volumes

**Table 5-3** provides the total calculated volume of groundwater in the Carrizo-Wilcox Aquifer in GMA 13 based on using specific yield and on using porosity. The use of porosity in Equation 5-4b leads to a total volume of 4.92 billion acre-feet per year (AFY), which is approximately 2.5 times greater than the total volume of 2.05 billion acre-feet (AF) that is calculated using specific yield. Table 5-3 also provides the distribution of the groundwater volumes by aquifer unit and by groundwater water quality classification. Based on calculations of groundwater volume using specific yield, the total volume of fresh, brackish (includes both the slightly saline and moderately saline water), and very saline groundwater is 460 million AFY, 840 million AF, and 740 million AF, respectively. Based on calculations of groundwater volume using porosity, the total volume of fresh, brackish (includes both the slightly saline and moderately saline water), and very saline groundwater is 1.07 billion AF, 2.06 billion AF, and 1.79 billion AF, respectively. The aquifer unit with the most groundwater is the lower Wilcox Aquifer with 37% of the groundwater. However, the majority of the groundwater (>60%) in the lower Wilcox Aquifer is very saline. Only about 22% of the groundwater is fresh water and the majority of that water occurs in the Carrizo Aquifer, which contains about 70% of the fresh water in the Carrizo-Wilcox Aquifer in GMA 13. The majority of the brackish water, which includes both the slightly saline and moderately saline water, is contained in the lower Wilcox Aquifer.

Besides aquifer unit and groundwater water quality classification, Table 5-3 also provides the distribution of groundwater between sands and clay layers. The average fraction of groundwater in the Carrizo-Wilcox Aquifer contained in sand is 0.38. The sand fraction values vary among the aquifer units and ranges from 0.64 in the Carrizo Aquifer to 0.28 in the lower Wilcox

Aquifer. With regard to water quality classification, the fraction of the total amount of fresh, slightly saline, moderately saline, and very saline groundwater is 0.58, 0.37, 0.43, and 0.38, respectively.

**Table 5-3. The volumes of fresh, moderately saline, slightly saline, very saline, and total groundwater volumes in the Carrizo-Wilcox Aquifer within GAM 13 based on using specific yield or porosity to calculate the volume in an unconfined aquifer.**

| Aquifer Unit | Total Volume (Millions of Acre-feet) | | | | | Total Volume in Sand (Millions of Acre-feet) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Slightly saline | Moderately saline | Very saline | Total | Fresh | Slightly saline | Moderately saline | Very saline | Total |
| **Use of Specific Yield in Calculating the Groundwater Volume in an Unconfined Aquifer** | | | | | | | | | | |
| Carrizo | 340.6 | 107.1 | 43.6 | 11.6 | 503 | 228.1 | 61.9 | 23.7 | 6.7 | 320.3 |
| Upper Wilcox | 69.9 | 120.3 | 128 | 34 | 352.2 | 27.4 | 45 | 45 | 10.9 | 128.3 |
| Middle Wilcox | 37 | 70.3 | 147.9 | 224.5 | 479.7 | 11.7 | 24.9 | 44.8 | 50.2 | 131.7 |
| Lower Wilcox | 16.4 | 77.4 | 144.7 | 471.3 | 709.9 | 3.2 | 30.1 | 57.9 | 108.2 | 199.4 |
| Total | 464 | 375.1 | 464.2 | 741.5 | 2044.9 | 270.4 | 162 | 171.4 | 176 | 779.7 |
| **Use of Porosity in Calculating the Groundwater Volume in an Unconfined Aquifer** | | | | | | | | | | |
| Carrizo | 736.3 | 209.7 | 83.6 | 22 | 1051.6 | 493 | 120.9 | 45.1 | 12.6 | 671.6 |
| Upper Wilcox | 150.5 | 234.6 | 239 | 59.7 | 683.8 | 58.5 | 87.1 | 83 | 18.8 | 247.5 |
| Middle Wilcox | 126.5 | 222.2 | 421.4 | 581.2 | 1351.3 | 39.4 | 78.4 | 129.7 | 132.6 | 380.1 |
| Lower Wilcox | 58 | 239.2 | 413.3 | 1124 | 1834.5 | 11.2 | 91 | 162.4 | 274.6 | 539.2 |
| Total | 1071.3 | 905.8 | 1157.2 | 1786.9 | 4921.2 | 602.2 | 377.4 | 420.1 | 438.6 | 1838.3 |

**Tables 5-4** and **5-5** provide the volumes of fresh, slightly saline, moderately saline, and very saline groundwater for the counties in GMA 13. **Tables 5-6** and **5-7** provide the volume of fresh, slightly saline, moderately saline, and very saline groundwater for the groundwater conservation districts (GCDs) in GMA 13.

**Table 5-4.** **The volume of fresh, slightly saline, moderately saline, very saline, and total groundwater in the Carrizo-Wilcox Aquifer within GAM 13 calculated using specific yield by county and by aquifer unit.**

| | Total Volume (AFY) | | | | | Total Volume in Sand (AFY) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer Unit | Fresh | Slightly saline | Moderately saline | Very saline | Total | Fresh | Slightly saline | Moderately saline | Very saline | Total |
| **Atascosa** | | | | | | | | | | |
| Carrizo | 75.4 | 13 | 0.9 | 0 | 89.2 | 55.1 | 8.9 | 0.6 | 0 | 64.5 |
| Upper Wilcox | 3.7 | 4.9 | 2.1 | 0.1 | 10.8 | 2 | 2.8 | 1.2 | 0 | 6 |
| Middle Wilcox | 6.3 | 14.9 | 15.3 | 9.1 | 45.6 | 2.5 | 4.9 | 4.2 | 2.1 | 13.6 |
| Lower Wilcox | 0.1 | 21.6 | 33.6 | 32.1 | 87.5 | 0 | 9.2 | 13.1 | 8 | 30.2 |
| Total | 85.5 | 54.4 | 52 | 41.3 | 233.1 | 59.5 | 25.7 | 19 | 10 | 114.3 |
| **Bexar** | | | | | | | | | | |
| Carrizo | 1.6 | 0 | 0 | 0 | 1.7 | 0.9 | 0 | 0 | 0 | 0.9 |
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 1.3 | 1.1 | 0.1 | 0 | 2.6 | 0.3 | 0.2 | 0 | 0 | 0.6 |
| Lower Wilcox | 0.9 | 2.6 | 1.2 | 0.1 | 4.8 | 0.1 | 0.4 | 0.2 | 0 | 0.7 |
| Total | 3.9 | 3.8 | 1.3 | 0.1 | 9.2 | 1.4 | 0.7 | 0.2 | 0 | 2.3 |
| **Caldwell** | | | | | | | | | | |
| Carrizo | 2.5 | 0.3 | 0 | 0 | 2.9 | 0.9 | 0.1 | 0 | 0 | 1 |
| Upper Wilcox | 0.2 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 3.9 | 0.9 | 0.9 | 2.6 | 8.3 | 0.7 | 0.2 | 0.2 | 0.4 | 1.4 |
| Lower Wilcox | 3.8 | 0 | 2.4 | 4.3 | 10.5 | 0.4 | 0 | 0.3 | 0.6 | 1.3 |
| Total | 10.4 | 1.2 | 3.3 | 6.9 | 21.8 | 1.9 | 0.3 | 0.5 | 1 | 3.7 |
| **Dimmit** | | | | | | | | | | |
| Carrizo | 21.4 | 2.2 | 0.3 | 0 | 23.9 | 14.3 | 1.3 | 0.2 | 0 | 15.7 |
| Upper Wilcox | 18 | 12.9 | 7.2 | 0 | 38.2 | 6.1 | 4.2 | 2.2 | 0 | 12.5 |
| Middle Wilcox | 2.2 | 2.4 | 15.7 | 9.7 | 30 | 0.6 | 0.7 | 4.8 | 3.1 | 9.2 |
| Lower Wilcox | 0 | 0.1 | 10.6 | 32.9 | 43.6 | 0 | 0.1 | 3.7 | 12.1 | 15.8 |
| Total | 41.7 | 17.6 | 33.8 | 42.6 | 135.7 | 21 | 6.3 | 10.9 | 15.2 | 53.3 |
| **Frio** | | | | | | | | | | |
| Carrizo | 48.4 | 1.1 | 0 | 0 | 49.6 | 34.8 | 0.8 | 0 | 0 | 35.6 |
| Upper Wilcox | 3.3 | 2.7 | 0.4 | 0 | 6.3 | 1.7 | 1.4 | 0.2 | 0 | 3.3 |
| Middle Wilcox | 4.3 | 14.3 | 10.9 | 0.4 | 29.9 | 1.9 | 6.6 | 4.7 | 0.2 | 13.3 |
| Lower Wilcox | 1.8 | 18.1 | 11.6 | 2.2 | 33.7 | 0.7 | 9.2 | 6.2 | 1.2 | 17.4 |
| Total | 57.8 | 36.2 | 22.8 | 2.7 | 119.5 | 39.1 | 18 | 11.1 | 1.4 | 69.6 |
| **Gonzales** | | | | | | | | | | |
| Carrizo | 36.3 | 9.7 | 10.7 | 10.8 | 67.5 | 22.6 | 5.7 | 6.1 | 6.1 | 40.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper Wilcox | 1.1 | 0.1 | 0.8 | 0.9 | 2.9 | 0.5 | 0 | 0.4 | 0.5 | 1.4 |
| Middle Wilcox | 3.3 | 9.9 | 25.4 | 47.1 | 85.7 | 1 | 3.6 | 10.3 | 17.8 | 32.6 |
| Lower Wilcox | 0.4 | 4.5 | 19.7 | 63.1 | 87.7 | 0.1 | 1.4 | 7 | 26.5 | 35 |
| Total | 41.1 | 24.2 | 56.6 | 121.8 | 243.7 | 24.2 | 10.7 | 23.9 | 50.8 | 109.6 |
| **Guadalupe** | | | | | | | | | | |
| Carrizo | 2 | 0 | 0 | 0 | 2.1 | 1.3 | 0 | 0 | 0 | 1.3 |
| Upper Wilcox | 0.1 | 0.1 | 0 | 0 | 0.2 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 3.4 | 2.8 | 0.4 | 0 | 6.6 | 0.7 | 0.6 | 0.1 | 0 | 1.4 |
| Lower Wilcox | 5.1 | 2.7 | 1.4 | 0.1 | 9.2 | 0.9 | 0.5 | 0.2 | 0 | 1.6 |
| Total | 10.6 | 5.6 | 1.8 | 0.2 | 18.1 | 3 | 1.1 | 0.3 | 0 | 4.4 |
| **Karnes** | | | | | | | | | | |
| Carrizo | 2.1 | 6.1 | 6.2 | 0.3 | 14.7 | 1.3 | 4.1 | 4 | 0.2 | 9.7 |
| Upper Wilcox | 0 | 0.3 | 0.4 | 0.1 | 0.8 | 0 | 0.2 | 0.3 | 0.1 | 0.5 |
| Middle Wilcox | 0 | 1.7 | 3.8 | 3.1 | 8.6 | 0 | 0.8 | 1.6 | 1.3 | 3.7 |
| Lower Wilcox | 0 | 0.2 | 4.9 | 16.4 | 21.6 | 0 | 0.1 | 2.6 | 8.9 | 11.7 |
| Total | 2.2 | 8.4 | 15.3 | 20 | 45.8 | 1.4 | 5.2 | 8.5 | 10.5 | 25.6 |
| **La Salle** | | | | | | | | | | |
| Carrizo | 51 | 17.2 | 2 | 0 | 70.3 | 33.5 | 10.5 | 1.2 | 0 | 45.2 |
| Upper Wilcox | 12 | 37 | 30 | 1.7 | 80.7 | 4.6 | 13.5 | 10.4 | 0.5 | 29 |
| Middle Wilcox | 0.1 | 1.1 | 33.8 | 33.3 | 68.2 | 0 | 0.4 | 8.6 | 6.6 | 15.6 |
| Lower Wilcox | 0 | 0.8 | 7.3 | 92.2 | 100.3 | 0 | 0.4 | 3.5 | 21 | 24.8 |
| Total | 63.1 | 56.1 | 73 | 127.2 | 319.5 | 38.1 | 24.7 | 23.7 | 28.1 | 114.6 |
| **Maverick** | | | | | | | | | | |
| Carrizo | 0.3 | 0 | 0 | 0 | 0.3 | 0.2 | 0 | 0 | 0 | 0.2 |
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 0.1 | 0 | 0.2 | 0.1 | 0.4 | 0 | 0 | 0 | 0 | 0.1 |
| Lower Wilcox | 0 | 0.1 | 0.2 | 0.9 | 1.2 | 0 | 0 | 0 | 0.2 | 0.2 |
| Total | 0.6 | 0.2 | 0.3 | 1 | 2.1 | 0.3 | 0 | 0 | 0.2 | 0.5 |
| **McMullen** | | | | | | | | | | |
| Carrizo | 22.3 | 20.9 | 4.9 | 0 | 48.1 | 13.8 | 12.2 | 2.9 | 0 | 28.9 |
| Upper Wilcox | 5.4 | 16.2 | 24.7 | 6.5 | 52.8 | 2.9 | 8.3 | 12.6 | 3 | 26.9 |
| Middle Wilcox | 0.1 | 1.6 | 15.4 | 35 | 52.1 | 0 | 0.4 | 3 | 5.6 | 9 |
| Lower Wilcox | 0 | 0.1 | 1.2 | 91.9 | 93.1 | 0 | 0 | 0.3 | 4.7 | 4.9 |
| Total | 27.7 | 38.8 | 46.2 | 133.3 | 246 | 16.7 | 21 | 18.7 | 13.3 | 69.7 |
| **Medina** | | | | | | | | | | |
| Carrizo | 1.2 | 0 | 0 | 0 | 1.2 | 0.5 | 0 | 0 | 0 | 0.5 |
| Upper Wilcox | 0.2 | 0 | 0 | 0 | 0.3 | 0.1 | 0 | 0 | 0 | 0.1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Middle Wilcox | 1.4 | 0.5 | 0.1 | 0 | 2 | 0.4 | 0.1 | 0 | 0 | 0.5 |
| Lower Wilcox | 1.4 | 1.4 | 0.2 | 0 | 2.9 | 0.2 | 0.2 | 0 | 0 | 0.5 |
| Total | 4.2 | 2 | 0.2 | 0 | 6.5 | 1.2 | 0.3 | 0 | 0 | 1.6 |
| **Uvalde** | | | | | | | | | | |
| Carrizo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 0.3 | 0 | 0 | 0 | 0.3 | 0.1 | 0 | 0 | 0 | 0.1 |
| Lower Wilcox | 0.4 | 0.3 | 0 | 0 | 0.7 | 0.1 | 0.1 | 0 | 0 | 0.1 |
| Total | 0.8 | 0.3 | 0 | 0 | 1.1 | 0.2 | 0.1 | 0 | 0 | 0.3 |
| **Webb** | | | | | | | | | | |
| Carrizo | 12.2 | 28.9 | 17.2 | 0.5 | 58.7 | 5.6 | 13.3 | 7.7 | 0.3 | 26.9 |
| Upper Wilcox | 14.6 | 41.9 | 61.8 | 24.8 | 143.1 | 4.5 | 12.6 | 17.5 | 6.8 | 41.4 |
| Middle Wilcox | 0 | 0.1 | 10.7 | 83.3 | 94 | 0 | 0 | 2 | 12.9 | 14.9 |
| Lower Wilcox | 0 | 0 | 0.1 | 131.1 | 131.2 | 0 | 0 | 0 | 23.2 | 23.2 |
| Total | 26.8 | 70.9 | 89.7 | 239.6 | 427 | 10.1 | 25.8 | 27.3 | 43.1 | 106.4 |
| **Wilson** | | | | | | | | | | |
| Carrizo | 42.8 | 6.2 | 1.4 | 0 | 50.3 | 30.9 | 4.3 | 0.9 | 0 | 36.1 |
| Upper Wilcox | 1.9 | 0.9 | 0.2 | 0 | 3 | 0.9 | 0.5 | 0.1 | 0 | 1.5 |
| Middle Wilcox | 5.2 | 12.5 | 13.3 | 0.8 | 31.8 | 1.6 | 4.2 | 4.7 | 0.3 | 10.8 |
| Lower Wilcox | 0.5 | 15.7 | 41 | 3.9 | 61.1 | 0.1 | 5.8 | 18.1 | 1.9 | 25.8 |
| Total | 50.4 | 35.3 | 55.9 | 4.7 | 146.2 | 33.4 | 14.8 | 23.8 | 2.2 | 74.2 |
| **Zavala** | | | | | | | | | | |
| Carrizo | 21.1 | 1.5 | 0 | 0 | 22.5 | 12.5 | 0.8 | 0 | 0 | 13.3 |
| Upper Wilcox | 9.1 | 3.2 | 0.4 | 0 | 12.6 | 4 | 1.4 | 0.1 | 0 | 5.6 |
| Middle Wilcox | 5.1 | 6.4 | 2.1 | 0 | 13.6 | 1.8 | 2.2 | 0.7 | 0 | 4.7 |
| Lower Wilcox | 2.1 | 9.1 | 9.4 | 0.2 | 20.9 | 0.5 | 2.8 | 2.7 | 0.1 | 6.1 |
| Total | 37.4 | 20.1 | 11.9 | 0.2 | 69.6 | 18.8 | 7.2 | 3.4 | 0.1 | 29.6 |
| **Grand Total** | | | | | | | | | | |
| Carrizo | 340.6 | 107.1 | 43.6 | 11.6 | 503 | 228.1 | 61.9 | 23.7 | 6.7 | 320.3 |
| Upper Wilcox | 69.9 | 120.3 | 128 | 34 | 352.2 | 27.4 | 45 | 45 | 10.9 | 128.3 |
| Middle Wilcox | 37 | 70.3 | 147.9 | 224.5 | 479.7 | 11.7 | 24.9 | 44.8 | 50.2 | 131.7 |
| Lower Wilcox | 16.4 | 77.4 | 144.7 | 471.3 | 709.9 | 3.2 | 30.1 | 57.9 | 108.2 | 199.4 |
| Total | 464 | 375.1 | 464.2 | 741.5 | 2044.9 | 270.4 | 162 | 171.4 | 176 | 779.7 |

**Table 5-5. The volume of fresh, slightly saline, moderately saline, very saline, and total groundwater in the Carrizo-Wilcox Aquifer within GAM 13 calculated porosity by county and by aquifer unit.**

| | Total Volume (AFY) | | | | | Total Volume in Sand (AFY) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer Unit | Fresh | Slightly saline | Moderately saline | Very saline | Total | Fresh | Slightly saline | Moderately saline | Very saline | Total |
| **Atascosa** | | | | | | | | | | |
| Carrizo | 159.9 | 24.8 | 1.7 | 0 | 186.4 | 117 | 17 | 1.1 | 0 | 135.1 |
| Upper Wilcox | 7.4 | 9.1 | 3.9 | 0.1 | 20.5 | 3.9 | 5.1 | 2.2 | 0.1 | 11.2 |
| Middle Wilcox | 20.7 | 44.4 | 41.6 | 22.3 | 129 | 8.1 | 14.8 | 11.5 | 5.1 | 39.5 |
| Lower Wilcox | 0.5 | 62.6 | 89.5 | 73 | 225.7 | 0.1 | 26.5 | 35.2 | 18.7 | 80.4 |
| Total | 188.5 | 140.9 | 136.6 | 95.5 | 561.6 | 129.2 | 63.3 | 49.9 | 23.8 | 266.2 |
| **Bexar** | | | | | | | | | | |
| Carrizo | 4 | 0 | 0 | 0 | 4 | 2.2 | 0 | 0 | 0 | 2.3 |
| Upper Wilcox | 0.2 | 0.1 | 0 | 0 | 0.3 | 0 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 4.9 | 4.1 | 0.3 | 0 | 9.2 | 1.1 | 0.9 | 0.1 | 0 | 2.1 |
| Lower Wilcox | 3.1 | 9.3 | 4.3 | 0.3 | 17.1 | 0.4 | 1.5 | 0.7 | 0.1 | 2.6 |
| Total | 12.2 | 13.6 | 4.7 | 0.3 | 30.8 | 3.9 | 2.4 | 0.7 | 0.1 | 7.1 |
| **Caldwell** | | | | | | | | | | |
| Carrizo | 6 | 0.8 | 0 | 0.1 | 6.9 | 2.1 | 0.3 | 0 | 0 | 2.4 |
| Upper Wilcox | 0.4 | 0 | 0 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 14.1 | 3.1 | 3.1 | 9 | 29.3 | 2.4 | 0.5 | 0.5 | 1.6 | 5.1 |
| Lower Wilcox | 13.4 | 0.1 | 8.1 | 14.3 | 36 | 1.4 | 0 | 1 | 1.9 | 4.3 |
| Total | 33.9 | 4 | 11.3 | 23.4 | 72.6 | 5.9 | 0.8 | 1.6 | 3.5 | 11.8 |
| **Dimmit** | | | | | | | | | | |
| Carrizo | 49.3 | 4.9 | 0.7 | 0 | 54.9 | 32.9 | 2.8 | 0.4 | 0 | 36.1 |
| Upper Wilcox | 41.3 | 28.8 | 15.8 | 0 | 85.8 | 13.9 | 9.4 | 4.8 | 0 | 28.2 |
| Middle Wilcox | 7.9 | 8 | 51.2 | 30.8 | 97.8 | 2.1 | 2.4 | 15.5 | 9.9 | 29.9 |
| Lower Wilcox | 0 | 0.4 | 33.8 | 102.1 | 136.2 | 0 | 0.2 | 11.5 | 36.8 | 48.5 |
| Total | 98.5 | 42 | 101.4 | 132.9 | 374.8 | 48.9 | 14.8 | 32.3 | 46.7 | 142.7 |
| **Frio** | | | | | | | | | | |
| Carrizo | 108.8 | 2.5 | 0 | 0 | 111.3 | 77.9 | 1.8 | 0 | 0 | 79.7 |
| Upper Wilcox | 7.2 | 5.7 | 0.8 | 0 | 13.7 | 3.7 | 3.1 | 0.4 | 0 | 7.1 |
| Middle Wilcox | 14.2 | 45.2 | 32.7 | 1.2 | 93.4 | 6.3 | 20.7 | 14.1 | 0.5 | 41.5 |
| Lower Wilcox | 5.8 | 56 | 33.5 | 6.1 | 101.5 | 2.5 | 28.3 | 17.9 | 3.3 | 52 |
| Total | 136 | 109.4 | 67 | 7.4 | 319.8 | 90.4 | 53.8 | 32.4 | 3.8 | 180.4 |
| **Gonzales** | | | | | | | | | | |
| Carrizo | 80.2 | 20.2 | 20.9 | 20.4 | 141.8 | 50 | 11.9 | 12.1 | 11.6 | 85.6 |
| Upper Wilcox | 2.4 | 0.2 | 1.6 | 1.6 | 5.8 | 1.1 | 0.1 | 0.7 | 0.8 | 2.6 |
| Middle Wilcox | 10.5 | 32 | 74.3 | 126 | 242.8 | 3.2 | 11.3 | 30 | 46.8 | 91.3 |
| Lower Wilcox | 1.3 | 13.5 | 55.2 | 150.7 | 220.7 | 0.2 | 4.1 | 19.2 | 62 | 85.6 |
| Total | 94.5 | 65.9 | 152 | 298.7 | 611.1 | 54.6 | 27.4 | 62 | 121.3 | 265.2 |
| **Guadalupe** | | | | | | | | | | |
| Carrizo | 5 | 0.1 | 0 | 0 | 5.1 | 3.1 | 0.1 | 0 | 0 | 3.2 |
| Upper Wilcox | 0.3 | 0.2 | 0 | 0 | 0.5 | 0.1 | 0.1 | 0 | 0 | 0.2 |
| Middle Wilcox | 12.2 | 9.9 | 1.5 | 0.1 | 23.7 | 2.7 | 2 | 0.3 | 0 | 5 |
| Lower Wilcox | 18 | 9.2 | 4.8 | 0.4 | 32.5 | 3.3 | 1.6 | 0.7 | 0 | 5.7 |
| Total | 35.5 | 19.4 | 6.3 | 0.5 | 61.8 | 9.3 | 3.7 | 1 | 0.1 | 14 |
| **Karnes** | | | | | | | | | | |
| Carrizo | 4.1 | 11.8 | 11.8 | 0.6 | 28.3 | 2.6 | 7.8 | 7.7 | 0.4 | 18.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper Wilcox | 0.1 | 0.5 | 0.7 | 0.2 | 1.5 | 0.1 | 0.3 | 0.5 | 0.1 | 1 |
| Middle Wilcox | 0 | 4.5 | 9.8 | 8 | 22.4 | 0 | 2.1 | 4.2 | 3.3 | 9.7 |
| Lower Wilcox | 0 | 0.6 | 11.7 | 38.2 | 50.5 | 0 | 0.3 | 6.3 | 20.7 | 27.4 |
| Total | 4.2 | 17.4 | 34.1 | 47 | 102.7 | 2.7 | 10.6 | 18.7 | 24.6 | 56.6 |
| **La Salle** | | | | | | | | | | |
| Carrizo | 102.3 | 33 | 3.7 | 0.1 | 139 | 67.3 | 20.1 | 2.2 | 0 | 89.6 |
| Upper Wilcox | 23.6 | 71 | 55 | 3 | 152.7 | 9.1 | 25.9 | 19.1 | 0.9 | 55 |
| Middle Wilcox | 0.3 | 3.1 | 91.3 | 84.5 | 179.1 | 0.1 | 1.1 | 23.7 | 17.2 | 42.1 |
| Lower Wilcox | 0 | 2.2 | 20 | 220 | 242.2 | 0 | 1.1 | 9.5 | 53.5 | 64.1 |
| Total | 126.2 | 109.3 | 170 | 307.5 | 713 | 76.5 | 48.2 | 54.6 | 71.7 | 250.9 |
| **Maverick** | | | | | | | | | | |
| Carrizo | 0.8 | 0 | 0 | 0 | 0.8 | 0.5 | 0 | 0 | 0 | 0.5 |
| Upper Wilcox | 0.3 | 0 | 0 | 0 | 0.3 | 0.2 | 0 | 0 | 0 | 0.2 |
| Middle Wilcox | 0.4 | 0.1 | 0.6 | 0.4 | 1.5 | 0.2 | 0 | 0.1 | 0.1 | 0.3 |
| Lower Wilcox | 0 | 0.5 | 0.6 | 3.3 | 4.4 | 0 | 0 | 0.1 | 0.6 | 0.7 |
| Total | 1.5 | 0.6 | 1.2 | 3.7 | 7.1 | 0.8 | 0.1 | 0.2 | 0.7 | 1.7 |
| **McMullen** | | | | | | | | | | |
| Carrizo | 42.2 | 37.5 | 8.5 | 0 | 88.2 | 26.2 | 21.9 | 5 | 0 | 53.1 |
| Upper Wilcox | 9.6 | 28.1 | 40.8 | 10.2 | 88.7 | 5.1 | 14.5 | 20.9 | 4.8 | 45.3 |
| Middle Wilcox | 0.2 | 4 | 35.9 | 78.6 | 118.7 | 0.1 | 1 | 7.1 | 12.8 | 20.9 |
| Lower Wilcox | 0 | 0.2 | 2.7 | 185.9 | 188.8 | 0 | 0.1 | 0.6 | 10.4 | 11.1 |
| Total | 52 | 69.7 | 87.9 | 274.7 | 484.4 | 31.4 | 37.5 | 33.6 | 28 | 130.4 |
| **Medina** | | | | | | | | | | |
| Carrizo | 3 | 0 | 0 | 0 | 3.1 | 1.3 | 0 | 0 | 0 | 1.3 |
| Upper Wilcox | 0.6 | 0.1 | 0 | 0 | 0.7 | 0.2 | 0 | 0 | 0 | 0.2 |
| Middle Wilcox | 5.2 | 1.9 | 0.2 | 0 | 7.3 | 1.5 | 0.4 | 0 | 0 | 1.9 |
| Lower Wilcox | 4.9 | 5.1 | 0.6 | 0 | 10.6 | 0.8 | 0.7 | 0.1 | 0 | 1.7 |
| Total | 13.7 | 7.1 | 0.8 | 0 | 21.6 | 3.8 | 1.2 | 0.1 | 0 | 5.1 |
| **Uvalde** | | | | | | | | | | |
| Carrizo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 0.9 | 0.1 | 0.1 | 0 | 1.1 | 0.3 | 0 | 0 | 0 | 0.4 |
| Lower Wilcox | 1.6 | 1 | 0.1 | 0 | 2.7 | 0.3 | 0.2 | 0 | 0 | 0.5 |
| Total | 2.7 | 1.2 | 0.2 | 0 | 4 | 0.8 | 0.2 | 0 | 0 | 1.1 |
| **Webb** | | | | | | | | | | |
| Carrizo | 25.6 | 57.6 | 33.3 | 0.8 | 117.3 | 11.7 | 26.3 | 14.6 | 0.5 | 53 |
| Upper Wilcox | 31.9 | 81.8 | 119 | 44.7 | 277.4 | 9.9 | 24.5 | 33.8 | 12.2 | 80.3 |
| Middle Wilcox | 0 | 0.3 | 31.4 | 217.9 | 249.6 | 0 | 0.1 | 6.1 | 34.5 | 40.7 |
| Lower Wilcox | 0 | 0 | 0.2 | 319 | 319.2 | 0 | 0 | 0.1 | 61.6 | 61.7 |
| Total | 57.5 | 139.7 | 183.9 | 582.4 | 963.5 | 21.5 | 50.8 | 54.6 | 108.8 | 235.8 |
| **Wilson** | | | | | | | | | | |
| Carrizo | 96 | 13.1 | 2.9 | 0 | 112 | 69.2 | 9.1 | 1.9 | 0 | 80.2 |
| Upper Wilcox | 4.2 | 2.1 | 0.4 | 0 | 6.8 | 2 | 1 | 0.2 | 0 | 3.2 |
| Middle Wilcox | 17.2 | 39.9 | 40.5 | 2.2 | 99.9 | 5.2 | 13.5 | 14.3 | 0.8 | 33.7 |
| Lower Wilcox | 1.9 | 48.1 | 116.9 | 9.8 | 176.7 | 0.3 | 17.2 | 50.8 | 4.8 | 73.1 |
| Total | 119.3 | 103.2 | 160.8 | 12 | 395.3 | 76.6 | 40.8 | 67.3 | 5.6 | 190.3 |
| **Zavala** | | | | | | | | | | |
| Carrizo | 49.2 | 3.4 | 0 | 0 | 52.6 | 29.1 | 1.8 | 0 | 0 | 30.9 |
| Upper Wilcox | 20.7 | 7.1 | 0.8 | 0 | 28.6 | 9.2 | 3.1 | 0.3 | 0 | 12.6 |
| Middle Wilcox | 17.8 | 21.6 | 6.9 | 0 | 46.3 | 6.2 | 7.5 | 2.2 | 0 | 15.9 |
| Lower Wilcox | 7.3 | 30.4 | 31.1 | 0.7 | 69.6 | 1.8 | 9.2 | 8.6 | 0.2 | 19.8 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | 95 | 62.5 | 38.9 | 0.7 | 197.1 | 46.2 | 21.6 | 11.1 | 0.2 | 79.2 |
| **Grand Total** | | | | | | | | | | |
| Carrizo | 736.3 | 209.7 | 83.6 | 22 | 1051.6 | 493 | 120.9 | 45.1 | 12.6 | 671.6 |
| Upper Wilcox | 150.5 | 234.6 | 239 | 59.7 | 683.8 | 58.5 | 87.1 | 83 | 18.8 | 247.5 |
| Middle Wilcox | 126.5 | 222.2 | 421.4 | 581.2 | 1351.3 | 39.4 | 78.4 | 129.7 | 132.6 | 380.1 |
| Lower Wilcox | 58 | 239.2 | 413.3 | 1124 | 1834.5 | 11.2 | 91 | 162.4 | 274.6 | 539.2 |
| Total | 1071.3 | 905.8 | 1157.2 | 1786.9 | 4921.2 | 602.2 | 377.4 | 420.1 | 438.6 | 1838.3 |

**Table 5-6. The volume of fresh, slightly saline, moderately saline, very saline, and total groundwater in the Carrizo-Wilcox Aquifer within GAM 13 calculated using specific yield by GCD and by aquifer unit**

| | Total Volume (AFY) | | | | | Total Volume in Sand (AFY) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aquifer Unit | Fresh | Slightly saline | Moderately saline | Very saline | Total | Fresh | Slightly saline | Moderately saline | Very saline | Total |
| **Area with No GCD** | | | | | | | | | | |
| Carrizo | 15.8 | 30.1 | 20.3 | 6.7 | 72.8 | 7.6 | 14 | 9.5 | 3.9 | 35 |
| Upper Wilcox | 14.9 | 42 | 62 | 25.3 | 144.2 | 4.6 | 12.6 | 17.7 | 7.1 | 42 |
| Middle Wilcox | 3.2 | 1.7 | 13.1 | 98.9 | 116.8 | 0.7 | 0.4 | 2.9 | 18.8 | 22.7 |
| Lower Wilcox | 4 | 2.8 | 3.2 | 150.9 | 160.9 | 0.4 | 0.4 | 0.7 | 31.3 | 32.8 |
| Total | 37.8 | 76.6 | 98.5 | 281.8 | 494.7 | 13.3 | 27.4 | 30.7 | 61.1 | 132.5 |
| **Evergreen UWCD** | | | | | | | | | | |
| Carrizo | 168.7 | 26.4 | 8.4 | 0.3 | 203.8 | 122.1 | 18 | 5.6 | 0.2 | 145.9 |
| Upper Wilcox | 8.8 | 8.8 | 3.1 | 0.2 | 21 | 4.5 | 4.8 | 1.8 | 0.1 | 11.3 |
| Middle Wilcox | 15.8 | 43.4 | 43.3 | 13.4 | 115.9 | 6 | 16.5 | 15.1 | 3.8 | 41.4 |
| Lower Wilcox | 2.4 | 55.6 | 91.1 | 54.6 | 203.8 | 0.9 | 24.3 | 40 | 19.9 | 85.1 |
| Total | 195.8 | 134.3 | 146 | 68.5 | 544.6 | 133.5 | 63.7 | 62.4 | 24 | 283.6 |
| **Gonzales County UWCD** | | | | | | | | | | |
| Carrizo | 37.2 | 8.9 | 7.6 | 4.6 | 58.3 | 22.6 | 5.2 | 4.4 | 2.5 | 34.5 |
| Upper Wilcox | 1.2 | 0.1 | 0.6 | 0.3 | 2.3 | 0.5 | 0 | 0.2 | 0.1 | 0.9 |
| Middle Wilcox | 5.5 | 10.3 | 24.1 | 34.2 | 74.1 | 1.3 | 3.6 | 9.7 | 12.3 | 26.9 |
| Lower Wilcox | 1.1 | 4.5 | 20.4 | 48.5 | 74.5 | 0.2 | 1.4 | 6.9 | 19.2 | 27.7 |
| Total | 45 | 23.8 | 52.7 | 87.6 | 209.1 | 24.5 | 10.2 | 21.2 | 34.1 | 90 |
| **Guadalupe County GCD** | | | | | | | | | | |
| Carrizo | 2 | 0 | 0 | 0 | 2.1 | 1.3 | 0 | 0 | 0 | 1.3 |
| Upper Wilcox | 0.1 | 0.1 | 0 | 0 | 0.2 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 3.4 | 2.8 | 0.4 | 0 | 6.6 | 0.7 | 0.6 | 0.1 | 0 | 1.4 |
| Lower Wilcox | 5.1 | 2.7 | 1.4 | 0.1 | 9.2 | 0.9 | 0.5 | 0.2 | 0 | 1.6 |
| Total | 10.6 | 5.6 | 1.8 | 0.2 | 18.1 | 3 | 1.1 | 0.3 | 0 | 4.4 |
| **McMullen GCD** | | | | | | | | | | |
| Carrizo | 22.3 | 20.9 | 4.9 | 0 | 48.1 | 13.8 | 12.2 | 2.9 | 0 | 28.9 |
| Upper Wilcox | 5.4 | 16.2 | 24.7 | 6.5 | 52.8 | 2.9 | 8.3 | 12.6 | 3 | 26.9 |
| Middle Wilcox | 0.1 | 1.6 | 15.4 | 35 | 52.1 | 0 | 0.4 | 3 | 5.6 | 9 |
| Lower Wilcox | 0 | 0.1 | 1.2 | 91.9 | 93.1 | 0 | 0 | 0.3 | 4.7 | 4.9 |
| Total | 27.7 | 38.8 | 46.2 | 133.3 | 246 | 16.7 | 21 | 18.7 | 13.3 | 69.7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Medina County GCD** | | | | | | | | | | |
| Carrizo | 1.2 | 0 | 0 | 0 | 1.2 | 0.5 | 0 | 0 | 0 | 0.5 |
| Upper Wilcox | 0.2 | 0 | 0 | 0 | 0.3 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 1.4 | 0.5 | 0.1 | 0 | 2 | 0.4 | 0.1 | 0 | 0 | 0.5 |
| Lower Wilcox | 1.4 | 1.4 | 0.2 | 0 | 2.9 | 0.2 | 0.2 | 0 | 0 | 0.5 |
| Total | 4.2 | 2 | 0.2 | 0 | 6.5 | 1.2 | 0.3 | 0 | 0 | 1.6 |
| **Uvalde County UWCD** | | | | | | | | | | |
| Carrizo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 0.3 | 0 | 0 | 0 | 0.3 | 0.1 | 0 | 0 | 0 | 0.1 |
| Lower Wilcox | 0.4 | 0.3 | 0 | 0 | 0.7 | 0.1 | 0.1 | 0 | 0 | 0.1 |
| Total | 0.8 | 0.3 | 0 | 0 | 1.1 | 0.2 | 0.1 | 0 | 0 | 0.3 |
| **Wintergarden GCD** | | | | | | | | | | |
| Carrizo | 93.5 | 20.8 | 2.3 | 0 | 116.7 | 60.2 | 12.5 | 1.4 | 0 | 74.1 |
| Upper Wilcox | 39.1 | 53.1 | 37.5 | 1.7 | 131.5 | 14.8 | 19.1 | 12.7 | 0.5 | 47.1 |
| Middle Wilcox | 7.5 | 9.8 | 51.5 | 43 | 111.9 | 2.4 | 3.3 | 14.1 | 9.8 | 29.6 |
| Lower Wilcox | 2.1 | 10 | 27.3 | 125.3 | 164.7 | 0.5 | 3.2 | 9.8 | 33.1 | 46.7 |
| Total | 142.2 | 93.8 | 118.7 | 170.1 | 524.8 | 77.9 | 38.2 | 38 | 43.4 | 197.5 |
| **Grand Total** | | | | | | | | | | |
| Carrizo | 340.6 | 107.1 | 43.6 | 11.6 | 503 | 228.1 | 61.9 | 23.7 | 6.7 | 320.3 |
| Upper Wilcox | 69.9 | 120.3 | 128 | 34 | 352.2 | 27.4 | 45 | 45 | 10.9 | 128.3 |
| Middle Wilcox | 37 | 70.3 | 147.9 | 224.5 | 479.7 | 11.7 | 24.9 | 44.8 | 50.2 | 131.7 |
| Lower Wilcox | 16.4 | 77.4 | 144.7 | 471.3 | 709.9 | 3.2 | 30.1 | 57.9 | 108.2 | 199.4 |
| Total | 464 | 375 | 464 | 742 | 2044 | 270 | 162 | 171 | 176 | 780 |

*Note*: UWCD stands for underground water conservation district

**Table 5-7. The volume of fresh, slightly saline, moderately saline, very saline, and total groundwater in the Carrizo-Wilcox Aquifer within GAM 13 calculated using porosity by GCD and by aquifer unit**

| Aquifer Unit | Total Volume (AFY) | | | | | Total Volume in Sand (AFY) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Slightly saline | Moderately saline | Very saline | Total | Fresh | Slightly saline | Moderately saline | Very saline | Total |
| **Area with No GCD** | | | | | | | | | | |
| Carrizo | 33.4 | 59.9 | 39.1 | 12.2 | 144.6 | 16 | 27.6 | 18 | 7.2 | 68.9 |
| Upper Wilcox | 32.6 | 81.9 | 119.4 | 45.6 | 279.5 | 10.1 | 24.5 | 34 | 12.8 | 81.4 |
| Middle Wilcox | 11.5 | 6.1 | 37.7 | 256.1 | 311.4 | 2.5 | 1.3 | 8.3 | 48.9 | 61 |
| Lower Wilcox | 14.3 | 9.9 | 10.3 | 363.7 | 398.2 | 1.5 | 1.5 | 1.8 | 78.8 | 83.7 |
| Total | 91.8 | 157.8 | 206.5 | 677.6 | 1133.7 | 30.2 | 55 | 62.2 | 147.6 | 295 |
| **Evergreen UWCD** | | | | | | | | | | |
| Carrizo | 18.9 | 17.3 | 5.8 | 0.3 | 42.3 | 9.6 | 9.5 | 3.3 | 0.2 | 22.5 |
| Upper Wilcox | 52.1 | 134 | 124.7 | 33.8 | 344.6 | 19.7 | 51.1 | 44 | 9.6 | 124.4 |
| Middle Wilcox | 8.2 | 167.3 | 251.7 | 127.2 | 554.4 | 2.9 | 72.3 | 110.2 | 47.5 | 232.9 |
| Lower Wilcox | 107.9 | 65.9 | 146.6 | 230.9 | 551.2 | 56.4 | 26.6 | 56.9 | 86.6 | 226.5 |
| Total | 187.2 | 384.6 | 528.7 | 392.2 | 1492.7 | 88.6 | 159.4 | 214.5 | 143.9 | 606.4 |
| **Gonzales County UWCD** | | | | | | | | | | |
| Carrizo | 18.4 | 33.5 | 72 | 97.2 | 221.1 | 4.4 | 11.5 | 28.5 | 34.1 | 78.6 |
| Upper Wilcox | 3.6 | 13.5 | 58.2 | 123.9 | 199.2 | 0.5 | 4.1 | 19.2 | 47.4 | 71.2 |
| Middle Wilcox | 35.5 | 19.4 | 6.3 | 0.5 | 61.8 | 9.3 | 3.7 | 1 | 0.1 | 14 |
| Lower Wilcox | 5 | 0.1 | 0 | 0 | 5.1 | 3.1 | 0.1 | 0 | 0 | 3.2 |
| Total | 62.5 | 66.5 | 136.5 | 221.7 | 487.2 | 17.3 | 19.4 | 48.7 | 81.6 | 167 |
| **Guadalupe County GCD** | | | | | | | | | | |
| Carrizo | 18 | 9.2 | 4.8 | 0.4 | 32.5 | 3.3 | 1.6 | 0.7 | 0 | 5.7 |
| Upper Wilcox | 52 | 69.7 | 87.9 | 274.7 | 484.4 | 31.4 | 37.5 | 33.6 | 28 | 130.4 |
| Middle Wilcox | 42.2 | 37.5 | 8.5 | 0 | 88.2 | 26.2 | 21.9 | 5 | 0 | 53.1 |
| Lower Wilcox | 9.6 | 28.1 | 40.8 | 10.2 | 88.7 | 5.1 | 14.5 | 20.9 | 4.8 | 45.3 |
| Total | 121.8 | 144.5 | 142.1 | 285.3 | 693.7 | 66 | 75.5 | 60.2 | 32.8 | 234.5 |
| **McMullen GCD** | | | | | | | | | | |
| Carrizo | 13.7 | 7.1 | 0.8 | 0 | 21.6 | 3.8 | 1.2 | 0.1 | 0 | 5.1 |
| Upper Wilcox | 3 | 0 | 0 | 0 | 3.1 | 1.3 | 0 | 0 | 0 | 1.3 |
| Middle Wilcox | 0.6 | 0.1 | 0 | 0 | 0.7 | 0.2 | 0 | 0 | 0 | 0.2 |
| Lower Wilcox | 5.2 | 1.9 | 0.2 | 0 | 7.3 | 1.5 | 0.4 | 0 | 0 | 1.9 |
| Total | 22.5 | 9.1 | 1.1 | 0 | 32.7 | 6.8 | 1.7 | 0.2 | 0 | 8.6 |
| **Medina County GCD** | | | | | | | | | | |
| Carrizo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper Wilcox | 0.1 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0 | 0.1 |
| Middle Wilcox | 0.9 | 0.1 | 0.1 | 0 | 1.1 | 0.3 | 0 | 0 | 0 | 0.4 |
| Lower Wilcox | 1.6 | 1 | 0.1 | 0 | 2.7 | 0.3 | 0.2 | 0 | 0 | 0.5 |
| Total | 2.7 | 1.2 | 0.2 | 0 | 4 | 0.8 | 0.2 | 0 | 0 | 1.1 |
| **Uvalde County UWCD** | | | | | | | | | | |
| Carrizo | 85.6 | 106.9 | 71.6 | 3 | 267.1 | 32.2 | 38.5 | 24.3 | 0.9 | 95.8 |
| Upper Wilcox | 25.9 | 32.7 | 149.4 | 115.3 | 323.3 | 8.3 | 11 | 41.4 | 27.1 | 88 |
| Middle Wilcox | 7.3 | 33 | 84.9 | 322.8 | 448 | 1.8 | 10.4 | 29.7 | 90.5 | 132.4 |
| Lower Wilcox | 1071.3 | 905.8 | 1157.2 | 1786.9 | 4921.2 | 602.2 | 377.4 | 420.1 | 438.6 | 1838.3 |
| Total | 1190.1 | 1078.4 | 1463.1 | 2228 | 5959.6 | 644.6 | 437.3 | 515.5 | 557.1 | 2154.5 |
| **Wintergarden GCD** | | | | | | | | | | |
| Carrizo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper Wilcox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Middle Wilcox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lower Wilcox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Grand Total** | | | | | | | | | | |
| Carrizo | 188.1 | 233.9 | 194.2 | 113.2 | 729.3 | 69.4 | 89.9 | 74.9 | 42.4 | 276.6 |
| Upper Wilcox | 169.4 | 331.9 | 539.6 | 593.4 | 1634.2 | 71.4 | 128.2 | 172.3 | 124.9 | 496.8 |
| Middle Wilcox | 106.2 | 263.5 | 389.3 | 706.7 | 1465.6 | 43.2 | 109.8 | 154.2 | 186.9 | 494.1 |
| Lower Wilcox | 1214.8 | 1012.8 | 1355.2 | 2391.6 | 5974.5 | 670.1 | 420.7 | 499.9 | 608.8 | 2199.5 |
| Total | 1678.5 | 1842 | 2478.2 | 3804.9 | 9803.6 | 854.2 | 748.5 | 901.2 | 963.1 | 3467 |

*Note*: UWCD stands for underground water conservation district

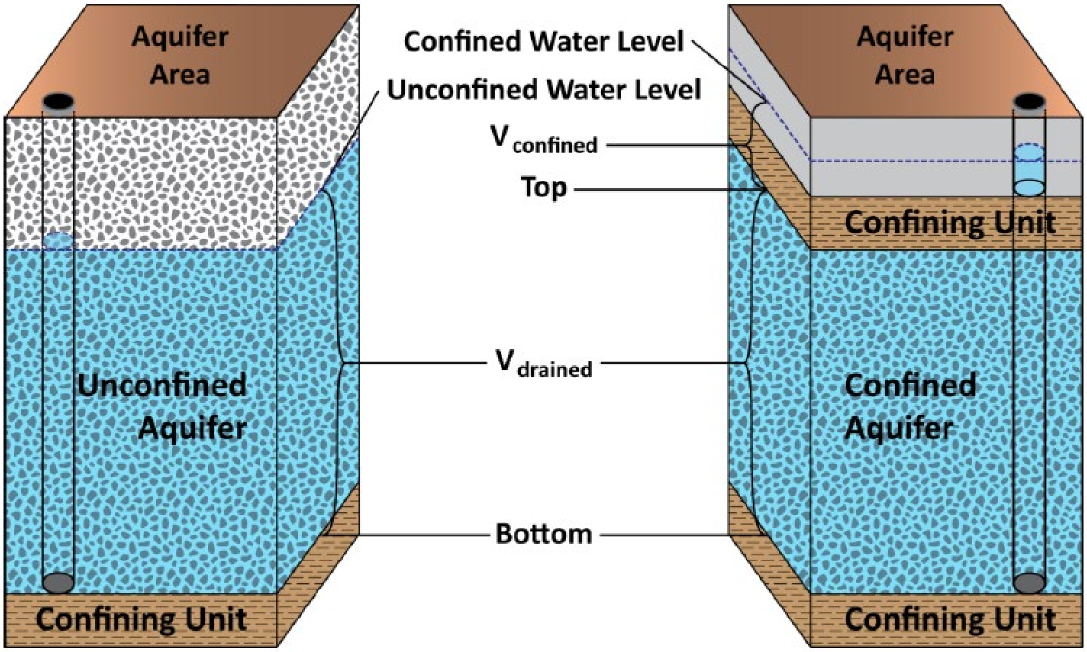


**Figure 5-1. Schematic graph showing the difference between unconfined and confined aquifers (from Wade and Bradley, 2013).**

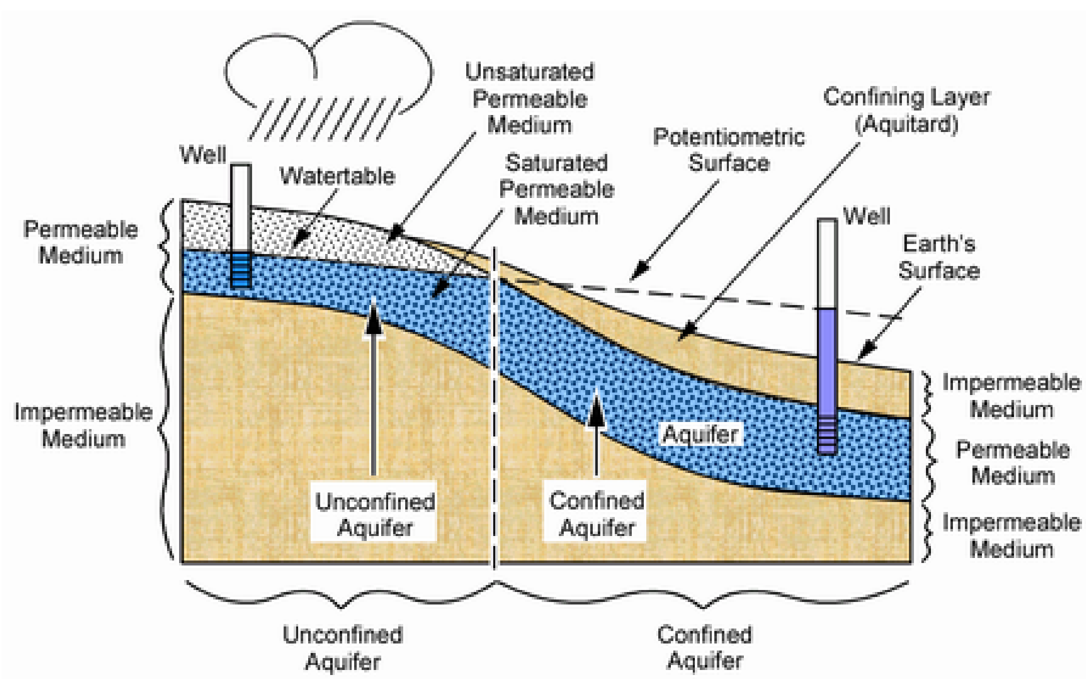


**Figure 5-2. Schematic of aquifer transitioning from unconfined an outcrop region, where recharge from precipitation occurs, to confined conditions in the down dip regions of the aquifer (from http://www.geo.brown.edu/research/Hydrology/ge58_IntrodHydrology/ge58_index.htm).**

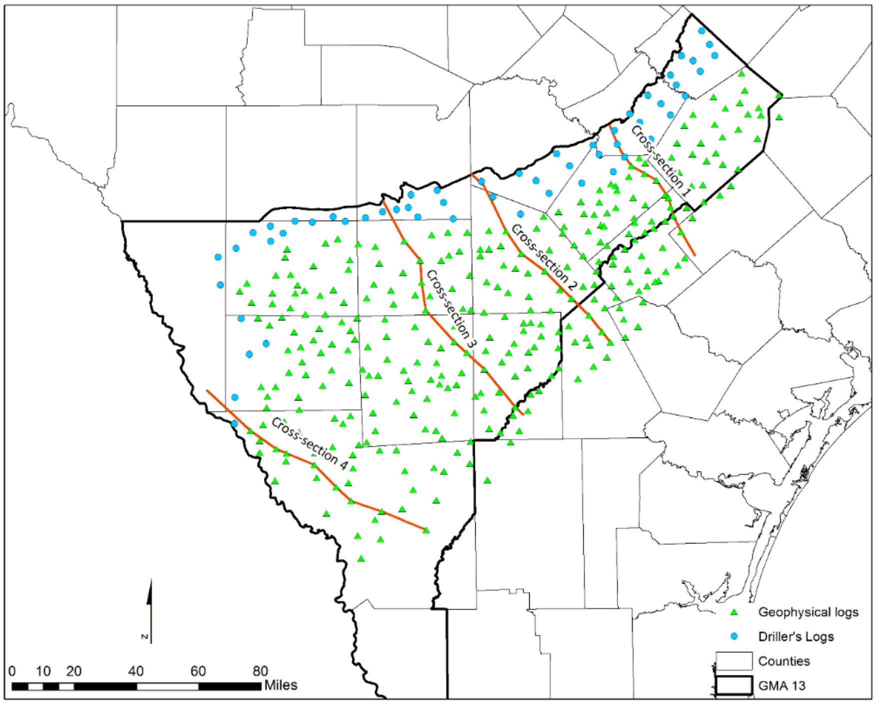


**Figure 5-3.** **Location of the 55 driller and 323 geophysical logs used to construct continuous profiles of sand and clay sequences that support calculations of volumes.**

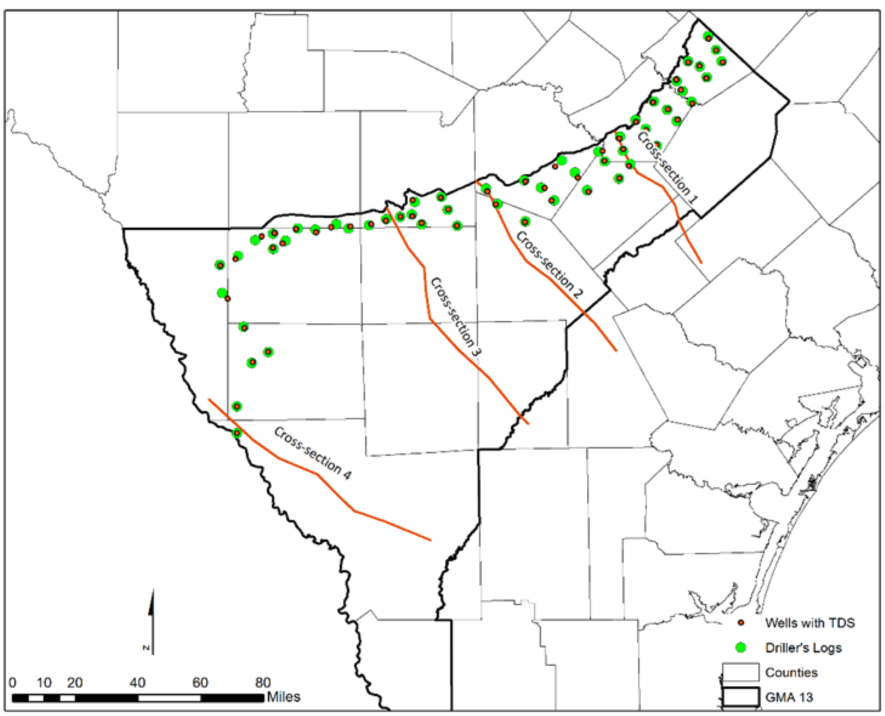


**Figure 5-4.** **Location driller logs and a nearby water well with measured concentrations of Total Dissolved Solids (TDS).**

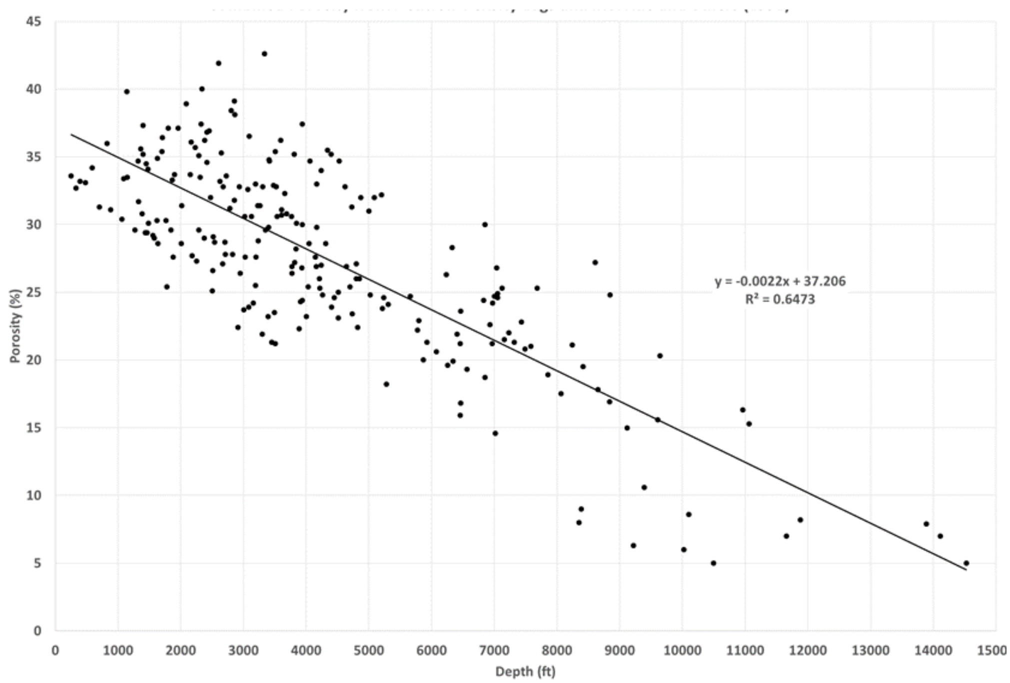


**Figure 5-5. Porosity as a function of depth based on porosity data from this study and McBride and others (1991).**

# 6 Construction and Application of Groundwater Models to Predict Drawdowns Associated with Pumping the Potential Production Areas

This section discusses the development and application of groundwater models to simulate changes in groundwater levels caused by pumping from Potential Production Areas (PPAs) identified in Section 4. For each PPA, several groundwater models were used to simulate pumping from candidate well fields for 50 years at the withdrawal rates of 5,000 AFY, 15,000 AFY, and 30,000 AFY. Drawdowns in the Carrizo-Wilcox Aquifer were tabulated after 30 years and 50 years of pumping at different distances down dip from the outcrop of the Carrizo-Wilcox Aquifer. In order to help evaluate the potential for significant drawdown impact in areas of concern, a sensitivity analysis was performed to document the sensitivity of simulated drawdown to changes in aquifer properties in the groundwater models.

## 6.1 Modeling Objectives and Approach

The primary modeling objective is to provide the TWDB with sufficient modeling results to adequately address House Bill 30 requirements to determine the amount of brackish groundwater that a PPA is capable of producing over a 30-year period and a 50-year period without causing a significant impact to water availability.

The expedited schedule of the project as well as the lack of measured water levels and aquifer tests in the areas of the PPA precluded the development of prediction with a high level of accuracy. The model simulations are considered be at a “scooping-level” because the groundwater models have not undergone the high level of model construction and calibration required by the TWDB Groundwater Availability Program. The inability to associate a high level of accuracy does not mean that the model results are inaccurate or unreliable but rather that the accuracy of the model prediction have not yet be thoroughly evaluated.

One problems associated with evaluation the model’s accuracy in the area of the PPAs is that there is a lack of hydrogeological data in the vicinity of the PPA This issue should not be too surprising because the location of the PPAs are in regions away from existing wells and groundwater use. To help address the unknowns with the aquifer properties and boundary conditions that leads to uncertainty in the model predictions, the model approach includes four investigations.

The four investigations involve simulating the impacts of pumping from two different well fields in each PPA, pumping at three different rates at each well field, simulating pumping using two groundwater models with different criteria for developing aquifer properties, and performing sensitivity analyses to quantify predictive uncertainty. **Table 6-1** summarizes the four main features of the modeling approach. After accounting for these four features, a total of 76 model simulations were made for each PPA.

For each PPA, two different well fields were used: one well field was located in the up-dip portion of the PPA, and the other well field was located in the down dip portion of the PPA. For each of the well fields, three different model runs were performed to simulate pumping rates at 5,000 AFY, 15,000 AFY, and 30,000 AFY. For each of the pumping rates and for each of the well field, drawdown impacts were simulated using two different groundwater models. Both groundwater models have the same numerical grid, which means they have the model layers and grid cells. The two groundwater models differ in the hydraulic properties used to represent the Carrizo-Wilcox Aquifer stratigraphy developed in Section 4. One groundwater model has hydraulic properties for the Carrizo-Wilcox Aquifer based on aquifer properties used in the Southern QCSP GAM. The other groundwater model based the hydraulic properties for the Carrizo-Wilcox Aquifer on a geohydrostratigraphic model developed for the project. The sensitivity analysis involved performing a series of model runs to document how changes in the different aquifer hydraulic properties affects the amount of drawdown simulated by the groundwater model.

**Table 6-1. Overview of the four main features of modeling approach.**

| Major Feature of the Modeling Approach | Rationale for the Modeling Approach |
|---|---|
| Two Well Fields | Because the drawdown impacts are a function of time, distance, and pumping rate, the groundwater modeling at each PPA includes simulating drawdown from two well fields located at different distances down dip from the outcrop of the Carrizo-Wilcox Aquifer. One well field was located in the up-dip portion of the PPA, and the other well field was located in the down dip portion of the PPA. |
| Three Pumping Rates | Because the drawdown impacts are a function of time, distance, and pumping rate, the drawdown produced by pumping each well field was evaluated at three different withdrawal rates. These three withdrawal rates were 5,000 AFY, 15,000 AFY, and 30,000 AFY. |
| Two Groundwater Models | Because of uncertainties with assigning hydraulic properties to model layers representing aquifers and hydrogeologic barriers, two groundwater models were used to simulate drawdown impacts caused by pumping a well field. Both groundwater models are three-dimensional models that have the same model layers and grid cells. One groundwater model has hydraulic properties for the Carrizo-Wilcox Aquifer based on aquifer properties used in the Southern QCSP GAM. The other groundwater model based the hydraulic properties for the Carrizo-Wilcox Aquifer on a geohydrostratigraphic model developed for the project. |
| Sensitivity Analysis | Because of the uncertainties associated with defining the aquifer properties based on limited field data, a sensitivity analysis was performed for both groundwater models for a pumping rate of 15,000 AFY. Each sensitivity model simulation involved adjusting between one to three hydraulic properties of the entire Carrizo-Wilcox Aquifer at a time. |

**Table 6-2** lists the sixteen model runs that comprise the sensitivity analysis. Four sensitivity analyses were performed for each PPA. The four runs were developed through the permutations of using the two different models to simulate the drawdown caused by pumping rate 15,000 AFY from two different well fields located in each PPA. Each of the sensitivity analysis involved varying model input parameters. The primary focus of the sensitivity analysis was on specific storage (Ss), vertical hydraulic conductivity (Kz), and horizontal hydraulic conductivity (Kh) for the Carrizo-Wilcox Aquifer. These three parameters were varied as a group for all of the model

layers associated the Carrizo-Wilcox Aquifer. These three parameters were increased and decrease by a factor of 3. Sensitivity model runs were performed that involved only one of the parameters (see runs 2 through 8 in Table 6-2). Also, sensitivity model runs were performed that involved varying all three of the hydraulic properties at the same time (see runs 9 through 16 in Table 6-2). In addition, the maximum potential recharge rate, R, was increased and decreased by a factor of 50%.

**Table 6-2. Overview of the four main features of modeling approach.**

| Run # | Number of Variables | Variable #1 | Multiplier | Variable #2 | Multiplier | Variable #3 | Multiplier |
|---|---|---|---|---|---|---|---|
| 1 | 1 | Ss | 0.33 | NA | NA | NA | NA |
| 2 | 1 | Ss | 3 | NA | NA | NA | NA |
| 3 | 1 | Kz | 0.33 | NA | NA | NA | NA |
| 4 | 1 | Kz | 3 | NA | NA | NA | NA |
| 5 | 1 | Kh | 0.33 | NA | NA | NA | NA |
| 6 | 1 | Kh | 3 | NA | NA | NA | NA |
| 7 | 1 | R | 0.5 | NA | NA | NA | NA |
| 8 | 1 | R | 1.5 | NA | NA | NA | NA |
| 9 | 3 | Ss | 3 | Kz | 3 | Kh | 3 |
| 10 | 3 | Ss | 3 | Kz | 0.33 | Kh | 3 |
| 11 | 3 | Ss | 0.33 | Kz | 3 | Kh | 3 |
| 12 | 3 | Ss | 0.33 | Kz | 0.33 | Kh | 3 |
| 13 | 3 | Ss | 3 | Kz | 3 | Kh | 0.33 |
| 14 | 3 | Ss | 3 | Kz | 0.33 | Kh | 0.33 |
| 15 | 3 | Ss | 0.33 | Kz | 3 | Kh | 0.33 |
| 16 | 3 | Ss | 0.33 | Kz | 0.33 | Kh | 0.33 |

*Note*: Ss = Specific Storage; Kz=vertical hydraulic conductivity; Kh=horizontal hydraulic conductivity, R= Potential Recharge; NA = Not Applicable

To help simplify the interpretation of the modeling results, the pumping that occurs in the groundwater model simulations is only from the PPA. Thus, all drawdown simulated by the groundwater model is attributed to the development of the PPA. There are two main reasons for including no other sources of other pumping. One reason is that the PPAs are located in confined portions of the aquifer and are far away from the unconfined regions of the aquifer. For the case of pumping a confined aquifer, simulated drawdowns from different well fields are additive. That is, the same amount of drawdown will be obtained whether or not the pumping from the two well fields are simulated together in the same model run or whether the pumping from each well field is simulated in different model runs and then added together. The other main reason is that removing all pumping except that from the PPA keeps the data analysis simple and the resulting drawdowns simple to interpret.

## 6.2 Model Layers

**Figure 6-1** shows four transects that intersect the four PPAs identified in Section 4. **Table 6-3** summarizes several key characteristics of the PPAs. **Figures 6-6** through **6-9** show the vertical cross-sections that were used to construct the groundwater models for the four PPAs. Each of vertical cross-sections has nine layers, **Table 6-4** shows which aquifer or formation is represented by a model layer for the four vertical cross-sections. For all of the groundwater models, the elevations for the top and bottom surfaces for the Sparta, Weches, and Queen City formations were extracted from the Southern QCSP GAM and the top and bottom surfaces for the Carrizo-upper Wilcox, middle Wilcox, and lower Wilcox were generated as part of this project in Section 4.

**Table 6-3. Description of the four potential production areas (PPAs).**

| PPA Number | County | Formation | Depth (ft) Below Ground Surface | Salinity Classification of Groundwater |
|---|---|---|---|---|
| 1 | Gonzales<br>Wilson | Lower Wilcox | 1,500 to 5,500 | slightly to moderately salinity |
| 2 | Wilson<br>Atascosa | Lower Wilcox | 1,500 to 5,500 | slightly to moderately salinity |
| 3 | Frio<br>Zavala | Lower Wilcox | 1,500 to 5,500 | slightly to moderately salinity |
| 4 | Webb | Carrizo-upper Wilcox | 1,500 to 5,500 | slightly to moderately salinity |

**Table 6-4. Formation or aquifer assigned to the nine layers in the vertical cross-sections and groundwater models for the four PPAs.**

| Model Layer | Modeled Cross-Sections for PPA #1 to #3 | Modeled Cross-Sections for PPA #4 |
|---|---|---|
| 1 | Sparta | Sparta |
| 2 | Weches | Weches |
| 3 | Queen City | Queen City |
| 4 | Reklaw | Reklaw |
| 5 | Carrizo-upper Wilcox | Carrizo-upper Wilcox (upper third) |
| 6 | Middle Wilcox | Carrizo-upper Wilcox (middle third) |
| 7 | Lower Wilcox (upper third) | Carrizo-upper Wilcox (lower third) |
| 8 | Lower Wilcox (middle third) | Middle Wilcox |
| 9 | Lower Wilcox (lower third) | Lower Wilcox |

## 6.3 Development of Three-Dimensional Groundwater Models

The code selected for the groundwater modeling is MODFLOW-USG (Panday and others, 2013). MODFLOW-USG is a three-dimensional control volume finite difference groundwater flow code that is supported by a suite of MODFLOW packages that simulate recharge, evapotranspiration, streams, springs and reservoirs. MODFLOW-USG is an enhanced version of the MODFLOW family of codes developed and supported by the United States Geological Survey. The benefits of using MODFLOW-USG for the current effort include the following: (1) MODFLOW incorporates the necessary physics of groundwater flow, (2) MODFLOW is the most widely accepted groundwater flow code in use today, (3) MODFLOW was written and is supported by the United States Geological Survey and is public domain, (4) MODFLOW is well documented (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996; Harbaugh and others, 2000; Harbaugh, 2005; Niswonger and others, 2011; Panday and others, 2013), and (5) MODFLOW has a large user group.

### *6.3.1 Construction of a Three-dimensional Models for Each Potential Production Area*

As previously stated, two groundwater models were constructed for each PPA. Both of these models have the same numerical grid and differ only in the aquifer properties used to represent the Carrizo-Wilcox Aquifer. For each PPA, the three-dimensional model grid was constructed from a representative vertical cross-section of the aquifers for that PPA. These representative vertical cross-sections are shown in Figures 6-6 through 6-9. The construction of a three-dimensional groundwater flow model from each of the vertical cross-sections can be conceptualized through the following four-step process.

<u>Step 1: Construct a Vertical Cross-Sectional Grid</u>. Figures 6-6 through 6-9 show the representative vertical cross-section developed for PPA #1 to #4, respectively. For all cross-sections, recharge occurs where the aquifers outcrop, which is illustrated by the blue colored grid cells. The green colored grid cells mark where the Sparta aquifer is overlain by the Yegua-Jackson Aquifer. At the locations of the green colored grid cells, a general head boundary (GHB) condition is used to represent the exchange of groundwater between the Sparta and the Yegua-Jackson Aquifer. This assumption is the same assumption used in the Southern QCSP GAM. The lowest and deepest model layer is model layer 9, which represents the lower Wilcox Aquifer. The base of the lower Wilcox Aquifer is considered to be a no-flow boundary. This assumption is the same assumption used in the Southern QCSP GAM. For the grid cells located at the most down-dip extent of each model layer, a no-flow boundary condition is imposed. This assumption is the same assumption used in the Southern QCSP GAM.

<u>Step 2: Assign Aquifer Properties</u>. The hydraulic properties assigned to the grid cells in the top four model layers were determined by intersecting the transects in Figure 6-1 with the Southern Queen City GAM. The top four model layers represent, from youngest to oldest formation, the Sparta Aquifer, the Weches formation, the Queen City Aquifer, and the Reklaw formation. Two different methods were used to assign hydraulic properties for the Carrizo-upper Wilcox, middle Wilcox, and lower Wilcox formations identified in Section 3. One method is called the groundwater availability model (GAM)-based method, and the other method is called the

geohydrostratigraphic model (GHSM)-based method. The GAM-based method involves extracting aquifer information from the Southern QCSP GAM in a similar manner as done for the top four model layers. The GHSM-based method involves using a geohydrostratigraphic (GHS) model of the Carrizo-Wilcox Aquifer to determine hydraulic properties for the grid cells. Three of the key parameter that are used to calculate hydraulic properties for the grid cells are measured values of hydraulic conductivity in the outcrop of the model layer, the depth below ground surfaced associated with the grid cell, and the average sand fraction in the aquifer at the grid cell location.

Step 3. Develop a Three-Dimensional Model. **Figure 6-10** shows the process used to construct the three-dimension model grids by replicating the vertical cross-section grids multiple times. With each replication, the width of vertical cross-section is expanded by another grid cell until the total width of the three-dimensional groundwater model is 100 miles wide. This procedure maintains the structure, hydraulic properties, and hydraulic boundaries in the original vertical cross-sectional model throughout the entire model domain. The lateral expansion of 50 miles on both sides of the original vertical cross-section is performed so that the lateral model boundaries are sufficiently far from the pumping at the well fields in the middle of the model that so that no-flow boundary conditions are justified.

Step 4. Refine Grid Spacing for Placement of Faults and Wells. The three-dimensional model developed in Step 3 consists of grid cells that are 1-mile by 1-mile. In the vicinity of the faults and the well, grid cells were refined. **Figure 6-11** shows examples of grid refinement from a three-dimensional groundwater models developed for PPA #1. In the vicinity of the faults, the 1-mile by 1-mile grid spacing was replaced by a uniform grid spacing of 1/8-mile by 1/8-mile for approximately one mile up dip and approximately one mile down dip of the fault location along the entire width of the model.

## 6.4 Well Fields

Figure 6-1 shows the location of the well fields in each PPA. **Table 6-5** provides the distance down dip to the two well fields in each PPA. The distance is measured from the start of the transect to the centroid of the well field. To produce 5,000 AFY, 15,000 AFY, and 30,000 AFY, the well fields were comprised of 9, 12, and 15 wells, respectively. Figures 6-2 through 6-5 provide a map of the location of the two well fields for Cross-sections 1, 2, 3, and 4, respectively. Each of the well fields consist of the 15 well used to extraction 30,000 AFY. In all cases, the each well in a well field has the same pumping rate as the other wells. As shown in **Table 6-6**, these pumping rates varied between 1,032 gallons per minute (gpm) to 1,239 gpm. For PPAs #1, #2, and #3, the production wells pump model layer 8, which is the middle third of the lower Wilcox formation. For PPA #4, the production well pumps model layer 6, which represents the middle third of the Carrizo-upper Wilcox Aquifer.

**Table 6-5. Average distance to the center of the well fields from the up-dip extend of the Carrizo-Wilcox outcrop.**

| Potential Brackish Production Zone | Distance from Up-Dip Extend of Carrizo-Wilcox Outcrop to Well Field | |
|---|---|---|
| | Up-Dip Well Field | Down-Dip Well Field |
| #1 | 25 miles | 32 miles |
| #2 | 32 miles | 41 miles |
| #3 | 31 miles | 39 miles |
| #4 | 60 miles | 70 miles |

**Table 6-6. Number of wells and average pumping rates for the modeled well fields.**

| Total Pumping (AFY) | Number of Wells | Pumping Rate (gpm) Per Well |
|---|---|---|
| 5,000 | 3 | 1,032 |
| 15,000 | 9 | 1,032 |
| 30,000 | 15 | 1,239 |

## 6.5 Development of a Geohydrostratigraphic Model for the Carrizo-Wilcox Aquifer

The continuous profiles of sand and clay sequences calculated from the 323 logs in Section 4 provide an excellent basis for developing a geohydrostratigraphic model for the Carrizo-Wilcox Aquifer. For this study, the purpose of a GHSM is to provide transmissive and storage properties for the Carrizo-Wilcox Aquifer that are reasonable, defensible, and also independent and separate from the existing Southern QCSP GAM. The process of building a GHSM involves developing relationships among the different geologic data sets, such as sand fraction and porosity, that can be used to estimate aquifer properties such as hydraulic conductivity and specific storage. Once this has been accomplished, then the continuous lithology data can be transformed via the GHSM to a continuous set of hydraulic properties.

A simple GHSM that has been commonly used to guide the development of groundwater model is to use sand thickness as an indicator of transmissivity. This practice is often used in developing regional scale groundwater models. More advanced applications of GHSM consider other factors besides sand thickness, such as porosity, depositional environment, depth, and temperature. Examples of GHSM that have been used to guide the development of groundwater models in Texas include: a groundwater transport models for Former Kelly Air Force Base in Bexar County (Young and others, 2003), water availability models for the Catahoula formation in Montgomery County , (LGB Guyton and INTERA, 2012); the Lower Colorado River Basin model in the Central Texas Gulf Coast (Young and Kelley, 2006; Young and others, 2009); and groundwater availability models for the Yegua-Jackson Aquifer (Deeds and others, 2010); Central Queen City/Sparta GAM (Dutton and others, 2003), the Southern Queen City/Sparta (Deeds and others, 2004), and the Northern Trinity and Woodbine Aquifers (Kelley and others, 2014).

### *6.5.1 Spatial Patterns in the Sand Fraction*

**Figures 6-12** through **6-15** show the sand fraction for the grid cells that represent the Carrizo-upper Wilcox (model layer 5), the middle Wilcox (model layer 6), and the lower Wilcox (model layers 7, 8, and 9) for the groundwater models for PPA #1 through #4, respectively. In the up dip region of the aquifers, the average sand fractions are about 0.80, 0.35, and 0.55 for the Carrizo-upper Wilcox Aquifer, the middle Wilcox, and the lower Wilcox aquifers, respectively. Where in the down dip region of the aquifers, the average sand fractions are about 0.35, 0.05, and 0.05 for the Carrizo-upper Wilcox Aquifer, the middle Wilcox, and the lower Wilcox aquifers, respectively. All four figures show that the middle Wilcox has significantly less sand than the other two aquifers and has sufficient clay across most of its extent to act as a hydrogeological barrier. Potentially important spatial patterns in sand fraction is evident in Figure 6-13.

### *6.5.2 Calculation of Equivalent Horizontal and Vertical Hydraulic Conductivity for a Model Layer*

For this study, the GHSM will estimate the horizontal and vertical hydraulic conductivity for a model layer based on the assumption of one-dimension flow through uniform layered media. For this condition, the equivalent horizontal and vertical hydraulic conductivity values (Kx and Kz, respectively) can be obtained using basic averaging equations (Maliva, 2016; Freeze and Cherry, 1979; Domenico and Schwartz, 1990). The equivalent horizontal hydraulic conductivity is the arithmetic mean of the horizontal hydraulic conductivity of the individual layers. The equivalent vertical hydraulic conductivity is the harmonic mean of the vertical hydraulic conductivity of the individual layers. **Figure 6-16** is a schematic showing the application of an arithmetic average and the harmonic average to calculate equivalent horizontal and vertical hydraulic conductivities based on one-dimensional vertical flow through layered media. For one-dimensional flow, the effective hydraulic conductivity is the weighted harmonic mean of the hydraulic conductivity of the different layers. For a two-layer aquifer consisting of a sand and clay layer, **Equation 6-1** calculates the arithmetic average and **Equation 6-2** calculates the harmonic average.

$$K_{Heffective} = [(K_{HS} * D_s) + [(K_{Hc} * D_c)]/(D_s + D_c) \qquad \text{(Equation 6-1)}$$

$$K_{Veffective} = (D_s + D_c)/[(D_s/Kz_s) + (D_c/Kz_c)] \qquad \text{(Equation 6-2)}$$

where:

| | | |
|---|---|---|
| $K_{Heffective}$ | = | equivalent horizontal hydraulic conductivity for the media |
| $Kz_{effective}$ | = | equivalent vertical hydraulic conductivity for the media |
| $D_s$ | = | total thickness of sand |
| $D_c$ | = | total thickness of clay |
| $K_{Hc}$ | = | hydraulic conductivity of clay |
| $K_{Hs}$ | = | hydraulic conductivity of sand |
| $Kz_c$ | = | vertical hydraulic conductivity of clay |
| $Kz_s$ | = | vertical hydraulic conductivity of sand |

### *6.5.3 Calculation of Horizontal Hydraulic Conductivity for Individual for Layers*

The application of Equation 6-1 to calculate an equivalent horizontal hydraulic conductivity value is, for all practical purposes, determined by the hydraulic conductivity of the sandy layers. As long as the clay layers are at least 100 times less permeable than the sands, then the actual permeability of the horizontal clay layers will have only a negligible impact on the calculation of equivalent horizontal hydraulic conductivity. The GHSM for the Carrizo-Wilcox Aquifer presumes that the hydraulic conductivity of the clay can be ignored in the application of Equation 6-1. The GHSM uses **Equation 6-3** to assign a horizontal hydraulic conductivity value to a sand bed. In using Equation 6-3, the GHSM is assuming that in the shallow regions of the Carrizo-Wilcox outcrop, the sands have similar hydraulic conductivity values, and these values change as a function of depth because of changes in porosity and temperature.

$$K_{Hlayer} = K_{baseline} * A_{porosity} * A_{temperature} * \qquad \text{(Equation 6-3)}$$

where

| | | |
|---|---|---|
| $K_{Hlayer}$ | = | horizontal hydraulic conductivity of the layer |
| $K_{baseline}$ | = | baseline value of horizontal hydraulic conductivity based on field data |
| $A_{porosity}$ | = | adjustments to account for the relationship between permeability and porosity based on Dutton and Loucks (2014) |
| $A_{temperature}$ | = | adjustments to account for the change in the viscosity and density of water with depth |

**Table 6-7** lists the hydraulic conductivity baseline value used by Equation 6-3 for Model Layers 5 through 9. The baseline values represent the median value of the hydraulic conductivity values assembled by Deeds and others (2010) from well tests primarily performed in the outcrop of the Carrizo-Wilcox Aquifer. Table 6-7 lists a hydraulic conductivity value of about 30 feet per

day (ft/day) for the Carrizo-upper Wilcox aquifer and values between 4 and 8 ft/day for the middle and lower Wilcox aquifers.

**Figure 6-17** shows the relationship used by the GHSM to adjust hydraulic conductivity with depth to account for a reduction in porosity with depth. The relationship shown in Figure 6-17 was developed by combining the relationships developed in **Figures 6-18** and **6-19**. Figure 6-18 shows the data developed in Section 4 to express porosity as a function of depth. Figure 6-19 shows a relationship between relative hydraulic conductivity and porosity that was developed from porosity and permeability data assembled by Dutton and Loucks (2014) in the Wilcox aquifer in south Texas. The relationship in Figure 6-19 is used by the GHSM.

**Table 6-7. Baseline hydraulic conductivity values used for the Carrizo-upper Wilcox, middle Wilcox, and lower Wilcox aquifers by the GeoHydroStratigraphic model.**

| Aquifer | Model Layer (s) | Number of Hydraulic Conductivity Measurements * | Median Value Used to Represent the Baseline Hydraulic Conductivity of Sand |
|---|---|---|---|
| Carrizo-upper Wilcox | 5 | 626 | 30.5 ft/day |
| Middle Wilcox | 6 | 217 | 8 ft/day |
| Lower Wilcox | 7,8,9 | 17 | 4.5 ft/day |

*Measurements are from Deeds and others (2004)

Equation 6-3 includes a temperature adjustment because hydraulic conductivity is a function of the density and viscosity of water, which are temperature dependent. **Equation 6-4** (Freeze and Cherry, 1979) shows how hydraulic conductivity is dependent on the density and viscosity of water. **Figure 6-20** shows how hydraulic conductivity will increase with increases in temperature from 32 degrees Fahrenheit (°F) to 180°F. This increase occurs primarily because the dynamic viscosity of water decreases with increases in temperature. The GHSM assumed that at shallow groundwater at GMA 13 is at 77°F and a geothermal gradient of about 20°F per 1,000 feet. These conditions lead to an increase in the hydraulic conductivity of approximately 140% per 5,000 feet of depth, or approximately 0.03% per one foot of depth.

$$K = k * \rho * g/\mu \qquad \text{(Equation 6-4)}$$

where

$K$ = hydraulic conductivity of media (L/T)
$k$ = intrinsic permeability of media ($L^2$)
$\rho$ = density of fluid ($M/L^3$)
$g$ = gravitational constant (980.6 $cm^2/s$)
$\mu$ = dynamic viscosity of fluid (M/[L*T])

### *6.5.4 Calculation of Vertical Hydraulic Conductivity for Individual for Layers*

The GHSM determines the vertical hydraulic conductivity of a sand layer by dividing the horizontal hydraulic conductivity of the sand layer by 10. The GHSM determines the vertical hydraulic conductivity of a clay layer by using a slightly modified version of Equation 6-1. The only modification to Equation 6-1 is to use a baseline value of 0.028 feet per day (ft/day) (0.00001 centimeter per second [cm/s]) for the vertical hydraulic conductivity of clay.

### *6.5.5 Calculation of Specific Storage for a Model Layer*

The GHSM uses the model of Shestakov (2002) to estimate specific storage values. Shestakov (2002) postulated a relationship based on geomechanical considerations as follows:

$$Ss = A / [D + z0] \qquad \text{(Equation 6-5)}$$

where

$Ss$ = Specific storage ($L^{-1}$)
$D$ = Depth ($L$)
$Zo$ = calibrated parameter
$A$ = Calibrated parameter, which is a function of $[1/(1+e)]$
$e$ = void space, which is defined as $e= [1/(1-\theta)]$, where $\theta$ = porosity

Shestakov (2002) showed that "A" in Equation 6-5 varied in the narrow range between 0.00020 per foot to 0.00098 per foot for sandy rocks and between 0.0033 per foot to 0.033 per foot for clayey rocks. Shestakov (2002) also shows that the variable "A" is also shown to be a function of the void space such that as the porosity becomes smaller, the specific storage value increases with all other factors remaining equal. This relationship is consistent with the Jacob Equation (Jacob, 1940) for calculating the specific storage from porosity and the compressibility of water and the rock matrix. The Shestakov model assumes a power-law relationship between porosity and depth, where the decrease is more pronounced at shallower depth than is allowed by a linear relationship between porosity and depth. The power-law relationship is consistent with the Magara (1978) observation that the rate of porosity decrease is fast at shallow depths and slows down with greater burial depth.

Previous application of the Shestakov model for estimating specific storage values include the Northern Trinity and Woodbine GAM (Kelly and others, 2014), the Yegua-Jackson GAM (Deeds and others, 2010), and the Lower-Colorado River Basin Model (Young and others, 2009; Young and Kelley, 2006). These applications have involved a modified version of Equation 6-5 that allows accounting for mixed sands and clay layers over thick intervals, a minimal value of specific storage prevent over extrapolation of the data used to developed Equation 6-5 similar to **Equation 6-6**. The GHSM used Equation 6-6 to calculate specific storage. In applying Equation 6-6, all of the variables are fixed, except SF, D, and e. The three unfixed variables are dependent on the grid cell location and vary across the model. The values for the fixed variables are based on primarily previous application of the Shestakov model to the Gulf Coast Aquifer System.

$$Ss = Ss_{min} + \{\frac{A1 * [e/(1-e)] * [SF + CM*(1-SF)]}{A2+D}\} \qquad \text{(Equation 6-6)}$$

where

Ss = Specific storage ($L^{-1}$)
$Ss_{min}$ = set to 5.0 E-7 $ft^{-1}$
A1= calibrated parameter that is set to 0.0025
e = void space that is calculated based on the porosity, θ, which is depth specific
SF = sand fraction that is determined by interpolation of measured sand fractions calculated from geophysical logs
CM = clay multiplier, which is set to 20
A2 = a calibrated parameter that is set to 5
D = depth which is determined by the location of the grid cell (L)

### *6.5.6 Representation of Faults*

Our review of the stratigraphy and water quality near the eight faults shown in the vertical cross-sections in Figures 6-6 to 6-9 indicate the fault offsets are not large enough to notably hinder horizontal flow. The primary impact of the fault on groundwater is for the offsets to cause discontinuities and/or breeches in confining layers. Most of the faults offsets were less than 200 feet. The greatest offset was about 400 feet. To account for this effect, the vertical hydraulic conductivity of the model layers within one-quarter of a mile of fault location was increased by a factor between 1.0 and 6.0. For an offset of 200 feet the multiplication factor was 2.5. For the maximum offset of about 400 feet the multiplication factor was 6.3.

## 6.6 Simulated drawdowns from Well Fields Located in Potential Production Area #1

This section describes the construction and application of two groundwater models to simulate the drawdowns that would be created by pumping Potential Production Area #1 at two proposed well fields.

### *6.6.1 Construction of Groundwater Models based on GAM and GHSM properties*

The two groundwater models constructed to simulate pumping from PPA #1 are three-dimensional models with the same model layers and vertical grid discretization as shown in Figure 6-6. The width of the two models is along the geologic strike for the Carrizo-Wilcox Aquifer and is 100 miles. The length of the two models along dip is 51 miles. The recharge rate applied to the outcrop was a uniform 1.5 inches per year.

**Table 6-8** provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 10-mile reaches for both models. The model properties were extracted from the Southern QCSP GAM and assigned to model layers 1 to 9. The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 1,000 for all model layers except for the model layers that represent the Reklaw formation and the middle Wilcox Aquifer. The ratio of Kx/Kz for these two model layers was

10,000. In addition, adjustments to the Kx/Kz ratios for the middle Wilcox were made based on the degree of confinement provided by the clay layers contained within the middle Wilcox and present on geophysical logs. These adjustments allow the Kx/Kz ratio to vary between 1,000 and 100,000.

Table 6-8 also provides the values for Kx, Kz, and Ss that were produced by the GHSM for model layers 5 to 9. **Figures 6-21** and **6-22** illustrate the values of Kx in Table 6-8. The two models have comparable Kx values for the Carrizo-upper Wilcox, but the GHSM-model has much lower Kx values for the lower Wilcox at large depths. Among the most notable difference between the two sets of hydraulic properties for the Carrizo-Wilcox Aquifer is that the vertical hydraulic conductivity values and the specific storage values are significantly lower for the GMA-based properties than the GHSM-based properties.

### *6.6.2 Simulated Drawdown Produced by Pumping from Potential Production Area #1*

Groundwater pumping at the rate of 5,000 AFY, 15,000 AFY and 30,000 AFY was simulated at two well fields in PPA #1 shown in Figure 6-1. Both well fields pump model layer 8, which represents the middle third of the lower Wilcox Aquifer. The up dip well field #1 is located 25 miles down dip from the outcrop, and the down dip well field #2 is located 32 miles down dip from the outcrop. **Figures 6-23** and **6-24** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GAM-based hydraulic properties for the Carrizo-Wilcox aquifer. **Figures 6-25** and **6-26** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GHSM-based hydraulic properties for the Carrizo-Wilcox aquifer.

Among the notable results that can be observed in the plotted drawdown in Figures 6-23 to 6-26 are the following:

- The Reklaw provides an effective hydraulic barrier that prevents appreciable drawdowns from migrating from the Carrizo-Wilcox Aquifer into the Queen City Aquifer
- The drawdown predicted in the Carrizo-Wilcox Aquifer outcrop is significantly higher from pumping Well Field #1 than from pumping Well Field #2
- There is less predicted drawdown in the outcrop of the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model

Drawdown values were recorded for all four model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 2.5 miles, 5.5 miles, 10.5 miles, 15.5 miles, and 30.5 miles. Table 6-9 provides the elevations and depths associated with these five monitoring locations.

**Table 6-8.** **Average values for Kx (feet per day), Kz (feet per day), and Ss (1/feet) by model layer for 10-mile reaches along dip for the groundwater models for PPA #1.**

| Reach (miles) | Property | Layer 1 | Layer 2 | Layer 3 | Layer 4 |
|---|---|---|---|---|---|
| **Common to Both GAM and GHSM based Groundwater Models** | | | | | |
| 0-10 | Kx | n/a | n/a | n/a | n/a |
| | Kz | n/a | n/a | n/a | n/a |
| | Ss | n/a | n/a | n/a | n/a |
| 10-20 | Kx | n/a | n/a | 1.93 | 1.12 |
| | Kz | n/a | n/a | 2.0E-03 | 1.2E-04 |
| | Ss | n/a | n/a | 3.9E-04 | 3.3E-05 |
| 20-30 | Kx | 2.4 | 1.0 | 2.0 | 1.6 |
| | Kz | 2.4E-03 | 1.0E-03 | 2.0E-03 | 1.6E-04 |
| | Ss | 1.1E-05 | 1.2E-05 | 5.0E-06 | 5.3E-06 |
| 30-40 | Kx | 0.3 | 0.8 | 0.2 | 0.9 |
| | Kz | 2.8E-04 | 8.3E-04 | 2.3E-04 | 9.0E-05 |
| | Ss | 4.5E-06 | 4.6E-06 | 3.4E-06 | 3.4E-06 |
| 40-51 | Kx | 0.0 | 0.1 | 0.0 | 1.1 |
| | Kz | 6.1E-06 | 5.8E-05 | 3.0E-06 | 1.1E-04 |
| | Ss | 2.5E-06 | 2.4E-06 | 2.0E-06 | 1.6E-06 |

| Reach (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| **Carrizo-Wilcox Aquifer Properties Extracted from the Southern QCSP GAM** | | | | | | |
| 0-10 | Kx | 1.3 | 5.3 | 5.8 | 6.8 | 6.8 |
| | Kz | 1.3E-03 | 3.6E-04 | 4.6E-02 | 5.4E-02 | 5.4E-02 |
| | Ss | 4.6E-04 | 1.1E-04 | 2.0E-05 | 3.0E-06 | 3.0E-06 |
| 10-20 | Kx | 28.46 | 1 | 1 | 2.48 | 3.22 |
| | Kz | 3.0E-02 | 3.4E-05 | 1.0E-03 | 2.6E-03 | 3.4E-03 |
| | Ss | 6.1E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 20-30 | Kx | 46.4 | 0.8 | 0.8 | 1.8 | 3.0 |
| | Kz | 4.6E-02 | 3.2E-05 | 8.1E-04 | 1.8E-03 | 3.0E-03 |
| | Ss | 3.1E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 30-40 | Kx | 10.9 | 0.3 | 2.6 | 3.0 | 3.0 |
| | Kz | 1.2E-02 | 2.9E-05 | 2.8E-03 | 3.2E-03 | 3.2E-03 |
| | Ss | 1.9E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 40-51 | Kx | 0.6 | 0.5 | 2.7 | 2.7 | 2.7 |
| | Kz | 5.8E-04 | 8.3E-06 | 2.7E-03 | 2.7E-03 | 2.7E-03 |
| | Ss | 2.3E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| **Carrizo-Wilcox Aquifer Properties Developed from the GeoHydroStratigraphic Model (GHSM)** | | | | | | |
| 0-10 | Kx | 30.8 | 3.1 | 3.7 | 3.7 | 3.6 |
| | Kz | 2.5E-01 | 6.5E-02 | 2.7E-01 | 2.7E-01 | 2.6E-01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Ss | 4.6E-04 | 2.6E-04 | 1.3E-04 | 5.5E-05 | 4.2E-05 |
| 10-20 | Kx | 28.0 | 2.0 | 3.2 | 3.0 | 2.8 |
| | Kz | 2.3E-01 | 5.4E-02 | 8.0E-02 | 7.4E-02 | 6.8E-02 |
| | Ss | 1.5E-05 | 2.3E-05 | 1.1E-05 | 9.1E-06 | 7.9E-06 |
| 20-30 | Kx | 22.1 | 1.5 | 2.5 | 2.2 | 1.9 |
| | Kz | 1.7E-01 | 3.9E-02 | 6.0E-02 | 5.2E-02 | 4.5E-02 |
| | Ss | 5.3E-06 | 1.2E-05 | 5.6E-06 | 5.0E-06 | 4.5E-06 |
| 30-40 | Kx | 11.9 | 1.1 | 1.2 | 0.9 | 0.7 |
| | Kz | 8.5E-02 | 2.3E-02 | 3.1E-02 | 2.4E-02 | 1.8E-02 |
| | Ss | 3.3E-06 | 6.4E-06 | 3.3E-06 | 3.1E-06 | 2.9E-06 |
| 40-51 | Kx | 3.5 | 0.2 | 0.1 | 0.1 | <0.1 |
| | Kz | 2.3E-02 | 4.5E-03 | 3.1E-03 | 2.1E-03 | 1.3E-03 |
| | Ss | 2.3E-06 | 4.8E-06 | 4.3E-06 | 4.1E-06 | 3.9E-06 |

**Table 6-9.** **Locations and elevation (in feet above mean sea level [amsl]) where drawdowns were monitored for the simulated pumping at Well Field #1 and Well Field #2 in Potential Production Area #1.**

| Monitoring Location (miles) | Ground Surface (ft, amsl) | Vertical Boundary | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|---|
| | | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 2.5 | 603.9 | Top | | | 603.9 | 523.8 | 473.6 |
| | | Bottom | | | 523.8 | 473.6 | 421.9 |
| 5.5 | 571.1 | Top | | 571.1 | 424.2 | 320.5 | 216.8 |
| | | Bottom | | 424.2 | 320.5 | 216.8 | 109.9 |
| 10.5 | 641.5 | Top | 641.5 | 380.3 | -171.5 | -326.5 | -481.5 |
| | | Bottom | 380.3 | -171.5 | -326.5 | -481.5 | -641.3 |
| 15.5 | 532 | Top | 442 | -283.3 | -578 | -868.6 | -1,159.3 |
| | | Bottom | -283.3 | -578 | -868.6 | -1,159.3 | -1,458.8 |
| 30.5 | 364.1 | Top | -2,031.2 | -2,818.6 | -3,429 | -3,946.7 | -4,464.4 |
| | | Bottom | -2,818.6 | -3,429 | -3,946.7 | -4,464.4 | -4,997.9 |

## Simulated Drawdown from the Groundwater Model with GAM-based Properties for the Carrizo-Wilcox Aquifer

**Tables 6-10** and **6-11** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-9 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GAM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-27** to **6-28** show the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-29** to **6-30** show the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-10 and 6-11 and Figures 6-27 through 6-30 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts 5 to 6 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and 7 to 13 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts that there is between 2 and 3 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 3 and 7 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 900 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 500 feet of drawdown at the Well Field #2
- After 30 years of pumping the lower Wilcox for 15,000 AFY at either Well Field #1 or Well Field #1, the groundwater model predicts less than 1 foot of across the entire Carrizo-upper Wilcox Aquifer.

**Simulated Drawdown from the Groundwater Model with GHSM-based Properties for the Carrizo-Wilcox Aquifer**

**Tables 6-12** and **6-13** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-9 for pumping at 5,000, 15,000, and 30,000 AFY as determined by the groundwater model that uses GHSM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-31** to **6-32** show the simulated drawdown along the center dip line of the groundwater model elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-33** to **6-34** show the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-12 and 6-13 and Figures 6-31 through 6-34 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts between 1 to 1.5 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 1 to 4 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts less than 1 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 1 to 2 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 300 feet of drawdown at the Well Field #1

- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 100 feet of drawdown at the Well Field #2
- After 30 years of pumping 15,000 AFY from the lower Wilcox Aquifer, the groundwater model predicts more than 30 foot of drawdown in the Carrizo Aquifer above the location the pumping wells in the lower Wilcox.

**Table 6-10. Simulated drawdown in feet at monitoring locations after pumping Well Field #1 in PPA #1 for 30 years and 50 years. as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 1.9 | 2.1 | 2.1 |
| | 15,000 | Not Present | Not Present | 5.7 | 6.3 | 6.4 |
| | 30,000 | Not Present | Not Present | 11.3 | 12.4 | 12.7 |
| 5.5 | 5,000 | Not Present | 0.1 | 2.3 | 3.5 | 4.2 |
| | 15,000 | Not Present | 0.2 | 7.1 | 10.7 | 12.7 |
| | 30,000 | Not Present | 0.5 | 14.0 | 21.1 | 25.2 |
| 10.5 | 5,000 | 0.0 | 0.3 | 5.0 | 8.8 | 9.5 |
| | 15,000 | 0.0 | 1.0 | 15.2 | 27.1 | 28.9 |
| | 30,000 | 0.0 | 2.0 | 30.0 | 53.6 | 57.4 |
| 15.5 | 5,000 | 0.0 | 1.4 | 20.6 | 21.5 | 15.8 |
| | 15,000 | 0.1 | 4.2 | 62.8 | 66.4 | 48.2 |
| | 30,000 | 0.3 | 8.3 | 123.5 | 130.7 | 95.3 |
| 30.5 | 5,000 | 0.1 | 5.6 | 49.5 | 72.8 | 29.3 |
| | 15,000 | 0.2 | 16.6 | 147.5 | 217.9 | 87.4 |
| | 30,000 | 0.4 | 33.2 | 292.9 | 431.8 | 173.7 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 2.8 | 3.0 | 3.0 |
| | 15,000 | Not Present | Not Present | 8.4 | 9.1 | 9.2 |
| | 30,000 | Not Present | Not Present | 16.6 | 18.0 | 18.3 |
| 5.5 | 5,000 | Not Present | 0.2 | 3.2 | 4.6 | 5.4 |
| | 15,000 | Not Present | 0.5 | 9.8 | 13.9 | 16.4 |
| | 30,000 | Not Present | 1.0 | 19.5 | 27.7 | 32.7 |
| 10.5 | 5,000 | 0.0 | 0.6 | 6.4 | 10.5 | 11.5 |
| | 15,000 | 0.0 | 1.7 | 19.4 | 32.1 | 34.9 |
| | 30,000 | 0.0 | 3.3 | 38.4 | 63.7 | 69.3 |
| 15.5 | 5,000 | 0.1 | 2.2 | 24.4 | 24.3 | 18.5 |
| | 15,000 | 0.3 | 6.5 | 74.1 | 74.6 | 56.3 |
| | 30,000 | 0.6 | 12.9 | 146.1 | 147.2 | 111.6 |
| 30.5 | 5,000 | 0.1 | 8.5 | 57.1 | 80.0 | 35.7 |
| | 15,000 | 0.4 | 25.3 | 170.4 | 239.6 | 106.5 |
| | 30,000 | 0.8 | 50.6 | 338.8 | 475.2 | 211.9 |

**Table 6-11. Simulated drawdown in feet at monitoring locations after pumping Well Field #2 in PPA #1 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.59 | 1.1 | 1.2 |
| | 15,000 | Not Present | Not Present | 2.83 | 3.15 | 3.24 |
| | 30,000 | Not Present | Not Present | 5.63 | 6.27 | 6.45 |
| 5.5 | 5,000 | Not Present | 0.04 | 0.91 | 2.69 | 3.90 |
| | 15,000 | Not Present | 0.13 | 3.51 | 5.27 | 7.04 |
| | 30,000 | Not Present | 0.26 | 6.98 | 10.48 | 14.01 |
| 10.5 | 5,000 | 0.00 | 0.29 | 2.31 | 5.01 | 6.69 |
| | 15,000 | 0.01 | 0.87 | 7.33 | 12.54 | 16.52 |
| | 30,000 | 0.02 | 1.72 | 14.55 | 24.95 | 32.90 |
| 15.5 | 5,000 | 0.06 | 1.28 | 9.98 | 9.90 | 9.85 |
| | 15,000 | 0.18 | 3.82 | 29.29 | 27.49 | 26.69 |
| | 30,000 | 0.36 | 7.59 | 58.05 | 54.63 | 53.11 |
| 30.5 | 5,000 | 0.10 | 9.64 | 91.26 | 139.05 | 37.49 |
| | 15,000 | 0.29 | 29.02 | 269.15 | 420.99 | 111.09 |
| | 30,000 | 0.57 | 57.06 | 509.04 | 738.96 | 218.96 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 1.23 | 2.3 | 2.2 |
| | 15,000 | Not Present | Not Present | 4.95 | 5.40 | 5.51 |
| | 30,000 | Not Present | Not Present | 9.87 | 10.75 | 10.98 |
| 5.5 | 5,000 | Not Present | 0.11 | 1.62 | 4.28 | 5.88 |
| | 15,000 | Not Present | 0.36 | 5.81 | 8.11 | 10.43 |
| | 30,000 | Not Present | 0.73 | 11.58 | 16.17 | 20.79 |
| 10.5 | 5,000 | 0.01 | 0.53 | 3.58 | 7.23 | 9.45 |
| | 15,000 | 0.02 | 1.60 | 11.08 | 17.44 | 22.66 |
| | 30,000 | 0.05 | 3.18 | 22.05 | 34.73 | 45.16 |
| 15.5 | 5,000 | 0.12 | 2.19 | 13.88 | 13.27 | 13.35 |
| | 15,000 | 0.35 | 6.50 | 40.30 | 36.02 | 35.35 |
| | 30,000 | 0.70 | 12.93 | 80.04 | 71.66 | 70.43 |
| 30.5 | 5,000 | 0.18 | 13.32 | 100.26 | 147.72 | 45.21 |
| | 15,000 | 0.52 | 39.95 | 295.56 | 446.38 | 133.45 |
| | 30,000 | 1.05 | 78.89 | 561.82 | 789.71 | 263.67 |

**Table 6-12. Simulated drawdown in feet at monitoring locations after pumping Well Field #1 in PPA #1 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.4 | 0.4 | 0.5 |
| | 15,000 | Not Present | Not Present | 1.2 | 1.3 | 1.4 |
| | 30,000 | Not Present | Not Present | 2.4 | 2.6 | 2.7 |
| 5.5 | 5,000 | Not Present | 0.3 | 0.5 | 0.9 | 1.2 |
| | 15,000 | Not Present | 1.0 | 1.5 | 2.8 | 3.6 |
| | 30,000 | Not Present | 1.9 | 2.9 | 5.6 | 7.1 |
| 10.5 | 5,000 | 1.9 | 1.6 | 2.0 | 2.9 | 3.6 |
| | 15,000 | 5.6 | 4.6 | 6.0 | 8.8 | 10.7 |
| | 30,000 | 11.1 | 9.2 | 12.0 | 17.5 | 21.4 |
| 15.5 | 5,000 | 5.2 | 5.1 | 5.4 | 6.3 | 6.6 |
| | 15,000 | 15.6 | 15.4 | 16.3 | 18.9 | 19.7 |
| | 30,000 | 30.9 | 30.5 | 32.3 | 37.6 | 39.2 |
| 30.5 | 5,000 | 8.0 | 9.1 | 13.1 | 14.1 | 16.6 |
| | 15,000 | 24.2 | 27.9 | 41.1 | 44.2 | 51.0 |
| | 30,000 | 48.1 | 55.3 | 81.1 | 87.0 | 100.5 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.8 | 0.8 | 0.9 |
| | 15,000 | Not Present | Not Present | 2.4 | 2.5 | 2.6 |
| | 30,000 | Not Present | Not Present | 4.7 | 5.0 | 5.1 |
| 5.5 | 5,000 | Not Present | 0.6 | 0.9 | 1.4 | 1.7 |
| | 15,000 | Not Present | 1.9 | 2.5 | 4.1 | 5.0 |
| | 30,000 | Not Present | 3.9 | 5.1 | 8.3 | 10.1 |
| 10.5 | 5,000 | 2.8 | 2.1 | 2.6 | 3.6 | 4.3 |
| | 15,000 | 8.4 | 6.2 | 7.8 | 10.8 | 12.9 |
| | 30,000 | 16.8 | 12.4 | 15.5 | 21.6 | 25.8 |
| 15.5 | 5,000 | 6.2 | 6.1 | 6.4 | 7.3 | 7.5 |
| | 15,000 | 18.5 | 18.2 | 19.2 | 21.8 | 22.5 |
| | 30,000 | 36.8 | 36.3 | 38.1 | 43.4 | 44.9 |
| 30.5 | 5,000 | 9.3 | 10.5 | 14.5 | 15.4 | 18.0 |
| | 15,000 | 28.1 | 31.9 | 45.3 | 48.3 | 55.3 |
| | 30,000 | 55.9 | 63.3 | 89.4 | 95.4 | 109.0 |

**Table 6-13. Simulated drawdown in feet at monitoring locations after pumping Well Field #2 in PPA #1 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.2 | 0.2 | 0.3 |
| | 15,000 | Not Present | Not Present | 0.6 | 0.7 | 0.8 |
| | 30,000 | Not Present | Not Present | 1.3 | 1.5 | 1.5 |
| 5.5 | 5,000 | Not Present | 0.2 | 0.3 | 0.6 | 0.7 |
| | 15,000 | Not Present | 0.5 | 0.9 | 1.7 | 2.1 |
| | 30,000 | Not Present | 1.1 | 1.7 | 3.3 | 4.2 |
| 10.5 | 5,000 | 1.4 | 1.0 | 1.3 | 1.8 | 2.1 |
| | 15,000 | 4.1 | 3.1 | 3.8 | 5.3 | 6.4 |
| | 30,000 | 8.2 | 6.1 | 7.6 | 10.6 | 12.7 |
| 15.5 | 5,000 | 3.9 | 3.5 | 3.5 | 3.7 | 3.7 |
| | 15,000 | 11.8 | 10.5 | 10.6 | 10.9 | 11.1 |
| | 30,000 | 23.5 | 20.9 | 21.0 | 21.8 | 22.1 |
| 30.5 | 5,000 | 13.5 | 20.4 | 51.2 | 65.9 | 43.8 |
| | 15,000 | 40.4 | 60.4 | 151.9 | 213.4 | 122.2 |
| | 30,000 | 79.0 | 113.3 | 256.3 | 337.7 | 222.0 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.5 | 0.5 | 0.5 |
| | 15,000 | Not Present | Not Present | 1.5 | 1.6 | 1.6 |
| | 30,000 | Not Present | Not Present | 3.0 | 3.2 | 3.3 |
| 5.5 | 5,000 | Not Present | 0.4 | 0.6 | 0.9 | 1.1 |
| | 15,000 | Not Present | 1.3 | 1.7 | 2.8 | 3.3 |
| | 30,000 | Not Present | 2.5 | 3.4 | 5.5 | 6.7 |
| 10.5 | 5,000 | 2.2 | 1.5 | 1.8 | 2.4 | 2.9 |
| | 15,000 | 6.7 | 4.5 | 5.5 | 7.3 | 8.5 |
| | 30,000 | 13.4 | 9.0 | 10.9 | 14.5 | 17.0 |
| 15.5 | 5,000 | 4.9 | 4.5 | 4.5 | 4.6 | 4.7 |
| | 15,000 | 14.8 | 13.4 | 13.5 | 13.9 | 14.0 |
| | 30,000 | 29.4 | 26.8 | 26.9 | 27.7 | 27.9 |
| 30.5 | 5,000 | 14.9 | 21.9 | 52.8 | 67.5 | 45.4 |
| | 15,000 | 44.8 | 64.9 | 156.6 | 218.1 | 127.0 |
| | 30,000 | 87.8 | 122.3 | 265.8 | 347.2 | 231.6 |

### *6.6.3 Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #1*

Table 6-2 describes the changes in the model input parameters associated with set of sixteen sensitivity runs performed for the groundwater models simulations involving GAM-based and the GHSM-based aquifer properties. In this section, Model Run 0 refers to the baseline run of 15,000 AFY for which simulated drawdowns are shown in Figures 6-27 to 6-34. **Tables 6-14** and **6-15** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-9** as determined by the groundwater model with GAM-based aquifer properties. **Tables 6-16** and **6-17** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-9** as determined by the groundwater model with GHSM-based aquifer properties.

- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 1 and 11.0 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is between 0.5 and 29 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 0.2 and 9 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown between less than 0.1 and 17 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is less than 0.5 feet and 7 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is less than 0.5 feet and 10 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is less than 0.5 feet and 4.0 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown less than 0.5 feet and 6 feet.

**Table 6-14. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #1 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 5.7 | 6.3 | 6.4 | | | 8.4 | 9.1 | 9.2 |
| | Run 1 | | | 8.4 | 9.2 | 9.4 | | | 11.4 | 12.3 | 12.5 |
| | Run 2 | | | 2.8 | 3.2 | 3.3 | | | 5.1 | 5.6 | 5.7 |
| | Run 3 | | | 5.3 | 6.6 | 7.0 | | | 8.0 | 9.7 | 10.1 |
| | Run 4 | | | 5.9 | 6.1 | 6.2 | | | 8.3 | 8.6 | 8.6 |
| | Run 5 | | | 3.9 | 4.3 | 4.4 | | | 6.5 | 7.1 | 7.2 |
| | Run 6 | | | 6.8 | 7.4 | 7.5 | | | 9.4 | 10.1 | 10.3 |
| | Run 7 | | | 5.7 | 6.3 | 6.4 | | | 9.5 | 10.1 | 10.3 |
| | Run 8 | | | 5.7 | 6.2 | 6.4 | | | 8.3 | 9.0 | 9.2 |
| | Run 9 | | | 4.5 | 4.6 | 4.7 | | | 6.4 | 6.6 | 6.7 |
| | Run 10 | | | 4.1 | 4.9 | 5.1 | | | 6.2 | 7.2 | 7.4 |
| | Run 11 | | | 9.1 | 9.4 | 9.4 | | | 12.4 | 12.7 | 12.7 |
| | Run 12 | | | 9.3 | 10.9 | 11.3 | | | 12.2 | 14.1 | 14.5 |
| | Run 13 | | | 1.2 | 1.3 | 1.3 | | | 2.9 | 3.0 | 3.0 |
| | Run 14 | | | 0.7 | 1.0 | 1.1 | | | 2.1 | 2.8 | 3.0 |
| | Run 15 | | | 6.8 | 6.9 | 7.0 | | | 8.9 | 9.2 | 9.2 |
| | Run 16 | | | 6.6 | 8.3 | 8.8 | | | 9.5 | 11.5 | 12.1 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.2 | 7.1 | 10.7 | 12.7 | | 0.5 | 9.8 | 13.9 | 16.4 |
| | Run 1 | | 0.5 | 10.3 | 14.8 | 17.9 | | 0.9 | 13.2 | 18.3 | 21.9 |
| | Run 2 | | 0.1 | 3.3 | 6.0 | 7.2 | | 0.2 | 5.9 | 9.1 | 10.7 |
| | Run 3 | | 0.1 | 6.4 | 13.0 | 12.0 | | 0.2 | 9.4 | 16.6 | 16.1 |
| | Run 4 | | 0.6 | 7.1 | 10.1 | 12.8 | | 1.1 | 9.5 | 13.0 | 15.9 |
| | Run 5 | | 0.2 | 6.7 | 12.6 | 18.3 | | 0.5 | 10.4 | 17.7 | 24.7 |
| | Run 6 | | 0.3 | 7.3 | 9.8 | 9.7 | | 0.5 | 9.9 | 12.7 | 12.7 |
| | Run 7 | | 0.2 | 7.1 | 10.7 | 12.7 | | 0.5 | 10.9 | 14.9 | 17.3 |
| | Run 8 | | 0.2 | 7.0 | 10.6 | 12.7 | | 0.4 | 9.8 | 13.9 | 16.4 |
| | Run 9 | | 0.3 | 4.7 | 5.9 | 6.5 | | 0.5 | 6.7 | 8.0 | 8.7 |
| | Run 10 | | 0.0 | 4.2 | 8.1 | 5.8 | | 0.1 | 6.4 | 10.6 | 8.3 |
| | Run 11 | | 0.8 | 9.5 | 11.3 | 12.5 | | 1.2 | 12.6 | 14.6 | 15.8 |
| | Run 12 | | 0.2 | 9.9 | 15.1 | 13.5 | | 0.4 | 12.8 | 18.3 | 16.9 |
| | Run 13 | | 0.1 | 2.2 | 4.3 | 6.4 | | 0.4 | 4.9 | 8.6 | 11.8 |
| | Run 14 | | 0.0 | 0.8 | 3.5 | 5.0 | | 0.0 | 2.7 | 8.1 | 10.6 |
| | Run 15 | | 1.2 | 12.2 | 19.6 | 25.5 | | 1.9 | 14.5 | 22.8 | 29.4 |
| | Run 16 | | 0.2 | 11.5 | 22.3 | 29.0 | | 0.3 | 14.9 | 27.0 | 35.1 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 1.0 | 15.2 | 27.1 | 28.9 | 0.0 | 1.7 | 19.4 | 32.1 | 34.9 |
| | Run 1 | 0.0 | 2.3 | 21.2 | 35.2 | 39.5 | 0.1 | 3.0 | 25.1 | 40.2 | 45.5 |
| | Run 2 | 0.0 | 0.2 | 6.7 | 17.1 | 17.5 | 0.0 | 0.5 | 11.6 | 22.9 | 23.8 |
| | Run 3 | 0.0 | 0.3 | 12.9 | 36.4 | 24.4 | 0.0 | 0.7 | 17.9 | 41.9 | 30.7 |
| | Run 4 | 0.0 | 2.1 | 15.3 | 24.6 | 30.7 | 0.1 | 2.9 | 18.7 | 29.0 | 35.9 |
| | Run 5 | 0.0 | 2.0 | 21.1 | 42.8 | 56.7 | 0.0 | 3.5 | 31.2 | 56.1 | 72.5 |
| | Run 6 | 0.0 | 0.6 | 10.5 | 18.6 | 15.0 | 0.0 | 0.9 | 13.5 | 22.0 | 18.8 |
| | Run 7 | 0.0 | 1.0 | 15.2 | 27.1 | 29.0 | 0.0 | 1.7 | 20.3 | 32.9 | 35.5 |
| | Run 8 | 0.0 | 1.0 | 15.1 | 27.1 | 28.9 | 0.0 | 1.6 | 19.3 | 32.1 | 34.9 |
| | Run 9 | 0.0 | 0.5 | 7.2 | 11.0 | 11.4 | 0.1 | 0.8 | 9.6 | 13.7 | 14.3 |
| | Run 10 | 0.0 | 0.1 | 5.3 | 19.0 | 7.6 | 0.0 | 0.1 | 8.1 | 22.1 | 10.7 |
| | Run 11 | 0.2 | 1.6 | 13.4 | 18.6 | 20.4 | 0.5 | 2.1 | 16.6 | 21.9 | 23.7 |
| | Run 12 | 0.0 | 0.5 | 13.6 | 28.9 | 18.7 | 0.0 | 0.7 | 16.7 | 32.4 | 22.4 |
| | Run 13 | 0.0 | 0.8 | 6.3 | 16.1 | 23.7 | 0.0 | 2.2 | 14.7 | 29.5 | 39.5 |
| | Run 14 | 0.0 | 0.0 | 1.8 | 14.9 | 16.1 | 0.0 | 0.2 | 6.6 | 30.5 | 31.2 |
| | Run 15 | 0.0 | 8.2 | 38.2 | 64.2 | 80.4 | 0.1 | 9.6 | 42.9 | 71.3 | 88.9 |
| | Run 16 | 0.0 | 2.6 | 37.0 | 73.3 | 80.0 | 0.0 | 4.0 | 44.7 | 83.2 | 93.1 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.1 | 4.2 | 62.8 | 66.4 | 48.2 | 0.3 | 6.5 | 74.1 | 74.6 | 56.3 |
| | Run 1 | 0.5 | 9.1 | 82.7 | 81.4 | 63.5 | 0.7 | 11.5 | 91.0 | 88.9 | 71.4 |
| | Run 2 | 0.0 | 1.1 | 30.6 | 47.0 | 31.1 | 0.1 | 2.2 | 47.4 | 57.6 | 40.1 |
| | Run 3 | 0.0 | 1.5 | 50.8 | 93.8 | 38.5 | 0.0 | 2.8 | 65.7 | 102.8 | 46.9 |
| | Run 4 | 0.7 | 8.5 | 61.5 | 56.1 | 53.2 | 1.2 | 11.0 | 69.3 | 63.0 | 60.3 |
| | Run 5 | 0.4 | 10.5 | 110.8 | 114.0 | 108.3 | 0.9 | 17.1 | 150.8 | 141.2 | 133.5 |
| | Run 6 | 0.1 | 1.7 | 28.4 | 39.6 | 21.0 | 0.1 | 2.6 | 33.4 | 44.0 | 25.4 |
| | Run 7 | 0.1 | 4.2 | 62.8 | 66.4 | 48.2 | 0.3 | 6.5 | 74.5 | 75.0 | 56.7 |
| | Run 8 | 0.1 | 4.2 | 62.8 | 66.3 | 48.2 | 0.3 | 6.4 | 74.1 | 74.5 | 56.3 |
| | Run 9 | 0.1 | 1.5 | 22.1 | 23.6 | 17.5 | 0.2 | 2.4 | 26.7 | 27.2 | 21.0 |
| | Run 10 | 0.0 | 0.2 | 12.1 | 45.4 | 10.1 | 0.0 | 0.4 | 18.3 | 49.8 | 13.7 |
| | Run 11 | 0.6 | 5.0 | 35.7 | 35.1 | 29.2 | 0.8 | 5.8 | 39.0 | 38.4 | 32.5 |
| | Run 12 | 0.0 | 1.5 | 33.2 | 60.5 | 24.0 | 0.0 | 2.0 | 37.6 | 64.5 | 28.0 |
| | Run 13 | 0.4 | 6.1 | 35.5 | 48.5 | 54.5 | 1.0 | 12.9 | 70.5 | 79.6 | 83.2 |
| | Run 14 | 0.0 | 0.4 | 15.4 | 58.3 | 34.6 | 0.0 | 1.1 | 41.8 | 98.7 | 60.8 |
| | Run 15 | 5.6 | 37.0 | 157.6 | 152.7 | 152.8 | 7.4 | 42.0 | 171.1 | 165.8 | 166.1 |
| | Run 16 | 0.3 | 12.3 | 184.0 | 192.9 | 139.0 | 0.6 | 18.6 | 212.3 | 211.7 | 158.4 |
| Monitoring Location at 30.5 miles | Run 0 | 0.2 | 16.6 | 147.5 | 217.9 | 87.4 | 0.4 | 25.3 | 170.4 | 239.6 | 106.5 |
| | Run 1 | 0.7 | 35.9 | 194.7 | 263.4 | 127.7 | 1.0 | 44.8 | 214.7 | 283.1 | 145.8 |
| | Run 2 | 0.0 | 4.3 | 95.9 | 171.3 | 50.1 | 0.1 | 8.9 | 121.0 | 194.0 | 67.4 |
| | Run 3 | 0.0 | 7.3 | 147.1 | 268.7 | 67.4 | 0.1 | 12.2 | 174.0 | 293.4 | 87.2 |
| | Run 4 | 1.0 | 27.8 | 137.4 | 165.1 | 102.4 | 1.7 | 37.7 | 156.1 | 183.2 | 119.5 |
| | Run 5 | 0.6 | 28.0 | 284.7 | 376.9 | 202.4 | 1.4 | 51.4 | 348.6 | 435.0 | 252.4 |
| | Run 6 | 0.1 | 6.5 | 68.6 | 107.8 | 37.9 | 0.1 | 9.1 | 77.8 | 116.9 | 45.8 |
| | Run 7 | 0.2 | 16.6 | 147.5 | 217.9 | 87.4 | 0.4 | 25.3 | 170.4 | 239.6 | 106.5 |
| | Run 8 | 0.2 | 16.6 | 147.5 | 217.9 | 87.4 | 0.4 | 25.3 | 170.3 | 239.6 | 106.4 |
| | Run 9 | 0.1 | 5.6 | 49.4 | 72.9 | 29.5 | 0.2 | 8.6 | 57.3 | 80.5 | 36.3 |
| | Run 10 | 0.0 | 0.8 | 45.3 | 105.3 | 15.5 | 0.0 | 1.5 | 56.0 | 115.1 | 22.3 |
| | Run 11 | 0.7 | 18.3 | 78.8 | 101.6 | 55.5 | 1.0 | 20.5 | 83.1 | 105.8 | 59.7 |
| | Run 12 | 0.0 | 5.4 | 88.9 | 145.4 | 44.9 | 0.0 | 6.8 | 95.9 | 152.2 | 50.6 |
| | Run 13 | 0.5 | 9.4 | 133.0 | 164.6 | 127.4 | 1.4 | 23.2 | 189.6 | 217.8 | 174.4 |
| | Run 14 | 0.0 | 1.3 | 121.7 | 331.3 | 55.9 | 0.0 | 4.4 | 199.1 | 427.2 | 95.7 |
| | Run 15 | 8.8 | 102.5 | 350.7 | 373.8 | 320.7 | 11.9 | 124.4 | 391.9 | 414.5 | 360.5 |
| | Run 16 | 0.5 | 50.1 | 443.2 | 654.5 | 261.7 | 0.9 | 75.6 | 507.3 | 713.7 | 315.2 |

**Table 6-15. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #1 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 2.8 | 3.2 | 3.2 | | | 5.0 | 5.4 | 5.5 |
| | Run 1 | | | 5.5 | 6.1 | 6.2 | | | 8.4 | 9.1 | 9.2 |
| | Run 2 | | | 0.9 | 1.0 | 1.0 | | | 2.1 | 2.3 | 2.3 |
| | Run 3 | | | 2.5 | 3.2 | 3.4 | | | 4.6 | 5.7 | 6.0 |
| | Run 4 | | | 2.9 | 3.0 | 3.1 | | | 4.8 | 5.0 | 5.0 |
| | Run 5 | | | 1.3 | 1.4 | 1.5 | | | 2.7 | 2.9 | 3.0 |
| | Run 6 | | | 4.6 | 5.0 | 5.2 | | | 7.2 | 7.8 | 7.9 |
| | Run 7 | | | 2.8 | 3.2 | 3.2 | | | 5.0 | 5.4 | 5.5 |
| | Run 8 | | | 2.8 | 3.1 | 3.2 | | | 4.9 | 5.4 | 5.5 |
| | Run 9 | | | 2.3 | 2.4 | 2.4 | | | 3.9 | 4.1 | 4.1 |
| | Run 10 | | | 1.8 | 2.3 | 2.4 | | | 3.5 | 4.1 | 4.3 |
| | Run 11 | | | 7.1 | 7.3 | 7.4 | | | 9.6 | 9.8 | 9.9 |
| | Run 12 | | | 7.4 | 8.7 | 9.1 | | | 10.4 | 11.9 | 12.4 |
| | Run 13 | | | 0.2 | 0.2 | 0.2 | | | 0.6 | 0.7 | 0.7 |
| | Run 14 | | | 0.1 | 0.1 | 0.2 | | | 0.4 | 0.6 | 0.6 |
| | Run 15 | | | 3.2 | 3.3 | 3.3 | | | 4.9 | 5.0 | 5.0 |
| | Run 16 | | | 3.3 | 4.3 | 4.5 | | | 5.6 | 6.9 | 7.3 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.1 | 3.5 | 5.3 | 7.0 | | 0.4 | 5.8 | 8.1 | 10.4 |
| | Run 1 | | 0.4 | 6.8 | 9.7 | 12.7 | | 0.8 | 9.7 | 13.2 | 16.8 |
| | Run 2 | | 0.0 | 1.0 | 1.8 | 2.6 | | 0.1 | 2.3 | 3.6 | 4.8 |
| | Run 3 | | 0.0 | 3.2 | 5.7 | 6.8 | | 0.1 | 5.7 | 8.8 | 10.6 |
| | Run 4 | | 0.3 | 3.6 | 5.2 | 6.7 | | 0.6 | 5.5 | 7.6 | 9.7 |
| | Run 5 | | 0.0 | 2.1 | 4.2 | 6.6 | | 0.2 | 4.2 | 7.5 | 11.0 |
| | Run 6 | | 0.2 | 5.0 | 6.3 | 7.0 | | 0.5 | 7.7 | 9.2 | 10.2 |
| | Run 7 | | 0.1 | 3.5 | 5.3 | 7.0 | | 0.4 | 5.8 | 8.1 | 10.4 |
| | Run 8 | | 0.1 | 3.5 | 5.2 | 7.0 | | 0.3 | 5.8 | 8.1 | 10.4 |
| | Run 9 | | 0.1 | 2.4 | 3.0 | 3.5 | | 0.3 | 4.1 | 4.8 | 5.5 |
| | Run 10 | | 0.0 | 2.0 | 3.4 | 3.0 | | 0.1 | 3.8 | 5.5 | 5.3 |
| | Run 11 | | 0.7 | 7.4 | 8.8 | 10.0 | | 1.1 | 9.8 | 11.3 | 12.6 |
| | Run 12 | | 0.2 | 8.1 | 10.9 | 11.5 | | 0.4 | 11.1 | 14.2 | 15.0 |
| | Run 13 | | 0.0 | 0.3 | 0.7 | 1.1 | | 0.1 | 1.1 | 2.0 | 2.9 |
| | Run 14 | | 0.0 | 0.1 | 0.3 | 0.8 | | 0.0 | 0.5 | 1.5 | 2.7 |
| | Run 15 | | 0.5 | 6.0 | 9.8 | 12.9 | | 1.0 | 8.2 | 12.9 | 16.8 |
| | Run 16 | | 0.1 | 5.7 | 11.0 | 16.6 | | 0.2 | 8.8 | 15.7 | 23.1 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 0.9 | 7.3 | 12.5 | 16.5 | 0.0 | 1.6 | 11.1 | 17.4 | 22.7 |
| | Run 1 | 0.0 | 2.3 | 13.7 | 21.6 | 28.5 | 0.1 | 3.2 | 17.7 | 26.9 | 35.2 |
| | Run 2 | 0.0 | 0.1 | 1.7 | 4.7 | 6.6 | 0.0 | 0.4 | 4.3 | 8.4 | 11.2 |
| | Run 3 | 0.0 | 0.4 | 6.9 | 14.2 | 14.9 | 0.0 | 0.8 | 11.3 | 19.5 | 21.4 |
| | Run 4 | 0.0 | 1.4 | 7.4 | 12.4 | 16.5 | 0.1 | 2.2 | 10.5 | 16.7 | 21.8 |
| | Run 5 | 0.0 | 0.7 | 6.0 | 14.0 | 20.8 | 0.0 | 1.9 | 11.9 | 23.2 | 32.5 |
| | Run 6 | 0.0 | 0.6 | 7.4 | 10.4 | 11.5 | 0.1 | 1.0 | 10.5 | 14.0 | 15.5 |
| | Run 7 | 0.0 | 0.9 | 7.3 | 12.5 | 16.5 | 0.1 | 1.6 | 11.1 | 17.4 | 22.7 |
| | Run 8 | 0.0 | 0.8 | 7.3 | 12.5 | 16.5 | 0.0 | 1.5 | 11.0 | 17.4 | 22.6 |
| | Run 9 | 0.0 | 0.4 | 3.5 | 5.2 | 6.4 | 0.1 | 0.7 | 5.6 | 7.7 | 9.2 |
| | Run 10 | 0.0 | 0.1 | 2.9 | 7.0 | 4.6 | 0.0 | 0.1 | 5.4 | 9.9 | 7.6 |
| | Run 11 | 0.3 | 1.7 | 10.2 | 13.6 | 16.5 | 0.5 | 2.2 | 12.7 | 16.2 | 19.3 |
| | Run 12 | 0.0 | 0.6 | 11.9 | 17.9 | 17.0 | 0.0 | 0.9 | 15.1 | 21.5 | 20.9 |
| | Run 13 | 0.0 | 0.1 | 0.8 | 2.5 | 4.1 | 0.0 | 0.4 | 3.1 | 6.9 | 9.9 |
| | Run 14 | 0.0 | 0.0 | 0.1 | 1.2 | 2.8 | 0.0 | 0.0 | 0.9 | 5.0 | 8.3 |
| | Run 15 | 0.0 | 4.6 | 18.5 | 31.8 | 40.6 | 0.1 | 6.2 | 23.6 | 39.8 | 50.5 |
| | Run 16 | 0.0 | 2.3 | 17.9 | 34.0 | 46.5 | 0.0 | 4.1 | 25.6 | 45.2 | 61.9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.2 | 3.8 | 29.3 | 27.5 | 26.7 | 0.4 | 6.5 | 40.3 | 36.0 | 35.4 |
| | Run 1 | 0.6 | 9.7 | 50.7 | 44.5 | 44.4 | 0.9 | 12.6 | 60.1 | 53.0 | 53.3 |
| | Run 2 | 0.0 | 0.5 | 7.7 | 11.8 | 11.6 | 0.1 | 1.6 | 17.0 | 19.1 | 18.5 |
| | Run 3 | 0.0 | 1.7 | 28.9 | 32.4 | 23.2 | 0.1 | 3.3 | 43.2 | 41.7 | 32.3 |
| | Run 4 | 0.8 | 6.0 | 27.3 | 26.3 | 27.5 | 1.4 | 8.8 | 35.5 | 33.7 | 35.2 |
| | Run 5 | 0.4 | 4.1 | 29.2 | 34.9 | 38.4 | 0.9 | 9.5 | 53.2 | 54.4 | 57.7 |
| | Run 6 | 0.1 | 2.0 | 20.7 | 19.1 | 15.9 | 0.1 | 3.0 | 26.1 | 23.8 | 20.7 |
| | Run 7 | 0.2 | 3.8 | 29.3 | 27.5 | 26.7 | 0.4 | 6.5 | 40.3 | 36.0 | 35.4 |
| | Run 8 | 0.2 | 3.8 | 29.3 | 27.5 | 26.7 | 0.4 | 6.4 | 40.3 | 36.0 | 35.3 |
| | Run 9 | 0.1 | 1.3 | 10.3 | 9.9 | 9.6 | 0.2 | 2.3 | 14.7 | 13.5 | 13.2 |
| | Run 10 | 0.0 | 0.2 | 8.7 | 15.0 | 6.4 | 0.0 | 0.4 | 14.9 | 19.3 | 10.0 |
| | Run 11 | 0.7 | 5.5 | 25.1 | 22.8 | 22.9 | 1.0 | 6.3 | 28.1 | 25.7 | 25.9 |
| | Run 12 | 0.0 | 1.9 | 32.2 | 31.9 | 22.1 | 0.0 | 2.5 | 36.8 | 36.1 | 26.4 |
| | Run 13 | 0.3 | 0.8 | 4.2 | 7.3 | 9.3 | 0.8 | 2.8 | 13.6 | 18.0 | 20.5 |
| | Run 14 | 0.0 | 0.0 | 0.9 | 4.7 | 6.0 | 0.0 | 0.3 | 5.3 | 15.1 | 15.9 |
| | Run 15 | 5.5 | 21.1 | 71.1 | 71.3 | 73.5 | 7.8 | 27.2 | 87.2 | 86.9 | 89.5 |
| | Run 16 | 0.4 | 11.4 | 86.5 | 80.4 | 78.1 | 0.7 | 19.1 | 117.1 | 103.2 | 101.5 |
| Monitoring Location at 30.5 miles | Run 0 | 0.3 | 29.0 | 269.1 | 421.0 | 111.1 | 0.5 | 40.0 | 295.6 | 446.4 | 133.4 |
| | Run 1 | 0.9 | 53.1 | 325.0 | 475.2 | 159.2 | 1.3 | 64.0 | 348.8 | 498.8 | 180.8 |
| | Run 2 | 0.1 | 11.7 | 215.5 | 371.0 | 69.7 | 0.1 | 18.7 | 240.5 | 394.1 | 88.1 |
| | Run 3 | 0.0 | 12.6 | 262.6 | 479.1 | 83.6 | 0.1 | 18.9 | 293.4 | 507.9 | 106.6 |
| | Run 4 | 1.3 | 48.0 | 261.7 | 360.2 | 137.8 | 2.1 | 60.1 | 284.1 | 382.0 | 158.4 |
| | Run 5 | 1.0 | 72.6 | 652.5 | 956.0 | 296.5 | 1.8 | 104.8 | 717.0 | 1016.7 | 350.7 |
| | Run 6 | 0.1 | 9.4 | 109.9 | 180.8 | 45.4 | 0.2 | 12.4 | 120.6 | 191.2 | 54.5 |
| | Run 7 | 0.3 | 29.0 | 269.1 | 421.0 | 111.1 | 0.5 | 40.0 | 295.6 | 446.4 | 133.4 |
| | Run 8 | 0.3 | 29.0 | 269.1 | 421.0 | 111.1 | 0.5 | 39.9 | 295.5 | 446.4 | 133.4 |
| | Run 9 | 0.1 | 9.7 | 89.8 | 140.4 | 37.2 | 0.2 | 13.4 | 98.8 | 149.1 | 44.9 |
| | Run 10 | 0.0 | 1.4 | 77.7 | 180.0 | 18.7 | 0.0 | 2.3 | 90.0 | 191.1 | 26.3 |
| | Run 11 | 0.9 | 25.1 | 124.2 | 174.2 | 67.8 | 1.2 | 27.6 | 128.7 | 178.7 | 72.1 |
| | Run 12 | 0.0 | 7.1 | 128.6 | 226.8 | 52.7 | 0.1 | 8.7 | 136.4 | 234.3 | 59.0 |
| | Run 13 | 1.1 | 46.7 | 506.3 | 682.7 | 270.5 | 2.2 | 74.1 | 564.1 | 736.3 | 319.0 |
| | Run 14 | 0.0 | 9.1 | 480.6 | 962.2 | 111.4 | 0.1 | 18.3 | 564.5 | 1041.6 | 154.2 |
| | Run 15 | 10.5 | 173.0 | 740.8 | 908.0 | 482.7 | 14.4 | 200.7 | 793.7 | 960.3 | 534.0 |
| | Run 16 | 0.7 | 87.9 | 815.3 | 1275.3 | 336.0 | 1.2 | 120.7 | 894.4 | 1351.3 | 402.6 |

**Table 6-16. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #1 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location at 2.5 miles | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | | | 1.2 | 1.3 | 1.4 | | | 2.4 | 2.5 | 2.6 |
| Run 1 | | | 2.2 | 2.4 | 2.4 | | | 3.6 | 3.8 | 3.8 |
| Run 2 | | | 0.3 | 0.3 | 0.3 | | | 0.8 | 0.9 | 0.9 |
| Run 3 | | | 2.0 | 2.6 | 2.8 | | | 3.9 | 4.6 | 4.9 |
| Run 4 | | | 0.8 | 0.9 | 0.9 | | | 1.7 | 1.8 | 1.8 |
| Run 5 | | | 0.2 | 0.2 | 0.2 | | | 0.4 | 0.5 | 0.5 |
| Run 6 | | | 2.7 | 2.9 | 3.0 | | | 4.2 | 4.5 | 4.6 |
| Run 7 | | | 1.2 | 1.4 | 1.4 | | | 2.5 | 2.7 | 2.7 |
| Run 8 | | | 0.8 | 1.0 | 1.0 | | | 1.4 | 1.6 | 1.7 |
| Run 9 | | | 0.8 | 0.9 | 0.9 | | | 1.7 | 1.8 | 1.8 |
| Run 10 | | | 1.7 | 2.3 | 2.6 | | | 3.6 | 4.3 | 4.6 |
| Run 11 | | | 2.7 | 2.7 | 2.8 | | | 3.9 | 4.0 | 4.0 |
| Run 12 | | | 5.9 | 6.8 | 7.2 | | | 8.4 | 9.4 | 9.7 |
| Run 13 | | | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 |
| Run 14 | | | 0.0 | 0.0 | 0.0 | | | 0.1 | 0.2 | 0.2 |
| Run 15 | | | 0.3 | 0.3 | 0.3 | | | 0.5 | 0.5 | 0.5 |
| Run 16 | | | 1.0 | 1.4 | 1.5 | | | 1.4 | 2.0 | 2.1 |

| Monitoring Location at 5.5 miles | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | | 1.0 | 1.5 | 2.8 | 3.6 | | 1.9 | 2.5 | 4.1 | 5.0 |
| Run 1 | | 1.8 | 2.5 | 4.3 | 5.2 | | 2.8 | 3.6 | 5.6 | 6.6 |
| Run 2 | | 0.2 | 0.4 | 0.9 | 1.4 | | 0.7 | 1.0 | 1.9 | 2.5 |
| Run 3 | | 0.8 | 2.4 | 5.2 | 7.1 | | 1.9 | 3.9 | 7.5 | 9.5 |
| Run 4 | | 1.1 | 1.2 | 1.8 | 2.2 | | 2.0 | 2.2 | 2.8 | 3.2 |
| Run 5 | | 0.2 | 0.5 | 1.3 | 1.9 | | 0.7 | 1.0 | 2.3 | 3.1 |
| Run 6 | | 1.8 | 2.6 | 3.9 | 4.6 | | 2.9 | 3.9 | 5.4 | 6.1 |
| Run 7 | | 1.1 | 1.6 | 2.9 | 3.6 | | 2.5 | 3.0 | 4.5 | 5.3 |
| Run 8 | | 0.8 | 1.3 | 2.6 | 3.3 | | 1.4 | 2.0 | 3.5 | 4.4 |
| Run 9 | | 0.9 | 1.0 | 1.4 | 1.6 | | 1.7 | 1.9 | 2.3 | 2.6 |
| Run 10 | | 0.6 | 1.8 | 3.6 | 4.7 | | 1.4 | 3.4 | 5.7 | 6.9 |
| Run 11 | | 2.5 | 2.8 | 3.5 | 3.8 | | 3.5 | 3.8 | 4.6 | 5.0 |
| Run 12 | | 2.3 | 5.6 | 8.7 | 9.9 | | 3.4 | 7.5 | 11.0 | 12.2 |
| Run 13 | | 0.0 | 0.0 | 0.1 | 0.1 | | 0.1 | 0.2 | 0.3 | 0.4 |
| Run 14 | | 0.0 | 0.0 | 0.1 | 0.4 | | 0.0 | 0.2 | 0.7 | 1.4 |
| Run 15 | | 0.8 | 0.9 | 1.5 | 2.0 | | 1.3 | 1.4 | 2.1 | 2.6 |
| Run 16 | | 0.7 | 2.1 | 6.0 | 8.2 | | 1.3 | 2.8 | 7.2 | 9.7 |

| Monitoring Location at 10.5 miles | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | 5.6 | 4.6 | 6.0 | 8.8 | 10.7 | 8.4 | 6.2 | 7.8 | 10.8 | 12.9 |
| Run 1 | 7.9 | 6.7 | 8.3 | 11.5 | 13.7 | ## | 7.7 | 9.5 | 12.9 | 15.2 |
| Run 2 | 2.6 | 1.4 | 2.2 | 4.1 | 5.6 | 5.0 | 3.0 | 4.2 | 6.5 | 8.3 |
| Run 3 | 4.4 | 4.2 | 7.9 | 14.3 | 18.4 | 7.2 | 5.8 | 10.1 | 17.4 | 21.6 |
| Run 4 | 5.9 | 5.0 | 5.4 | 6.7 | 7.8 | 8.5 | 6.6 | 7.0 | 8.4 | 9.6 |
| Run 5 | 2.8 | 4.2 | 5.5 | 8.5 | 10.9 | 5.9 | 7.6 | 9.1 | 12.8 | 15.7 |
| Run 6 | 5.3 | 3.5 | 5.0 | 7.4 | 8.9 | 6.8 | 4.5 | 6.2 | 8.9 | 10.4 |
| Run 7 | 6.2 | 4.9 | 6.2 | 8.9 | 10.8 | ## | 7.0 | 8.5 | 11.4 | 13.4 |
| Run 8 | 5.6 | 4.6 | 6.0 | 8.7 | 10.6 | 8.4 | 6.1 | 7.6 | 10.6 | 12.6 |
| Run 9 | 3.9 | 2.2 | 2.6 | 3.4 | 4.1 | 5.3 | 3.3 | 3.7 | 4.6 | 5.3 |
| Run 10 | 2.0 | 1.4 | 4.1 | 8.5 | 10.2 | 3.5 | 2.4 | 5.9 | 11.0 | 12.7 |
| Run 11 | 7.0 | 4.7 | 5.2 | 6.3 | 7.1 | 8.1 | 5.5 | 6.1 | 7.3 | 8.2 |
| Run 12 | 5.5 | 3.9 | 8.5 | 14.5 | 16.3 | 6.8 | 4.8 | 10.0 | 16.4 | 18.3 |
| Run 13 | 0.9 | 0.6 | 0.8 | 1.6 | 2.3 | 2.5 | 2.2 | 2.5 | 3.9 | 5.0 |
| Run 14 | 0.5 | 0.1 | 0.6 | 1.8 | 3.9 | 1.7 | 0.9 | 2.2 | 5.3 | 8.9 |
| Run 15 | 6.1 | 9.1 | 9.7 | 12.4 | 14.8 | 9.8 | ## | 11.8 | 14.5 | 17.0 |
| Run 16 | 4.8 | ## | 14.8 | 23.3 | 29.1 | 8.4 | ## | 17.4 | 26.6 | 32.7 |

| Monitoring Location at 15.5 miles | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | 15.6 | 15.4 | 16.3 | 18.9 | 19.7 | 18.5 | 18.2 | 19.2 | 21.8 | 22.5 |
| Run 1 | 19.4 | 19.4 | 20.4 | 23.1 | 23.8 | 21.3 | 21.1 | 22.1 | 24.8 | 25.5 |
| Run 2 | 9.4 | 8.1 | 9.0 | 11.4 | 12.6 | 12.9 | 12.0 | 12.9 | 15.4 | 16.4 |
| Run 3 | 12.8 | 14.8 | 19.7 | 29.7 | 31.9 | 15.9 | 18.0 | 23.1 | 33.5 | 35.7 |
| Run 4 | 16.3 | 15.2 | 15.2 | 15.3 | 15.2 | 19.0 | 17.9 | 17.9 | 17.9 | 17.7 |
| Run 5 | 28.1 | 24.9 | 25.1 | 26.1 | 26.7 | 35.1 | 33.1 | 33.4 | 34.3 | 34.4 |
| Run 6 | 8.0 | 8.1 | 9.8 | 13.1 | 13.8 | 9.4 | 9.4 | 11.1 | 14.6 | 15.3 |
| Run 7 | 16.3 | 15.6 | 16.5 | 19.1 | 19.9 | 20.4 | 19.3 | 20.1 | 22.6 | 23.3 |
| Run 8 | 15.6 | 15.3 | 16.3 | 18.9 | 19.7 | 18.4 | 18.2 | 19.1 | 21.7 | 22.4 |
| Run 9 | 6.5 | 5.9 | 6.1 | 6.9 | 7.2 | 8.0 | 7.4 | 7.7 | 8.4 | 8.6 |
| Run 10 | 3.4 | 4.5 | 9.1 | 17.1 | 16.5 | 5.0 | 6.1 | 11.3 | 19.8 | 19.1 |
| Run 11 | 10.2 | 9.7 | 9.9 | 10.7 | 10.9 | 11.2 | 10.6 | 10.9 | 11.7 | 11.9 |
| Run 12 | 7.7 | 8.9 | 14.6 | 23.8 | 23.1 | 8.9 | 10.0 | 16.0 | 25.5 | 24.9 |
| Run 13 | 14.1 | 10.0 | 9.9 | 9.7 | 10.0 | 21.1 | 17.3 | 17.2 | 16.7 | 16.6 |
| Run 14 | 9.3 | 5.4 | 7.0 | 10.7 | 14.6 | 16.4 | 12.5 | 14.8 | 20.7 | 24.8 |
| Run 15 | 39.5 | 37.5 | 37.5 | 36.5 | 35.7 | 43.6 | 41.6 | 41.5 | 40.5 | 39.5 |
| Run 16 | 38.2 | 41.0 | 44.2 | 52.7 | 55.2 | 42.8 | 46.2 | 49.4 | 58.0 | 60.4 |

| Monitoring Location at 30.5 miles | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | 24.2 | 27.9 | 41.1 | 44.2 | 51.0 | 28.1 | 31.9 | 45.3 | 48.3 | 55.3 |
| Run 1 | 30.4 | 34.2 | 47.7 | 50.8 | 57.8 | 32.7 | 36.5 | 50.1 | 53.2 | 60.2 |
| Run 2 | 14.9 | 18.1 | 30.4 | 33.2 | 39.7 | 19.7 | 23.1 | 36.0 | 38.9 | 45.7 |
| Run 3 | 19.7 | 28.8 | 61.3 | 71.2 | 71.2 | 23.9 | 33.5 | 66.5 | 76.6 | 76.8 |
| Run 4 | 26.3 | 27.4 | 31.1 | 32.0 | 35.0 | 30.0 | 31.1 | 34.8 | 35.8 | 38.8 |
| Run 5 | 51.3 | 54.1 | 64.7 | 67.2 | 75.9 | 62.8 | 65.9 | 76.9 | 79.6 | 88.5 |
| Run 6 | 10.4 | 13.6 | 24.6 | 27.9 | 28.0 | 12.0 | 15.2 | 26.3 | 29.6 | 29.7 |
| Run 7 | 24.4 | 28.0 | 41.2 | 44.2 | 51.1 | 28.7 | 32.5 | 45.8 | 48.9 | 55.8 |
| Run 8 | 24.2 | 27.9 | 41.1 | 44.2 | 51.0 | 28.1 | 31.9 | 45.2 | 48.3 | 55.3 |
| Run 9 | 8.7 | 9.9 | 14.3 | 15.3 | 17.5 | 10.5 | 11.7 | 16.1 | 17.1 | 19.4 |
| Run 10 | 4.7 | 10.2 | 29.2 | 40.5 | 27.6 | 6.6 | 12.6 | 32.4 | 43.7 | 31.2 |
| Run 11 | 13.6 | 14.9 | 19.4 | 20.4 | 22.7 | 14.7 | 15.9 | 20.5 | 21.5 | 23.8 |
| Run 12 | 10.1 | 17.0 | 37.7 | 49.1 | 37.0 | 11.4 | 18.4 | 39.2 | 50.7 | 38.7 |
| Run 13 | 31.1 | 31.3 | 32.5 | 32.8 | 34.1 | 41.6 | 42.0 | 43.4 | 43.8 | 45.2 |
| Run 14 | 17.7 | 23.8 | 51.6 | 58.2 | 72.3 | 28.9 | 37.1 | 70.8 | 78.7 | 96.4 |
| Run 15 | 73.9 | 74.5 | 76.2 | 76.7 | 78.3 | 81.2 | 81.8 | 83.6 | 84.1 | 85.7 |
| Run 16 | 67.0 | 78.3 | 118.8 | 128.1 | 149.2 | 75.3 | 86.9 | 127.9 | 137.3 | 158.6 |

**Table 6-17. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #1 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Run 0 | | | 0.6 | 0.7 | 0.8 | | | 1.5 | 1.6 | 1.6 |
| Run 1 | | | 1.5 | 1.6 | 1.7 | | | 2.6 | 2.7 | 2.8 |
| Run 2 | | | 0.1 | 0.1 | 0.1 | | | 0.3 | 0.4 | 0.4 |
| Run 3 | | | 0.8 | 1.0 | 1.1 | | | 1.9 | 2.2 | 2.4 |
| Run 4 | | | 0.5 | 0.6 | 0.6 | | | 1.3 | 1.3 | 1.3 |
| Run 5 | | | 0.1 | 0.1 | 0.1 | | | 0.2 | 0.3 | 0.3 |
| Run 6 | | | 1.6 | 1.7 | 1.8 | | | 2.8 | 3.0 | 3.0 |
| Run 7 | | | 0.7 | 0.7 | 0.8 | | | 1.6 | 1.7 | 1.7 |
| Run 8 | | | 0.5 | 0.6 | 0.6 | | | 0.9 | 1.0 | 1.1 |
| Run 9 | | | 0.5 | 0.5 | 0.5 | | | 1.2 | 1.2 | 1.2 |
| Run 10 | | | 0.6 | 0.8 | 0.9 | | | 1.6 | 1.9 | 2.0 |
| Run 11 | | | 2.1 | 2.2 | 2.2 | | | 3.3 | 3.4 | 3.4 |
| Run 12 | | | 3.5 | 4.0 | 4.2 | | | 5.3 | 5.9 | 6.1 |
| Run 13 | | | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 |
| Run 14 | | | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 |
| Run 15 | | | 0.2 | 0.2 | 0.2 | | | 0.4 | 0.4 | 0.4 |
| Run 16 | | | 0.5 | 0.8 | 0.9 | | | 0.9 | 1.2 | 1.3 |
| Run 0 | | 0.5 | 0.9 | 1.7 | 2.1 | | 1.3 | 1.7 | 2.8 | 3.3 |
| Run 1 | | 1.2 | 1.8 | 3.0 | 3.7 | | 2.1 | 2.7 | 4.1 | 4.9 |
| Run 2 | | 0.1 | 0.1 | 0.3 | 0.5 | | 0.3 | 0.5 | 0.9 | 1.2 |
| Run 3 | | 0.4 | 1.1 | 2.3 | 3.1 | | 1.0 | 2.1 | 3.8 | 4.8 |
| Run 4 | | 0.7 | 0.8 | 1.2 | 1.5 | | 1.5 | 1.6 | 2.1 | 2.5 |
| Run 5 | | 0.1 | 0.2 | 0.6 | 0.9 | | 0.4 | 0.6 | 1.4 | 1.9 |
| Run 6 | | 1.2 | 1.7 | 2.4 | 2.8 | | 2.1 | 2.7 | 3.6 | 4.0 |
| Run 7 | | 0.6 | 0.9 | 1.7 | 2.1 | | 1.6 | 2.0 | 2.9 | 3.5 |
| Run 8 | | 0.5 | 0.7 | 1.5 | 2.0 | | 1.0 | 1.3 | 2.4 | 2.9 |
| Run 9 | | 0.5 | 0.6 | 0.8 | 1.0 | | 1.2 | 1.3 | 1.6 | 1.8 |
| Run 10 | | 0.3 | 0.7 | 1.3 | 1.8 | | 0.8 | 1.6 | 2.6 | 3.2 |
| Run 11 | | 2.1 | 2.3 | 2.8 | 3.1 | | 3.0 | 3.2 | 3.9 | 4.2 |
| Run 12 | | 1.6 | 3.5 | 5.1 | 5.8 | | 2.5 | 5.0 | 6.8 | 7.6 |
| Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.1 | 0.2 |
| Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.1 | 0.3 |
| Run 15 | | 0.5 | 0.6 | 1.1 | 1.4 | | 0.9 | 1.0 | 1.5 | 1.9 |
| Run 16 | | 0.4 | 1.2 | 3.4 | 4.7 | | 0.8 | 1.8 | 4.6 | 6.2 |
| Run 0 | 4.1 | 3.1 | 3.8 | 5.3 | 6.4 | 6.7 | 4.5 | 5.5 | 7.3 | 8.5 |
| Run 1 | 6.5 | 5.1 | 6.2 | 8.2 | 9.6 | 9.0 | 6.1 | 7.3 | 9.6 | 11.1 |
| Run 2 | 1.6 | 0.6 | 0.9 | 1.5 | 2.2 | 3.4 | 1.7 | 2.2 | 3.3 | 4.1 |
| Run 3 | 3.7 | 2.6 | 4.2 | 6.4 | 8.1 | 6.4 | 4.0 | 6.1 | 9.0 | 10.9 |
| Run 4 | 4.1 | 3.5 | 3.8 | 4.8 | 5.5 | 6.6 | 5.0 | 5.4 | 6.5 | 7.4 |
| Run 5 | 1.4 | 2.0 | 2.7 | 4.3 | 5.7 | 3.5 | 4.5 | 5.5 | 7.8 | 9.7 |
| Run 6 | 5.0 | 2.6 | 3.4 | 4.5 | 5.2 | 6.5 | 3.6 | 4.5 | 5.8 | 6.6 |
| Run 7 | 4.3 | 3.2 | 3.9 | 5.4 | 6.4 | 8.0 | 5.0 | 5.9 | 7.6 | 8.8 |
| Run 8 | 4.1 | 3.0 | 3.8 | 5.3 | 6.3 | 6.7 | 4.5 | 5.4 | 7.1 | 8.4 |
| Run 9 | 3.0 | 1.5 | 1.7 | 2.1 | 2.5 | 4.4 | 2.5 | 2.7 | 3.3 | 3.7 |
| Run 10 | 2.2 | 0.9 | 1.9 | 3.2 | 4.1 | 3.7 | 1.7 | 3.2 | 4.9 | 5.9 |
| Run 11 | 6.3 | 4.0 | 4.3 | 5.1 | 5.6 | 7.4 | 4.8 | 5.2 | 6.0 | 6.6 |
| Run 12 | 5.9 | 3.2 | 5.8 | 8.2 | 9.4 | 7.3 | 4.0 | 7.0 | 9.8 | 11.1 |
| Run 13 | 0.2 | 0.1 | 0.2 | 0.5 | 0.7 | 0.9 | 0.8 | 0.9 | 1.6 | 2.1 |
| Run 14 | 0.2 | 0.0 | 0.1 | 0.2 | 0.5 | 0.9 | 0.3 | 0.6 | 1.1 | 2.0 |
| Run 15 | 4.0 | 6.3 | 6.8 | 8.8 | 10.5 | 7.0 | 8.4 | 8.8 | 11.0 | 12.9 |
| Run 16 | 3.3 | 6.5 | 9.1 | 13.5 | 16.6 | 6.3 | 8.8 | 11.7 | 16.9 | 20.5 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 11.8 | 10.5 | 10.6 | 10.9 | 11.1 | 14.8 | 13.4 | 13.5 | 13.9 | 14.0 |
| | Run 1 | 16.0 | 14.9 | 15.0 | 15.4 | 15.5 | 18.0 | 16.7 | 16.8 | 17.3 | 17.4 |
| | Run 2 | 5.9 | 4.2 | 4.2 | 4.4 | 4.8 | 9.0 | 7.3 | 7.3 | 7.6 | 7.9 |
| | Run 3 | 11.0 | 9.8 | 10.8 | 12.7 | 13.4 | 14.2 | 13.0 | 14.1 | 16.3 | 17.0 |
| | Run 4 | 11.8 | 10.8 | 10.7 | 10.6 | 10.6 | 14.6 | 13.5 | 13.5 | 13.4 | 13.2 |
| | Run 5 | 16.0 | 13.2 | 13.2 | 13.4 | 13.8 | 22.6 | 20.5 | 20.5 | 20.7 | 20.8 |
| | Run 6 | 7.4 | 6.4 | 6.7 | 7.4 | 7.6 | 8.9 | 7.7 | 8.1 | 8.8 | 9.0 |
| | Run 7 | 12.1 | 10.6 | 10.7 | 11.0 | 11.2 | 15.9 | 14.0 | 14.0 | 14.3 | 14.4 |
| | Run 8 | 11.8 | 10.5 | 10.6 | 10.9 | 11.1 | 14.8 | 13.4 | 13.5 | 13.8 | 13.9 |
| | Run 9 | 5.0 | 4.1 | 4.1 | 4.1 | 4.2 | 6.5 | 5.6 | 5.6 | 5.6 | 5.6 |
| | Run 10 | 3.7 | 3.1 | 4.5 | 6.2 | 6.5 | 5.4 | 4.7 | 6.4 | 8.4 | 8.7 |
| | Run 11 | 9.0 | 8.1 | 8.0 | 8.1 | 8.1 | 10.0 | 9.1 | 9.0 | 9.1 | 9.1 |
| | Run 12 | 8.3 | 7.7 | 9.8 | 12.4 | 12.7 | 9.6 | 8.8 | 11.1 | 13.9 | 14.3 |
| | Run 13 | 4.9 | 3.1 | 3.1 | 3.1 | 3.3 | 9.6 | 7.4 | 7.4 | 7.2 | 7.3 |
| | Run 14 | 4.2 | 1.6 | 1.6 | 1.5 | 2.0 | 8.7 | 4.9 | 4.9 | 5.0 | 6.0 |
| | Run 15 | 27.5 | 26.1 | 26.1 | 25.5 | 25.1 | 32.0 | 30.6 | 30.6 | 30.0 | 29.5 |
| | Run 16 | 28.1 | 27.0 | 27.5 | 29.0 | 29.6 | 33.1 | 32.6 | 33.1 | 34.8 | 35.3 |
| Monitoring Location at 30.5 miles | Run 0 | 40.4 | 60.4 | 151.9 | 213.4 | 122.2 | 44.8 | 64.9 | 156.6 | 218.1 | 127.0 |
| | Run 1 | 47.6 | 67.7 | 159.6 | 221.1 | 130.2 | 50.2 | 70.4 | 162.3 | 223.9 | 132.9 |
| | Run 2 | 30.1 | 49.6 | 140.1 | 201.4 | 109.8 | 35.3 | 55.0 | 146.1 | 207.5 | 116.2 |
| | Run 3 | 32.5 | 65.9 | 201.8 | 319.1 | 133.3 | 37.2 | 71.1 | 207.8 | 325.2 | 139.7 |
| | Run 4 | 45.9 | 57.8 | 110.3 | 141.6 | 104.3 | 50.1 | 62.0 | 114.6 | 145.9 | 108.7 |
| | Run 5 | 105.8 | 141.3 | 299.0 | 393.1 | 280.9 | 118.9 | 154.7 | 312.8 | 407.1 | 295.1 |
| | Run 6 | 15.0 | 26.4 | 71.8 | 110.8 | 49.3 | 16.7 | 28.1 | 73.7 | 112.7 | 51.2 |
| | Run 7 | 40.5 | 60.4 | 151.9 | 213.4 | 122.2 | 45.1 | 65.2 | 156.9 | 218.4 | 127.3 |
| | Run 8 | 40.4 | 60.4 | 151.9 | 213.4 | 122.2 | 44.8 | 64.9 | 156.6 | 218.1 | 127.0 |
| | Run 9 | 14.1 | 20.7 | 51.2 | 71.7 | 41.2 | 16.0 | 22.7 | 53.2 | 73.7 | 43.3 |
| | Run 10 | 7.9 | 25.1 | 83.6 | 150.4 | 43.7 | 10.0 | 28.0 | 87.2 | 154.1 | 47.7 |
| | Run 11 | 19.5 | 26.2 | 56.9 | 77.4 | 47.1 | 20.6 | 27.4 | 58.0 | 78.5 | 48.2 |
| | Run 12 | 14.0 | 33.1 | 93.5 | 160.5 | 54.6 | 15.4 | 34.5 | 95.1 | 162.1 | 56.4 |
| | Run 13 | 89.9 | 110.5 | 187.0 | 234.7 | 200.6 | 102.7 | 123.4 | 200.2 | 248.0 | 214.1 |
| | Run 14 | 58.0 | 112.7 | 378.9 | 563.0 | 282.2 | 72.2 | 129.5 | 400.8 | 585.9 | 307.2 |
| | Run 15 | 140.6 | 161.6 | 238.8 | 286.8 | 253.1 | 149.7 | 170.7 | 248.1 | 296.0 | 262.4 |
| | Run 16 | 114.5 | 175.3 | 453.1 | 639.5 | 363.6 | 124.4 | 185.5 | 464.0 | 650.5 | 374.9 |

## 6.7 Simulated drawdowns from Well Fields Located in Potential Production Area #2

This section describes the construction and application of two groundwater models to simulated the drawdowns that would be created by pumping Potential Production Area #2 at two proposed well fields.

### *6.7.1 Construction of Groundwater Models based on GAM and GHSM properties*

The two groundwater models constructed to simulate pumping from PPA #2 are three-dimensional models with the same model layers and vertical grid discretization as shown in Figure 6-7. The width of the two models is along the geologic strike for the Carrizo-Wilcox Aquifer and is 100 miles. The length of the two models along dip is 71 miles. The recharge rate applied to the outcrop was a uniform 1.5 inches per year.

**Table 6-18** provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 15-mile reaches for both models. The model properties extracted from the Southern QCSP GAM and assigned to model layers 1 to 9. The values for vertical hydraulic conductivity (Kz) were determined by imposing ratio of Kx/Kz of 1,000 for all model layers except for the model layers that represent the Reklaw formation and the middle Wilcox Aquifer. The ratio of Kx/Kz for these two model layers was 10,000. In addition, adjustments to the Kx/Kz ratios for the middle Wilcox were made based on the degree of confinement provided by the clay layers contained within the middle Wilcox and present on geophysical logs. These adjustments allow the Kx/Kz ratio to vary between 1,000 and 100,000.

Table 6-8 also provides the values for Kx, Kx, and Ss that were produced by the GHSM for model Layers 5 to 9. **Figures 6-35** and **6-36** illustrate the values of Kx in Table 6-18. The two models have comparable Kx values for the Carrizo-upper Wilcox, but the GHSM-model has much lower Kx values for the lower Wilcox at large depths. Among the most notable difference between the two sets of hydraulic properties for the Carrizo-Wilcox Aquifer is that the vertical hydraulic conductivity values and the specific storage values are significantly lower for the GMA-based properties than the GHSM-based properties. Simulated Drawdown Produced by Pumping from Potential Production Area #2.

Groundwater pumping at the rate of 5,000 AFY, 15,000 AFY and 30,000 AFY was simulated at two well fields in PPA #1 shown in Figure 6-7. Both well fields pump model layer 8, which represents the middle third of the lower Wilcox Aquifer. The up dip well field #1 is located 32 miles down dip from the outcrop, and the down dip well field #2 is located 41 miles down dip from the outcrop. **Figures 6-37** and **6-38** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GAM-based hydraulic properties for the Carrizo-Wilcox aquifer. **Figures 6-39** and **6-40** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GHSM-based hydraulic properties for the Carrizo-Wilcox aquifer.

Among the notable results that can be observed in the plotted drawdown in Figures 6-37 to 6-40 are the following:

- The Reklaw provides as an effective hydraulic barrier that prevents appreciable drawdowns from migrating from the Carrizo-Wilcox Aquifer into the Queen City Aquifer
- The drawdown predicted in the Carrizo-Wilcox Aquifer outcrop is significantly higher from pumping Well Field #1 than from pumping Well Field #2
- There is significantly less predicted drawdown in down-dip of the well field in the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model
- There is less predicted drawdown in down-dip of the well field in the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model

To help to quantify the drawdown in areas of interest and at time of interest, drawdown values were recorded for all four model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 2.5 miles, 5.5 miles, 10.5 miles, 15.5 miles, and 30.5 miles. Table 6-19 provides the elevations and depths associated with these five monitoring locations.

**Table 6-18. Average values for Kx (ft per day), Kz (feet per day), and Ss (1/ foot) by model layer for 15-mile reaches along dip for the groundwater models for PPA # 2.**

**Common to Both GAM and GHSM based Groundwater Models for Cross-Section 2**

| Reach (miles) | Property | Layer 1 | Layer 2 | Layer 3 | Layer 4 |
|---|---|---|---|---|---|
| 0-15 | Kx | n/a | n/a | n/a | n/a |
| | Kz | n/a | n/a | n/a | n/a |
| | Ss | n/a | n/a | n/a | n/a |
| 15-30 | Kx | 5.53 | 1 | 4.27 | 1 |
| | Kz | 5.5E-03 | 1.0E-03 | 4.3E-03 | 1.0E-04 |
| | Ss | 2.1E-05 | 1.6E-05 | 3.6E-05 | 8.6E-06 |
| 30-45 | Kx | 2.7 | 1.2 | 1.2 | 1.0 |
| | Kz | 2.7E-03 | 1.2E-03 | 1.2E-03 | 1.0E-04 |
| | Ss | 4.2E-06 | 6.2E-06 | 4.1E-06 | 4.8E-06 |
| 45-60 | Kx | 0.2 | 1.0 | 0.3 | 1.0 |
| | Kz | 1.8E-04 | 1.0E-03 | 2.8E-04 | 1.0E-04 |
| | Ss | 4.1E-06 | 4.2E-06 | 2.6E-06 | 2.9E-06 |
| 60-714 | Kx | 0.0 | 1.0 | 0.0 | 1.0 |
| | Kz | 4.6E-06 | 1.1E-03 | 2.8E-05 | 1.1E-04 |
| | Ss | 2.8E-06 | 2.5E-06 | 2.0E-06 | 1.8E-06 |

**Carrizo-Wilcox Aquifer Properties Extracted from the Southern QCSP GAM**

| Reach (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 2.3 | 3.1 | 7.7 | 7.7 | 7.7 |
| | Kz | 2.3E-03 | 7.0E-04 | 1.9E-02 | 1.9E-02 | 1.9E-02 |
| | Ss | 3.2E-04 | 5.2E-05 | 6.4E-06 | 3.0E-06 | 3.0E-06 |
| 15-30 | Kx | 31.84 | 1.06 | 3 | 3 | 3 |
| | Kz | 3.2E-02 | 1.1E-04 | 3.0E-03 | 3.0E-03 | 3.0E-03 |
| | Ss | 5.3E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 30-45 | Kx | 12.9 | 0.5 | 2.8 | 2.8 | 2.8 |
| | Kz | 1.3E-02 | 2.1E-05 | 2.8E-03 | 2.8E-03 | 2.8E-03 |
| | Ss | 2.6E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 45-60 | Kx | 10.2 | 0.3 | 1.0 | 1.0 | 1.0 |
| | Kz | 1.0E-02 | 9.4E-06 | 1.0E-03 | 1.0E-03 | 1.0E-03 |
| | Ss | 1.5E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 60-71 | Kx | 2.0 | 0.4 | 1.0 | 1.0 | 1.0 |
| | Kz | 2.1E-03 | 5.8E-06 | 1.1E-03 | 1.1E-03 | 1.1E-03 |
| | Ss | 2.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |

**Carrizo-Wilcox Aquifer Properties Developed from the GeoHydroStratigraphic Model (GHSM)**

| Reach (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 30.1 | 4.0 | 3.8 | 3.8 | 3.7 |
| | Kz | 5.0E-03 | 1.5E-03 | 5.7E-03 | 5.5E-03 | 5.5E-03 |
| | Ss | 3.7E-01 | 3.7E-01 | 3.6E-01 | 3.6E-01 | 3.6E-01 |
| 15-30 | Kx | 26.0 | 2.7 | 2.7 | 2.5 | 2.3 |
| | Kz | 4.7E-03 | 1.1E-03 | 1.4E-03 | 1.3E-03 | 1.3E-03 |
| | Ss | 3.5E-01 | 3.3E-01 | 3.3E-01 | 3.2E-01 | 3.1E-01 |
| 30-45 | Kx | 16.7 | 1.1 | 1.4 | 1.2 | 1.1 |
| | Kz | 2.2E-03 | 5.9E-04 | 7.5E-04 | 6.6E-04 | 5.7E-04 |
| | Ss | 3.2E-01 | 3.0E-01 | 2.9E-01 | 2.8E-01 | 2.7E-01 |
| 45-60 | Kx | 7.7 | 0.4 | 0.2 | 0.1 | 0.1 |
| | Kz | 9.2E-04 | 2.4E-04 | 1.8E-04 | 1.5E-04 | 1.2E-04 |
| | Ss | 2.7E-01 | 2.5E-01 | 2.4E-01 | 2.3E-01 | 2.2E-01 |
| 60-71 | Kx | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Kz | 2.6E-04 | 8.0E-05 | 4.9E-05 | 3.6E-05 | 2.6E-05 |
| | Ss | 2.3E-01 | 2.1E-01 | 1.9E-01 | 1.8E-01 | 1.7E-01 |

**Table 6-19. Locations where drawdowns were monitored for the simulated pumping at Well Field #1 and Well Field #2 in Potential Production Area #2.**

| Monitoring Location (miles) | Ground Surface (ft, msl) | Vertical Boundary | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|---|
| | | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 2.5 | 740.8 | Top | | | 740.8 | 570.6 | 550.3 |
| | | Bottom | | | 570.6 | 550.3 | 529.3 |
| 5.5 | 675.4 | Top | | 675.4 | 469.3 | 267.3 | 222.5 |
| | | Bottom | | 469.3 | 267.3 | 222.5 | 176.5 |
| 10.5 | 743.9 | Top | 743.9 | 649.6 | -30.7 | -225.4 | -309.8 |
| | | Bottom | 649.6 | -30.7 | -225.4 | -309.8 | -396.7 |
| 15.5 | 621.6 | Top | 621.6 | 11.4 | -532.5 | -719.9 | -844.1 |
| | | Bottom | 11.4 | -532.5 | -719.9 | -844.1 | -972 |
| 30.5 | 459.9 | Top | -910.8 | -1783.8 | -2348.6 | -2702.8 | -3056.9 |
| | | Bottom | -1783.8 | -2348.6 | -2702.8 | -3056.9 | -3421.8 |

## Simulated Drawdown from the Groundwater Model with GAM-based Properties for the Carrizo-Wilcox Aquifer

**Tables 6-20** and **6-21** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-19 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GAM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-41** to **6-42** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-43** to **6-44** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-20 and 6-21 and Figures 6-41 through 6-44 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts about 13 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and about 15 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts about 10 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and about 12 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 400 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 400 feet of drawdown at the Well Field #2

- After 30 years of pumping 15,000 AFY the drawdown, the groundwater model predicts less than 1 foot of across the entire Carrizo Aquifer for pumping the lower Wilcox at either Well Field #1 or Well Field #2

**Simulated Drawdown from the Groundwater Model with GHSM-based Properties for the Carrizo-Wilcox Aquifer**

**Tables 6-22** and **6-23** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-9 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GHSM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-45** to **6-46** shows the simulated drawdown along the center dip line of the groundwater model elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-47** to **6-48** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-22 and 6-23 and Figures 6-31 through 6-34 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts about 5 of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and about 8 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts about 2 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and about 4 to 5 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 500 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 800 feet of drawdown at the Well Field #2
- After 30 years of pumping 15,000 AFY the drawdown, the groundwater model predicts a maximum of 3 feet of drawdown in the Carrizo Aquifer above the location the pumping wells in the lower Wilcox

**Table 6-20. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #2 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 4.5 | 4.6 | 4.6 |
| | 15,000 | Not Present | Not Present | 13.6 | 13.7 | 13.7 |
| | 30,000 | Not Present | Not Present | 27.1 | 27.5 | 27.5 |
| 5.5 | 5,000 | Not Present | 0.3 | 5.2 | 5.1 | 5.2 |
| | 15,000 | Not Present | 0.8 | 15.7 | 15.2 | 15.6 |
| | 30,000 | Not Present | 1.6 | 31.4 | 30.5 | 31.2 |
| 10.5 | 5,000 | 0.0 | 0.2 | 7.4 | 7.1 | 6.7 |
| | 15,000 | 0.0 | 0.5 | 22.1 | 21.1 | 20.0 |
| | 30,000 | 0.0 | 1.1 | 44.2 | 42.3 | 40.0 |
| 15.5 | 5,000 | 0.0 | 0.6 | 10.6 | 12.0 | 11.0 |
| | 15,000 | 0.0 | 1.8 | 31.7 | 35.8 | 32.9 |
| | 30,000 | 0.1 | 3.6 | 63.3 | 71.8 | 65.7 |
| 30.5 | 5,000 | 0.1 | 1.2 | 45.3 | 84.8 | 36.5 |
| | 15,000 | 0.2 | 3.6 | 136.1 | 249.3 | 108.7 |
| | 30,000 | 0.4 | 7.1 | 265.2 | 448.8 | 212.3 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 7.3 | 7.4 | 7.4 |
| | 15,000 | Not Present | Not Present | 22.0 | 22.2 | 22.2 |
| | 30,000 | Not Present | Not Present | 44.0 | 44.4 | 44.4 |
| 5.5 | 5,000 | Not Present | 0.5 | 7.9 | 7.9 | 8.0 |
| | 15,000 | Not Present | 1.6 | 23.7 | 23.7 | 24.0 |
| | 30,000 | Not Present | 3.2 | 47.4 | 47.3 | 48.0 |
| 10.5 | 5,000 | 0.0 | 0.3 | 10.1 | 9.9 | 9.5 |
| | 15,000 | 0.0 | 1.0 | 30.2 | 29.6 | 28.5 |
| | 30,000 | 0.0 | 2.0 | 60.5 | 59.3 | 57.1 |
| 15.5 | 5,000 | 0.0 | 0.9 | 13.4 | 15.0 | 14.0 |
| | 15,000 | 0.0 | 2.6 | 40.3 | 44.8 | 42.0 |
| | 30,000 | 0.1 | 5.2 | 80.5 | 89.8 | 83.9 |
| 30.5 | 5,000 | 0.1 | 1.5 | 49.2 | 88.7 | 40.6 |
| | 15,000 | 0.3 | 4.5 | 147.8 | 261.0 | 120.8 |
| | 30,000 | 0.6 | 9.0 | 288.6 | 472.3 | 236.5 |

**Table 6-21. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #2 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 3.4 | 3.4 | 3.4 |
| | 15,000 | Not Present | Not Present | 10.1 | 10.1 | 10.1 |
| | 30,000 | Not Present | Not Present | 20.1 | 20.1 | 20.1 |
| 5.5 | 5,000 | Not Present | 0.2 | 4.1 | 3.9 | 3.9 |
| | 15,000 | Not Present | 0.5 | 12.2 | 11.8 | 11.7 |
| | 30,000 | Not Present | 1.0 | 24.2 | 23.6 | 23.2 |
| 10.5 | 5,000 | 0.0 | 0.2 | 5.7 | 5.0 | 5.0 |
| | 15,000 | 0.0 | 0.5 | 17.0 | 15.1 | 14.8 |
| | 30,000 | 0.0 | 1.0 | 33.9 | 30.0 | 29.6 |
| 15.5 | 5,000 | 0.0 | 0.5 | 9.0 | 8.6 | 8.2 |
| | 15,000 | 0.0 | 1.4 | 26.9 | 25.6 | 24.7 |
| | 30,000 | 0.0 | 2.9 | 53.7 | 51.1 | 49.2 |
| 30.5 | 5,000 | 0.1 | 0.9 | 34.9 | 31.3 | 23.2 |
| | 15,000 | 0.2 | 2.8 | 104.8 | 93.7 | 69.3 |
| | 30,000 | 0.3 | 5.6 | 208.2 | 186.6 | 137.8 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 5.9 | 5.9 | 5.9 |
| | 15,000 | Not Present | Not Present | 17.7 | 17.7 | 17.7 |
| | 30,000 | Not Present | Not Present | 35.4 | 35.4 | 35.4 |
| 5.5 | 5,000 | Not Present | 0.4 | 6.5 | 6.5 | 6.5 |
| | 15,000 | Not Present | 1.2 | 19.5 | 19.6 | 19.4 |
| | 30,000 | Not Present | 2.4 | 39.0 | 39.0 | 38.7 |
| 10.5 | 5,000 | 0.0 | 0.3 | 8.2 | 7.7 | 7.6 |
| | 15,000 | 0.0 | 0.9 | 24.7 | 23.0 | 22.8 |
| | 30,000 | 0.0 | 1.9 | 49.3 | 45.9 | 45.5 |
| 15.5 | 5,000 | 0.0 | 0.7 | 11.8 | 11.5 | 11.2 |
| | 15,000 | 0.0 | 2.2 | 35.5 | 34.5 | 33.7 |
| | 30,000 | 0.0 | 4.4 | 70.8 | 68.7 | 67.2 |
| 30.5 | 5,000 | 0.1 | 1.3 | 39.2 | 35.6 | 27.7 |
| | 15,000 | 0.3 | 3.8 | 117.7 | 106.7 | 82.7 |
| | 30,000 | 0.5 | 7.5 | 234.1 | 212.4 | 164.6 |

**Table 6-22. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #2 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 1.35 | 1.57 | 1.57 |
| | 15,000 | Not Present | Not Present | 4.64 | 5.22 | 5.22 |
| | 30,000 | Not Present | Not Present | 11.10 | 11.97 | 11.98 |
| 5.5 | 5,000 | Not Present | 0.07 | 2.71 | 2.55 | 2.83 |
| | 15,000 | Not Present | 0.20 | 8.46 | 8.08 | 8.87 |
| | 30,000 | Not Present | 0.41 | 17.89 | 17.47 | 19.00 |
| 10.5 | 5,000 | 0.01 | 0.21 | 6.75 | 7.54 | 5.92 |
| | 15,000 | 0.04 | 0.64 | 20.39 | 22.77 | 17.87 |
| | 30,000 | 0.09 | 1.27 | 41.04 | 46.50 | 36.57 |
| 15.5 | 5,000 | 0.06 | 0.75 | 10.13 | 13.64 | 10.20 |
| | 15,000 | 0.17 | 2.26 | 30.53 | 40.83 | 30.45 |
| | 30,000 | 0.34 | 4.47 | 61.02 | 82.53 | 61.35 |
| 30.5 | 5,000 | 0.69 | 2.28 | 46.65 | 129.65 | 34.45 |
| | 15,000 | 2.11 | 6.92 | 140.87 | 378.76 | 101.97 |
| | 30,000 | 4.12 | 13.51 | 273.64 | 678.23 | 198.34 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 2.30 | 2.66 | 2.66 |
| | 15,000 | Not Present | Not Present | 10.25 | 10.87 | 10.87 |
| | 30,000 | Not Present | Not Present | 24.22 | 25.18 | 25.19 |
| 5.5 | 5,000 | Not Present | 0.16 | 4.11 | 3.84 | 4.19 |
| | 15,000 | Not Present | 0.52 | 14.41 | 14.00 | 14.92 |
| | 30,000 | Not Present | 1.09 | 31.45 | 31.17 | 32.91 |
| 10.5 | 5,000 | 0.05 | 0.39 | 8.91 | 9.62 | 7.95 |
| | 15,000 | 0.14 | 1.18 | 27.83 | 30.32 | 25.31 |
| | 30,000 | 0.28 | 2.37 | 57.15 | 63.09 | 53.02 |
| 15.5 | 5,000 | 0.1 | 1.2 | 12.8 | 16.4 | 13.1 |
| | 15,000 | 0.3 | 3.8 | 40.7 | 58.4 | 49.1 |
| | 30,000 | 0.6 | 7.4 | 79.3 | 102.2 | 81.5 |
| 30.5 | 5,000 | 0.11 | 1.23 | 12.77 | 16.41 | 13.06 |
| | 15,000 | 0.32 | 3.72 | 39.17 | 50.06 | 39.90 |
| | 30,000 | 0.63 | 7.43 | 79.31 | 102.19 | 81.48 |

**Table 6-23. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #2 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.72 | 0.74 | 0.74 |
| | 15,000 | Not Present | Not Present | 2.14 | 2.22 | 2.22 |
| | 30,000 | Not Present | Not Present | 4.67 | 4.75 | 4.75 |
| 5.5 | 5,000 | Not Present | 0.03 | 1.72 | 1.48 | 1.37 |
| | 15,000 | Not Present | 0.10 | 5.15 | 4.45 | 4.11 |
| | 30,000 | Not Present | 0.20 | 10.35 | 9.07 | 8.40 |
| 10.5 | 5,000 | 0.01 | 0.19 | 4.35 | 3.23 | 2.70 |
| | 15,000 | 0.03 | 0.58 | 12.96 | 9.67 | 8.09 |
| | 30,000 | 0.07 | 1.14 | 25.72 | 19.37 | 16.19 |
| 15.5 | 5,000 | 0.03 | 0.53 | 7.51 | 6.36 | 4.62 |
| | 15,000 | 0.10 | 1.56 | 22.40 | 19.04 | 13.79 |
| | 30,000 | 0.19 | 3.08 | 44.37 | 37.96 | 27.45 |
| 30.5 | 5,000 | 0.03 | 0.53 | 7.51 | 6.36 | 4.62 |
| | 15,000 | 0.10 | 1.56 | 22.40 | 19.04 | 13.79 |
| | 30,000 | 0.19 | 3.08 | 44.37 | 37.96 | 27.45 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | 0.03 | 0.53 | 7.51 |
| | 15,000 | Not Present | Not Present | 0.10 | 1.56 | 22.40 |
| | 30,000 | Not Present | Not Present | 0.19 | 3.08 | 44.37 |
| 5.5 | 5,000 | Not Present | 0.10 | 2.99 | 2.64 | 2.50 |
| | 15,000 | Not Present | 0.31 | 9.37 | 8.49 | 8.06 |
| | 30,000 | Not Present | 0.63 | 20.15 | 18.72 | 17.87 |
| 10.5 | 5,000 | 0.04 | 0.40 | 6.50 | 5.07 | 4.56 |
| | 15,000 | 0.13 | 1.21 | 19.65 | 15.56 | 13.99 |
| | 30,000 | 0.25 | 2.40 | 39.92 | 32.34 | 29.12 |
| 15.5 | 5,000 | 0.07 | 1.00 | 10.49 | 9.24 | 7.42 |
| | 15,000 | 0.22 | 2.98 | 31.47 | 27.88 | 22.36 |
| | 30,000 | 0.43 | 5.91 | 63.11 | 56.45 | 45.32 |
| 30.5 | 5,000 | 1.16 | 2.90 | 43.87 | 38.16 | 19.59 |
| | 15,000 | 3.44 | 8.64 | 131.06 | 114.62 | 58.41 |
| | 30,000 | 6.76 | 17.03 | 259.50 | 228.53 | 116.11 |

### *6.7.2 Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #2*

Table 6-2 describes the changes in the model input parameter associated with set of sixteen sensitivity runs performed for the groundwater models simulations involving GAM-based and the GHSM-based aquifer properties. In this section, Model Run 0 refers to the baseline run of 15,000 AF for which simulated drawdowns are shown in Figures 6-27 to 6-31. **Tables 6-24** and **6-25** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-9** as determined by the groundwater model with GAM-based aquifer properties. **Tables 6-26** and **6-27** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-9** as determined by the groundwater model with GHSM-based aquifer properties.

Among the notable results that can be gleaned from a review of **Tables 6-24** through **6-27** are:

- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 2 and 19 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is between 4 and 21 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 0.5 and 16 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is between 1 and 18 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that 2.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 14 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that 5.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 17 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that 2.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 11.0 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that 5.5 mile monitoring location in the lower Wilcox the drawdown between less than 0.5 feet and 11 feet.

**Table 6-24. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #2 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 13.6 | 13.7 | 13.7 | | | 22.0 | 22.2 | 22.2 |
| | Run 1 | | | 18.6 | 18.8 | 18.8 | | | 28.3 | 28.6 | 28.6 |
| | Run 2 | | | 7.6 | 7.7 | 7.7 | | | 13.8 | 14.0 | 14.0 |
| | Run 3 | | | 8.2 | 9.0 | 9.0 | | | 10.7 | 11.8 | 11.8 |
| | Run 4 | | | 10.8 | 11.0 | 11.0 | | | 16.6 | 16.8 | 16.8 |
| | Run 5 | | | 4.6 | 5.5 | 5.5 | | | 9.3 | 10.3 | 10.3 |
| | Run 6 | | | 14.3 | 14.4 | 14.4 | | | 21.6 | 21.7 | 21.7 |
| | Run 7 | | | 13.6 | 13.7 | 13.7 | | | 22.0 | 22.2 | 22.2 |
| | Run 8 | | | 7.4 | 7.9 | 7.9 | | | 10.0 | 10.7 | 10.7 |
| | Run 9 | | | 8.0 | 8.1 | 8.1 | | | 11.9 | 12.0 | 12.0 |
| | Run 10 | | | 6.6 | 7.0 | 7.0 | | | 8.6 | 9.2 | 9.2 |
| | Run 11 | | | 14.4 | 14.5 | 14.5 | | | 19.7 | 19.8 | 19.8 |
| | Run 12 | | | 10.5 | 11.2 | 11.2 | | | 13.3 | 13.9 | 13.9 |
| | Run 13 | | | 2.5 | 2.7 | 2.7 | | | 6.1 | 6.4 | 6.4 |
| | Run 14 | | | 2.0 | 2.4 | 2.4 | | | 4.0 | 4.9 | 4.9 |
| | Run 15 | | | 11.5 | 12.0 | 12.0 | | | 18.7 | 19.3 | 19.3 |
| | Run 16 | | | 8.1 | 9.8 | 9.8 | | | 10.7 | 12.9 | 13.0 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.8 | 15.7 | 15.2 | 15.6 | | 1.6 | 23.7 | 23.7 | 24.0 |
| | Run 1 | | 1.1 | 21.1 | 20.6 | 21.1 | | 2.1 | 30.2 | 30.3 | 30.7 |
| | Run 2 | | 0.4 | 9.1 | 8.7 | 8.9 | | 1.0 | 15.2 | 15.1 | 15.3 |
| | Run 3 | | 0.2 | 12.0 | 11.0 | 11.4 | | 0.4 | 14.8 | 13.9 | 14.4 |
| | Run 4 | | 1.6 | 11.9 | 12.4 | 12.6 | | 3.1 | 17.2 | 18.2 | 18.4 |
| | Run 5 | | 0.5 | 10.7 | 9.8 | 10.3 | | 1.2 | 15.8 | 15.2 | 15.7 |
| | Run 6 | | 0.7 | 15.0 | 14.9 | 15.0 | | 1.3 | 22.1 | 22.2 | 22.3 |
| | Run 7 | | 0.8 | 15.7 | 15.2 | 15.6 | | 1.6 | 23.7 | 23.7 | 24.0 |
| | Run 8 | | 0.6 | 10.6 | 9.8 | 10.2 | | 1.0 | 13.4 | 12.6 | 13.0 |
| | Run 9 | | 1.0 | 8.4 | 8.5 | 8.6 | | 1.8 | 12.1 | 12.4 | 12.5 |
| | Run 10 | | 0.1 | 7.4 | 7.7 | 7.5 | | 0.2 | 9.6 | 9.9 | 9.7 |
| | Run 11 | | 2.0 | 14.8 | 15.0 | 15.2 | | 3.1 | 19.8 | 20.3 | 20.5 |
| | Run 12 | | 0.2 | 11.8 | 12.1 | 12.0 | | 0.3 | 14.5 | 14.8 | 14.7 |
| | Run 13 | | 0.4 | 3.9 | 4.3 | 4.4 | | 1.2 | 7.5 | 8.5 | 8.6 |
| | Run 14 | | 0.1 | 5.8 | 4.5 | 5.0 | | 0.2 | 9.8 | 8.0 | 8.6 |
| | Run 15 | | 2.1 | 14.6 | 16.5 | 16.7 | | 4.0 | 20.6 | 23.5 | 23.8 |
| | Run 16 | | 0.4 | 19.7 | 16.0 | 17.4 | | 0.8 | 23.3 | 19.7 | 21.1 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 0.5 | 22.1 | 21.1 | 20.0 | 0.0 | 1.0 | 30.2 | 29.6 | 28.5 |
| | Run 1 | 0.0 | 0.8 | 28.6 | 27.5 | 26.3 | 0.0 | 1.3 | 37.7 | 37.1 | 35.9 |
| | Run 2 | 0.0 | 0.3 | 13.7 | 13.0 | 12.0 | 0.0 | 0.6 | 20.4 | 19.8 | 18.7 |
| | Run 3 | 0.0 | 0.2 | 19.3 | 18.9 | 15.5 | 0.0 | 0.3 | 22.8 | 22.2 | 18.8 |
| | Run 4 | 0.0 | 1.2 | 18.1 | 18.0 | 17.2 | 0.0 | 1.9 | 23.7 | 23.9 | 23.1 |
| | Run 5 | 0.0 | 0.7 | 25.7 | 24.2 | 22.1 | 0.0 | 1.1 | 33.4 | 31.8 | 29.5 |
| | Run 6 | 0.0 | 0.5 | 17.2 | 17.3 | 16.2 | 0.0 | 1.0 | 24.2 | 24.6 | 23.4 |
| | Run 7 | 0.0 | 0.5 | 22.1 | 21.1 | 20.0 | 0.0 | 1.0 | 30.2 | 29.6 | 28.5 |
| | Run 8 | 0.0 | 0.5 | 17.8 | 16.3 | 15.2 | 0.0 | 0.7 | 21.0 | 19.6 | 18.4 |
| | Run 9 | 0.0 | 0.8 | 10.2 | 10.1 | 9.8 | 0.0 | 1.4 | 14.1 | 14.1 | 13.8 |
| | Run 10 | 0.0 | 0.1 | 9.0 | 11.1 | 7.9 | 0.0 | 0.1 | 11.5 | 13.5 | 10.3 |
| | Run 11 | 0.0 | 1.5 | 17.3 | 17.3 | 16.9 | 0.0 | 2.4 | 22.4 | 22.6 | 22.2 |
| | Run 12 | 0.0 | 0.2 | 14.2 | 16.0 | 12.9 | 0.0 | 0.3 | 16.9 | 18.8 | 15.7 |
| | Run 13 | 0.0 | 0.4 | 10.6 | 10.8 | 9.9 | 0.0 | 0.9 | 17.1 | 17.4 | 16.2 |
| | Run 14 | 0.0 | 0.1 | 14.1 | 12.7 | 10.4 | 0.0 | 0.1 | 22.1 | 19.6 | 16.9 |
| | Run 15 | 0.0 | 2.7 | 32.9 | 33.4 | 31.2 | 0.0 | 3.4 | 40.0 | 40.8 | 38.6 |
| | Run 16 | 0.0 | 0.6 | 43.0 | 37.5 | 33.9 | 0.0 | 0.8 | 48.5 | 42.8 | 39.0 |
| Monitoring Location at 15.5 miles | Run 0 | 0.0 | 1.8 | 31.7 | 35.8 | 32.9 | 0.0 | 2.6 | 40.3 | 44.8 | 42.0 |
| | Run 1 | 0.1 | 2.8 | 39.6 | 44.1 | 41.3 | 0.1 | 3.6 | 48.9 | 53.9 | 51.1 |
| | Run 2 | 0.0 | 0.7 | 21.0 | 24.4 | 21.2 | 0.0 | 1.3 | 28.6 | 32.4 | 29.3 |
| | Run 3 | 0.0 | 0.6 | 28.8 | 39.1 | 25.7 | 0.0 | 0.9 | 33.1 | 43.5 | 30.2 |
| | Run 4 | 0.1 | 4.0 | 27.7 | 31.2 | 30.8 | 0.2 | 5.4 | 33.9 | 37.8 | 37.4 |
| | Run 5 | 0.1 | 4.8 | 48.9 | 56.6 | 55.2 | 0.2 | 7.6 | 60.4 | 69.5 | 68.1 |
| | Run 6 | 0.0 | 0.7 | 20.3 | 23.9 | 19.4 | 0.0 | 1.2 | 27.4 | 31.2 | 26.8 |
| | Run 7 | 0.0 | 1.8 | 31.7 | 35.8 | 32.9 | 0.1 | 2.6 | 40.3 | 44.8 | 42.0 |
| | Run 8 | 0.0 | 1.7 | 27.8 | 31.8 | 28.9 | 0.0 | 2.2 | 31.8 | 36.0 | 33.2 |
| | Run 9 | 0.0 | 1.0 | 13.2 | 14.7 | 13.7 | 0.1 | 1.6 | 17.2 | 18.8 | 17.9 |
| | Run 10 | 0.0 | 0.1 | 11.4 | 20.1 | 9.2 | 0.0 | 0.2 | 14.1 | 22.9 | 11.8 |
| | Run 11 | 0.1 | 2.2 | 21.1 | 23.0 | 22.1 | 0.2 | 3.1 | 26.3 | 28.3 | 27.5 |
| | Run 12 | 0.0 | 0.3 | 17.3 | 26.2 | 15.4 | 0.0 | 0.4 | 20.0 | 29.0 | 18.3 |
| | Run 13 | 0.1 | 2.4 | 23.2 | 27.8 | 27.4 | 0.2 | 5.5 | 34.2 | 40.4 | 39.9 |
| | Run 14 | 0.0 | 0.3 | 27.5 | 35.3 | 26.1 | 0.0 | 0.8 | 40.5 | 49.3 | 39.9 |
| | Run 15 | 0.8 | 19.1 | 62.3 | 72.5 | 72.0 | 1.3 | 22.3 | 71.1 | 82.1 | 81.6 |
| | Run 16 | 0.0 | 4.5 | 74.5 | 86.1 | 77.3 | 0.1 | 5.6 | 82.2 | 94.5 | 85.9 |
| Monitoring Location at 30.5 miles | Run 0 | 0.2 | 3.6 | 136.1 | 249.3 | 108.7 | 0.3 | 4.5 | 147.8 | 261.0 | 120.8 |
| | Run 1 | 0.4 | 5.1 | 152.7 | 265.9 | 126.4 | 0.5 | 6.0 | 163.6 | 276.9 | 137.8 |
| | Run 2 | 0.1 | 2.0 | 110.4 | 223.7 | 82.5 | 0.1 | 2.7 | 124.5 | 237.7 | 96.5 |
| | Run 3 | 0.0 | 1.4 | 119.1 | 313.3 | 73.1 | 0.0 | 1.8 | 128.0 | 322.0 | 82.1 |
| | Run 4 | 1.1 | 6.6 | 142.0 | 202.7 | 130.8 | 1.4 | 7.7 | 151.9 | 212.6 | 141.0 |
| | Run 5 | 1.6 | 12.7 | 354.8 | 537.0 | 318.9 | 2.2 | 15.9 | 390.9 | 573.4 | 356.3 |
| | Run 6 | 0.0 | 1.0 | 50.9 | 115.3 | 35.3 | 0.0 | 1.4 | 58.4 | 122.9 | 43.0 |
| | Run 7 | 0.2 | 3.6 | 136.1 | 249.3 | 108.7 | 0.3 | 4.5 | 147.8 | 261.0 | 120.8 |
| | Run 8 | 0.2 | 3.5 | 134.4 | 247.6 | 107.2 | 0.3 | 4.3 | 142.9 | 256.1 | 116.3 |
| | Run 9 | 0.1 | 1.3 | 46.8 | 84.5 | 37.6 | 0.1 | 1.8 | 51.9 | 89.6 | 42.7 |
| | Run 10 | 0.0 | 0.2 | 32.8 | 130.1 | 14.8 | 0.0 | 0.2 | 37.2 | 134.5 | 18.2 |
| | Run 11 | 0.3 | 2.7 | 60.0 | 97.8 | 51.6 | 0.4 | 3.3 | 65.8 | 103.6 | 57.6 |
| | Run 12 | 0.0 | 0.4 | 43.8 | 141.3 | 25.9 | 0.0 | 0.6 | 46.9 | 144.5 | 29.5 |
| | Run 13 | 3.1 | 13.5 | 281.1 | 369.9 | 272.5 | 4.6 | 17.1 | 318.4 | 407.6 | 310.9 |
| | Run 14 | 0.1 | 2.7 | 242.0 | 586.0 | 165.3 | 0.1 | 3.9 | 284.9 | 628.6 | 203.0 |
| | Run 15 | 10.5 | 29.7 | 422.5 | 512.2 | 416.9 | 12.0 | 32.5 | 442.9 | 532.8 | 437.6 |
| | Run 16 | 0.6 | 10.5 | 402.2 | 745.1 | 320.1 | 0.7 | 12.6 | 424.3 | 767.2 | 343.9 |

**Table 6-25. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #2 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 10.1 | 10.1 | 10.1 | | | 17.7 | 17.7 | 17.7 |
| | Run 1 | | | 15.8 | 15.8 | 15.8 | | | 25.0 | 25.0 | 25.0 |
| | Run 2 | | | 4.1 | 4.1 | 4.1 | | | 9.1 | 9.1 | 9.1 |
| | Run 3 | | | 6.4 | 6.6 | 6.6 | | | 8.9 | 9.4 | 9.4 |
| | Run 4 | | | 8.2 | 8.2 | 8.2 | | | 13.6 | 13.6 | 13.6 |
| | Run 5 | | | 2.9 | 2.9 | 2.9 | | | 5.6 | 5.7 | 5.7 |
| | Run 6 | | | 12.2 | 12.2 | 12.2 | | | 19.3 | 19.3 | 19.3 |
| | Run 7 | | | 10.1 | 10.1 | 10.1 | | | 17.7 | 17.7 | 17.7 |
| | Run 8 | | | 5.9 | 6.0 | 6.0 | | | 8.2 | 8.3 | 8.3 |
| | Run 9 | | | 6.1 | 6.1 | 6.1 | | | 9.9 | 9.9 | 9.9 |
| | Run 10 | | | 4.9 | 5.0 | 5.0 | | | 7.1 | 7.3 | 7.3 |
| | Run 11 | | | 13.3 | 13.3 | 13.3 | | | 18.6 | 18.7 | 18.7 |
| | Run 12 | | | 9.5 | 9.9 | 9.9 | | | 12.0 | 12.3 | 12.4 |
| | Run 13 | | | 0.7 | 0.7 | 0.7 | | | 2.5 | 2.5 | 2.5 |
| | Run 14 | | | 0.6 | 0.6 | 0.6 | | | 1.9 | 2.0 | 2.0 |
| | Run 15 | | | 8.8 | 8.8 | 8.8 | | | 15.2 | 15.2 | 15.2 |
| | Run 16 | | | 6.9 | 7.3 | 7.3 | | | 9.7 | 10.3 | 10.3 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.5 | 12.2 | 11.8 | 11.7 | | 1.2 | 19.5 | 19.6 | 19.4 |
| | Run 1 | | 0.9 | 18.2 | 18.0 | 17.8 | | 1.7 | 27.0 | 27.3 | 27.1 |
| | Run 2 | | 0.2 | 5.4 | 5.1 | 5.0 | | 0.6 | 10.5 | 10.3 | 10.2 |
| | Run 3 | | 0.2 | 10.2 | 8.6 | 8.3 | | 0.3 | 13.2 | 11.6 | 11.3 |
| | Run 4 | | 1.1 | 9.3 | 9.8 | 9.7 | | 2.3 | 14.3 | 15.3 | 15.2 |
| | Run 5 | | 0.3 | 6.8 | 6.6 | 6.4 | | 0.7 | 10.8 | 10.9 | 10.6 |
| | Run 6 | | 0.6 | 13.2 | 12.8 | 12.7 | | 1.1 | 20.1 | 19.8 | 19.7 |
| | Run 7 | | 0.5 | 12.2 | 11.8 | 11.7 | | 1.2 | 19.5 | 19.6 | 19.4 |
| | Run 8 | | 0.4 | 8.6 | 8.0 | 7.9 | | 0.7 | 11.2 | 10.7 | 10.5 |
| | Run 9 | | 0.7 | 6.5 | 6.6 | 6.5 | | 1.4 | 10.2 | 10.4 | 10.3 |
| | Run 10 | | 0.1 | 6.1 | 5.7 | 5.3 | | 0.2 | 8.4 | 8.0 | 7.6 |
| | Run 11 | | 1.7 | 13.7 | 14.0 | 14.0 | | 2.8 | 18.9 | 19.4 | 19.4 |
| | Run 12 | | 0.2 | 11.2 | 10.8 | 10.5 | | 0.3 | 13.7 | 13.3 | 13.0 |
| | Run 13 | | 0.1 | 1.2 | 1.4 | 1.4 | | 0.4 | 3.4 | 4.0 | 3.9 |
| | Run 14 | | 0.0 | 2.1 | 1.5 | 1.4 | | 0.1 | 5.1 | 4.0 | 3.8 |
| | Run 15 | | 1.5 | 11.7 | 13.7 | 13.5 | | 3.2 | 17.3 | 20.2 | 20.1 |
| | Run 16 | | 0.3 | 16.7 | 14.3 | 13.6 | | 0.6 | 20.7 | 18.3 | 17.6 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 0.5 | 17.0 | 15.1 | 14.8 | 0.0 | 0.9 | 24.7 | 23.0 | 22.8 |
| | Run 1 | 0.0 | 0.9 | 24.3 | 22.1 | 22.0 | 0.0 | 1.4 | 33.2 | 31.4 | 31.3 |
| | Run 2 | 0.0 | 0.2 | 8.3 | 6.9 | 6.6 | 0.0 | 0.4 | 14.1 | 12.6 | 12.3 |
| | Run 3 | 0.0 | 0.2 | 16.6 | 12.1 | 10.8 | 0.0 | 0.3 | 20.4 | 15.7 | 14.3 |
| | Run 4 | 0.0 | 1.1 | 13.6 | 13.1 | 13.1 | 0.0 | 1.9 | 19.0 | 18.8 | 18.9 |
| | Run 5 | 0.0 | 0.6 | 15.1 | 13.4 | 13.3 | 0.0 | 1.2 | 22.3 | 20.1 | 20.0 |
| | Run 6 | 0.0 | 0.5 | 15.2 | 13.9 | 13.4 | 0.0 | 0.9 | 22.2 | 21.0 | 20.5 |
| | Run 7 | 0.0 | 0.5 | 17.0 | 15.1 | 14.8 | 0.0 | 0.9 | 24.7 | 23.0 | 22.8 |
| | Run 8 | 0.0 | 0.5 | 13.9 | 11.6 | 11.4 | 0.0 | 0.7 | 17.2 | 14.8 | 14.7 |
| | Run 9 | 0.0 | 0.6 | 7.9 | 7.5 | 7.4 | 0.0 | 1.1 | 11.7 | 11.3 | 11.3 |
| | Run 10 | 0.0 | 0.1 | 8.0 | 6.9 | 5.5 | 0.0 | 0.1 | 10.7 | 9.4 | 7.9 |
| | Run 11 | 0.0 | 1.4 | 15.8 | 15.4 | 15.4 | 0.0 | 2.3 | 21.0 | 20.8 | 20.8 |
| | Run 12 | 0.0 | 0.2 | 14.1 | 12.6 | 11.2 | 0.0 | 0.3 | 16.6 | 15.2 | 13.8 |
| | Run 13 | 0.0 | 0.2 | 3.2 | 3.1 | 3.1 | 0.0 | 0.6 | 7.5 | 7.4 | 7.3 |
| | Run 14 | 0.0 | 0.0 | 5.1 | 3.2 | 2.7 | 0.0 | 0.1 | 11.1 | 7.7 | 6.9 |
| | Run 15 | 0.0 | 3.6 | 24.4 | 24.1 | 23.9 | 0.0 | 4.7 | 31.3 | 31.4 | 31.2 |
| | Run 16 | 0.0 | 0.8 | 33.8 | 26.1 | 25.5 | 0.0 | 1.1 | 39.9 | 31.6 | 31.1 |
| Monitoring Location at 15.5 miles | Run 0 | 0.0 | 1.4 | 26.9 | 25.6 | 24.7 | 0.0 | 2.2 | 35.5 | 34.5 | 33.7 |
| | Run 1 | 0.0 | 2.4 | 36.4 | 35.3 | 34.8 | 0.0 | 3.2 | 45.7 | 45.0 | 44.6 |
| | Run 2 | 0.0 | 0.4 | 14.7 | 13.2 | 11.8 | 0.0 | 0.9 | 22.1 | 20.8 | 19.5 |
| | Run 3 | 0.0 | 0.6 | 28.4 | 24.2 | 17.6 | 0.0 | 0.8 | 33.4 | 29.1 | 22.6 |
| | Run 4 | 0.1 | 3.0 | 22.8 | 23.5 | 24.3 | 0.1 | 4.3 | 29.2 | 30.2 | 31.1 |
| | Run 5 | 0.0 | 2.5 | 33.1 | 33.8 | 34.7 | 0.0 | 4.9 | 46.1 | 47.4 | 49.1 |
| | Run 6 | 0.0 | 0.7 | 19.4 | 18.1 | 15.8 | 0.0 | 1.1 | 26.4 | 25.3 | 23.1 |
| | Run 7 | 0.0 | 1.4 | 26.9 | 25.6 | 24.7 | 0.0 | 2.2 | 35.5 | 34.5 | 33.7 |
| | Run 8 | 0.0 | 1.4 | 24.3 | 22.8 | 22.0 | 0.0 | 1.9 | 28.8 | 27.4 | 26.7 |
| | Run 9 | 0.0 | 0.7 | 11.0 | 10.7 | 10.3 | 0.0 | 1.3 | 15.0 | 14.8 | 14.5 |
| | Run 10 | 0.0 | 0.1 | 11.6 | 11.5 | 6.1 | 0.0 | 0.2 | 14.7 | 14.6 | 8.8 |
| | Run 11 | 0.1 | 2.0 | 20.2 | 20.1 | 20.0 | 0.1 | 3.0 | 25.5 | 25.6 | 25.6 |
| | Run 12 | 0.0 | 0.3 | 19.0 | 18.9 | 13.4 | 0.0 | 0.4 | 21.6 | 21.5 | 16.2 |
| | Run 13 | 0.0 | 0.6 | 8.4 | 8.9 | 9.2 | 0.0 | 2.0 | 17.6 | 18.7 | 19.5 |
| | Run 14 | 0.0 | 0.1 | 12.3 | 9.4 | 6.4 | 0.0 | 0.4 | 24.0 | 20.0 | 15.9 |
| | Run 15 | 0.2 | 14.2 | 52.4 | 55.4 | 57.7 | 0.2 | 17.6 | 62.3 | 65.9 | 68.4 |
| | Run 16 | 0.0 | 3.6 | 66.2 | 61.5 | 58.9 | 0.0 | 4.8 | 76.0 | 71.4 | 69.5 |
| Monitoring Location at 30.5 miles | Run 0 | 0.2 | 2.8 | 104.8 | 93.7 | 69.3 | 0.3 | 3.8 | 117.7 | 106.7 | 82.7 |
| | Run 1 | 0.3 | 4.5 | 124.7 | 113.6 | 90.8 | 0.4 | 5.4 | 136.5 | 125.4 | 103.2 |
| | Run 2 | 0.1 | 1.2 | 74.2 | 63.7 | 39.6 | 0.1 | 1.9 | 90.4 | 79.5 | 54.7 |
| | Run 3 | 0.0 | 1.3 | 114.1 | 101.7 | 43.7 | 0.0 | 1.8 | 125.2 | 112.5 | 53.7 |
| | Run 4 | 0.8 | 4.5 | 92.9 | 88.5 | 83.8 | 1.1 | 5.7 | 104.2 | 99.8 | 95.5 |
| | Run 5 | 0.9 | 6.6 | 193.6 | 180.3 | 162.8 | 1.5 | 9.7 | 236.1 | 223.0 | 207.3 |
| | Run 6 | 0.0 | 1.0 | 49.6 | 45.4 | 25.5 | 0.0 | 1.4 | 57.3 | 53.1 | 33.4 |
| | Run 7 | 0.2 | 2.8 | 104.8 | 93.7 | 69.3 | 0.3 | 3.8 | 117.7 | 106.7 | 82.7 |
| | Run 8 | 0.2 | 2.8 | 103.6 | 92.5 | 68.3 | 0.2 | 3.6 | 113.9 | 102.8 | 79.2 |
| | Run 9 | 0.1 | 1.0 | 36.0 | 32.3 | 24.1 | 0.1 | 1.4 | 41.4 | 37.7 | 29.6 |
| | Run 10 | 0.0 | 0.2 | 37.0 | 42.4 | 8.8 | 0.0 | 0.3 | 42.3 | 47.6 | 12.1 |
| | Run 11 | 0.3 | 2.5 | 51.3 | 47.6 | 40.5 | 0.4 | 3.2 | 57.3 | 53.7 | 46.7 |
| | Run 12 | 0.0 | 0.5 | 50.9 | 56.4 | 21.2 | 0.0 | 0.6 | 54.2 | 59.8 | 25.1 |
| | Run 13 | 0.9 | 3.8 | 90.3 | 86.8 | 85.7 | 1.9 | 6.4 | 128.8 | 125.5 | 125.8 |
| | Run 14 | 0.0 | 1.1 | 120.4 | 94.4 | 42.2 | 0.1 | 2.0 | 167.8 | 138.2 | 73.5 |
| | Run 15 | 7.4 | 19.0 | 252.1 | 249.4 | 253.3 | 9.2 | 22.3 | 277.0 | 274.4 | 278.8 |
| | Run 16 | 0.5 | 8.3 | 310.1 | 276.6 | 203.6 | 0.7 | 10.6 | 337.9 | 304.2 | 233.3 |

**Table 6-26. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #2 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 4.6 | 5.2 | 5.2 | | | 10.2 | 10.9 | 10.9 |
| | Run 1 | | | 11.2 | 11.8 | 11.8 | | | 19.3 | 19.9 | 19.9 |
| | Run 2 | | | 0.9 | 1.2 | 1.2 | | | 2.5 | 3.0 | 3.0 |
| | Run 3 | | | 4.5 | 5.7 | 5.8 | | | 7.7 | 9.5 | 9.5 |
| | Run 4 | | | 5.3 | 5.6 | 5.6 | | | 10.6 | 10.9 | 10.9 |
| | Run 5 | | | 0.8 | 1.2 | 1.2 | | | 2.2 | 3.1 | 3.1 |
| | Run 6 | | | 11.1 | 11.3 | 11.3 | | | 18.1 | 18.3 | 18.4 |
| | Run 7 | | | 6.9 | 7.2 | 7.2 | | | 14.4 | 14.8 | 14.8 |
| | Run 8 | | | 4.0 | 4.7 | 4.7 | | | 6.7 | 7.7 | 7.7 |
| | Run 9 | | | 4.0 | 4.1 | 4.1 | | | 7.6 | 7.7 | 7.7 |
| | Run 10 | | | 3.5 | 4.3 | 4.3 | | | 6.0 | 7.1 | 7.1 |
| | Run 11 | | | 13.9 | 14.1 | 14.1 | | | 19.9 | 20.1 | 20.1 |
| | Run 12 | | | 10.4 | 11.9 | 11.9 | | | 13.0 | 14.6 | 14.6 |
| | Run 13 | | | 0.0 | 0.1 | 0.1 | | | 0.4 | 0.5 | 0.5 |
| | Run 14 | | | 0.0 | 0.1 | 0.1 | | | 0.3 | 0.6 | 0.6 |
| | Run 15 | | | 4.5 | 4.9 | 4.9 | | | 8.9 | 9.4 | 9.4 |
| | Run 16 | | | 4.2 | 6.0 | 6.0 | | | 6.9 | 9.7 | 9.7 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.2 | 8.5 | 8.1 | 8.9 | | 0.5 | 14.4 | 14.0 | 14.9 |
| | Run 1 | | 0.5 | 16.7 | 15.6 | 16.8 | | 1.0 | 24.2 | 23.6 | 24.8 |
| | Run 2 | | 0.0 | 1.7 | 2.4 | 2.7 | | 0.1 | 4.6 | 5.0 | 5.5 |
| | Run 3 | | 0.1 | 8.3 | 9.6 | 9.8 | | 0.2 | 13.4 | 13.9 | 14.4 |
| | Run 4 | | 0.5 | 7.2 | 7.7 | 8.1 | | 1.2 | 12.1 | 13.1 | 13.5 |
| | Run 5 | | 0.0 | 3.8 | 4.4 | 5.0 | | 0.2 | 8.4 | 8.4 | 9.4 |
| | Run 6 | | 0.3 | 12.1 | 12.5 | 12.5 | | 0.6 | 18.9 | 19.5 | 19.5 |
| | Run 7 | | 0.2 | 9.9 | 9.8 | 10.6 | | 0.6 | 17.5 | 17.6 | 18.4 |
| | Run 8 | | 0.2 | 8.1 | 7.6 | 8.4 | | 0.4 | 12.1 | 11.2 | 12.2 |
| | Run 9 | | 0.3 | 4.5 | 4.8 | 4.9 | | 0.7 | 8.1 | 8.5 | 8.7 |
| | Run 10 | | 0.0 | 3.6 | 6.1 | 4.9 | | 0.1 | 6.5 | 9.1 | 7.8 |
| | Run 11 | | 1.3 | 14.8 | 15.1 | 15.5 | | 2.1 | 20.3 | 21.1 | 21.4 |
| | Run 12 | | 0.1 | 12.3 | 14.4 | 13.3 | | 0.2 | 14.9 | 17.1 | 16.1 |
| | Run 13 | | 0.0 | 0.1 | 0.3 | 0.3 | | 0.0 | 0.7 | 1.3 | 1.4 |
| | Run 14 | | 0.0 | 0.1 | 0.6 | 0.6 | | 0.0 | 0.8 | 2.2 | 2.4 |
| | Run 15 | | 0.4 | 8.2 | 9.7 | 10.1 | | 0.8 | 12.2 | 14.6 | 15.0 |
| | Run 16 | | 0.1 | 18.9 | 15.5 | 18.3 | | 0.2 | 26.1 | 21.2 | 24.7 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 0.6 | 20.4 | 22.8 | 17.9 | 0.1 | 1.2 | 27.8 | 30.3 | 25.3 |
| | Run 1 | 0.1 | 1.6 | 32.5 | 34.4 | 29.4 | 0.3 | 2.1 | 39.5 | 42.4 | 37.4 |
| | Run 2 | 0.0 | 0.1 | 6.8 | 10.2 | 6.3 | 0.0 | 0.3 | 12.9 | 16.1 | 11.6 |
| | Run 3 | 0.0 | 0.2 | 19.0 | 32.1 | 16.1 | 0.0 | 0.4 | 27.4 | 39.2 | 22.5 |
| | Run 4 | 0.2 | 1.4 | 16.2 | 17.9 | 16.5 | 0.6 | 2.4 | 21.8 | 24.3 | 22.8 |
| | Run 5 | 0.0 | 0.5 | 18.3 | 21.2 | 17.7 | 0.1 | 1.4 | 30.9 | 34.0 | 29.8 |
| | Run 6 | 0.0 | 0.4 | 15.9 | 20.4 | 14.6 | 0.1 | 0.7 | 22.5 | 27.3 | 21.5 |
| | Run 7 | 0.1 | 0.7 | 21.2 | 23.9 | 19.0 | 0.2 | 1.5 | 29.9 | 33.0 | 28.1 |
| | Run 8 | 0.0 | 0.6 | 20.3 | 22.5 | 17.6 | 0.1 | 1.1 | 26.7 | 28.5 | 23.5 |
| | Run 9 | 0.1 | 0.4 | 7.7 | 9.0 | 7.4 | 0.2 | 0.8 | 11.4 | 13.0 | 11.4 |
| | Run 10 | 0.0 | 0.0 | 4.9 | 16.4 | 5.2 | 0.0 | 0.1 | 8.5 | 20.6 | 8.3 |
| | Run 11 | 0.4 | 1.7 | 19.1 | 20.8 | 19.3 | 0.7 | 2.3 | 24.1 | 26.5 | 25.1 |
| | Run 12 | 0.0 | 0.2 | 16.6 | 28.1 | 14.9 | 0.0 | 0.3 | 19.4 | 31.0 | 17.8 |
| | Run 13 | 0.0 | 0.0 | 1.8 | 2.5 | 1.9 | 0.0 | 0.2 | 5.4 | 7.0 | 6.0 |
| | Run 14 | 0.0 | 0.0 | 1.8 | 5.7 | 1.6 | 0.0 | 0.0 | 6.9 | 14.8 | 6.4 |
| | Run 15 | 0.3 | 4.5 | 27.8 | 32.4 | 29.6 | 0.9 | 6.1 | 33.8 | 39.3 | 36.3 |
| | Run 16 | 0.0 | 1.4 | 58.2 | 63.2 | 48.3 | 0.1 | 2.3 | 73.8 | 77.0 | 61.7 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.2 | 2.3 | 30.5 | 40.8 | 30.4 | 0.3 | 3.7 | 39.2 | 50.1 | 39.9 |
| | Run 1 | 0.4 | 5.0 | 45.1 | 56.2 | 46.4 | 0.6 | 6.1 | 52.3 | 64.3 | 54.9 |
| | Run 2 | 0.0 | 0.4 | 12.6 | 21.9 | 12.2 | 0.1 | 1.0 | 20.9 | 31.0 | 20.6 |
| | Run 3 | 0.0 | 0.7 | 27.6 | 59.6 | 23.9 | 0.1 | 1.3 | 37.9 | 69.4 | 32.4 |
| | Run 4 | 0.7 | 4.9 | 25.1 | 30.5 | 29.5 | 1.1 | 7.3 | 31.6 | 37.9 | 37.2 |
| | Run 5 | 0.3 | 3.2 | 35.3 | 45.0 | 40.0 | 0.6 | 7.3 | 53.4 | 66.0 | 62.0 |
| | Run 6 | 0.1 | 0.9 | 19.3 | 30.2 | 17.6 | 0.1 | 1.3 | 25.8 | 37.1 | 24.4 |
| | Run 7 | 0.2 | 2.3 | 31.1 | 41.6 | 31.2 | 0.4 | 4.0 | 40.9 | 52.2 | 42.0 |
| | Run 8 | 0.2 | 2.3 | 30.4 | 40.7 | 30.3 | 0.3 | 3.7 | 38.3 | 48.9 | 38.8 |
| | Run 9 | 0.1 | 0.8 | 10.9 | 14.6 | 11.1 | 0.2 | 1.5 | 14.8 | 18.9 | 15.5 |
| | Run 10 | 0.0 | 0.0 | 6.3 | 28.7 | 5.8 | 0.0 | 0.1 | 10.3 | 34.1 | 9.0 |
| | Run 11 | 0.5 | 3.2 | 23.1 | 27.8 | 24.9 | 0.8 | 4.1 | 28.0 | 33.3 | 30.6 |
| | Run 12 | 0.0 | 0.4 | 19.7 | 43.6 | 16.9 | 0.0 | 0.6 | 22.6 | 46.6 | 20.0 |
| | Run 13 | 0.2 | 0.5 | 6.0 | 8.1 | 7.3 | 0.5 | 1.9 | 13.5 | 17.9 | 17.2 |
| | Run 14 | 0.0 | 0.0 | 5.9 | 18.6 | 5.0 | 0.0 | 0.2 | 16.4 | 38.0 | 15.1 |
| | Run 15 | 2.4 | 20.2 | 49.2 | 60.3 | 60.8 | 3.6 | 25.8 | 57.4 | 69.6 | 70.3 |
| | Run 16 | 0.2 | 6.5 | 89.8 | 119.8 | 88.5 | 0.4 | 10.3 | 110.4 | 140.9 | 110.4 |
| Monitoring Location at 30.5 miles | Run 0 | 2.1 | 6.9 | 140.9 | 378.8 | 102.0 | 3.0 | 8.9 | 156.2 | 394.7 | 118.4 |
| | Run 1 | 4.0 | 10.8 | 168.5 | 407.4 | 132.9 | 5.0 | 12.3 | 178.0 | 417.5 | 144.6 |
| | Run 2 | 0.8 | 3.4 | 101.1 | 337.4 | 66.5 | 1.3 | 4.9 | 120.7 | 358.1 | 82.8 |
| | Run 3 | 0.3 | 2.6 | 108.5 | 489.8 | 59.0 | 0.5 | 3.7 | 127.5 | 509.4 | 72.7 |
| | Run 4 | 7.8 | 13.8 | 147.2 | 283.8 | 135.7 | 10.0 | 16.6 | 158.4 | 295.8 | 149.2 |
| | Run 5 | 11.6 | 24.7 | 353.9 | 759.2 | 304.8 | 16.6 | 32.2 | 399.5 | 808.0 | 356.8 |
| | Run 6 | 0.3 | 1.8 | 50.1 | 177.2 | 31.0 | 0.5 | 2.4 | 57.1 | 184.5 | 38.0 |
| | Run 7 | 2.1 | 6.9 | 141.0 | 378.9 | 102.1 | 3.0 | 8.9 | 157.0 | 395.5 | 119.1 |
| | Run 8 | 2.1 | 6.9 | 140.9 | 378.7 | 102.0 | 3.0 | 8.8 | 156.0 | 394.4 | 118.1 |
| | Run 9 | 0.7 | 2.3 | 47.2 | 126.5 | 34.2 | 1.1 | 3.0 | 52.9 | 132.4 | 40.3 |
| | Run 10 | 0.0 | 0.2 | 21.1 | 196.7 | 9.4 | 0.0 | 0.3 | 27.5 | 206.5 | 12.9 |
| | Run 11 | 2.3 | 5.1 | 64.8 | 145.0 | 54.6 | 2.9 | 6.0 | 69.7 | 150.2 | 60.3 |
| | Run 12 | 0.1 | 1.0 | 42.4 | 223.5 | 24.0 | 0.1 | 1.2 | 45.9 | 227.4 | 27.9 |
| | Run 13 | 16.4 | 27.2 | 263.5 | 477.7 | 261.5 | 24.1 | 36.6 | 299.6 | 517.4 | 304.9 |
| | Run 14 | 0.6 | 4.1 | 185.3 | 872.7 | 114.3 | 1.2 | 6.5 | 238.9 | 945.4 | 151.3 |
| | Run 15 | 57.6 | 74.2 | 398.4 | 624.0 | 421.5 | 66.9 | 84.0 | 417.2 | 643.7 | 442.7 |
| | Run 16 | 6.2 | 20.8 | 426.1 | 1146.8 | 308.2 | 8.7 | 26.4 | 470.2 | 1192.2 | 355.4 |

**Table 6-27. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #2 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | 2.1 | 2.2 | 2.2 | | | 5.3 | 5.4 | 5.4 |
| | Run 1 | | | 7.2 | 7.2 | 7.2 | | | 13.4 | 13.4 | 13.4 |
| | Run 2 | | | 0.2 | 0.2 | 0.2 | | | 0.9 | 0.9 | 0.9 |
| | Run 3 | | | 2.3 | 2.4 | 2.4 | | | 5.0 | 5.4 | 5.4 |
| | Run 4 | | | 2.6 | 2.6 | 2.6 | | | 6.2 | 6.2 | 6.2 |
| | Run 5 | | | 0.2 | 0.3 | 0.3 | | | 1.0 | 1.0 | 1.0 |
| | Run 6 | | | 7.5 | 7.4 | 7.4 | | | 13.6 | 13.6 | 13.6 |
| | Run 7 | | | 3.3 | 3.3 | 3.3 | | | 8.4 | 8.4 | 8.4 |
| | Run 8 | | | 2.1 | 2.2 | 2.2 | | | 4.5 | 4.6 | 4.6 |
| | Run 9 | | | 1.9 | 1.9 | 1.9 | | | 4.5 | 4.5 | 4.5 |
| | Run 10 | | | 1.5 | 1.7 | 1.7 | | | 3.4 | 3.8 | 3.8 |
| | Run 11 | | | 11.2 | 11.2 | 11.2 | | | 16.8 | 16.8 | 16.8 |
| | Run 12 | | | 8.8 | 9.5 | 9.5 | | | 11.2 | 12.2 | 12.2 |
| | Run 13 | | | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 |
| | Run 14 | | | 0.0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 |
| | Run 15 | | | 2.2 | 2.2 | 2.2 | | | 5.0 | 5.0 | 5.0 |
| | Run 16 | | | 2.7 | 2.9 | 2.9 | | | 5.3 | 5.8 | 5.8 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.1 | 5.1 | 4.4 | 4.1 | | 0.3 | 9.4 | 8.5 | 8.1 |
| | Run 1 | | 0.4 | 12.6 | 11.4 | 10.9 | | 0.7 | 18.7 | 17.8 | 17.3 |
| | Run 2 | | 0.0 | 0.5 | 0.6 | 0.5 | | 0.0 | 2.1 | 1.9 | 1.7 |
| | Run 3 | | 0.0 | 5.9 | 4.9 | 3.9 | | 0.1 | 10.8 | 9.0 | 7.7 |
| | Run 4 | | 0.2 | 3.9 | 4.4 | 4.2 | | 0.7 | 7.6 | 8.5 | 8.3 |
| | Run 5 | | 0.0 | 1.1 | 1.4 | 1.3 | | 0.1 | 3.7 | 4.2 | 3.9 |
| | Run 6 | | 0.2 | 9.2 | 8.6 | 8.1 | | 0.5 | 15.2 | 14.8 | 14.2 |
| | Run 7 | | 0.1 | 5.8 | 5.3 | 4.9 | | 0.4 | 11.6 | 11.1 | 10.7 |
| | Run 8 | | 0.1 | 5.1 | 4.4 | 4.1 | | 0.3 | 8.9 | 7.9 | 7.5 |
| | Run 9 | | 0.1 | 2.4 | 2.4 | 2.3 | | 0.4 | 5.2 | 5.2 | 5.1 |
| | Run 10 | | 0.0 | 2.0 | 2.9 | 1.9 | | 0.0 | 4.5 | 5.5 | 4.1 |
| | Run 11 | | 1.0 | 12.3 | 12.4 | 12.3 | | 1.8 | 17.5 | 18.0 | 17.9 |
| | Run 12 | | 0.1 | 11.7 | 12.3 | 10.5 | | 0.2 | 14.4 | 15.1 | 13.2 |
| | Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.2 | 0.2 |
| | Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.2 | 0.1 |
| | Run 15 | | 0.2 | 4.4 | 5.8 | 5.7 | | 0.5 | 7.5 | 9.6 | 9.4 |
| | Run 16 | | 0.1 | 13.1 | 10.2 | 9.2 | | 0.2 | 20.9 | 16.6 | 15.3 |
| Monitoring Location at 10.5 miles | Run 0 | 0.0 | 0.6 | 13.0 | 9.7 | 8.1 | 0.1 | 1.2 | 19.7 | 15.6 | 14.0 |
| | Run 1 | 0.1 | 1.8 | 25.3 | 20.4 | 19.1 | 0.3 | 2.5 | 31.9 | 27.4 | 26.2 |
| | Run 2 | 0.0 | 0.0 | 2.4 | 1.7 | 1.0 | 0.0 | 0.2 | 6.4 | 4.7 | 3.4 |
| | Run 3 | 0.0 | 0.2 | 14.9 | 11.2 | 6.0 | 0.0 | 0.5 | 23.8 | 17.8 | 11.3 |
| | Run 4 | 0.1 | 1.1 | 8.7 | 8.6 | 8.6 | 0.4 | 2.1 | 13.5 | 13.8 | 14.0 |
| | Run 5 | 0.0 | 0.2 | 5.2 | 4.7 | 4.1 | 0.0 | 0.9 | 12.6 | 11.8 | 11.4 |
| | Run 6 | 0.0 | 0.5 | 13.7 | 11.6 | 9.1 | 0.1 | 0.8 | 19.8 | 17.9 | 15.2 |
| | Run 7 | 0.0 | 0.6 | 13.3 | 10.2 | 8.6 | 0.2 | 1.4 | 21.1 | 17.6 | 15.9 |
| | Run 8 | 0.0 | 0.6 | 13.0 | 9.7 | 8.1 | 0.1 | 1.2 | 19.4 | 15.2 | 13.6 |
| | Run 9 | 0.1 | 0.3 | 4.7 | 3.9 | 3.3 | 0.2 | 0.6 | 7.9 | 7.1 | 6.5 |
| | Run 10 | 0.0 | 0.0 | 3.9 | 5.7 | 1.9 | 0.0 | 0.1 | 7.4 | 9.4 | 4.2 |
| | Run 11 | 0.4 | 1.7 | 16.1 | 15.4 | 15.0 | 0.8 | 2.4 | 20.9 | 20.8 | 20.5 |
| | Run 12 | 0.0 | 0.3 | 17.5 | 18.4 | 11.5 | 0.0 | 0.4 | 20.5 | 21.4 | 14.5 |
| | Run 13 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.6 | 0.7 | 0.7 |
| | Run 14 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 1.3 | 0.8 | 0.3 |
| | Run 15 | 0.1 | 3.5 | 13.4 | 15.0 | 15.5 | 0.5 | 5.6 | 18.9 | 21.1 | 21.9 |
| | Run 16 | 0.0 | 1.4 | 37.9 | 26.9 | 22.3 | 0.0 | 2.8 | 54.8 | 40.2 | 35.8 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.1 | 1.6 | 22.4 | 19.0 | 13.8 | 0.2 | 3.0 | 31.5 | 27.9 | 22.4 |
| | Run 1 | 0.3 | 4.5 | 39.3 | 35.7 | 30.4 | 0.5 | 5.7 | 46.7 | 43.6 | 38.6 |
| | Run 2 | 0.0 | 0.1 | 5.8 | 4.3 | 2.0 | 0.0 | 0.5 | 12.6 | 10.1 | 6.0 |
| | Run 3 | 0.0 | 0.6 | 25.0 | 22.9 | 8.9 | 0.0 | 1.3 | 37.2 | 33.4 | 16.0 |
| | Run 4 | 0.3 | 2.8 | 15.5 | 16.1 | 15.8 | 0.6 | 5.0 | 21.9 | 23.2 | 23.4 |
| | Run 5 | 0.0 | 0.9 | 12.9 | 11.9 | 9.8 | 0.2 | 3.1 | 26.5 | 26.2 | 24.3 |
| | Run 6 | 0.1 | 0.9 | 18.6 | 17.3 | 10.7 | 0.1 | 1.4 | 24.9 | 23.8 | 16.9 |
| | Run 7 | 0.1 | 1.6 | 22.6 | 19.4 | 14.1 | 0.3 | 3.1 | 32.5 | 29.3 | 23.7 |
| | Run 8 | 0.1 | 1.6 | 22.4 | 19.0 | 13.8 | 0.2 | 3.0 | 31.3 | 27.7 | 22.2 |
| | Run 9 | 0.1 | 0.6 | 7.7 | 6.8 | 5.0 | 0.2 | 1.2 | 11.5 | 10.6 | 8.7 |
| | Run 10 | 0.0 | 0.0 | 6.2 | 11.1 | 2.1 | 0.0 | 0.1 | 10.6 | 16.5 | 4.4 |
| | Run 11 | 0.5 | 3.0 | 20.9 | 20.6 | 19.1 | 0.8 | 3.9 | 25.6 | 25.9 | 24.5 |
| | Run 12 | 0.0 | 0.5 | 22.9 | 29.0 | 12.9 | 0.0 | 0.7 | 26.2 | 32.5 | 16.2 |
| | Run 13 | 0.0 | 0.0 | 0.5 | 0.5 | 0.4 | 0.0 | 0.2 | 2.3 | 2.5 | 2.4 |
| | Run 14 | 0.0 | 0.0 | 0.9 | 0.4 | 0.1 | 0.0 | 0.0 | 4.5 | 2.9 | 0.8 |
| | Run 15 | 0.6 | 10.6 | 27.7 | 31.3 | 33.1 | 1.2 | 16.1 | 36.9 | 41.4 | 43.7 |
| | Run 16 | 0.1 | 4.6 | 66.9 | 56.2 | 40.4 | 0.2 | 8.4 | 91.8 | 79.7 | 63.2 |
| Monitoring Location at 30.5 miles | Run 0 | 2.3 | 6.2 | 110.7 | 94.7 | 41.6 | 3.4 | 8.6 | 131.1 | 114.6 | 58.4 |
| | Run 1 | 4.9 | 11.3 | 148.5 | 132.0 | 75.7 | 6.2 | 13.4 | 160.7 | 144.5 | 89.1 |
| | Run 2 | 0.6 | 2.1 | 60.9 | 47.9 | 13.6 | 1.2 | 3.7 | 84.8 | 69.9 | 24.7 |
| | Run 3 | 0.4 | 2.8 | 109.9 | 117.5 | 22.0 | 0.7 | 4.4 | 136.1 | 143.5 | 33.6 |
| | Run 4 | 6.8 | 10.2 | 87.4 | 79.1 | 61.2 | 9.5 | 13.6 | 101.6 | 93.8 | 77.6 |
| | Run 5 | 7.1 | 12.0 | 155.8 | 130.0 | 77.8 | ## | 19.8 | 208.0 | 181.6 | 125.6 |
| | Run 6 | 0.4 | 2.2 | 54.6 | 56.9 | 17.2 | 0.6 | 2.9 | 62.5 | 65.0 | 23.8 |
| | Run 7 | 2.3 | 6.2 | 110.8 | 94.7 | 41.6 | 3.5 | 8.7 | 131.5 | 115.1 | 58.8 |
| | Run 8 | 2.2 | 6.2 | 110.7 | 94.7 | 41.6 | 3.4 | 8.6 | 131.0 | 114.6 | 58.4 |
| | Run 9 | 0.8 | 2.1 | 37.0 | 31.6 | 13.9 | 1.2 | 2.9 | 44.1 | 38.7 | 19.9 |
| | Run 10 | 0.0 | 0.3 | 25.3 | 54.6 | 3.7 | 0.0 | 0.5 | 33.9 | 67.1 | 6.2 |
| | Run 11 | 2.9 | 5.6 | 59.4 | 54.3 | 36.3 | 3.6 | 6.6 | 64.5 | 59.7 | 42.2 |
| | Run 12 | 0.1 | 1.4 | 55.0 | 92.3 | 17.4 | 0.2 | 1.6 | 59.5 | 97.4 | 21.5 |
| | Run 13 | 3.6 | 4.8 | 44.1 | 37.4 | 27.2 | 8.3 | 10.4 | 72.4 | 65.4 | 54.9 |
| | Run 14 | 0.2 | 1.1 | 59.7 | 38.3 | 6.3 | 0.6 | 2.7 | 109.7 | 79.1 | 16.9 |
| | Run 15 | ## | 47.4 | 178.9 | 176.7 | 178.8 | ## | 60.1 | 203.9 | 202.8 | 207.9 |
| | Run 16 | 6.7 | 18.6 | 335.2 | 286.5 | 125.7 | ## | 25.9 | 395.7 | 345.7 | 175.6 |

## 6.8 Simulated drawdowns from Well Fields Located in Potential Production Area #3

This section describes the construction and application of two groundwater models to simulated the drawdowns that would be created by pumping Potential Production Area #3 at two proposed well fields.

### *6.8.1 Construction of Groundwater Models based on GAM and GHSM properties*

The two groundwater models constructed to simulate pumping from PPA #3 are three-dimensional models with the same model layers and vertical grid discretization as shown in Figure 6-8. The width of the two models is along the geologic strike for the Carrizo-Wilcox Aquifer and is 100 miles. The length of the two models along dip is 83 miles. The recharge rate applied to the outcrop was a uniform 1.5 inches per year.

**Table 6-28** provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 15-mile reaches for both models. The model properties extracted from the Southern QCSP GAM and assigned to model layers 1 to 9. The values for vertical hydraulic conductivity (Kz) were determined by imposing ratio of Kx/Kz of 1,000 for all model layers except for the model layers that represent the Reklaw formation and the middle Wilcox Aquifer. The ratio of Kx/Kz for these two model layers was 10,000. In addition, adjustments to the Kx/Kz ratios for the middle Wilcox were made based on the degree of confinement provided by the clay layers contained within the middle Wilcox and present on geophysical logs. These adjustments allow the Kx/Kz ratio to vary between 1,000 and 100,000.

Table 6-8 also provides the values for Kx, Kx, and Ss that were produced by the GHSM for model Layers 5 to 9. **Figures 6-49** and **6-50** illustrate the values of Kx in Table 6-18. The two models have comparable Kx values for the Carrizo-upper Wilcox, but the GHSM-model has much lower Kx values for the lower Wilcox at large depths Among the most notable difference between the two sets of hydraulic properties for the Carrizo-Wilcox Aquifer is that the vertical hydraulic conductivity values and the specific storage values are significantly lower for the GMA-based properties than the GHSM-based properties.

### *6.8.2 Simulated Drawdown Produced by Pumping from Potential Production Area #3*

Groundwater pumping at the rate of 5,000 AFY, 15,000 AFY and 30,000 AFY was simulated at two well fields in PPA #3 shown in Figure 6-8. Both well fields pump model layer 8, which represents the middle third of the lower Wilcox Aquifer. The up dip well field #1 is located 31 miles down dip from the outcrop, and the down dip well field #2 is located 39 miles down dip from the outcrop. **Figures 6-51** and **6-52** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GAM-based hydraulic properties for the Carrizo-Wilcox aquifer. **Figures 6-53** and **6-54** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GHSM-based hydraulic properties for the Carrizo-Wilcox aquifer.

Among the notable results that can be observed in the plotted drawdown in Figures 6-51 to 6-54 are the following:

- The Reklaw provides as an effective hydraulic barrier that prevents appreciable drawdowns from migrating from the Carrizo-Wilcox Aquifer into the Queen City Aquifer
- The drawdown predicted in the Carrizo-Wilcox Aquifer outcrop is significantly higher from pumping Well Field #1 than from pumping Well Field #2
- There is significantly less predicted drawdown in down-dip of the well field in the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model
- There is less predicted drawdown in down-dip of the well field in the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model

To help to quantify the drawdown in areas of interest and at time of interest, drawdown values were recorded for all four model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 2.5 miles, 5.5 miles, 10.5 miles, 15.5 miles, and 30.5 miles. Table 6-29 provides the elevations and depths associated with these five monitoring locations.

**Table 6-28 Average values for Kx (feet per day), Kz (feet per day), and Ss(1/feet) by model layer for 15-mile reaches along dip for the groundwater models for PPA # 3**

**Common to Both GAM and GHSM based Groundwater Models for Cross-Section 3**

| Distance (miles) | Property | Layer 1 | Layer 2 | Layer 3 | Layer 4 |
|---|---|---|---|---|---|
| 0-15 | Kx | n/a | n/a | 2.5 | 1.0 |
| | Kz | n/a | n/a | 2.5E-03 | 1.0E-04 |
| | Ss | n/a | n/a | 5.5E-04 | 2.8E-05 |
| 15-30 | Kx | 1.77524962 | 1.23896884 | 1.44454073 | 1.0001 |
| | Kz | 1.8E-03 | 1.2E-03 | 1.5E-03 | 1.0E-04 |
| | Ss | 2.2E-03 | 1.7E-04 | 7.4E-05 | 4.8E-06 |
| 30-45 | Kx | 3.9 | 1.0 | 1.1 | 1.0 |
| | Kz | 3.9E-03 | 1.0E-03 | 1.1E-03 | 1.0E-04 |
| | Ss | 4.5E-06 | 7.2E-06 | 4.7E-06 | 3.3E-06 |
| 45-60 | Kx | 1.5 | 1.0 | 0.8 | 1.0 |
| | Kz | 1.5E-03 | 9.7E-04 | 8.3E-04 | 1.0E-04 |
| | Ss | 4.5E-06 | 5.7E-06 | 3.0E-06 | 2.2E-06 |
| 60-84 | Kx | 0.2 | 0.9 | 0.1 | 1.0 |
| | Kz | 1.8E-04 | 9.8E-04 | 1.5E-04 | 1.1E-04 |
| | Ss | 3.5E-06 | 3.6E-06 | 2.2E-06 | 1.4E-06 |

**Carrizo-Wilcox Aquifer Properties Extracted from the Southern QCSP GAM**

| Distance (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 19.7 | 5.0 | 4.1 | 6.4 | 6.4 |
| | Kz | 2.0E-02 | 2.3E-03 | 6.6E-03 | 1.0E-02 | 1.0E-02 |
| | Ss | 1.4E-05 | 1.9E-05 | 4.5E-06 | 3.0E-06 | 3.0E-06 |
| 15-30 | Kx | 41.11840131 | 1.95169999 | 2.57816925 | 2.99999999 | 2.99999999 |
| | Kz | 4.2E-02 | 3.6E-04 | 2.7E-03 | 3.1E-03 | 3.1E-03 |
| | Ss | 3.6E-06 | 3.2E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 30-45 | Kx | 31.2 | 1.6 | 3.0 | 3.0 | 3.0 |
| | Kz | 3.1E-02 | 9.0E-05 | 3.0E-03 | 3.0E-03 | 3.0E-03 |
| | Ss | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 45-60 | Kx | 14.1 | 1.4 | 1.4 | 1.4 | 1.4 |
| | Kz | 1.4E-02 | 4.7E-05 | 1.4E-03 | 1.4E-03 | 1.4E-03 |
| | Ss | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 60-84 | Kx | 4.0 | 0.4 | 1.0 | 1.0 | 1.0 |
| | Kz | 4.5E-03 | 6.7E-06 | 1.1E-03 | 1.1E-03 | 1.1E-03 |
| | Ss | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |

**Carrizo-Wilcox Aquifer Properties Developed from the GeoHydroStratigraphic Model (GHSM)**

| Distance (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 24.4 | 4.6 | 4.1 | 4.0 | 4.0 |
| | Kz | 2.9E-03 | 1.6E-03 | 3.7E-03 | 3.6E-03 | 3.6E-03 |
| | Ss | 3.7E-01 | 3.6E-01 | 3.6E-01 | 3.6E-01 | 3.6E-01 |
| 15-30 | Kx | 21.1 | 4.2 | 3.3 | 3.2 | 3.0 |
| | Kz | 2.9E-03 | 1.5E-03 | 2.1E-03 | 2.0E-03 | 1.9E-03 |
| | Ss | 3.4E-01 | 3.3E-01 | 3.2E-01 | 3.2E-01 | 3.2E-01 |
| 30-45 | Kx | 14.4 | 1.8 | 2.0 | 1.8 | 1.7 |
| | Kz | 1.7E-03 | 7.3E-04 | 1.1E-03 | 1.0E-03 | 9.3E-04 |
| | Ss | 3.1E-01 | 3.0E-01 | 3.0E-01 | 2.9E-01 | 2.9E-01 |
| 45-60 | Kx | 7.9 | 0.6 | 0.5 | 0.4 | 0.4 |
| | Kz | 8.4E-04 | 3.6E-04 | 3.6E-04 | 3.1E-04 | 2.7E-04 |
| | Ss | 2.8E-01 | 2.7E-01 | 2.6E-01 | 2.6E-01 | 2.5E-01 |
| 60-84 | Kx | 3.9 | 0.1 | 0.0 | 0.0 | 0.0 |
| | Kz | 4.5E-04 | 1.6E-04 | 1.2E-04 | 9.1E-05 | 6.9E-05 |
| | Ss | 2.5E-01 | 2.3E-01 | 2.2E-01 | 2.1E-01 | 2.0E-01 |

**Table 6-29. Locations where drawdowns were monitored for the simulated pumping at Well Field #1 and Well Field #2 in Potential Production Area #3.**

| Monitoring Location (miles) | Ground Surface (ft, msl) | Vertical Boundary | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|---|
| | | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 2.5 | 754.8 | Top | | 754.8 | 712.8 | 623.7 | 596.7 |
| | | Bottom | | 712.8 | 623.7 | 596.7 | 569 |
| 5.5 | 650.8 | Top | | 650.8 | 423.1 | 318.9 | 274.6 |
| | | Bottom | | 423.1 | 318.9 | 274.6 | 229 |
| 10.5 | 687.7 | Top | 487.6 | 159.6 | -66.5 | -196.2 | -269.7 |
| | | Bottom | 159.6 | -66.5 | -196.2 | -269.7 | -345.5 |
| 15.5 | 578.2 | Top | 73.2 | -311.3 | -548.8 | -703.6 | -805.9 |
| | | Bottom | -311.3 | -548.8 | -703.6 | -805.9 | -911.4 |
| 30.5 | 541.2 | Top | -1258.1 | -1824.5 | -2098.3 | -2333.7 | -2528.6 |
| | | Bottom | -1824.5 | -2098.3 | -2333.7 | -2528.6 | -2729.5 |

## Simulated Drawdown from the Groundwater Model with GAM-based Properties for the Carrizo-Wilcox Aquifer

**Tables 6-30** and **6-31** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-19 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GAM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-55** to **6-56** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-57** to **6-58** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-30 and 6-31 and Figures 6-55 through 6-58 are the following:

- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts about 9 to 11 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and 10 to 11 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts about 5 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 5 to 7 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 300 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 300 feet of drawdown at the Well Field #2

- After 30 years of pumping 15,000 AFY the drawdown, the groundwater model predicts a maximum drawdown of about 9 feet drawdown in the Carrizo Aquifer above the locations the pumping wells in the lower Wilcox

**Simulated Drawdown from the Groundwater Model with GHSM-based Properties for the Carrizo-Wilcox Aquifer**

**Tables 6-32** and **6-33** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-9 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GHSM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-59** to **6-60** shows the simulated drawdown along the center dip line of the groundwater model elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-61** to **6-62** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-32 and 6-33 and Figures 6-59 through 6-62 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts 5 to 6 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 6 to 9 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts about 2 feet of drawdown in the lower Wilcox at the 2.5 mile monitoring point location and between 3 to 4 feet in the lower Wilcox at the 5.5 monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 300 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 400 feet of drawdown at the Well Field #2
- After 30 years of pumping 15,000 AFY the drawdown, the groundwater model predicts a maximum drawdown of about 10 feet drawdown in the Carrizo Aquifer above the locations the pumping wells in the lower Wilcox

**Table 6-30. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #3 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.3 | 3.2 | 3.3 | 3.5 |
| | 15,000 | Not Present | 1.0 | 9.6 | 9.9 | 10.5 |
| | 30,000 | Not Present | 2.1 | 19.3 | 19.9 | 21.0 |
| 5.5 | 5,000 | Not Present | 0.2 | 3.4 | 3.8 | 3.9 |
| | 15,000 | Not Present | 0.6 | 10.1 | 11.4 | 11.6 |
| | 30,000 | Not Present | 1.3 | 20.2 | 22.8 | 23.3 |
| 10.5 | 5,000 | 0.9 | 2.8 | 4.9 | 6.9 | 6.2 |
| | 15,000 | 2.8 | 8.3 | 14.6 | 20.8 | 18.8 |
| | 30,000 | 5.7 | 16.5 | 29.3 | 41.7 | 37.6 |
| 15.5 | 5,000 | 1.5 | 2.9 | 12.5 | 12.9 | 14.0 |
| | 15,000 | 4.6 | 8.8 | 37.5 | 38.8 | 42.2 |
| | 30,000 | 9.2 | 17.6 | 74.8 | 77.7 | 84.4 |
| 30.5 | 5,000 | 2.3 | 8.5 | 70.1 | 98.6 | 36.3 |
| | 15,000 | 6.8 | 25.3 | 199.2 | 252.0 | 107.6 |
| | 30,000 | 13.6 | 49.8 | 373.1 | 443.2 | 210.3 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.7 | 4.9 | 5.0 | 5.2 |
| | 15,000 | Not Present | 2.1 | 14.6 | 15.0 | 15.6 |
| | 30,000 | Not Present | 4.1 | 29.3 | 30.2 | 31.2 |
| 5.5 | 5,000 | Not Present | 0.3 | 5.0 | 5.5 | 5.6 |
| | 15,000 | Not Present | 0.9 | 14.9 | 16.5 | 16.7 |
| | 30,000 | Not Present | 1.9 | 30.0 | 33.0 | 33.5 |
| 10.5 | 5,000 | 1.3 | 3.4 | 6.4 | 8.6 | 8.0 |
| | 15,000 | 3.8 | 10.2 | 19.2 | 25.9 | 23.9 |
| | 30,000 | 8.9 | 20.9 | 38.6 | 52.0 | 48.0 |
| 15.5 | 5,000 | 2.0 | 3.6 | 14.0 | 14.7 | 15.9 |
| | 15,000 | 6.1 | 10.9 | 41.9 | 44.1 | 47.7 |
| | 30,000 | 13.1 | 22.1 | 83.8 | 88.4 | 95.4 |
| 30.5 | 5,000 | 3.0 | 9.6 | 72.1 | 100.6 | 38.5 |
| | 15,000 | 9.0 | 28.5 | 205.2 | 258.0 | 114.1 |
| | 30,000 | 18.5 | 56.5 | 385.2 | 455.3 | 223.4 |

**Table 6-31. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #3 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.2 | 1.8 | 1.9 | 1.9 |
| | 15,000 | Not Present | 0.6 | 5.4 | 5.8 | 5.8 |
| | 30,000 | Not Present | 1.1 | 10.9 | 11.7 | 11.5 |
| 5.5 | 5,000 | Not Present | 0.2 | 1.9 | 2.2 | 2.3 |
| | 15,000 | Not Present | 0.6 | 5.8 | 6.6 | 7.0 |
| | 30,000 | Not Present | 1.1 | 11.6 | 13.2 | 14.1 |
| 10.5 | 5,000 | 0.9 | 2.1 | 2.7 | 3.7 | 3.8 |
| | 15,000 | 2.6 | 6.4 | 8.1 | 11.1 | 11.4 |
| | 30,000 | 5.2 | 12.7 | 16.2 | 22.2 | 22.9 |
| 15.5 | 5,000 | 1.5 | 2.3 | 6.4 | 7.7 | 7.1 |
| | 15,000 | 4.4 | 6.9 | 19.2 | 23.1 | 21.4 |
| | 30,000 | 8.8 | 13.7 | 38.4 | 46.3 | 42.8 |
| 30.5 | 5,000 | 2.3 | 8.5 | 30.1 | 26.1 | 20.5 |
| | 15,000 | 7.0 | 25.5 | 90.8 | 78.9 | 61.2 |
| | 30,000 | 13.9 | 50.4 | 180.2 | 157.3 | 122.0 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.4 | 3.1 | 3.2 | 3.2 |
| | 15,000 | Not Present | 1.3 | 9.2 | 9.7 | 9.6 |
| | 30,000 | Not Present | 2.5 | 18.5 | 19.5 | 19.4 |
| 5.5 | 5,000 | Not Present | 0.3 | 3.2 | 3.5 | 3.7 |
| | 15,000 | Not Present | 0.9 | 9.5 | 10.5 | 11.0 |
| | 30,000 | Not Present | 1.7 | 19.1 | 21.0 | 22.1 |
| 10.5 | 5,000 | 1.2 | 2.8 | 3.9 | 5.1 | 5.2 |
| | 15,000 | 3.6 | 8.4 | 11.8 | 15.3 | 15.7 |
| | 30,000 | 8.4 | 17.1 | 23.7 | 30.6 | 31.4 |
| 15.5 | 5,000 | 2.0 | 3.0 | 7.7 | 9.3 | 8.7 |
| | 15,000 | 6.0 | 9.0 | 23.3 | 27.9 | 26.2 |
| | 30,000 | 12.8 | 18.3 | 46.7 | 56.0 | 52.5 |
| 30.5 | 5,000 | 3.1 | 9.7 | 32.3 | 28.3 | 22.8 |
| | 15,000 | 9.4 | 29.1 | 97.4 | 85.4 | 68.2 |
| | 30,000 | 19.1 | 57.9 | 193.5 | 170.4 | 136.0 |

**Table 6-32. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #3 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.2 | 1.8 | 1.9 | 2.2 |
| | 15,000 | Not Present | 0.6 | 5.4 | 5.7 | 6.8 |
| | 30,000 | Not Present | 1.2 | 10.9 | 11.6 | 13.8 |
| 5.5 | 5,000 | Not Present | 0.3 | 2.3 | 2.8 | 3.0 |
| | 15,000 | Not Present | 0.9 | 6.8 | 8.6 | 8.9 |
| | 30,000 | Not Present | 1.9 | 13.8 | 17.3 | 18.1 |
| 10.5 | 5,000 | 1.3 | 1.5 | 4.1 | 5.2 | 4.9 |
| | 15,000 | 4.0 | 4.5 | 12.2 | 15.7 | 14.9 |
| | 30,000 | 8.1 | 8.9 | 24.5 | 31.8 | 30.1 |
| 15.5 | 5,000 | 2.4 | 2.8 | 6.7 | 8.2 | 8.5 |
| | 15,000 | 7.0 | 8.2 | 20.0 | 24.9 | 25.9 |
| | 30,000 | 14.1 | 16.4 | 40.0 | 50.4 | 52.3 |
| 30.5 | 5,000 | 4.9 | 9.7 | 49.8 | 95.3 | 23.1 |
| | 15,000 | 14.5 | 28.7 | 140.9 | 236.0 | 68.6 |
| | 30,000 | 28.6 | 56.0 | 261.0 | 398.6 | 134.2 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.4 | 3.1 | 3.2 | 3.5 |
| | 15,000 | Not Present | 1.2 | 9.3 | 9.7 | 10.7 |
| | 30,000 | Not Present | 2.6 | 18.8 | 19.6 | 21.7 |
| 5.5 | 5,000 | Not Present | 0.5 | 3.5 | 4.1 | 4.2 |
| | 15,000 | Not Present | 1.5 | 10.5 | 12.4 | 12.8 |
| | 30,000 | Not Present | 3.1 | 21.2 | 25.1 | 25.9 |
| 10.5 | 5,000 | 1.7 | 1.9 | 5.2 | 6.4 | 6.2 |
| | 15,000 | 4.9 | 5.7 | 15.5 | 19.4 | 18.7 |
| | 30,000 | 12.0 | 11.6 | 31.3 | 39.3 | 37.8 |
| 15.5 | 5,000 | 2.9 | 3.3 | 7.7 | 9.4 | 9.8 |
| | 15,000 | 8.5 | 10.0 | 23.2 | 28.6 | 29.7 |
| | 30,000 | 18.4 | 20.1 | 46.6 | 57.9 | 60.0 |
| 30.5 | 5,000 | 5.7 | 10.6 | 50.9 | 96.4 | 24.5 |
| | 15,000 | 16.9 | 31.4 | 144.2 | 239.4 | 73.0 |
| | 30,000 | 34.0 | 61.8 | 267.8 | 405.7 | 143.0 |

**Table 6-33. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #3 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| **30 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.1 | 0.8 | 0.9 | 0.9 |
| | 15,000 | Not Present | 0.4 | 2.3 | 2.7 | 2.5 |
| | 30,000 | Not Present | 0.7 | 4.7 | 5.5 | 5.1 |
| 5.5 | 5,000 | Not Present | 0.2 | 1.1 | 1.3 | 1.5 |
| | 15,000 | Not Present | 0.7 | 3.2 | 3.8 | 4.4 |
| | 30,000 | Not Present | 1.5 | 6.5 | 7.7 | 8.9 |
| 10.5 | 5,000 | 1.1 | 1.1 | 1.9 | 2.3 | 2.4 |
| | 15,000 | 3.4 | 3.3 | 5.8 | 6.8 | 7.1 |
| | 30,000 | 6.8 | 6.5 | 11.7 | 13.7 | 14.2 |
| 15.5 | 5,000 | 2.1 | 2.3 | 3.1 | 3.8 | 3.6 |
| | 15,000 | 6.2 | 6.9 | 9.4 | 11.5 | 10.8 |
| | 30,000 | 12.3 | 13.7 | 18.9 | 23.3 | 21.7 |
| 30.5 | 5,000 | 4.6 | 8.0 | 17.2 | 16.2 | 11.1 |
| | 15,000 | 13.9 | 24.1 | 52.0 | 49.1 | 33.0 |
| | 30,000 | 27.5 | 47.6 | 103.5 | 98.5 | 65.9 |
| **50 Years** | | | | | | |
| 2.5 | 5,000 | Not Present | 0.3 | 1.5 | 1.7 | 1.6 |
| | 15,000 | Not Present | 0.9 | 4.6 | 5.1 | 4.9 |
| | 30,000 | Not Present | 1.8 | 9.3 | 10.3 | 9.9 |
| 5.5 | 5,000 | Not Present | 0.4 | 1.9 | 2.1 | 2.3 |
| | 15,000 | Not Present | 1.2 | 5.5 | 6.3 | 7.0 |
| | 30,000 | Not Present | 2.5 | 11.2 | 12.6 | 14.0 |
| 10.5 | 5,000 | 1.5 | 1.5 | 2.8 | 3.2 | 3.3 |
| | 15,000 | 4.5 | 4.5 | 8.3 | 9.5 | 9.8 |
| | 30,000 | 10.4 | 9.0 | 16.8 | 19.1 | 19.9 |
| 15.5 | 5,000 | 2.6 | 2.9 | 4.1 | 4.9 | 4.6 |
| | 15,000 | 7.9 | 8.8 | 12.2 | 14.6 | 13.9 |
| | 30,000 | 16.6 | 17.7 | 24.5 | 29.4 | 28.0 |
| 30.5 | 5,000 | 5.6 | 9.1 | 18.5 | 17.5 | 12.7 |
| | 15,000 | 16.8 | 27.3 | 55.9 | 53.0 | 37.6 |
| | 30,000 | 33.5 | 54.2 | 111.4 | 106.4 | 75.3 |

### *6.8.3 Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #3*

Table 6-2 describes the changes in the model input parameter associated with set of sixteen sensitivity runs performed for the groundwater models simulations involving GAM-based and the GHSM-based aquifer properties. In this section, Model Run 0 refers to the baseline run of 15,000 AF for which simulated drawdowns are shown in Figures 6-27 to 6-34. **Tables 6-34** and **6-35** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-29** as determined by the groundwater model with GAM-based aquifer properties. **Tables 6-36** and **6-37** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-29** as determined by the groundwater model with GHSM-based aquifer properties.

Among the notable results that can be gleaned from a review of **Tables 6-34** through **6-37** are:

- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 1.5 and 20 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 and 17 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 2.5 mile monitoring location in the lower Wilcox the drawdown is between 0.5 and 16 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 5.5 mile monitoring location in the lower Wilcox the drawdown is between 0.5 and 18 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that 2.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 19 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that 5.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 20 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that 2.5 mile monitoring location in the lower Wilcox the drawdown is between less than 0.5 feet and 15. feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that 5.5 mile monitoring location in the lower Wilcox the drawdown between less than 0.5 feet and 15 feet.

**Table 6-34. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #3 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | 1.0 | 9.6 | 9.9 | 10.5 | | 2.1 | 14.6 | 15.0 | 15.6 |
| | Run 1 | | 1.4 | 12.3 | 12.7 | 13.3 | | 2.6 | 17.8 | 18.3 | 18.9 |
| | Run 2 | | 0.6 | 6.0 | 6.2 | 6.6 | | 1.3 | 10.2 | 10.5 | 10.9 |
| | Run 3 | | 0.5 | 11.7 | 11.9 | 12.6 | | 1.0 | 19.0 | 19.4 | 20.0 |
| | Run 4 | | 1.6 | 5.7 | 6.0 | 6.3 | | 2.8 | 8.1 | 8.5 | 8.8 |
| | Run 5 | | 0.8 | 6.1 | 6.6 | 7.4 | | 1.9 | 10.3 | 11.0 | 11.8 |
| | Run 6 | | 1.1 | 11.5 | 11.7 | 11.9 | | 1.9 | 16.9 | 17.1 | 17.3 |
| | Run 7 | | 1.2 | 9.7 | 10.0 | 10.5 | | 2.6 | 14.8 | 15.2 | 15.8 |
| | Run 8 | | 1.0 | 9.6 | 9.9 | 10.5 | | 2.1 | 14.6 | 15.0 | 15.6 |
| | Run 9 | | 1.2 | 5.5 | 5.7 | 5.8 | | 2.1 | 7.7 | 7.9 | 8.0 |
| | Run 10 | | 0.3 | 9.7 | 9.8 | 9.8 | | 0.7 | 15.7 | 15.9 | 15.8 |
| | Run 11 | | 2.2 | 8.9 | 9.1 | 9.3 | | 3.5 | 11.7 | 11.9 | 12.1 |
| | Run 12 | | 0.8 | 19.7 | 20.0 | 20.1 | | 1.5 | 31.0 | 31.3 | 31.5 |
| | Run 13 | | 0.4 | 1.6 | 1.8 | 2.0 | | 1.2 | 3.3 | 3.6 | 3.8 |
| | Run 14 | | 0.1 | 1.8 | 2.2 | 3.1 | | 0.2 | 3.5 | 3.9 | 5.2 |
| | Run 15 | | 1.6 | 4.7 | 5.1 | 5.5 | | 3.1 | 7.0 | 7.6 | 8.0 |
| | Run 16 | | 0.4 | 6.7 | 7.3 | 9.5 | | 0.8 | 9.9 | 10.5 | 12.7 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.6 | 10.1 | 11.4 | 11.6 | | 0.9 | 15.0 | 16.5 | 16.7 |
| | Run 1 | | 0.9 | 12.8 | 14.3 | 14.6 | | 1.2 | 18.2 | 19.9 | 20.1 |
| | Run 2 | | 0.4 | 6.3 | 7.4 | 7.5 | | 0.6 | 10.5 | 11.7 | 11.9 |
| | Run 3 | | 0.5 | 12.5 | 13.8 | 13.9 | | 0.7 | 19.8 | 21.2 | 21.4 |
| | Run 4 | | 0.8 | 6.1 | 7.0 | 7.0 | | 1.1 | 8.5 | 9.4 | 9.5 |
| | Run 5 | | 0.4 | 7.5 | 9.3 | 9.5 | | 0.6 | 11.6 | 13.8 | 14.0 |
| | Run 6 | | 0.9 | 11.7 | 12.3 | 12.3 | | 1.4 | 17.1 | 17.7 | 17.8 |
| | Run 7 | | 0.8 | 10.1 | 11.4 | 11.6 | | 1.4 | 15.2 | 16.7 | 16.9 |
| | Run 8 | | 0.6 | 10.1 | 11.4 | 11.6 | | 0.9 | 15.0 | 16.5 | 16.7 |
| | Run 9 | | 0.8 | 5.6 | 6.1 | 6.1 | | 1.3 | 7.7 | 8.3 | 8.4 |
| | Run 10 | | 0.3 | 9.9 | 10.5 | 10.0 | | 0.5 | 15.9 | 16.5 | 16.0 |
| | Run 11 | | 1.6 | 9.0 | 9.6 | 9.7 | | 2.4 | 11.7 | 12.4 | 12.5 |
| | Run 12 | | 0.8 | 20.1 | 20.9 | 20.6 | | 1.3 | 31.4 | 32.3 | 31.9 |
| | Run 13 | | 0.2 | 2.4 | 2.8 | 2.8 | | 0.4 | 4.2 | 4.7 | 4.8 |
| | Run 14 | | 0.1 | 2.7 | 4.7 | 5.0 | | 0.2 | 4.9 | 7.5 | 7.9 |
| | Run 15 | | 0.6 | 6.2 | 6.9 | 6.9 | | 0.8 | 8.5 | 9.3 | 9.4 |
| | Run 16 | | 0.6 | 9.3 | 12.9 | 13.7 | | 0.7 | 12.4 | 16.2 | 17.0 |
| Monitoring Location at 10.5 miles | Run 0 | 2.8 | 8.3 | 14.6 | 20.8 | 18.8 | 3.8 | 10.2 | 19.2 | 25.9 | 23.9 |
| | Run 1 | 4.5 | 11.2 | 17.9 | 24.6 | 22.5 | 5.4 | 13.0 | 22.8 | 30.0 | 28.0 |
| | Run 2 | 1.3 | 4.8 | 10.0 | 15.2 | 13.4 | 2.0 | 6.6 | 14.2 | 20.1 | 18.2 |
| | Run 3 | 1.1 | 6.6 | 20.5 | 26.6 | 21.3 | 1.7 | 8.5 | 27.7 | 34.3 | 29.0 |
| | Run 4 | 4.9 | 9.1 | 9.0 | 13.3 | 12.2 | 6.2 | 11.0 | 11.3 | 15.8 | 14.8 |
| | Run 5 | 6.3 | 15.9 | 15.3 | 27.0 | 23.9 | 8.3 | 19.9 | 19.8 | 32.3 | 29.2 |
| | Run 6 | 1.4 | 4.2 | 14.1 | 16.6 | 14.8 | 2.0 | 5.5 | 19.2 | 21.9 | 20.3 |
| | Run 7 | 4.9 | 8.9 | 14.8 | 20.9 | 18.8 | 8.5 | 12.1 | 19.7 | 26.2 | 24.2 |
| | Run 8 | 2.8 | 8.3 | 14.6 | 20.8 | 18.8 | 3.8 | 10.2 | 19.2 | 25.9 | 23.9 |
| | Run 9 | 1.5 | 3.3 | 6.8 | 8.9 | 8.3 | 2.3 | 4.4 | 8.8 | 11.2 | 10.6 |
| | Run 10 | 0.2 | 1.6 | 12.7 | 15.9 | 11.3 | 0.3 | 2.4 | 18.6 | 22.0 | 17.3 |
| | Run 11 | 4.4 | 6.6 | 10.5 | 13.0 | 12.3 | 6.3 | 8.3 | 13.0 | 15.7 | 15.1 |
| | Run 12 | 0.8 | 4.3 | 23.9 | 27.6 | 22.9 | 1.2 | 5.7 | 34.8 | 38.9 | 34.3 |
| | Run 13 | 5.0 | 8.9 | 6.5 | 10.0 | 8.7 | 7.3 | 12.8 | 9.5 | 13.3 | 11.8 |
| | Run 14 | 0.9 | 4.9 | 8.8 | 20.4 | 16.2 | 1.7 | 8.8 | 15.2 | 28.8 | 23.7 |
| | Run 15 | 13.3 | 22.4 | 15.3 | 18.5 | 16.4 | 15.1 | 25.0 | 17.8 | 21.2 | 19.0 |
| | Run 16 | 5.7 | 21.7 | 26.8 | 44.3 | 37.9 | 7.1 | 24.9 | 30.5 | 48.8 | 42.2 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 4.6 | 8.8 | 37.5 | 38.8 | 42.2 | 6.1 | 10.9 | 41.9 | 44.1 | 47.7 |
| | Run 1 | 7.2 | 11.9 | 42.6 | 44.1 | 48.0 | 8.6 | 13.8 | 46.8 | 49.3 | 53.3 |
| | Run 2 | 2.1 | 5.2 | 29.4 | 30.6 | 33.1 | 3.3 | 7.1 | 34.7 | 36.4 | 39.3 |
| | Run 3 | 1.8 | 7.0 | 57.5 | 51.0 | 44.5 | 2.7 | 8.9 | 65.2 | 59.3 | 53.1 |
| | Run 4 | 7.8 | 9.8 | 20.8 | 25.9 | 30.2 | 9.7 | 11.8 | 23.2 | 28.6 | 33.0 |
| | Run 5 | 11.9 | 17.6 | 47.6 | 61.8 | 73.9 | 15.4 | 21.9 | 53.8 | 68.8 | 81.5 |
| | Run 6 | 1.9 | 4.4 | 26.1 | 24.8 | 22.8 | 2.6 | 5.7 | 30.7 | 30.1 | 28.2 |
| | Run 7 | 6.1 | 9.5 | 37.8 | 38.9 | 42.3 | 9.7 | 12.7 | 42.8 | 44.5 | 48.1 |
| | Run 8 | 4.6 | 8.8 | 37.5 | 38.8 | 42.2 | 6.1 | 10.9 | 41.9 | 44.1 | 47.7 |
| | Run 9 | 2.1 | 3.5 | 13.7 | 14.5 | 15.6 | 3.0 | 4.6 | 15.7 | 16.9 | 18.0 |
| | Run 10 | 0.2 | 1.7 | 25.6 | 26.4 | 15.9 | 0.4 | 2.5 | 31.5 | 32.5 | 21.9 |
| | Run 11 | 5.4 | 6.9 | 18.4 | 19.4 | 20.8 | 7.3 | 8.6 | 20.7 | 22.1 | 23.5 |
| | Run 12 | 1.1 | 4.5 | 40.6 | 40.3 | 30.3 | 1.5 | 6.0 | 50.9 | 51.5 | 41.7 |
| | Run 13 | 9.9 | 10.6 | 17.4 | 25.7 | 31.8 | 13.7 | 14.8 | 22.8 | 31.5 | 38.2 |
| | Run 14 | 1.9 | 5.6 | 45.7 | 52.9 | 55.8 | 3.3 | 9.7 | 67.4 | 70.6 | 76.3 |
| | Run 15 | 24.2 | 25.5 | 34.1 | 41.6 | 49.3 | 27.1 | 28.3 | 37.1 | 44.7 | 52.6 |
| | Run 16 | 10.8 | 23.3 | 103.9 | 103.2 | 114.4 | 13.4 | 26.7 | 110.3 | 109.8 | 121.8 |
| Monitoring Location at 30.5 miles | Run 0 | 6.8 | 25.3 | 199.2 | 252.0 | 107.6 | 9.0 | 28.5 | 205.2 | 258.0 | 114.1 |
| | Run 1 | 10.7 | 30.7 | 208.8 | 261.6 | 117.7 | 12.6 | 33.4 | 213.7 | 266.6 | 123.1 |
| | Run 2 | 3.2 | 18.8 | 184.3 | 237.1 | 91.5 | 4.8 | 22.0 | 192.6 | 245.4 | 100.5 |
| | Run 3 | 2.7 | 19.3 | 213.4 | 327.4 | 92.6 | 4.0 | 22.6 | 223.4 | 337.4 | 103.3 |
| | Run 4 | 11.7 | 28.9 | 165.7 | 189.0 | 108.3 | 14.3 | 31.6 | 169.1 | 192.3 | 111.7 |
| | Run 5 | 19.4 | 68.8 | 475.3 | 545.4 | 301.2 | 24.9 | 76.0 | 487.4 | 557.5 | 314.1 |
| | Run 6 | 2.4 | 9.4 | 79.1 | 116.9 | 39.6 | 3.4 | 11.2 | 84.0 | 121.9 | 45.1 |
| | Run 7 | 7.6 | 25.9 | 199.4 | 252.2 | 107.7 | 11.4 | 30.4 | 206.0 | 258.8 | 114.7 |
| | Run 8 | 6.8 | 25.3 | 199.2 | 252.0 | 107.6 | 9.0 | 28.4 | 205.2 | 258.0 | 114.1 |
| | Run 9 | 2.7 | 8.9 | 67.0 | 84.6 | 36.5 | 3.9 | 10.4 | 69.5 | 87.1 | 39.2 |
| | Run 10 | 0.3 | 3.9 | 67.5 | 140.4 | 23.9 | 0.5 | 5.2 | 73.8 | 146.8 | 29.9 |
| | Run 11 | 6.8 | 13.9 | 74.4 | 92.0 | 44.2 | 8.7 | 15.9 | 76.9 | 94.5 | 46.8 |
| | Run 12 | 1.4 | 9.0 | 88.6 | 161.2 | 43.8 | 2.0 | 11.3 | 99.0 | 171.9 | 55.3 |
| | Run 13 | 18.8 | 59.6 | 345.0 | 379.1 | 263.8 | 24.3 | 66.2 | 355.6 | 389.8 | 274.9 |
| | Run 14 | 3.3 | 37.0 | 489.2 | 648.5 | 204.1 | 5.4 | 46.0 | 524.8 | 684.3 | 241.0 |
| | Run 15 | 41.0 | 84.0 | 377.2 | 411.4 | 296.8 | 45.3 | 88.5 | 382.1 | 416.2 | 301.7 |
| | Run 16 | 17.2 | 73.4 | 599.1 | 759.0 | 320.8 | 21.3 | 80.0 | 612.2 | 772.1 | 334.9 |

**Table 6-35. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #3 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | 0.6 | 5.4 | 5.8 | 5.8 | | 1.3 | 9.2 | 9.7 | 9.7 |
| | Run 1 | | 0.9 | 8.2 | 8.7 | 8.6 | | 1.8 | 12.7 | 13.3 | 13.2 |
| | Run 2 | | 0.2 | 2.5 | 2.7 | 2.6 | | 0.6 | 5.1 | 5.4 | 5.4 |
| | Run 3 | | 0.3 | 6.6 | 7.0 | 6.8 | | 0.6 | 12.1 | 12.6 | 12.5 |
| | Run 4 | | 0.8 | 3.1 | 3.4 | 3.4 | | 1.6 | 5.0 | 5.3 | 5.3 |
| | Run 5 | | 0.3 | 2.4 | 2.7 | 2.7 | | 0.8 | 4.7 | 5.3 | 5.2 |
| | Run 6 | | 0.8 | 8.5 | 8.7 | 8.7 | | 1.6 | 13.4 | 13.7 | 13.6 |
| | Run 7 | | 0.7 | 5.5 | 5.9 | 5.8 | | 1.6 | 9.4 | 9.9 | 9.8 |
| | Run 8 | | 0.6 | 5.4 | 5.8 | 5.8 | | 1.3 | 9.2 | 9.7 | 9.7 |
| | Run 9 | | 0.7 | 3.3 | 3.4 | 3.4 | | 1.4 | 5.1 | 5.3 | 5.3 |
| | Run 10 | | 0.2 | 6.1 | 6.3 | 6.1 | | 0.5 | 11.1 | 11.3 | 11.1 |
| | Run 11 | | 1.7 | 6.9 | 7.1 | 7.1 | | 2.9 | 9.5 | 9.8 | 9.8 |
| | Run 12 | | 0.7 | 16.7 | 17.0 | 16.8 | | 1.3 | 27.5 | 27.9 | 27.8 |
| | Run 13 | | 0.1 | 0.4 | 0.5 | 0.5 | | 0.4 | 1.2 | 1.4 | 1.4 |
| | Run 14 | | 0.0 | 0.4 | 0.7 | 0.6 | | 0.1 | 1.2 | 1.6 | 1.5 |
| | Run 15 | | 0.9 | 2.8 | 3.2 | 3.2 | | 1.9 | 4.5 | 5.1 | 5.1 |
| | Run 16 | | 0.2 | 3.7 | 4.6 | 4.3 | | 0.4 | 4.6 | 5.7 | 5.4 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.6 | 5.8 | 6.6 | 7.0 | | 0.9 | 9.5 | 10.5 | 11.0 |
| | Run 1 | | 0.9 | 8.6 | 9.6 | 10.2 | | 1.2 | 13.1 | 14.2 | 14.8 |
| | Run 2 | | 0.2 | 2.7 | 3.2 | 3.5 | | 0.4 | 5.3 | 6.0 | 6.4 |
| | Run 3 | | 0.5 | 7.2 | 8.0 | 8.5 | | 0.7 | 12.7 | 13.7 | 14.3 |
| | Run 4 | | 0.7 | 3.5 | 3.9 | 4.1 | | 1.0 | 5.3 | 5.8 | 6.1 |
| | Run 5 | | 0.4 | 3.1 | 3.8 | 4.3 | | 0.6 | 5.6 | 6.5 | 7.2 |
| | Run 6 | | 0.8 | 8.7 | 9.1 | 9.3 | | 1.3 | 13.5 | 14.0 | 14.2 |
| | Run 7 | | 0.7 | 5.8 | 6.6 | 7.1 | | 1.2 | 9.8 | 10.7 | 11.2 |
| | Run 8 | | 0.6 | 5.8 | 6.6 | 7.0 | | 0.9 | 9.5 | 10.5 | 11.0 |
| | Run 9 | | 0.6 | 3.4 | 3.6 | 3.8 | | 1.0 | 5.2 | 5.6 | 5.7 |
| | Run 10 | | 0.3 | 6.3 | 6.6 | 6.4 | | 0.5 | 11.3 | 11.6 | 11.4 |
| | Run 11 | | 1.4 | 7.0 | 7.4 | 7.7 | | 2.2 | 9.6 | 10.1 | 10.3 |
| | Run 12 | | 0.9 | 17.0 | 17.6 | 17.6 | | 1.3 | 27.9 | 28.5 | 28.6 |
| | Run 13 | | 0.1 | 0.7 | 0.8 | 0.9 | | 0.3 | 1.7 | 1.8 | 2.0 |
| | Run 14 | | 0.0 | 0.6 | 1.2 | 1.5 | | 0.1 | 1.7 | 2.7 | 3.3 |
| | Run 15 | | 0.7 | 4.0 | 4.2 | 4.6 | | 0.9 | 5.8 | 6.1 | 6.5 |
| | Run 16 | | 0.6 | 5.3 | 7.3 | 9.0 | | 0.8 | 6.5 | 8.7 | 10.6 |
| Monitoring Location at 10.5 miles | Run 0 | 2.6 | 6.4 | 8.1 | 11.1 | 11.4 | 3.6 | 8.4 | 11.8 | 15.3 | 15.7 |
| | Run 1 | 4.4 | 9.7 | 11.5 | 15.0 | 15.5 | 5.4 | 11.6 | 15.7 | 19.7 | 20.2 |
| | Run 2 | 1.0 | 2.9 | 4.0 | 6.2 | 6.3 | 1.7 | 4.5 | 7.0 | 9.6 | 9.9 |
| | Run 3 | 1.1 | 5.5 | 11.6 | 14.4 | 13.5 | 1.6 | 7.5 | 17.3 | 20.6 | 19.8 |
| | Run 4 | 4.3 | 7.1 | 5.2 | 6.7 | 6.9 | 5.6 | 9.1 | 7.2 | 8.8 | 9.1 |
| | Run 5 | 4.8 | 10.0 | 6.5 | 10.1 | 10.6 | 6.8 | 14.0 | 9.9 | 14.0 | 14.6 |
| | Run 6 | 1.4 | 3.8 | 10.1 | 11.4 | 11.2 | 2.0 | 5.1 | 14.8 | 16.4 | 16.2 |
| | Run 7 | 4.6 | 7.0 | 8.2 | 11.1 | 11.5 | 8.3 | 10.2 | 12.2 | 15.5 | 15.9 |
| | Run 8 | 2.6 | 6.4 | 8.1 | 11.1 | 11.4 | 3.6 | 8.4 | 11.8 | 15.3 | 15.7 |
| | Run 9 | 1.4 | 2.6 | 3.9 | 5.0 | 5.1 | 2.2 | 3.6 | 5.8 | 7.0 | 7.1 |
| | Run 10 | 0.1 | 1.4 | 8.1 | 9.2 | 7.4 | 0.3 | 2.2 | 13.1 | 14.4 | 12.4 |
| | Run 11 | 4.6 | 6.2 | 7.9 | 9.3 | 9.5 | 6.6 | 8.0 | 10.4 | 12.0 | 12.2 |
| | Run 12 | 0.9 | 4.4 | 19.9 | 21.5 | 19.8 | 1.2 | 5.9 | 30.5 | 32.4 | 30.8 |
| | Run 13 | 3.1 | 4.8 | 2.4 | 2.5 | 2.6 | 4.9 | 8.0 | 4.5 | 4.5 | 4.6 |
| | Run 14 | 0.6 | 1.6 | 1.7 | 4.6 | 4.5 | 1.2 | 4.0 | 4.5 | 9.1 | 9.3 |
| | Run 15 | 11.0 | 18.3 | 10.3 | 9.7 | 9.9 | 12.8 | 21.2 | 12.6 | 12.0 | 12.2 |
| | Run 16 | 5.2 | 16.8 | 14.1 | 22.5 | 23.7 | 6.8 | 20.5 | 16.4 | 25.5 | 27.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 4.4 | 6.9 | 19.2 | 23.1 | 21.4 | 6.0 | 9.0 | 23.3 | 27.9 | 26.2 |
| | Run 1 | 7.3 | 10.4 | 24.7 | 29.3 | 27.4 | 8.8 | 12.4 | 28.7 | 34.1 | 32.3 |
| | Run 2 | 1.8 | 3.1 | 11.4 | 14.5 | 13.0 | 2.9 | 4.9 | 15.9 | 19.6 | 18.0 |
| | Run 3 | 1.8 | 5.9 | 32.2 | 31.4 | 24.5 | 2.7 | 7.9 | 39.3 | 39.0 | 32.0 |
| | Run 4 | 7.2 | 7.8 | 11.0 | 14.2 | 13.5 | 9.1 | 9.8 | 13.3 | 16.8 | 16.0 |
| | Run 5 | 9.8 | 11.2 | 18.8 | 27.3 | 25.6 | 13.5 | 15.6 | 24.7 | 34.1 | 32.2 |
| | Run 6 | 1.9 | 4.0 | 17.1 | 17.6 | 15.4 | 2.7 | 5.3 | 21.5 | 22.6 | 20.5 |
| | Run 7 | 5.8 | 7.5 | 19.4 | 23.2 | 21.4 | 9.6 | 10.8 | 24.1 | 28.4 | 26.6 |
| | Run 8 | 4.4 | 6.9 | 19.2 | 23.1 | 21.4 | 6.0 | 9.0 | 23.3 | 27.9 | 26.2 |
| | Run 9 | 2.0 | 2.7 | 7.2 | 8.7 | 8.2 | 2.9 | 3.8 | 9.0 | 10.9 | 10.3 |
| | Run 10 | 0.2 | 1.5 | 16.6 | 16.3 | 9.5 | 0.4 | 2.3 | 22.1 | 21.8 | 14.8 |
| | Run 11 | 5.7 | 6.5 | 12.3 | 14.3 | 13.7 | 7.8 | 8.3 | 14.7 | 16.9 | 16.3 |
| | Run 12 | 1.2 | 4.6 | 32.7 | 31.8 | 24.4 | 1.6 | 6.1 | 42.9 | 42.7 | 35.5 |
| | Run 13 | 6.5 | 5.9 | 5.8 | 7.5 | 6.9 | 9.9 | 9.5 | 9.8 | 12.0 | 11.1 |
| | Run 14 | 1.3 | 2.0 | 9.2 | 15.2 | 12.4 | 2.6 | 4.6 | 19.7 | 27.2 | 23.4 |
| | Run 15 | 21.2 | 21.2 | 21.5 | 23.5 | 21.8 | 24.3 | 24.4 | 24.8 | 26.8 | 25.0 |
| | Run 16 | 10.5 | 18.2 | 52.0 | 61.9 | 56.3 | 13.4 | 22.1 | 58.3 | 68.8 | 62.9 |
| Monitoring Location at 30.5 miles | Run 0 | 7.0 | 25.5 | 90.8 | 78.9 | 61.2 | 9.4 | 29.1 | 97.4 | 85.4 | 68.2 |
| | Run 1 | 11.4 | 32.0 | 102.3 | 90.1 | 73.1 | 13.5 | 35.0 | 107.8 | 95.5 | 78.9 |
| | Run 2 | 3.1 | 17.7 | 73.7 | 62.3 | 43.6 | 4.7 | 21.5 | 82.7 | 71.1 | 52.9 |
| | Run 3 | 2.7 | 20.6 | 120.2 | 110.7 | 58.6 | 4.1 | 24.5 | 131.2 | 121.4 | 69.5 |
| | Run 4 | 11.9 | 24.6 | 60.1 | 51.6 | 48.9 | 14.6 | 27.7 | 63.9 | 55.3 | 52.7 |
| | Run 5 | 18.6 | 53.5 | 151.7 | 127.0 | 117.6 | 24.6 | 61.9 | 165.9 | 140.7 | 132.3 |
| | Run 6 | 2.6 | 10.2 | 48.4 | 45.2 | 28.3 | 3.6 | 12.1 | 53.4 | 50.2 | 33.8 |
| | Run 7 | 7.7 | 26.1 | 91.0 | 79.1 | 61.3 | 11.7 | 30.9 | 98.2 | 86.2 | 68.8 |
| | Run 8 | 7.0 | 25.5 | 90.8 | 78.9 | 61.2 | 9.4 | 29.1 | 97.4 | 85.4 | 68.2 |
| | Run 9 | 2.7 | 8.8 | 30.7 | 26.7 | 20.8 | 3.9 | 10.4 | 33.3 | 29.3 | 23.6 |
| | Run 10 | 0.3 | 4.0 | 45.2 | 50.5 | 15.5 | 0.5 | 5.4 | 51.8 | 57.0 | 21.0 |
| | Run 11 | 7.3 | 14.6 | 39.2 | 35.1 | 29.6 | 9.4 | 16.8 | 41.9 | 37.8 | 32.4 |
| | Run 12 | 1.5 | 9.9 | 69.5 | 73.8 | 37.0 | 2.1 | 12.3 | 80.0 | 84.6 | 48.5 |
| | Run 13 | 16.4 | 31.1 | 72.5 | 58.5 | 59.8 | 21.8 | 38.0 | 83.0 | 68.7 | 70.5 |
| | Run 14 | 2.8 | 29.8 | 156.9 | 124.5 | 69.3 | 5.0 | 40.8 | 188.9 | 155.3 | 98.3 |
| | Run 15 | 40.4 | 58.6 | 108.1 | 93.0 | 95.5 | 45.4 | 63.7 | 113.7 | 98.5 | 101.1 |
| | Run 16 | 18.0 | 74.5 | 272.4 | 236.2 | 182.3 | 22.8 | 82.8 | 288.5 | 251.7 | 199.0 |

**Table 6-36. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #3 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | 0.6 | 5.4 | 5.7 | 6.8 | | 1.2 | 9.3 | 9.7 | 10.7 |
| | Run 1 | | 1.1 | 8.9 | 9.2 | 10.4 | | 1.9 | 13.5 | 14.0 | 15.1 |
| | Run 2 | | 0.1 | 1.5 | 2.0 | 2.7 | | 0.5 | 3.9 | 4.4 | 5.2 |
| | Run 3 | | 0.5 | 8.6 | 9.3 | 10.4 | | 1.0 | 15.3 | 16.0 | 17.1 |
| | Run 4 | | 0.7 | 3.1 | 3.4 | 3.9 | | 1.3 | 5.3 | 5.7 | 6.2 |
| | Run 5 | | 0.1 | 1.8 | 2.3 | 3.6 | | 0.3 | 4.2 | 4.8 | 6.3 |
| | Run 6 | | 1.2 | 8.7 | 8.9 | 9.3 | | 2.0 | 12.7 | 13.0 | 13.3 |
| | Run 7 | | 0.7 | 5.4 | 5.8 | 6.8 | | 1.5 | 9.4 | 9.8 | 10.8 |
| | Run 8 | | 0.5 | 5.4 | 5.7 | 6.8 | | 0.9 | 9.3 | 9.7 | 10.7 |
| | Run 9 | | 0.7 | 2.8 | 3.0 | 3.2 | | 1.4 | 4.6 | 4.8 | 5.1 |
| | Run 10 | | 0.3 | 5.9 | 6.8 | 6.4 | | 0.7 | 10.5 | 11.3 | 10.9 |
| | Run 11 | | 2.1 | 7.2 | 7.4 | 7.7 | | 3.2 | 9.8 | 10.1 | 10.4 |
| | Run 12 | | 1.3 | 18.2 | 18.9 | 18.7 | | 2.1 | 26.3 | 27.0 | 26.8 |
| | Run 13 | | 0.0 | 0.1 | 0.2 | 0.3 | | 0.1 | 0.4 | 0.7 | 1.0 |
| | Run 14 | | 0.0 | 0.1 | 0.4 | 0.8 | | 0.0 | 0.6 | 1.4 | 2.5 |
| | Run 15 | | 0.4 | 3.1 | 3.6 | 4.6 | | 0.9 | 5.1 | 5.8 | 6.9 |
| | Run 16 | | 0.2 | 5.3 | 5.5 | 9.9 | | 0.5 | 6.8 | 7.0 | 11.7 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.9 | 6.8 | 8.6 | 8.9 | | 1.5 | 10.5 | 12.4 | 12.8 |
| | Run 1 | | 1.5 | 10.7 | 12.4 | 12.9 | | 2.1 | 14.8 | 16.8 | 17.3 |
| | Run 2 | | 0.3 | 2.2 | 4.0 | 4.1 | | 0.7 | 4.7 | 6.7 | 7.0 |
| | Run 3 | | 0.8 | 11.2 | 14.2 | 13.2 | | 1.3 | 17.7 | 20.8 | 19.8 |
| | Run 4 | | 1.0 | 4.0 | 5.1 | 5.2 | | 1.6 | 6.0 | 7.3 | 7.5 |
| | Run 5 | | 0.4 | 3.6 | 6.1 | 6.4 | | 0.8 | 6.7 | 9.4 | 9.9 |
| | Run 6 | | 1.3 | 9.3 | 10.4 | 10.1 | | 2.0 | 13.0 | 14.3 | 14.0 |
| | Run 7 | | 1.0 | 6.9 | 8.6 | 9.0 | | 1.8 | 10.7 | 12.6 | 13.0 |
| | Run 8 | | 0.8 | 6.8 | 8.6 | 8.9 | | 1.2 | 10.4 | 12.4 | 12.8 |
| | Run 9 | | 0.8 | 3.1 | 3.8 | 3.8 | | 1.4 | 4.8 | 5.5 | 5.6 |
| | Run 10 | | 0.4 | 6.3 | 9.4 | 6.7 | | 0.7 | 10.9 | 13.9 | 11.1 |
| | Run 11 | | 2.3 | 7.5 | 8.3 | 8.4 | | 3.2 | 9.9 | 10.9 | 11.0 |
| | Run 12 | | 1.4 | 19.0 | 21.8 | 19.3 | | 2.1 | 26.6 | 29.8 | 27.3 |
| | Run 13 | | 0.0 | 0.2 | 0.7 | 0.7 | | 0.2 | 1.0 | 1.9 | 2.0 |
| | Run 14 | | 0.0 | 0.4 | 2.1 | 1.8 | | 0.1 | 1.7 | 5.3 | 5.3 |
| | Run 15 | | 1.1 | 5.7 | 7.3 | 7.4 | | 1.4 | 7.6 | 9.7 | 9.8 |
| | Run 16 | | 1.0 | 12.8 | 16.3 | 17.9 | | 1.3 | 15.1 | 18.5 | 20.3 |
| Monitoring Location at 10.5 miles | Run 0 | 4.0 | 4.5 | 12.2 | 15.7 | 14.9 | 4.9 | 5.7 | 15.5 | 19.4 | 18.7 |
| | Run 1 | 5.6 | 6.4 | 16.5 | 20.1 | 19.4 | 6.5 | 7.5 | 19.9 | 24.1 | 23.5 |
| | Run 2 | 2.0 | 1.8 | 6.1 | 9.6 | 8.5 | 3.0 | 3.2 | 9.3 | 13.1 | 12.1 |
| | Run 3 | 2.2 | 3.7 | 19.9 | 27.5 | 19.9 | 3.1 | 4.9 | 25.9 | 34.0 | 26.5 |
| | Run 4 | 5.0 | 4.8 | 7.6 | 9.1 | 9.1 | 6.4 | 6.1 | 9.6 | 11.4 | 11.4 |
| | Run 5 | 6.6 | 6.2 | 11.1 | 15.7 | 15.6 | 8.6 | 9.5 | 16.1 | 20.7 | 20.5 |
| | Run 6 | 2.3 | 2.7 | 11.6 | 14.6 | 12.2 | 3.0 | 3.6 | 14.9 | 18.3 | 15.9 |
| | Run 7 | 6.9 | 4.7 | 12.3 | 15.8 | 14.9 | 10.9 | 6.4 | 16.0 | 19.7 | 18.9 |
| | Run 8 | 4.0 | 4.4 | 12.2 | 15.7 | 14.9 | 4.9 | 5.5 | 15.5 | 19.4 | 18.7 |
| | Run 9 | 2.1 | 1.9 | 4.6 | 5.9 | 5.6 | 2.7 | 2.7 | 6.2 | 7.6 | 7.4 |
| | Run 10 | 0.4 | 0.9 | 9.1 | 16.8 | 7.8 | 0.6 | 1.5 | 13.4 | 21.3 | 12.1 |
| | Run 11 | 5.0 | 4.3 | 9.1 | 10.6 | 10.4 | 6.6 | 5.5 | 11.2 | 13.0 | 12.9 |
| | Run 12 | 1.7 | 2.9 | 21.9 | 29.8 | 21.0 | 2.3 | 3.8 | 28.6 | 37.4 | 28.8 |
| | Run 13 | 3.1 | 1.3 | 1.9 | 3.1 | 2.9 | 5.3 | 3.4 | 4.6 | 6.1 | 5.8 |
| | Run 14 | 1.2 | 0.6 | 3.6 | 9.5 | 6.1 | 2.6 | 2.0 | 9.2 | 17.9 | 14.0 |
| | Run 15 | 11.3 | 12.3 | 15.0 | 16.3 | 15.6 | 13.6 | 14.2 | 17.5 | 19.1 | 18.5 |
| | Run 16 | 8.0 | 11.6 | 31.9 | 40.5 | 38.3 | 9.5 | 13.6 | 35.6 | 44.0 | 42.0 |
| Monitoring Location at 15.5 miles | Run 0 | 7.0 | 8.2 | 20.0 | 24.9 | 25.9 | 8.5 | 10.0 | 23.2 | 28.6 | 29.7 |
| | Run 1 | 9.7 | 11.2 | 24.7 | 29.8 | 31.2 | 11.0 | 12.6 | 27.7 | 33.5 | 34.9 |
| | Run 2 | 3.9 | 4.2 | 13.0 | 17.6 | 17.7 | 5.5 | 6.2 | 16.7 | 21.7 | 22.3 |
| | Run 3 | 4.0 | 6.9 | 32.1 | 44.7 | 32.0 | 5.3 | 8.7 | 37.8 | 51.1 | 38.8 |
| | Run 4 | 8.9 | 8.9 | 12.7 | 14.3 | 16.7 | 10.6 | 10.5 | 14.8 | 16.7 | 19.0 |
| | Run 5 | 15.5 | 14.3 | 23.6 | 29.0 | 35.1 | 19.2 | 19.5 | 30.0 | 35.3 | 41.9 |
| | Run 6 | 3.1 | 4.1 | 15.3 | 20.1 | 16.2 | 4.0 | 5.2 | 18.2 | 23.6 | 19.7 |
| | Run 7 | 9.0 | 8.6 | 20.2 | 25.0 | 26.0 | 12.9 | 11.0 | 23.9 | 29.0 | 30.1 |
| | Run 8 | 7.0 | 8.2 | 20.0 | 24.9 | 25.9 | 8.5 | 9.9 | 23.2 | 28.6 | 29.7 |
| | Run 9 | 2.9 | 3.1 | 7.1 | 8.8 | 9.1 | 3.8 | 4.0 | 8.6 | 10.5 | 10.8 |
| | Run 10 | 0.5 | 1.6 | 13.3 | 26.2 | 10.3 | 0.9 | 2.3 | 17.4 | 30.7 | 14.5 |
| | Run 11 | 6.3 | 6.2 | 11.7 | 13.7 | 14.2 | 8.0 | 7.6 | 13.7 | 16.0 | 16.4 |
| | Run 12 | 2.3 | 4.3 | 26.0 | 39.8 | 24.3 | 3.0 | 5.4 | 32.1 | 47.1 | 31.9 |
| | Run 13 | 9.1 | 5.1 | 7.1 | 8.0 | 10.4 | 13.3 | 9.6 | 12.3 | 12.9 | 15.9 |
| | Run 14 | 3.7 | 2.9 | 14.8 | 24.3 | 20.7 | 6.7 | 6.5 | 25.8 | 38.1 | 35.7 |
| | Run 15 | 24.4 | 23.9 | 27.6 | 27.2 | 30.9 | 27.5 | 26.9 | 30.9 | 30.6 | 34.5 |
| | Run 16 | 17.6 | 22.7 | 56.7 | 70.1 | 73.7 | 20.4 | 26.0 | 61.5 | 74.8 | 79.1 |
| Monitoring Location at 30.5 miles | Run 0 | 14.5 | 28.7 | 140.9 | 236.0 | 68.6 | 16.9 | 31.4 | 144.2 | 239.4 | 73.0 |
| | Run 1 | 19.1 | 33.7 | 146.8 | 242.0 | 76.0 | 21.1 | 35.8 | 149.3 | 244.6 | 79.4 |
| | Run 2 | 9.3 | 22.7 | 132.6 | 227.2 | 56.9 | 11.8 | 25.7 | 137.0 | 231.9 | 63.2 |
| | Run 3 | 7.9 | 22.6 | 157.2 | 348.5 | 65.0 | 10.1 | 25.7 | 162.7 | 354.6 | 72.9 |
| | Run 4 | 19.7 | 31.7 | 109.4 | 153.6 | 65.1 | 22.2 | 34.2 | 112.0 | 156.3 | 67.9 |
| | Run 5 | 42.2 | 77.9 | 311.2 | 444.3 | 175.5 | 48.7 | 84.9 | 319.1 | 452.4 | 185.3 |
| | Run 6 | 4.9 | 10.3 | 56.6 | 120.4 | 27.6 | 6.1 | 11.7 | 58.9 | 122.9 | 30.9 |
| | Run 7 | 15.1 | 29.3 | 141.3 | 236.3 | 68.8 | 18.9 | 33.1 | 145.5 | 240.6 | 73.7 |
| | Run 8 | 14.4 | 28.7 | 140.9 | 236.0 | 68.6 | 16.9 | 31.4 | 144.2 | 239.4 | 72.9 |
| | Run 9 | 5.2 | 9.9 | 47.3 | 78.9 | 23.1 | 6.3 | 11.1 | 48.7 | 80.4 | 24.9 |
| | Run 10 | 0.9 | 4.6 | 47.8 | 161.2 | 16.5 | 1.4 | 5.9 | 51.7 | 165.9 | 20.7 |
| | Run 11 | 9.6 | 14.5 | 52.3 | 84.0 | 29.0 | 11.2 | 16.1 | 54.1 | 85.9 | 31.0 |
| | Run 12 | 3.5 | 9.4 | 60.7 | 176.4 | 32.3 | 4.4 | 11.0 | 65.2 | 182.0 | 39.6 |
| | Run 13 | 39.5 | 64.3 | 198.2 | 262.9 | 143.5 | 46.4 | 71.4 | 206.0 | 270.8 | 152.5 |
| | Run 14 | 13.6 | 47.9 | 362.7 | 646.5 | 120.3 | 19.5 | 57.4 | 383.3 | 668.8 | 146.2 |
| | Run 15 | 65.8 | 91.2 | 226.6 | 291.5 | 174.6 | 70.9 | 96.3 | 231.8 | 296.7 | 179.9 |
| | Run 16 | 39.9 | 83.5 | 424.2 | 712.2 | 205.6 | 45.3 | 89.5 | 431.5 | 719.8 | 215.3 |

**Table 6-37. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #3 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | 0.4 | 2.3 | 2.7 | 2.5 | | 0.9 | 4.6 | 5.1 | 4.9 |
| | Run 1 | | 0.8 | 5.0 | 5.4 | 5.2 | | 1.5 | 8.2 | 8.7 | 8.5 |
| | Run 2 | | 0.0 | 0.3 | 0.6 | 0.5 | | 0.2 | 1.2 | 1.6 | 1.5 |
| | Run 3 | | 0.3 | 4.0 | 4.8 | 4.3 | | 0.8 | 8.2 | 9.0 | 8.5 |
| | Run 4 | | 0.4 | 1.6 | 1.9 | 1.8 | | 0.9 | 3.2 | 3.5 | 3.4 |
| | Run 5 | | 0.0 | 0.5 | 0.9 | 0.8 | | 0.1 | 1.7 | 2.3 | 2.1 |
| | Run 6 | | 1.0 | 5.2 | 5.5 | 5.4 | | 1.7 | 8.3 | 8.6 | 8.5 |
| | Run 7 | | 0.4 | 2.3 | 2.7 | 2.6 | | 1.0 | 4.7 | 5.2 | 5.0 |
| | Run 8 | | 0.3 | 2.3 | 2.7 | 2.5 | | 0.6 | 4.6 | 5.1 | 4.9 |
| | Run 9 | | 0.5 | 1.2 | 1.4 | 1.3 | | 1.0 | 2.4 | 2.6 | 2.5 |
| | Run 10 | | 0.2 | 3.0 | 3.8 | 3.2 | | 0.6 | 6.3 | 7.1 | 6.5 |
| | Run 11 | | 1.8 | 4.9 | 5.1 | 5.1 | | 2.8 | 7.1 | 7.4 | 7.3 |
| | Run 12 | | 1.3 | 13.9 | 14.7 | 14.0 | | 2.1 | 20.9 | 21.8 | 21.2 |
| | Run 13 | | 0.0 | 0.0 | 0.1 | 0.0 | | 0.0 | 0.1 | 0.3 | 0.3 |
| | Run 14 | | 0.0 | 0.0 | 0.1 | 0.0 | | 0.0 | 0.1 | 0.3 | 0.2 |
| | Run 15 | | 0.3 | 2.1 | 2.8 | 2.6 | | 0.7 | 3.7 | 4.7 | 4.5 |
| | Run 16 | | 0.1 | 2.8 | 3.6 | 3.1 | | 0.3 | 4.0 | 4.8 | 4.2 |
| Monitoring Location at 5.5 miles | Run 0 | | 0.7 | 3.2 | 3.8 | 4.4 | | 1.2 | 5.5 | 6.3 | 7.0 |
| | Run 1 | | 1.4 | 6.3 | 6.9 | 7.8 | | 1.9 | 9.3 | 10.1 | 11.0 |
| | Run 2 | | 0.1 | 0.6 | 1.1 | 1.3 | | 0.4 | 1.7 | 2.4 | 2.8 |
| | Run 3 | | 0.6 | 5.6 | 6.8 | 6.9 | | 1.1 | 9.9 | 11.2 | 11.4 |
| | Run 4 | | 0.8 | 2.3 | 2.7 | 3.1 | | 1.2 | 3.9 | 4.4 | 4.8 |
| | Run 5 | | 0.3 | 1.3 | 2.0 | 2.5 | | 0.6 | 3.2 | 4.1 | 4.9 |
| | Run 6 | | 1.2 | 5.7 | 6.2 | 6.3 | | 1.9 | 8.7 | 9.3 | 9.4 |
| | Run 7 | | 0.8 | 3.3 | 3.8 | 4.4 | | 1.4 | 5.7 | 6.4 | 7.1 |
| | Run 8 | | 0.7 | 3.2 | 3.8 | 4.4 | | 1.0 | 5.5 | 6.3 | 7.0 |
| | Run 9 | | 0.6 | 1.4 | 1.7 | 1.8 | | 1.1 | 2.6 | 2.9 | 3.1 |
| | Run 10 | | 0.3 | 3.5 | 5.1 | 3.6 | | 0.6 | 6.8 | 8.4 | 6.8 |
| | Run 11 | | 2.0 | 5.2 | 5.6 | 5.9 | | 2.9 | 7.3 | 7.8 | 8.1 |
| | Run 12 | | 1.5 | 14.9 | 16.4 | 15.0 | | 2.2 | 21.6 | 23.4 | 22.1 |
| | Run 13 | | 0.0 | 0.1 | 0.2 | 0.2 | | 0.1 | 0.4 | 0.7 | 0.9 |
| | Run 14 | | 0.0 | 0.0 | 0.2 | 0.2 | | 0.0 | 0.3 | 0.9 | 1.0 |
| | Run 15 | | 1.1 | 4.2 | 5.1 | 6.0 | | 1.4 | 5.9 | 7.2 | 8.2 |
| | Run 16 | | 0.9 | 6.6 | 7.6 | 9.8 | | 1.3 | 8.7 | 9.5 | 12.2 |
| Monitoring Location at 10.5 miles | Run 0 | 3.4 | 3.3 | 5.8 | 6.8 | 7.1 | 4.5 | 4.5 | 8.3 | 9.5 | 9.8 |
| | Run 1 | 5.3 | 5.3 | 9.7 | 10.7 | 11.2 | 6.2 | 6.4 | 12.4 | 13.8 | 14.3 |
| | Run 2 | 1.4 | 0.9 | 1.8 | 2.6 | 2.6 | 2.4 | 2.0 | 3.6 | 4.6 | 4.7 |
| | Run 3 | 2.0 | 2.9 | 10.2 | 12.7 | 10.3 | 2.9 | 4.2 | 14.8 | 17.5 | 15.2 |
| | Run 4 | 4.0 | 3.5 | 4.4 | 4.7 | 4.9 | 5.1 | 4.6 | 6.2 | 6.7 | 6.9 |
| | Run 5 | 4.3 | 3.3 | 4.2 | 5.2 | 5.5 | 6.2 | 6.0 | 7.8 | 8.8 | 9.2 |
| | Run 6 | 2.3 | 2.4 | 7.3 | 8.3 | 7.6 | 3.0 | 3.3 | 10.0 | 11.3 | 10.6 |
| | Run 7 | 5.9 | 3.4 | 5.9 | 6.8 | 7.1 | 10.0 | 5.1 | 8.7 | 9.7 | 10.1 |
| | Run 8 | 3.4 | 3.2 | 5.8 | 6.8 | 7.1 | 4.5 | 4.4 | 8.3 | 9.5 | 9.8 |
| | Run 9 | 1.8 | 1.3 | 2.2 | 2.6 | 2.6 | 2.5 | 2.1 | 3.4 | 3.8 | 3.9 |
| | Run 10 | 0.3 | 0.7 | 5.3 | 8.7 | 4.3 | 0.6 | 1.3 | 8.7 | 12.4 | 7.5 |
| | Run 11 | 4.9 | 3.8 | 6.3 | 6.8 | 7.0 | 6.5 | 4.9 | 8.2 | 9.0 | 9.2 |
| | Run 12 | 1.8 | 2.9 | 17.4 | 21.1 | 16.4 | 2.4 | 3.8 | 23.5 | 28.0 | 23.3 |
| | Run 13 | 1.2 | 0.4 | 0.5 | 0.7 | 0.7 | 2.7 | 1.5 | 1.8 | 2.2 | 2.3 |
| | Run 14 | 0.5 | 0.1 | 0.3 | 0.8 | 0.6 | 1.4 | 0.7 | 1.6 | 3.0 | 2.6 |
| | Run 15 | 8.1 | 9.0 | 10.5 | 10.9 | 11.1 | 9.7 | 10.9 | 13.0 | 13.7 | 14.0 |
| | Run 16 | 6.7 | 8.5 | 15.4 | 17.4 | 18.5 | 8.4 | 10.8 | 19.2 | 21.0 | 22.5 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 6.2 | 6.9 | 9.4 | 11.5 | 10.8 | 7.9 | 8.8 | 12.2 | 14.6 | 13.9 |
| | Run 1 | 9.3 | 10.4 | 14.1 | 16.4 | 15.8 | 10.6 | 12.0 | 16.6 | 19.4 | 18.9 |
| | Run 2 | 2.9 | 2.8 | 4.0 | 5.6 | 4.7 | 4.5 | 4.7 | 6.5 | 8.5 | 7.7 |
| | Run 3 | 3.7 | 6.2 | 16.5 | 22.3 | 15.0 | 5.2 | 8.3 | 21.4 | 27.8 | 20.5 |
| | Run 4 | 7.2 | 7.2 | 7.3 | 7.9 | 7.6 | 8.8 | 9.0 | 9.3 | 10.1 | 9.8 |
| | Run 5 | 10.6 | 9.5 | 9.2 | 11.0 | 10.3 | 14.4 | 14.5 | 14.5 | 16.5 | 15.7 |
| | Run 6 | 3.1 | 4.1 | 9.4 | 11.8 | 9.4 | 4.1 | 5.2 | 11.9 | 14.6 | 12.4 |
| | Run 7 | 7.9 | 7.2 | 9.6 | 11.6 | 10.8 | 12.0 | 9.8 | 12.8 | 15.0 | 14.2 |
| | Run 8 | 6.2 | 6.9 | 9.4 | 11.5 | 10.8 | 7.9 | 8.8 | 12.2 | 14.5 | 13.9 |
| | Run 9 | 2.6 | 2.5 | 3.4 | 4.1 | 3.8 | 3.5 | 3.5 | 4.6 | 5.4 | 5.2 |
| | Run 10 | 0.5 | 1.5 | 8.0 | 14.8 | 5.4 | 0.8 | 2.3 | 11.6 | 18.9 | 8.7 |
| | Run 11 | 6.2 | 6.0 | 7.8 | 8.7 | 8.6 | 7.9 | 7.3 | 9.6 | 10.8 | 10.6 |
| | Run 12 | 2.5 | 4.8 | 20.7 | 28.7 | 18.3 | 3.1 | 5.9 | 26.2 | 35.2 | 25.1 |
| | Run 13 | 4.1 | 2.4 | 2.0 | 2.5 | 2.2 | 7.3 | 5.5 | 4.9 | 5.6 | 5.1 |
| | Run 14 | 1.7 | 1.1 | 1.6 | 3.2 | 1.9 | 4.0 | 3.3 | 5.1 | 8.3 | 6.0 |
| | Run 15 | 18.4 | 19.6 | 18.7 | 19.5 | 18.3 | 21.4 | 23.1 | 22.3 | 23.2 | 22.0 |
| | Run 16 | 15.5 | 19.0 | 26.5 | 32.5 | 30.3 | 18.8 | 23.3 | 31.7 | 37.9 | 35.9 |
| Monitoring Location at 30.5 miles | Run 0 | 13.9 | 24.1 | 52.0 | 49.1 | 33.0 | 16.8 | 27.3 | 55.9 | 53.0 | 37.6 |
| | Run 1 | 19.5 | 30.2 | 59.2 | 56.2 | 41.4 | 21.7 | 32.5 | 61.9 | 59.0 | 44.8 |
| | Run 2 | 8.0 | 16.9 | 42.2 | 39.1 | 21.3 | 10.7 | 20.4 | 47.2 | 44.3 | 27.2 |
| | Run 3 | 7.7 | 22.4 | 80.3 | 97.5 | 35.2 | 10.3 | 26.2 | 87.3 | 104.9 | 42.8 |
| | Run 4 | 17.4 | 21.5 | 31.5 | 27.4 | 27.3 | 20.2 | 24.2 | 34.5 | 30.3 | 30.5 |
| | Run 5 | 33.9 | 45.3 | 73.7 | 61.5 | 58.3 | 41.3 | 53.2 | 82.9 | 70.7 | 69.4 |
| | Run 6 | 5.1 | 10.6 | 31.6 | 37.5 | 17.3 | 6.4 | 12.2 | 33.9 | 40.0 | 20.3 |
| | Run 7 | 14.5 | 24.6 | 52.4 | 49.4 | 33.1 | 18.5 | 28.9 | 57.0 | 54.0 | 38.2 |
| | Run 8 | 13.9 | 24.1 | 52.0 | 49.1 | 33.0 | 16.8 | 27.3 | 55.9 | 53.0 | 37.6 |
| | Run 9 | 4.9 | 8.3 | 17.5 | 16.6 | 11.1 | 6.2 | 9.6 | 19.1 | 18.1 | 12.9 |
| | Run 10 | 0.8 | 4.6 | 30.5 | 57.5 | 9.6 | 1.4 | 6.1 | 35.3 | 63.2 | 13.3 |
| | Run 11 | 9.8 | 13.4 | 23.2 | 22.2 | 17.4 | 11.5 | 15.1 | 24.9 | 24.0 | 19.4 |
| | Run 12 | 3.8 | 10.3 | 46.2 | 75.8 | 24.9 | 4.7 | 12.0 | 50.5 | 81.3 | 31.6 |
| | Run 13 | 23.6 | 25.1 | 33.0 | 26.5 | 28.3 | 30.5 | 32.4 | 41.2 | 34.6 | 37.8 |
| | Run 14 | 9.3 | 27.5 | 85.7 | 77.0 | 26.6 | 15.2 | 38.3 | 107.0 | 97.9 | 43.3 |
| | Run 15 | 52.3 | 54.6 | 65.0 | 58.0 | 63.3 | 58.1 | 60.5 | 71.1 | 63.9 | 69.5 |
| | Run 16 | 38.7 | 70.2 | 155.5 | 146.7 | 98.5 | 45.5 | 77.9 | 165.1 | 156.3 | 110.2 |

## 6.9 Simulated drawdowns from Well Fields Located in Potential Production Area #4

This section describes the construction and application of two groundwater models to simulated the drawdowns that would be created by pumping Potential Production Area #4 at two proposed well fields.

### *6.9.1 Construction of Groundwater Models based on GAM and GHSM properties*

The two groundwater models constructed to simulate pumping from PPA #4 are three-dimensional models with the same model layers and vertical grid discretization as shown in Figure 6-9. The width of the two models is along the geologic strike for the Carrizo-Wilcox Aquifer and is 100 miles. The length of the two models along dip is 84 miles. The recharge rate applied to the outcrop was a uniform 1.5 inches per year.

**Table 6-38** provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 15-mile reaches for both models. The model properties extracted from the Southern QCSP GAM and assigned to model layers 1 to 9. The values for vertical hydraulic conductivity (Kz) were determined by imposing ratio of Kx/Kz of 1,000 for all model layers except for the model layers that represent the Reklaw formation and the middle Wilcox Aquifer. The ratio of Kx/Kz for these two model layers was 10,000. In addition, adjustments to the Kx/Kz ratios for the middle Wilcox were made based on the degree of confinement provided by the clay layers contained within the middle Wilcox and present on geophysical logs. These adjustments allow the Kx/Kz ratio to vary between 1,000 and 100,000.

Table 6-8 also provides the values for Kx, Kx, and Ss that were produced by the GHSM for model Layers 5 to 9. **Figures 6-63** and **6-64** illustrate the values of Kx in Table 6-38. The two figures illustrate that the GAM-based model has significantly lower Kx values for the middle Wilcox than does the GHSM –based model. Among the most notable difference between the two sets of hydraulic properties for the Carrizo-Wilcox Aquifer is that the vertical hydraulic conductivity values and the specific storage values are significantly lower for the GMA-based properties than the GHSM-based properties.

A comparison of the hydraulic conductivity values in the Southern QCSP GAM and of the field measured values from Deeds and others (2004) indicate that the Carrizo Aquifer is significantly less permeable in the vicinity of cross-section 4 than cross section 1 in Figure 6-6. To account for this observation, the hydraulic conductivity baseline value used in Equation 6-3 for the Carrizo-upper Wilcox Aquifer has been reduced from 30.5 ft/day to 4 ft/day.

### *6.9.2 Simulated Drawdown Produced by Pumping from Potential Production Area #4*

Groundwater pumping at the rate of 5,000 AFY, 15,000 AFY and 30,000 AFY was simulated at two well fields in PPA #4 shown in Figure 6-9. Both well fields pump model layer 6, which represents the middle third of the lower Carrizo upper Wilcox Aquifer. The up dip Well Field #1 is located 60 miles down dip from the outcrop, and the down dip well field #2 is located 70 miles down dip from the outcrop. **Figures 6-65** and **6-66** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GAM-based hydraulic properties for the Carrizo-Wilcox aquifer. **Figures 6-67** and **6-68** show the simulated drawdown at 50 years for the three pumping rates at Well Field #1 and Well Field #2, respectively, by the groundwater model with the GHSM-based hydraulic properties for the Carrizo-Wilcox aquifer.

Among the notable results that can be observed in the plotted drawdown in **Figures 6-65 to 6-69** are the following:

- The Reklaw provides as an effective hydraulic barrier that prevents appreciable drawdowns from migrating from the Carrizo-Wilcox Aquifer into the Queen City Aquifer
- The drawdown predicted in the Carrizo-Wilcox Aquifer outcrop is significantly higher from pumping Well Field #1 than from pumping Well Field #2
- There is less predicted drawdown in down-dip of the well field in the Carrizo-Wilcox Aquifer from the GHSM-based model than in the GAM-based model

To help to quantify the drawdown in areas of interest and at time of interest, drawdown values were recorded for all four model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 2.5 miles, 5.5 miles, 10.5 miles, 15.5 miles, and 30.5 miles. **Table 6-39** provides the elevations and depths associated with these five monitoring locations.

**Table 6-38 Average values for Kx (feet per day), Kz (feet per day), and Ss(1/feet) by model layer for 15-mile reaches along dip for the groundwater models for PPA # 4**

**Common to Both GAM and GHSM based Groundwater Models for Cross-Section 1**

| Reach (miles) | Property | Layer 1 | Layer 2 | Layer 3 | Layer 4 |
|---|---|---|---|---|---|
| 0-15 | Kx | n/a | n/a | 1.0 | 0.2 |
| | Kz | n/a | n/a | 1.0E-03 | 2.3E-05 |
| | Ss | n/a | n/a | 1.2E-03 | 2.8E-03 |
| 15-30 | Kx | n/a | n/a | 2.14827653 | 0.27893404 |
| | Kz | n/a | n/a | 2.1E-03 | 2.8E-05 |
| | Ss | n/a | n/a | 4.1E-04 | 3.0E-05 |
| 30-45 | Kx | n/a | n/a | 1.6 | 0.7 |
| | Kz | n/a | n/a | 1.6E-03 | 7.1E-05 |
| | Ss | n/a | n/a | 8.6E-05 | 5.5E-05 |
| 45-60 | Kx | 4.7 | 1.0 | 0.6 | 0.8 |
| | Kz | 4.7E-03 | 1.0E-03 | 5.6E-04 | 7.8E-05 |
| | Ss | 1.1E-05 | 1.1E-05 | 6.5E-06 | 4.2E-06 |
| 60-84 | Kx | 1.6 | 0.9 | 0.4 | 0.6 |
| | Kz | 1.7E-03 | 9.7E-04 | 4.5E-04 | 6.7E-05 |
| | Ss | 3.5E-06 | 4.3E-06 | 2.9E-06 | 3.0E-06 |

**Carrizo-Wilcox Aquifer Properties Extracted from the Southern QCSP GAM**

| Reach (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 0.5 | 0.4 | 0.4 | 4.1 | 3.0 |
| | Kz | 5.3E-04 | 4.4E-04 | 4.1E-04 | 2.1E-03 | 3.0E-03 |
| | Ss | 1.5E-05 | 1.5E-05 | 1.3E-05 | 3.0E-05 | 4.3E-06 |
| 15-30 | Kx | 1.0001 | 1.0001 | 1.0001 | 0.38167787 | 3.00000017 |
| | Kz | 1.0E-03 | 1.0E-03 | 1.0E-03 | 6.9E-05 | 3.0E-03 |
| | Ss | 5.3E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 30-45 | Kx | 1.0 | 1.0 | 1.0 | 0.3 | 3.0 |
| | Kz | 1.0E-03 | 1.0E-03 | 1.0E-03 | 2.8E-05 | 3.0E-03 |
| | Ss | 5.3E-06 | 3.1E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 45-60 | Kx | 1.0 | 1.0 | 1.0 | 0.3 | 1.1 |
| | Kz | 1.0E-03 | 1.0E-03 | 1.0E-03 | 9.8E-06 | 1.1E-03 |
| | Ss | 3.6E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |
| 60-84 | Kx | 1.0 | 1.0 | 1.0 | 0.3 | 1.0 |
| | Kz | 1.1E-03 | 1.1E-03 | 1.1E-03 | 3.8E-06 | 1.1E-03 |
| | Ss | 1.8E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 | 3.0E-06 |

**Carrizo-Wilcox Aquifer Properties Developed from the GeoHydroStratigraphic Model (GHSM)**

| Reach (miles) | Property | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
|---|---|---|---|---|---|---|
| 0-15 | Kx | 1.7 | 1.5 | 2.2 | 5.0 | 3.0 |
| | Kz | 1.5E-03 | 1.4E-03 | 1.8E-03 | 1.7E-03 | 1.6E-03 |
| | Ss | 3.4E-01 | 3.1E-01 | 4.6E-01 | 4.4E-01 | 4.4E-01 |
| 15-30 | Kx | 1.6 | 1.2 | 1.8 | 3.9 | 2.2 |
| | Kz | 1.4E-03 | 1.2E-03 | 1.5E-03 | 1.3E-03 | 1.2E-03 |
| | Ss | 3.4E-01 | 2.7E-01 | 4.3E-01 | 4.3E-01 | 4.3E-01 |
| 30-45 | Kx | 1.2 | 0.8 | 1.4 | 2.8 | 1.5 |
| | Kz | 1.1E-03 | 9.6E-04 | 1.1E-03 | 1.0E-03 | 8.2E-04 |
| | Ss | 2.9E-01 | 2.3E-01 | 4.0E-01 | 4.0E-01 | 4.0E-01 |
| 45-60 | Kx | 0.9 | 0.4 | 0.4 | 0.8 | 0.4 |
| | Kz | 8.6E-04 | 5.9E-04 | 5.5E-04 | 4.6E-04 | 3.4E-04 |
| | Ss | 3.3E-01 | 1.4E-01 | 1.9E-01 | 1.9E-01 | 1.9E-01 |
| 60-84 | Kx | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 |
| | Kz | 5.6E-04 | 3.5E-04 | 2.6E-04 | 2.0E-04 | 1.2E-04 |
| | Ss | 3.3E-01 | 1.2E-01 | 6.6E-02 | 6.6E-02 | 6.6E-02 |

**Table 6-39. Locations where drawdowns were monitored for the simulated pumping at Well Field #1 and Well Field #2 in Potential Production Area #4**

| Monitoring Location (miles) | Ground Surface (ft, msl) | Vertical Boundary | Carrizo-upper Wilcox | Middle Wilcox | Lower Wilcox | | |
|---|---|---|---|---|---|---|---|
| | | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 2.5 | 745.1 | Top | | | | 745.1 | 709.8 |
| | | Bottom | | | | 709.8 | 469.3 |
| 5.5 | 739.8 | Top | | | | 739.8 | 487.7 |
| | | Bottom | | | | 487.7 | 148.9 |
| 10.5 | 656.2 | Top | | 656.2 | 415.8 | 310.8 | 21.5 |
| | | Bottom | | 415.8 | 310.8 | 21.5 | -492.8 |
| 15.5 | 708.8 | Top | 607 | 370.8 | 134.6 | -108.7 | -410 |
| | | Bottom | 370.8 | 134.6 | -108.7 | -410 | -938.1 |
| 30.5 | 675.6 | Top | -227.1 | -569.6 | -912 | -1264.8 | -1797.8 |
| | | Bottom | -569.6 | -912 | -1264.8 | -1797.8 | -2444 |

### Simulated Drawdown from the Groundwater Model with GAM-based Properties for the Carrizo-Wilcox Aquifer

**Tables 6-40** and **6-41** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-19 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GAM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-69** to **6-70** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-71** to **6-72** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-40 and 6-41 and Figures 6-69 through 6-72 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #1 the groundwater model predicts between 2 and 8 feet of drawdown in the Carrizo-upper Wilcox at the 15.5 mile monitoring point location and between 20 and 24 feet in the Carrizo-upper Wilcox at the 30.5 mile monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts less than 4 feet of drawdown in the Carrizo-upper Wilcox at the 15.5 mile monitoring point location and between 8 to 10 feet in the Carrizo-upper Wilcox at the 30.5 mile monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 300 feet of drawdown at the Well Field #1

- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 700 feet of drawdown at the Well Field #2

**Simulated Drawdown from the Groundwater Model with GHSM-based Properties for the Carrizo-Wilcox Aquifer**

**Tables 6-42** and **6-43** provide drawdown at 30 and 50 years at the monitoring locations listed in Table 6-9 for pumping at 5,000, 15,000, and 30,000 years as determined by the groundwater model that uses GHSM-based properties for the Carrizo-Wilcox Aquifer. **Figures 6-73** to **6-74** shows the simulated drawdown along the center dip line of the groundwater model elapsed times of 5, 10, 30, and 50 years for pumping Well Field #1 at 15,000 AFY. **Figures 6-75** to **6-76** shows the simulated drawdown along the center dip line of the groundwater model at elapsed times of 5, 10, 30, and 50 years for pumping Well Field #2 at 15,000 AFY.

Among the notable results that can be gleaned from a review of Tables 6-42 and 6-43 and Figures 6-73 through 6-76 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts less than 1 foot of drawdown in the Carrizo-upper Wilcox at the 15.5 mile monitoring point location and less than 2 feet in the Carrizo-upper Wilcox at the 30.5 mile monitoring point location
- After 30 years pumping 15,000 AFY from Well Field #2 the groundwater model predicts less than 0.5 foot of drawdown in the Carrizo-upper Wilcox at the 15.5 mile monitoring point location and less than 0.5 foot in the Carrizo-upper Wilcox at the 30.5 mile monitoring point location
- After 30 years of pumping 15,000 AFY, the groundwater model predicts about 500 feet of drawdown at the Well Field #1
- After 30 years of pumping 15,000 AFY, the groundwater model predicts more than 1000 feet of drawdown at the Well Field #2

**Table 6-40. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #4 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | | | Middle Wilcox | Lower Wilcox |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 15,000 | Not Present | Not Present | Not Present | 0.01 | 0.01 |
| | 30,000 | Not Present | Not Present | Not Present | 0.02 | 0.01 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.45 | 0.07 | 0.00 |
| | 15,000 | Not Present | 0.01 | 1.36 | 0.20 | 0.01 |
| | 30,000 | Not Present | 0.01 | 2.71 | 0.40 | 0.03 |
| 15.5 | 5,000 | 0.86 | 1.38 | 2.69 | 0.21 | 0.01 |
| | 15,000 | 2.59 | 4.13 | 8.06 | 0.62 | 0.02 |
| | 30,000 | 5.14 | 8.21 | 16.02 | 1.23 | 0.03 |
| 30.5 | 5,000 | 6.93 | 6.74 | 8.00 | 0.30 | 0.00 |
| | 15,000 | 20.78 | 20.23 | 24.03 | 0.90 | 0.01 |
| | 30,000 | 41.25 | 40.19 | 47.74 | 1.79 | 0.01 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 15,000 | Not Present | Not Present | Not Present | 0.01 | 0.00 |
| | 30,000 | Not Present | Not Present | Not Present | 0.02 | 0.01 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.01 | 0.01 |
| | 15,000 | Not Present | Not Present | Not Present | 0.03 | 0.02 |
| | 30,000 | Not Present | Not Present | Not Present | 0.05 | 0.04 |
| 10.5 | 5,000 | Not Present | 0.01 | 0.85 | 0.15 | 0.01 |
| | 15,000 | Not Present | 0.02 | 2.56 | 0.45 | 0.04 |
| | 30,000 | Not Present | 0.04 | 5.10 | 0.90 | 0.08 |
| 15.5 | 5,000 | 1.95 | 2.86 | 4.82 | 0.47 | 0.02 |
| | 15,000 | 5.84 | 8.56 | 14.48 | 1.40 | 0.05 |
| | 30,000 | 11.62 | 17.05 | 28.82 | 2.78 | 0.11 |
| 30.5 | 5,000 | 11.25 | 10.85 | 12.32 | 0.84 | 0.01 |
| | 15,000 | 33.74 | 32.54 | 36.98 | 2.52 | 0.03 |
| | 30,000 | 67.09 | 64.75 | 73.60 | 5.00 | 0.06 |

**Table 6-41. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #4 for 30 years and 50 years, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | | | Middle Wilcox | Lower Wilcox |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 15,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 30,000 | Not Present | Not Present | Not Present | 0.01 | 0.00 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.18 | 0.03 | 0.00 |
| | 15,000 | Not Present | 0.00 | 0.55 | 0.09 | 0.00 |
| | 30,000 | Not Present | 0.01 | 1.10 | 0.18 | 0.01 |
| 15.5 | 5,000 | 0.52 | 1.20 | 0.08 | 0.00 | 0.52 |
| | 15,000 | 1.59 | 3.63 | 0.25 | 0.01 | 1.59 |
| | 30,000 | 3.16 | 7.23 | 0.50 | 0.01 | 3.16 |
| 30.5 | 5,000 | 2.91 | 3.56 | 0.12 | 0.00 | 2.91 |
| | 15,000 | 8.80 | 10.76 | 0.35 | 0.00 | 8.80 |
| | 30,000 | 17.53 | 21.44 | 0.69 | 0.00 | 17.53 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 15,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 30,000 | Not Present | Not Present | Not Present | 0.01 | 0.01 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.00 | 0.00 |
| | 15,000 | Not Present | Not Present | Not Present | 0.01 | 0.01 |
| | 30,000 | Not Present | Not Present | Not Present | 0.03 | 0.02 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.45 | 0.09 | 0.01 |
| | 15,000 | Not Present | 0.01 | 1.37 | 0.27 | 0.02 |
| | 30,000 | Not Present | 0.03 | 2.73 | 0.55 | 0.04 |
| 15.5 | 5,000 | 1.14 | 1.48 | 2.82 | 0.25 | 0.01 |
| | 15,000 | 3.45 | 4.46 | 8.51 | 0.76 | 0.03 |
| | 30,000 | 6.88 | 8.89 | 16.97 | 1.53 | 0.05 |
| 30.5 | 5,000 | 5.93 | 6.03 | 6.99 | 0.41 | 5.93 |
| | 15,000 | 17.88 | 18.16 | 21.07 | 1.24 | 17.88 |
| | 30,000 | 35.66 | 36.23 | 42.05 | 2.47 | 35.66 |

**Table 6-42. Simulated drawdown at monitoring locations after pumping Well Field #1 in PPA #4 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | | | Middle Wilcox | Lower Wilcox |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.01 | 0.00 | 0.00 |
| | 15,000 | Not Present | 0.00 | 0.02 | 0.01 | 0.00 |
| | 30,000 | Not Present | 0.00 | 0.04 | 0.01 | 0.00 |
| 15.5 | 5,000 | 0.00 | 0.00 | 0.04 | 0.01 | 0.00 |
| | 15,000 | 0.00 | 0.01 | 0.12 | 0.03 | 0.00 |
| | 30,000 | 0.00 | 0.02 | 0.23 | 0.05 | 0.00 |
| 30.5 | 5,000 | 0.57 | 0.41 | 0.63 | 0.17 | 0.00 |
| | 15,000 | 1.68 | 1.21 | 1.90 | 0.52 | 0.01 |
| | 30,000 | 3.27 | 2.36 | 3.71 | 1.01 | 0.01 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.04 | 0.02 | 0.00 |
| | 15,000 | Not Present | 0.00 | 0.13 | 0.07 | 0.00 |
| | 30,000 | Not Present | 0.00 | 0.26 | 0.13 | 0.00 |
| 15.5 | 5,000 | 0.01 | 0.03 | 0.20 | 0.07 | 0.00 |
| | 15,000 | 0.02 | 0.10 | 0.61 | 0.22 | 0.01 |
| | 30,000 | 0.05 | 0.20 | 1.19 | 0.44 | 0.01 |
| 30.5 | 5,000 | 1.91 | 1.56 | 1.74 | 0.73 | 0.01 |
| | 15,000 | 5.69 | 4.64 | 5.24 | 2.23 | 0.04 |
| | 30,000 | 11.17 | 9.12 | 10.33 | 4.38 | 0.09 |

**Table 6-43. Simulated drawdown at monitoring locations after pumping Well Field #2 in PPA #4 for 30 years and 50 years, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| Monitoring Location (miles) | Pumping Rate (AFY) | Carrizo-upper Wilcox | | | Middle Wilcox | Lower Wilcox |
|---|---|---|---|---|---|---|
| | | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 |
| 30 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 10.5 | 5,000 | Not Present | 0.0 | 0.0 | 0.0 | 0.0 |
| | 15,000 | Not Present | 0.0 | 0.0 | 0.0 | 0.0 |
| | 30,000 | Not Present | 0.0 | 0.0 | 0.0 | 0.0 |
| 15.5 | 5,000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 15,000 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| | 30,000 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 30.5 | 5,000 | 0.03 | 0.02 | 0.04 | 0.01 | 0.00 |
| | 15,000 | 0.10 | 0.08 | 0.12 | 0.03 | 0.00 |
| | 30,000 | 0.19 | 0.15 | 0.24 | 0.06 | 0.00 |
| 50 Years | | | | | | |
| 2.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 5.5 | 5,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 15,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| | 30,000 | Not Present | Not Present | Not Present | 0.0 | 0.0 |
| 10.5 | 5,000 | Not Present | 0.00 | 0.00 | 0.00 | 0.00 |
| | 15,000 | Not Present | 0.00 | 0.01 | 0.01 | 0.00 |
| | 30,000 | Not Present | 0.00 | 0.03 | 0.01 | 0.00 |
| 15.5 | 5,000 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 |
| | 15,000 | 0.00 | 0.01 | 0.08 | 0.02 | 0.00 |
| | 30,000 | 0.00 | 0.02 | 0.16 | 0.04 | 0.00 |
| 30.5 | 5,000 | 0.25 | 0.21 | 0.25 | 0.09 | 0.00 |
| | 15,000 | 0.76 | 0.65 | 0.78 | 0.29 | 0.00 |
| | 30,000 | 1.48 | 1.27 | 1.53 | 0.57 | 0.01 |

### *6.9.3 Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #4*

Table 6-2 describes the changes in the model input parameter associated with set of sixteen sensitivity runs performed for the groundwater models simulations involving GAM-based and the GHSM-based aquifer properties. In this section, Model Run 0 refers to the baseline run of 15,000 AF for which simulated drawdowns are shown in Figures 6-27 to 6-34. **Tables 6-44** and **6-45** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-39** as determined by the groundwater model with GAM-based aquifer properties. **Tables 6-46** and **6-47** provide the sensitivity results for drawdown at the five monitoring locations in Table drawdown at 30 and 50 years at the monitoring locations in **Table 6-39** as determined by the groundwater model with GHSM-based aquifer properties.

Among the notable results that can be gleaned from a review of **Tables 6-44** through **6-45** are:

- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 15.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.5 feet and 22 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GAM-based properties predicts that at the 30.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.5 feet and 70 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 15.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.5 feet and 19 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GAM-based properties predicts that at the 30.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 1 feet and 37 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that at the 15.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.1 feet and 3 feet.
- After 30 years of pumping the Well Field #1 for 15,000 AFY, the model with GHSM-based properties predicts that at the 30.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.1 feet and 22 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that at the 15.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown is between less than 0.1 feet and 2.0 feet.
- After 30 years of pumping the Well Field #2 for 15,000 AFY, the model with GHSM-based properties predicts that at the 30.5 mile monitoring location in the Carrizo-upper Wilcox the drawdown between less than 0.1 feet and 13 feet.

**Table 6-44. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #4 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.0 | | | | 0.2 | 0.1 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.1 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 5.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.1 | 0.1 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.1 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.1 | | | | 0.2 | 0.3 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.1 | | | | 0.0 | 0.3 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 10.5 miles | Run 0 | | 0.0 | 1.4 | 0.2 | 0.0 | | 0.0 | 2.6 | 0.5 | 0.0 |
| | Run 1 | | 0.0 | 4.0 | 0.8 | 0.1 | | 0.0 | 5.4 | 1.3 | 0.3 |
| | Run 2 | | 0.0 | 0.1 | 0.0 | 0.0 | | 0.0 | 0.5 | 0.0 | 0.0 |
| | Run 3 | | 0.0 | 1.4 | 0.1 | 0.0 | | 0.0 | 2.8 | 0.2 | 0.0 |
| | Run 4 | | 0.0 | 1.0 | 0.4 | 0.1 | | 0.0 | 1.8 | 0.8 | 0.2 |
| | Run 5 | | 0.0 | 0.2 | 0.0 | 0.0 | | 0.0 | 0.8 | 0.3 | 0.0 |
| | Run 6 | | 0.1 | 2.1 | 0.1 | 0.0 | | 0.2 | 3.2 | 0.3 | 0.0 |
| | Run 7 | | 0.0 | 1.4 | 0.2 | 0.0 | | 0.0 | 2.6 | 0.5 | 0.0 |
| | Run 8 | | 0.0 | 1.4 | 0.2 | 0.0 | | 0.0 | 2.6 | 0.5 | 0.0 |
| | Run 9 | | 0.0 | 0.6 | 0.1 | 0.0 | | 0.1 | 1.2 | 0.2 | 0.0 |
| | Run 10 | | 0.0 | 0.4 | 0.0 | 0.0 | | 0.1 | 1.0 | 0.0 | 0.0 |
| | Run 11 | | 0.2 | 3.6 | 0.9 | 0.3 | | 0.3 | 4.5 | 1.3 | 0.5 |
| | Run 12 | | 0.3 | 4.5 | 0.1 | 0.0 | | 0.5 | 5.9 | 0.2 | 0.0 |
| | Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | | 0.0 | 1.1 | 1.0 | 0.5 | | 0.0 | 2.0 | 1.9 | 1.2 |
| | Run 16 | | 0.0 | 3.5 | 0.6 | 0.0 | | 0.0 | 6.2 | 1.2 | 0.1 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 2.6 | 4.1 | 8.1 | 0.6 | 0.0 | 5.8 | 8.6 | 14.5 | 1.4 | 0.1 |
| | Run 1 | 9.7 | 13.9 | 22.3 | 2.7 | 0.2 | 13.6 | 19.0 | 29.8 | 4.2 | 0.4 |
| | Run 2 | 0.1 | 0.2 | 0.7 | 0.0 | 0.0 | 0.6 | 1.1 | 2.8 | 0.1 | 0.0 |
| | Run 3 | 2.4 | 5.2 | 7.9 | 0.2 | 0.0 | 6.0 | 10.6 | 15.3 | 0.5 | 0.0 |
| | Run 4 | 2.9 | 3.7 | 6.1 | 1.2 | 0.1 | 6.0 | 7.3 | 10.8 | 2.6 | 0.3 |
| | Run 5 | 0.3 | 0.5 | 1.7 | 0.2 | 0.0 | 1.5 | 2.4 | 6.3 | 0.9 | 0.0 |
| | Run 6 | 5.2 | 7.2 | 9.3 | 0.4 | 0.0 | 7.9 | 10.6 | 13.6 | 0.7 | 0.0 |
| | Run 7 | 2.6 | 4.1 | 8.1 | 0.6 | 0.0 | 5.8 | 8.6 | 14.5 | 1.4 | 0.1 |
| | Run 8 | 2.6 | 4.1 | 8.1 | 0.6 | 0.0 | 5.8 | 8.6 | 14.5 | 1.4 | 0.1 |
| | Run 9 | 1.2 | 1.6 | 2.8 | 0.2 | 0.0 | 2.8 | 3.6 | 5.3 | 0.5 | 0.0 |
| | Run 10 | 0.9 | 2.7 | 2.0 | 0.0 | 0.0 | 2.6 | 5.2 | 4.3 | 0.1 | 0.0 |
| | Run 11 | 10.0 | 12.1 | 15.9 | 2.7 | 0.4 | 12.4 | 14.9 | 19.4 | 3.8 | 0.8 |
| | Run 12 | 12.1 | 17.0 | 19.0 | 0.4 | 0.0 | 15.2 | 20.9 | 24.2 | 0.7 | 0.0 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 15 | 4.6 | 5.7 | 8.8 | 3.6 | 0.7 | 8.2 | 10.0 | 14.9 | 6.9 | 1.9 |
| | Run 16 | 5.1 | 9.9 | 23.0 | 1.8 | 0.0 | 10.3 | 18.7 | 39.4 | 3.8 | 0.1 |
| Monitoring Location at 30.5 miles | Run 0 | 20.8 | 20.2 | 24.0 | 0.9 | 0.0 | 33.7 | 32.5 | 37.0 | 2.5 | 0.0 |
| | Run 1 | 47.3 | 46.1 | 52.6 | 7.2 | 0.1 | 61.2 | 59.5 | 67.4 | 15.4 | 0.4 |
| | Run 2 | 3.3 | 3.6 | 5.1 | 0.1 | 0.0 | 9.5 | 9.5 | 12.1 | 0.2 | 0.0 |
| | Run 3 | 22.5 | 24.0 | 21.5 | 0.3 | 0.0 | 37.5 | 38.1 | 35.6 | 0.8 | 0.0 |
| | Run 4 | 19.6 | 18.5 | 22.2 | 2.4 | 0.0 | 31.1 | 29.5 | 33.1 | 6.3 | 0.2 |
| | Run 5 | 8.3 | 8.3 | 15.6 | 0.5 | 0.0 | 21.9 | 21.4 | 33.6 | 1.9 | 0.0 |
| | Run 6 | 22.3 | 21.0 | 19.3 | 0.9 | 0.0 | 30.4 | 28.5 | 27.0 | 2.1 | 0.0 |
| | Run 7 | 20.8 | 20.2 | 24.0 | 0.9 | 0.0 | 33.7 | 32.5 | 37.0 | 2.5 | 0.0 |
| | Run 8 | 20.8 | 20.2 | 24.0 | 0.9 | 0.0 | 33.7 | 32.5 | 37.0 | 2.5 | 0.0 |
| | Run 9 | 8.1 | 7.6 | 8.2 | 0.3 | 0.0 | 13.6 | 12.6 | 13.0 | 0.9 | 0.0 |
| | Run 10 | 7.7 | 11.1 | 5.2 | 0.0 | 0.0 | 14.5 | 17.0 | 9.5 | 0.1 | 0.0 |
| | Run 11 | 34.4 | 32.6 | 33.5 | 11.5 | 0.5 | 41.2 | 39.1 | 40.1 | 18.2 | 1.3 |
| | Run 12 | 43.0 | 43.2 | 35.5 | 1.8 | 0.0 | 52.4 | 51.8 | 44.5 | 3.6 | 0.0 |
| | Run 13 | 0.2 | 0.2 | 0.8 | 0.0 | 0.0 | 1.7 | 1.6 | 3.6 | 0.2 | 0.0 |
| | Run 14 | 0.1 | 0.3 | 0.6 | 0.0 | 0.0 | 1.3 | 2.1 | 3.6 | 0.0 | 0.0 |
| | Run 15 | 39.0 | 37.1 | 45.6 | 13.5 | 0.5 | 57.5 | 55.0 | 64.6 | 29.6 | 2.0 |
| | Run 16 | 47.9 | 51.0 | 69.5 | 2.6 | 0.0 | 73.6 | 77.1 | 103.1 | 7.2 | 0.1 |

**Table 6-45. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #4 at five monitoring locations, as determined by the groundwater model using GAM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.0 | | | | 0.2 | 0.1 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 5.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.1 | 0.1 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.1 | | | | 0.2 | 0.3 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.1 | | | | 0.0 | 0.2 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 10.5 miles | Run 0 | | 0.0 | 0.6 | 0.1 | 0.0 | | 0.0 | 1.4 | 0.3 | 0.0 |
| | Run 1 | | 0.0 | 2.7 | 0.7 | 0.1 | | 0.1 | 4.1 | 1.2 | 0.2 |
| | Run 2 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 3 | | 0.0 | 0.6 | 0.0 | 0.0 | | 0.0 | 1.6 | 0.1 | 0.0 |
| | Run 4 | | 0.0 | 0.4 | 0.2 | 0.0 | | 0.0 | 0.9 | 0.5 | 0.1 |
| | Run 5 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.2 | 0.1 | 0.0 |
| | Run 6 | | 0.1 | 1.5 | 0.1 | 0.0 | | 0.2 | 2.6 | 0.2 | 0.0 |
| | Run 7 | | 0.0 | 0.6 | 0.1 | 0.0 | | 0.0 | 1.4 | 0.3 | 0.0 |
| | Run 8 | | 0.0 | 0.6 | 0.1 | 0.0 | | 0.0 | 1.4 | 0.3 | 0.0 |
| | Run 9 | | 0.0 | 0.2 | 0.0 | 0.0 | | 0.0 | 0.6 | 0.1 | 0.0 |
| | Run 10 | | 0.0 | 0.2 | 0.0 | 0.0 | | 0.1 | 0.6 | 0.0 | 0.0 |
| | Run 11 | | 0.3 | 3.0 | 0.9 | 0.2 | | 0.4 | 3.9 | 1.3 | 0.5 |
| | Run 12 | | 0.4 | 4.0 | 0.2 | 0.0 | | 0.6 | 5.5 | 0.3 | 0.0 |
| | Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | | 0.0 | 0.4 | 0.4 | 0.2 | | 0.0 | 1.0 | 1.1 | 0.6 |
| | Run 16 | | 0.0 | 1.4 | 0.3 | 0.0 | | 0.0 | 3.3 | 0.7 | 0.1 |
| Monitoring Location at 15.5 miles | Run 0 | 1.1 | 1.6 | 3.6 | 0.3 | 0.0 | 3.5 | 4.5 | 8.5 | 0.8 | 0.0 |
| | Run 1 | 7.6 | 9.3 | 16.4 | 1.9 | 0.1 | 12.3 | 14.6 | 24.6 | 3.4 | 0.3 |
| | Run 2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.3 | 0.8 | 0.0 | 0.0 |
| | Run 3 | 1.0 | 2.0 | 3.8 | 0.1 | 0.0 | 3.4 | 5.5 | 9.5 | 0.3 | 0.0 |
| | Run 4 | 1.2 | 1.4 | 2.6 | 0.5 | 0.0 | 3.5 | 3.8 | 6.1 | 1.4 | 0.1 |
| | Run 5 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | 0.4 | 0.6 | 1.7 | 0.2 | 0.0 |
| | Run 6 | 3.8 | 4.8 | 7.1 | 0.3 | 0.0 | 6.8 | 8.2 | 11.8 | 0.6 | 0.0 |
| | Run 7 | 1.1 | 1.6 | 3.6 | 0.3 | 0.0 | 3.5 | 4.5 | 8.5 | 0.8 | 0.0 |
| | Run 8 | 1.1 | 1.6 | 3.6 | 0.3 | 0.0 | 3.5 | 4.5 | 8.5 | 0.8 | 0.0 |
| | Run 9 | 0.4 | 0.6 | 1.3 | 0.1 | 0.0 | 1.6 | 1.9 | 3.1 | 0.3 | 0.0 |
| | Run 10 | 0.3 | 1.1 | 1.0 | 0.0 | 0.0 | 1.4 | 2.8 | 2.8 | 0.0 | 0.0 |
| | Run 11 | 9.6 | 10.4 | 14.4 | 2.5 | 0.3 | 12.4 | 13.3 | 18.3 | 3.7 | 0.7 |
| | Run 12 | 11.5 | 14.4 | 18.5 | 0.4 | 0.0 | 15.2 | 18.6 | 24.3 | 0.7 | 0.0 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | 2.1 | 2.3 | 3.7 | 1.4 | 0.2 | 5.1 | 5.3 | 8.1 | 3.6 | 0.9 |
| | Run 16 | 2.4 | 3.9 | 10.4 | 0.7 | 0.0 | 6.8 | 9.8 | 23.0 | 2.1 | 0.1 |
| Monitoring Location at 30.5 miles | Run 0 | 8.4 | 8.8 | 10.8 | 0.3 | 0.0 | 17.9 | 18.2 | 21.1 | 1.2 | 0.0 |
| | Run 1 | 31.4 | 31.8 | 36.6 | 4.5 | 0.1 | 45.9 | 46.2 | 52.5 | 11.2 | 0.4 |
| | Run 2 | 0.5 | 0.7 | 1.0 | 0.0 | 0.0 | 2.4 | 2.8 | 3.7 | 0.1 | 0.0 |
| | Run 3 | 9.1 | 10.6 | 10.4 | 0.1 | 0.0 | 19.9 | 21.5 | 21.6 | 0.4 | 0.0 |
| | Run 4 | 8.0 | 7.9 | 9.4 | 0.9 | 0.0 | 16.6 | 16.3 | 18.1 | 3.0 | 0.1 |
| | Run 5 | 1.2 | 1.5 | 2.8 | 0.1 | 0.0 | 5.7 | 6.1 | 9.5 | 0.4 | 0.0 |
| | Run 6 | 14.9 | 14.6 | 14.2 | 0.6 | 0.0 | 23.2 | 22.6 | 22.3 | 1.7 | 0.0 |
| | Run 7 | 8.4 | 8.8 | 10.8 | 0.3 | 0.0 | 17.9 | 18.2 | 21.1 | 1.2 | 0.0 |
| | Run 8 | 8.4 | 8.8 | 10.8 | 0.3 | 0.0 | 17.9 | 18.2 | 21.1 | 1.2 | 0.0 |
| | Run 9 | 3.3 | 3.3 | 3.7 | 0.1 | 0.0 | 7.2 | 7.0 | 7.4 | 0.4 | 0.0 |
| | Run 10 | 3.2 | 5.0 | 2.7 | 0.0 | 0.0 | 7.8 | 9.8 | 6.2 | 0.0 | 0.0 |
| | Run 11 | 28.8 | 28.1 | 28.7 | 9.7 | 0.5 | 36.1 | 35.1 | 35.8 | 16.5 | 1.3 |
| | Run 12 | 36.4 | 37.1 | 33.2 | 1.6 | 0.0 | 46.5 | 46.5 | 42.9 | 3.5 | 0.0 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.3 | 0.0 | 0.0 |
| | Run 15 | 16.0 | 15.7 | 18.5 | 4.8 | 0.2 | 30.1 | 29.4 | 33.0 | 13.7 | 0.9 |
| | Run 16 | 19.6 | 22.4 | 31.0 | 1.0 | 0.0 | 38.9 | 42.9 | 58.0 | 3.5 | 0.0 |

**Table 6-46. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #1 located in PPA #4 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.0 | | | | 0.3 | 0.1 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.1 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 5.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.1 | 0.1 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.1 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.2 | 0.1 | | | | 0.4 | 0.4 |
| | Run 12 | | | | 0.1 | 0.0 | | | | 0.2 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| Monitoring Location at 10.5 miles | Run 0 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.1 | 0.0 |
| | Run 1 | | 0.0 | 0.5 | 0.4 | 0.0 | | 0.1 | 1.2 | 1.2 | 0.2 |
| | Run 2 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 3 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 4 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.1 | 0.0 |
| | Run 5 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 6 | | 0.0 | 0.3 | 0.1 | 0.0 | | 0.1 | 0.7 | 0.3 | 0.0 |
| | Run 7 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.1 | 0.0 |
| | Run 8 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.1 | 0.0 |
| | Run 9 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 10 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 11 | | 0.3 | 1.3 | 1.0 | 0.3 | | 0.6 | 2.1 | 1.6 | 0.8 |
| | Run 12 | | 0.4 | 1.0 | 0.4 | 0.0 | | 0.8 | 1.7 | 0.8 | 0.1 |
| | Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.2 | 0.3 | 0.1 |
| | Run 16 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.3 | 0.2 | 0.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 0.2 | 0.0 |
| | Run 1 | 0.3 | 0.8 | 2.2 | 1.3 | 0.1 | 1.3 | 2.4 | 4.5 | 3.2 | 0.4 |
| | Run 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.1 | 0.0 |
| | Run 4 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.5 | 0.4 | 0.0 |
| | Run 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 6 | 0.1 | 0.3 | 0.7 | 0.2 | 0.0 | 0.5 | 1.1 | 1.6 | 0.7 | 0.0 |
| | Run 7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 0.2 | 0.0 |
| | Run 8 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 0.2 | 0.0 |
| | Run 9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 |
| | Run 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 11 | 1.8 | 2.3 | 3.1 | 2.3 | 0.5 | 3.1 | 3.7 | 4.5 | 3.4 | 1.3 |
| | Run 12 | 1.8 | 2.9 | 2.4 | 0.9 | 0.0 | 3.8 | 4.9 | 3.7 | 1.7 | 0.1 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.2 | 0.3 | 1.1 | 1.1 | 0.3 |
| | Run 16 | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 | 0.1 | 0.3 | 1.7 | 0.7 | 0.0 |
| Monitoring Location at 30.5 miles | Run 0 | 1.7 | 1.2 | 1.9 | 0.5 | 0.0 | 5.7 | 4.6 | 5.2 | 2.2 | 0.0 |
| | Run 1 | 14.7 | 12.9 | 12.3 | 7.4 | 0.3 | 25.8 | 23.3 | 20.6 | 14.5 | 1.2 |
| | Run 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.4 | 0.0 | 0.0 |
| | Run 3 | 1.8 | 0.9 | 1.5 | 0.2 | 0.0 | 6.4 | 4.2 | 4.3 | 0.9 | 0.0 |
| | Run 4 | 1.5 | 1.2 | 2.0 | 1.1 | 0.0 | 4.9 | 4.3 | 5.5 | 3.8 | 0.2 |
| | Run 5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.5 | 0.4 | 1.1 | 0.4 | 0.0 |
| | Run 6 | 6.6 | 4.8 | 3.6 | 1.3 | 0.0 | 12.2 | 9.6 | 6.3 | 3.1 | 0.1 |
| | Run 7 | 1.7 | 1.2 | 1.9 | 0.5 | 0.0 | 5.7 | 4.6 | 5.2 | 2.2 | 0.0 |
| | Run 8 | 1.7 | 1.2 | 1.9 | 0.5 | 0.0 | 5.7 | 4.6 | 5.2 | 2.2 | 0.0 |
| | Run 9 | 0.6 | 0.4 | 0.6 | 0.2 | 0.0 | 2.1 | 1.7 | 1.8 | 0.7 | 0.0 |
| | Run 10 | 0.4 | 0.2 | 0.3 | 0.0 | 0.0 | 1.9 | 1.4 | 1.0 | 0.1 | 0.0 |
| | Run 11 | 15.7 | 14.1 | 11.0 | 8.3 | 1.4 | 20.7 | 18.7 | 14.5 | 11.4 | 3.3 |
| | Run 12 | 21.9 | 18.4 | 8.1 | 3.4 | 0.1 | 30.6 | 25.3 | 11.3 | 5.6 | 0.3 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | 3.2 | 2.8 | 5.5 | 4.3 | 0.5 | 10.5 | 9.5 | 14.5 | 12.5 | 2.4 |
| | Run 16 | 4.2 | 3.3 | 5.7 | 1.6 | 0.0 | 13.9 | 12.3 | 15.5 | 6.7 | 0.1 |

**Table 6-47. Results from a sensitivity analysis of simulated drawdowns caused by pumping 15,000 AFY from Well Field #2 located in PPA #4 at five monitoring locations, as determined by the groundwater model using GHSM-based hydraulic properties for the Carrizo-Wilcox Aquifer.**

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 2.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.0 | | | | 0.2 | 0.1 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.1 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 5.5 miles | Run 0 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 1 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 2 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 3 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 4 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 5 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 6 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 7 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 8 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 9 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 10 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 11 | | | | 0.1 | 0.1 | | | | 0.3 | 0.3 |
| | Run 12 | | | | 0.0 | 0.0 | | | | 0.1 | 0.0 |
| | Run 13 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 14 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 15 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |
| | Run 16 | | | | 0.0 | 0.0 | | | | 0.0 | 0.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 10.5 miles | Run 0 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 1 | | 0.0 | 0.1 | 0.1 | 0.0 | | 0.0 | 0.5 | 0.5 | 0.1 |
| | Run 2 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 3 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 4 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 5 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 6 | | 0.0 | 0.1 | 0.0 | 0.0 | | 0.0 | 0.3 | 0.1 | 0.0 |
| | Run 7 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 8 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 9 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 10 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 11 | | 0.2 | 0.7 | 0.6 | 0.2 | | 0.4 | 1.4 | 1.1 | 0.5 |
| | Run 12 | | 0.2 | 0.6 | 0.3 | 0.0 | | 0.5 | 1.2 | 0.6 | 0.0 |
| | Run 13 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 16 | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 15.5 miles | Run 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 1 | 0.1 | 0.2 | 0.6 | 0.3 | 0.0 | 0.5 | 0.8 | 2.0 | 1.4 | 0.1 |
| | Run 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 6 | 0.0 | 0.1 | 0.2 | 0.1 | 0.0 | 0.2 | 0.4 | 0.7 | 0.3 | 0.0 |
| | Run 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | Run 9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 11 | 1.0 | 1.1 | 1.8 | 1.4 | 0.3 | 2.2 | 2.3 | 3.2 | 2.5 | 0.8 |
| | Run 12 | 1.0 | 1.5 | 1.6 | 0.6 | 0.0 | 2.8 | 3.1 | 2.9 | 1.3 | 0.1 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 |
| | Run 16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 |

| | | 30 years | | | | | 50 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 6 | 7 | 8 | 9 | 5 | 6 | 7 | 8 | 9 |
| Monitoring Location at 30.5 miles | Run 0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.8 | 0.6 | 0.8 | 0.3 | 0.0 |
| | Run 1 | 4.0 | 3.7 | 3.6 | 2.1 | 0.1 | 10.3 | 9.8 | 8.8 | 6.2 | 0.4 |
| | Run 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 3 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.9 | 0.5 | 0.7 | 0.1 | 0.0 |
| | Run 4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.6 | 0.6 | 0.8 | 0.5 | 0.0 |
| | Run 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 6 | 1.8 | 1.3 | 1.1 | 0.4 | 0.0 | 5.0 | 4.0 | 2.8 | 1.4 | 0.0 |
| | Run 7 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.8 | 0.6 | 0.8 | 0.3 | 0.0 |
| | Run 8 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.8 | 0.6 | 0.8 | 0.3 | 0.0 |
| | Run 9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.2 | 0.3 | 0.1 | 0.0 |
| | Run 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.1 | 0.2 | 0.0 | 0.0 |
| | Run 11 | 8.6 | 7.9 | 6.3 | 4.9 | 0.8 | 13.4 | 12.5 | 9.8 | 8.0 | 2.4 |
| | Run 12 | 12.7 | 10.4 | 5.0 | 2.2 | 0.0 | 21.1 | 17.3 | 8.2 | 4.5 | 0.2 |
| | Run 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Run 15 | 0.2 | 0.2 | 0.4 | 0.3 | 0.0 | 1.3 | 1.3 | 2.0 | 1.8 | 0.3 |
| | Run 16 | 0.3 | 0.2 | 0.4 | 0.1 | 0.0 | 1.8 | 1.7 | 2.2 | 0.8 | 0.0 |

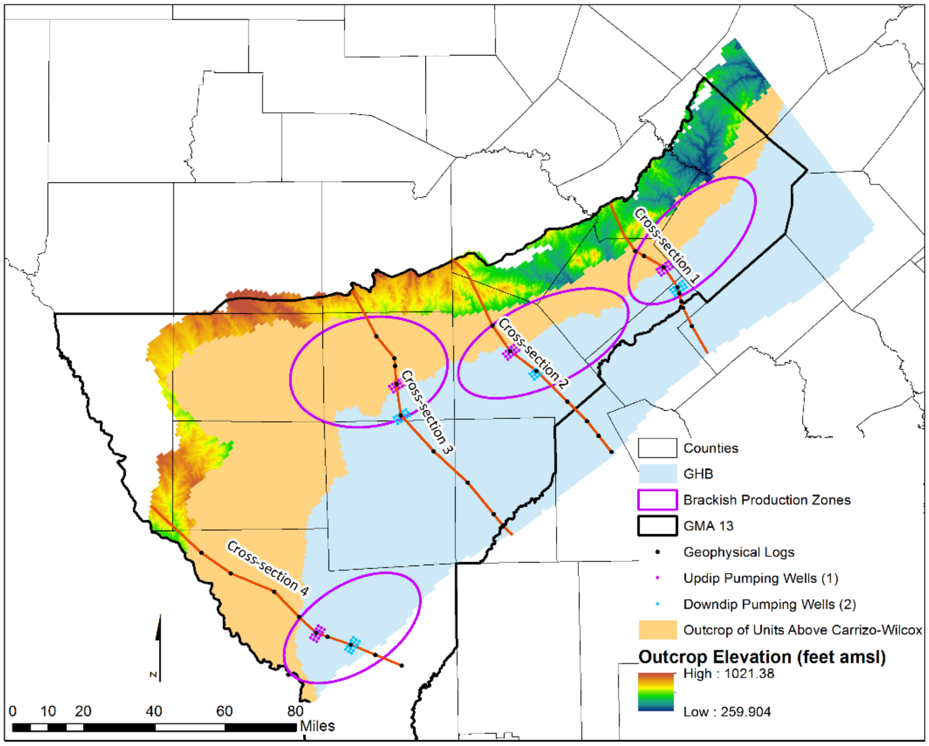


**Figure 6-1.** **Location of transects through the four potential brackish production zones that were used for developing groundwater models for each potential production area.**

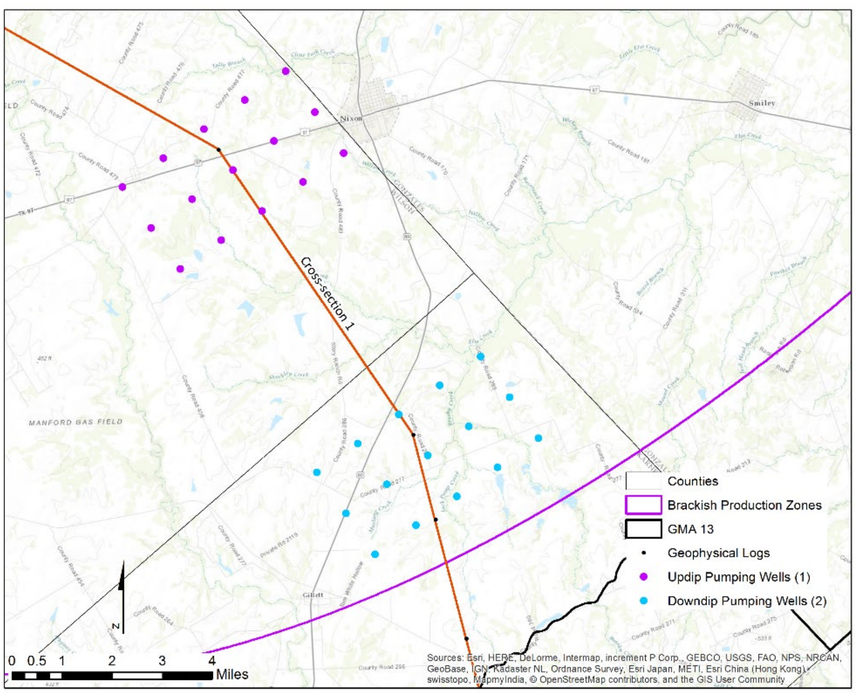


**Figure 6-2.** **Location the two well fields along cross-section #1. Both well fields are illustrated using the 15 well network used to pump 30,000 AFY.**

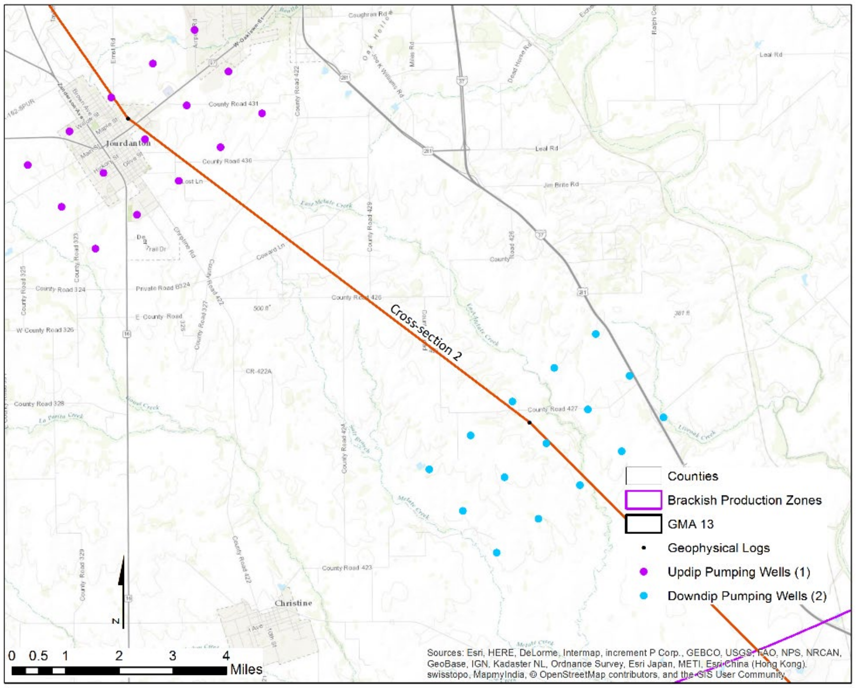


**Figure 6-3.** **Location of the two well fields along cross-section #2. Both well fields are illustrated using the 15 well network used to pump 30,000 AFY.**

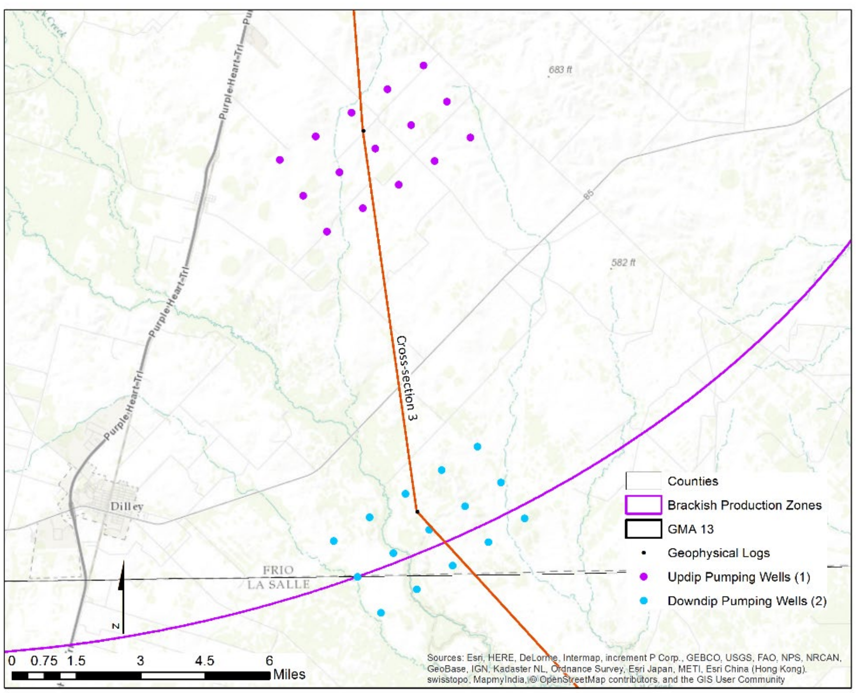


**Figure 6-4.** **Location of the two well fields along cross-section #3. Both well fields are illustrated using the 15 well network used to pump 30,000 AFY.**

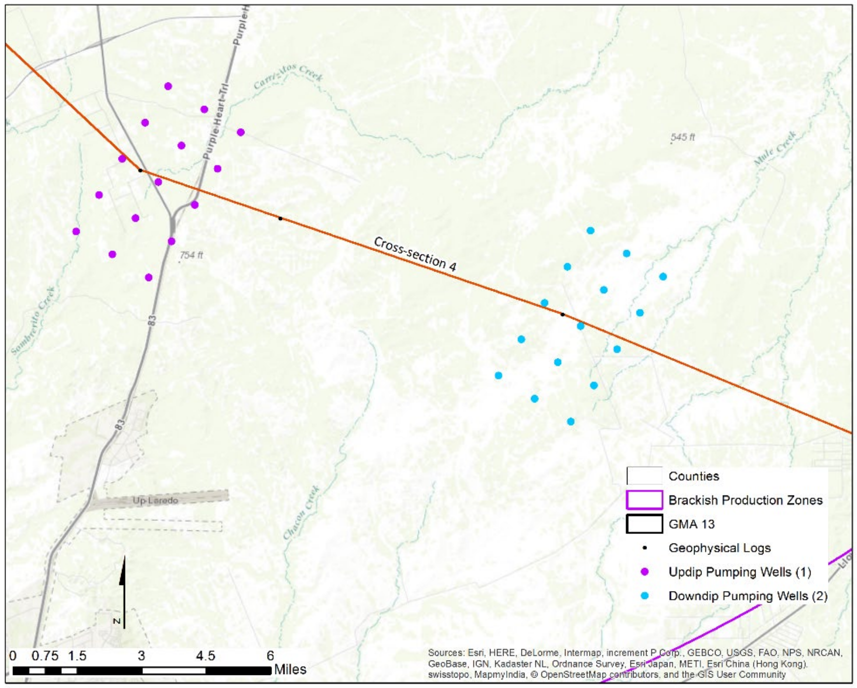


**Figure 6-5. Location of the two well fields along cross-section #4. Both well fields are illustrated using the 15 well network used to pump 30,000 AFY.**

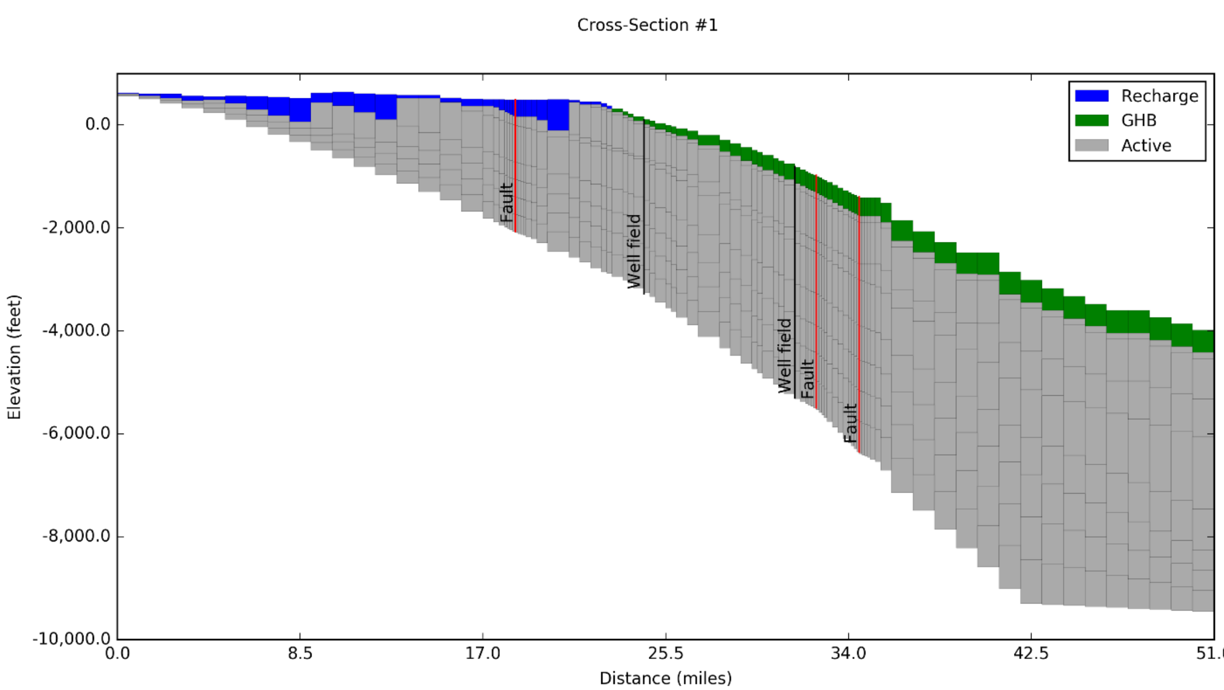


**Figure 6-6. Vertical cross-section that shows the nine model layers and the hydraulic boundary conditions used in the groundwater model and the position of two well fields and three fault zones along the transect that intersects PPA #1.**

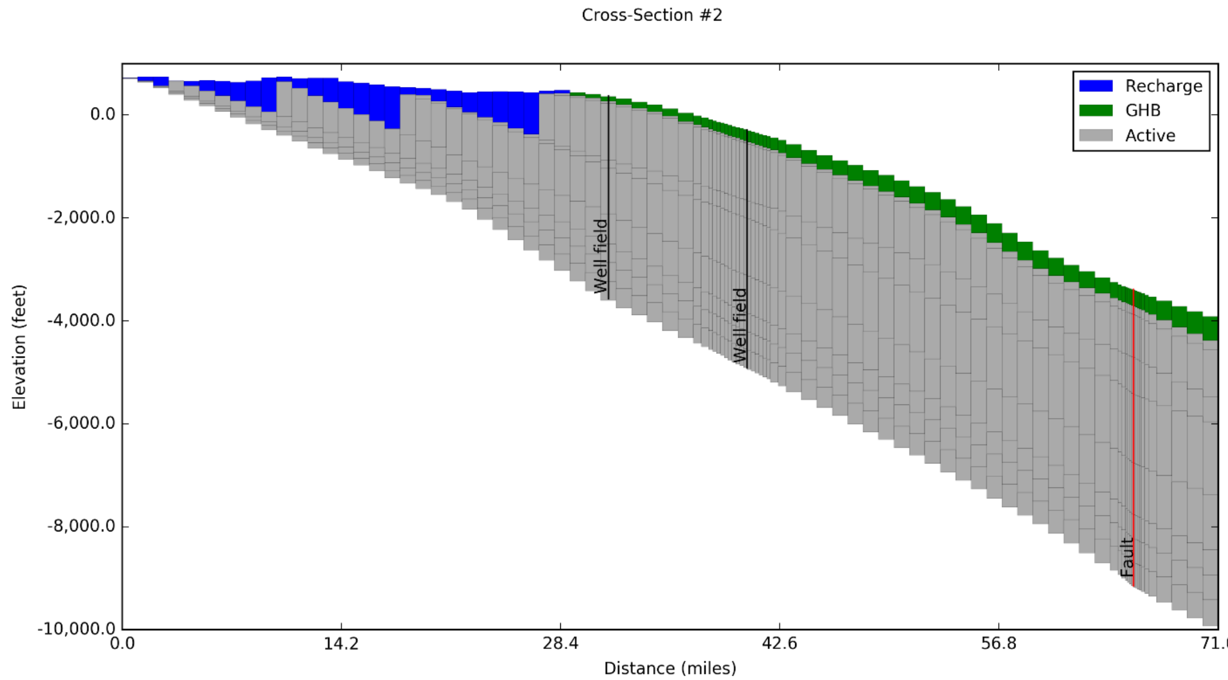


**Figure 6-7.** **Vertical cross-section that shows the nine model layers and the hydraulic boundary conditions used in the groundwater model and the position of two well fields and three fault zones along the transect that intersects PPA #2.**

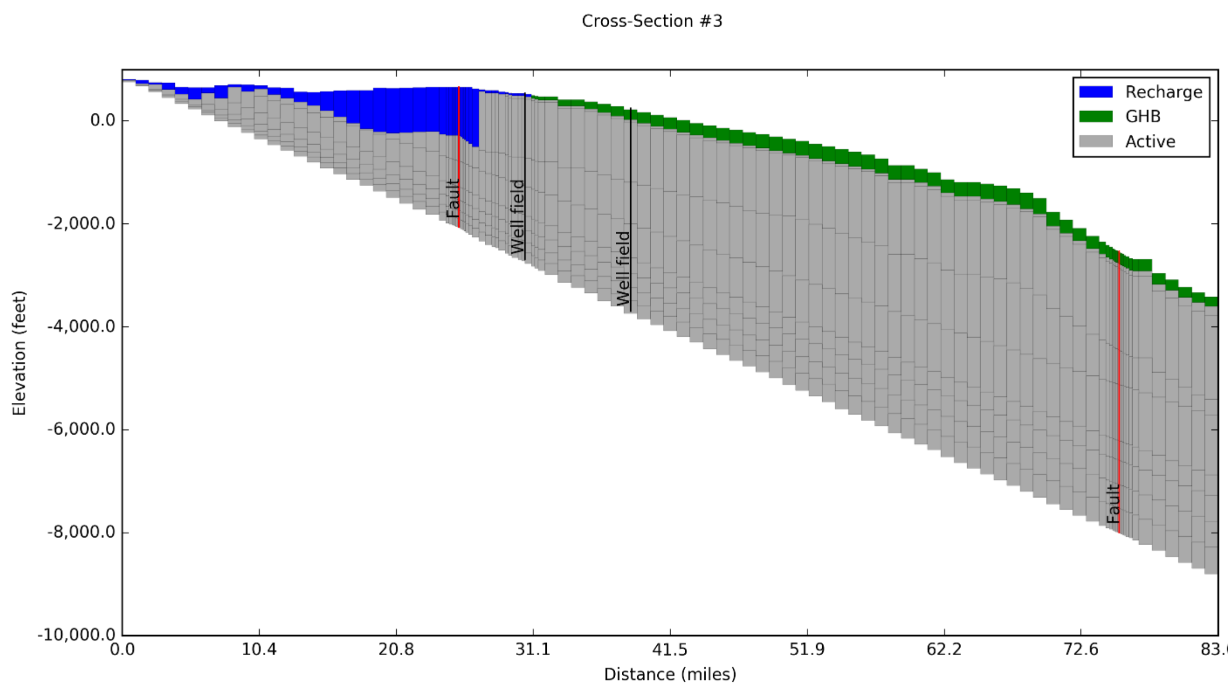


**Figure 6-8.** **Vertical cross-section that shows the nine model layers and the hydraulic boundary conditions used in the groundwater model and the position of two well fields and three fault zones along the transect that intersects PPA #3.**

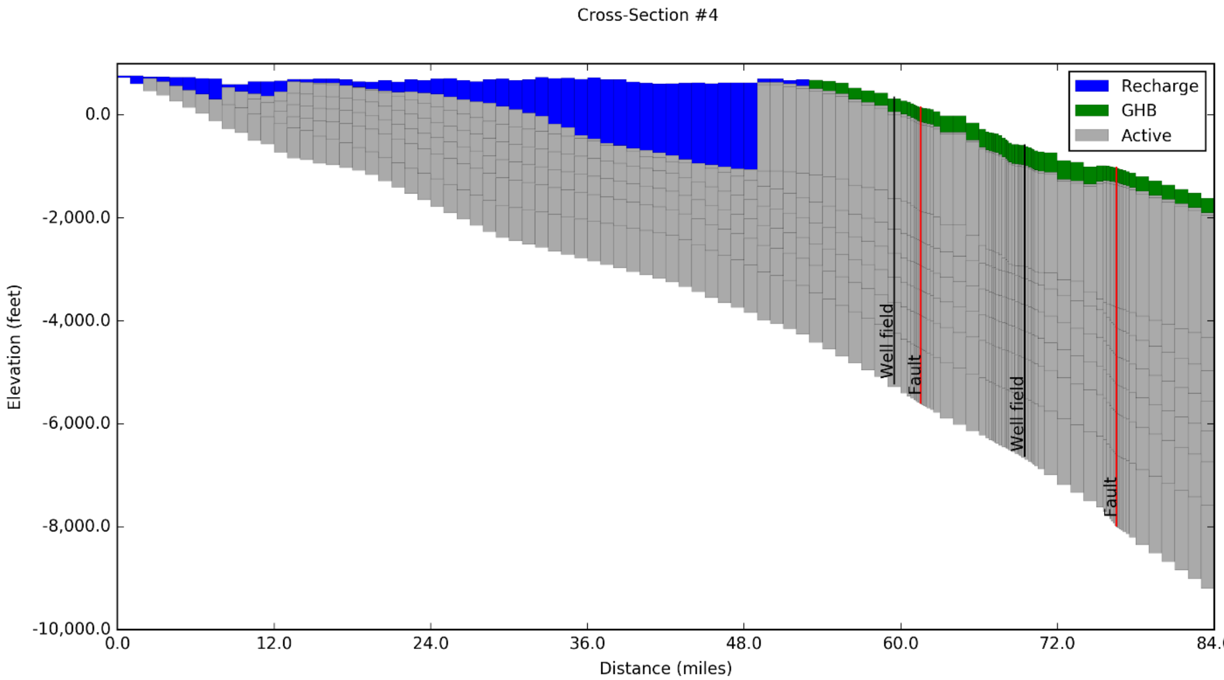


**Figure 6-9.** **Vertical cross-section that shows the nine model layers and the hydraulic boundary conditions used in the groundwater model and the position of two well fields and three fault zones along the transect that intersects PPA #4.**

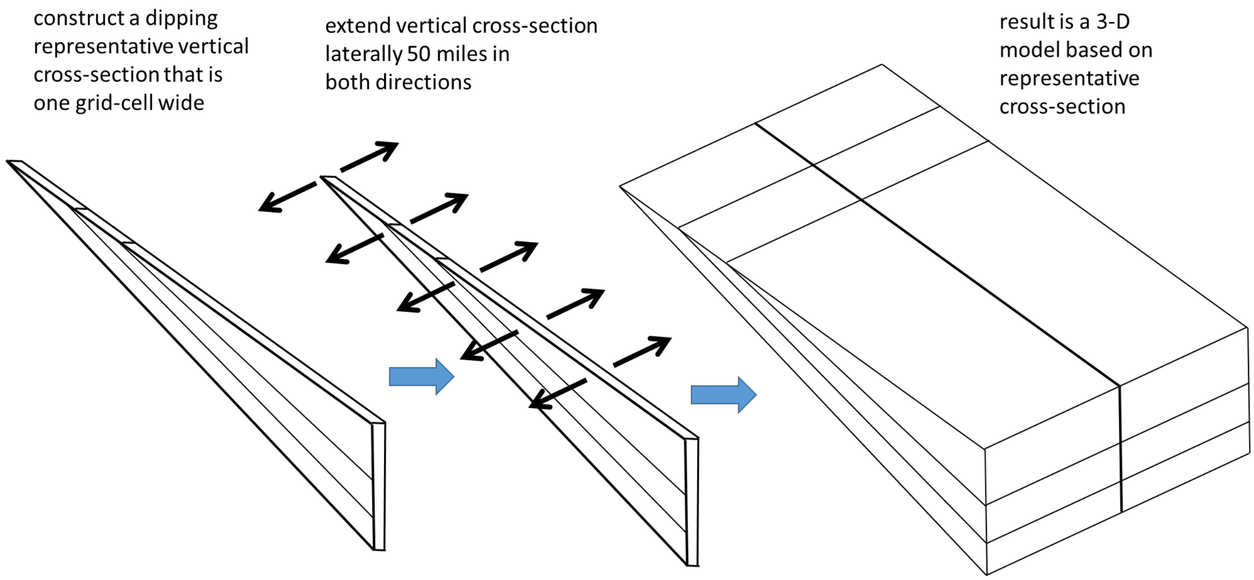


**Figure 6-10. Schematic showing the lateral outward replication of a vertical cross-section, which is one grid-cell wide, to construct a three-dimensional model that covers a distance of 50 miles on both sides of the original cross-section.**

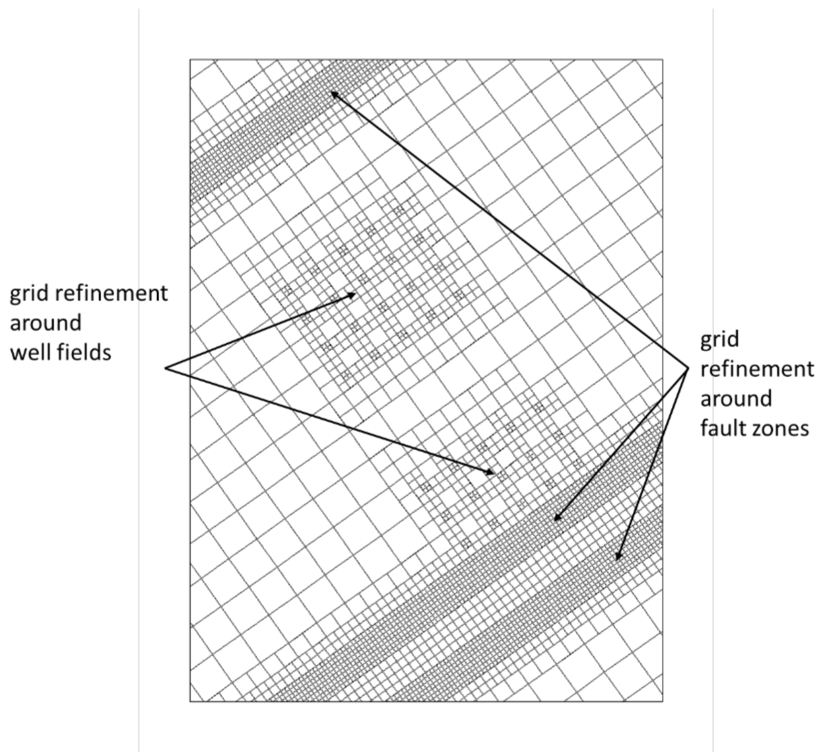


**Figure 6-11. Aerial view of the groundwater model for PPA #1 showing the type of grid refinement that occurs in the vicinity of the well fields and faults to reduce from 1-mile by 1-mile grid cells to 1/8-mile by 1/8-mile grid cells.**

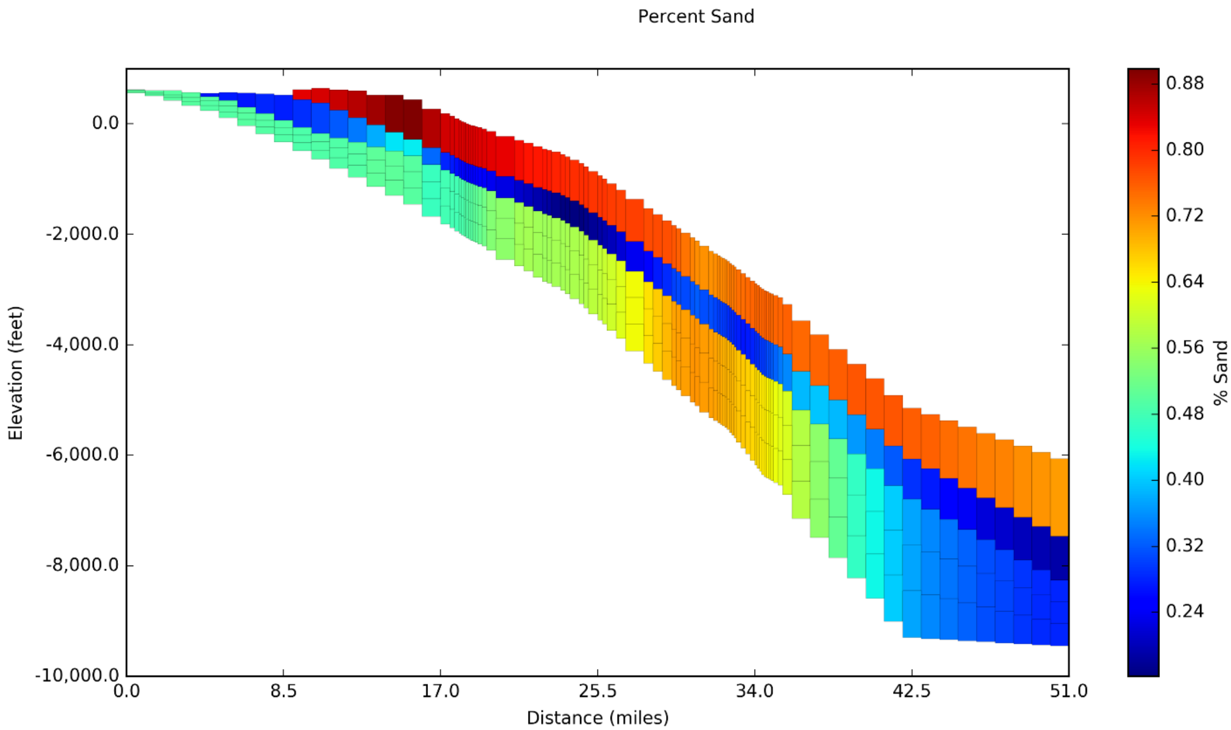


**Figure 6-12.** **Sand fraction for model layers 5, 6, 7, 8, and 9 for a vertical cross-section cut through the three-dimensional model for PPA #1.**

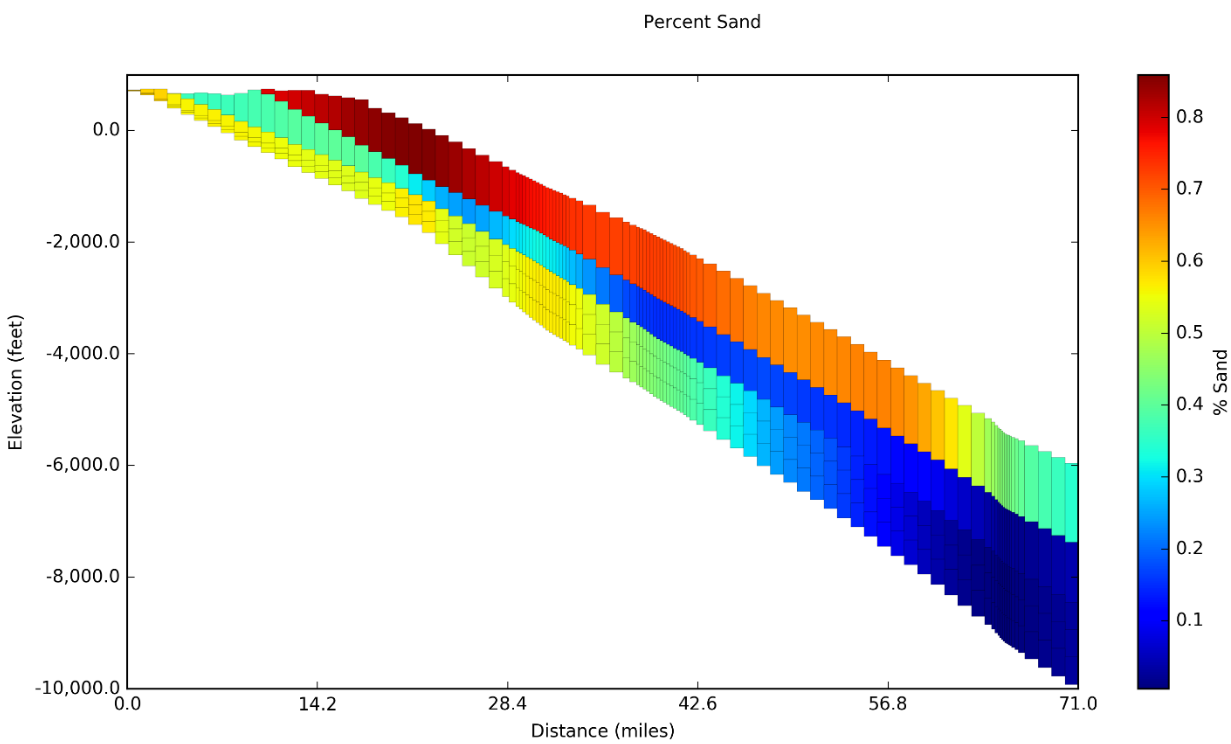


**Figure 6-13.** **Sand fraction for model layers 5, 6, 7, 8, and 9 for a vertical cross-section cut through the three-dimensional model for PPA #2.**

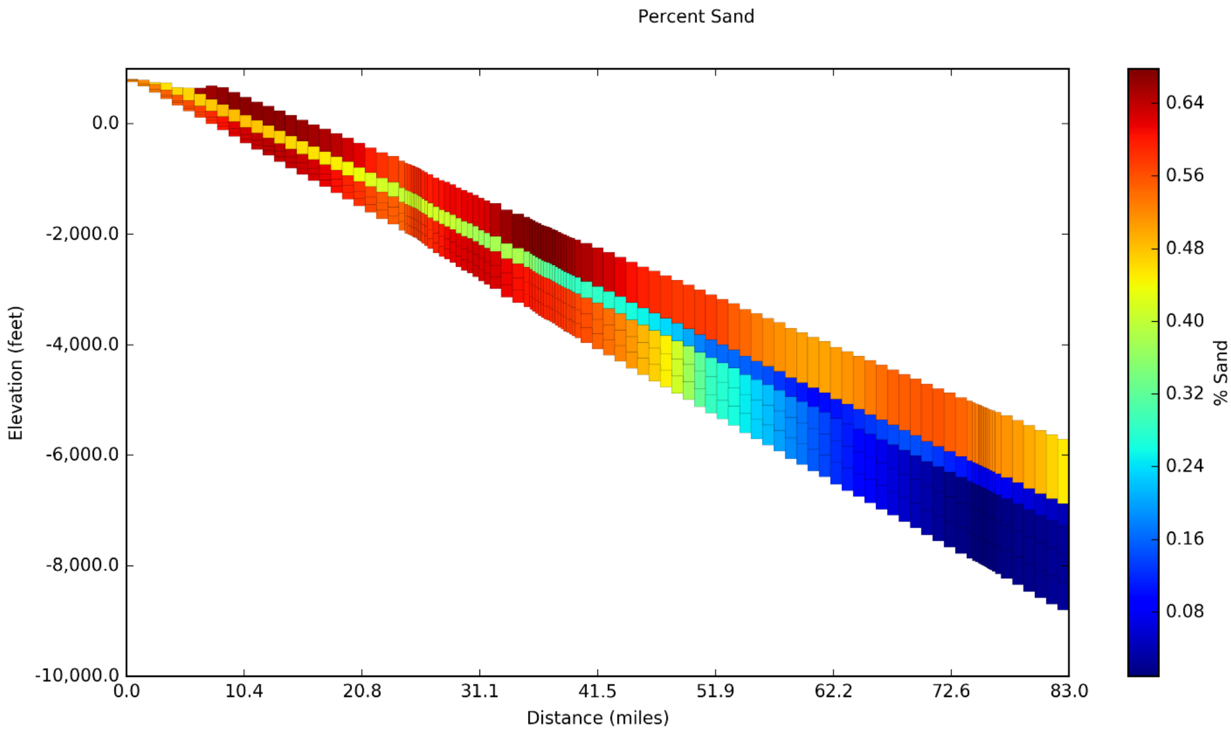


**Figure 6-14.** **Sand fraction for model layers 5, 6, 7, 8, and 9 for a vertical cross-section cut through the three-dimensional model for PPA #3.**

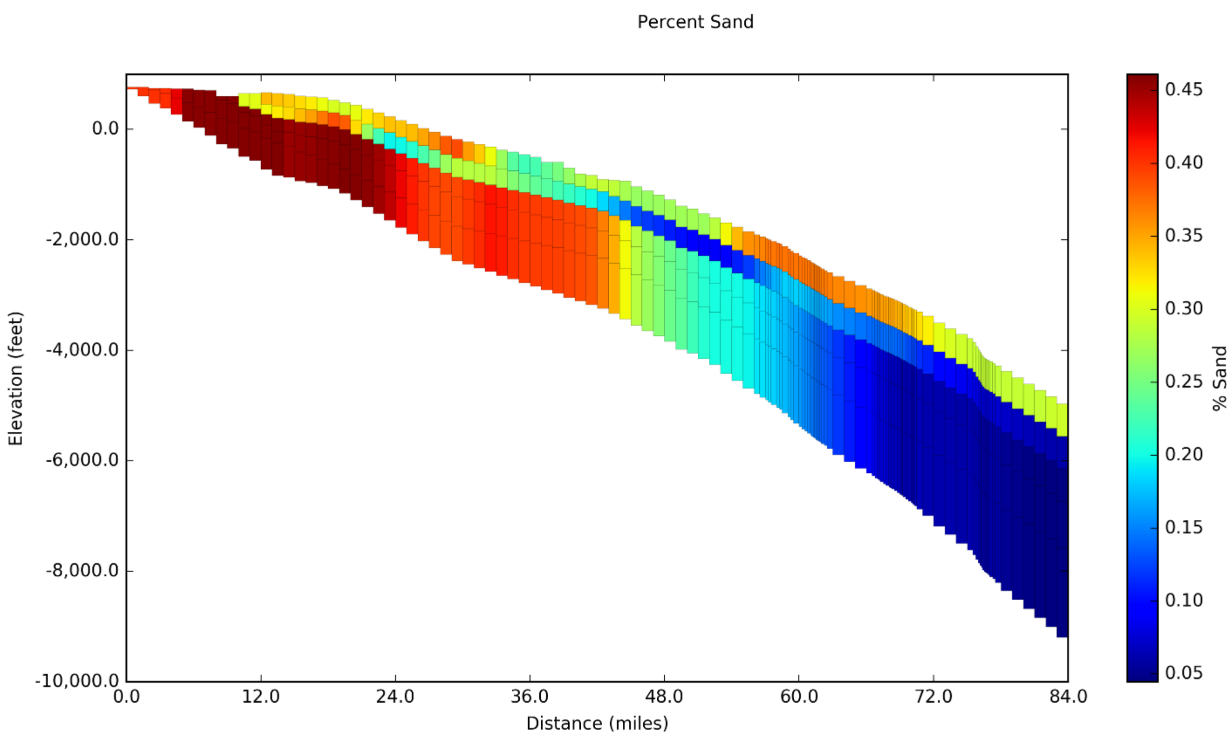


**Figure 6-15.** **Sand fraction for model layers 5, 6, 7, 8, and 9 for a vertical cross-section cut through the three-dimensional model for PPA #4.**

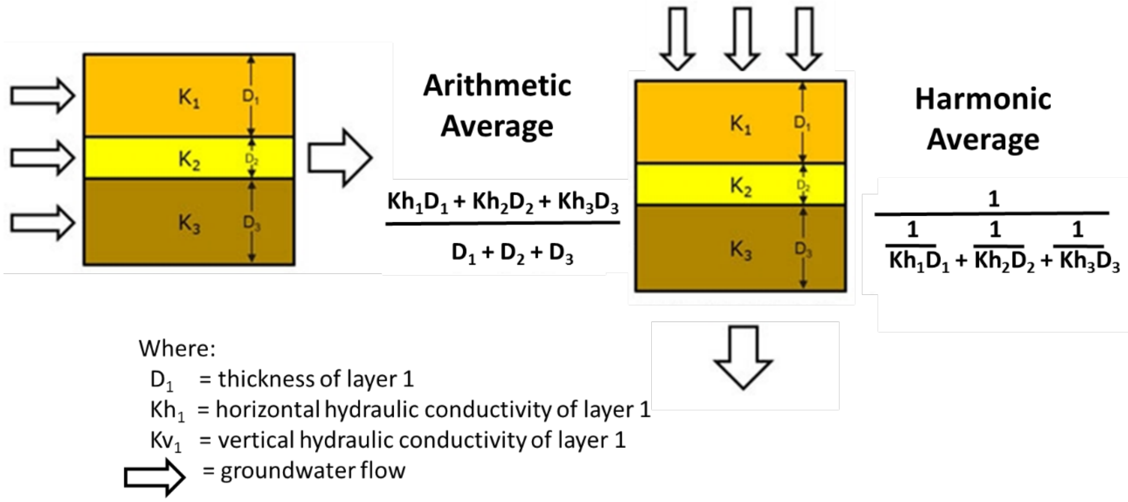


**Figure 6-16.** **Schematic showing the application of an arithmetic average and a harmonic average to calculate equivalent horizontal and vertical hydraulic conductivities based on the assumption of one-dimension flow through uniform layered media.**

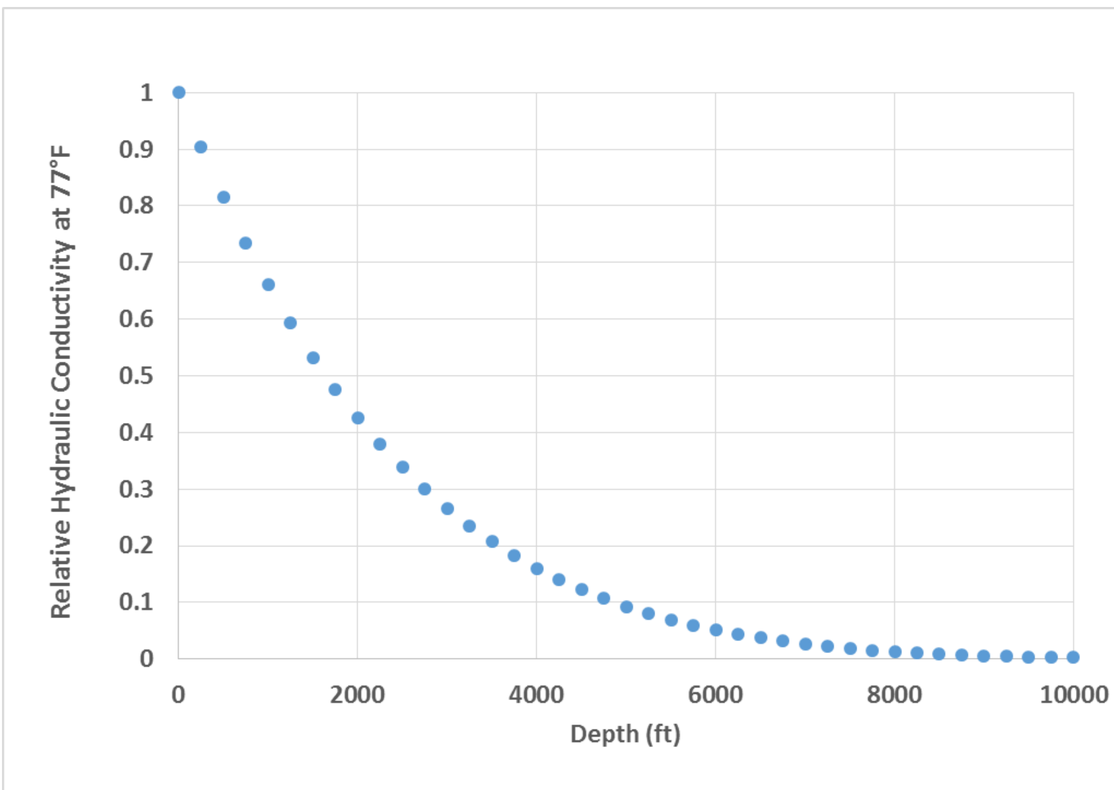


**Figure 6-17.** **Relationship used by the GeoHydroStratigraphic Model to account for hydraulic conductivity decrease with depth caused by a decrease in porosity with depth.**

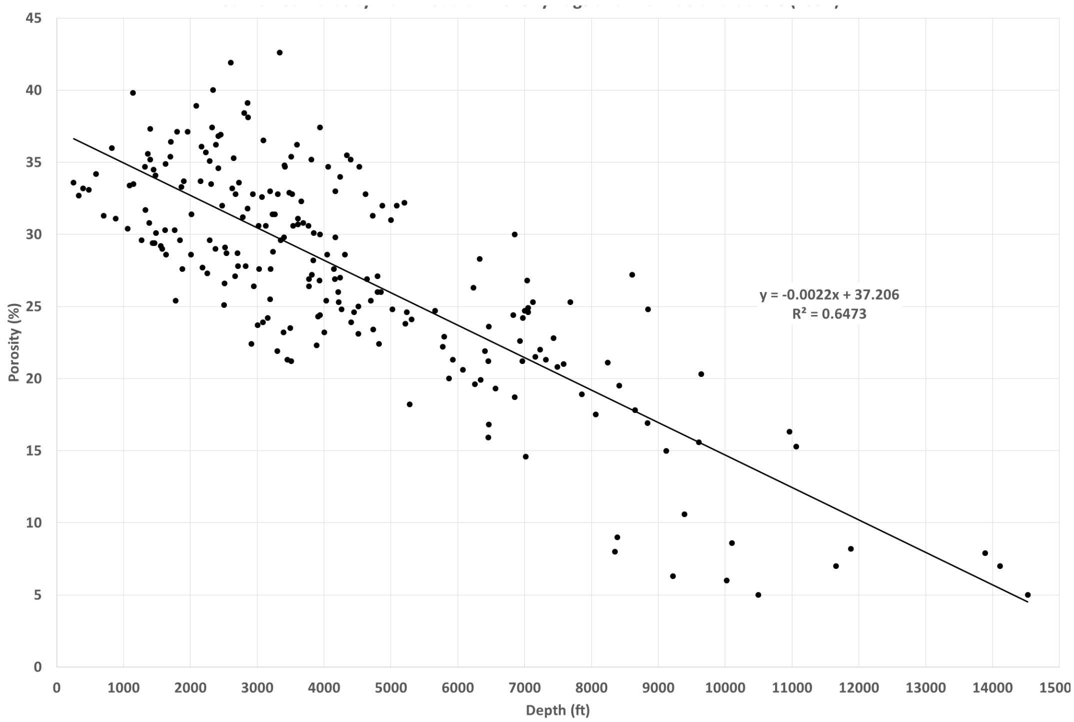


**Figure 6-18.** **Porosity as a function of depth based on porosity data from this study and McBride and others (1991).**

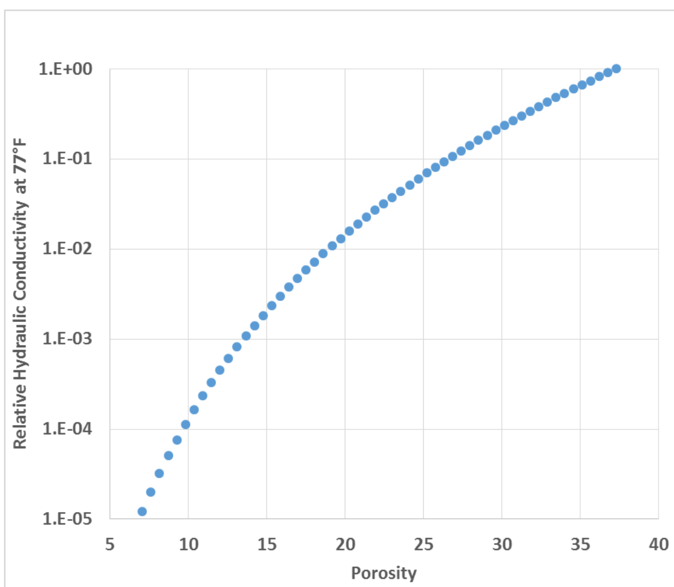


**Figure 6-19.** **Change in relative hydraulic conductivity as a function of change in porosity based on data from Dutton and Loucks (2014).**

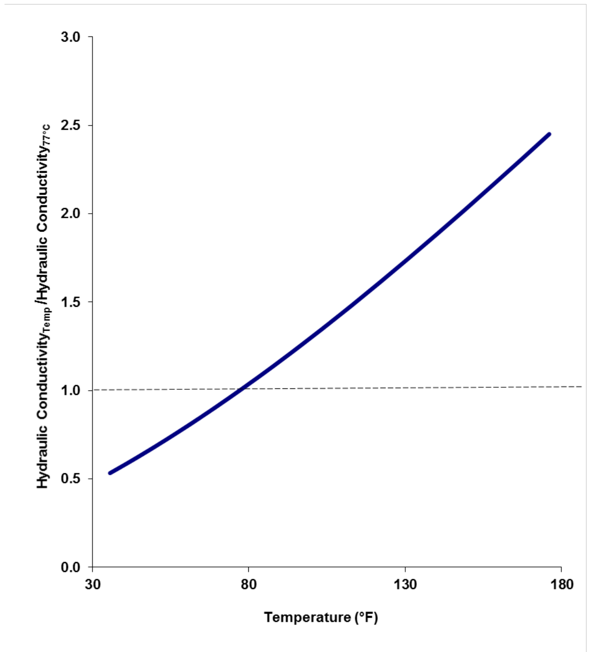


**Figure 6-20. Relative change in hydraulic conductivity values caused by the temperature dependence of the density and viscosity of water.**

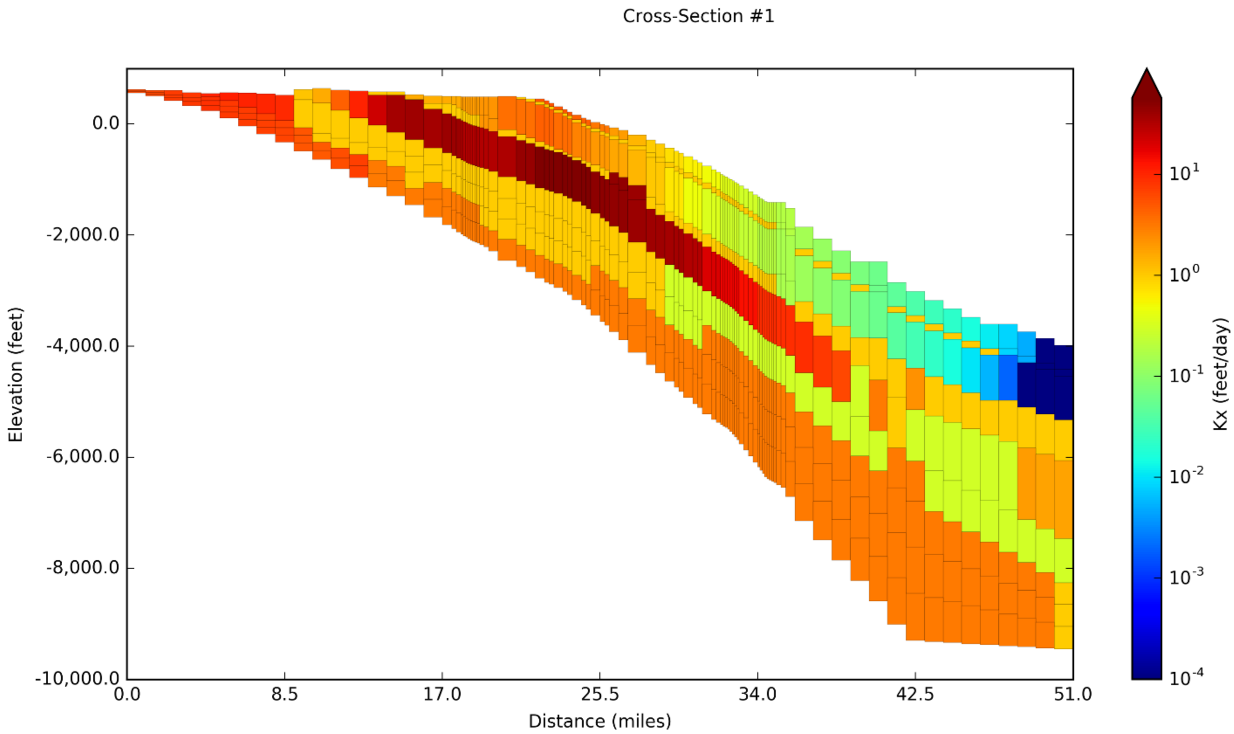


**Figure 6-21. Horizontal hydraulic conductivity values in the groundwater model for PPA #1 with properties that are GAM-based for model layers 1 to 9.**

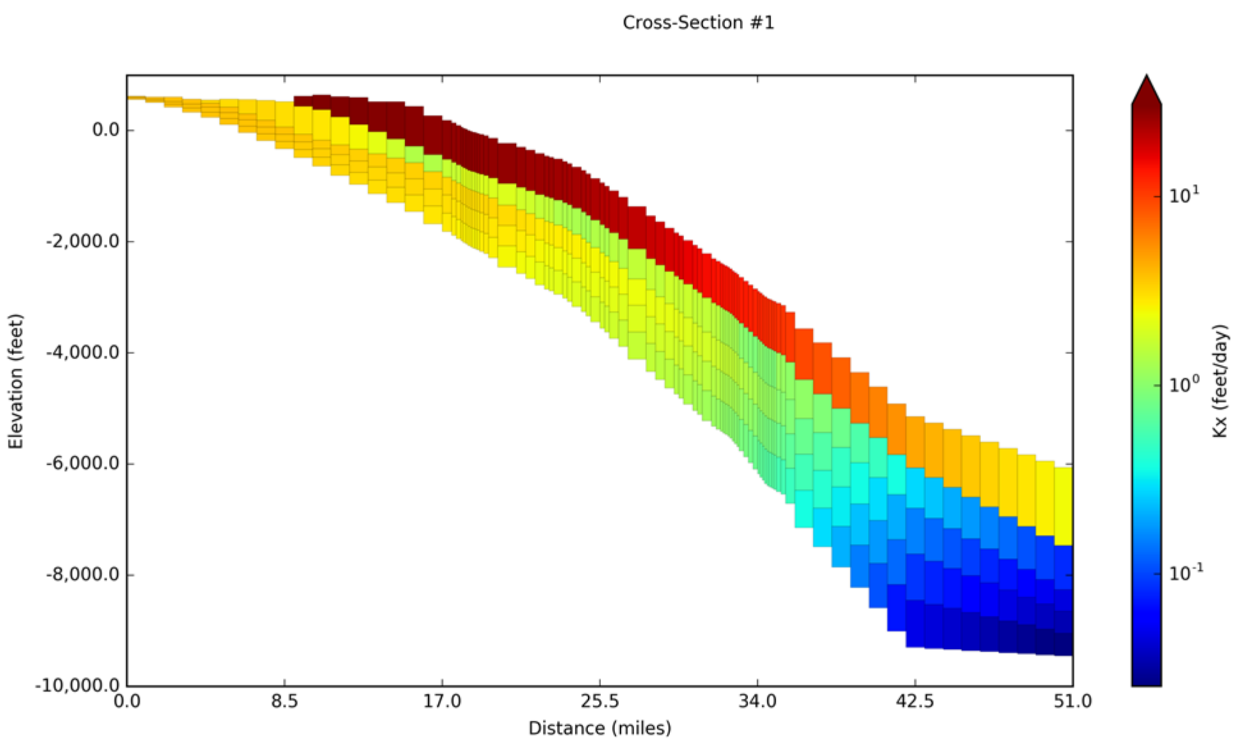


**Figure 6-22. Horizontal hydraulic conductivity values in the groundwater model for PPA #1 with properties that are GHSM-based for model layers 5 to 9.**

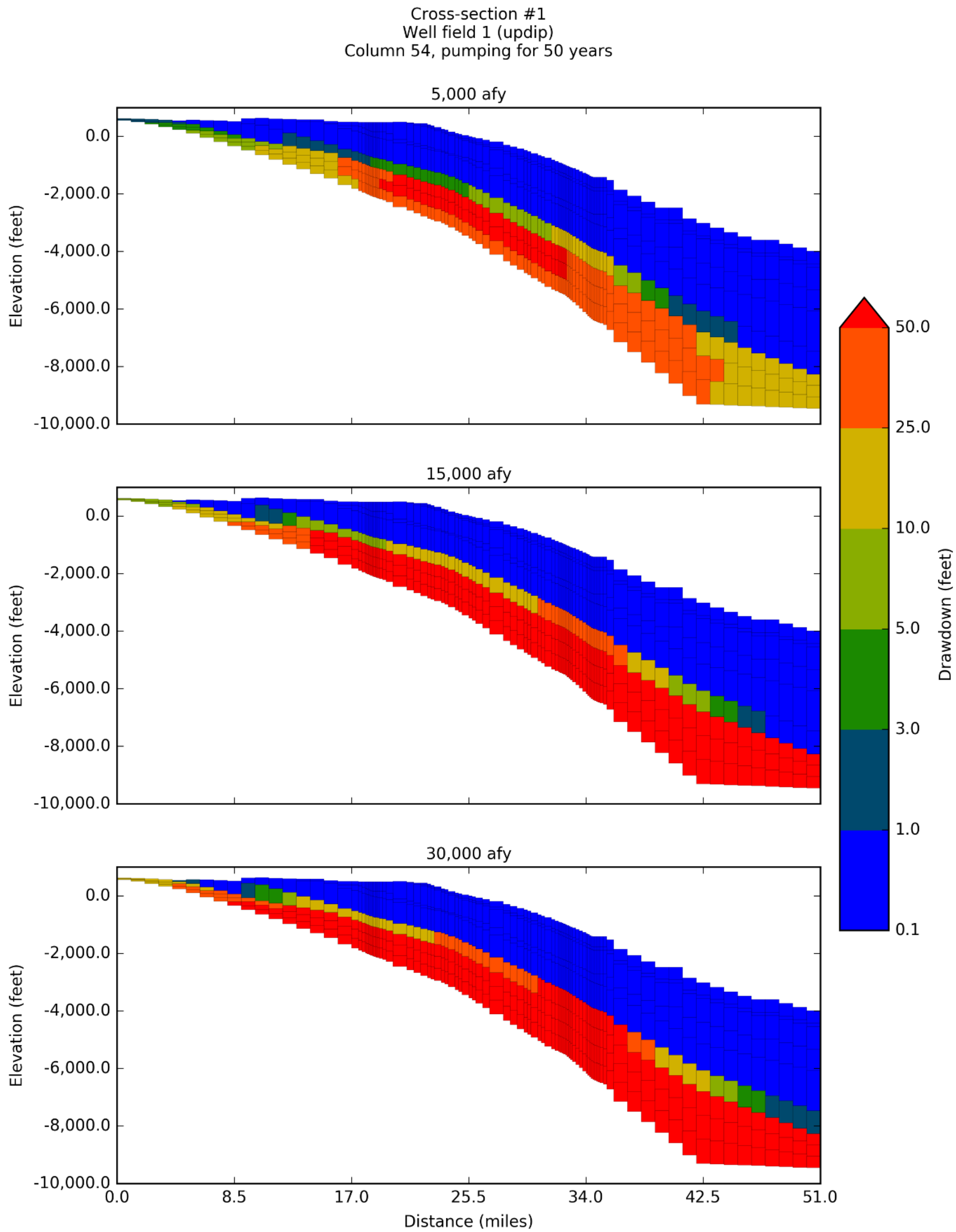


**Figure 6-23. Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #1 at 5,000 AFY, 15,000 AFY, and 30,000 AFY as determined by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

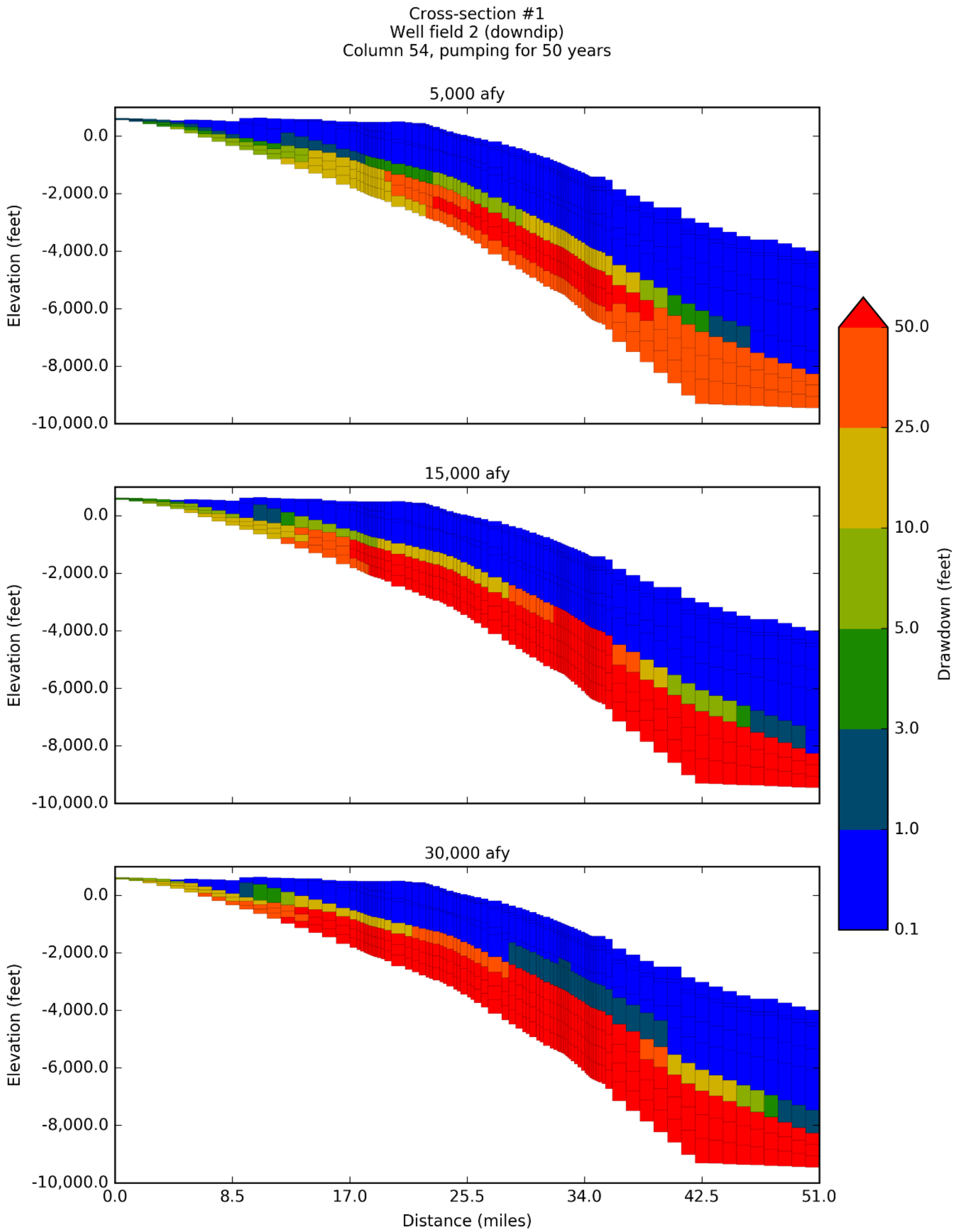


**Figure 6-24.** **Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #1 at 5,000 AFY, 15,000 AFY, and 30,000 AFY as determined by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

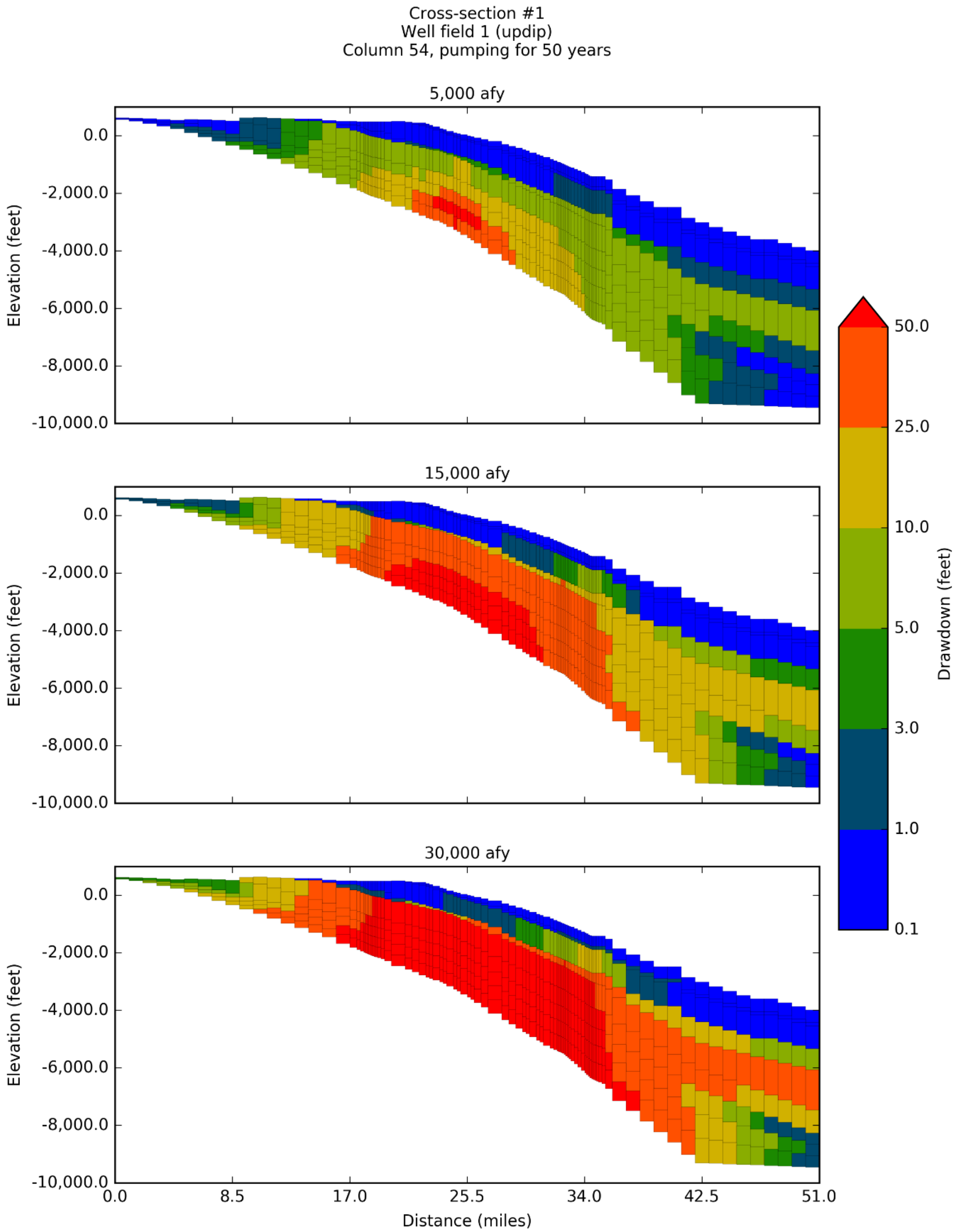


**Figure 6-25. Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #1 at 5,000 AFY, 15,000 AFY, and 30,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

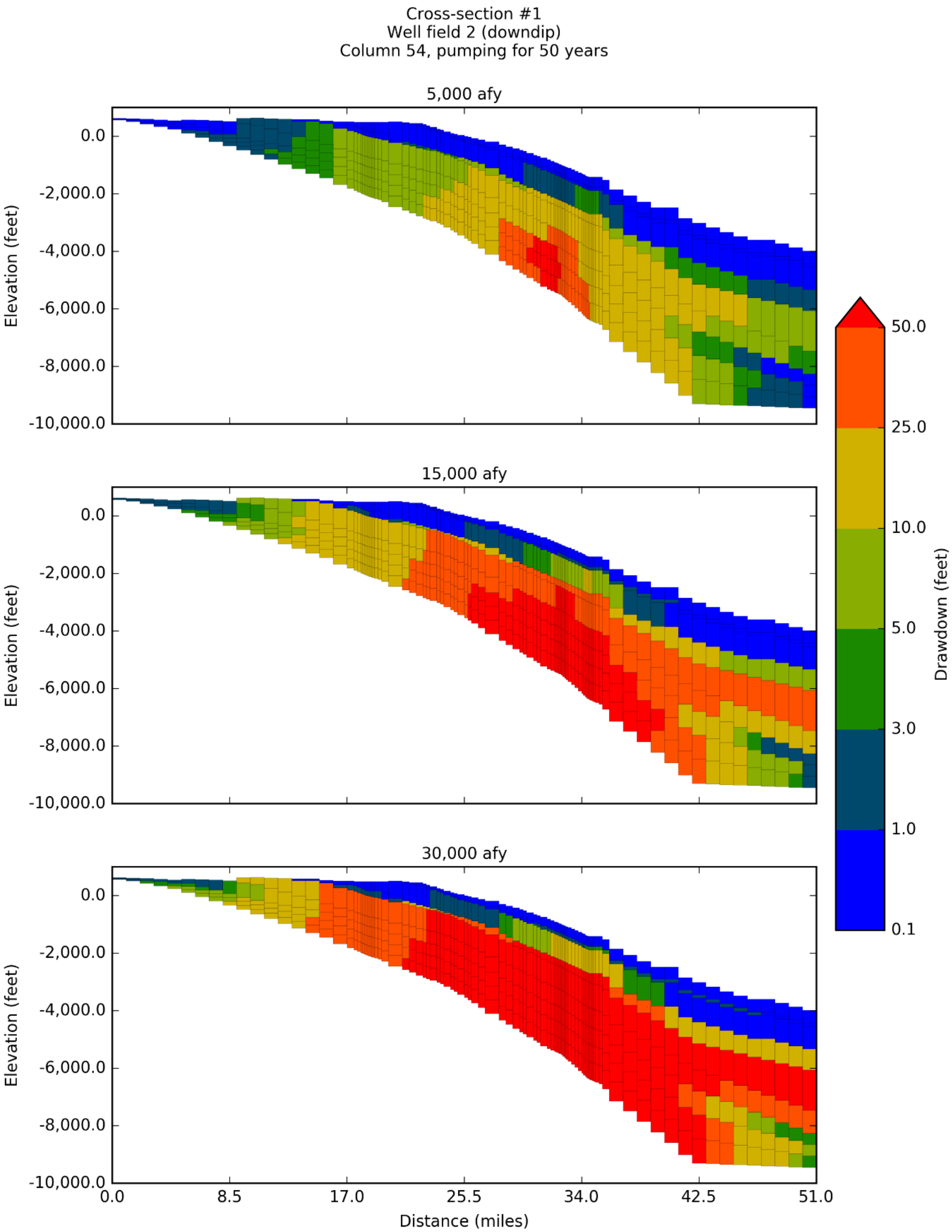


**Figure 6-26.** **Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #1 at 5,000 AFY, 15,000 AFY, and 30,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

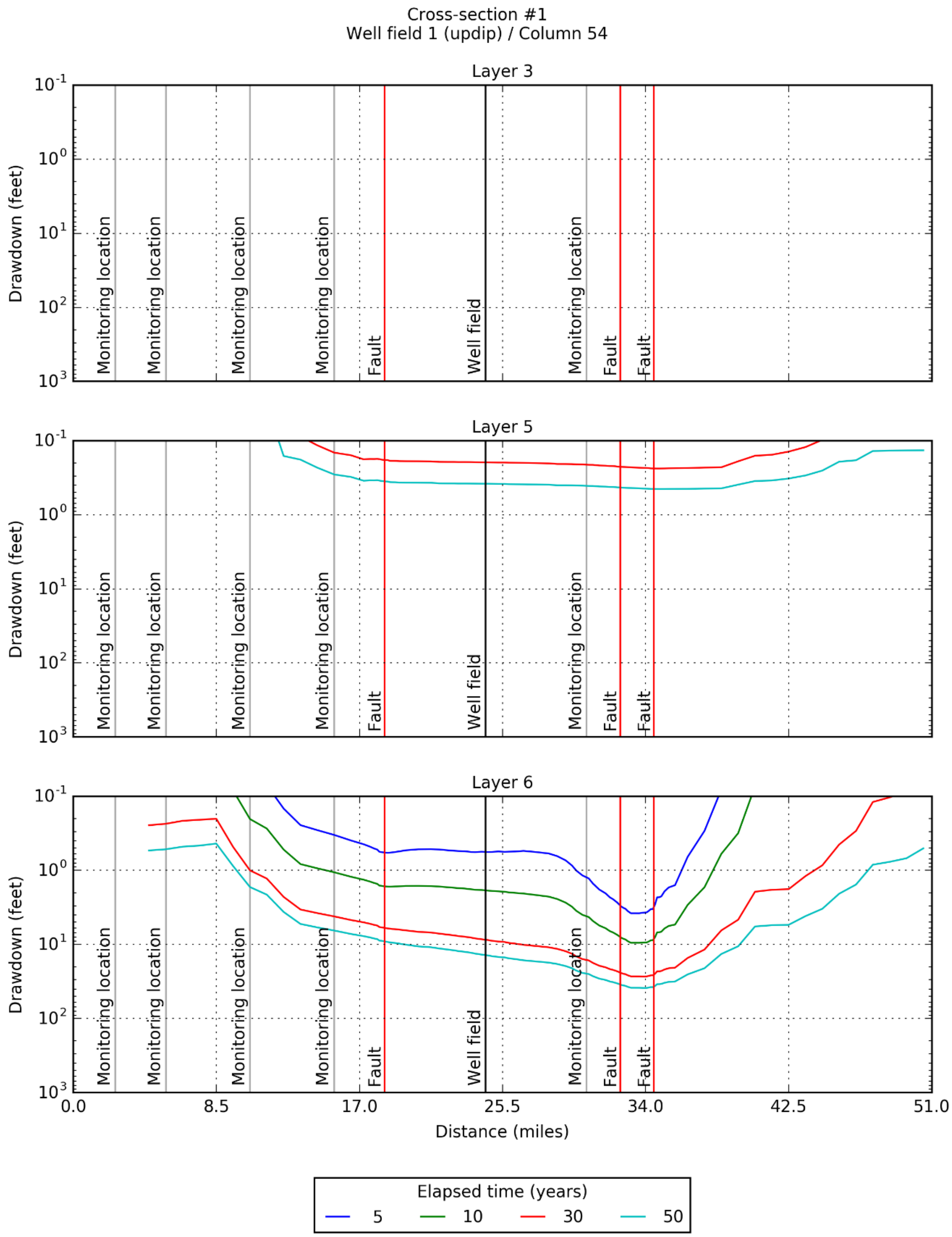


**Figure 6-27. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GAM based hydraulic properties for Carrizo-Wilcox Aquifer.**

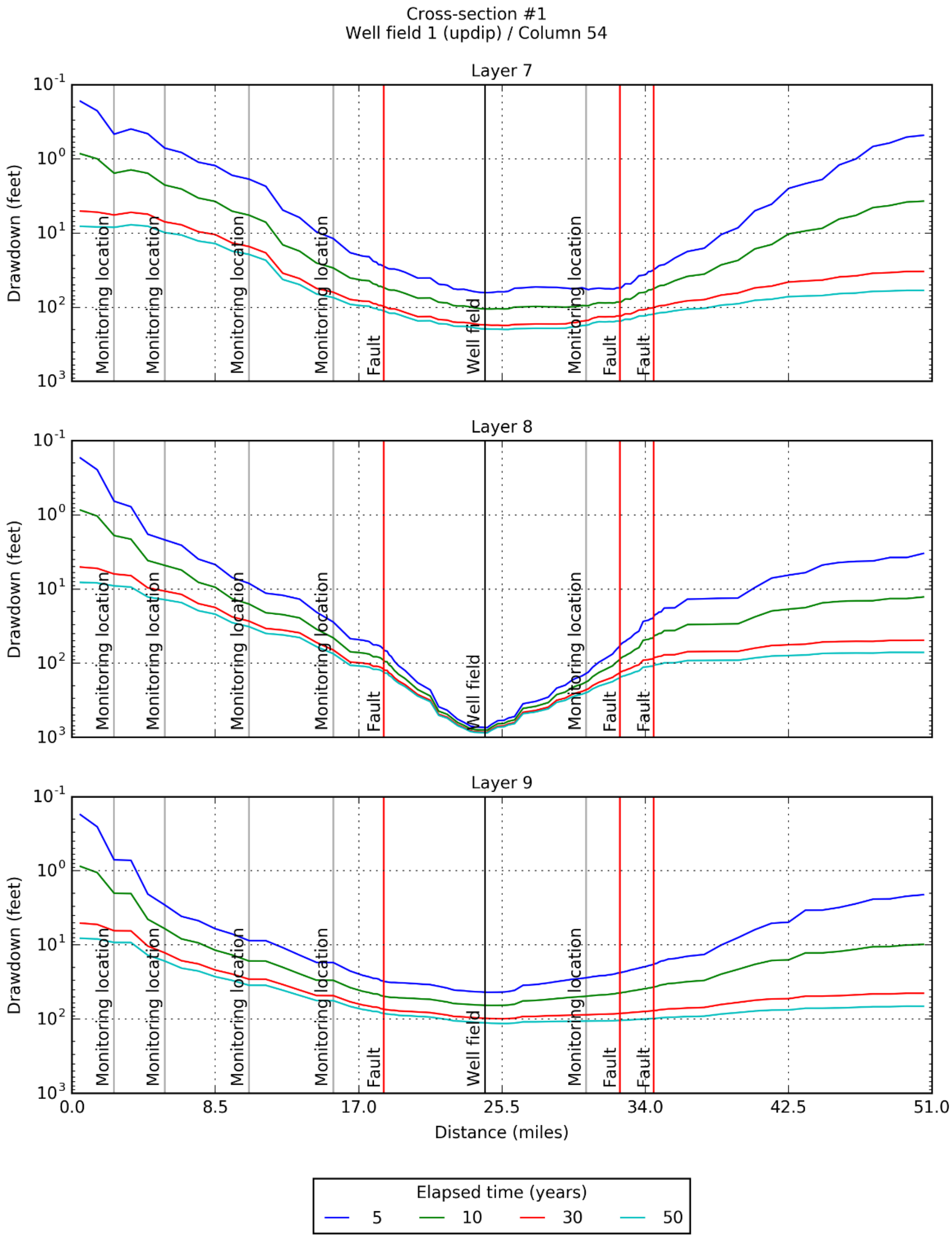


**Figure 6-28.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

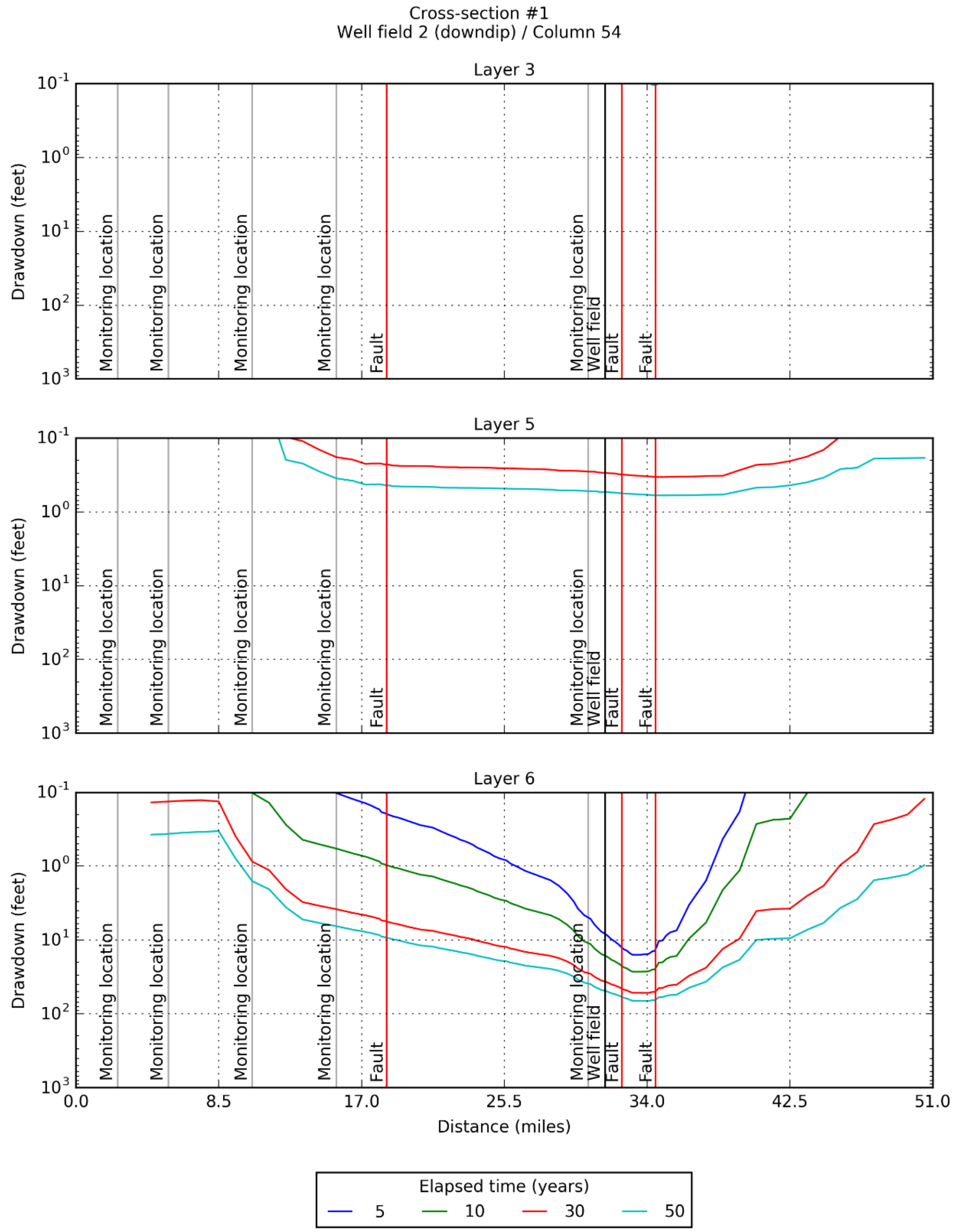


**Figure 6-29.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

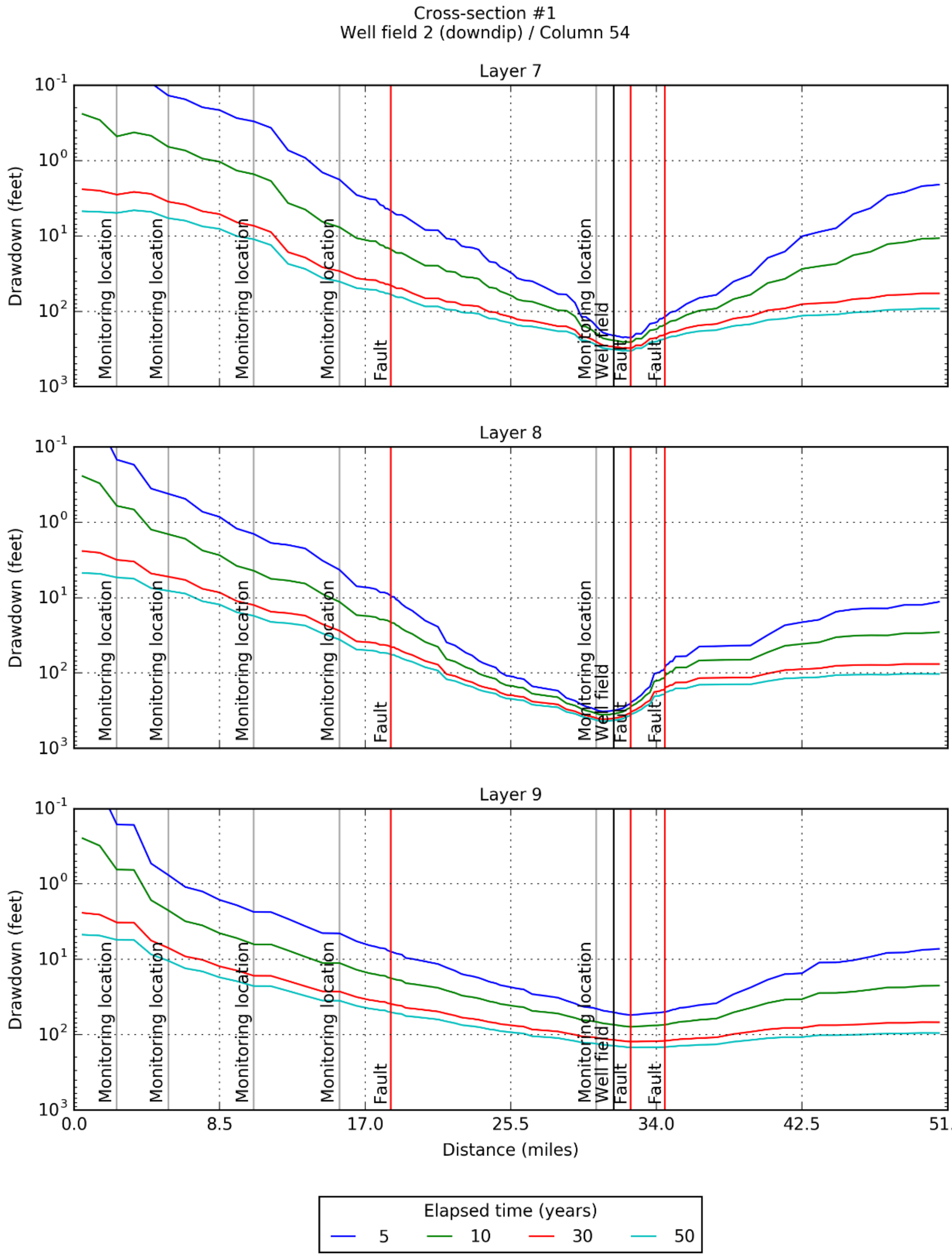


**Figure 6-30. Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

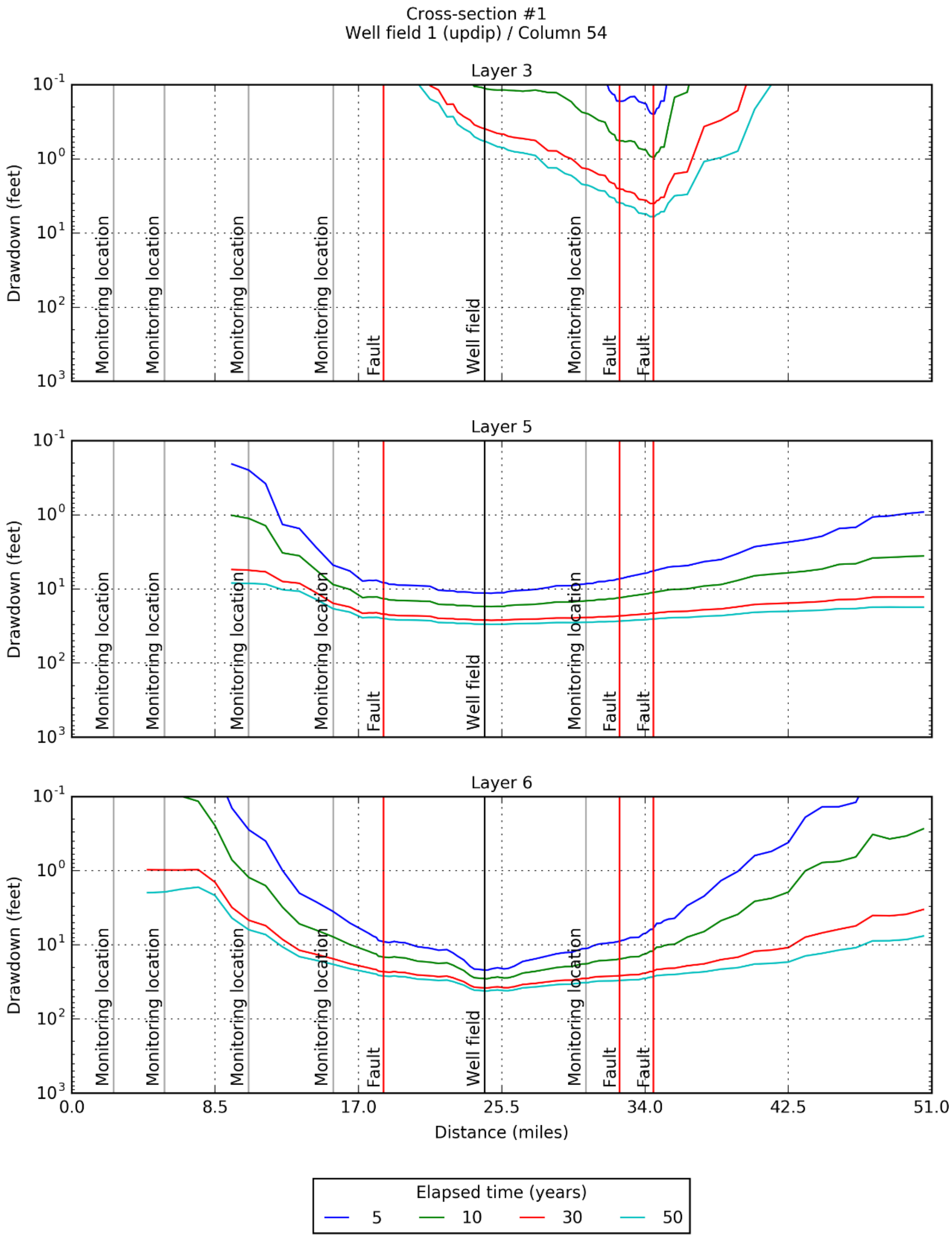


**Figure 6-31. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

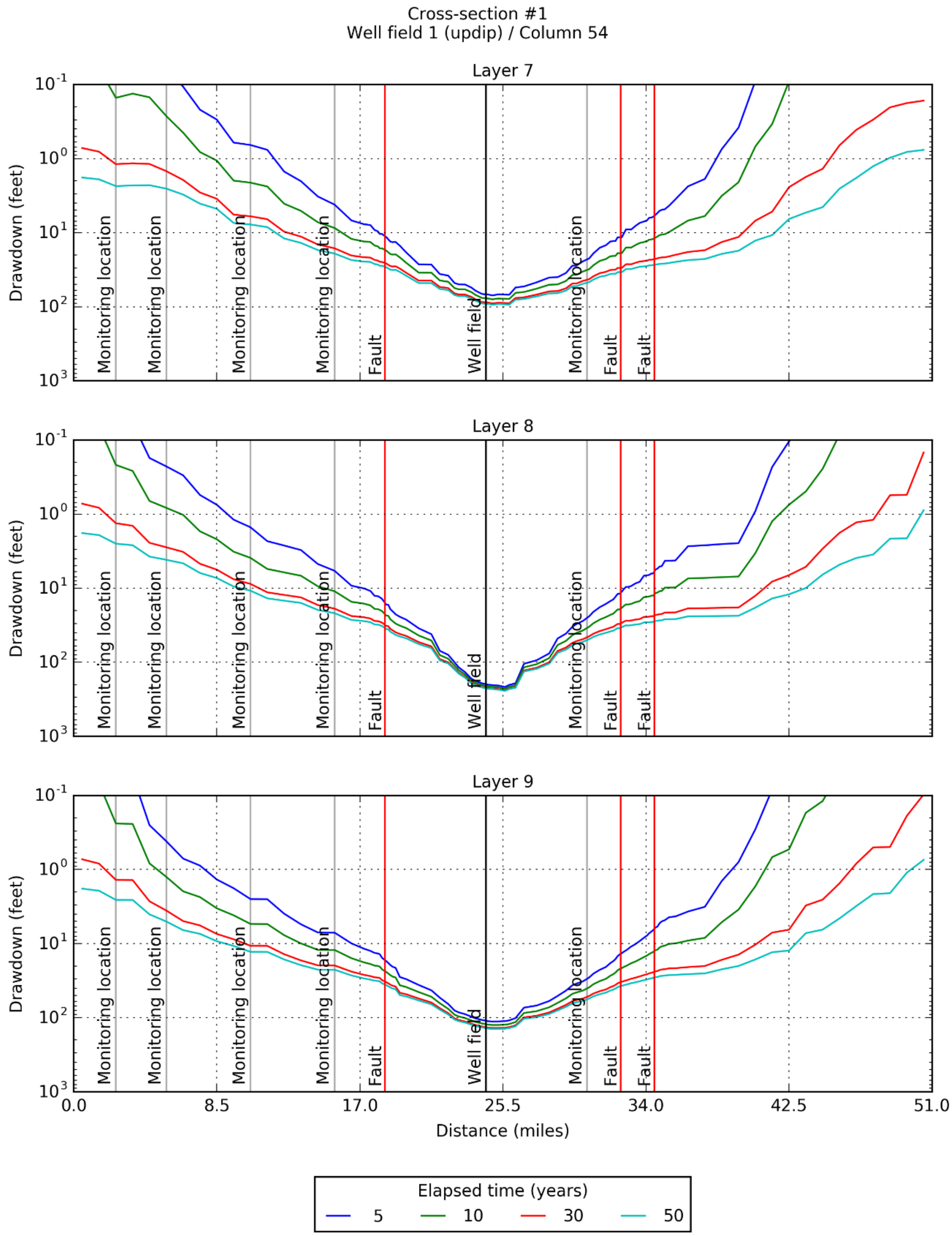


**Figure 6-32.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

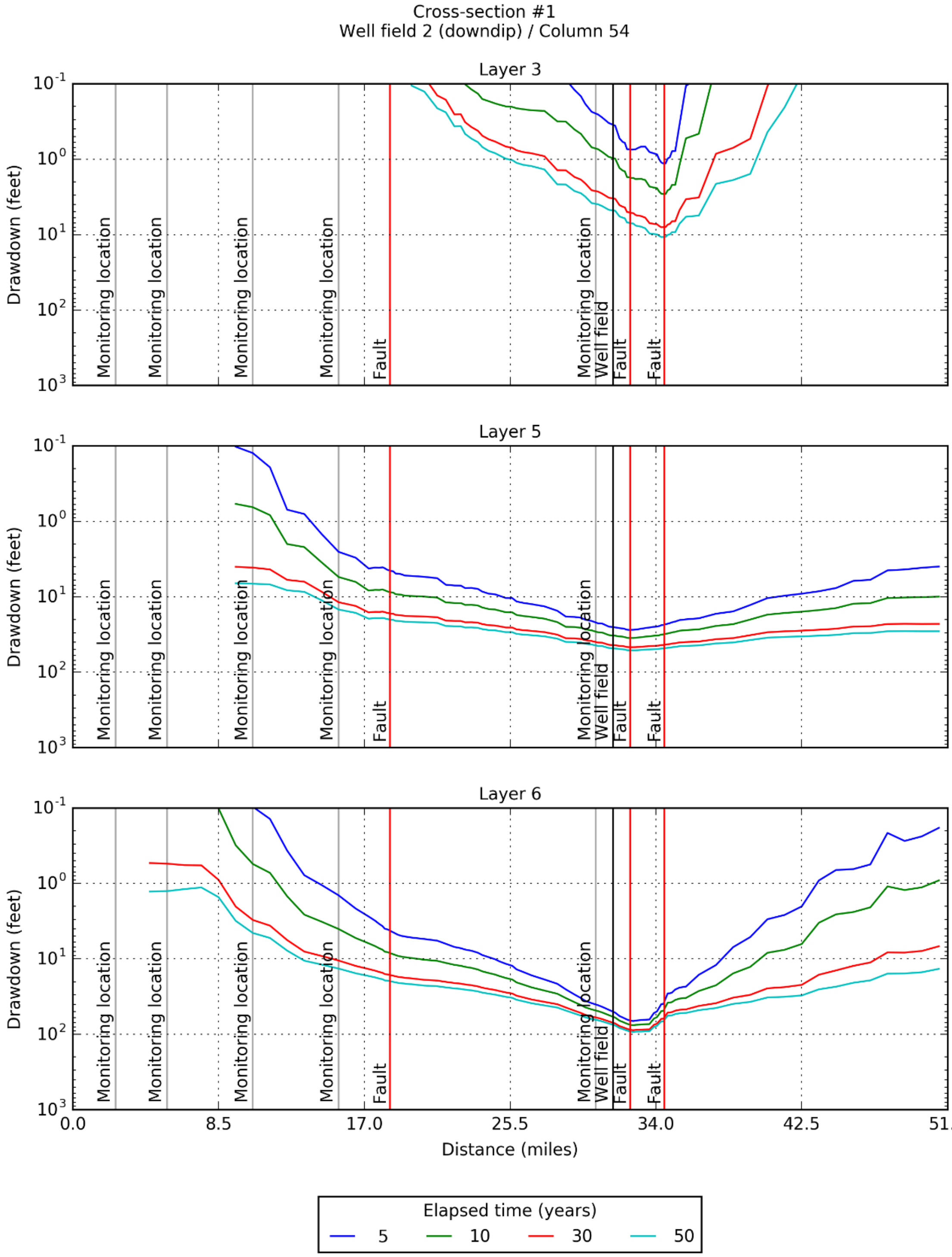


**Figure 6-33.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

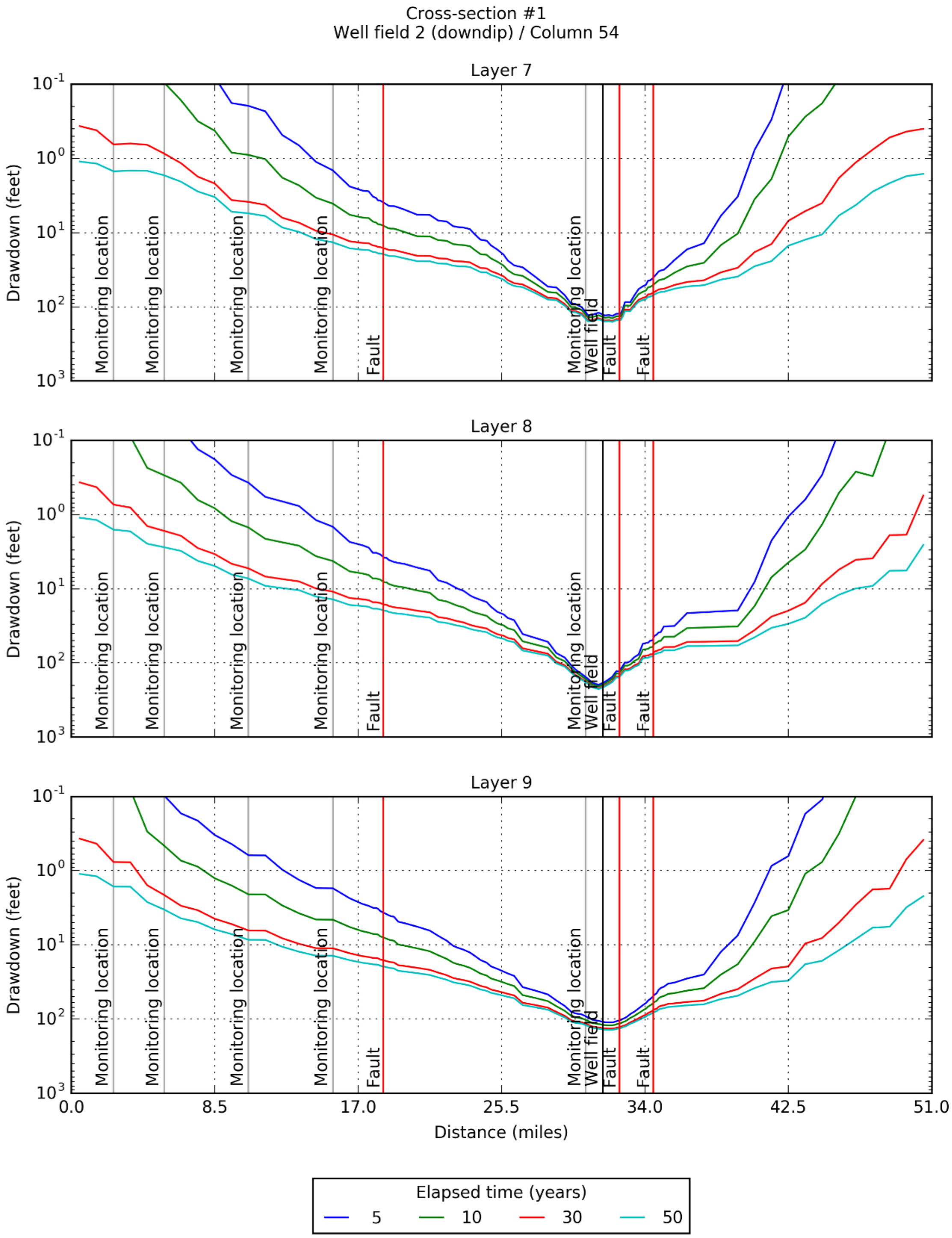


**Figure 6-34.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #1 at 15,000 AFY as determined by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

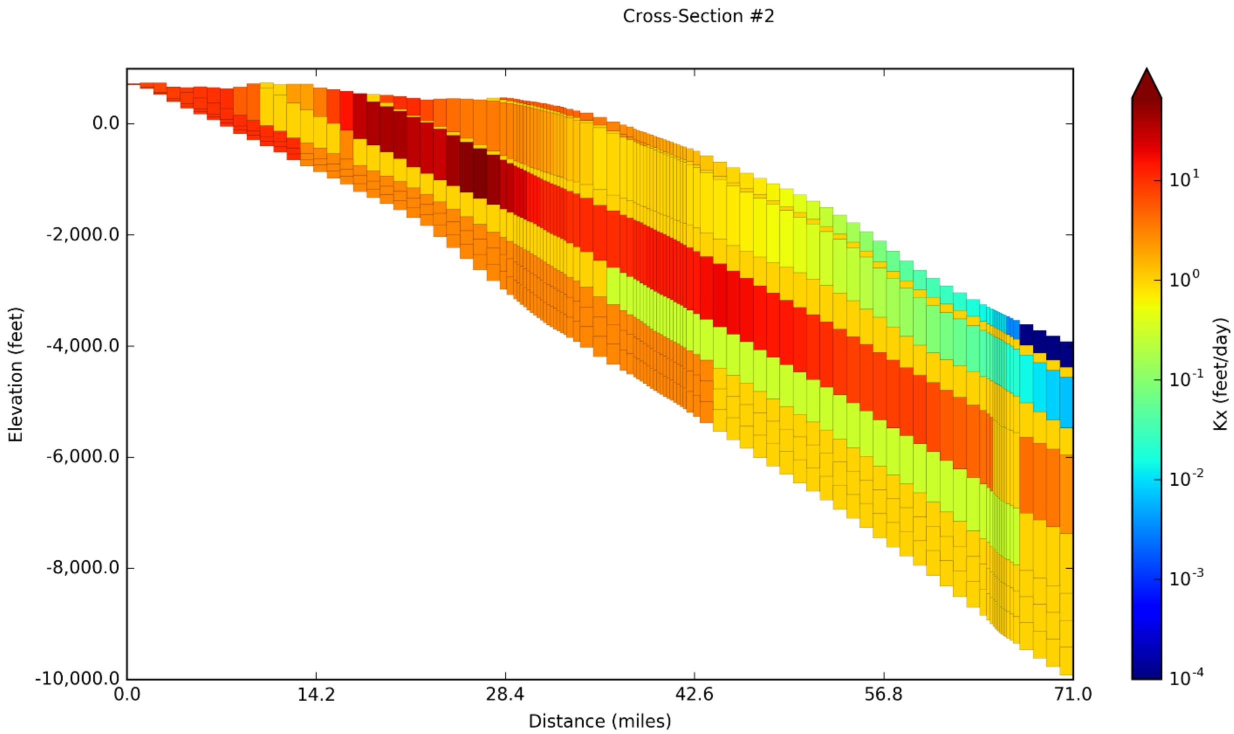


**Figure 6-35. Horizontal hydraulic conductivity values in the groundwater model for PPA #2 with properties that are GAM-based for model layers 1 to 9.**

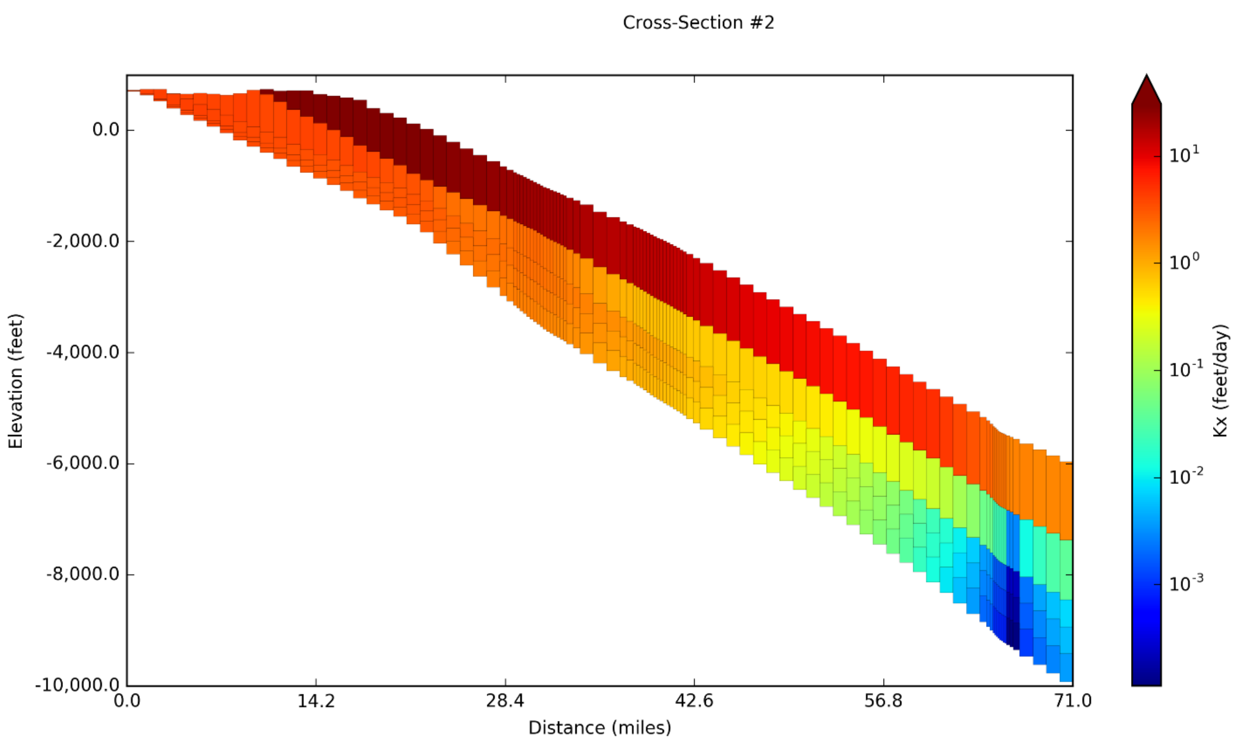


**Figure 6-36. Horizontal hydraulic conductivity values in the groundwater model for PPA #2 with properties that are GHSM-based for model layers 1 to 9.**

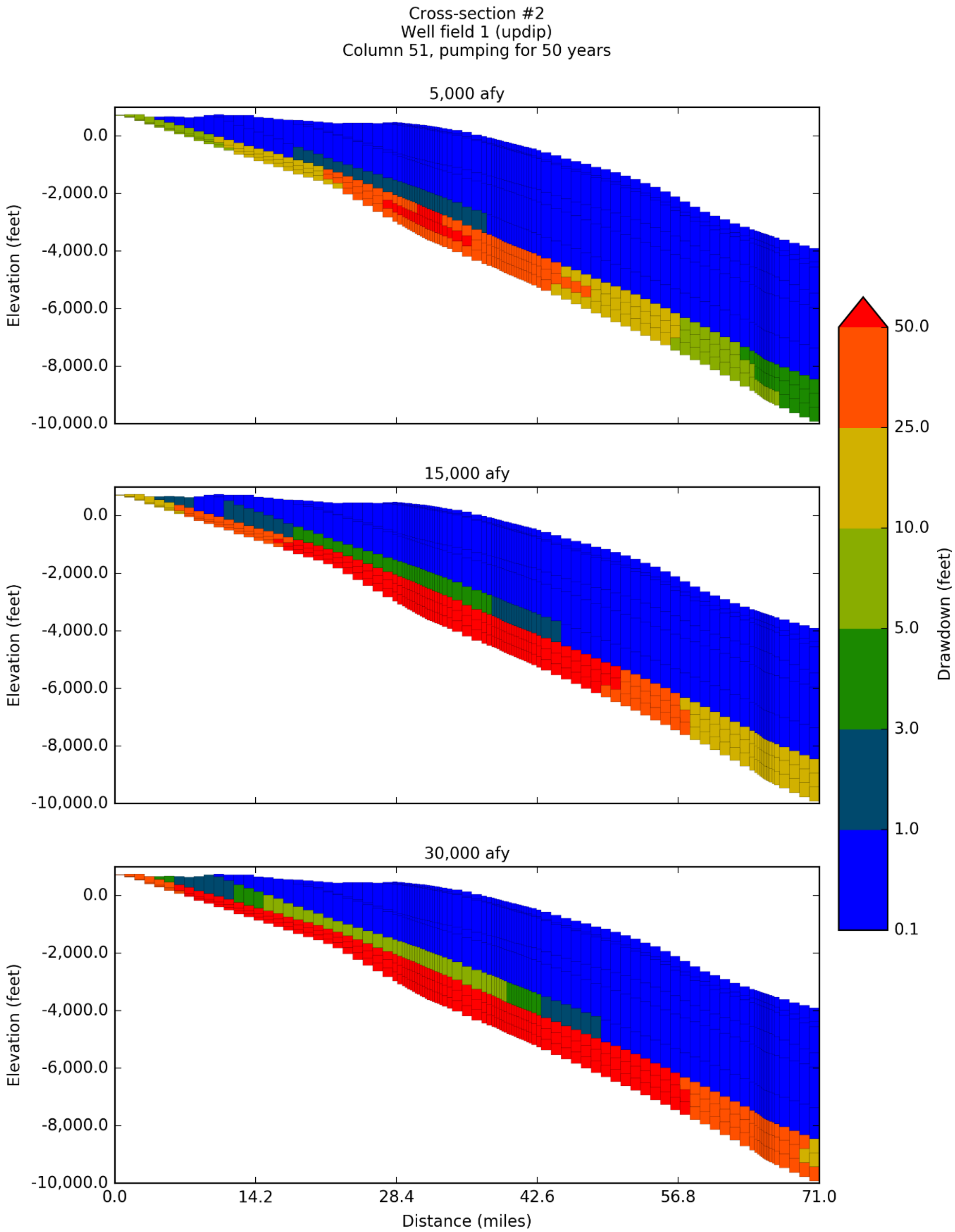


**Figure 6-37. Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #2 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

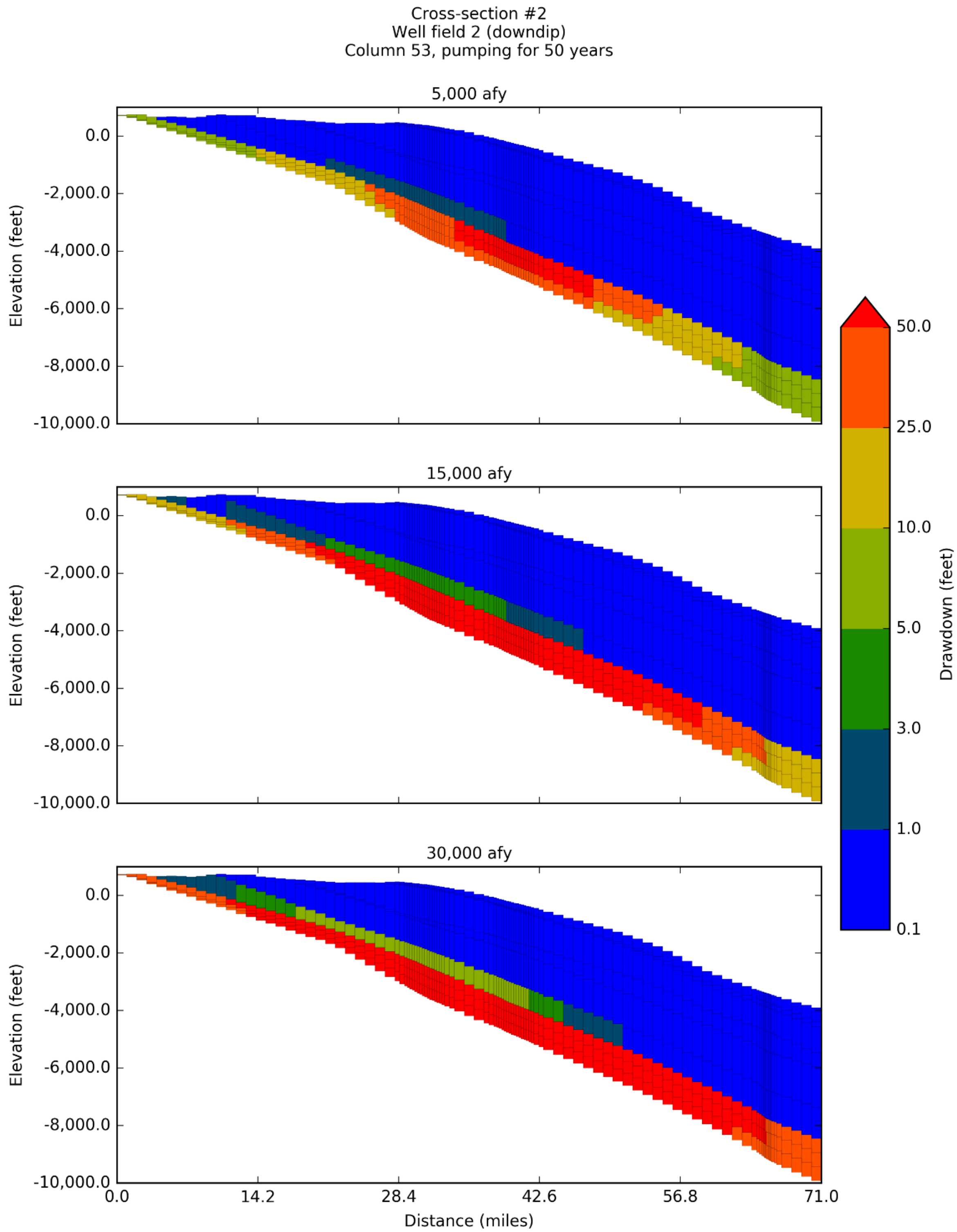


**Figure 6-38. Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #2 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

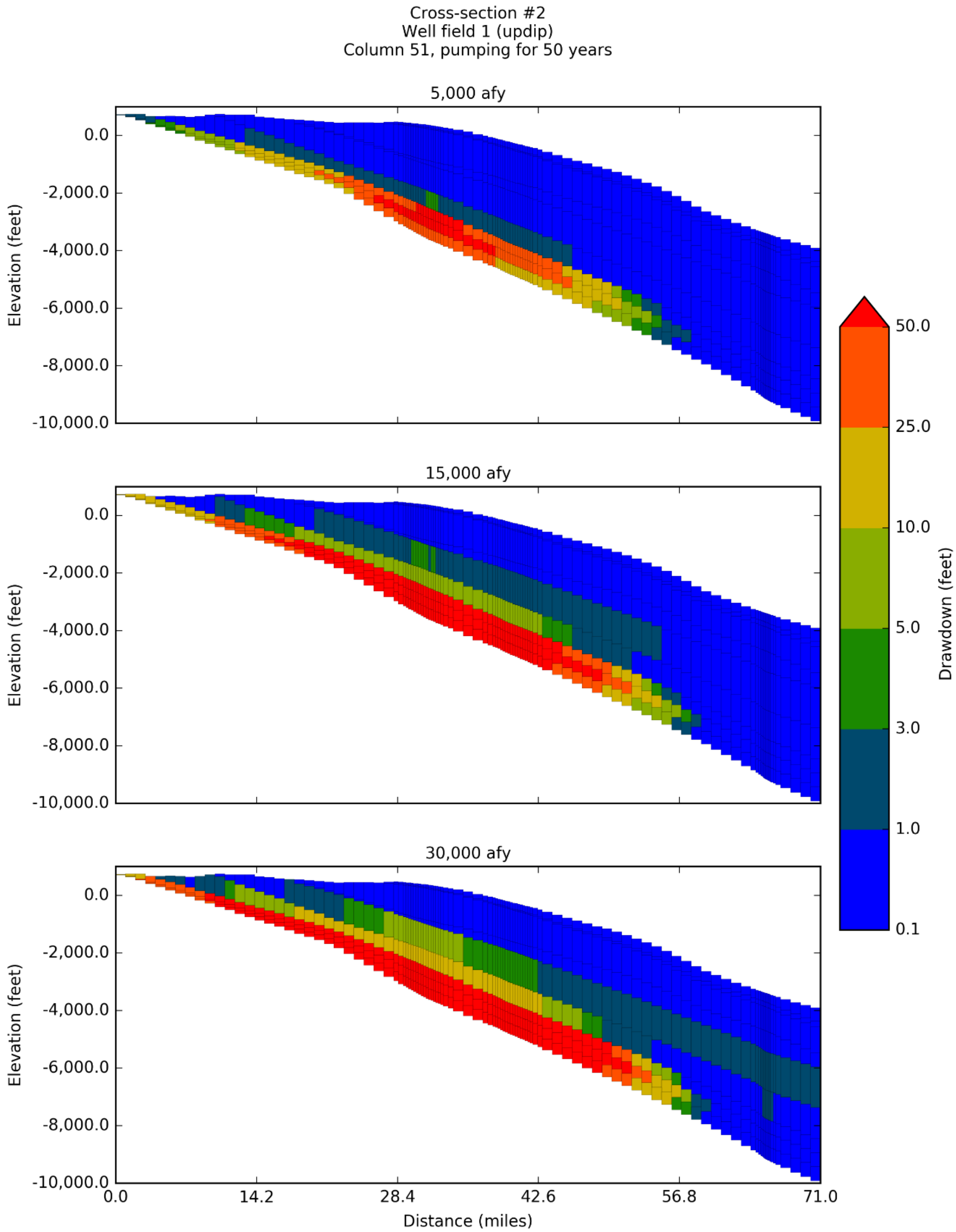


**Figure 6-39. Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #2 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

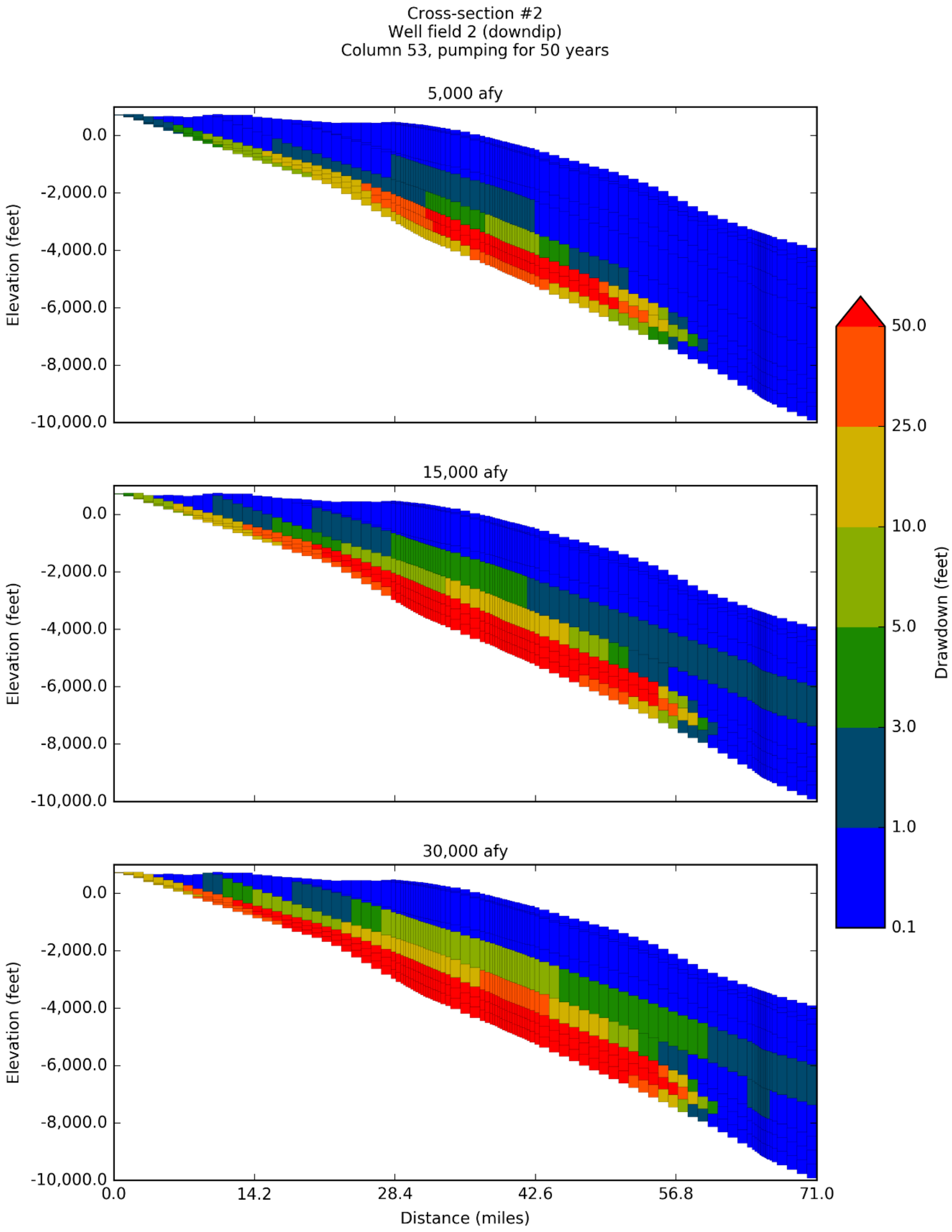


**Figure 6-40.** **Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #2 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

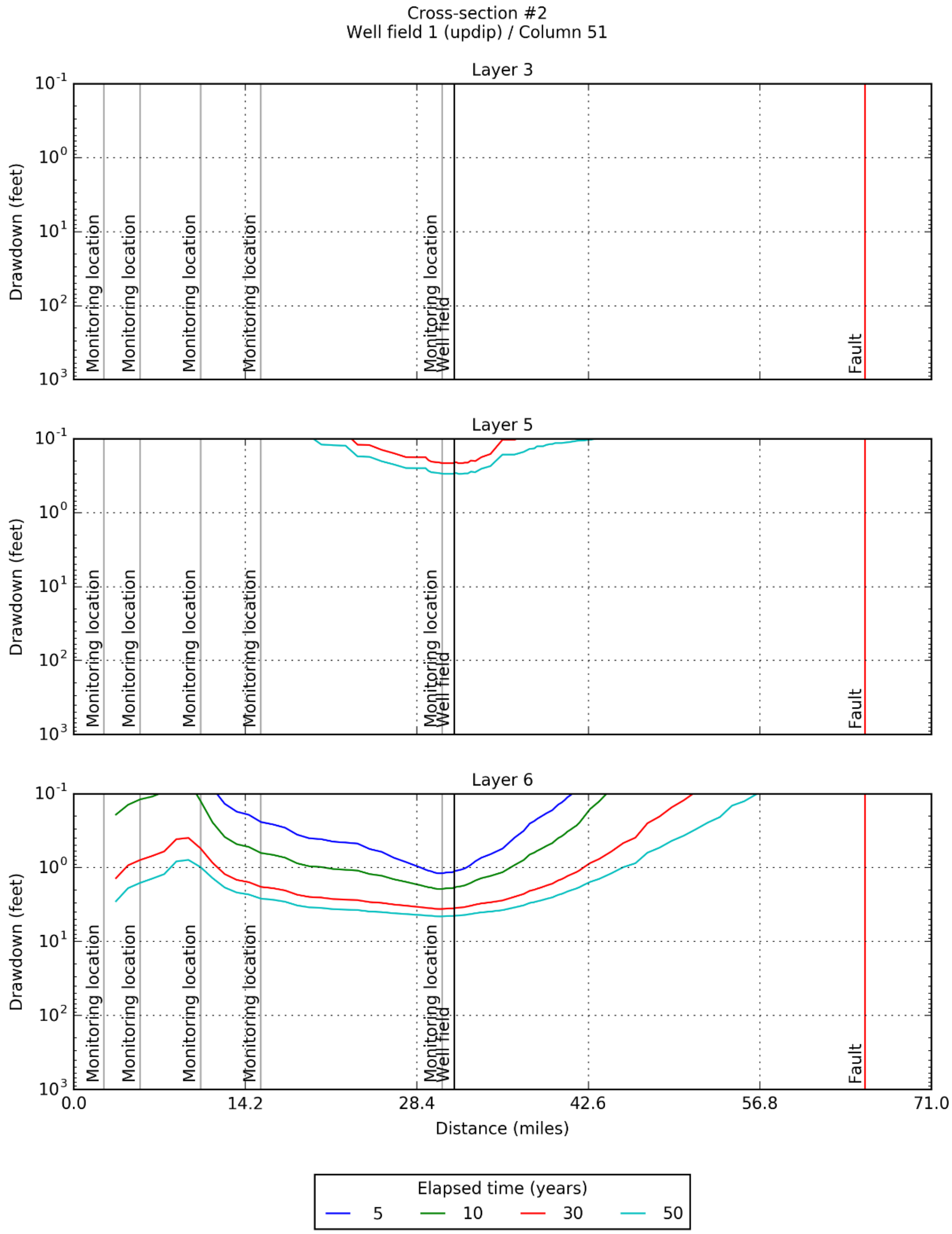


**Figure 6-41.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #2 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

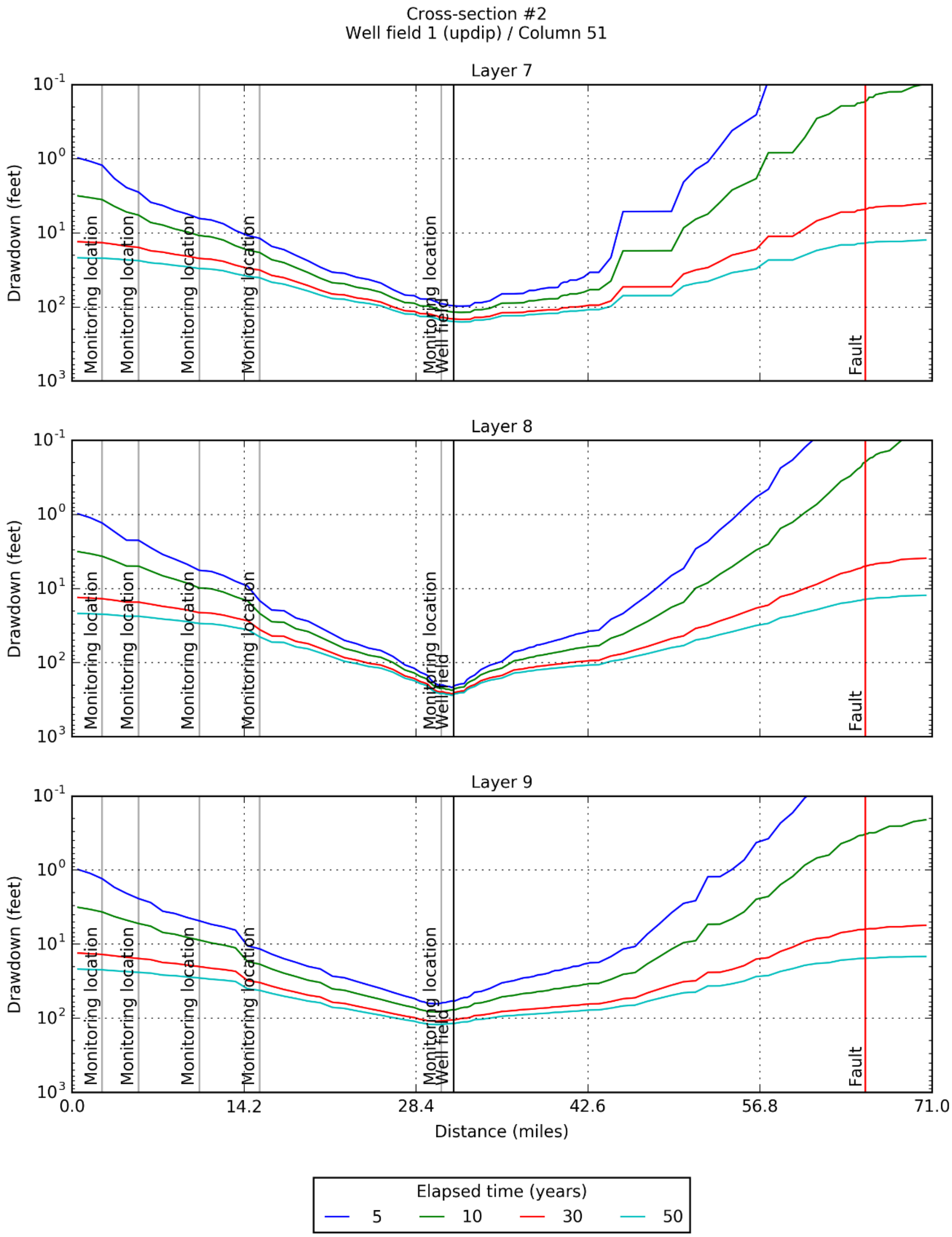


**Figure 6-42. Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #2 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

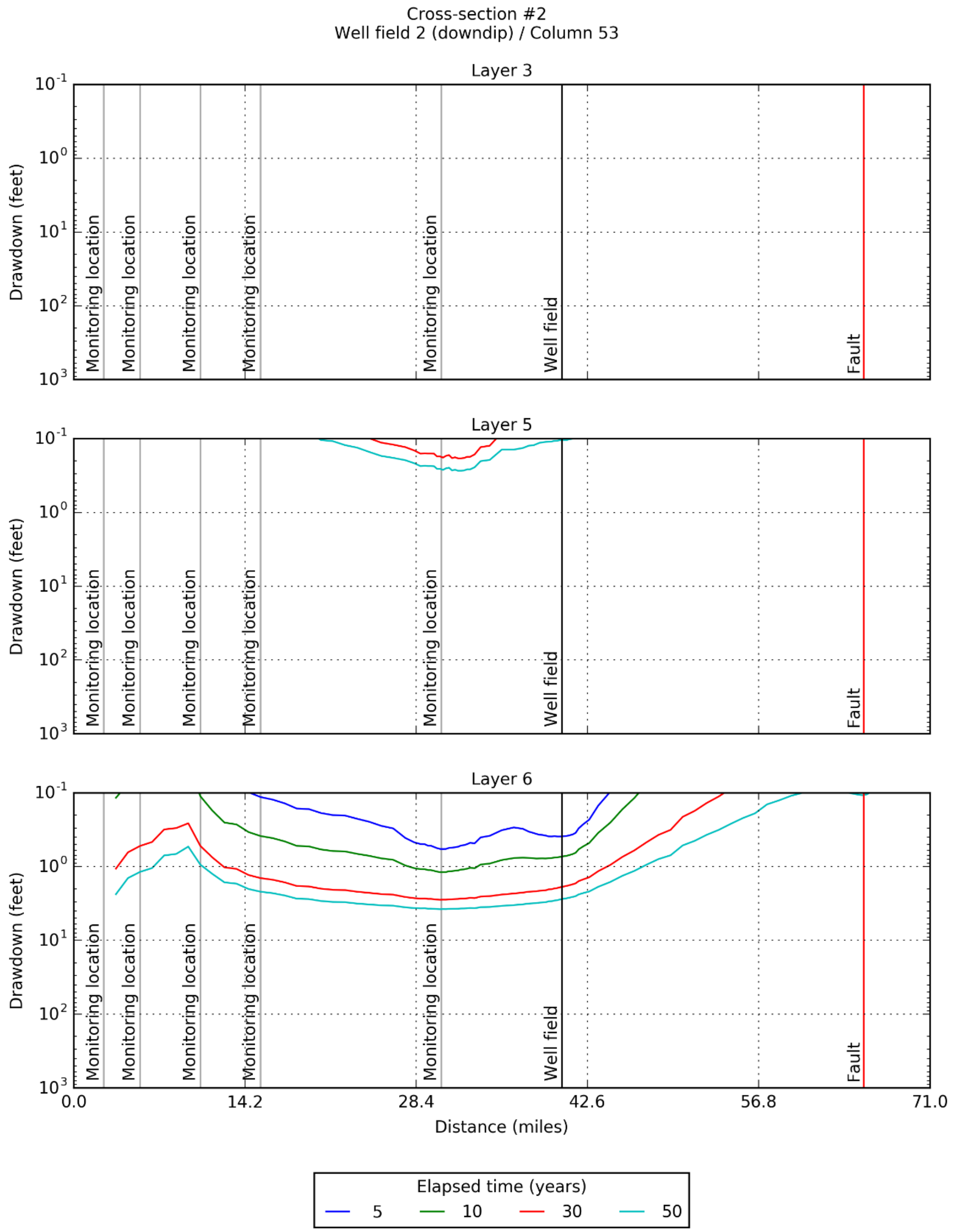


**Figure 6-43. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #2 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

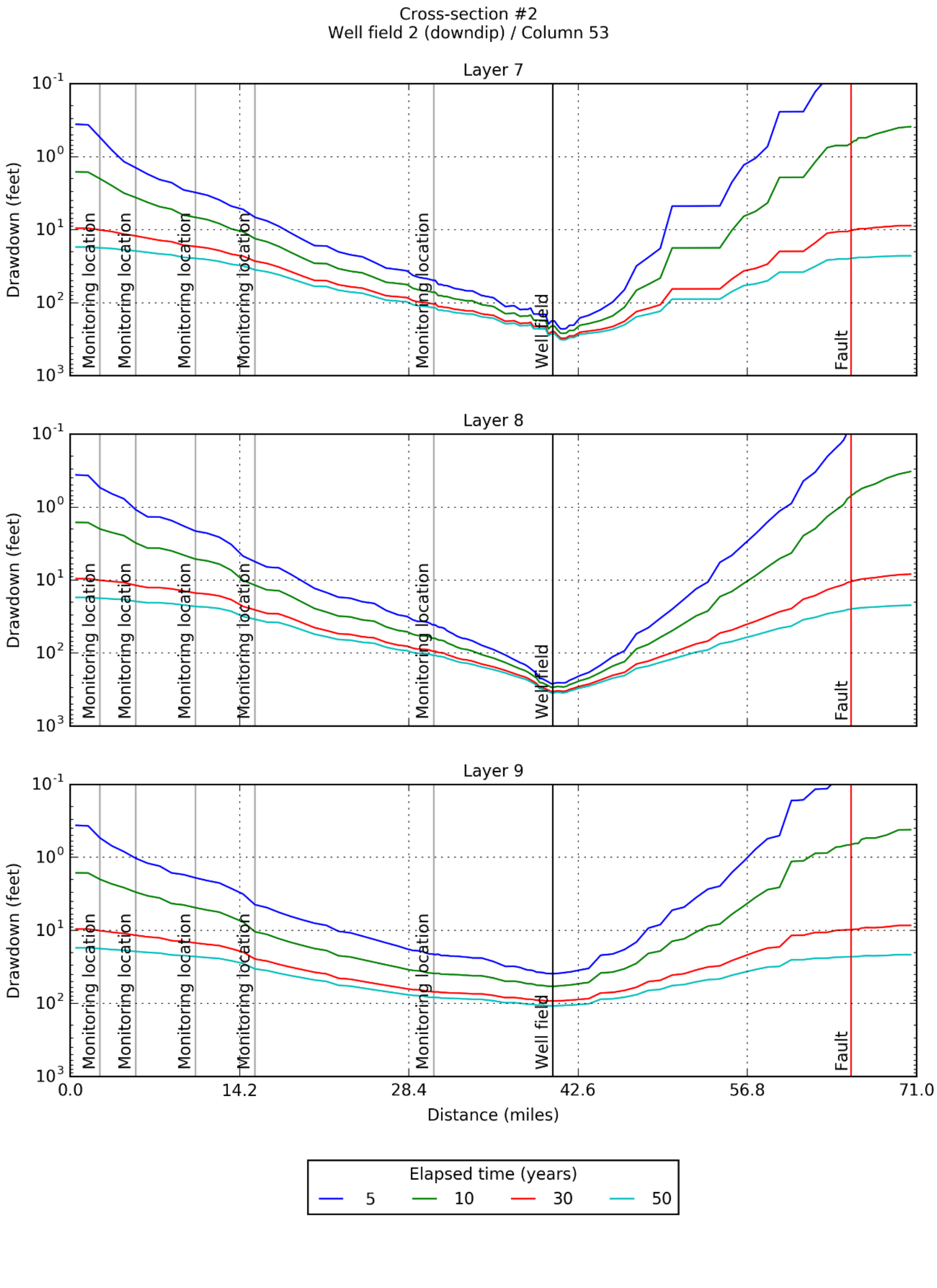


**Figure 6-44.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #2 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

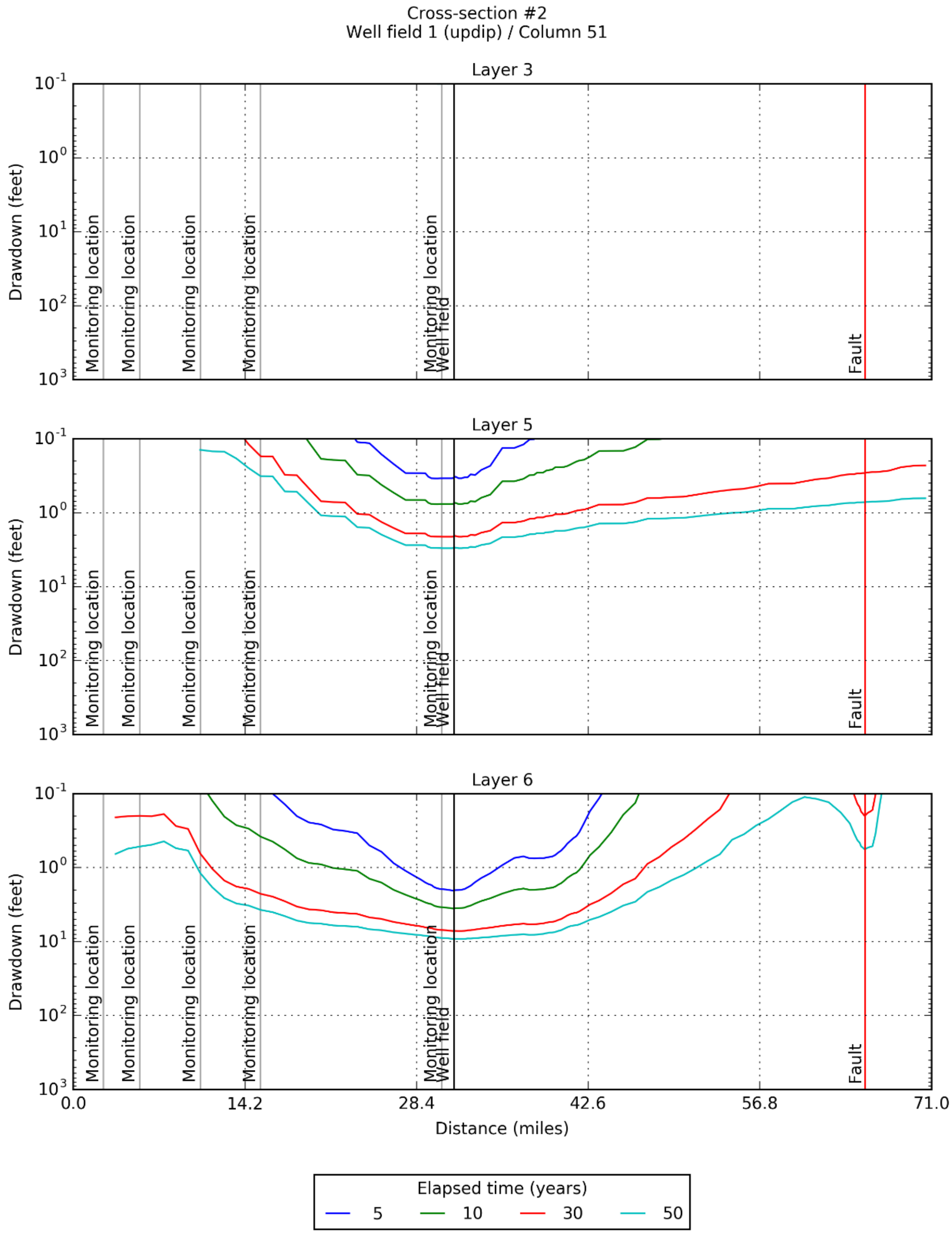


**Figure 6-45.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #2 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

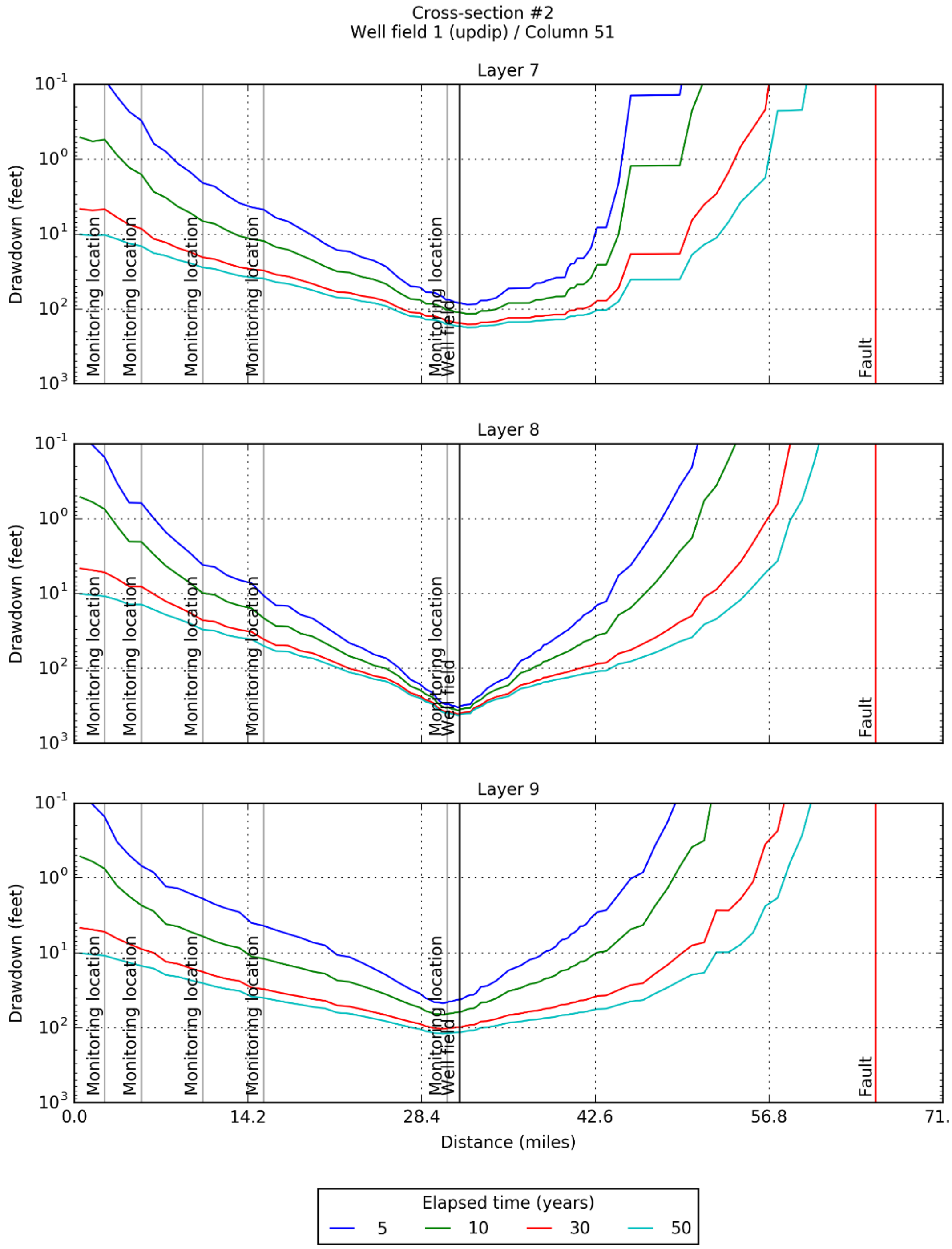


**Figure 6-46.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #2 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

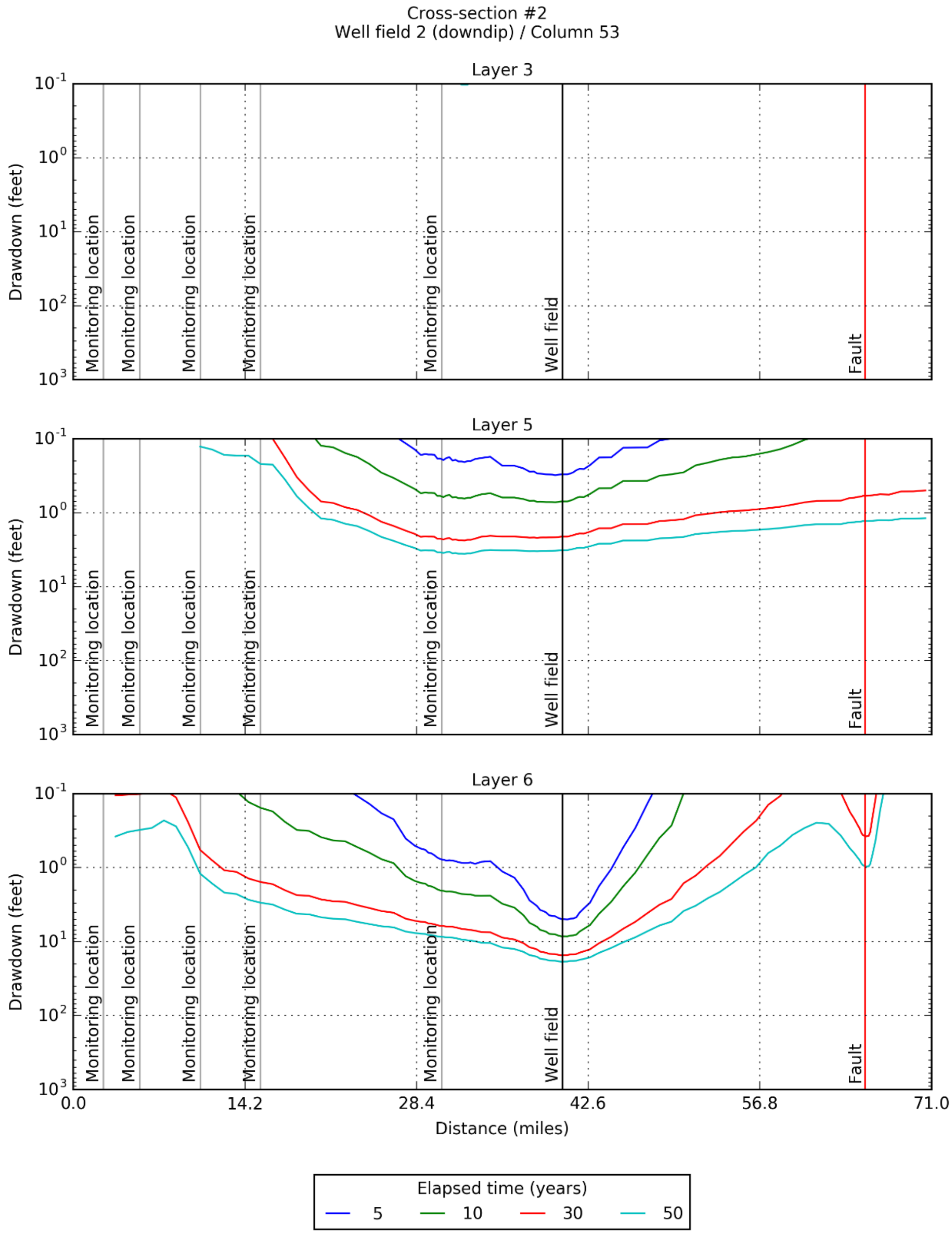


**Figure 6-47.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #2 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

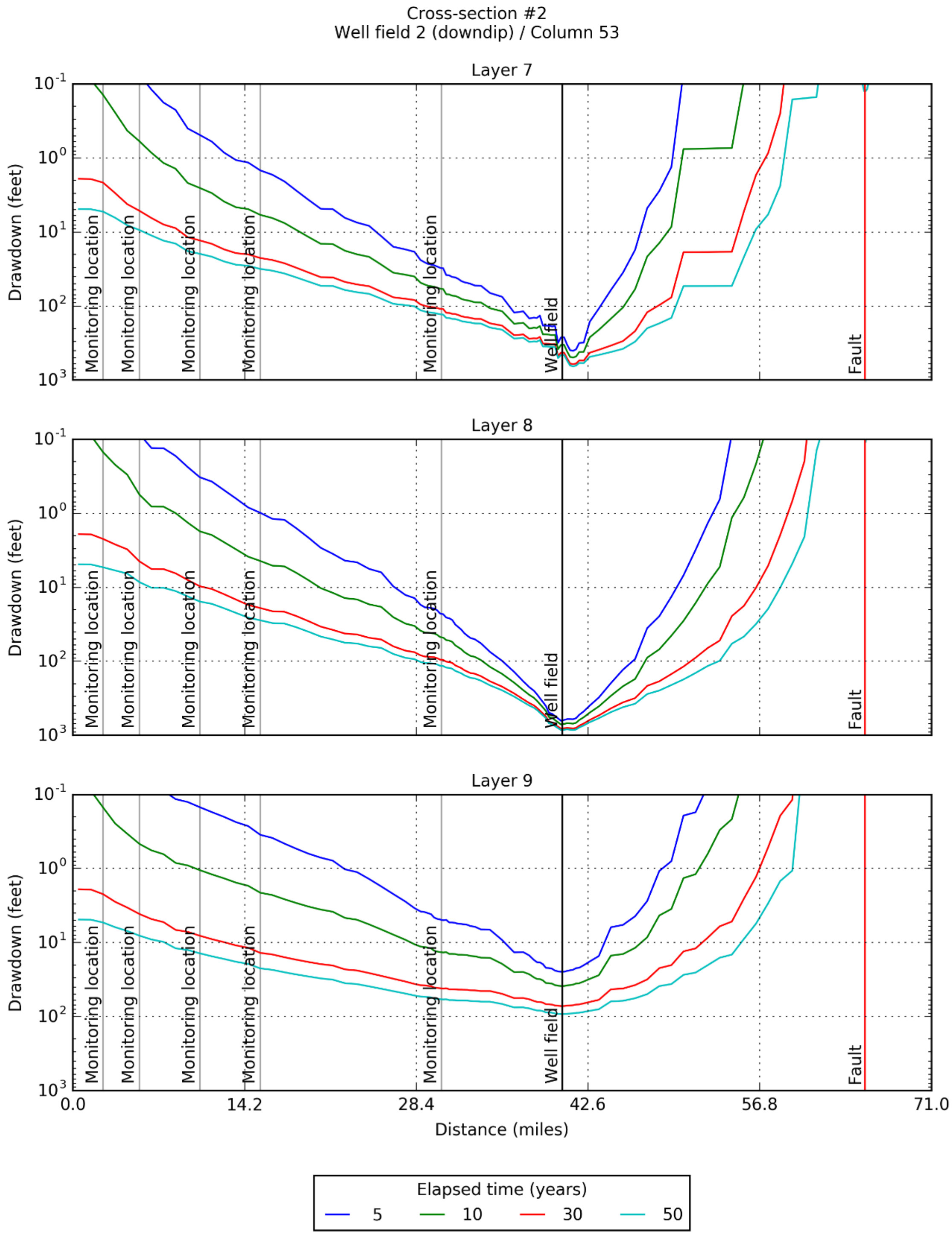


**Figure 6-48.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #2 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

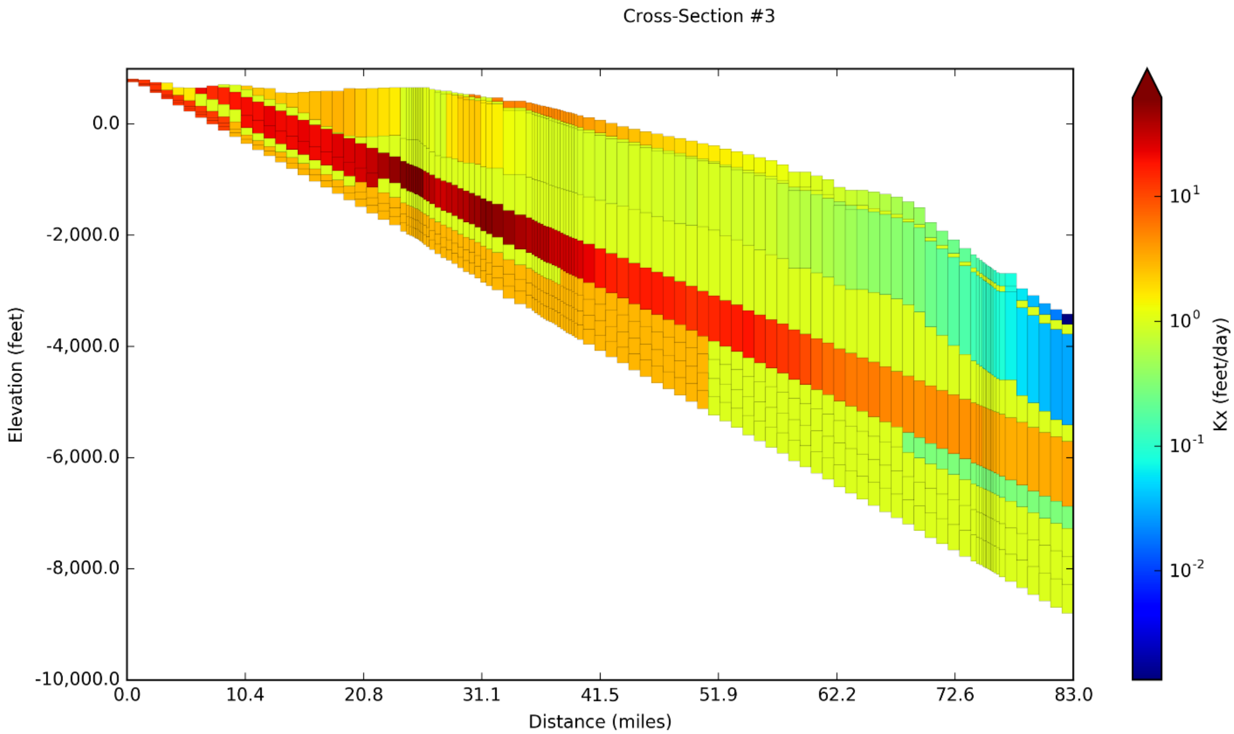


**Figure 6-49. Horizontal hydraulic conductivity values in the groundwater model for PPA #3 with properties that are GAM-based for model layers 1 to 9.**

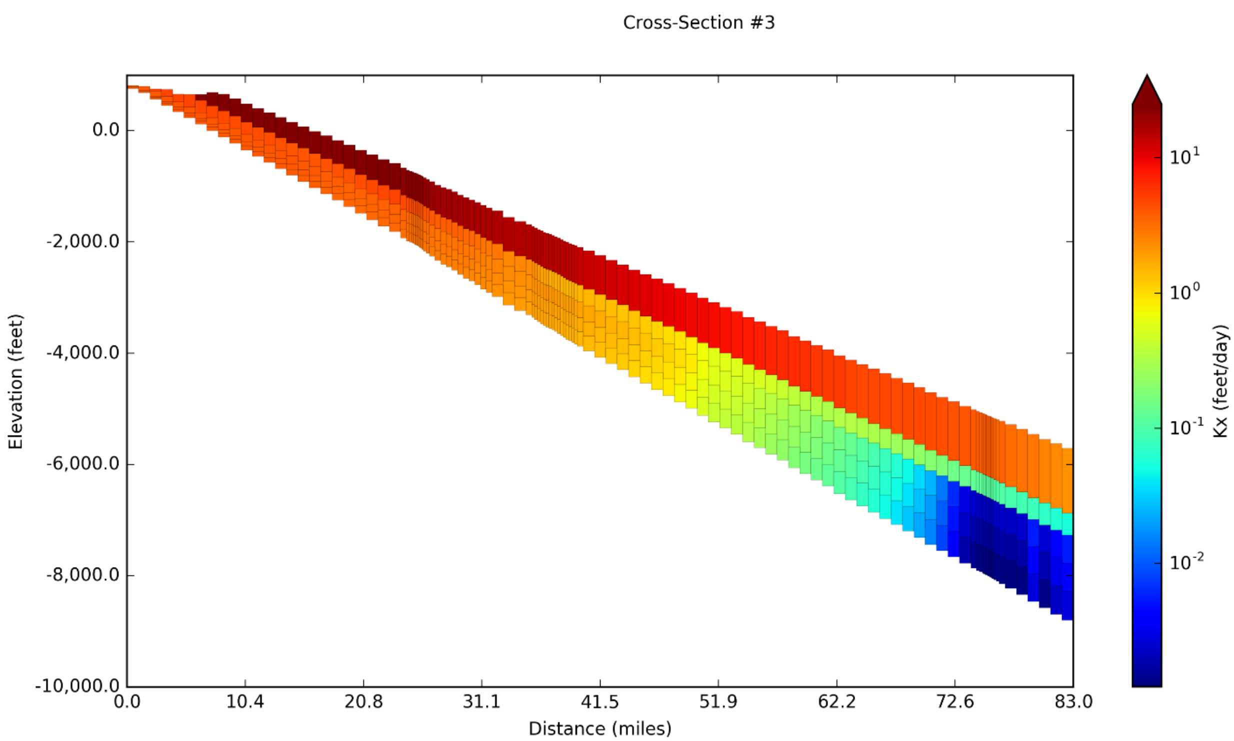


**Figure 6-50. Horizontal hydraulic conductivity values in the groundwater model for PPA #3 with properties that are GHSM-based for model layers 5 to 9.**

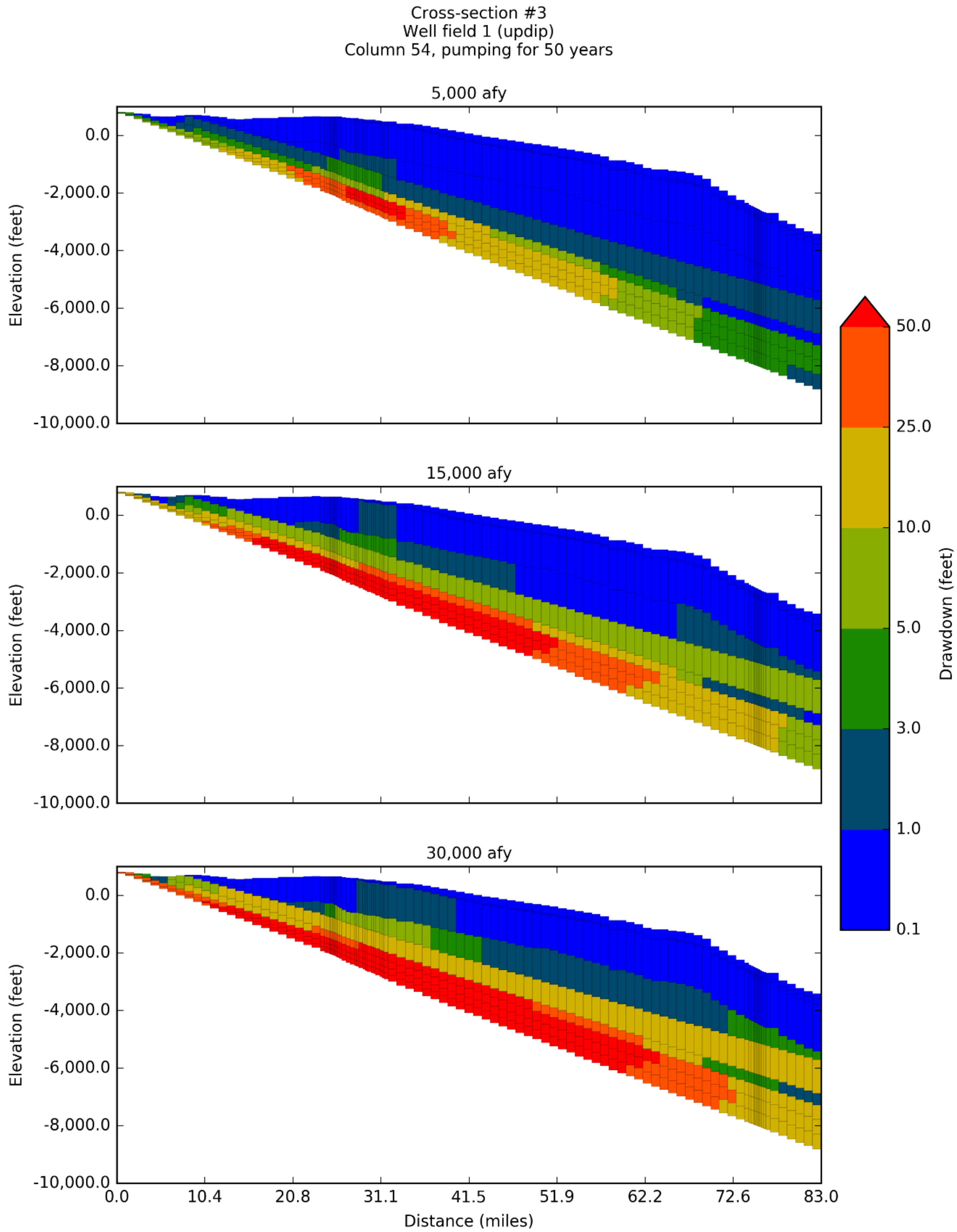


**Figure 6-51.** **Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #3 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

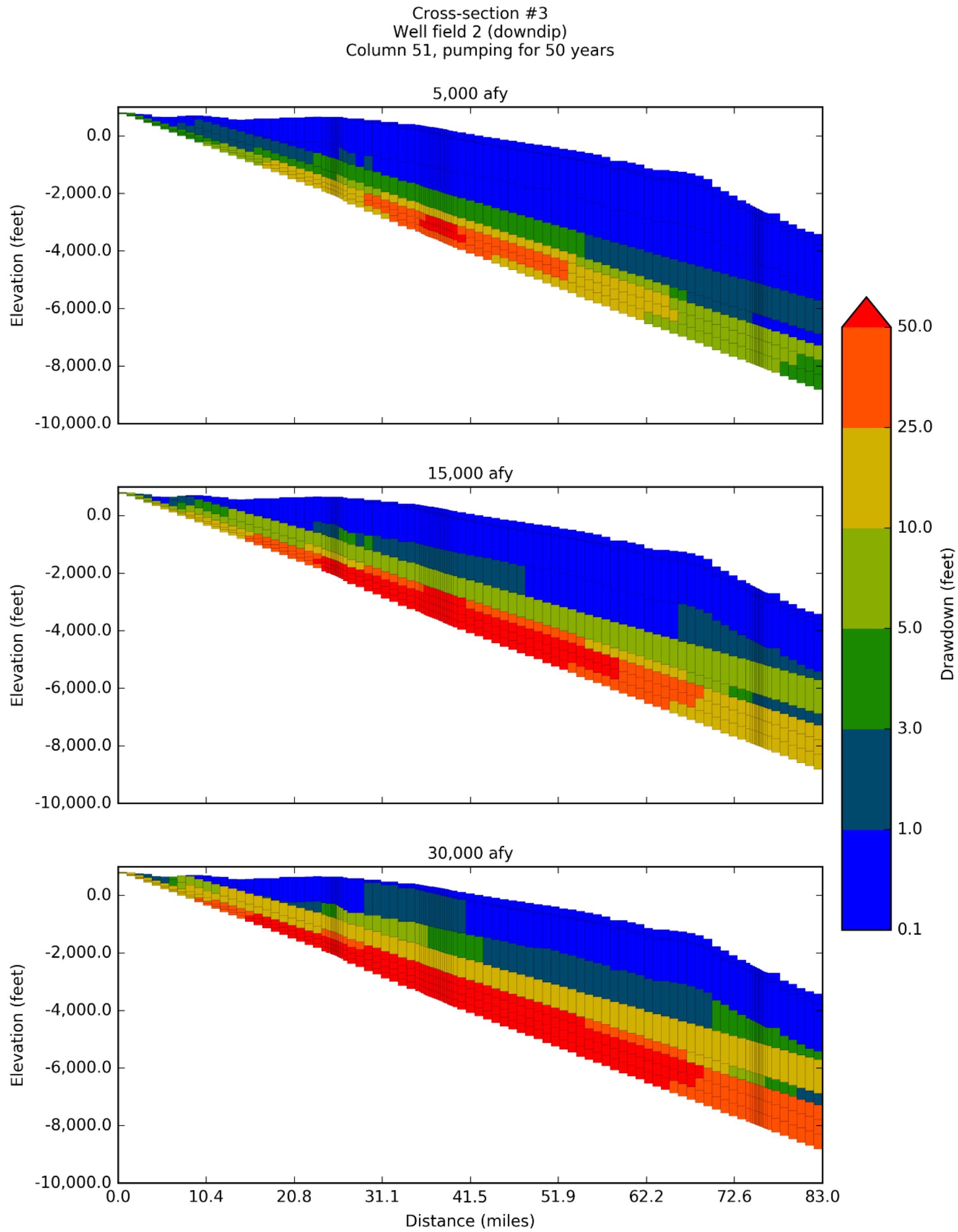


**Figure 6-52.** **Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #3 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

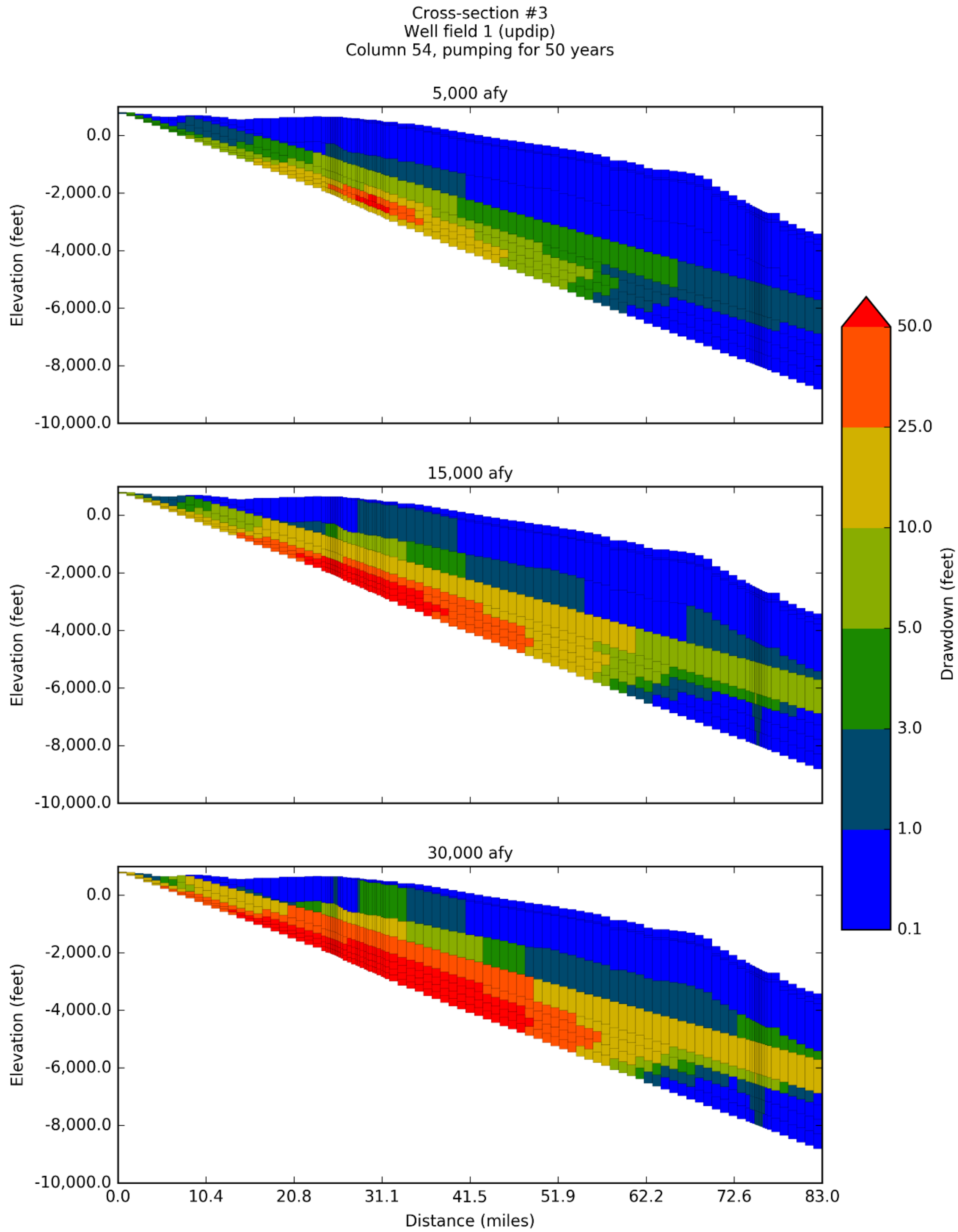


**Figure 6-53.** **Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #3 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

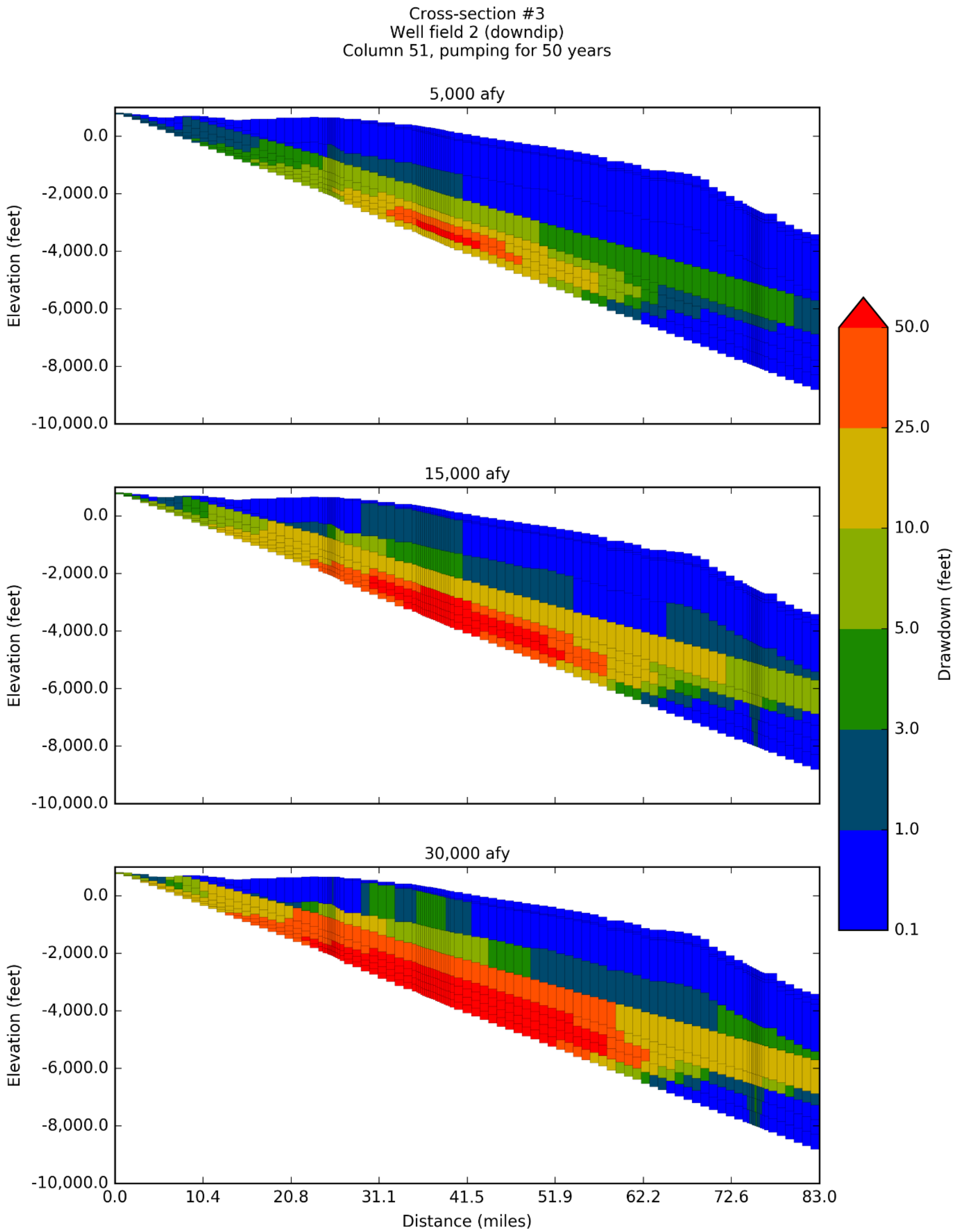


**Figure 6-54. Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #3 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

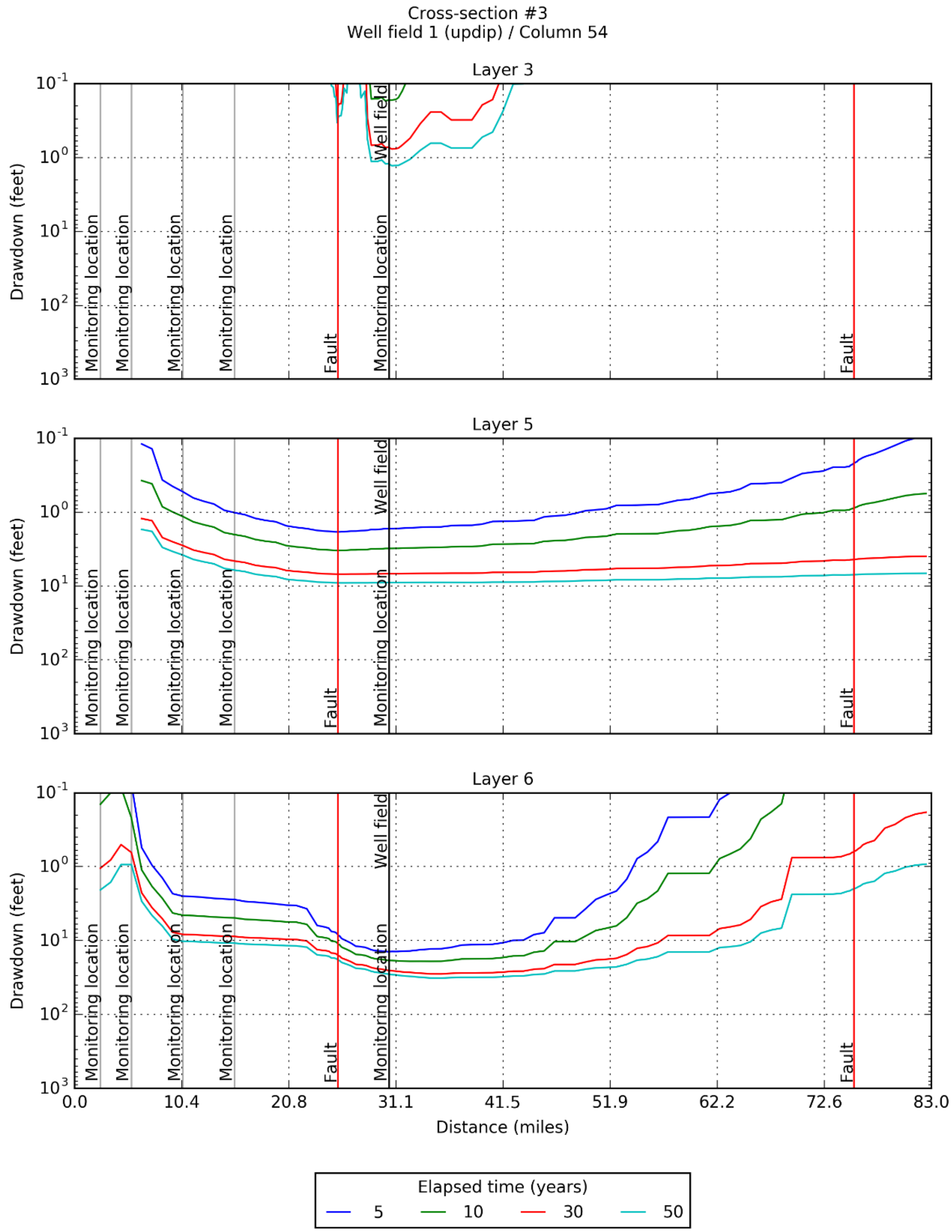


**Figure 6-55. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #3 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

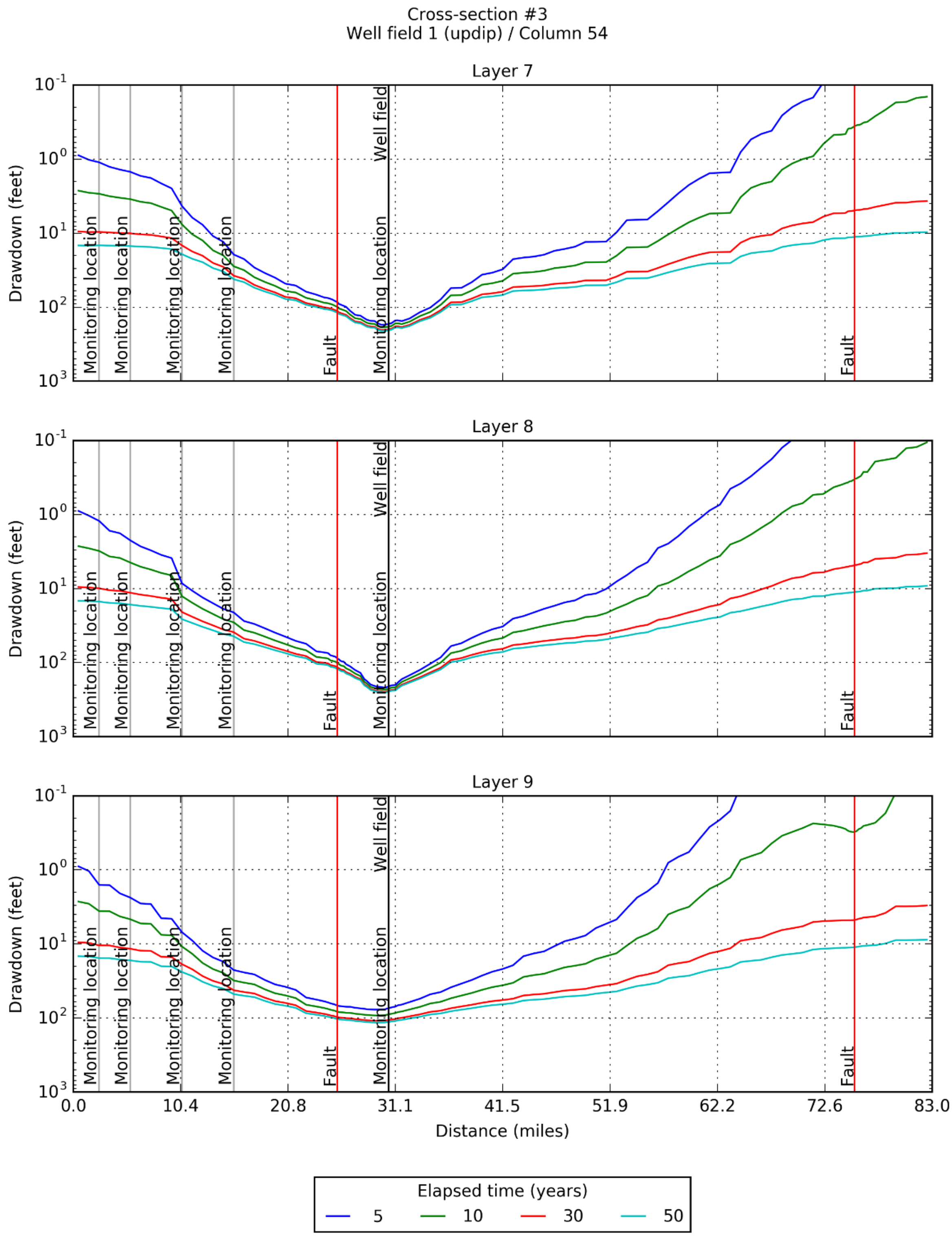


**Figure 6-56.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #3 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

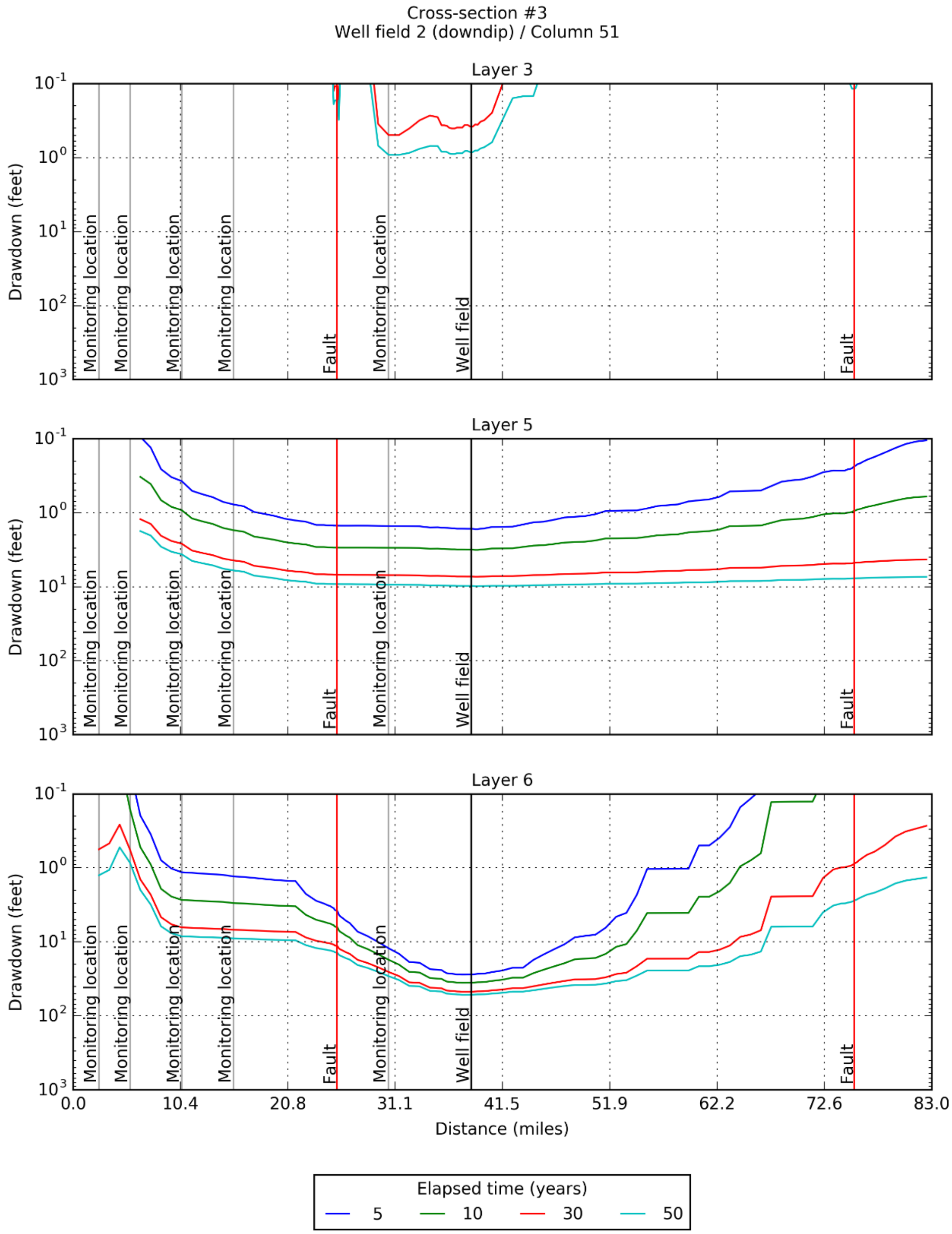


**Figure 6-57. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #3 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

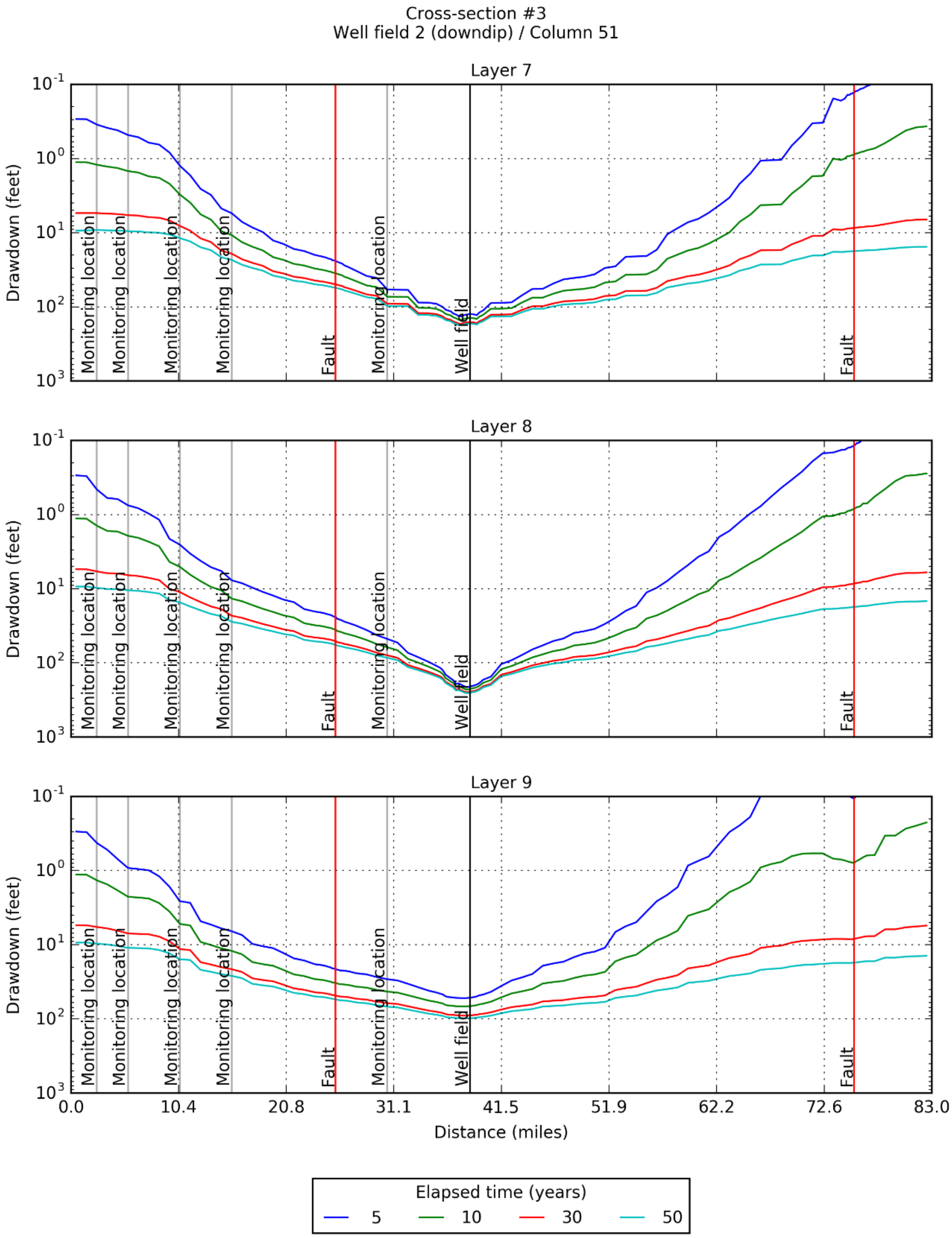


**Figure 6-58.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #3 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

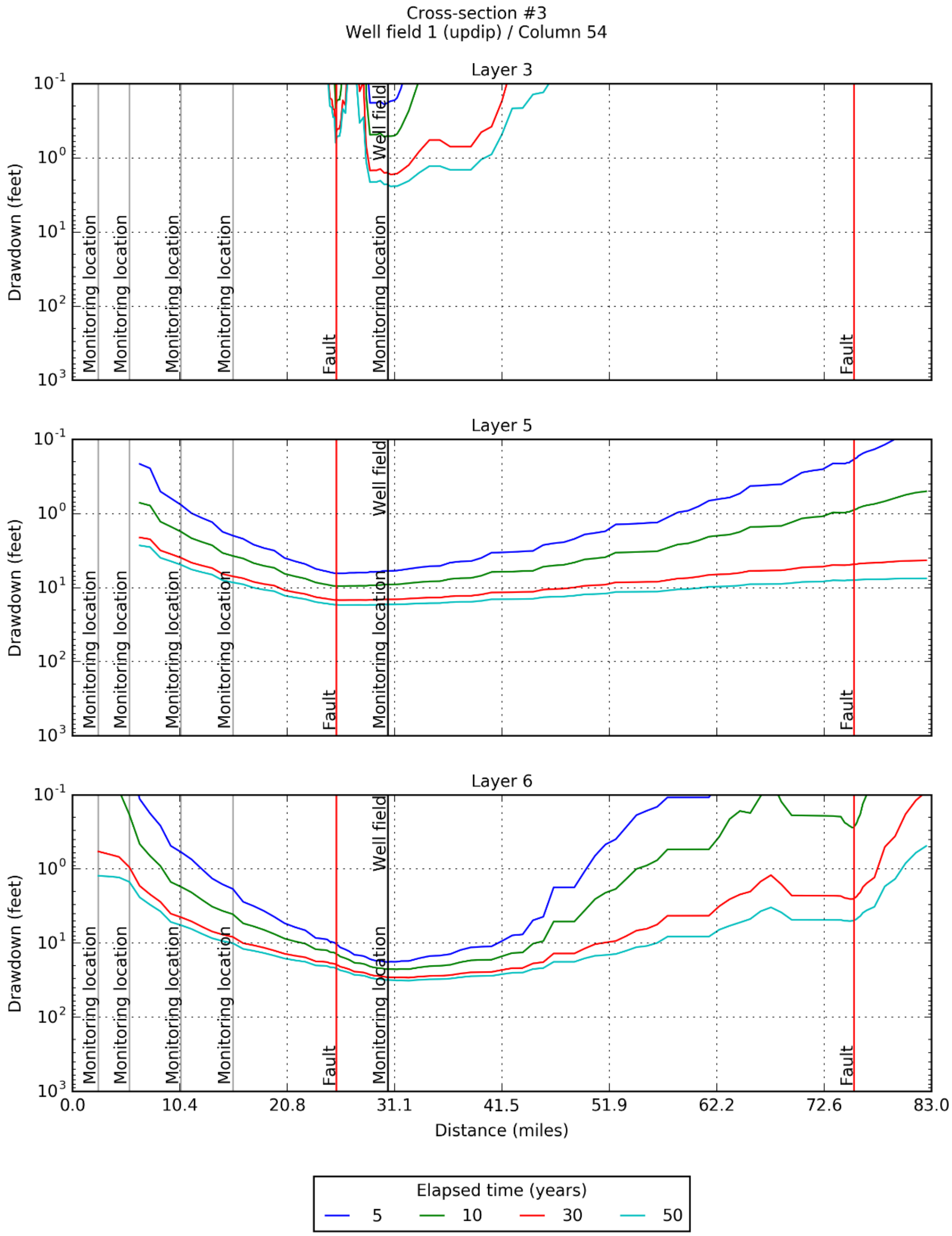


**Figure 6-59. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #3 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer**

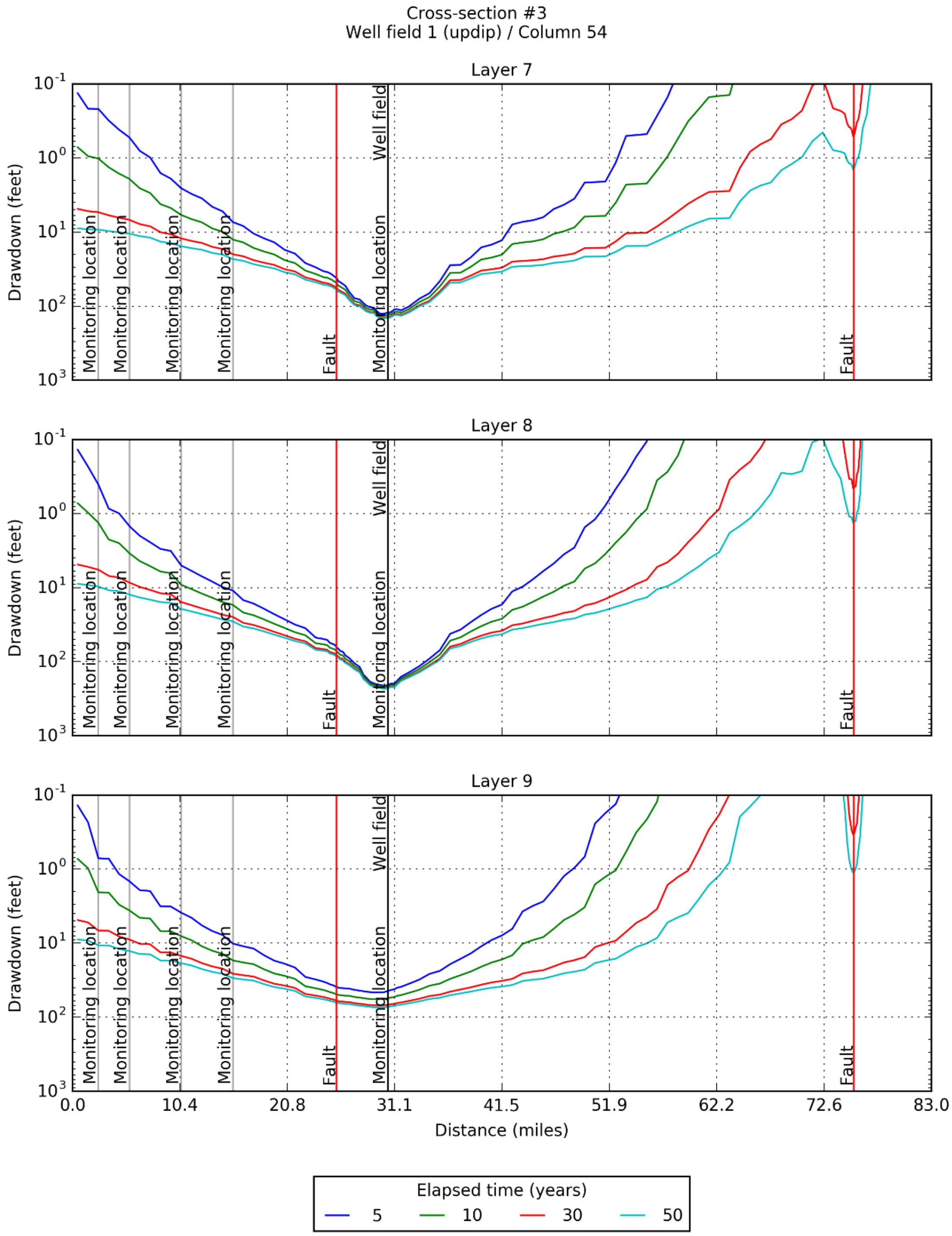


**Figure 6-60.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #3 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

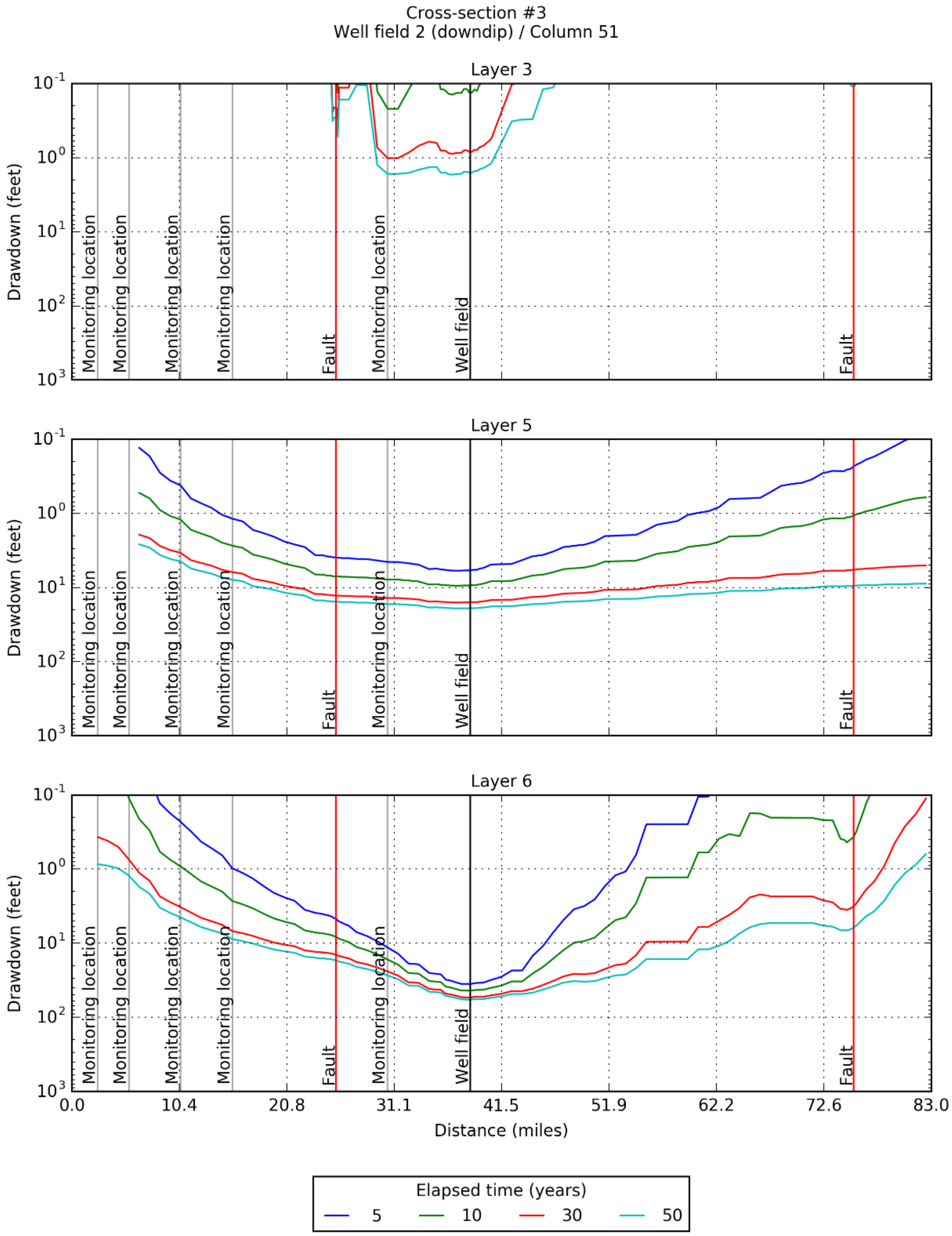


**Figure 6-61.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #3 at 15,000 AFY produced by the groundwater model with GHSM- based hydraulic properties for Carrizo-Wilcox Aquifer.**

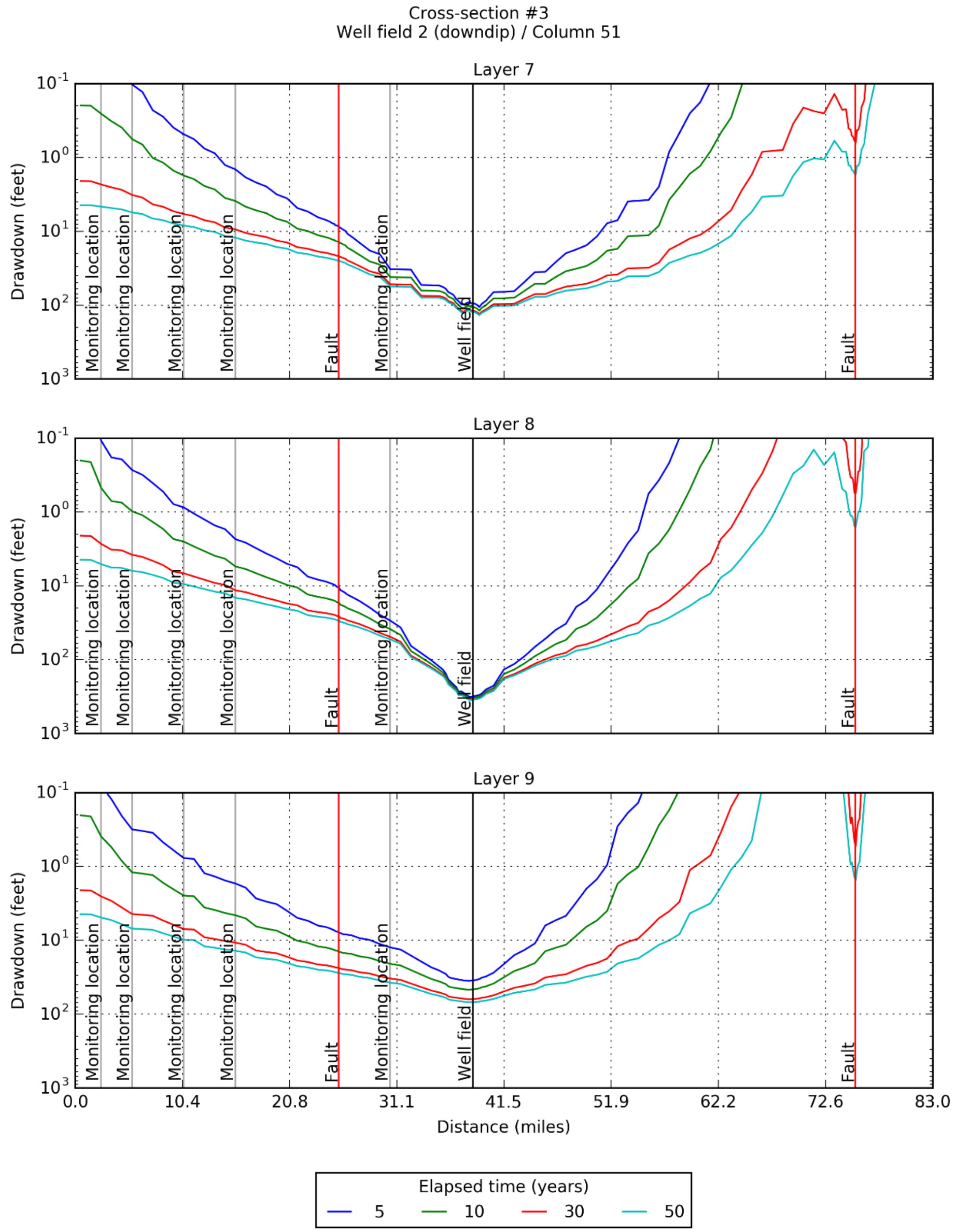


**Figure 6-62. Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #3 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

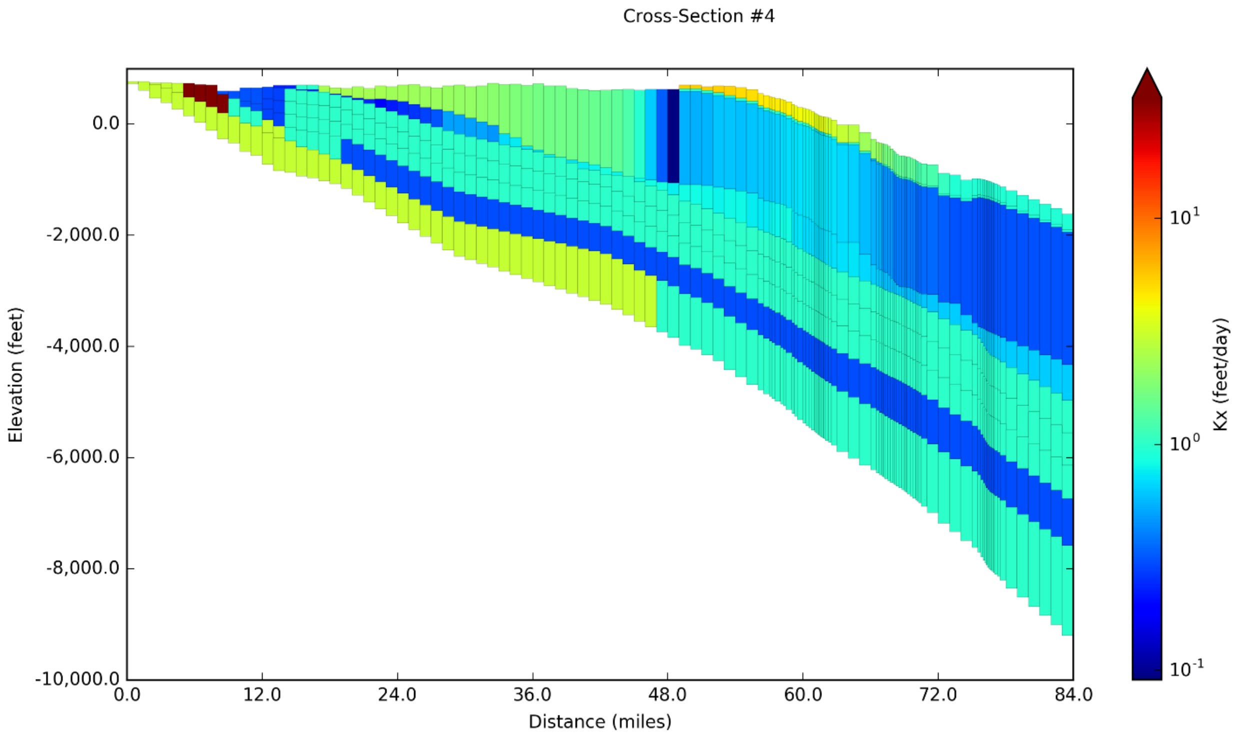


**Figure 6-63. Horizontal hydraulic conductivity values in the groundwater model for PPA #4 with properties that are GAM-based for model layers 1 to 9.**

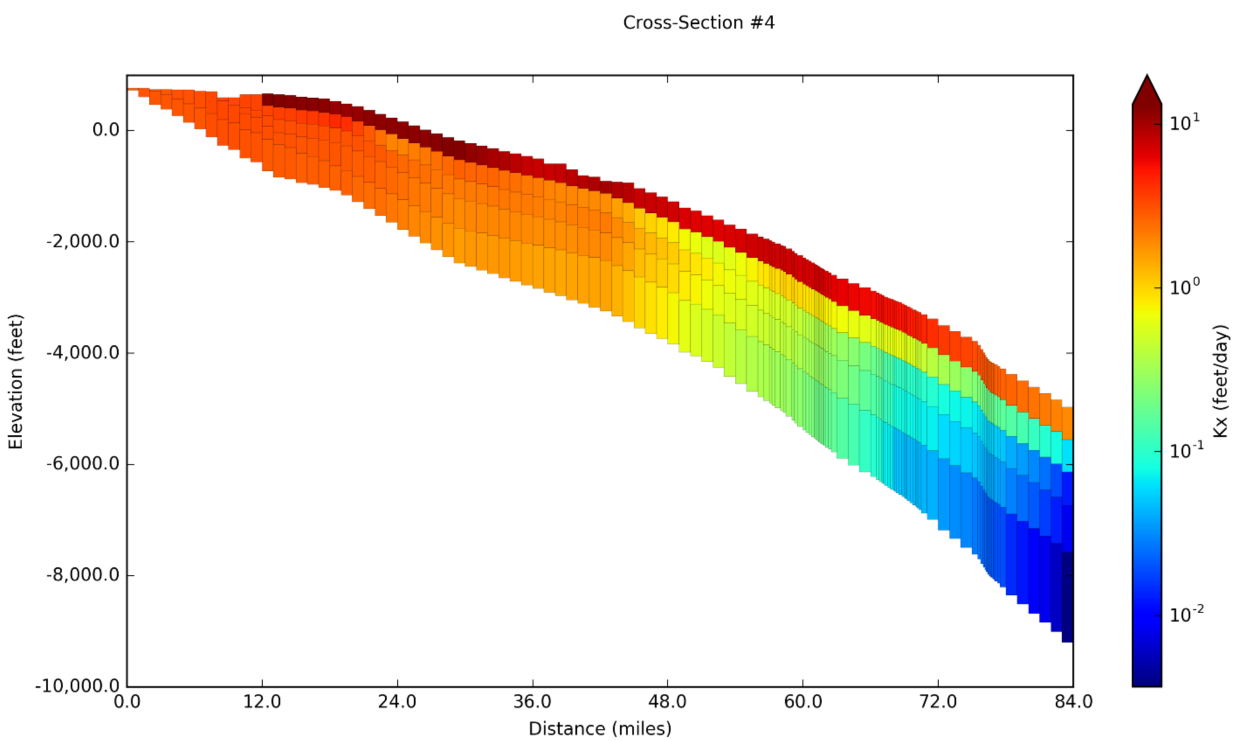


**Figure 6-64. Horizontal hydraulic conductivity values in the groundwater model for PPA #4 with properties that are GHSM-based for model layers 5 to 9.**

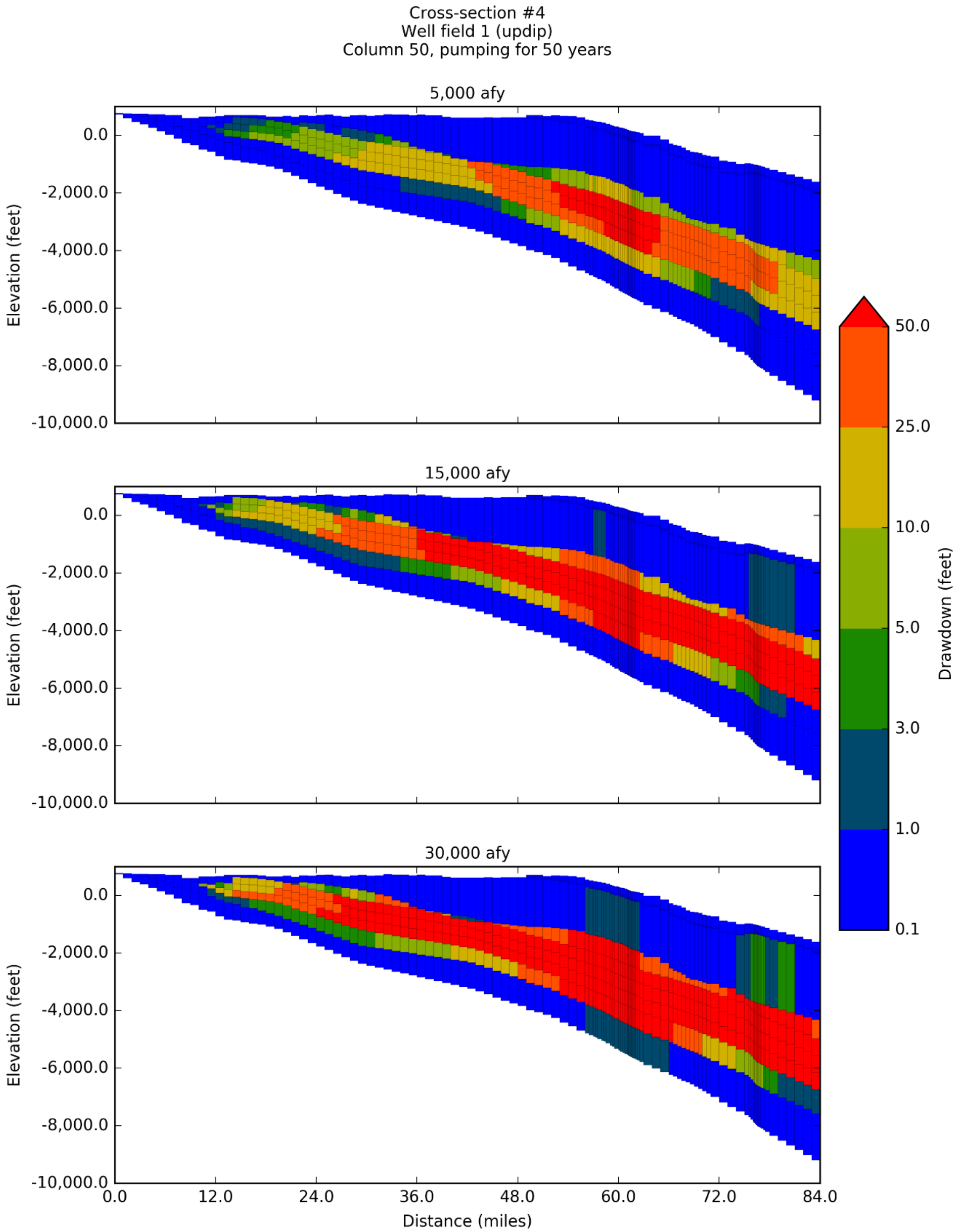


**Figure 6-65.** **Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #4 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

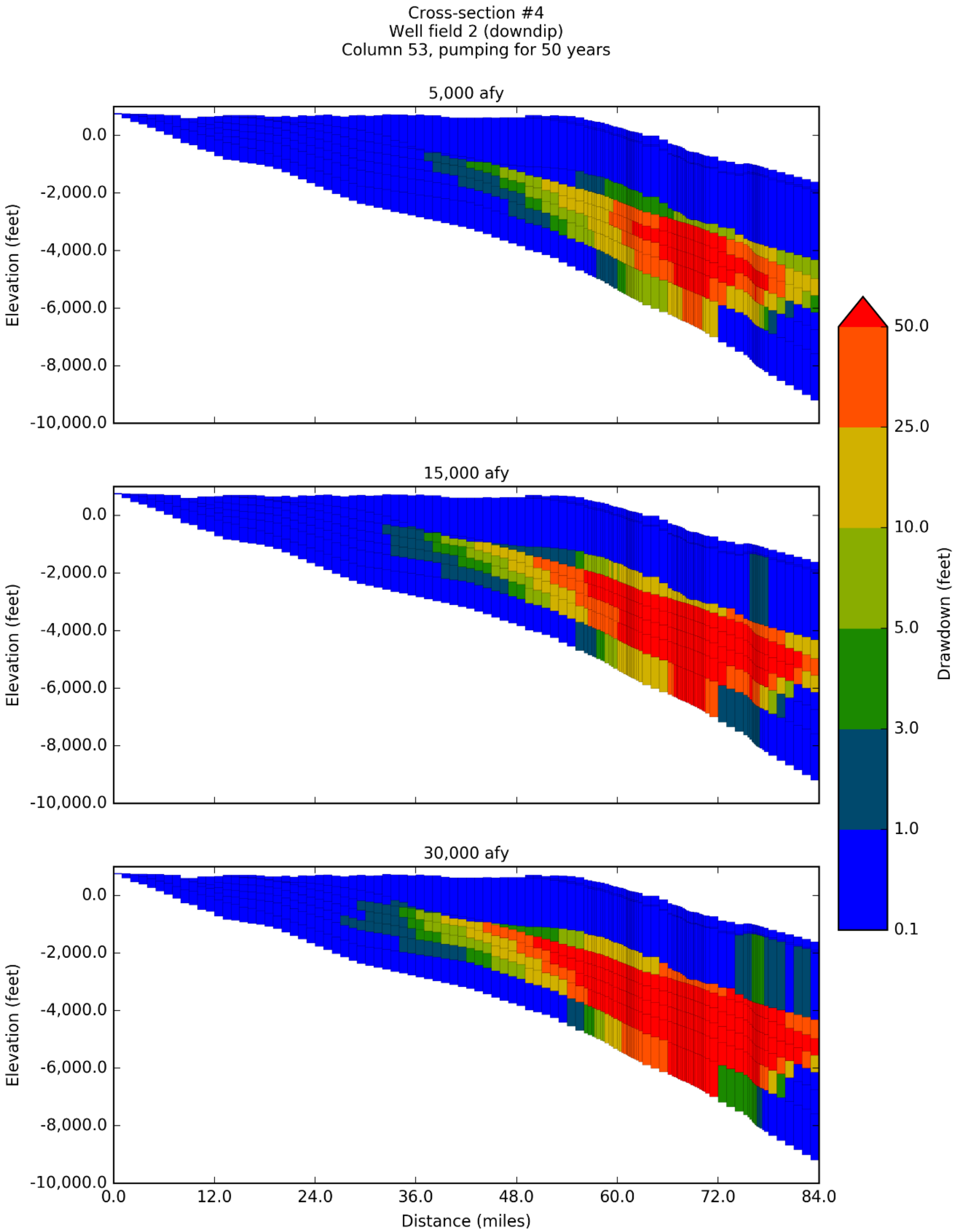


**Figure 6-66. Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #4 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

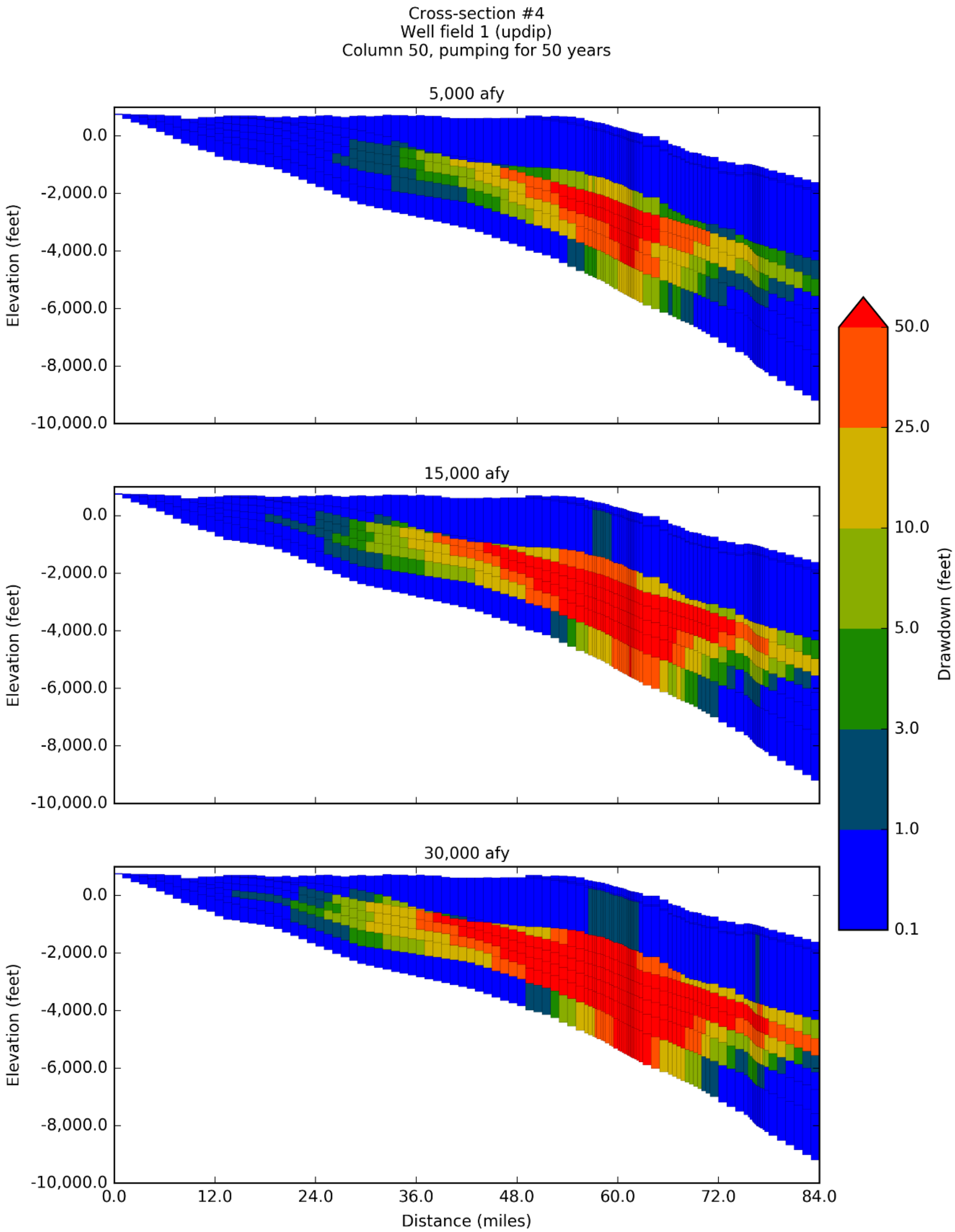


**Figure 6-67. Simulated drawdown at 50 years after pumping the up dip Well Field #1 located in PPA #4 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

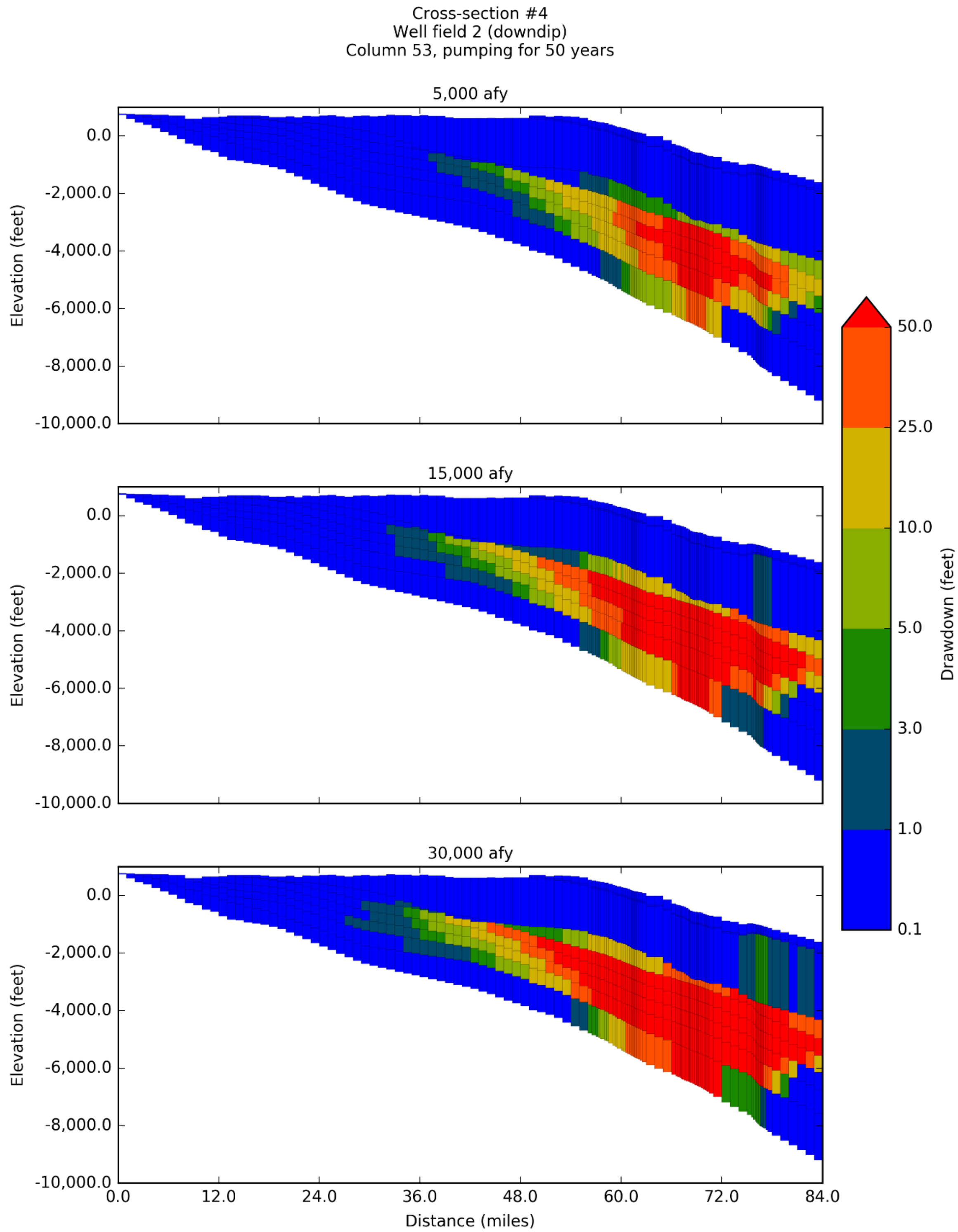


**Figure 6-68.** **Simulated drawdown at 50 years after pumping the up dip Well Field #2 located in PPA #4 at 5,000 AFY, 15,000 AFY, and 30,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

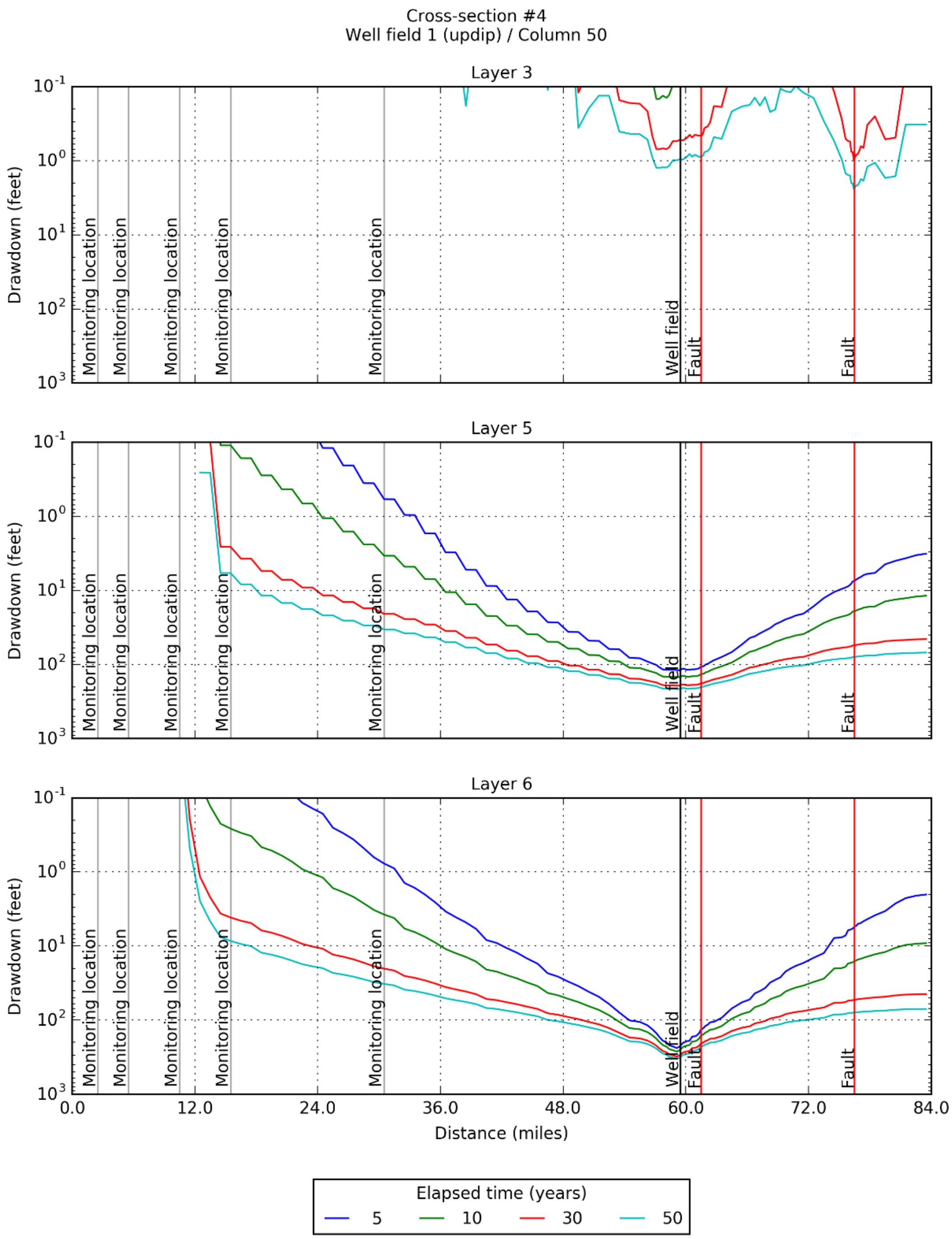


**Figure 6-69. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #4 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

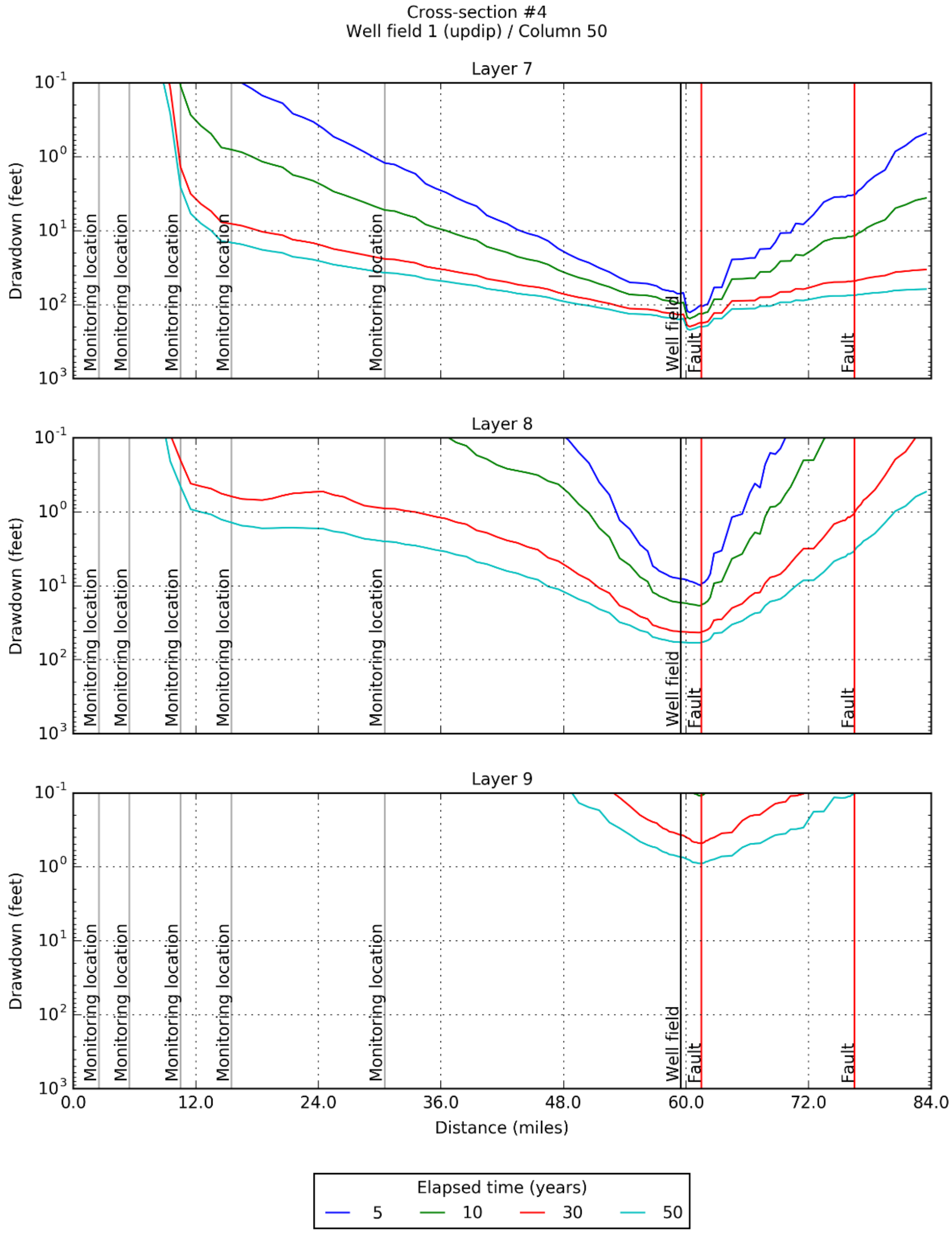


**Figure 6-70.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #4 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

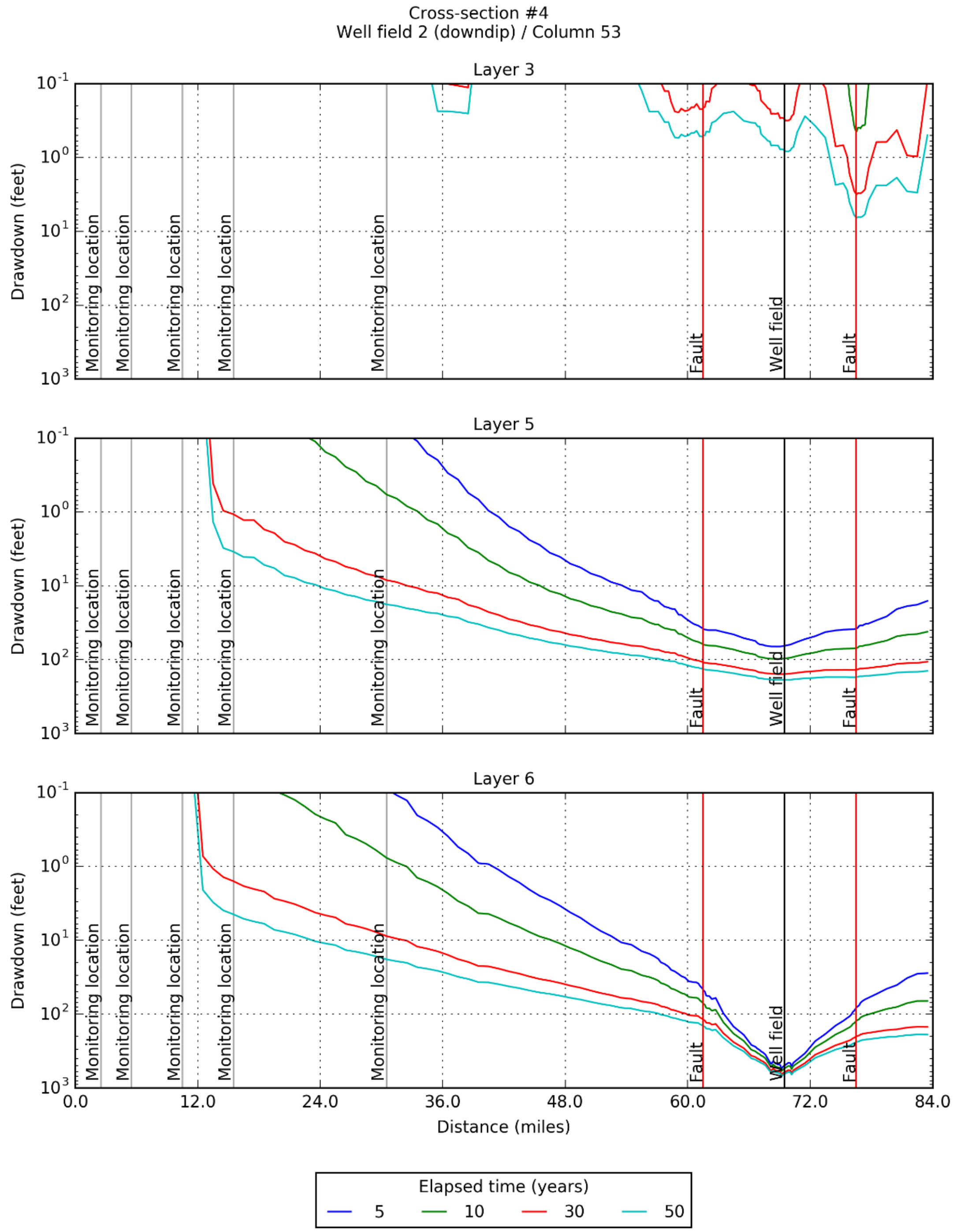


**Figure 6-71. Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #4 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

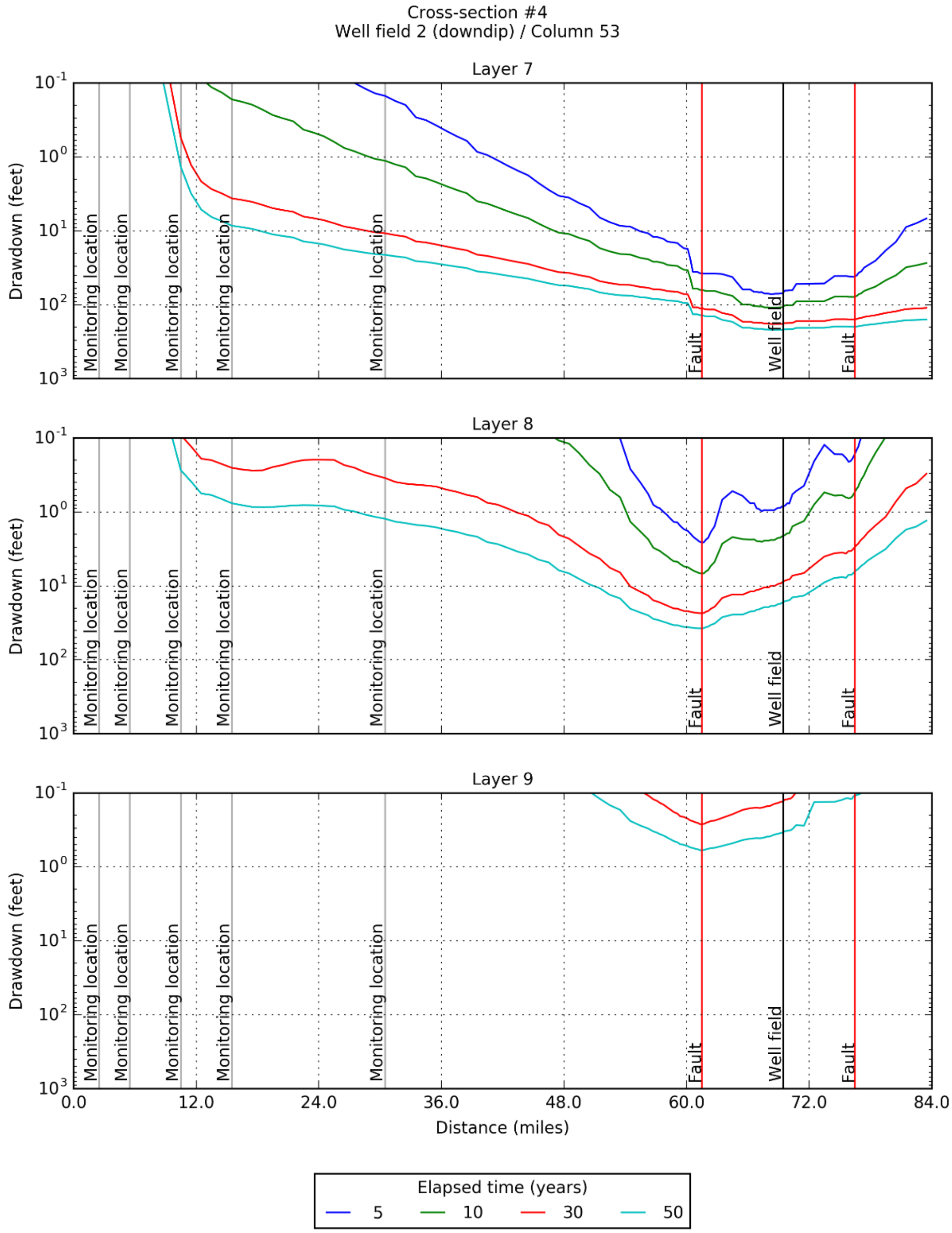


**Figure 6-72.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #4 at 15,000 AFY produced by the groundwater model with GAM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

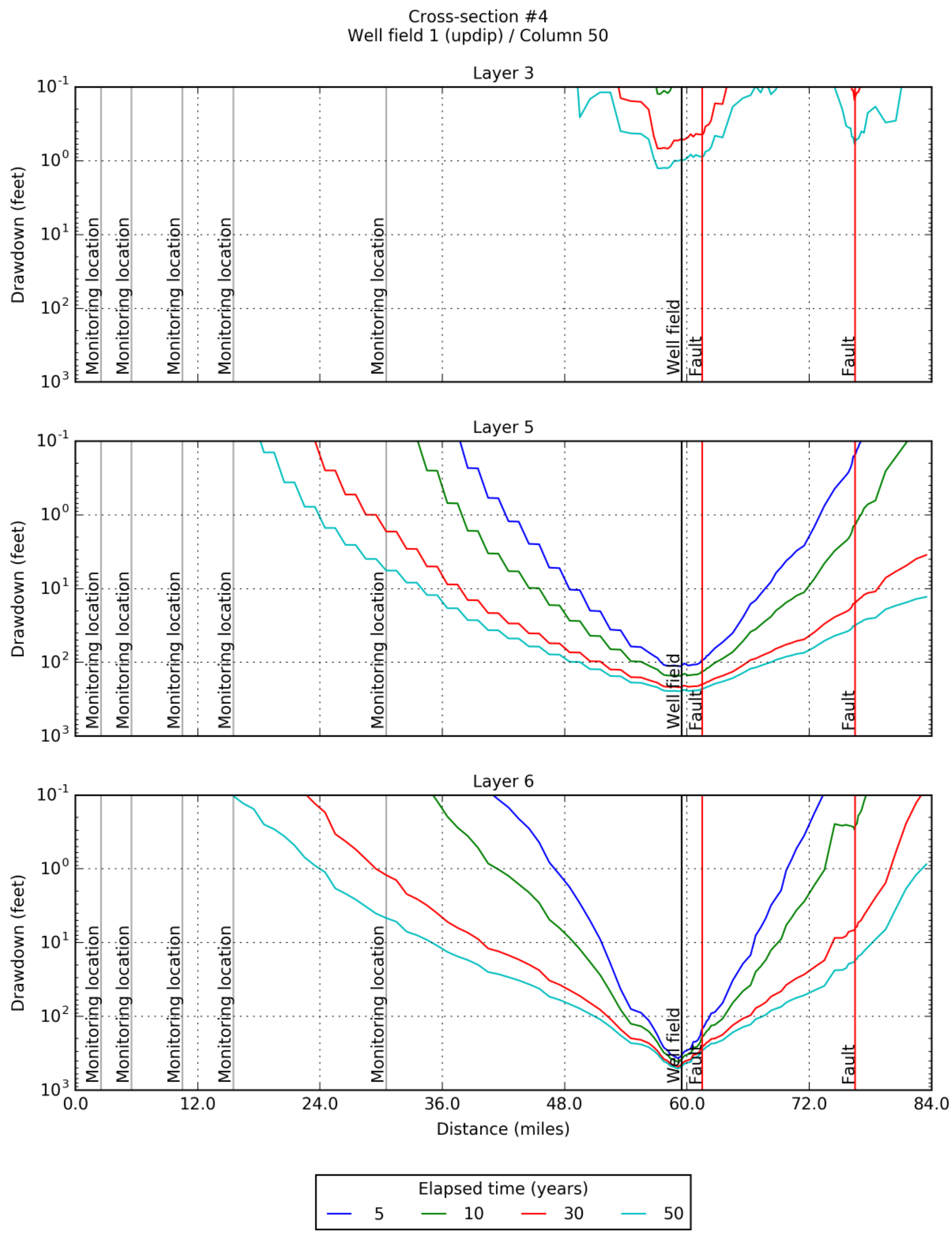


**Figure 6-73.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #1 located in PPA #4 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer**

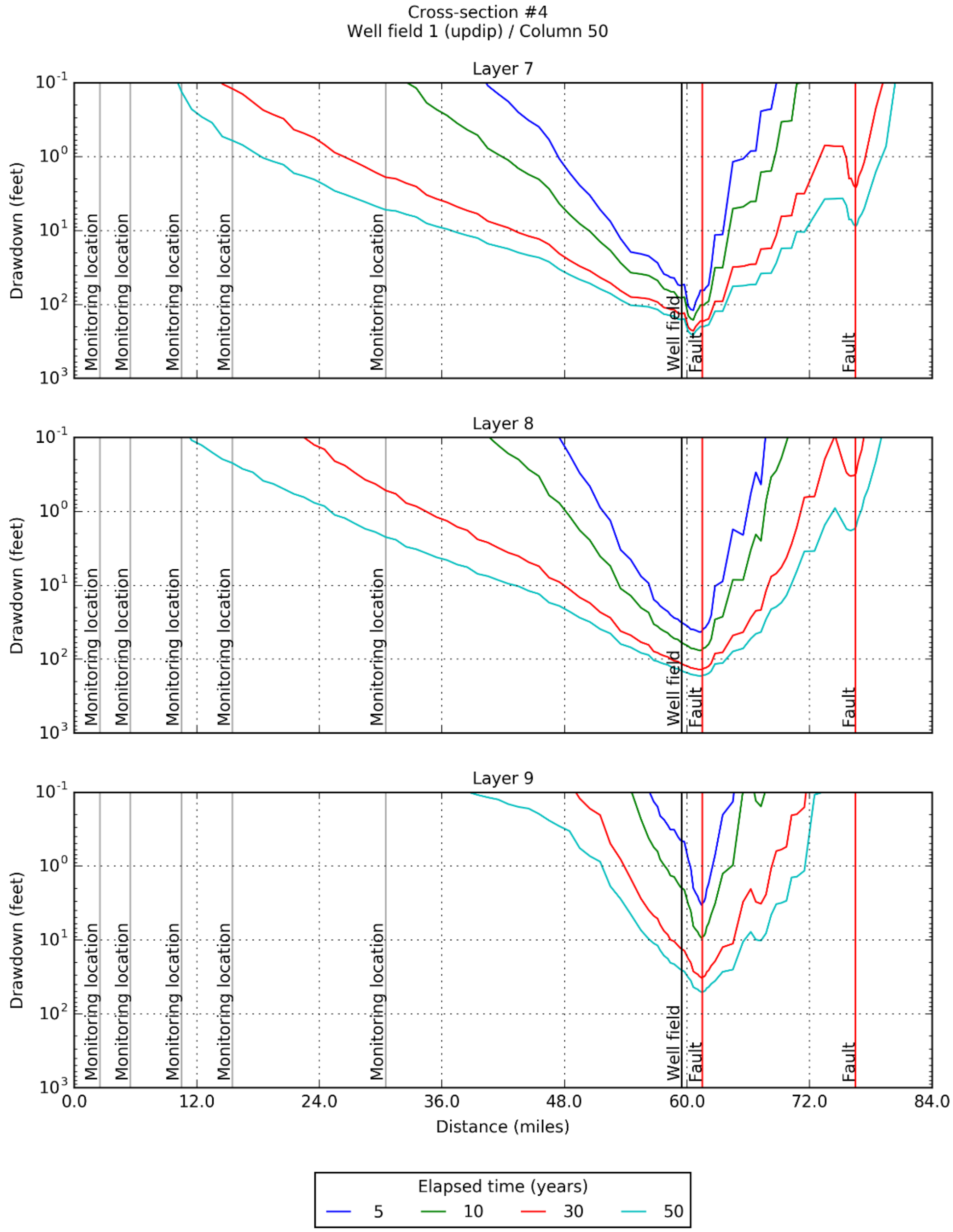


**Figure 6-74. Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #1 located in PPA #4 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

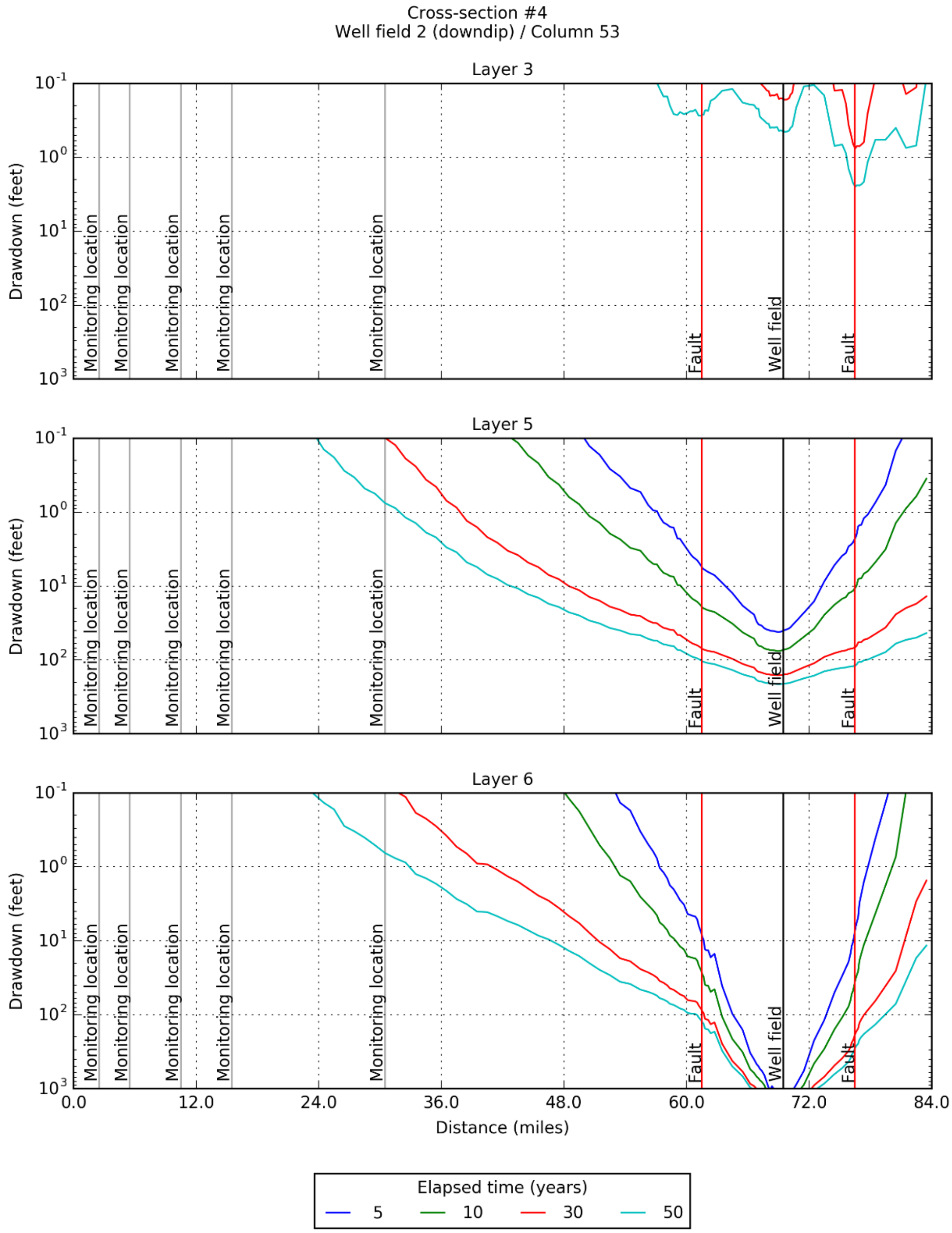


**Figure 6-75.** **Simulated drawdown at 5, 10, 30, and 50 years for model layers 3, 5, and 6 after pumping the up dip Well Field #2 located in PPA #4 at 15,000 AFY produced by the groundwater model with GHSM- based hydraulic properties for Carrizo-Wilcox Aquifer.**

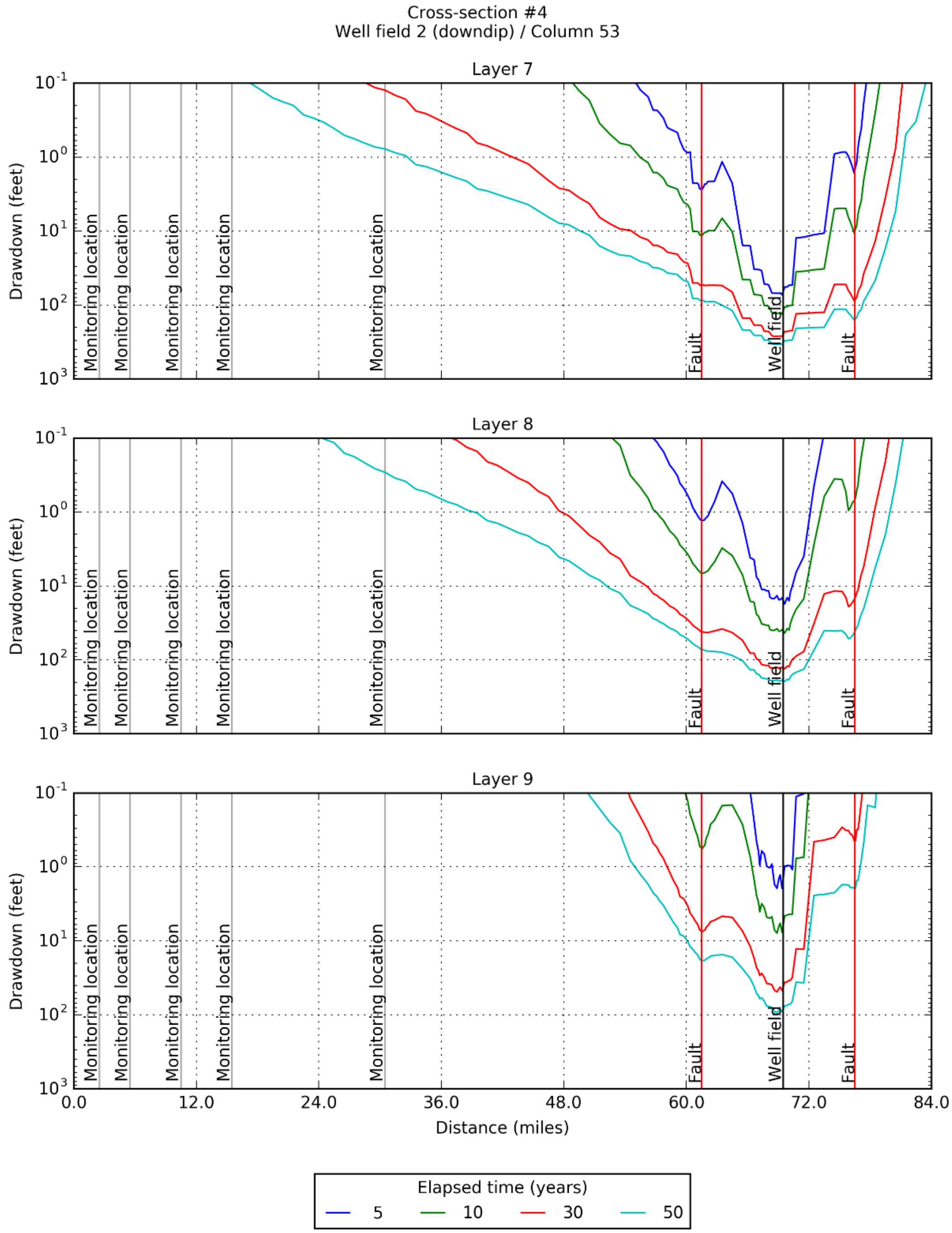


**Figure 6-76. Simulated drawdown at 5, 10, 30, and 50 years for model layers 7, 8, and 9 after pumping the up dip Well Field #2 located in PPA #4 at 15,000 AFY produced by the groundwater model with GHSM-based hydraulic properties for Carrizo-Wilcox Aquifer.**

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