Fillmore and Piru Basins
Groundwater Sustainability Agency

Appendix K

Monitoring Network and Data Gaps Analysis Technical Memorandum

Fillmore and Piru Groundwater Basins Monitoring Program and Data Gap Analysis Technical Memorandum

Prepared for

Fillmore and Piru Basins
Groundwater Sustainability Agency

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Certification

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List of Acronyms and Abbreviations

AB	assembly bill
ADCP	acoustic doppler current profiler
AF	acre-feet
AFY	acre-feet per year
Ag	agriculture
AMI	automated (or advanced) metering infrastructure
amsl	above mean sea level
APN	assessor parcel number
B	boron
bgs	below ground surface
BMP	best management practices
BOS	bottom of screen
CA	California
CalGEM	Geologic Energy Management Division (formerly DOGGR)
CASGEM	California statewide groundwater elevation monitoring
CCR	California Code of Regulations
CDPH	California Department of Public Health
cfs	cubic feet per second
CIMIS	California irrigation management information system
Cl	chloride
COC	chemical of concern
CWC	California Water Code
DBS&A	Daniel B. Stephens & Associates, Inc.
DDW	[SWRCB] Division of Drinking Water
DEM	digital elevation model
DOGGR	Division of Oil, Gas, and Geothermal Resources (reorganized as CalGEM)
DQO	data quality objective
DTW	depth to water
DWR	[CA] Department of Water Resources
DWUs	downstream water users
EGM96	Earth Gravitational Model of 1996
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration

ET0	reference evapotranspiration
FCGMA	Fox Canyon Groundwater Management Agency
FICO	Farmers Irrigation Company
FPBGSA	Fillmore and Piru Basins Groundwater Sustainability Agency
GAMA	[USGS] groundwater ambient monitoring & assessment
GIS	geographic information system
GPS	global positioning system
GSP	groundwater sustainability plan
HASP	health and safety plan
HCM	hydrogeologic conceptual model
Hydrodata	[VCWPD] hydrologic data server
ID	identification
LiDAR	light detection and ranging
NCCAG	natural communities commonly associated with groundwater
M&I	municipal and industrial
MCL	maximum contaminant level
MOU	memorandum of understanding
MS4	municipal separate storm sewer system
NAD	North American datum
NAVD88	North American vertical datum of 1988
ND	not detected
NGVD29	national geodetic vertical datum of 1929
NO3	nitrate
NWIS	national water information system
OFR	open file report
PBP	priority basin project
PSI	pounds per square inch
PSW	public-supply well
PVC	polymerizing vinyl chloride
QA	quality assurance
QC	quality control
RASA	regional aquifer-system analysis
RP	reference point (elevation)
RWQCB	[CA] Regional Water Quality Control Board
SAP	sampling and analysis plan

SCE	Southern California Edison
SCV-GSA	Santa Clarita Valley Groundwater Sustainability Agency
SO4	sulfate
SUM	summation
SWL	static water level
SWN	[CA DWR] state well number
SWRCB	[CA] State Water Resource Control Board
TD	total depth
TDS	total dissolved solids
TFR	total filterable residue
TMDL	total maximum daily load
TNC	The Nature Conservancy
TOS	top of screen
URL	uniform resource locator (web address)
USGS	U.S. Geological Survey
UWCD	United Water Conservation District
VC	Ventura County
VCWPD	Ventura County Watershed Protection District
VCWWD#16	Ventura County Waterworks District Number 16
VRGWFM	Ventura Regional Groundwater Flow Model
WGS84	world geodetic system 1984
WL	water level
WLE	water level elevation
WQ	water quality
WY	water year

1. Introduction

Daniel B. Stephens & Associates, Inc. (DBS&A) has prepared this Fillmore and Piru Basins Monitoring Program and Data Gap Analysis Technical Memorandum (Tech Memo) for the Fillmore and Piru Basins Groundwater Sustainability Agency (FPBGSA or Agency) and is under contract to prepare their Sustainable Groundwater Management Act (SGMA) of 2014 mandated Groundwater Sustainability Plans (GSP or Plan). This Tech Memo is intended to be included as an Appendix in the final GSPs. SGMA requires separate Plans be prepared for each basin. Fillmore (DWR basin ID: 4-4.05) and Piru (4-4.06) subbasins (hereafter referred to as "basins") (Figure 1-1) are hydrogeologically connected (UWCD, 2016) and have historically been managed and monitored together. In keeping with this historical precedent, this Tech Memo has been prepared to cover both basins.

SGMA requires that all California Department of Water Resources (DWR) designated "medium" and "high" priority basins be managed sustainably over a 20-year GSP implementation horizon. Basins identified by the DWR as "Critically Overdrafted" were required to submit their Plans to the DWR by January 31, 2020. Fillmore and Piru basins are both designated as "high" priority basins but are not considered "Critically Overdrafted", accordingly their GSPs are due January 31, 2022 under the current DWR published SGMA timeline.

The majority of Tech Memo was completed early in the GSP development process (September 2020) to provide a foundational summary of the hydrogeological conditions in these basins and to help the FPBGSA, stakeholders, and other interested parties understand the extent to which readily available data exist for use in developing the GSPs. Minor wording changes were incorporated based on a limited number of comments from the public review process.

On January 18, 2024 DWR notified the FPBGSA that the GSPs for the Fillmore and Piru subbasins were determined to be incomplete (Appendix M of the GSPs). This was largely due to insufficient justification of proposed minimum thresholds for reductions of groundwater in storage and depletions of interconnected surface water. The FPBGSA was provided a 180-day period following the notification to address these deficiencies, during which the FPBGSA technical consulting team held six consultation meetings with DWR staff. One of the outcomes of these consultations was the need to expand the data gaps discussion for the Del Valle GDE near the Piru-Santa Clara River Valley East subbasin boundary and beneficial uses for reaches of the Santa Clara River and its tributaries (e.g., Sespe Creek, Piru Creek, Hopper Creek).

1.1 Problem Definition and Background

This section describes the purpose of the Tech Memo and provides background information.

1.1.1 Purpose

The purpose of this Monitoring Program and Data Gap Analysis Tech Memo is to aid in the development of a monitoring network that is capable of providing sustainability indicator data of sufficient accuracy and quantity to demonstrate sustainable management of the Fillmore and Piru basins. The Tech Memo describes the datasets available for GSP preparation, established monitoring networks and how data (knowledge) gaps could be filled in the future. Tech Memo components detail:

- Historical Datasets
- Existing Monitoring Networks
- Groundwater Data Trend Analysis
- Data Gap Analysis
- Recommendations

This Tech Memo is not intended to impose specific monitoring wells and/or sampling locations on United Water Conservation District (UWCD) or Ventura County Watershed Protections District (VCWPD) with respect to their existing long-standing monitoring programs. However, SGMA requires principal aquifer-specific evaluation (DWR, 2016b), which from a review of the existing monitoring networks, may be a challenge in these basins (see Sections 5.3 and 5.4). Optimization and/or expansion of current monitoring programs may be necessary as many existing groundwater monitoring points utilize privately owned agricultural wells or municipal wells potentially screened across multiple water-bearing units.

Recent (2018 and 2019 where available) data for Fillmore and Piru basins GSP preparation are displayed graphically on maps and charts in this Tech Memo. This Tech Memo serves as a starting point for GSP preparation and as a 2019 available data summary update on groundwater conditions in the basins. Recent data summarized in this Tech Memo have been displayed in formats resembling UWCD's historically published Piru and Fillmore Basins Groundwater Conditions Reports, where practicable, for ease of comparison.

1.1.2 Background

Annual, and later, biennial Piru and Fillmore Basins Groundwater Conditions Reports were produced by UWCD to synthesize available up-to-date data for the Basin's AB 3030 Council (Section 1.1.5) and stakeholders. The final two biennial groundwater conditions report in the series (UWCD, 2015 and OFR 2016-01) were prepared for years 2012 to 2013 and 2014 to 2015. These reports are available for download from UWCD's website and earlier reports are available from UWCD upon request. The biennial reports contain basin-specific recent and historical hydrologic information. Note that the DWR 2019 groundwater basin boundary mapping shown on maps in this Tech Memo and those shown in UWCD's historical reports are not the same.

DBS&A has developed this Tech Memo as a companion document to the FPBGSA's Sampling and Analysis Plan (SAP) (FPBGSA, 2020) that was a preceding DBS&A project deliverable. The SGMA focused SAP details monitoring protocols and standard methods for water quality and groundwater level data collection in the Fillmore and Piru basins.

The SAP is referenced throughout this Tech Memo where applicable. SAP components include, but are not necessarily limited to, descriptions of the following:

- Water sample collection procedures
- Analytical methods to be used
- Groundwater level measurement protocol in water wells
- Data quality assurance (QA) and quality control (QC) procedures

1.1.3 Technical or Regulatory Guidelines and Guidance

In cooperation with UWCD, DBS&A has developed this Tech Memo in accordance with the DWR's SGMA inspired technical assistance guidance document series Best Management Practices (BMP). This Tech Memo has been prepared in general accordance with the DWR's BMP #2 - Monitoring Networks and Identification of Data Gaps (DWR, 2016b). Much of the content contained in the DWR's BMP #2 was directly applicable to the development of this Tech Memo and BMP content has been liberally reproduced in this Tech Memo. Additionally, the most recent biennial Groundwater Conditions Report prepared by UWCD for years 2014 and 2015 (UWCD, 2016) was relied upon heavily in preparing Sections 2 and 3 (Historical Datasets and Existing Monitoring Networks, respectively) of this Tech Memo. URL links to complete documents, available online and cited in this Tech Memo, are included in the References Section, where available.

Additional sources of technical guidance considered in preparation of this Tech Memo include, but are not limited to, the following documents:

- BMP #1 - Monitoring Protocols, Standards, and Sites (DWR, 2016a)
- Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 (EPA, 2006)
- Title 23 of the California Code of Regulations (CCR)

This Tech Memo has been prepared to satisfy, in part, criteria contained in 23 CCR Subarticle 4 - Monitoring Networks:

- § 354.32 - Intro to Monitoring Networks
- § 354.34 - Monitoring Networks
- § 354.36 - Representative Monitoring
- § 354.38 - Assessment & Improvement of Monitoring Networks (Data Gaps)
- § 354.40 - Reporting Monitoring Data to the Department (addressed in the SAP)

Monitoring programs are to be reviewed and modified, as necessary, at least every five years as part of the periodic GSP evaluation (5 year updates).

1.1.4 SGMA Sustainability Indicators

Six sustainability indicators are defined in the SGMA legislation. These are potential effects caused by groundwater conditions occurring in a basin that, when significant and unreasonable, are considered undesirable results. The basins' GSPs will describe sustainable management criteria that will serve as metrics for evaluating undesirable results relative to the sustainability indicators. Data must be sufficient to limit uncertainty when used to assess the sustainability indicators (DWR, 2017). The essences of the six indicators are as follow:

- Groundwater Levels
- Groundwater Storage
- Seawater Intrusion
- Water Quality
- Land Subsidence
- Interconnected Surface Water

Land Subsidence and Ecological (i.e., interconnected surface water) monitoring networks and available data are not included in this Monitoring Program Tech Memo. They will be discussed in separate subsequent tech memos. This Tech Memo addresses data collection (e.g., water quality and groundwater levels) indicative of the sustainability of human and environmental beneficial uses of groundwater in the basins. Additional analyses considerations may be necessary to address ecological receptors.

Seawater intrusion is not a directly applicable sustainability indicator of concern in these inland basins and has not historically been monitored in Fillmore and Piru basins. Reported groundwater levels have historically remained above sea level, even during prolonged periods of drought. Water level and water quality monitoring is conducted by UWCD and VCWPD in wells in the down-gradient Santa Clara River Valley-Oxnard subbasin (DWR basin ID: 4-4.02) as part of a seawater intrusion coastal monitoring network. This monitoring program confirms that seawater intrusion is limited to the near-coastal setting and does not threaten other groundwater basins in Ventura County.

1.1.5 Historical and Current Groundwater Management in the Basins

Groundwater management of the Fillmore and Piru basins did not originate with the 2014 SGMA legislation. The Santa Clara Water Conservation District (predecessor agency of UWCD) was formed in 1927, with the mission of conserving and enhancing the water resources of the Santa Clara River through managed aquifer recharge activities. Congruently, the County of Ventura has a history of issuing regulating ordinances for the groundwater resources of the basins within its boundary (e.g., well permits).

California Assembly Bill (AB) 3030 was enacted in 1992, which established in the California Water Code (CWC) sections 10750-10756, a systematic procedure for a local agency to develop a groundwater management plan. Subsequently, in 1995, a Memorandum of Understanding (MOU) was signed among UWCD, the City of Fillmore, water companies and other pumpers with the intent to produce an AB 3030 groundwater management plan (adopted in 1996), which would be a cooperative plan for both basins. The Plan outlined the roles of the various parties for implementing a groundwater management program, including the establishment of a Groundwater Management Council to manage the Plan (UWCD, 2016).

SB 1938 (2002) and AB 359 (2013) required additional elements be included in all AB 3030 management plans, and an updated Draft Piru/Fillmore Basins AB 3030 Groundwater Management Plan (PF GMC, 2013) was submitted to the AB 3030 Groundwater Management

Council in 2011 but was never formally adopted and therefore never finalized. The Draft Plan update included Basin Management Objectives (BMOs) for groundwater quality, surface water quality and groundwater elevation at various locations (UWCD, 2016). The AB 3030 process has since been superseded by the Sustainable Groundwater Management Act.

The Fillmore and Piru Basins Groundwater Sustainability Agency (FPBGSA or Agency), since its formation in 2017, is responsible for management of the basins' groundwater resources. The Agency is a joint powers authority (JPA) comprised of the following three local public agencies: County of Ventura, City of Fillmore, and UWCD (Figure 1-1). The Board consists of six Directors: three Member Directors (i.e., County of Ventura, City of Fillmore and UWCD), two groundwater Pumper Stakeholder Directors (one representing each basin), and an Environmental Stakeholder Director (FPBGSA Bylaws, 2018). The FPBGSA Board of Directors are the GSP preparation principal decision makers and will use data collected through monitoring program activities in their basins management decision making process.

UWCD is authorized under the California Water Code to conduct water resource investigations, acquire water rights, build facilities to store and recharge water, construct wells and pipelines for water deliveries, commence actions involving water rights and water use, and prevent interference with, or diminution of, stream/river flows and their associated natural subterranean supply of water (California Water Code, section 74500 et al.). The County of Ventura exercises water management and land use authority on land overlying the entire county including Fillmore and Piru Basins. The City of Fillmore is a local municipality that exercises water supply, water management, and land use authority within its boundaries.

The Pumper Stakeholder Directors appointed to the FPBGSA Board are currently the president of the Fillmore Pumpers Association and president of the Piru Pumpers Association. An Environmental Stakeholder Director has been appointed to the Board representing a diverse group of environmental stakeholders including several advocacy groups active in the basins.

1.2 Basins Hydrogeologic Conceptual Model

The following is a summary description of the Fillmore and Piru basins hydrogeologic conceptual model (HCM).

1.2.1 Geographic Description

The geographic area covered by this Tech Memo is the DWR Bulletin 118 Fillmore and Piru basins 2019 updated mapping delineated on Figure 1-1. The basins are alluvial groundwater basins located along the Santa Clara River Valley and fully within Ventura County, California. They are connected subbasins, as mentioned above, in a series that comprises the larger groundwater system that drains the Santa Clara River Watershed (UWCD, 2016).

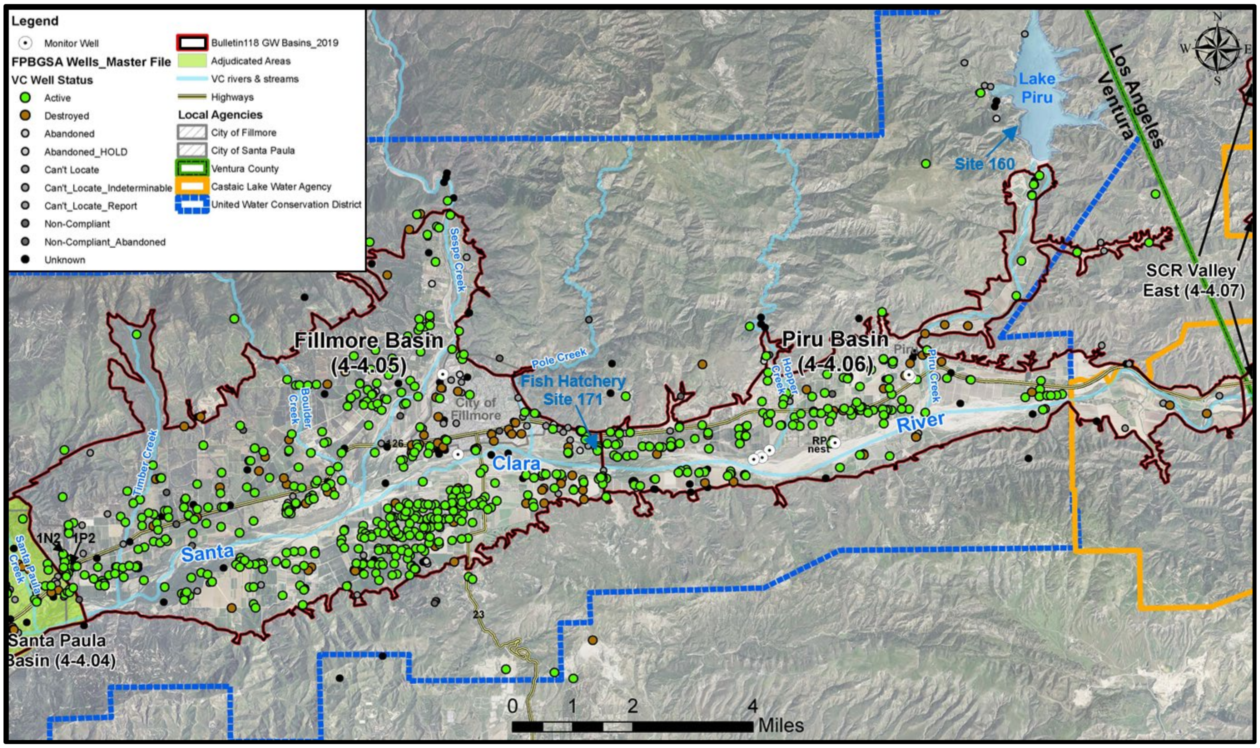


Figure 1-1. Fillmore and Piru basins area map showing FPBGSA's well inventory displayed by Ventura County well status and select monitor wells.

The surface area of the Fillmore and Piru basins are approximately 22,600 acres (35 square miles) and 10,900 acres (17 square miles), respectively. Both basins are also located within UWCD's boundaries, except for the eastern portion of the Piru basin (Figure 1-1). The hydrogeologically connected adjudicated Santa Paula basin (DWR basin ID: 4-4.04) is west (downgradient) of Fillmore basin and Santa Clara River Valley East basin (DWR basin ID: 4-4.07) is east (upgradient) of Piru basin.

The City of Fillmore and town of Piru are municipalities located within these basins but the predominant land use is agricultural (Section 2.4). Other land uses consist of residential, commercial/industrial, and open space (UWCD, 2016).

1.2.1 Physical Setting

Groundwater aquifers in the Fillmore and Piru basins consist of water-bearing unconsolidated alluvium (permeable material) beneath the ground (land) surface from which groundwater can be extracted from a water well. Movement of groundwater through the alluvium is primarily controlled by water level elevation gradients. Figure 1-1 shows wells in basins by status (e.g., active, abandoned, etc.) designation. There are 12.0 active wells per square mile in Fillmore basin and 8.6 active wells per square mile in Piru basin.

Figure 1-2 shows generalized surface geology as mapped by the USGS (as part of their RASA Program work in Ventura County) and includes identified fault traces in the basins. Fillmore and Piru basins mapping generally includes the alluvium of the valley floor and portions of the outcropping Pico and San Pedro Formations near the north margins of the basins. Major faults include the Oak Ridge fault that roughly aligns with the south boundaries of the basins and the San Cayetano fault with traces roughly paralleling portions of the north boundary of both basins.

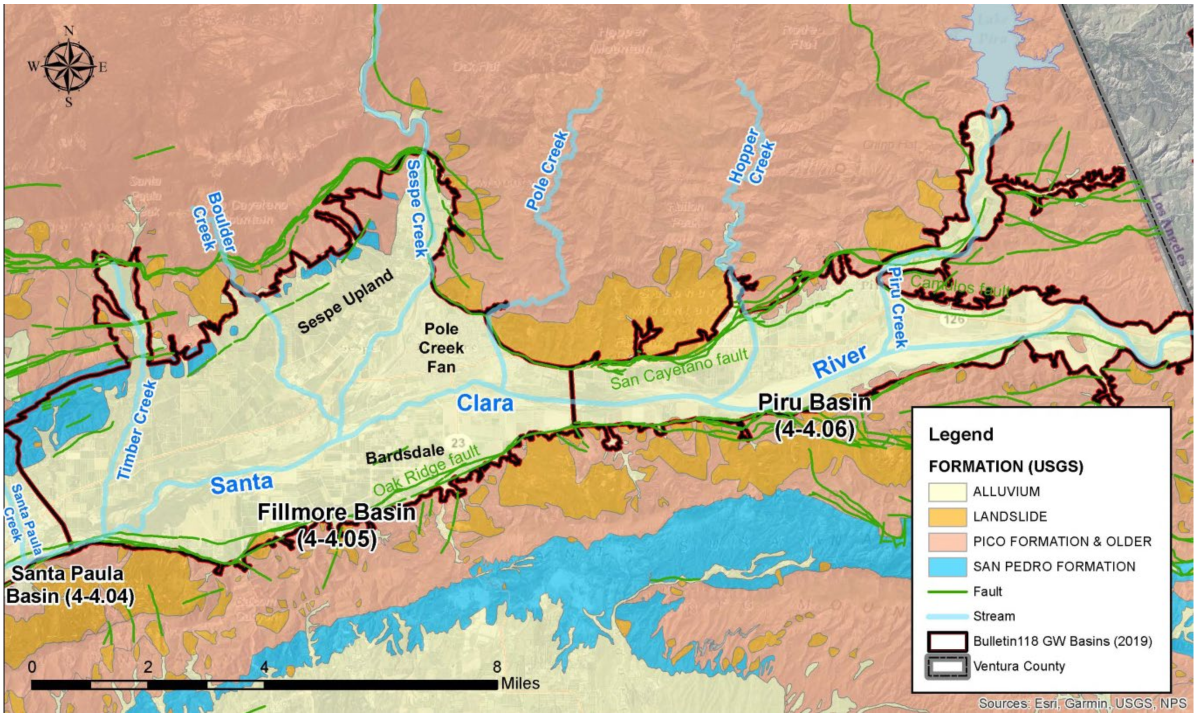


Figure 1-2. Surface geology and fault trace map.

The Fillmore basin is contiguous with Piru basin and the Santa Paula basin (Figure 1-1). The Fillmore basin extends northward to include the Pole Creek fan and the greater floodplain of

Sespe Creek (Figure 1-2), extending approximately 4 miles north of Highway 126. The western boundary of the Fillmore basin is located approximately 0.5 miles west of Willard Road, which is just east of the City of Santa Paula and is distinguished by an area of rising groundwater (a gaining reach of the river) (UWCD, 2016).

Piru basin lies east of Fillmore basin with its eastern boundary extending to approximately 500 feet (0.1 mile) west of the Ventura/Los Angeles County Line. The alluvium of the eastern portion of Piru basin (i.e., the area outside of UWCD's boundary) is at a point where the alluvium is thin and underlain by non-water-bearing rocks. The western boundary of Piru basin is located approximately one mile upstream of the City of Fillmore near the Fillmore Fish Hatchery. The topographic narrows in this vicinity are reported to result in a gaining reach of the Santa Clara River (UWCD, 2016).

Groundwater flux in the Fillmore and Piru basins generally moves east-to-west through the alluvium. Groundwater recharge to Fillmore basin from Sespe Creek in the vicinity of Sespe Upland (Figure 1-2) generally flows towards the southwest (Mann, 1959). Site-specific flow paths in the basins and groundwater gradients are often influenced by localized and/or transient pumping depressions induced by well fields and individual wells pumped at high extraction rates.

1.2.2 Groundwater Recharge

The primary sources of groundwater recharge in the Fillmore and Piru basins are infiltration of Santa Clara River flow and its tributaries. In Fillmore basin, groundwater recharge associated with Sespe Creek flows originating from the Sespe Creek watershed are a major source of recharge (Figures 2-7 and 2-8 in Section 2.2.2.2 show Santa Clara River and Sespe Creek historical surface water flow hydrographs). Most of the low flow and a portion of the high flow surface water provide recharge to the Fillmore basin. Additional sources of recharge include underflow from Piru basin to Fillmore basin and recharge from lower Piru Creek in Piru basin (UWCD, 2016).

In both basins, recharge also takes place from streams overlying San Pedro Formation outcrop to the north, from direct rainfall penetration on San Pedro outcrop and alluvium of the main basin, and from agricultural return flow. UWCD's Piru spreading grounds located just west of Piru Creek have not been used since 2008 due to permitting issues at the facility (the streamflow diversion structure lacks a fish screen) (UWCD, 2016).

UWCD is party to a water conservation agreement between the DWR and the Downstream Water Users (DWUs). The DWUs consist of UWCD, Los Angeles County Waterworks District, Newhall Land and Farming, and Valencia Water District. The program is designed to hold back flood flows in Castaic Lake and release them at a later date (often in the spring) to promote percolation in the basins downstream of the dam, benefiting the DWU's. UWCD often represents the DWUs in coordinating the storage and release of water with DWR, who operates Castaic Lake, and by monitoring the associated release (in-stream flow gaging discussed in Section 2.2.2.1 of this Tech Memo) to ensure that the flows are optimally benefiting the basins. In most years the majority of released water that makes it across the Ventura County line percolates in the Santa Clara River channel within the Piru basin, while some of the surface flow may make it to the Fillmore basin where the remainder percolates (UWCD, 2016).

UWCD's conservation releases from Lake Piru provide groundwater recharge to both the Fillmore and Piru basins often at times when natural runoff in the Santa Clara River watershed is limited. The conservation releases contribute to groundwater underflow that exists between the groundwater basins downstream of Fillmore and Piru basins. Released water that does not percolate into the Fillmore and Piru basins flows downstream to the Santa Paula basin and to the UWCD operated Freeman Diversion. In addition to the conservation releases, UWCD is required to release Lake Piru water continuously to maintain fish habitat in lower Piru Creek, and some of this water serves as recharge to the Piru basin. Piru Mutual Water Company and Rancho Temescal operate diversions on lower Piru Creek that divert a portion of the creek flow for agricultural beneficial uses (UWCD, 2016).

Groundwater levels in both basins benefit from wastewater discharges to the Santa Clara River in Los Angeles County, most notably from the Valencia treatment plant located adjacent to the Santa Clara River near Interstate 5. Dry season perennial surface water flows across the Los Angeles/Ventura County Line and infiltrates as groundwater recharge upstream of the confluence of the Santa Clara River with Piru Creek. Surface water sometimes extends across this "dry gap" (which commonly extends from near the historic Rancho Camulos to around Cavin Road) during the wet season when runoff from storms generates sufficient flow to overcome the significant infiltration capacity of this reach (UWCD, 2016).

1.2.3 UWCD Groundwater Flow Model and HCM

UWCD published the documentation of their Ventura Regional Groundwater Flow Model (VRGWFM) and hydrogeologic conceptual model (HCM) in 2018. The calibration period consisted of the years 1985 through 2015. The model received a favorable review from an external panel that included recognized industry experts (UWCD, 2018) and has largely replaced the use of a Ventura County-wide predecessor model prepared by the USGS (Hanson et al., 2003). The UWCD model has been used in preparation of three GSPs for basins in Ventura County managed by the Fox Canyon Groundwater Management Agency (FCGMA).

The VRGWFM is currently being updated by UWCD to include the remaining groundwater basins within its service area. The HCM has been updated by UWCD as part of these efforts to append the river basins (Santa Paula, Fillmore and Piru basins) to the model. Aquifer zones that were delineated from this updated HCM are described in the following Section.

UWCD’s updated numerical groundwater flow model and HCM documentation will be included as an appendix of the FPBGSA’s GSPs. The calibrated model will be used to better understand groundwater flow and surface water interactions in the basins. The FPBGSA’s GSPs preparation are expected to benefit from using the model to quantify water budgets for historical, current and future conditions, as well as forecasting how potential future climate change and potential management actions will affect the progress towards sustainability.

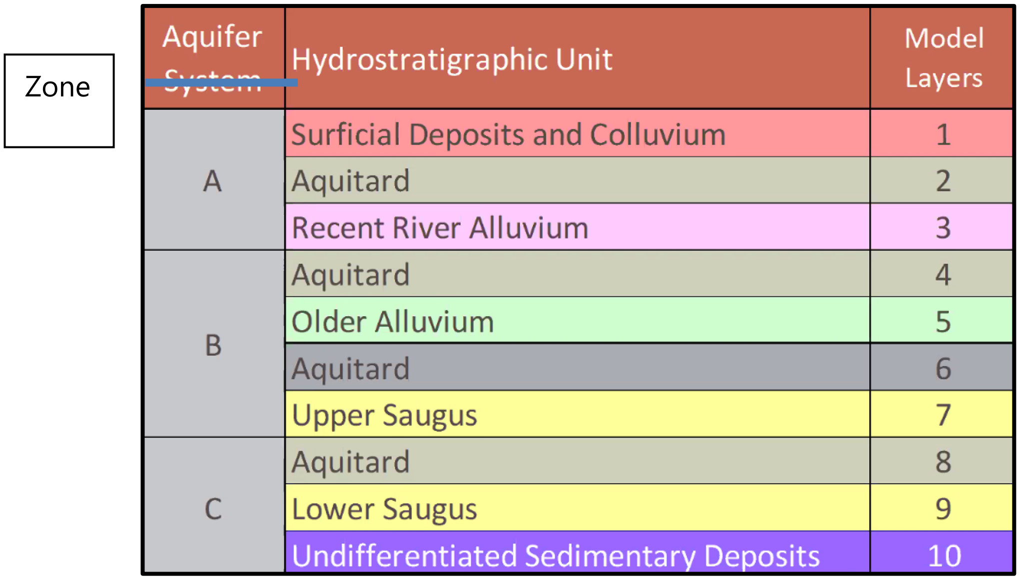
The flow model was calibrated to observed water levels in wells, and the historical surface water flow rates in the basins. The next anticipated steps in UWCD’s model development process include, but are not necessarily limited to, the following:

- Validation period analysis for years 2016 through 2019
- Sensitivity analysis
- Publication of model documentation (which will be included as an appendix to the GSPs)

1.2.4 Aquifer Zones

UWCD’s published VRGWFM layering includes 15 layers (UWCD, 2018). However, the deepest of these are not mapped in the Fillmore and Piru basins. The 10 model layers (Table 1-1) included in UWCD’s HCM of the Fillmore and Piru basins have been combined to delineate three aquifer zones (i.e., water-bearing units) for the purpose of data analysis in this Tech Memo. UWCD’s model layering (draft July 2020) and proposed aquifer zones are shown in Table 1-1.

Table 1-1. UWCD Groundwater Flow Model Layering, Hydrostratigraphic Units and Aquifer ZoneDesignation in the Fillmore and Piru Basins



Aquifer ~~System~~ Zone	Hydrostratigraphic Unit	Model Layers
A	Surficial Deposits and Colluvium	1
	Aquitard	2
	Recent River Alluvium	3
B	Aquitard	4
	Older Alluvium	5
	Aquitard	6
	Upper Saugus	7
C	Aquitard	8
	Lower Saugus	9
	Undifferentiated Sedimentary Deposits	10

Source: Reproduced from UWCD presentation on 6/18/2020)

Figure 1-3 shows wells contained in FPBGSA's well inventory (see Section 2.1.1) categorized by the draft aquifer zone designation. These are all historical and currently active wells included in the well inventory file (see Section 2.1.1). Active wells included in existing monitoring networks in the Fillmore and Piru basins are described with respect to aquifer zones for groundwater quality data collection in Section 5.3 and water level in Section 5.4.

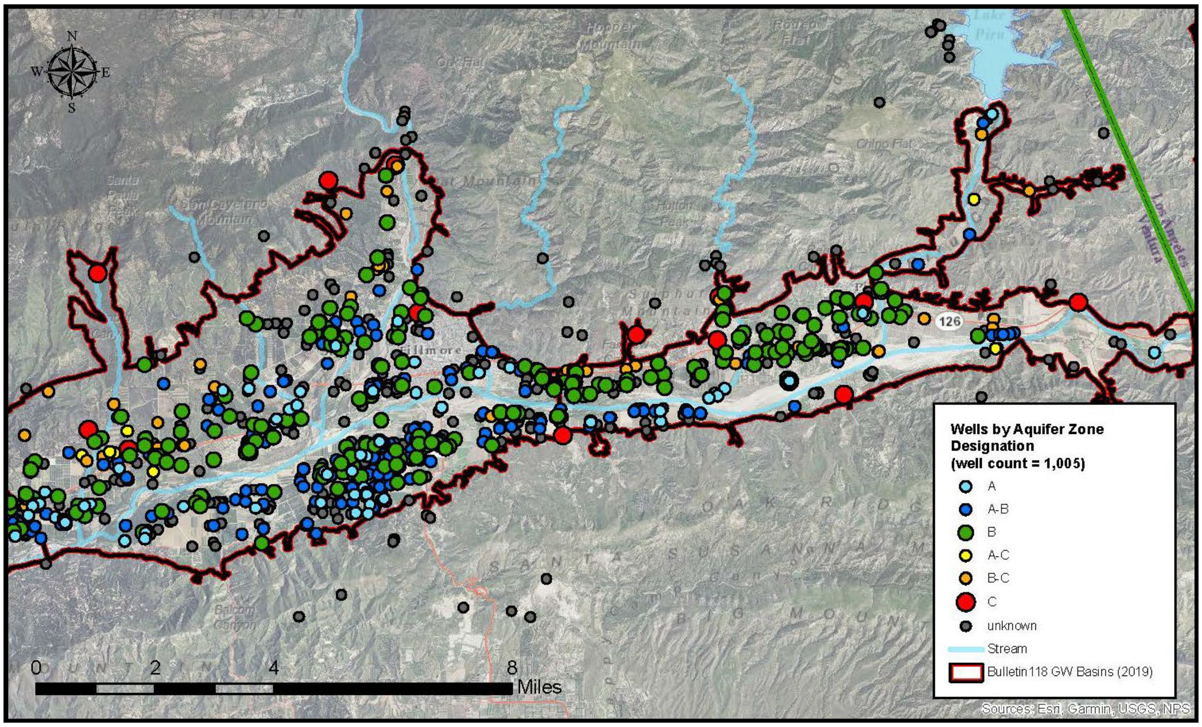


Figure 1-3. FPBGSA water well inventory (active and historical) by Aquifer Zone Designation from UWCD VRGWFM update layering (July 2020).

From Figure 1-3, many wells are screened across multiple mapped aquifer zones. Observed water level measurements from these wells are aggregate piezometric heads from different zones and can obscure interpretation of these data. As an example, two nearby wells may have top of screen intervals of similar depth within the upper aquifer zone; however, the bottom of screen intervals of one well may be much deeper than the other and completed with screened interval across multiple aquifer zones. Cross-connection between aquifer zones could produce similar observed groundwater levels in the two wells.

Wells shown as light blue circles are completed solely within Zone A (shallowest mapped zone). They are few in number and are generally near the Santa Clara River channel or prominent tributaries where groundwater levels are nearest the ground surface in the basins. See Section 5.5.3 for a summary of the wells accessing groundwater from the various aquifer zones in 2018 for each of the basins.

Most of the wells screened in a discrete aquifer zone were completed in Zone B (represented as dark green circles on the map). Few productions wells in the basins were constructed with screened intervals extending down into Zone C (represented as yellow, orange, or red circles on the map). Wells shown as dark grey circles on Figure 1-3 are either of unknown screened interval or located outside a DWR mapped basin.

The Fillmore and Piru basins have historically been considered to be unconfined groundwater systems (Mann, 1959), but recent hydrostratigraphic cross-sections of the basins prepared for the development of the HCM shows a greater level of confinement (especially in the west portion of Fillmore basin) than has been historically understood (UWCD, presentation during the FPBGSA 9/27/2019 monthly meeting). Vertical head gradients from available groundwater data from wells in the basins are discussed in the following Section.

Principal aquifers as defined under SGMA require GSP aquifer-specific evaluation (DWR, 2016b). The evaluation included in this Tech Memo includes identification of “aquifer zones” that may or may not constitute principal aquifers requiring individual evaluation. The evaluations by aquifer zone presented in this Tech Memo serve to provide the FPBGSA board of directors with the best available information for GSP preparation and to inform their decision on designating primary aquifers in the basins.

1.2.5 Vertical Head Gradients

In order to assess groundwater vertical gradients within and between the groundwater aquifers of the Fillmore and Piru basins, water level information is needed from wells open (“screened”) discretely within a single aquifer zone (often bracketed vertically by clay layers). For unconfined aquifers, a water-table is the upper boundary of the aquifer zone. The upper water surface (water-table) is at atmospheric pressure, and is therefore able to rise and fall within the upper and lower bounds of an aquifer. In the case of confined aquifers, the aquifer is fully saturated and bounded by layers of fine grained impermeable material (e.g., clay and silt) above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water level (potentiometric surface) will rise above the top of the aquifer.

Static water levels for some wells in the Fillmore and Piru basins (especially in the western portion of Fillmore basin) are above their perforated intervals and higher than clay layers (identified from well completion reports) that may serve as confining beds. These observations suggest that there is some level of aquifer confinement (or semi-confinement) in portions of the basins.

The USGS installed the RP1 multiple-well (nested) groundwater monitoring facility in Piru basin (labeled “RP nest” in Figure 1-1) in 1994 as part of their Regional Aquifer-System Analysis (RASA) Program. There are no nested groundwater monitoring well facilities in Fillmore basin. The RP1 facility includes five 2-inch piezometers installed in a single borehole, each completed within discrete (i.e., 20 feet long) depth intervals open to a particular aquifer zone with annular seals installed above each screened interval. The annular seals are emplaced to hydraulically isolate each screened interval from cross-communication within the borehole and gravel pack envelope. Densmore, 1996 includes all of the monitor wells the USGS installed in the late 1980 and early 1990s in Ventura County.

Figure 1-4 is a groundwater hydrograph that shows water level observations as depth below ground surface for each of the five piezometers included in the RP1 nest. The discrete screened intervals for each piezometer are shown in the legend of the figure along with the corresponding aquifer zone designation from UWCD's model layering. Groundwater levels from each of the upper four piezometers completed in aquifer zones A and B (aggregate screened interval of 50 to 330 feet bgs) track roughly together (approximately within a foot of each other). The deepest piezometer completed in aquifer zone C (screened 590 to 610 feet bgs) shows observed water levels commonly 3 to 6 feet deeper. This suggests that this lower zone is somewhat isolated from the zones above in this portion of Piru basin and exhibits a downward vertical gradient.

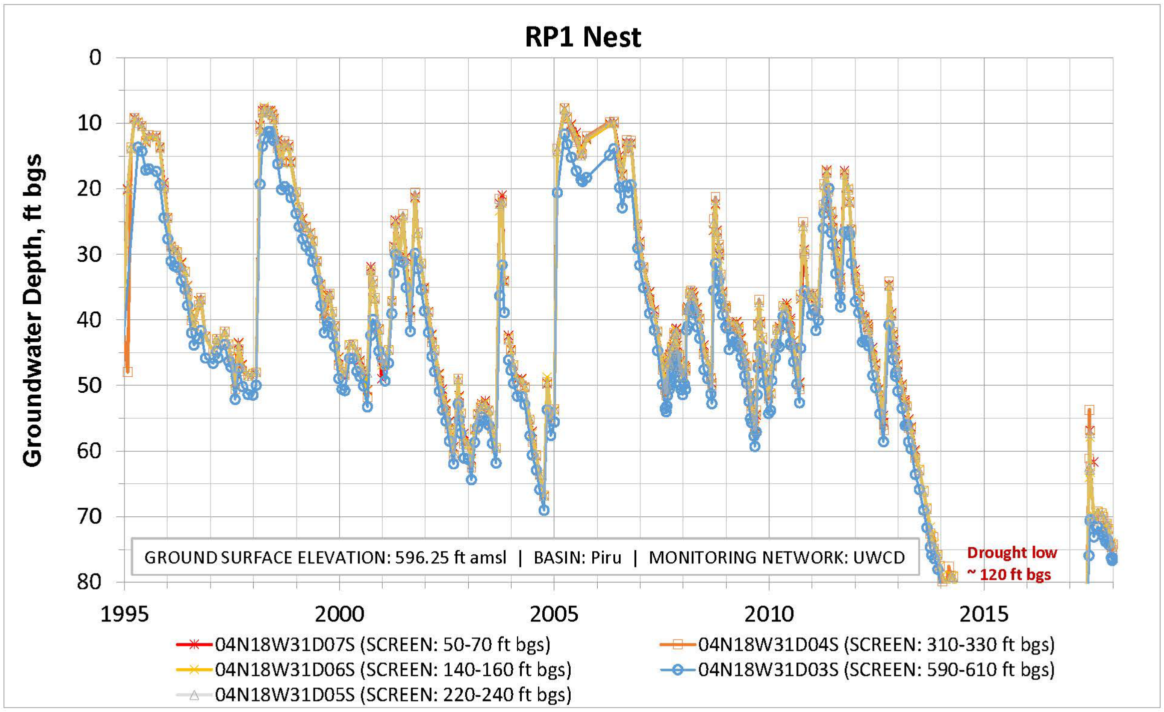


Figure 1-4. RP1 nested monitoring site hydrograph showing depth to groundwater measurements below ground surface.

Figure 1-5 shows the geophysical logs, generalized lithologic descriptions and multiple-well construction diagram modified from Figure 25 of the USGS report. A more detailed lithologic log is included in Table 24 of the USGS report. Minimal fine grained material (e.g., clay layers) are apparent from the geophysical logs. However, the detailed lithologic log does note "some clay" from 80 to 100 feet bgs (Densmore, 1996).

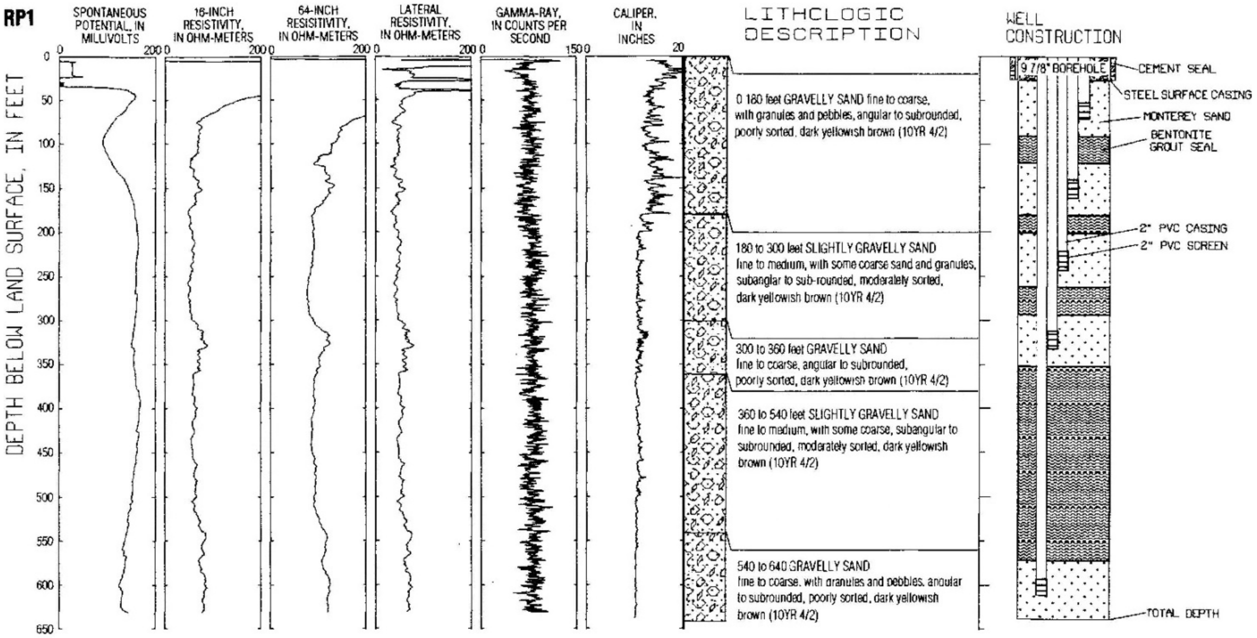


Figure 1-5. Geophysical logs, stratigraphic column and well-construction diagram for multiple-well monitoring site RP1. Modified from Figure 25 (Densmore, 1996).

The trend analysis (see Table 4-4 and Section 4.1.2) included in this Tech Memo includes evaluation of water quality patterns in each of the RP1 nested piezometers for the five primary chemicals of concern in the basins. Water quality short-term trends identified for each of the completions were not identical for any of the piezometers. Observed differences in water quality suggest that aquifer zones may exist in the basins even if groundwater level vertical gradients and distinct clay (confining) layers are not readily apparent (especially in the four upper completions) in the RP1 nested site in Piru basin.

Data are sparse for evaluating vertical gradients and the degree of confinement (if any) in the basins. A review of available water level records from adjacent well pairs (i.e., clusters) screened in different zones was performed. Few well pairs within approximately half a mile of each other, screened in different discrete aquifer zones with sufficient water level records, were identified.

However, water levels in paired wells in the Sespe Upland area (Fillmore basin north of SCR) and near the Fillmore/Piru basins boundary indicate potential semi-confined conditions in deeper screened wells. It is anticipated that UWCD's groundwater flow model will assist in further evaluating vertical head gradients and the appropriateness of the three draft aquifer zone designations presented in this Tech Memo.

Paired wells 03N21W01P02S (1P2 screened 75-104 feet bgs) and 03N21W01N02S (1N2 screened 200-400 feet bgs) near the Santa Paula-Fillmore basins boundary show 1N2 maximum water level elevations higher than in 1P2 (Figure 1-1 for location). Water level fluctuation in 1N2 are also more dynamic (i.e., greater in magnitude) which is indicative of confined/semi-confined aquifer conditions. Groundwater level hydrographs for these wells are included in Appendix A and are also included on figures in Section 4.2.1 displaying depth to water for wet, dry, and average groundwater level representative years

Additional evidence of the presence of upward vertical head gradients near the Santa Paula/Fillmore basin boundary include the presence of rising groundwater and flowing artesian wells (e.g., 03N21W12H01S and 03N21W12F02S) when water levels are high in the basins. Ancillary evidence includes elevated manganese in groundwater in wells near the basin boundary (see Figure 4-12 in Section 4.1.3.4).

1.3 Data Quality Objectives

The quality of the available data evaluated in this Tech Memo was assessed with respect to sufficiency for use in GSP preparation. FPBGSA policy makers must have a satisfactory level of confidence in the quality of the data in which they rely to inform their decisions. Two primary data quality attributes are quantity (e.g., spatial and temporal coverage) and accuracy (see FPBGSA SAP). Tech Memo evaluations are performed to assure that the basins-specific Data Quality Objectives (DQOs) are met, and that the analysis level of confidences is known and documented.

1.3.1 U.S. EPA Data Quality Objective Process

The following excerpt is from DWR's BMP #2 (DWR, 2016b):

> The GSP Regulations require GSAs to develop a monitoring network. The monitoring network must be capable of capturing data on a sufficient temporal frequency and spatial distribution to demonstrate short-term, seasonal, and long-term trends in basin conditions for each of the sustainability indicators, and provide enough information to evaluate GSP implementation. A

> monitoring network should be developed in such a way that it demonstrates progress toward achieving measurable objectives.
>
> As described in the Monitoring Protocols, Standards, and Sites BMP, it is suggested that each GSP incorporate the Data Quality Objective (DQO) process following the U.S. EPA Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA, 2006). Although strict adherence to this method is not required, it does provide a robust approach to consider and assures that data is collected with a specific purpose in mind, and efforts for monitoring are as efficient as possible to achieve the objectives of the GSP and compliance with the GSP Regulations.

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (U.S. EPA, 2006). The DQOs clarify the monitoring program objectives, define the most appropriate types of data and conditions under which to collect the data, and specify acceptance criteria that will be used to evaluate whether the quantity and quality of data collected are sufficient to support decision making. The DQOs are used to develop a scientific and resource-effective design for data collection.

1.3.2 Basins-Specific Data Quality Objectives

The seven steps of the DQO process for this Tech Memo are presented in Table 1-2.

Table 1-2. Data Quality Objectives.

Step 1: State the Problem - define sustainability indicators and planning considerations of the GSP and sustainability goal
Historical datasets and existing monitor sites included in active monitoring networks (e.g., water quality and groundwater level data collection) are administered by independent entities that are not necessarily directly regulated by the FPBGSA and were designed and developed prior to SGMA with their entity specific purposes and goals. Data must be sufficient to limit uncertainty when used to assess the sustainability indicators.
Step 2: Identify the Goal(s) - describe the quantitative measurable objectives (MOs) and minimum thresholds (MTs) for each of the sustainability indicators
Develop a FPBGSA monitoring program, relying heavily on existing monitoring networks to the extent practicable, that is capable of providing sustainability indicator data of sufficient accuracy and quantity to demonstrate that the basins are being sustainably managed. MOs and MTs will be developed by the FPBGSA board of directors as part of the basins' GSPs sustainable management criteria.
Step 3: Identify the Inputs - describe the data necessary to evaluate the sustainability indicators and other GSP requirements (i.e., water budget)
Water budget components that are described in this Tech Memo include, but are not necessarily limited to, the following:

- Groundwater extraction (production);
- Surface water streamflow; and
- Meteorological (precipitation and evaporation).

Additional data necessary to evaluate the sustainability indicators described in this Tech Memo include, but are not necessarily limited to, the following:

- Water quality;
- Groundwater level; and
- Land use.

Step 4: Define the Boundaries of the Study - This is commonly the extent of the Bulletin 118 groundwater basin or subbasin, unless multiple GSPs are prepared for a given basin. In that case, evaluation of the coordination plan and specifically how the monitoring will be comparable and meet the sustainability goals for the entire basin should be described

- The horizontal study boundaries are defined as the boundaries of the Fillmore (4-4.05) and Piru (4-4.06) subbasins.
- The vertical boundaries are defined as the base of groundwater below ground surface that is of a quality and quantity that it can be beneficially used.
- There is no foreseeable temporal boundary as up-to-date water quality and water level data will continue to be necessary through GSP implementation and into the future to ensure sustainability in the basins is maintained once achieved.

Step 5: Develop an Analytical Approach - Determine how the quantitative sustainability indicators will be evaluated (i.e., are special analytical methods required that have specific data needs)

- Groundwater quality sample analytical results will be compared to the FPBGSA approved sustainable management criteria protective of water quality in the basins.
- Groundwater levels will be compared to the FPBGSA approved sustainable management criteria protective of groundwater levels in the basins and any sustainability indicators in which water level is established as a viable proxy in the basins' GSPs.

Step 6: Specify Performance or Acceptance Criteria - Determine what quality the data must have to achieve the objective and provide some assurance that the analysis is accurate and reliable

Analytical and Methodological Data Quality Objectives are described in FPBGSA's SAP (FPBGSA, 2020). The Data Gap Analysis component (Section 5) in this Tech Memo evaluates historical datasets and active monitoring sites included in current monitoring networks active in the basins. Spatial and temporal data gaps are considered in this evaluation and recommendations are presented on how refinement and expansion of the existing monitoring programs might minimize or eliminate data gaps, especially in critical areas.

Step 7: Develop a Plan for Obtaining Data - Once the objectives are known determine how these data should be collected. Existing data sources should be used to the greatest extent possible

It is not the purpose of this Tech Memo to establish specific monitoring points but it is recognized that optimization and/or expansion of current monitoring programs may be necessary as many existing groundwater monitoring points utilize privately owned agricultural wells or municipal wells potentially screened across multiple water-bearing units.

1.4 Representative Monitoring Points

Representative monitoring points (RMPs) are, as defined by the DWR in BMP #2, a subset of the complete monitoring network within a basin. RMPs "can be used to consolidate reporting of quantitative observations of the sustainability indicators . . . Agencies can adopt a single network of RMPs or have a unique set of RMPs for each sustainability indicator" (DWR, 2016b).

The following excerpt is from DWR's BMP #2 (DWR, 2016b):

> If RMPs are used to represent groundwater elevations from a number of surrounding monitoring wells, the GSP should demonstrate that each RMP's historical measured groundwater elevations, groundwater elevation trends, and seasonal fluctuations are similar to the historical measurements in the surrounding monitoring wells. If RMPs are used to represent groundwater quality from a number of surrounding monitoring wells, the GSP should demonstrate that each RMP's historical measured groundwater quality and groundwater quality trends are similar to historical measurements in the surrounding monitoring wells.
>
> The use of groundwater levels as a proxy may be utilized where clear correlation can be made for each sustainability indicator. The use of the proxy can facilitate the illustration of where minimum thresholds and measureable objectives occur. A series of RMPs or a single RMP may be adequate to characterize a management area or basin. Use of the RMP should include identification and description of possible interference with the monitoring objective.

There are established monitoring points in the Fillmore and Piru basins included in existing monitoring networks administered by UWCD and VCWPD that have historically served as local indicators of the "health" (i.e., groundwater conditions) of the basins. Many of these monitoring sites (Figure 1-6) have the most comprehensive available long-term and high-frequency record sets due to their historical reporting significance. These wells may serve as a viable starting point for identifying RMPs for the basins' GSPs and were included in trend analysis in Section 4 of this Tech Memo. Further analysis than is contained in this Tech Memo and FPBGSA Board of Director policy decisions are needed to establish RMPs that will have sustainable management criteria site-specific MO and MTs protective of the sustainability indicators in the basins.

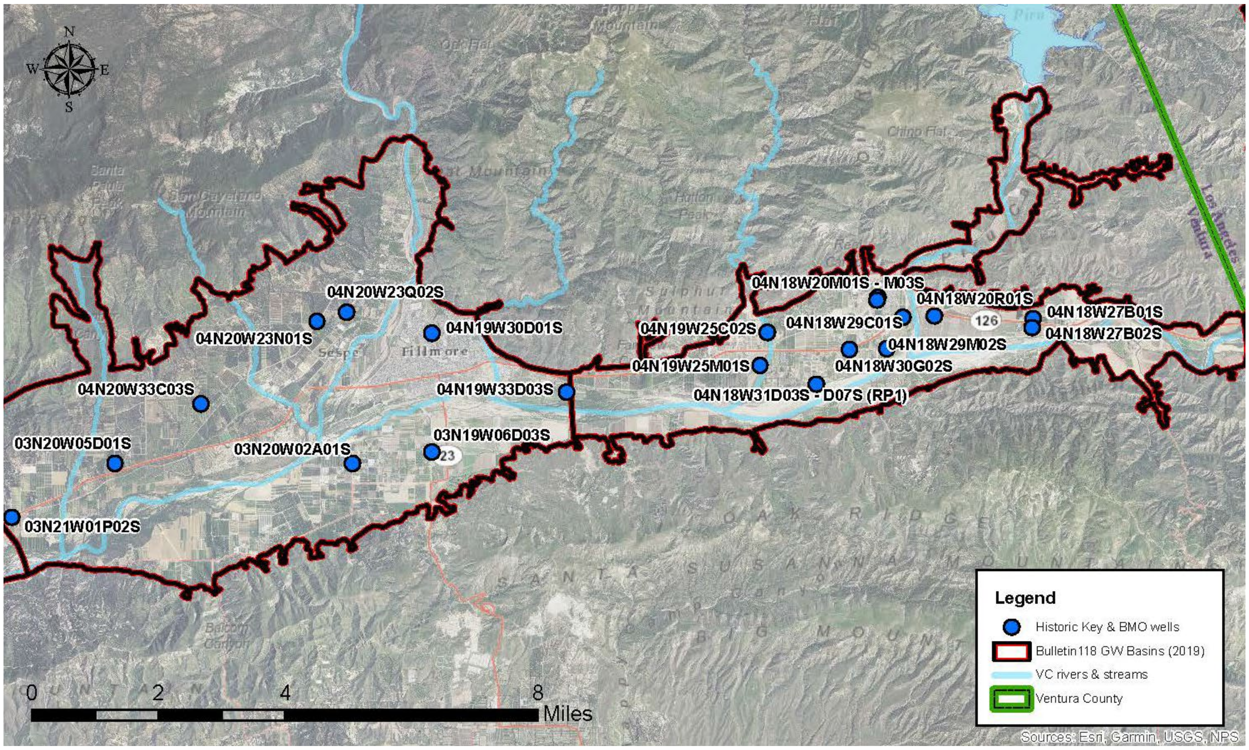


Figure 1-6. Historically reported Key and BMO wells in the Fillmore and Piru basins.

Table 1-3 lists the locally reported groundwater level indicator wells and Table 1-4 lists the groundwater quality indicator wells with their historical period of record.

Table 1-3. Locally reported groundwater level BMO, Key and select wells by published report and entity.

Monitored Well	DWR Basin	AB 3030 Draft Plan	UWCD Monthly Report	VCWPD Annual Report	Water Level Period of Record
03N20W02A01S	Fillmore	WL BMO	WL Key		1950 - present
03N20W05D01S	Fillmore			WL Key	1972 - present
03N21W01P02S	Fillmore	WL			1972 - present
04N18W27B02S	Piru	WL			1932 - present
04N18W29M02S	Piru	WL BMO	WL Key		1968 - present
04N18W30G02S	Piru		WL Historic		1927 - 1971
04N19W25C02S	Piru			WL Key	1972 - present
04N19W25M01S	Piru	WL BMO	WL Key		1979 - present
04N19W30D01S	Fillmore	WL & WQ			1972 - present
04N19W33D03S	Fillmore	WL			1972 - present
04N20W23N01S	Fillmore		WL Key		2015 - present
04N20W23Q02S	Fillmore	WL BMO	WL Historic		1978 - present
04N20W33C03S	Fillmore	WL & WQ			1972 - present

Table 1-4. AB 3030 Draft Plan historically reported groundwater quality BMO wells.

Monitored Well	Basin	AB 3030 Draft Plan	Water Quality Period of Record
04N19W30D01S	Fillmore	WL & WQ	1953, 1961-62, 1981 - present
04N20W33C03S	Fillmore	WL & WQ	1965, 1976 - present
03N19W06D03S	Fillmore	WQ	1962-63, 1968 - present
04N18W20M01S, M02S, M03S	Piru	WQ	1951-56, 1961 - present
04N18W29C01S	Piru	WQ	1971-77, 1990, 2004 - present
04N18W20R01S	Piru	WQ	1998 - present
04N18W27B01S	Piru	WQ	1951-1988, 1999 - present
04N18W31D03S, D04S, D05S, D06S, D07S	Piru	WQ	1994 - present

Historically established groundwater level monitoring points identified in the Draft AB 3030 Groundwater Management Plan update are listed in Table 1-3. These monitoring points have well site-specific groundwater level Basin Management Objectives (BMOs) for two sites each in the Fillmore and Piru basins. The table also identifies additional wells that have historically been reported in the Piru and Fillmore Basins Groundwater Conditions Reports but do not have established BMOs.

UWCD reports the groundwater level elevations for the AB 3030 wells (labeled as Key wells in Table 1-3) in their Hydrologic Conditions Report that is updated and published monthly. One of BMO wells, 04N20W23Q02S, has been subsequently replaced by UWCD in their monthly reporting with well 04N20W23N01S due to site access issues. 23Q02S continues to be monitored by VCWPD as part of their quarterly groundwater level measurement network described later in this Tech Memo in Section 3.3.

VCWPD reports the groundwater level elevations on a “Key” well for each basin within its Agency’s boundary. These are well 03N20W05D01S (located approximately 1.6 miles southwest of AB 3030 reported well 04N20W33C03S) in Fillmore basin and 04N19W25C02S (located approximately 0.5 miles north of AB 3030 BMO well 04N19W25M01S) in Piru basin. VCWPD identifies and reports a running five year trend for each of these wells. A groundwater quality trend is also reported for the wells that VCWPD samples annually in the fall (see Section 4.1.2).

Table 1-4 includes the list of the historically established BMO groundwater quality monitoring points identified in the Draft AB 3030 Groundwater Management Plan update. These monitoring points (Figure 1-6) have well site-specific groundwater level Basin Management Objectives (BMOs) for three sites in Fillmore basin and five sites in Piru basin. In addition to these well monitoring sites, surface water site-specific BMOs are also identified in the Draft AB 3030 Groundwater Management Plan update. Although the AB 3030 thresholds identified in the Draft Plan may not be directly applicable to sustainable groundwater management under SGMA, these thresholds are discussed later in this Tech Memo in Section 4 (Trend Analysis) to give historical context to the analysis.

2. Historical Datasets Available for GSP Preparation

This section describes historical datasets and Section 3 discusses existing monitoring networks in the basins that will serve as ongoing sources of data collection in the Fillmore and Piru basins that will add to the historical datasets and provide additional data for analysis that will inform GSP annual reporting and 5-year updates.

An initial data transfer was received from UWCD for use in preparation of the Fillmore and Piru basins' GSPs in mid-February 2019. These datasets include available groundwater level, production and water quality data for the Fillmore and Piru basins and adjacent areas (e.g., eastern Santa Paula basin). Subsequent data requests of UWCD and VCWPD updated the datasets to include available records through the end of calendar year 2018. Ventura County Waterworks District No. 16 (VCWWD#16) also contributed groundwater quality and level data from four monitoring wells surrounding the unincorporated town of Piru's Waste Water Treatment Plant effluent percolation ponds. These assimilated local agency datasets and publicly available (for download) surface water data (i.e., streamflow gaging, precipitation and evaporation) are detailed below.

Nearly all available groundwater level and water quality records contained in the available datasets are associated with a water well included in the FPBGSA well file inventory (described in Section 2.1.1) or surface water monitoring site inventory. Records that are from a site of unknown location were excluded from the FPBGSA's database. Section 5.1 expands on this potential data gap. Additional information is available in FPBGSA's Sampling and Analysis Plan on how the agency intends to QA/QC data collected in the future for use in assessing sustainability in the context of the six Sustainability Indicators (FPBGSA, 2020).

The Agency has developed an online database platform to provide the public access to data used in preparation of the Fillmore and Piru basins GSPs. The publicly accessible database includes basic querying and graphing (i.e., water level hydrographs and water quality time-series data charting) tools for public use. The database is intended to be the repository for the FPBGSA's data into the future and is anticipated to be updated periodically as additional data are collected and become available for import.

2.1 Groundwater

Available groundwater data (i.e., quality and water level) for GSP preparation in the Fillmore and Piru basins has historically been collected by several organizations. Historical and current sources (monitoring entities) of these data are described in Section 3 of this Tech Memo including the primary existing monitoring networks in the basins administered by UWCD and VCWPD. These Agencies supplement their individual data collection efforts by sharing data between their individual entities and gathering data from other sources where available for inclusion in their respective databases.

Figure 2-1 shows all active and historical wells that have available measured groundwater level and water quality data.

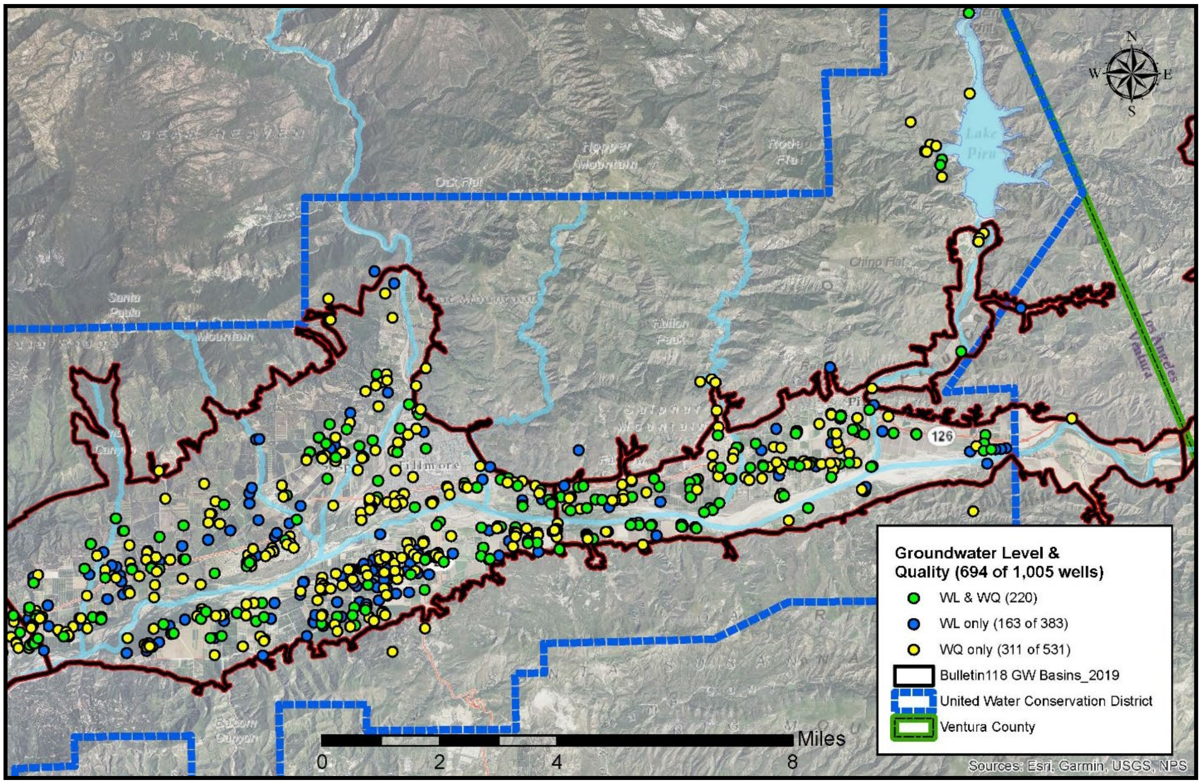


Figure 2-1. All known water wells (active and historical) by data type association.

Of the 1,005 wells in FPBGSA's well inventory as of June 2020, 694 of these have at least one water level or one water quality record associated with a well in FPBGS's well inventory file (Figure 2-1), and 220 of these have at least one water level and one water quality record associated with the same well.

2.1.1 Well Inventory

Separate water well inventory files (in GIS shapefile format) available for use in the basins are maintained by UWCD and VCWPD for their own uses. Information is shared between the entities but the well files are maintained independently. Each file includes active and inactive wells, a number of which have been abandoned or destroyed and no longer exist. These well inventory files contain, but are not necessarily limited to, the following attribute table fields:

- DWR State Well Number (SWN);
- Well Construction (attribute table field include the following):
  - well screen interval
  - seal depth
  - borehole depth
  - borehole diameter
  - casing installation depth
  - casing diameter
- Year constructed;
- Status from VCWPD well inventory file (general categories include the following):
  - active
  - destroyed
  - abandoned
  - can't locate
  - non-compliant
  - unknown
- Main Use (types include):
  - agricultural production
  - cathodic protection

  - domestic production
  - exploratory boring
  - groundwater monitor (observation) well
  - municipal or industrial
  - unknown
- Well Permit number
- APN
- Notes (miscellaneous)

The primary type of wells included in UWCD and VCWPD's well inventories are water wells (subject to the DWR well construction standards). However, UWCD maintains a separate database of borehole electrical logs. Electrical resistivity logs from oil well exploration available from the Geologic Energy Management Division (CalGEM), formerly the Division of Oil, Gas, and Geothermal Resources (DOGGR); and from water wells in the basins have been used in updating the HCM.

With the exception of the "Status" and "Notes" fields, well inventory attribute table fields are typically populated from available DWR Well Completion Reports (WCR) that are required well drilling contractor submittals following construction completion of a new water well. The DWR requires a WCR be submitted for newly constructed wells or if work is completed on an existing well that modifies (alters) its original construction (e.g., deepened or lined) or is destroyed (CWC Section 13751). Both UWCD and VCWPD actively update their well inventory files to include information available from these forms and other sources where available. Historically, WCRs were considered proprietary information and were not publicly accessible. Under CWC Section 13752, information contained in WCRs is available to the public with the exception of well owner details which are redacted from publicly accessible copies of these forms.

VCWPD maintains an archive of DWR WCRs for wells located within Ventura County and acts as an agent of the DWR in inventorying, tracking and receiving final WCRs from well drilling contractors who operate in the County. All WCRs available for wells in and near the Fillmore and Piru basins were requested and received from the County. In total, WCRs for 664 wells were received.

Both of the well inventory files maintained by UWCD and VCWPD were requested and received by DBS&A for GSP preparation purposes. The files received contain Fillmore and Piru basins and adjacent areas wells and are a subset of the Agencies' complete files. UWCD's well file was used as the primary well inventory source and VCWPD's well inventory file was used to supplement incomplete UWCD well inventory records where possible. This included incorporating VCWPD's well inventory "Status" and "Main Use" fields for all wells in the file, and assimilating 49 wells that were not included in UWCD's well file into FPBGSA's well inventory shapefile. UWCD's well inventory file contained 57 wells that were not in VCWPD's well inventory file. DBS&A was in communication with UWCD and VCWPD staff during this process.

In total, 1,005 wells (active, abandoned and destroyed) are currently included in FPBGSA's well inventory shapefile (Figure 1-1). Of these wells, 625 are located within Fillmore basin (of which 421 are identified as active in VCWPD's well status) and 234 are within Piru basin (147 are active). There are a few wells contained in FPBGSA's well inventory that are currently identified as unknown status since cathodic protection and monitor wells were not included in VCWPD's well inventory file transfer although these data exist (these data should be included in a future follow-up update). The remaining wells in FPBGSA's well inventory file are located in Santa Paula basin or outside a DWR mapped groundwater basin. All wells included in the well inventory file are within Ventura County. It is anticipated that the Agency's well inventory file will be updated and maintained through future data requests of UWCD and VCWPD.

2.1.2 Quality

Groundwater quality data are available for over half of the wells contained in the FPBGSA inventory well file (i.e., 531 of 1,005 wells). Of these, 129 wells have only one associated water quality sample. In total, there are over 7,200 groundwater quality records in FPBGSA's database with a date range of 1923 through 2018 (median year sampled of 1993). These data are archived in FPBGSA's database.

Time-series graphs for all wells that contain at least one total dissolved solids (TDS), sulfate (SO_4), chloride (Cl), nitrate (NO_3), or boron (B) record are included in the Appendix D. A trend analysis of these chemicals (analytes) is included in Section 4.1 of this Tech Memo for wells in Fillmore or Piru basins that contain sufficient data (i.e., at least six data points) to perform the analysis.

Records that did not contain a site identifier (typically DWR SWN) for a well contained in UWCD's or VCWPD's well inventory files were excluded from FPBGSA's dataset for GSP preparation. Two groundwater quality records did not contain a sample date so these were also excluded.

In Fillmore basin, 316 wells have at least one historical water quality sample record with an average number of records of 10 per well (the median is 4 records per well). The maximum number of records associated with a well in Fillmore basin is 68 (well 03N21W12H01S). This well is included in UWCD's water quality monitoring network (see Section 3.1).

In Piru basin, 146 wells have at least one historical water quality sample record and of these, the average number of records per well is 13 and the median is 7. The maximum number of records associated with a well in Piru basin is 103 for well 04N18W27B01S which is included in UWCD's water quality monitoring network. The second most is 68 water quality records for well 04N18W20M01S which is a public-supply well (Warring Water) that is not included in either UWCD or VCWPD's respective water quality monitoring networks. Water quality records for this well and other potable supply wells are obtained annually from the State Water Resource Control Board (SWRCB) Division of Drinking Water (formerly under the California Department of Public Health) by UWCD and processed for inclusion in their water quality database.

2.1.3 Level

There are over 35,500 water level records in FPBGSA's database with a date range of 1906 through September 2019 (median year measured of 1997). These data are archived in FPBGSA's database.

The groundwater level data assembled in FPBGSA's database for GSP preparation are static water level measurements. Pumping depressed water level measurements, although useful for groundwater analytical purposes, are not included in the database. However, pumping water level measurements are sporadically entered in the "Notes" field in the database that contains miscellaneous germane information. Questionable measurement qualifiers (e.g., pumped recently) are used to flag records in the database that may not represent static groundwater level conditions. Additional information on qualifying groundwater level data is presented in FPBGSA's Sampling and Analysis Plan (FPBGSA, 2020).

There is a greater number of recent (i.e., 1990s through 2019) water level measurement records compared to the earlier period of record (i.e., 1920s through 1980s). This is not surprising when considering anthropological factors such as population increases over this same timeframe which predictably led to increased groundwater demand from the basins. From a basic economic perspective, resource costs increase with scarcity and so the willingness to expend resources to measure and quantify available groundwater has increased (historically often following periods of drought). In addition, advances in recording water level measurement technology over the last 20 years have lowered the cost of pressure transducers and data loggers which enable the amassing of high-frequency water level datasets for individual wells at relatively low cost compared to more labor intensive manual measurement methods (see Section 3.3.2 for a description of the pressure transducers deployed in the Fillmore and Piru basins and available data).

Water level measurement data are available for 384 of 1,005 wells included in FPBGSA's well inventory file and are archived in FPBGSA's database. Of these, 70 wells have only one associated water level elevation (WLE) measurement. Many of these are single measurements recorded on DWR WCRs and transcribed into UWCD's water level database. In addition, 83 wells have one record in the water level database, but no reported WLE. This can result when a reference point (RP) elevation for a well is unknown from which to calculate a WLE from a DTW measurement. Another common occurrence of this situation is when a field technician arrives at a well site and the pump is running. Standard practice is to record in the database a record entry with a "no measurement" qualifier.

Records that did not contain a well identifier (typically DWR SWN) for a well contained in UWCD's or VCWPD's well inventory files were excluded from FPBGSA's dataset for GSP preparation. In addition, duplicate records were found for two wells during DBS&A's data collection and inventorying QA/QC process. Duplicate records were purged from FPBGSA's database to retain only unique records for GSP preparation.

Water level elevation (WLE) is calculated in FPBGSA's database as reference point (RP) elevation minus depth to water (DTW). RP elevations for many of the wells with recent WLEs in the Fillmore and Piru basins were updated by UWCD in 2010 from a Ventura County 2005 light detection and ranging (LiDAR) dataset to establish accurate RPs (referenced to NGVD29 datum) for the wells included in their monitoring network. Of these, 72 are within Fillmore and Piru basins (41 and 31, respectively). They also collected accurate horizontal GPS locations using a handheld Trimble system and measured vertical RP height ("stick-up") relative to ground surface for each well. "Stick-up" can be a negative value if for example the top of casing was in a vault below ground surface. VCWPD has also determined accurate RPs in NGVD29 for the wells they measure using the same LiDAR dataset processed to one foot ground surface elevation contours.

Other sources of RP elevations for some wells included in FPBGSA's water level database are from Google Earth's DEM (EGM96 datum) and unknown sources. Additional information and potential data gaps related to reference point elevations are included in Section 5.1.3.

In Fillmore basin, 112 wells have at least two historical WLE records and of these, 61 wells have at least 50 associated records. In Piru basin, 74 wells have at least two historical WLE records and of these, 44 wells have 50 or more associated records. Groundwater level hydrographs for all wells in FPBGSA's database that contain at least two water level elevation records are included in Appendix A of this Tech Memo.

UWCD reviewed the preliminary draft set of groundwater level hydrographs produced from the initial data transfer from their databases (mid-February 2019) and determined that an additional effort of qualifying suspect records was warranted. The results of this QC effort were received from UWCD and the additional record qualifiers were incorporated into FPBGSA's database. These UWCD flagged records were not plotted on the final hydrographs included in Appendix A of this Tech Memo but the qualified records were not removed from FPBGSA's database.

A trend analysis of the groundwater level data presented on hydrographs for wells in Fillmore and Piru basins are included in Section 4.2 of this Tech Memo for those record sets that contain sufficient data for the analysis.

2.1.4 Extraction

Available groundwater extraction (pumping) records for individual wells in Fillmore and Piru basins are described in this Section. Historical groundwater extraction records were requested and received from UWCD as part of the aforementioned initial FPBGSA data transfer in mid-February 2019.

Basins-wide groundwater production record keeping began with the advent of a UWCD funding mechanism tied to groundwater produced within their boundary. Detailed pumping records by well are available for nearly a 40-year period in Fillmore and Piru basins. Pumpers that produce groundwater from the Fillmore and Piru basins pay UWCD an extraction fee based on the number of acre-feet (AF) they pump during a 6-month period (reporting to UWCD twice per calendar year). Period 1 covers January through June and period 2 covers July through December of each year. Groundwater extractions were first reported to UWCD in 1979 with 1980 constituting the first relatively complete calendar year of record.

Following the formation of the FPBGSA in 2017, pumpers in the Fillmore and Piru basins have been required to report their groundwater extractions to the Agency. As an administration cost savings measure, the Agency has utilized UWCD's reported pumping records from wells in the Fillmore and Piru basins and accounting system to invoice well operators on a biennial calendar year basis for the Agency's levied groundwater extraction fee. Note that the Agency also has a substantial DWR administered Proposition 1 Grant that offsets the local cost burden of GSP preparation. SGMA groundwater extraction reporting requirements are discussed in Section 5.5.1 of this Tech Memo.

Groundwater pumpers in the basins have historically been required to self-report groundwater extractions by well to UWCD by one of four methods: crop factor, domestic multiplier, electrical meter (based on SCE efficiency testing) or water flow meter. In 2013, UWCD's Board of Directors voted to eliminate the option of reporting by crop factor, effective January 1, 2014. Beginning in 2014, UWCD continued to accept reporting by crop factor but a 10% penalty was assessed against pumpers that continued to report using the crop factor method (UWCD, 2016). Reporting method is identified as a populated field in the groundwater extractions dataset (i.e., tabulated table) received from UWCD.

For wells with water meters, reporting typically involves filing out a form and submitting an accompanying photo of the digital totalizer reading. The extent to which "smart meters" or automated (advanced) metering infrastructure (AMI) technology is used by individual well owners to quantify their groundwater production is unknown in the basins. There is not currently a mechanism by which well owners can automatically report groundwater production from their water meters to UWCD or the FPBGSA.

De minimis domestic (M&I) pumping can be reported to UWCD using a multiplier of 0.2 AF per person per 6-month period with a minimum of 0.5 AF (e.g., if there are 1 or 2 people reporting domestic usage on a well then 0.5 AF minimum is assessed). Beginning the first billing cycle (period 1) of 2015, an additional field was added to UWCD's pumping database that allows for the identification of water reported using the domestic multiplier method. In previous years this was reported as M&I by the crop factor method (UWCD, 2016). De minimis pumpers (extractors) that have a meter on their well discharge have the option of calculating their usage based on the meter reading which may show less than 0.5 AF usage, and are billed based on actual usage.

Figures 2-2 and 2-3 plot calendar years 1980 through 2018 annual basin total (delineated by DWR 2019 mapping) groundwater extractions for Fillmore and Piru basins. In the early and mid-2000s, the Fillmore and Piru basins experienced significant agricultural land transition from oranges to row crops and nurseries (see Section 2.4), which likely resulted in an increase in groundwater demand (UWCD, 2016).

Pumping historically reported by UWCD in their Piru and Fillmore Basins Groundwater Conditions Reports used different basins mapping (and included nearby wells outside the basins but within UWCD's boundary) that has been supplanted for SGMA purposes by the requirement to produce GSPs that cover California's groundwater basins as mapped by DWR. As a result, UWCD historically reported annual pumping volumes by basin do not exactly match the values shown graphically in the figures below. Fillmore basin annualized reported pumping summed by DWR 2019 basin mapping is lower and Piru basins pumping is higher as compared to UWCD historically reported basins annual totals.

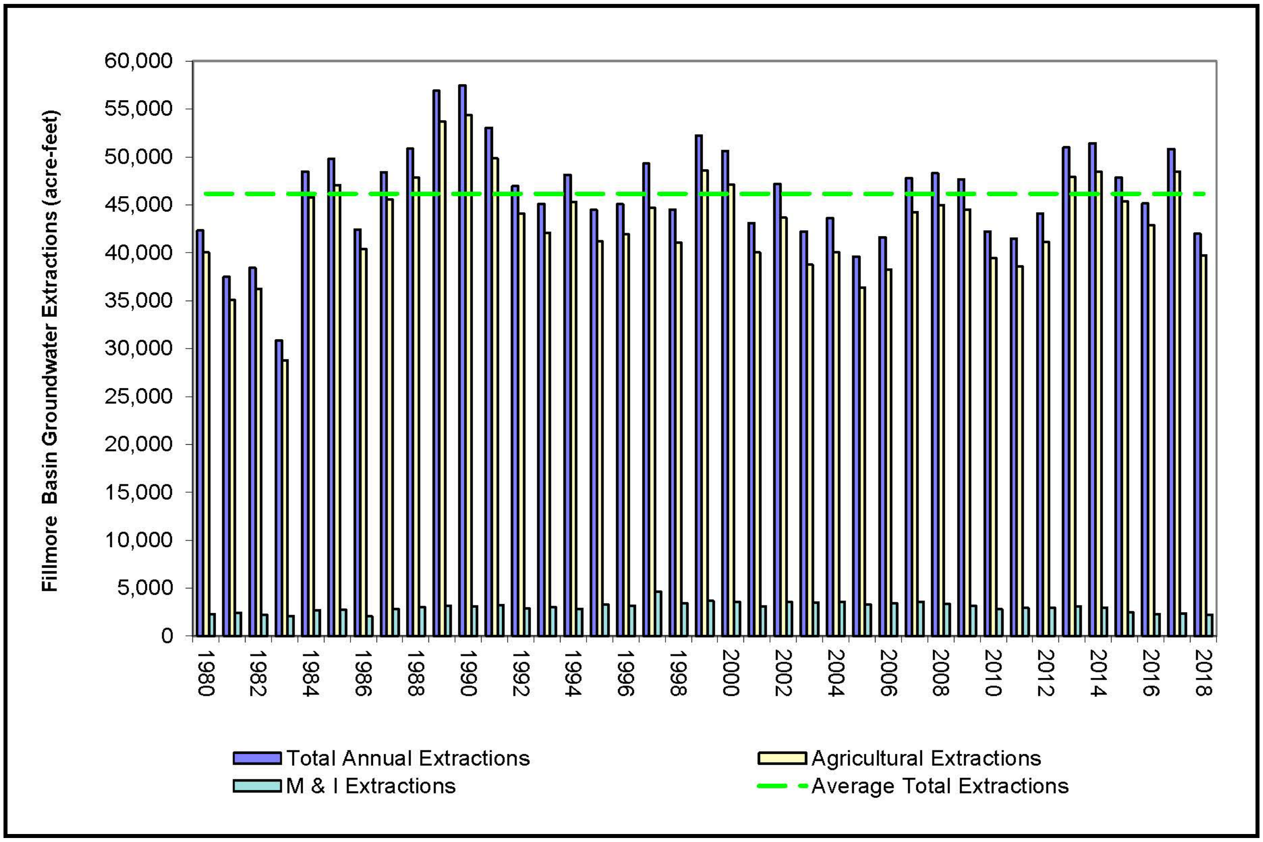


Figure 2-2. Historical annual calendar year groundwater extractions (reported to UWCD) for the Fillmore basin using DWR 2019 basin boundaries.

In calendar year 2018 a total of 41,977 AF of groundwater extraction was reported for the Fillmore basin from 301 wells. This is 4,173 AF less than the historical average of 46,150 AF (1980 through 2018). Agricultural uses accounted for approximately 95 percent of the groundwater extraction in the basin in 2018. The long-term (i.e., 1980 to 2018) average water use distribution is 93 percent agriculture and seven percent municipal and industrial (M&I). For

2018, 76 percent of the pumping volume was reported by water meter (from 163 wells). The remaining pumping was reported by electrical efficiency, de minimis domestic multiplier, crop factor (with penalty), or estimate from historical usage.

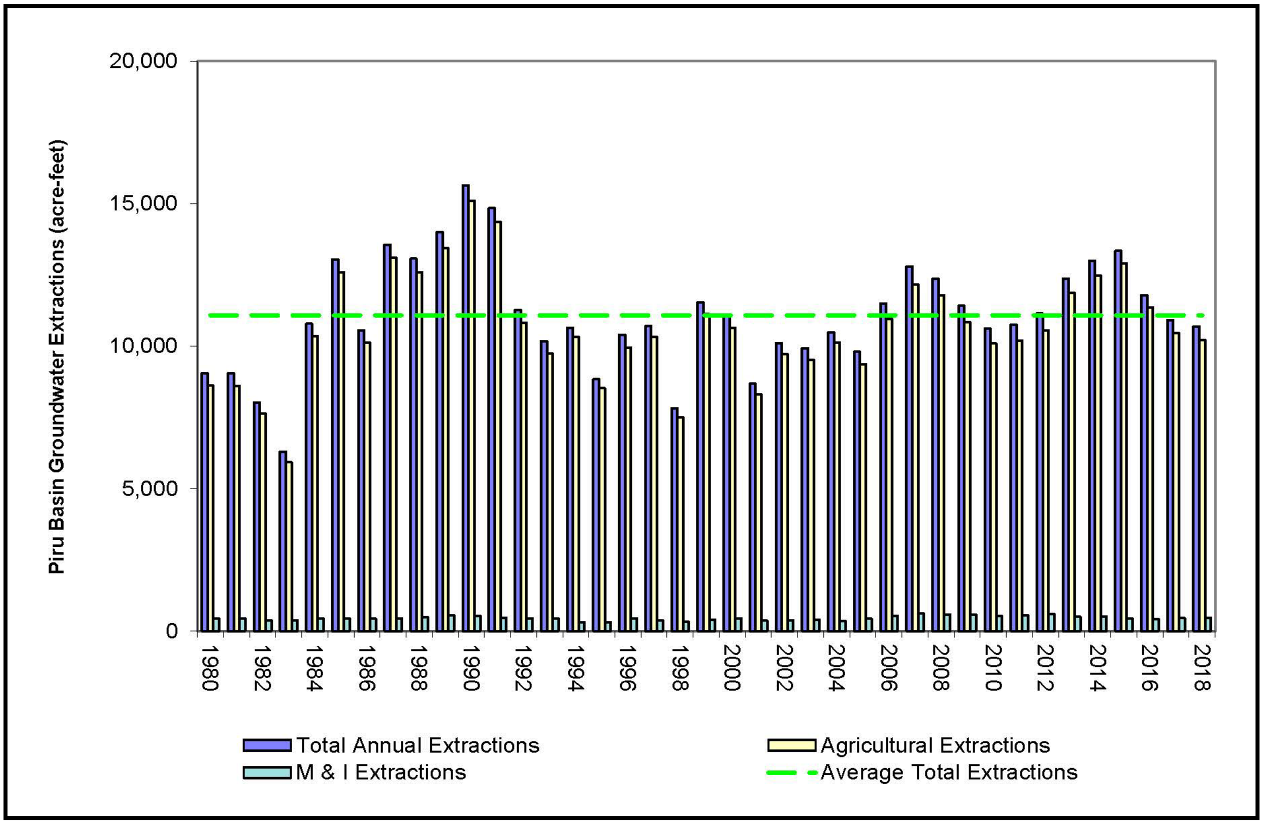


Figure 2-3. Historical annual calendar year groundwater extractions (reported to UWCD) for the Piru basin using DWR 2019 basin boundaries.

In calendar year 2018, a total of 10,689 AF of groundwater extraction was reported for the Piru basin from 107 wells, totaling 390 AF less than the historical average of 11,080 AF (1980 through 2018). Agricultural water use accounted for approximately 96 percent of the groundwater extraction in 2018. The long-term (i.e., 1980 to 2018) average water use is proportioned as 96 percent agriculture and four percent M&I. For 2018, 64 percent of the reported pumping volume was by water meter (from 60 wells). The remaining pumping was reported by electrical efficiency, de minimis domestic multiplier, crop factor (with penalty), or estimate from historical usage.

Figure 2-4 shows the spatial distribution of calendar year 2018 pumping in the Fillmore and Piru basins. Each dot on the maps represent a single well with the dot scaling representing the magnitude of annual pumping reported for each well. Reported de minimis extractions from wells are included on the dasymetric map.

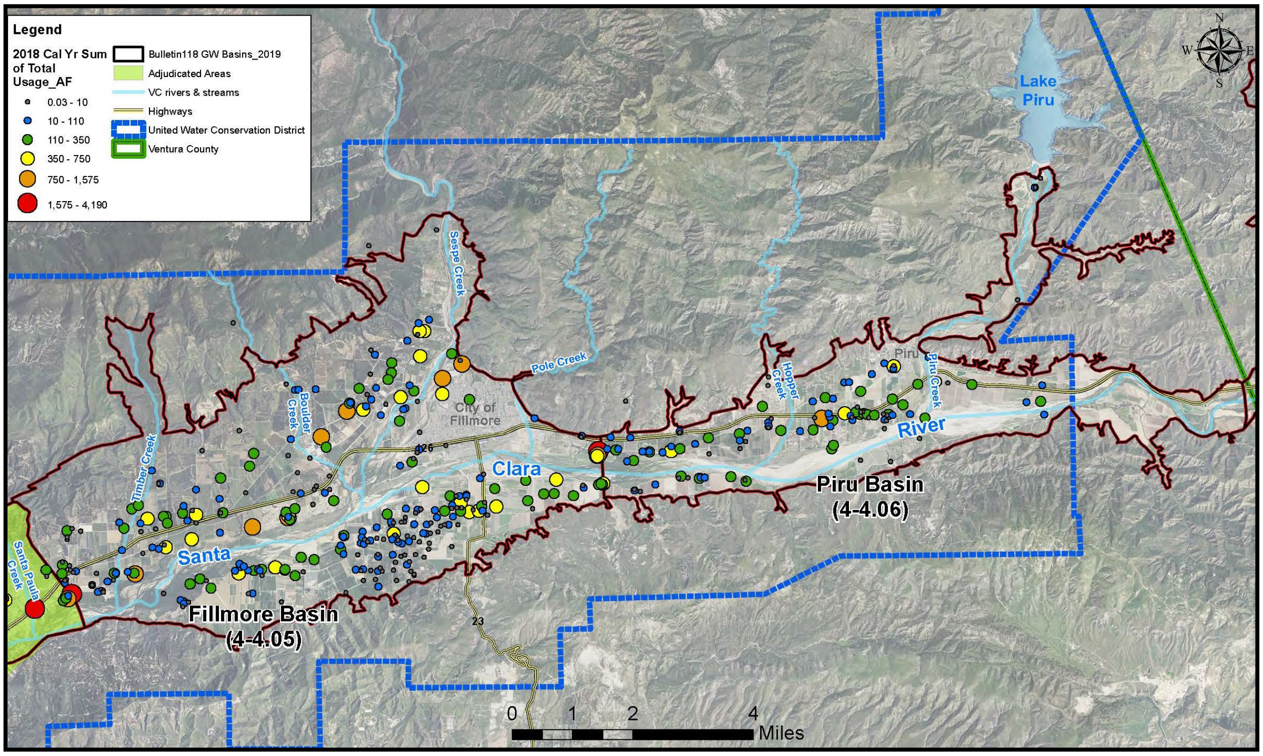


Figure 2-4. Groundwater extraction for calendar year 2018 by well.

In 2018 the single well with the largest extraction in the Fillmore and Piru basins was a Farmers Irrigation Company well that was completed in 2012 just east of the Fillmore/Santa Paula basin boundary. Water pumped from this well in Fillmore basin is exported for use in Santa Paula basin (UWCD, 2016).

2.2 Surface Water

Streamflow and water quality datasets of the Santa Clara River and its tributaries are described in this Section.

2.2.1 Quality

UWCD maintains a surface water quality monitoring point inventory file (in GIS shapefile format) for their use. The file contains attribute table fields that include a descriptive Location Name (e.g., "Santa Clara River at Newhall Crossing") and unique Well ID for each site. Well IDs are assigned by UWCD employing a standardized naming convention (e.g., 04N18W25SW2) that mimics DWR's SWN naming system.

UWCD's surface water quality monitoring point inventory file was requested and received by DBS&A for FPBGSA's GSPs preparation purposes. The shapefile received from UWCD was clipped to include surface water monitoring points within the Fillmore and Piru basins and nearby areas (including sites near Lake Piru) for assessing boundary conditions.

In total, 47 monitoring sites with surface water quality data are included in FPBGSA's surface water monitoring point inventory shapefile (Figure 2-5). This file was slightly modified from UWCDs file to include a few additional sites not originally included in UWCD's file and exclusion of three obsolete sites with no associated surface water quality data. DBS&A worked closely with UWCD staff during this process.

Of the sites included in FPBGSA's surface water monitoring point inventory, 16 are located within Fillmore basin (of which 4 are included in UWCD's current surface water quality monitoring network) and 13 are within Piru basin (of which 5 are active sites and 4 are alternate sites or sampled periodically). The remaining monitoring sites in FPBGSA's surface water quality monitoring point inventory file are located in Santa Paula basin, SCR Valley East basin or outside a DWR mapped groundwater basin. UWCD's existing surface water monitoring network is described in Section 3.2 of this Tech Memo.

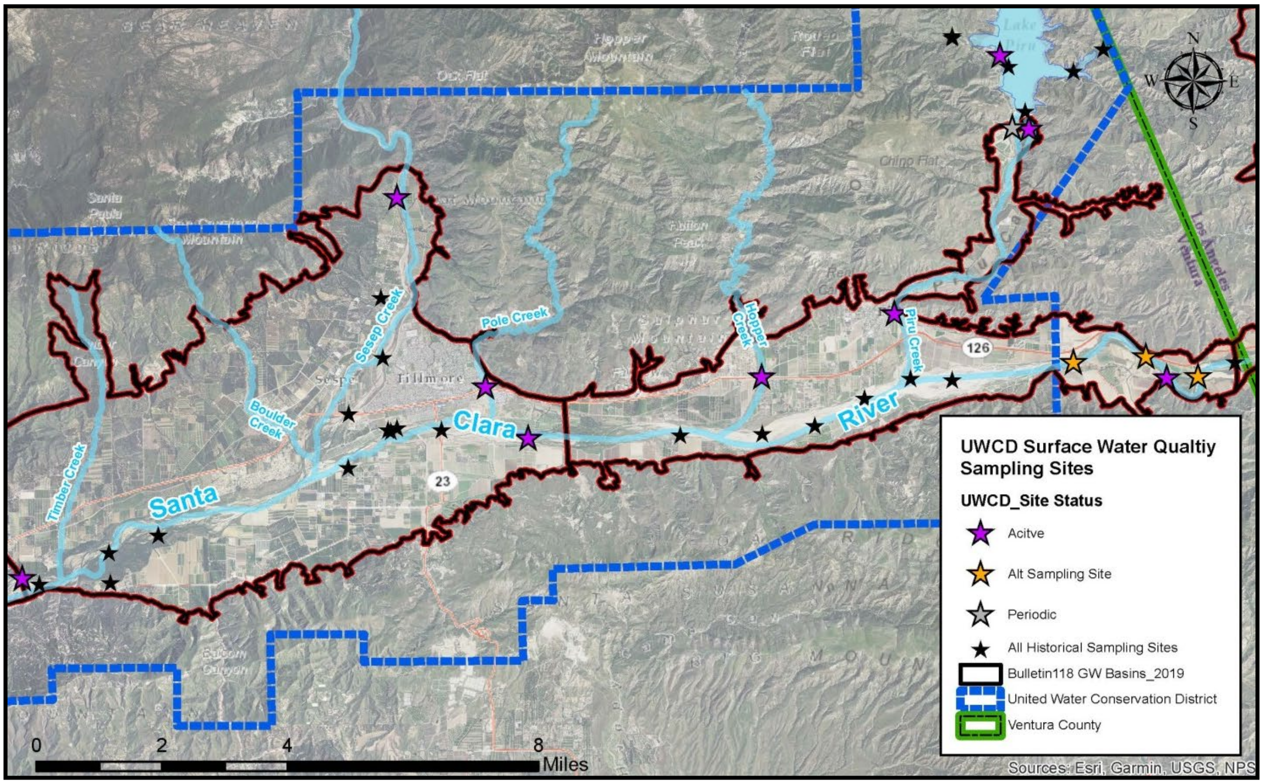


Figure 2-5. Surface water sampling sites by activity status.

Water quality sample records are available for 41 of the 47 monitoring sites contained in FPBGSA's surface water quality monitoring point inventory file. Of these, 6 sites have only one associated water quality sample record. These data are archived in FPBGSA's database.

There are over 3,100 surface water quality records in FPBGSA's database with a date range of 1951 through 2018. From a review of the "Source of Data" field, surface water data received from UWCD generally originated from the following entities:

- City of Fillmore
- CA DWR
- CA SWRCB DDW (formally under CDPH)
- USGS
- UWCD

Time-series graphs for all sites that contain total dissolved solids (TDS), sulfate (SO_4), chloride (Cl), nitrate (NO_3), or boron (B) are included in Appendix D of this Tech Memo. Two records that did not contain a well identifier for sites contained in UWCD's surface water quality monitoring point inventory file were excluded from FPBGSA's dataset for GSP preparation.

2.2.2 Streamflow Gaging

Available streamflow discharge data for the Fillmore and Piru basins includes measurements from the Santa Clara River and tributaries. Figure 2-6 shows the location of streamflow gaging sites in the basins and nearby areas.

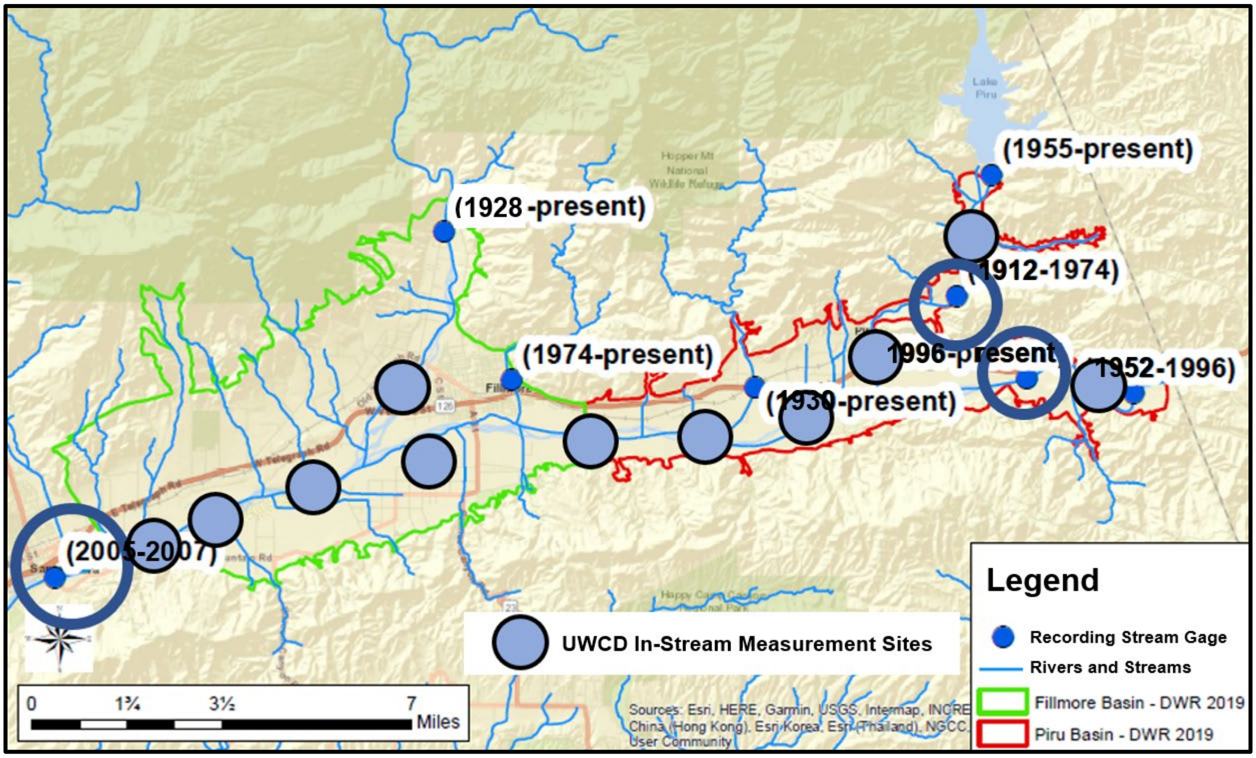


Figure 2-6. Recording and UWCD manual in-stream flow gaging sites showing calendar year period of record (figure modified from UWCD presentation slide presented at the FPBGSA 9/27/2019 monthly meeting).

Computing streamflow discharge in its simplest form is a volumetric flow rate calculation of stream (current) velocity multiplied by the stream channel wetted cross-sectional area (i.e., width x height). Discharge is commonly reported in units of cubic feet per second (cfs). A single measurement represents a snapshot in time but stream flow is often reported as averages of many measurements (e.g., average daily, monthly or annual cfs). Peak flow is another frequently reported streamflow data statistic.

2.2.2.1 *Manual Measurements*

Manual (hand) streamflow calculations are based on velocity measurements from a current meter at several intervals along a cross-sectional profile of a stream channel. Established manual streamflow discharge measurement techniques include, but are not limited to, the following methods:

- In-stream wading measurements (e.g., using a top-set wading rod)
- Bridge suspended current meter
- Acoustic doppler current profiler (ADCP)

UWCD has historically collected in-stream discharge measurements using a top-set wading rod equipped with a current meter or SonTek FlowTracker2 Acoustic Doppler Velocimeter®. Figure 2-6 shows the approximate locations of historical UWCD's in-stream measurement sites. Streamflow data collected at these sites totals over 500 measurements in the Santa Clara River and tributaries, with the majority of these measurements collected during the past 20 years from 1999 through 2019. UWCD streamflow measurements have been used to estimate percolation rates within various reaches of the stream channels of the Fillmore and Piru basins (UWCD, presentation during the FPBGSA 9/27/2019 monthly meeting). A subset of these data were received from UWCD and are included in FPBGSA's database for GSP preparation.

As mentioned in Section 1.2.2, Santa Clara River reaches of perennial rising groundwater exist near the basins boundaries (i.e., Santa Paula/Fillmore basins and Fillmore/Piru basins). UWCD intermittently monitors these streamflow discharges and collects GPS point data of the distal up-stream extent where water is flowing in the river channel. UWCD has established monitoring points where they have determined the approximate location of peak flow at the Santa Paula/Fillmore and Fillmore/Piru basins boundaries.

2.2.2.2 *Recording Gages*

Recording streamflow gages typically measure surface water stage height (i.e., water surface level). Site-specific rating curves are established by correlating stage height with manual streamflow discharge measurements, which are periodically collected for this purpose. Recording gages can be affixed to a bridge or other stationary structure that transverse a water course. These stations are equipped with a device (e.g., affixed float or sensor) that can measure stage. Stilling wells installed in stream banks are also commonly employed and are frequently constructed adjacent to weirs that afford ideal laminar flow conditions.

Recording gages can be equipped with telemetry systems that transmit data in near real-time. Data that are publicly accessible in real-time (e.g., via the USGS National Water Information System [NWIS]) are generally initially reported as “Provisional” and are later evaluated with a QA/QC process and revised by the monitoring entity, if necessary, before being published as “Approved.”

As mentioned above, a site-specific rating curve (i.e., calibration) is developed using manual flow velocity measurements (see manual measurement methods listed in Section 2.2.2.1 above) and stream channel wetted cross-sectional geometry approximations. The rating curve is generally revised overtime (e.g., as additional velocity data are collected or if the channel is significantly modified) typically using linear regression methods.

Table 2-1 shows the active and historical recording streamflow gages in Fillmore and Piru basins operated by the USGS or VCWPD.

Table 2-1. Streamflow gages in Fillmore and Piru basins showing active and historical water year period of record.

VCWPD Site ID	USGS Site ID	Currently Active	DWR Basin	VCWPD WY Period of Record	USGS WY Period of Record	Site Name
701	11110500	Yes	Piru	1931-2019	1931-1983	Hopper Creek at Hwy 126 nr Piru [VC maintained gage]
706	11110000	No	Piru	1912-1974	1912-1974	Piru Creek nr Piru
707	11108500	No	Piru	1953-1996	1953-1996	Santa Clara River at L.A-Ventura Co. Line CA (Blue-Cut)
707A	11109000	Yes	Piru	1928-1932, 1997-2019	1928-1932, 1997-2019	Santa Clara River nr Piru CA (Newhall Bridge) [USGS maintained gage]
710	11113000	No	Fillmore	1912-13, 1928-1934		Sespe Creek nr Fillmore at RR Bridge
710A	11113000	No	Fillmore	1935-38		Sespe Creek nr Fillmore (Grand Ave)
710B	11113000	No	Fillmore	1939-1993		Sespe Creek nr Fillmore
710C	11113000	No	Fillmore	1991-93(partial)		Sespe Creek nr Fillmore at Diversion
710D	11113000	Yes	Fillmore	1994-2016	1912-13, 1928-1985, 1991-92, 1994-2019	Sespe Creek nr Fillmore (Grand Ave) [USGS maintained gage]
713	None	Yes	Fillmore	1974(partial)-2017	-	Pole Creek at Sespe Ave [VC maintained gage]
714	11109800	Yes	Piru	1956-2016	1956 - 2019	Piru Creek blw Santa Felicia Dam CA [USGS maintained gage]

Streamflow datasets are available for download through the USGS NWI Web Interface (USGS, 2020). These datasets include, but are not necessarily limited to, the following:

- Daily streamflow data and statistics
- Average monthly (statistics)
- Average annual (statistics)
- Annual streamflow peak

Streamflow datasets are also available for download through the VCWPD's Hydrologic Data Server (Hydrodata) (VCWPD, 2020). These datasets include, but are not necessarily limited to, the following:

- Average daily streamflow
- Annual and event streamflow peaks

Figure 2-7 shows historical annual surface water flows for the Santa Clara River near the Los Angeles/Ventura County Line for water years 1953 to 2019 (USGS ID 11108500 labeled on Figure 2-6). These flows (converted to annual water year volumes in AF) are displayed as a column chart on the primary (left) Y-axis and as average annual flow in cubic feet per second (cfs) on the secondary (right) Y-axis. Select streamflow peaks in cfs are displayed on the figure. The maximum Santa Clara River peak flow discharge for the period of record is 68,800 cfs on 1/25/1969. For comparison to the wettest year of the last 15 years, less than half (32,000 cfs) of this peak flow (measured on 1/9/2005) is estimated by the USGS. Note that dry season perennial flow in east Piru basin is largely dependent on LA County operated Valencia wastewater treatment plant discharges.

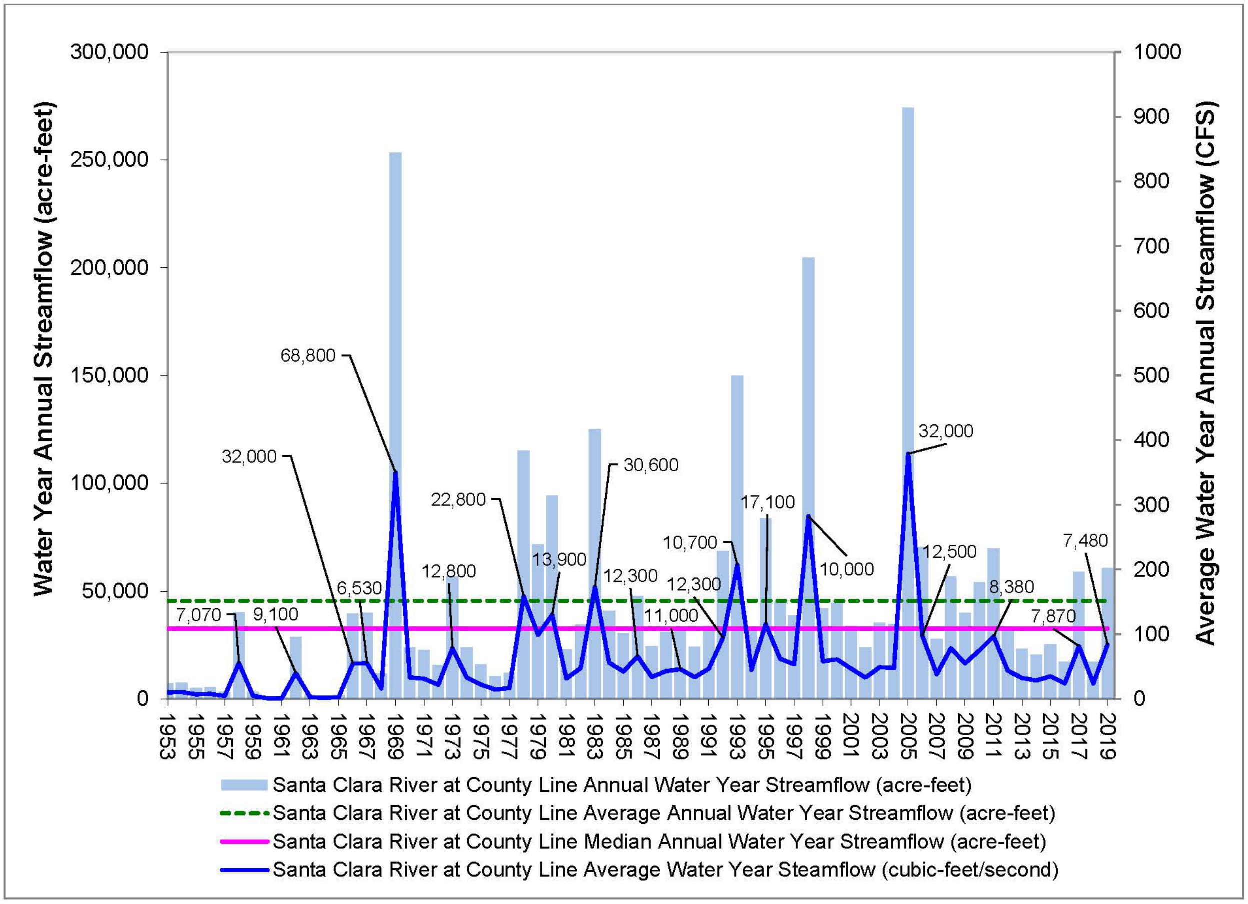


Figure 2-7. Santa Clara River historical annual streamflow near Ventura/LA County Line (streamflow data from USGS). Labeled values shown are peak flows (cfs) for select water years.

Figure 2-8 shows historical annual surface water flows for Sespe Creek for water years 1928 to 2019 (USGS ID 11113000 labeled on Figure 2-6). The average annual flow in Sespe Creek from 1928 to 2019 is approximately 85,000 AF. During many years, Sespe Creek flow is greater than Santa Clara River flow near Ventura/LA County Line. Downstream of this gage, lower Piru Creek (above which Lake Piru is impounded) and Sespe Creek in Fillmore basin contribute flow to the Santa Clara River before it flows out of Fillmore basin into the Santa Paula basin.

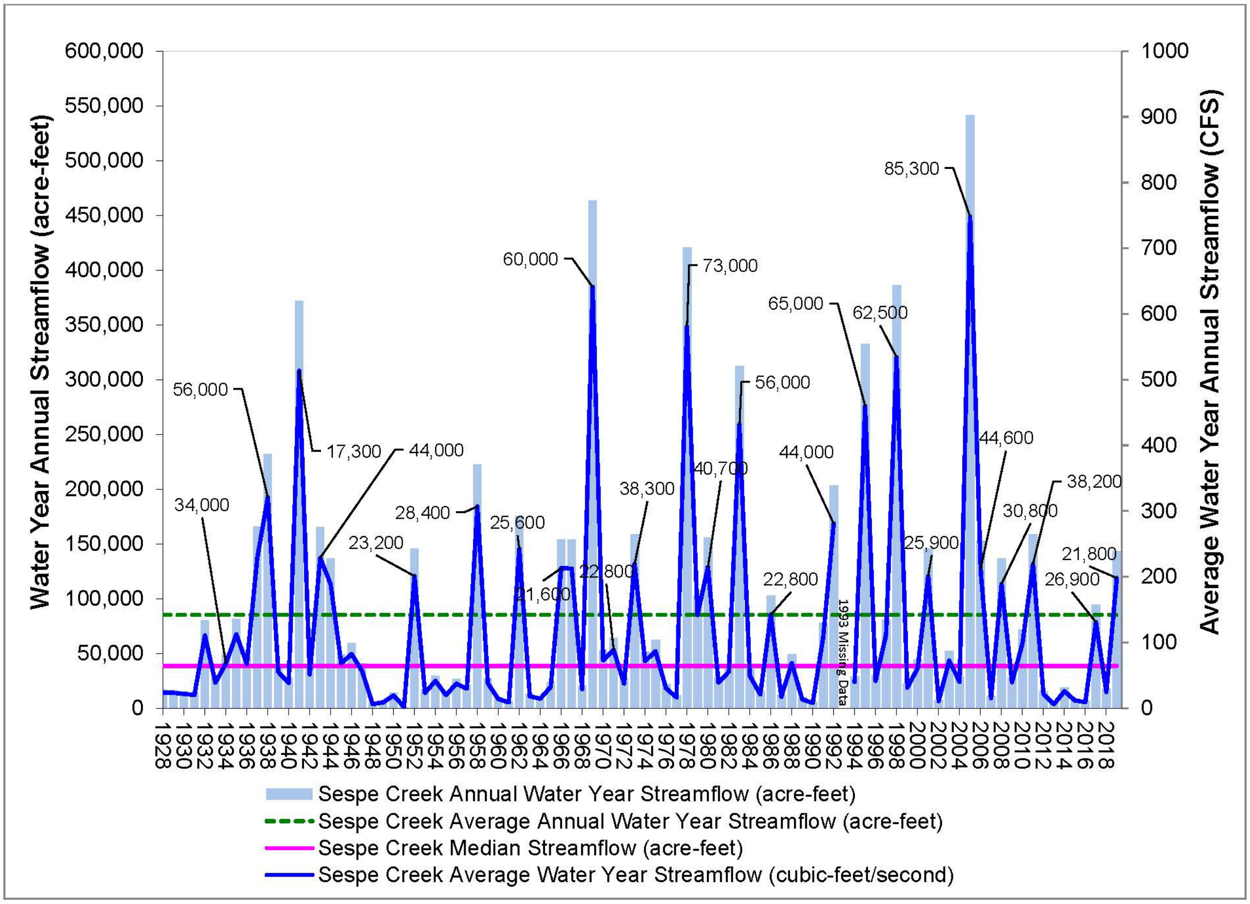


Figure 2-8. Sespe Creek historical annual streamflow (streamflow data from USGS and VCWPD). Labeled values shown are peak flows (CFS) for select water years.

2.3 Meteorological

Measured precipitation (i.e., rain) gage and evaporation data are available for download through VCWPD's Hydrodata online portal. These atmospheric datasets are discussed in this Section.

2.3.1 Precipitation

Fillmore and Piru basin rain gage sites with available data accessible through VCWPD's Hydrodata portal are shown in Table 2-2. Precipitation datasets include hourly totals for recording gages and daily rainfall totals for standard (i.e., manually measured) gages. Data can also be downloaded by summed monthly or water year totals. There are eight Active sites (stations) and 14 Inactive sites within the Fillmore and Piru basins. One site located outside of the basins to the north near the entrance of Lake Piru (Piru-Temescal Guard Station Site 160), is also shown in the table since it has historically been reported by UWCD in the Piru and Fillmore Basins Groundwater Conditions reports (UWCD, 2016).

Table 2-2. Active and Inactive precipitation gages in Fillmore and Piru basins.

VC Site ID	Name	DWR Basin	Type	Status	Lat	Long	Elevation	Daily Totals	Hourly Totals
011	Fillmore at Fillmore	Fillmore	Standard	Inactive	34° 24' 18.0" N	118° 54' 54.0" W	530	1905 - 1947	N/A
025	Piru-Newhall Ranch	Piru	Standard	Active	34° 24' 5.7" N	118° 43' 28.3" W	825	1927 - 2019	N/A
036	Piru Citrus Assoc	Piru	Standard	Inactive	34° 24' 36.0" N	118° 47' 42.0" W	700	1926 - 1966	N/A
036A	Piru-County Fire Station	Piru	Recording	Active	34° 24' 48.6" N	118° 47' 48.5" W	700	1966 - 2019	2012 - 2019
039	Fillmore-Rancho Sespe	Fillmore	Recording	Inactive	34° 23' 1.1" N	118° 57' 45.7" W	360	1912 - 2009	2000 - 2009
094	Fillmore-Leavens & Goodenough Ranch	Piru	Standard	Inactive	34° 23' 30.0" N	118° 50' 24.0" W	600	1931 - 1947	N/A
094A	Fillmore-Double H-N Ranch	Piru	Standard	Inactive	34° 23' 42.0" N	118° 51' 6.0" W	600	1947 - 1972	N/A
094B	Fillmore-Double H-N Ranch	Piru	Standard	Inactive	34° 23' 54.0" N	118° 50' 49.0" W	560	1972 - 1987	N/A
094C	Fillmore-Fairview Ranch	Piru	Recording	Inactive	34° 23' 51.2" N	118° 51' 36.5" W	640	1987 - 2009	2004 - 2008
096	Bardsdale-Young Ranch	Fillmore	Standard	Inactive	34° 21' 49.0" N	118° 56' 42.0" W	400	1931 - 1985	N/A
096A	Bardsdale-Lander Ranch	Fillmore	Recording	Inactive	34° 21' 43.0" N	118° 57' 1.0" W	390	1985 - 2009	2004 - 2009
101	Piru-Camulos Ranch	Piru	Standard	Inactive	34° 24' 22.0" N	118° 45' 22.0" W	725	1928 - 1974	N/A
101A	Piru-Camulos Ranch	Piru	Recording	Active	34° 24' 21.8" N	118° 45' 25.3" W	725	1974 - 2019	1976 - 2019
106	Piru - Procter and Lothridge	Piru	Standard	Inactive	34° 24' 15.0" N	118° 49' 0.0" W	640	1931 - 1939	N/A
106A	106A - Piru RAWS	Piru	Non-Standard Recorder	Active	34° 24' 15.3" N	118° 48' 35.8" W	614	2001 - 2011	2001 - 2011
160	Piru-Temescal Guard Station	Outside (Lake Piru)	Standard	Active	34° 28' 27.8" N	118° 45' 39.7" W	1105	1949 - 2016	N/A
171	Fillmore-Fish Hatchery	Fillmore	Recording	Active	34° 23' 36.9" N	118° 53' 5.9" W	465	1956 - 2019	1976 - 2019
199	Fillmore-County Fire Station	Fillmore	Standard	Inactive	34° 24' 10.8" N	118° 55' 32.6" W	435	1959 - 2009	N/A
199A	Fillmore Sanitation	Fillmore	Recording	Active	34° 23' 25.4" N	118° 56' 23.7" W	390	2009 - 2019	2009 - 2019
235	Piru-L.A./Ventura County Line	Piru	Nat Weather Service Site	Inactive	34° 23' 58.9" N	118° 42' 14.7" W	800	1993 - 2006	1993 - 2006
235A	Piru-L.A./Ventura County Line	Piru	Recording	Active	34° 23' 58.9" N	118° 42' 18.0" W	800	2006 - 2019	2006 - 2019
276	Piru CIMIS 101	Piru	CIMIS Site	Inactive	34° 24' 8.7" N	118° 47' 16.0" W	640	N/A	1991 - 2005
400	Fillmore-Grand Ave (Type B)	Fillmore	Non-Standard Recorder	Active	34° 26' 30.4" N	118° 55' 38.6" W	580	1998 - 2014	1998 - 2014

Ventura County-wide precipitation for water year 2019 (October 2018 through September 2019) was above the long-term average. This constituted the second above average precipitation water year since the drought period of 2012 through 2016.

Figure 2-9 shows water years 1957 through 2019 recorded precipitation from the Fillmore Fish Hatchery Site (rain gage) 171 near the Fillmore/Piru basin boundary. The location of the Fish Hatchery gage and the Piru-Temescal Guard Station Site 160 are shown on Figure 1-1.

Figure 2-9 shows annual precipitation totals for individual water years, the mean and median precipitation, and the cumulative departure from average precipitation over the period of record. Long-term wet and dry cycles are evident from the cumulative departure plots, where wet periods are indicated by upward trends and dry periods are indicated by downward trends.

Over the last two decades since 1998 (the record-high precipitation year for the gage), the Piru and Fillmore basins have had a greater number of below-average precipitation years than above-average precipitation years.

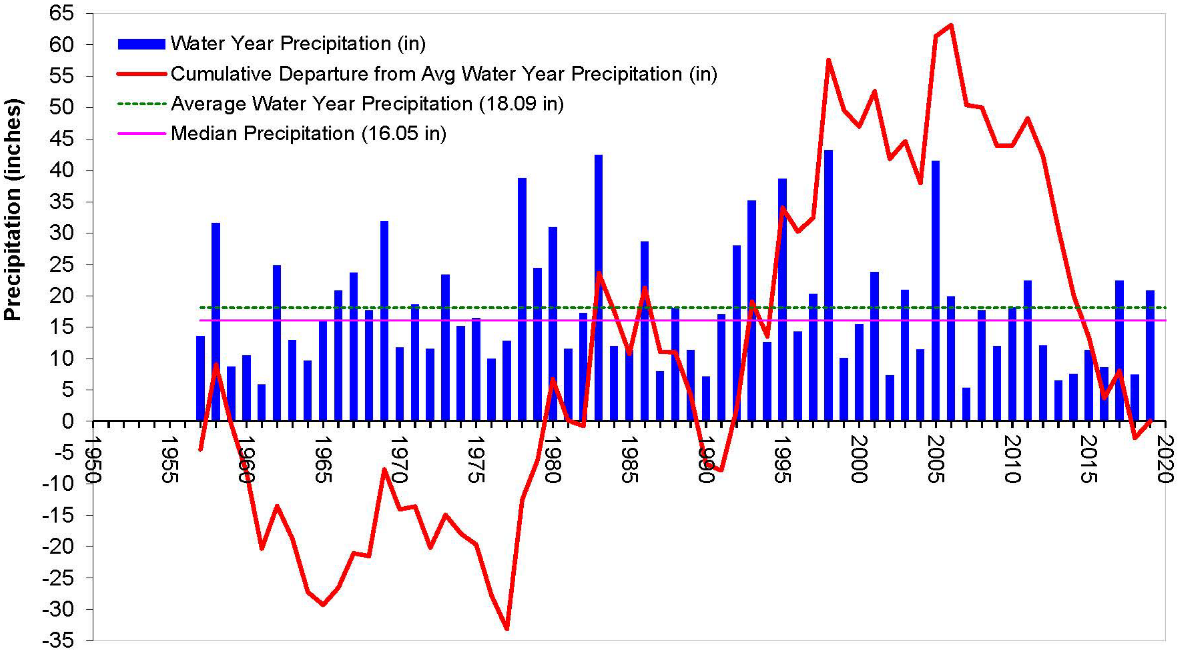


Figure 2-9. Fillmore and Piru basins historical annual precipitation (Fillmore Fish Hatchery Rain Gage 171; Data from Ventura County Watershed Protection District).

The basins average and median water year precipitation from the available period of record for Gage 171 was 18.09 inches and 16.05 inches respectively. Precipitation for water year 2019 was 20.78 inches. This wet year followed the dry 2018 water year with recorded precipitation of only 7.38 inches which was 10.7 inches below the historical average precipitation.

Data for the Piru-Temescal Guard Station Site 160 (Active site) are available online and were downloaded for water years 1950 through 2019. Historically this gage, located at an elevation of 1,105 feet above mean seal level (amsl), shows higher precipitation rates than the Fish Hatchery gage (465 feet, amsl). The differences in gage recorded rainfall are likely associated with difference in elevation associated orographic effects.

VCWPD reports long-term (base period 1957 - 1992) average seasonal (i.e., water year) precipitation of 20.33 and 18.28 for Gage 160 and Gage 171, respectively. According to

VCWPD, the 35-year period, spanning October 1957 to September 1992, is the best base period for representing long-term averages for multiple sites in Ventura County (VCWPD Hydrodata, 2020). The base period can be used to compute typical monthly precipitation totals (Figure 2-10) for Gage 171. Note that the average water year precipitation (18.28 inches) for this base period (1957-1992) is higher than the average (18.09 inches) shown above on Figure 2-9 for the entire period of record from 1957 through 2019, which includes the record setting drought years of 2012 to 2016.

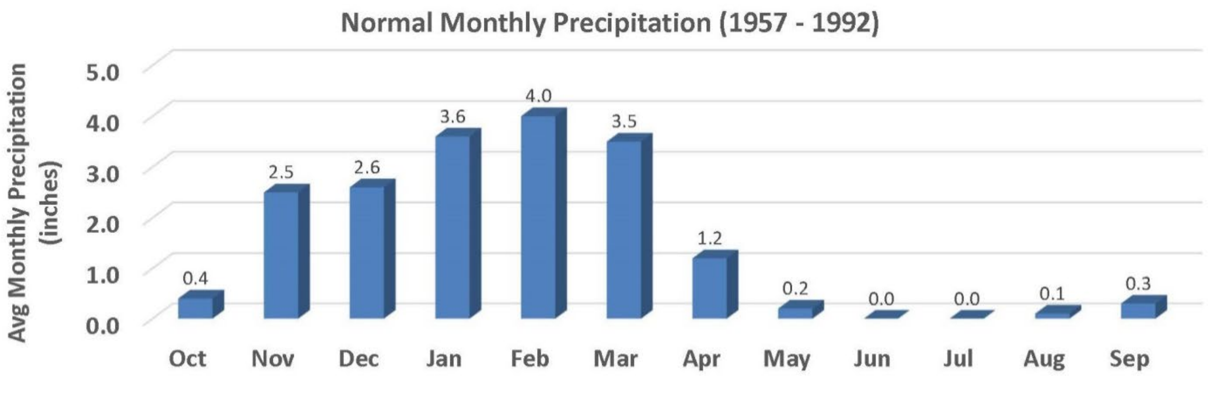


Figure 2-10. Average monthly precipitation for the period 1957 to 1992 for the Fillmore Fish Hatchery Rain Gage 171 (average water year total is 18.28 inches for the period).

Figure 2-10 shows a typical Mediterranean climate type precipitation distribution (mild wet winter and dry summer). From year-to-year it is common for precipitation to differ significantly from this long-term average pattern. For water year 2017, two storm systems contributed to the majority of the recorded above average precipitation of 22.42 inches. Monthly precipitation totals for water year 2019 were below average for nine months out of the water year but was considerably above average for January, February and May that produced an overall above average year total of 20.78 inches. The timing and intensity of precipitation throughout the year impacts both surface water runoff (to rivers and streams) and groundwater recharge. Recent climate change predictions anticipate more extreme climatic conditions (i.e., less frequent, more intense precipitation events and longer periods of drought) that may somewhat deviate from historical trends (Oakley et al., 2019).

2.3.2 Evapotranspiration

Evapotranspiration (ET) is a water budget component that combines the processes of plant transpiration, surface water and soil moisture evaporation. ET can be estimated from weather station measured parameters that include, but are not necessarily limited to, the following components:

- Wind speed
- Air temperature
- Humidity
- Solar radiation

Site-specific evapotranspiration is dependent on the parameters listed above but also includes factors such as vegetation ground cover and soil moisture. Actual ET is approximately equal to potential evapotranspiration when the water supply available to ET is greater than or equal to the demand. Commonly reported (e.g., by the California Irrigation Management Information System [CIMIS]) Reference Evapotranspiration (ET0) is potential evapotranspiration estimated with a standardized ground cover surface (i.e., short grass). ET0 is commonly corrected to site-specific crop coefficients to estimate Actual ET.

Plant transpiration and soil moisture evaporation can be both challenging to measure directly and costly to quantify. Weighing type lysimeters can be used to directly measure ET but are often cost prohibitive for use in application other than academic research. Estimates of ET can be derived from evaporation measurements (a component of ET) when the suite of weather station measured parameters listed above are not available. Evaporation is commonly measured with a “Class A” Evaporation Pan.

There is one site within the Fillmore and Piru basins that records monthly evaporation data. This site, Fillmore Fish Hatchery Site 171 (Figure 1-1), is shared by the rain gage site discussed in Section 2.3.1. The available period of record is from water year 1970 through 2008 (VCWPD Hydrodata, 2020). The site is listed with an Active status and it is unknown why post-2008 evaporation data is unavailable for download.

Piru-Temescal Guard Station Site 160, also discussed in the Section 2.3.1, has available evaporation data for water year 1952 through 2013. This site is located outside of the basins, north of Piru basin, near the entrance of Lake Piru. The site is listed as Active on the Hydrodata portal (2020).

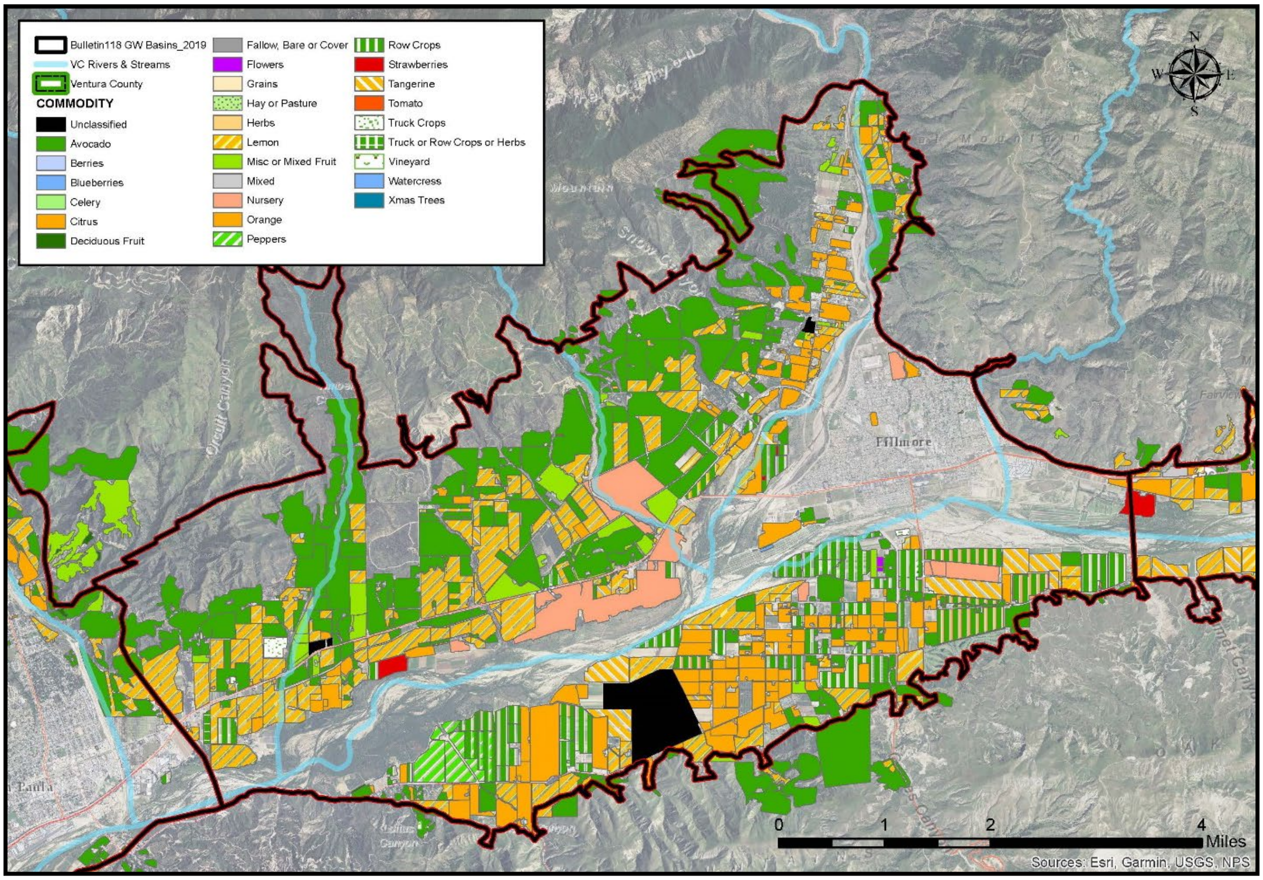
Site 171 evaporation data shows a long-term average of five inches per month (i.e., 60 inches per year), with the highest rates occurring in the summer and the lowest in the winter. Average winter and summer monthly evaporation rates are approximately 3 inches and 7 inches, respectively.

2.4 Agricultural Land Use

Agricultural crop mapping data are particularly important in the Fillmore and Piru basins due to agricultural uses of groundwater accounting for the bulk of the water pumped in the basins (95 and 96 percent, respectively in 2018). Two agricultural land use datasets are available for use in the Fillmore and Piru basins GSPs preparation. DWR has published California statewide crop mapping data for 2014 and 2016, and the Ventura County Agricultural Commissioner’s office has archived countywide crop mapping beginning in 2011. Available Natural Communities Commonly Associated with Groundwater (NCCAG) vegetation and wetlands mapping are not discussed in this Section but will be covered in a subsequent tech memo.

DWR crop mapping coverages include main season agricultural land use, managed wetlands, and urban boundaries. These data are derived from remote sensing, agronomic analysis and ground truthing. These datasets were originally prepared by Land IQ, LLC and provided to the DWR who reviewed and in some cases revised the mapping using additional analyses.

Ventura County Agricultural Commissioner’s “Crops Now” (land use) mapping was requested and received in shapefile format for alternate years 2011, 2013, 2015, 2017 and 2019. Figures 2-11 and 2-12 show 2019 mapping for the Fillmore and Piru basins, respectively. A generalized commodity grouping has been applied to the detailed “crop list” field contained in the attribute table of the GIS coverage for simplified display by crop. All citrus on the 2019 maps is displayed in orange for ease of comparison to UWCD’s published mapping of these data in their Fillmore and Piru Basins Groundwater Conditions Report series.



Sources: Esri, Garmin, USGS, NPS

Figure 2-11. **Fillmore basin agricultural land use map for 2019 (Ventura Co. Ag Commissioner).**

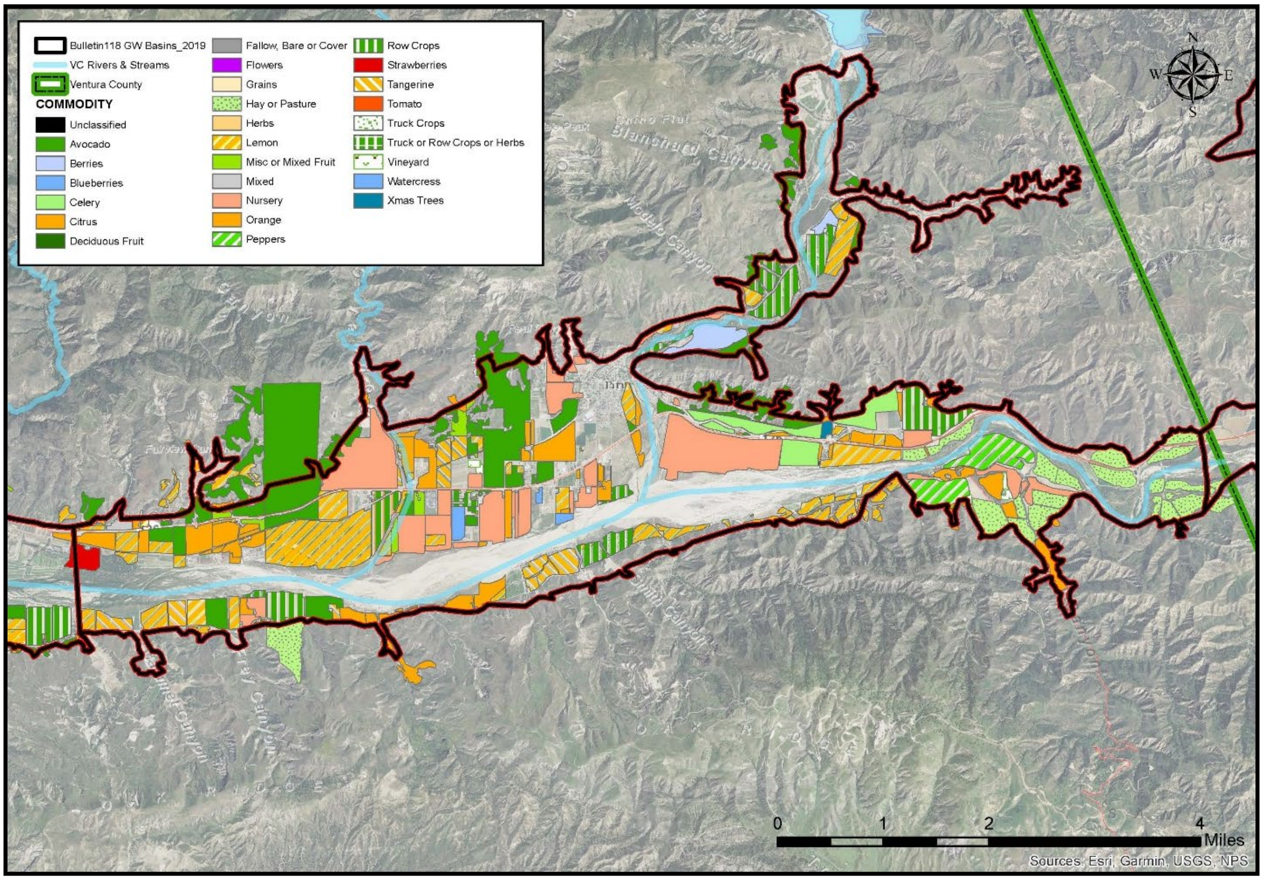


Figure 2-12. **Fillmore basin agricultural land use map for 2019 (Ventura Co. Ag Commissioner).**

From a review of earlier available crop mapping (e.g., VC Ag Commissioner Crops Now 2011 mapping not shown here), the 2019 maps show that significant acreage was converted from citrus to row crops, particularly in the Piru basin and the Fillmore basin south of the river. They also show increased avocado acreage replacing citrus acreage in the Fillmore basin north of the Santa Clara River. In the early and mid-2000s there was a significant increase in container plant nurseries in both the Fillmore and Piru basins. These nursery operations commonly displaced citrus groves (UWCD, 2016).

Agricultural irrigated land hillside expansion is apparent from the maps in the Fillmore basin along the southern flank of the Fillmore basin on the hillsides south of Bardsdale. In Piru basin there has been hillside expansion along most of the southern portion of the basin. In the northern portion of Piru basin there has been expansion of the large plantings near the western end of the basin in the vicinity of Fairview Canyon, northwest of the town of Piru and the hillsides along the lower Piru Creek stream channel (UWCD, 2016).

3. Existing Monitoring Networks

The Water Resources Department of UWCD and the Water Resources Division of VCWPD have existing long-standing monitoring networks in Ventura County and include data collection in Fillmore and Piru basins. The U. S. Geological Survey (USGS) has historically conducted studies in the basins, but does not routinely monitor for water quality or groundwater level in wells in the basins. Some of these studies have included targeted data collection programs and have contributed to the available datasets in the basins. As mentioned in Section 1.2.6, the USGS installed the only nested (multiple-well) groundwater monitoring facility (RP1) in the basins as part of their Regional Aquifer-System Analysis (RASA) Program.

Spatial groundwater quality and level monitor well density included in existing monitoring networks is evaluated in Sections 5.3 and 5.4, respectively. The evaluation includes consideration of the number and distribution of monitor wells screened discretely in a single aquifer zone in the Fillmore and Piru basins.

3.1 Groundwater Quality

From DWR’s BMP #2 (DWR, 2016b):

> The following represent specific practices to be employed in the execution of the GSP:
>
> - Monitor groundwater quality data from each principal aquifer in the basin that is currently, or may be in the future, impacted by degraded water quality.
>   - The spatial distribution must be adequate to map or supplement mapping of known contaminants.
>   - Monitoring should occur based upon professional opinion, but generally correlate to the seasonal high and low, or more frequent as appropriate...
> - Collect groundwater quality data from each principal aquifer in the basin that is currently, or may be in the future, impacted by degraded water quality...
> - Define the three-dimensional extent of any existing degraded water quality impact.
> - Data should be sufficient for mapping movement of degraded water quality.
> - Data should be sufficient to assess groundwater quality impacts to beneficial uses and users.

- Data should be adequate to evaluate whether management activities are contributing to water quality degradation."

Groundwater quality monitoring in the basins is conducted by several organizations in addition to the monitoring programs administered by UWCD and VCWPD. For water purveyors' wells that produce groundwater for human use and consumption, monitoring of a variety of regulated constituents, including biological constituents, is required by law and ensures that groundwater is safe for potable uses. These data are available from the CA SWRCB Division of Drinking Water (UWCD, 2016) for water systems with 15 or more connections. Other sources of groundwater quality monitoring may include, but are not limited to, the following:

- California Department of Water Resources
- City of Fillmore potable water supply wells
- Waste Water Treatment Plants (i.e., City of Fillmore, Ventura County Waterworks District No. 16 servicing the unincorporated town of Piru, and Los Angeles County Sanitation District operated Saugus and Valencia plants)
- Landfill (i.e., Toland Road) operators
- Consultant reports and technical studies
- Individual well owners

UWCD and VCWPD's respective active groundwater quality monitoring networks are shown on Figure 3-1. UWCD samples monitoring and production wells in the basins biannually in the spring and fall in order to evaluate the quality of groundwater within their boundary (UWCD, 2016). These scheduled sampling runs are occasionally supplemented by targeted event-based sampling. VCWPD annually samples production wells within the basins in the fall. VCWPD's list of groundwater sampling wells is a bit more fluid than UWCD's and is somewhat dependent on availability of staff's time and the Agency's annual budget. There is a core group of wells that VCWPD prioritizes to be sampled almost every year (green squares on Figure 3-1) and if one of these wells is unavailable for some reason, they will often sample a near-by well that is pumping (VCWPD, 2020). Potential groundwater quality spatial and temporal data gaps are discussed in Section 5.3 of this Tech Memo.

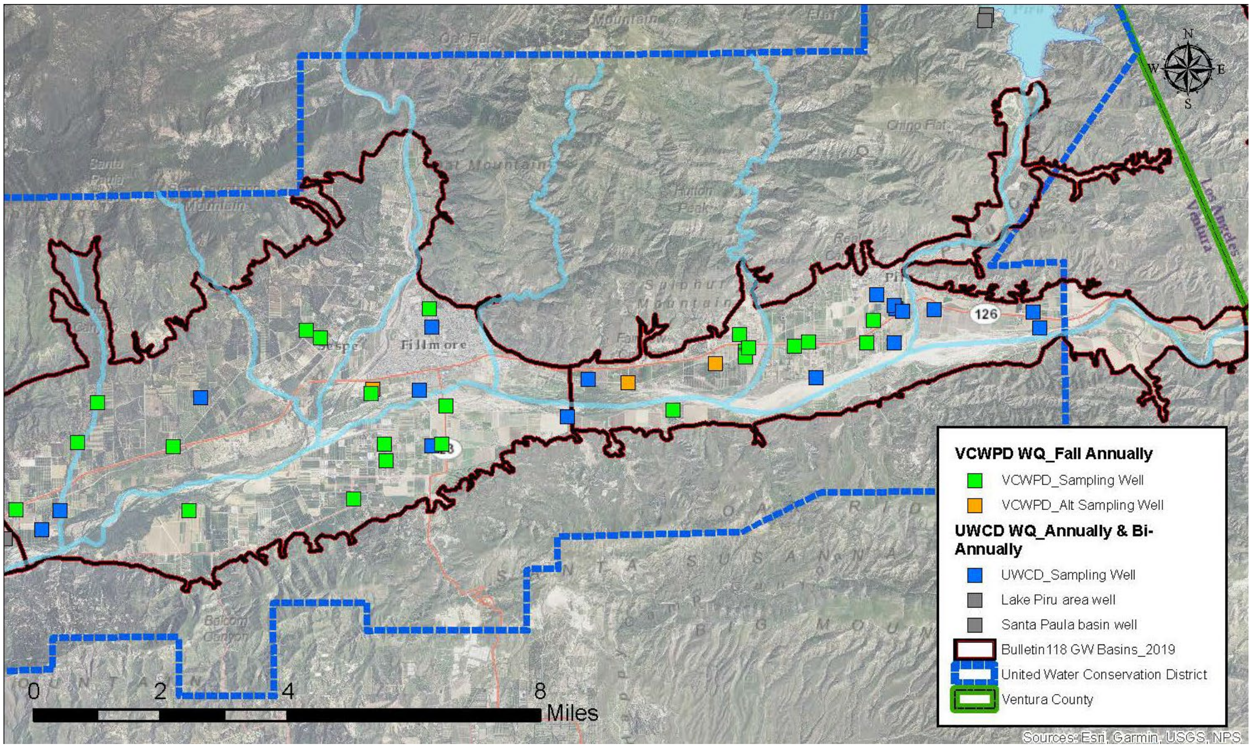


Figure 3-1. UWCD and VCWPD active status water quality sampling well sites and schedules.

Approximately 45 wells are sampled for groundwater quality within the Fillmore and Piru basins as part of UWCD and VCWPD's 2019 respective monitoring program lists (Figure 3-1). For Fillmore basin, VCWPD samples 14 wells (and has one alternate well shown as an orange square on Figure 3-1) and UWCD samples seven wells for a total of 21 unique wells. For Piru basin, VCWPD samples 10 wells (and has two alternate wells) and UWCD samples 14 wells (including the five 2-inch piezometers that comprise the RP1 nested site) for a total of 24 different wells.

3.1 Surface Water Quality

UWCD conducts monthly surface water sampling for TDS, chloride, and nitrate in the Santa Clara River downstream of the Ventura/Los Angeles County Line (see Figure 2-5 in Section 2.2.1). On a quarterly basis, surface water samples are collected for general mineral analysis from the Santa Clara River and tributaries at approximately eight locations. On alternate quarters, UWCD has a reduced suite of analytes run for some sample locations (UWCD, 2016).

The Ventura County Stormwater Resources Group coordinates surface water sampling for all MS4 permittees (Cities and County), and they collect wet and dry weather runoff samples in storm drains and rivers. For the Santa Clara River watershed, they sample at UWCD's Freeman Diversion Facility in Saticoy and one storm drain each in the Cities of Santa Paula and Fillmore (VCWPD, 2019). Annual reports are published and can be downloaded from their website (www.vcstormwater.org).

3.2 Groundwater Level

Existing monitoring networks in the Fillmore and Piru basins form the basis for the development of FPBGSA's water level monitoring program intended to demonstrate sustainable management in the basins. DWR BMP #2 advises that "Professional judgment should be used to refine the monitoring frequency and density" (DWR, 2016b). The following are four factors proposed by the DWR (adapted from ACWI, 2013) for GSA consideration when determining long-term monitoring (i.e. measurement) frequency of wells incorporated in the agency's monitoring network:

- Aquifer type and position (scale ranging shallow, unconfined to deep, confined)
- Groundwater flow and recharge rate (rapid to slow)
- Aquifer development (greater to less withdrawal)
- Climatic conditions (more to less variable)

The following excerpt from DWR's BMP #2 (DWR, 2016b) includes monitoring site frequency and density requirements for SGMA compliant water level monitoring programs:

> - Groundwater level data will be collected from each principal aquifer in the basin.
> - Groundwater level data must be sufficient to produce seasonal maps of potentiometric surfaces or water table surfaces throughout the basin that clearly identify changes in groundwater flow direction and gradient.
> - Groundwater levels will be collected during the middle of October and March for comparative reporting purposes.
>   - While semi-annual monitoring is required, more frequent, quarterly, monthly, or daily monitoring may be necessary to provide a more robust understanding of groundwater dynamics within the system.
>   - Agencies will need to adjust the monitoring frequency to address uncertainty, such as in specific places where sustainability indicators are of concern, or to track specific management actions and projects as they are implemented.

  - Select wells should be monitored frequently enough to characterize the season high and low within the basin.
- Data must be sufficient for mapping groundwater depressions, recharge areas, and along margins of basins where groundwater flow is known to enter or leave a basin.
- Well density must be adequate to determine changes in storage.
- Data must be able to demonstrate the interconnectivity between shallow groundwater and surface water bodies, where appropriate.
- Data must be able to map the effects of management actions, i.e., managed aquifer recharge or hydraulic seawater intrusion barriers.
- Data must be able to demonstrate conditions at basin boundaries.
  - Agencies may consider coordinating monitoring efforts with adjacent basins to provide consistent data across basin boundaries.
  - Agencies may consider characterization and continued impacts of internal hydraulic boundary conditions, such as faults, disconformities, or other internal boundary types.
- Data must be able to characterize conditions and monitor adverse impacts as they may affect the beneficial uses and users identified within the basin.

Groundwater level monitoring in the Fillmore and Piru basins is conducted by several organizations in addition to the monitoring programs administered by UWCD and VCWPD. These sources of water level data and/or monitoring in the basins may include, but are not limited to, the following:

- CA DWR (CASGEM);
- USGS special studies (e.g., RASA Program)
- UCSB special studies (e.g., graduate student theses, dissertations, and projects)
- City of Fillmore potable water supply wells (it is unknown if the City has monitored water levels in their wells in recent years)
- Waste Water Treatment Plant (e.g., the unincorporated town of Piru's Plant that has monitoring wells surrounding its effluent percolation ponds and operated by Ventura County Waterworks District No. 16)
- Landfill (i.e., Toland Road monitoring wells) operators
- Consultant reports and technical studies

- A few private well owners and purveyors of pumped groundwater in the basins are known to measure and maintain water level records for their wells

Potential groundwater level spatial and temporal data gaps are discussed in Section 5.4 of this Tech Memo.

3.2.1 UWCD and VCWPD Networks

UWCD and VCWPD's active monitoring networks are shown on Figure 3-2. Groundwater levels are measured in wells included on VCWPD and UWCD's respective water level monitoring program lists. Measurements are made with either a steel survey tape, acoustic sounder (VCWPD only), dual-wire or single-wire electric sounder. Monitoring protocols and standard methods for measuring groundwater levels in wells are described in the FPBGSA's SAP (FPBGSA, 2020).

VCWPD monitors groundwater levels in wells on a quarterly basis and UWCD conducts its monitoring on monthly, bimonthly, semi-annual or event-based schedules. Five wells in the basins are shown on Figure 3-2 (red circles) that are monitored by both UWCD and VCWPD staff. The overlap between VCWPD and UWCD's monitoring networks is useful as a QA/QC measure to ensure consistency between data collected by the different entities (UWCD, 2016).

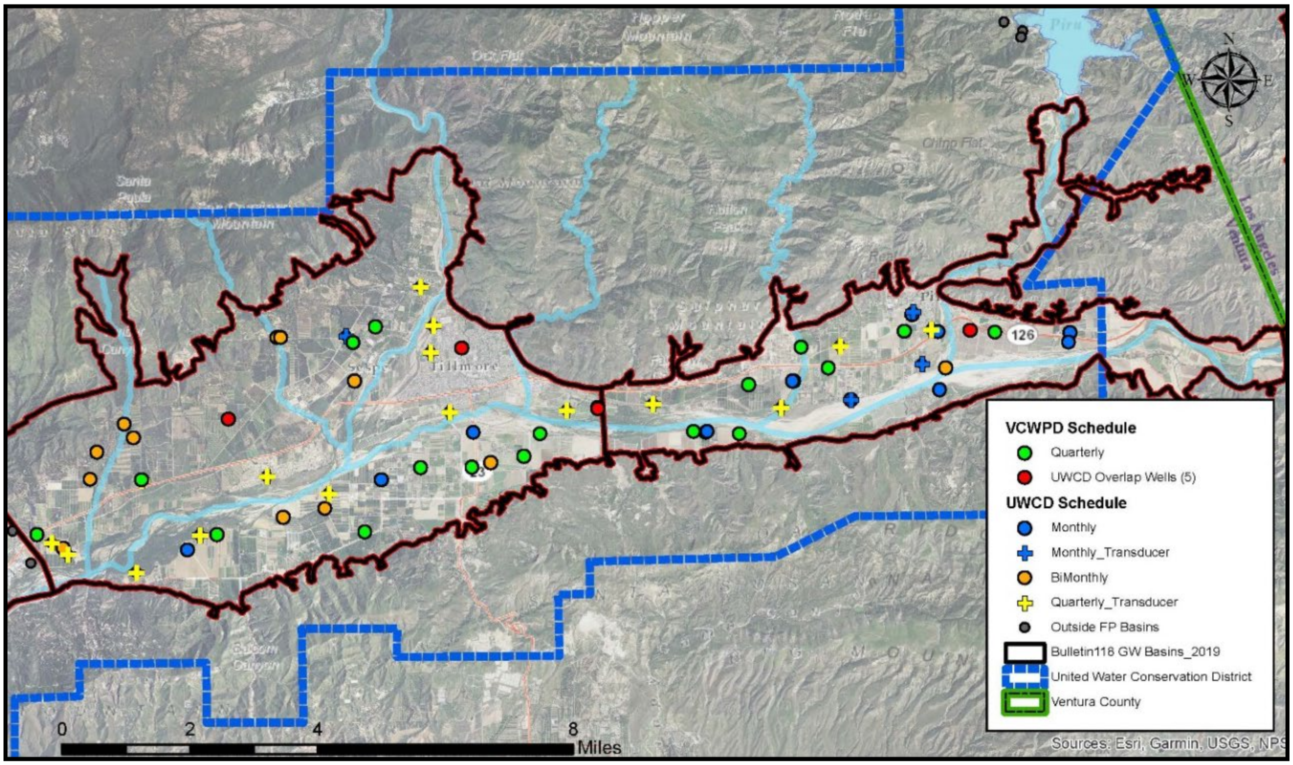


Figure 3-2. UWCD and VCWPD active status groundwater level measurement well sites and schedules.

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program is a collaboration between local monitoring parties and the DWR to collect statewide groundwater elevation measurements from wells in each basin throughout the State. Much of the water level data directly collected or gathered from other sources by VCWPD and UWCD is reported to the State and made publicly available as part of the program. VCWPD acts as the CASGEM submitting agency for water level data collected in Ventura County (VCWPD, 2016).

More than 70 unique wells are measured for groundwater level within the Fillmore and Piru basins according to UWCD and VCWPD 2019 respective monitoring program lists (Figure 3-2).

From the lists, 41 wells are monitored for water level in the Fillmore basin. VCWPD monitors 14 wells and there are four overlap wells included in the 31 wells UWCD monitors. Of these, 13 wells were equipped with pressure transducers and data loggers as of the end of 2019. An additional pressure transducer was installed near the Fillmore Fish Hatchery in winter 2020 (data from this sensor are not yet available).

A total of 30 wells are monitored for groundwater levels in the Piru basin according to the 2019 lists. Of these, VCWPD monitored eight, UWCD monitored 22 wells and there was one overlap well. UWCD has eight wells equipped with pressure transducers and data loggers in Piru basin.

3.2.2 Pressure Transducers and Data Loggers

Pressure transducers and data loggers can be used for recording water level measurements in wells on user defined or event based schedules. The electrical components of the device are sealed in a housing that is installed below the water level surface in the well. The devices can be downloaded during well-site visits or can be connected to telemetry systems to transmit data remotely.

Measured raw data are pressure (commonly reported in pounds per square inch [psi]) exerted by the water column and atmosphere above the sensor. As the water column above the sensor increases, the measured pressure increases. A simple linear relationship (correction coefficient) can be applied to adjust output readings to depth to water in the well or water level elevation referenced to mean sea level (given a RP elevation has been surveyed for the site). Further detail regarding pressure transducer and data logger field procedures and the DWR’s recommendations are described in the FPBGSA’s SAP (FPBGSA, 2020).

Office-based data processing includes tying the pressure transducers to manual water level measurements and periodically checking (i.e., QA/QC) the reliability of the high-frequency pressure transducer measurements against periodic manual measurements to ensure a high level of confidence in the data. If deployed pressure transducers are not vented to the atmosphere, data should be barometrically corrected for changes in atmospheric pressure.

Data obtained from the UWCD deployment of pressure transducers and data loggers is an important component of the groundwater level monitoring network in the Fillmore and Piru basins. UWCD expends considerable staff time maintaining and processing the pressure transducer data they collect in the Fillmore and Piru basins and other basins within their Agency’s boundary.

In addition to these data, UWCD also requests pressure transducer data recorded by Farmers Irrigation Company (FICO) in their wells roughly three times per year. Data from five FICO wells near the Santa Paula/Fillmore basins boundary are processed and archived by UWCD. FICO operates primarily in Santa Paula basin but has one well just across the basin boundary in Fillmore basin. The sensor in this well (i.e., 03N21W12F07S) is the only known pressure transducer employed for groundwater level monitoring in the Fillmore and Piru basins that is connected to a telemetry system.

Most of the pressure transducers in the Fillmore and Piru basins operated by UWCD are programed to a recording frequency of every four hours (six water level measurement per day). These high-frequency data provide a level of detail that is useful in assessing short-term trends that may be masked by biannual or monthly water level measurement programs. Potential groundwater level short-term trends that can be assessed from these data may include, but are not necessarily limited to, the following:

- Daily diurnal fluctuations
- Groundwater recharge events (e.g., in shallow wells near the Santa Clara River);
- Pumping from nearby wells
- Drawdown and recovery when installed in pumping wells

Pressure transducers and data loggers are also valuable for collecting highly reliable data for assessing seasonal high and low trends. UWCD produces groundwater level hydrographs from the high-frequency pressure transducer data that they use to pick spring high (max) and fall low (min) water levels that are processed for import into their database and are included in FPBGSA's database for GSP preparation.

These data are especially useful for the spring high and fall low groundwater level elevation contouring. UWCD uses these data and manual water level measurements for groundwater level contouring for inclusion on maps in their hydrogeological conditions report series. UWCD does not store the voluminous recording pressure transducer data directly in their database but maintains these records in excel files for individual wells and archives raw data logger downloaded files on their servers.

Table 3-1. Pressure Transducers and Data Loggers in Fillmore and Piru basins and their available period of record.

Pressure Transducer & Data Logger Equipped Well	DWR Basin	Owner Entity	Water Level Period of Record
03N20W03D03S	Fillmore	UWCD	06/2019 - present
03N20W03H01S	Fillmore	UWCD	08/2015 - present
03N20W05D03S	Fillmore	UWCD	04/2013 - present
03N20W07HRP9	Fillmore	UWCD	04/2017 - present
03N20W08VCWPD8	Fillmore	UWCD	04/2017 - present
03N21W12B04S	Fillmore	UWCD	01/2012 - present
03N21W12F02S	Fillmore	UWCD	01/2012 - 05/2012
03N21W12F07S	Fillmore	FICO	01/2016 - present
03N21W12H01S	Fillmore	UWCD	01/2012 - present
04N19W32B03S	Fillmore	UWCD	2020 - present
04N19W32F02S	Fillmore	UWCD	09/2009 - 01/2012
04N20W23N01S	Fillmore	UWCD	02/2015 - present
04N20W24C02S	Fillmore	UWCD	12/2010 - present
04N20W24Q03S	Fillmore	UWCD	02/2011 - present
04N20W25B03S	Fillmore	UWCD	07/2014 - present
04N20W36MW104	Fillmore	UWCD	09/2008 - present
04N18W20M01S	Piru	UWCD	07/2017 - present
04N18W20P02S	Piru	UWCD	09/2008 - 07/2017
04N18W20P04S	Piru	UWCD	09/2008 - present
04N18W29M02S	Piru	UWCD	11/2007 - present
04N18W31D03S	Piru	UWCD	11/2007 - 09/2010, 06/2017 - present
04N18W31D04S	Piru	UWCD	09/2010 - present
04N18W31D07S	Piru	UWCD	11/2007 - 07/2013
04N19W25A02S	Piru	UWCD	04/2013 - present
04N19W34D01S	Piru	UWCD	12/2015 - present
04N19W36D01S	Piru	UWCD	09/2008 - present

Table 3-1 shows the currently and historically deployed pressure transducer in the Fillmore and Piru basins (locations shown on Figure 3-2 above). Groundwater level hydrographs from high-frequency recording pressure transducers deployed in the Fillmore, Piru, and east Santa Paula basins are in Appendix B.

3.3 Adjacent Basins Monitoring Networks and Coordination

As mentioned above, the Fillmore and Piru basins are hydrogeologically connected to adjacent basins. These basins are the adjudicated Santa Paula basin (DWR basin ID: 4-4.04) located west (down-gradient) of Fillmore basin and Santa Clara River Valley East basin (DWR basin ID: 4-4.07) located east (up-gradient) of Piru basin.

Groundwater basins that have gone through an adjudication process (such as the Santa Paula basin) are exempt from a number of the SGMA requirements but do have new requirements to report basin conditions to the DWR (UWCD, 2016). UWCD and VCWPD existing long-standing monitoring networks in Ventura County both include monitoring in Santa Paula basin. The respective entities regularly measure wells for groundwater level and sample for water quality on similar schedules as described earlier in this Section. These existing monitoring networks that operate in multiple basins have a benefit of providing continuity to data collection that affords a high level of data consistency and reliability for comparison across basin boundaries.

SCR Valley East basin is a DWR designated “high” priority basin and is located almost entirely in Los Angeles County and is outside the boundary of UWCD. VCWPD’s boundary includes only the west most 67 acre sliver of the basin that protrudes into Ventura County. Historically similar to Fillmore and Piru basins, groundwater monitoring and management existed in SCR Valley East basin prior to SGMA. Consultants are currently preparing a GSP for that basin for the Santa Clarita Valley Groundwater Sustainability Agency (SCV-GSA) under the same SGMA timeline as the Fillmore and Piru basins. Monitoring program coordination between the FPBGSA and SCV-GSA will be important in ensuring data consistency and reliability for comparison across basin boundaries.

4. Trend Analysis

The trend analysis included in this Section includes evaluation of groundwater quality analytes (chemicals) and water level observations from select wells in Fillmore and Piru basins that contain sufficient data for the analysis. Although data from east Santa Paula basin and from wells outside DWR mapped groundwater basins are archived in FPBGSA’s database, these data are not included in the trend analysis presented in this Section. Consideration of the aquifer zone or zones (Section 1.2.5) in which a well is open (screened) is important in appropriately interpreting the observed trends. An evaluation of observed groundwater level in wells for wet, average and dry precipitation years compared with screened interval depth is included in Section 4.2.1.

The following excerpt is from 23 CCR §354.34. Monitoring Network:

> (a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate <u>short-term</u>, <u>seasonal</u>, and <u>long-term</u> trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation [text underlining emphasis added].

Evaluation of trend types (i.e., short-term, seasonal and long-term), as understood from the SGMA legislation, require data collected at varying frequencies although high-frequency data can be paired down for analysis that require less frequent data. Short-term and seasonal trend evaluations may require higher frequency data than long-term trends and therefore require a greater level of effort and cost to gather the necessary data. Short-term trend analysis is used here as analogous with “recent” trends discussed in Section 4.1.1 (USGS GAMA Trends) and is simply defined as trends identified from data collected since the year 2000 (Dupuy et al., 2019).

Wells equipped with data loggers (e.g., pressure transducers and water quality sensors) can be useful tools for assessing short-term and seasonal trends. Often collection of higher frequency data from newly established monitoring sites is necessary to assess site-specific short-term and seasonal trends. Overtime, once these trends are understood, it may be determined from the data that less frequent monitoring is adequate for collecting representative data for describing local groundwater conditions. “An understanding of the full range of monitoring well conditions should be reached prior to establishing a long-term monitoring frequency” (DWR, 2016b).

Seasonal trends (e.g., minimum and maximum annual fluctuation or separating summer and winter collected data for independent evaluation) can be assessed utilizing biannual, quarterly or higher frequency data. Less frequent (e.g., annual or biennial) data collection can be leveraged for assessing long-term trends. Trend analysis results may be somewhat dependent on the time period selected for data evaluation. Commonly, data availability influences the time period selected for analysis.

For the trend analysis presented in this Tech Memo the following trend type general criteria were used for analysis of select groundwater data:

- Short-Term (Recent): Available data since the year 2000
- Seasonal (Short-Term): Available biannual or higher frequency data

- Long-Term: Last 36 years (1983 - 2018)

The long-term time period of water years 1983 through 2018 employed for the purpose of data trend analysis in this Tech Memo was selected with consideration of available annual precipitation data (see Figure 2-9). The time period includes both wet and dry cycles including the recent drought years. Water year 1983 is among the wettest on record and the ensuing period through 2018 includes several above average years, some of which are over twice the long-term average (i.e., 1998 and 2005). A standardized period of analysis is used in this Tech Memo for assessing trends to facilitate better comparison of trend spatial distribution from well to well. Complete record sets (i.e., including data prior to 1983) for the groundwater data analyzed in this Section are included in the Appendix of this Tech Memo (Appendix A for water level and Appendix D for groundwater quality).

As mentioned above, complete datasets are currently available through calendar year 2018 and more recent data are presented in this Tech Memo where available. Trends are assessed through 2018 in order to provide context of groundwater conditions leading into the potential adoption and initiation of the GSPs implementation period. Future analysis in the GSPs may include the identification of base periods that differ from the time periods used in this Tech Memo and may include stakeholder input and additional recent data, if available.

Note that according to VCWPD, the base period of October 1957 to September 1992 is the best 35 year period for representing long-term averages for multiple sites in Ventura County (VCWPD Hydrodata, 2020). However, this period excludes recent data and may not be representative of future climatic conditions. The nearly three-decades following this period have proven to be more dynamic and extreme (in both wet and dry periods) than the previous 35 years.

Trends are commonly described as increasing, decreasing, relatively stable or no clear trend. For groundwater levels, an increasing trend is one in which water level elevations are increasing relative to mean sea level and inversely, depth to water is decreasing. When describing water quality trends, “degrading” is sometimes used to denote increasing trends while “improving” is used for describing decreasing trends.

4.1 Groundwater Quality

Groundwater quality in the Fillmore and Piru basins is generally of a high quality and is consumed for a variety of beneficial uses in the basins that include, but are not limited to, domestic, agricultural crop irrigation and environmental uses. The main water quality concern over the past couple of decades for agricultural users in the Piru basin (and to a lesser extent in the down-gradient Fillmore basin) has been impacts associated with high chloride concentrations in the Santa Clara River (SCR) flows sourcing from Los Angeles County (UWCD, 2016). Chloride in the groundwater of the basins is discussed in Section 4.1.2.3 below.

From 1951 to 1968 elevated concentrations of TDS, sulfate, chloride and boron were recorded near the Ventura/Los Angeles County Line, and is generally attributed to the surface discharge of oil field brines prior to the enactment of the Federal Clean Water Act (UWCD, 2016). However, high TDS and chloride persisted in Santa Clara River in surface water sampled near the County Line and in local groundwater after passage of the Clean Water Act.

In Fillmore basin according to VCWPD (2016):

> . . . County records indicate that water wells are generally no deeper than approximately 950 feet. Water quality can vary greatly depending on depth of the well. Shallow groundwater is generally younger and recharged by river flows. Deeper groundwater is older and has acquired chemistry through dissolution of constituents from the surrounding sediments . . . Water quality tends to become poorer to the southeast portion of the basin in the vicinity of the Oak Ridge fault.

4.1.1 USGS GAMA-Priority Basin Project Public-Supply Well Results: Inorganic Data and Trends

A USGS GAMA California statewide groundwater trend analysis published in 2019 (Dupuy et al.) is summarized in this Subsection as it pertains to the Fillmore and Piru basins. Where available, the inorganic data and USGS assigned trends span the time period of 1974 through 2014. Analysis results are available via an online portal that includes an interactive map and basic data querying tools. Figure 4-1 shows the location of the wells included in the USGS analyzed dataset. Orange dots on the map are those wells that have study identified recent trends and yellow dots are those with no recent identified trends.

Data for all public-supply wells (PSW) shown on the map are available for download through the portal and these data are also included in FPBGSA’s database. Domestic-supply wells were included in the USGS GAMA-Priority Basin Project (PBP) but no domestic wells were included in the study for Fillmore and Piru basins.

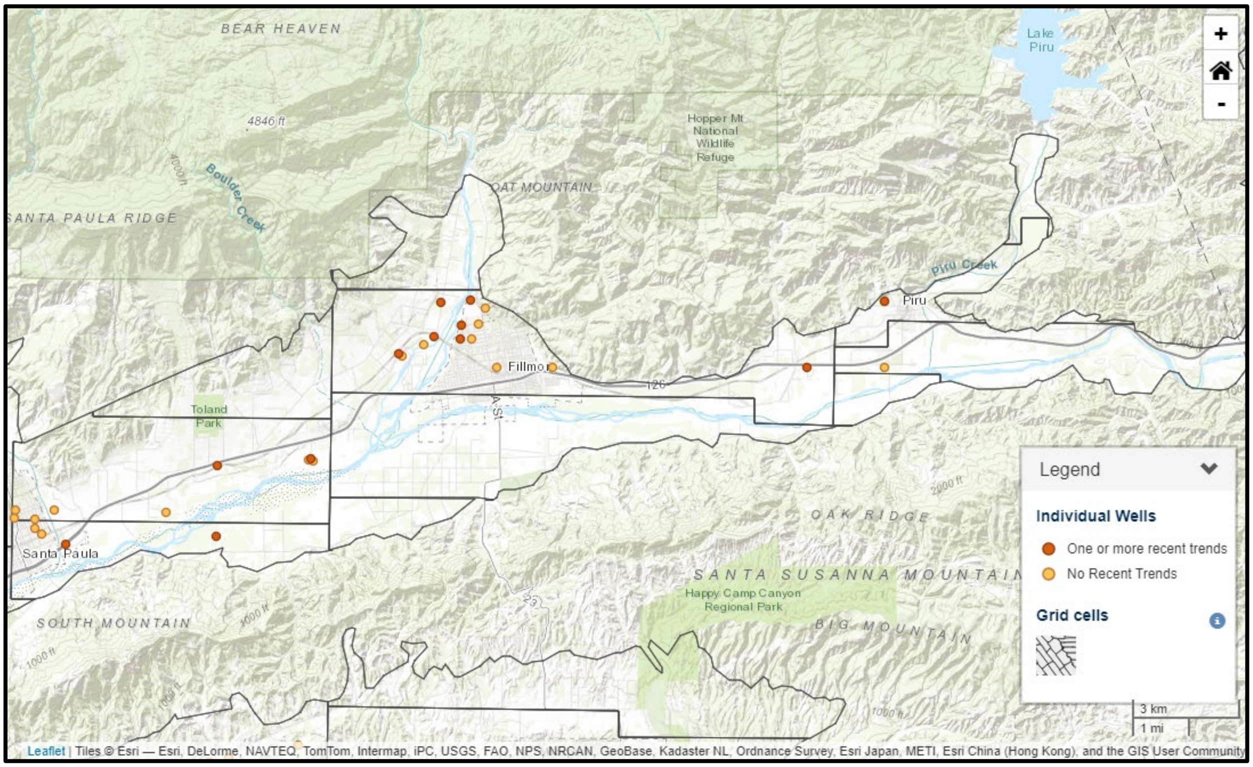


Figure 4-1. Fillmore and Piru basins portion of USGS CA GAMA-Priority Basin Project Public-Supply Well Results: Inorganic Data and Trends (map modified from USGS online viewer [Dupuy et al., 2019]).

Figure 4-1 shows the basins subdivided into equal-area grid cells that were originally created by the GAMA Priority Basin Project for the purpose of assessing water quality conditions of groundwater resources used for public drinking water in the State of California. The number and size of grid cells were based on the size of the area being sampled and the number of public-supply wells available to sample in each study area (Johnson et al., 2018). The study area boundaries are reportedly based on basin and subbasin boundaries, local geology, local knowledge, and watershed data. Cell-specific information is available for user inputted constituents (e.g., chloride), including information about the location, number of wells tested for trends, and the cell score (Dupuy et al., 2019). Wells located in the eastmost portion of Santa Paula basin are included in cells that are mostly within Fillmore basin. It appears that DWR 2003 Bulletin 118 groundwater basins mapping were used by the USGS in cropping the grid cells to include only the portion of a cell within a mapped groundwater basin.

Time-series graphs showing the USGS identified trends are also available via the online portal. Trends are shown on the graphs using the Theil-Sen Slope estimator method for fitting a straight line (linear regression) through sample points. Microsoft Excel® employs a least squares estimate approach for fitting linear "best-fit" lines to data points. The least squares method is valid when the data elements fit a straight line but is somewhat sensitive to outliers. Interpretation of trend results must account for this potential method limitation.

Different types of trends are defined for the USGS GAMA statewide trend study. These are shown graphically in Figure 4-2. Seasonal and Reversal trends are not identified from any of the water quality constituents analyzed in the USGS study for wells in Fillmore and Piru basins.

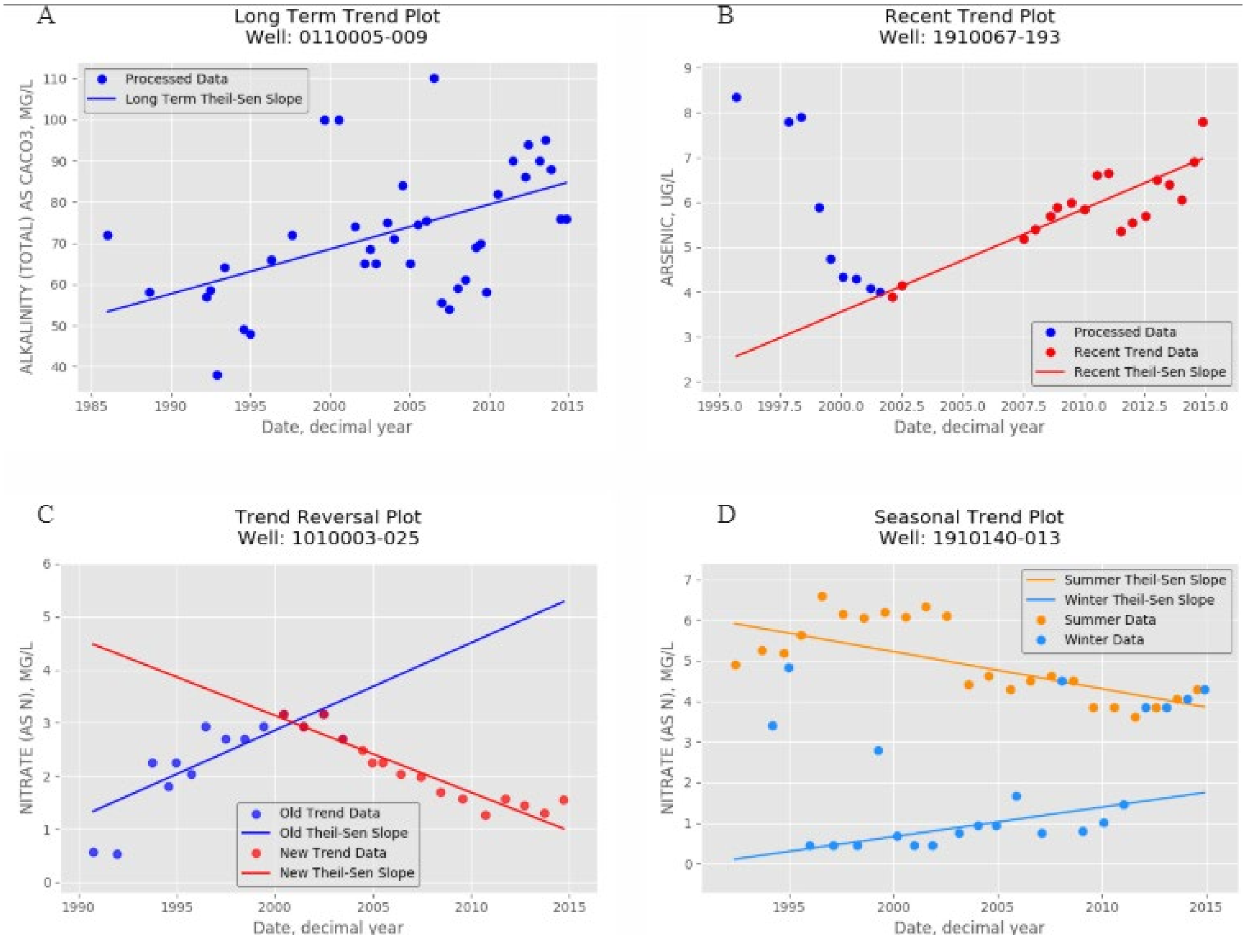


Figure 4-2. Examples of (A) long-term, (B) recent, (C) reversing, and (D) seasonal trends (Modified from Figure 1 [Dupuy et al., 2019]).

According to metadata available through the interactive map (Dupuy et al., 2019):

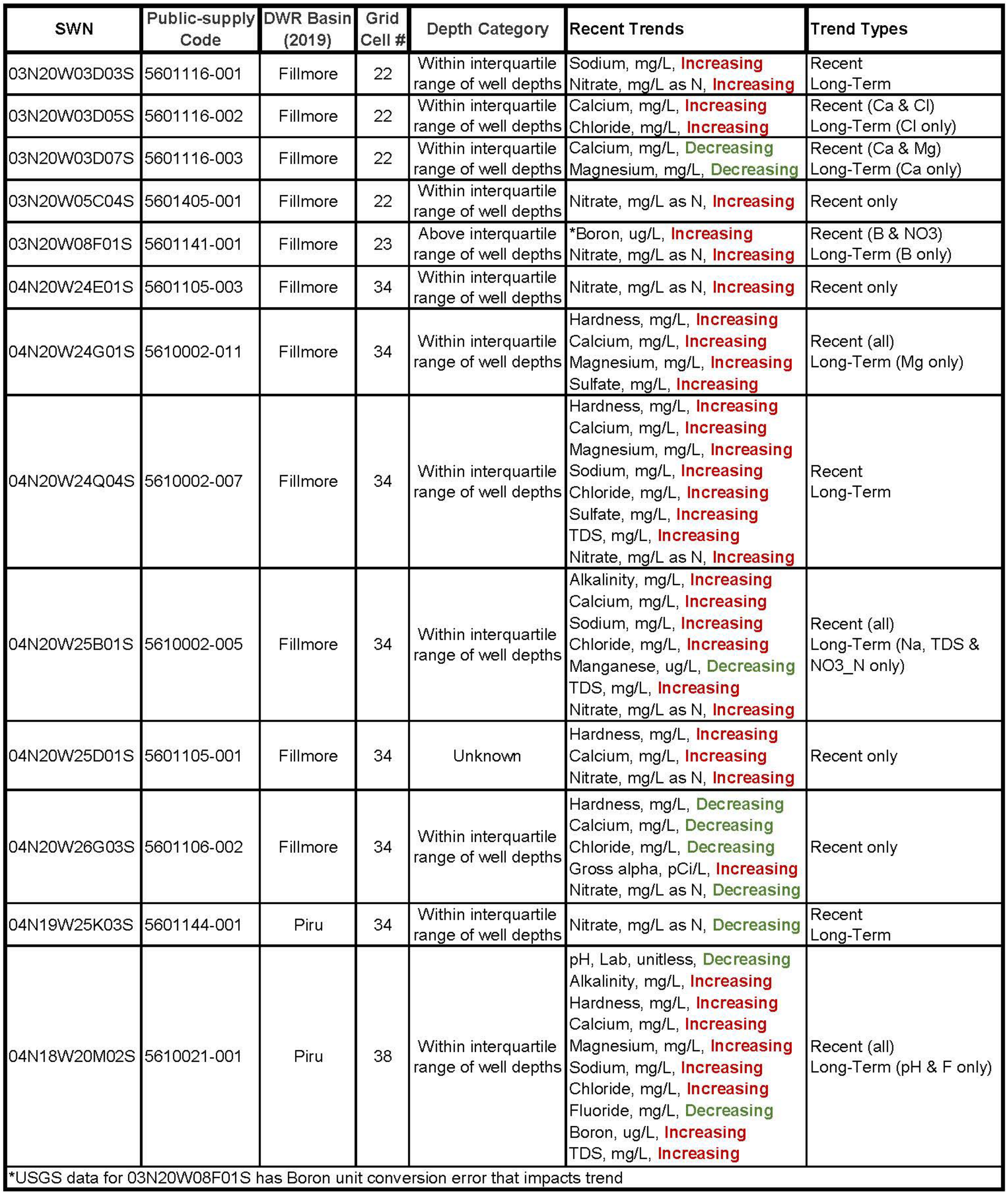
> Trend results can be shown from wells that have increasing trends or decreasing trends. Wells that were tested but do not have significant trends and wells that were not tested can also be shown. Wells with less than 4 data points were not tested for trends . . .
>
> Tests for trends were applied to different time periods and in different ways in order to identify long-term trends (LT), recent trends (RT), reversals in water quality trends (TRV) and trends that have seasonal concentration differences (ST). LTs were computed using the entire period of record, while RTs were computed using data since the year 2000. TRVs were computed for datasets with at least 8 data points spanning at least 8 years. STs were computed using sampling that occurred during the summer or winter when the water-quality data was statistically different . . .
>
> Public-supply wells were categorized by well depth by calculating the interquartile range (25th - 75 percentile) of well depth within each study unit. Public-supply wells with well depth above (shallower) the interquartile range, within the interquartile range, or below (deeper) the interquartile range can be filtered. Wells without well depth information were categorized as unknown.

Table 4-1 lists the wells located in the Fillmore and Piru basins included in the USGS trend analysis. The grid cell number is shown on the table for assistance in approximately locating the wells on Figure 4-1. Trends were identified for the following analytes for wells that contained sufficient data according to the USGS criteria described above:

- Alkalinity, mg/L
- Boron, µg/L
- Calcium, mg/L
- Chloride, mg/L
- Fluoride, mg/L
- Gross Alpha, pCi/L
- Hardness, mg/L
- Magnesium, mg/L
- Manganese, µg/L
- Nitrate as N, mg/L
- pH (lab reported), unitless
- Sodium, mg/L
- Sulfate, mg/L

- TDS, mg/L

Table 4-1. USGS CA GAMA-Priority Basin Project public-supply well Results for wells the in Fillmore and Piru basins.



SWN	Public-supply Code	DWR Basin (2019)	Grid Cell #	Depth Category	Recent Trends	Trend Types
03N20W03D03S	5601116-001	Fillmore	22	Within interquartile range of well depths	Sodium, mg/L, Increasing Nitrate, mg/L as N, Increasing	Recent Long-Term
03N20W03D05S	5601116-002	Fillmore	22	Within interquartile range of well depths	Calcium, mg/L, Increasing Chloride, mg/L, Increasing	Recent (Ca & Cl) Long-Term (Cl only)
03N20W03D07S	5601116-003	Fillmore	22	Within interquartile range of well depths	Calcium, mg/L, Decreasing Magnesium, mg/L, Decreasing	Recent (Ca & Mg) Long-Term (Ca only)
03N20W05C04S	5601405-001	Fillmore	22	Within interquartile range of well depths	Nitrate, mg/L as N, Increasing	Recent only
03N20W08F01S	5601141-001	Fillmore	23	Above interquartile range of well depths	*Boron, ug/L, Increasing Nitrate, mg/L as N, Increasing	Recent (B & NO3) Long-Term (B only)
04N20W24E01S	5601105-003	Fillmore	34	Within interquartile range of well depths	Nitrate, mg/L as N, Increasing	Recent only
04N20W24G01S	5610002-011	Fillmore	34	Within interquartile range of well depths	Hardness, mg/L, Increasing Calcium, mg/L, Increasing Magnesium, mg/L, Increasing Sulfate, mg/L, Increasing	Recent (all) Long-Term (Mg only)
04N20W24Q04S	5610002-007	Fillmore	34	Within interquartile range of well depths	Hardness, mg/L, Increasing Calcium, mg/L, Increasing Magnesium, mg/L, Increasing Sodium, mg/L, Increasing Chloride, mg/L, Increasing Sulfate, mg/L, Increasing TDS, mg/L, Increasing Nitrate, mg/L as N, Increasing	Recent Long-Term
04N20W25B01S	5610002-005	Fillmore	34	Within interquartile range of well depths	Alkalinity, mg/L, Increasing Calcium, mg/L, Increasing Sodium, mg/L, Increasing Chloride, mg/L, Increasing Manganese, ug/L, Decreasing TDS, mg/L, Increasing Nitrate, mg/L as N, Increasing	Recent (all) Long-Term (Na, TDS & NO3_N only)
04N20W25D01S	5601105-001	Fillmore	34	Unknown	Hardness, mg/L, Increasing Calcium, mg/L, Increasing Nitrate, mg/L as N, Increasing	Recent only
04N20W26G03S	5601106-002	Fillmore	34	Within interquartile range of well depths	Hardness, mg/L, Decreasing Calcium, mg/L, Decreasing Chloride, mg/L, Decreasing Gross alpha, pCi/L, Increasing Nitrate, mg/L as N, Decreasing	Recent only
04N19W25K03S	5601144-001	Piru	34	Within interquartile range of well depths	Nitrate, mg/L as N, Decreasing	Recent Long-Term
04N18W20M02S	5610021-001	Piru	38	Within interquartile range of well depths	pH, Lab, unitless, Decreasing Alkalinity, mg/L, Increasing Hardness, mg/L, Increasing Calcium, mg/L, Increasing Magnesium, mg/L, Increasing Sodium, mg/L, Increasing Chloride, mg/L, Increasing Fluoride, mg/L, Decreasing Boron, ug/L, Increasing TDS, mg/L, Increasing	Recent (all) Long-Term (pH & F only)

*USGS data for 03N20W08F01S has Boron unit conversion error that impacts trend

In total, 11 wells in Fillmore basin and two wells in Piru basin were identified with water quality trends in the USGS study. These wells are not evenly distributed throughout the basins with the majority of wells concentrated in the Sespe Upland area of Fillmore basin adjacent to Sespe Creek (grid cell 34). Of the 48 identified trends, 38 are increasing (degrading) and 10 are decreasing (improving). These recent trends include data since the year 2000 which is in a sense "weighted" by a very wet year (i.e., 2005) early in the period and a severe drought at the end of the period of evaluation.

Record sets from the wells analyzed in the USGS GAMA trend study were also included in Section 4.1.2 for the primary chemicals of concern in the Fillmore and Piru basins. Additional datasets from wells including domestic wells that were not included in the USGS GAMA trend study were included in the analysis summarized in Section 4.1.2 below. In some cases, expanded datasets were available for wells included in the USGS GAMA trend study. Similar trend results were generally identified in this Tech Memo even though trend analysis criteria tailored to the Fillmore and Piru basins available groundwater quality dataset differs somewhat. In a couple instances USGS GAMA study identified trends were reported as "insufficient data" and increasing nitrate trends for wells 04N20W24E01S and 04N20W25D01S were reported as "Relatively Stable" according to the criteria developed for the independent evaluation included in the following Section of this Tech Memo.

4.1.2 Primary Chemicals of Concern

Historically water quality chemicals (analytes or constituents) of concern (COCs) in the basins have generally included, but are not necessarily limited to, the following analytes:

- TDS
- Sulfate
- Chloride
- Nitrate
- Boron (UWCD monitoring program only)

In addition to these chemicals, other chemicals of concern are evaluated in Section 4.1.3 that do not have sufficient datasets that meet the trend analysis criteria presented in this Section or the chemical has not historically been raised as a prominent concern in the basins (e.g., iron and manganese). The Federal EPA regulations and California Code of Regulations (CCR) identify maximum contaminant levels (MCLs) for drinking water for a wide range of chemicals. The federal EPA also provides secondary MCLs (non-enforceable guidelines) for contaminates that may cause cosmetic (e.g., skin or tooth discoloration) or aesthetic (e.g., taste, odor or color) effects. The MCLs and secondary MCLs (where applicable) for the five chemicals of concern and additional chemicals of concern assessed in this Tech Memo are shown in Table 4-2.

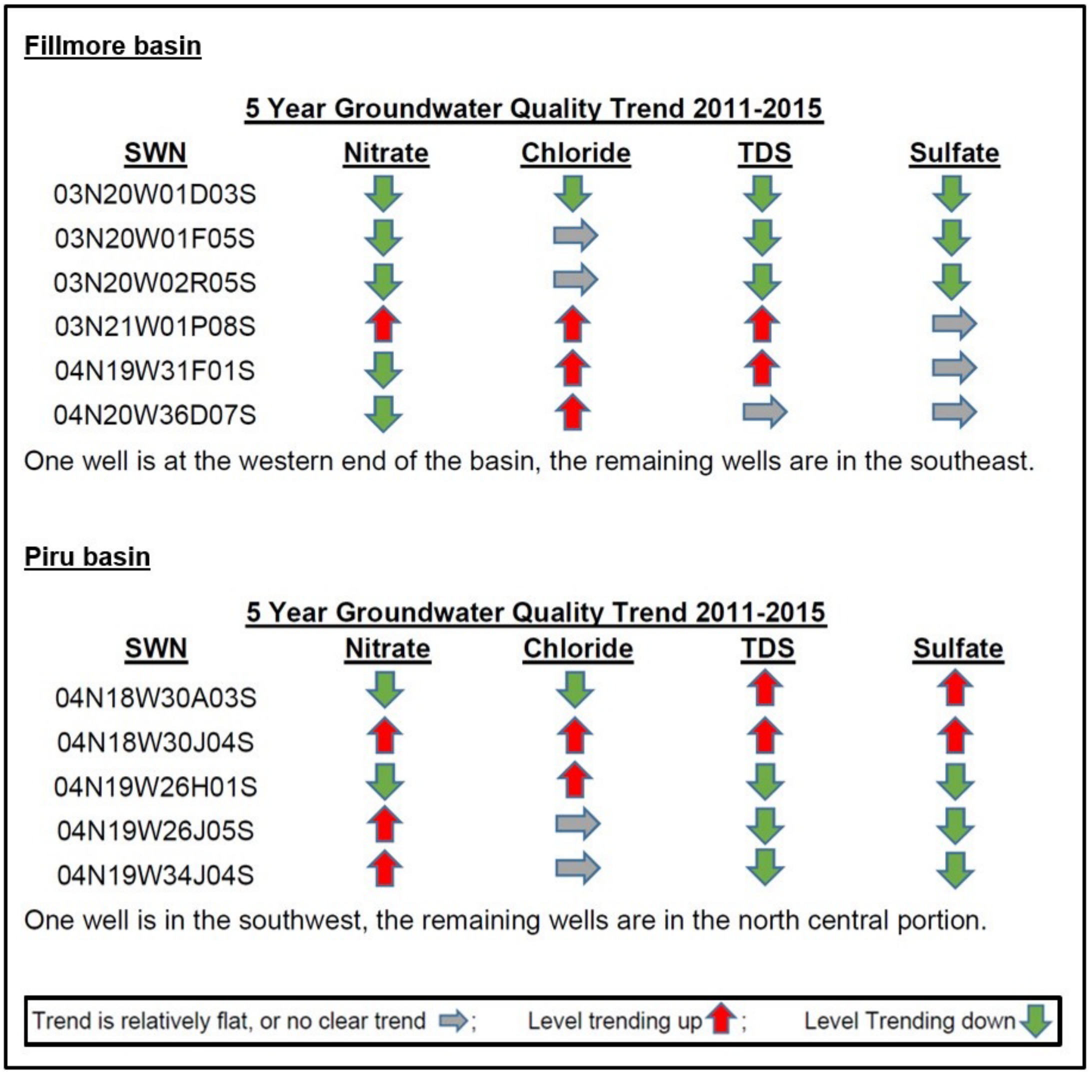
Table 4-2. Select U.S. Environmental Protection Agency Primary and Secondary Standards (May 2009) and California Code of Regulations, Title 22 Maximum Contaminant Levels (February 2012).

Chemical	Chemical Formula	EPA MCL (mg/l) *unless noted*	CCR, Title 22 MCL (mg/l)
Gross Alpha		15 pCi/L	
Lead	Pb	0.015*	
Nitrate (as Nitrogen)	N	10	10
Nitrate	NO_3		45
Selenium	Se	0.05	0.05
Uranium	U	0.03 (~20 pCi/L)	
		Secondary MCL (mg/l)	
Boron	B		1**
Chloride	Cl	250	
Iron	Fe	0.3	
Manganese	Mn	0.05	
Sulfate	SO_4	250	
Total Dissolved Solids	TDS	500	

*0.015 mg/L (15 µg/L) is the Action Level for Lead, the public health goal is zero.

**California State Notification Level, Boron is an unregulated chemical without an established

The five primary chemicals of concern analyzed in this Section have been used historically as water quality indicators of the “health” of the basins. Both UWCD and VCWPD have traditionally reported on the trends of these analytes in annual or biennial reports, with the exception of boron in which only UWCD has systematically reported. VCWPD reports the groundwater trends of six wells for Fillmore basin and five wells in Piru basin for the period from 2011 to 2015 in their most recently published Annual Report of Groundwater Conditions (VCWPD, 2016). These trends are shown graphically in Figure 4-3.



Fillmore basin

5 Year Groundwater Quality Trend 2011-2015

SWN	Nitrate	Chloride	TDS	Sulfate
03N20W01D03S	⬇	⬇	⬇	⬇
03N20W01F05S	⬇	⇨	⬇	⬇
03N20W02R05S	⬇	⇨	⬇	⬇
03N21W01P08S	⬆	⬆	⬆	⇨
04N19W31F01S	⬇	⬆	⬆	⇨
04N20W36D07S	⬇	⬆	⇨	⇨

One well is at the western end of the basin, the remaining wells are in the southeast.

Piru basin

5 Year Groundwater Quality Trend 2011-2015

SWN	Nitrate	Chloride	TDS	Sulfate
04N18W30A03S	⬇	⬇	⬆	⬆
04N18W30J04S	⬆	⬆	⬆	⬆
04N19W26H01S	⬇	⬆	⬇	⬇
04N19W26J05S	⬆	⇨	⬇	⬇
04N19W34J04S	⬆	⇨	⬇	⬇

One well is in the southwest, the remaining wells are in the north central portion.

Trend is relatively flat, or no clear trend ⇨; Level trending up ⬆; Level Trending down ⬇

Figure 4-3. Fillmore and Piru basins five year groundwater quality trend 2011-2015. Modified from VCWPD Basin Summary Sheets (summary pages v and vii) from the 2015 Annual Report of Groundwater Conditions (VCWPD, 2016).

As mentioned above in Section 1.4 (Representative Monitoring Points), BMOs were established for water quality at various locations in the basins' Draft AB 3030 Groundwater Management Plan update. The BMOs were generally based on the groundwater quality objectives identified by the Los Angeles Regional Water Quality Control Board (CA RWQCB-LA, 1994), except in the Piru basin east of Piru Creek. The Regional Board's Basin Plan objectives for groundwater east of Piru creek were set unreasonably high for TDS, sulfate and chloride, and are reflective of historic (i.e., 1951 to 1968) pollution generally attributed to the surface discharge of oil field brines prior to the enactment of the Federal Clean Water Act. The BMOs for the Piru basin east of Piru Creek in the Plan were set to agree with the Regional Board's objectives for the Piru basin west of Piru Creek (UWCD, 2016). For details on criteria the Regional Board used to set groundwater basin objectives refer to Draft 2013 Piru/Fillmore basins AB 3030 Groundwater Management Plan update (PF GMC, 2013) and California Regional Water Quality Control Board, Los Angeles Region's Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (CA RWQCB-LA, 1994). These historical BMOs for the basins are mentioned here to provide context for historical concern of specific groundwater quality constituents in the basins.

Groundwater quality data from select wells within the Fillmore and Piru basins that contained robust record sets as defined by the criteria outlined below were included in the trend analysis for the five primary chemicals of concern. These criteria are slightly more rigorous than that of the USGS GAMA Trend Study and allows for standardized comparison of trends from well to well in the basins. The time periods and criteria for evaluation of the three trend types include:

- Short-Term (Recent) and Seasonal: Available data since the year 2000. Annual minimum sampling frequency (biannual for seasonal assessment) with at least 6 data points (12 for seasonal assessment) spanning 8 years and no more than 4 year gaps.
- Long-Term: Last 36 years from 1983 - 2018. Data spans complete time period with no more than 6 year gaps.

Groundwater quality record sets for individual wells included in this evaluation generally comprise, but are not necessarily limited to, wells historically reported by VCWPD (see Figure 4-3), UWCD (including the former Draft AB 3030 Plan BMO wells), USGS GAMA wells and select additional wells. All available record sets for wells that met the criteria outlined above were used in the analysis. The groundwater quality time-series trend analysis graphs are included in Appendix E.

There are more recent (short-term) than long-term available data for trend analysis (see Section 2 for discussion of available data). For wells with sufficient data according to the criteria outlined above, both short-term and long-term trends are shown on the time-series water quality graphs. Graphs for 51 wells were prepared and analyzed (24 wells in Fillmore basin and 27 in Piru basin). All of these show at least one recent-trend that met the testing criteria but only nine of these (eight in Fillmore basin and one in Piru basin) show at least one long-term trend.

A number of wells in the basins have sufficient datasets for seasonal variance (fluctuation) trends analysis but none of the water quality results for the five primary chemicals of concern analyzed for this Tech Memo showed a strong seasonal variance trend. Seasonal groundwater level fluctuation is observed in groundwater level measurements and is discussed in Section 4.2.3 of this Tech Memo. More general climatic (wet/dry precipitation) cycles and corresponding groundwater level fluctuations on longer time periods may correlate to water quality variance in for some chemicals (e.g., chloride) in some wells in the basins.

The interpreted short-term trends for the five primary chemicals of concern for wells in Fillmore and Piru basins are shown in Table 4-3 and Table 4-4, respectively. Water quality analytes that were reported by the laboratory as “Not Detected” (ND) are plotted as zero on the time-series graphs. This was taken into account when interpreting the raw linear best-fit line trend results.

Table 4-3. Fillmore basin groundwater quality Trend Analysis summary.

SWN	DWR Basin (2019)	Screen, ft bgs	Short-Term TDS Trend	Short-Term Sulfate (SO4) Trend	Short-Term Chloride (Cl) Tend	Short-Term Nitrate (NO3) Trend	Short-Term Boron (B) Trend
03N19W06D03S	Fillmore	184-400	Decreasing	Decreasing	Increasing	Increasing	Decreasing
03N20W01D03S	Fillmore	Unknown	Decreasing	Decreasing	Decreasing	Decreasing	Relatively Stable
03N20W01F05S	Fillmore	100-200	Decreasing	Decreasing	Relatively Stable	Decreasing	Relatively Stable
03N20W02R05S	Fillmore	93-133	Relatively Stable	Relatively Stable	Increasing	Trend Reversal	Relatively Stable
03N20W03D03S	Fillmore	102-397	Insufficient Data	Insufficient Data	Insufficient Data	Increasing	Insufficient Data
03N20W03D05S	Fillmore	274-436	Relatively Stable	Relatively Stable	Increasing	Relatively Stable	Relatively Stable
03N20W03D07S	Fillmore	224-484	Decreasing	Decreasing	Relatively Stable	Decreasing	Increasing
03N20W05C04S	Fillmore	221-362	Insufficient Data	Insufficient Data	Insufficient Data	Increasing	Insufficient Data
03N20W06N02S	Fillmore	240-350	Decreasing	Decreasing	Increasing	Decreasing	Relatively Stable
03N20W08F01S	Fillmore	100-152	Insufficient Data	Insufficient Data	Insufficient Data	Increasing	Insufficient Data
03N21W01P05/8S	Fillmore	180-380 160-260	Decreasing	Decreasing	Relatively Stable	No Clear Trend	Relatively Stable
03N21W12H01S	Fillmore	74-150	Increasing	Relatively Stable	Increasing	Increasing	Relatively Stable
04N19W30D01S	Fillmore	60-380	Increasing	Increasing	Increasing	Increasing	Relatively Stable
04N19W31F01S	Fillmore	60-100	Insufficient Data	Relatively Stable	Relatively Stable	Relatively Stable	Relatively Stable
04N19W33M05S	Fillmore	37-107	Decreasing	Decreasing	Increasing	Relatively Stable	Decreasing
04N20W24E01S	Fillmore	80-500	Insufficient Data	Insufficient Data	Insufficient Data	Relatively Stable	Insufficient Data
04N20W24G01S	Fillmore	100-260	Increasing	Insufficient Data	No Clear Trend	Decreasing	Increasing
04N20W24Q04S	Fillmore	90-300	Increasing	Increasing	Increasing	Increasing	Increasing
04N20W25B01S	Fillmore	50-280	Increasing	Increasing	Increasing	Increasing	Relatively Stable
04N20W25D01S	Fillmore	67-187	Relatively Stable	Relatively Stable	Increasing	Relatively Stable	Insufficient Data
04N20W26G03S	Fillmore	294-374	Decreasing	Relatively Stable	Decreasing	Trend Reversal	Relatively Stable
04N20W33C03S	Fillmore	470-700	Decreasing	Relatively Stable	Increasing	No Clear Trend	Relatively Stable
04N20W36D07S	Fillmore	120-280	Insufficient Data	Decreasing	Increasing	Relatively Stable	Relatively Stable
04N20W36MW104	Fillmore	10-40	Increasing	Increasing	Increasing	Increasing	Increasing

SWN	DWR Basin (2019)	Screen, ft bgs	Long-Term TDS Trend	Long-Term Sulfate (SO4) Trend	Long-Term Chloride (Cl) Tend	Long-Term Nitrate (NO3) Trend	Long-Term Boron (B) Trend
03N20W03D05S	Fillmore	274-436	Relatively Stable	Insufficient Data	Trend Reversal	Decreasing	Insufficient Data
03N20W03D07S	Fillmore	224-484	Relatively Stable	Relatively Stable	Relatively Stable	Decreasing	Insufficient Data
03N20W05C04S	Fillmore	221-362	Insufficient Data	Insufficient Data	Insufficient Data	Trend Reversal	Insufficient Data
03N20W06N02S	Fillmore	240-350	Relatively Stable	Relatively Stable	Increasing	Decreasing	Relatively Stable
03N21W01P05/8S	Fillmore	180-380 160-260	Insufficient Data	Relatively Stable	Increasing	Increasing	Relatively Stable
04N19W30D01S	Fillmore	60-380	Increasing	Insufficient Data	Increasing	Relatively Stable	Insufficient Data
04N20W25B01S	Fillmore	50-280	Increasing	Increasing	Increasing	Increasing	Insufficient Data
04N20W25D01S	Fillmore	67-187	Relatively Stable	Relatively Stable	Trend Reversal	Decreasing	Insufficient Data

Table 4-4. Piru basin groundwater quality Trend Analysis summary.

SWN	DWR Basin (2019)	Screen, ft bgs	Short-Term TDS Trend	Short-Term Sulfate (SO4) Trend	Short-Term Chloride (Cl) Tend	Short-Term Nitrate (NO3) Trend	Short-Term Boron (B) Trend
04N18W20M01S	Piru	220-420	Increasing	Increasing	Increasing	Relatively Stable	Relatively Stable
04N18W20M02S	Piru	160-369	Increasing	Relatively Stable	Increasing	Relatively Stable	Increasing
04N18W20M03S	Piru	160-450	Increasing	Increasing	Increasing	Increasing	Increasing
04N18W20P02S	Piru	137-177	Decreasing	Decreasing	No Clear Trend	Relatively Stable	Increasing
04N18W20P04S	Piru	100-140	Decreasing	Decreasing	No Clear Trend	No Clear Trend	Relatively Stable
04N18W20R01S	Piru	190-319	Increasing	Relatively Stable	Trend Reversal	Increasing	Relatively Stable
04N18W27B01S	Piru	156-280	Increasing	Increasing	Increasing	Increasing	Relatively Stable
04N18W27H01S	Piru	40-120	Relatively Stable	Relatively Stable	Insufficient Data	Increasing	Relatively Stable
04N18W29C01S	Piru	356-500	Relatively Stable	Relatively Stable	No Clear Trend	Relatively Stable	Relatively Stable
04N18W29F01S	Piru	110-275	Relatively Stable	Relatively Stable	No Clear Trend	Decreasing	No Clear Trend
04N18W30J04S	Piru	79-250	Increasing	Increasing	Increasing	Increasing	Increasing
04N18W31D03S	Piru	590-610	Relatively Stable	Relatively Stable	Increasing	Increasing	Relatively Stable
04N18W31D04S	Piru	310-330	Decreasing	Decreasing	Relatively Stable	Relatively Stable	Decreasing
04N18W31D05S	Piru	220-240	Trend Reversal	Relatively Stable	Increasing	Relatively Stable	Relatively Stable
04N18W31D06S	Piru	140-160	Increasing	Increasing	Increasing	Increasing	Increasing
04N18W31D07S	Piru	50-70	Relatively Stable	Relatively Stable	No Clear Trend	Increasing	Relatively Stable
04N19W25K03S	Piru	400-480	Insufficient Data	Insufficient Data	Insufficient Data	Decreasing	Insufficient Data
04N19W25K04S	Piru	220-370	Relatively Stable	Relatively Stable	Relatively Stable	Relatively Stable	Relatively Stable
04N19W25M03S	Piru	210-250	Increasing	Relatively Stable	Increasing	Increasing	Increasing
04N19W26H01S	Piru	568-612	Decreasing	Decreasing	Increasing	Decreasing	Relatively Stable
04N19W26J02S	Piru	Unknown	Insufficient Data	Decreasing	Decreasing	Decreasing	Relatively Stable
04N19W26J03S	Piru	400-650	Decreasing	Relatively Stable	Relatively Stable	Decreasing	Relatively Stable
04N19W26J05S	Piru	200-250	Relatively Stable	Relatively Stable	Relatively Stable	Increasing	Relatively Stable
04N19W33B01S	Piru	206-306	Trend Reversal	Relatively Stable	Trend Reversal	Increasing	Decreasing
04N19W34J04S	Piru	60-160	Relatively Stable	Relatively Stable	Increasing	Increasing	Relatively Stable
04N19W35G01S	Piru	24-79	Relatively Stable	Relatively Stable	No Clear Trend	Relatively Stable	Relatively Stable
04N19W36D01S	Piru	18-73	Increasing	Relatively Stable	Increasing	Increasing	Relatively Stable

SWN	DWR Basin (2019)	Screen, ft bgs	Long-Term TDS Trend	Long-Term Sulfate (SO4) Trend	Long-Term Chloride (Cl) Tend	Long-Term Nitrate (NO3) Trend	Long-Term Boron (B) Trend
04N18W20M01S	Piru	220-420	No Clear Trend	Relatively Stable	No Clear Trend	Relatively Stable	Insufficient Data

The following subsections include maps that show the five primary chemicals of concern short-term trends identified in Tables 4-3 and 4-4 plotted graphically for the purpose of assessing geospatial patterns in water quality trends in wells in the basins. For trends that were reported as short-term trend reversal in the tables, the text color in the tables indicate whether the most recent limb of the trend is identified as increasing (red text) or decreasing (green text). The most recent limb of identified short-term trend reversals was plotted on the maps in the following figures (e.g., the TDS short-term trend reversal for 04N19W33B01S in Piru basin was plotted with increasing trend symbology on Figure 4-4).

4.1.2.1 *Total Dissolved Solids*

TDS is the aggregate concentration of dissolved chemicals in water. TDS can be reported by either total filterable residue (TFR) or by summation (SUM), which is calculated by summing the mass of the major anions and cations in a water sample. TDS by Summation commonly yields a slightly higher value than the TDS by TFR. The wet chemistry evaporative method (i.e., TFR) is now the standard laboratory analysis for TDS and is recommended method for water sample analysis in the basins. Historically, VCWPD reported TDS as SUM for the groundwater samples they collected but have moved to reporting results as TFR in recent years.

The water quality time-series graphs for TDS in the Tech Memo (Appendix D and E) show TFR and SUM laboratory results plotted as independent series since an invalid trend may be inadvertently identified from plotting a combination of TFR and SUM results as a single series. However, a single trend is reported for TDS and included on Tables 4-3 and 4-4. Figure 4-4 shows total dissolved solid (TDS) short-term trend results from Tables 4-3 and 4-4 plotted in map view for the Fillmore and Piru basins.

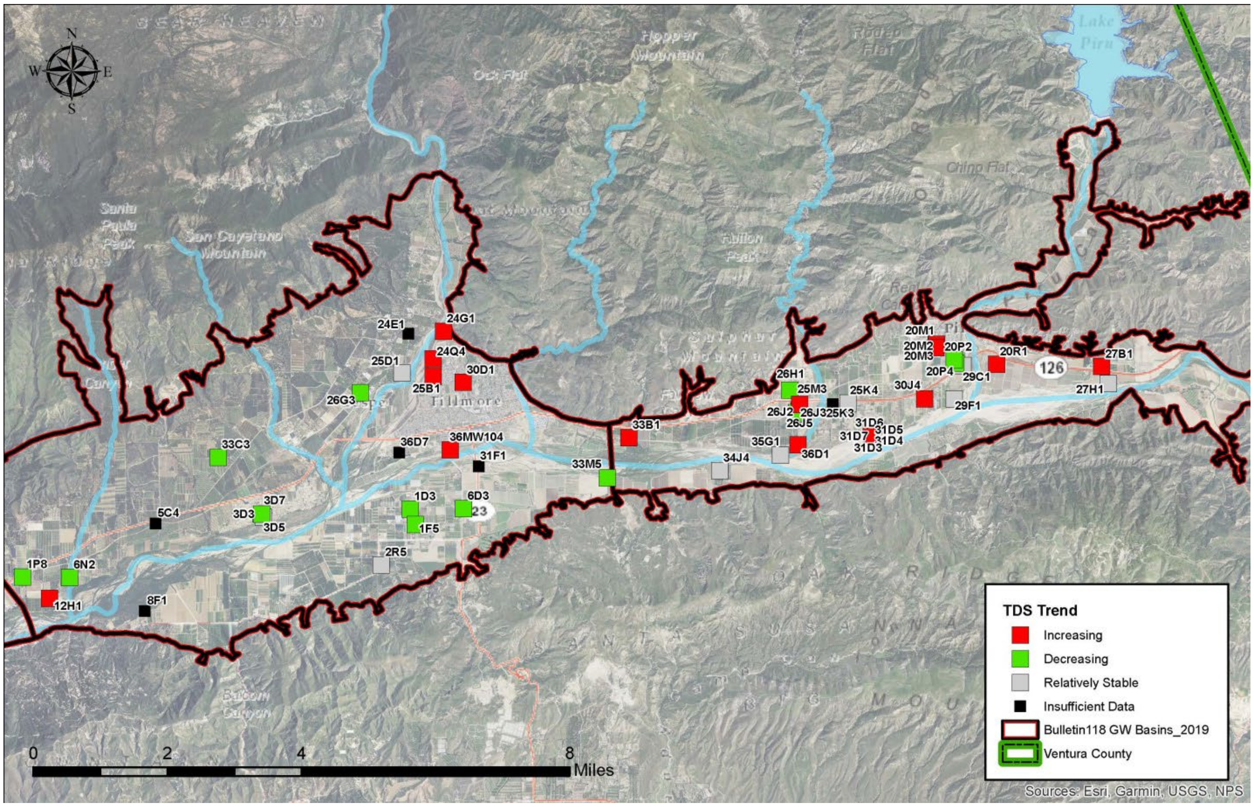


Figure 4-4. Total Dissolved Solids Short-Term Trend Analysis results map.

TDS short-term trend results for Fillmore basin show concentrations to be increasing in six wells, decreasing in nine wells and relatively stable in three wells. Six wells shown on Figure 4-4 did not meet the criteria for testing and were reported as "insufficient data" (these wells are included for ease of map comparison since at least one of the other primary chemical of concern include a reported trend). TDS short-term trend results show concentrations to be decreasing (improving) or relatively stable overall at 12 of 18 wells tested in Fillmore basin.

The area of notable exception where TDS concentrations appear to be increasing in Fillmore basin is the Pole Creek Fan and adjacent areas to the west near Sespe Creek (City of Fillmore wells) and in a shallow monitoring well (labeled as 36MW104 on Figure 4-4) near Santa Clara River. Well 36MW104 served as an up-gradient monitoring well for the City of Fillmore's old waste water treatment plant (the new plant is located approximately a half mile to the west of the old plant).

TDS short-term trend results for Piru basin show concentrations to be increasing in 11 wells, decreasing in five wells and relatively stable in nine wells. Two wells shown on Figure 4-4 did not meet the criteria for testing and were reported as "insufficient data". TDS short-term trend results show reported concentration to be increasing (degrading) or relatively stable overall at 20 of 25 wells tested in Piru basin. The RP1 multiple-well (nested) groundwater monitoring site (facility) in Piru basin (Figure 1-1 for location and Figure 1-4 for groundwater level hydrograph) is shown to be increasing in TDS concentration in two of the monitoring site's completions, decreasing in one completion and relatively stable concentration in the deepest and shallowest completions (Table 4-4).

TDS long-term trend results for Fillmore basin show concentrations to be increasing in two wells and relatively stable in four wells (Table 4-3). Long-term trend results in Piru basin show concentrations with no clear trend in one well (04N18W20M01S in Table 4-4) located in the north central portion of the basin west of Piru Creek. The locations of these wells are shown on Figure 4-4, as these wells also have identified short-term trends. As mentioned above, the trend analysis groundwater time-series graphs are in Appendix E.

4.1.2.2 Sulfate

Sulfate is commonly the largest component of TDS in water samples collected in the Fillmore and Piru basin and therefore often tracks with a similar trend. This was a consideration when determining to plot TDS and sulfate on the same graph for each well in the figures included in Appendix E. Figure 4-5 shows sulfate short-term trend results plotted in map view for the Fillmore and Piru basins.

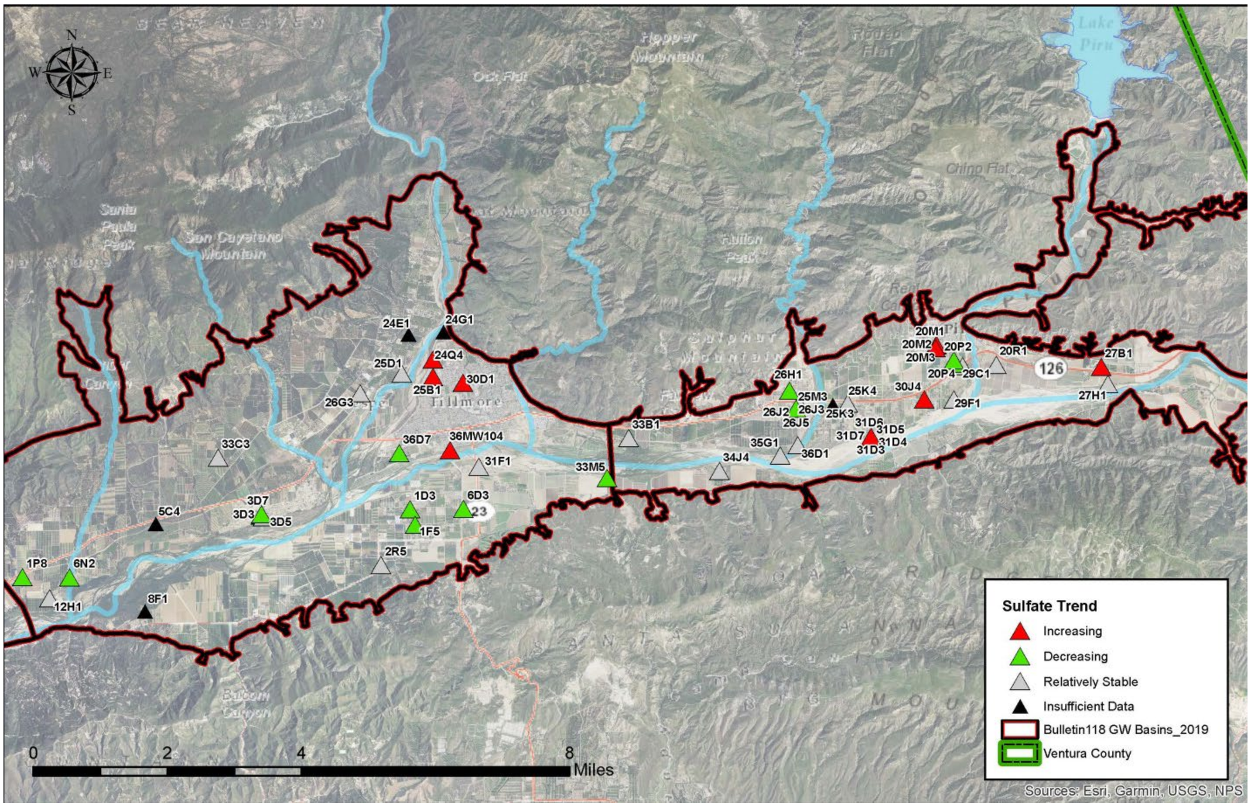


Figure 4-5. Sulfate Short-Term Trend Analysis results map.

Sulfate short-term trend results for Fillmore basin show concentrations to be increasing in four wells, decreasing in eight wells and relatively stable in seven wells. Five wells shown on Figure 4-5 did not meet the criteria for testing and were reported as "insufficient data". Sulfate short-term trend results show reported concentration to be decreasing or relatively stable overall (15 of 19 wells tested) in Fillmore basin.

The area of notable exception where sulfate concentrations appear to be increasing in Fillmore basin (similar to TDS reported results) is the Pole Creek Fan and adjacent areas to the west near Sespe Creek and in a shallow monitoring well (labeled as 36MW104 on Figure 4-5) near Santa Clara River.

Sulfate short-term trend results for Piru basin show concentrations to be increasing in five wells, decreasing in five wells and relatively stable in 16 wells. One well shown on Figure 4-5 did not meet the criteria for testing and were reported as "insufficient data". Sulfate short-term trend results show reported concentration to be relatively stable overall (16 of 26 wells tested) in Piru basin. The RP1 multiple-well groundwater monitoring site in Piru basin is shown to be increasing in sulfate concentration in one completion, decreasing in another and relatively stable concentration in three completions (i.e., shallowest, deepest and middle piezometers).

Sulfate long-term trend results for Fillmore basin show concentrations to be increasing in one well and relatively stable in four wells (Table 4-3). Long-term trend results in Piru basin show concentrations to be relatively stable in well 04N18W20M01S (Table 4-4).

4.1.2.3 Chloride

Much of the SCR high chloride base flows that enter Ventura County from Los Angeles County originate as discharge from the Valencia wastewater treatment plant in Santa Clarita (UWCD, 2016) and other sources include urban and stormwater runoff (VCWPD, 2016). Elevated chloride concentrations impair its value as irrigation water when diverted from the SCR, and the long-term groundwater recharge to the basin of this water has been recognized to be degrading the groundwater in eastern Piru basin. These high chloride groundwater concentrations have made a steady advance westward with groundwater flow down the Piru basin (UWCD, 2016).

Figure 4-6 shows chloride short-term trend results plotted in map view for the Fillmore and Piru basins.

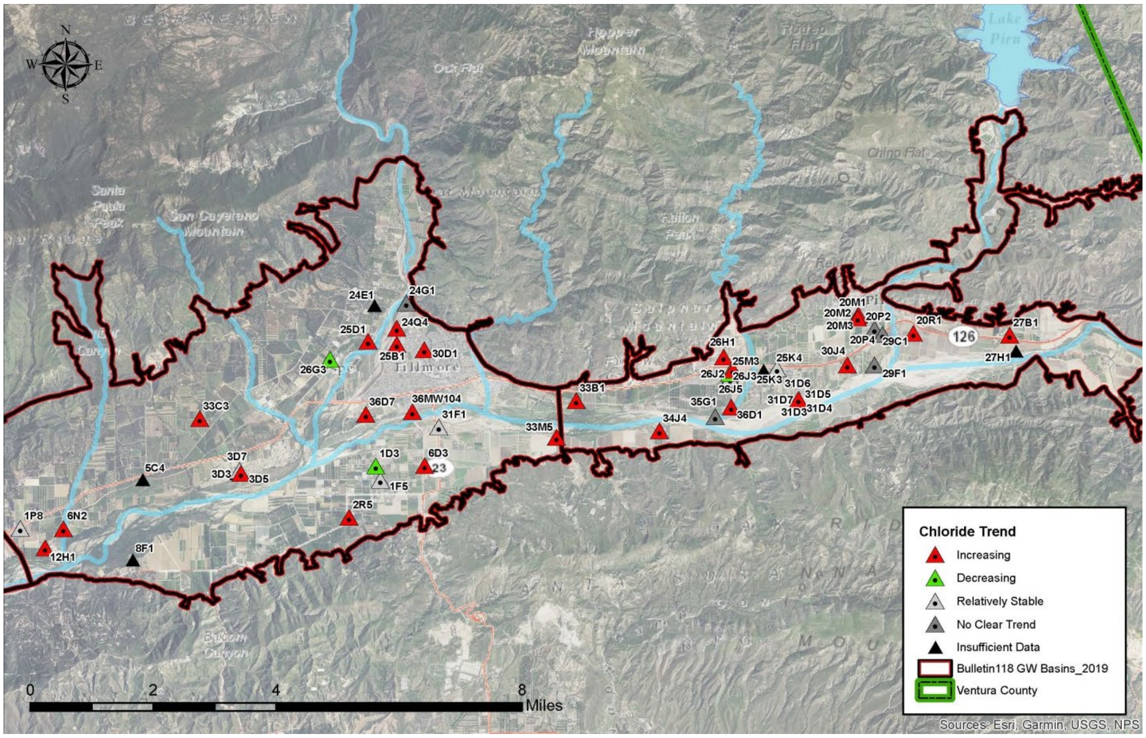


Figure 4-6. **Chloride Short-Term Trend Analysis results map.**

Chloride short-term trend results for Fillmore basin show concentrations to be increasing in 13 wells, decreasing in two wells and relatively stable in four wells. One well was reported as "no clear trend" and four wells shown on Figure 4-6 were reported as "insufficient data" since the available record sets for these wells do not meet the Tech Memo established criteria for testing. Chloride short-term trend results show reported concentration to be increasing overall (13 of 20 wells tested) in Fillmore basin.

Chloride short-term trend results for Piru basin show concentrations to be increasing in 14 wells, decreasing in one well and relatively stable in four wells. Six wells were reported as "no clear trend" and two wells shown on Figure 4-6 were reported as "insufficient data" since the available record sets for these wells do not meet the Tech Memo established criteria for testing. Chloride short-term trend results show reported concentration to be increasing overall (14 of 25 wells tested) in Piru basin. The RP1 multiple-well groundwater monitoring site in Piru basin is shown to be increasing in chloride concentration in three completions, relatively stable in one completion and reported as "no clear trend" in the shallowest completion (Table 4-4).

Chloride trend results in several wells, especially in Piru basin (e.g., RP1 04N18W31D05/06S), appear to be correlated to groundwater level. This is commonly an inverse relationship and in some cases there is an observed lag in time from when groundwater level increases and chloride decreases. There are also wells in Piru basin that have increasing chloride trends while groundwater levels are also increasing in the basins which may indicate recharge of high chloride surface water. This was not investigated beyond the observation that chloride concentration trends in some wells appear to be somewhat related to climatic cycles and changes in groundwater levels in the basins.

As mentioned above, a number of wells in the basins have sufficient datasets for chloride seasonal variance trend analysis but none of the water quality results analyzed for this Tech Memo showed a strong seasonal variance trend. Chloride long-term trend results for Fillmore basin show concentrations to be increasing in four wells, exhibiting trend reversal (with the recent limb increasing) in two wells and relatively stable in one well (Table 4-3). Long-term trend results in Piru basin show concentrations with no clear trend in well 04N18W20M01S (Table 4-4).

4.1.2.4 Nitrate

USGS GAMA trends reports nitrate as nitrogen (nitrate as N, MCL = 10 mg/L) and this Tech Memo repots nitrate (MCL = 45 mg/L). Nitrate as reported in this Tech Memo is for consistency for comparison with UWCD historical reporting in the basins. Nitrate and nitrate as N can be approximately converted from one form to the other based on the atomic weight of nitrogen. A comparison was performed of the results presented in this Tech Memo with those reported in the USGS GAMA trend study. It does not appear that significant differences in trend results were identified by assessing nitrate trends from one analytical form verse the other.

Figure 4-7 shows nitrate short-term trend results plotted in map view for the Fillmore and Piru basins.

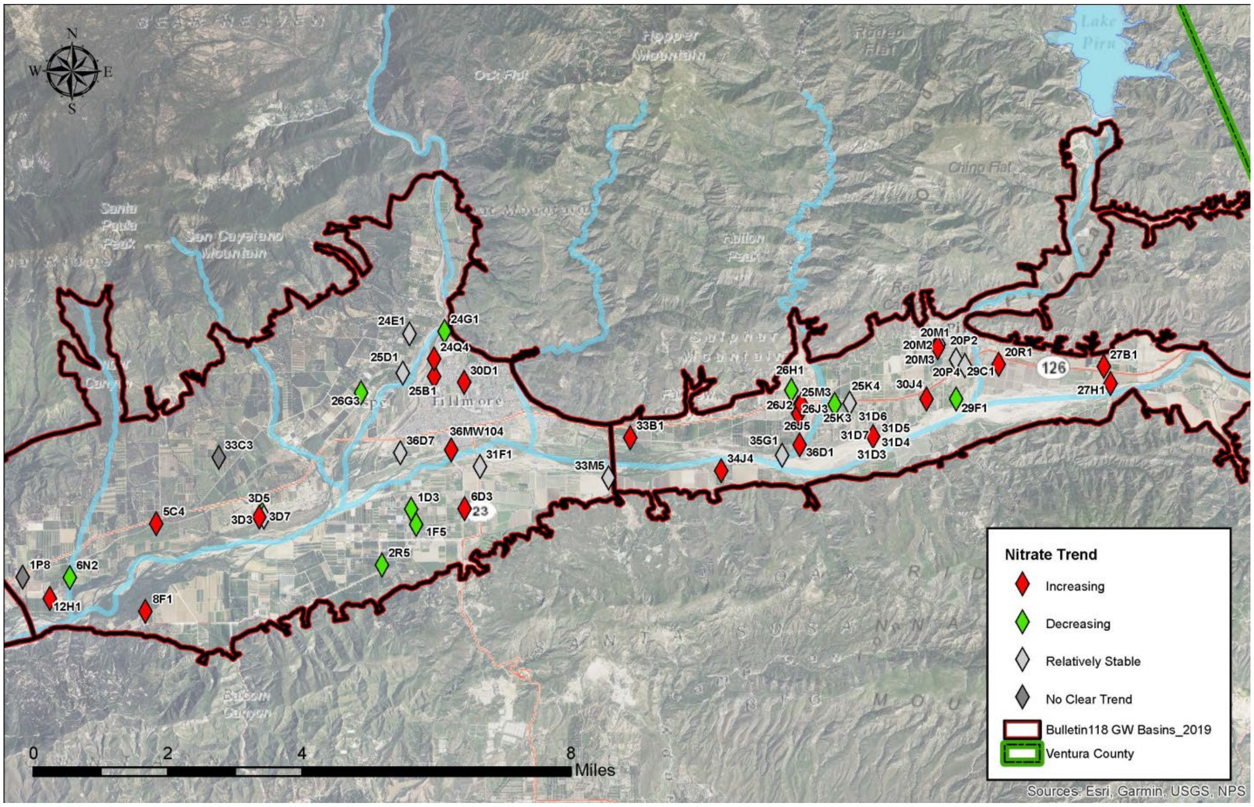


Figure 4-7. Nitrate Short-Term Trend Analysis results map.

Nitrate short-term trend results for Fillmore basin show concentrations to be increasing in nine wells, decreasing in seven wells, relatively stable in six wells and two wells were reported as “no clear trend”. Nitrate short-term trend results show reported concentration to be increasing or relatively stable overall (15 of 24 wells tested) in Fillmore basin. VCWPD reports that historically nitrate concentrations have been elevated in Fillmore basin (VCWPD, 2016).

Nitrate short-term trend results for Piru basin show concentrations to be increasing in 13 wells, decreasing in five wells, relatively stable in eight wells, and one well was reported as “no clear trend". Nitrate short-term trend results show reported concentration to be increasing or relatively stable overall (21 of 27 wells tested) in Piru basin. The RP1 multiple-well groundwater monitoring site in Piru basin is shown to be increasing in nitrate concentration in three completions including the shallowest and deepest piezometers. Two completions are reported as exhibiting relatively stable short-term trends (Table 4-4).

As mentioned above, a number of wells in the basins have sufficient datasets for nitrate seasonal variance trend analysis but none of the water quality results analyzed for this Tech Memo showed a strong seasonal variance trend. A few wells (e.g., 03N21W01P08S and 04N20W33C03S) appeared on preliminary analysis to possibly show a seasonal nitrate correlation but on further inspection were reported as "No Clear Trend".

Nitrate long-term trend results for Fillmore basin show concentrations to be increasing in two wells, decreasing in four wells, exhibiting trend reversal (with the recent limb increasing) in one well and relatively stable in one well (Table 4-3). Long-term trend results in Piru basin show concentrations to be relatively stable in well 04N18W20M01S (Table 4-4).

4.1.2.5 Boron

As mentioned previously, elevated concentrations of boron in eastern Piru basin are generally attributed to historical surface discharge of oil field brines. Anecdotally, there tends to me more concern among citrus growers than avocado growers with respect to detrimental impacts associated with elevated concentration of boron in irrigation water pumped from the Fillmore and Piru basins.

Figure 4-8 shows boron short-term trend results plotted in map view for the Fillmore and Piru basins. As mentioned above, VCWPD does not routinely sample for boron in the basins so there are fewer record sets that meet the criteria for trend analysis (shown as "Insufficient Data" on the figure) than for the other four primary chemicals of concern.

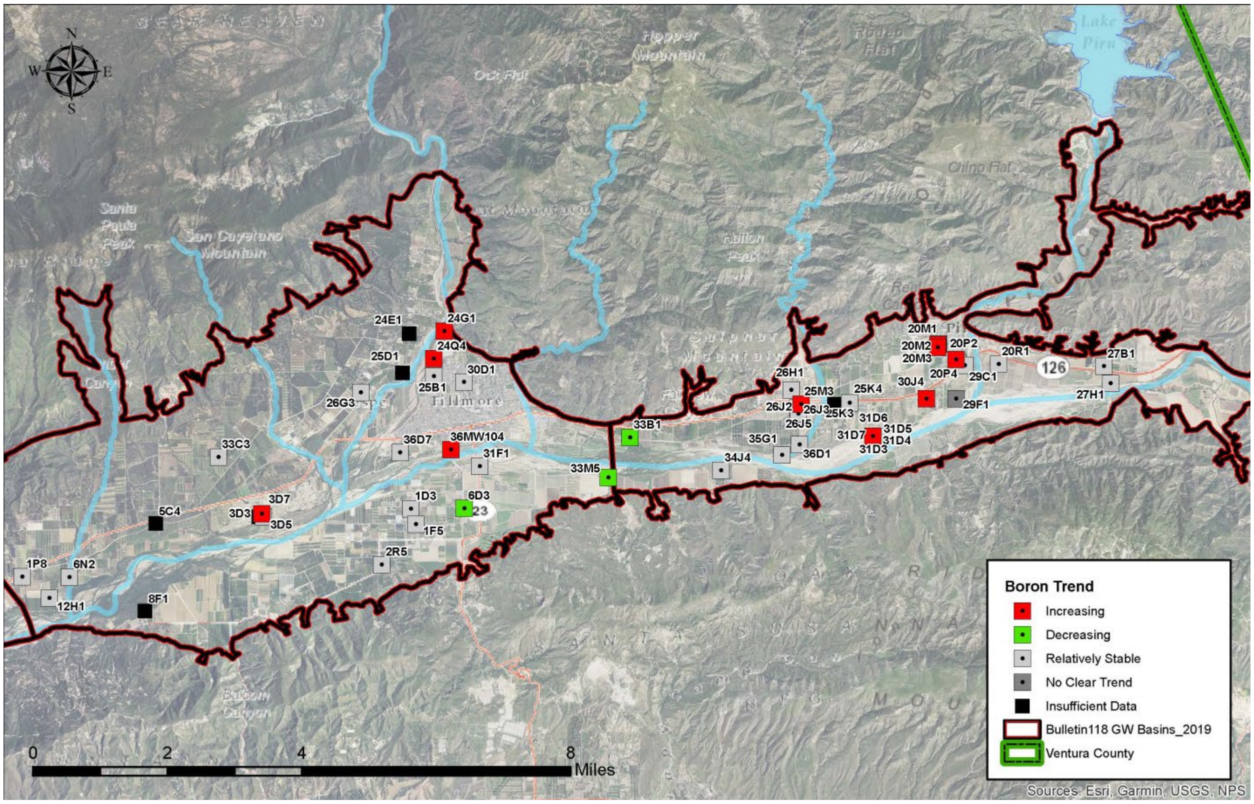


Figure 4-8. Boron Short-Term Trend Analysis results map.

Boron short-term trend results for Fillmore basin show concentrations to be increasing in four wells, decreasing in two wells and relatively stable in 13 wells. Five wells shown on Figure 4-8 did not meet the criteria for testing and were reported as "insufficient data". Boron short-term trend results show reported concentration to be relatively stable overall (13 of 19 wells tested) in Fillmore basin.

Boron short-term trend results for Piru basin show concentrations to be increasing in six wells, decreasing in two wells and relatively stable in 17 wells. One well each was reported as "no clear trend" or "insufficient data". Boron short-term trend results show reported concentration to be relatively stable overall (17 of 26 wells tested) in Piru basin. The RP1 multiple-well groundwater monitoring site in Piru basin is shown to be increasing in boron concentration in two completions, decreasing in one completion and relatively stable concentrations in the deepest and shallowest completions (Table 4-4). These are similar to the trend results reported for TDS for RP1.

Boron long-term trend results for Fillmore basin show concentrations to be relatively stable in two wells (Table 4-3). Long-term trend results in Piru basin could not be assessed for well 04N18W20M01S due to insufficient data (Table 4-4).

4.1.3 Additional Chemicals of Concern

Additional potential chemicals of concern in the Fillmore and Piru basins were identified from a review of available groundwater quality data, the most recent Annual Report of Groundwater Conditions (VCWPD, 2016) and Piru/Fillmore Basins Groundwater Conditions report (UWCD, 2016). These additional chemicals include:

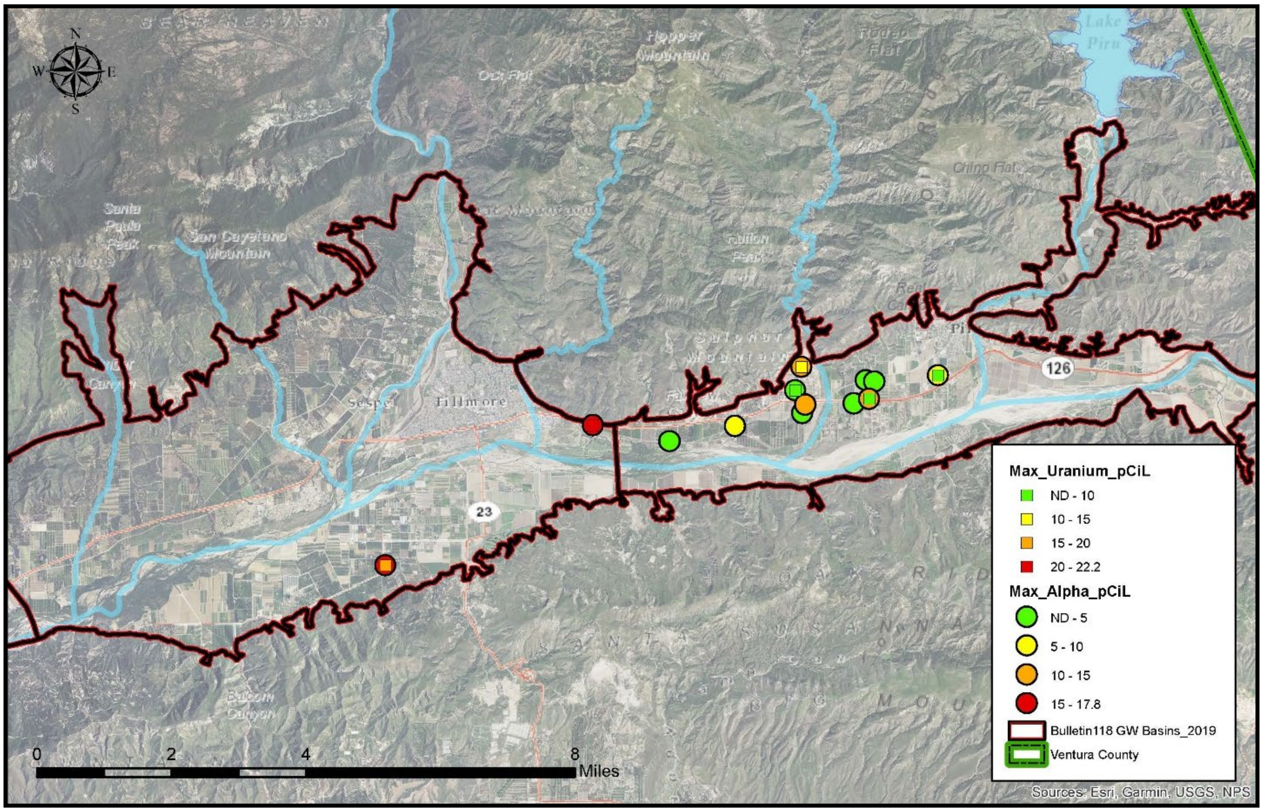
- Radiochemistry
- Selenium
- Lead
- Iron and manganese

Systematic trend analysis was not performed for these analytes since sufficient datasets were not available or the chemical has not historically been raised as a prominent concern in the basins (i.e., iron and manganese). With the exception of iron and manganese concentration mapping, a wide evaluation time period window was required to assemble adequate analytical data for geospatial evaluation. Narrower time period windows are preferred for comparative analysis from well to well than are used here but this exercise serves to identify potential areas in the basins that may have elevated chemical concentrations. The maps in the following Subsections show maximum concentration in a well for the chemical-specific period of evaluation. Reported concentrations over the MCL, Action Level, or secondary MCL (Table 4-2) are displayed as red symbols.

4.1.3.1 Radiochemistry

Gross alpha is a measure of the overall radioactivity of radium and uranium in water. Alpha radiation exists in the soil and can also be present in the air and groundwater. These naturally occurring radioactive elements emit alpha particles as they decay which can pose health risks when exposed to prolonged elevated levels.

Figure 4-9 shows radiochemistry (i.e., gross alpha and uranium) water quality sampling results collected by VCWPD from 2005 through 2015 plotted in map view for the Fillmore and Piru basins. Prior to 2005, VCWPD did not sample groundwater for gross alpha or metals.



Sources: Esri, Garmin, USGS, NPS

Figure 4-9. Maximum Gross Alpha and Uranium concentration available water quality sampling results from 2005 through 2015 from wells in Fillmore and Piru basins.

There are at least three wells known in Fillmore basin that have reported elevated gross alpha or uranium. A single sample from well 03N20W02R05S (Figure 4-9) shows gross alpha above the MCL. For a well (04N19W29R02S) in east Fillmore basin near the Fillmore/Piru basin boundary, VCWPD received a memo in June 2008 from the Ventura County Resource Management Agency Division of Environmental Health that explained that the well owner tried to certify the well as a domestic well. Owners of wells with elevated constituents that exceed MCLs for drinking water are sent letters to let them know they should not be drinking the water. The sampled groundwater in the well exceeded the drinking water MCL for nitrate and gross alpha so Environmental Health was not able to certify the well. The radiochemistry data is unavailable so the well is not shown on Figure 4-9.

In October 2008 as part of the VCWPD's annual sampling, County staff arranged to sample a neighbor's well (04N19W29R06S) for radiochemistry and it was found to have elevated gross alpha and uranium. County staff has been unable to get any response from the owner of

04N19W29R06S since sampling the well and has therefore not been able to sample the well again (VCWPD, 2020). Additional radiochemistry sampling is likely appropriate in Fillmore basin to corroborate sparse groundwater sample results and to determine the potential extent of elevated gross alpha and uranium in wells in Fillmore basin.

In the vicinity of Hopper Creek in Piru basin, elevated gross alpha has also been detected in a few wells (orange circles on Figure 4-9). None of these samples exceeded the drinking water MCL.

4.1.3.2 Selenium

Figure 4-10 shows maximum selenium water quality sampling results collected by VCWPD and Ventura County Waterworks District No. 16 (i.e., four monitor wells that surround the Piru waste water treatment plant effluent percolation ponds) from 2005 through 2018 plotted in map view for the Fillmore and Piru basins.

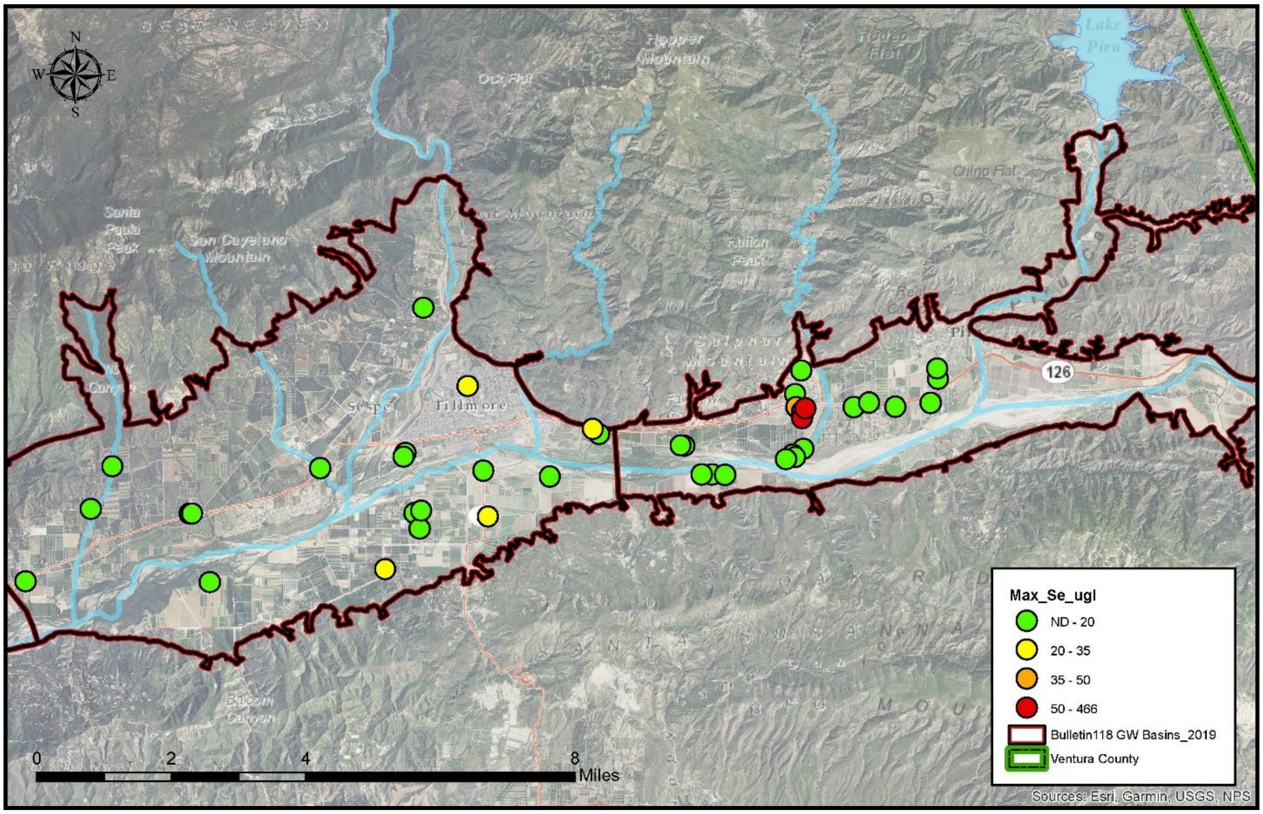


Figure 4-10. Maximum Selenium concentration available water quality sampling results from 2005 through 2018 from wells in Fillmore and Piru basins.

An area in Piru basin just west of Hopper Creek in Piru has reported high selenium that is several times the MCL in three wells. VCWPD reports, "One well located south of Highway 126 has consistently been found to have selenium levels that exceed the primary MCL for drinking water of 0.05 mg/l (50 µg/l). Elevated selenium concentrations occur in wells perforated in the interval between approximately 125 to 250 feet below ground surface" (VCWPD, 2016). Two wells screened below 250 feet bgs (i.e., approximately screened 400 to 650 feet bgs) in the same vicinity of Hopper Creek do not have reported elevated selenium levels.

4.1.3.3 Lead

Figure 4-11 shows maximum lead water quality sampling results collected from 1995 through 2018 plotted in map view for the Fillmore and Piru basins.

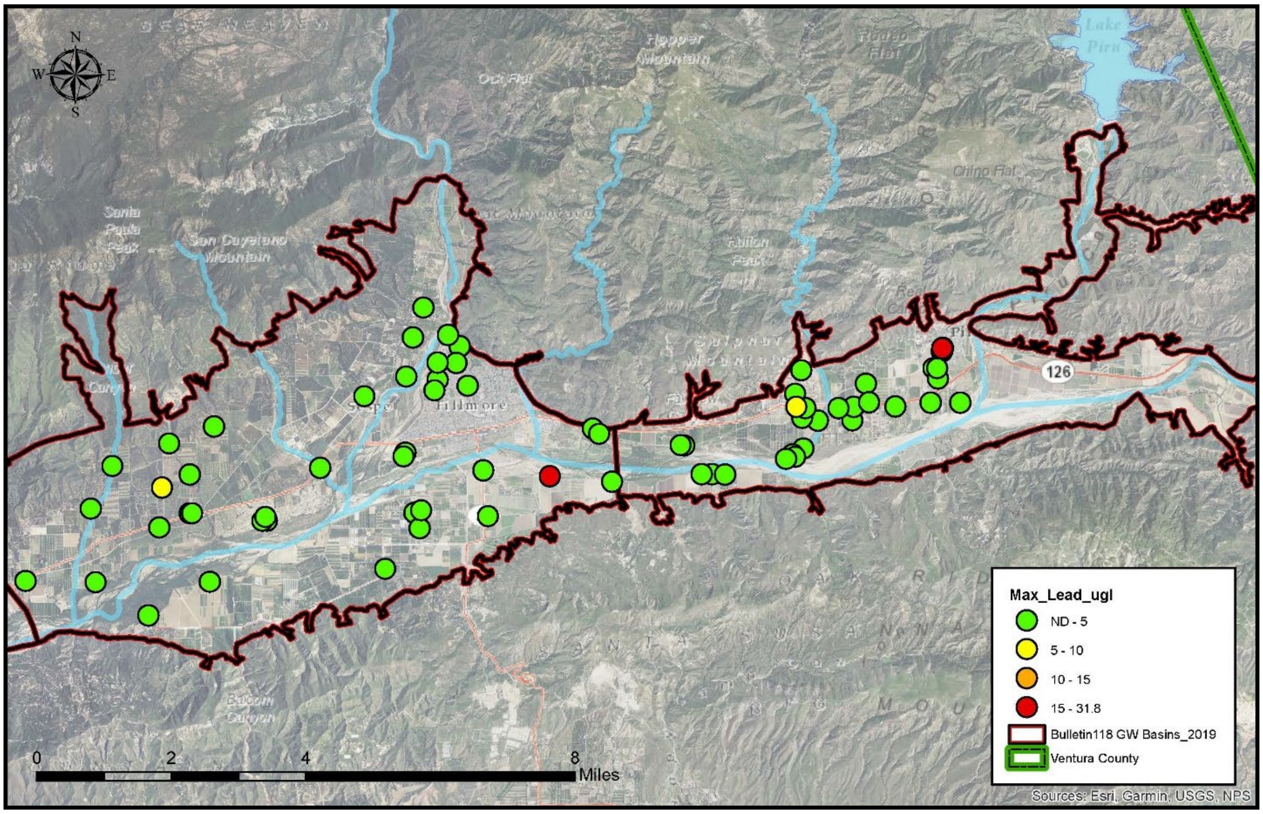


Figure 4-11. Maximum Lead concentration available water quality sampling results from 1995 through 2018 from wells in Fillmore and Piru basins.

One well in east Fillmore basin shown on Figure 4-11 has reported lead above the U.S. EPA Action Level of 15 µg/l (note that the public health goal is zero for lead in drinking water). This sample collected from the well in 2011 is somewhat suspect since a sample collected the previous year was reported as “not detected” (ND) for lead. Similarly, another well in Fillmore basin had reported lead over 15 times the U.S. EPA Action Level with previous and subsequent samples reporting lead concentration as ND. This highly suspect water quality sample result was not plotted on Figure 4-11.

A well in Piru basin west of Piru Creek is shown with elevated lead. This well was destroyed in 2017 and nearby wells screened at similar depths do not show elevated lead. It appears from this limited analysis that elevated concentration of lead in the Fillmore and Piru basins are not common or widespread.

4.1.3.4 Iron and Manganese

Iron and manganese are commonly considered together when evaluating groundwater sample results. The chemicals are often found at elevated concentration in older (more mineralized) groundwater accessed from deep wells, and are predominantly associated with aesthetic water quality concerns from a public health perspective. Figure 4-12 shows maximum iron and manganese water quality sampling results collected from 2015 through 2018 plotted in map view for the Fillmore and Piru basins.

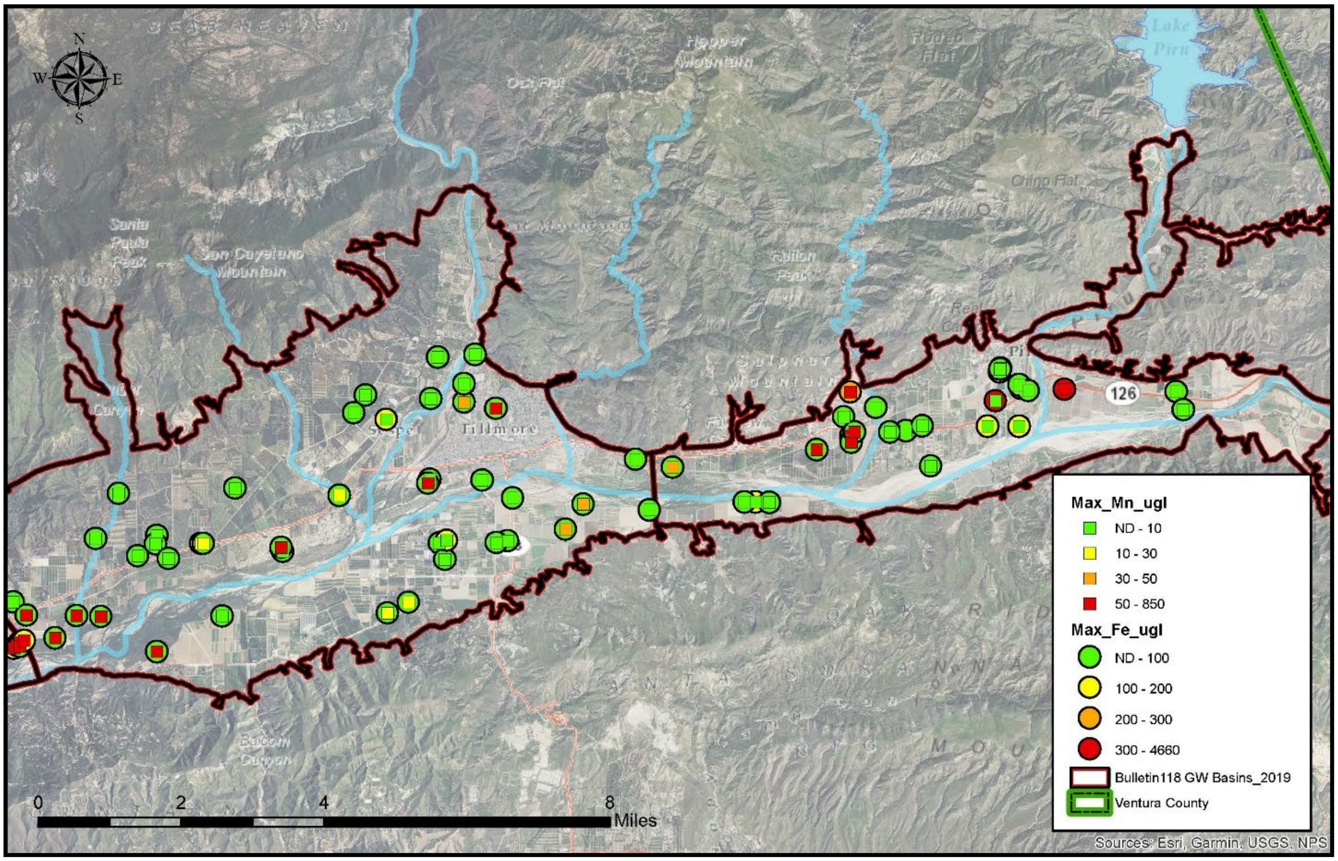


Figure 4-12. Maximum Iron and Manganese concentration available water quality sampling results from 2015 through 2018 from wells in Fillmore and Piru basins.

A well in Piru basin east of Piru Creek is the only well in the basins with iron above the U.S. EPA secondary MCL. This sample laboratory result from 2016 shown on Figure 4-12 is suspect, as two samples from the previous year show iron to be ND and subsequent samples show concentrations to be below 200 µg/L. It appears from this limited analysis that elevated concentration of iron in the Fillmore and Piru basins are not common or widespread.

Manganese above the U.S. EPA secondary MCL is shown in 13 wells in Fillmore basin and 7 wells in Piru basin on Figure 4-12. Of these 20 wells, 13 have bottom screened depths below 250 feet bgs. Notably, the majority of the elevated manganese wells near the Santa Paula/Fillmore basins boundary are shallower screened wells (bottom screened depths above 250 feet bgs). As mentioned in Section 1.2.2 (Physical Setting), areas at the basins boundaries are distinguished by areas of rising groundwater. It is possible that the elevated manganese is associated with upwelling of deep groundwater governed by upward vertical gradients (associated with confined aquifer conditions) in the area near the Santa Paula and Fillmore basins boundary but further investigation is needed to validate this speculation.

4.2 Groundwater Level

From a review of the static groundwater level record sets available from wells in the Fillmore and Piru basins (Appendix A) it is apparent that groundwater level trends are intrinsically tied to climatic cycles (i.e., wet and dry periods) and the availability of native and nonnative nonlocal (i.e., imported) surface water that recharges the groundwater basins as seepage (losing reaches) in the Santa Clara River channel and its tributaries that overlie the basins. In wet periods the basins generally “fill up” with observed groundwater levels rising to near the ground surface in wells that are located near the Santa Clara River channel. The absolute height that water level can rise in wells is generally controlled by topographic lows such as stream channels where groundwater contributes to surface water flow (gaining reaches). “Topped off” groundwater elevations in wells are apparent in many wells in the basins (Appendix C) where water levels rise to a well-specific elevation and then level out. A few wells near the basins boundaries are known to flow artesian when water levels are high in the basins.

Assessing trends in the Fillmore and Piru basins would be misleading by applying a “best-fit” line approach (as was used in the water quality trend analysis in Section 4.1). Groundwater level is drawn down during periods of drought (decreasing trend) but during wet periods increase until they level out under full conditions which resemble a relatively stable trend. Many wells in the basins are in a since reset with respect to water level trend when the basins are refilled.

As mentioned earlier in this Tech Memo, Draft AB 3030 Groundwater Management Plan update identified BMOs for groundwater elevations were established for various “Key” wells in the basins. A review of the methodology applied in the Draft Plan update is summarized here to provide context for historical concern of groundwater level and the use of historical droughts as benchmark low water levels. Similar to the Draft Plan update, the groundwater level trend analysis presented in this Section includes evaluation of drought low water levels in individual wells.

The BMOs for key wells in the Draft Plan update were intended to sustain groundwater elevations above the lowest recorded level of the 1984 to 1991 drought. The lowest water level recorded for each well from the 1984-91 period was established as the BMO. Benchmark #1 was the 2004 low water level year (final year of a 6 year moderately dry period) and benchmark #2 was defined as halfway between benchmark #1 and the BMO for each key well (UWCD, 2016).

For the water level trend analysis presented in this Tech Memo, the criteria outlined below was used to select robust record sets available for wells in the Fillmore and Piru basins. The time periods and criteria for evaluation of the three trend types include:

- Short-Term (Recent): Available data since the year 2000 to assess whether 2011 water levels represent near basin full conditions when compared to the basin full high (max) water level (e.g., 2005). Annual minimum measurement frequency with at least 6 data points spanning 8 years and no more than 4 year gaps. High-frequency pressure transducer data were considered as part of the analysis where available (Appendix B pressure transducer hydrographs).
- Seasonal (Short-Term): Available data from the year 2000 - 2011 to assess spring high (maximum) and fall low (minimum) water level average annual variance (fluctuation). Biannual measurement minimum frequency with at least 12 data points spanning 8 years and no more than 4 year gaps. High-frequency pressure transducer data, including data since the year 2011, were considered as part of the analysis where available.
- Long-Term: Last 36 years from 1983 - 2018 maximum (basin full) and drought low water level difference to assess the magnitude range of groundwater level fluctuation in wells. Datasets included span the evaluation time period with no more than 6 year gaps and groundwater level did not decline below the bottom of the screened interval of the well (dry well) during the recent drought. Records dating back to 1950 where available are used to assess historical drought low water levels.

Record sets from wells within the Fillmore and Piru basins used in the groundwater level trend analysis include, but are not necessarily limited to, wells historically reported by VCWPD, UWCD (including the former Draft AB 3030 Plan BMO wells and pressure transducer record sets) and select additional CASGEM wells. All available water level record sets that met the criteria outlined above were used in the analysis. The groundwater level trend analysis hydrographs are included in Appendix C.

Available high-frequency pressure transducer and data logger records can be especially useful for showing short-term and seasonal trends. These record sets maintained by UWCD are described in Section 3.3.2 and the groundwater level hydrographs are in Appendix B of this Tech Memo. The longest available pressure transducer records extend back in time over 10 years (earliest data from 2007). These data were used in the trend analysis for those record sets that extend back far enough for evaluation in a manner consistent for comparison from well to well.

The interpreted short-term, seasonal and long-term trends for the wells in Fillmore and Piru basins included in the analysis are shown on Table 4-5 and Table 4-6, respectively. There are more recent (short-term) than long-term available data for trend analysis (see Section 2 for discussion of available data). For wells with sufficient data according to the criteria outlined above, both short-term and long-term minimum and maximum water level elevation labels are shown on the hydrographs in Appendix C. Hydrographs for 51 wells were prepared and analyzed (28 wells in Fillmore basin and 23 in Piru basin).

All wells included in the trend evaluation were evaluated for seasonal fluctuation trends. For wells in which an annual seasonal fluctuation is not apparent, a result of "No Clear Trend" was reported. "Insufficient Data" was reported in the tables for wells that did not have sufficient available record sets that met the evaluation criteria outlined above for short-term or long-term trend evaluation.

Table 4-5. Fillmore basin groundwater level Trend Analysis summary.

SWN	DWR Basin (2019)	Screen, feet bgs	Short-Term: WL High (Basin Full) since 2000 less 2011 High in feet	Seasonal (Short-Term): Average Annual Variance in feet	Long-Term: High (max) WL less Recent Drought Low (min) in feet	Notes
03N19W06D02S	Fillmore	216-405	5	6	68	
03N20W01C04S	Fillmore	49-218	4	5	45	Pre-2000 Drought Minimum WL
03N20W02A01S	Fillmore	Unknown	3	6	49	Recent Drought Minimum WL
03N20W03N01S	Fillmore	120-172	1	4	39	Recent Drought Minimum WL.
03N20W05D01S	Fillmore	215-315	11	14	53	Pre-2000 Drought Minimum WL
03N20W05D03S	Fillmore	200-385	13	11	Insufficient Data	
03N20W08A01S	Fillmore	Unknown	1	4	24	Recent Drought Minimum WL. Well near Santa Paula/ Fillmore basins boundary area of rising groundwater.
03N20W09D01S	Fillmore	210-310	1	3	29	
03N20W11C01S	Fillmore	Unknown	7	5	48	Recent Drought Minimum WL.
03N21W01N02S	Fillmore	200-400	27	11	48	Pre-2000 Drought Minimum WL. Well included in Santa Paula basin adjudication and water levels appear to be somewhat linked to general trends in that basin.
03N21W01P02S	Fillmore	75-104	5	12	Insufficient Data	
03N21W12B02S	Fillmore	Unknown	3	3	14	Recent Drought Minimum WL. Well near Santa Paula/ Fillmore basins boundary area of rising groundwater.
03N21W12B04S	Fillmore	120-360	Insufficient Data	10*	Insufficient Data	
03N21W12F07S	Fillmore	120-400	Insufficient Data	5*	Insufficient Data	
03N21W12H01S	Fillmore	74-150	Insufficient Data	> 8*	Insufficient Data	Well Flows Artesian when Basin WLs are High.
04N19W30D01S	Fillmore	60-380	12	13	65	
04N19W31Q01S	Fillmore	100-250	4	7	Insufficient Data	
04N19W31R01S	Fillmore	60-137	6	6	72	
04N19W32M02S	Fillmore	180-300	3	6	29	Pre-2000 Drought Minimum WL.
04N19W33D03S	Fillmore	140-506	0	2	35	Well near Fillmore/Piru basins boundary area of rising groundwater & Flows Artesian when Basin WLs are High.
04N19W33D04S	Fillmore	140-486	0	3	29	Pre-2000 Drought Minimum WL. Well near Fillmore/Piru basins boundary area of rising groundwater & Flows Artesian when Basin WLs are High.
04N20W23Q02S	Fillmore	327-567	20	15	66	
04N20W24C02S	Fillmore	Unknown	16	18	Insufficient Data	
04N20W24Q03S	Fillmore	120-300	Insufficient Data	12*	Insufficient Data	
04N20W26C02S	Fillmore	155-255	17	20	66	
04N20W26L01S	Fillmore	110-397	Insufficient Data	10**	43**	Recent Drought Minimum WL.
04N20W33C03S	Fillmore	470-700	18	20	70	
04N20W36MW104	Fillmore	10-40	Insufficient Data	8	Insufficient Data	Well Dry in Recent Drought.

*Estimate from high-frequency Pressure Transducer data outside evaluation window.

**Greater gap in record set than denoted in the trend evaluation criteria but analysis was performed with reasonable certainty.

Table 4-6. Piru basin groundwater level Trend Analysis summary.

SWN	DWR Basin (2019)	Screen, feet bgs	Short-Term: WL High (Basin Full) since 2000 less 2011 High in feet	Seasonal (Short-Term): Average Annual Variance in feet	Long-Term: High (max) WL less Recent Drought Low (min) in feet	Notes
04N18W19R01S	Piru	220-401	17	16	145	Pre-2000 Drought Minimum WL.
04N18W20M02S	Piru	160-369	22	22	Insufficient Data	
04N18W20P02S	Piru	137-177	Insufficient Data	22	Insufficient Data	Well Dry in Recent Drought WL.
04N18W20P04S	Piru	100-140	Insufficient Data	23	Insufficient Data	Well Dry in Recent Drought WL.
04N18W20R01S	Piru	190-319	16	26	148	
04N18W27B02S	Piru	140-255	2	20	102	Pre-2000 Drought Minimum WL.
04N18W28C02S	Piru	390-750	39	16	145	
04N18W29M02S	Piru	Unknown	11	24	> 118	Well Dry in Rencent Drought.
04N18W29P01S	Piru	Unknown-232	25	No Clear Trend	89	Pre-2000 Drought Minimum WL.
04N18W31D03S	Piru	590-610	9	19	Insufficient Data	RP1 Piezometer
04N18W31D04S	Piru	310-330	10	23	Insufficient Data	RP1 Piezometer
04N18W31D05S	Piru	220-240	9	22	Insufficient Data	RP1 Piezometer
04N18W31D06S	Piru	140-160	9	22	Insufficient Data	RP1 Piezometer
04N18W31D07S	Piru	50-70	9	21	Insufficient Data	RP1 Piezometer, Well Dry in Recent Drought.
04N19W25C02S	Piru	265-504	13	12	103	
04N19W25K04S	Piru	220-370	12	No Clear Trend	Insufficient Data	Short-Term Trend since 2000 is generally downward.
04N19W25M01S	Piru	Unknown	7	14	96	
04N19W26P01S	Piru	212-268	6	10	82	Pre-2000 Drought Minimum WL.
04N19W34J01S	Piru	72-120	2	8	Insufficient Data	
04N19W34K01S	Piru	5-120	0	7	60	
04N19W35G01S	Piru	24-79	5	No Clear Trend	Insufficient Data	Well Dry in Recent Drought, monitoring well adjacent Fillmore WWTP percolation ponds.
04N19W35L02S	Piru	Unknown	3	9	74	Pre-2000 Drought Minimum WL
04N19W36D01S	Piru	18-73	8	No Clear Trend	Insufficient Data	Well Dry in Recent Drought, monitoring well adjacent Fillmore WWTP percolation ponds.

The "Notes" field in the tables denotes which wells were determined to have historical (before the year 2000) drought low observed water levels that were deeper than the recent drought low water levels. Wells that went "dry" during the recent drought (i.e., groundwater level was below the bottom of the screened interval of the well) are also identified in the tables along with other well-specific information pertinent to trend interpretation.

4.2.1 Water Level and Well Screen Depth Comparative Evaluation

Observed static groundwater level in wells compared with screened interval depth is evaluated in this Section. This exercise functions in part to assess potential correlation that may indicate heterogeneous aquifer conditions (e.g., confined or semi-confined) that may be present in some areas or zones of the Fillmore and Piru basins. This evaluation serves to inform the ensuing water level evaluation of short-term, seasonal and long-term water level trends. In addition to the graphed water levels shown in the figures, the same depth to water (DTW) data shown on the graphs for individual wells is displayed in map view to provide spatial context to the evaluation. Each dot on the maps represents a single well, with the dot scaling representing the minimum DTW (i.e., maximum water level elevation) for the year (i.e., 2005, 2011 or 2016).

Well screen depth in feet is graphed on the y-axis against water level depth below reference point (RP) on the x-axis on the cross-plots (scatter plots) shown in the figures. RP stick-up above ground surface is not known for many of the wells with historical water levels so depth below RP is shown (see Section 2.1.3 and 5.1.3). Typically RP height is not more than a foot or two of actual ground surface so using depth below RP for the purpose of this evaluation does not significantly distort the results.

Minimum (typically spring high) DTW measurements in wells for 2005 (wet precipitation year), 2011 (average) and 2016 (dry) are shown for individual wells by basin. Wells in Fillmore basin are shown as blue dots and wells in Piru basin are represented with orange dots on the graphs and maps in the following figures. All wells with known top and or bottom screen interval with a water level measurement for at least one of the three years of evaluation were included in the analysis. DTW on the y-axis is plotted in reverse order (i.e., zero in the upper left corner of the graphs) for ease of interpretation. The red line on each graph visually shows how static water levels (SWL) in wells compare to top of screen (TOS) and bottom of screen (BOS). Points that plot below the red line represent SWL below TOS. Wells that were flowing artesian are shown as purple dots (for years 2005 and 2011) and dry wells are shown as red dots (for dry year 2016) on the graphs and maps.

Figure 4-13 characterizes “topped off” (i.e., basin full) 2005 wet precipitation year groundwater level conditions. In Fillmore basin DTW is greatest in the vicinity of Sespe Upland (i.e., five wells with DTW ranging 99 to 139 feet below RP). In Piru basin the deepest DTW in 2005 was recorded in a well west of Piru Creek near the north flank of the basin (i.e., 04N18W20M02S DTW of 84 feet below RP). Artesian flow was recorded in two Fillmore Fish Hatchery wells near the Fillmore/Piru basin boundary. Artesian conditions in a couple of wells near the Santa Paula/Fillmore basin boundary are known but these wells were not measured in 2005 according to the available water level records.

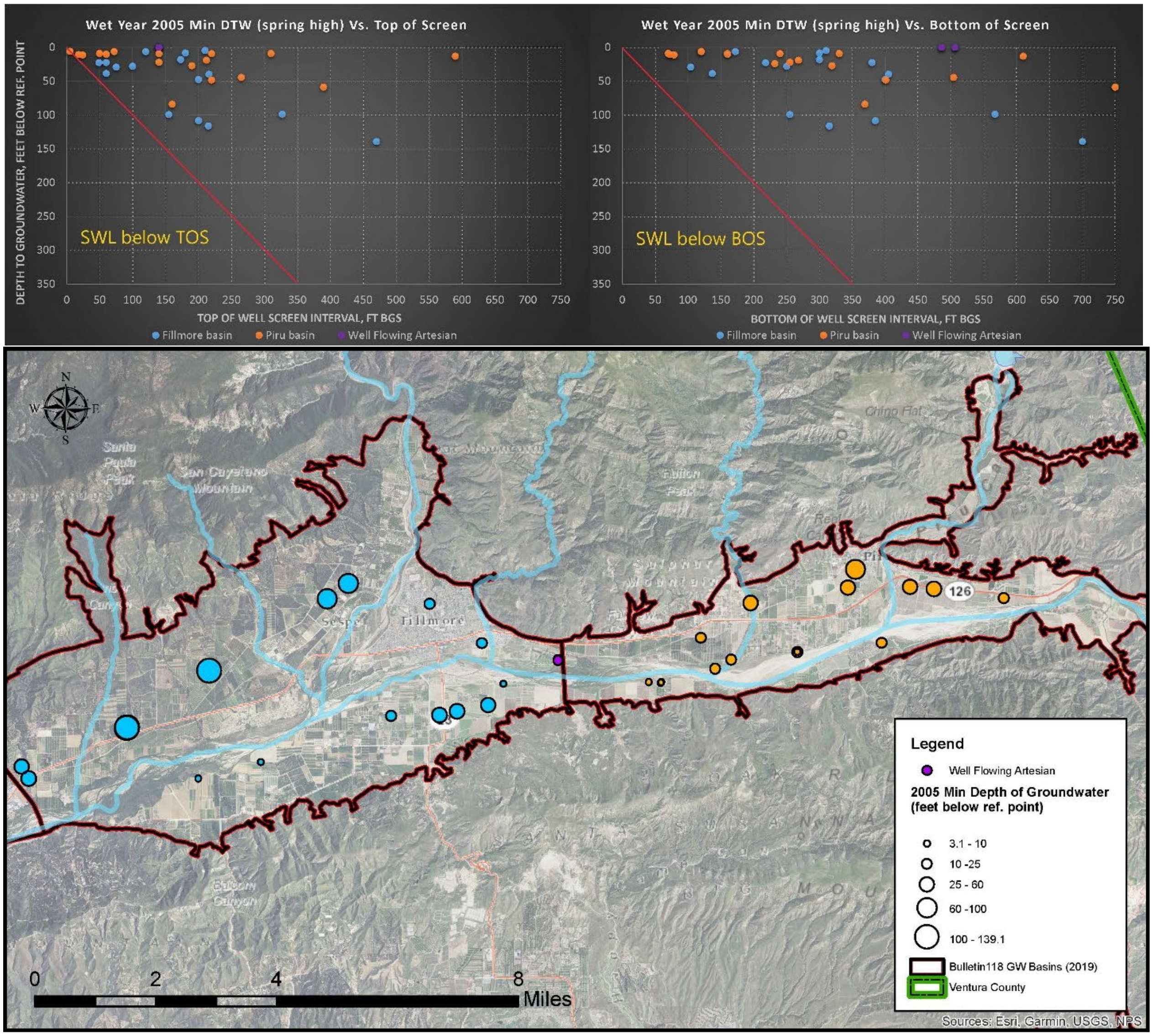


Figure 4-13. Fillmore and Piru basins 2005 wet precipitation year minimum (water level high) depth to groundwater and corresponding depth to groundwater verse screen interval scatter plots.

Ground surface elevation of the Sespe Upland and nearby areas, where the deepest DTW was recorded in wells in 2005, increases to the north at a steeper gradient than the more subdued underlying water table/potentiometric surface. This is linked to deeper depth to water in wells in this area as compared to wells located in lower lying and closer to high recharge areas (e.g., Santa Clara River channel). In very wet years, this up-slope available groundwater storage can fill but drains somewhat quickly down steep groundwater gradients to the south and southwest.

Figure 4-14 shows 2011 groundwater level depths in Fillmore and Piru basins wells which represents somewhat “average” conditions. Although the preceding year (i.e., 2010) was closer to a representative average precipitation year, 2011 was selected for the purpose of this analysis since it was the last year before the recent drought years that began in 2012 and represents somewhat average full groundwater levels in the basins below the very wet year “topped off” levels.

Similarly to 2005 groundwater levels, Fillmore basin DTW is greatest in the vicinity of Sespe Upland (i.e., five wells with DTW greater than 100 feet below RP). In Piru basin the deepest DTW was recorded in well 04N18W20M02S (i.e., DTW of 106 feet below RP). DTW in four other wells in Piru basin in the same area range 61 to 86 feet below RP. Artesian flow was recorded in Fillmore Fish Hatchery wells.

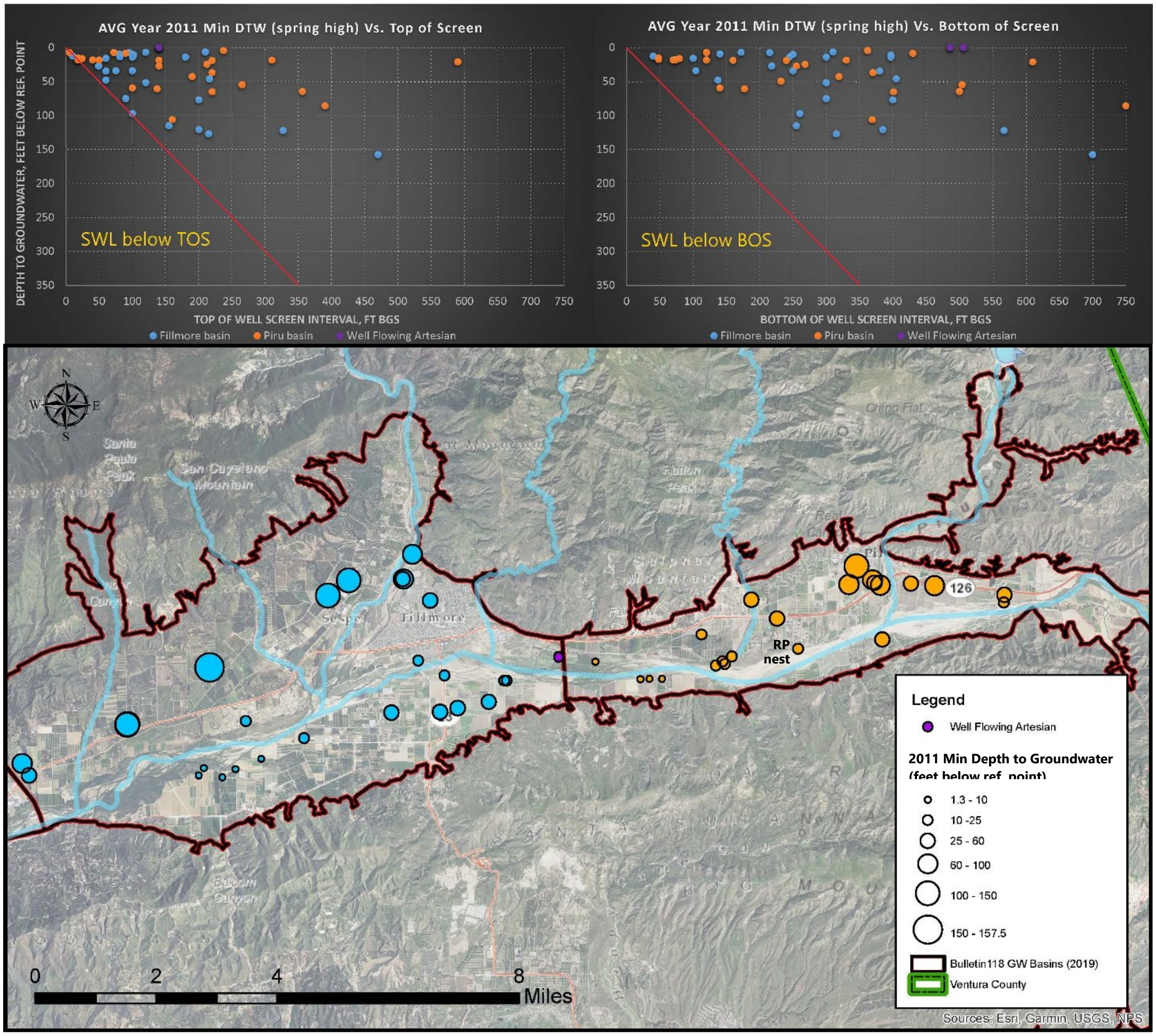


Figure 4-14. **Fillmore and Piru basins 2011 average precipitation year minimum (water level high) depth to groundwater and corresponding depth to groundwater verse screen interval scatter plots.**

From Figure 4-14, there is a somewhat discernable correlation between top of screen depth and DTW under average groundwater level conditions. DTW generally increases with increasing top of screen depth. There does not appear to be a strong correlation between DTW and bottom of screen depth. Sespe Upland wells are generally deeper than 250 feet bgs and show the deepest groundwater levels in the basins in 2011.

Figure 4-15 shows 2016 recent drought (dry) groundwater level depths in wells in Fillmore and Piru basins. A number of wells in Piru basin and a shallow monitoring well in Fillmore basin were reported as “dry” (i.e., groundwater level was below the bottom of the screened interval of the well). Dry wells are shown on the graphs as red dots and plotted DTW is bottom of screened interval (actual DTW is unknown for these wells). Two wells with reported water levels have bottom of screen depth in excess of 1,000 feet bgs so these wells were plotted with bottom of screen of 750 feet bgs with labels showing their actual depths so as not to distort the graph based on these deep completion wells in Fillmore basin. Static water level in several wells is shown to be below top of screen. Artesian flow was not observed in any wells reported from the available water level data in Fillmore and Piru basins in 2016.

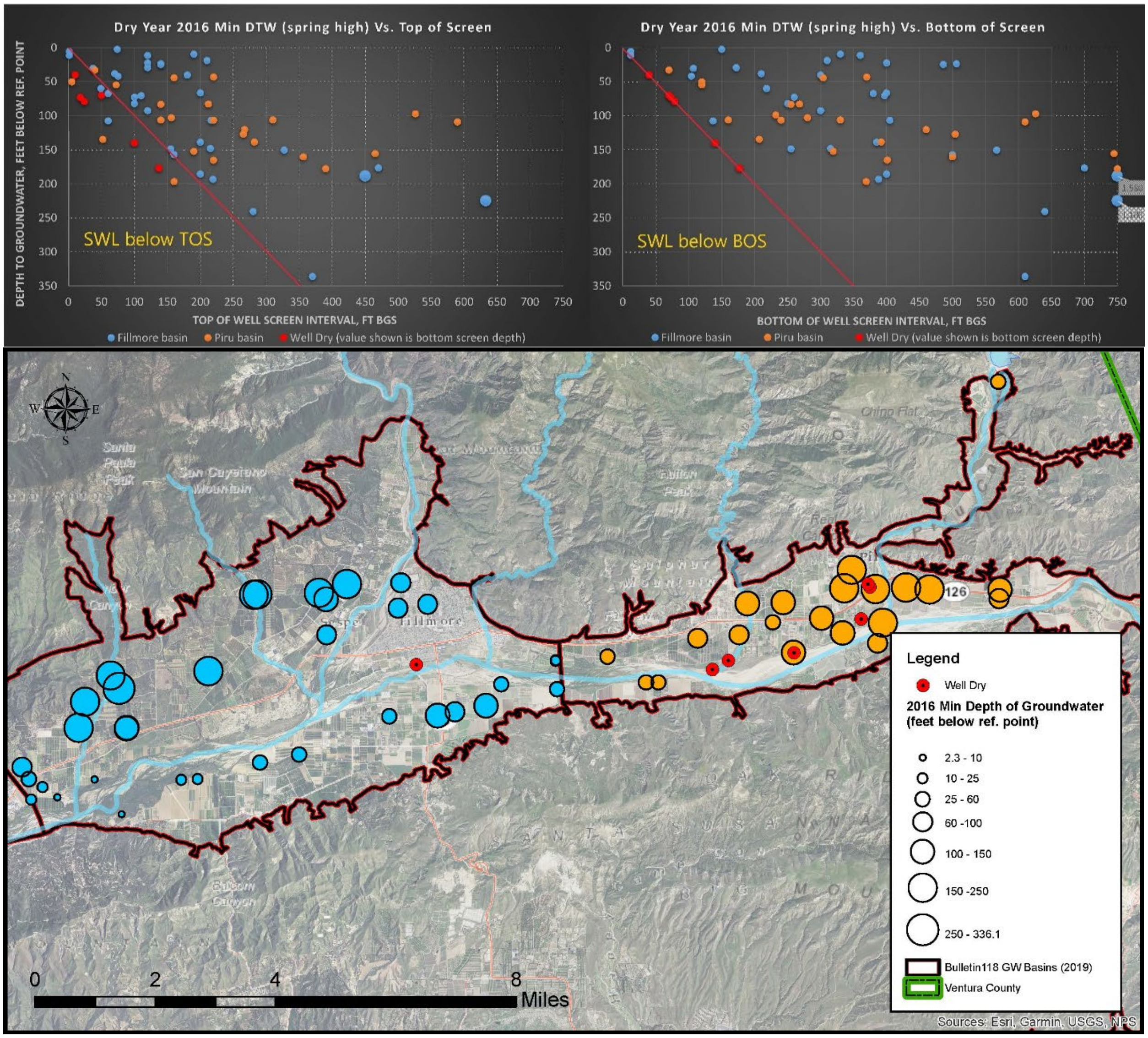


Figure 4-15. Fillmore and Piru basins 2016 dry precipitation year minimum (water level high) depth to groundwater and corresponding depth to groundwater verse screen interval scatter plots.

From Figure 4-15, there is a general correlation between top of screen depth and DTW under drought groundwater level conditions where many wells in Fillmore basin were at historical low levels. DTW for wells in both basins generally increases with increasing top of screen depth. This relationship is less discernable using this “cross-plot” technique when water levels were higher under “basin” full or average conditions. When the basins are relatively full, water levels are more similar to each other and are likely more highly influenced by ground surface elevation than aquifer characteristics.

There may be a discernable correlation between bottom of screen depth and DTW but the relationship is less apparent than that of top of screen. This is likely because many of the wells in the basins for which water level data is available are screened across multiple aquifer zones which can complicate or obscure interpretation (see Section 5.4.1.2).

Two wells near the Santa Paula/Fillmore basin boundary are shown on each of the three figures in this Subsection. These wells are discussed as a shallow and deep completion well pair in Section 1.2.6 (Vertical Head Gradients). Well 03N21W01P02S (1P2) is screened 75-104 feet bgs and 03N21W01N02S (1N2) is screened 200-400 feet bgs. Water levels are relatively stable in 1P2 as compared to 1N2 and differences are less apparent in “basin full” conditions where water levels are high in both wells. The separation of water levels in these paired wells in average and drought years may be indicative of confined/semi-confined aquifer conditions. Additional information is needed to confirm aquifer conditions in this area such as a nested monitoring site with piezometers screened discretely in a single aquifer zone (see Section 6.2).

Figure 4-16 shows water column height (i.e., maximum static DTW recent drought low) in feet above or below top of well casing screen for wells that were measured for water level in 2016. This was calculated as top of screen depth minus DTW so in the instances where DTW is deeper than a well’s top of screen depth the difference is a negative value as shown on the figure. These are the same wells shown in Figure 4-15 above. A color ramp is employed that ranges greater than 100 feet of groundwater above top of screen (blue symbols) to DTW deeper than 10 feet below top of screen (red symbols). Wells that were dry in 2016 are shown on the figure as dark red symbols. Well symbol shapes shown on the figure are distinguished by well type or main use (i.e., agricultural production, domestic/municipal or monitor) from the FPBGSA well inventory.

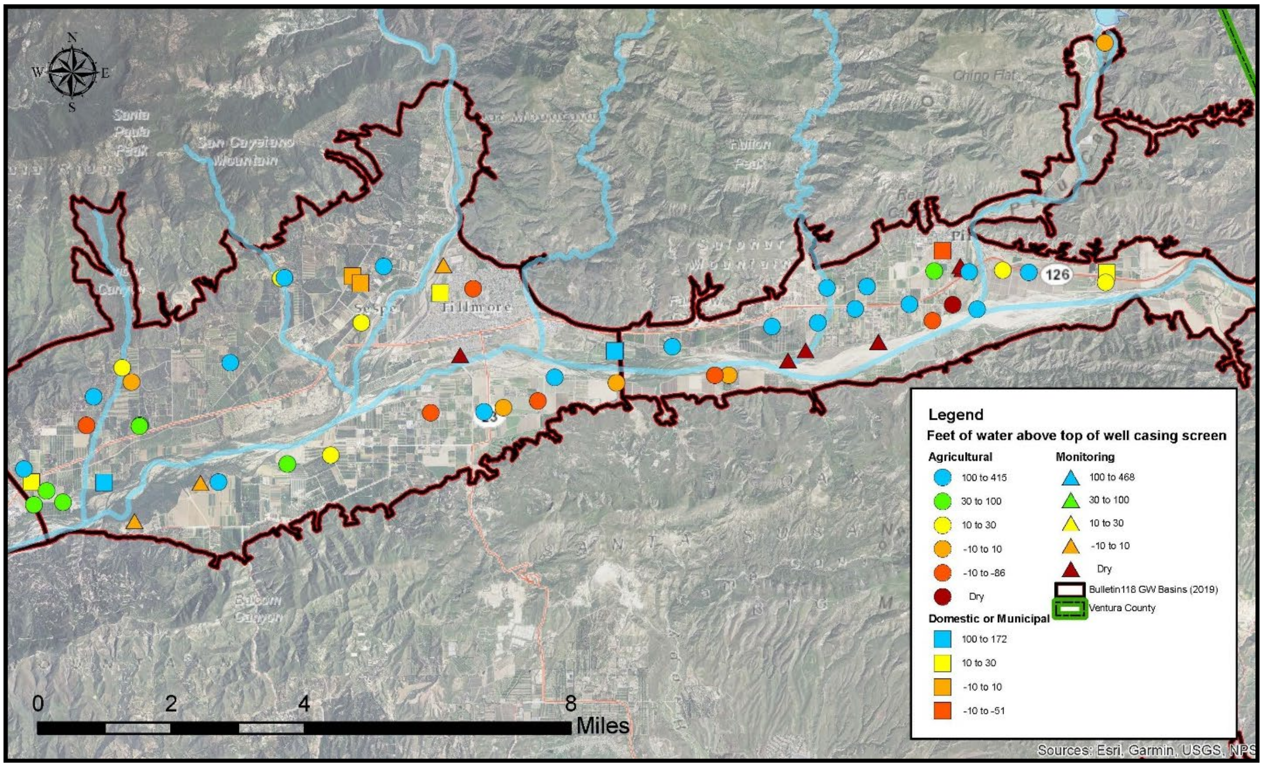


Figure 4-16. Top of well screen depth compared to recent drought low (2016) static depth to water in wells in the Fillmore and Piru basins.

From the figure, a number of production wells in 2016 (especially in Fillmore basin) had observed static water level below the top of well casing screened interval. One production well was reported as dry in Piru basin and the remaining dry wells shown on the figure are monitor wells (most of which are completed to relatively shallow depths bgs). Further evaluation using UWCD's VRGWFM when calibration is complete for the river basins expansion will be useful to quantify the extent of wells in the basins that had DTW below top of well screen or went dry during the recent drought. This evaluation might include output of pumping induced groundwater levels which when compared to top of well screen would likely yield results where many additional wells would be shown to have pumping DTW below the top of screened interval.

Water levels below the top of the perforated interval in a well might be an undesirable condition for groundwater pumpers. If air bubbles from cascading (free falling) water are entrained in water flowing towards the pump it can be damaged through the process of cavitation. It can be difficult to airlift monitor wells (e.g., for collecting groundwater samples) that have a portion of their screens exposed to the atmosphere. Steel screens located above the water table are also subject to rust and corrosion.

4.2.2 Short-Term Trends

Recent groundwater level trends since the year 2000 are generally decreasing in wells in the Fillmore and Piru basins which is evident from available water level records from wells reviewed for this trend analysis. VCWPD reports the groundwater level trend of both Fillmore and Piru basins to be downward for the five year period from 2011 to 2015 in their most recently published Annual Report of Groundwater Conditions (VCWPD, 2016). Prior to the recent drought, the basins were at approximately near full capacity consequentially from very wet years in 1998 and 2005 and were generally full in 2011 which was a moderately above average wet year.

California has experienced two statewide droughts thus far in this century (past 20 years). The first was from 2007 through 2009 (DWR, 2020) but is not particularly evident in many of the groundwater level hydrographs from wells in the Fillmore and Piru basins. Groundwater levels rapidly declined in the recent drought years of 2012 through 2016 and recovered somewhat following the above average precipitation years of 2017 and 2019.

For this analysis, available water level data since the year 2000 were used to assess whether 2011 high (maximum) water level was near the Short-Term (2000-2018) high (basin full) water level in individual wells. For wells with record sets that extend back further in time, the maximum water level in wells in the basins was typically during or shortly following very wet years 1983, 1998 or 2005. Groundwater level increases resulting from UWCD surface water releases from Lake Piru and water released to the Santa Clara River from Castaic Lake in LA County are evident in groundwater level hydrographs, especially in the Piru basin. Pressure transducer recorded spring high and fall low (minimum) water level elevation data were used in this analysis where available.

As mentioned above, tabulated results of the short-term trend analysis are shown in Tables 4-5 and 4-6 for Fillmore and Piru basins, respectively. Figure 4-17 shows the results graphically in map view to add spatial perspective to these analysis results. A couple of wells near the basins boundaries are known from available water level records to flow artesian when water levels are high in the basins. These are shown as purple dots on the figure and wells where water level dropped below the bottom of the screened interval of the well casing (“dry” well) during the last drought are shown as red dots.

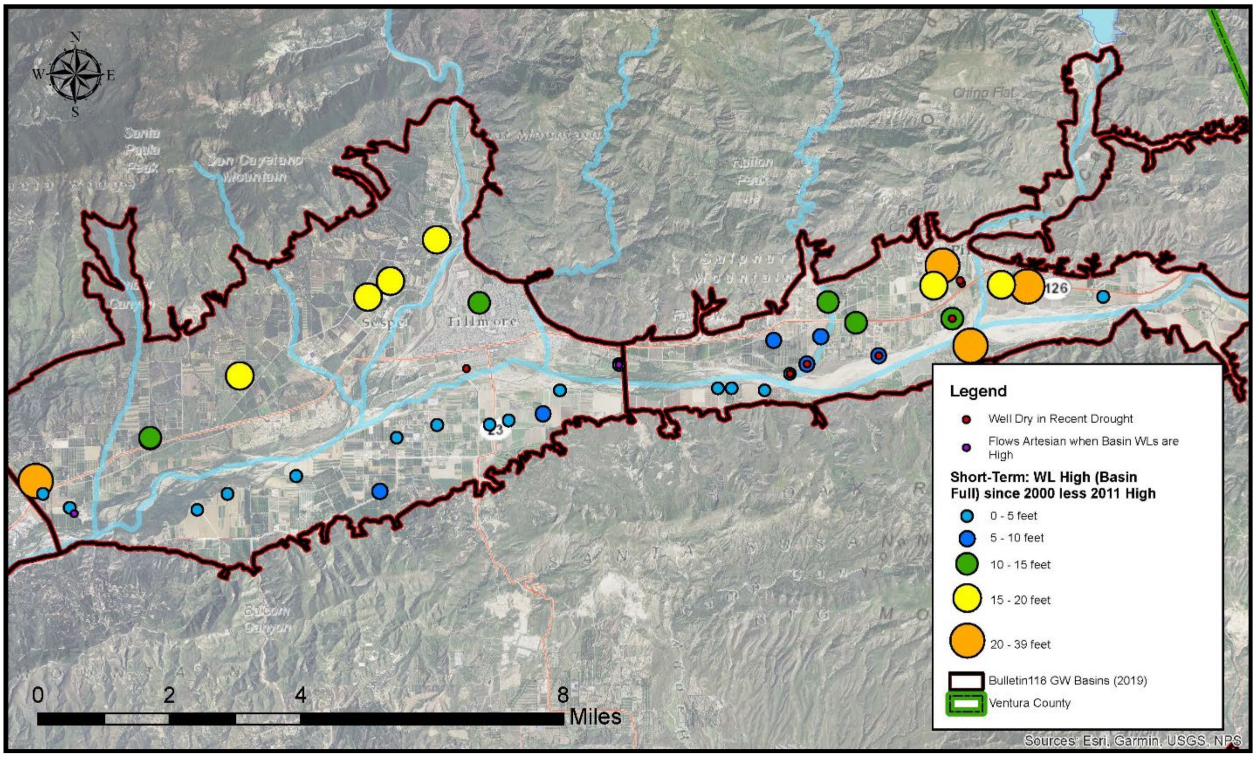


Figure 4-17. Short-term (since the year 2000) maximum water level (basin full) less 2011 maximum water level (difference) in feet.

This analysis serves in part to delineate which geographic areas in the basins were “full” before the start of the recent drought (2012 - 2016). For a few wells, groundwater level elevation was slightly higher in 2010 or 2012 than in 2011 so the higher water level was used as the pre-drought maximum water level in the assessment. The maximum water level elevation observations used in the evaluation are labeled on the hydrographs in Appendix C. Areas in the basins that were full before the start of the recent drought will likely follow a similar pattern of refilling more readily in wet years following future droughts. Areas that were not full in 2011 may indicate that they recharge more slowly following wet years and may only “top off” during very wet climatic cycles or are impacted by other factors. It may be determined by the FPBGSA Board of Directors that it is appropriate to manage areas that recover more slowly following droughts according to different sustainable management criteria than the basin as a whole.

The basins were generally near full capacity (little available storage) in 2011 prior to the start of the recent drought with water levels in wells ranging from zero to 39 feet deeper than maximum water levels observed earlier in the 2000s (i.e., typically 2005). The greatest in magnitude differences are shown in wells in the central portion of Piru basin, and in Sespe Upland and Pole

Creek Fan (Figure 1-2) areas of Fillmore basin. One well (i.e., 03N21W01N02S) shown as an orange circle on Figure 4-17 located near the Santa Paula/Fillmore basin boundary is included in the Santa Paula basin adjudication and water levels appear to be somewhat linked to the reported general water level trend condition in that basin of long-term gradual decline.

4.2.3 Seasonal Trends

Available data from 2000 through 2011 were used in the seasonal trend analysis to assess spring maximum (high) and fall minimum (low) water level average annual variance (fluctuation). These data included manual water level measurements and seasonal maximum (spring) and minimum (fall) water level records from recording pressure transducers.

The 12 years from 2000 - 2011 were chosen in order to include in the evaluation record sets from the most wells practicable in the basins and to exclude the extreme recent drought and recovery years. In very dry or wet years, seasonal fluctuation trends in wells are often masked by dominate climatic cycle increasing or decreasing water level trends that can span several years. In drought years for example, water level may continue to decline from fall low level through the following spring (where normally there would be a “spring high” increase). Accordingly, in this analysis water levels recorded in the recent drought years were not used except for a few wells in Fillmore basin where high-frequency pressure transducer data were used and seasonal trends were apparent within the more dominant climatic driven trends. Seasonal variance from pressure transducer data outside the evaluation time period window are estimates and should be reevaluated as additional water level data become available, especially for average precipitation years where UWCD did not release surface water to Santa Clara River in the fall. These estimated values are noted in Table 4-5.

The method used to evaluate seasonal trends consisted of averaging of the minimum (min) and maximum (max) annual fluctuations for each of the 12 years of the evaluation period for which sufficient data were available. Only years with both spring (or late winter) and fall (or late summer) measurements were used. Potential outlier highest and lowest values were discarded in the calculation to account for extreme above (e.g., 2005) and below average precipitation years that fell within the time period of evaluation. UWCD surface water releases to Santa Clara River and subsequent groundwater recharge to the basins in the fall of some years dampen the annual fluctuation magnitude that likely would have occurred under more natural recharge conditions.

Figure 4-18 shows the tabulated results from Tables 4-5 and 4-6 graphically in map view to add spatial perspective to these analysis results. Average tabulated results by basin are included in Section 5.4.1 (Table 5-4) for potential data gap analysis consideration. As mentioned above, wells known to flow artesian when water levels are high in the basins are shown as purple dots on the figure and wells that went "dry" during the last drought are shown as red dots.

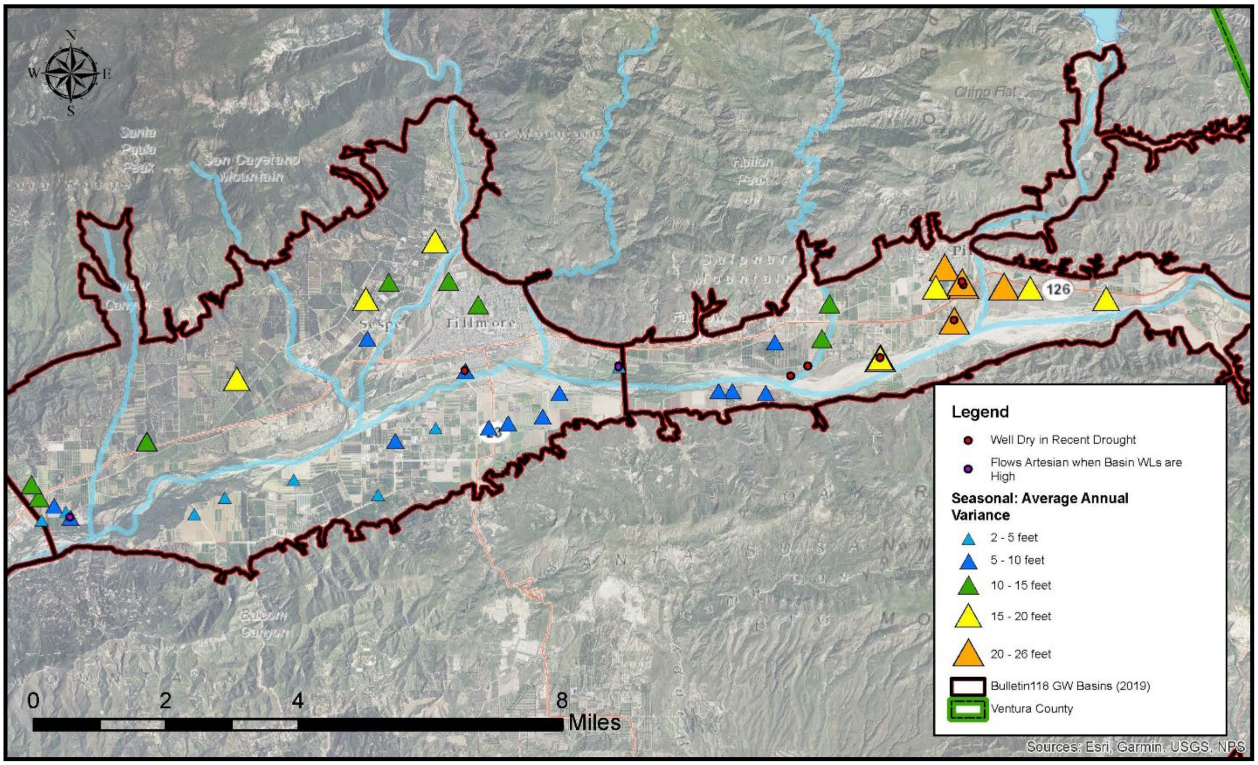


Figure 4-18. Seasonal water level average annual variance (fluctuation) in feet.

From the figure, the greatest in magnitude differences are shown in wells in the central portion of Piru basin, and in the Sespe Upland and Pole Creek Fan areas of Fillmore basin. This is a similar distribution as shown in Figure 4-17 above which suggest that wells that were not as "full" in 2011 also have a greater seasonal fluctuation.

4.2.4 Long-Term Trends

Groundwater levels in wells for years 1983 - 2018 (last 36 years) maximum (basin full) and recent drought low water level (typically in 2016) difference were analyzed to assess the long-term magnitude range of groundwater level fluctuation in wells in Fillmore and Piru basins. Water level data from 2019 shown on groundwater level hydrographs were not considered in the analysis since fall low water levels were not available for many of the wells included in the analysis. These 2019 water levels were not vital to the analysis since water levels in the basins were generally not at extreme high or low levels that would have impacted the analysis results. For wells with water level records dating back to the 1950s and 1960s, historical drought low water level was assessed. Groundwater level hydrographs for select wells analyzed in this section are in Appendix C and hydrographs for all wells in FPBGSA's database that contain at least two water level elevation records are included in Appendix A of this Tech Memo.

Figure 4-19 shows graphically the tabulated results from Tables 4-5 and 4-6 in map view to add spatial perspective to these analysis results. Average tabulated results by basin are included in Section 5.4.1 (Table 5-4) for potential data gap analysis consideration. As mentioned above, wells known to flow artesian when water levels are high in the basins are shown as purple dots on the figure and wells that went "dry" during the last drought are shown as red dots. The maximum and minimum water level elevation observations used in the evaluation are labeled on the hydrographs in Appendix C.

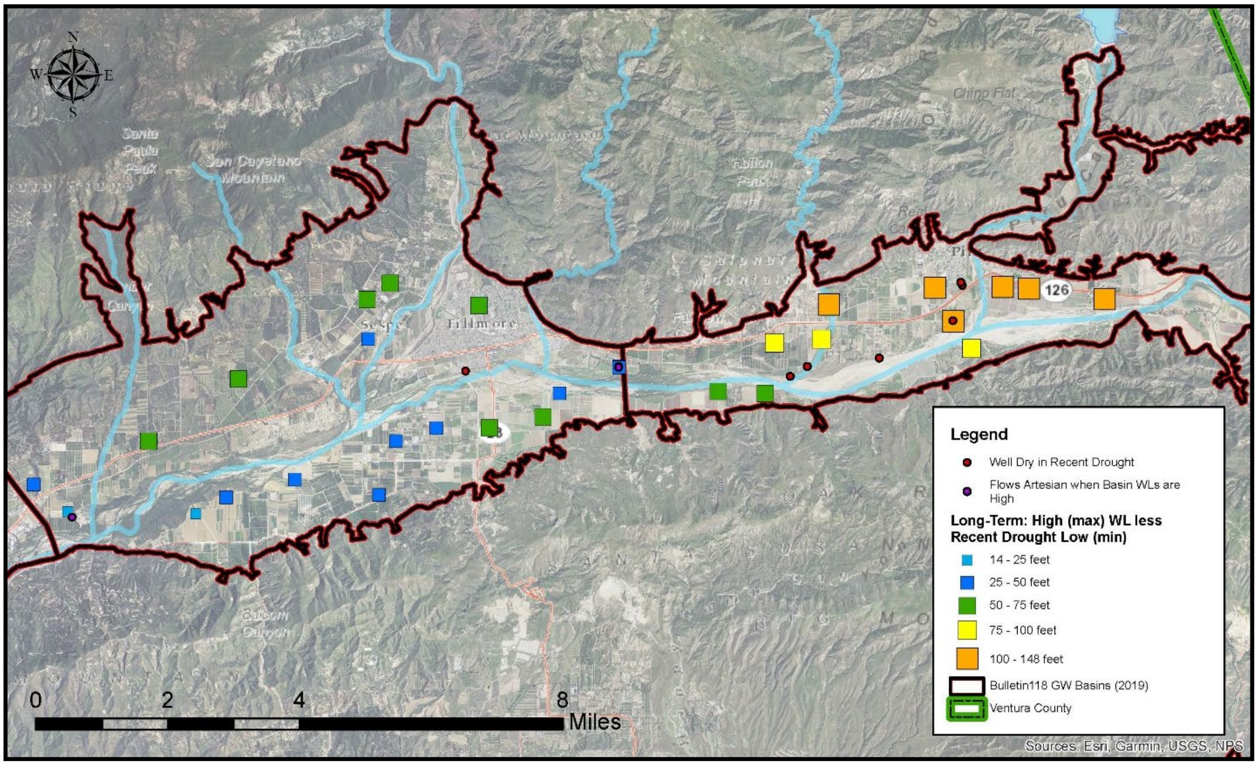


Figure 4-19. Long-term maximum water level (basin full) less recent drought low water level (difference) in feet.

Differences in basin size (i.e., aquifer storage capacity) and geomorphology contribute to the observed differences in groundwater level hydrographs from wells in each of the two basins and in the long-term groundwater level fluctuation magnitude distribution shown in Figure 4-19. Fillmore basin is larger in surface area and aquifer volume with more wells and four times the annual average groundwater production (i.e., 46,150 AFY) of Piru basin (i.e., 11,080 AFY). Piru basin is an elongated, relatively narrow basin with a shallower aquifer system than Fillmore basin. The eastern portion of the Piru basin has a very thin aquifer system that constrains the potential of underflow from SCR Valley East basin. Instead the majority of up-gradient water enters the basin as overflow (surface water) and base flows generally infiltrate in the "dry gap" east of the lower Piru Creek confluence with the SCR. Consequently, the dominate groundwater recharge water budget component in Piru basin is from surface water.

Groundwater levels in wells in Piru basin generally tend to drawdown more rapidly and to a greater depth below ground surface (shown in Figure 4-19) and respond more rapidly to recharge events than wells in Fillmore basin. However, many wells in Piru basin did not reach basin "full" levels in the year 2011 preceding the start of the recent drought (as did most wells in Fillmore basin). Underflow from Piru basin is a major water budget recharge component to Fillmore basin (especially in dry years) which may explain why Fillmore basin was closer to full capacity in 2011 than Piru basin.

Figure 4-20 shows wells with lengthy time period record sets that allowed for evaluation of the severity of the recent drought that ended in 2017 compared to the past historical droughts of the twentieth century. Green circles on the map represent wells that reached their lowest water level prior to the most recent drought and orange circles represent those wells that reached historical low water level during the recent drought.

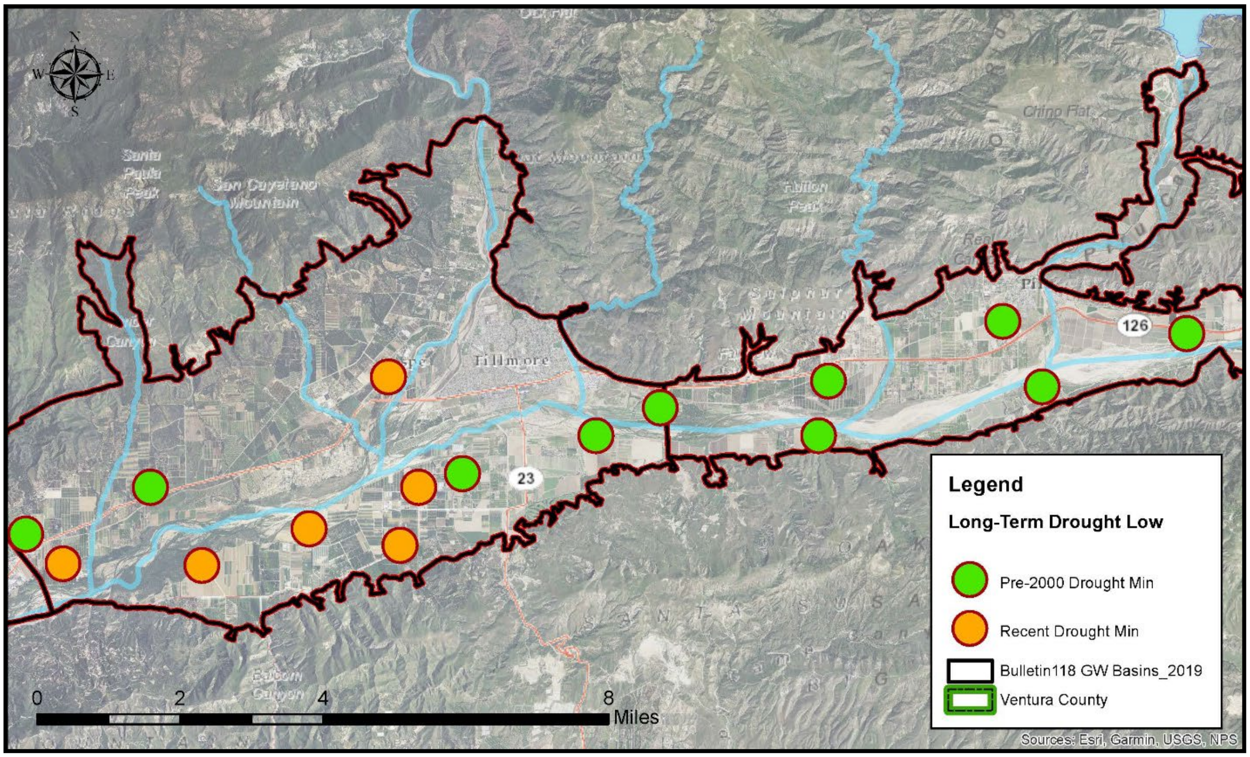


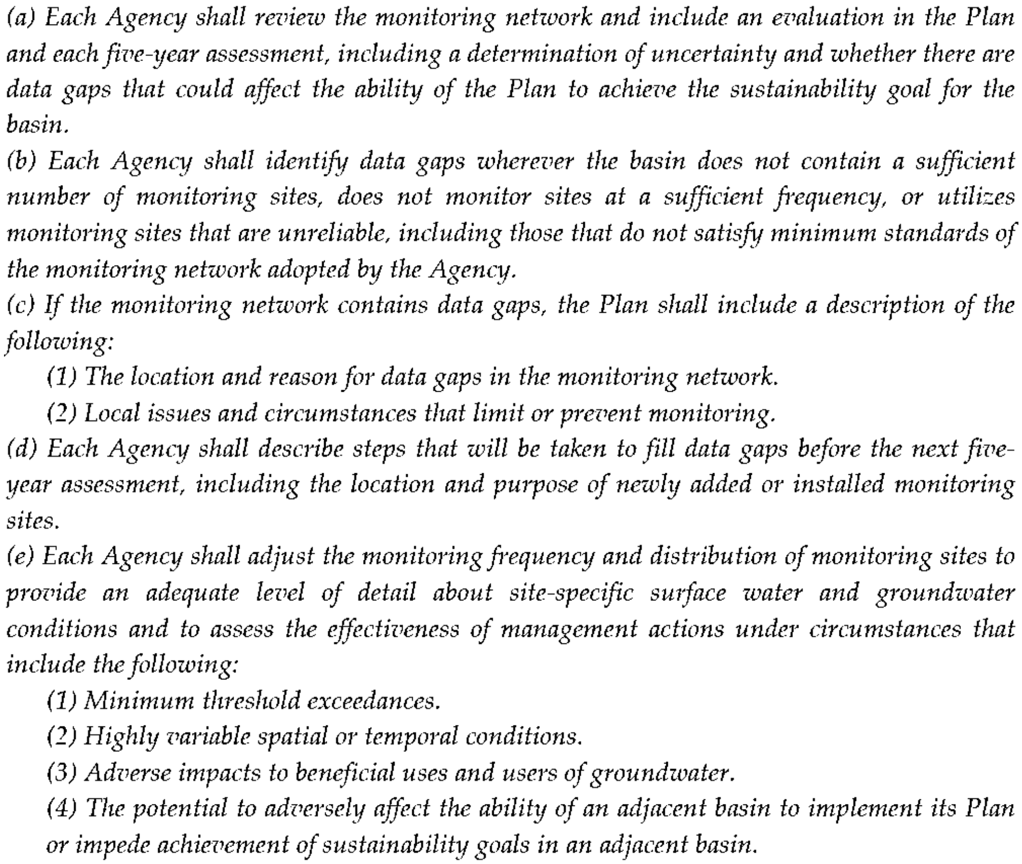
Figure 4-20. **Long-Term groundwater level drought low in select wells if Fillmore and Piru basins.**

From the figure, the recent drought spanned a period where many wells in the Fillmore basin reached historical low groundwater level. However, in Piru basin from a review of the limited record sets from individual wells that extend from the present back through the 1960s or older, it appears that measured groundwater level lows in wells in previous droughts were generally deeper than during the recent drought. It is probable that water levels in Piru basin would have generally reached historical lows if not for the SCR perennial base flows sourcing from LA County that contribute groundwater recharge to the basin even during droughts. The construction of groundwater storage facilities (i.e., surface water reservoirs) that include Lake Piru in Ventura County in the 1950s and California Aqueduct connected Pyramid Lake and Castaic Lake in Los Angeles County in the 1970s also contributes to changes in long-term trends in the basins.

The DWR published in 2015 the report, “California’s Most Significant Droughts: Comparing Historical and Recent Conditions” and subsequently updated it in January 2020. The report frames the recent drought severity relative to historical statewide droughts (i.e., 1929-1934, 1976-1977 and 1987-1992) and considers changed conditions since these major droughts (DWR, 2020). The time period length and severity of these statewide droughts experienced locally in the Fillmore and Piru basins may vary somewhat from the state as a whole but the report is recommended for consideration in contextualizing the recent drought.

5. Analysis of Potential Data Gaps

A data (or knowledge) gap is defined in the SGMA regulations as a “lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of Plan implementation, and could limit the ability to assess whether a basin is being sustainably managed” [23 CCR §351 (l)]. Data gaps are addressed in the SGMA regulations regarding Assessment and Improvement of Monitoring Network (a)-(e) contained in 23 CCR §354.38. The regulations are reproduced below:



> *(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.*
> *(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.*
> *(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:*
> *(1) The location and reason for data gaps in the monitoring network.*
> *(2) Local issues and circumstances that limit or prevent monitoring.*
> *(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.*
> *(e) Each Agency shall adjust the monitoring frequency and distribution of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:*
> *(1) Minimum threshold exceedances.*
> *(2) Highly variable spatial or temporal conditions.*
> *(3) Adverse impacts to beneficial uses and users of groundwater.*
> *(4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.*

The term “potential” data gap is used in this section, as the determination of a data gap can be subjective, depending on the criteria used for determining if data gaps significantly affect the understanding of the basin setting or sustainability effectiveness evaluation of GSP implementation. Comparison of data collection cost with respect to significance to GSP preparation and implementation should be considered when determining priority of filling data gaps. In addition, not all data gaps must be filled in order to produce a SGMA compliant GSP. For example, if new groundwater monitoring facilities are constructed for the purpose of filling data gaps in the vicinity of the Fillmore and Piru basins boundaries, very little water level data will be available from these new wells for assessing vertical gradients before GSPs are due to DWR. However, these data will inform subsequent GSP 5-year assessments (i.e., updates). “These regular assessments will allow the GSA to adaptively manage, focus, and prioritize future monitoring” (DWR, 2016b). The following flow chart (Figure 5-1) is from BMP #2 and lays out the path GSA’s should follow to identify and address data gaps in their sustainability planning (DWR, 2016b).

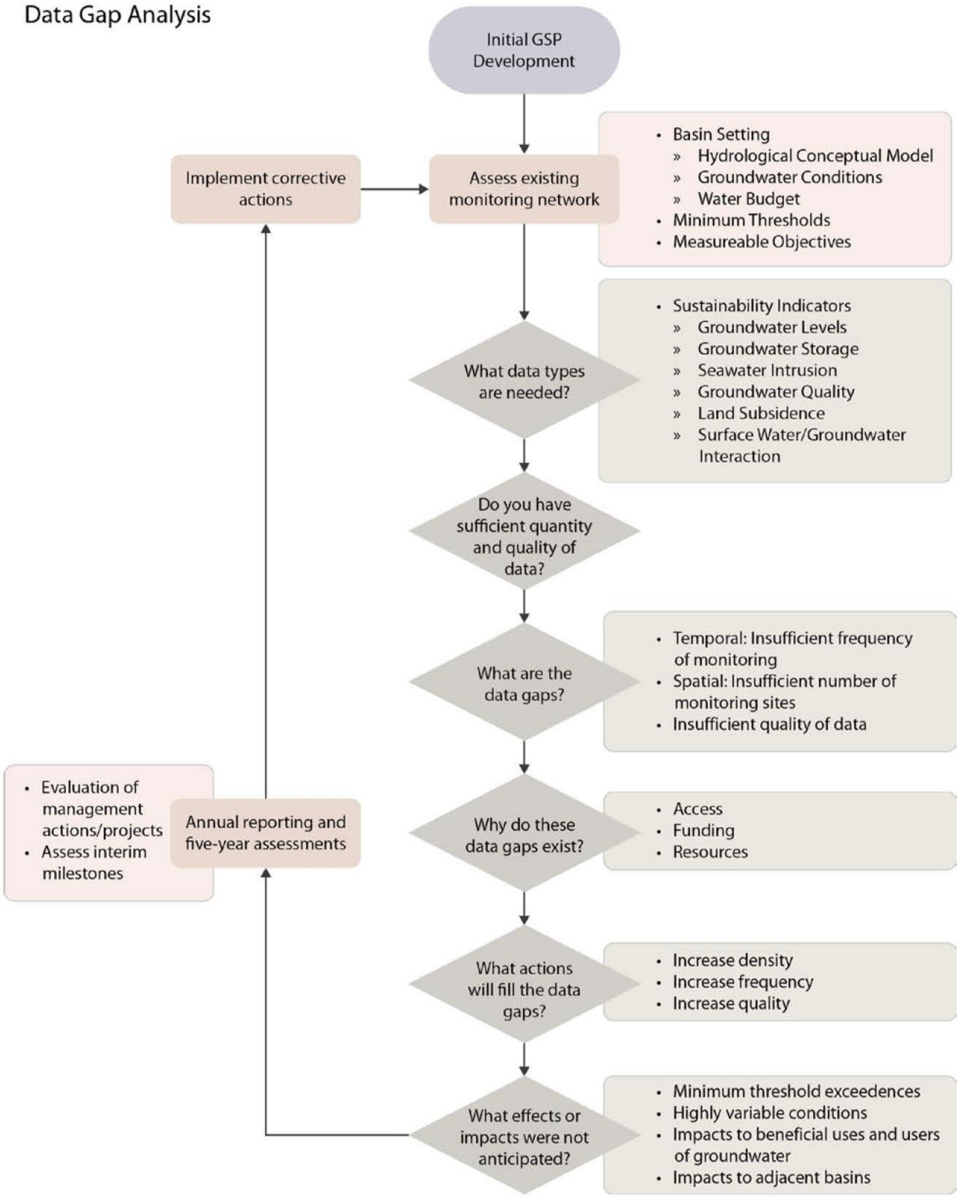


Figure 5-1. Data Gap Analysis Flow Chart (reproduced from DWR BMP #2 - Figure 4).

From the available data in the Fillmore and Piru basins reviewed in preparing this Tech Memo, data are generally of high quality and expected to be of sufficient or nearly sufficient quantity and quality for use in assessing many of the SGMA sustainability indicators. In addition, VCWPD and UWCD's existing monitoring networks include substantial annual data collection activities in the basins. A number of potential data gaps ranging in sustainability evaluation significance are presented in this Section and the concluding Section 6 of this Tech Memo provides FPBGSA monitoring program recommendations on prioritizing the filling of data gaps.

Potential data gaps are present in the historical groundwater datasets presented in Section 2 and in existing monitoring networks summarized in Section 3. However, existing monitoring networks are the focus since they facilitate the gathering of new data and by their enhancement, where practicable, afford important documentation of the progression towards sustainable management in the basins.

5.1 Well Construction and Geographic Location

Section 2.1.1 (Well Inventory) describes the available well construction information for wells in the Fillmore and Piru basins which are generally from DWR well completion reports (WCR). Both UWCD and VCWPD actively update their well inventory files to include information available from these publicly accessible forms and other sources (e.g., consultant As-Built reports and well owner reported information), where available. In addition to construction information, WCRs include well location information.

5.1.1 Well Completion Reports

WCRs are available for 570 (i.e., 415 in Fillmore and 155 in Piru basin) of the 859 wells in Fillmore and Piru basins included in the FPBGSA's well inventory as of June 2020. For wells in which WCR's were not available (i.e., from VCWPD and/or DWR), many of these are older (i.e., 1920s to early 1950s) constructed wells that are now destroyed or abandoned, little is known, and often even historical well locations are suspect as well construction regulations in California were less rigorous (casually enforced or nonexistent) prior to the advent of county-specific or local groundwater management agency regulation. Records are predictably most complete for newer constructed wells in the basins and those with a VCWPD identified active status. The source of well construction information contained in VCWPD and UWCD's well inventories that do not have an available WCR are largely unknown. In some cases the source is identified in a notes field in the files.

Historically, WCR identified well locations were frequently shown on hand drawn maps that were rarely to scale and often reference land marks that may no longer exist (e.g., private agricultural field dirt roads, trees or fence posts). DWR now requires GPS coordinates to be included in addition to a map showing the location. VCWPD is responsible for issuing well permits in the County and routinely collects GPS locations while observing the emplacement of annular seals in newly constructed wells or modified (e.g., liner installation) in the basins. VCWPD updates their well inventory file with these locations and periodically shares the latest version with UWCD for their updates. Both VCWPD and UWCD actively improve the GIS well locations in their well inventory files through periodic ground truthing field efforts of existing wells identified with potentially suspect locations and as new information becomes available from other sources (e.g., high resolution aerial photographs). As mentioned in Section 2.1.3, UWCD collected accurate GPS locations for the wells included in their monitoring network in 2010.

Table 5-1 shows the number of wells in Fillmore and Piru basins with available groundwater data (all historical records) relative to known well screen interval depth. Well construction information is not identified on all WCRs, especially older ones, so the number of available WCRs for wells in the basins is not synonymous with number of wells with known well construction.

Table 5-1. Summary statistics of available data for wells in the Fillmore and Piru basins. The first number in each cell is the number of wells with known screen interval depth and the second is the total number of wells included in FPBGSA's database.

Number of Wells	Fillmore Basin	Piru Basin
Wells with Water Level > 1 Record	77 of 115	49 of 74
Wells with Water Quality Records	204 of 316	97 of 146
Wells with Production Records	284 of 381	105 of 131
FPBGSA Well Inventory Total	387 of 625	147 of 234

Groundwater data from wells of unknown construction are less useful for GSP preparation than data from wells of known construction and screened intervals that are discretely in a single aquifer zone. Well construction is known for most wells included in VCWPD and UWCD's current monitoring networks for groundwater quality and the majority of wells monitored for water level in the basins. Wells of unknown construction that are actively monitored in the basins should be investigated (e.g., contact owner for records or perform a well video survey) to determine construction, if possible. Alternatively, they should be replaced in the monitoring networks with wells of known construction if potential substitute monitor points exist nearby. Data gaps associated with wells screened across multiple aquifer zones (e.g., agricultural production wells) are identified in Section 5.4.1.2 later in this Tech Memo.

5.1.2 UWCD and VCWPD Well Inventory GIS Locations

As mentioned previously, FPBGSA's well inventory file for GSP preparation was compiled from UWCD's well file (used as the primary well inventory source) and VCWPD's well inventory file (used to supplement incomplete UWCD well inventory records). These well inventories contain essential well construction and geographic location information needed for mapping and interpreting available groundwater data (e.g., water quality, level and production). These files are the best available information for use in the Fillmore and Piru basins but lack metadata (e.g., source information) in some instances that might be a potential data gap that may require additional investigation beyond the scope of this Tech Memo.

Not all groundwater quality and level records received from UWCD could be tied to a GIS monitoring point location. A small number of records were from unknown wells (i.e., not included in either UWCD or VCWPD's well inventories) and were consequently excluded from the FPBGSA's database. A future investigation could include an attempt to determine the historical monitoring point locations for these "orphan" records beyond the effort included in DBS&A's data reduction and cataloging process for producing reasonably reliable, internally consistent datasets. Data from wells of unknown location and construction are not suitable for preparation of the GSPs for the Fillmore and Piru basins.

Figure 5-2 shows the location of all wells contained in UWCD and VCWPD's individual well inventories. A careful comparison of this figure with Figure 1-1 (FPBGSA's well file inventory) reveals the wells from VCWPD's well file that were incorporated into the FPBGSA's master well file and were not in UWCD's well file (e.g., three destroyed wells in Piru Canyon). VCWPD and UWCD staff were consulted during this FPBGSA well inventory development process. Criteria for incorporating VCWPD unique wells included those that have available water quality, level, production data or WCRs associated with them.

In some cases, discrepancies existed in construction and or location information contained in VCWPD and UWCD's independent well inventory files. Many of these were resolved but additional future effort is likely needed to reconcile the two well files, if necessary. Discrepancies, in most cases, represent very small differences in well location or construction. Well location discrepancies were typically on the order of tens to hundreds of feet. Overall, there is good agreement between the two files and FPBGSA's well inventory file compiled from these files is expected to be sufficient for GSP preparation purposes.

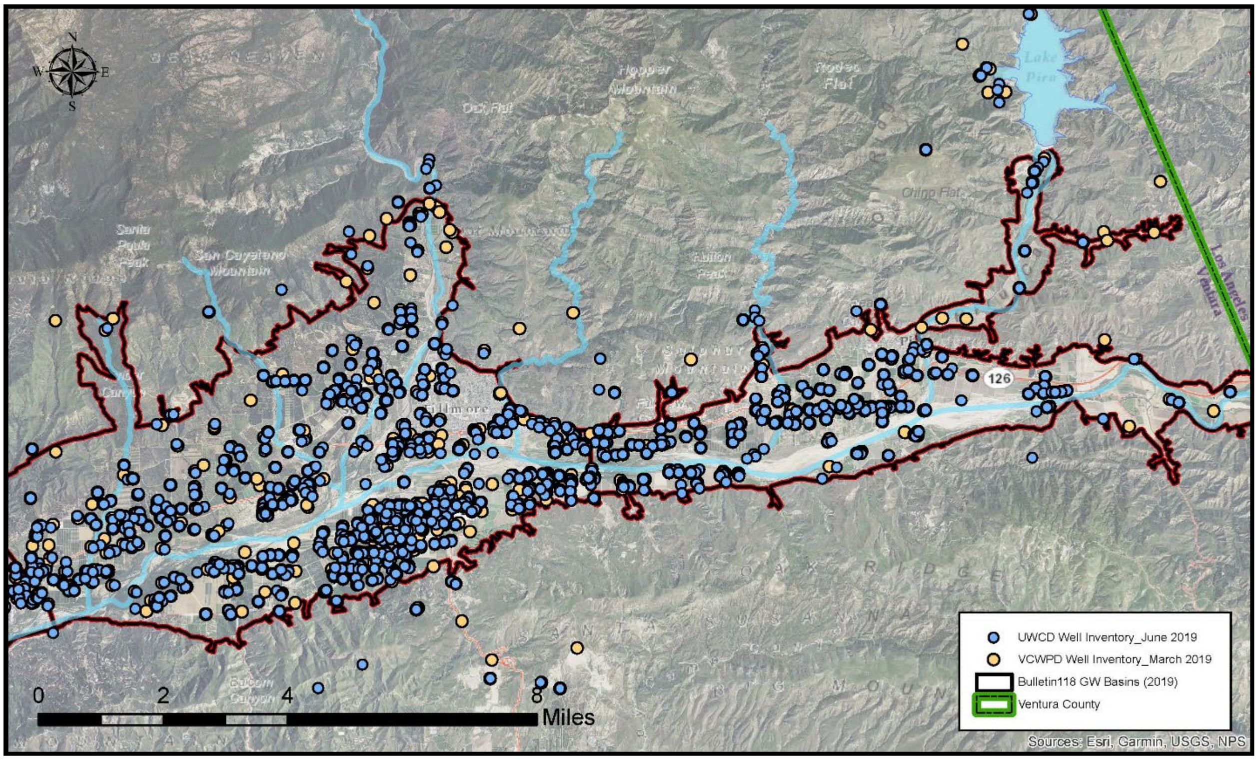


Figure 5-2. GIS locations of the wells contained in UWCD and VCWPD's well inventories.

For SGMA purposes, the locations of wells on the land surface should be surveyed to North American Datum 1983 (NAD83) (see FPBGSA SAP for monitor point accuracy survey requirements). DWR's standard horizontal projected coordinate system is California Teale Albers, NAD83. Feature class (location) data uploaded through the SGMA portal is required to be converted to this projected coordinate system for consistency across datasets (FPBGSA, 2020).

All wells included in FPBGSA's well inventory have been projected into a consistent coordinate system. However, available well locations in Fillmore and Piru basins originate from different geographic and projected coordinate systems which have historically been referenced in locating wells in the basins. These include, but are not necessarily limited to, the following systems:

- NAD27
- NAD83
- WGS84

- Unknown (e.g., undocumented estimation from USGS topo map quadrangles)

UWCD currently uses NAD83 (State Plane CA_V) but some well locations in their well file source from Google Earth aerial imagery georeferenced to the World Geodetic System 1984 (WGS84). Wells plotted using these two coordinate systems are typically very close to each other in the Fillmore and Piru basins. In addition, some GIS well locations were likely historically digitized with unknown accuracy from USGS topo map quadrangles.

VCWPD uses NAD 1927 (NAD27 in State Plane CA_V) in projecting the wells in their respective well inventory. A transformation was performed on VCWPD's well file to project to NAD 1983 in Figure 5-2. Without conversion to like projections, wells plot approximately 250 to 300 feet from each other in the Fillmore and Piru basins.

5.1.3 Ground Surface and Reference Point Elevation Data

For SGMA evaluations, ground surface elevation and top of casing elevation reference points should be measured to North American Vertical Datum 1988 (NAVD88). FPBGSA's SAP describes required survey accuracy requirements (FPBGSA, 2020). Section 2.1.3 summarizes the available ground surface data used for establishing reference points (RPs) for calculating groundwater level elevations for wells in the Fillmore and Piru basins. Differing vertical datums have historically been used in referencing groundwater level data contained in FPBGSA's database. These may include, but are not necessarily limited to, the following sources of ground surface and RP elevation data:

- NGVD29 (2005 LiDAR dataset): VCWPD and UWCD groundwater level elevation data
- NAVD88: UWCD HCM DEM for VRGWFM
- EGM96 (Google Earth DEM): select UWCD wells (since establishing LiDAR RPs in 2010) for establishing temporary RPs for use until more reliable ground surface data are gathered
- Unknown (e.g., undocumented estimation from USGS topo map quadrangles)

The vertical differences between these datums vary with location but are likely not a major source of error when used for regional water level evaluations (e.g., groundwater flow modeling or basin-wide groundwater level contouring) as are envisioned for the Fillmore and Piru basins GSPs but may pose issues when used for site-specific evaluations. It is mentioned here because DTW below ground surface requires a known ground surface elevation and stick-up. Wells with UWCD LiDAR established RPs are the only records contained in the FPBGSA's water level database for which DTW below ground surface can be accurately calculated from the available data. Maps contained in Section 4.2.1 show DTW below RP since measurement offset height above/below ground surface is largely unknown for the wells not included in UWCD's monitoring network.

5.1.4 Sounding Tubes

Ventura County Code of Ordinance requires that new wells be "constructed with a sounding tube, tap hole with plug, or similar access for water level measuring equipment. For wells fitted with a well cap, the cap shall have a removable plug for this purpose" (Ord. No. 4814). Unfortunately, many existing wells in the basins were historically constructed without adequate access into the well casing for measuring water level or the access has since been obstructed.

Well casing access restrictions are an important consideration when identifying existing production wells for potential addition or replacement of monitoring points in existing groundwater monitoring networks. Office based evaluations can easily identify wells screened discretely in a single aquifer zone and located in data poor areas from the available well inventory files (e.g., Figure 1-3). However, after receiving permission from the well owner, a site visit is often required to establish if the well has sufficient access into the casing for manual measurement and if access restrictions disqualify the well as a potential candidate for future pressure transducer and data logger deployment.

5.2 Historical Groundwater Data

Considerable historical groundwater datasets are available from monitoring points in the Fillmore and Piru basins. These data are critical for documenting past conditions and developing realistic basin-specific sustainable management criteria. Unknown sources of historical data and potential temporal data gaps exist in these datasets and are described in this Section. Spatial data density is also an important consideration but is not discussed in this Section since this is not a data gap that can likely be filled. Data density for wells included in existing monitoring networks is described in Sections 5.3.1 and 5.4.1 later in this Tech Memo.

5.2.1 Sources

Historical sources of groundwater quality and levels contained in UWCD's databases are generally not as well documented for records before the 1990s as are the more recent records from the last 30 years. Source fields for some records are unpopulated (e.g., for water quality), identified as "unknown" (e.g., for water levels) or references a source other than the original data collection entity for many of these older historical records.

Data collection procedures for groundwater quality sampling and water level measurement standards are generally undocumented and of unknown accuracy. Only one or two water level measurements exist in UWCD's database for a number of wells. Many of these are from DWR WCRs and were made by drillers in recently completed wells. These measurements are often of questionable reliability.

5.2.2 Temporal

In BMP #2, the DWR describes four types of temporal data gaps. These are shown on Figure 5-3 using example groundwater level data to illustrate these kinds of temporal data gaps. The figure is reproduced here from the BMP document (DWR, 2016b).

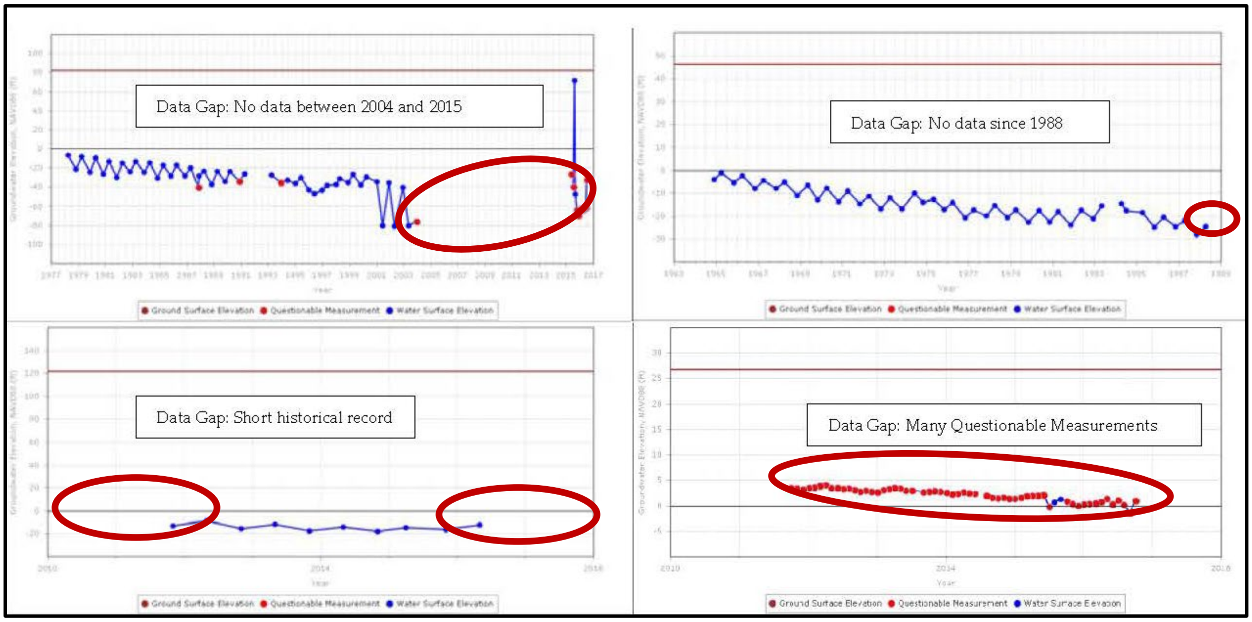


Figure 5-3. Examples of Hydrographs with Temporal Data Gaps (reproduced from DWR BMP #2 - Figure 5, red circling added for clarification).

The trend analysis presented in Section 4 of this Tech memo includes a criteria for analysis that disqualify record sets for analysis inclusion if considerable data gaps existed that could impair the trend identification results. General data gaps and examples of how these were considered in the trend analysis include, but are not necessarily limited to, the following for each of the DWR identified temporal types:

- Multiple sequential years without available data (e.g., gaps of no more than 6 years from the long-trend analysis criteria)
- Short historical record (e.g., record set must span at least 8 years from the short-term trend analysis criteria)
- No recent data (e.g., data since the year 2000 from the short-term trend analysis criteria)
- Many questionable measurements (e.g., these data are flagged in FPBGSA's database and were not included in the trend analysis)

Available groundwater level historical data (hydrographs in Appendix A), existing monitoring networks and a trend analysis that includes 51 wells (28 wells in Fillmore basin and 23 in Piru basin) are described in this Tech Memo. There are wells in the basins with available long record sets that were not included in the trend analysis but these are from wells that do not have recent data (many of which have been destroyed). From a review of the groundwater level hydrographs from wells included in the trend analysis (Appendix C), it appears that there is likely sufficient available datasets from wells in each of the basis without significant temporal data gaps for use in GSP preparation.

Available groundwater quality data are also described and analyzed for trends for primary chemicals of concern in this Tech Memo (Appendix E). The groundwater quality trend analysis included 51 wells (24 wells in Fillmore basin and 27 in Piru basin) with recent data. From a review of these time-series graphs, it appears that there is likely sufficient available recent (i.e., since the year 2000) datasets from wells in each of the basis without significant temporal data gaps for use in GSP preparation. However the long-term trend identification exercise reveals that there are not many wells with long record sets (1983-2018) that do not contain substantial gaps (greater than 6 years).

Higher monetary cost and more intensive field effort (e.g., pump or bailer to purge and sample) is required to collect a water sample from a well than to measure it for water level. This may partially explain the differences in long-term available groundwater quality record sets compared to water levels from wells in the basins. In addition, groundwater quality is generally less dynamic than water level fluctuation so it is not surprising that there are more available long-term water level records from wells in the basins. Recent datasets constitute data from approximately the last 20 years and will likely be adequate for preparing SGMA compliant GSPs for the Fillmore and Piru basins.

5.3 Existing Network Groundwater Quality Monitoring

Groundwater quality data collected from existing monitoring networks are described in Section 3.1 of this Tech Memo. This Section addresses FPBGSA monitoring program potential data gaps that may be present according to SGMA requirements if UWCD's and VCWPD's existing monitoring networks are the only sources of active data collection in the basins. From 23 CCR §354.34(c) (4), groundwater monitoring programs, with respect to the SGMA sustainability indicator of degraded water quality, should "Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues."

The USGS installed RP1 nested site is the only multiple-well groundwater monitoring facility in the basins and UWCD includes this site in their groundwater monitoring program, as mentioned previously. At least one new multiple-well (nested) groundwater monitoring facility is recommended in the basins to partially fill potential well density data gaps in the basins. Potential new groundwater monitor wells are discussed in Section 6.2 of this Tech Memo.

5.3.1 Well Spatial Density

BMP #2 provides guidelines for assessing spatial density of wells for collecting groundwater level data (Section 5.4.1) but is less explicit with respect to groundwater quality. Local knowledge and stakeholder input is important in ensuring that appropriate representative data are collected for sufficiently documenting conditions in the Fillmore and Piru basins. Historically recognized chemicals of concern are described and analyzed for trends in Section 4.1 of this Tech Memo.

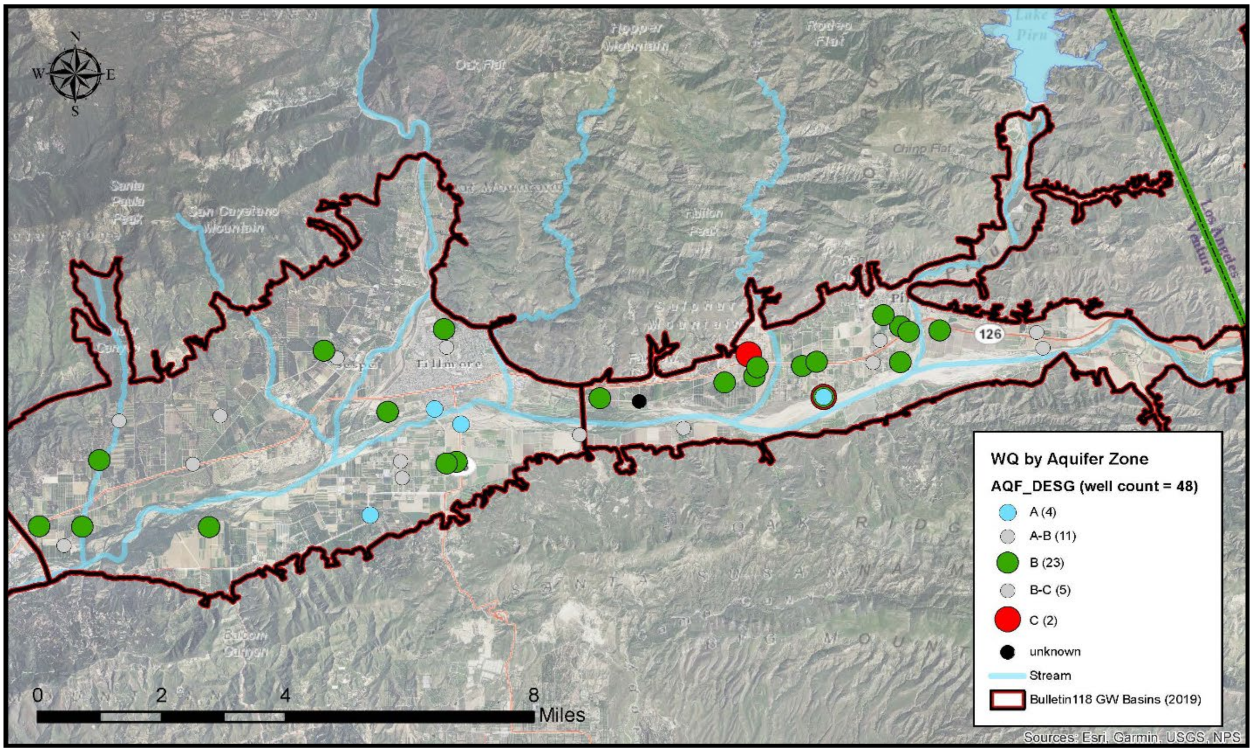


Figure 5-4. Wells currently monitored for groundwater quality by VCWPD and UWCD by aquifer zone designation.

Figure 5-4 shows wells currently monitored for groundwater quality by VCWPD and UWCD categorized by aquifer zone designation from UWCD's draft VRGWFM update layering (July 2020). These are the same wells shown in Figure 3-1. Note that Figure 3-1 shows one alternate VCWPD sampling well in Fillmore basin and two in Piru basins (orange squares in the figure). These alternate wells are also included on Figure 5-4 for comparison purposes but are not included in the tabulated number of wells per basin in Table 5-2, as they are only sampled as alternate wells if a VCWPD core group well is unavailable.

Table 5-2. Summary of the number of wells in the Fillmore and Piru basins included in VCWPD and UWCD's groundwater quality monitoring networks.

Number of Wells	Fillmore Basin	Piru Basin
Zone A	3	1
Zone B	9	13
Zone C	0	2
Screened Across Multiple Zones or of Unknown Construction	9	8
Total	21	24

The number of wells in the basin divided by the ground surface area in square miles yields the monitoring site density. Fillmore basin surface area is approximately 35 square miles and Piru basin is 17 square miles.

5.3.1.1 Horizontal

The horizontal distribution of wells sampled for groundwater quality in the Fillmore and Piru basins is extensive when considering the size of the basins. There are 0.6 wells per square mile in Fillmore basin and 1.4 wells per square mile in Piru basin (this value includes each of the five piezometers in the RP1 multiple-well groundwater monitoring site as individual wells). Note that well density here is reported as wells per square mile and well density is reported in Section 5.4.1 as wells per 100 square miles for consistency with BMP #2 recommended standards for groundwater level monitoring programs (DWR, 2016b).

From Figure 5-4, there is an apparent lateral (and vertical) well distribution data gap in the eastern portion of Piru basin outside UWCD's boundary but within Ventura County. However, there are no VCWPD identified active status wells in this area. As mentioned previously, this is an area where the groundwater aquifer is thin and depth to groundwater is understood to be shallow as there is perineal SCR flow in this reach sourcing from Los Angeles County.

VCWPD samples 14 core group wells in Fillmore basin and 10 wells in Piru basin but does not analyze samples from these wells for boron. When these are removed from the monitoring well density total, there are 0.2 wells per square mile in Fillmore basin and 0.8 wells per square mile in Piru basin with respect to boron sampling density. Short-term boron trend results (Section 4.1.2.5) show reported concentration to be relatively stable overall but from Figure 4-8, there are areas in both Fillmore and Piru basins where concentrations are increasing. It is recommended that VCWPD add boron to the suite of chemicals for which their annual groundwater samples are analyzed for in the basins. The cost is minimal for the addition of this constituent to VCWPD's existing analyte suite and would likely not heavily burden Fillmore and Piru basins rate payers if the FPBGSA were to offer financial reimbursement to the VCWPD for this additional laboratory analysis.

From the additional chemicals of concern mapping presented in Section 4.1.3, there are known elevated concentrations of radiochemistry in Fillmore basin groundwater near the west side of the Fillmore/Piru basins boundary (Figure 4-9), from the available data. There also appears to be elevated concentrations of Selenium in Piru basin groundwater near Hopper Creek. Additional groundwater sampling from wells surrounding these known "hot spots" is recommended to delineate the extent and potential sources of the elevated concentrations of these chemicals in the groundwater of the basins. Wells screened discretely in each of the aquifer zones, if available, should be sampled to determine if the contamination varies vertically within the water-bearing units.

5.3.1.2 Vertical

From Table 5-2, approximately half of the monitored wells in Fillmore basin and a third of the wells in Piru basin are screened discretely in a single aquifer zone. There are 0.1 wells per square mile in each of the basins in Aquifer Zone A. These represent a total of four wells in both basins combined and are shown as light blue circles in Figure 5-4. Three of these are near the SCR channel and one is in the vicinity of Bardsdale. The only Zone A well in Piru basin is the upper most completion of the RP1 nested site.

The majority of wells currently monitored by VCWPD and UWCD screened in a single aquifer zone are completed in Zone B. There are 0.3 wells per square mile in Fillmore basin and 0.8 well per square mile in Piru basin. Overall this represents a good distribution of Aquifer Zone B wells. There is a potential monitoring point data gap in Fillmore basin north of SCR between Timber Creek and Boulder Creek. In Piru basin, there are no monitoring points discretely in a single aquifer zone south of SCR and in the eastern portion of the basin, as mentioned above.

There are two monitored wells screened discretely in Aquifer Zone C, both of which are in Piru basin. One of these is the deepest completion of the RP1 nested site. There are not many wells that access groundwater from Zone C (see Section 5.5.3) but this is a potential data gap, especially in Fillmore basin where there are no groundwater quality monitoring points in this deepest mapped zone.

5.3.2 Temporal Assessment

As previously mentioned, a SGMA requirement is the development of a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in the basins. At a minimum, biannual data is needed to assess seasonal groundwater quality trends for evaluation of GSP implementation.

Groundwater quality samples are currently collected on varying schedules in the basins. UWCD samples monitoring and production wells in the basins biannually (in the spring and fall) and VCWPD annually samples production wells within the basins in the fall. VCWPD's list of groundwater sampling wells is somewhat dependent on availability of staff time and the Agency's annual budget. There are a core group of wells VCWPD prioritizes to be sampled almost every year and if one of these wells is unavailable for some reason, they will often sample a near-by well that is pumping.

Wells sampled in the basins as part of VCWPD county-wide groundwater quality monitoring program may not be sufficient for SGMA purposes. It is important to sample the same wells from year-to-year and to collect at least a spring and fall sample each year. Over a period of years that include both dry and wet precipitation years, if groundwater quality seasonal variability is demonstrated to be minimal in a particular well, annual sampling may be sufficient for GSP purposes.

5.4 Existing Network Groundwater Level Monitoring

Groundwater level data collected from existing monitoring networks are described in Section 3.3 of this Tech Memo. This Section addresses FPBGSA monitoring program potential data gaps that may be present if VCWPD and UWCD's existing monitoring networks are the only sources of active data collection in the basins.

SGMA regulations regarding the groundwater monitoring program design goals with respect to the sustainability indicator of chronic lowering of groundwater level from 23 CCR §354.34(c) include the ability to:

> (1) Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:
>
> > (A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.

> (B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

Potential spatial and temporal data gaps that may exist in the FPBGSA's groundwater level monitoring program are identified in this Section in order to address the SGMA legislation requirements presented herein.

5.4.1 Well Spatial Density

BMP #2 identifies existing references to assess the monitoring well density adequacy per hundred square miles (these references are considering basins much larger in geographic area than the Fillmore and Piru basins). "While these estimates may provide, guidance, the necessary monitoring point density for GSP depends on local geology, extent of groundwater use, and how the GSPs define undesirable results" (DWR, 2016b). The summary table in BMP #2 (BMP Table 1) suggests a range of 0.2 to 6.3 wells per 100 square miles. From the table, for basins pumping more than 10,000 AFY, 4.0 wells per 100 square miles is suggested by DWR (citing Hopkins, 1994).

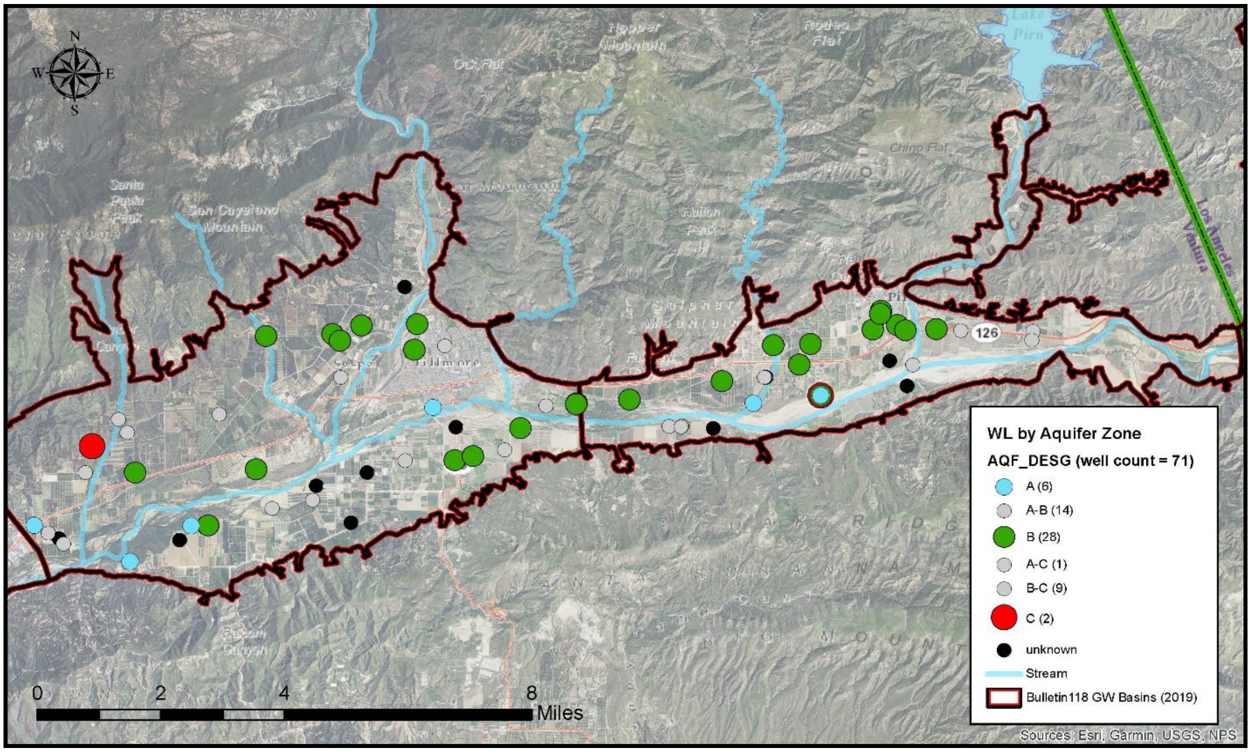


Figure 5-5. Wells currently monitored for groundwater level by VCWPD and UWCD by aquifer zone designation.

Figure 5-5 is dasymetric mapping of wells currently monitored for groundwater level by VCWPD and UWCD categorized by aquifer zone designation from UWCD's draft VRGWFM update layering (July 2020). These are the same wells shown in Figure 3-2.

Table 5-3 is a tabulated summary of the number of wells in the Fillmore and Piru basins included in VCWPD and UWCD's groundwater level monitoring networks. The second value in each cell is the theoretical number of wells per 100 square miles (the combined surface area of the basins is less than 100 square miles). Note that well density reported here as number of wells per 100 square miles is for consistency for comparison with BMP #2 recommended standards for groundwater level monitoring programs (DWR, 2016b).

Table 5-3. Summary of the number of wells in the Fillmore and Piru basins included in VCWPD and UWCD's groundwater level monitoring networks. The second value in each cell is the theoretical number of wells per 100 square miles.

Number of Wells	Fillmore Basin	Piru Basin
Zone A	4 | 11.4	2 | 11.8
Zone B	14 | 40.0	14 | 82.4
Zone C	1 | 2.9	1 | 5.9
Screened Across Multiple Zones or of Unknown Construction	22 | 62.9	13 | 76.5
Total	41 | 117.1	30 | 176.5

From what appears to be an update to the 1994 Hopkins publication mentioned above, additional considerations are included for evaluation of monitoring well density such as aquifer water level fluctuation, aquifer type and long-term drawdown (Hopkins et al., 2016). Basin-specific statistical average values are shown in Table 5-4 for use as parameters in assessing sufficiency of monitor well density by basin.

Table 5-4. Historical average groundwater production (1980 - 2018), static water level average maximum drought drawdown (1983 - 2018) and average annual seasonal fluctuation (2000 - 2011).

	Average Groundwater Production, AFY	Average Maximum Drawdown (Long-Term Trend Analysis, feet)	Average Annual Fluctuation (Seasonal Trend Analysis, feet)
Fillmore Basin	46,150	46.9	8.9
Piru Basin	11,080	104.4	17.7

5.4.1.1 Horizontal

The horizontal distribution of wells sampled for groundwater quality in the Fillmore and Piru basins is extensive when considering the size of the basins. There are 117.1 wells per 100 square miles (1.2 wells per square mile) in Fillmore basin and 176.5 wells per 100 square miles (1.8 wells per square mile) in Piru basin. The Piru basin value includes each of the five piezometers in the RP1 multiple-well groundwater monitoring site as individual wells. The location of the RP1 nested monitoring site is labeled in Figure 5-5.The Piru basin comprises half the surface area and a quarter of the annual groundwater extractions of Fillmore basin. This should be balanced against the finding that Piru basin has twice the long-term drawdown and seasonal fluctuation of observed groundwater levels than Fillmore basin when considering monitoring network density in the basins. From this, it appears appropriate that the existing monitoring networks measure more wells per 100 square miles in Piru basin than in Fillmore basin.

From Figure 5-5, an apparent lateral (and vertical) well distribution data gap is in the eastern portion of Piru basin outside UWCD’s boundary but within Ventura County. The majority of this area is within the Santa Clarita Valley Water Agency (SCV Water) service area, but they do not have any customers in Ventura County (Rick Viergutz, 2024, personal communication). When the GSA was being formed, SCV Water was approached about having a representative on the board of directors for the Piru subbasin, but that offer was declined and they were not directly involved in the development of the Piru GSP.

While there are no wells identified as active by VCWPD in this area (see Section 5.3.1.1), well logs obtained during the 180-day resubmission period indicate that shallow monitoring wells may be present (Figure 5-6). It is unknown if they are currently being monitored or have been in the past. It is recommended that these wells be investigated to determine if they can be added into the Piru subbasin groundwater monitoring network.

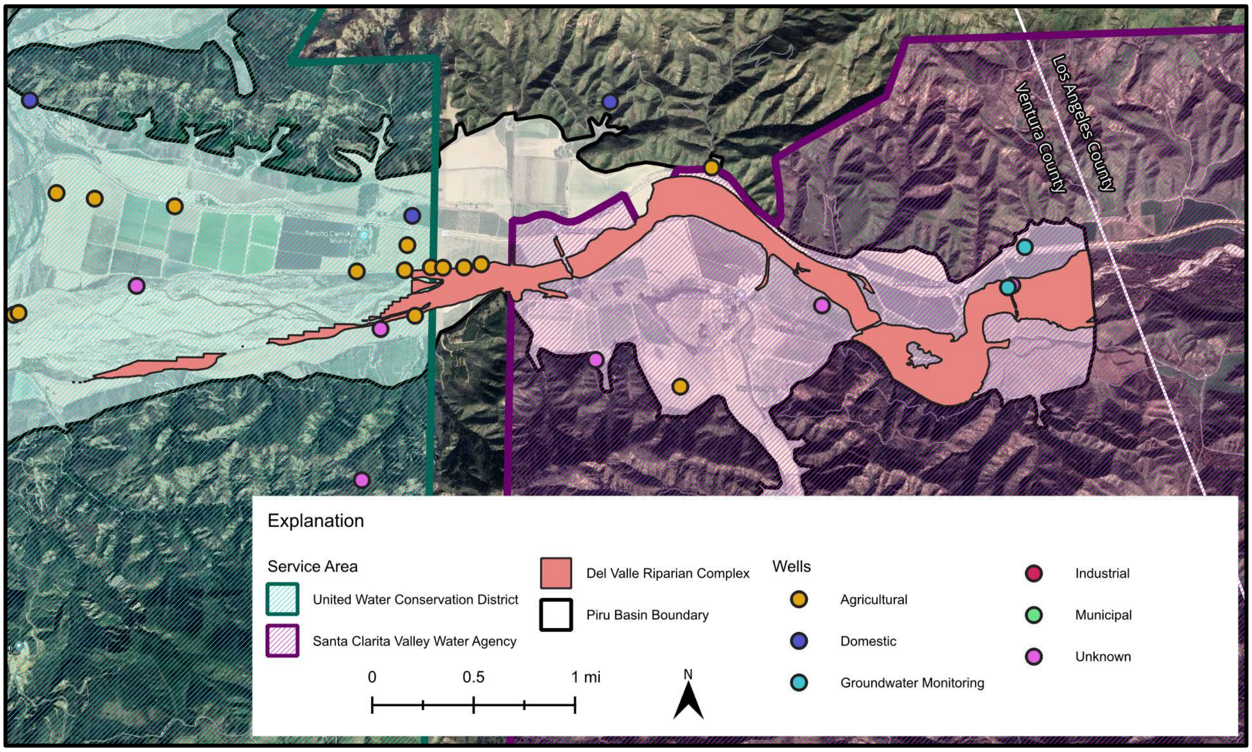


Figure 5-6. Administrative service areas, Del Valle GDE area, and known well locations.

There are also no monitoring points in Piru basin completed in the alluvium of lower Piru Creek that extends to near Santa Felicia Dam, which impounds Lake Piru. UWCD has periodically collected water level data from 04N18W03K01S (“shop well” below the dam) located in the northern most portion of the basin. It is recommended that this well be added to UWCD’s water level monitoring network for regular measurement.

5.4.1.2 *Vertical*

From Table 5-3, approximately half of the monitored wells in the Fillmore and Piru basins are screened discretely in a single aquifer zone. In Aquifer Zone A, there are 11.4 wells per 100 square miles in Fillmore basin and 11.8 in Piru basin. These represent a total of 6 wells in both basins combined and are shown as light blue circles in Figure 5-4. These are all near the SCR channel. One of only two discretely Zone A wells in Piru basin is the upper most completion of the RP1 nested site.

The majority of wells currently monitored by VCWPD and UWCD screened in a single aquifer zone are completed in Zone B. There are 40.0 wells per 100 square miles in Fillmore basin and

82.4 wells per 100 square miles in Piru basin. Overall this represents a good distribution of Aquifer Zone B wells. There is a potential monitoring point data gap in Fillmore basin north of SCR and between Timber Creek and Boulder Creek. In Piru basin, there are no monitoring points screened discretely in a single aquifer zone south of SCR and in the eastern portion of the basin, as mentioned above.

There are two wells screened discretely in Aquifer Zone C, one each in the Fillmore and Piru basins. One of these is the deepest completion of the RP1 nested site. There are not many wells that access groundwater from Zone C (see Section 5.5.3). This is a potential data gap since there are inadequate groundwater monitoring points in this deepest mapped zone.

The monitor well density range presented from the references in BMP #2 may be appropriate for monitoring the minimally pumped upper and lower zones (i.e., Zones A and C) in the basins but may not be applicable for evaluating the dynamic in level fluctuation and consumptive use of Zone B groundwater for various beneficial uses the basins.

5.4.2 Temporal Assessment

Groundwater levels in California basins are often at their highest annual levels during the spring of each year following winter precipitation and groundwater recharge. They are often at their lowest in the fall preceding the start of the winter rainy season with much of the annual precipitation falling from November through February in Ventura County. Temporal coordination of groundwater level collection activities across the State is important for comparison of water level measurements collected by different monitoring entities. The DWR's BMP #2 specifies that "Groundwater levels will be collected during the middle of October and March for comparative reporting purposes" (DWR, 2016b).

With respect to the length of the monitoring event time windows DWR offers, "Groundwater elevation data will form the basis of basin-wide water-table and piezometric maps, and should approximate conditions at a discrete period in time. Therefore, all groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1 to 2 week period" (DWR, 2016a).

As subsequently mentioned, a SGMA requirement is the development of a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in the basins. At a minimum, biannual data is needed to assess seasonal groundwater level trends for evaluation of GSP implementation. Likely water levels will be collected by both UWCD and VCWPD as part of their established monitoring networks in the basins during other times of the year for various purposes, but as tight (short) a monitoring event time window as reasonably possible should be scheduled around the middle of October and March of each year. A potential data gap exists in that UWCD and VCWPD historically did not routinely coordinate their monitoring event campaigns. However, they have been coordinating their groundwater monitoring more closely since 2019.

Equipping additional wells with pressure transducers and data loggers in the Fillmore and Piru basins is recommended for collecting highly reliable data for assessing short-term and seasonal high and low trends. Additional device uses and a description of pressure transducers and data loggers currently deployed in the Fillmore and Piru basins is in Section 3.3.2.

5.5 Groundwater Extraction

Available groundwater extraction records from wells in the Fillmore and Piru basins are described in Section 2.1.4 of this Tech Memo.

5.5.1 Groundwater Reporting

Groundwater production from wells in Fillmore and Piru basins are currently reported biannually by calendar year to UWCD. A SGMA annual reporting requirement is the reporting of groundwater extractions on a water year basis [23 CCR §356.2 (b) (2)]. Water years begin October 1 and end September 30 of the following year and are intended to capture a complete annual wet period as opposed to splitting it across two years as is commonly an artifact of calendar year reporting. This is not easily accomplished under FPBGSA’s current reporting mechanism that is tied to UWCD’s accounting system (as an FPBGSA cost saving measure) that if modified would impact several additional basins within UWCD’s boundary.

Voluntary quarterly reporting was implemented by UWCD starting in Fall 2022 to more accurately quantify groundwater extractions within a water year. As of the WY 2023 GSP annual report, approximately 60 to 70 percent of groundwater extractions in Fillmore and Piru subbasins are reported on a quarterly basis. Pumping not reported quarterly for Period 2 (July-December) is partitioned according to the fraction of estimated ET demand that occurred over that period during each respective water year.

Other groundwater extraction data potential data gaps include reporting method and tracking of potential non-reporters. Not all production wells in the basins are equipped with water meters and known non-reporters are billed based on average historical production (estimated from the previous three years of the same period), if available. These average historical production billing estimates are incorporated into UWCD's groundwater production data and are not well documented as estimates in all cases (i.e., records prior to 2010).

As mentioned in Section 2.1.4, pumping from wells not equipped with a water meter are reported by electrical efficiency, de minimis domestic multiplier, crop factor (with penalty), or estimate from historical usage. Pumping was reported by at least one of these methods in Fillmore basin in 2018 for 138 wells (representing 24 percent of the reported volume pumped) and in Piru basin for 47 wells (36 percent of the reported volume pumped). Fitting of wells with water meters to record groundwater extraction is not mandated by SGMA but the FPBGSA could determine that this is needed to better quantify the volume of groundwater produced from the basins.

One area that has unreported pumping to UWCD is between the eastern boundary of UWCD's service area and the Piru-Santa Clara River Valley East basin boundary. Historically, little to no groundwater was believed to be pumped in this area. Agricultural fields are owned by Camulos Ranch, LLC and Newhall Land and Farming Company, both of which have surface water diversion rights. Camulos Ranch, LLC have routinely reported diversions starting in 2016 that indicate groundwater is not used for irrigation. According to the Supplemental Statement of Water Diversion and Use forms submitted by the Newhall Land and Farming Company, their diversion has not been used since at least 2009 and groundwater is pumped instead. From 2009 through 2016, they reported using 330 AFY, while from 2017 through 2023, reported extractions ranged from 575 to 722 AFY. It is unclear where this pumping occurs, but the most likely candidate wells are 04N18W26R01S, 04N18W24N01S, 04N18W26Q03S, and 04N18W25G01S (Figure 5-7).

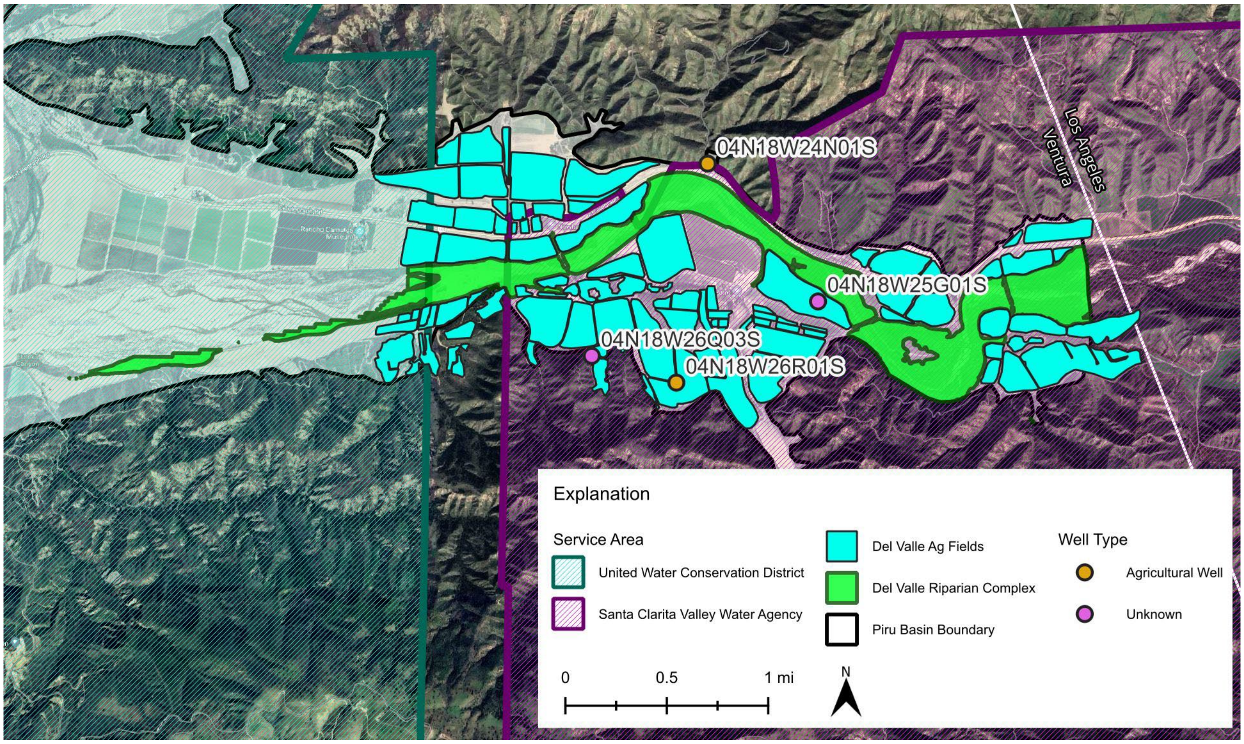


Figure 5-7. Agricultural fields and possible extraction wells in the Del Valle GDE area.

Assuming these extraction values are accurate (they are self-reported and to our knowledge have not been verified), this represents about 5 percent of average annual groundwater extractions in the Piru basin. Therefore, unreported pumping is likely not a widespread occurrence in the basins and the historical assumption of it being a minor percentage of total pumping in the basins is reasonably accurate. The location of pumping and extraction volumes will be requested from Newhall Land and Farming Company in the future.

5.5.2 De minimis Extractors

Estimates of de minimis groundwater production from wells are represented in UWCD's pumping records that are included in the FPBGSA's database. The accuracy of these estimates and combined cumulative groundwater production of de minimums pumpers in the basins has not been well quantified. However, back of the envelope type calculations suggest that de minimus groundwater user pumping is not a large percentage of the overall pumping in the basins.

From UWCD's 2018 pumping records, 47 wells were reported as extracting one AFY or less and an additional 34 wells reported between one and two AFY for a total of 93 AFY in Fillmore basin.

In Piru basin, 11 wells reported one AFY or less and eight wells pumped 1 to 2 AFY for a total of 20 AFY. These extractions represent less than one percent (i.e., 0.2 percent) of the total 2018 reported pumping in the basins.

5.5.3 Extractions by Aquifer Zone

Table 5-5 show the number of wells accessing groundwater from each aquifer zone or zones (i.e., from wells screened across multiple zones) in calendar year 2018 for each of the basins. The volume extracted and percent of total extractions for the basin are also tabulated. Pumping for 2018 is shown graphically on Figure 2-4 in Section 2.1.4 with dot magnitude symbology for 2018 annual pumping by well in the Fillmore and Piru basins.

Table 5-5. Summary of Fillmore and Piru basins wells accessing groundwater from each aquifer zone or zones in 2018.

Fillmore Basin Pumping				Piru Basin Pumping			
Aquifer Zone(s)	Number of Wells	Extractions in AFY	Percent of Total	Aquifer Zone(s)	Number of Wells	Extractions in AFY	Percent of Total
A	24	422	1.0	A	3	35	0.3
A-B	97	13,857	33.0	A-B	12	809	7.6
B	86	16,556	39.4	B	55	5,765	53.9
A-C	3	804	1.9	A-C	1	93	0.9
B-C	18	3,660	8.7	B-C	12	1,801	16.8
C	2	340	0.8	C	2	338	3.2
Unknown	71	6,338	15.1	Unknown	22	1,849	17.3
2018 Total	301	41,977	100	**2018 Total**	107	10,689	100

Table 5-5 results show that minimal total current pumping in the basins is discretely from Zones A or C. In 2018, 24 wells in Fillmore basin screened discretely in Zone A and three wells in the Piru basin extracted groundwater from the basins. This constituted one percent of the total year's pumping in Fillmore basin and only 0.3 percent in Piru basin. There were 23 wells that reported groundwater extractions to UWCD for which at least some of the water came from Aquifer Zone C (based on known screen interval) in Fillmore basin and 15 wells in Piru basin. Of these, only two producing wells in each basin had known construction discretely screened in Zone C.

Most of the wells screened in a discrete aquifer zone were completed in Zone B. In Fillmore basin, 86 wells which pumped 39 percent of the groundwater extracted in 2018 were completed discretely in this zone. In Piru basin, 55 wells representing 54 percent of the pumping was solely from Zone B.

From the table, it is apparent that a number of wells in the basins are screened across multiple aquifer zones. As mentioned previously, this is a potential data gap when collecting groundwater quality or level data from these wells in the basins. However, this is not necessarily a significant data gap with respect to groundwater extraction data. UWCD's expansion of the VRGWFM uses a modeling package that partitions the total reported groundwater production by model layer (see Section 1.2.5). What is identified here as a data gap are the 71 wells in Fillmore basin (15 percent of 2018 pumping) and 22 wells in Piru basin (17 percent of 2018 pumping) with unknown construction (i.e., screened interval depth).

UWCD's groundwater flow model currently accounts for this well construction screened interval data gap by utilizing a set of rules. If well casing or borehole depth is known, then it is assigned as the bottom of the screened interval. For wells with no construction depth information, modeled groundwater production from the basins' Aquifer Zones are accounted for according to the following criteria (UWCD, 2020):

- Fillmore basin - screened interval is assigned to Aquifer Zone B (i.e., Model Layers 5 and 7) as default
- Piru basin - screened interval is assigned to Aquifer Zones A and B (i.e., Model Layers 3 and 5) as default
- If production wells have available water level observation data, assigned screened interval may be manually adjusted to achieve a better calibration (i.e., simulated water levels fit with observed water levels)

5.6 Interconnected Surface Water and Beneficial Uses

Designations of beneficial uses for reaches of the Santa Clara River and its tributaries vary between federal and state agencies. This has resulted in some confusion about the GSA's responsibility for establishing SMCs related to interconnected surface water (ISW), particularly surrounding steelhead (*O. mykiss*) habitat. The subsections below describe the beneficial uses of stream reaches designated by the National Marine Fisheries Service (NMFS) and the Los Angeles Regional Water Quality Control Board (LARWQCB), followed by a discussion of the potential beneficial uses based on analyses performed during GSP development and local knowledge.

Recommendations for addressing the ISW data gaps are discussed in Section 6 of this Tech Memo and Section 4.9 of the Fillmore subbasin GSP.

5.6.1 National Marine Fisheries Service (NMFS) Designated Beneficial Uses

In 2005, NMFS designated approximately 29,565 net river miles (47,470 km) in California, Oregon, Washington, and Idaho as critical habitat for critical habitat for chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) (70 FR 52488 & 70 FR 52630). This resulted in the Santa Clara River from the Pacific Ocean to the confluence with Piru Creek, Sespe Creek, Hopper Creek, and Piru Creek up to Santa Felicia Dam (Figure 5-8) being designated uniformly as spawning, rearing, and migration habitat for steelhead. It is unclear how or why these designations were made, as no specific documentation of the methodology applied to the Santa Clara River or its tributaries was included in the final rule, and the link to the reference list (http://swr.nmfs.noaa.gov) is broken.

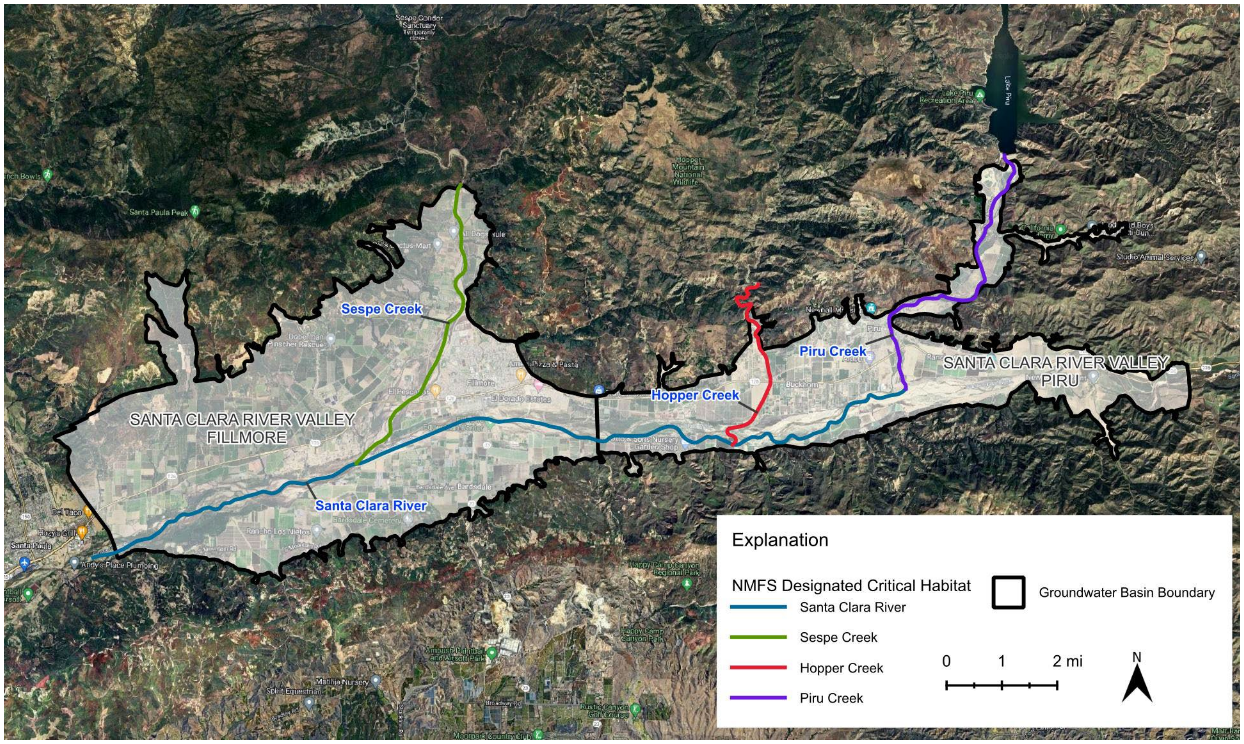
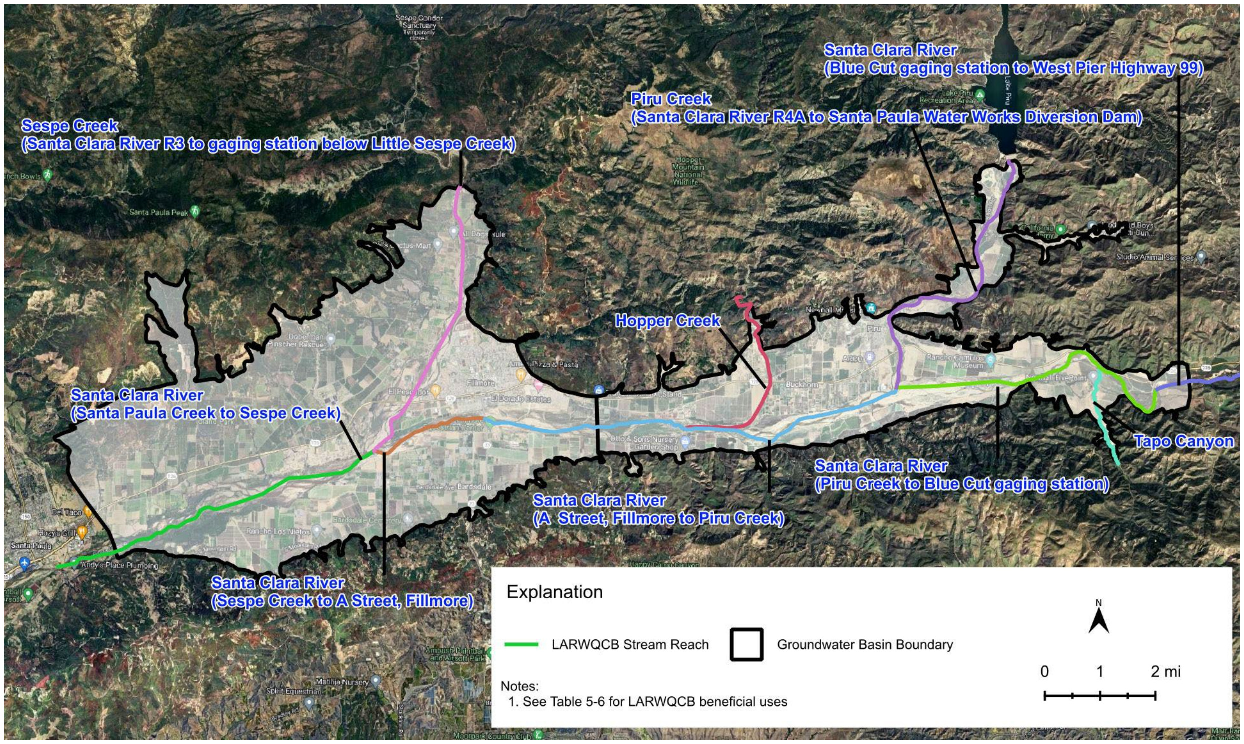


Figure 5-8. Stream reaches in the Fillmore and Piru Basins designed as critical steelhead habitat for spawning, rearing, and migration by NMFS.

5.6.2 Los Angeles Regional Water Quality Control Board (LARWQCB) Designated Beneficial Uses

The LARWQCB's Basin Plan is designed to preserve and enhance water quality and protect the beneficial uses of all regional waters. Specifically, the Basin Plan (1) designates beneficial uses for surface and ground waters, (2) sets narrative and numerical objectives that must be attained or maintained to protect the designated beneficial uses and conform to the state's antidegradation policy, and (3) describes implementation programs to protect all waters in the Region. The plan is a "living document," meaning that it is reviewed on a triennial basis and updated as necessary. The most recent updates are dated May 18, 2020 for plan text and tables and October 9, 2020 for geospatial data.

The LARWCB Basin Plan subdivides the Santa Clara River and its tributaries into nine reaches (Figure 5-9) that were evaluated for numerous beneficial uses (Table 5-6).



Notes:
1. See Table 5-6 for LARWQCB beneficial uses

Figure 5-9. LARWQCB stream reaches.

Table 5-6. LARWQCB beneficial uses.

Stream Section	WBD No.	AQUA	WARM	COLD	SAL	EST	MAR	WILD	BIOL	RARE	MIGR	SPWN	SHELL	WET
Santa Clara River (Santa Paula Creek to Sespe Creek)	180701020902		E					E		E	E			E
Santa Clara River (Sespe Creek to A Street, Fillmore)	180701020802		E					E		E	E			E
Santa Clara River (A Street, Fillmore to Piru Creek)	180701020802		E					E		E	E			E
Santa Clara River (Piru Creek to Blue Cut gaging station)	180701020403		E					E		E	E			E
Santa Clara River (Blue Cut gaging station to West Pier Highway 99)	180701020403		E					E		E				E
Santa Clara River (West Pier Highway 99 to Bouquet Canyon Rd.)	180701020403		E					E		E				E
Sespe Creek (Santa Clara River R3 to gaging station below Little Sespe Creek)	180701020706		E	E				E	E	E	E	E		E
Hopper Creek	180701020801		E	E				E		Eg				E
Piru Creek (Santa Clara River R4A to Santa Paula Water Works Diversion Dam)	180701020604		E	E				E		Eg	E	E		E
Tapo Canyon	180701020403		E					E						

E = Existing beneficial use; P = Potential beneficial use. I = Intermittent beneficial use;
g = Condor refuge

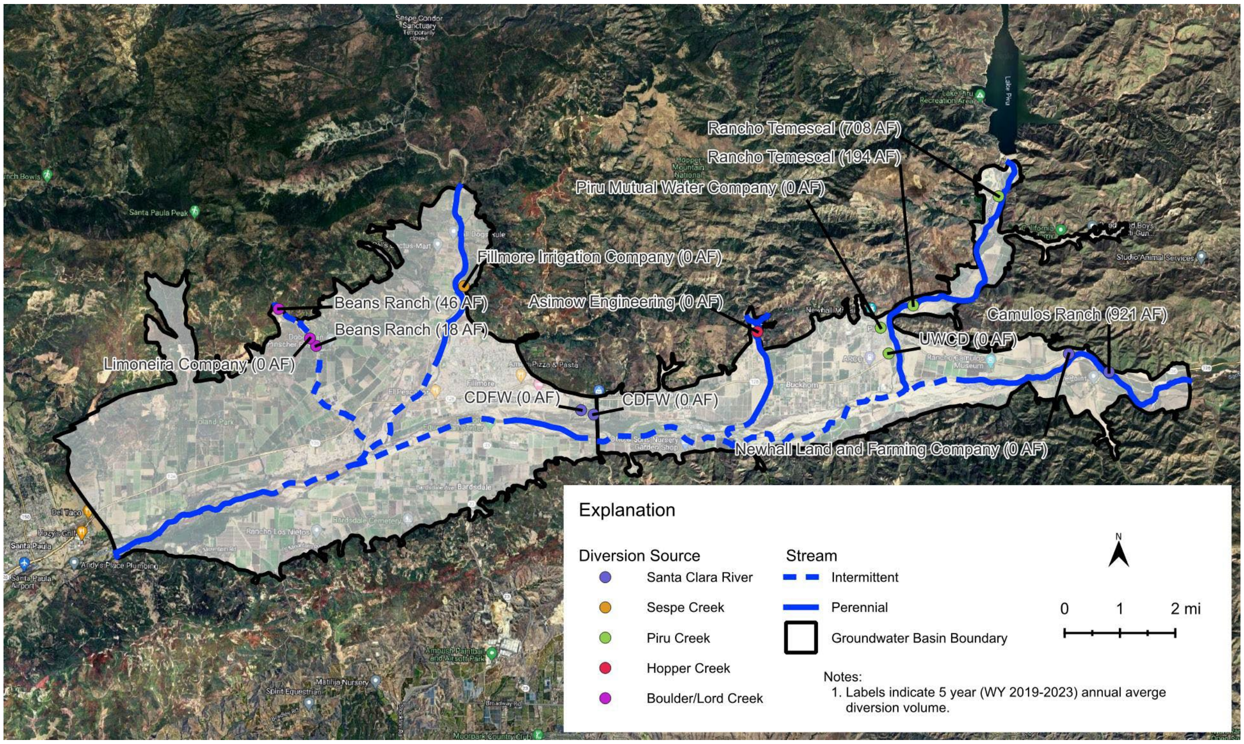
Definitions of relevant beneficial uses are provided below:

- Warm Freshwater Habitat (WARM): Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Cold Freshwater Habitat (COLD): Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Wildlife Habitat (WILD): Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
- Preservation of Biological Habitats (BIOL): Uses of water that support designated areas or habitats, such as Areas of Special Biological Significance (ASBS), established refuges, parks, sanctuaries, ecological reserves, or other areas where the preservation or enhancement of natural resources requires special protection.
- Rare, Threatened, or Endangered Species (RARE): Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.
- Migration of Aquatic Organisms (MIGR): Uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.
- Spawning, Reproduction, and/or Early Development (SPWN): Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Wetland Habitat (WET): Uses of water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.The Santa Clara River generally has WARM, WILD, RARE, MIGR, and WET beneficial uses identified. The absence of COLD, SPWN, and BIOL beneficial uses indicates that the LARWQCB does not consider the Santa Clara River in the Fillmore and Piru Basins to be viable spawning and rearing habitat for steelhead, and is instead a seasonal migratory corridor. The RARE beneficial use designation is likely associated with riparian habitat for the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Survival of this vegetative habitat requires groundwater levels within some distance of the rooting zone, but does not require surface flows.

The two stream reaches in the Fillmore and Piru Basins with designated beneficial uses consistent with steelhead spawning and rearing habitat (COLD and SPWN) are Sespe Creek and Piru Creek. Sespe Creek is also the only reach within the groundwater basins with the BIOL beneficial use designation, indicating it has particular habitat importance.

In addition to environmental beneficial uses, the LARWQCB has also designated several existing or potential beneficial uses for the Santa Clara River and its tributaries related to surface water diversions for human water use (e.g., municipal, industrial, agricultural). The only active legal surface water diversion from the Santa Clara River in the Fillmore and Piru Basins occurs at the eastern end of the Piru basin (Figure 5-10), where streamflow in the summer is largely supported by effluent discharges from the Saugus and Valencia wastewater treatment plants upstream. The only other surface water diversion rights are held by the California Department of Fish and Wildlife (CDFW) and UWCD. According to reports submitted to the SWRCB electronic Water Rights Information Management System (eWRIMS) by CDFW, no diversions have taken place, and they are not anticipated to divert in the future. Although UWCD has a legal diversion right in the basin, the diversion physically takes place downstream at the Freeman Diversion in the adjacent Santa Paula groundwater subbasin.



Notes:
1. Labels indicate 5 year (WY 2019-2023) annual averge diversion volume.

Figure 5-10. Surface water diversions in the Fillmore and Piru Basins.

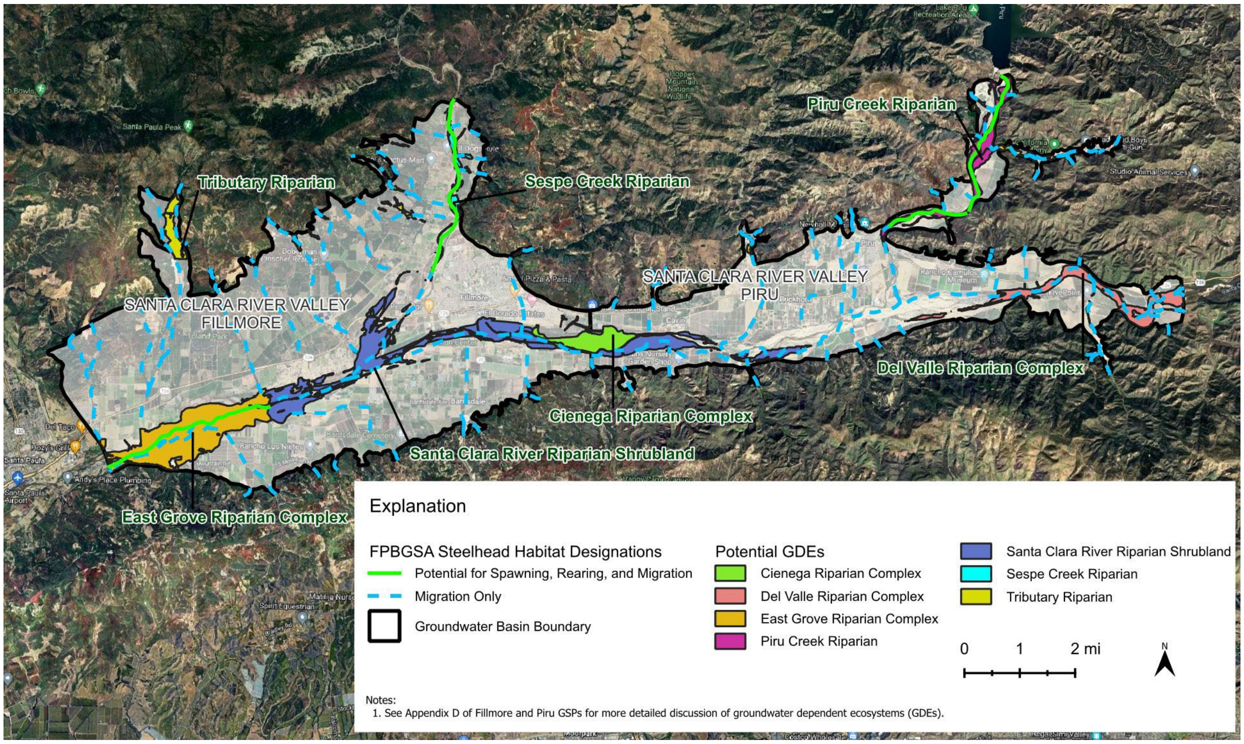
Several diversions from tributaries to the Santa Clara River are reported in eWRIMS. Piru Creek has the greatest annual average diversion volume reported, which is approximately 900 AFY. These occur in Piru Canyon where little groundwater pumping occurs and streamflow is sustained predominantly by releases from the Santa Felicia dam. Comparatively minor diversions occur on Boulder/Lord Creek near the margin of the Fillmore subbasin, but groundwater and surface water are unlikely to be interconnected in that area.

5.6.3 FPBGSA Designated Interconnected Surface Waters and Beneficial Uses

After extensive review and evaluation of the NMFS and LARWQCB designated beneficial uses, and incorporating decades of surface water data collection and local knowledge by UWCD staff, FBGSA is generally in agreement with the LARWQCB that the Santa Clara River is predominantly a migratory corridor for fish from January 1 to May 31 (UWCD, 2020), and the upland tributaries are much more likely to provide suitable habitat for steelhead spawning and rearing. This is supported by Stoecker and Kelly (2005), who state that 98 percent of observed trout occurrence in the Sespe Creek drainage is attributable to Sespe Creek tributaries. The lack of documentation available as to how habitat designations were arrived at for specific stream reaches, combined with the number of net stream miles (29,565) and geographic distribution (CA, WA, OR, ID) classified simultaneously, suggests that the NMFS analysis was not nearly as detailed as that conducted by the LARWQCB. Furthermore, the most recent southern California steelhead report (NMFS, 2023) states that steelhead have not been reported in the Santa Clara River since 2012, and had non-zero abundances for 4 of the 13 years (31 percent) data were available. However, this finding is complicated by the fact that CDFW has not reported steelhead data for the Santa Clara River since 2014.

FPBGSA's current conceptual understanding is that groundwater is consistently interconnected with surface water along three reaches of the Santa Clara River and along reaches of Sespe Creek and Piru Creek (Figure 5-11). The three reaches along the Santa Clara River are referred to as East Grove, Cienega Springs (or Cienega), and Del Valle (see Appendix G for more detailed discussion). These are generally located at the western Fillmore subbasin boundary, the Fillmore-Piru subbasin boundary, and the Piru-Santa Clara River Valley East subbasin boundary, respectively. East Grove and Cienega Springs coincide with known areas of rising groundwater; however, the interconnectedness between groundwater and surface water in the Del Valle area is currently unknown due to lack of data.

The East Grove GDE area may be suitable spawning and rearing habitat (Figure 5-11) for steelhead as model results and physical observations indicate surface flows are present year-round, even during extended drought periods (see Section 3.6 of Appendix J). These flows result from cool (~65 to 70°F) groundwater discharging into the stream, which is warmer than steelhead prefer but below their threshold temperature of about 73°F. Shading from vegetation has the potential to keep surface water temperatures from rising too high by blocking direct solar radiation. However, the presence of potentially suitable habitat does not necessarily mean that it is used by steelhead, and as stated above, no steelhead data have been reported by CDFW since 2014. This represents a data gap that will be addressed during implementation of the GSP (see Section 6.3 of this Tech Memo and Section 4.9 of the GSPs).



Notes:
1. See Appendix D of Fillmore and Piru GSPs for more detailed discussion of groundwater dependent ecosystems (GDEs).

Figure 5-11. Reach-specific steelhead habitat designations determined by the FPBGSA.

The Cienega Springs GDE area is not considered to be suitable spawning and rearing habitat for steelhead as surface water flows are highly variable (i.e., “flashy”) and can disappear during short drought periods (see Section 3.6 of Appendix J). Even if a minor amount of surface flow is present, surface water temperatures outside the migration season are unlikely to meet steelhead habitat requirements. However, this reach of the Santa Clara River is still important from a terrestrial habitat perspective, especially for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*). Therefore, SMCs for the Cienega Springs GDE area should be developed that are protective of terrestrial vegetation.

Similar to Cienega Springs, the Del Valle GDE sustains vegetation important for terrestrial habitat. The degree of interconnection between groundwater and surface water in this area is largely unknown due to lack of data. This reach of the Santa Clara River is not designated by any federal or state agency as critical fish habitat, and therefore SMCs should be developed that are protective of terrestrial vegetation.

Groundwater and surface water are believed to be interconnected along the perennial reaches of Sespe Creek from Freeman Road north to the basin boundary and Piru Creek within Piru

Canyon. Shallow groundwater monitoring along the northern portion of Sespe Creek within the groundwater subbasin is limited. Few wells are present in the area and the flashy nature of streamflow in Sespe Creek makes monitoring well installation near the streambed challenging, as high-flow events can easily destroy them.

Similar to the upper portion of Sepse Creek within the groundwater basin, there are few wells located in Piru Canyon. Unlike Sespe Creek, flows in Piru Creek are primarily regulated by releases from Santa Felicia Dam and therefore the risk of high flow events destroying monitoring wells is significantly lower. Santa Felicia Dam is licensed under the Federal Energy Regulatory Commission (FERC; Project No. 2153), which requires minimum releases for habitat and migration (UWCD, 2012). The small number of wells in Piru Canyon have reported total extractions ranging from 0 to 100 AFY over the last decade (2014-2023), with an average of 10.4 AFY. Reported surface water diversions in Piru Canyon from 2010-2023 ranged from about 414 to 2,100 AFY and averaged about 1,020 AFY. The relatively low groundwater extraction volume compared with surface water diversion volumes, combined with required releases from Santa Felicia Dam, result in a very low probability that groundwater extractions are significantly and unreasonably impacting streamflow in Piru Canyon.

6. FPBGSA Monitoring Program Recommendations

This final section summarizes and prioritizes recommendations on how refinement and or expansion of the existing monitoring networks in the basins might minimize or eliminate data gaps, especially in critical areas. GSP preparation and submittal to the DWR by January 2022 is envisioned to use to the extent possible the available data described in Section 2 of this Tech Memo. Recommendations offered here are not likely to provide substantial additional data for GSP preparation but will inform GSP 5-year update assessments and annual reporting. From BMP #2 (DWR, 2016b):

> Direct actions GSAs could take to fill data gaps include:
>
> - Increasing the frequency of monitoring. For instance, some groundwater elevation measurements are taken twice a year in the spring and fall, but perhaps those measurements need to be increased to quarterly, monthly, or more frequently, if needed.
> - Increasing the spatial distribution and density of the monitoring network.
> - Increasing the quality of data through improved collection methods and data management methods."

6.1 Data Gaps Priority Ranking

A number of data gaps and potential existing monitoring network enhancements were identified in the previous Section. Prioritization levels are used to rank FPBGSA monitoring program recommendations included herein. A simple "Very High-High-Medium-Low-Very Low" priority classification ranking system is employed. GSP preparation and implementation "value added" evaluated against cost is considered in this recommendation prioritization. For example, it would be advantageous in GSP implementation sustainability evaluation to only use groundwater data collected from properly constructed multiple-well monitoring facilities with completions in each of the aquifer zones in the basins. Construction of twenty of these facilities equally spaced across the basins would greatly decrease GSP analysis uncertainty and would be consistent with the DWR's data quality recommendations but would likely be cost prohibitive for FPBGSA rate payers in the Fillmore and Piru basins.

Table 6-1 summarizes Section 5 data gap analysis recommendations and ranks them by priority for consideration of the FPBGSA Board of Directors. They are ordered by Tech Memo Section number.

Table 6-1. Data gap analysis recommendations ranked by priority.

Data Gaps Section	Priority Level	Description of Potential Data Gap
5.1.1	Very Low	Investigate wells of unknown construction or source of construction data included in FPBGSA's well inventory file for wells with associated historical groundwater quality, level and production data.
5.1.1 5.1.4 5.3.1.1 5.4.1.1	High	Investigate wells included in VCWPD and UWCD's existing monitoring networks of unknown well construction (e.g., contact owner for records or perform a well video survey). If screened interval cannot be determined, they should be replaced in the monitoring networks with wells of known construction if potential substitute monitor points exist nearby.
5.1.2	Very Low	Determine, to the extent practicable, the historical monitoring point locations for groundwater quality and level records of unknown GIS well location.
5.1.2	Medium	Resolve discrepancies in construction and/or location information contained in VCWPD and UWCD's independent well inventory files.
5.1.3	Low	Evaluate historical water level data RP elevation accuracy and consistency of vertical datum reference.
5.1.3	High	Evaluate existing monitoring network water level data RP elevation accuracy, consistency of vertical datum reference and recording of measurement offset height above/below RP for DTW below ground surface calculations.

Data Gaps Section	Priority Level	Description of Potential Data Gap
5.2.1 5.2.2	Very Low	Evaluate historical data of unknown sources and potential temporal data gaps.
(5.1.4) 5.3.1.1 5.3.1.2 5.4.1.2	Medium	Identify additional monitoring points (for collecting groundwater quality and level) using existing wells screened discretely in each of the aquifer zones, where possible. For water quality, these might include additional groundwater sampling from existing wells surrounding known radiochemistry and selenium "hot spots".
(1.2.6) 5.3.1.2 5.4.1.2 6.2	High	Construct a new multiple-well groundwater monitoring site near the Santa Paula/Fillmore basin boundary (Figure 6-1) for assessing vertical groundwater gradients and collecting aquifer zone specific water quality samples.
5.3.2	High	VCWPD samples wells for water quality annually in the fall. UWCD and VCWPD should coordinate fall sample events to the extent possible.
(5.1.4) 5.4.1.2	High	Identify additional monitoring points for measuring groundwater levels using existing shallow wells screened discretely in Zone A (or construct new shallow monitoring wells [Figure 6-1]) near the SCR and its tributaries.
(5.1.4) 5.4.2	Medium	Equip additional wells in the basins with pressure transducers and data loggers (AMI equipment can include pressure transducers for measuring water level). Wells identified in the GSPs as sustainable management criteria representative monitoring points should be prioritized for pressure transducer and data logger deployment.
5.5.1	Medium	Consider a policy that establishes groundwater extraction reporting method requirements for all pumping wells in the basins. Additionally, consider commissioning a feasibility study that includes cost estimates to equip large capacity production wells in the basins with AMI technology.
5.5.1	Very High	Gather groundwater production data sufficient for reporting to DWR by water year and for use in preparing water budgets.
5.5.1	Low	Quantification of potential unreported pumping in the basins.
5.6.3	High	Determination of interconnection between groundwater and surface water and steelhead habitat suitability for the East Grove GDE area of the Santa Clara River.
5.6.3	Medium	Determination of interconnection between groundwater and surface water and steelhead habitat suitability for Sespe Creek north of Telegraph Road to the groundwater basin boundary,
5.6.3	Very Low	Determination of interconnection between groundwater and surface water and steelhead habitat suitability for Piru Creek within Piru Canyon.

Additional potential data gaps not included in Table 6-1 likely exist in the basins and may become apparent through the GSP preparation process. It is also anticipated that this list will evolve as stakeholders advocate for revision of the priority level ratings presented here or identify additional data gaps not considered in this Tech Memo. Table 6-1 is intended to serve as a starting point for cataloging potential data gaps in the basins from which to begin developing a FPBGSA directed approach for systematically filling those gaps that are most significant in evaluating GSP implementation. All of the potential data gaps contained in Table 6-1 are not needed to be filled for the FPBGSA to make informed decisions on the groundwater conditions in the Fillmore and Piru basins. The priority level designations are provided to merely assist the reader in understanding the relative importance of the potential data gaps.

6.2 Potential New Monitor Wells

Monitor well spatial density data gaps are identified in the previous Section of this Tech Memo and new monitor wells are recommended for addressing those gaps that cannot be filled by additional monitoring of existing wells in the Fillmore and Piru basins. Many of the wells currently monitored by VCWPD and UWCD in the basins are screened discretely in Zone B. The majority of the remaining monitored wells are of unknown construction or screened across multiple aquifer zones (Figures 5-4 and 5-5). Water level measurements from these wells are aggregate piezometric heads from the different zones and can obscure interpretation from these data.

There are few wells included in the existing monitoring networks discretely screened in Zones A or C and available data are limited for evaluating vertical head gradients in the Fillmore and Piru basins (as described in Section 1.2.6). Nested (multiple-depth completion) groundwater monitoring wells such as the RP1 site (Figure 6-1; 04N18W31D03S, 04N18W31D04S, 04N18W31D05S, 04N18W31D06S, and 04N18W31D07S in DMS) in Piru basin are useful for obtaining aquifer zone-specific water levels and water quality samples. The preliminary evaluation included in this Tech Memo relies on available data for assessing the extent of aquifer confinement and vertical gradients (Section 1.2.5) in the basins and would be greatly enhanced by additional data from new nested groundwater sites and/or paired well clusters.

The following excerpts are from DWR's BMP #2 (DWR, 2016b):

> When installing a new monitoring site, GSAs should take that opportunity to gather as much information about the subsurface conditions as possible.

> Agencies must address a number of issues prior to designing the monitoring site, including, but not limited to, establishing the reason for installing the monitoring site, obtaining access agreements, assessing how the monitoring site may improve the basin conceptual model, assessing how the monitoring site may reduce uncertainty, etc.

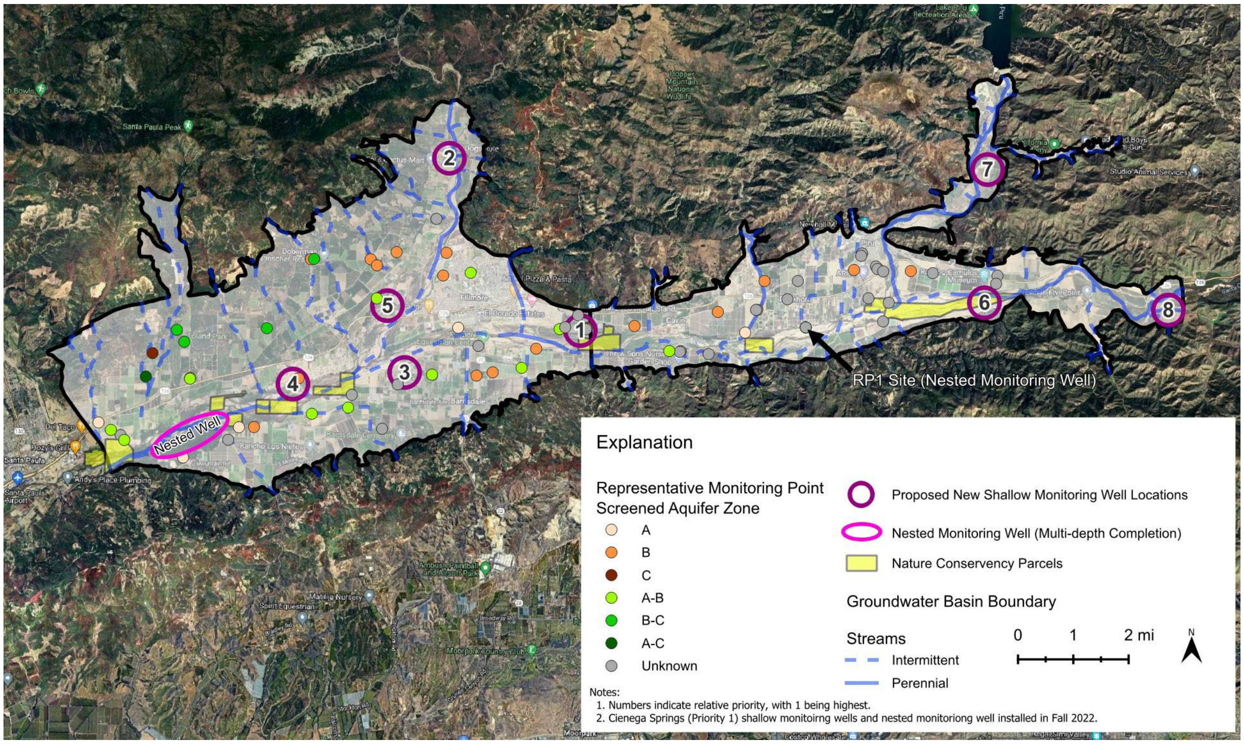
Generalized workflow for installing new monitor well facilities in the Fillmore and Piru basins may include, but is not limited to, the following components:

- Planning
- Well siting
- Property acquisition and/or easement
- Permitting
- Driller solicitation
- Final site-specific design and construction
- Data collection schedule and responsible monitoring entity

6.2.1 Locations

The FPBGSA has a DWR administered Proposition 1 Grant with funding provision for planning and installation of additional monitor well facilities in the Fillmore and Piru basins. The Agency's grant application envisioned installing one new nested site each near the Santa Paula/Fillmore and Fillmore/Piru basins boundaries. The data syntheses and analysis performed as part of this Tech Memo has informed and refined design considerations and siting of potential new monitor well facilities.

Installation of a new nested monitor site is recommended near the Santa Paula/Fillmore basin boundary, as generally originally proposed, with the purpose of reducing HCM down-gradient boundary conditions uncertainty. The proposed target area is shown as a pink oval on Figure 6-1. In addition to long-term data collection for assessing vertical head gradients and difference in groundwater quality between aquifer zones, HCM boundary hydrostratigraphy can be refined from pilot borehole logging and testing. The Nature Conservancy (TNC) owns property in the target vicinity and is a known potential candidate for requesting a well site easement. There are two Zone A wells shown in the vicinity of the pink oval that are monitored by UWCD, but these are very shallow (10- to 12-foot deep) unpermitted wells that do not meet DWR well construction standards (e.g., boreholes were drilled using a post hole digging type auger and it is unknown if surface seals were emplaced during construction).



Notes:
1. Numbers indicate relative priority, with 1 being highest.
2. Cienega Springs (Priority 1) shallow monitoirng wells and nested monitoriong well installed in Fall 2022.

Figure 6-1. Proposed new monitor sites and wells currently monitored for groundwater level by VCWPD and UWCD by aquifer zone designation.

It is recommended that a portion of the earmarked funds for the other originally proposed nested site near the Fillmore/Piru basins be reallocated instead for installation of a new shallow (Zone A) piezometer at the Fillmore/Piru basins boundary near the Fillmore Fish Hatchery (Figure 6-1). Two discretely screened Zone B Fish Hatchery owned wells (and a Zone A-B screened well) are currently monitored by UWCD near the Fillmore/Piru basin boundary. A new Zone A well near these wells would allow for vertical gradient analysis of this well cluster (i.e., nearby Zone A and B discretely screened wells). Note that there is potential that Fish Hatchery groundwater pumping which constitutes the largest pumping by a single entity in the basins for some years may complicate interpretation of water level data gathered from a new monitor well facility (i.e., measured water levels may not be representative static water levels if they are significantly influenced by the nearby pumping). Under this proposal, there would not be a well screened discretely in Zone C at the Fillmore/Piru basins boundary but the potential cost savings would free up funds for construction of additional Zone A monitoring wells adjacent to the Santa Clara River channel and its major tributaries.

A total of eight proposed new shallow (i.e., Zone A) monitoring wells are shown on Figure 6-1 (including the Fillmore/Piru basins boundary Zone A new monitor well described above). These are represented as purple circles on the map and are labeled numerically by suggested priority (i.e., "1" is the highest priority and "8" is the lowest). Detailed costing has not yet been quoted for installation of these proposed new shallow monitor wells but these eight shallow monitoring wells may be potentially less costly than one nested monitoring well. Once detailed costs are obtained (including planning and property/easement acquisition costs), the final number of new monitor wells can be accurately determined with respect to available budget. These new wells, coupled with existing Zone A wells currently monitored by UWCD, would enhance the FPBGSA's monitoring program by yielding groundwater level and quality data for evaluation of sustainability of the water resources of this uppermost aquifer zone in the Fillmore and Piru basins.

As discussed in Section 5.6, most stream reaches in the Fillmore and Piru basins are ephemeral and therefore only transiently interconnected with groundwater.Areas with likely interconnected surface water often support woodland forests, some of which have persisted since the 1700s (Beller et al., 2016). The proposed new Zone A monitor wells would improve assessment of the extent of perennial interconnected surface water, particularly near the Cienega Springs and Del Valle GDEs and Sespe Creek between Telegraph Road and where it enters the groundwater basin. The area near Cienega Springs has extensive woody vegetation but tends to go dry during droughts more so than the Del Valle GDE upstream and the East Grove GDE downstream.

There are many wells in these basins that are not a part of the monitoring network. It is likely that some of the proposed locations for new shallow monitoring wells could be supplanted by nearby existing wells that are appropriately constructed and which access permission could be established with the land owner. It is recommended that some office analyses be performed to determine likely candidate wells near the proposed new monitoring well sites . This office analysis should be followed by field reconnaissance to determine if access into the well is feasible and the land owner is potentially amenable to granting access.

6.2.2 Construction

From BMP #2, "New wells must meet applicable well installation standards set in California DWR Bulletin 74-81 and 74-90, or as updated" (DWR, 2016b). In addition to these State-wide standards, DWR published Bulletin 74-9 (1968), Water Well Standards: Ventura County in which VCWPD references when issuing well permits. California well standards include, but are not limited to, the following general provisions:

- Sealing the Upper Annular Space
- Surface Construction Features
- Casing Material and Installation
- Sealing-Off Strata
- Well Development
- Water Quality Sampling
- Disinfection

Table 6-2 tabulates estimated aquifer zone depth and thickness for the proposed new multiple-well (nested) monitor facility and seven shallow (Zone A) monitor well locations shown on Figure 6-1. These values are rough estimates, interpolated in some cases from wells greater than a mile away. However, these estimates are useful for planning purposes and if these new proposed monitor wells are constructed, logging of the boreholes will provide further refinement to the basins' HCM.

Values shown for the shallow monitor wells are for the location at the center of the blue circles on Figure 6-1. Aquifer zone depth and thickness ranges shown for the nested site are the estimated minimum and maximum values from points on and within the pink oval (values from the point at the center of the oval lie within this range). Note that estimated values within this approximately 2-mile by 1-mile wide oval range considerably, and values likely range similarly throughout the basins. If these new monitor wells are constructed, it is very unlikely that they will be sited in the exact locations shown on the map.

In addition to estimated Aquifer Zone B and C depth and thicknesses for the proposed new multiple-well monitor facility shown in the table, these are also shown for the seven proposed shallow monitor well locations (unshaded cells in the table). These are included in order to provide additional detail from UWCD's model layering at each of the locations. Very thin zones are likely computer modeling artifacts and should be interpreted as such.

Table 6-2. Estimated Aquifer zone depths below ground surface and thickness in feet (from UWCD VRGWFM update layering, July 2020) for proposed new monitor well sites.

Proposed New Monitor Site from Figure 6-1	DWR Basin	Aquifer Zone A Bottom Depth bgs & Thickness in feet	Aquifer Zone B Bottom Depth bgs & (Thickness) in feet	Aquifer Zone C Bottom Depth bgs & (Thickness) in feet
1*	Fillmore/Piru	76	645 (569)	839 (194)
2	Fillmore	15	82 (66)	94 (12)
3	Fillmore	105	557 (451)	1,351 (794)
4	Fillmore	97	515 (418)	1,159 (643)
5	Fillmore	136	471 (335)	1,447 (976)
6	Piru	64	135 (70)	168 (33)
7	Piru	29	33 (4)	45 (12)
8	Piru	43	47 (4)	50 (3)
Nested Well*	Fillmore	97 - 158	365 - 516 (245 - 419)	521 - 1,048 (156 - 532)

* Installed Fall 2022

For planning purposes from the table, preliminary design construction depth of the eight proposed new monitor wells are recommended to include four 2-inch PVC cased piezometers completed to an approximate depth of 100 feet bgs (Sites 1 through 5) and three piezometers completed to a depth of 50 feet bgs (Sites 6 through 8). The 100-foot piezometers should generally include a screened interval of 40 feet with bottom cap and sealed from the top of the screen to the ground surface. The 50-foot piezometers should include a screened interval of approximately 20 feet (with bottom sump cap) and sealed from the top of the screened casing to the ground surface. Final design should be customized for the actual strata and conditions encountered and logged while drilling each borehole to promote collection of the most representative groundwater data from the target zone as possible.

Figure 6-2 is a generalized well design schematic for constructing the proposed new shallow monitor wells. A routinely utilized and cost-effective drilling method for this type of monitor well installation is hollow stim auger but other methods may also be appropriate for this application.

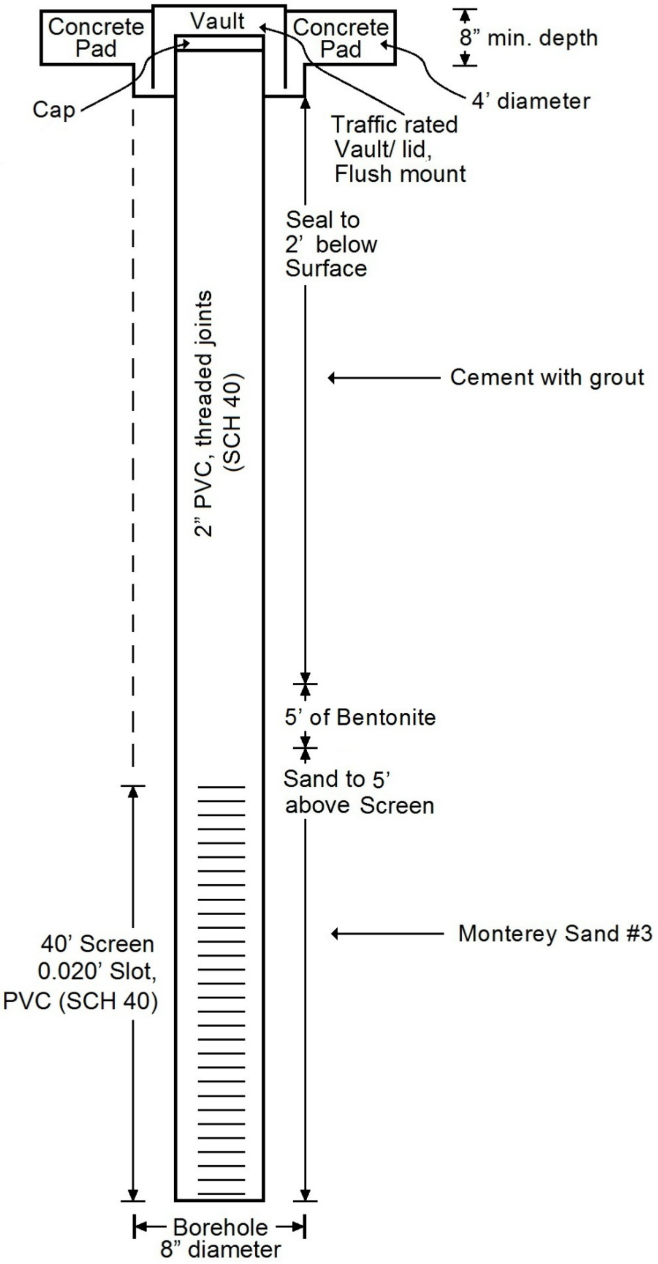


Figure 6-2. Generalized schematic for proposed new shallow (Zone A) monitor wells (not to scale).

Figure 1-5 shows the final well design schematic for the USGS installed RP1 multiple-well groundwater monitoring facility and can serve as an example of a potential generalized well construction design. From Table 6-2, well construction depth of the individual 2-inch PVC cased piezometers could include a Zone A 100-foot, Zone B 300-foot, and Zone C 500-foot completion. An optional additional Zone B completion should be considered depending on borehole logging findings and cost constraints. Screened intervals for each completion should be 20 to 40 feet and should be capped at the bottom. Annular seals should be emplaced to hydraulically isolate each screened interval from cross-communication within the borehole and gravel pack envelope.

Drilling of an approximately 600-foot pilot borehole by reverse rotary methods (or other appropriate method) is recommended as a target total depth. In addition to creating a log of the pilot borehole cuttings, a borehole geophysical log suite (e.g., electric log) should also be run in the open borehole to inform final well design and to collect additional information about the subsurface conditions near the Santa Paula/Fillmore basins boundary to refine the HCM.

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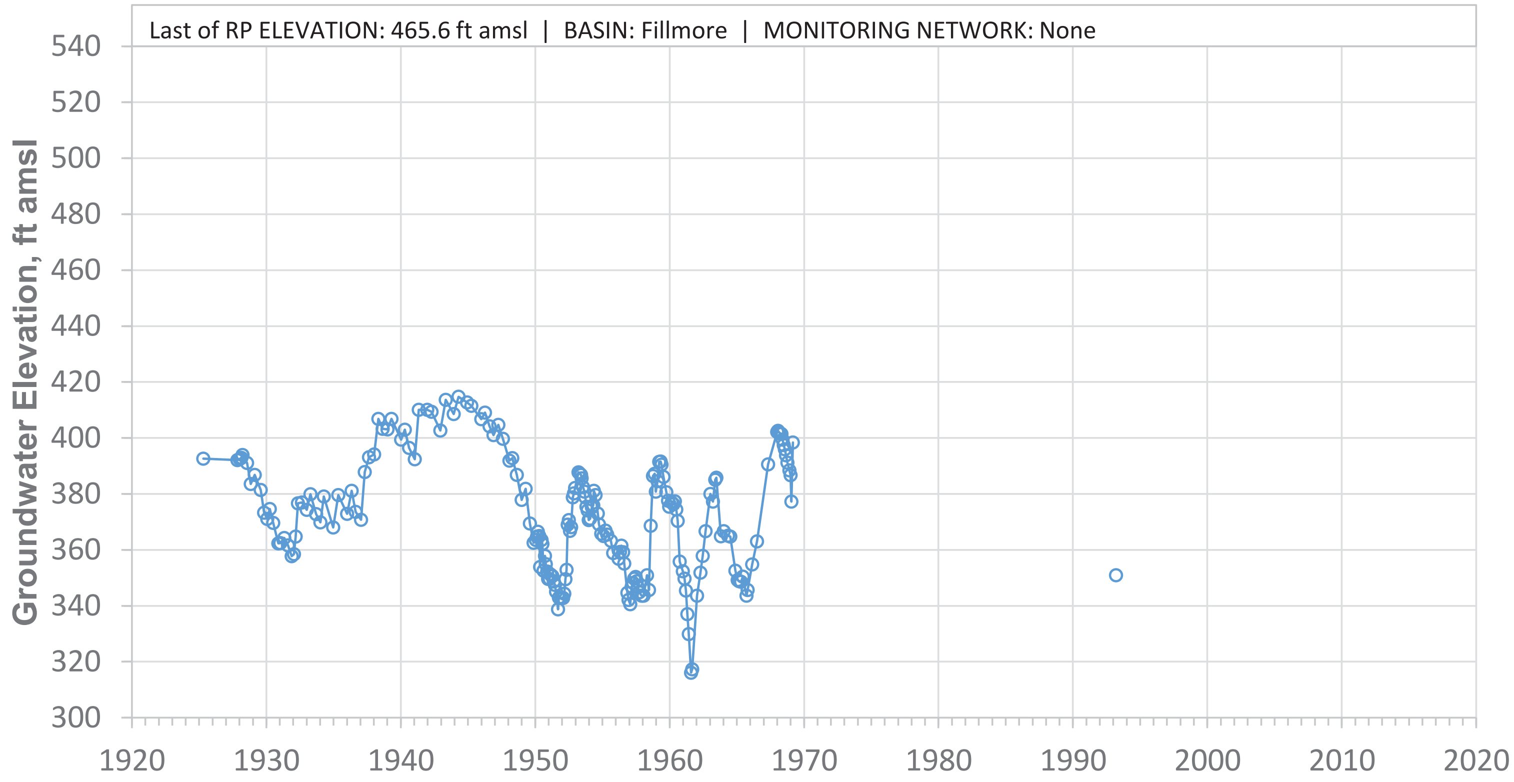
Appendix A

Groundwater Level Hydrographs

a Geo-Logic Company

03N19W05D01S

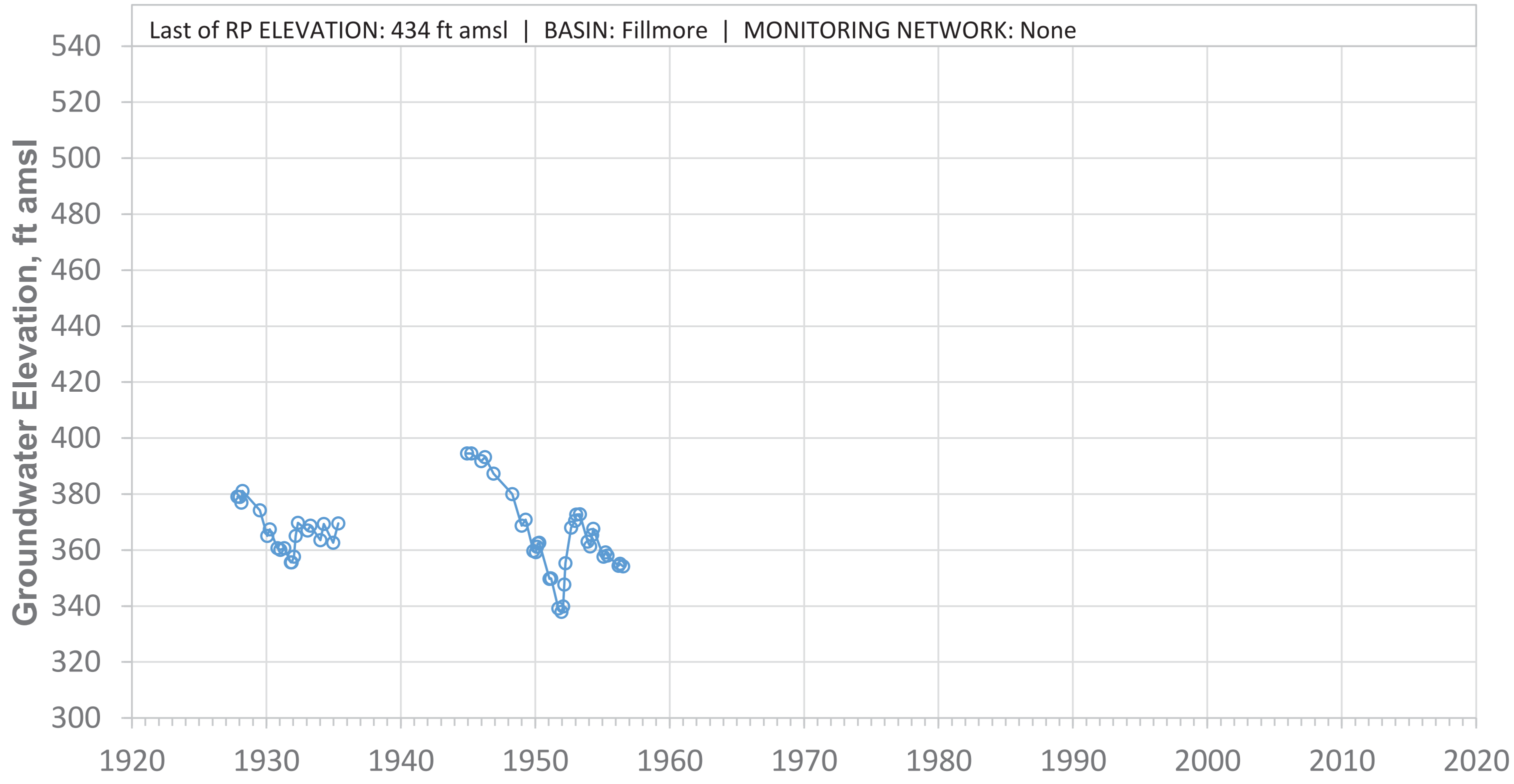
Last of RP ELEVATION: 465.6 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: 60-137 ft bgs | CURRENT USE: Agricultural | STATUS: Can't_Locate_Report

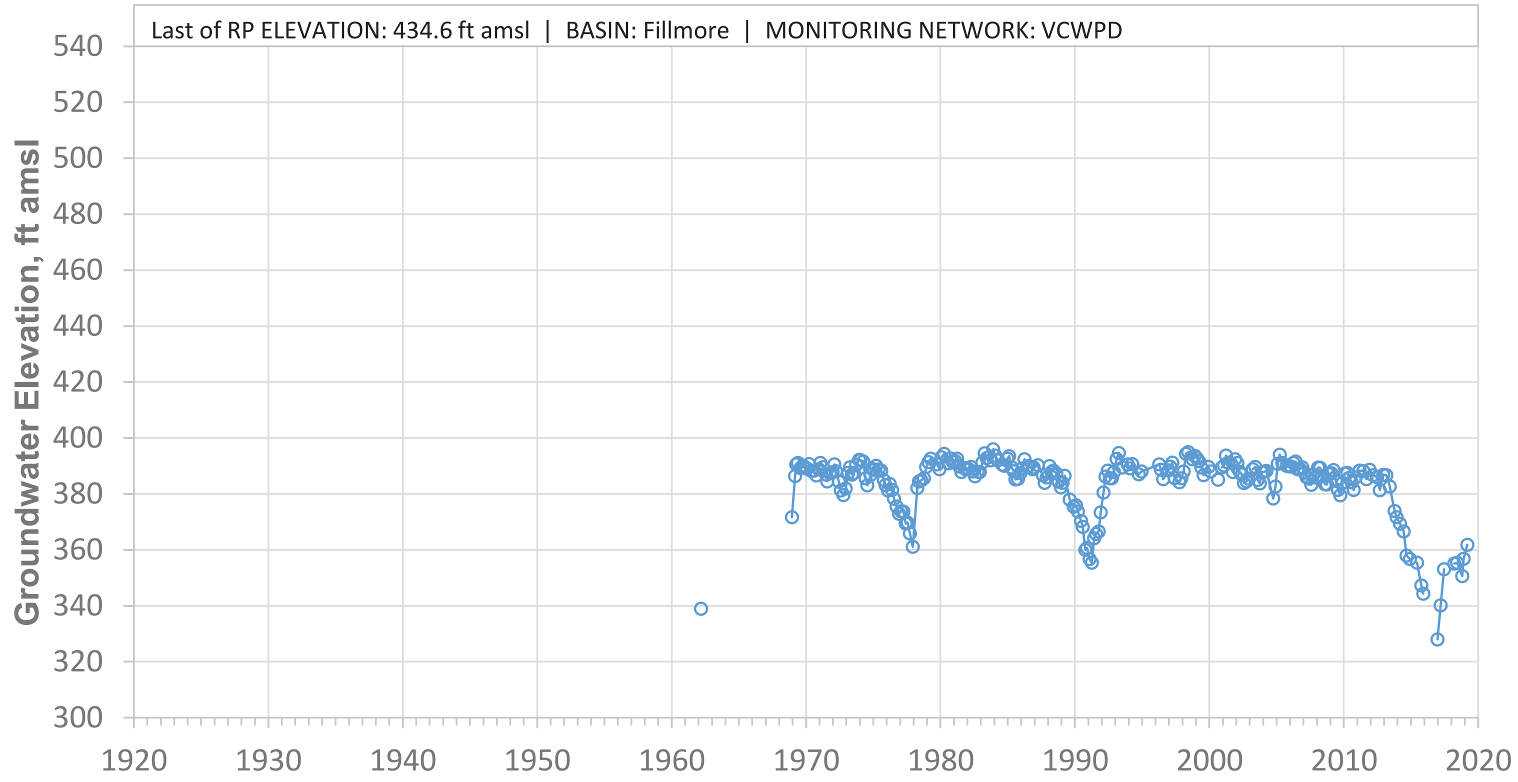
03N19W06D01S

Last of RP ELEVATION: 434 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



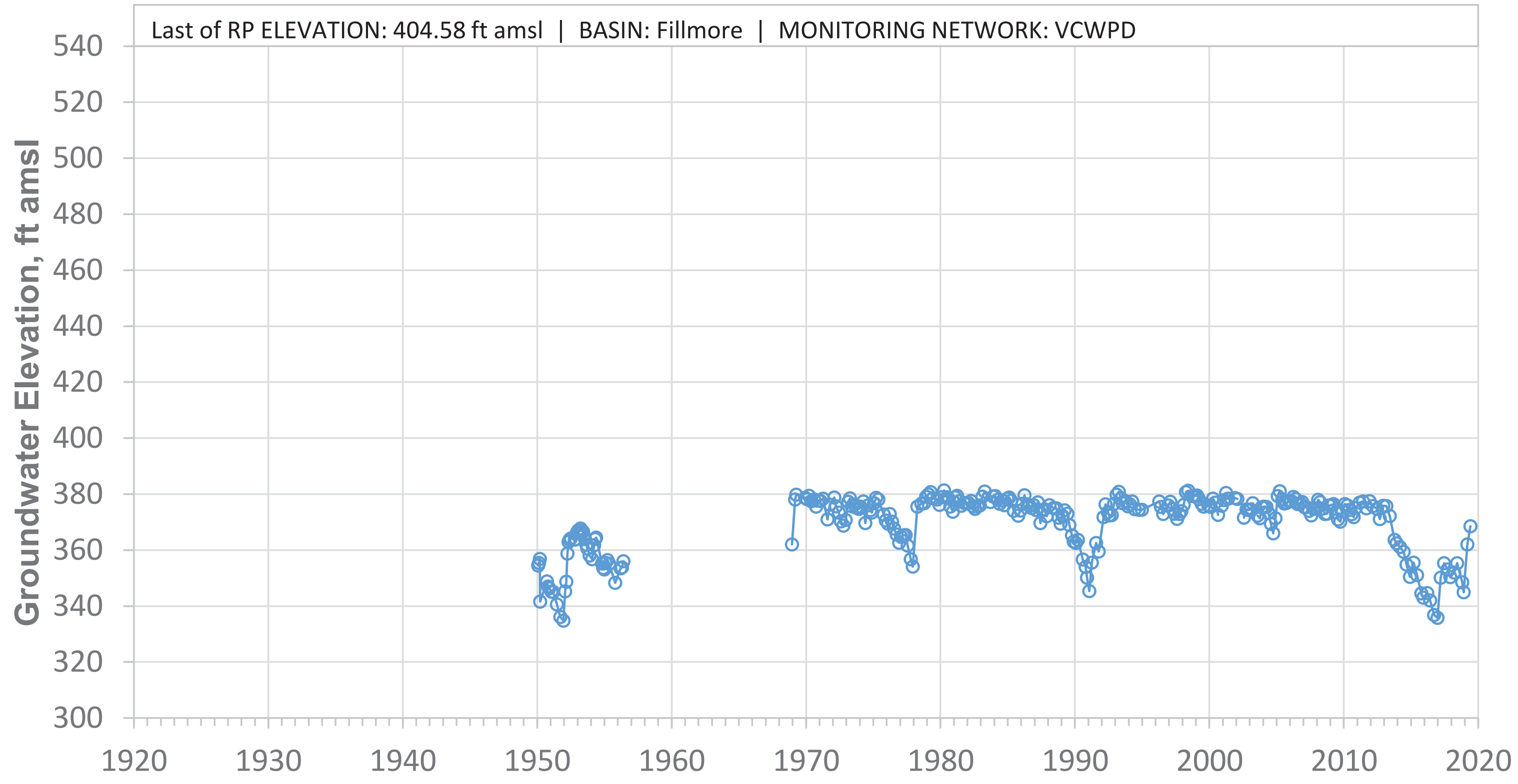
SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Non-Compliant_Abandoned

03N19W06D02S



SCREEN: 216-405 ft bgs | CURRENT USE: Agricultural | STATUS: Active

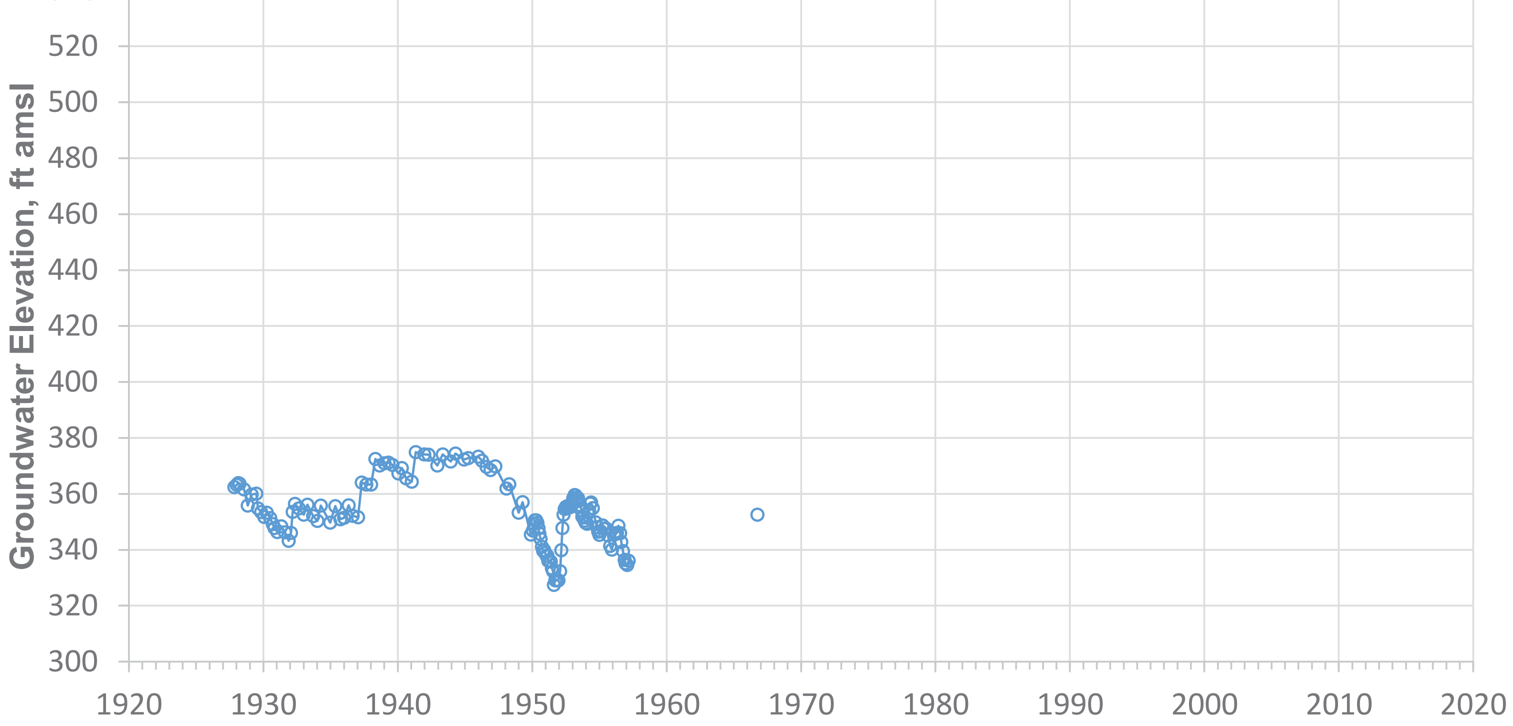
03N20W01C04S



SCREEN: 49-218 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W01D01S

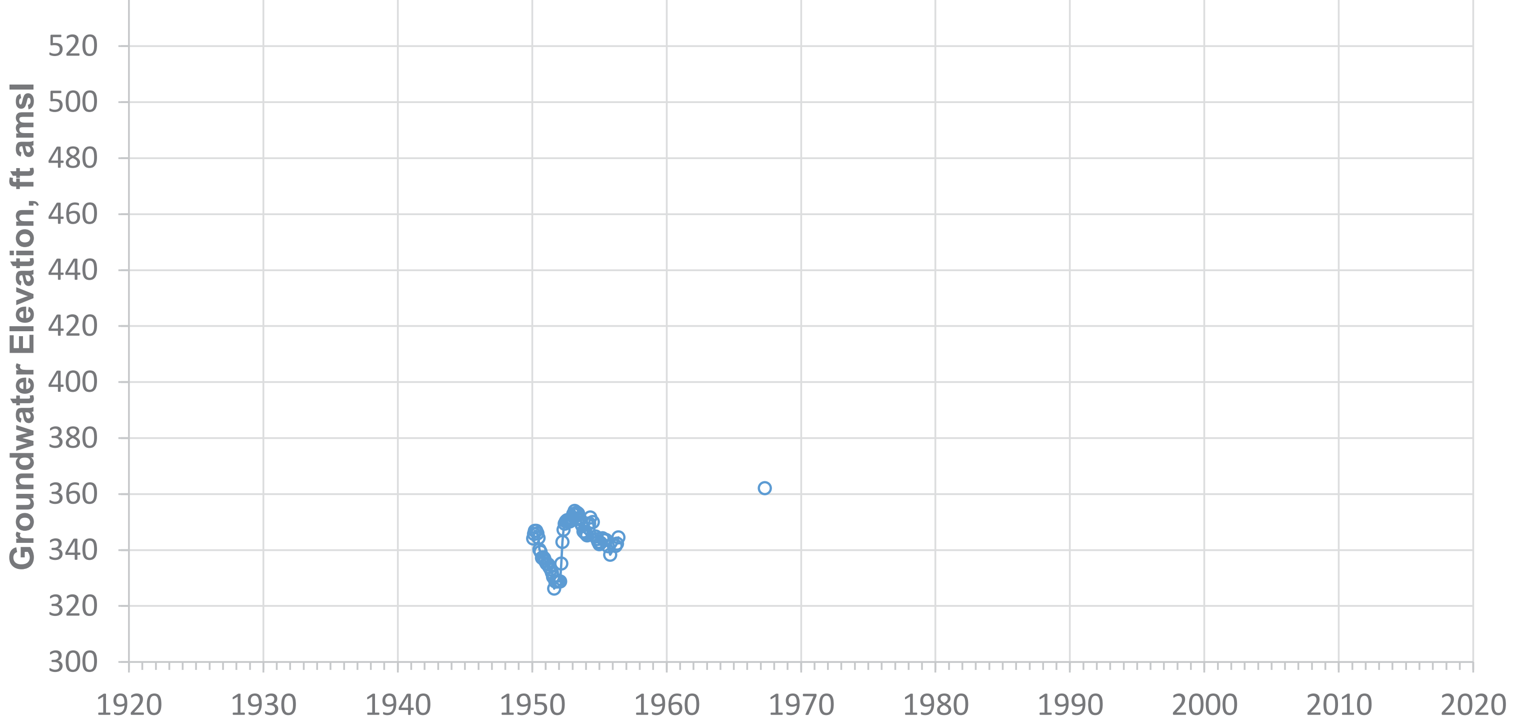
Last of RP ELEVATION: 409.1 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

03N20W01E01S

Last of RP ELEVATION: 402.2 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

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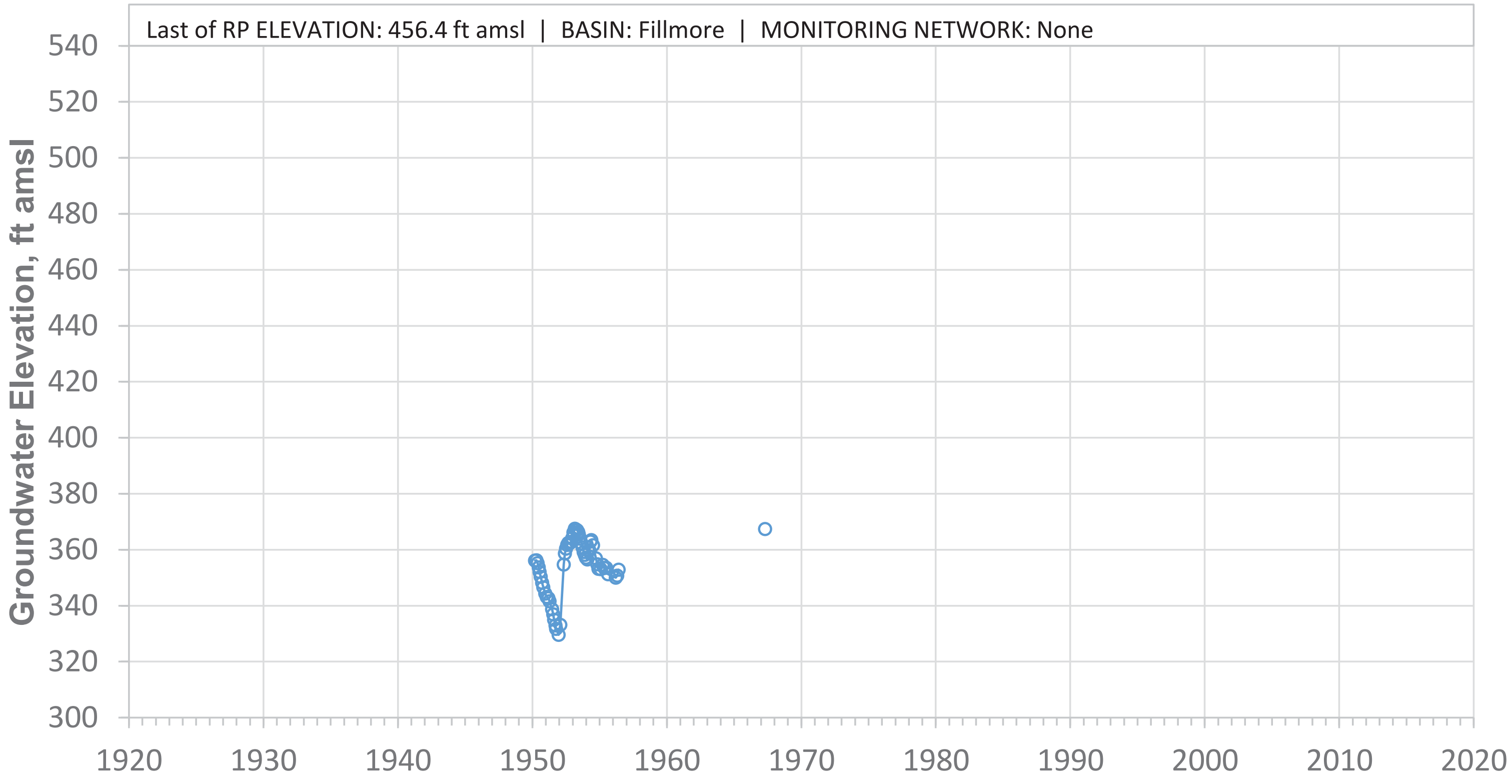
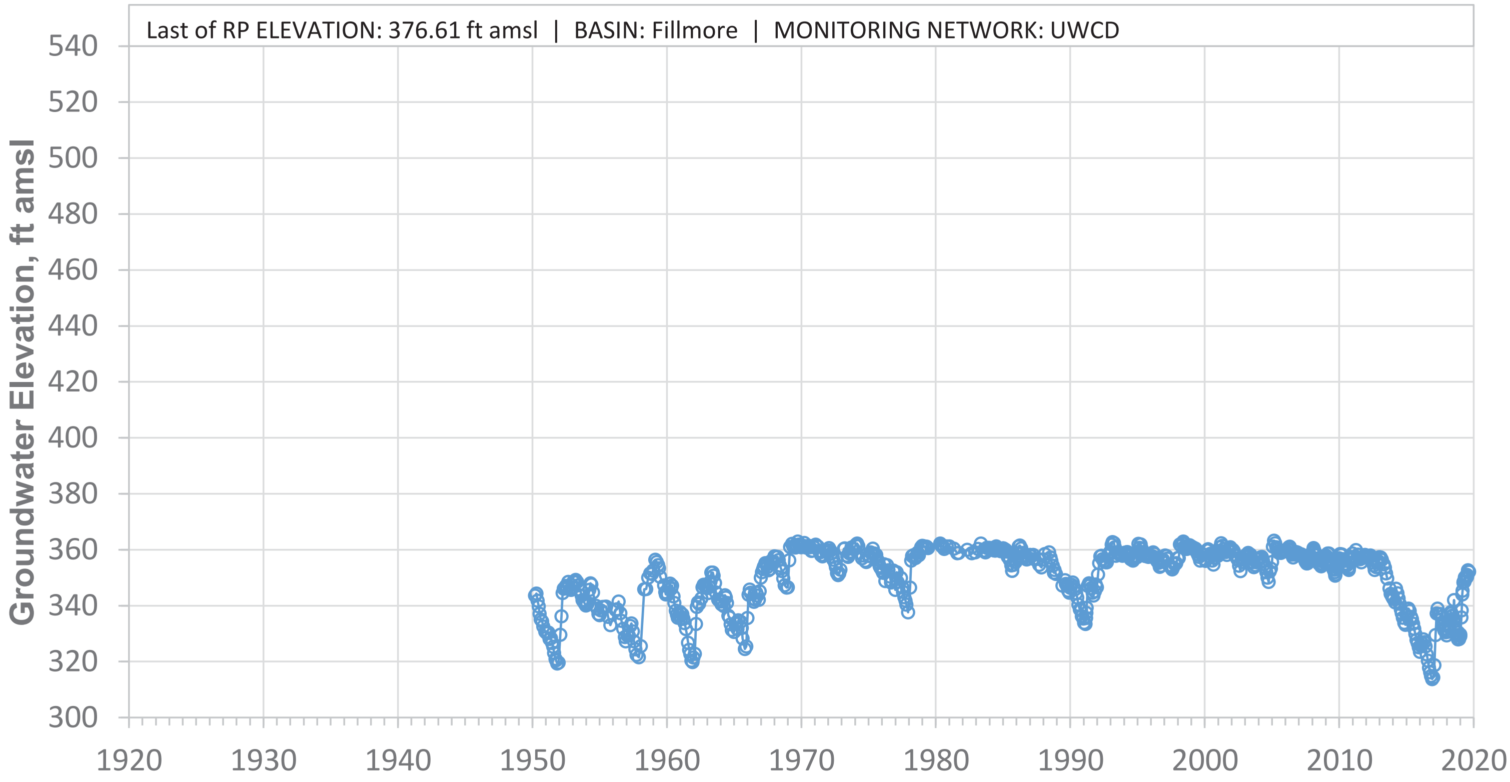


Last of RP ELEVATION: 456.4 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Destroyed

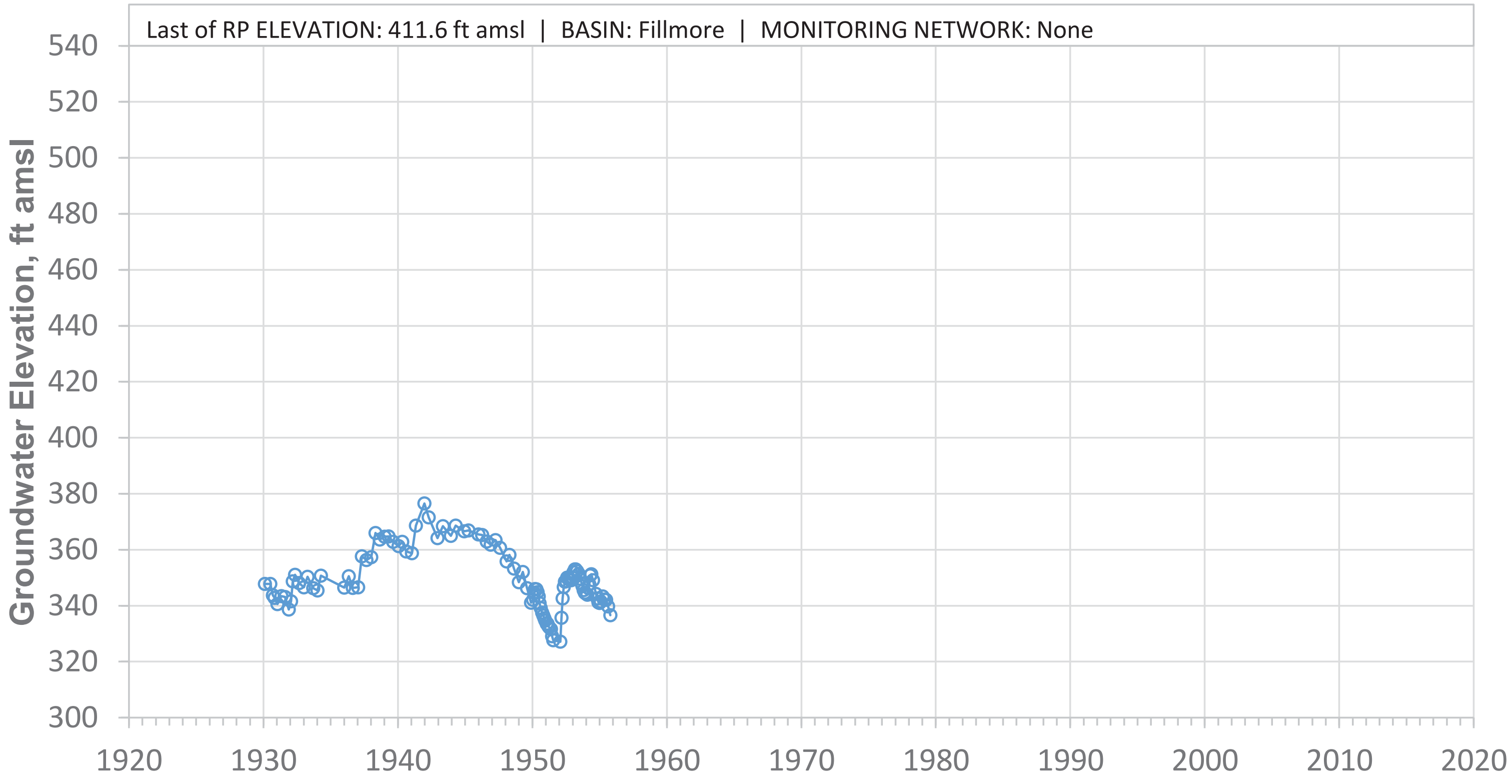
03N20W02A01S



Last of RP ELEVATION: 376.61 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

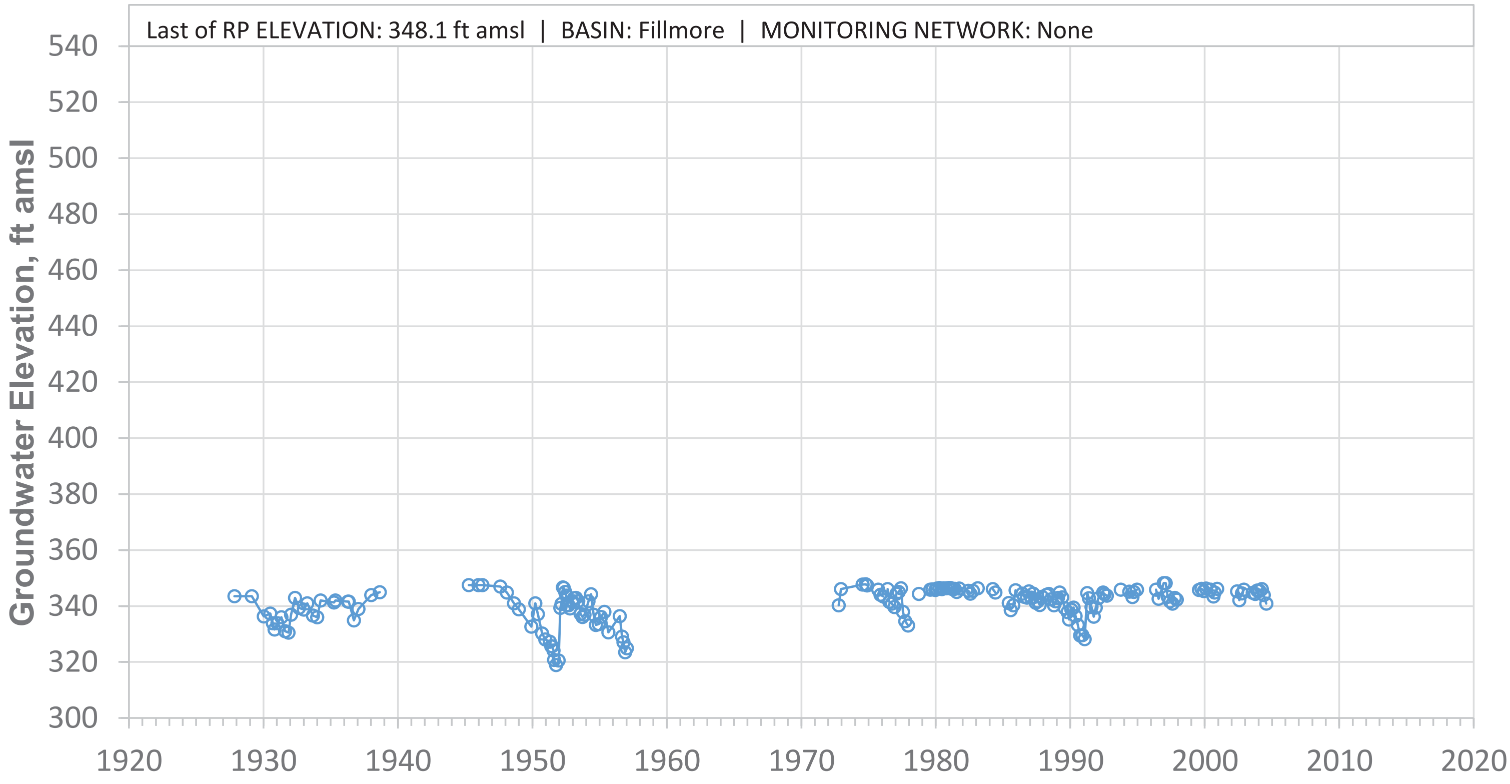
SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

03N20W02R02S


Last of RP ELEVATION: 411.6 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

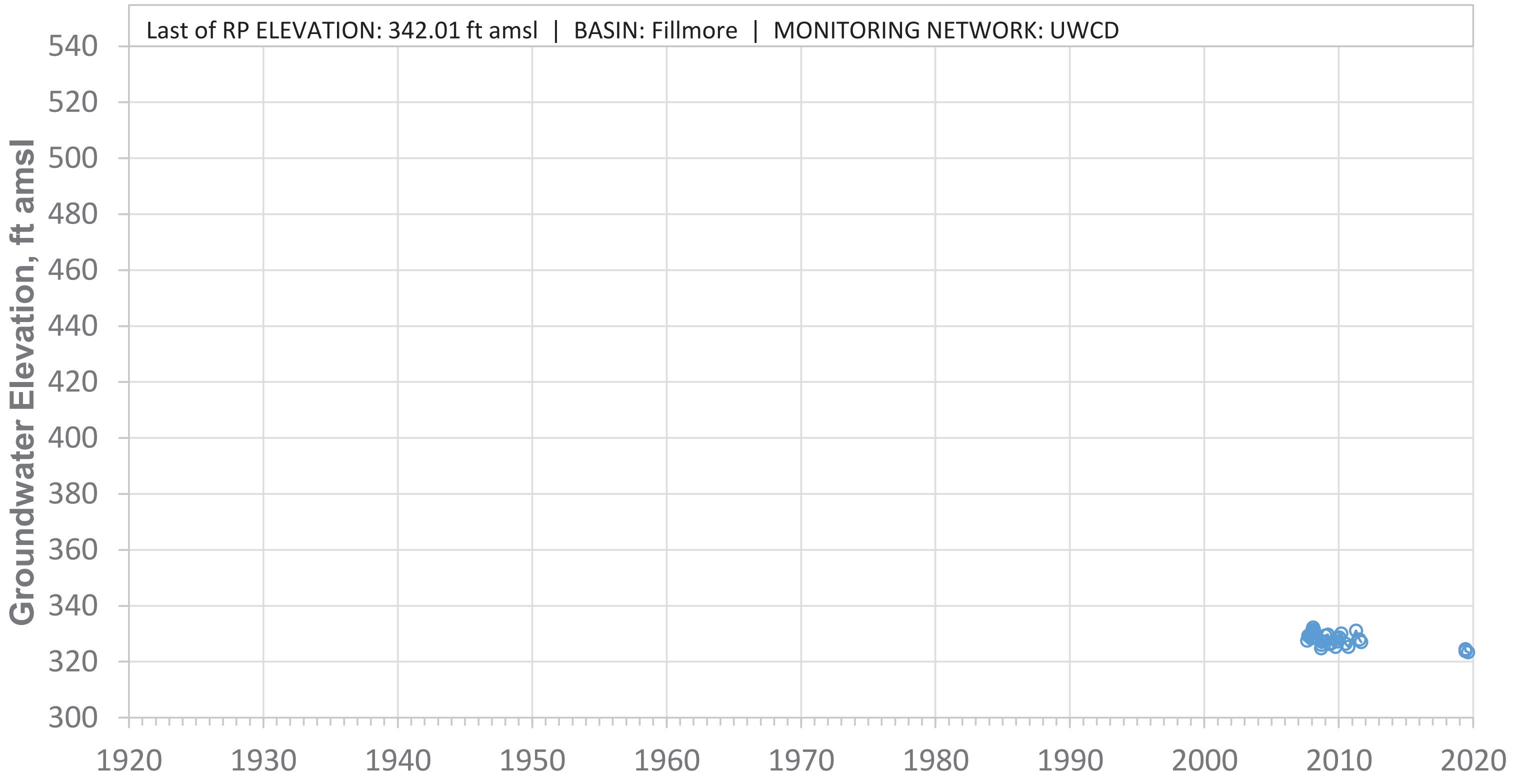
SCREEN: 116-120 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W03D01S


Last of RP ELEVATION: 348.1 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

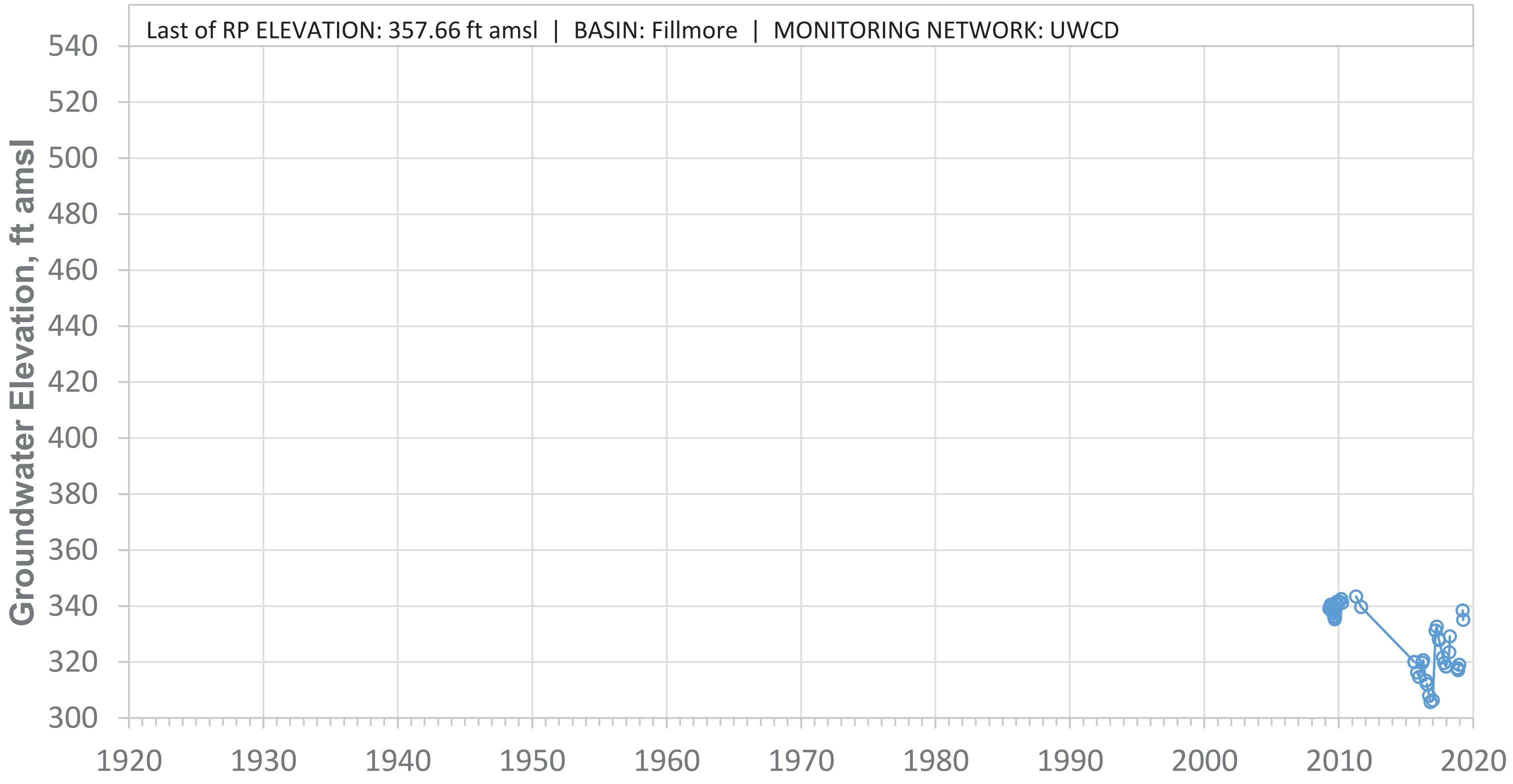
SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed

03N20W03D03S


Last of RP ELEVATION: 342.01 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

SCREEN: 102-397 ft bgs | CURRENT USE: Agricultural | STATUS: Active

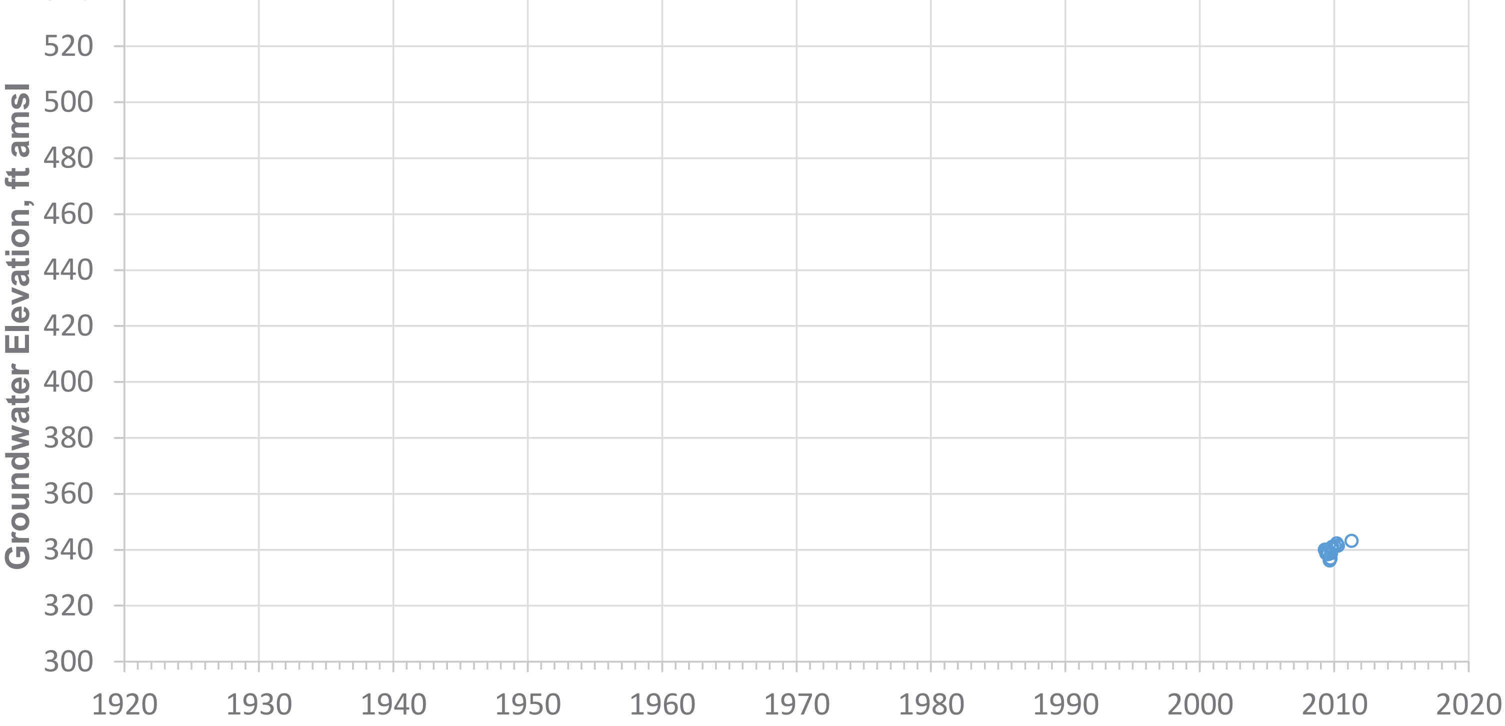
03N20W03H01S


Last of RP ELEVATION: 357.66 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W03H02S

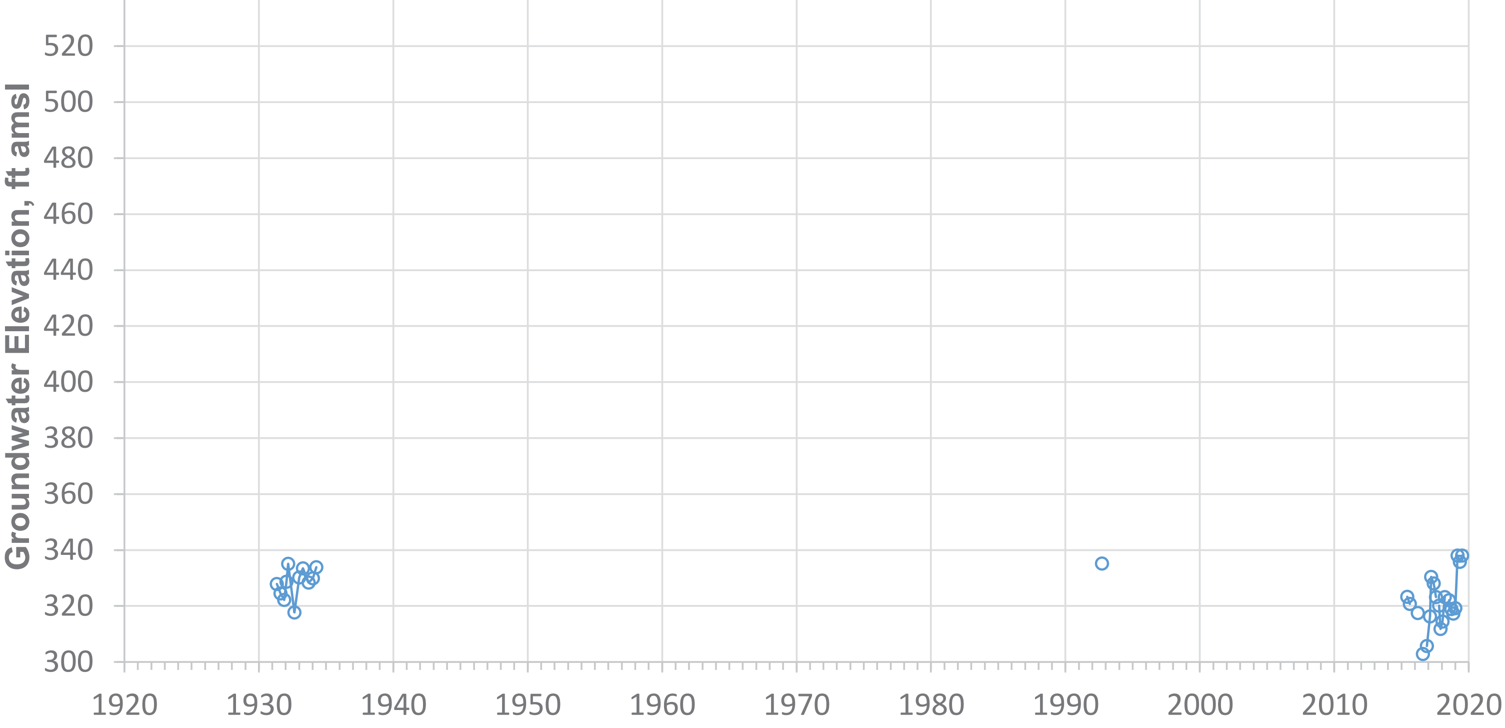
Last of RP ELEVATION: 357.48 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: 100-397 ft bgs | CURRENT USE: Agricultural | STATUS: Active

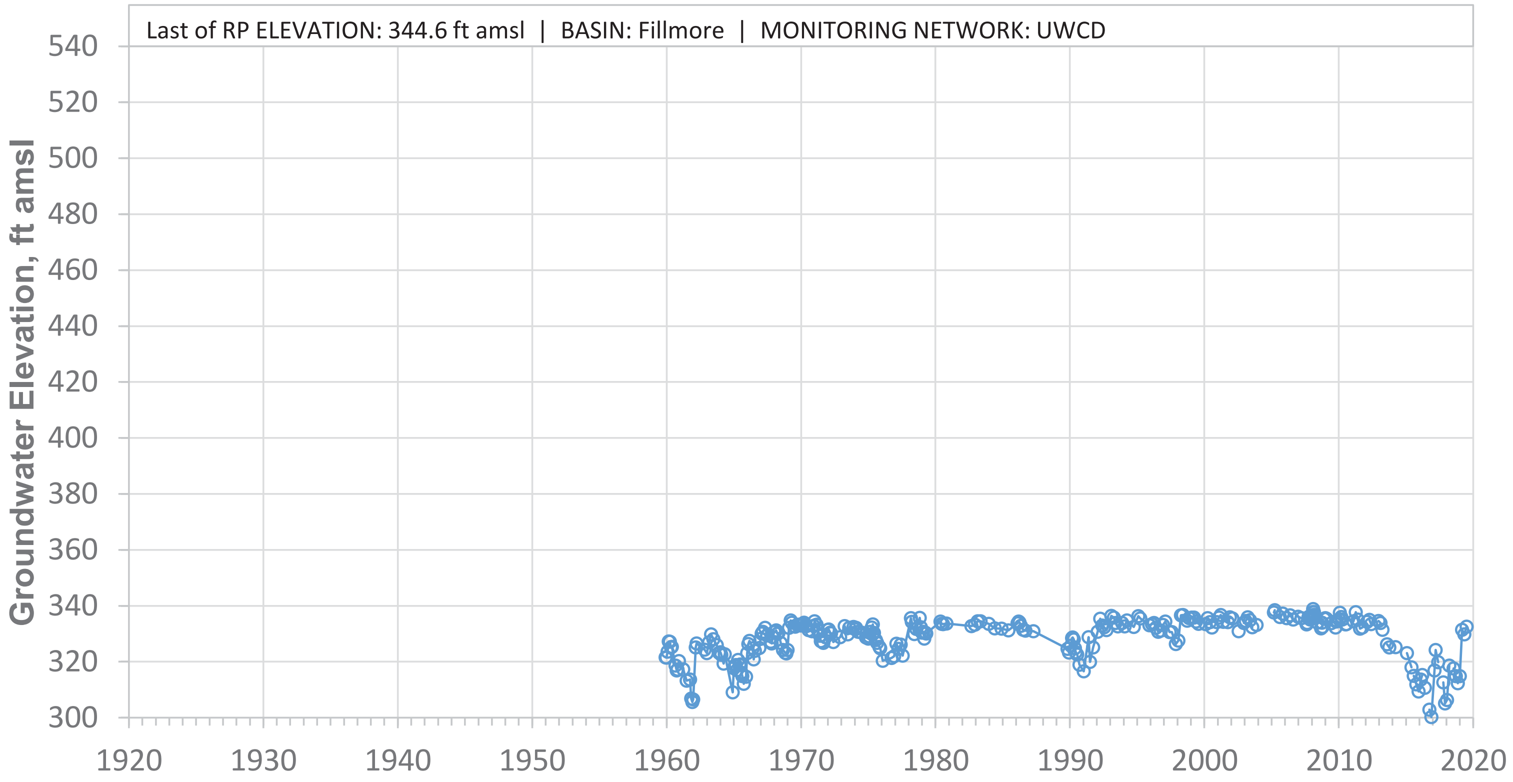
03N20W03J02S

Last of RP ELEVATION: 355.82 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD



SCREEN: 70-210 ft bgs | CURRENT USE: Agricultural | STATUS: Active

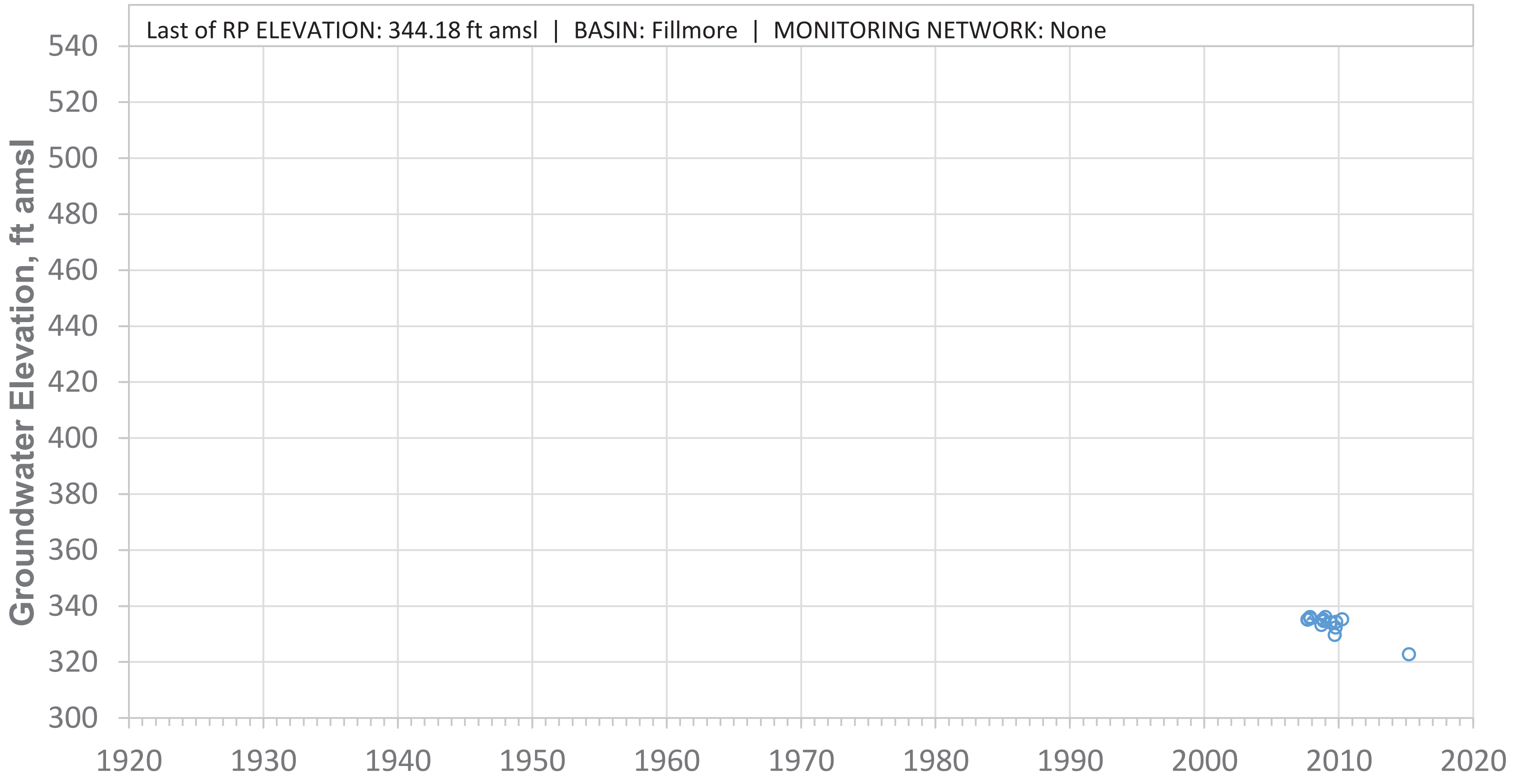
03N20W03N01S



Last of RP ELEVATION: 344.6 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

SCREEN: 120-172 ft bgs | CURRENT USE: Agricultural | STATUS: Active

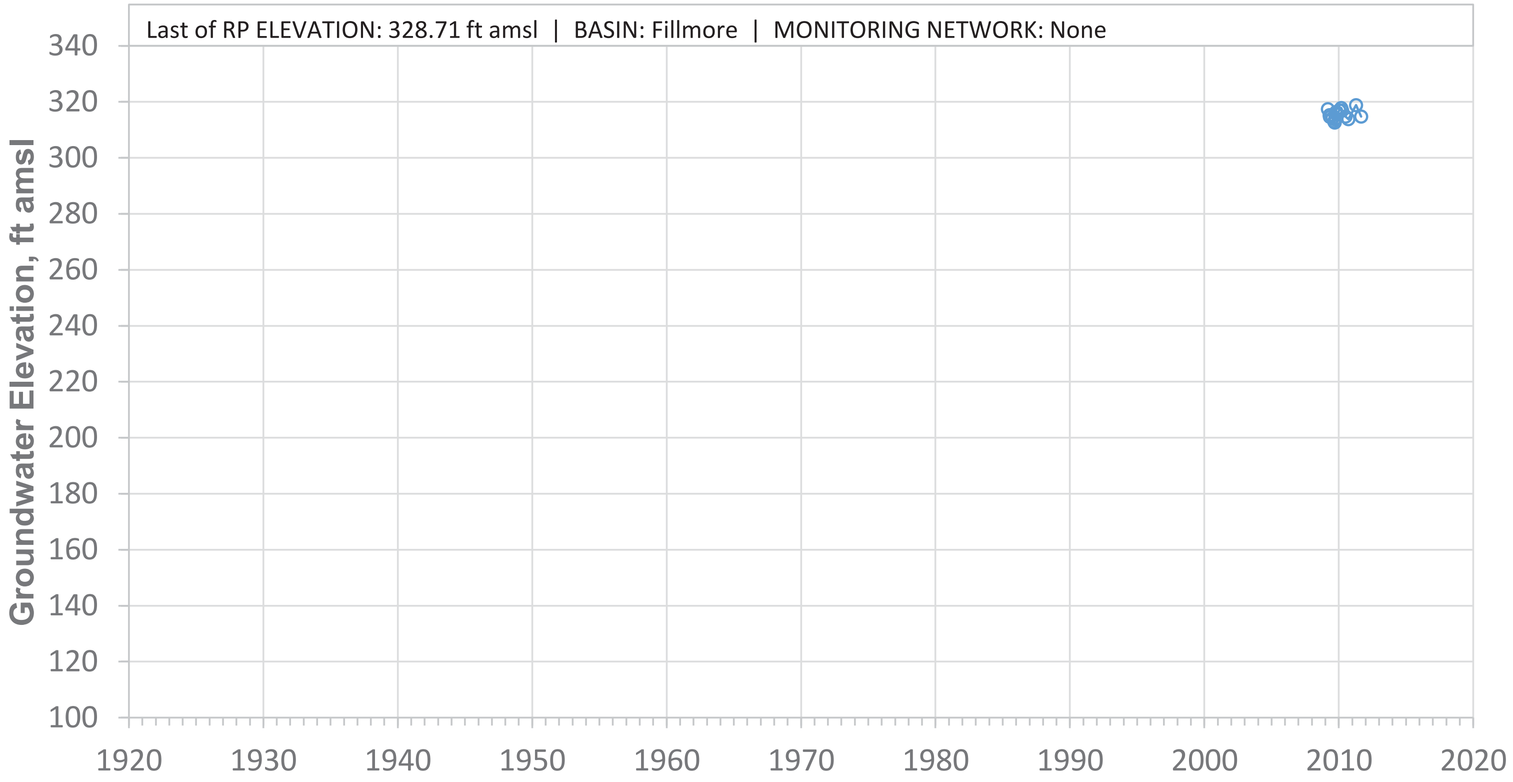
03N20W03P01S



Last of RP ELEVATION: 344.18 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

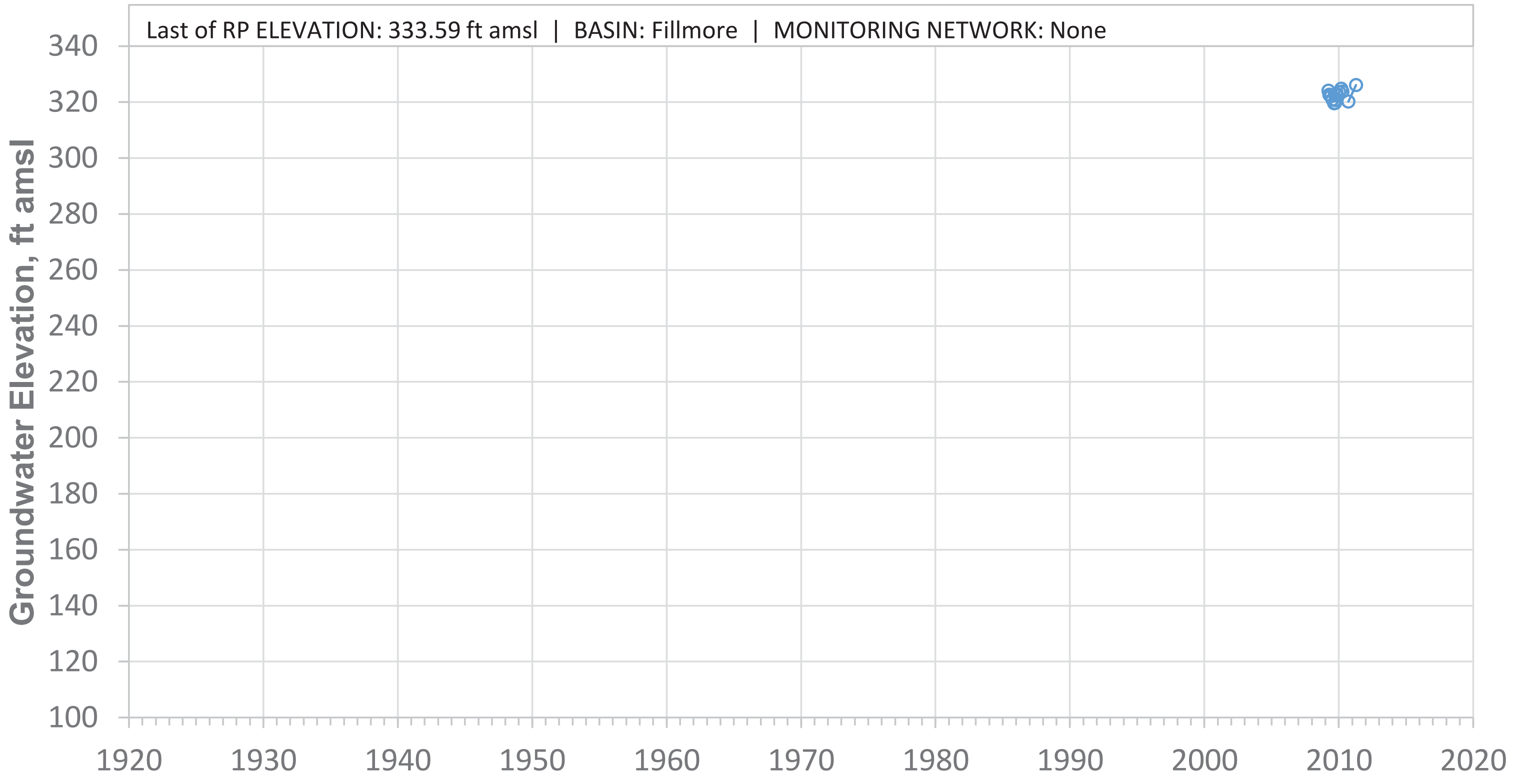
SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W04N05S



SCREEN: 100-250 ft bgs | CURRENT USE: Agricultural | STATUS: Active

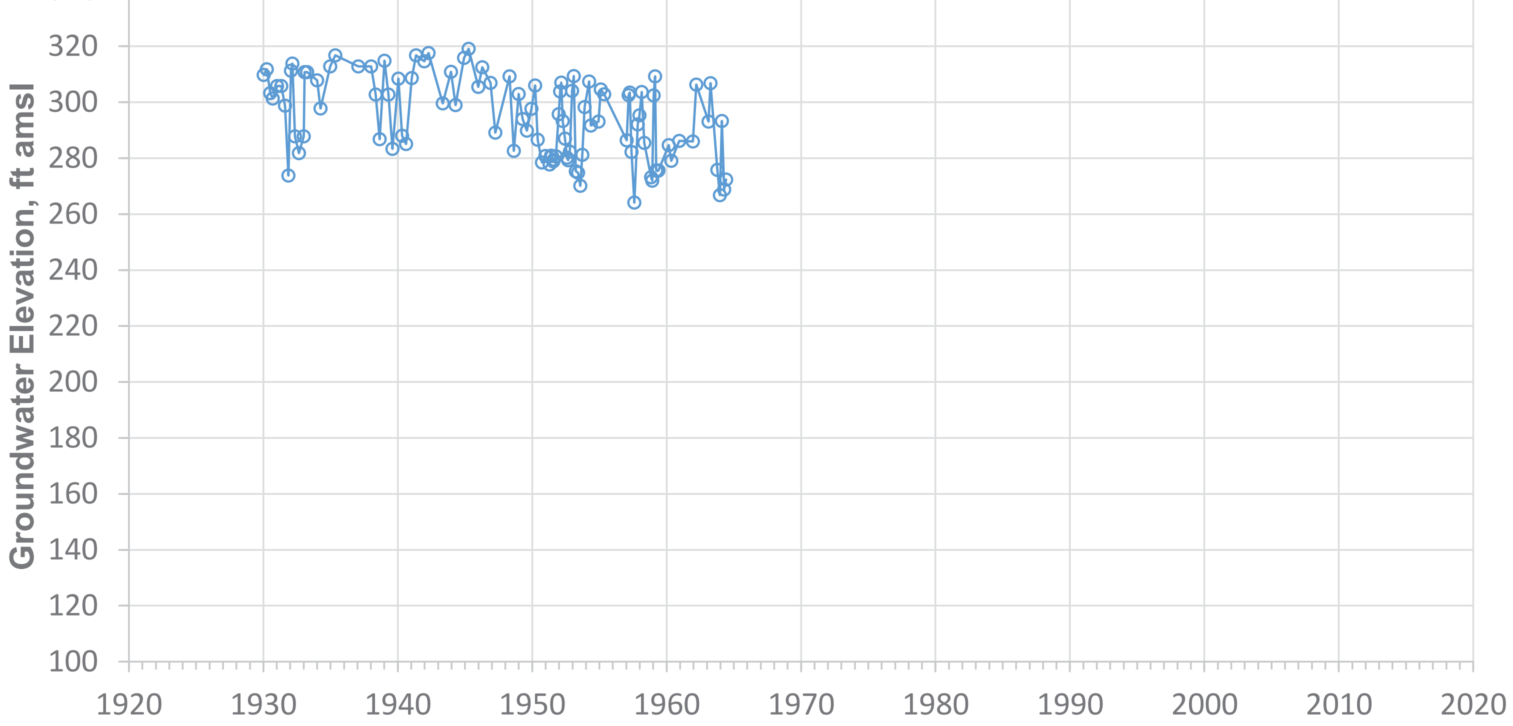
03N20W04R02S



SCREEN: 95-215 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W05C02S

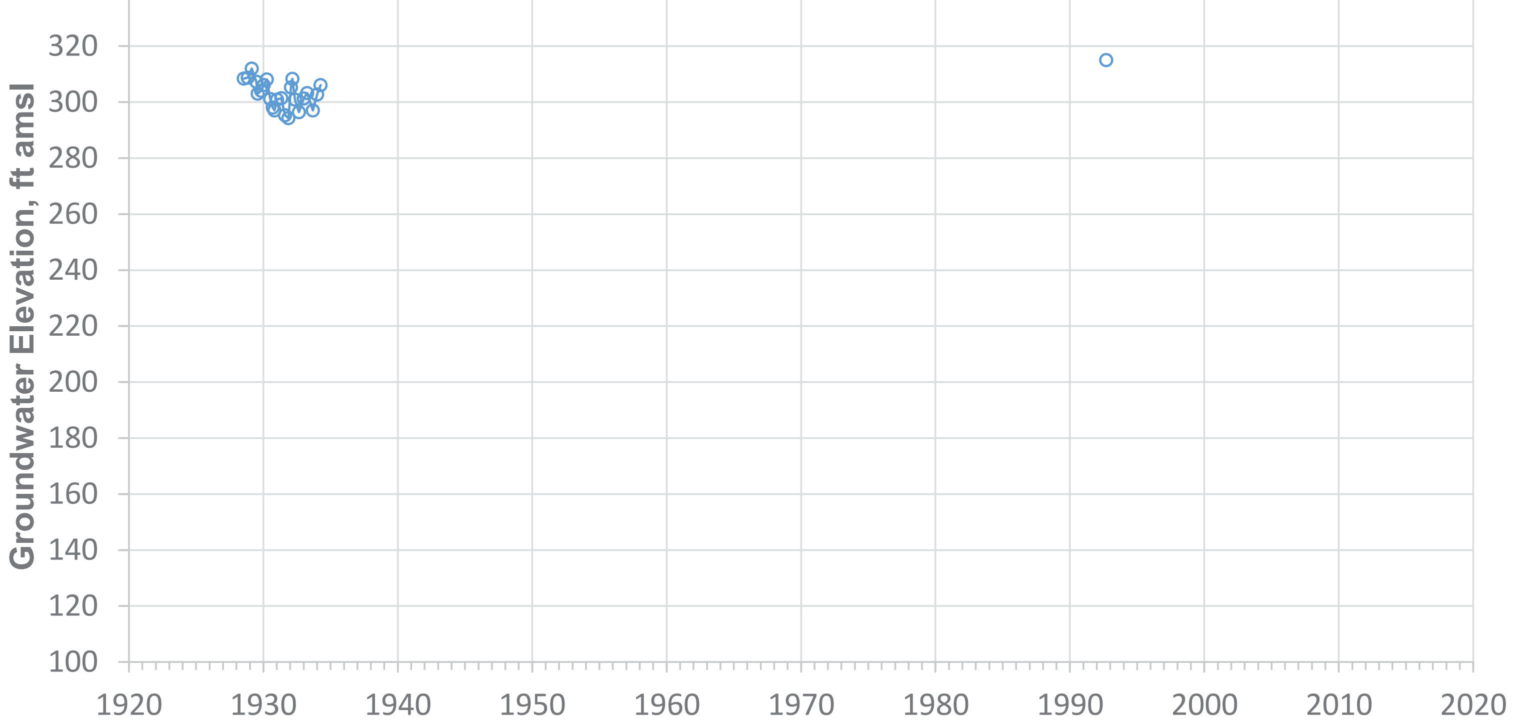
Last of RP ELEVATION: 411.8 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



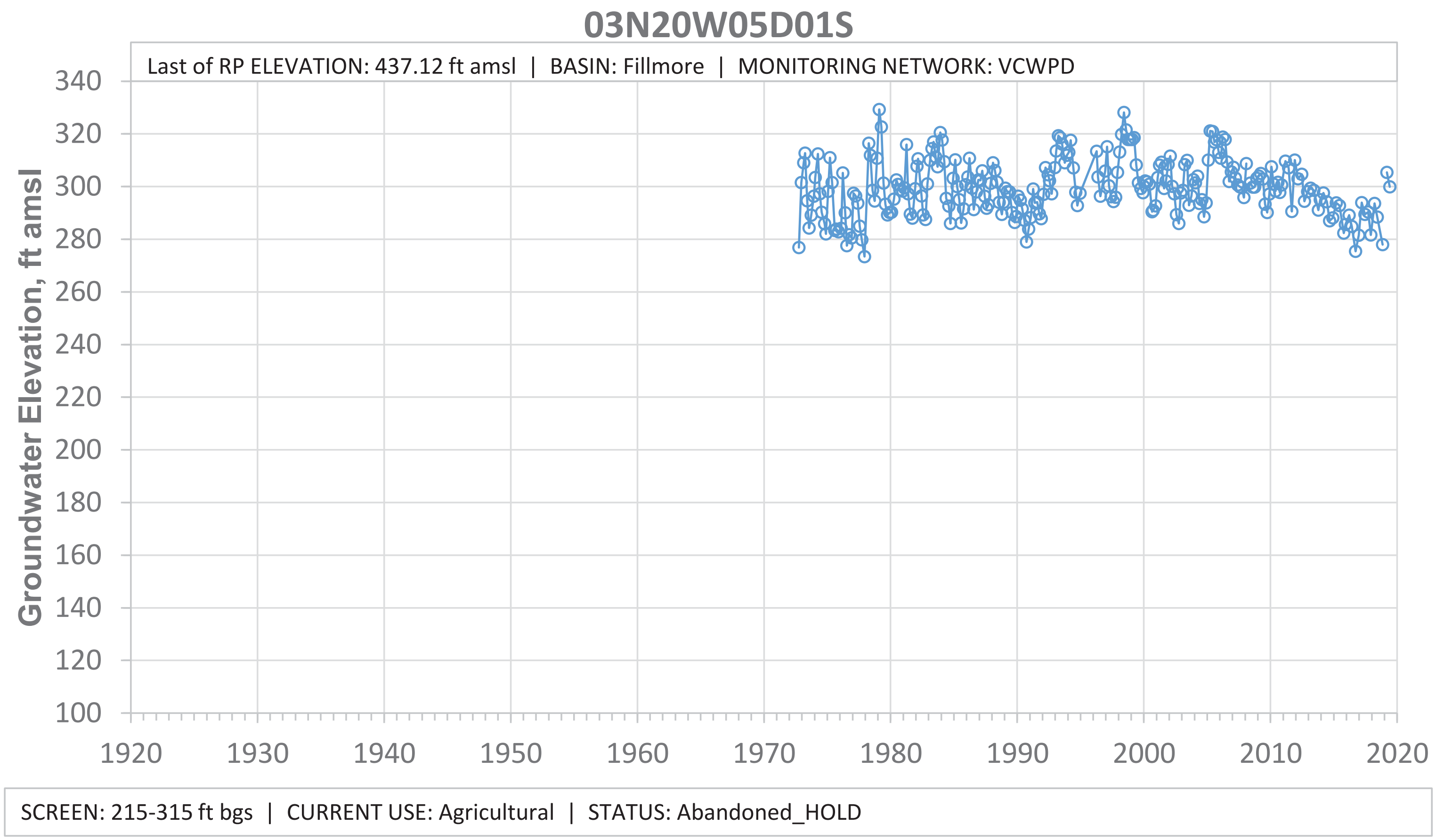
SCREEN: 135-402 ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed

03N20W05C03S

Last of RP ELEVATION: 403.3 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



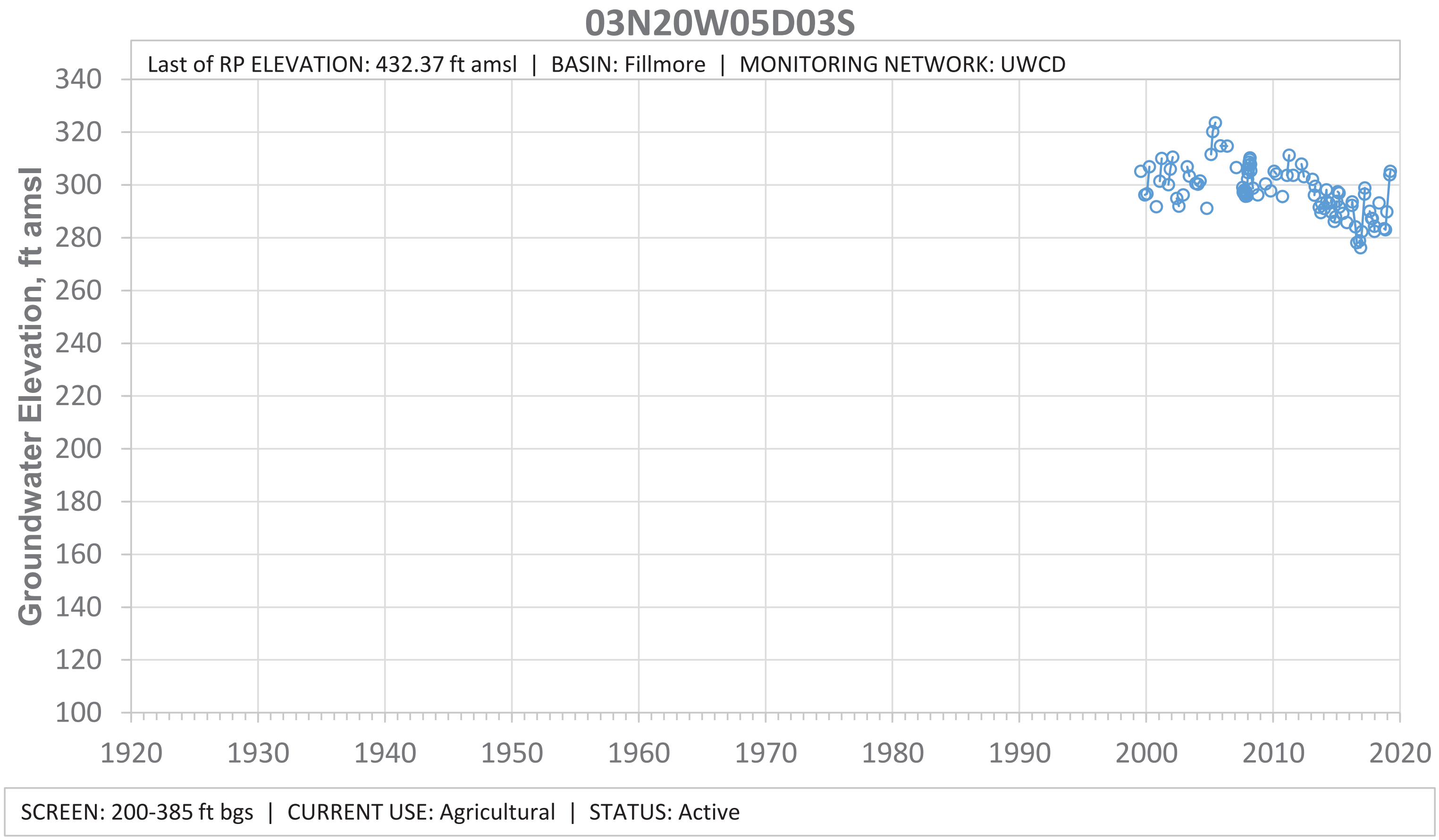
SCREEN: 221-362 ft bgs | CURRENT USE: Domestic | STATUS: Destroyed



03N20W05D01S

Last of RP ELEVATION: 437.12 ft amsl | BASIN: Fillmore | MONITORING NETWORK: VCWPD

SCREEN: 215-315 ft bgs | CURRENT USE: Agricultural | STATUS: Abandoned_HOLD

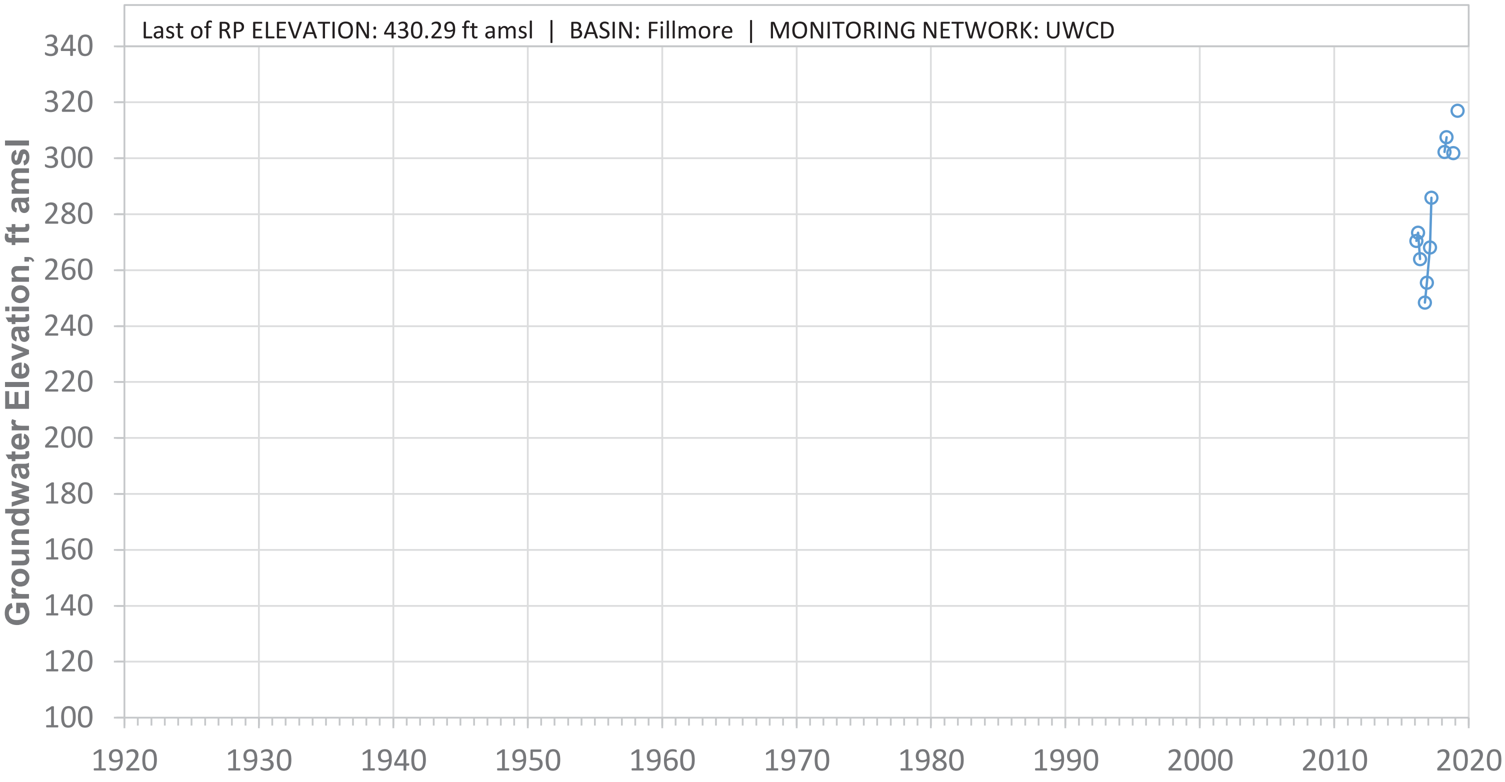


03N20W05D03S

Last of RP ELEVATION: 432.37 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

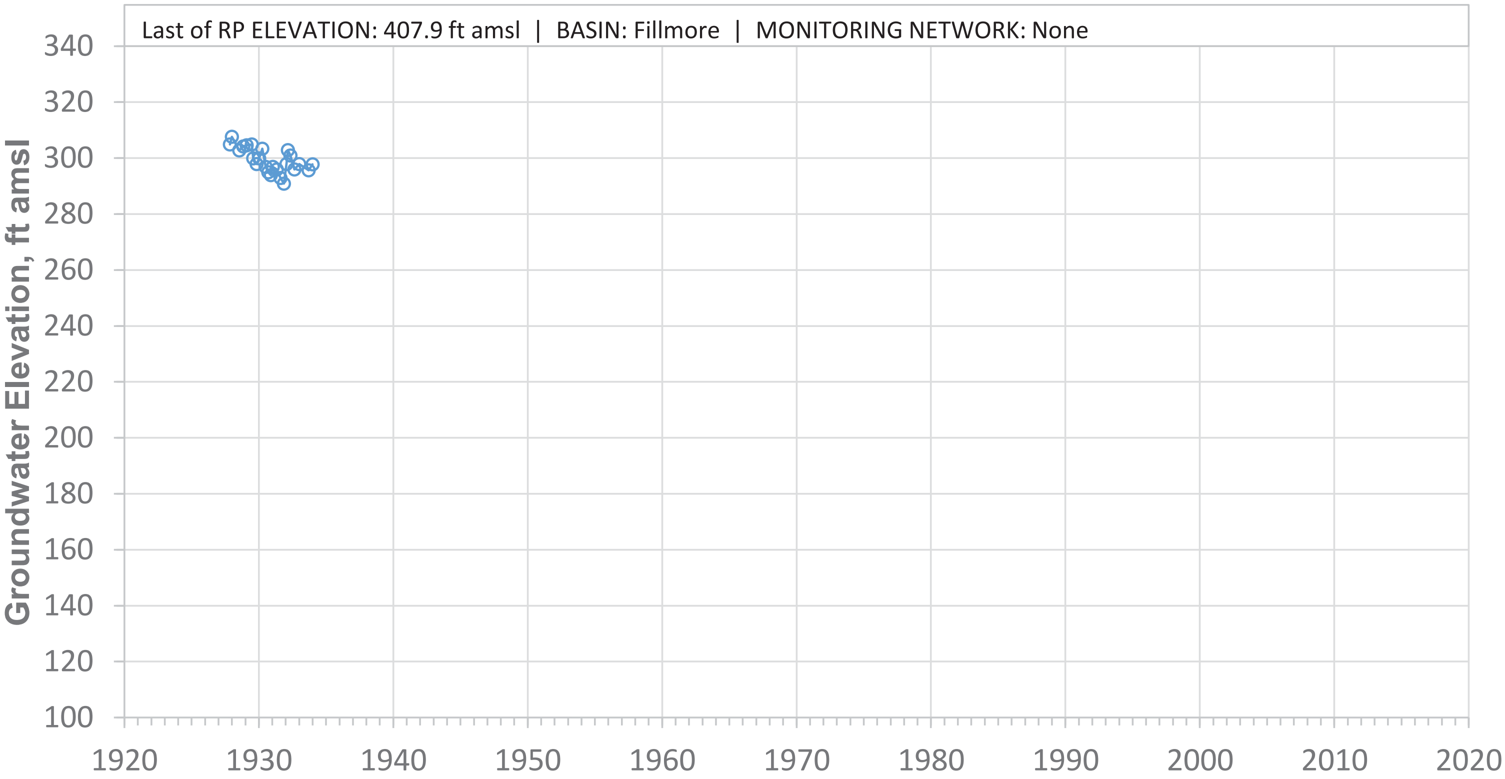
SCREEN: 200-385 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W06D03S


Last of RP ELEVATION: 430.29 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

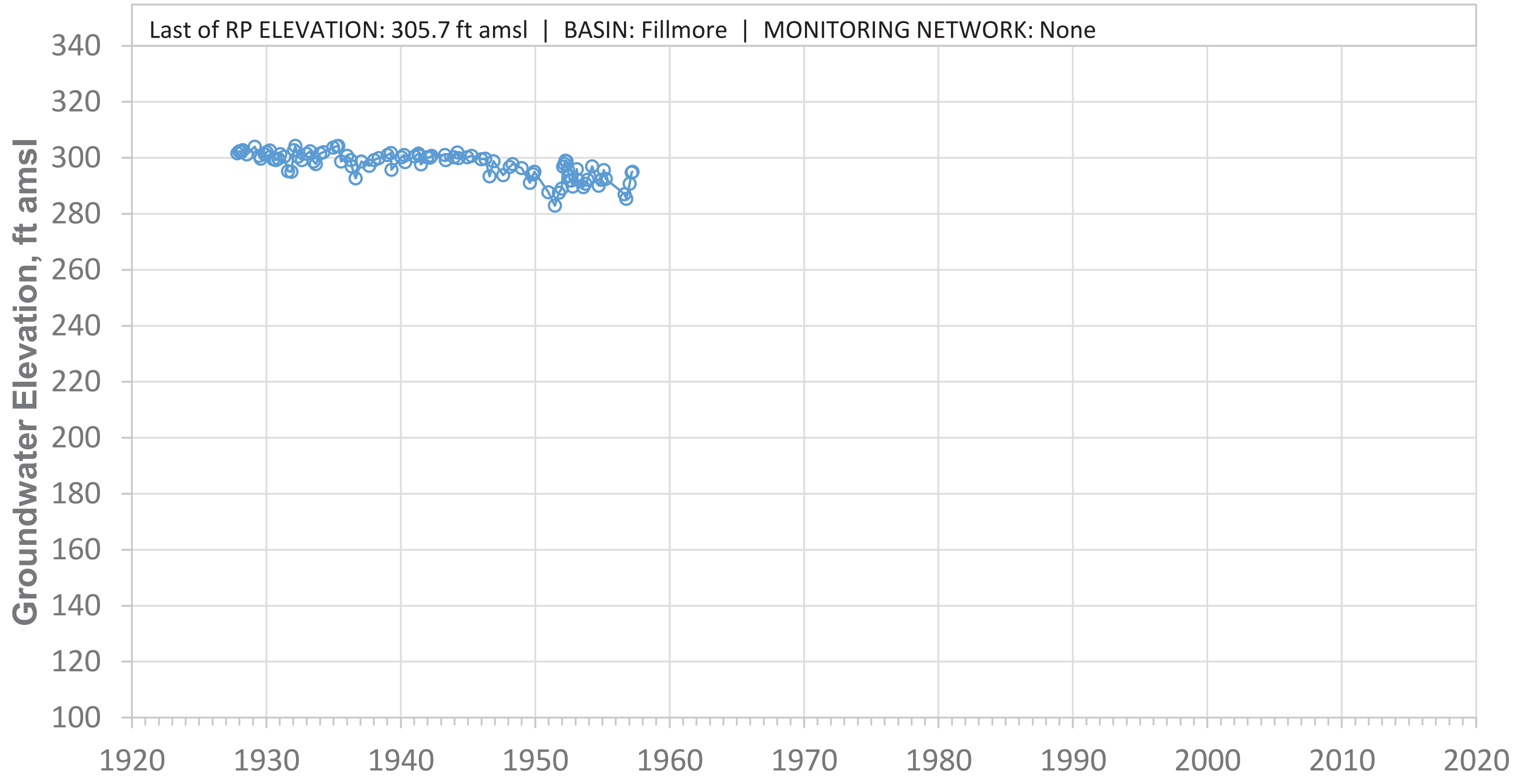
SCREEN: 160-500 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W06G01S


Last of RP ELEVATION: 407.9 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: 158-230 ft bgs | CURRENT USE: Agricultural | STATUS: Active

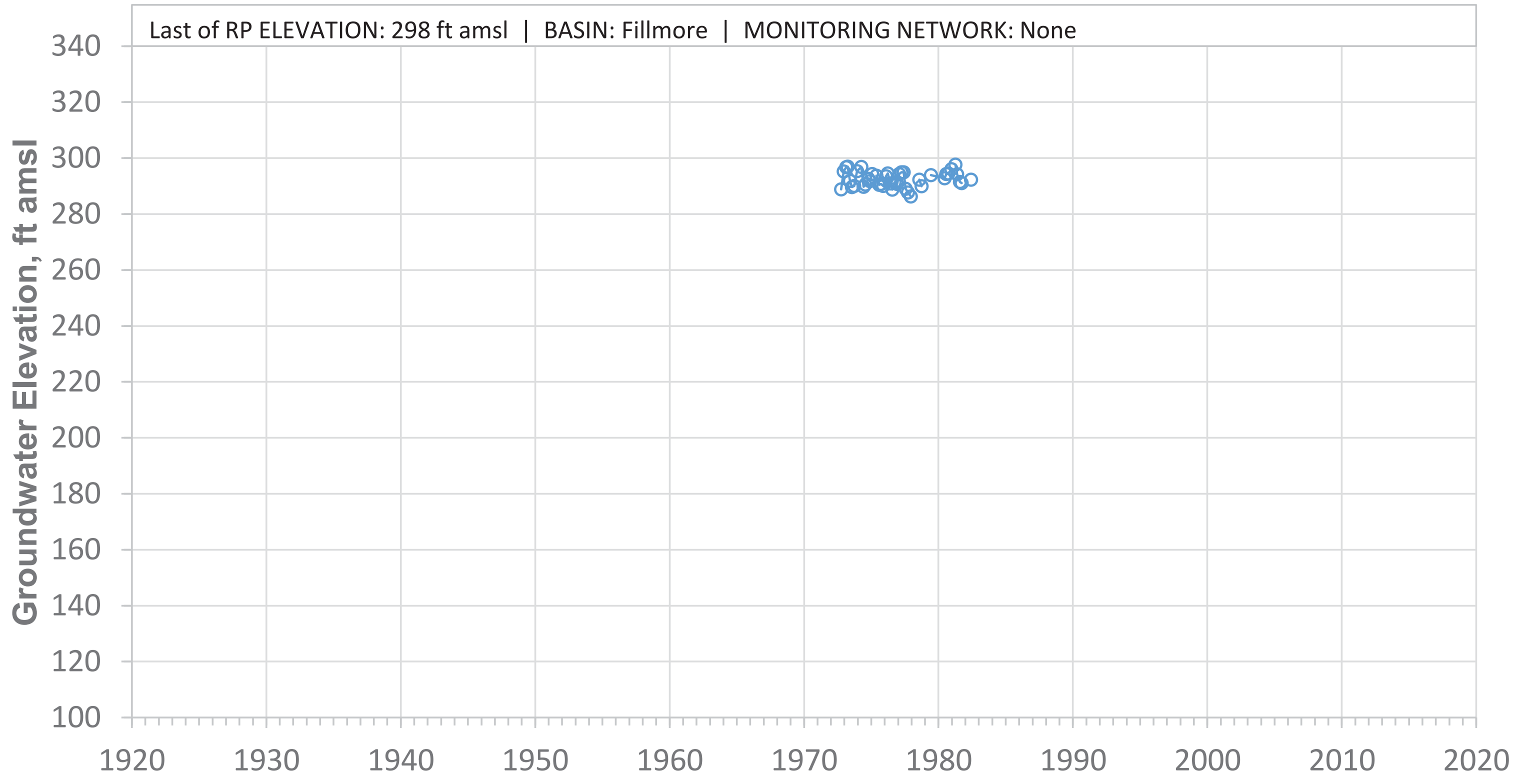
03N20W06J01S



Last of RP ELEVATION: 305.7 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Active

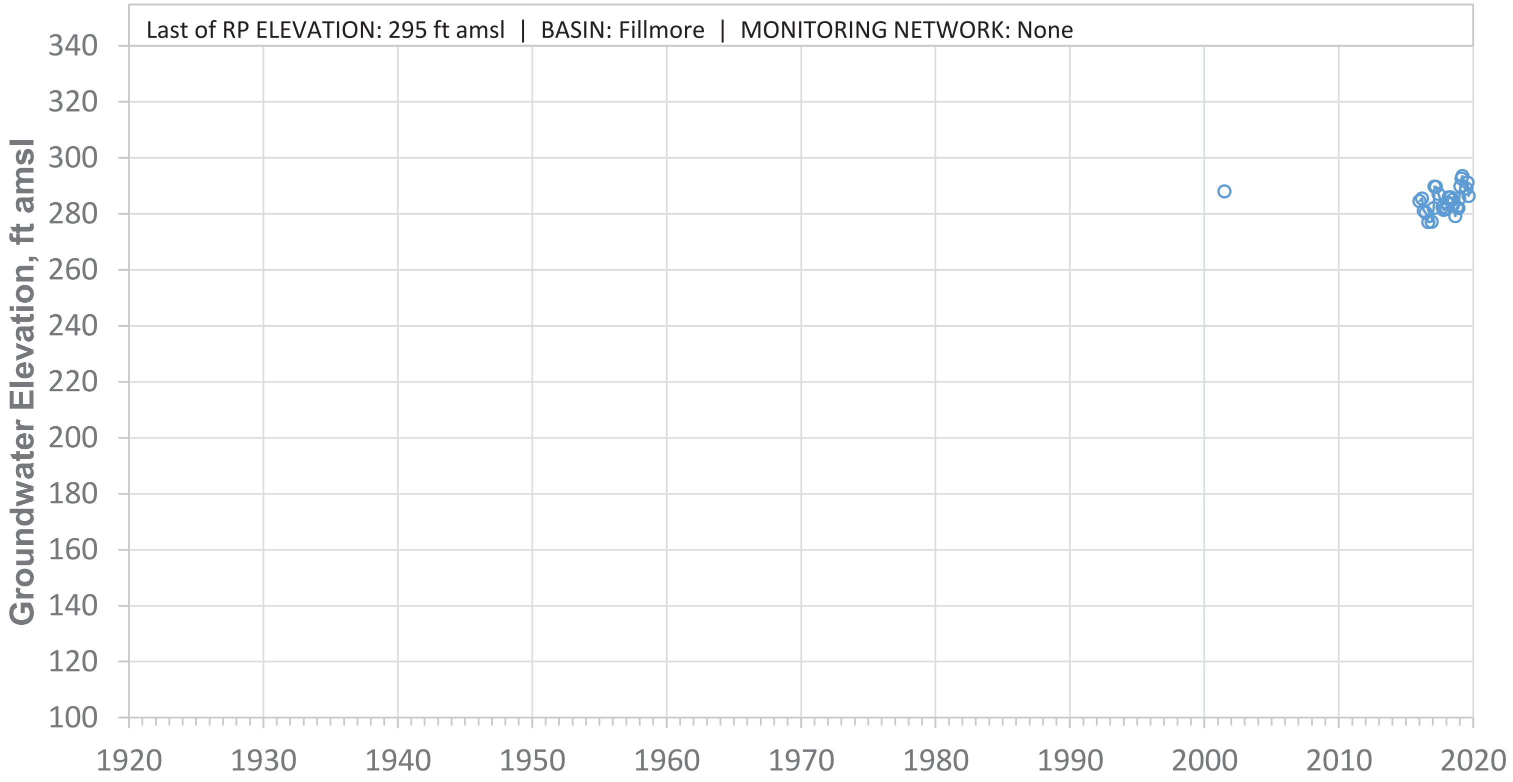
03N20W06P01S



Last of RP ELEVATION: 298 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: 50-100 ft bgs | CURRENT USE: Domestic | STATUS: Active

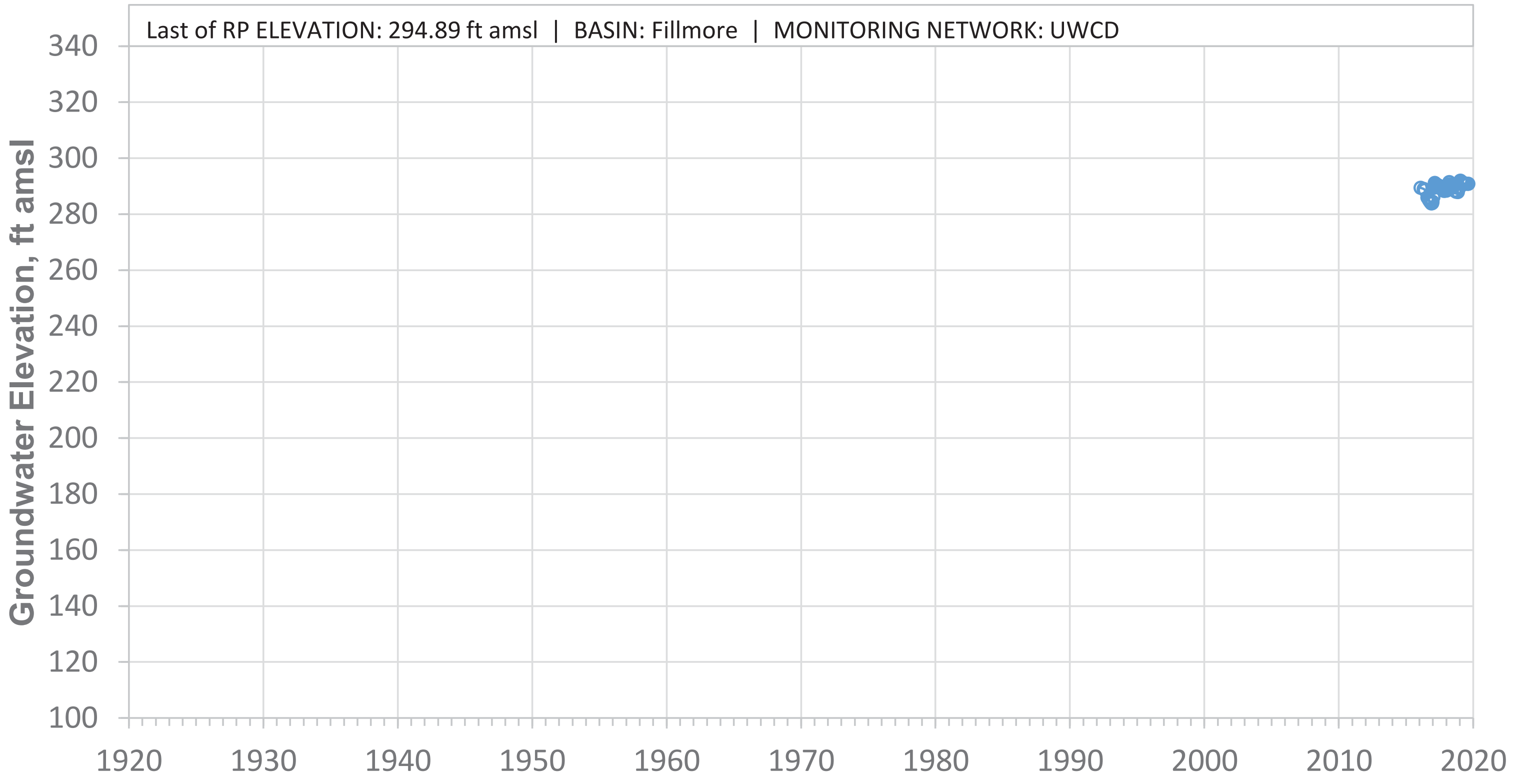
03N20W06P04S



Last of RP ELEVATION: 295 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: 190-330 ft bgs | CURRENT USE: Domestic | STATUS: Active

03N20W07HRP9

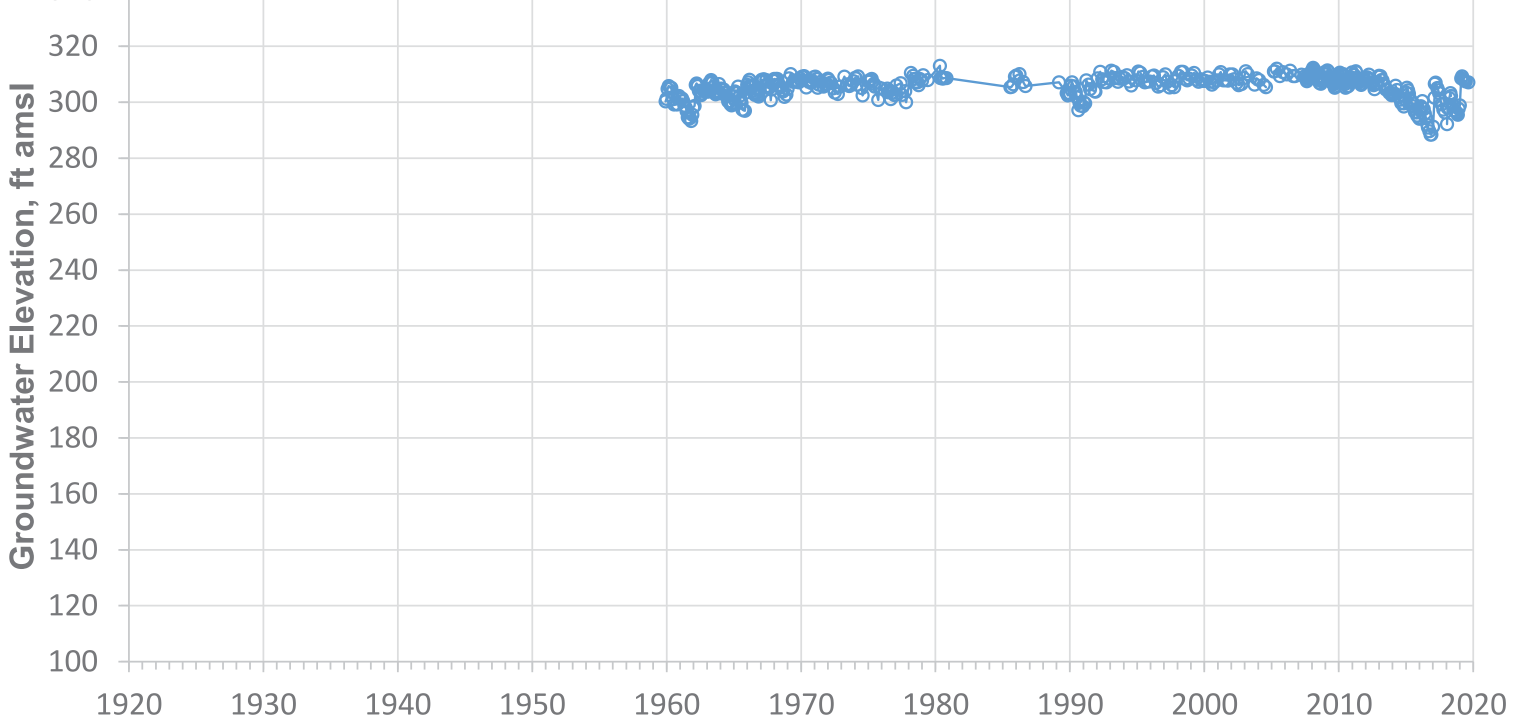


Last of RP ELEVATION: 294.89 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

SCREEN: 1-12 ft bgs | CURRENT USE: Observation | STATUS: Unknown

03N20W08A01S

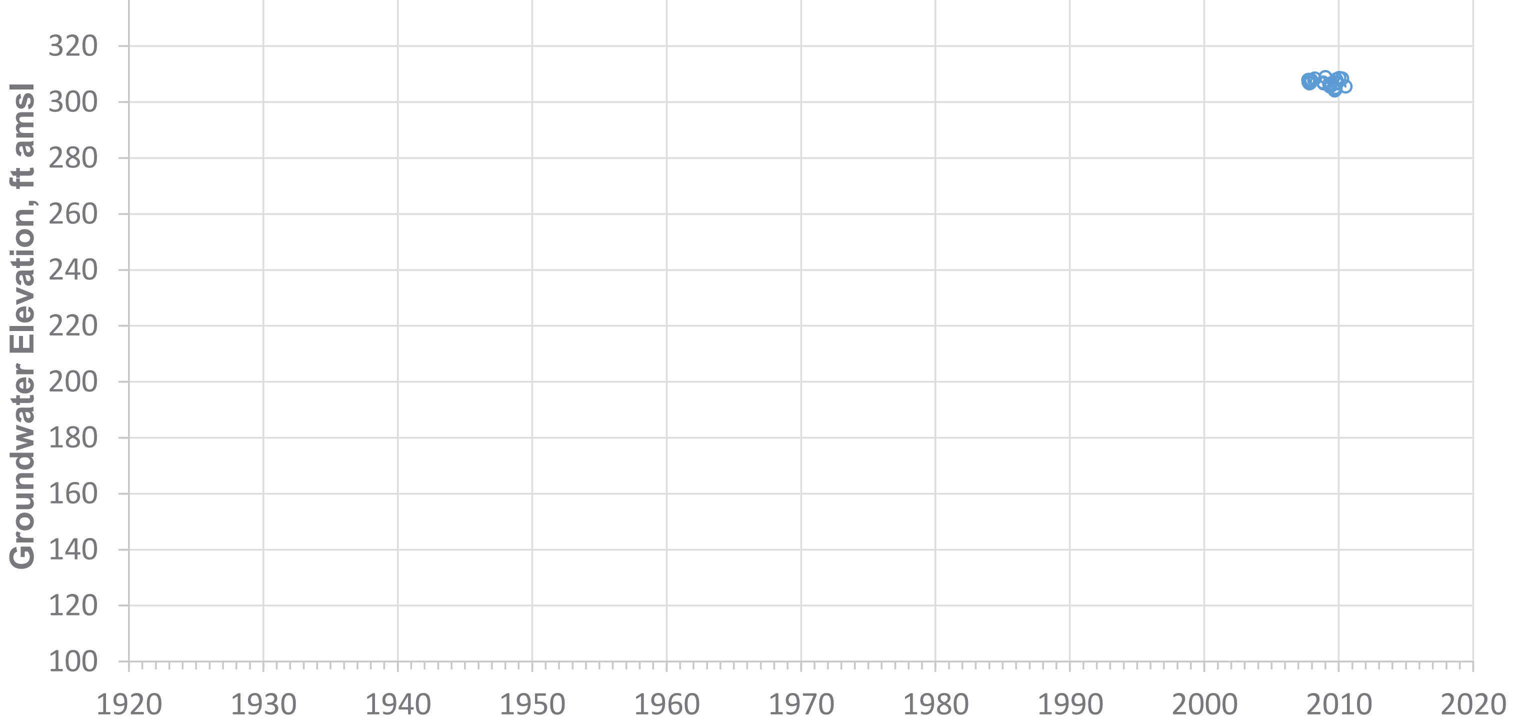
Last of RP ELEVATION: 320.35 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD



SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Active

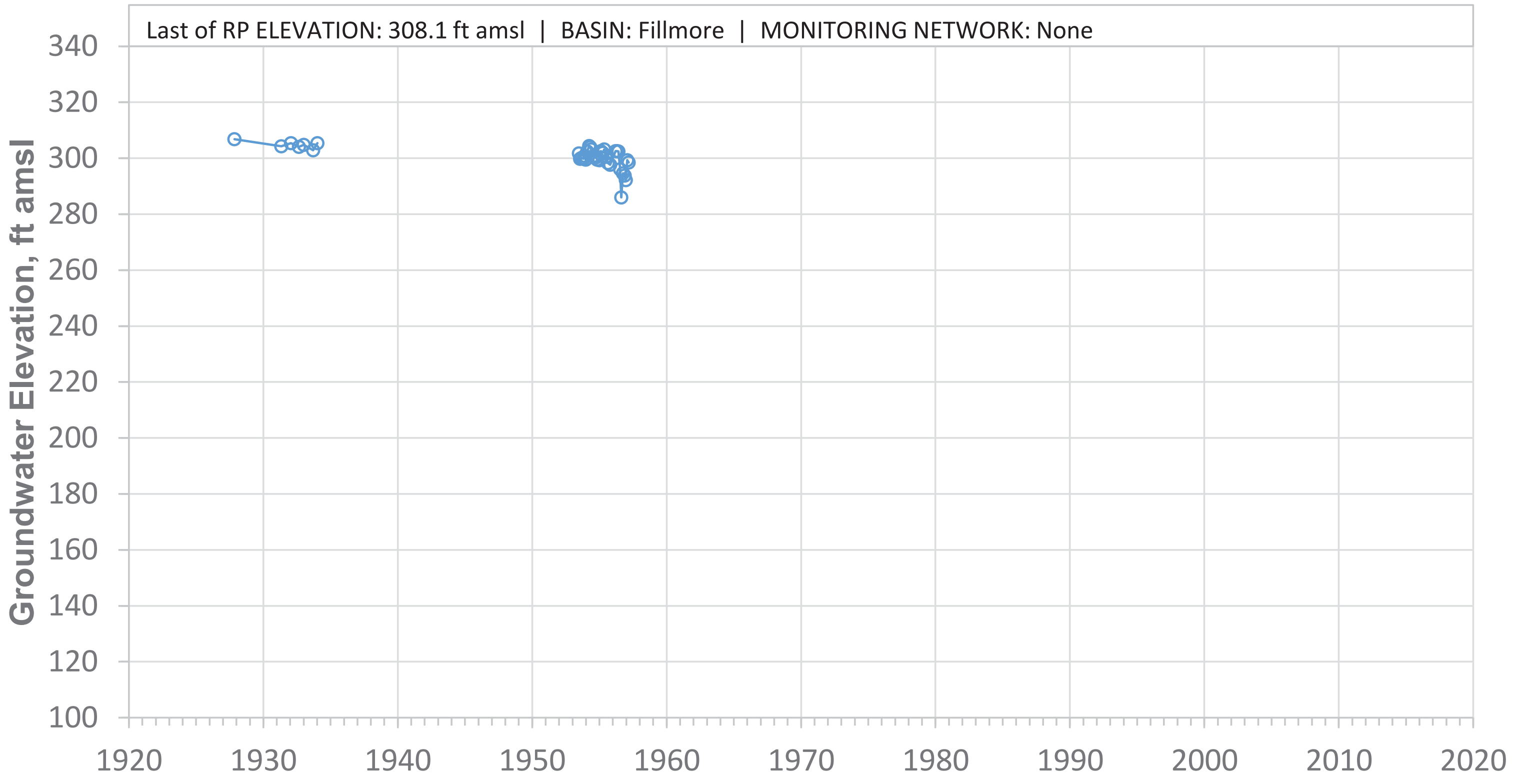
03N20W08B02S

Last of RP ELEVATION: 309.13 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



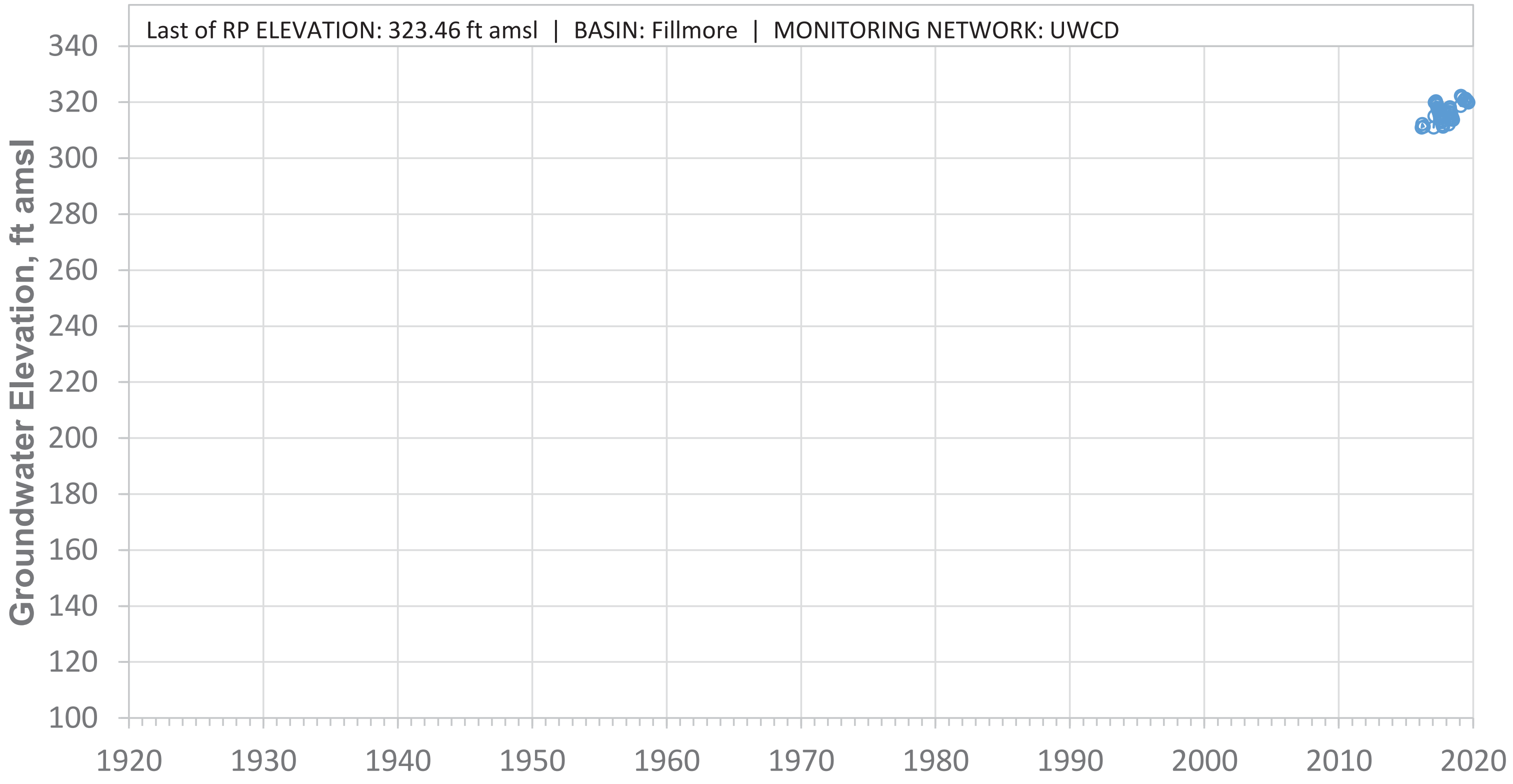
SCREEN: 202-307 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W08G01S

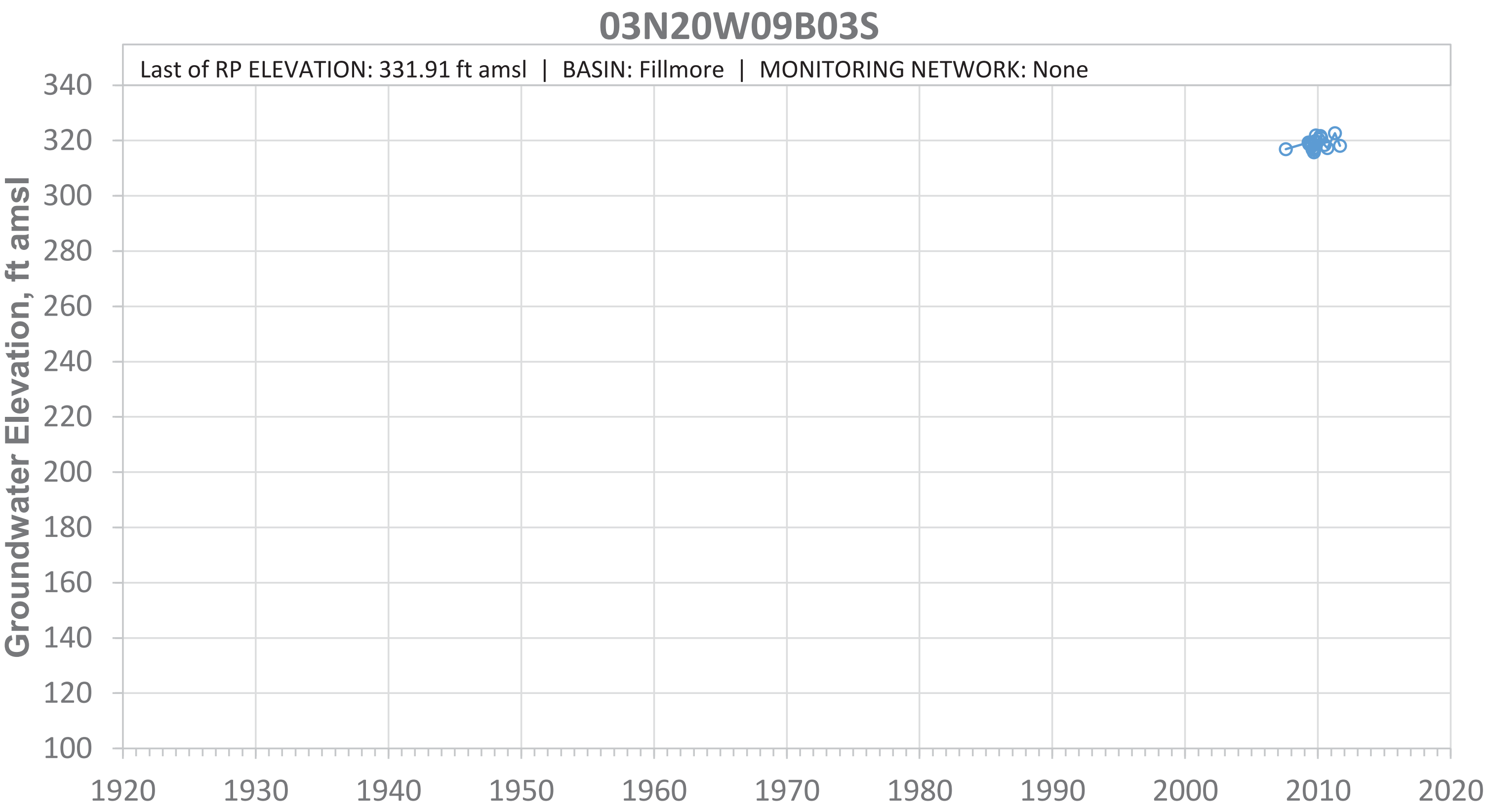

Last of RP ELEVATION: 308.1 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Unknown | STATUS: Can't Locate

03N20W08VCWPD8

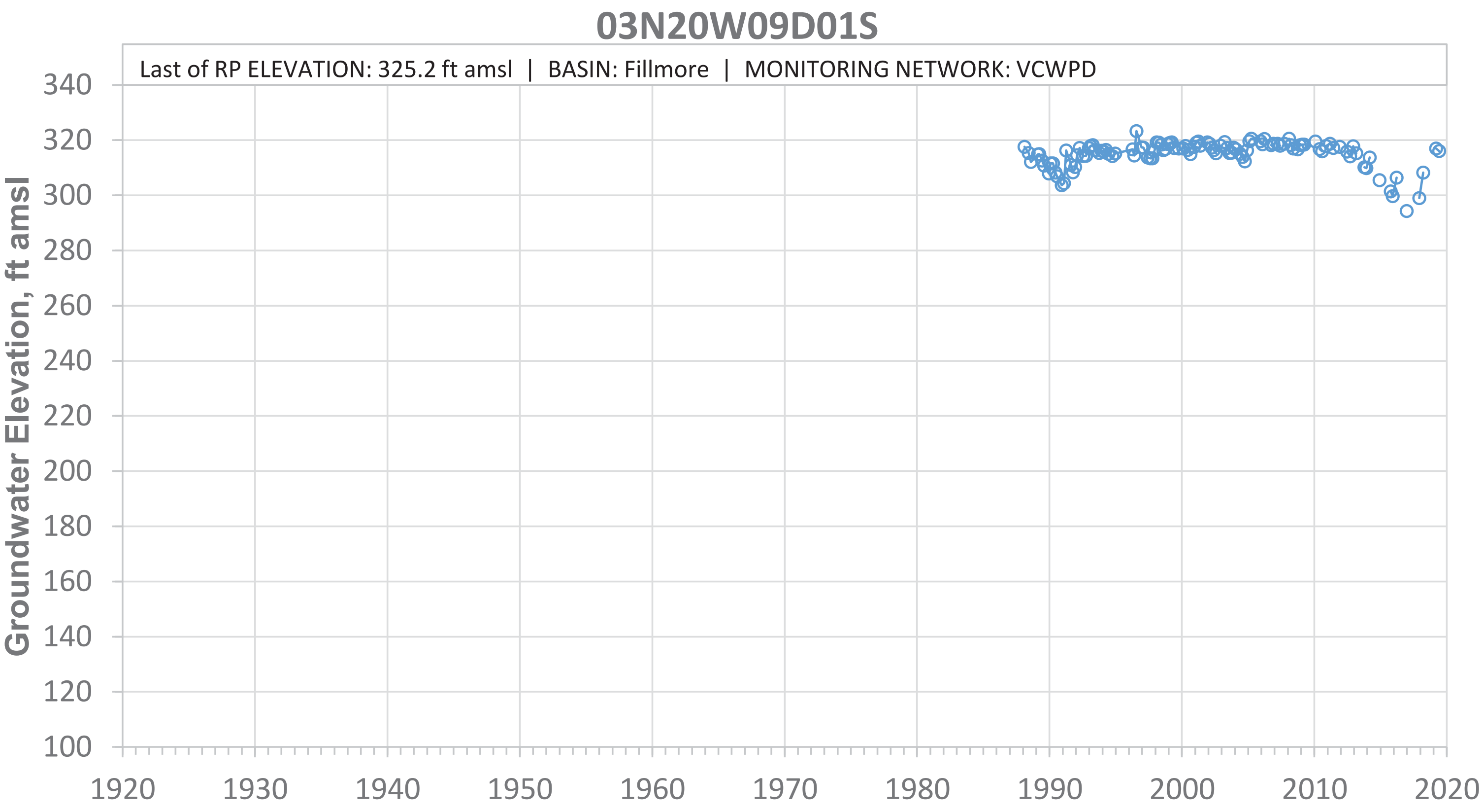

Last of RP ELEVATION: 323.46 ft amsl | BASIN: Fillmore | MONITORING NETWORK: UWCD

SCREEN: 1-12 ft bgs | CURRENT USE: Observation | STATUS: Unknown


03N20W09B03S

Last of RP ELEVATION: 331.91 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

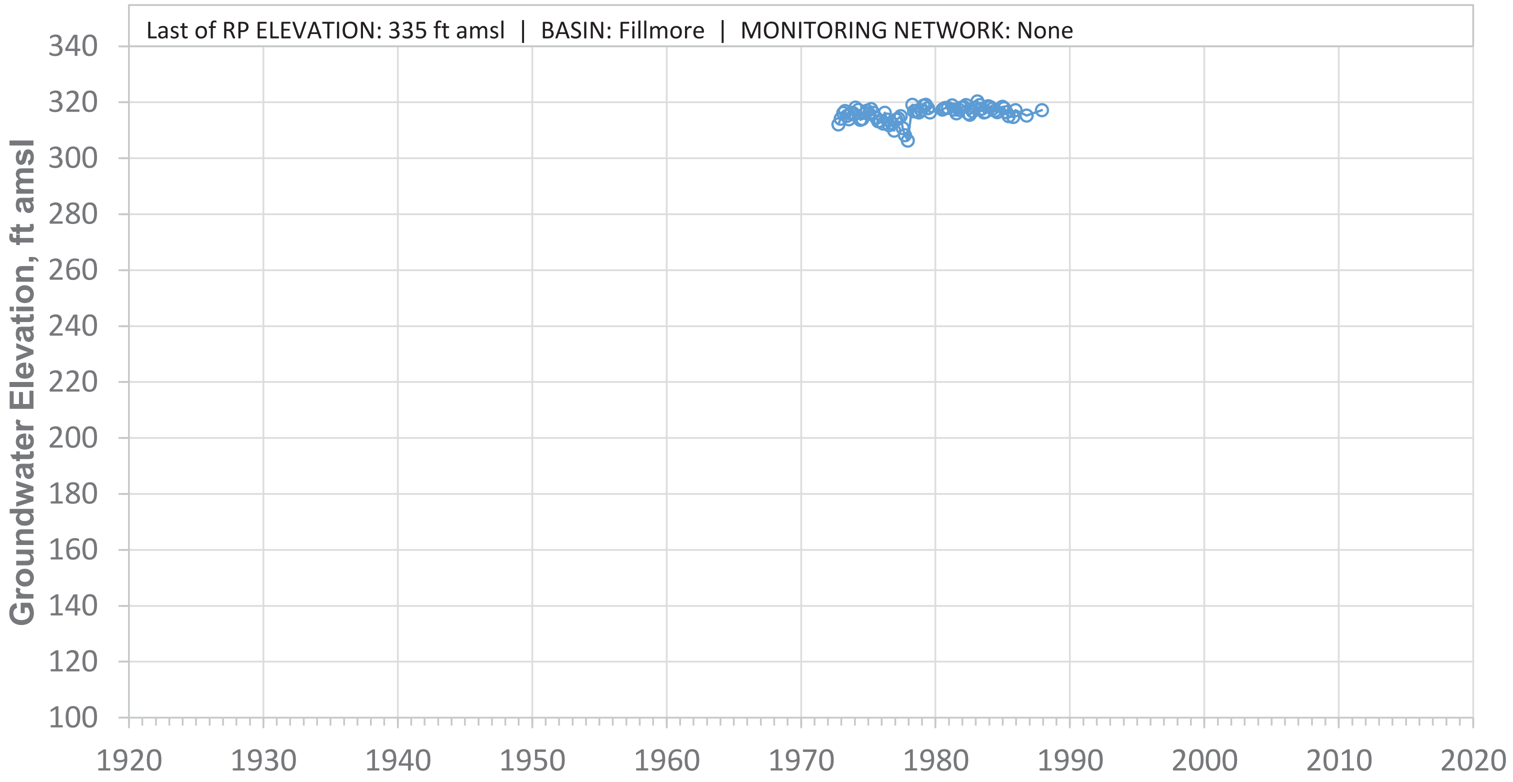
SCREEN: 80-140 ft bgs | CURRENT USE: Domestic | STATUS: Active


03N20W09D01S

Last of RP ELEVATION: 325.2 ft amsl | BASIN: Fillmore | MONITORING NETWORK: VCWPD

SCREEN: 210-310 ft bgs | CURRENT USE: Agricultural | STATUS: Active

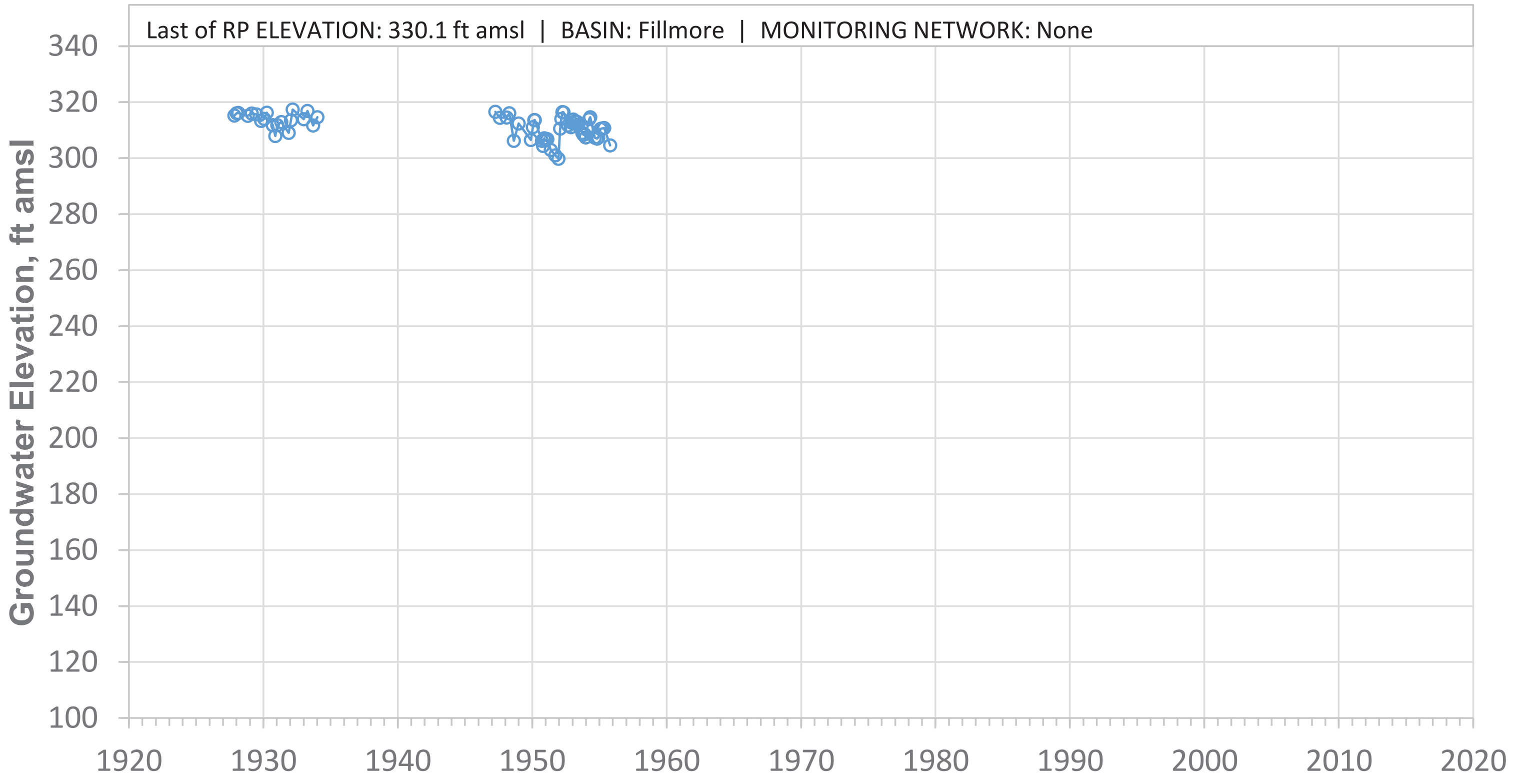
03N20W09F01S



Last of RP ELEVATION: 335 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

03N20W09G01S

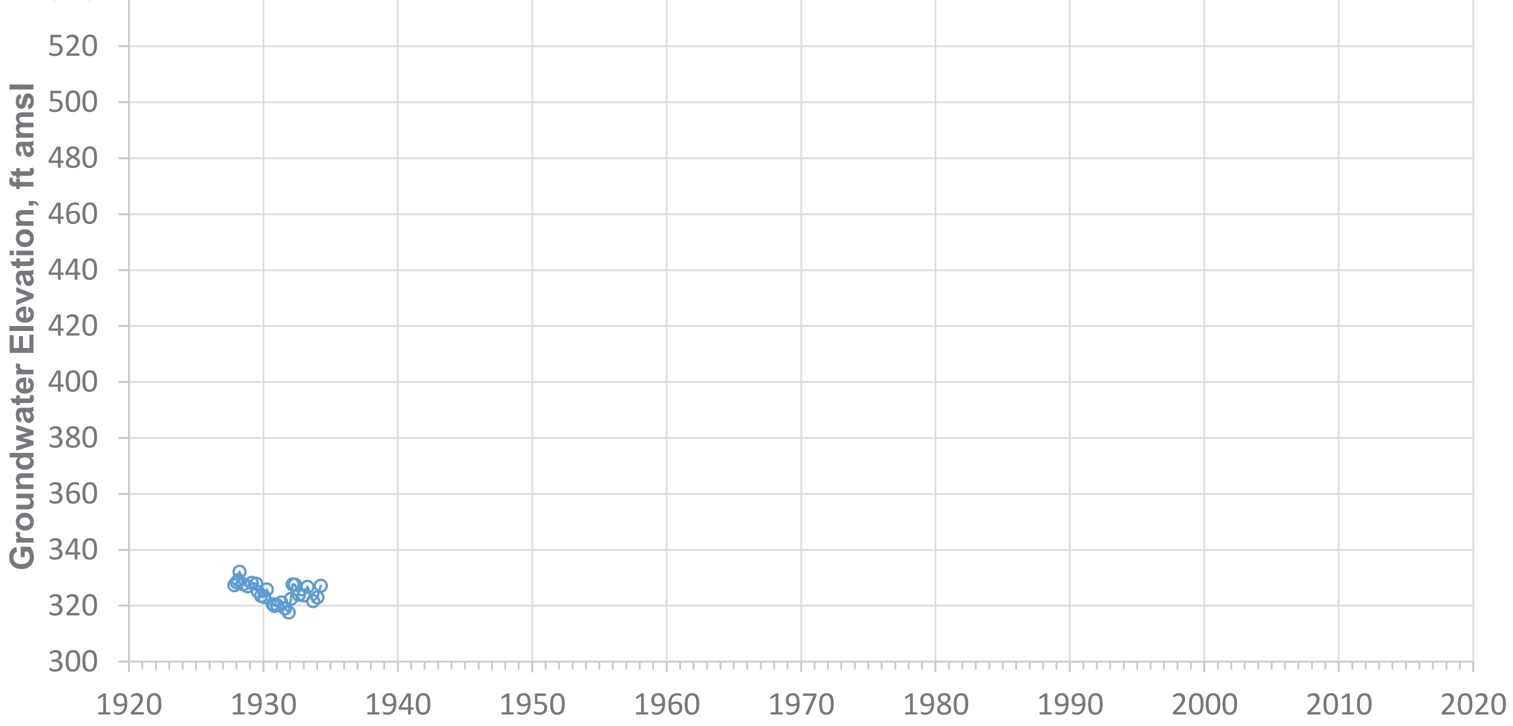


Last of RP ELEVATION: 330.1 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Can't Locate

03N20W10C01S

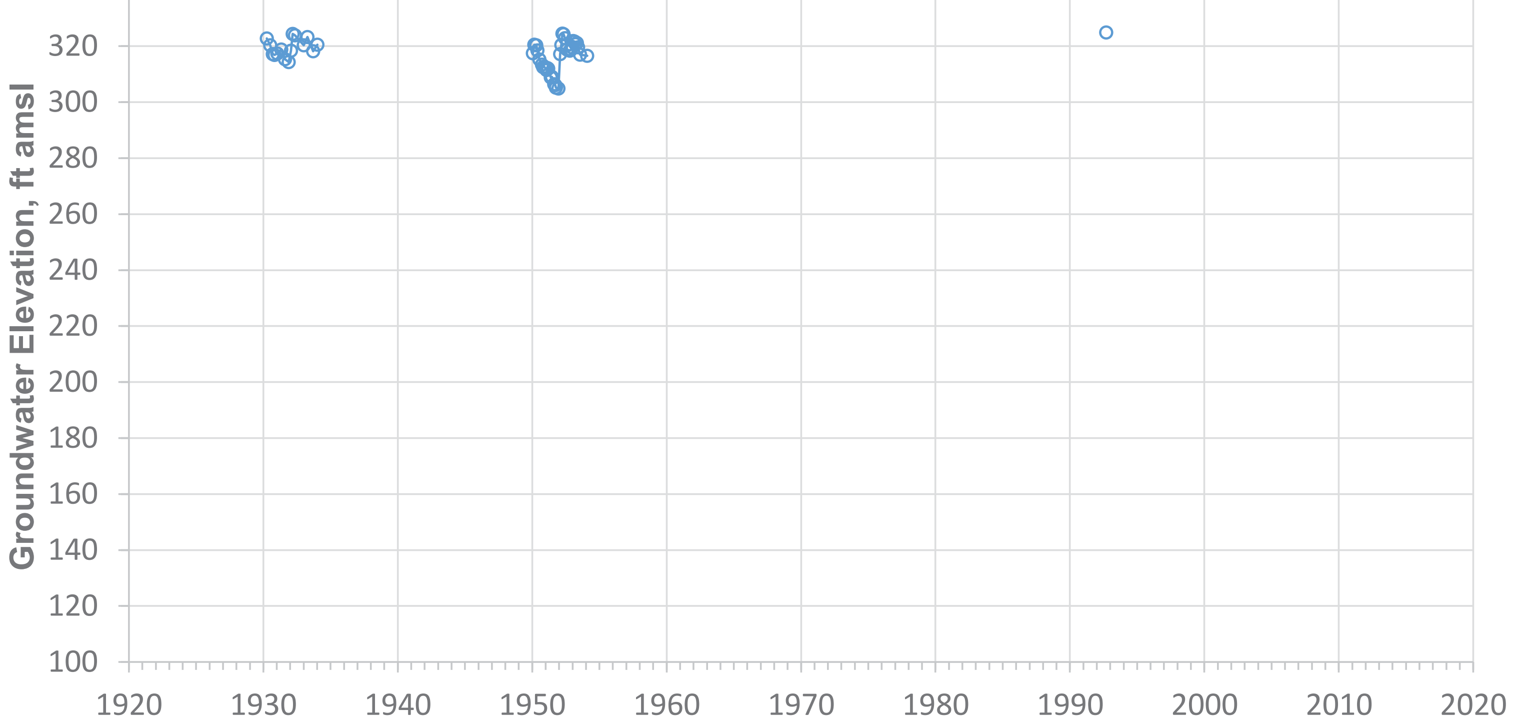
Last of RP ELEVATION: 332.9 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: Unknown ft bgs | CURRENT USE: Unknown | STATUS: Destroyed

03N20W10D02S

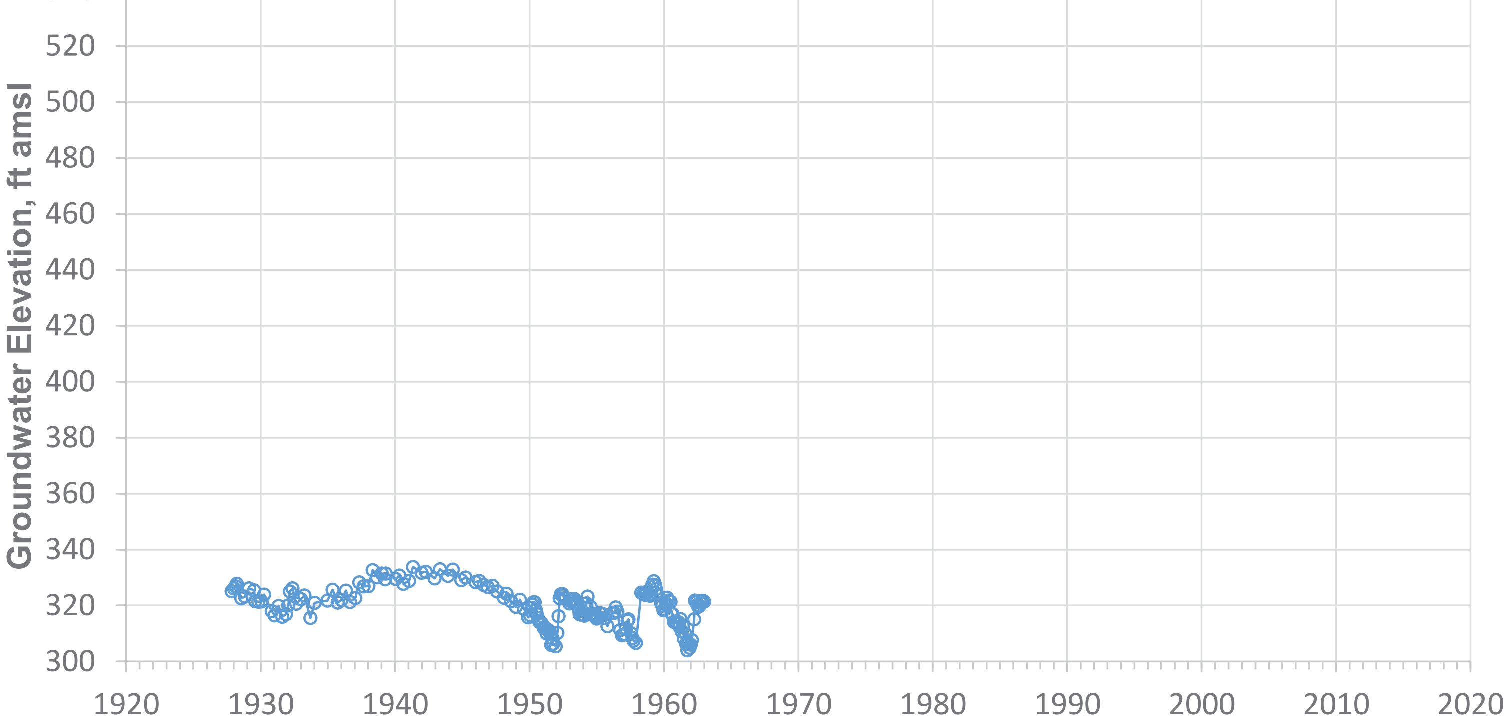
Last of RP ELEVATION: 336.3 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: 50-135 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W10F01S

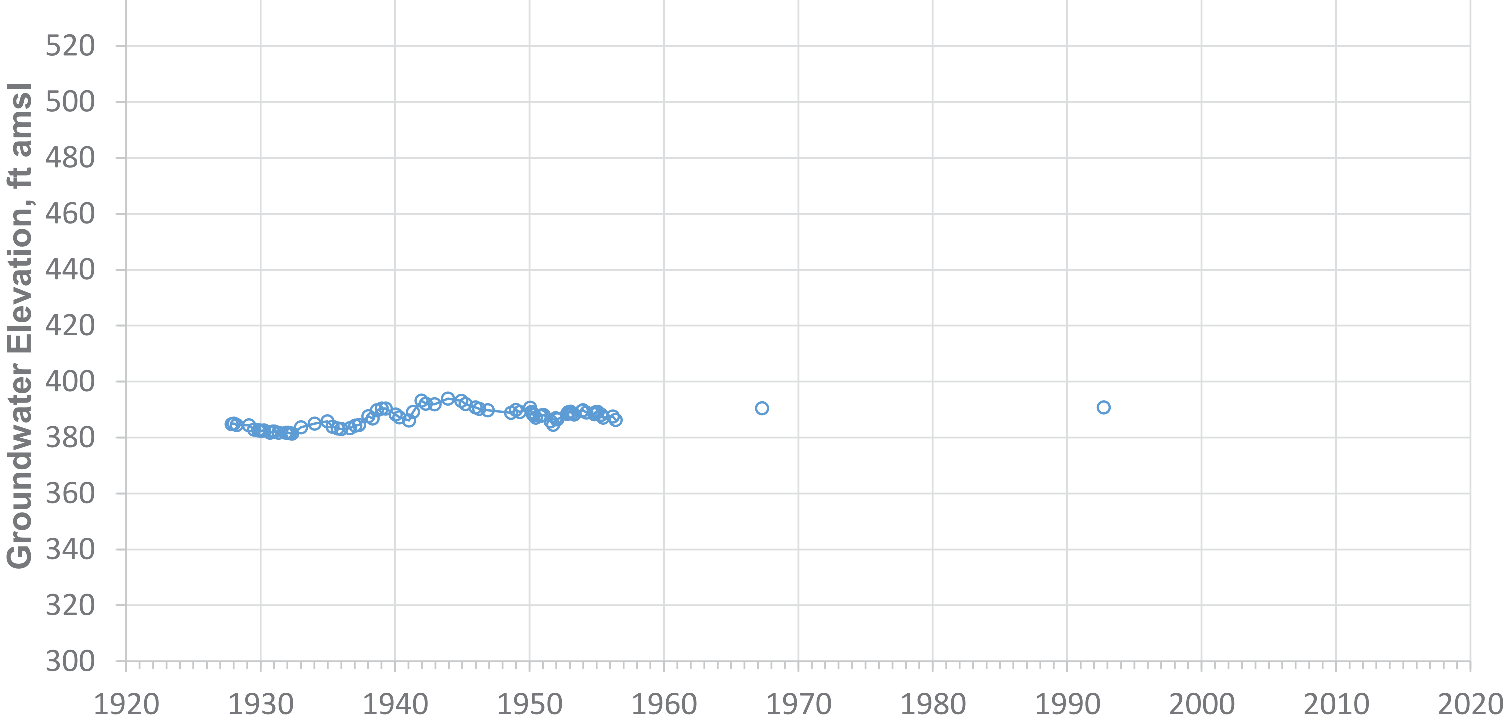
Last of RP ELEVATION: 343.8 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed

03N20W11A01S

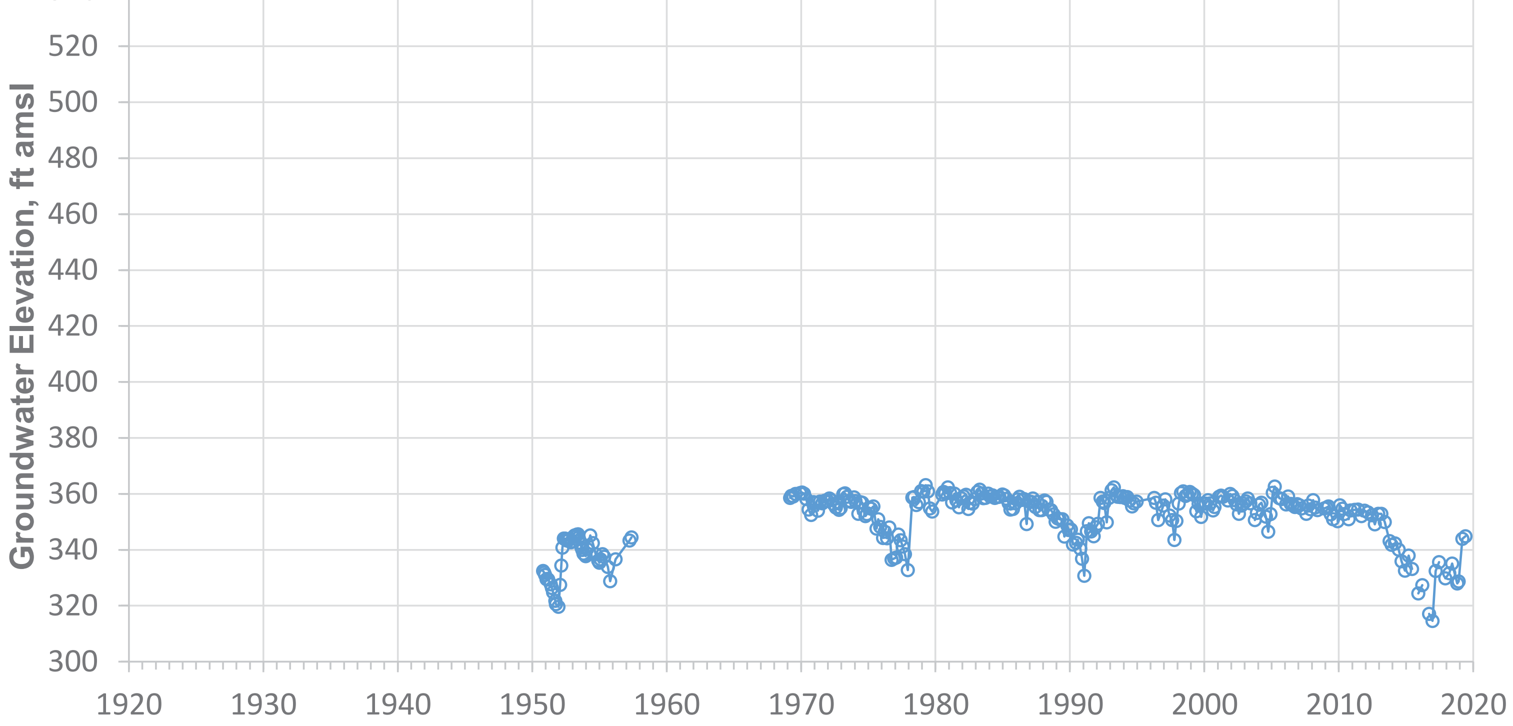
Last of RP ELEVATION: 424 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: 127-150 ft bgs | CURRENT USE: Domestic | STATUS: Active

03N20W11C01S

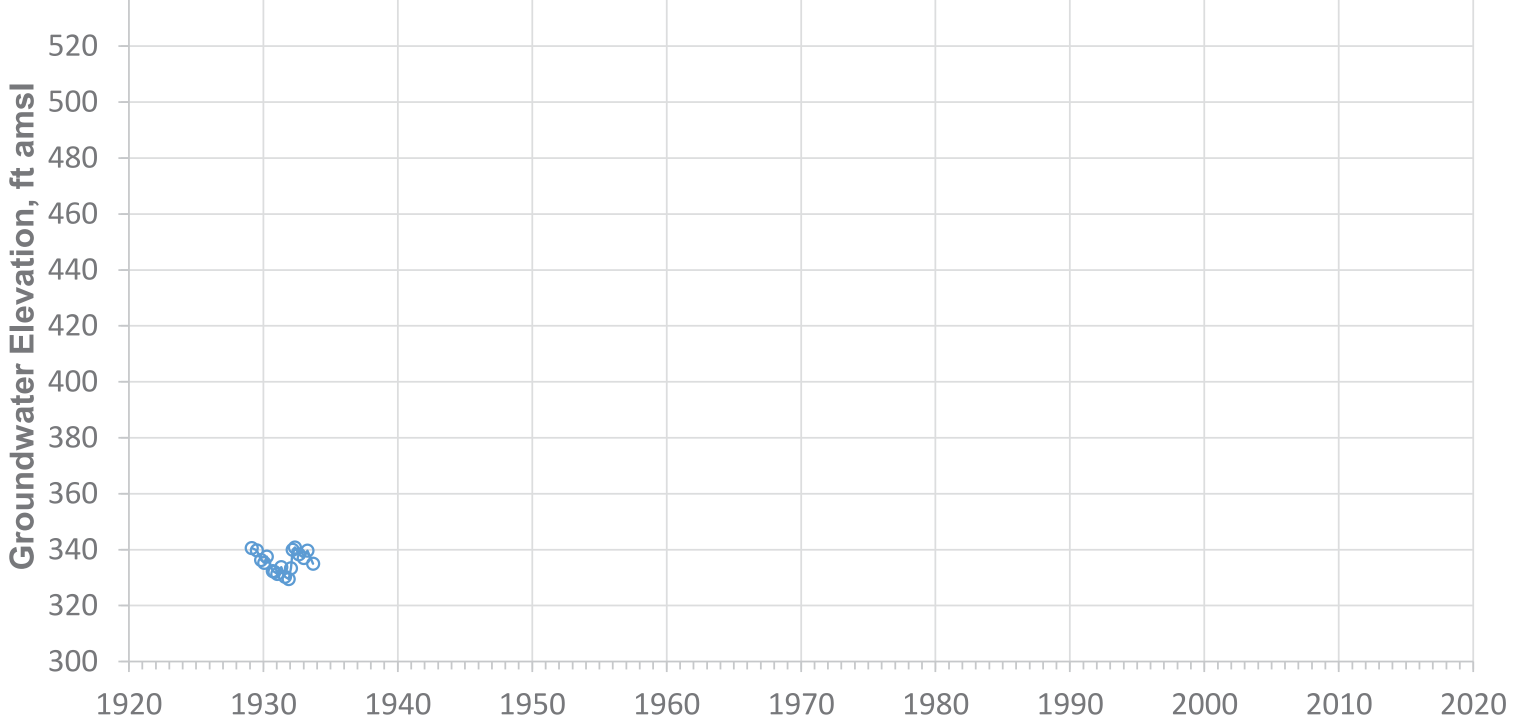
Last of RP ELEVATION: 397.11 ft amsl | BASIN: Fillmore | MONITORING NETWORK: VCWPD



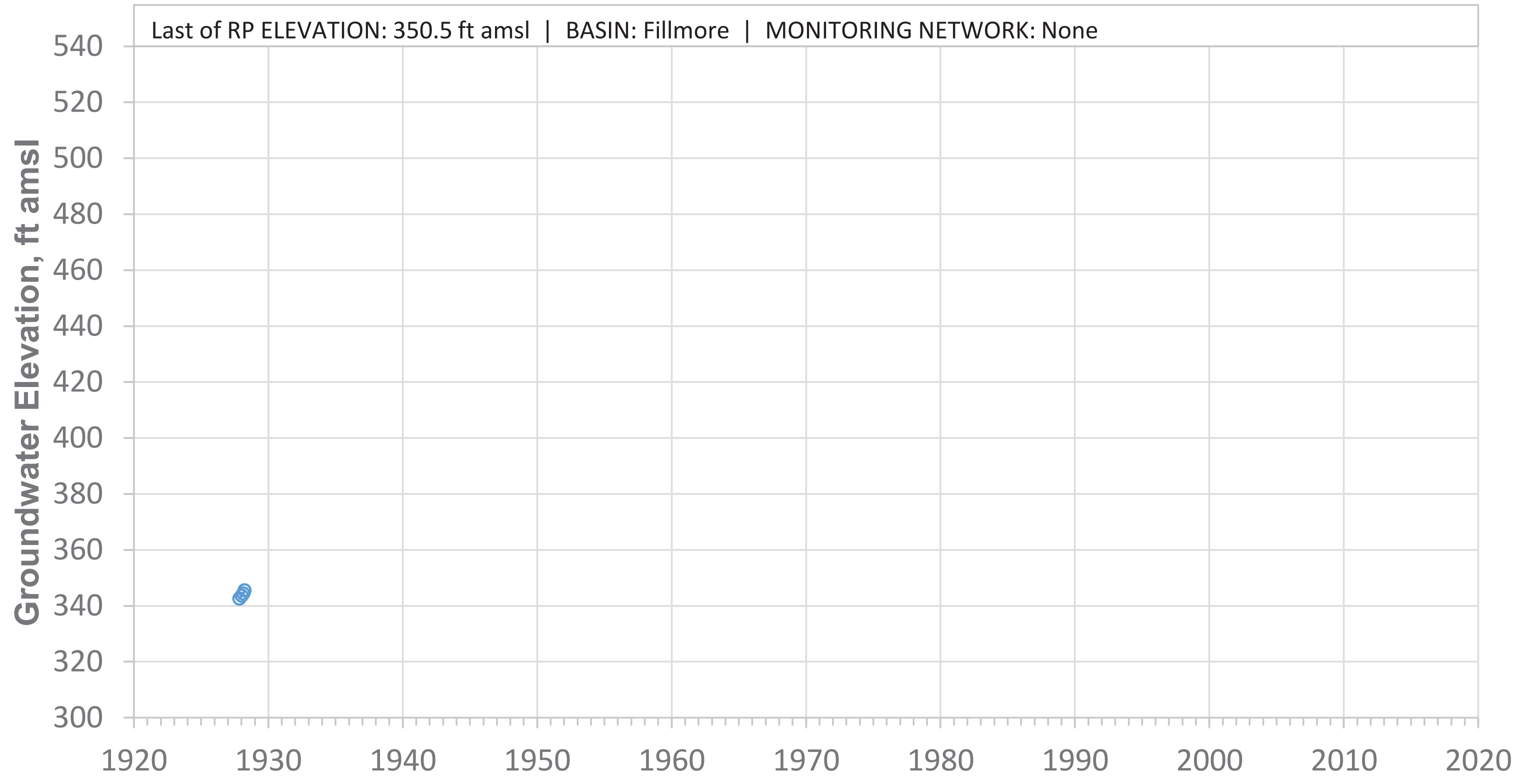
SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N20W11D02S

Last of RP ELEVATION: 367.3 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



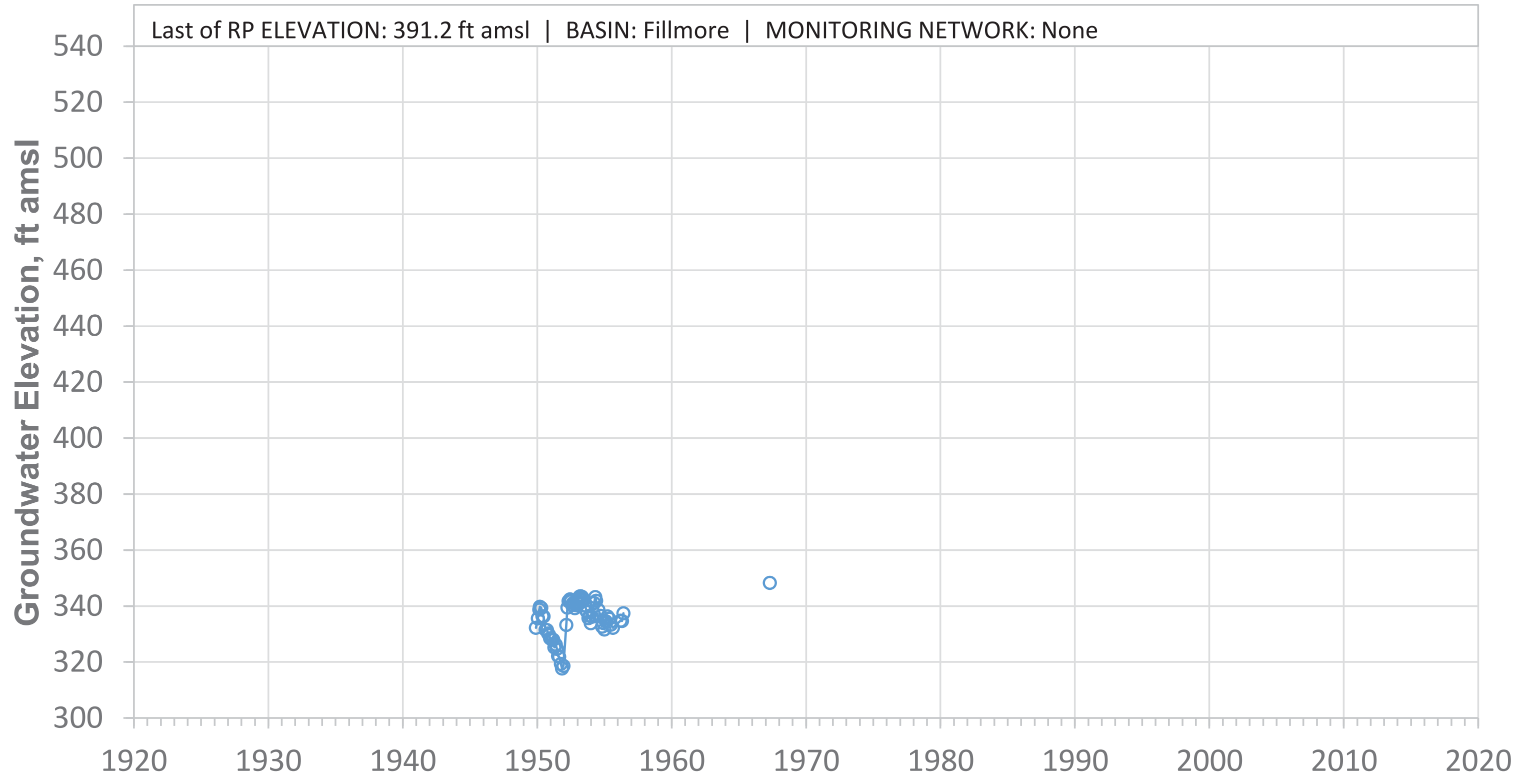
SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed



03N20W11D03S

Last of RP ELEVATION: 350.5 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed



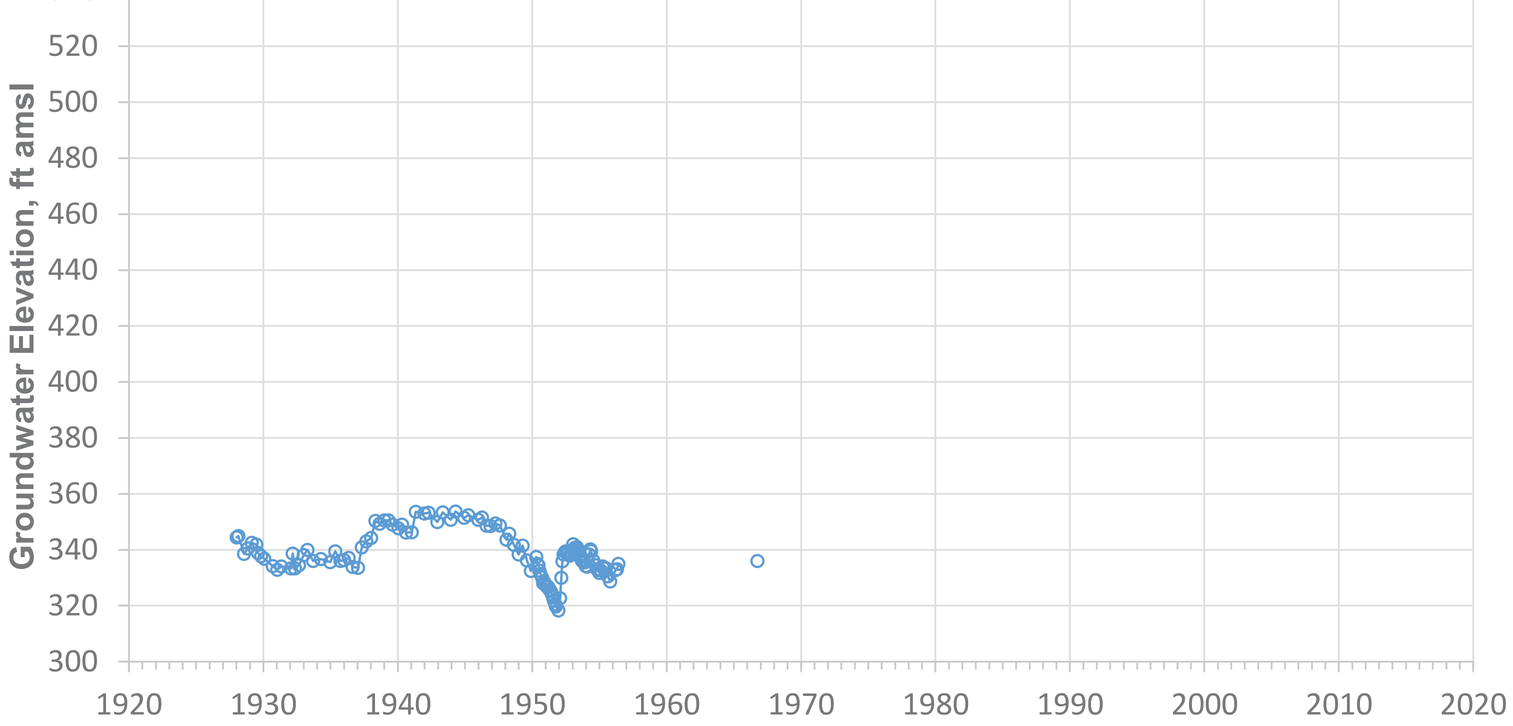
03N20W11D04S

Last of RP ELEVATION: 391.2 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Can't Locate

03N20W11D05S

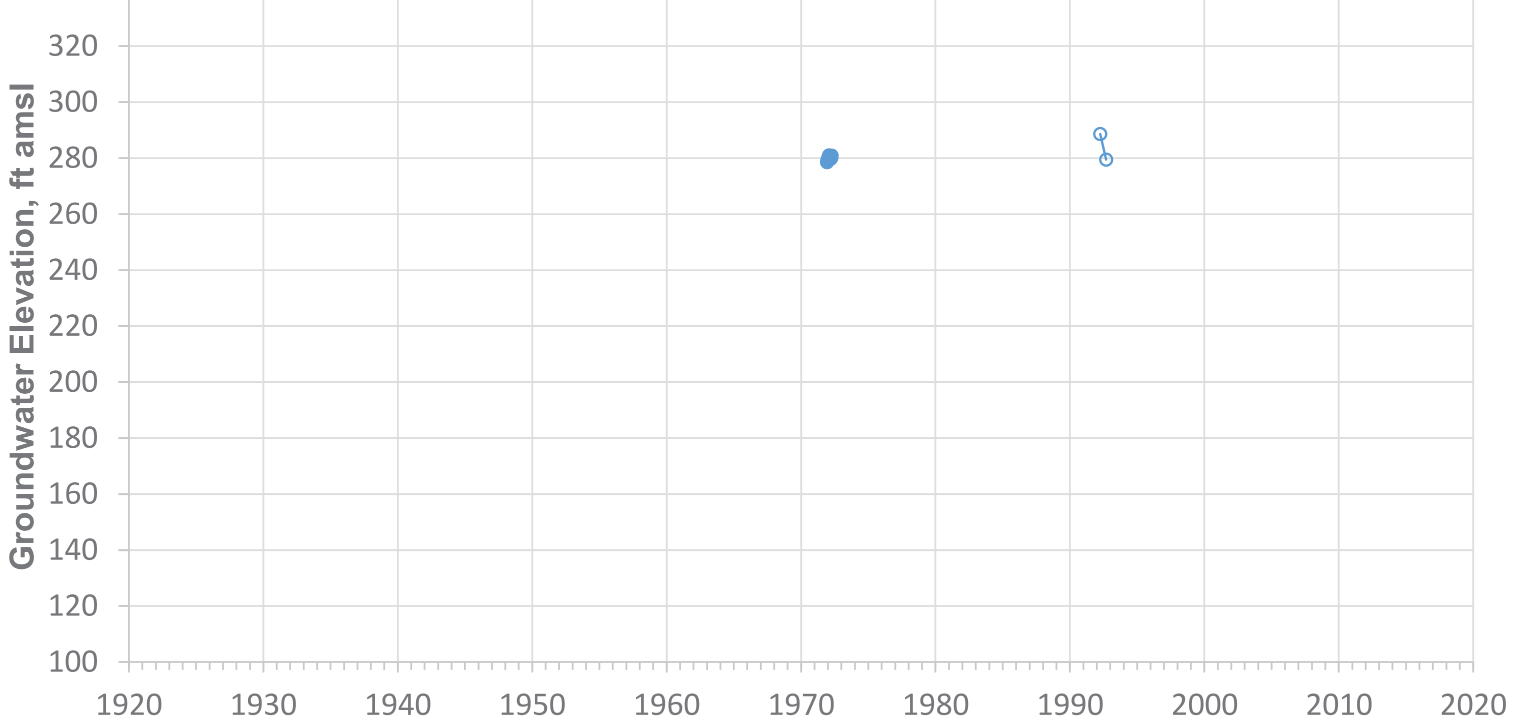
Last of RP ELEVATION: 390.5 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

03N21W01F01S

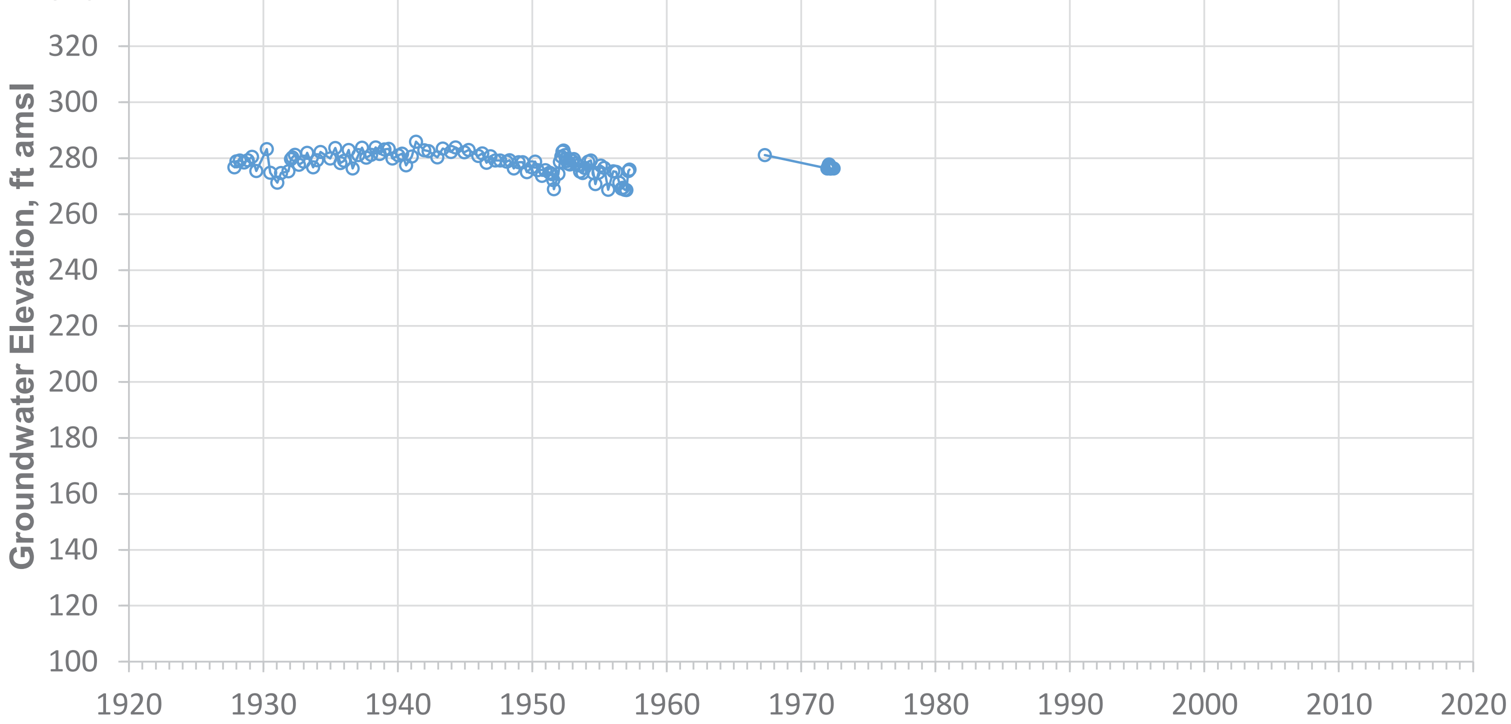
Last of RP ELEVATION: 384.8 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



SCREEN: 110-160 ft bgs | CURRENT USE: Domestic | STATUS: Active

03N21W01K01S

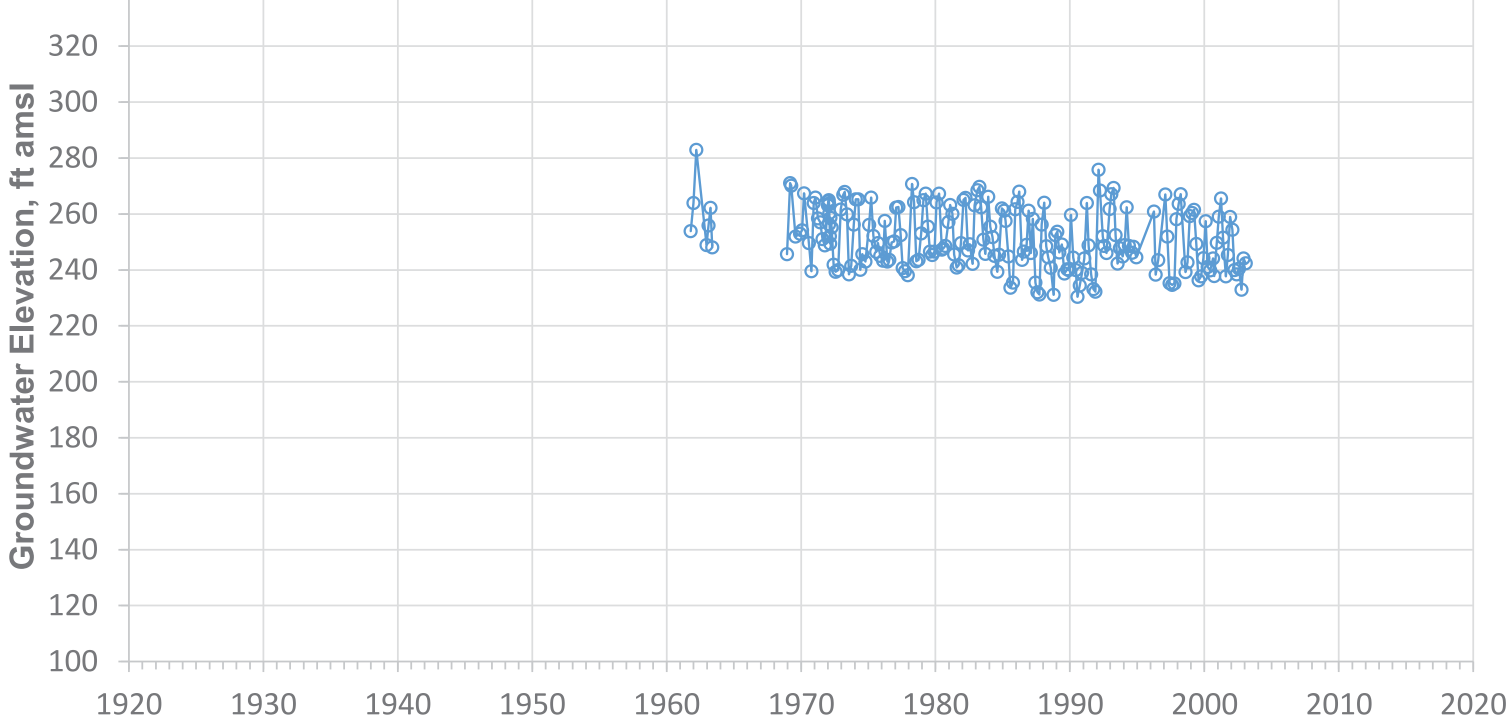
Last of RP ELEVATION: 316.7 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None



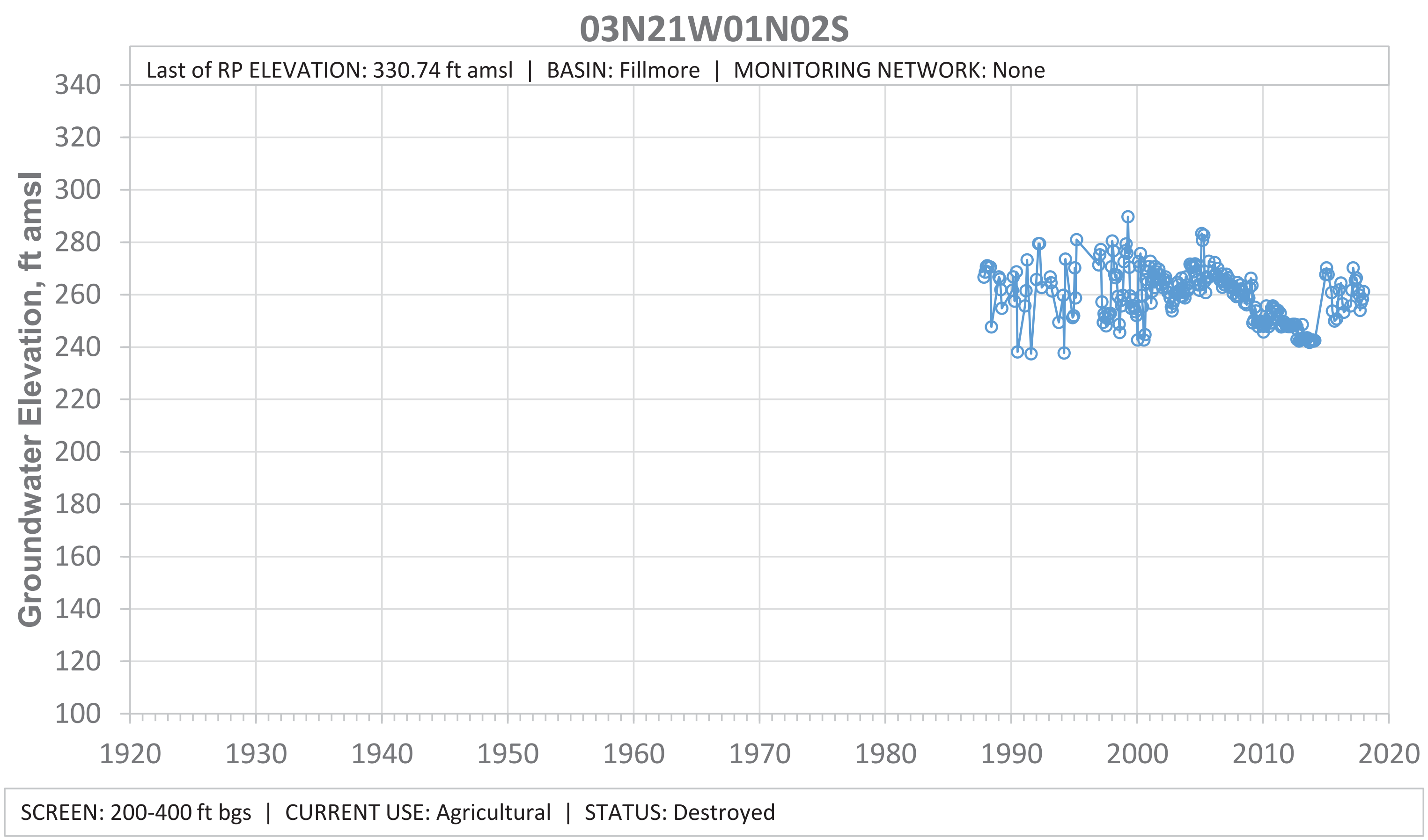
SCREEN: 52-106 ft bgs | CURRENT USE: Unknown | STATUS: Can't Locate

03N21W01N01S

Last of RP ELEVATION: 320.9 ft amsl | BASIN: Santa Paula | MONITORING NETWORK: None

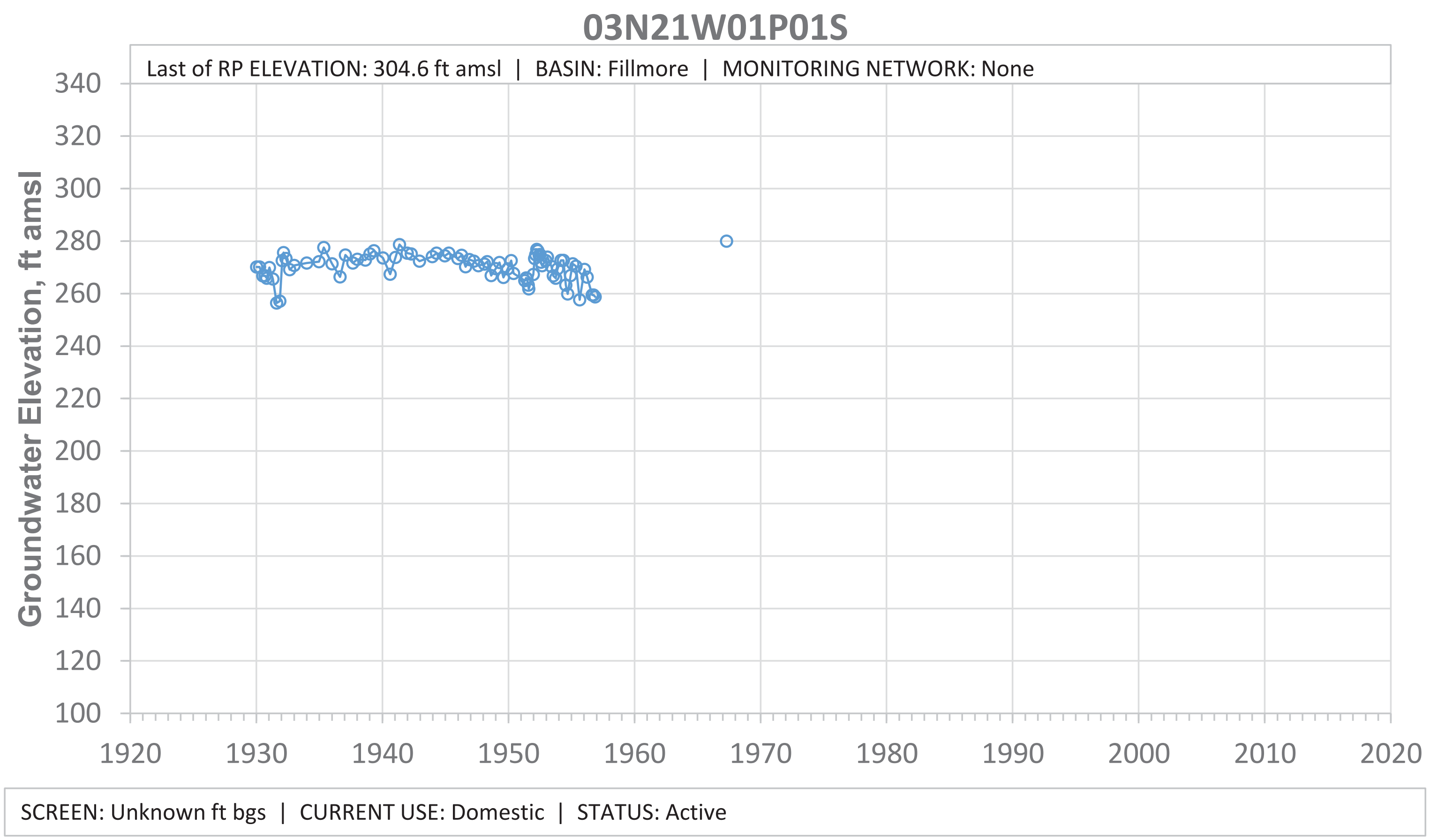


SCREEN: 303-366 ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed



Last of RP ELEVATION: 330.74 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

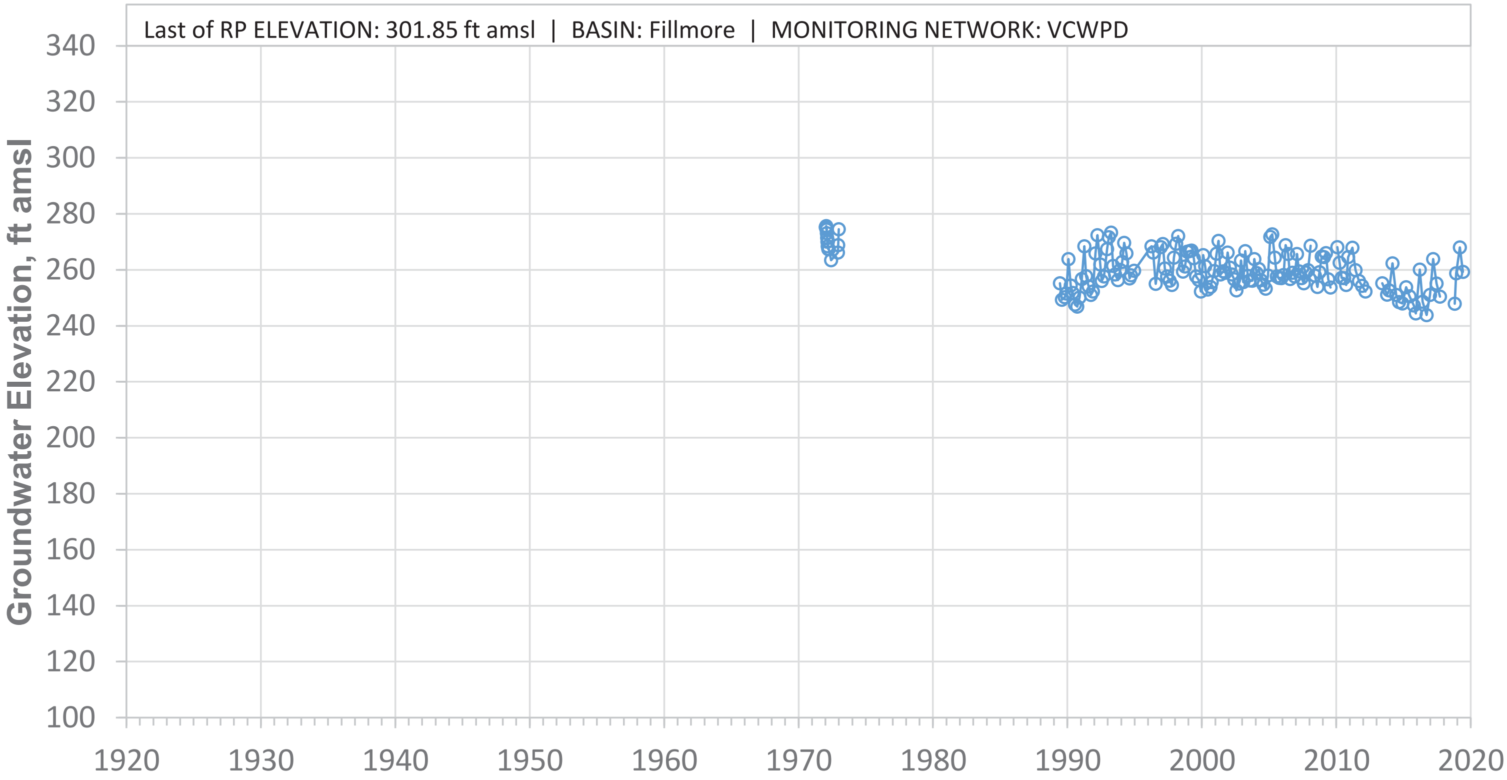
SCREEN: 200-400 ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed



Last of RP ELEVATION: 304.6 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Domestic | STATUS: Active

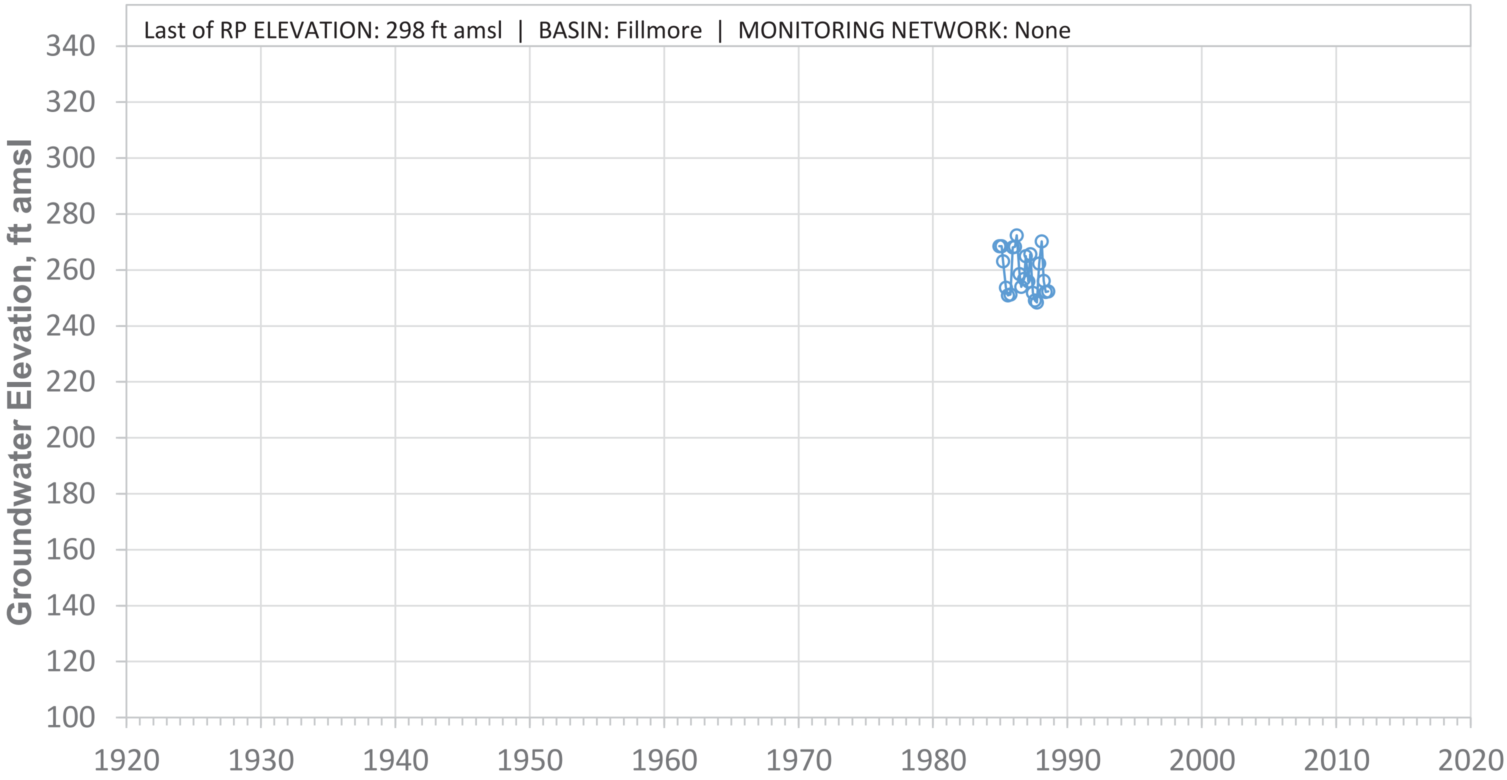
03N21W01P02S



Last of RP ELEVATION: 301.85 ft amsl | BASIN: Fillmore | MONITORING NETWORK: VCWPD

SCREEN: 75-104 ft bgs | CURRENT USE: Domestic | STATUS: Active

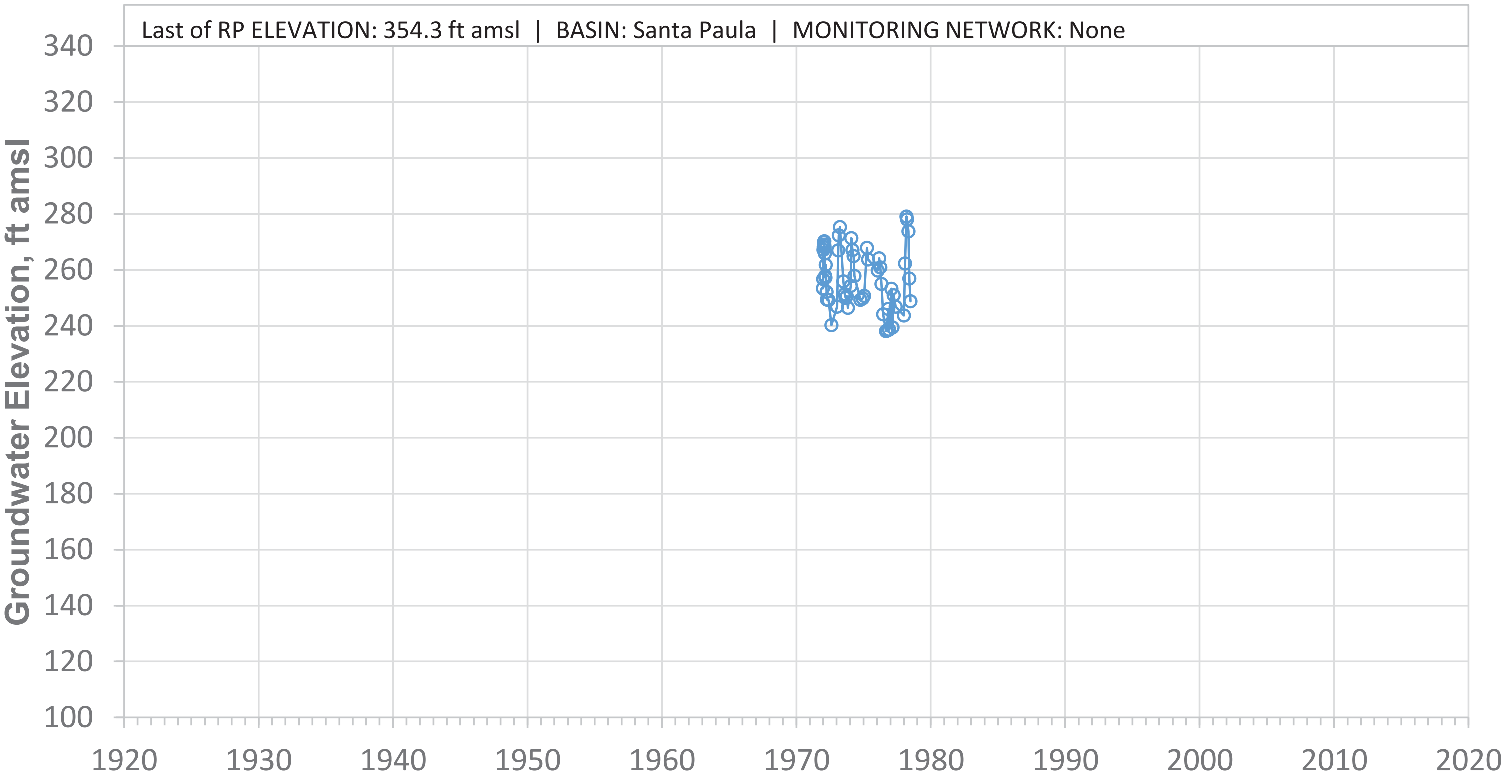
03N21W01P07S



Last of RP ELEVATION: 298 ft amsl | BASIN: Fillmore | MONITORING NETWORK: None

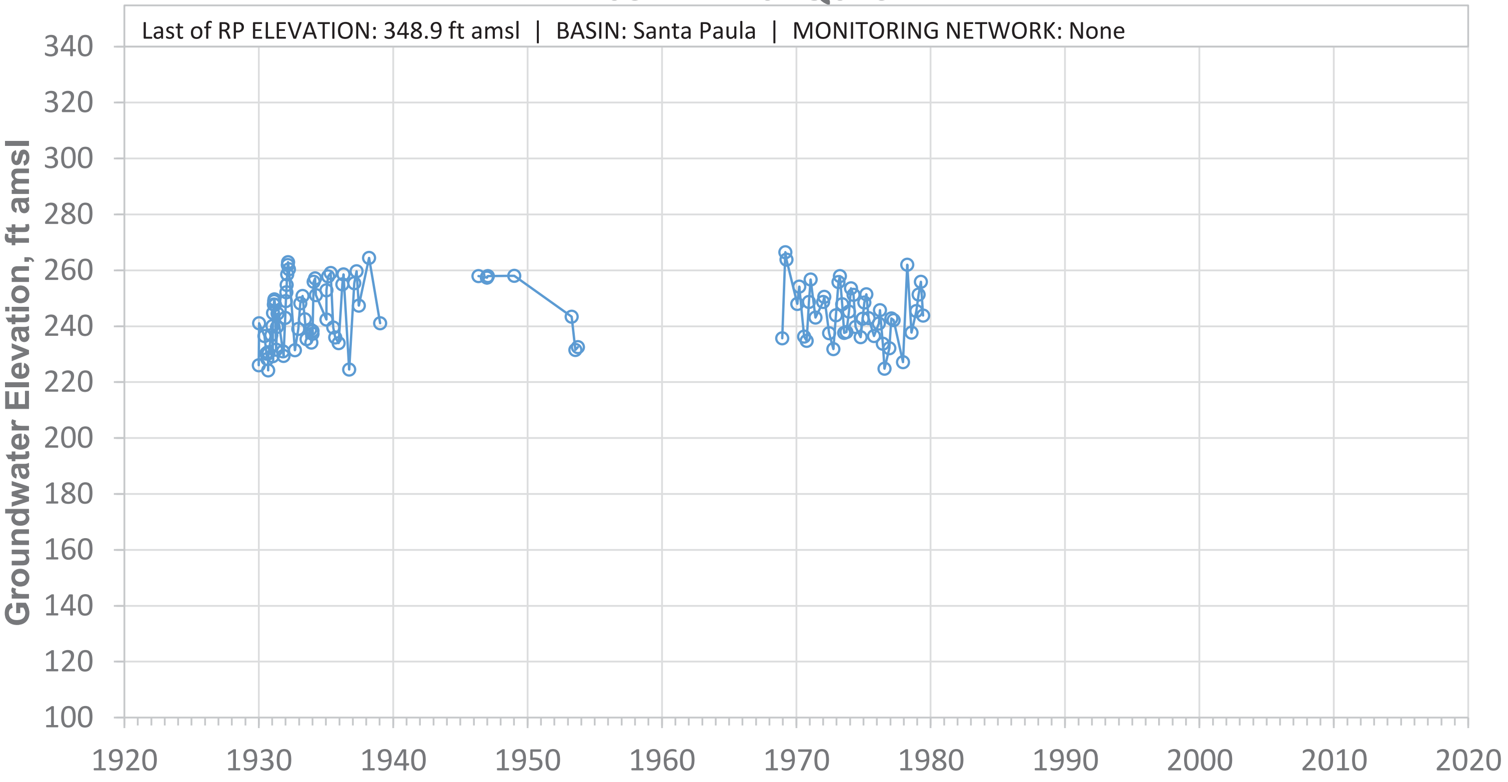
SCREEN: 220-260 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N21W02P01S


Last of RP ELEVATION: 354.3 ft amsl | BASIN: Santa Paula | MONITORING NETWORK: None

SCREEN: 220-466 ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed

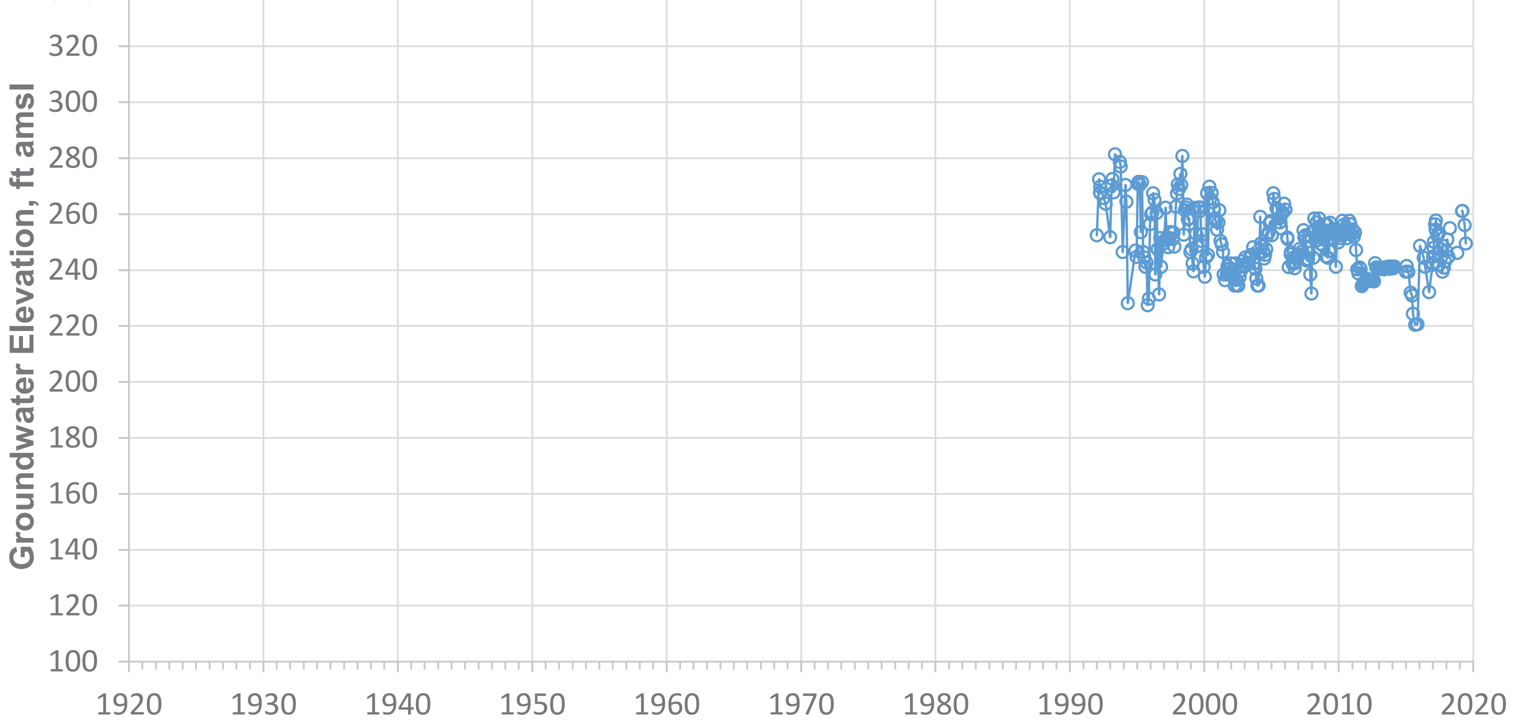
03N21W02Q01S


Last of RP ELEVATION: 348.9 ft amsl | BASIN: Santa Paula | MONITORING NETWORK: None

SCREEN: Unknown ft bgs | CURRENT USE: Agricultural | STATUS: Destroyed

03N21W02R02S

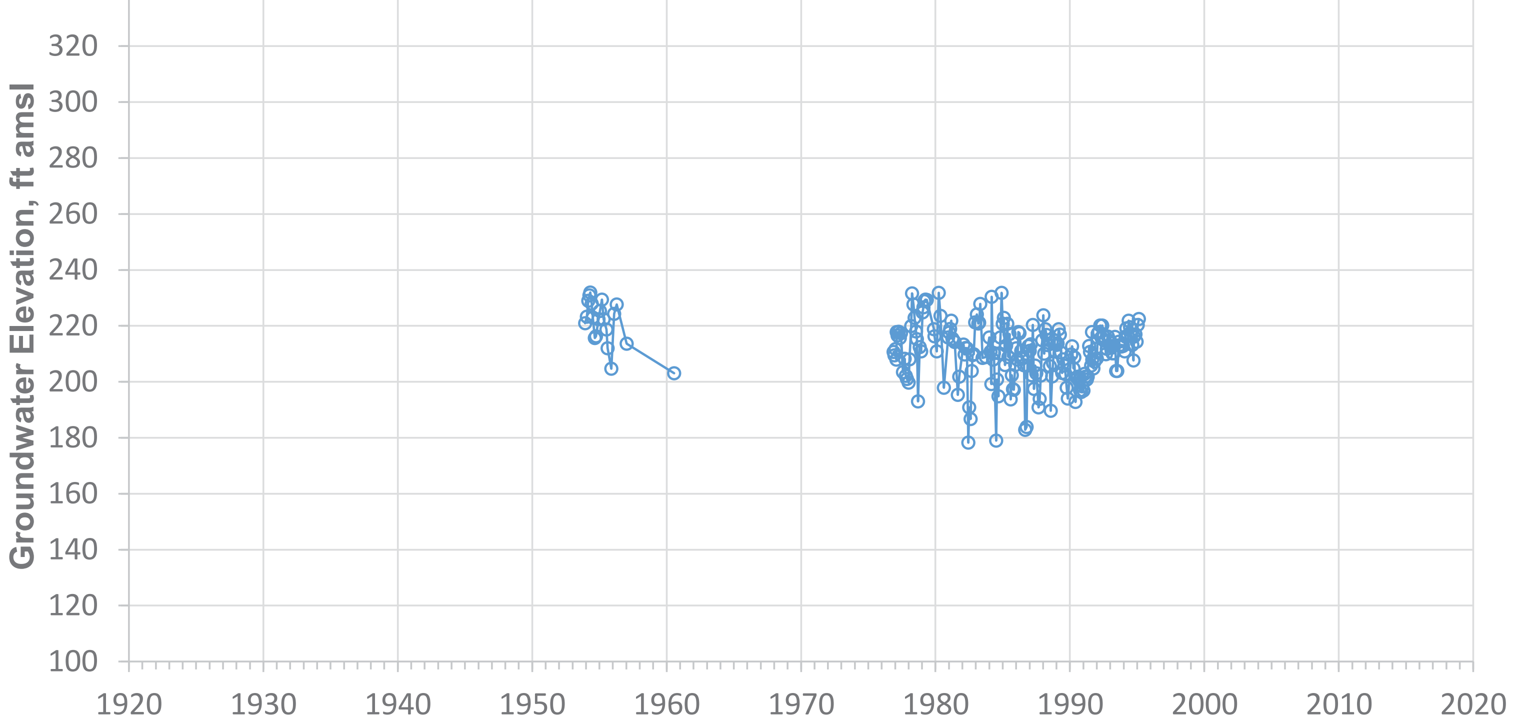
Last of RP ELEVATION: 322.72 ft amsl | BASIN: Santa Paula | MONITORING NETWORK: UWCD



SCREEN: 202-360 ft bgs | CURRENT USE: Agricultural | STATUS: Active

03N21W03R02S

Last of RP ELEVATION: 374.84 ft amsl | BASIN: Santa Paula | MONITORING NETWORK: None



SCREEN: 238-524 ft bgs | CURRENT USE: Municipal | STATUS: Destroyed