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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan Monitoring Networks Draft

Prepared by:

September 2018

Chapter 4 Monitoring Networks

This section of the Cuyama Basin Groundwater Sustainability Plan (GSP) discusses the planned monitoring networks needed to guide the GSP's path to sustainability. Monitoring networks need to be established for each sustainability indicator either directly or through monitoring through a proxy. This section was prepared to meet the requirements of DWR's GSP regulations. This section discusses the objectives of the monitoring networks, existing monitoring networks used in the development of each network, and establishes a monitoring network for each sustainability indicator. Data gaps and a plan to fill data gaps if they are present are provided for each monitoring network.

This section does not include information about basin settings, undesirable results, sustainability thresholds, water budget information, or projects and management actions.

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Acronyms

ACWI	Advisory Committee on Water Information
AFY	Acre feet per year
ARS	Agricultural Research Service
Basin	Cuyama Valley Groundwater Basin
BMP	Best Management Practices
CA	California
CASGEM	California Statewide Groundwater Elevation Monitoring
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CBWD	Cuyama Basin Water District
CCSD	Cuyama Community Services District
CEDEN	California Environmental Data Exchange Network
CGPS	CGPS
DWR	California Department of Water Resources
EPA	Environmental Protection Agency
GAMA	Groundwater Ambient Monitoring and Assessment
GICIMA	Groundwater Information Center Interactive Map
GSA	Groundwater Sustainability Agency
IRLP	Irrigated Lands Program
MSC	Master Site Code
msl	mean sea level
NWIS	National Water Information System
NGWMN	National Ground-Water Monitoring Network
NWQMC	National Water Quality Monitoring Council
SBCWA	Santa Barbara County Water Agency
SLOCFC&WCD	San Luis Obispo County Flood Control & Water Conservation District
SWN	State Well Number
TSS	Technical Services Support
USGS	United States Geological Survey
VCWPD	Ventura County Water Protection District

WDL	Water Data Library

4.1 Useful Terms

The monitoring networks section includes descriptions of groundwater wells, water quality measurements, subsidence stations, and other related components. A list of technical terms and a description of the terms are listed below. Figure 4-1 shows a diagram of a monitoring well with well related terms identified on the diagram. The terms and their descriptions are identified here to guide readers through the section and are not a definitive definition of each term:

- Well related terms:
  - **Ground Surface Elevation –** The elevation in feet above mean sea level (msl) at the well's location.
  - **Total Well Depth** – The depth that a well is installed to. This is often deeper than the bottom of the screened interval.
  - **Screened interval** – The portion of a well casing that is screened to allow water from the surrounding soil into the well pipe. There can be several screened intervals within the same well. Screened interval is usually reported in feet below ground surface elevation for both the upper most limit and lower most limit of the screen.
  - **Top Perforation –** The distance to the top of the perforation from the ground surface elevation.
  - **Bottom Perforation –** The distance to the bottom of the perforation from the ground surface elevation.
  - **Water Surface Elevation –** The elevation above mean sea level (msl) that water is encountered inside the well
  - **Depth to Water –** The distance from the ground surface or the well' to where water is encountered inside the well
- **Historical high groundwater elevations** – This is the highest measurement of groundwater elevation (closest to the ground surface) in a monitoring well that was recorded. Measurements of groundwater elevation are used to indicate the elevation of groundwater levels in the area near the monitored well.
- **Historical low groundwater elevations** – This is the lowest measurement of groundwater elevation (furthest from the ground surface) in a monitoring well that was recorded. Measurements of groundwater elevation are used to indicate the elevation of groundwater levels in the area near the monitored well.
- **Depth to Groundwater –** This is the distance from the ground surface to groundwater, typically reported at a well.
- **Hydrograph –** A hydrograph is a graph that shows the changes in groundwater elevation over time for each monitoring well. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater is rising or descending over time.

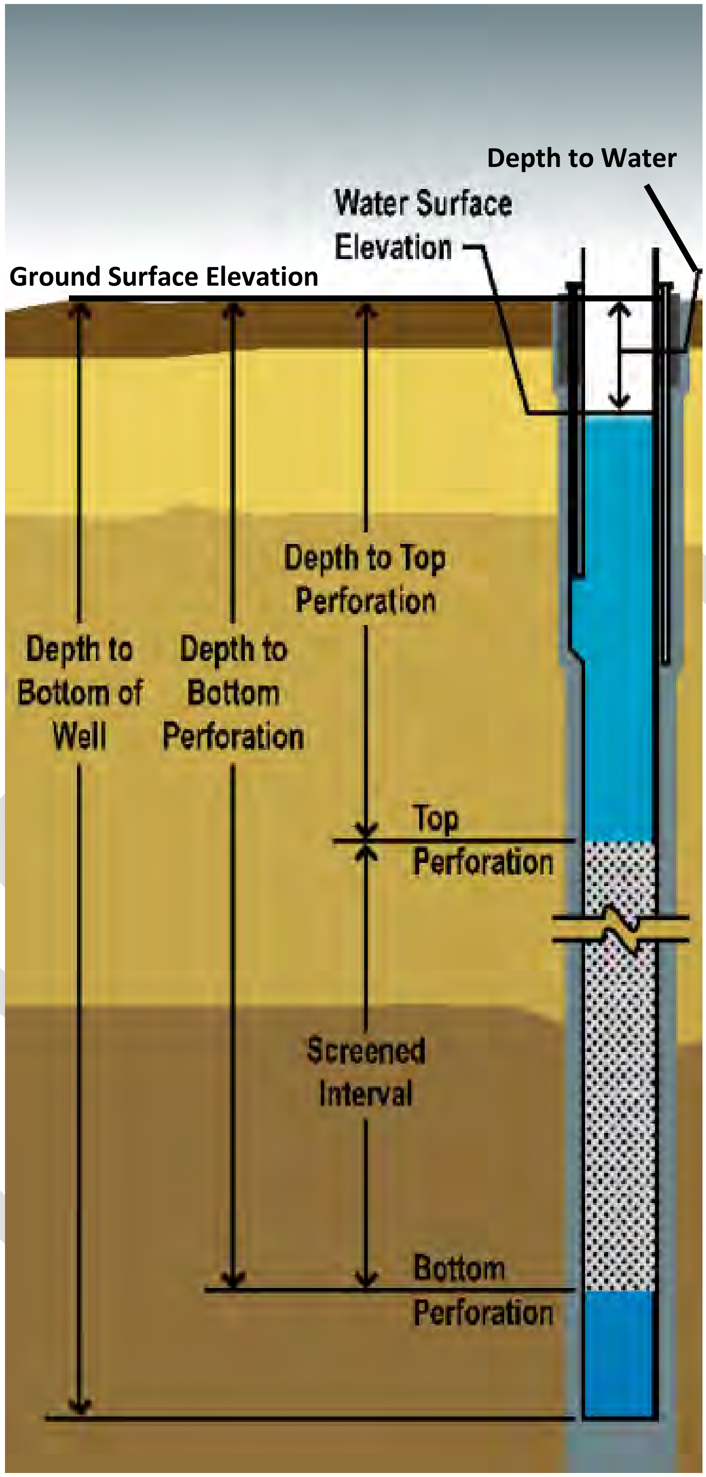

Figure 4-1: Well Completion Diagram

- **Constituent** – Refers to a water quality parameter measured to assess groundwater quality.
- **Subsidence** (refer to appendix Z which was included with Groundwater Conditions) – Refers to the sinking or downward settling of the earth's surface, not restricted in rate, magnitude, or area involved, and is often the result of over-extraction of subsurface water.
- **Best Management Practice** – Refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science (California (CA) Code of Regulations, Title 23, Article 2).
- **Data Gap** – Refers to 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 sustainable managed (CA Code of Regulations, Title 23, Article 2).
- **Representative Monitoring** – Refers to a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin (CA Code of Regulations, Title 23, Article 2).

4.2 Monitoring Network Objectives

This section describes the Cuyama Valley Groundwater Basin (Basin) Monitoring Networks for the five sustainability indicators that apply to the Basin. The objective of these monitoring networks is to detect undesirable results in the basin as described in Section 3 of this Groundwater Sustainability Plan (GSP) using the sustainability thresholds described in Section 5 of this GSP. Other, related objectives of the monitoring network were defined by the GSP regulations promulgated by the Department of Water Resources (DWR):

- Demonstrate progress toward achieving measurable objectives described in the Plan
- Monitor impacts to the beneficial uses or users of groundwater
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Quantify annual changes in water budget components

The monitoring network plan provided to the Basin is intended to monitor:

- Chronic lowering of groundwater levels
- Reduction in groundwater storage
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

The monitoring networks described in this section were designed by evaluating data provided by DWR, USGS, participating counties, and private landowners. Wells currently used for such activity are included and considered based on criteria further described below.

4.2.1 Basin Conditions Relevant to Measurement Density and Frequency

This section summarizes key basin conditions that influence the development of monitoring networks. The key conditions include hydrogeologic considerations, land use considerations, and historical groundwater conditions considerations.

The Basin, as described in the Section 2.1, is composed of one principal aquifer comprised of three geologic groups: Younger Alluvium, Older Alluvium, and Morales Formation. The majority of groundwater in the aquifer is stored in the younger and older alluvium. There are no major stratigraphic aquitards or barriers to groundwater movement amongst the alluvium and Morales Formation. The aquifer ranges from 10's to 100's of feet thick, with median reported hydraulic conductivity ranges from 1.22 – 72.1 ft/day (see Table 2.1-1 for detailed values). Figure 2.1-2 shows the extent of these formations throughout the basin.

The largest groundwater use within the Basin is for agriculture and irrigation. Figures 1-6 through 1-13 show the extent of land used for irrigated agriculture within the Basin. Based on the most recent data from 2016, approximately 53 square miles of agriculture overlies approximately 378 square miles of the Basin totaling roughly 14%.

Data provided in Section 2.2 shows the historical declining trend of groundwater levels within the central portion of the basin. Generally, groundwater elevations in this portion of the basin have been decreasing from the 1940s and 1950s to the present, as shown in Figure 4-2.

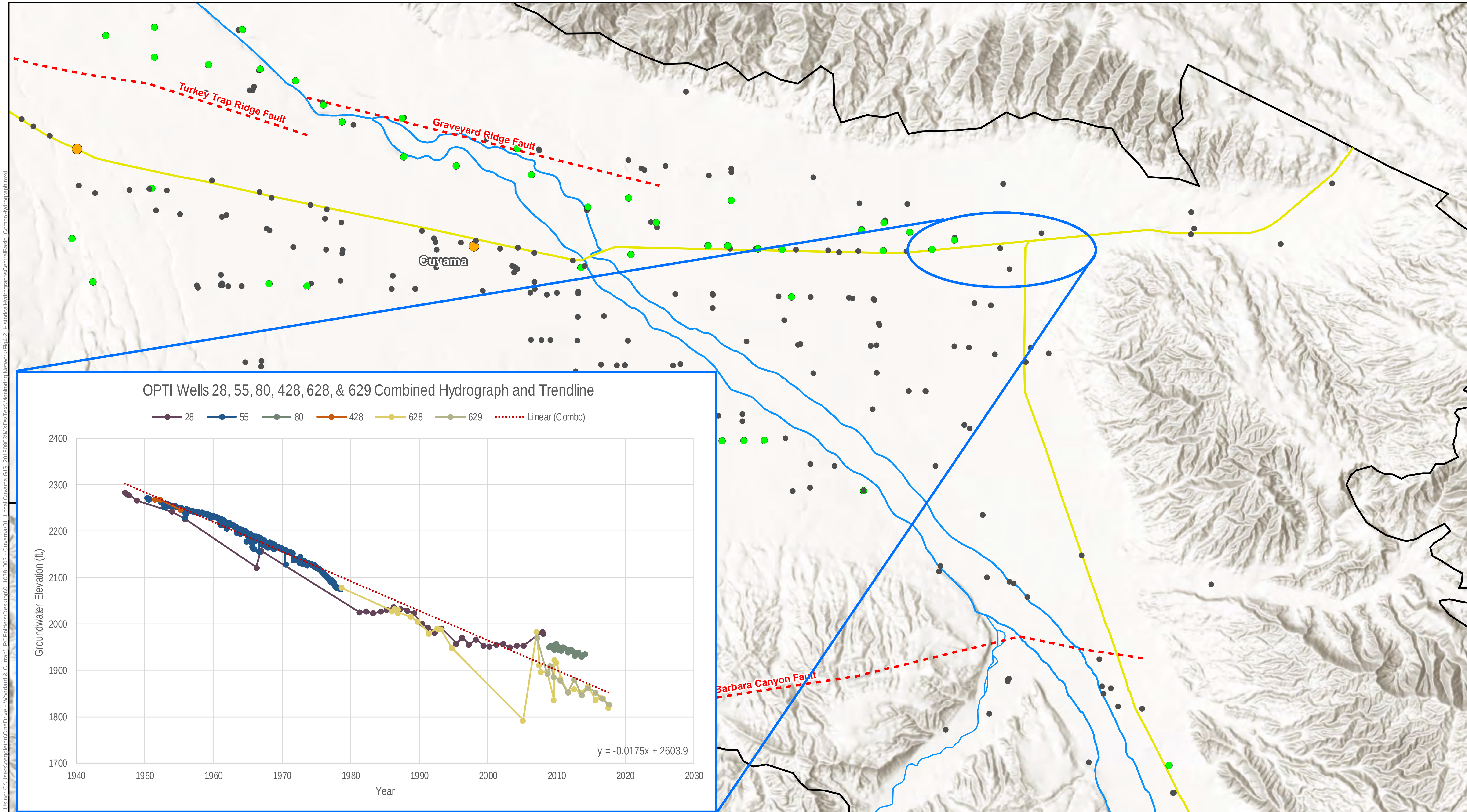

Figure 4-2: Cuyama GW Basin Central Basin with Combined Hydrograph

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Currently Monitored Wells
- Not Currently Monitored

N

0 0.5 1 2 Miles

4.3 Existing Monitoring Used

This section discusses current groundwater level monitoring with the Basin.

4.3.1 Groundwater Level Monitoring

This section describes the groundwater level monitoring that has been conducted by agencies and private land owners in the Basin.

Department of Water Resources, Statewide Dataset / CASGEM

The State of California has several water-related database portals accessible online. These include, but are not limited to, the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, Water Data Library (WDL), and the Groundwater Information Center Interactive Map Application (GICIMA). The data for these portals is organized and saved in one master database, where each portal accesses and displays the intended data dependent on the search criteria and portal being used.

In an attempt to include all available data related to the Basin, DWR was contacted directly and provided a link to Groundwater Sustainability Agency (GSA) representatives to download the entire State's database. Cuyama data was then extracted from this dataset.

Although the master dataset was used to collect the initial data, the CASGEM portal was utilized throughout the planning process to verify data (DWR CASGEM Online System, 2018). CASGEM is tasked with tracking seasonal and long-term groundwater elevation trends in groundwater basins throughout the state. CASGEM was initialized by Senate Bill x7-6 passed by the legislature in 2009 to establish collaboration between local monitoring parties and DWR to collect groundwater elevations (DWR Groundwater Monitoring [CASGEM] 2018).

CASGEM allows locally agencies to be designated CASGEM monitoring entities for groundwater basins throughout the state (CASGEM Brochure 2018). CASGEM monitoring entities can measure groundwater elevation or compile data from other agencies to fulfill a monitoring plan and each is responsible for submitting that data to DWR. Three monitoring entities operate as CASGEM monitoring entities in the Cuyama Basin; the Santa Barbara County Water Agency (SBCWA), Ventura County Watershed Protection District (VCWPD), and San Luis Obispo Flood Control & Water Conservation District (SLOFC&WCD).

CASGEM includes two kinds of wells in its database:

- CASGEM Wells – Wells with well construction information
- Voluntary Wells – Wells included in the CASGEM database on a volunteer basis where the well construction has not been identified or made public

There are currently six CASGEM wells and 107 voluntary wells in the Basin. Figure 4-3 shows the locations of these wells.

Most wells were measured on a semi-annual schedule. Summary data about the wells reported through CASGEM can be seen in Table 4-1.

CASGEM Wells	
Number of CASGEM wells	6
Number of voluntary wells	107
Total number of DWR and CASGEM wells	222
Earliest measurement year	1946
Longest period of record	68 years
Median period of record	12 years
Median number of records for a single well	19

Table 4-1: Summary Statistics for CASGEM Wells within Cuyama Basin

Spatial distribution of the wells is best suited to capture groundwater trends in the central portion of the Basin, and around the Ventucopa area. There are also several monitoring wells in the south eastern portion of the Basin near the junction of Highway 33 and Lockwood Valley Road. CASGEM data is sparser along the north facing slopes of the main Cuyama Valley and the western portion of the Basin, as can be seen in Figure 4-3.

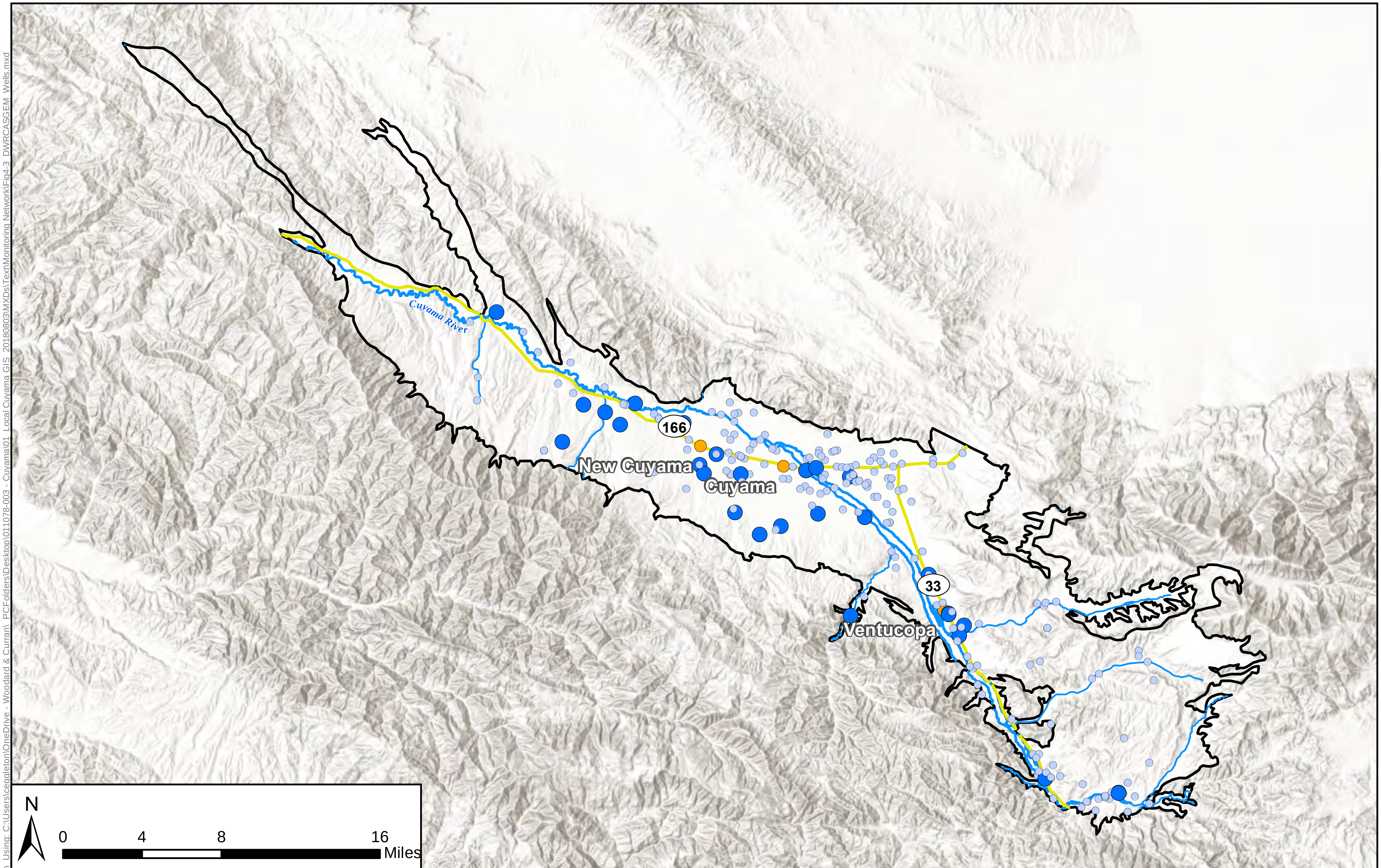

Figure 4-3: Cuyama GW Basin DWR / CASGEM Wells

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Legend

- Cuyama Basin
- Towns
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- Cuyama River
- Streams
- DWR Database Wells Last Measured in 2017-2018
- DWR Database Wells Last Measured 2016 and Earlier

United States Geological Survey

The United States Geological Survey (USGS) has the most groundwater elevation monitoring locations within the Basin. Many of these wells were installed for a 1966 groundwater study and have since been retired.

It should be noted that there are significant overlaps between the DWR provided datasets and the USGS provided datasets. Approximately 106 wells appeared in both downloaded datasets. Discussion about overlapping data is provided in Section 4.3.2 below.

USGS data may be accessed through their online portals for the National Ground-Water Monitoring Network (NGWMN), Groundwater Watch, and National Water Information System (NWIS).

The USGS online data portals provide "Approved" data which has been quality-assured and fit to be published, and "Provisional" data which is unverified and subject to revision. The USGS was contacted directly and coordinated download of their monitoring records in the Basin, and to obtain all available data, the USGS URL Generation tool was used to download all provisional and approved data within the Basin.

USGS has approximately 25 approved wells within the basin, but many more that have data that is provisional. Summary statistics of this data may be found in Table 4-2 below.

USGS Wells	
Number of Approved wells	25
Number of Provisional wells	451
Total number of USGS wells	476
Earliest measurement date	1946
Longest period of record	68 years
Median period of record	2 years
Median number of records for a single well	2 years

Table 4-2: Cuyama Basin USGS Well Statistics

A significant portion of the USGS wells are located near the Cuyama River and in the central portion of the Basin. Wells are also found along many of the tributaries that feed the Cuyama River during large precipitation events. Well locations are included in Figure 4-4.

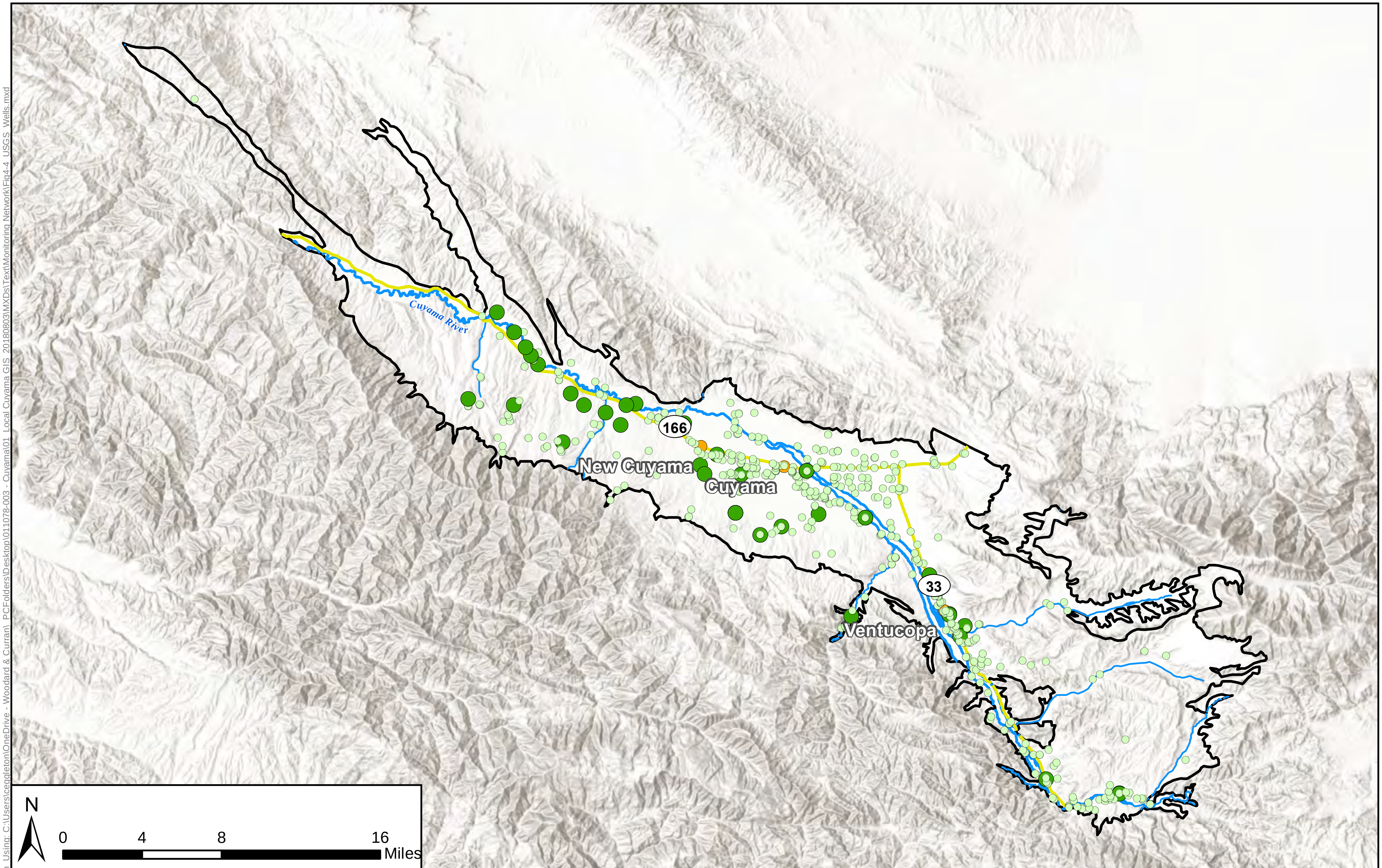

Figure 4-4: Cuyama GW Basin USGS Wells

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- Cuyama Basin
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- Streams
- USGS Database Wells Last Measured in 2017-2018
- USGS Database Wells Last Measured 2016 or Earlier

Santa Barbara County Water Agency

The Santa Barbara County Water Agency (SBCWA) manages data for 29 wells within the Cuyama Basin. Some of those wells are owned by private land owners, while others owned by local agencies such as Caltrans and the California Department of Fish and Wildlife. Many of these wells are included in the DWR statewide dataset. Summary statistics for these wells are included in Table 4-3 below.

SBCWA Wells	
Number of SBCWA wells	29
Earliest measurement date year	1988
Longest period of record	30 years
Median period of record	1.4 years
Median number of records for a single well	9
Number of SBCWA wells included in the Monitoring Network	30

Table 4-3: Cuyama Basin SBCWA Well Statistics

Wells managed by SBCWA are located within Santa Barbara County near the Cuyama River and Miranda Canyon, as well as between Cottonwood Canyon and Aliso Canyon. Figure 4-5 shows the locations of the SBCWA managed wells.

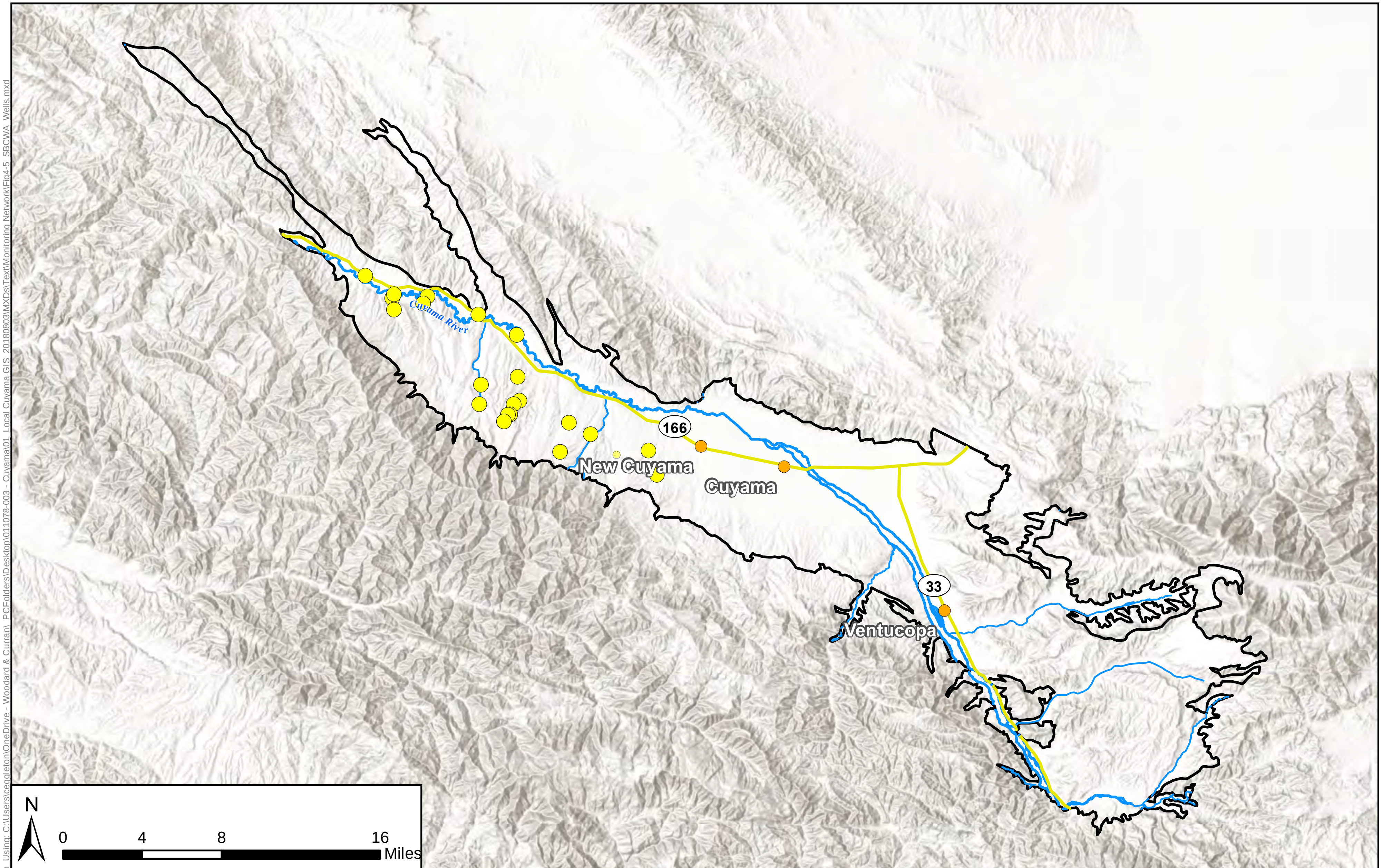

Figure 4-5: Cuyama GW Basin
Santa Barbara County Wells

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- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Santa Barbara County Database Wells Last Measured in 2017-2018
- Santa Barbara County Database Wells Last Measured 2016 or Earlier

San Luis Obispo County Flood Control & Water Conservation District

San Luis Obispo County Flood Control & Water Conservation District (SLOCFC&WCD) manages two wells within the Basin. SLOCFC&WCD also reports the data for the two wells to DWR, thus all data is for the wells is incorporated through the DWR dataset.

The wells are located in the central portion of the Basin, north of the Cuyama River and east of Highway 33. Both wells meet the minimum requirements to be included in the monitoring network, and summary statistics are provided in Table 4-4 below.

SLOCFC&WCD Wells	
Number of SLOCFC&WCD wells	2
Earliest measurement date year	1990
Longest period of record	28 years
Median period of record	18 years
Median number of records for a single well	35

Table 4-4: Cuyama Basin SLOCFC&WCD Wells Statistics

Locations for the two SLOCFC&WCD managed wells are provided in Figure 4-6.

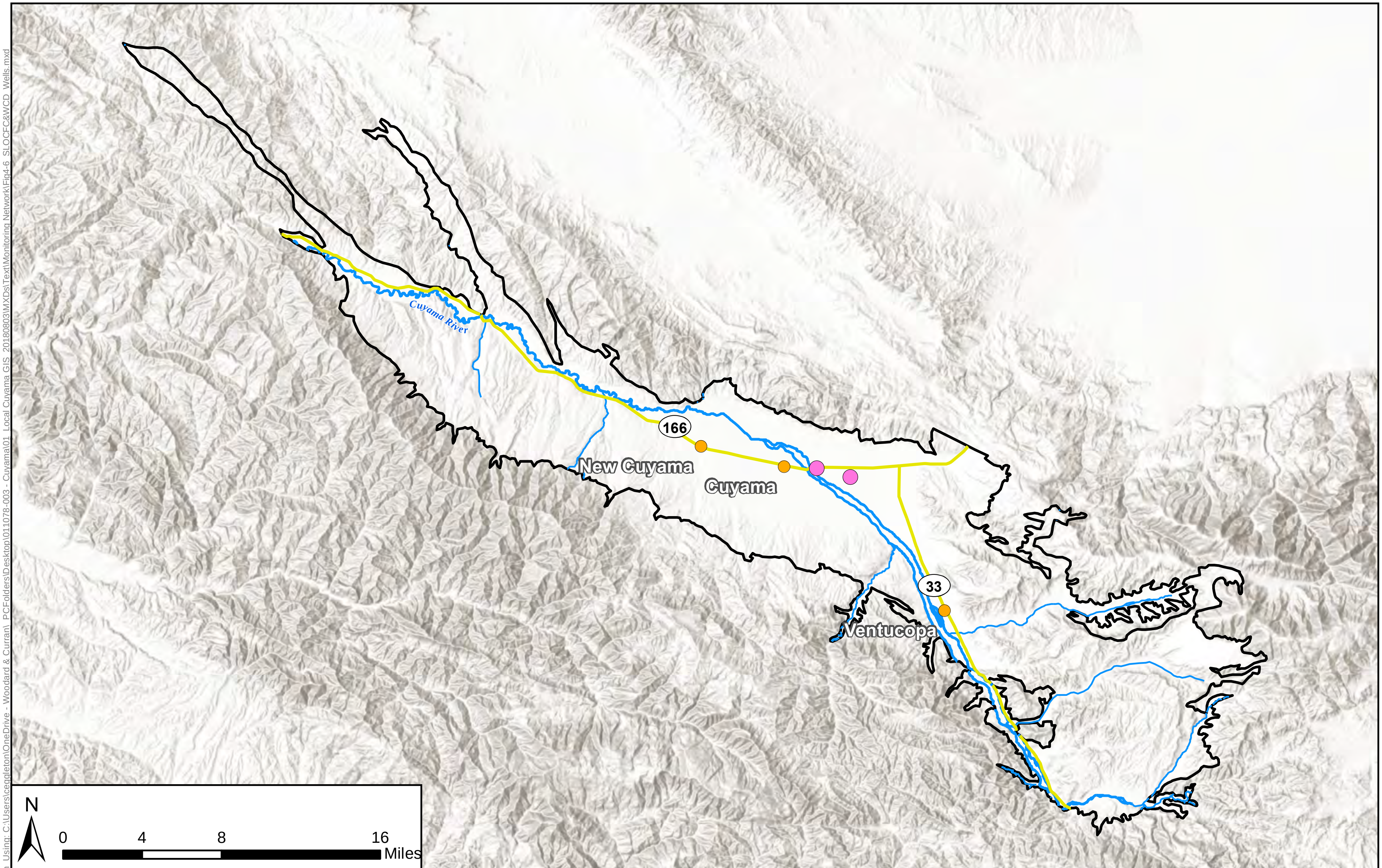

Figure 4-6: Cuyama GW Basin SLOCF&WCD Wells

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- Cuyama Basin
- San Luis Obispo County Wells Last Measured in 2017-2018
- Towns
- Highways
- Cuyama River
- Streams

Ventura County Watershed Protection District

The Ventura County Watershed Protection District (VCWPD) manages 22 groundwater elevation monitoring wells within the Basin. Twenty of those wells are incorporated in the DWR dataset.

The majority of wells managed by VCWPD are discontinued and no longer measure groundwater elevations. Five of the 22 wells have measured elevation data within the last decade are currently active. A summary of the wells statistics is provided in Table 4-5 below.

VCWPD Wells	
Number of SLOCFC&WCD wells	22
Earliest measurement date year	1971
Longest period of record	46 years
Median period of record	5.8 years
Median number of records for a single well	21.5

Table 4-5: Cuyama Basin VCWPD Wells

The VCWPD wells are located in the south eastern portion of the Basin that intersects with Ventura County. The wells are primarily found near the Cuyama River close to agricultural lands. Locations for the wells are provided in Figure 4-7.

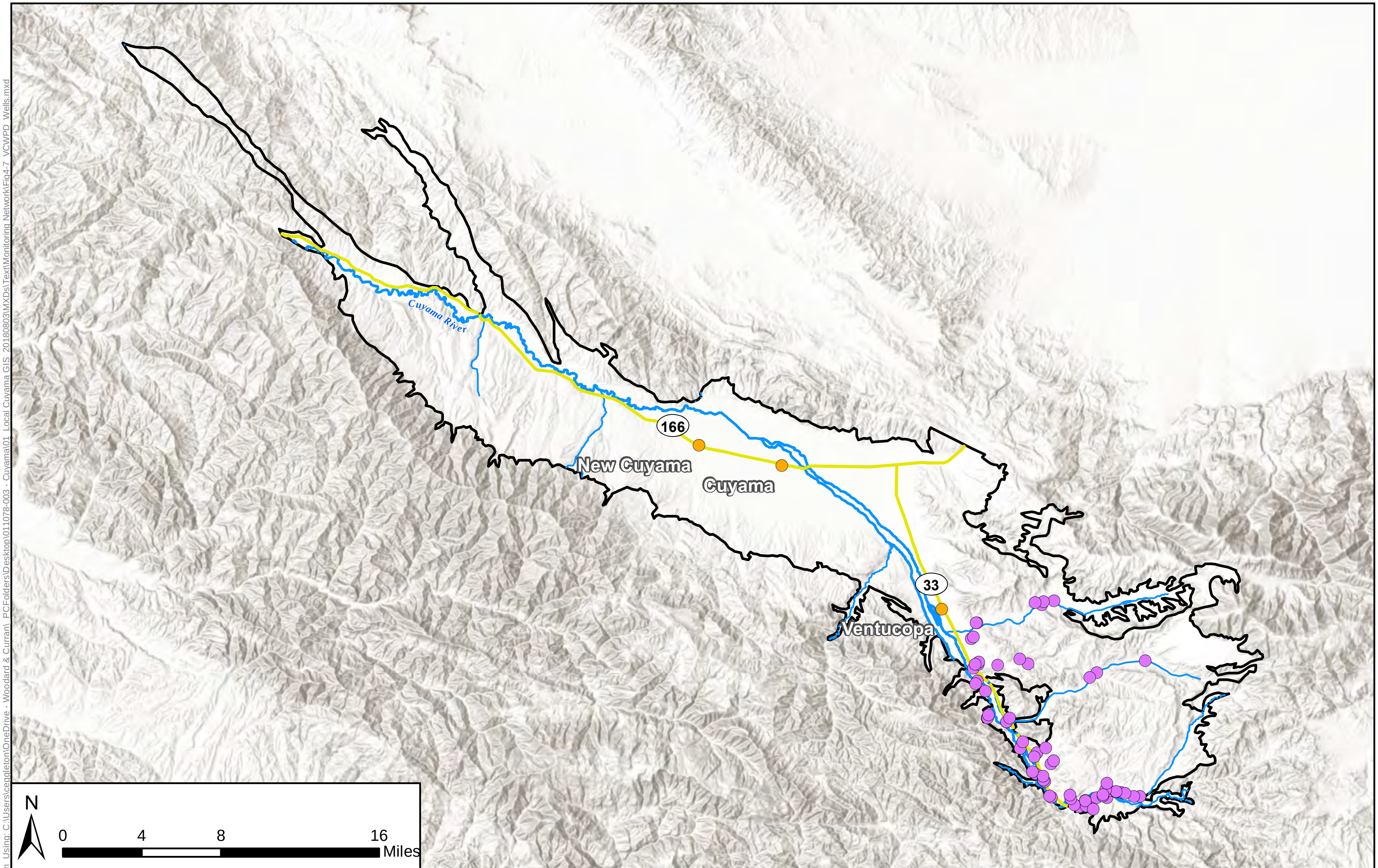

Figure 4-7: Cuyama GW Basin
VCWPD Wells

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Ventura County Watershed Protection District
- Towns
- Highways
- Cuyama River
- Streams

Cuyama Community Services District

The Cuyama Community Services District (CCSD) manages two production wells, one of which has been retired. The CCSD wells are located just south of the CCSD. Data for these wells is included in the SBCWA dataset, as well as the DWR and USGS datasets. Summary statistic for the wells is included in Table 4-6. Locations for these wells can be found in Figure 4-8.

CCSD Wells	
Number of CCSD wells	2
Earliest measurement date year	1981
Longest period of record	37 years
Median period of record	11 years
Median number of records for a single well	79

Table 4-6: Cuyama Basin CCSD Well Statistics

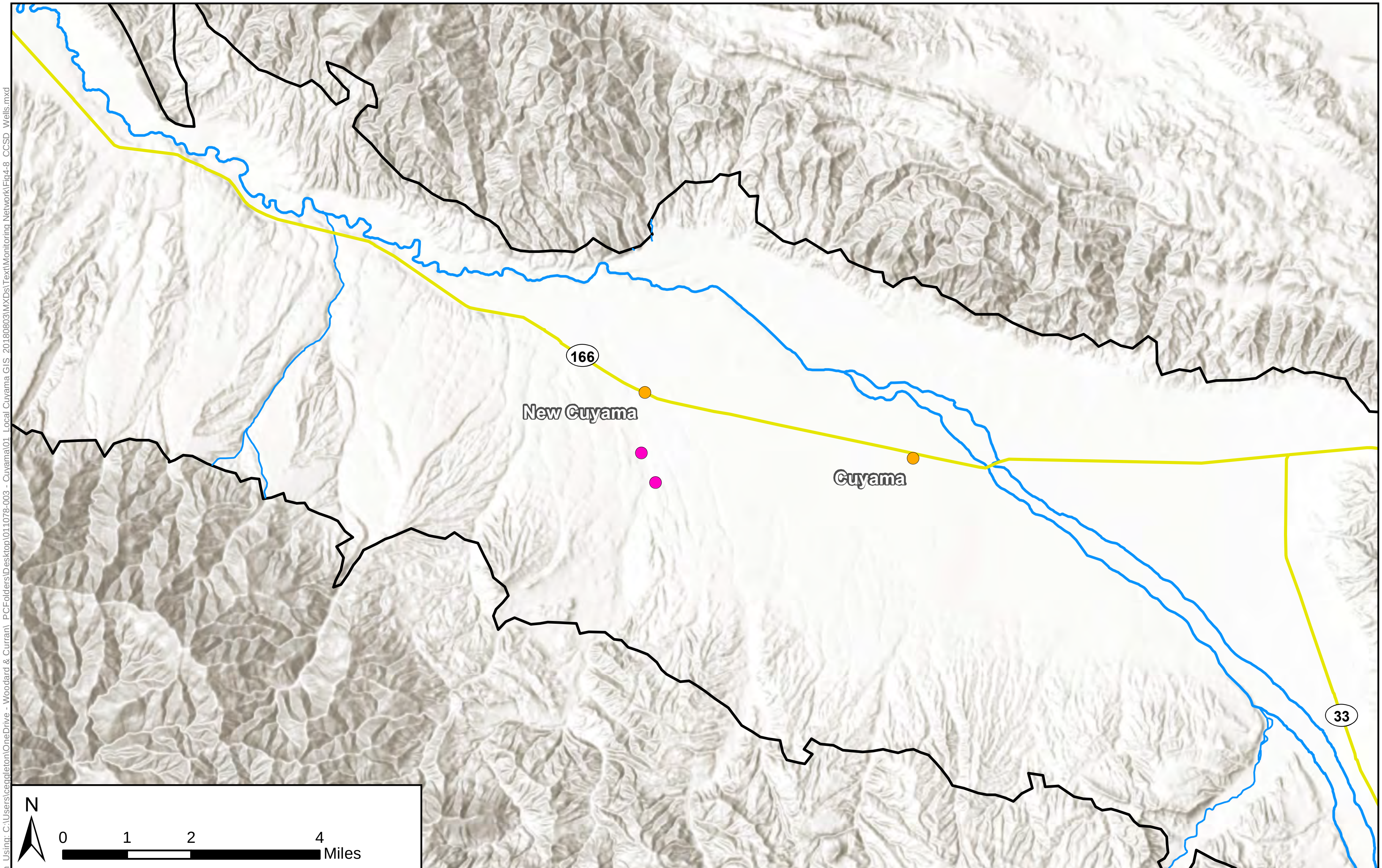

Figure 4-8: Cuyama GW Basin CCSD Wells

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Legend

- Cuyama Basin
- CCSD Wells
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- Cuyama River
- Streams

Private Landowners

Private landowners within the Basin own and operate large numbers of wells, primarily for irrigation and domestic use. Landowners have provided data on 99 wells. Summary statistics for these wells is provided in Table 4-7.

Private Landowner Wells	
Number of Private Landowner wells	99
Earliest measurement date year	1975
Longest period of record	42 years
Median period of record	15 years
Median number of records for a single well	16

Table 4-7: Cuyama Basin Private Landowner Well Statistics

The private landowner wells with provided information are distributed throughout the Basin. The majority of wells are located within the central portion of the Basin near the Cuyama River and Highway 166. There is an additional cluster towards the western portion of the basin that runs along the Cuyama River. Private landowner wells are shown in Figure 4-9.

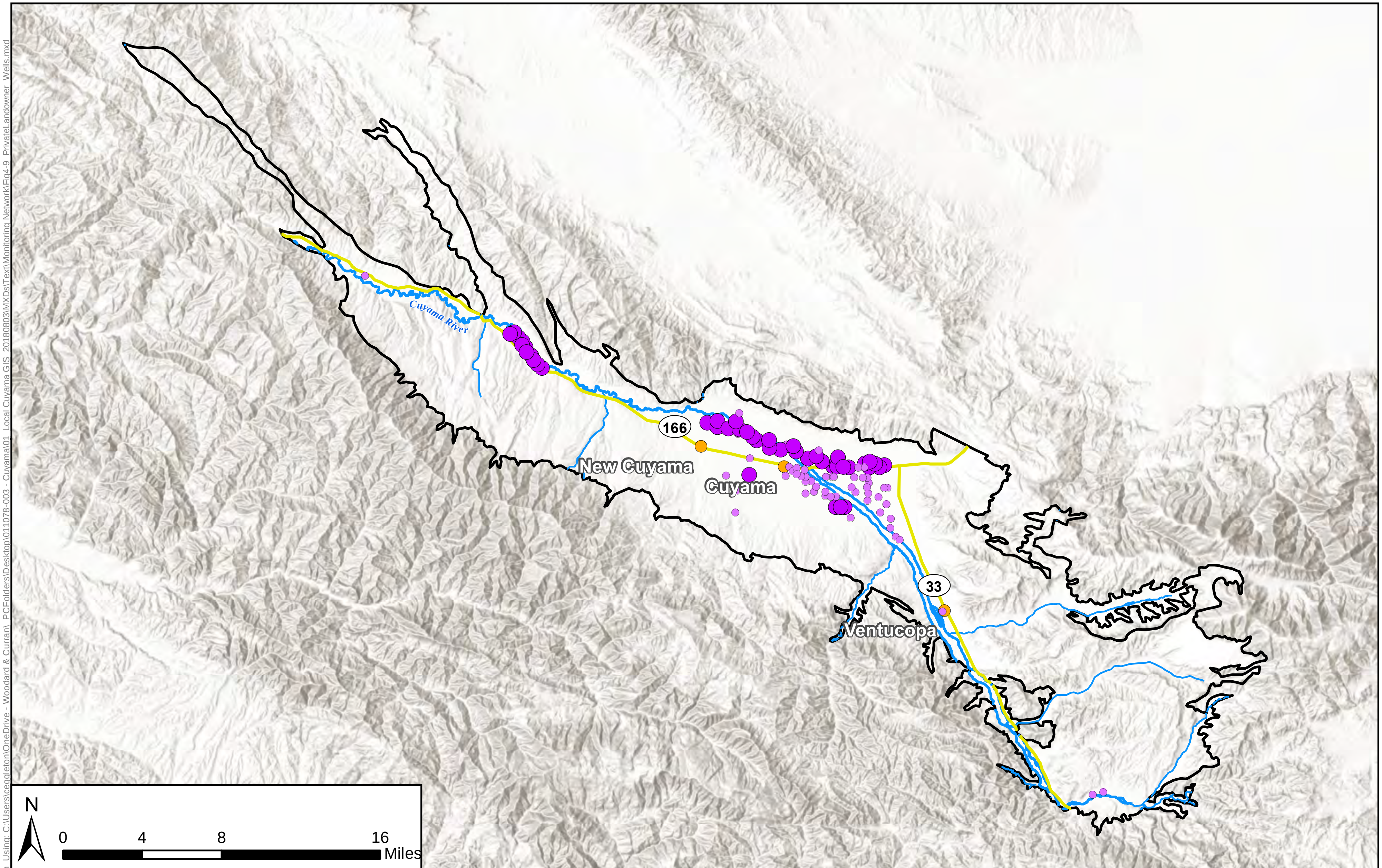

Figure 4-9: Cuyama GW Basin
Private Landowner Wells

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- Cuyama Basin
- Towns
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- Streams
- Private Landowner Reported Wells Last Measured in 2017-2018
- Private Landowner Reported Wells Last Measured 2016 and Earlier

4.3.2 Overlapping and Duplicate Data

Many of the data sources used to compile and create the Cuyama Basin Database contain duplicate entries for wells, metadata, groundwater level measurements, and groundwater quality measurements. Much of the well information managed by the counties within the Basin is also provided and incorporated into the DWR dataset. Many of the USGS wells and DWR wells overlap between datasets.

To avoid duplicate entries when compiling the Cuyama Basin Database, wells were organized by their State Well Number (SWN), Master Site Code (MSC), USGS ID, Local Name, and Name. Duplicates were identified and then removed or combined as necessary. Each unique well was then assigned an OPTI ID which was used as the primary identification number for all other processes and mapping exercises.

OPTI IDs were used to identify wells in the database within the Basin because not all data sources use similar identification methods, as shown in Table 4-8 below.

Managing Entity	SWN	CASGEM ID	USGS ID	MSC	Local Name	Name
DWR	✔ (green)	✔ (green)		✔ (green)		
USGS	✔ (black)		✔ (green)		✔ (red)	
SLOCFC&WCD	✔ (green)					
SBCWA	✔ (black)		✔ (red)		✔ (black)	
VCWPD	✔ (green)					
Private Landowners					✔ (black)	✔ (green)

✔ (green) = All wells had this information, ✔ (black) = Some wells had the information, ✔ (red) = Few wells had the information

Table 4-8: Well Identification Matrix

4.3.3 Groundwater Quality Monitoring (Combine Existing Programs)

This section discusses existing groundwater quality monitoring programs collected for GSP development.

NWQMC / USGS / IRLP

The National Water Quality Monitoring Council (NWQMC) was created in 1997 to provide a collaborative, comparable, and cost-effective approach for monitoring and assessing the United State's water quality. Several organizations contribute to the database including the Advisory Committee on Water Information (ACWI), the Agricultural Research Service (ARS), the Environmental Protection Agency (EPA), and USGS (NWQMC, 2018).

A single online portal provides access to data from the contributing agencies. Initial water quality data for the Cuyama Basin was downloaded through NWQMC and included data for USGS monitoring sites and Irrigated Land Regulatory Program (IRLP) monitoring sites. IRLP was initiated in 2003 to prevent agricultural runoff from impairing surface waters, and in 2012, groundwater regulations were added to the program. IRLP water quality measurements are sampled from surface locations (DWR IRLP, 2018).

There are currently five IRLP measurement sites within the Cuyama Basin. IRLP uses the California Environmental Data Exchange Network (CEDEN) to manage the data associated with the program. CEDEN data is then incorporated with USGS data, and thus included in the NWQMC database (DWR CEDEN, 2018).

The NWQMC database provides data on 47 water quality monitoring sites. Summary statistics for this information is shown in Table 4-9.

NWQMC, USGS, and IRLP Water Quality Monitoring Sites	
Number of measurement sites	176
Earliest measurement date year	1940
Longest period of record	53 years
Median period of record	<1 year
Median number of records for a single site	2

Table 4-9: Cuyama Basin NWQMC, USGS, IRLP Water Quality Monitoring Sites Summary Statistics

The majority of the water quality monitoring sites included in the NWQMC database are located in the central portion of the basin and along the Cuyama River as it follows Highway 33. These monitoring sites can be seen in Figure 4-10.

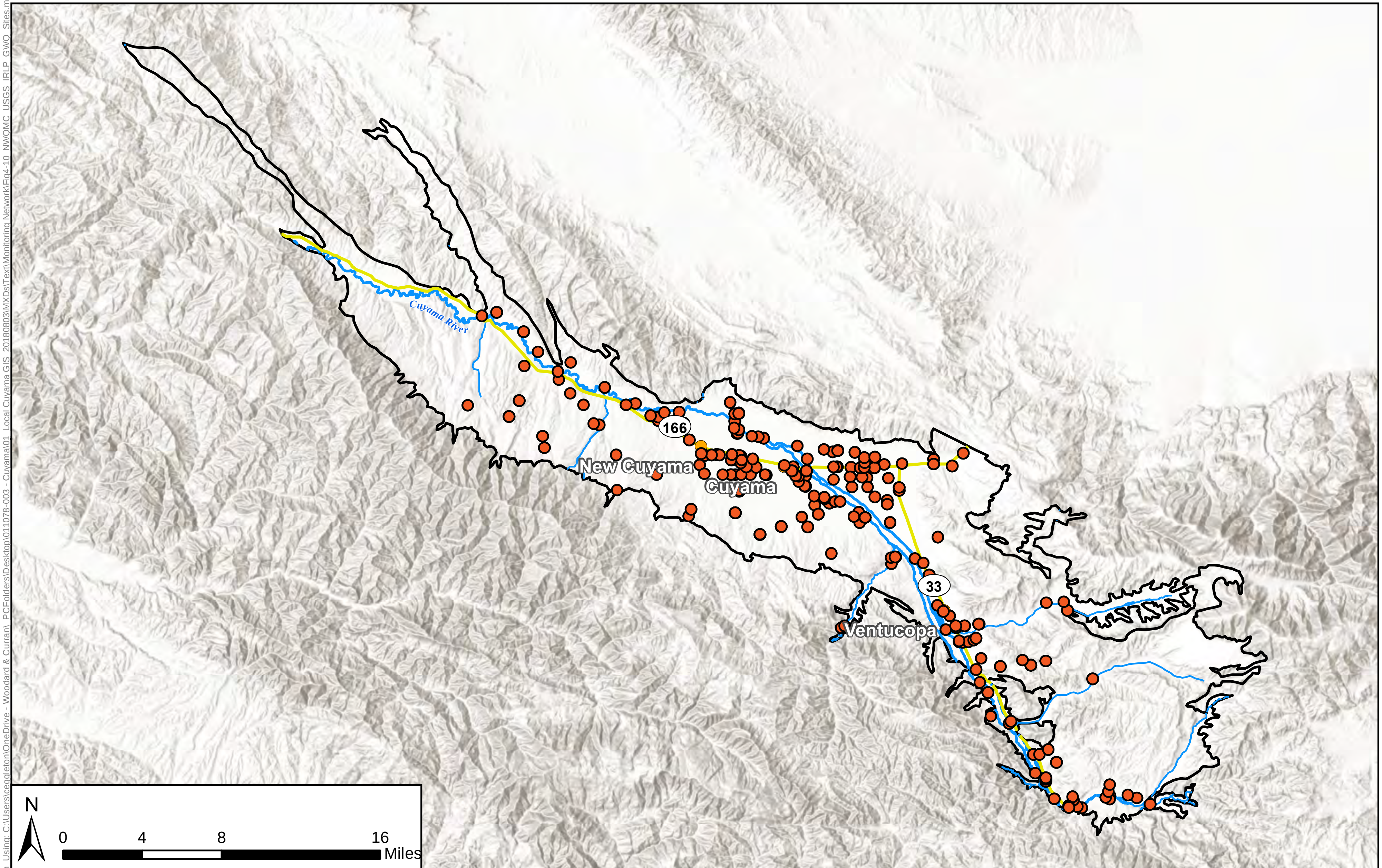

Figure 4-10: Cuyama GW Basin USGS/NWQMC/ IRLP Groundwater Quality Monitoring Sites

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Cuyama Basin

USGS/NWQMC/IRLP Groundwater Quality Sites

Towns

Highways

Cuyama River

Streams

Figure Exported: 9/14/2018 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran_PCFolders\Desktop\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\Text\Monitoring Network\Fig4-10_NWQMC_USGS_IRLP_GWQ_Sites.mxd

GAMA / DWR

The Groundwater Ambient Monitoring and Assessment (GAMA) Program is the State of California's groundwater quality monitoring program created by the State Water Resources Control Board in 2000, and later expanded by Assembly Bill 599, the Groundwater Quality Monitoring Act of 2001 (DWR GAMA 2018). The purpose of GAMA is to improve statewide comprehensive groundwater monitoring and increase the availability of information to the general public about groundwater quality and contamination information. Additionally, GAMA aims to establish groundwater quality on basin wide scales, continue with groundwater quality sampling and studies, and centralize the information and data for the public and decision makers to enhance groundwater resource protection.

DWR also publishes statewide water quality data via the California Natural Resources Agency. Access to DWR and GAMA information and data is accessible through separate online portals.

There are 213 GAMA and DWR groundwater quality monitoring sites within the Basin. Summary statistics for these sites is included in Table 4-10.

GAMA / DWR Water Quality Monitoring Sites	
Number of measurement sites	213
Earliest measurement date year	1942
Longest period of record	41 years
Median period of record	<1 year
Median number of records for a single site	2

Table 4-10: Cuyama Basin GAMA / DWR Groundwater Quality Monitoring Sites Summary Statistics

The GAMA / DWR groundwater quality monitoring locations are spread throughout the Basin, loosely following the Cuyama River. There are currently 60 water quality monitoring sites per 100 miles^2 within the Basin. These locations can be seen in Figure 4-11.

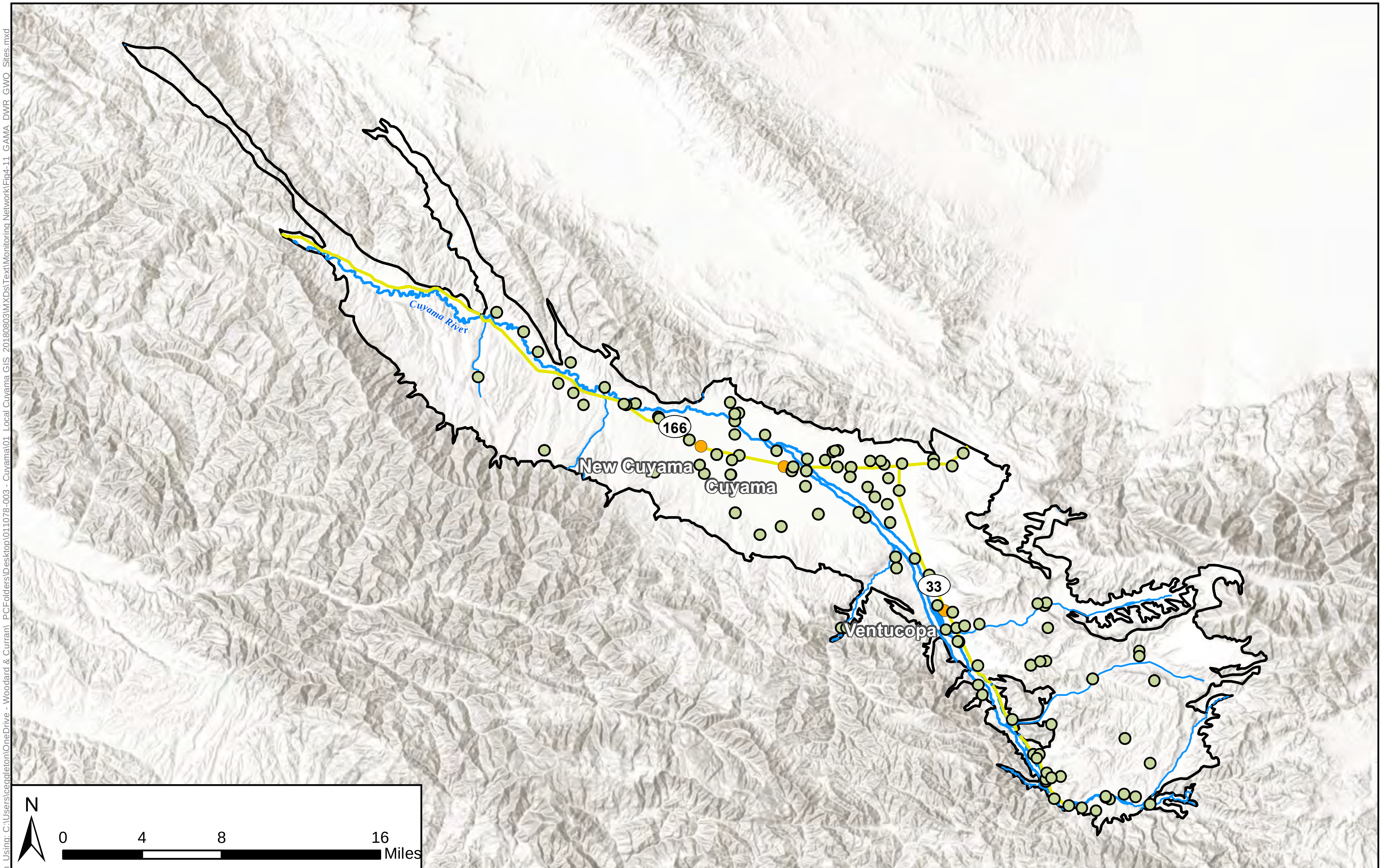

Figure 4-11: Cuyama GW Basin GAMA/DWR Groundwater Quality Monitoring Sites

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Legend

- Cuyama Basin
- GAMA/DWR Groundwater Quality Sites
- Towns
- Highways
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Ventura County Watershed Protection District

VCWPD has 51 groundwater wells that have been utilized for groundwater quality monitoring within the Basin. All of the wells are incorporated into the DWR, GeoTracker, or USGS datasets. Summary statistics for the wells are included in Table 4-11, and locations of these wells are included in Figure 4-12.

VCWPD Water Quality Monitoring Sites	
Number of measurement sites	51
Earliest measurement date	1957
Longest period of record	45
Median period of record	7
Median number of records for a single site	5

Table 4-11: Cuyama Basin VCWPD Water Quality Sites Summary Data

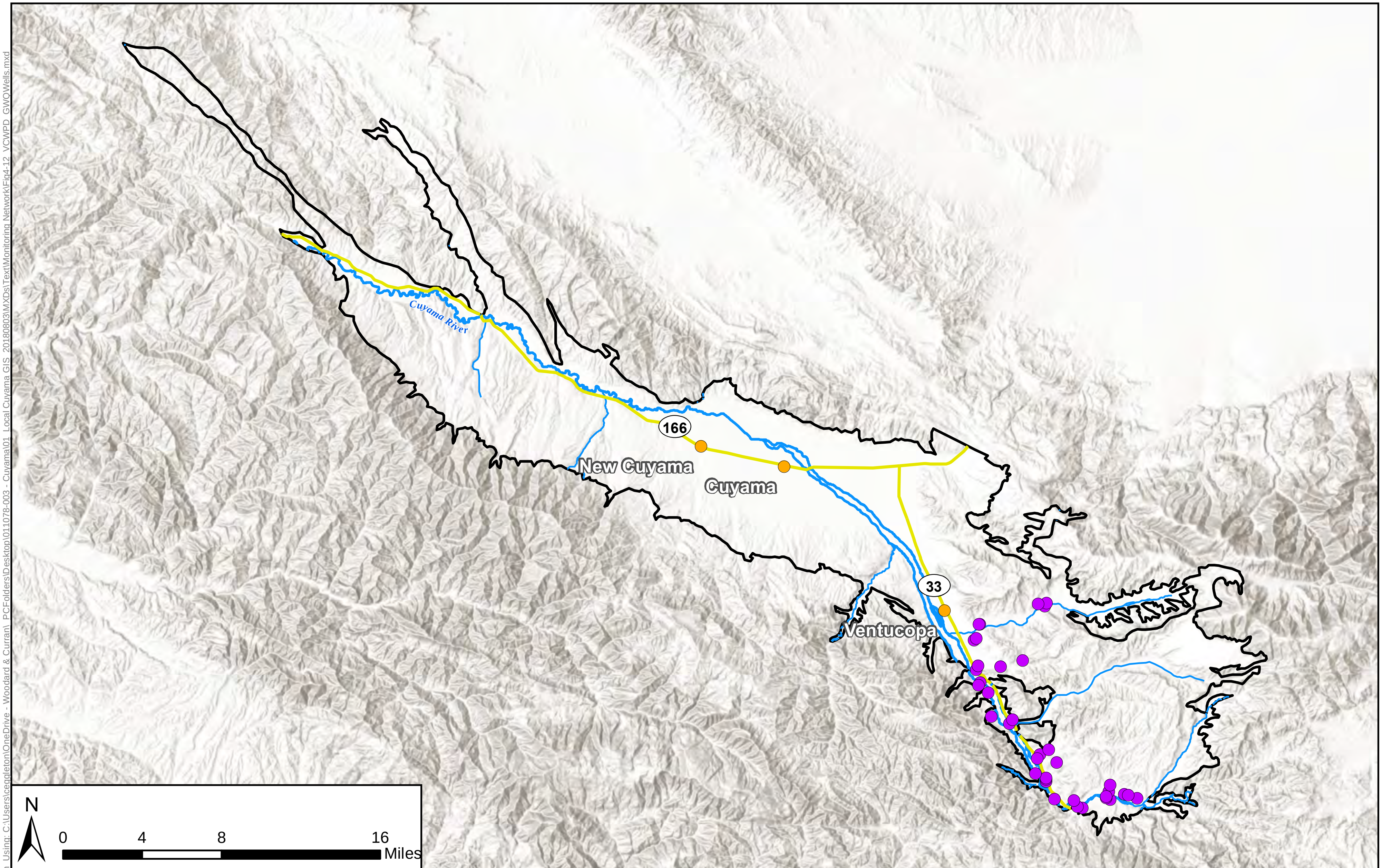

Figure 4-12: Cuyama GW Basin
VCWPD Groundwater Quality Wells

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Legend

- Cuyama Basin
- Towns
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- Cuyama River
- Streams
- Ventura County Watershed Protection District Groundwater Quality Monitoring Wells

Private Landowners

Private landowners within the Basin conducted groundwater quality testing, which has been incorporated into this document and associated analysis. Eleven wells measured Total Dissolved Solids in 2015. Summary statistics for these sites can are included in Table 4-12 and locations are included in Figure 4-13.

Private Landowner Water Quality Monitoring Sites	
Number of measurement sites	11
Earliest measurement date	1/12/2015
Longest period of record	N/A
Median period of record	N/A
Median number of records for a single site	1

Table 4-12: Cuyama Basin Landowner Water Quality Sites Summary Data

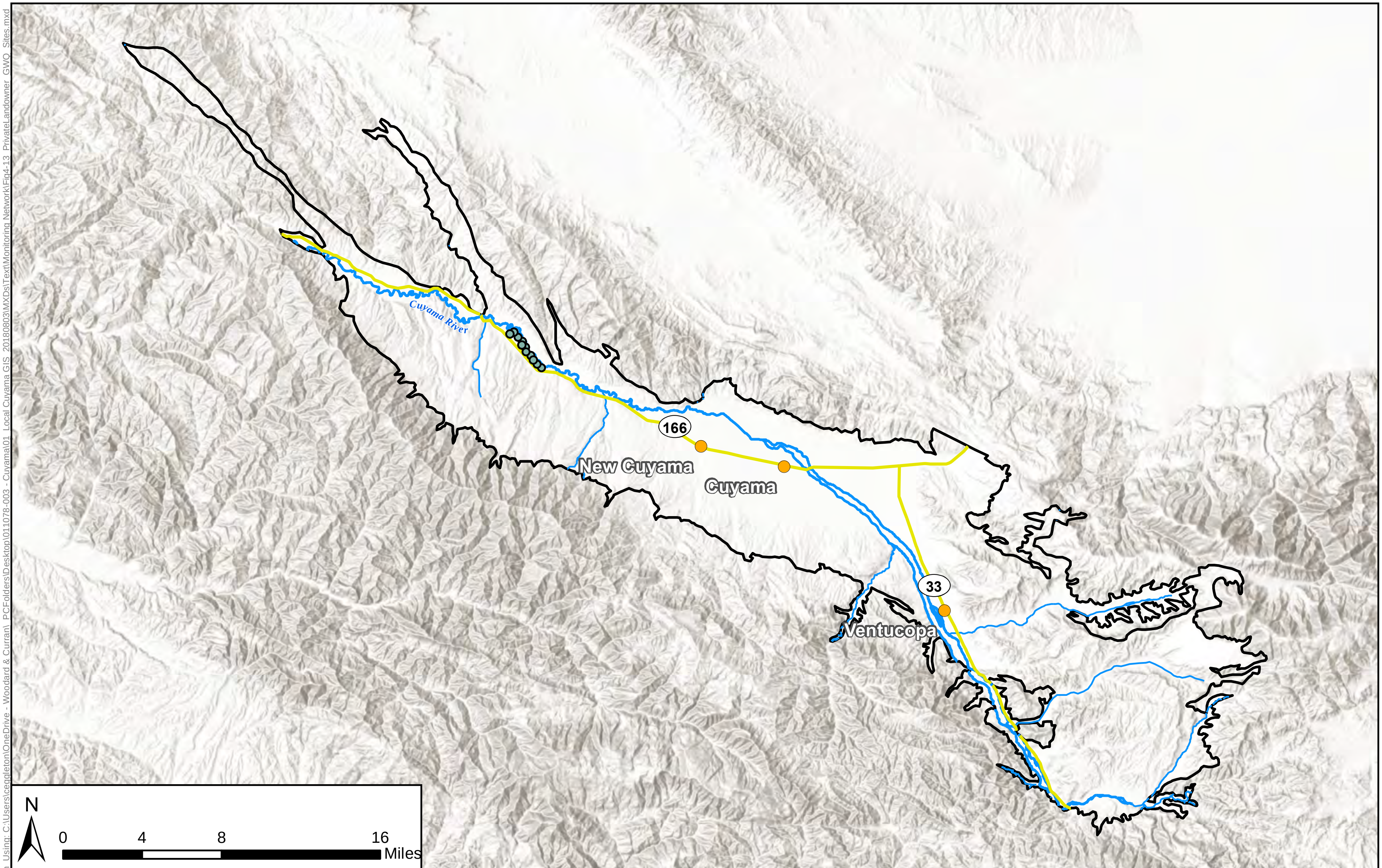

Figure 4-13: Cuyama GW Basin Private Land-owner Groundwater Quality Monitoring Sites

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- Streams
- Private Landowner Groundwater Quality Monitoring Sites

4.3.4 Subsidence Monitoring

Subsidence is the sinking or downward settling of the earth's surface and is often the result of over-extraction of subsurface water. Subsidence can be measured in a few different methods such as with InSAR, Continuous Geographic Positioning System (CGPS), Extensometers, and Spirit Leveling. Appendix Z, a subsidence white paper contains further information about these methods and the physics behind land subsidence.

The Basin hosts two CGPS stations with three others just outside the Basin's boundary, as shown in Figure 2.2-22. CGPS stations measure surface movement in all three axis directions; up/down, east/west, and north/south. CGPS stations are placed in the center of the Cuyama Valley to measure subsidence, while other are placed on ridges around the valley to also measure tectonic movements.

4.3.5 Surface Water Monitoring

Surface water monitoring within the Basin is conducted through stream and river gages placed along the Cuyama River or one of its tributaries. USGS manages most flow gages in California, and currently operates one active stream gage along Santa Barbara Creek. There is an additional gage (ID 11136800) along the Cuyama River downstream of the Basin before Twitchell Reservoir, however, this gage also receives water from non-Cuyama Basin watershed areas. Data for surface flow gages is obtained through the NWIS Mapping portal (USGS NWIS 2017). Existing and discontinued gages are included in Figure 4-14.

USGS has operated three additional gages within the Basin, however, two of those gages were discontinued in the 1970's. Gage ID 11136500 operated from 1945 to 1958 and was brought back into service from 2009 to 2014.

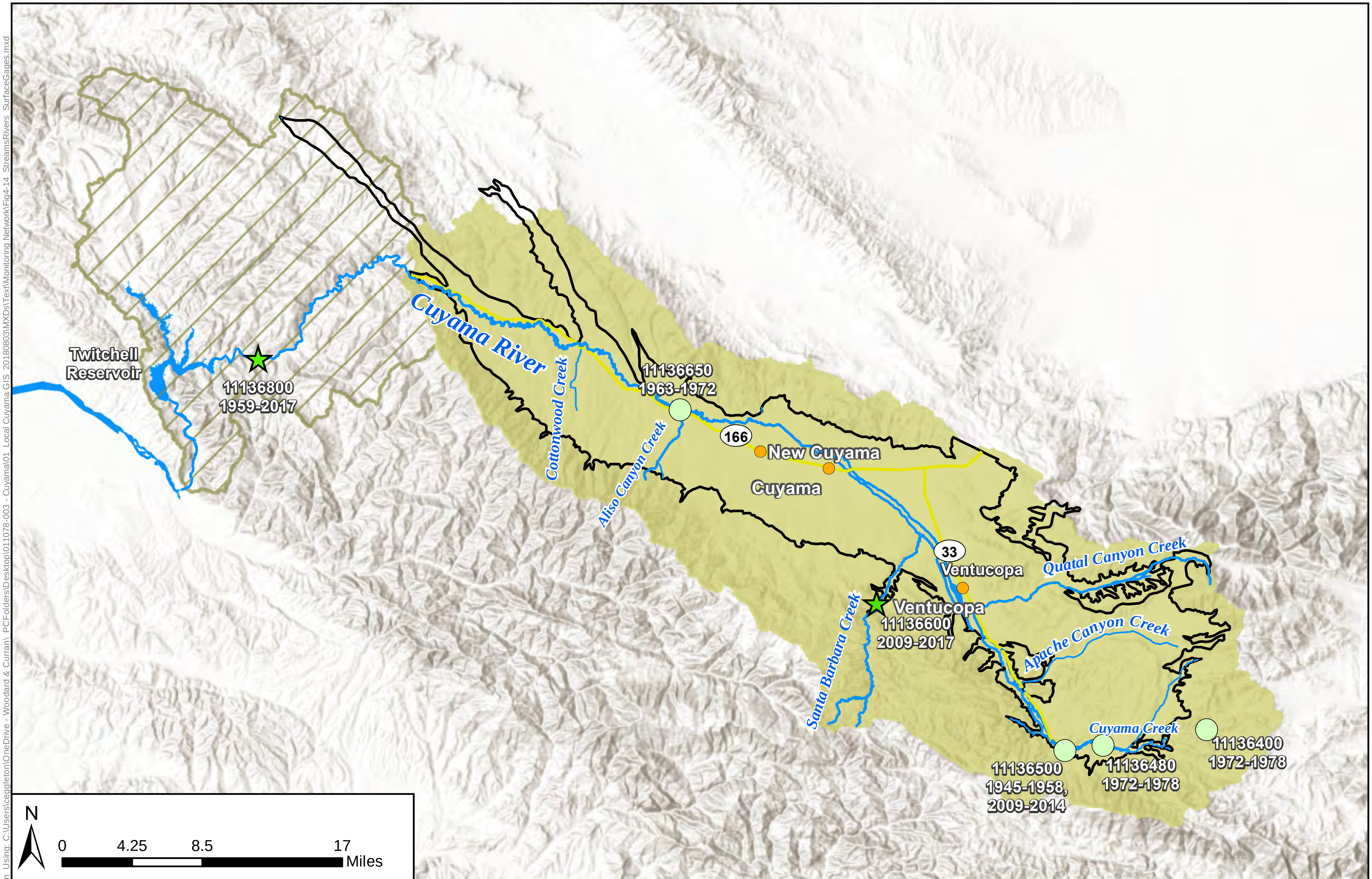

Figure 4-14: Rivers, Streams, and Surface Flow Gages

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Figure Exported: 9/14/2018 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran\ PCFolders\Desktop\011078-003 - Cuyama\01 Local Cuyama GIS 20180803\MXDs\TextMonitoring Network\Fig4-14 StreamsRivers SurfaceGages.mxd

4.4 Monitoring Rationales

This section discusses the reasoning behind monitoring network selection. Monitoring networks in the Cuyama GSP were developed to ensure that they were able to detect changes in basin conditions so that the Cuyama Basin Groundwater Sustainability Agency (CBGSA) can manage the basin to ensure the basin's sustainability goal is met, and that no undesirable results are present after 20 years of sustainable management.

The monitoring networks were selected specifically to detect short term, seasonal, and long term trends in groundwater. The monitoring networks have been selected to include an adequate amount of temporal frequency and spatial density to evaluate information about groundwater conditions that are necessary to evaluate the effectiveness of projects and management actions undertaken by the GSA.

Explanations of how each monitoring network will be developed and implemented will be described in the projects and management actions section of the GSP as individual projects that the GSA will undertake as part of GSP implementation. The schedule and costs associated with developing and implementing each network will be discussed in the Implementation Section of the GSP

4.5 Groundwater Level Monitoring Network

Groundwater level monitoring is conducted through a groundwater well monitoring network. This section will provide information on how the level monitoring network was developed, criteria for selecting representative wells, monitoring frequency, spatial density, summary protocols, and identification and strategies to fill data gaps.

4.5.1 Management Areas

Management Areas have not been selected at the time of writing this GSP section. Management Areas allow flexibility in establishing monitoring networks both spatially and temporally to match conditions and use in the management area. At this time, it is recommended due to the sparsity of monitored wells to use the same monitoring network selection criteria across all management areas in the basin.

4.5.2 Monitoring Wells Selected for Monitoring Network

A set of well tiering criteria were created to rank existing groundwater level measuring sites within the basin into six different tiers, shown in Figure 4-15.

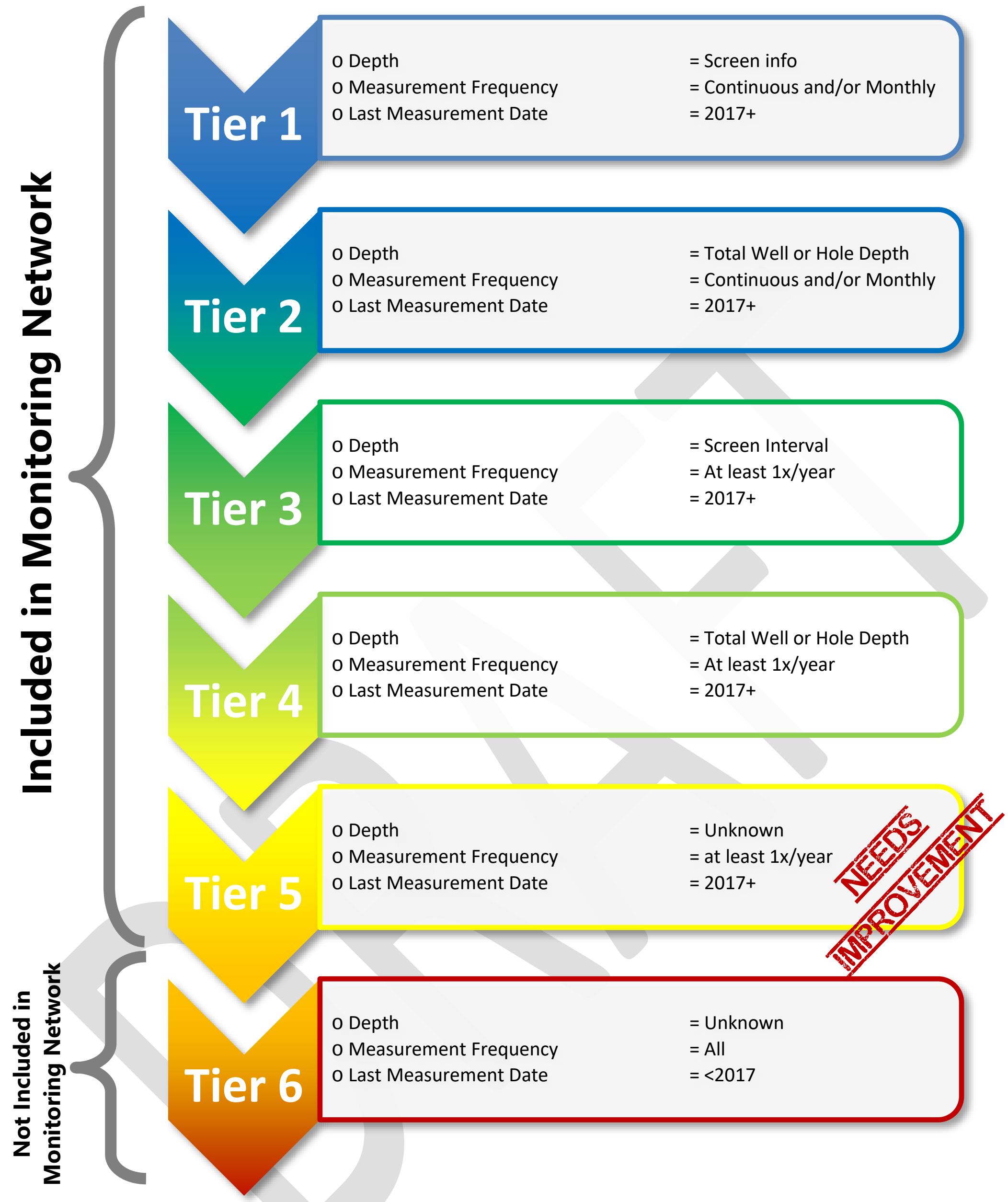

Figure 4-15: Cuyama Well Tiering Criteria

Tier 1 encompasses wells with the most amount of metadata as well as consistent water elevation data that are still operating and functional. As tiering levels increase, requirements around well metadata and frequency of monitoring decrease, but all the wells are still active and functioning. Tier 5 captures the remaining "active" wells, but the metadata and/or frequency of monitoring would benefit from improvement.

Tier 6 includes all other wells that are no longer operational, which are categorized as those who do not have recorded data from January 1, 2017 to August 1, 2018 This approximate two-year cut off was determined as being a reasonable amount of time for a monitoring agency or organization to obtain, log, and report well information and measurements, and as an indicator of whether a well was currently monitored or not.

Table 4-13 shows the number of monitoring wells selected from each existing monitoring program.

Monitoring Group	Number of Wells Selected for Monitoring Network
CASGEM	28
USGS	42
SBCWA	30
SLOCFC&WCD	2
VCWPD	5
CCSD	1
Private Landowner	43

Table 4-13: Number of Wells Selected for Monitoring Network

Thirteen percent of the CASGEM wells meet the minimum requirements for inclusion in the Cuyama Basin Monitoring Network (monitoring network) based on the metadata and the groundwater elevation measurements available for each well. Nine percent of the USGS wells meet the minimum requirements for inclusion in the Monitoring Network based on the metadata and the groundwater elevation measurements available for each well. Ninety-six percent of the SBCWA wells meet the minimum requirements for inclusion in the Monitoring Network based on the metadata and the groundwater elevation measurements available for each well. included in the Monitoring Network, as can be seen in Figure 4-16. Forty-three percent of the private landowner operated wells are active and included in the monitoring network.

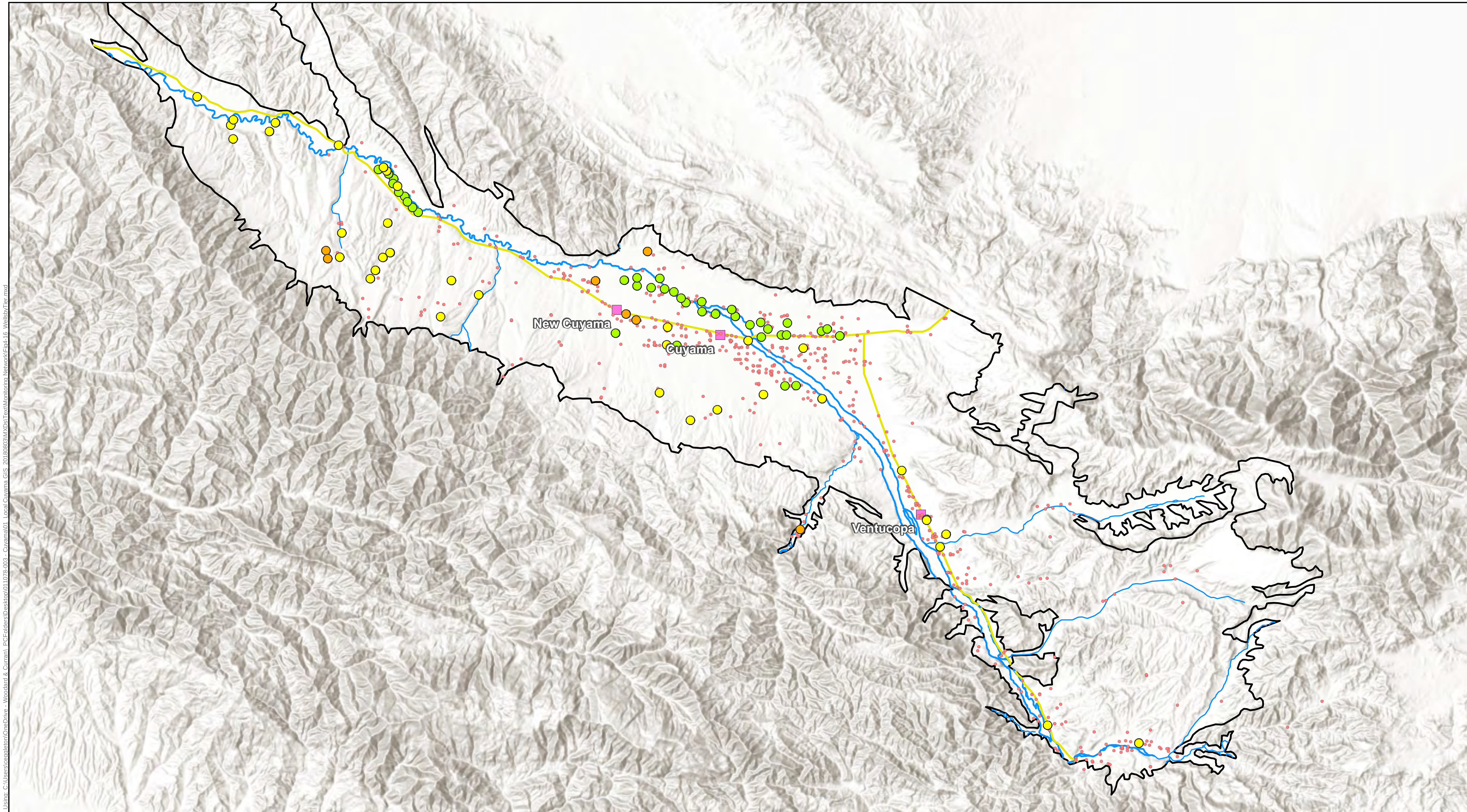

Figure 4-16: Cuyama GW Basin Groundwater Level Wells by Tier

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- Streams

Monitoring Network Wells

- Tier 1
- Tier 2
- Tier 3
- Tier 4
- Tier 5
- Tier 6

N

0 2 4 8 Miles

4.5.3 Monitoring Frequency

A successful monitoring frequency and schedule should allow the monitoring network to adequately interpret the fluctuations over time of the groundwater system based on shorter-term and long-term trends and conditions. These changes may be the result of storm events, droughts or other climatic variations, seasons, and anthropogenic activities such as pumping.

Monitoring frequency must, at a minimum, occur within the same designated time-period for all wells to ensure that measurements represent the same condition for the aquifer.

The *Monitoring Networks and Identification of Data Gaps Best Management Practices (BMP)* published by DWR provides guidance for the monitoring frequency based on the discussion presented in the *National Framework for Ground-water Monitoring in the United States* (ACWI, 2013). This analysis and discussion provide guidance on monitoring frequency based on aquifer properties and degree of use, as shown in Table 4-14.

The guidance recommends that initial characterization of monitoring locations use frequent measurements to establish the dynamic range at each monitoring site and to identify external stresses affecting groundwater levels. An understanding of these conditions based on professional judgement should be reached before normal monitoring frequencies are followed.

Aquifer Type	Nearby Long-Term Aquifer Withdrawals		
	Small Withdrawals	***Moderate Withdrawals***	***Large Withdrawals***
Unconfined Aquifer			
"low" recharge (<5 inches/year)	Quarterly	Quarterly	Monthly
"high" recharge (>5 inches/year)	Quarterly	Monthly	Daily
Confined Aquifer			
"low" hydraulic conductivity (<200 feet/day)	Quarterly	Quarterly	Monthly
"high" hydraulic conductivity (>200 feet/day)	Quarterly	Monthly	Daily

Table 4-14: Monitoring frequency Based on Aquifer Properties and Degree of Use

The Basin is an unconfined aquifer with large withdrawals, with a "low" recharge rate of less than 5-inches per year. Based on the data in Table 4-14 provided by DWR, the Basin's groundwater monitoring frequency should be on a monthly basis. This GSP recommends monitoring the groundwater level network monthly for the first three years of GSP implementation and consideration of reducing the monitoring frequency to quarterly measurements after that. Ideally, the monitoring network would be monitored simultaneously to gain a 'snapshot' of groundwater conditions. Since that is not practical monitoring of the level network should be conducted within one week for each measurement period.

4.5.4 Spatial Density

Spatial density of the monitoring network was considered both for the selection of the entire monitoring network, and for the selection of representative wells (Section 4.5.5) The goal of the groundwater level monitoring network is to provide adequate coverage of the entire aquifer within the Basin. This includes the ability to monitor and identify groundwater changes across the basin through time. Consideration of the spatial location of monitoring wells should include proximity to other monitoring wells and proximity to other prominent features such as faults or production wells. Monitoring wells in close proximity to active pumping wells could be influenced by groundwater withdrawals, thus skewing static level monitoring.

The *Monitoring Networks and Identification of Data Gaps BMP* published by DWR provides different sources and condition dependent densities to guide monitoring network implementation (Table 4-15). This information was adapted from the *CASGEM Groundwater Elevation Monitoring Guidelines* (DWR, 2010). While these estimates provide guidance to monitoring well site spatial densities, monitoring points should primarily be influence by local geology, groundwater use, and GSP defined undesirable rates. Professional judgement is essential to determine final locations.

Reference	Monitoring Well Density (wells per 100 miles^2)
Heath (1976)	0.2-10
Sophocleous (1983)	6.3
Hopkins (1994)	
Basins pumping more than 10,000 AFY per 100 miles^2	4.0
Basins pumping between 1,000 and 10,000 AFY per 100 miles^2	2.0
Basins pumping between 250 and 1,000 AFY per 100 miles^2	1.0
Basins pumping between 100 and 250 AFY per 100 miles^2	0.7

Table 4-15: Monitoring Well Density Considerations

PRELIMINARY AND WILL BE UPDATED WHEN WATER BUDGET INFORMATION IS COMPLETE, it is estimated that the basin pumps approximately over 10,000 AFY per 100 square miles. The basin has 378 square miles of area. Based on Hopkins well density estimate guidelines, the Basin should have 4 monitoring wells per 100 square miles, Sophocleous, 6.3 monitoring wells per 100 square miles. Based on Heath, the basin should have between 0.2 and 10 monitoring wells per 100 square miles. Due to the geologic and topographic variability within the basin, as well as the severity of groundwater declines and hydrogeologic uncertainty in various portions of the basin, this GSP recommends a density greater than the most conservative estimate of 10 wells per 100 square miles, which is over 38 monitoring wells

4.5.5 Representative Monitoring

There are two categories of wells were identified within the monitoring network:

- **Representative Wells** – These wells will be used to monitor sustainability in the basin. Minimum thresholds and measurable objectives will also be calculated for these wells.
- **Monitoring Well** – Other wells are included in the monitoring network to provide redundancy for representative wells, and to maintain a robust network for evaluation as part of five-year GSP updates.

Representative monitoring wells were selected as part of monitoring network development. Representative monitoring wells are wells that represent conditions in the basin, and in locations that allow monitoring on the well to indicate the long term, regional changes in its vicinity.

Representative groundwater level and groundwater storage sites within each management area were selected by several different criteria. These include:

1. **Adequate Spatial Distribution –** Representative monitoring does not usually require wells to be spatially "clumped" together within the Basin. Adequately spaced wells will provide greater Basin coverage with fewer monitoring sites.
2. **Robust and Extensive Historical Data –** representative monitoring sites with longer and more robust historical data provide insight into long-term trends that can provide information about groundwater conditions through varying climatic periods such as droughts and wet periods. Historical data may also show changes in groundwater conditions through anthropogenic effects as well. While some sites chosen may not have extensive historical data, they may still be selected because there are no wells nearby with longer records.
3. **Increased Density in Heavily Pumped Areas –** Selection of additional wells in heavily pumped areas such as in the central portion of the Basin and other agriculturally intensive areas will provide additional data where the most groundwater change occurs.
4. **Increased Density near Areas of Geologic, Hydrologic, or Topologic Uncertainty** – Having a greater density of representative wells in areas of uncertainty, such as around faults or large elevation gradients may provide insightful information about groundwater dynamics to improve management practices and strategies.
5. **Wells with Multiple Depths** – The utilization of wells with different screen intervals is important to collect data on the groundwater conditions at different elevations within the aquifer. This can be achieved by using wells with different screen depths that are close to one another, or by using multi-completion wells.
6. **Consistency with BMPs –** Using published Best Management Practices (BMPs) provided by DWR will ensure consistency across all basins and ensure compliance with established regulations.
7. **Adequate Well Construction Information –** Well information such as perforation depths, construction date, and well depth should be considered and encouraged when considering wells to be included.
8. **Professional Judgement** – Professional judgement is used to make the final decision about each well, particularly when more than one suitable well exists in an area of interest.

4.5.6 Groundwater Level Monitoring Network

The Groundwater Level Monitoring Network is comprised of 88 of wells within the Basin. Forty-nine of those wells are representative wells. Overall well density is 23.3 wells per 100 square miles. Figure 4-17 shows the locations of the groundwater level monitoring network monitoring wells and representative wells.

Table 4-16 includes the wells in the Groundwater Level Monitoring Network. Representative wells, those with sufficient data and representative trends within the Basin, are identified with the asterisk (*) next to the OPTI ID and are sorted first. Metadata for the wells is also included.

The proposed monitoring frequency is monthly for the first three years of GSP implementation with an option to reduce to quarterly monitoring if the CBGSA Board decides that it is appropriate. This monitoring frequency captures short term, seasonal, and long-term trends in groundwater levels. The well density of 23.3 wells per 100 square miles in the monitoring network provides a spatial density that adequately covers the primary aquifer in the Basin, and is useful for determining flow directions and hydraulic gradients as well as change in storage calculations for use in future water budgeting efforts in portions of the basin with significant land use.

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (ft.)	Hole Depth (ft.)	Screen Interval	Well Elevation (ft. above MSL)	Reference Point Elevation (ft. above MSL	First Measurement Year	Last Measurement Year	Measurement Period (yrs)	Measurement Count
2*	SB County		73.0		N/A	3720		2011	2017	6	17
62*	SB County		212		N/A	2921		1966	2018	52	65
72*	DWR/USGS	1/1/1980	790	820	340 - 350 ft.	2171		1981	2018	37	114
77*	DWR/USGS	12/4/2008	980	1003.5	960 - 980 ft.	2286		2009	2018	9	47
85*	Private Landowner		233		N/A	3047		1950	2018	68	282
89*	Private Landowner	1/1/1965	125		N/A	3461		1965	2017	52	68
91*	DWR/USGS	9/29/2009	980	1000	960 - 980 ft.	2474		2009	2018	9	47
95*	Private Landowner	4/9/2009	805.	825.	N/A	2449		2009	2018	9	32
96*	Private Landowner	2/1/1980	500		N/A	2606		1983	2018	35	61
98*	DWR		750.		N/A	2688		2008	2018	10	32
99*	DWR/USGS	9/10/2009	750	906	730 - 750 ft.	2513		2009	2018	9	43
100*	DWR/USGS	11/1/1988	284.	302.	N/A	3004		2010	2018	8	28
101*	DWR/USGS		200	220	N/A	2741		2008	2018	10	42
103*	DWR/USGS	7/23/2010	1030.	1040.	N/A	2289		2012	2018	6	25
106*	DWR/USGS		227.5		N/A	2327	2327	2016	2018	2	9
108*	DWR/USGS		328.75		N/A	2629	2630	2016	2018	2	8
115*	DWR/USGS		1200		N/A	2276	2278	2016	2018	2	4
117*	DWR/USGS		212		N/A	2098	2095	2016	2018	2	10
118*	DWR/USGS		500		N/A	2270	2271	2016	2018	2	11
121*	DWR/USGS		98.25		N/A	1984	1985	2016	2018	2	16
123*	DWR		138		N/A	2165	2167	2016	2018	2	14
127*	DWR/USGS		100.25		N/A	2364	2365	2016	2018	2	14
316*	DWR/USGS	9/29/2009	830	1000	N/A	2474		2009	2018	9	27
317*	DWR/USGS	9/29/2009	700	1000	N/A	2474		2009	2018	9	28
322*	DWR/USGS	4/9/2009	850	906	N/A	2513		2009	2018	9	27
324*	DWR/USGS	9/10/2009	560	906	N/A	2513		2009	2018	9	26
325*	DWR/USGS	9/10/2009	380	906	N/A	2513		2009	2018	9	26
420*	DWR/USGS	12/4/2008	780	1003.5	N/A	2286		2009	2018	9	29
421*	DWR/USGS	12/4/2008	620	1003.5	N/A	2286		2009	2018	9	29
422*	DWR/USGS	12/4/2008	460	1003.5	N/A	2286		2009	2018	9	28
602*	DWR/USGS	6/12/1905	725		325 - 725 ft.	2114		1992	2017	25	29
604*	DWR/USGS		924		454 - 924 ft.	2125		1995	2017	22	28
608*	DWR/USGS	6/10/1905	745		440 - 745 ft.	2224		1995	2017	22	26
609*	DWR/USGS	6/15/1905	970		476 - 970 ft.	2167		1995	2017	22	31
610*	DWR/USGS		780		428 - 780 ft.	2442		1995	2017	22	27
612*	DWR/USGS		1070		657 - 1070 ft.	2266		1995	2017	22	24
613*	DWR/USGS		830		330 - 830 ft.	2330		1995	2017	22	24
615*	SB County		865		480 - 865 ft.	2327		1995	2017	22	22

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (ft.)	Hole Depth (ft.)	Screen Interval	Well Elevation (ft. above MSL)	Reference Point Elevation (ft. above MSL	First Measurement Year	Last Measurement Year	Measurement Period (yrs)	Measurement Count
620*	SB County	6/19/1905	1035		550 - 1035 ft.	2432		1997	2017	20	25
627*	SB County	6/23/1905	960		460 - 960 ft.	2279		2001	2017	16	19
629*	USGS		1000		500 - 1000 ft.	2379		2005	2017	12	13
633*	USGS		1000		500 - 1000 ft.	2364		1998	2017	19	23
830*	DWR/USGS		77.2		N/A	1571		2017	2018	1	6
833*	DWR/USGS		503.55		N/A	1457		2017	2018	1	6
835*	DWR/USGS		162.2		N/A	1555		2017	2018	1	6
840*	Private Landowner	11/21/2014	900		200 - 880 ft.	1713		2015	2018	3	7
841*	Private Landowner	12/12/2014	600		170 - 580 ft.	1761		2015	2018	3	11
845*	Private Landowner	7/12/2015	380		100 - 360 ft.	1712		2015	2018	3	8
849*	Private Landowner	6/23/2015	570		150 - 550 ft.	1713		2015	2018	3	10
74	DWR/USGS				N/A	2193		2008	2018	10	45
84	SB County		200		N/A	2923		2008	2018	10	28
102	DWR/USGS				N/A	2046		2010	2018	8	22
104	DWR/USGS		640		479 - 639 ft.	2299	2301	2008	2017	9	32
105	DWR/USGS		Confidential		N/A	2374	2375	1990	2017	27	38
109	DWR/USGS		503.55		N/A			2017	2018	1	5
120	DWR/USGS		15.4		N/A	1705	1707	2016	2017	1	2
122	DWR		63.2		N/A	2129	2131	2016	2018	2	16
125	DWR/USGS		26		N/A	2283	2284	2016	2018	2	9
128	DWR/USGS	3/15/1990	140.	150.	N/A	3721		2014	2017	3	8
467	DWR/USGS	1/1/1963	1140.	1215.	N/A	2224					
571	DWR/USGS	1/1/1951			N/A	2307		2017	2018	1	2
591	DWR/USGS		720	740	N/A	1715		2017	2018	1	2
597	DWR/USGS		390	670	N/A	1694		2017	2018	1	2
601	DWR/USGS	6/14/1905	723		338 - 723 ft.	2074		1993	2017	24	32
603	DWR/USGS	6/15/1905	800		398 - 800 ft.	2097		1994	2017	23	33
614	SB County		745		405 - 745 ft.	2337		1995	2017	22	25
618	SB County	6/18/1905	927		496 - 927 ft.	2163		1996	2017	21	31
619	SB County	6/19/1905	1040		569 - 1040 ft.	2307		1997	2017	20	28
621	SB County	6/19/1905	974		540 - 974 ft.	2126		1998	2017	19	30
623	SB County	6/21/1905	1040		530 - 1040 ft.	2288		1999	2017	18	29
637	USGS	6/30/1905	980		540 - 980 ft.	2110		2009	2017	8	10
640	USGS	6/30/1905	840		400 - 840 ft.	2239		2008	2017	9	16
641	USGS	7/2/1905	800		360 - 800 ft.	2204		2010	2017	7	7
642	USGS	7/2/1905	1000		550 - 1000 ft.	2232		2010	2017	7	8
644	USGS	7/5/1905	950		490 - 950 ft.	2143		2013	2017	4	10
645	USGS	7/8/1905	930		310 - 930 ft.	2362		2015	2017	2	5
646	Private Landowner	7/8/1905	900		460 - 900 ft.	2188		2016	2017	1	4

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (ft.)	Hole Depth (ft.)	Screen Interval	Well Elevation (ft. above MSL)	Reference Point Elevation (ft. above MSL	First Measurement Year	Last Measurement Year	Measurement Period (yrs)	Measurement Count
831	DWR/USGS		213.75		N/A	1557		2017	2018	1	6
832	DWR/USGS		131.8		N/A	1630		2016	2018	2	8
834	DWR/USGS		320		N/A	1508		2017	2018	1	2
836	DWR/USGS		325		N/A	1486		2017	2018	1	6
842	Private Landowner	12/19/2014	450		60 - 430 ft.	1759		2015	2018	3	13
843	Private Landowner	1/5/2015	620		60 - 600 ft.	1761		2015	2018	3	9
844	Private Landowner	7/17/2015	730		100 - 720 ft.	1713		2015	2018	3	9
846	Private Landowner	6/15/2015	610		130 - 590 ft.	1715		2015	2018	3	10
847	Private Landowner	7/26/2015	600		180 - 580 ft.	1733		2015	2018	3	9
848	Private Landowner	6/30/2015	390		110 - 370 ft.	1694		2015	2018	3	7
850	Private Landowner	8/13/2015	790		180 - 780 ft.	1759		2015	2018	3	9

Table 4-16: Wells included in the Groundwater Levels and Storage Monitoring Network

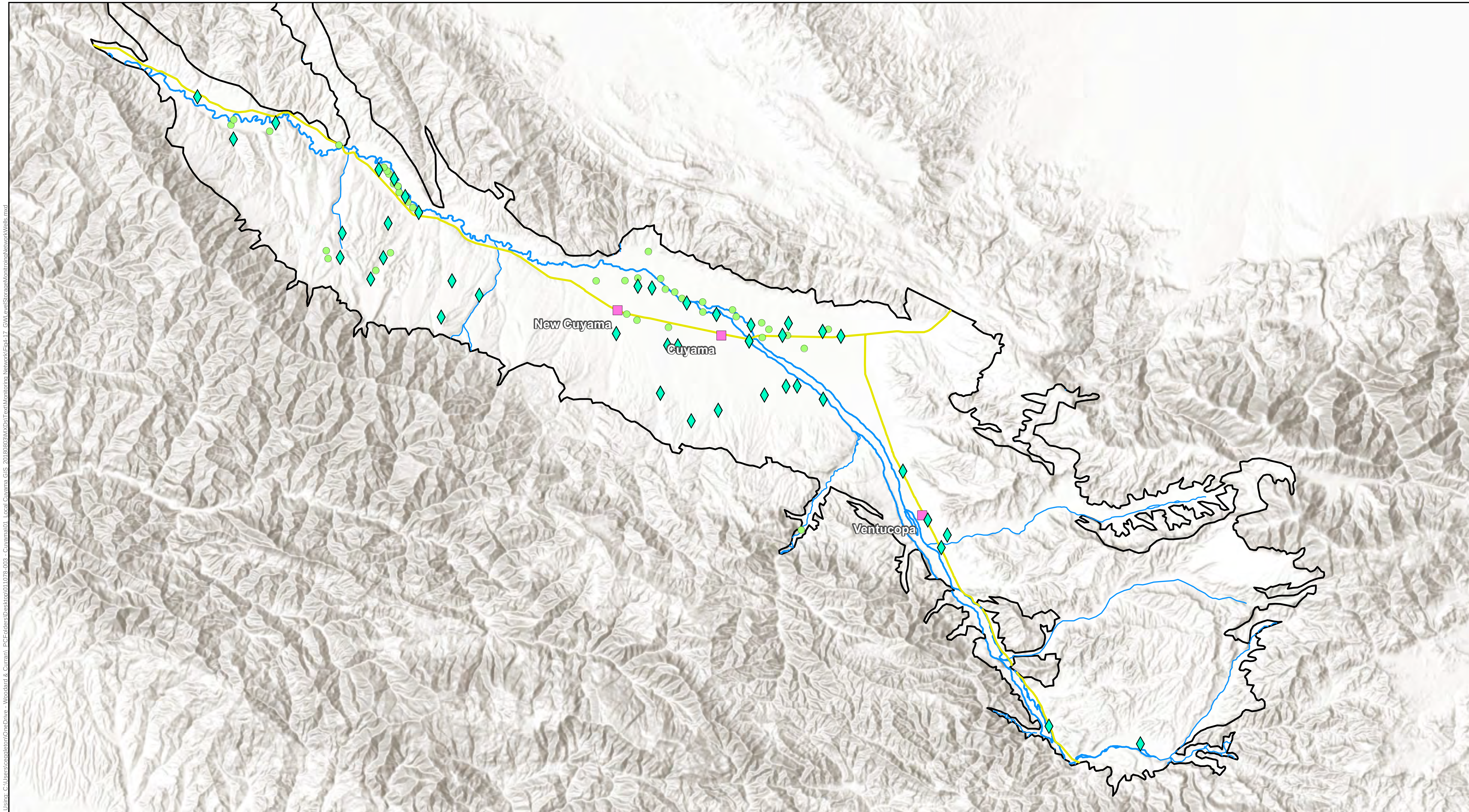

Figure 4-17: Cuyama GW Basin Groundwater Level & Storage Monitoring Network Wells

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- Streams

Monitoring Network Wells

- Representative Wells
- Monitoring Network Wells

N

0 2 4 8 Miles

4.5.7 Monitoring Protocols

Monitoring protocols for the groundwater level monitoring network are included in Appendix K.

4.5.8 Data Gaps

Groundwater levels monitoring data gaps are the result of two monitoring characteristics:

- Spatial distribution of the wells
- Well construction information

The spatial distribution of the groundwater levels monitoring network provides coverage of the majority of the Basin. There are several areas, identified by the red ovals in Figure 4-18, that do not have adequate monitoring. Additional monitoring wells added in these areas will provide more information that can be used to detect changes in conditions in the basin.

Well construction information is not available for many wells within the Basin. Monitoring wells with construction information featuring total depth and screened interval are preferred, because that information is useful in understanding what monitoring measurements mean in terms of basin conditions at different depths.

4.5.9 Plan to fill data gaps

This GSP has identified a number of activities to increase the robustness of the groundwater level monitoring network.

The CBGSA has already been awarded a Category 1 Grant Fund, which includes a task to expand the groundwater level monitoring network. This task includes identification of additional monitoring wells for hand measurements as well as installation of continuous monitoring equipment into ten existing wells. This task will both increase the spatial coverage of the monitoring network and the temporal coverage in the wells with additional continuous monitoring.

DWR provides Technical Support Services (TSS) to support GSAs as they develop GSPs. Opportunities within the TSS include the installation of new monitoring wells and downhole video logging. New wells drilled by DWR's TSS will improve the density and sampling frequency for level monitoring within the Basin. Downhole video logging will provide more well construction information to better utilize well data within the Basin.

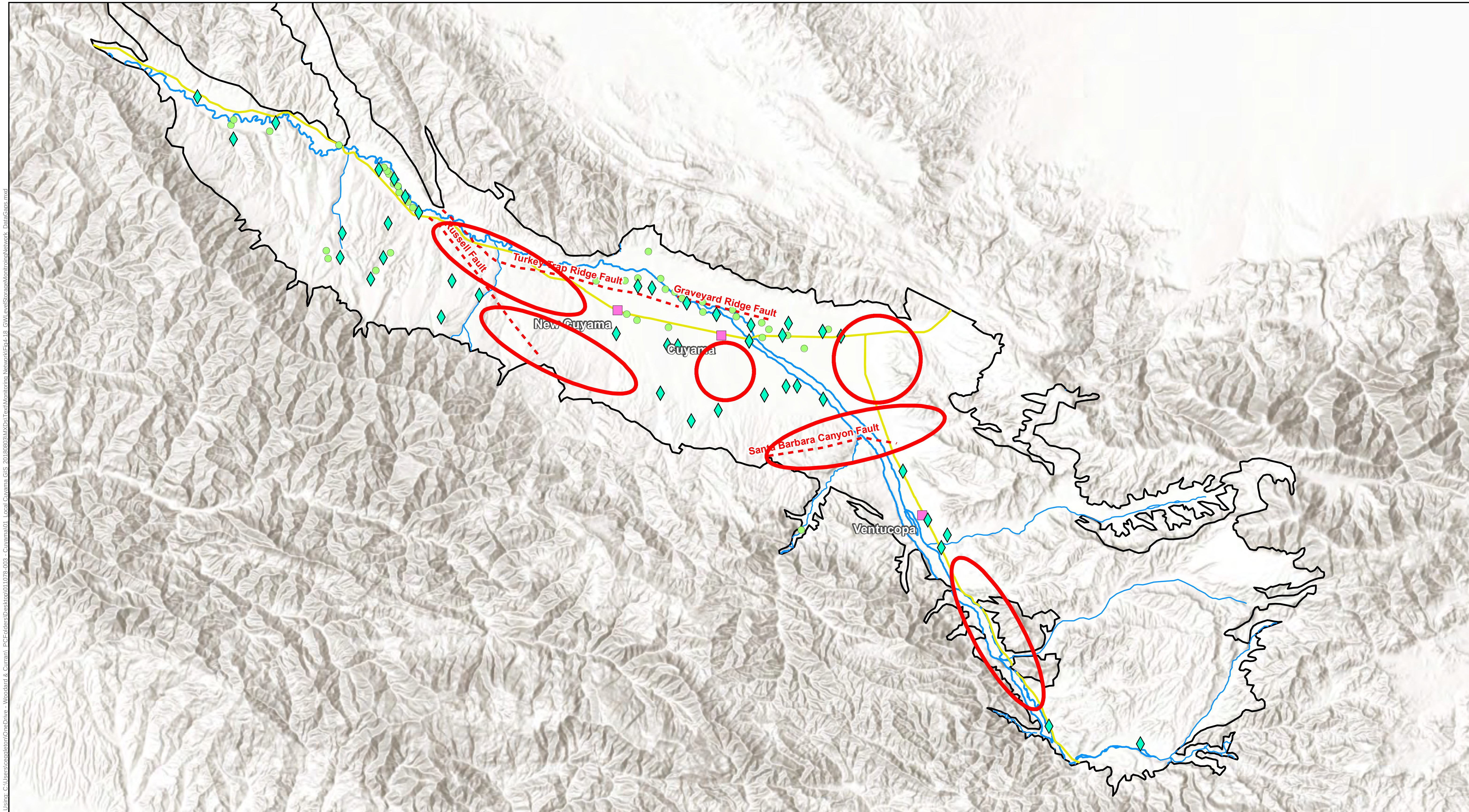

Figure 4-18: Cuyama GW Basin Groundwater Level & Storage Monitoring Network Data Gaps

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- Highways
- Cuyama River
- Streams

Monitoring Network Wells

- Representative Wells
- Monitoring Network Wells

N

0 2 4 8 Miles

4.6 Groundwater Storage Monitoring Network

Groundwater in storage is monitored through the measurement of groundwater levels. Therefore, the Groundwater storage monitoring network will use the groundwater level monitoring network. Thresholds for groundwater storage will be discussed in Section 5.

4.7 Seawater Intrusion Monitoring Network

The Cuyama Groundwater Basin is geographically and geologically isolated from the Pacific Ocean and any other large source of saline water. Thus, the Basin is not at risk for seawater intrusion. salinity is monitored as part of the groundwater quality network, but seawater intrusion is not a concern for the Basin.

4.8 Degraded Groundwater Quality Monitoring Network

Due to the relationship of undesirable results for water quality and the causal nexus of groundwater quality and GSP actions, the groundwater quality network is established to monitor for salinity.

4.8.1 Management Areas

Management Areas have not been selected at the time of writing this GSP section. Management Areas allow flexibility in establishing monitoring networks both spatially and temporally to match conditions and use in the management area. At this time, it is recommended due to the sparsity of monitored sites to use the same monitoring network selection criteria across all management areas in the basin.

4.8.2 Monitoring Sites Selected for Monitoring Network

Table 4-17 lists the monitoring sites selected for the groundwater quality monitoring network by monitoring group. Monitoring sites selected for inclusion into the network were monitored within the years of 2008-2018. Many additional monitoring sites have been monitored for salinity, however, they were not monitored in the last 10 years, indicating that they are unlikely to be monitored again by that monitoring agency. Note that due to duplication of wells being in both USGS and DWR's networks, the total number of selected groundwater quality networks wells (64) is less than the sum of wells shown in Table 4-17

Monitoring Group	Number of Wells Selected for Monitoring Network
NWQC, USGS, IRLP	43
GAMA, DWR	20
BCWPD	7
Private Landowner	11

Table 4-17: Groundwater Quality Monitoring Sites by Source

4.8.3 Monitoring Frequency

Monitoring agencies such as the USGS and DWR were contacted to inquire about when they would next monitor their sites for groundwater quality, including salinity. The agencies communicated that they ‘usually’ monitor annually, but the timing of that monitoring is not set and changes from year to year. Additionally, depending on funding and staff availability, there may be years where no groundwater quality monitoring is conducted by an agency.

Although DWR does not provide specific recommendations on the frequency of monitoring in relationship to aforementioned groundwater characteristics, however, concentrations of groundwater quality, especially salinity, do not fluctuate significantly throughout a year to require multiple samples per year. The Basin, in coordination with partnering agencies, will compile salinity samples once a year, as is consistently practiced by USGS.

4.8.4 Spatial Density

DWR’s *Monitoring Networks and Identification of Data Gaps BMP* states “The spatial distribution must be adequate to map or supplement mapping of known contaminants.” Using this guidance, professional judgement was used to identify representative wells within each management area. Heavily pumped areas, such as the central portion of the Basin, require additional monitoring sites, while areas of lower pumping or less agricultural or municipal groundwater use need less monitoring.

The selected groundwater quality representative and monitoring wells provide adequate coverage of the Basin’s aquifer. The groundwater quality monitoring network is composed of 64 of wells within the Basin. Providing a monitoring site density of 17 sites per 100 square miles. This significantly exceeds the density recommended by reference materials for groundwater level density shown in Table 4-15.

4.8.5 Representative Monitoring

Representative monitoring sites were selected for groundwater quality using the considerations used to select representative groundwater level monitoring wells (Section 4.5.5). Due to the uncertainty of the monitoring frequency, all monitoring network wells were selected to be representative wells.

4.8.6 Groundwater Quality Monitoring Network

Figure 4-19 shows the groundwater quality monitoring network and representative and monitoring sites. The Groundwater Quality Monitoring Network is composed of 64 of wells within the Basin. All 64 wells are representative wells.

Table 4-18 shows the wells in the groundwater quality monitoring network. Representative wells, those with sufficient data and represent trends within the Basin, are identified with the asterisk (*) next to the OPTI ID and are sorted first. Metadata for the wells is also included.

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth	Hole Depth	Screen Interval	Well Elevation	First Measurement Date	Last Measurement Date	Measurement Period (years)	Measurement Count
61*	Department of Water Resources		357.		Unknown	3681	2008-09-25	2008-09-25	0	3
72*	Santa Barbara County Water Agency	1/1/1980	790	820	340 to 350 ft.	2171	2008-09-15	2017-07-14	9	13
73*	Santa Barbara County Water Agency	8/26/1982	880.	1021.	Unknown	2252	2010-08-03	2011-07-12	1	2
74*	Santa Barbara County Water Agency				Unknown	2193	2008-09-17	2017-07-13	9	11
76*	USGS	9/1/1960	720		Unknown	2277	1960-09-22	2008-09-17	48	10
77*	Santa Barbara County Water Agency	12/4/2008	980	1003.5	960 to 980 ft.	2286	2009-04-08	2009-04-08	0	1
79*	USGS		600	750	Unknown	2374	2008-07-08	2011-08-11	3	7
81*	USGS		155.		Unknown	2698	2011-08-16	2011-08-16	0	1
83*	Santa Barbara County Water Agency	1/1/1972	198.		Unknown	2858	2011-08-16	2011-08-16	0	1
85*	Santa Barbara County Water Agency		233		Unknown	3047	1964-02-07	2011-07-12	47	46
86*	USGS	1/1/1995	230.		Unknown	3141				0
87*	USGS		232.		Unknown	3546				0
88*	USGS	9/4/2007	400	400.	Unknown	3549	2011-08-18	2011-08-18	0	1
90*	Santa Barbara County Water Agency	8/8/2006	800	800	Unknown	2552	2008-09-17	2012-09-20	4	6
91*	Santa Barbara County Water Agency	9/29/2009	980	1000	960 to 980 ft.	2474	2009-11-05	2009-11-05	0	1
94*	USGS		550	720	Unknown	2456	2008-07-29	2010-07-29	2	6
95*	Santa Barbara County Water Agency	4/9/2009	805.	825.	Unknown	2449	2011-08-19	2011-08-19	0	1
96*	Santa Barbara County Water Agency	2/1/1980	500		Unknown	2606	2011-08-19	2011-08-19	0	1
98*	Santa Barbara County Water Agency		750.		Unknown	2688	2011-08-16	2011-08-16	0	1
99*	Santa Barbara County Water Agency	9/10/2009	750	906	730 to 750 ft.	2513	2009-11-04	2009-11-04	0	1
101*	Santa Barbara County Water Agency		200	220	Unknown	2741	2008-09-25	2008-09-25	0	3
102*	Santa Barbara County Water Agency				Unknown	2046	2011-08-15	2017-07-13	6	7
130*	USGS				Unknown	3536	2011-08-19	2011-08-19	0	1
131*	USGS				Unknown	2990	2011-08-17	2011-08-17	0	1
157*	USGS		71.0		Unknown	3755				0
196*	USGS		741	755	Unknown	3117				
204*	USGS	1/1/1935			Unknown	3693	2011-08-18	2011-08-18	0	1
226*	USGS	1/1/1971		220.	Unknown	2945	2011-08-18	2011-08-18	0	1
227*	USGS				Unknown	3002	1966-07-01	2011-08-17	45	2
242*	USGS		155	187	Unknown	2933	2012-07-18	2012-07-18	0	1
269*	USGS	1/1/1951			Unknown	2756	2008-09-16	2008-09-16	0	3
309*	USGS	2/2/1980	1100	1100	Unknown	2513	2011-08-11	2011-08-11	0	1
316*	USGS	9/29/2009	830	1000	Unknown	2474	2009-11-05	2009-11-05	0	1
317*	USGS	9/29/2009	700	1000	Unknown	2474	2009-11-05	2009-11-05	0	1
318*	USGS	9/29/2009	610	1000	Unknown	2474	2009-11-04	2009-11-04	0	1
322*	USGS	4/9/2009	850	906	Unknown	2513	2009-11-03	2009-11-03	0	1
324*	USGS	9/10/2009	560	906	Unknown	2513	2009-11-04	2009-11-04	0	1
325*	USGS	9/10/2009	380	906	Unknown	2513	2009-11-04	2009-11-04	0	1
400*	USGS		2120.	2200.	Unknown	2298	1958-05-26	2011-08-15	53	8
420*	USGS	12/4/2008	780	1003.5	Unknown	2286	2009-04-07	2009-04-07	0	1
421*	USGS	12/4/2008	620	1003.5	Unknown	2286	2009-04-07	2009-04-07	0	1
422*	USGS	12/4/2008	460	1003.5	Unknown	2286	2009-04-08	2009-04-08	0	1
424*	USGS		1000.	1020.	Unknown	2291	2011-08-15	2011-08-15	0	1
467*	USGS	1/1/1963	1140.	1215.	Unknown	2224	2012-07-18	2017-07-13	5	6
568*	USGS	1/1/1948	188	188	Unknown	1905	2008-09-15	2008-09-15	0	3

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth	Hole Depth	Screen Interval	Well Elevation	First Measurement Date	Last Measurement Date	Measurement Period (years)	Measurement Count
702*	USGS				Unknown	3539				
703*	USGS				Unknown	1613				
710*	DWR				Unknown	2942				
711*	DWR				Unknown	1905				
712*	DWR				Unknown	2171				
713*	DWR				Unknown	2456				
721*	DWR				Unknown	2374				
758*	DWR				Unknown	3537				
840*	Private Landowner	11/21/2014	900		200 to 880 ft.	1713				
841*	Private Landowner	12/12/2014	600		170 to 580 ft.	1761				
842*	Private Landowner	12/19/2014	450		60 to 430 ft.	1759				
843*	Private Landowner	1/5/2015	620		60 to 600 ft.	1761				
844*	Private Landowner	7/17/2015	730		100 to 720 ft.	1713				
845*	Private Landowner	7/12/2015	380		100 to 360 ft.	1712				
846*	Private Landowner	6/15/2015	610		130 to 590 ft.	1715				
847*	Private Landowner	7/26/2015	600		180 to 580 ft.	1733				
848*	Private Landowner	6/30/2015	390		110 to 370 ft.	1694				
849*	Private Landowner	6/23/2015	570		150 to 550 ft.	1713				
850*	Private Landowner	8/13/2015	790		180 to 780 ft.	1759				

Table 4-18: Wells Included in the Groundwater Quality Monitoring Network

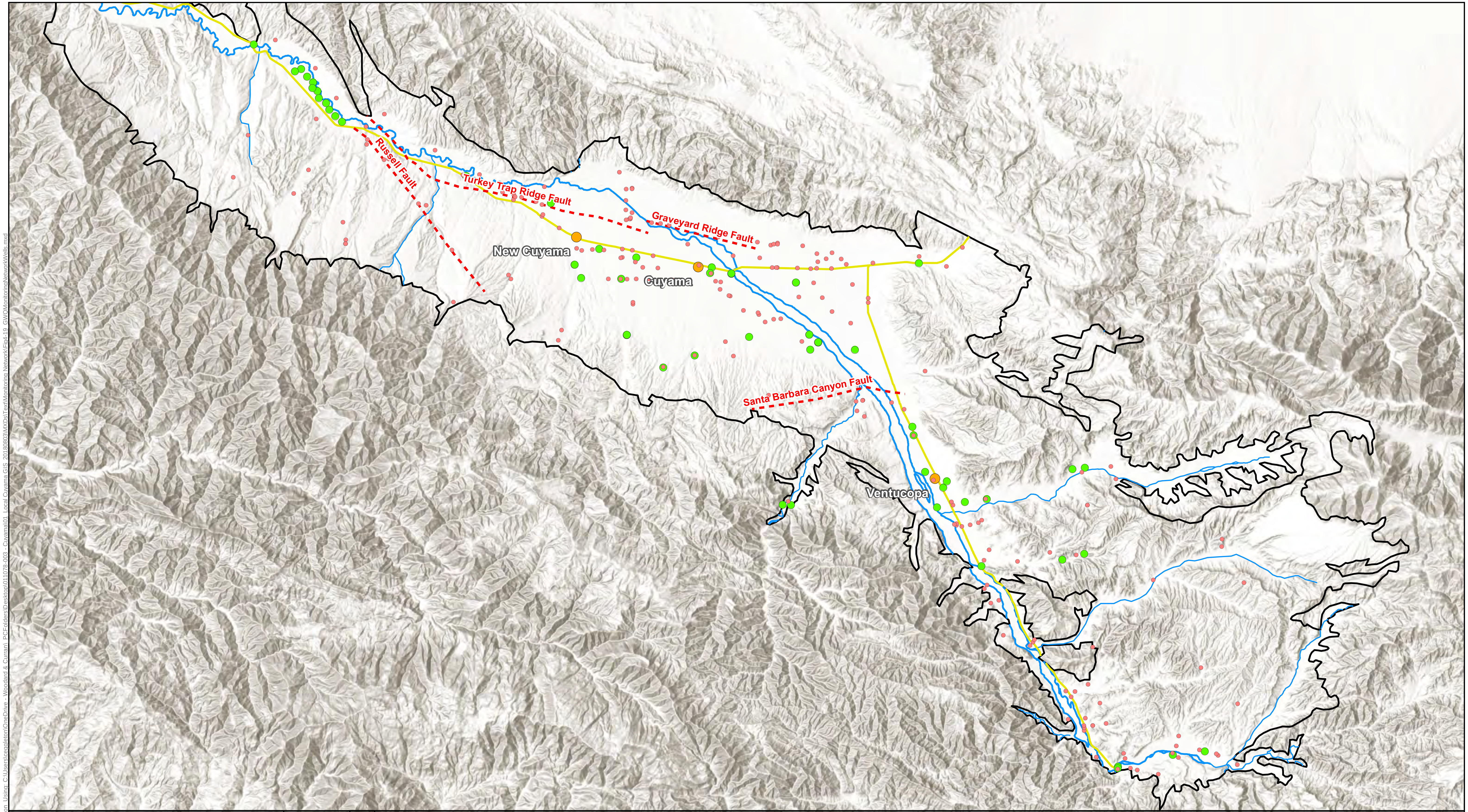

Figure 4-19: Cuyama GW Basin Groundwater Quality Monitoring Network Wells

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Representative Wells and Groundwater Quality Monitoring Network Wells
- Non-Groundwater Quality Monitoring Network Wells

All wells included in the Groundwater Quality Monitoiring Network have been measured since 1/1/2008. Wells measured prior to 2008 are not included.

N

0 1.75 3.5 7 Miles

4.8.7 Monitoring Protocols

Existing groundwater quality monitoring programs use their agency's specific monitoring protocols.

For recommended additional monitoring recommended in Section 4.8.9, the monitoring protocols will use DWR's *Monitoring Networks and Identification of Data Gaps BMP* which sites the USGS's 1995 publication *Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data* (Appendix A) for the groundwater quality sampling protocols. This publication includes protocols for equipment selection, setup, use, field evaluation, sample collection techniques, sample handling, and sample testing, and is included in Appendix L.

4.8.8 Data Gaps

Groundwater quality monitoring data gaps have three components:

- Spatial distribution of the wells
- Well/measurement depths for three-dimensional constituent mapping
- Temporal sampling

The spatial distribution of the groundwater quality monitoring network provides coverage of several portions of the Basin. There are several areas, identified by the red ovals in Figure 4-20, that do not have adequate monitoring. Additional sampling taken within these identified areas will provide more information about salinity in the indicated locations.

Well construction of wells used in salinity sampling is mostly unknown, and the depth of the water used for sampling is not known at most monitoring sites. Additional information about how salinity may change at different depths in the aquifer would be valuable, and requires samples from wells with construction information.

The entire Basin is identified as a groundwater quality monitoring temporal data gap. Management entities within the Basin responsible for groundwater quality sampling were contacted by a GSA representative in September 2018, to understand the timing of current monitoring schedules, and whether those management entities were intending to continue quality monitoring in the future. All management entities are anticipating continuing with groundwater quality sampling within the Basin, but the schedule of the sampling was unknown.

4.8.9 Plan to fill data gaps

The CBGSA will fill the temporal and spatial data gaps by implementing its own salinity sampling program, and will fill the well construction knowledge gap at least partially by using DWR's TSS program.

The CBGSA will develop and perform a project to perform annual monitoring of salinity in the basin. This new monitoring program will focus on using wells that have both construction information and pumps installed. Details of the new monitoring program, such as the targeted number and distribution of sampling sites will be detailed as a project in the projects and management actions section of this GSP (Section 6).

DWR provides Technical Support Services (TSS) to support GSAs as they develop GSPs. Downhole video logging performed by the TSS program in existing salinity monitoring wells will provide more well construction information to better utilize well data within the Basin.

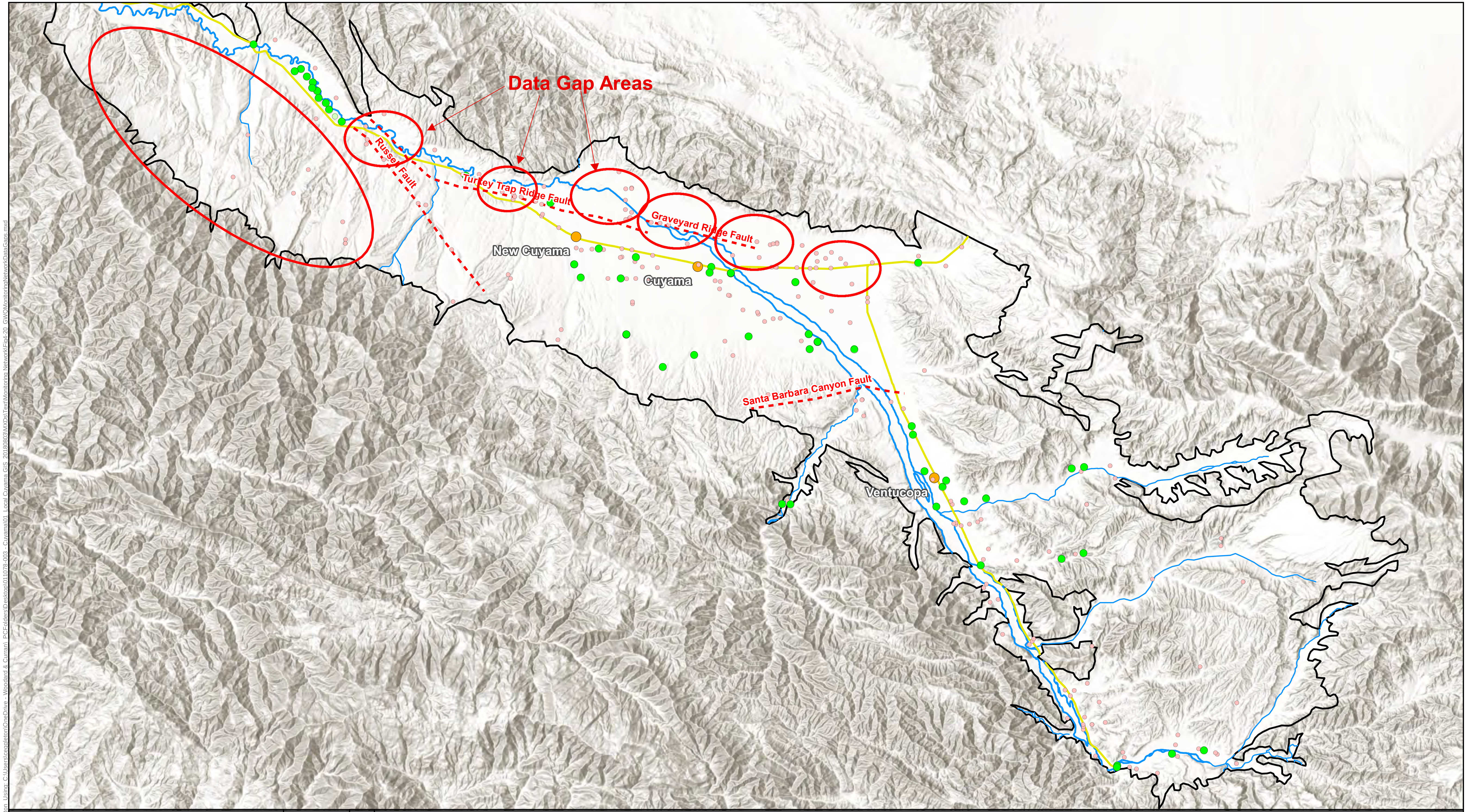

Figure 4-20: Cuyama GW Basin Groundwater Quality Monitoring Network Data Gaps

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4.9 Land Subsidence Monitoring Network

4.9.1 Management Areas

Management Areas have not been selected at the time of writing this GSP section. Management Areas allow flexibility in establishing monitoring networks both spatially and temporally to match conditions and use in the management area. At this time, it is recommended due to the sparsity of monitored sites to use the same monitoring network selection criteria across all management areas in the basin.

4.9.2 Monitoring Sites Selected for Monitoring Network

There are currently two subsidence monitoring stations within the Basin, and three outside of the Basin. Figure 4-21 shows the locations of existing subsidence monitoring stations, which make up the current subsidence monitoring network. The two stations within the Basin, Sites CUHS and VCST are both include in the monitoring network because they are active and provide Basin specific data. The three stations located outside of the Basin, Sites P521, BCWR, and OZST, are also included in the monitoring network. These stations are important to understand the general dynamic movement trends of the Basin because they detect tectonic movement in the area of the Basin.

4.9.3 Monitoring Frequency

Subsidence monitoring frequencies should capture long-term and seasonal fluctuations in ground level changes. DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific monitoring frequency or interval guidance. However, CGPS stations allow for data sampling to be taken several times a minute, more than enough for seasonal fluctuations to captured in the data. Long-term trends are easily compiled from continuous data.

4.9.4 Spatial Density

The current spatial density of subsidence monitoring stations within the basin is 0.5 stations per 100 miles^2. These stations are included in Figure 4-21. DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific spatial density guidelines for subsidence monitoring networks, and thus relies on professional judgment on site identification. Current stations, in and outside of the basin, do not adequately cover the Basin to capture subsidence variations. Potential areas for new station are discussed further in the following sections.

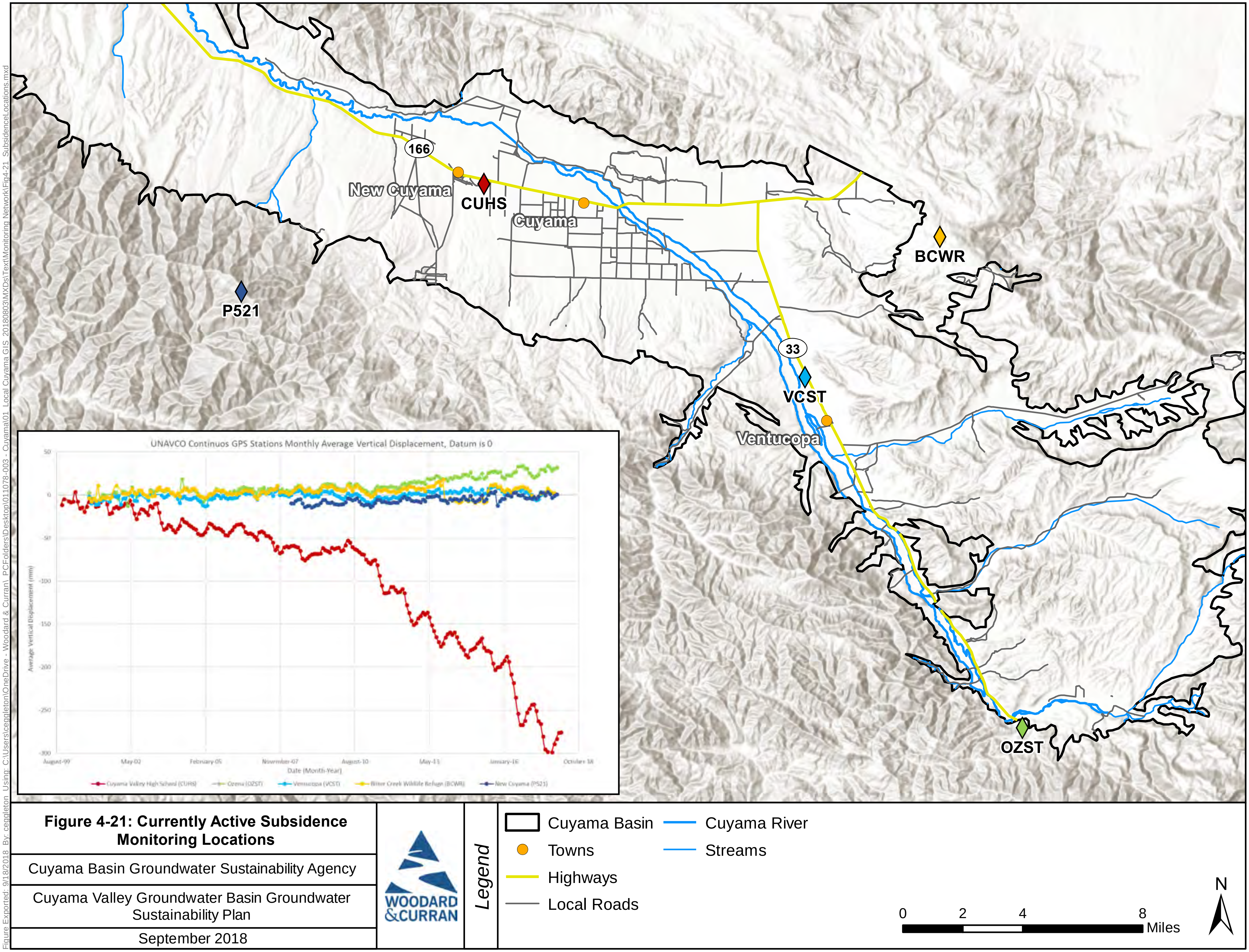

Figure 4-21: Currently Active Subsidence Monitoring Locations

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4.9.5 Monitoring Protocols

DWR's provided *Monitoring Networks and Identification of Data Gaps GMP* does not provide specific monitoring protocols for subsidence monitoring networks. CGPS station measurements are logged digitally, and depending on the station and network setup, either require downloading at the physical station site or are uploaded automatically to a server. Data management will also depend on the monitoring agency. Current operating stations will continue to be managed by their current entity, and the GSA will be responsible for downloading data on a fixed schedule. New stations will require downloading the data as equipment storage or need requires and providing quality assurance review of the data.

Data should be saved on a regular annual schedule. All data should be reviewed for quality and logged appropriately.

4.9.6 Data Gaps

New subsidence monitoring sites should be chosen to provide data on areas most at risk for land subsidence. Six potential new site locations were identified within the Basin, as shown in Figure 4-22. These locations were identified by focusing on the areas with significant or new groundwater pumping that did not currently have subsidence monitoring nearby.

A. Identified as an area with relatively new and increased agricultural activity and pumping with no nearby stations.
B. Identified because there are currently no nearby stations and the Russell Fault bisects this area.
C. Identified because of the CCSD and proximity to the heavily pumped central portion of the Basin.
D. Identified because this is the most heavily pumped portion of the Basin and there are currently no nearby stations.
E. Identified because of its proximity to the heavily pumped portion of the Basin, on the north facing slop of the valley. Additionally, there are currently no stations nearby.
F. Identified because this is the transition into the heavily pumped central portion of the Basin near current agricultural pumping. This is also an area with faults.

4.9.7 Plan to fill data gaps

New monitoring sites should be located near areas with the greatest groundwater pumping, or where pumping is new. This is because pumping is the primary driving force for subsidence with the Basin. Although there are multiple ways to measure subsidence, CGPS stations are likely the best option for the Basin. CGPS stations are relatively low cost when compared to labor intensive land surveys, construction of borehole extensometers, and frequent satellite data processing. CGPS stations require comparatively little maintenance and provide continuous information allowing detailed land subsidence analysis.

Increasing data collection on subsidence for the Basin requires the addition of several new CGPS stations. Theses stations can be managed solely by the GSA or can be incorporated into CORS via coronation with USGS. Site selection, equipment, and management will require coordination with USGS

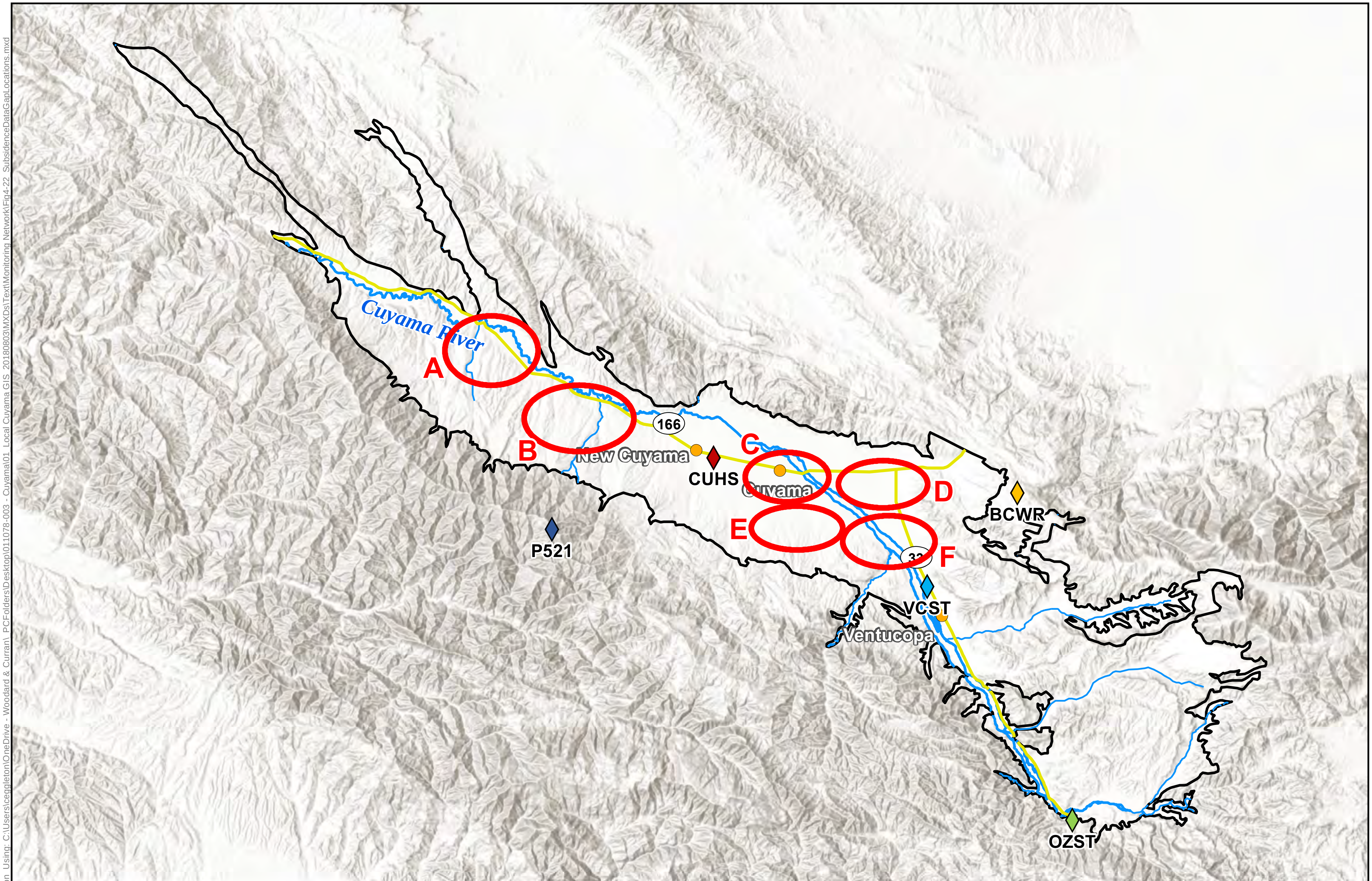

Figure 4-22: Subsidence Monitoring Location Data Gap Areas

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams

Figure Exported: 9/18/2018 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran\ PCFolders\Desktop\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\TextMonitoring Network\Fig4-22_SubsidenceDataGapLocations.mxd

4.10 Depletions of Interconnected Surface Water Monitoring Network

Monitoring Networks for depletions of surface water cannot be developed until the numerical modeling effort can inform the GSP about the amounts and locations of depletions. This section will be added prior to plan completion.

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Appendix A - Monitoring Protocols BMP

Appendix B - Water Quality Monitoring Standards From USGS