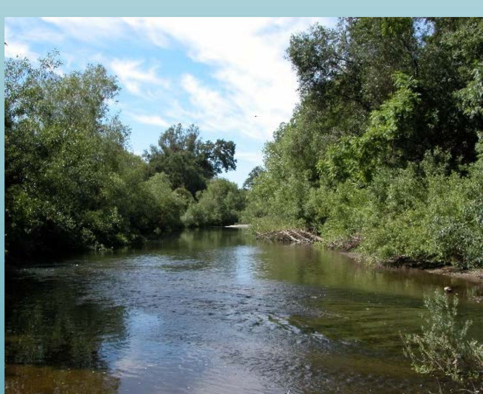
NAPA COUNTY

GROUNDWATER SUSTAINABILITY

Annual Report – Water Year 2017



Prepared by

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Napa County
Groundwater Sustainability:
Annual Report – Water Year 2017

February 2018

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ABBREVIATIONS AND ACRONYMS

Basin Analysis Report	*Napa Valley groundwater sustainability: a basin analysis report for the Napa Valley Subbasin*
BOS	Board of Supervisors
CASGEM	California Statewide Groundwater Elevation Monitoring
CCP	Center for Collaborative Policy
CGS	California Geological Survey
Cl	chloride
DMS	Database Management System
DWR	California Department of Water Resources
DFW	California Department of Fish and Wildlife
EC	electrical conductivity
ET	Evapotranspiration
eWRIMS	State Water Resources Control Board Electronic Water Rights Information Management System
GDE	Groundwater Dependent Ecosystems
GPM	Gallons per minute
GRAC	Groundwater Resources Advisory Committee
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWL	Groundwater Level
GWQ	Groundwater Quality
IRWMP	Integrated Water Resources Management Plan
LGA	Local Groundwater Assistance
LSCE	Luhdorff & Scalmanini, Consulting Engineers, Inc.
MST	Milliken-Sarco-Tulucay
NAVD88	North American Vertical Datum of 1988
NCFCWCD	Napa County Flood Control and Water Conservation District
NSH	Napa State Hospital
Plan	*Napa County groundwater monitoring plan 2013*

QA, Qa	Quaternary Alluvium
Qsb	Quaternary sedimentary basin
RCD	Resource Conservation District
RWMG	Regional Water Management Group
SGMA	Sustainable Groundwater Management Act
SMR	Soil moisture retention
Subbasin	Napa Valley Subbasin
SWN	State Well Number
SWP	State Water Project
SWRCB	California State Water Resources Control Board
Tss	Tertiary sedimentary rocks
Tsv	Tertiary Sonoma volcanic rocks
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
WAA	Water Availability Analysis
WICC	Watershed Information & Conversation Council
WY	Water Year

EXECUTIVE SUMMARY

ES 1. INTRODUCTION

Groundwater and surface water are highly important natural resources in Napa County. Together, the County and other municipalities, water districts, commercial and industrial operations, the agricultural community, and the general public, are stewards of the available water resources. Everyone living and working in Napa County has a stake in protecting the county's groundwater resources, including groundwater supplies, groundwater quality, and associated watersheds (GRAC, 2014).

Since 2008, the County and others' efforts have been instrumental in implementing groundwater management actions to better understand groundwater conditions, establish monitoring to track conditions, conduct education and outreach, and develop other programs to assess and maintain groundwater sustainability. These efforts included the adoption of Goals and Policies in Napa County's 2008 General Plan, commencing new studies of the County's groundwater resources in 2009, and creation of a Groundwater Resources Advisory Committee (GRAC; 2011 to 2014) to spearhead management implementation and community outreach.

A Napa County Groundwater Monitoring Plan 2013 (Plan) was prepared to formalize and augment groundwater monitoring efforts conducted as part of a Comprehensive Groundwater Monitoring Program. The Plan recommended annual reports on groundwater conditions and modifications to the countywide groundwater monitoring program as needed. Previously, three Annual Reports have been prepared (LSCE, 2015; LSCE, 2016a; and LSCE, 2017a).

This is the first Annual Report prepared to also meet the annual reporting requirements of the Sustainable Groundwater Management Act (SGMA). In December 2016, Napa County submitted the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c) as an alternative to a Groundwater Sustainability Plan (GSP) in accordance with the GSP Regulations developed by the California Department of Water Resources (DWR). This Report, *Napa County Groundwater Sustainability: Annual Report – Water Year 2017,* presents an update on groundwater conditions and water use in the Napa Valley Subbasin (Subbasin), as required by Section 356.2 of the GSP Regulations. This Report also provides an update on the recommended SGMA implementation actions presented in the Basin Analysis Report.

ES 2. GROUNDWATER RESOURCES GOALS AND MANAGEMENT OBJECTIVES

DWR has identified the major groundwater basins and subbasins in and around Napa County. The basins include the Napa-Sonoma Valley (which in Napa County includes the Napa Valley and Napa-Sonoma Lowlands Subbasins), Berryessa Valley, Pope Valley, and a small part of the Suisun-Fairfield Valley Groundwater Basins (**Figure 2-1**). For purposes of local planning, understanding, and studies, the County has been subdivided into a series of groundwater subareas. These subareas were delineated based on the main watersheds, groundwater basins, and the County's environmental resource planning areas (**Figure 2-2**).

The countywide groundwater level monitoring program includes the following objectives:

- Expand groundwater level monitoring in priority County subareas to improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify hydraulic connections in aquifer systems and aquifer-specific groundwater conditions, especially in areas where short- and long-term development of groundwater resources are planned;
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation, surface water seepage to groundwater, groundwater discharge to streams) or induced factors (e.g., pumping, purposeful recharge/infiltration operations, application of recycled water) that affect groundwater levels and trends;
- Identify appropriate monitoring sites to further evaluate groundwater-surface water interaction and recharge/discharge mechanisms, including whether groundwater utilization is affecting surface water flows;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; and update these analyses as additional data become available.

Based on the analysis of existing groundwater data and conditions described in the report *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a) and with input received from the Groundwater Resources Advisory Committee (GRAC), the key objectives for future groundwater level monitoring for each subarea are summarized in LSCE (2013a) and **Section 3** of this Report.

ES 2.1 Sustainable Groundwater Management Act

In September 2014, the California Legislature passed the Sustainable Groundwater Management Act (SGMA). SGMA changes how groundwater is managed in the state and includes certain requirements of local agencies managing groundwater basins or subbasins that DWR designates as medium-priority or high-priority. Previously under the California Statewide Groundwater Elevation Monitoring Program[1] (CASGEM), DWR classified California's groundwater basins and subbasins as either high, medium, low, or very low priority. The priority classifications are based on eight criteria that include the overlying population, the reliance on groundwater, and the number of wells in a basin or subbasin.

In Napa County, the Napa Valley Subbasin was ranked medium priority (**Figure 2-1**). All other Napa County basins and subbasins were ranked as very low priority. For most basins designated by DWR as medium-priority or high-priority, SGMA requires the designation of groundwater sustainability agencies (GSA) and the adoption of groundwater sustainability plans (GSP); or development of an alternative to a

[11] CASGEM is the California Statewide Groundwater Elevation Monitoring program implemented under Water Code Part 2.11 Groundwater Monitoring and administered by DWR.

GSP, provided that the local entity (entities) can meet certain requirements. Under SGMA, Section 10733.6, a local entity (or entities) can pursue an alternative to a GSP provided that certain sustainability objectives are met. An alternative to a GSP may include, "An analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years" (Section 10733.6(b)(3)). In response to SGMA, Napa County prepared a Basin Analysis Report for the Napa Valley Subbasin per the requirements of Water Code Section 10733.6 (b)(3). While the Basin Analysis Report analyzes areas outside the Subbasin to determine how those areas affect recharge and runoff in the Subbasin, the areas outside the Subbasin are not subject to SGMA. The Basin Analysis Report (LSCE, 2016c) was submitted to DWR on December 16, 2016 in compliance with SGMA.

During the past eight years, Napa County has made significant progress towards implementing groundwater-related studies and implementing recommendations provided by those studies to improve local understanding of groundwater conditions. In conformance with SGMA, the intent of the GRAC, and the direction of the Napa County Board of Supervisors (April 2014), the Napa Valley Subbasin SGMA Sustainability Goal is:

> *To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.*

The Basin Analysis Report comprises a first step in the implementation of SGMA monitoring and reporting requirements. This Report provides an update on the recommended SGMA implementation actions presented in the Basin Analysis Report (see **Section7**) and presents an update on groundwater conditions (see **Section 5**) and water use in the Napa Valley Subbasin (see **Section 6**), as required by Section 356.2 of the GSP Regulations. This Report also includes recommendations that are currently being implemented to maintain or improve groundwater conditions to ensure overall water resources sustainability in the Napa Valley Subbasin (see **Section 8**). SGMA implementation activities underway or completed in 2017, in addition to the monitoring efforts and analyses presented in this Report, included (**Figure 7-1**):

A. Completion of the Northeast Napa Area Special Groundwater Study,

B. Designation of the Northeast Napa Management Area within the Napa Valley Subbasin,

C. Preparation and application of revised conditions of approval requiring additional monitoring and reporting of groundwater conditions and water use for discretionary projects,

D. Providing tools and training to Napa County well owners to support monitoring and awareness of groundwater conditions in wells that they own,

E. Development of datasets to support the expansion of the groundwater flow model developed for the Northeast Napa Management Area to the entire Napa Valley Subbasin,

F. Collaborations and project development to improve best available water use data, and

G. On-going coordination with other water management and planning programs.

ES 3. GROUNDWATER MONITORING NETWORK

Groundwater level monitoring was conducted at a total of 107 sites across Napa County in water year 2017. These included 61 sites within the Napa Valley Subbasin (**Table ES-1)**. **Figure 4-1** shows the distribution of sites monitored in 2017 according to the data reporting entity. Out of the total 107 sites monitored in 2017, 96 were wells monitored by Napa County. Four were wells monitored by DWR. The remaining seven sites were regulated facilities with multiple wells with data reported as part of the State Water Resources Control Board (SWRCB) Geotracker Program.

Two wells previously monitored by Napa County left the monitoring network at the request of the owner in 2017. During the summer of 2017, DWR temporarily suspended monitoring efforts at four wells that it has monitored. That suspension was extended in response to multiple, large wildfires that burned in many areas around Napa Valley in October 2017.

Table ES-1 Groundwater Level Monitoring Sites in the Napa Valley Subbasin and Napa County Groundwater Subareas

Groundwater Basin or Groundwater Subarea	Number of Monitored Wells, Fall 2014	Number of Monitored Wells, Fall 2015	Number of Monitored Wells, Fall 2016	Number of Monitored Wells, Fall 2017
Napa-Sonoma Valley – Napa Valley Subbasin	64	56	57	61
Napa Valley Floor-Calistoga	10	9	7	7
Napa Valley Floor-MST	27	27	26	25
Napa Valley Floor-Napa	21	20	21	21
Napa Valley Floor-St. Helena	14	14	14	14
Napa Valley Floor-Yountville	12	14	13	13
Carneros	12	12	12	12
Jameson/American Canyon	1	1	1	1
Napa River Marshes	1	-	-	-
Angwin	5	5	5	5
Berryessa	2	3	1	1
Central Interior Valleys	1	2	2	2
Eastern Mountains	3	4	3	3
Knoxville	-	-	-	-
Livermore Ranch	-	-	-	-
Pope Valley	1	1	1	1
Southern Interior Valleys	-	-	-	-
Western Mountains	2	1	2	2
Unknown[1]	3	-	-	-
Total Sites	**115**	**113**	**108**	**107**

[1] In 2014 three sites in the Geotracker regulated groundwater monitoring network were reporting groundwater level data but had not yet reported location information for the monitored wells.

ES 4. SUMMARY AND RECOMMENDATIONS

ES 4.1 Groundwater Conditions

Groundwater level trends in the alluvial aquifer system[2] of the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin are stable in the majority of wells with long-term groundwater level records (see **Sections 5.1.1 and 5.1.2**). While many wells showed some degree of response to recent drought conditions (i.e., 2012-2015), the water levels observed in recent years were generally higher than groundwater levels in the same wells during the 1976 to 1977 drought. Groundwater levels showed continued stable conditions with decreasing depths to groundwater in 2017, consistent with the very wet water year[3] conditions.

Groundwater levels recorded in 2017 were above the minimum thresholds established as sustainability criteria for the Napa Valley Subbasin for all 18 wells where data are available (see **Section 5.1.3**). Two other wells where sustainability criteria have been established were not accessible due to wildfire damage or concerns about site safety resulting from wildfires.

Although designated as a groundwater subarea for local planning purposes, the majority of the MST is not part of a groundwater basin as mapped by DWR. Groundwater level declines observed in the MST Subarea as early as the 1960s and 1970s have stabilized since about 2009 (see **Section 5.2**). Groundwater level responses differ within the MST Subarea and even within the north, central, and southern sections of this subarea, indicating that localized conditions, whether geologic or anthropogenic in nature, might be the primary influence on groundwater conditions in this local subarea.

ES 4.2 Napa Valley Subbasin Groundwater Storage Changes

In the principal aquifer system of the Napa Valley Subbasin, the volume of groundwater in storage increased in both spring 2016 and spring 2017 relative to the prior year (see **Section 5.1.4**). The magnitude of the increase in 2016 was 1,586 acre-feet greater than the increase in 2017 despite much more precipitation occurring in water year 2017. This result is consistent with the finding that the Subbasin has been at a relatively full condition with respect to groundwater storage capacity (LSCE, 2016c).

Maps of saturated thickness and groundwater storage changes in the principal aquifer system show increases in saturated thickness and groundwater storage, primarily from St. Helena southward in the Subbasin between 2015 and 2016 (**Figures 5-9A and 5-9B**). A small area of less than two feet of saturated thickness decrease is mapped near Rutherford. The greatest increases in saturated thickness and groundwater storage occurred along the western margin of the Subbasin along Dry Creek. The change in saturated thickness and groundwater storage from spring 2016 to spring 2017 were also

[2] The alluvial aquifer system of the Quaternary Alluvial Deposits is the principal aquifer supplying water to wells in the Napa Valley Subbasin (LSCE, 2016c).

[3] Consistent with the GSP Regulation, the term "water year" is used in this report to refer to the period from October 1 through the following September 30, with the year designated according to the calendar year in which it ends (i.e., water year 2017 spanned from October 1, 2016 through September 30, 2017).

broadly positive, with no areas showing a decrease in saturated thickness greater than two feet (**Figures 5-10A and 5-10B**).

ES 4.3 Napa Valley Subbasin Water Use

Total water use in the Napa Valley Subbasin, including groundwater extracted from the Subbasin, surface water from sources within the Napa River Watershed, and imported surface water delivered through the State Water Project, is estimated to have been 34,793 acre-feet in water year 2016 and 34,142 acre-feet in water year 2017 (**Table 6-6**). Total estimated groundwater use in the Subbasin was 17,039 acre-feet in water year 2016 and 15,831 acre-feet in water year 2017. Estimates of groundwater use in 2016 and 2017 are presented along with values for 1988 – 2015 developed for the Basin Analysis Report (LSCE, 2016c) in **Figure 6-8**. The figure also includes calculated annual and cumulative changes in groundwater storage in the alluvial aquifer system of the Subbasin. As noted above, annual groundwater storage changes were positive in both water year 2016 and water year 2017, at 6,056 acre-feet and 4,470 acre-feet, respectively. Cumulative changes in groundwater storage show a net increase of 13,702 acre-feet from water years 1988 to 2017 in the principal aquifer of Napa Valley Subbasin (**Table ES-2**).

Groundwater use in water years 2016 and 2017 was comparable to amounts used in recent years dating back to 2004 (**Figure 6-8**). Over a 30-year period, annual storage changes in the aquifer system have fluctuated between positive and negative values, generally in accordance with the water year type. Cumulative changes in groundwater storage have also fluctuated between positive and negative values, indicating stable groundwater storage conditions and the absence of chronic depletions of groundwater storage~~,~~. Groundwater use in the Subbasin in water years 2016 and 2017 remained below the sustainable yield range of 17,000 to 20,000 acre-feet per year identified in the Basin Analysis Report (LSCE, 2016c). Together, the findings presented in this report regarding groundwater conditions at representative monitoring sites, changes in groundwater storage, and groundwater use demonstrate that the Napa Valley Subbasin has continued to be managed sustainably through 2017.

Table ES-2 Napa Valley Subbasin Principal Aquifer Groundwater Storage Changes, Water Years 1988 – 2017

Water Year	Water Year Classification	Napa Valley Subbasin Alluvial Aquifer Storage (Acre-feet)	Annual Storage Change (Acre-feet)	Cumulative Storage Change (Acre-feet)
1988	Normal (below average)	205,596	-	-
1989	Normal (below average)	198,305	(7,290)	(7,290)
1990	Dry	202,469	4,164	(3,126)
1991	Dry	192,046	(10,424)	(13,550)
1992	Normal (below average)	212,532	20,486	6,936
1993	Wet	215,486	2,953	9,890
1994	Dry	208,000	(7,486)	2,404
1995	Very Wet	215,361	7,361	9,765
1996	Wet	211,141	(4,220)	5,545
1997	Wet	216,835	5,695	11,239
1998	Very Wet	219,733	2,898	14,138
1999	Normal (above average)	219,981	247	14,385
2000	Normal (above average)	213,878	(6,103)	8,282
2001	Dry	210,997	(2,881)	5,401
2002	Normal (above average)	214,534	3,537	8,938
2003	Wet	208,394	(6,140)	2,798
2004	Normal (below average)	204,592	(3,802)	(1,004)
2005	Wet	217,650	13,058	12,054
2006	Very Wet	222,904	5,254	17,308
2007	Very Dry	200,359	(22,545)	(5,237)
2008	Normal (below average)	201,029	670	(4,567)
2009	Normal (below average)	205,160	4,132	(436)
2010	Wet	210,929	5,769	5,333
2011	Wet	214,705	3,776	9,109
2012	Normal (below average)	210,338	(4,367)	4,742
2013	Normal (below average)	201,193	(9,145)	(4,403)
2014	Dry	191,523	(9,670)	(14,073)
2015	Normal (below average)	208,771	17,248	3,175
2016	Normal (below average)	214,827	6,056	9,232
2017	**Very Wet**	**219,298**	**4,470**	**13,702**
	Average (1988 – 2017)	**209,619**	**472**	
	Median (1988 – 2017)	**210,963**	**2,898**	

ES 4.4 Recommendations for Continued SGMA Implementation[4]

The following sections summarize recommendations presented in the Basin Analysis Report (LSCE, 2016c) and the Northeast Napa Management Area Report (LSCE, 2018a, **Appendix A**), with an emphasis on recommendations prioritized for near-term implementation.

ES 4.4.1 Data Gap Refinement (SGMA Implementation Recommendations 11, 13, and 14)

Outreach to well owners in Napa County will continue through the Watershed Information and Conservation Council (WICC), public presentations regarding groundwater conditions, Napa County's groundwater list-serve, and other means to solicit wells for voluntary inclusion in the County's monitoring network. Napa County will also review discretionary projects recently approved by the County with conditions of approval requiring that project wells be made available for inclusion in the County's monitoring network.

Coordination with other county departments and other agencies that collect or utilize groundwater data could also provide an additional data in areas of interest. Several local agencies, including the Town of Yountville, City of St. Helena, and City of Napa, already monitor groundwater levels at locations around the county.

ES 4.4.2 Ongoing Water Quality Sampling (SGMA Implementation Recommendation 15)

Baseline groundwater quality sampling planned to occur at 16 wells distributed throughout the Napa-Sonoma Valley Groundwater Basin in 2017 was delayed due to access limitations and staffing restrictions in response to the large wildfires that affected the county in fall 2017. Sampling at these wells is recommended to be conducted in 2018. Additional water quality sampling for a reduced set of constituents, including nitrate and chloride, is also recommended for the five dual-completion monitoring wells constructed in 2014 at surface water-groundwater monitoring sites (LSCE, 2016b). An initial round of sampling and analysis was completed in June 2015 with a combination of County matching funds, DWR grant funds, and DWR in-kind support. Continued sampling of these wells is recommended in the Basin Analysis Report.

ES 4.4.3 Improve Data Collection and Evaluation from Discretionary Permittees Required to Monitor Groundwater Conditions and Groundwater Use (SGMA Implementation Recommendations 16 and 25)

Through coordination between the Napa County Public Works Department and Planning, Building, and Environmental Services Department, continue to improve procedures for receiving data reported by permittees required to report groundwater data and regularly incorporate those data into the Napa County Groundwater Data Management System.

[4] The Basin Analysis Report for the Napa Valley Subbasin includes a comprehensive list of monitoring and management recommendations developed since 2011. Additional recommendations developed for the Basin Analysis Report were added to the list in sequence, beginning at number 13. Recommendations 1 – 12 are referenced in this Section where applicable to ongoing activities.

ES 4.4.4 Evaluate Strategic Recharge and Water Conservation Opportunities (SGMA Implementation Recommendations 8 and 19)

In 2017, Napa County worked with the Napa County Resource Conservation District (Napa RCD) to develop a project to improve the understanding water uses in unincorporated areas within the Napa Valley Subbasin. The objectives of the project include working with landowners to collect data on the timing of water availability, storage, and use at the farm scale for the purpose of quantifying the effects of existing efficiency and conservation efforts and identifying potential improvements to existing practices. The project would build on existing water use efficiency trainings and outreach conducted by the Napa RCD. A funding request for the project is currently pending as part of a grant application to the California Wildlife Conservation Board. Implementation of the project would begin in 2018, depending upon grant funding and other funding availability.

ES 4.4.5 Evaluate Distribution of Groundwater Dependent Ecosystems; Coordinate Evaluation with Guidance Developed by DWR, Nature Conservancy, California Native Plant Society or Others (SGMA Implementation Recommendations 11 and 20)

In 2018 with technical assistance from the Napa RCD, Napa County will review guidance on evaluating Groundwater Dependent Ecosystems (GDEs) recently released by The Nature Conservancy (2018), in order to refine the mapping and assessment of GDEs presented in the Basin Analysis Report. In cooperation with the WICC and the Napa RCD, Napa County has developed a pilot web-based application to allow RCD staff to submit observations about streamflow conditions from areas within the Napa Valley Subbasin. This effort is planned to be expanded to allow data collection by volunteers using a custom-built mobile software application to be developed by Napa County in late 2018. Through this approach, Napa County will be able to efficiently collect standardized information and photographs documenting streamflow conditions at priority sites multiple times throughout each dry season. This information will complement existing stream gaging station data collected by Napa County, the Napa RCD, and U.S. Geological Survey.

ES 4.4.6 Update the Napa County Groundwater Ordinance for the Northeast Napa Management Area (SGMA Implementation Recommendation 28)

On October 24, 2017, the Napa County Board of Supervisors directed County staff to update the Napa County Groundwater Ordinance to reflect the additional requirements for project-specific analysis and to incorporate water use criteria and water use reporting requirements for the Northeast Napa Management Area using an approach similar to what has already been implemented in the MST Subarea. In response, Napa County Public Works Department and Planning, Building, and Environmental Services Department staff plan to develop an update to the Groundwater Ordinance in 2018. For discretionary projects in the Northeast Napa Management Area, additional project-specific analyses (Napa County Water Availability Analysis-Tier 2) will be required to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells) (Napa County, 2015).

ES 4.4.7 Implement Improvements to Napa County's Data Management System (SGMA Implementation Recommendation 1.1b)

In 2017, Napa County began development of field data tool to assist staff in the collection and management of groundwater level data. A pilot, mobile application (Collector Application) was developed using ArcGIS Online and tested by County staff. In 2018, Napa County will continue to test and improve the application's functionality and integration with the County's DMS, which will allow for improved well data management and spatial mapping.

1 INTRODUCTION

1.1 Purpose

Groundwater and surface water are highly important natural resources in Napa County. Together, the County, municipalities, water districts, commercial and industrial operations, the agricultural community, and the public are stewards of the available water resources. Everyone living and working in Napa County has a stake in protecting the county's groundwater resources; including groundwater supplies, quality, and associated watersheds (GRAC, 2014). Without sustainable groundwater resources, the character of the County would be significantly different in terms of its economy, communities, rural character, ecology, housing, and lifestyles.

Similar to other areas in California, businesses and residents of Napa County face many water-related challenges including:

- Sustaining the quality, availability, and reliability of local and imported water supplies;
- Meeting challenges arising during drought and flood conditions;
- Avoiding environmental effects due to water use; and
- Changes in long-term availability due to global warming and/or climate change.

To address these challenges, long-term, systematic monitoring programs are essential to provide data and the scientific analyses that allow for improved evaluation of water resources conditions and to facilitate effective water resources planning. In 2009, Napa County embarked on a countywide project referred to as the "Comprehensive Groundwater Monitoring Program, Data Review, and Policy Recommendations for Napa County's Groundwater Resources" (Comprehensive Groundwater Monitoring Program), to meet identified action items in the 2008 General Plan update. The program emphasizes developing a sound understanding of groundwater conditions and implementing an expanded groundwater monitoring and data management program as a foundation for future coordinated, integrated water resources planning and dissemination of water resources information.

On June 28, 2011, the Napa County Board of Supervisors adopted a resolution to establish a Groundwater Resources Advisory Committee (GRAC). On September 20, 2011, the Board of Supervisors appointed 15 residents to the GRAC, which held its first organizational meeting on October 27, 2011. GRAC members represented diverse interests, including environmental, agricultural, development, and community interests.

The GRAC was created to assist County staff and technical consultants with recommendations regarding:

- Synthesis of existing information and identification of critical data needs;
- Development and implementation of an ongoing non-regulatory groundwater monitoring program;
- Development of revised well pump test protocols and related revisions to the County's groundwater ordinance;
- Conceptualization of hydrogeologic conditions in various areas of the County and an assessment of groundwater resources as data become available;
- Development of groundwater sustainability objectives that can be achieved through

voluntary means and incentives; and

- Building community support for these activities and next steps.

From January 2012 until January 2013, the GRAC reviewed and provided feedback on the development of the *Napa County Groundwater Monitoring Plan 2013* (Plan) (LSCE, 2013a).

The Plan was prepared to formalize and augment groundwater monitoring efforts to better understand the groundwater resources of Napa County. The Plan aids in making the County eligible for public funds administered by the California Department of Water Resources (DWR) and establishes regular evaluation of trends to identify changes in levels and/or quality and factors related to those changes that warrant further examination to ensure sustainable water resources over the long-term. The Plan included refinement of criteria used to identify priority monitoring areas, a proposed expanded monitoring network, and the annual reporting of groundwater conditions (the purpose of this report).

The Napa County groundwater monitoring program relies on both publicly-owned and volunteered private wells. To fulfill its mission and garner community interest and support, the GRAC developed a Communication and Education Plan, designed to implement the Plan through voluntary participation. This effort included the development of an outreach brochure and a series of fact sheets on specific topics.

Some of the many activities accomplished by the GRAC in 2011 to 2014:

- Provided updates to agriculture industry groups, environmental organizations and others;
- Led and supported outreach efforts to well owners for volunteer monitoring wells which has been very successful in adding new wells to the Napa County groundwater monitoring program;
- Held a joint public outreach meeting of the GRAC and Watershed Information and Conservation Council (WICC) Board (July 25, 2013);
- Reviewed and recommended modifications to the Napa County Water Availability Analysis and Groundwater Ordinance; and
- Developed and approved Groundwater Sustainability Objectives (GRAC, 2014).

The Plan recommended annual reports on groundwater conditions and modifications to the countywide groundwater monitoring program as needed. To date, three Annual Reports have been prepared (LSCE, 2015; LSCE, 2016a; and LSCE, 2017a). This is the first Annual Report prepared to also meet the annual reporting requirements of the Sustainable Groundwater Management Act (SGMA).

In December 2016, Napa County submitted the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c) as an alternative to a Groundwater Sustainability Plan (GSP) in accordance with the GSP Regulations developed by DWR. Development of a Basin Analysis Report was possible in part because of groundwater resources studies and management activities initiated in prior years, including many that were completed with assistance from the GRAC. As with any GSP, progress towards maintaining sustainable groundwater conditions in the Napa Valley Subbasin did not end with submittal of the Basin Analysis Report. Additional public outreach and scientific study is underway to improve upon best-available datasets regarding groundwater conditions, water use, surface water-groundwater interactions, groundwater dependent ecosystems, and other priorities identified in the Basin Analysis Report.

This Report, *Napa County Groundwater Sustainability: Annual Report – Water Year 2017* [5], presents an update on groundwater conditions and water use in the Napa Valley Subbasin (Subbasin), as required by Section 356.2 of the GSP Regulations. This Report also provides an update on the recommended SGMA implementation actions presented in the Basin Analysis Report. **Table 1-1** provides a cross reference between the required Annual Report elements described in the GSP Regulations and the corresponding components included in this Report.

Table 1-1 Groundwater Sustainability Plan Regulations Annual Reporting Requirements

GSP Regulations Reference	Required Component Summary	Corresponding Annual Report Contents
356.2(a)	General Information, including an executive summary and location map depicting the basin covered by the report	Executive Summary, Figure 2-1
356.2(b)(1)(A)	Groundwater elevation contour maps for each principal aquifer in the basin	Section 5.1, Figures 5-5 and 5-6
356.2(b)(1)(B)	Hydrographs of groundwater elevations and water year type	Section 5.1, Table 5-1, Figure 5-1, Figure 5-7, Figure 5-8, Figures 5-15 – 5-20, Appendix C
356.2(b)(2)	Groundwater extraction for the preceding water year	Section 6.1, Figure 6-5, Figure 6-6, Figure 6-7, Table 6-6
356.2(b)(3)	Surface water supply used or available for use for groundwater recharge or in-lieu use for the preceding water year	Section 6.2, Table 6-7
356.2(b)(4)	Total water use by water use sector	Section 6.1, Table 6-3, Table 6-4, Table 6-5, Table 6-6
356.2(b)(5)(A)	Change in groundwater storage maps for each principal aquifer in the basin	Section 5.1.4, Figure 5-9B, Figure 5-10B
356.2(b)(5)(B)	A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available	Section 6.1, Figure 6-8
356.2(c)	A description of progress towards implementing the Plan (Basin Analysis Report)	Section 5.1.3, Table 5-2, Section 7, Table 7-1, Figure 7-1

[5] Consistent with the GSP Regulation, the term "water year" is used in this report to refer to the period from October 1 through the following September 30, with the year designated according to the calendar year in which it ends (i.e., water year 2017 spanned from October 1, 2016 through September 30, 2017).

1.2 Organization of Report

This Report summarizes activities implemented to improve the understanding of groundwater resource conditions and availability and actions taken to ensure groundwater sustainability.

The Report includes the following sections:

Section 2: Hydrogeology of Napa County

- DWR Basins/Subbasins and County Subareas
- Summary of Geology and Groundwater Resources
- Groundwater Studies and Programs: 2009 – 2017
- Recent Groundwater Reports

Section 3: Groundwater Resources Goals and Management Objectives

- Napa County Water Resources Goals and Policies
- Overarching Groundwater Monitoring Objectives

Section 4: Groundwater Monitoring Network

- Groundwater Level Monitoring
- Surface Water-Groundwater Monitoring
- Representative Monitoring Sites

Section 5: Groundwater Level Trends and Flow Directions

- Napa Valley Floor Subbasin
  - Napa Valley Subbasin – Calistoga and St. Helena Subareas
  - Napa Valley Subbasin – Yountville and Napa Subareas
  - Napa Valley Subbasin Sustainability Indicators
  - Napa Valley Subbasin Groundwater Level Change in Storage
- Milliken-Sarco-Tulucay (MST) Subarea
- Napa-Sonoma Lowlands Subbasin and Subareas South of the Napa Valley Floor
- Subareas East and West of the Napa Valley Floor
- Pope Valley Subbasin and Pope Valley Subarea
- Angwin Subarea
- Napa Valley Surface Water-Groundwater Monitoring

Section 6: Napa Valley Subbasin Water Use and Surface Water Availability

- Water Use by Sector
- Surface Water Supply Available for Use for Groundwater Recharge or In-lieu Use

Section 7: Implementation of the Basin Analysis Report for the Napa Valley Subbasin

- Northeast Napa Management Area Designation
- Revised Conditions of Approval for Discretionary Permits
- Expand the Capacity to Encourage Groundwater Stewardship

- Napa Valley Subbasin Model Dataset Development
- Collaborations to Improve Best Available Water Use Data
- Coordination with Other Water Management and Planning Programs
    - Integrated Regional Water Management Plans
    - Napa County Watershed Information and Conservation Council of Napa County

Section 8: Summary and Recommendations

- Data Gap Refinement
- Ongoing Water Quality Sampling
- Improve Data Collection and Evaluation from Discretionary Permittees Required to Monitor Groundwater Conditions and Groundwater Use
- Evaluate Strategic Recharge and Water Conservation Opportunities
- Evaluate Distribution of Groundwater Dependent Ecosystems; Coordinate Evaluation with Guidance from DWR, The Nature Conservancy, California Native Plant Society or Others
- Update the Napa County Groundwater Ordinance for the Northeast Napa Management Area
- Implement Improvements to Napa County's Data Management System

2 HYDROGEOLOGY OF NAPA COUNTY

This section summarizes the countywide geologic and hydrologic setting and includes information about DWR groundwater basin/subbasin delineations and a description of the Napa County groundwater monitoring subareas. The studies that form the basis of the understanding of County hydrogeology are referenced, including the *Updated Hydrogeologic Conceptualization and Characterization of Conditions* (LSCE and MBK, 2013).

2.1 DWR Basins/ Subbasins and County Subareas

DWR has identified the major groundwater basins and subbasins in and around Napa County. The basins include the Napa-Sonoma Valley (which in Napa County includes the Napa Valley and Napa-Sonoma Lowlands Subbasins), Berryessa Valley, Pope Valley, and a small part of the Suisun-Fairfield Valley Groundwater Basins (**Figure 2-1**). These basins and subbasins are generally defined based on boundaries to groundwater flow and the presence of water-bearing geologic units. These groundwater basins defined by DWR are not confined within county boundaries, and DWR-designated “basin” or “subbasin” designations do not cover all of Napa County.

Groundwater conditions outside of the DWR-designated basins and subbasins are also very important in Napa County. An example of such an area is the Milliken-Sarco-Tulucay (MST) area, a locally identified groundwater deficient area. For purposes of local planning, understanding, and studies, the County has been subdivided into a series of groundwater subareas (**Figure 2-2**). These subareas were delineated based on the main watersheds and the County’s environmental resource planning areas, and with consideration of groundwater basins; these geographic subareas are not groundwater basins or subbasins. The subareas include the Knoxville, Livermore Ranch, Pope Valley, Berryessa, Angwin, Central Interior Valleys, Eastern Mountains, Southern Interior Valleys, Jameson/American Canyon, Napa River Marshes, Carneros, Western Mountains Subareas and five Napa Valley Floor Subareas (Calistoga, St. Helena, Yountville, Napa, and MST).[6]

DWR has given the Napa Valley Subbasin a “medium priority”[7] ranking according to the criteria specified in California Water Code Part 2.11 Groundwater Monitoring (i.e., this relates to the CASGEM program). The priority ranking method used by DWR primarily considers the population within a basin or subbasin, projected population growth, the density of wells, overlying irrigated agriculture, and the degree to which groundwater is used as a source of supply. As required by SGMA, in 2016 DWR published a list of basins subject to conditions of critical overdraft. No basins or subbasins in Napa County are designated on that list. Sometime in 2018, DWR is expected to release updated priority rankings that will

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[6] The majority of the following Napa Valley Floor Subareas align with the Napa Valley Subbasin: Calistoga, St. Helena, Yountville, and Napa. Most of the Napa Valley Floor-MST Subarea is located outside of the Napa Valley Subbasin and other designated basins or subbasins in Napa County.

[7] As part of the CASGEM Program, DWR has developed the Basin Prioritization process. The California Water Code (§10933 and §12924) requires DWR to prioritize California’s groundwater basins and subbasins statewide. As such, DWR developed the CASGEM Groundwater Basin Prioritization Process. Details are available at http://www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm.

incorporate additional criteria to address connections between surface water and groundwater in basins across the state.

2.2 Summary of Geology and Groundwater Resources

2.2.1 Previous Studies

Previous hydrogeologic studies and mapping efforts in Napa County are divisible into geologic studies and groundwater studies. The more significant studies and mapping efforts are mentioned in this section. **Table 2-1** shows the chronological sequence of these efforts that span more than six decades. Weaver (1949) presented geologic maps which covered the southern portion of the county and provided a listing of older geologic studies. Kunkel and Upson (1960) examined the groundwater and geology of the northern portion of the Napa Valley. DWR (Bulletin 99, 1962) presented a reconnaissance report on the geology and water resources of the eastern area of the County; Koenig (1963) compiled a regional geologic map which encompasses Napa County. Fox and others (1973) and Sims and others (1973) presented more detailed geologic mapping of Napa County. Faye (1973) reported on the groundwater of the northern Napa Valley. Johnson (1977) examined the groundwater hydrology of the MST area.

Helley and others (1979) summarized the flatland deposits of the San Francisco Bay Region, including those in Napa County. Fox (1983) examined the tectonic setting of Cenozoic rocks, including Napa County. Farrar and Metzger (2003) continued the study of groundwater conditions in the MST area.

Wagner and Bortugno (1982) compiled and revised the regional geologic map of Koenig (1963). Graymer and others (2002) presented detailed geologic mapping of the southern and portions of the eastern areas of the County, while Graymer and others (2007) compiled geologic mapping of the rest of Napa County.

In 2005 to 2007, DHI Water & Environment (DHI) contributed to the 2005 *Napa County Baseline Data Report* (DHI, 2006a and Jones & Stokes et al., 2005) which was part of the County's General Plan update (Napa County, 2008). A computer model was developed by DHI in conjunction with the Napa Valley and Lake Berryessa Surface Water models to simulate existing groundwater and surface water conditions on a regional basis primarily in the North Napa Valley and the MST and Carneros Subareas (DHI, 2006b). A 2007 technical memorandum, *Modeling Analysis in Support of Vineyard Development Scenarios Evaluation* (DHI, 2007), was prepared to document the groundwater model update which was used to evaluate various vineyard development scenarios.

Additional geologic maps, groundwater studies, and reports are listed in the references of the *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a). Additional work has been conducted to update the conceptualization and characterization of hydrogeologic conditions particularly for the Napa Valley Floor (LSCE and MBK, 2013 and LSCE, 2013b).

Table 2-1 Summary and Chronology of Hydrogeologic and Geologic Studies and Mapping Efforts in Napa County

Hydrogeologic and/or Geologic Studies and Mapping Efforts	Year of Report or Map Publication							
	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Weaver, 1949	Report and Map produced							
Kunkel and Upson,1960			Report and Map produced					
DWR, 1962			Report only					
Koenig, 1963			Map only					
Fox et al., 1973				Report only				
Sims et al., 1973				Map only				
Faye, 1973				Report and Map produced				
Johnson, 1977				Report only				
Helley et al., 1979				Report and Map produced				
Wagner and Bortugno, 1982					Map only			
Fox, 1983					Report and Map produced			
Graymer et al., 2002							Map only	
Farrar and Metzger, 2003							Report and Map produced	
Graymer et al., 2007							Map only	
DHI, 2006 and 2007							Report only	
LSCE, 2011a								Report only
LSCE and MBK, 2013								Report and Map produced
LSCE, 2013a								Report only
LSCE, 2013b								Report only
LSCE, 2014								Report only
LSCE, 2015								Report and Map produced
LSCE, 2016a								Report and Map produced
LSCE, 2016b								Report and Map produced
LSCE, 2016c								Report and Map produced
LSCE, 2017a								Report and Map produced
LSCE, 2017b								Report and Map produced
LSCE, 2018a								Report and Map produced
LSCE, 2018b (This Report)								Report and Map produced

◆ = Report and Map produced = ◆ Report only ◆ = Map only

Highlights of additional groundwater studies between 2009 and 2018 are provided in Section 2.3 followed by summaries of the recent reports in Section 2.4 including: 1) *Napa County Groundwater/Surface Water Monitoring Facilities to Track Resource Interrelationships and Sustainability* (LSCE, 2016b)*, 2) Napa Valley Groundwater Sustainability: A Basin Analysis Report* (LSCE, 2016c), 3) *Northeast Napa Area: Special Groundwater Study* (LSCE, 2017b), and 4) *Napa Valley Groundwater Sustainability Northeast Napa Management Area: An Amendment to the 2016 Basin Analysis Report for the Napa Valley Subbasin* (LSCE, 2018a).

2.2.2 Precipitation Monitoring and Water Year Classifications

Infiltration of precipitation has been shown to provide significant groundwater recharge in Napa County, particularly in unconsolidated geologic settings (Kunkel and Upson 1960, LSCE and MBK 2013).

Precipitation records in Napa County date to 1906 at the longest continually operating gauge at the Napa State Hospital (GHCND: USC00046074). In a separate analysis, precipitation data from the Napa State Hospital gauge in Napa (elevation 35 feet) have been shown to have strong linear correlations (i.e., $R^2 \geq 0.90$) with monthly and annual precipitation totals from two other gauges in St. Helena (elevation 1,780 feet) and Angwin (elevation 1,815 feet) (2NDNature, 2014). Based on the strength of those correlations, the Napa State Hospital gauge has been recommended for use as an index gauge for the Napa River Watershed.

The water year classification presented in **Table 2-2** is revised from the version developed by 2NDNature (2014). The classification presented here accounts for gaps in the daily precipitation record at the Napa State Hospital gauge. Specifically, missing daily precipitation data in the Napa State Hospital gauge record from water years 1920 through 2015 were estimated based on daily data from the St. Helena precipitation gauge (GHCND: USC0004764) and Oakville precipitation gauge (elevation: 190 feet, CIMIS Station No. 77). These gauges show very strong linear correlations (i.e., $R^2 > 0.99$) for cumulative daily data from the Napa State Hospital gauge. Estimated daily precipitation values were calculated to fill gaps in the Napa State Hospital gauge record using observed values from either the Oakville or St. Helena gauges and the linear regression for cumulative daily precipitation between those gauges and the Napa State Hospital gauge.

A frequency analysis was used to define very dry, dry, normal, wet, and very wet water year types according to exceedance probabilities calculated from the 96-year period of record for precipitation at the Napa State Hospital gauge from water years 1920 through 2015. Data from water years prior to 1920 were excluded from the frequency analysis due to large gaps in the Napa State Hospital gauge record prior to that year that were not able to be estimated using data from other gauges. Further information regarding precipitation in Napa County is included in **Section 5**.

Table 2-2 Napa River Watershed Water Year Classification

Year Type	Water Year Precipitation Total		Annual Precipitation Exceedance Probability (%)	Number of Years in Period of Record
	Lower Bound (inches)	Upper Bound (inches)		
Very Dry		15.19	≥ 91	9
Dry	15.20	19.67	≥ 67	23
Normal	19.68	26.99	≥ 33	33
Wet	27.00	36.75	≥ 10	22
Very Wet	36.76		< 10	9
Napa State Hospital (NSH) Average Annual Water Year Precipitation (1920 – 2015) = 24.86 inches Period of record used for frequency analysis: 1920 – 2015				

2.2.3 Summary of Geology and Groundwater Resources

The geology of Napa County can be divided into three broad geologic units based on their ages and geologic nature. These units are: 1) Mesozoic Basement Rocks (pre-65 million years (my)), which underlie all of Napa County, but are primarily exposed in the Eastern County area and the Western Mountains Subarea, 2) Older Cenozoic Volcanic and Sedimentary Deposits (65 my to 2.5 my), including Tertiary Sonoma Volcanics (Miocene and Pliocene; 10 my to 2.5 my) which are found throughout the county, especially in the mountains surrounding Napa Valley, and 3) Younger Cenozoic Volcanic and Sedimentary Deposits (post 2.6 my to present), including the Quaternary Alluvial Deposits of the Napa Valley Floor. The Quaternary Alluvial Deposits comprise the principal aquifer system of the Napa Valley Subbasin (LSCE, 2016c).

Direct infiltration of precipitation is a major component of recharge in the main Napa Valley Floor. Outside of the Napa Valley Floor, percolation of surface water appears to be the primary source of recharge. The rate of recharge within areas such as the MST Subarea has been shown to be significantly higher where streams and tributaries cross highly permeable outcrops (e.g., the tuffaceous member of the Sonoma Volcanics or shallow alluvium). Recharge outside of the Napa Valley Floor, throughout much of the county is generally limited by underlying shallow bedrock of low permeability. An additional component of groundwater recharge that is less understood is deep percolation through fractured rock and fault zones. This type of recharge can be very difficult to quantify due to the highly variable size and distribution of faults, fractures, and joints in a given area.

Groundwater Occurrence and Quality in the Sonoma Volcanics

Groundwater occurs in the Sonoma Volcanics in Napa County and yields water to wells. Well yields are highly variable from less than 10 to several hundred gallons per minute (gpm). The most common yields are between 10 to 100 gpm. Faye (1973) reported well-test information which showed an average yield of 32 gpm and an average specific capacity of 0.6 gallons per minute per foot of drawdown. From the available well log data, the Tertiary marine sedimentary rocks are poor groundwater producers either for a lack of water or poor water quality (high salinity). At great depths, groundwater quality in the Tertiary marine sedimentary rocks is generally poor due to elevated chloride (salt) concentrations.

According to Kunkel and Upson (1960), groundwater in the Sonoma Volcanics is generally of good quality except in three areas. The first area with poor groundwater quality, the Tulucay Creek drainage basin, east of the City of Napa, contains groundwater with elevated iron, sulfate, and boron. The Suscol area, south of the City of Napa, is the second area where some wells exhibit poor quality groundwater due to elevated chloride concentrations, possibly from leakage from salty water in the Napa River, alluvial material above, or the existence of zones of unusually saline connate water deep within the Sonoma Volcanics. The third area of poor groundwater quality, the Calistoga area in the northern end of the Napa Valley, contains isolated wells with naturally occurring elevated chloride, boron, and some trace metal concentrations.

Kunkel and Upson (1960) reported that the principal water yielding units of the Sonoma Volcanics are the tuffs, ash-type beds, and agglomerates. The lava flows were reported to be generally non-water bearing. However, it may be possible that fractured, fragmental, or weathered lava flows could yield water to wells. The hydrogeologic properties of the volcanic-sourced sedimentary deposits of the Sonoma Volcanics are complex and poorly understood.

Groundwater Occurrence in Other Units and in the Quaternary Sedimentary Deposits

Several hundred wells and test holes on record have been drilled into the exposed Huichica Formation. Well yields tend to be low to modest (< 10 gpm to tens of gpm). Only a few known wells on record are completed in the Clear Lake Volcanics near the northern County line. Three wells report high yields of 400 to 600 gpm. Much of the Clear Lake Volcanics to the south appear to be thinner, limited in extent, and in ridge-top locations where possible groundwater production appears to be less likely.

Groundwater production from Quaternary Alluvium Deposits is variable, with yields ranging from <10 gpm in the East and West mountainous areas to a high of 3,000 gpm along the Napa Valley Floor where the alluvium is thickest (>200 feet). According to Faye (1973), average yield of wells completed in the alluvium is 220 gpm. Many wells drilled in the alluvium within the last 30 years extend beyond the alluvium and into the underlying Cenozoic units. Kunkel and Upson (1960) report that groundwater in the alluvium is generally of good quality. The groundwater is somewhat hard and of the bicarbonate type, with small concentrations of sulfate, chloride, and total dissolved solids. A few isolated areas have increased chloride and boron concentrations. The Quaternary Alluvial Deposits comprise the principal aquifer system of the Napa Valley Subbasin (LSCE, 2016c).

2.3 Groundwater Studies and Programs: 2009 to 2018

This section summarizes the recently completed studies and recommendations by Napa County.

2.3.1 Napa County's Comprehensive Groundwater Monitoring Program

In 2009, Napa County implemented a Comprehensive Groundwater Monitoring Program to meet action items identified in Napa County's 2008 General Plan update (Napa County, 2008). The program emphasizes developing a sound understanding of groundwater conditions and implementing an expanded groundwater monitoring and data management program as a foundation for future coordinated, integrated water resources planning and dissemination of water resources information. The program covers the continuation and refinement of countywide groundwater level and quality monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability. This information is critical to enable integrated water resources planning and the dissemination of water resources information to the public, state, and local decision-makers. Napa County's combined efforts through the Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project on groundwater (CCP, 2010) and the efforts of the Watershed Information and Conservation Council (WICC) of Napa County create a foundation for the County's continued efforts to increase public outreach and participation in water resources understanding, planning, and management.

Napa County's Comprehensive Groundwater Monitoring Program involved many tasks that led to the preparation of five technical memorandums and a report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a). That report and the other related documents are available on the WICC website (http://www.napawatersheds.org/groundwater). The report documents existing knowledge of countywide groundwater conditions and establishes a framework for the monitoring and reporting of groundwater levels and groundwater quality on a periodic basis. The report also summarizes priorities for groundwater level and quality monitoring for each of the county subareas.

The *Napa County Groundwater Monitoring Plan 2013* (Plan) (LSCE, 2013a) was prepared to formalize and augment groundwater monitoring efforts to better understand the groundwater resources of Napa County, aid in making the County eligible for public funds administered by DWR, and regularly evaluate trends to identify changes in levels and/or quality and factors related to those changes that warrant further examination to ensure sustainable water resources. The Plan included refinement of criteria used to identify priority monitoring areas and a proposed expanded monitoring network. During Plan implementation, the GRAC led and supported outreach efforts to well owners for volunteer monitoring wells; the GRAC efforts were very successful in adding new wells to the Napa County groundwater monitoring program.

2.3.2 Napa County Statewide Groundwater Elevation Monitoring (CASGEM)

This section describes the DWR California Statewide Groundwater Elevation Monitoring (CASGEM) program. The wells included by the County in the CASGEM program are a *subset* of the overall network of wells monitored in Napa County.

In November 2009, Senate Bill SBX7 – 6 mandated that the groundwater elevations in all basins and subbasins in California be regularly and systematically monitored with the goal of demonstrating seasonal and long-term trends in groundwater elevations. In accordance with the mandate, DWR developed the CASGEM program. DWR is facilitating the statewide program which began with the opportunity for local entities to apply to DWR to assume the function of regularly and systematically collecting and reporting groundwater level data for the above purpose. These entities are referred to as Monitoring Entities.

Wells designated for inclusion in the CASGEM program are for purposes of measuring groundwater levels on a semi-annual or more frequent basis that are representative of groundwater conditions in the state's groundwater basins and subbasins. A key aspect of the program is to make certain elements of the groundwater level information available to the public. On December 29, 2010, the County applied to DWR to become the local countywide Monitoring Entity responsible for designating wells as appropriate for monitoring and reporting groundwater elevations for purposes of the CASGEM program.

Some well owners whose wells are included in the County monitoring network have elected to be part of the CASGEM program. The wells in the CASGEM program are a *subset* of the overall wells monitored, i.e., the County has a much larger overall monitoring network. The County's participation in the CASGEM program complements other pre-existing groundwater monitoring that has been ongoing in Napa County for some time (the overall historical monitoring record began in 1920).

Following confirmation, the County, as the Monitoring Entity, proceeded to identify a *subset* of monitored wells to be included in the CASGEM network and to prepare a CASGEM Network Plan as required by DWR (LSCE, 2011b and LSCE, 2014). The initial CASGEM Network Plan submitted to DWR included a subset of fourteen wells. DWR formally designated Napa County as the Monitoring Entity for two basins in August 2014, specifically:

- Napa County was designated as the Monitoring Entity for the 2-2.01 Napa Valley Subbasin (medium priority basin)
- Napa County was designated as the Monitoring Entity for the 2-2.03 Napa-Sonoma Lowlands Subbasin in Napa County (very low priority basin)

The current CASGEM network wells, which includes 33 wells, are located primarily on the Napa Valley Floor, Carneros Subarea, and in the MST Subarea. Nineteen of the CASGEM Network wells in Napa County are located in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin (see **Section 4.1.3**). Some of these wells do not have sufficient construction details to define which portion of the aquifer system is represented by measured water levels. Additional data collection and surveying will be performed, with this information provided in future annual reports as it becomes available. Depending on the results of the County's evaluation, future actions may include removal and replacement of CASGEM wells with wells that are more representative of local groundwater conditions to better meet the objectives of the CASGEM program and the overall objectives of the County's Comprehensive Groundwater Monitoring Program (**Figure 4-2**).

In addition to the CASGEM well network described herein, the County is currently exploring the availability of additional monitoring wells in the Pope Valley Groundwater Basin[8]. There is a well

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[8] The Overall Basin Ranking Score for the Pope Valley Groundwater Basin is "0.0"; the very low priority basin ranking range is 0-5.4. http://www.water.ca.gov/groundwater/casgem/pdfs/basin_prioritization/NCRO%2074.pdf

monitored by the County in Pope Valley, however, it is not designated as a CASGEM well. Public outreach is underway through community organizations and other contacts. The Berryessa Valley Groundwater Basin has a very low DWR priority and extremely small utilization of groundwater[9]. Per discussions with DWR, outreach will continue but no monitoring is planned in this groundwater basin at this time.

The Suisun-Fairfield Valley Basin and the Napa-Sonoma Lowlands Subbasin are two examples of basins that do not conform to county boundaries, and they are also basins with a very low-priority designation from DWR. While these two basins have low groundwater utilization and less extensive monitoring than other basins, they are situated adjacent to the bay and delta water ways and are important areas to monitor for protection against saltwater intrusion. The Suisun-Fairfield Valley Basin, which is mostly in Solano County and has only a very small area (less than 0.3% of the total basin area) in Napa County, is being monitored in its entirety by Solano County Water Agency as the CASGEM Monitoring Entity for Solano County. The monitoring of Napa-Sonoma Lowlands Subbasin, whose area is shared with Solano County in more equitable portions (63% in Napa County, 37% in Solano County), is anticipated to have monitoring that is coordinated between the two respective Monitoring Entities in the future. Currently, all monitoring is within the Napa County portion of the subbasin. In the future, monitoring in this subbasin will expand as necessary to ensure representative coverage and will be coordinated between the two Monitoring Entities.

2.3.3 Updated Hydrogeologic Conceptualization and Characterization of Conditions

In 2012, activities were implemented to update the characterization and conceptualization of hydrogeologic conditions (LSCE and MBK, 2013). This work included:

1) Updated Napa Valley hydrogeologic conceptualization,
2) Linking well construction information to groundwater level monitoring data,
3) Groundwater recharge characterization and estimates, and
4) Evaluation of surface water/groundwater interrelationships.

Updated Napa Valley Geologic Conceptualization

As a part of the updated hydrogeologic conceptualization (LSCE and MBK, 2013), eight cross-valley geologic sections were constructed (**Figure 2-3**). About 1,300 water well drillers’ reports were reviewed and located on topographic base maps; 191 of these were selected for use in the cross sections. Geologic correlations seen on the cross sections were extended between sections by available well control and surficial geologic maps. From the geologic cross-sections and correlations of other water well drillers’ reports, the Quaternary alluvium was separated from underlying units, and an isopach (contours of equal thickness) map was constructed.

[9] The Overall Basin Ranking Score for the Berryessa Valley Groundwater Basin is “0.0”; the very low priority basin ranking range is 0-5.4.
http://www.water.ca.gov/groundwater/casgem/pdfs/basin_prioritization/NCRO%2062.pdf

The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013b). The fluvial facies consist of a thin narrow band of stream channel sands and gravels deposited by the Napa River. The sand and gravel beds tend to be thicker and/or more numerous in the fluvial facies area. They are interbedded with finer-grained clay beds of probable floodplain origin. Wells constructed in the fluvial facies tend to be moderately high yielding (for the valley, roughly 50 to 200 gallons per minute, or gpm). Local areas where thicker sand and gravel beds are reported, the well yields are the highest in the valley, ranging from about 200 to 2,000 gpm.

These areas with thick sand and gravel beds occur in the Yountville Narrows area, which extends about five miles from Oakville south to Ragatz Lane. Local areas of relatively lower well yield values of 200 to 500 gpm occur to the north and south. Hydraulic properties of these deposits are recorded during airlift testing, and drawdown values are generally not reported. Only a few well pump test results have been found, and these are in the high yielding area just north of the Yountville Narrows.

The alluvial fan facies of the Quaternary alluvium extends outward from the central fluvial facies and thins to zero thickness at the edge of the valley sides. These deposits appear to have been deposited as tributary streams and alluvial fans. These deposits appear to consist of interbedded sandy clays with thin beds (less than 10 feet thick) of sand and gravel. Wells constructed in the alluvial plain facies tend to be low yielding, ranging from a few gpm to a few tens of gpm. By at least 1970, most wells drilled on the alluvial plain facies were constructed to deeper depths into the underlying Sonoma Volcanics, although the proportion of groundwater that such wells derive from the Sonoma Volcanics is believed to be low.

The boundaries of certain alluvial facies (shown in **Figure 2-4**) coincide with areas of shallow groundwater levels. This suggests a relationship between shallow depths to groundwater and Quaternary Alluvial Fan (Qaa) and Quaternary Fluvial (Qaf) units. These areas represent somewhat more likely areas of connection between surface waters and groundwater.

At the northern end of the lower valley, the Quaternary alluvial fan transitions to the sedimentary basin facies. The sedimentary basin facies is characterized by fine-grained silt, sand, and clays with thin to scattered thicker beds of sand and gravel. The sedimentary basin facies is believed to be floodplain deposits that extend to the southern marshland/estuary deposits. As noted, the extent of this facies is poorly known due to lack of well control farther south. Limited information indicates low to moderate well yields of a few gpm to possibly up to 100 gpm. Again, the lack of well pump test information makes hydraulic properties of the deposits difficult to assess.

Portions of Napa Valley north of Lodi Lane were not characterized according to their Quaternary alluvial facies by LSCE and MBK (2013). However, depths to groundwater in the vicinity of monitored wells indicate the potential for connection between surface water and groundwater in the vicinity of Garnett Creek and Cyrus Creek in and near Calistoga.

Beneath the alluvium is a complex sequence of Tertiary sedimentary deposits (Huichica Formation) and igneous deposits of the Sonoma Volcanics. These units are strongly deformed by folding and faulting and have complex stratigraphic relationships. A structure contour map (contours of elevation) of the top of these units and the subcrop[10] pattern was developed from the geologic cross-sections, lateral correlations informed by borehole lithologies between cross sections, and surficial geologic map relationships (LSCE and MBK, 2013). From north of the City of Napa near Oak Knoll Avenue extending southward through the City, these deposits are dominated by fine-grained basin fill deposits with few sand and gravels of floodplain or estuarine origin. North towards Yountville, sedimentary deposits of the Huichica Formation appear to overlie Sonoma Volcanics andesites and tuffs. Sonoma Volcanics and the older Mesozoic Great Valley sequence are exposed in a structural uplift area in the small hills in the Yountville area.

Further north, a Sonoma Volcanics andesite flow breccia appears to transition into a sedimentary conglomerate along the center of the valley. This unit is encountered in deep, high yielding wells also completed in the overlying alluvium fluvial facies, but it is not clear if this unit also is high yielding. Overlying the conglomerate/breccia on the east is the Tertiary sedimentary deposits sequence (Huichica Formation) of sandstones and mudstones. To the west of the unit occur older Sonoma Volcanics andesites, tuffs in the south, and possibly younger Sonoma Volcanics tuffs interbedded with Tertiary sedimentary deposits (Huichica Formation) of sand and gravels and clays. All of the Tertiary units beneath the Napa Valley Floor appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013).

Although many different geologic units underlie the Napa Valley Subbasin, the Quaternary alluvium unit forms the principal aquifer system for water supply purposes (LSCE, 2016c).

Linking Well Construction Information to Groundwater Monitoring Data

As part of the updated hydrogeologic characterization (LSCE and MBK, 2013), existing monitoring well construction data from all available public sources were reviewed to determine the distribution of aquifer-specific monitoring data in the Napa Valley. This effort addresses recommendations from the Comprehensive Groundwater Monitoring Program to identify and fill data gaps that will allow for analysis of groundwater occurrence and flow as a more robust understanding of the extent of groundwater resources in the county is developed. A major component of this work included identifying construction information for previously monitored wells in Napa Valley.

Groundwater level monitoring needs identified through the Comprehensive Groundwater Management Program include improved spatial distribution of groundwater level monitoring, additional characterization of subsurface geologic conditions in county subareas to identify aquifer characteristics, further examination of well construction information to define which portion of the aquifer system is represented by water levels measured in the currently monitored wells (and in many cases to link construction information to the monitored wells), and improve the understanding of surface water/groundwater interactions and relationships.

[10] Occurrence of strata in contact with the undersurface of a stratigraphic unit, which in this case includes the strata beneath the alluvium.

Groundwater Recharge Characterization and Estimates

Another important feature of the updated hydrogeologic investigation was the development of improved characterization of groundwater recharge in the areas of greatest groundwater development, with an emphasis on Napa Valley. Understanding the volume of and mechanisms driving groundwater recharge in the county are essential in determining where and how much groundwater can be produced without incurring negative impacts (LSCE, 2011a). The high permeability of the alluvial sediments in the Napa Valley permit precipitation and surface water to readily infiltrate and recharge groundwater throughout the majority of the valley floor.

Mass balance and streamflow infiltration methods were used to estimate regional and local recharge. Streamflow infiltration can be characterized by comparing the elevation of surface water to the shallowest adjacent groundwater. Detailed remotely sensed elevation data of the mainstem Napa River and several major tributaries were obtained for this purpose. LiDAR data were paired with previously collected groundwater level data and estimates of areas of greatest recharge potential to characterize the potential for direct hydraulic connections between surface water and groundwater and the potential for groundwater recharge through streambed infiltration.

In addition, mass balance recharge estimates have been developed for the Napa River watershed and major tributary watersheds using a range of available data (LSCE and MBK, 2013). Available records for streamflow, precipitation, land use, and vegetative cover throughout these watersheds have been used to develop spatially-distributed estimates of annual hydrologic inputs and outputs in order to solve for the volume of groundwater recharge at the watershed scale. Key components of this work included quantifying the distribution of precipitation across the land surface, quantifying the amount of water that returns to the atmosphere by evapotranspiration, and quantifying the hydraulic properties of soil and alluvial materials through which water must infiltrate to reach groundwater. Estimates developed through the mass balance approach have been evaluated using a sensitivity analysis to determine the degree to which any individual or set of inputs affects the recharge estimate.

Additional work has been conducted in the Napa Valley Subbasin to quantify recharge for water budget purposes (LSCE, 2016c); see also **Section 2.4.2**, below.

Groundwater-Surface Water Interrelationships

Depth to Groundwater Relative to Stream Thalweg

The groundwater surface elevation and the estimated stream thalweg elevation data are important components for characterizing the groundwater-surface water relationship in the Napa Valley area. The spring 2010 contours of equal groundwater elevation were used to provide a snapshot representation of groundwater conditions with which to compare the vertical relationship between groundwater and surface water (LSCE and MBK, 2013 and LSCE, 2013b). This spatial relationship assisted in developing an understanding of the nature of water exchange between the groundwater and surface water systems.

Other Areas of County

Potential connections between surface water and groundwater in other areas of the county are less well known. Perennial and intermittent water courses have been mapped in Napa County as part of the U.S. Geological Survey National Hydrography Dataset[11] (**Figure 2-5**).

2.3.4 Annual Groundwater Reports

In 2015, Napa County began to submit Annual Reports to the County Board of Supervisors and the public that summarize activities implemented as part of the County's Comprehensive Groundwater Monitoring Program during the prior year to improve the understanding of groundwater resource conditions and availability. The 2014, 2015, and 2016 Annual Reports included summaries of current monitoring activities and additionally recommended groundwater monitoring needed to fill specific data gaps, and activities implemented since 2014 (LSCE, 2015; LSCE, 2016a; LSCE, 2017a). The 2014, 2015, and 2016 Annual Reports also summarize the overarching groundwater level and quality monitoring objectives defined by the County and the GRAC. These objectives provide the framework necessary to ensure that the monitoring program and data collected from the countywide monitoring facilities can address these objectives. This 2017 Annual Report presents an update on both groundwater conditions and water use in the Napa Valley Subbasin as required for Annual Reports by Section 356.2 of the GSP Regulations developed by DWR.

The 2015 Annual Report (LSCE, 2016a) also includes an update on groundwater quality data reported between 2009 and 2015. Those data were reviewed to provide an updated understanding of conditions and trends relative to the most recent countywide review of groundwater quality data published in the Napa County Groundwater Conditions and Groundwater Monitoring Recommendations Report (LSCE, 2011a). Between 2009 and 2015, groundwater quality data were available from a total of 81 sites. Groundwater quality data show generally good water quality with stable conditions in the Napa Valley Floor Subareas between 2009 and 2015 compared to the conditions reported previously based on data reported through 2008 (LSCE, 2011a); the 2015 Annual Report also presents groundwater quality information for other Subareas (LSCE, 2016a; see also LSCE, 2016c).

2.4 Recent Groundwater Reports

2.4.1 Napa County Groundwater/Surface Water Monitoring Facilities

In January of 2014, Napa County implemented a project to monitor interactions between groundwater and surface water resources in the Napa Valley Subbasin (LSCE, 2016b). Initial funding for the project was provided by DWR, through the Local Groundwater Assistance Grant Program, and the County. The project scope included monitoring facilities construction, data collection, and presentation of the results of initial data collection efforts. The project included construction of five dual-completion monitoring wells adjacent to the Napa River and Dry Creek in the Napa Valley Subbasin (**Figure 2-6**). Prior to construction of the monitoring facilities, hydrologic and geologic data were compiled and evaluated for

[11] In addition to the countywide dataset available from the U.S. Geological Survey (USGS), a dataset of stream alignments with attributes including perennial and intermittent flow designations, is available from the Napa RCD. The Napa RCD dataset is under review as part of ongoing efforts to characterize connections between surface water and groundwater.

each site to inform the monitoring well design. Monitoring well construction and development occurred in September and October of 2014. Data collection at the sites began in October of 2014 with manual groundwater level measurements followed by the installation of continuously recording pressure and electrical conductivity transducers.

The following paragraphs summarize initial project implementation activities, as documented in the *Napa County groundwater/surface water monitoring facilities report (LSCE, 2016b).* Data were regularly downloaded from project transducers in 2015 and 2016. The transducers were re-calibrated and serviced as needed. Project data were reviewed for quality control purposes and incorporated into an existing Napa County Data Management System (DMS). Data analysis occurred as the data were collected to track groundwater-surface water interactions. Project outreach occurred through a variety of means, including presentations to the WICC, presentations to community groups around Napa Valley, and a field tour organized by the Sacramento-based Water Education Foundation.

The construction of dedicated monitoring facilities to track groundwater-surface water interactions in the Napa Valley Subbasin provides the County with an important source of data about these interconnected resources. Data collected in 2015 and 2016 show that shallow groundwater and surface waters were hydraulically connected throughout much of the winter and spring at the mainstem Napa River sites, and longer into summer in some locations. The direction of flow indicated by monitoring data varied between gaining stream (flow of groundwater into surface water) and losing stream (flow of surface water into the groundwater system) at most sites. Two sites maintained losing stream conditions (flow from surface water into groundwater) throughout 2015: Site 2 located on Dry Creek at Washington Street and Site 5 located on the Napa River at Pope Street. Water year 2015 marked the fourth year of California's statewide drought. Continued data collection in subsequent years has provided a more robust understanding of the range of conditions at these sites (see **Section 5.7**).

Implementation of groundwater-surface water monitoring in the Napa Valley Subbasin has already proven to be very valuable for improving the understanding of surface water and groundwater interactions. Similar facilities at additional locations would help further this understanding and aid in ongoing efforts to sustainably manage the Napa Valley Subbasin. Additional monitoring will also be key to the objective of maintaining or improving streamflow during drier years and/or seasons. As a result, it is recommended that the County, in coordination with the Napa RCD, the Napa County Flood Control and Water Conservation District and others, as appropriate:

- Evaluate stream gaging network objectives, particularly with respect to the water budget requirements contained in the SGMA GSP Regulations and determine the need and feasibility of additional streamflow monitoring sites.
- Consider additional areas that may also benefit from nested groundwater monitoring wells located near the Napa River or its tributaries (similar to the facilities constructed as part of the current project) to monitor groundwater/surface water interactions in areas where data are lacking or where geologic conditions indicate that conditions are not adequately represented by the current monitoring network.
- Continue efforts to integrate data collected at the groundwater/surface water monitoring sites with existing remote data acquisition systems in order to facilitate monitoring aquifer conditions in real-time.

2.4.2 Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

In response to the SGMA, Napa County prepared a Basin Analysis Report (LSCE, 2016c), an alternative submittal per the requirements of Water Code Section 10733.6 (b)(3). The report was submitted to DWR on December 16, 2017 and is undergoing review at this time. The Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated by the State as a medium priority basin and is subject to specific requirements under SGMA. The report includes analysis of areas outside of the Subbasin to determine how those areas affect recharge and runoff in the Subbasin, although areas outside of the Subbasin are not subject to SGMA.

During the past eight years, Napa County has made significant progress towards implementing groundwater-related studies and recommendations. In conformance with SGMA, the intent of the GRAC, and the direction of the Napa County Board of Supervisors (April 2014), the *Napa Valley Subbasin SGMA Sustainability Goal* is:

> *To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.*

As described in the Basin Analysis Report and this Annual Report (LSCE, 2018b), groundwater conditions in the Napa Valley Subbasin have been, and continue to be, assessed using current and historical groundwater level and groundwater quality data. An extensive network of wells is used in these annual assessments. Groundwater level trends in the Napa Valley Subbasin are stable in a majority of wells having long-term groundwater level records. Several wells have shown at least some degree of response to recent drought conditions; however, levels were generally higher than they were in the same wells during the 1976 to 1977 drought.

The Napa River system is affected by a number of factors, groundwater being only one of them. The river system is influenced by dry (low rainfall) years and also drier periods within the year. Records dating back to the 1930s show the Napa River system has experienced these temporal and seasonal effects over many decades, particularly during the summer to fall period. As described above, the new groundwater monitoring wells and surface water monitoring facilities provide for the collection of continuous groundwater level and stream data to better assess the spatial and temporal interconnection of surface water and groundwater resources. The timing and amount of precipitation and natural groundwater recharge events affect the amount of groundwater baseflow discharged to the Napa River system. Heterogeneous (i.e., variable) subsurface conditions also affect the amount and location of recharge to groundwater and discharge to surface water.

While outflows from the Subbasin, including groundwater pumping, influence the surface water system, monitoring data and water budget analyses indicate that effects on the Napa River due to more or less groundwater pumping did not change during water years 1988-2015, the study period for the Napa Valley Subbasin Basin Analysis Report. Additionally, groundwater pumping is a relatively small outflow component compared to surface water stormflows and groundwater baseflow discharged to the River and ultimately to the San Pablo Bay, both of which are primarily driven by precipitation. Flow and other aspects of the Napa River are affected by many factors beyond the County's control (e.g., precipitation and climate change), and some factors within the State's control (e.g., upstream damming or withdrawal of water from tributaries and historical removal of natural wetlands and floodplains). These are not under the purview of SGMA, though the Napa County Board of Supervisors is addressing many of them in other appropriate forums.

Groundwater and surface water supplies, including imported surface water supplies, in the Napa Valley Subbasin are dependent on population trends and land uses and their associated water demands. Long-term conditions in the Napa Valley Subbasin during the 1988 to 2015 base period (e.g., Basin Analysis Report study period) have been marked by stable land uses and stable supplies of imported surface water. While most of the population in the Subbasin lives in the four incorporated municipalities (Cities of Napa, St. Helena, Calistoga, and Town of Yountville), the majority of the land is outside the municipalities and used primarily for agriculture. Municipal water use in the Subbasin ranged from a low of 14,700 acre-feet per year (AFY) in 2015 to a high of 20,400 AFY in 2002. Average annual municipal use in the Subbasin was 17,300 AFY over the 1988 to 2015 study period. The majority of this water is provided by reservoirs, increasing amounts of imported State Water Project water, and to a much smaller extent groundwater. Over the 28-year base period, water uses in the unincorporated part of the Subbasin have increased from about 4,000 AFY to about 5,000 AFY, and are mostly supplied by groundwater.

Agricultural water supplies include groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River system within the Subbasin, and surface water diverted from the Subbasin watershed (i.e., hillside areas). On average, the rate of total water use (surface water and groundwater) by agriculture within the Subbasin has decreased slightly from approximately 18,000 AFY between 1988 and 1991 to approximately 16,000 AFY between 2012 and 2015. With variations in the water supply mix on a year-to-year basis, surface water use has decreased by about 8,900 AFY, while groundwater utilization has increased by about 7,400 AFY over the same period. These changes are affected by a number of factors, including increases from new and expanded wineries and vineyards, balanced against greatly improved conservation practices and decreased residential population in the unincorporated areas. The Basin Analysis Report also includes estimated additional groundwater needs for wineries and vineyards looking forward through 2025, based on proposals for new or modified land uses within the Subbasin from 2010 to 2015.

A combined surface water and groundwater watershed-scale water budget for the Subbasin was developed to assess inflows and outflows to the Subbasin and to determine the average annual change in groundwater storage over the 28-year base period (using a model with a monthly time step). The very large volumes of upland runoff and surface water outflows that move through and out of the Subbasin in most years are the predominant factors relating to change in storage as compared to the amounts of groundwater pumped from the Subbasin or flowing out of the Subbasin as subsurface outflow. Average annual changes in groundwater storage over the base period are positive, indicating that current groundwater pumping rates are below the sustainable yield for the Subbasin. The average annual increase in storage is estimated to be 5,900 AFY, which is consistent with stable to slightly above average cumulative precipitation inputs over the 28-year base period. A separate independent analysis of groundwater levels and corresponding spring-to-spring changes was also conducted to compute the change in groundwater storage; this analysis also shows positive average annual changes in groundwater storage for the 1988 to 2015 base period (LSCE, 2016c).

The analyses presented in the Napa Valley Subbasin Basin Analysis Report demonstrate that the basin has operated within its sustainable yield over a period of more than 20 years. Stable groundwater levels observed during recent drought conditions (from 2012 through 2015), along with absence of undesirable results, suggest that recent rates of groundwater pumping have not exceeded the sustainable yield of the Subbasin. The sustainable yield analysis establishes the maximum amount of water that can be withdrawn annually from the Subbasin groundwater supply without causing an undesirable result. The sustainable yield is within approximately 17,000 AFY to 20,000 AFY. By comparison, groundwater pumping averaged about 18,000 AFY during the 2012 to 2015 drought.

The Napa Valley Subbasin Basin Analysis Report will implement legislative SGMA monitoring and reporting requirements and also provides additional recommendations to maintain or improve groundwater conditions and ensure overall water resources sustainability. It is critical that the County continue to invest in the Groundwater Program to expand the range of information and understanding of this complex water resources system. Where the County has discretionary authority, permit holders should be required to monitor their use, and data must be made available for analysis when needed. Abusive water use, when identified, must be corrected. Education and outreach should be made available to all users; only by collaborating as a community and sharing our understanding and stewardship responsibilities can the people living and working in Napa County collectively ensure that water resources are sustainable over the long-term.

2.4.3 Northeast Napa Area: Special Groundwater Study and Management Area Basin Analysis Report Amendment

On October 24, 2017, the Napa County Board of Supervisors received a report on groundwater conditions in a portion of the Napa Valley Subbasin, known as the northeast Napa Study Area (**Figure 2-7**). The report, *Northeast Napa Area: Special Groundwater Study*, (Special Study Report) was initiated by Napa County to understand recent, historical changes in water level trends in a small portion of the Napa Valley Subbasin (LSCE, 2017b).

This northeast Napa Study Area, or Study Area, experienced historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall Napa Valley Subbasin. The Study Area contains two wells that experienced historical groundwater level declines of between 20 feet and 30 feet[12], with groundwater levels in those same wells having stabilized since about 2009. Due to potential concerns relating to continued groundwater development in the area, and due to the complex hydrogeologic setting which includes mapped faults and the Napa River in relatively close proximity to the area of interest, the County authorized a study to better understand groundwater conditions and potential factors relating to historical groundwater levels in the northeast Napa Area. The study, conducted between 2016 and

[12] Both of these wells are constructed in aquifer units with semi-confined characteristics. Groundwater level declines in these wells do not imply equivalent declines in the unconfined water table.

2017, included evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in an area of interest near Petra Drive, and potential streamflow effects.

The objectives of the Special Study were to:

1. Examine existing and future water use in the northeast Napa Area,
2. Identify sources of groundwater recharge, and
3. Evaluate the geologic setting to address questions regarding the potential for long-term effects on groundwater resources and streamflow.

As part of the Special Study, a transient numerical groundwater flow model was developed that incorporates the data collected for a base period of water years from 1988 to 2015 to analyze groundwater conditions in the Study Area and the area of interest near Petra Drive. The objectives of the groundwater flow model included:

1. Assessment of potential mutual well interference of wells located in the Petra Drive area;
2. Assessment of the potential streamflow effects from current and historical land uses;
3. Assessment of the potential influence of previously documented groundwater cones of depression in an area external to the Napa Valley Subbasin known as the MST Subarea to the east of the Study Area;
4. Assessment of the groundwater supply sufficiency to meet current and potential future groundwater demands for the Study Area; and
5. Assessment of whether potential groundwater management measures or controls (similar to those previously implemented in the MST) are warranted in the Study Area.

At their meeting on October 24, 2017, the Board of Supervisors chose to support the findings and recommendations of the Special Study Report and directed staff to develop documentation to formally establish the Northeast Napa Management Area covering approximately 1,960 acres within the 45,928-acre Napa Valley Subbasin (**Figure 2-8**). In response, Napa County developed an amendment to the Basin Analysis Report for the Napa Valley Subbasin (Northeast Napa Management Area Report) (LSCE, 2018a). The Northeast Napa Management Area Report is included with this Annual Report as **Appendix A**. The Special Study Report describing the methods and results of the Northeast Napa Special Groundwater Study is included as an appendix of the Northeast Napa Management Area Report.

The amendment is a supplement to the Basin Analysis Report for the Napa Valley Subbasin, the purpose of which is to designate a management area within the Napa Valley Subbasin: The Northeast Napa Management Area. GSP Regulations adopted by the California Water Commission in 2016 define a management area as, “an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors” (Section 351).

The Basin Analysis Report Amendment was developed as a supplement to the Basin Analysis Report for the Napa Valley Subbasin. It does not change the findings of the 2016 Basin Analysis Report, rather it provides additional detail about conditions in the Northeast Napa Management Area and establishes additional sustainable management criteria and management actions intended to support continued groundwater sustainability in the Napa Valley Subbasin.

3 GROUNDWATER RESOURCES GOALS AND MANAGEMENT OBJECTIVES

3.1 Napa County Water Resources Goals and Policies

The County's 2008 General Plan update recognizes, "water is one of the most complex issues related to land use planning, development, and conservation; it is governed and affected by hundreds of federal, state, regional, and local mandates pertaining to pollution, land use, mineral resources, flood protection, soil erosion, reclamation, etc. Every year, the state legislature considers hundreds of bills relating to water issues, and in Napa County, more than two dozen agencies have some say in decisions and regulations affecting water quality and water use." As part of the 2008 General Plan update, and within the Conservation Element, six goals are set forth relating to the county's water resources, including surface water and groundwater. Complementing these goals are 28 policies and 10 water resources action items (one of which is "reserved" for later description). Napa County's six water resources goals are included below (the entire group of water resources goals, policies, and action items is included in LSCE, 2011a).

> **Goal CON-8:** Reduce or eliminate groundwater and surface water contamination from known sources (e.g., underground tanks, chemical spills, landfills, livestock grazing, and other dispersed sources such as septic systems).
>
> **Goal CON-9:** Control urban and rural storm water runoff and related non-point source pollutants, reducing to acceptable levels pollutant discharges from land-based activities throughout the county.
>
> **Goal CON-10:** Conserve, enhance and manage water resources on a sustainable basis to attempt to ensure that sufficient amounts of water will be available for the uses allowed by this General Plan, for the natural environment, and for future generations.
>
> **Goal CON-11:** Prioritize the use of available groundwater for agricultural and rural residential uses rather than for urbanized areas and ensure that land use decisions recognize the long-term availability and value of water resources in Napa County.
>
> **Goal CON-12:** Proactively collect information about the status of the County's surface and groundwater resources to provide for improved forecasting of future supplies and effective management of the resources in each of the County's watersheds.
>
> **Goal CON-13:** Promote the development of additional water resources to improve water supply reliability and sustainability in Napa County, including imported water supplies and recycled water projects.

Addressing the six water resources goals above, Napa County has produced specific General Plan Action Items related to the focus and objective of this Plan. Those action items include:

Action Item CON WR-1: Develop basin-level watershed management plans for each of the three major watersheds in Napa County (Napa River, Putah Creek, and Suisun Creek). Support each basin-level plan with focused sub-basin (drainage-level) or evaluation area-level implementation strategies, specifically adapted and scaled to address identified water resource problems and restoration opportunities. Plan development and implementation shall utilize a flexible watershed approach to manage surface water and groundwater quality and quantity. The watershed planning process should be an iterative, holistic, and collaborative approach, identifying specific drainage areas or watersheds, eliciting stakeholder involvement, and developing management actions supported by sound science that can be effectively implemented. [Implements Policies 42 and 44]

Action Item CON WR-4: Implement a countywide watershed monitoring program to assess the health of the County's watersheds and track the effectiveness of management activities and related restoration efforts. Information from the monitoring program should be used to inform the development of basin-level watershed management plans as well as focused sub-basin (drainage-level) implementation strategies intended to address targeted water resource problems and facilitate restoration opportunities. Over time, the monitoring data will be used to develop overall watershed health indicators and as a basis of employing adaptive watershed management planning. [Implements Policies 42, 44, 47, 49, 63, and 64]

Action Item CON WR-6: Establish and disseminate standards for well pump testing and reporting and include as a condition of discretionary projects that well owners provide to the County upon request information regarding the locations, depths, yields, drilling and well construction logs, soil data, water levels and general mineral quality of any new wells. [Implements Policy 52 and 55]

Action Item CON WR-7: The County, in cooperation with local municipalities and districts, shall perform surface water and groundwater resources studies and analyses and work toward the development and implementation of an integrated water resources management plan (IRWMP) that covers the entirety of Napa County and addresses local and state water resource goals, including the identification of surface water protection and restoration projects, establishment of countywide groundwater management objectives and programs for the purpose of meeting those objectives, funding, and implementation. [Implements Policy 42, 44, 61 and 63]

Action Item CON WR-8: The County shall monitor groundwater and interrelated surface water resources, using County-owned monitoring wells and stream and precipitation gauges, data obtained from private property owners on a voluntary basis, data obtained via conditions of approval associated with discretionary projects, data from the State Department of Water Resources, other agencies and organizations. Monitoring data shall be used to determine baseline water quality conditions, track groundwater levels, and identify where problems may exist. Where there is a demonstrated need for additional management actions to address groundwater problems, the County shall work collaboratively with property owners and other stakeholders to prepare a plan for managing groundwater supplies pursuant to State Water Code Sections 10750-10755.4 or other applicable legal authorities. [Implements Policy 57, 63 and 64]

Action Item CON WR-9.5: The County shall work with the SWRCB[13], DWR, DPH, CalEPA, and applicable County and City agencies to seek and secure funding sources for the County to develop and expand its groundwater monitoring and assessment and undertake community-based planning efforts aimed at developing necessary management programs and enhancements.

Based on the GRAC's charge from the Napa County Board of Supervisors and a review of many definitions in published literature, the GRAC (2014) defined "groundwater sustainability[14]" as:

Groundwater sustainability depends on the development and use of groundwater in a manner that can be maintained indefinitely without causing unacceptable economic, environmental, or social consequences, while protecting economic, environmental, and social benefits.

The GRAC concluded that groundwater sustainability is both a goal and a process; most importantly, it is a shared responsibility. Everyone living and working in the county has a stake in protecting groundwater resources, including groundwater supplies, groundwater quality, and the watersheds that support groundwater resources (GRAC, 2014). The GRAC further found that healthy communities, healthy agriculture and healthy environments exist together and not in isolation. Without sustainable groundwater resources, the character of the county would be significantly different in terms of its economy, communities, rural character, ecology, housing, and lifestyles. The GRAC also developed five major sustainability objectives that include: initiating and carrying out outreach and education efforts; optimizing existing water supplies and systems; continuing long-term monitoring and evaluation; improving the scientific understanding of groundwater recharge and groundwater-surface water interactions; and improving preparedness to address groundwater issues that might emerge (GRAC, 2014).

3.1.1 Napa Valley Subbasin Sustainability Goal

SGMA requires that each agency shall establish a sustainability goal (Section 354.24). In conformance with SGMA and the intent of the GRAC (February 2014) and the direction of the County Board of Supervisors (April 2014), the Napa Valley Subbasin SGMA Sustainability Goal is (LSCE, 2016c):

To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.

As described in the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c), the Napa Valley Subbasin has been operated within the sustainable yield for at least 20 years based on the current understanding

[13] SWRCB is the California State Water Resources Control Board. DPH is the California Department of Public Health.
[14] The definition for Groundwater Sustainability developed by the GRAC is separate from the definition of Sustainable Groundwater Management applied in the 2014 Sustainable Groundwater Management Act, see **Section 3.1.1** of this Report for additional information.

of hydrogeologic conditions and management measures. The Napa Valley Subbasin is generally a full basin, benefitting from high precipitation, corresponding high potential for substantial amounts of recharge, and land use dominated by vineyards that have a comparatively low water requirement.

3.1.2 Napa Valley Subbasin Sustainability Criteria

SGMA establishes undesirable results for applicable sustainability indicators, including a description of the process and criteria used to define undesirable results for the Napa Valley Subbasin. A "sustainability indicator" (SGMA Article 2) refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are "caused by groundwater conditions occurring throughout the basin" (Section 354.26). Undesirable results include one or more of the following (SGMA Definitions):

i. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

ii. Significant and unreasonable reduction of groundwater storage.

iii. Significant and unreasonable seawater intrusion.

iv. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

v. Significant and unreasonable land subsidence that substantially interferes with surface land uses.

vi. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The Napa River system is considered to be the most sensitive sustainability indicator in the Napa Valley Subbasin, so the measurable objectives and minimum thresholds (i.e., metrics required by SGMA to track conditions relative to the sustainability indicators) were established in the Basin Analysis Report to ensure continued groundwater sustainability, or improve groundwater conditions, and provide ongoing management targets devised to address potential future effects on surface water.

SGMA defines "representative monitoring" as "a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin" (Section 351). This subset of the County's groundwater monitoring sites is for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley Subbasin, these representative sites are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined based on work conducted for the Basin Analysis Report (LSCE, 2016c) and the Northeast Napa Management Area Report (LSCE, 2018a). Many of the representative sites are monitored for more than one sustainability indicator. In the Napa Valley Subbasin, 21 Representative Monitoring Sites have been selected to monitor sustainability indicators and to set minimum thresholds and measurable objectives to alert stakeholders and ultimately avoid chronic lowering of groundwater levels, land subsidence, reduced groundwater storage, streamflow depletion, degraded groundwater quality, and seawater intrusion.

SGMA defines a "minimum threshold" as "a numeric value for each sustainability indicator used to define undesirable results" (Section 351). The Napa Valley Subbasin Basin Analysis Report discusses the preliminary minimum thresholds established to quantify groundwater conditions for each applicable sustainability indicator at representative monitoring sites. Justification is provided for the thresholds based on best available data, including groundwater levels, groundwater quality, and surface water flows.

SGMA defines "measurable objectives" as "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions" (Section 351). Measurable objectives for each sustainability indicator are based on quantitative values using the same metrics and monitoring sites that are used to define the minimum thresholds. These objectives provide a reasonable margin of operational flexibility under adverse conditions where applicable and utilize components such as historical water budgets, seasonal and long-term trends, and periods of drought. See **Section 5.1.3** of this annual report for further discussion of the measurable objectives compared with 2017 monitoring results.

For representative monitoring sites where long-term periods of record are not available, as in the case of the dedicated monitoring facilities constructed in 2014 to monitor groundwater-surface water interactions, minimum thresholds and measurable objectives established in the Basin Analysis Report will be reviewed and reevaluated in future years as the collection of available data for each site expands to better reflect true long-term variability and representativeness of conditions at those sites.

This 2017 Annual Report summarizes groundwater conditions and compares them to the current minimum thresholds and the measurable objectives established in the Basin Analysis Report (LSCE, 2016c) and the Northeast Napa Management Area Report (LSCE, 2018a)).

3.2 Overarching Groundwater Monitoring Objectives

This section describes the water level and quality objectives established for the countywide Comprehensive Groundwater Monitoring Program[15] (LSCE, 2013a). The overarching groundwater monitoring objectives are linked to: 1) the County's General Plan goals and action items presented above, and 2) hydrogeologic conditions and potential areas of concern, including (but not limited to):

- Monitoring trends in groundwater levels and storage (e.g., groundwater balance) to assess and ensure long-term groundwater availability and reliability;
- Monitoring of groundwater-surface water interactions to ensure sufficient amounts of water are available to the natural environment and for future generations;

[15] These objectives were developed by the Napa County GRAC prior to passage of the 2014 Sustainable Groundwater Management Act. SGMA defines Measurable Objectives as quantitative means of evaluating the efficacy of groundwater basin management, which is different from the approach applied by the GRAC.

- Monitoring in significant recharge areas to assess factors (natural and human-influenced) that may affect groundwater recharge (including climate change) and also aid the identification of opportunities to enhance groundwater recharge and storage;
- Monitoring to establish baseline conditions in areas of potential saline water intrusion;
- Monitoring of general water quality to establish baseline conditions, trends, and protect and preserve water quality.
- Identify where data gaps occur in the key subareas and provide infill, replacement, and/or project-specific monitoring (e.g., such as may occur for planned projects or expansion of existing projects) as needed; and
- Coordinate with other entities on the collection, utilization, and incorporation of groundwater level data in the countywide DMS.

In addition to the countywide monitoring objectives summarized below, the Plan also includes subarea-level objectives for groundwater level and groundwater quality monitoring, based on the analysis of existing groundwater data and conditions described in the report *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a) and with input received from the GRAC.

3.2.1 Groundwater Level Monitoring Objectives

The countywide groundwater level monitoring program includes the following objectives:

- Expand groundwater level monitoring in priority County subareas to improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, especially in areas where short- and long-term development of groundwater resources are planned (this includes additional monitoring of the Tertiary formation aquifer in the area between the MST Subarea and the northeastern part of the Napa Subarea to determine whether groundwater water conditions in the MST Subarea are affecting other areas (LSCE and MBK, 2013);
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation, surface water seepage to groundwater, groundwater discharge to streams) or induced factors (e.g., pumping, purposeful recharge/infiltration operations; application of recycled water) that affect groundwater levels and trends;
- Identify appropriate monitoring sites to further evaluate groundwater-surface water interaction and recharge/discharge mechanisms, including whether groundwater utilization is affecting surface water flows;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

3.2.2 Groundwater Quality Monitoring Objectives

The primary objectives of the countywide groundwater quality monitoring program include (LSCE, 2013a):

- Evaluate groundwater quality conditions in the various county subareas and identify differences in water quality spatially between areas and vertically in the aquifer system within a subarea;
- Detect the occurrence of and factors attributable to natural (e.g., general minerals and trace metals) or other constituents of concern;
- Establish baseline conditions in areas of potential saltwater intrusion, including the extent and natural occurrence and/or causes of saltwater beneath the Carneros, Jameson/American Canyon and Napa River Marshes Subareas;
- Assess the changes and trends in groundwater quality; and
- Identify the natural and human factors that affect changes in water quality.

4 GROUNDWATER MONITORING NETWORK

4.1 Groundwater Level Monitoring

Groundwater level monitoring was conducted at a total of 107 sites across Napa County in water year 2017 (**Table 4-1)**. **Figure 4-1** shows the distribution of sites monitored in 2017 according to the data reporting entity.

Table 4-1 Current Groundwater Level Monitoring Sites in Napa County by Reporting Entity

Reporting Program	Number of Monitored Wells, Fall 2016	Number of Monitored Wells, Fall 2017
Napa County		
CASGEM		
Surface Water-Groundwater Monitoring Wells	*10*	*10*
Domestic and Irrigation Wells	*23*	*23*
CASGEM Subtotal	33	33
State Water Data Library	18	16
County Volunteer Groundwater Monitoring Program	47	47
Napa County Subtotal	**98**	**96**
California Department of Water Resources		
State Water Data Library / Volunteered Sites	**4**	**4**
State Water Resources Control Board		
Geotracker	**6**	**7**
Total Sites, All Entities	**108**	**107**

Out of the total 107 sites monitored in 2017, 96 wells were monitored by Napa County. Four wells were wells monitored by DWR. The remaining seven sites were regulated facilities with multiple wells with data reported as part of the State Water Resources Control Board (SWRCB) Geotracker Program (**Table 4-1**).

Two wells previously monitored by Napa County left the monitoring network at the request of the owner in 2017 (**Table 4-2**). During the summer of 2017, DWR temporarily suspended monitoring efforts at four wells that it has monitored. That suspension was extended in response to multiple, large wildfires that burned in many areas around Napa Valley in 2017.

Wells monitored in 2017 were distributed across 13 of 18 groundwater subareas (**Table 4-3**). As in previous years, most monitored wells were in the five Napa Valley Floor groundwater subareas and the Carneros Subarea. Groundwater levels were monitored at 61 sites distributed throughout the Napa Valley Subbasin designated by DWR.

Additional summary information for currently monitored sites is provided in **Appendix B**.

Table 4-2 Napa County Monitoring Network Status Changes and Updates Through October 2017

Well ID	Status Change	Groundwater Subarea
NapaCounty-10	Left monitoring network at owner's request	MST
NapaCounty-148	Left monitoring network at owner's request	MST

4.1.1 Napa County Monitoring Network

Out of the total 107 sites monitored in 2017, 96 wells were monitored by Napa County. Eight wells were monitored by Napa County on a monthly interval, to address temporal data gaps identified in the 2014 Annual Monitoring Report (LSCE, 2015). Ten wells were monitored using continuously recording instrumentation at dedicated monitoring wells constructed as part of the County's Surface Water–Groundwater Monitoring Project.

Table 4-3 Groundwater Level Monitoring Sites in the Napa Valley Subbasin and Napa County Groundwater Subareas

Groundwater Basin or Groundwater Subarea	Number of Monitored Sites, Fall 2014	Number of Monitored Sites, Fall 2015	Number of Monitored Sites, Fall 2016	Number of Monitored Sites, Fall 2017
Napa-Sonoma Valley – Napa Valley Subbasin	64	56	57	61
Napa Valley Floor-Calistoga	10	9	7	7
Napa Valley Floor-MST	27	27	26	25
Napa Valley Floor-Napa	21	20	21	21
Napa Valley Floor-St. Helena	14	14	14	14
Napa Valley Floor-Yountville	12	14	13	13
Carneros	12	12	12	12
Jameson/American Canyon	1	1	1	1
Napa River Marshes	1	-	-	-
Angwin	5	5	5	5
Berryessa	2	3	1	1
Central Interior Valleys	1	2	2	2
Eastern Mountains	3	4	3	3
Knoxville	-	-	-	-
Livermore Ranch	-	-	-	-
Pope Valley	1	1	1	1
Southern Interior Valleys	-	-	-	-
Western Mountains	2	1	2	2
Unknown[1]	3	-	-	-
Total Sites	**115**	**113**	**108**	**107**

[1] In 2014 three sites in the Geotracker regulated groundwater monitoring network were reporting groundwater level data but had not yet reported location information for the monitored wells.

4.1.2 CASGEM Monitoring Network

The CASGEM Monitoring Network is a subset of the total wells in the monitoring program. Well owners voluntarily choose whether to participate in the State's CASGEM Program. As of fall 2016 the Napa County CASGEM Monitoring Network included 23 privately-owned wells monitored by Napa County and 10 dedicated monitoring wells from the Surface Water-Groundwater Monitoring Project (**Figure 2-6**). Wells in the CASGEM monitoring network are distributed across all five Napa Valley Floor Subareas (Calistoga, St. Helena, Yountville, Napa, and MST) as well as the Carneros, Angwin, and Western Mountains Subareas (**Table 4-4 and Figure 4-2**). Nineteen of the CASGEM Network wells in Napa County are located in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin (**Table 4-5**). In addition, six CASGEM Network wells are located in the Napa-Sonoma Lowlands Subbasin of the Napa-Sonoma Valley, while eight are not located in any groundwater basin or subbasin.

Table 4-4 Current CASGEM Network Sites in Napa County by Groundwater Subarea

Groundwater Subarea	Number of Monitored Sites, Fall 2017
Napa Valley Floor-Calistoga	1
Napa Valley Floor-MST	5
Napa Valley Floor-Napa	9
Napa Valley Floor-St. Helena	5
Napa Valley Floor-Yountville	5
Carneros	6
Jameson/American Canyon	-
Napa River Marshes	-
Angwin	1
Berryessa	-
Central Interior Valleys	-
Eastern Mountains	-
Knoxville	-
Livermore Ranch	-
Pope Valley	-
Southern Interior Valleys	-
Western Mountains	1
Total Sites	**33**

Table 4-5 Current CASGEM Network Sites in Napa County by Groundwater Basin

Basin/Subbasin Number	Basin Name	Subbasin Name	Number of Monitored Sites, Fall 2017
2-2.01	Napa-Sonoma Valley	Napa Valley	19
2-2.03	Napa-Sonoma Valley	Napa-Sonoma Lowlands	6
5-20	Berryessa Valley	-	-
5-68	Pope Valley	-	-
2-3	Suisun-Fairfield Valley	-	-
-	Non-basin Areas	-	8
		Total Sites	**33**

4.1.3 DWR Monitoring Network

DWR currently monitors four wells in Napa County as part of its voluntary groundwater monitoring efforts (**Table 4-1**). Three of these wells are monitored at monthly intervals, while one is monitored semi-annually. These wells are distributed across the Napa Valley Groundwater Subbasin. As noted in **Section 4.1**, DWR suspended monitoring at all four wells over the summer of 2017. DWR staff have indicated that monitoring will resume after safety assessments are made in response to the wildfires that affected Napa County in 2017.

4.1.4 State Water Resources Control Board Geotracker Network

The State Water Resources Control Board (SWRCB) stores environmental data for regulated facilities in California in their Geotracker database, including groundwater levels and groundwater quality. Data from these regulated facilities usually include manual measurements and samples from groundwater monitoring wells (typically shallow) at each site. Groundwater level data are available for seven Geotracker sites located throughout Napa County in 2017 (**Table 4-1**). The groundwater level monitoring frequency is typically semi-annual or quarterly, although more frequent measurements are sometimes recorded. Geotracker sites with data reported in 2016 are located in the Napa Valley Floor-Napa, Napa Valley Floor-MST, Berryessa, and Central Interior Valleys Subareas (**Figure 4-1**). Five of the sites are located within the Napa Valley Groundwater Subbasin, while the other two are not within any designated groundwater basin.

4.2 Surface Water-Groundwater Monitoring

Funding from the DWR 2012 Local Groundwater Assistance Grant Program enabled Napa County to construct 10 monitoring wells at five sites in the Napa Valley Subbasin in September 2014. These wells comprise the groundwater monitoring facilities for the Napa County Surface Water-Groundwater Monitoring Project. In addition to grant funding from DWR, Napa County provided matching funds to cover a portion of the monitoring well construction and instrumentation costs (LSCE, 2016b).

4.2.1 Surface Water-Groundwater Monitoring Network

Four of the current surface water-groundwater sites are located along the Napa River while one is adjacent to Dry Creek (**Figure 2-6**). The five sites are within the Napa, Yountville, and St. Helena Subareas of the Napa Valley Floor. These are three of the six subareas where paired surface water-groundwater monitoring was recommended in the 2013 Plan.

Each of the five sites includes a dual-completion monitoring well to enable monitoring of groundwater conditions at specific depth intervals. These dual-completion wells consist of two separate casings in a single borehole. Each casing is independent of the other with distinct total depths and screen intervals. The construction details for each casing were developed based on site-specific hydrogeologic and surface water channel considerations.

In general, groundwater monitoring facilities at each site consist of one shallow casing constructed to represent groundwater conditions at the water table surface and at elevations similar to the adjacent surface water channel. The second casing at each site is constructed to a deeper depth with screen intervals coinciding with aquifer materials and depths likely to be accessed by production wells in the vicinity. Paired casings are separated within the borehole by intermediate seals designed to provide a physical separation such that groundwater conditions reflected by each casing are not influenced by conditions in other portions of the groundwater system.

4.3 SGMA Representative Monitoring Sites

Groundwater level conditions are currently monitored at 61 sites distributed throughout the Subbasin (**Table 4-3** and **Figure 4-3**). These sites include 20 wells identified as groundwater level representative wells in the Basin Analysis Report (**Table 4-6**).[16] SGMA defines "representative monitoring" as "a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin" (Section 351). This subset of representative monitoring sites is established for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley Subbasin, these sites are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined.

Napa County has used the term "representative" in reference to hydrographs presented in previous reports (LSCE, 2011a; 2015; 2016a). Specific representative monitoring sites that typify conditions in the Subbasin are designated in the Basin Analysis Report, to align ongoing monitoring efforts with SGMA (LSCE, 2016c). Seven of the SGMA representative wells were selected because of their long historical groundwater level record and their prior use in Napa County groundwater-related reports as "representative" wells with hydrographs that typify groundwater conditions and trends in the Subbasin. Ten relatively new wells in the surface water-groundwater monitoring network were selected because of their construction and location, for the specific purpose of assessing surface water and groundwater interaction. One other well, 5N4W-15E1, was selected because of its location in the southern part of the Subbasin, moderate historical groundwater level record, and likely construction in unconfined part of the groundwater system and for the purpose of tracking groundwater trends and gradients near the adjoining subbasin. Well 5N4W-15E1 is currently only associated with minimum thresholds and measurable objectives for groundwater quality.[17] As part of its ongoing efforts to refine the understanding of how groundwater conditions in individual wells relate to different aquifer zones in the Subbasin, Napa County will continue to review new information on well construction and other information that may provide additional insights on the interpretation of well-specific data in relation to the hydrogeologic conceptual model for the Subbasin. One example of such review is NapaCounty-135, which is understood to be in an area where alluvial deposits are relatively thin. Analysis conducted for this Report has shown that the well likely has the majority of its screened interval in formations of the Tertiary Sonoma Volcanics, below the alluvium.

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[16] Well 5N/4W-15E1 is currently the only representative monitoring site designated for groundwater quality criteria, but not groundwater level criteria. Therefore, a total of 21 representative monitoring sites are established for the Napa Valley Subbasin, twenty of which have groundwater level criteria.

[17] Groundwater quality monitoring also occurs at the 10 dedicated monitoring wells owned by Napa County at surface water-groundwater monitoring sites and three additional production wells monitored by DWR in the Napa Valley Subbasin. In addition, groundwater quality monitoring is planned to occur at up to 16 wells in the Napa County voluntary monitoring network.

Table 4-6 Napa Valley Subbasin Representative Monitoring Sites

Well ID	Data Source	Aquifer Designation[1]	Subarea	Well Depth (ft)	Basis for Selection
06N04W17A001M	DWR	Qa	Yountville	250	Long record
06N04W27L002M	DWR	Qa	Napa	120	Long record
07N05W09Q002M	DWR	ND	St. Helena	232	Long record
08N06W10Q001M	DWR	ND	Calistoga	200	Long record
5N/4W-15E1	DWR	Qa	Napa	158	Moderate record [2]
NapaCounty-76	Napa County	Tsv	Napa	405	Aquifer-specific construction, Moderate record
NapaCounty-122	Napa County	Tss	MST	210	Aquifer-specific construction, Moderate record
NapaCounty-229	Napa County	Tss	MST	350	Aquifer-specific construction, Moderate record
NapaCounty-128	Napa County	Qa	Calistoga	50	Long record
NapaCounty-133	Napa County	Qa	Yountville	120	Long record
NapaCounty-135	Napa County	Qa, Tsv	Yountville	125	Long record
Napa County 214s-swgw1	Napa County	Qa	Napa	53	Designated SW/GW facility [3]
Napa County 215d-swgw1	Napa County	Qa	Napa	98	Designated SW/GW facility
Napa County 216s-swgw2	Napa County	Qa	Yountville	50	Designated SW/GW facility
Napa County 217d-swgw2	Napa County	Qa	Yountville	86	Designated SW/GW facility
Napa County 218s-swgw3	Napa County	Qa	Napa	40	Designated SW/GW facility
Napa County 219d-swgw3	Napa County	Qa	Napa	93	Designated SW/GW facility
Napa County 220s-swgw4	Napa County	Qa	Yountville	45	Designated SW/GW facility
Napa County 221d-swgw4	Napa County	Qa	Yountville	85	Designated SW/GW facility
Napa County 222s-swgw5	Napa County	Qa	St. Helena	40	Designated SW/GW facility
Napa County 223d-swgw5	Napa County	Qa	St. Helena	100	Designated SW/GW facility

1 Aquifer Designations: Qa = Quaternary Alluvium, Tsv = Tertiary Sonoma Volcanic Rocks, Tss = Tertiary Sedimentary Rocks, ND = Not Determined

2 Well 5N4W-15E1 is currently designated as a representative site for groundwater quality criteria only.

3 Designated SW/GW facility refers to surface water and groundwater monitoring facilities installed as part of the DWR Local Groundwater Assistance Program grant awarded to Napa County for purposes of evaluating the connectivity between groundwater and surface water.

5 GROUNDWATER LEVEL CONDITIONS AND TRENDS

Groundwater data availability in Napa County varies widely between local subareas. The bulk of sites with historical and current groundwater level and quality data are located in the Napa Valley Floor Subareas (e.g., the Calistoga, St. Helena, Yountville, Napa, and MST Subareas) with less abundant records available in other Napa County subareas. Except for the MST Subarea, the Napa Valley Floor subareas generally coincide with the Napa Valley Groundwater Subbasin delineated by DWR. This section presents a discussion of groundwater levels, with a focus on groundwater level characteristics by local subarea.

Precipitation records in Napa County date to 1906 at the longest continually operating gauge at the Napa State Hospital (GHCND: USC00046074). In a separate analysis, precipitation data from the Napa State Hospital gauge in Napa (elevation 35 feet) have been shown to have strong linear correlations (i.e., $R^2 \geq 0.90$) with monthly and annual precipitation totals from two other gauges in St. Helena (elevation 1,780 feet) and Angwin (elevation 1,815 feet) (2NDNature, 2014). Based on the strength of those correlations, the Napa State Hospital gauge has been recommended for use as an index gauge for the Napa River Watershed.

Napa County received below average precipitation at the Napa State Hospital gauge during water years 2012, 2013, 2014, 2015, and 2016. Water year 2014 registered as a Dry year on the five-stage rating system of Very Dry, Dry, Normal, Wet and Very Wet water year types (**Table 5-1**). Since 1949 when most long-term groundwater monitoring records begin, comparable multi-water year periods with below average precipitation occurred in 1990-1991 (both Dry), 1976-1977 (both Very Dry), and 1959-1962 (all Dry), and 1954-1955 (both Dry).

Table 5-1 Recent Napa State Hospital Annual Precipitation Totals and Napa River Watershed Water Year Types

Water Year	Annual Precipitation (in) (updated values from LSCE)	Water Year Type
2009	21.31	Normal (below average)
2010	28.85	Wet
2011	36.62	Wet
2012	21.75	Normal (below average)
2013	20.26	Normal (below average)
2014	19.67	Dry
2015	20.72	Normal (below average)
2016	24.42	Normal (below average)
2017	45.50	Very Wet
Napa State Hospital (NSH) Average Annual Water Year Precipitation (1920 – 2016) = 24.85 inches		

Figure 5-1 depicts both the annual water year precipitation recorded at the Napa State Hospital gauge along with the cumulative departure from the mean water year precipitation value for water years 1950 through 2017. A cumulative departure from mean curve is often used to identify trends in historical climatic conditions, such as periods of dry, average, or wet conditions. To develop a cumulative departure curve, the long-term mean (average) of a set of climatic data is calculated and compared to each annual amount, to determine the amount of annual departures from the mean. The cumulative departure curve is then compiled by progressively accumulating these annual departure amounts, from the first year through the last year of the historical period. The cumulative departure curve always begins and ends at zero, because the values are a measure of deviation from an arithmetic mean across the complete dataset on which the mean is calculated. Downward trends through time are indicative of a period of overall dry conditions, upward trends indicate a period of overall wet climatic conditions, and level sections of the curve indicate a period of overall average conditions. This cumulative departure curve was developed for the Napa Valley Subbasin to identify precipitation trends over time.

The cumulative departure values calculated for **Figure 5-1** provide a tally of precipitation received relative to the mean value over time. Beginning in water year 1988, the first year of the study period used for the Basin Analysis Report, three different periods are evident. From 1988 to 1994, the Subbasin received below average precipitation in six of seven years. From 1995 to 2006, the Subbasin received above average precipitation in nine of twelve years, resulting in a broadly positive trend in the cumulative departure curve. From 2007 to 2016, the Subbasin received below average precipitation in eight of ten years.

Notably, the eight-year span from 1987 through 1994, with only one year of above average precipitation, resulted in a net cumulative departure deficit[18] of 48.24 inches (**Figure 5-1**). This protracted period contrasts with the Very Dry years of 1976 and 1977, which although more acute, produced a less severe net cumulative departure deficit of 28.55 inches. Groundwater level records from the Napa Valley Groundwater Subbasin that include both of these time periods generally show the lowest spring groundwater levels in 1977, as compared to the 1987 to 1994 period. This indicates that the Subbasin experienced sufficient recharge relative to outflows allowing it to maintain relatively stable spring groundwater levels over an eight-year period when precipitation totals were below average on the whole.

The five-year span from 2012 through 2016 produced a net cumulative departure deficit of 32.53 inches. Despite the decline in the cumulative departure curve of precipitation in Napa Valley, groundwater levels in the Napa Valley Subbasin have remained stable since 2012 at the Subbasin scale. Groundwater levels in the Quaternary alluvial formations that comprise the principal aquifer system of the Napa Valley Subbasin continued to experience groundwater recharge and corresponding rises in groundwater levels from fall to spring during this time.

[18] The progressive accumulation or deficit of precipitation (i.e., cumulative annual departure relative to the mean) can have important effects on hydrologic relationships (e.g., streamflow) that are directly related to precipitation.

Water year 2017 was the single wettest year since 1983 in the Subbasin. Depths to water in the Subbasin in spring 2017 ranged from 2.5 feet to 21.2 feet below ground surface (**Figure 5-2**). The values shown in **Figure 5-2** are interpolated from measured wells throughout the Subbasin.

Overall, the depth to the groundwater table in the alluvial aquifer of the Subbasin is quite shallow; the depth to groundwater in the main part of the Napa Valley Floor in the spring 2017 was between 2.5 and 21.2 feet. While agricultural land use, especially vineyards, have covered much of the Napa Valley Floor for decades, the water requirements for this type of agricultural land use are significantly lower than agricultural commodities grown elsewhere in California, such as the Central Valley (LSCE, 2016c). **As a result, due to high recharge potential in most years, low water requirements and a hydrogeologic setting conducive to recharge, the Napa Valley Subbasin remains full overall.**

Underlying geologic setting and differences in aquifer zones within a subarea or groundwater subbasin are additional considerations relevant to the interpretation of groundwater levels, particularly for wells constructed entirely or partially within the alluvium in Napa Valley. **Figure 5-3** depicts three wells located relatively near each other at the land surface which exhibit distinct groundwater levels due in part to having been constructed within different aquifer zones. Well 07N05W09Q2 has a total depth of 232 feet and is located near the center of Napa Valley, where the alluvium extends to approximately 200 feet below ground surface (LSCE and MBK, 2013). NapaCounty-138 has a total depth of 321 feet and is located closer to the western edge of Napa Valley in an area where the alluvium extends only about 50 feet below ground surface. NapaCounty-177 has a total depth of 123 feet and is located closer to the center of Napa Valley where the alluvium extends to depths of about 130 feet. The lower static water levels measured in the fall at NapaCounty-138 indicate that the well draws water from a geologic formation below the alluvium and is therefore not interpreted to provide accurate representation of static groundwater level conditions in the alluvial aquifer system in fall when water levels in the well are most impacted by groundwater pumping that has occurred over the dry season. Knowledge of the geologic setting and construction details for a given well are important considerations when interpreting groundwater level data.

Figure 5-4 depicts another example of the influence that aquifer zones can have on water levels in wells located in the same area. In this case, the well located east of the Napa River is constructed in the Sonoma Volcanics, while the wells west of the Napa River are constructed within alluvial sediments. Additional discussion of these wells is provided in **Section 5.1.2**.

The groundwater elevation contours described below are derived from available depth to water measurements made in wells. Prior to interpolating groundwater elevations across the valley, depth to water values were converted to groundwater elevation values by subtracting the measured depth to water from the reference point elevation at each monitored well. In this way, the depth to water measurements were related to the North American Vertical Datum 1988 (NAVD88) as a standard point of reference. The resulting groundwater elevation values at each well were used to interpolate groundwater elevation contours for the alluvial aquifer system of the Napa Valley Floor and in the aquifer system of the volcanic sediments and volcanic rock formations in the MST area. A contour line represents a line of equal elevation of the water surface similar to the way a topographic map contour line shows a line of equal elevation of ground surface. The direction of groundwater flow is perpendicular to the contour lines.

5.1 Napa Valley Subbasin

The Napa Valley Floor Subarea is subdivided into five smaller subareas. From north to south these areas are Calistoga, St. Helena, Yountville, Napa, and the MST. The groundwater level conditions in each of these areas are described below.

Over the length of the Napa Valley, groundwater is contained in and moves primarily through the older and younger Quaternary alluvial formations from Calistoga to San Pablo Bay and is assumed, for the purposes of contouring groundwater data on a regional basis, to represent a single aquifer. These alluvial formations comprise the principal aquifer system of the Napa Valley Subbasin (LSCE, 2016c). Groundwater levels that were determined to represent a non-alluvial part of the aquifer system were excluded from the contouring dataset. Monitoring conducted since 2014 at dedicated monitoring wells along the Napa River and Dry Creek within Napa Valley and data from other wells show that within the Napa Valley alluvial formations groundwater conditions range from unconfined to semi-confined throughout the Valley Floor and Napa Valley Subbasin. The degree of confinement in groundwater results from variations in the nature of geologic materials, with more aerially extensive and thicker areas of fine-grained, low-permeability materials leading to semi-confined conditions in underlying aquifer materials that can result in groundwater levels in deeper portions of the alluvium being offset from groundwater levels in shallower portions of the alluvium. These differences in groundwater levels are an indication of physical resistance to vertical groundwater flow between unconfined to semi-confined areas. Data from wells constructed in semi-confined portions of the Subbasin are included in the development of groundwater level contour maps for spring only if spring groundwater levels measured at those locations are consistent with groundwater levels in other wells in the vicinity.

Interpreted groundwater elevation contours for spring and fall 2017 are shown in **Figures 5-5** and **5-6,** respectively. Groundwater elevation contours for Napa Valley in spring 2017 are similar to those developed for prior years dating back to spring 2010 (LSCE, 2013b; LSCE, 2015; LSCE, 2016a; LSCE, 2017a). Contours across these time periods show a generally southeasterly to east-southeasterly groundwater gradient paralleling the valley axis from Calistoga to Yountville with similar groundwater elevation ranges. In the southern portion of the valley, near the City of Napa, contours indicate a more eastward flow direction, consistent with the spring contours dating back to 2014. Through the valley, groundwater elevations in spring 2017 ranged from 386 feet near Calistoga to 5 feet along the Napa River near First Street in Napa.

5.1.1 Napa Valley Subbasin – Calistoga and St. Helena Subareas

The hydrographs for the representative wells illustrated on **Figure 5-7** show groundwater elevations and corresponding depth to groundwater from 1970 to present, as available[19]. Groundwater levels have been generally stable over time in the Calistoga Subarea and northern portion of the St. Helena Subarea. Groundwater levels in the representative wells are frequently very shallow at less than 10 feet below the ground surface in the spring. Minor seasonal groundwater level variations of about 10 feet occur

[19] Hydrographs contained in Figures 5-7, 5-8, 5-13, and 5-14 include only data that are not designated with questionable measurement flags, which are used to indicate when a measurement is likely to not accurately represent a static water level. Hydrographs for the same wells are included in Appendix C with all available data points plotted.

between spring and fall in the Calistoga Subarea. Groundwater levels in well 08N06W10Q1 have been lower in the late September to December timeframe in seven years since 2001. However, in every year since 1970, including 2017 groundwater levels returned to within 10 feet of the ground surface the following spring.

Elsewhere in the St. Helena Subarea, groundwater levels exhibit greater seasonal declines of about 20 feet. Groundwater levels at well 07N05W09Q2 have remained relatively stable although somewhat susceptible to dry years. An example of this occurred in 1976 and 1977, two Very Dry years in the Napa River Watershed. In 1976, the spring groundwater level measurement was 18.8 feet below ground surface, lower by more than 10 feet from the prior spring. In 1977, the spring groundwater level measurement was 26.7 feet below ground surface, down almost 8 feet from the spring 1976 measurement. Spring water levels in the same well in 2014 and 2015 were 18.1 feet and 12.7 feet below ground surface, respectively; the spring 2014 and 2015 levels are above the levels measured in 1976 and 1977. In 2017 the spring groundwater level was measured as high as 9.2 feet below ground surface. Fall water levels in 07N05W09Q2 remained about 5 feet above levels recorded at similar times of year from 2013 to 2015.

NapaCounty-132 was noted in the 2014 Annual Monitoring Report for possible signs of declining water levels. This well is recorded as having a total depth of 265 feet, screened from 25 feet to 265 feet, in an area where the thickness of alluvial deposits is likely less than 100 feet. The driller's Log for the well indicates extensive clay (or fine grained, low permeability) layers were encountered, particularly in the upper 100 feet of the boring. In spring 2015 a depth to groundwater of 16.1 feet was measured at this well, which is more comparable to levels seen prior to 2014. A site visit to this well conducted in 2015 showed that much of the surrounding acreage is planted in young vines. A subsequent review of aerial photography showed that a large-scale vineyard replanting took place in 2007. Given these observations it is possible that changing irrigation demands have been a factor in this area since 2007.

Monthly groundwater level monitoring conducted at NapaCounty-132 in 2017 showed groundwater levels as high as 7.6 feet below ground surface in spring 2016 (**Appendix C**). That level was more than 7 feet above the depth to water recorded in spring 2015.

5.1.2 Napa Valley Subbasin – Yountville and Napa Subareas

The representative hydrographs shown in **Figure 5-8** show groundwater elevations and corresponding depths to water in the Yountville and Napa Subareas. Long-term groundwater elevations have remained stable in most of the representative wells in the Yountville Subarea. In the Yountville Subarea, the depth to groundwater in the spring is generally less than 10 to 20 feet under non-drought conditions, similar in nature to the Calistoga and St. Helena Subareas to the north. Seasonal fluctuations vary by proximity to the center of the valley. Along the western and eastern edges of the subarea, levels are more subject to larger seasonal fluctuations. Groundwater elevations in the center of the valley fluctuate seasonally approximately 10 to 25 feet, and near the edge of the valley fluctuate approximately 25 to 35 feet.

In the Napa Subarea, depth to water ranges from about 20 to 30 feet below ground surface during the spring. Seasonal groundwater elevations in this subarea generally fluctuate from 10 to 40 feet. Long-term trends have been generally stable with the exception of the northeastern area at NapaCounty-75 and Napa County-76 where groundwater levels have locally declined by about 20 to 30 feet over the past 15 years[20] (**Appendix C**).

NapaCounty-75 and NapaCounty-76 are located east of the Napa River and East Napa Fault and west of Soda Creek Fault. Both wells are completed below the alluvium in the Sonoma Volcanics formations. The Sonoma Volcanics are also present in the MST Subarea to the east, where previous monitoring has shown several pumping depressions (LSCE, 2011a). Analyses conducted with the groundwater flow model developed for the Northeast Napa Special Groundwater Study found a trend of decreasing subsurface inflow into the Napa Valley Subbasin from portions of the MST Subarea east of the Soda Creek Fault resulting from the influence of the cones of depression east of the Soda Creek Fault outside of the Subbasin (**Figure 2-8**) (LSCE, 2017b).

Three monitored wells located west of the Napa River and nearest to NapaCounty-75 and NapaCounty-76 (i.e., 06N04W27L002M, NapaCounty-218s, and NapaCounty-219d) are constructed to depths of 120 feet or less and are completed in the alluvium. These three wells have shown stable groundwater level trends. Well 06N04W27L002M, in particular, has shown stable water levels since the 1960s. It appears that the extent of the pumping depression beyond the MST subarea is limited to the northeastern Napa Subarea east of the Napa River.

Although NapaCounty-75 is no longer actively monitored by Napa County, three additional wells have been added to the County's monitoring networks in this area in the last three years, NapaCounty-182, NapaCounty-228, and NapaCounty-229 (**Appendix C**).

In the southwestern part of the Yountville Subarea and at the Napa Valley margin, groundwater levels in NapaCounty-135 have exhibited increasing seasonal variation from spring to fall, since the first measurements were recorded in the late 1970s and early 1980s. The well also experienced very limited water level recovery in spring 2014, with a measurement of 76 feet below ground surface (**Figure 5-8**). In response to these observations Napa County began monitoring this well at monthly intervals in fall 2015. Water levels measured at NapaCounty-135 recovered to 23.8 feet below ground surface and in 2016 and 21.3 feet in 2017, indicating that groundwater storage depletions observed during the prior years were resolved with a return to more moderate and then wet water year conditions.

Regarding the increasing seasonal variation observed at NapaCounty-135, monthly data collected at this well in the fall of 2015 and 2016 show monthly variations between October and November of 7 and 23 feet, respectively. Spring measurements recorded in March and April 2017 differed by more than 6 feet. These variations indicate the potential variability that semi-annual data collection at this well from 1979 through 2014 did not capture.

Very little construction information is available for NapaCounty-135. It is known to have a total depth of 125 feet and is located in an area where the total thickness of the alluvium is likely less than 50 feet, based on contours of alluvium thickness developed as part of the report *Updated Hydrogeologic Conceptualization and Characterization of Conditions Report* (LSCE and MBK Engineers, 2013). As at

[20] NapaCounty-75 is among the wells that left the monitoring network in 2015. The latest available measurement from this well was recorded in October 2014.

NapaCounty-132, the construction information and alluvium thickness data for the area around the well suggest that a substantial portion of the well screen is likely exposed to geologic formations below the alluvium, as a result conditions in this well in the fall are reflective of conditions in older, semi-consolidated formations below the primary alluvial aquifer of the Napa Valley Subbasin.

5.1.3 Napa Valley Subbasin Sustainability Indicators

As described in **Section 2.4.2**, the Basin Analysis Report for the Napa Valley Subbasin provides an updated sustainability goal for the Subbasin based on the requirements of SGMA (LSCE, 2016c). The Basin Analysis Report meets the functionally equivalent standard for alternatives to a Groundwater Sustainability Plan (GSP) in part by updating sustainability criteria for the Napa Valley Subbasin in conformance to the definitions provided in SGMA. To evaluate the condition of the Subbasin in relation to the sustainability goal, the sustainability criteria include measurable objectives and minimum thresholds developed to avoid the six undesirable results identified in SGMA (LSCE, 2016c). For SGMA purposes a “measurable objective” is “specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions” (Section 351). SGMA additionally defines a “minimum threshold” as “a numeric value for each sustainability indicator used to define undesirable results” (Section 351).

At all 18 wells with available data, the lowest recorded groundwater elevation for fall 2017 was equal to or greater than the minimum threshold (**Table 5-2**). In nine wells the lowest recorded groundwater elevation for fall 2017 was at or above the measurable objective.

The measurable objectives established in the Basin Analysis Report for the Napa Valley Subbasin provide a reasonable margin of operational flexibility under adverse conditions where applicable and utilize components such as historical water budgets, seasonal and long-term trends, and periods of drought. Groundwater elevations serve as the proxy for multiple sustainability indicators where reasonable. For representative monitoring sites where, long-term periods of record are not available, as in the case of the dedicated monitoring wells constructed in 2014, which were developed specifically to monitor groundwater-surface water interactions, measurable objectives established at these facilities will be reviewed and reevaluated as appropriate, as the collection of available data for each site expands to better reflect true long-term variability at those locations.

As noted earlier in this Report, the Napa River system is considered to be the most sensitive sustainability indicator in the Napa Valley Subbasin (also see **Section 3**). Measurable objectives and minimum thresholds were established to ensure continued groundwater sustainability, or improve groundwater conditions, and provide ongoing management targets devised to address potential future effects on surface water.

Based on the analyses of surface water and groundwater interconnections, measurable objectives and minimum thresholds for streamflow depletion are set at 16 SGMA-related representative wells in the Subbasin (**Table 5-2**) (LSCE, 2016c). The measurable objectives represent the mean fall groundwater level elevations that occurred historically. The minimum thresholds represent the lowest static groundwater level elevation that has occurred historically in the fall and an elevation below which additional streamflow depletion is likely to occur, i.e., expand the duration of annual no flow days in some reaches of the Napa River. The minimum thresholds also represent the lowest static groundwater elevation to which groundwater levels may reasonably be lowered at the end of a dry season without exacerbating streamflow depletion. These levels are not acceptable on a continuous basis as this would contribute to a worsening of existing conditions. Taken together, the measurable objectives and minimum thresholds represent the fall groundwater elevations within which groundwater elevations are reasonably likely to fluctuate during fall (including fall periods for all water year types) without exacerbating streamflow depletion.

Measurable objectives and minimum thresholds for the avoidance of chronic groundwater level decline, land subsidence, and a reduction in groundwater storage are based on fall groundwater levels at representative wells that use the fall groundwater elevations for avoidance of streamflow depletion as the proxy (**Table 5-2**). One additional well NapaCounty-135, located away from the Napa River, is an additional representative well used for these sustainability indicators.

5.1.4 Napa Valley Subbasin Groundwater Level Change in Storage

Additional analysis of groundwater levels in the Napa Valley Subbasin was conducted for this Report to evaluate changes in groundwater in storage in the principal aquifer, the alluvial aquifer system, in accordance with the requirement of the GSP Regulations (Section 356.2(b)(5)). This analysis builds on a similar analysis performed as part of the Basin Analysis Report (LSCE, 2016c). The objective of the analysis provided in this report is to continue tracking changes in groundwater storage for the alluvial aquifer system over time and identify any chronic storage depletions, if any.

The analysis relies on water level measurements from 24 wells located throughout the Napa Valley Subbasin (**Table 5-3**). Two wells, located at the northern and southern ends of the Subbasin were duplicated as “Auxiliary” wells for the analysis to achieve a result inclusive of the entire Subbasin. Use of these auxiliary wells in the analysis assumes a consistent water level condition between the true well and the auxiliary well. This approach is consistent with the method used for the earlier analysis described in the Basin Analysis Report (LSCE, 2016c). However, the 24 wells used for this analysis is reduced from 32 wells used in the earlier analysis, in order to omit deeper wells that have greater exposure to deeper water-bearing formations, which are less likely to represent the local condition in the alluvial aquifer system. The annual groundwater storage volumes produced with the set of 24 wells results in an increased correlation coefficient relative to the annual precipitation at the Napa State Hospital reference gauge, increasing to 0.72 with the 24-well set from 0.61 for the 32-well set used in the earlier analysis. This increased correlation implies a more accurate result since precipitation is the primary source of recharge for the alluvial aquifer system in the Napa Valley Subbasin.

Table 5-2 Sustainability Indicators: Groundwater Levels

Representative Monitoring Sites Well ID	Date Monitored	Measured Minimum 2016 Fall WLE (Feet, AMSL)[1]	Chronic Lowering of GWLs		Reduced GW Storage		Land Subsidence		Streamflow Depletion	
			Minimum Threshold (Fall GWE, Feet AMSL)	Measurable Objective (Fall GWE, Feet AMSL)	Minimum Threshold (Fall GWE, Feet AMSL)	Measurable Objective (Fall GWE, Feet AMSL)	Minimum Threshold (Fall GWE, Feet AMSL)	Measurable Objective (Fall GWE, Feet AMSL)	Minimum Threshold (Fall GWE, Feet AMSL)	Measurable Objective (Fall GWE, Feet AMSL)
06N04W17A001M[2]	-	-	37	50	37	50	37	50	37	50
06N04W27L002M	9/25/2017	12.3	-2	12	-2	12	-2	12	-2	12
07N05W09Q002M	9/25/2017	135	127	135	127	135	127	135	127	135
08N06W10Q001M	9/25/2017	282	269	281	269	281	269	281	269	281
NapaCounty-76[3]	-	-	-30	20	-30	20	-	-	-	-
NapaCounty-122	11/8/2017	-23	-45	-26	-45	-26	-45	-26	-	-
NapaCounty-128	10/3/2017	331	320	331	320	331	320	331	320	331
NapaCounty-133	10/25/2017	75	72	76	72	76	72	76	72	76
NapaCounty-135	10/26/2017	38	20	60	20	60	20	60	-	-
Napa County 214s-swgw1	10/22/2017	2	2	4	2	4	-	-	2	4
Napa County 215d-swgw1	11/6/2017	2	2	4	2	4	-	-	2	4
Napa County 216s-swgw2	11/7/2017	74	61	76	61	76	-	-	61	76
Napa County 217d-swgw2	10/30/2017	64	61	76	61	76	-	-	61	76
Napa County 218s-swgw3	11/17/2017	33	29	32	29	32	-	-	29	32
Napa County 219d-swgw3	10/24/2017	33	29	32	29	32	-	-	29	32
Napa County 220s-swgw4	10/31/2017	77	75	77	75	77	-	-	75	77
Napa County 221d-swgw4	10/25/2017	77	75	77	75	77	-	-	75	77
Napa County 222s-swgw5	10/15/2017	187	185	190	185	190	-	-	185	190
Napa County 223d-swgw5	9/26/2017	168	164	175	164	175	-	-	164	175
NapaCounty-229	11/8/2017	-62	-69	-51	-69	-51	-69	-51	-	-

1. Values below a Minimum Threshold shown in bold.

2. Well 06N04W17A001M was not monitored during Fall 2017, due to wildfire activity in the vicinity.

3. Well NapaCounty-76 was damaged in a wildfire that burned through the area in October 2017 and, as a result, was not accessible for monitoring.

Depths of the wells included in the analysis range from 40 feet to 321 feet. Water levels in these wells are expected to represent local groundwater levels in the principal aquifer, namely the Quaternary alluvial aquifer. As noted earlier in this Report, some of these wells occur in areas of relatively thin alluvial deposits and may draw water from deeper formations, particularly later during the dry season. Since this analysis is conducted using spring water levels, when static water levels in the wells are within the alluvial zone, it is assumed that any vertical gradients between the shallow alluvium and deeper formations are negligible.

For each year, a continuous surface representing the groundwater table of the alluvial aquifer was created by interpolating available water level measurements, using the Inverse Distance Weighting method in ArcGIS software. The saturated thickness of the alluvium throughout the Subbasin was calculated by subtracting the depth to groundwater table from the previously mapped alluvium thickness dataset (LSCE and MBK Engineers, 2013). The total saturated volume of alluvium was calculated from the summation of saturated alluvium thickness throughout the Subbasin. Finally, the volume of groundwater that occurs in the alluvium was calculated by multiplying the saturated volume of alluvium by 0.06, the bulk specific yield of the aquifer (LSCE, 2016c). This procedure is consistent with the method used for the earlier analysis described in the Basin Analysis Report (LSCE, 2016c).

Results of the analysis are summarized in **Table 5-4**. The annual change in groundwater in storage was positive for both 2016 and 2017, the two years since the analysis was last performed for the Basin Analysis Report. Year-to-year changes in saturated thickness calculated as part of the analysis are depicted in **Figures 5-9A and 5-10A**. The change from spring 2015 to spring 2016 (**Figure 5-9A**) show increases in saturated thickness in the principal aquifer system, primarily from St. Helena southward in the Subbasin. A small area of less than two feet of saturated thickness decrease is mapped near Rutherford. The greatest increases in saturated thickness occurred along the western margin of the Subbasin along Dry Creek. The change in saturated thickness from spring 2016 to spring 2017 were also broadly positive, with no areas showing a decrease in saturated thickness greater than two feet (**Figure 5-10A**). Areas within the Subbasin with no value shown for change in saturated thickness represent areas where the interpolated groundwater surface was below the bottom of the Quaternary alluvial deposits.

Changes in groundwater storage in the principal aquifer system of the Subbasin are shown in **Figures 5-9B and 5-10B** at a resolution of 5 acres. As noted above, areas within the Subbasin with no value shown for change in groundwater storage represent areas where the interpolated groundwater surface was below the bottom of the Quaternary alluvial deposits. Volumetric changes depicted in these figures are similar to the changes in saturated thickness shown in **Figures 5-9A and 5-10A**. Changes in groundwater storage between spring 2015 and spring 2016 were positive throughout the Subbasin at magnitudes of up to 4.53 acre-feet per 5-acre map unit (**Figure 5-9B**). The small area where a reduction in saturated thickness is map near Rutherford corresponds with reductions in groundwater storage of up to 0.59 acre-feet per 5-acre mapped unit. From spring 2016 to spring 2017, groundwater storage changes were also generally positive throughout the Subbasin, with increases of up to 2.54 acre-feet per 5-acre map unit (**Figure 5-10B**). Three areas within the Subbasin are shown as having experienced declines in groundwater storage, corresponding to the same areas where declines in saturated thickness are mapped. Declines in groundwater storage between spring 2016 and spring 2017 are not more than 0.44 acre-feet per 5-acre map unit.

Subbasin-wide results summarized in **Table 5-4** show storage increases of 6,056 acre-feet from spring 2015 to spring 2016 and a further increase of 4,470 acre-feet from spring 2016 to spring 2017. This result is perhaps counterintuitive given that the water year precipitation recorded at the Napa State Hospital reference gauge in 2017 was well above average and 86% greater than the 2016 precipitation total (**Table 5-1**). This again indicates the relatively full nature of storage conditions in the Subbasin. If the Subbasin was not already experiencing a full condition, it would be unreasonable to find that the accretion of storage in 2017 was only 165 acre-feet greater than the increase observed in 2016, despite approximately 80,000 acre-feet of additional precipitation falling directly on the Subbasin in the latter year[21].

From 1988 through 2017 the cumulative annual storage changes were 13,702 acre-feet, which is the fourth largest cumulative change condition in the 30-year dataset (**Table 5-4**). While the cumulative change in storage for spring 2017 was not the single largest among the results of this analysis, it also points to the relatively full condition of the Napa Valley Subbasin. By comparison, the period from 1995 to 1999, which included four consecutive wet and very wet years, resulted in maximum cumulative storage change of 14,385 acre-feet (**Table 5-4**).

[21] 21.08 inches of additional precipitation at the Napa State Hospital gauge in 2017 compared to 2016, if falling equally over the 45,928-acre Subbasin would amount to 80,680 acre-feet of additional rainfall in 2017. The actual amount is likely greater given that up-valley areas of the Subbasin typically receive more precipitation, on average, than the lower-valley areas where the Napa State Hospital gauge is located. This estimate also does not account for many tens of thousands of additional acre-feet of precipitation that fell in the greater Napa Valley Subbasin watershed, leading to even more potential for recharge through mountain-front processes and streamflow infiltration.

Table 5-3 Spring Depths to Groundwater, 2015 - 2017

Well ID	RPE[2]	Depth[3]	2015 Depth to Water (feet below ground surface)	2016 Depth to Water (feet below ground surface)	2017 Depth to Water (feet below ground surface)
NapaCounty127AUX[1]	392.5	149	14.3	13.4	6.6
NapaCounty127	392.5	149	14.3	13.4	6.6
NapaCounty128	343.7	50	6.5	5.7	6.3
08N06W10Q001M	293.4	200	7.5	6.6	6.0
NapaCounty222s-swgw5	217.1	40	25.1	22.8	23.3
07N05W09Q002M	158.2	232	15.5	17.5	9.7
NapaCounty132	142.7	265	16.1	12.3	9.3
NapaCounty131	173.5	221	17.7	10.0	11.5
NapaCounty138	195.1	321	9.3	6.9	6.6
NapaCounty204	141.7	220	20.0	18.2	17.4
NapaCounty177	149.3	123	9.7	8.7	8.4
NapaCounty220s-swgw4	98.2	45	15.4	10.2	10.4
NapaCounty133	94.7	120	10.5	7.7	7.5
NapaCounty179	74.3	150	14.4	10.0	8.1
06N04W17A001M	70.3	250	12.6	11.4	3.0
NapaCounty218s-swgw3	56.1	40	20.9	13.9	13.1
NapaCounty216s-swgw2	103.1	50	21.4	15.0	15.1
NapaCounty139	85.8	120	12.2	9.3	8.3
NapaCounty135	129.2	125	39.4	25.3	22.8
NapaCounty185	83.0	260		13.0	11.2
06N04W27L002M	53.6	120	29.7	25.3	19.8
NapaCounty152	78.3	-	11.0	9.0	7.7
NapaCounty136	53.2	120	24.5	19.5	14.4
NapaCounty214s-swgw1	20.1	53	16.9	16.3	15.3
NapaCounty18	124.3	189	23.5	23.5	20.6
NapaCounty18AUX[1]	124.3	189	23.5	23.5	20.6

1. Auxiliary data point to achieve water level interpolation covering entire Subbasin
2. Reference Point Elevation (ft, NAVD88)
3. Total depth of the well (ft)

Table 5-4 Napa Valley Subbasin Principal Aquifer Groundwater Storage Changes, Water Years 1988 - 2017

Water Year	Water Year Classification	Napa Valley Subbasin Alluvial Aquifer Storage (Acre-feet)	Annual Storage Change (Acre-feet)	Cumulative Storage Change (Acre-feet)
1988	Normal (below average)	205,596	-	-
1989	Normal (below average)	198,305	(7,290)	(7,290)
1990	Dry	202,469	4,164	(3,126)
1991	Dry	192,046	(10,424)	(13,550)
1992	Normal (below average)	212,532	20,486	6,936
1993	Wet	215,486	2,953	9,890
1994	Dry	208,000	(7,486)	2,404
1995	Very Wet	215,361	7,361	9,765
1996	Wet	211,141	(4,220)	5,545
1997	Wet	216,835	5,695	11,239
1998	Very Wet	219,733	2,898	14,138
1999	Normal (above average)	219,981	247	14,385
2000	Normal (above average)	213,878	(6,103)	8,282
2001	Dry	210,997	(2,881)	5,401
2002	Normal (above average)	214,534	3,537	8,938
2003	Wet	208,394	(6,140)	2,798
2004	Normal (below average)	204,592	(3,802)	(1,004)
2005	Wet	217,650	13,058	12,054
2006	Very Wet	222,904	5,254	17,308
2007	Very Dry	200,359	(22,545)	(5,237)
2008	Normal (below average)	201,029	670	(4,567)
2009	Normal (below average)	205,160	4,132	(436)
2010	Wet	210,929	5,769	5,333
2011	Wet	214,705	3,776	9,109
2012	Normal (below average)	210,338	(4,367)	4,742
2013	Normal (below average)	201,193	(9,145)	(4,403)
2014	Dry	191,523	(9,670)	(14,073)
2015	Normal (below average)	208,771	17,248	3,175
2016	Normal (below average)	214,827	6,056	9,232
2017	**Very Wet**	**219,298**	**4,470**	**13,702**
	Average (1988 – 2017)	**209,619**	**472**	
	Median (1988 – 2017)	**210,963**	**2,898**	

5.2 Milliken-Sarco-Tulucay (MST) Subarea

Although designated as a groundwater subarea for local planning purposes, the majority of the MST is not part of a groundwater basin as mapped by DWR. In the MST, the aquifer system is composed primarily of the Sonoma Volcanics and associated Tertiary sedimentary deposits. These aquifer materials have different hydraulic properties than the Napa Valley Subbasin alluvial deposits and the level of communication and connectivity between the two areas is believed to be more limited. Groundwater levels used for contour mapping in the MST Subarea generally represent conditions of a composite aquifer system of those Sonoma Volcanics and Tertiary sediments as previously described by Farrar and Metzger (2003).

Historically, groundwater flow directions in the MST Subarea were generally from the Coast Range Mountains that include Mt. George[22] along the eastern border of the MST Subarea toward the Napa River to the west. Beginning in the 1970s, investigators have identified pumping depressions in the northern, central, and southern parts of the MST (Johnson 1975, Farrar and Metzger 2003). The current coverage of wells does not extend to the former location of the central (and deepest) pumping depression and; therefore, flow directions cannot be visualized and evaluated. However, the coverage does extend to the former locations of the northern and southern depressions, and they are shown in the spring and fall 2017 groundwater level contour maps (**Figure 5-11** and **5-12**).

In the northern MST, the highest groundwater elevations of 36 feet and 38 feet occurred between Monticello Road along the lower one mile of Sarco Creek. The disparity in groundwater elevations was greater in spring than in fall, possibly indicating greater recharge occurring along lower Sarco Creek in the spring. Groundwater flow directions were to the east and north of this area. Groundwater elevation gradients were steepest to the east and were towards an area of -40 feet groundwater elevations (NAVD88) east of Vichy Avenue. A less steep northerly gradient to the north were toward Milliken Creek where monitored wells recorded spring groundwater elevations of -6 feet and -9 feet, respectively.

In the southern MST, groundwater flow continues to be generally northwest (unchanged direction since 2009) in the spring and fall 2017 with a minimum spring groundwater elevation of about -47 feet (NAVD88). However, the western portion of this area has no coverage of wells with water level data, which limits the ability to define the extent of the pumping depression.

Representative hydrographs for the MST illustrated on **Figures 5-13 and 5-14** show groundwater elevations and corresponding depths to groundwater since 1970 in the northern (**Figure 5-13**) and central/southern parts of the MST (**Figure 5-14**). In the northern MST, groundwater levels were stable throughout the late seventies until the mid-1980s (1986), at which time a decline of about 10 to 40 feet occurred. Following this decline, groundwater levels stabilized until the late 1990s to early 2000s. After that time, groundwater levels experienced a gradual decline of about 10 to 30 feet until approximately 2009. After 2009, groundwater levels have shown signs of stabilizing in three of four currently monitored wells in the northern MST (NapaCounty-2, NapaCounty-43, and NapaCounty-122), while

[22] This range if referenced as the Howell Mountains by Farrar and Metzger (2003). However, that name does not appear in the USGS Geographic Names Information System as of 2018.

NapaCounty-98 has shown continued declines, possibly resulting from recent dry years. Depths to groundwater in the northern part of the MST Subarea currently range from about 60 to 200 feet.

An important feature within the northern part of the MST is the Soda Creek Fault that several previous investigators have described as an occasional barrier to groundwater flow. It is described by Weaver (1949) as a normal fault with more than 700 feet vertical displacement downward on the western side. Johnson (1977) and Farrar and Metzger (2003) describe groundwater elevations were about 10 feet higher on the eastern side of the fault during their respective study periods.

In **Figure 5-14**, groundwater elevations in the central and southern portion of the MST have stabilized since about 2009. The groundwater elevations in the central portion of the MST began to decline in the 1950s and currently have declined up to 250 feet in some locations. The central portion of the MST also corresponds to an area in which the main water bearing rocks of the Sonoma Volcanics utilized elsewhere in the subarea, the tuffaceous member of that unit, is not present. Based on the groundwater level trends and local geologic conditions, some of these trends may be the result of variations in geologic conditions or increasing levels of development relative to conditions 40 to 50 years ago. However, the stability of water levels over the past eight years indicates that rate of groundwater extraction is being balanced by rates of groundwater recharge.

5.3 Napa-Sonoma Lowlands Subbasin and Subareas South of the Napa Valley Floor

In 2017, twelve groundwater level monitoring sites were located in the Carneros Subarea (**Table 4-3**). The longest period of record among them extended back to October 2011 (**Appendix B**). All monitored wells are located in the southern half of the subarea at land surface elevations between 100 feet and 15 feet (NAVD88). Patterns of groundwater level fluctuations in these wells have shown annual variations of approximately 5 feet from spring to fall, though several wells saw spring 2017 water levels rise more than 10 feet relative to levels in spring 2016 and spring 2015 (**Appendix C**). Groundwater elevations range from about 30 feet, relative to mean sea level, to -5 feet, relative to mean sea level. Depths to groundwater below ground surface have varied more widely from 5 feet to 100 feet. Groundwater levels have been stable to increasing in 10 of the currently monitored wells. Two wells which had experienced declining groundwater levels in recent years, NapaCounty-150 and NapaCounty-153, showed recovery in spring 2017.

In the Jameson/American Canyon Subarea the only current groundwater level data are from one well recently volunteered for monitoring. Spring and fall measurements recorded in that well between 2014 and 2017 found shallow depths to groundwater ranging from 3 feet in the spring to 14 feet in the fall.

5.4 Subareas East and West of the Napa Valley Floor

The Eastern Mountains and Western Mountains Subareas flank the Napa Valley Floor Subareas and comprise the uplands of the Napa River Watershed. The geology of these large subareas is complex and highly variable. Recent efforts to expand the Napa County monitoring network have resulted in five wells volunteered for monitoring between the two subareas (**Table 4-3**).

Groundwater level monitoring data for these wells are limited to three years of semi-annual measurements. The depths to groundwater in these wells ranged from 36 feet to 240 feet from ground surface elevations ranging from 390 feet to 1660 feet, mean sea level.

5.5 Pope Valley Basin and Pope Valley Subarea

The only current groundwater level monitoring site in Pope Valley is a single well in the Pope Valley Basin with data available from 2014 to 2017 (**Table 4-3**). Depths to water have ranged from 3 to 16 feet below ground surface over that time.

5.6 Angwin Subarea

In 2017, groundwater level monitoring in the Angwin Subarea was performed at five wells by Napa County, Howell Mountain Mutual Water Company, and Pacific Union College at recently volunteered wells (**Table 4-3**).

Groundwater level monitoring data for the Angwin Subarea wells are available from 2014 to 2017. Depths to groundwater in these wells ranged from 95 feet to 233 feet from relatively high ground surface elevations ranging from 1608 feet to 1747 feet (NAVD88).

5.7 Napa Valley Surface Water-Groundwater Monitoring

Data from Sites 1 (**Figure 5-15**), 3 (**Figure 5-17**), and 4 (**Figure 5-18**) show that groundwater levels were above or very near the riverbed at these sites throughout 2017, indicating connectivity between groundwater and the nearby surface water. Site 2 (**Figure 5-16**) and Site 5 (**Figure 5-19**) recorded groundwater levels in the uppermost part of the aquifer system at or above the streambed for a portion of the year in 2017. Groundwater levels in the deeper monitoring well at Site 5 (NapaCounty-223d-swgw5) were recorded to be at the elevation of the adjacent Napa River streambed in January and April 2017, while water levels in the deeper monitoring well at Site 2 (NapaCounty-217d-swgw2) remained several feet below the streambed throughout the year.

Site 1 is located within the City of Napa and is the farthest downstream along the Napa River (**Figure 2-6**). The river is perennially wetted and tidally-influenced at this site with a 5-foot to 7-foot tidal range observed during the period of record. Data from Site 1 show that groundwater levels were above the elevation of the riverbed and near to or slightly above the elevation of water in the river channel, indicating a connection between groundwater and surface water. However, the fine-grained nature of the riverbed in the vicinity of Site 1 and the distinct and stable differences in electrical conductivity concentrations between the river and both monitoring wells suggest a limited degree of flow between groundwater and surface water at this site (LSCE, 2016b).

Data from Sites 3 and 4 along the Napa River showed groundwater elevations more than 15 feet above the adjacent streambed in late spring, gradually declining to a level one to two feet above the adjacent streambed by late September 2017 (**Figure 5-17** and **Figure 5-18**). This pattern is different from the pattern observed in the 2015 at these sites, where groundwater levels dipped below the streambed for several weeks during what was a much drier water year than 2017. The progression of incrementally higher groundwater elevations in the late dry season at Sites 3 and 4 over just three years demonstrates the relatively full condition of the Subbasin. Also, the transition between groundwater elevations dipping below the streambed in late summer in one year, and remaining a foot or more above the streambed just two years later, indicates that Sites 3 and 4 may be well suited to evaluating the efficacy of water conservation and enhanced groundwater recharge efforts in their vicinity.

At both Site 2 (**Figure 5-14**) and Site 5 (**Figure 5-17**) the direction of groundwater flow was predominantly away from the streambed and into the subsurface in 2017, as in the two prior years. At both sites, the streams are mapped by the USGS as intermittent in the reaches adjacent to the monitoring sites (**Figure 2-6**). The seasonal disconnection between shallow groundwater and the streambed observed at these sites, even after a very wet precipitation year, indicates that these are perennially losing reaches where surface water infiltrates along the streambed to recharge the alluvial aquifer of the Napa Valley Subbasin. However, the period of hydraulic disconnection at Site 5 was shorter in 2017 than in the prior two years, with groundwater levels below the streambed elevation from early September through early November.

At Site 2, located along Dry Creek, a pattern similar to Site 5 occurred in 2017, such that unconfined groundwater levels were at or above the streambed during the winter and spring while stormflows provided recharge. Unlike at Site 5, however, the deeper, semi-confined portion of the aquifer system at Site 2 did not see groundwater levels equilibrate with the shallow, unconfined part of the aquifer system between 2015 and 2017. At both Sites 2 and 5, groundwater levels in the shallow, unconfined part of the aquifer system were consistently below the streambed elevation in the summer and part of the fall of 2017, indicating that groundwater was disconnected from the stream, although recharge to the groundwater system likely occurred for a portion of that period while water flowed in the streambed.

Site 2 also showed groundwater level differences between the shallow and deep casings of at least 5 feet for most or all of 2017. Given that most groundwater withdrawals in Napa Valley occur from depths greater than 50 feet, these water level differences show how the groundwater system's response to pumping from deeper aquifer units does not necessarily lead to an equivalent reduction in shallow groundwater levels, even at times of the year when the streambed is dry and groundwater recharge is not occurring along the stream.

Although the period of record at these sites is short compared to many wells monitored by Napa County, **Figure 5-20** demonstrates how the range of groundwater elevations monitored at a Surface Water – Groundwater Network site are comparable to a well constructed in a similar part of the aquifer system nearby. NapaCounty-133 is located approximately 0.5 miles south from Site 4 and a similar distance from the Napa River (**Figure 4-2**). Data from NapaCounty-133 from 1978 through 2016 show a similar range and stable trend in groundwater elevations from spring to fall across the full period of record, including 2017.

6 NAPA VALLEY SUBBASIN WATER USE AND SURFACE WATER AVAILABILITY

GSP Regulations require reporting of best available information for water use by water use sector, groundwater extraction, and surface water used or available for groundwater recharge or in-lieu use[23] (Section 356.2(b)(2-4)). The following sections are included to meet the requirements for SGMA reporting and align with the format of water use information presented in the Basin Analysis Report with updated data and estimates for water years 2016 and 2017.

6.1 Subbasin Water Use by Sector

6.1.1 Agricultural Water Use

Water supplies available to agricultural land uses (specifically for crop production, rather than related activities such as winery operations; which are discussed in **Section 6.1.3** below) in the Subbasin include groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River system within the Subbasin, and to a lesser extent surface water diverted outside the Subbasin from the adjacent watershed into Lake Hennessey. Diversions of surface water from the Subbasin watersheds are a minor source of supply to agriculture within the Subbasin, although the Cities of Napa and St. Helena have reported some sales of water totaling a few hundred acre-feet in most years.

Data from DWR land use maps for 1987 and 2011 notwithstanding, as in many areas of the state, there is no comprehensive data collection effort in the Subbasin to monitor groundwater use by agriculture. Limited data on surface water diversions are available from the State Water Resources Control Board (SWRCB) Electronic Water Rights Information Management System (eWRIMS). In response to the lack of comprehensive data, a root zone water balance model was developed for the Basin Analysis Report to more accurately quantify rates of water application to meet evapotranspiration demands by crops or other irrigated vegetation (LSCE, 2016c). The Root Zone Model accounts for applications of groundwater, surface water, and recycled water to meet crop water demands. Estimates of water use for crop production in 2016 and 2017 were developed for this Report based on linear relationships between monthly irrigation demand and environmental variables (i.e., precipitation and reference evapotranspiration (ETo)).

Monthly values of each variable were used to determine a relationship that might be used to predict water usage (from groundwater and surface water) for years without simulated or measured values using data based on monthly simulated quantities from the Root Zone Model from water years 2011 to 2025.[24] On average, most groundwater pumping and surface water use occur in May, June, July, August, and September. A collection of plots that illustrate the linear and non-linear relationships between total

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[23] SGMA defines in-lieu use as “groundwater use by persons who could otherwise extract groundwater in order to leave groundwater in the basin” (Section 10721(m)).

[24] Although simulated Root Zone Model data including groundwater pumping and surface water use for various categories of water use are available from water year 1988 to 2025, the land use coverage from 2011 was selected to represent current conditions and only simulated water use data from 2011 on was used for this interpolating exercise.

groundwater pumping, vineyard groundwater pumping, other agricultural groundwater pumping, total surface water use, vineyard surface water use, other agricultural surface water use, and either ETo or precipitation is included in **Appendix E**.

Relationships with a coefficient of determination (R^2) value of greater than 0.75 were initially selected for consideration for interpolating water budget components for 2016 and 2017 using precipitation data and evapotranspiration data. The table below summarizes the R^2 values for each relationship described above (**Table 6-1**). Not all months with R^2 values greater than 0.75 for either ETo of precipitation were used to develop monthly use estimates. For example, coefficients of determination values are high between precipitation and five out six water use categories in June (**Table 6-1**); however, the strength of those correlations are greatly influenced by a very small number of data pairs where high precipitation totals occur. Since the datasets for 2016 and 2017 include no precipitation in June, using the calculated linear correlation produces high estimates for water relative to the water year types classifications for those years (**Table 5-1**), in response to this observation Method 2 was used to estimate water use in June.

Four interpolation methods were employed to estimate monthly pumping and surface water use amounts:

> **Method 1:** Linear interpolation using linear relationships between measured ETo or precipitation for water use categories with an R^2 value of greater than 0.75;
>
> **Method 2:** Average monthly proportions of groundwater pumping for each category ("Other Agricultural Pumping", "Vineyard Groundwater Pumping", "Semi-Agricultural Pumping", and "Urban Groundwater Pumping") were estimated based on estimates of total groundwater pumping and Root Zone Model simulated values. Average monthly proportions of surface water use were also estimated for each surface water use category ("Other Agricultural Surface Water Use", "Vineyard Surface Water Use", "Semi-Agricultural Surface Water Use", and "Urban Surface Water Use") based on estimates of total surface water use and Root Zone Model simulated values (**Figure 6-1**).
>
> **Method 3:** For months with no acceptable linear correlation (e.g., February, March, July, August, and December) to use for interpolation, average monthly proportions of annual totals of groundwater pumping and surface water use values were used from Root Zone Model output (from water years 2011-2025) (**Figure 6-2**).
>
> **Method 4:** For months in which the only interpolated values are for total groundwater pumping or total surface water use, the monthly average proportion of total groundwater to total surface water use is employed to estimate the other total water use category (either total groundwater pumping or total surface water use) (**Figure 6-3**).

These four methods employed together provide monthly estimates for each category of water use for groundwater pumping and surface water for water years 2016 and 2017, putting the most confidence in the linearly interpolated values (from Method 1). Certain monthly category values estimated using Method 2 above had to be slightly adjusted in order to agree with the linearly interpolated total groundwater pumping or total surface water use amount when one or more groundwater or surface water categories (e.g., "Other Agricultural Pumping", "Vineyard Surface Water Use", etc.) are interpolated from the linear interpolation method (these months were June, September, October, and November). Adjustments were minor[25], indicating that the linearly interpolated total groundwater/surface water amount agrees well with the proportion of the other linearly interpolated water use category for that particular month. Interpolated and estimated monthly water use values are presented in **Table 6-2** for 2016 and 2017.

The estimated agricultural water uses for water years 2016 and 2017 are summarized in **Table 6-3**. Groundwater use comprised 78% of agricultural water use in both 2016 and 2017. Surface water use, supplied primarily by diversions occurring within the Subbasin, comprised 19% of agricultural water use in both water year 2016 and water year 2017. Recycled water use comprised 3% of agricultural water use in both 2016 and 2017. Accuracy data are not available for the water year 2016 and water year 2017 estimates of agricultural water use in the Subbasin. Additional study and data collection planned to occur regarding water use and water conservation practices (see **Sections 8.1.3 and 8.1.4**). The planned efforts will provide a basis for evaluating the accuracy of unincorporated area water use estimates.

[25] Total monthly adjustments ranged from 1% to 7% of the total monthly groundwater pumping and from 0.1% to 3.7% of the total monthly surface water use.

Table 6-1 Coefficient of Determination (R^2) Values for Napa Valley Subbasin Agricultural Water Use and Evapotranspiration and Precipitation

Month	Evapotranspiration						Precipitation					
	Total GW Pumping	Vineyard GW Pumping	Other Ag GW Pumping	Total SW Use	Vineyard SW Use	Other Ag SW Use	Total GW Pumping	Vineyard GW Pumping	Other Ag GW Pumping	Total SW Use	Vineyard SW Use	Other Ag SW Use
January	0.67	N/A	**0.77**	0.52	N/A	**0.77**	0.13	N/A	0.09	0.17	N/A	0.09
February	0.06	N/A	0.06	0.06	N/A	N/A	0.19	N/A	0.12	0.18	N/A	N/A
March	0.07	N/A	0.05	0.09	N/A	0.09	0.33	N/A	0.22	0.33	N/A	0.05
April	0.56	0.22	0.36	0.63	0.10	0.12	**0.75**	0.26	0.34	**0.83**	0.13	0.12
May	0.44	0.46	0.21	0.23	0.49	0.38	0.28	0.21	0.58	**0.76**	0.17	0.29
June	0.60	0.60	0.52	0.60	0.65	0.69	**0.89**	**0.87**	**0.96**	**0.89**	**0.75**	0.72
July	0.06	0.04	0.32	0.24	0.05	0.21	0.03	0.02	0.08	0.08	0.04	0.08
August	0.05	0.08	0.03	0.04	0.03	0.01	0.41	0.47	0.09	0.06	0.35	0.11
September	**0.84**	**0.86**	0.51	0.62	**0.84**	0.47	**0.98**	**0.98**	**0.75**	**0.84**	**0.97**	0.72
October	**0.96**	N/A	**0.95**	**0.96**	N/A	**0.93**	**0.95**	N/A	**0.93**	**0.96**	N/A	**0.91**
November	**0.82**	N/A	**0.76**	**0.79**	N/A	**0.81**	0.41	N/A	0.33	0.49	N/A	0.39
December	0.04	N/A	0.01	0.22	N/A	0.01	0.25	N/A	0.12	0.34	N/A	0.13

Table 6-2 Interpolated and Estimated Values of Water Use Components for 2016 and 2017

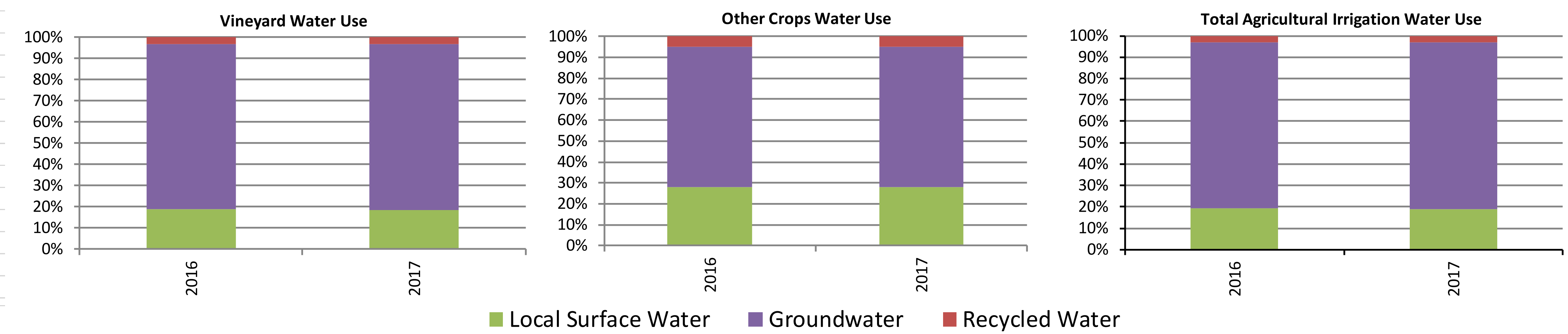
Month	Year	Groundwater Pumping Components (Acre-Feet)					Surface Water Use Components (Acre-Feet)				
		Other Agricultural Pumping	Vineyard Groundwater Pumping	Semi-Agricultural Pumping	Urban Groundwater Pumping	Total Groundwater Pumping	Other Agricultural Surface Water Use	Vineyard Surface Water Use	Semi-Agricultural Surface Water Use	Urban Surface Water Use	Total Surface Water Use
October	2015	-25.6	*0.0*	*-20.8*	*-161.9*	-208.3	-10.3	*0.0*	*-3.7*	*-662.6*	-676.6
November	2015	-2.1	*0.0*	*-2.1*	*-22.2*	-26.4	-1.2	*0.0*	*-0.3*	*-136.2*	-137.7
December	2015	-0.5	0.0	-0.4	-5.7	-6.5	-0.4	0.0	-0.1	-41.1	-41.5
January	2016	-16.3	0.0	-12.7	-196.7	-225.6	-7.4	0.0	-1.4	-907.1	-915.9
February	2016	0.0	0.0	-9.9	-116.5	-126.5	0.0	0.0	-1.3	-550.0	-551.3
March	2016	-11.4	0.0	-141.3	-829.2	-981.9	0.0	0.0	-19.0	-2,344.4	-2,363.4
April	2016	-9.0	-13.8	-37.2	-248.2	-308.2	-0.1	-2.8	-5.9	-789.9	-798.7
May	2016	-76.2	-765.4	-96.6	-580.6	-1,518.8	-8.7	-139.2	-13.2	-1,576.7	-1,737.7
June	2016	*-74.2*	*-1,736.0*	*-63.1*	*-374.0*	-2,247.3	*-46.0*	*-629.6*	*-19.2*	*-1,894.4*	-2,589.1
July	2016	-110.4	-3,326.8	-89.3	-530.6	-4,057.2	-68.4	-746.0	-22.7	-2,093.3	-2,930.4
August	2016	-79.5	-3,115.0	-68.3	-414.1	-3,676.9	-44.6	-698.4	-17.8	-1,809.8	-2,570.7
September	2016	-54.6	-1,268.8	*-13.3*	*-393.1*	-1,729.8	*-4.1*	-245.1	*5.9*	*-1,310.2*	-1,553.6
October	2016	-16.0	*0.0*	*-13.7*	*-104.6*	-134.3	-6.4	*0.0*	*-2.8*	*-452.3*	-461.5
November	2016	-9.4	*0.0*	*-10.1*	*-105.7*	-125.2	-5.1	*0.0*	*-1.4*	*-613.7*	-620.2
December	2016	-2.3	0.0	-1.8	-26.8	-30.9	-1.6	0.0	-0.4	-185.1	-187.1
January	2017	-19.5	0.0	-15.2	-235.3	-270.0	-8.9	0.0	-1.7	-1,092.6	-1,103.2
February	2017	-0.1	0.0	-11.9	-139.4	-151.4	0.0	0.0	-1.6	-662.5	-664.1
March	2017	-13.6	0.0	-169.1	-992.1	-1,174.9	0.0	0.0	-22.9	-2,824.0	-2,846.9
April	2017	-7.9	-12.2	-32.8	-219.0	-271.9	-0.1	-2.5	-5.2	-700.3	-708.1
May	2017	-76.5	-768.6	-97.0	-583.1	-1,525.2	-8.7	-139.8	-13.2	-1,583.3	-1,745.0
June	2017	-71.4	-1,670.6	-60.7	-359.9	-2,162.6	*-46.0*	*-629.6*	*-19.2*	*-1,894.4*	-2,589.1
July	2017	-114.2	-3,442.7	-92.5	-549.1	-4,198.4	-68.4	-746.0	-22.7	-2,093.3	-2,930.4
August	2017	-82.2	-3,223.4	-70.7	-428.5	-3,804.9	-44.6	-698.4	-17.8	-1,809.8	-2,570.7
September	2017	-54.6	-1,268.8	*-13.3*	*-393.1*	-1,729.8	*-4.1*	-245.1	*5.9*	*-1,310.2*	-1,553.6

Explanation:

Method 1 – Linearly interpolated values estimated using relationships between actual measured monthly ET or precipitation.
Method 2 – Estimated values based on monthly average proportions of each water use category.
Method 3 – Estimated values based on monthly proportions of annual groundwater and surface water totals from the previous year.
Method 4 – Estimated values based on monthly surface water to groundwater total proportions.
italic Italic values indicate a slight adjustment was made to water use category values in order to match the linearly interpolated total values.

Table 6-3 Napa Valley Subbasin Agricultural Water Use

Year	Vineyards – Local Supply: Surface Water (Diversions Within Subbasin) [AF]	Vineyards – Local Supply: Groundwater [AF]	Vineyards – Local Supply: Recycled Water [AF]	Vineyards: **Total [AF]**	All Other Crops – Local Supply: Surface Water (Diversions Within Subbasin) [AF]	All Other Crops – Local Supply: Groundwater [AF]	All Other Crops – Local Supply: Recycled Water [AF]	All Other Crops: **Total [AF]**	All Agricultural Irrigation – Local Supply: Surface Water (Diversions Within Subbasin) [AF]	All Agricultural Irrigation – Local Supply: Groundwater [AF]	All Agricultural Irrigation – Local Supply: Recycled Water [AF]	All Agricultural Irrigation: **Total [AF]**
2016	2,461	10,225	407	**13,093**	191	459	33	**683**	2,652	10,684	440	**13,776**
2017	2,461	10,386	407	**13,254**	193	467	33	**693**	2,654	10,853	440	**13,947**



NOTES:
All data are estimates calculated from relationships between precipitation and reference evapotranspiration measured in the Subbasin in water years 2016 and 2017 and outputs from the Napa Valley Subbasin Rootzone Model published in the 2016 Basin Analysis Report for the Napa Valley Subbasin (LSCE, 2016c)

6.1.2 Municipal Water Use

Four municipalities overlie parts of the Napa Valley Subbasin: Calistoga, St. Helena, Yountville, and Napa (**Figure 2-1**). Municipal sector water use data for water years 2016 and 2017 were provided for this Report by the City of Napa, City of St. Helena, City of Calistoga, Town of Yountville, and the Napa County Flood Control and Water Conservation District. Annual calendar year reports of diversion and water use were available for 2015 and 2016 from Rector Reservoir through the State Water Resources Control Board (water right application number: A010456). Available data are summarized in **Table 6-4**. Water supplied from Rector Reservoir to user other than the Town of Yountville are estimated for water year 2017 based on the average of water supplied from 2012 through 2016.

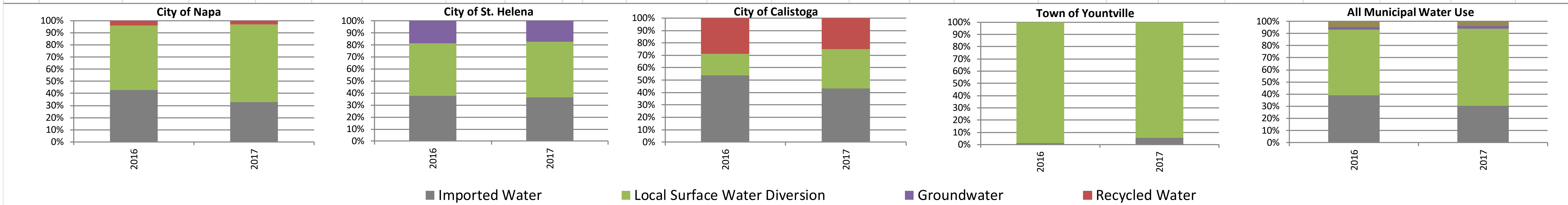
The sources of supply for municipal water suppliers in the Napa Valley Subbasin remained consistent in water years 2016 and 2017 as in the latter years of the Basin Analysis Report 1988 – 2015 study period. Surface water, from local sources and the State Water Project, comprised the majority of water supplied by municipalities in the Subbasin. State Water Project water supplies, delivered from reservoirs outside of Napa County via the North Bay Aqueduct, comprised 39% and 30% of municipal water use in water years 2016 and 2017, respectively. Local reservoirs, located outside the Subbasin but within the Subbasin watershed, supplied 54% and 64% of municipal water use in water years 2016 and 2017, respectively. Groundwater pumped from the Subbasin accounted for 2% of the municipal water use in both years. Recycled water comprised 5% and 4% of municipal water use in water years 2016 and 2017, respectively.

All four municipalities in the Napa Valley Subbasin currently re-use wastewater, at varying treatment levels. The Cities of Calistoga and St. Helena produce recycled water, which is used to irrigate city-owned properties. The Town of Yountville has a tertiary treatment facility and produces recycled water, some of which is used for the irrigation of some Town properties and some of which is sold to local vineyards for use as irrigation water. The Napa Sanitation District (NSD) provides recycled water along two main pipelines to the southeast and north of the Soscol Water Recycling Facility, including a branch that now extends to the MST Subarea adjacent to the Napa Valley Subbasin. The NSD is working with water users throughout southern Napa County to identify areas where recycled water could replace the use of potable, surface or groundwater. The pipeline serving the MST Subarea was put into service in 2016 and is designed to initially deliver up to 700 acre-feet per year (230 million gallons), with the potential to deliver up to 2,000 acre-feet per year (650 million gallons). An extension to this new system was recently completed following the award of drought-relief grant funding.

The 2015 City of Napa Urban Water Management Plan reports an estimated accuracy of 2% for water meters used to track the supply used from sources owned by the City, local reservoirs in the Subbasin watershed. The same 2% accuracy estimate pertains to the State Water Project deliveries to Calistoga, St. Helena, and Yountville reported in **Table 6-4**, as those data were reported by the City of Napa.

Table 6-4 Napa Valley Subbasin Municipal Water Use

Year	City of Napa					City of St. Helena				City of Calistoga					Town of Yountville			State of CA	All Municipal Suppliers				
	Imported Supply	*Local Supply*				*Imported Supply*	*Local Supply*			*Imported Supply*	*Local Supply*				*Imported Supply*	*Local Supply*		*Local Supply*	*Imported Supply*	*Local Supply*			
	State Water Project [AF]	Lake Hennessey [AF]	Milliken Reservoir [AF]	Recycled Water [AF]	**Total [AF]**	State Water Project /City of Napa Purchase [AF]	Bell Canyon [AF]	Groundwater [AF]	**Total [AF]**	State Water Project [AF]	Kimball Reservoir [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	State Water Project [AF]	Rector Reservoir [AF]	**Total [AF]**	Rector Reservoir [AF]	State Water Project [AF]	Surface Water, Local Reservoirs [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
2016	4,612	5,683	39	428	10,763	574	670	285	**1,529**	503	162	0	268	**934**	6	481	**482**	944	5,695	7,980	285	697	14,656
2017	3,565	6,841	157	364	10,926	607	769	293	**1,670**	409	302	0	238	**949**	27	444	**507**	1,202	4,607	9,715	293	601	15,217



NOTES:
All data are direct measurements reported by each entity, except for water year 2017 uses supplied by Rector Reservoir, which is shown here as average of reported data from\ 2012 to 2016.
City of Napa uses shown are 89.9% of the total amount reflecting the estimated proportion of the City of Napa Population within the Napa Valley Subbasin as of the 2010 census.
The City of Napa 2015 Urban Water Management Plan Update estimates the accuracy of metered use by source is +/- 2%.

6.1.3 Unincorporated Area Water Use

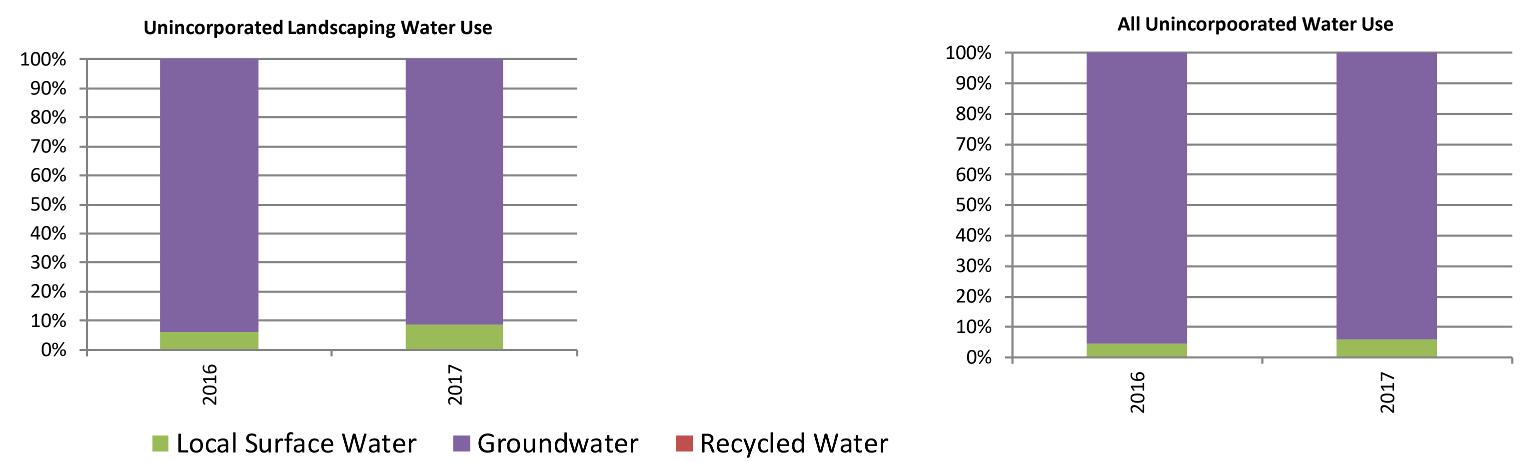
Water use in unincorporated areas of the Subbasin is estimated in **Table 6-5**. The sources of supply are consistent with information presented in the Basin Analysis Report (LSCE, 2016c). The estimate of indoor residential water use is projected based on a per capita daily demand of 60.3 gallons and estimated for the entire unincorporated Subbasin based on the projected population. Water use for landscape irrigation in unincorporated areas is based on the linear correlation analysis described in Section 6.1.1, using data from the Root Zone Model and precipitation and evapotranspiration data from 2016 and 2017.

Water use by wineries in the Subbasin was updated for water years 2016 and 2017 using the same estimation method developed for the Basin Analysis Report, which estimates water use based on the details of approved winery permits in the Subbasin (outside of municipal boundaries). The water year 2016 and water year 2017 estimates are updated to reflect wineries permits, including new permits and modifications of existing permits, approved in each of those years (**Figure 6-4**). In 2016 Napa County approved a total of five permits for wineries in the Napa Valley Subbasin, all of which were permits for new wineries. In 2017 Napa County approved a total of 14 permits for wineries in the Napa Valley Subbasin, 11 of which were permits for new wineries. As in the Basin Analysis Report, the estimates of winery water use assume that all use is supplied by groundwater and that all wineries are operating at their full, permitted capacity. The estimated water use by wineries decreased slightly in water years 2016 and 2017 relative to the estimate of 1,222 acre-feet in 2015 despite the addition of newly permitted wineries. This reduction is likely due to updates made to the winery dataset by Napa County Dept. of Planning, Building, and Environmental Services staff for wineries approved prior to 2016.

Overall, 95% and 94% of water use in unincorporated areas of the Subbasin, excluding water used for crop production, is estimated to have been supplied by groundwater in water years 2016 and 2017, respectively (**Table 6-5**). The remaining proportions are estimated to have been supplied by diversions of surface water from within the Subbasin. Accuracy data are not available for the water year 2016 and water year 2017 estimates of water use in unincorporated areas of the Subbasin. Additional study and data collection planned to occur regarding water use and water conservation practices (see **Sections 8.1.3 and 8.1.4**). The planned efforts will provide a basis for evaluating the accuracy of unincorporated area water use estimates.

Table 6-5 Napa Valley Subbasin Unincorporated Water Use

Year	Unincorporated Domestic (Indoor) [1]		Unincorporated Landscaping Irrigation [2]				Unincorporated Wineries [3]		All Unincorpoorated [4]			
	Local Supply		*Local Supply*				*Local Supply*		*Local Supply*			
	Groundwater [AF]	**Total [AF]**	Surface Water [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	Groundwater [AF]	**Total [AF]**	Surface Water [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
2016	366	**366**	291	4,497	0	**4,788**	1,207	**1,207**	291	6,070	-	6,361
2017	363	**363**	294	3,109	0	**3,403**	1,213	**1,213**	294	4,685	-	4,979



NOTES:

Unincorporated Domestic Indoor use data are estimates calculated based on a per household demand of 161 gallons per day for indoor uses (Aquacraft, 2011) and annual unincorporated Subbasin population and average household size based on population projections based on U.S. Census data for 2000 and 2010.

Unincorporated Landscape Irrigation use data are estimates calculated from relationships between precipitation and reference evapotranspiration measured in the Subbasin in water years 2016 and 2017 and outputs from the Napa Valley Subbasin Rootzone Model published in the 2016 Basin Analysis Report for the Napa Valley Subbasin (LSCE, 2016c)

Unicorporated Wineries uses data are estimates calculated based on Napa County Planning, Building, and Environmental Services Dept. records of permitted wineries, includes uses for winemaking, visitation, events, and employees with average per unit water demands applied as described in the Napa County Water Availability Analysis Guidance Document (Napa County, 2015).

6.1.4 Water Use Summary

Total water use in the Napa Valley Subbasin, including groundwater extracted from the Subbasin, surface water from sources within the Napa River Watershed, and imported surface water delivered through the State Water Project, is estimated to have been 34,793 acre-feet in water year 2016 and 34,142 acre-feet in water year 2017 (**Table 6-6**). State Water Project supplies provided less than 17% of water used in 2016 and 2017 across the Subbasin. Reservoirs located in the Subbasin watershed provided 31.4% and 37.1% of water used in 2016 and 2017, respectively. Groundwater pumped in the Subbasin provided 49% and 46.4% of water used in 2016 and 2017, respectively. Recycled water, produced by the City of St. Helena and the NSD, supplied 3.3% and 3% of total water used in 2016 and 2017, respectively.

Total estimated groundwater use in the Subbasin was 17,039 acre-feet in water year 2016 and 15,831 acre-feet in water year 2017. These estimates are primarily composed of extrapolations of Root Zone Model calculations using evapotranspiration and precipitation data from 2016 and 2017. **Figure 6-5** shows the distribution of water supply wells according to the designated use provided on Well Completion Reports, to demonstrate the variability in groundwater well densities across the Subbasin. The mapped densities apply to the entire section, not only the portion within the Subbasin, based on the total number of wells by type as provided in the DWR Well Completion Report Web Map Application. The two most common well types, domestic and irrigation wells, are found throughout the Subbasin, with the exception of some sections in the vicinity of Napa and near the southern boundary of the Subbasin. Domestic wells are most concentrated near the head of Napa Valley in the vicinity of Calistoga. High concentrations of domestic wells are also found in the sections that overlie portions of the narrow, eastward extension of the Subbasin, although it is not clear how many of the wells in those sections are located within the extent of the Quaternary alluvium that is the basis for the Subbasin boundary. Irrigation wells are distributed more evenly throughout the Subbasin, with a slightly higher concentration to the south of St. Helena.

The distribution of groundwater extraction in water years 2016 and 2017 is shown **Figure 6-6** and **Figure 6-7** based on the sum of outputs from the Root Zone Model[26], census estimates for population in the unincorporated areas, groundwater use reported by municipalities, and winery water use estimates. The amounts of groundwater extraction shown in these figures are specific to the area within the Subbasin, even where a section includes areas outside of the Subbasin. Groundwater extraction shows similar distributions in both years. The area of greatest groundwater use was located between St. Helena and Yountville. The highest estimated use per section was 456 acre-feet in 2016 and 389 acre-feet in 2017.

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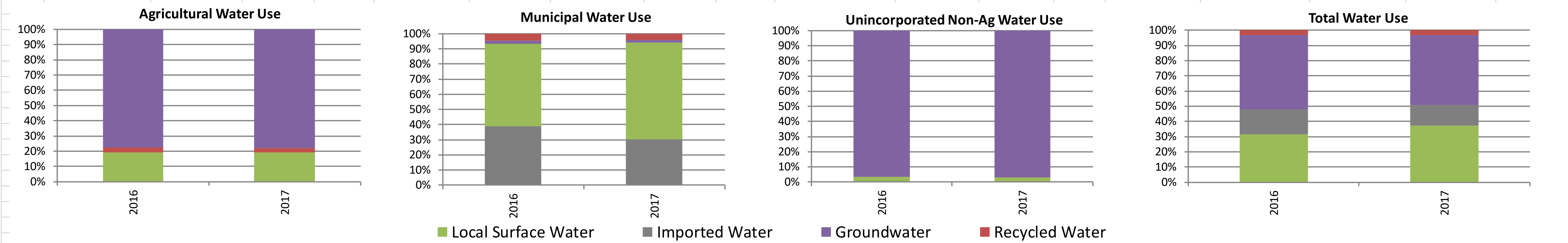
[26] Since estimates of groundwater use for irrigation were derived from Root Zone Model outputs developed for the Basin Analysis Report, the distribution of irrigation demand included in these figures is based on scaled Root Zone Model outputs for comparable years. Root Zone Model the output for 2015 was scaled to match the total irrigation demand estimated for 2016, and the Root Zone Model output for 2011 was scaled for match the total irrigation demand estimated for 2017.

Estimates of groundwater use in water years 2016 and 2017 are presented along with values for 1988 – 2015 developed for the Basin Analysis Report (LSCE, 2016c) in **Figure 6-8**. The figure also includes calculated annual and cumulative changes in groundwater storage in the alluvial aquifer system of the Subbasin. Water year types are indicated by labels along the bottom axis of the figure. The "Variable" label is used when both above and below average years occurred over time. "Dry" and "Wet" labels are used when a series of years of the same type occurred or when particularly notable single years occurred. As described above annual groundwater storage changes were positive in both 2016 and 2017, at 6,056 acre-feet and 4,470 acre-feet, respectively. Cumulative changes in groundwater storage show a net increase of 13,702 acre-feet from water year 1988 – 2017 (**Table 5-4**).

Groundwater use in water years 2016 and 2017 was comparable to amounts used in recent years dating back to 2004 (**Figure 6-8**). Over the full 30-year period, annual storage changes in the aquifer system have fluctuated between positive and negative values, generally in accordance with the water year type. Cumulative changes in groundwater storage have also fluctuated between positive and negative values, indicating stable groundwater storage conditions and the absence of chronic depletions of groundwater storage. Groundwater use in the Subbasin in water years 2016 and 2017 remained below the sustainable yield range of 17,000 to 20,000 acre-feet per year identified in the Basin Analysis Report (LSCE, 2016c).

Table 6-6 Napa Valley Subbasin Total Water Use

Year	Agricultural Irrigation Uses				Municpal Uses					Unincorporated, Non-Agricultural Uses				Total Water Use				
	Local Supply				*Imported Supply*	*Local Supply*				*Local Supply*				*Imported Supply*	*Local Supply*			
	Surface Water (Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	State Water Project [AF]	Surface Water, Local Reservoirs [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	Surface Water (Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	State Water Project [AF]	Surface Water (Local Reservoirs and Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
2016	2,652	10,684	440	**13,776**	5,695	7,980	285	697	**14,656**	291	6,070	0	**6,361**	5,695	10,923	17,039	1,136	**34,793**
2017	2,654	10,853	440	**13,947**	4,607	9,715	293	601	**15,217**	294	4,685	0	**4,979**	4,607	12,663	15,831	1,041	**34,142**



6.2 Surface Water Supply Available for Use for Groundwater Recharge or In-lieu Use

GSP Regulations call for annual reporting on the supply of surface water available for use for groundwater recharge or in-lieu use to offset groundwater pumping. **Table 6-7** presents estimates based on a method developed by DWR (DWR, 2017). The DWR method is one approach for estimating the availability of surface water available for recharge (WAFR) based on historical gauged streamflow, monthly simulated outflows from the Water Evaluation and Planning (WEAP) model, and information on existing water rights and water diversions in each gauged watershed. This method results in estimates of water that may be available to divert for groundwater recharge projects while allowing for minimum streamflow requirements and the capacity of existing, approved diversions.

The DWR WAFR method provides a way to estimate the amount of surface water available for recharge based on the proportion of average annual gauged outflow that could potentially be diverted by a conceptual replenishment project, referred to as the WAFR Fraction. A range of conceptual replenishment projects is envisioned, resulting in a range of WAFR Fractions for a given gauged watershed. The so-called Best Estimate WAFR Fraction replicates the capacity of the single largest existing diversion in the gauged watershed. Additional bounds for the WAFR estimate are provided by calculating a WAFR Fraction based on one-half of the single largest existing diversion capacity, the Lower Uncertainty WAFR Fraction, and doubling the single largest existing diversion capacity, the Upper Uncertainty WAFR Fraction.

Instream flow requirements are also taken into account as part of the conceptual replenishment projects. The WAFR Fractions calculated based on the conceptual project capacities described above are also subject to instream flow requirements that limit the potential for surface water diversions. Existing instream flow requirements, whether established for the watershed as a whole or the largest existing diversion, were used as applicable. If neither are applicable, an instream flow requirement was determined by the Tennant method (Tennant, 1975). Instream flow requirements are assumed to be applied constantly throughout the year. The DWR method varies the instream flow requirement for the Lower Uncertainty WAFR Fraction estimate to account for the potential for additional constraints on diversions. The Lower Uncertainty WAFR Fraction uses a doubled instream flow requirement relative to the existing requirement, while the Upper Uncertainty WAFR Fraction and the Best Estimate WAFR Fractions apply the existing instream flow requirement.

As described above, the DWR method allows for uncertainty by including a range of WAFR fractions for each gauged watershed. In addition to the Lower and Upper Uncertainty WAFR Fractions, DWR allows for a maximum project estimate with an unlimited diversion capacity. **Table 6-7** omits the maximum project estimate for the Napa River because the WAFR fraction used by DWR, 95.59%, represents a level of diversion that is not practical for the Napa Valley Subbasin.

Estimates for the surface water supply from the Napa River that could have been available for groundwater recharge or in-lieu use range from 3,390 acre-feet to 12,800 acre-feet in 2016 and from 11,400 acre-feet to 43,200 acre-feet in 2017. The higher amounts estimated for 2017 are a direct result of the larger stream discharge measured at the USGS Napa River near Napa stream gauge in 2017. These estimates are understood to be preliminary, pending confirmation of actual surface water diversions in the watershed and the timing of storm flows relative to restrictions on diversions that were implemented as part of the 1976 Permanent Injunction 31785 and any subsequent limitations imposed by the DWR Watermaster or the State Water Resources Control Board.

In addition, the Upper Uncertainty estimate of 43,200 acre-feet in 2017, also likely exceeds practical limitations given that stormflows occur during the winter and spring when the Subbasin is most full. The addition of 43,200 acre-feet to the Napa Valley Subbasin could raise groundwater levels by 15 feet on average (allowing for an average 6 percent specific yield across the Subbasin). Given the depths to water observed in spring 2017 (**Figure 5-2**) it is unlikely that the Subbasin has sufficient capacity to retain that much additional recharge, even if sufficient projects were developed to augment recharge to that degree.

Table 6-7 Napa Valley Subbasin Surface Water Supply Used or Available for Use for Groundwater Recharge or In-Lieu Use

Water Year	USGS Napa River near Napa Gauge Outflow (TAF)	Low Uncertainty, 3.03% (TAF)	Best Estimate, 6.52% (TAF)	Upper Uncertainty, 11.46% (TAF)
2016	111.8	3.39	7.29	12.8
2017	376.2	11.4	24.5	43.2
TAF: Thousand Acre-Feet				

Other sources of water for groundwater recharge and in-lieu use in the Napa Valley Subbasin include recycled water and conservation. Additional study is planned to better understand the benefits, both existing benefits and potential future benefits, of water conservation by grape growers in the Subbasin. Recycled water is currently used in the Subbasin to offset groundwater use. It is estimated that 440 acre-feet of recycled water was used for crop production in the Subbasin in water year 2016 and water year 2017 (**Table 6-3**). These amounts are based on the areas where recycled water has been identified as a source of irrigation supply in DWR land use maps. This assumes that crops irrigated by recycled water would otherwise be irrigated by groundwater, if recycled water were unavailable. Additional recycled water use in the Subbasin occurs by customers of the City of Calistoga and the City of Napa/Napa Sanitation District. However, neither Calistoga nor Napa currently supplies groundwater from the Subbasin to their customers, so the production of recycled water by those systems is not likely to offset groundwater use that would otherwise occur in the Subbasin. Recycled water is also not currently known to be used for groundwater recharge purposes in the Subbasin.

7 IMPLEMENTATION OF THE BASIN ANALYSIS REPORT FOR THE NAPA VALLEY SUBBASIN[27]

In December 2016, Napa County submitted the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c) as an alternative to a Groundwater Sustainability Plan (GSP) in accordance with the GSP Regulations developed by DWR. Development of a Basin Analysis Report was possible in part because of groundwater resources studies and management activities initiated in prior years, including many that were completed with assistance from the GRAC. As with any GSP, progress towards maintaining sustainable groundwater conditions in the Napa Valley Subbasin did not end with submittal of the Basin Analysis Report. Additional public outreach and scientific study is underway to improve upon best-available datasets regarding groundwater conditions, water use, surface water-groundwater interactions, groundwater dependent ecosystems, and other priorities identified in the Basin Analysis Report. **Figure 7-1** illustrates the implementation activities conducted in 2016 and 2017.

The Basin Analysis Report (LSCE, 2016c) includes a discussion of groundwater management policies and projects currently implemented in the Napa Valley Subbasin. They include Napa County General Plan policies, Napa County’s Groundwater Ordinance, Napa County’s Water Availability Analysis procedure for discretionary proposed permits, water conservation outreach and education, collaboration with other water management planning programs, and ongoing water resources monitoring efforts. In addition, the Basin Analysis Report summarizes groundwater management recommendations developed by the County since 2011 and records the status or anticipated completion of those recommendations. Thirteen of those recommendations were newly developed for the Basin Analysis Report. Those recommendations are included in **Table 7-1** below with updated notations regarding status, as appropriate.

Table 7-1 includes five new management recommendations (Items 26 – 30) and an expansion of one management recommendation from the Basin Analysis Report (Item 19) developed as part of the Northeast Napa Special Groundwater Study (see **Section 2.4.3**). Together, these six management recommendations were presented to the Napa County Board of Supervisors on October 24, 2017, as part of the Special Study Report. The Board of Supervisors indicated its support for the new management recommendations, and they were subsequently included in an amendment to the Basin Analysis Report establishing the Northeast Napa Management Area (LSCE, 2018a, **Appendix A**). Napa County will lead implementation of these management actions, with outreach to users of groundwater and other stakeholders as described in the Basin Analysis Report (LSCE, 2016b). These management actions complement the management actions described in the Basin Analysis Report in that they are intended to maintain groundwater sustainability for the Napa Valley Subbasin.

[27] The Basin Analysis Report for the Napa Valley Subbasin includes a comprehensive list of monitoring and management recommendations developed since 2011. Additional recommendations developed for the Basin Analysis Report were added to the list in sequence, beginning at number 13. Recommendations 1 – 12 are referenced in this Section where applicable to ongoing activities.

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
Napa County Groundwater Conditions and Groundwater Monitoring Recommendations (2011)				
1.1a	Entry of archived data not previously available, link WellMA table information, add well construction data from wells the County monitors, add recent surface water delivery information, add municipal pumping data, and other information along with development and implementation of quality control protocols for inputting new data and reviewing existing data discrepancies	**Near to Long Term**	**1**	**Complete**
1.1b	Establishment of a map-interface with the DMS to enhance the use of the database by non-database users	**Near Term to Mid Term**	**1**	**2018**
2.1a	Input CASGEM groundwater level data into the DMS	**Ongoing**	**1**	**Complete**
2.1b	Establish data format to meet DWR guidelines for electronic data transfer	**Near Term**	**1**	**Complete**
2.1c	Optimize CASGEM monitoring well network per DWR guidelines by filling in data gaps where identified	**Mid to Long Term**	**3**	**Complete**
3.1a	Update County field procedures for measuring groundwater levels	**Near Term**	**1**	**Complete**
3.1b	Develop and/or expand aquifer-specific groundwater monitoring network in Napa Valley Floor, Pope Valley and Carneros Subareas by identifying existing wells with well construction data and constructing new aquifer-specific monitoring wells as needed where data gaps may exist	**Near to Mid Term**	**2**	**Ongoing**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
3.1c	Develop aquifer-specific groundwater monitoring network in other Subareas by identifying existing monitored wells with well construction data and constructing new wells where data gaps may exist	**Mid to Long Term**	**3**	**Ongoing**
4.1a	Update geologic cross sections for the Napa Valley Floor and Carneros Subareas (previous ones were 50 years old)	**Near to Mid Term**	**2**	**Complete**
4.1b	Develop new geologic cross sections in those areas with the greatest short- and long-term growth and/or land use potential	**Near to Long Term**	**2**	**2019**
4.1c	Investigate groundwater/surface water interactions and the effect of recharge and pumping on groundwater levels in the Napa Valley Floor Subareas, along with the Carneros Subarea to assess the sustainability of groundwater resources. May include groundwater modeling, as needed.	**Near to Mid Term**	**1**	**Complete/ Ongoing**
5.1a	Prepare workplan for the purposes of preparing a Groundwater Sustainability Plan; workplan includes steps to implement County Monitoring Program and CASGEM Program	**Near Term**	**1**	**Complete (Basin Analysis Report; Monitoring Program and CASGEM Plan)**
5.1b	Utilize the Watershed Information & Conservation Council (WICC) Board for various public outreach components related to groundwater sustainability planning	**Near Term**	**2**	**Ongoing**
5.1c	Develop objectives for public outreach, including information sharing and education about the County's groundwater resources	**Near to Mid Term**	**2**	**Complete**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
5.1d	Preparation of a Groundwater Sustainability Plan for Napa County	**Near to Mid Term**	**2**	**Complete (Basin Analysis Report)**
5.2a	Public outreach, including information sharing and education about the County's groundwater resources	**Ongoing**	**3**	**Ongoing**
6.1a	Updating of Ordinances 13.04, 13.12, and 13.15	**Mid Term**	**2**	**Complete**
6.1b	Update Groundwater Permitting Process	**Mid Term**	**3**	**Complete**
Groundwater Resources Advisory Committee (February 2014)				
7	Develop and widely distribute public outreach programs and materials; educate people about opportunities for taking action	**Near Term/ Ongoing**	**1**	**Ongoing**
8	Support landowners in implementing best sustainable practices; Solicit information on, and widely share best practices with regard to water use in vineyards, wineries, and other agricultural/commercial applications	**Near Term/ Ongoing**	**1**	**Ongoing**
9	Enhance the water supply system and infrastructure to improve water supply reliability (regional and local)	**Near Term (evaluate and rank opportunities); Long Term – seek funding for high value projects**	**2**	**Ongoing**
10	Share groundwater conditions data and results; updates through BOS/WICC/Other	**Near Term/ Ongoing**	**1**	**Ongoing**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
11	Continue to improve scientific understanding of groundwater recharge and groundwater- surface water interactions	**Near Term/ Ongoing**	**1**	**Ongoing**
12	Improve preparedness for responding to long-term trends and evolving issues; improve preparedness for responding to acute crises, such as water supply disruptions and multiyear drought conditions	**Long Term**	**3**	**2020**
Basin Analysis Report for the Napa Valley Subbasin (2016)				
13	Address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the alluvial aquifer	**Near Term**	**1**	**Ongoing**
14	Evaluate and address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the semi-confined to confined portions of the aquifer system	**Near Term**	**1**	**Ongoing**
15	Implement Napa County groundwater quality monitoring program; includes water quality monitoring in a subset of current monitoring network wells	**Near Term**	**1**	**Ongoing**
16	Coordinate with existing discretionary permit applicants (e.g., wineries and others) regarding existing groundwater level and/or water quality information)	**Near Term**	**1**	**2018**
17	Coordinate with RCD and others regarding current stream gaging and supplemental needs for SGMA purposes; consider areas that may also benefit from nearby shallow nested groundwater monitoring wells (similar to LGA SW/GW facilities)	**Near- to Mid Term**	**2**	**2019**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
18	Install test hole(s) and multiple completion monitoring wells at south end of Napa Valley Subbasin/Napa Sonoma Lowlands Subbasin for improved understanding of freshwater/salt water interface	**Mid Term**	**2**	**2020**
19	Evaluate strategic recharge opportunities, particularly along Subbasin margin and in consideration of hydrogeologic factors and O'Geen (2015) mapping. Evaluate approaches for retaining and using stormwater and/or tile drain water to increase water conservation, examining opportunities to reduce pumping and streamflow diversions, potentially lessening streamflow effects during drier years or drier periods of the year, and creating additional climate resiliency through targeted recharge strategies	**Near- to Mid Term**	**2**	**2019**
20	Evaluate distribution of Groundwater Dependent Ecosystems and relationships to depth to groundwater; coordinate evaluation with BMPs or guidance developed by DWR, Nature Conservancy, California Native Plant Society or others	**Near Term**	**1**	**2019**
21	Review of and coordination with BMPs published on DWR's web site (DWR is due to post BMPS by January 1, 2017)	**Near Term**	**1**	**2018**
22	Evaluate and address uncertainties in historical water budgets to improve calibration of budget components and reduce uncertainty of projected future water budgets.	**Near- to Mid Term**	**1-2**	**2020**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
23	Revise the standard Conditions of Approval used by Napa County for discretionary projects to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this plan, and provisions for permit modification based on monitoring results	**Near Term**	**2**	**Complete**
24	Expand the capacity to encourage groundwater stewardship/groups through education, facilitation, and equipment	**Near- to Mid Term**	**2**	**On-going**
25	Develop an improved understanding of surface water and groundwater uses in unincorporated areas in the County and trends in those uses	**Near Term**	**1**	**2019**
26	Expand and improve the groundwater flow model developed for the Northeast Napa Special Groundwater Study (LSCE, 2017b) to facilitate further regional groundwater analyses and assessment of streamflow depletion required for continued SGMA implementation.	**Near- to Mid Term**	**1**	**2021**
27	Expand the existing network of dedicated surface water/groundwater monitoring facilities and construct shallow nested groundwater monitoring wells east of the Napa River in the vicinity of Petra Drive.	**Mid Term**	**1**	**2020**

Table 7-1 Napa Valley Subbasin Summary of Recommended SGMA Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
28	For discretionary projects in the Northeast Napa Management Area, additional project-specific analyses (Napa County Water Availability Analysis-Tier 2) will be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result. In addition, the Napa County Board of Supervisors has directed staff to update the Napa County Groundwater Ordinance to reflect the additional requirements for project-specific analysis and to incorporate water use criteria and water use reporting requirements for the Management Area using an approach similar to what has already been implemented in the MST Subarea.	**Near Term**	**1**	**Initiation in 2018, then ongoing**
29	As a precautionary measure, Napa County will track new non-discretionary groundwater wells constructed in the Northeast Napa Management Area, including their planned usage and location.	**Near Term**	**2**	**Initiation in 2019, then ongoing**
30	Develop appropriate standards and require that pumping test data be collected when new production wells are constructed in areas where the distribution of hydraulic conductivities is less known, including the Northeast Napa Management Area east of the Napa River and in deeper geologic units throughout the rest of the Napa Valley Subbasin.	**Mid Term**	**1**	**Initial standards developed by 2019, then ongoing**

[1] Implementation schedule reflects relative multi-year time frames for completing or conducting the task. Near, Mid, and Long Terms are reflective of 3, 5, and 10-year periods.

[2] Priority ranking is on a scale of 1 to 3 with 1 being the highest priority and 3 being the lowest.

7.1 Northeast Napa Management Area Designation

Following completion of the Basin Analysis Report, Napa County undertook the Northeast Napa Special Groundwater Study (Special Study) to refine the understanding of groundwater conditions in a 6,090-acre area within the Napa Valley Subbasin. The Special Study was referenced as a planned implementation activity in the Basin Analysis Report.

At their meeting on October 24, 2017, the Board of Supervisors chose to support the findings and recommendations of the Special Study Report and directed staff to develop documentation to formally establish the Northeast Napa Management Area covering approximately 4% or 1,960 acres within the 45,928-acre Napa Valley Subbasin (**Figure 2-8**). In response, Napa County developed an Amendment to the Basin Analysis Report for the Napa Valley Subbasin (the Northeast Napa Management Area Report) (LSCE, 2018a, **Appendix A**).

The Amendment is a supplement to the Basin Analysis Report for the Napa Valley Subbasin, the purpose of which is to designate a management area within the Napa Valley Subbasin: The Northeast Napa Management Area. GSP Regulations adopted by the California Water Commission in 2016 define a management area as, “an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors” (Section 351).

The Basin Analysis Report Amendment was developed as a supplement to the Basin Analysis Report for the Napa Valley Subbasin, demonstrating Napa County’s active commitment to ensuring the sustainability of the Subbasin. The Amendment does not change the findings of the 2016 Basin Analysis Report, rather it provides additional detail about conditions in the Northeast Napa Management Area and establishes additional sustainable management criteria and management actions intended to support continued groundwater sustainability in the Napa Valley Subbasin.

The Basin Analysis Report Amendment includes refined definitions for undesirable results[28] in the Napa Valley Subbasin by considering the possibility of future localized conditions that could create significant and unreasonable effects in the Northeast Napa Management Area that may not be experienced throughout the Subbasin due to local geologic conditions. By refining the definitions for undesirable results in this manner, this Amendment intends to be protective of conditions within the Management Area even to a greater degree than would occur if the Management Area were not designated.

The Amendment designates seven representative monitoring sites as a subset of monitoring sites in the area for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley Subbasin, these seven sites

[28] According to SGMA definitions, Undesirable Results include: chronic lowering of groundwater levels (overdraft); significant and unreasonable reduction of groundwater storage; significant and unreasonable seawater intrusion; significant and unreasonable land subsidence that substantially interferes with surface land uses and; depletions of interconnected surface water due to groundwater extraction and use in the Subbasin that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined. Many sites are monitored for more than one sustainability indicator. Four of the representative sites designated for the Northeast Napa Management Area were previously designated as representative sites for the Napa Valley Subbasin. The sustainability criteria established for those sites in the 2016 Basin Analysis Report are incorporated here for tracking conditions in the Management Area.

The Amendment presents Northeast Napa Management Area minimum thresholds for all six undesirable results described in SGMA (**Table 7-2**). Minimum thresholds are set (in feet above mean sea level) to avoid chronic lowering of groundwater levels and reduced groundwater storage for seven representative monitoring sites. Minimum thresholds for surface water depletion due to groundwater extraction and use in the Subbasin are provided for two representative sites; for one representative monitoring site to avoid degraded groundwater quality (e.g., for nitrate); for one representative monitoring site (for chloride concentrations) to avoid seawater intrusion; and for two representative monitoring sites to avoid land subsidence.

Northeast Napa Management Area measurable objectives, or specific quantifiable goals for maintaining or improving groundwater conditions, are provided with respect to chronic lowering of groundwater levels and reduced groundwater storage depletions for seven representative monitoring sites (**Table 7-2**). Measurable objectives for surface water due to groundwater extraction and use in the Subbasin are provided in this Amendment for two representative monitoring sites. The measurable objective to maintain or improve groundwater quality is set for one representative monitoring site; for one representative monitoring site to avoid seawater intrusion; and for two representative monitoring sites to avoid land subsidence.

Table 7-2 Northeast Napa Management Area Representative Monitoring Sites: Minimum Thresholds and Measurable Objectives for Sustainability Indicators

Well ID	Sustainability Indicators and Minimum Thresholds and Measurable Objectives											
	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective
	Chronic Lowering of GWLs (Fall GWE, Feet NAVD88[1])	Chronic Lowering of GWLs (Fall GWE, Feet NAVD88)	Reduced GW Storage (Fall GWE, Feet NAVD88)	Reduced GW Storage (Fall GWE, Feet NAVD88)	Seawater Intrusion (Chloride, mg/L)	Seawater Intrusion (Chloride, mg/L)	Degraded GW Quality (NO3-N mg/L)	Degraded GW Quality (NO3-N mg/L)	Land Subsidence (Fall GWE, Feet NAVD88)	Land Subsidence (Fall GWE, Feet NAVD88)	Surface Water Depletion (Fall GWE, Feet NAVD88)	Surface Water Depletion (Fall GWE, Feet NAVD88)
NapaCounty-76	-30	20	-30	20								
NapaCounty-122	-45	-26	-45	-26					-45	-26		
NapaCounty-229	-69	-51	-69	-51			10	8	-69	-51		
Napa County 214s-swgw1	2	4	2	4	500	300					2	4
Napa County 215d-swgw1	2	4	2	4								
Napa County 218s-swgw3	29	32	29	32							29	32
Napa County 219d-swgw3	29	32	29	32								

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).

7.2 Revised Conditions of Approval for Discretionary Permits (SGMA Implementation Recommendation 23)

In 2017 Napa County staff revised the standard Conditions of Approval (CoA) used by the Planning, Building, and Environmental Services Department when recommending County approval of discretionary projects proposing to use groundwater as a source of supply. The revised CoA requires that permittees monitor groundwater levels in project wells and record amounts of groundwater pumped at regular intervals. In addition, permittees are required to report those data to the County and make project wells available as part of the County's groundwater monitoring program, subject to certain conditions. The revised CoA language is excerpted below.

> ***GROUND WATER MANAGEMENT – WELLS***
>
> *This condition is implemented jointly by the Public Works and PBES Departments:*
>
> *The permittee shall be required (at the permittee's expense) to record well monitoring data (specifically, static water level no less than quarterly, and the volume of water withdrawn no less than monthly). Such data will be provided to the County, if the Director of Planning, Building, and Environmental Services (PBES Director) determines that substantial evidence [1] indicates that water usage at the project is affecting, or would potentially affect, groundwater supplies or nearby wells. If data indicates the need for additional monitoring, and if the applicant is unable to secure monitoring access to neighboring wells, onsite monitoring wells may need to be established to gauge potential impacts on the groundwater resource utilized for the project. Water usage shall be minimized by use of best available control technology and best water management conservation practices.*
>
> *In order to support the County's groundwater monitoring program, well monitoring data as discussed above will be provided to the County if the Director of Public Works determines that such data could be useful in supporting the County's groundwater monitoring program. The project well will be made available for inclusion in the groundwater monitoring network if the Director of Public Works determines that the well could be useful in supporting the program.*
>
> *In the event that changed circumstances or significant new information provide substantial evidence [1] that the groundwater system referenced in this use permit would significantly affect the groundwater basin, the PBES Director shall be authorized to recommend additional reasonable conditions on the permittee, or revocation of this permit, as necessary to meet the requirements of the County Code and to protect public health, safety, and welfare.*
>
> *1. Substantial evidence is defined by case law as evidence that is of ponderable legal significance, reasonable in nature, credible and of solid value. The following constitute substantial evidence: facts, reasonable assumptions predicated on facts; and expert opinions supported by facts. Argument, speculation, unsubstantiated opinion or narrative, or clearly inaccurate or erroneous information do not constitute substantial evidence.*

7.3 Expand the Capacity to Encourage Groundwater Stewardship (SGMA Implementation Recommendation 24)

Since 2016, Napa County has expanded its efforts to empower County residents to monitor and understand groundwater conditions in wells that they own through the Do It Yourself (DIY) Groundwater

Level Monitoring Program.[29,30] The County maintains an acoustic groundwater level sounder and makes it available to residents as a short-term free rental. In addition to providing the acoustic sounder, County staff also provide training to residents who use the sounder to ensure that they collect accurate data. To date, the program has assisted nine well owners in measuring nine wells within the county. The program has been advertised in the Napa RCD and Napa County Farm Bureau newsletters, direct emails through the Napa Valley Grapegrowers Association and Napa Valley Vintners, promoted on the County's social media channels, and hosted on the County and WICC websites. Expanded promotion of the Do It Yourself (DIY) Groundwater Level Monitoring Program (during community events, meetings and lectures) is planned for 2018 to increase awareness and participation.

In July 2017, Napa County published the *Well Owners Guide, A Guide for Private Well Owners in Napa County* (Guide) (Napa County, 2017).[31] This 23-page document communicates important concepts including state and local standards for well construction, well permitting requirements, the importance of regular well maintenance, and land use practices to limit risks to groundwater quality. The Guide also answers frequently asked questions about the County's Voluntary Groundwater Monitoring Program and provides information on the County's Do It Yourself (DIY) Groundwater Level Monitoring Program. The Guide is available on the WICC website and on the County groundwater webpage.[32,33]

7.4 Napa Valley Subbasin Groundwater Model Dataset Development (SGMA Implementation Recommendation 25)

In 2017 Napa County began development of spatial datasets to expand on work conducted Northeast Napa Special Groundwater Study and Basin Analysis Report to provide several important datasets needed to develop a numerical groundwater flow model for the Napa Valley Subbasin. These datasets include spatially distributed groundwater pumping data and surface water diversion data necessary to characterize water uses within the Subbasin at the parcel scale to facilitate Subbasin groundwater management efforts.

7.5 Collaborations to Improve Best Available Water Use Data (SGMA Implementation Recommendation 25)

In 2017, Napa County worked with the Napa County Resource Conservation District (Napa RCD) to develop a project to improve the understanding water uses in unincorporated areas within the Napa Valley Subbasin. The objectives of the project include working with landowners to collect data on the timing of water availability, storage, and use at the farm scale for the purpose of quantifying the effects of existing efficiency and conservation efforts and identifying potential improvements to existing practices. The project will build on existing water use efficiency trainings and outreach conducted by the Napa RCD. A funding request for the project is currently pending as part of grant application to the California Wildlife Conservation Board.

[29] https://www.napawatersheds.org/files/managed/Document/7964/DIYmonitoring_flyer.pdf
[30] https://www.napawatersheds.org/app_pages/view/7819
[31] https://www.napawatersheds.org/files/managed/Document/8773/20170720_Well_Owners_Guide_Final.pdf
[32] https://www.napawatersheds.org/groundwater
[33] https://www.countyofnapa.org/1230/Groundwater

7.6 Coordination with Other Water Management and Planning Programs

7.6.1 Integrated Regional Water Management Plans

Integrated Regional Water Management (IRWM) is defined by DWR as "a collaborative effort to identify and implement water management solutions on a regional scale that increase self-reliance, reduce conflict, and manage water to concurrently achieve social, environmental, and economic objectives" (DWR, 2015a).

Napa County's Participation in San Francisco Bay Area and Westside Sacramento IRWMPs

In 2005, the County formed the Napa County regional water management group (RWMG), a working group of local water agencies, where the Napa County Flood Control and Water Conservation District served as the lead agency. The County RWMG worked together to draft the Napa-Berryessa Integrated Regional Water Management Plan (IRWMP) Functional Equivalent (Napa-Berryessa Regional Water Management Group, 2005).

In 2009, DWR established IRWM regions that have been accepted through the Regional Acceptance Process (DWR, 2009). Currently, there are two formally accepted regions that include Napa County; these regions are: 1) the San Francisco Bay Area Region (which covers the generally southern part of Napa County and focuses on the Napa River and Suisun Creek watersheds), and 2) the Westside Sacramento Region (which covers the generally northern part of Napa County and focuses on the Putah Creek/Lake Berryessa watershed; the Westside Region also covers parts of Yolo, Solano, Lake, and Colusa Counties).

The County is contributing to two larger regional IRWMPs. The County actively collaborates with the San Francisco Bay and Westside RWMGs to update the IRWMP for the San Francisco Bay (Kennedy Jenks et al., 2013) and to develop a new IRWMP for the Westside Sacramento Region (Kennedy Jenks, 2013, and currently under another update). The County's representation and participation in both the San Francisco Bay and Westside IRWMPs enables further coordination and sharing of information on water resources management planning programs and projects (particularly those that are a high priority for the County) and other information for IRWMP grant funding and implementation.

7.6.2 Watershed Information and Conservation Council (WICC) of Napa County (SGMA Implementation Recommendations 5.1b, 5.2a, 7, and 25)

The WICC[34] was established in 2002 to serve as an advisory committee to Napa County Board of Supervisors – assisting with the Board's decision making and serving as a conduit for citizen input by gathering, analyzing, and recommending options related to the management of watershed resources (WICC, 2015). The WICC has achieved significant accomplishments in its 16-year history – both alone and in partnership with nonprofits, public agencies, and private landowners.

[34] Prior to 2015 this organization was named the Watershed Information Center and Conservancy.

The WICC Mission is: improving the health of Napa County's watersheds by informing, engaging and fostering partnerships within the community.

The 2015 WICC Strategic Plan outlines five goals, including (WICC, 2015):

- Goal 1: Coordinate and facilitate watershed planning, research, and monitoring efforts among Napa County organizations, agencies, landowners and citizens.
- Goal 2: Strengthen and expand community understanding, connections and involvement to improve the health of Napa County's watersheds.
- Goal 3: Support informed decision-making on topics that affect the health of Napa County's watersheds.
- Goal 4: Improve WICC Board efficiency and effectiveness.
- Goal 5: Explore additional funding opportunities to support the goals of the WICC.

Additionally, Subgoal 1B to Goal 1 includes the WICC serving as the local clearinghouse for groundwater resource data, mapping, and monitoring (Implements: Napa County General Plan Action Item CON WR-4). As part of developing education and outreach for the community regarding groundwater conditions, the WICC is expanding groundwater information on the WICC website by offering an online groundwater information portal: www.napawatersheds.org/groundwater. This new initiative provides groundwater summary data and graphs for the County's groundwater basins and/or subareas that are delineated on the website's interactive maps. Data are displayed at the watershed scale and are not project or parcel specific. Information includes:

- Updates on groundwater resource issues locally and throughout California,
- Articles explaining key technical issues related to groundwater,
- Updates on groundwater mapping and monitoring in Napa County,
- Educational materials and resources on groundwater recharge areas and ways to improve these areas,
- Report on the Napa County Voluntary Groundwater Level Monitoring Program, and
- Educational guides, resources and videos.

Napa County conducted public outreach regarding the status of SGMA implementation and groundwater conditions in several ways in 2017. An annual groundwater conditions presentation was provided to the Board of Supervisors in April 2017 and again to the WICC in July 2017. Two poster presentations with handouts were developed for the biennial Napa County Watershed symposium in May 2017. In October 2017, the Special Study Report was presented to the Board of Supervisors. Then in January 2018, the Special Study Report was presented to the WICC to further inform the public about the results of the Special Study and the Board of Supervisors support for establishing the Northeast Napa Management Area.

The County posted documents and other resources pertaining to the Basin Analysis Report, 2016 Annual Report, and Special Study Report to its groundwater information webpage as well as the WICC website including. These resources included copies of presentation slides, a frequently asked questions document, and the state's GSP Regulations. Links to pertinent state websites were also posted to the two County websites.

Throughout 2017, the County continued to provide notifications of new document availability and public meetings through the WICC's automated weekly news digest, distributed by email on the Thursday mornings. The County also communicated with stakeholders and the public regarding SGMA implementation, including updates on the DWR public comment period following submittal of the Basin Analysis Report, using a groundwater list-serve. Sixteen separate announcements were sent to an average of 102 recipients on the list-serve between April 1, 2015 and February 28, 2017.

In June 2017, Napa County published and promoted an update to its Groundwater Outreach Brochure that describes the County's monitoring efforts and available resources. In July 2017, Napa County published the *Well Owners Guide, A Guide for Private Well Owners in Napa County* (Guide) (Napa County, 2017). This 23-page document communicates important concepts including state and local standards for well construction, well permitting requirements, the importance of regular well maintenance, and land use practices to limit risks to groundwater quality. The Guide also answers frequently asked questions about the County's Voluntary Groundwater Monitoring Program and provides information on the County's Do It Yourself (DIY) Groundwater Level Monitoring Program. The Guide is featured on the WICC website homepage and is available to for download.[35]. In July 2017, the County also released a video on local social media channels promoting the Voluntary Groundwater Monitoring Program.[36] The video is available via links on both the WICC and County websites.

[35] https://www.napawatersheds.org/files/managed/Document/8773/20170720_Well_Owners_Guide_Final.pdf
[36] https://www.youtube.com/watch?v=yyGHAWyegK0

8 SUMMARY AND RECOMMENDATIONS

Groundwater level monitoring was conducted at a total of 107 sites across Napa County in 2017, including 61 wells within the Napa Valley Subbasin (**Table 4-1** and **Table 4-3)**. The number and distribution of wells monitored in 2017 was generally consistent with monitoring conducted since 2014, when the County initiated annual reporting as part of the ongoing Groundwater Monitoring Program (**Table 4-3**).

Groundwater level trends in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin are stable in the majority of wells with long-term groundwater level records (see **Sections 5.1.1 and 5.1.2**). While many wells showed some degree of response to recent drought conditions (i.e., 2012-2015), the water levels observed in recent years were generally higher than groundwater levels in the same wells during the 1976 to 1977 drought. Groundwater levels showed continued stable conditions with decreasing depths to groundwater in 2017, consistent with the very wet water year conditions.

Groundwater levels recorded in 2017 were above the minimum thresholds established as sustainability criteria for the Napa Valley Subbasin for all 18 wells where data are available (see **Section 5.1.3**). Two wells where sustainability criteria have been established were not accessible due to wildfire damage or concerns about site safety resulting from wildfires.

In the principal aquifer system of the Napa Valley Subbasin, the volume of groundwater in storage increased in both spring 2016 and spring 2017 relative to the prior year (see **Section 5.1.4**). The magnitude of the increase in 2016 was 1,586 acre-feet greater than the increase in 2017 despite much more precipitation occurring in water year 2017. This result is consistent with the finding that the Subbasin has been at a relatively full condition with respect to groundwater storage capacity (LSCE, 2016c).

Maps of saturated thickness and groundwater storage changes in the principal aquifer system show increases in saturated thickness and groundwater storage, primarily from St. Helena southward in the Subbasin between 2015 and 2016 (**Figures 5-9A and 5-9B**). A small area of less than two feet of saturated thickness decrease is mapped near Rutherford. The greatest increases in saturated thickness and groundwater storage occurred along the western margin of the Subbasin along Dry Creek. The change in saturated thickness and groundwater storage from spring 2016 to spring 2017 were also broadly positive, with no areas showing a decrease in saturated thickness greater than two feet (**Figures 5-10A and 5-10B**).

Total water use in the Napa Valley Subbasin, including groundwater extracted from the Subbasin, surface water from sources within the Napa River Watershed, and imported surface water delivered through the State Water Project, is estimated to have been 34,793 acre-feet in water year 2016 and 34,142 acre-feet in water year 2017 (**Table 6-6**). Total estimated groundwater use in the Subbasin was 17,039 acre-feet in water year 2016 and 15,831 acre-feet in water year 2017. Estimates of groundwater use in 2016 and 2017 are presented along with values for 1988 – 2015 developed for the Basin Analysis Report (LSCE, 2016c) in **Figure 6-8**. The figure also includes calculated annual and cumulative changes in groundwater storage in the alluvial aquifer system of the Subbasin. As noted above annual groundwater storage changes were positive in both water years 2016 and 2017, at 6,056 acre-feet and 4,470 acre-feet, respectively. Cumulative changes in groundwater storage show a net increase of 13,702 acre-feet from water years 1988 to 2017 in the principal aquifer of Napa Valley Subbasin (**Table 5-4**).

Groundwater use in water years 2016 and 2017 was comparable to amounts used in recent years dating back to 2004 (**Figure 6-8**). Over the full 30-year period, annual storage changes in the aquifer system have fluctuated between positive and negative values, generally in accordance with the water year type. Cumulative changes in groundwater storage have also fluctuated between positive and negative values, indicating stable groundwater storage conditions and the absence of chronic depletions of groundwater storage. Groundwater use in the Subbasin in water years 2016 and 2017 remained below the sustainable yield range of 17,000 to 20,000 acre-feet per year identified in the Basin Analysis Report (LSCE, 2016c). Together, the findings presented in this report regarding groundwater conditions at representative monitoring sites, changes in groundwater storage, and groundwater use demonstrate that the Napa Valley Subbasin has continued to be managed sustainably through 2017.

Although designated as a groundwater subarea for local planning purposes, the majority of the MST is not part of a groundwater basin as mapped by DWR. Groundwater level declines observed in the MST Subarea as early as the 1960s and 1970s have stabilized since about 2009 (see **Section 5.2**). Groundwater level responses differ within the MST Subarea and even within the north, central, and southern sections of this subarea, indicating that localized conditions, whether geologic or anthropogenic in nature, might be the primary influence on groundwater conditions in this local subarea.

8.1 Recommendations for Continued SGMA Implementation[37]

The following sections summarize recommendations presented in the Basin Analysis Report (LSCE, 2016c) and the Northeast Napa Management Area Report (LSCE, 2018a, **Appendix A**), with an emphasis on recommendations prioritized for near-term implementation.

8.1.1 Data Gap Refinement (SGMA Implementation Recommendations 11, 13, and 14)

Outreach to well owners in Napa County will continue through the WICC, County website and groundwater list-serve, public presentations regarding groundwater conditions, and other means to solicit wells for voluntary inclusion in the County's monitoring network. Napa County will also review discretionary projects recently approved by the County with conditions of approval requiring that project wells be made available for inclusion in the County's monitoring network.

Coordination with other county departments and other agencies that collect or utilize groundwater data could also provide an additional data in areas of interest. Several local agencies, including the Town of Yountville, City of St. Helena, and City of Napa, already monitor groundwater levels at locations around the county.

[37] The Basin Analysis Report for the Napa Valley Subbasin includes a comprehensive list of monitoring and management recommendations developed since 2011. Additional recommendations developed for the Basin Analysis Report were added to the list in sequence, beginning at number 13. Recommendations 1 – 12 are referenced in this Section where applicable to ongoing activities.

8.1.2 Ongoing Water Quality Sampling (SGMA Implementation Recommendation 15)

Baseline groundwater quality sampling is planned to occur at 16 wells distributed throughout the Napa-Sonoma Valley Groundwater Basin in 2017 was delayed due to access limitations and staffing restrictions in response to the large wildfires that affected the county in fall 2017. Sampling at these wells is recommended to be conducted in 2018. Additional water quality sampling for a reduced set of constituents, including nitrate and chloride, is also recommended for the five dual-completion monitoring wells constructed in 2014 at surface water-groundwater monitoring sites. An initial round of sampling and analysis was completed in June 2015 with a combination of County matching funds, DWR grant funds, and DWR in-kind support. Continued sampling of these wells is recommended in the Basin Analysis Report.

8.1.3 Improve Data Collection and Evaluation from Discretionary Permittees Required to Monitor Groundwater Conditions and Groundwater Use (SGMA Implementation Recommendations 16 and 25)

Through coordination between the Napa County Public Works Department and Planning, Building, and Environmental Services Department, continue to improve procedures for receiving data reported by permittees required to report groundwater data and regularly incorporate those data into the Napa County Groundwater Data Management System.

8.1.4 Evaluate Strategic Recharge and Water Conservation Opportunities (SGMA Implementation Recommendations 8 and 19)

In 2017, Napa County worked with the Napa RCD to develop a project to improve the understanding water uses in unincorporated areas within the Napa Valley Subbasin. The objectives of the project include working with landowners to collect data on the timing of water availability, storage, and use at the farm scale for the purpose of quantifying the effects of existing efficiency and conservation efforts and identifying potential improvements to existing practices. The project will build on existing water use efficiency trainings and outreach conducted by the Napa RCD. A funding request for the project is currently pending as part of grant application to the California Wildlife Conservation Board. Implementation of the project would begin in 2018, if the grant is funded. Alternate funding opportunities will be pursued, if grant funds are not available.

8.1.5 Evaluate Distribution of Groundwater Dependent Ecosystems; Coordinate Evaluation with Guidance Developed by DWR, Nature Conservancy, California Native Plant Society or Others (SGMA Implementation Recommendations 11 and 20)

In 2018 with technical assistance from the Napa RCD, Napa County will review guidance on evaluating GDEs recently released by The Nature Conservancy (2018), in order to refine the mapping and assessment of GDEs presented in the Basin Analysis Report. In cooperation with the WICC and the Napa RCD, Napa County has developed a pilot web-based application that allows RCD staff to submit observations about streamflow conditions within the Napa Valley Subbasin. This effort is planned to be expanded to allow data collection by volunteers using a custom-built mobile software application that will be developed by Napa County in late 2018. Through this approach, Napa County will be able to efficiently collect standardized information and photographs documenting streamflow conditions at priority sites multiple times throughout each dry season. This information will complement existing stream gaging station data collected by Napa County, the Napa RCD, and USGS.[38]

8.1.6 Update the Napa County Groundwater Ordinance for the Northeast Napa Management Area (SGMA Implementation Recommendation 28)

On October 24, 2017, the Napa County Board of Supervisors directed County staff to update the Napa County Groundwater Ordinance to reflect the additional requirements for project-specific analysis and to incorporate water use criteria and water use reporting requirements for the Northeast Napa Management Area using an approach similar to what has already been implemented in the MST Subarea. In response, Napa County Public Works Department and Planning, Building, and Environmental Services Department staff plan to develop an update to the Groundwater Ordinance in 2018. For discretionary projects in the Northeast Napa Management Area, additional project-specific analyses (Napa County Water Availability Analysis-Tier 2) will be required to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells) (Napa County, 2015).

8.1.7 Implement Improvements to Napa County's Data Management System (SGMA Implementation Recommendation 1.1b)

In 2017, Napa County began development of field data tool to assist staff in the collection and management of groundwater level data. A pilot, mobile application (Collector Application) was developed using ArcGIS Online and tested by County staff. In 2018, Napa County will continue to test and improve the application's functionality and integration with the County's DMS, which will allow for improved well data management and spatial mapping.

[38] see https://napa.onerain.com/home.php

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FIGURES

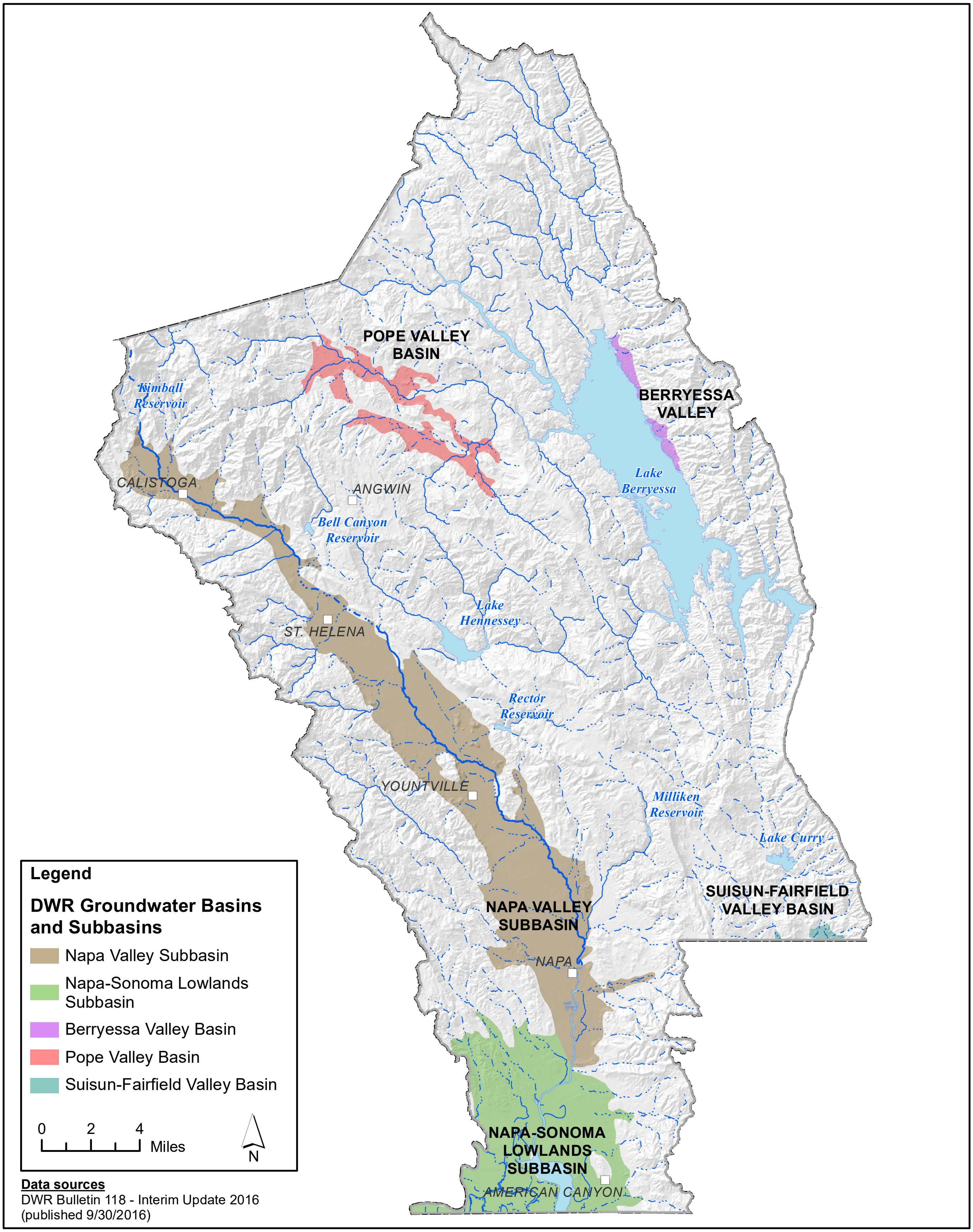

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FIGURE 2-1
Groundwater Basins and Subbasins in Napa County, CA

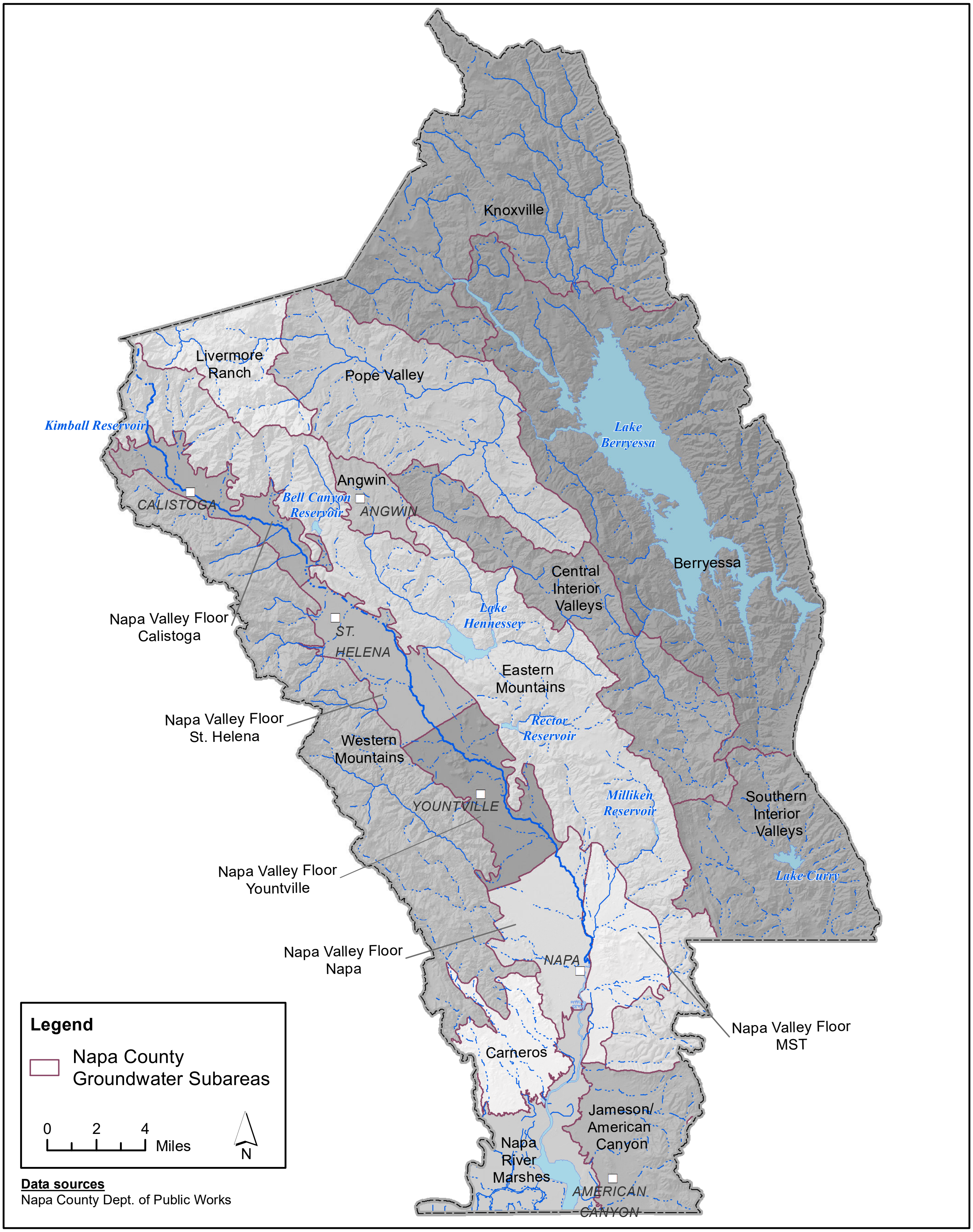

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FIGURE 2-2
Napa County Groundwater Subareas

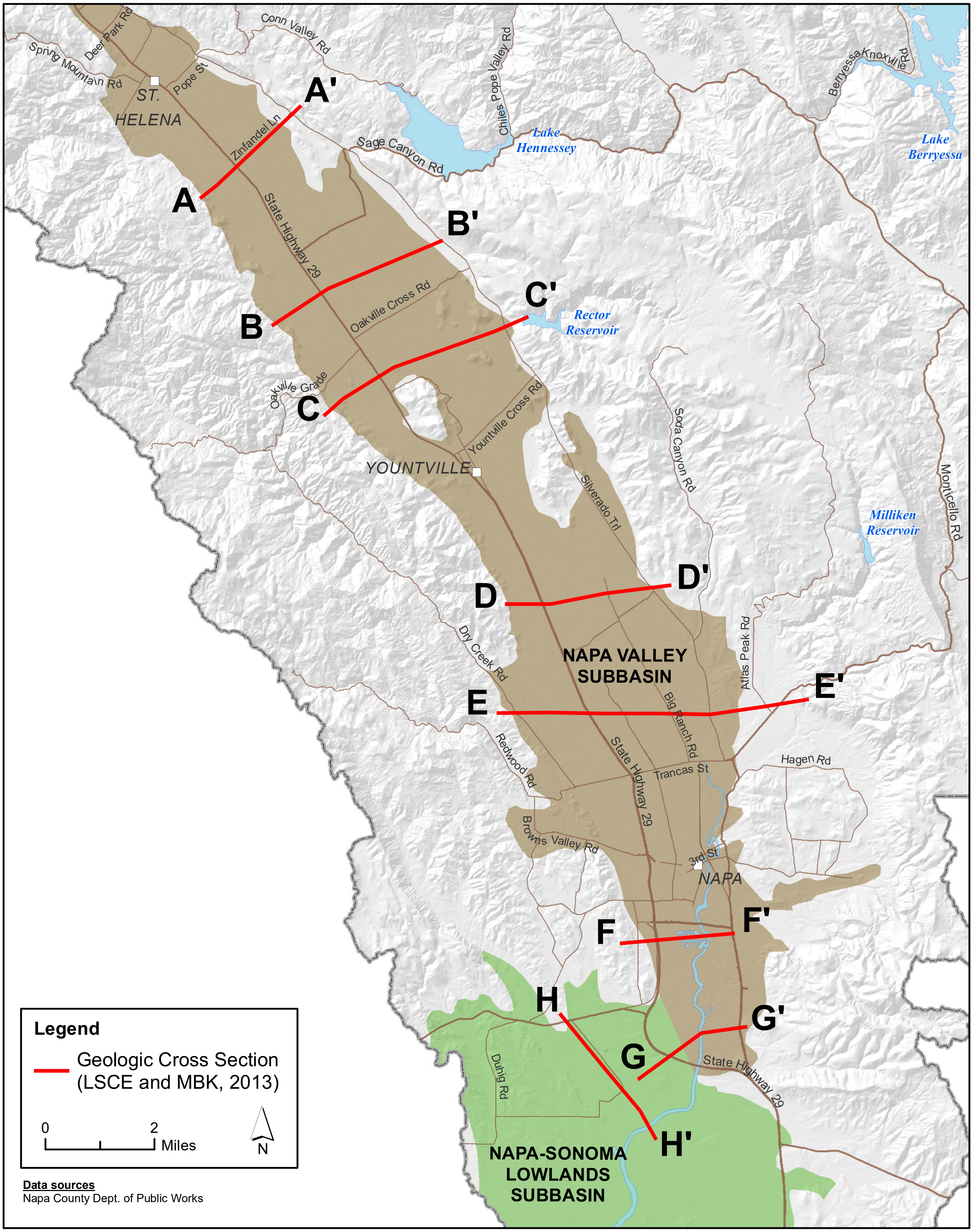

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FIGURE 2-3
Updated Hydrogeologic Conceptualization
Geologic Cross Section Locations

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

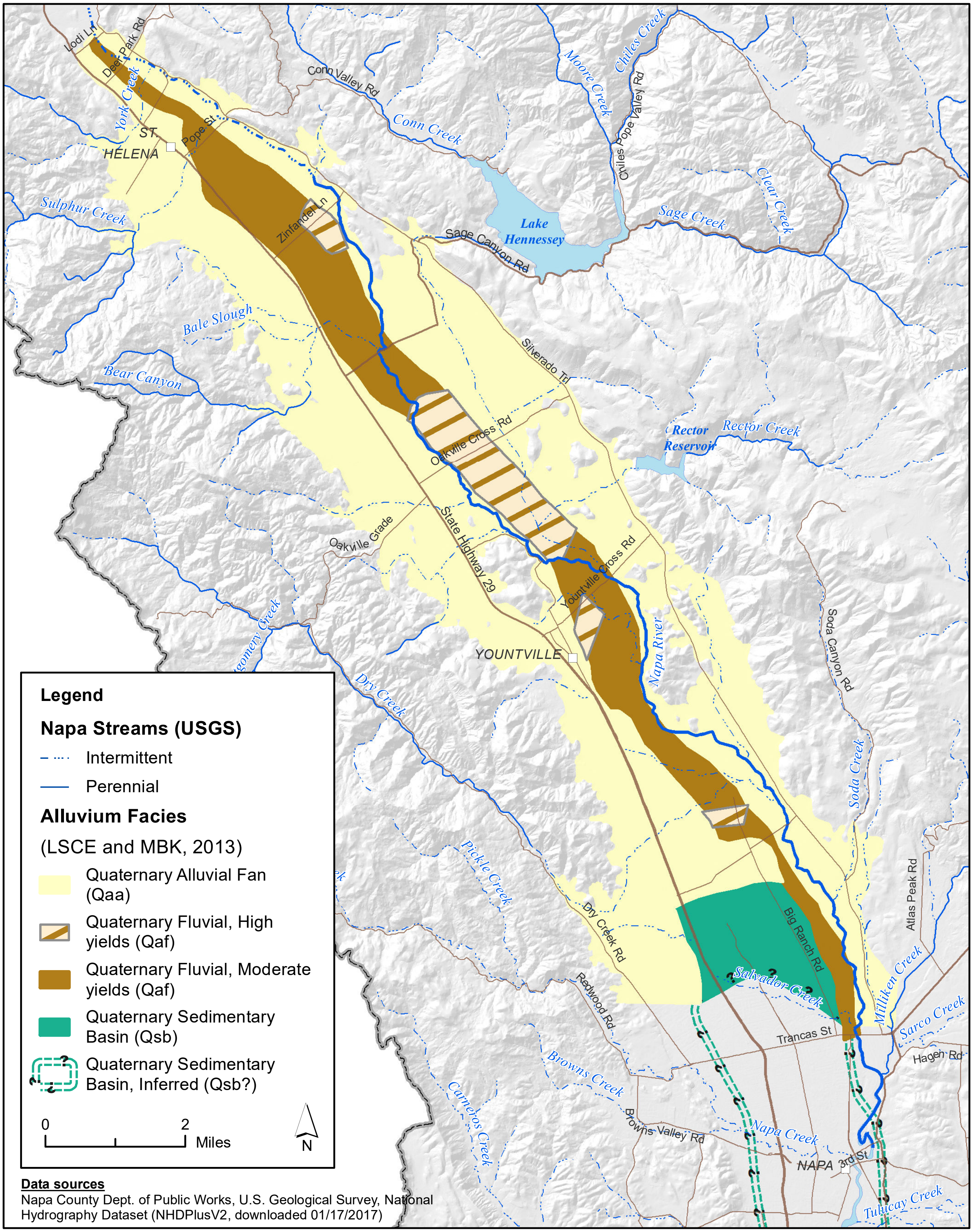

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FIGURE 2-4

Streams and Alluvium Facies, Napa Valley Floor

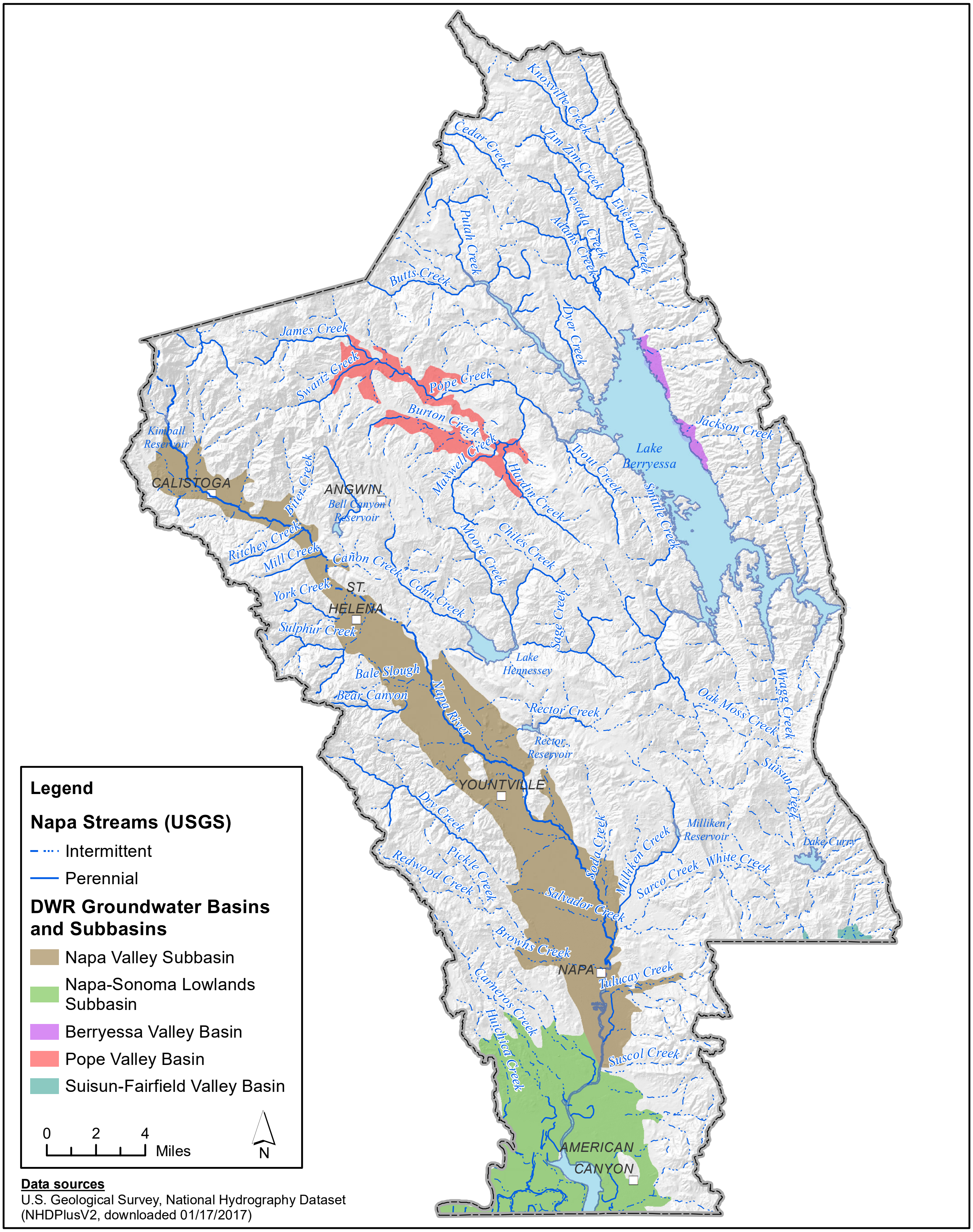

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FIGURE 2-5
Perennial Streams and Intermittent Streams, Napa County

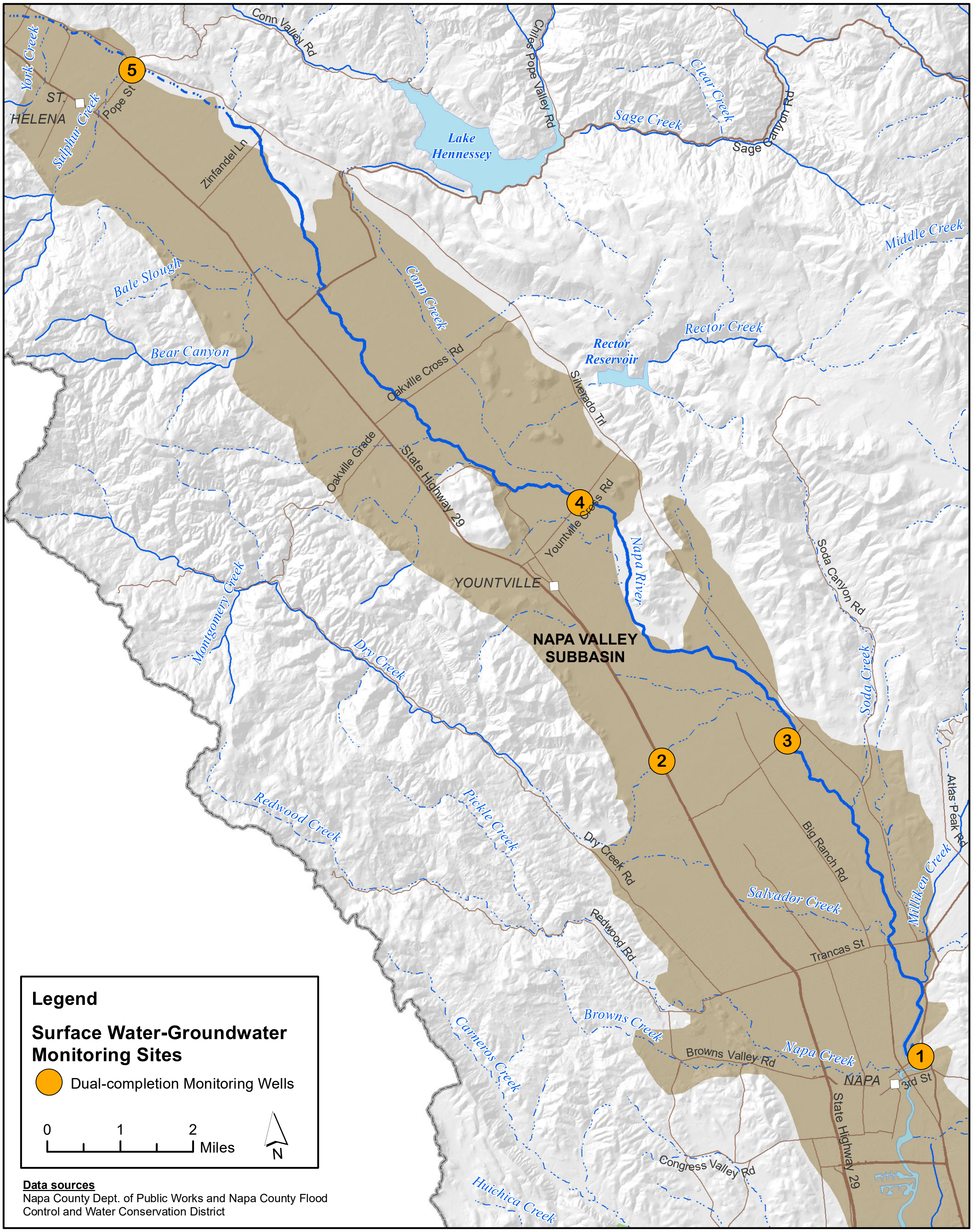

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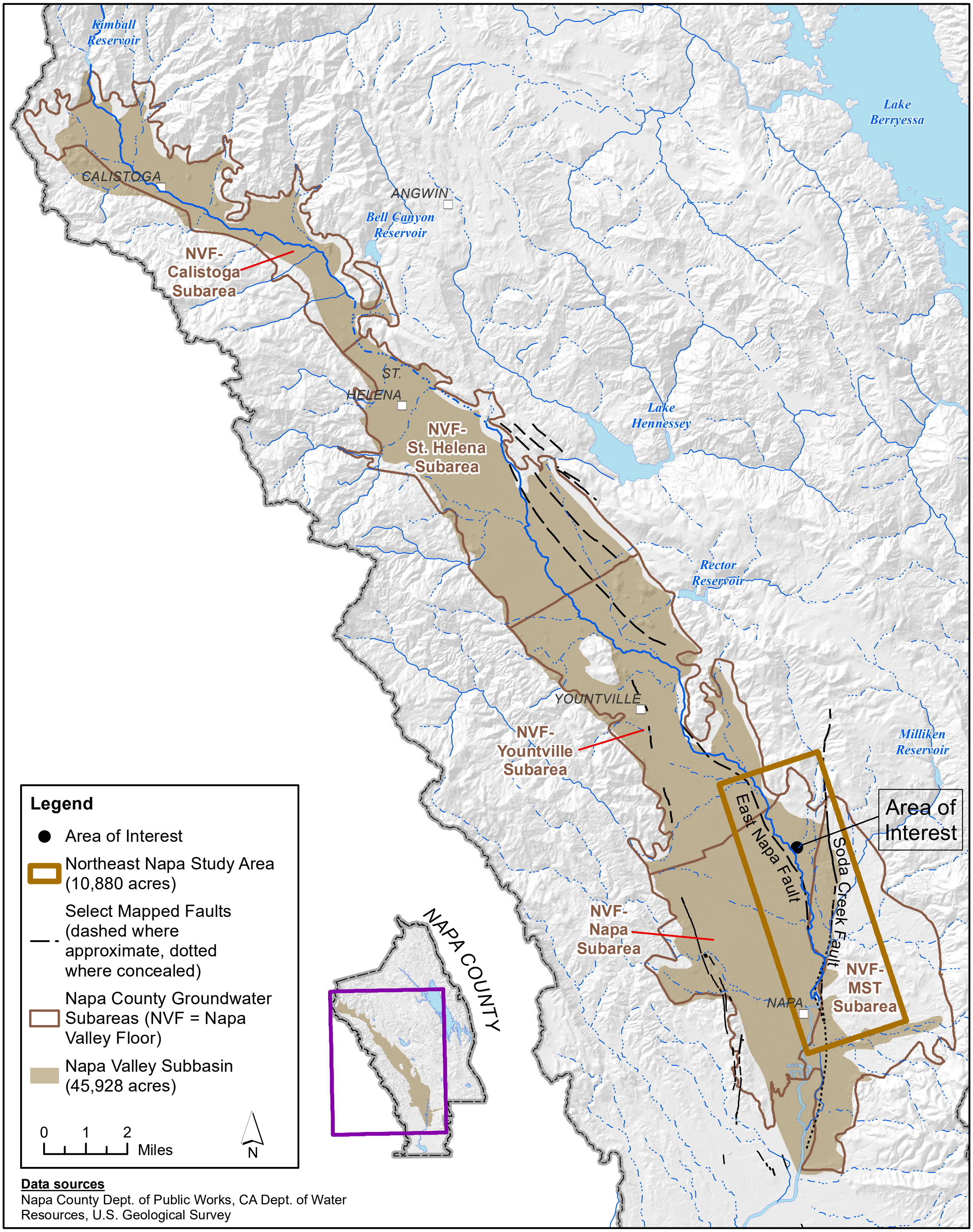
FIGURE 2-6
Napa County Surface Water-Groundwater Monitoring Sites

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, U.S. Geological Survey

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FIGURE 2-7
Northeast Napa Area of Interest

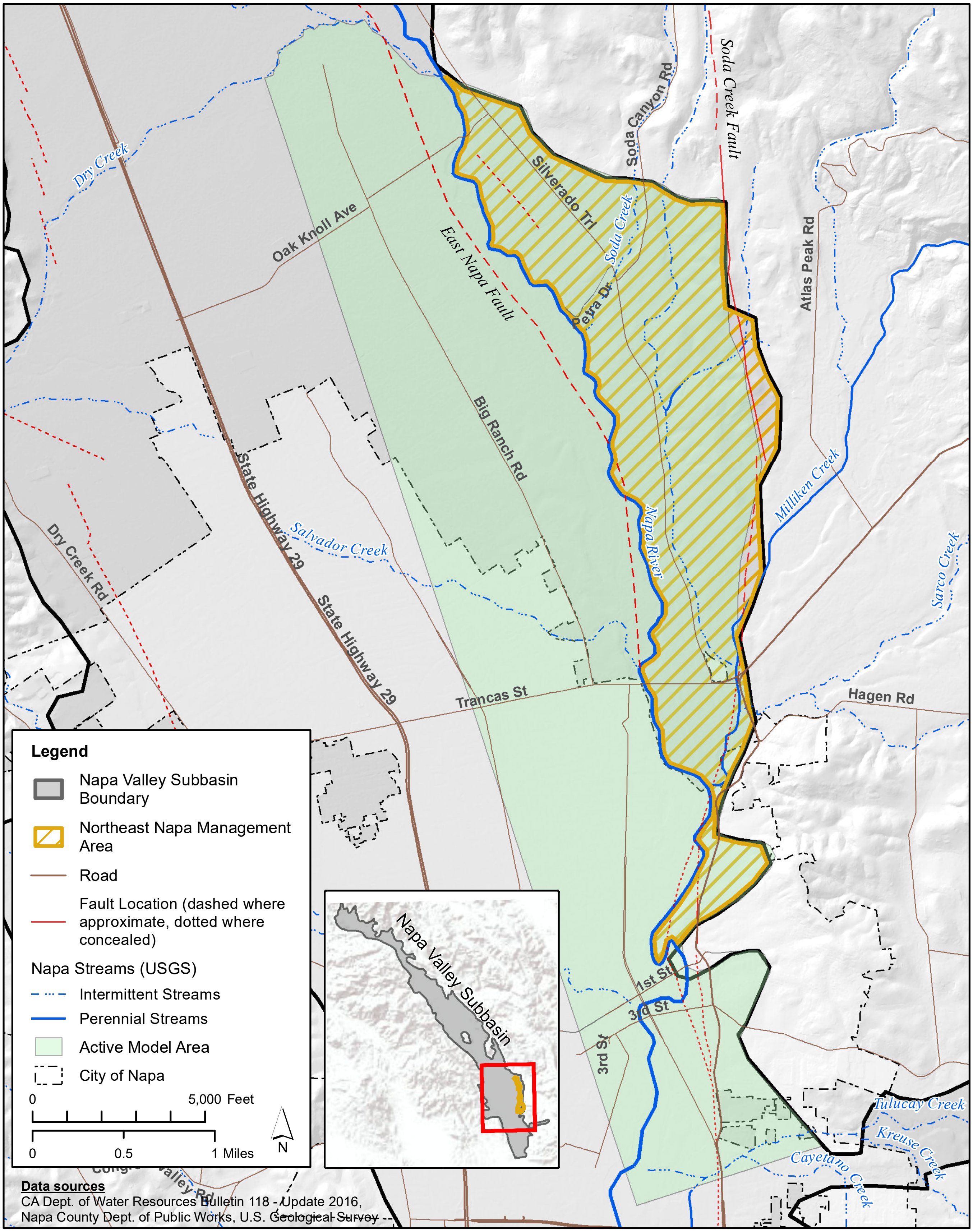

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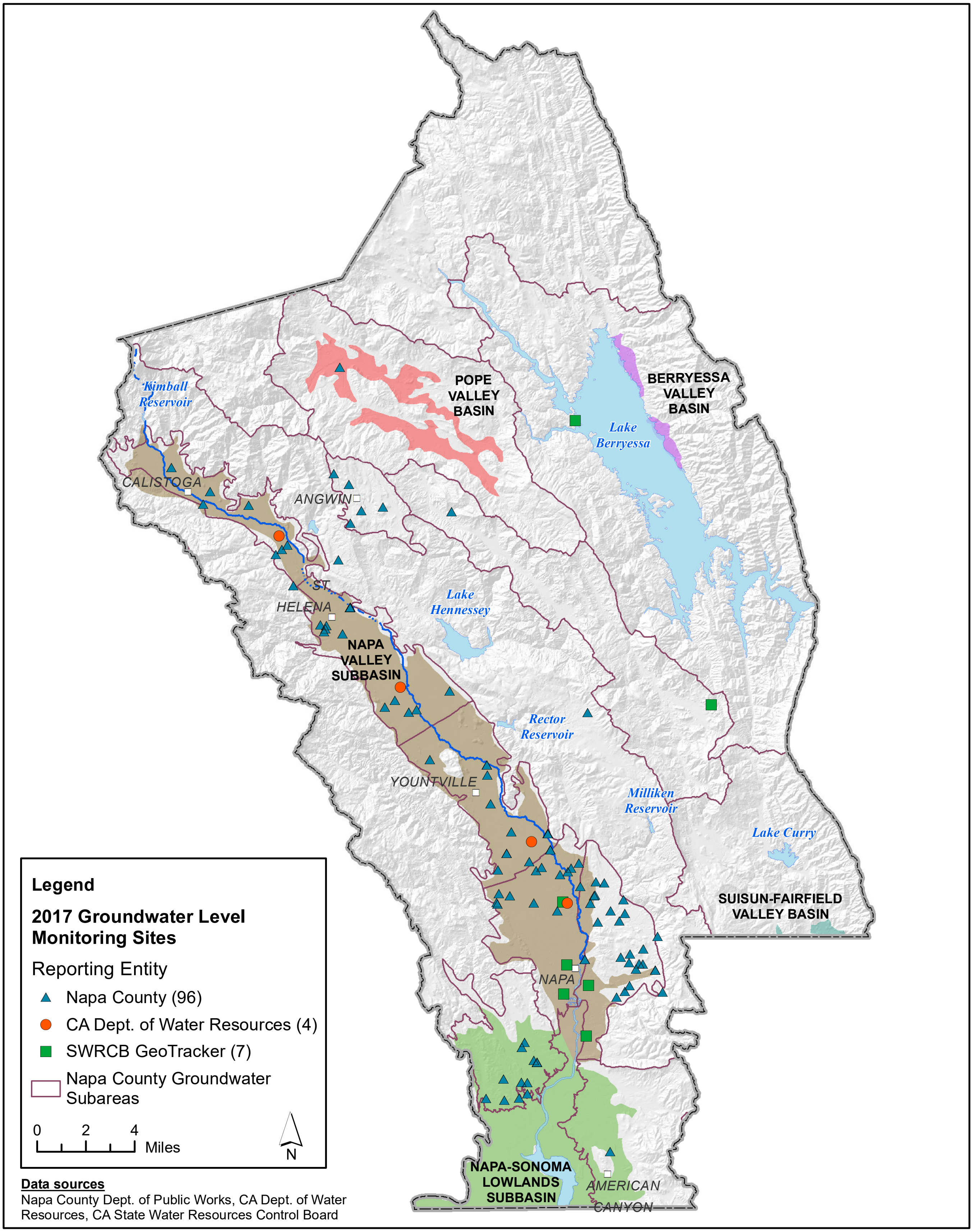
FIGURE 2-8
Napa Valley Subbasin: Northeast Napa Management Area



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, CA State Water Resources Control Board

X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\4-1 2017 Current GWL Monitoring Sites by Entity.mxd

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FIGURE 4-1
Current Groundwater Level Monitoring Sites by Reporting Entity

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

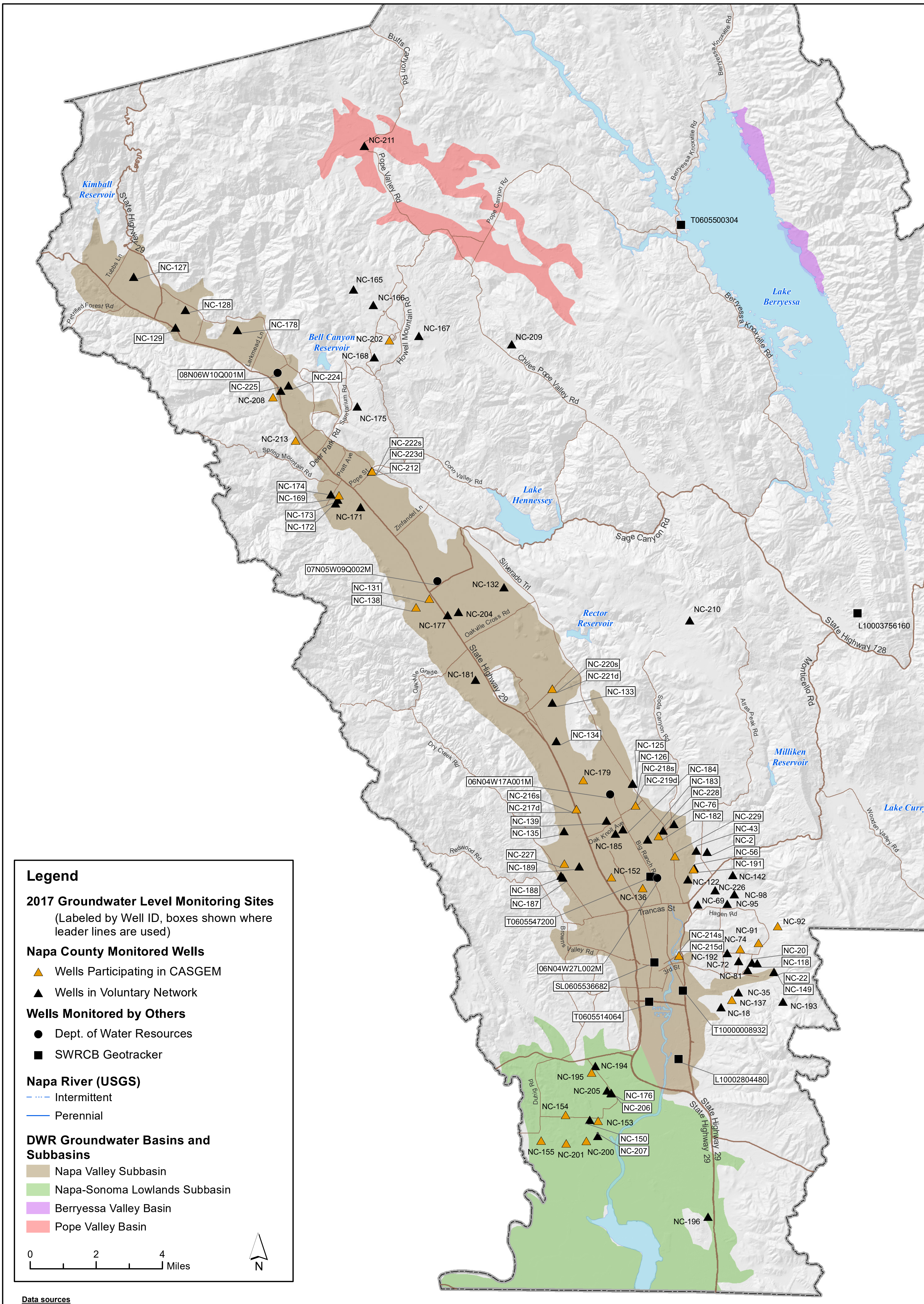

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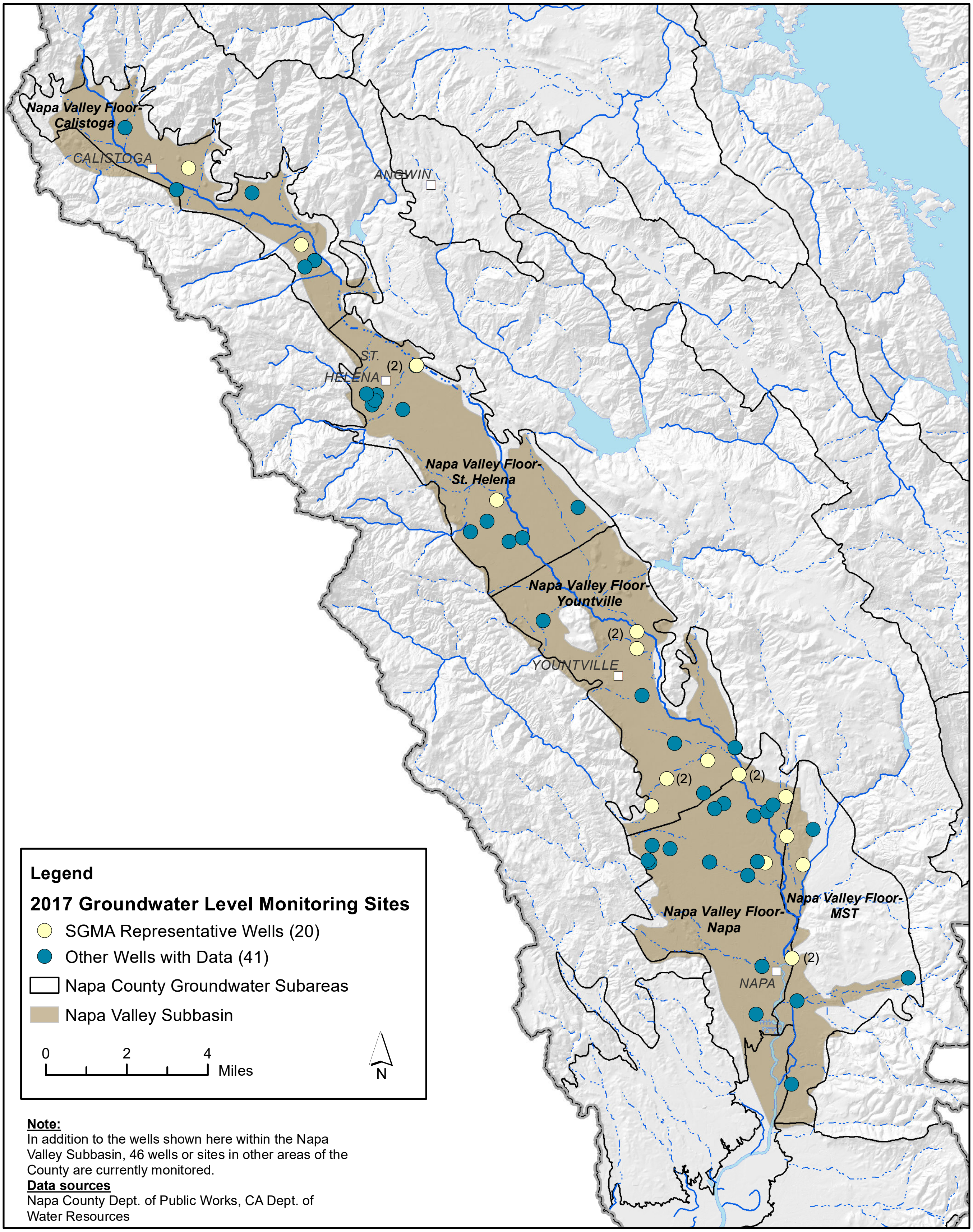
FIGURE 4-2
Current Groundwater Level Monitoring Network and CASGEM Sites, Napa County, CA



X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\4-3 Representative Wells and Wells Utilized for Analyses.mxd

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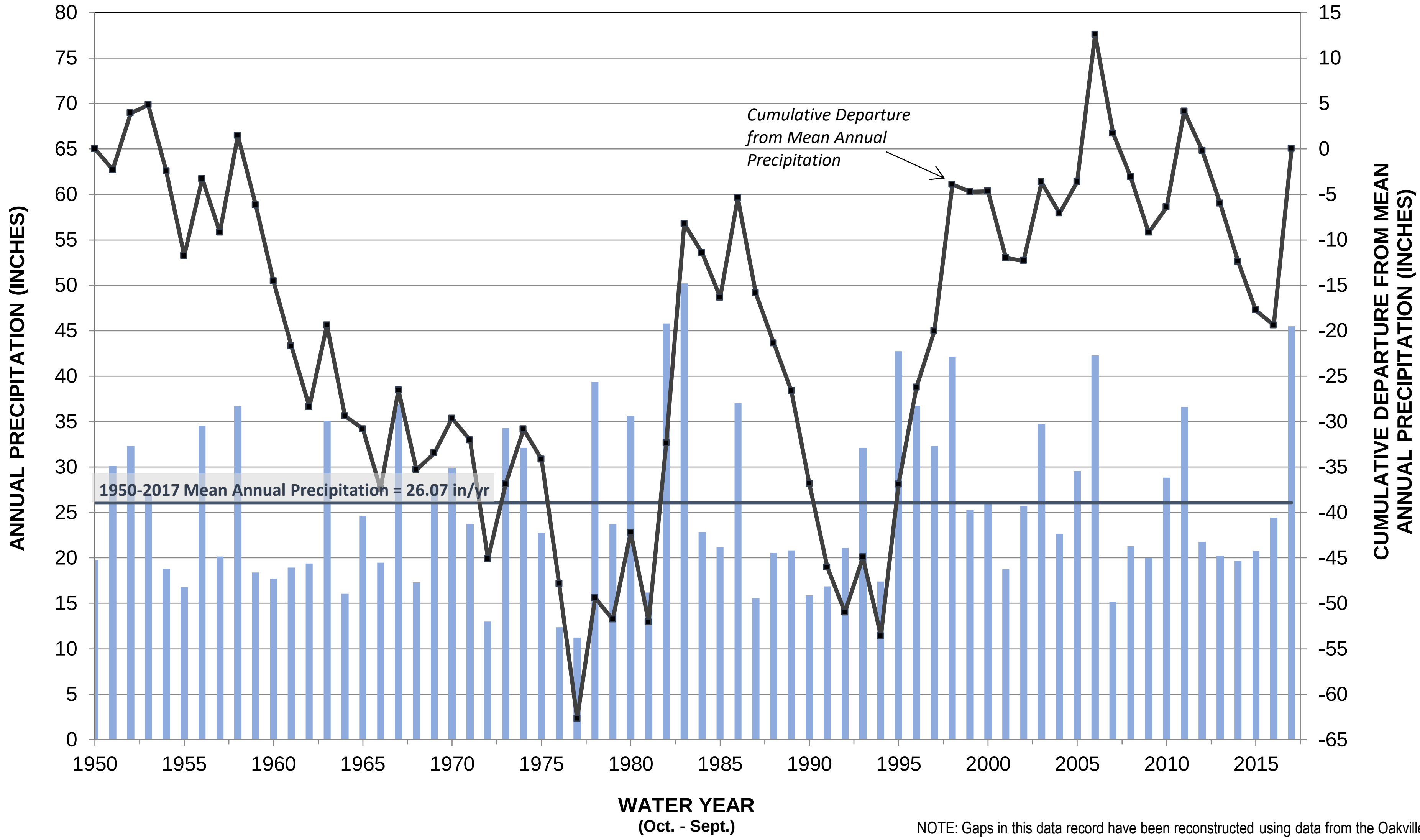
FIGURE 4-3

Representative Wells and Wells Utilized for Analyses in the Napa Valley Subbasin



NOTE: Gaps in this data record have been reconstructed using data from the Oakville CIMIS station (77) and NOAA Saint Helena, CA station (GHCND:USC0004764).

X:\2017\17-030 Napa Co. - 2017-2018 General Services\DATA\DMS\Rainfall_Data_WY2017\NSH_Cumulative_Dep.xlsx

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FIGURE 5-1
Napa State Hospital Water Year Precipitation and Cumulative Departure, Water Years 1950 - 2017

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

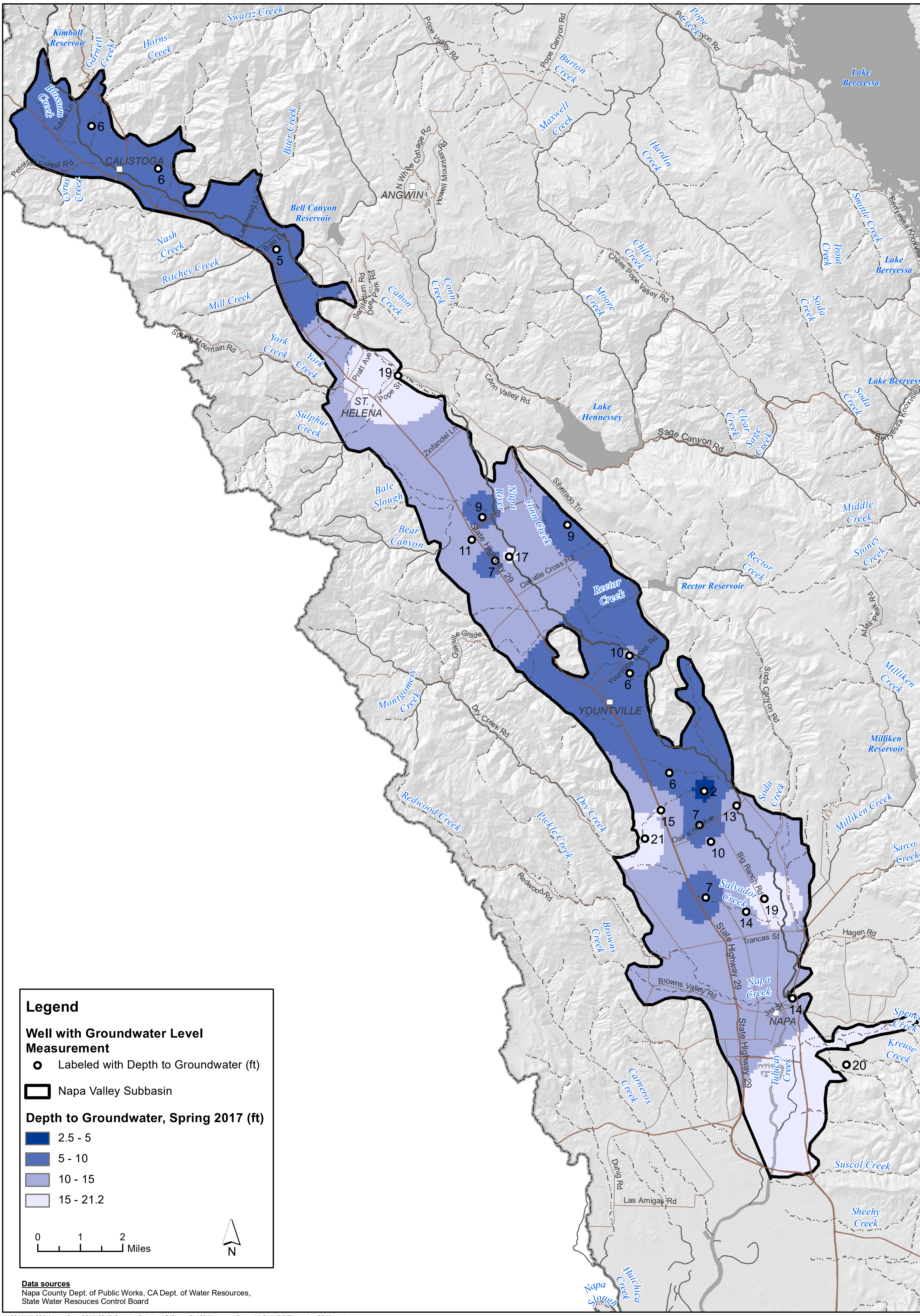

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FIGURE 5-2
Napa Valley Subbasin Spring 2017
Interpolated Depth to Groundwater

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

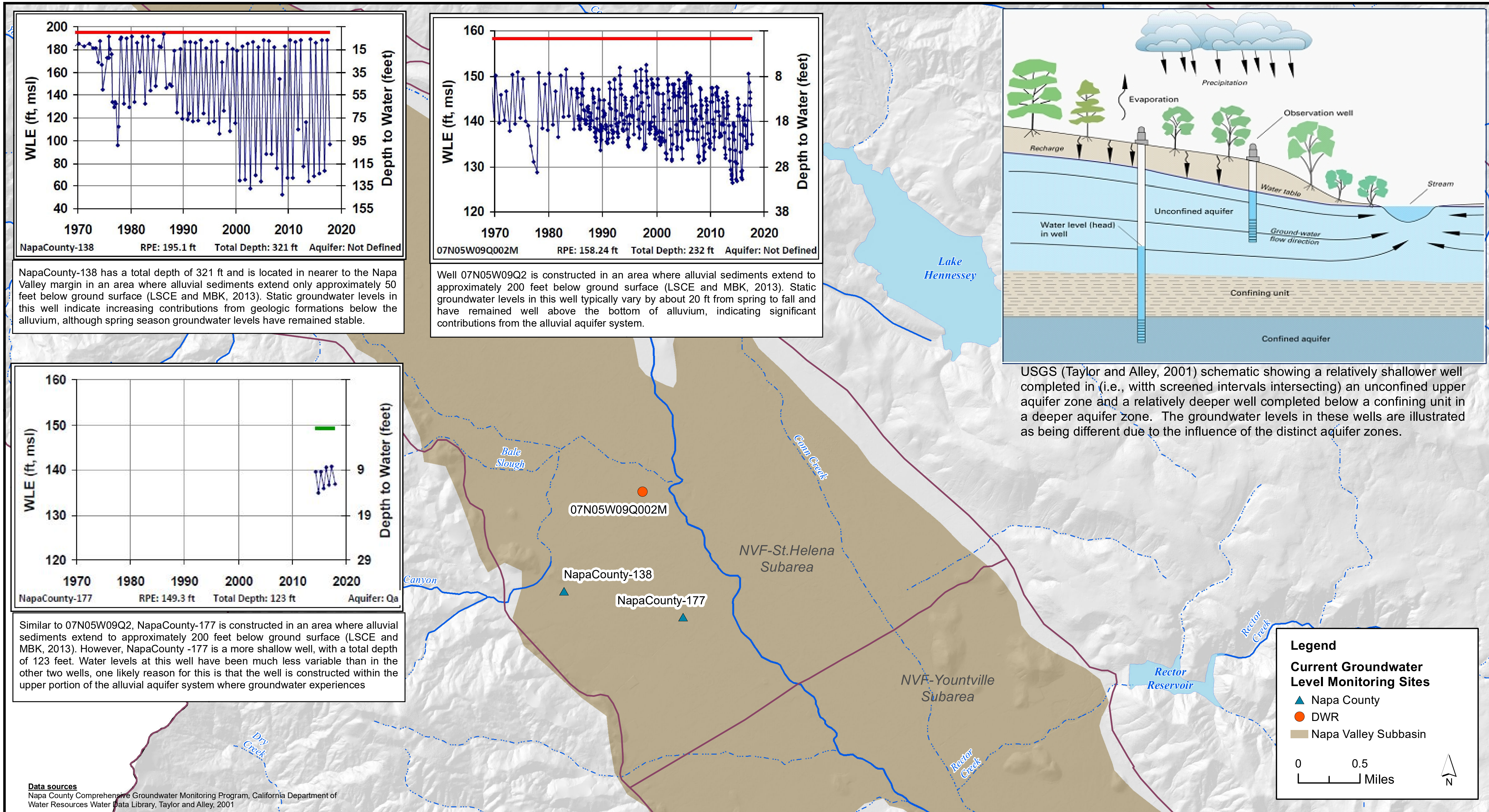

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FIGURE 5-3

Southern St. Helena Subarea Aquifer Zone Schematic and Illustrative Hydrographs

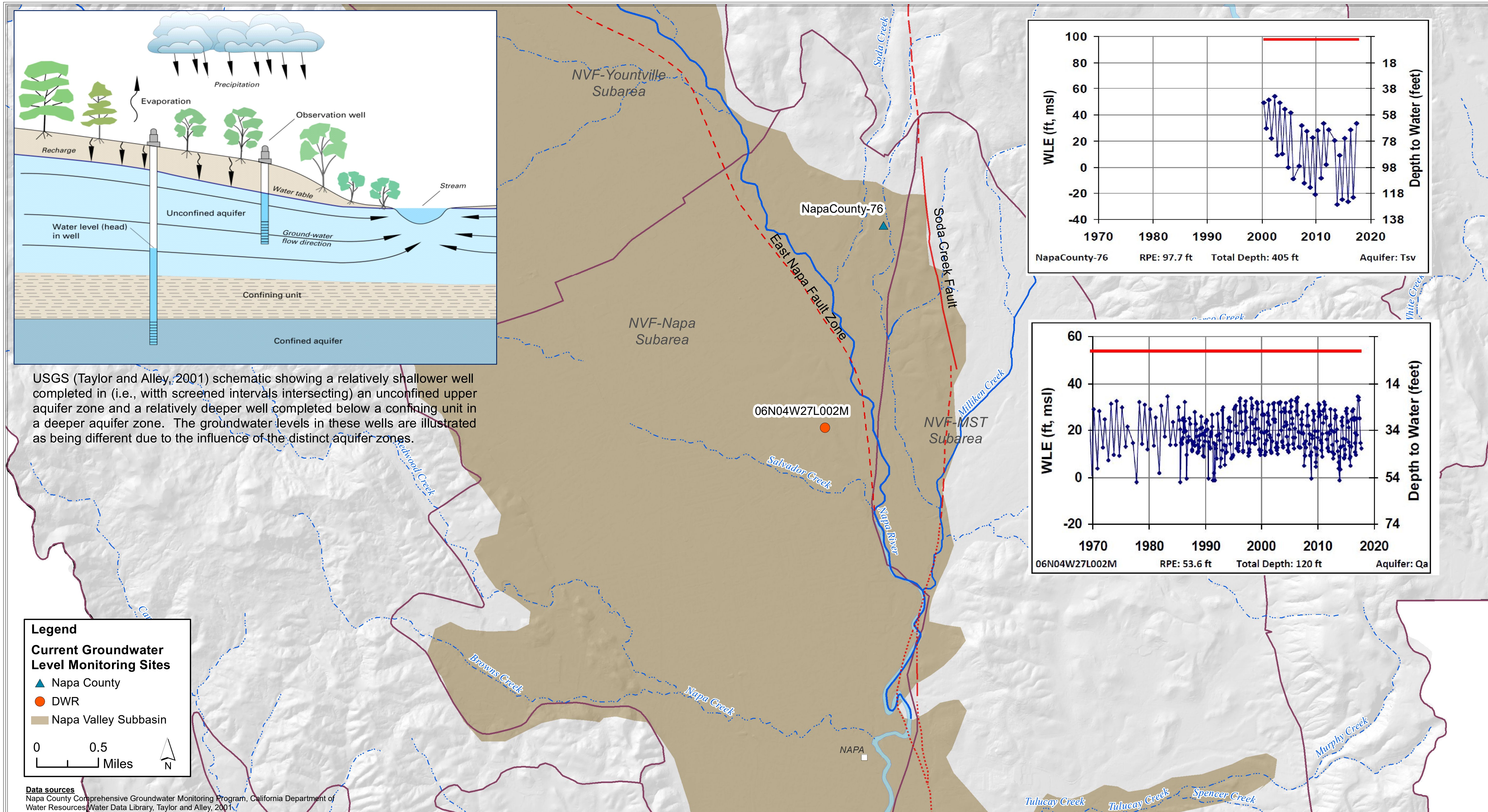

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FIGURE 5-4

Northeast Napa Subarea Aquifer Zone Schematic and Illustrative Hydrographs

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

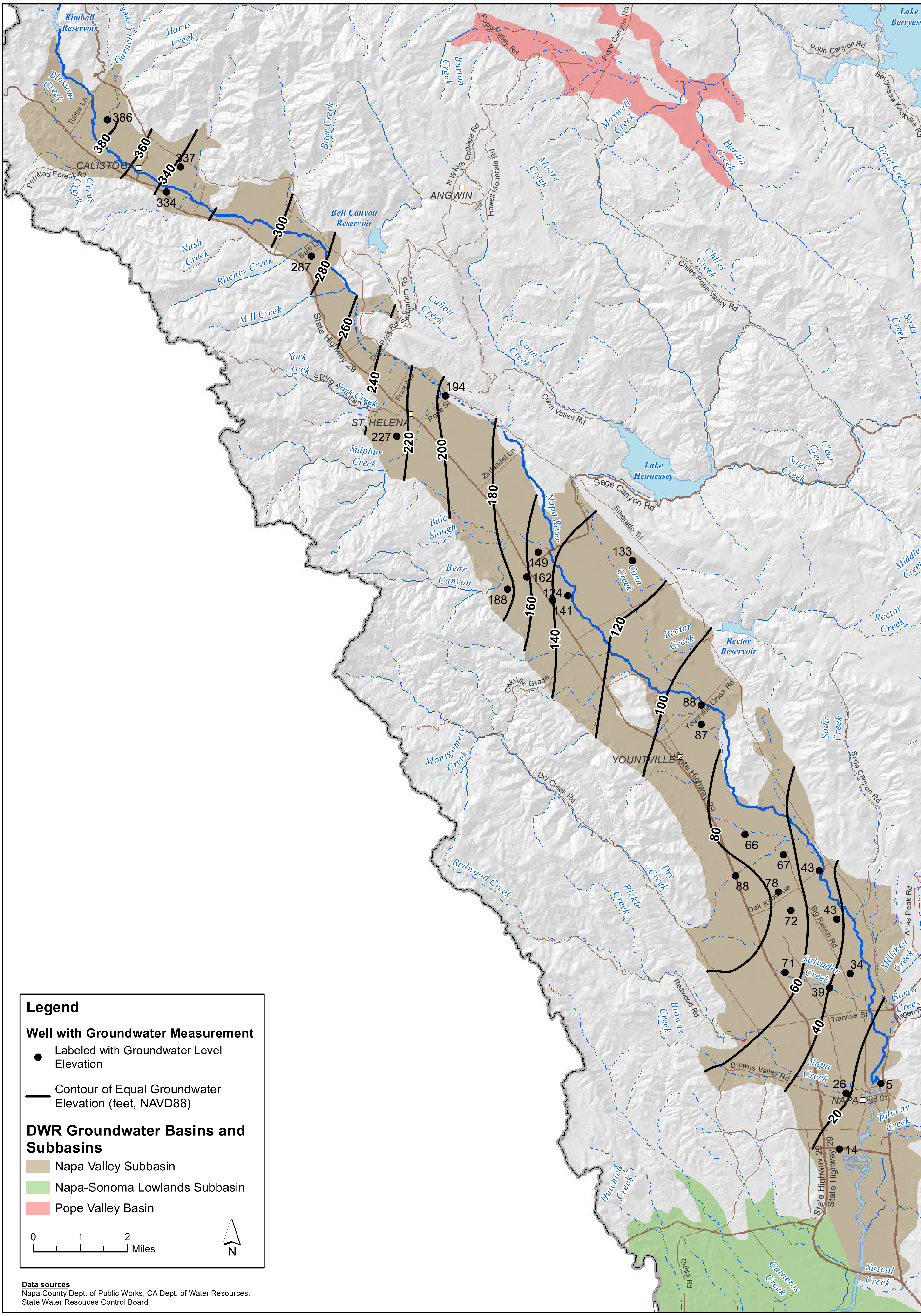

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FIGURE 5-5
Contours of Equal Groundwater Elevation, Spring 2017
Napa Valley Subbasin, Napa County, CA

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

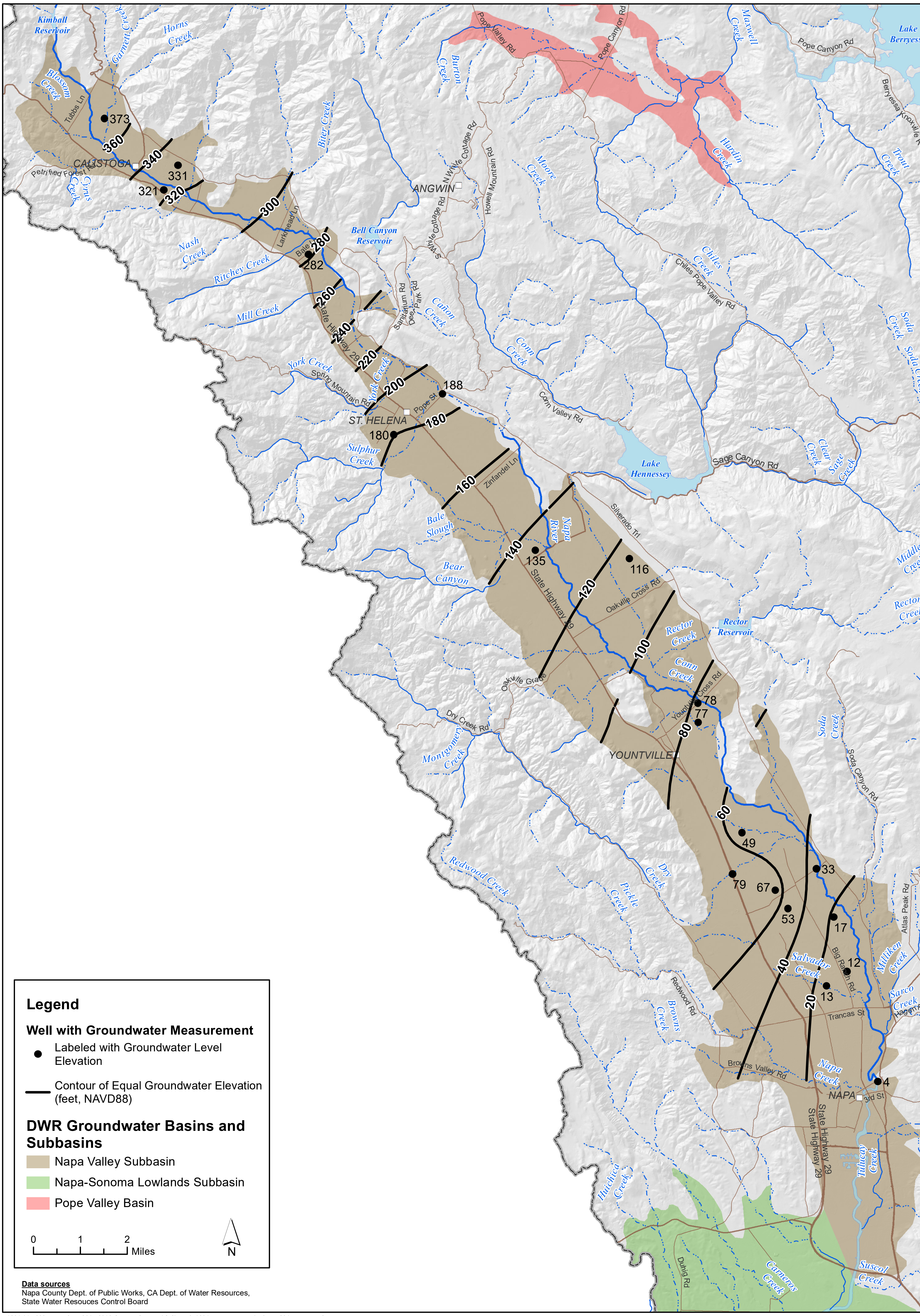

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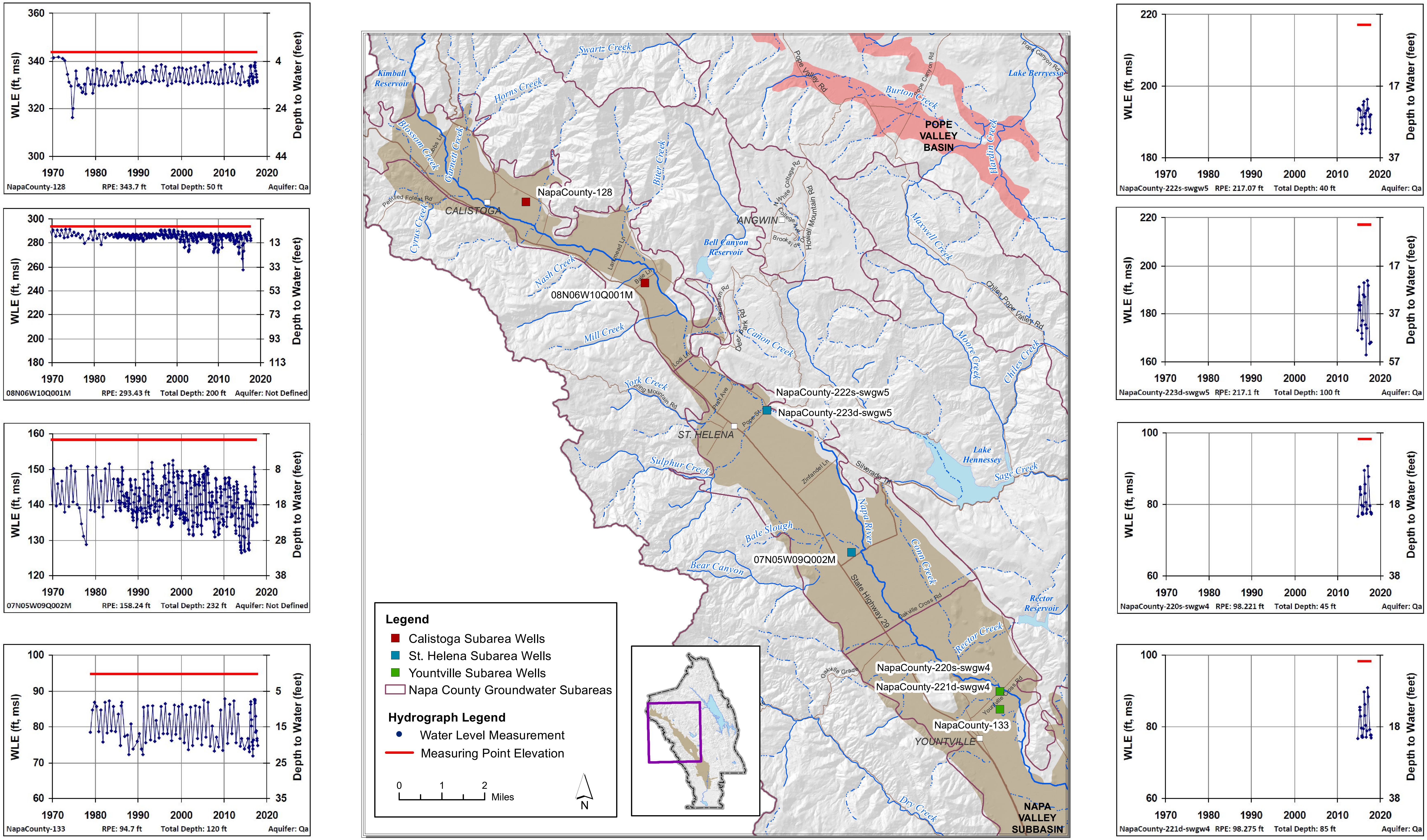
FIGURE 5-6
Contours of Equal Groundwater Elevation, Fall 2017
Napa Valley Floor, Napa County, CA



Path: X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\5-7 HydrographNorthernNapaValley_thru2017.mxd

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FIGURE 5-7
Sustainable Groundwater Management Act Representative Groundwater Hydrographs, Northern Napa Valley Subbasin

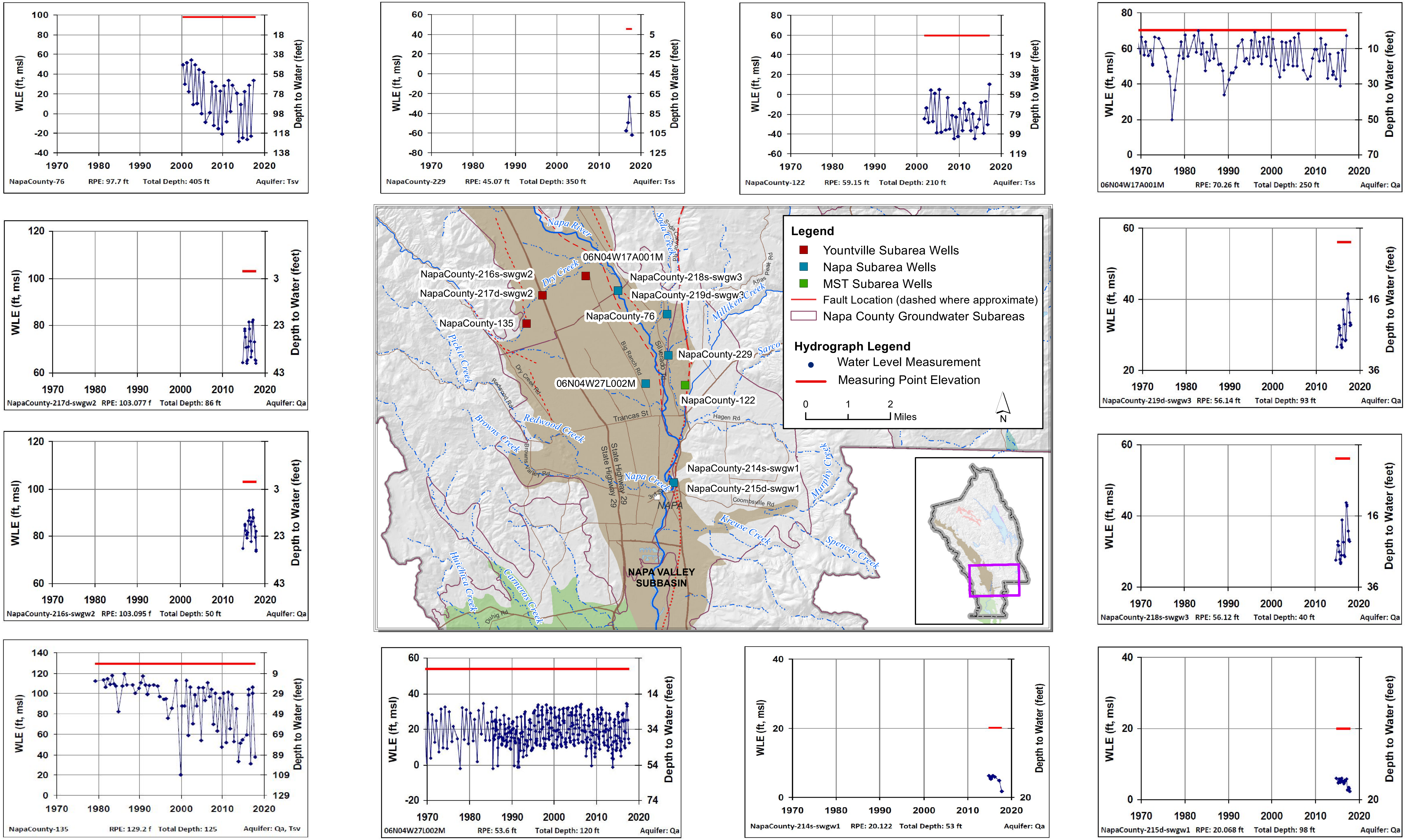

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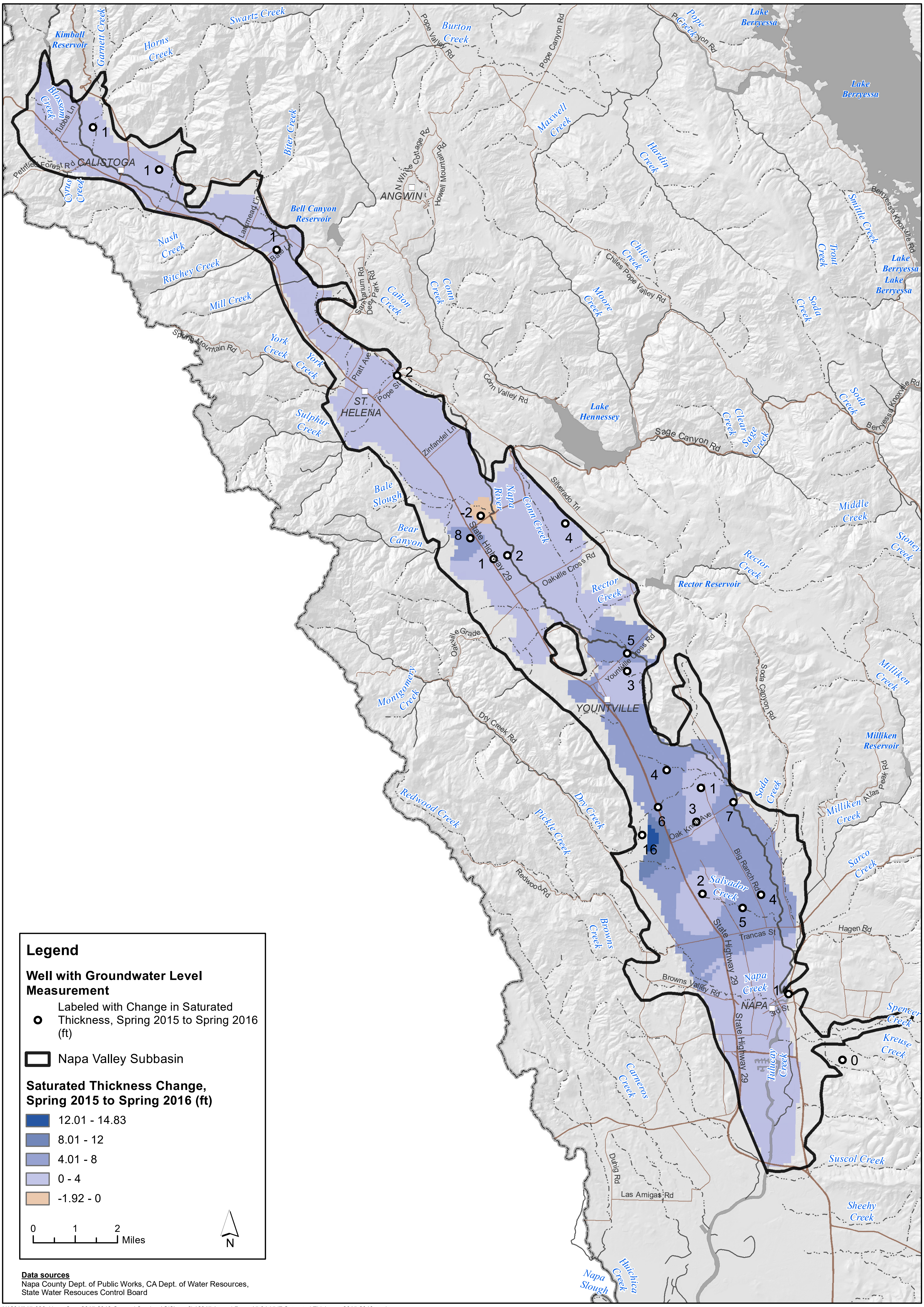
FIGURE 5-8

Sustainable Groundwater Management Act Representative Groundwater Hydrographs, Southern Napa Valley Subbasin



X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\5-9A NVF Saturated Thickness 2015-2016.mxd

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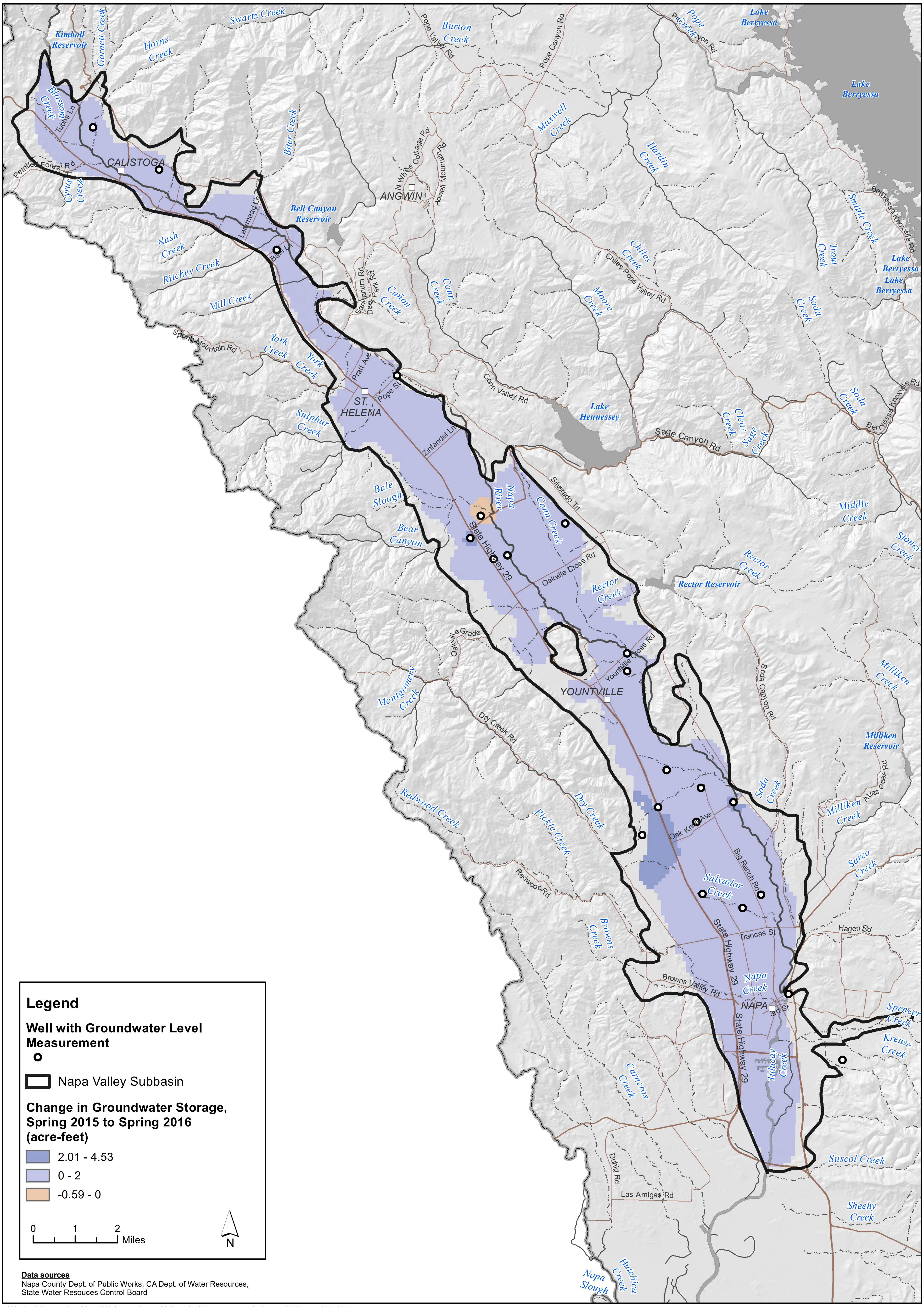
FIGURE 5-9A
Napa Valley Subbasin Principal Aquifer
Change in Saturated Thickness, Spring 2015 to Spring 2016

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, State Water Resouces Control Board

X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\5-9B NVF GW Storage 2015-2016.mxd

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FIGURE 5-9B
Napa Valley Subbasin Principal Aquifer
Change in Groundwater Storage, Spring 2015 to Spring 2016

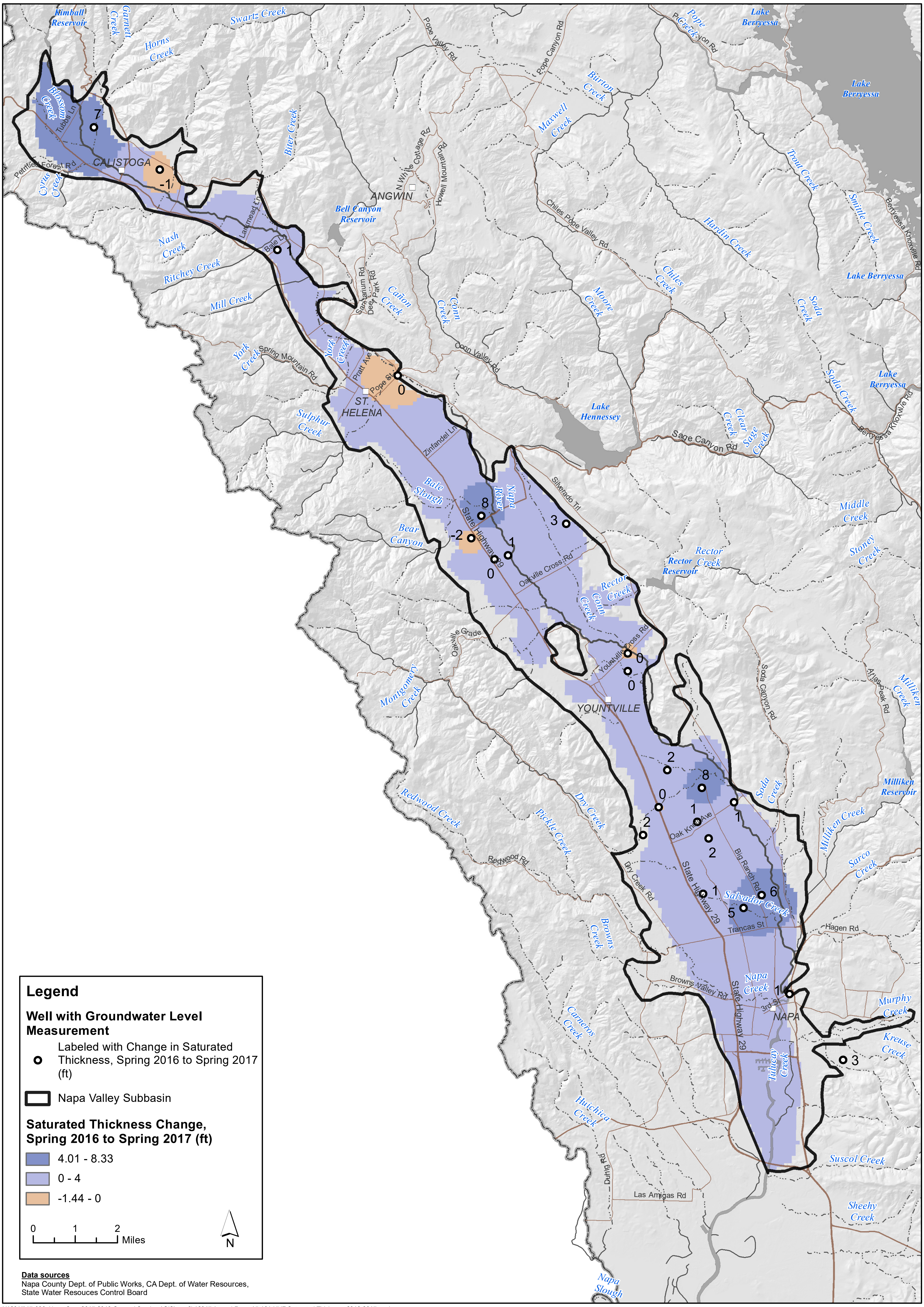

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FIGURE 5-10A
Napa Valley Subbasin Principal Aquifer
Change in Saturated Thickness, Spring 2016 to Spring 2017

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

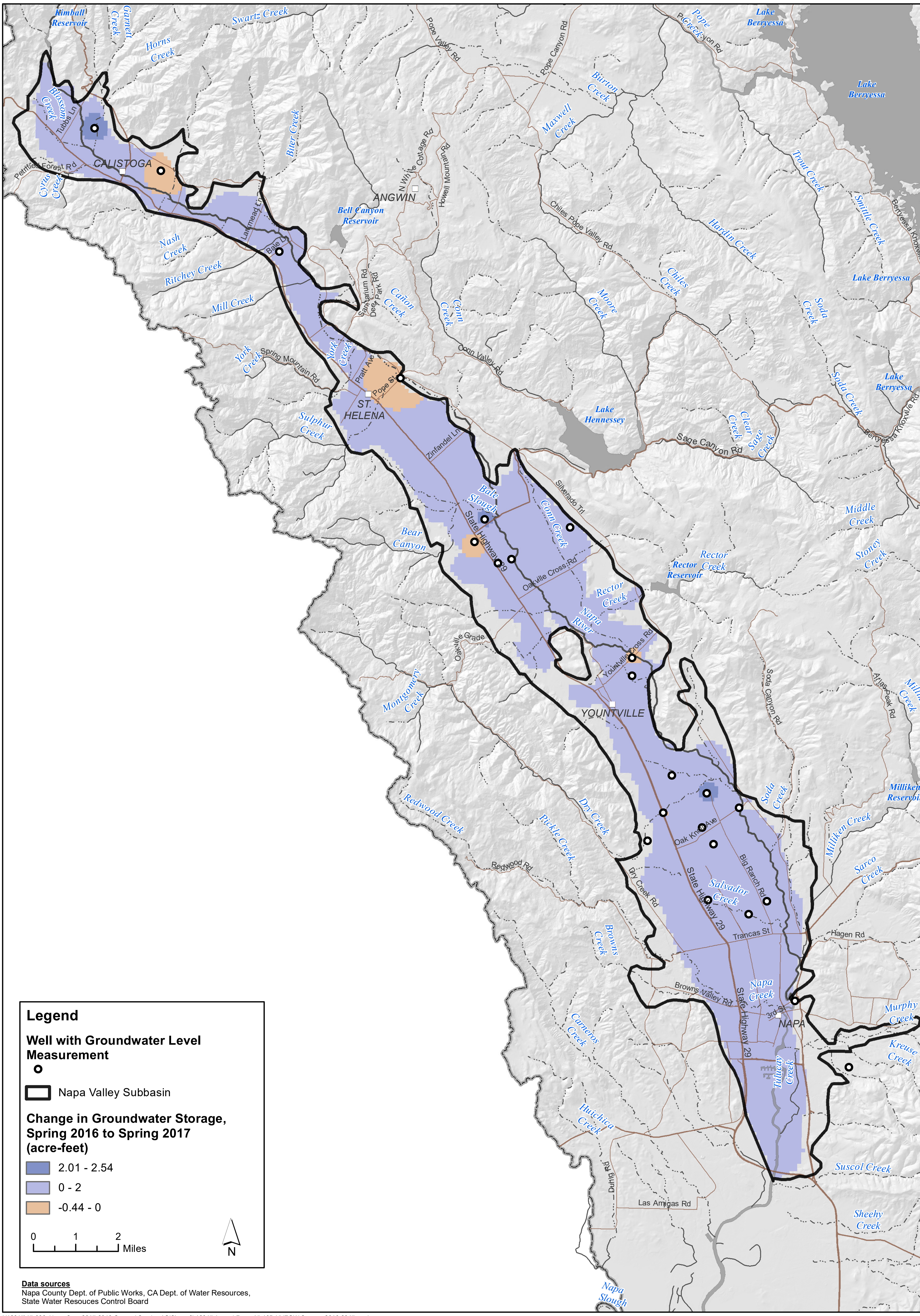

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FIGURE 5-10B
Napa Valley Subbasin Principal Aquifer
Change in Groundwater Storage, Spring 2016 to Spring 2017

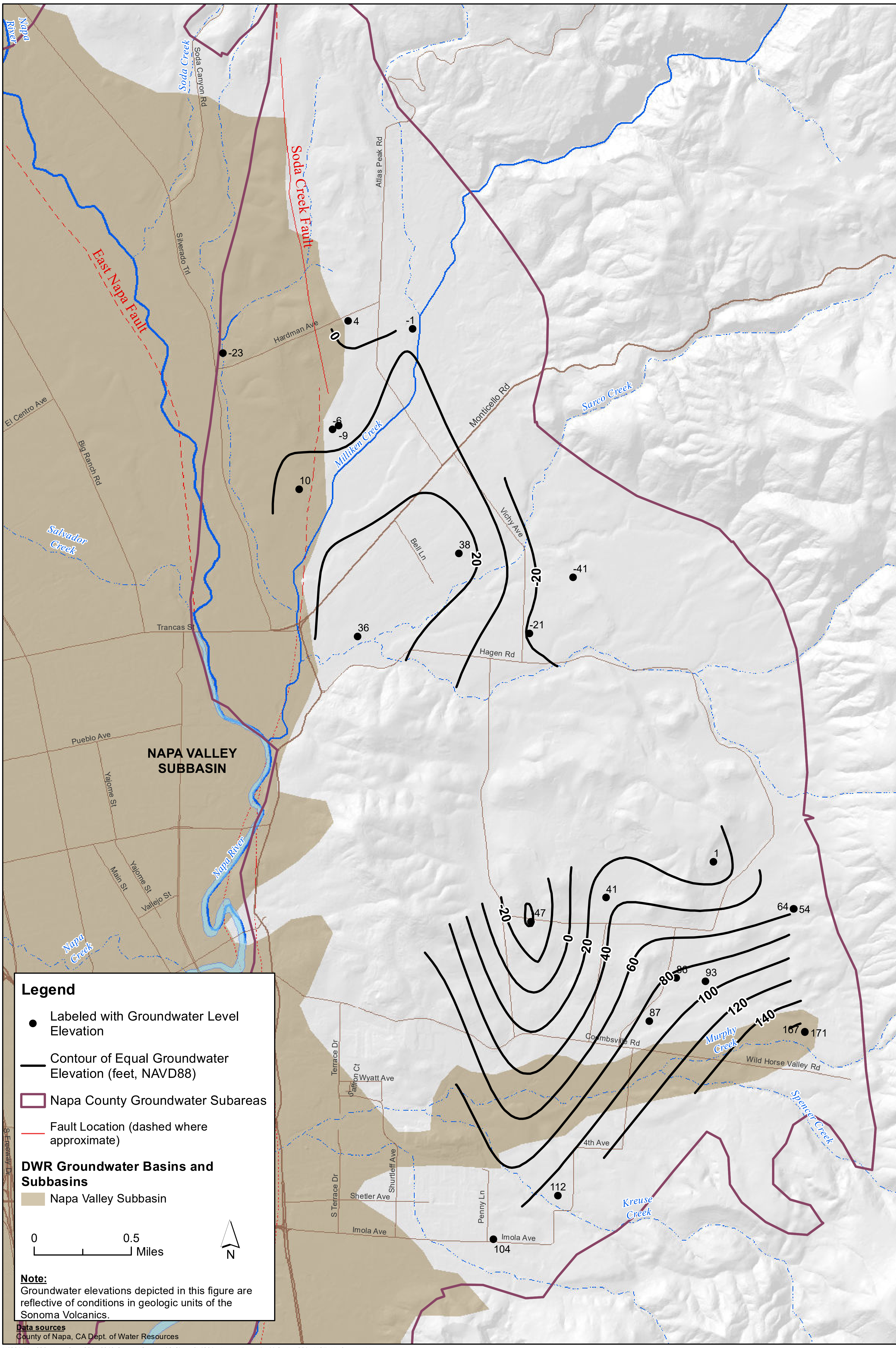

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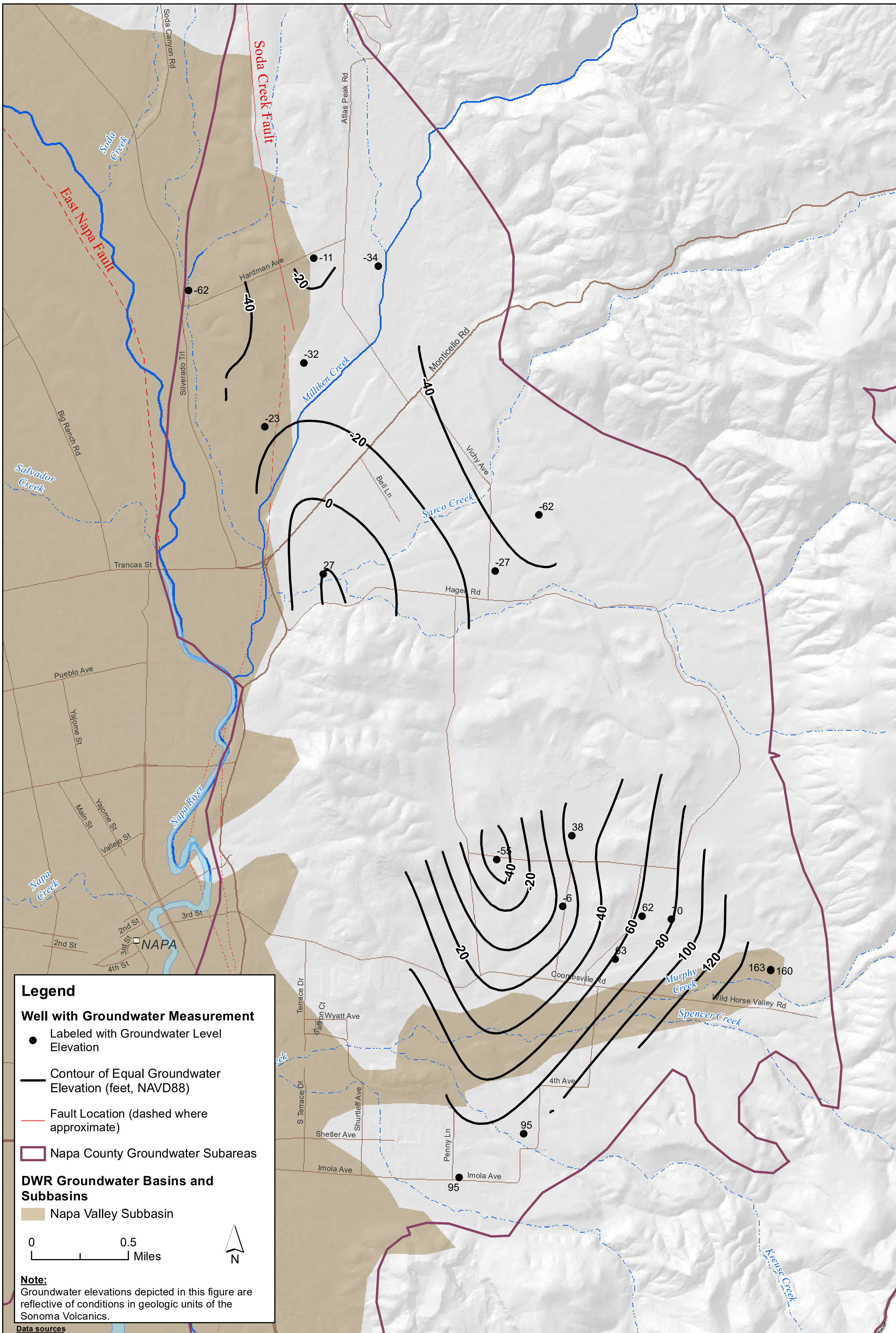
FIGURE 5-11

Contours of Equal Groundwater Elevation, Spring 2017
MST Subarea, Napa County, CA

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\5-12 Fall 2017 MST WL Contour Map.mxd

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FIGURE 5-12

Contours of Equal Groundwater Elevation, Fall 2017

MST Subarea, Napa County, CA

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

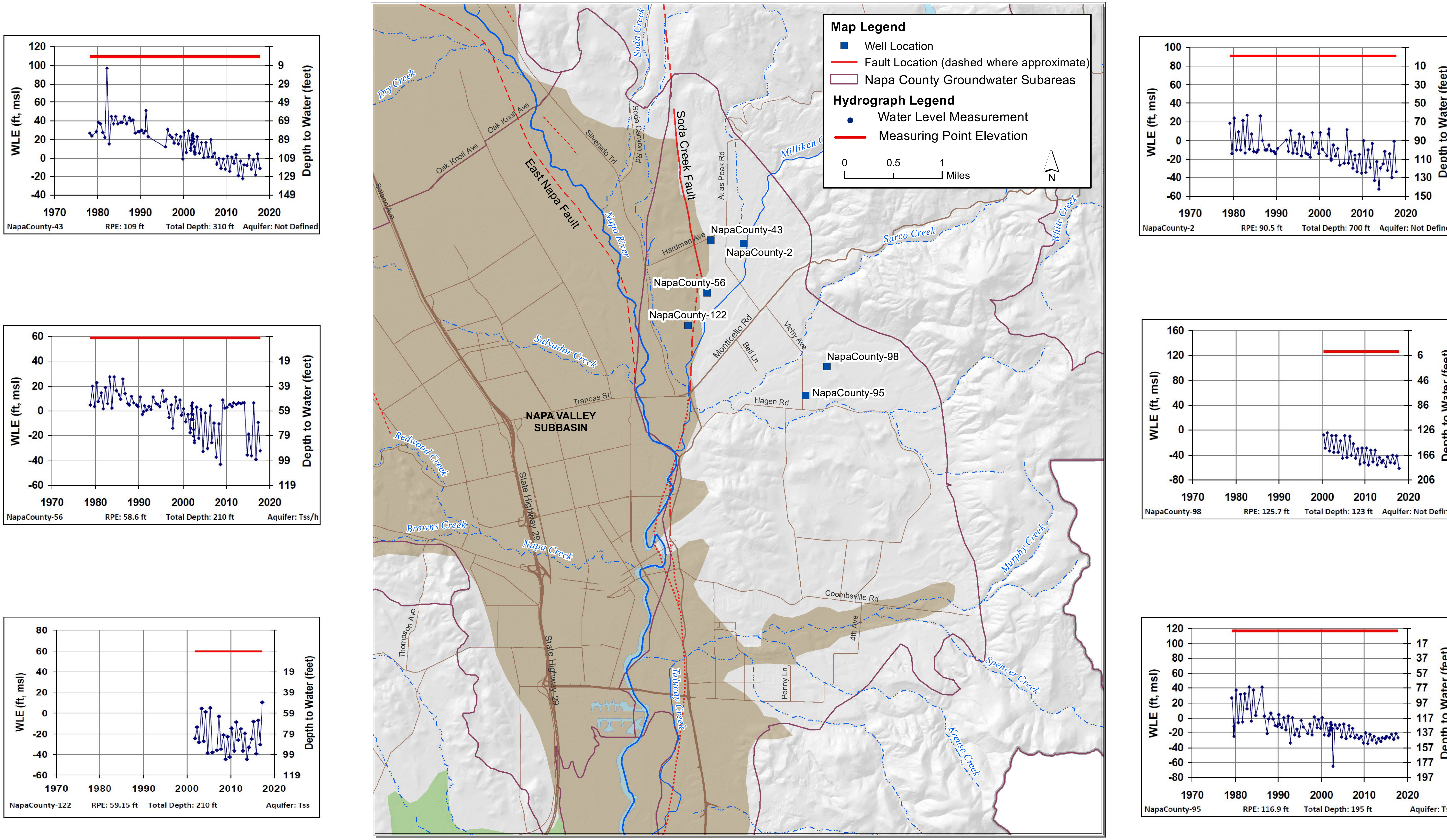

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FIGURE 5-13

Representative Groundwater Hydrographs, Northern MST Subarea

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

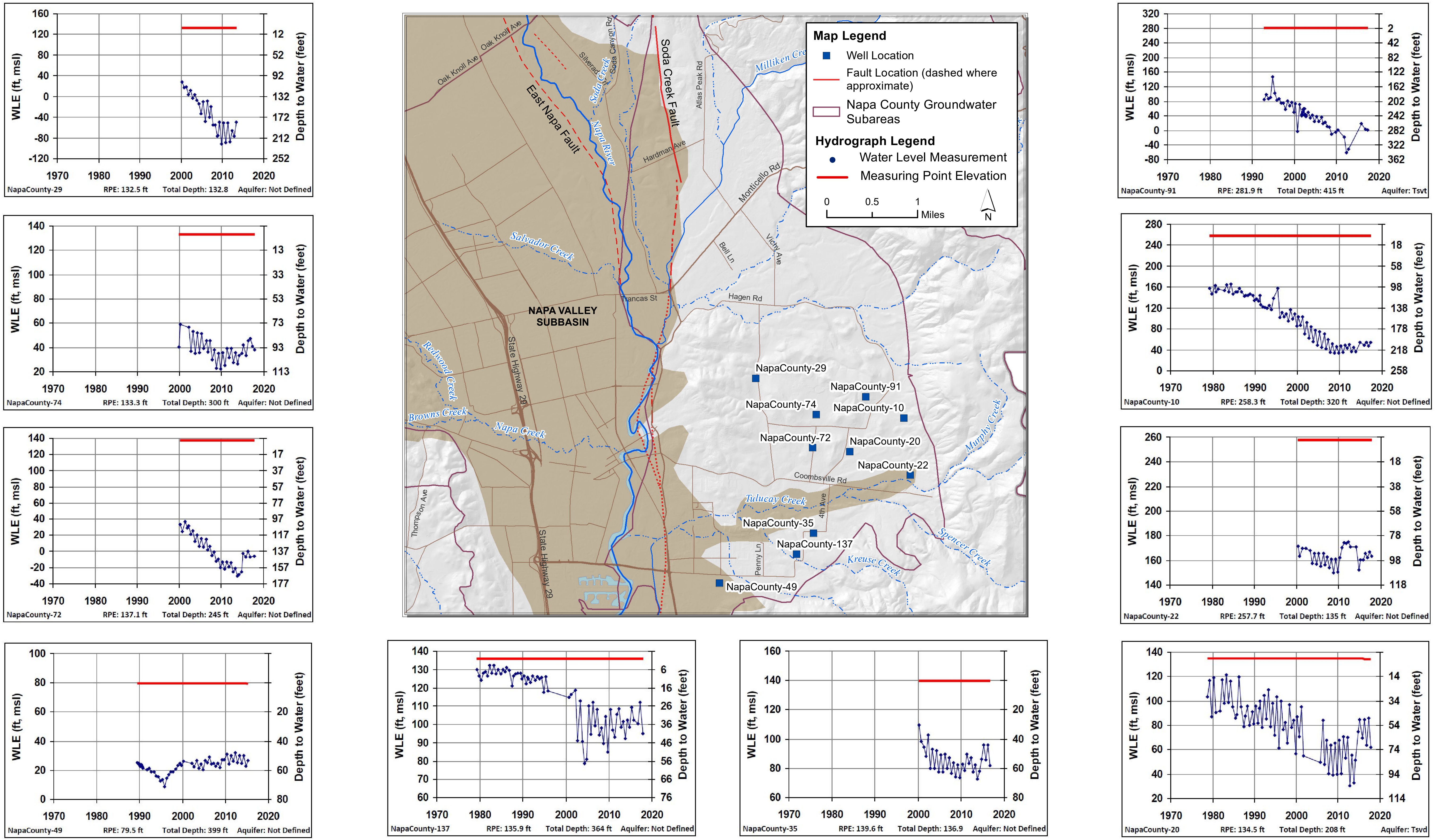

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FIGURE 5-14
Representative Groundwater Hydrographs, Southern MST Subarea

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

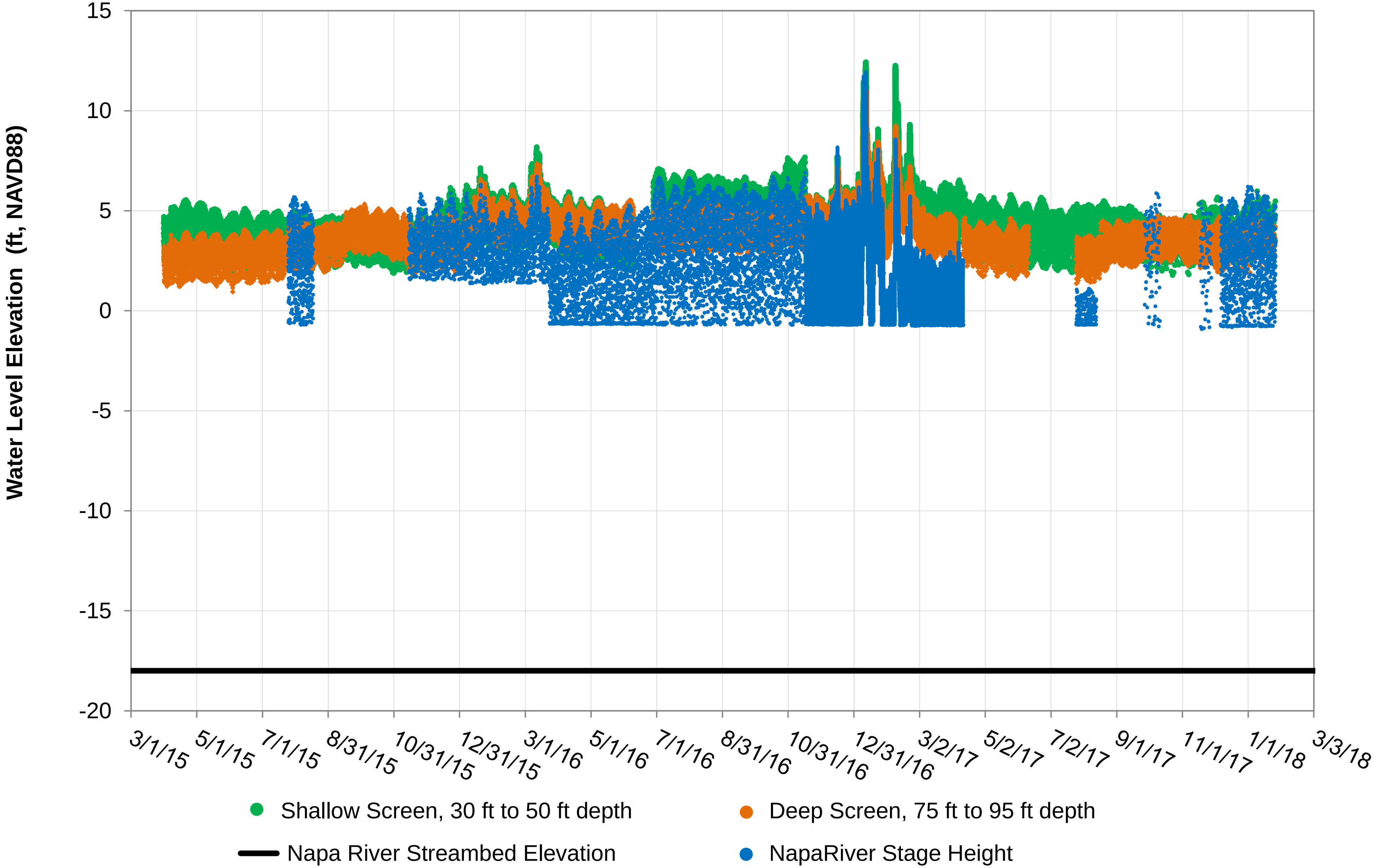

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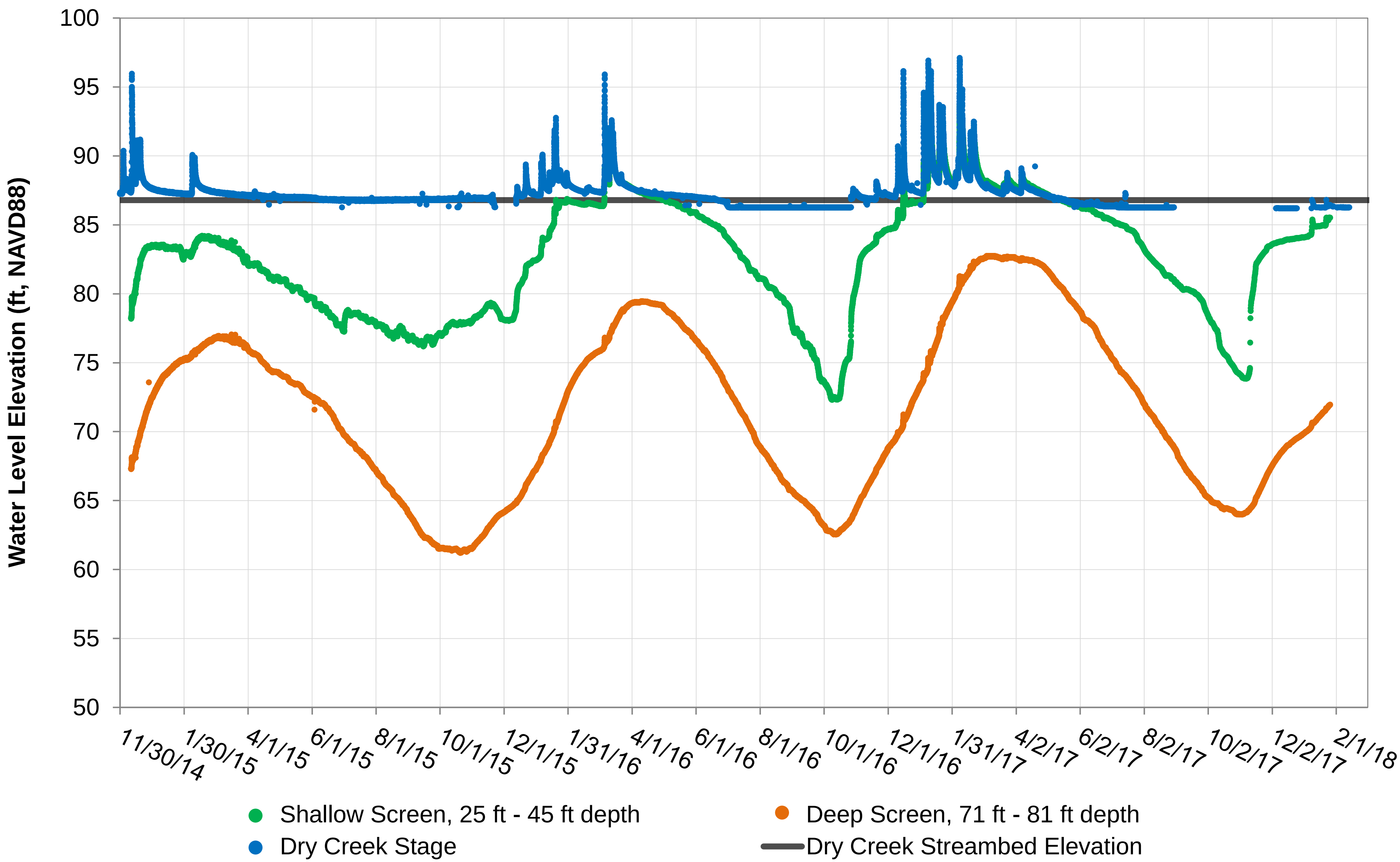
FIGURE 5-15
Surface Water-Groundwater Hydrograph
Site 1: Napa River at First Street

Napa County Groundwater Sustainability:
Annual Report - Water Year 2017



Note: Creek stage values below the streambed elevation reflect conditions where water is present in the channel in a pool or depression at the gauge but not above the surveyed thalweg elevation.

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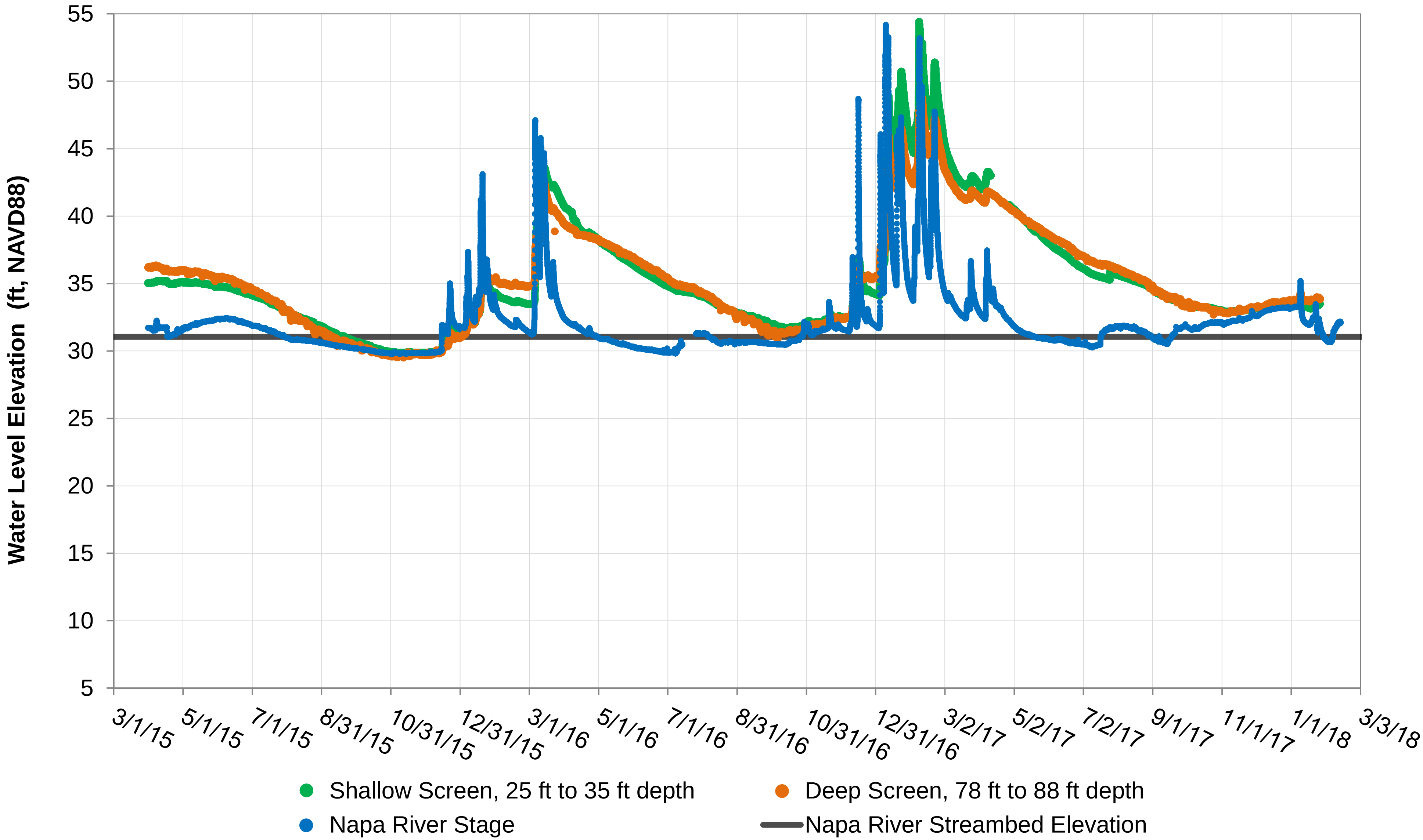
FIGURE 5-16
Surface Water-Groundwater Hydrograph
Site 2: Dry Creek at Washington Street

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



Note: Creek stage values below the streambed elevation reflect conditions where water is present in the channel in a pool or depression at the gauge but not above the surveyed thalweg elevation.

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FIGURE 5-17
Surface Water-Groundwater Hydrograph
Site 3: Napa River at Oak Knoll Avenue

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

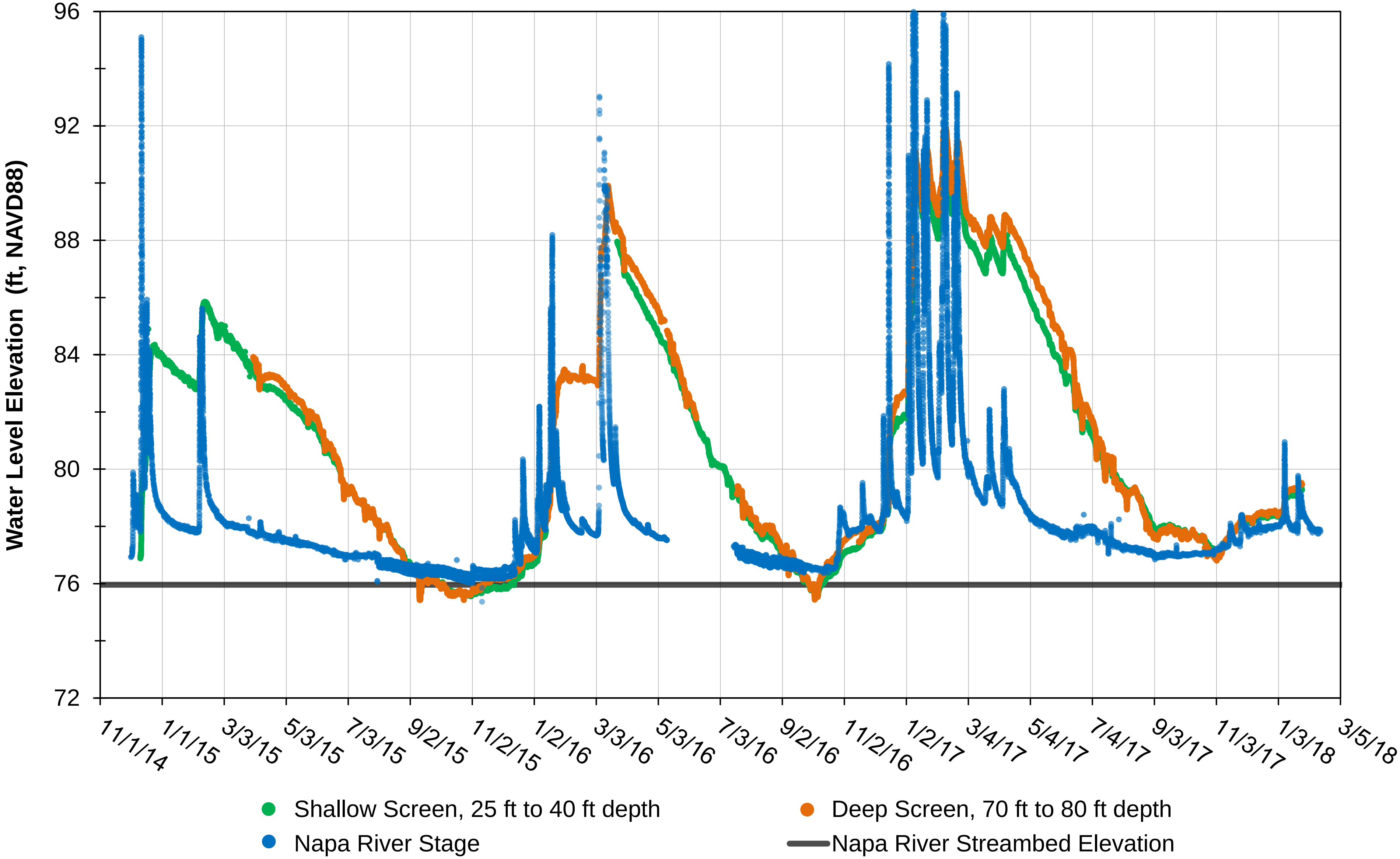

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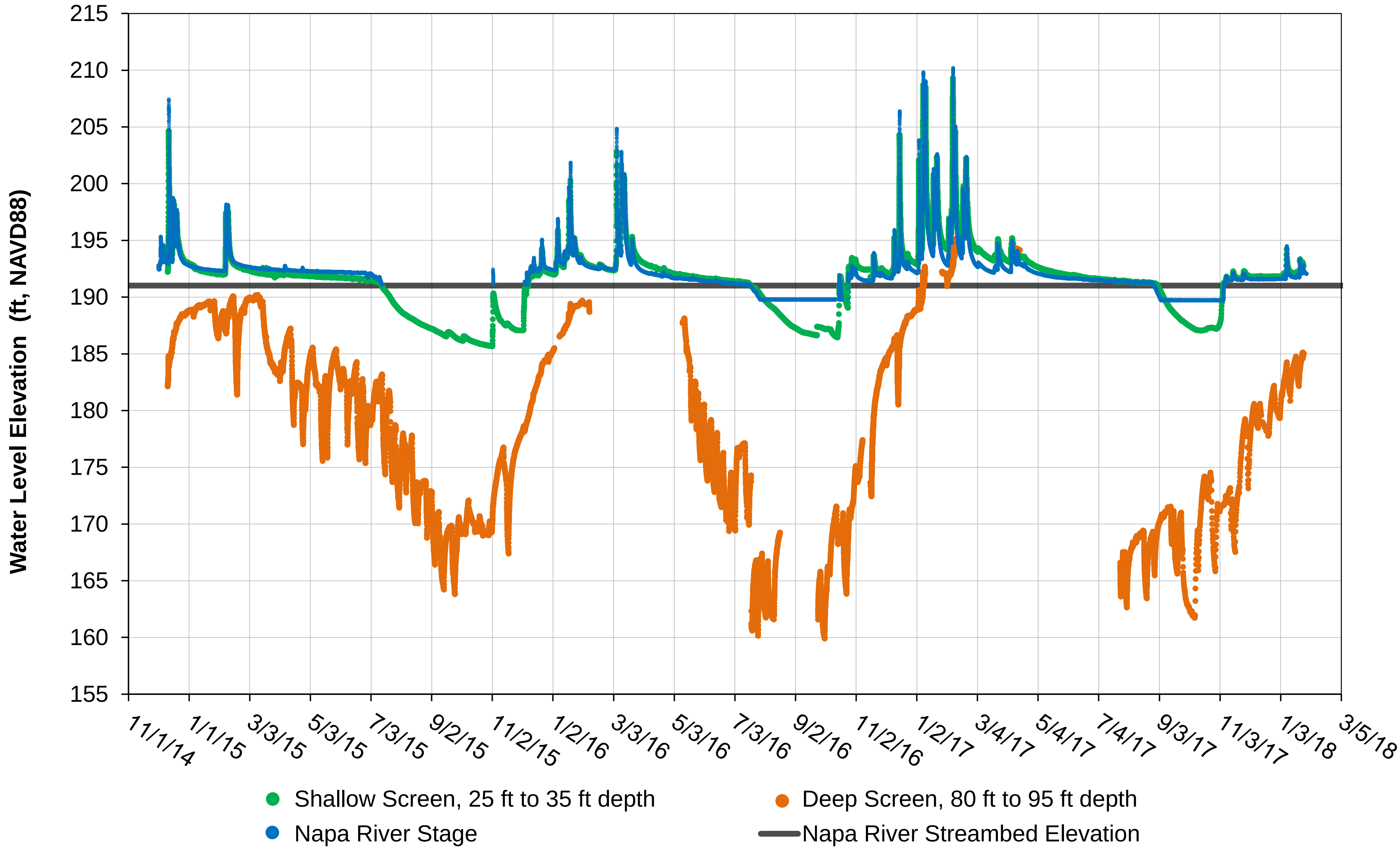
FIGURE 5-18
Surface Water-Groundwater Hydrograph
Site 4: Napa River at Yountville Cross Road



Note: Creek stage values below the streambed elevation reflect conditions where water is present in the channel in a pool or depression at the gauge but not above the surveyed thalweg elevation.

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FIGURE 5-19
Surface Water-Groundwater Hydrograph
Site 5: Napa River at Pope Street

Napa County Groundwater Sustainability:
Annual Report - Water Year 2017

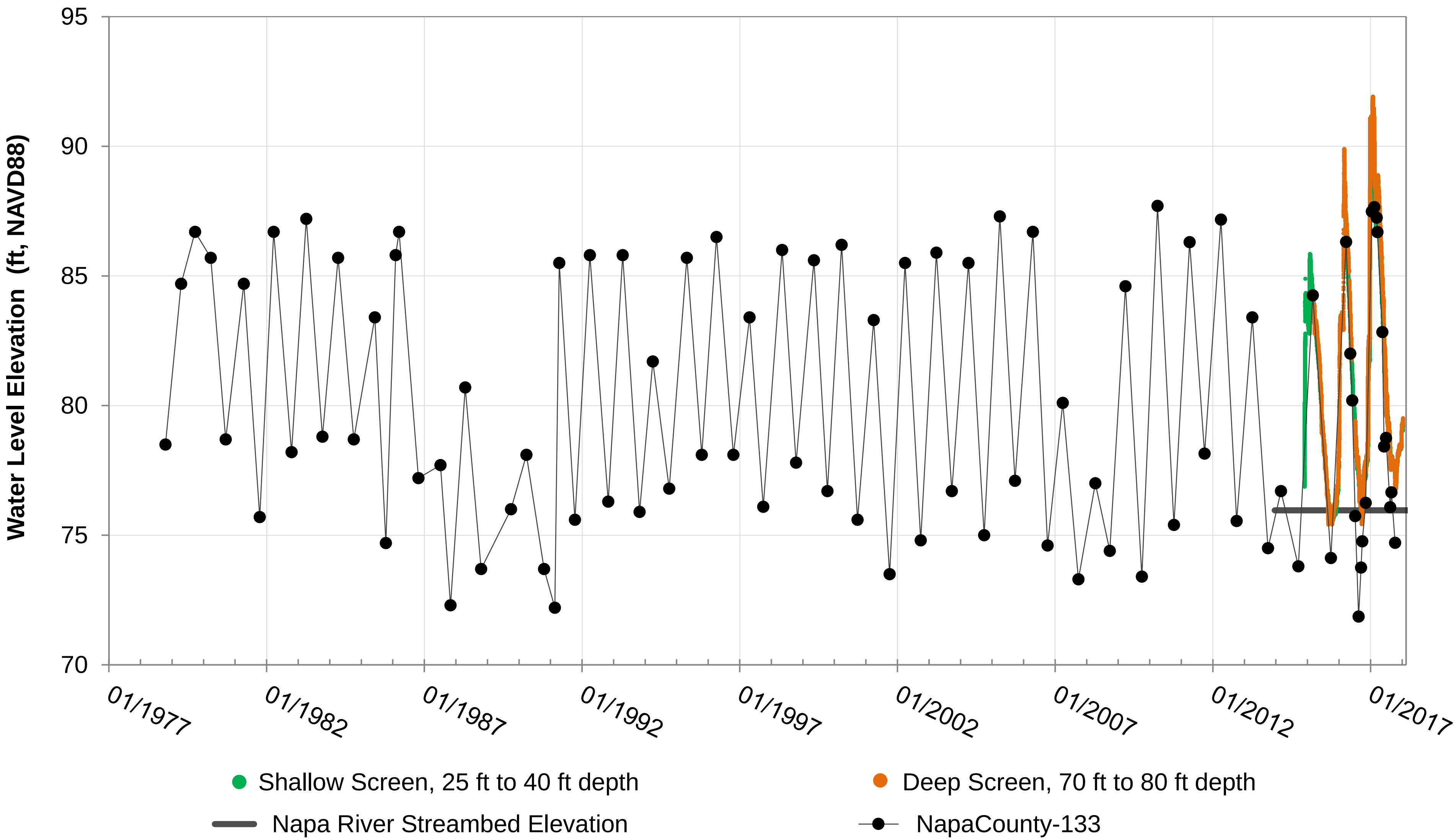

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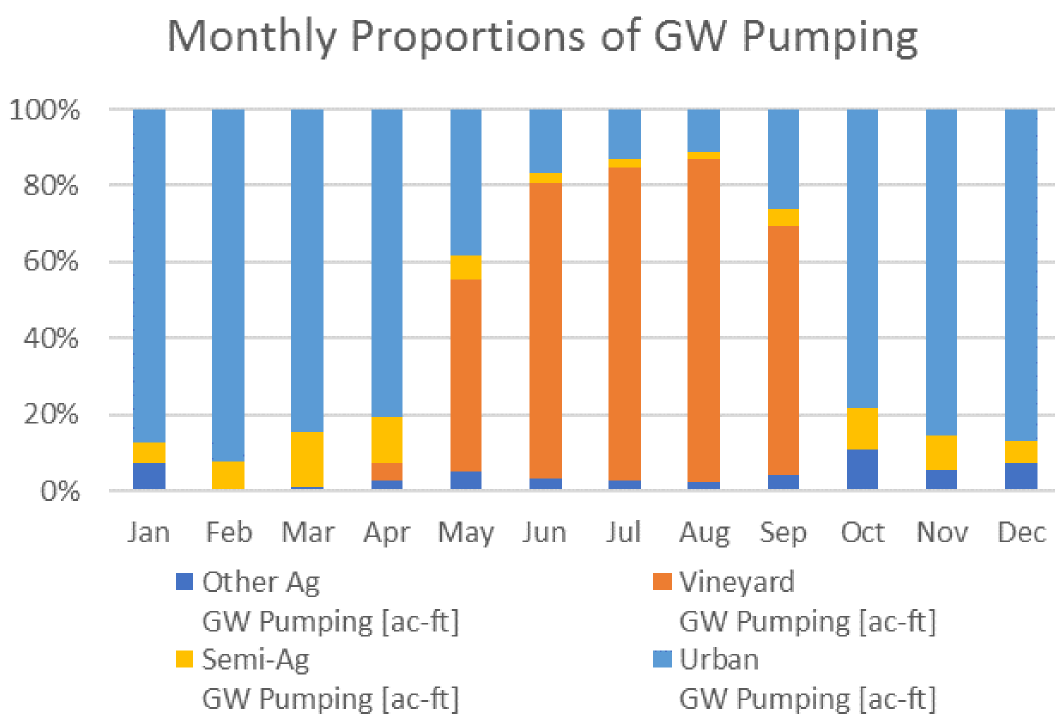
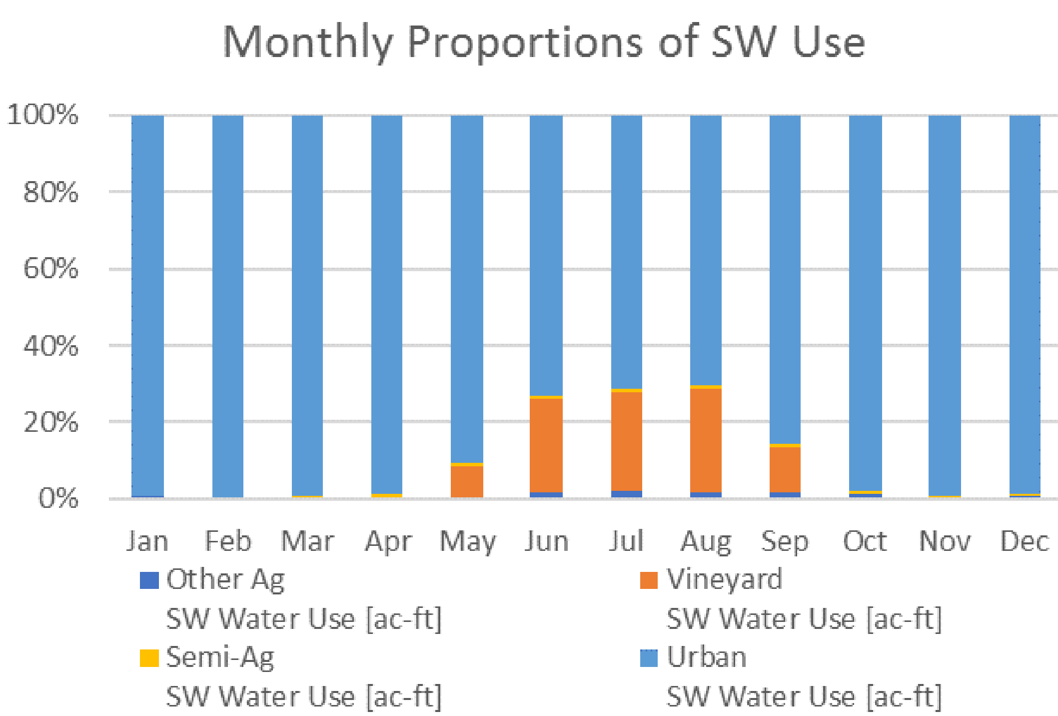
FIGURE 5-20
Surface Water-Groundwater Network Historical Hydrograph
Site 4: Napa River at Yountville Cross Road

Napa County Groundwater Sustainability: Annual Report - Water Year 2017





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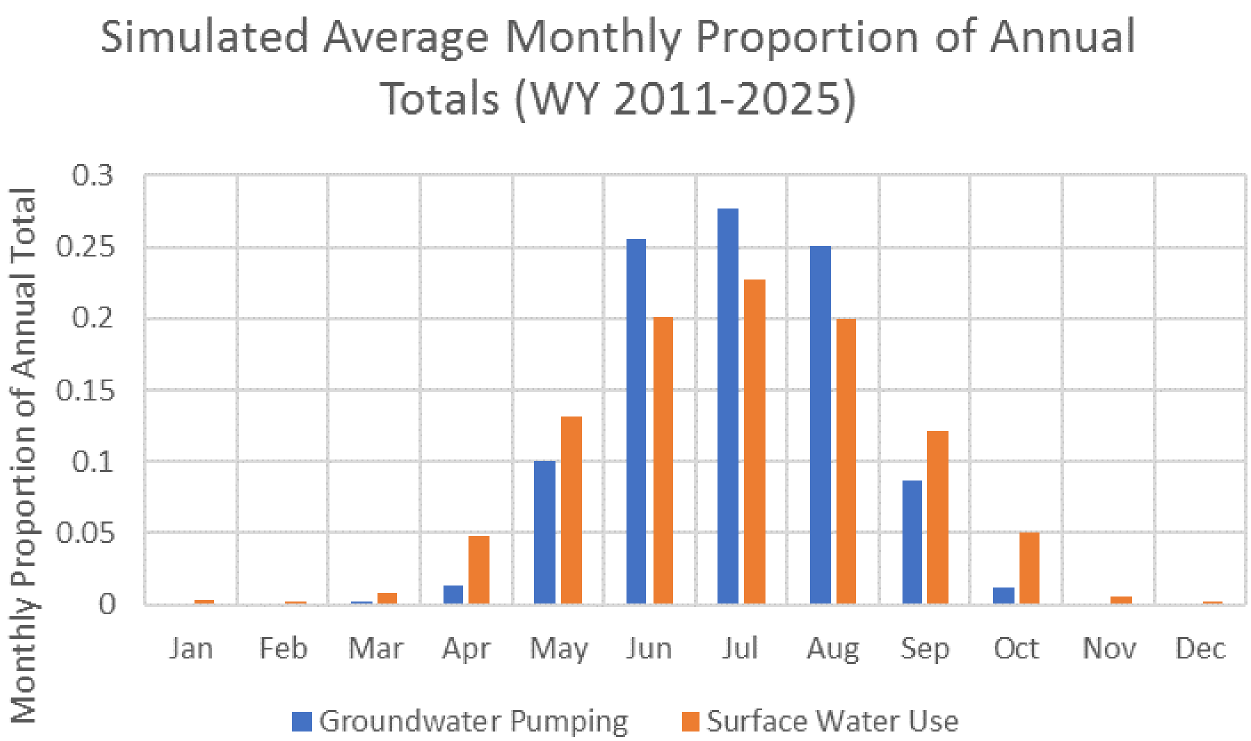
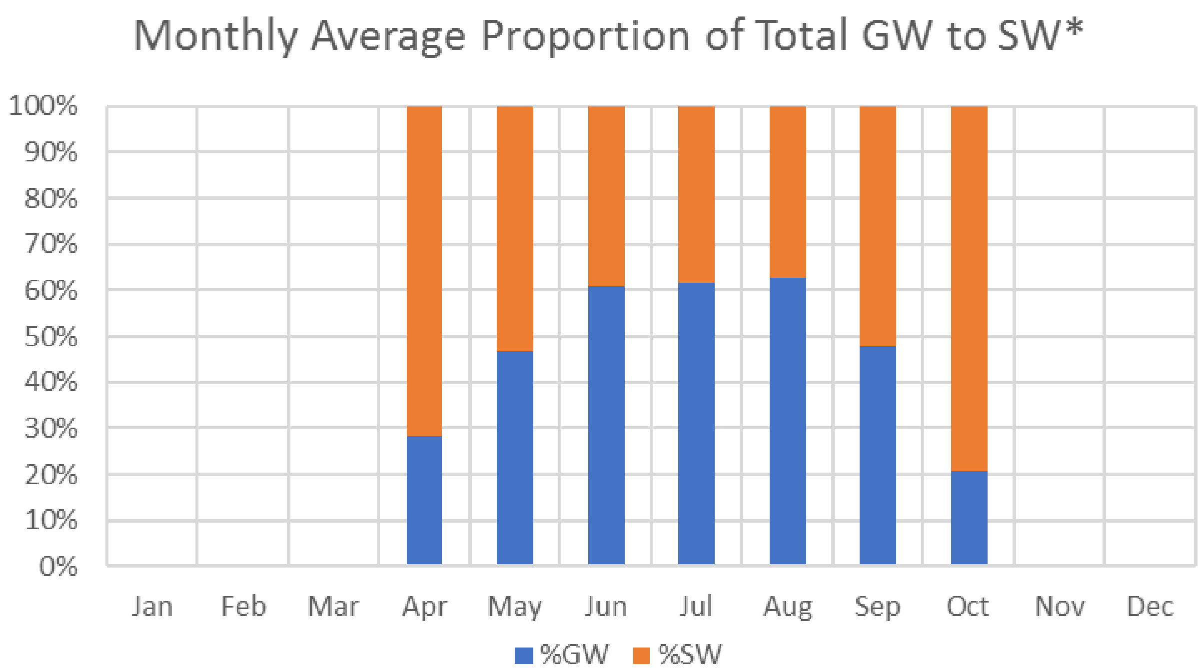
CONSULTING ENGINEERS

FIGURE 6-1
Monthly Proportions of Groundwater and Surface Water Use for Irrigataion

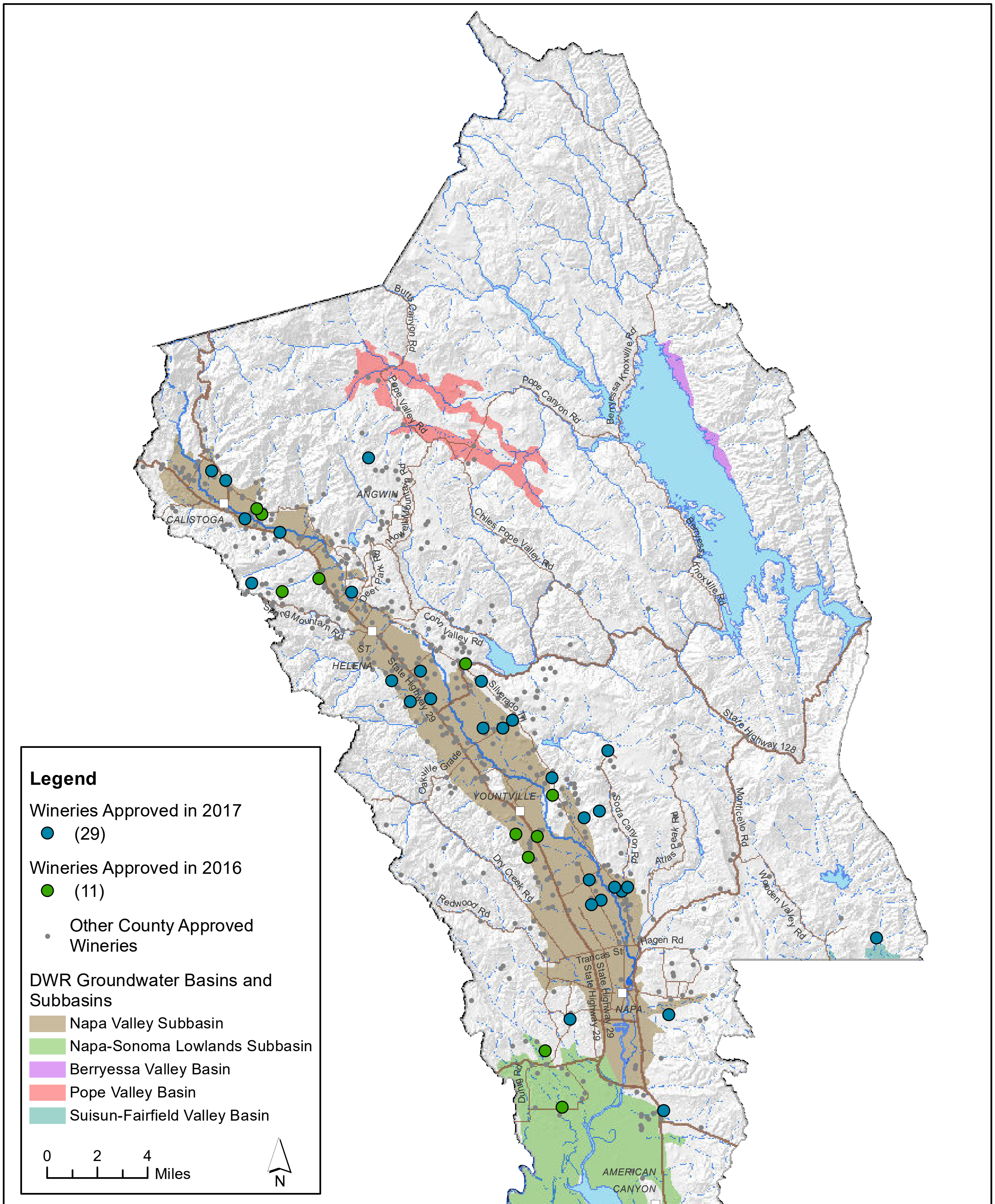


Simulated Average Monthly Proportion of Annual Totals (WY 2011-2025)
Monthly Proportion of Annual Total
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Groundwater Pumping
Surface Water Use



*Winter months were not estimated for this analysis.

FIGURE 6-3 Monthly Average Proportion of Total Groundwater and Surface Water Use for Irrigation



Data sources
Napa County Dept. of Planning, Building, and Environmental Services

X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\6-4 Wineries 2016 2017.mxd

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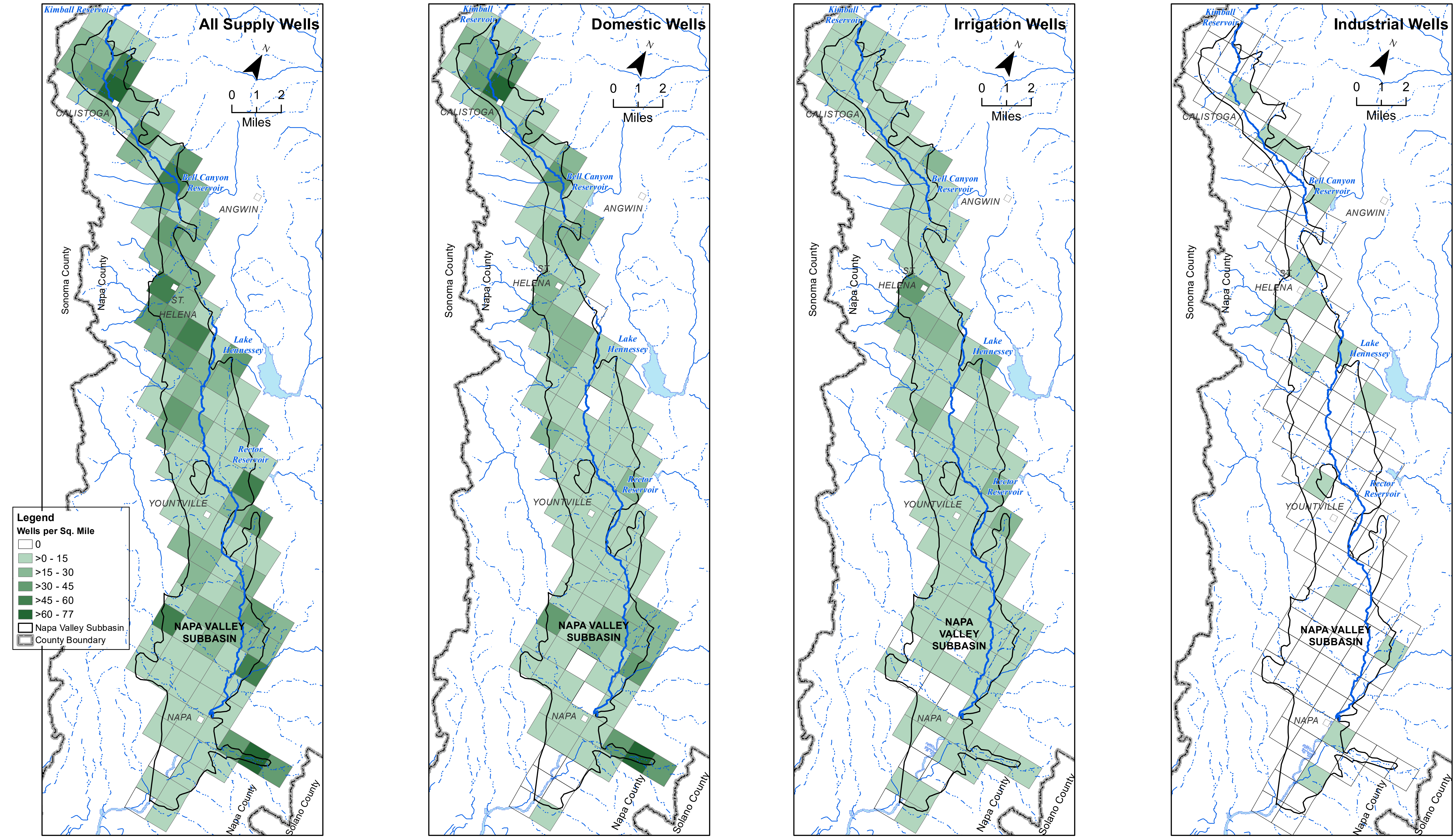
FIGURE 6-4
Winery Permits Approved by Napa County in 2016 and 2017

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



Data sources: CA Dept. of Water Resources Bulletin 118 - Update 2003 downloaded 01/14/2016), CA Dept. of Water Resources Well Completion Report Summary for Napa County dated 12/22/2015

X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\6-5 Areas of GW Use_Well Distribution in NV Subbasin V2.mxd

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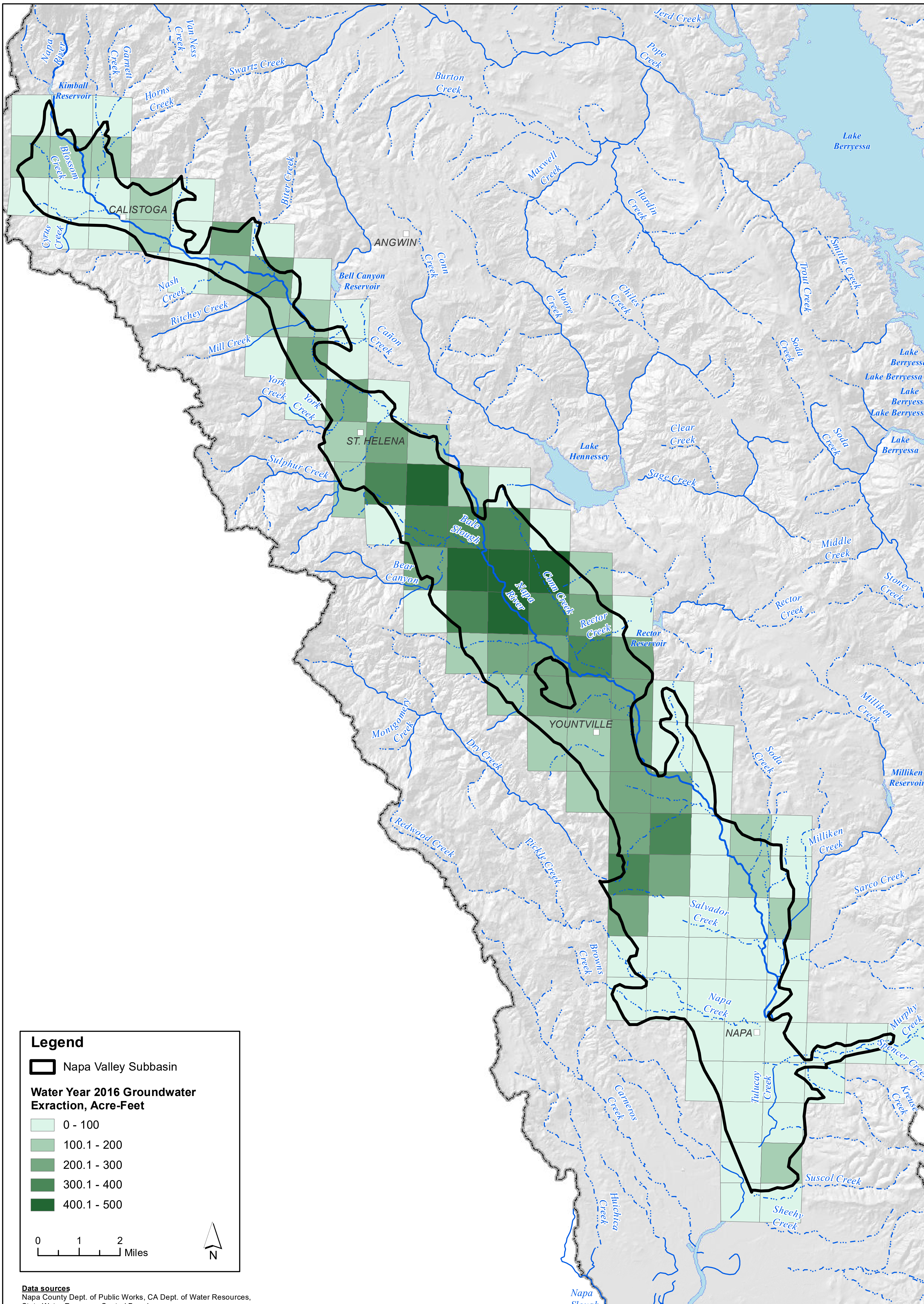
FIGURE 6-5

Areas of Groundwater Use, Napa Valley Subbasin

Napa County Groundwater Sustainability: Annual Report - Water Year 2017



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, State Water Resouces Control Board

X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\2017 Annual Report\6-6 GW Extraction 2016.mxd

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FIGURE 6-6
Estimated Volume of Groundwater Use, Napa Valley Subbasin 2016

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

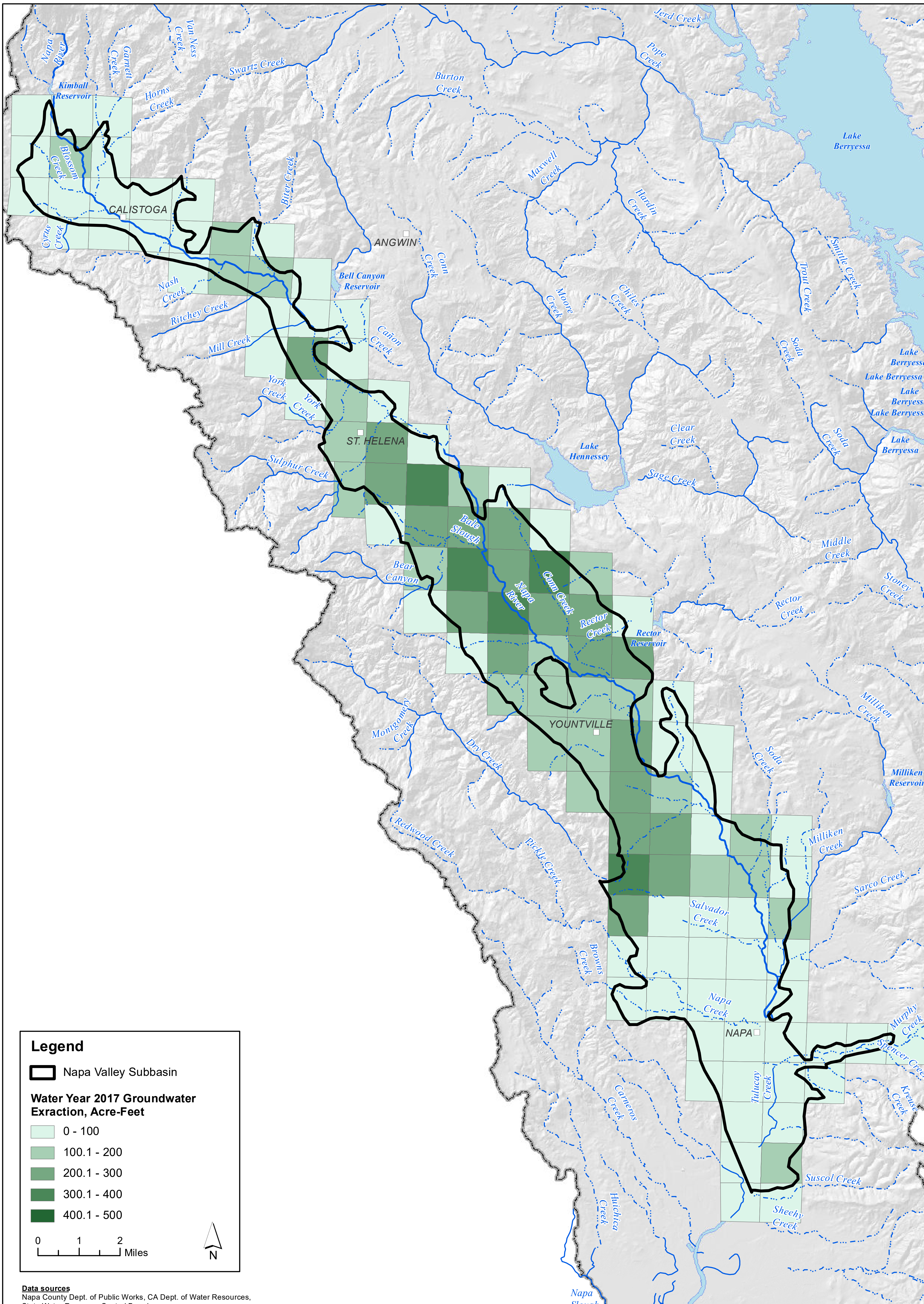

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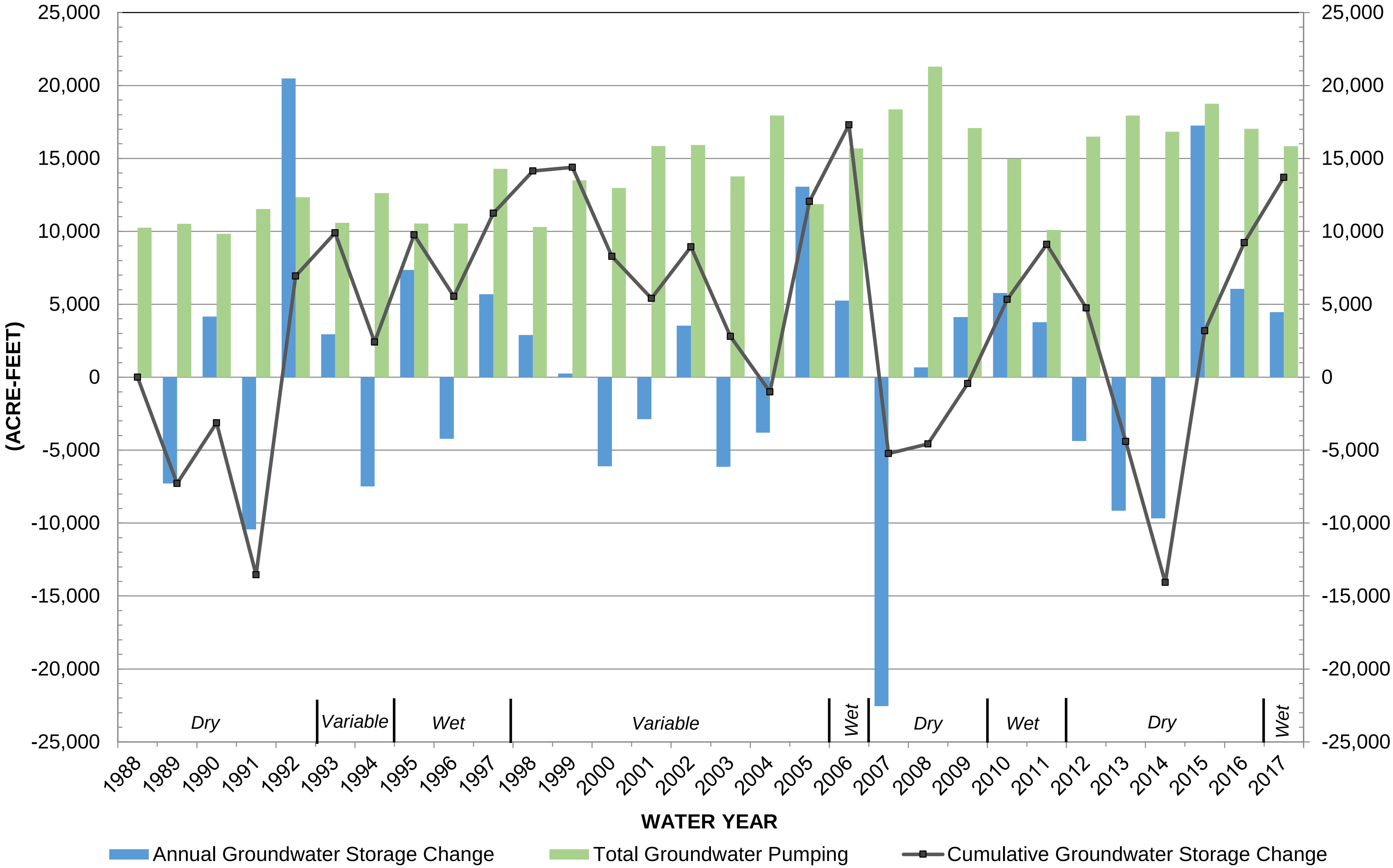
FIGURE 6-7
Estimated Volume of Groundwater Use, Napa Valley Subbasin 2017



X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\GWL Change in Storage\Change_in_GW_Storage_Updated_20171218.xlsx

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FIGURE 6-8
Napa Valley Subbasin Groundwater Use and Groundwater Storage Changes, Water Years 1988 - 2017

Napa County Groundwater Sustainability: Annual Report - Water Year 2017

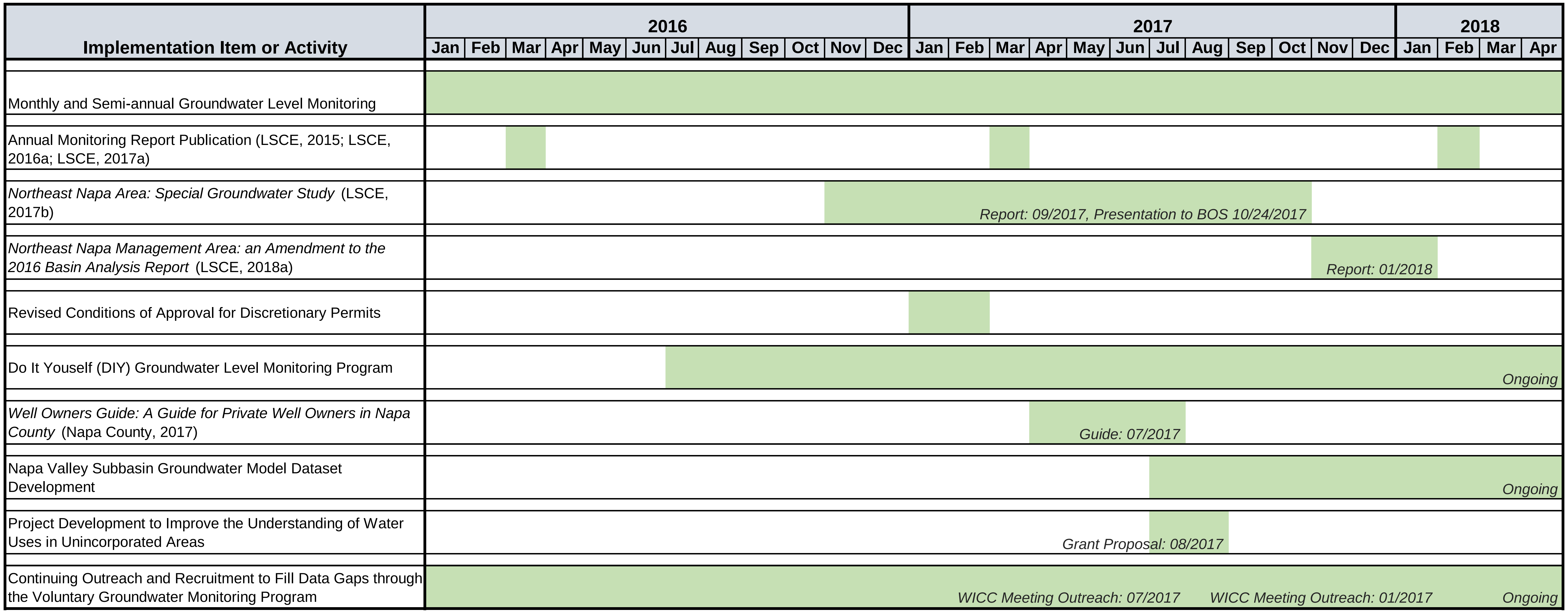

FIGURE 7-1
Napa County SGMA Implementation Activities for the Napa Valley Subbasin

APPPENDIX A

Napa Valley Groundwater Sustainability Northeast Napa Management Area:

An Amendment to the 2016 Basin Analysis Report for the Napa Valley Subbasin

NAPA VALLEY GROUNDWATER SUSTAINABILITY

Northeast Napa Management Area:

An Amendment to the 2016 Basin Analysis Report for the Napa Valley Subbasin

Prepared by

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

January 2018

Napa Valley

Groundwater Sustainability

Northeast Napa Management Area:

An Amendment to the 2016 Basin Analysis Report
for the Napa Valley Subbasin

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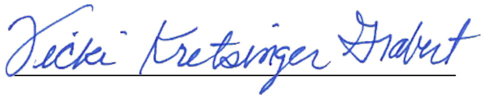

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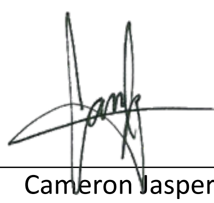

Cameron Jasper
Staff Hydrogeologist

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Appendices

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List of Abbreviations & Acronyms

Basin Analysis Report	*Napa Valley Groundwater Sustainability, A Basin Analysis Report for the Napa Valley Subbasin*
DWR	California Department of Water Resources
GRAC	Groundwater Resources Advisory Committee
GSP	Groundwater Sustainability Plan
GW	groundwater
GWE	groundwater elevation
GWL	groundwater level
GWQ	groundwater quality
LGA	DWR Local Groundwater Assistance Grant Program
Management Area	Northeast Napa Management Area
MCL	Maximum Contaminant Level
mg/L	Milligrams Per Liter
MST	Milliken-Sarco-Tulucay
Qa	Quaternary Alluvium
Special Study Report	*Northeast Napa Area: Special Groundwater Study*
SGMA	Sustainable Groundwater Management Act
SW/GW	Surface Water and Groundwater
Tss	Tertiary Sedimentary Rocks
Tsv	Tertiary Sonoma Volcanic Rocks
USGS	U.S. Geological Survey

EXECUTIVE SUMMARY

ES 1 Introduction

This report has been developed as an Amendment to the report *Napa Valley Groundwater Sustainability, A Basin Analysis Report for the Napa Valley Subbasin* (Basin Analysis Report), approved by the Napa County Board of Supervisors on December 13, 2016 and submitted to the California Department of Water Resources as an Alternative Submittal to meet the requirements of a Groundwater Sustainability Plan (GSP) in accordance with Section 10733.6(b)(3) of the California Water Code. Section 355.10(b) of the GSP Regulations allows that "An Agency may amend a Plan at any time, and submit the amended Plan to the Department for evaluation pursuant to the requirements of this Subchapter." Napa County has developed this Amendment in order to support its continued implementation of the Sustainable Groundwater Management Act (SGMA) for the Napa Valley Groundwater Subbasin.

This Amendment is a supplement to the 2016 Basin Analysis Report for the Napa Valley Subbasin, the purpose of which is to designate a management area within the Napa Valley Subbasin: The Northeast Napa Management Area. This Amendment does not change the findings of the 2016 Basin Analysis Report, instead it provides additional detail about conditions in the Northeast Napa Management Area and establishes additional sustainable management criteria and management actions intended to support continued groundwater sustainability in the Napa Valley Subbasin.

GSP Regulations adopted by the California Water Commission in 2016 define a management area as, "an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors" (Section 351).

On October 24, 2017, the Napa County Board of Supervisors supported the findings and recommendations of a report on groundwater conditions in a portion of the Napa Valley Subbasin, known as the northeast Napa Study Area (**Figure 1-1**). The report, *Northeast Napa Area: Special Groundwater Study*, (Special Study Report) was initiated by Napa County to understand recent, historical changes in water level trends in a small portion of the Napa Valley Subbasin. The Special Study Report is included as an appendix to this Report (**Appendix A**).

The northeast Napa Study Area, or Study Area, experienced historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall Napa Valley Subbasin. The Study Area contains two wells that experienced historical groundwater level declines of between 20 feet and 30 feet[1], with groundwater levels in those same wells having stabilized since about 2009. Due to potential concerns relating to continued groundwater development in the area, and due to the complex hydrogeologic setting which includes mapped faults and the Napa River in relatively close proximity to the area of interest, the County authorized a study to better understand groundwater conditions and potential factors relating to historical groundwater levels in the northeast Napa Area. The study, conducted between 2016 and 2017, included evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in an area of interest near Petra Drive, and potential streamflow effects.

In supporting the findings and recommendations of the Special Study Report, the Board of Supervisors directed staff to develop documentation to formally establish the Northeast Napa Management Area covering approximately 1,960 acres within the 45,928-acre Napa Valley Subbasin.

This Amendment summarizes key findings of the Special Study and presents additional sustainable management criteria and management actions for incorporation as part of the Napa Valley Subbasin Basin Analysis Report.

ES 2 Northeast Napa Management Area Description

The Northeast Napa Management Area (Management Area) covers approximately 1,960 acres within the Napa Valley Subbasin, extending from the eastern margin of the Subbasin westward to the Napa River and from the confluence with Dry Creek southward to a location near First Street in the City of Napa (**Figure 2-1**).

The Management Area overlies all or part of 591 parcels (**Figure 2-2**). Land uses within the Management Area include urban and semi-agricultural uses, native vegetation, and agricultural uses (including mixed uses within portions of the City of Napa and rural residences, farmsteads, and other commercial uses in unincorporated areas). Land uses within the Management Area have been largely stable since 1987, based on data from land use surveys performed by the California Department of Water Resources (DWR) (**Figures 2-3 and 2-4)**. Lands used for growing crops have covered 46% to 48% of the Management Area. Urban and semi-agricultural land uses have comprised about 22% of the Management Area, with undeveloped and uncropped areas (i.e., native land use classes) covering 30% of 32% of the Management Area. Land use changes documented between 1987 and 2011 include a 5.5% expansion in the areas classified by DWR as agricultural (i.e., areas used to grow a crop). Agricultural classes mapped by DWR do not include facilities primarily used for the processing of harvested crops, such as wineries,

[1] Both of these wells are constructed in aquifer units with semi-confined characteristics. Groundwater level declines in these wells do not imply equivalent declines in the unconfined water table.

which are classified as urban or semi-agricultural. This is not equivalent to the Napa County General Plan definition of agriculture which is inclusive of winery facilities.

Napa County has issued permits for 16 wineries in the Management area, since the late 1970s. Since the end of the study period in 2015, Napa County has approved three additional discretionary permits for wineries in the Management Area. These include two permits for new wineries and one permit for a modification to an existing winery permit.

The Management Area contains 280 water supply wells, the majority of which, 240, are domestic wells serving residences outside the City of Napa (**Figure 2-5**). Twenty-four irrigation wells and 16 wells classified as Industrial or Other Production Wells[2] are also found in the Management Area. The average total depth of wells in the Management Area ranges from 346 feet below ground surface for domestic wells to 473 feet below ground surface for irrigation wells.

Interactions between groundwater and surface water in the Management Area are variable both in their magnitude and location. Four creeks flow through the Management Area, eventually joining with the Napa River. The Special Study results indicate that three of these, Soda Creek, Hardman Creek, and Milliken Creek, experienced losing conditions[3] on an annual basis throughout the 28-year study period. In contrast, groundwater discharge contributes significantly to streamflow during most months of the year along the Napa River adjacent to the Management Area. This reach of the Napa River is categorized as perennial and subject to tidal influences from San Pablo Bay (USGS, 2016, LSCE, 2016c). Consistent with available long-term stream gage data in the Subbasin (LSCE, 2016b), the Special Study results find that less groundwater is discharged to the Napa River in the reach adjacent to the Management Area during drier water years when recharge and subsurface flows are reduced.

[2] The planned uses of water supply wells summarized here are based on the categories included on Well Completion Reports developed by the California Department of Water Resources and completed by state licensed well drilling contractors who drill, construct, modify, deepen, or destroy wells, subject to the requirements of California Water Code Section 13751. Since the use of a given well can fall into multiple categories, and can change over time, the summary presented in this report reflects the presumed primary use of a well based on land uses within the Management Area between 1988 and 2015. The planned use designations provided on Well Completion Reports do not indicate or limit the amount of groundwater pumping that can occur at a given well, nor do they necessarily indicate a relative difference in demand between any individual wells with different planned use designations.

[3] A losing condition occurs when surface water flows are reduced due to percolation of surface water through the streambed. A losing condition can vary in magnitude, and can reverse to become a gaining condition, depending on the physical properties of the streambed and the nature of the hydraulic connection between surface water and the uppermost saturated zone of the groundwater system.

The influence of groundwater pumping and climatic effects on groundwater discharge to the Napa River were analyzed using the results from the baseline calibrated model and two sensitivity scenarios: pumping restricted to 1988 pumping levels and doubled pumping relative to the estimated pumping that has occurred over the 1988 to 2015 base period.[4] Climatic effects were found to have a much greater effect on groundwater discharge to the River for the baseline, calibrated model simulation, the 1988 pumping scenario, and the doubled pumping scenario..

The results of the Special Study indicate that this localized area within the Napa Valley Subbasin is in balance, with inflows and outflows nearly equal, over the 28-year period studied. During drier years, groundwater levels have declined and in normal to wetter years groundwater levels have recovered. East of the Napa River, two wells in Napa County's monitoring network, completed in deeper formations, showed historical groundwater level declines; however, groundwater levels in these wells have stabilized since about 2009. The study indicates that the main factor contributing to prior declines in these wells is the effect of the cones of depression that developed in an area east of the Napa Valley Subbasin and within the Milliken-Sarco-Tulucay (MST) Groundwater Subarea[5]. The dense spacing of private water supply wells in portions of the Study Area east of the Napa River, particularly along Petra Drive, may also have contributed to the localized groundwater decline.

Additional pumping can occur in the northeast Napa Study Area; however, the Special Study Report recommends targeted management measures to ensure groundwater conditions remain sustainable and streamflow depletion caused by pumping does not become significant and unreasonable.

The findings of the Special Study show that groundwater conditions in the Napa Valley Subbasin east of the Napa River within the Study Area are significantly influenced by climatic factors, geologic features that are distinct from those of the larger Napa Valley Subbasin, and cones of depression in the adjacent MST Groundwater Subarea external to the Napa Valley Subbasin (LSCE, 2017). Because the northeast Napa Area, east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because groundwater conditions are significantly influenced by climatic factors, Napa County has designated the Northeast Napa Management Area within the Napa Valley Subbasin (**Figure 2-1**).

[4] The sensitivity scenario with no pumping was not included in the analysis because non-zero values are required for the analysis.

[5] The term MST Subarea refers to the region defined by Napa County for water resources planning and management purposes (see **Figure 1-1**). The term MST Area is used in this report when describing conditions in the general vicinity of the Milliken, Sarco, and Tulucay Creeks.

ES 3 Napa Valley Subbasin Sustainability Goal

The 2016 Basin Analysis Report for the Napa Valley Subbasin includes the following SGMA Sustainability Goal for the Napa Valley Subbasin:

To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.

As a part of the Napa Valley Subbasin, sustainable management criteria have been developed for the Northeast Napa Management Area to ensure that the Subbasin and the Management Area can continue to be managed sustainably without experiencing undesirable results (see **Section 3**).

The current understanding of hydrogeologic conditions and water uses in the Napa Valley Subbasin, and on-going management efforts, demonstrates that the Subbasin has operated within its sustainable yield without causing undesirable results for at least 10 years, both at the subbasin scale and within the Northeast Napa Management Area. The Napa County Board of Supervisors establishment of the Groundwater Resources Advisory Committee (GRAC), acceptance of the GRAC's sustainability goal and objectives for all of Napa County, implementation of key GRAC recommendations, and adherence to the SGMA and GSP Regulations demonstrates the County's intent to maintain sustainable conditions.

This Amendment to the 2016 Basin Analysis Report includes refined definitions for undesirable results[6] in the Napa Valley Subbasin by considering the possibility of future localized conditions that could create significant and unreasonable effects in the Northeast Napa Management Area that may not be experienced throughout the Subbasin. By refining the definitions for undesirable results in this manner, this Amendment intends to be protective of conditions within the Management Area even to a greater degree than would occur if the Management Area were not designated.

This Amendment designates seven representative monitoring sites as a subset of monitoring sites in the area for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley

[6] According to SGMA definitions, Undesirable Results include: chronic lowering of groundwater levels (overdraft); significant and unreasonable reduction of groundwater storage; significant and unreasonable seawater intrusion; significant and unreasonable land subsidence that substantially interferes with surface land uses and; depletions of interconnected surface water due to groundwater extraction and use in the Subbasin that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Subbasin, these seven sites are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined. Many sites are monitored for more than one sustainability indicator. Four of the representative sites designated for the Northeast Napa Management Area were previously designated as representative sites for the Napa Valley Subbasin. The sustainability criteria established for those sites in the 2016 Basin Analysis Report are incorporated here for tracking conditions in the Management Area.

Northeast Napa Management Area minimum thresholds (in feet above mean sea level) to avoid chronic lowering of groundwater levels and reduced groundwater storage are provided in this Amendment for seven representative monitoring sites (**Table 3-11**). Minimum thresholds for surface water depletion due to groundwater extraction and use in the Subbasin are provided for two representative sites; for one representative monitoring site to avoid degraded groundwater quality (e.g., for nitrate); for one representative monitoring site (for chloride concentrations) to avoid seawater intrusion; and for two representative monitoring sites to avoid land subsidence.

Northeast Napa Management Area measurable objectives, or specific quantifiable goals for maintaining or improving groundwater conditions, are provided with respect to chronic lowering of groundwater levels and reduced groundwater storage depletions for seven representative monitoring sites (**Table 3-11**). Measurable objectives for surface water due to groundwater extraction and use in the Subbasin are provided in this Amendment for two representative monitoring sites. The measurable objective to maintain or improve groundwater quality is set for one representative monitoring site; for one representative monitoring site to avoid seawater intrusion; and for two representative monitoring sites to avoid land subsidence.

ES 4 Management Actions

In supporting the Special Study Report, the Napa County Board of Supervisors indicated support for six management actions in the report, which are relevant to the Napa Valley Subbasin and Northeast Napa Management Area. These management actions were developed based on needs identified during the Special Study. Napa County will lead implementation of these management actions, with outreach to users of groundwater and other stakeholders as described in the 2016 Basin Analysis Report (LSCE, 2016b). These management actions complement the management actions described in the 2016 Basin Analysis Report in that they are intended to enable continued attainment of the Sustainability Goal for the Napa Valley Subbasin.

1. **Groundwater Flow Model Development:** The development of a Napa Valley Subbasin-wide modeling tool will help facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources. Having completed the updated hydrogeologic conceptualization for the Napa Valley Subbasin and in order to facilitate further regional groundwater

analyses and assessment of streamflow depletion required for continued implementation of SGMA, Napa County will develop a groundwater flow model for the entire Napa Valley Subbasin.

2. **Additional Surface Water/Groundwater Monitoring Facilities:** Napa County will expand its existing network of dedicated surface water/groundwater monitoring facilities and construct shallow nested groundwater monitoring wells (like the recently installed Local Groundwater Assistance Surface Water/Groundwater monitoring facilities) east of the Napa River in the vicinity of Petra Drive. This will provide data to improve the understanding of the effect of pumping on potential streamflow depletion.
3. **Discretionary Project WAA Review in the Management Area:** For discretionary projects in the Northeast Napa Management Area, additional project-specific analyses (Napa County Water Availability Analysis-Tier 2) will be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells) (Napa County, 2015, see Basin Analysis Report Appendix I). In addition, the Napa County Board of Supervisors has directed staff to update the Napa County Groundwater Ordinance to reflect the additional requirements for project-specific analysis and to incorporate water use criteria and water use reporting requirements for the Management Area using an approach similar to what has already been implemented in the MST Subarea.
4. **New Well Tracking in the Management Area:** As a precautionary measure, Napa County will track new non-discretionary groundwater wells constructed in the Northeast Napa Management Area, including their planned usage and location. The County will formalize the scope and procedures to be used for this effort as part of the update to the Napa County Groundwater Ordinance initiated by the County Board of Supervisors on October 24, 2017. As part of the tracking effort, applicants will be informed of potential well interference effects, if they propose well construction in an area that already has densely spaced wells. Following installation of the additional surface water/groundwater monitoring facilities and ongoing data collection, evaluation and annual reporting, the County will assess whether any further measures are needed in the future to ensure groundwater sustainability.
5. **New Well Pump Testing to Refine Aquifer Properties Characterization:** Napa County will develop appropriate standards and require that pumping test data be collected when new production wells are constructed in areas where the distribution of hydraulic conductivities is less known, including the Northeast Napa Management Area east of the Napa River and in deeper geologic units throughout the rest of the Napa Valley Subbasin. Because older and less productive geologic formations occur near ground

surface in the northeast Napa Area east of the Napa River, it is likely that pump tests will need to be performed for all new production wells in that area (**Figure 2-1**). Test results will not only provide valuable information regarding aquifer properties; true pump testing will provide well owners with more meaningful information about well capacity than the typical tests of well yield reported on historical well completion reports. Similar pump testing will be required for non-domestic production wells, and for wells that are completed in deeper units below the Quaternary alluvium throughout the Napa Valley Subbasin.

6. **Increased Water Conservation and Recharge:** Napa County will evaluate approaches for retaining and using stormwater and/or tile drain water to increase water conservation, examining opportunities to reduce pumping and streamflow diversions, potentially lessening streamflow effects during drier years or drier periods of the year, and creating additional climate resiliency through targeted recharge strategies.

1.0 INTRODUCTION

On October 24, 2017, the Napa County Board of Supervisors supported the findings and recommendations of a report on groundwater conditions in a portion of the Napa Valley Subbasin, known as the northeast Napa Study Area (**Figure 1-1**). The report, *Northeast Napa Area: Special Groundwater Study*, (Special Study Report) was initiated by Napa County to understand recent, historical changes in water level trends in a small portion of the Napa Valley Subbasin. The Special Study Report is included as an appendix to this Report (**Appendix A**).

The northeast Napa Study Area, or Study Area, experienced historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall Napa Valley Subbasin. The Study Area contains two wells that experienced historical groundwater level declines of between 20 feet and 30 feet[7], with groundwater levels in those same wells having stabilized since about 2009. Due to potential concerns relating to continued groundwater development in the area, and due to the complex hydrogeologic setting which includes mapped faults and the Napa River in relatively close proximity to the area of interest, the County authorized a study to better understand groundwater conditions and potential factors relating to historical groundwater levels in the northeast Napa Area. The study, conducted between 2016 and 2017, included evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in an area of interest near Petra Drive, and potential streamflow effects.

The objectives of the Special Study were to:

1. Examine existing and future water use in the northeast Napa Area,
2. Identify sources of groundwater recharge, and
3. Evaluate the geologic setting to address questions regarding the potential for long-term effects on groundwater resources and streamflow.

As part of the Special Study, a transient numerical groundwater flow model has been developed that incorporates the data collected for a base period of water years from 1988 to 2015 to analyze groundwater conditions in the study area and the area of interest near Petra Drive. The objectives of the groundwater flow model included:

1. Assessment of potential mutual well interference of wells located in the Petra Drive area;
2. Assessment of the potential streamflow effects from current and historical land uses;

[7] Both of these wells are constructed in aquifer units with semi-confined characteristics. Groundwater level declines in these wells do not imply equivalent declines in the unconfined water table.

3. Assessment of the potential influence of previously documented groundwater cones of depression in an area external to the Napa Valley Subbasin known as the Milliken-Sarco-Tulucay (MST) Subarea[8] to the east of the Study Area;
4. Assessment of the groundwater supply sufficiency to meet current and potential future groundwater demands for the Study Area; and
5. Assessment of whether potential groundwater management measures or controls (similar to those previously implemented in the MST Area through the Napa County Groundwater Ordinance) are warranted in the Study Area.

1.1 Background

In response to the 2014 Sustainable Groundwater Management Act, Napa County prepared a Basin Analysis Report, as an Alternative Submittal, per the requirements of Water Code Section 10733.6 (b)(3), for the Napa Valley Subbasin (Subbasin) of the Napa-Sonoma Groundwater Basin. The Basin Analysis Report provides an analysis of basin conditions for the Subbasin and demonstrates that the Subbasin has operated within its sustainable yield over a period of at least 10 years. The Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated as a medium priority basin and is subject to specific requirements under the Act.

While the majority of wells with long-term groundwater level records exhibit stable trends, periods of year-to-year declines in groundwater levels have been observed in two wells in the Napa Subarea[9]. These wells are located near the Napa Valley margin, east of the Napa River, in an area where the East Napa Fault follows the Napa River and the Soda Creek Fault follows the eastern basin margin.

Water levels in northeastern Napa Subarea wells monitored by the County (NapaCounty-75 and Napa County-76) east of the Napa River have stabilized since 2009, though declines were observed over approximately the prior decade. To ensure continuation of the current stable groundwater levels, further study in this area was recommended in the *Napa County Groundwater Monitoring Program 2015 Annual Report and CASGEM Update* (LSCE, 2016a). The study was recommended given the potential for a hydraulic connection between the aquifer

[8] The term MST Subarea refers to the region defined by Napa County for water resources planning and management purposes (see **Figure 1-1**). The term MST Area is used in this report when describing conditions in the general vicinity of the Milliken, Sarco, and Tulucay Creeks.

[9] For purposes of local planning, understanding, and studies, Napa County has established a series of groundwater subareas that encompass the entire county. These subareas were delineated based on the watershed boundaries, groundwater basins, and the County's environmental resource planning areas. The County's groundwater subareas do not conform to the boundaries for groundwater basins and subbasins established by the California Department of Water Resources.

units in the vicinity of these wells and those of the MST Subarea and an apparent increase in new well permits over the past 10 years. The Napa County Board of Supervisors discussed the recommended Study Area and provided direction to staff at their April 5, 2016 meeting, and approved the contract for the study on July 19, 2016. The Board of Supervisors supported the findings and recommendations of the resulting Special Study report at a regular meeting on October 24, 2017. At the same meeting, the Board of Supervisors directed staff to develop documentation to formally establish the Northeast Napa Management Area covering approximately 1,960 acres within the 45,928-acre Napa Valley Subbasin.

1.2 Purpose and Objectives

This report has been developed as an Amendment to the report *Napa Valley Groundwater Sustainability, A Basin Analysis Report for the Napa Valley Subbasin* (Basin Analysis Report), approved by the Napa County Board of Supervisors on December 13, 2016 and submitted to the California Department of Water Resources as an Alternative Submittal to meet the requirements of a Groundwater Sustainability Plan (GSP) in accordance with Section 10733.6(b)(3) of the California Water Code. Section 355.10(b) of the GSP Regulations allows that “An Agency may amend a Plan at any time, and submit the amended Plan to the Department for evaluation pursuant to the requirements of this Subchapter.”

This Amendment is a supplement to the 2016 Basin Analysis Report for the Napa Valley Subbasin, the purpose of which is to designate a management area within the Napa Valley Subbasin: The Northeast Napa Management Area. GSP Regulations adopted by the California Water Commission in 2016 define a management area as, “an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors” (Section 351).

This Amendment has been developed as a supplement to the 2016 Basin Analysis Report for the Napa Valley Subbasin. It does not change the findings of the 2016 Basin Analysis Report, rather it provides additional detail about conditions in the Northeast Napa Management Area, and establishes additional sustainable management criteria and management actions intended to support continued groundwater sustainability in the Napa Valley Subbasin.

Regarding the establishment of management areas in order to promote sustainable groundwater management, the GSP Regulations state that,

> “*(a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at*

large, provided that undesirable results are defined consistently throughout the basin.

(b) A basin that includes one or more management areas shall describe the following in the Plan:

(1) The reason for the creation of each management area.

(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.

(3) The level of monitoring and analysis appropriate for each management area.

(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.

(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas." (Section 354.20(a)).

This Amendment summarizes key findings of the Special Study and presents additional sustainable management criteria and management actions that supplement the Napa Valley Subbasin Basin Analysis Report.

1.3 Report Organization

This report is organized as follows:

2. Northeast Napa Management Area Description
    a. Northeast Napa Management Area Setting and Hydrogeologic Conceptualization
    b. Northeast Napa Area Special Groundwater Study Findings
    c. Basis for Establishing the Northeast Napa Management Area
3. Napa Valley Subbasin Sustainability Goal
    a. Sustainability Indicators and Undesirable Results
    b. Northeast Napa Management Area Representative Monitoring Sites
    c. Northeast Napa Management Area Minimum Thresholds
    d. Northeast Napa Management Area Measurable Objectives
    e. Preventing Undesirable Results Outside of the Northeast Napa Management Area
4. Management Actions
    a. Napa Valley Subbasin Groundwater Flow Model
    b. Surface Water/Groundwater Monitoring Facilities
    c. Discretionary Project Review in the Management Area

2.0 NORTHEAST NAPA MANAGEMENT AREA DESCRIPTION

The Northeast Napa Management Area (Management Area) covers approximately 1,960 acres within the Napa Valley Subbasin, extending from the eastern margin of the Subbasin to the Napa River from the confluence with Dry Creek south to a location near First Street in the City of Napa (**Figure 2-1**). The Management Area adjoins approximately six miles of the mainstem Napa River. Two named tributaries to the Napa River cross the Management area: Milliken Creek and Soda Creek. Milliken Creek flows for approximately 1.25 miles across the Management Area and is identified on U.S. Geological Survey (USGS) topographic maps as a perennial stream. Soda Creek flows for approximately one mile across the Management Area and is identified on USGS topographic maps as an intermittent stream. A water course left unnamed on USGS topographic maps, referenced in the Special Study Report as Hardman Creek, also crosses the Management Area before meeting Milliken Creek near Trancas Street (**Figure 2-1**).

The Management Area overlies all or part of 591 parcels (**Figure 2-2**). Land uses within the Management Area include urban and semi-agricultural uses, native vegetation, and agricultural uses (including mixed uses within portions of the City of Napa and rural residences, farmsteads, and other commercial uses in unincorporated areas). **Table 2-1** provides a summary of land use according to the classifications applied in prior surveys by the California Department of Water Resources (DWR) in 1987 and 2011.

Land uses within the Management Area have been largely stable since 1987 (**Figures 2-3 and 2-4).** The changes documented over that time include a 5.5% expansion in the areas classified by DWR as agricultural (i.e., areas used to grow a crop). Crop types identified by the DWR include vineyards, deciduous fruit and nut crops, grain crops, field crops, and pasture (DWR, 1987 and DWR, 2011). Agricultural classes do not include facilities primarily used for the processing of harvested crops, such as wineries, which are classified as urban or semi-agricultural. This is not equivalent to the Napa County General Plan definition of agriculture which is inclusive of winery facilities.

The Management Area contains 280 water supply wells, the majority of which are domestic wells serving residences outside the City of Napa (**Table 2-2** and **Figure 2-5**)[10]. The average total depth of wells in the Management Area ranges from 346 feet below ground surface for domestic wells to 473 feet below ground surface for irrigation wells. The count and total depth of wells in the Management Area were determined through a review of available Well Completion Reports and land use data, including information about the number of residences per parcel, maintained by the Napa County Assessor's office. Additional information regarding the process used to locate wells in the Management Area is contained in the Special Study Report (**Appendix A**).

Napa County has issued permits for 16 wineries in the Management area, since the late 1970s. Since the end of the study period in 2015, Napa County has approved three additional discretionary permits for wineries in the Management Area. These include two permits for new wineries and one permit for a modification to an existing winery permit. All three of the winery permits approved since 2015 project no net increase or a net decrease in groundwater use as compared to uses at each site. In total, current estimated water uses at the sites are 12.57 acre-feet/year. With the proposed changes in land use and increased water conservation, total proposed groundwater use is 12.19 acre-feet/year. The proposed total annual groundwater use of 12.19 acre-feet/year represents 1.7% of the average annual groundwater pumping in the Special Study Area east of the Napa River from 1988 to 2015. Permits for all three wineries require monitoring of groundwater levels and groundwater pumping. Additionally, all three permits require that the owner report to the County the amounts of groundwater pumped, either once annually or at the County's request.

[10] The planned uses of water supply wells summarized here are based on the categories included on Well Completion Reports developed by the California Department of Water Resources and completed by state licensed well drilling contractors who drill, construct, modify, deepen, or destroy wells, subject to the requirements of California Water Code Section 13751. Since the use of a given well can fall into multiple categories, and can change over time, the summary presented in this report reflects the presumed primary use of a well based on land uses within the Management Area between 1988 and 2015. The planned use designations provided on Well Completion Reports do not indicate or limit the amount of groundwater pumping that can occur at a given well, nor do they necessarily indicate a relative difference in demand between any individual wells with different planned use designations.

Table 2-1. Northeast Napa Management Area Land Use Summary

	1987 (acres)	2011 (acres)
Total Agriculture Classes	892	941
Total Native Classes	626	598
Total Urban and Semi-Ag [1]	429	429
unclassified	1	-
Total[2]	**1,948**	**1,968**

1 Semi-Ag classes (e.g., Farmsteads)
2 *Slight differences in total acreage are due to gaps in datasets.*
Sources: DWR (1987 & 2011)

Table 2-2. Northeast Napa Management Area Production Wells Summary by Type

Well Type	Count	Average Total Depth (feet)
Domestic	240	346
Irrigation	24	473
Industrial/Other Production[1]	16	441
Public Supply	0	n/a
Total	**280**	**362**

1 Other Production wells include 16 that supply wineries. While Napa County classifies wineries as an agricultural land use, this summary aligns with the well type designations available on DWR Well Completion Reports filed by well drillers following well construction, modification, or destruction.

2.1 Northeast Napa Management Area Setting and Hydrogeologic Conceptualization

The geologic setting of the Napa Valley Subbasin determines the physical properties of the aquifer system as well as the structural properties that influence groundwater storage, availability, recharge, and flow within the subsurface. These physical and structural properties are described as part of the conceptual model for the Napa Valley Subbasin, which includes the northeast Napa Study Area (LSCE, 2016b). The components of the hydrogeologic conceptual model also describe the primary processes that lead to inflows, outflows and groundwater storage.

Subbasin inflows are characterized by:

1) Root Zone Groundwater Recharge;
2) Napa Valley Subbasin Uplands Runoff;
3) Napa Valley Subbasin Uplands Subsurface Inflow; and
4) Surface Water Deliveries.

Subbasin outflows consist of:

1) Surface Water Outflow of Stormflow and Baseflow;
2) Subsurface Groundwater Outflow;
3) Consumptive Use of Surface Water and Groundwater; and
4) Urban Wastewater Outflow.

Subbasin groundwater storage consists of groundwater storage, primarily from Quaternary alluvial deposits.

The Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin underlies much of the Napa Valley and lies entirely within Napa County, overlain by the City of Napa, Town of Yountville, City of St. Helena, and City of Calistoga (**Figure 1-1**). Surficial geologic maps of the Napa Valley area have been developed by various authors spanning over a hundred years. Three major geologic units in the Napa Valley area have been consistently recognized and remain largely unchanged, except in the names applied to them and interpretations of how they were originally formed. These three major units are Mesozoic rocks including formations of the Franciscan Complex and Great Valley Complex, Tertiary volcanic rocks (i.e., Sonoma Volcanics) and sedimentary rocks, and Quaternary sedimentary deposits.

Contemporary geologic cross sections developed in the vicinity of the Northeast Napa Management Area show the general subsurface geologic patterns of the lower valley associated with the northeast Napa Study Area. Notably, the cross sections and a map of alluvium thickness developed as part of the *Updated Hydrogeologic Conceptualization and Characterization of Conditions* report show distinctly thinner alluvial deposits east of the Napa River in the Study Area. This offset in the alluvium thickness west and east of the Napa River is associated with the East Napa Fault Zone described in that report (LSCE and MBK, 2013).

The Quaternary alluvial deposits comprise the primary aquifer units of the Subbasin. The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013). The alluvial deposits have different well yields and variable hydraulic properties. In the Study Area, alluvial deposits are a significant source of groundwater west of the Napa River; however, east of the River the alluvium is considerably thinner and indicated to be unsaturated in some locations. All of the Tertiary units beneath the Napa Valley Floor and beneath the Study Area appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013). Although wells completed in these Tertiary units may be locally capable of producing sufficient volumes of water to meet various water demands, their contribution to the overall production of groundwater within the Study Area is limited, and their hydraulic properties are reflective of this.

There are two main faults in the Study Area: the East Napa Fault Zone and the Soda Creek Fault (**Figure 2-1**). The East Napa Fault is a concealed fault extending northward just west of or below the river from near Trancas Street to Oak Knoll Avenue (LSCE and MBK, 2013). Evidence of the fault zone has been derived from subsurface information and from an isostatic gravity map.[11] Other concealed faults, whether mapped or not, exist in this area as part of the East Napa Fault Zone. One such fault is located on the east side of the Napa River between Petra Drive and Oak Knoll Avenue, but its northward and southward extent is still unknown. Soda Creek Fault slices through the Sonoma Volcanics along the western edge of the MST and appears to partially limit groundwater flow from the MST into the Napa Valley, acting as a hydraulic barrier at depth.

The physical conditions described above are incorporated in the current day hydrogeologic conceptualization of the Napa Valley Subbasin and are reflected in the groundwater model developed as part of the northeast Napa Area study (LSCE, 2017).

2.2 Northeast Napa Area Special Groundwater Study Findings

The USGS public domain software, MODFLOW (and accompanying model packages), was selected as the modeling platform to develop a numerical groundwater flow model to conduct analyses in the Study Area. The total active modeled area covers approximately 9.5 square miles (6,090 acres) and contains six model layers (**Figure 2-1**). The model grid cell size is 100 feet by 100 feet. The first three model layers (layers 1-3) compose the alluvial aquifer; the next two model layers (layers 4-5) represent the underlying Tertiary sediments and rocks; and the base layer (layer 6) represents the Tertiary Sonoma Volcanics. The transient model simulates groundwater and surface water conditions over a 28-year period from 1988 to 2015.

The model includes a total of 10 rivers, creeks, and tributaries. Eleven surface water diversions are also represented. The model contains 594 wells (actual and “inferred”, with the latter based on estimated water demands and water sources). Irrigation pumping demands include

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[11] Isostatic gravity maps depict detectable variations in gravitational force (e.g., gravity) observed over an area. After controlling for influences including latitude and tidal fluctuations, isostatic gravity maps provide a representation of geologic structure that results from variations in rock density across geologic formations.

demands for agricultural crop irrigation as well as irrigation demands for landscaping associated with residences and commercial land uses, where groundwater is identified as the water source. Water demands for indoor residential uses and winery uses in unincorporated areas not supplied with surface water by the City of Napa were also distributed to wells in the model domain.

The model was calibrated to improve its ability to simulate groundwater level measurements from throughout the Active Model Area by adjusting the following components: aquifer parameters (horizontal and vertical hydraulic conductivity and storage), streambed conductivity, model layering, and general head boundary conditions. One hundred eighty-two (182) wells with water level data were used for model calibration, including 12 County monitored wells and two Napa County surface water/groundwater monitoring facilities, each of which include two dedicated monitoring wells.

Results from the calibrated model for the northeast Napa Study Area indicate that groundwater in this localized area is in balance, with inflows and outflows nearly equal, over the 28-year period studied. During drier years, groundwater levels have declined and in normal to wetter years groundwater levels have recovered. East of the Napa River, two wells in Napa County's monitoring network, completed in deeper formations, showed historical groundwater level declines; however, groundwater levels in these wells have stabilized since about 2009. The study indicates that the main factor contributing to prior declines in these wells is the effect of the cones of depression that developed in the MST Subarea east of the Napa Valley Subbasin. The dense spacing of private water supply wells in portions of the Study Area east of the Napa River, particularly along Petra Drive, may also have contributed to the localized groundwater decline.

Interactions between groundwater and surface water in the Management Area are variable both in their magnitude and location. Four creeks flow through the Management Area, eventually joining with the Napa River. The Special Study results indicate that three of these, Soda Creek, Hardman Creek, and Milliken Creek, experienced losing conditions[12] on an annual basis throughout the 28-year study period. In contrast, groundwater discharge contributes significantly to streamflow during most months of the year along the Napa River adjacent to the Management Area. This reach of the Napa River is categorized as perennial and subject to tidal influences from San Pablo Bay (USGS, 2016, LSCE, 2016c). Consistent with available long-term stream gage data in the Subbasin (LSCE, 2016b), the Special Study results find that less

[12] A losing condition occurs when surface water flows are reduced due to percolation of surface water through the streambed. A losing condition can vary in magnitude, and can reverse to become a gaining condition, depending on the physical properties of the streambed and the nature of the hydraulic connection between surface water and the uppermost saturated zone of the groundwater system.

groundwater is discharged to the Napa River in the reach adjacent to the Management Area during drier water years when recharge and subsurface flows are reduced.

To test the sensitivity of Study Area conditions to groundwater pumping, three model scenarios were developed to test the response of the surface water and groundwater system in the Study Area to different amounts of pumping over the 28-year study period. The three scenarios are summarized in **Table 2-3**.

Table 2-3. Groundwater Pumping Scenarios Evaluated by the Calibrated Special Study Flow Model

	Description
Baseline	Pumping rates in all supply wells are calculated based on documented land uses and source of supply. Pumping to meet irrigation water demands (includes crops and landscaping) vary monthly based on vegetation type, evapotranspiration, and available soil moisture during the 28-year study period.
No Pumping Scenario	No groundwater pumping by any supply wells in any month during the 28-year study period.
1988 Pumping Scenario	Monthly pumping rates for the first water year of the Baseline simulation, prior to pumping rate increases occurring the 1990s, are repeated for each of the 28 years of the study period.
Doubled Pumping Scenario	Monthly pumping rates are doubled relative to each month in the 28-year Baseline simulation pumping dataset.

The influence of groundwater pumping and climatic effects, represented by recharge and lateral subsurface flow, on groundwater discharge to the Napa River were analyzed using the results from the baseline calibrated model and two sensitivity scenarios: pumping restricted to 1988 pumping levels and doubled pumping relative to the estimated pumping that has occurred over the 1988 to 2015 base period.[13] Climatic effects were found to have a much greater effect on groundwater discharge to the Napa River for all three groundwater pumping options: the baseline pumping simulation, 1988 pumping scenario, and doubled pumping scenario.

Additional pumping can occur in the northeast Napa Study Area; however, the Study Report recommends targeted management measures to ensure groundwater conditions remain

[13] The sensitivity scenario with no pumping was not included in the correlation analysis because non-zero values are required for the analysis.

sustainable and streamflow depletion caused by pumping does not become significant and unreasonable.

Study findings and recommended actions to maintain groundwater sustainability in the northeast Napa Area (and the Napa Valley Subbasin) are summarized below. The recommended actions are consistent with groundwater management measures referenced in the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016b).

FINDINGS

A summary of the findings from the analysis of groundwater and surface water in the northeast Napa Study Area are listed below:

1) Groundwater storage played the smallest role in the water budget, hovering around net-zero annually (inflow equals outflow and little water depleting or replenishing storage).
2) Groundwater pumping makes up the next smallest component of flow in the model domain's water budget.
3) Lateral subsurface flow through all of the model's boundaries is generally a net positive number; more groundwater is flowing into the model domain than is flowing out through the subsurface. When groundwater does flow out of the model area through the subsurface, it typically leaves the model via the east side near the Soda Creek Fault. This is likely influenced by the lower groundwater levels in the MST driving the easterly horizontal flow gradient.
4) Recharge plays a key role; it is the second largest water budget component.
5) Within the model area flows to the Napa River dominate the groundwater budget; a large component of groundwater in the model discharges into the Napa River as baseflow. On the other hand, tributaries in the area most often discharge to groundwater, recharging the groundwater system on a seasonal basis.
6) Tributaries on the east side of the Napa River consistently show net losing stream conditions over time, despite seasonal fluctuations where gaining stream conditions occur briefly. As an example, Soda Creek consistently exhibits net losing stream conditions on an annual basis (even during wet winter conditions and also during the scenario when no pumping was simulated); the Creek is more affected by precipitation, and therefore climate, than groundwater pumping in determining the rate of streamflow and leakage to groundwater.
7) The model results indicate a decreasing trend in the amount of groundwater contributing to streamflow starting in the late 1990s. As illustrated by similar results from the sensitivity scenario in which no groundwater pumping occurred, this recent trend can be attributed to reduced precipitation in recent years (climatic effects), and not due to groundwater pumping. Statistical analyses indicate that this trend is more related to climatic effects, including reduced recharge and subsurface lateral flows, rather than to groundwater pumping.

8) Lateral flow, the third largest component of the model domain water budget, was typically a net inflow into the area, but a trend is seen starting in 1992 that shows less regional groundwater flowing into the model area. In some years, the net annual lateral flow is out of the model domain, which may indicate a future trend, or may be the result of climatic effects during increasingly drier water years.

9) Geologic faulting in the model area is important to the overall behavior of water levels east of the Napa River. Additional concealed faults may be present, which may affect water levels in deeper wells in the Petra Drive area.

10) Statistical analyses of water budget components (including recharge, lateral flows and pumping) relative to stream leakage (groundwater contributions to Napa River baseflow) show that, over the 28-year base period, climate effects have a much greater influence on stream leakage than pumping. Climate-driven variables account for 87 to 92% of the effect on groundwater discharge to Napa River, while pumping contributes to 8 to 13% of the effect on groundwater discharge to the River.

11) Modeling scenarios showed:

    a) Annual stream leakage fluxes (in and out of the surface water) were very similar even with no pumping occurring showing minimal stream impacts due to pumping;

    b) When pumping was reduced, a slight increase in the amount of groundwater contribution to the Napa River occurred (this had about a third of the effect that subsurface lateral flow had on this type of change). For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping reduced to 1988 conditions, the relative influence of pumping on baseflow was 2%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

    c) When pumping was doubled, a slight decrease in the amount of groundwater contributed to the Napa River occurred. For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping doubled, the relative contribution to baseflow effects was 10%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

12) Some drawdown effects on groundwater levels in the Petra Drive area are associated with mutual well interference; these are compounded by the high density of wells. However, these lowered levels are not as significant as the regional influence of the eastern boundary and movement of groundwater towards the MST.

2.3 Basis for Establishing the Northeast Napa Management Area

The average annual water budget developed for the northeast Napa Study Area shows the area to be in balance with inflows and outflows nearly equal over the 28-year period from 1988 to 2015. The findings of the northeast Napa Area study show that groundwater conditions in the Napa Valley Subbasin east of the Napa River within the Study Area are significantly influenced by climatic factors, geologic features that are distinct from those of the larger Napa Valley Subbasin, and cones of depression in the adjacent MST Subarea external to the Napa Valley Subbasin (LSCE, 2017). Because the northeast Napa Area, east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because groundwater conditions are significantly influenced by climatic factors, Napa County has designated the Northeast Napa Management Area within the Napa Valley Subbasin (**Figure 2-1**). The management area designation includes additional representative monitoring sites, minimum thresholds, measurable objectives, and management actions described in the following sections of this Amendment to the 2016 Basin Analysis Report.

3.0 NAPA VALLEY SUBBASIN SUSTAINABILITY GOAL

The 2016 Basin Analysis Report for the Napa Valley Subbasin includes the following SGMA Sustainability Goal for the Napa Valley Subbasin:

To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.

As a part of the Napa Valley Subbasin, the sustainable management criteria presented below for the Northeast Napa Management Area have been developed to ensure that the Subbasin can continue to be managed sustainably without experiencing undesirable results.

3.1 Sustainability Indicators and Undesirable Results

The Sustainable Groundwater Management Act (SGMA) establishes six sustainability indicators to be used for determining whether undesirable results occur in a groundwater basin or subbasin. The 2016 Basin Analysis Report documents that the Napa Valley Subbasin has not experienced significant and unreasonable effects due to groundwater conditions occurring throughout the Subbasin that would constitute an undesirable result.

This Amendment to the 2016 Basin Analysis Report provides additional descriptions of significant and unreasonable effects that would constitute undesirable results. The undesirable results described below are used to guide the establishment of minimum thresholds and measurable objectives for the Northeast Napa Management Area described in the following sections.

As required by Section 354.20(a) of the GSP Regulations, the undesirable results described below are consistent for the Napa Valley Subbasin and for the Northeast Napa Management Area. In addition, it is acknowledged that, due to differences in geology and aquifer characteristics, the Management Area may, in the future, experience effects due to groundwater conditions that lead to undesirable results within the Northeast Napa Management Area that do not also occur throughout the Napa Valley Subbasin. Both Management Area-specific undesirable results and the broader, Subbasin-wide undesirable results are described below.

3.1.1 Depletions of Interconnected Surface Water

Depletions of interconnected surface water would become significant and unreasonable if, as a result of groundwater extraction and use in the Subbasin:

1. the timing and duration of direct hydraulic connections between groundwater and surface water along the Napa River or its tributaries overlying the Subbasin are reduced relative to the extent of historical conditions or,
2. if the volume of surface water flowing into the groundwater system as a result of groundwater extraction and use in the Subbasin exceeds both flows that have occurred historically and flows that would otherwise occur due to climate change-related shifts in precipitation, temperature, evapotranspiration, and soil moisture in the future.

Consistent with specifications contained in the GSP Regulations, significant and unreasonable depletions of interconnected surface water are determined based on effects resulting from groundwater extraction and use in the Subbasin. The GSP Regulations define the minimum thresholds for depletions of interconnected surface water as follows:

> "The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results." (GSP Regulations Section 354.28(c)(6)).

3.1.2 Degraded Water Quality

Degraded water quality would become significant and unreasonable if groundwater conditions and land uses in the Subbasin result in increased concentrations of groundwater quality constituents contributed as a result of land use activities at a majority of the representative wells in the Napa Valley Subbasin such that water quality no longer meets state or federal standards for the intended beneficial uses of the well.

3.1.3 Seawater Intrusion

Seawater intrusion would become significant and unreasonable if groundwater conditions in the Subbasin increase the flow of seawater into the Napa Valley Subbasin such that chloride concentrations measured in representative wells reach levels that would result in groundwater being unsuitable for beneficial uses in portions of the following Napa County groundwater subareas that overly the Napa Valley Subbasin: Napa Valley Floor-Napa Subarea, Napa Valley Floor-Milliken-Sarco-Tulucay Subarea, or the Carneros Subarea

3.1.4 Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels would become significant and unreasonable if groundwater conditions in the Napa Valley Subbasin result in prolonged, year-to-year reductions in groundwater levels below levels recorded historically at a majority of the representative wells in the Subbasin, excluding groundwater level declines that may occur during drought conditions[14] unless groundwater level declines observed during periods of drought result in reduced groundwater levels over a long-term period that is at least 10 years in length, not ending in drought conditions, and including a balance of above average and below average water years.

Due to the limited thickness of alluvial aquifer materials and the more restrictive hydraulic properties of the Tertiary sedimentary and Sonoma Volcanics formations, the potential exists for chronic lowering of groundwater levels in the Tertiary sedimentary and Sonoma Volcanics formations within the Management Area that do not propagate to other parts of the Napa Valley Subbasin. Nevertheless, chronic lowering of groundwater levels in the Tertiary sedimentary and Sonoma Volcanics formations due to groundwater conditions in the Management Area would also be considered significant and unreasonable, excluding groundwater level declines that may occur during drought conditions unless declines during drought conditions are not ameliorated after at least two subsequent non-drought water years.

3.1.5 Reductions of Groundwater Storage

Reductions in groundwater storage would become significant and unreasonable if groundwater conditions in the Napa Valley Subbasin result in reductions in groundwater storage that exceed the Subbasin sustainable yield, excluding groundwater level declines that may occur during drought conditions unless groundwater storage declines observed during periods of drought result in reduced groundwater storage over a long-term period that is at least 10 years in length, not ending in drought conditions, and including a balance of above average and below average water years.

3.1.6 Land Subsidence

Land subsidence would become significant and unreasonable if groundwater conditions in the Napa Valley Subbasin result in permanent, inelastic subsidence to a degree that disrupts or causes accelerated damage to important public or private infrastructure (such as: roadways, railways, bridges, and water supply infrastructure).

Best available information, as presented in the Special Study Report (**Appendix A**), demonstrates that undesirable results for the six sustainability indicators described above have

[14] The Sustainable Groundwater Management Act defines the undesirable result of chronic lowering of groundwater levels as "Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (10721(x)(1)).

not occurred and are not occurring in the Northeast Napa Management Area as a result of groundwater conditions and groundwater use in the Napa Valley Subbasin.

3.2 Northeast Napa Management Area Representative Monitoring Sites

Napa County currently monitors groundwater levels in five production wells within the Northeast Napa Management Area. The County also monitors groundwater levels (GWL) and groundwater quality (GWQ) at two surface water/groundwater monitoring sites, located on the Napa River near the upstream and downstream extents of the Management Area (**Figure 3-1**). Surface water monitoring currently occurs at three locations on the Napa River adjacent to the Management Area (**Figure 3-2**). River stage data are collected at all three surface water monitoring sites; however, only the USGS gage (Station Name: Napa River near Napa) records stream discharge.

Figures 3-3, 3-4, and **3-5** depict relative exposure to the three primary aquifer zones for currently and formerly monitored wells, along with other wells whose construction information was recorded for the northeast Napa Study. Thin alluvial deposits east of the Napa River, in the Management Area, result in limited exposures to the alluvial aquifer zone, which wells west of the River commonly have a majority of their screened interval in the alluvium (**Figure 3-3**). Two Napa County surface water/groundwater monitoring facilities (SWGW1 and SWGW3) provide the best opportunities for monitoring the alluvial aquifer zone near to the Management Area.

Wells throughout much of the Management Area are screened in the Tertiary sedimentary formation that underlies the thin alluvium (**Figure 3-4**). Two wells monitored by Napa County (Wells 122 and 229) have over 95% of their perforated interval within the Tertiary aquifer zone. Well 229 is located is an area of more concentrated production wells. Well 122 is located near the eastern border of the Subbasin across which the northeast Napa Area study found the influence of cones of depression in the MST Subarea have propagated.

Exposure to the Sonoma Volcanics aquifer zone is greater in the northern half of the Management Area (**Figure 3-5**). Well 76, also monitored by Napa County, is located in that part of the Management Area and is also located between most of the wells in the Management Area with similar exposure to the Sonoma Volcanics and the adjacent MST Subarea.

Representative monitoring sites selected for the Management Area include seven wells that are currently monitored by Napa County (**Table 3-1**). Six of the wells have over 95% of their perforated intervals within the aquifer zone that they are intended to represent. The exception, NapaCounty-76, has 75% of its well screens within the Sonoma Volcanics aquifer zone that it is selected to represent. Four of the wells were previously selected to serve as representative sites for the Napa Valley Subbasin (LSCE, 2016b). These four are nested observation wells constructed as dedicated surface water/groundwater monitoring facilities at two sites on the Napa River that bookend the Management Area, at First Street in Napa and along Oak Knoll Avenue (**Figure 3-6**).

An additional dedicated surface water/groundwater monitoring site is planned to be installed east of the Napa River between the two existing sites at First Street in Napa and along Oak Knoll Avenue. The new site will also serve as a representative monitoring site for the Management Area (see **Section 4.1.2**).

Two wells along Petra Drive currently monitored by Napa County (Wells 182 and 228) are not recommended to be included as representative sites for the Management Area at this time due to uncertainty about the effects on groundwater conditions of concealed faults or other geologic features in the vicinity of Petra Drive. If ongoing monitoring network evaluations indicate a need for additional monitoring locations in the Tertiary sedimentary formation, the County could attempt to resume monitoring of a well historically monitored by DWR, located along Silverado Trail approximately 1,000 feet north of the intersection with Petra Drive (**Figure 3-1**).

3.2.1 Monitoring Network Evaluation and Reporting

Monitoring network evaluation and reporting for the Northeast Napa Management Area will occur as part of current efforts conducted for the overall Napa Valley Subbasin described in the 2016 Basin Analysis Report, including Annual Reporting, data management, and data submittal to DWR as required by SGMA and the GSP Regulations.

Monitoring of groundwater conditions at representative sites for three sustainability indicators (chronic lowering of groundwater levels, reductions of groundwater storage, and land subsidence) are conducted semi-annually in spring and fall. Monitoring at representative sites for depletions of interconnected surface waters is conducted with continuously recording water level transducers and manual measurements conducted at least semi-annually in spring and fall. Monitoring at representative sites for sustainability indicators related to groundwater quality (degraded water quality and seawater intrusion) is conducted by transducers continuously recording electrical conductivity at the four designated surface water/groundwater monitoring wells and through annual groundwater quality sampling for general minerals, including nitrate, and drinking water metals.

Napa County currently uses several methods to analyze data collected at representative sites, and other monitored sites. Groundwater level changes are evaluated using hydrographs, groundwater elevation contour mapping and quantitative comparisons of long-term changes at individual wells. Groundwater storage changes are evaluated through annual calculation of groundwater storage changes in the alluvial aquifer zone based on year-to-year changes in groundwater levels, and by comparison to results from the groundwater storage changes calculated for the 1988 to 2015 base period analyzed in the 2016 Basin Analysis Report (LSCE, 2016b). Seawater intrusion is evaluated using chloride concentration isocontour mapping and hydrographs of electrical conductivity in surface water and shallow groundwater at the designated surface water-groundwater monitoring sites. Groundwater quality is evaluated by mapping spatial variations in concentrations of water quality constituents and water quality time series plots. Depletions of surface water due to groundwater use in interconnected aquifer units is evaluated by hydrographs of groundwater levels.

The methods of data analysis described above are currently implemented by Napa County. As described in **Section 4** of this Amendment and Section 10.2 of the 2016 Basin Analysis Report, Napa County is working to implement additional phases of data collection and analysis in future years. Additional planned monitoring and analysis will include development of a numerical groundwater flow model to simulate groundwater conditions, surface water-groundwater interactions, and rates of streamflow depletion at the reach scale and across the Napa Valley Subbasin, in an application similar to the numerical model developed for the Northeast Napa Special Groundwater Study. A Napa Valley Subbasin-wide modeling tool will facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface water and groundwater resources. The modeling tool will be supported by additional data collection regarding aquifer properties, through required aquifer testing, and improved tracking of new well permits, and synthesis of water use and groundwater level data collected pursuant to discretionary permits issued by Napa County.

3.3 Northeast Napa Management Area Minimum Thresholds

The GSP Regulations define minimum thresholds as “the numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results” (354.28(a)). This section presents preliminary minimum thresholds established to quantify groundwater conditions for each applicable sustainability indicator at representative monitoring sites designated for the Northeast Napa Management Area. Justification is provided for the thresholds based on best available data, including groundwater levels, groundwater quality, and surface water flows. As noted above, groundwater level thresholds are used as a proxy for multiple sustainability indicators. **Table 3-2** shows the relationship between representative monitoring sites, the sustainability indicators applicable to those sites, the data category for the measurable objective and minimum threshold (e.g., groundwater level, groundwater quality or other), and which sustainability indicators use groundwater elevations as a proxy.

For representative monitoring sites where long-term periods of record are not available, as in the case of the dedicated monitoring wells constructed in 2014 to monitor groundwater-surface water interactions, minimum thresholds established here will be reviewed and reevaluated in future years as the collection of available data for each site expands to better reflect true long-term variability at those sites.

Table 3-1. Representative Monitoring Sites, Napa Valley Subbasin: Northeast Napa Management Area

Well ID	Data Source	Aquifer Desig-nation[1]	Subarea	Well Depth (ft)	Basis for Selection	Designated as a Represen-tative Site in the 2016 Basin Analysis Report
NapaCounty-122	Napa County	Tss	MST	210	Aquifer-specific construction, Moderate record	-
NapaCounty-229	Napa County	Tss	MST	350	Aquifer-specific construction, Moderate record	-
NapaCounty-76	Napa County	Tsv	Napa	405	Aquifer-specific construction, Moderate record	-
Napa County 214s-swgw1	Napa County	Qa	Napa	53	Designated SW/GW facility[2]	Yes
Napa County 215d-swgw1	Napa County	Qa	Napa	98	Designated SW/GW facility	Yes
Napa County 218s-swgw3	Napa County	Qa	Napa	40	Designated SW/GW facility	Yes
Napa County 219d-swgw3	Napa County	Qa	Napa	93	Designated SW/GW facility	Yes

1. Aquifer Designations: Qa = Quaternary Alluvium, Tsv = Tertiary Sonoma Volcanic Rocks, Tss = Tertiary Sedimentary Rocks
2. Designated SW/GW facility: refers to surface water and groundwater monitoring facilities installed as part of the DWR Local Groundwater Assistance Program grant awarded to Napa County for purposes of evaluating the connectivity between groundwater and surface water.

Table 3-2. Representative Monitoring Sites and Sustainability Indicators

Well ID	Sustainability Indicators[3]					
	Chronic Lowering of GWLs	Reduced GW Storage	Seawater Intrusion	Degraded GW Quality	Land Subsidence	Surface Water Depletion
NapaCounty-76	GWE[1]	GWE				
NapaCounty-122	GWE	GWE			GWE	
NapaCounty-229	GWE	GWE		GWQ[2]	GWE	
Napa County 214s-swgw1	GWE	GWE	GWQ			GWE
Napa County 215d-swgw1	GWE	GWE				
Napa County 218s-swgw3	GWE	GWE				GWE
Napa County 219d-swgw3	GWE	GWE				

1. GWE: Groundwater Elevation; data category for establishing minimum thresholds and measurable objectives for avoiding the undesirable result of depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water (e.g., streamflow depletion). Since the river system in the Napa Valley Subbasin is considered sensitive to climate and groundwater condition variability, GWE's set for the surface water depletion sustainability indicator serve as a proxy for many other sustainability indicators.
2. GWQ: Groundwater Quality
3. Where neither GWE nor GWQ is indicated, this does not mean that groundwater elevations and/or quality are not being measured, rather it means that groundwater elevations and/or groundwater quality are not being assessed for purposes of evaluating one or more sustainability indicators at this representative monitoring site.

3.3.1 Minimum Threshold: Depletions of Interconnected Surface Water

Based on the analyses of surface water and groundwater interconnections, including the relationship of those connections to seasonal and annual groundwater elevation fluctuations (see Basin Analysis Report Chapter 4), minimum thresholds are set at two wells in the Subbasin (**Table 3-3**). Both wells were constructed as dedicated monitoring wells, (i.e., observation wells) as part of the DWR Local Groundwater Assistance Program grant awarded to Napa County for the specific purpose of evaluating the connectivity between groundwater and surface water. These thresholds represent the lowest static groundwater level elevation that has occurred historically in the fall and an elevation below which additional streamflow depletion is likely to occur, i.e., expand the duration of annual no flow days in the Napa River. These thresholds represent the lowest static groundwater elevation to which groundwater levels may reasonably be lowered at the end of a dry season without exacerbating streamflow depletion. These levels are not acceptable on a continuous basis as this would contribute to a worsening of existing conditions. These groundwater elevation thresholds also serve as proxies for many other sustainability indicators, as shown in **Table 3-2.**

Table 3-3. Minimum Thresholds to Avoid Undesirable Results Due to Surface Water Depletion

Well ID	Minimum Threshold: Minimum Fall Groundwater Elevation (Feet, NAVD88[1])
NapaCounty-214s-swgw1	2[2]
NapaCounty-218s-swgw3	29

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).
2. The Napa County surface water/groundwater monitoring facilities are relatively new with limited data; minimum thresholds will be re-evaluated with additional data.

As described in **Section 4.1.1**, Napa County plans to develop a groundwater flow model for the Napa Valley Subbasin. The Subbasin-wide modeling tool will provide additional capabilities for quantifying stream depletion on a volumetric basis spatially and temporally. Results from the calibrated model will be used to refine minimum thresholds established for depletions of interconnected surface water at representative sites throughout the Subbasin.

3.3.2 Minimum Threshold: Avoid Degraded Groundwater Quality

The minimum threshold for avoidance of undesirable results due to degraded groundwater quality is based on groundwater quality concentrations remaining below water quality objectives. The focus for SGMA purposes is on constituents contributed due to activities at the land surface rather than on the presence of naturally occurring constituents. NapaCounty-229 (i.e., Well 229) is the only additional well newly designated as a representative site for the degraded groundwater quality sustainability indicator in the Northeast Napa Management Area. Well 229, selected as a representative monitoring site for the older, pre-alluvial aquifer zone, is a privately-owned domestic well where prior available groundwater quality data are limited to one test for total coliform and fecal coliform in 2014. An example of the minimum thresholds at this site is shown in **Table 3-4** for nitrate as nitrogen.

Table 3-4. Minimum Threshold to Avoid Undesirable Results Due to Degraded Groundwater Quality

Well ID	Minimum Threshold: GW Quality Objective (example Nitrate-N mg/L[1])
NapaCounty-229	10 mg/L
1. The Maximum Contaminant Level (MCL) for Nitrate as Nitrogen is 10 mg/L.	

3.3.3 Minimum Threshold: Avoid Seawater Intrusion

The minimum threshold for avoidance of undesirable results due to seawater intrusion is based on groundwater quality concentrations remaining stable in the representative well designated for this sustainability indicator (**Table 3-5**). NapaCounty-214s-swgw1 (i.e., Well 214s) is located along the Napa River at the southern boundary of the Northeast Napa Management Area. Although the well has a short period of record, having been constructed in 2014, it is an observation well with a screened interval located at the water table surface, and is suited to monitoring for changes in water quality that could result from the migration of the brackish to saline water from the adjacent Napa River into the groundwater of the Napa Valley Subbasin.

Table 3-5. Minimum Threshold to Avoid Undesirable Results Due to Seawater Intrusion

Well ID	Minimum Threshold: Maintain Chloride Concentrations at or Below Secondary MCL[1] (mg/L)
NapaCounty-214s-swgw1	500
1. Secondary Recommended Maximum Contaminant Level for chloride is 500 mg/L.	

3.3.4 Minimum Thresholds: Avoid Chronic Lowering of Groundwater Levels, Reductions of Groundwater Storage, and Land Subsidence

The minimum thresholds for avoidance of undesirable results due to chronic groundwater level decline, reductions in groundwater storage, and land subsidence are based on groundwater levels set at minimum fall level observed over the historical period. Two representative wells (Wells 214s and 218s) use the groundwater elevations for avoidance of streamflow depletion as the proxy (**Table 3-3**). Five other representative wells are also used for these sustainability indicators (**Table 3-6**). The minimum threshold for each well is the lowest fall level observed over the entire historical period.

Table 3-6. Minimum Thresholds to Avoid Undesirable Results due to Chronic Lowering of Groundwater Levels, Reduced Groundwater Storage, and Land Subsidence

Well ID	Minimum Threshold: Avoid Groundwater Level Decline over Successive Years and Land Subsidence (Fall GWE, Feet, NAVD88[1])	Minimum Threshold: Avoid Reduced Groundwater Storage (Avoidance of Chronic GWE Decline is Proxy; Fall GWE, Feet, NAVD88[1])
NapaCounty-122	-45	-45
NapaCounty-229	-62	-62
NapaCounty-76	-30	-30
Napa County 215d-swgw1	2	2
Napa County 219d-swgw3	29	29

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).

3.4 Northeast Napa Management Area Measurable Objectives

The GSP Regulations define “measurable objectives” as “specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions” (Section 351). This section establishes measurable objectives for each sustainability indicator at representative monitoring sites designated for the Northeast Napa Management Area, based on quantitative values using the same metrics and monitoring sites that are used to define the minimum thresholds. These objectives provide a reasonable margin of operational flexibility under adverse conditions where applicable and utilize components such as historical water budgets, seasonal and long-term trends, and periods of drought. Similar to the minimum thresholds discussed in Section 3.3, groundwater elevations serve as the proxy for multiple sustainability indicators where reasonable. Interim milestones are not included here because the Subbasin has been shown to have been sustainably managed for a period of at least 10 years, consistent with the authorization contained in Section 10733.6(b)(3) of the California Water Code allowing for Alternative Submittals to meet the requirements of a GSP.

For representative monitoring sites where long-term periods of record are not available, as in the case of the dedicated monitoring wells constructed in 2014 to monitor groundwater-surface water interactions, measurable objectives established here will be reviewed and reevaluated in future years as the collection of available data for each site expands to better reflect true long-term variability at those sites.

3.4.1 Measurable Objectives: Depletions of Interconnected Surface Water

Based on the analyses of surface water and groundwater interconnections, including the relationship of this connection to seasonal and annual groundwater elevation fluctuations (see Basin Analysis Report Chapter 4), measurable objectives for streamflow depletion are set at two wells in the Subbasin that are adjacent to the Management Area (**Table 3-7**). Both wells were constructed as dedicated monitoring wells, (i.e., observation wells) as part of the DWR Local Groundwater Assistance Program grant awarded to Napa County for purposes of evaluating the connectivity between groundwater and surface water. These objectives represent the mean fall groundwater level elevations that occurred historically. These objectives represent the fall groundwater elevations within which groundwater elevations are reasonably likely to fluctuate during fall without exacerbating streamflow depletion. These measurable groundwater elevation objectives also serve as proxies for many other sustainability indicators, as shown in **Table 3-2.** (Measurable objectives and minimum thresholds are shown together in **Table 3-11**.)

Table 3-7. Measurable Objectives for Avoiding Undesirable Results Due to Surface Water Depletion

Well ID	Measurable Objective for Streamflow: Fall Groundwater Elevation (Feet, NAVD88[1])
NapaCounty-214s-swgw1	4
NapaCounty-218s-swgw3	32

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).

3.4.2 Measurable Objective: Maintain or Improve Groundwater Quality

The measurable objective for maintaining or improving groundwater quality is based on groundwater sample concentrations remaining below water quality objectives and groundwater quality at concentrations similar to and/or improved compared to historical observations in the groundwater basin. NapaCounty-229 (i.e., Well 229) is the only additional well newly designated as a representative site for the degraded groundwater quality sustainability indicator in the Northeast Napa Management Area (**Table 3-8**). Measurable objectives for this newly designated representative well will be re-evaluated after baseline water quality conditions are established (approximately three years of sampling and analysis of conditions). An example of measurable objectives for nitrate-nitrogen is shown in **Table 3-8**.

Table 3-8. Measurable Objective to Avoid Undesirable Results Due to Degraded Groundwater Quality

Well ID	Measurable Objective: GW Quality Objective (example Nitrate-N mg/L[1])
NapaCounty-229	8 mg/L
1. The Maximum Contaminant Level (MCL) for Nitrate as Nitrogen is 10 mg/L.	

3.4.3 Measurable Objective: Avoid Seawater Intrusion

The measurable objective for avoidance of undesirable results due to seawater intrusion is based on groundwater quality concentrations remaining stable in the representative well designated for this sustainability indicator (**Table 3-9**). NapaCounty-214s-swgw1 (i.e., Well 214s) is located along the Napa River at the southern boundary of the Northeast Napa Management Area. Although the well has a short period of record, having been constructed in 2014, it is an observation well with a screened interval located at the water table surface, and is suited to monitoring for changes in water quality that could result from the migration of the brackish to saline water from the adjacent Napa River into the groundwater of the Napa Valley Subbasin.

Table 3-9. Measurable Objective to Avoid Undesirable Results Due to Seawater Intrusion

Well ID	Measurable Objective: Maintain Chloride Concentrations At or Below Secondary MCL[1] (mg/L)
NapaCounty-214s-swgw1	300
1. Secondary Recommended Maximum Contaminant Level for chloride is 500 mg/L.	

3.4.4 Measurable Objectives: Avoid Chronic Lowering of Groundwater Levels, Reductions of Groundwater Storage, and Land Subsidence

The measurable objectives for avoidance of undesirable results due to chronic groundwater level decline, reductions in groundwater storage, and land subsidence are based on groundwater levels set at minimum fall level observed over the historical period. Two representative wells (Wells 214s and 218s) use the groundwater elevations for avoidance of surface water depletion as the proxy (**Table 3-7**). Five other representative wells are also used for these sustainability indicators (**Table 3-10**). The measurable objective is the fall level observed prior to the recent drought period. As described above, for the selected representative sites for this indicator, the minimum threshold is the fall groundwater elevation above which groundwater elevations are to be maintained in order to avoid undesirable results. Similarly, for these sites, the measurable objective is the fall groundwater elevation, at or above which, to maintain groundwater sustainability or improve groundwater conditions. Well 229 was added to the Napa County monitoring network in 2016; therefore, it does not yet have a sufficient period of record with which to establish a measurable objective. The measurable objective for Well 229 will be re-evaluated after baseline conditions are established (approximately five years of monitoring to include a range of water year conditions).

Table 3-10. Measurable Objectives to Avoid Undesirable Results due to Chronic Lowering of Groundwater Levels, Reduced Groundwater Storage, and Land Subsidence

Well ID	Measurable Objective: Avoid Groundwater Level Decline over Successive Years and Land Subsidence (Fall GWE, Feet, NAVD88[1])	Measurable Objective: Avoid Reduced Groundwater Storage (Avoidance of Chronic GWE Decline is Proxy; Fall GWE, Feet, NAVD88[1])
NapaCounty-122	-26	-26
NapaCounty-229	-51	-51
NapaCounty-76	20	20
Napa County 215d-swgw1	4	4
Napa County 219d-swgw3	32	32

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).

Table 3-11 summarizes the minimum thresholds and measurable objectives (respectively) for all representative sites and sustainability indicators.

Table 3-11. Northeast Napa Management Area Representative Monitoring Sites: Minimum Thresholds and Measurable Objectives for Sustainability Indicators

Well ID	Sustainability Indicators and Minimum Thresholds and Measurable Objectives											
	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective	Min Threshold	Measurable Objective
	Chronic Lowering of GWLs (Fall GWE, Feet NAVD88[1])	Chronic Lowering of GWLs (Fall GWE, Feet NAVD88)	Reduced GW Storage (Fall GWE, Feet NAVD88)	Reduced GW Storage (Fall GWE, Feet NAVD88)	Seawater Intrusion (Chloride, mg/L)	Seawater Intrusion (Chloride, mg/L)	Degraded GW Quality (NO3-N mg/L)	Degraded GW Quality (NO3-N mg/L)	Land Subsidence (Fall GWE, Feet NAVD88)	Land Subsidence (Fall GWE, Feet NAVD88)	Surface Water Depletion (Fall GWE, Feet NAVD88)	Surface Water Depletion (Fall GWE, Feet NAVD88)
NapaCounty-76	-30	20	-30	20								
NapaCounty-122	-45	-26	-45	-26					-45	-26		
NapaCounty-229	-69	-51	-69	-51			10	8	-69	-51		
Napa County 214s-swgw1	2	4	2	4	500	300					2	4
Napa County 215d-swgw1	2	4	2	4								
Napa County 218s-swgw3	29	32	29	32							29	32
Napa County 219d-swgw3	29	32	29	32								

1. Elevation in feet relative to the North American Vertical Datum of 1988 (NAVD88).

3.5 Preventing Undesirable Results Outside of the Northeast Napa Management Area

As described in **Section 3.1**, the undesirable results described in this Amendment to the 2016 Basin Analysis Report are consistent for the Napa Valley Subbasin and for the Northeast Napa Management Area. In addition, it is acknowledged that, due to differences in geology and aquifer characteristics, the Management Area may, in the future, experience effects due to groundwater conditions that lead to undesirable results within the Northeast Napa Management Area that do not also occur throughout the Napa Valley Subbasin. In order to prevent any future localized undesirable results that occur within the Northeast Napa Management Area from affecting other portions of the Napa Valley Subbasin, the minimum thresholds and measurable objectives established in this Amendment are equivalent to similar criteria previously established for the Subbasin in the 2016 Basin Analysis Report (LSCE, 2016b). Further, the criteria established for representative sites newly designated in this Amendment are set using rationale consistent with the rationale used to set sustainability criteria for other representative monitoring sites in the Subbasin.

4.0 MANAGEMENT ACTIONS

The following management actions were originally presented to the Napa County Board of Supervisors on October 24, 2017, as part of the Special Study Report. Napa County will lead implementation of these management actions, with outreach to users of groundwater and other stakeholders as described in the 2016 Basin Analysis Report (LSCE, 2016b). These management actions complement the management actions described in the 2016 Basin Analysis Report in that they are intended to enable continued attainment of the Sustainability Goal for the Napa Valley Subbasin.

4.1.1 Napa Valley Subbasin Groundwater Flow Model

Modeling tools help facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources. Large regional models can be especially useful tools to examine complicated scenarios. As described in this study (and previous studies LSCE and MBK, 2013 and LSCE, 2016b), the geologic and hydrogeologic setting in Napa County, and specifically the Napa Valley Floor, is extremely complex. The updated hydrogeologic conceptualization, aspects of which were utilized for the northeast Napa Area study, shows that the subsurface is so complex that the prior two-layer model for the north Napa Valley area, which focused on the alluvium with unconfined and semi-confined aquifer characteristics, needs significant refinement for future use and to improve the model's predicative utility.

The numerical groundwater flow model developed for the northeast Napa Area study allows quantitative assessment of locally occurring mutual well interference and potential streamflow depletion under varying water year types. It is a tool that facilitates understanding about the underlying groundwater system in this local area; however, that understanding is subject to assumptions.

Having completed the updated hydrogeologic conceptualization for the Napa Valley Subbasin and to facilitate further regional groundwater analyses and assessment of streamflow depletion required for continued implementation of SGMA, Napa County will develop a more detailed groundwater flow model for the entire Napa Valley Subbasin. Ongoing improvement of datasets and models/tools to understand mechanisms and results of predictive scenarios will help inform future approaches to ensuring sustainability.

Efforts to conduct groundwater modeling for the Napa Valley Subbasin would be similar to those implemented for the Special Study but on a larger scale. These include:

- Incorporation of updated physical hydrogeologic conceptualization in the model structure
- Updated aquifer parameters
- Incorporation of faults and other geologic features

- Estimating streambed properties
- Estimating water source utilization, including well types and points of surface water diversion as possible based on best available data
- Incorporation of surface water/groundwater interaction that allows quantification of streamflow depletion on a volumetric basis spatially and temporally
- Sensitivity analyses of parameters until such parameters can be refined through proper empirical analysis and testing.

Groundwater Flow Model Development: Napa County will develop a Napa Valley Subbasin-wide modeling tool to facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources.

4.1.2 Additional Surface Water/Groundwater Monitoring Facilities

As discussed in the County's report, *Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin* (LSCE, 2016b), the implementation of the DWR Local Groundwater Assistance (LGA) program to construct and implement coupled surface water and groundwater monitoring in and near the Napa River system has been very valuable for improving the understanding of surface water and groundwater interaction. Similar facilities at additional locations would help further this understanding and are important for the County's SGMA sustainability goal. These facilities would be key to the objective of maintaining or improving streamflow during drier years and/or seasons. Although this study utilized dozens of monitoring wells with historical groundwater level records to evaluate observed and simulated groundwater level trends, there are no shallow monitoring wells located east of the Napa River and constructed in the alluvial deposits. Monitoring wells constructed to monitor groundwater level responses in the shallow alluvial deposits would improve understanding of the effect of pumping from relatively deeper parts of the groundwater system on the water table. This would further improve the understanding of the effect of pumping on potential streamflow depletion.

Surface Water/Groundwater Monitoring Facilities: Napa County will expand its existing network of dedicated surface water/groundwater monitoring facilities and construct shallow nested groundwater monitoring wells (like the recently installed Local Groundwater Assistance Surface Water/Groundwater monitoring facilities) east of the Napa River in the vicinity of Petra Drive. This will provide data to improve the understanding of the effect of pumping on potential streamflow depletion.

4.1.3 Discretionary Project Review in the Management Area

Based on the results of the northeast Napa Area study, the groundwater system in the Study Area is "about in balance" over the study period. The model sensitivity scenario, in which groundwater pumping was increased, provides insight into the relatively minor effect that an increase in pumping has on the overall water budget in the Study Area. Relatively small amounts of increased pumping may be considered for proposed discretionary projects in the Northeast Napa Management Area. However, it is recommended that additional project-specific analyses (as described in the Napa County Water Availability Analysis-Tier 2) be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells) (Napa County, 2015, see Basin Analysis Report Appendix I).

The project-specific information to be incorporated in the analysis includes:

- Parcel specific information on current and proposed water use (surface water and groundwater);
- Water demand estimates that include normal and dry-year water types;
- Existing and proposed well location and construction information (for all water uses);
- Existing well performance data, to the extent available. These data include well yields, specific capacities, water level recovery rates (from pumping tests), if any.

Discretionary Project WAA Review in the Management Area: For discretionary projects in the Northeast Napa Management Area, additional project-specific analyses (Napa County Water Availability Analysis-Tier 2) will be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells) (Napa County, 2015, see Basin Analysis Report Appendix I). In addition, the Napa County Board of Supervisors has directed staff to update the Napa County Groundwater Ordinance to reflect the additional requirements for project-specific analysis and to incorporate water use criteria and water use reporting requirements for the Management Area using an approach similar to what has already been implemented in the MST Subarea.

4.1.4 New Well Tracking in the Management Area

Pumping amounts for existing domestic supply wells located in the Northeast Napa Management Area are relatively small.

New Well Tracking in the Management Area: As a precautionary measure, Napa County will track new non-discretionary groundwater wells constructed in the Northeast Napa Management Area, including their planned usage and location. The County will formalize the scope and procedures to be used for this effort as part of the update to the Napa County Groundwater Ordinance initiated by the County Board of Supervisors on October 24, 2017.

Applicants will be informed of potential well interference effects, if they propose well construction in an area that already has densely spaced wells.

4.1.5 New Well Pump Testing to Refine Aquifer Properties Characterization

The distribution of the hydraulic conductivities in the Napa Valley as presented by Faye (1973) was based on data recorded on historical drillers' reports. During the updated hydrogeologic conceptualization (LSCE and MBK, 2013), it became evident, based on the approximately 1,300 reports reviewed, that most of the "test" data are insufficient to adequately determine or estimate aquifer characteristics and to reliably determine well yield, since most of these data were recorded during airlift operations rather than a pumping test. As further discussed in the Special Study, similar limitations were encountered with the quality of well test data in the Special Study Area. Currently, test methods accepted in the County's Well and Groundwater Ordinance allow bailing, airlifting, pumping, or any manner of testing generally acceptable within the well drilling industry to determine well yield.

New Well Pump Testing: Napa County will develop appropriate standards and require that pumping test data be collected when new production wells are constructed in areas where the distribution of hydraulic conductivities is less well known, including the Northeast Napa Management Area east of the Napa River and in deeper geologic units throughout the rest of the Napa Valley Subbasin. Because older and less productive geologic formations occur near ground surface in the northeast Napa Area east of the Napa River, it is likely that pump tests will need to be performed for all new production wells in that area (**Figure 2-1**). Test results will not only provide valuable information regarding aquifer properties; true pump testing will provide well owners with more meaningful information about well capacity than the typical tests of well yield reported on historical well completion reports. Similar pump testing will be required for non-domestic production wells, and for wells that are completed in deeper units below the Quaternary alluvium throughout the Napa Valley Subbasin.

4.1.6 Increased Water Conservation and Evaluation of Recharge Opportunities

In recognition of the County's countywide goals to promote sustainable use and management of water, maintain or improve ecosystem health, and increase climate resiliency, these goals will receive extra attention across the entire Napa Valley Subbasin. Innovative conservation approaches will be encouraged, along with targeted recharge strategies that have the potential to improve ecologic habitat, sustain water resources, and improve water resources resiliency under future climate conditions. As described in the Napa Valley Subbasin Basin Analysis Report, opportunities for strategic recharge will be evaluated, particularly along the Subbasin margin and in consideration of hydrogeologic factors (LSCE, 2016b).

Increased Water Conservation and Recharge: Napa County will evaluate approaches for retaining and using stormwater and/or tile drain water to increase water conservation, examining opportunities to reduce pumping and streamflow diversions, potentially lessening streamflow effects during drier years or drier periods of the year, and creating additional climate resiliency through targeted recharge strategies.

5.0 SUMMARY

This Amendment to the report *Napa Valley Groundwater Sustainability, A Basin Analysis Report for the Napa Valley Subbasin* (LSCE, 2016b) designates the Northeast Napa Management Area over approximately 1,960 acres of the 45,928-acres Subbasin. Section 355.10(b) of the GSP Regulations allows that "An Agency may amend a Plan at any time, and submit the amended Plan to the Department for evaluation pursuant to the requirements of this Subchapter." Napa County has developed this Amendment in order to support its continued implementation of the SGMA for the Napa Valley Groundwater Subbasin.

This Amendment does not change the findings of the 2016 Basin Analysis Report, instead it provides additional detail about conditions in the Study Area, specifically the area designated as the Northeast Napa Management Area and establishes additional sustainable management criteria and management actions intended to support continued groundwater sustainability in the Napa Valley Subbasin.

In 2016, Napa County initiated a Special Groundwater Study to understand recent, historical changes in water level trends in a small portion of the Napa Valley Subbasin. The study area included a portion of the Subbasin marked by abrupt variations in the nature and quality of water-bearing geologic formations in the Subbasin. The geologic variation has been mapped as coincident with the East Napa Fault Zone, which generally follows the Napa River channel in portions of the Subbasin between the Town of Yountville and the City of Napa.

A numerical groundwater flow model was developed for the study to analyze groundwater conditions in an area covering approximately 9.5 square miles over a 28-year period from 1988 to 2015. The average annual water budget developed for the Study Area using the numerical flow model shows the area to be in balance with inflows and outflows nearly equal over the 28-year period.

Additional analyses performed using the numerical flow model show that groundwater conditions in the Napa Valley Subbasin east of the Napa River within the study area are significantly influenced by climatic factors, geologic features that are distinct from those of the larger Napa Valley Subbasin, and cones of depression in the adjacent MST Subarea external to the Napa Valley Subbasin (LSCE, 2017).

GSP Regulations adopted by the California Water Commission in 2016 define a management area as, "an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors" (Section 351). Because the northeast Napa Area, east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because groundwater conditions are significantly influenced by climatic factors, Napa County has designated the Northeast Napa Management Area within the Napa Valley Subbasin.

The management area designation includes seven representative monitoring sites, each with quantitative minimum thresholds and measurable objectives, established to aid the County in evaluating future groundwater conditions in the Northeast Napa Management Area.

This Amendment also incorporates six management actions developed based on needs identified during the Special Study. Napa County will lead implementation of these management actions, with outreach to users of groundwater and other stakeholders as described in the 2016 Basin Analysis Report (LSCE, 2016b). These management actions complement the management actions described in the 2016 Basin Analysis Report in that they are intended to enable continued attainment of the SGMA Sustainability Goal for the Napa Valley Subbasin. The management actions include:

1. Napa Valley Subbasin Groundwater Flow Model Development
2. Additional Surface Water/Groundwater Monitoring Facilities
3. Discretionary Project Review in the Management Area
4. New Well Tracking in the Management Area
5. New Well Pump Testing to Refine Aquifer Properties Characterization
6. Increased Water Conservation and Evaluation of Recharge Opportunities

6.0 REFERENCES

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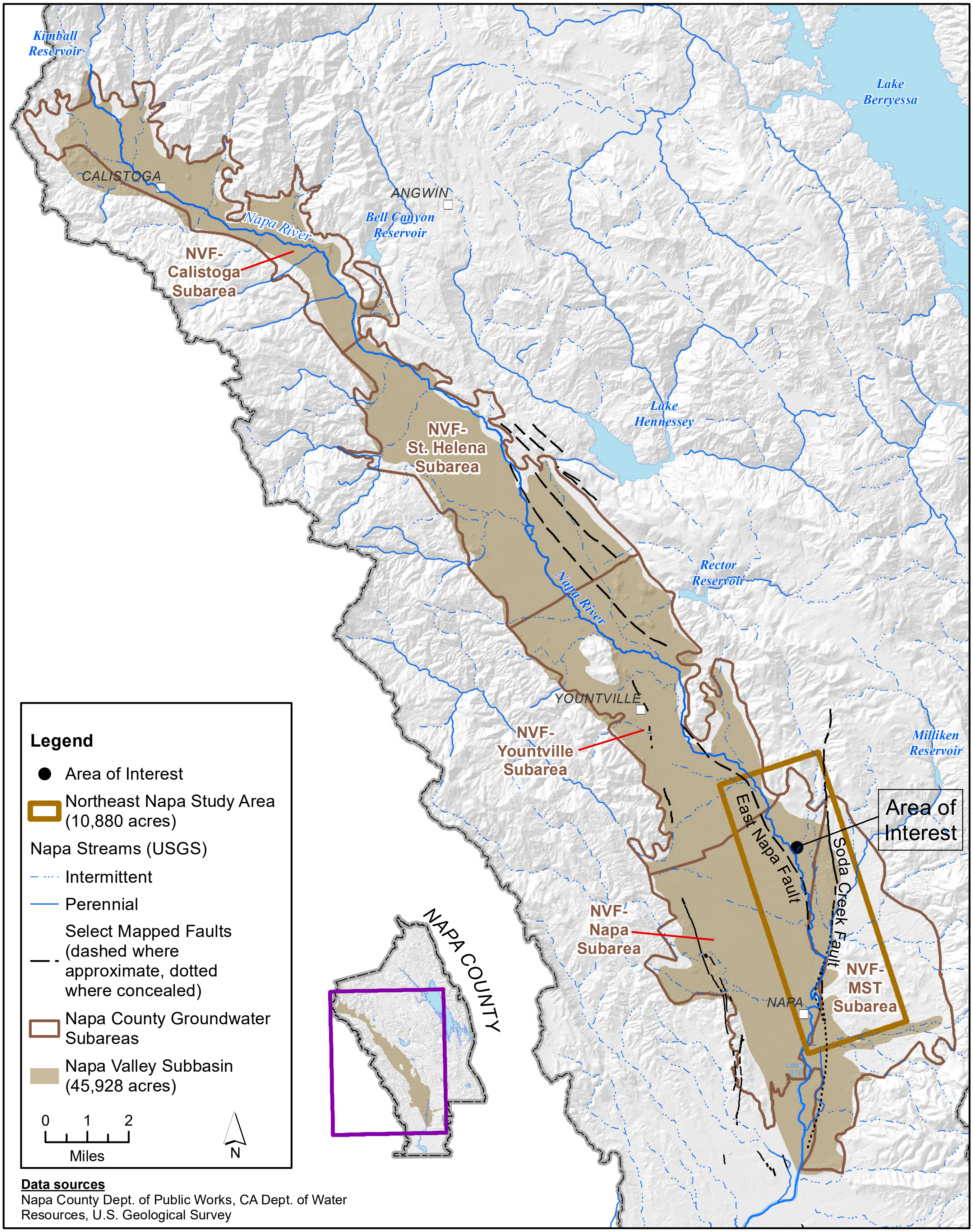
FIGURES



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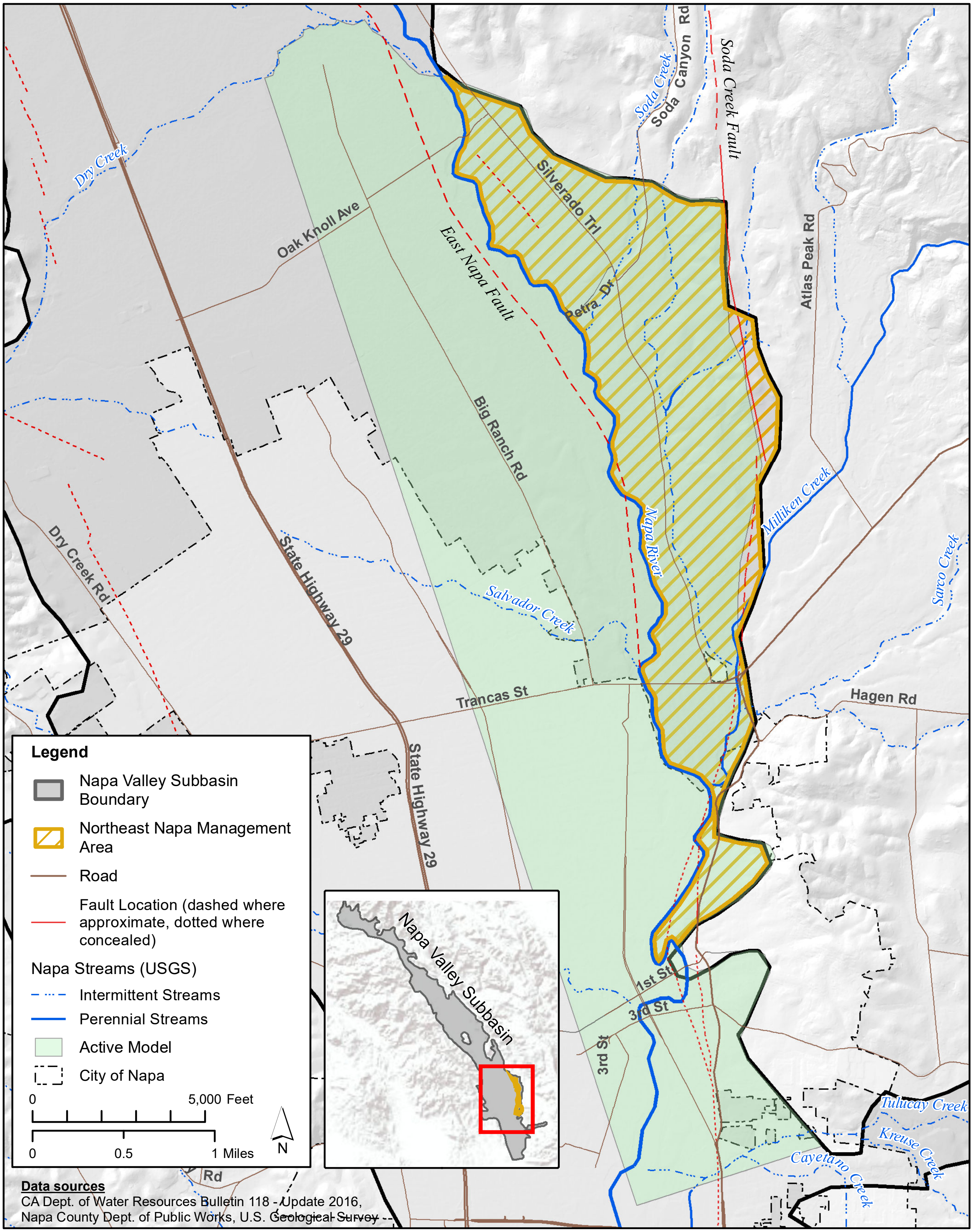
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

FIGURE 1-1

Northeast Napa Area of Interest



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2016,
Napa County Dept. of Public Works, U.S. Geological Survey

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FIGURE 2-1

Napa Valley Subbasin: Northeast Napa Management Area

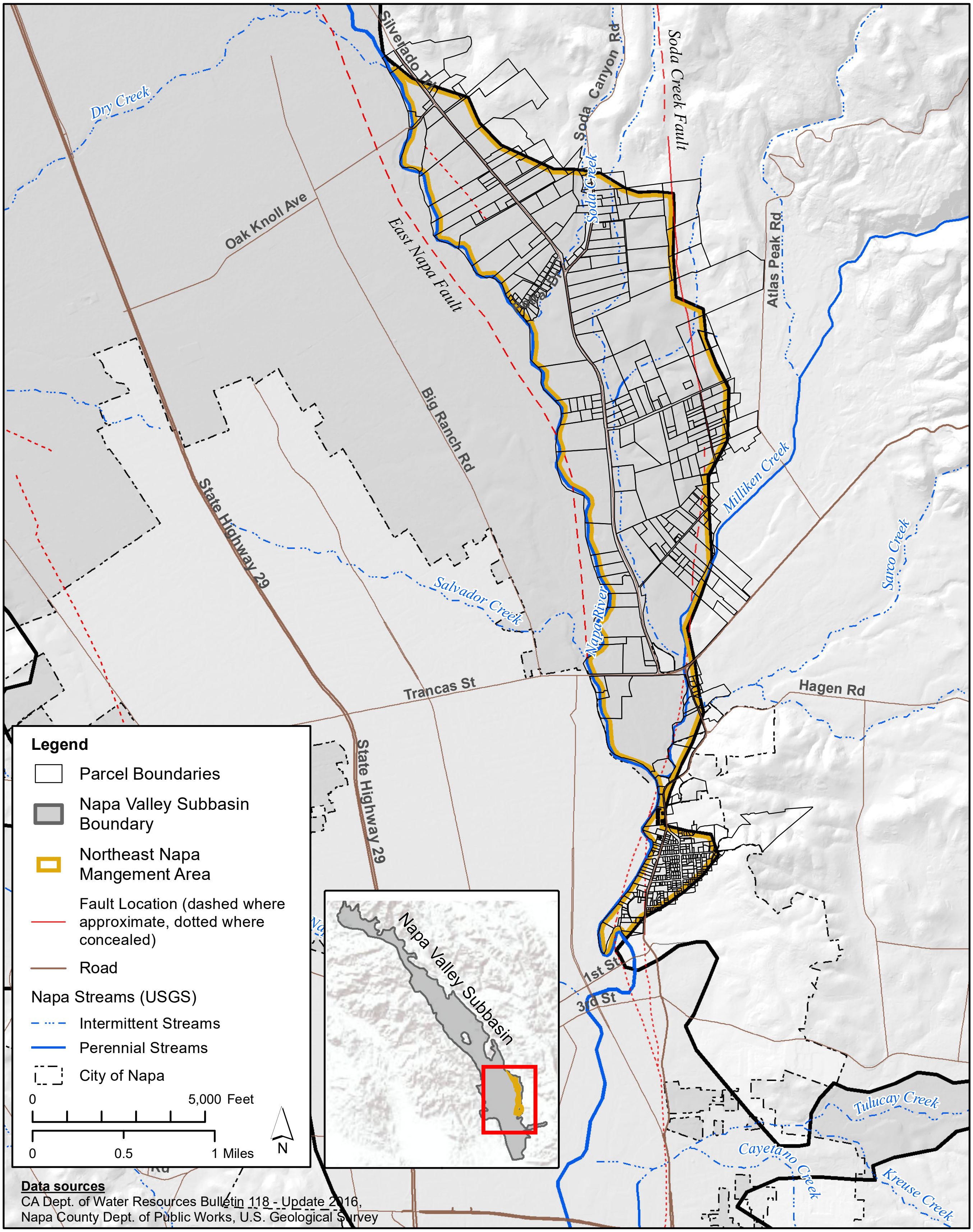

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FIGURE 2-2

Northeast Napa Management Area Parcels

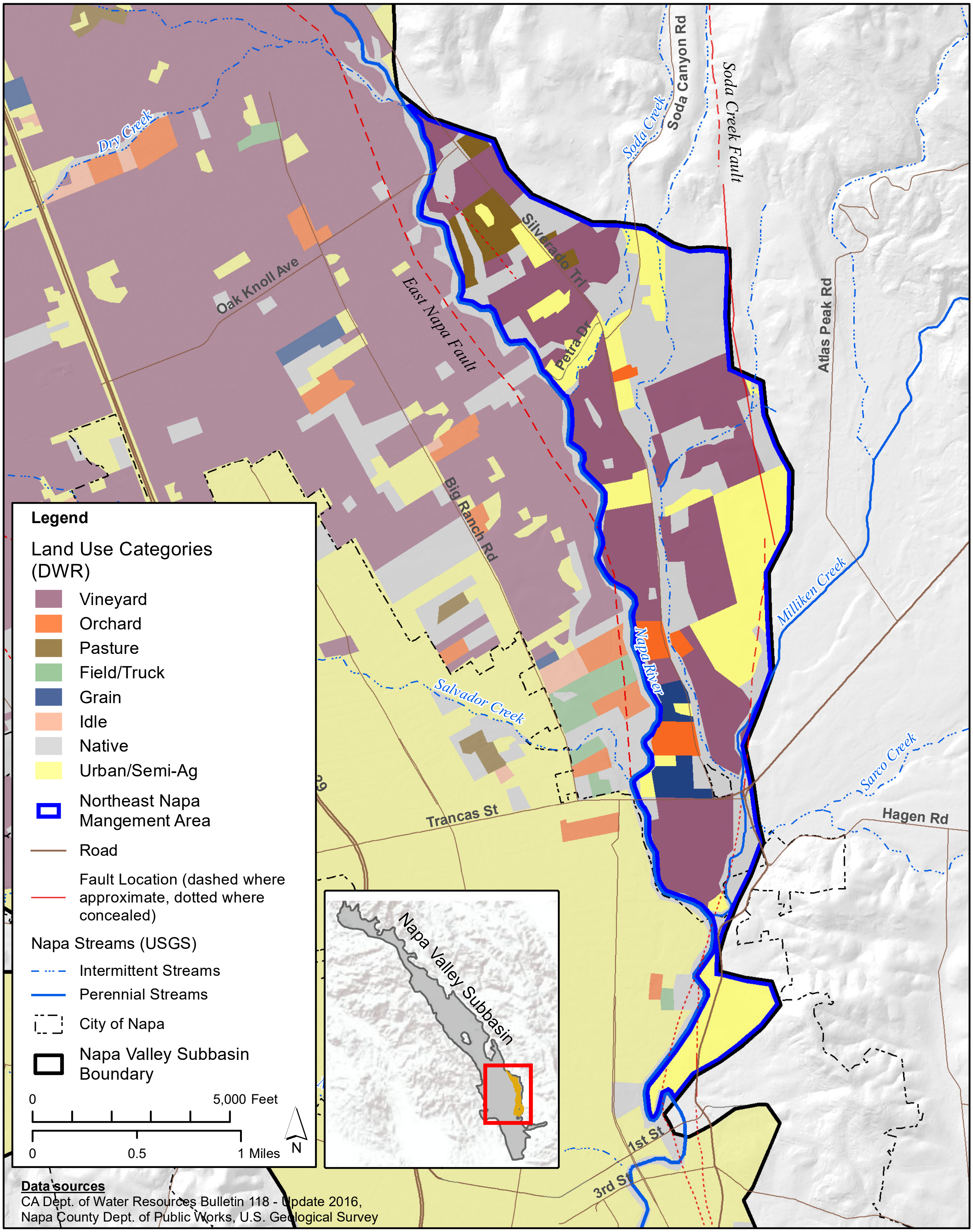

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FIGURE 2-3
Northeast Napa Management Area 1987 Land Use

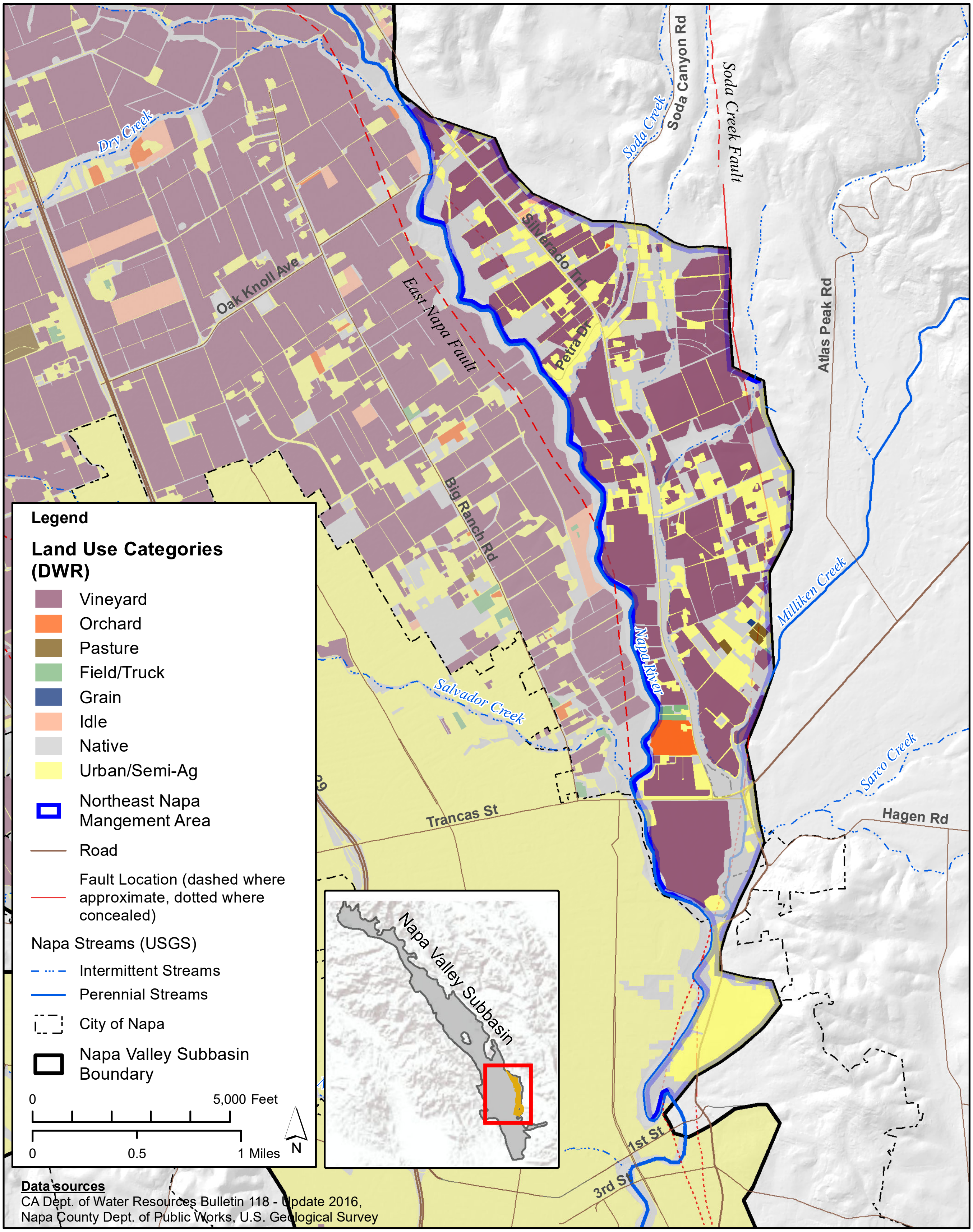

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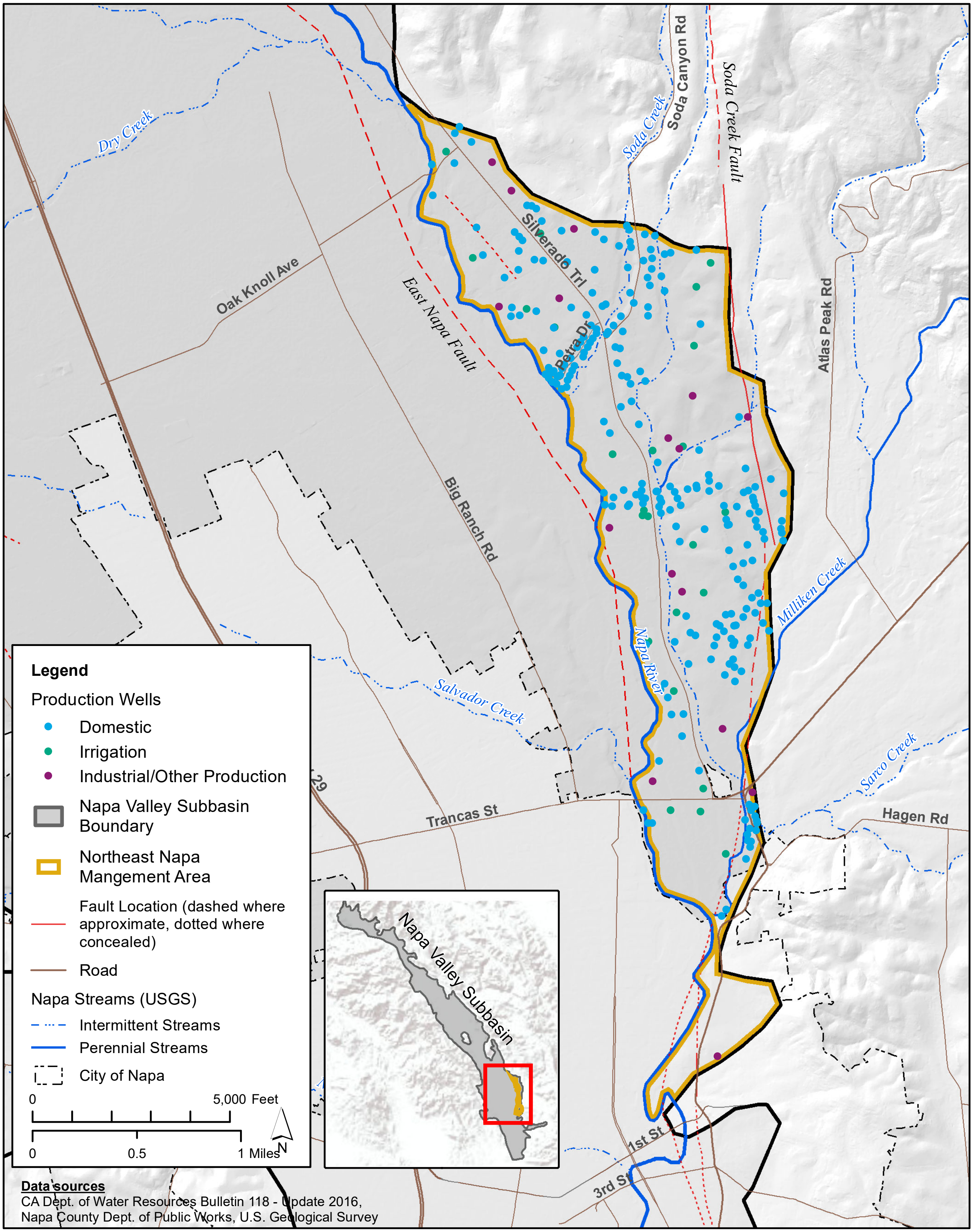
FIGURE 2-4
Northeast Napa Management Area 2011 Land Use



X:\2017\17-030 Napa Co. - 2017-2018 General Services\GIS\mapfile\NE Napa Mgmt Area\NENMA Wells by Type.mxd

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CONSULTING ENGINEERS

FIGURE 2-5
Northeast Napa Management Area
Production Wells by Type

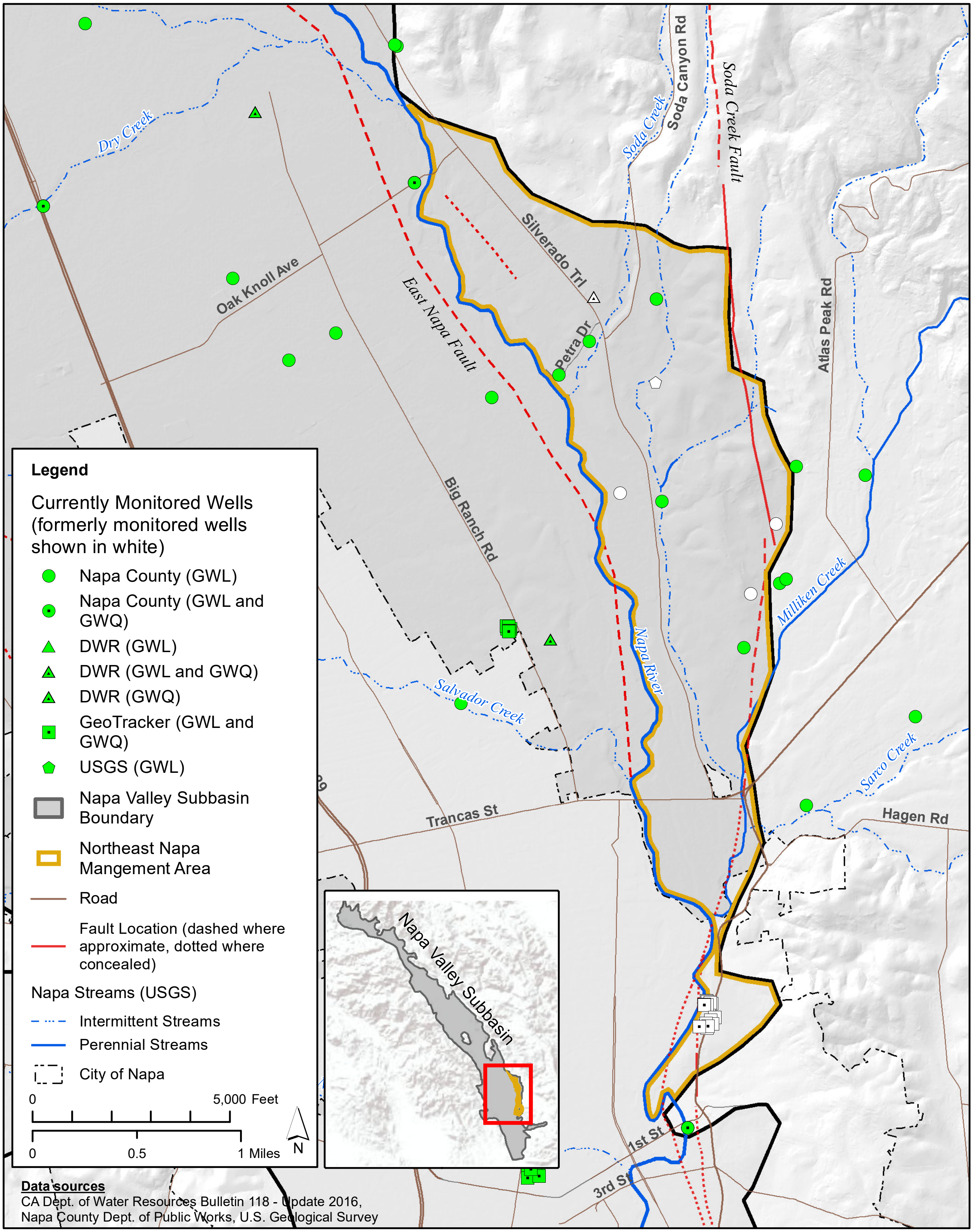

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FIGURE 3-1

Northeast Napa Management Area
Current and Previously Monitored Groundwater Sites

Napa Valley Groundwater Sustainability
Northeast Napa Management Area: An Amendment to the
2016 Basin Analysis Report for the Napa Valley Subbasin

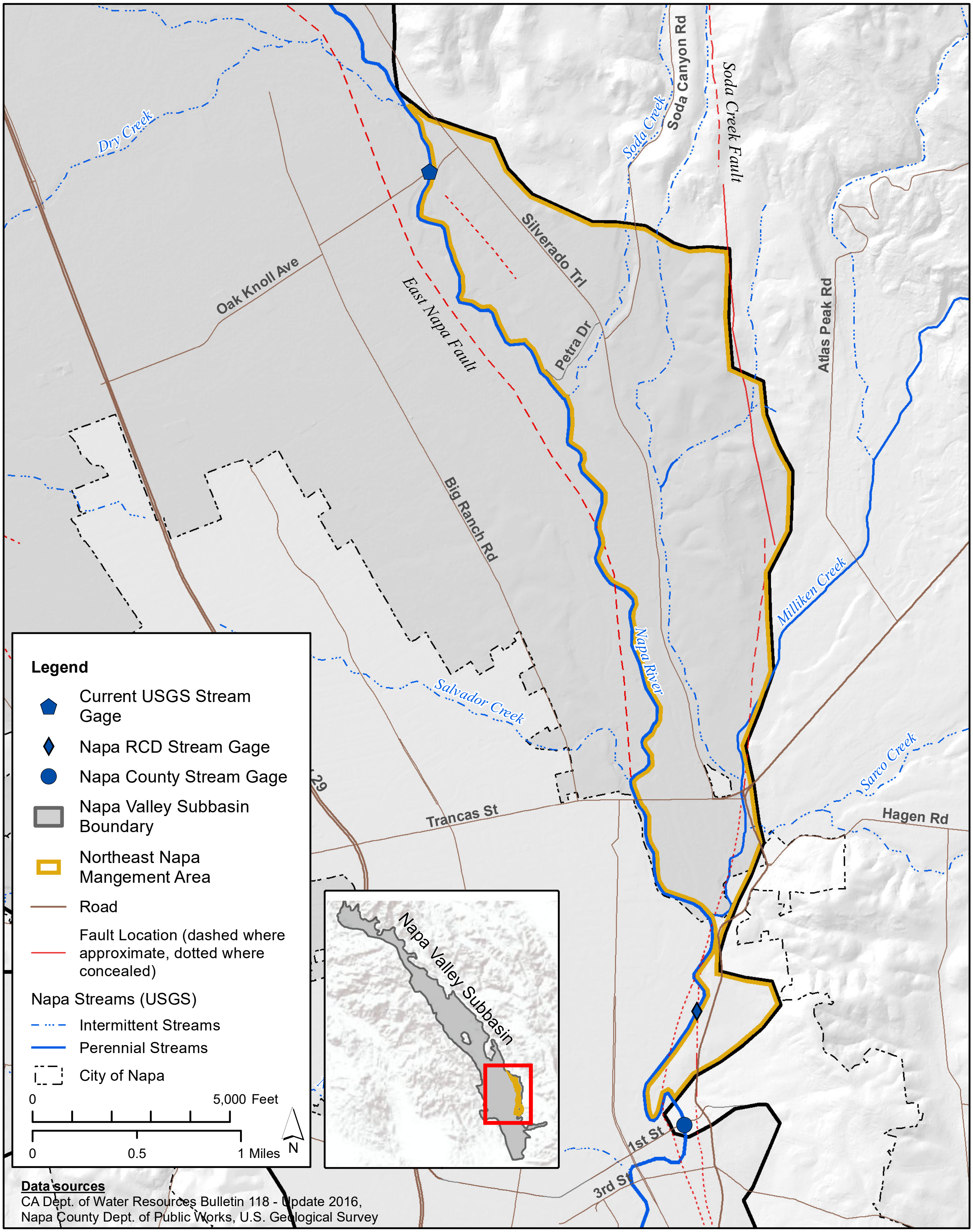

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FIGURE 3-2

Northeast Napa Management Area
Currently Monitored Surface Water Sites

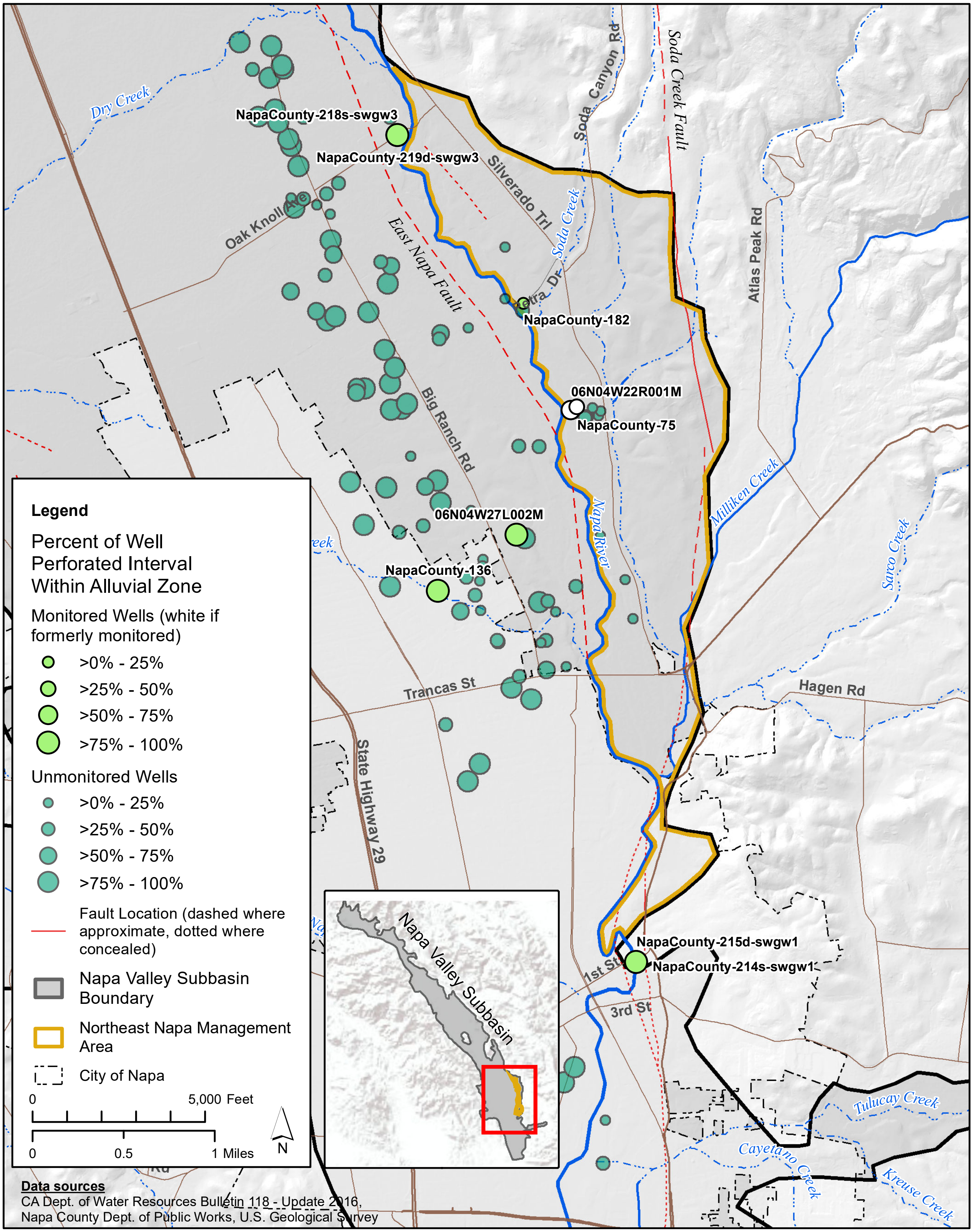

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FIGURE 3-3

Well Perforated Intervals Percent Within Alluvial Zone: Northeast Napa Management Area

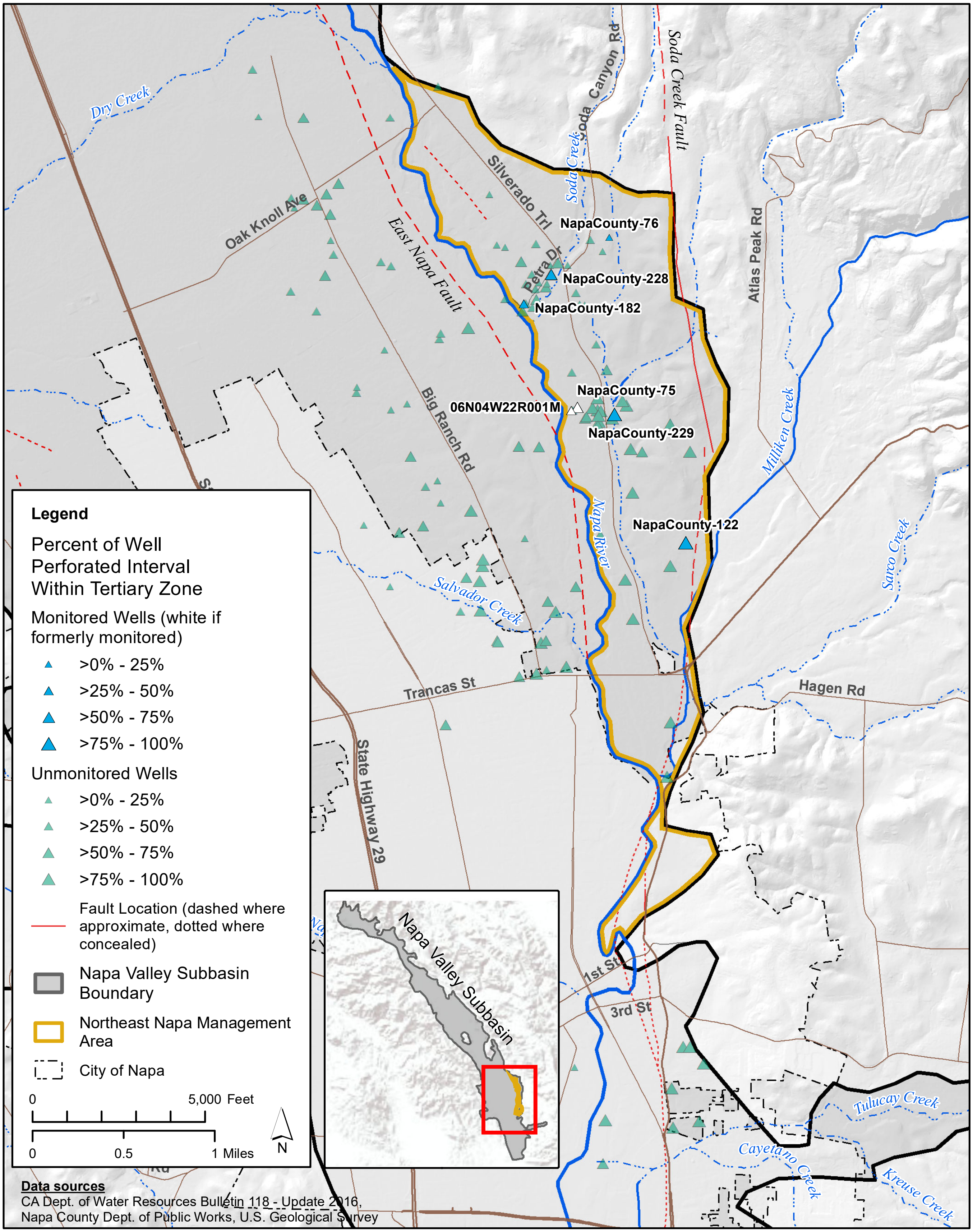

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FIGURE 3-4

Well Perforated Intervals Percent Within Tertiary Zone: Northeast Napa Management Area

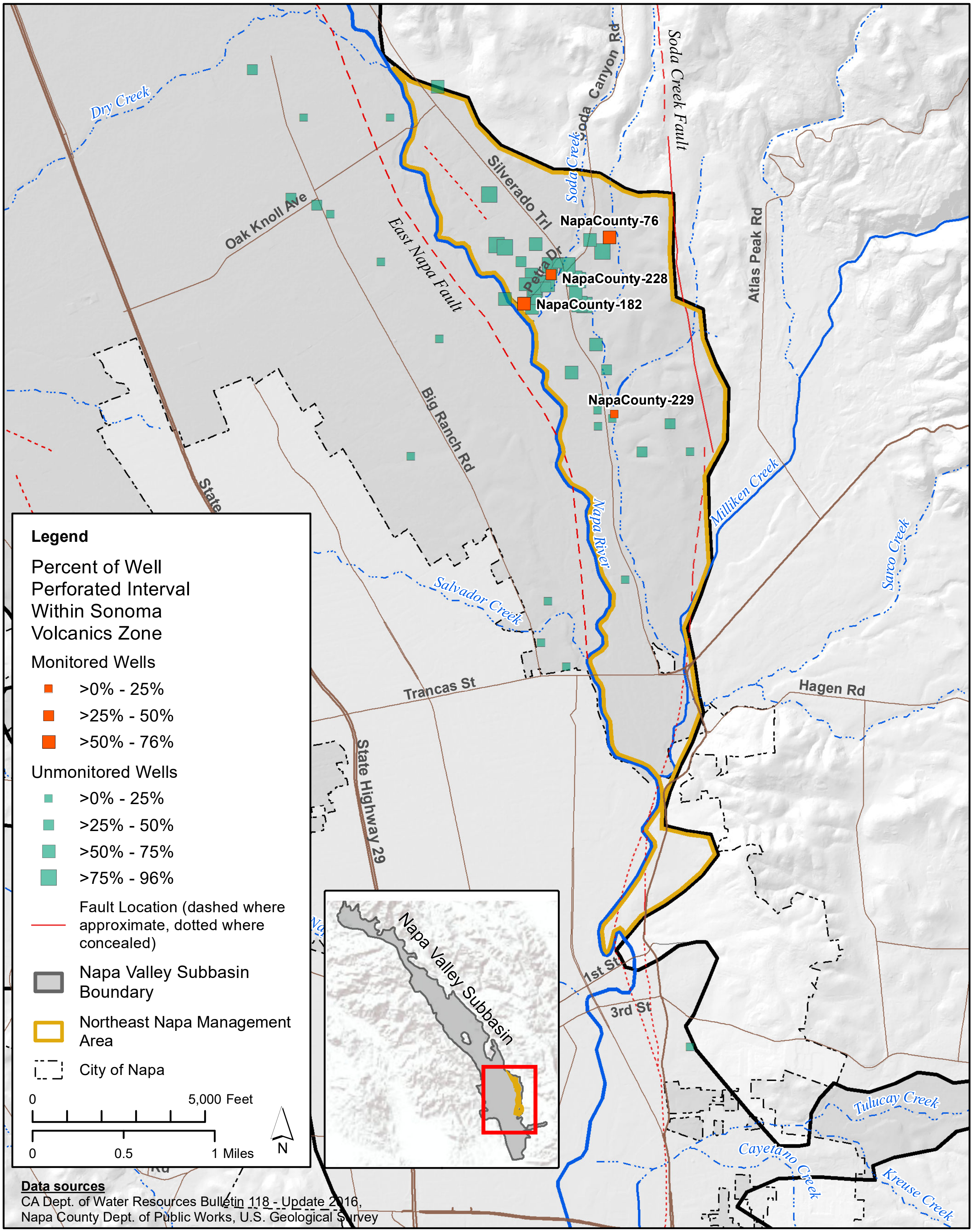

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FIGURE 3-5

Well Perforated Intervals Percent Within Sonoma Volcanics Zone: Northeast Napa Management Area

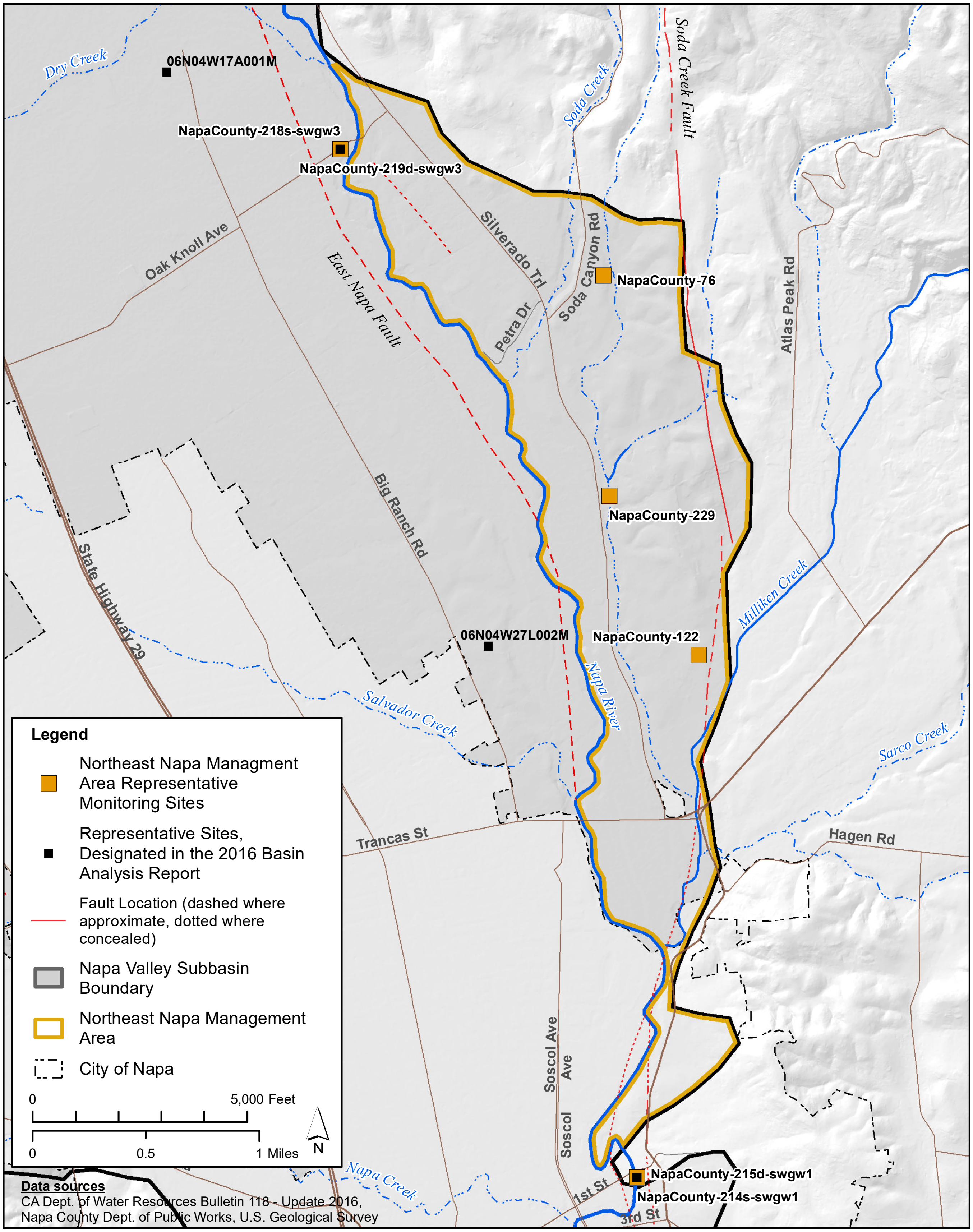

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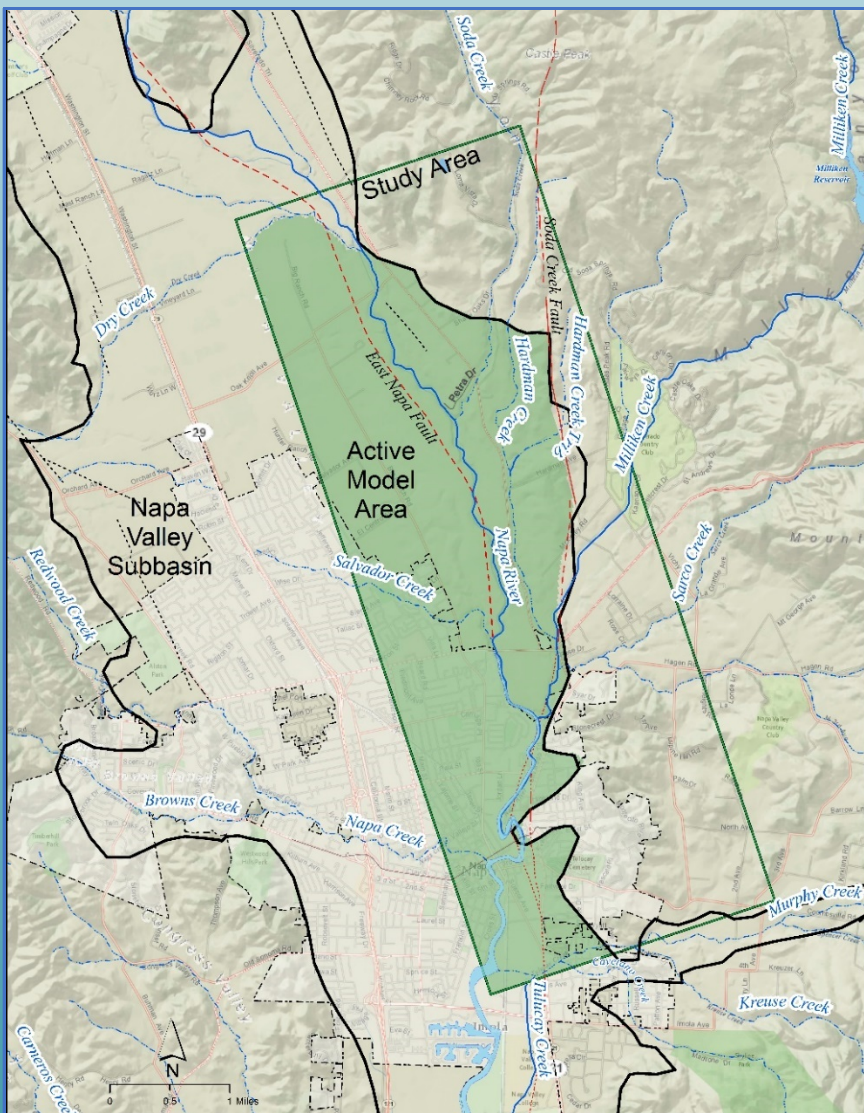
FIGURE 3-6

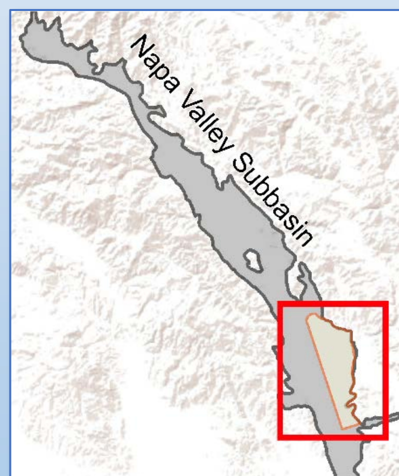
Northeast Napa Management Area: Representative Monitoring Sites

Appendix A
Northeast Napa Area
Special Groundwater Study

NORTHEAST NAPA AREA:

SPECIAL GROUNDWATER STUDY





Prepared by

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

September 2017

Northeast Napa Area:
Special Groundwater Study

Prepared for
Napa County

Prepared by

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LIST OF ABBREVIATIONS AND ACRONYMS

AF	Acre-feet
AFY	Acre-feet per year
AOI	Area(s) of Interest
AWC	Available Water Capacity
BCM	U.S. Geological Survey California Basin Characterization Model
BMP	Best Management Practices
BOS	Board of Supervisors
CalEPA	California Environmental Protection Agency
CASGEM	California Statewide Groundwater Elevation Monitoring
CCP	Center for Collaborative Policy
CDPH	California Department of Public Health
CEMAR	Center for Ecosystem Management and Restoration
CEQA	California Environmental Quality Act
CFS	Cubic feet per second
CFWS	California Fish and Wildlife Service
CGPS	Continuous Global Positioning System
CGS	California Geological Survey
CIMIS	California Irrigation Management Information System
DMS	Database Management System
DWR	California Department of Water Resources
DFW	California Department of Fish and Wildlife
EC	Electrical conductivity
ET	Evapotranspiration
eWRIMS	State Water Resources Control Board Electronic Water Rights Information Management System
ft	Feet
ft/d	Feet per day
ft^3/d	Cubic feet per day
GAMA	Groundwater Ambient Monitoring Assessment

GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information Systems
GPM	Gallons per minute
GRAC	Groundwater Resources Advisory Committee
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GPS	Global Positioning System
GWE	Groundwater Elevation
GWL	Groundwater Level
GWQ	Groundwater Quality
IRWMP	Integrated Water Resources Management Plan
ITRC	Irrigation Training & Research Center
Ksat	Saturated hydraulic conductivity
LGA	Local Groundwater Assistance
LSCE	Luhdorff & Scalmanini, Consulting Engineers, Inc.
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
MST	Milliken-Sarco-Tulucay
m.y.	Million years
NBA	North Bay Aqueduct
NCFCWCD	Napa County Flood Control and Water Conservation District
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NSH	Napa State Hospital
POD	Points of Diversion
QA	Quaternary Alluvium
Qsb	Quaternary sedimentary basin
RCD	Resource Conservation District
RWMG	Regional Water Management Group
S	Storativity
SAGBI	Soil Agricultural Groundwater Banking Index

SGMA	Sustainable Groundwater Management Act
SSURGO	Soil Survey Geographic Database
Subbasin	Napa Valley Subbasin
SWN	State Well Number
SWP	State Water Project
SWRCB	California State Water Resources Control Board
T	Transmissivity
Tca/b	Sonoma Volcanics conglomerate/breccias
Tcg/b	Tertiary Conglomerate/breccias
Td	Tertiary marine rocks
TDS	total dissolved solids
TQsb	Tertiary and early Quaternary sedimentary basin deposits
TQsbu	Tertiary - Quaternary sedimentary basin deposits undivided
Tsct	Tuff beds
Tss/h	Tertiary sedimentary rocks
Tsv	Sonoma volcanics
Tsva	Sonoma volcanics andesite
Tsvab	Andesite lava flows or breccias
Tsvt	Tuffs
µg/L	Micrograms Per Liter
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
WAA	Water Availability Analysis
WDL	Water Data Library
WELO	Water Efficient Landscape Ordinance
WICC	Watershed Information & Conversation Council
WQ	Water Quality
WTP	Water Treatment Plant
WY	Water Year

Overview

Groundwater level trends in a small portion of the Napa Valley Subbasin led to a special study of an area northeast of the City of Napa and west of the Milliken, Sarco, Tulucay (MST) Subarea. This area, referred to as the northeast Napa Area, or Study Area, shows historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall groundwater basin. The Study Area contains some wells that have historical groundwater level declines, but those levels have stabilized since about 2009. Land use in the Study Area is marked by agriculture (vineyards) and wineries, as well as urban and semi-agricultural land uses.

The County authorized this study to better understand groundwater conditions and potential factors relating to historical groundwater level declines in this localized area. Potential concerns included continued groundwater development in the area (particularly east of the Napa River), a complex hydrogeologic setting which includes mapped faults (East Napa Fault Zone, the Soda Creek Fault and other concealed faults), and the presence of the Napa River.

The study includes evaluation of the potential effects from pumping in the Study Area; potential mutual well interference in the Petra Drive area; potential streamflow effects; assessment of the potential influence of previously documented groundwater cones of depression in the MST Subarea; assessment of the groundwater supply sufficiency to meet current and potential future groundwater demands for the Study Area; and assessment of whether potential groundwater management measures or controls are warranted in the Study Area.

EXECUTIVE SUMMARY

ES 1 Introduction

In order to understand recent changes in water level trends in a small portion of the Napa Valley Subbasin, Napa County directed an investigation into the northeastern corner of the Napa Subarea (**Figure 1-1**). This area, referred to as the northeast Napa Area, or Study Area, shows historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall Napa Valley Subbasin. The Study Area contains two wells that have historical groundwater level declines of between 20 feet and 30 feet[1], but those levels have stabilized since about 2009. Due to potential concerns relating to continued groundwater development in the area, and due to the complex hydrogeologic setting which includes mapped faults and the Napa River in relatively close proximity to the area of interest, the County authorized this study to better understand groundwater conditions and potential factors relating to historical groundwater levels in the northeast Napa Area. The study includes evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in the Petra Drive area, and potential streamflow effects.

The objectives of this study are designed to:

1. Examine existing and future water use in the northeast Napa Area,

[1] Both of these wells are constructed in aquifer units with semi-confined characteristics. Groundwater level declines in these wells do not imply equivalent declines in the unconfined water table.

2. Identify sources of groundwater recharge, and
3. Evaluate the geologic setting to address questions regarding the potential for long-term effects on groundwater resources and streamflow.

Significant data collection and compilation occurred to complete the analysis. Existing information was reviewed, including well locations, well construction, and water use. Well performance data including yield, specific capacity, and pump test data (if available) were tabulated. The geologic and hydrogeologic setting was evaluated within the context of historical groundwater conditions and trends for the Study Area, and in consideration of previously mapped faults, the thickness of the alluvium, and the channel geometry of the Napa River and tributaries within the Study Area. The potential recharge to the Study Area was estimated spatially using a previously completed Root Zone Model (LSCE, 2016c). Datasets for water demands were developed for the study; these account for land uses, sources of supply, locations of wells and surface water diversions, and variations in rainfall over time. Streamflow, surface water level data (stage data), and diversion amounts were collected and estimated for the Napa River and 9 tributaries within the Study Area.

A transient numerical groundwater flow model has been developed that incorporates the data collected for a base period of water years from 1988 to 2015 to analyze groundwater conditions in the study area and the area of interest near Petra Drive. The purpose of the groundwater flow model included the assessment of potential mutual well interference of wells located in the Petra Drive area; assessment of the potential streamflow effects from current land use; assessment of the potential influence of previously documented groundwater cones of depression in the MST Subarea to the east of the Study Area; assessment of the groundwater supply sufficiency to meet current and potential future groundwater demands for the Study Area; and the assessment of whether potential groundwater management measures or controls (like those successfully implemented in the MST) are warranted in the Study Area.

ES 2 Study Area Description

The northeast Napa Study Area (Study Area) covers approximately 10,880 acres within and adjacent to the Napa Valley Groundwater Subbasin and includes about 16% of the Subbasin (**Figure 2-3**). Approximately 1,960 acres of the Study Area (about 4% of the Napa Valley Subbasin) is east of the Napa River and includes the area of interest near Petra Drive. As its name suggests, the Study Area coincides with the northeastern portion of the Napa Valley Floor – Napa Subarea. The Study Area extends south from Dry Creek to Tulucay Creek along the Napa River, for about 6.5 miles. Laterally, the Study Area extends from the eastern boundary of the Napa Valley Subbasin westward to about the midline of the Subbasin. The Study Area purposely spans the Napa River to allow for a more complete analysis of interactions between surface water and groundwater, and to facilitate comparisons of groundwater conditions east of the Napa River with conditions in the larger portion of the Napa Valley Subbasin on the west side of the River.

The numerical groundwater flow model (Model) covers the Study Area, with its Active Model Area boundaries delineated based on the Napa Valley Subbasin hydrogeologic conceptual model (LSCE, 2016c). The Active Model Area covers 6,090 acres (which is somewhat smaller than the total Study Area), with over 2,000 acres located within the City of Napa, and the remainder overlying unincorporated areas of the Napa Valley Subbasin (**Figure 1-1**). The model simulates groundwater and surface water conditions over the selected base period of water year[2](WY) 1988 to 2015. This base period represents: long-term annual water supply; inclusion of both wet and dry stress periods; antecedent dry conditions; adequate data availability; inclusion of current land use conditions; and current water management conditions.

Land use in the Active Model Area is marked by agriculture (39%), as well as urban and semi-agricultural land uses (40%). Land use surveys from 1987, 1999, and 2011 conducted by the California Department of Water Resources (DWR) were incorporated into this analysis, including some identification of irrigation water source and irrigation methods. Land use classifications used are consistent with those applied in DWR land use surveys. Agricultural uses, municipal land use, rural residential and farmsteads, and wineries were incorporated into the land use assessment in this report. Water sources for all land use classes in the Study Area include groundwater, surface water[3], and recycled water.

ES 3 Geology, Aquifers, and Groundwater Occurrence

The geologic setting of the Napa Valley Subbasin determines the physical properties of the aquifer system as well as the structural properties that influence groundwater storage, availability, recharge and flow within the subsurface. These physical and structural properties are described as part of the conceptual model for the Napa Valley Subbasin, which includes the current Study Area (LSCE, 2016c). The components of the hydrogeologic conceptual model also describe the primary processes that lead to inflows, outflows and groundwater storage.

Subbasin inflows are characterized by:

1) Root Zone Groundwater Recharge;
2) Napa Valley Subbasin Uplands Runoff;
3) Napa Valley Subbasin Uplands Subsurface Inflow; and
4) Surface Water Deliveries.

Subbasin outflows consist of:

1) Surface Water Outflow of Stormflow and Baseflow;
2) Subsurface Groundwater Outflow;
3) Consumptive Use of Surface Water and Groundwater; and
4) Urban Wastewater Outflow.

Subbasin groundwater storage consists of groundwater storage, primarily from Quaternary alluvial deposits.

[2] In this report, a water year refers to the period from October 1 through the following September 30, designated by the calendar year in which it ends (e.g., November 1, 1987 and July 1, 1988 are both in the 1988 water year).
[3] Sources of surface water in the Study Area include direct diversions from the Napa River, primarily for crop production in areas of agricultural land uses, and surface water distributed by the City of Napa from sources including the City's reservoirs in the Napa River Watershed and reservoirs outside of the Napa River Watershed that are part of the State Water Project.

The Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin underlies much of the Napa Valley and lies entirely within Napa County, overlain by the City of Napa, Town of Yountville, City of St. Helena, and City of Calistoga. Surficial geologic maps of the Napa Valley area, developed by various authors spanning over a hundred years. Three major geologic units in the Napa Valley area have been consistently recognized and remain largely unchanged, except in the names applied to them and interpretations of how they were originally formed. These three major units are Mesozoic rocks, Tertiary volcanic and sedimentary rocks, and Quaternary sedimentary deposits. These same major geologic units exist within the northeast Napa Study Area and are represented in the numerical groundwater flow model Active Model Area.

Contemporary geologic cross sections developed in the vicinity of the Active Model Area have informed the model development and have been used to incorporate the current day hydrogeologic conceptualization into the model design (LSCE and MBK, 2013). These cross sections show the general subsurface geologic patterns of the lower valley associated with the northeast Napa Study Area.

The Quaternary alluvial deposits comprise the primary aquifer units of the Subbasin. The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013). The alluvial deposits have different well yields and variable hydraulic properties. In the Study Area, alluvial deposits are a significant source of groundwater west of the Napa River; however, east of the River the alluvium is thinner and also indicated to be unsaturated in some locations. All of the Tertiary units beneath the Napa Valley Floor and beneath the Study Area appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013). Although wells completed in these Tertiary units may be locally capable of producing sufficient volumes of water to meet various water demands, their contribution to the overall production of groundwater within the Study Area is limited, and their hydraulic properties are reflective of this.

There are two main faults in the Study Area: the East Napa Fault Zone and the Soda Creek Fault (**Figure-1-1**). The East Napa Fault is a concealed fault extending northward just west of or below the river from near Trancas Street to Oak Knoll Avenue (LSCE and MBK, 2013). Evidence of the fault zone has been derived from subsurface information and from an isostatic gravity map.[4] Other concealed faults, whether mapped or not, exist in this area as part of the East Napa Fault Zone. One such fault is located on the east side of the Napa River between Petra Drive and Oak Knoll Avenue, but its northward and southward extent is still unknown. Soda Creek Fault slices through the Sonoma Volcanics along the western edge of the MST and appears to limit flow from the MST into the Napa Valley, acting as a hydrologic barrier at depth.

ES 4 Northeast Napa Area Model Development

The U.S. Geological Survey public domain software, MODFLOW (and accompanying model packages), was selected as the modeling platform to develop a numerical groundwater flow model to conduct analyses in the Study Area. The total active modeled area is approximately 9.5 square miles and contains

[4] Isostatic gravity maps depict detectable variations in gravitational force (e.g., gravity) observed over an area. After controlling for influences including latitude and tidal fluctuations, isostatic gravity maps provide a representation of geologic structure that results from variations in rock density across geologic formations.

6 model layers (**Figure 3-2**). The model grid cell size is 100 feet by 100 feet. The first three model layers (layers 1-3) compose the alluvial aquifer; the next two model layers (layers 4-5) represent the underlying Tertiary sediments and rocks; and the base layer (layer 6) represents the Sonoma Volcanics. The transient model simulates groundwater and surface water conditions over a 28-year period from 1988 to 2015. The model includes a total of 10 rivers, creeks, and tributaries. Eleven surface water diversions are also represented. The model contains 594 wells (actual and "inferred", with the latter based on estimated water demands and water sources). Irrigation pumping demands include demands for agricultural crop irrigation as well as irrigation demands for landscaping associated with residences and commercial land uses. Where groundwater is identified as the water source, water demands for indoor residential uses and winery uses were also distributed to wells in the model domain.

The model was calibrated to improve its ability to simulate groundwater level measurements from throughout the Active Model Area by adjusting the following components: aquifer parameters (horizontal and vertical hydraulic conductivity and storage), streambed conductivity, model layering, and general head boundary conditions. 182 wells with water level data were used for model calibration, including 12 County monitored wells and 4 County surface water/groundwater interaction monitored locations.

ES 5 Model Scenarios

The calibrated baseline model provides insight into the workings of the groundwater system in the northeast Napa Area.

Three sensitivity scenarios were created to evaluate groundwater and surface water responses to a range of groundwater pumping conditions within the Active Model Area, relative to the results to the baseline calibrated model. The sensitivity scenarios include:

- Reduced pumping to zero (no pumping);
- Reduced pumping to rates in each well for each month in water year 1988;
- Doubled pumping in each well for each stress period for the duration of the simulation period.

ES 6 Findings and Recommendations

The results for the northeast Napa Area study indicate that groundwater in this localized area is in balance, with inflows and outflows nearly equal, over the 28-year period studied. During drier years, groundwater levels have declined and in normal to wetter years groundwater levels have recovered. East of the Napa River, two wells in Napa County's monitoring network, completed in deeper formations, showed historical groundwater level declines; however, groundwater levels in these wells have stabilized since about 2009. The study indicates that the main factor contributing to prior declines in these wells is the effect of the cones of depression that developed in the MST in response to pumping in poorly permeable aquifer materials. The dense spacing of private water supply wells, particularly in the Petra Drive area, may also have contributed to the localized groundwater decline.

Groundwater discharge contributes significantly to the baseflow component of streamflow during most months of the year in this reach of the Napa River in the model domain, which is categorized as perennial. However, most tributaries to the Napa River in the model domain, such as Soda Creek, are categorized as seasonally intermittent. A losing condition is typical for Soda Creek during most times of the year (especially in the summer and fall), and its flows are affected more by drier water years rather than by pumping.

Typical of streams in the area, less groundwater is discharged to the Napa River during drier water years when recharge and lateral subsurface flows into the Study Area are reduced. The influence of groundwater pumping and climatic effects, represented by recharge and lateral subsurface flow, on groundwater discharge to the Napa River were analyzed using the results from the baseline calibrated model and two sensitivity scenarios: pumping restricted to 1988 pumping levels and doubled pumping relative to the estimated pumping that has occurred over the 1988 to 2015 base period.[5] Climatic effects were found to have a much greater effect on groundwater discharge to the River for all three groundwater pumping options.

Additional pumping can occur in the northeast Napa Study Area; however, targeted management measures are recommended to ensure groundwater conditions remain sustainable and streamflow depletion caused by pumping does not become significant and unreasonable. Because the northeast Napa Area, especially east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because the average annual water budget is about in balance, it is recommended that the area east of the Napa River become a management area within the Napa Valley Subbasin to ensure groundwater sustainability. The management area would include 1,950 acres (4% of the Napa Valley Subbasin) (**Figure 5-1**).

Study findings and recommended actions to maintain groundwater sustainability in the northeast Napa Area (and also the Napa Valley Subbasin) are summarized below. The recommended actions are consistent with the potential groundwater management measures referenced in the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c).

FINDINGS

A summary of the findings from the analysis of groundwater and surface water in the northeast Napa Area are listed below:

1) Groundwater storage played the smallest role in the water budget, hovering around net-zero annually (inflow equals outflow and little water depleting or replenishing storage).
2) Groundwater pumping makes up the next smallest component of flow in the model domain's water budget.
3) Lateral subsurface flow through all of the model's boundaries is generally a net positive number; more groundwater is flowing into the model domain than is flowing out through the subsurface. When groundwater does flow out of the model area through the subsurface, it typically leaves the model via the east side near the Soda Creek Fault. This is likely influenced by the lower groundwater levels in the MST driving the easterly horizontal flow gradient.
4) Recharge plays a key role; it is the second largest water budget component.

[5] The sensitivity scenario with no pumping was not included in the analysis because non-zero values are required for the analysis.

5) Within the model area flows to the Napa River dominate the groundwater budget; a large component of groundwater in the model discharges into the Napa River as baseflow. On the other hand, tributaries in the area most often discharge to groundwater, recharging the groundwater system on a seasonal basis.

6) Tributaries on the east side of the Napa River consistently show net losing[6] stream conditions over time, despite seasonal fluctuations where gaining stream conditions occur briefly. As an example, Soda Creek consistently exhibits net losing stream conditions on an annual basis (even during wet winter conditions and also during the scenario when no pumping was simulated); the Creek is more affected by precipitation, and therefore climate, than groundwater pumping in determining the rate of stream flow and leakage to groundwater.

7) The model results indicate a decreasing trend in the amount of groundwater contributing to stream flow starting in the late 1990s. As illustrated during the sensitivity scenario in which no groundwater pumping occurred, this recent trend can be attributed to less precipitation (climatic effects), and not due to groundwater pumping. Statistical analyses indicate that this trend is more related to climatic effects, including reduced recharge and subsurface lateral flows, rather than to groundwater pumping.

8) Lateral flow, the third largest component of the model domain water budget, was typically a net inflow into the area, but a trend is seen starting in 1992 that shows less regional groundwater flowing into the model area. In some years, the net annual lateral flow is out of the model domain, which may indicate a future trend, or may be the result of climatic effects during increasingly drier water years.

9) Geologic faulting in the model area is important to the overall behavior of water levels east of the Napa River. Additional concealed faults may be present, which may affect water levels in deeper wells in the Petra Drive area.

10) Statistical analyses of water budget components (including recharge, lateral flows and pumping) relative to stream leakage (groundwater contributions to Napa River baseflow) show that, over the 28-year base period, climate effects have a much greater influence on stream leakage than pumping. Climate-driven variables account for 87 to 92% of the effect on groundwater discharge to Napa River, while pumping contributes to 8 to 13% of the effect on groundwater discharge to the River.

11) Modeling scenarios showed:

    a) Annual stream leakage fluxes (in and out of the surface water) were very similar even with no pumping occurring showing minimal stream impacts due to pumping;

    b) When pumping was reduced, a slight increase in the amount of groundwater contribution to the Napa River occurred (this had about a third of the effect that subsurface lateral flow had on this type of change). For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping

[6] Water is flowing into the ground from a stream when there is no direct connection between the stream and groundwater. A stream connected with groundwater may also have a losing condition when the stage in the stream is higher than the groundwater elevation.

reduced to 1988 conditions, the relative influence of pumping on baseflow was 2%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

c) When pumping was doubled, a slight decrease in the amount of groundwater contributed to the Napa River occurred. For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping doubled, the relative contribution to baseflow effects was 10%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

12) Some drawdown effects on groundwater levels in the Petra Drive area are associated with mutual well interference; these are compounded by the high density of wells. However, these lowered levels are not as significant as the regional influence of the eastern boundary and movement of groundwater towards the MST.

RECOMMENDATIONS

A summary of the recommendations from the analysis of groundwater and surface water conditions in the northeast Napa Area is provided below.

A. **Surface Water/Groundwater Monitoring Facilities** It is recommended that the County construct shallow nested groundwater monitoring wells (like the recently installed Local Groundwater Assistance Surface Water/Groundwater monitoring facilities) east of the Napa River in the vicinity of Petra Drive. This will provide data to improve the understanding of the effect of pumping on potential streamflow depletion.

B. **Management Area Designation** It is recommended that a Sustainable Groundwater Management Act (SGMA) Management Area be designated for a portion of the Study Area, namely the Northeast Napa Area/East of the Napa River. SGMA defines a "management area" as an area within a basin for which a Groundwater Sustainability Plan (in this case, the Napa Valley Subbasin Basin Analysis Report) may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors (GSP Regulations Article 21, Section 351)(LSCE, 2016c). The northeast Napa Study Area east of the Napa River meets the criteria for management area designation due to geologic features and aquifer parameters that are distinct from those of the larger Napa Valley Subbasin.

C. **Discretionary Project WAA Review in the Management Area** For discretionary projects, it is recommended that additional project-specific analyses (Napa County Water Availability Analysis (WAA)(2015)-Tier 2) be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells).

D. **New Well Tracking in the Management Area** As a precautionary measure, it is recommended that the County track new non-discretionary groundwater wells constructed in this area, including their planned usage and location.

E. **New Well Pump Testing** It is recommended that pumping test data be collected when new production wells are constructed in areas where the distribution of hydraulic conductivities is less known, including the northeast Napa Area east of the Napa River and in deeper geologic units throughout the rest of the Napa Valley Subbasin. Because older and less productive geologic formations occur near ground surface in the northeast Napa Area east of the Napa River, it is recommended that a pump test be performed for all new production wells in that area (**Figure 5-1**). Test results will not only provide valuable information regarding aquifer properties; true pump testing will provide well owners with more meaningful information about well capacity than the typical tests of well yield reported on historical well completion reports. Similar pump testing is recommended for non-domestic production wells completed in deeper units below the Quaternary alluvium throughout the Napa Valley Subbasin.

F. **Groundwater Flow Model Development** It is recommended that a similar model be created for the entire Napa Valley Subbasin. The development of a Napa Valley Subbasin-wide modeling tool would help facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources. With the updated hydrogeologic conceptualization for the Napa Valley Subbasin and the implementation of SGMA, it is recommended for regional groundwater analyses and assessment of streamflow depletion that a groundwater flow model be developed.

G. **Increased Water Conservation and Recharge** It is recommended that countywide goals to promote sustainable use and management of water, maintain or improve ecosystem health, and increase climate resiliency receive extra attention in the northeast Napa Area. This should include evaluating approaches for retaining and using stormwater and/or tile drain water to increase water conservation, examining opportunities to reduce pumping and streamflow diversions, potentially lessening streamflow effects during drier years or drier periods of the year, and creating additional climate resiliency through targeted recharge strategies.

1 INTRODUCTION

Within the Napa Valley Subbasin, there is an area where historical groundwater level trends are different than those that are typical of groundwater level trends for the overall groundwater basin. This area, referred to below as the northeast Napa Area, or Study Area, is not considered to be representative of the overall Napa Valley Subbasin. In December 2015, Napa County staff reviewed updated groundwater monitoring data and the *Napa County Comprehensive Groundwater Monitoring Program 2014 Annual Report and CASGEM Update* (2014 Annual Report) and identified an area of potential concern, the northeastern corner of the Napa Subarea (Lederer, December 7, 2015 Memo). In this area, historical groundwater level declines had occurred in some wells, but groundwater levels have stabilized since about 2009. Because of the potential concerns relating to continued groundwater development in the area, and due to the hydrogeologic setting which includes mapped faults and the relative close proximity of the Napa River to the area of interest, the County authorized this study to better understand groundwater conditions and potential factors relating to historical groundwater level declines in this area. This analysis includes evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in the Petra Drive area, and potential streamflow effects.

1.1 Background

Groundwater level trends in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin are stable in the majority of wells with long-term groundwater level records (LSCE, 2016 and 2017). While many wells have shown at least some degree of response to recent drought conditions, the water levels observed in recent years are generally higher than groundwater levels in the same wells during the 1976 to 1977 drought. Elsewhere in the county, long-term groundwater level records are more limited, with the exception of the Milliken-Sarco-Tulucay (MST) Subarea.

Although designated as a groundwater subarea for local planning purposes, most of the MST is not part of a groundwater basin as mapped by the California Department of Water Resources (DWR). Groundwater level declines observed in the MST Subarea as early as the 1960s and 1970s have stabilized in most areas since about 2009. Groundwater level responses differ within the MST Subarea and even within the north, central, and southern sections of this subarea, indicating that localized conditions, whether geologic or anthropogenic in nature, might be the primary influence on groundwater level conditions in the MST Subarea.

While most wells in the Napa Valley Subbasin with long-term groundwater level records exhibit stable trends, periods of year-to-year declines in groundwater levels have been observed in some wells. From 2001 to 2009 water levels in spring declined by 28.8 feet at well NapaCounty-76 and 18.1 feet at well NapaCounth-75.[7] These wells are located near the Napa Valley margin, east of the Napa River, in an area where the East Napa Fault follows the Napa River and the Soda Creek Fault follows the eastern basin margin. This area (**Figure 1-1**) is characterized in part by relatively thin alluvial deposits, which may contribute to more groundwater being withdrawn from underlying semi-consolidated deposits that have low water producing properties.

[7] Both of these wells are constructed in aquifer units with semi-confined characteristics. Groundwater level declines in these wells do not imply equivalent declines in the unconfined water table.

Water levels in northeastern Napa Subarea wells monitored by the County (NapaCounty-75 and Napa County-76) east of the Napa River have stabilized since 2009, though declines were observed over approximately the prior decade. To ensure continuation of the current stable groundwater levels, further study in this area was recommended in the Napa County Groundwater Monitoring Program 2014 and 2015 Annual Reports and CASGEM Updates (LSCE, 2015 and 2016). This study was also recommended given the potential for a hydraulic connection between the aquifer units in the vicinity of these wells and those of the MST Subarea and an apparent increase in new well permits over the past 10 years.

1.2 Study Objectives

The study was designed to examine existing and future water use in the northeast Napa Area, sources of groundwater recharge, and the geologic setting to address questions regarding the potential for long-term effects on groundwater resources and streamflow.

The study began in fall 2016 and involves the following tasks and objectives:

1. Review existing information (as known and available, such as well locations, well construction, and water use) pertaining to the Study Area, including Petra Drive;
2. Evaluate the geologic and hydrogeologic setting and historical groundwater conditions and trends for the Study Area, including previously mapped faults, the thickness of the alluvium in the Study Area, especially near the Napa River and Soda Creek;
3. Tabulate and evaluate existing well performance data (to the extent available), including yield, specific capacity, and pump test data (if any);
4. Estimate potential recharge to the Study Area;
5. Assess mutual well interference, including an analysis of potential effects from the wells located in the Petra Drive area and within the overall Study Area;
6. Assess potential streamflow effects from current land use and known proposed projects;
7. Investigate the potential influence of previously documented groundwater cones of depression in the MST Subarea on the Study Area;
8. Estimate water demands for the overall Study Area along with sources of supply used to meet Study Area water demands, including demands for variable water year types;
9. Estimate groundwater supply sufficiency to meet the current and potential future groundwater demands for the overall Study Area and other potential considerations with respect to proposed future groundwater use; and
10. Evaluate whether potential groundwater management measures or controls (like those that have been successfully implemented in the MST) are warranted.

1.3 Report Organization

The Northeast Napa Area report is organized as follows:

2 STUDY AREA DESCRIPTION AND STUDY PERIOD DETERMINATION
- Base Period Selection
- Land Uses
- Water Sources
- Geology, Aquifers, and Groundwater Occurrence

3 NORTHEAST NAPA AREA MODEL DEVELOPMENT
- Model Discretization
- Model Boundary
- Physical Parameters
- Deep Percolation
- Streamflow and Diversions
- Well Locations and Pumping Demand Allocation
- Initial Conditions
- Model Calibration and Sensitivity
- Sensitivity Analysis

4 DISCUSSION OF MODEL RESULTS
- Groundwater Availability in the Model Area
- Streamflow Depletion
- Mutual Well Interference and Regional Effects on Water Levels
- Summary of Findings

5 RECOMMENDATIONS
- Surface Water/Groundwater Monitoring Facilities
- Northeast Napa Area – East of the Napa River
- Aquifer Properties
- Napa Valley Subbasin Groundwater Flow Model
- Increased Water Conservation and Evaluation of Recharge Opportunities

2 STUDY AREA DESCRIPTION AND STUDY PERIOD DETERMINATION

The Department of Water Resources (DWR) has identified the major groundwater basins and subbasins in and around Napa County; these include the Napa-Sonoma Valley Basin (which in Napa County includes the Napa Valley and Napa-Sonoma Lowlands Subbasins), Berryessa Valley Basin, Pope Valley Basin, and a very small part of the Suisun-Fairfield Valley Groundwater Basin (DWR, 2016) (**Figure 2-1)**. These groundwater basins and subbasins defined by DWR are not confined by county boundaries, and DWR-designated "basin" or "subbasin" designations do not cover all of Napa County.

Groundwater conditions outside of the DWR-designated basins and subbasins are also very important in Napa County. An example of such an area is the Milliken-Sarco-Tulucay (MST) area, a locally identified groundwater deficient area. For purposes of local planning, understanding, and studies, the county has been subdivided into a series of groundwater subareas (**Figure 2-2**). These subareas were delineated based on the main watersheds and the County's environmental resource planning areas, and with consideration of groundwater basins; these geographic subareas are not groundwater basins or subbasins. The subareas include the Knoxville, Livermore Ranch, Pope Valley, Berryessa, Angwin, Central Interior Valleys, Eastern Mountains, Southern Interior Valleys, Jameson/American Canyon, Napa River Marshes, Carneros, Western Mountains Subareas and five Napa Valley Floor Subareas (Calistoga, St. Helena, Yountville, Napa, and MST).[8]

DWR has given the Napa Valley Subbasin a "medium priority" ranking according to the criteria specified in California Water Code Part 2.11 Groundwater Monitoring (i.e., this relates to the CASGEM program).[9] The priority ranking method used by DWR primarily considers the population within a basin or subbasin, projected population growth, the density of wells, overlying irrigated agriculture, and the degree to which groundwater is used as a source of supply. As required by the 2014 Sustainable Groundwater Management Act (SGMA), in 2016 DWR published a list of basins subject to conditions of critical overdraft. No basins or subbasins in Napa County are designated on that list. In Fall 2017, DWR is due to release updated priority rankings that will incorporate additional criteria to address connections between surface water and groundwater.

The northeast Napa Study Area (Study Area) covers 10,880 acres within and adjacent to the Napa Valley Subbasin (**Figure 2-3**). As its name suggests, the Study Area contains the northeastern portion of the Napa Valley Floor – Napa Subarea. The Study Area extends from Dry Creek south to Tulucay Creek along the Napa River, for about 6.5 miles, with a width of about 2.5 miles (**Figure 1-1**). The Study Area is about 2.5 miles in width, extending from near the middle of the Napa Valley Subbasin eastward beyond the Soda Creek Fault. While the study was prompted in part due to groundwater level declines and reports of increased well replacement activity along Petra Drive east of the Napa River, the Study Area spans the Napa River to allow for a more complete analysis of interactions between surface water and

[8] Most the MST is located outside the areas that are DWR-designated groundwater basins.

[9] As part of the CASGEM Program, DWR has developed the Basin Prioritization process. The California Water Code (§10933 and §12924) requires DWR to prioritize California's groundwater basins and subbasins statewide. As such, DWR developed the CASGEM Groundwater Basin Prioritization Process. Details are available at http://www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm.

groundwater and to facilitate comparisons of groundwater conditions east of the Napa River with conditions in the larger portion of the Napa Valley Subbasin west of the River.

As part of the study, a numerical groundwater flow model (Model) has been developed to analyze groundwater conditions in the Study Area and in the vicinity of the area of interest near Petra Drive. The Active Model Area represented by the Model has boundaries delineated based on the Napa Valley Subbasin hydrogeologic conceptual model. The Active Model Area covers 6,090 acres within the Napa Valley Subbasin (**Figure 1-1**); 2,140 acres (35%) of the Active Model Area are located within the City of Napa, while 3,960 acres (65%) are in unincorporated areas of the Napa Valley Subbasin. **Sections 3.1 and 3.2** provide additional detail about the delineation of the Model boundaries.

2.1 Base Period Selection

The current study utilizes the same base period of water years (WY) 1988 to 2015 as developed for the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c). The base period selection was carried out to establish a representative period of years over which analysis can be conducted to evaluate long-term conditions, with minimal bias that might result from wet or dry periods or significant changes in other conditions including land use and water demands. The base period selection process is detailed in the Basin Analysis Report.[10] The following list is a summary of the criteria applied to the selection process. For the Napa Valley Subbasin, the base period selected spans from WY 1988 to 2015, as this period represents:

- Long-term annual water supply
  - Long-term mean water supply, or the measure of whether the basin has experienced natural groundwater recharge during a particular time period and also what the primary component is that contributes to natural groundwater recharge (in this case, precipitation).
  - Long-term precipitation records and daily average streamflow discharges for the Napa River are used.
- Inclusion of both wet and dry stress periods
  - This removes any bias that might shift the sustainable yield number away from what is representative
- Antecedent dry conditions
  - This is intended to minimize differences in groundwater in the unsaturated (vadose) zone at the beginning and at the end of the base period, assuming that any water unaccounted for in the unsaturated zone is minimized.
- Adequate data availability
  - Available hydrologic and land and water use data are sufficient during the base period.
- Inclusion of current cultural conditions
  - There are relatively stable trends in major land uses, particularly the agricultural classes which are most dependent on water sources within the Subbasin.

[10] See Section 6.1 in the Basin Analysis Report.

  - Based on three snapshots in time of the land use and water use (1987, 1999, and 2011), the acreages of agriculture classes, native classes, and urban/semi-agricultural classes remain very similar.
  - Vineyards dominate the agricultural land use, and the amount of irrigated acreage in the Napa Valley Subbasin fluctuates very little between those three snapshots (ranging between almost 17,000 acres to over 21,000 acres).
- Current water management conditions
  - Water sources for agricultural and urban entities during the base period are consistently from groundwater, surface water from local water ways, and imported via the North Bay Aqueduct

Demand for water within the Model area is determined by land uses, weather patterns, and cropping patterns, among other factors. The following sections describe the land uses and sources of water supply in the overall Napa Valley Subbasin, with an emphasis on the current Model area over the 1988 to 2015 base period.

2.2 Land Uses

For decades, land use in the Napa Valley Subbasin has been marked by agriculture (vineyards) and wineries. Total acreages of vineyards, other agricultural crops, native vegetation, and urban land uses (e.g., residential, commercial, and industrial areas occurring over a range of densities) in the Subbasin have remained relatively constant over the selected base period (LSCE, 2016c). Land use surveys were conducted by DWR in 1987, 1999, and 2011 during which DWR staff conducted thorough assessments of agricultural, urban, and native land use classes. In 1987 and 2011, DWR surveyors also recorded information on irrigation water source and irrigation methods across the land use classes.

Land use classifications used in this report are consistent with those applied in DWR land use surveys. Under this approach agriculture classes specifically reference areas used to grow a particular crop. Crop types identified in the Model area by the DWR land use surveys are summarized in **Section 2.2.1**. Across the larger Napa Valley Subbasin crop types mapped by DWR include vineyards, deciduous fruit and nut crops, citrus and subtropical crops, truck, nursery, and berry crops, grain crops, field crops, and pasture (DWR, 1987 and DWR, 2011). As mapped by DWR, agricultural classes do not include facilities primarily used for the processing of harvested crops, such as wineries. This is not equivalent to the Napa County General Plan definition of agriculture which is inclusive of winery facilities. Winery permit records and water demands are summarized in Sections 2.24 and 3.6.3, in this report.

Urban and Semi-Agricultural classes, as defined by DWR land use maps, include developed land uses that are not used for crop production. Urban sub-classes include residential, commercial, industrial, urban landscaping, and vacant land use types. Semi-agricultural sub-classes include farmsteads (with and without a residence), livestock production facilities, and miscellaneous areas such as small roads, ditches, and other areas within cropped fields that are not used for growing a crop. Wineries are not a specific land use class used by DWR, but instead are represented as semi-agricultural or urban-commercial classifications.

Due to differences in the sources of water supply for areas served by municipal water systems in the Subbasin and those areas outside of municipal service areas, this Report includes an additional distinction between municipal and unincorporated areas. Municipal areas are those within the water system service boundaries as depicted in the spatial dataset Napa County of water system boundaries maintained by Napa County, except for agricultural land use units within those boundaries, which are considered to have an independent source of supply. Unincorporated water uses referenced within this Report refer to land use units and areas of the Subbasin not served by municipal water systems, excluding the agricultural land uses that are specific to the production of a crop. These include rural residences, which may be mapped by DWR as semi-agricultural or urban-residential land uses, and wineries.

As noted in above, 65% (3,960 acres) of the Active Model Area is in unincorporated areas of the Napa Valley Subbasin. Most this area was mapped as having an agricultural land use in 1987 and 2011 (**Table 2-1**). **Figures 2-4 and 2-5** show how the urban and agriculture land uses are differentiated from north to south across the Active Model Area, with agriculture being the primary land use in the northern part of the study area and urban land uses associated with the City of Napa predominating to the south. Native vegetation and associated land use classes occur primarily along the Napa River and around ponds located within the northern portion of the study area.

Table 2-1. Active Model Area Land Use Summary

	1987 (acres)	2011 (acres)
Total Agriculture Classes	2,549	2,391
Total Native Classes [1]	1,178	1,266
Total Urban and Semi-Ag [2]	2,302	2,433
unclassified	61	-
Total	**6,090**	**6,090**

1 Native classes in 2011 include 315 acres of Napa River riparian corridor and a pond near Hardman Ave that have no designated land use class in the 2011 DWR survey data.
2 Semi-Ag classes (e.g., Farmsteads)
Sources: DWR (1987 & 2011)

2.2.1 Agricultural

Vineyards comprised much of the agricultural land uses in the Active Model Area over the base period. In 1987, vineyards and orchards comprised 91% of the total agricultural land uses, while in 2011 they accounted for 97% of total agricultural land uses (**Table 2-2)**. Out of six classes of agricultural land uses found in the Active Model Area, only vineyards and idle lands were stable to slightly increasing in size between 1987 and 2011. All other classes declined considerably, with pasture and grain acreage nearly absent in 2011.

Changes in the irrigation status were minor between 1987 and 2011 in the Active Model Area (**Table 2-3**). The total irrigated acreage in both surveys was about 4,500 acres. Areas classified as not irrigated decreased between 1987 and 2011, by about 250 acres. **Figures 2-6 and 2-7** show that despite the overall consistency in total irrigated acreage, some areas have shifted from non-irrigated to irrigated, particularly in the unincorporated portion of the Active Model Area. West of Big Ranch Road between Oak Knoll Avenue and Trancas Street several land use units are shown to have converted to an irrigated status in the 2011 survey relative to the 1987 survey.

Table 2-2. Active Model Area Agriculture Land Use Classes Summary

Agriculture Classes	1987 (acres)	2011 (acres)
Vineyard	2,129	2,294
Orchard	177	33
Pasture	80	3
Field/Truck	80	21
Grain	59	1
Idle	23	40
Total	**2,548**	**2,391**

Sources: DWR (1987 & 2011)

Another area where a similar transition occurred is east of Silverado Trail from Oak Knoll Avenue to approximately one-half mile south of Soda Creek Road. While some of these changes may be due to more precise survey methods used in 2011, some of these changes also coincide with changes in land use types between the two surveys.

Table 2-3. Active Model Area Irrigation Status – All Land Use Classes Summary

Irrigation Status	1987 (acres)	2011 (acres)
Irrigated	4,490	4,515
Not Irrigated	1,516	1,260
Total	6,005	5,775

Sources: DWR (1987 & 2011)

2.2.2 Municipal

Municipal land use in the Active Model Area consists of areas incorporated in the City of Napa. Water supplied to City of Napa customers within the Active Model Area consists of surface water from reservoirs located in the Napa River Watershed outside of the Active Model Area or from State Water Project accounts (City of Napa, 2011). Well completion reports on file with DWR show that non-municipal production wells do exist within the City. These include two community supply wells located amongst residential parcels that are very near the municipal boundary. These wells are likely associated with small community water systems not supplied by the City of Napa. **Section 3.6** provides additional information about how water demands in the Active Model Area may be met by groundwater pumping at wells located within the City of Napa.

2.2.3 Rural Residential and Farmsteads

Data from the Napa County Assessor identify 511 single family residences in the unincorporated Active Model Area. This represents 17.4 % of the total number of single family residences in the Napa Valley Subbasin. Comparisons between the unincorporated area residential and semi-agricultural (e.g., farmstead) land uses is difficult due to the limited survey resolution of the 1987 survey. However, the 2011 land use data, and well completion report records indicate that the greatest densities of residences in the unincorporated Active Model Area occur along Petra Drive, along and near Hardman Avenue, and near the intersections of El Centro Avenue and Big Ranch Road and Salvador Avenue and Big Ranch Road.

2.2.4 Wineries

Napa County records show that, as of 2015, 24 permitted wineries exist within the Active Model Area (**Figure 2-8**). As of early 2017, these include two wineries with proposed use permit modifications to increase the winery size and the scope of associated marketing activities. Three other new wineries are proposed in addition to the 24 existing, permitted wineries in Active Model Area.[11]

2.3 Water Sources

Water supplies for agricultural and urban entities are currently sourced from groundwater pumped from the Subbasin, surface water diverted and captured from local water ways within the Napa Valley Watershed, and imported surface water delivered from the State Water Project via the North Bay Aqueduct. Over the 1988 to 2015 base period, the sole water source for the City of Napa, has been surface water (LSCE, 2016c). While the population within the Active Model Area has likely increased from 1988 through 2015, the effect on water supplies within the Subbasin has been limited. The 1987 DWR Land Use survey indicates that agriculture was somewhat more reliant on surface water at the beginning of the base period, with about 60% of agricultural classes mapped as using surface water in 1987 (**Figure 2-9**). For the agricultural sector, water demand is mostly met by groundwater as identified by the 2011 DWR Land Use Survey and reports of surface water diversion filed with the State Water Resources Control Board (**Figure 2-10**). However, given the lack of agricultural water districts or large scale irrigation water conveyance infrastructure in Napa Valley, those diversions of surface water would also have been sourced from within the Subbasin, as opposed to streams or reservoirs elsewhere.

Table 2-4. Active Model Area Water Sources – All Land Use Classes Summary

Water Source	1987 (acres)	2011 (acres)
Groundwater	2,291	2,401
Surface Water	3,715	3,374
Recycled Water	-	-
Total	6,005	5,775

Sources: DWR (1987 & 2011)

2.4 GEOLOGY, AQUIFERS, AND GROUNDWATER OCCURRENCE

2.4.1 Hydrogeologic Conceptual Model

The geologic setting of the Napa Valley Subbasin determines the physical properties of the aquifer system as well as the structural properties that influence groundwater flow. These physical and structural properties are described as part of the conceptual model for the Napa Valley Subbasin, which includes the current Study Area (LSCE, 2016c). The hydrogeologic conceptual model also describes the

[11] Summaries of proposed winery modification permits and new winery permits were provided by Napa County Planning, Building, and Environmental Services Department in February 2017.

major physical components and interactions of surface water and groundwater systems within the Subbasin, to provide a framework for understanding Subbasin conditions and responses to management actions (**Figure 2-11)**.

Table 2-5 lists the components of the hydrogeologic conceptual model of the Napa Valley Subbasin developed for the Basin Analysis Report (LSCE, 2016c). The components of the hydrogeologic conceptual model are depicted in **Figure 2-11**. Together the components represent the physical properties of the Subbasin aquifer system and the primary processes that lead to inflows and outflows of water. The following sections describe the hydrogeologic conceptual model components that occur within the Study Area.

2.4.1.1 *Prior Studies*

Previous hydrogeologic studies and mapping efforts in Napa County are divisible into geologic studies and groundwater studies. The more significant studies and mapping efforts are mentioned in this section. Additional information about recent studies and mapping efforts in the Napa Valley Subbasin is available in the *Napa County Comprehensive Groundwater Monitoring Program 2016 Annual Report and CASGEM Update* (LSCE, 2017a). Weaver (1949) presented geologic maps which covered the southern portion of the county and provided a listing of older geologic studies. Kunkel and Upson (1960) examined the groundwater and geology of the northern portion of the Napa Valley. DWR (Bulletin 99, 1962) presented a reconnaissance report on the geology and water resources of the eastern area of the County; Koenig (1963) compiled a regional geologic map which encompasses Napa County. Fox and others (1973) and Sims and others (1973) presented more detailed geologic mapping of Napa County. Faye (1973) reported on the groundwater of the northern Napa Valley. Johnson (1977) examined the groundwater hydrology of the MST area.[12]

Helley and others (1979) summarized the flatland deposits of the San Francisco Bay Region, including those in Napa County. Fox (1983) examined the tectonic setting of Cenozoic rocks, including Napa County. Farrar and Metzger (2003) continued the study of groundwater conditions in the MST area.

Wagner and Bortugno (1982) compiled and revised the regional geologic map of Koenig (1963) at a scale of 1:250,000. Graymer and others (2002) presented detailed geologic mapping of the southern and portions of the eastern areas of the County, while Graymer and others (2007) compiled geologic mapping of the rest of Napa County.

In 2005 to 2007, DHI Water & Environment (DHI) contributed to the 2005 *Napa County Baseline Data Report* (DHI, 2006a and Jones & Stokes et al., 2005) which was part of the County's General Plan update (Napa County, 2008). A groundwater model was developed by DHI in conjunction with the Napa Valley and Lake Berryessa Surface Water models to simulate existing groundwater and surface water conditions on a regional basis primarily in the North Napa Valley and the MST and Carneros Subareas (DHI, 2006b). A 2007 technical memorandum, *Modeling Analysis in Support of Vineyard Development Scenarios Evaluation* (DHI, 2007), was prepared to document the groundwater model update which was used to evaluate various vineyard development scenarios. Additional geologic maps, groundwater

[12] The term MST area is used in this report when describing conditions in the general vicinity of the Milliken, Sarco, and Tulucay creeks. The term MST Subarea refers to the region defined by Napa County for water resources planning and management purposes (see **Figure 2-2**).

studies, and reports are listed in the references of the *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a).

Table 2-5. Napa Valley Subbasin Hydrogeologic Conceptual Model Components

Component	Processes
Subbasin Inflows	
Root Zone Groundwater Recharge (Recharge)	Percolation of soil moisture originating as precipitation and irrigation less losses due to evapotranspiration
Napa Valley Subbasin Uplands Runoff	Surface water flow into the Subbasin from the Napa River Watershed hillsides/uplands
Napa Valley Subbasin Uplands Subsurface Inflow	Groundwater flow into the Subbasin from upslope geologic formations
Surface Water Deliveries	Includes water imported by municipal purveyors and used to meet consumptive and non-consumptive uses
Subbasin Outflows	
Surface Water Outflow: Stormflow and Baseflow[13]	Surface water flows leaving the Subbasin through the Napa River, includes storm runoff and groundwater discharge to surface water (i.e., baseflow)
Subsurface Groundwater Outflow	Groundwater flow from the Napa Valley Subbasin into the Lowlands Subbasin through Quaternary deposits at the Subbasins' boundary
Consumptive Use of Surface Water and Groundwater	Surface water and groundwater use within the Subbasin that meet consumptive demands and result in Subbasin outflows through evapotranspiration.
Urban Wastewater Outflow	Wastewater conveyed out of the Subbasin to the Napa Sanitation District Treatment Facility
Subbasin Groundwater Storage	
Quaternary Alluvial Deposits Groundwater Storage	Groundwater stored in the unconsolidated Quaternary age deposits within the Subbasin[14]

[13] In this report the exchange of water between surface water and groundwater is referred to as "stream leakage". This term accounts for both the contribution to surface water baseflow by the groundwater system (negative stream leakage values) and the flow of water from surface waters into the groundwater system (positive stream leakage).

[14] Groundwater storage in deeper unconsolidated Tertiary deposits is discussed briefly in the model results section, but this is a very small proportion of the storage available in the Quaternary Alluvial Deposits.

In more recent years, Napa County has implemented several projects to refine the hydrogeologic conceptualization and characterization of hydrogeologic conditions particularly for the Napa Valley Floor (LSCE and MBK, 2013; LSCE, 2013, LSCE, 2016b; and LSCE, 2016c). These projects provided the first updates to the hydrogeologic conceptualization of Napa Valley outside of the MST Subarea in over 30 years, accounting for new information from hundreds of wells drilled during that time. The work conducted on behalf of Napa County has included: 1) an updated Napa Valley hydrogeologic conceptualization, 2) linking well construction information to groundwater level monitoring data, 3) groundwater recharge characterization and estimates, 4) sustainable yield analysis, and 5) analyses of surface water/groundwater interrelationships.

2.4.2 Basin/Subbasin Boundaries

As with all groundwater basins and subbasins delineated by DWR, the Napa Valley Subbasin boundary is generally delineated based on the presence of water-bearing geologic formations and boundaries to groundwater flow. The Napa Valley Subbasin was delineated based on a 1:250,000 scale map of surficial geology, resulting in some variation between the Subbasin boundary and later maps of surficial geology produced at larger scales (Wagner and Bortugno, 1982).

2.4.2.1 *Napa Valley Subbasin*

The Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin (Subbasin) underlies much of Napa Valley from a southern boundary near the Highway 12/29 Bridge over the Napa River northward for approximately 30 miles to the head of Napa Valley upstream of Calistoga (**Figure 2-1**). The Subbasin lies entirely within Napa County and is overlain in part by the City of Napa, Town of Yountville, City of St. Helena, and City of Calistoga.

The Subbasin, located in the southern-central Coast Range Province north of the San Francisco Bay region, is an active zone of complex tectonic deformation and downwarping generally associated with the San Andreas Fault. This region of the Coast Range is characterized by northwest trending faults and low mountainous ridges separated by intervening stream valleys. The Napa Valley is a relatively narrow, flat-floored stream valley drained by the Napa River. The Valley Floor descends from elevations of about 420 feet at the northwest end to about sea level at the southern end.

The Subbasin is bounded by the north, east, and west by mountainous areas. The mountains to the north are dominated by Mount St. Helena at a height of 4,343 feet. The lower mountainous area to the east of the Subbasin is the Howell Mountains declining from 2,889 feet southward through lower elevations at 2,037 feet above Stag's Leap, 1,877 feet at Mount George, and 1,630 feet at Sugarloaf south of the MST area. To the west of the Subbasin, the Mayacamas Mountains decline from peaks to 2,200 feet in the north, to about 1,500 feet northwest of Napa. Farther south, the mountainous area declines to elevations of 200 to 100 feet, then disappears beneath the plains of the Carneros area and Lowlands Subbasin that border San Pablo Bay.

Figure 2-12a describes the major rock types and deposits in Napa Valley according to relative time of formation and serves as a legend for the Napa Valley surficial geology map (**Figure 2-12b**). Minor rock types and deposits are described in their respective original sources published by Bezore and others (2002, 2004 and 2005) and Clahan and others (2004 and 2005) by the California Geological Survey and Graymer and others (2002, 2006 and 2007) by the United States Geological Survey. **Figure 2-12b** shows a composite simplification of outcropping deposits, rock types, and structural fault boundaries at the land surface in and around Napa Valley Subbasin.

Surficial geologic maps of the Napa Valley area, developed by various authors spanning over a hundred years, differ through time in the detail of mapping, characterization of rock types, and nomenclature of various units. In the last forty years, the development of radiometric-age dating techniques and the evolution of plate tectonic theory have led to a better understanding of the geologic history of the region. However, even the most recent geologic reports and maps exhibit conflicting map units, lithology, and nomenclature.

Despite the differences noted above, three major geologic units in the Napa Valley area have been consistently recognized and remain largely unchanged, except in the names applied and interpretations of how they formed. These three units are Mesozoic rocks, Tertiary volcanic and sedimentary rocks, and Quaternary sedimentary deposits (**Figures 2-12a** and **2-12b**). In the Subbasin, the geologic units are divisible into two broad categories based on geologic age, degree of lithification (i.e., the hardness or rock-like nature), and the amount of deformation (i.e., deformed by folding and faulting). These two categories are Mesozoic (older than 63 million years (m.y.)) rocks and Cenozoic (younger than 63 m.y.) rocks and unconsolidated deposits. The Quaternary deposits and Tertiary Sonoma Volcanics comprise the major geologic units within the Active Model Area.

2.4.2.2 *MST Subarea (not a basin)*

To the east of the City of Napa, there is a unique feature of a low elevation around a central low highland. The area is drained by the tributary Milliken, Sarco, and Tulucay Creeks headed on the higher mountainous area to the north, east, and south. This area is termed the MST Subarea from the contraction of the primary tributary creek names. Only the westernmost portions of the MST Subarea, between Hardman Creek and the Soda Creek Fault, and a narrow band of alluvial deposits along the lower reaches of Tulucay Creek are included in the Napa Valley Subbasin.

2.4.3 Cenozoic Rocks and Unconsolidated Deposits

The Cenozoic geologic units are divisible into two main groups: 1) the older Tertiary (post 63 m.y. – 2.5 m.y.) volcanic and sedimentary rocks, 2) and the Quaternary (2.5 m.y. – present) sedimentary deposits. The main Tertiary rocks in the Subbasin are of the youngest age, largely Pliocene (5 m.y to 2.5 m.y). These consist of volcanic rocks and sedimentary rocks which are interfingered and interbedded. The volcanic rocks are composed of a complex sequence, including lava flows and fine-grained volcanic ejecta composed of ash and flow tuffs. Variations in mineral composition, types of volcanic processes, and the location of eruption sites lead to complex relationships in the volcanic deposits which make surface mapping difficult.

The Tertiary volcanic rocks have been termed the Sonoma Volcanics; these rocks extend across much of the Subbasin and across much of Sonoma County to the west. In the Napa Valley area, the Sonoma Volcanics are exposed at the surface over large areas around the upper valley, across large areas in the Howell Mountains to the east, and at more limited areas along the west margin of the Napa Valley. Beneath the Napa Valley Floor, the Sonoma Volcanics occur largely buried beneath younger geologic units. In the Yountville Narrows, there are many small knobs of outcropped Sonoma Volcanics. In the

MST area, the Sonoma Volcanics occur in the surrounding mountains, the central upland, and beneath the entire area.

The Tertiary sedimentary rocks are more limited in surface exposures and commonly referred to as the Huichica Formation. North of Conn Creek, these rocks occur in a small area on the Napa Valley Floor margin and a larger area occurs in the adjacent mountainous area. In the MST area, Tertiary sedimentary rocks occur on the north margin and lap into the Napa Valley Floor margin. A large area of Tertiary sedimentary rocks is exposed across most of the Carneros area to the southwest of the Napa Valley. The relationship between these three areas and to the Sonoma Volcanics is not entirely clear.

The Sonoma Volcanics units which were formed at high temperatures as (e.g., lava flows and flow tuffs) appear to be well lithified, Sonoma Volcanics units formed at lower temperatures, such as landslide tuffs, ash falls, and volcanic-sedimentary interbeds appear to be weakly to moderately lithified. The thicker Tertiary sedimentary rocks also appear to be moderately to well lithified. Both the Sonoma Volcanics and the Tertiary sedimentary rocks are strongly deformed as evidenced by the commonality of steeply dipping beds, folding, and faulting.

The Quaternary (post 2.5 m.y) sedimentary deposits, collectively termed alluvium, cover the Napa Valley Floor. The youngest deposits of the current streams and alluvial fans are of Holocene age (100,000 years to present). Older deposits exposed as terraces, alluvial fans, and beneath the Holocene deposits are of Pleistocene age (2.5 m.y. to 100,000 years). At the south end of the Napa Valley Subbasin marshland, tidal flat, and estuary deposits occur. The Quaternary deposits appear to be only slightly deformed and weakly consolidated to unconsolidated. The Quaternary deposits are the primary water bearing formation of the Subbasin (LSCE and MBK, 2013; Faye 1973).

2.4.3.1 *Geologic Cross Sections*

Geologic sections developed in the vicinity of the Active Model Area have informed the model development and have been used to incorporate the existing hydrogeologic conceptual model into the model design. These five cross sections were developed as part of the updated hydrogeologic conceptualization (LSCE and MBK, 2013) and the installation report for surface water-groundwater monitoring facilities (LSCE, 2016b). The locations and details of three cross-valley geologic sections and two surface water-groundwater monitoring sites were developed and are shown on **Figures 2-13a** through **2-18** with a legend for the corresponding geologic units on **Figure 2-13b**. The following sections summarize the geologic observations on the cross sections by the various valley areas from south to north. These cross sections show the general geologic patterns of the lower valley. Quaternary alluvium (Qa) grades southward into fine-grained Quaternary sedimentary basin deposits (Qsb). The alluvium overlies Tertiary sedimentary rocks (Tss/h) which declines southward and transitions into thick, fine-grained Tertiary and early Quaternary sedimentary basin deposits (TQsb). The sedimentary rocks and basin deposits overlie the lower member Sonoma Volcanics andesite flows with tuffs (Tsva, Tsvt), which descend to depths of 1,000 feet or more below the City of Napa.

At the north end of the lower valley, cross-section D-D' appears to show Quaternary alluvium of unconsolidated deposits, including lenses of thick sands and gravel beds, especially to the east, and more widespread fine-grained clays with thin beds of sand with gravels (**Figure 2-14**). The alluvium thins east and west towards the margins of the valley. Below the alluvium, a thin sequence of finer-grained deposits occurs with some thin sand and gravel beds and some volcanic ash beds. This unit was correlated to the Tertiary sedimentary rocks (Tss/h) exposed in the MST area.

Deeper boreholes encountered volcanic materials of the lower member Sonoma Volcanics, but these appeared to occur in bands or zones. To the east, andesite lava flows and breccias with tuffs (Tsva) occur. In this area, thin Tertiary sedimentary rocks occur overlying the andesite unit. In the center of cross-section D-D’, between two possible faults, limited information indicates tuff beds (Tsct) occur, but whether these are of the lower or upper member is not clear. To the west, a mix of andesite lava flows or breccias (Tsvab?), and tuffs (Tsvt) occur; these are probably the lower member Sonoma Volcanics.

Cross-section E-E’ (**Figure 2-15**) shows a similar pattern for the Quaternary alluvium. The east side of cross-section E-E’ shows Tertiary sedimentary rocks above the Sonoma Volcanics in the MST area. Beneath the alluvium, the main valley area shows thick, fine-grained deposits with some sand and gravel beds. This unit is termed Tertiary Quaternary sedimentary basin deposits. Only one deep well (projected on to this section) encountered Sonoma Volcanics of uncertain correlation at great depth. On the west side of cross-section E-E’, lower member Sonoma Volcanics (Tsva) are overlain by sedimentary deposits of uncertain correlation (TQsu) in a fault band block.

Cross-section F-F’ (**Figure 2-16**) shows Quaternary sedimentary basin deposits (Qsb) up to about 300 feet thick and largely composed of clays with thin interbeds of sand. These are believed to be floodplain , marshland, and estuary origin. These deposits are underlain by thick clay with sands deposits of the Tertiary-Quaternary sedimentary basin deposits (TQsb). Some thick sand or sandstone beds occur interbedded with fine-grained units. The TQsb units are believed to be marshland, estuary, and lacustrine deposits. The unit may be equivalent, in part, to the diatomaceous lake beds in the MST area, and the Tertiary sedimentary rocks of the MST and Carneros areas. As such, the age of the unit would range from the Pliocene and possibly into the Quaternary (early Pleistocene). Below these units, the lower member of the Sonoma Volcanics of andesite flows and tuffs rise from great depth below the center of the valley to surface exposures, or near surface, by faulting.

Cross-section 1A-1A’ is located near the eastern margin of the Napa Valley Floor. USGS surficial geologic mapping indicates that the alluvium at the site consists of younger alluvium (Qhay) with terrace deposits (Qht) also in the vicinity (Graymer et al. 2007). Four well completion reports (WCRs) used for cross section preparation at this site indicate that Quaternary alluvium (Qa) thicknesses range from approximate 50 feet bgs east of Site 1 to approximate 200 feet bgs west of the project site (**Figure 2-17**). WCRs for a shallow monitoring well drilled nearest to the proposed monitoring well site indicates an alluvium largely composed of sandy silt and silty sand, with sand and gravel units beginning at 19 feet to 25 feet bgs. The WCR for well 05N04W02N-01, a 560-feet boring approximately 800 feet west of the project site, records two coarse-grained units beginning at 20 feet bgs and continuing to 70 feet bgs. The project monitoring well encountered similar materials from 29 feet bgs to 52 feet bgs. The lithologic log for well 05N04W02N-01 (approximately 800 feet west of the project site) records a transition from alluvial deposits to volcanic deposits at a depth of about 220 feet. Construction records for 05N04W02L-80b and 05N04W02L to the east of the project site indicate a shallower contact with volcanic rock at depths of less than 100 feet. This offset is interpreted to occur in part due to displacement by the East Napa Fault Zone (LSCE and MBK, 2013).

Cross-section 3A-3A’ is located near the eastern margin of the Napa Valley Floor. **Figure 2-18** shows the alluvium increasing in thickness from the valley margin westward to a thickness of about 100 feet near the Site 3 monitoring facilities. The alluvium at Site 3 is underlain by Sonoma Volcanics sedimentary rocks (Tss/h). Here the sedimentary rocks are thinner and underlain by the andesite flows and breccias (Tsva). Four well completion reports for wells nearest to the monitoring well at Site 3 indicate that Quaternary alluvium (Qa) thickness ranges from approximately 30 feet to 100 feet below ground surface. Well completion reports west of the Napa River indicate locally thick coarse-grained lithologic units distributed throughout the alluvium. These are consistent with observations reported for wells used in the development of cross-section D-D' in the *Updated Hydrogeologic Conceptualization and Characterization of Conditions* report (LSCE and MBK, 2013).

2.4.4 Key Geologic Formations and Structures

2.4.4.1 *Alluvium*

The Quaternary deposits comprise the primary aquifer units of the Napa Valley Subbasin. From the geologic cross-sections and correlations of other water well drillers' reports, the Quaternary alluvium was distinguished from underlying units, and an isopach map[15] was constructed (**Figure 2-19**). The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013). The fluvial facies consists of a thin narrow band of stream channel sands and gravels deposited by the Napa River. The sand and gravel beds tend to be thicker and/or more numerous in the fluvial facies area. They are interbedded with finer-grained clay beds of probable floodplain origin. Groundwater production from Quaternary alluvium is variable. According to Faye (1973), average yield of wells completed in the alluvium is 220 gpm. Wells constructed in the fluvial facies tend to be moderately high yielding (for the valley, roughly 50 to 200 gpm). Many wells drilled in the alluvium within the last 30 years extend beyond the alluvium and into the underlying Cenozoic units.

The alluvial plain facies of the Quaternary alluvium extends outward from the central fluvial facies and thins to zero thickness at the edge of the valley sides (**Figure 2-19**). These deposits consist of interbedded sandy clays with thin beds (less than 10 feet thick) of sand and gravel and appear to have been deposited as tributary streams and alluvial fans. Wells constructed in the alluvial plain facies tend to be low yielding, ranging from a few gpm to a few tens of gpm. By at least 1970, most wells drilled on the alluvial plain facies were constructed to deeper depths into the underlying Sonoma Volcanics.

At the northern end of the lower valley, the sedimentary basin facies of the alluvium is characterized by fine-grained silt, sand, and clays with thin to scattered thicker beds of sand and gravel. The sedimentary facies is believed to be floodplain deposits that extend to the southern marshland/estuary deposits. As noted, the extent of this facies is poorly known due to lack of well control farther south. Limited information indicates low to moderate well yields of a few gpm to possibly up to 100 gpm. Again, the lack of pump test information makes hydraulic properties of the deposits difficult to assess. Portions of Napa Valley north of Deer Park Road were not characterized according to their Quaternary alluvial facies by LSCE and MBK (2013).

[15] Isopach contours are lines of equal thickness and represent the depth to the bottom of alluvial deposits from the land surface at a given location.

2.4.4.2 *Sonoma Volcanics*

Beneath the alluvium is a complex sequence of Tertiary sedimentary deposits (Huichica Formation) and igneous deposits of the Sonoma Volcanics. These units are strongly deformed by folding and faulting and have complex stratigraphic relationships. A structure contour map (elevations) of the top of these subcrop units where they are in contact with overlying alluvium (**Figure 2-20**) was developed from the geologic cross-sections, lateral correlations, and surficial map relationships (LSCE and MBK, 2013). From north of the City of Napa and southward, these deposits are dominated by fine-grained basin fill with few sand and gravels of floodplain, estuary origin. North towards Yountville, sedimentary deposits of the Huichica Formation appear to overlie Sonoma Volcanic andesites and tuffs.

All of the Tertiary units beneath the Napa Valley Floor appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013). Although wells completed in these units may be locally capable of producing sufficient volumes of water to meet various water demands, their contribution to the overall production of groundwater within the Subbasin is limited.

2.4.4.3 *Faults*

East Napa Fault Zone

The east boundary fault has been mapped in the Active Model Area as a concealed fault extending northward just west of or below the river from near Trancas Street to Oak Knoll Avenue (**Figure 1-1)** (LSCE and MBK, 2013). Evidence of the fault zone has been derived from subsurface information and from the isostatic gravity map[16] from Langenheim and others (2006). LSCE and MBK (2013) found some subsurface evidence that a concealed fault may extend northward below the trend of Napa River parallel to the valley side, with a secondary segment located east of the Napa River between Petra Drive and Oak Knoll Avenue. This fault zone may extend further north on the east side of the Yountville Narrows as shown on the California Geological Survey (CGS) map of the Yountville Quad (Bezore and others, 2005).

Soda Creek Fault

The Soda Creek Fault slices through the Sonoma Volcanics along the western edge of the MST (**Figure 1-1**). To the west of the fault the Sonoma Volcanics have been down dropped as much as 700 feet and covered by the younger Cenozoic alluvium (Qoal) described above. The Soda Creek Fault appears to limit flow from the MST into the Napa Valley. Others have concluded that this fault acts as a hydraulic barrier at depth. This study re-considers that finding using the numerical flow model described in **Section 3**.

[16] Isostatic gravity maps depict detectable variations in gravitational force (e.g., gravity) observed over an area. After controlling for influences including latitude and tidal fluctuations, isostatic gravity maps provide a representation of geologic structure that results from variations in rock density across geologic formations.

2.4.5 Hydrologic Features

2.4.5.1 *Streams*

In addition to the mainstem Napa River, streams within or adjacent to the study area include Dry Creek, Soda Creek, Salvador Creek[17], Hardman Creek[18], Milliken Creek, Sarco Creek, Napa Creek, Tulucay Creek, and Cayetano Creek (**Figure 1-1**). Within the Active Model Area only the Napa River and Milliken Creek are designated as perennial streams by the USGS. Nevertheless, surface water-groundwater interactions are considered along all of the streams and the Napa River within the Active Model Area for this study.

2.4.5.2 *Tile Drains*

An uncertain number of vineyards in the Active Model Area have subsurface drain tile systems installed to remove shallow groundwater from the root zone to benefit crop health at certain stages of growth. No public data on the specifics of tile drains in the Subbasin are available presently, but the prevalence of farm ponds across the Valley and the incentive to reuse water when possible suggests that a portion of the drained water offsets groundwater pumping.

[17] The name Salvador Creek is used in the U.S. Geological Survey National Hydrography Dataset. Other sources refer to this feature as Salvador Channel.

[18] Hardman Creek is a tributary to Milliken Creek. The name Hardman Creek is a designation developed for this study because it was necessary to account for its flows into the Study Area separately from the flows from Milliken Creek because the two streams enter the Study Area at different locations. The U.S. Geological Survey National Hydrography Dataset and a dataset of streams maintained by Napa County show this feature as an unnamed intermittent stream. It has a confluence with Milliken Creek near Monticello Road and Silverado Trail.

3 NORTHEAST NAPA AREA MODEL DEVELOPMENT

The Northeast Napa Area Model is developed using the MODFLOW-NWT platform, utilizing the Newton-Raphson formulation for MODFLOW-2005. This platform was selected due its ability to improve solution of unconfined groundwater flow problems. This platform also helps with solving problems involving drying and rewetting nonlinearities of the unconfined groundwater flow equation. The Northeast Napa Area Model also utilizes the Streamflow Routing Package (SFR2) for MODFLOW, due to its ability to include unsaturated flow beneath streams, along with other stream/aquifer interactions, and diversions of surface water from streams for surface water deliveries. Another MODFLOW package that the Northeast Napa Area Model utilizes is the Revised Multi-Node Well (MNW2) Package. This package can simulate wells that are open to multiple aquifers, which can provide preferential pathways to flow that short-circuit normal fluid flowlines, as well as account for wells' being partially penetrating within a model layer or aquifer unit. The General Head Boundary (GHB) Package for MODFLOW was also used for most of the model boundaries.

3.1 Model Discretization

3.1.1 Model Domain Discretization

The Active Model Area (or active model domain) coincides with the western and southern boundary of the Study Area. The active model domain is bounded in the north by Dry Creek on the northwest and the edge of the alluvium on the northeast. The eastern boundary of the active model domain is the Soda Creek Fault and the edge of the alluvium. The active model domain's boundary is made up mostly of general head boundaries except for the northeastern edge of the alluvium which is a no-flow boundary (**Figure 3-1a and 3-1b**).

The total active modeled area is approximately 9.5 square miles (6,090 acres) on a finite-difference grid comprising 359 rows and 132 columns, and 6 layers. About 56 percent of the cells are active. The model has a uniform horizontal discretization of 100 feet by 100 feet, and is oriented parallel to the Napa Valley axis, at about 19.5 degrees west of north.

The vertical discretization of the model consists of six layers that generally thicken with depth. The top layer (layer 1) has an upper altitude of land surface. The first three model layers compose the alluvial aquifer; the next two lower model layers represent the underlying Tertiary sediments and rocks; and the base layer, layer 6, represents the Sonoma Volcanics. The base of the alluvium is used as the bottom of layer 3, and the bottom of the model (bottom of layer 6) represents 1,200 feet below land surface to accommodate the deepest wells in the area (**Figure 3-2**).

The depth of layer 3, the base of the Quaternary alluvium, is based on previous work by LSCE (LSCE and MBK, 2013), which mapped the isopach and facies of the alluvial units in the Napa Valley Floor. The alluvium ranges in thickness from less than a foot on the eastern edges of the model domain (where the Tertiary deposits and the Sonoma Volcanics outcrop) to almost 250 feet in the northwest and western portion of the model (**Figure 3-3**). There are many occurrences of interbedded clay deposits seen in well completion reports on the east side of Napa River. To capture the nature of this heterogeneity, the Quaternary alluvium is generally divided equally into the model's uppermost three layers to allow for different aquifer properties to be assigned with depth.

Layers 4 and 5 are comprised of Tertiary and early Quaternary sedimentary basin deposits (TQsb) on the western portion of the active model domain, and Tertiary sedimentary rocks (Tss/h) on the east and north. The base elevation of layer 5 is interpolated from geologic cross sections that denote the depth to the bottom of these two units. The East Napa Fault Zone provides sharp changes in the depths of layer 5 (LSCE and MBK, 2013). The thickness of these deposits, making up the combined thickness of layers 4 and 5, ranges from less than 50 feet in the northeast model area to over 300 feet and as thick as 600 feet in the southern portion of the model (**Figure 3-4**). The thickness of layers 4 and 5 are equal, equally dividing the Tertiary unit in half.

Layer 6 consists of the lower Tertiary member Sonoma Volcanics andesite flows and tuffs, which descend to depths of 1,000 feet or more below the City of Napa. Layer 6 on the west side of the model domain represents the tuffaceous Sonoma Volcanic unit (Tsvt), and the east side of the model domain represents the andesite lava flows and breccias with tuff seen in the Tsva unit (LSCE and MBK, 2013). The base of layer 6 occurs at approximately 1,200 feet below land surface, with thicknesses ranging from about 500 feet in the south to over 1,000 feet in the northeast (**Figure 3-5**).

3.1.2 Temporal Discretization

The flow model is transient; this means it has many different stress periods which are divided into time steps. To represent the agricultural growing season adequately, the annual hydrologic cycle was divided into 12 monthly stress periods. Model stresses, including boundary conditions, pumping, recharge, surface water diversions, and streamflows are constant within each monthly stress period. Variations in stresses are simulated by changing stresses from one monthly stress period to the next. Stress periods for this model were further divided into two time steps for which water levels and flows were calculated. The total simulation length was 28 years (or 336 monthly stress periods), from October 1987 through September 2015.

3.2 Model Boundary

3.2.1 General Heads

The active model boundary consists of no-flow cells in the northeast and general head boundaries elsewhere. The general head boundaries allow for groundwater to move in and out of the model domain with more flexibility compared to a specified head or constant head boundary. The general head boundary cells are defined for each monthly stress period based on groundwater level elevations and monthly fluctuations interpolated from available groundwater level measurements.

Available groundwater level data from 41 wells within and adjacent to the Active Model Area were used to generate spatially continuous spring and fall seasonal raster datasets for each year of the base period and encompassing all general head boundary cells. Wells with data were classified according to their construction information as representative of unconfined aquifer conditions (associated with model layers 1 to 3) or semiconfined to confined aquifer conditions (associated with model layers 4 to 6). Interpolations of available data occurred separately for the unconfined and semi-confined to confined datasets. Semi-annual head boundary values defined for each general head cell were then interpolated temporally for each cell to define the boundary head for both unconfined and semiconfined to confined conditions for all 336 monthly stress periods.

An adjustment to the general head boundaries occurred during calibration to obey the observed vertical hydraulic gradient on the east side of the Model where the Soda Creek Fault is coincident with the model boundary. Although it remains unknown what the exact effect the Soda Creek Fault has on the aquifer units on either side of it, wells completed in deeper parts of the Tertiary sediments and the Sonoma Volcanics are known to have lower water levels compared to wells completed in upper portions of the Tertiary sedimentary unit. General heads in layer 5 were decreased by 30 feet from the potentiometric surface seen in layer 4; general heads in layer 6 were decreased by 80 feet from those in layer 4. This allowed the Model to simulate the vertical hydraulic gradient that is observed in wells completed at different depths within the subsurface in that area, which is assumed to be a result of the Soda Creek Fault.

3.3 Physical Parameters

3.3.1 Aquifer Parameter Data

Aquifer properties were initially assigned according to the range of hydraulic conductivity values developed by LSCE in 2013 (LSCE, 2013). Specific yield and storage values were assigned based on typical values for unconfined, semiconfined, and confined aquifers.

3.3.1.1 *Horizontal Hydraulic Conductivity, Kh*

Existing literature provided initial estimates of horizontal hydraulic conductivity. Estimates for aquifer hydraulic conductivity ranges were developed and reported in LSCE (2013) for the Quaternary alluvium. The Quaternary alluvium and sedimentary basin deposits on the west and east sides of the Napa River have slightly lower hydraulic conductivities compared to the thin band of high conductivity fluvial deposits running in a north-northwest to south-southwest direction on the west side of the East Napa Fault Zone. Well completion reports and existing cross sections do not depict any continuous clay unit that would provide a defined aquitard unit. Rather, the well completion reports illustrate that the Quaternary alluvium deposits on the east side of the model area exhibit some degree of heterogeneity with depth, with the presence of interbedded clay beds of varying thicknesses. To capture this heterogeneity within the Quaternary alluvium on the east side of the model, the occurrence of a lower conductivity unit is simulated on the east side of the model in layer 2. Layer 3's hydraulic conductivity on the east side is greater than layer 2 and relatively lower than layer 1, to be consistent with the interbedded nature of clays in that area with depth. The hydraulic conductivity for layer 1, the uppermost layer, is related to the recharge potential (O'Geen et al., 2015) to appropriately allow recharge to percolate down to the water table. This was done by applying the range of estimated hydraulic conductivity for the horizontal conductivity (HK, or Kx and Ky) to the recharge potential units of the Soil Agricultural Groundwater Banking Index (O'Geen et al., 2015), and then applying a multiplier to achieve the vertical hydraulic conductivity (VK, or Kz).

The hydraulic conductivity of the Tertiary sedimentary rocks (Tss/h) in the north and east of layers 4 and 5 is low, consistent with the thin sequence of finer-grained deposits with some thin sand and gravel beds and some volcanic ash beds. This unit is reported to have slightly higher well yields compared to the Sonoma Volcanics below it, but it still has low well yields (LSCE and MBK, 2013). The Tertiary and early Quaternary sedimentary basin deposits (TQsb) in layers 4 and 5 have lithologic characteristics similar to those recorded in the Tertiary sedimentary rocks – fine-grained, clay with sand deposits.

Hydraulic conductivity values in layer 4 are the same as in layer 5, but differ between the Tss/h on the east and the TQsb on the west, with slightly higher hydraulic conductivity values on the west compared to the east.

The hydraulic conductivity of layer 6 represents either the andesitic Sonoma Volcanics on the east or the tuffaceous Sonoma Volcanics on the west. The andesite unit of the Sonoma Volcanics has lower hydraulic conductivity compared to the tuffaceous unit, and the hydraulic conductivities for layer 6 reflect this.

The calibrated horizontal hydraulic conductivity distribution is shown for all 6 layers **Figure 3-6**.

3.3.1.2 *Vertical Hydraulic Conductivity, Kv*

Generally, the vertical hydraulic conductivity is an order of magnitude lower than the horizontal hydraulic conductivity. There are four exceptions to this general rule in the Model. One exception lies in areas where upper model layers are extremely thin; as seen on the eastern part of the Model, where the Tertiary sediments and Sonoma Volcanics outcrop, where layers 1, 2, 3, and sometimes 4 are essentially non-existent placeholders. These areas are assigned very thin thicknesses (about 0.1 feet thick) and high vertical conductivity for the Model to allow for recharge to pass through directly to the exposed Tertiary sediments and Sonoma Volcanics unit appropriately. A second exception to this general rule of vertical conductivity being one order of magnitude less than the horizontal conductivity occurs in layer 1, the uppermost layer, where the recharge potential (O'Geen et al., 2015) as a percentage is used as a multiplier to the horizontal conductivity. This allows the Model to more accurately depict layer 1's soil properties' ability to transmit recharge water to the lower layers of the aquifer materials. A third exception occurs in the Tertiary sedimentary rocks (Tss/h) unit on the east side of Napa River, where more vertical hydraulic gradients are observed in water levels from wells in this area. Instead of one order of magnitude lower for vertical hydraulic conductivity, this unit has a vertical hydraulic conductivity that is three orders of magnitude lower compared to the horizontal hydraulic conductivity. The fourth, and last, exception is for the conductivity of fault cells representing the East Napa Fault Zone and the concealed fault to the east of the Napa River in the northeast area of the model. Here, these cells are assigned a very low hydraulic conductivity for both the horizontal and vertical direction parameters.

The calibrated vertical hydraulic conductivity distribution is shown for all six layers **Figure 3-7**.

3.3.1.3 *Storage Coefficient*

The storage values for the model are typical of unconfined, semi-confined, and confined aquifers, with layer 1 representing a more unconfined aquifer; layers 2 and 3 represent a more semi-confined to confined aquifer, and layers 4 and 5 have storage values in the confined aquifer range. Storage values were developed during model calibration to accommodate variability in water levels as seen by seasonal fluctuation in observed water levels with depth. Storage values decrease with depth and range from 0.001 in layer 1 to 1e-7 in layers 4, 5, and 6.

3.3.1.4 *Fault Zones*

During model calibration, two wells (e.g., NapaCounty-182 and NapaCounty-228) were showing measured water levels significantly lower than simulated water levels. Even with adjusting aquifer parameters and general head boundary conditions to improve the vertical hydraulic gradient, it became evident that wells in this area may be subject to some other hydrogeologic function. The East Napa Fault Zone, on the west side of the Model in that area was initially only used to help create the shift of the model layering where layers 4 and 5 were shifted up on the east. During calibration, a two to three-cell wide line of low permeability cells was placed in layers 4, 5, and 6 (the Tertiary sedimentary rocks and the Sonoma Volcanics) to represent a suspected hindrance to flow along the fault boundary. Simulated water levels improved in those wells of concern, but still not enough to capture the full picture. Another concealed fault has been mapped on the east side of the Napa River (LSCE & MBK, 2013), which is located between approximately 500 and 1,000 feet east of the Napa River near Petra Drive. This fault was added to the model simulation as a 200-foot wide low permeability unit with the same hydraulic conductivity as the East Napa Fault Zone (1e-3 ft/d) in layers 4, 5, and 6. The Soda Creek Fault on the east side of the Model is not explicitly simulated in the same manner as the two previous faults because it coincides with part of the eastern general head boundary. This part of the general head boundary is assigned lower heads in layers 5 and 6 to account for the vertical hydraulic gradient that occurs near this area.

3.3.2 Stream Alignments and Streambed Properties

The surface water bodies present in the flow model consist of a total of 10 rivers, creeks, and tributaries. Eleven surface water diversions are also represented in the model area. The surface water bodies are simulated using MODFLOW's Streamflow Routing Package as shown in **Table 3-1**.

These surface water features have incised below the ground surface. To accommodate this with the model layering, the bottom elevation of layer 1 coincides with of the bottom of the streambed thickness. The streambed thickness was set to 5 feet for all tributaries to the Napa River. The Napa River is simulated to have a streambed thickness of 5 feet in the northern portion of the model domain, 7 feet in the middle of the model area, and 10 feet in the southern portion of the model domain. Streambed conductivity was a calibrated parameter to allow for the appropriate relationship of baseflow to groundwater recharge to occur (LSCE, 2016c).

3.4 Deep Percolation

The recharge for the model period is based on spatial interpolation from LSCE's Root Zone Model (LSCE, 2016c). The Root Zone Model uses land use information, crop type, root depths, water source (surface water/groundwater), irrigation type, soil properties (moisture capacity, soil type, etc.), precipitation, and evapotranspiration data. Transient monthly recharge values are applied to each active model cell for the duration of the model time period. Recharge values are spatially interpolated to model grid cells using Root Zone Model data for water years 1988 to 2015. Examples of the monthly variability in groundwater recharge are shown using April 2003 (**Figure 3-8**) and December 2002 (**Figure 3-9**).

Table 3-1. Surface Waters Represented in the Active Model Area

Surface Water Body	SFR Segments	Stream Outflow
Napa River	1-19	Not applicable (leaves model through southern boundary)
Soda Creek	20-26	Enters Napa River
Hardman Creek	27-32	Enters Milliken Creek
Hardman Creek Tributary	33-34	Enters Hardman Creek
Milliken Creek	35-36	Enters Napa River
Sarco Creek	37-38	Enters Milliken Creek
Salvador Channel	39-42	Enters Napa River
Tulucay Creek	43-47	Enters Napa River
Cayetano Creek	48-49	Enters Tulucay Creek
Napa Creek	50-54	Enters Napa River

Diversion ID	SFR Segment	Diverting water from:
A023886B	55	Napa River (seg 2)
S002619	56	Napa River (seg 6)
A002914	57	Napa River (seg 8)
S002270	58	Napa River (seg 9)
S022596	59	Napa River (seg 10)
A025449	60	Napa River (seg 10)
A000631	61	Napa River (seg 13)
S015457	62	Napa River (seg 13)
A023522	63	Salvador Channel (seg 42)
S015025	64	Salvador Channel (seg 42)
S001799	65	Napa River (seg 17)

3.5 Streamflow and Diversions

The datasets for the Streamflow Routing Package (SFR2) were developed at the locations where the streams enter the model domain using a combination of available stream gage records spanning the base period for the Napa River near Napa gage (at Oak Knoll Avenue) and for calculated streamflow in the streams that enter the Active Model Area. **Figure 3-10** shows the location of stream gages and precipitation gages near the Active Model Area.

Streamflow data sets for streams other than the Napa River that enter the active model were developed using the U.S. Geological Survey Basin Characterization Model (BCM). The BCM simulates watershed hydrologic processes from 1900 to 2010 on monthly time steps based on observed precipitation, potential evapotranspiration, and site-specific geologic conditions. BCM results for groundwater recharge and runoff for the individual tributary watershed were post-processed to calculate streamflow discharge into the Active Model Area. For years between 2011 and 2015, when BCM data are not available, regression analyses were performed to derive relationships between observed precipitation and calculated BCM streamflow discharge. Those relationships were then used to estimate monthly streamflow from 2011 through 2015. **Figure 3-11** shows the results of the regression analyses at six tributaries. **Figure 3-12** provides an example of the extrapolation that occurred to estimate monthly streamflow post-2011 for the Napa Creek subwatershed.

Streamflow data from gages other than the Napa River near Napa gage were reviewed for consistency with calculated streamflow data from the BCM.

Diversions of streamflow were accounted for based on permitted direct diversions published by the State Water Resources Control Board through the electronic Water Rights Information Management System (eWRIMS) within the Active Model Area. The locations of permitted Points of Diversions are shown in **Figure 3-13.** The Points of Diversion in **Figure 3-13** are labeled with the associated water right Application Number, since only the Application Number is provided in reports of diversion. All Points of Diversion within the Active Model Area are located in unincorporated portions of Napa Valley Subbasin. For this report surface water diverted at these locations is assumed to be applied to meet water demands in the unincorporated portion of the Active Model Area. Although the municipal water supply for the City of Napa was sourced from surface waters throughout the study period, those sources have Points of Diversion located out of the Active Model Area, either elsewhere in the Napa River Watershed (City of Napa reservoirs) or elsewhere in California (State Water Project north of Delta reservoirs).

All the permitted Points of Diversion are located along the Napa River except for two associated with diversion Application Numbers S015025 and A023533, which are along Salvador Creek. The reported diversions amounts were downloaded from the State Water Resources Control Board eWRIMS for all available years, which ranged from water years 2007 through 2015. Average monthly values for each Point of Diversion were used to account for diversions of surface water in the Model throughout the base period (**Table 3-2**).

Average reported diversions were 156 AFY throughout the Active Model Area (**Table 3-2**). For comparison purposes, **Table 3-2** groups reported diversions by their location relative to the Napa River. Although reports filed by surface water diverters do not specify exactly where diverted water is used, for this report the location of the point of diversion provided by the State Water Resources Control Board is interpreted to be consistent with the side of the Napa River where the water is eventually used.[19] Based on available eWRIMS reports, the majority of surface water diversions have occurred at points of diversion along the eastern side of the Napa River (**Table 3-2**).

While the reports of surface water diversions available through eWRIMS do not specify the locations where diverted water is used, the reports do describe the acreage over which water is applied. **Table 3-3** shows that 1,723 acres in the Active Model Area were mapped as having surface water as the source of

[19] In the Active Model Area one water right Application Number, A025449, is associated with two Points of Diversion, one east of the Napa River and one west of the Napa River. In this case the diversion is attributed, in this report, as occurring west of the Napa River because the Application Number is classified as a Point of Diversion to Offstream Storage and the western Point of Diversion coincides with a pond.

supply in 2011 (DWR, 2011). Reports of diversion filed between water years 2007 and 2015 account for diversions applied to 556 acres, leaving 1,176 acres where land use mapping designates surface water as the source of supply and were no reports of diversions are available through eWRIMS.

Average annual rates of diversion within the study area are calculated to be 0.28 AFY/Acre, compared to 0.27 AFY/Acre across the entire Napa Valley Subbasin. At the Subbasin average annual rate of diversion, it is estimated that 315 AFY of additional unreported diversions may have occurred throughout the Active Model Area. After accounting for potential unreported diversions, total diversions of surface water are estimated to average 471 AFY across the Active Model Area (**Table 3-3**).

Table 3-3. Average Reported Surface Water Diversions and Estimated Volume of Unreported Surface Water Diversions in the Northeast Napa Study Area

	West of Napa River	East of Napa River	Entire Study Area
2011 irrigated agricultural land use units supplied by surface water (acres)	1,098	625	1,723
Area accounted for by reported diversions of surface water for irrigation and/or frost protection (acres)	146	410	556
Average of reported annual water diversion for irrigation and/or frost protection: 2007-2015 (AFY)	15.7	140.3	156
Areal average of reported surface water diversions in study area (AFY/Acre)	0.11	0.34	0.28
Surface water supplied area with no reported surface water diversions: 2007 – 2015 (acres)	952	215	1,167
Estimated unreported surface water diversions in study area at 0.27 AFY/Acre rate of reported diversions in Napa Valley Subbasin for irrigation with or without frost protection (AFY)	**257**	**58**	**315**

Table 3-2. Average Reported Surface Water Diversions in the Northeast Napa Study Area: Water Years 2007-2015

Diversion Application Number [1,2]	Average Diversion (AF)												
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Annual Total**
Points of Diversion on the West Side of Napa River													
S015025	0.05	0.00	0.00	0.00	0.00	0.01	0.06	0.10	0.13	0.15	0.16	0.11	0.8
S002270	0.00	0.00	3.28	1.05	2.66	2.29	1.96	0.06	0.00	0.00	0.00	0.00	11.3
A025449	0.00	0.00	0.67	0.25	1.08	1.08	0.00	0.00	0.00	0.00	0.00	0.00	3.1
A023886B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A023522	0.04	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.10	0.10	0.10	0.05	0.5
Total: West Side	**0.09**	**0.00**	**3.94**	**1.30**	**3.75**	**3.39**	**2.09**	**0.23**	**0.22**	**0.25**	**0.26**	**0.16**	**15.7**
Points of Diversion on the East Side of Napa River													
S022596	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.1
S015457	0.48	0.00	0.00	0.00	0.00	0.88	3.83	0.00	2.83	0.00	2.84	0.00	10.8
S002619	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
S001799	0.00	0.00	0.00	0.00	0.00	0.00	5.14	6.43	9.00	9.00	5.57	0.57	35.7
A002914	0.00	0.00	0.00	0.00	31.20	31.20	31.20	0.00	0.00	0.00	0.00	0.00	93.6
A000631	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total: East Side	**0.49**	**0.00**	**0.00**	**0.00**	**31.20**	**32.08**	**40.17**	**6.43**	**11.84**	**9.03**	**8.43**	**0.60**	**140.3**
Total – All Diversions	**0.57**	**0.00**	**3.94**	**1.30**	**34.95**	**35.46**	**42.26**	**6.66**	**12.06**	**9.27**	**8.69**	**0.76**	**155.9**

1 Four points of diversion within the study area (S008239, A025449 (East Side), S015308, and S015765) have no annual reports available on the State Water Resources Control Board Electronic Water Rights Information System

2 Three points of diversion (A023886B, S002619, and A000631) have filed annual reports showing no diversions for water years 2007 – 2015.

3.6 Well Locations and Pumping Demand Allocation

The model contains 594 wells in the active model domain. Well completion depths are based on information recorded in well completion reports (WCR) provided by DWR. For wells with a well completion report, 174 wells, the well depth and well screen interval information for that specific well were used. For wells without a well completion report, but whose location was inferred (e.g., 420 wells), the well depth and screen interval information were set to average values for wells of the same type within the same Township/Range/Section. Groundwater pumping is simulated using the Multi-Node Well Package (MNW2), which allows for wells to be screened in one or more layers, and the model determines how much water is withdrawn from each layer based on pumping rates, water levels, and aquifer properties. Well pumping rates are developed by accounting for the total water uses applicable to each well based on well type and water demand, as described below.

3.6.1 Well Locations

Production wells (i.e., wells other than monitoring wells, cathode protection wells, or other well types not associated with groundwater pumping demands) in the study area were located by reviewing well completion reports provided by DWR for the Study Area. **Figure 3-14a** shows the distribution of those wells. Inferred wells are those whose existence was inferred based on the presence of an unmet groundwater demand. County Assessor records for residential dwellings in the unincorporated part of the Active Model Area were compared against records of domestic wells with a well completion report. Where no record of a well completion report was found, an inferred well was placed. Irrigation wells were inferred when the density of located irrigation wells by Township/Range/Section was less than that represented by DWR in a summary of WCRs for Napa County.

Figure 3-14b depicts the location of all located and inferred production wells in 3D to convey their vertical and horizontal distribution. In addition to the wells, this figure shows the land surface and model layer 6.

3.6.1 Pumping Demands for Irrigation

Irrigation pumping demands include demands for agricultural crop irrigation as well as irrigation demands for landscaping associated with residences and commercial land uses, including wineries. These demands were incorporated from the Napa Valley Subbasin Root Zone Model (LSCE, 2016c). Root Zone Model irrigation demands for groundwater are specific to land uses where groundwater is the identified source of supply. In some cases, where no source of supply is noted in the land use surveys, the Root Zone Model assumes the groundwater is the source of supply by default, unless the land use is within an area with a municipal distribution system. **Figure 3-15** shows an example of how the irrigation pumping demands from the Root Zone Model were overlaid with the Napa County parcel dataset in order to attribute the land use based groundwater demands to wells in the Active Model Area. Irrigation demands for wells located on residential parcels are applied to a domestic well on that parcel, if available. In some cases, typically on larger parcels that contain both a residence and agricultural land uses, the only record of well construction is for an irrigation well. In those cases, irrigation demands are applied to the available irrigation well.

3.6.2 Pumping Demands for Residential Uses

The total annual groundwater demand for indoor domestic use in the Active Model Area was derived from the estimate of annual demands for indoor domestic water use for the unincorporated portion of the Napa Valley Subbasin (LSCE, 2016c). The Subbasin-wide annual values were reduced for the study area based on the 17.43% of residences in the unincorporated part of the Study Area as compared to the unincorporated Subbasin as whole. Annual demands are distributed equally amongst all Study Area residences and divided evenly into monthly increments.

3.6.3 Pumping Demands for Winery Uses

The annual water demand of each of the 24 permitted wineries in the Study Area was obtained from the Napa County Winery permit database. As in the Napa Valley Subbasin Basin Analysis Report, both the annual and monthly demands were assumed to be supplied entirely by groundwater and constant throughout the 1988 to 2015 period (LSCE, 2016c).

Table 3-4 presents the total groundwater pumping demands calculated to have occurred in the Active Model Area during the study period. Groundwater demand for domestic and winery uses are generally steady over the study period, with some variation in the domestic demand due to water year types, with wetter years such as 2011 having less groundwater demand due to lower demand for residential irrigation in areas supplied by groundwater. Similarly, crop irrigation groundwater demands vary by water year type. Groundwater demand is shown to be evenly distributed in the Active Model Area east and west of the Napa River.

Table 3-4. Summary of Annual Groundwater Pumping by Groundwater Use Sector in Northeast Napa Study Area

Water Year	Pumping by Sector[1,2] (AF) - West of Napa River						Pumping by Sector[1,2] (AF) - East of Napa River						Total in Study Area (AF)
	Domestic - Located	Domestic - Inferred	Irrigation - Located	Irrigation -Inferred	Winery Demand	Total - West Side	Domestic - Located	Domestic - Inferred	Irrigation - Located	Irrigation -Inferred	Winery Demand	Total - East Side	
1988	64	313	267	0	16	660	101	304	86	34	50	574	1234
1989	63	287	257	2	16	624	95	279	83	34	50	540	1164
1990	58	280	236	5	16	594	89	276	81	39	50	536	1130
1991	68	302	275	8	16	667	100	300	97	51	50	598	1266
1992	70	296	281	11	16	675	101	297	103	58	50	609	1284
1993	63	277	248	14	16	616	93	280	96	57	50	576	1192
1994	71	294	278	17	16	677	101	300	110	70	50	631	1307
1995	60	270	232	19	16	596	88	275	94	62	50	569	1166
1996	58	273	223	22	16	592	87	279	94	63	50	573	1164
1997	80	309	312	28	16	745	110	324	135	99	50	718	1463
1998	57	252	209	26	16	560	82	261	93	67	50	554	1114
1999	73	279	275	31	16	673	98	296	124	97	50	665	1338
2000	71	276	263	34	16	660	95	294	122	96	50	657	1317
2001	82	289	310	38	16	735	107	314	147	122	50	741	1475
2002	83	295	310	42	16	745	108	321	150	127	50	756	1501
2003	72	269	256	41	16	653	94	291	127	108	50	670	1324
2004	93	319	348	53	16	828	120	354	178	156	50	858	1685
2005	68	252	227	43	16	605	86	274	116	99	50	625	1229
2006	80	278	284	50	16	708	102	310	150	136	50	747	1455
2007	94	313	339	60	16	823	118	354	182	167	50	871	1693
2008	104	323	388	64	16	896	130	374	212	201	50	966	1862
2009	89	295	305	62	16	766	109	335	169	158	50	820	1587
2010	79	262	265	56	16	678	97	299	149	143	50	738	1416
2011	65	234	193	51	16	558	77	258	108	98	50	591	1149
2012	86	277	292	61	16	732	104	319	166	160	50	800	1531
2013	97	306	338	68	16	825	118	354	193	185	50	900	1725
2014	90	299	298	68	16	770	109	339	169	159	50	827	1597
2015	99	315	347	71	16	849	122	366	199	191	50	927	1776
Average	**76**	**287**	**281**	**37**	**16**	**697**	**101**	**308**	**133**	**108**	**50**	**701**	**1398**

1. "Located" refers to water uses on parcels with a known a record of well construction. "Inferred" refers to water uses on parcels where groundwater is identified as the source of supply, based on land use mapping, but where a well completion report was not found.
2. Pumping by domestic wells includes water for indoor residential use and outdoor irrigation demands at residential parcels as calculated by the Napa Valley Subbasin Root Zone Model (LSCE, 2016c). Pumping by irrigation wells is assigned to meet irrigation demands calculated by the Napa Valley Subbasin Root Zone Model (LSCE, 2016c). Winery pumping is calculated to meet winery-specific water demands based on the permitted uses for each County-permitted winery.

3.7 Initial Conditions

3.7.1 Unconfined Aquifer System

Groundwater levels for the unconfined layers in the model, layers 1–3, were interpolated across all cells based on the available monitoring data from Fall 1987 in the model vicinity. **Figure 3-18** depicts the distribution of water levels for the initial condition in layers 1–3.

3.7.2 Semi-Confined Aquifer System

Groundwater levels for the semi-confined layers in the model, layers 4 – 6, were interpolated across all cells based on the available monitoring data from Fall 1987 in the model vicinity. **Figure 3-19** depicts the distribution of water levels for the initial condition in layers 4–6.

3.8 Model Calibration and Sensitivity

The MODFLOW-NWT model was calibrated manually by adjusting the following components: aquifer parameters (horizontal and vertical hydraulic conductivity and storage), streambed conductivity, model layering, and general head boundary conditions.

3.8.1 Observations Used in Model Calibration

There are 280 wells that have been identified to be within the Active Model Area and have historical water level measurements during the model simulation period. When the well's screened interval was known, the observation location was placed in the Model accordingly spatially and vertically. If the well's screened interval or well depth was unknown, an assumption was made about the vertical placement of the well depth. Of the 280 wells with available water level data, 182 wells were used in calibration. Some target wells were removed from the calibration target dataset because they were located too close to the general head boundary and not representative of modeled results. 153 of the target wells are shallow monitoring wells from regulated facilities; many wells are clustered together in various locations. The non-regulated facility wells, for which there are 29, are a mix of Napa County monitored wells (12 County monitored wells and 4 County surface water/groundwater interaction monitored locations), DWR wells (7), and USGS wells (6), for a total of 182 simulated observation points for use in calibration. (**Figure 3-20**).

Aquifer properties, including horizontal conductivity, vertical conductivity, storage, and streambed conductivity, were adjusted until simulated water levels reasonably matched observed water levels at the 182 calibration target locations throughout the active model domain. Other changes to the initial model included separating the Tertiary geologic unit into two separate layers to account for the vertical hydraulic gradient observed in wells with water levels completed at different depths within it on the east side of the Napa River. Another adjustment to model layering occurred with the deepening of the alluvium in the corridor of the Napa River to accommodate historical erosion and incision by the Napa River, which was a minor change from the isopach development of the base of the Quaternary alluvium from LSCE and MBK (2013) based on cross sections developed by LSCE (2013) which showed the alluvium thickness near the Napa River increasing from about 100 to 200 feet thick from north to south.

The model area lacks long-term surface water gaging data, except for the USGS station 11458000 NAPA R NR NAPA CA located near the northern boundary of the model. Although this stream data matches the simulated data, the station is too close to the model boundary where surface water input data are specified, so this does not provide an effective calibration observation target location. Another gage station located on Salvador Creek only has data from 2014-2015 during the simulation period; it also does not provide a sufficient dataset to be used as an effective calibration observation target location. Lastly, Napa River at Lincoln Bridge was considered as a potential surface water calibration target for the southern portion of the model area, but this gage station is heavily influenced by the tides, which the groundwater model does not explicitly simulate. The lack of long-term surface water observation data is not an issue for the scale and scope of this model, as multiple groundwater monitoring locations of various depths are available for calibration, near and far from surface water bodies.

3.8.2 Simulated and Observed Water Levels

A simple method of assessing the overall model fit is to plot the simulated water levels against the observed water levels. For a perfect fit, all points would show a 1:1 relationship and fall on the 1:1 diagonal line on the plot. Factors that can affect the 1:1 relationship include unknown and assumed screened intervals for target wells. Target well screen completions were not always known, so the model layer that the target well was placed in may be inaccurate, leading to overestimation or underestimation by the Model, depending on the actual target well screen. **Figure 3-21** shows the simulated vs observed water level plot. Many of the target wells plot on or near the 1:1 line, but there are several outliers.

Hydrographs were created that plot the observed water levels with the simulated water levels at each model layer for all target well locations. These hydrographs are included in **Appendix A**. Select hydrographs for seven wells of interest are included in **Figure 3-22**. This figure shows the behavior of the simulated water levels fluctuating seasonally and over the years, related to the climate and pumping demands in various parts of the model area. Wells of interest in the Petra Drive area (Napa County Wells 75, 76, 182, and 228) show the behavior of the Model in that area of interest.

In the northeast, NapaCounty-76 shows a lot of simulated vertical variability between model layers, and seasonal fluctuations of about 40 feet as seen in the upper portion of the Tertiary sedimentary deposits (layer 4). The calibrated model generally follows the observed yearly trends, dropping in water levels between 2002 and 2009, rising slightly until 2011, then dropping to 2014, and rising into 2015.

Following Soda Creek to the southwest, two selected calibration wells, NapaCounty-228 and NapaCounty-182, show a different trend. The observed water level records for these wells are brief, starting in 2015 for well 228 and 2014 for well 182, but the observed records show seasonal fluctuations between 20 and 70 feet for well 228 and about 25 to 40 feet for well 182. Simulated water levels at this location were unable to replicate the high end of the seasonal fluctuation. The Model was not able to drop water levels to the depths observed. The calibration process included varying aquifer properties (conductivity, storage, and streambed conductivity) but these low observed levels were still unachievable. As a result, a closer look at the geology and mapping of faults was undertaken. The East Napa Fault was added to the Model as a series of cells with low permeability. This improved the model’s fit to these two wells. Another fault, a concealed fault, was mapped on the east side of the Napa River, to the northwest of these wells. The extent of this concealed fault is unknown, so for this model exercise, the extent is limited to the mapped feature. It is possible that this concealed fault extends to the south closer to the Petra Drive wells. The mapped extent of the concealed fault feature was added to the model simulation, and simulated water levels in these two wells dropped somewhat, but the levels are still about 60 feet higher than the observed water levels. Simulated results indicate that the alluvium (layers 1-3) is mostly dry in this area, which is corroborated by driller's accounts of first encountered water in well completion reports in this area. Simulation results also indicate that surface water flow to the groundwater aquifer via Soda Creek is mostly positive for the simulation period, indicating losing stream conditions (**Figure 3-23**). These two wells (NapaCounty-182 and -228) are within 200 to 500 feet from Soda Creek, which is likely why the simulated water levels in these two wells are higher than observed, as the Model simulates surface water recharging the groundwater in this area.

Further to the south along the Napa River, NapaCounty-75 is another selected well used for model calibration. This well has a lengthy period of record with observed water levels fluctuating seasonally about 20 feet. The calibrated model generally follows the seasonal fluctuations and the yearly trends in the Tertiary sedimentary deposits (comprising layers 4 and 5) for this location.

On the west side of the Napa River, three wells are selected for model calibration discussion: 06N04W27L002M (27L2), NapaCounty-136, and T0605500110MW-5. Well 27L2 is in a part of the Model where simulations have very little vertical hydraulic gradient. The simulated water levels in these three wells show a good match in the magnitude of the elevation, and the yearly trends compared to observed water levels. The simulated seasonal fluctuations in NapaCounty-136 and T0605500110MW-5 are a good match to observed measurements, but the simulated seasonal fluctuations in 27L2 are muted compared to observed values.

3.8.3 Baseline Water Budget

The water budget components discussed in this section include: 1) groundwater storage, 2) lateral flow (via general head boundaries or through the sides of an area of interest), 3) recharge, 4) stream leakage, and 5) groundwater pumping. When discussing water budget components, positive fluxes indicate water entering the groundwater system (to be used or made available by the Model for lateral flow, pumping, and regional flow). Negative fluxes indicate water leaving the groundwater system (e.g., via groundwater pumping and discharges to streamflow). In modeling terms, negative fluxes for storage indicate groundwater leaving the portion of the active groundwater system that is used for pumping or lateral flow or stream contributions, and being placed into groundwater storage, indicating replenishment of storage. In modeling terms, a positive net storage term indicates that water is entering the active model domain to be made available for pumping/lateral flow/stream contribution by *leaving* storage, which occurs during storage depletion. Negative fluxes for stream leakage indicate water leaving the groundwater system to feed the surface water feature during gaining stream conditions; positive fluxes for stream leakage indicate water leaving the stream and entering the groundwater system.

The water budget for the entire model is available for each time step and stress period (two time steps per monthly stress period, for a total of 672 values for the 28-year simulation period), but it is summarized by water year for discussion of results (**Table 3-5**). The net change in storage for the entire model domain ranges from a replenishment of 2,015 AFY (an excess of groundwater placed into storage) during a brief replenishment period in 2000 to a depletion of 3,524 AFY (decrease in groundwater in storage, or depletion) during a dry period in 2007. Generally, the storage component of the water budget hovers around zero (inflow equal outflows); on average storage accounts for the smallest portion of the water budget (**Figure 3-24**). Groundwater pumping makes up the next smallest component, averaging around -1,357 AFY (which equates to approximately 0.22 AFY/acre for the entire active model area).[20] Net recharge across the model domain ranges from zero AFY in 1991 to as high as 11,685 AFY in 1998, averaging around 4,900 AFY (which equates to approximately 0.8 AFY/acre), and is based on Root Zone Model results for this area (LSCE, 2016c).[21]

Net lateral flow through the sum of all of the model's general head boundary cells is generally positive (water flowing overall into the Model), averaging around 2,700 AFY for the 28-year model period. Net lateral flow remains mostly positive during the simulation period, except for five years when the net flow is out of the model domain to neighboring areas (negative numbers of average annual flow). Most of the water leaving the Model is through the general head boundary on the east side near the Soda Creek Fault. **Figure 3-25** shows the different regions of the general head boundary that have been used to examine how water flows in and out of the model domain with depth. The average annual flow through these eight different regions of the model's boundary is depicted in **Figure 3-26**. Generally, on average, water flows in from the west, northwest, and southeast towards the east and southwest (**Figure 3-26**).

[20] Groundwater pumping rates output by the Model reflect the net flow between Model layers through all wells simulated by the Model. These amounts differ from the pumping demands used as an input dataset because the model accounts for inflow and outflow from groundwater storage in such a way that the groundwater body within the Model domain is tracked separately from the volume of groundwater storage. In some time steps some amount of pumping demand is met by reductions in storage rather than outflows from the groundwater body.

[21] The annual recharge value of zero AFY in 1991 indicates that over the course of that year, within the Active Model Area, the timing of precipitation and irrigation applications did not exceed the amount removed from the root zone by evaporation and transpiration and the amount retained in the soil profile as soil moisture storage.

Table 3-5. Water Budget Components for the Model Domain

Water Year	Net Change in Storage (AFY)	Lateral Flow In/Out (AFY)	Recharge (AFY)	Net Stream Leakage (AFY)	Pumping (AFY)
1988	2,740	4,509	3,320	-9,423	-1,147
1989	-550	4,451	3,434	-6,252	-1,085
1990	953	5,394	1,220	-6,517	-1,051
1991	-294	7,953	0	-6,471	-1,188
1992	-1,574	8,510	1,855	-7,579	-1,213
1993	-833	5,665	7,540	-11,247	-1,125
1994	1,390	5,453	2,754	-8,356	-1,242
1995	-1,104	-421	11,115	-8,484	-1,106
1996	205	2,334	7,350	-8,786	-1,104
1997	170	2,444	7,781	-8,988	-1,407
1998	-422	-108	11,685	-10,092	-1,064
1999	2,335	2,422	4,523	-7,988	-1,293
2000	-2,015	5,835	4,323	-6,870	-1,274
2001	875	6,553	2,050	-8,042	-1,438
2002	-134	3,390	5,264	-7,056	-1,465
2003	-590	831	7,073	-6,023	-1,291
2004	1,068	1,187	5,483	-6,083	-1,655
2005	-1,593	3,372	7,164	-7,744	-1,201
2006	-389	-820	10,837	-8,199	-1,430
2007	3,524	454	1,611	-3,918	-1,672
2008	1,623	-3,863	4,265	-177	-1,849
2009	-1,741	1,945	2,962	-1,597	-1,569
2010	-1,960	2,752	5,064	-4,453	-1,404
2011	-1,030	887	7,726	-6,451	-1,133
2012	2,259	2,803	1,590	-5,133	-1,520
2013	1,520	-673	2,915	-2,046	-1,717
2014	-779	510	2,174	-323	-1,583
2015	-839	1,685	4,208	-3,290	-1,766

	Avg Annual Change in Storage (AFY)	*Avg Annual Net Lateral Flow (Into Model) (AFY)*	*Avg Annual Recharge (AFY)*	*Avg Annual Stream Leakage (AFY)*	*Avg Annual Pumping (AFY)*
Average	***101***	***2,695***	***4,903***	***-6,342***	***-1,357***

Time series plots for groups of model boundaries show net annual flow on the west and east sides of the model (**Figures 3-27 and 3-28**). The model output also allows for observing which aquifer units (vertically) are accepting or providing the most water through each of the different model boundary regions (**Tables 3-6, 3-7, and 3-8** and **Figures 3-27, 3-28, and 3-29**). The net flow through the western side of the Model is almost always into the Model (positive values), as exemplified by flow through the Quaternary alluvium through this side of the Model, but some water is leaving the model domain via layers 4 and 5, and a very small amount via layer 6 starting around 2001. A small amount of water enters the Model through the eastern side of the Model in layers 1-3 (Quaternary alluvium), and most of the water leaves the Model out of the eastern boundary through the deeper aquifer units, including the Sonoma Volcanics.

Table 3-6. Annual Flows Through the Eastern General Head Boundary

	Soda Creek Fault				Southeast							
Water Year	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3) Total	TQsb Flow (Lays 4-5 Total)	Tsv Flow (Lay 6) Total	Grand Total
1988	162	-585	-3,398	-3,821	487	1,605	1,131	3,222	649	1,019	-2,267	-599
1989	172	-833	-3,491	-4,152	478	1,636	1,144	3,258	650	803	-2,347	-894
1990	197	-974	-3,533	-4,310	499	1,491	1,114	3,104	696	517	-2,419	-1,206
1991	201	-621	-3,431	-3,851	510	1,598	1,099	3,207	711	977	-2,332	-644
1992	186	-652	-3,440	-3,905	500	1,660	1,116	3,276	686	1,008	-2,324	-629
1993	119	-359	-3,368	-3,609	440	1,664	1,092	3,196	558	1,304	-2,276	-413
1994	170	-505	-3,386	-3,722	515	1,578	1,066	3,160	685	1,073	-2,320	-562
1995	101	-1,121	-3,520	-4,540	434	840	939	2,212	534	-281	-2,581	-2,328
1996	134	-906	-3,476	-4,249	468	1,109	994	2,572	602	203	-2,482	-1,677
1997	129	-991	-3,470	-4,331	442	1,225	1,044	2,712	572	235	-2,425	-1,619
1998	96	-1,279	-3,557	-4,740	396	1,141	1,045	2,582	492	-138	-2,512	-2,158
1999	168	-923	-3,476	-4,231	467	1,407	1,092	2,965	634	484	-2,384	-1,266
2000	179	-1,102	-3,519	-4,443	448	1,594	1,180	3,222	626	492	-2,339	-1,221
2001	196	-871	-3,441	-4,116	451	2,070	1,281	3,802	646	1,200	-2,160	-314
2002	161	-1,268	-3,516	-4,623	449	1,407	1,126	2,982	610	138	-2,390	-1,641
2003	153	-1,837	-3,654	-5,337	443	902	1,035	2,381	597	-935	-2,618	-2,956
2004	168	-1,512	-3,573	-4,917	464	1,007	1,042	2,513	632	-505	-2,531	-2,405
2005	150	-1,616	-3,615	-5,081	441	1,094	1,063	2,598	590	-522	-2,551	-2,483
2006	133	-1,834	-3,700	-5,402	387	751	1,028	2,166	520	-1,083	-2,672	-3,236
2007	199	-1,284	-3,513	-4,598	499	1,429	1,142	3,070	697	146	-2,371	-1,528
2008	191	-1,809	-3,655	-5,273	492	808	1,056	2,356	683	-1,001	-2,599	-2,917
2009	192	-1,538	-3,580	-4,926	488	1,185	1,119	2,792	680	-353	-2,461	-2,134
2010	188	-1,739	-3,632	-5,183	451	1,162	1,122	2,736	639	-577	-2,510	-2,448
2011	153	-1,698	-3,633	-5,178	420	1,263	1,137	2,820	573	-436	-2,496	-2,358
2012	204	-1,331	-3,523	-4,649	476	1,638	1,207	3,322	681	307	-2,316	-1,328
2013	193	-1,604	-3,589	-5,000	474	1,137	1,121	2,732	667	-467	-2,468	-2,268
2014	208	-1,646	-3,603	-5,041	490	1,061	1,107	2,658	698	-586	-2,495	-2,383
2015	180	-1,401	-3,515	-4,736	467	1,242	1,111	2,819	647	-159	-2,404	-1,916
Average	***167***	***-1,209***	***-3,529***	***-4,570***	***463***	***1,311***	***1,098***	***2,873***	***631***	***102***	***-2,430***	***-1,698***

Table 3-7. Annual Flows Through the Northern and Southern General Head Boundary

	North				South			
Water Year	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total
1988	804	-849	-474	-520	-684	626	99	41
1989	1,433	-748	-392	293	-640	665	126	151
1990	467	-752	-423	-709	-728	694	128	94
1991	519	-522	-270	-273	-676	683	125	132
1992	1,398	-562	-239	596	-648	677	131	159
1993	725	-521	-228	-24	-699	610	117	28
1994	441	-356	-144	-58	-646	637	116	107
1995	689	-299	-104	286	-751	476	84	-191
1996	589	-245	-53	292	-716	462	72	-182
1997	362	-232	-43	87	-735	594	103	-37
1998	332	-49	35	318	-748	561	100	-86
1999	499	-7	89	582	-702	637	115	51
2000	759	-282	-49	428	-711	655	117	60
2001	611	-270	-53	287	-696	685	117	107
2002	222	-99	31	154	-725	634	114	23
2003	219	-100	32	151	-743	604	109	-31
2004	384	-184	-6	194	-718	596	107	-15
2005	439	-233	-45	161	-715	626	115	26
2006	528	-252	-95	181	-717	584	109	-24
2007	420	-444	-162	-186	-682	693	129	139
2008	311	-696	-336	-721	-678	670	126	119
2009	1,208	-571	-230	408	-653	674	127	147
2010	1,244	-548	-193	503	-666	627	113	74
2011	675	-395	-119	161	-733	565	99	-69
2012	234	-193	-4	37	-699	581	98	-20
2013	403	-359	-109	-65	-733	696	128	91
2014	75	-162	6	-81	-732	709	131	108
2015	139	-99	37	78	-779	690	126	38
Average	***576***	***-358***	***-126***	***92***	***-705***	***629***	***114***	***37***

Table 3-8. Annual Flows Through the Western General Head Boundary

	Northwest Higher K				Northwest of Salvador Crk				Southwest				West Central							
Water Year	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3)	TQsb Flow (Lays 4-5)	Tsv Flow (Lay 6)	Total	Qa Flow (Lays 1-3) Total	TQsb Flow (Lays 4-5 Total)	Tsv Flow (Lay 6) Total	Grand Total
1988	1,242	-380	-225	636	9,826	-5,879	-810	3,137	-3,300	2,754	277	-268	-1,546	3,005	563	2,022	6,223	-500	-196	5,527
1989	1,286	-264	-137	886	5,122	-2,483	-233	2,406	-3,612	3,010	305	-298	-1,024	2,417	462	1,855	1,771	2,681	397	4,849
1990	1,068	-262	-120	686	10,842	-5,882	-742	4,218	-3,133	2,901	299	67	2,154	-108	117	2,163	10,931	-3,351	-446	7,134
1991	1,216	-245	-124	847	11,238	-5,480	-624	5,134	-2,915	2,732	280	97	925	1,313	353	2,590	10,463	-1,680	-115	8,669
1992	1,737	-278	-141	1,318	10,046	-4,829	-536	4,681	-3,021	2,760	283	21	-804	2,590	514	2,300	7,958	244	119	8,321
1993	1,272	-259	-135	877	5,751	-1,818	-8	3,925	-3,331	2,667	261	-403	-5,223	5,847	964	1,588	-1,532	6,437	1,082	5,987
1994	887	-171	-77	639	6,444	-2,286	-98	4,060	-3,405	2,645	254	-505	-3,367	4,309	739	1,682	560	4,498	818	5,876
1995	855	-131	-50	674	3,635	-1,324	-8	2,303	-3,980	2,315	201	-1,464	-2,629	2,471	433	275	-2,118	3,330	576	1,788
1996	1,197	-166	-69	962	7,018	-3,161	-291	3,566	-3,081	2,216	214	-651	-5,117	4,441	689	13	17	3,330	543	3,891
1997	982	-169	-77	737	10,312	-5,934	-791	3,587	-3,861	2,707	255	-899	-1,872	2,024	369	521	5,562	-1,371	-244	3,947
1998	463	11	57	531	2,256	-682	64	1,638	-3,902	2,734	258	-909	-2,275	2,359	411	495	-3,458	4,422	790	1,754
1999	610	25	71	706	3,387	-1,269	-66	2,052	-3,427	2,772	277	-378	-1,169	1,491	289	611	-599	3,019	571	2,991
2000	1,357	-210	-100	1,048	13,115	-7,917	-1,180	4,018	-3,313	2,810	282	-220	1,084	418	153	1,655	12,244	-4,899	-844	6,501
2001	1,216	-147	-50	1,019	8,490	-4,130	-447	3,913	-3,960	3,173	314	-474	-944	2,425	467	1,948	4,801	1,321	284	6,406
2002	865	-102	-29	734	9,396	-5,142	-667	3,588	-4,053	3,056	307	-690	642	382	143	1,167	6,850	-1,805	-246	4,799
2003	855	-102	-29	724	10,565	-6,529	-958	3,077	-3,982	2,908	293	-781	3,301	-2,414	-287	600	10,738	-6,138	-981	3,619
2004	930	-136	-51	743	9,805	-6,096	-878	2,831	-4,104	2,960	300	-845	2,433	-1,625	-159	648	9,063	-4,898	-788	3,377
2005	1,047	-158	-66	823	10,887	-6,337	-886	3,665	-3,667	2,766	269	-631	3,773	-1,871	-147	1,755	12,040	-5,600	-829	5,611
2006	1,147	-65	30	1,113	11,641	-7,285	-1,069	3,287	-4,805	3,010	281	-1,514	1,319	-1,763	-242	-687	9,303	-6,103	-1,000	2,199
2007	1,258	-242	-123	893	10,564	-7,050	-1,081	2,434	-4,796	3,376	336	-1,084	-1,707	1,255	173	-279	5,319	-2,661	-695	1,964
2008	1,411	-373	-216	822	15,299	-11,509	-2,006	1,784	-4,947	3,176	308	-1,464	118	-1,379	-290	-1,550	11,881	-10,085	-2,204	-408
2009	1,721	-322	-177	1,222	14,876	-10,175	-1,684	3,017	-4,160	3,092	312	-755	664	-588	-101	-25	13,101	-7,993	-1,649	3,459
2010	1,793	-322	-175	1,296	15,397	-10,542	-1,732	3,123	-4,034	3,043	314	-678	3,170	-2,069	-259	841	16,325	-9,890	-1,852	4,583
2011	1,442	-255	-131	1,056	12,844	-8,402	-1,300	3,142	-4,414	3,126	323	-965	-864	661	102	-101	9,007	-4,870	-1,006	3,131
2012	985	-160	-69	757	12,772	-8,052	-1,213	3,507	-4,352	3,425	378	-549	-274	570	106	403	9,131	-4,216	-797	4,118
2013	1,218	-249	-133	836	14,724	-10,695	-1,836	2,192	-4,734	3,250	320	-1,164	1,539	-1,638	-265	-365	12,748	-9,333	-1,914	1,500
2014	974	-176	-87	710	16,328	-11,568	-1,999	2,761	-4,875	3,296	325	-1,254	4,993	-3,861	-552	580	17,420	-12,309	-2,314	2,797
2015	893	-115	-41	737	12,606	-7,872	-1,194	3,540	-4,956	3,316	320	-1,320	1,642	-1,060	-117	466	10,185	-5,731	-1,031	3,423
Average	***1,140***	***-194***	***-88***	***858***	***10,185***	***-6,083***	***-867***	***3,235***	***-3,933***	***2,928***	***291***	***-714***	***-38***	***700***	***165***	***828***	***7,355***	***-2,648***	***-499***	***4,208***

Stream leakage (or surface water flow to the aquifer) is another component of special interest in the water budget. This component accounts for the largest outflow of groundwater from the model domain (on average -6,342 AFY, leaving the model and discharging into surface water). The annual stream leakage from the Napa River and all of its simulated tributaries in the model varies from -177 AFY (the negative number indicates that groundwater is contributing to surface water during gaining stream conditions) to nearly -11,250 AFY. A more detailed discussion of stream leakage from different sections of the Napa River and its individual tributaries is in **Section 4.2** below.

3.9 Sensitivity Analysis

Four categories of model sensitivity are discussed in this section, including: aquifer parameter adjustments; general head boundary conditions; streambed properties; recharge; and groundwater pumping. The Model's sensitivity to aquifer parameter adjustments was seen during calibration, where certain adjustments to horizontal conductivity did little to change the simulated water levels at target calibration well locations. The relationship of horizontal conductivity to storage (or hydraulic diffusivity), however, was an important sensitivity explored during model calibration. Changing this ratio allowed for the model to simulate the seasonal fluctuations observed in measured water level data.

The two faults that are simulated to occur in layers 4, 5, and 6 (the East Napa Fault Zone and a concealed fault located about 500 to 1,000 feet east of the Napa River in the vicinity of Petra Drive) were tested for their sensitivity to hydraulic conductivity changes. The cells representing these two fault zones were simulated with 1e-6 ft/d and 1e-3 ft/d for both horizontal and vertical conductivity, and the resultant simulated water levels did not show a notable change using these two values; this indicates that as long as the low hydraulic conductivity barrier unit is present, the model is insensitive to decreasing the order of magnitude of those low permeability units.

Initial estimates of streambed conductivity were similar to low permeability clays (e.g. 0.005 ft/d), but this resulted in very little groundwater contribution to surface water (or baseflow), which is inconsistent with previous analyses in the Annual Water Budget for the whole Napa Valley Subbasin that show the relationship between baseflow (groundwater contribution to surface water) and recharge (as a function of precipitation) (LSCE, 2016c). The Model showed sensitivity to streambed conductivity when streambed conductivity was increased to allow for more groundwater contribution. The streambed conductivity was adjusted until the Model's overall water balance was consistent with the relationship described in the Napa Valley Subbasin Annual Water Budget Results for 1988 to 2015 (LSCE, 2016c). The calibrated streambed conductivity was 0.5 ft/d.

3.9.1 Sensitivity to Groundwater Pumping

To test the sensitivity of the model to groundwater pumping, three additional model scenarios were developed: 1) the first sensitivity scenario involved reducing the amount of groundwater pumping to zero (no pumping); 2) the second sensitivity scenario involved reducing the amount of groundwater pumping to the groundwater pumping rates seen in each well for each month in water year 1988 (prior to the pumping increase occurring in the 1990s); and 3) the third sensitivity scenario involved doubling the amount of pumping in each well for each stress period. The overall water budget components of storage and recharge are similar to the baseline calibrated model scenario for all three sensitivity scenarios (**Figure 3-30**).

The sensitivity scenario of double pumping increases the amount of groundwater flowing into the model domain laterally through the boundaries, whereas the sensitivity scenario with zero pumping reduces the average net lateral flow into the model. Differences in stream leakage are small, with the difference between stream leakage from sensitivity scenarios being smaller than the difference in pumping between scenarios. Differences in stream leakage between different pumping sensitivity scenarios are small, but the cumulative effect over time is of note. For example, doubling the pumping results in approximately 9,300 AF cumulatively less groundwater contributed to streams over a 28-year period (approximately 330 AFY). This means that approximately 9,300 AF of groundwater would have contributed to stream baseflow; but instead, when pumping is doubled, it is unavailable to surface waters during this 28-year period (**Figure 3-31**).

Differences in simulated Napa River stage and water table elevations at Petra Drive are very small for the scenario in which groundwater pumping is eliminated. While eliminating pumping does result in higher stage in the Napa River during both wet years and dry years, the resulting change in stage is less than 0.02 feet (**Figure 3-32**). Water table elevations[22] at the River are also increased slightly in both wet years and dry years with pumping eliminated, with increases of less than 0.06 feet. (**Figure 3-33**).

[22] Water table elevations in Layer 1, the uppermost model layer in the unconfined aquifer.

4 DISCUSSION OF MODEL RESULTS

Three main topics of discussion are presented below using the calibrated Northeast Napa Area Model simulation results. The first topic of discussion is the availability of groundwater in the model area, looking particularly at the difference between simulated water budget components east of the Napa River and west of the Napa River. Second, simulation results are discussed pertaining to surface water and groundwater interaction (including stream leakage when 1) groundwater discharges to surface water and contributes to stream baseflow, or 2) surface water discharges to groundwater[23]), including comparisons of portions of the Napa River and its various tributaries. Last, the Petra Drive area in the northeastern portion of the model domain is discussed, including recent water level observations as they pertain to local water budget components. Throughout this section, the behavior of groundwater (and surface water) during different water year types (wet, dry) is also discussed.

4.1 Groundwater Availability in the Model Area

This Model was constructed to better understand groundwater availability in the model area, particularly east of the Napa River, which may be constrained by two faults and may have a limited subsurface inflow component. **Table 4-1** tabulates the annual water budget components for the land east of the Napa River and allows for comparison to the land west of (and including) Napa River. **Appendix B** illustrates the spatial distribution of simulated water levels for select months during the 28-year model period.

The annual water budget is illustrated in **Figure 4-1**, which shows the average annual flows for selected water budget components from the west and east sides of the Napa River. In general, for the entire model domain, groundwater storage changes are minimal, with slightly more storage changes occurring in the Quaternary Alluvial deposits (layers 1-3) compared to the deeper Tertiary deposits (layers 4-6). Tertiary deposits have a much lower storativity value, and as a result, much less water moves in or out of storage compared to upper model layers. Water enters the model more on the west side and leaves on the east side (via general head boundaries). There is more recharge on the west side of the Napa River (average of 3,129 AFY over its 3,720 acres, or 0.84 AFY/acre) compared to the east side of the Napa River (average of 1,774 AFY over its 2,368 acres, or 0.75 AFY/acre). The stream leakage component on the different sides of the Napa River shows large variations (more detailed discussion of the relationship between streamflow and groundwater is in **Section 4.2**), with much more groundwater contribution to surface water bodies in the west (including to the Napa River) compared to the east, where on average the net stream leakage component indicates losing stream conditions. The streams on the west side include the Napa River, Salvador Channel, and Napa Creek. The streams on the east side include the following tributaries to Napa River: Soda Creek, Hardman Creek (and Tributary), Milliken Creek, Sarco Creek, Tulucay Creek, and Cayetano Creek. Total pumping on the east side of the Napa River (average annual pumping is 712 AFY, or 0.30 AFY/acre) is slightly higher on average compared to the west side (average annual pumping is 645 AFY, or 0.17 AFY/acre).

[23] Surface water infiltrates to the groundwater system when the stage in the stream is higher than groundwater elevations or groundwater head at the streambed. Surface water can also infiltrate to the groundwater system when there is no direct connection between a stream and the groundwater body. Streamflow depletion occurs when pumping causes less groundwater to be discharged to surface water by capturing groundwater that would have discharged to the stream, or by inducing infiltration and reducing streamflow.

Table 4-1. Eastern and Western Model Areas Simulated Annual Water Budget Components

	Storage (negative indicates storage replenishment; positive means storage depletion)								Lateral Flow Through Model Boundaries*								Recharge		Stream Leakage (positive indicates losing stream conditions)		Pumping		Lateral Flow To/From the West (negative indicates flow to the west; positive indicates flow to the east)				Vertical Flow (negative indicates downward direction)			
	West				East				West				East				West	East	West**	East	West	East					West		East	
Water Year	Net Lay 1-3 Storage (AFY)	Net Lay 4-5 Storage (AFY)	Net Lay 6 Storage (AFY)	Total Net Flow From/To Storage (AFY)	Net Lay 1-3 Storage (AFY)	Net Lay 4-5 Storage (AFY)	Net Lay 6 Storage (AFY)	Total Net Flow From/To Storage (AFY)	Net Lay 1-3 GHB (AFY)	Net Lay 4-5 GHB (AFY)	Net Lay 6 GHB (AFY)	Total Net GHB (AFY)	Net Lay 1-3 GHB (AFY)	Net Lay 4-5 GHB (AFY)	Net Lay 6 GHB (AFY)	Total Net GHB (AFY)	Recharge (AFY)	Recharge (AFY)	Net Flow From Stream Leakage (AFY)	Net Flow From Stream Leakage (AFY)	Total Pumping (AFY)	Total Pumping (AFY)	Net Qa East/West Flow (AFY)	Net TsshTQsb East/West Flow (AFY)	Net Tsv East/West Flow (AFY)	Total Flow East/West (AFY)	Flow From lays 1-3 to lays 4-5 (AFY)	Flow from lays 4-5 to lay 6 (AFY)	Flow From lays 1-3 to lays 4-5 (AFY)	Flow from lays 4-5 to lay 6 (AFY)
1988	1,771.23	-2.27	-32.18	1,736.78	1,020.13	-0.63	-16.45	1,003.04	7,151	-1,129	-589	5,434	-215	1,526	-2,236	-925	2,132	1,188	-10,836	1,414	-559	-588	-2,092	-209	209	-2,092	-677	-605	-462	-1,230
1989	-570.78	-0.09	-0.49	-571.37	21.80	-0.03	0.06	21.83	3,334	2,149	76	5,559	-183	1,353	-2,278	-1,107	2,237	1,197	-7,761	1,509	-532	-553	-1,090	-209	230	-1,068	2,684	7	-489	-1,199
1990	899.90	0.15	0.70	900.74	51.77	0.21	0.74	52.72	11,488	-3,887	-798	6,803	-159	1,097	-2,348	-1,409	823	397	-8,062	1,546	-504	-547	-407	58	310	-39	-4,050	-925	-253	-1,189
1991	-248.14	0.06	0.32	-247.76	-47.12	0.20	0.58	-46.34	11,097	-1,994	-327	8,776	-127	1,555	-2,250	-823	0	0	-8,282	1,811	-576	-612	-598	-31	300	-329	-1,721	-468	-50	-1,160
1992	-1,479.57	-0.24	-1.30	-1,481.11	-91.03	-0.36	-1.36	-92.75	9,474	-116	-75	9,283	-133	1,584	-2,224	-773	1,211	644	-9,100	1,521	-591	-623	-802	-149	274	-677	489	-188	-232	-1,165
1993	-677.00	-0.17	-0.68	-677.86	-153.76	-0.23	-0.79	-154.78	-671	6,100	895	6,324	-304	1,830	-2,186	-660	4,875	2,665	-12,501	1,254	-538	-587	-2,336	-380	199	-2,517	7,578	835	-659	-1,212
1994	1,222.12	0.22	0.81	1,223.15	165.68	0.38	1.17	167.23	1,136	4,337	717	6,190	-109	1,606	-2,234	-737	1,804	950	-9,782	1,426	-599	-644	-1,253	-185	275	-1,163	5,397	554	-409	-1,203
1995	-945.71	-0.11	-0.55	-946.37	-157.83	0.01	-0.15	-157.97	-1,322	3,168	493	2,339	-374	124	-2,509	-2,760	7,029	4,086	-9,517	1,033	-525	-580	-1,946	22	303	-1,621	3,625	275	-1,738	-1,377
1996	203.43	0.06	0.12	203.61	1.55	-0.04	-0.04	1.47	703	3,200	490	4,392	-256	603	-2,405	-2,059	4,647	2,703	-10,196	1,410	-521	-583	-1,721	-49	297	-1,474	4,074	298	-1,264	-1,309
1997	158.60	0.01	0.06	158.67	10.61	0.06	0.26	10.93	6,035	-1,429	-263	4,343	-322	754	-2,332	-1,899	4,938	2,843	-10,301	1,314	-676	-731	-1,778	-70	310	-1,537	-1,014	-460	-1,087	-1,266
1998	-292.16	-0.16	-1.04	-293.36	-127.88	-0.16	-0.42	-128.46	-2,999	4,537	837	2,376	-433	360	-2,411	-2,484	7,339	4,346	-11,027	935	-502	-562	-2,266	-122	281	-2,107	5,327	585	-1,503	-1,295
1999	2,187.23	0.55	2.71	2,190.48	142.50	0.46	1.55	144.51	14	3,183	667	3,864	-231	1,051	-2,262	-1,442	2,905	1,619	-9,365	1,377	-617	-676	-1,267	-71	315	-1,023	3,734	382	-639	-1,192
2000	-1,945.18	-0.36	-1.32	-1,946.86	-66.87	-0.32	-0.70	-67.89	13,113	-4,999	-871	7,243	-243	1,066	-2,231	-1,408	2,750	1,573	-8,400	1,530	-606	-668	-1,086	-163	289	-960	-4,813	-1,021	-560	-1,170
2001	848.26	0.10	0.26	848.63	26.12	0.07	-0.05	26.14	5,515	1,226	241	6,981	-199	1,810	-2,039	-428	1,324	726	-9,521	1,480	-686	-752	-947	-358	252	-1,053	2,174	91	-32	-1,077
2002	-147.83	0.04	0.16	-147.63	12.05	0.28	0.82	13.15	7,183	-1,750	-214	5,218	-271	709	-2,266	-1,828	3,343	1,921	-8,549	1,493	-697	-767	-1,111	-46	325	-832	-1,481	-452	-813	-1,201
2003	-536.49	-0.10	-0.43	-537.02	-52.59	-0.13	-0.45	-53.16	11,067	-6,099	-954	4,014	-301	-386	-2,496	-3,183	4,514	2,558	-7,386	1,363	-610	-680	-707	297	405	-5	-6,700	-1,263	-1,312	-1,278
2004	1,029.78	0.23	1.04	1,031.05	35.94	0.23	0.78	36.95	9,556	-4,946	-795	3,814	-245	34	-2,416	-2,627	3,564	1,919	-7,616	1,532	-785	-870	-650	251	407	8	-5,438	-1,092	-1,137	-1,284
2005	-1,474.97	-0.26	-0.87	-1,476.10	-116.30	-0.22	-0.60	-117.12	12,591	-5,658	-859	6,073	-293	31	-2,439	-2,701	4,557	2,607	-9,113	1,369	-569	-632	-1,031	147	357	-527	-6,057	-1,101	-1,215	-1,265
2006	-324.39	0.03	-0.11	-324.47	-64.48	0.03	0.07	-64.39	9,963	-6,173	-1,051	2,739	-384	-581	-2,594	-3,559	6,832	4,005	-9,328	1,129	-675	-755	-1,389	240	393	-756	-6,700	-1,349	-1,814	-1,383
2007	3,319.63	0.51	2.06	3,322.20	200.76	0.35	1.24	202.35	5,851	-2,902	-814	2,135	-147	737	-2,271	-1,681	1,043	568	-5,540	1,622	-791	-881	-194	7	356	169	-2,932	-1,000	-581	-1,222
2008	1,579.31	0.22	1.03	1,580.56	42.54	0.05	0.36	42.95	12,325	-10,554	-2,471	-700	-180	-455	-2,529	-3,164	2,705	1,560	-1,957	1,780	-872	-978	61	295	400	757	-11,770	-2,619	-1,411	-1,398
2009	-1,653.04	-0.19	-0.74	-1,653.97	-86.88	-0.12	-0.42	-87.41	14,418	-8,348	-1,826	4,245	-131	205	-2,373	-2,300	1,892	1,070	-3,358	1,761	-740	-829	-80	106	359	385	-9,000	-1,971	-912	-1,279
2010	-1,858.65	-0.26	-1.04	-1,859.95	-99.01	-0.10	-0.46	-99.57	17,677	-10,275	-2,022	5,379	-184	-32	-2,411	-2,627	3,231	1,833	-5,970	1,517	-658	-746	-384	142	364	122	-11,136	-2,181	-1,099	-1,268
2011	-885.52	-0.25	-1.25	-887.02	-141.27	-0.29	-1.05	-142.62	9,775	-5,155	-1,130	3,491	-295	82	-2,390	-2,603	4,875	2,851	-7,823	1,371	-537	-597	-1,111	-68	299	-880	-5,187	-1,265	-1,294	-1,263
2012	2,126.04	0.37	1.57	2,127.97	129.25	0.34	1.23	130.82	9,452	-4,347	-836	4,270	-146	867	-2,188	-1,467	1,022	569	-6,727	1,594	-713	-806	-274	-78	332	-21	-4,245	-1,038	-439	-1,154
2013	1,445.62	0.29	1.18	1,447.08	71.97	0.23	0.75	72.96	13,246	-9,499	-1,986	1,761	-206	137	-2,364	-2,433	1,860	1,055	-3,814	1,768	-807	-910	-116	173	391	447	-10,318	-2,190	-889	-1,265
2014	-738.15	-0.27	-1.31	-739.72	-37.67	-0.32	-1.20	-39.19	17,586	-12,279	-2,277	3,030	-173	33	-2,380	-2,520	1,432	742	-2,195	1,872	-748	-835	134	232	414	780	-13,504	-2,540	-818	-1,239
2015	-757.68	-0.10	-0.34	-758.12	-80.74	-0.03	-0.08	-80.86	10,425	-5,655	-975	3,795	-286	459	-2,283	-2,110	2,733	1,475	-5,045	1,755	-829	-937	-553	70	379	-104	-5,961	-1,249	-831	-1,240
Average	*80.57*	*-0.07*	*-1.13*	*79.37*	*21.76*	*0.00*	*-0.52*	*21.23*	*8,042*	*-2,832*	*-597*	*4,613*	*-233*	*648*	*-2,334*	*-1,918*	*3,129*	*1,774*	*-7,824*	*1,482*	*-645*	*-712*	*-964*	*-5*	*322*	*-647*	*-2,772*	*-784*	*-855*	*-1,242*

*Positive values of flow for the west side of the model indicates flow entering the model via the general head boundary on the west side, moving eastward into the model domain; Negative values of flow for the east side of the model indicates flow leaving the model via the general head boundary on the east side, moving eastward.

**The western portion of the model in this analysis contains all of the Napa River model cells and accompanying stream leakage components, as well as Salvador Channel and Napa Creek and the land west of the Napa River. The eastern ortion contains land on the east side of Napa River and only eastern tributaries to the Napa River (including Soda Creek, Hardman Creek (and Tributary), Miliken Creek, Sarco Creek, Tulucay Creek, and Cayetano Creek.

Both sides of the Napa River typically replenish groundwater storage during wet years (e.g., 1995, 1998, 2010, and 2011) and sometimes remove water from storage during dry years (e.g., 2012 and 2013). The largest proportion of water moving in and out of storage occurs in the Quaternary alluvium (layers 1-3), as these upper units have a higher storage coefficient compared to deeper more confined units. The stream leakage component on the west side and including the Napa River mimic the reverse pattern of the recharge, so groundwater contribution to the streams occurs more during wet years (e.g., 1993, 2006, 2007). The eastern tributaries follow a similar but muted pattern, although streams are always showing net losing (contributing to groundwater) conditions on an annual basis on the east side of the Napa River; drier years result in more surface water flow to groundwater (e.g., 1991, 2001, 2014) compared to wet years (e.g., 1995, 1998, 2006) (**Figure 4-2**).

Pumping increased during the base period on both sides of the Napa River. Relative annual trends in groundwater pumping tend to be related to the amount of recharge; low recharge (during drier years) is typically associated with higher pumping amounts, and lower pumping amounts tend to occur when recharge is typically higher (during wet years).

Lateral groundwater movement between the east and west sides of the Active Model Area is mostly toward the Napa River, to the west, with exceptions occurring during recent periods of low recharge (e.g., 2007 to 2010 and 2013-2014) where the net lateral movement of all aquifer units was in the easterly direction. The largest component of lateral flow east or west occurs in the Quaternary alluvium (layers 1-3). The Tertiary deposits (layers 4-5) show a trend of net lateral movement toward the east over time within the 28-year simulation period. The Sonoma Volcanics unit (layer 6) is consistently moving water to the east at the Napa River border. The lateral movement shows similar groundwater pumping trends starting in 1993 when increases in pumping result in less movement to the west, with movement to the east in some years as noted above.

Vertical movement within the different aquifer units is typically in the downward direction, with larger amount of water moving downward on the west side of the Napa River from the Quaternary alluvium (layers 1-3) down to the Tertiary deposits (layers 4-5) on an average annual basis, as compared to areas east of the Napa River. The eastern side shows more water moving vertically downward from the Tertiary deposits (layers 4-5) to the Sonoma Volcanics (layer 6). The vertical flow generally follows the annual trend of the recharge with a slight delay (of about one year) where the west side of Napa River shows less downward flow to deeper aquifer units during or soon after wetter years; more downward flow occurs in drier years. The east side of the Napa River exhibits less downward flow during dry years compared to wet years with little to no delay. These results indicate recharge infiltrates downward to the Tertiary units on the east side where the Quaternary alluvium is typically thinner than alluvial deposits to the west of the Napa River.

4.2 Streamflow Effects

This Model simulates the interaction between surface water and groundwater at ten different rivers and creeks. The stream leakage component, or groundwater-surface water interaction component, from all simulated surface water features is discussed below. The Napa River is divided into six different areas for understanding the simulated behavior of the river and its interaction with the aquifer below it.

Tributaries are further grouped into western and eastern tributaries based on their location relative to the Napa River.

4.2.1 Napa River Surface Water Flow to Groundwater

The Napa River is divided into six different stream segments for the purposes of observing the surface water – groundwater interaction of the Napa River along its natural course in the model domain (almost 8 miles). The stream segments are listed below from north to south, and are illustrated in **Figure 4-3**:

1) North segments (Napa River to Soda Creek Tributary)
2) Middle segments (north of Salvador Creek)
3) Southern segment 1 (north of Milliken Creek)
4) Southern segment 2 (north of Napa Creek)
5) Southern segment 3 (north of Tulucay Creek)
6) Outflow (north of model boundary)

Most of the Napa River segments exhibit gaining stream conditions throughout the simulation period, except for the southernmost segment (near the model's outflow, near the model boundary). Time series plots of the monthly surface water flow to groundwater values for the Napa River segments are shown in **Figure 4-4**. This plot reveals the behavior of the surface water – groundwater interaction at various locations along the Napa River, including over the entire Napa River in the model domain. The time series plot shows typical surface water hydrograph patterns with peaks of negative surface water flow to the aquifer (meaning that flow is moving from groundwater to surface water, under gaining stream conditions) occurring between February and May, followed by less contribution from groundwater in the summer, with some brief months of losing stream conditions at the end of fall or early winter (December to February).

The total (or net) annual surface water flow to groundwater attributed to the Napa River is shown in **Figure 4-5** for each water year in the 28-year simulation period. This plot indicates that, on average, most segments of the Napa River exhibit gaining stream conditions, again except for the outflow portion of Napa River in the southernmost part of the Active Model Area near the southern model boundary. A trend appears starting in the late 1990s and early 2000s where on average, less groundwater contributes to the Napa River, as seen in the North Segments and Middle Segments. The Middle Segment (north of Salvador Creek and south of Soda Creek) trends toward losing stream conditions toward the end of the simulation period (in 2014). The net annual surface water flow to groundwater component for the Napa River shows a related pattern to recharge in that as recharge increases, more contribution from groundwater occurs. In wet years, there is more groundwater contributed to surface water than in dry years.

A closer look at the relationship between surface water and groundwater in the Napa River reveals that the climate (precipitation and recharge) plays a stronger role in the simulated contribution to surface water from groundwater, compared to other factors such as groundwater pumping. Plotting the precipitation on one axis and the stream leakage component for the Napa River on the other axis illustrates the relationship between water availability and groundwater contribution to surface water (**Figure 4-6**). The three pumping sensitivity scenarios' annual stream leakage components for the Napa River are also plotted in this figure. The relatively small difference between stream leakage values compared from the two extreme scenarios: 1) a scenario with double the amount of groundwater pumping to 2) the scenario with zero pumping. This comparison demonstrates the relatively minor role groundwater pumping has on Napa River groundwater contributions compared to the larger effect climate and precipitation have on this component. When annual precipitation totals are greater, stream leakage is more negative, which means more groundwater contribution to the Napa River during wetter years. Conversely, when annual precipitation totals are low, less groundwater is contributed to the Napa River, despite the scenario where there is zero groundwater pumping (**See Section 3.9.1**).

4.2.2 Tributaries Surface Water Flow to Groundwater

There are nine different tributaries simulated in the model domain; seven occur on the east side of Napa River, and two occur on the west side of Napa River. The net annual surface water flow to groundwater time series plot is presented in **Figure 4-7**. Sarco Creek consistently shows stable gaining stream conditions, with groundwater contributing to surface water. Napa Creek begins the simulation period as a gaining stream, but the creek exhibits a trend toward losing stream conditions starting in the early 2000s (and becomes a net losing stream during water years 2007-2009 and 2012-2015). Cayetano Creek and the Hardman Creek Tributary show the smallest amount of surface water-groundwater interaction, likely due to their short length in the model area and their apparent intermittent flow nature. The remainder of the tributaries (Salvador Channel in the west, Soda Creek, Hardman Creek, Milliken, Sarco, and Tulucay Creeks in the east) all exhibit net annual losing stream conditions during the entire simulation period. One exception occurs in Tulucay Creek in 2006 when the net surface water-groundwater flow was showing slight gaining stream conditions.

The tributaries' stream leakage (or annual surface water flow to groundwater) sensitivity to groundwater pumping is minimal, with stream leakage being influenced more by the amount of precipitation in a given year compared to how much groundwater is being pumped. For example, the simulated stream leakage in Soda Creek is plotted against annual precipitation in **Figure 4-8.** Without any groundwater pumping in the Active Model Area, surface water still enters the groundwater body each year along Soda Creek. The relationship between stream leakage in Soda Creek and precipitation is that of less losing stream conditions with more precipitation.

Overall, the total annual simulated surface water flow to groundwater component of the Model indicates that the Napa River is a major sink for groundwater (groundwater discharges to surface water); groundwater discharge to the Napa River dominates the stream leakage water budget component for the entire model domain (**Figure 4-9**). Overall, the tributaries on the west side of the Napa River show annual variations between being net gaining stream and net losing stream conditions, with more occurrences of net annual losing stream conditions starting in the early 2000s. The later trend likely reflects more recent climatic changes with more dry years of less than average precipitation. The eastern tributaries on the whole exhibit solely losing stream conditions, indicating that more surface water leaks out of those tributaries to enter the groundwater system than groundwater contributes to them in the form of baseflow, which is consistent with increased depths to groundwater, increased vertical gradients and separation between groundwater and streambeds in these areas.

4.2.3 Statistical Analysis of the Relative Influence on Stream Leakage

A multiple linear regression (MLR) analysis was performed on the Napa River stream leakage component of the water budget to ascertain how variability in the three other major water budget components account for variations in stream leakage along the Napa River on an annual basis across the model domain. The analysis focused on Napa River stream leakage because the Napa River is a primary surface water feature in the model domain and because at this location within the Subbasin it experiences a consistent hydraulic connection to groundwater as compared to the tributaries that are more variably connected to groundwater within the model domain. The analysis shows that recharge to the model due to percolation from the soil root zone accounts for the largest influence on Napa River stream leakage, 48% (**Table 4-2**). Almost as high an influence, but slightly lower, is the influence of subsurface lateral flow through the model's boundaries, 44%. Groundwater pumping had a very small relative influence on stream leakage, six times less than the influence of recharge for the baseline calibrated model scenario over the 1988 to 2015 study period, at only 8% (**Table 4-2**).

The MLR analysis used annual datasets for groundwater pumping, recharge, and stream leakage. This analysis is similar to the MLR analysis conducted for the Basin Analysis Report (LSCE 2016c), except that this analysis includes lateral flow and is based on annual datasets. These additions to the analytical approach were implemented to more fully account for relevant groundwater flow processes and to improve the regression coefficient results. **During the full study period, the relative influence of groundwater pumping on stream leakage was 8%, compared to 92% for the two climate-influenced variables (48% for recharge and 44% for lateral flow)** (**Table 4-2**). This proportion was unchanged for the scenario where pumping rates were held at 1988 levels throughout the study period. The proportional impact of pumping increased to 13% for the scenario where pumping was doubled relative to the baseline scenario.[24]

Table 4-2. Summarized Results of Multiple Linear Regression Analysis of Napa River Stream Leakage as a Function of Groundwater Pumping, Recharge and Lateral Flow

Model Scenario	Relative influence of Recharge	Relative influence of Pumping	Relative influence of Lateral flow	Coefficient of multiple correlation (R)	R^2	Adjusted R^2
For 1988-2015 Period (Entire study period)						
(1) Baseline	48%	8%	44%	0.87	0.76	0.70
(2) 1988 Pumping	47%	8%	44%	0.88	0.77	0.71
(3) Double Pumping	46%	13%	41%	0.87	0.76	0.70
For 1995-2015 Period						
(1) Baseline	49%	6%	46%	0.88	0.77	0.69
(2) 1988 Pumping	50%	2%	48%	0.88	0.77	0.69
(3) Double Pumping	47%	10%	43%	0.88	0.77	0.69
Note: Relative influence values may not sum to 100% due to rounding.						

A subset of more recent years was also analyzed by MLR to evaluate whether the relative influence of pumping has changed with time. The 1995-2015 period was selected, to allow for an approximately equal number of years with above average and below average precipitation, to minimize the potential impacts of variations in recharge on the analysis. For this period, influences of recharge and lateral flow

[24] The sensitivity scenario with no pumping was not included in the analysis because non-zero values are required for the analysis.

were similar to the results for the entire study period, with relative influences of 49% and 46%, respectively. The influence of pumping over the 1995 to 2015 period decreased to 6% for the baseline water budget, 2% for the 1988 pumping scenario and 10% for the doubled pumping scenario.

4.3 Mutual Well Interference and Regional Effects on Water Levels

In the Petra Drive area, where many private wells are densely spaced, water level declines until about 2009 have been observed in some wells (e.g., Napa County Wells 75 and 76). The water budget of this particular area sheds light on the mechanisms for water level changes in this area. Water budget components have been estimated for the main Petra Drive area (**Figure 3-25**) using post-processed simulation results. These flows have been summarized by water year for the 28-year simulation period. A panel of time-series plots illustrates the amount of flow associated with each water budget component within the Petra Drive main area over time (**Figure 4-10**). Average annual storage changes were less than 10 AFY, so these do not play an important role in the overall water budget in this area. The recharge and stream leakage in this area show similar trends over time (increases in recharge during wet periods are associated with more negative stream leakage, which means that recharge water is being made available to contribute to surface water bodies in the area (Napa River and Soda Creek). Groundwater in this area moves downward vertically over time, showing a trend of more water moving downward throughout the simulation period, and more water moving vertically from the thin Quaternary alluvium down to the Tertiary sedimentary deposits (Tss/h). The thickness of the Quaternary alluvium increases from less than a foot near the northeastern model boundary to just over 100 feet to the southwest at the Napa River, and this vertical flow likely represents much of the recharge percolating downward toward pumping stresses.

For discussion of lateral flow through the Petra Drive area, the area was divided into four directions (northwest, east, west, and south) (**Figure 3-25**). Time series plots of the annual net lateral flow are shown in the four lower panels of graphs in **Figure 4-10**. Groundwater enters the main Petra Drive area from the northwest, mostly coming from the Quaternary alluvium (Qa, layers 1-3) and Sonoma Volcanics (Tsv, layer 6), and a minor contribution from the Tertiary sedimentary unit (Tss/h, layers 4-5). **Groundwater leaves the main Petra Drive area out of the eastern and southern borders (in the direction of the MST), mostly via the Sonoma Volcanics.** A very small amount of the flow through the eastern border is into the main Petra Drive area in the Quaternary alluvium upper model layers, likely because of recharge water following the path of the water table and topography, and a connection to Soda Creek. Some groundwater leaves the Petra Drive area to the east through the Tertiary sedimentary unit, and over time it appears that the amount of groundwater moving to the east out of the Petra Drive area is increasing since 1993 (doubling in this period from around 60 AFY in 1993 to about 120 AFY in 2015). The western border of the Petra Drive area coincides with the Napa River, and groundwater flows into the Petra Drive area to the east in all model layers, with the most water entering the area via the Quaternary alluvium, which follows the pattern of the net stream leakage, with more groundwater flowing into the Petra Drive area via the western border when there is more groundwater contributing to the Napa River during wet years (e.g., water year 2006). All model layers show groundwater leaving the main Petra Drive area through the south, with most of the water leaving through the lower Tertiary model layers. On average, more water comes in laterally via the west and northwest than leaves via the south and east.

The average annual water budget components of the Petra Drive area (**Figure 4-11**) indicate that the two largest components of flow in the Petra Drive area are stream leakage and lateral flow. Gaining stream conditions in the Napa River dominate the stream leakage term in the water budget, as Soda Creek is consistently a losing stream on an overall annual basis. Lateral flow provides the greatest amount of inflow to the Petra Drive area, followed by recharge. Pumping accounts for the other mechanism for groundwater to leave the Petra Drive area, making up about half of the amount of water that recharge provides.

Groundwater flows from the north and northwest to the south and southeast, with some minor deviations (**Figure 4-12**). The local effects of Petra Drive pumping (and mutual well interference) are visible in the spring 2009 and spring 2016 maps, where the groundwater levels are pulled slightly lower to the northwest in the vicinity of the Petra Drive cluster of wells on the northwest side of Soda Creek. **The groundwater levels locally in the Petra Drive area are slightly lower due to mutual well interference, but also due to the more regional drawdown occurring to the east in the MST outside the Napa Valley Subbasin.** Wet years (e.g., 2006) show the mutual well interference being minimal to nonexistent compared to drier years, while the lower water levels are still present in the southeast.

A brief analytic analysis of distance drawdown was performed using the calibrated Model’s aquifer parameters of storage and hydraulic conductivity for a typical well in the Petra Drive area. The Modified Nonequilibrium Equation (Driscoll, 1986) for flow from a pumping well and drawdown at a specified distance was employed. For the Petra Drive example, the following equation was used:

$$s = \frac{0.183\,Q}{T} log \frac{2.25Tt}{r^2S}$$

Where *Q* is the pumping rate (here 1 gpm, or 192.5 ft^3/d), *r* is the distance to the nearby well (here 115 feet [25]), *S* is the storativity (here 1.00E-07), *T* is the transmissivity or hydraulic conductivity times saturated thickness (here the HK = 10 ft/d and the typical screened interval was 100 ft, making the transmissivity 1,000 ft^3/d), and *t* is for time since pumping started (here 1 day, 100 days, and 365 days). The resultant drawdown felt at 115 feet from a typical well on Petra Drive is 0.22 feet after 1 day; 0.29 feet after 100 days; and 0.31 feet after 1 year. This indicates that less than half of a foot of drawdown or mutual well interference from one well occurs, and is relatively minor compared to the regional trends of water levels, but also that when compounded, many wells in close proximity will result in superimposing that incremental drawdown to further lower groundwater levels.

[25] The average distance between each well located along Petra and the nearest neighboring well is 115 feet.

5 FINDINGS AND RECOMMENDATIONS

This section summarizes the findings of this investigation and describes recommended actions to maintain groundwater sustainability in the northeast Napa Area (and the Napa Valley Subbasin) and to ensure that future land and water uses do not contribute to significant and unreasonable streamflow depletion.

The results for the northeast Napa Area study indicate that groundwater in this localized area is in balance, with inflows and outflows nearly equal, over the 28-year period studied. During drier years, groundwater levels have declined and in normal to wetter years groundwater levels have recovered. East of the Napa River, two wells in Napa County's monitoring network, completed in deeper formations, showed historical groundwater level declines; groundwater levels in these wells have stabilized since about 2009. The study indicates that the main factor contributing to the declines in these wells is the effect of the cones of depression that developed in the MST in response to pumping in poorly permeable aquifer materials. However, the dense spacing of private water supply wells, particularly in the Petra Drive area, may also have contributed to the localized groundwater decline.

Groundwater discharge contributes significantly to streamflow in the reach of the Napa River in the model domain that is categorized as perennial. However, other tributaries to the Napa River in the model domain, such as Soda Creek, are categorized as seasonally intermittent. A losing condition is typical for Soda Creek, and its flows are more affected by drier water years rather than by pumping.

Less groundwater is discharged to the Napa River during drier water years when recharge and lateral subsurface flows into the Study Area are reduced. The study assessed the difference in effects on groundwater discharge when no pumping occurred in the Study Area and also the effect of doubling the pumping relative to the pumping estimated for the 1988 to 2015 study period. Climatic effects were found to have a much greater effect on groundwater discharge to the River when statistically compared to: 1) the base period pumping, 2) pumping held steady at a rate comparable to what was estimated for 1988, and 3) double the pumping relative to the base period. Additional pumping can occur in the northeast Napa Study Area; however, other measures are recommended to ensure groundwater conditions remain sustainable and streamflow depletion caused by pumping does not become significant and unreasonable. Because the northeast Napa Area, especially east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because the average annual water budget is about in balance, it is recommended that the area east of the Napa River become a management area within the Napa Valley Subbasin to ensure groundwater sustainability. The management area would include 1,950 acres (4% of the Napa Valley Subbasin) (**Figure 5-1**).

Study findings and recommended actions to maintain groundwater sustainability in the northeast Napa Area (and also the Napa Valley Subbasin) are summarized below. The recommended actions are consistent with groundwater management measures referenced in the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c).

5.1 Summary of Findings

A summary of the findings from the analysis of groundwater and surface water in the northeast Napa Area are listed below.

1) Groundwater storage played the smallest role in the water budget, hovering around net-zero annually (inflow equals outflow and little water depleting or replenishing storage).
2) Groundwater pumping makes up the next smallest component of flow in the model domain's water budget.
3) Lateral subsurface flow through all of the model's boundaries is generally a net positive number; more groundwater is flowing into the model domain than is flowing out through the subsurface. When groundwater does flow out of the model area through the subsurface, it typically leaves the model via the east side near the Soda Creek Fault. This is likely influenced by the lower groundwater levels in the MST driving the easterly horizontal flow gradient.
4) Recharge plays a key role; it is the second largest water budget component.
5) Within the model area flows to the Napa River dominate the groundwater budget; a large component of groundwater in the model discharges into the Napa River as baseflow. On the other hand, tributaries in the area most often discharge to groundwater, recharging the groundwater system on a seasonal basis.
6) Tributaries on the east side of the Napa River consistently show net losing stream conditions over time, despite seasonal fluctuations where gaining stream conditions occur briefly. As an example, Soda Creek consistently exhibits net losing stream conditions on an annual basis (even during wet winter conditions and also during the scenario when no pumping was simulated); the Creek is more affected by precipitation than groundwater pumping in determining the rate of stream leakage to groundwater.
7) The model results indicate a decreasing trend in the amount of groundwater contributing to stream flow starting in the late 1990s. As illustrated during the sensitivity scenario in which no groundwater pumping occurred, this recent trend can be attributed to less precipitation (climatic effects), and not due to groundwater pumping. Statistical analyses indicate that this trend is more related to climatic effects, including reduced recharge and subsurface lateral flows, rather than to groundwater pumping.
8) Lateral flow, the third largest component of the model domain's water budget, was typically a net inflow into the area, but a trend is seen starting in 1992 that shows less regional groundwater flowing into the model area. In some years, the net annual lateral flow is out of the model domain, which may indicate a future trend, or may be the result of climatic effects during increasingly drier water years.
9) Geologic faulting in the model area is important to the overall behavior of water levels east of the Napa River. Additional concealed faults may be present, which may affect water levels in deeper wells in the Petra Drive area.
10) Statistical analyses of water budget components (including recharge, lateral flows and pumping) relative to stream leakage (groundwater contributions to Napa River baseflow) show that, over the 28-year base period, climate effects have a much greater influence on stream leakage than

pumping. Climate-driven variables account for 87 to 92% of the effect on groundwater discharge to Napa River, while pumping contributes to 8 to 13% of the effect on groundwater discharge to the River.

11) Modeling scenarios showed:
    a) Annual stream leakage fluxes (in and out of the surface water) were very similar even with no pumping occurring showing minimal stream impacts due to pumping;
    b) When pumping was reduced, a slight increase in the amount of groundwater contribution to the Napa River occurred (this had about a third of the effect that subsurface lateral flow had on this type of change). For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping reduced to 1988 conditions, the relative influence of pumping on baseflow was 2%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.
    c) When pumping was doubled, a slight decrease in the amount of groundwater contributed to the Napa River occurred. For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping doubled, the relative contribution to baseflow effects was 10%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.
12) Some drawdown effects on groundwater levels in the Petra Drive area are associated with mutual well interference; these are compounded by the high density of wells. However, these lowered levels are not as significant as the regional influence of the eastern boundary and movement of groundwater towards the MST.

5.2 Recommendations

A summary of the recommendations from the analysis of groundwater and surface water conditions in the northeast Napa Area are listed below.

5.2.1 Surface Water/Groundwater Monitoring Facilities

As discussed in the County's report, *Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin* (LSCE, 2016c), the implementation of the DWR Local Groundwater Assistance (LGA) program to construct and implement coupled surface water and groundwater monitoring in and near the Napa River system has been very valuable for improving the understanding of surface water and groundwater interaction. Similar facilities at additional locations would help further this understanding, and are important for the County's Sustainable Groundwater Management Act sustainability goal. These facilities would be key to the objective of maintaining or improving streamflow during drier years and/or seasons. Although this study utilized dozens of monitoring wells with historical groundwater level records to evaluate observed and simulated groundwater level trends, there are no shallow monitoring wells located east of the Napa River and constructed in the alluvial deposits. Monitoring wells constructed to monitor groundwater level responses in the shallow alluvial deposits would improve understanding of the effect of pumping from relatively deeper parts of the groundwater system on the water table. This would further improve the understanding of the effect of pumping on potential streamflow depletion.

Recommendation:

A. **Surface Water/Groundwater Monitoring Facilities** It is recommended that the County construct shallow nested groundwater monitoring wells (like the recently installed Local Groundwater Assistance Surface Water/Groundwater monitoring facilities) east of the Napa River in the vicinity of Petra Drive. This will provide data to improve the understanding of the effect of pumping on potential streamflow depletion.

5.2.2 Northeast Napa Area – East of the Napa River

5.2.2.1 *Proposed Management Area – Northeast Napa/East of the Napa River*

The findings of the northeast Napa Area study indicate groundwater conditions are significantly influenced by climatic factors, geologic features that are distinct from those of the larger Napa Valley Subbasin, and cones of depression in the adjacent MST Subarea, outside of the Napa Valley Subbasin. Because the northeast Napa Area, especially east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock and because the average annual water budget shows the area to be in balance with inflows and outflows nearly equal, it is recommended that this area (east of the Napa River) become a management area within the Napa Valley Subbasin (**Figure 5-1**).

Recommendation:

B. **Management Area Designation** It is recommended that a Sustainable Groundwater Management Act (SGMA) Management Area be designated for a portion of the Study Area, i.e., Northeast Napa Area/East of the Napa River. SGMA defines a “management area” as an area within a basin for which a Groundwater Sustainability Plan (in this case, the Napa Valley Subbasin Basin Analysis Report) may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors (GSP Regulations Article 21, Section 351)(LSCE, 2016c). The northeast Napa Study Area east of the Napa River meets the criteria for management area designation due to geologic features and aquifer parameters that are distinct from those of the larger Napa Valley Subbasin.

5.2.2.2 *Discretionary Projects in the Management Area*

Based on the results of this study, the groundwater system in the Study Area is “about in balance” over the study period. The model sensitivity scenario, in which groundwater pumping was increased, provides insight into the relatively minor effect that an increase in pumping has on the overall water budget in the Study Area. Relatively small amounts of increased pumping may be considered for proposed discretionary projects in the Management Area: Northeast Napa/East of the Napa River. However, it is recommended that additional project-specific analyses (as described in the Napa County Water Availability Analysis (2015), Tier 2) be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid stream flow effects] and avoid mutual well interference to neighboring wells).

The project-specific information recommended to be incorporated in the analysis includes:

- Parcel specific information on current and proposed water use (surface water and groundwater);
- Water demand estimates that include normal and dry-year water types;
- Existing and proposed well location and construction information (for all water uses);
- Existing well performance data, to the extent available. These data include well yields, specific capacities, water level recovery rates (from pumping tests), if any.

Recommendation:

C. **Discretionary Project WAA Review in the Management Area** For discretionary projects, it is recommended that additional project-specific analyses (Napa County Water Availability Analysis (WAA)(2015)-Tier 2) be conducted to ensure that the proposed project location or planned use of groundwater does not cause an undesirable result (e.g., locate proposed wells at appropriate distances from surface water [or consider well construction approaches that avoid streamflow effects] and avoid mutual well interference to neighboring wells).

5.2.2.3 *New Well Tracking in the Management Area*

Pumping amounts for existing domestic supply wells located in the recommended Management Area: Northeast Napa/East of the Napa River are relatively small.

Recommendation:

D. **New Well Tracking in the Management Area** As a precautionary measure, it is recommended that the County track new non-discretionary groundwater wells constructed in this area, including their planned usage and location.

Applicants should be informed of potential well interference effects, if they propose well construction in an area that already has densely spaced wells.

Following installation of the recommended monitoring facilities (**Section 5.1**), and ongoing data collection, evaluation and reporting, it is recommended that the County assess whether any further measures are needed in the future to ensure groundwater sustainability.

5.2.3 New Well Pump Tests

The distribution of the hydraulic conductivities in the Napa Valley as presented by Faye (1973) was based on data recorded on historical drillers' reports. During the updated hydrogeologic conceptualization (LSCE and MBK, 2013), it became evident, based on the approximately 1,300 reports reviewed, that most of the "test" data are insufficient to adequately determine or estimate aquifer characteristics and to reliably determine well yield, since most of these data were recorded during airlift operations rather than a pumping test. As discussed in this study, similar limitations were encountered with the well test data. Currently, test methods accepted in the County's Well and Groundwater Ordinance allow bailing, airlifting, pumping, or any manner of testing generally acceptable within the well drilling industry to determine well yield.

Recommendation:

E. **New Well Pump Testing** It is recommended that pumping test data be collected when new production wells are constructed in areas where the distribution of hydraulic conductivities is less known, including the northeast Napa Area east of the Napa River and in deeper geologic units throughout the rest of the Napa Valley Subbasin. Because older and less productive geologic formations occur near ground surface in the northeast Napa Area east of the Napa River, it is recommended that a pump test be performed for all new production wells in that area (**Figure 5-1**). Test results will not only provide valuable information regarding aquifer properties; true pump testing will provide well owners with more meaningful information about well capacity than the typical tests of well yield reported on historical well completion reports. Similar pump testing is recommended for non-domestic production wells, and for wells that are completed in deeper units below the Quaternary alluvium throughout the Napa Valley Subbasin.

5.2.4 Napa Valley Subbasin Groundwater Flow Model

In 2006, a groundwater flow model was developed for the Napa River watershed which was generally conceptualized as a large basin of impermeable rock overlain in three distinct areas by more permeable units (DHI, 2006). The three areas that were the focus of the groundwater model were the north Napa Valley area and the MST and Carneros Subareas. The groundwater model encompassed the Napa River watershed and consisted of two layers. The upper layer was designated as being unconfined and the lower layer was designated as confined. Each of the three modeled areas was represented as a separate water-producing geologic unit. The geologic unit that was conceptualized as the primary source for groundwater in the north Napa Valley area was the alluvium. Aquifer parameters and their distribution were based on previous work presented in Faye (1973), and extrapolated to the rest of the Napa Valley Floor to the south.

Modeling tools help facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources. Large regional models can be especially useful tools to examine complicated scenarios. As described in this study (and previous studies LSCE and MBK, 2013 and LSCE, 2016b), the geologic and hydrogeologic setting in Napa County and specifically the Napa Valley Floor, is extremely complex. The updated hydrogeologic conceptualization, aspects of which were utilized for this study, shows that the subsurface is so complex that the prior two-layer model for the north Napa Valley area, which focused on the alluvium with unconfined and semi-confined aquifer characteristics, needs significant refinement for future use and to improve the model's predicative utility.

The numerical groundwater flow model developed for the northeast Napa Area study allows quantitative assessment of locally occurring mutual well interference and potential streamflow depletion under varying water year types. It is a tool that facilitates understanding about the underlying groundwater system in this local area; however, that understanding is subject to assumptions.

With the updated hydrogeologic conceptualization for the Napa Valley Subbasin and the implementation of SGMA, it is recommended for regional groundwater analyses and assessment of streamflow depletion that a groundwater flow model be developed for the entire Napa Valley Subbasin. Ongoing improvement of datasets and models/tools to understand mechanisms and results of predictive scenarios will help inform future approaches to ensuring sustainability.

Efforts to conduct groundwater modeling for the Napa Valley Subbasin would be similar to those implemented for this study but on a larger scale. These include:

- Incorporation of updated physical hydrogeologic conceptualization in the model structure
- Updated aquifer parameters
- Incorporation of faults and other geologic features
- Estimating streambed properties
- Estimating water source utilization, including well types and points of surface water diversion as best possible based on available data
- Incorporation of surface water/groundwater interaction that allows quantification of streamflow depletion spatially and temporally
- Sensitivity analyses of parameters until such parameters can be refined through proper empirical analysis and testing.

Recommendation:

F. **Groundwater Flow Model Development** It is recommended that a similar model be created for the entire Napa Valley Subbasin. The development of a Napa Valley Subbasin-wide modeling tool would help facilitate the examination of water resources management scenarios, including the effects of climate change and other stresses on surface and groundwater resources. With the updated hydrogeologic conceptualization for the Napa Valley Subbasin and the implementation of SGMA, it is recommended for regional groundwater analyses and assessment of streamflow depletion that a groundwater flow model be developed.

5.2.5 Increased Water Conservation and Evaluation of Recharge Opportunities

It is recommended, in addition to the County's countywide goals to promote sustainable use and management of water, maintain or improve ecosystem health, and increase climate resiliency, that these goals receive extra attention across the entire northeast Napa Study Area. Innovative conservation approaches are encouraged, along with targeted recharge strategies that have the potential to improve ecologic habitat, sustain water resources, and improve water resources resiliency under future climate conditions. As described in the Napa Valley Subbasin Basin Analysis Report, it is recommended that opportunities for strategic recharge be evaluated, particularly along the Subbasin margin and in consideration of hydrogeologic factors (LSCE, 2016c).

Recommendation:

G. **Increased Water Conservation and Recharge** It is recommended that countywide goals to promote sustainable use and management of water, maintain or improve ecosystem health, and increase climate resiliency receive extra attention in the northeast Napa Area. This should include evaluating approaches for retaining and using stormwater and/or tile drain water to increase water conservation, examining opportunities to reduce pumping and streamflow diversions, potentially lessening streamflow effects during drier years or drier periods of the year, and creating additional climate resiliency through targeted recharge strategies.

6 REFERENCES

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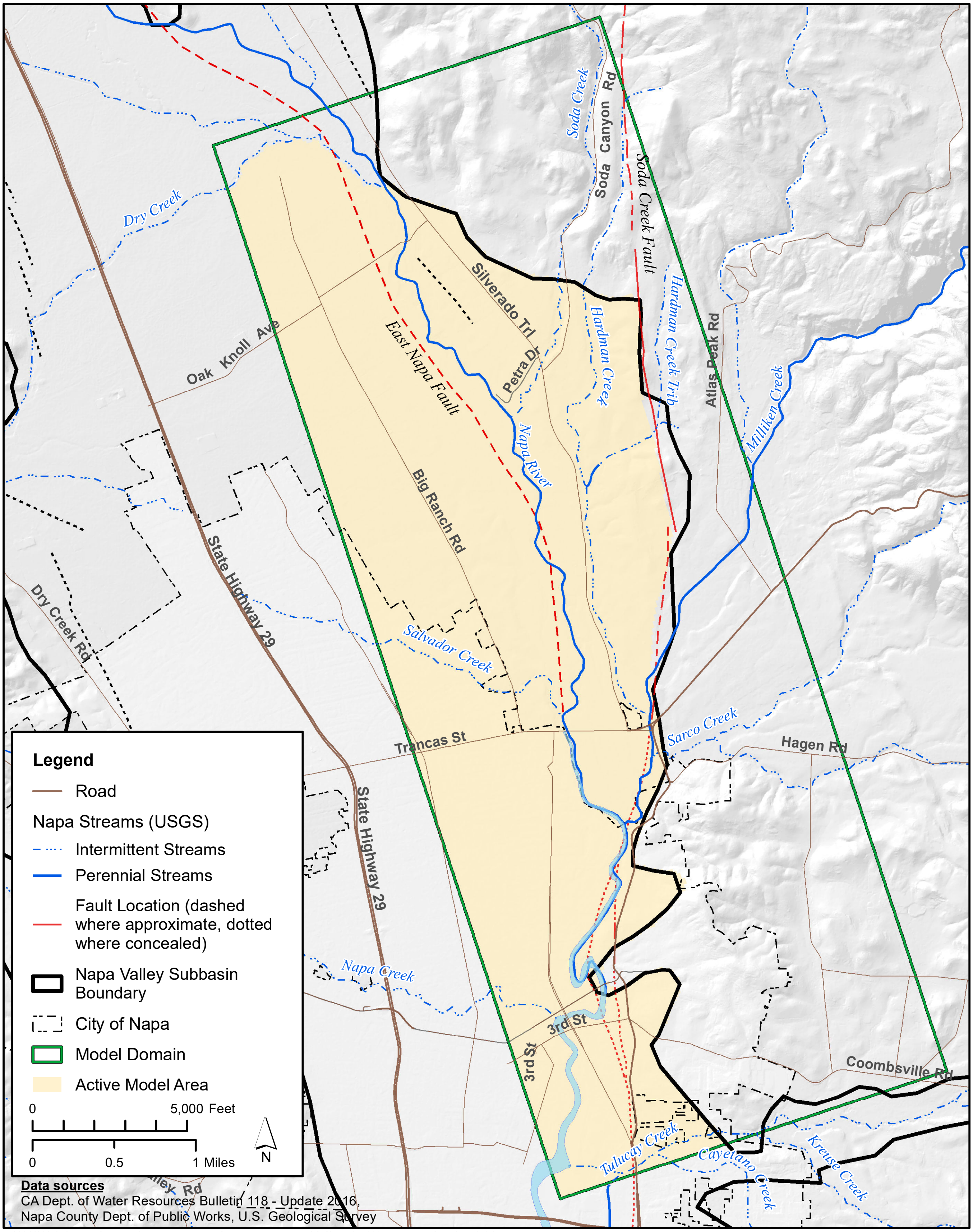
FIGURES



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2016,
Napa County Dept. of Public Works, U.S. Geological Survey

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FIGURE 1-1

Northeast Napa Study Area Location

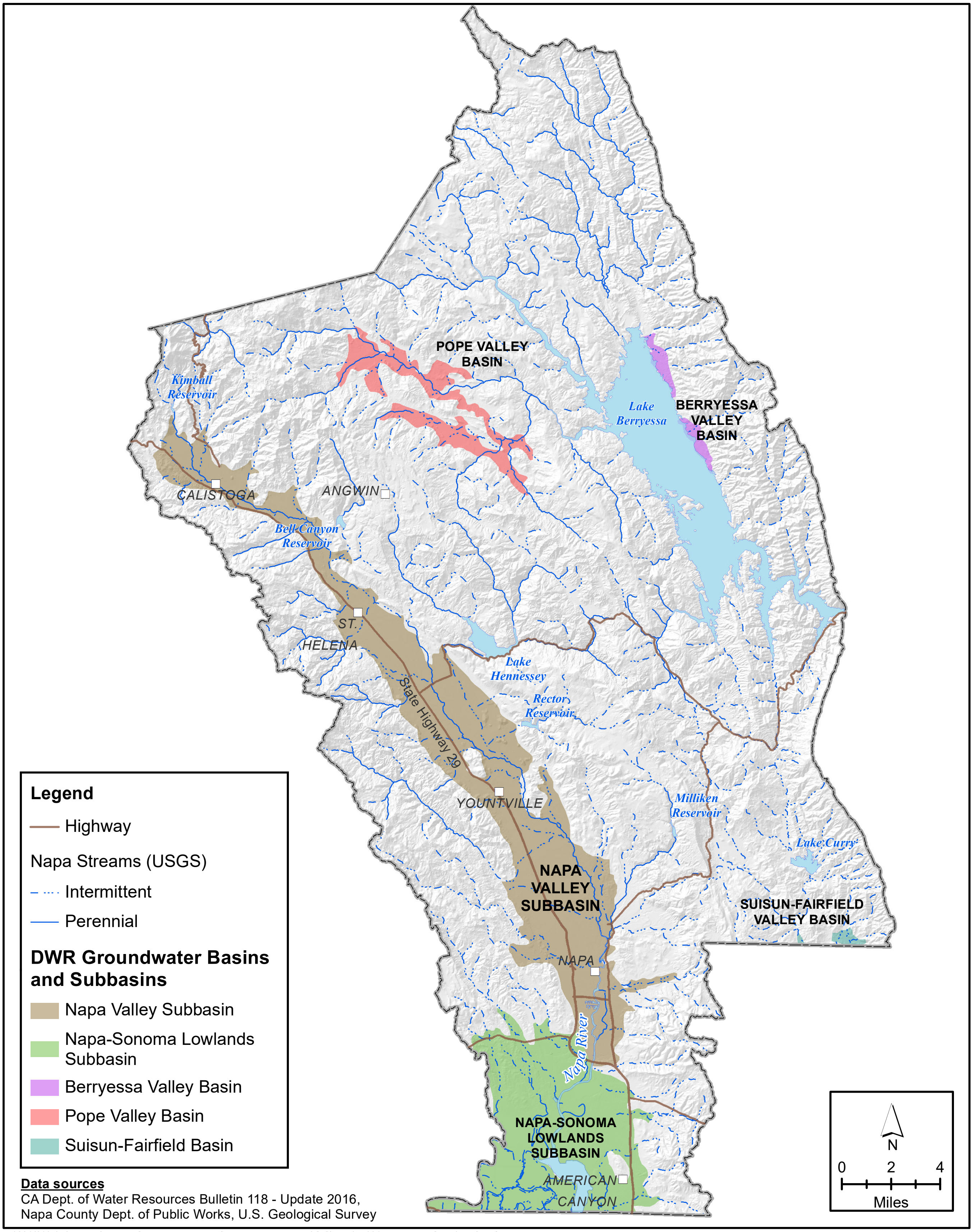

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FIGURE 2-1

Groundwater Basins and Subbasins in Napa County

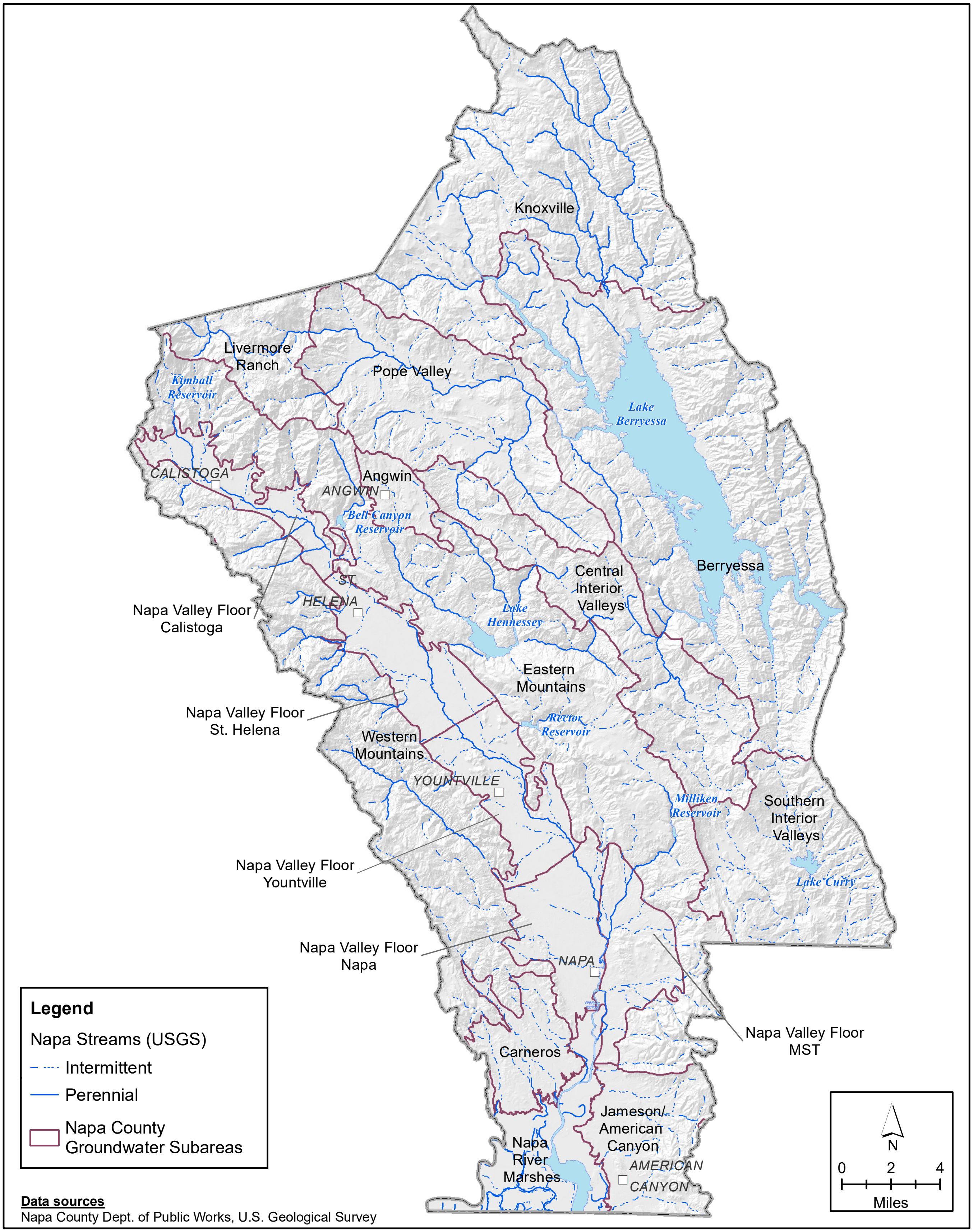

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FIGURE 2-2

Napa County Groundwater Subareas

Northeast Napa Area: Special Groundwater Study

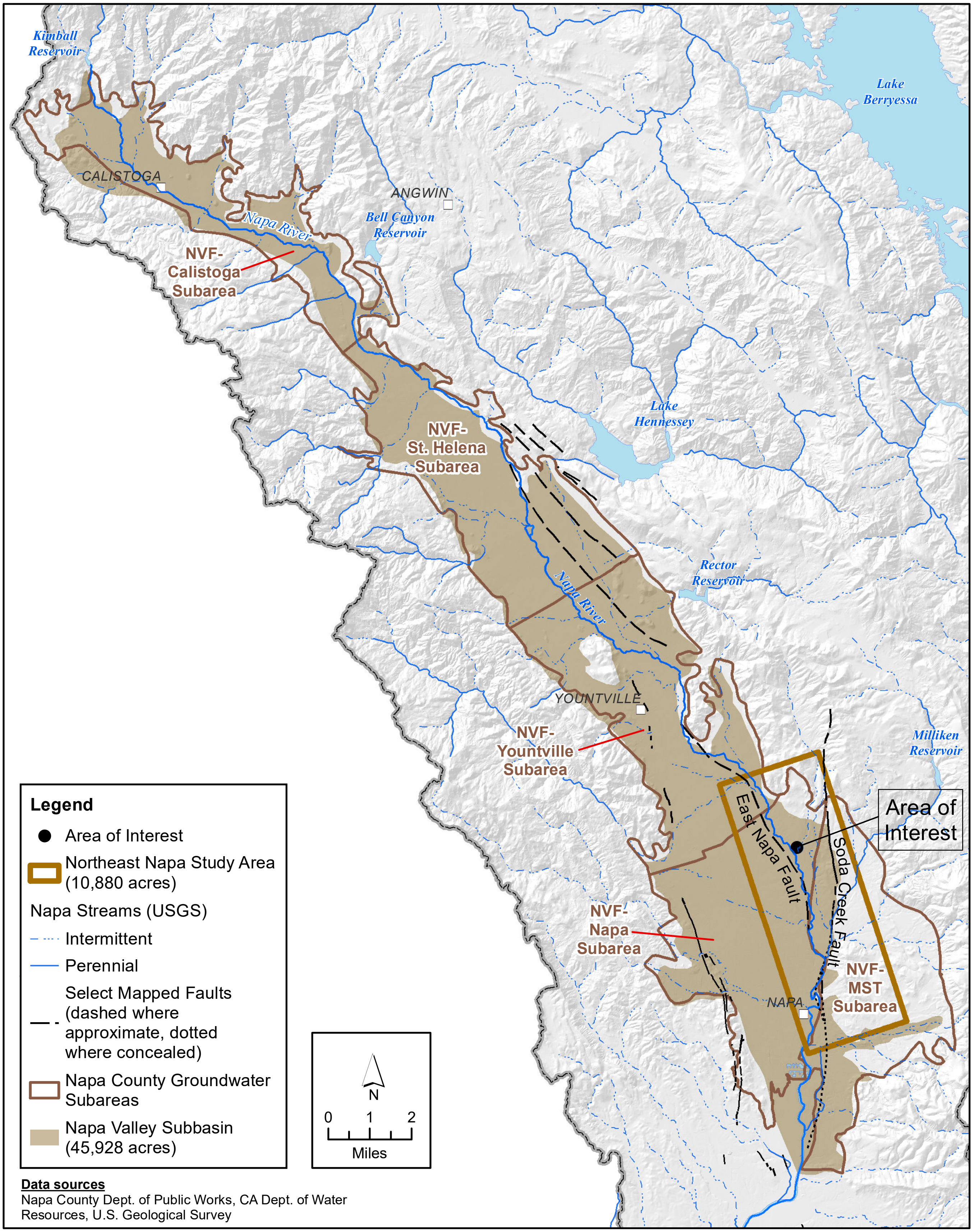

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FIGURE 2-3

Northeast Napa Area of Interest

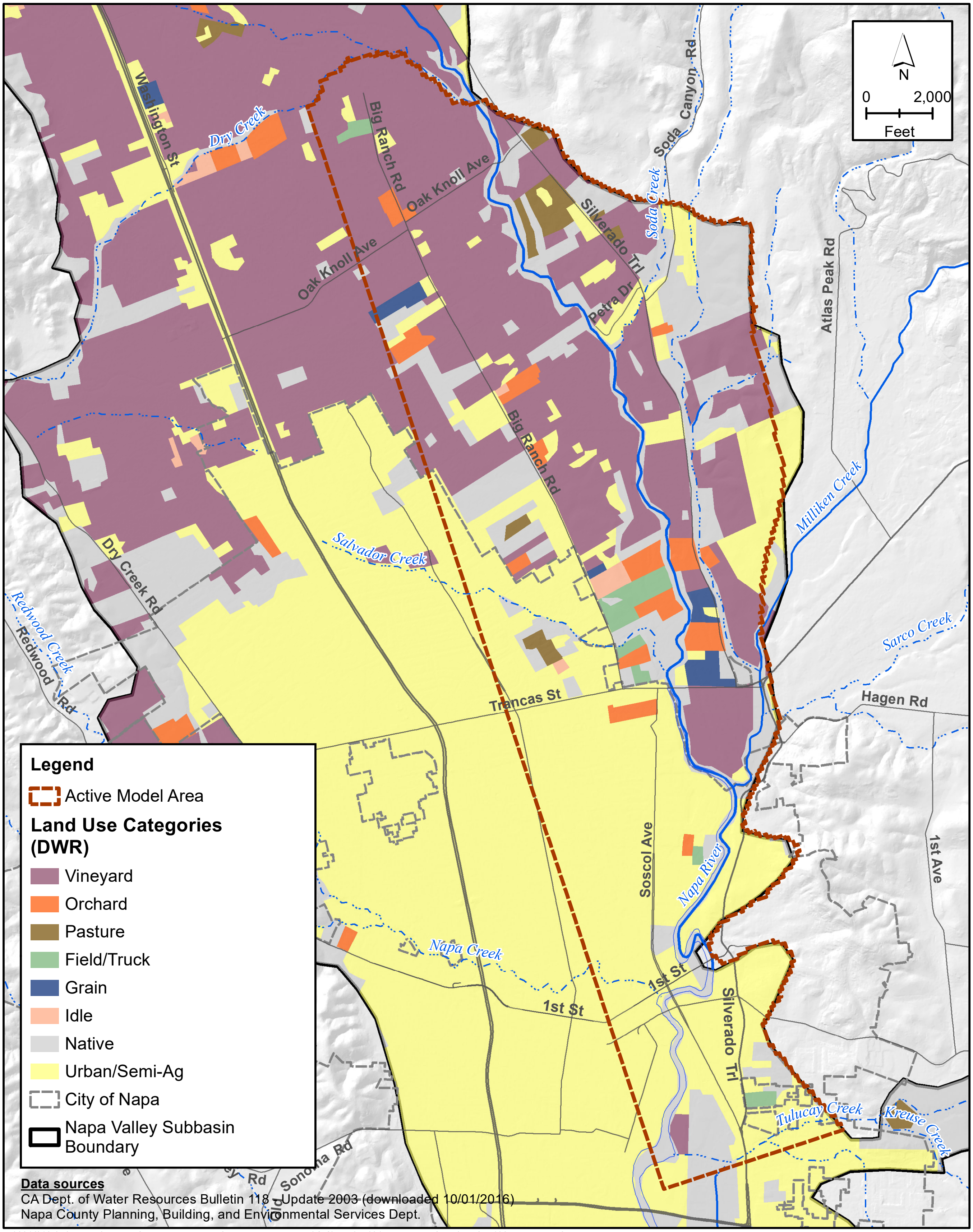

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FIGURE 2-4

1987 Land Use Categories

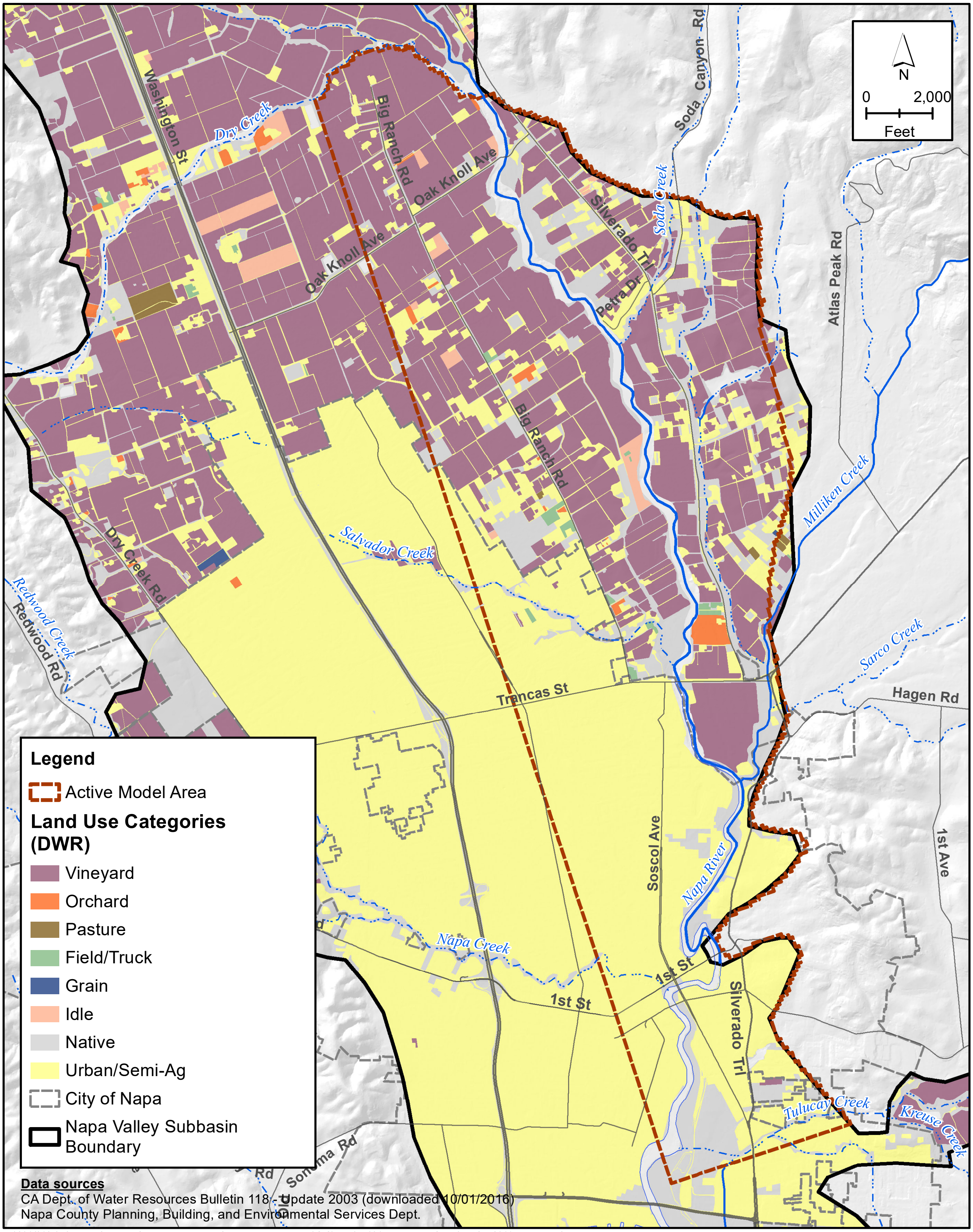

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FIGURE 2-5

2011 Land Use Categories

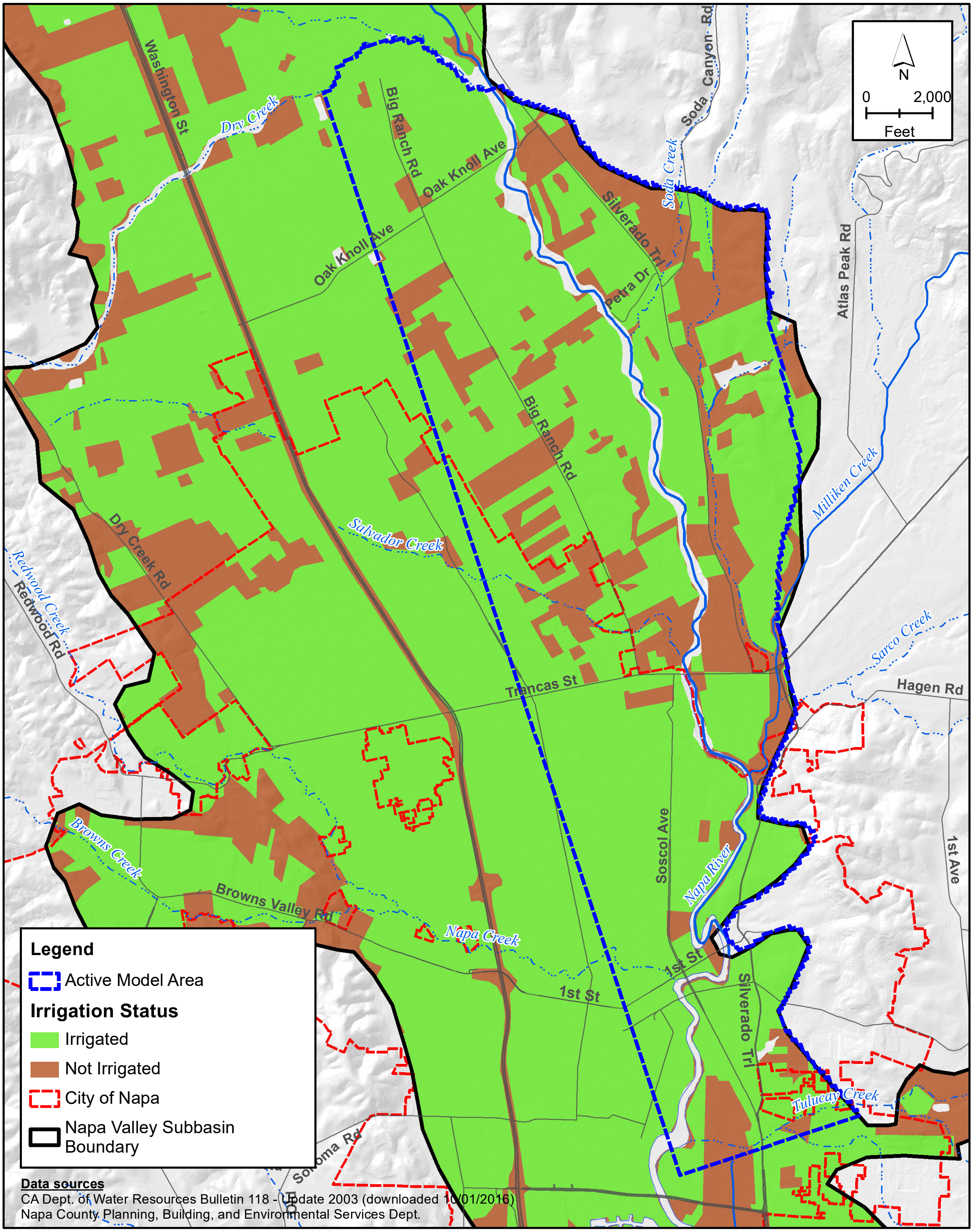

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FIGURE 2-6

1987 Land Use - Irrigation Status

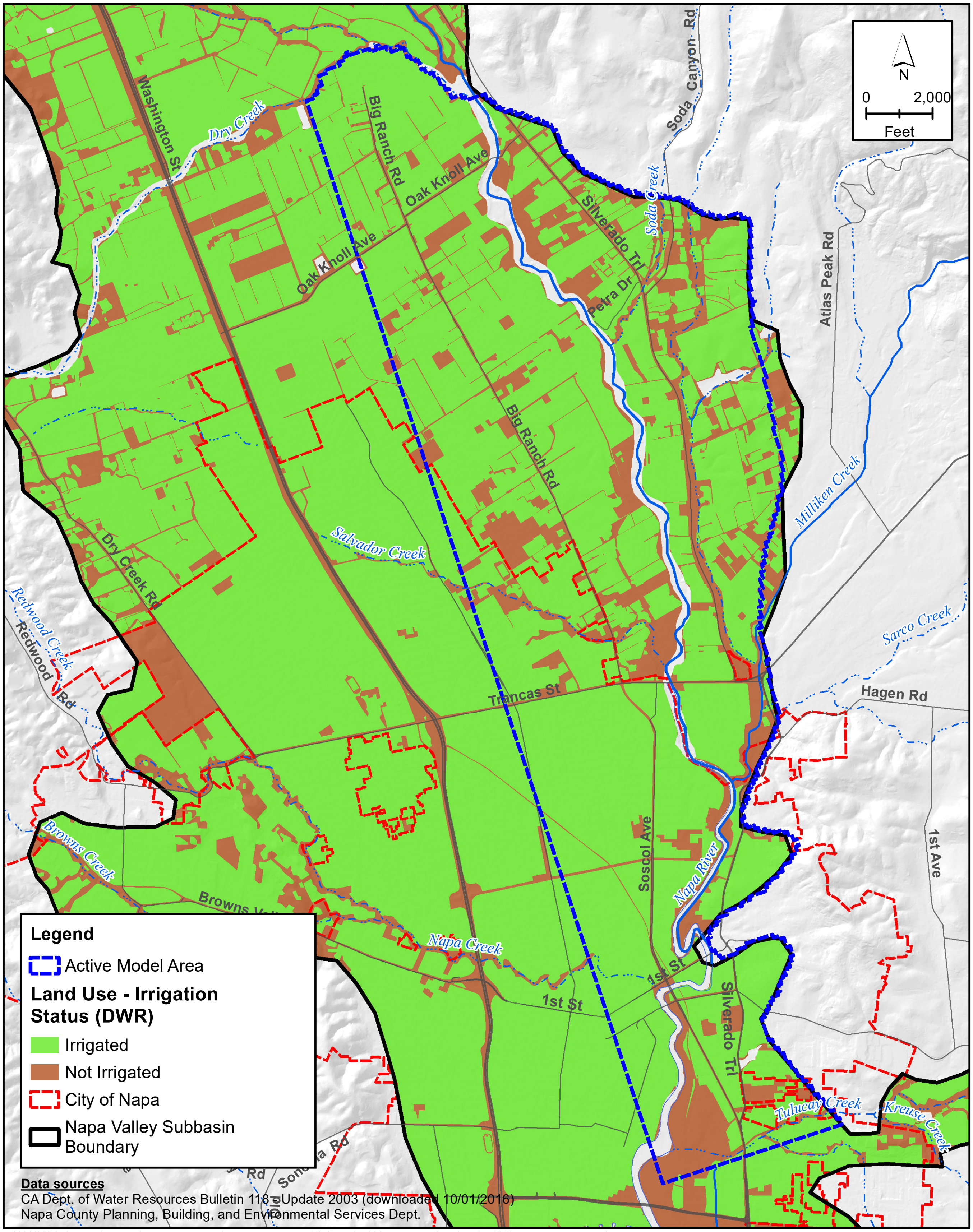

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FIGURE 2-7

2011 Land Use - Irrigation Status

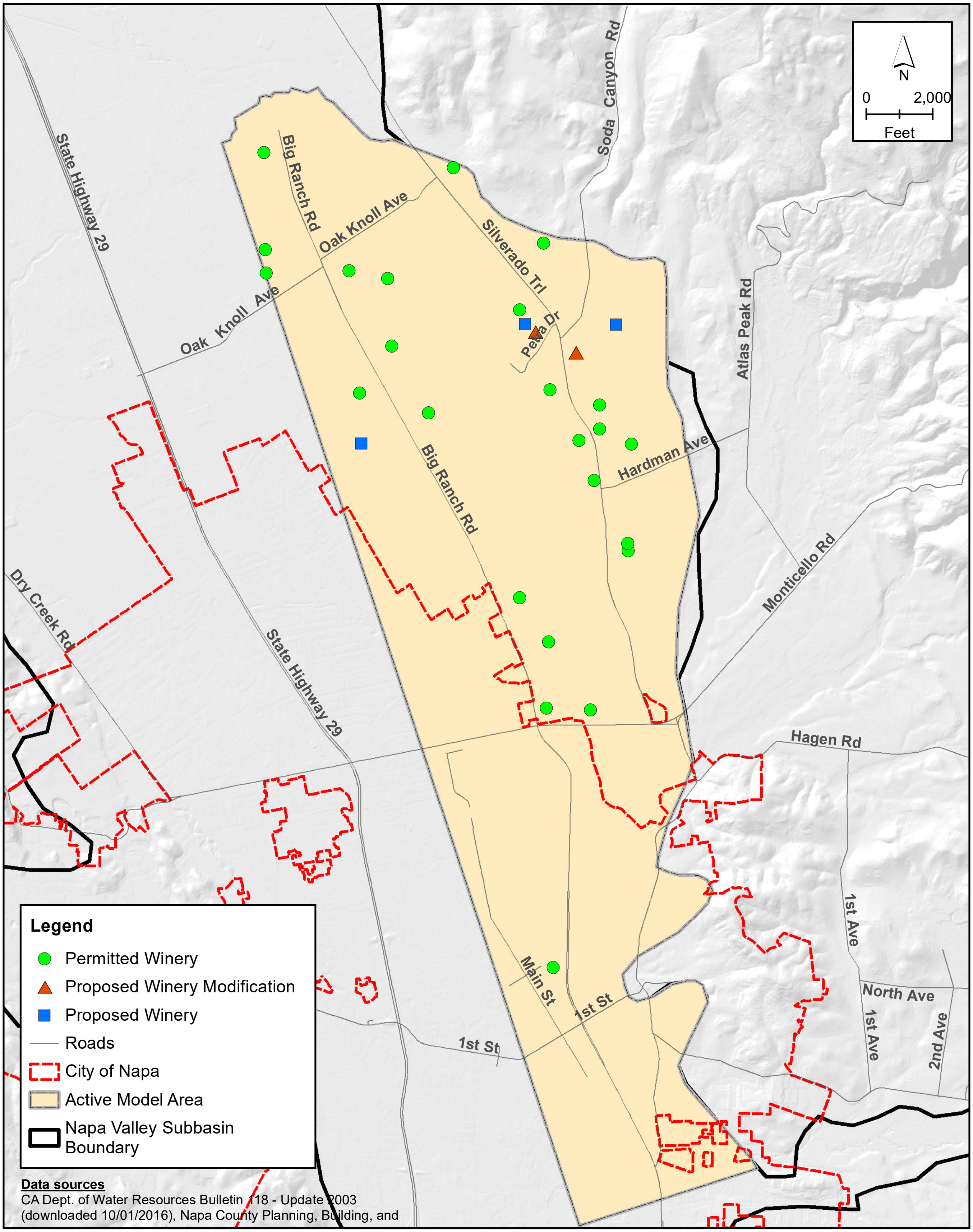

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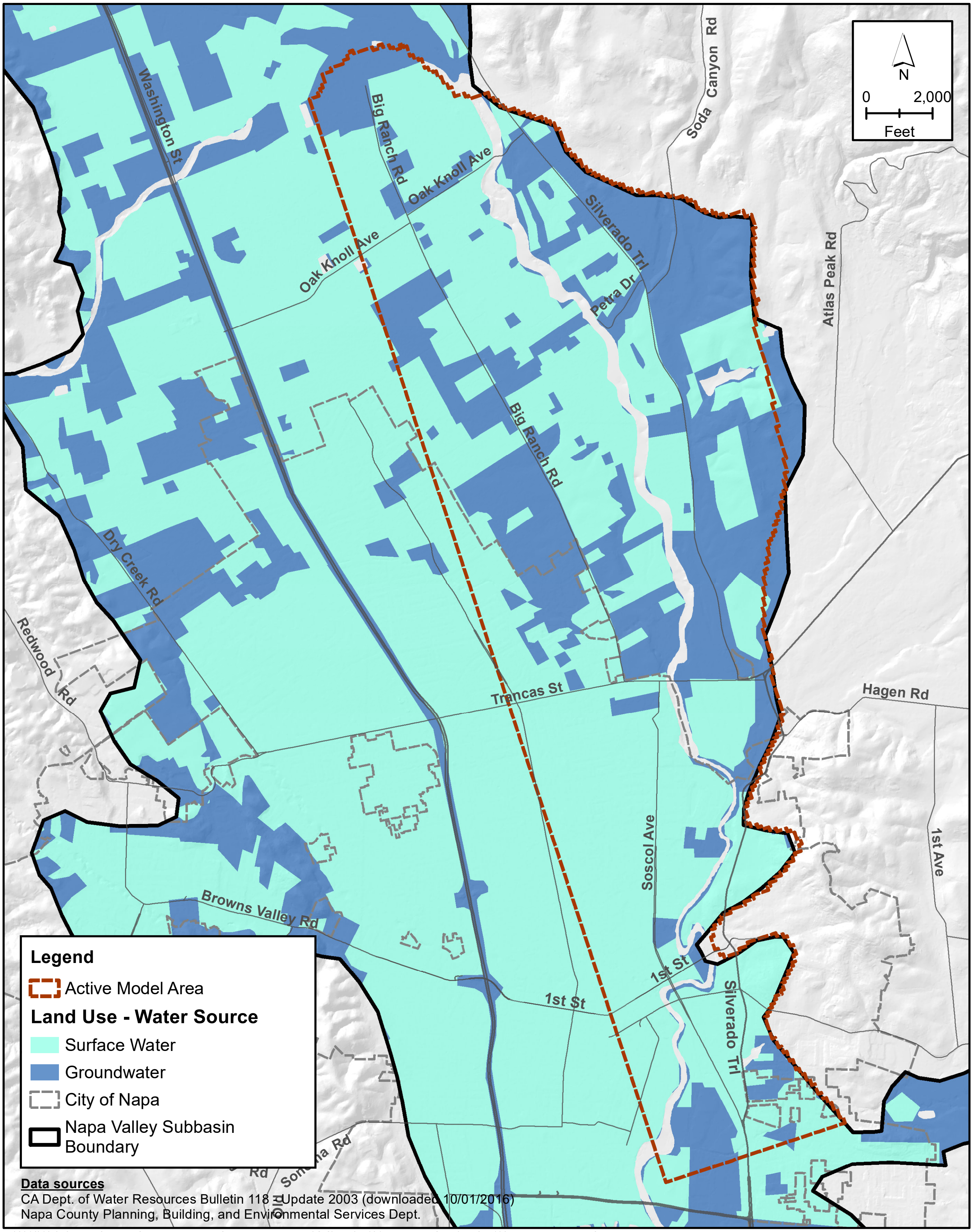
FIGURE 2-8

Existing and Proposed Winery Locations



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 10/01/2016)
Napa County Planning, Building, and Environmental Services Dept.

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FIGURE 2-9

1987 Land Use - Water Sources

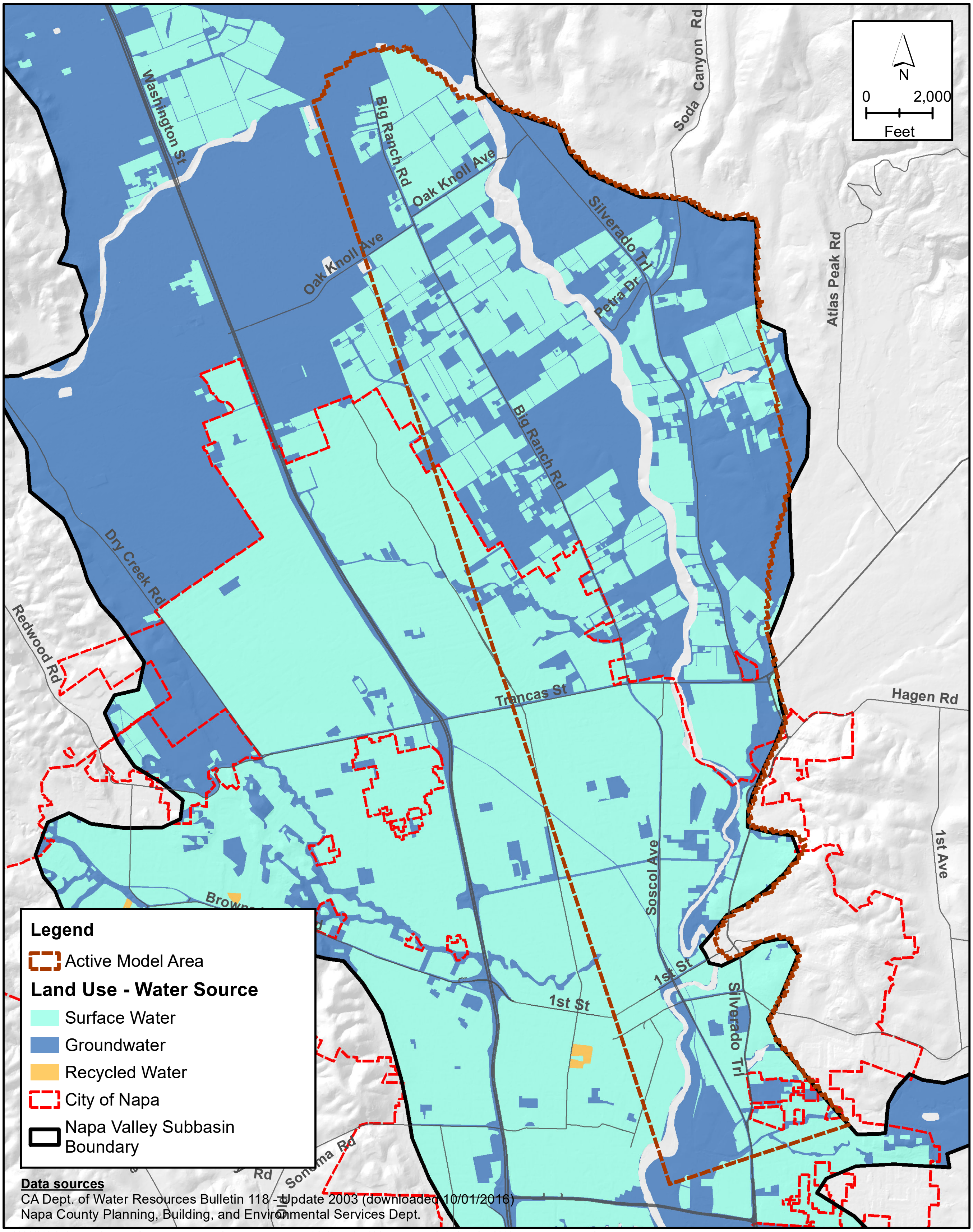

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FIGURE 2-10

2011 Land Use - Water Sources

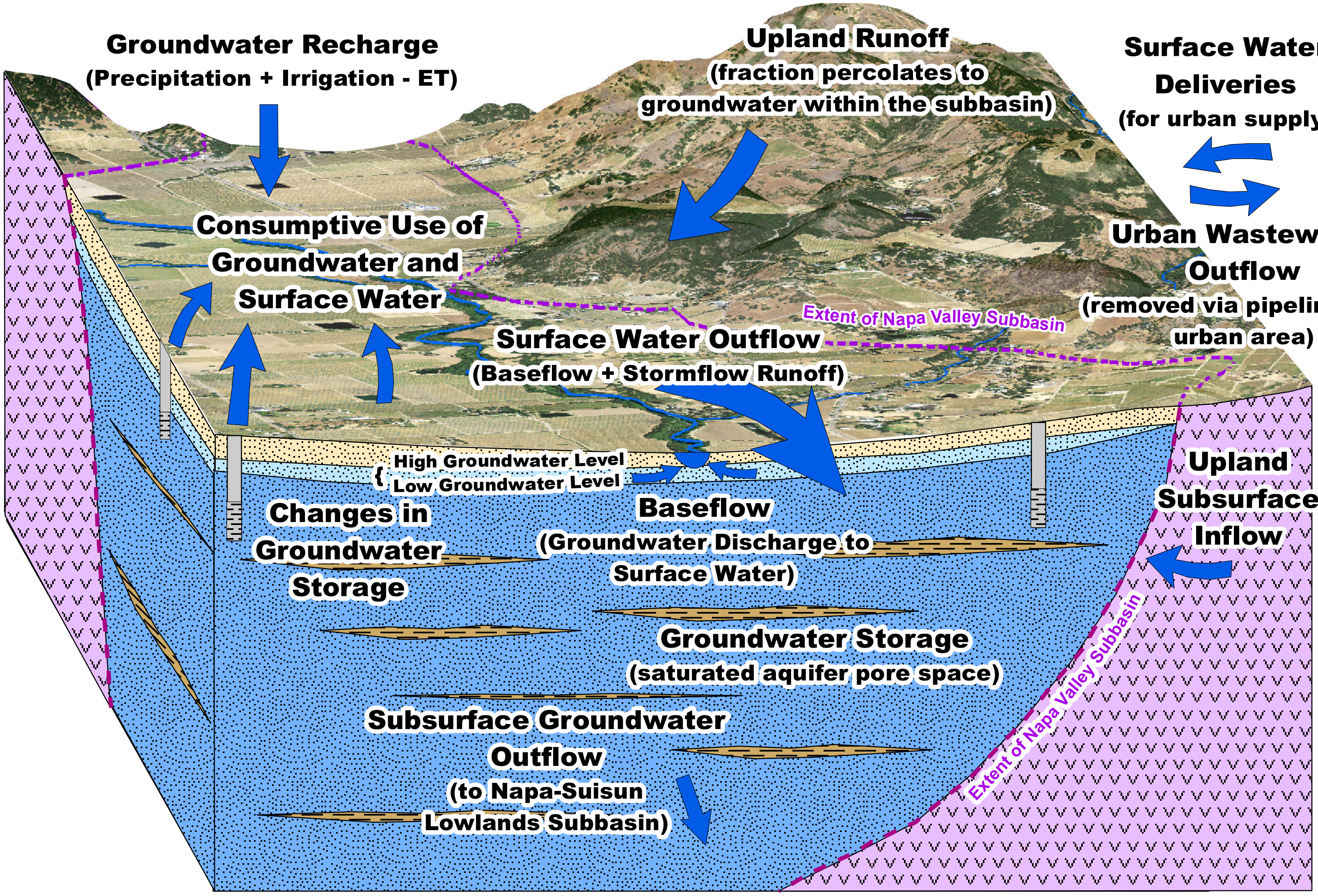

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FIGURE 2-11
Schematic of Hydrogeologic Conceptual Model Components in the Napa Valley Subbasin

Northeast Napa Area: Special Groundwater Study

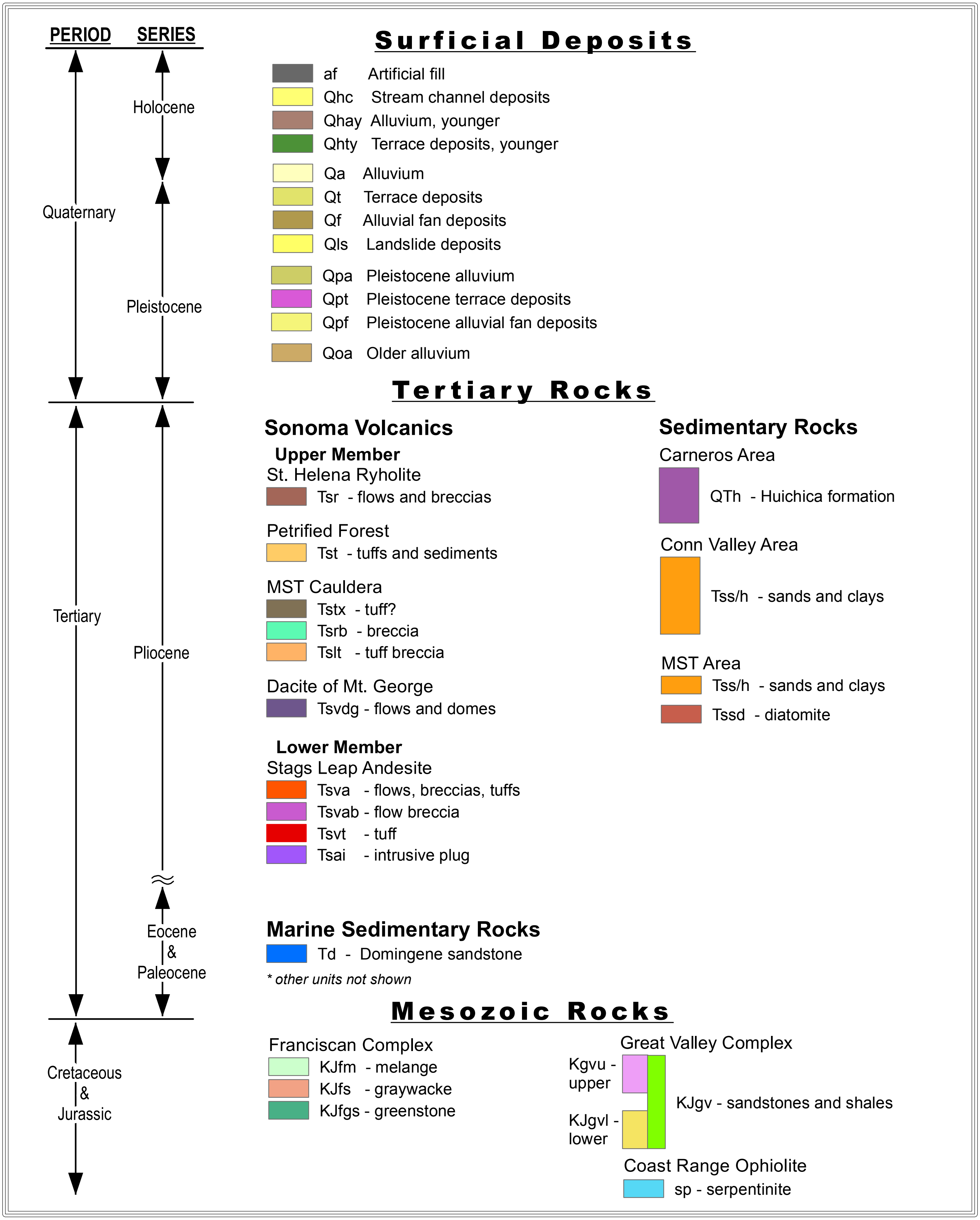

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Figure 2-12a
Major Surficial Rocks and Deposits of Napa Valley

Northeast Napa Area: Special Groundwater Study

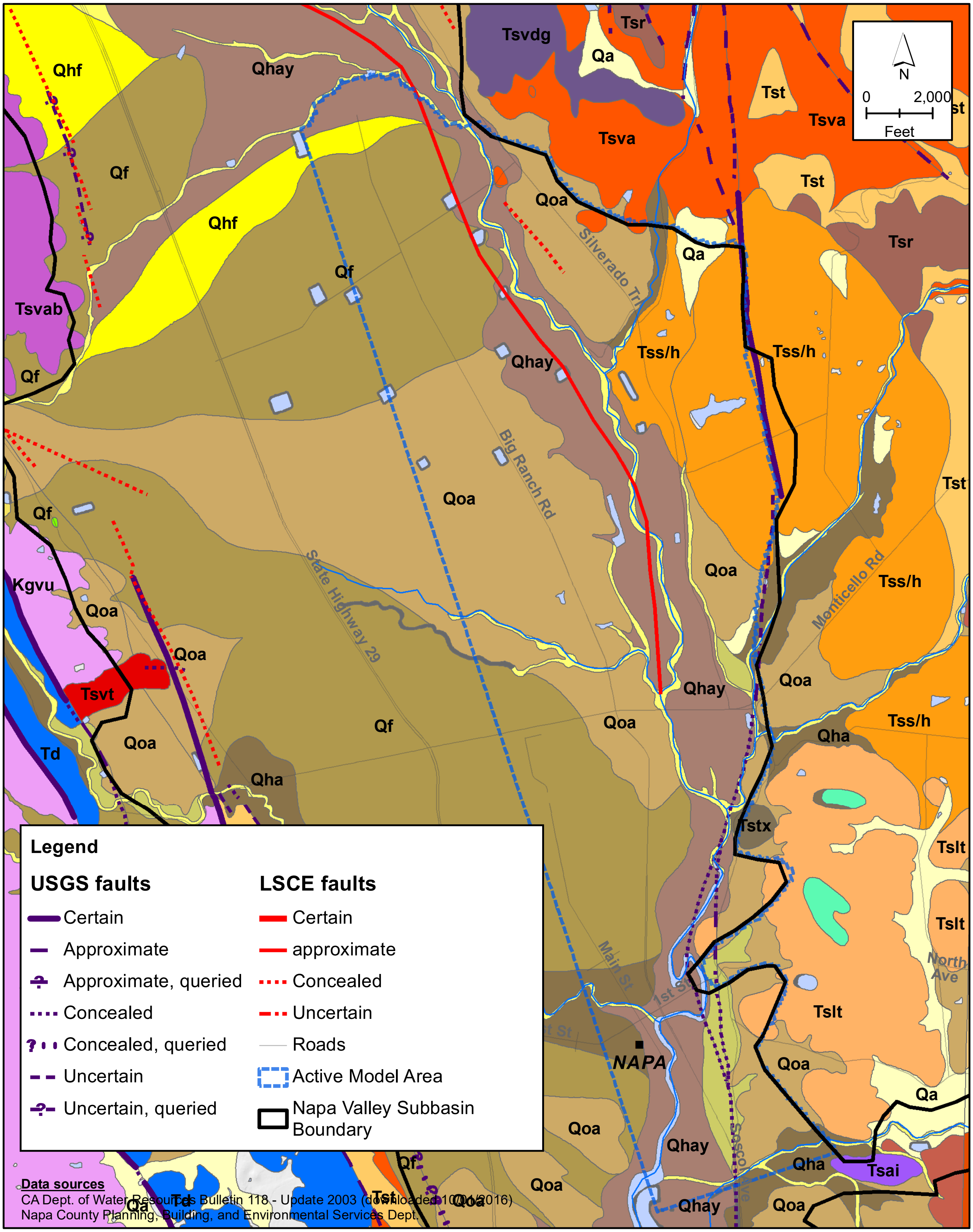

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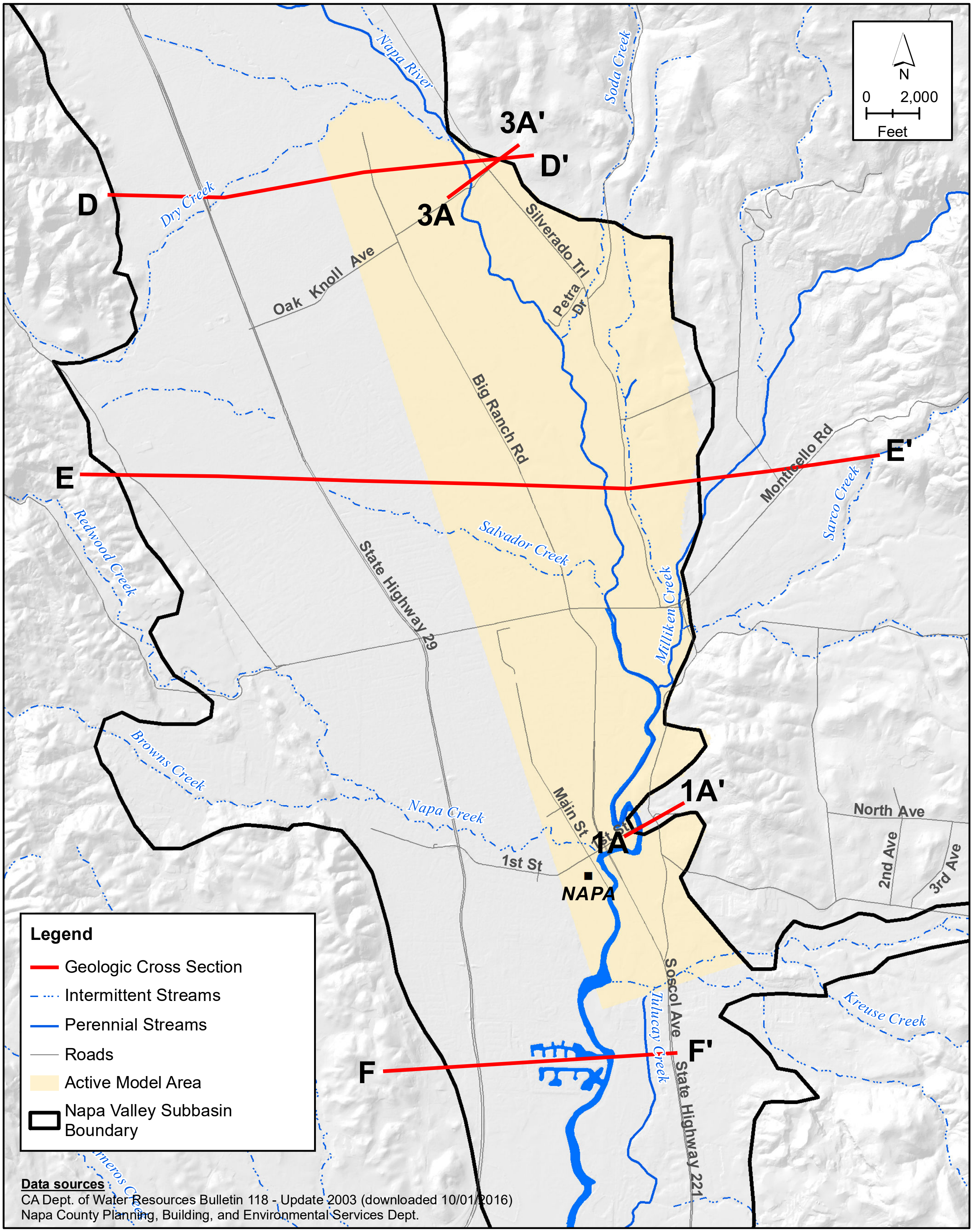
FIGURE 2-12b

Surficial Geology of NE Napa Study Area



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 2-x Geologic Cross Section Locations.mxd

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FIGURE 2-13a

Geologic Cross Section Location Map

Stratigraphy

- QTh: Quaternary Tertiary Huichica formation
- Qsb: Quaternary sedimentary basin deposits
- Tst/s: Tertiary Sonoma Volcanic tuff and sediments
- TQsu: Tertiary Quaternary sedimentary deposits, undifferentiated
- KJgv: Mesozoic Great Valley Complex
- Qa: Quaternary alluvium
- Qa/sb: Quaternary alluvium/sedimentary basin deposits
- TQsb: Tertiary Quaternary sedimentary basin deposits
- Tcg/ab: Tertiary Sonoma Volcanic conglomerate/breccia
- Tcg/ab?: Tertiary Sonoma Volcanic conglomerate/breccia
- Td: Tertiary marine rock
- Tsr: Tertiary Sonoma Volcanic rhyolite
- Tss/h: Tertiary sedimentary rock
- Tss/h?: Tertiary sedimentary rock
- Tst: Tertiary Sonoma Volcanic tuff
- Tsva: Tertiary Sonoma Volcanic andesite flow
- Tsvat: Tertiary Sonoma Volcanic andesite and tuff
- Tsva?: Tertiary Sonoma Volcanic andesite flow
- Tsvab: Tertiary Sonoma Volcanic andesite flow or breccia
- Tsvt: Tertiary Sonoma Volcanic tuff
- Tsvt?: Tertiary Sonoma Volcanic tuff
- Tst?: Tertiary Sonoma Volcanic tuff

Well Lithology

- Basalt
- Clay
- Clay and Basalt
- Clay and Gravel
- Clay and Sand (or Sandstone)
- Clay and Tuff
- Clay, Sand, and Gravel
- Gravel
- Rock
- Sand
- Sand (or Sandstone) and Gravel
- Sand and Clay
- Sandstone
- Tuff or Ash
- Unknown
- Faults
- Possible Faults

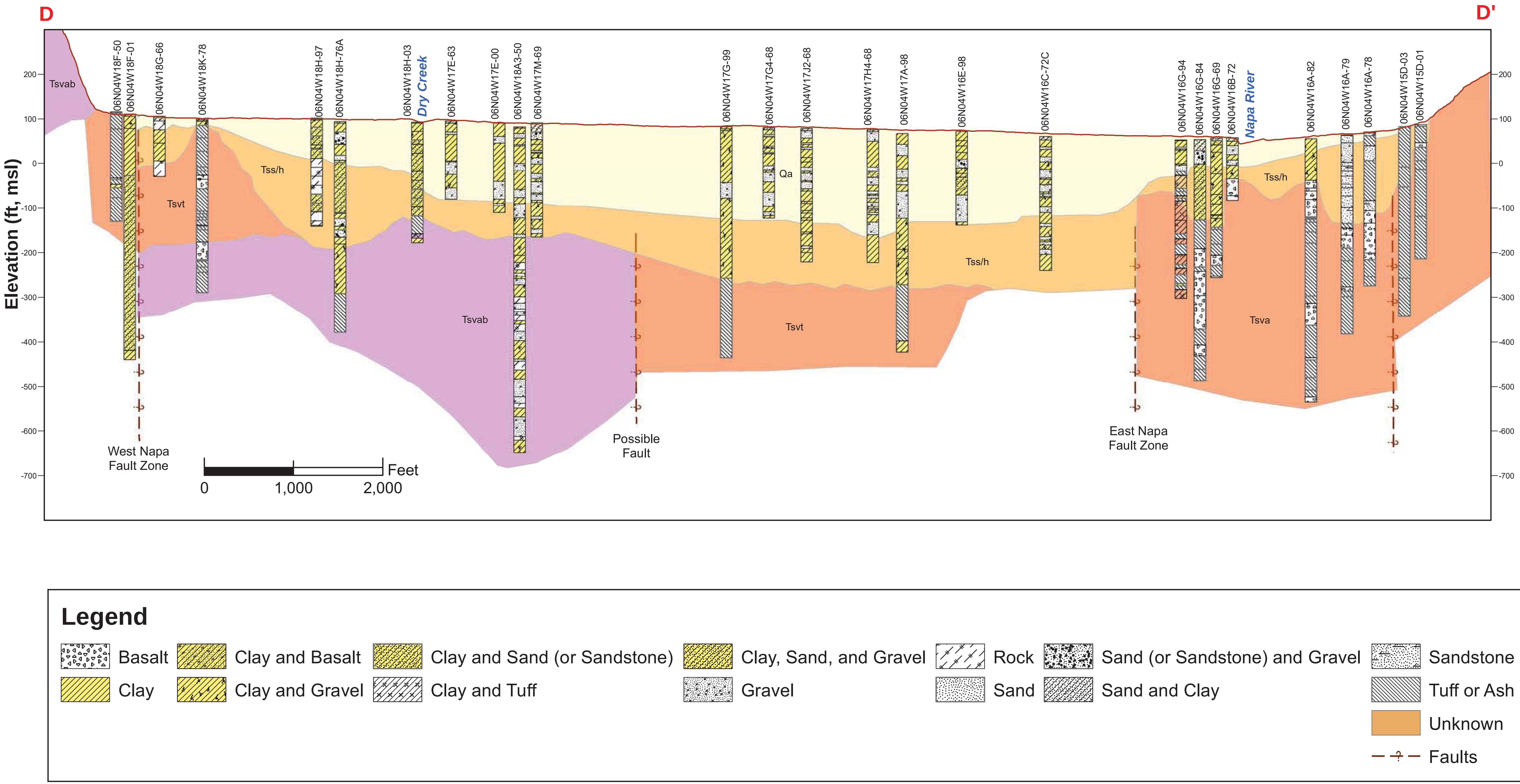

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Figure 2-14
Geologic Cross Section D-D'
Southern NVF-Yountville Subarea, Napa County, CA

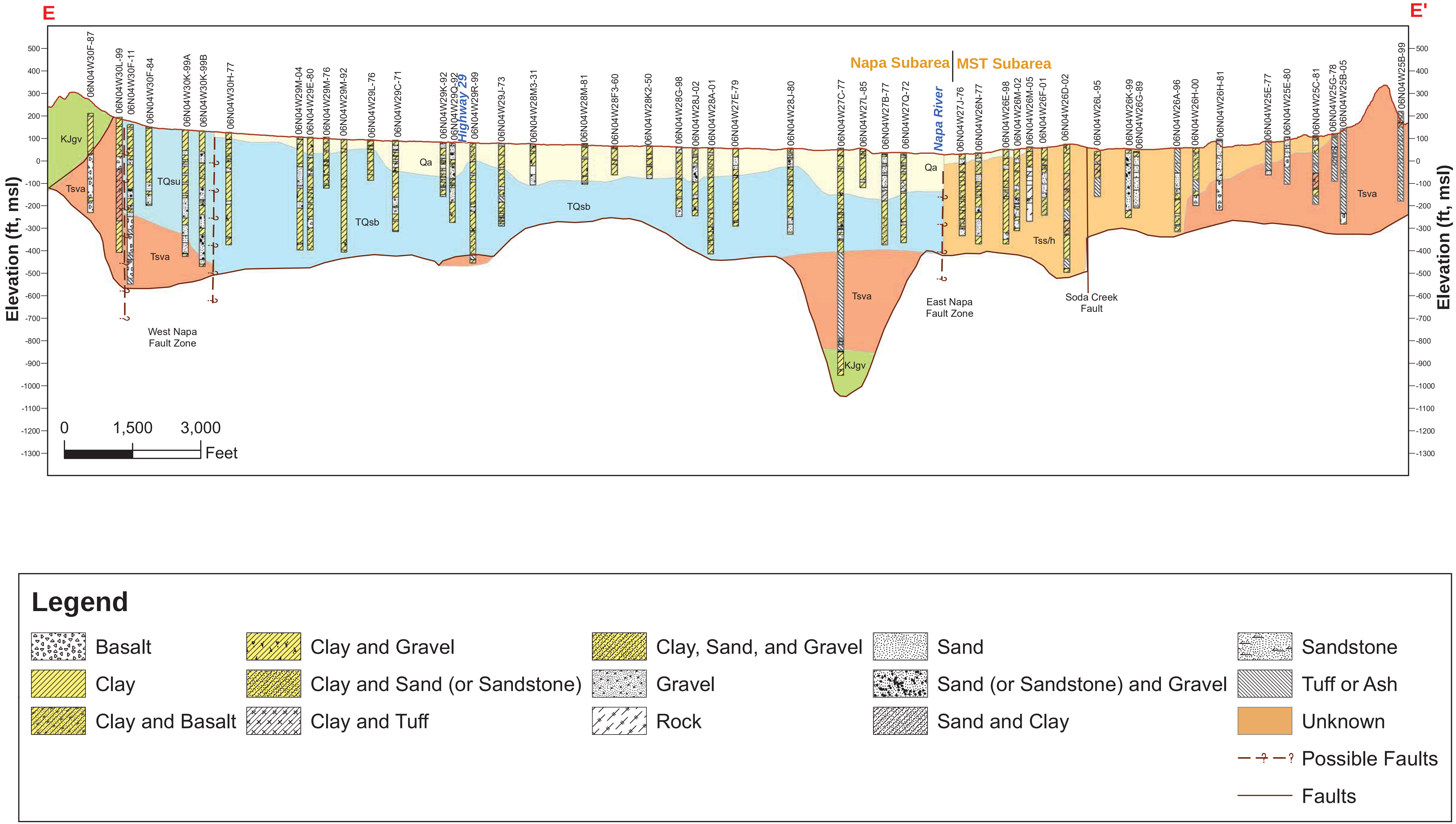

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Figure 2-15
Cross Section E-E'
Norhtern NVF-Napa Subarea, Napa County, CA

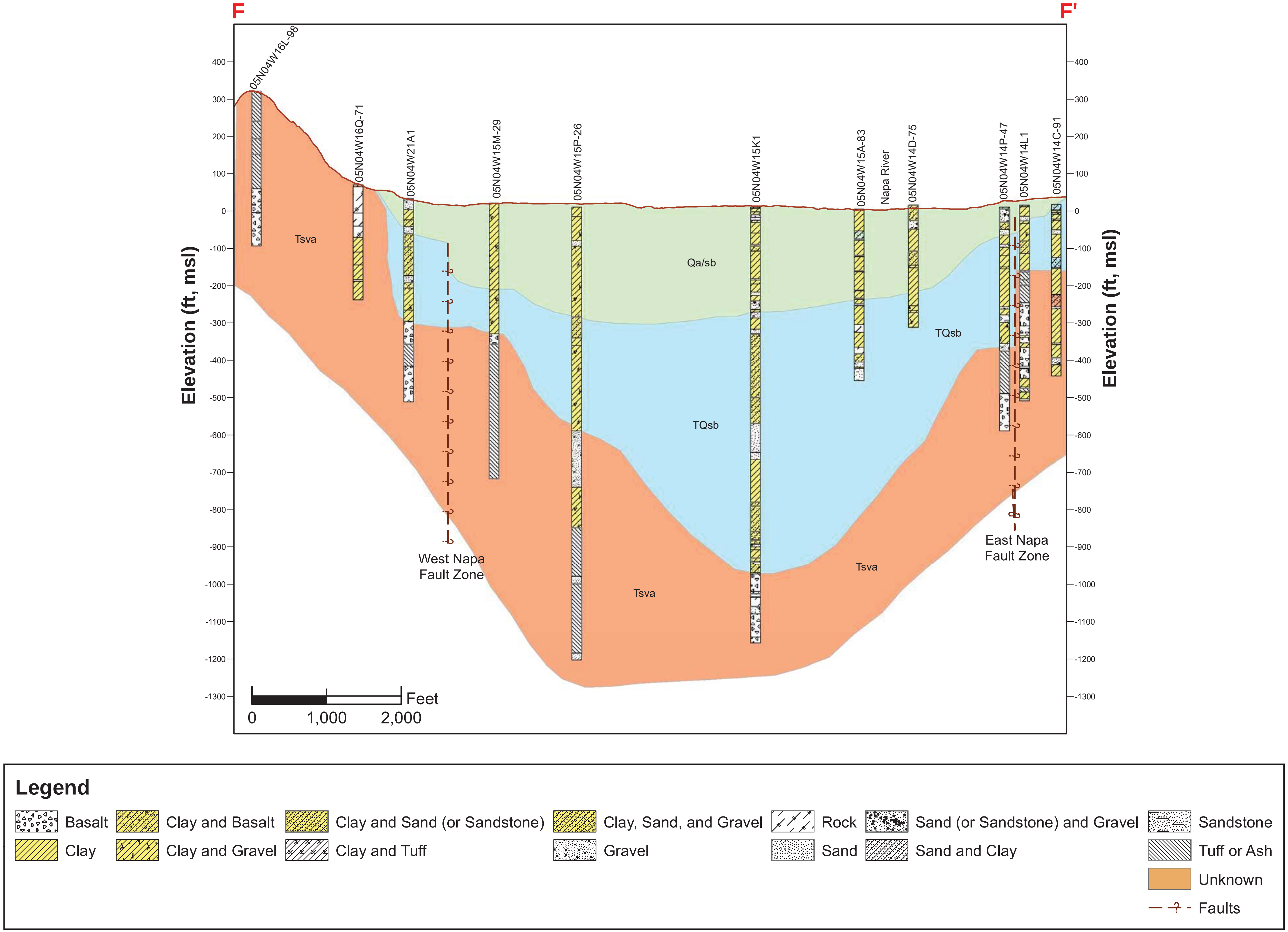

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Figure 2-16
Cross Section F-F'
Southern NVF-Napa Subarea, Napa County, CA

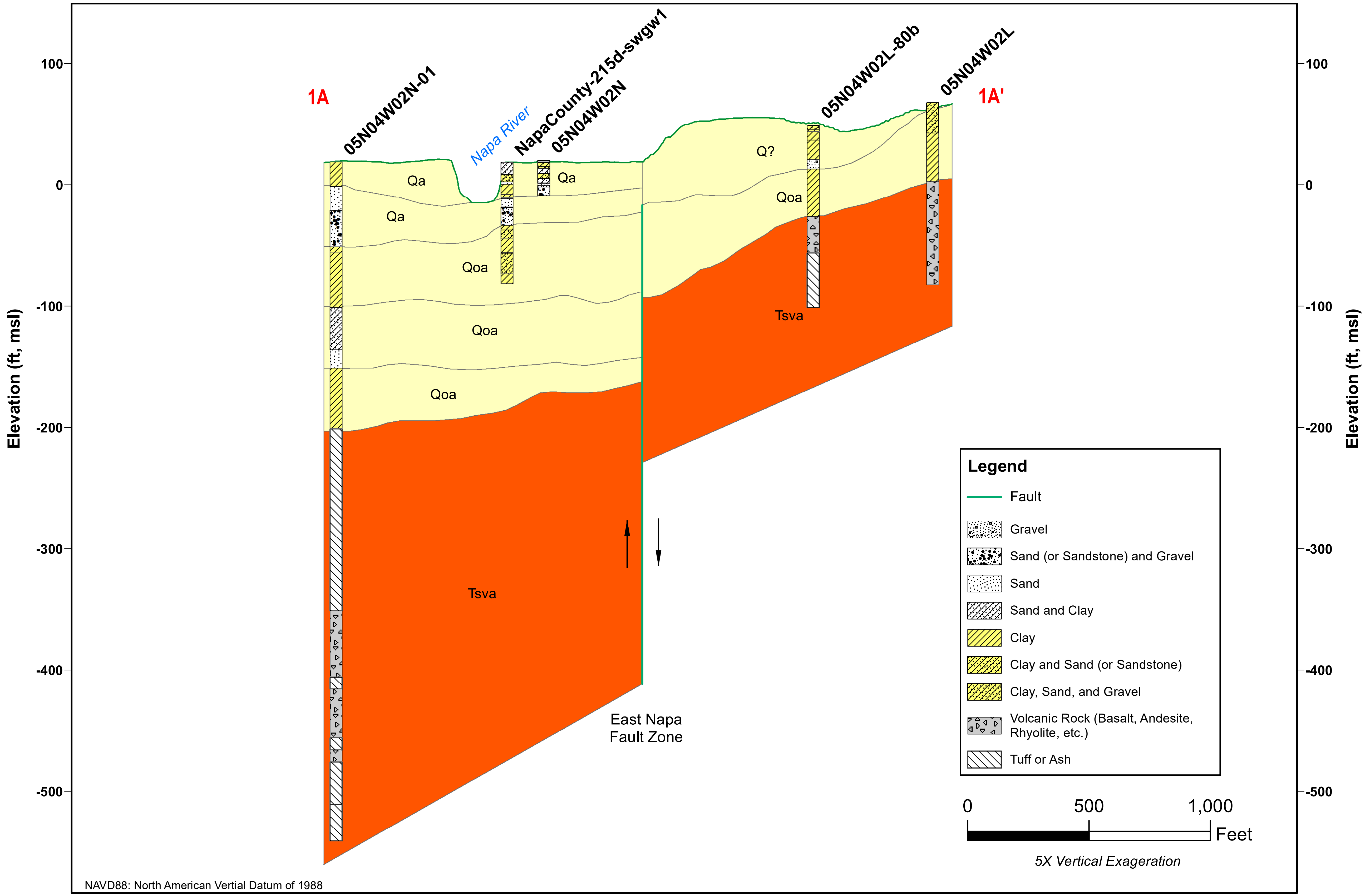

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Figure 2-17
Geologic Cross Section
Site 1 - Napa River at First Street

Northeast Napa Area: Special Groundwater Study

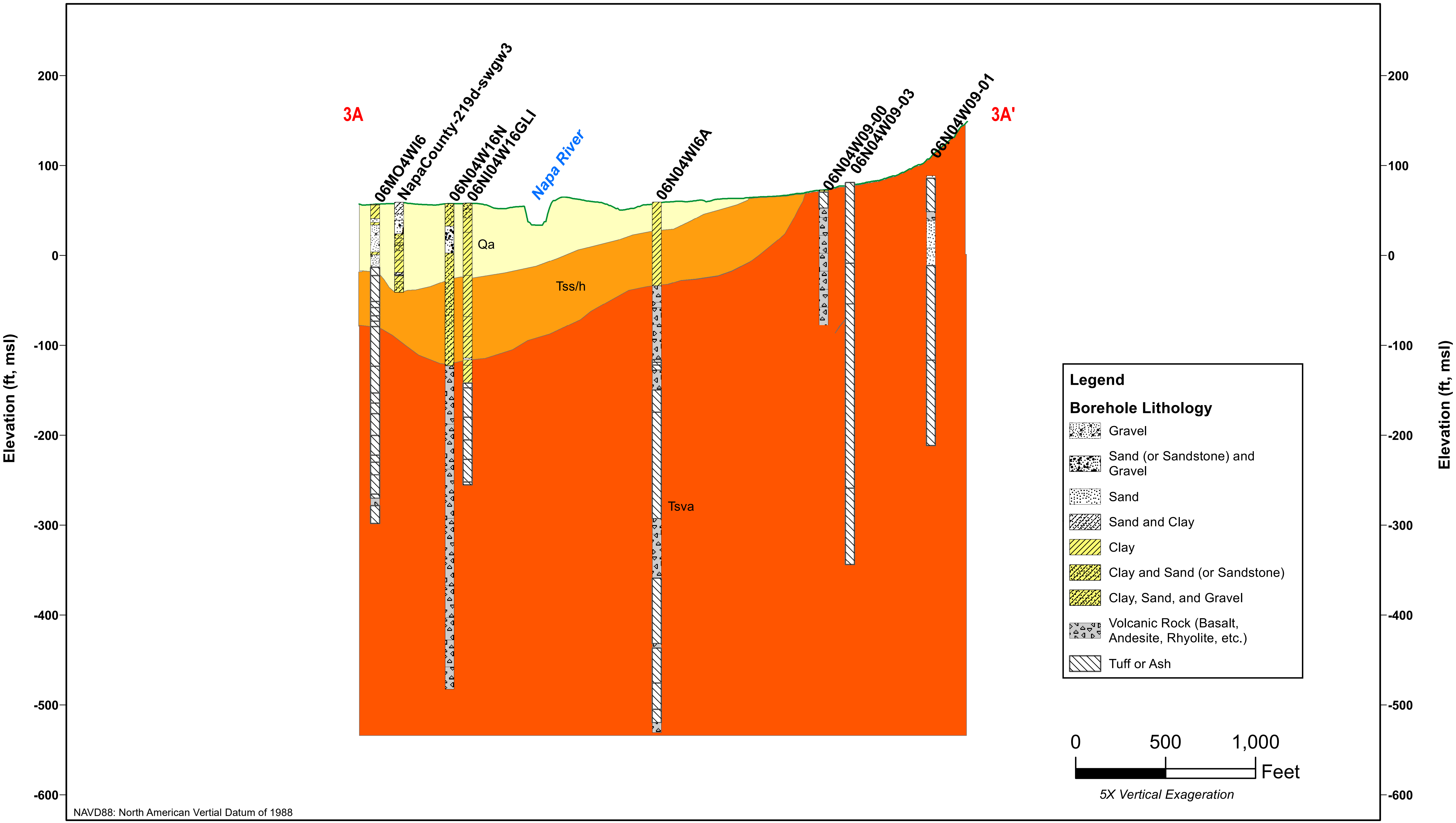

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Figure 2-18
Geologic Cross Section
Site 3 - Napa River at Oak Knoll Avenue

Northeast Napa Area: Special Groundwater Study

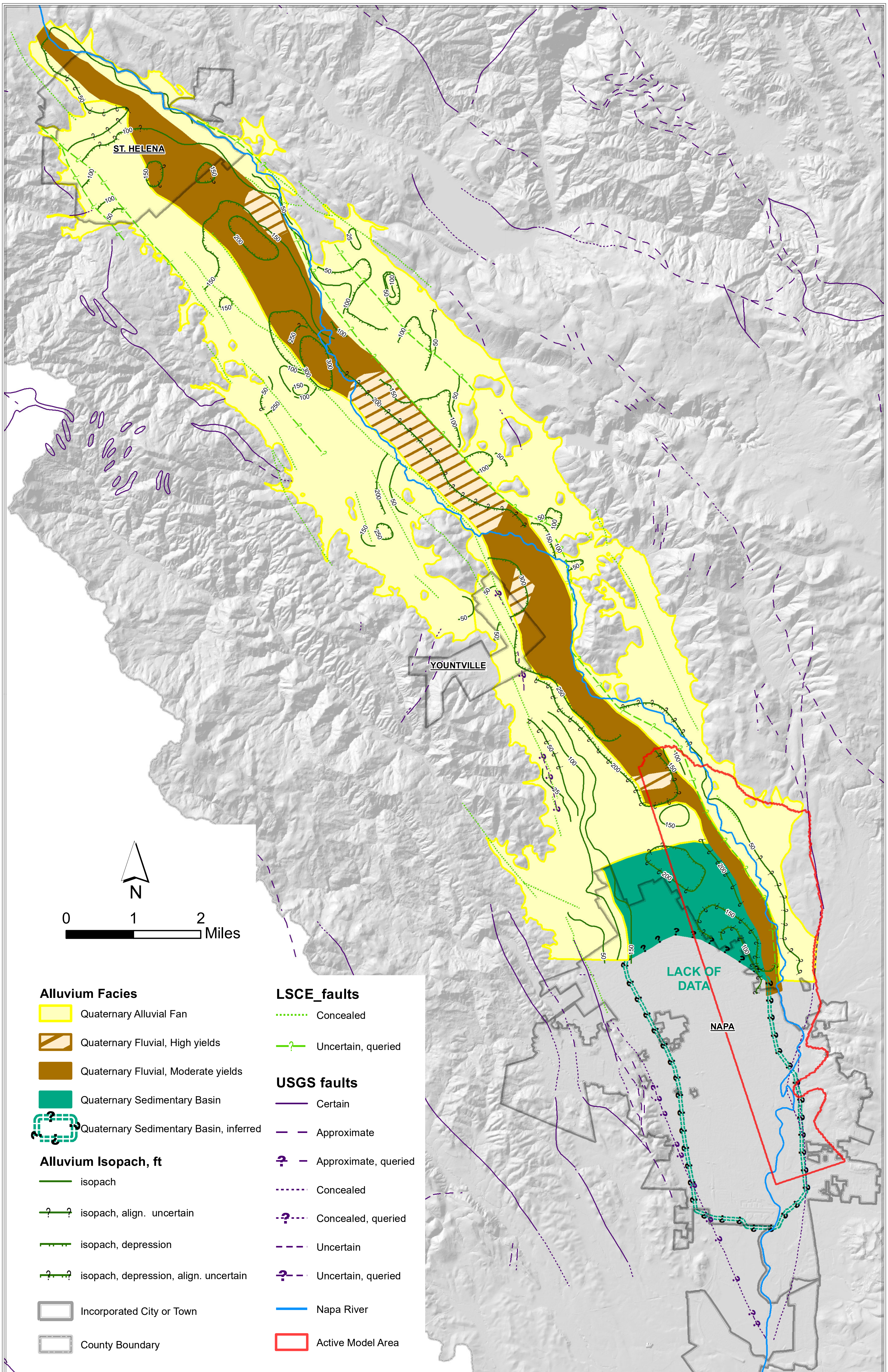

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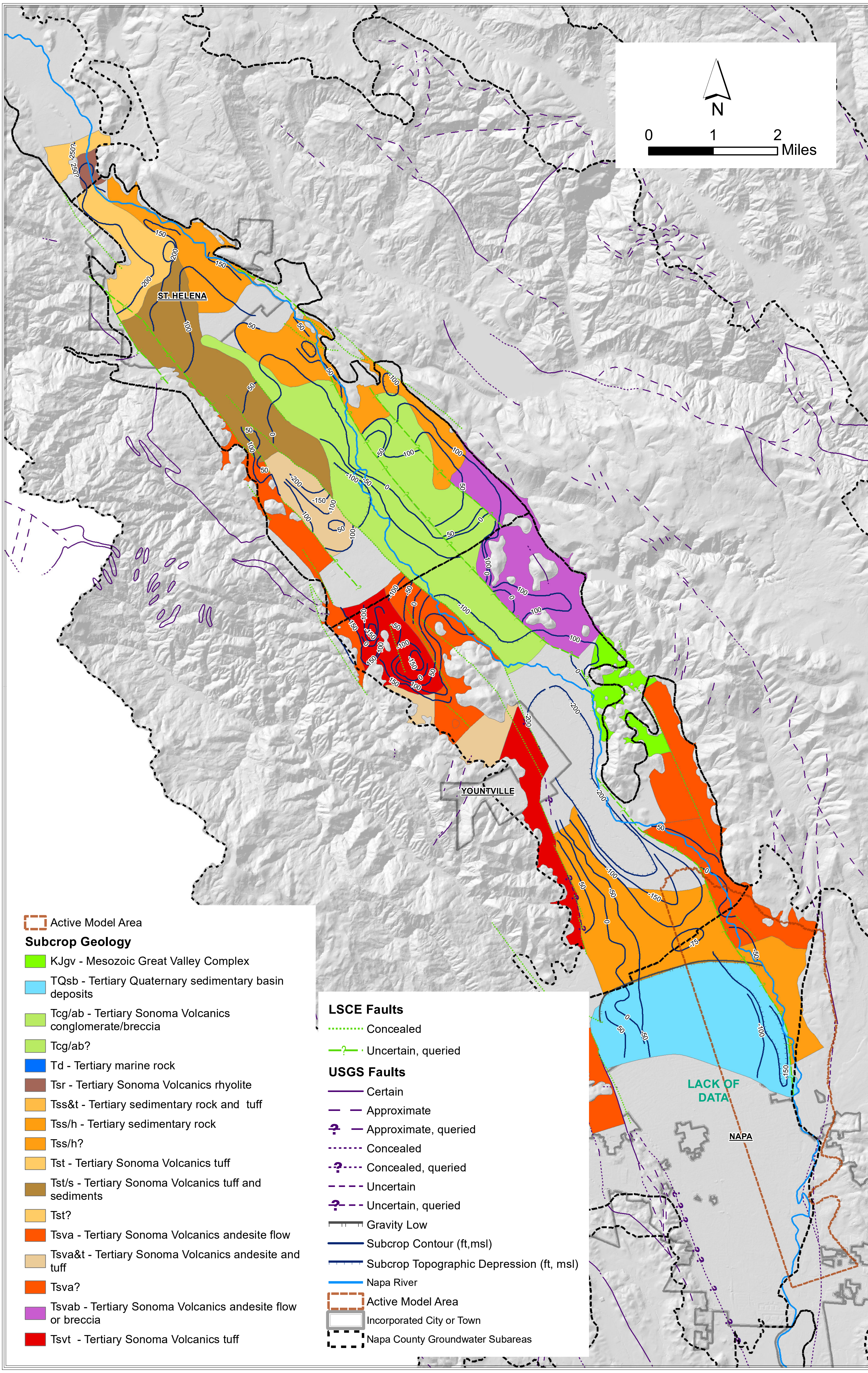
Figure 2-19

Napa Valley Floor Isopach and Facies Map of Alluvium



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 2-x NVF Structure Contour Map.mxd

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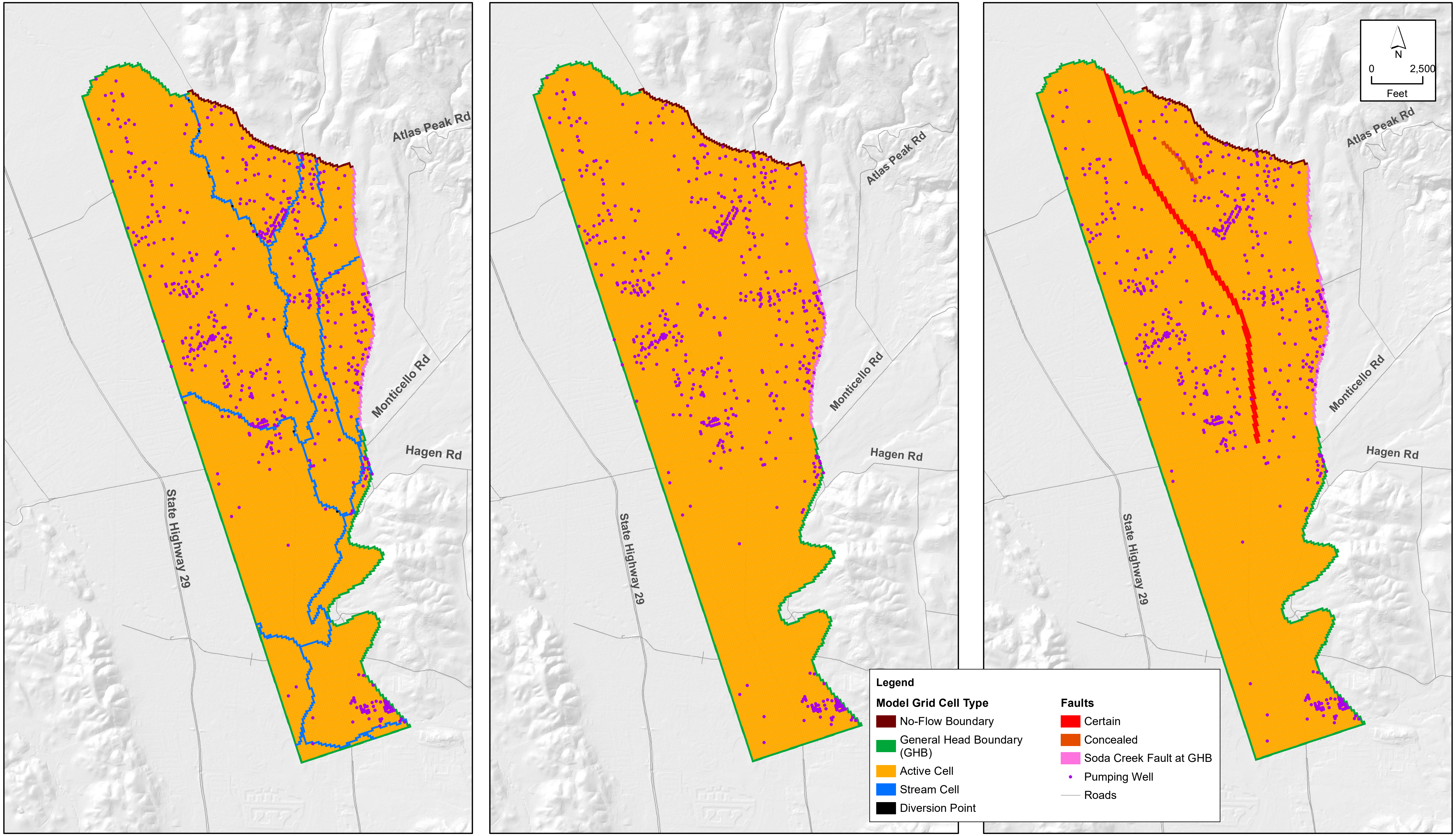
Figure 2-20

Napa Valley Floor Structure Contours and Pre-Alluvium Subcrop Geology



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-y1 Model features.mxd

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FIGURE 3-1a
Model Features
Layer 1 (Left), Layers 2 & 3 (Middle), Layers 4,5 & 6 (Right)

Northeast Napa Area: Special Groundwater Study

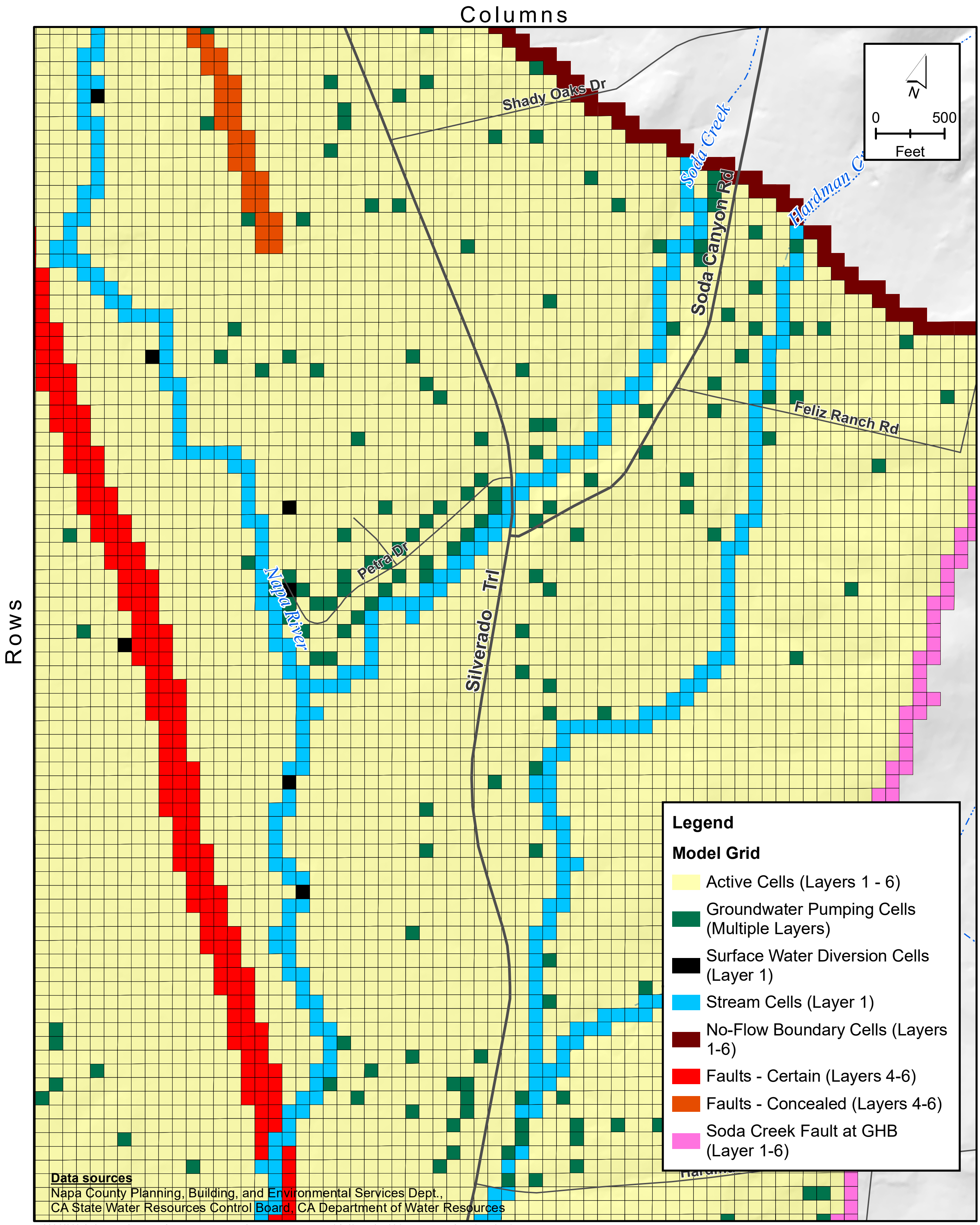

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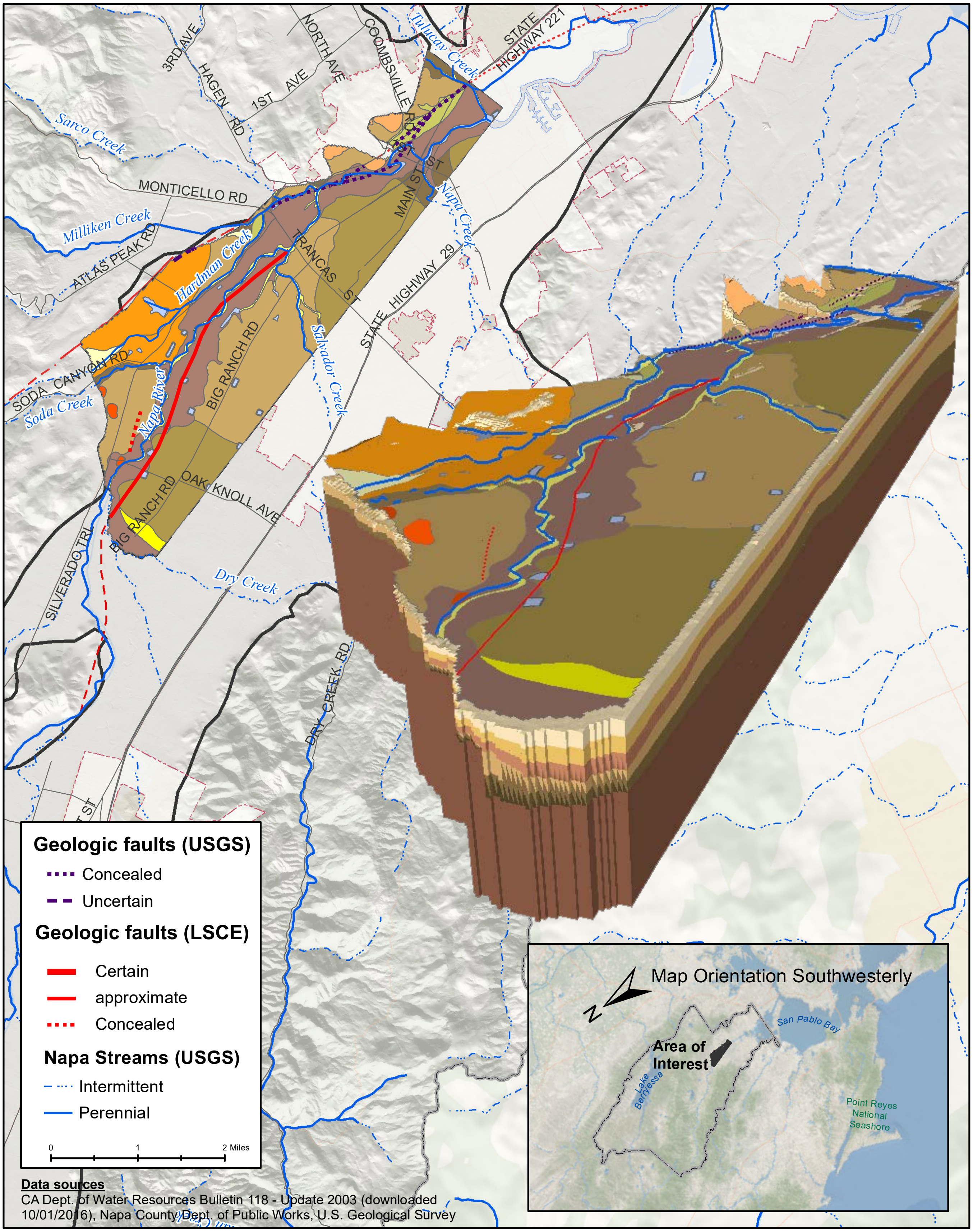
FIGURE 3-1b

Model Features Detail - Layer 1 Through Layer 6



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 10/01/2016), Napa County Dept. of Public Works, U.S. Geological Survey

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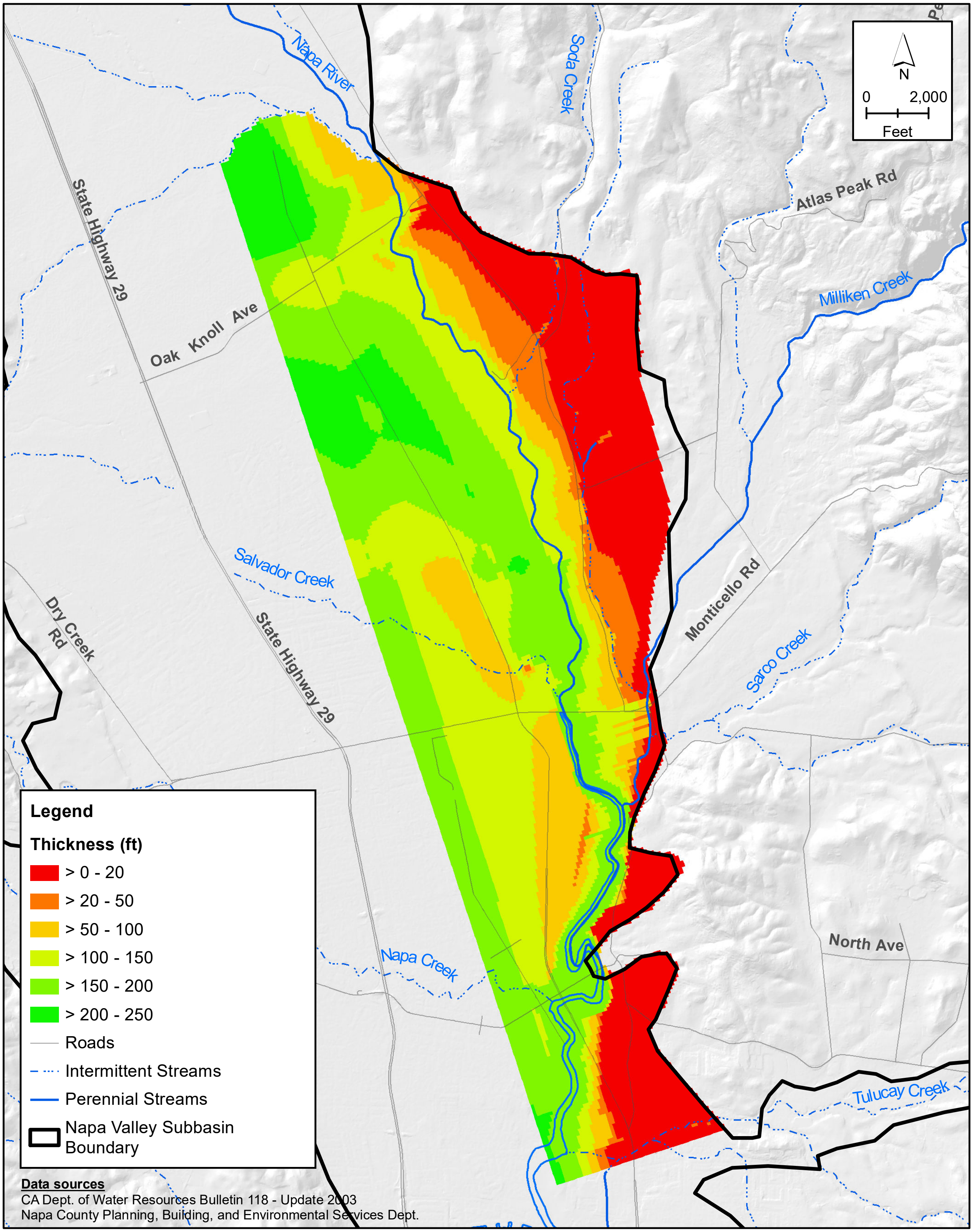
FIGURE 3-2

Geology with Layers 1 - 6 in the Active Model Area



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-x1 Quaternary Alluvial Thickness.mxd

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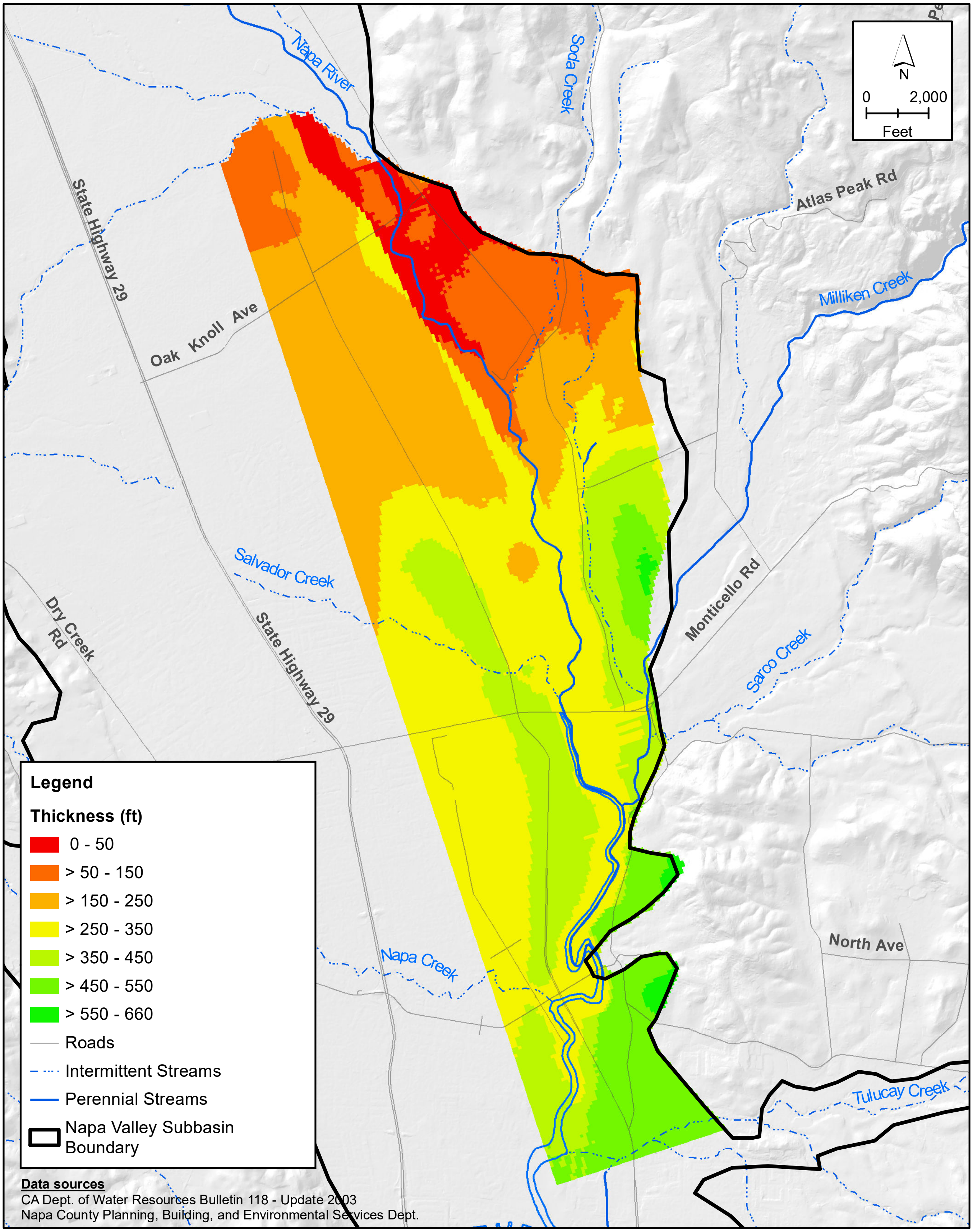
FIGURE 3-3
Thickness of Quaternary Alluvium, Model Layers 1 through 3



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-x2 Tertiary and Early QuatThickness.mxd

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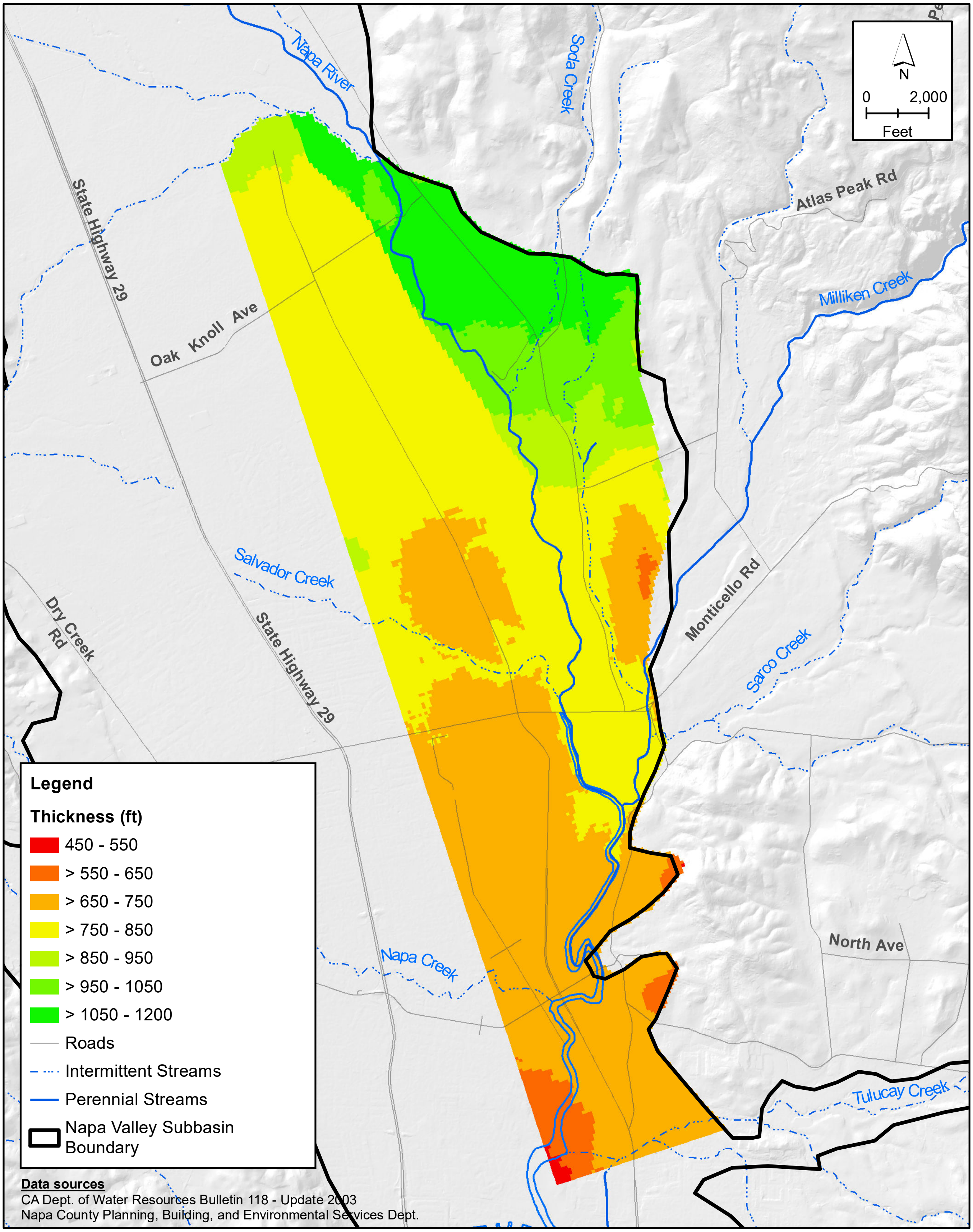
FIGURE 3-4
Thickness of Tertiary and Early Quaternary Deposits, Model Layers 4 and 5



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-x3 Sonoma Volcanics Thickness.mxd

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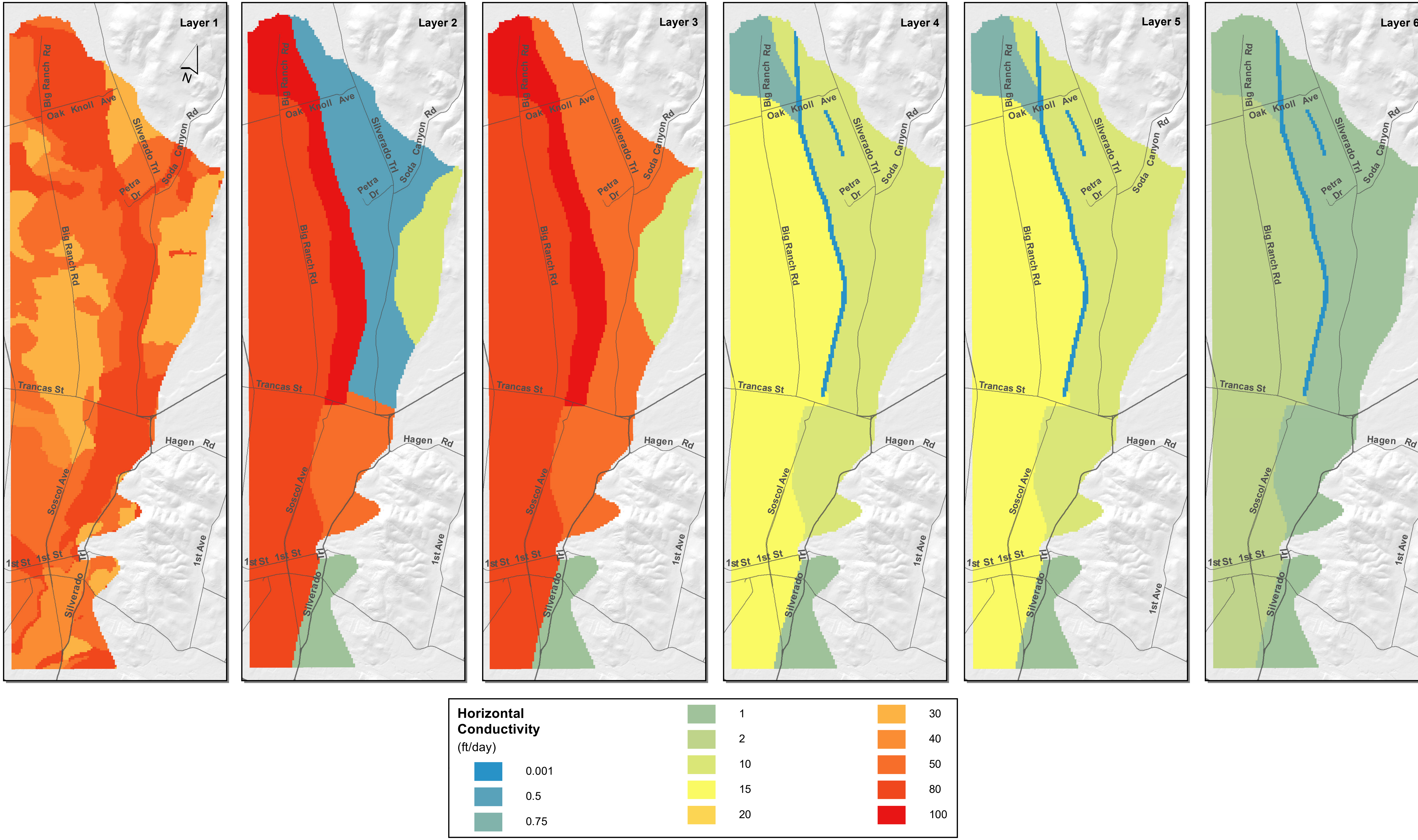
FIGURE 3-5
Thickness of Sonoma Volcanics, Model Layer 6



Path: \\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-x10 Horizontal Conductivity 6 Panel.mxd

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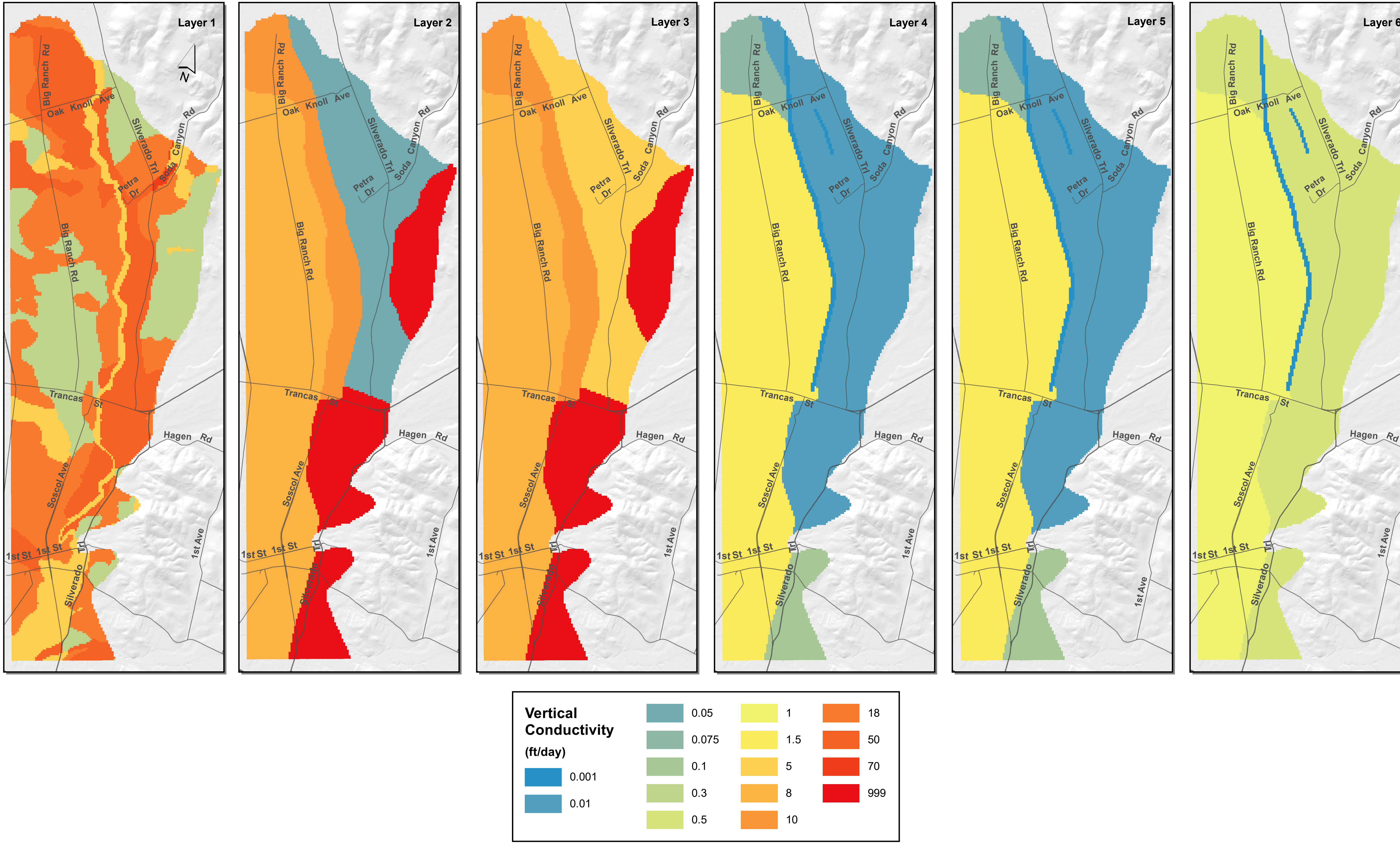
FIGURE 3-6
Calibrated Horizontal Saturated Hydraulic Conductivity
Northeast Napa Area: Special Groundwater Study



Path: \\lsceexser\clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Figure 3-7_Vertical Conductivity.mxd

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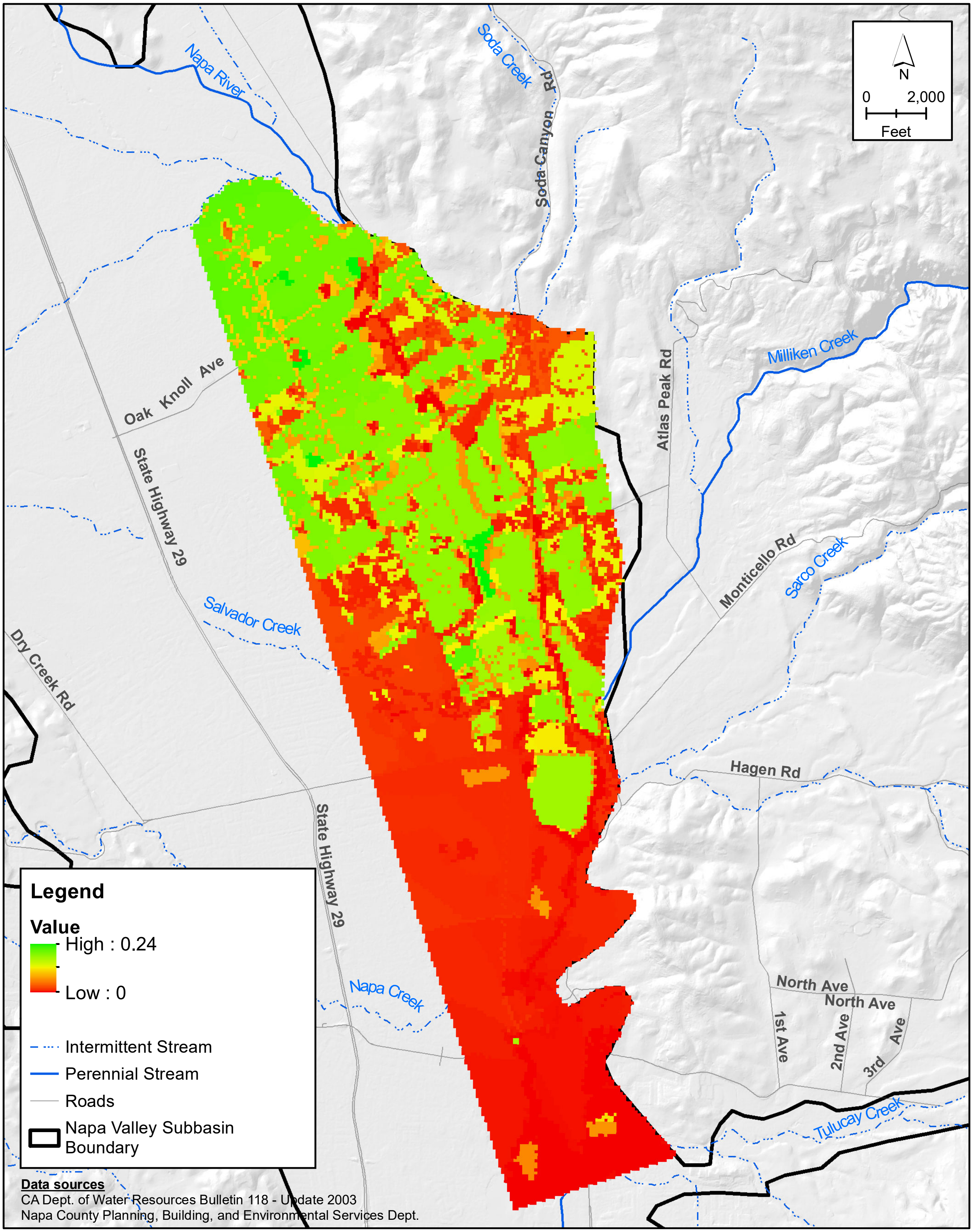
FIGURE 3-7
Calibrated Vertical Saturated Hydraulic Conductivity
Northeast Napa Area: Special Groundwater Study



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig x-x Recharge_Apr_2003.mxd

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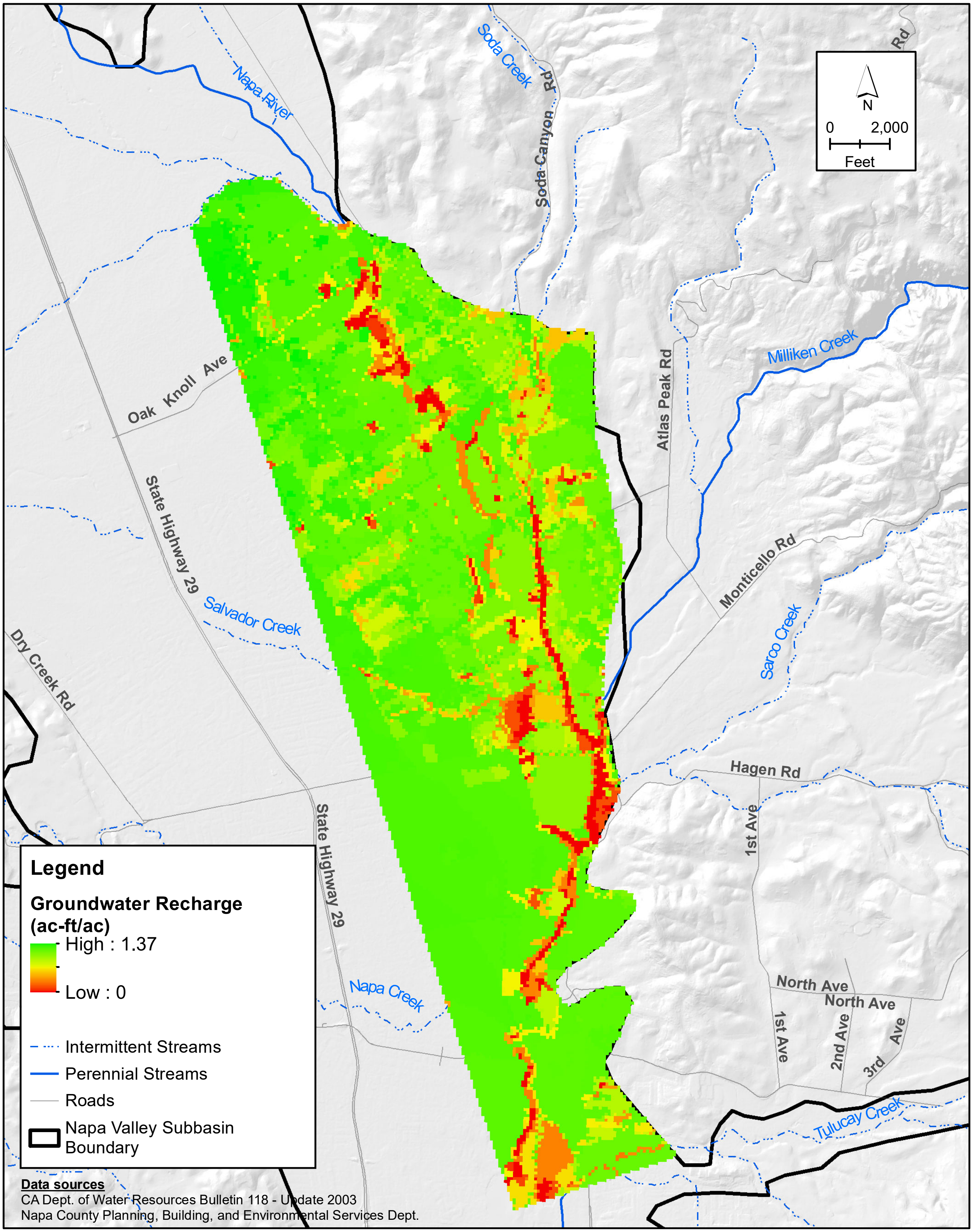
FIGURE 3-8

Groundwater Recharge, April 2003



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig x-x Recharge_Dec_2002.mxd

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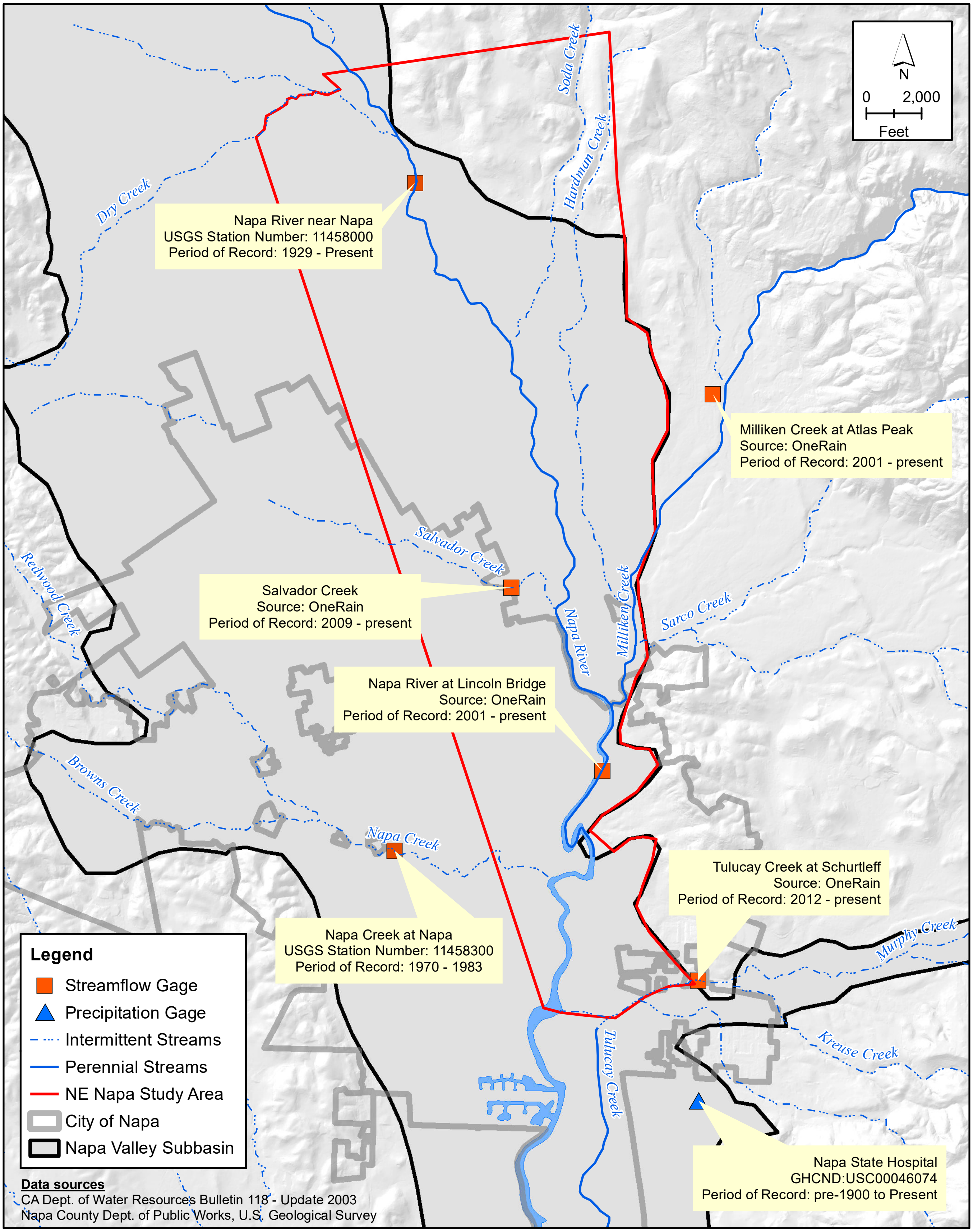
FIGURE 3-9

Groundwater Recharge, December 2002



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Figure 2-x Rain and Stream Gage Locations.mxd

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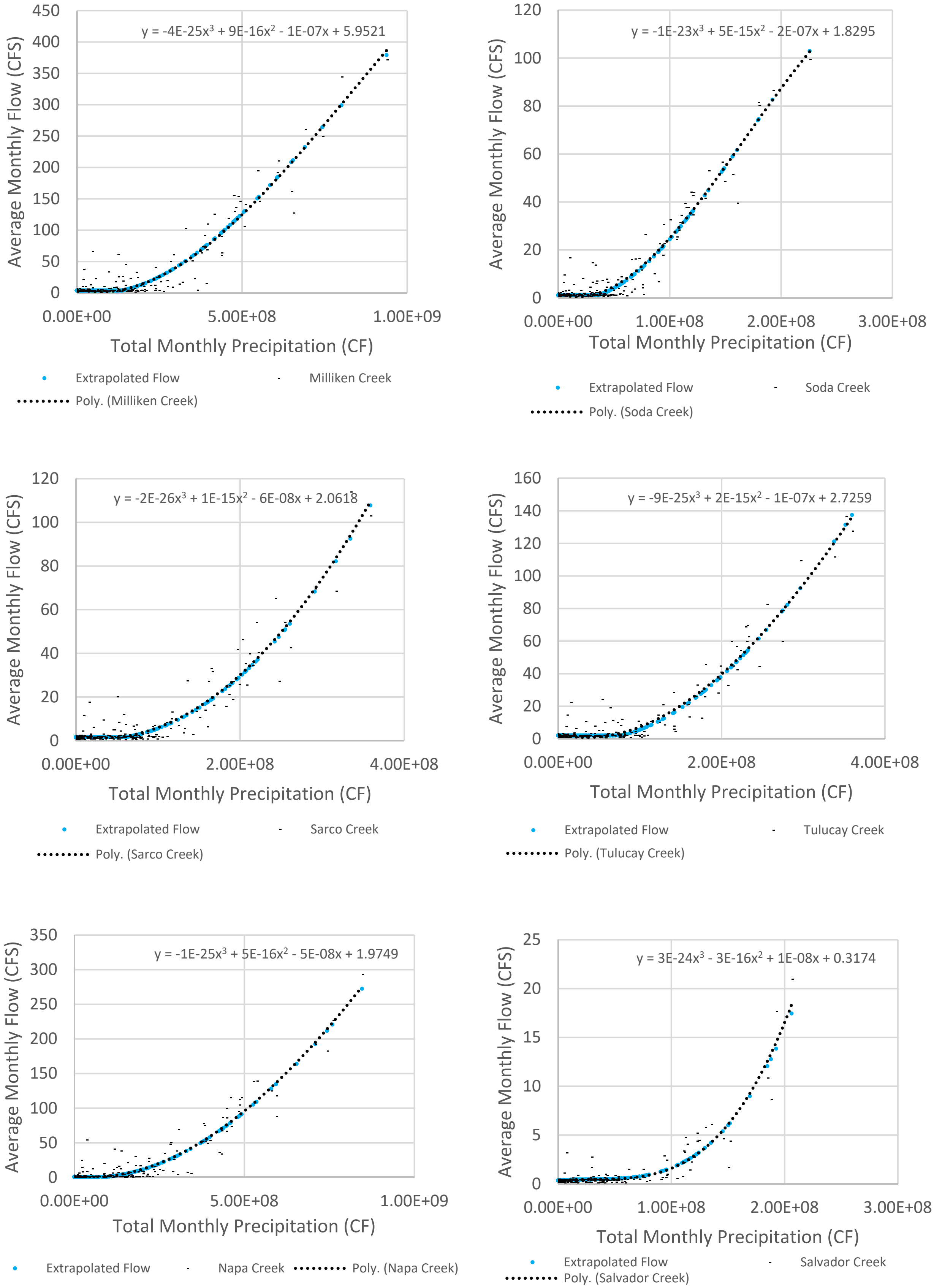
FIGURE 3-10

Precipitation and Streamflow Gage Locations



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\DATA\Data for Model Set-up\NAPA_SW_INFLOWS_TO_MODEL_20170302.xlsx\REGRESSION_FIGURE

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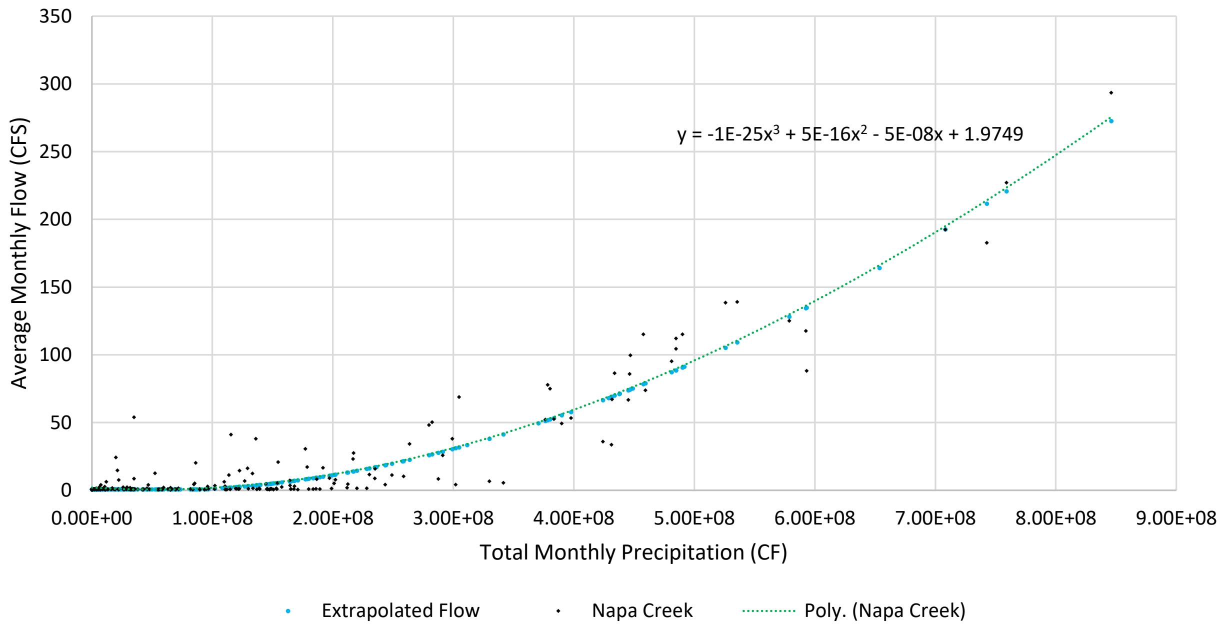
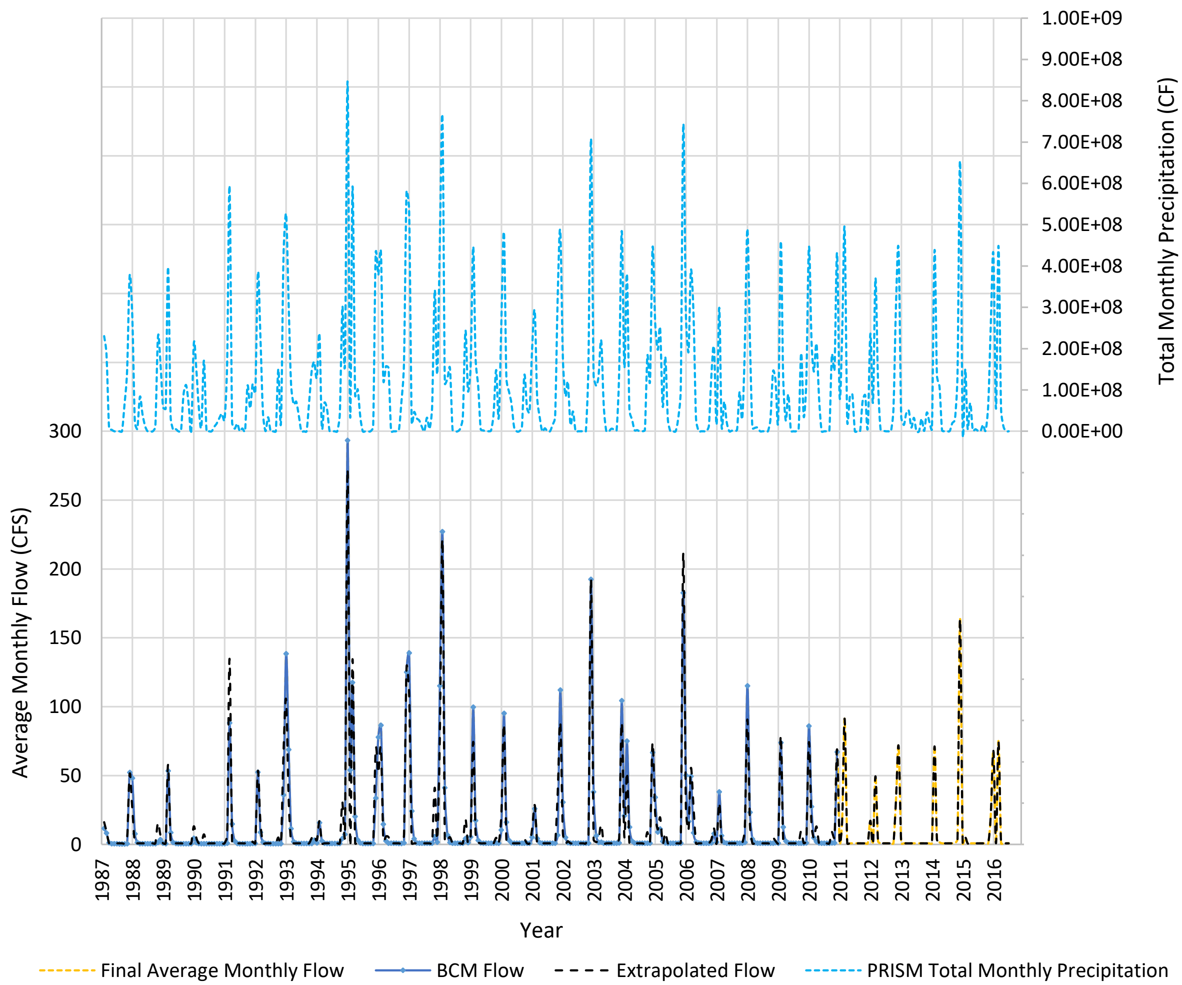
FIGURE 3-11

Example Regression Analyses for Streamflow Extrapolations





X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\DATA\Data for Model Set-up\NAPA_SW_INFLOWS_TO_MODEL_20170302.xlsx\DATA_FIGURE

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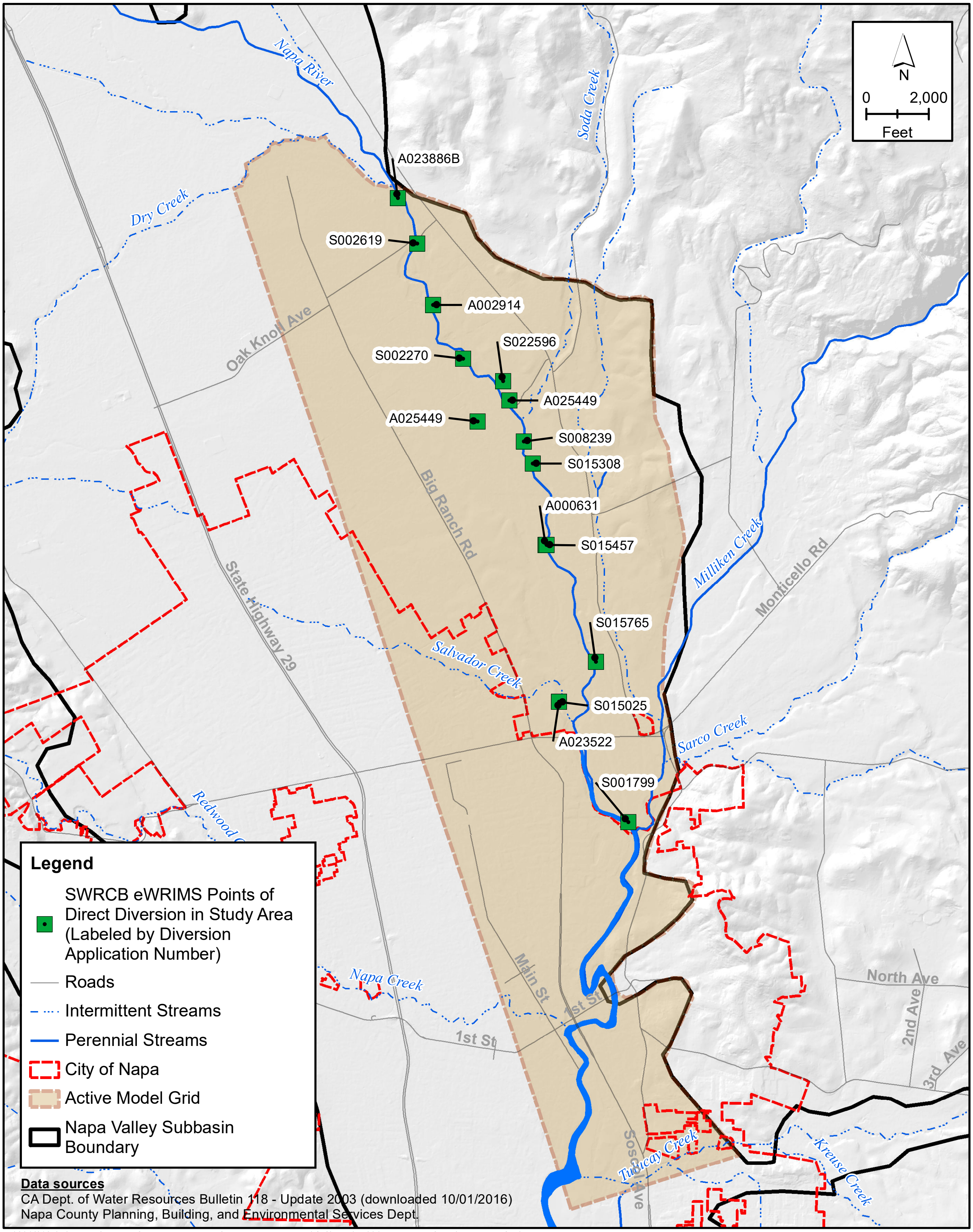
FIGURE 3-12
Napa Creek Subwatershed Precipitation and Streamflow



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Figure x-x Surface Water Diversions.mxd

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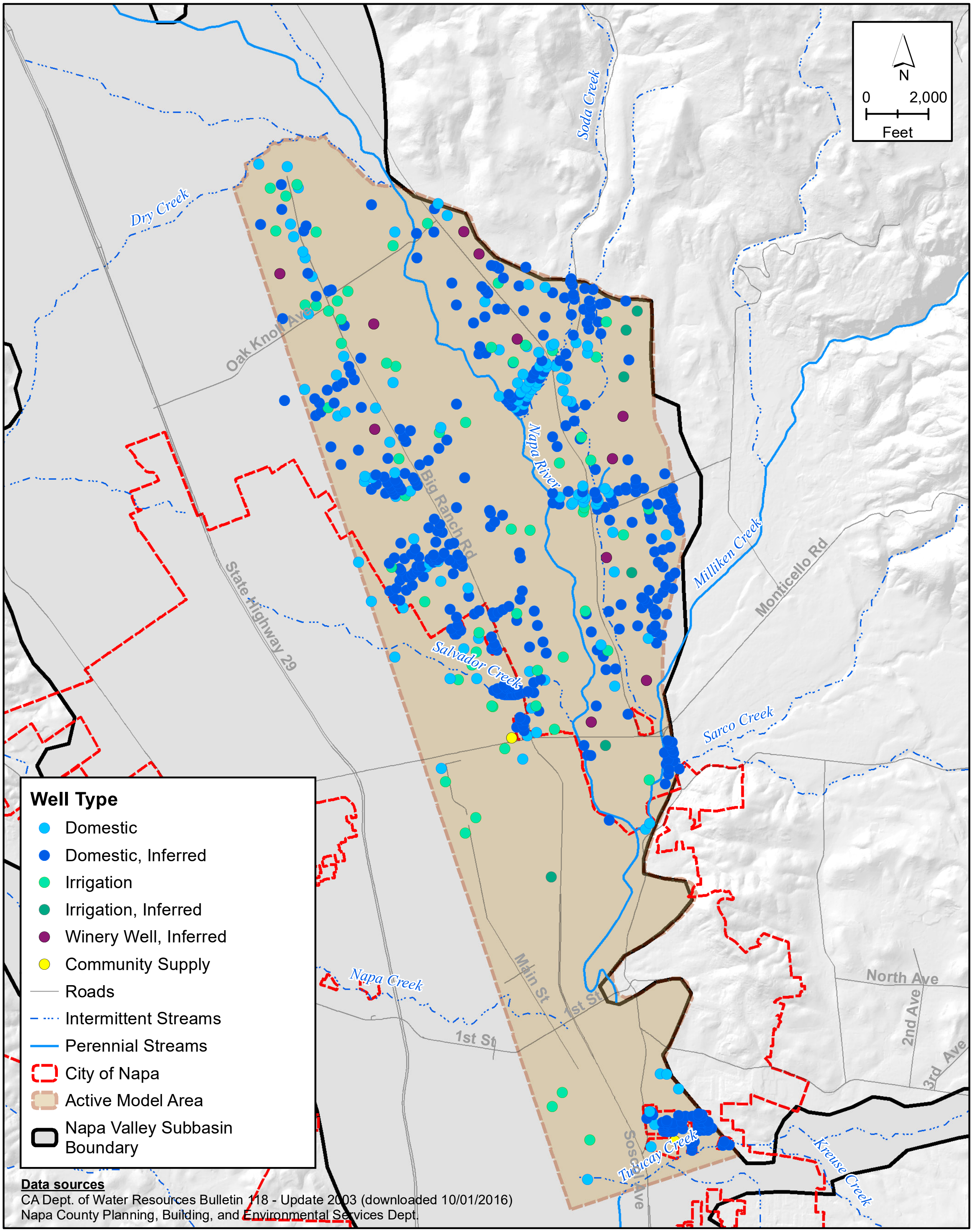
FIGURE 3-13

Permitted Surface Water Diversions



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Figure x-x Well LocationsMayDay2017.mxd

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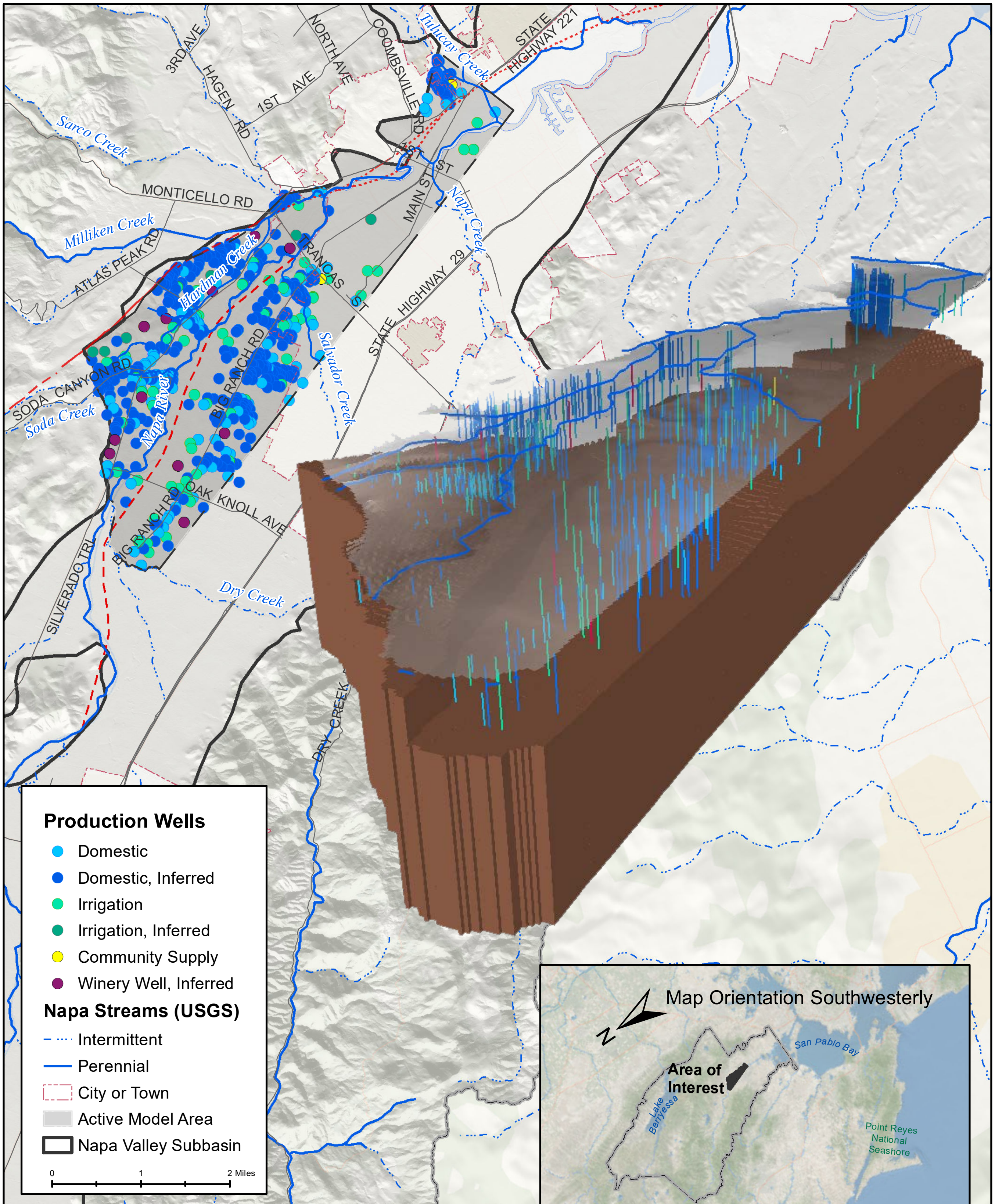
FIGURE 3-14a

Located and Inferred Water Supply Well Locations



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2016 (downloaded 10/01/2016), Napa County Dept. of Public Works, U.S. Geological Survey

X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Templates\ProductionWellsMapFig 1-13DsouthView Study area location.mxd

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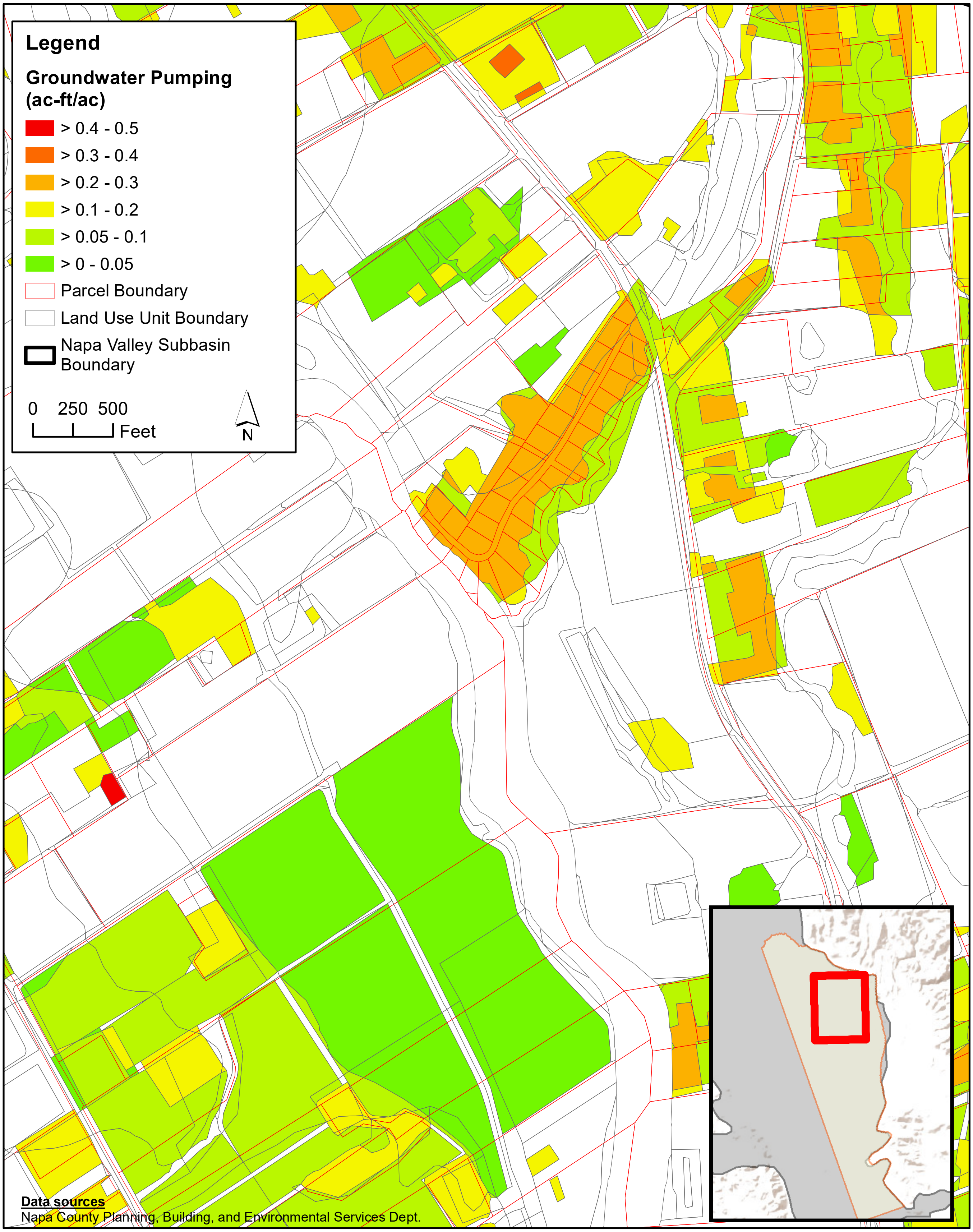
FIGURE 3-14b

Production Wells in the Active Model Area

Northeast Napa Area Special Groundwater Study



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig x-x Groundwater Demand for Irrigation_July_2003.mxd

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FIGURE 3-15
Groundwater Demand for Irrigation in July 2003
An Example from a Selected Area in NE Napa Study Area

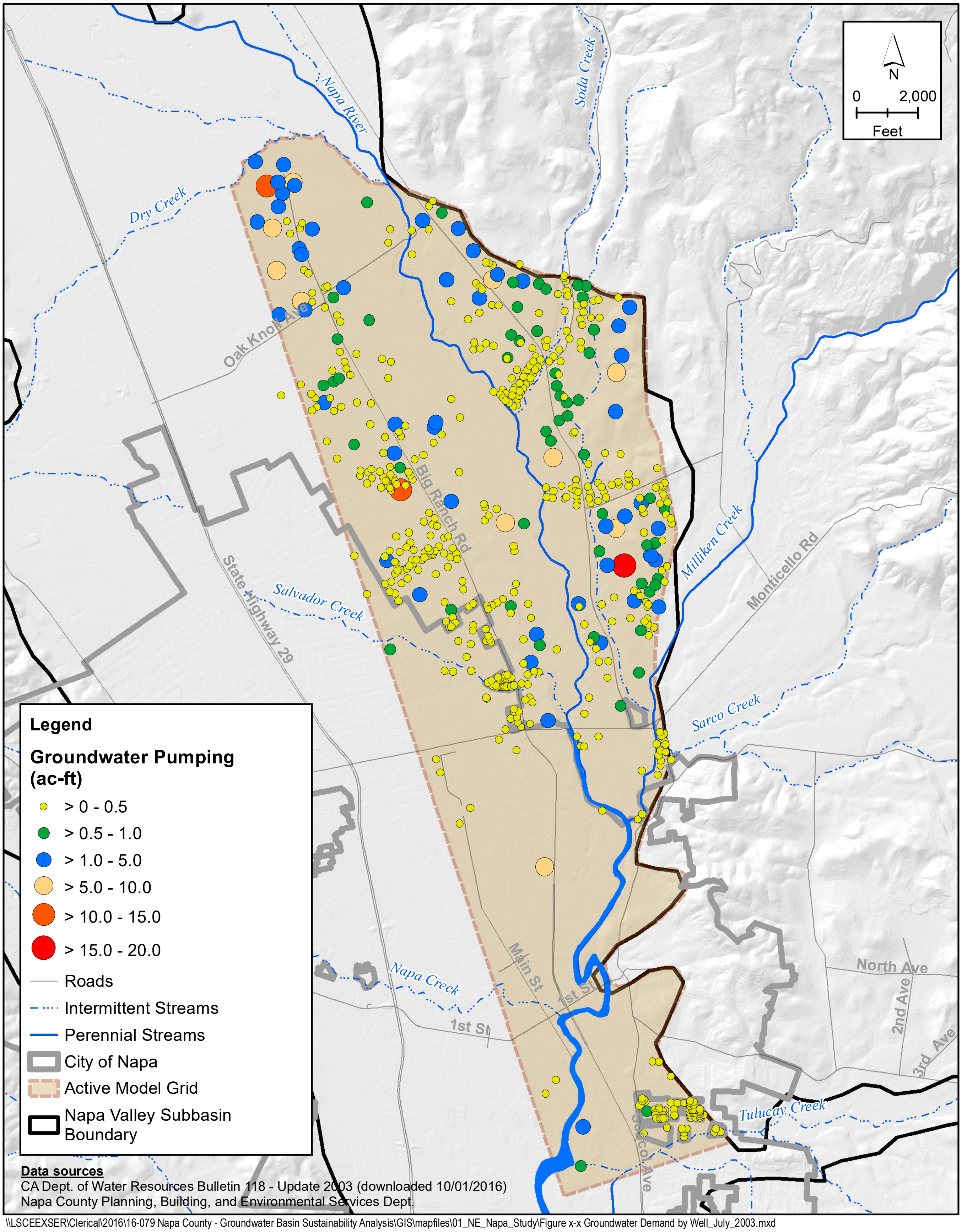

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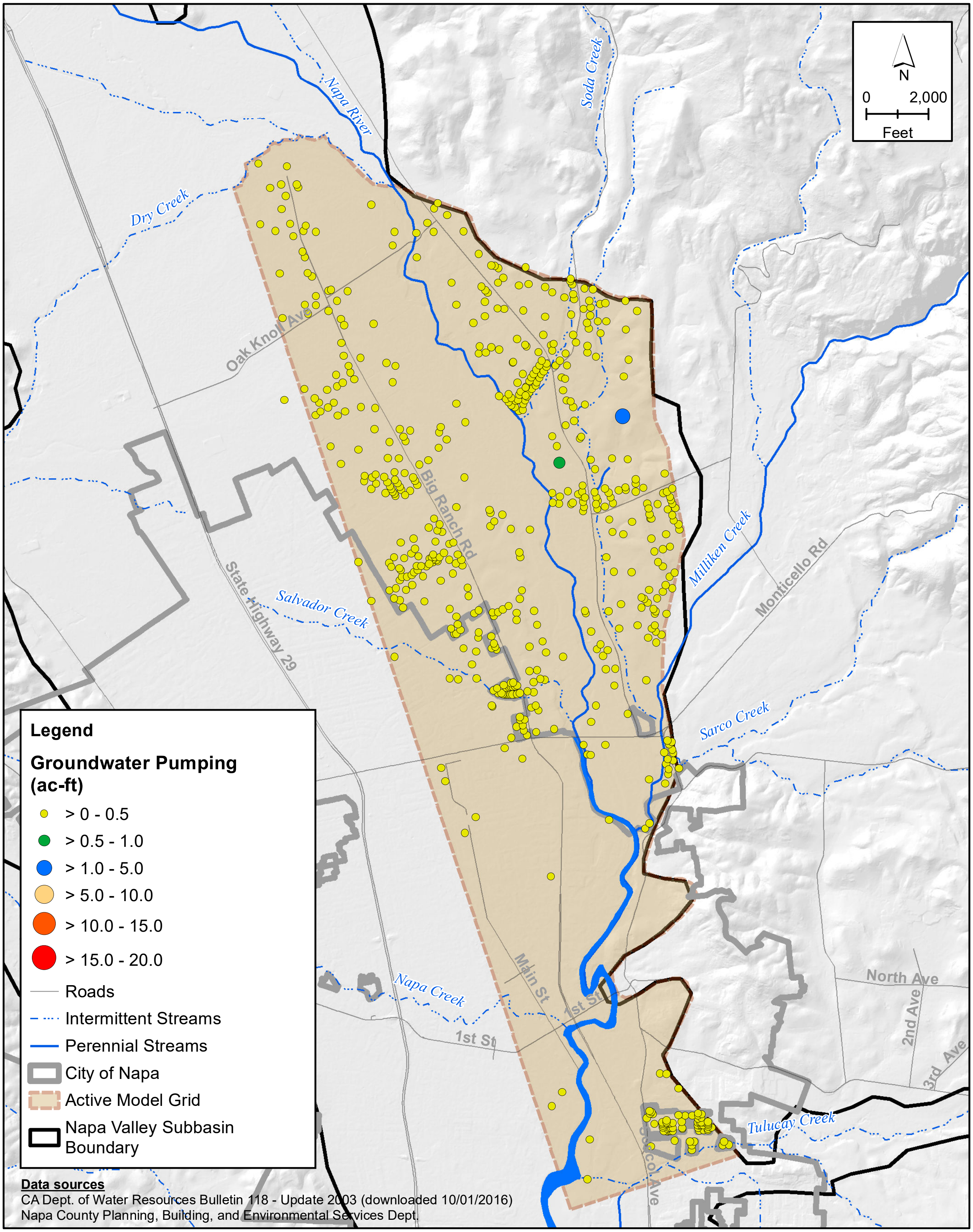
FIGURE 3-16

Groundwater Demand by Well for All Uses in July 2003



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Figure x-x Groundwater Demand by Well_Dec_2002.mxd

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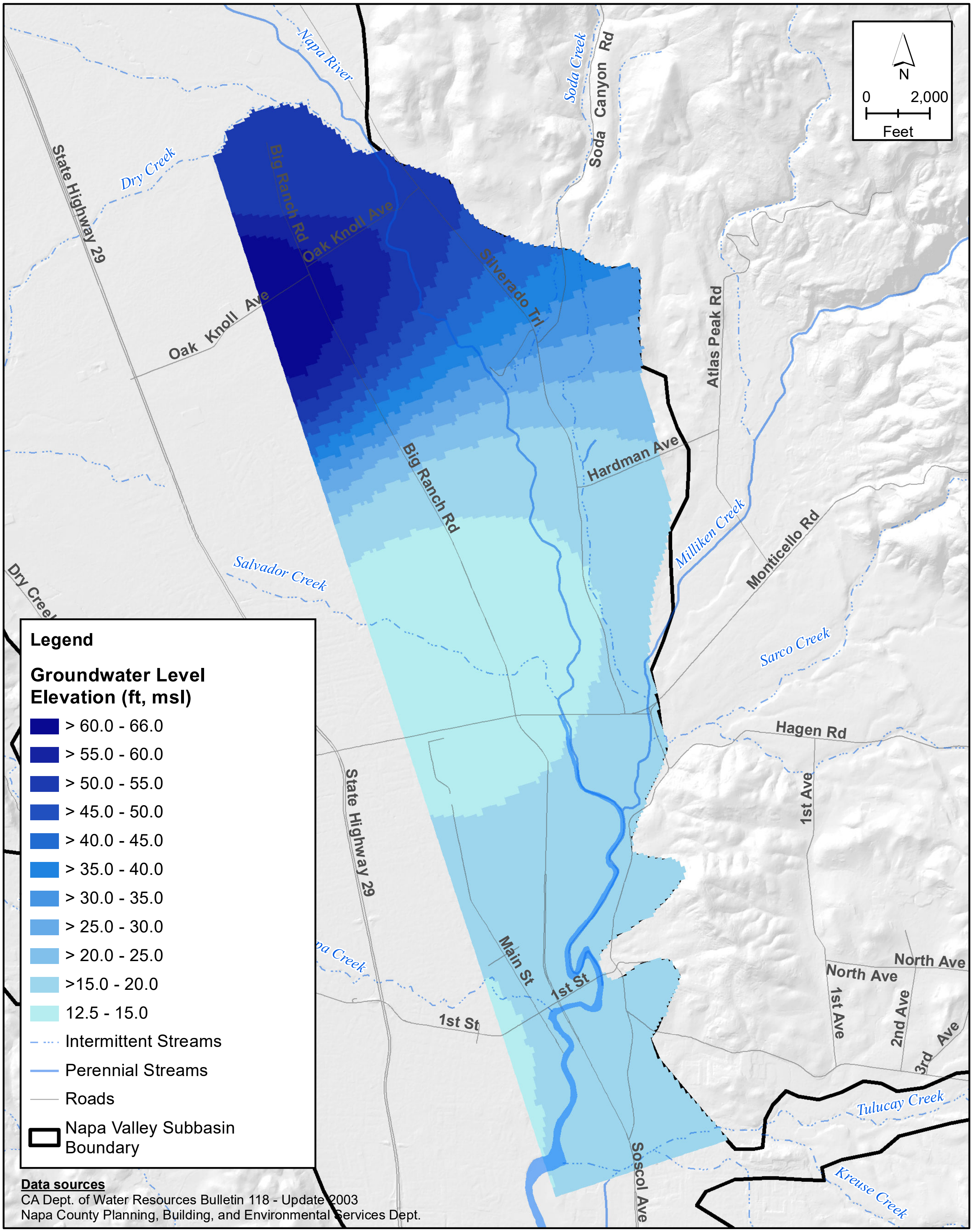
FIGURE 3-17

Groundwater Demand by Well for All Uses in December 2002



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003
Napa County Planning, Building, and Environmental Services Dept.

\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig x-x Initial Conditions - Unconfined.mxd

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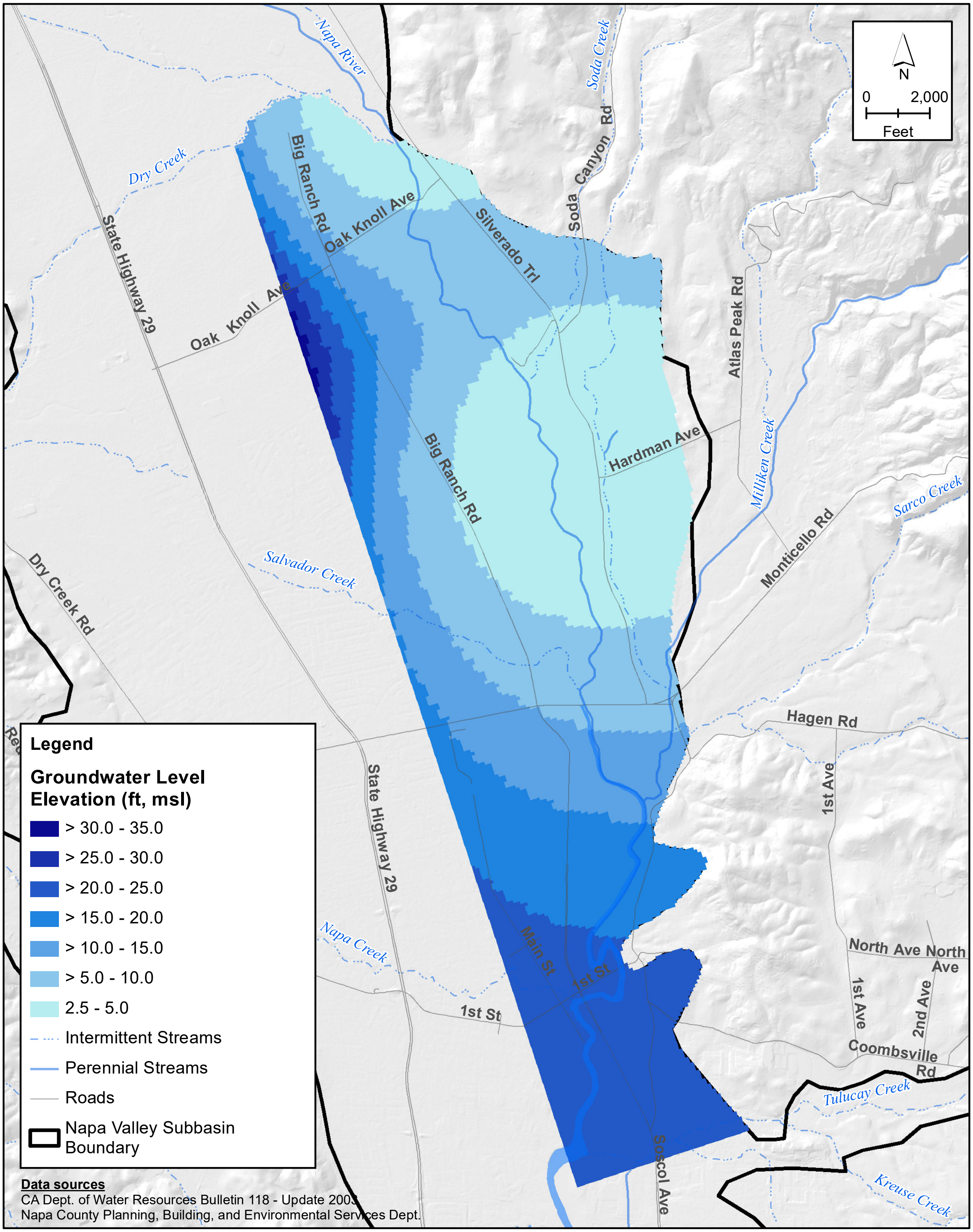
FIGURE 3-18

Initial Condition: Unconfined Aquifer, October 1987



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig x-x Initial Conditions - Semiconfined.mxd

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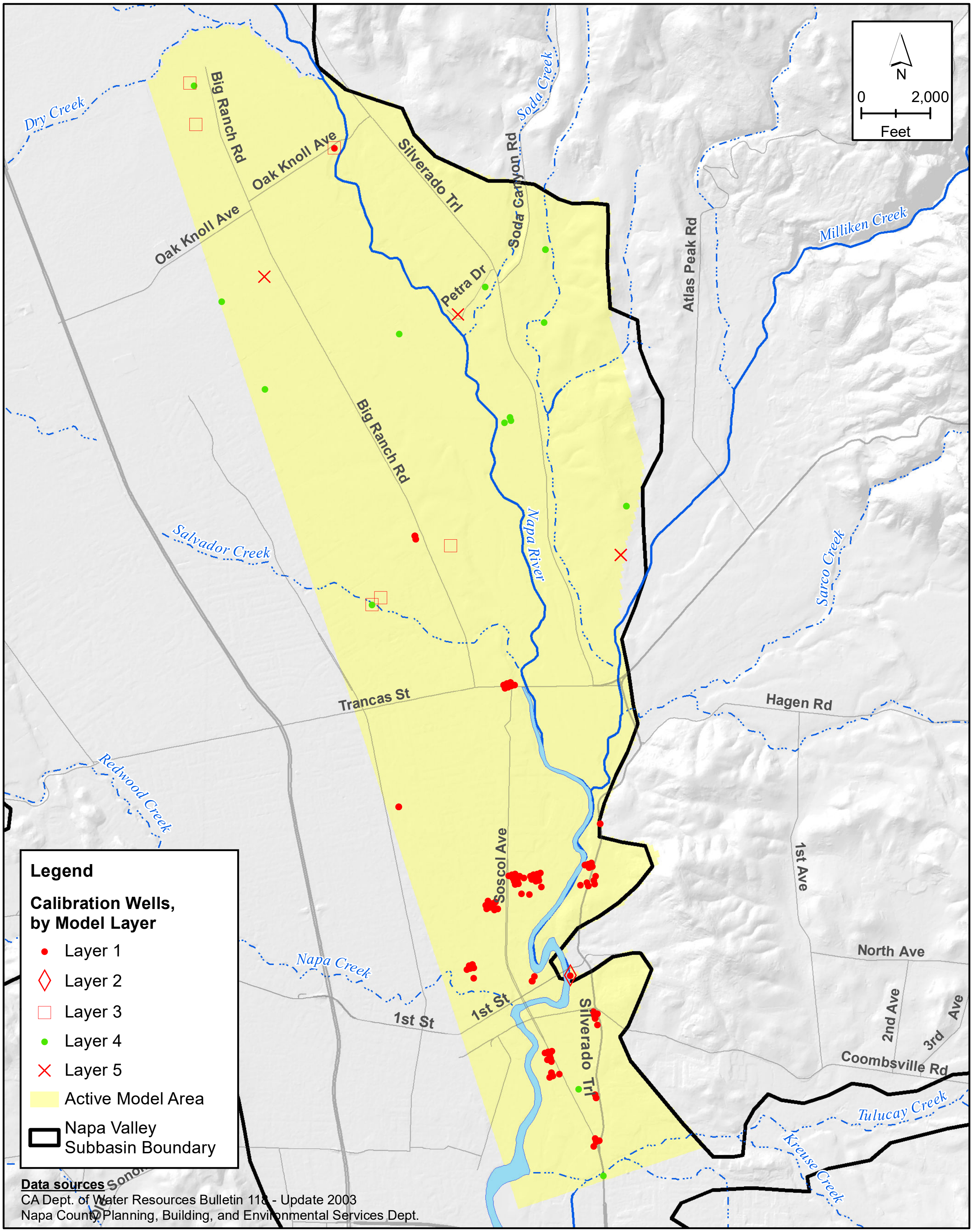
FIGURE 3-19

Initial Condition: Semi-confined Aquifer, October 1987



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-Z1 Calibration target Well Locations.mxd

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FIGURE 3-20

Calibration Target Well Locations

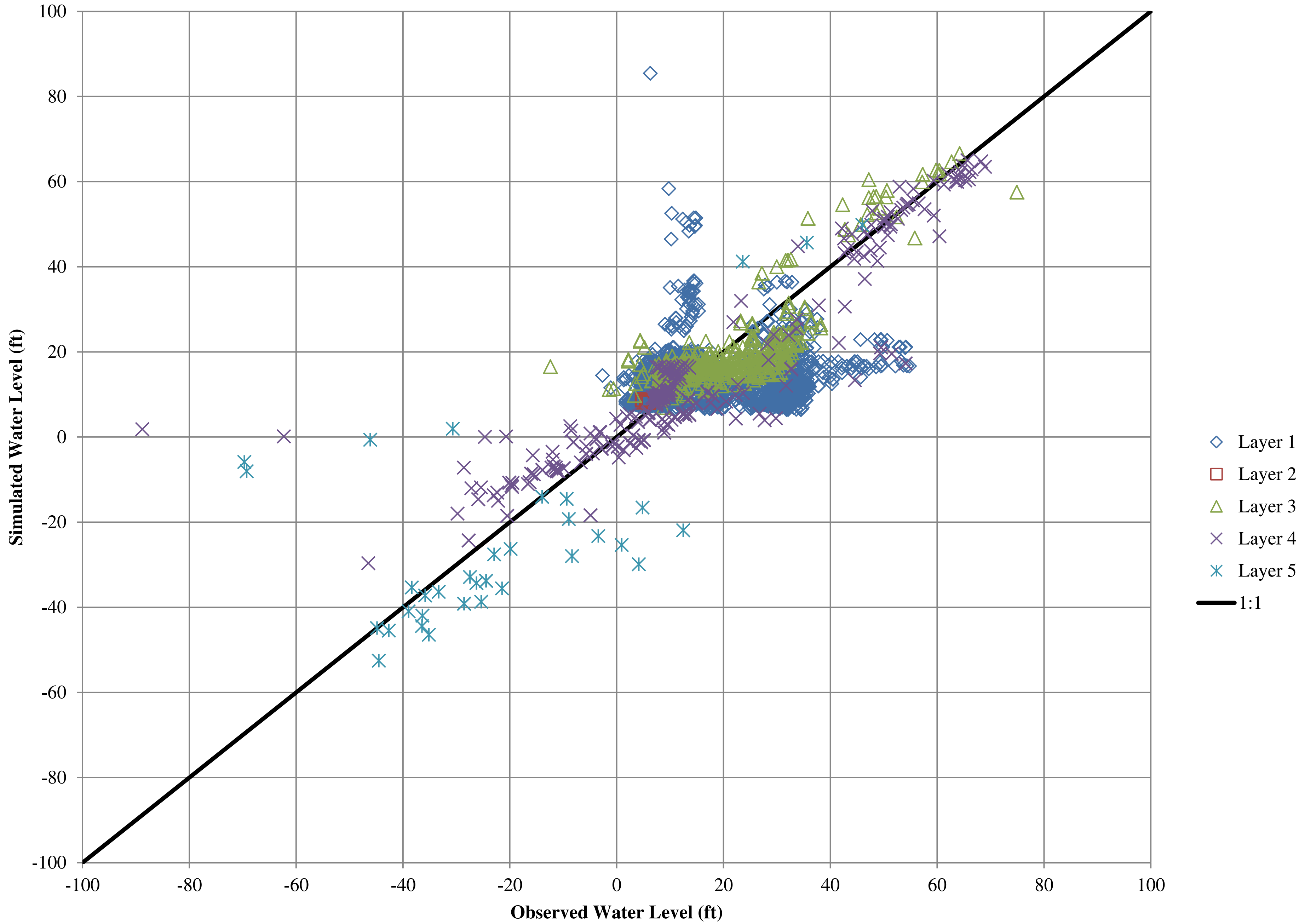

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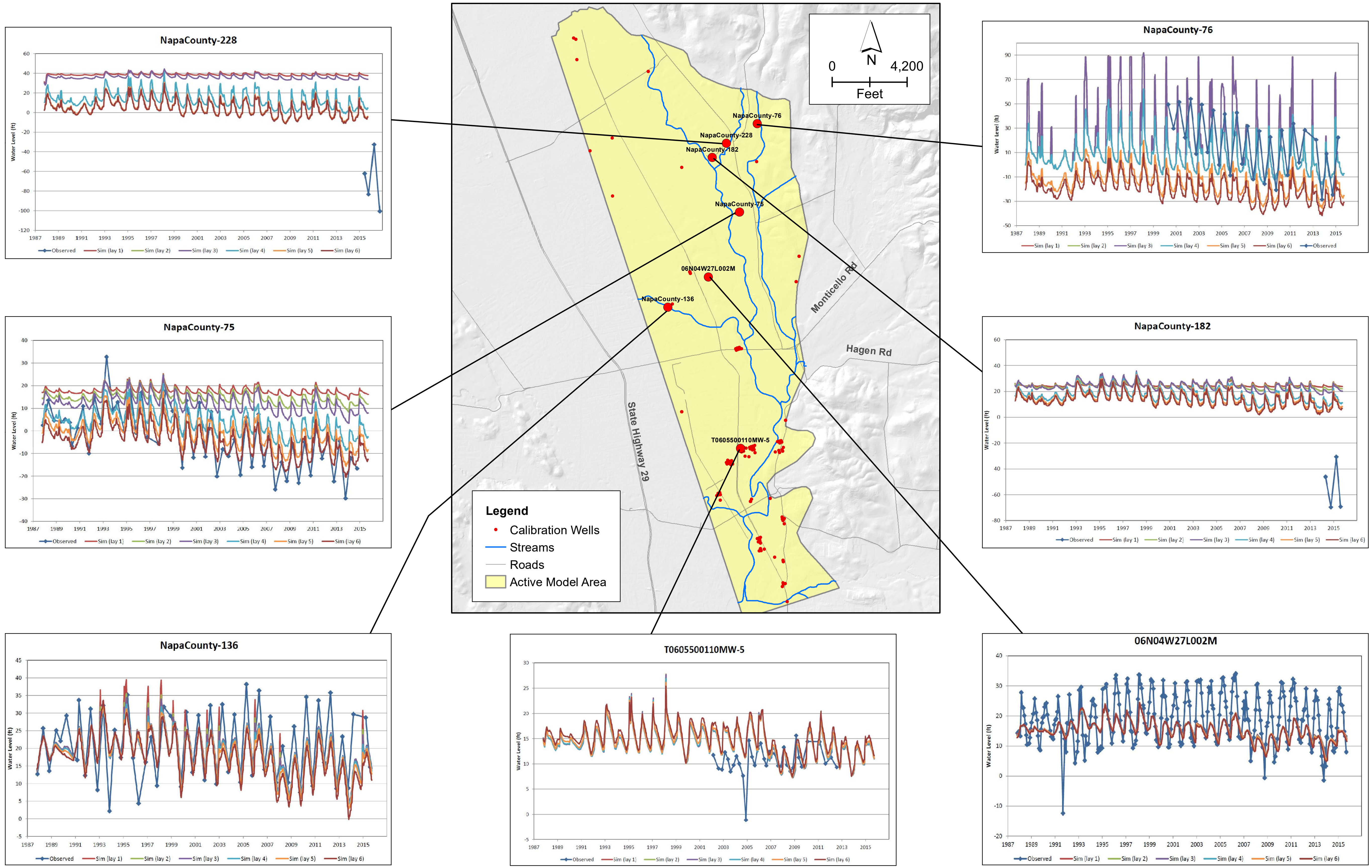
FIGURE 3-21
Simulated Vs Observed Water Level
Calibration Plot
Northeast Napa Area: Special Groundwater Study



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 3-XXX WLTarget Hydrographs.mxd

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FIGURE 3-22

Selected Water Level Targets for Calibration

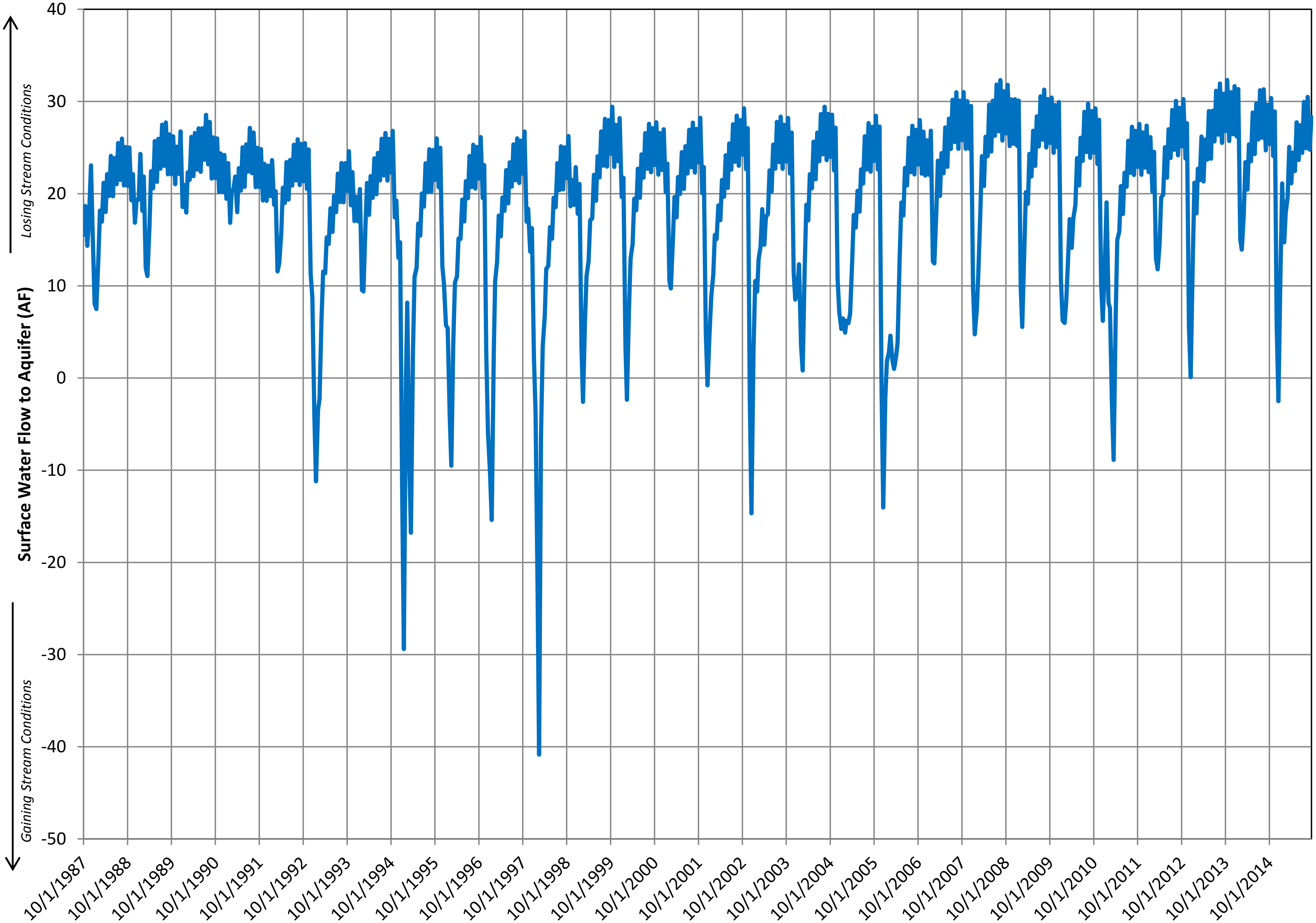

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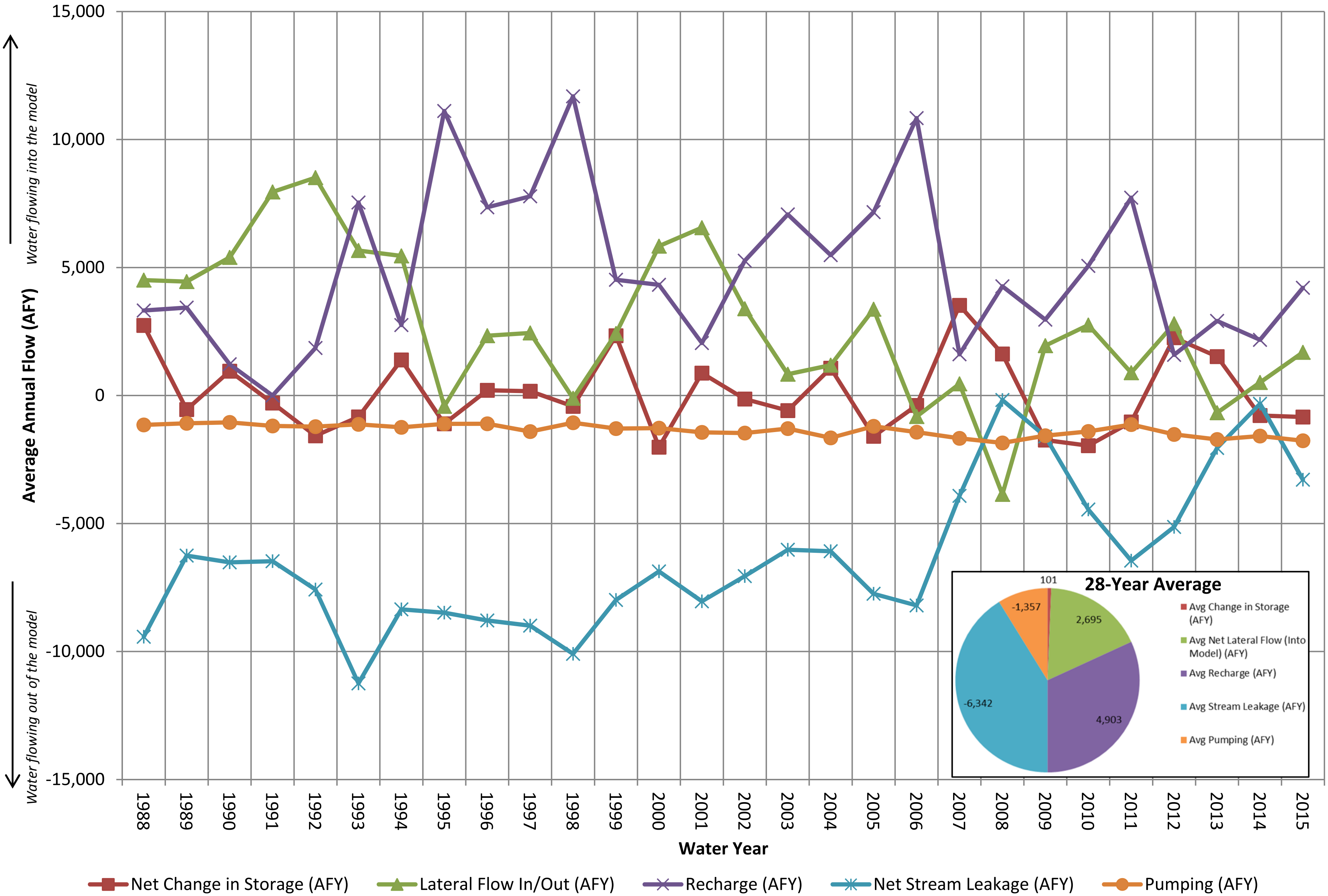
FIGURE 3-23
Simulated Surface Water Flow to Aquifer in Soda Creek Model Segments
Northeast Napa Area: Special Groundwater Study



Note: Positive storage value indicates water entering the model via storage depletion; negative storage value indicates water going into storage restoration. Negative stream leakage indicates gaining stream conditions. Positive lateral flow indicates water entering the model domain through its boundaries; negative lateral flow indicates water leaving the model domain via its boundaries.

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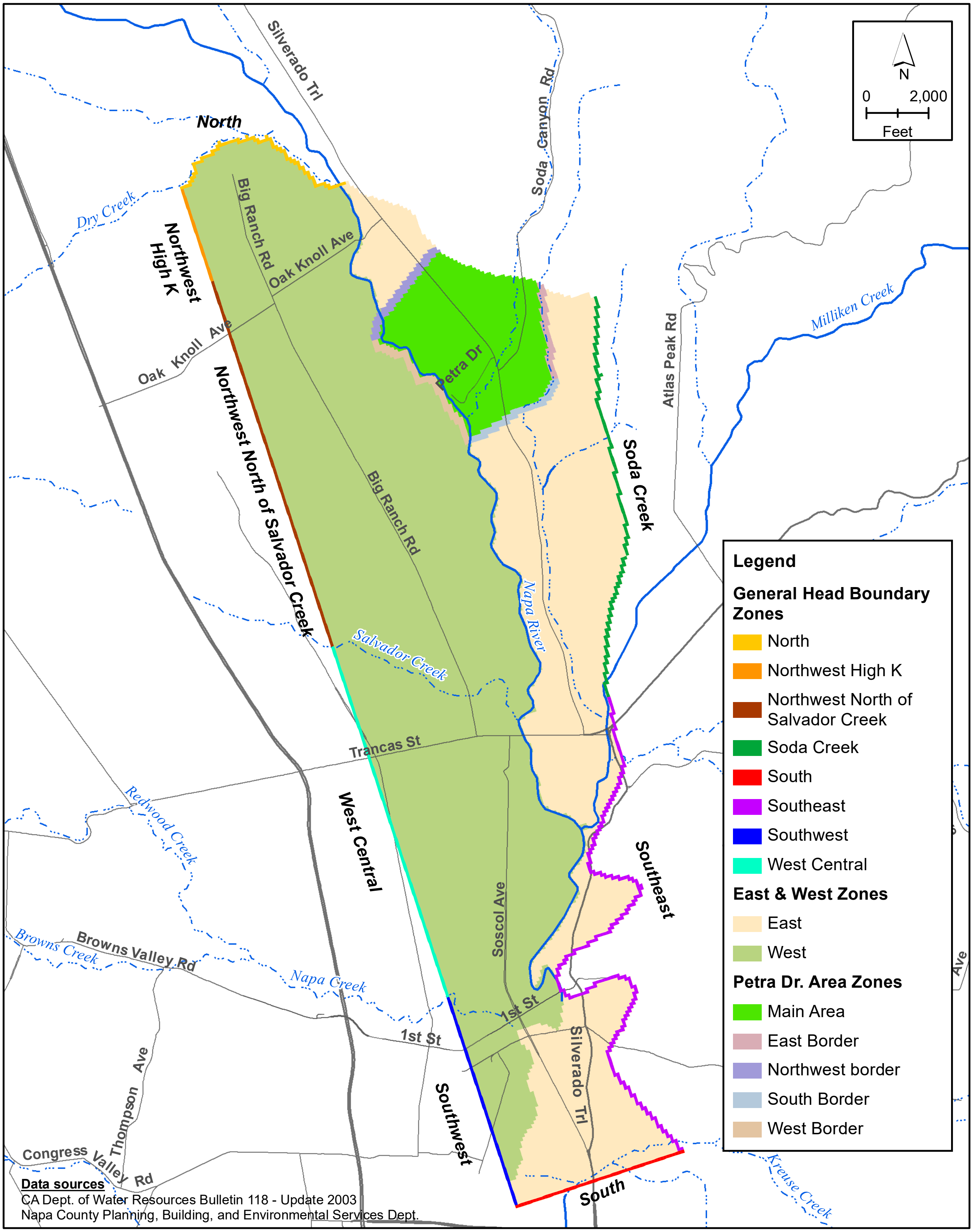
Figure 3-24
Average Annual Water Budget Components for the Entire Model Domain
Northeast Napa Area: Special Groundwater Study



\\LSCEEXSER\Clerical\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 4-1 Zonebudget Areas.mxd

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FIGURE 3-25

Zonebudget Areas for Focused Water Budget Analysis

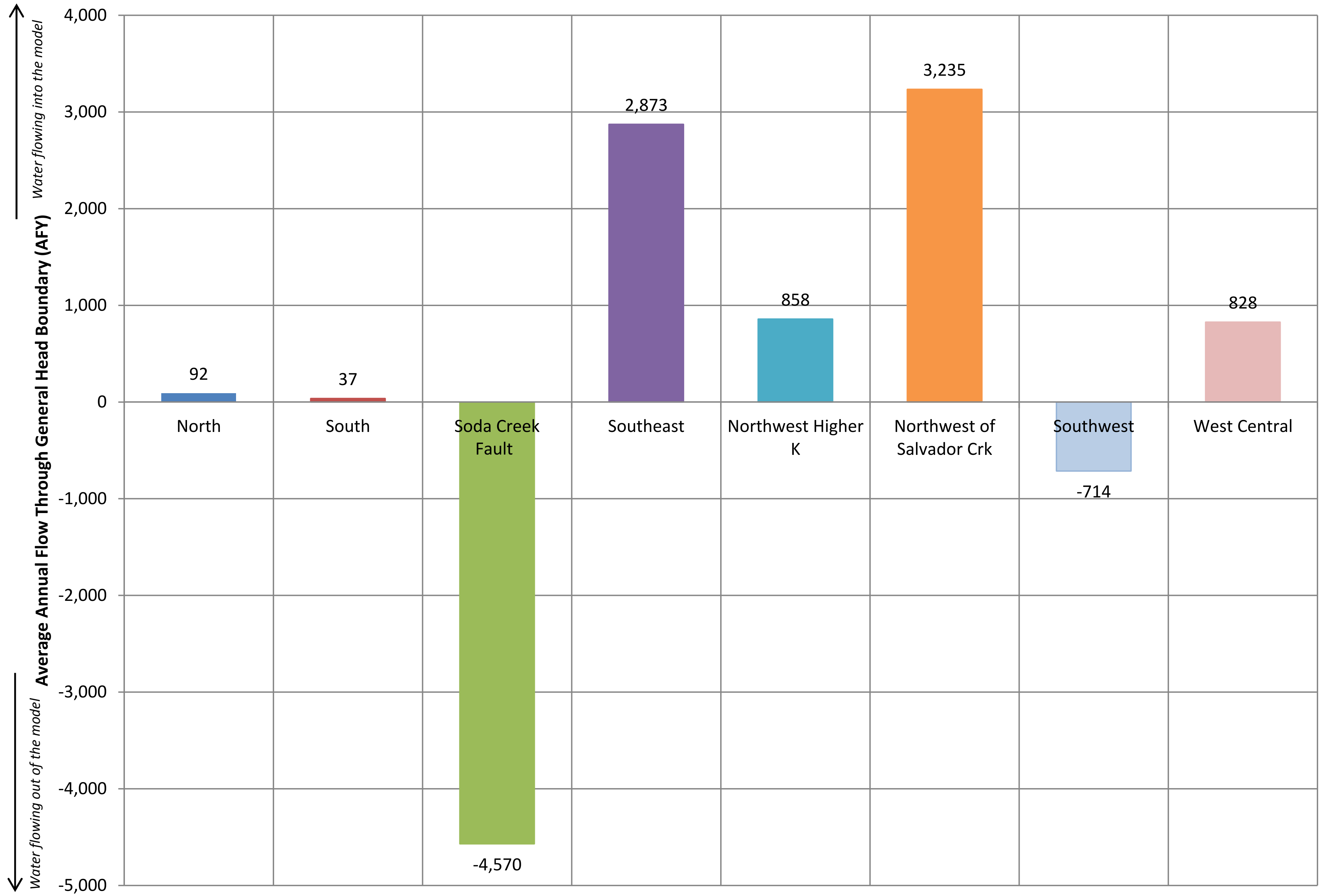

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FIGURE 3-26
Average Annual Flow Through
Different Regions of the Model's General Head Boundaries
Northeast Napa Area: Special Groundwater Study

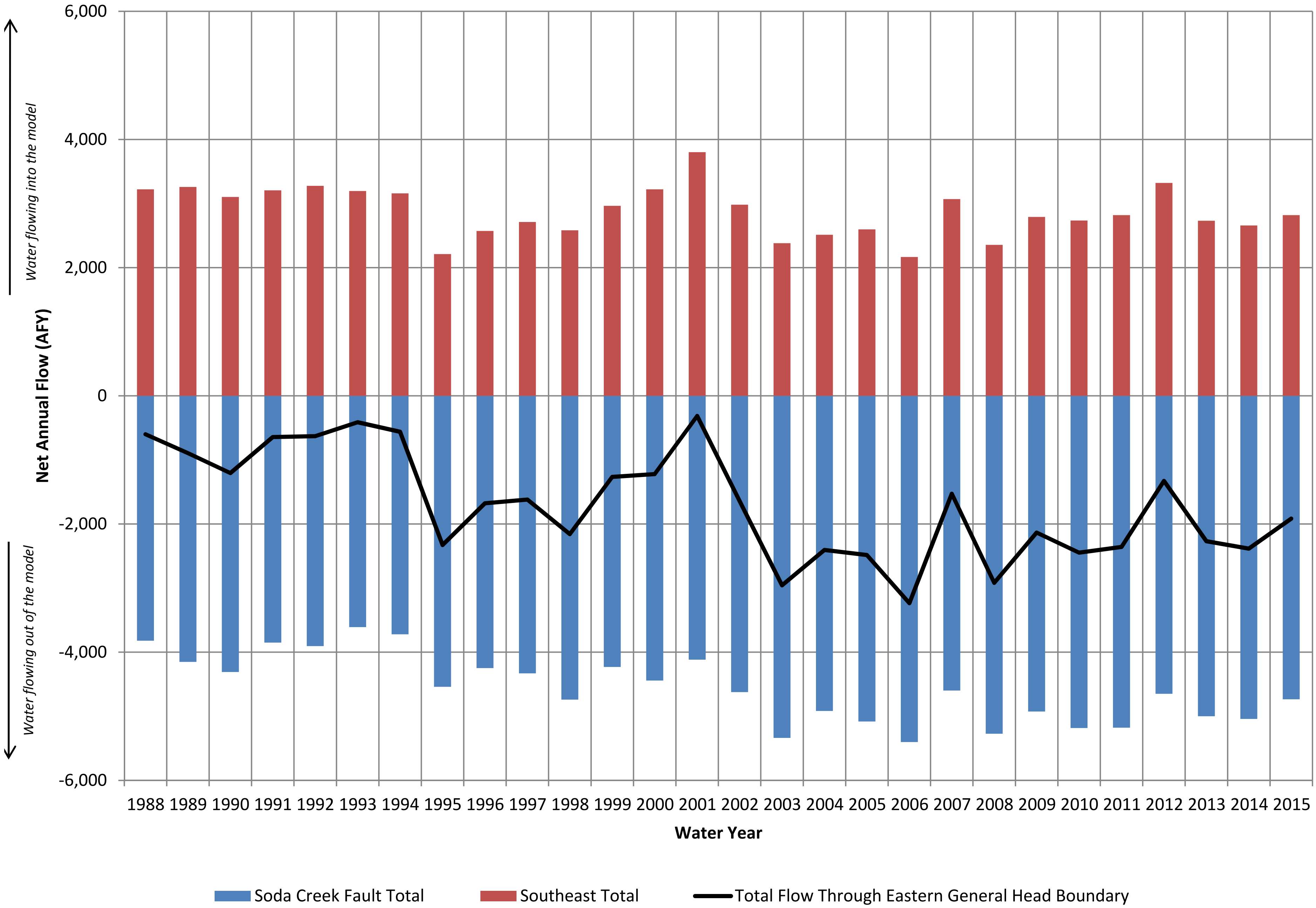

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FIGURE 3-27
Net Annual Flow Through Different Sections of the Eastern General Head Boundary
Northeast Napa Area: Special Groundwater Study

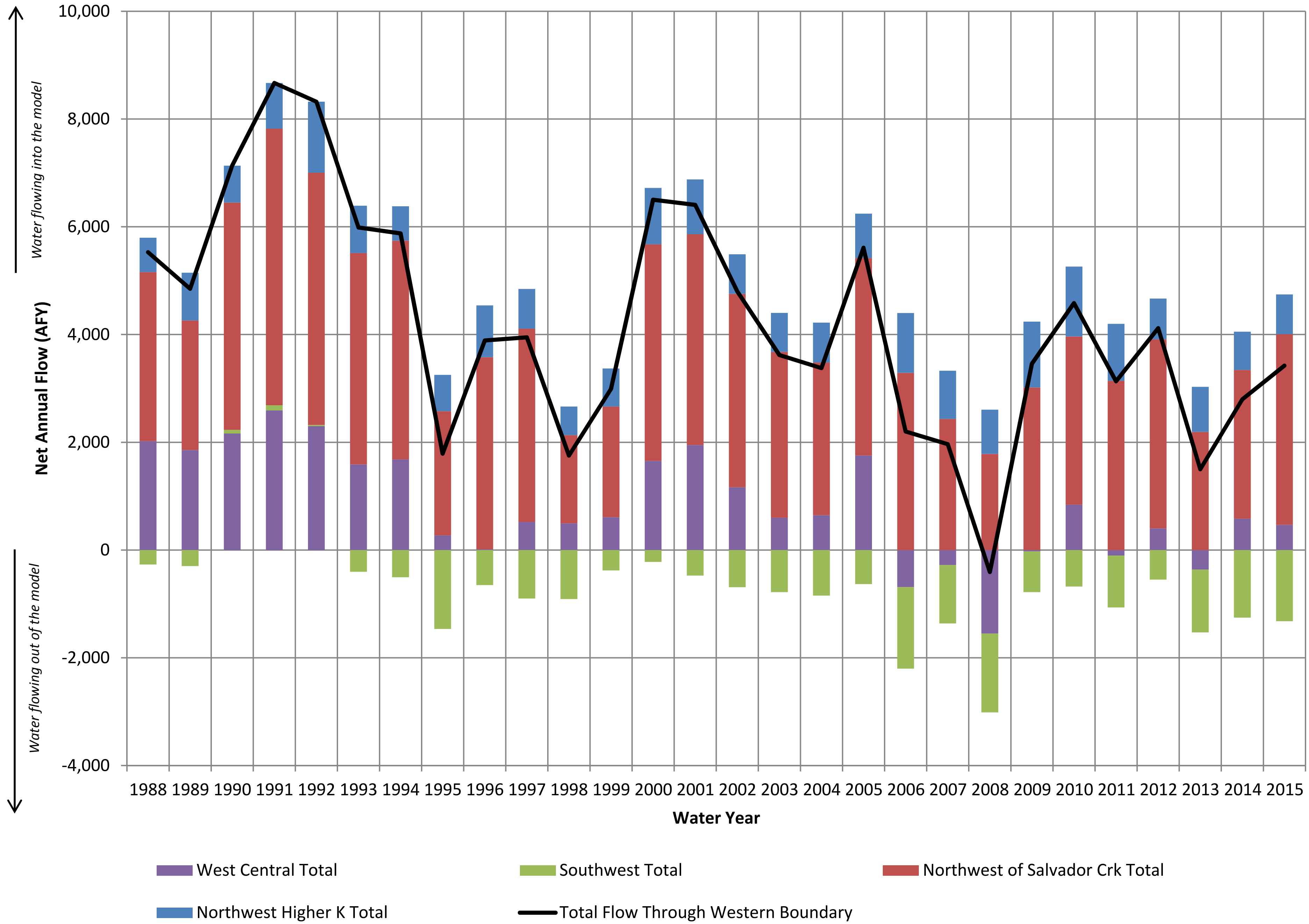

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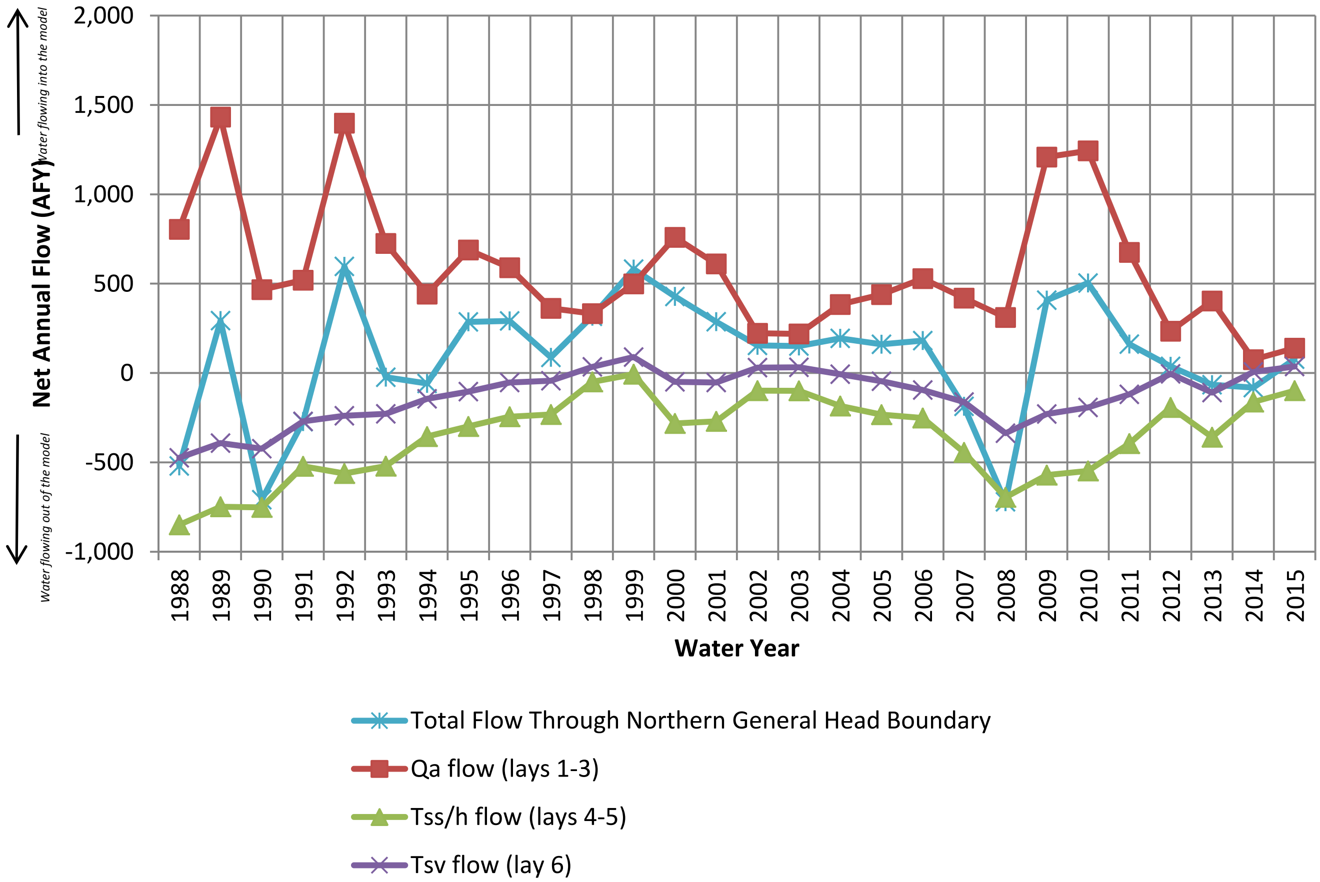
FIGURE 3-28
Net Annual Flow Through Different Sections of the Western General Head Boundary
Northeast Napa Area: Special Groundwater Study



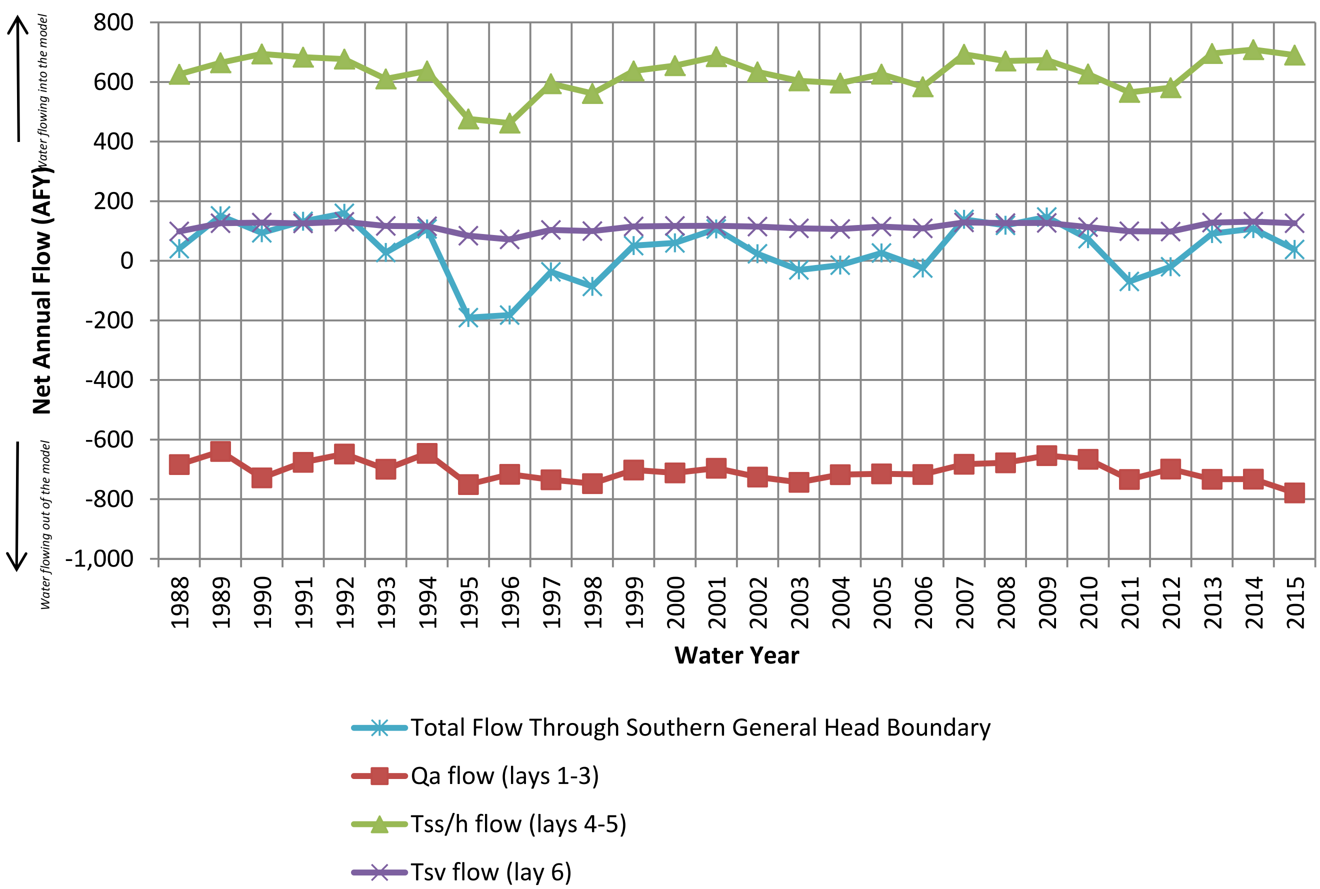


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FIGURE 3-29
Net Annual Flow Through the
Northern and Southern General Head Boundaries
Northeast Napa Area: Special Groundwater Study

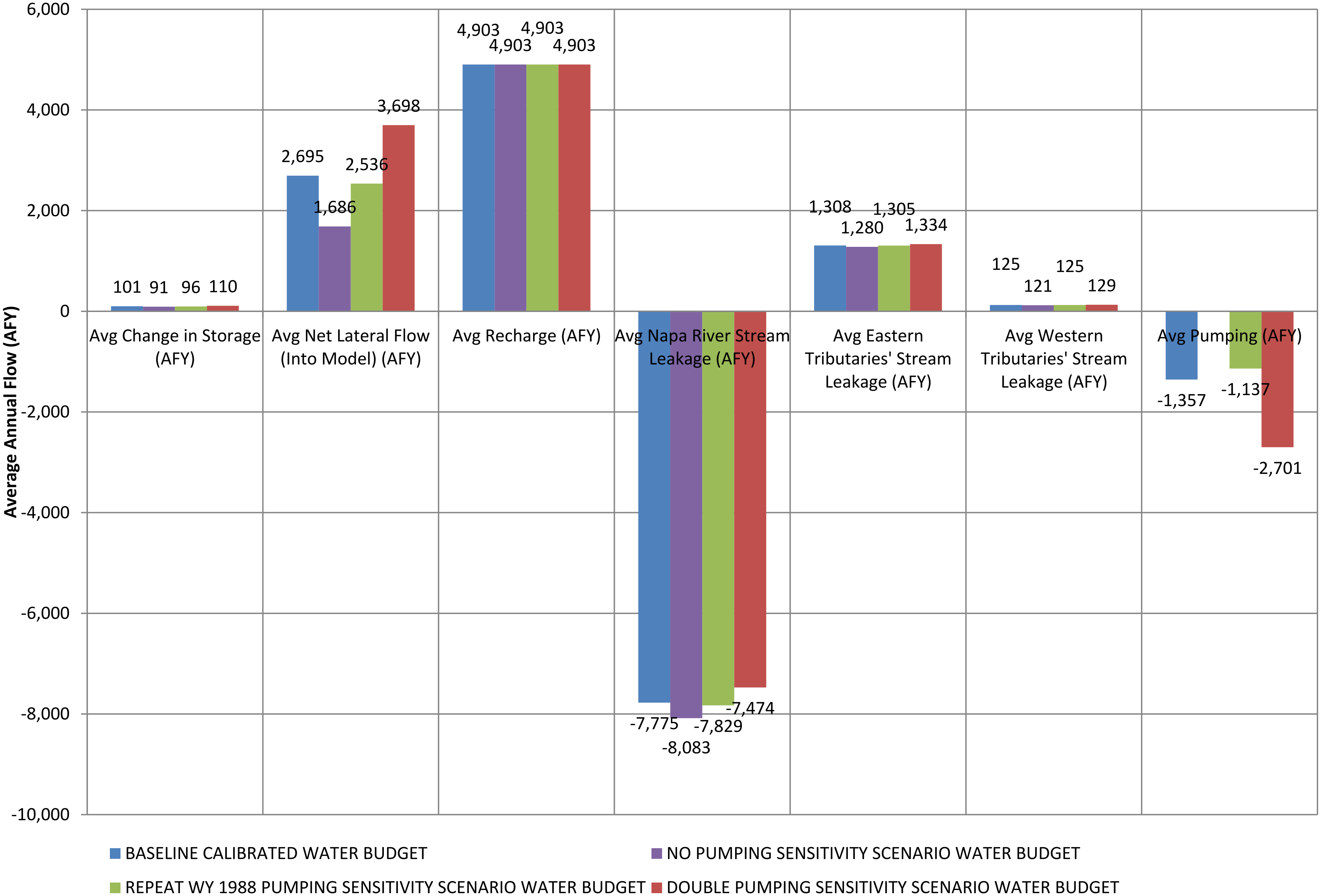

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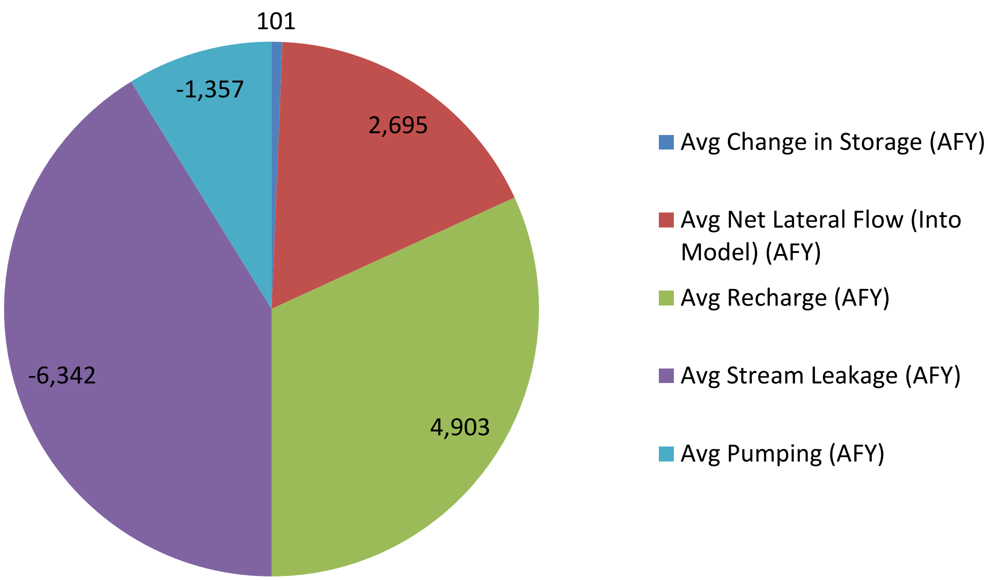
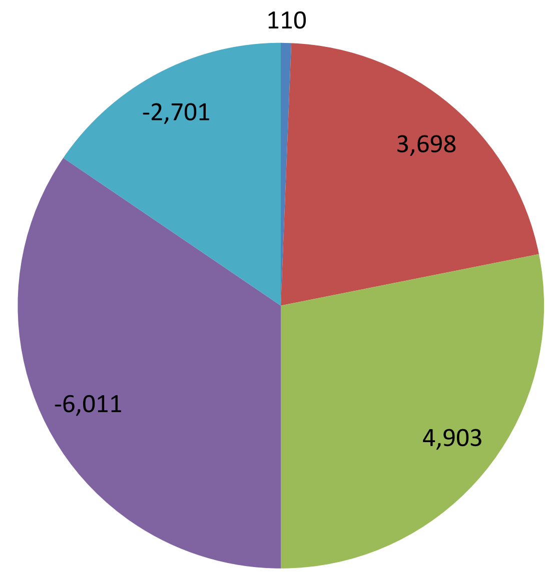
FIGURE 3-30
Average Annual Water Budget Components for Baseline and Three Pumping Sensitivity Scenarios
Northeast Napa Area: Special Groundwater Study



BASELINE CALIBRATED WATER BUDGET



DOUBLE PUMPING SENSITIVITY SCENARIO WATER BUDGET

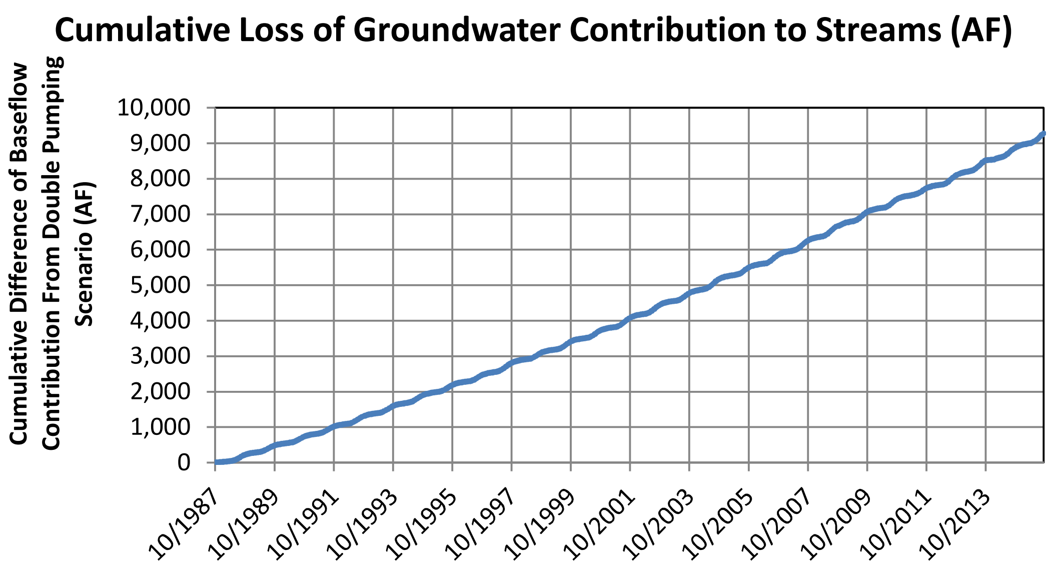


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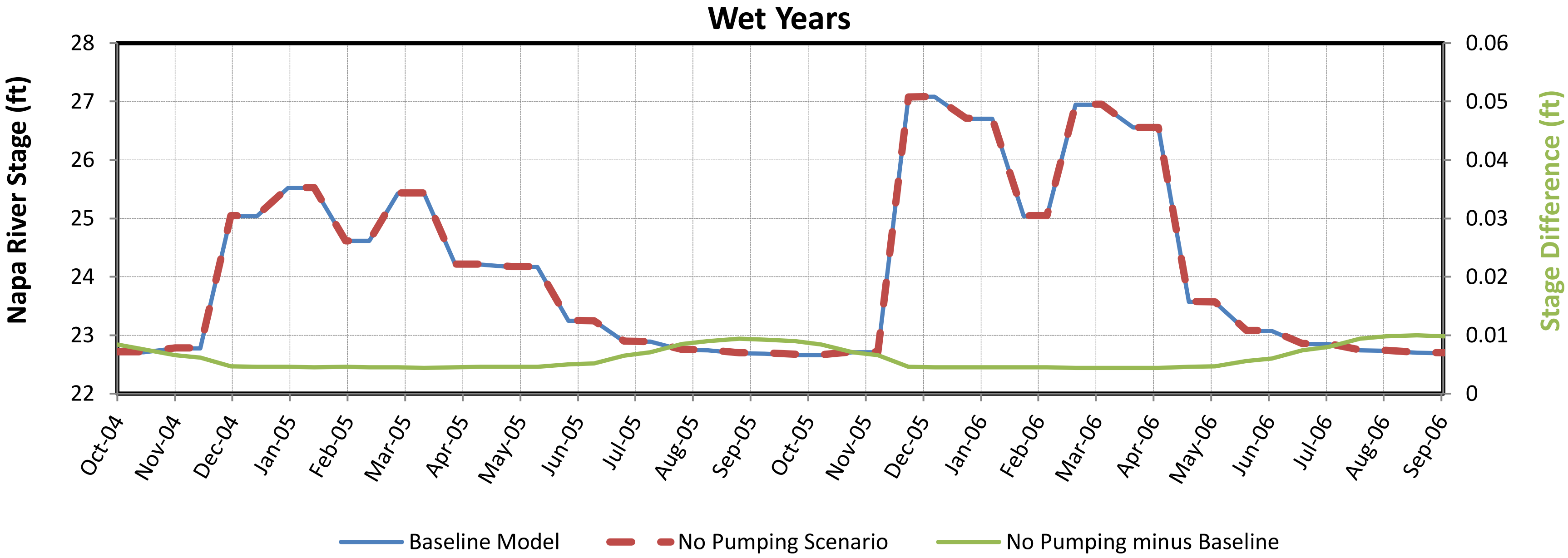
FIGURE 3-31
Sensitivity Run Comparison of Water Budget Components & Cumulative Loss of Groundwater Contribution to Streams
Northeast Napa Area: Special Groundwater Study



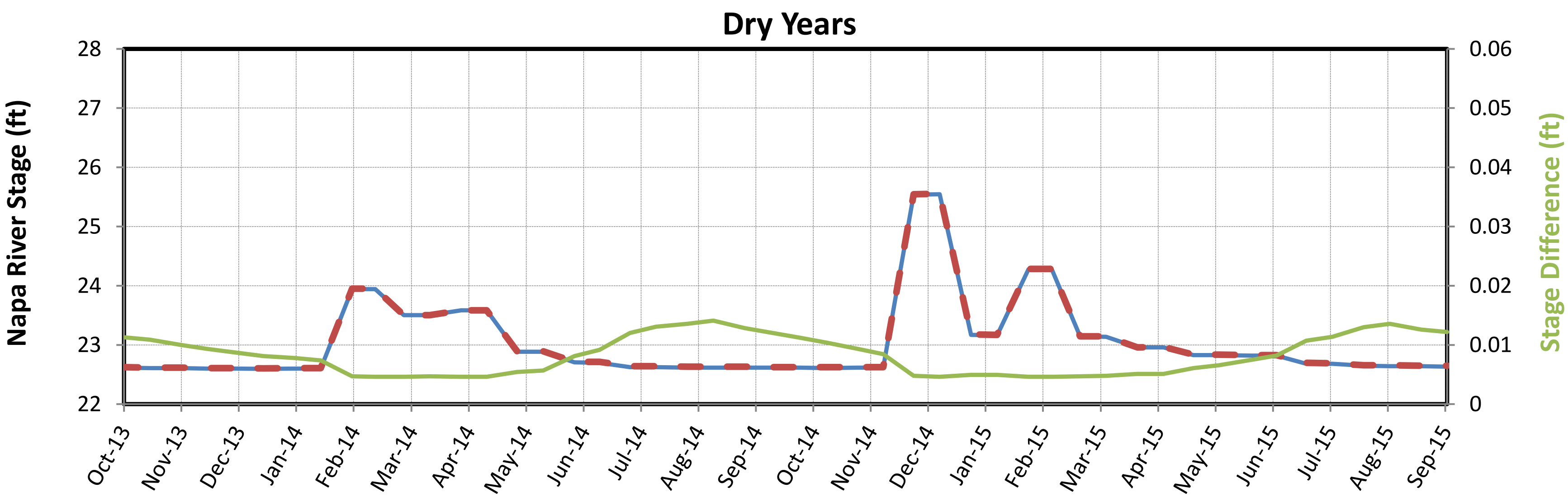


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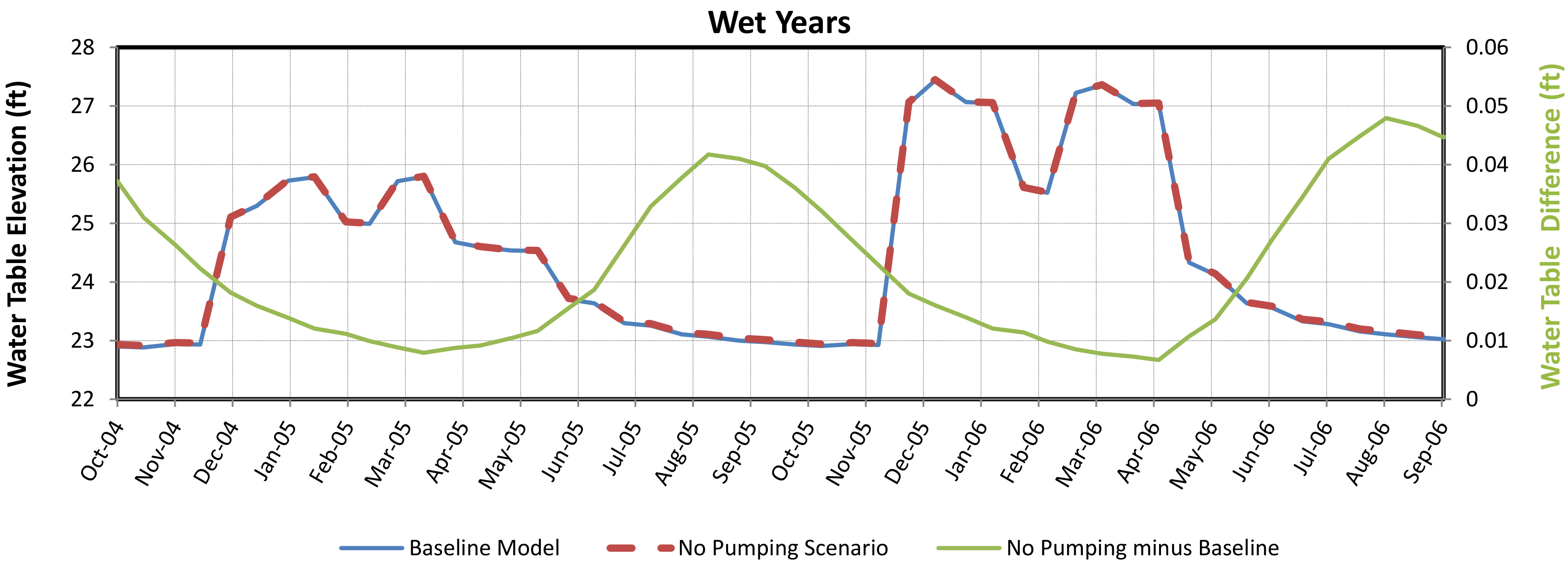
FIGURE 3-32
Napa River Stage at Petra Drive (Row 111 Column 62)
Baseline Calibrated Model and No Pumping Scenario
Northeast Napa Area: Special Groundwater Study



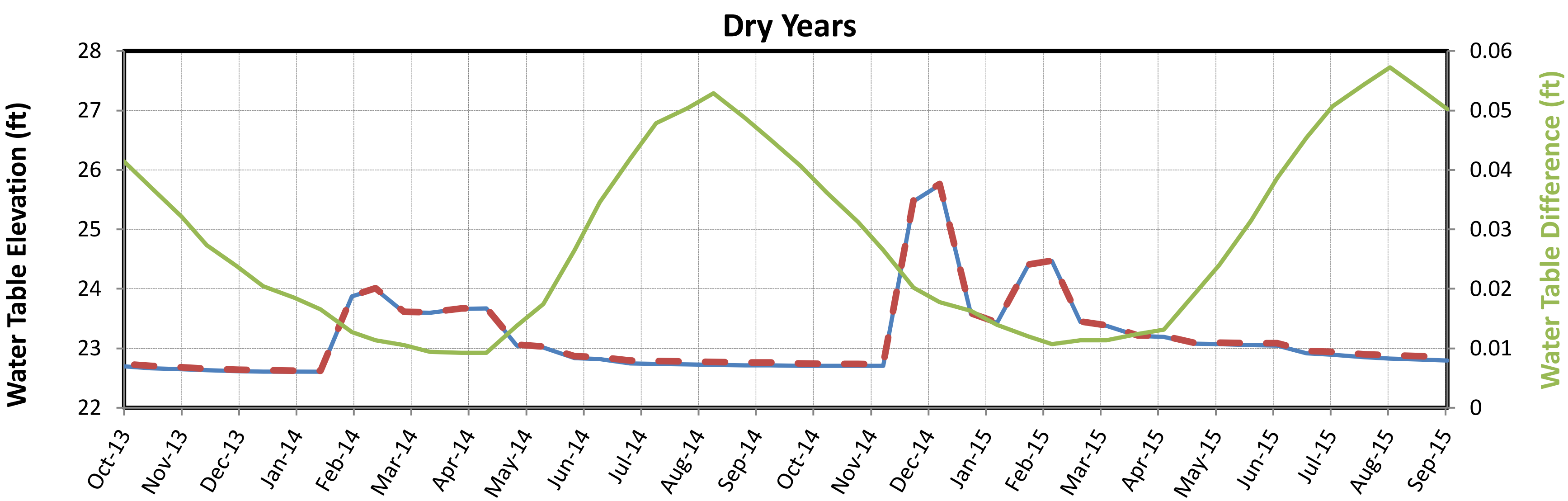


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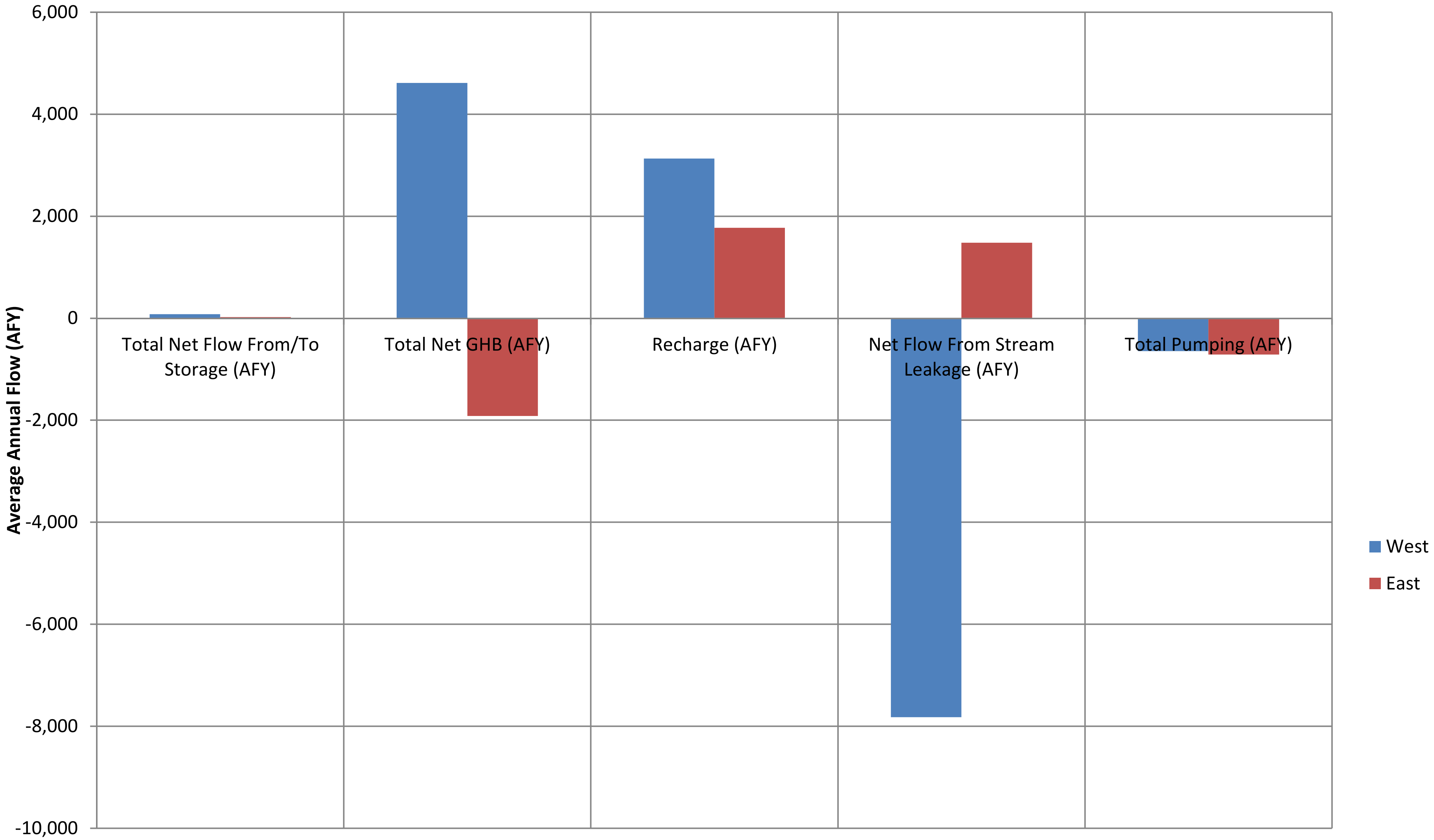
FIGURE 3-33
Water Table Elevation at Petra Drive (Row 111 Column 62)
Baseline Calibrated Model and No Pumping Scenario
Northeast Napa Area: Special Groundwater Study



Note: The western portion of the model in this analysis contains all of the Napa River model cells and accompanying stream leakage components, as well as Salvador Channel and Napa Creek and the land west of the Napa River. The eastern portion contains land on the east side of Napa River and only eastern tributaries to the Napa River (including Soda Creek, Hardman Creek (and Tributary), Miliken Creek, Sarco Creek, Tulucay Creek, and Cayetano Creek.

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FIGURE 4-1
Average Annual Water Budget Components
Comparison of Western and Eastern Sides of the Model Domain

Northeast Napa Area: Special Groundwater Study

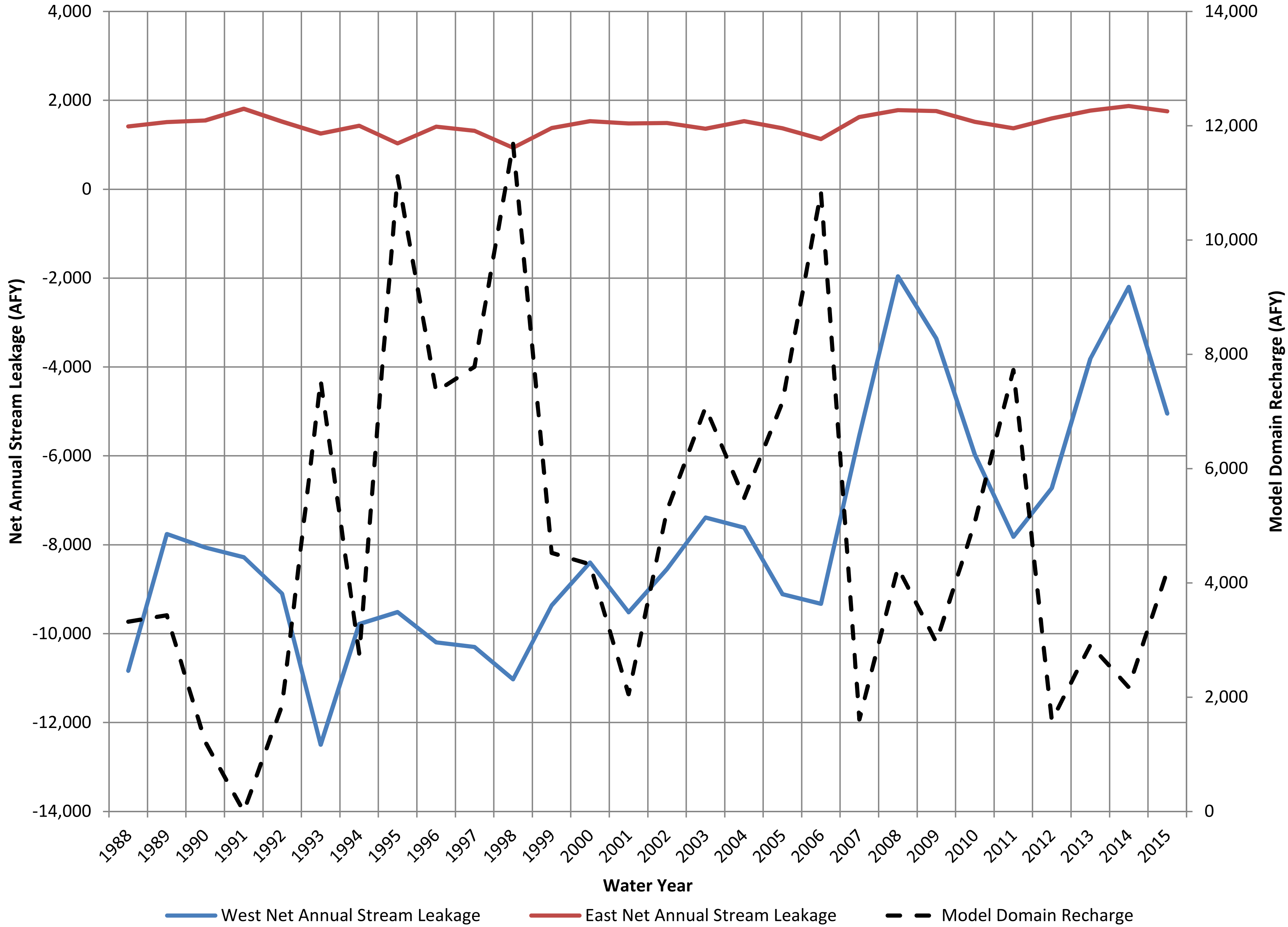

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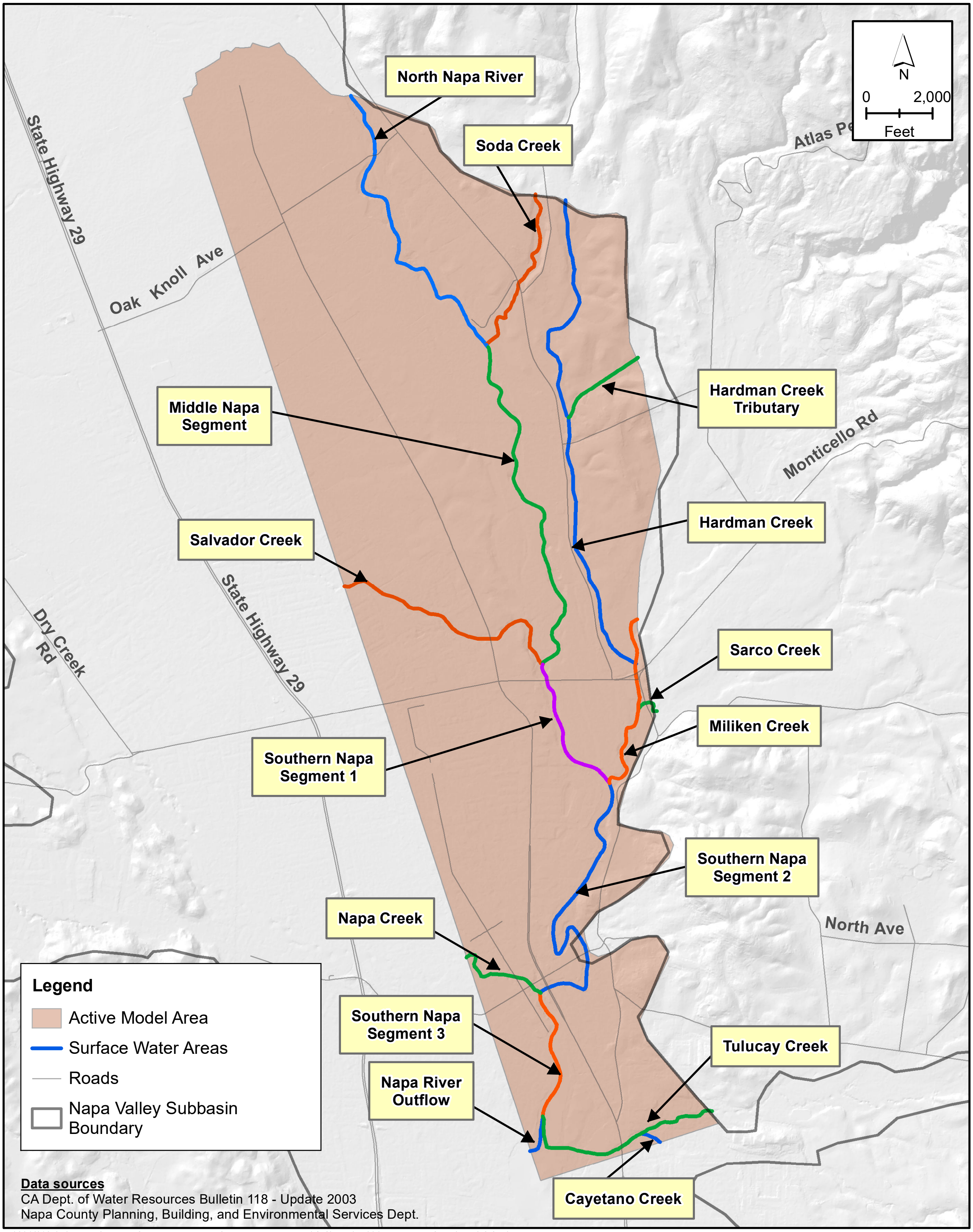
FIGURE 4-2
Net Annual Stream Leakage
Comparison of Western and Eastern Sides of the Model Domain

Northeast Napa Area: Special Groundwater Study



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Fig 4-2 Surface Water Areas.mxd

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FIGURE 4-3
Surface Water Areas of Interest for Surface Water – Groundwater Interaction

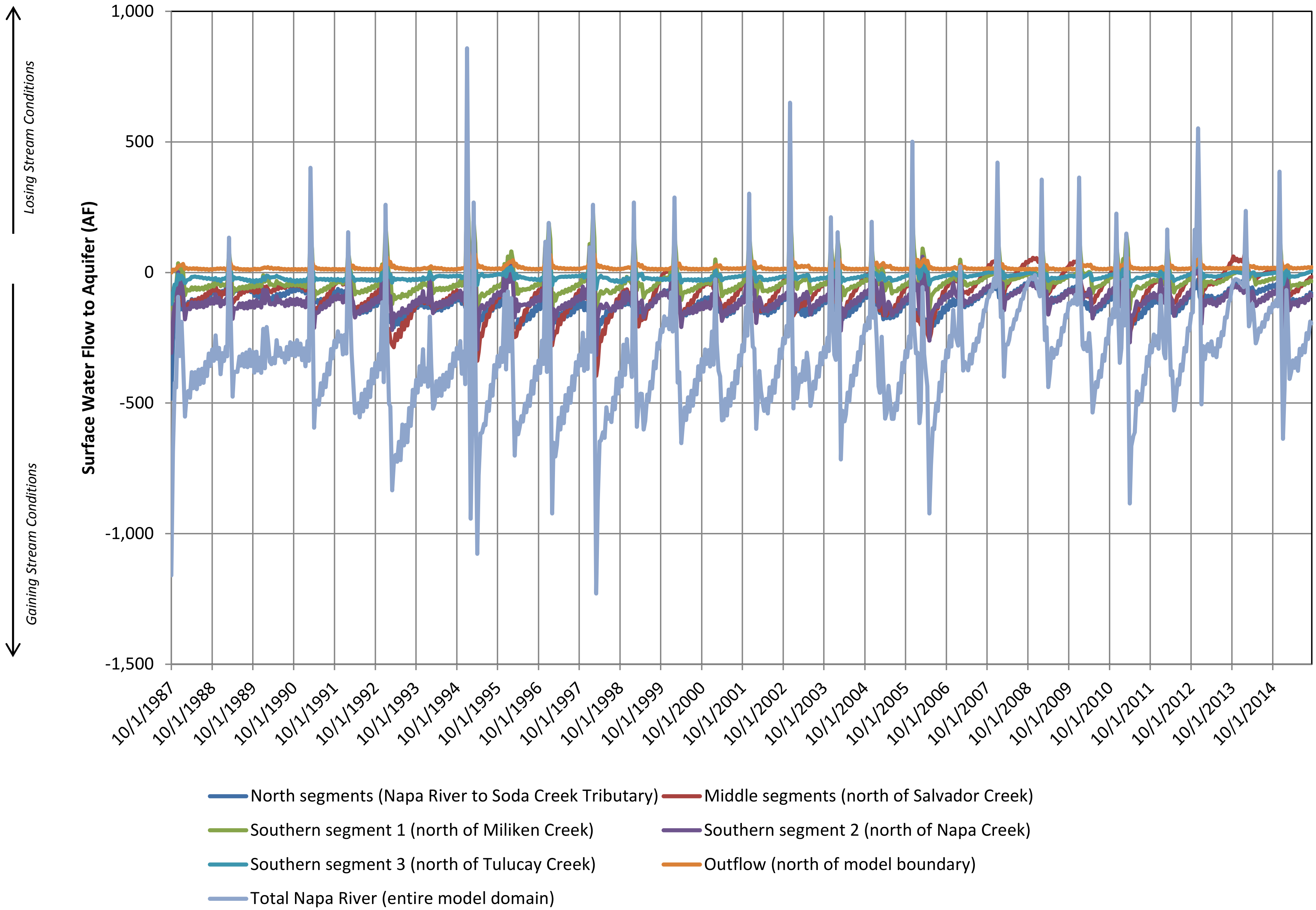

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FIGURE 4-4
Simulated Surface Water Flow to Aquifer in Napa River Model Segments
Northeast Napa Area: Special Groundwater Study

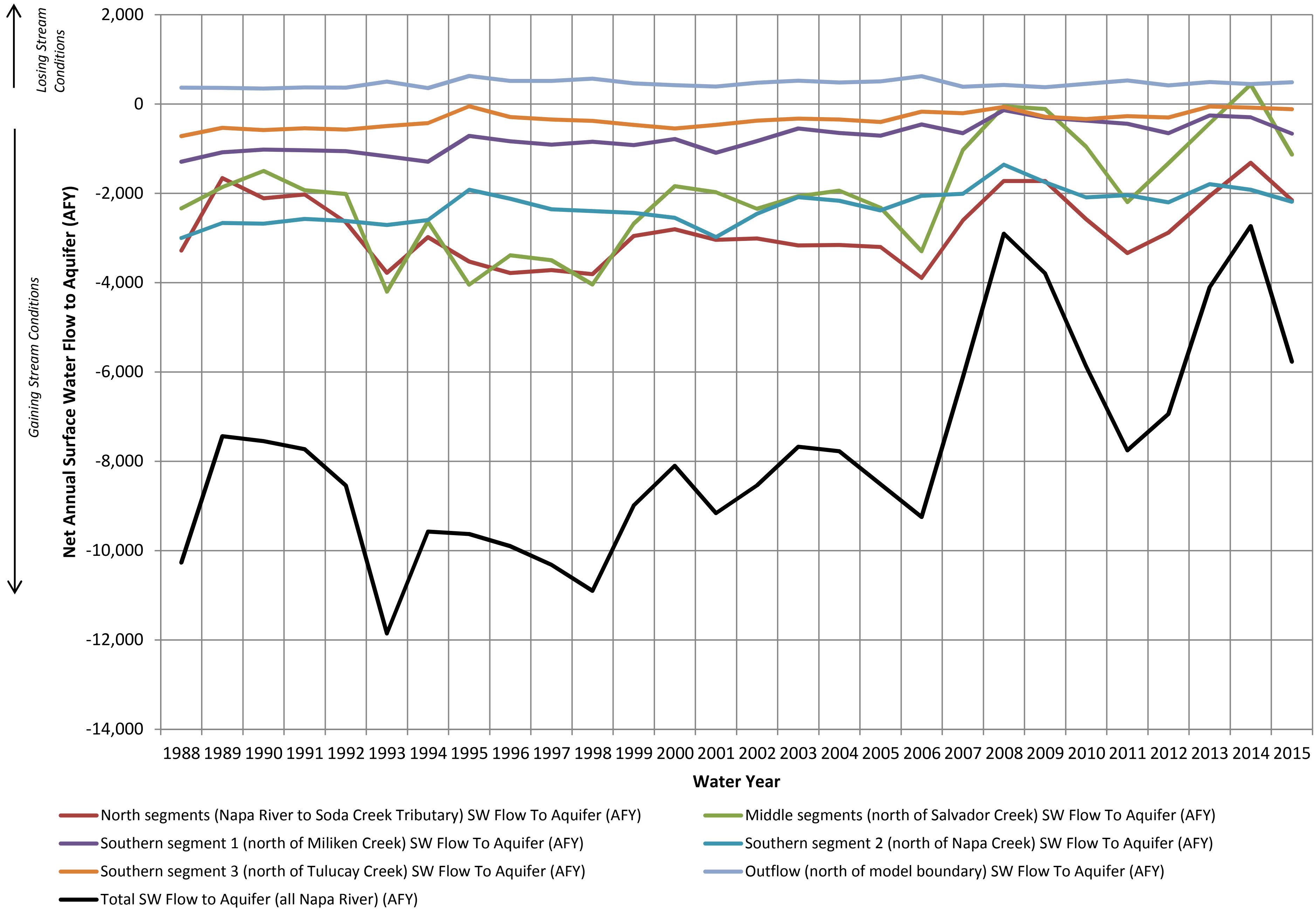

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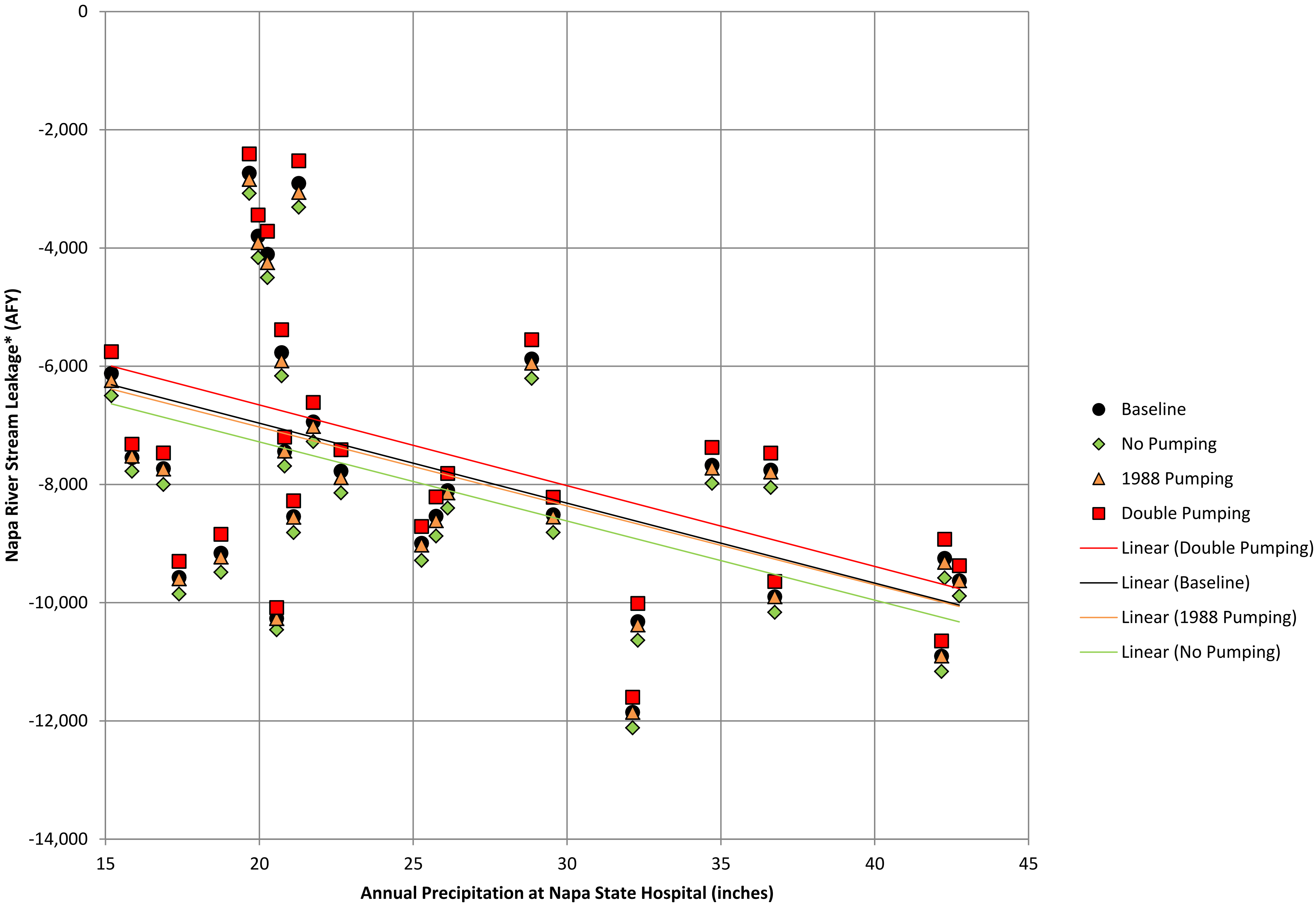
FIGURE 4-5

Total Annual Simulated Surface Water Flow to Groundwater at Napa River Model Segments

Northeast Napa Area: Special Groundwater Study



**Negative stream leakage indicates water exiting the groundwater body and entering the Napa River during net gaining stream conditions.*

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Figure 4-6
Relationship Between Annual Precipitation and Simulated Stream Leakage in the Napa River
Northeast Napa Area: Special Groundwater Study

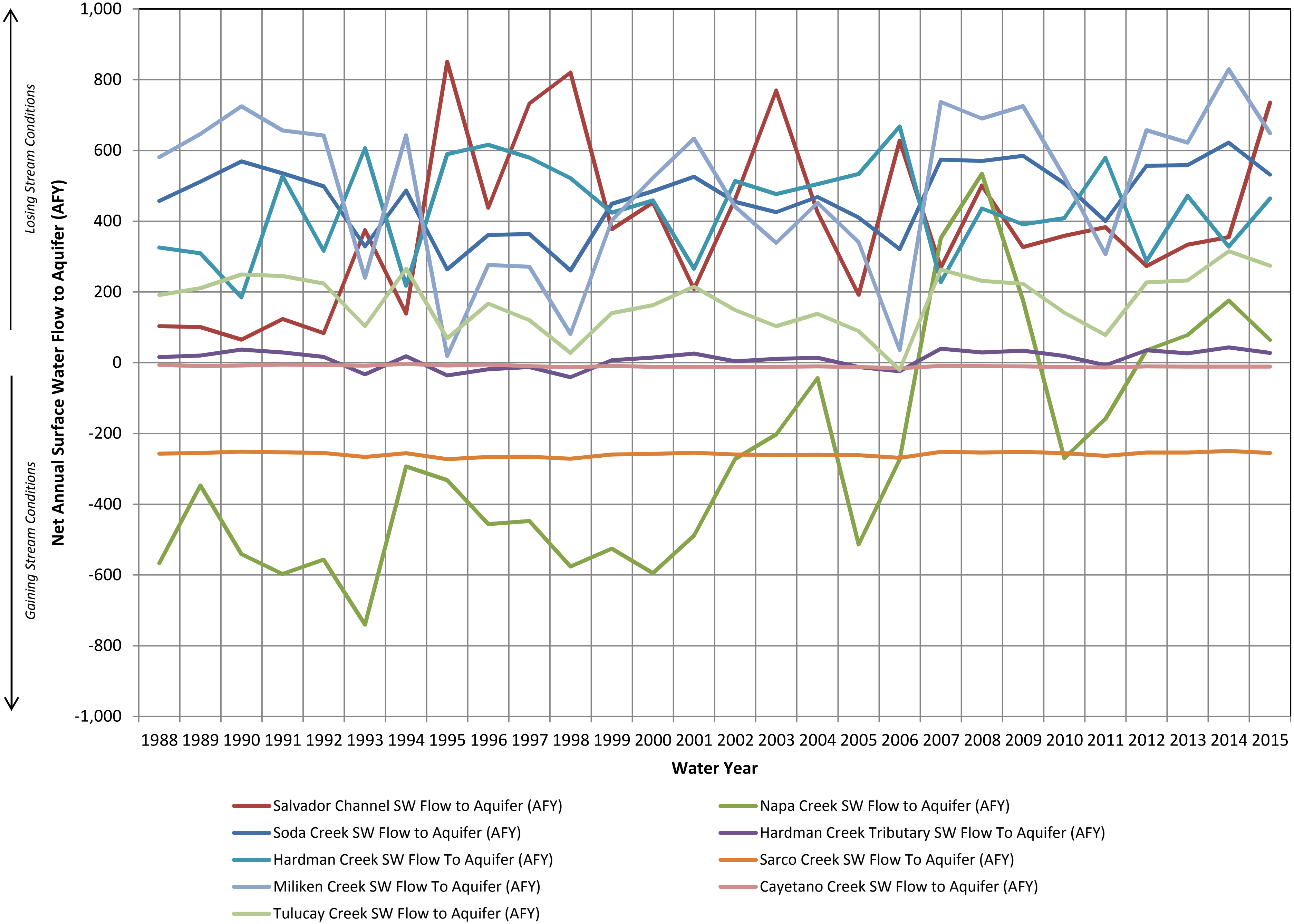

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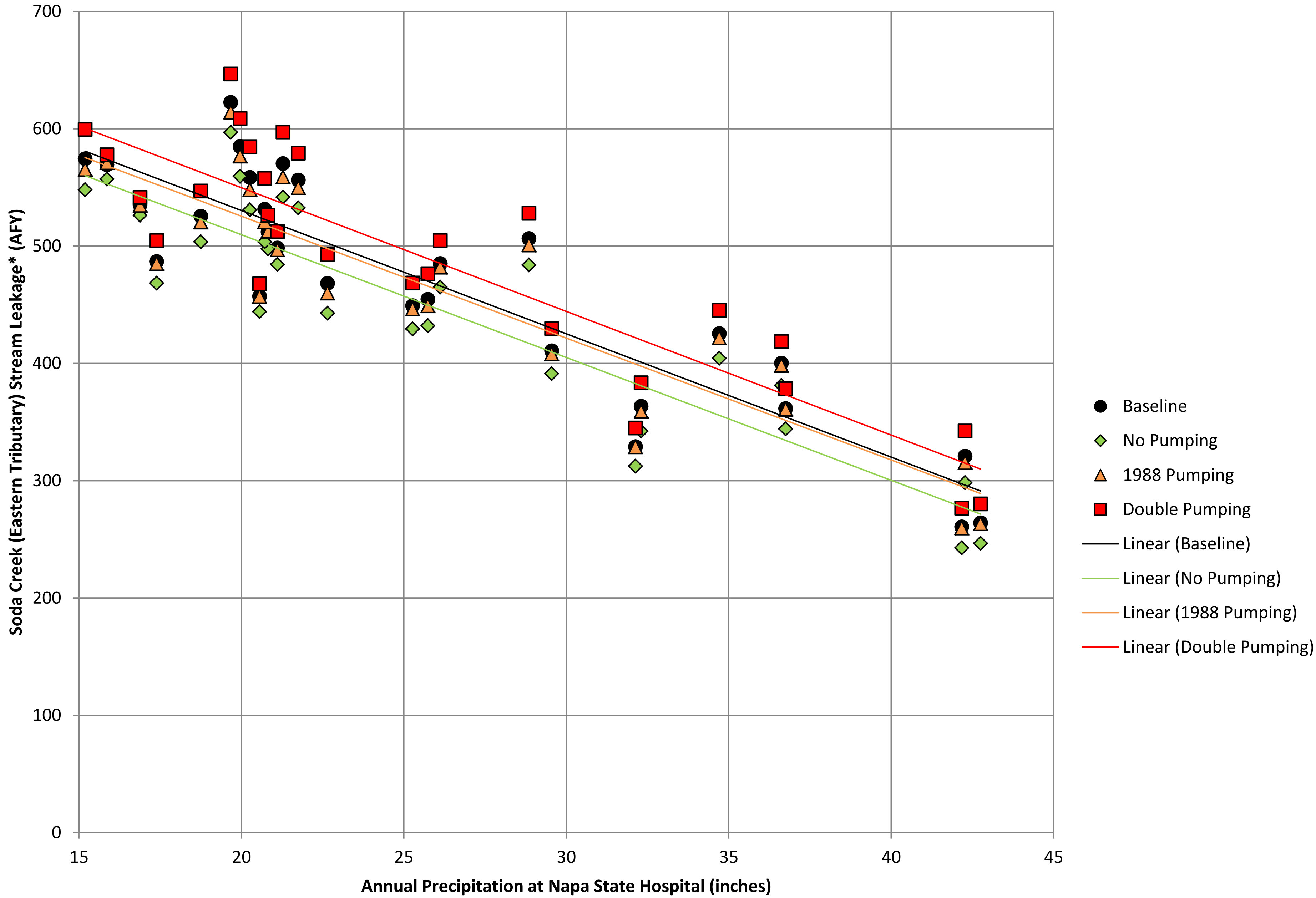
Figure 4-7
Total Annual Simulated Surface Water Flow to Groundwater in All Tributary Model Segments
Northeast Napa Area: Special Groundwater Study



Positive stream leakage indicates surface water entering the groundwater body and leaving Soda Creek during net losing stream conditions.

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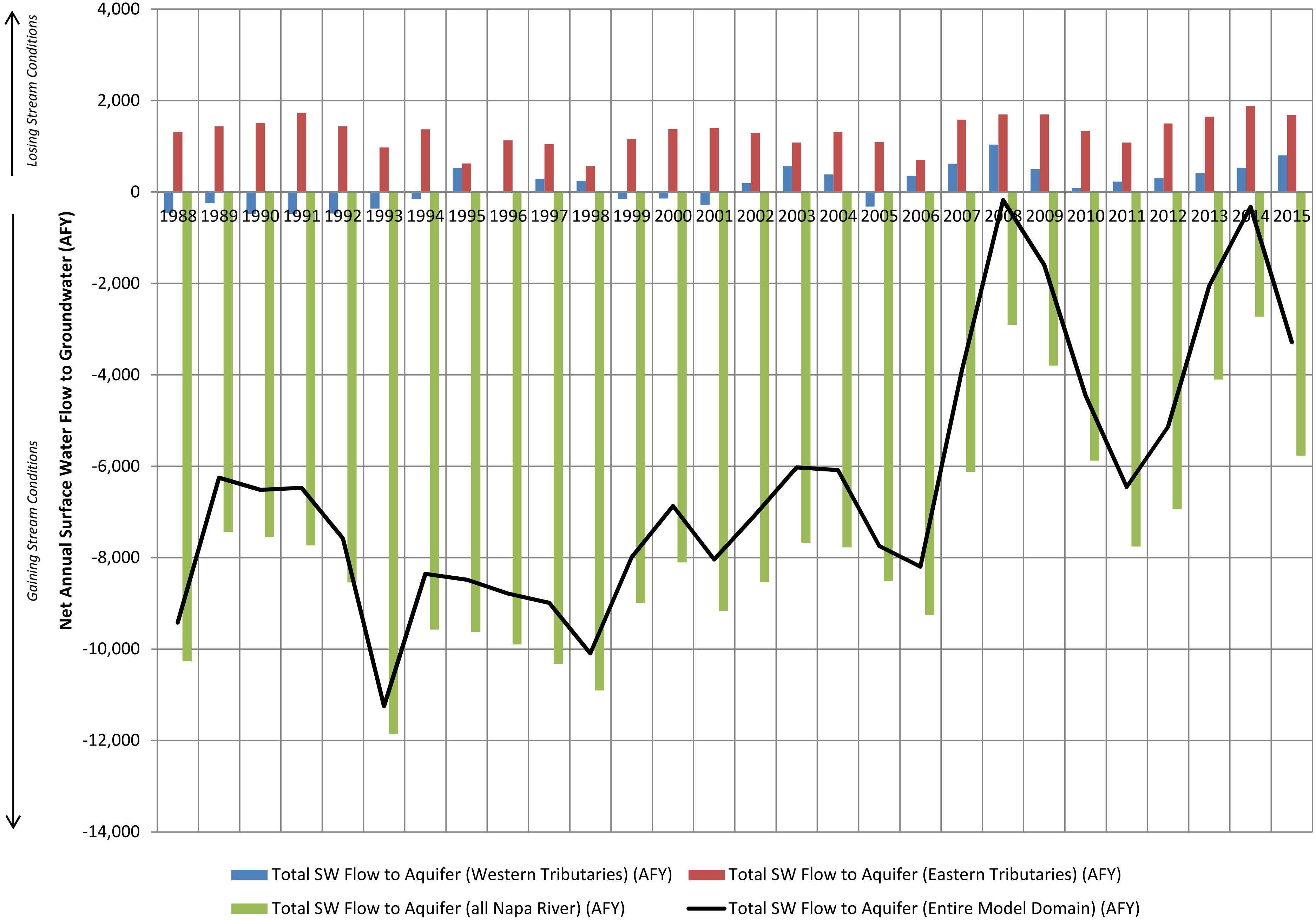
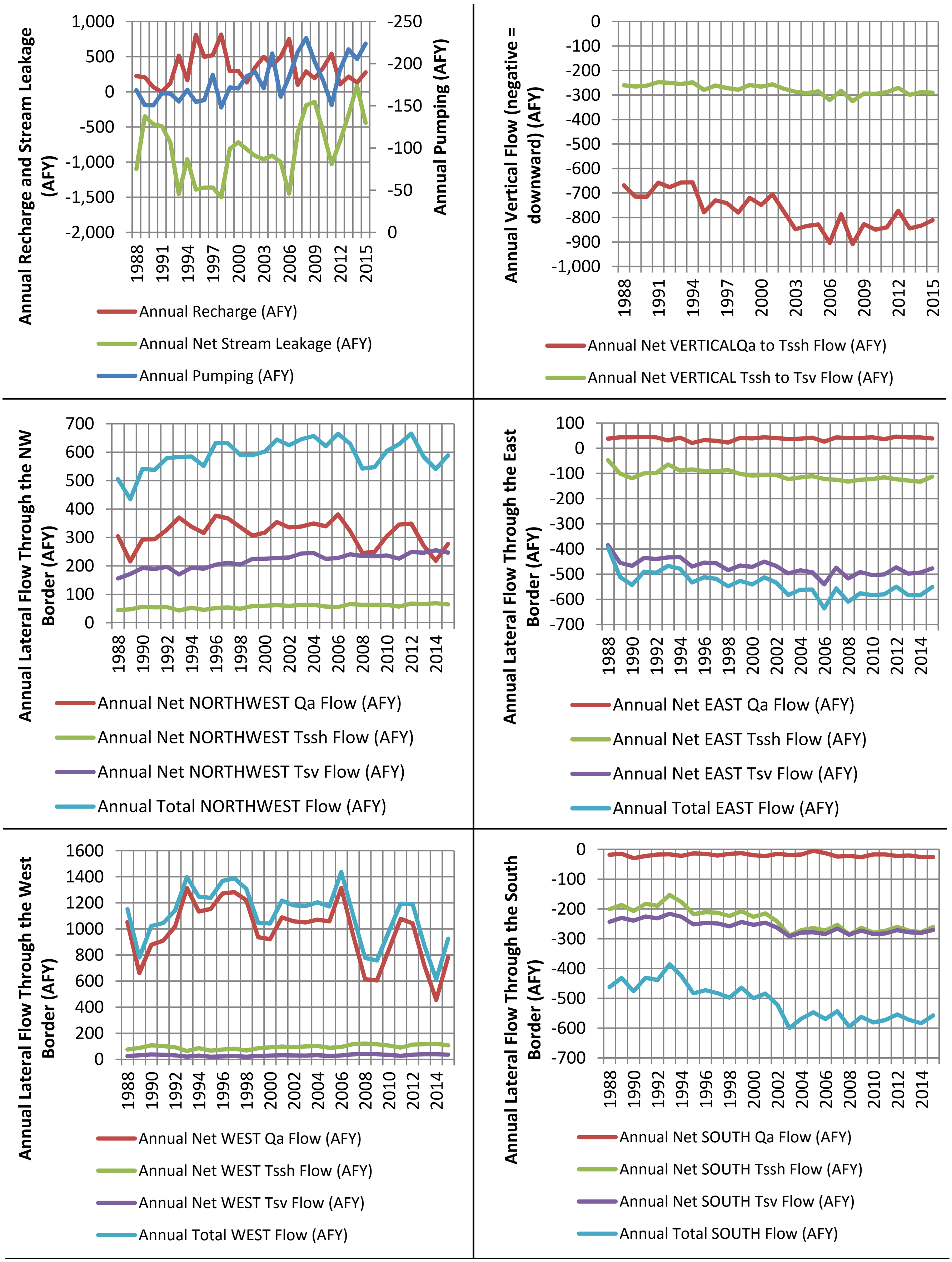
Figure 4-8
Relationship Between Annual Precipitation and Simulated Stream Leakage in Soda Creek (Eastern Tributary)
Northeast Napa Area: Special Groundwater Study



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

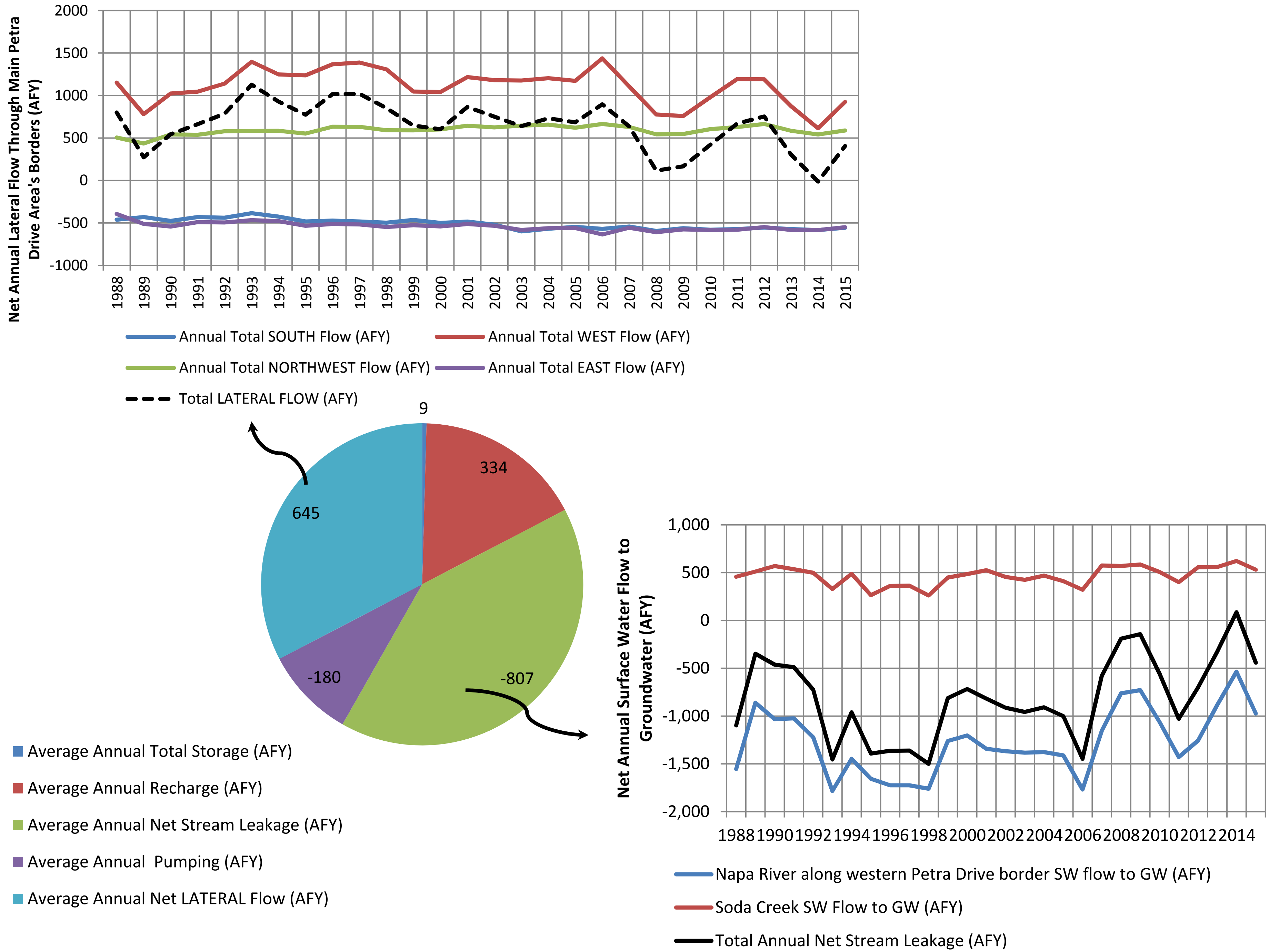
Figure 4-9
Total Annual Simulated Surface Water Flow to Groundwater in Western & Eastern Tributaries, Napa River, and the Entire Model Domain
Northeast Napa Area: Special Groundwater Study



Note: negative flows indicate water leaving the groundwater body within the Petra Drive area; positive flows indicate water entering the groundwater body within the Petra Drive area.

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

FIGURE 4-10
Total Annual Simulated Water Budget Components
Time Series Plots for the Petra Drive Area
Northeast Napa Area: Special Groundwater Study



LUHDORFF & SCALMANINI
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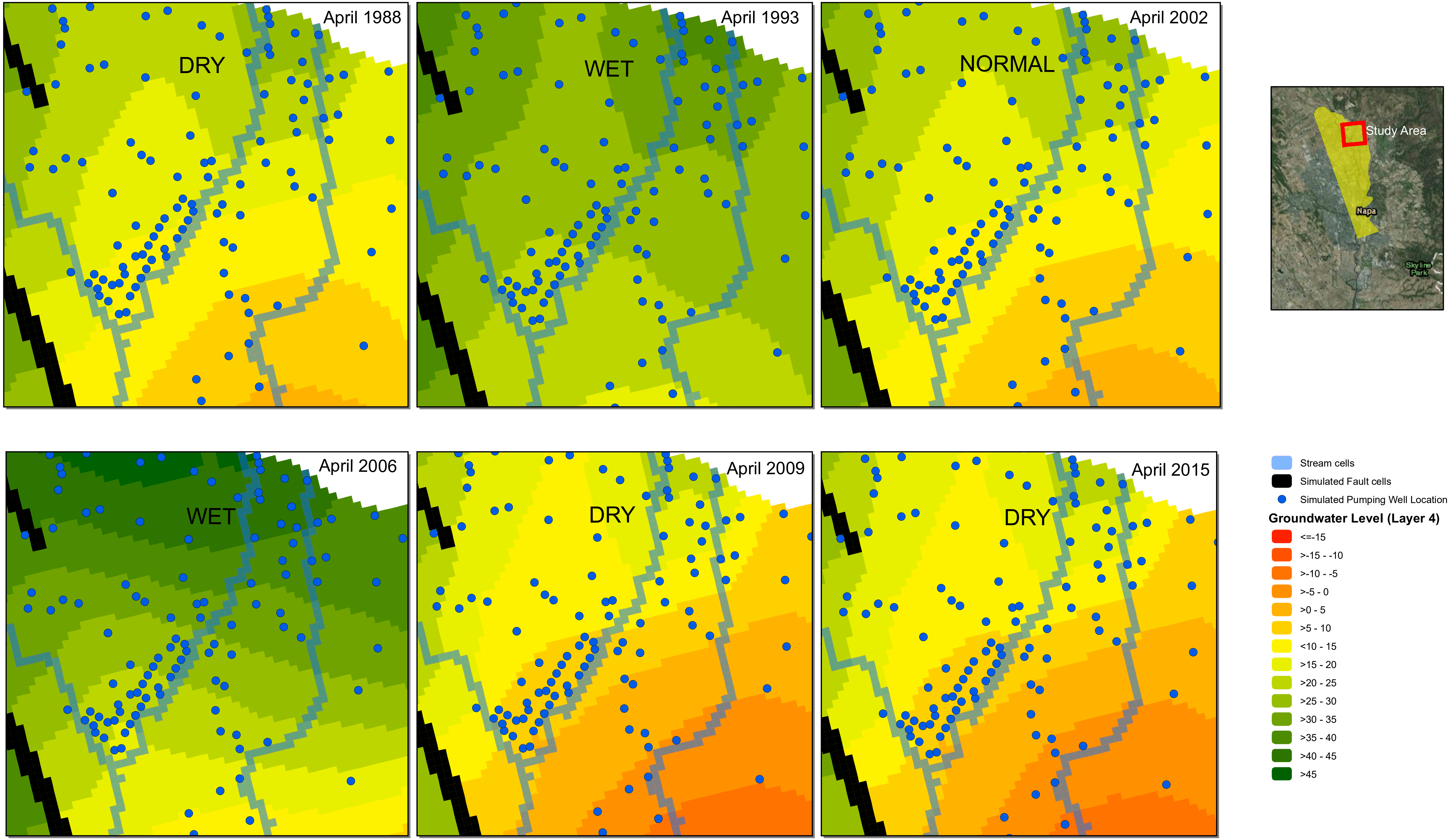
FIGURE 4-11
Average Annual Simulated Water Budget Components for the Petra Drive Area
Northeast Napa Area: Special Groundwater Study



Path: X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\2016 Annual Report\4-10 SimulatedWaterLevelMaps_Study_Area.mxd

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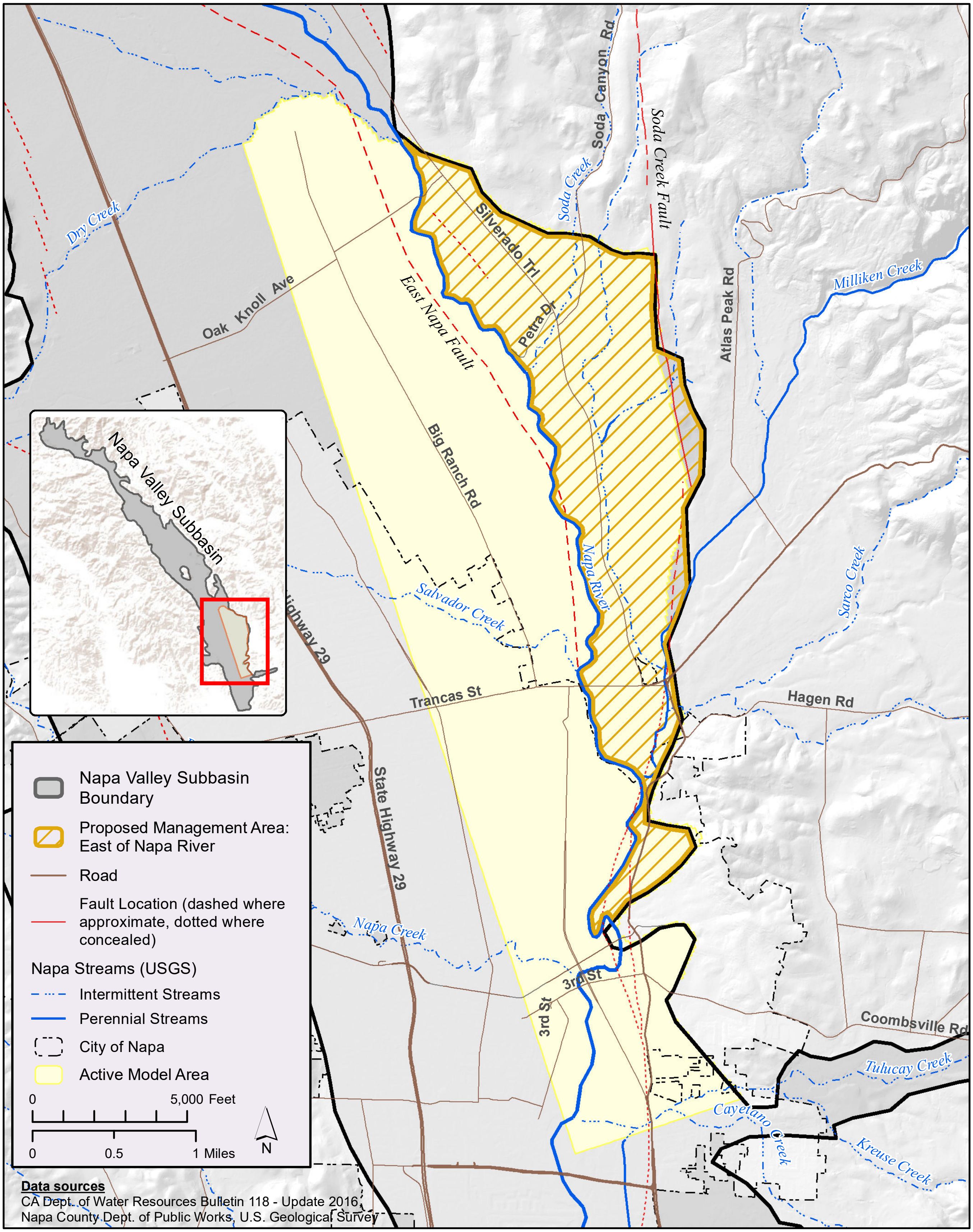
CONSULTING ENGINEERS

FIGURE 4-12
Simulated Water Level Maps
Layer 4 Select Time Periods
Northeast Napa Area: Special Groundwater Study



X:\2016\16-079 Napa County - Groundwater Basin Sustainability Analysis\GIS\mapfiles\01_NE_Napa_Study\Templates\Fig 5-1 PropManagementNorthEastNapa_ALT.mxd

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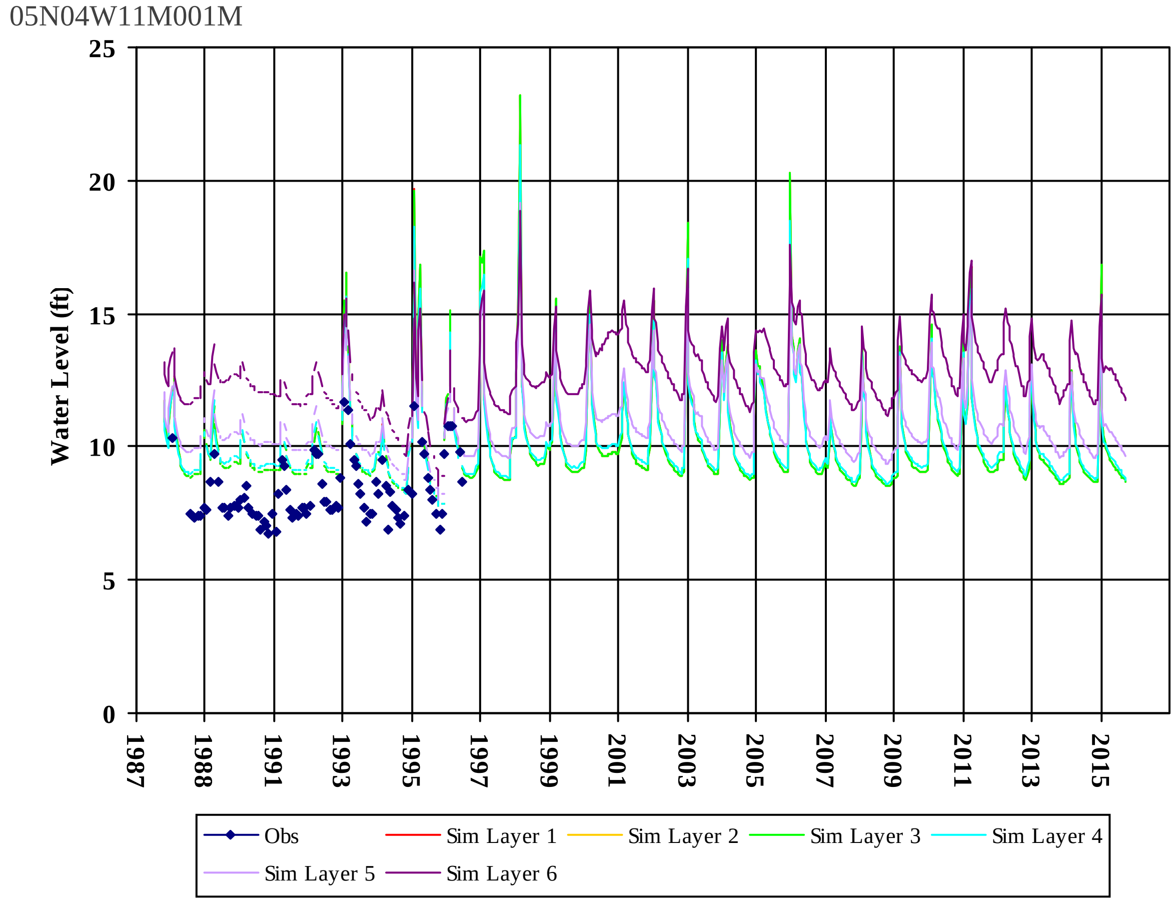
FIGURE 5-1
Proposed Management Area: Northeast Napa Area/East of the Napa River

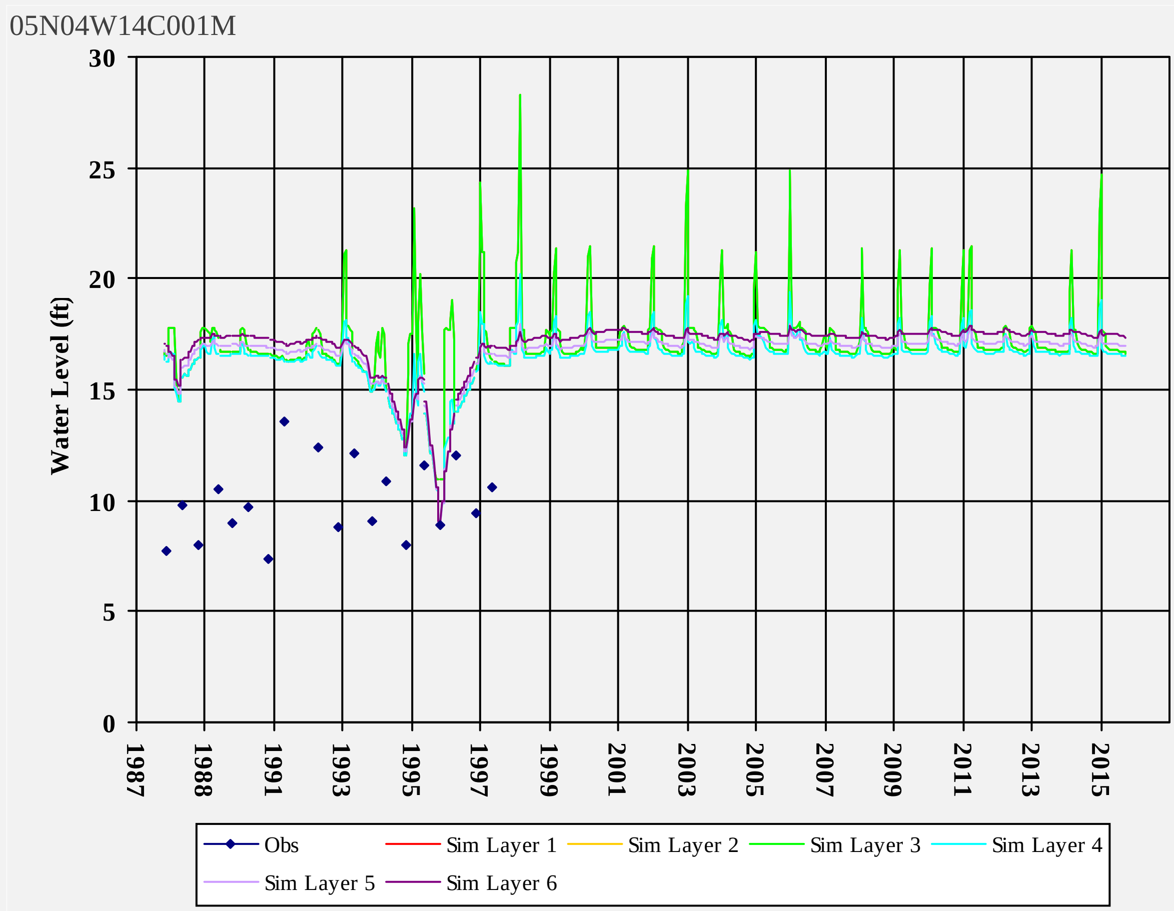
APPENDICES

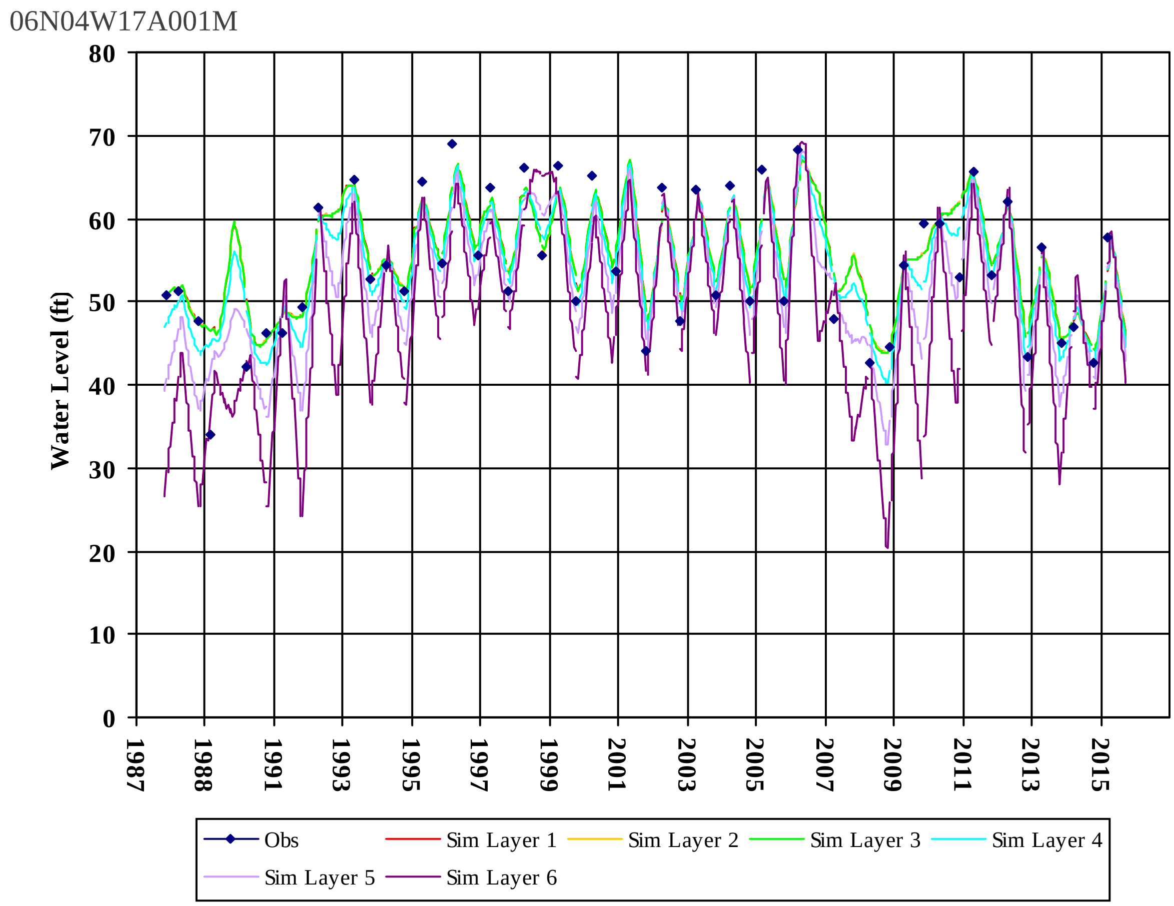
APPENDIX A
Calibration Target Hydrographs

Well Depth: 77
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 4

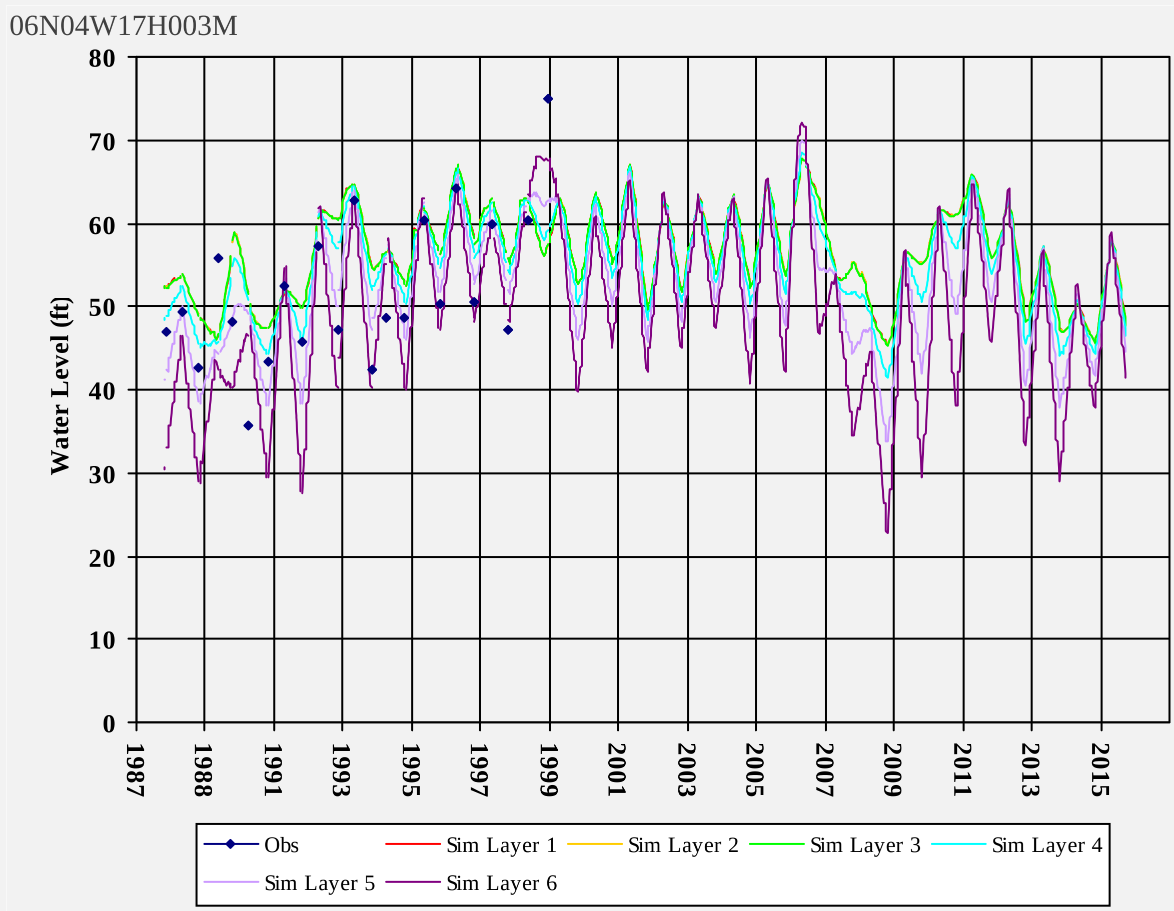


Well Depth: 220
Hole Depth: 220
Top Perf: 30
Bottom Perf: 220
Est Model Layer: 4



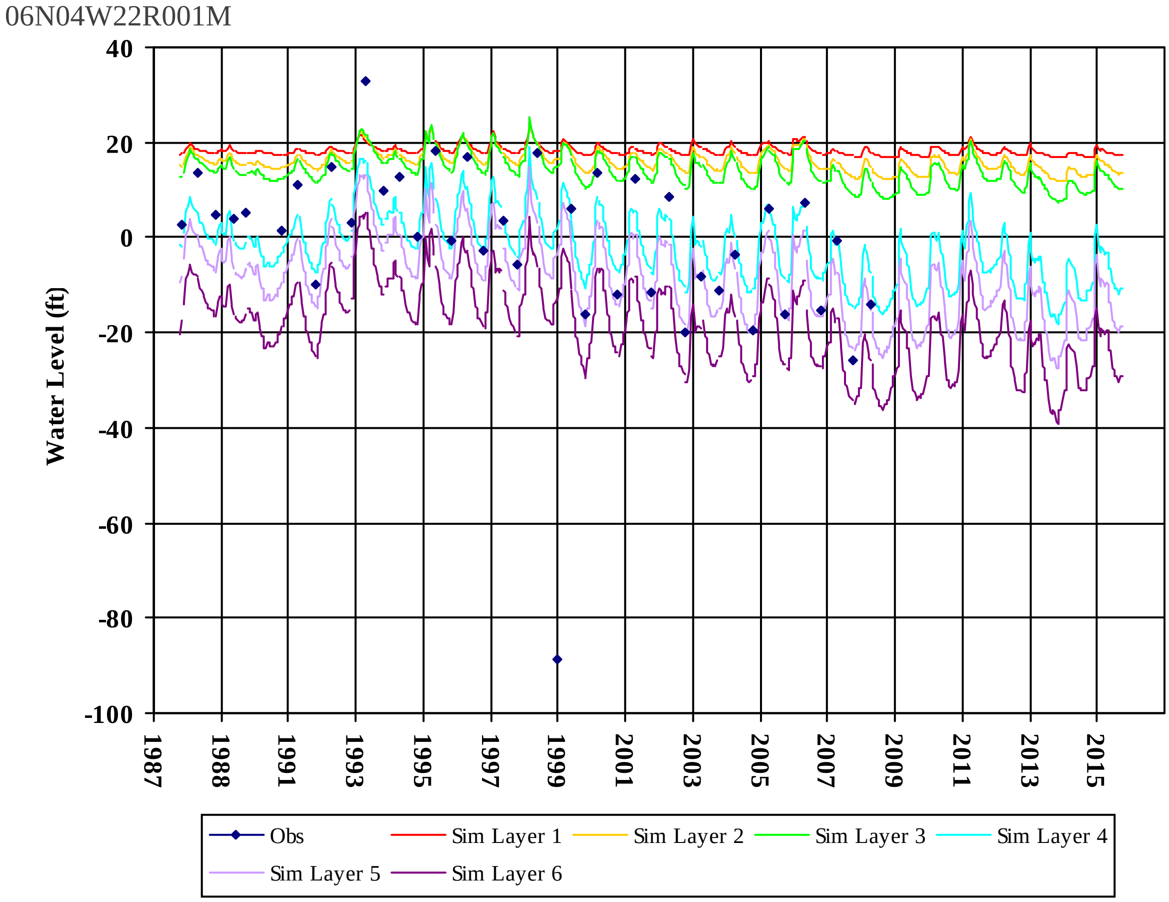


Well Depth: 250
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 4

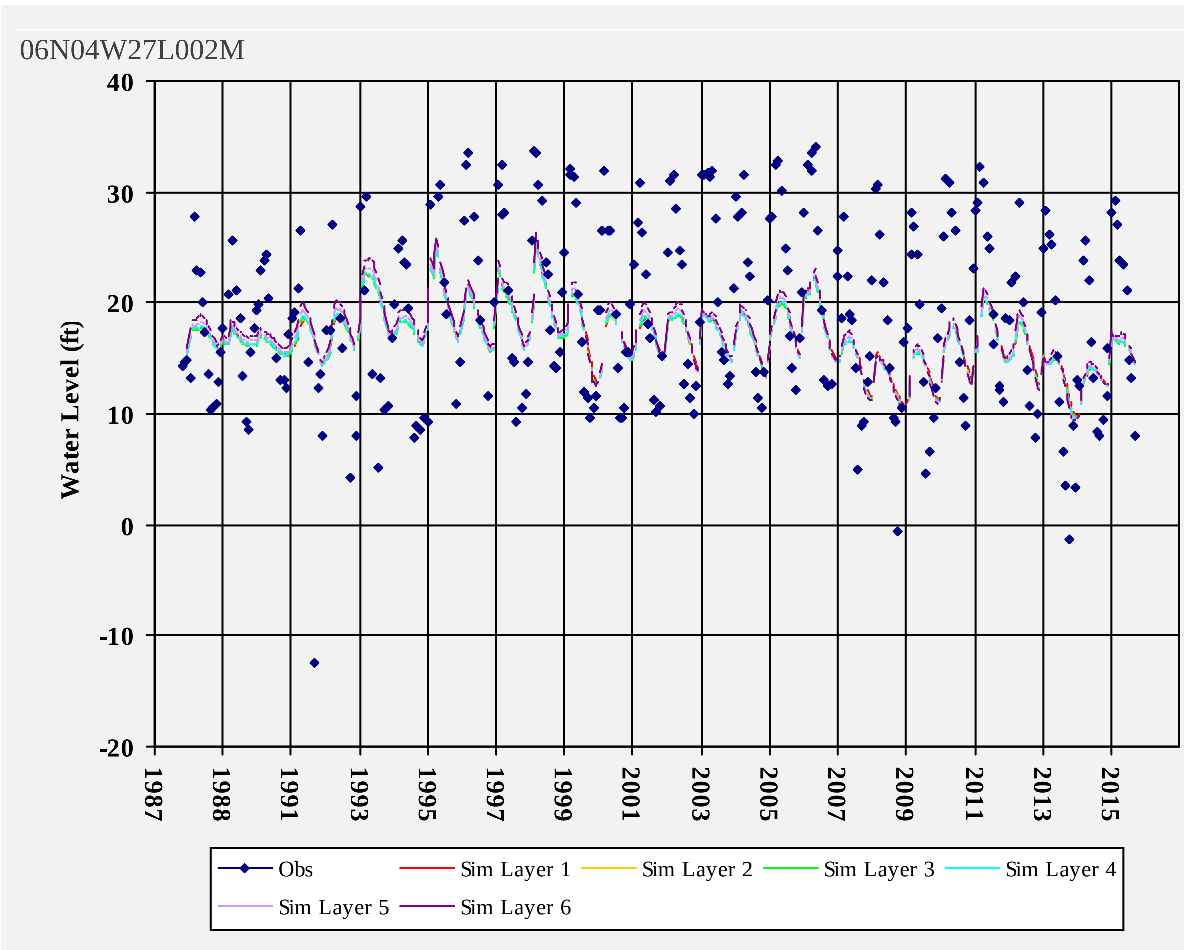


Well Depth: 82
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 3

Well Depth:	205
Hole Depth:	
Top Perf:	45
Bottom Perf:	205
Est Model Layer:	4

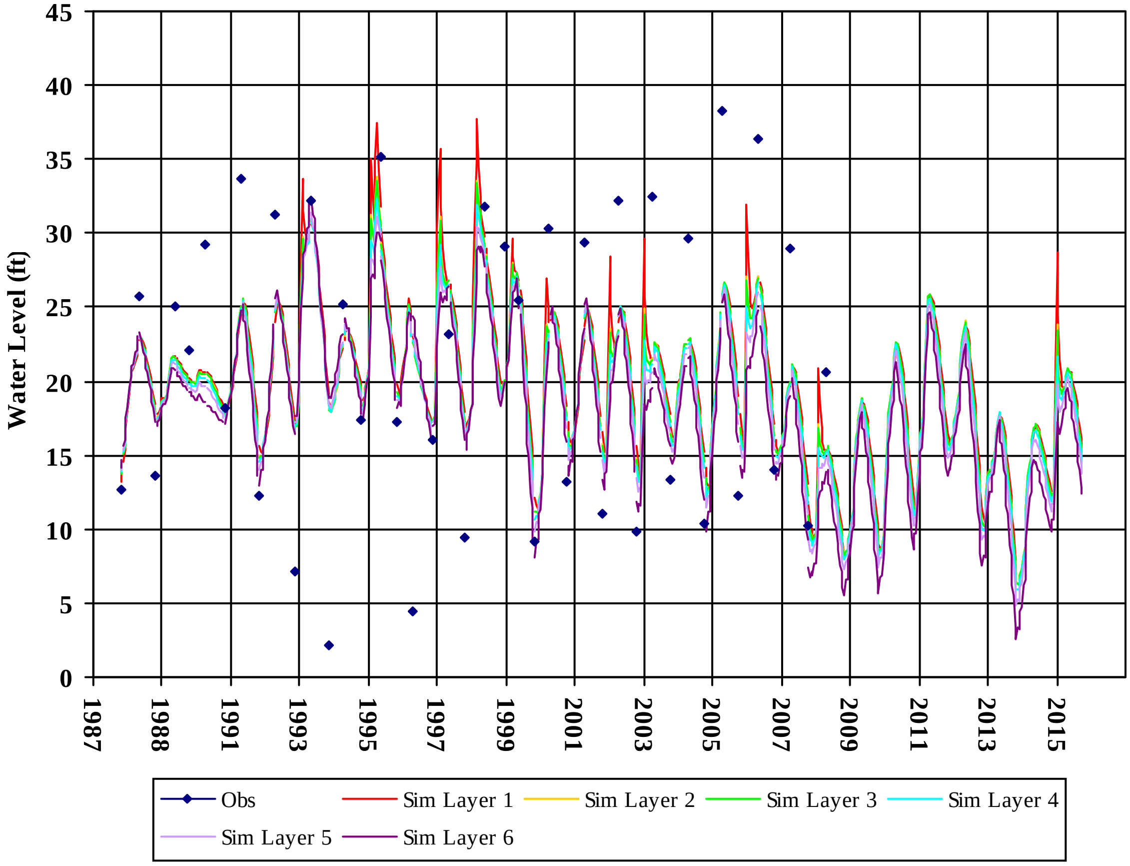


Well Depth:	120
Hole Depth:	122
Top Perf:	60
Bottom Perf:	120
Est Model Layer:	3



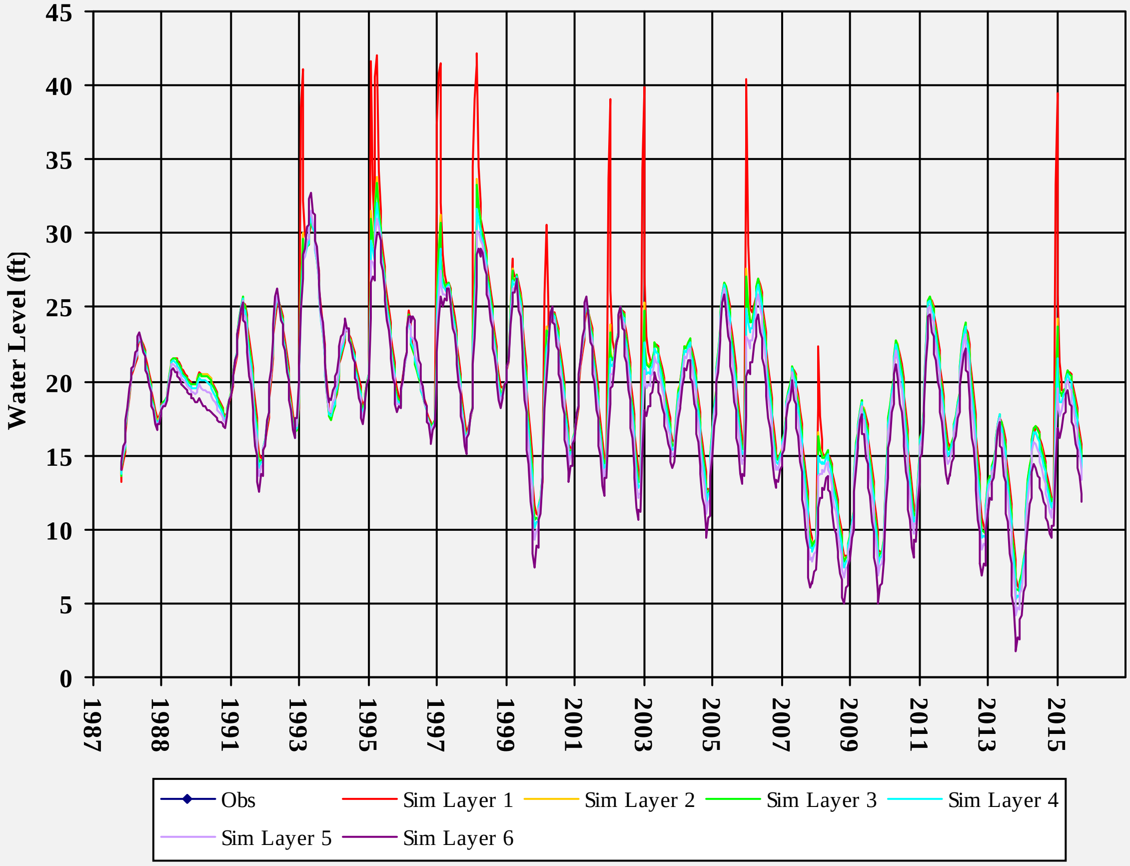
Well Depth: 120
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 3

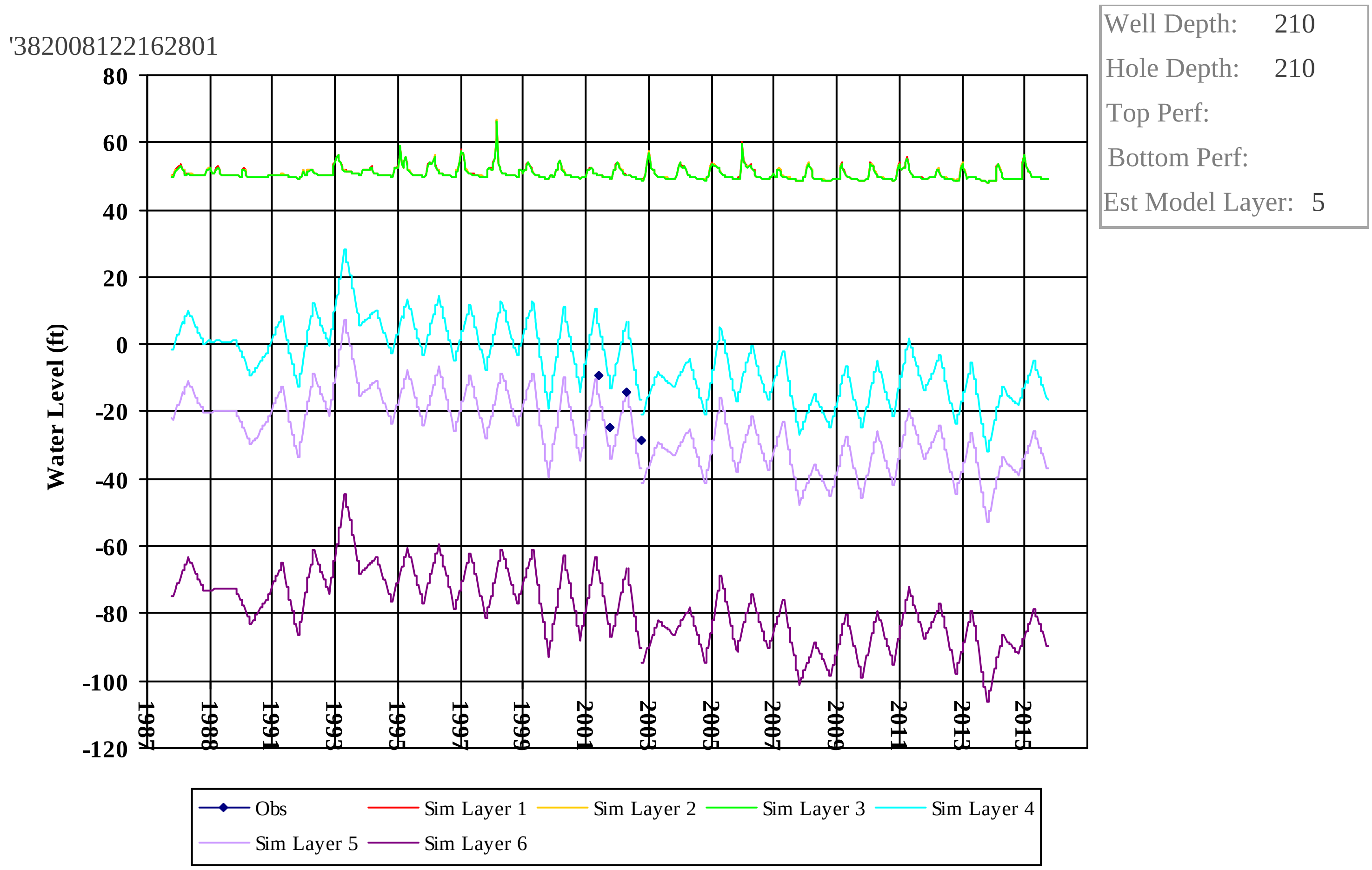
06N04W27N001M

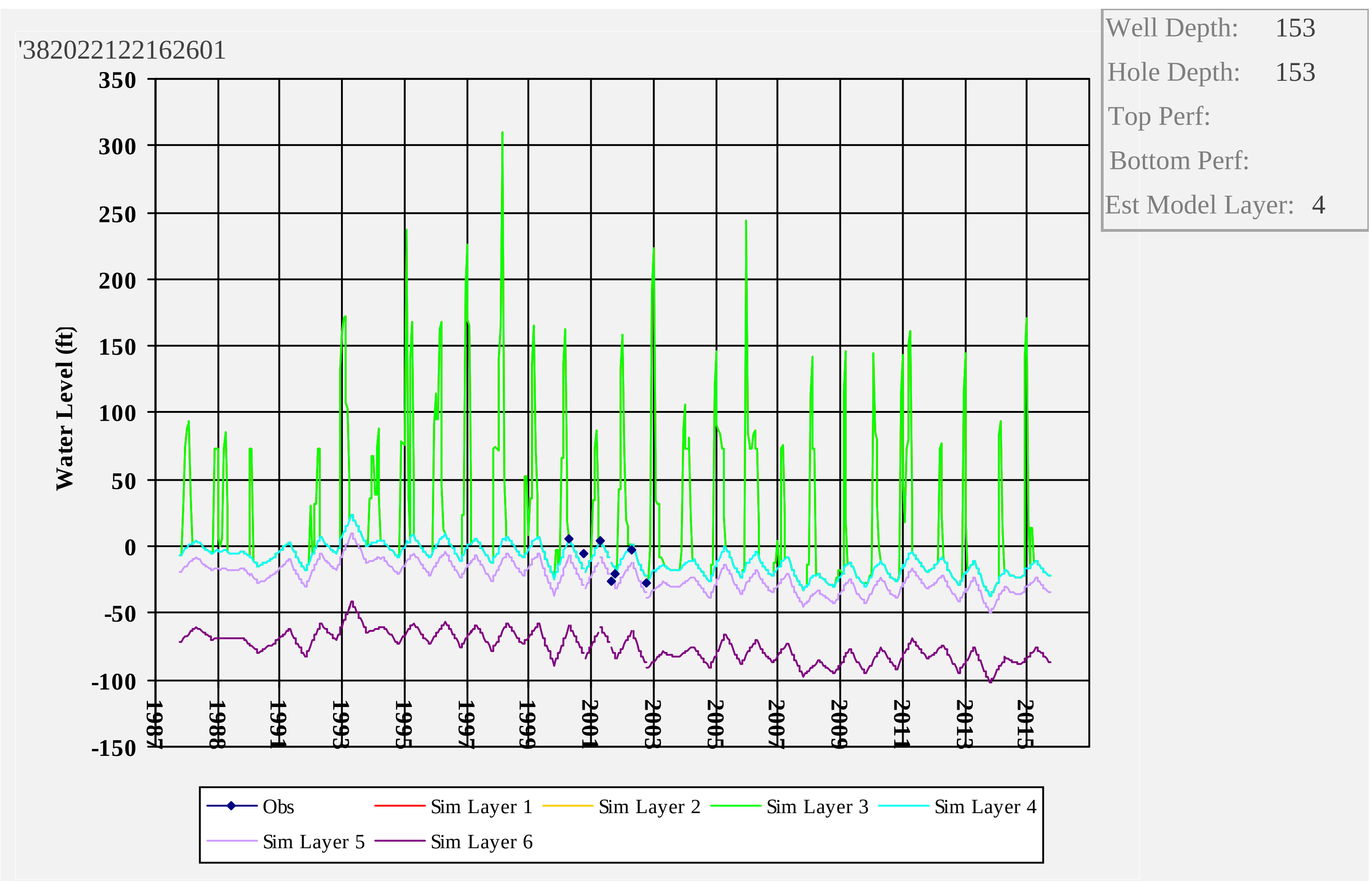


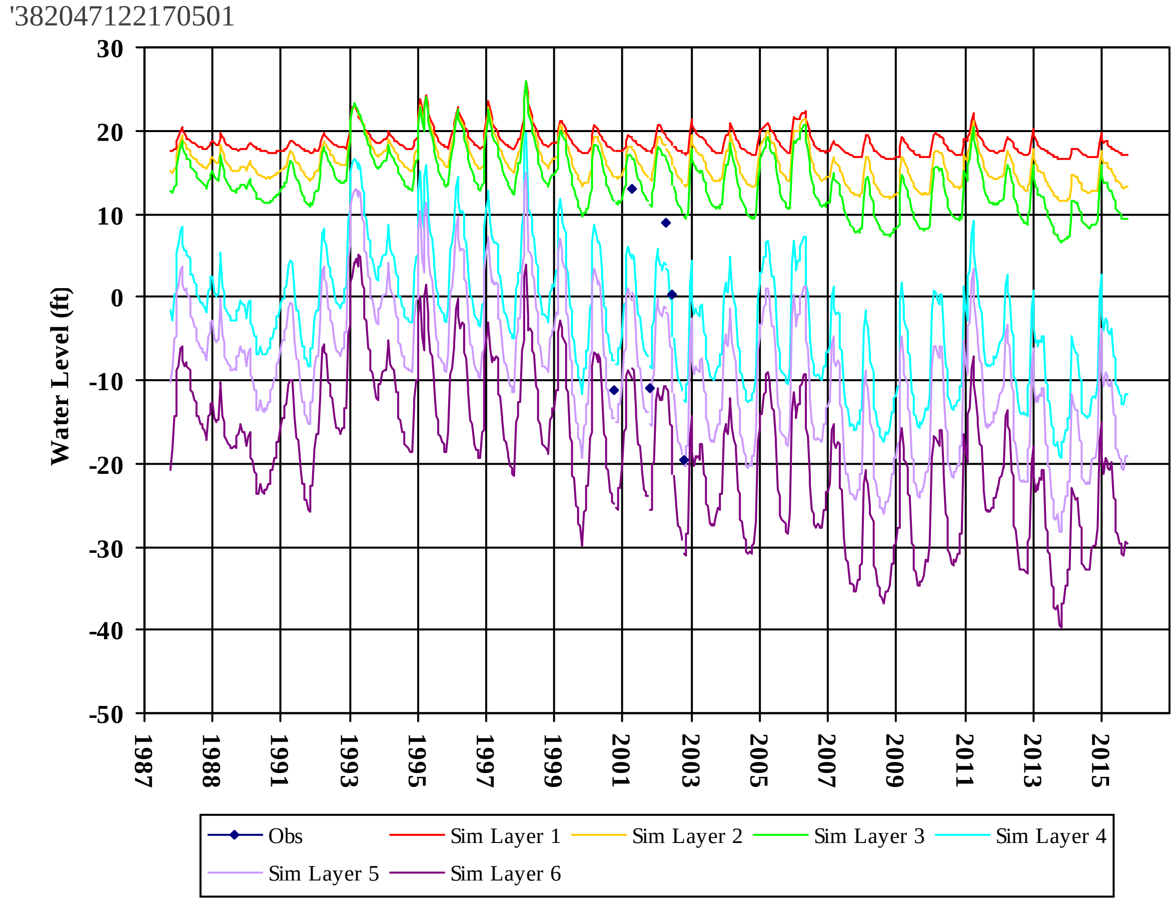
Well Depth: 190
Hole Depth: 190
Top Perf:
Bottom Perf:
Est Model Layer: 4

'381951122175401

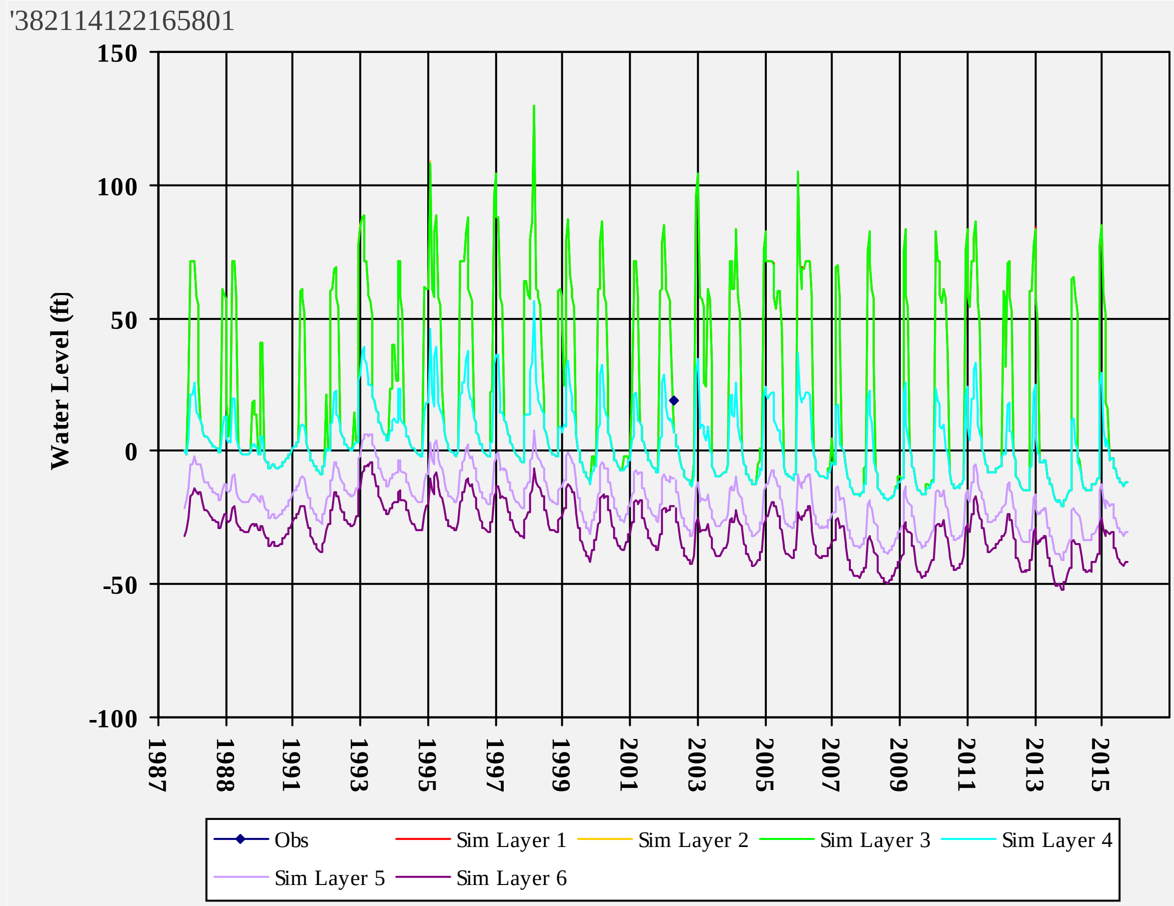



'382008122162801
Well Depth: 210
Hole Depth: 210
Top Perf:
Bottom Perf:
Est Model Layer: 5
Water Level (ft)
80
60
40
20
0
-20
-40
-60
-80
-100
-120
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6


'382022122162601
Well Depth: 153
Hole Depth: 153
Top Perf:
Bottom Perf:
Est Model Layer: 4
Water Level (ft)
350
300
250
200
150
100
50
0
-50
-100
-150
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

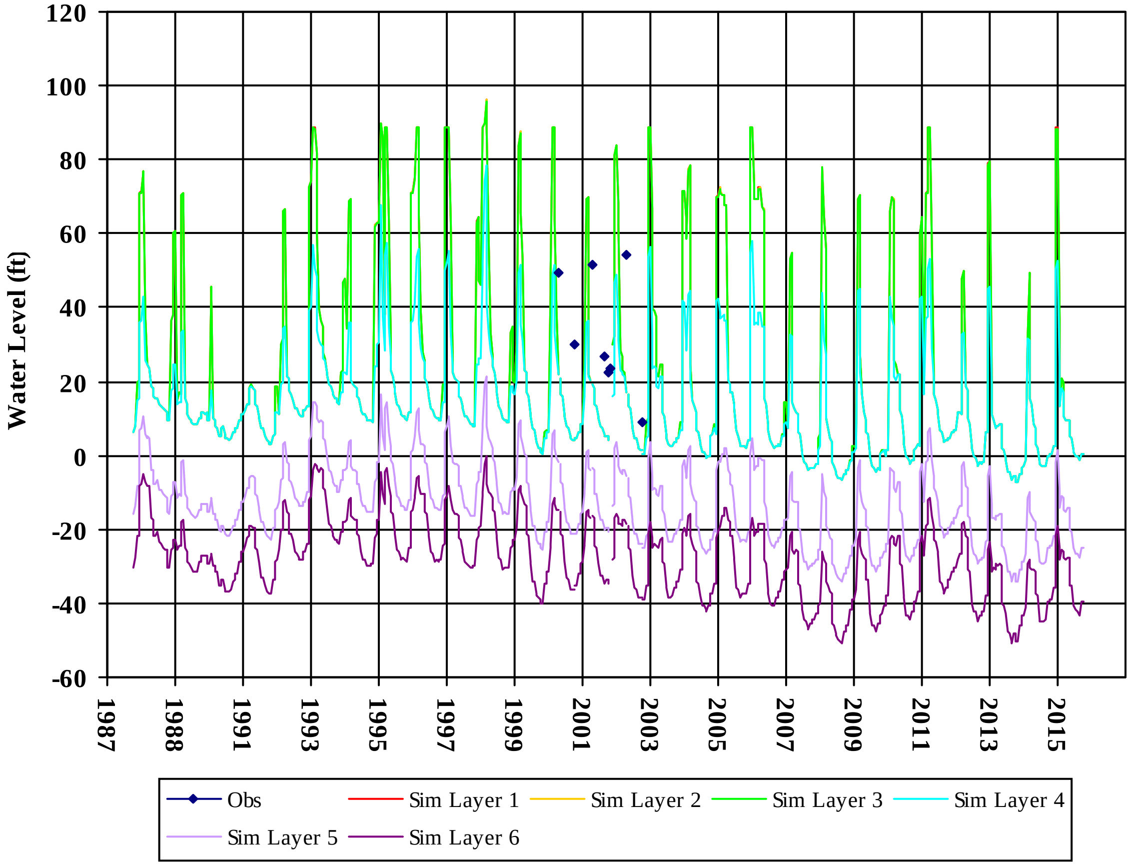


Well Depth:	205
Hole Depth:	208
Top Perf:	
Bottom Perf:	
Est Model Layer:	4



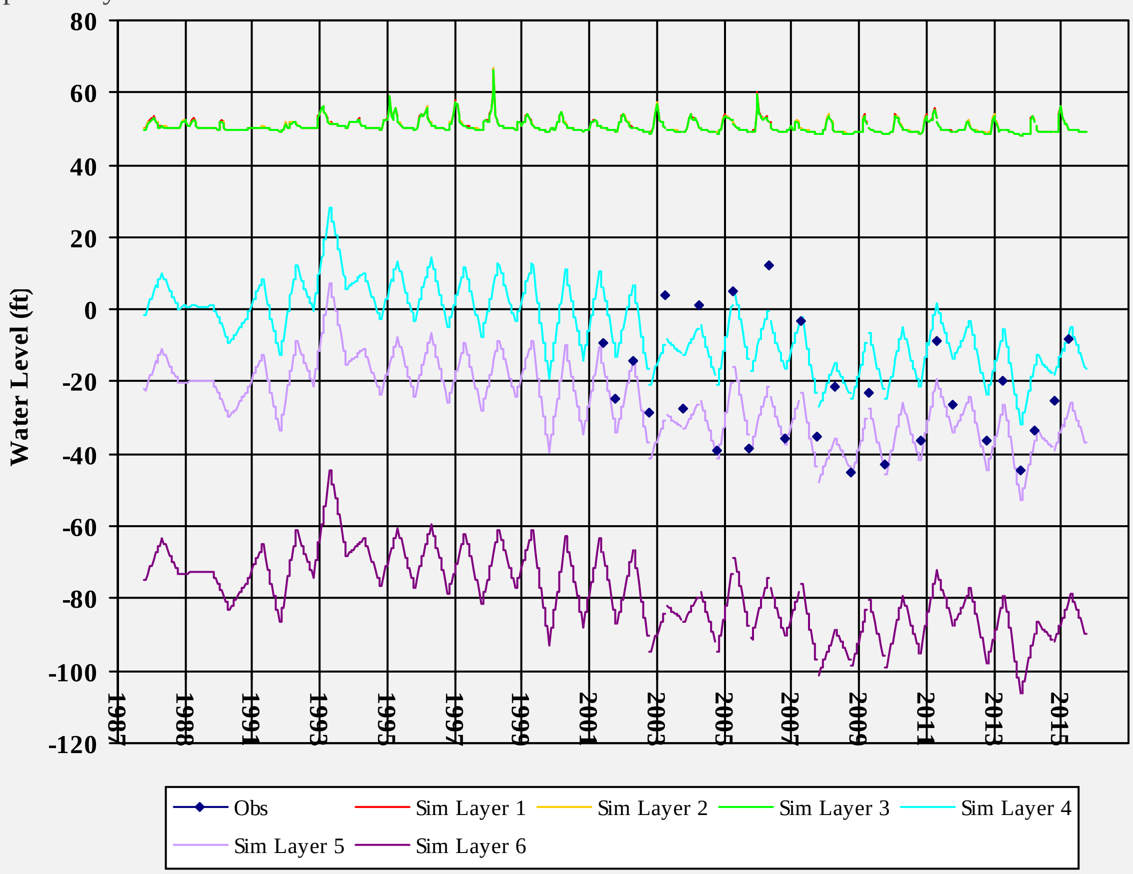
Well Depth:	520
Hole Depth:	520
Top Perf:	
Bottom Perf:	
Est Model Layer:	4

'382135122165901



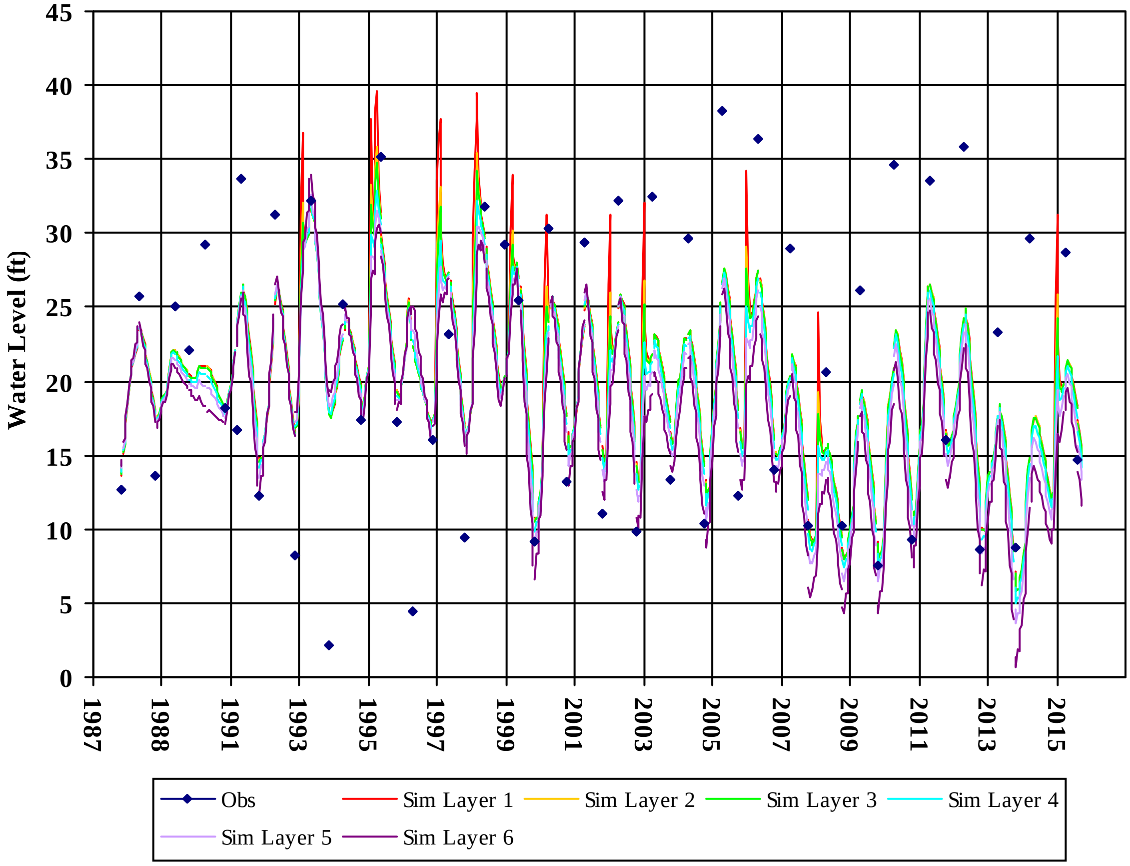
Well Depth: 395
Hole Depth: 405
Top Perf:
Bottom Perf:
Est Model Layer: 4

NapaCounty-122



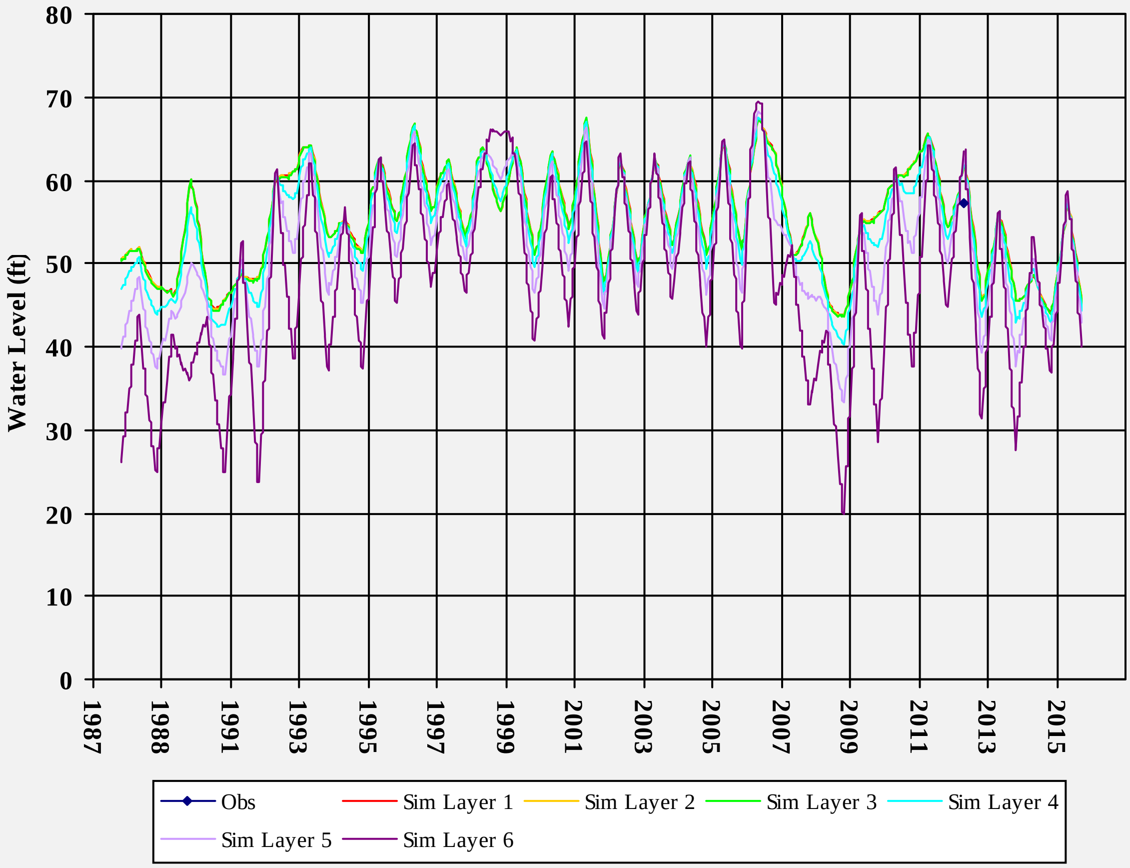
Well Depth:
Hole Depth: 0
Top Perf:
Bottom Perf:
Est Model Layer: 5

NapaCounty-136



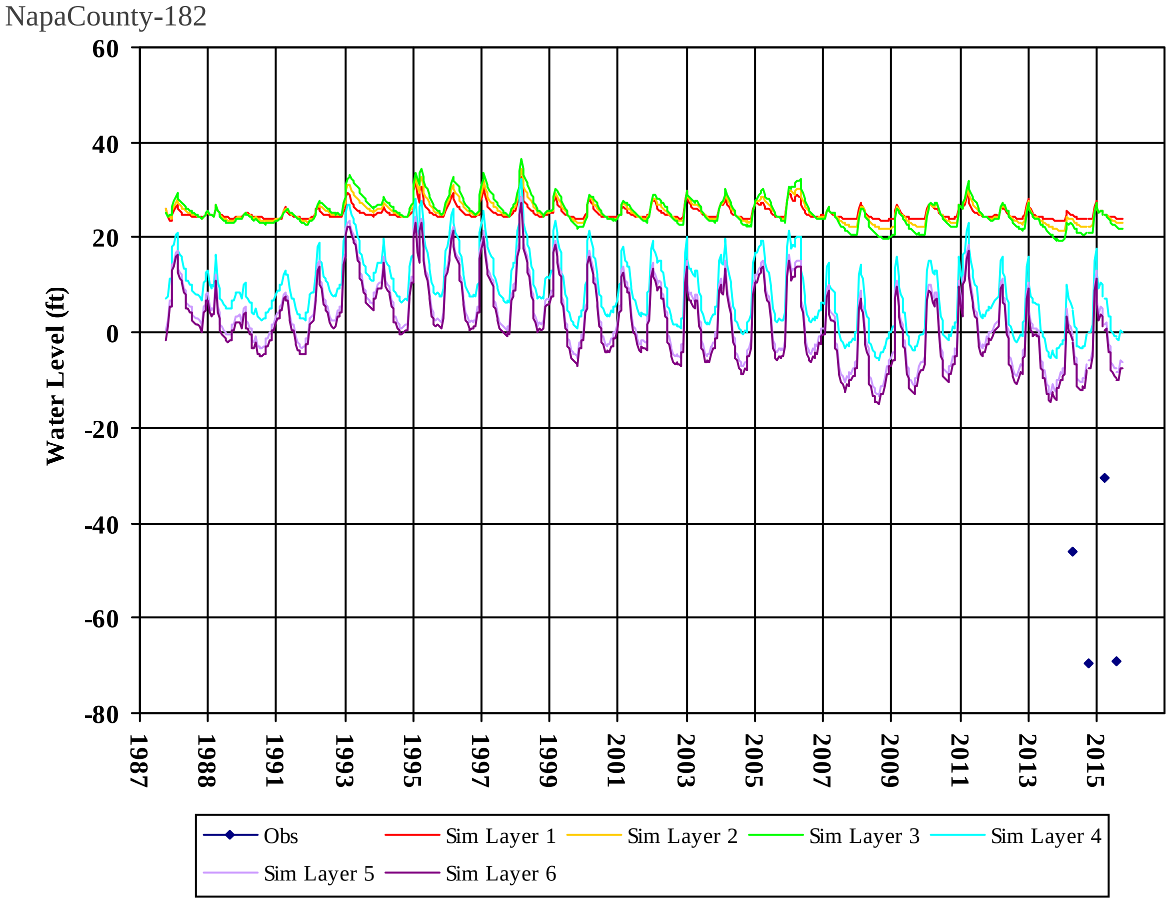
Well Depth: 120
Hole Depth: 120
Top Perf:
Bottom Perf:
Est Model Layer: 3

NapaCounty-151

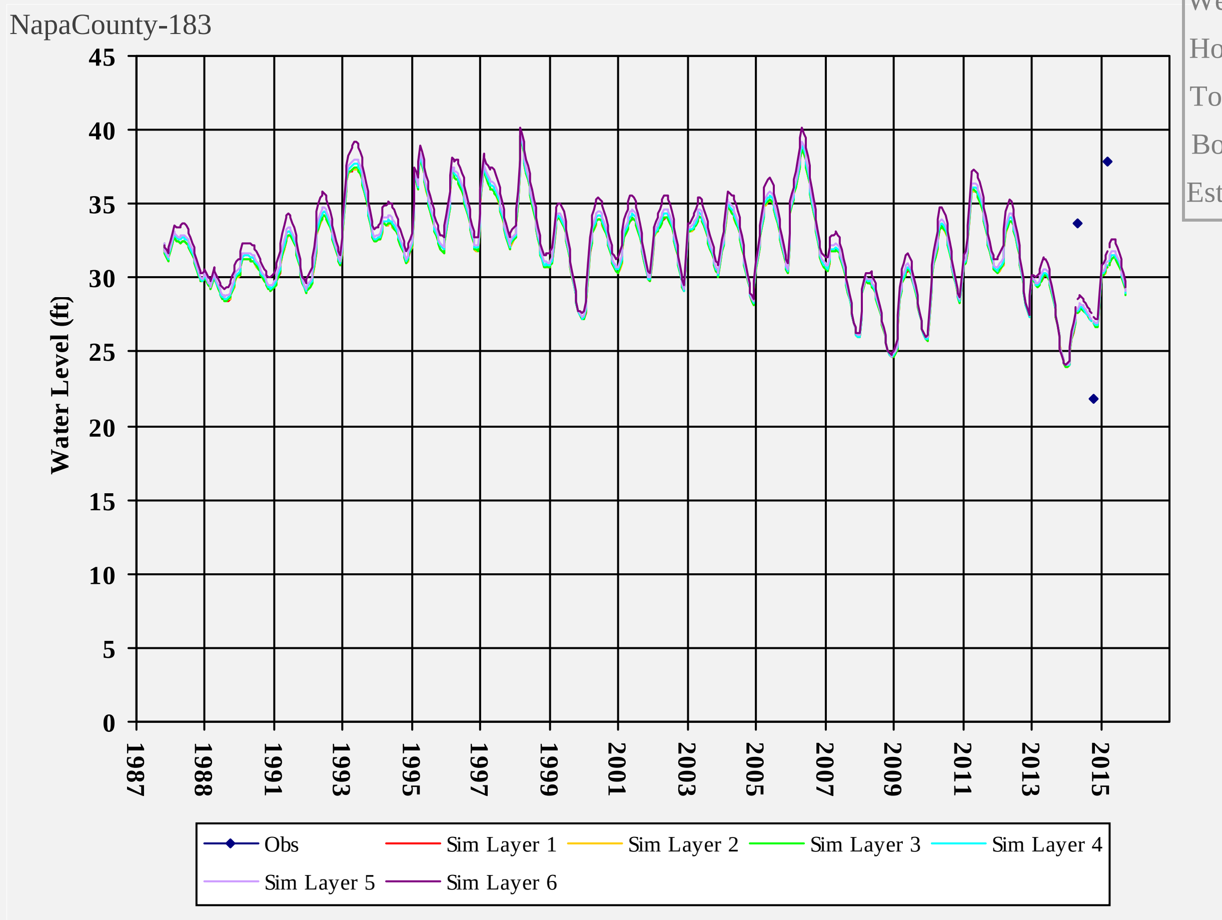


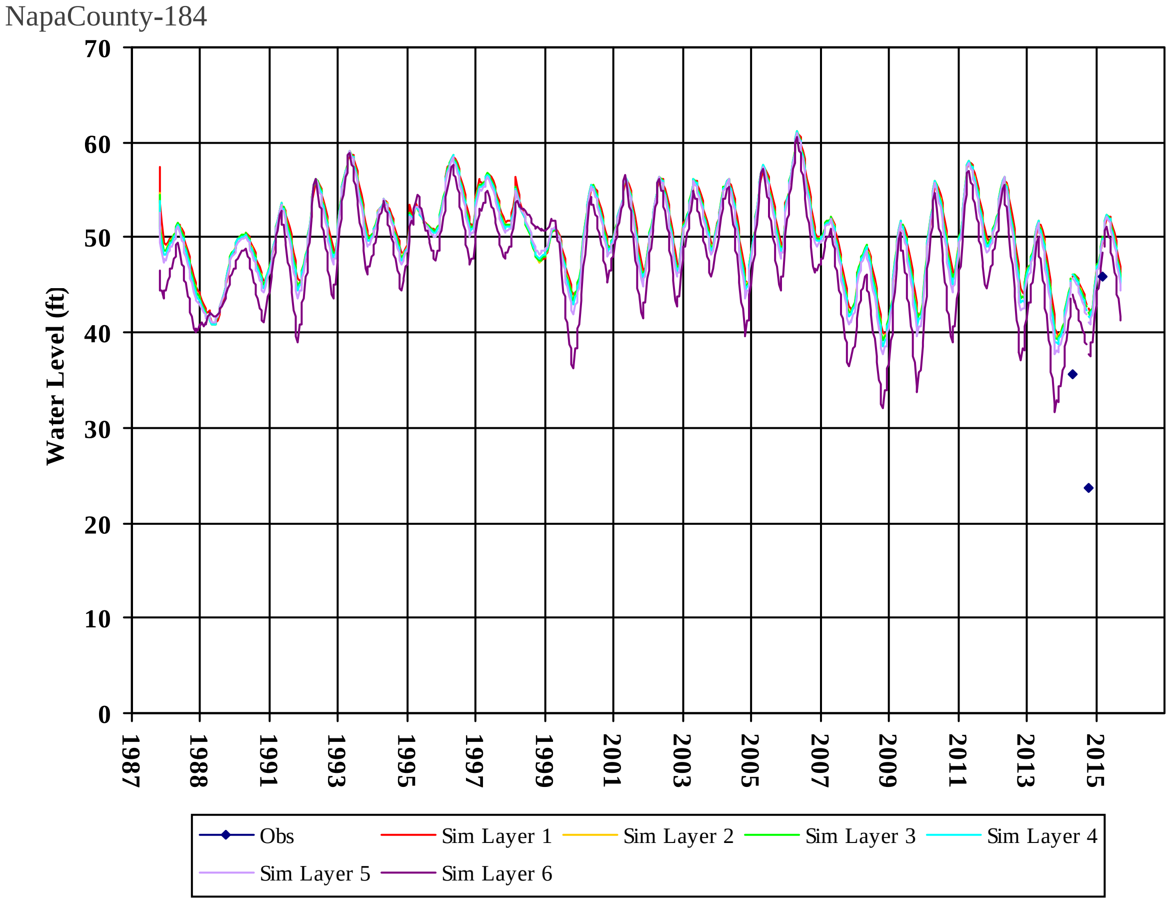
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 3

Well Depth:	400
Hole Depth:	405
Top Perf:	100
Bottom Perf:	400
Est Model Layer:	5

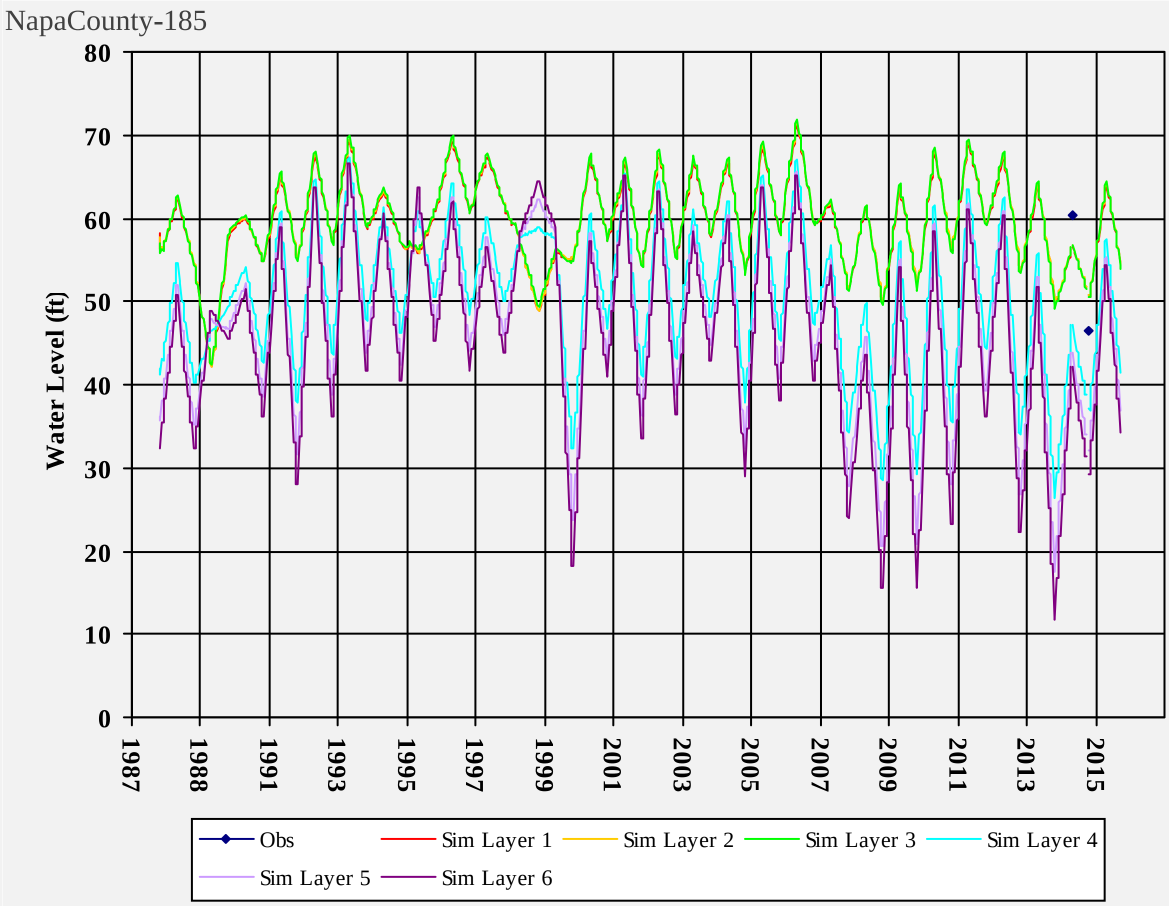


Well Depth:	310
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	4

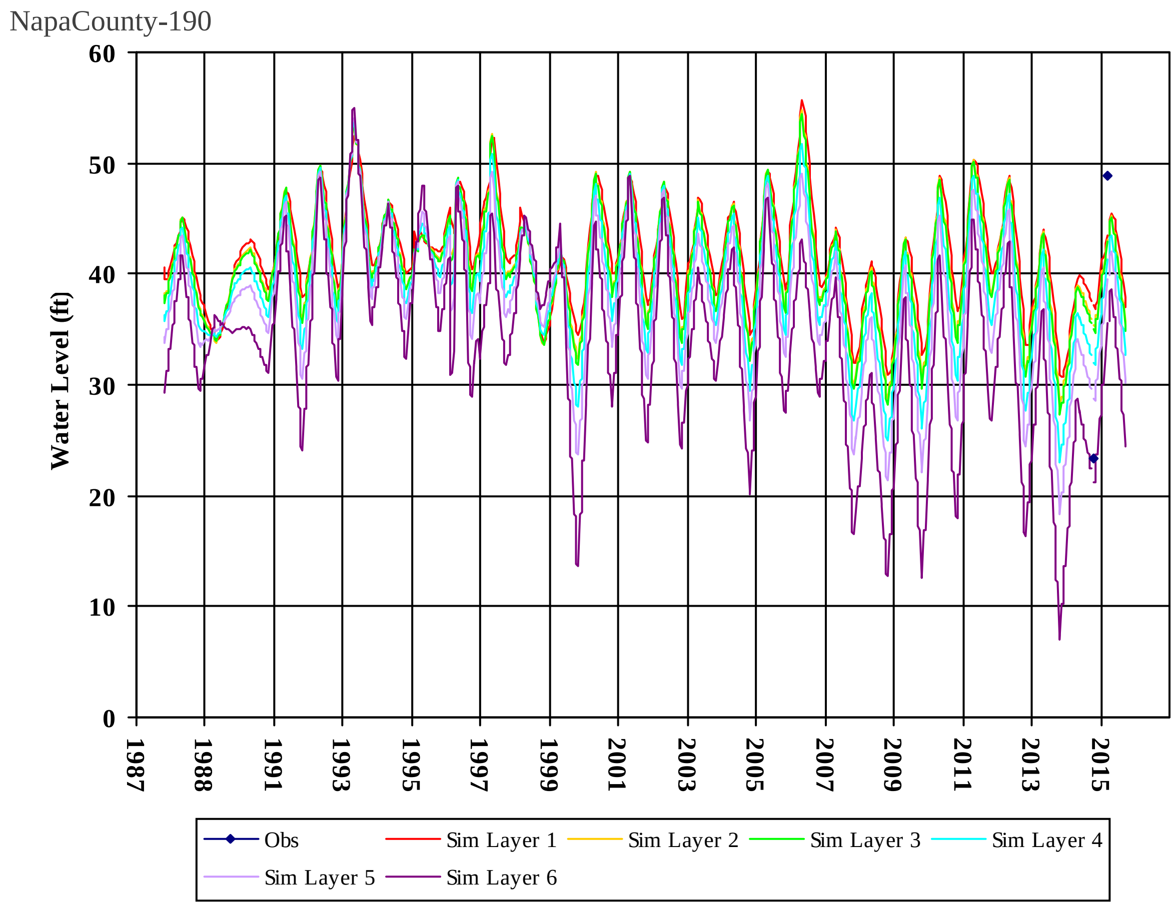




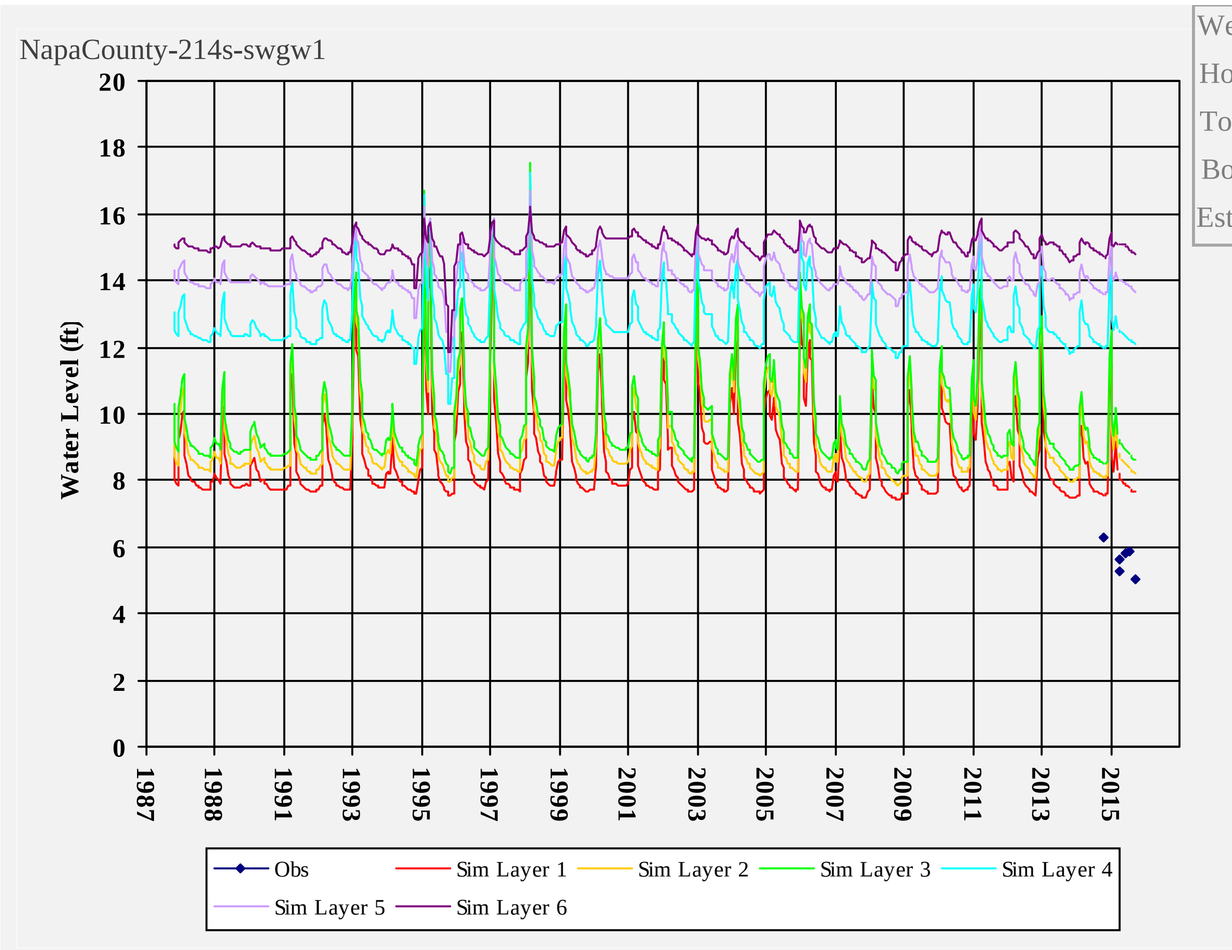
Well Depth: 755
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 5



Well Depth: 260
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 4

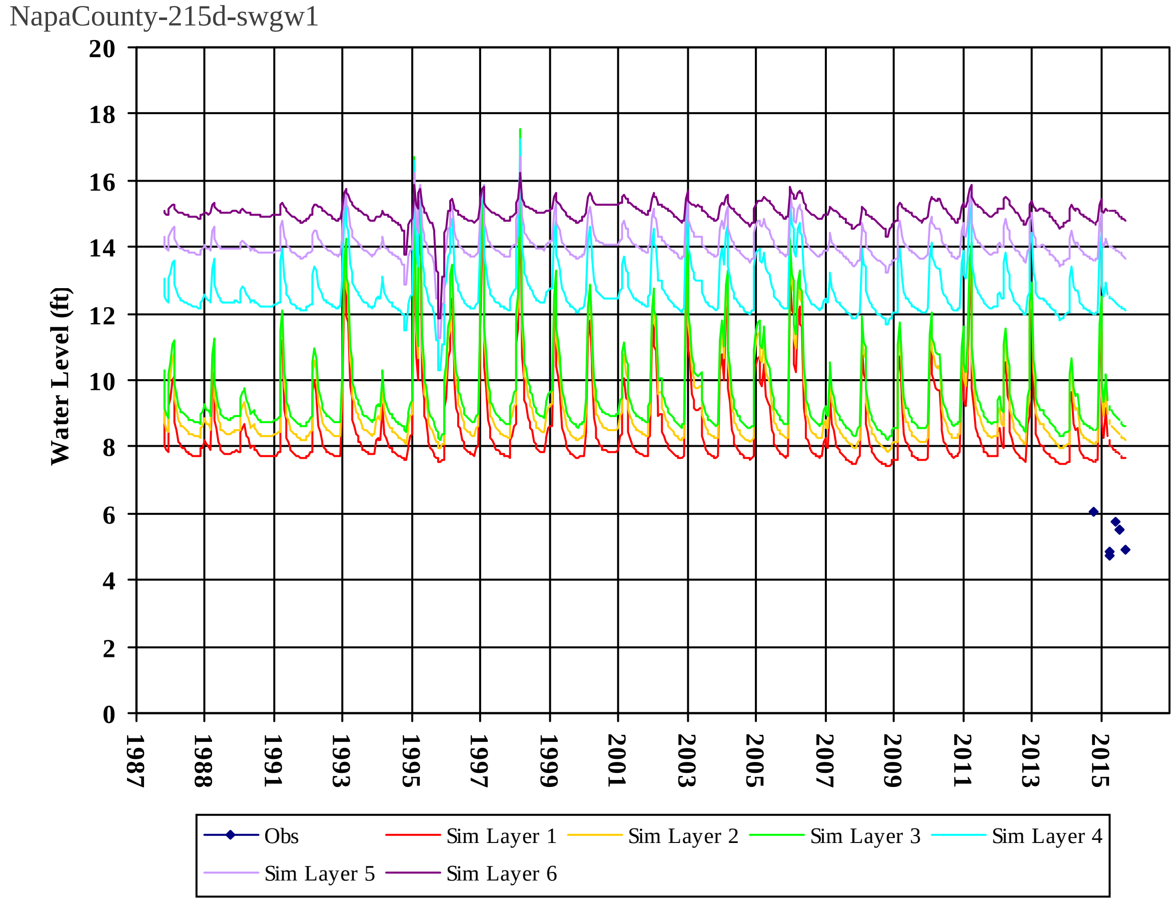


Well Depth:	464
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	4

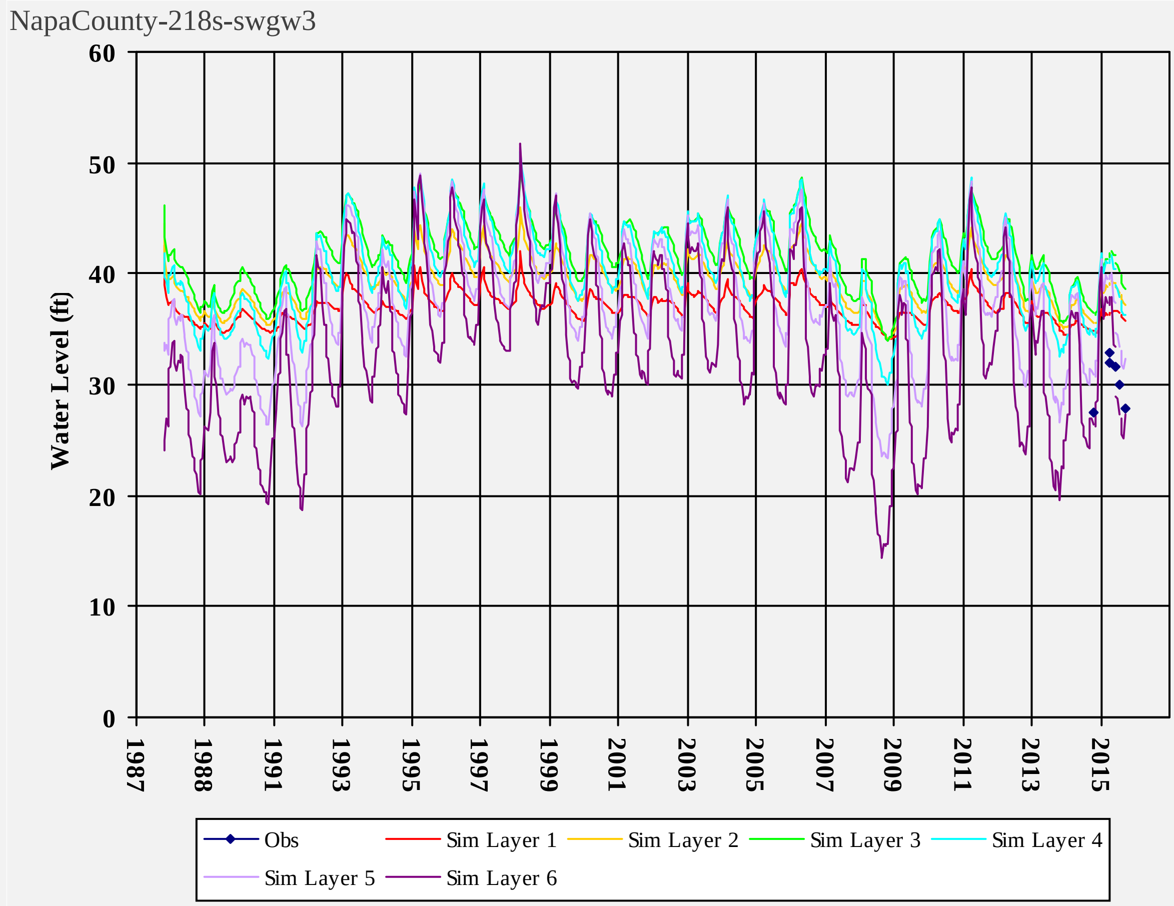


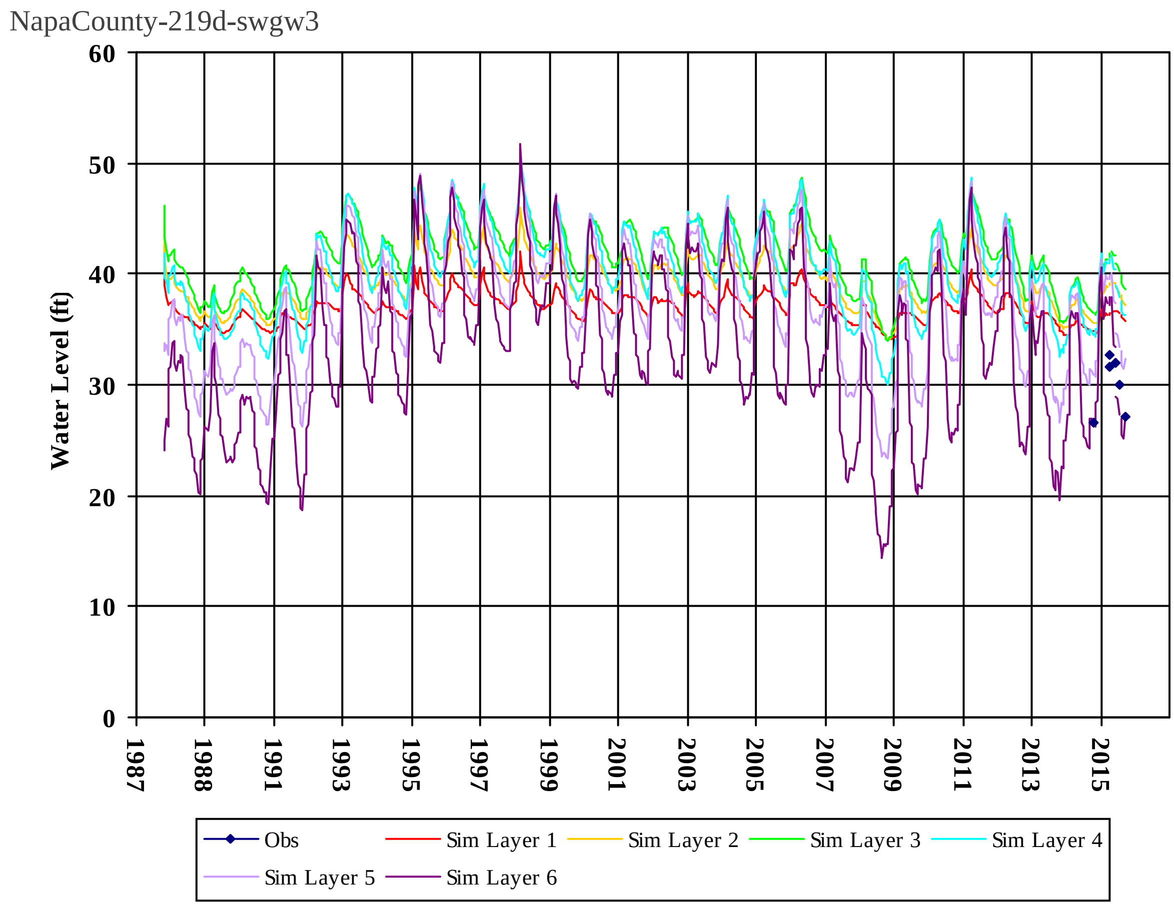
Well Depth:	53
Hole Depth:	100
Top Perf:	30
Bottom Perf:	50
Est Model Layer:	1

Well Depth:	98
Hole Depth:	100
Top Perf:	75
Bottom Perf:	95
Est Model Layer:	2

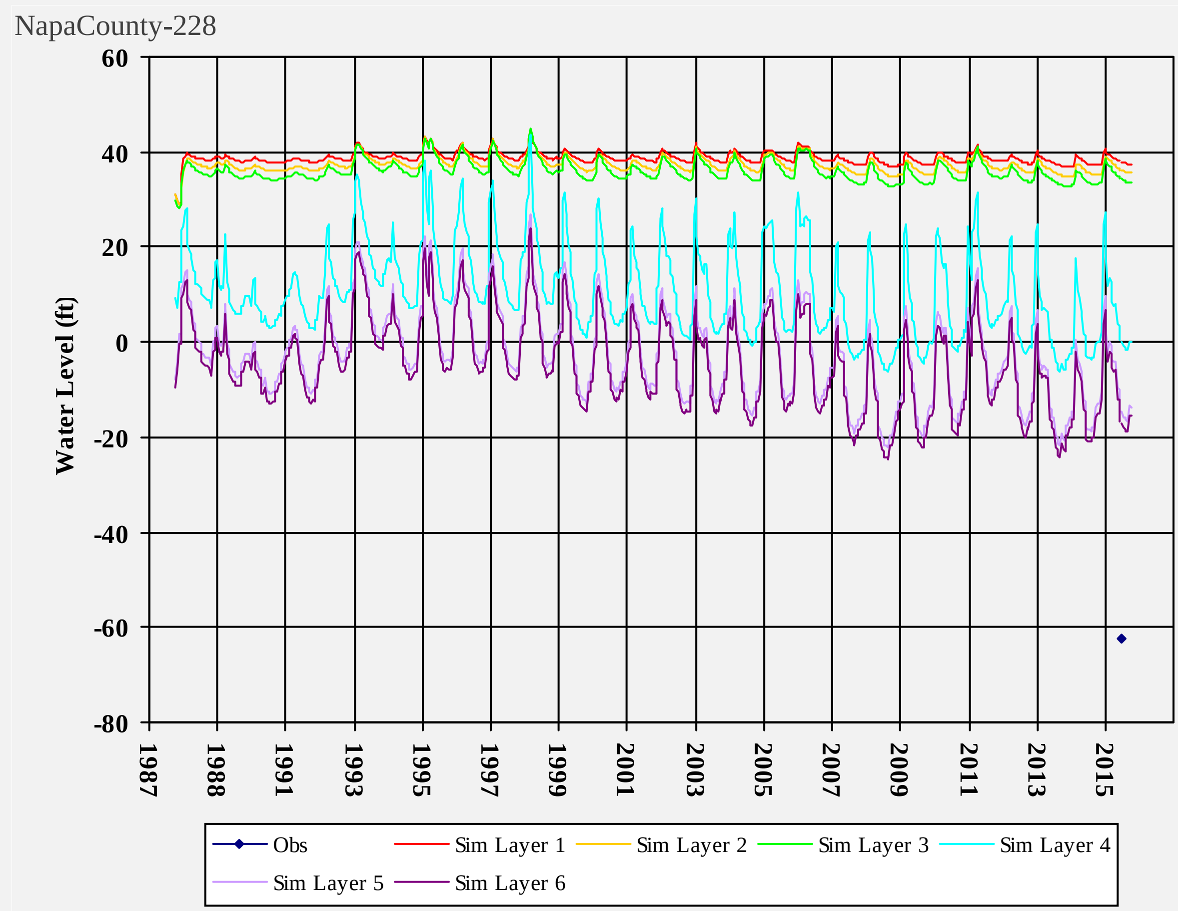


Well Depth:	40
Hole Depth:	100
Top Perf:	25
Bottom Perf:	35
Est Model Layer:	1

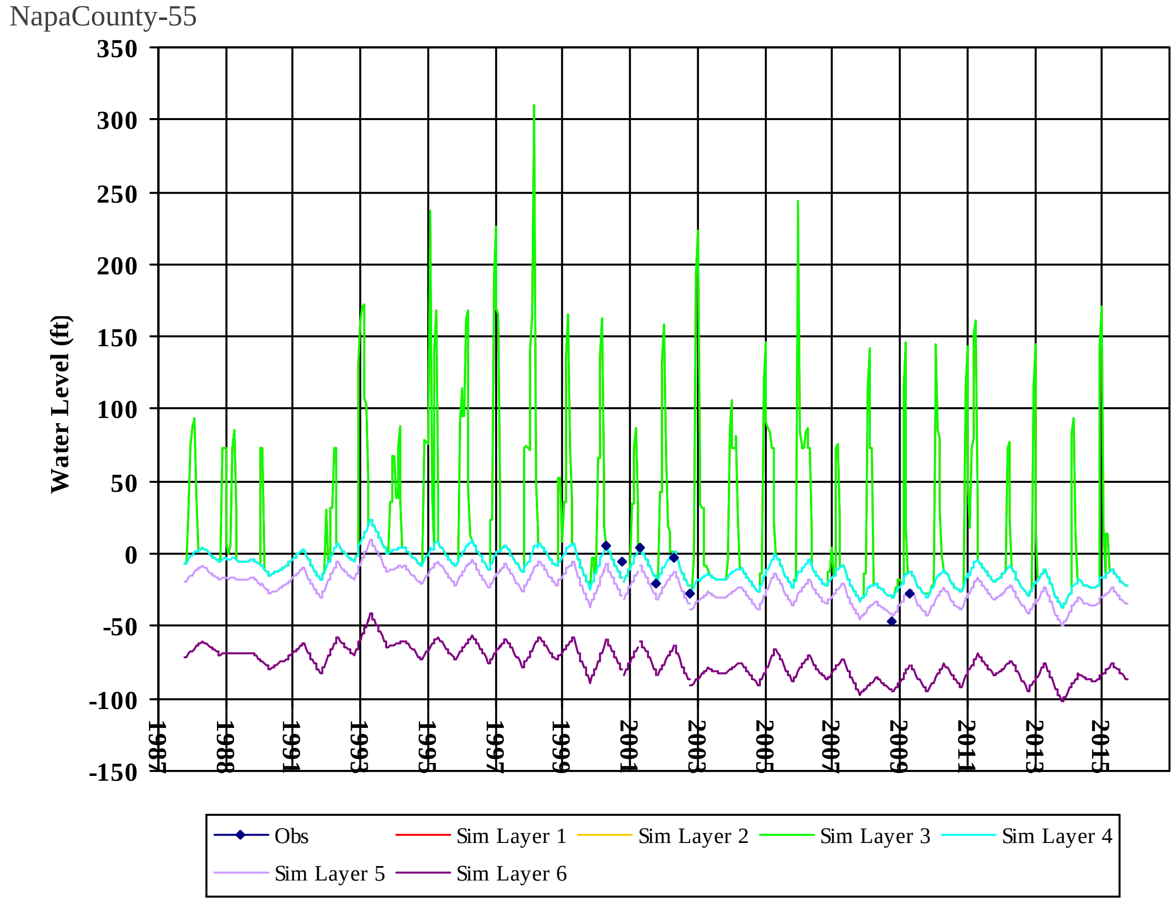




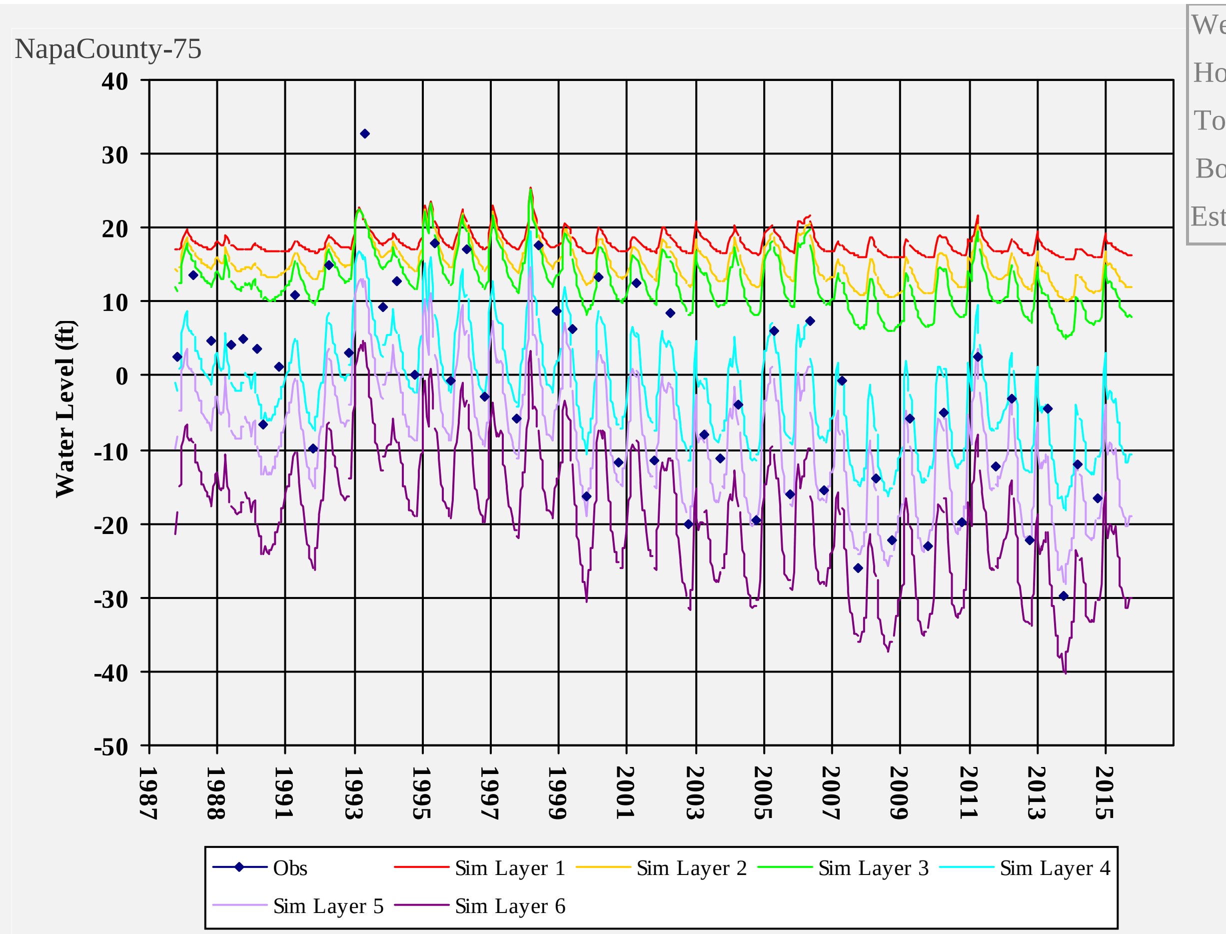
Well Depth:	93
Hole Depth:	100
Top Perf:	78
Bottom Perf:	88
Est Model Layer:	3



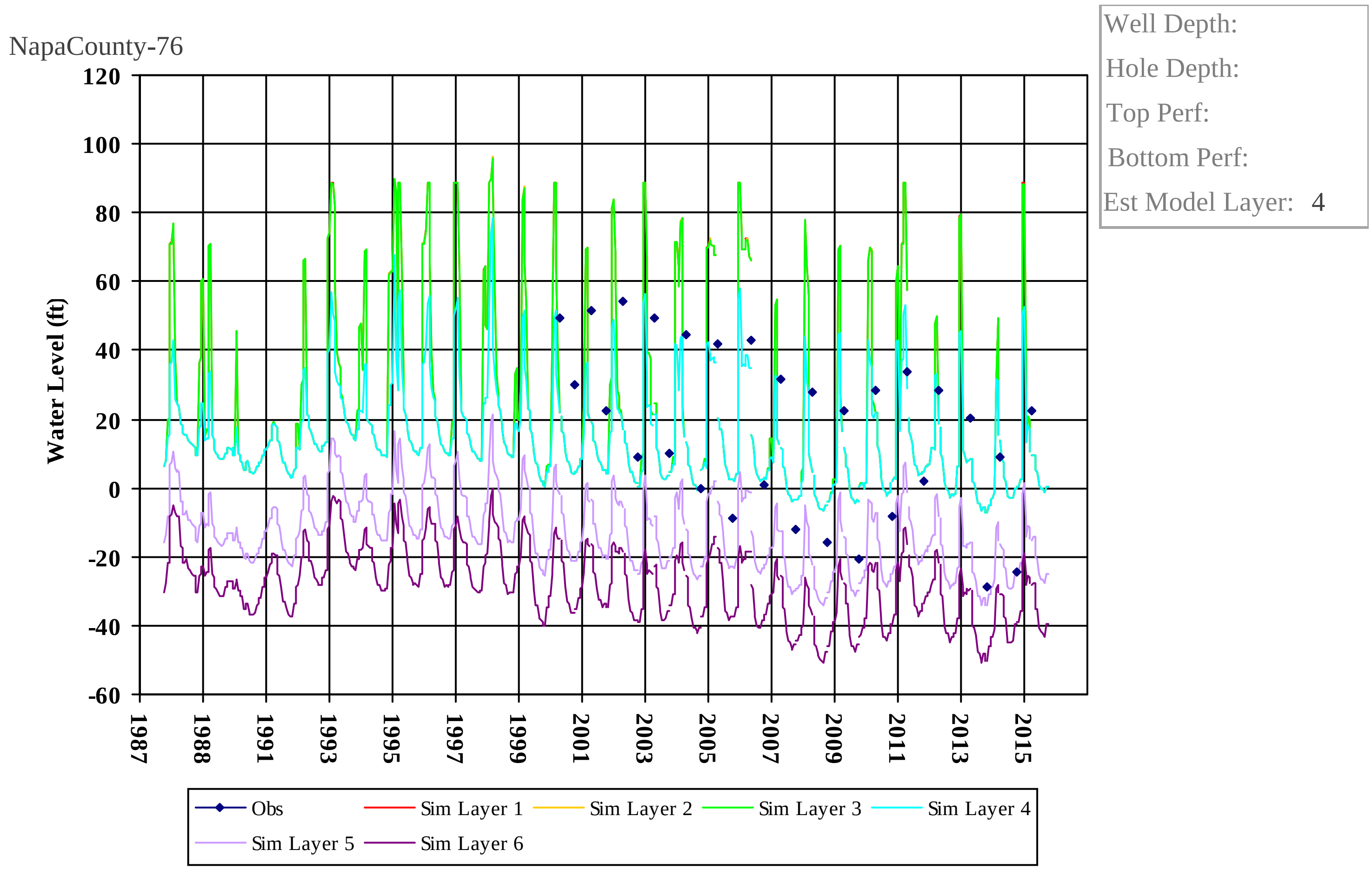
Well Depth:	206
Hole Depth:	
Top Perf:	96
Bottom Perf:	206
Est Model Layer:	4

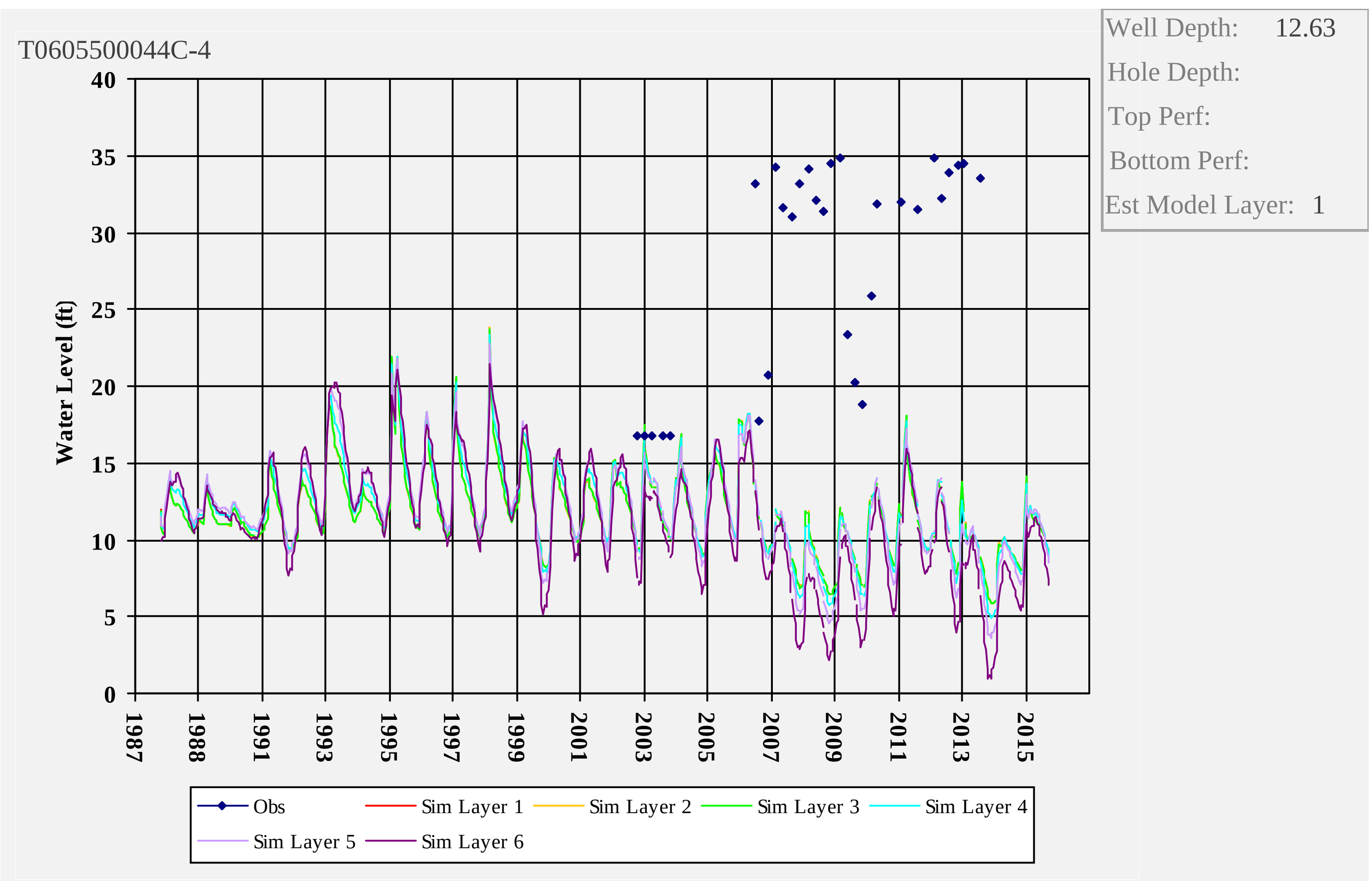


Well Depth:	153
Hole Depth:	153
Top Perf:	
Bottom Perf:	
Est Model Layer:	4

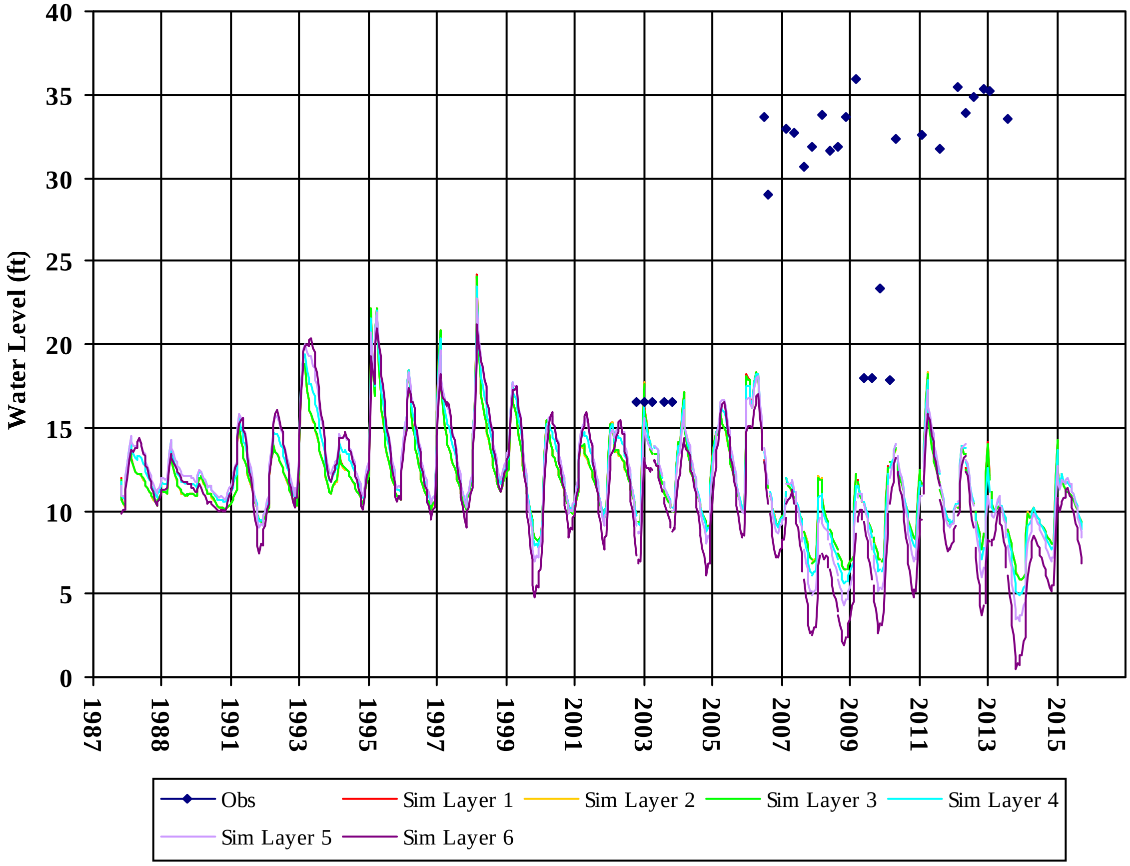


Well Depth:	205
Hole Depth:	208
Top Perf:	45
Bottom Perf:	205
Est Model Layer:	4


NapaCounty-76
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 4
Water Level (ft)
120
100
80
60
40
20
0
-20
-40
-60
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

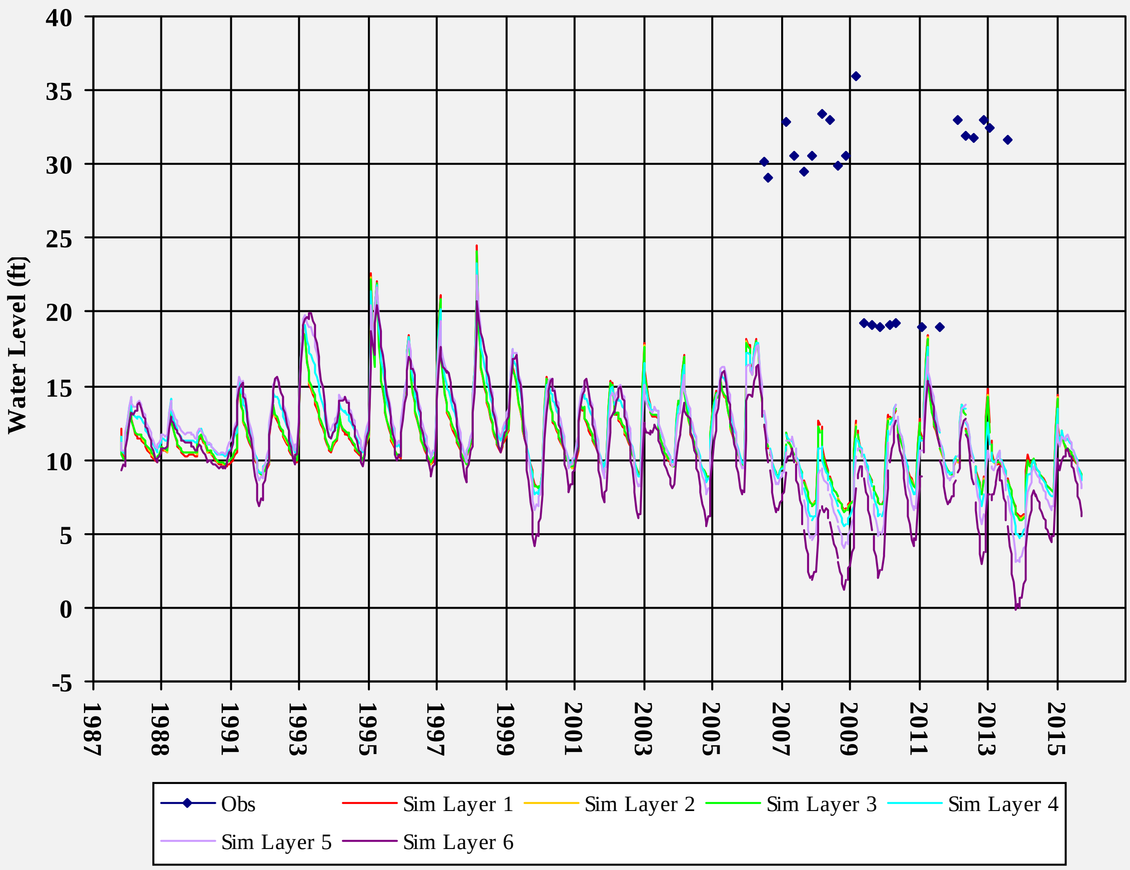

T0605500044C-4
Well Depth: 12.63
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
Water Level (ft)
40
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

T0605500044C-5



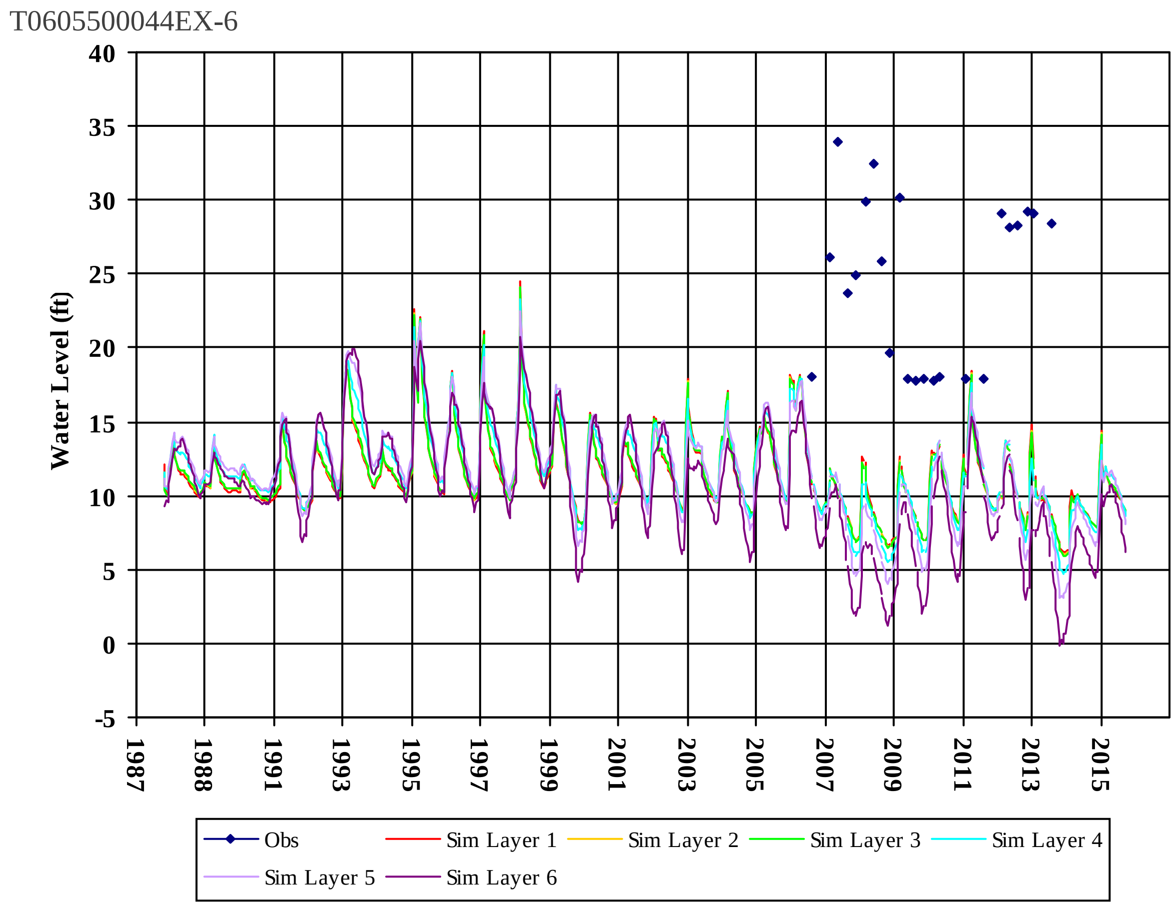
Well Depth: 12.25
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500044EX-5

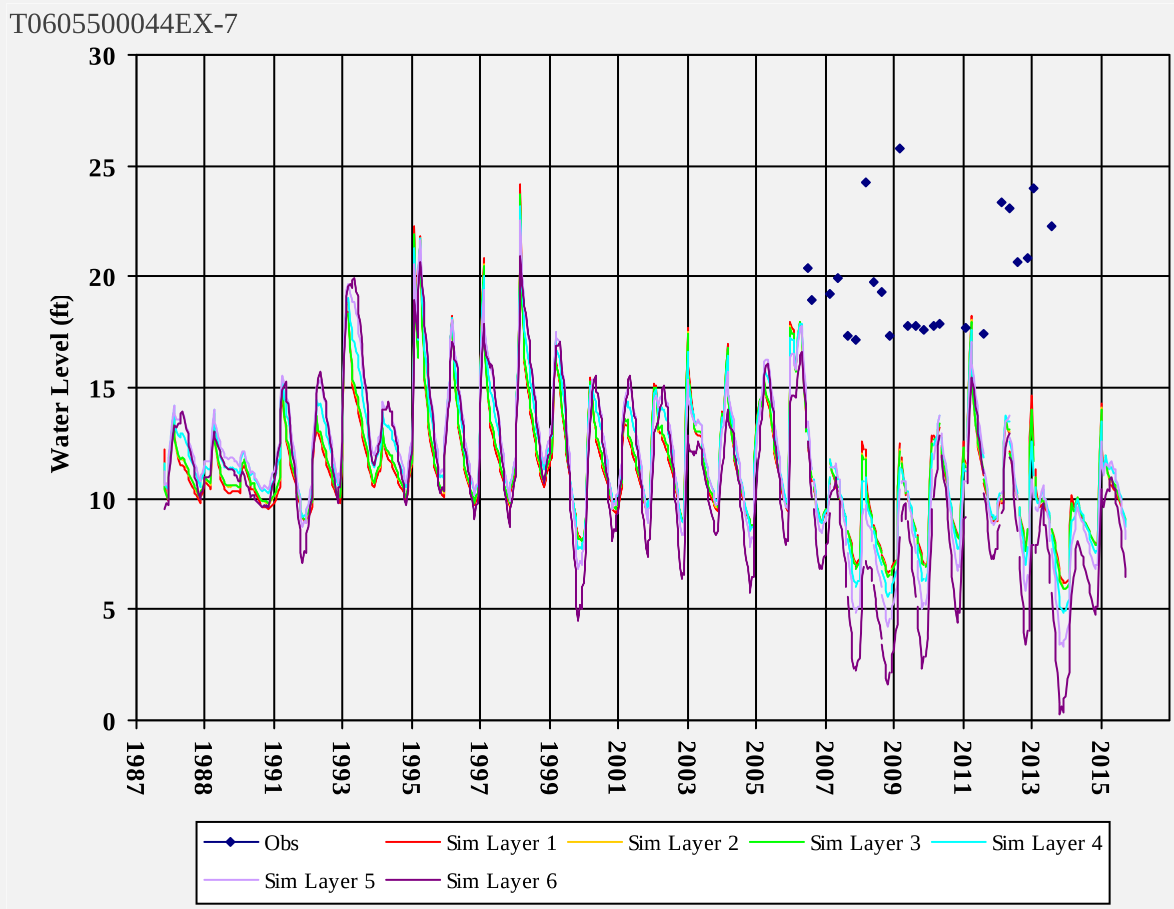


Well Depth: 27.15
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

Well Depth: 27.55
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

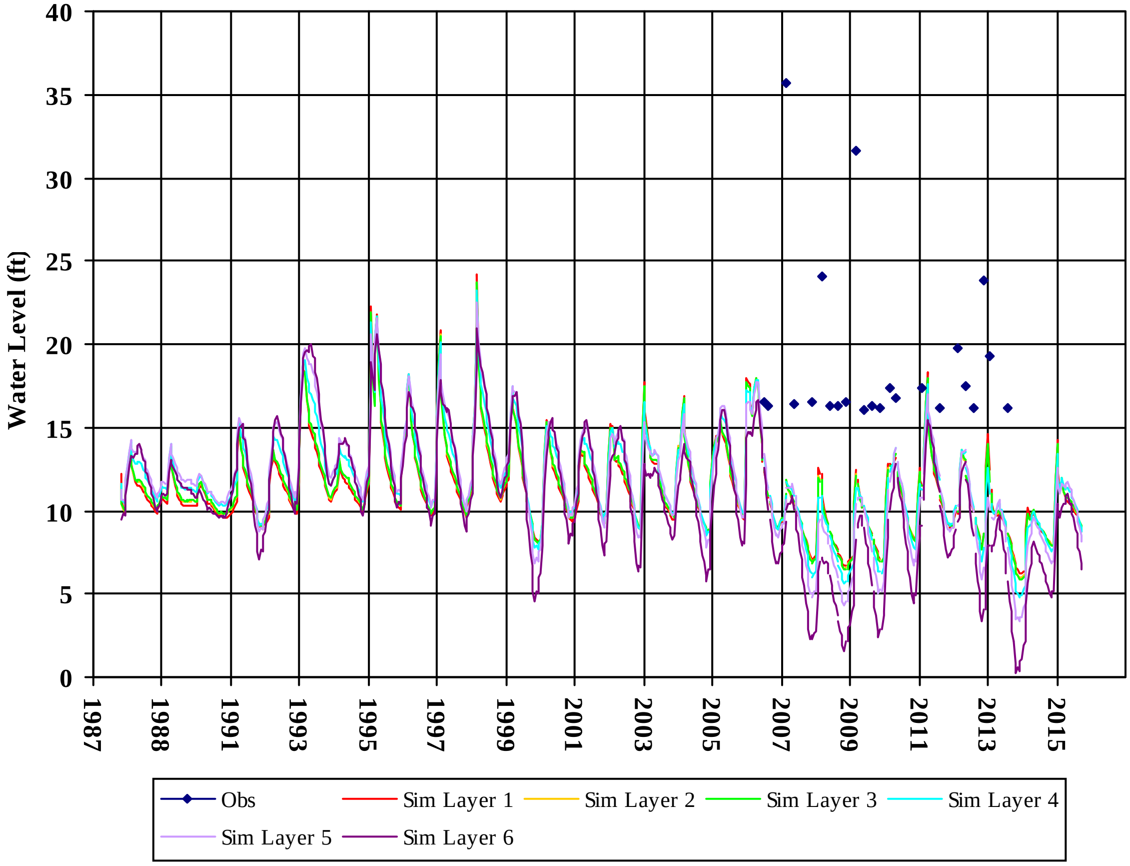


Well Depth: 27.65
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



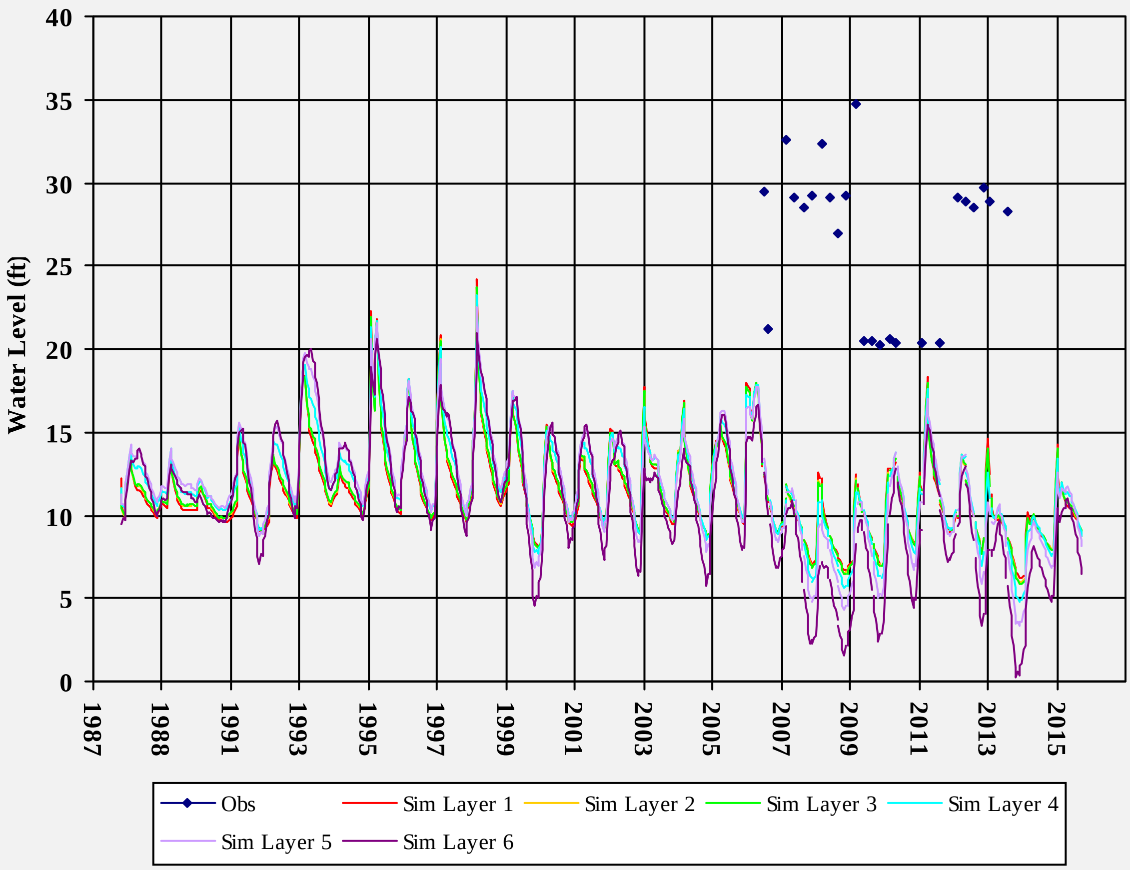
Well Depth:	27.56
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

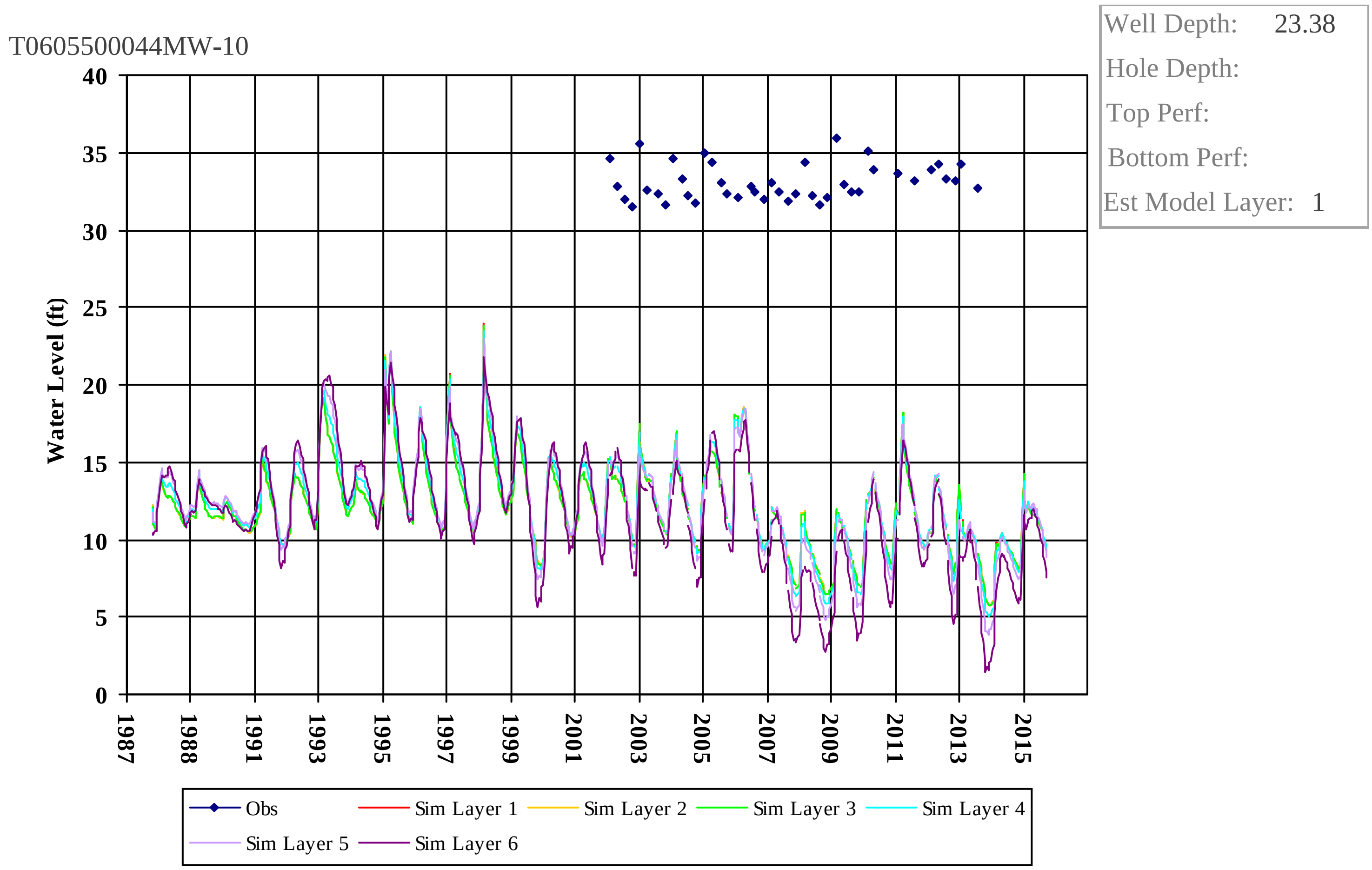
T0605500044EX-8

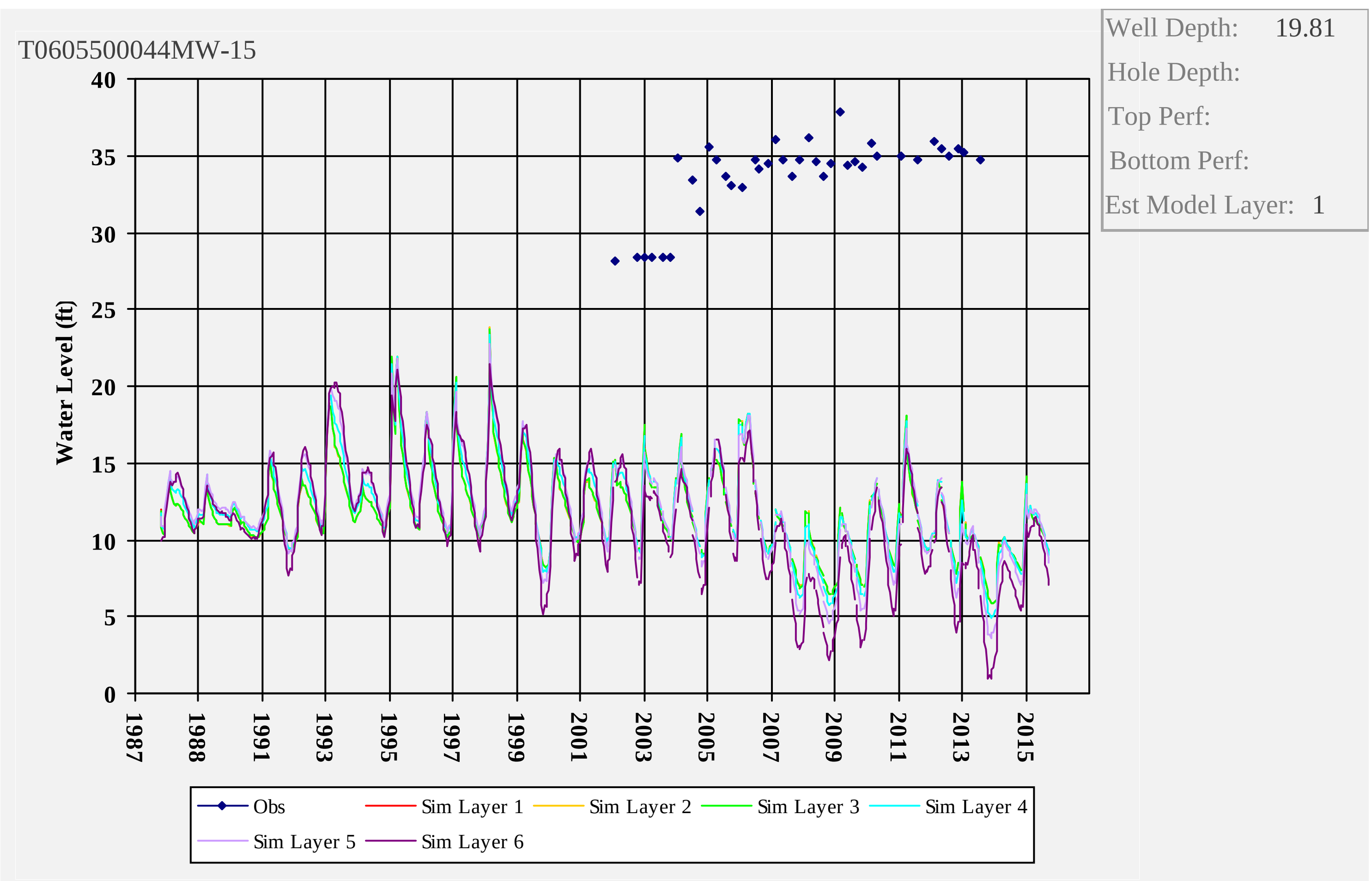


Well Depth:	27.81
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

T0605500044EX-9

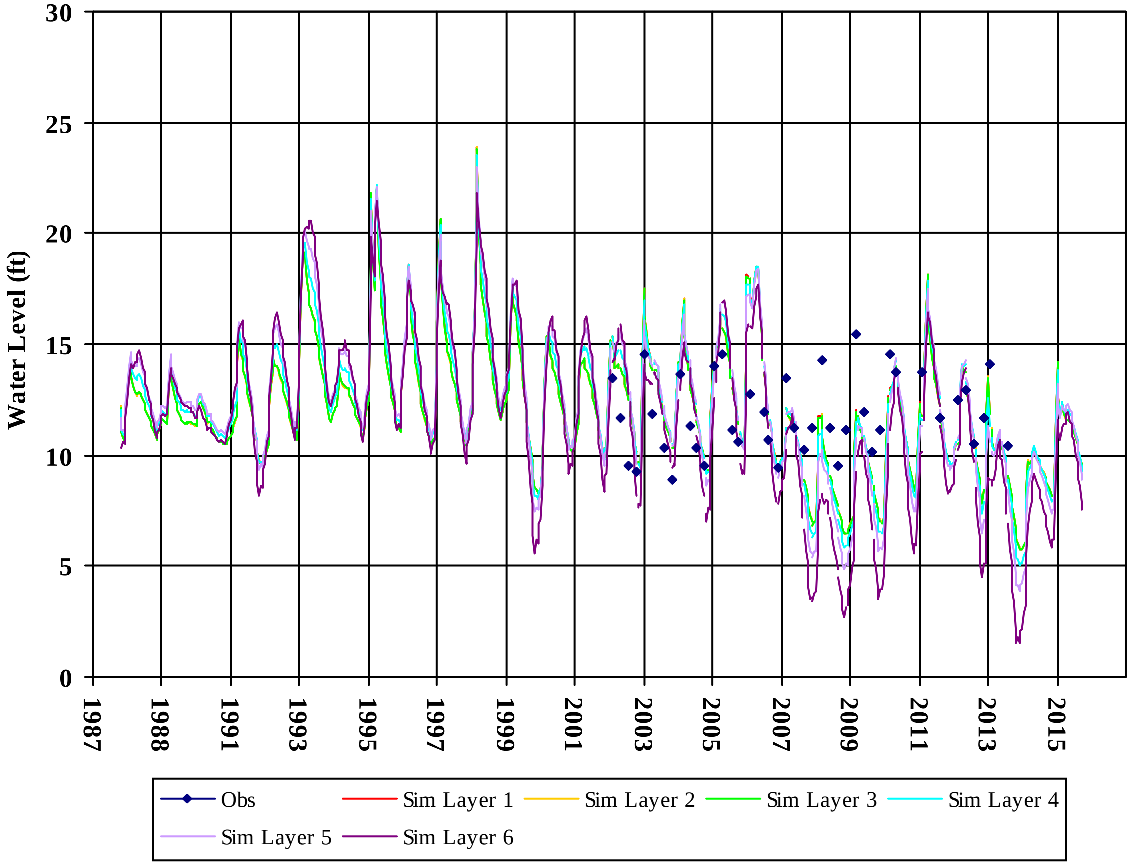



Well Depth: 23.38
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
T0605500044MW-10
Water Level (ft)
40
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6


Well Depth: 19.81
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
T0605500044MW-15
Water Level (ft)
40
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

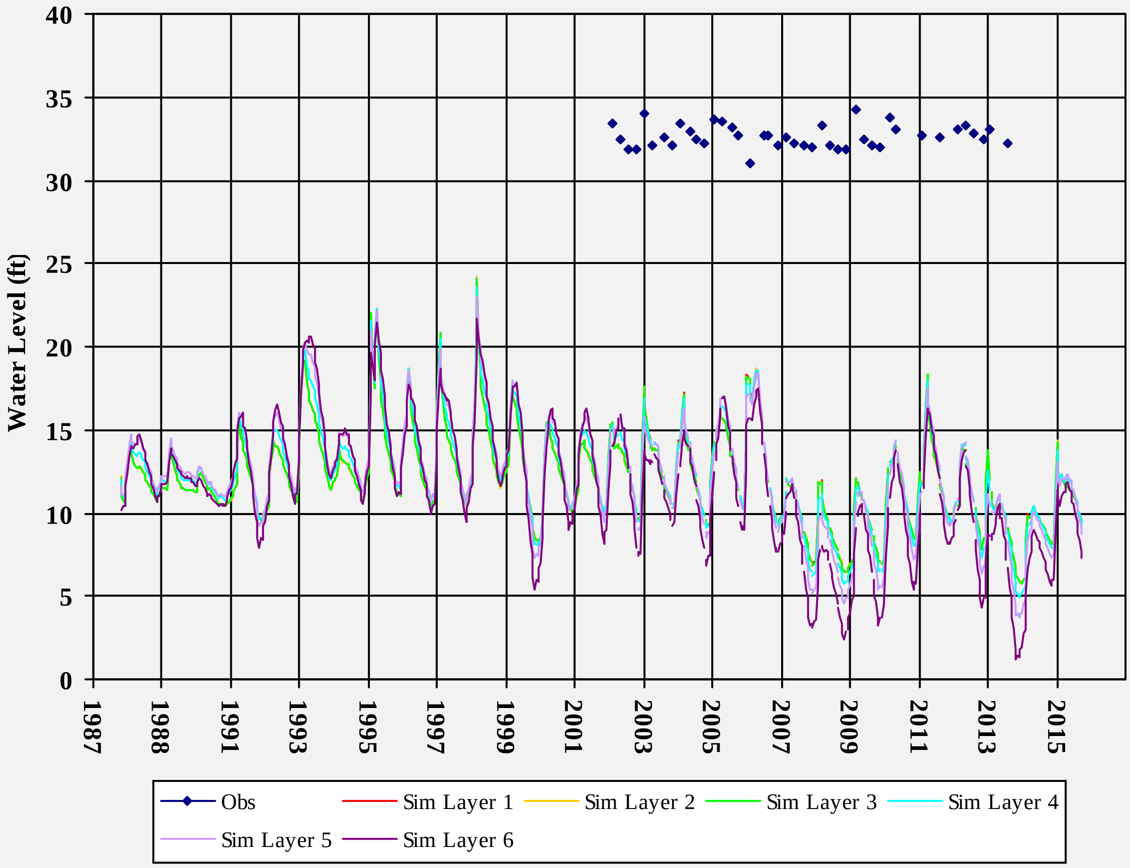
Well Depth: 46.52
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500044MW-16

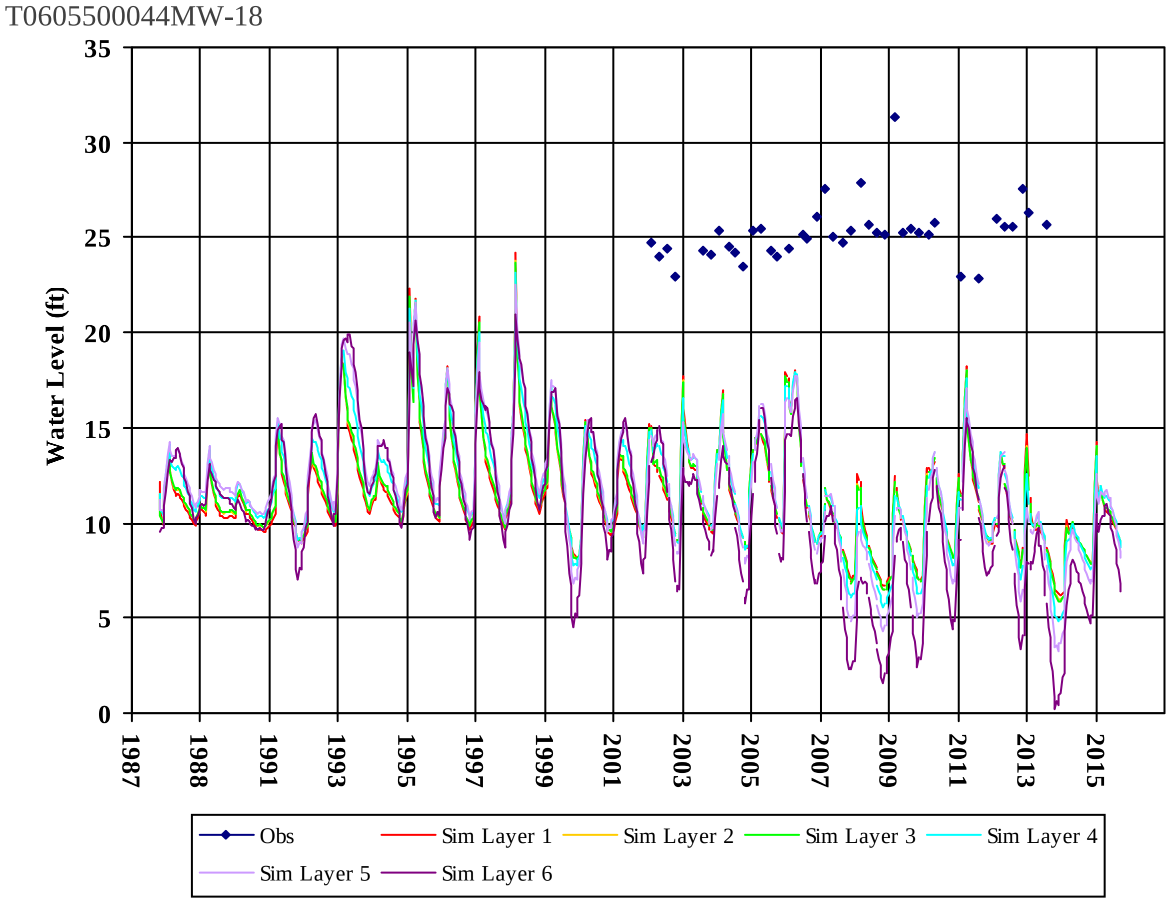


Well Depth: 25.15
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

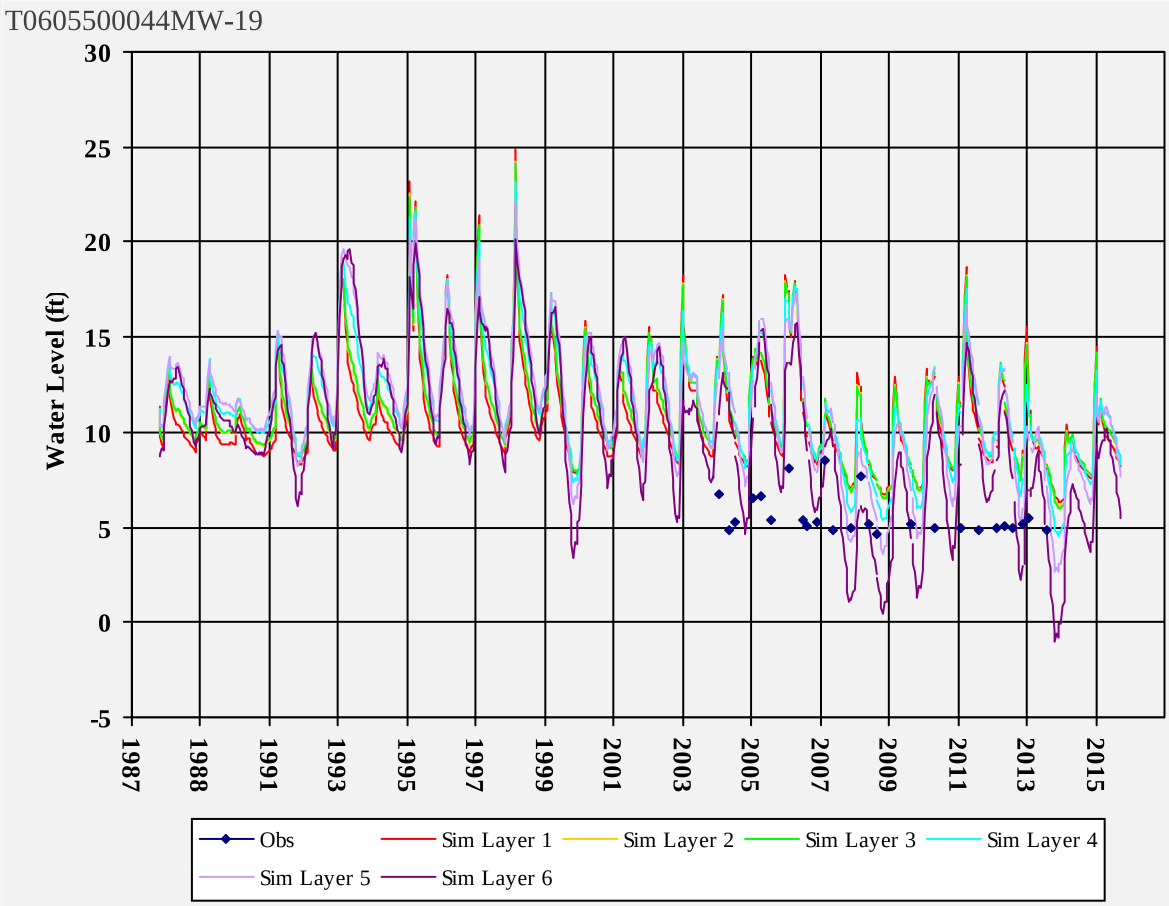
T0605500044MW-17

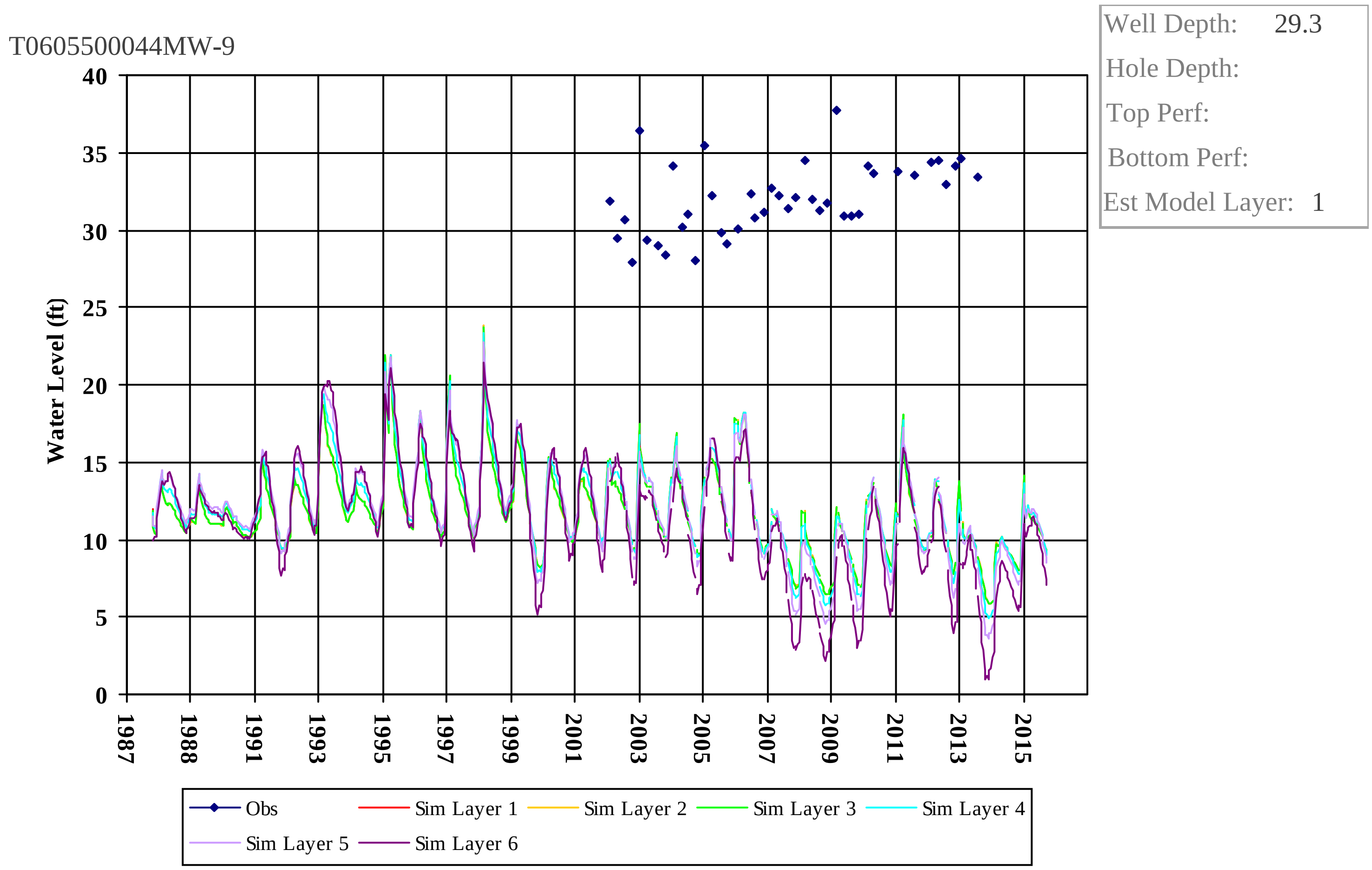


Well Depth:	21.35
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

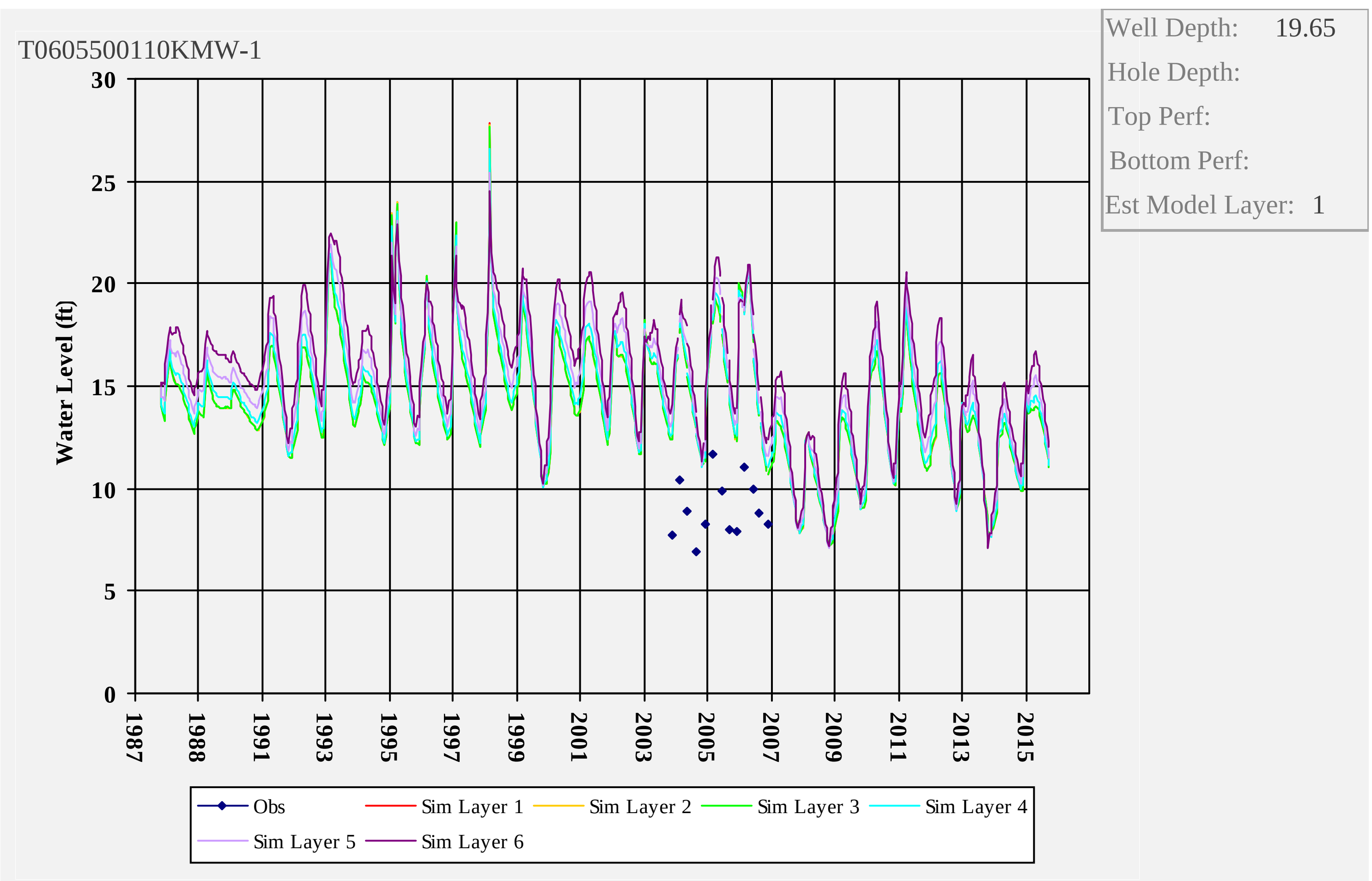


Well Depth:	21.14
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1





T0605500044MW-9
Well Depth: 29.3
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
Water Level (ft)
40
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6



T0605500110KMW-1
Well Depth: 19.65
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
Water Level (ft)
30
25
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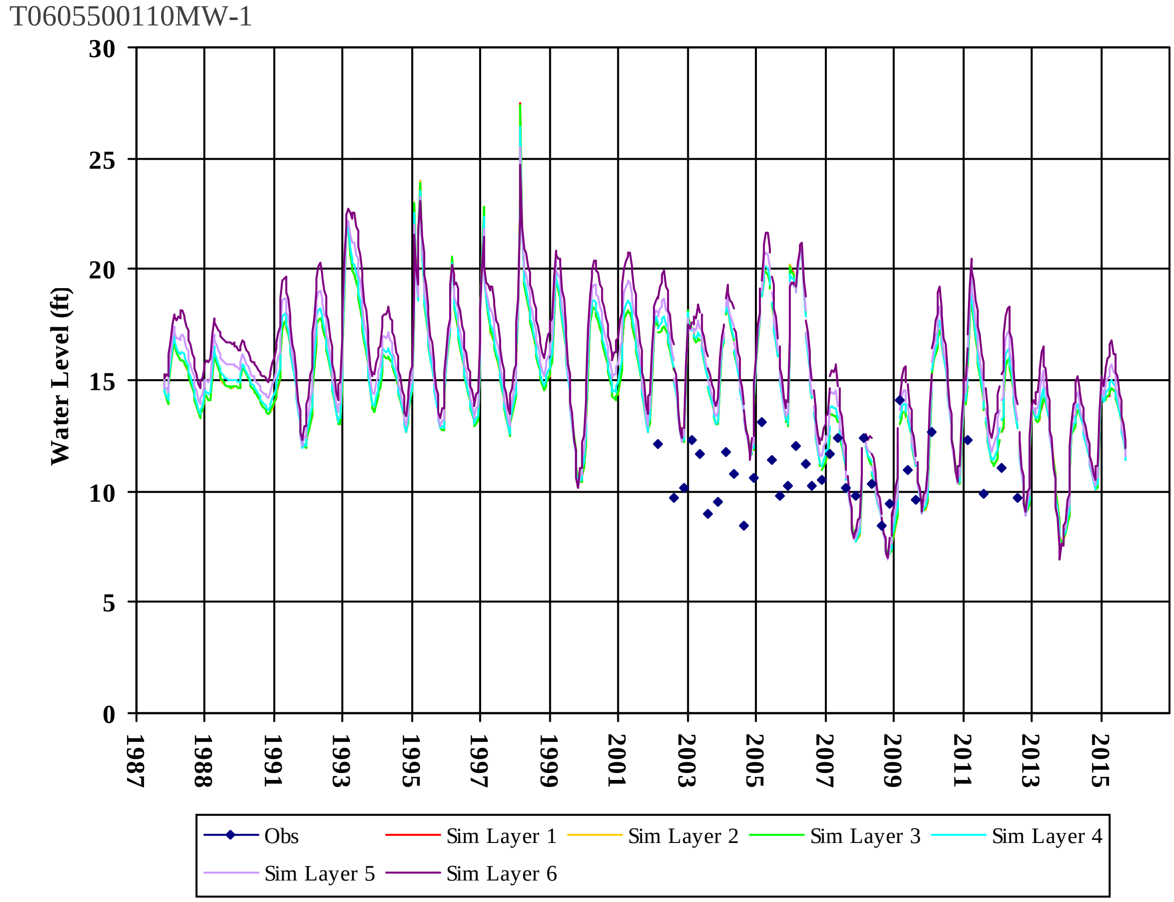
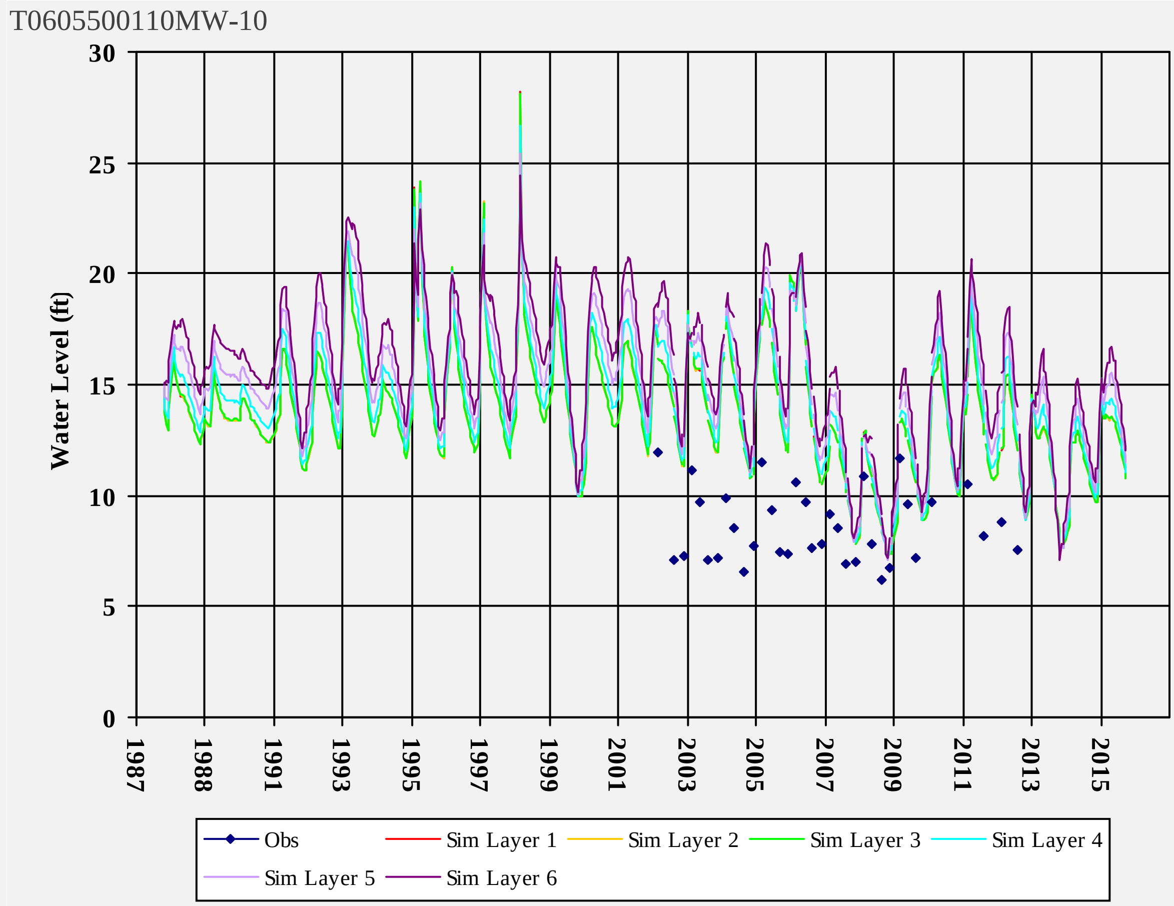
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

Well Depth: 24.19
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth: 22.95
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth:	22.92
Hole Depth:	
Top Perf:	
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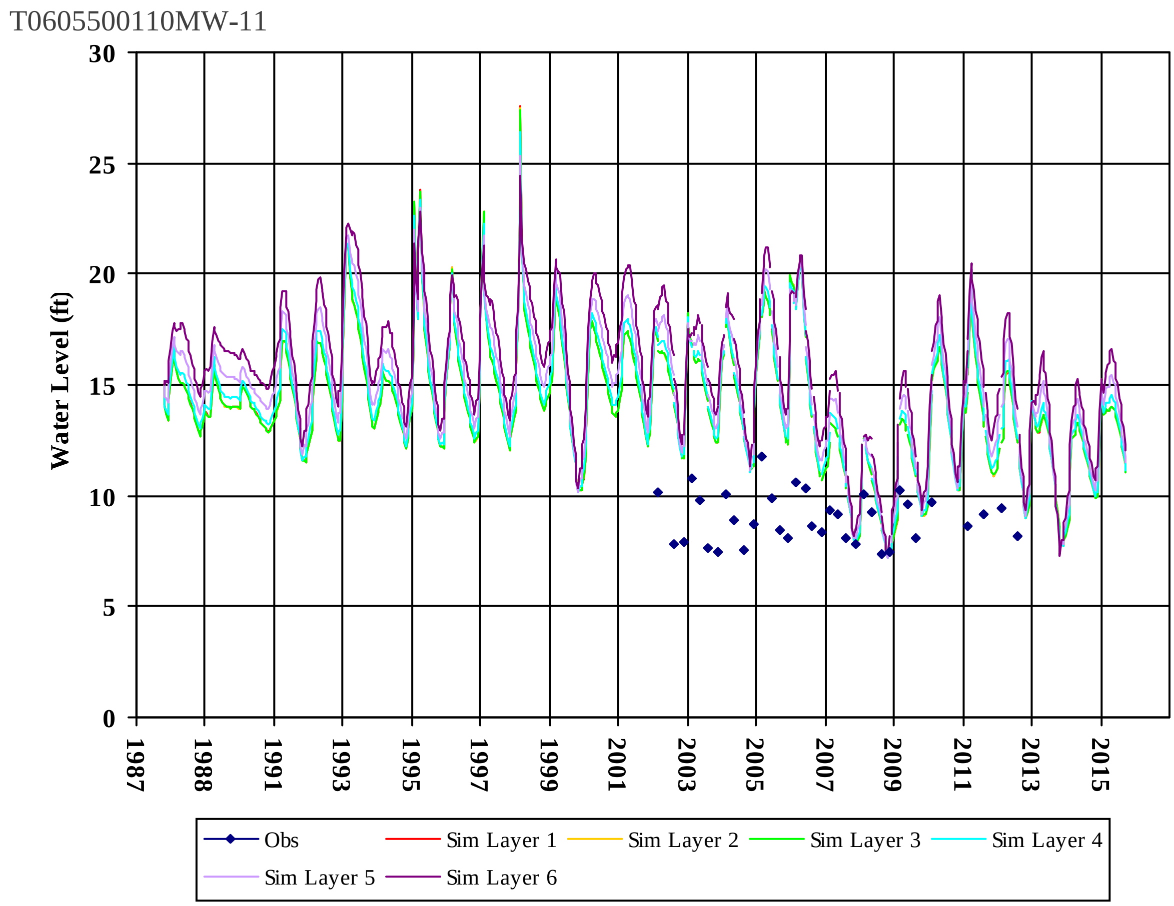
Est Model Layer:	1



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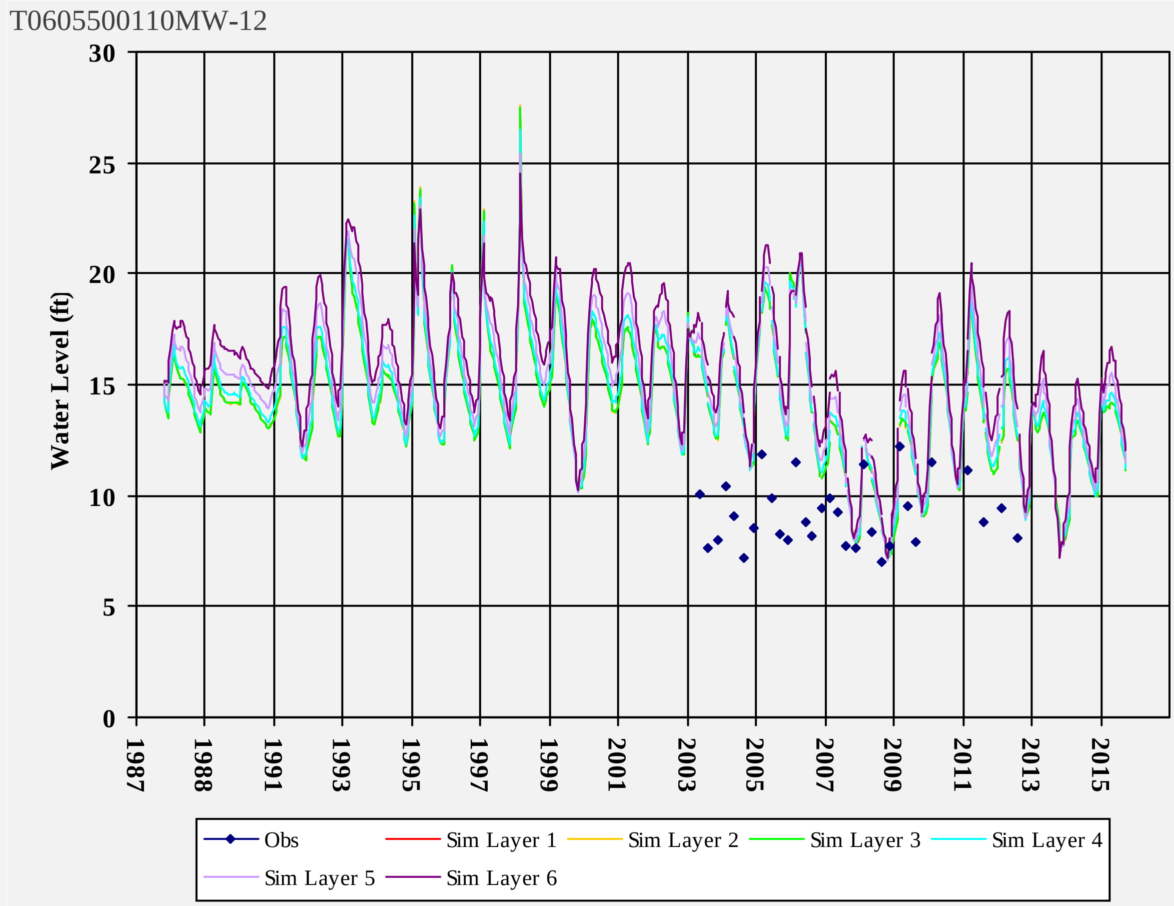
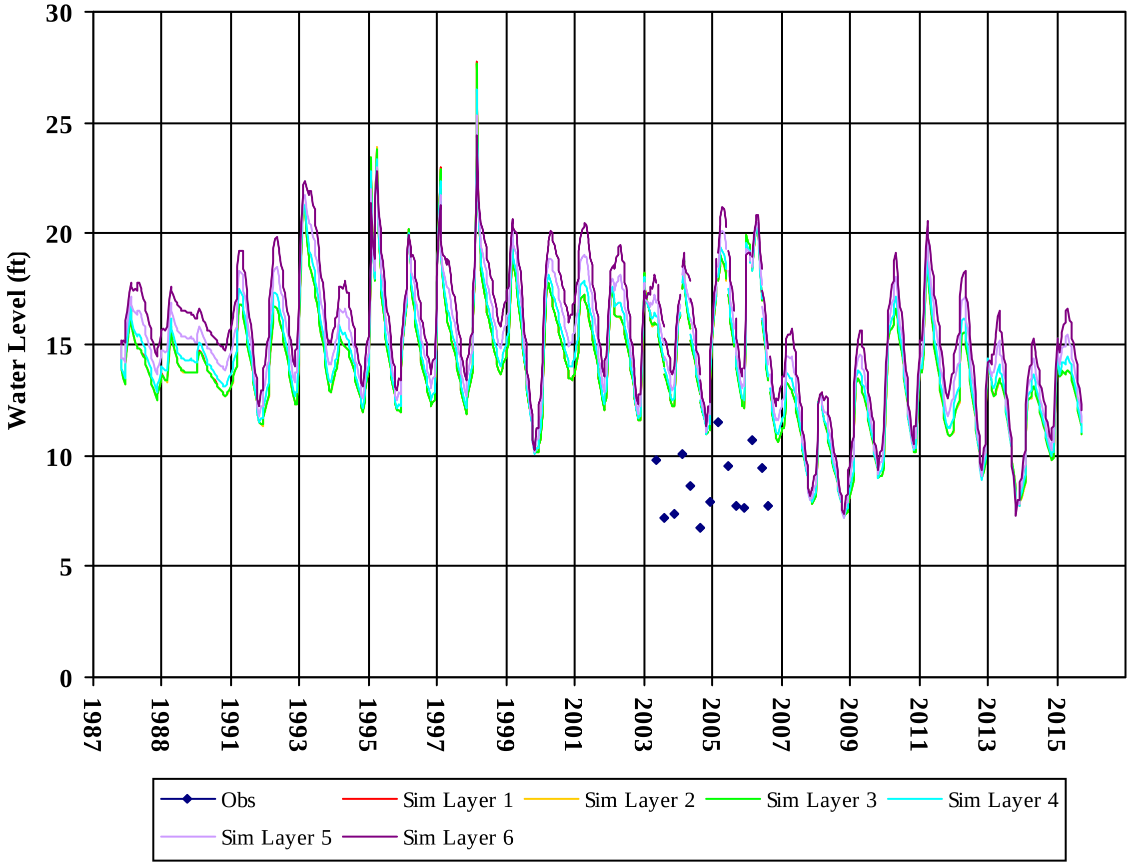
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



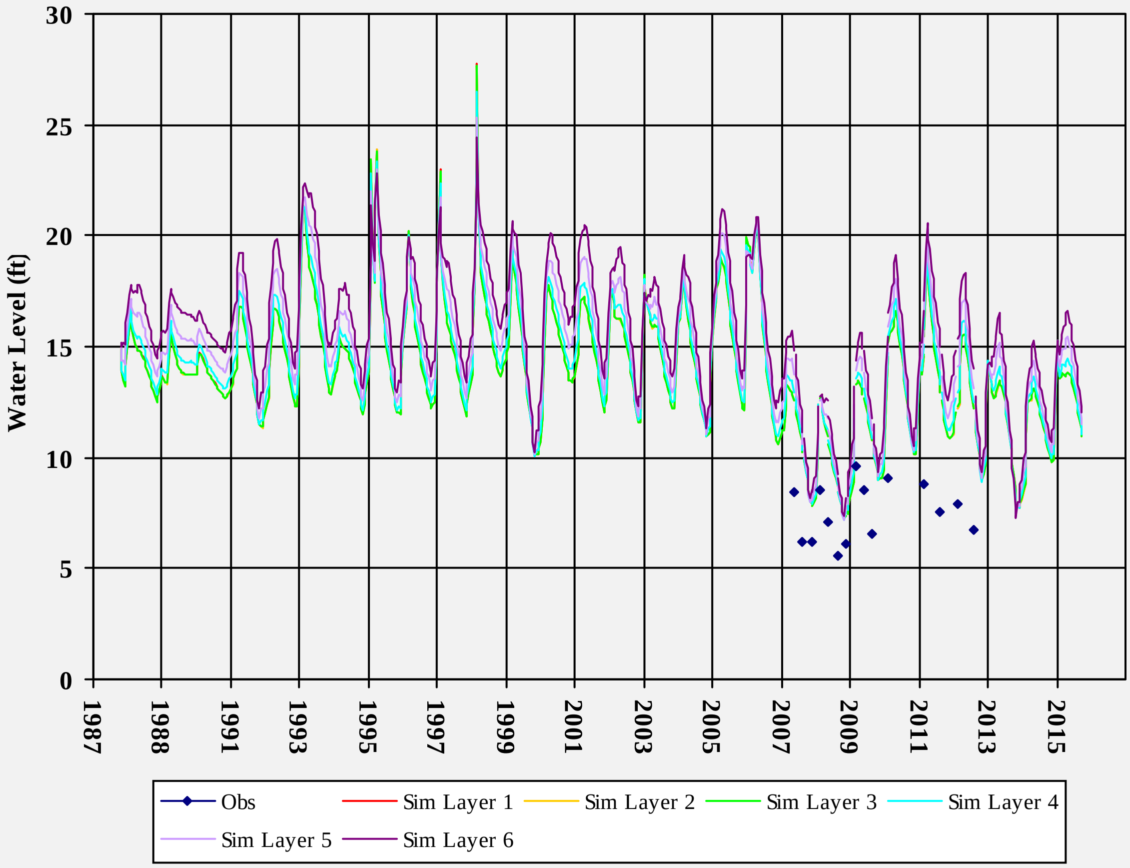
Well Depth: 20.41
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500110MW-13

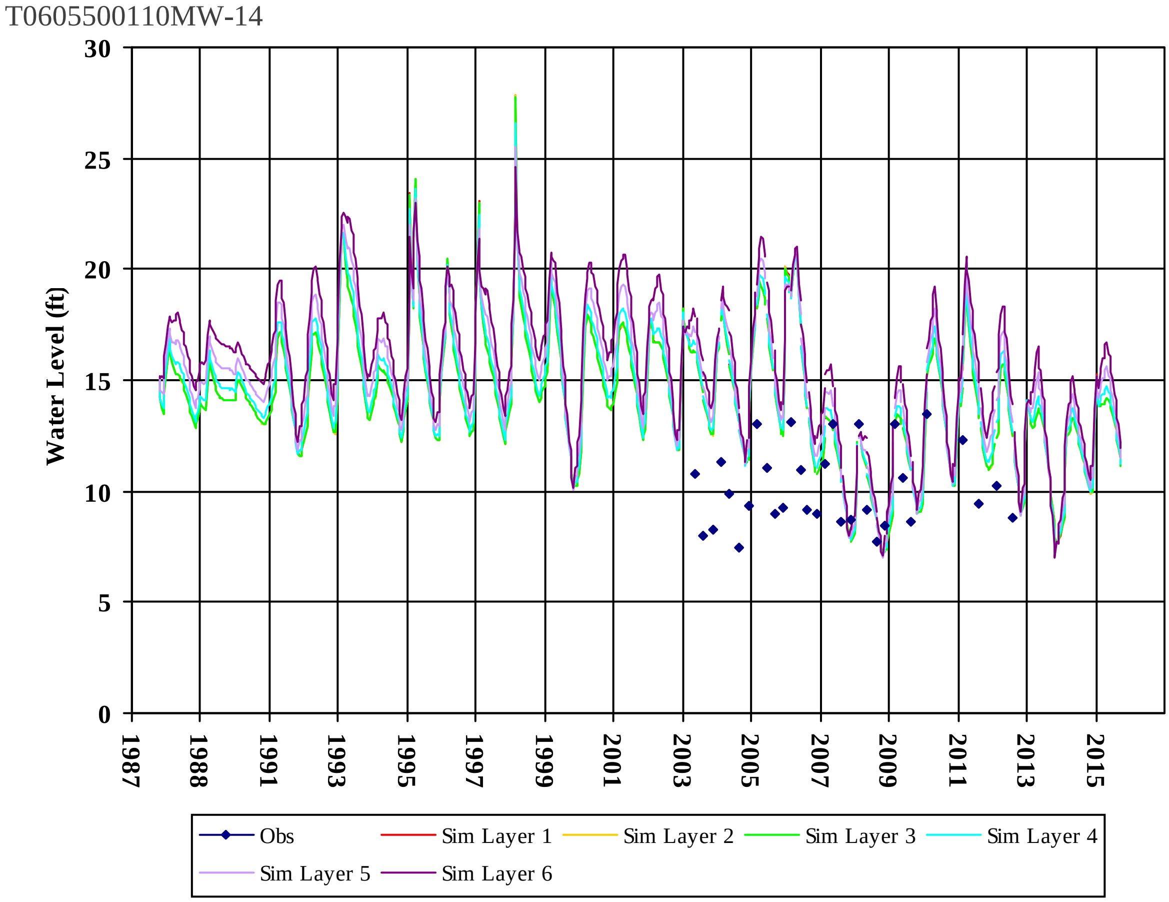


Well Depth: 20.07
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

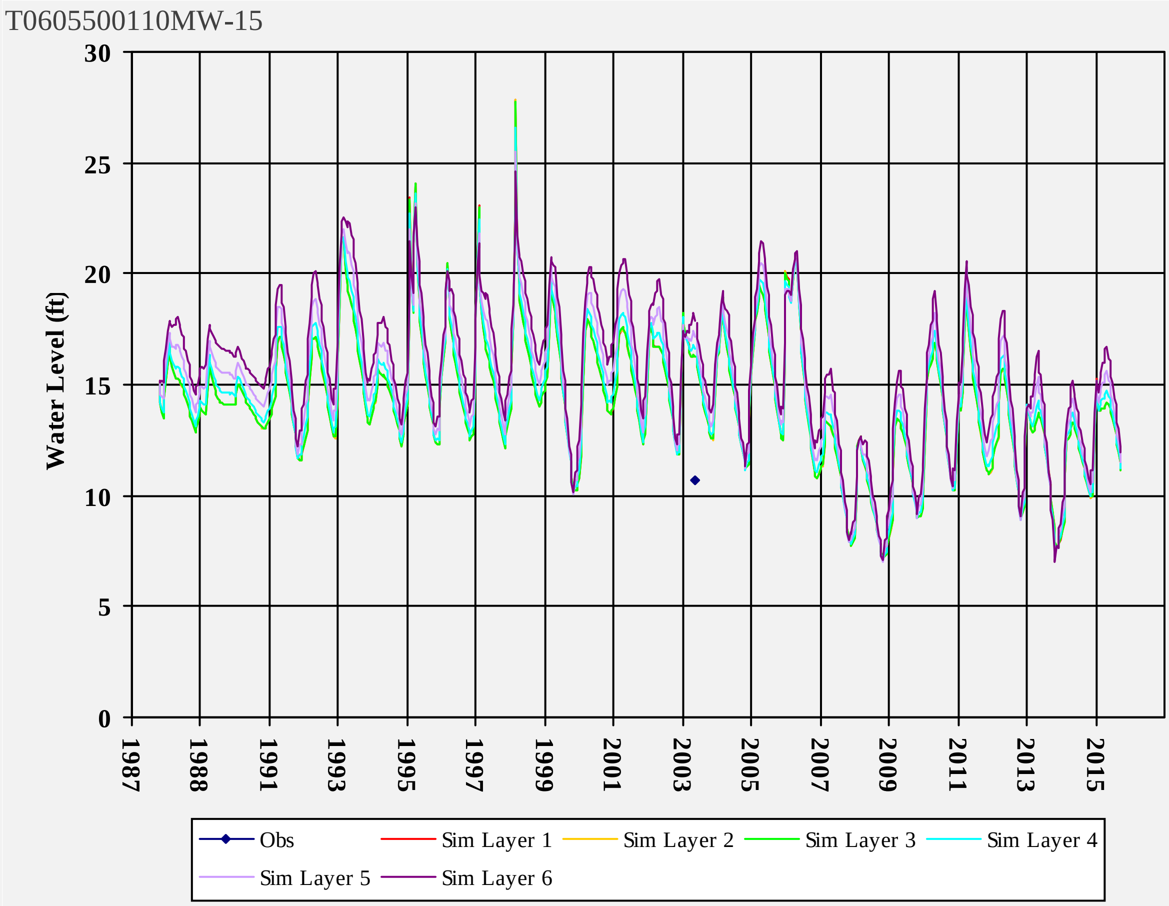
T0605500110MW-13A



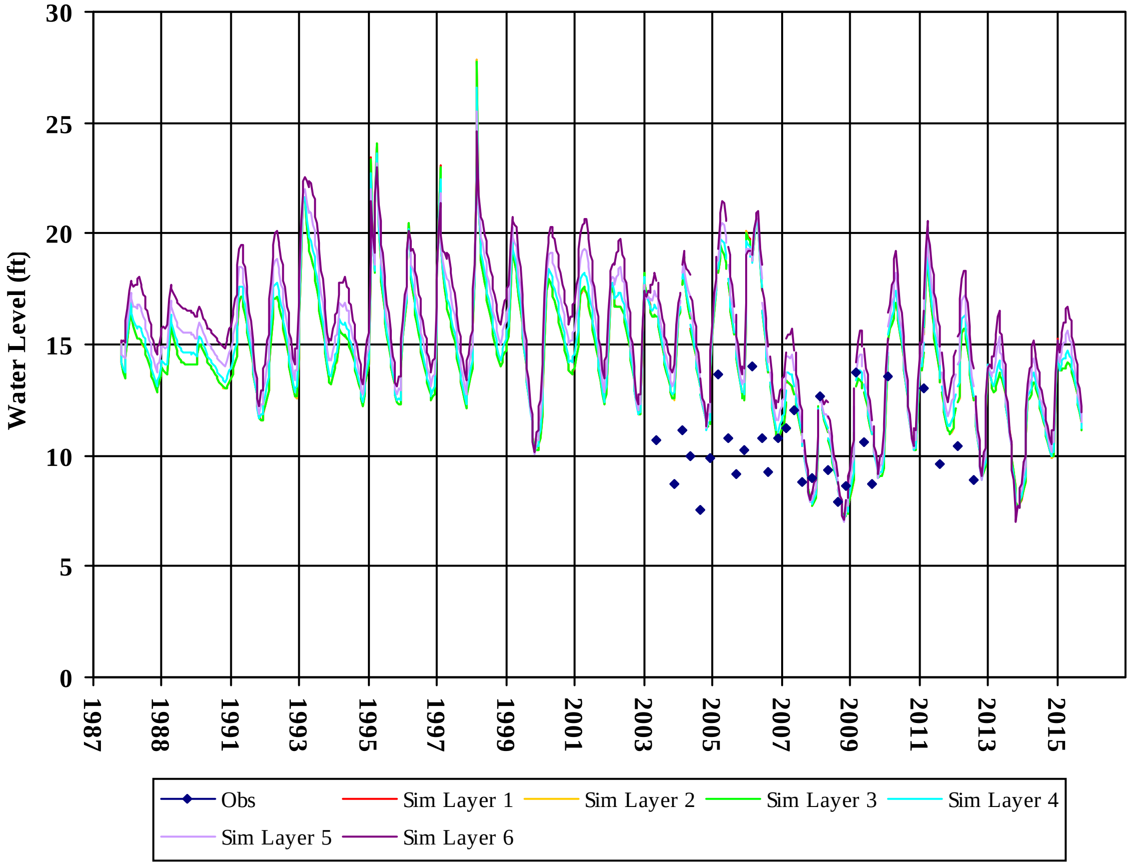
Well Depth:	15.61
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



Well Depth:	16.22
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

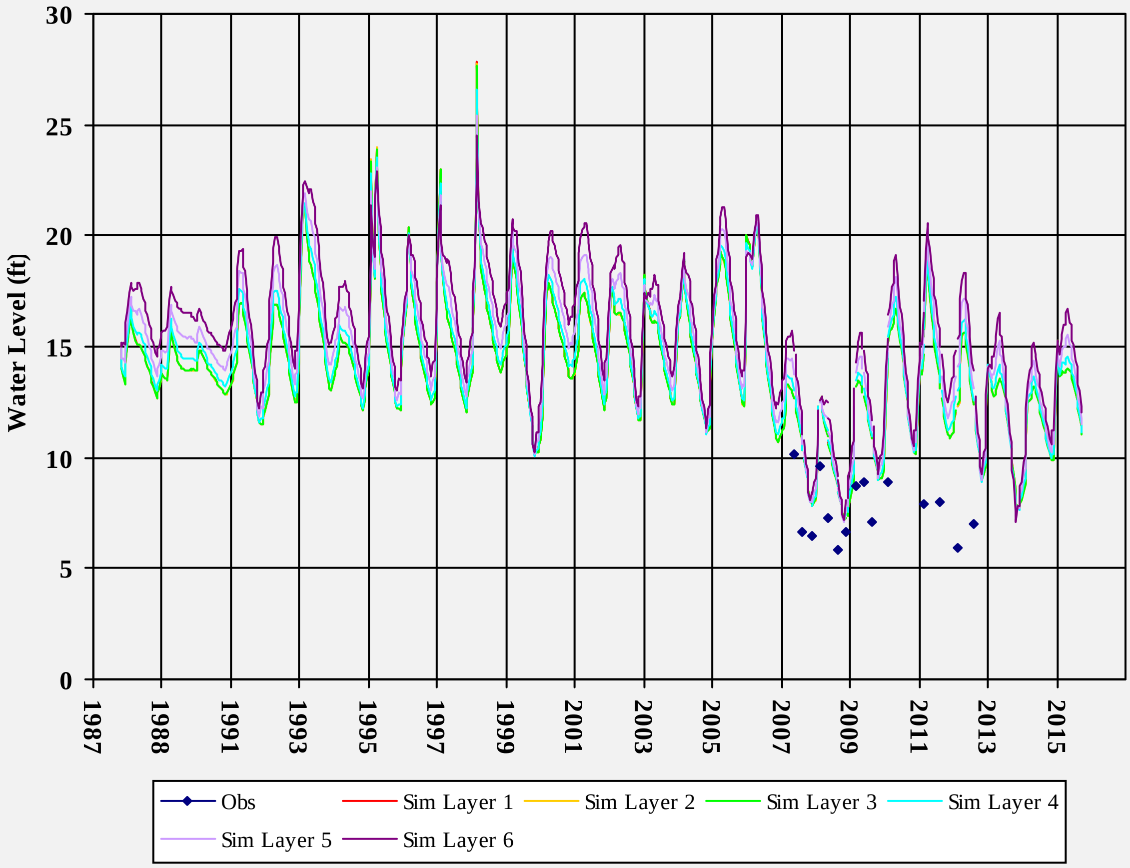


T0605500110MW-16



Well Depth:	15.61
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

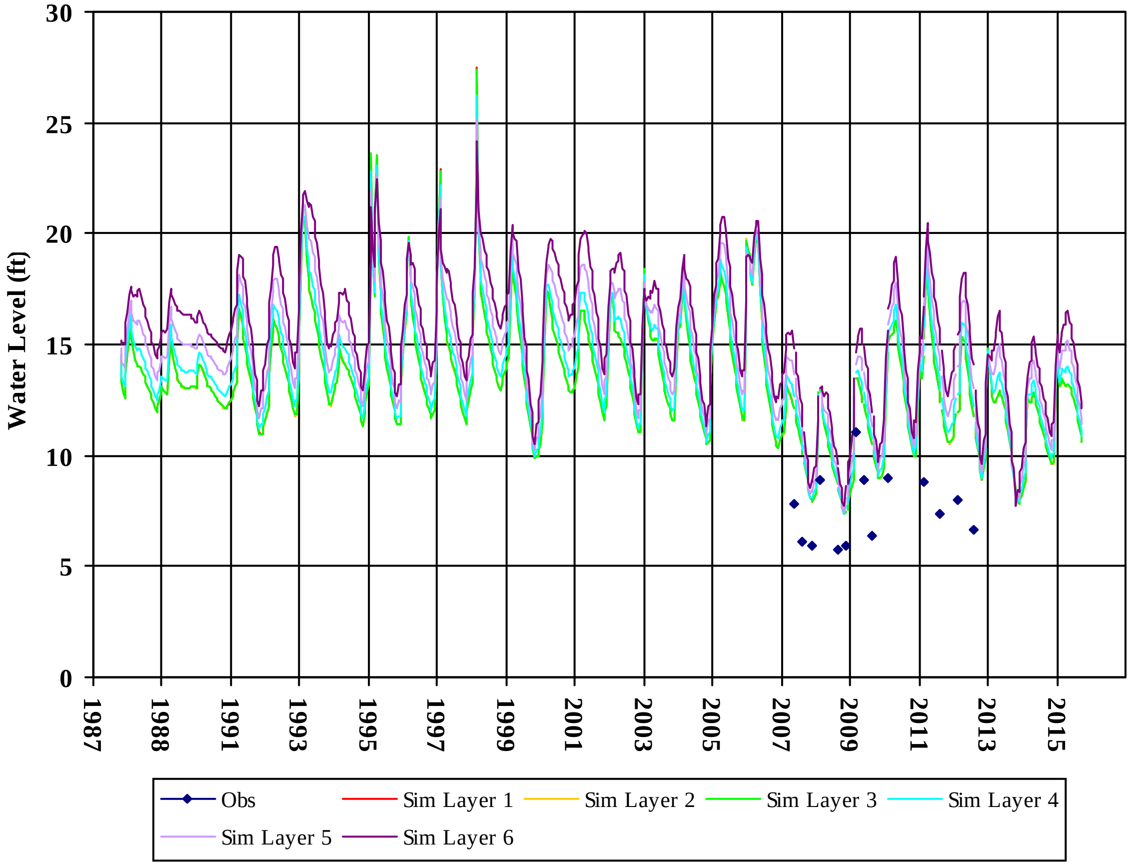
T0605500110MW-17



Well Depth:	20.37
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

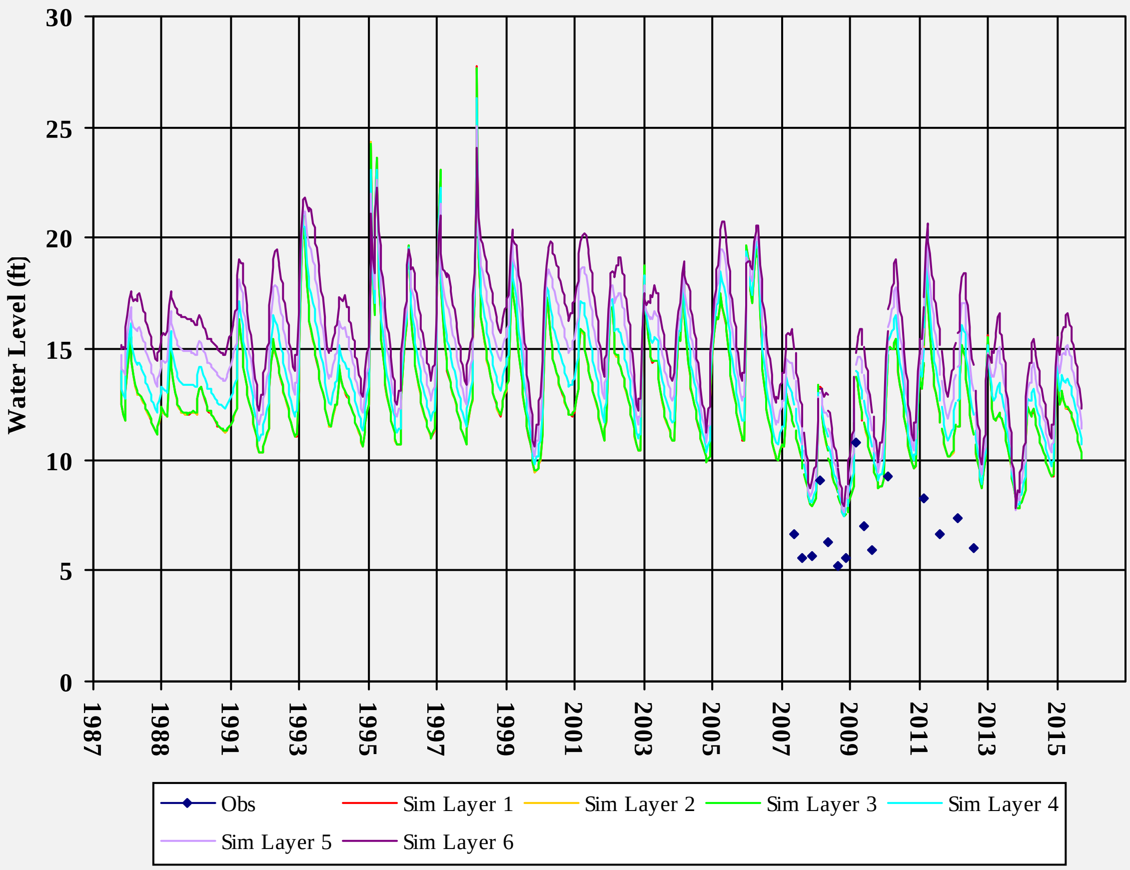
T0605500110MW-18

Well Depth:	24.77
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

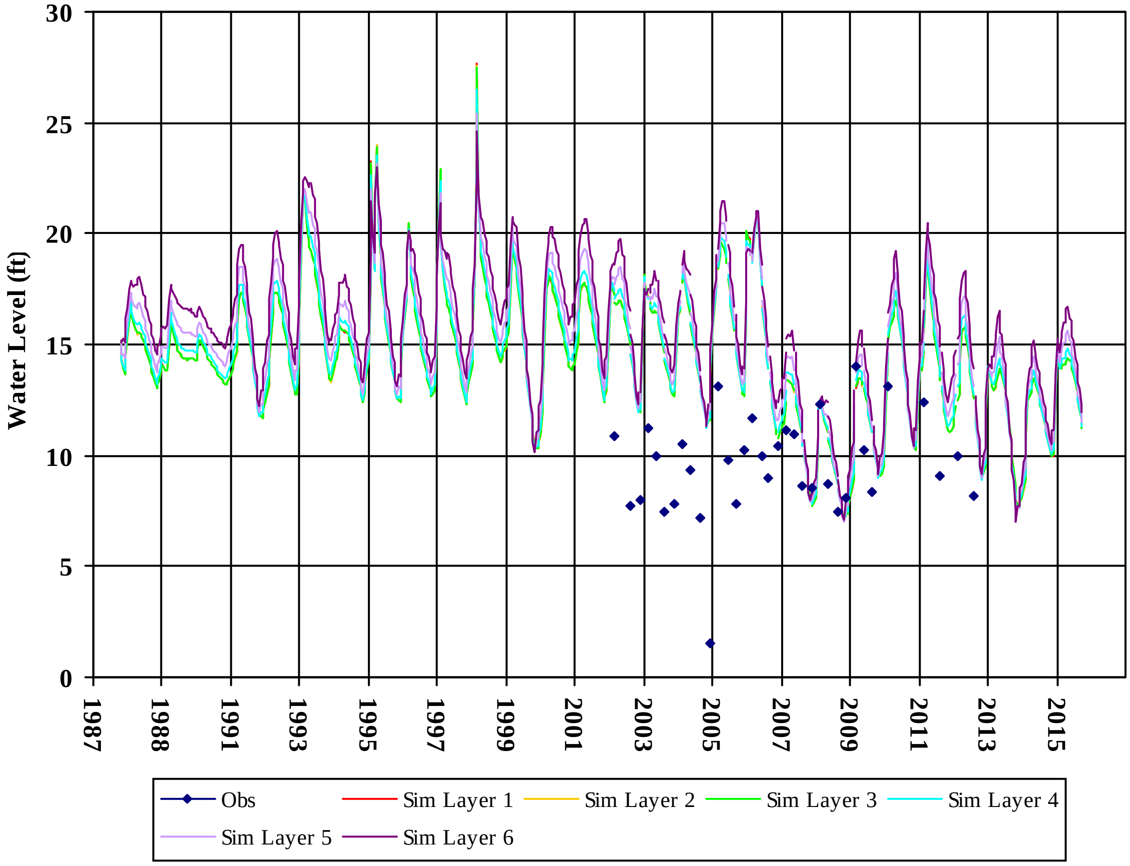


T0605500110MW-19

Well Depth:	25.34
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

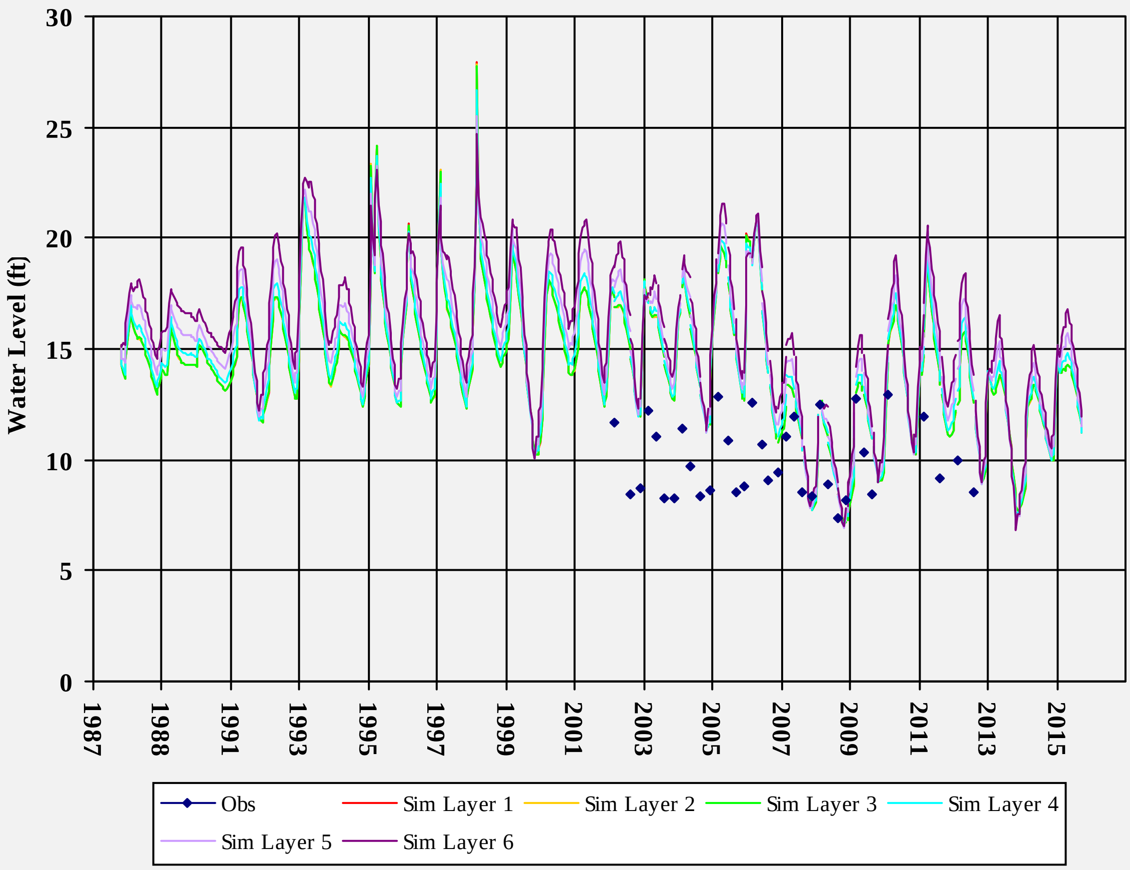


T0605500110MW-3

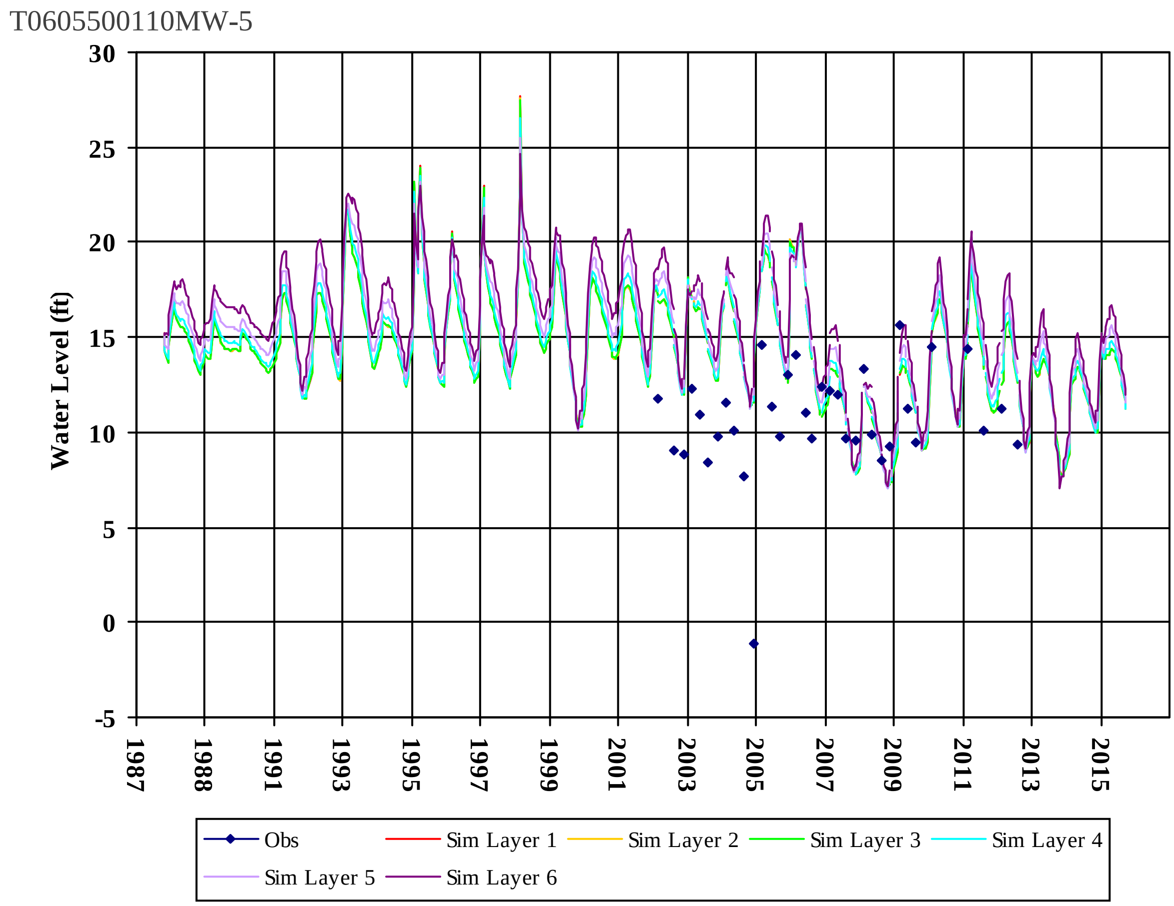


Well Depth: 23.88
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

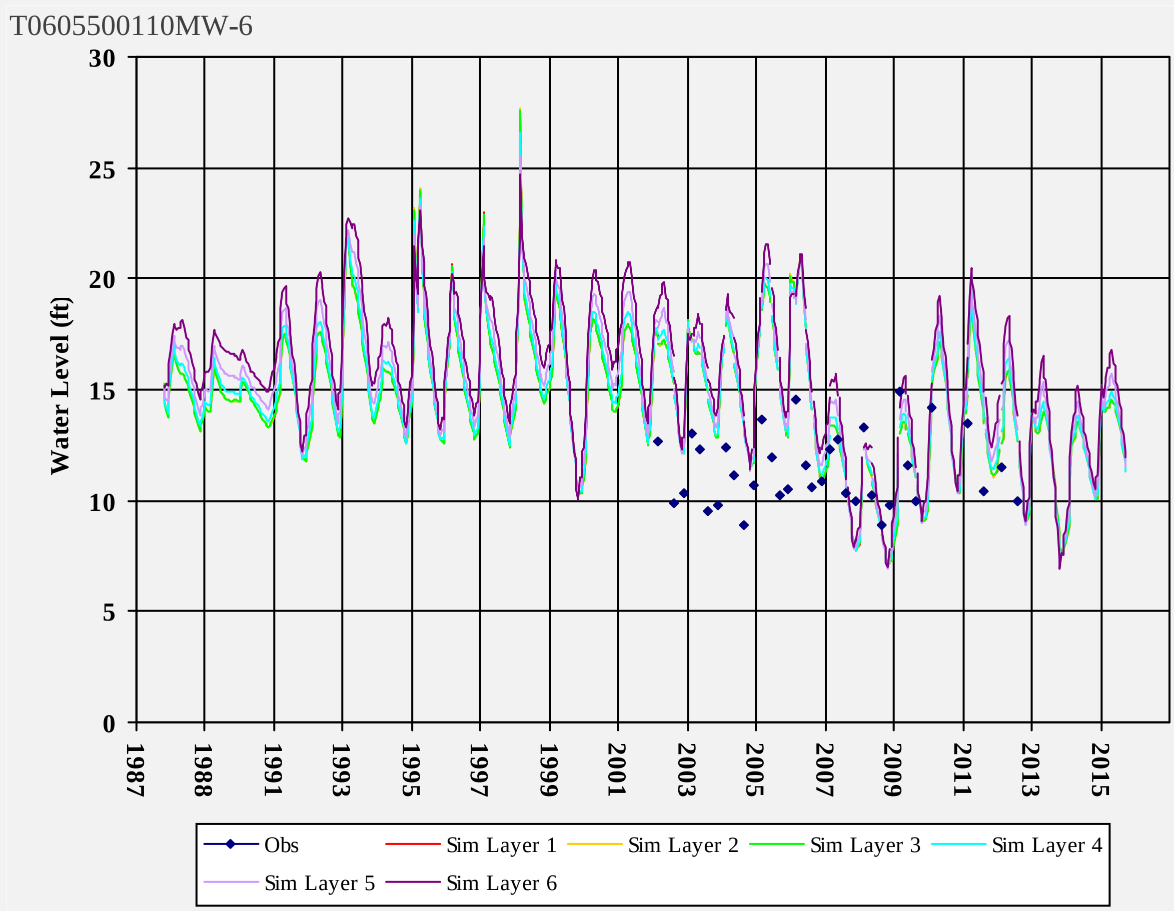
T0605500110MW-4



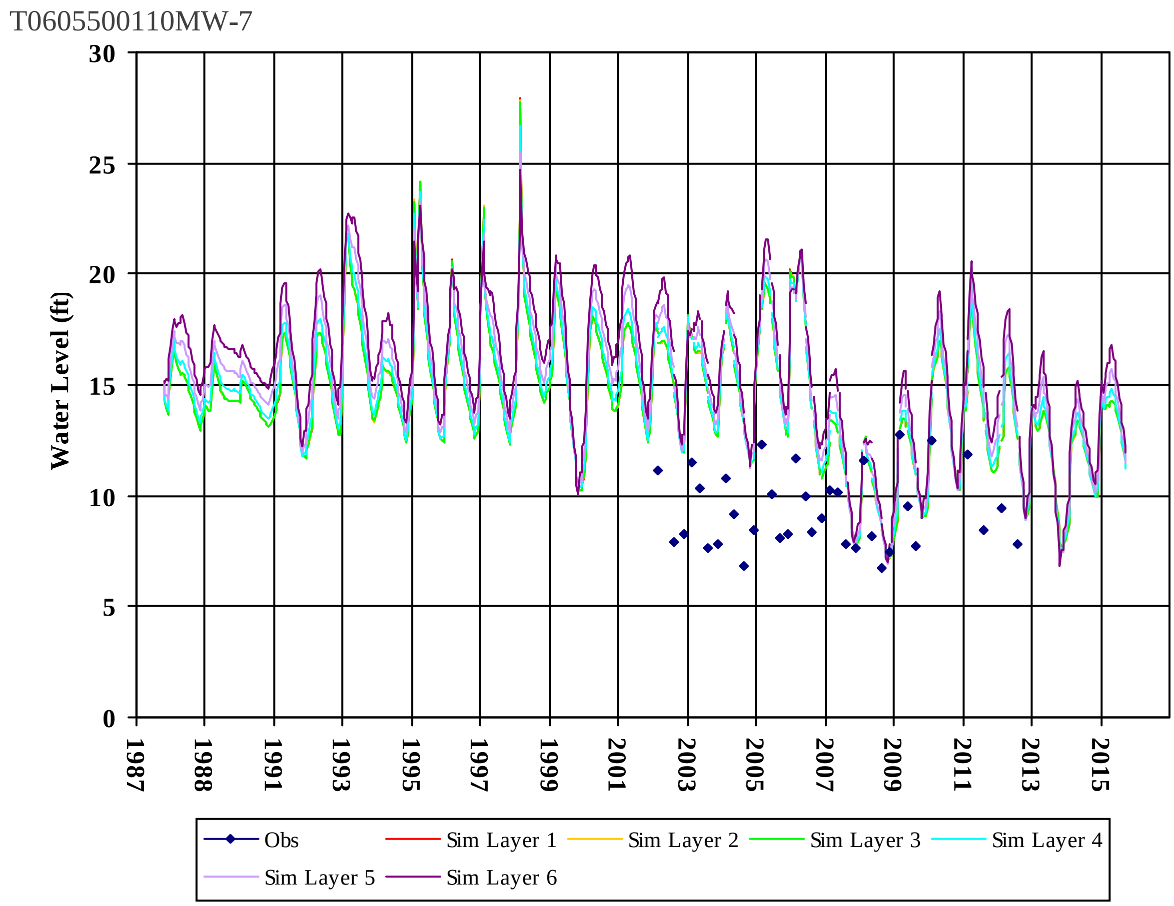
Well Depth: 24.28
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



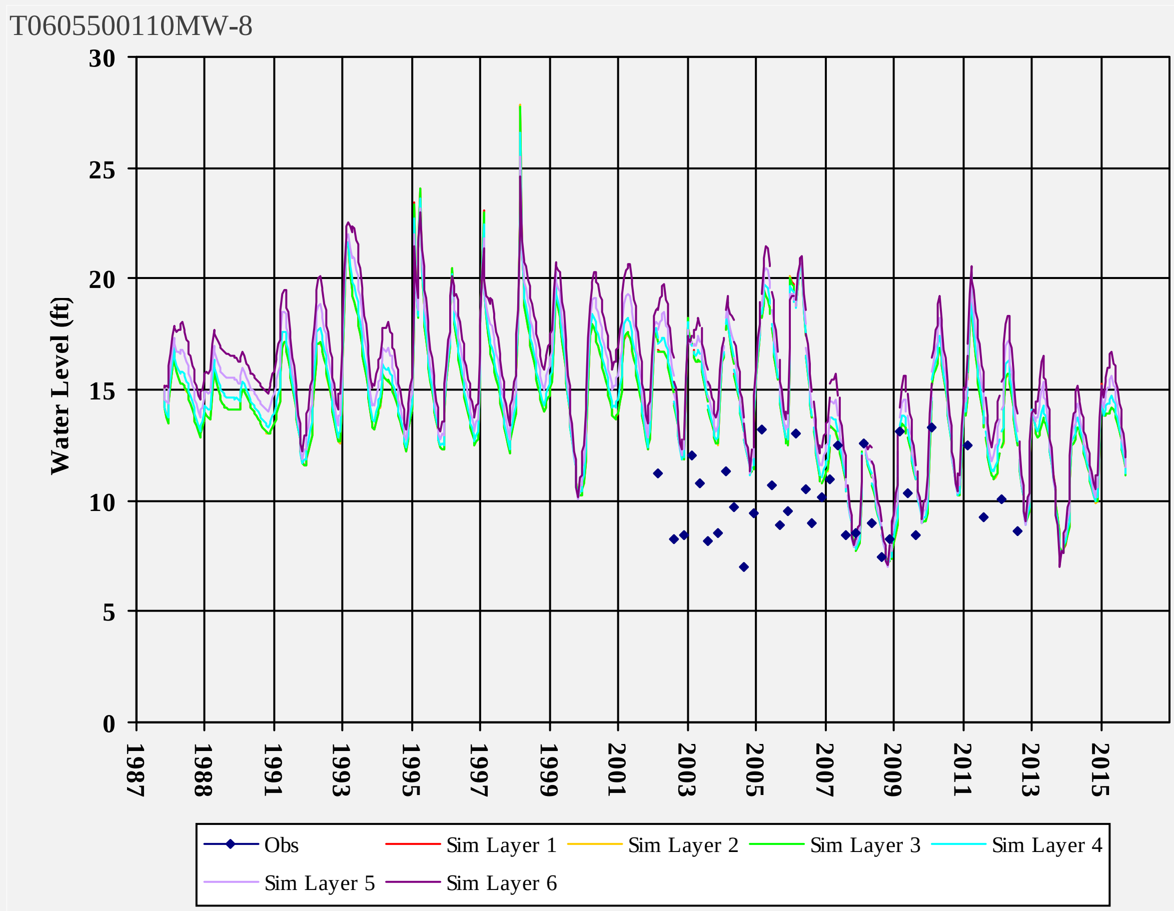
Well Depth: 23.68
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth: 24.04
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

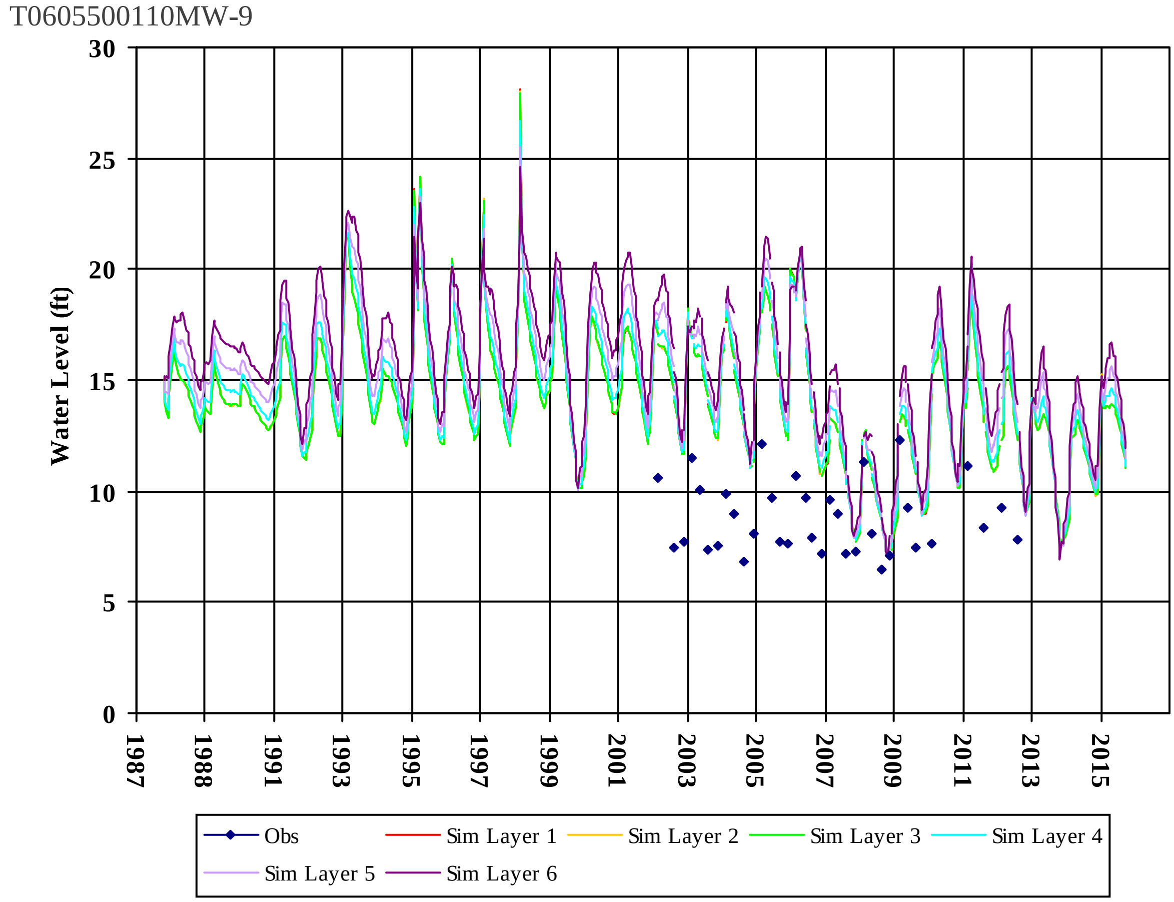


Well Depth: 15.51
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

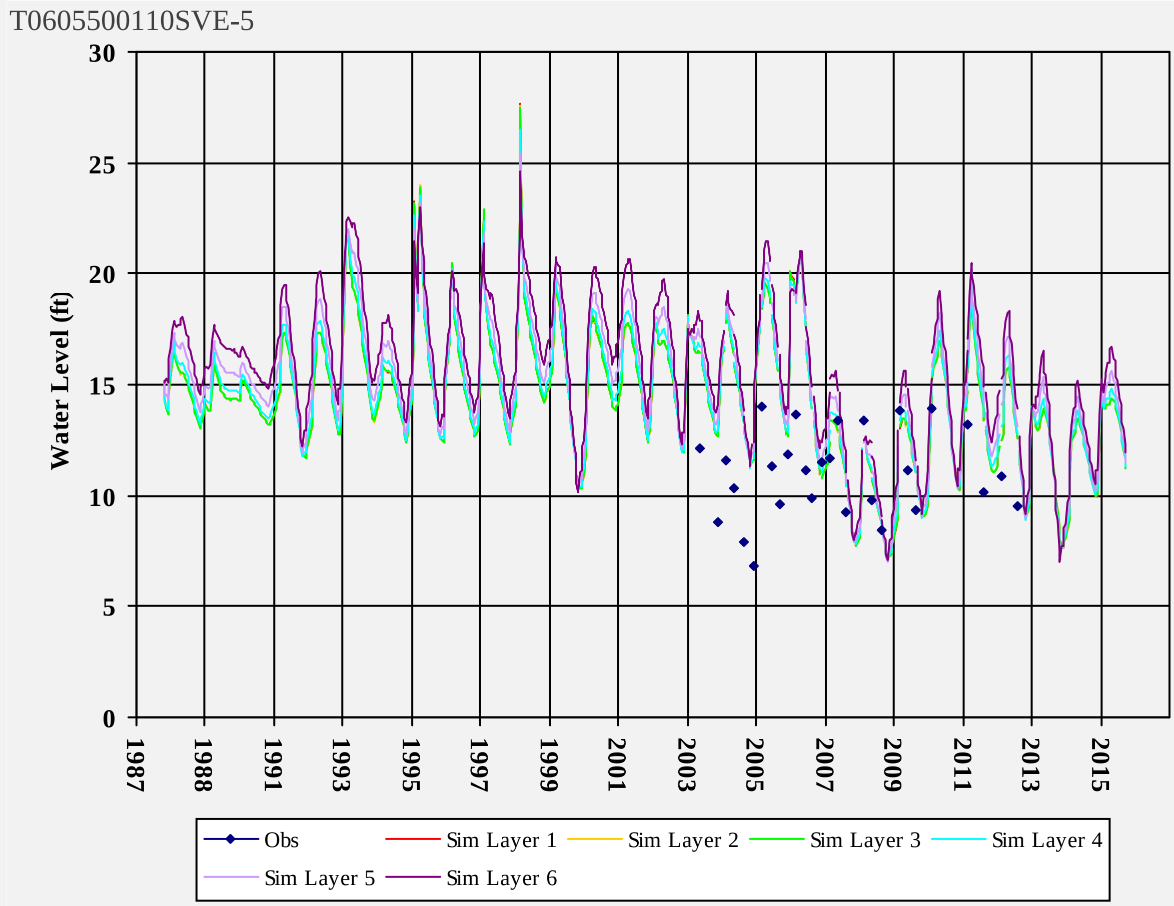


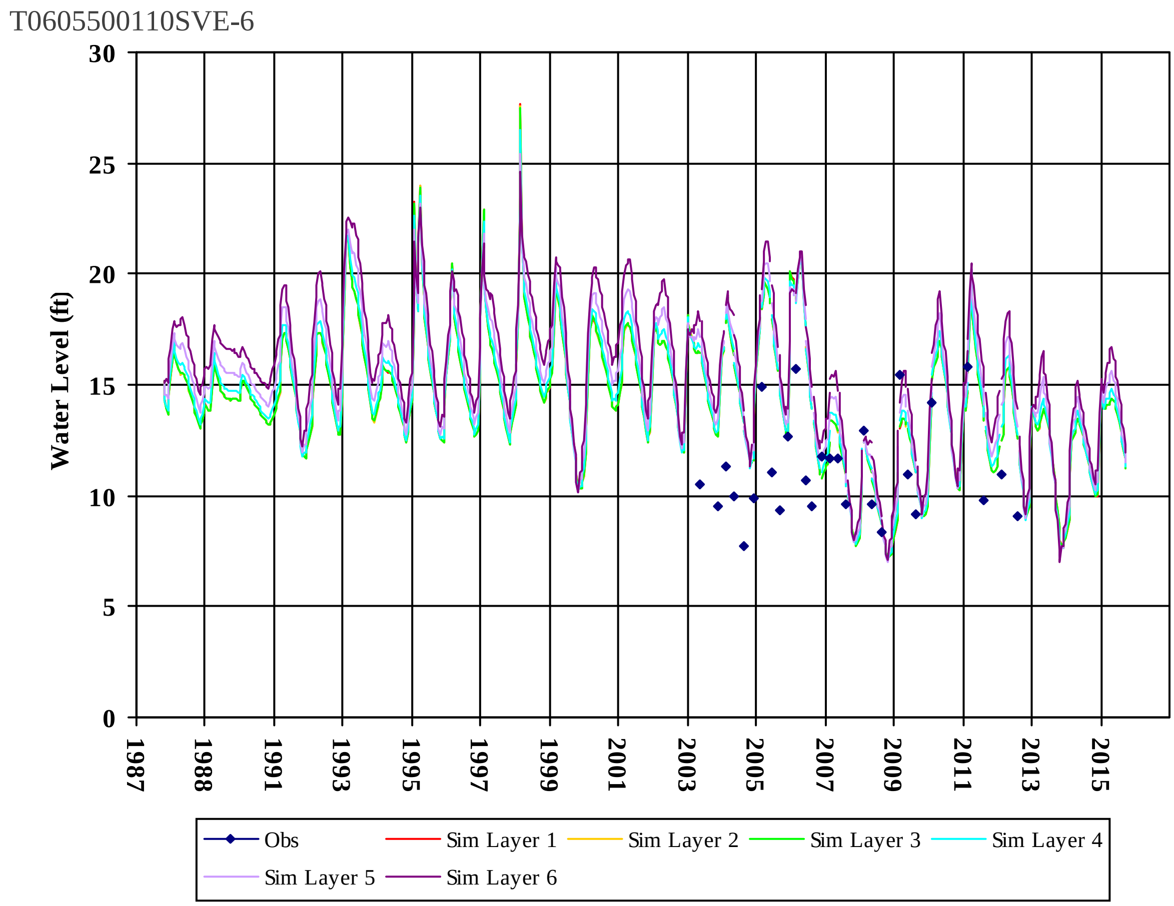
Well Depth: 15.29
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

Well Depth: 23.51
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

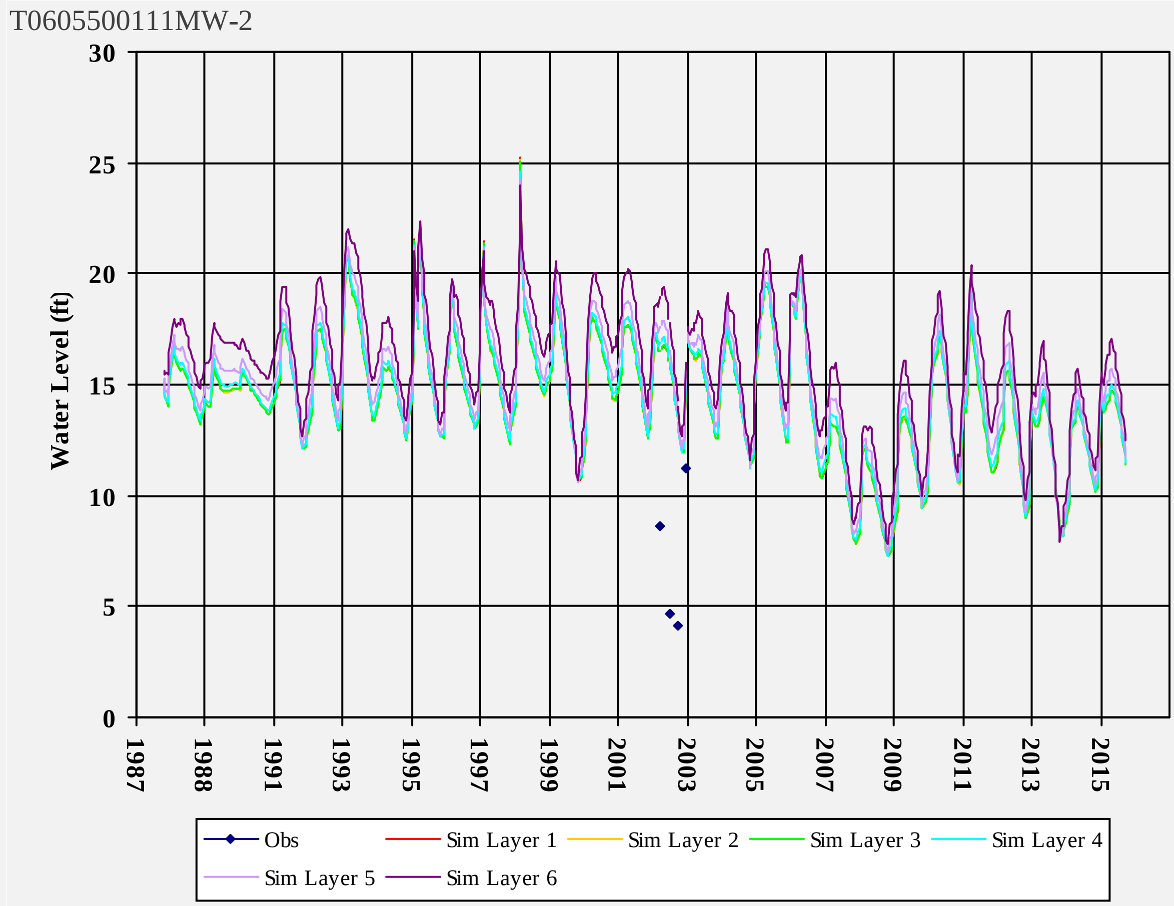


Well Depth: 14.91
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

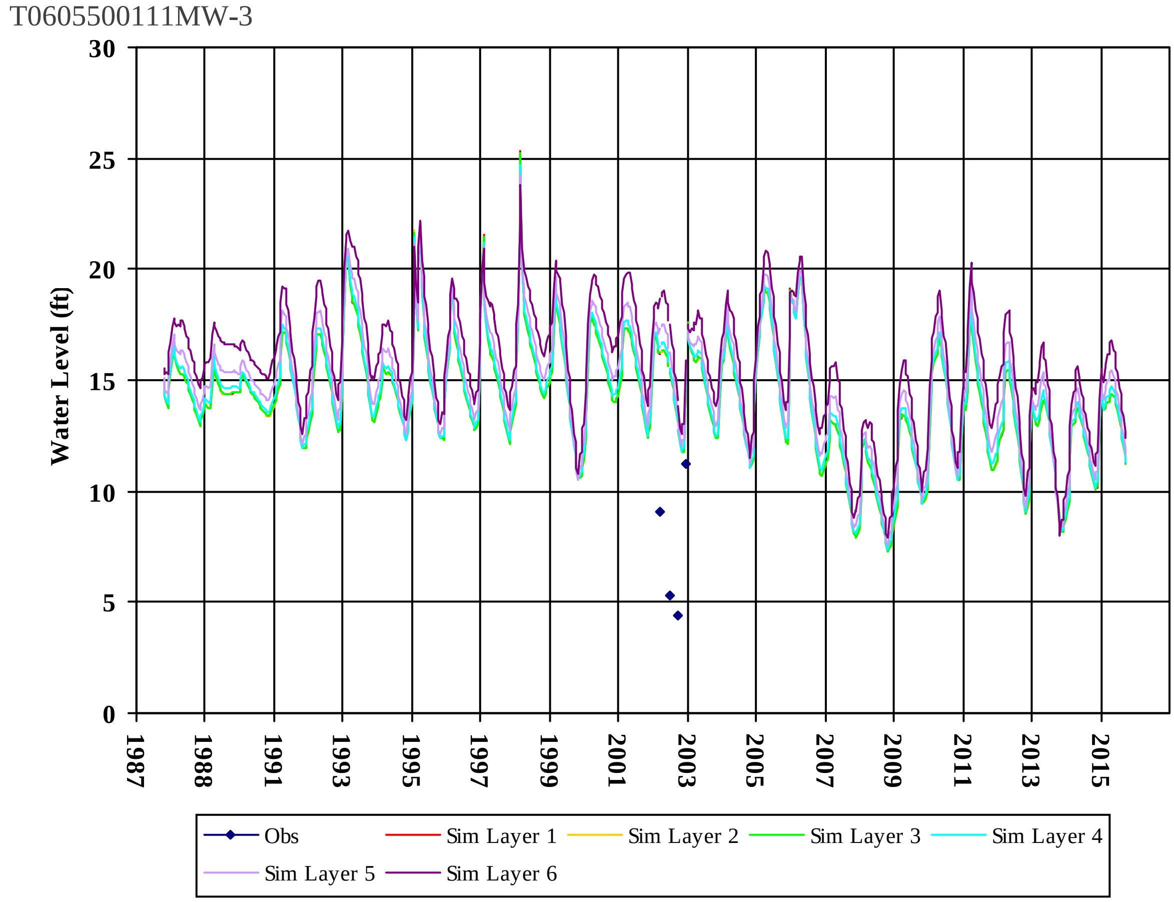




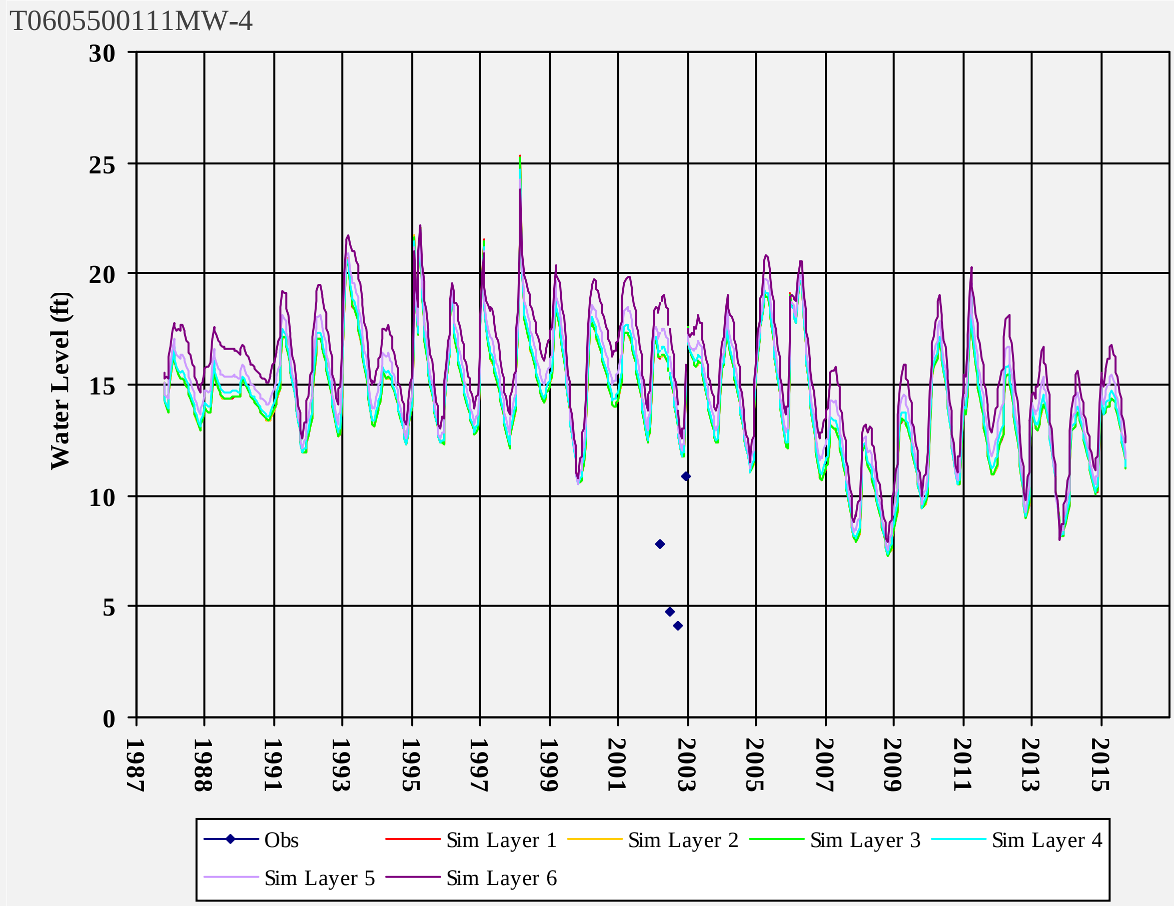
Well Depth: 15.16
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



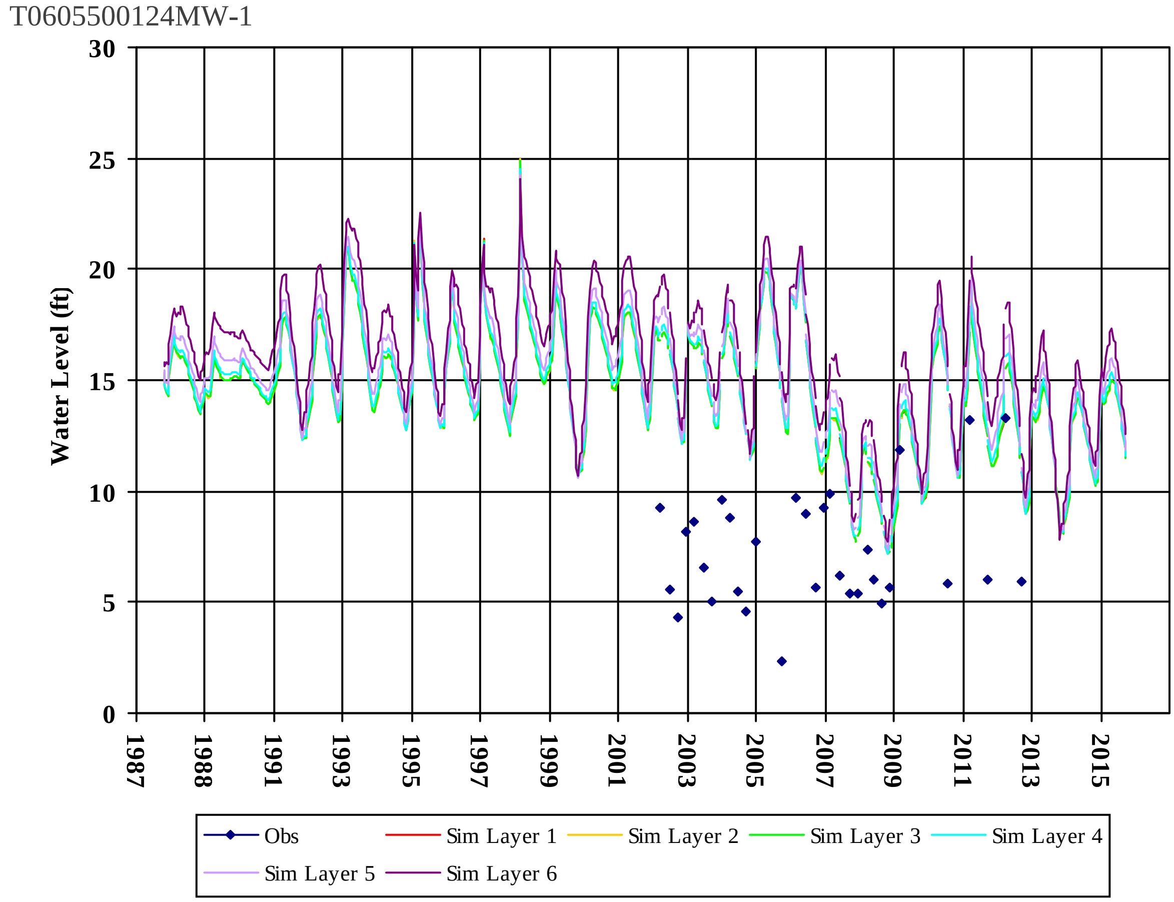
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



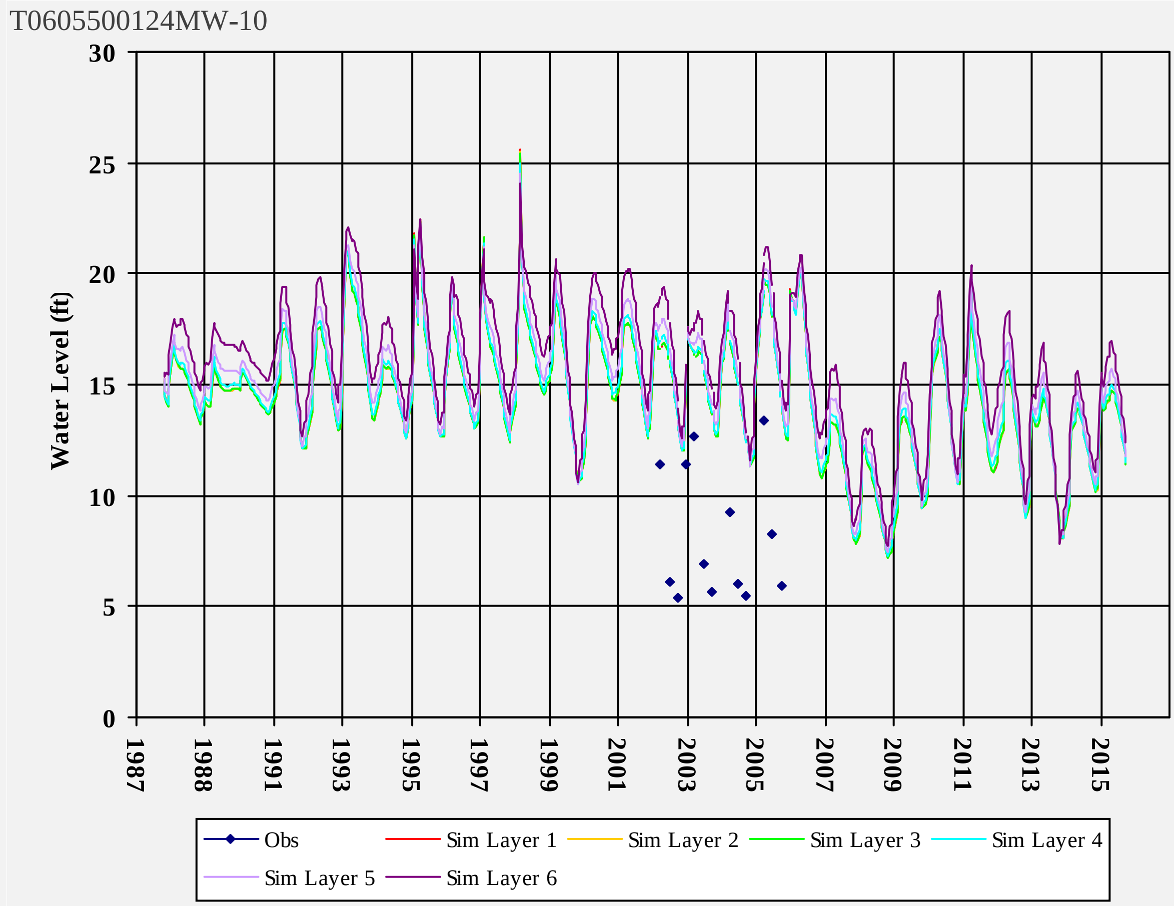
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



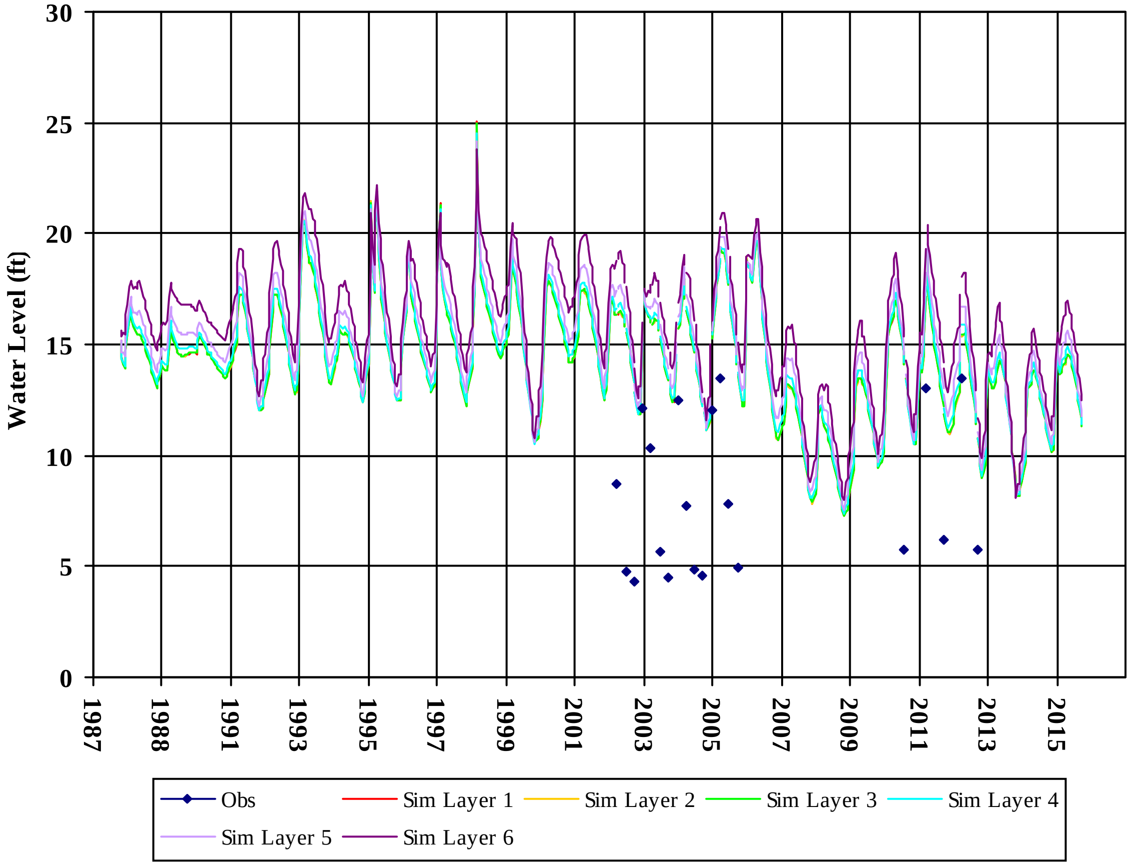
Well Depth:	25
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

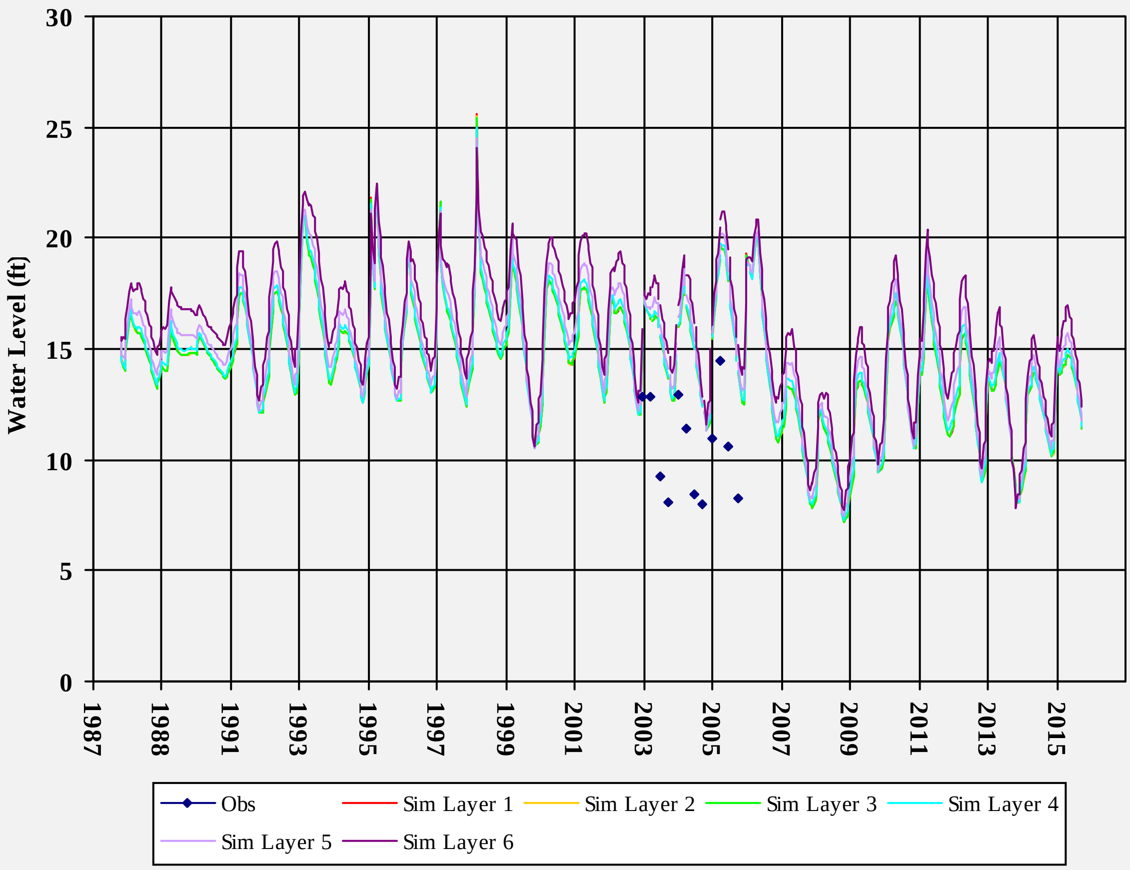
T0605500124MW-11

Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

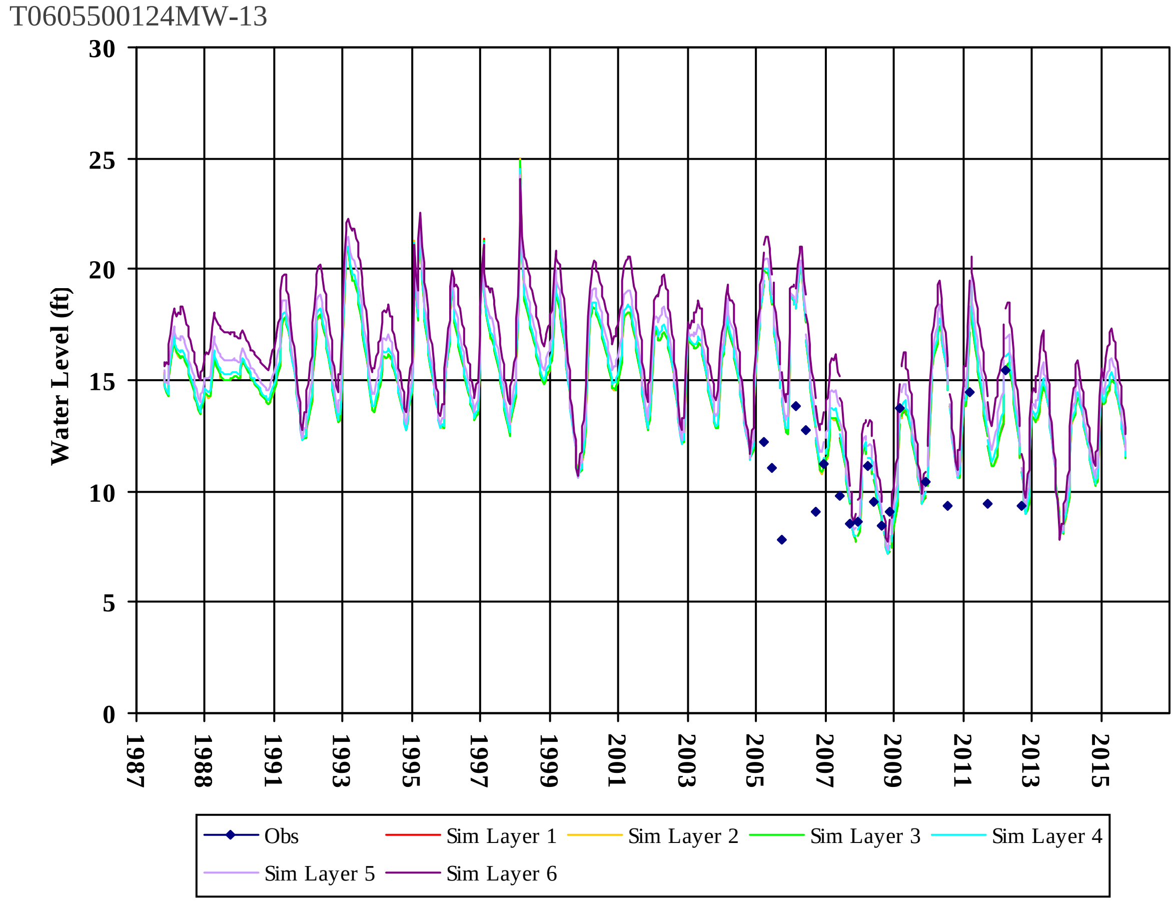


T0605500124MW-12

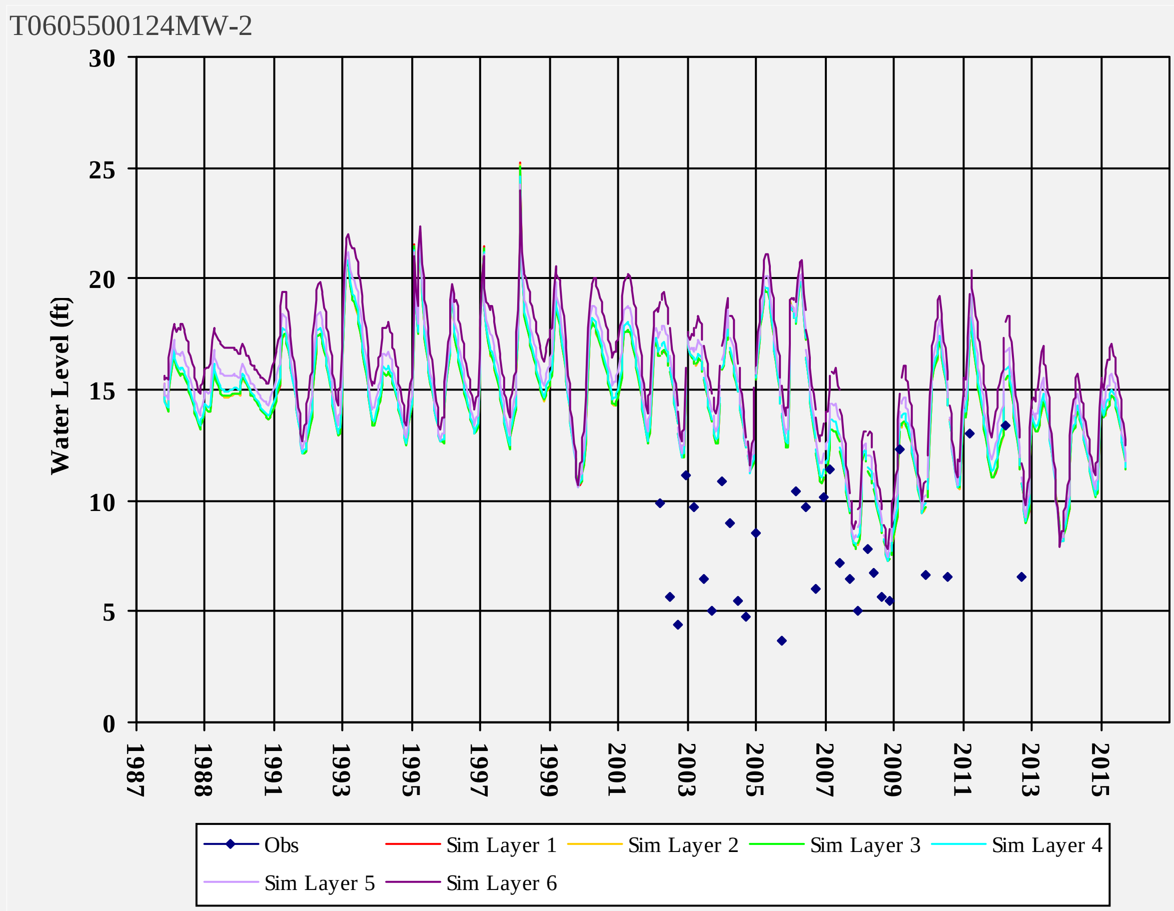
Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



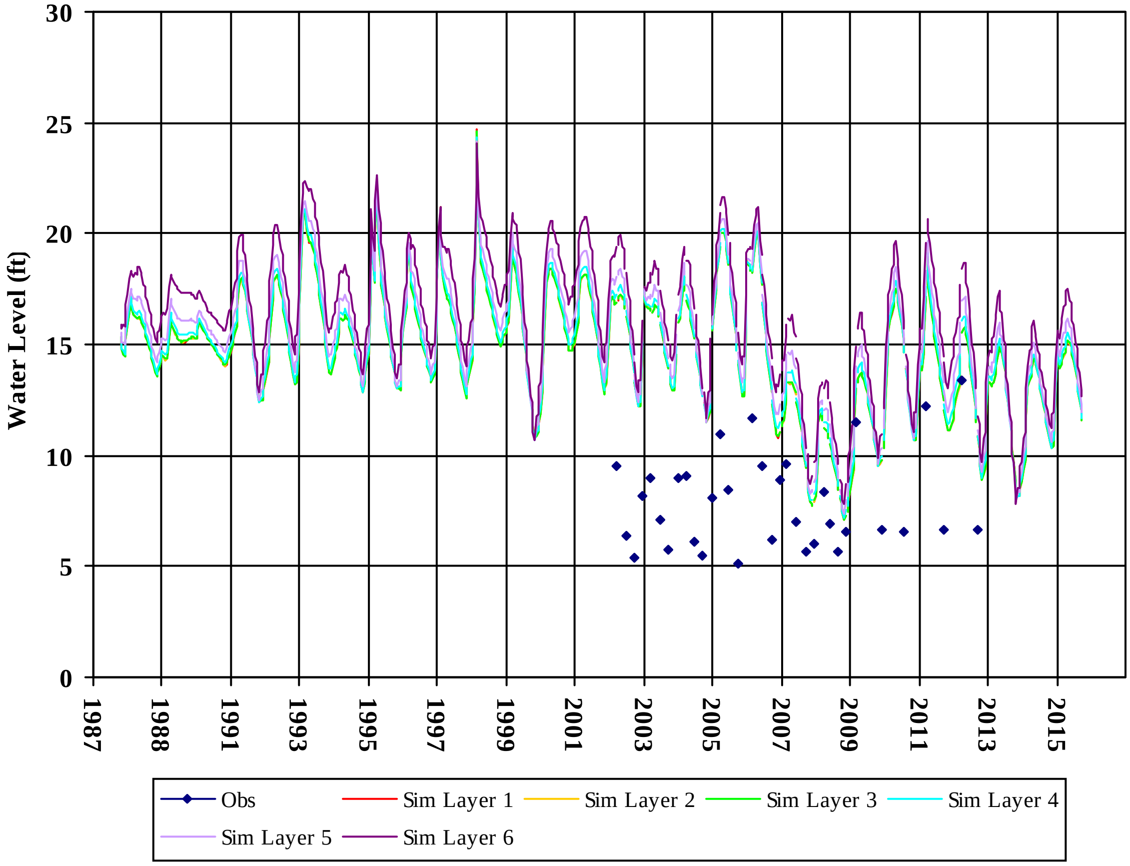
Well Depth: 15.5
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth: 25
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

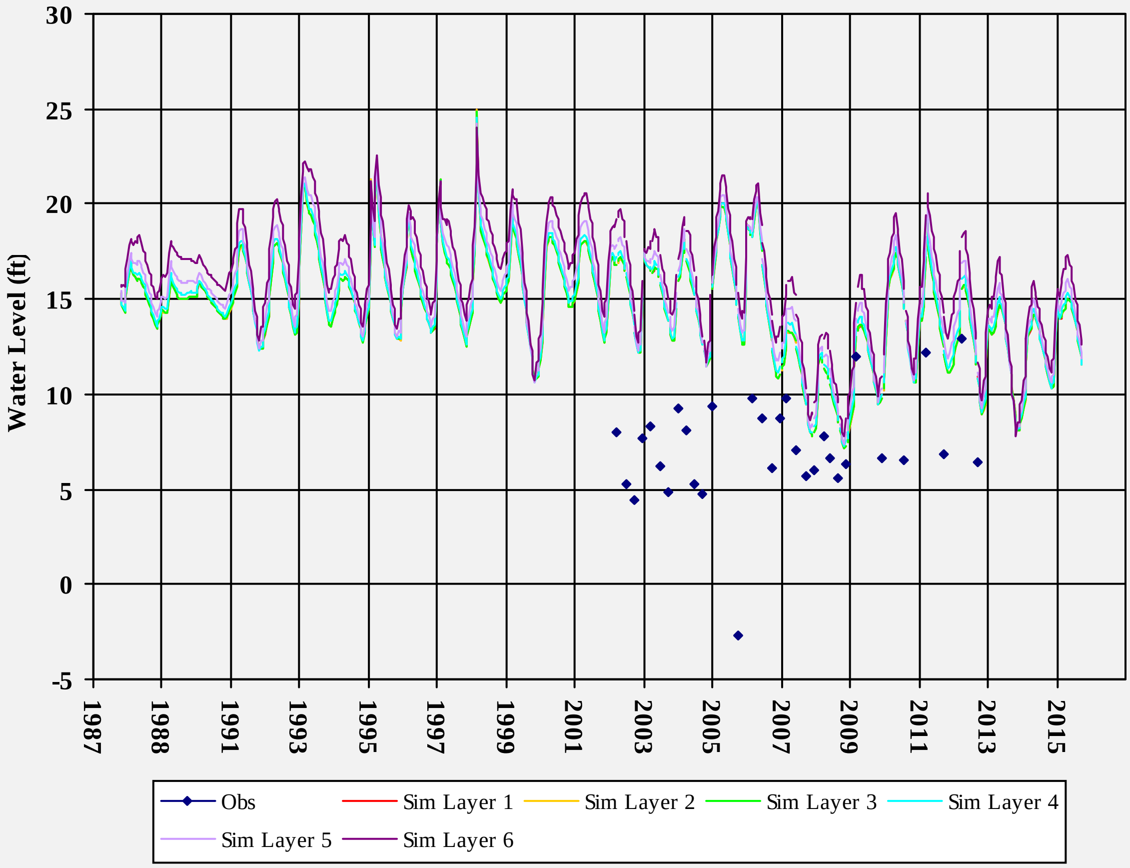


T0605500124MW-3



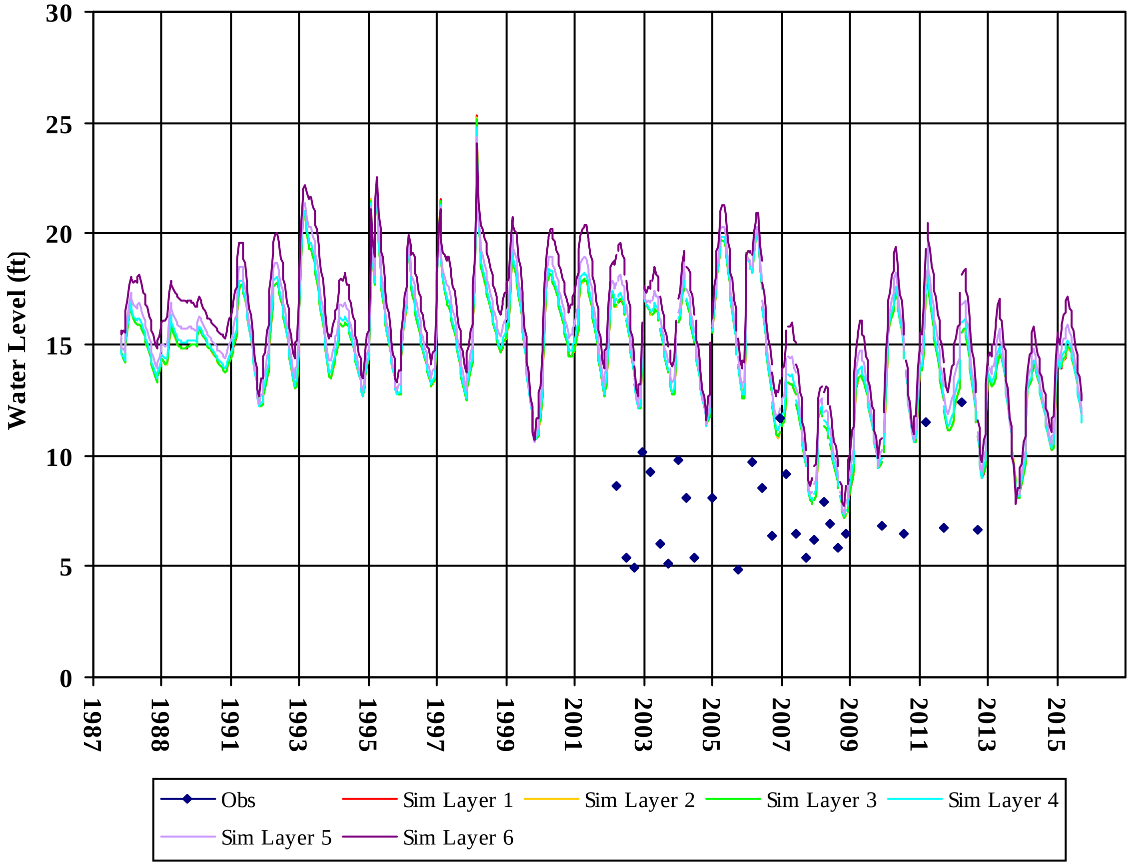
Well Depth: 25
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500124MW-4



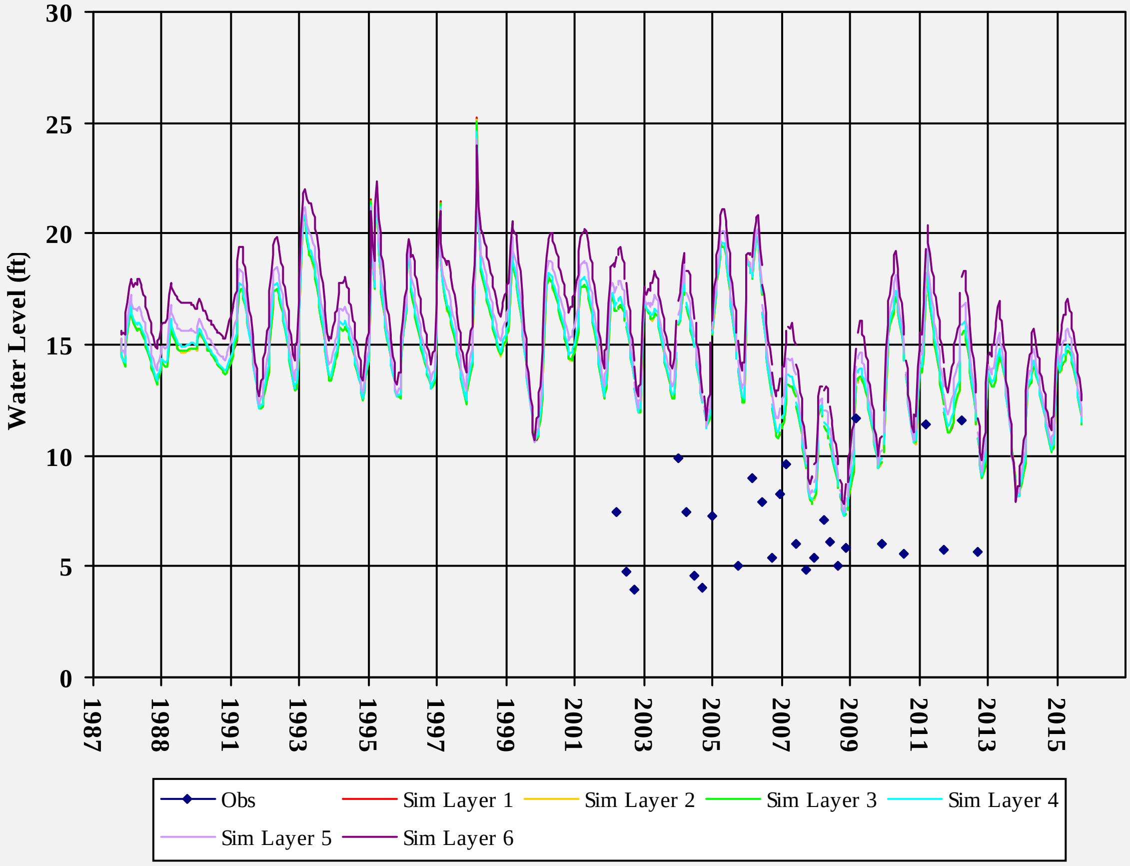
Well Depth: 30
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500124MW-5



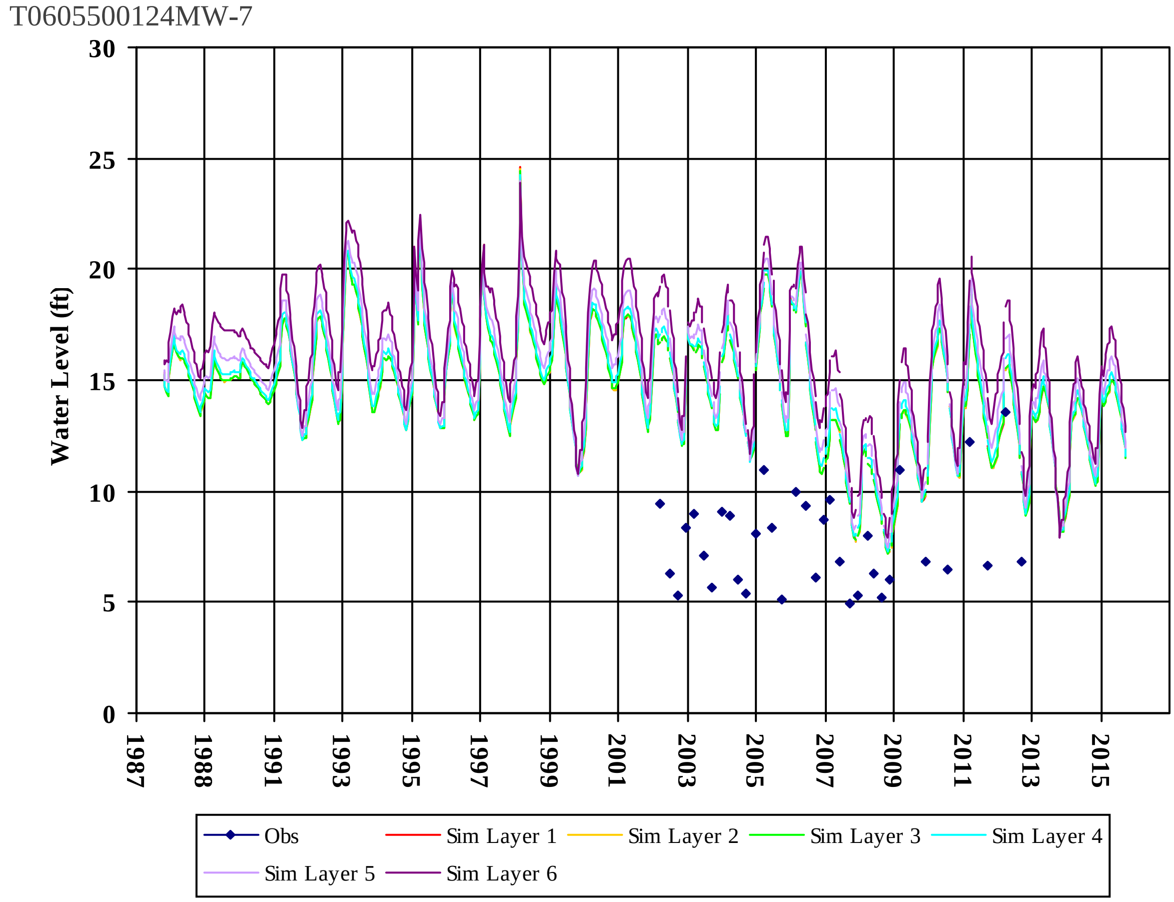
Well Depth:	30
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

T0605500124MW-6

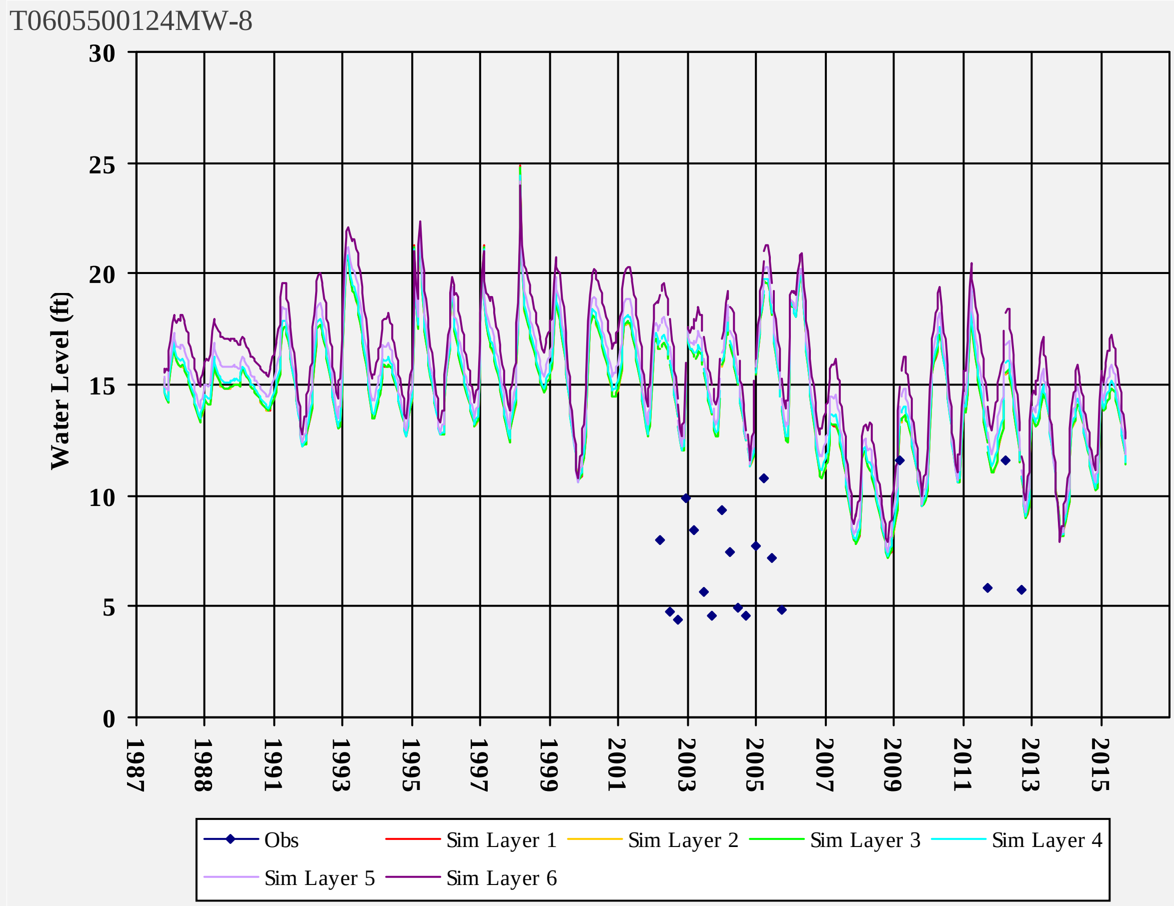


Well Depth:	25
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

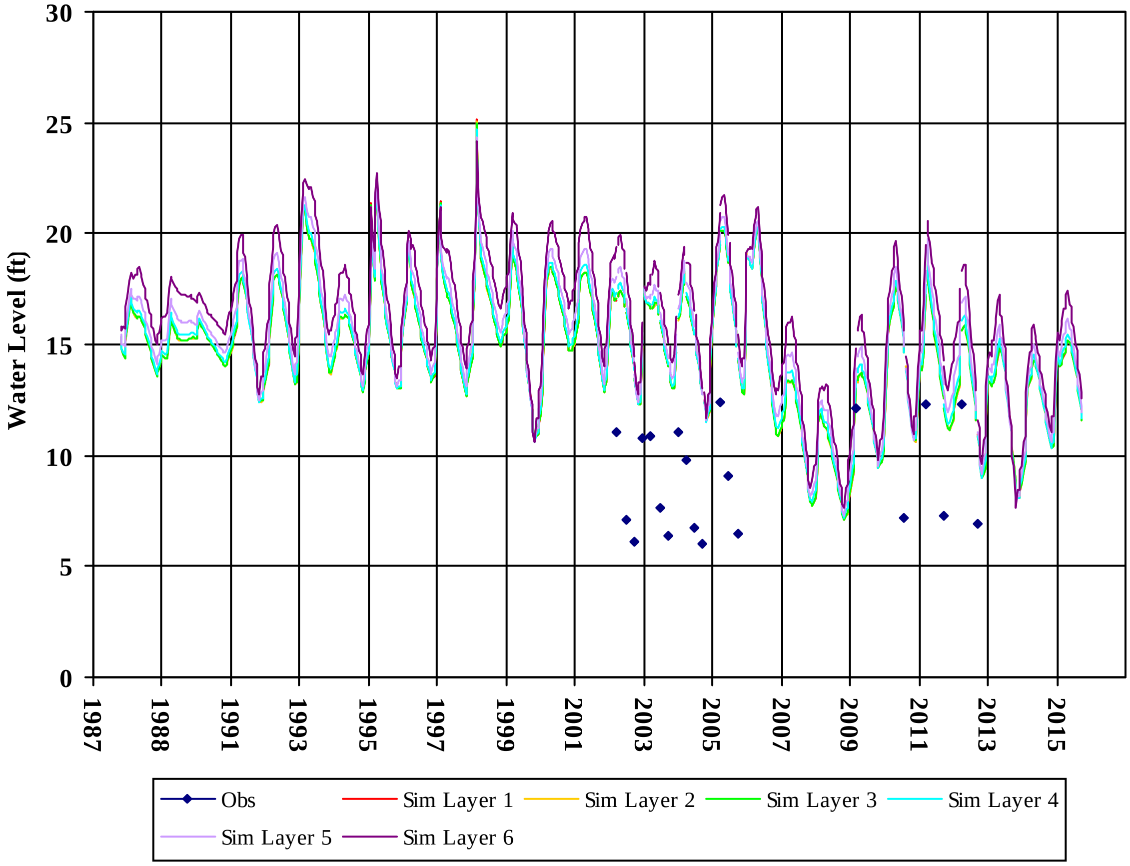
Well Depth: 30
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

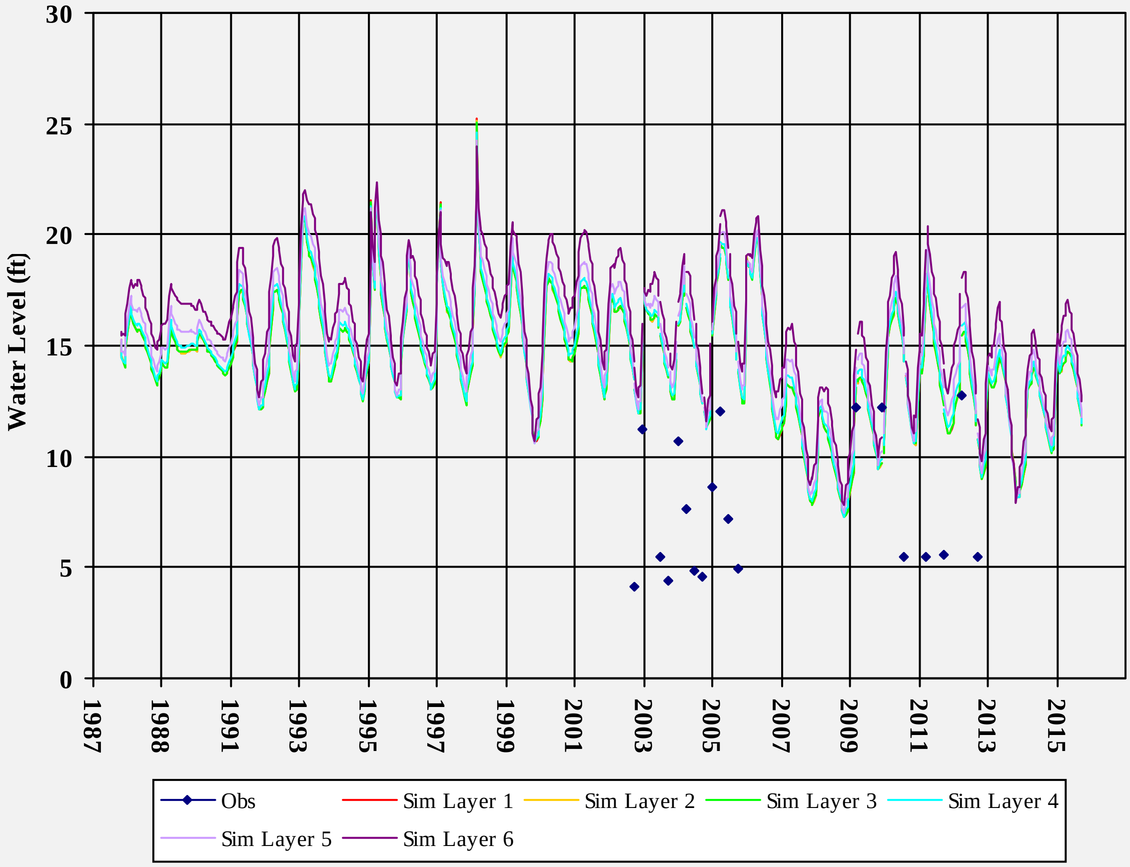


T0605500124MW-9



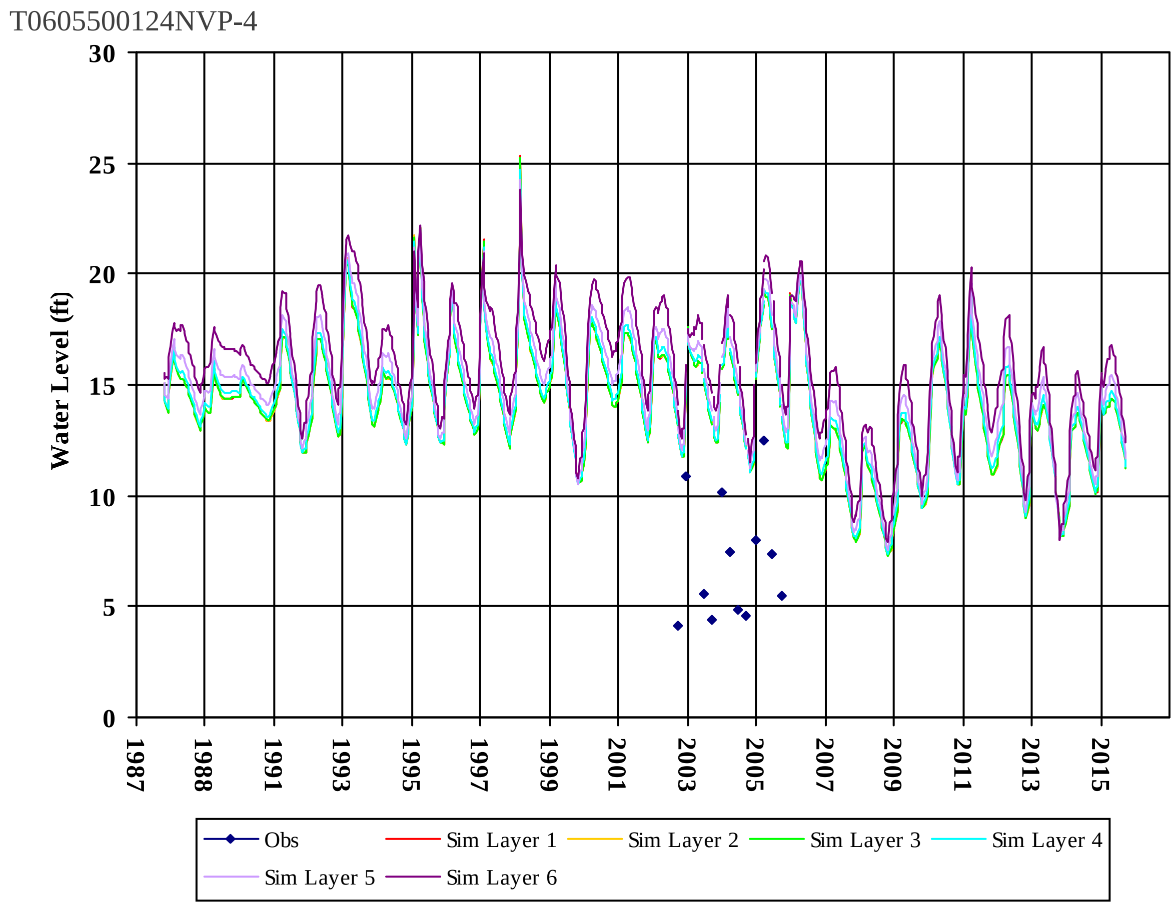
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500124NVP-2

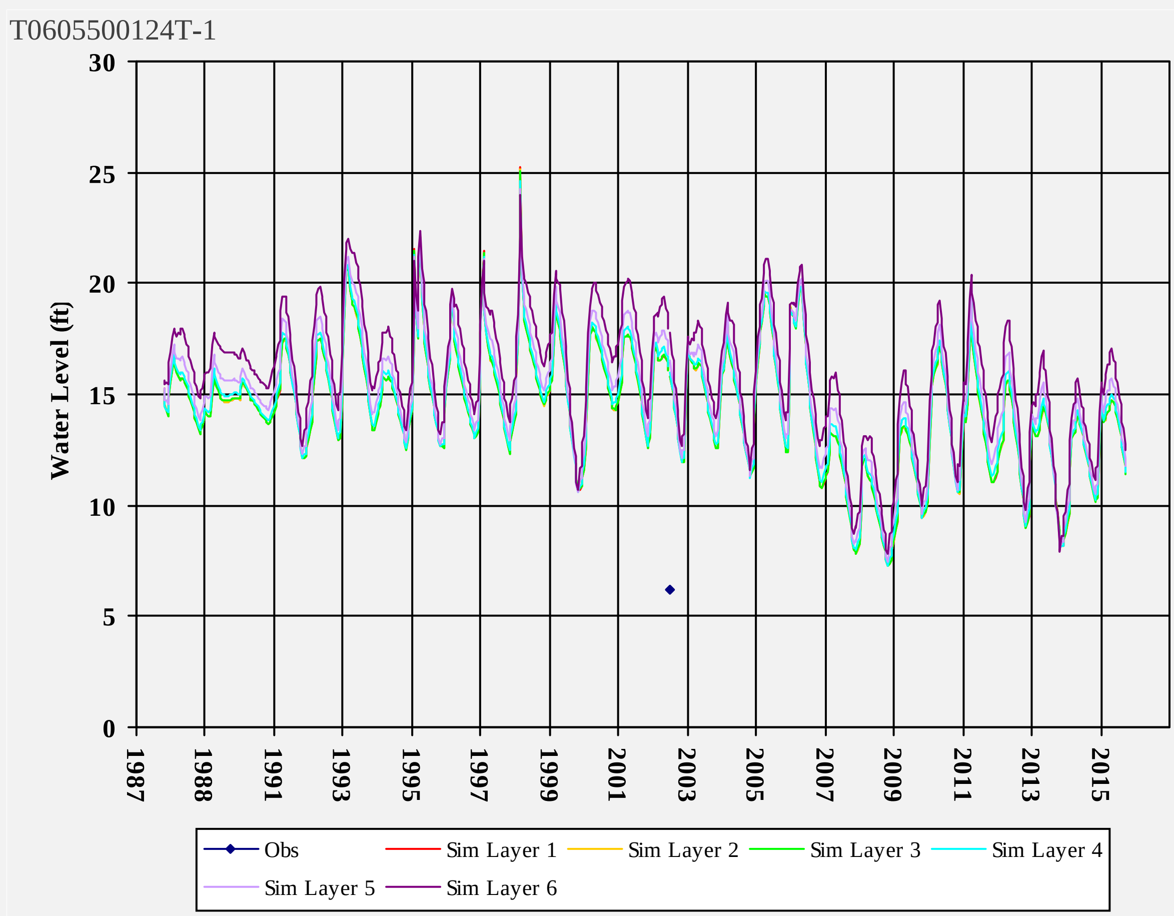


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

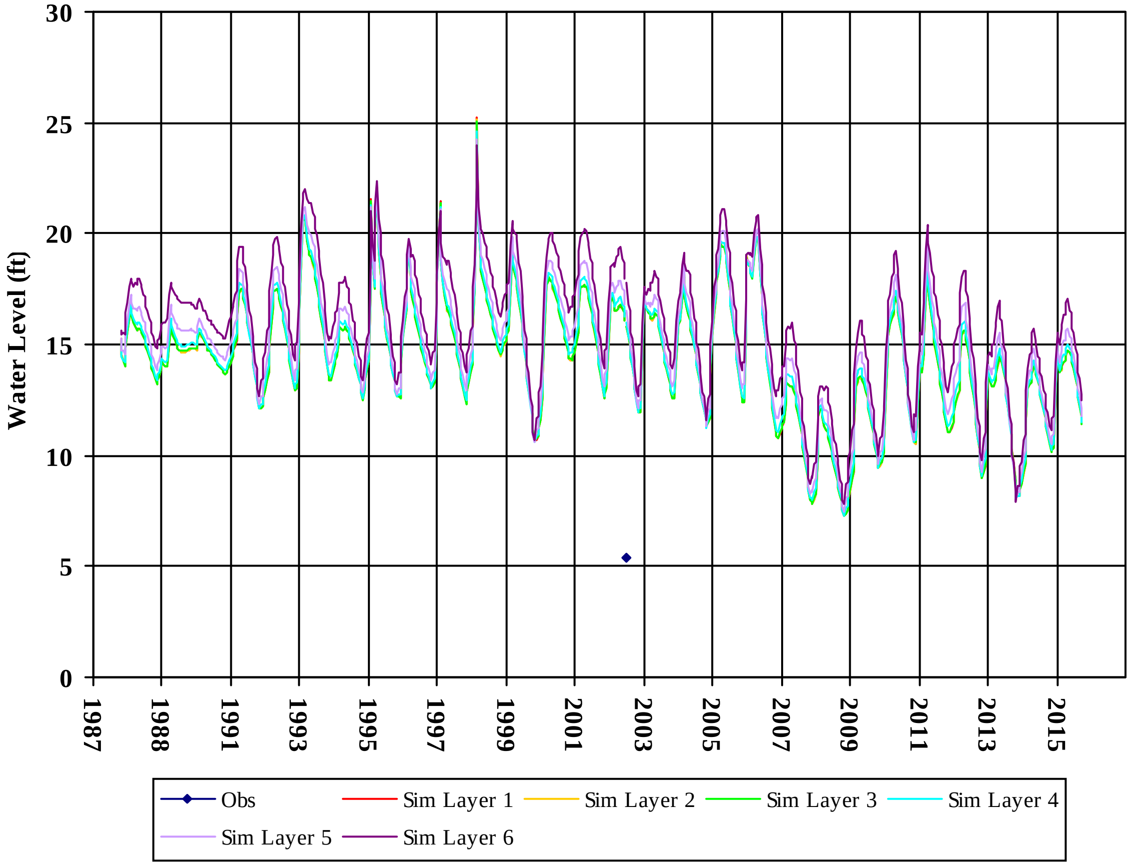
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

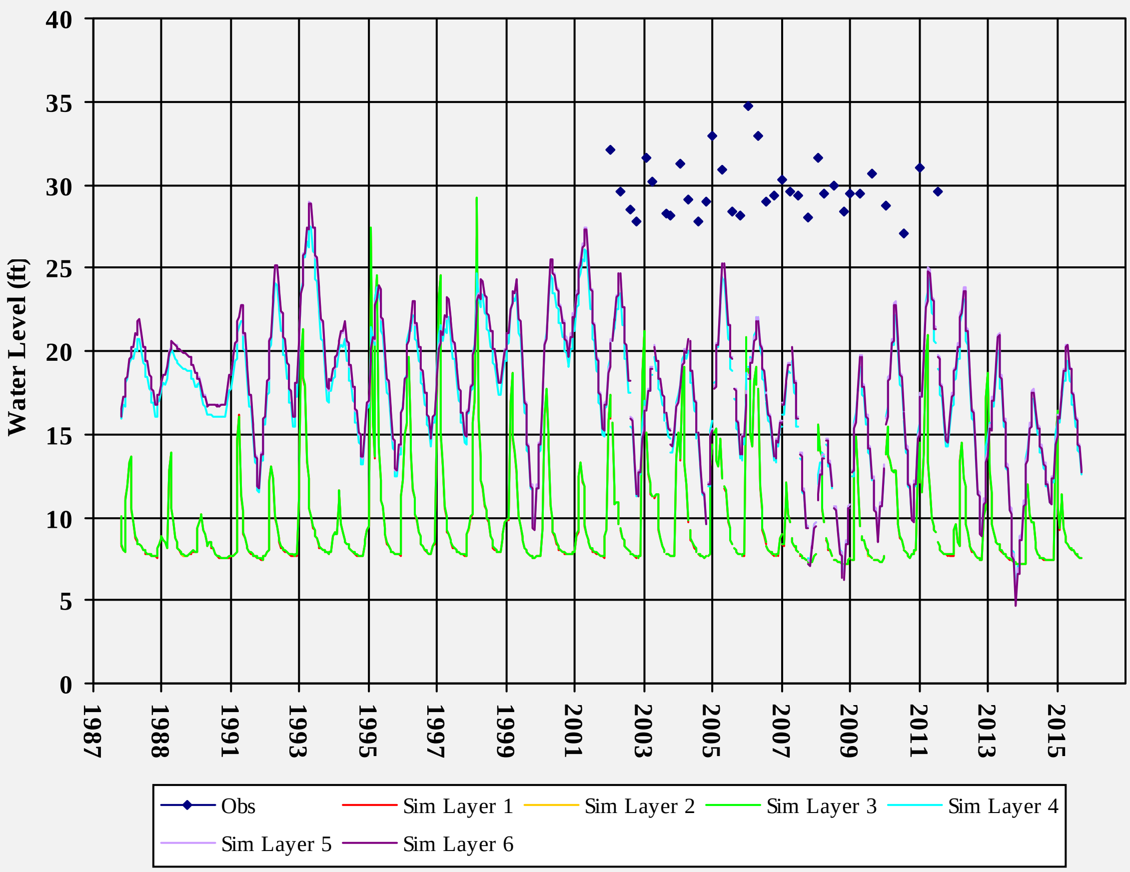


T0605500124T-2



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138MW-1



Well Depth:
Hole Depth:
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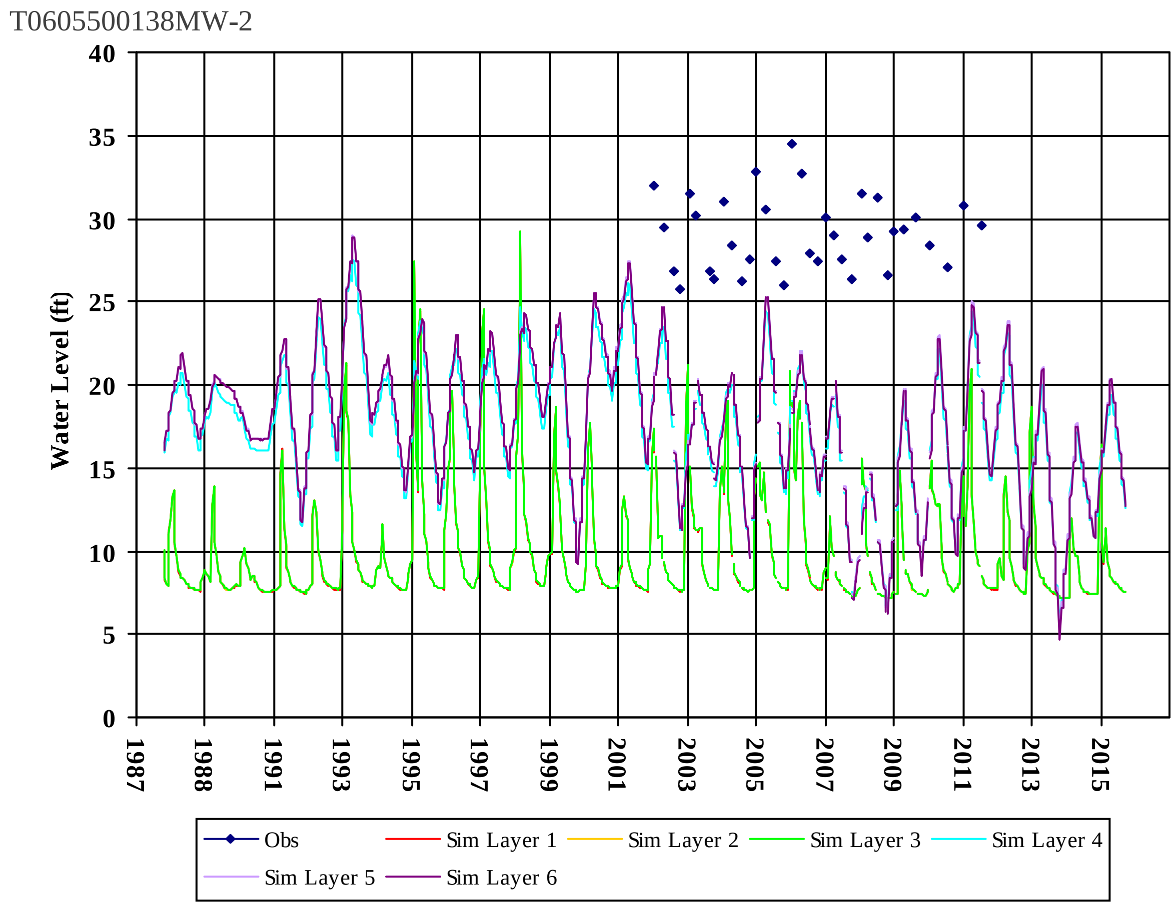
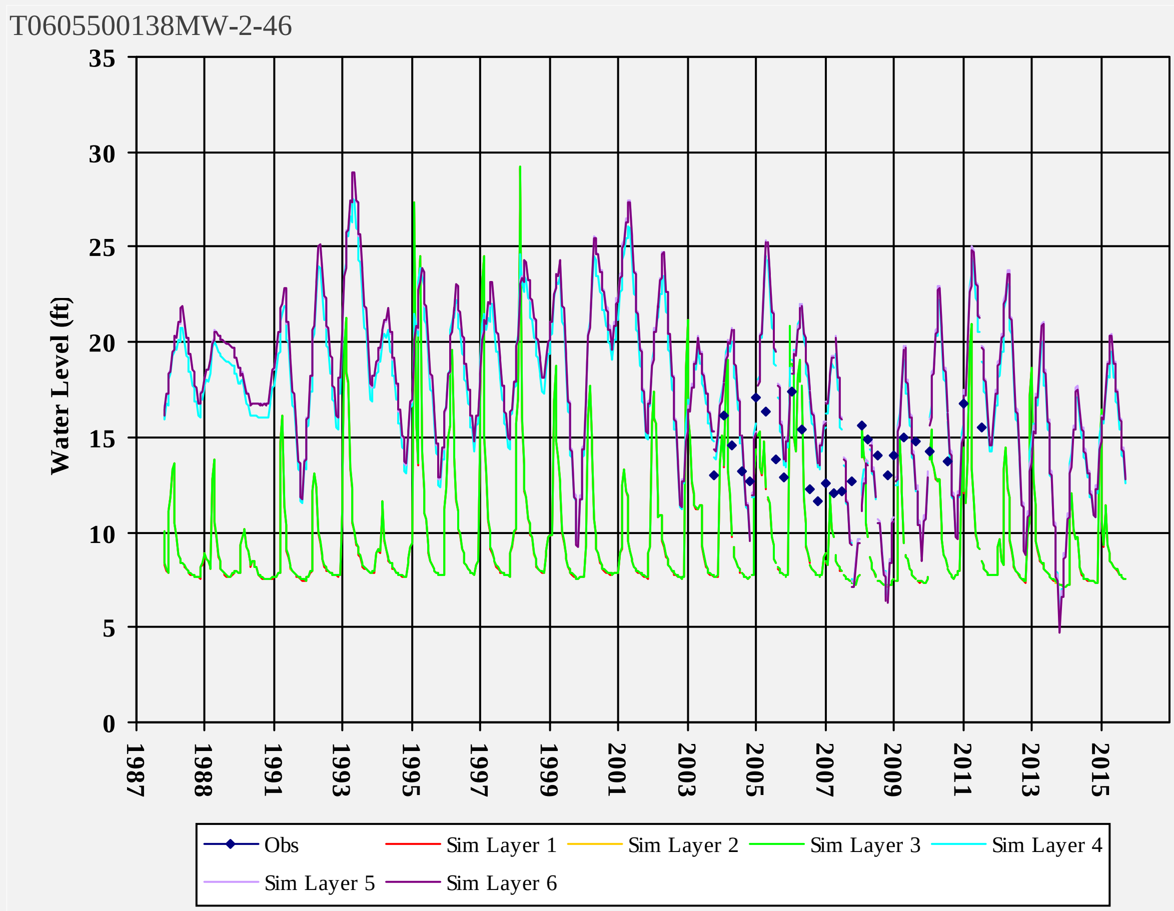
Bottom Perf:
Est Model Layer: 1

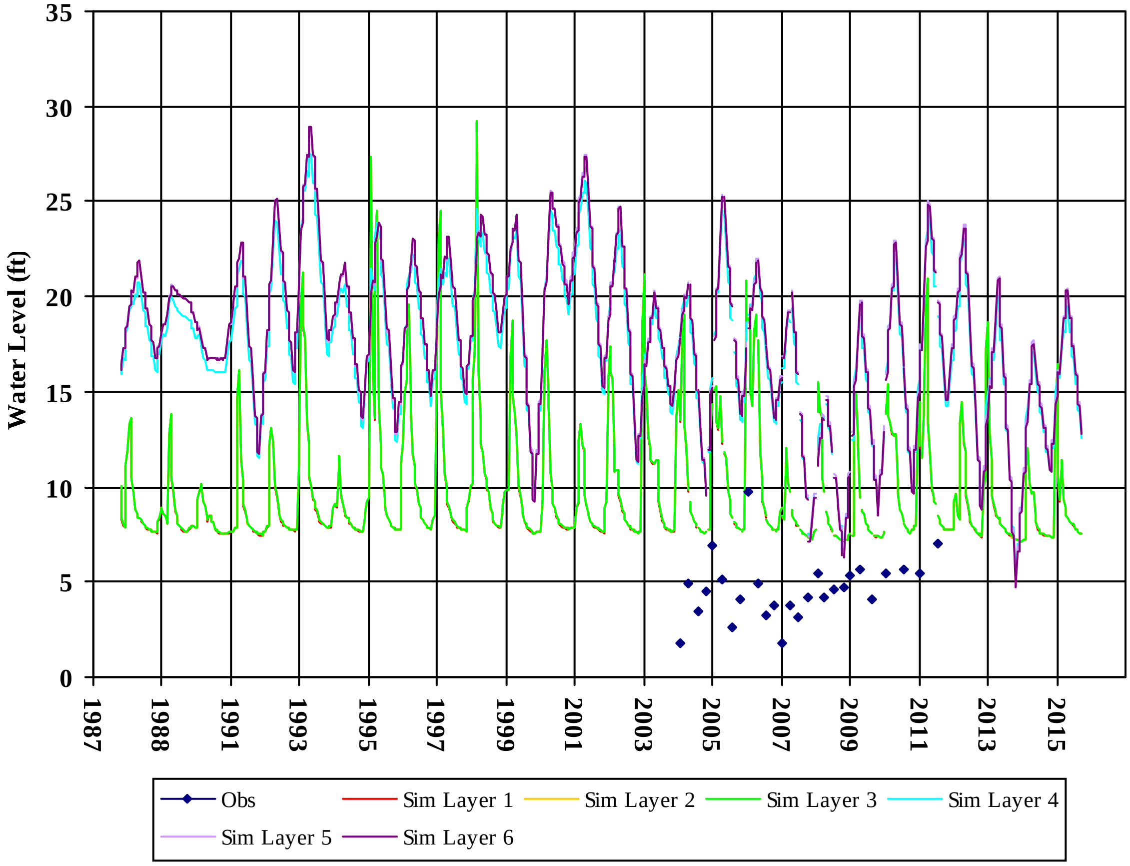


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



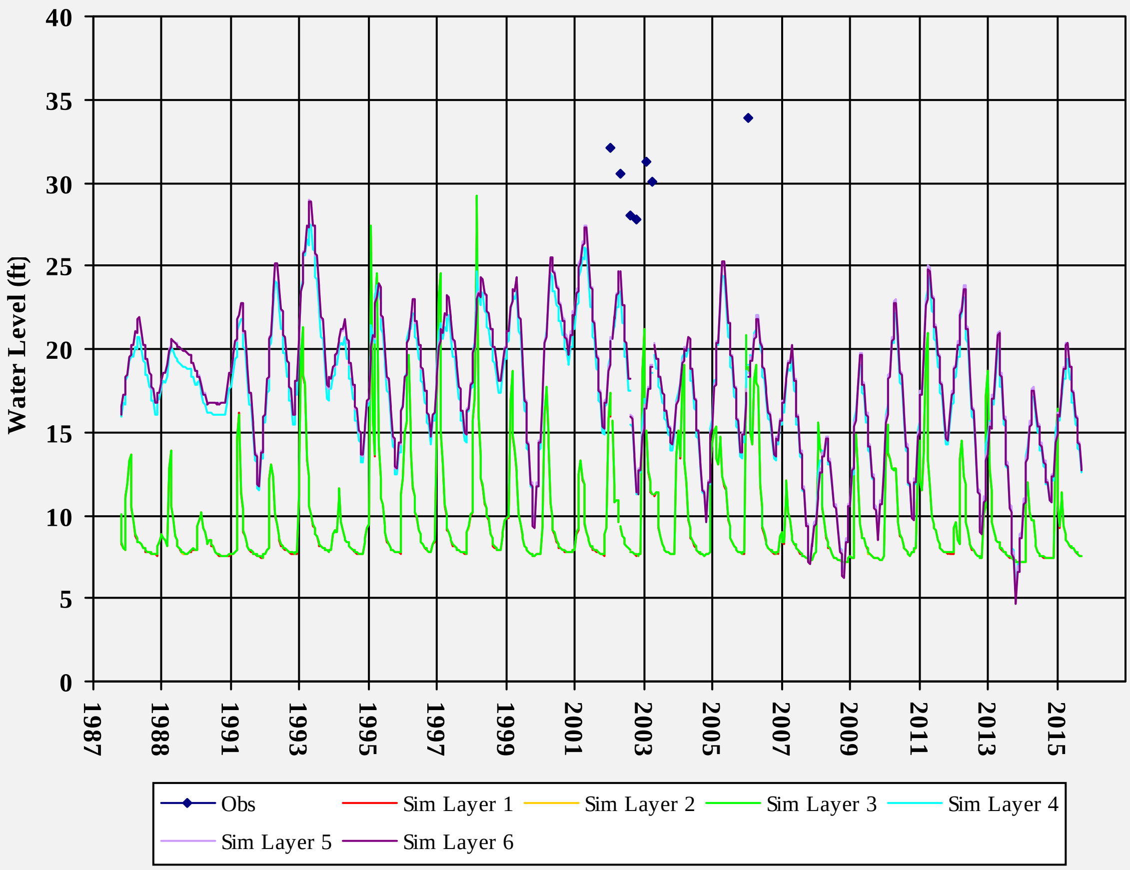
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138MW-2-73



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

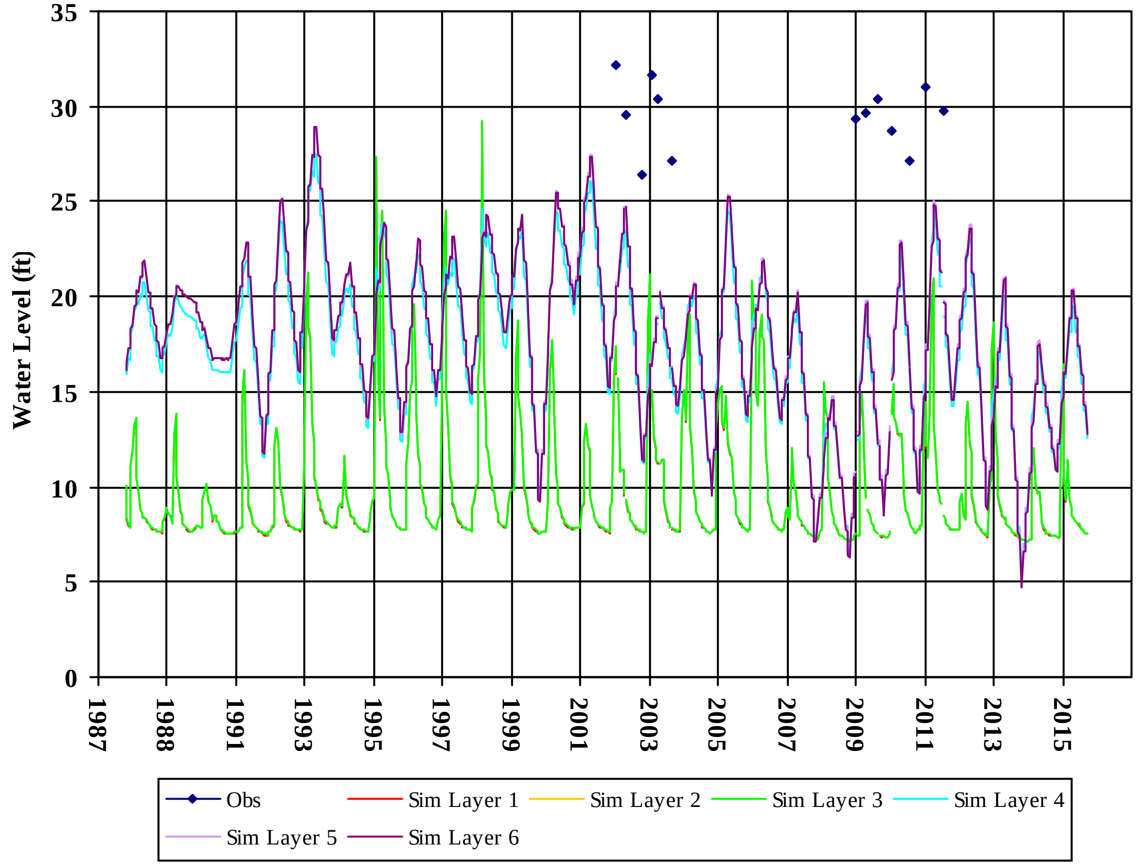
T0605500138MW-3



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

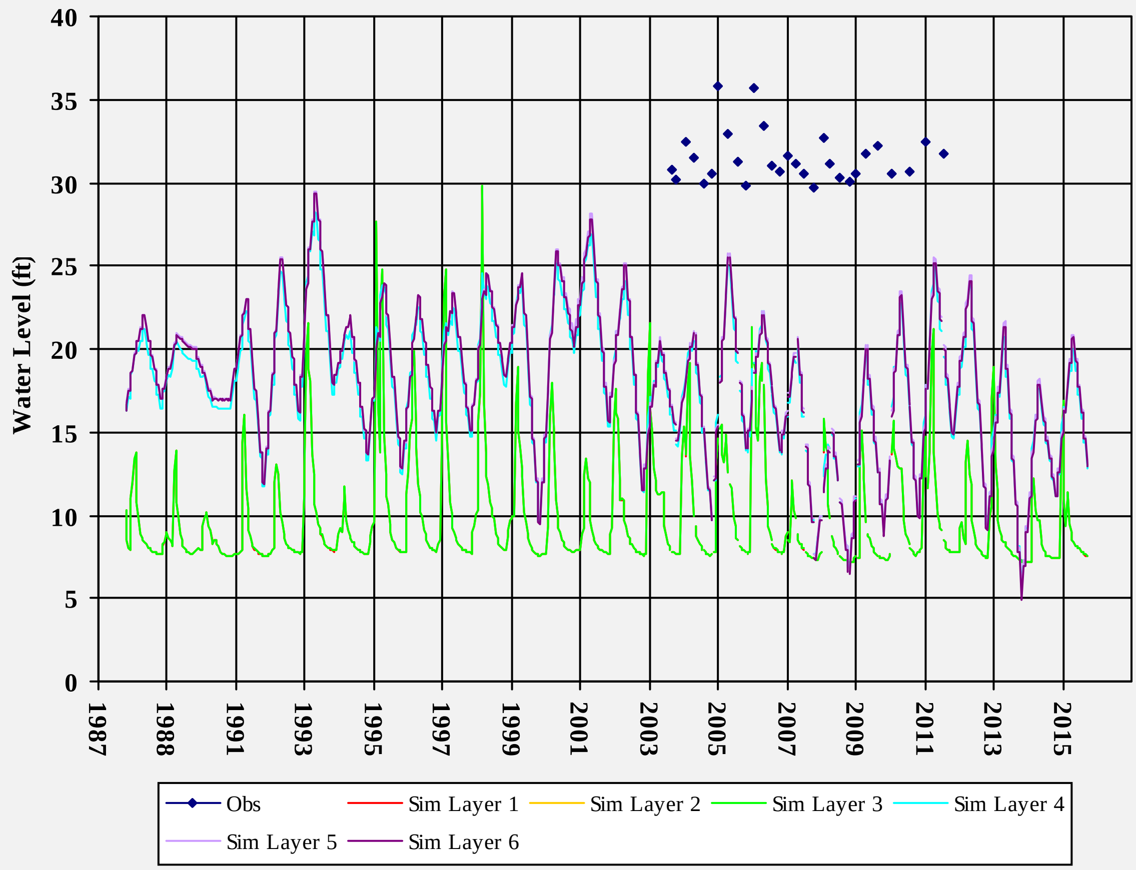
T0605500138S-1

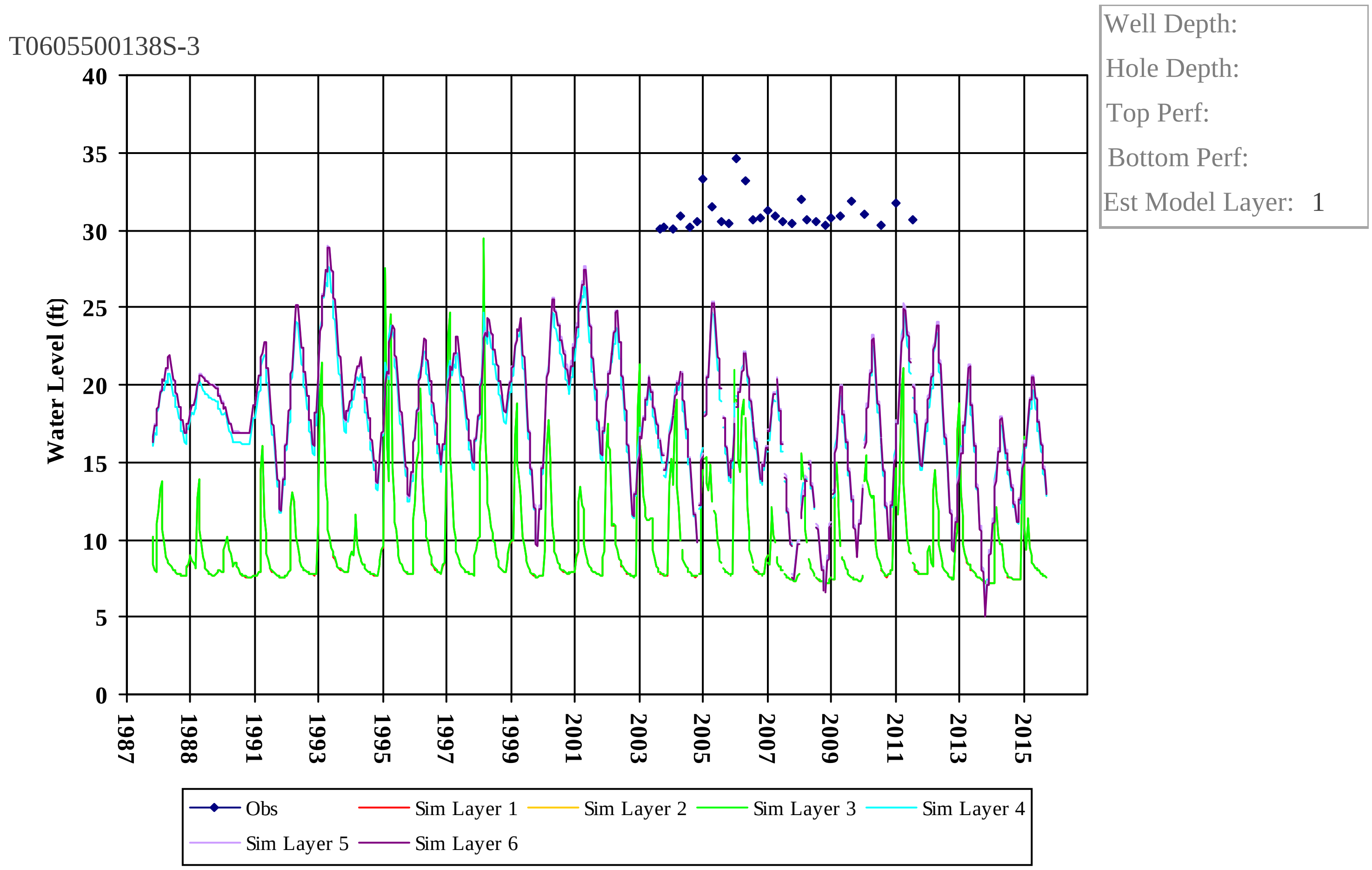
Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



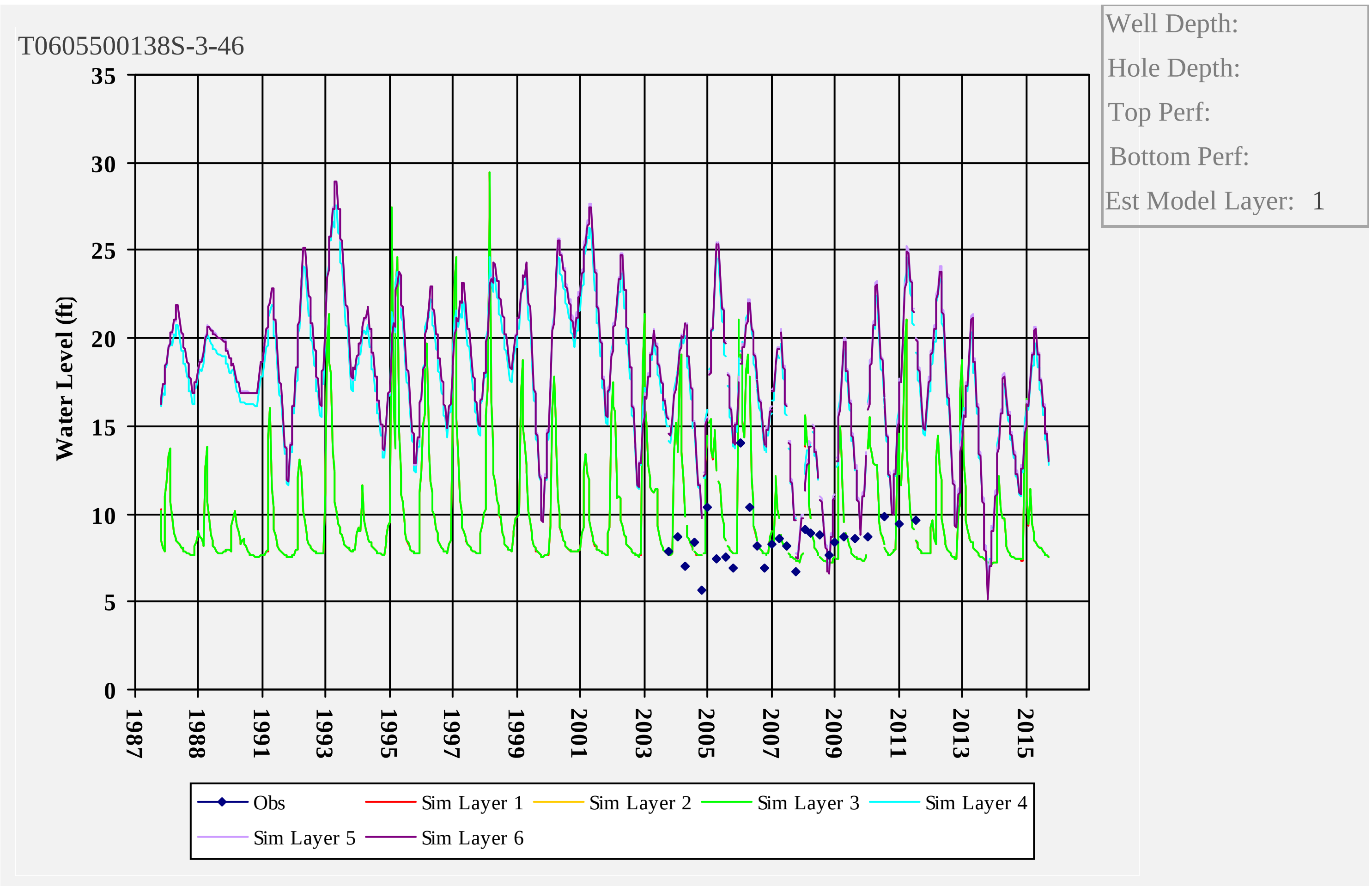
T0605500138S-2

Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

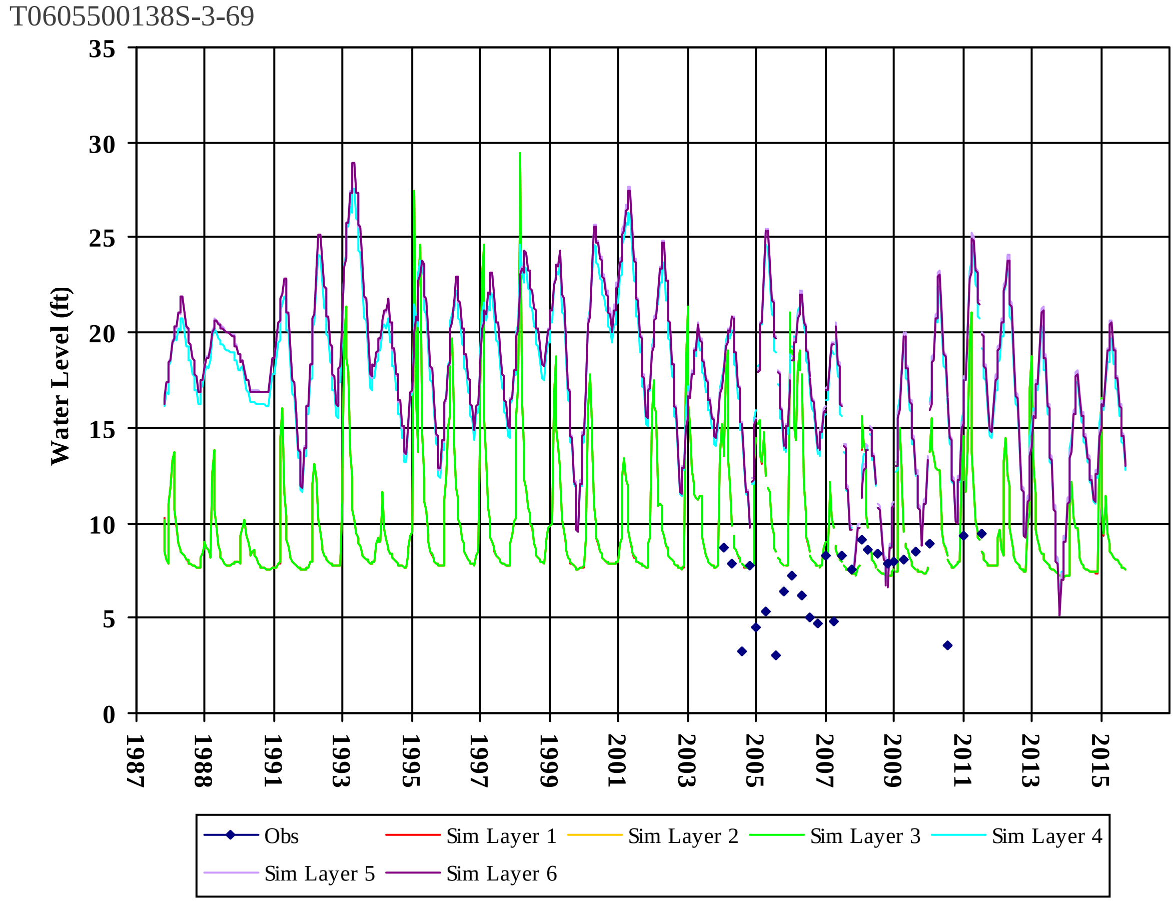




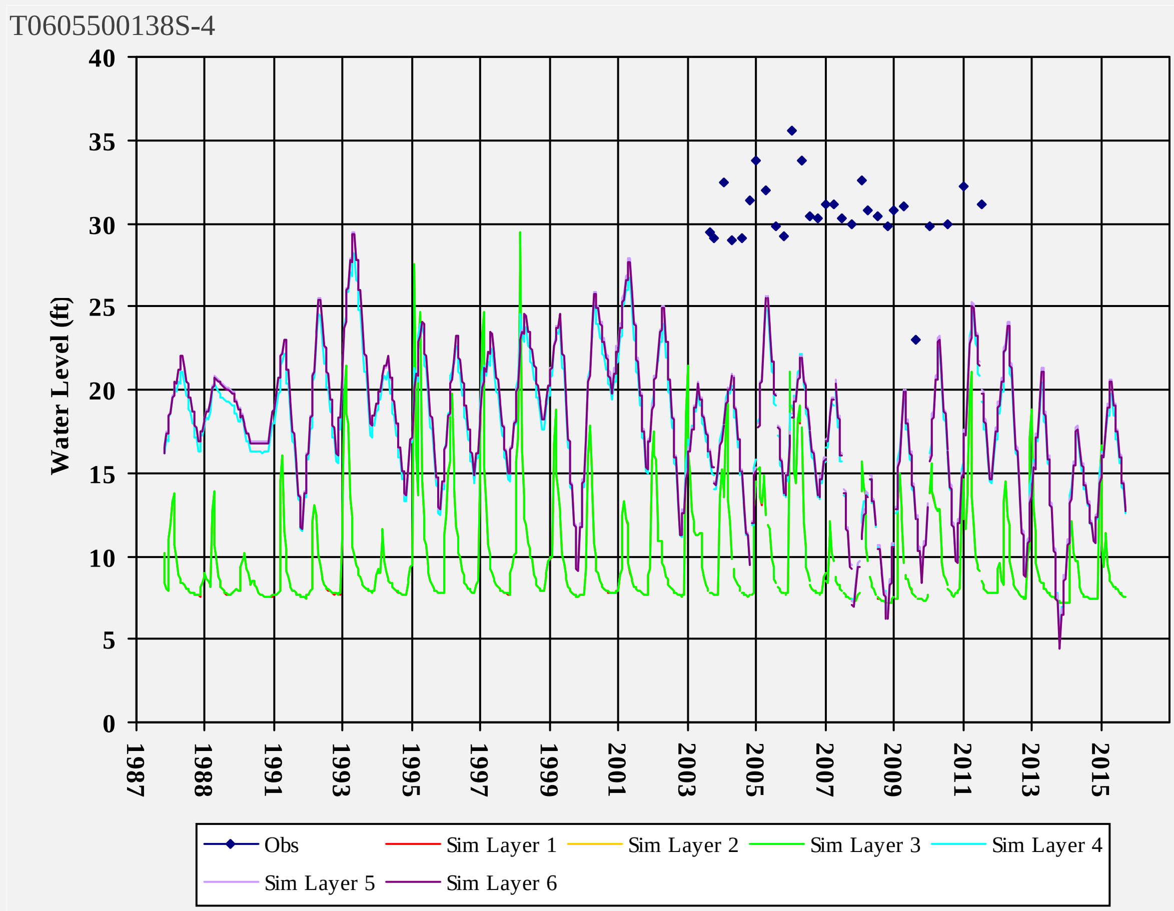
T0605500138S-3
Water Level (ft)
40
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



T0605500138S-3-46
Water Level (ft)
35
30
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

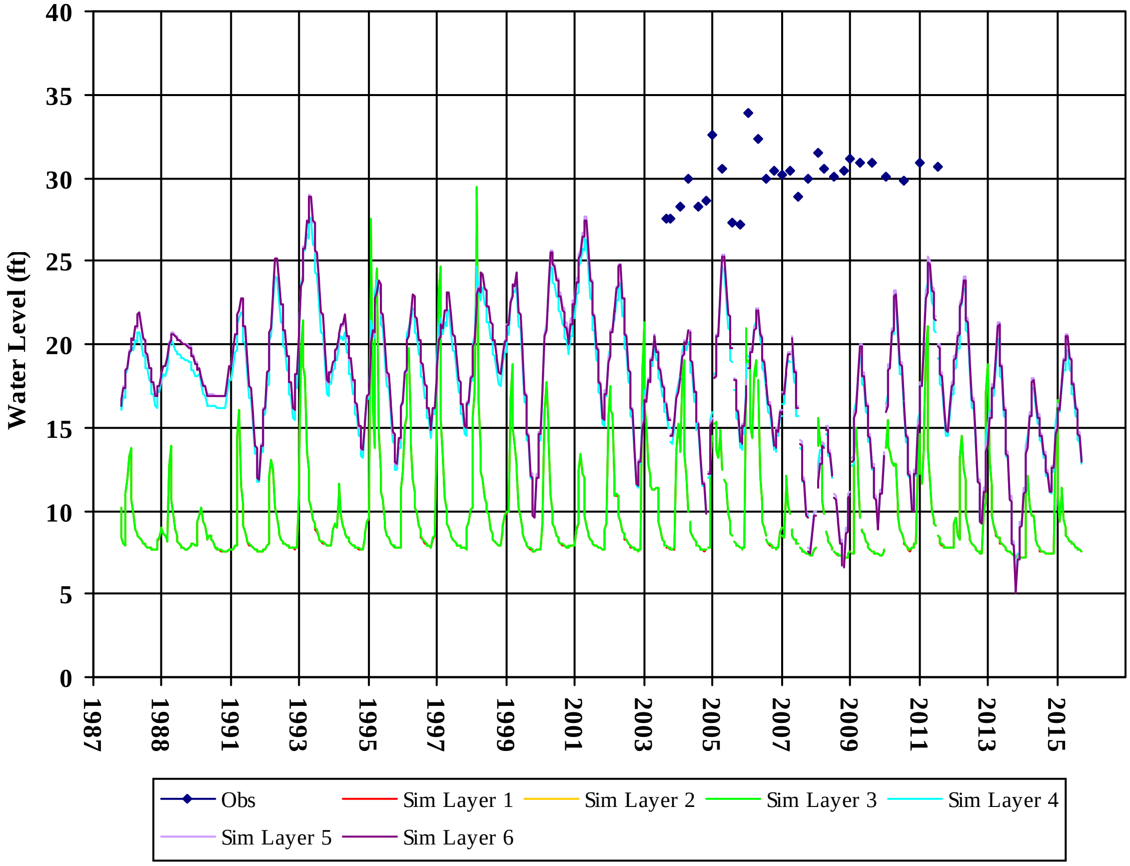


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



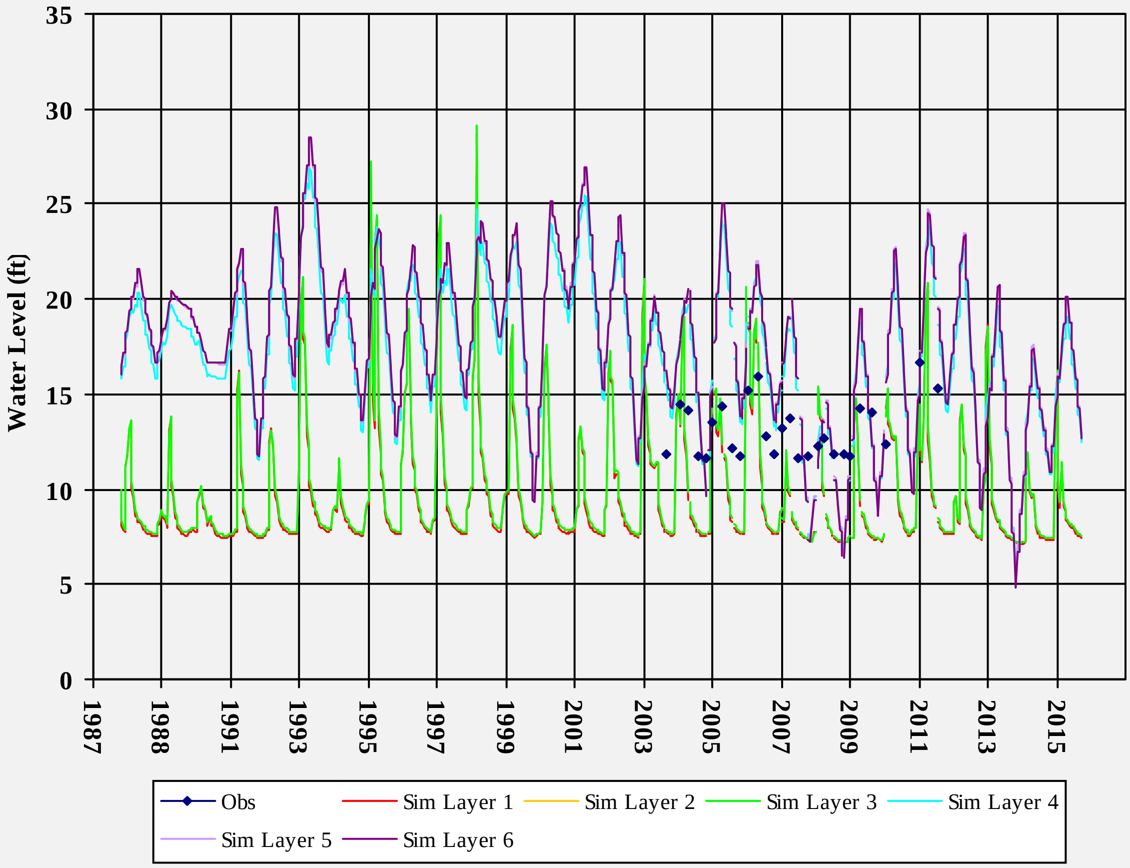
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138S-5



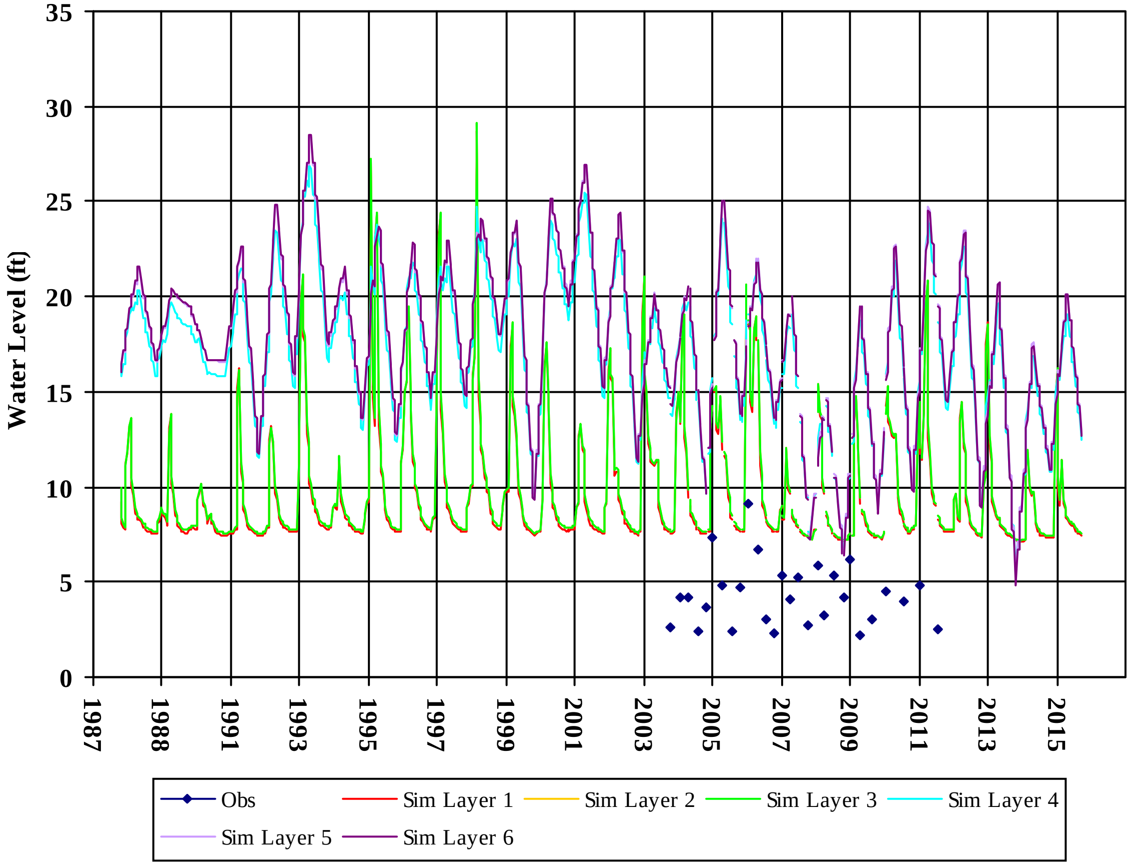
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138S-6



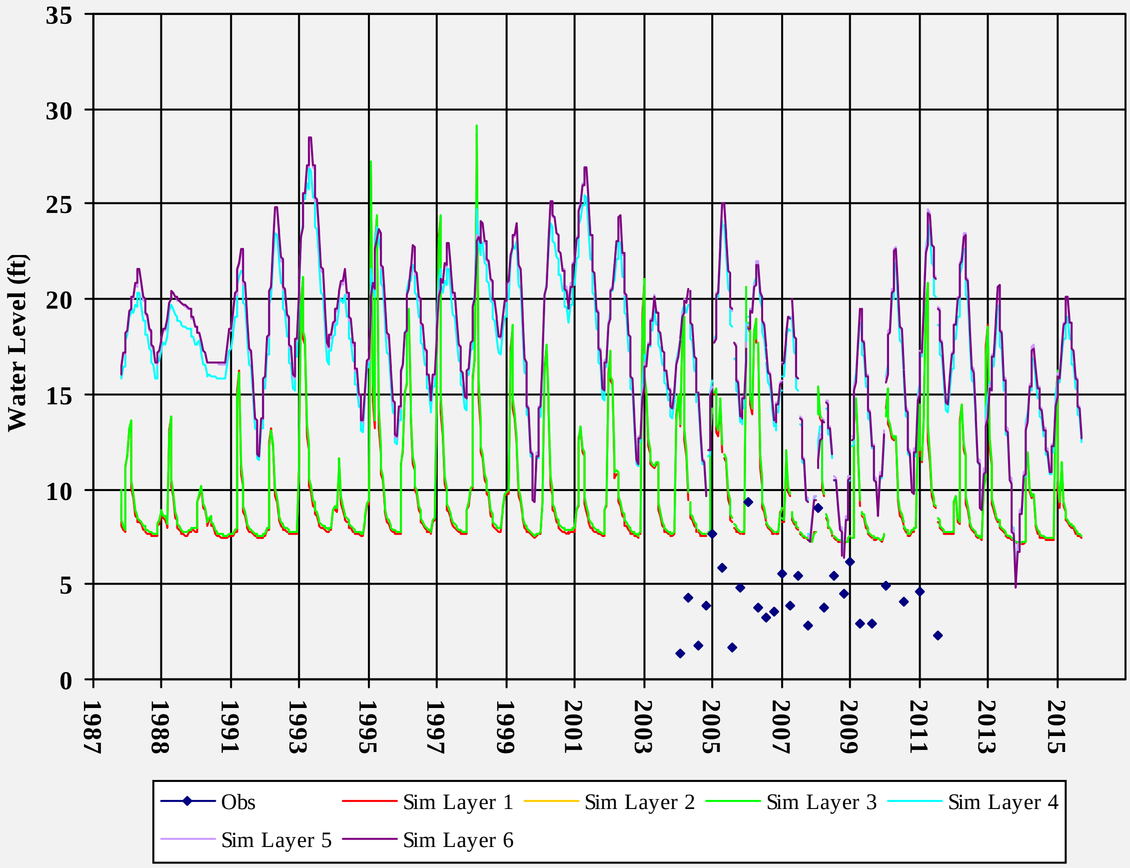
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138S-6-46



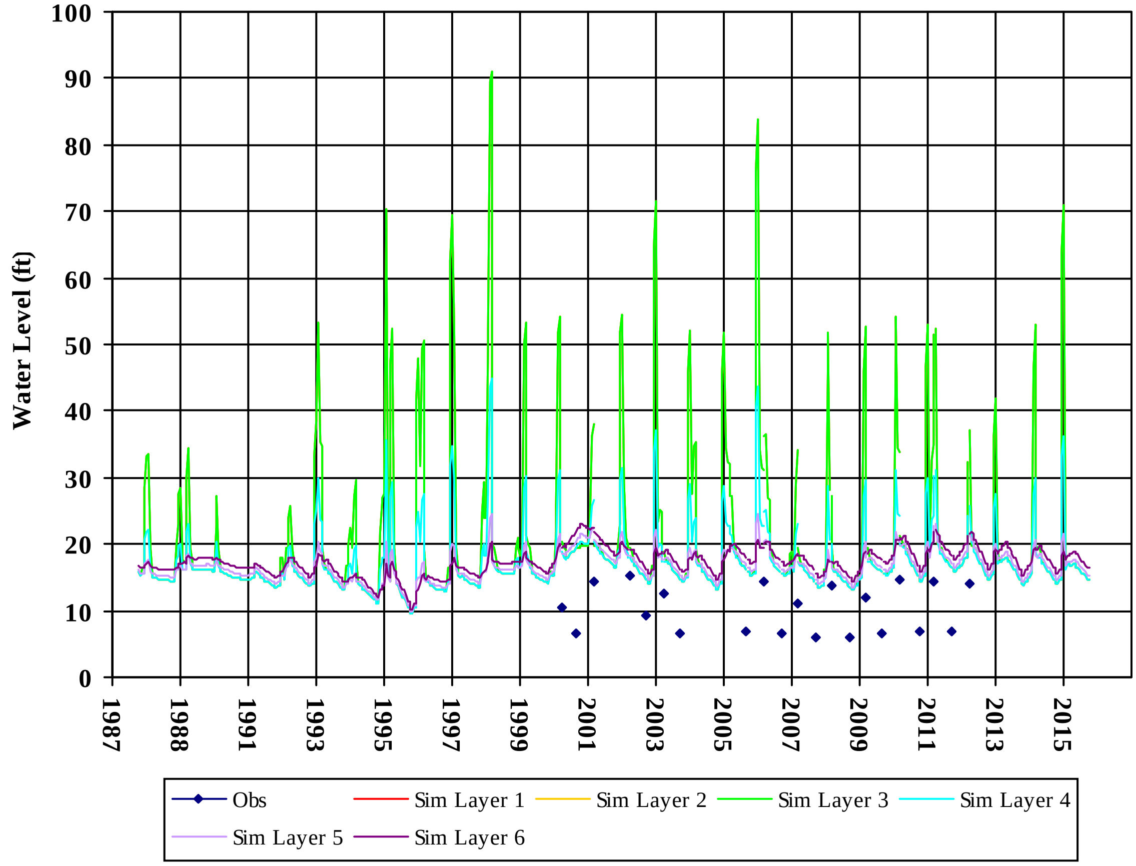
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500138S-6-72



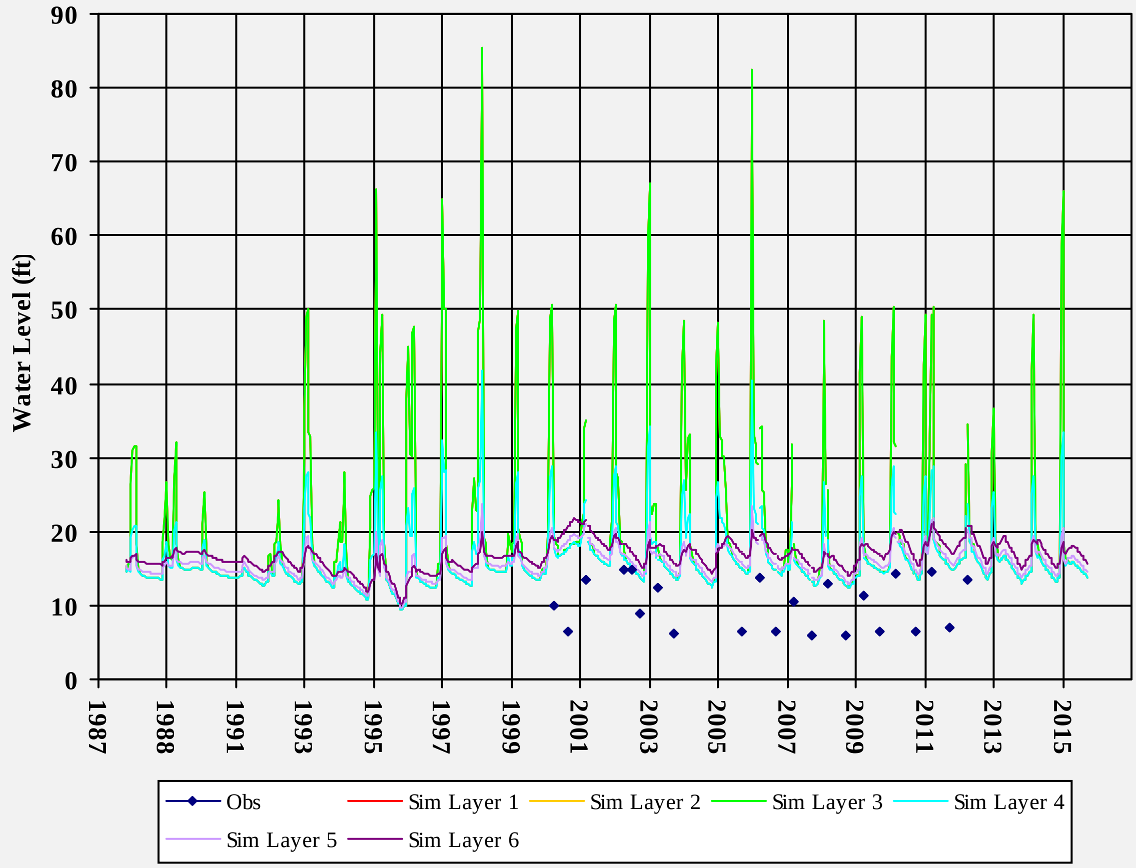
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500140MW-1



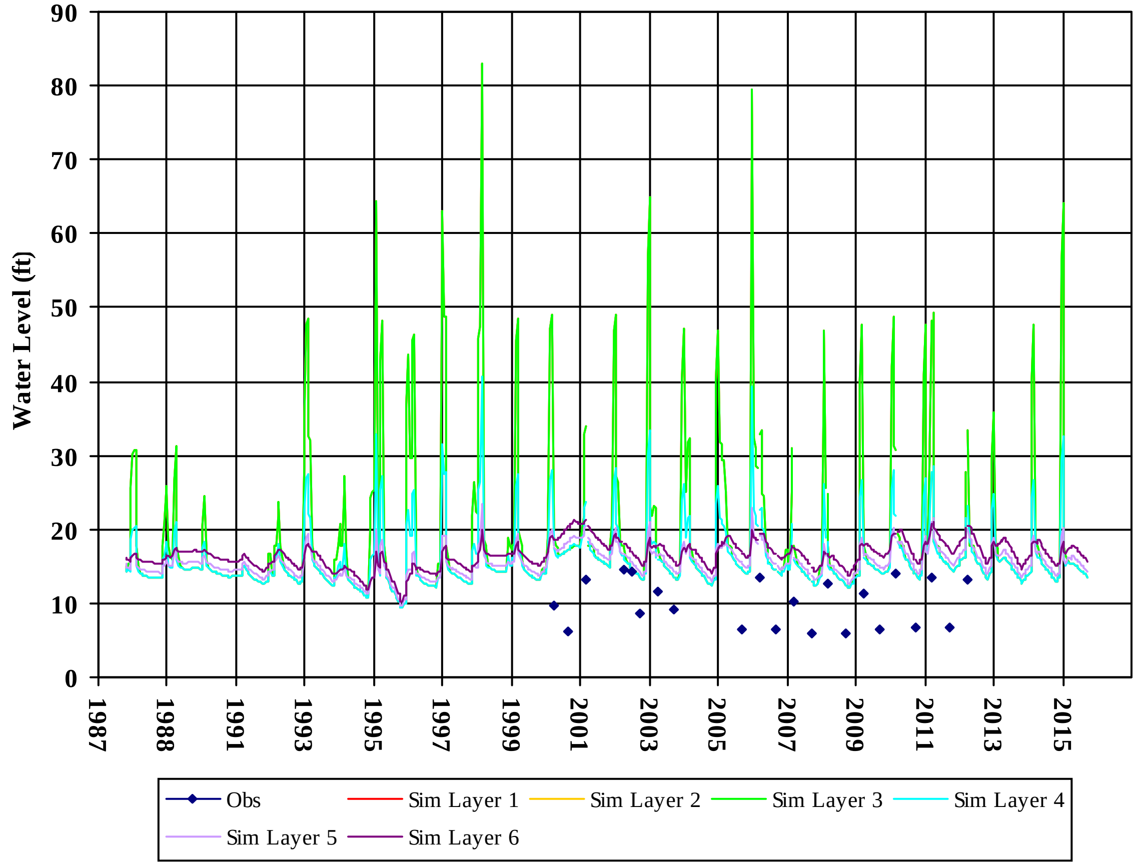
Well Depth: 24.86
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500140MW-2



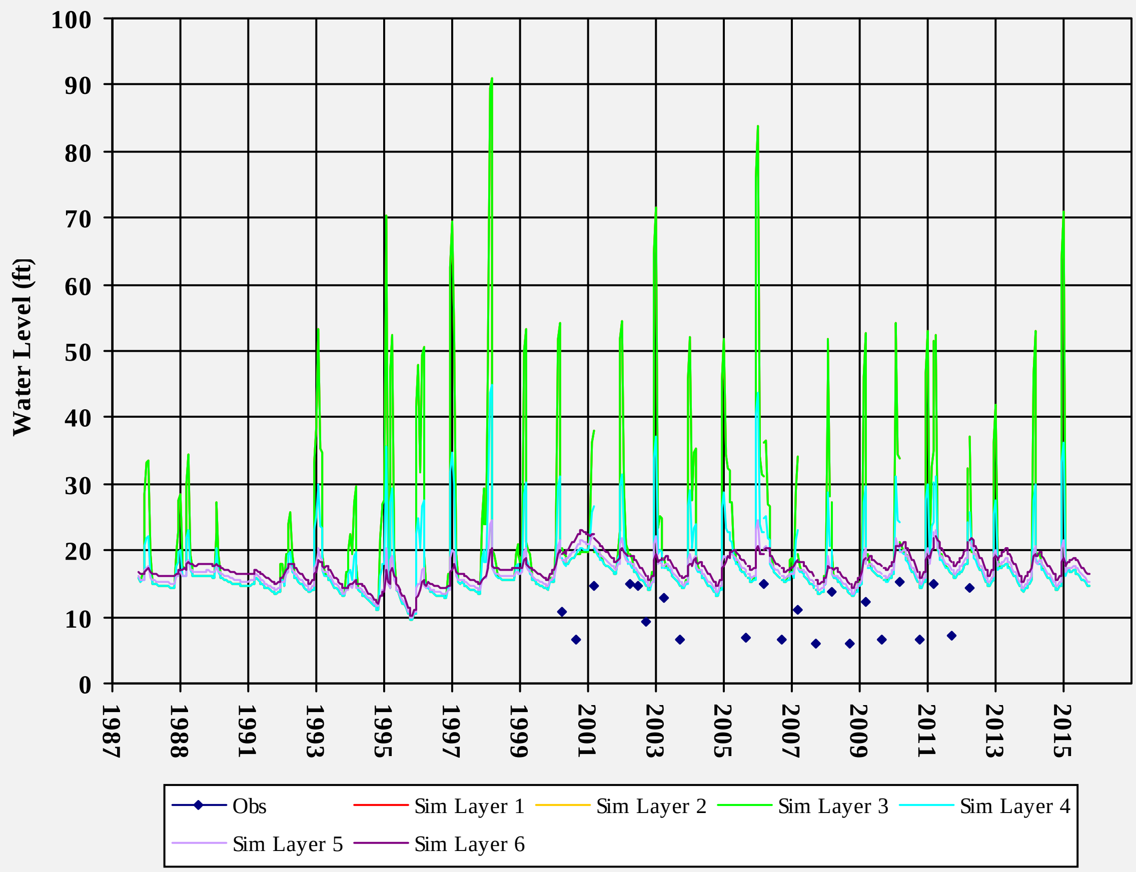
Well Depth: 24.87
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500140MW-3



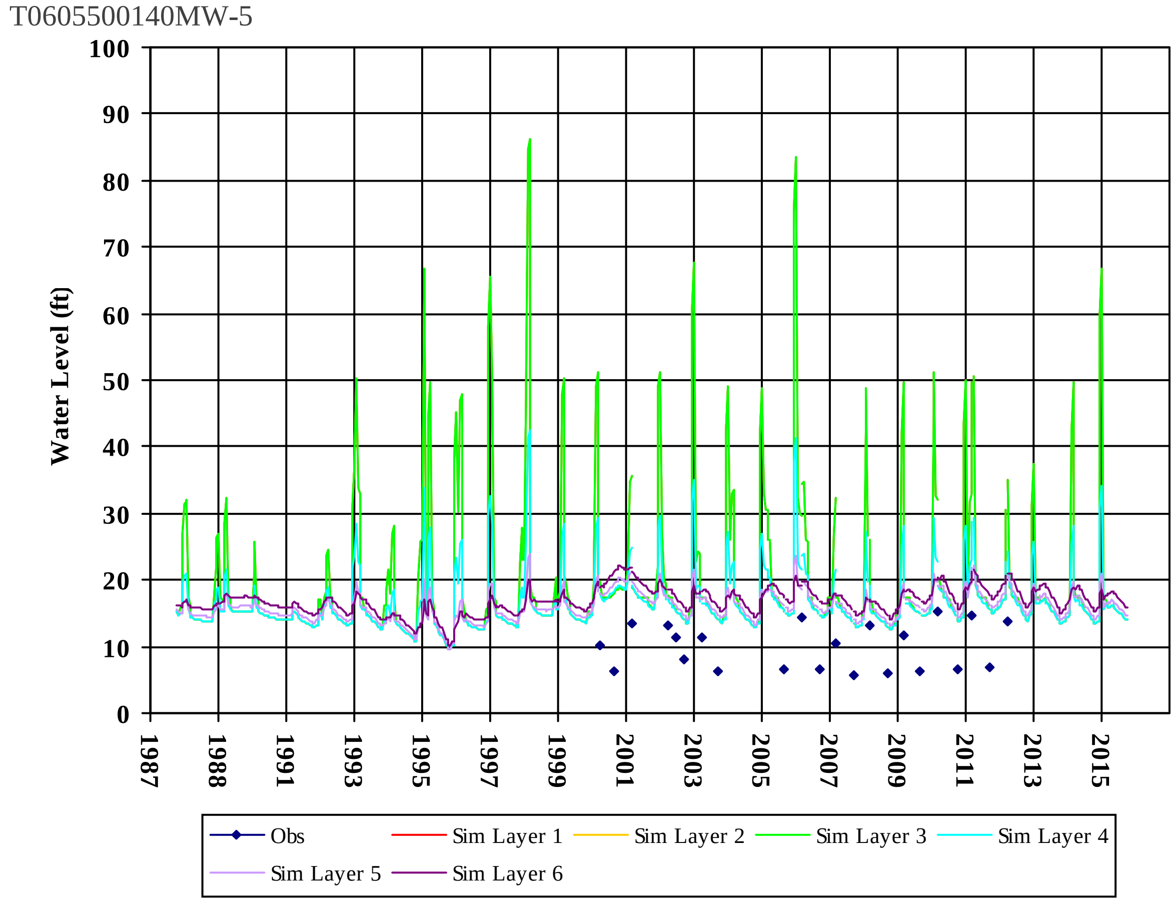
Well Depth: 25.05
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500140MW-4

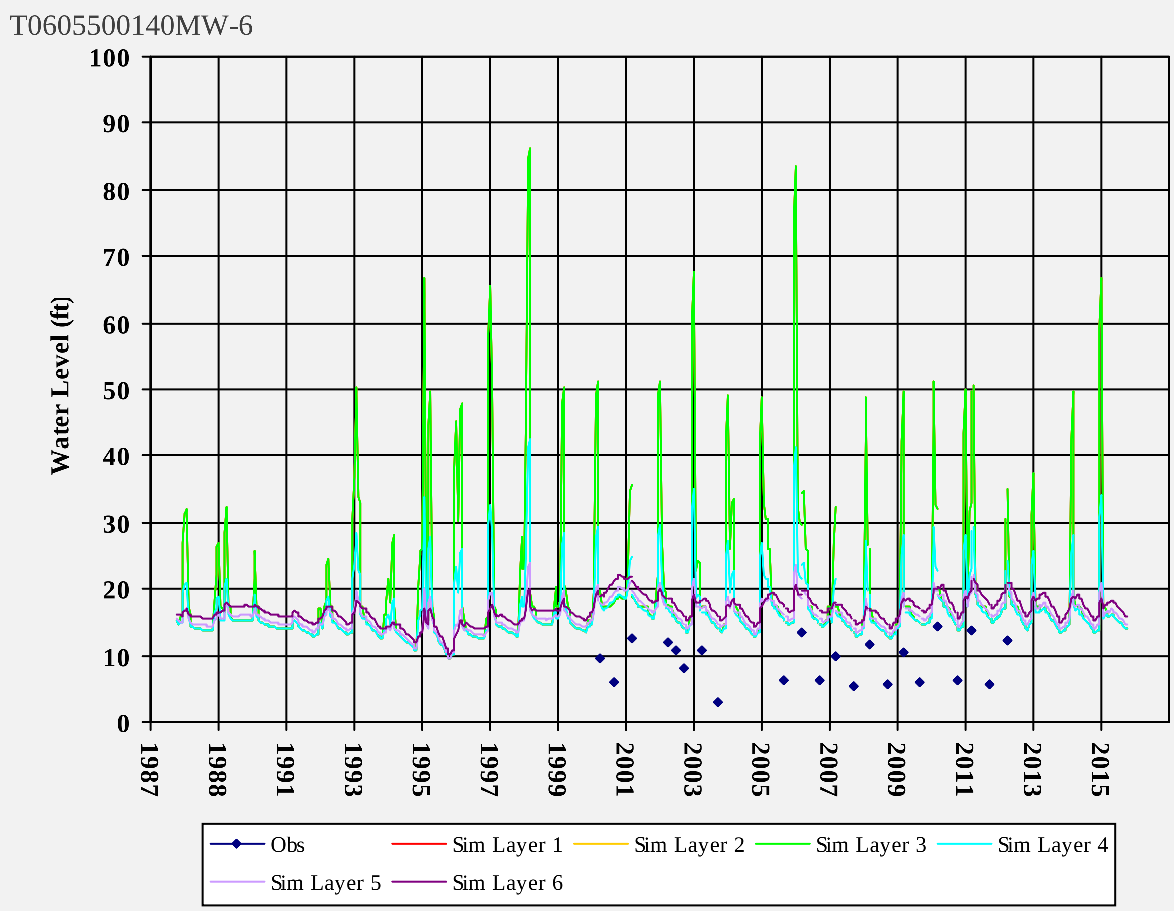


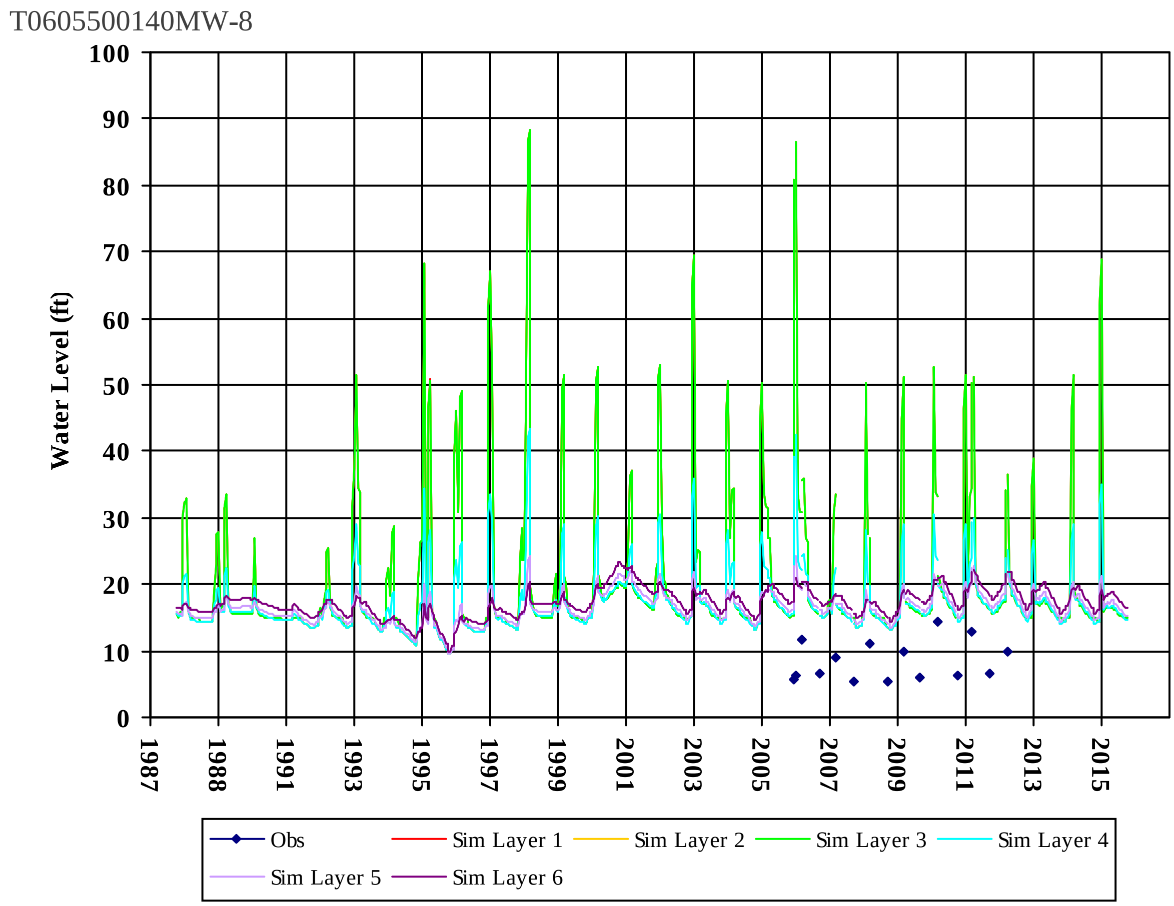
Well Depth: 23.48
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

Well Depth:	25.02
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

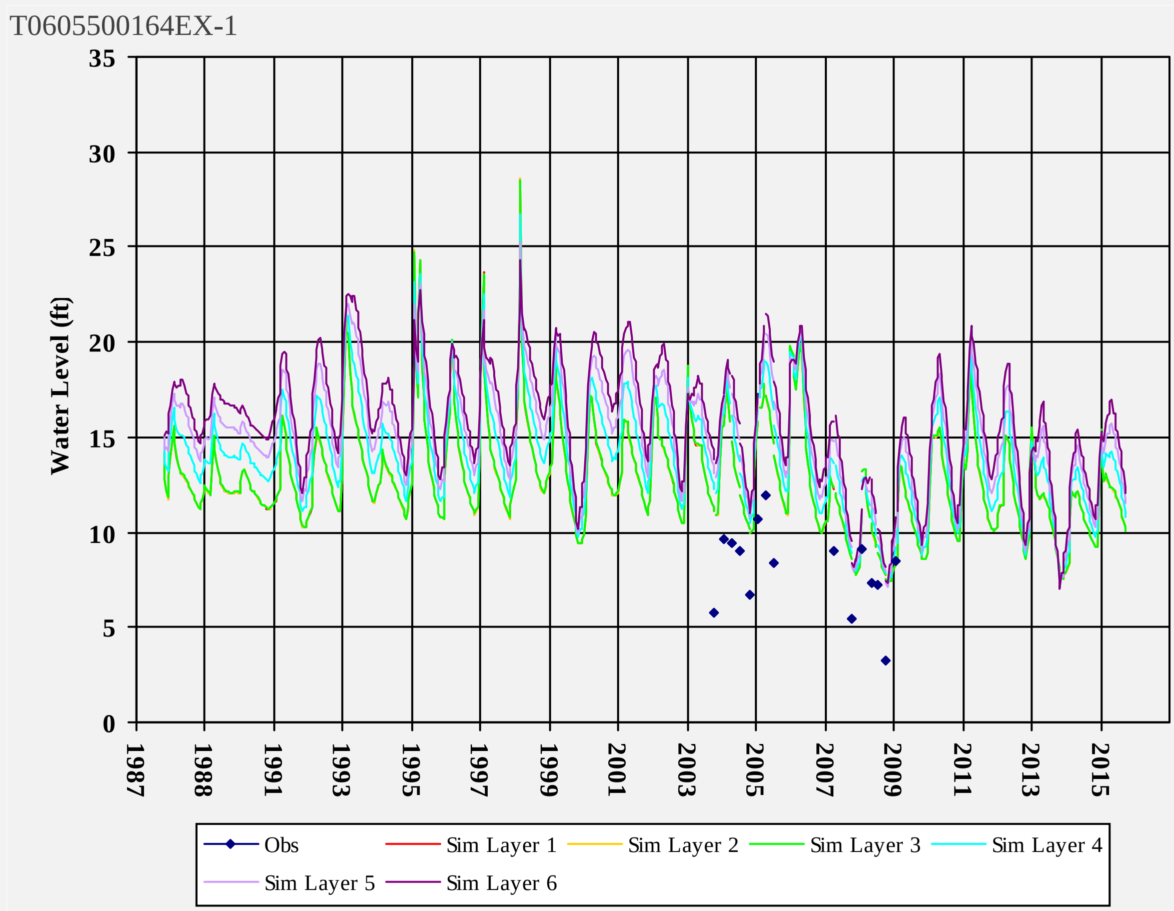


Well Depth:	25.05
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1





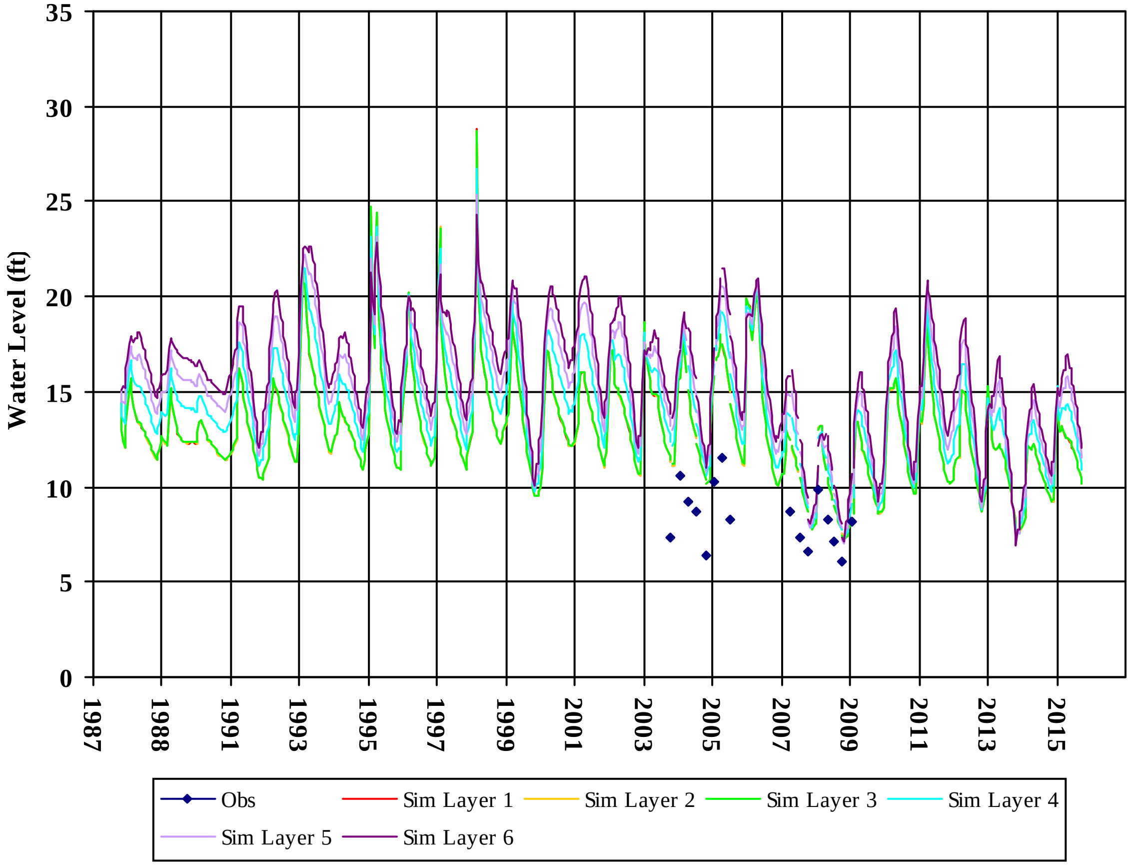
Well Depth: 19.87
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth: 37
Hole Depth: 37
Top Perf: 10
Bottom Perf: 35
Est Model Layer: 1

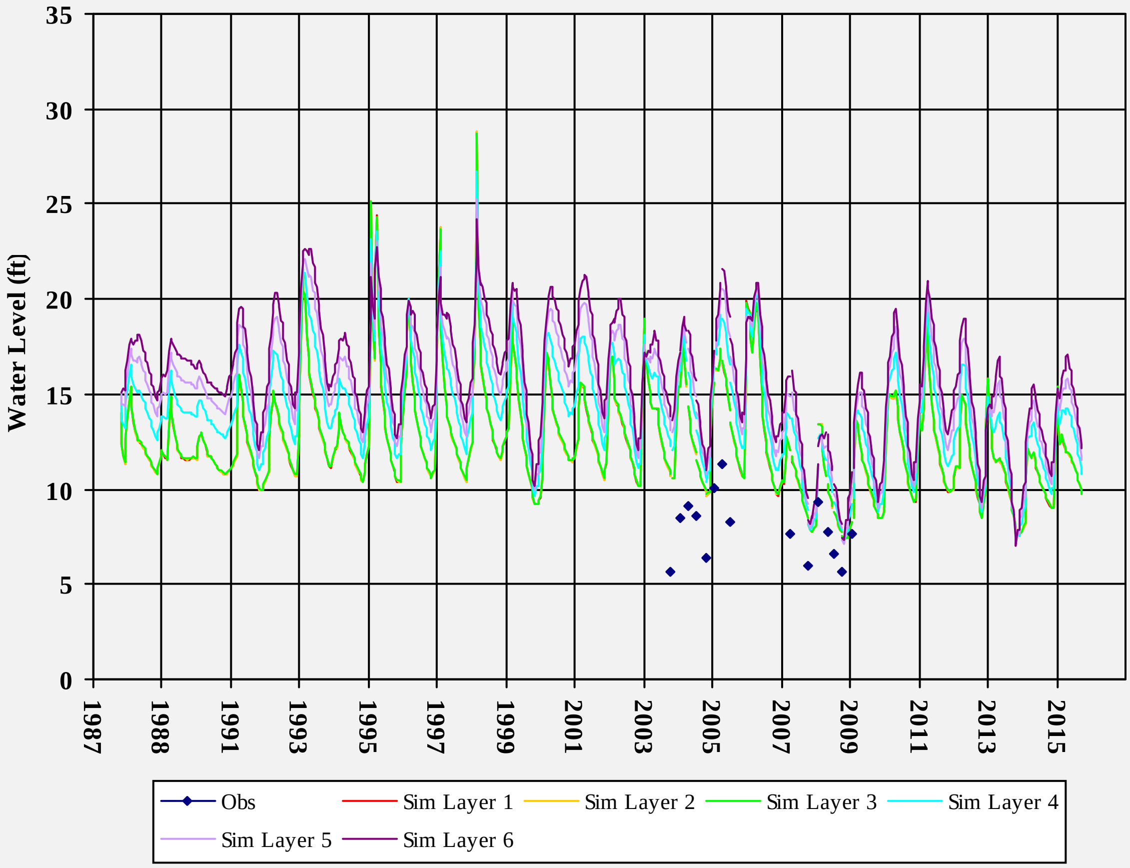
T0605500164EX-2

Well Depth:	28
Hole Depth:	30
Top Perf:	8
Bottom Perf:	28
Est Model Layer:	1

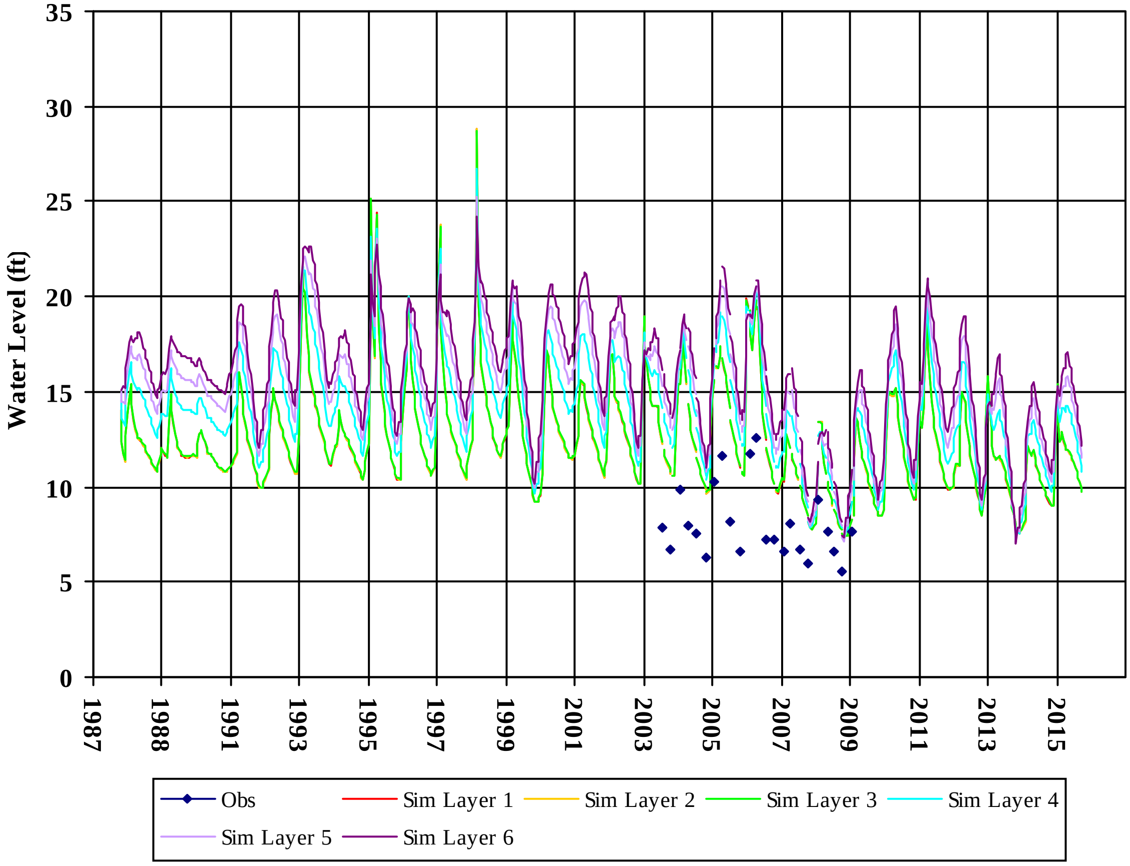


T0605500164EX-3

Well Depth:	20
Hole Depth:	20
Top Perf:	5
Bottom Perf:	20
Est Model Layer:	1

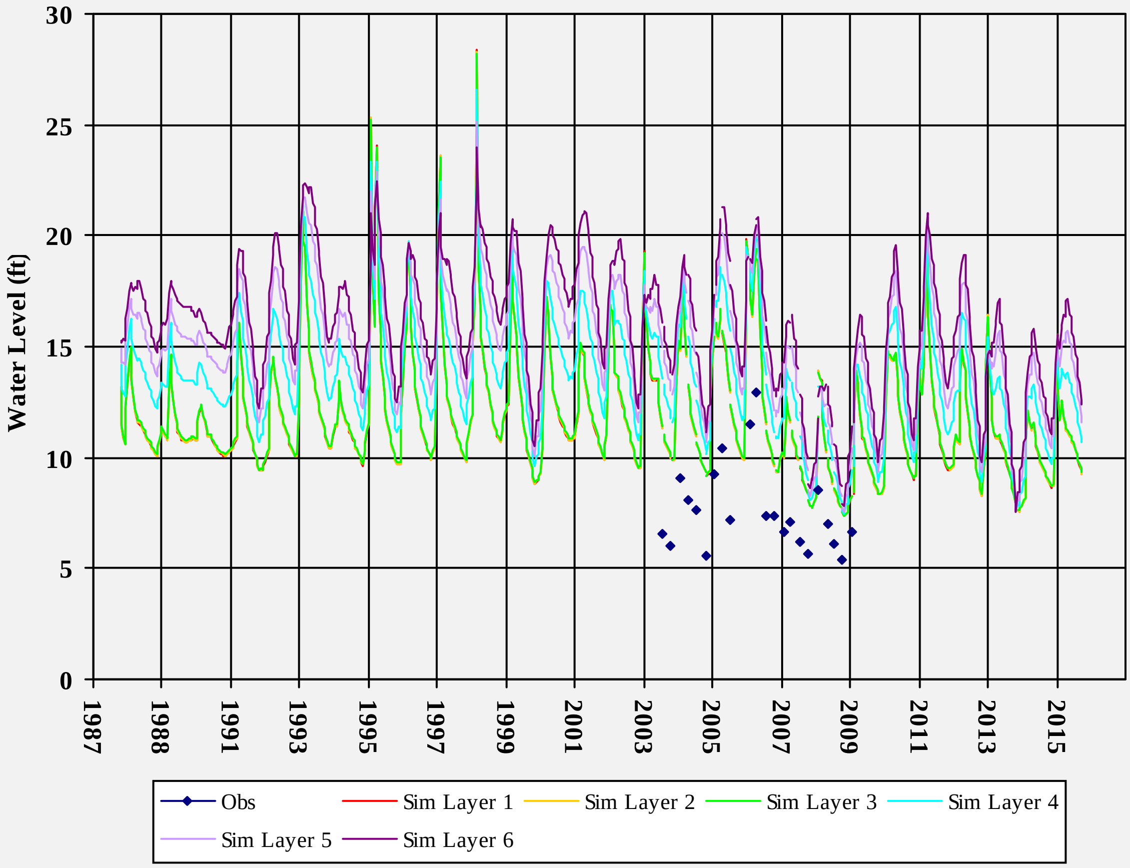


T0605500164MW-1



Well Depth:	25
Hole Depth:	25
Top Perf:	5
Bottom Perf:	25
Est Model Layer:	1

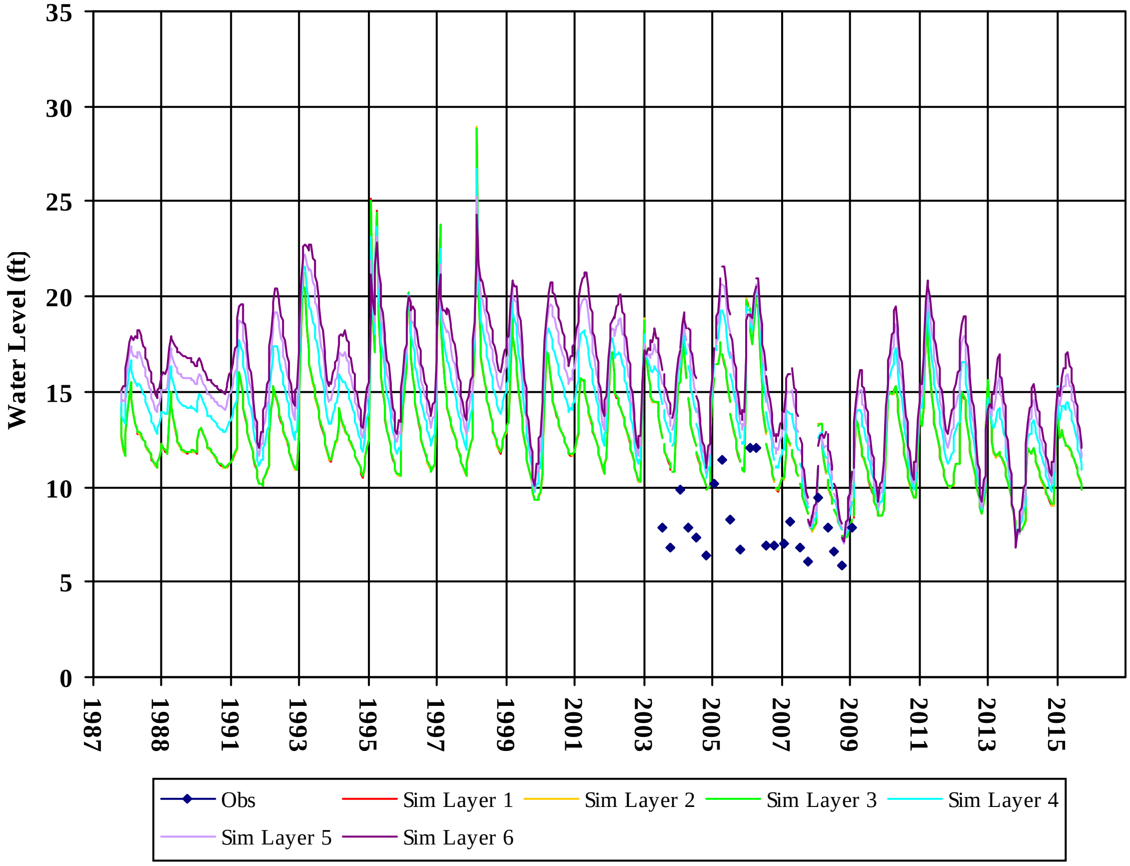
T0605500164MW-10



Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

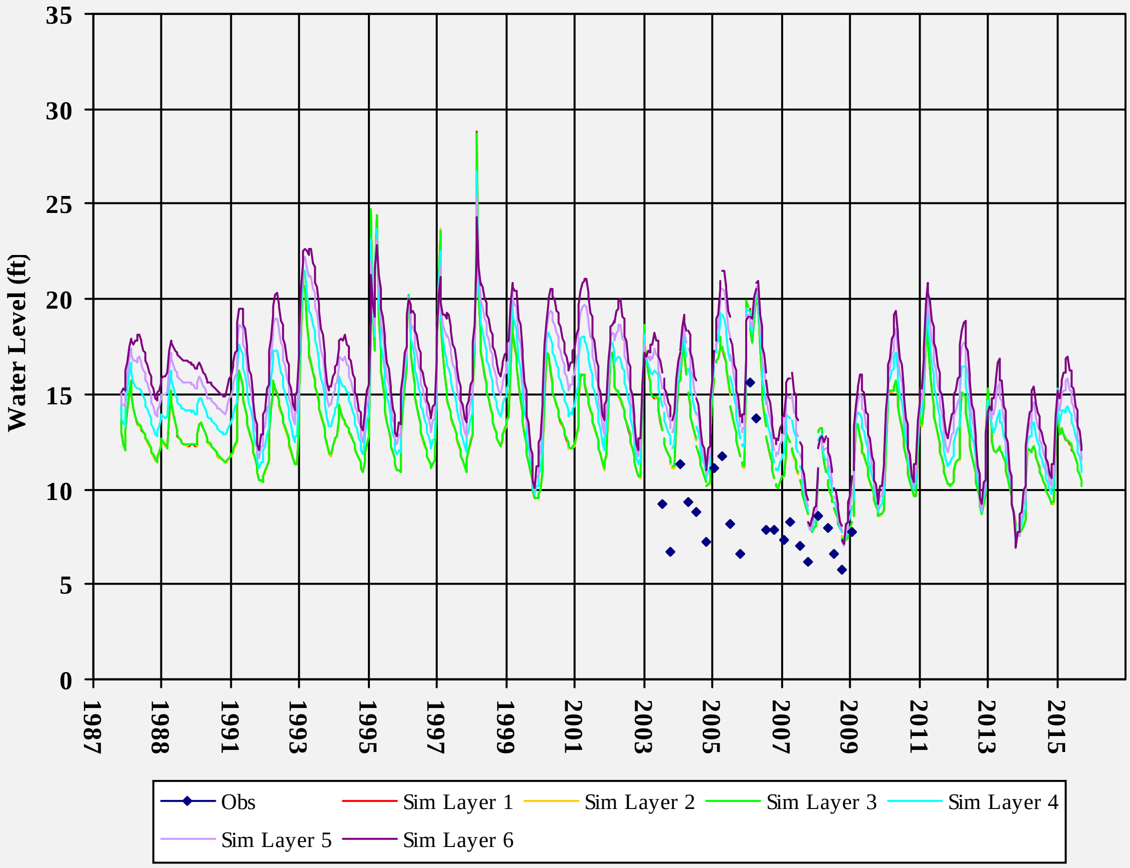
T0605500164MW-2

Well Depth:	21
Hole Depth:	21
Top Perf:	6
Bottom Perf:	21
Est Model Layer:	1

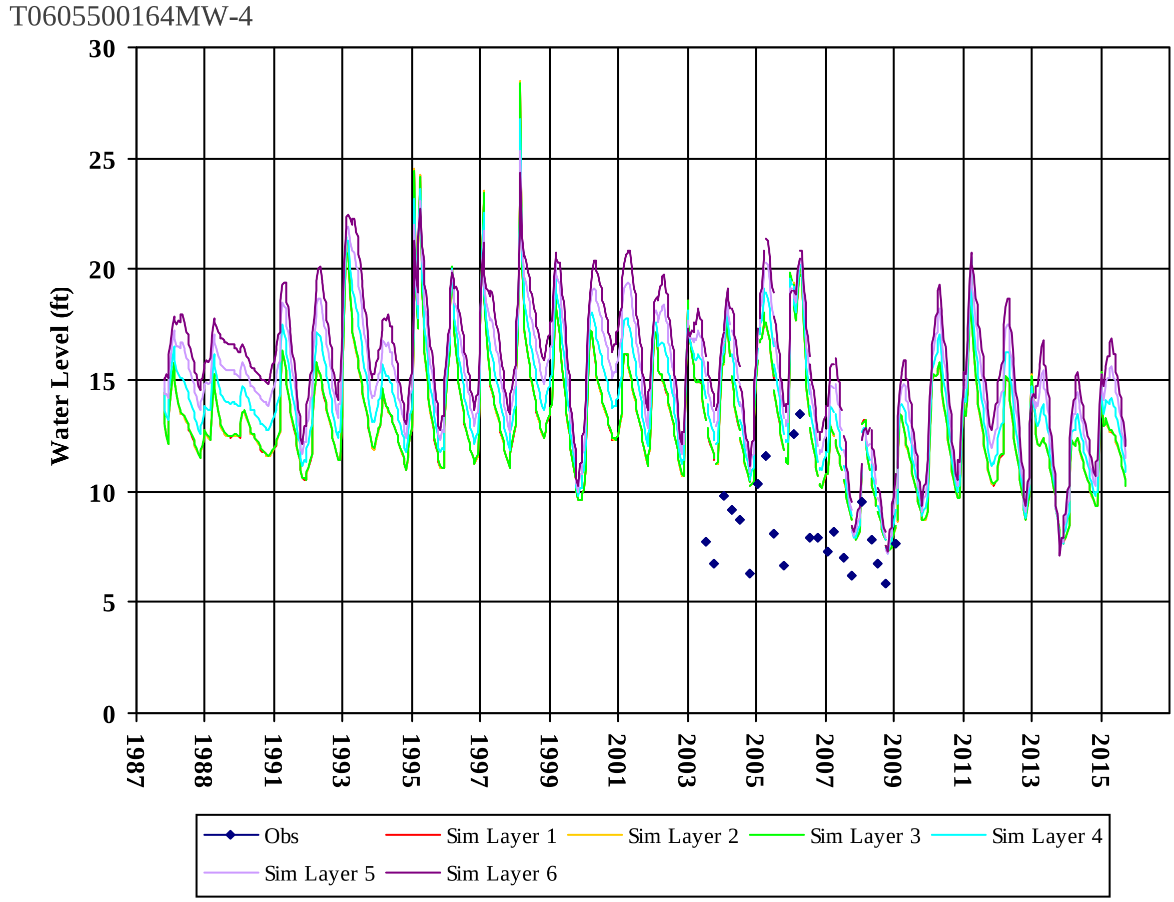


T0605500164MW-3

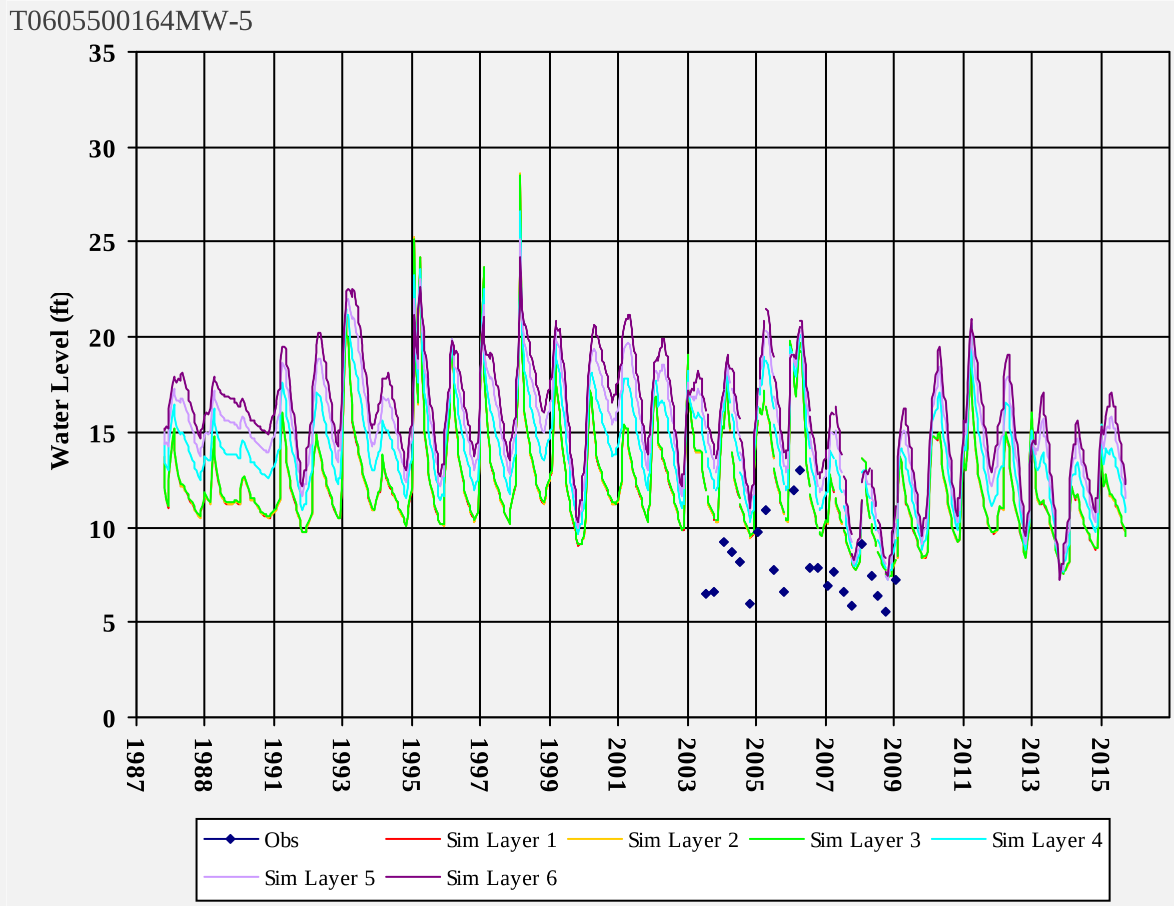
Well Depth:	21
Hole Depth:	22
Top Perf:	6
Bottom Perf:	21
Est Model Layer:	1

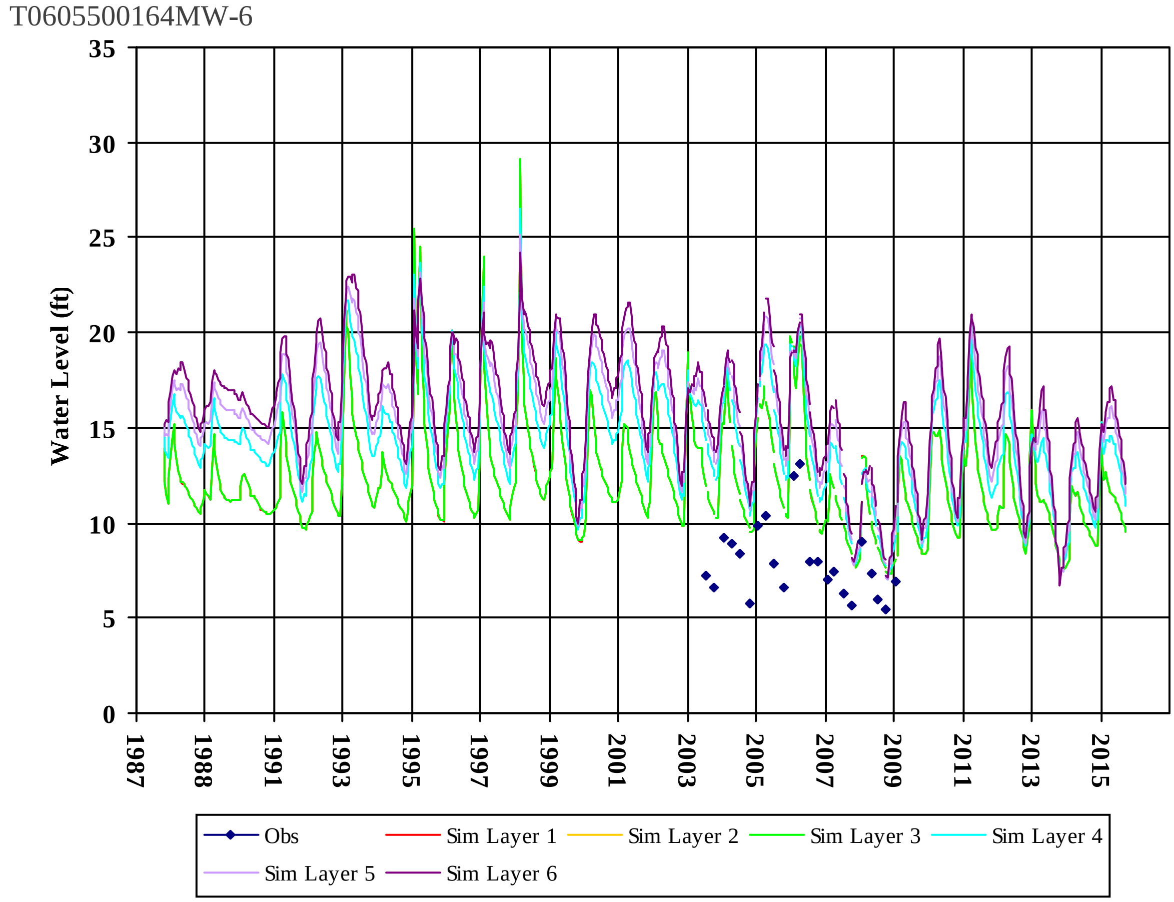


Well Depth:	22
Hole Depth:	22
Top Perf:	5
Bottom Perf:	22
Est Model Layer:	1

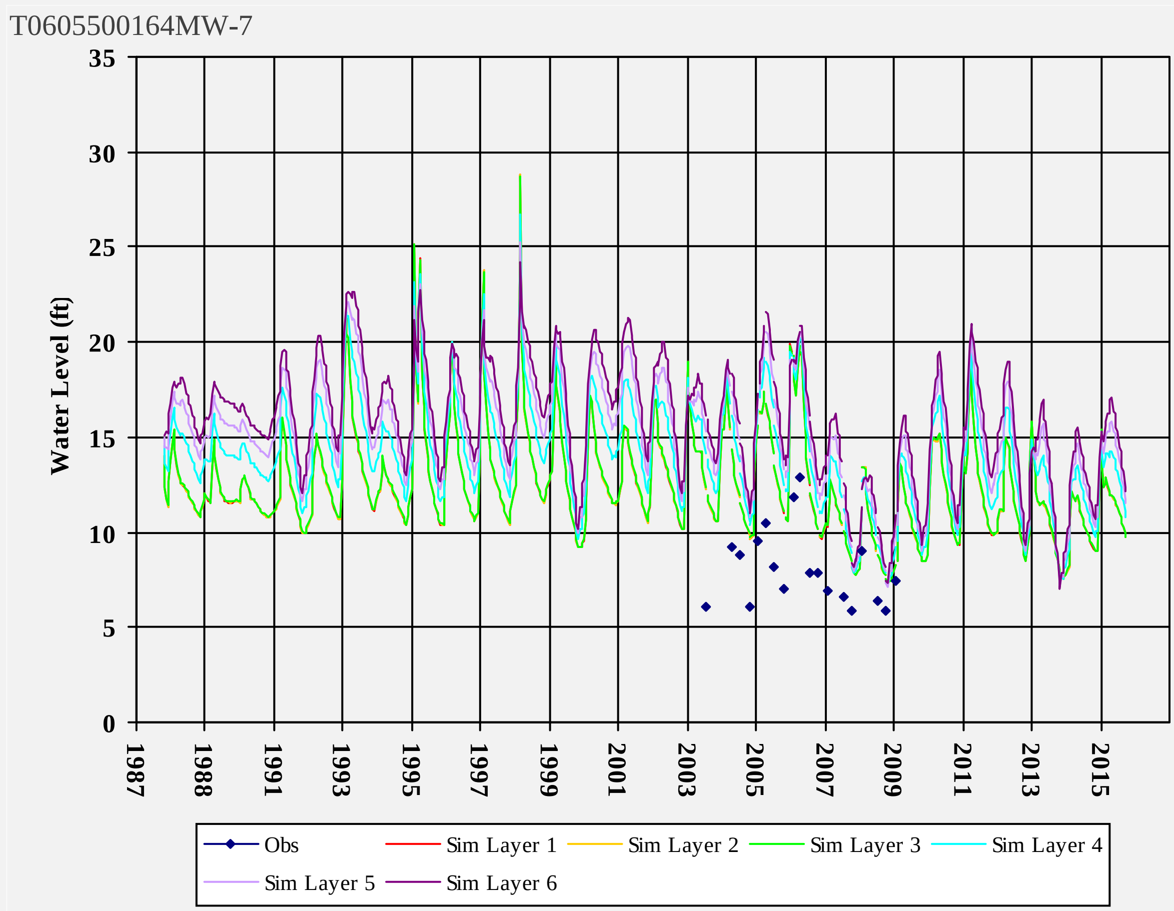


Well Depth:	22
Hole Depth:	22
Top Perf:	5
Bottom Perf:	22
Est Model Layer:	1

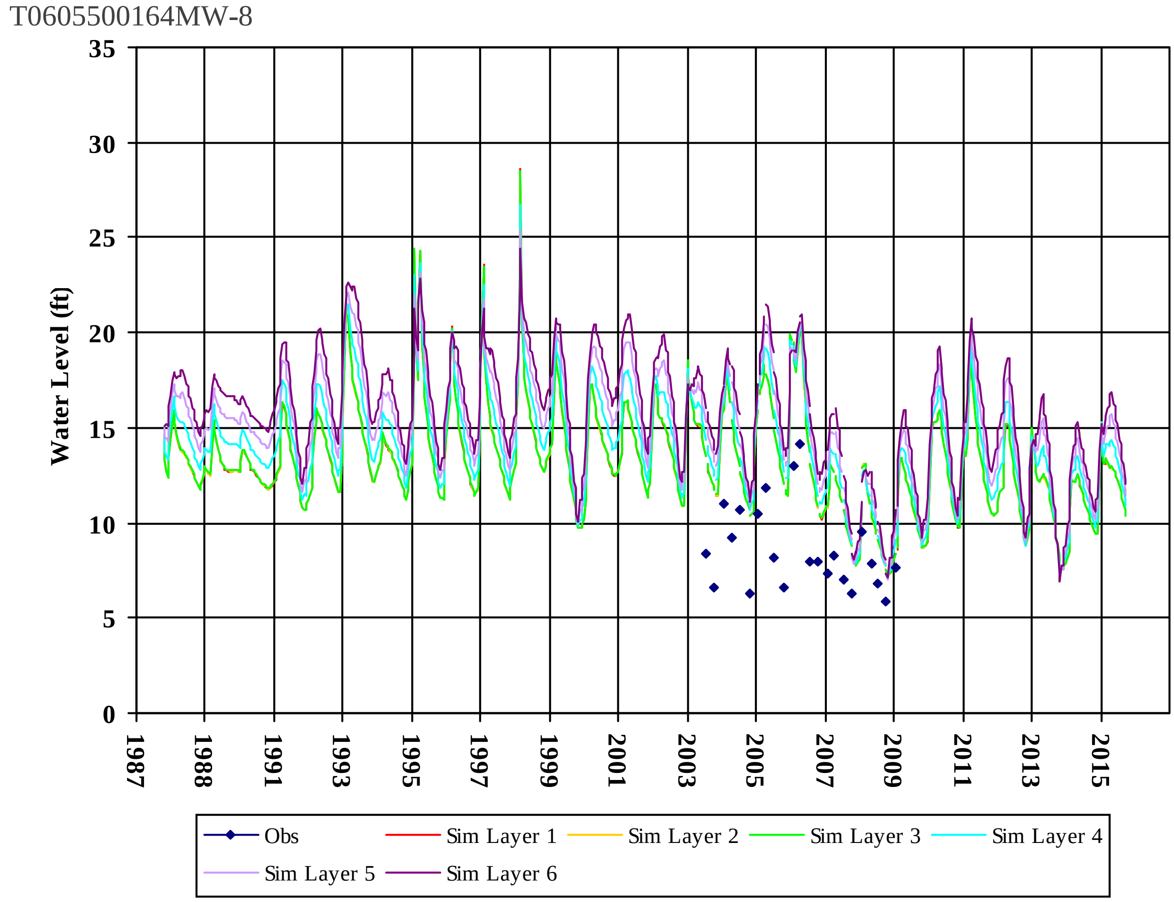




Well Depth:	25
Hole Depth:	25
Top Perf:	5
Bottom Perf:	25
Est Model Layer:	1



Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



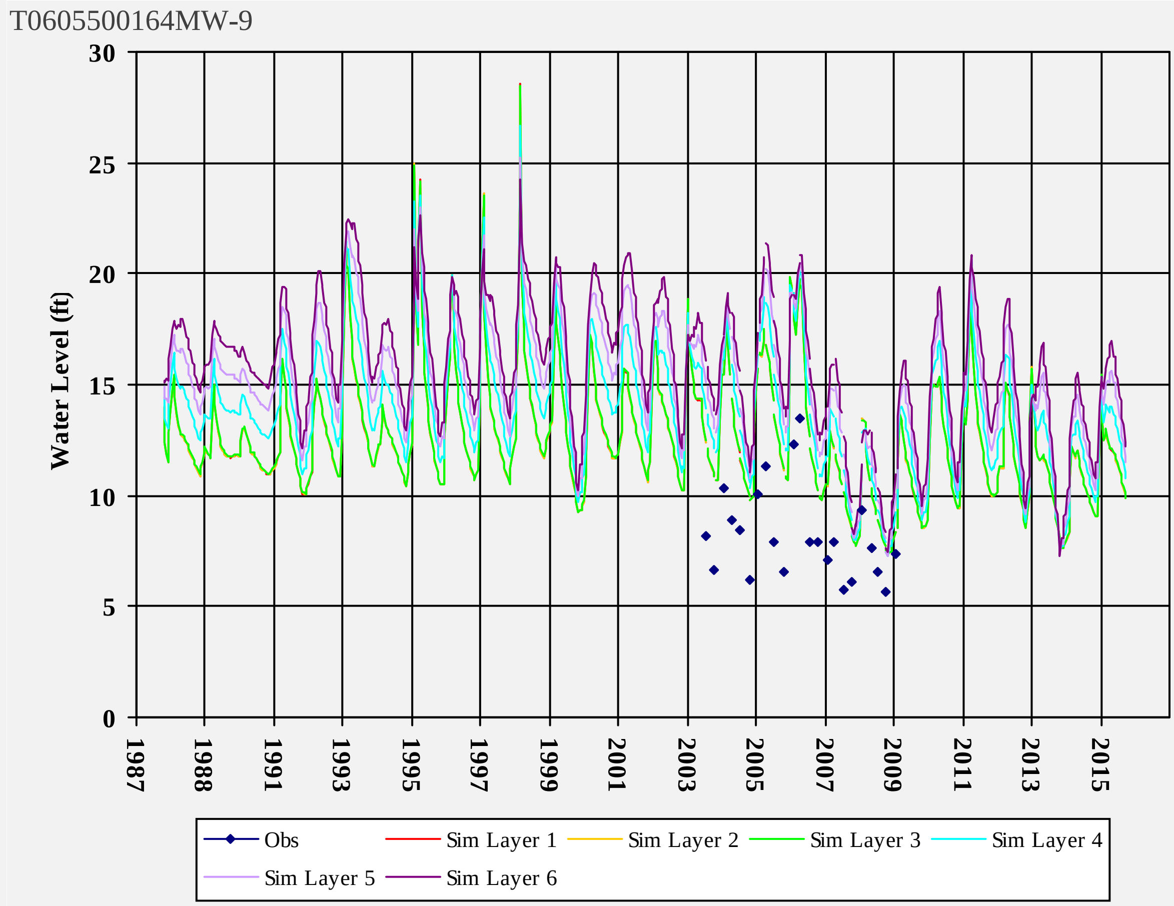
Well Depth:

Hole Depth:

Top Perf:

Bottom Perf:

Est Model Layer: 1



Well Depth:

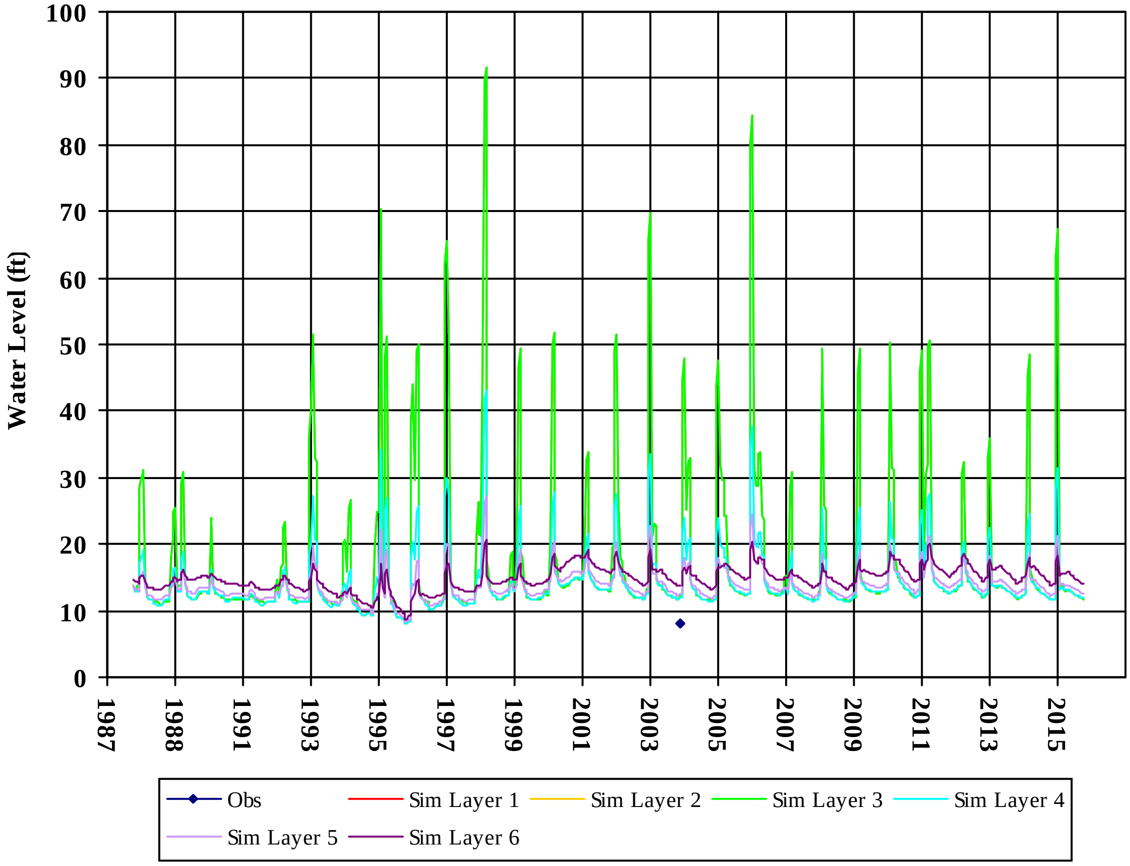
Hole Depth:

Top Perf:

Bottom Perf:

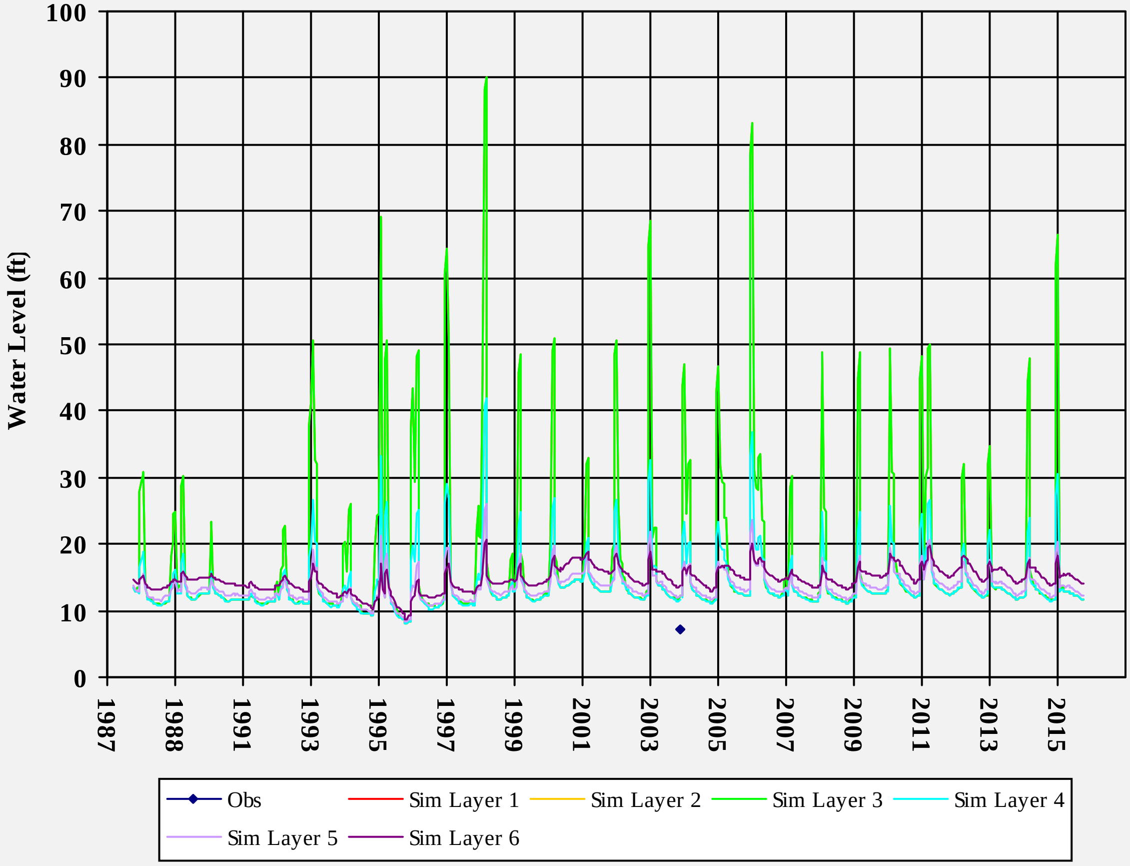
Est Model Layer: 1

T0605500195MW-1



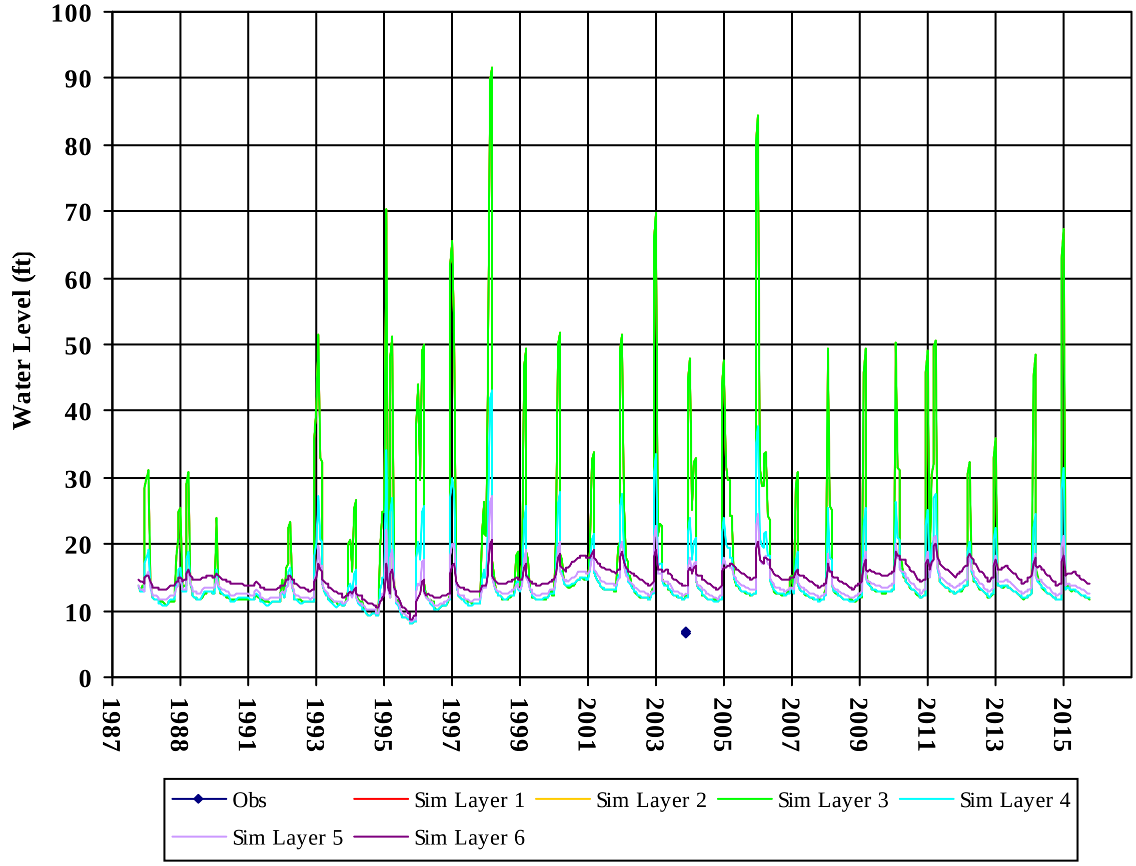
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500195MW-2



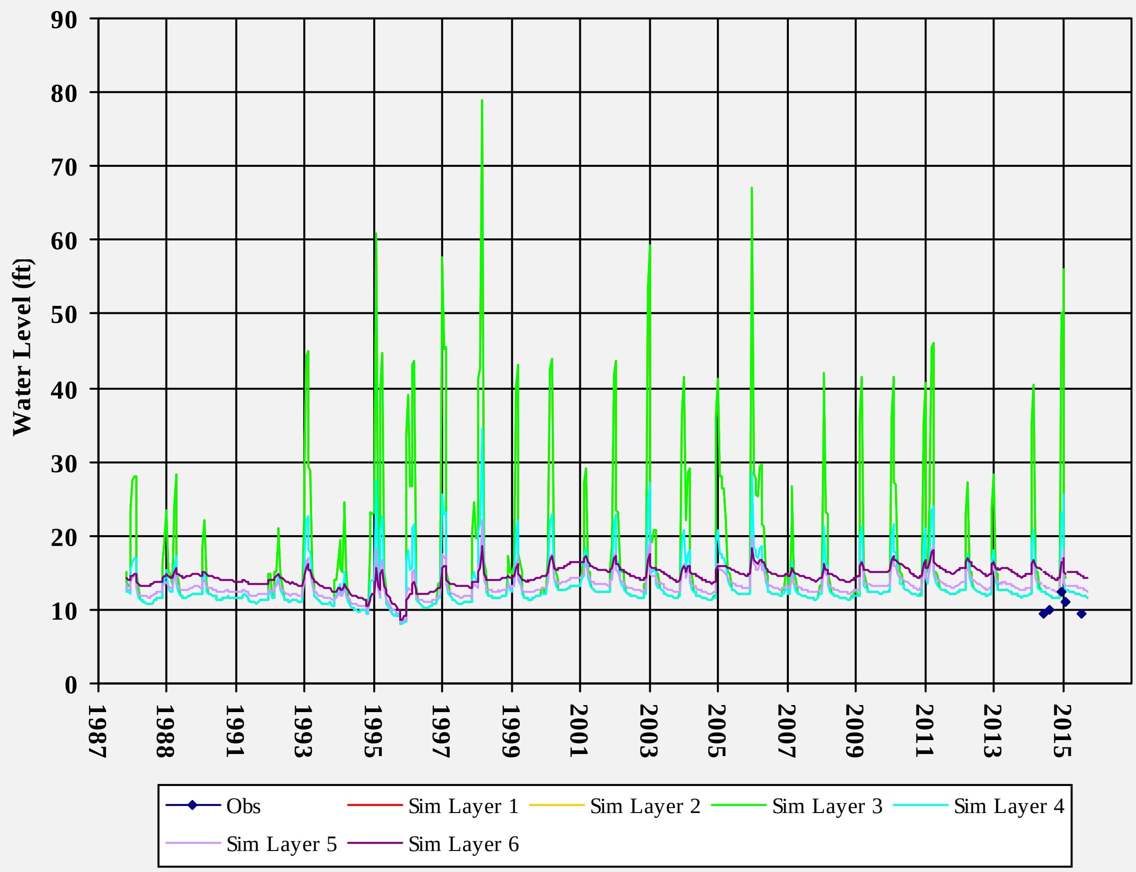
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500195MW-3



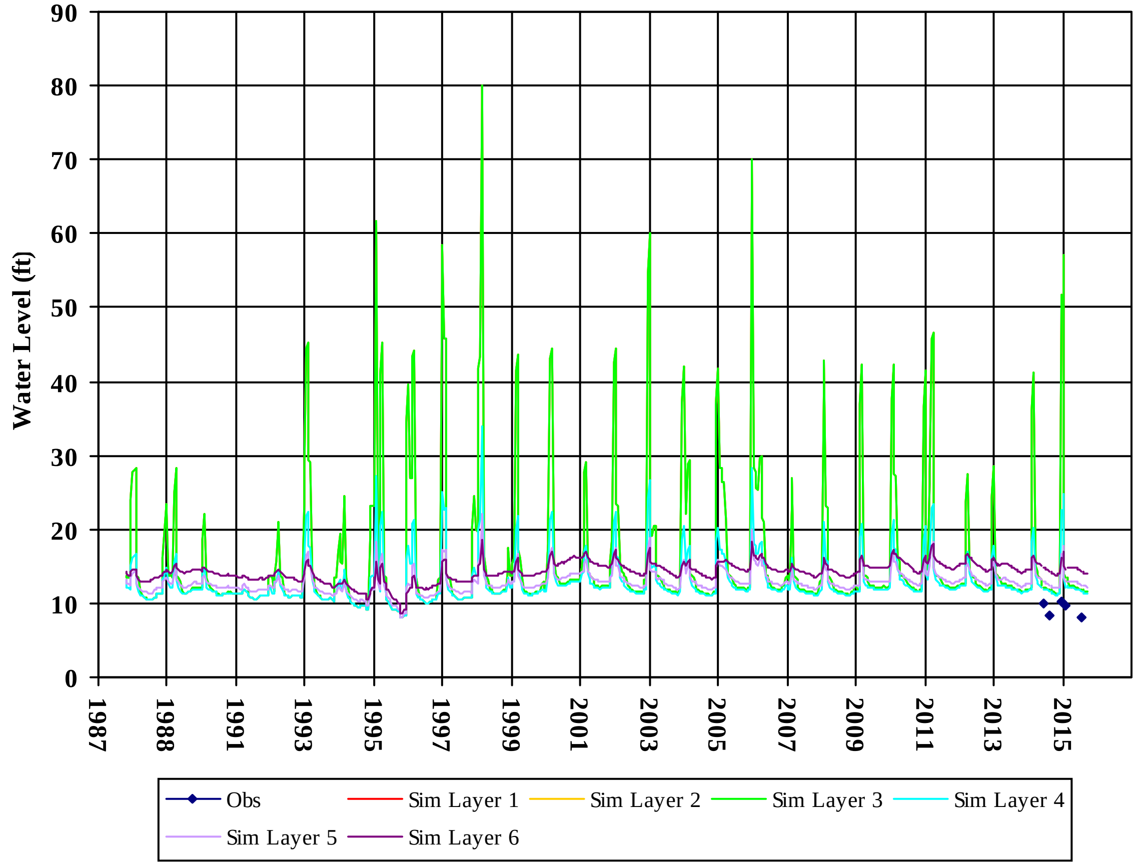
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500200MW-1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500200MW-2



Well Depth:

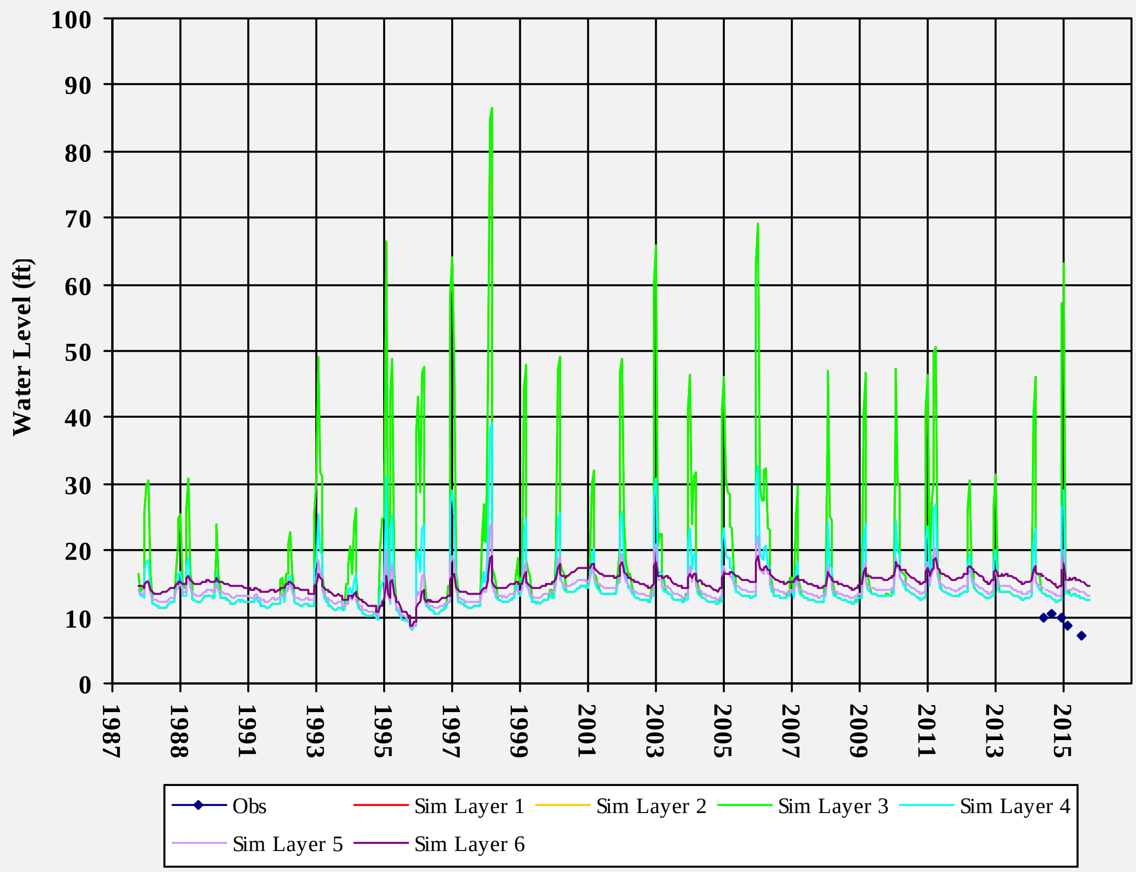
Hole Depth:

Top Perf:

Bottom Perf:

Est Model Layer: 1

T0605500200MW-3



Well Depth:

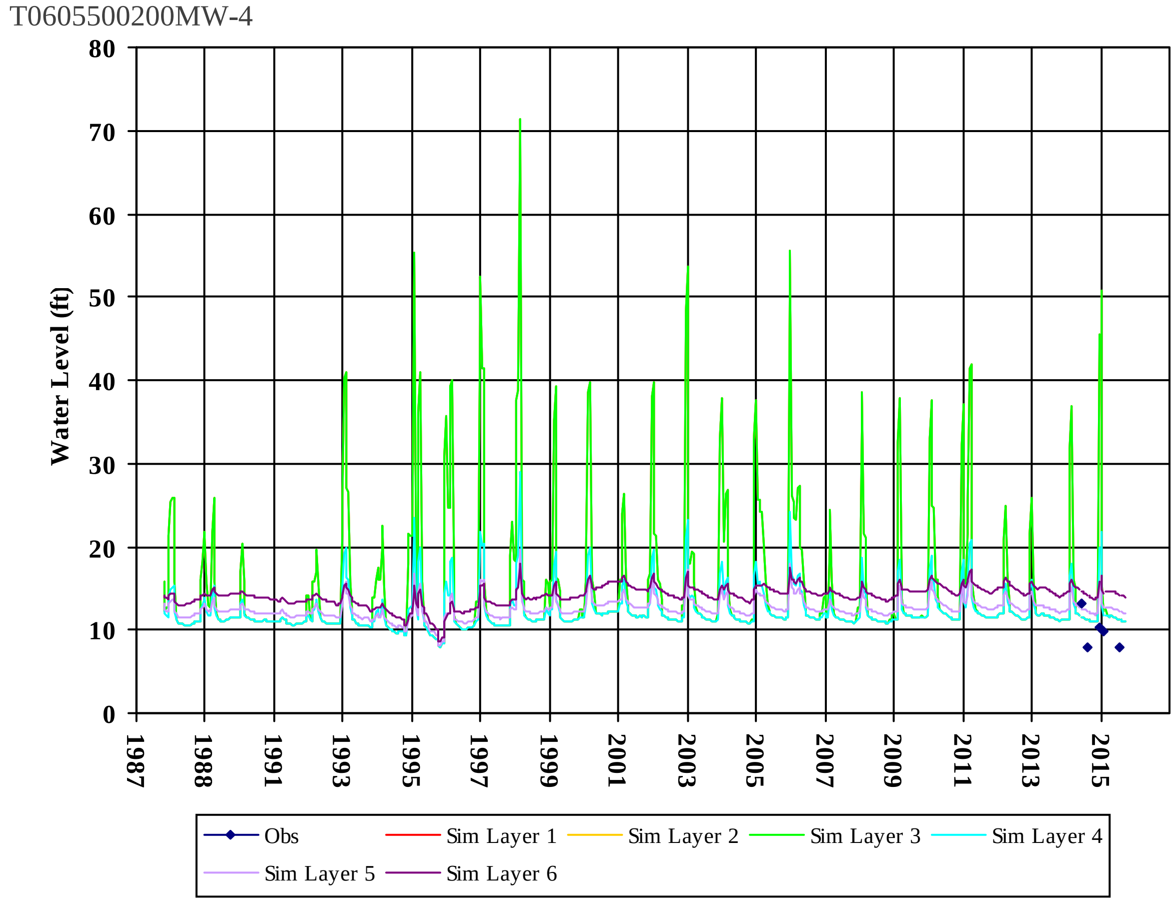
Hole Depth:

Top Perf:

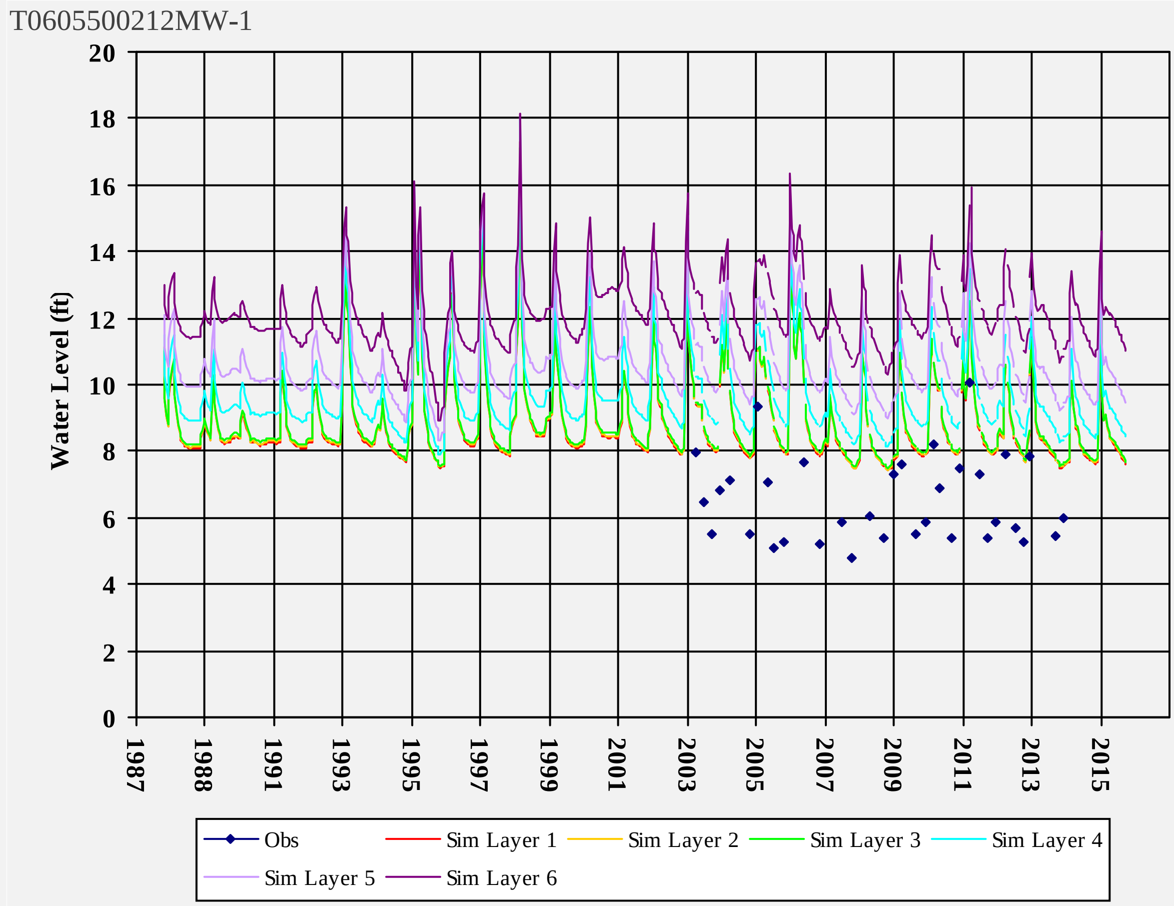
Bottom Perf:

Est Model Layer: 1

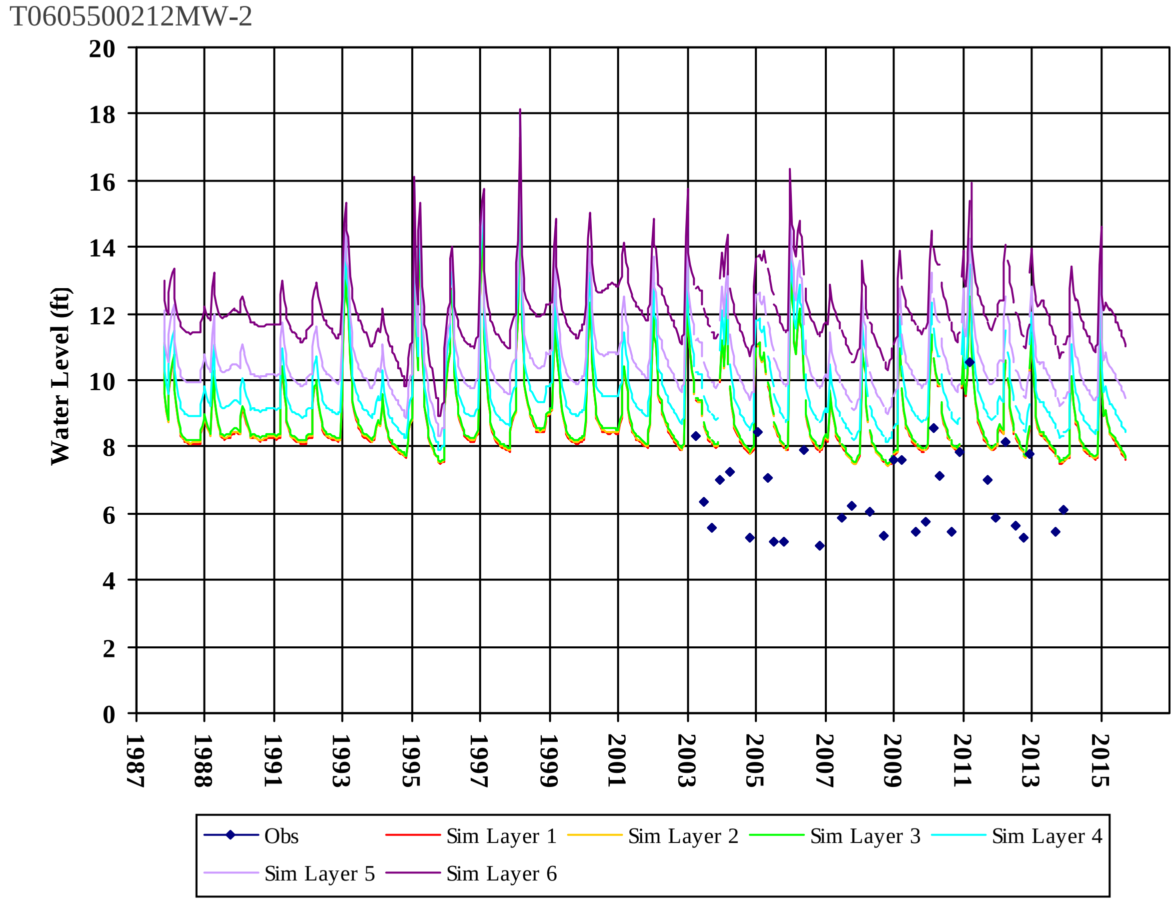
Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



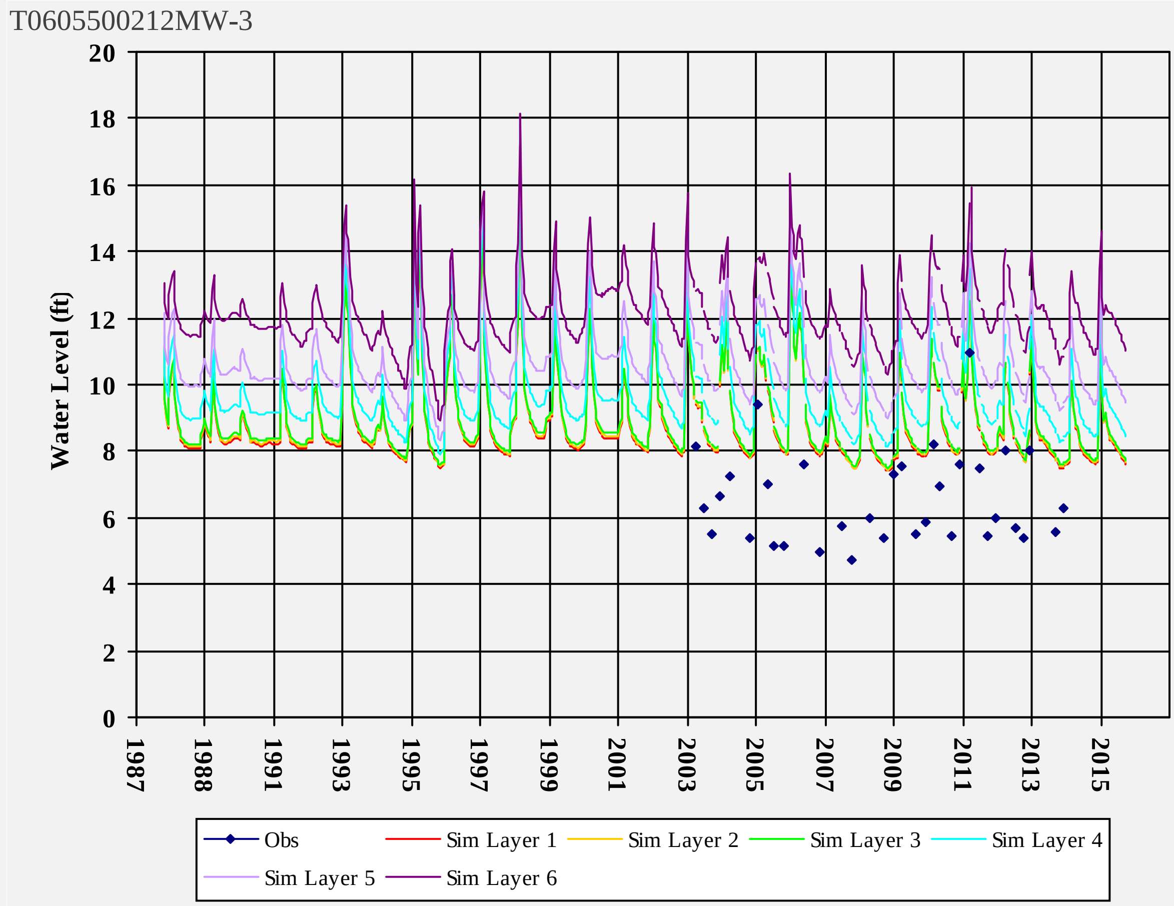
Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



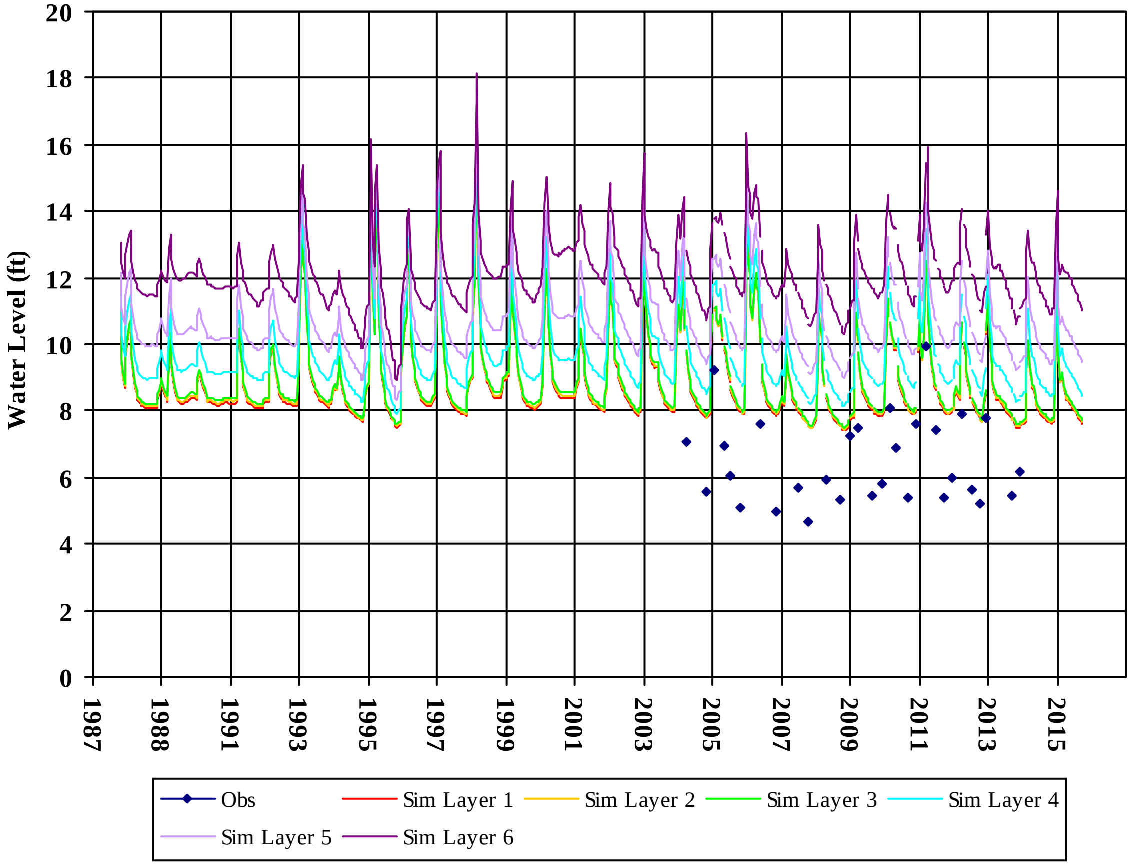
Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

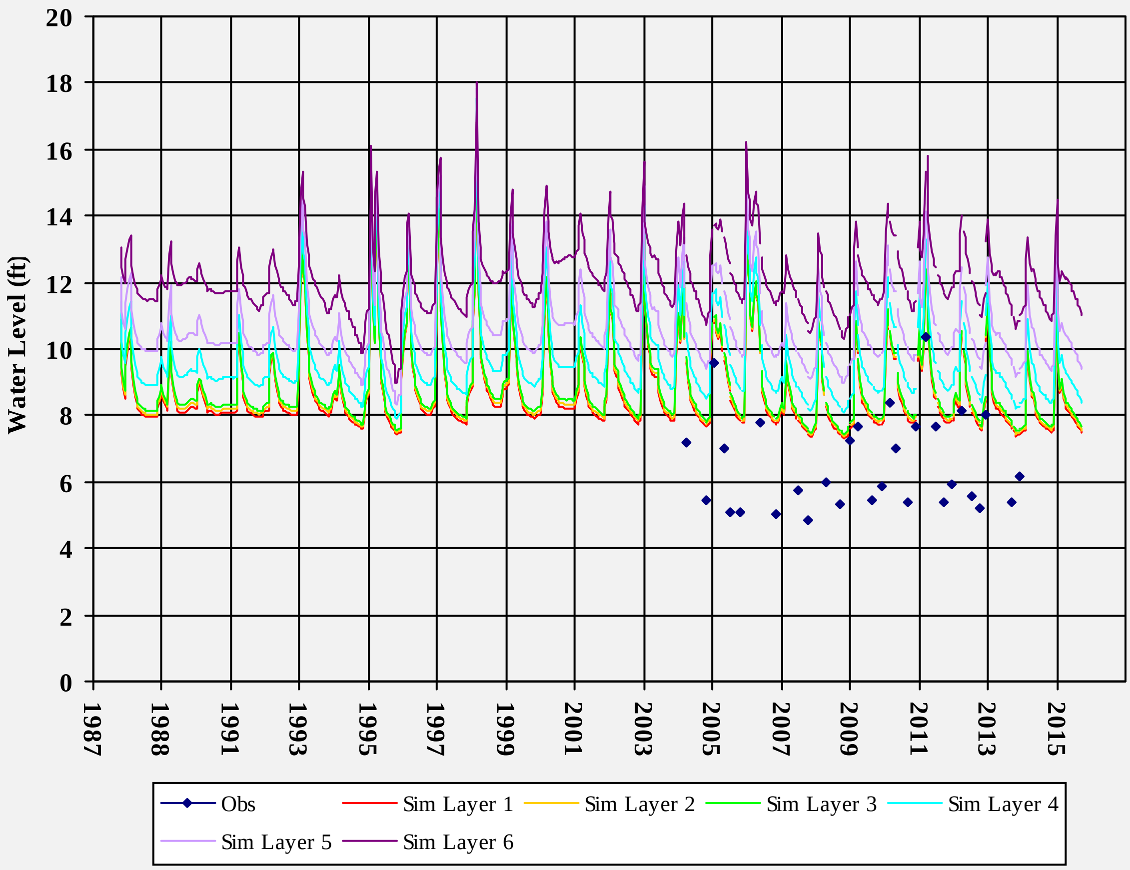


T0605500212MW-4



Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

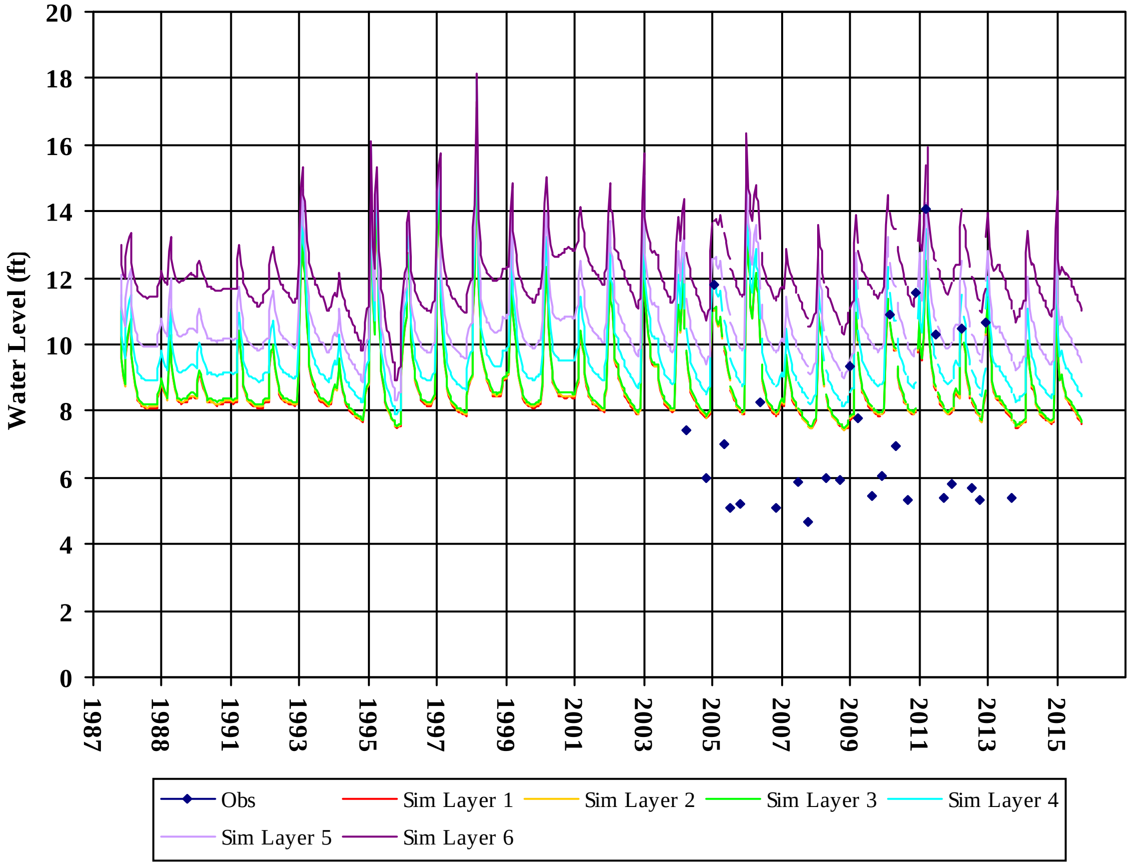
T0605500212MW-5



Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

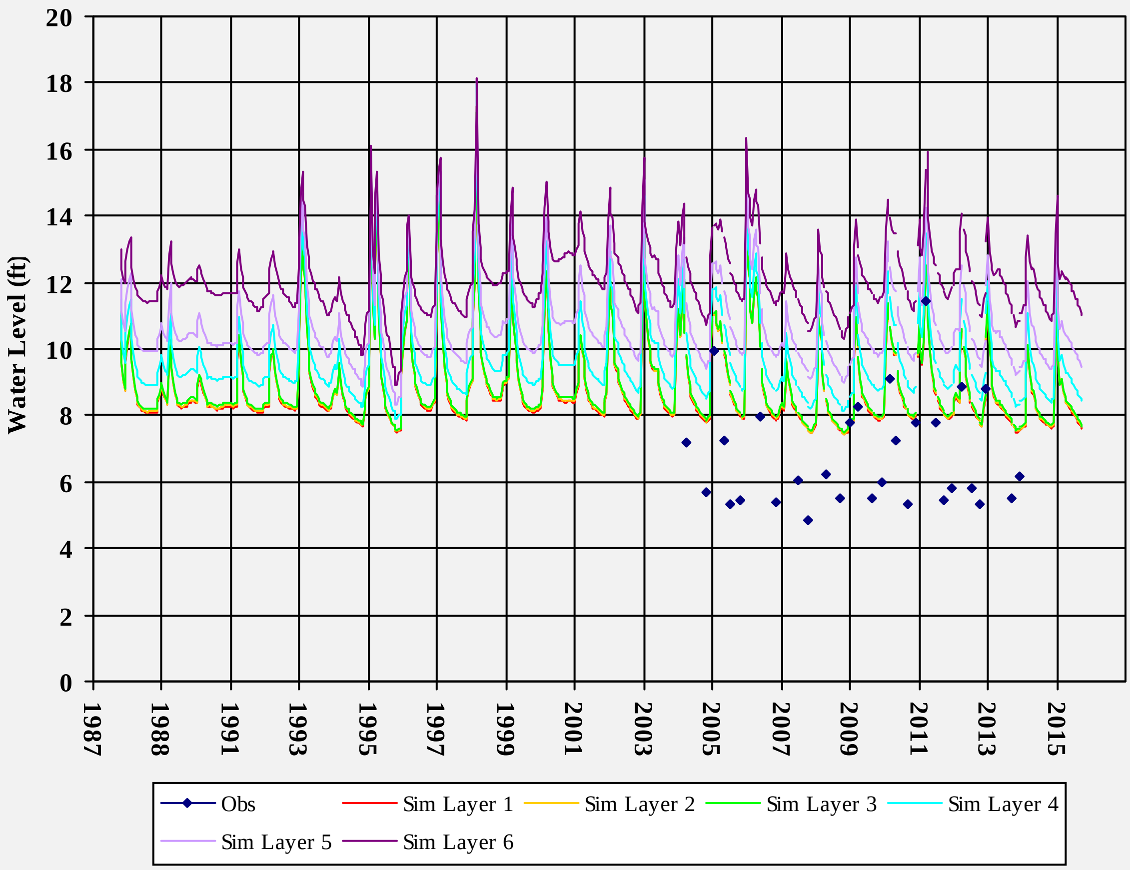
Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

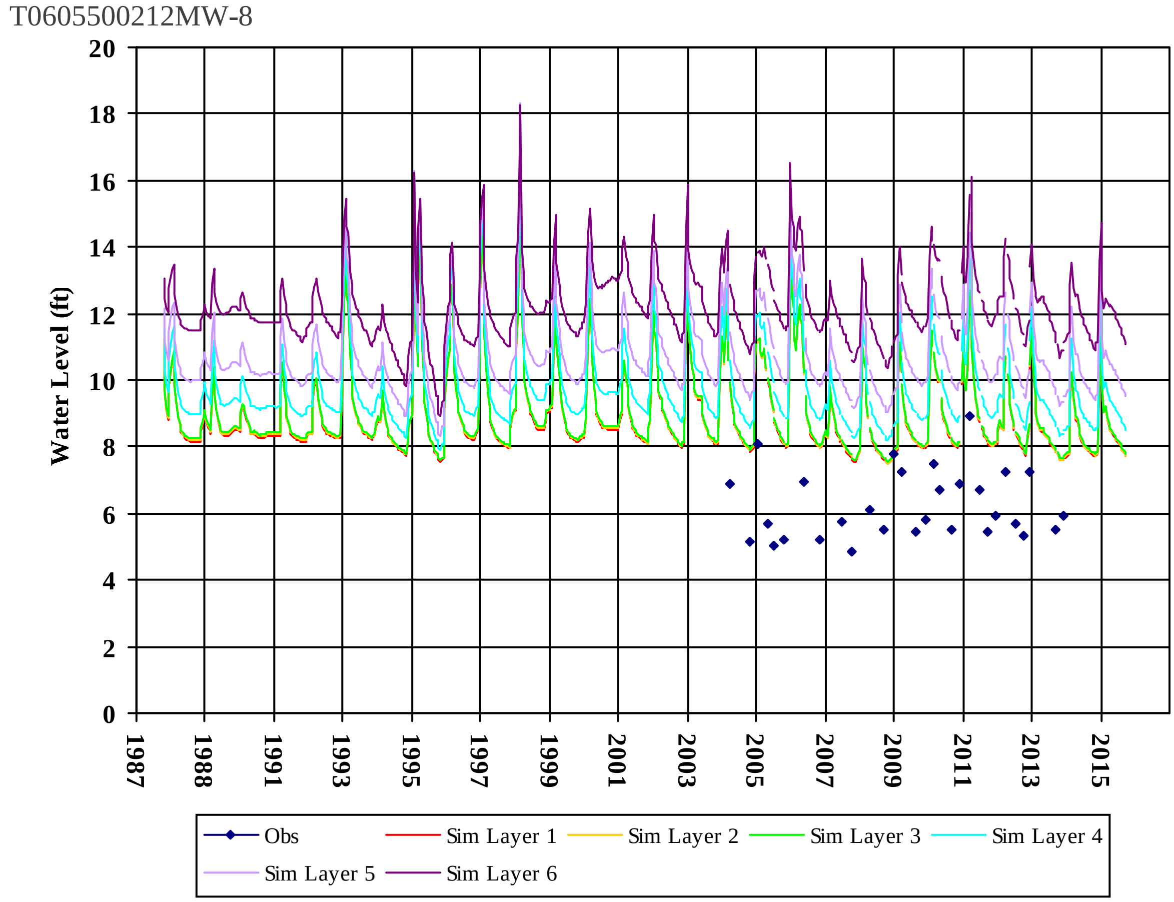
T0605500212MW-6



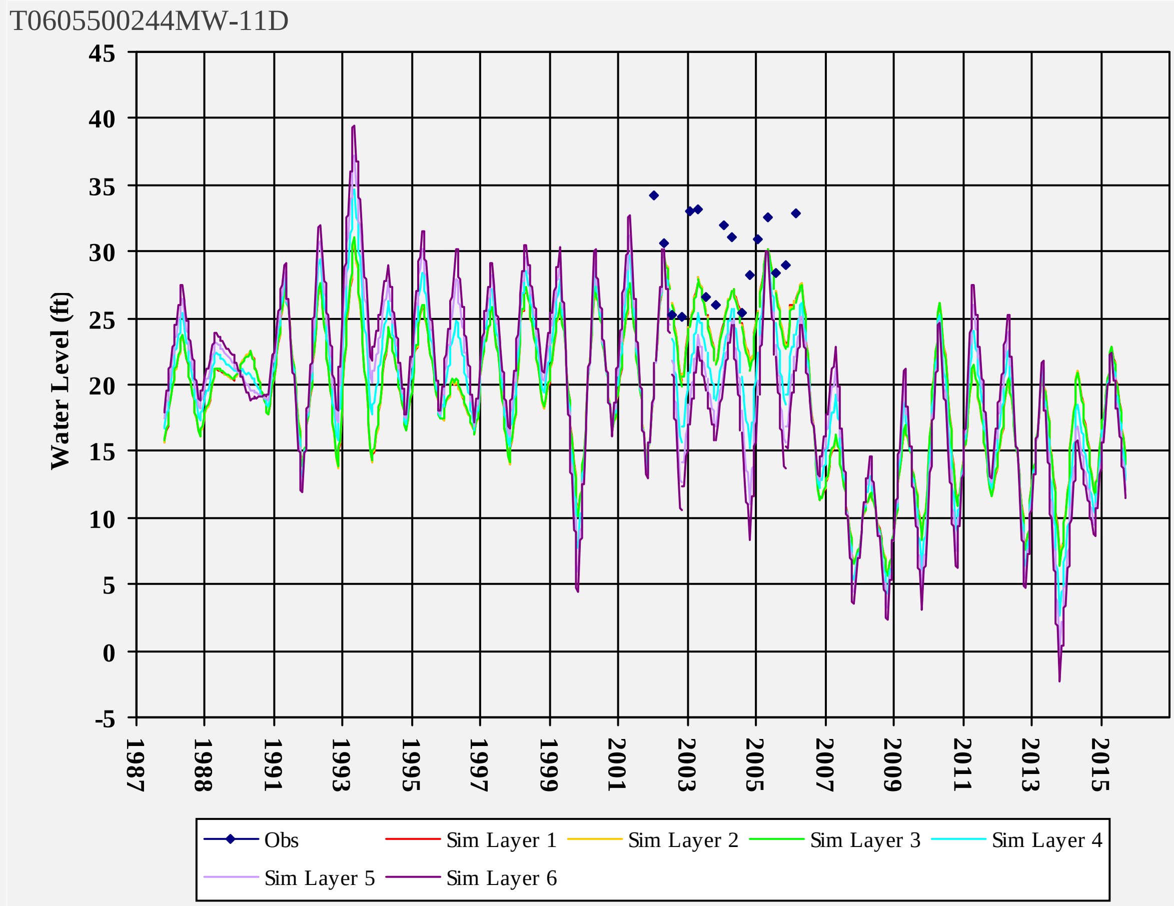
Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500212MW-7



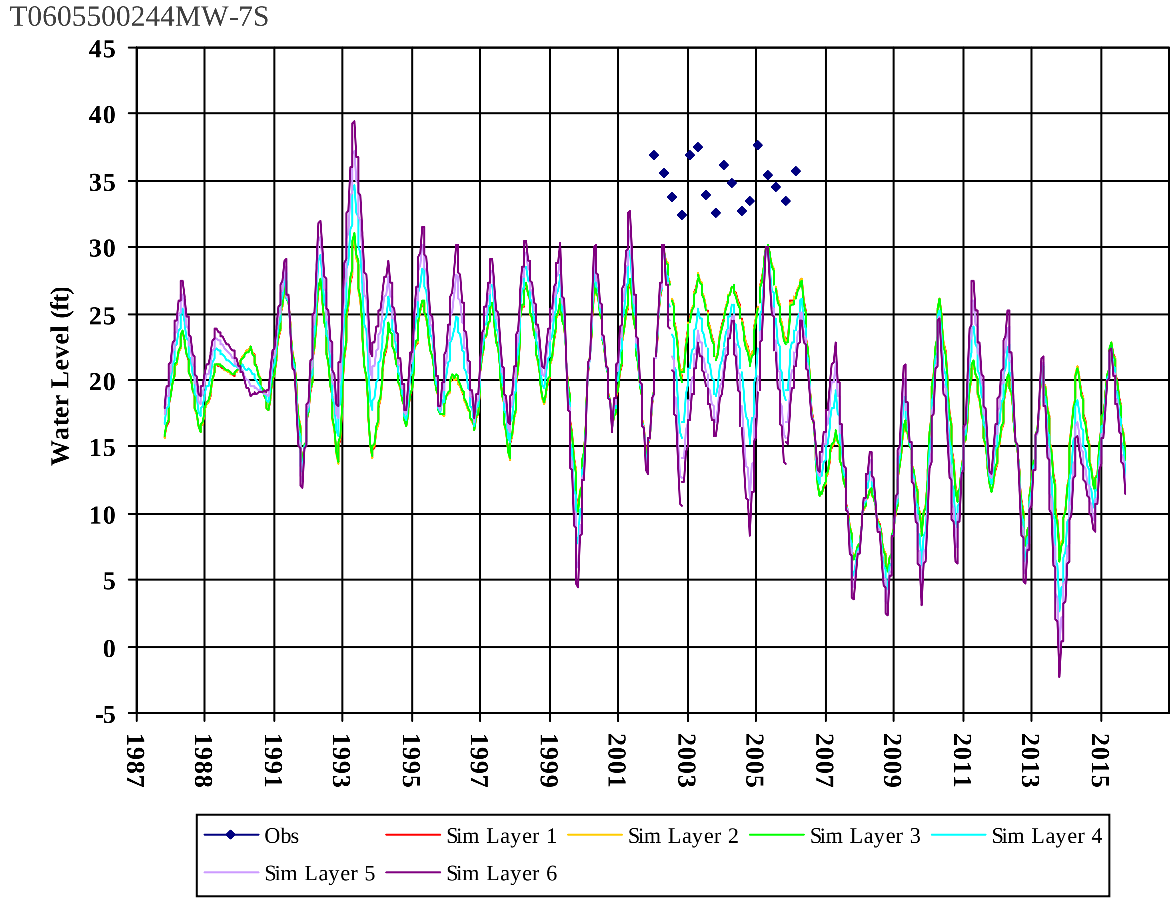


Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

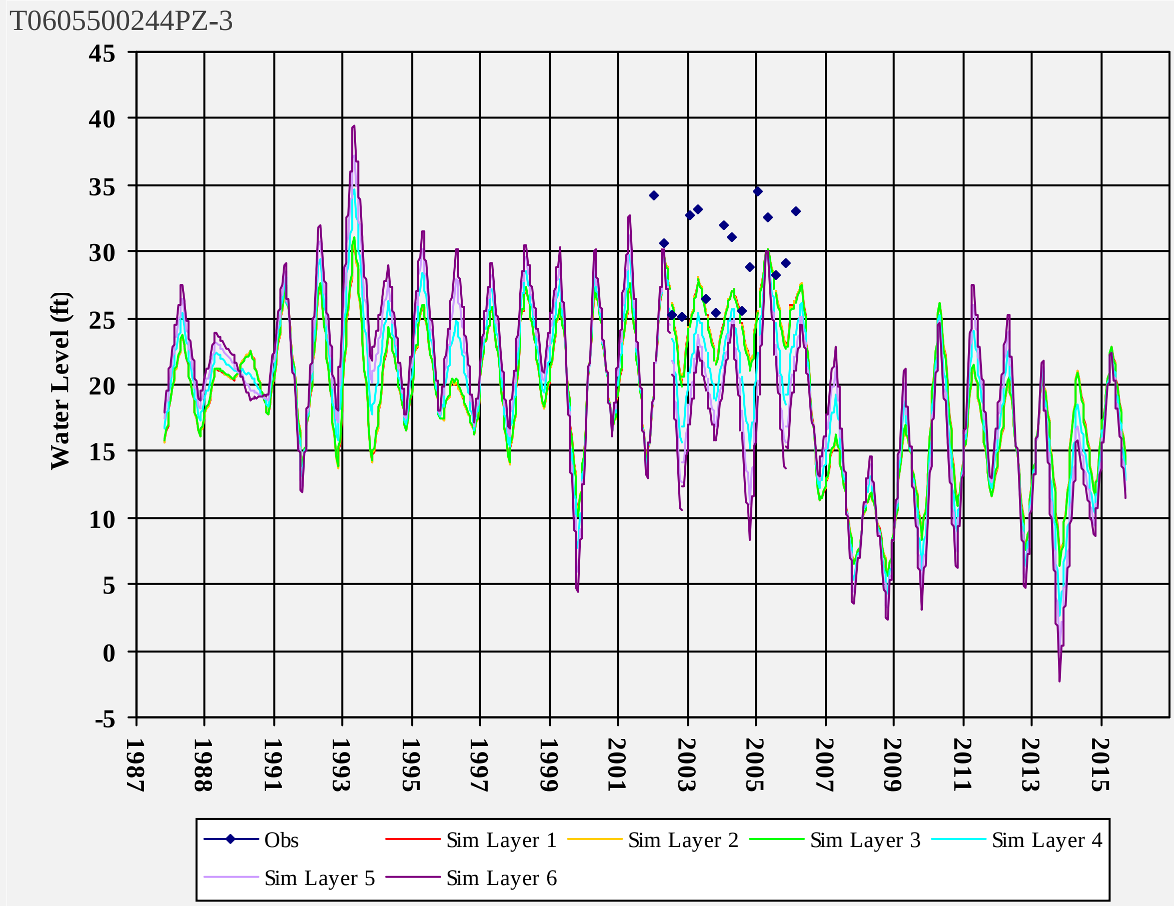


Well Depth: 71.78
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

Well Depth: 20.18
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

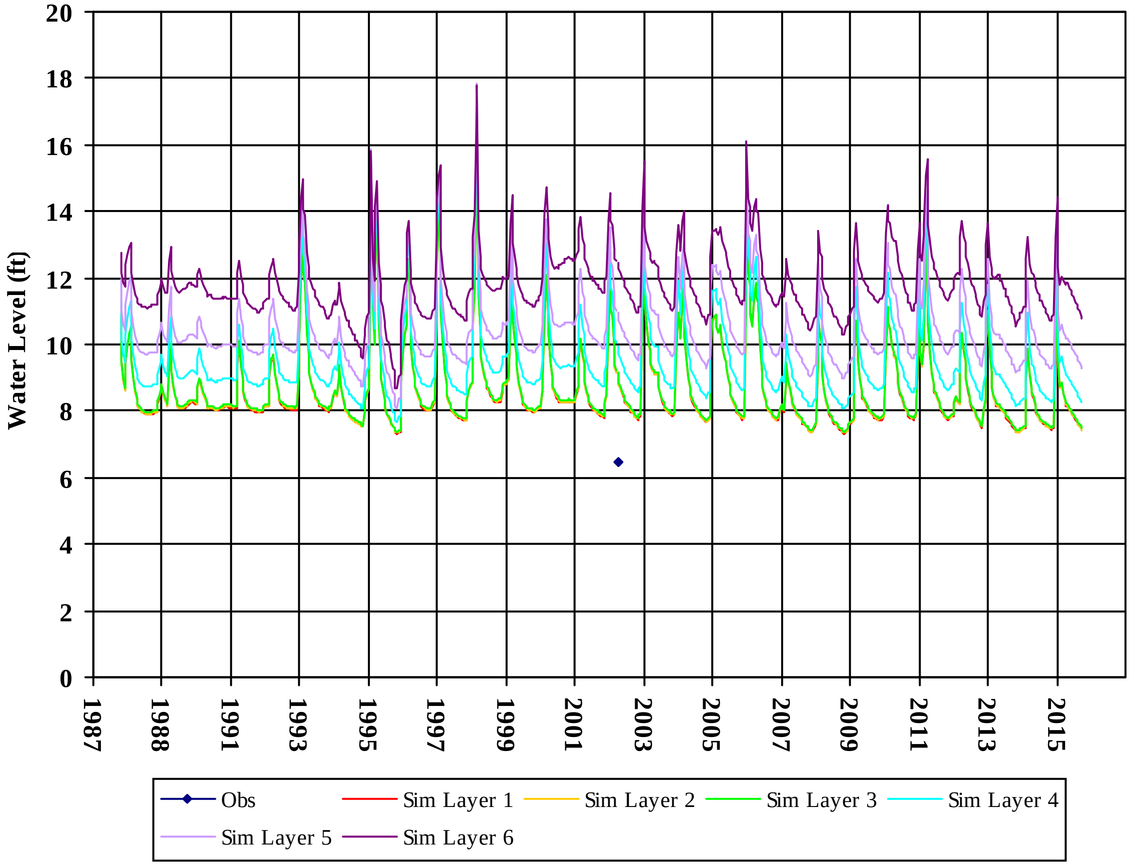


Well Depth: 42.97
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



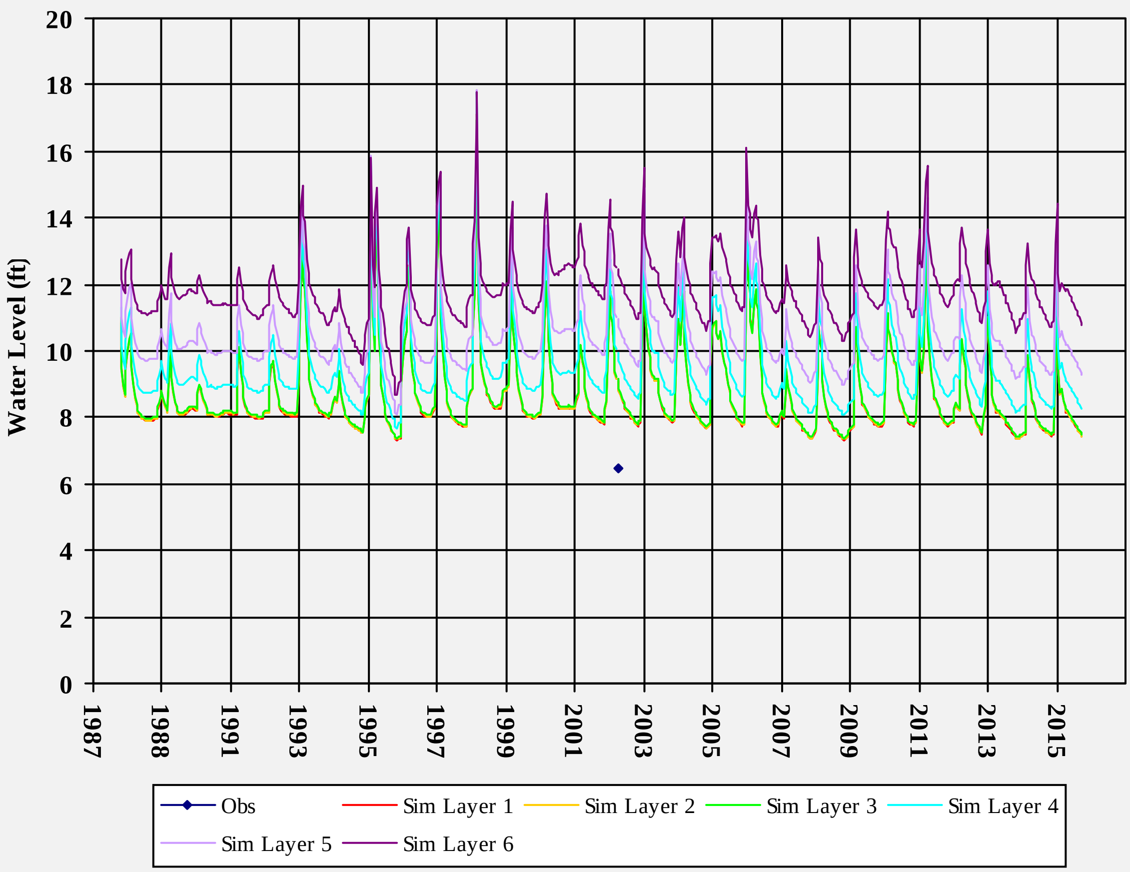
T0605500254MW-1

Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

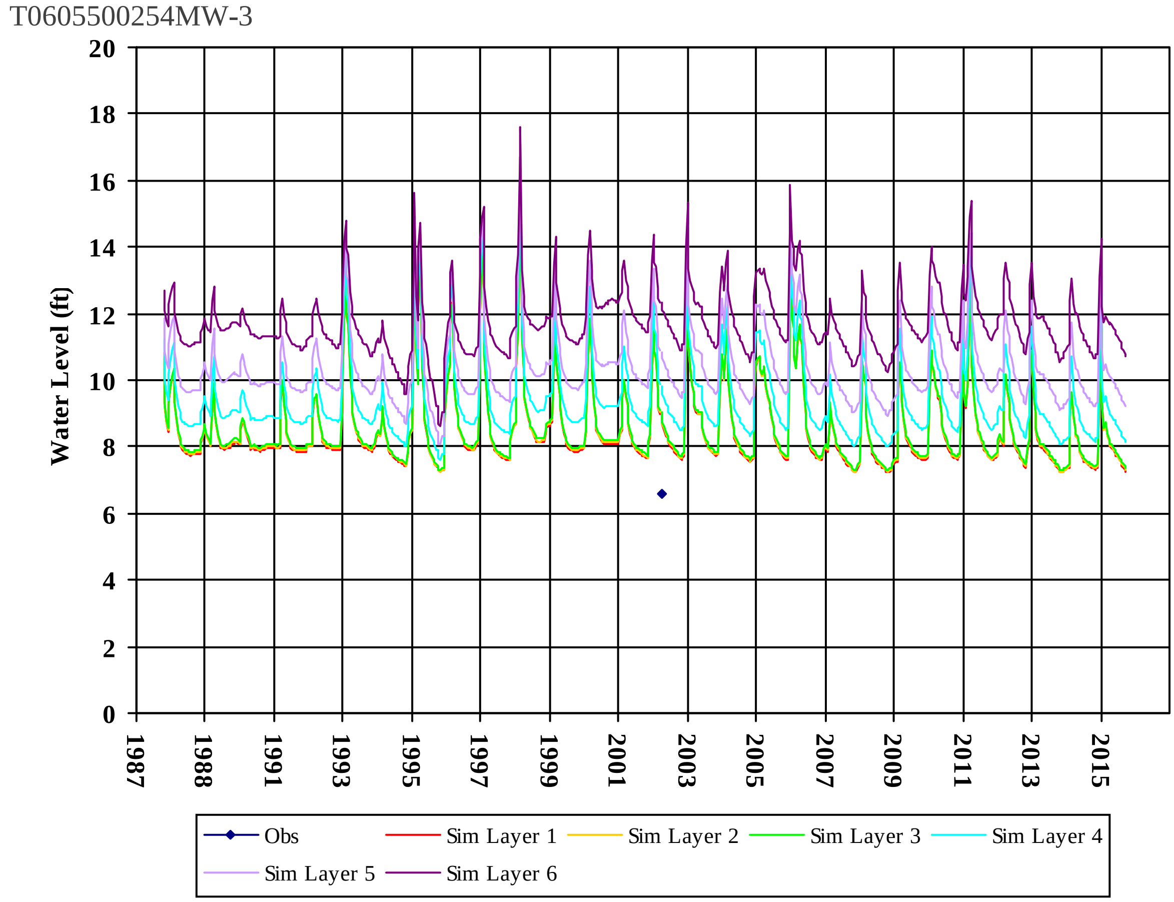


T0605500254MW-2

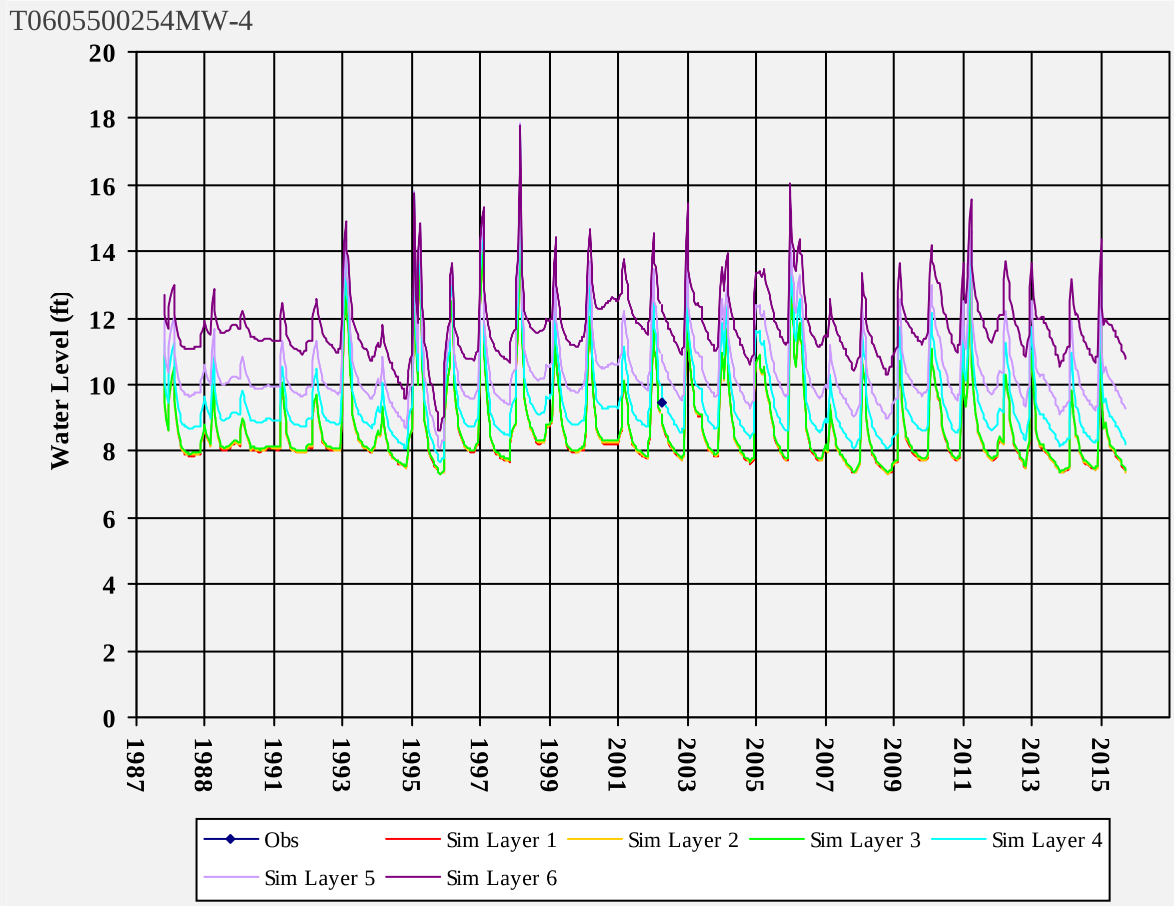
Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



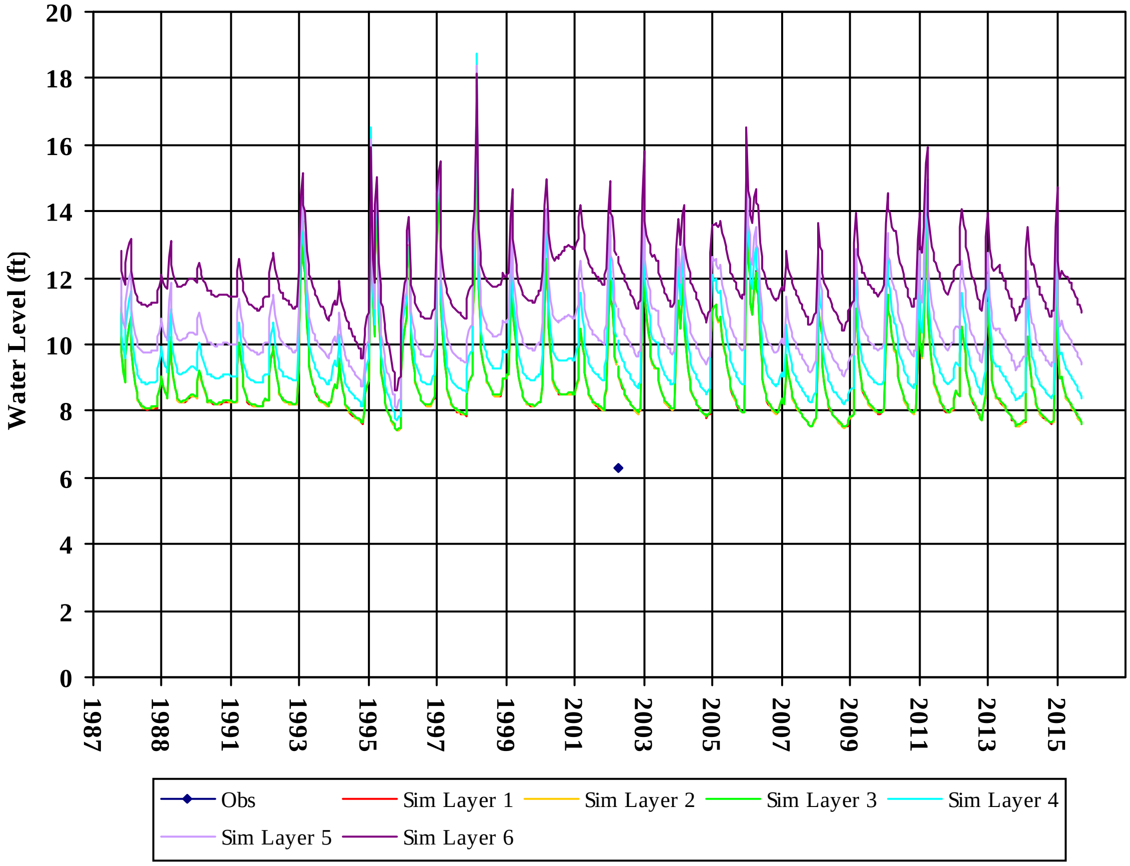
Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



Well Depth:	20
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

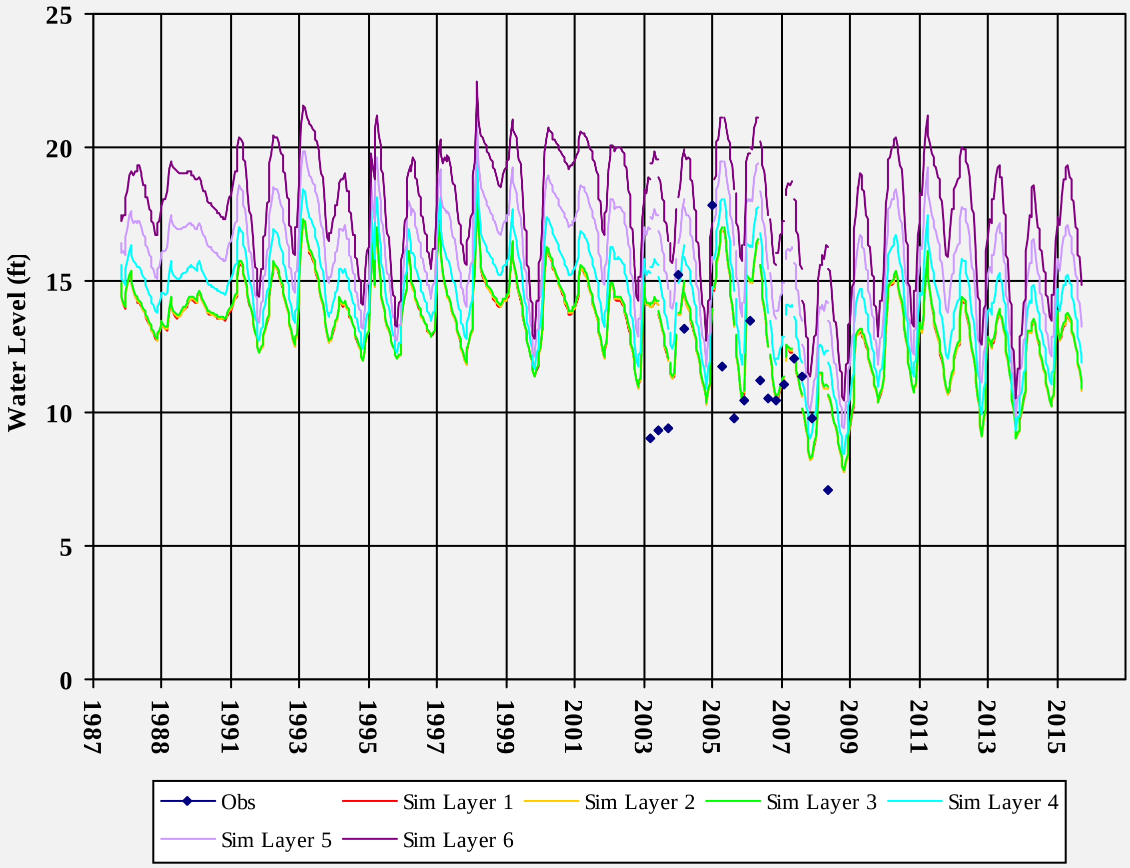


T0605500254MW-5

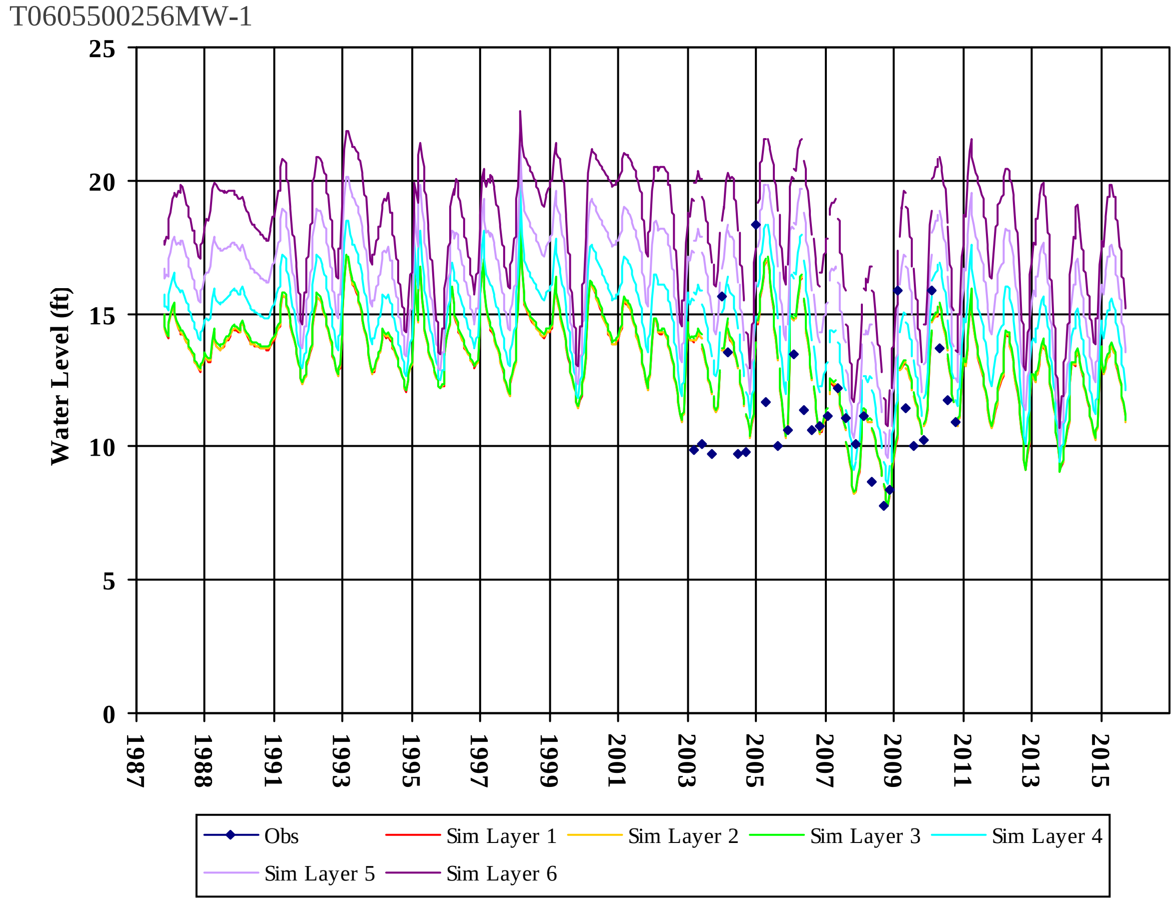


Well Depth: 20
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

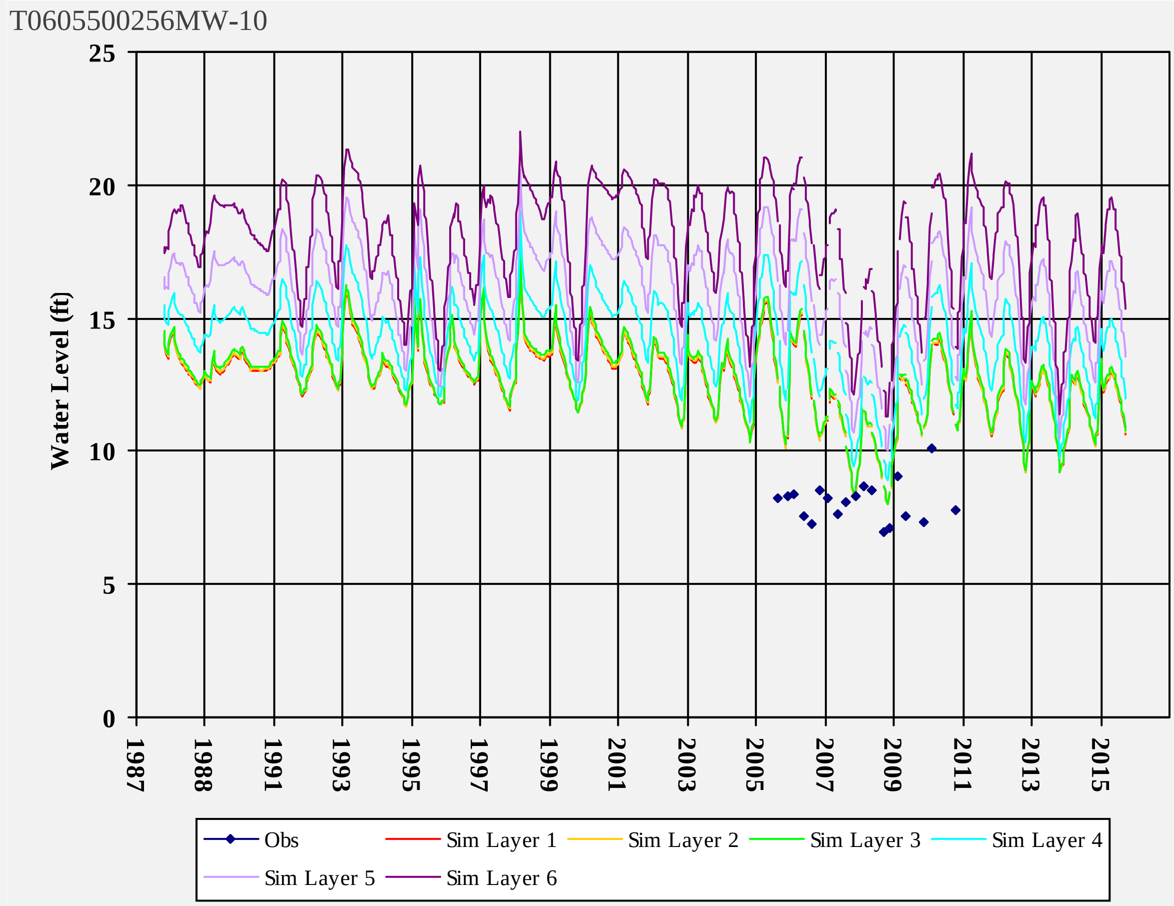
T0605500256EW-1



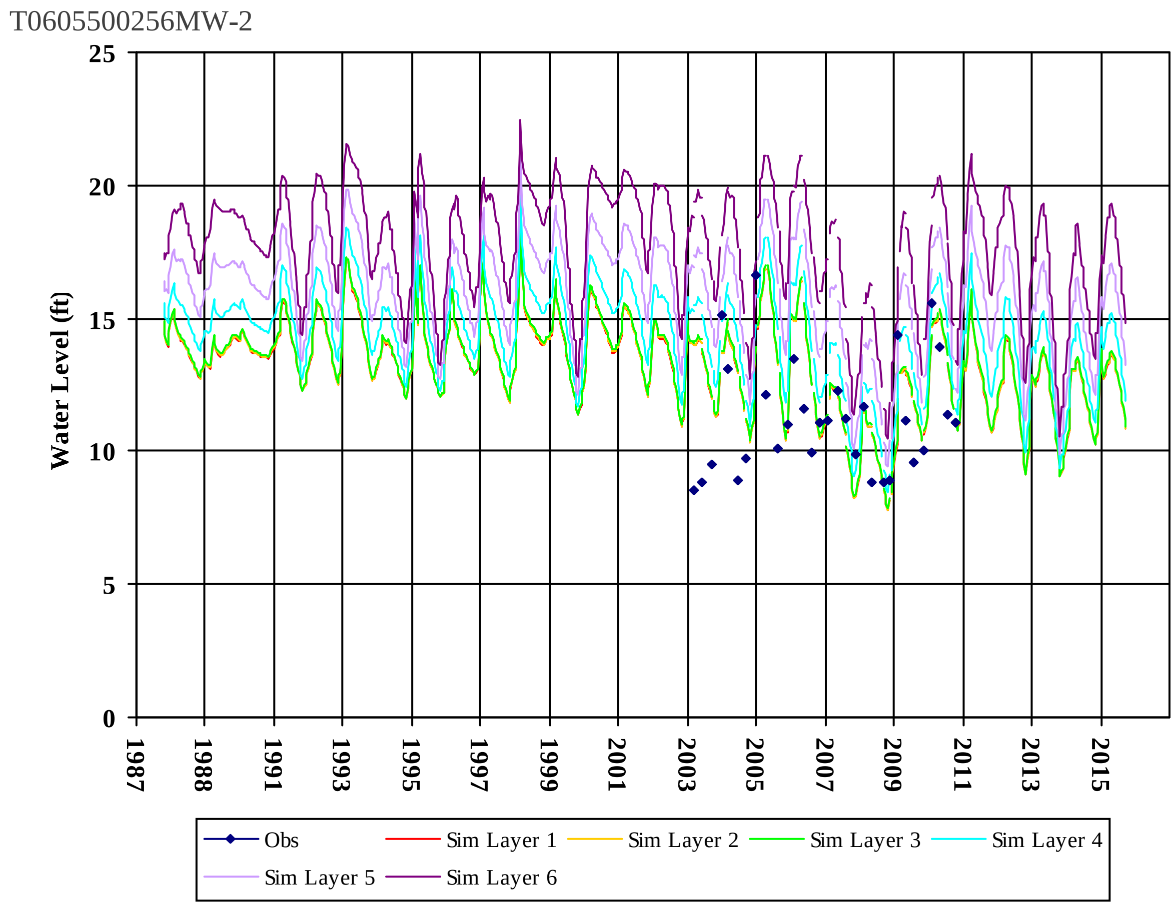
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



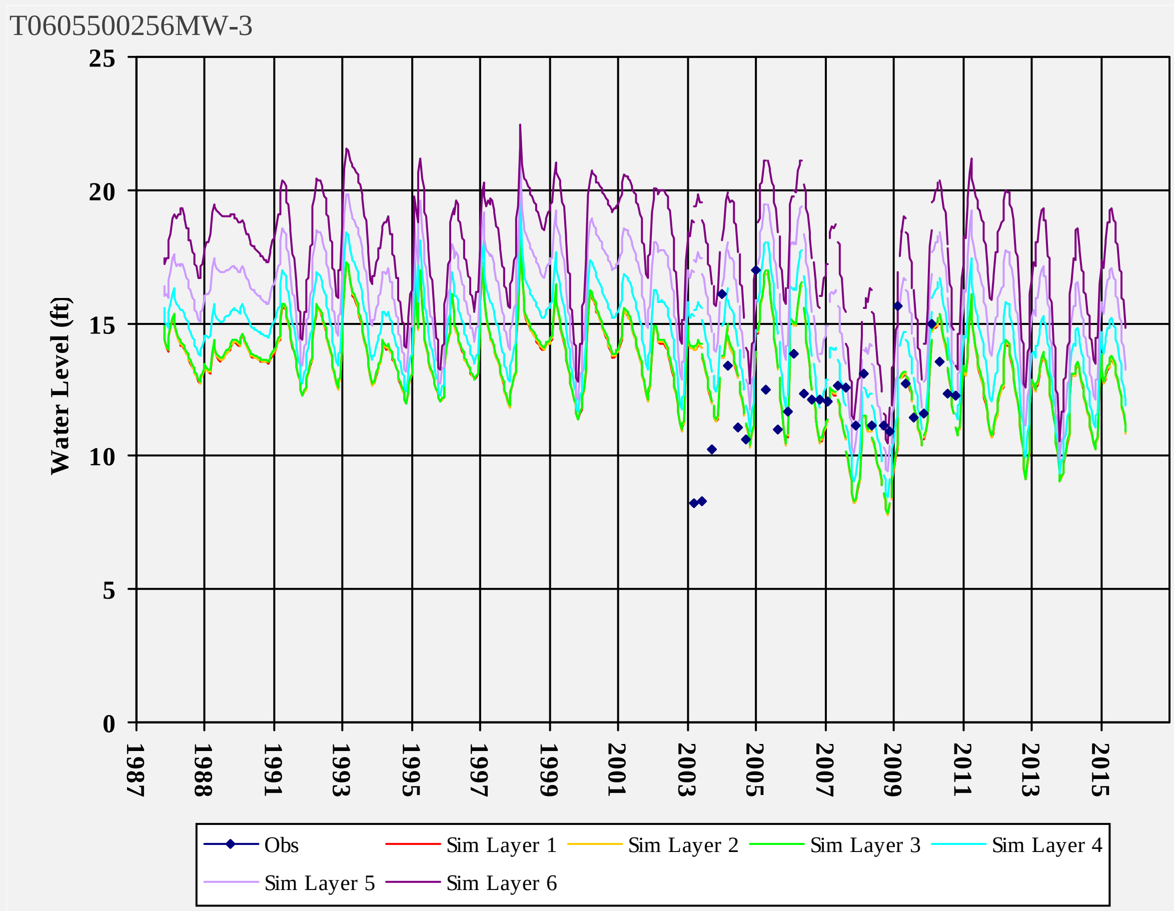
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

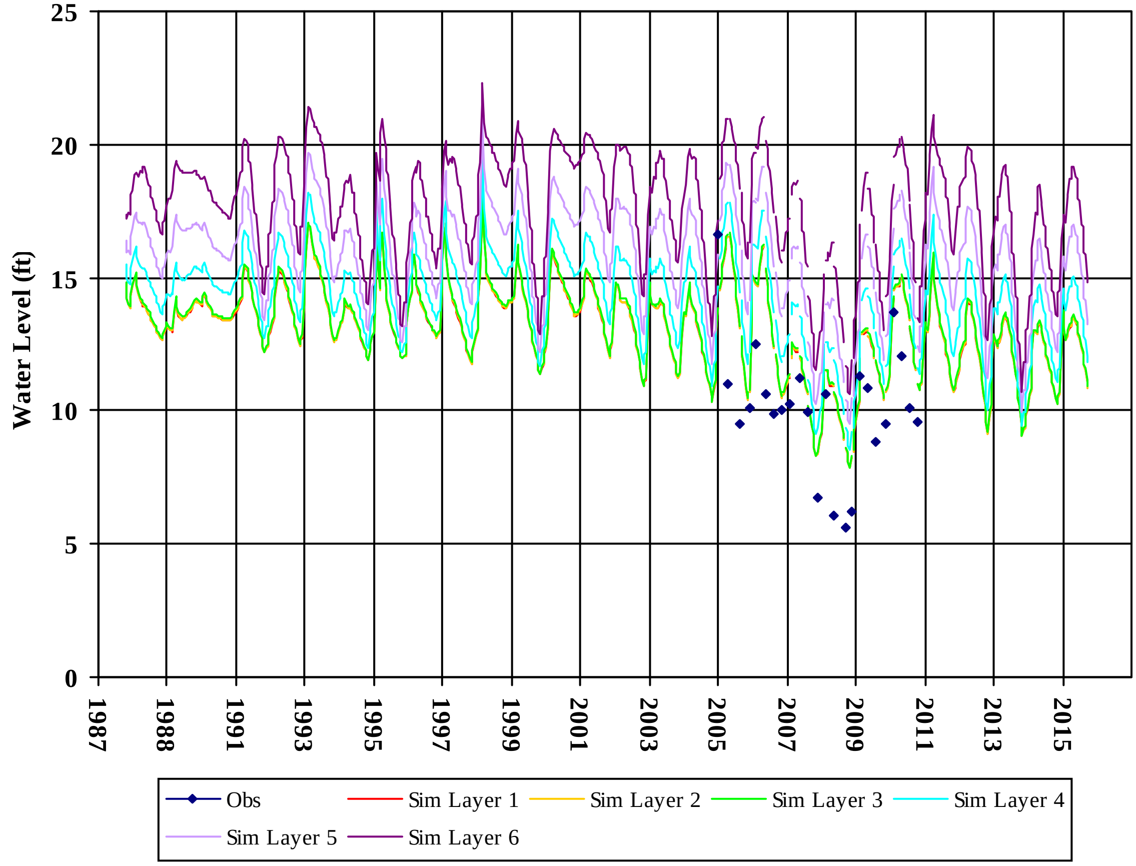


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



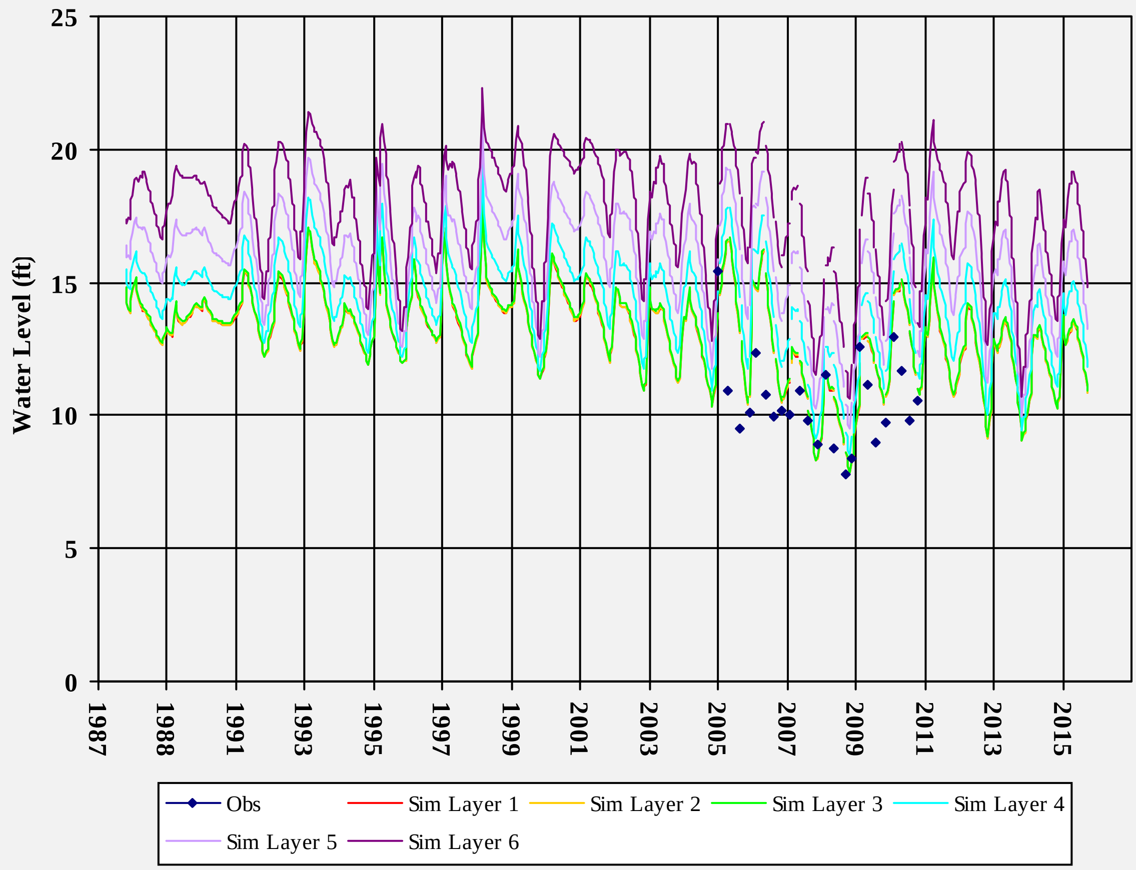
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500256MW-4



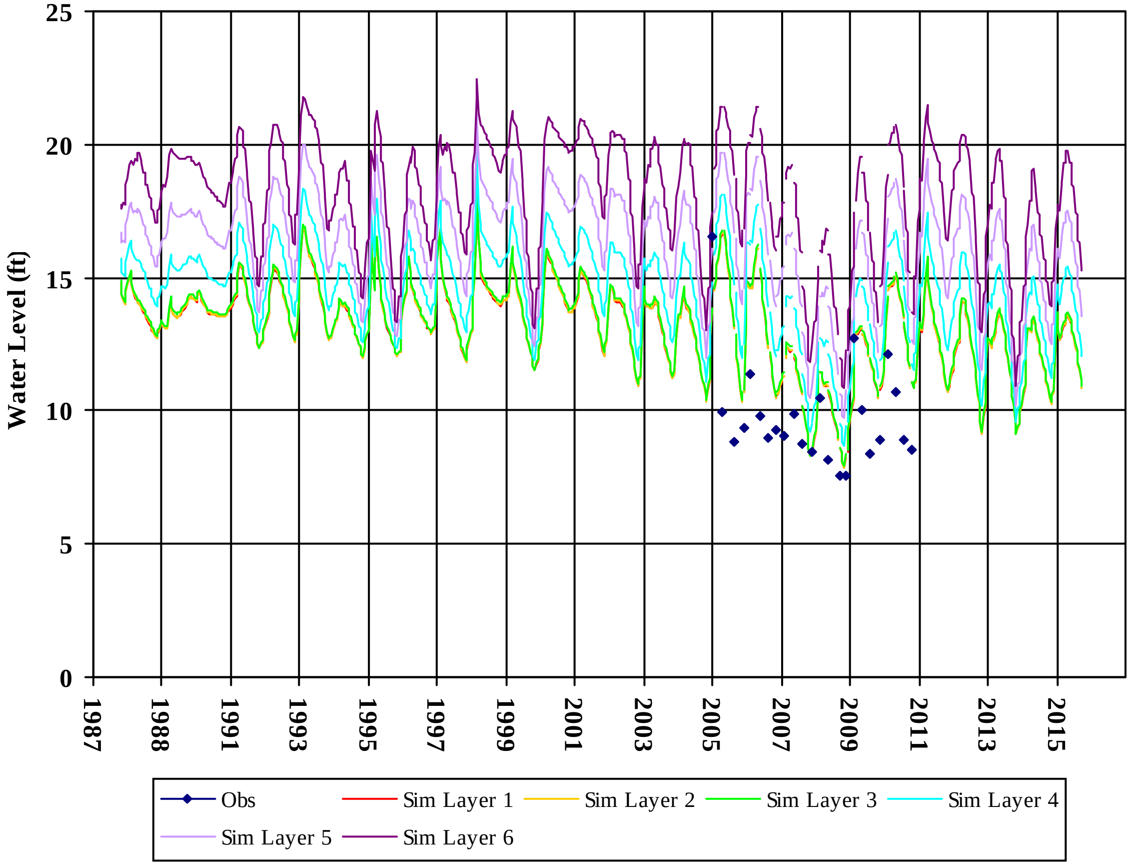
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500256MW-5



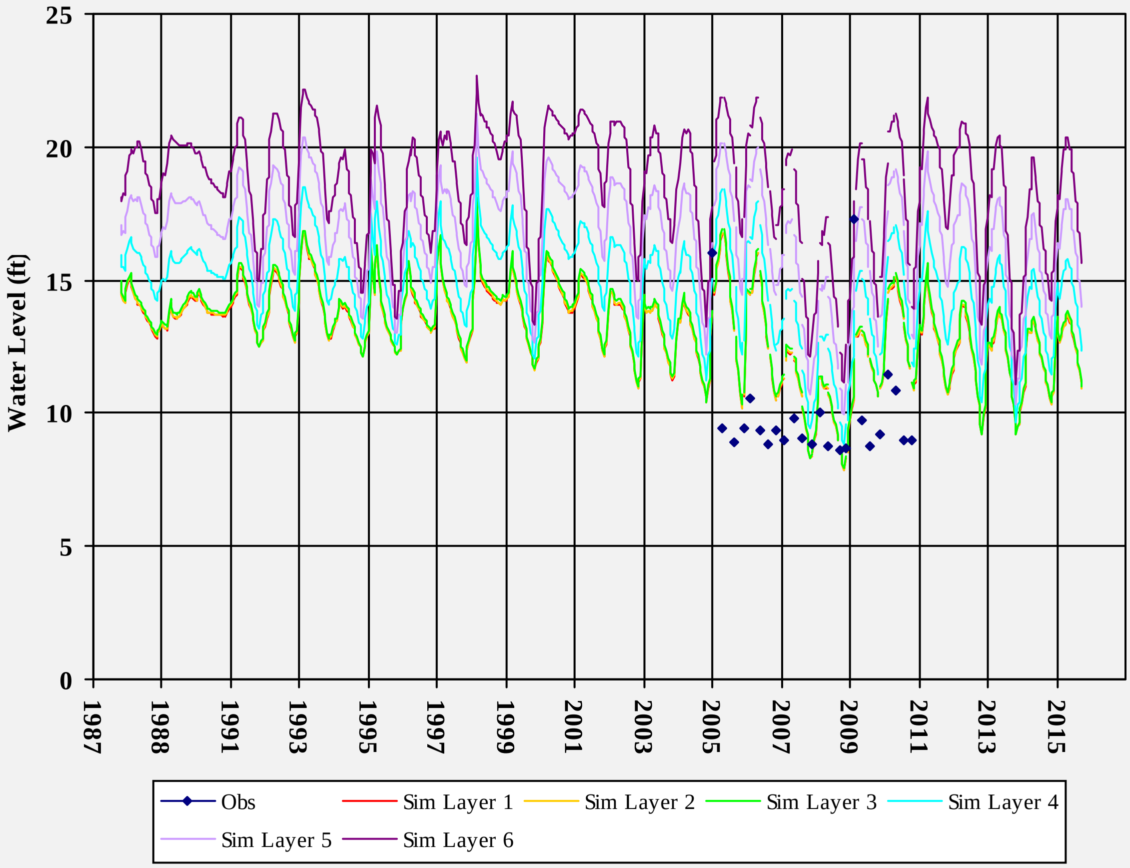
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500256MW-6



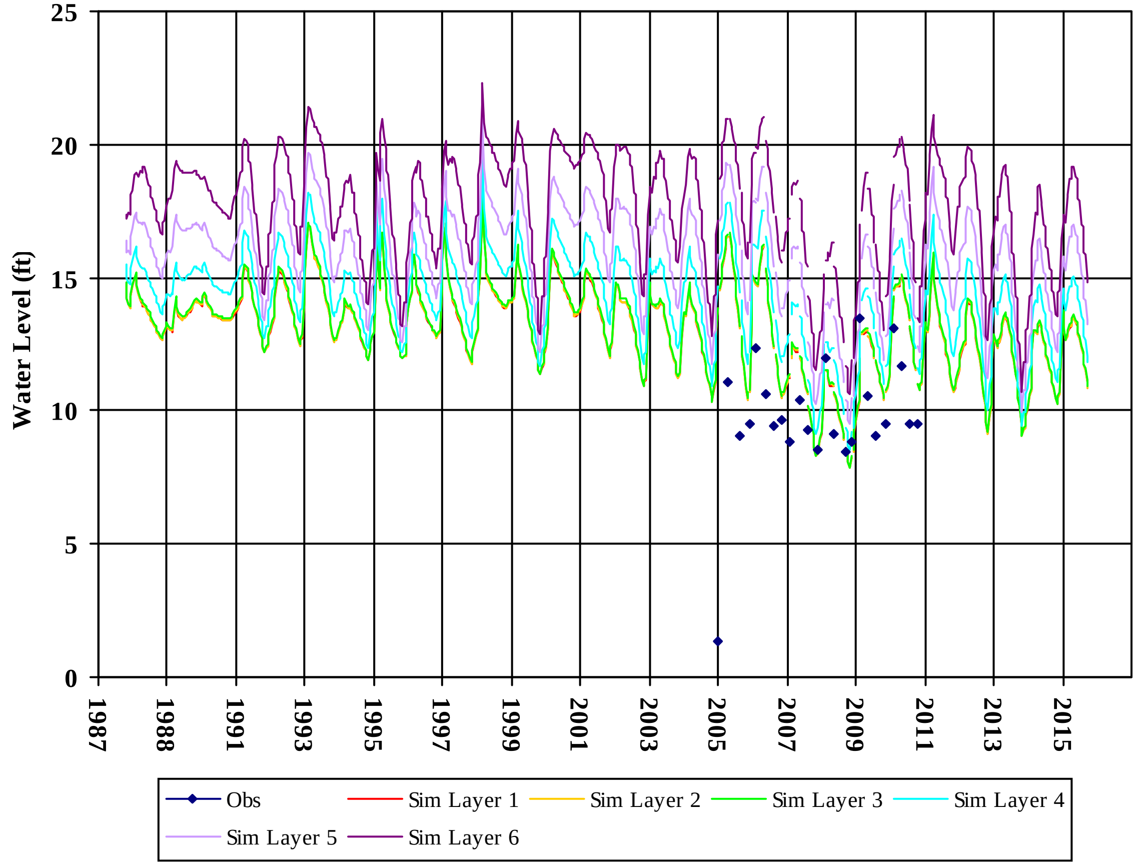
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500256MW-7



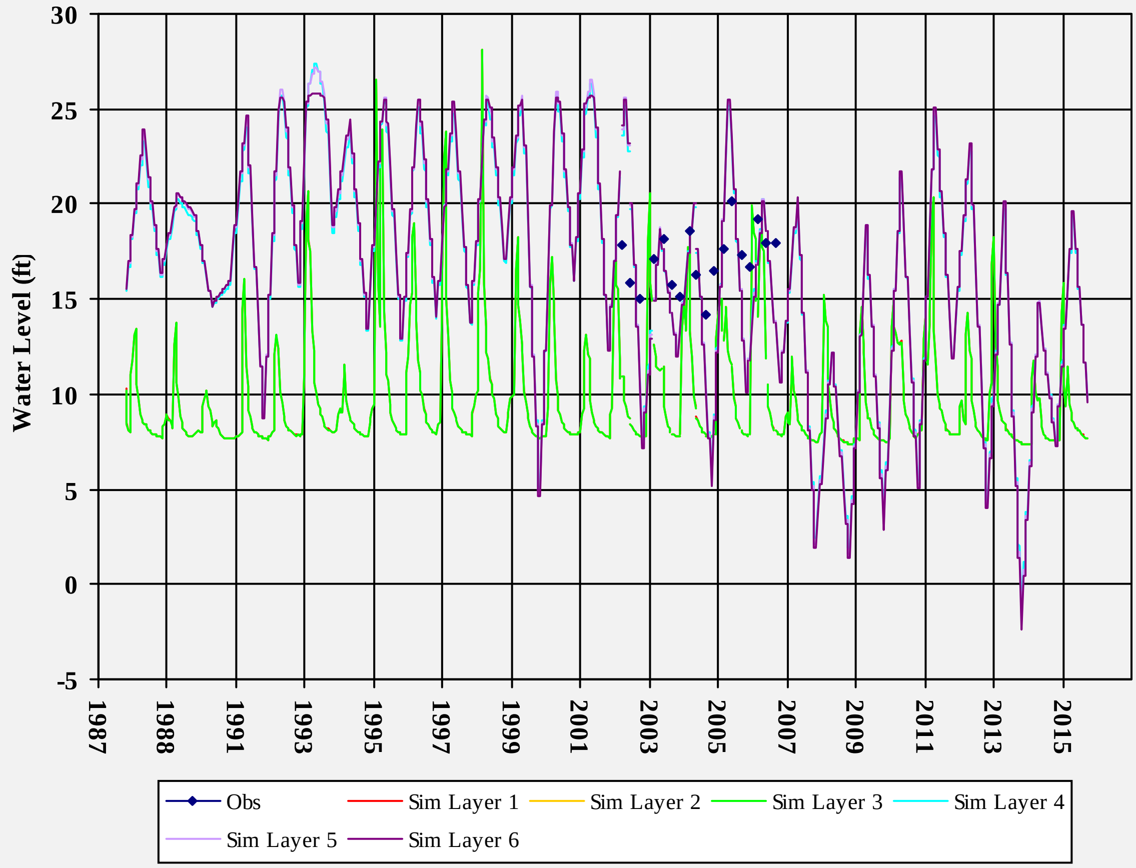
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605500256MW-8

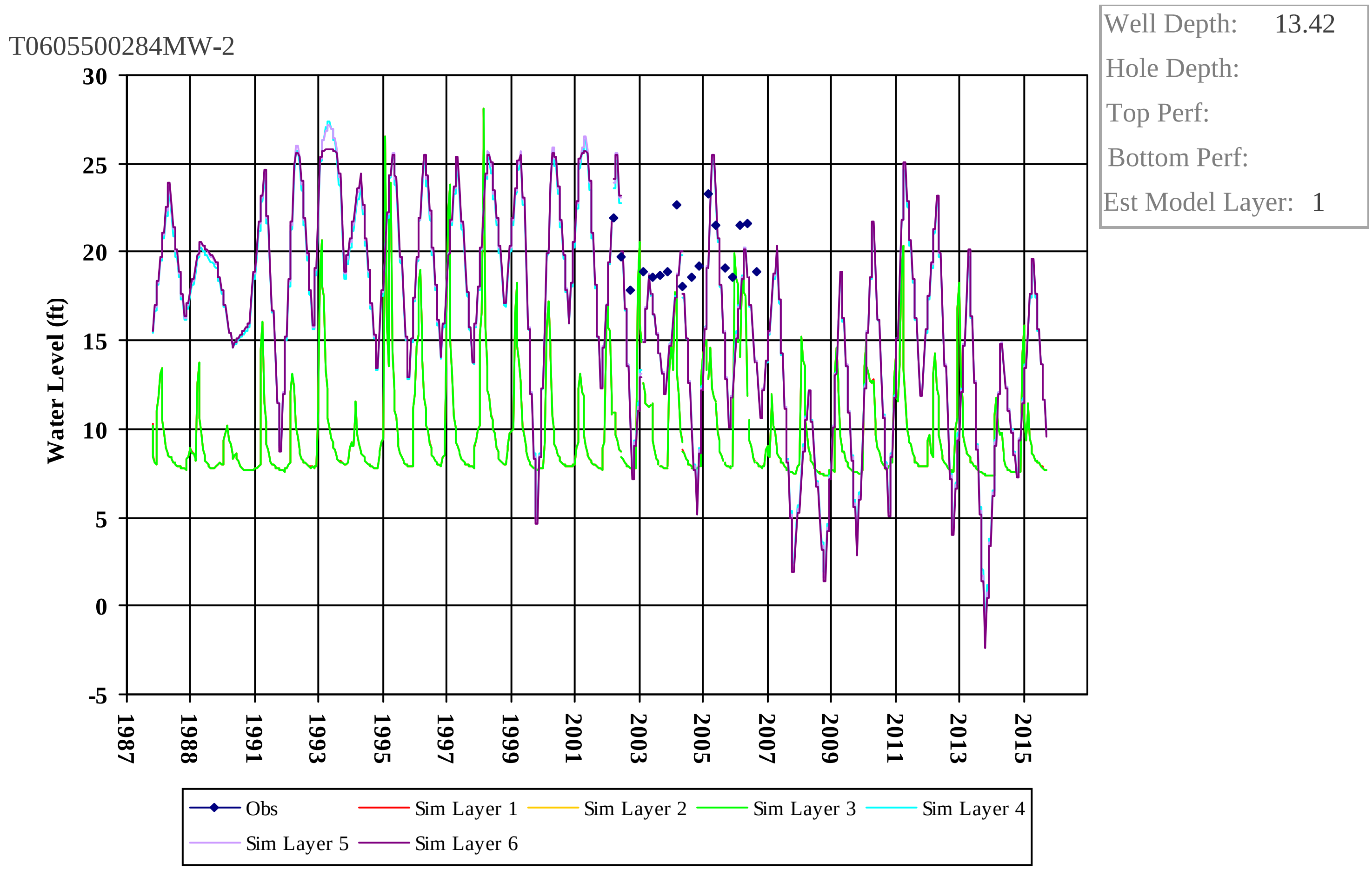


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

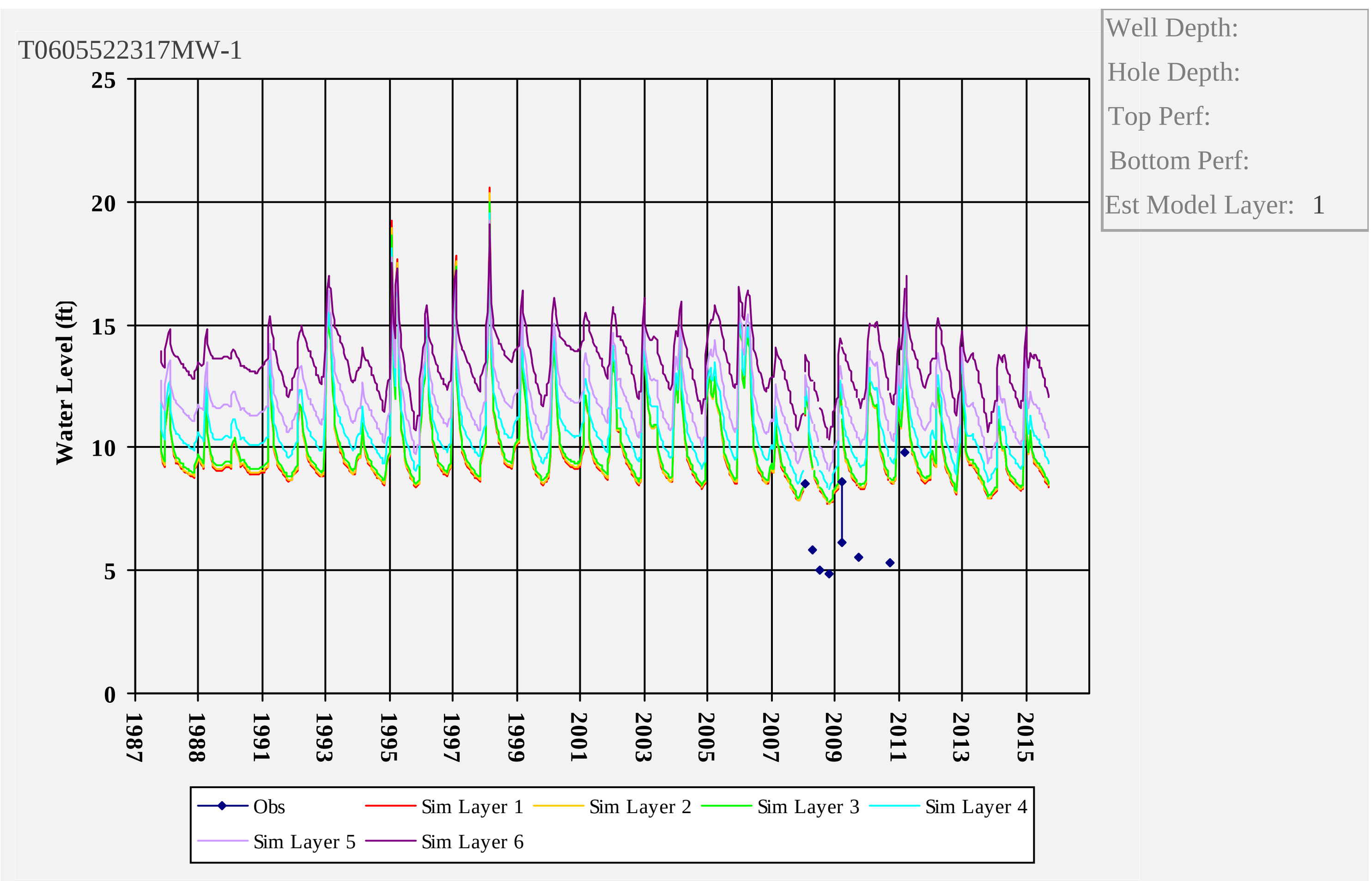
T0605500284MW-1



Well Depth: 19.8
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

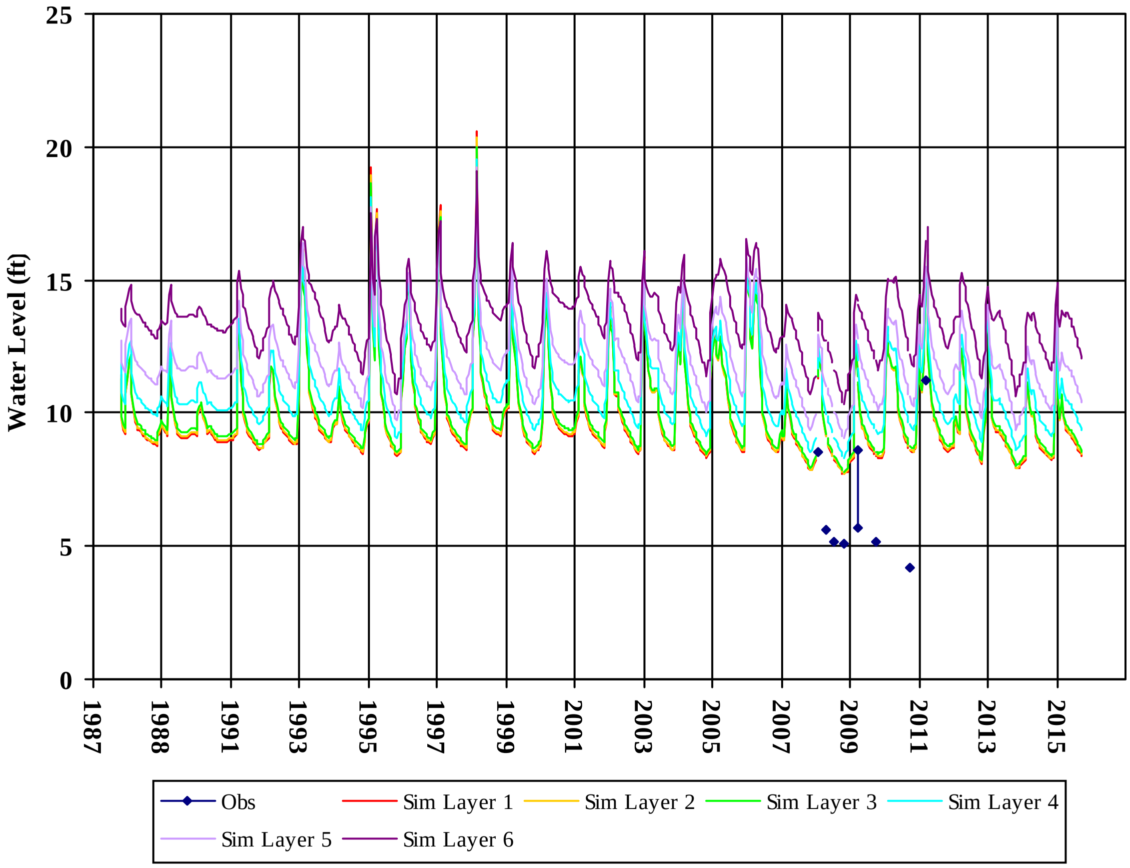


T0605500284MW-2
Well Depth: 13.42
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
Water Level (ft)
30
25
20
15
10
5
0
-5
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6



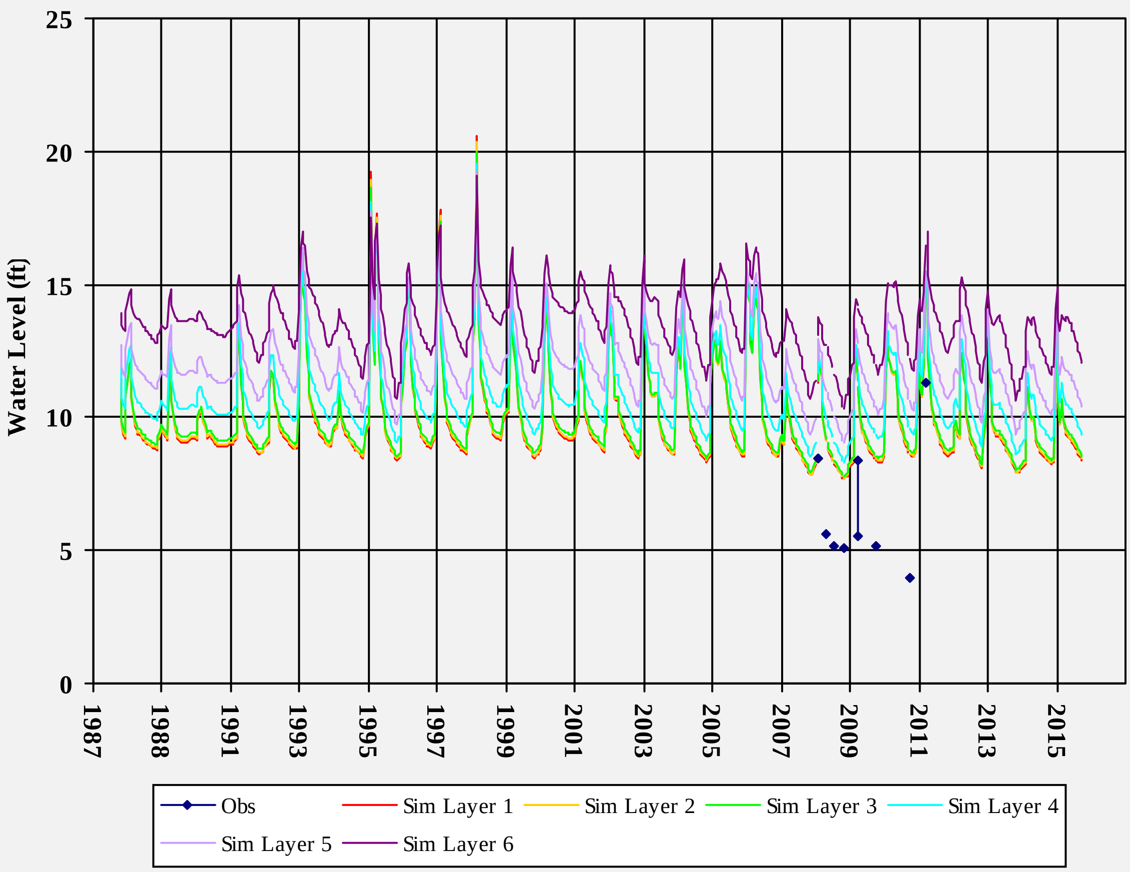
T0605522317MW-1
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1
Water Level (ft)
25
20
15
10
5
0
1987
1988
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Obs
Sim Layer 1
Sim Layer 2
Sim Layer 3
Sim Layer 4
Sim Layer 5
Sim Layer 6

T0605522317MW-2



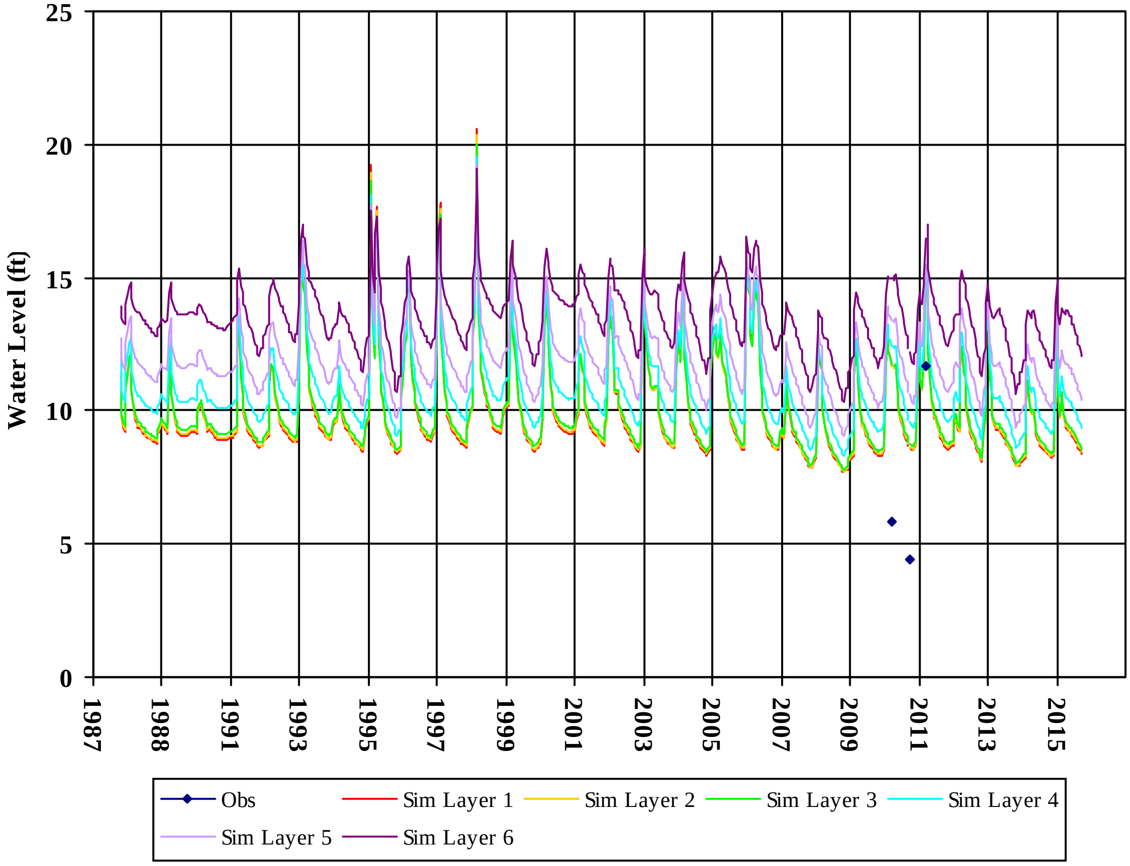
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-3



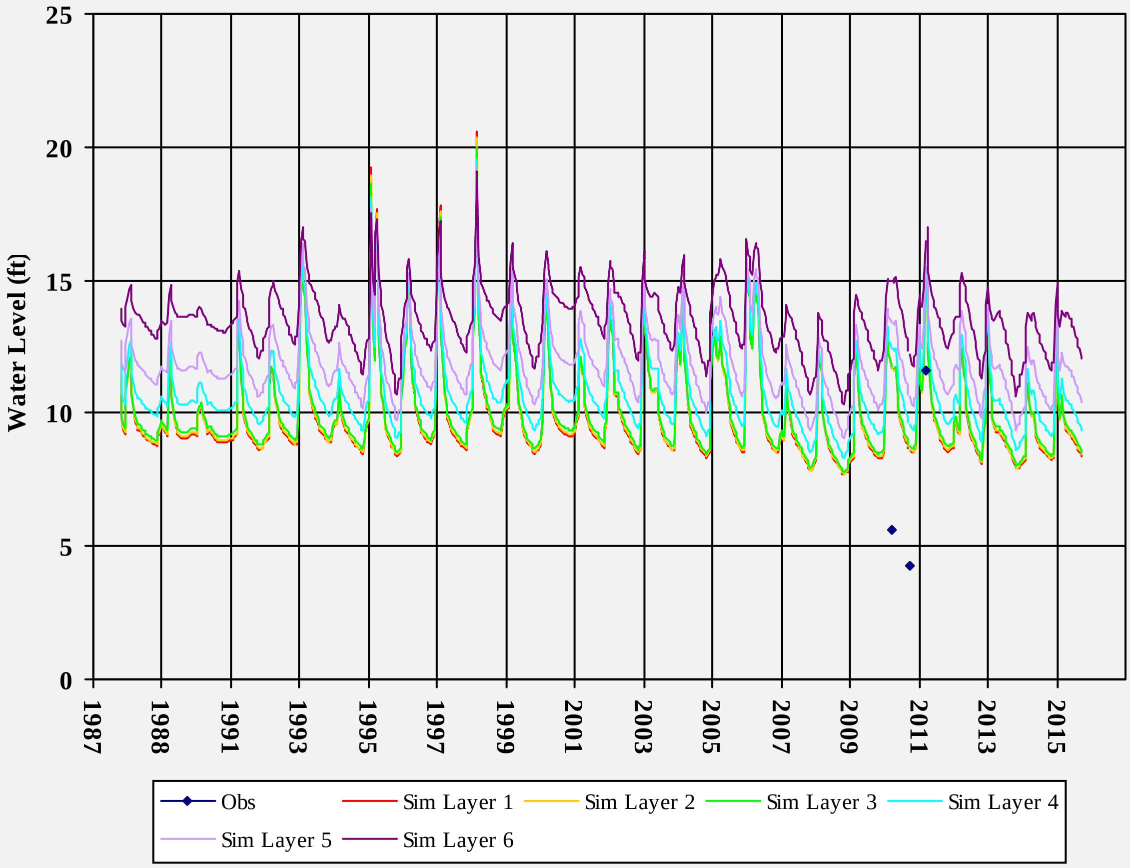
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-4



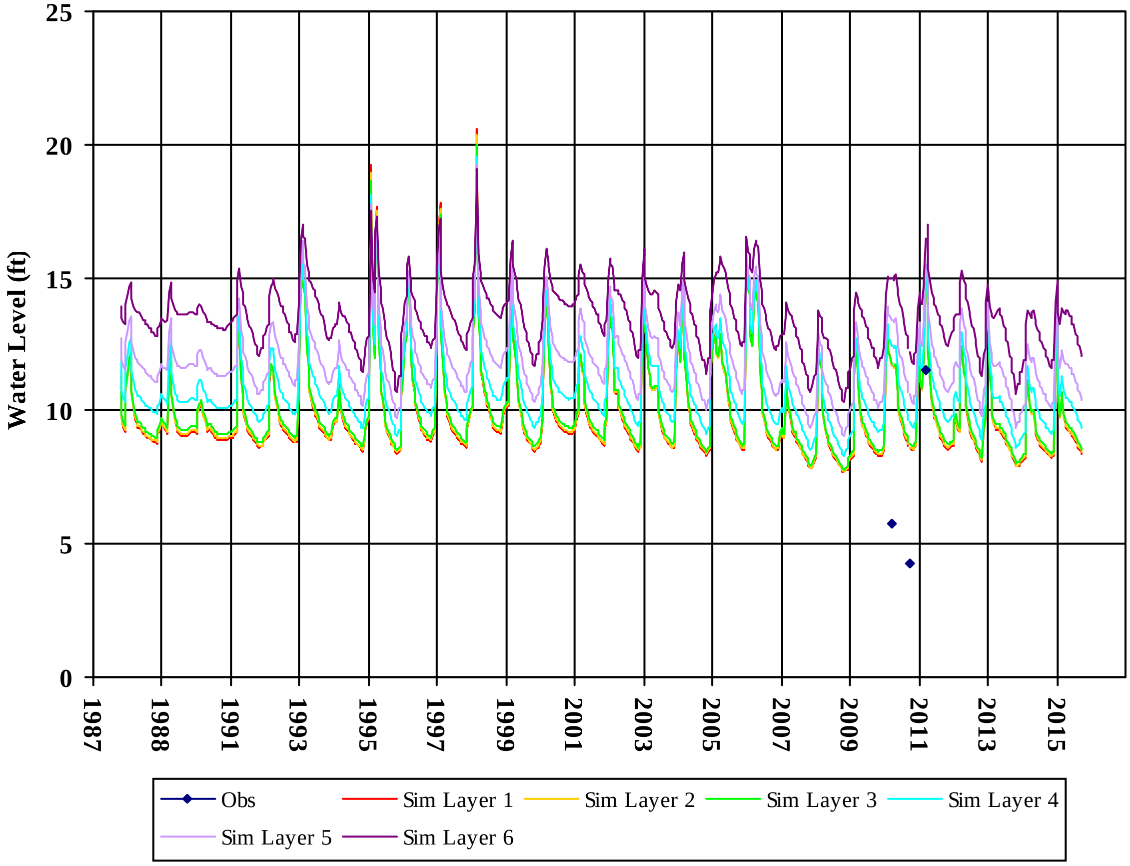
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-5



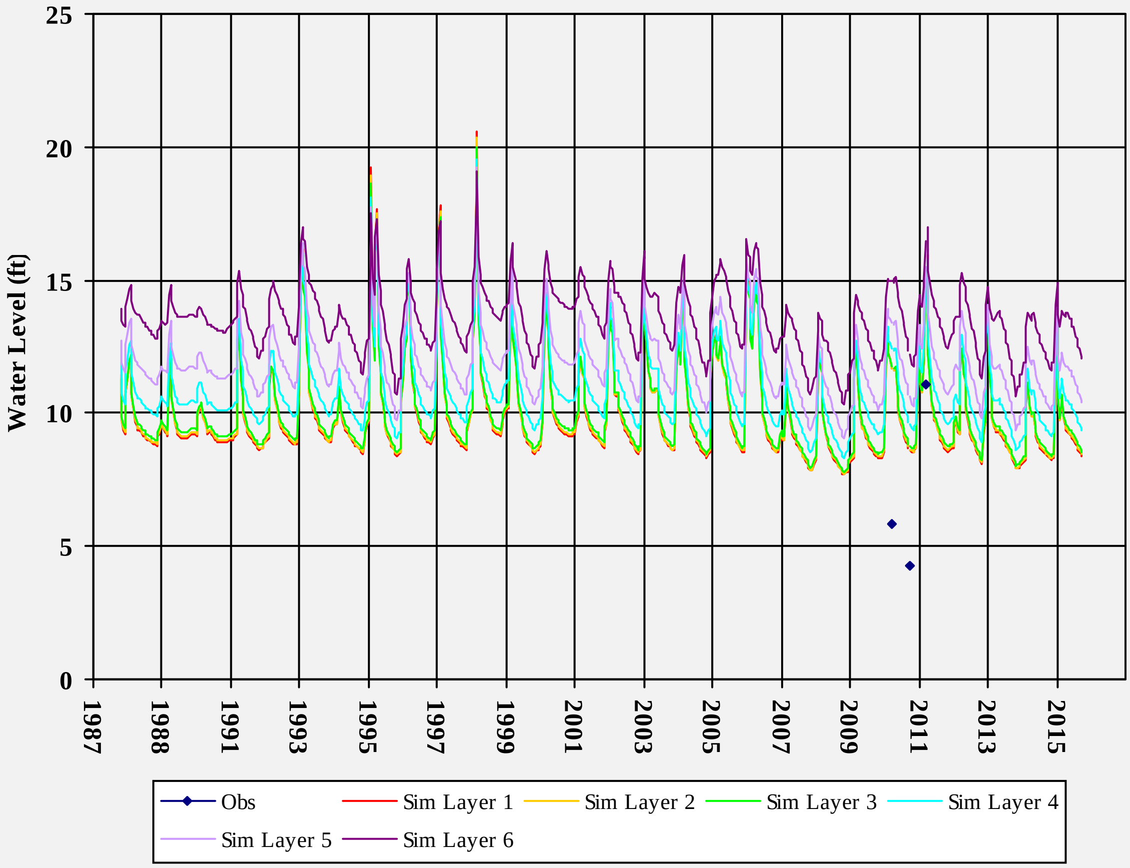
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-6



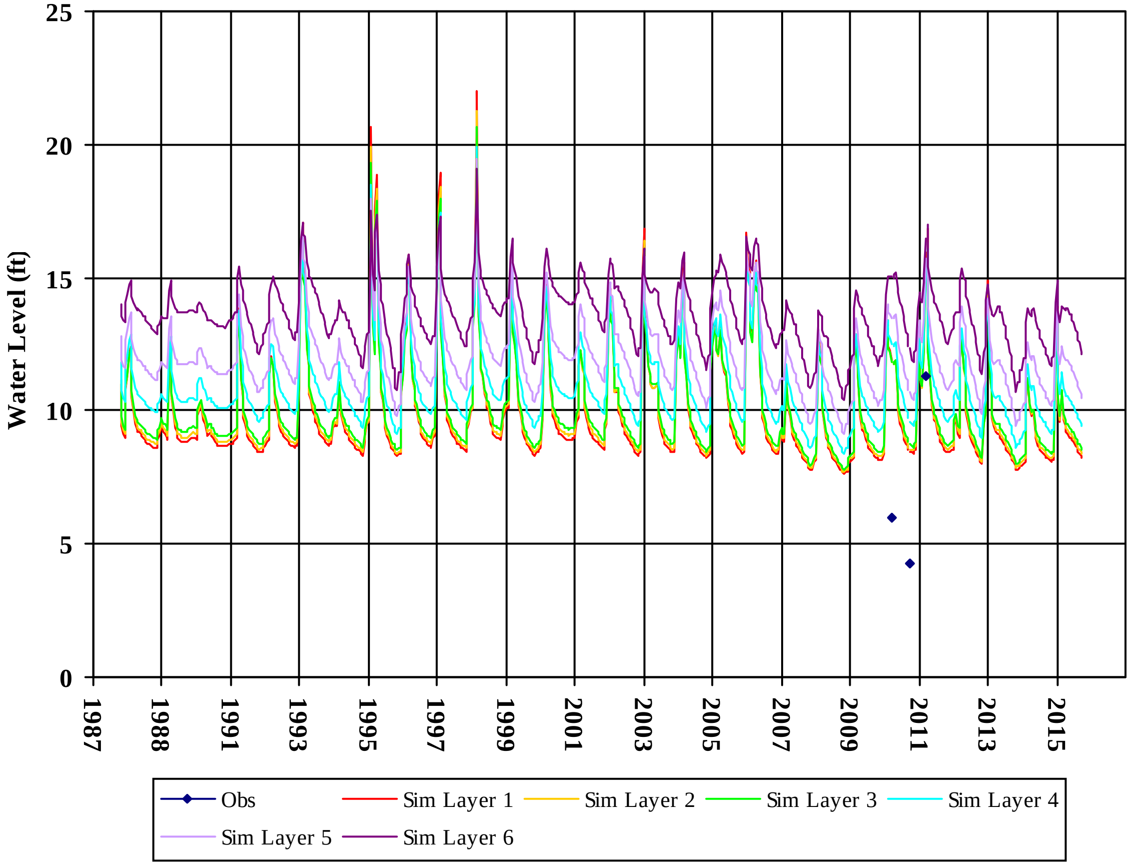
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-7



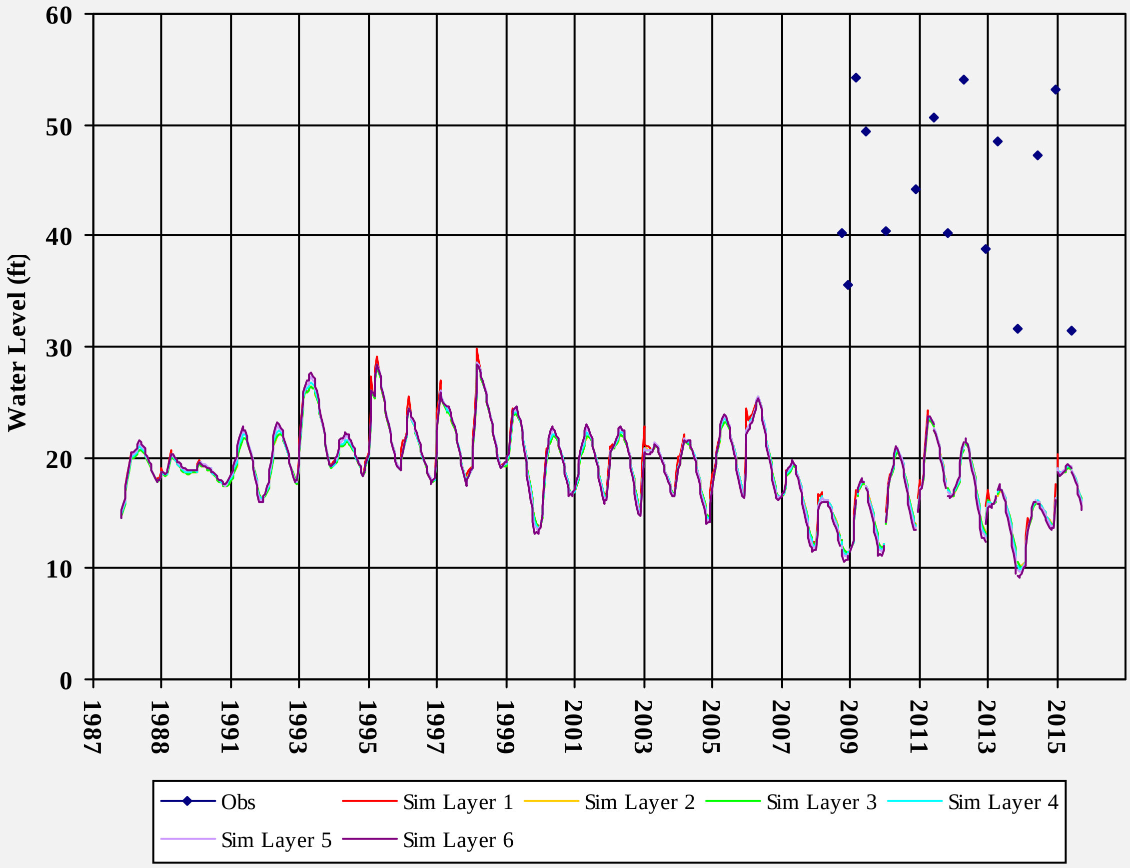
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605522317MW-8



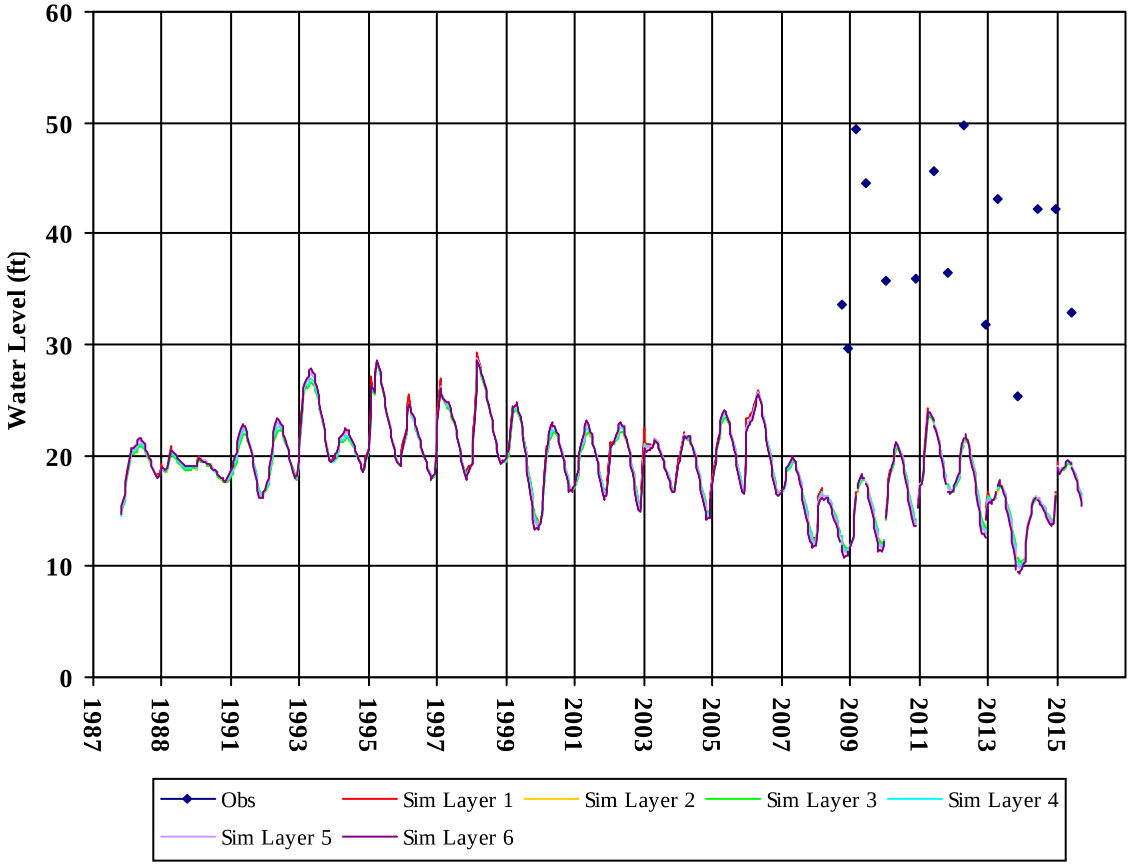
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605547200MW-1



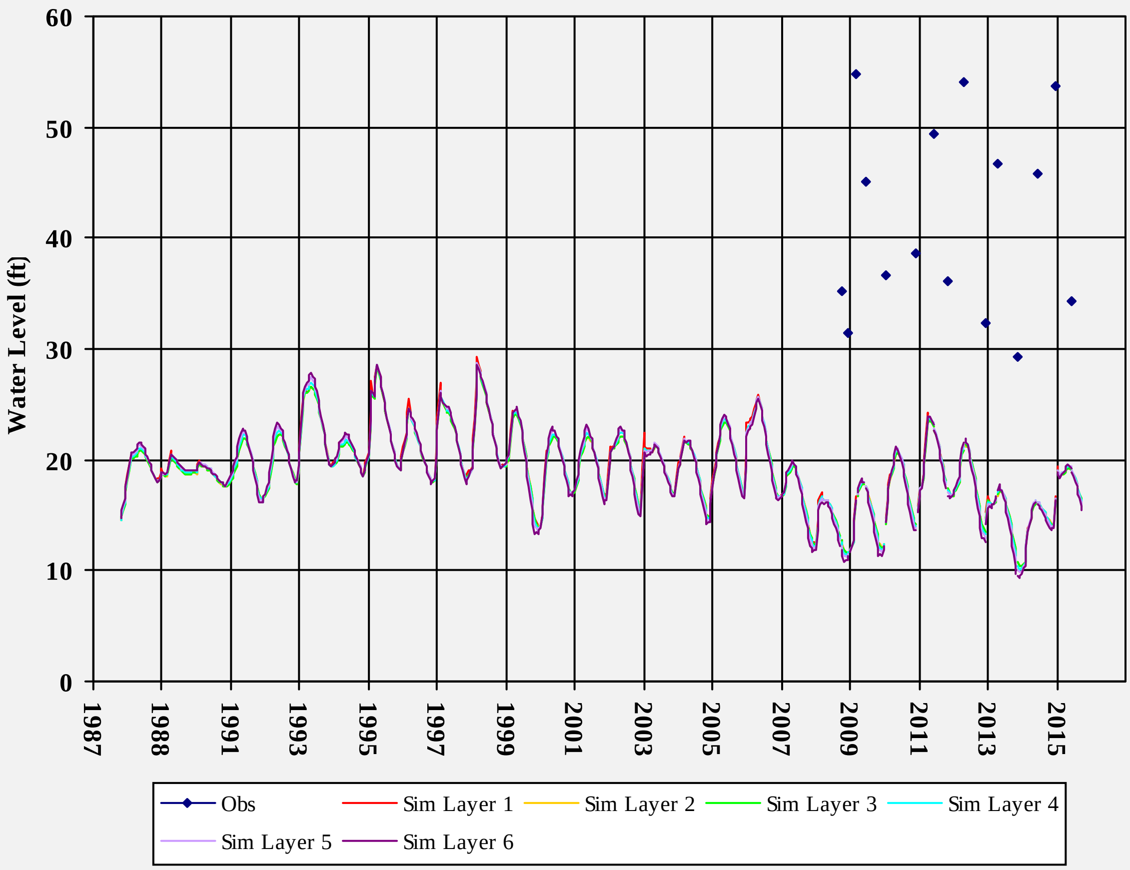
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605547200MW-2



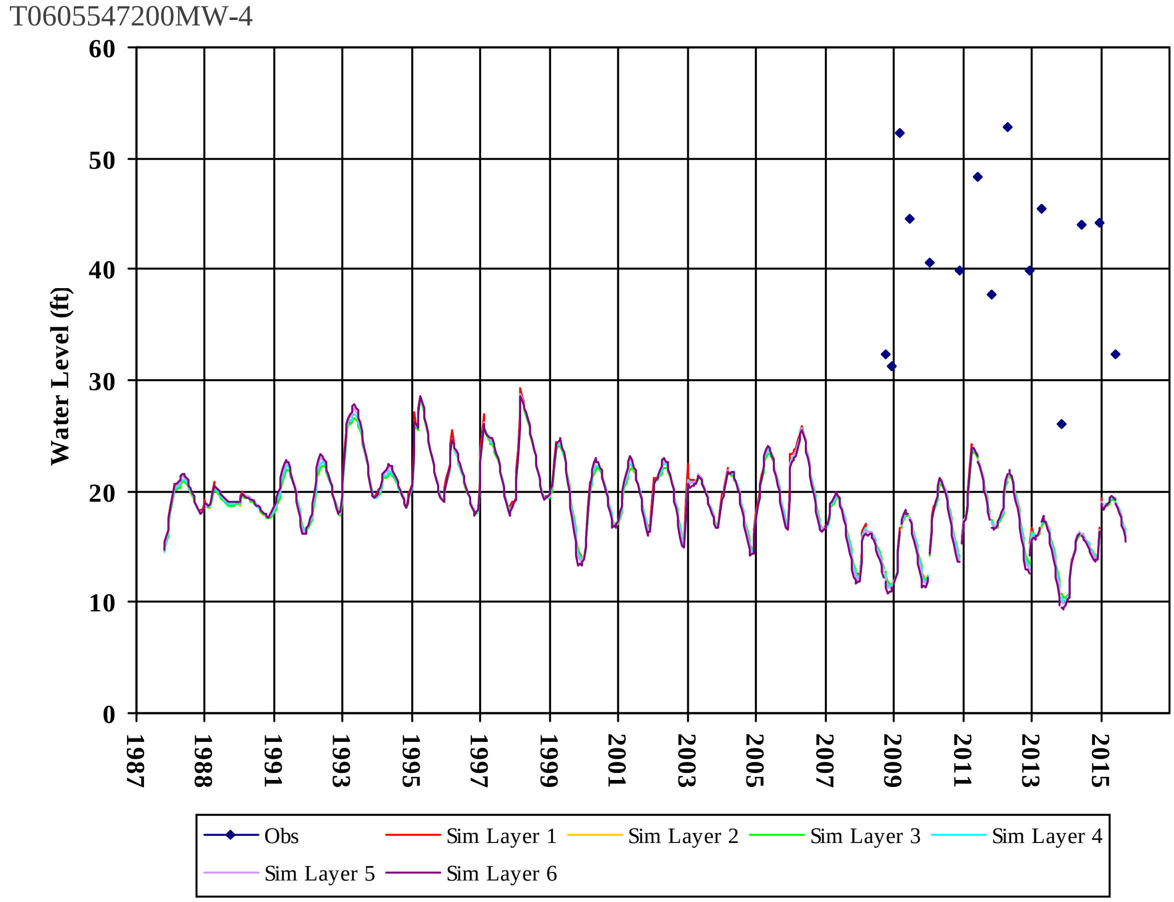
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605547200MW-3

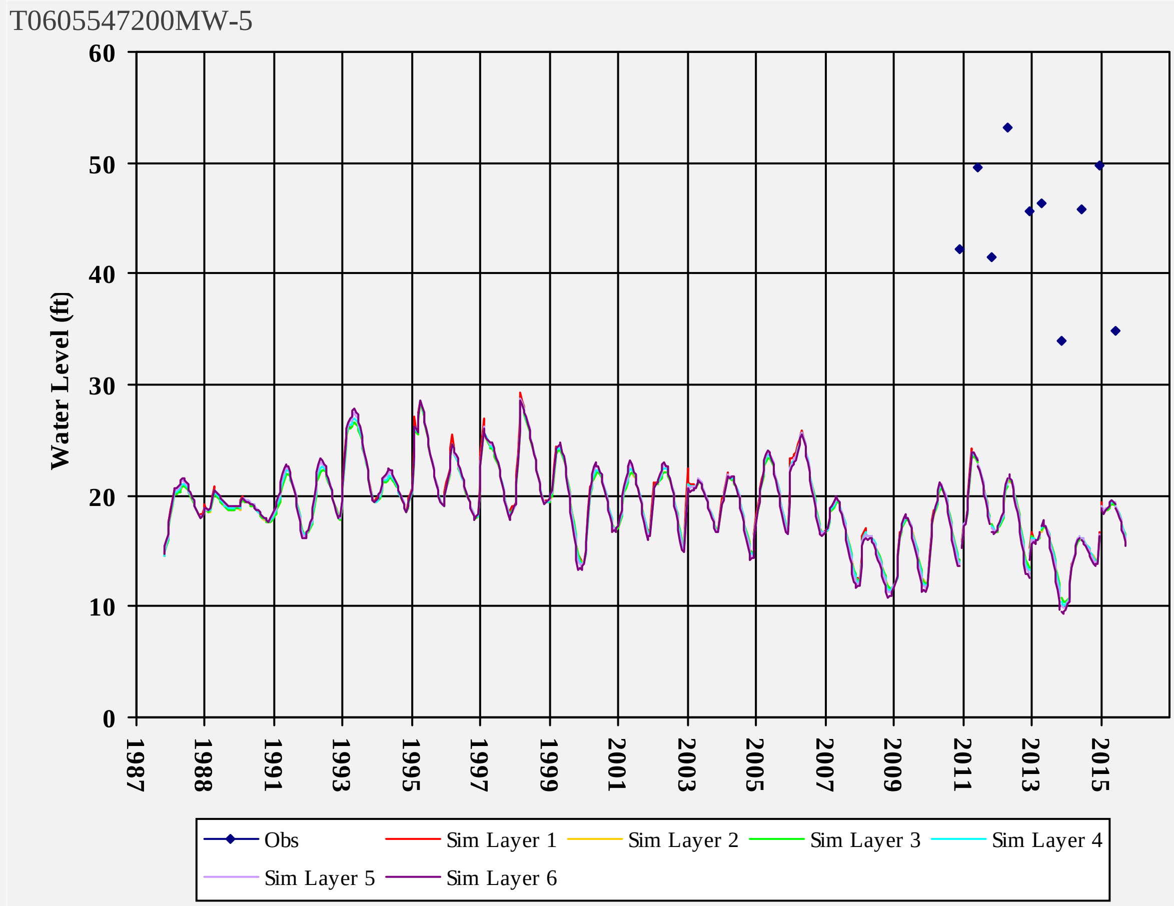


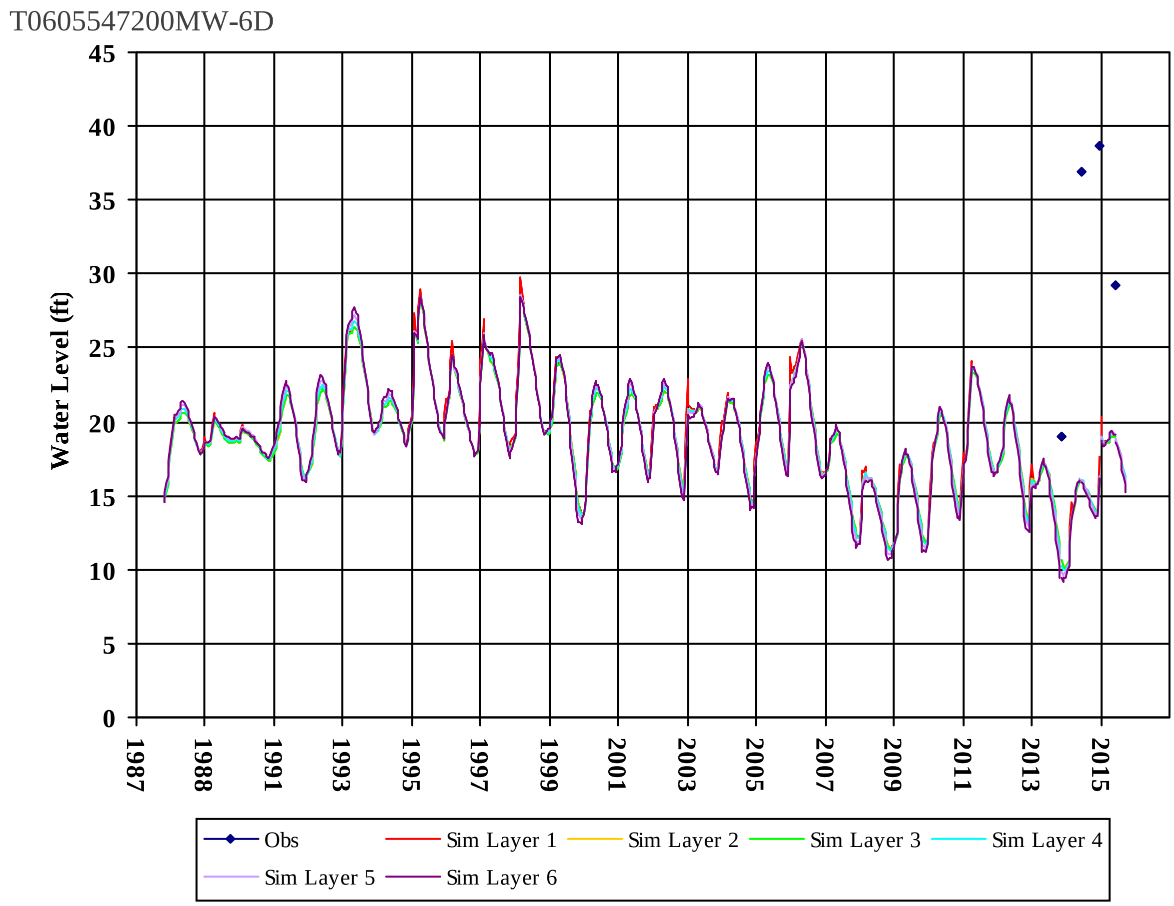
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

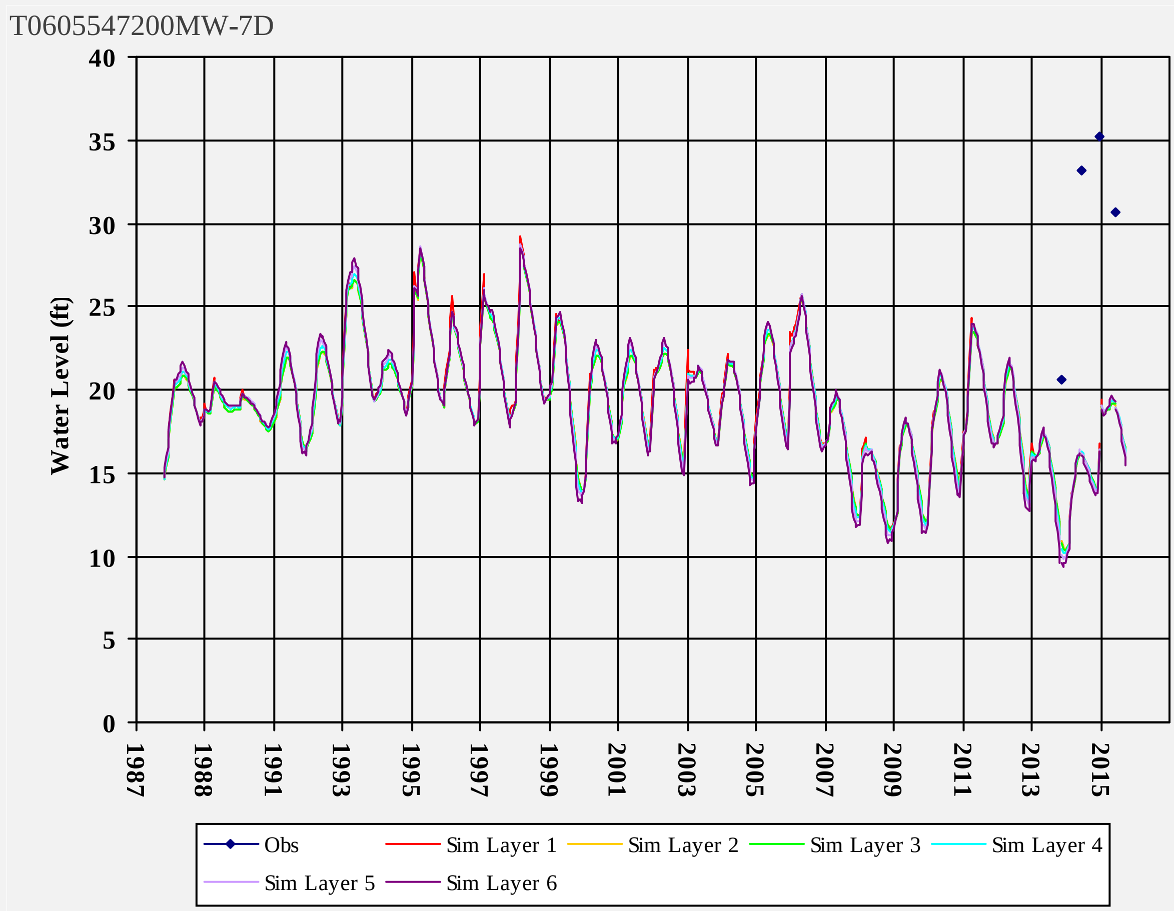


Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1



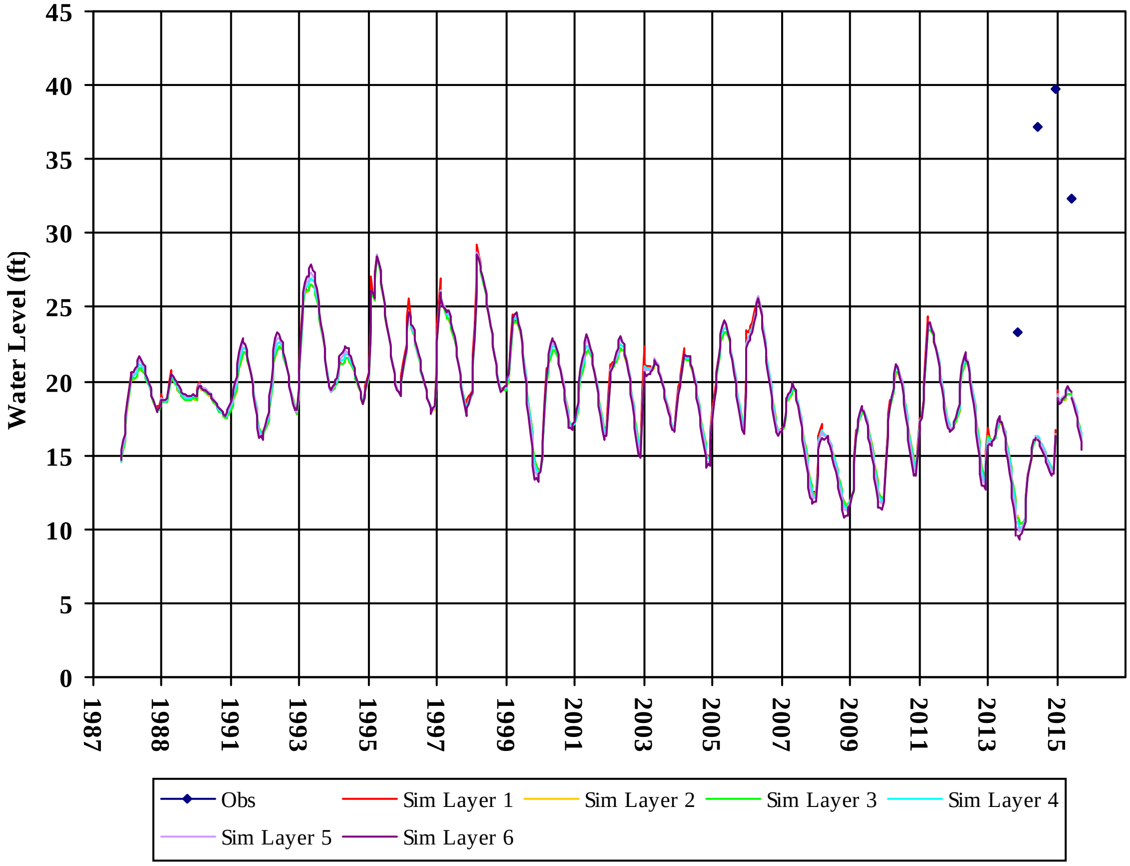


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



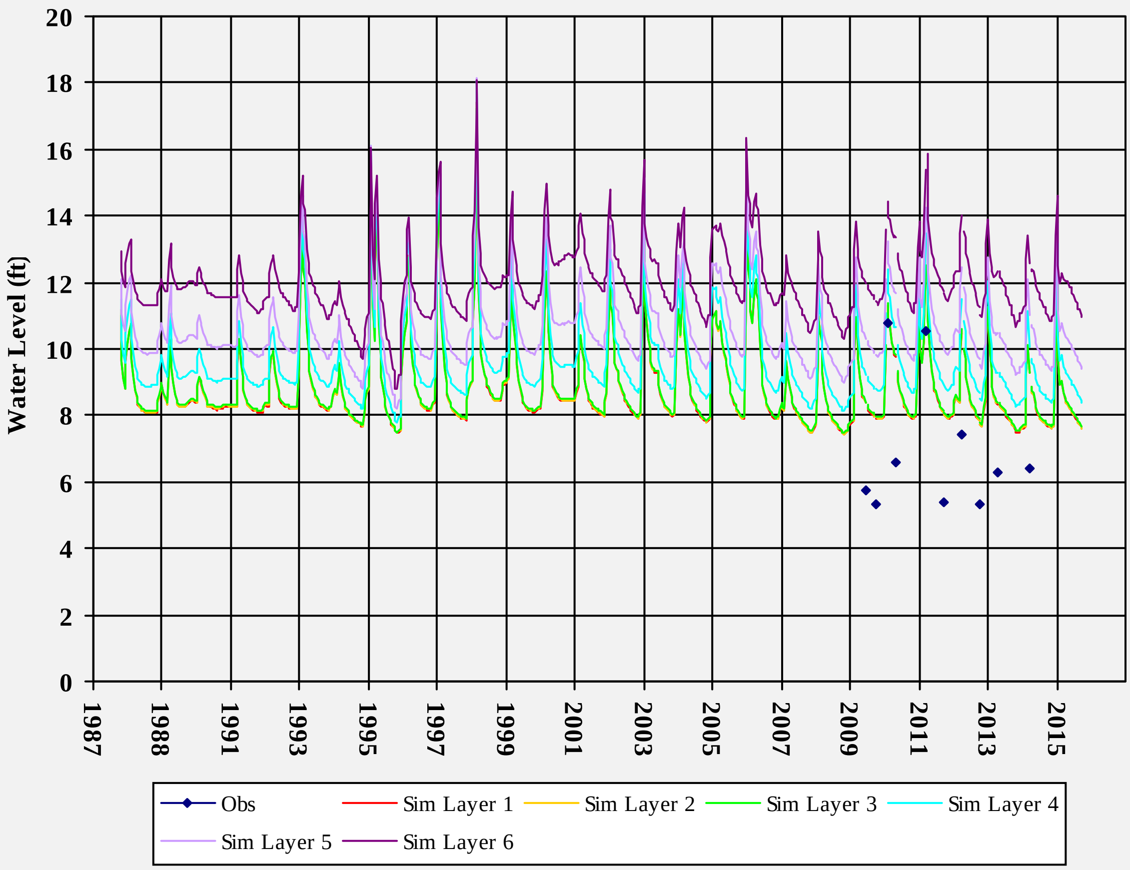
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605547200MW-8D



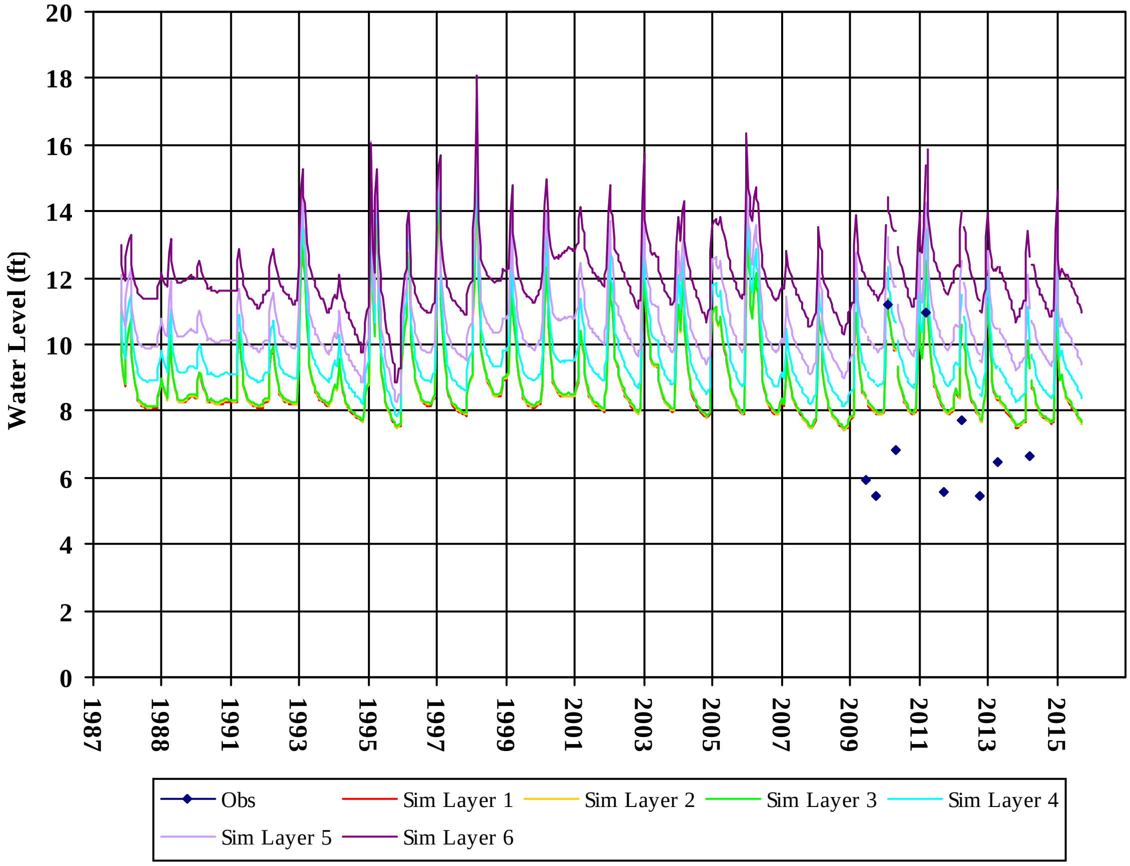
Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

T0605575085MW-1



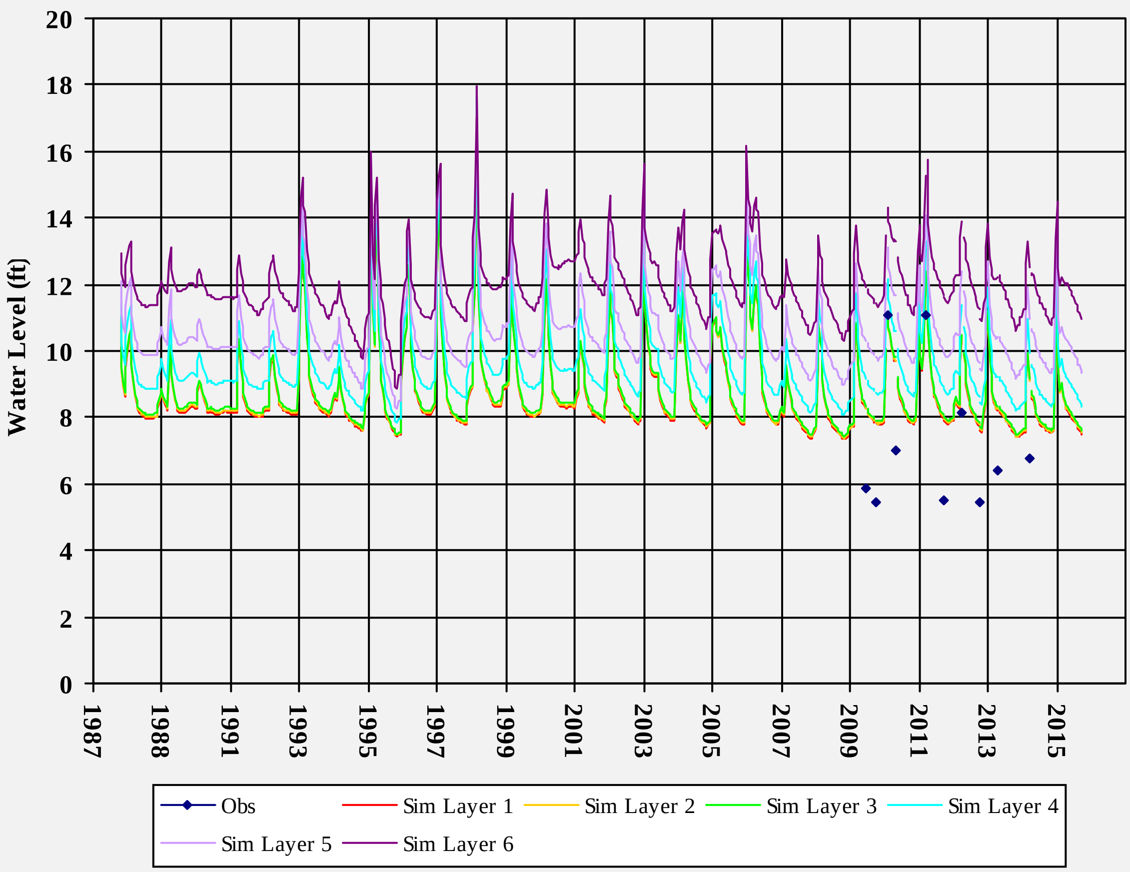
Well Depth:	
Hole Depth:	
Top Perf:	
Bottom Perf:	
Est Model Layer:	1

T0605575085MW-2



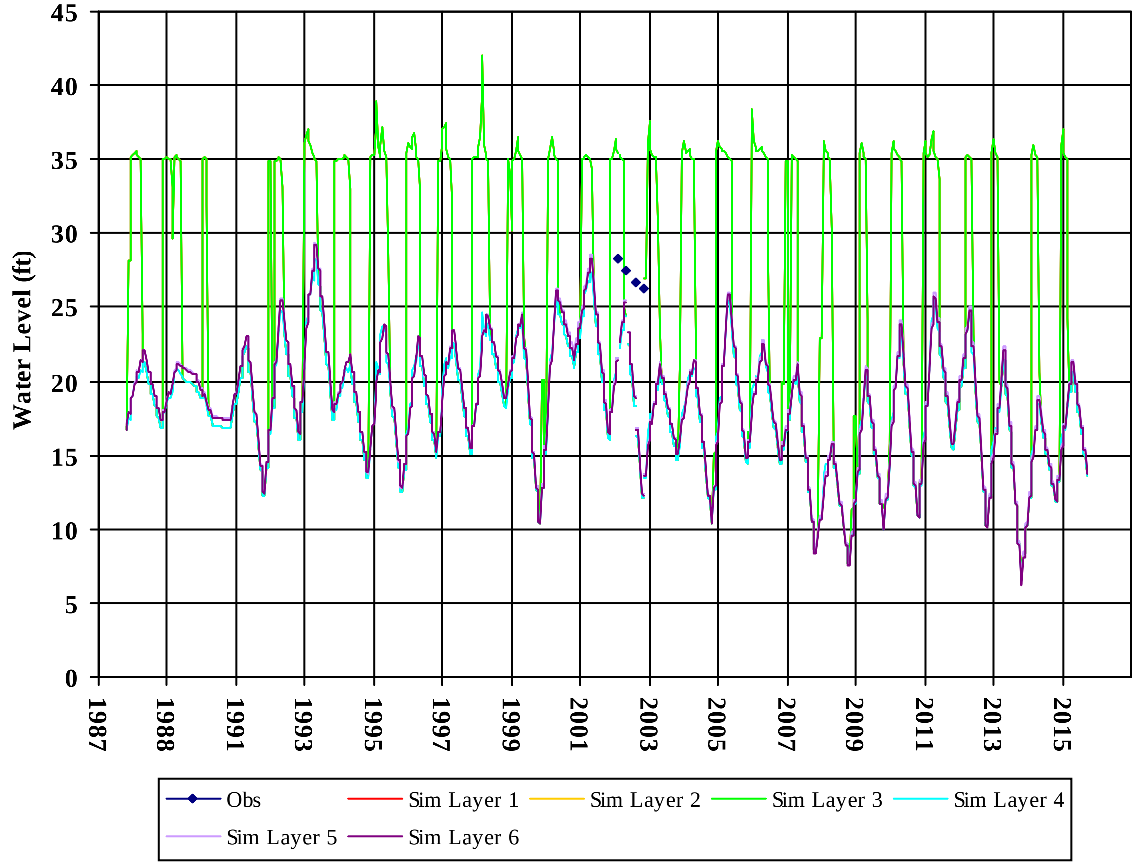
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605575085MW-3



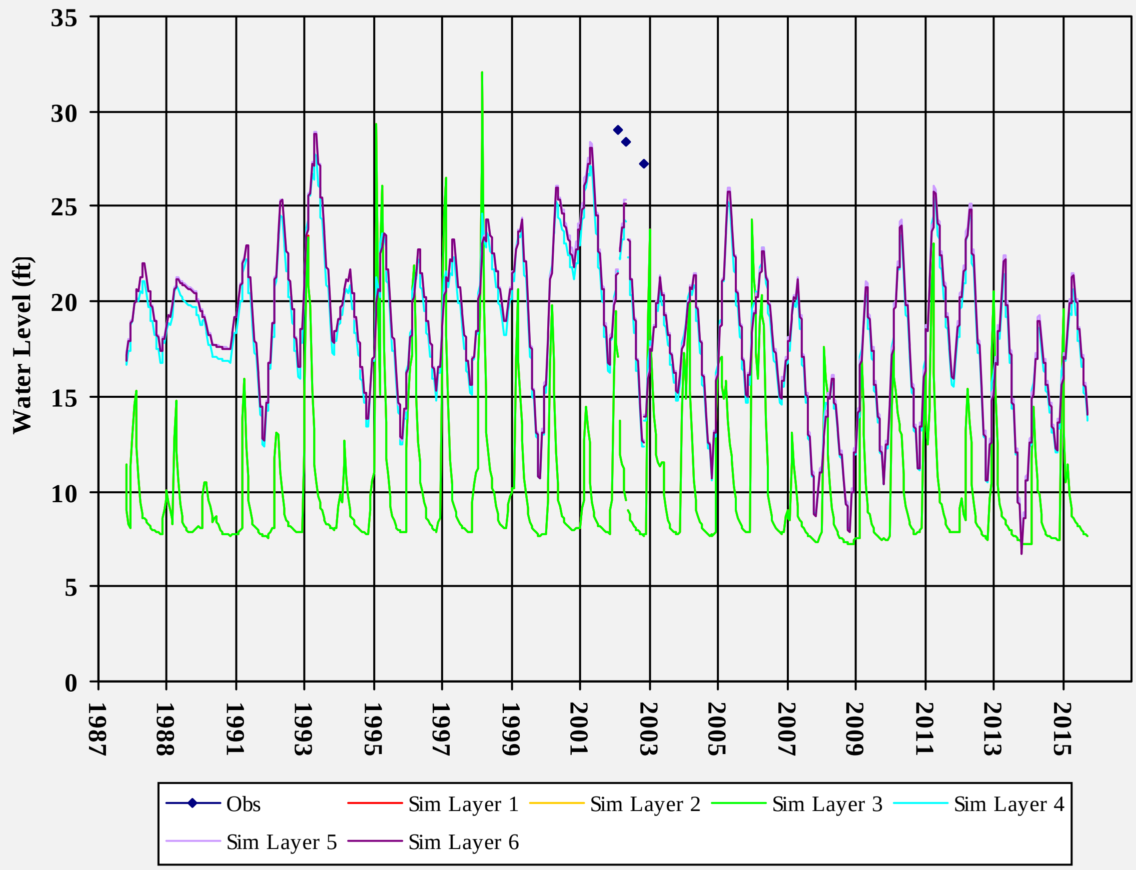
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605591222MW-1



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605591222MW-2



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
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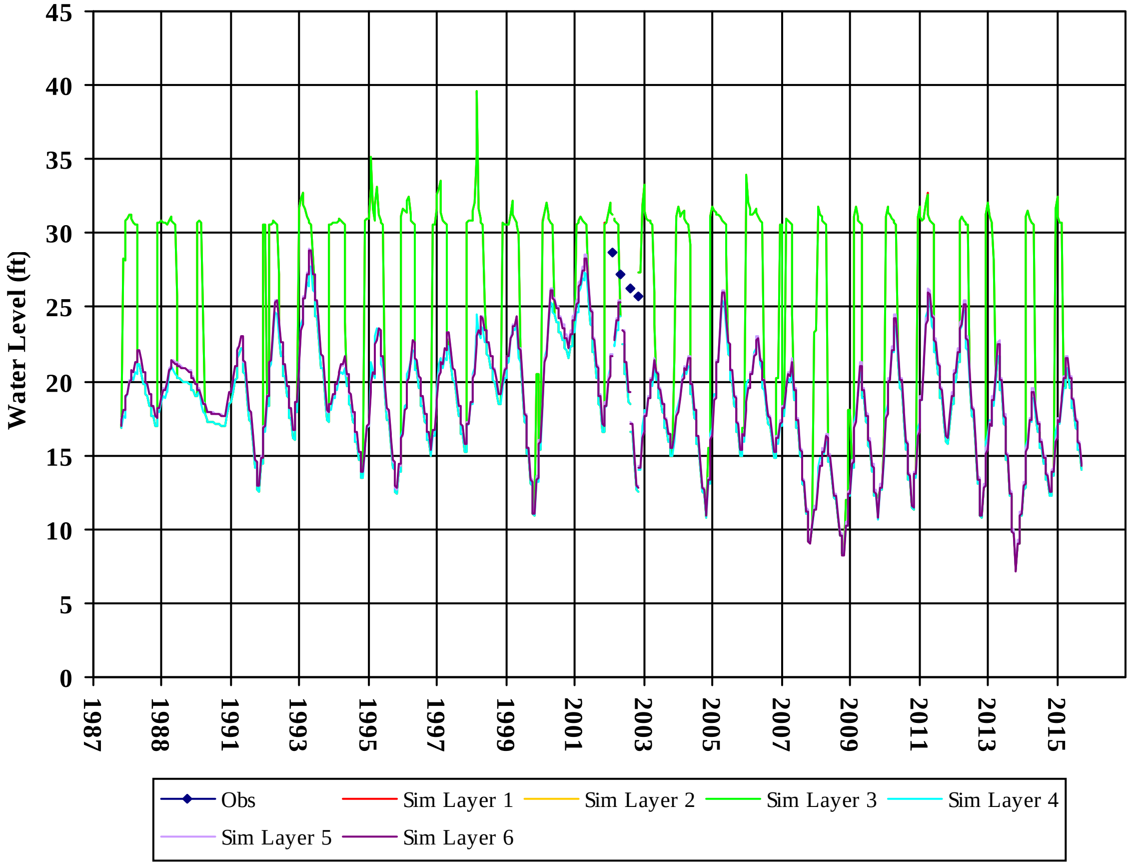
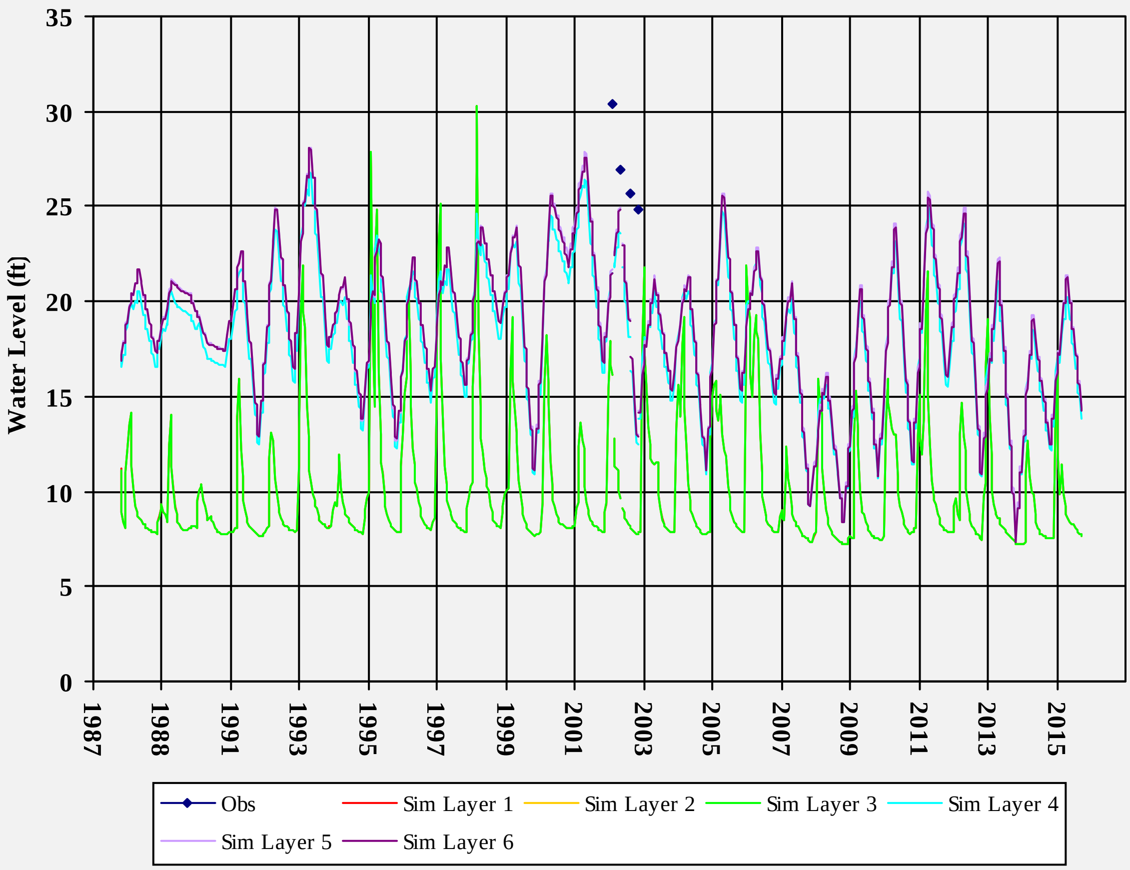


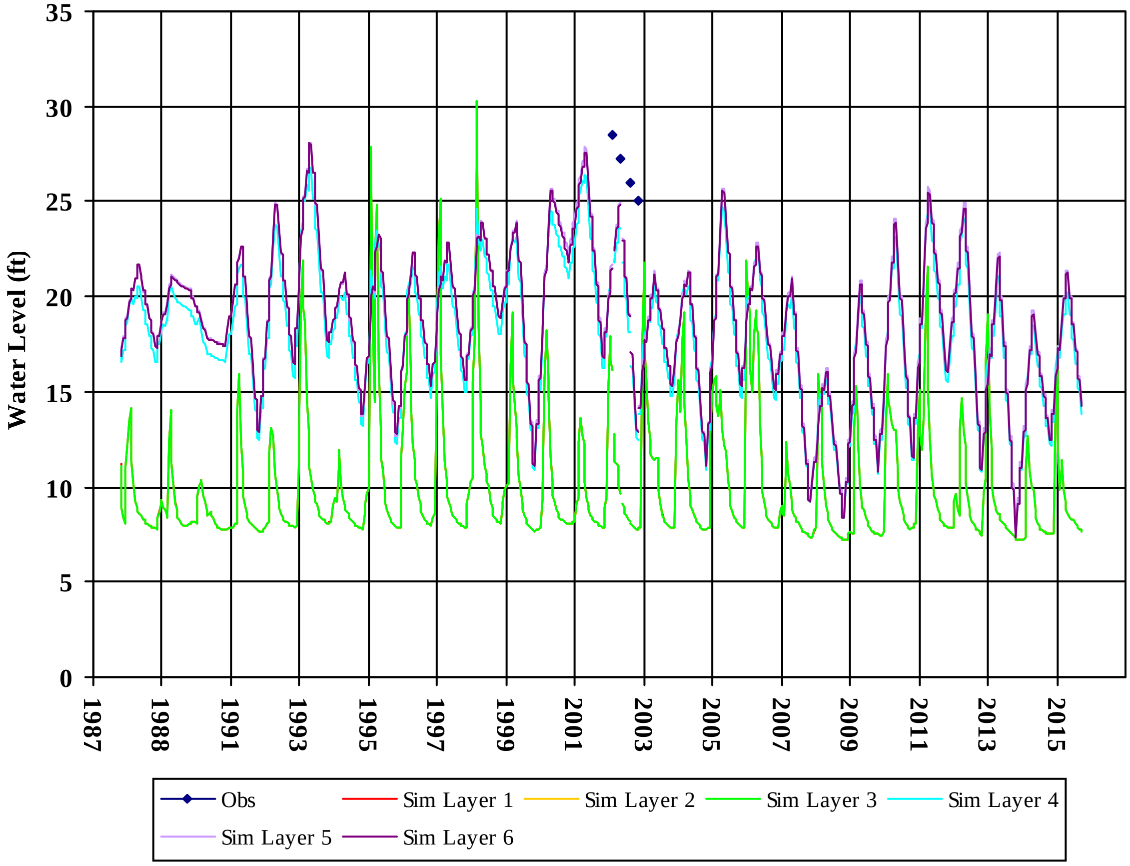
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605591222MW-4



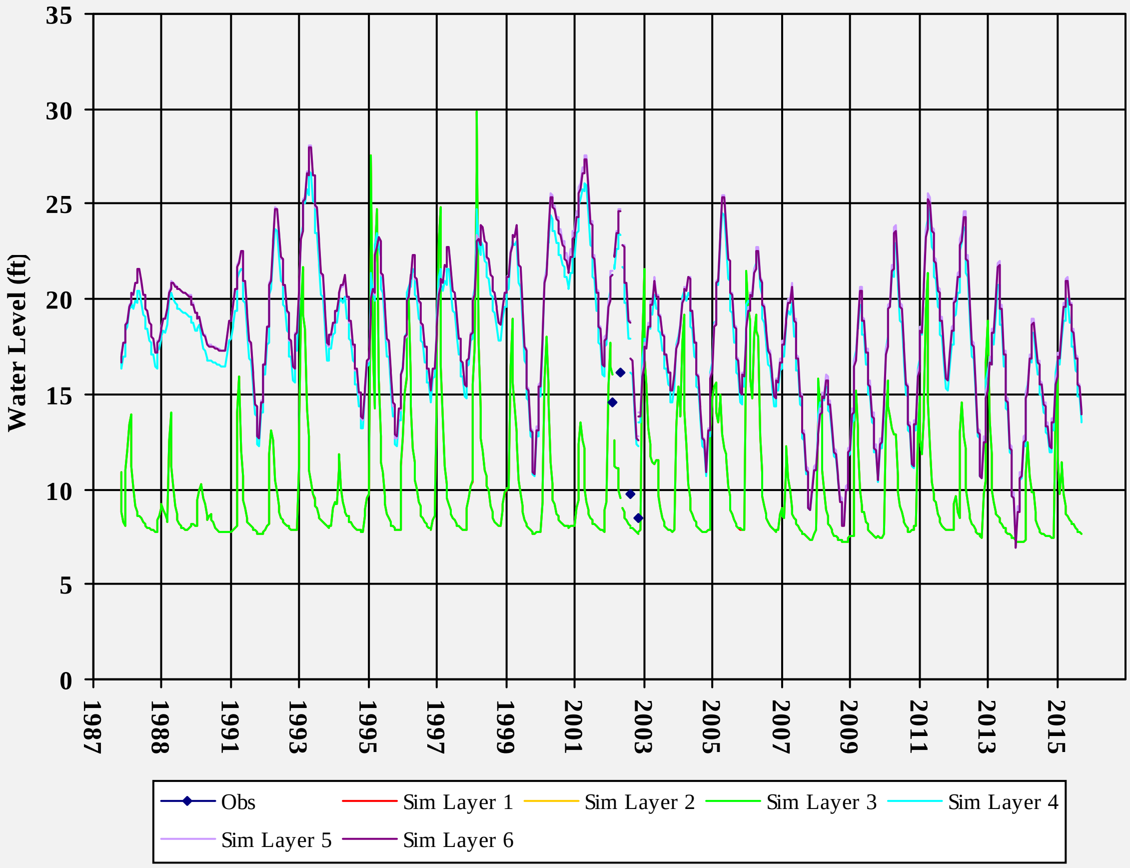
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

T0605591222MW-5

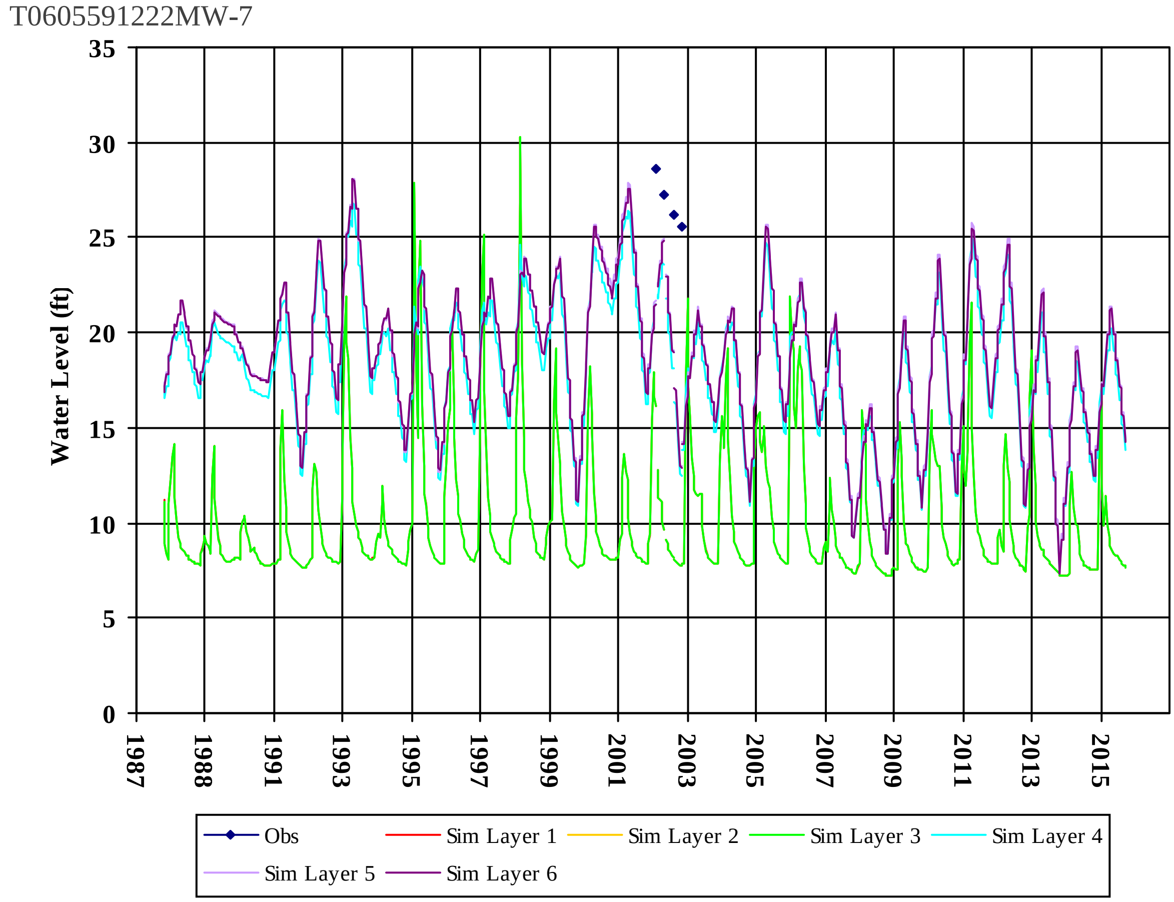


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

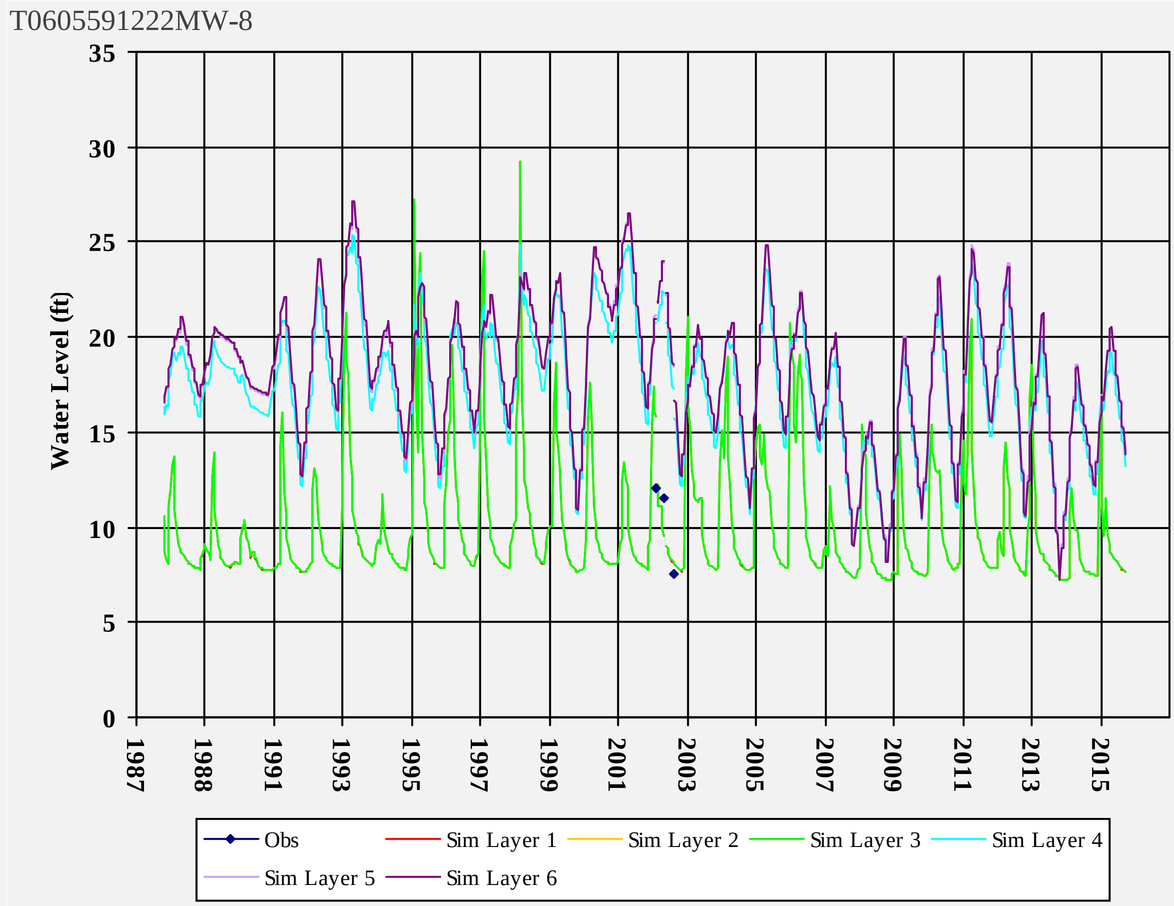
T0605591222MW-6



Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

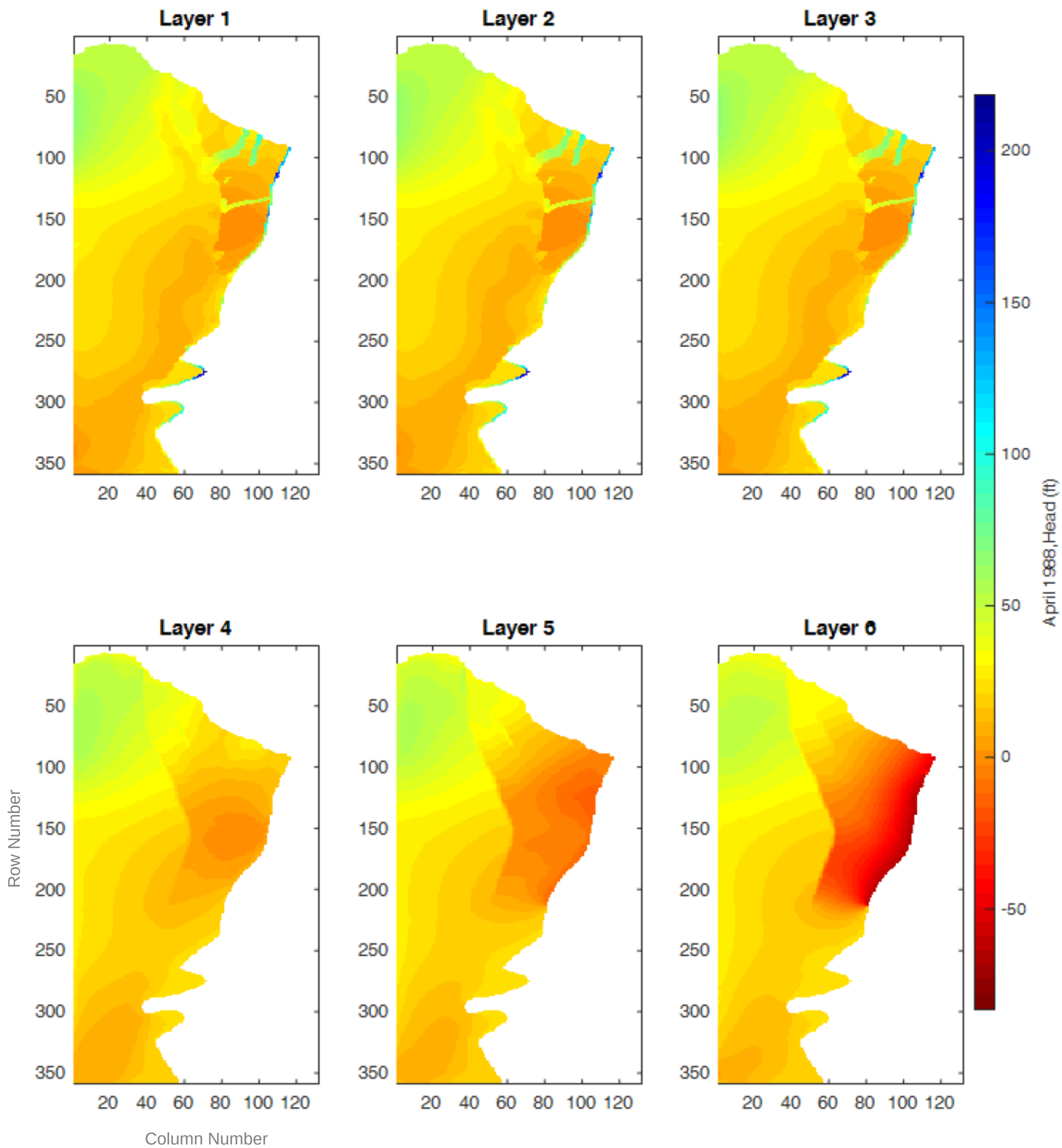


Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1



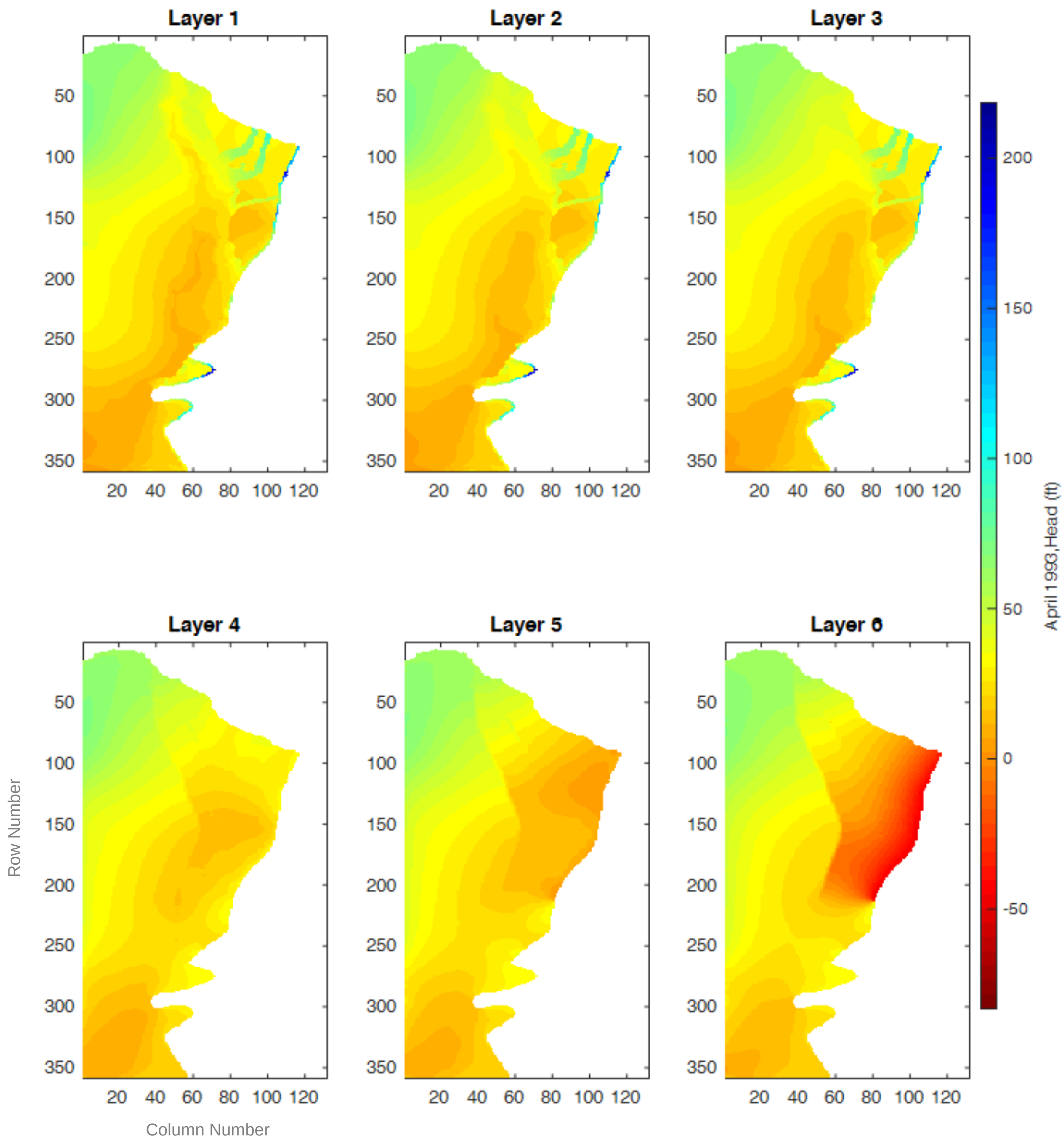
Well Depth:
Hole Depth:
Top Perf:
Bottom Perf:
Est Model Layer: 1

APPENDIX B
Spatial Distribution of Simulated Water Levels for Selected Months



APPENDIX B-1

Spatial Distribution of Simulated Water Levels for Selected Months, April 1988



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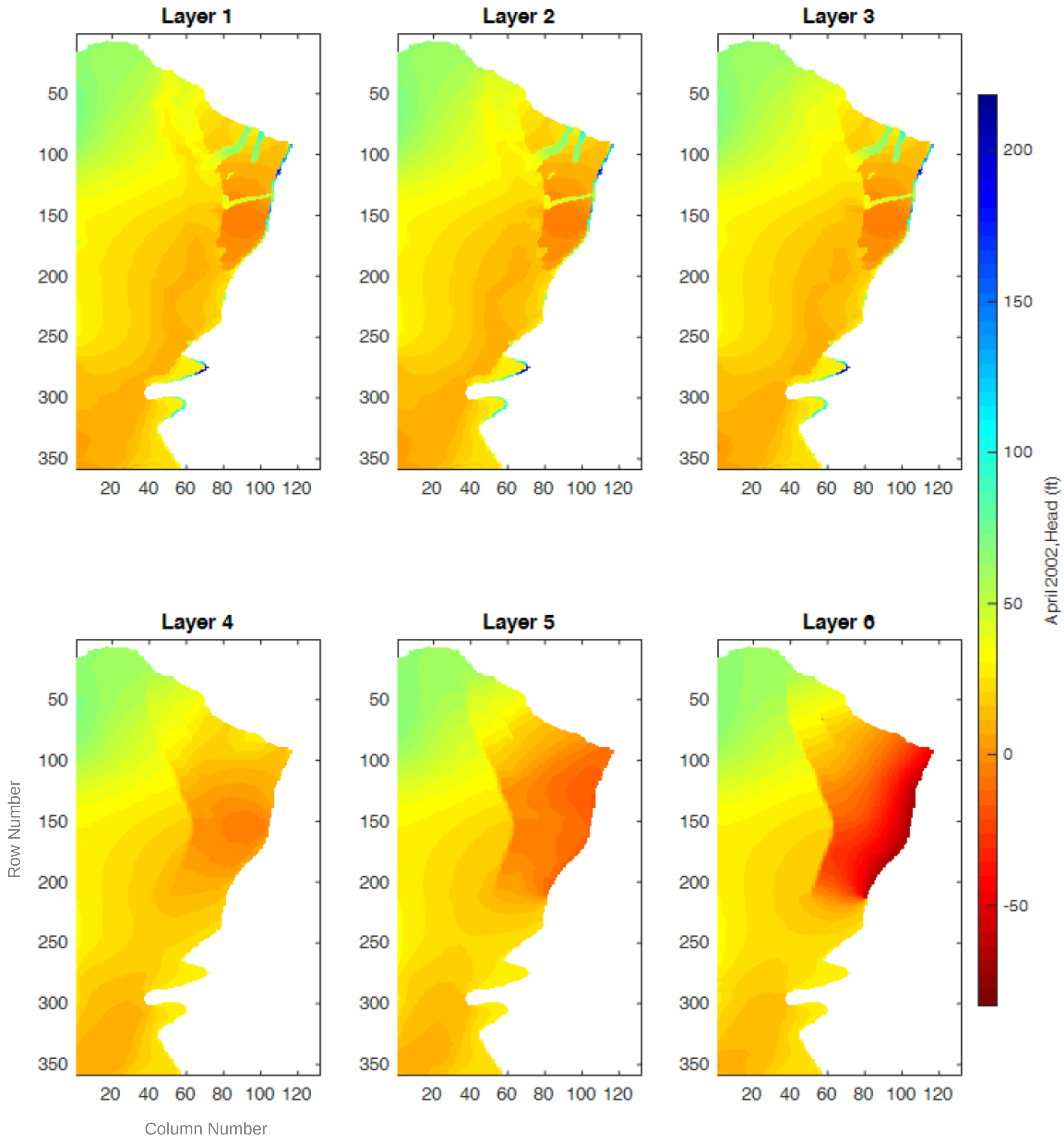
APPENDIX B-2

Spatial Distribution of Simulated Water Levels for Selected Months, April 1993



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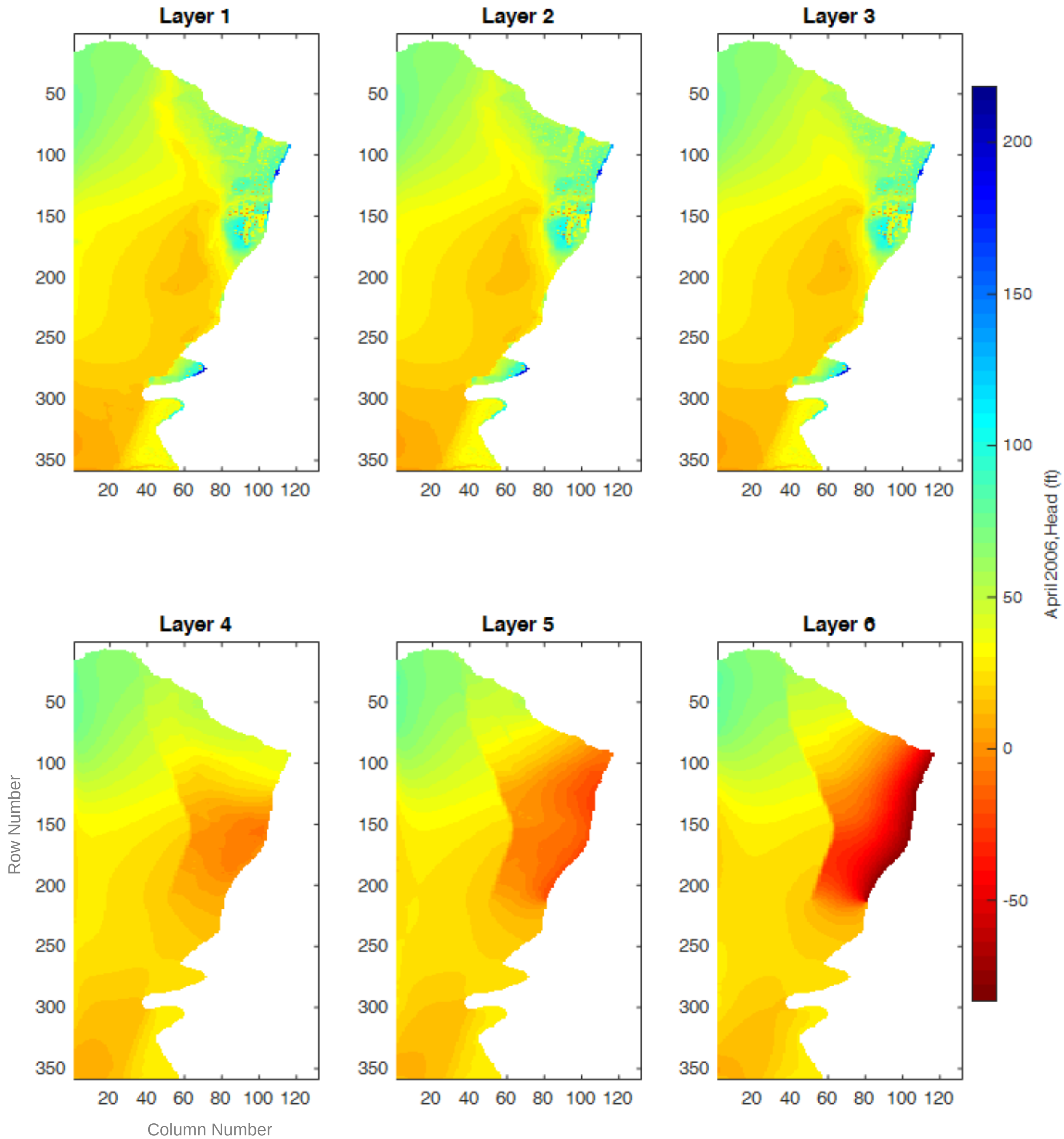
APPENDIX B-3

Spatial Distribution of Simulated Water Levels for Selected Months, April 2002



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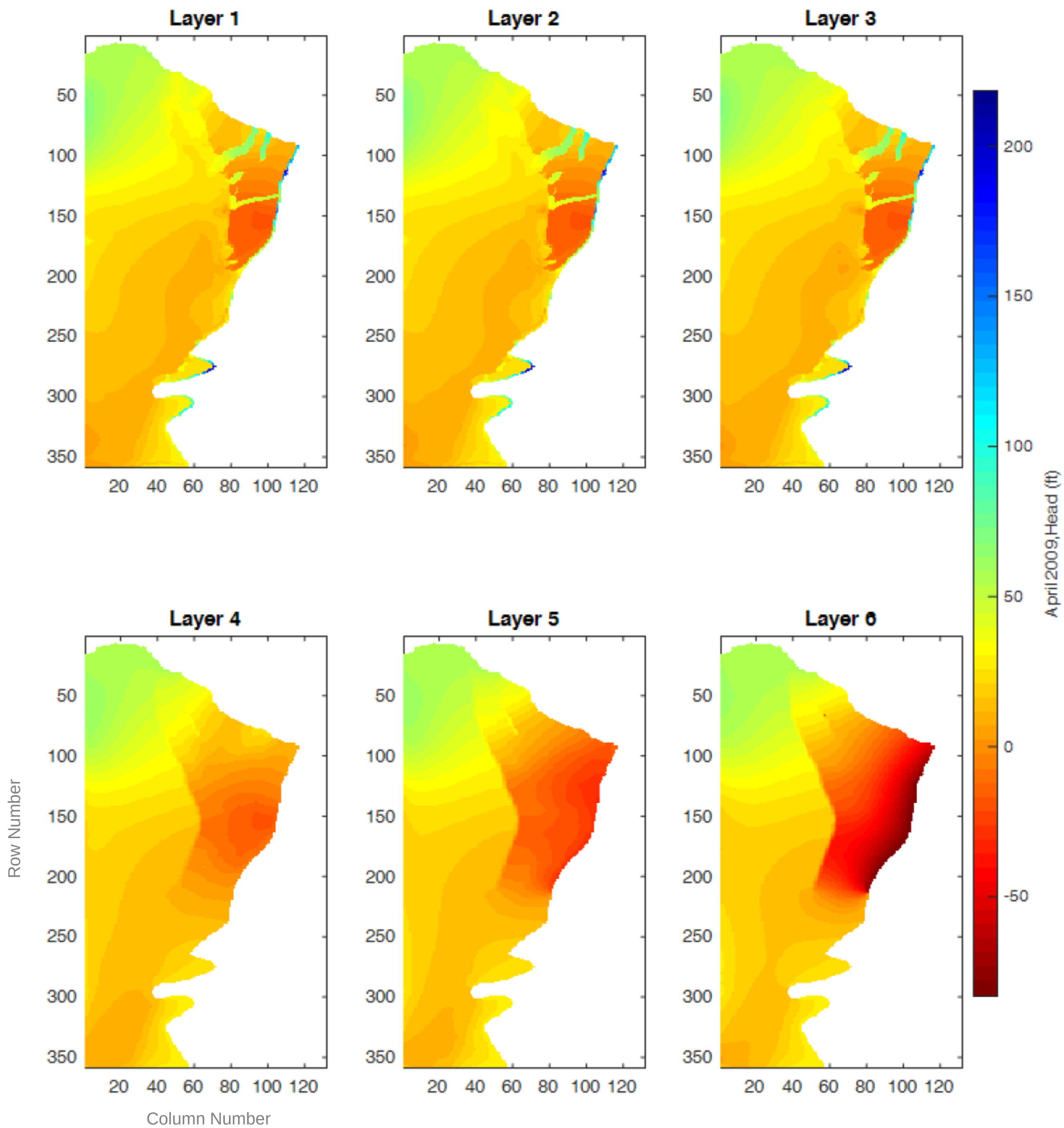
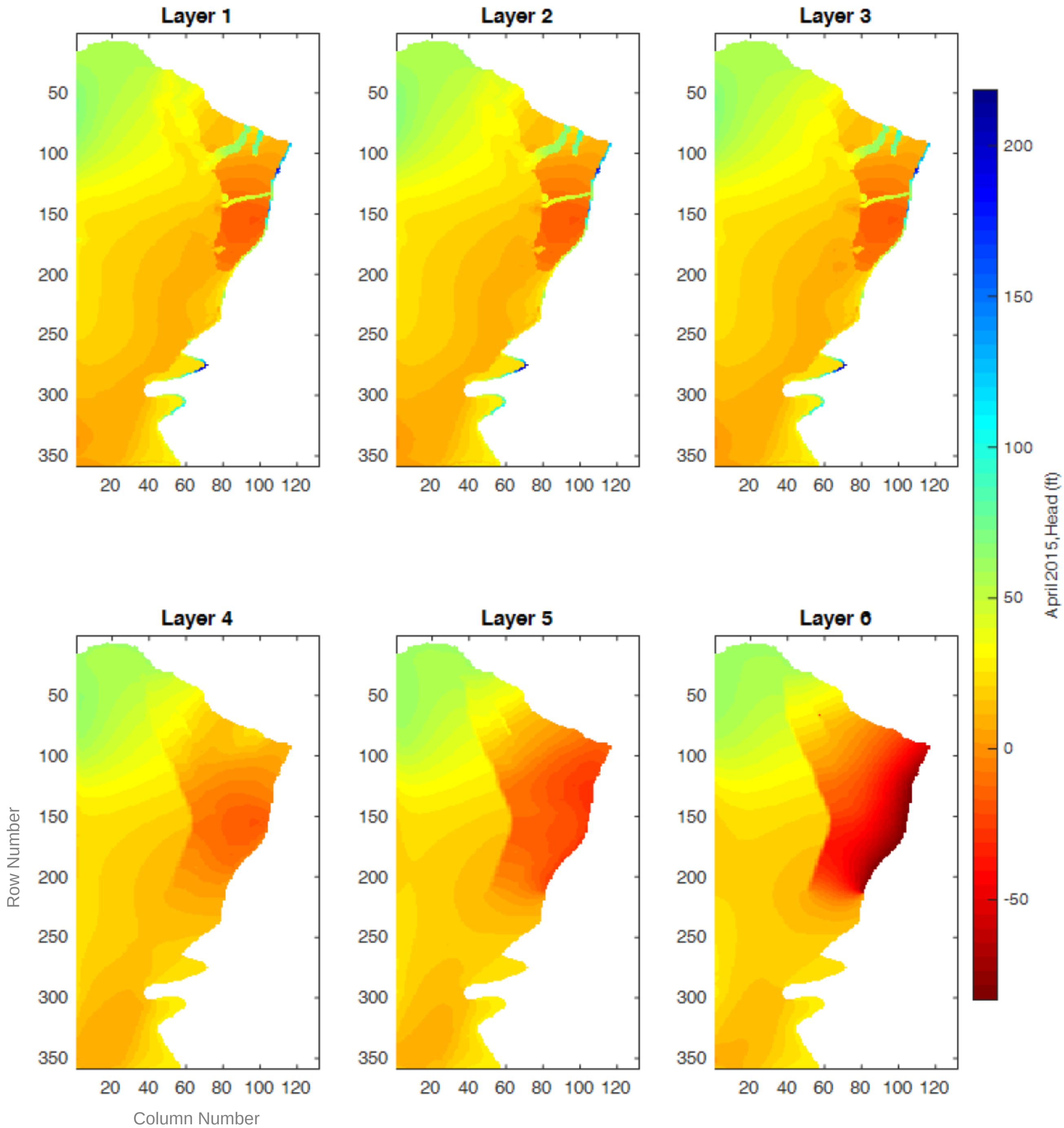
APPENDIX B-4

Spatial Distribution of Simulated Water Levels for Selected Months, April 2006



APPENDIX B-5

Spatial Distribution of Simulated Water Levels for Selected Months, April 2009



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APPENDIX B-6

Spatial Distribution of Simulated Water Levels for Selected Months, April 2015

APPPENDIX B

Summary of Currently Monitored Wells

Well ID or SYS NO	Napa County Subarea	SWN	SRC	Monitoring Frequency	Period of Record	DWR Subbasin Number	DWR Basin	DWR Subbasin	Aquifer Designation
08N06W10Q001M	Napa Valley Floor-Calistoga	008N006W10Q001M	DWR	Monthly	1949 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Not Defined
NapaCounty-127	Napa Valley Floor-Calistoga	009N007W25N001M	NapaCounty	Semi-Annual	1962 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-128	Napa Valley Floor-Calistoga	009N006W31Q001M	NapaCounty	Monthly	1962 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-178	Napa Valley Floor-Calistoga		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-224	Napa Valley Floor-Calistoga		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-225	Napa Valley Floor-Calistoga		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
L10002804480	Napa Valley Floor-MST		Geotracker	Monthly to Quarterly	2005 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-122	Napa Valley Floor-MST	006N004W26L005M	NapaCounty	Semi-Annual	2001 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tss
NapaCounty-149	Napa Valley Floor-MST	005N003W08E00_M	NapaCounty	Semi-Annual	2010 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-22	Napa Valley Floor-MST	005N003W08E001M	NapaCounty	Semi-Annual	2000 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-43	Napa Valley Floor-MST	006N004W23Q003M	NapaCounty	Semi-Annual	2001 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
T10000008932	Napa Valley Floor-MST		Geotracker	Monthly to Quarterly	2016 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
06N04W27L002M	Napa Valley Floor-Napa	006N004W27L002M	DWR	Monthly	1966 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-136	Napa Valley Floor-Napa	006N004W27N001M	NapaCounty	Monthly	1979 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-152	Napa Valley Floor-Napa	006N004W28Mx	NapaCounty	Semi-Annual	2012 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-182	Napa Valley Floor-Napa		NapaCounty	Monthly	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv
NapaCounty-183	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa, Tsv?
NapaCounty-184	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv, Tss/h?
NapaCounty-185	Napa Valley Floor-Napa		NapaCounty	Monthly	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-187	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv?, KJgv?
NapaCounty-188	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv, KJgv
NapaCounty-189	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-214s-swgw1	Napa Valley Floor-Napa	05N04W02N002M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-215d-swgw1	Napa Valley Floor-Napa	05N04W02N001M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-218s-swgw3	Napa Valley Floor-Napa	06N04W16G001M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-219d-swgw3	Napa Valley Floor-Napa	06N04W16G002M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-227	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2015 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-228	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2015 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-229	Napa Valley Floor-Napa		NapaCounty	Semi-Annual	2016 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tss
NapaCounty-76	Napa Valley Floor-Napa	006N004W15R003M	NapaCounty	Semi-Annual	2000 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv
SL0605536682	Napa Valley Floor-Napa		Geotracker	Monthly to Quarterly	2005 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
T0605514064	Napa Valley Floor-Napa		Geotracker	Monthly to Quarterly	2005 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
T0605547200	Napa Valley Floor-Napa		Geotracker	Monthly to Quarterly	2008 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
07N05W09Q002M	Napa Valley Floor-St. Helena	007N005W09Q002M	DWR	Monthly	1949 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Not Defined
NapaCounty-131	Napa Valley Floor-St. Helena	007N005W16L001M	NapaCounty	Semi-Annual	1963 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-132	Napa Valley Floor-St. Helena	007N005W14B002M	NapaCounty	Monthly	1962 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa, Tsvab
NapaCounty-138	Napa Valley Floor-St. Helena	007N005W16N002M	NapaCounty	Semi-Annual	1949 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-169	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-171	Napa Valley Floor-St. Helena		NapaCounty	Monthly	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tst/s
NapaCounty-172	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-173	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-174	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-177	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-204	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa

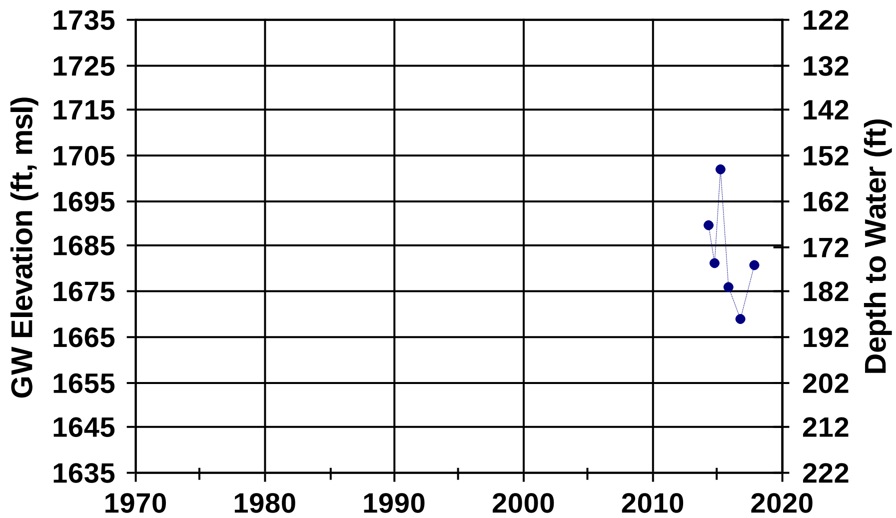
Well ID or SYS NO	Napa County Subarea	SWN	SRC	Monitoring Frequency	Period of Record	DWR Subbasin Number	DWR Basin	DWR Subbasin	Aquifer Designation
NapaCounty-212	Napa Valley Floor-St. Helena		NapaCounty	Semi-Annual	2015 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-222s-swgw5	Napa Valley Floor-St. Helena	08N05W30Q001M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-223d-swgw5	Napa Valley Floor-St. Helena	08N05W30Q002M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
06N04W17A001M	Napa Valley Floor-Yountville	006N004W17A001M	DWR	Semi-Annual	1949 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-125	Napa Valley Floor-Yountville	006N004W09Q001M	NapaCounty	Semi-Annual	1979 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsva
NapaCounty-126	Napa Valley Floor-Yountville	006N004W09Q002M	NapaCounty	Semi-Annual	1984 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsva
NapaCounty-133	Napa Valley Floor-Yountville	007N004W31M001M	NapaCounty	Monthly	1978 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-134	Napa Valley Floor-Yountville	006N004W06L002M	NapaCounty	Semi-Annual	1963 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-135	Napa Valley Floor-Yountville	006N004W19B001M	NapaCounty	Monthly	1979 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa, Tsv
NapaCounty-139	Napa Valley Floor-Yountville	006N004W17R002M	NapaCounty	Semi-Annual	1978 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-179	Napa Valley Floor-Yountville		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-181	Napa Valley Floor-Yountville		NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Tsv
NapaCounty-216s-swgw2	Napa Valley Floor-Yountville	06N04W18J003M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-217d-swgw2	Napa Valley Floor-Yountville	06N04W18J004M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-220s-swgw4	Napa Valley Floor-Yountville	07N04W31D001M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-221d-swgw4	Napa Valley Floor-Yountville	07N04W31D002M	NapaCounty	Semi-Annual	2014 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	Qa
NapaCounty-129	Western Mountains	008N006W06L004M	NapaCounty	Semi-Annual	1962 - 2017	2-2.01	NAPA-SONOMA VALLEY	NAPA VALLEY	
NapaCounty-150	Carneros	004N004W05C001M	NapaCounty	Semi-Annual	2011 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-153	Carneros	004N004W05A001M	NapaCounty	Semi-Annual	2012 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	TQsb
NapaCounty-154	Carneros	005N004W31R001M	NapaCounty	Semi-Annual	2012 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	TQsb
NapaCounty-155	Carneros	004N004W06M001M	NapaCounty	Semi-Annual	2012 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	TQsb
NapaCounty-176	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-194	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-195	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-200	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-201	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-205	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-206	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-207	Carneros		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-196	Jameson/American Canyon		NapaCounty	Semi-Annual	2014 - 2017	2-2.03	NAPA-SONOMA VALLEY	NAPA-SONOMA LOWLANDS	
NapaCounty-211	Pope Valley		NapaCounty	Semi-Annual	2014 - 2017	5-68	POPE VALLEY		
NapaCounty-165	Angwin		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-166	Angwin		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-167	Angwin		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-168	Angwin		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-202	Angwin		NapaCounty	Semi-Annual	2014 - 2017		Outside		
T0605500304	Berryessa		Geotracker	Monthly to Quarterly	2002 - 2017		Outside		
L10003756160	Central Interior Valleys		Geotracker	Monthly to Quarterly	1990 - 2017		Outside		
NapaCounty-209	Central Interior Valleys		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-175	Eastern Mountains		NapaCounty	Semi-Annual	2014 - 2017		Outside		Tsv
NapaCounty-193	Eastern Mountains		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-210	Eastern Mountains		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-208	Napa Valley Floor-Calistoga		NapaCounty	Semi-Annual	2014 - 2017		Outside		Tsv
NapaCounty-118	Napa Valley Floor-MST	005N003W07B00_My	NapaCounty	Semi-Annual	2001 - 2017		Outside		

Well ID or SYS NO	Napa County Subarea	SWN	SRC	Monitoring Frequency	Period of Record	DWR Subbasin Number	DWR Basin	DWR Subbasin	Aquifer Designation
NapaCounty-137	Napa Valley Floor-MST	005N004W13H001M	NapaCounty	Semi-Annual	1979 - 2017		Outside		
NapaCounty-142	Napa Valley Floor-MST	006N004W25G00_M	NapaCounty	Semi-Annual	2001 - 2017		Outside		
NapaCounty-18	Napa Valley Floor-MST	005N004W13G004M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-191	Napa Valley Floor-MST		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-192	Napa Valley Floor-MST		NapaCounty	Semi-Annual	2014 - 2017		Outside		
NapaCounty-2	Napa Valley Floor-MST	006N004W23J001M	NapaCounty	Semi-Annual	1979 - 2017		Outside		
NapaCounty-20	Napa Valley Floor-MST	005N003W07C003M	NapaCounty	Semi-Annual	1978 - 2017		Outside		Tsvd
NapaCounty-226	Napa Valley Floor-MST		NapaCounty	Semi-Annual	2015 - 2017		Outside		
NapaCounty-35	Napa Valley Floor-MST	005N003W18D001M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-56	Napa Valley Floor-MST	006N004W26G001M	NapaCounty	Semi-Annual	1978 - 2017		Outside		Tss/h
NapaCounty-69	Napa Valley Floor-MST	006N004W35G005M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-72	Napa Valley Floor-MST	005N003W07D003M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-74	Napa Valley Floor-MST	005N003W06M001M	NapaCounty	Semi-Annual	1999 - 2017		Outside		
NapaCounty-81	Napa Valley Floor-MST	005N003W07F003M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-91	Napa Valley Floor-MST	005N003W06B002M	NapaCounty	Semi-Annual	1992 - 2017		Outside		Tsvt
NapaCounty-92	Napa Valley Floor-MST	005N003W06A001M	NapaCounty	Semi-Annual	1999 - 2017		Outside		
NapaCounty-95	Napa Valley Floor-MST	006N004W36G001M	NapaCounty	Semi-Annual	1979 - 2017		Outside		Tsvt
NapaCounty-98	Napa Valley Floor-MST	006N004W36A001M	NapaCounty	Semi-Annual	2000 - 2017		Outside		
NapaCounty-213	Western Mountains		NapaCounty	Semi-Annual	2014 - 2017		Outside		

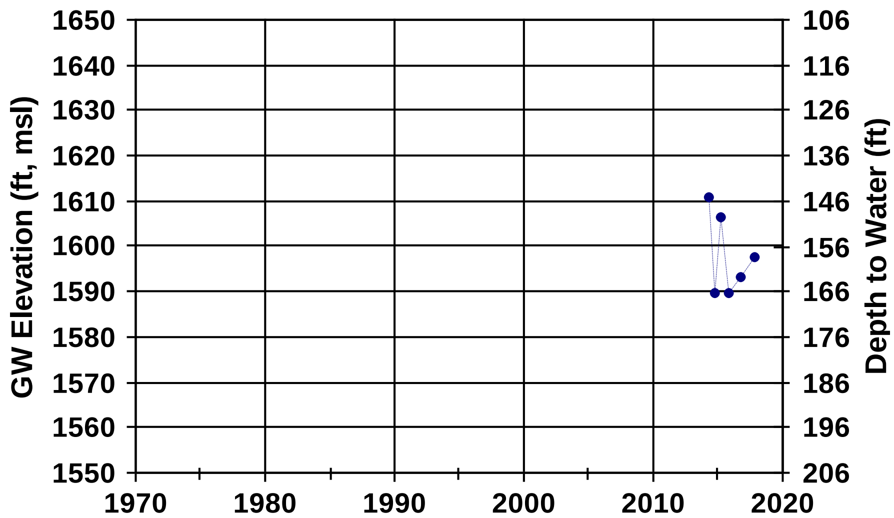
APPEDNDIX C

Groundwater Level Hydrographs for Currently Monitored Wells

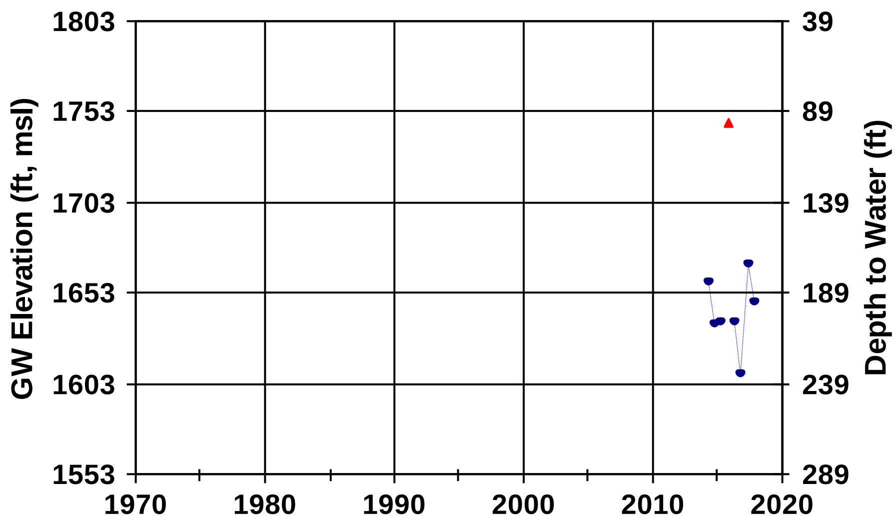
WellID: NapaCounty-165 RPE: 1857 ft, msl SWN: Unknown
Subarea: Angwin Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/16/2017



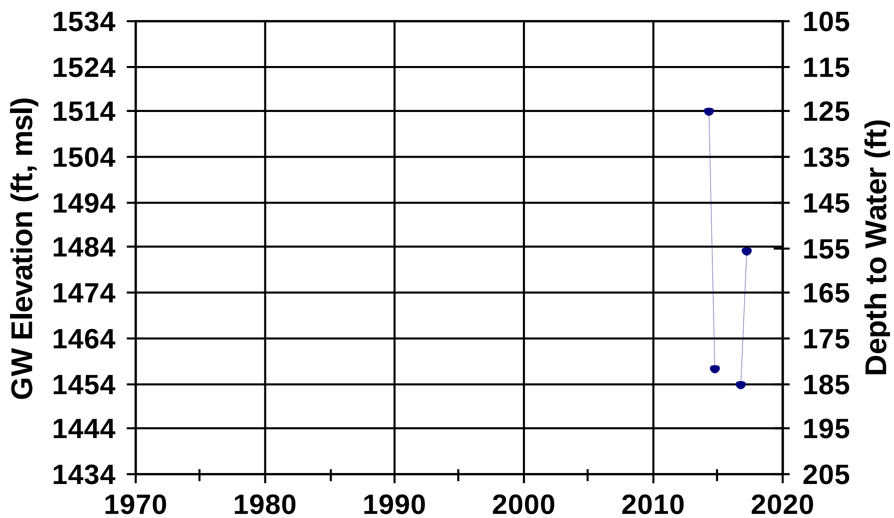
WellID: NapaCounty-166 RPE: 1755.8 ft, msl SWN: Unknown
Subarea: Angwin Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/16/2017



WellID: NapaCounty-167 RPE: 1842.3 ft, msl SWN: Unknown
Subarea: Angwin Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/20/2017

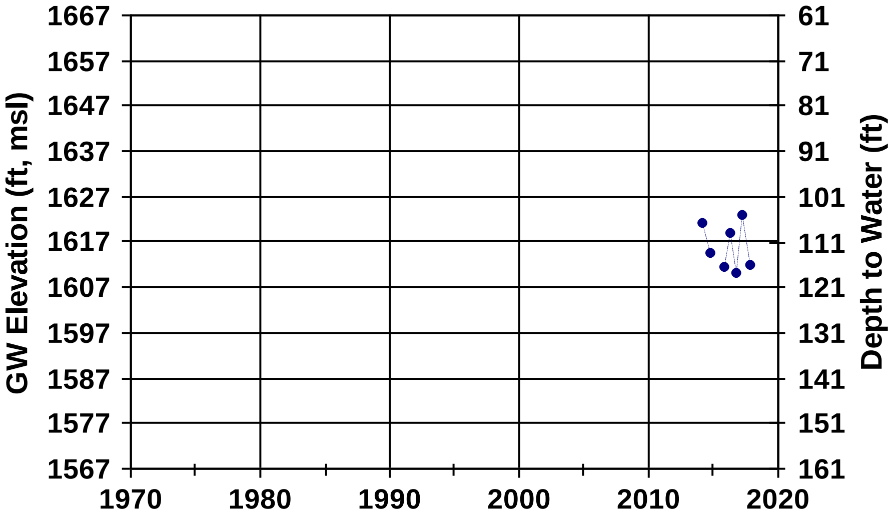


WellID: NapaCounty-168 RPE: 1639 ft, msl SWN: Unknown
Subarea: Angwin Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/12/2017

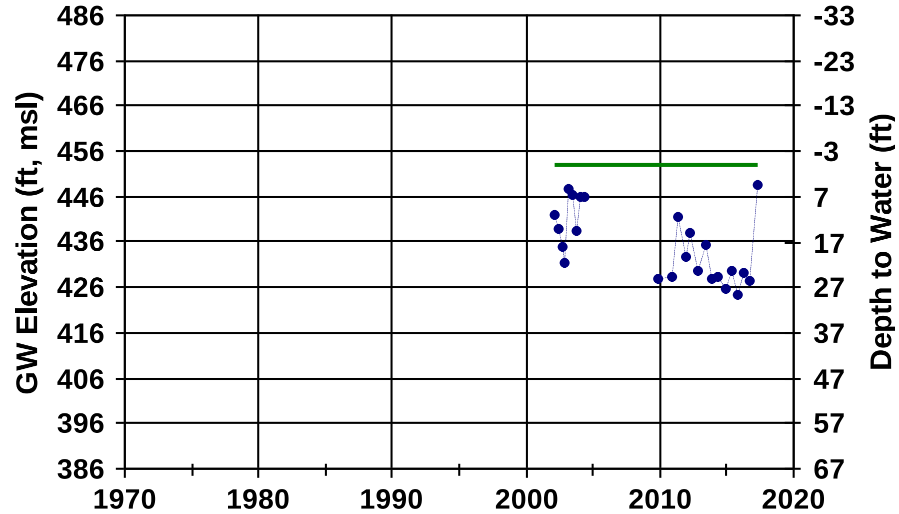


Measured Water Levels Questionable Measurements Reference Point Elevation

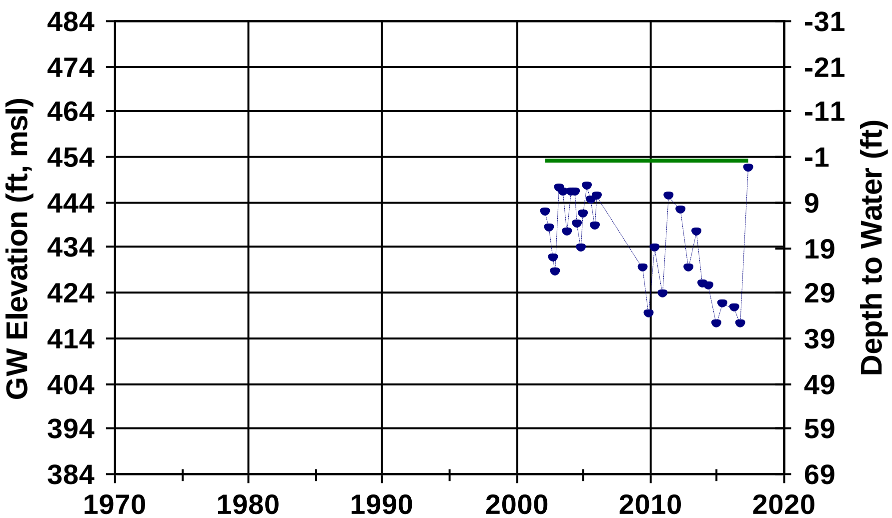
WellID: NapaCounty-202 RPE: 1728.2 ft, msl SWN: Unknown
Subarea: Angwin Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/31/2017



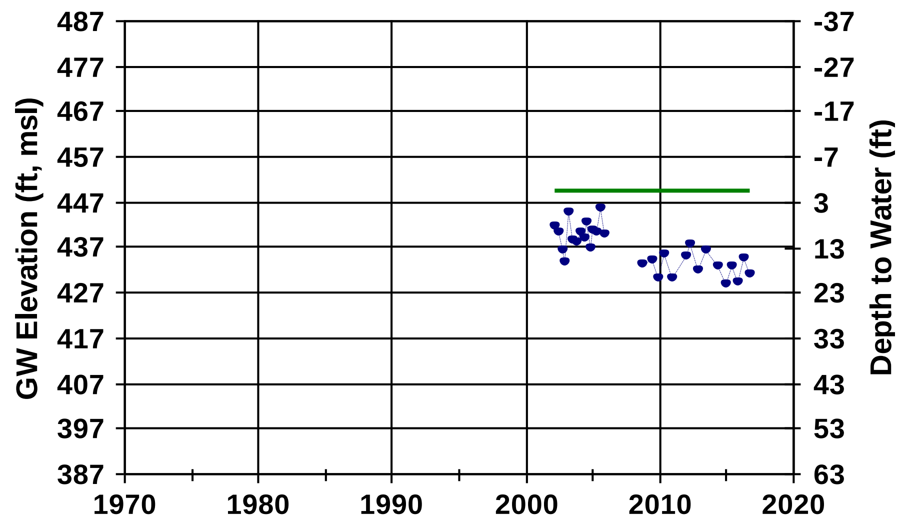
WellID: T0605500304MW-1 RPE: 452.82 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017



WellID: T0605500304MW-12 RPE: 453.06 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017

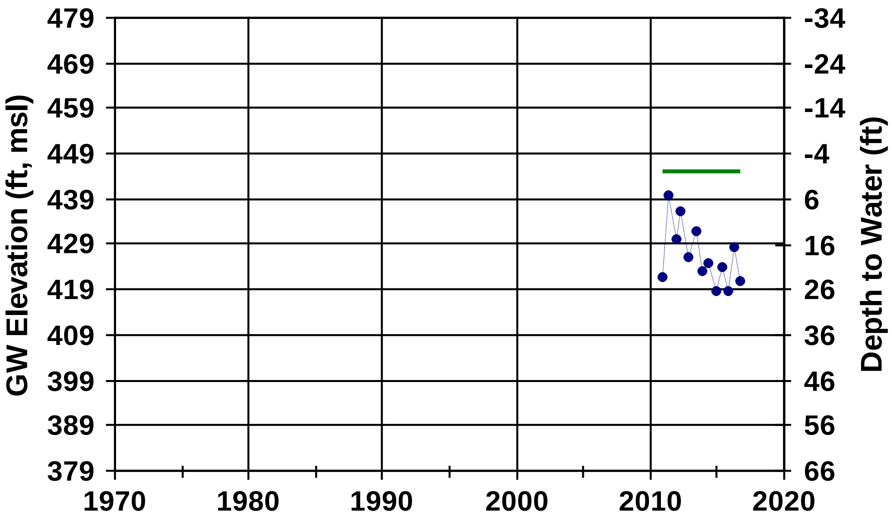


WellID: T0605500304MW-14 RPE: 449.75 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/5/2016

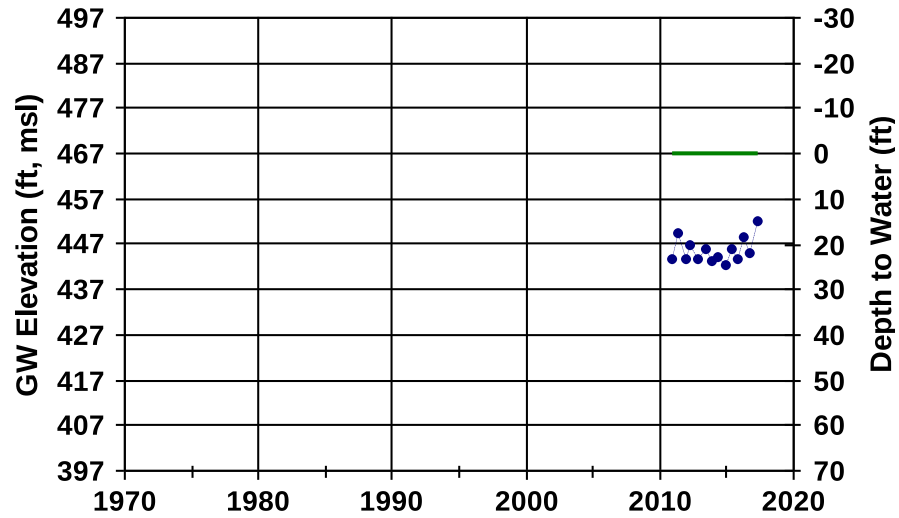


Measured Water Levels Questionable Measurements Reference Point Elevation

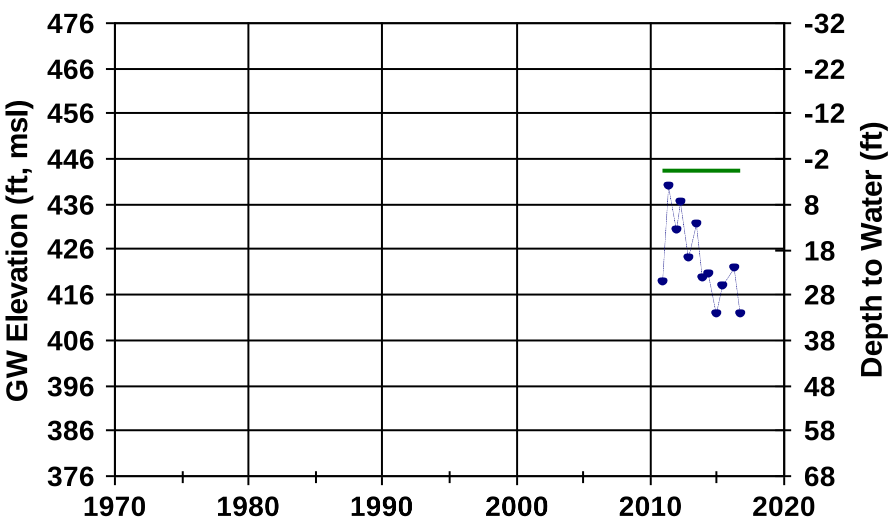
WellID: T0605500304MW-16 RPE: 444.87 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/5/2016



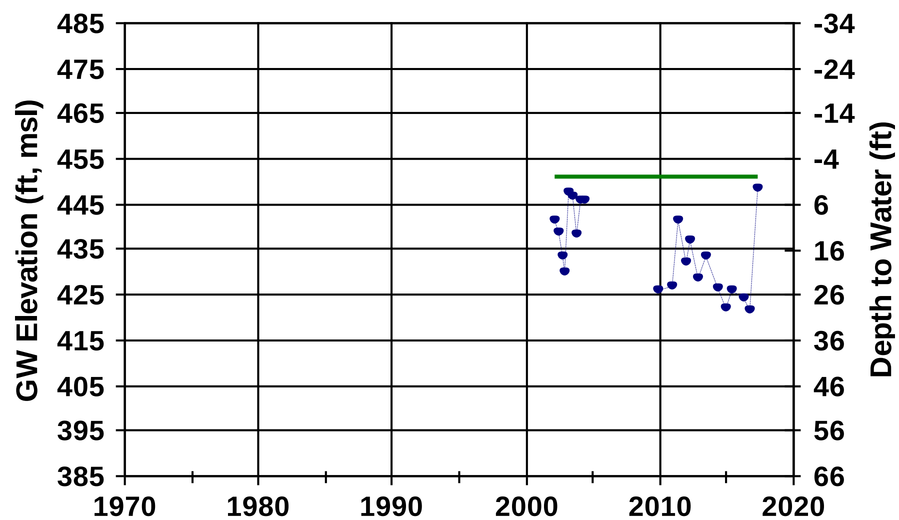
WellID: T0605500304MW-18 RPE: 467.06 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017



WellID: T0605500304MW-19 RPE: 443.59 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/5/2016

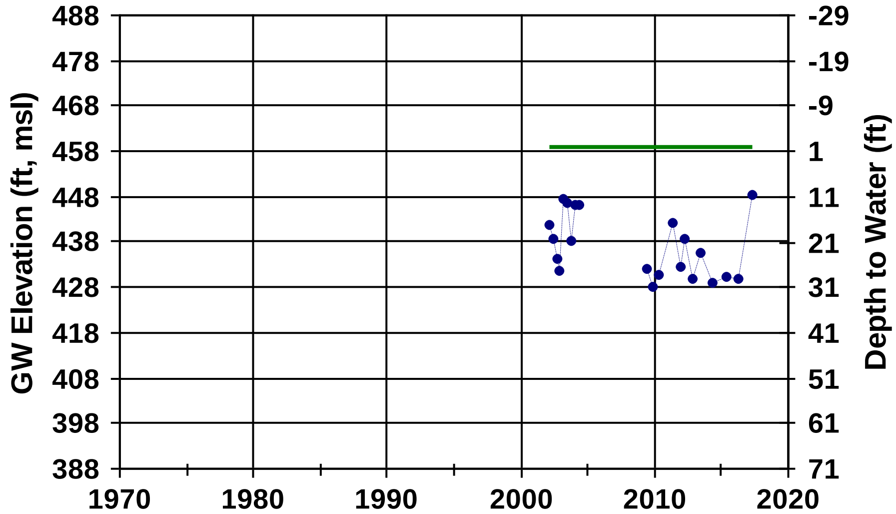


WellID: T0605500304MW-3 RPE: 450.99 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017

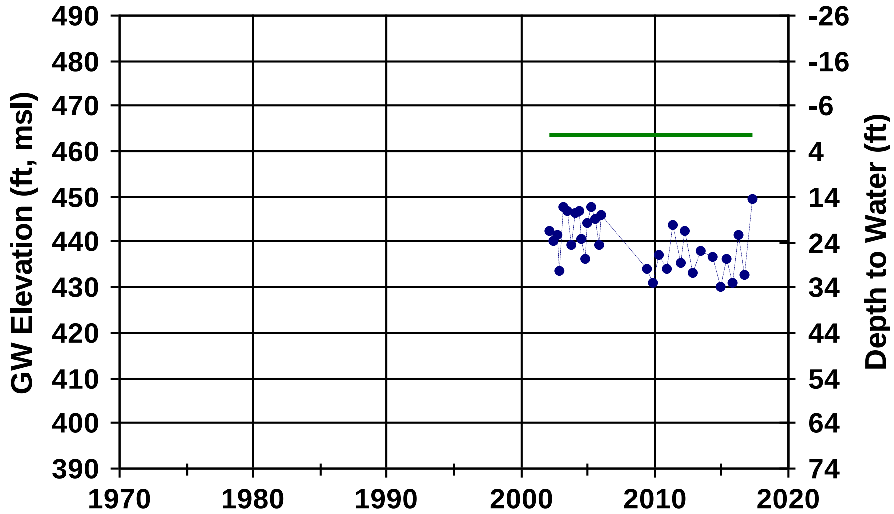


Measured Water Levels Questionable Measurements Reference Point Elevation

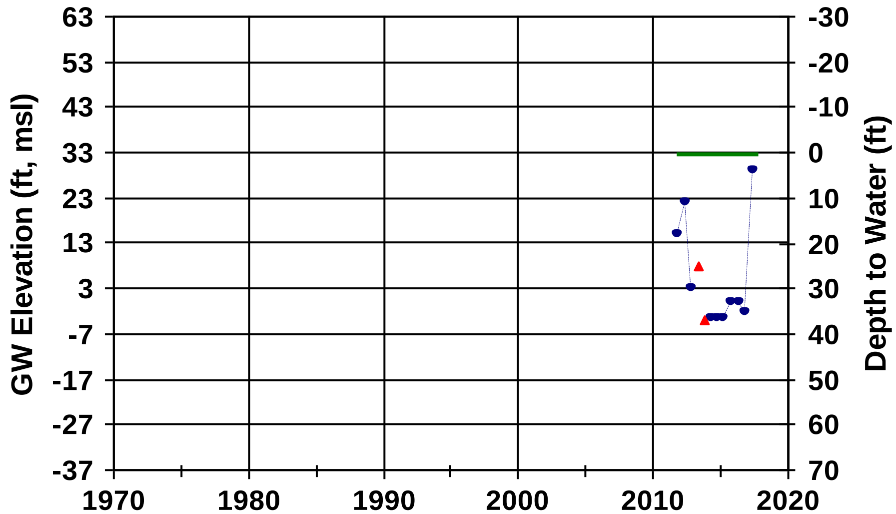
WellID: T0605500304MW-4 RPE: 458.83 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017



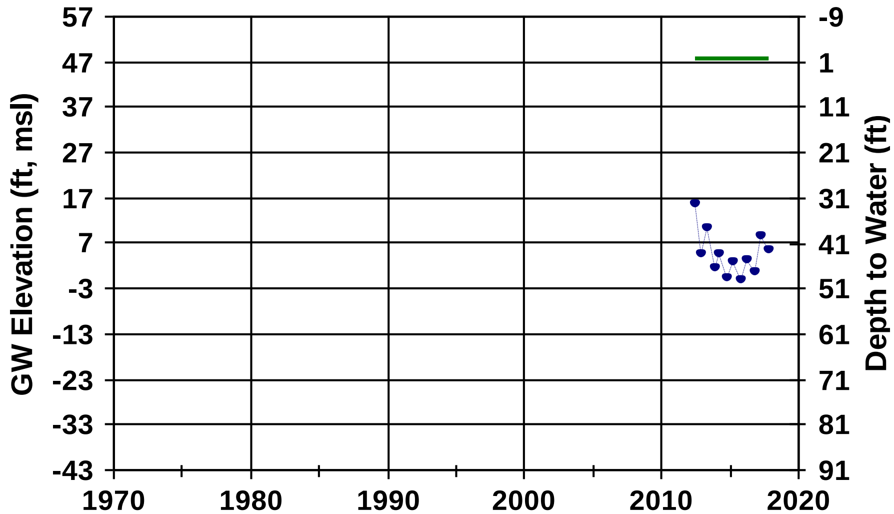
WellID: T0605500304MW-8 RPE: 463.73 ft, msl SWN: Unknown
Subarea: Berryessa Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/11/2017



WellID: NapaCounty-150 RPE: 32.7 ft, msl SWN: 004N004W05C001
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 4/27/2017

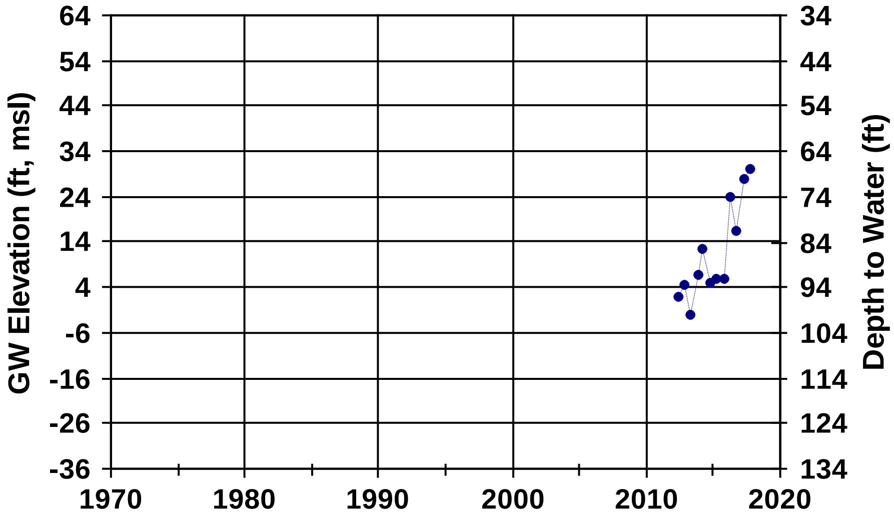


WellID: NapaCounty-153 RPE: 47.35 ft, msl SWN: 004N004W05A001
Subarea: Carneros Source: NapaCounty Aquifer Zone: TQsb
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/26/2017

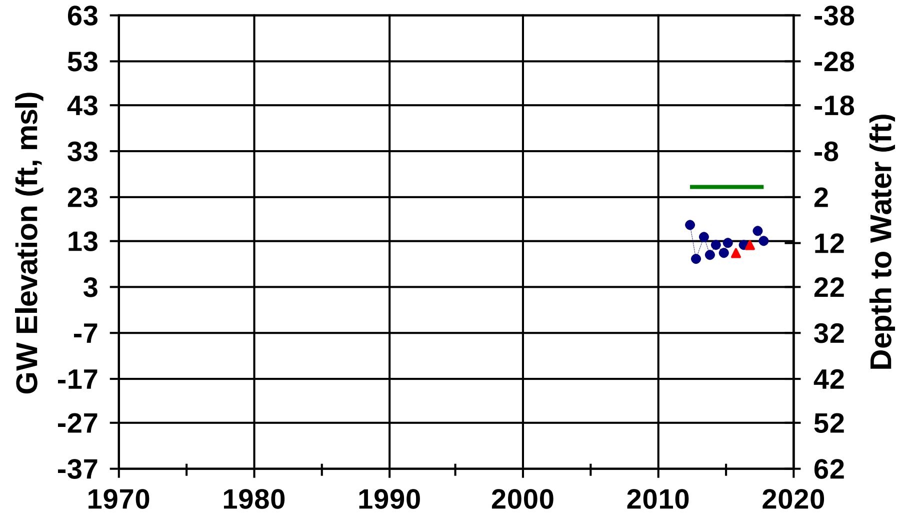


Measured Water Levels   Questionable Measurements   Reference Point Elevation

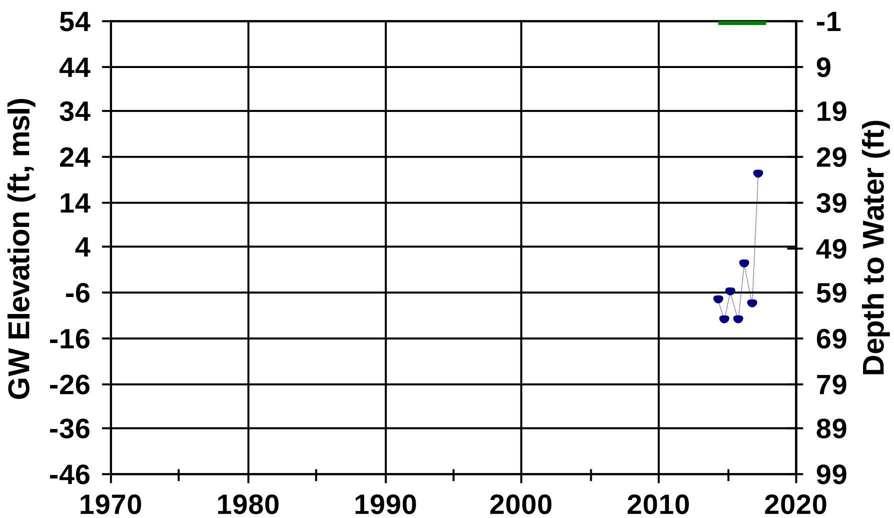
WellID: NapaCounty-154 RPE: 98 ft, msl SWN: 005N004W31R001
Subarea: Carneros Source: NapaCounty Aquifer Zone: TQsb
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017



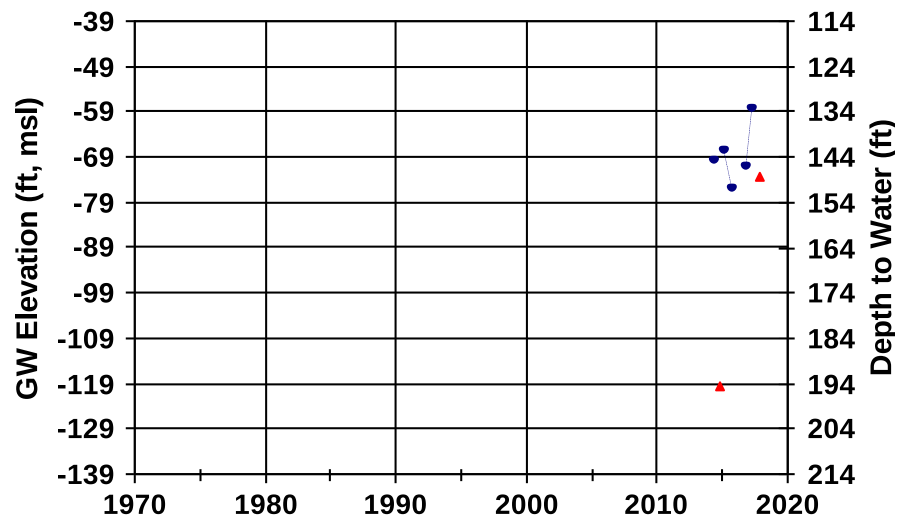
WellID: NapaCounty-155 RPE: 25 ft, msl SWN: 004N004W06M001
Subarea: Carneros Source: NapaCounty Aquifer Zone: TQsb
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017



WellID: NapaCounty-176 RPE: 53.4 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 4/10/2017

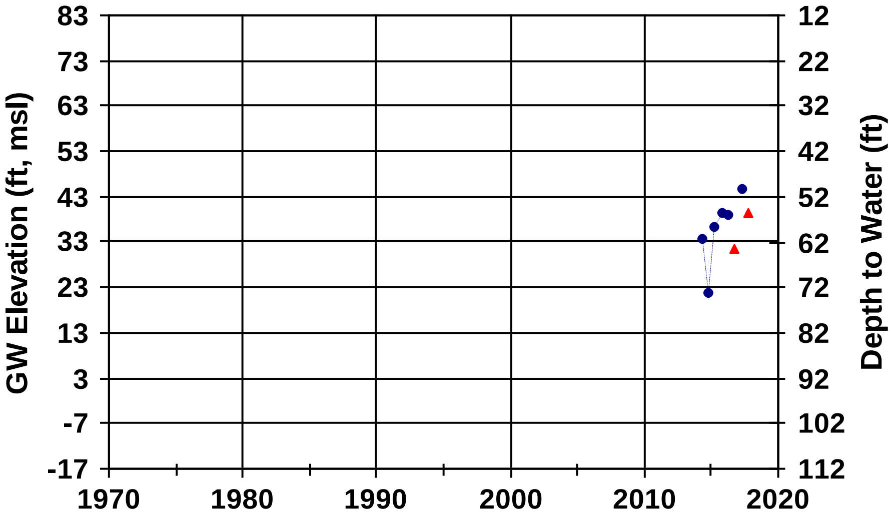


WellID: NapaCounty-194 RPE: 75.1 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/26/2017

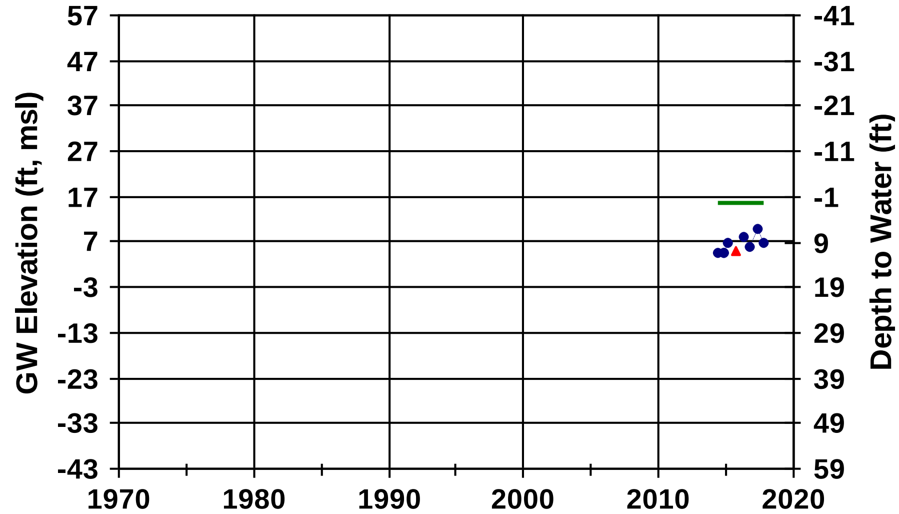


Measured Water Levels Questionable Measurements Reference Point Elevation

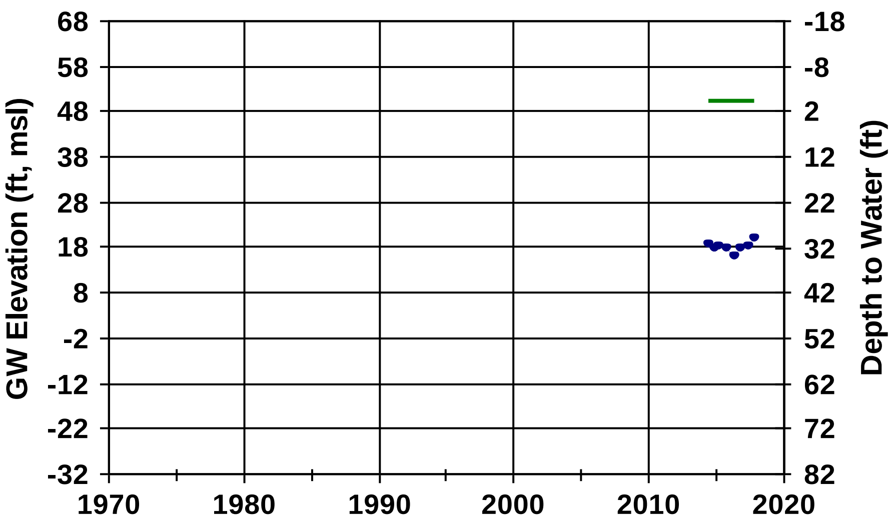
WellID: NapaCounty-195 RPE: 94.8 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/26/2017



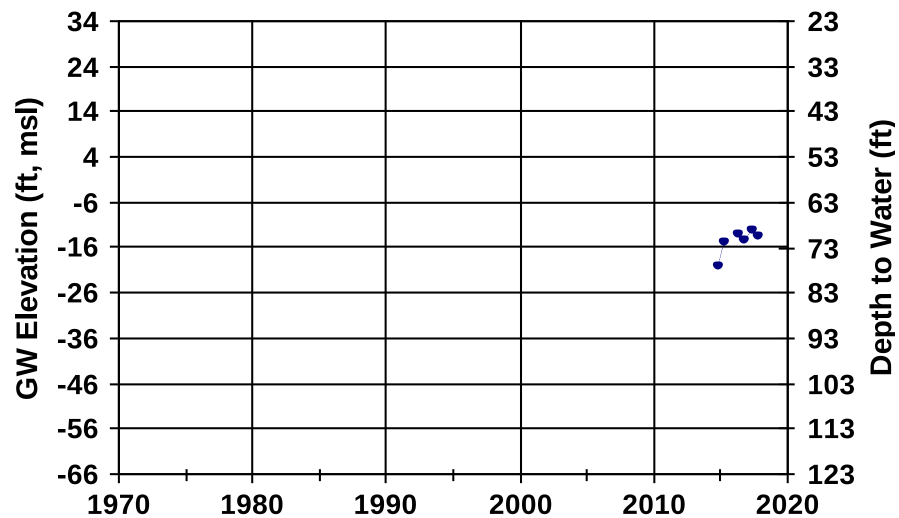
WellID: NapaCounty-200 RPE: 15.7 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017



WellID: NapaCounty-201 RPE: 50.4 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017

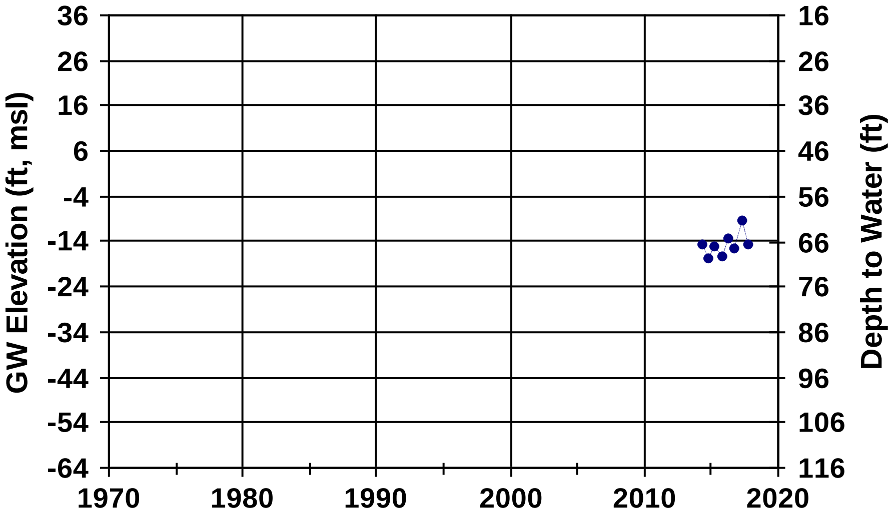


WellID: NapaCounty-205 RPE: 56.8 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017

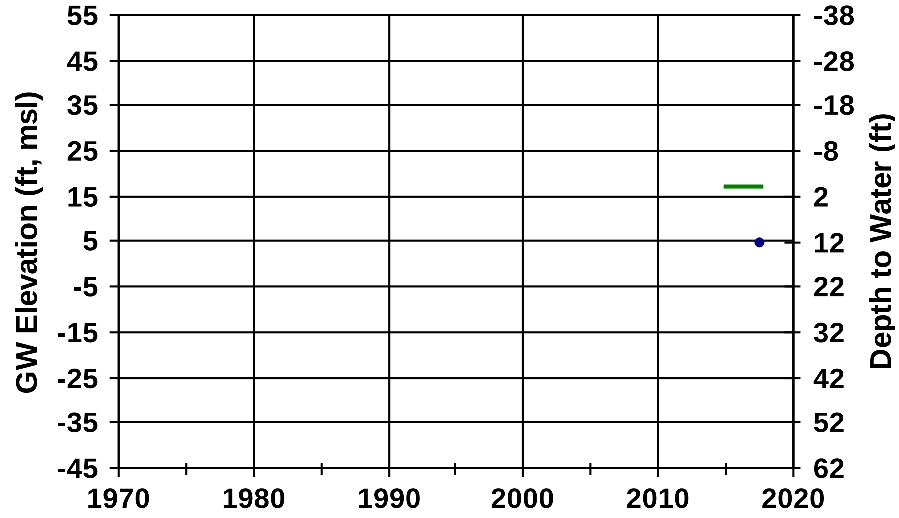


Measured Water Levels Questionable Measurements Reference Point Elevation

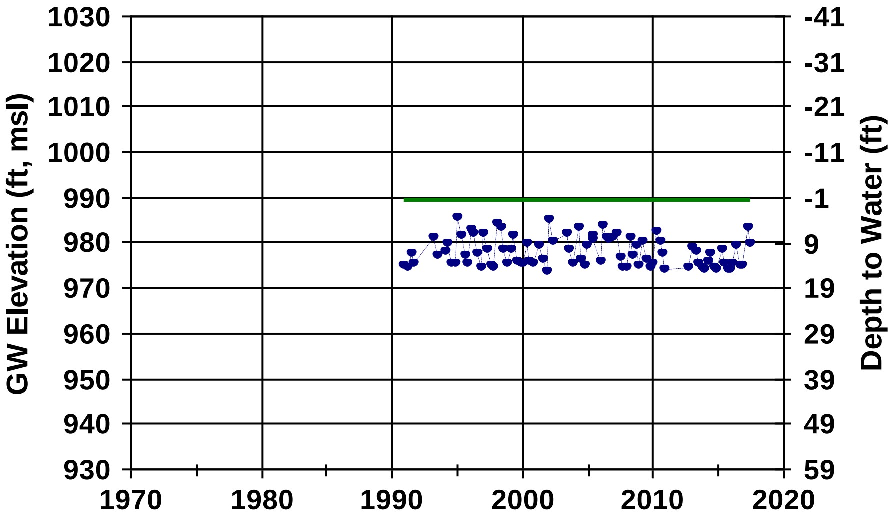
WellID: NapaCounty-206 RPE: 52.4 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 10/31/2017



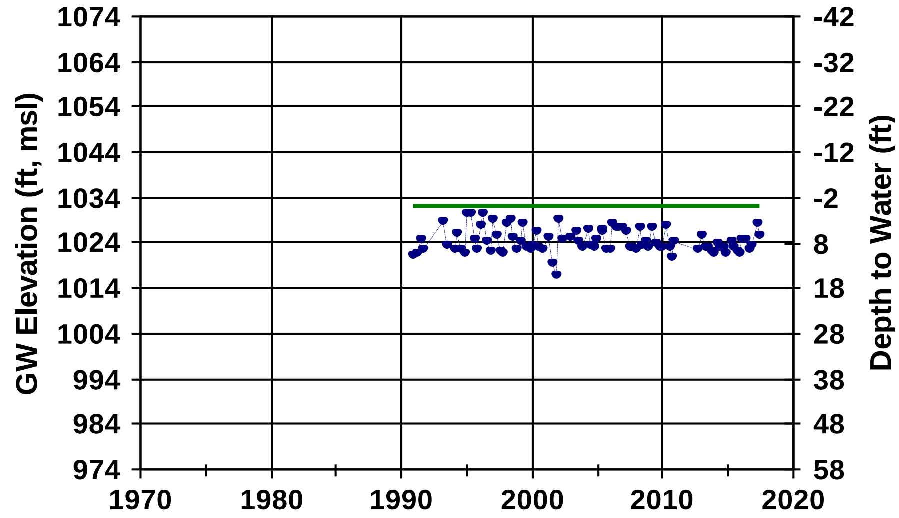
WellID: NapaCounty-207 RPE: 17 ft, msl SWN: Unknown
Subarea: Carneros Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 6/21/2017



WellID: L10003756160MW-6 RPE: 989.39 ft, msl SWN: Unknown
Subarea: Central Interior Valleys Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 6/1/2017

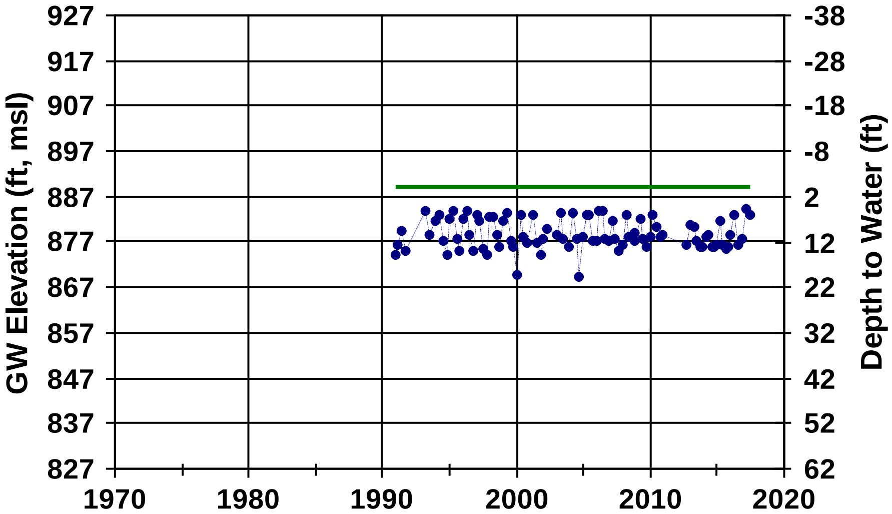


WellID: L10003756160MW-7 RPE: 1032.16 ft, msl SWN: Unknown
Subarea: Central Interior Valleys Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 6/1/2017

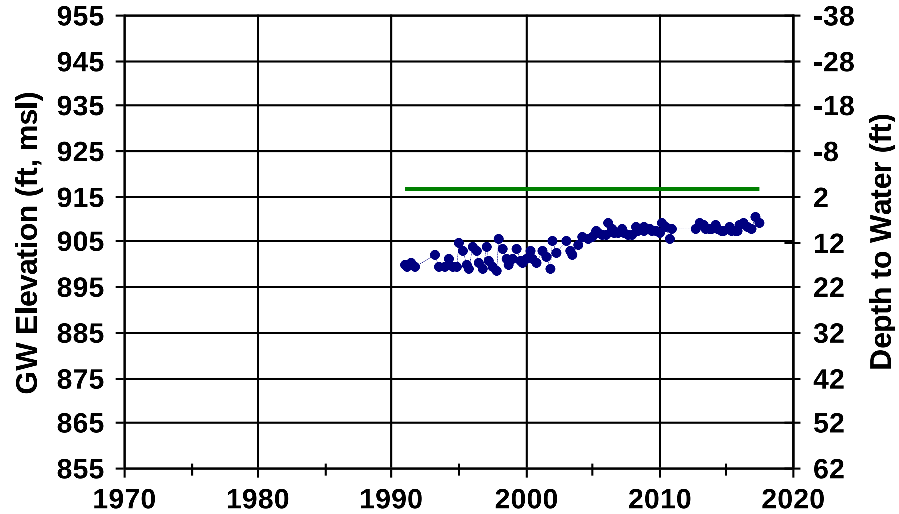


Measured Water Levels Questionable Measurements Reference Point Elevation

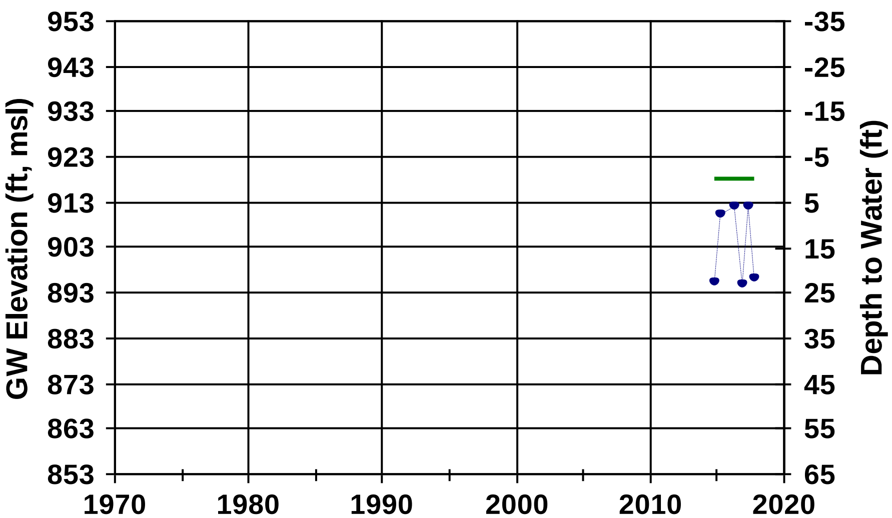
WellID: L10003756160MW-8 RPE: 889.03 ft, msl SWN: Unknown
Subarea: Central Interior Valleys Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 6/1/2017



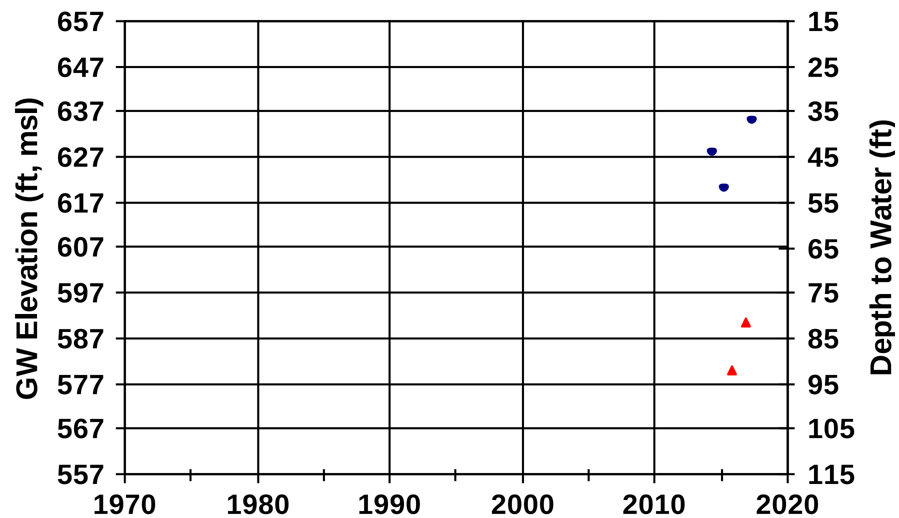
WellID: L10003756160MW-9 RPE: 916.87 ft, msl SWN: Unknown
Subarea: Central Interior Valleys Source: Geotracker Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 6/1/2017



WellID: NapaCounty-209 RPE: 918 ft, msl SWN: Unknown
Subarea: Central Interior Valleys Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/3/2017

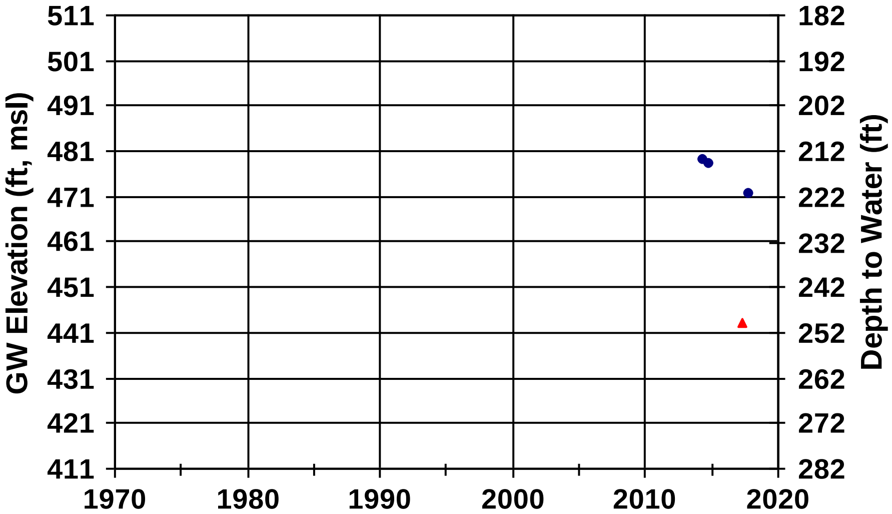


WellID: NapaCounty-175 RPE: 672.3 ft, msl SWN: Unknown
Subarea: Eastern Mountains Source: NapaCounty Aquifer Zone: Tsv
Groundwater Basin Not within a basin Last Msmt Date 4/12/2017

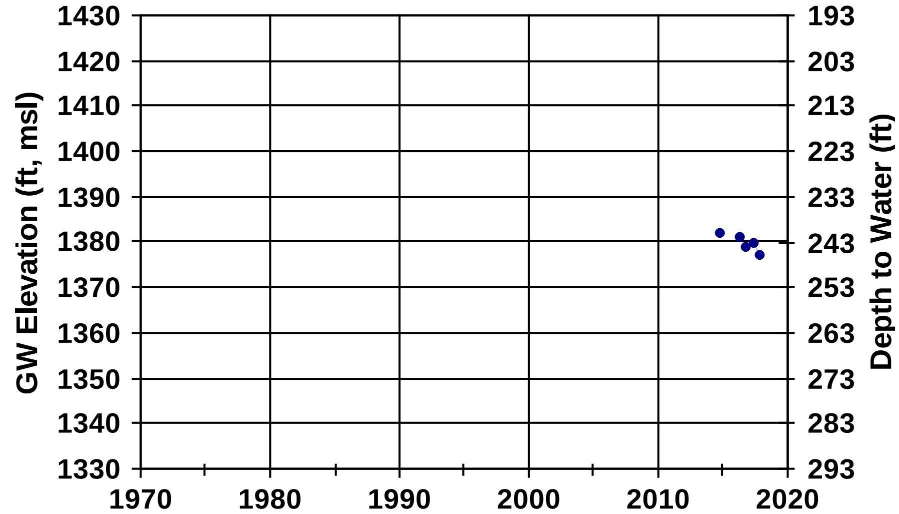


Measured Water Levels Questionable Measurements Reference Point Elevation

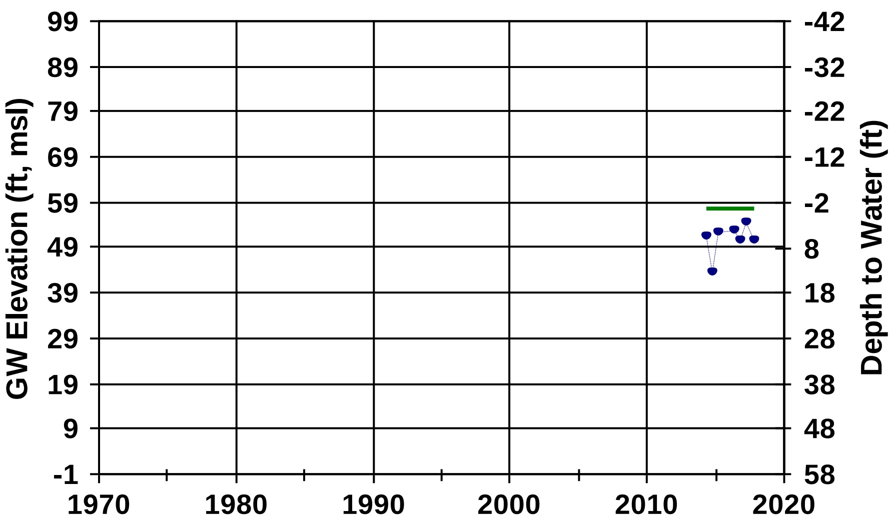
WellID: NapaCounty-193 RPE: 693.1 ft, msl SWN: Unknown
Subarea: Eastern Mountains Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/27/2017



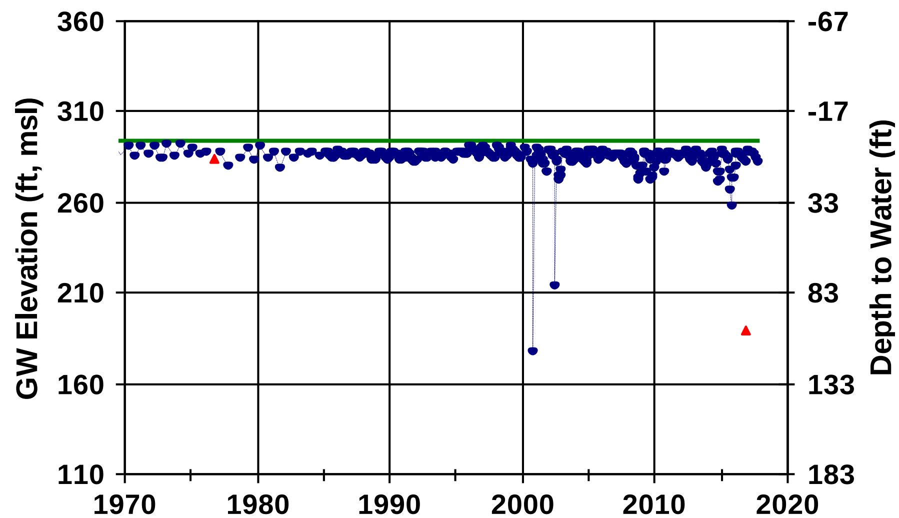
WellID: NapaCounty-210 RPE: 1622.9 ft, msl SWN: Unknown
Subarea: Eastern Mountains Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/24/2017



WellID: NapaCounty-196 RPE: 57.4 ft, msl SWN: Unknown
Subarea: Jameson/American Canyon Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA-SONOMA LOWLANDS SUBBASIN Last Msmt Date 11/8/2017

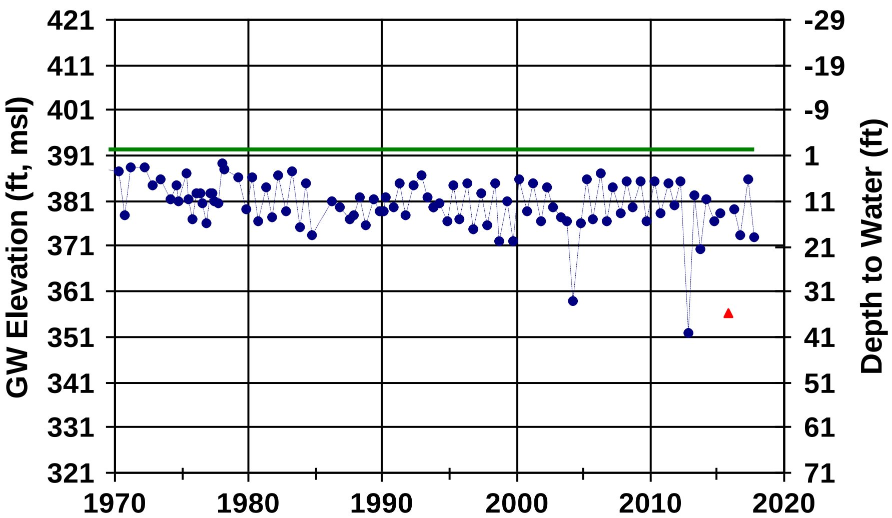


WellID: 08N06W10Q001M RPE: 293.43 ft, msl SWN: 008N006W10Q001
Subarea: Napa Valley Floor-Calistoga Source: DWR Aquifer Zone: Not Defined
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 9/25/2017

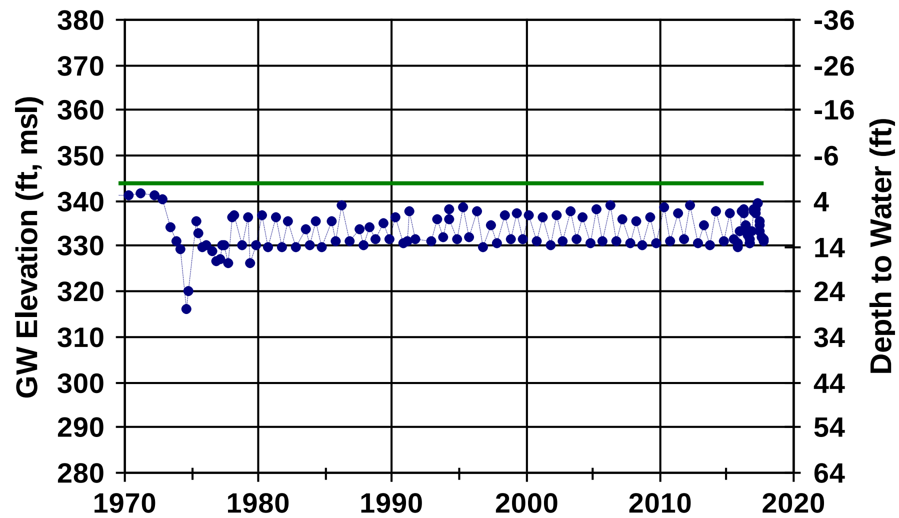


Measured Water Levels Questionable Measurements Reference Point Elevation

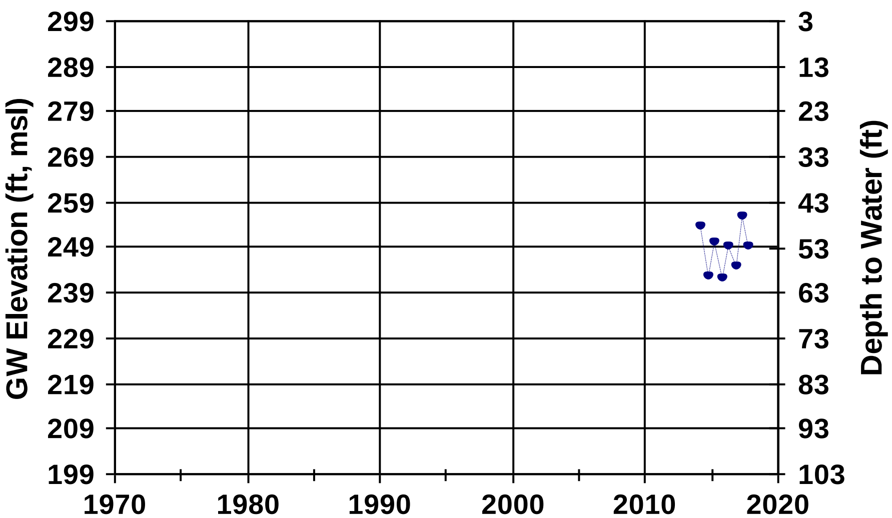
WellID: NapaCounty-127 RPE: 392.5 ft, msl SWN: 009N007W25N001
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/3/2017



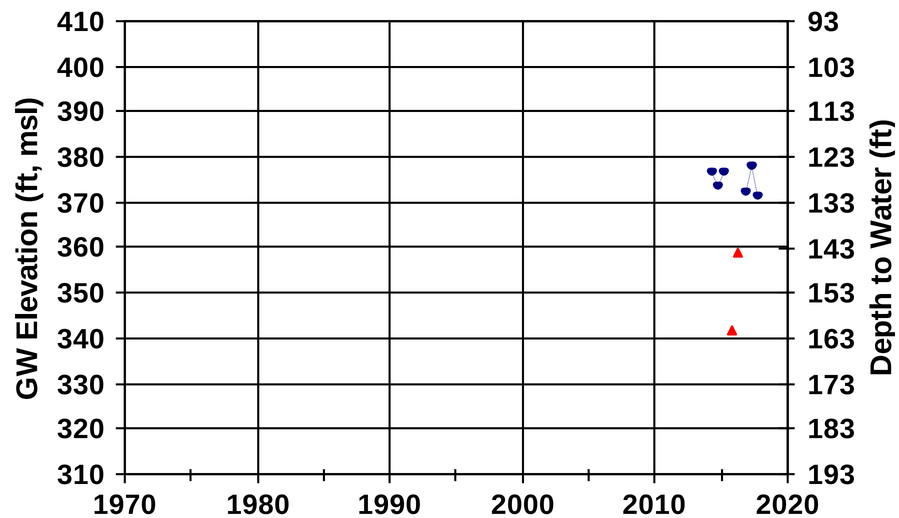
WellID: NapaCounty-128 RPE: 343.7 ft, msl SWN: 009N006W31Q001
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/3/2017



WellID: NapaCounty-178 RPE: 301.5 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/3/2017

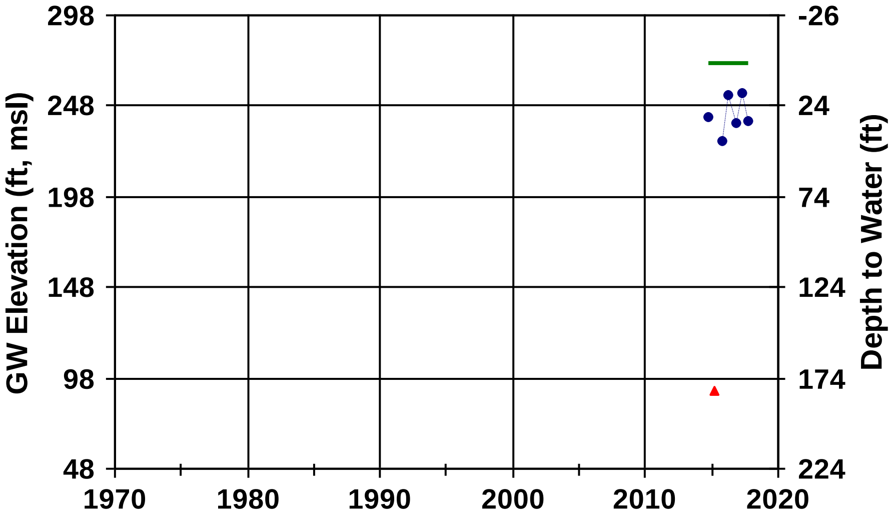


WellID: NapaCounty-208 RPE: 503.4 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone: Tsv
Groundwater Basin Not within a basin Last Msmt Date 10/23/2017

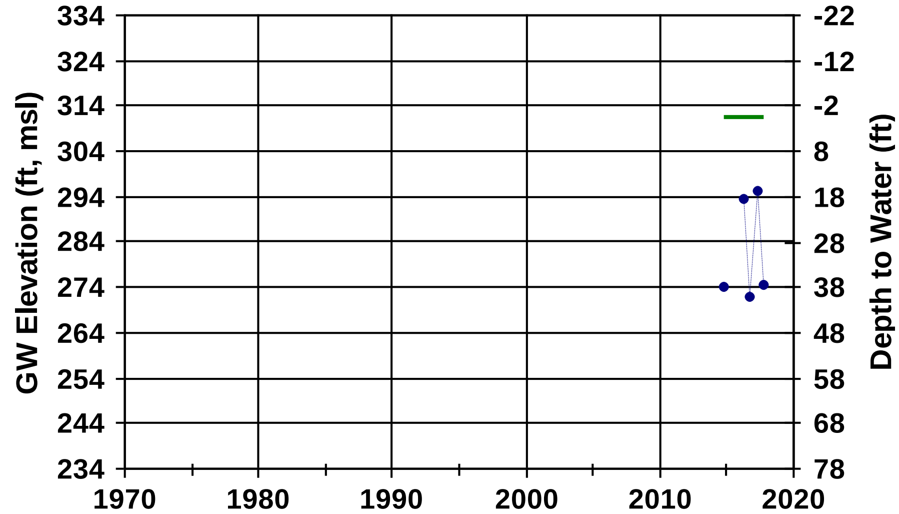


Measured Water Levels Questionable Measurements Reference Point Elevation

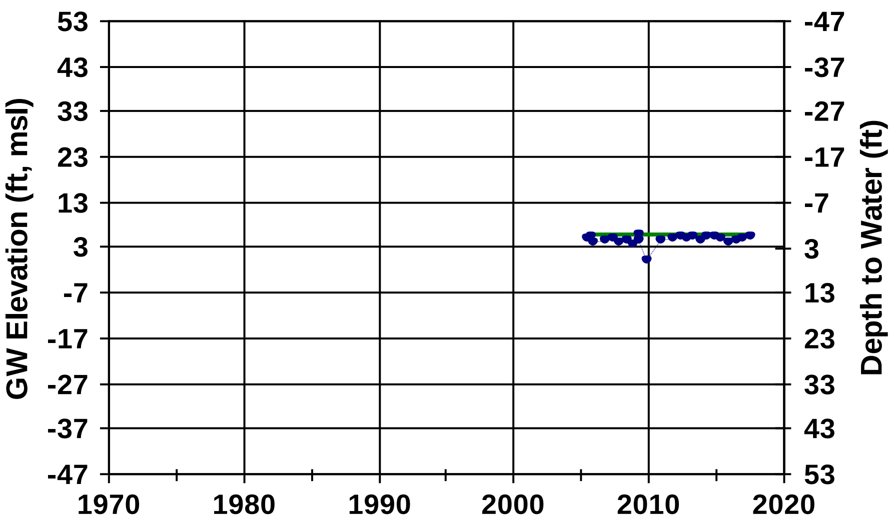
WellID: NapaCounty-224 RPE: 272 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/23/2017



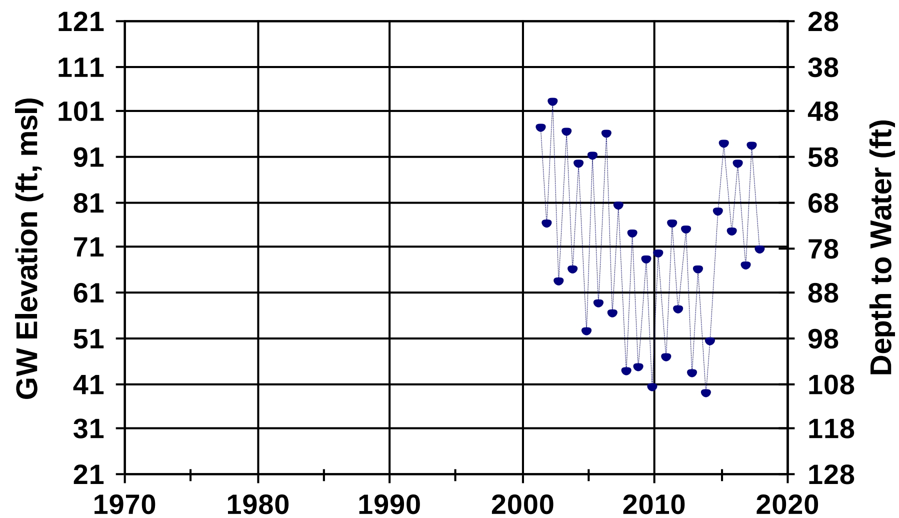
WellID: NapaCounty-225 RPE: 311.75 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Calistoga Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/23/2017



WellID: L10002804480DW-1 RPE: 8.73 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/19/2017

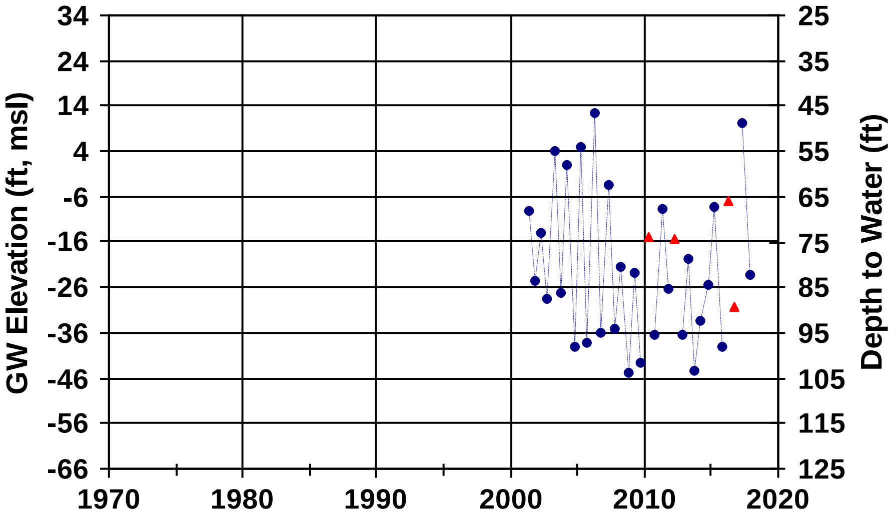


WellID: NapaCounty-118 RPE: 148.65 ft, msl SWN: 005N003W07B00_
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017

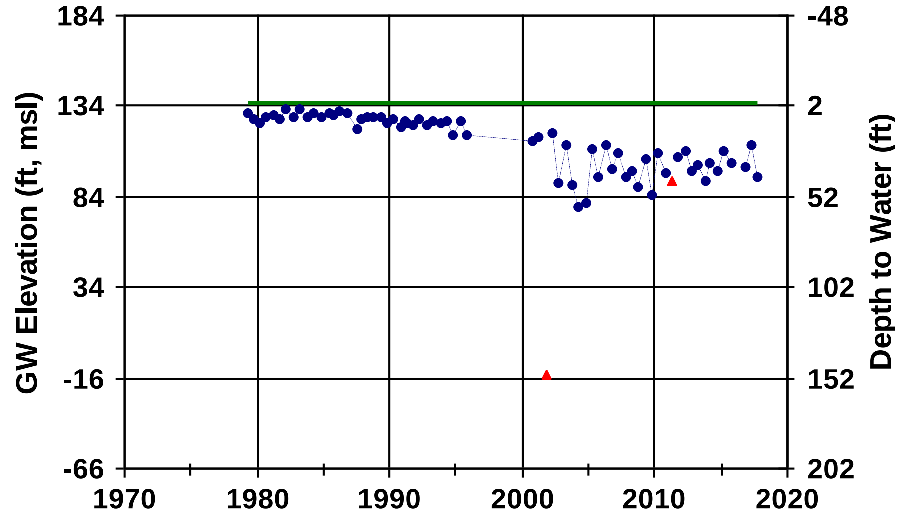


Measured Water Levels Questionable Measurements Reference Point Elevation

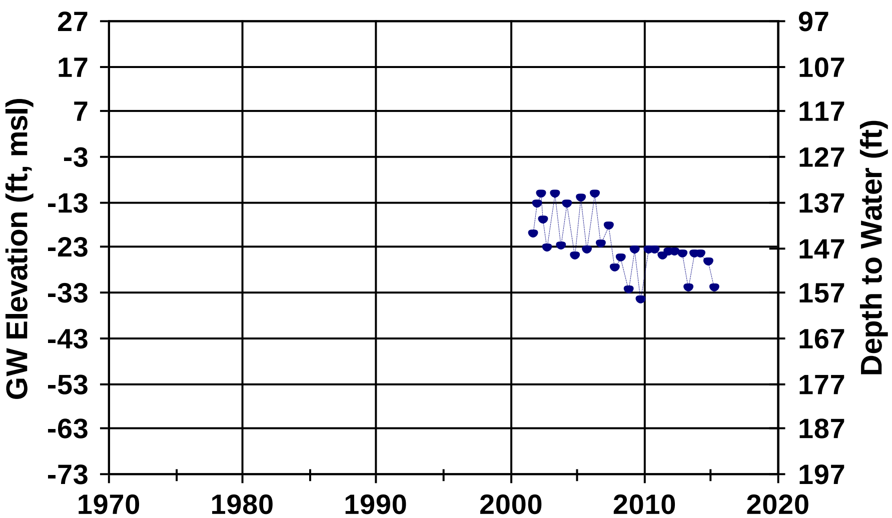
WellID: NapaCounty-122 RPE: 59.15 ft, msl SWN: 006N004W26L005
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/8/2017



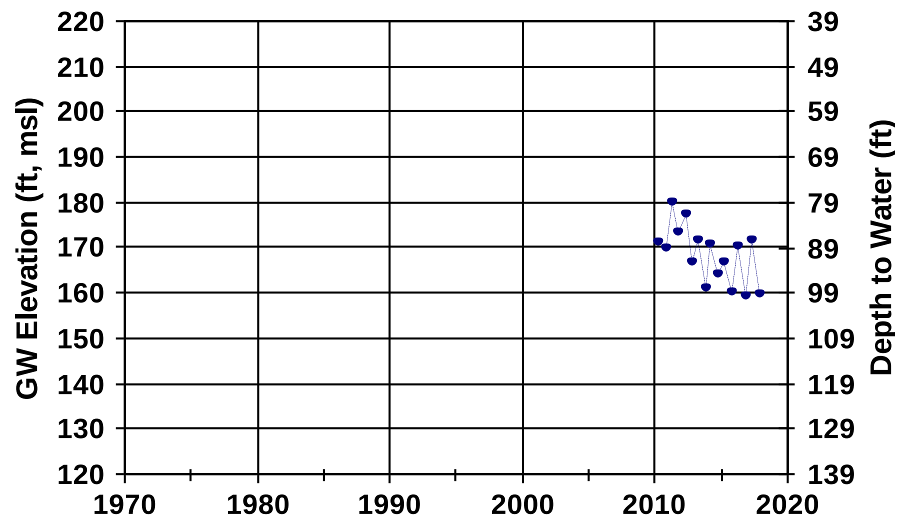
WellID: NapaCounty-137 RPE: 135.9 ft, msl SWN: 005N004W13H001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/27/2017



WellID: NapaCounty-142 RPE: 124.2 ft, msl SWN: 006N004W25G00_
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 3/11/2015

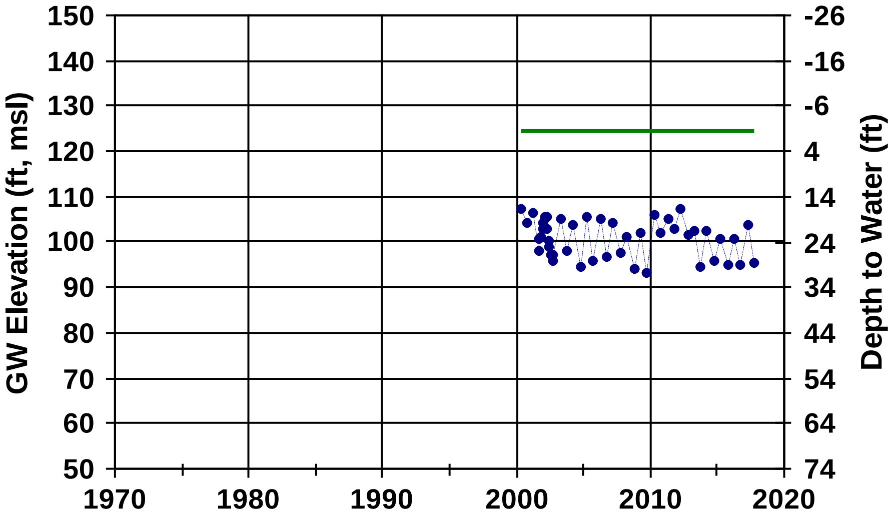


WellID: NapaCounty-149 RPE: 258.9 ft, msl SWN: 005N003W08E00_
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/30/2017

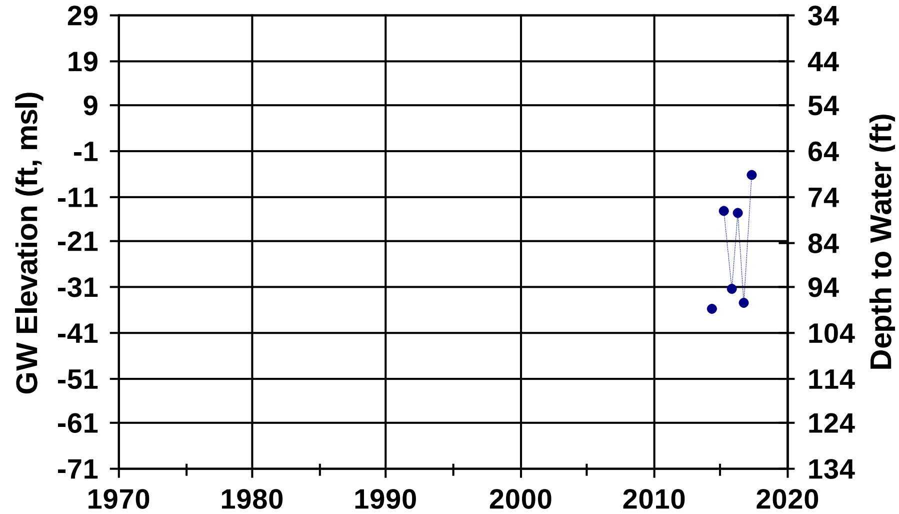


Measured Water Levels Questionable Measurements Reference Point Elevation

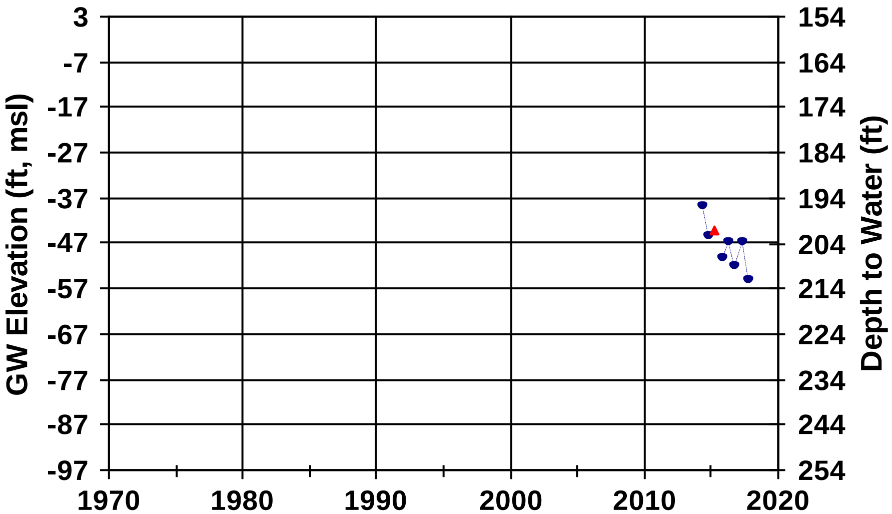
WellID: NapaCounty-18 RPE: 124.3 ft, msl SWN: 005N004W13G004
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/24/2017



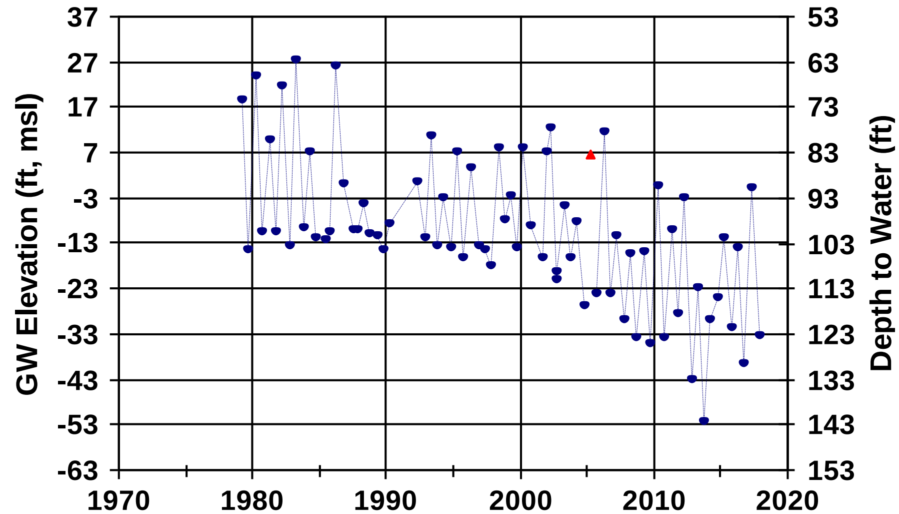
WellID: NapaCounty-191 RPE: 63.1 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 4/13/2017



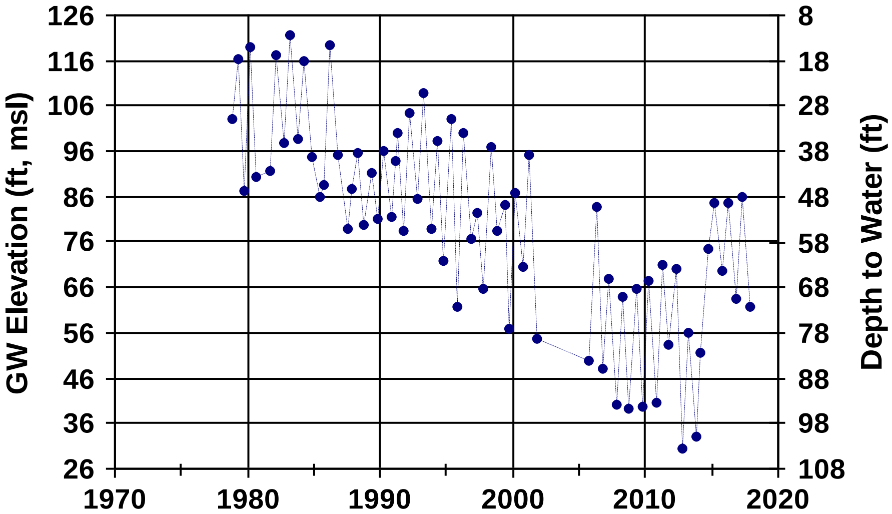
WellID: NapaCounty-192 RPE: 156.8 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017



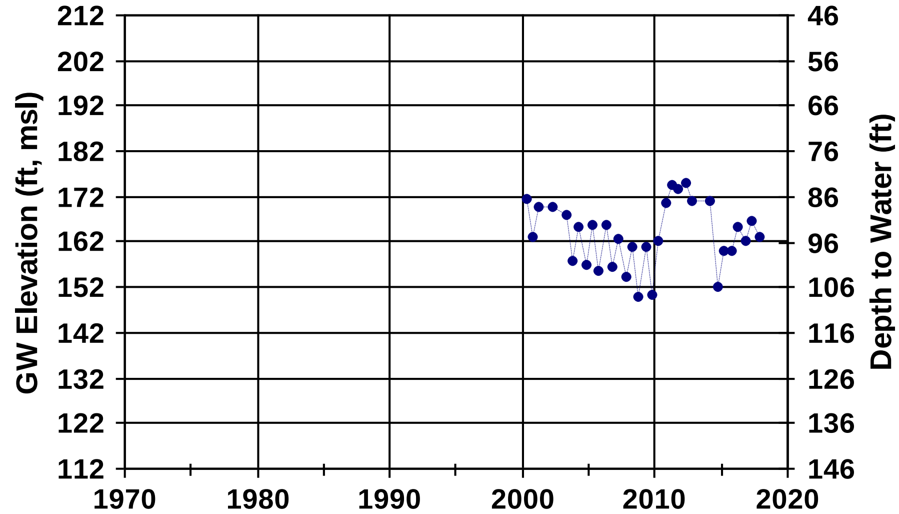
WellID: NapaCounty-2 RPE: 90.5 ft, msl SWN: 006N004W23J001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 11/8/2017



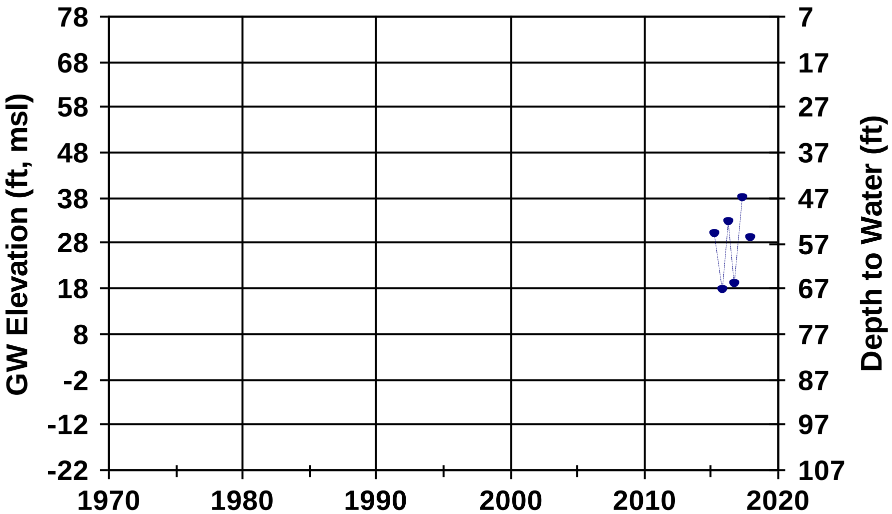
WellID: NapaCounty-20 RPE: 134.5 ft, msl SWN: 005N003W07C003
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone: Tsvd
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017



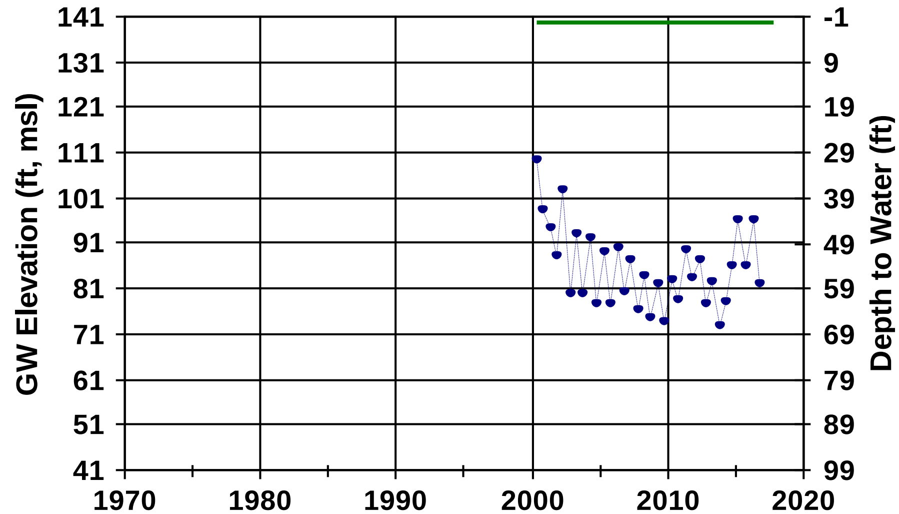
WellID: NapaCounty-22 RPE: 257.7 ft, msl SWN: 005N003W08E001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/30/2017



WellID: NapaCounty-226 RPE: 84.9 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 12/19/2017

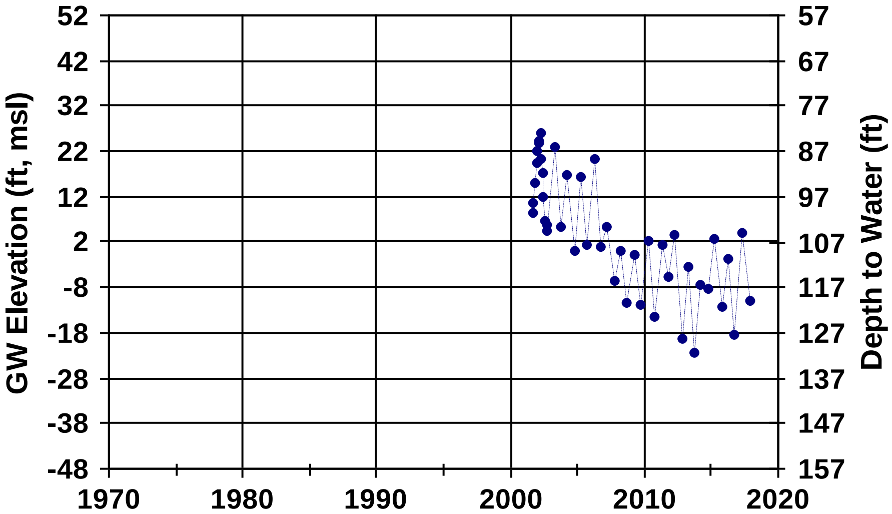


WellID: NapaCounty-35 RPE: 139.6 ft, msl SWN: 005N003W18D001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/11/2016

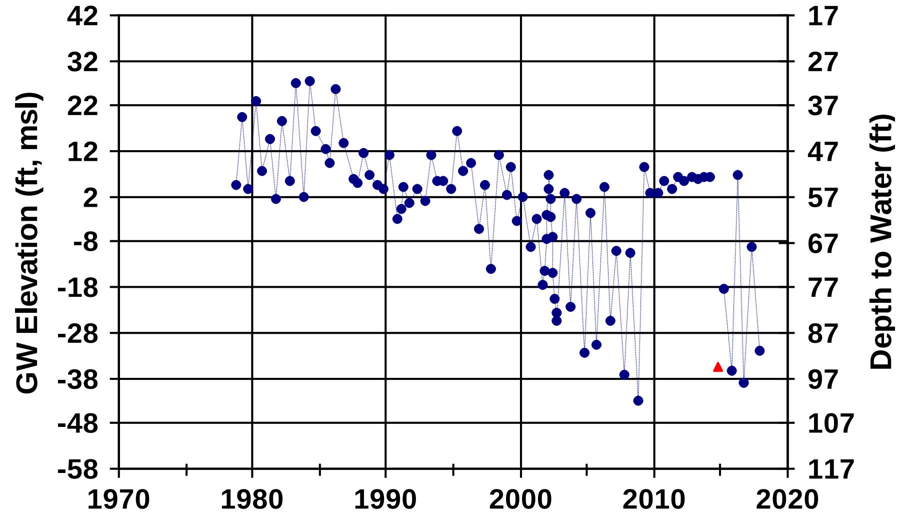


Measured Water Levels Questionable Measurements Reference Point Elevation

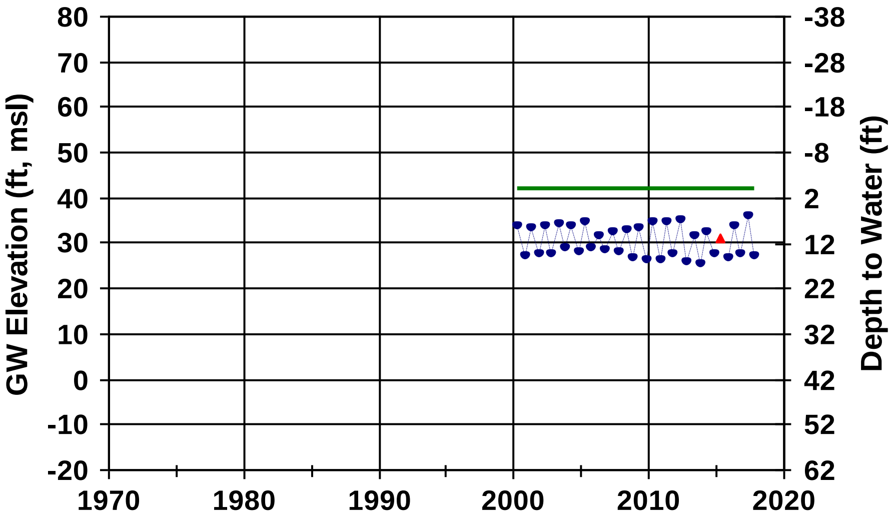
WellID: NapaCounty-43 RPE: 109 ft, msl SWN: 006N004W23Q003
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/8/2017



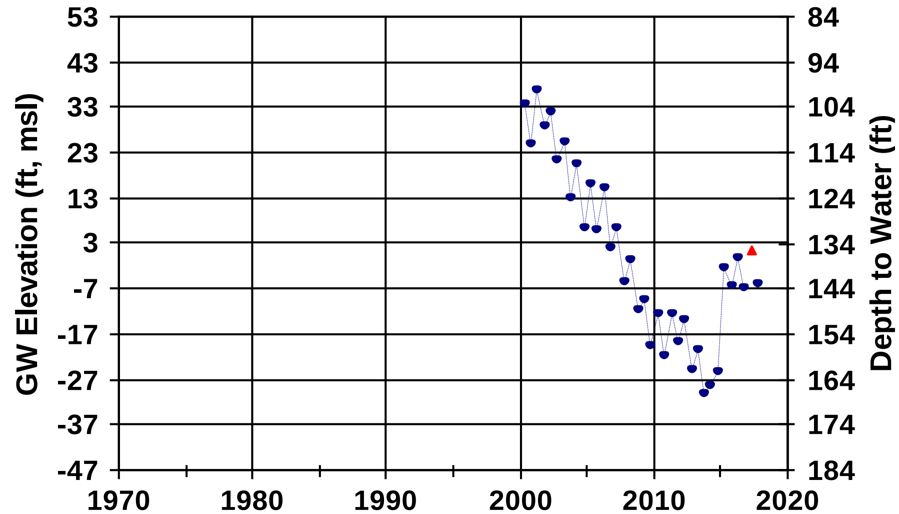
WellID: NapaCounty-56 RPE: 58.6 ft, msl SWN: 006N004W26G001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone: Tss/h
Groundwater Basin Not within a basin Last Msmt Date 11/8/2017



WellID: NapaCounty-69 RPE: 42.1 ft, msl SWN: 006N004W35G005
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 11/8/2017

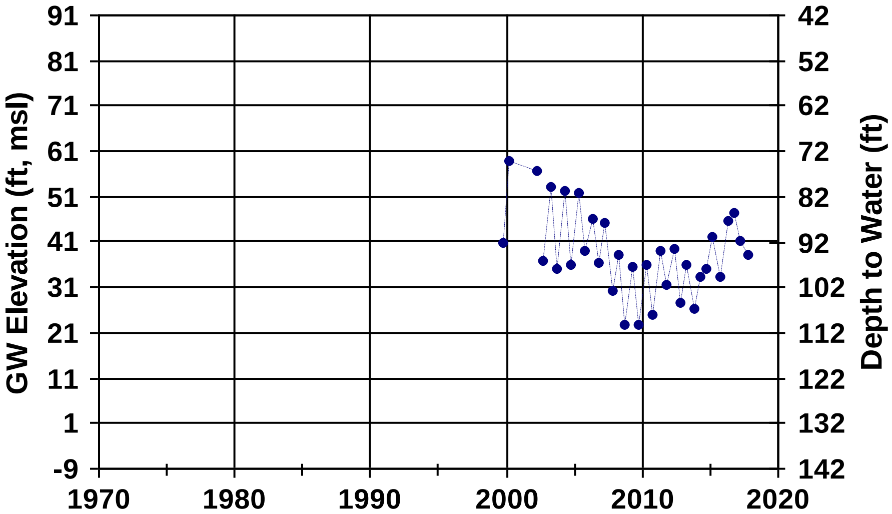


WellID: NapaCounty-72 RPE: 137.1 ft, msl SWN: 005N003W07D003
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017

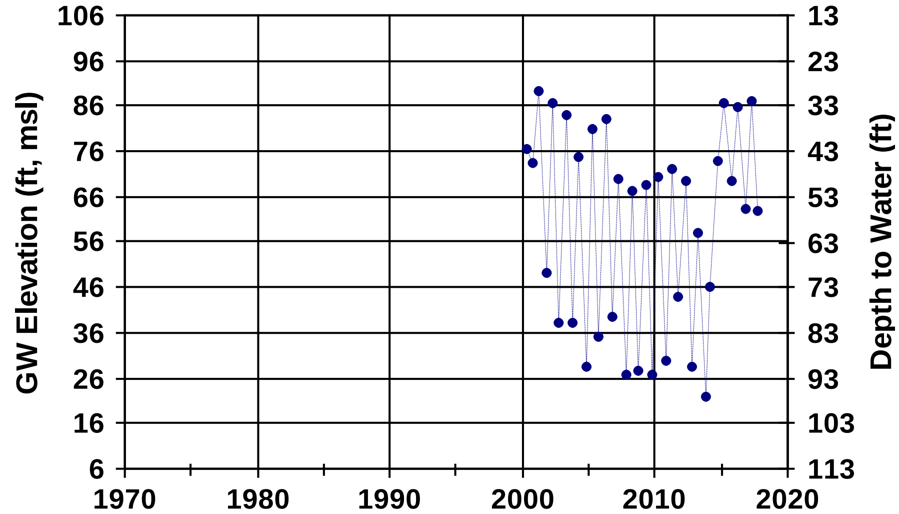


Measured Water Levels Questionable Measurements Reference Point Elevation

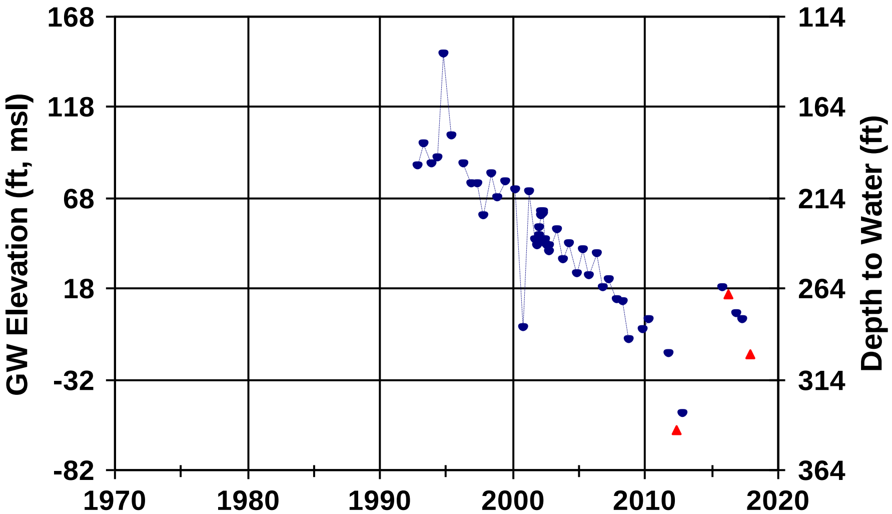
WellID: NapaCounty-74 RPE: 133.3 ft, msl SWN: 005N003W06M001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017



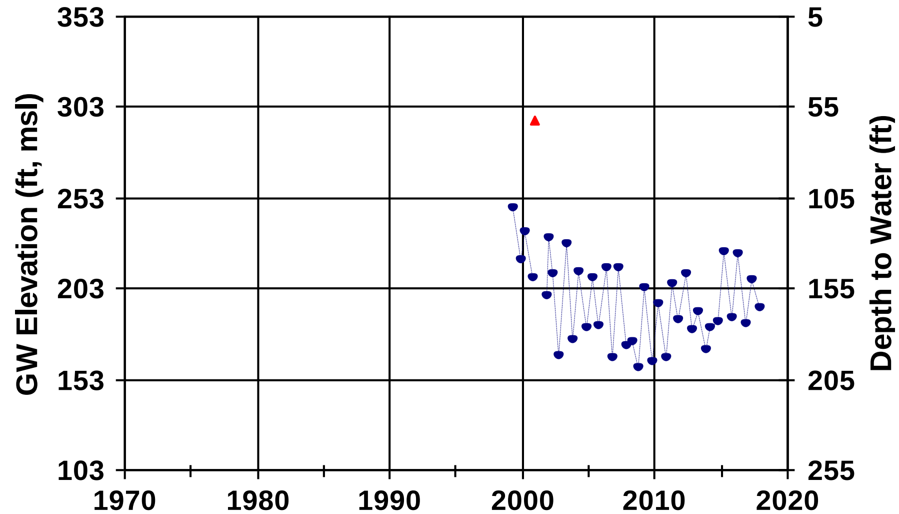
WellID: NapaCounty-81 RPE: 118.6 ft, msl SWN: 005N003W07F003
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/27/2017



WellID: NapaCounty-91 RPE: 281.9 ft, msl SWN: 005N003W06B002
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone: Tsvt
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017

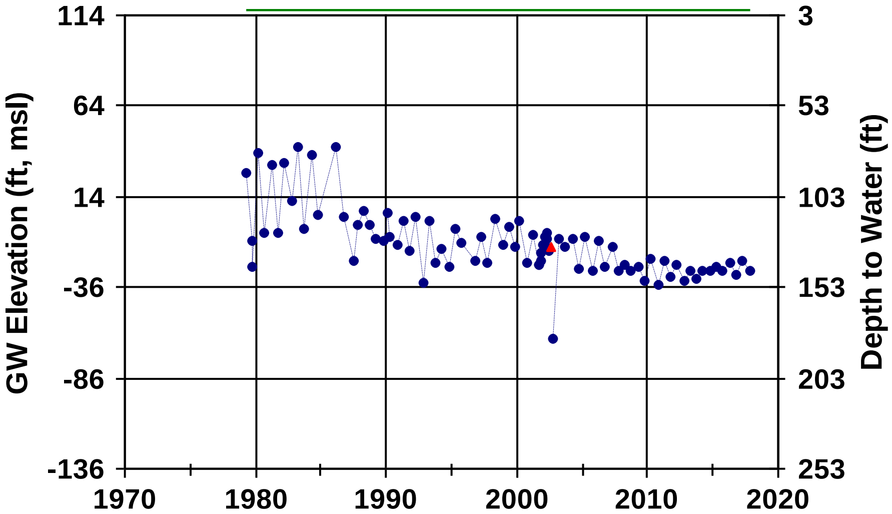


WellID: NapaCounty-92 RPE: 358.2 ft, msl SWN: 005N003W06A001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/30/2017

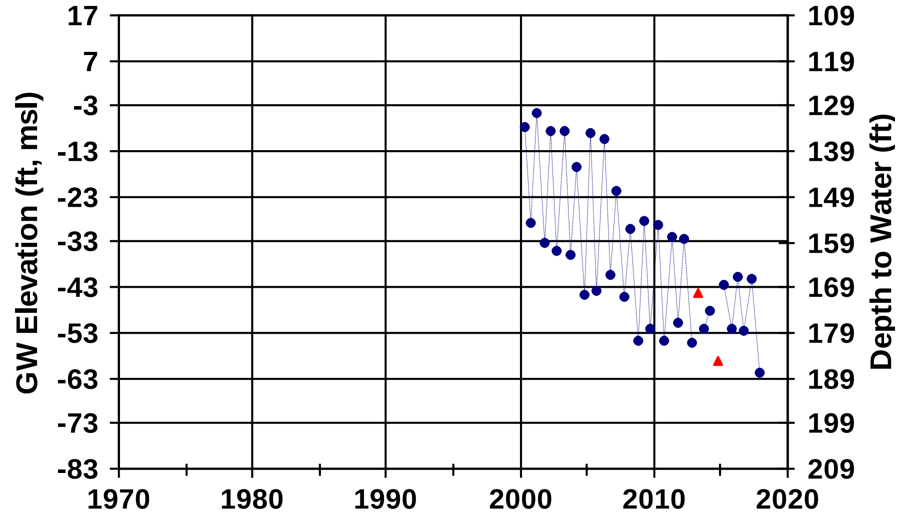


Measured Water Levels Questionable Measurements Reference Point Elevation

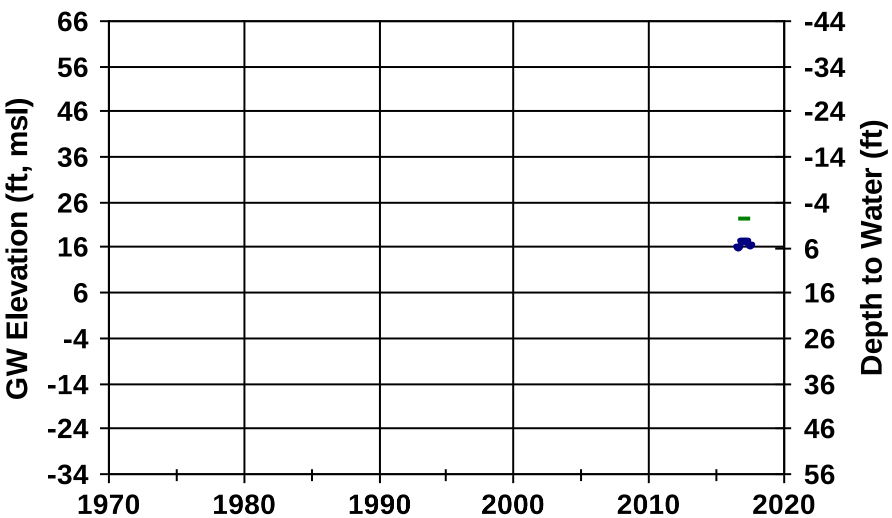
WellID: NapaCounty-95 RPE: 116.9 ft, msl SWN: 006N004W36G001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone: Tsvt
Groundwater Basin Not within a basin Last Msmt Date 11/8/2017



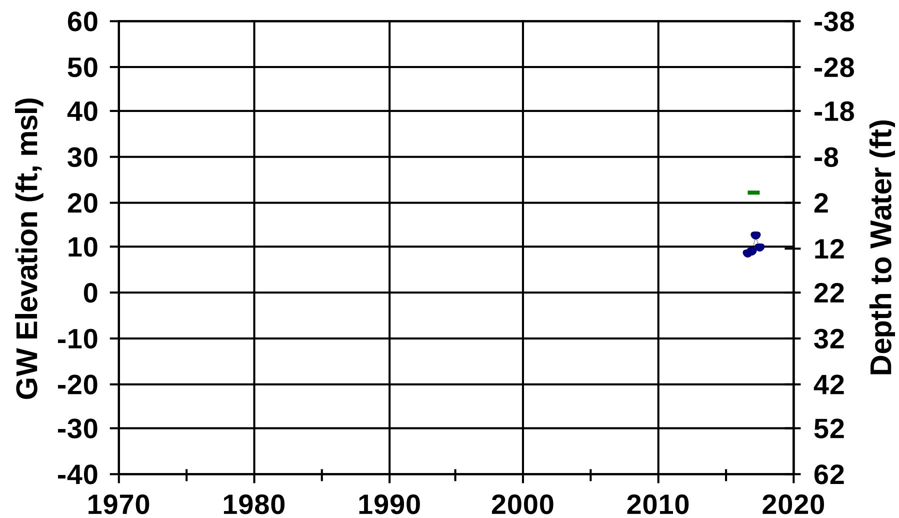
WellID: NapaCounty-98 RPE: 125.7 ft, msl SWN: 006N004W36A001
Subarea: Napa Valley Floor-MST Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 11/8/2017



WellID: T10000008932MW-1 RPE: 22.22 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/22/2017

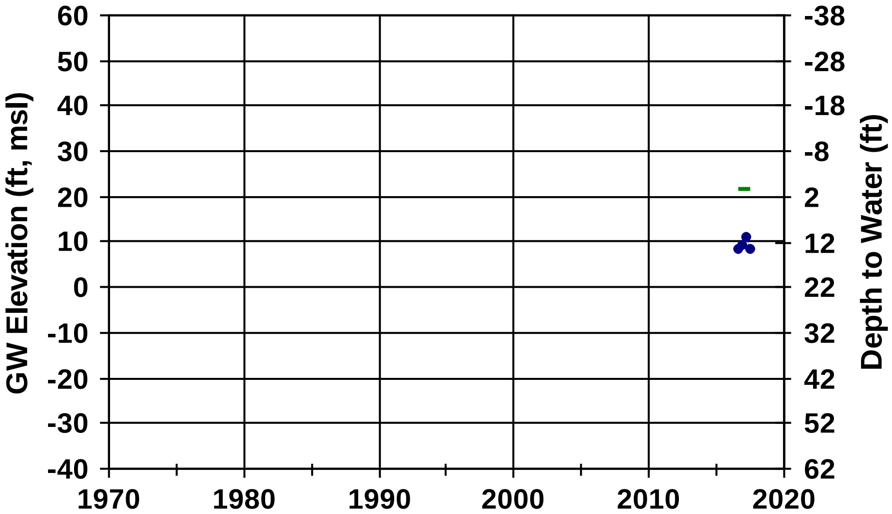


WellID: T10000008932MW-2 RPE: 22.3 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/22/2017

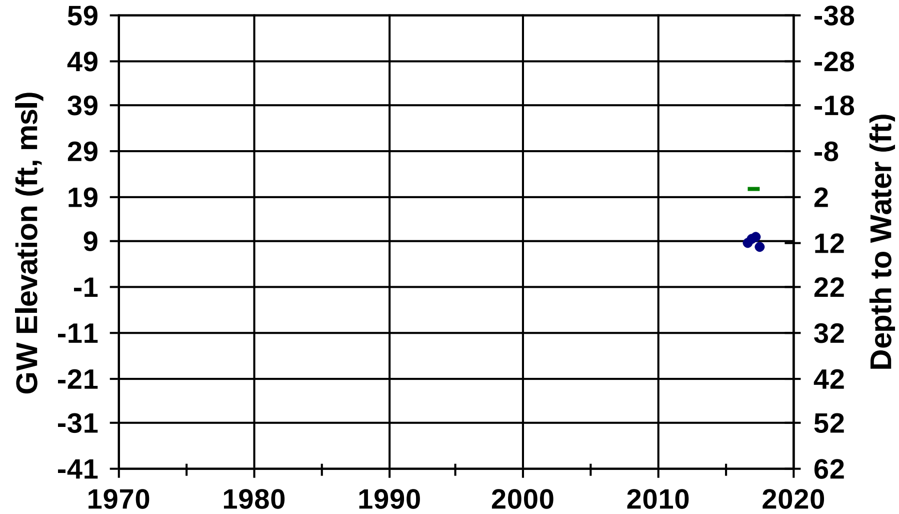


Measured Water Levels Questionable Measurements Reference Point Elevation

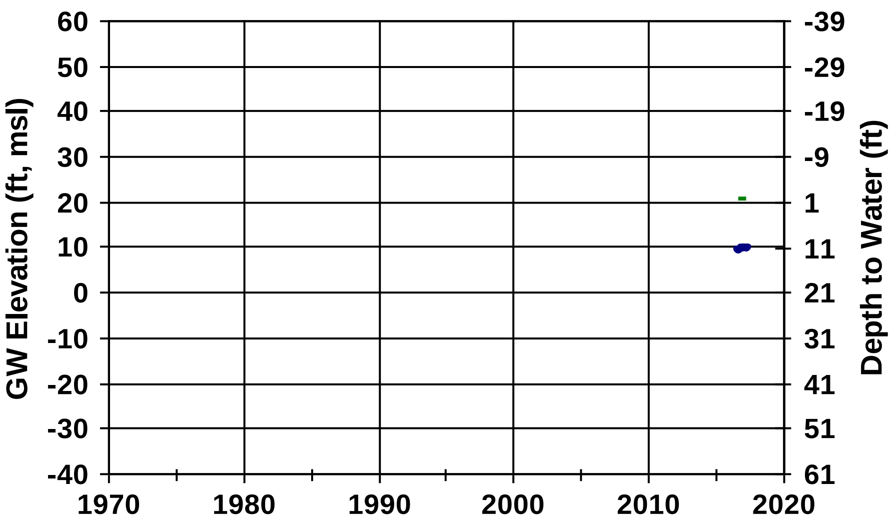
WellID: T10000008932MW-3 RPE: 21.76 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/22/2017



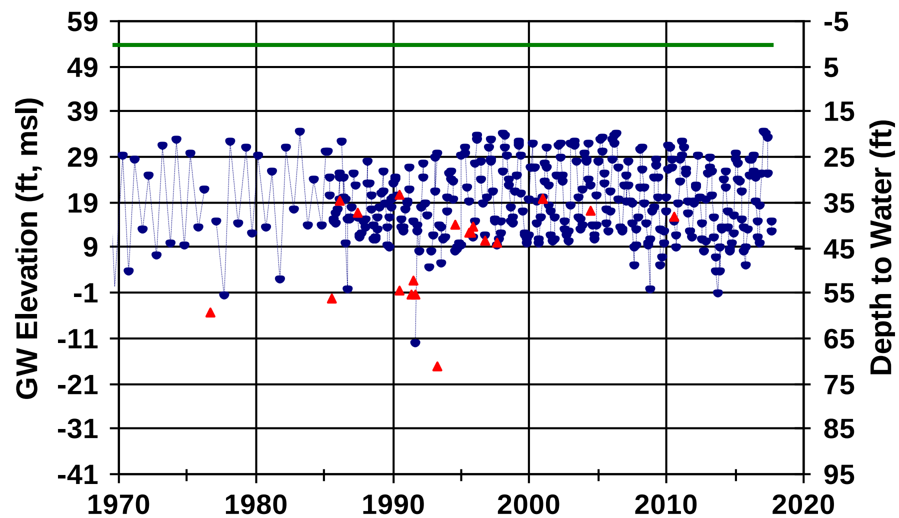
WellID: T10000008932MW-4 RPE: 20.56 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/22/2017



WellID: T10000008932MW-5 RPE: 20.63 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-MST Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/1/2017

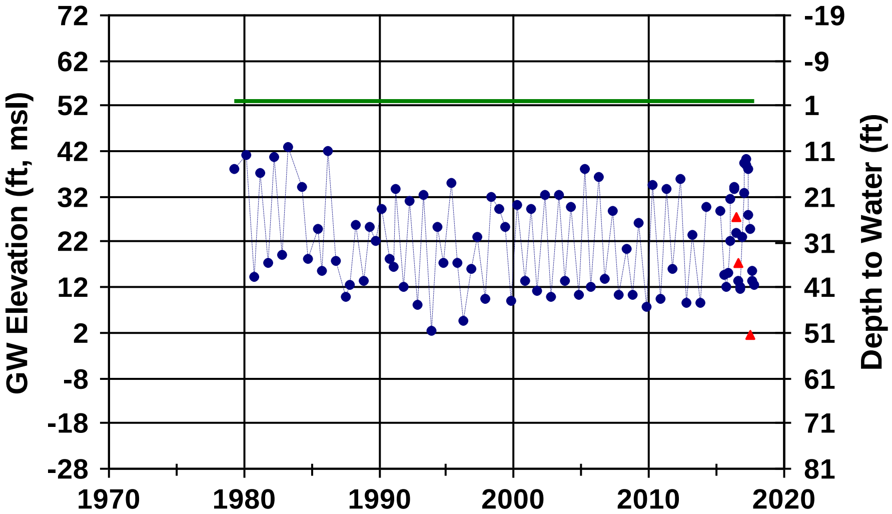


WellID: 06N04W27L002M RPE: 53.6 ft, msl SWN: 006N004W27L002
Subarea: Napa Valley Floor-Napa Source: DWR Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 9/25/2017

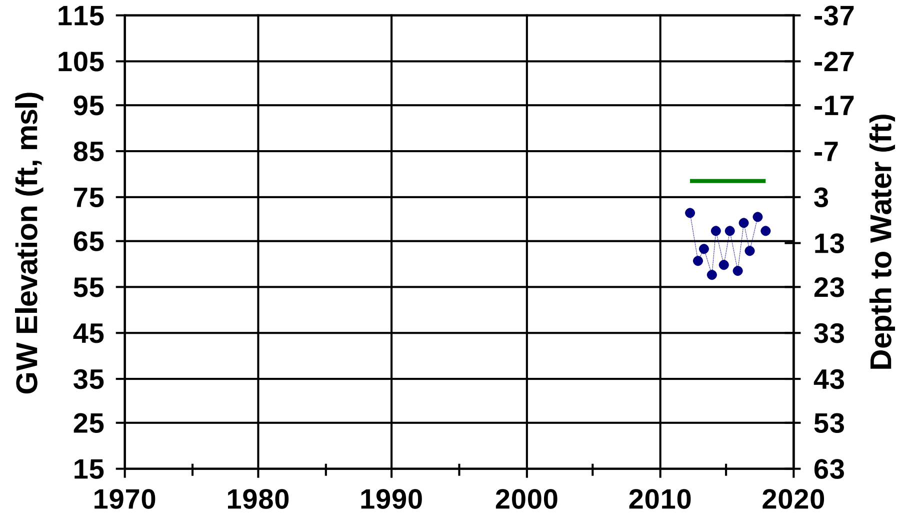


Measured Water Levels Questionable Measurements Reference Point Elevation

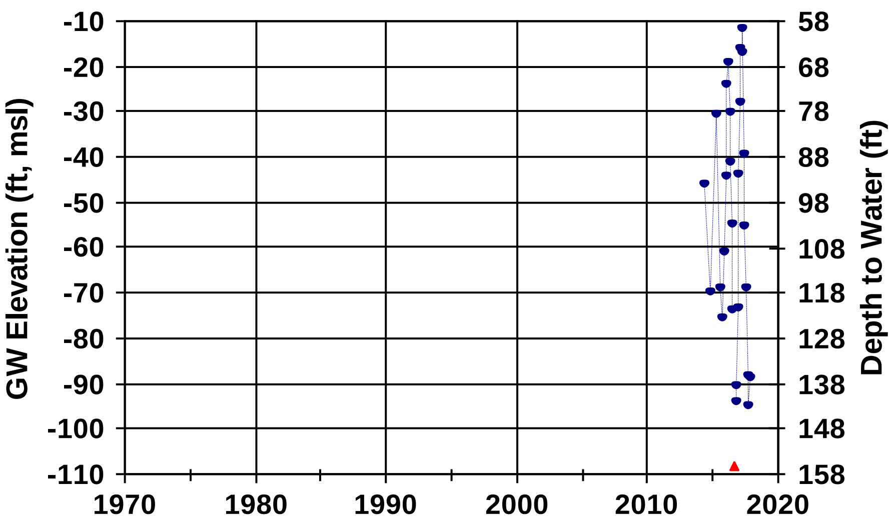
WellID: NapaCounty-136 RPE: 53.2 ft, msl SWN: 006N004W27N001
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017



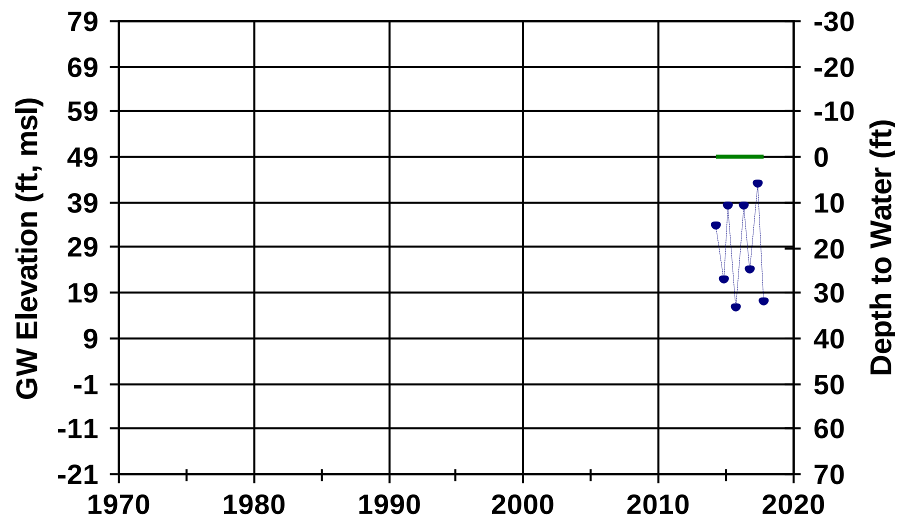
WellID: NapaCounty-152 RPE: 78.3 ft, msl SWN: 006N004W28Mx
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 12/19/2017



WellID: NapaCounty-182 RPE: 48.1 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Tsv
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

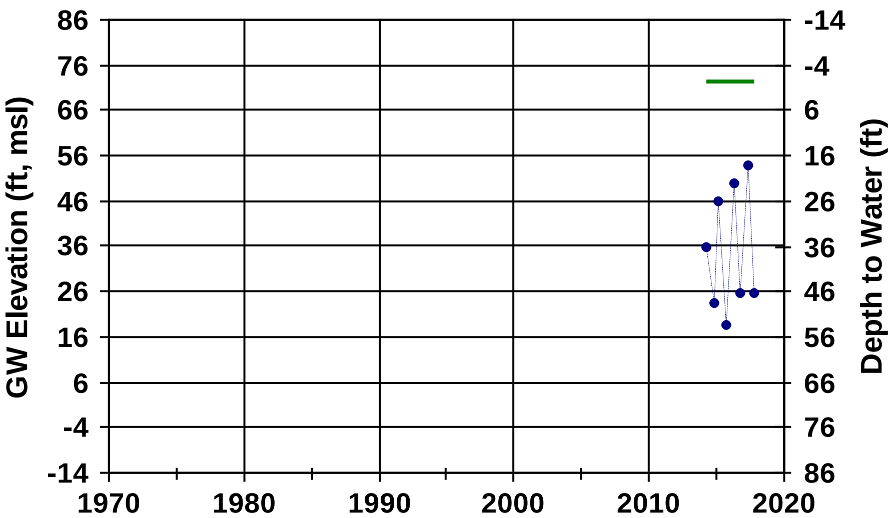


WellID: NapaCounty-183 RPE: 48.9 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa, Tsv?
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017

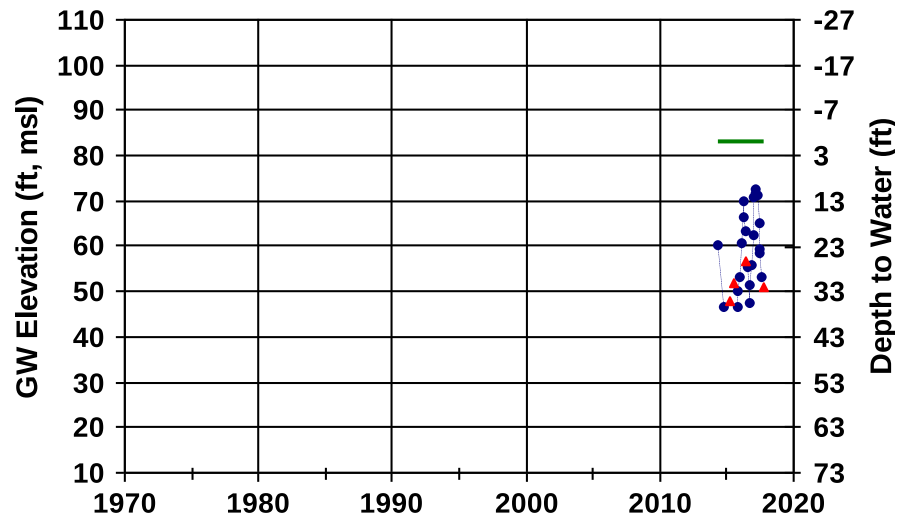


Measured Water Levels Questionable Measurements Reference Point Elevation

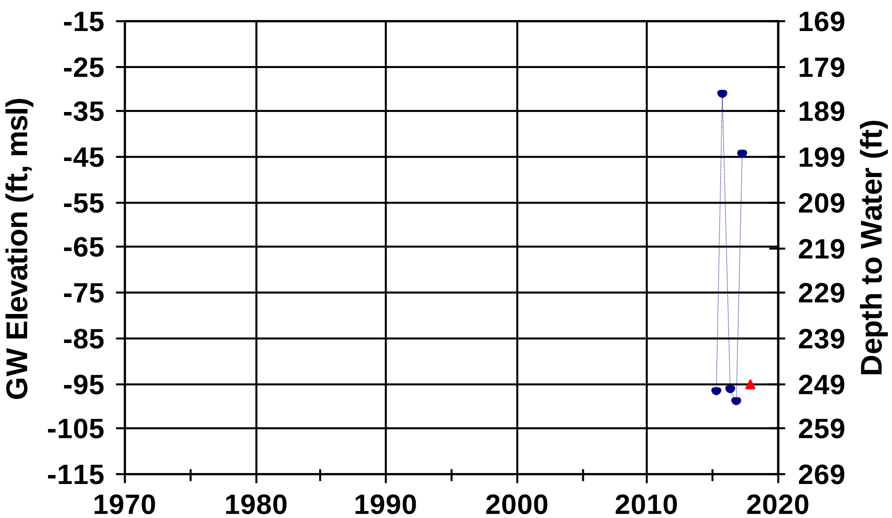
WellID: NapaCounty-184 RPE: 72.5 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Tsv, Tss/h?
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/27/2017



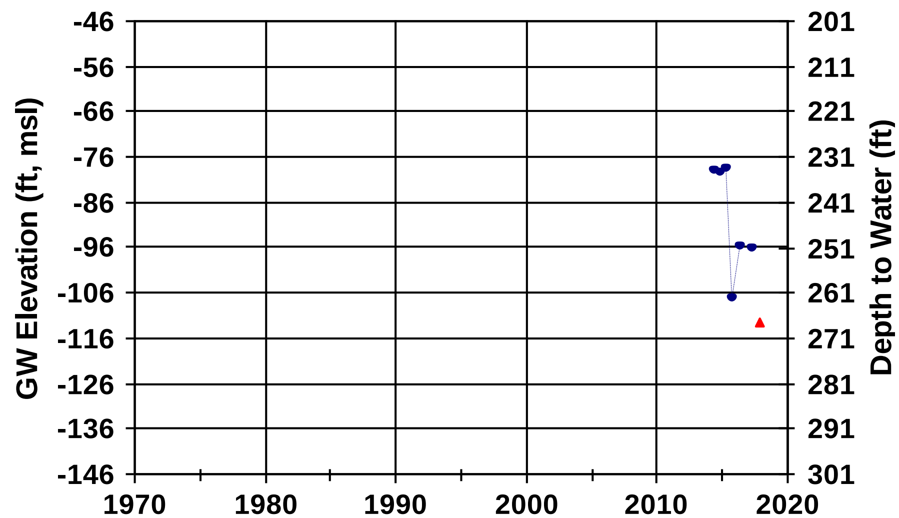
WellID: NapaCounty-185 RPE: 83 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 9/13/2017



WellID: NapaCounty-187 RPE: 153.5 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Tsv?, KJgv?
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

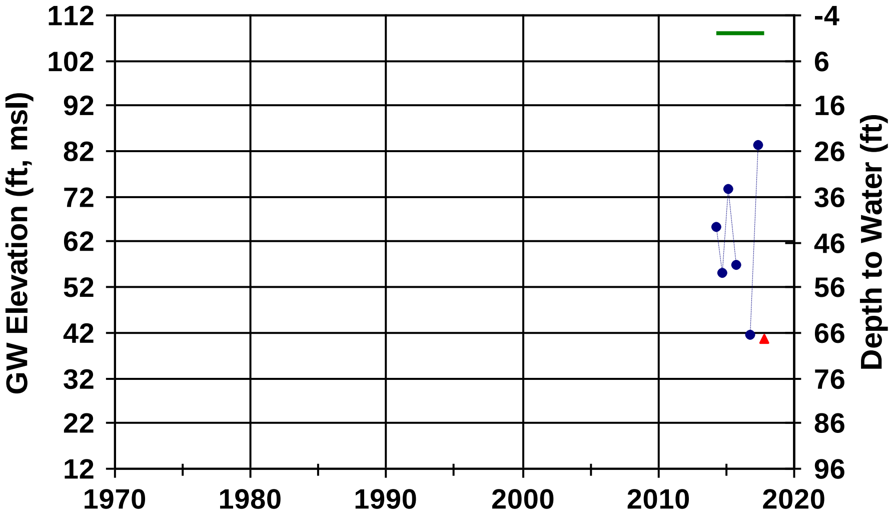


WellID: NapaCounty-188 RPE: 154.6 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Tsv, KJgv
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

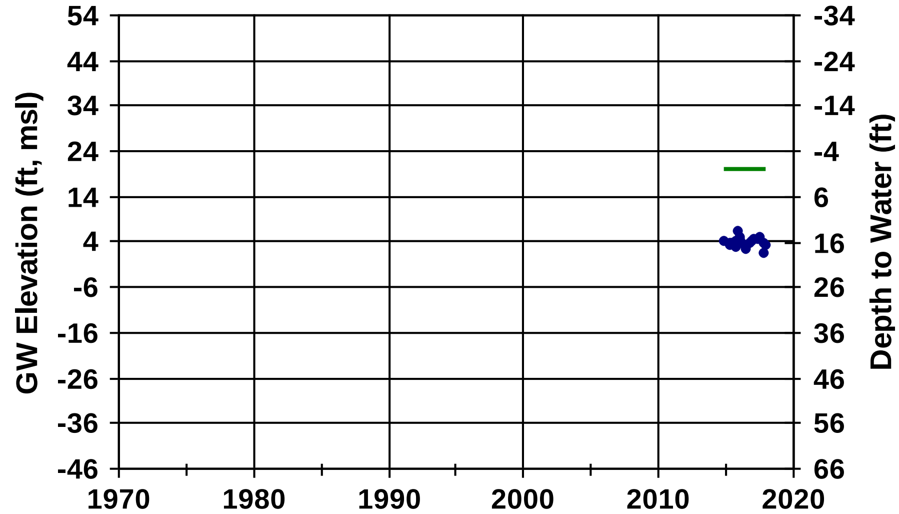


Measured Water Levels Questionable Measurements Reference Point Elevation

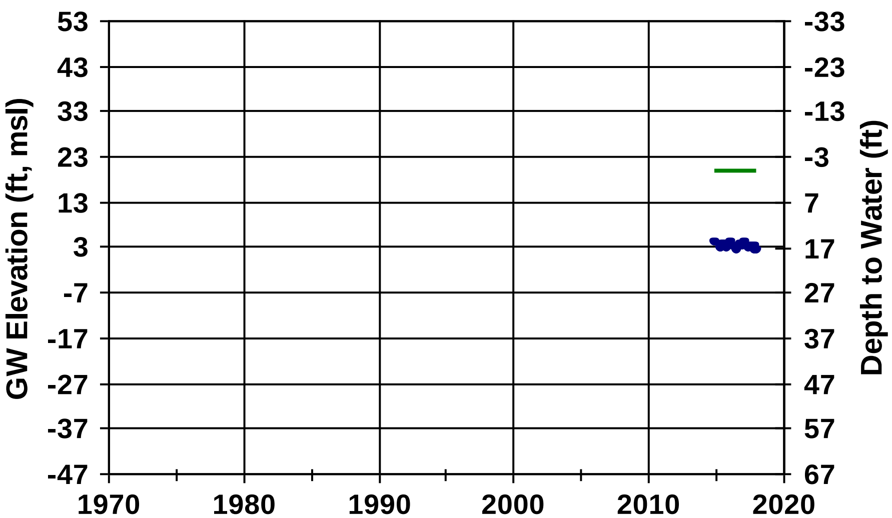
WellID: NapaCounty-189 RPE: 108.25 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/31/2017



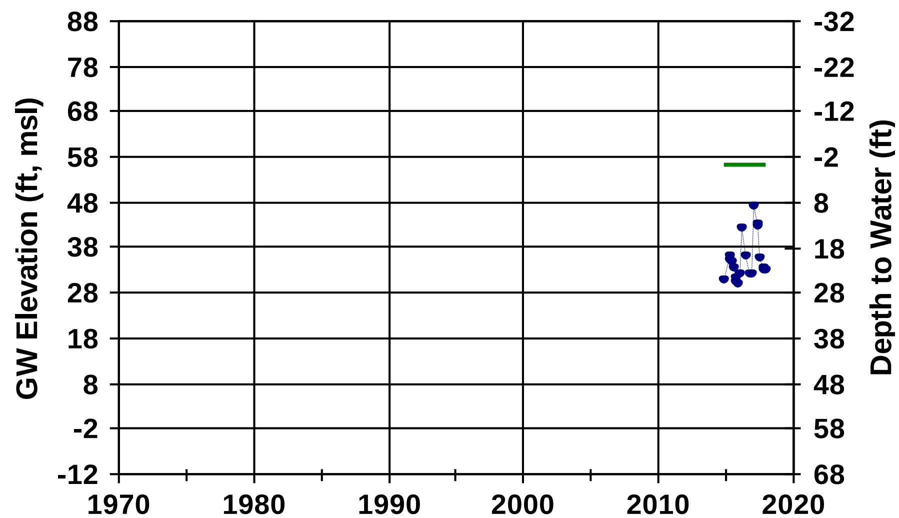
WellID: NapaCounty-214s-swgw1 RPE: 20.12 ft, msl SWN: 05N04W02N002M
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017



WellID: NapaCounty-215d-swgw1 RPE: 20.07 ft, msl SWN: 05N04W02N001M
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

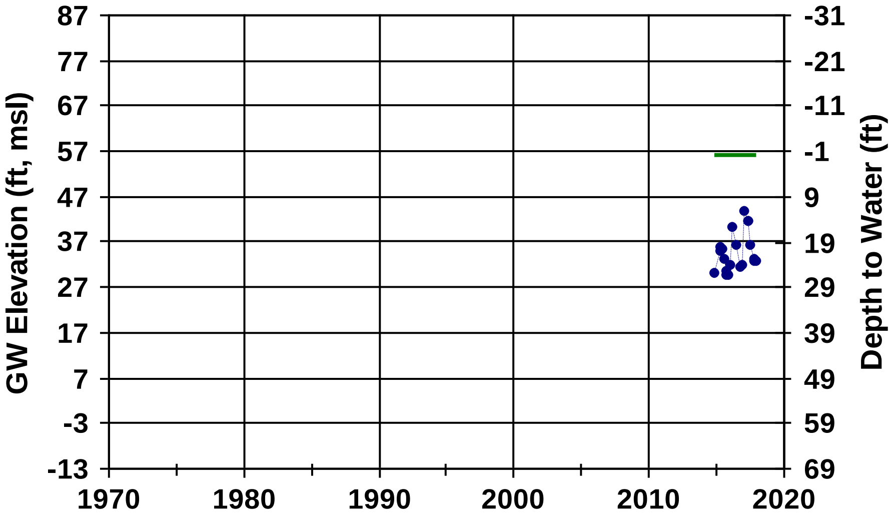


WellID: NapaCounty-218s-swgw3 RPE: 56.12 ft, msl SWN: 06N04W16G001M
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

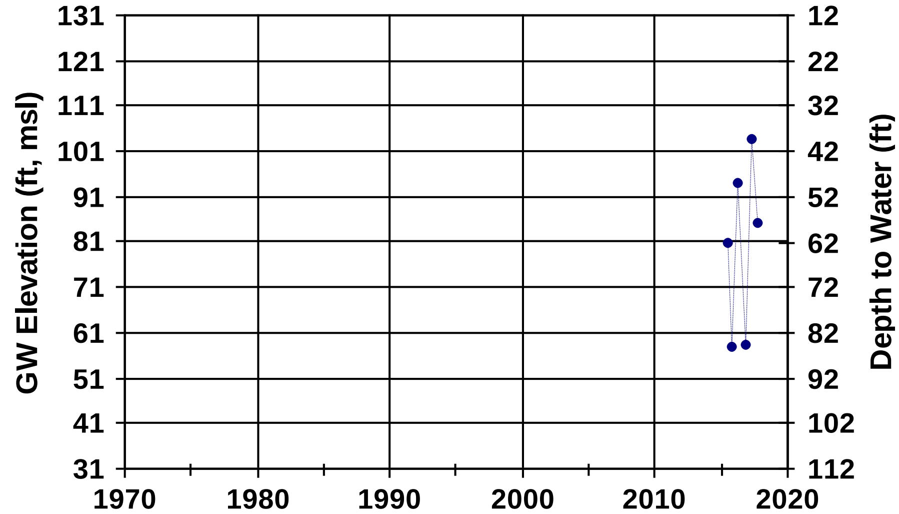


Measured Water Levels Questionable Measurements Reference Point Elevation

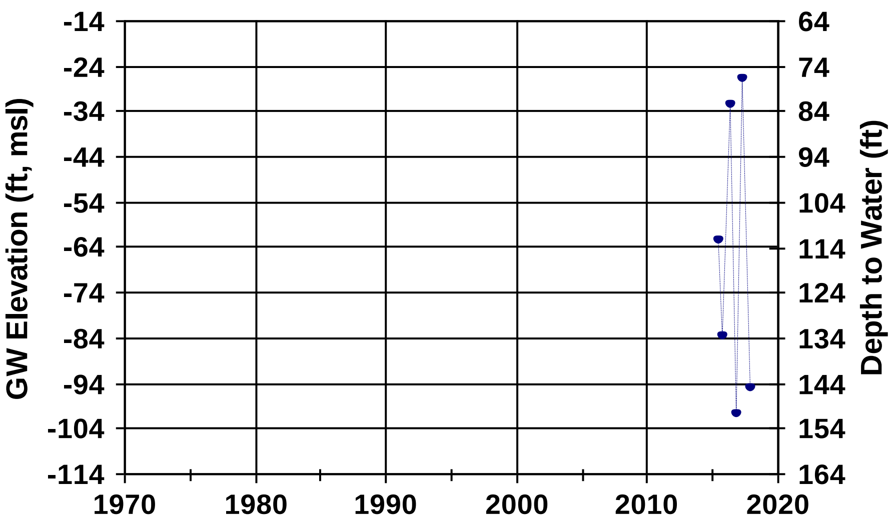
WellID: NapaCounty-219d-swgw3 RPE: 56.14 ft, msl SWN: 06N04W16G002M
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017



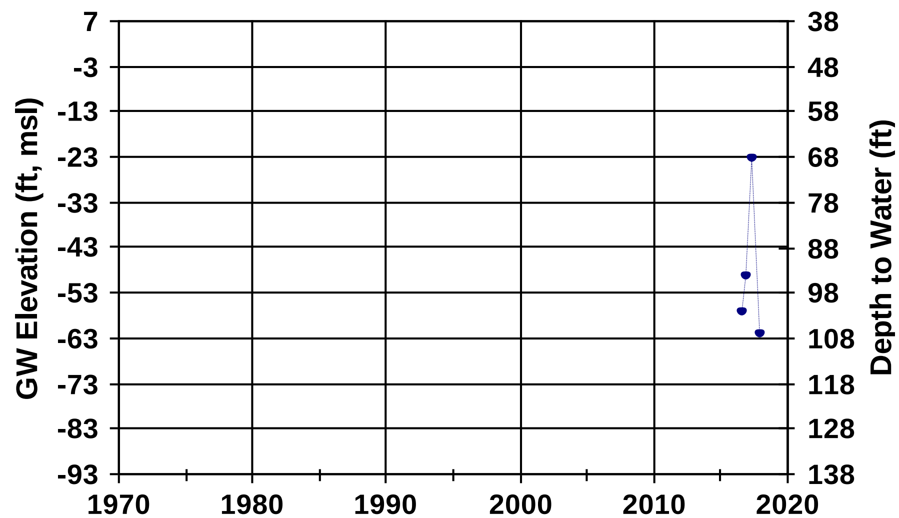
WellID: NapaCounty-227 RPE: 143.3 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



WellID: NapaCounty-228 RPE: 50.2 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

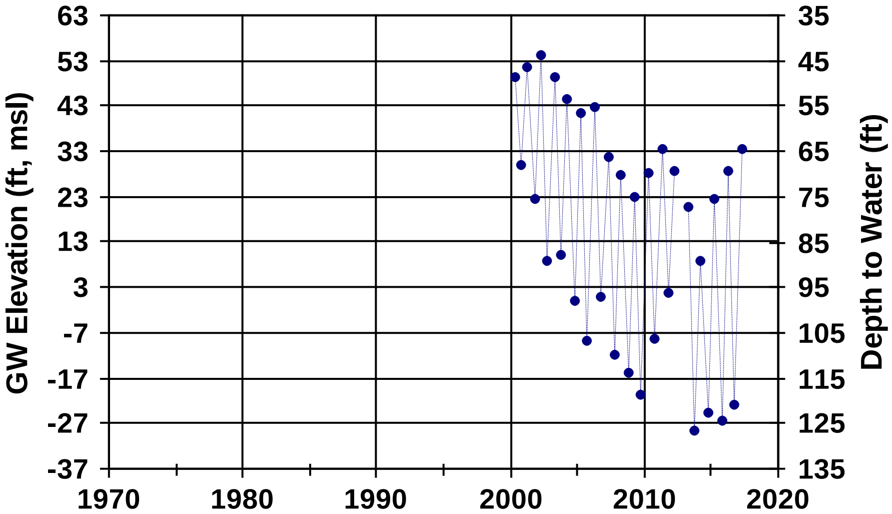


WellID: NapaCounty-229 RPE: 45.07 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/8/2017

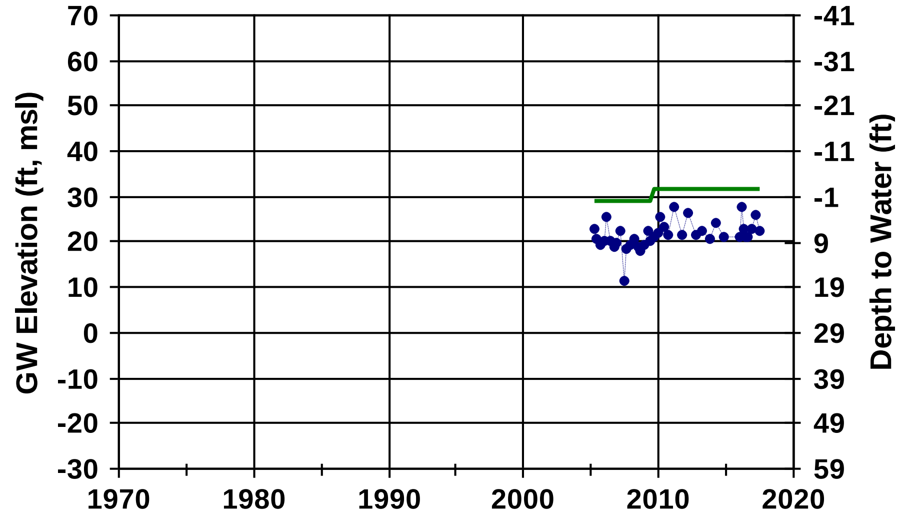


Measured Water Levels Questionable Measurements Reference Point Elevation

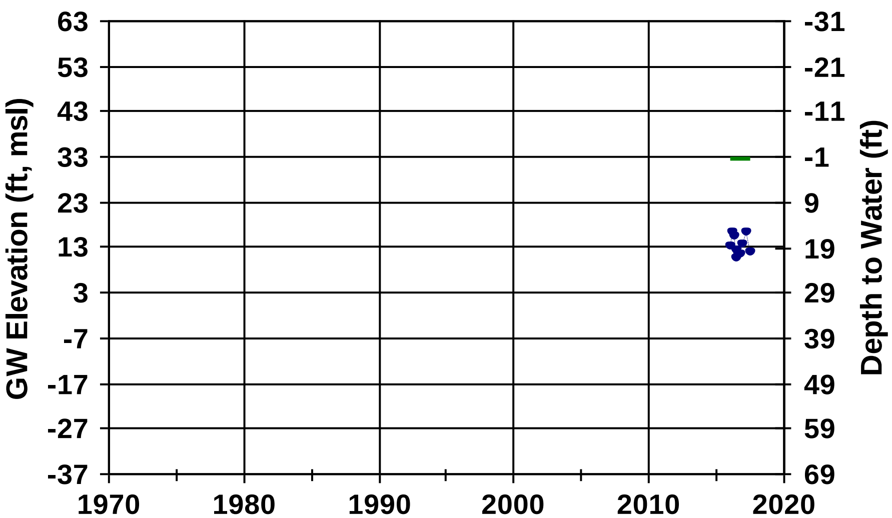
WellID: NapaCounty-76 RPE: 97.7 ft, msl SWN: 006N004W15R003
Subarea: Napa Valley Floor-Napa Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/20/2017



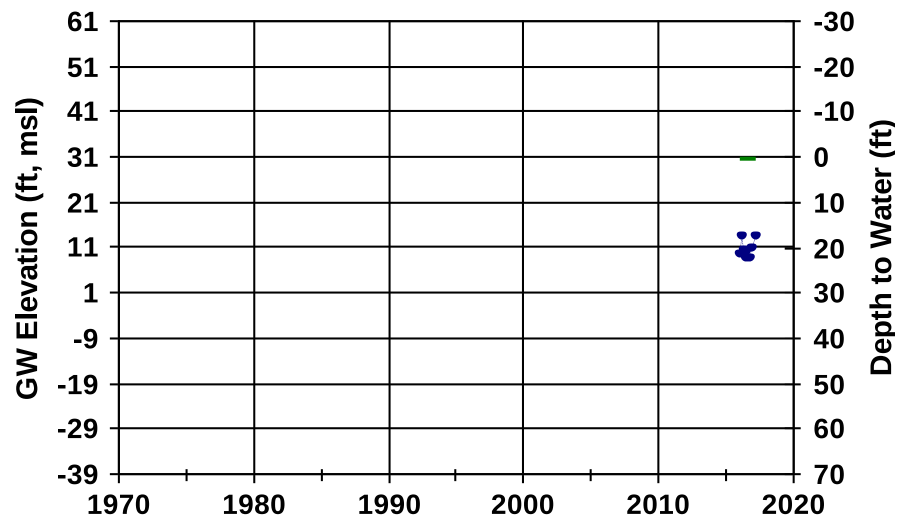
WellID: SL0605536682MW-1 RPE: 31.63 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



WellID: SL0605536682MW-10 RPE: 32.43 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017

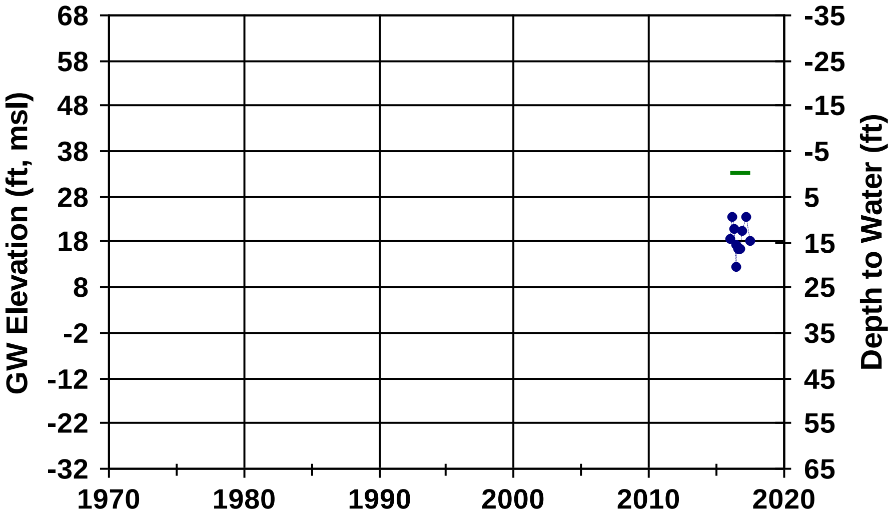


WellID: SL0605536682MW-11 RPE: 30.71 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/6/2017

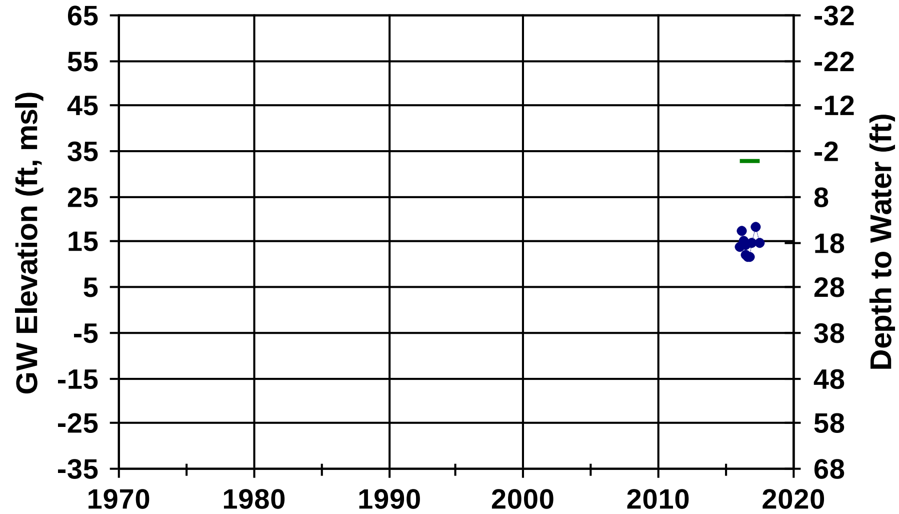


Measured Water Levels — Questionable Measurements — Reference Point Elevation

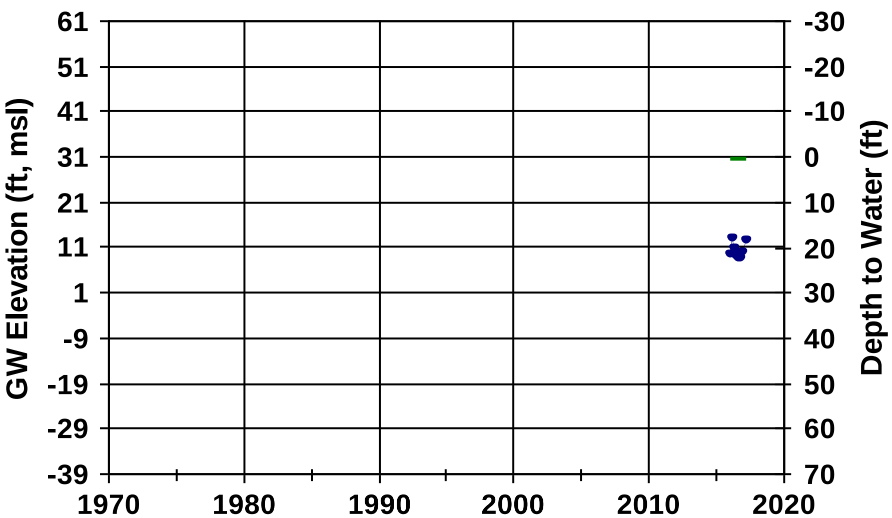
WellID: SL0605536682MW-12 RPE: 33.26 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



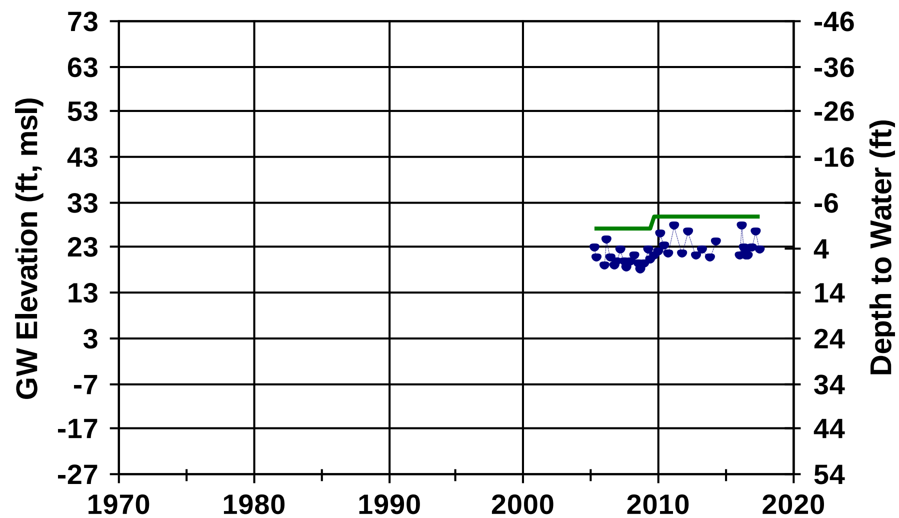
WellID: SL0605536682MW-13 RPE: 32.95 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



WellID: SL0605536682MW-14 RPE: 30.59 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/6/2017

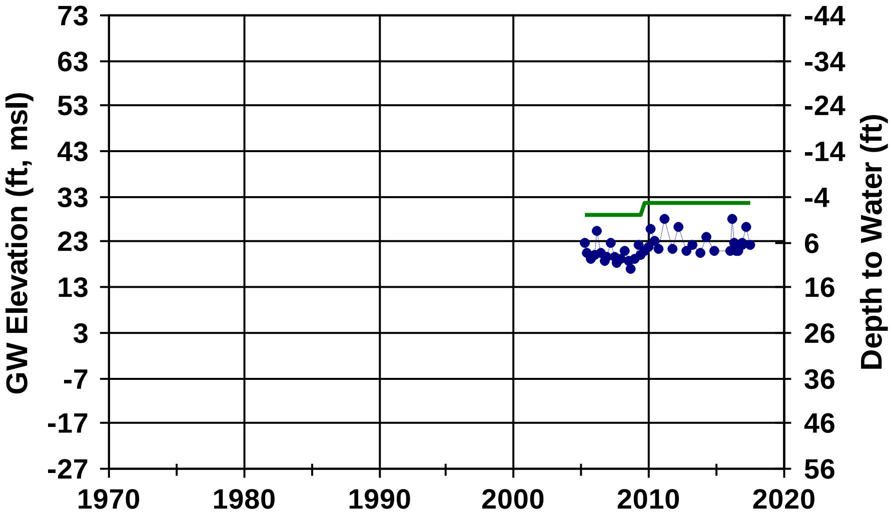


WellID: SL0605536682MW-2 RPE: 27.24 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/7/2017

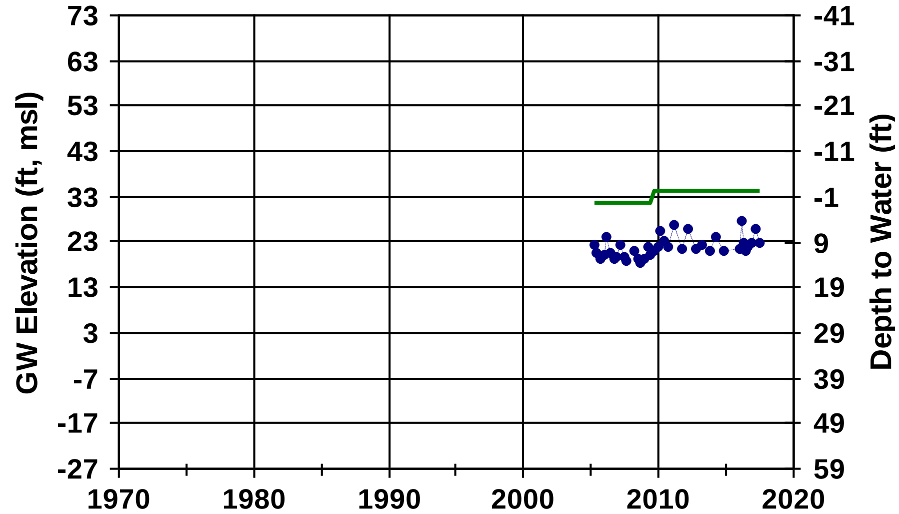


Measured Water Levels Questionable Measurements Reference Point Elevation

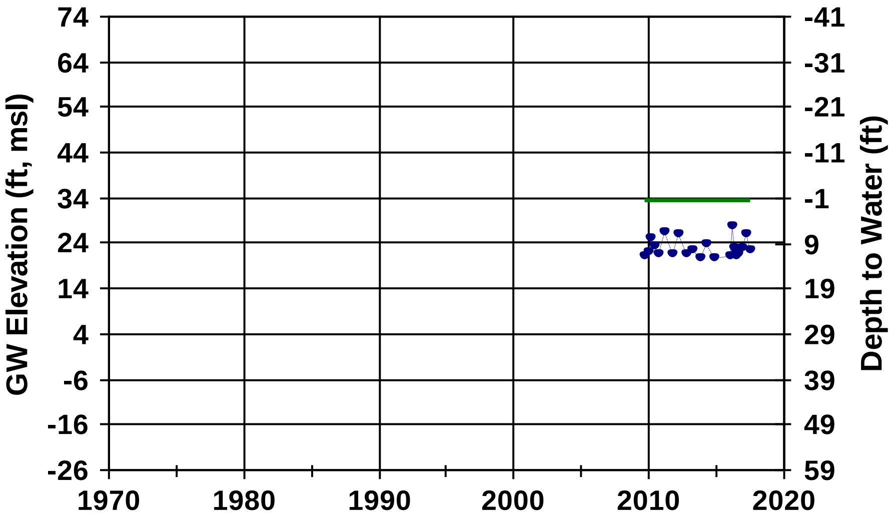
WellID: SL0605536682MW-3 RPE: 28.86 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



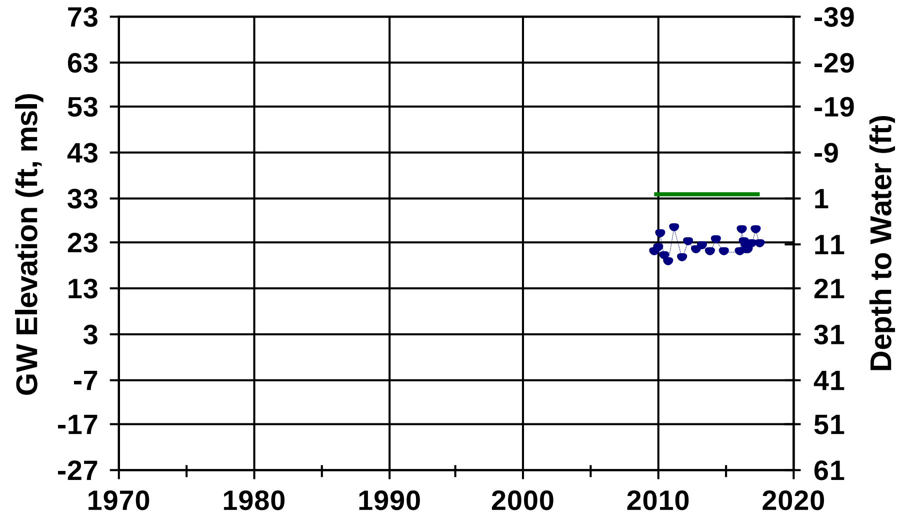
WellID: SL0605536682MW-4 RPE: 31.59 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



WellID: SL0605536682MW-5 RPE: 33.35 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017

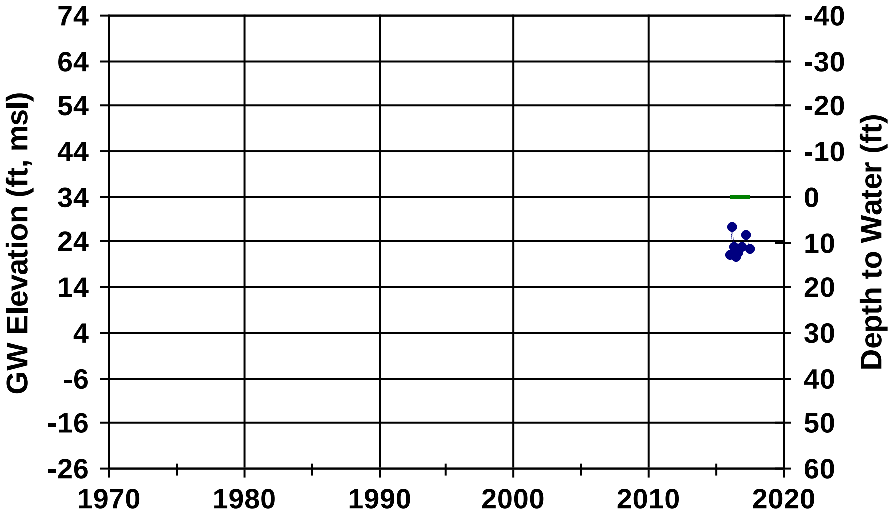


WellID: SL0605536682MW-6 RPE: 33.75 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017

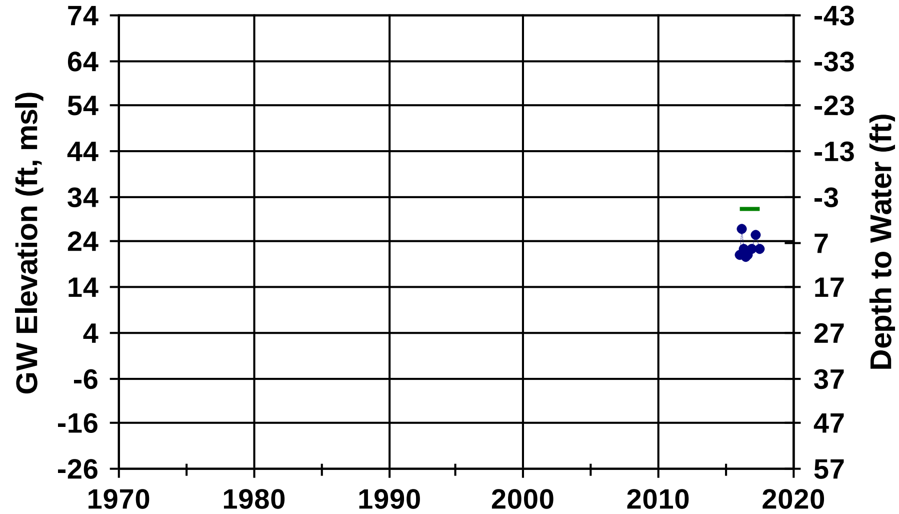


Measured Water Levels Questionable Measurements Reference Point Elevation

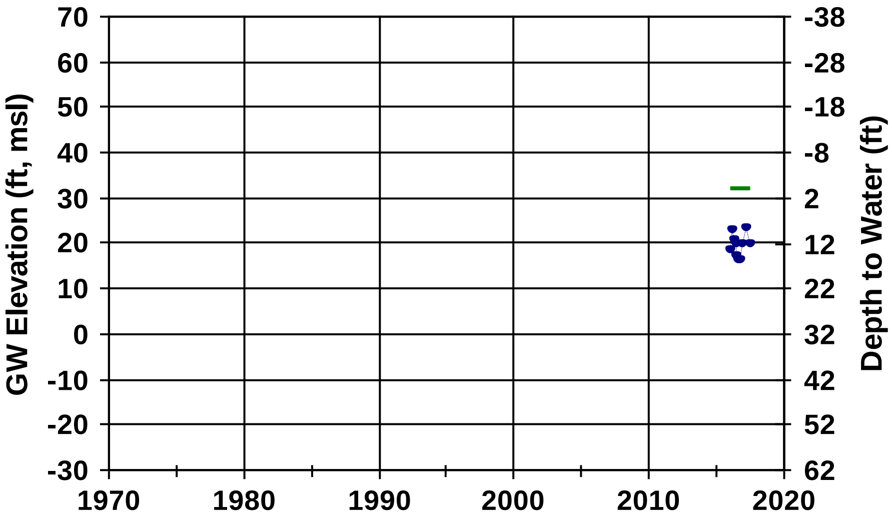
WellID: SL0605536682MW-7 RPE: 33.89 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



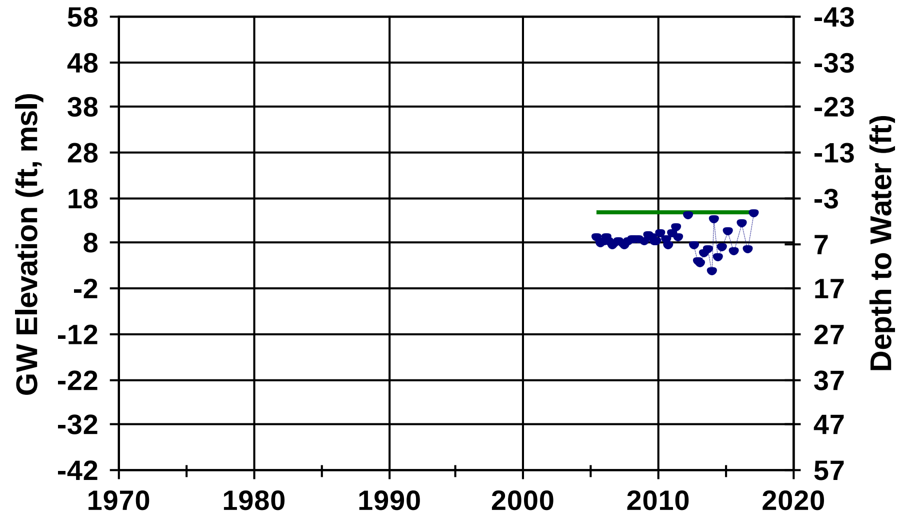
WellID: SL0605536682MW-8 RPE: 31.12 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017



WellID: SL0605536682MW-9 RPE: 32.24 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 6/6/2017

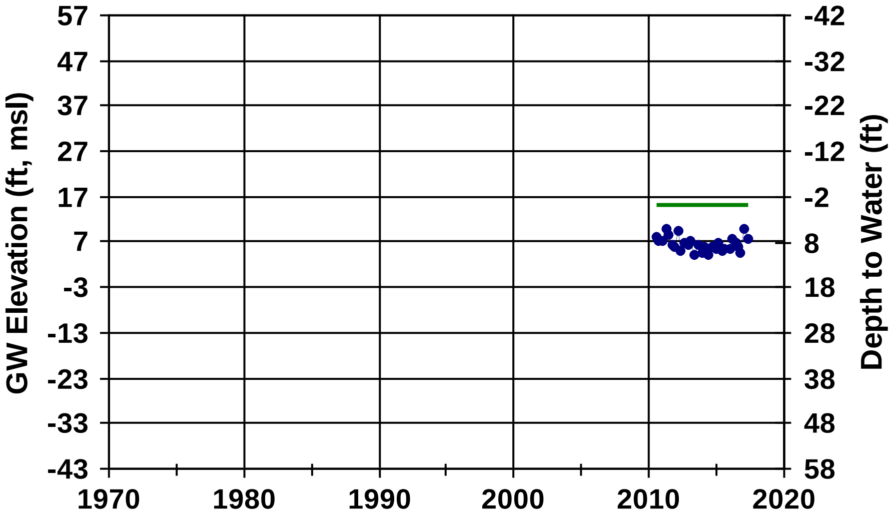


WellID: T0605514064MW1 RPE: 14.72 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

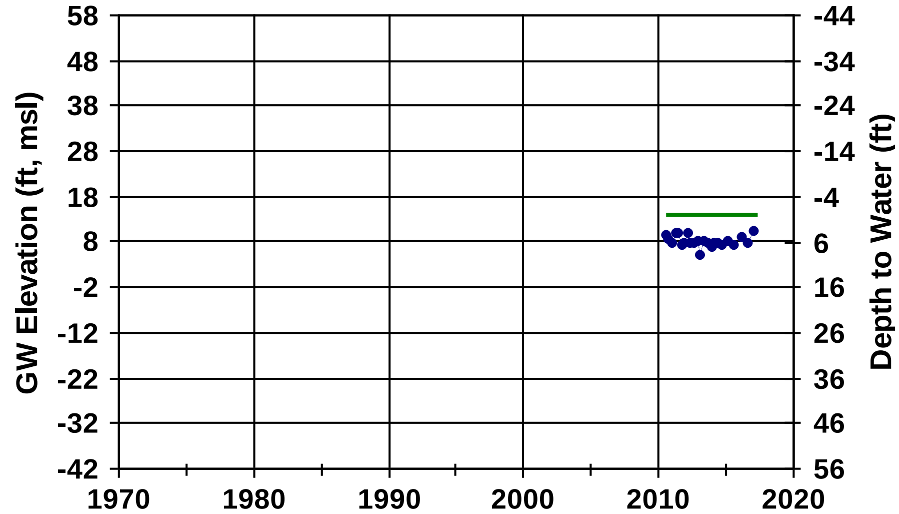


Measured Water Levels Questionable Measurements Reference Point Elevation

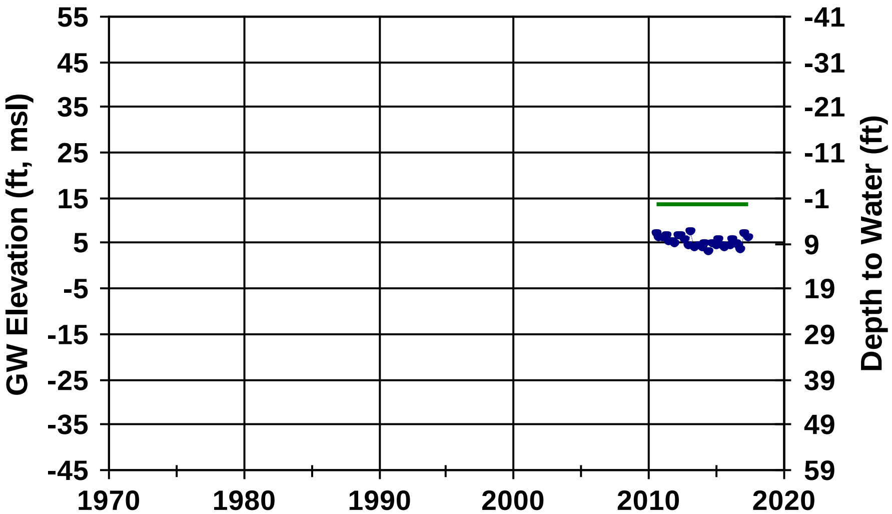
WellID: **T0605514064MW10** RPE: 15.18 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017



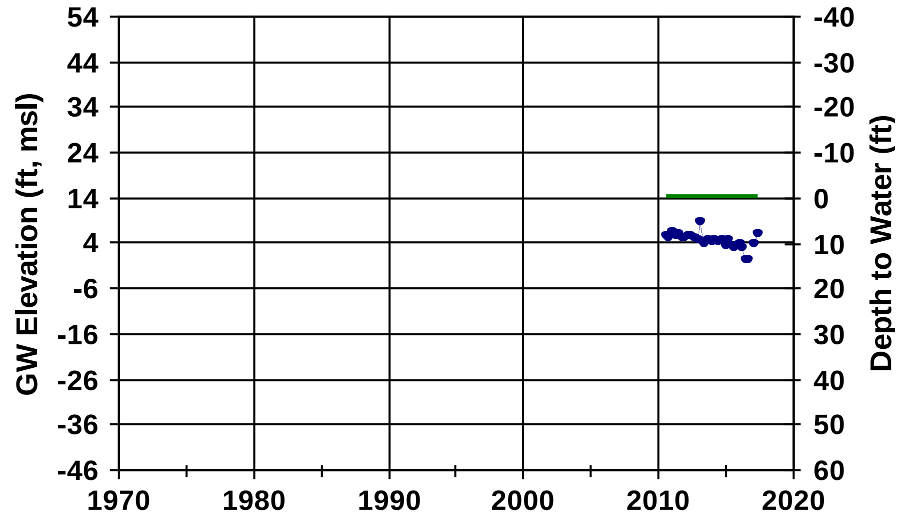
WellID: **T0605514064MW11** RPE: 13.82 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: **T0605514064MW12** RPE: 13.71 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

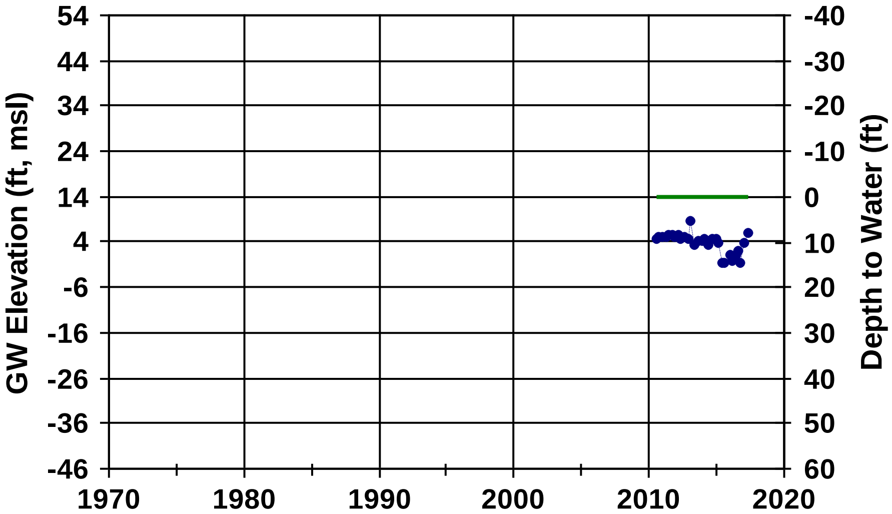


WellID: **T0605514064MW13** RPE: 14.46 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

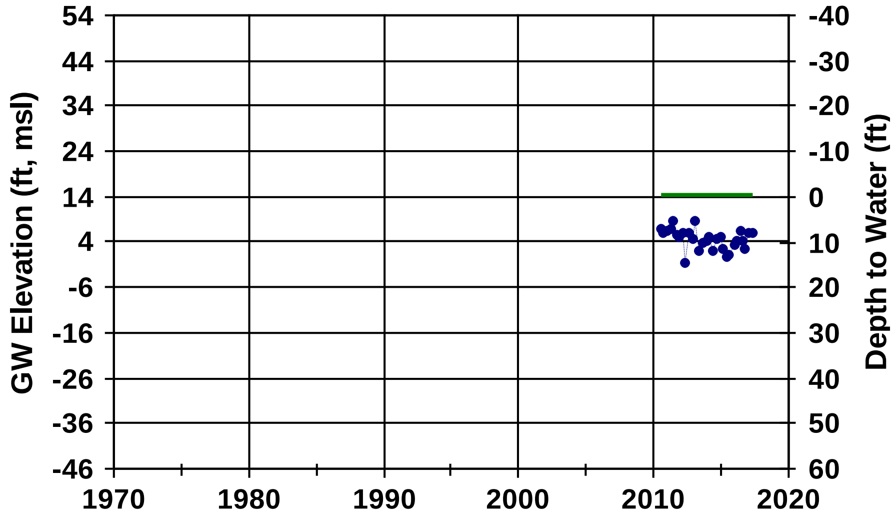


Measured Water Levels   Questionable Measurements   Reference Point Elevation

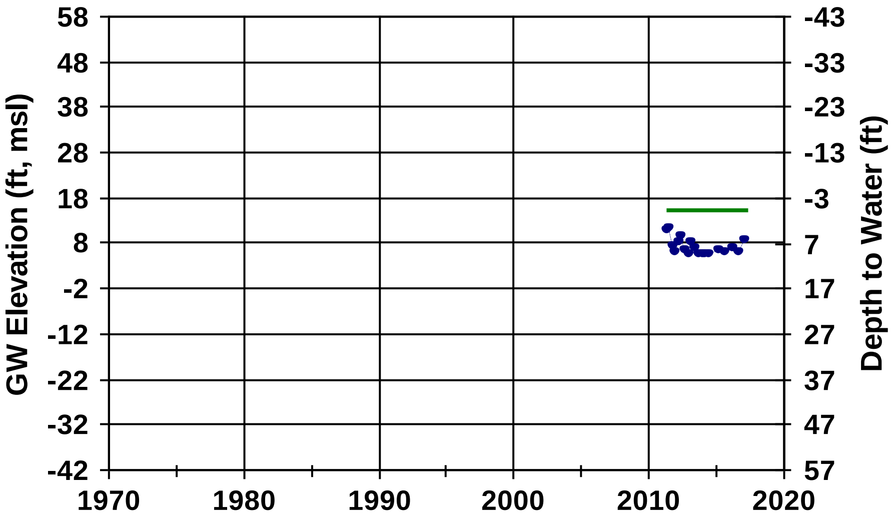
WellID: **T0605514064MW14** RPE: 14 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017



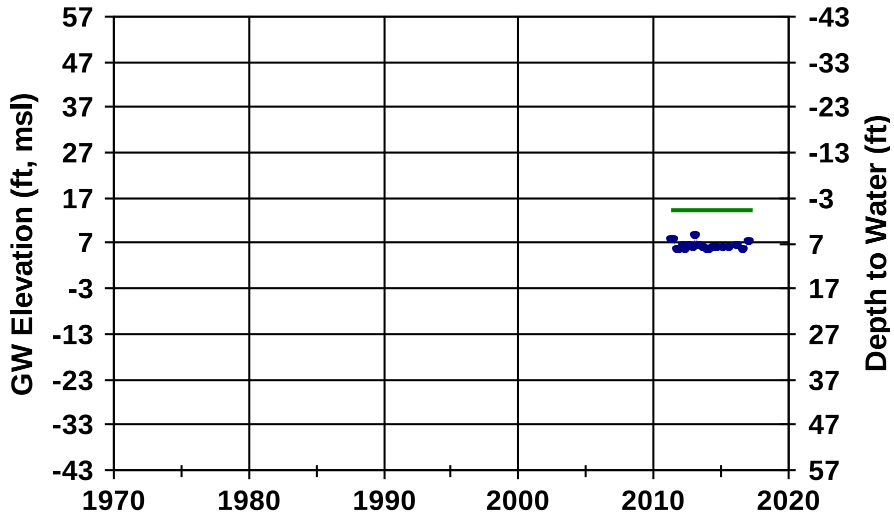
WellID: **T0605514064MW15** RPE: 14.29 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017



WellID: **T0605514064MW16** RPE: 15.22 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

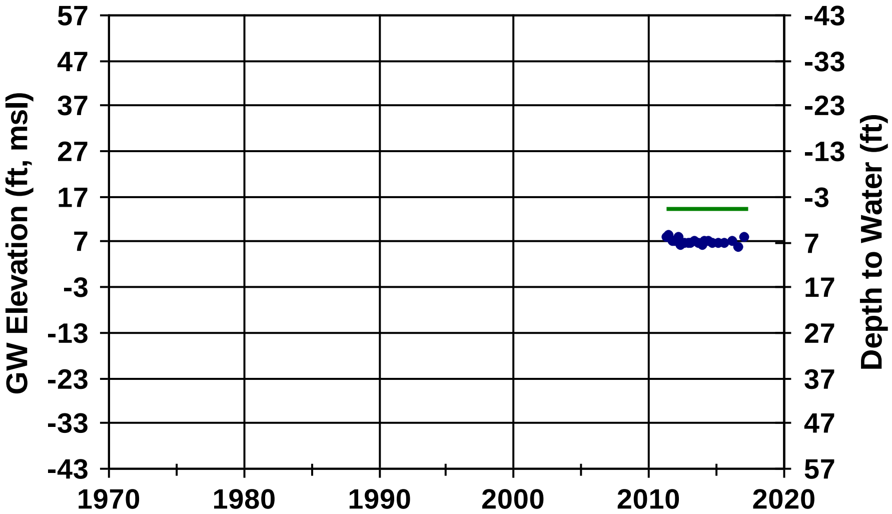


WellID: **T0605514064MW17** RPE: 14.11 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

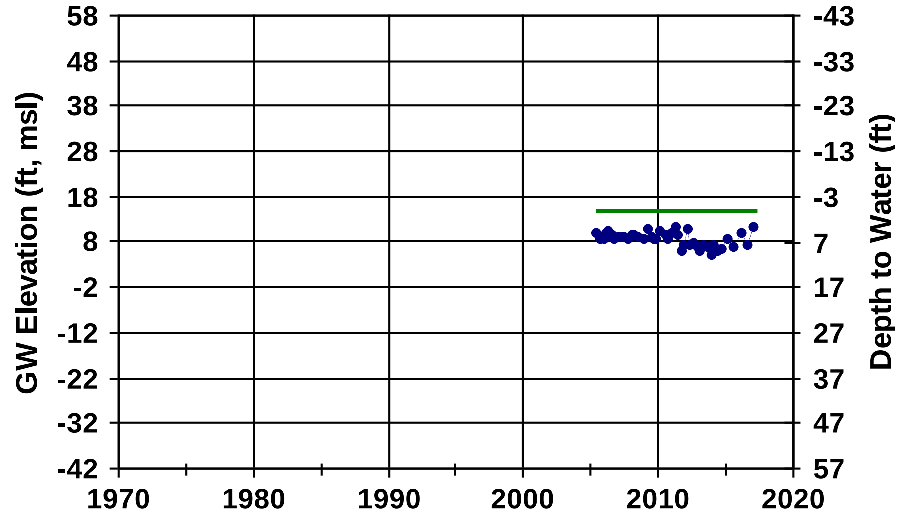


Measured Water Levels — Questionable Measurements — Reference Point Elevation

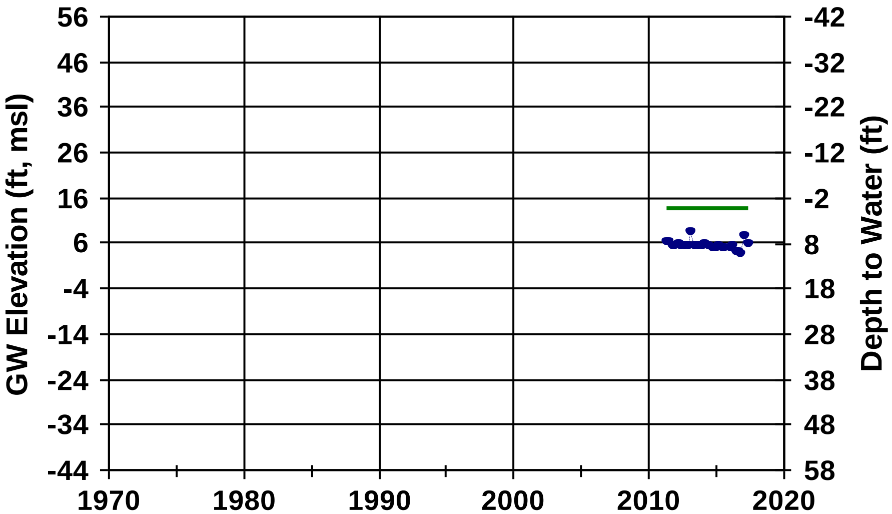
WellID: T0605514064MW18 RPE: 14.33 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



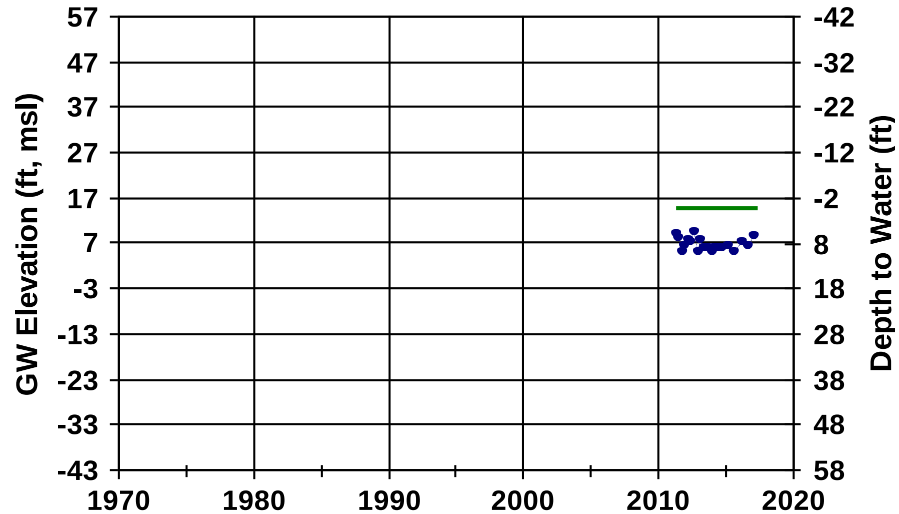
WellID: T0605514064MW2 RPE: 14.61 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: T0605514064MW20 RPE: 13.91 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

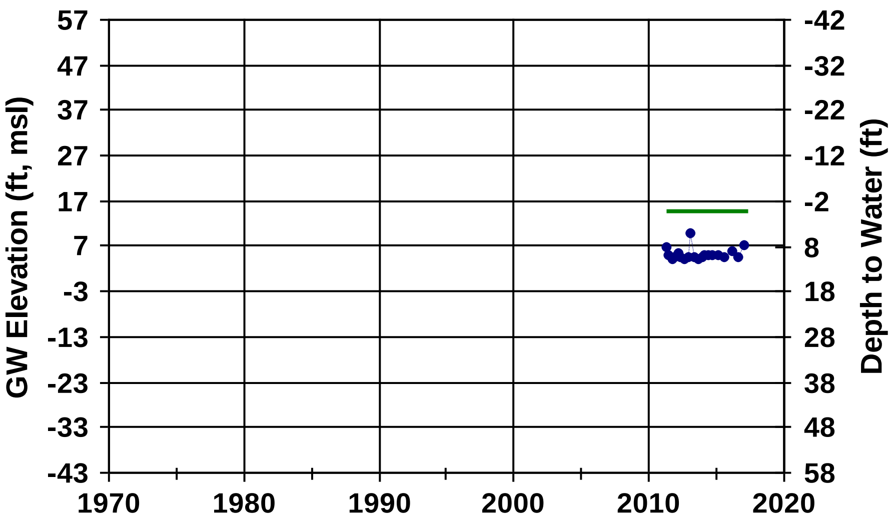


WellID: T0605514064MW21A RPE: 14.79 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

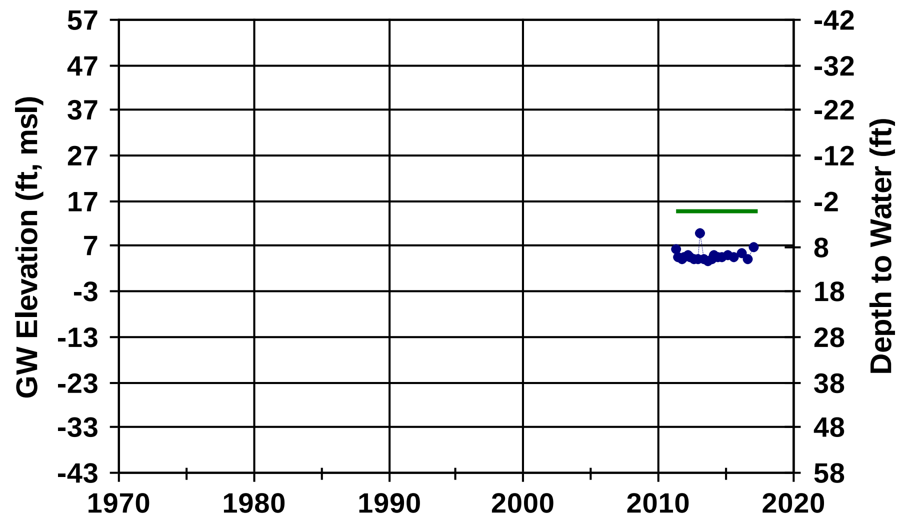


Measured Water Levels ▲ Questionable Measurements Reference Point Elevation

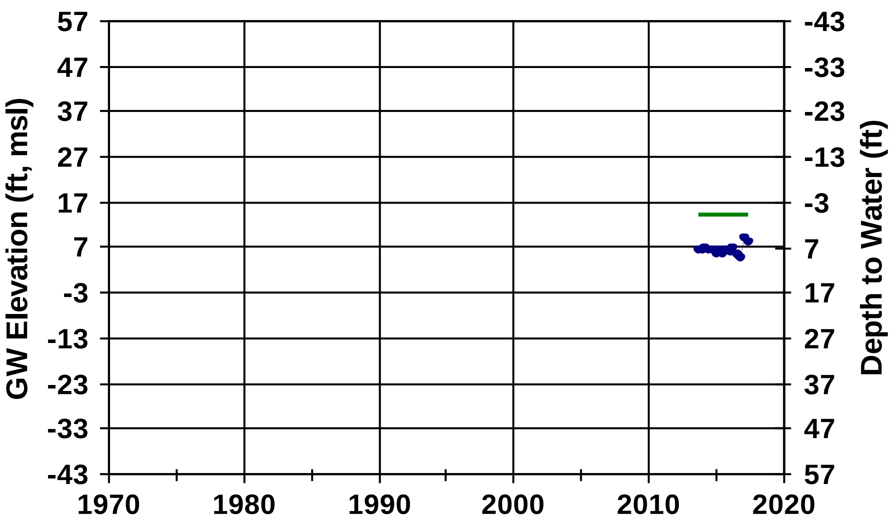
WellID: T0605514064MW21B RPE: 14.85 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



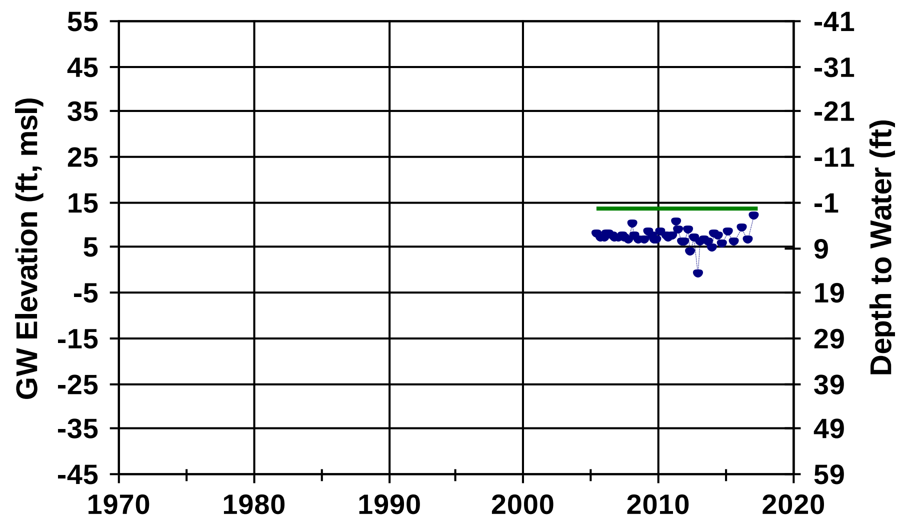
WellID: T0605514064MW21C RPE: 14.82 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: T0605514064MW22 RPE: 14.29 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

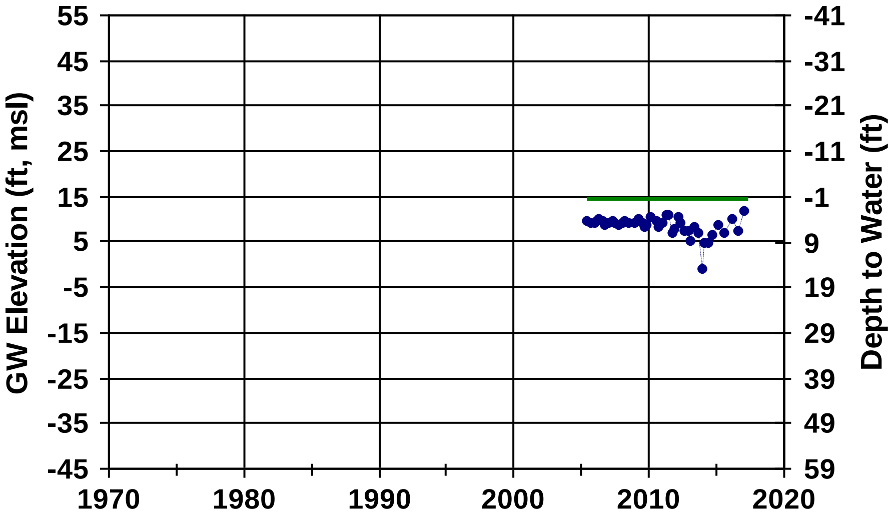


WellID: T0605514064MW3 RPE: 13.68 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

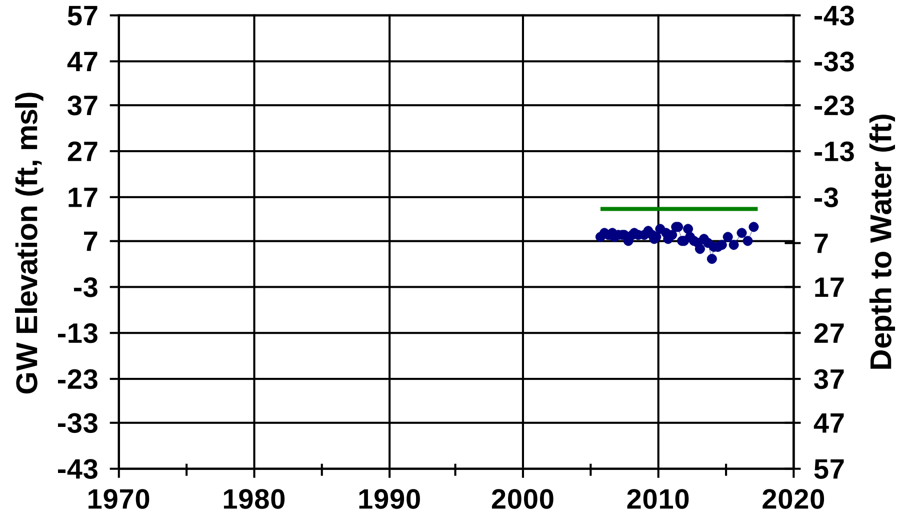


Measured Water Levels Questionable Measurements Reference Point Elevation

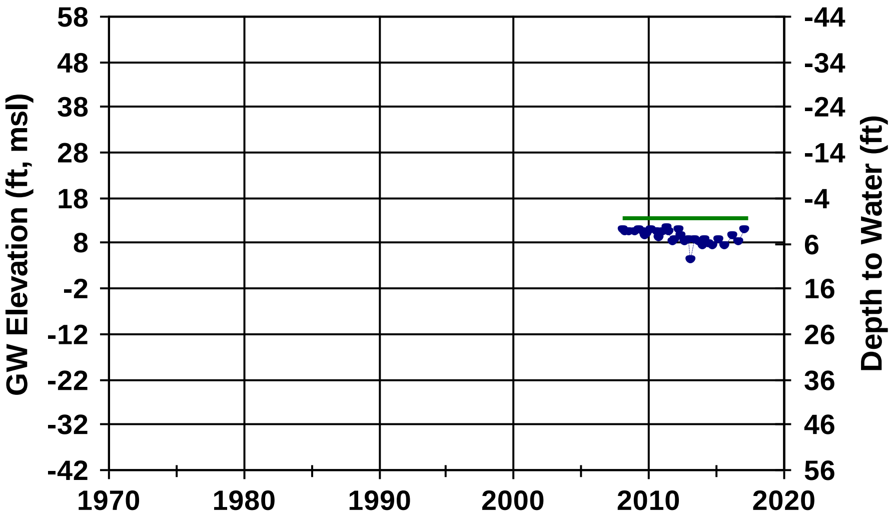
WellID: T0605514064MW4 RPE: 14.4 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



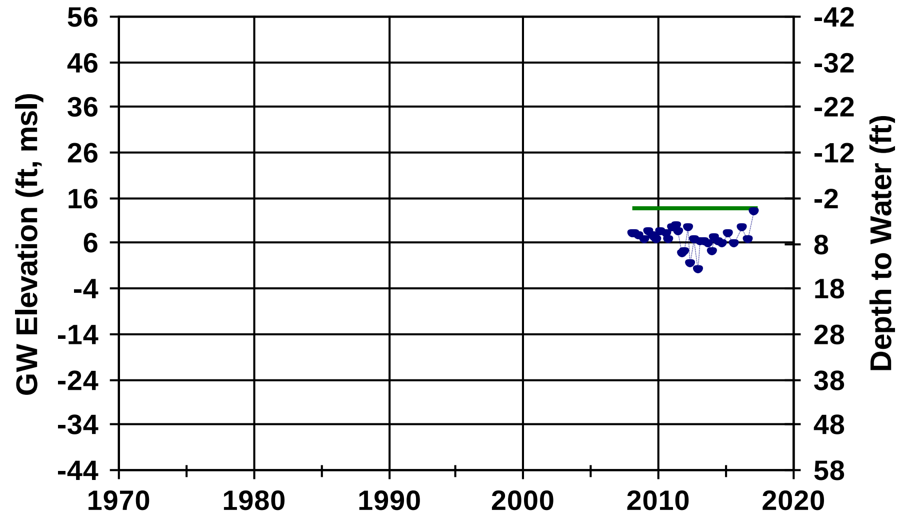
WellID: T0605514064MW5 RPE: 14.09 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: T0605514064MW6 RPE: 13.65 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

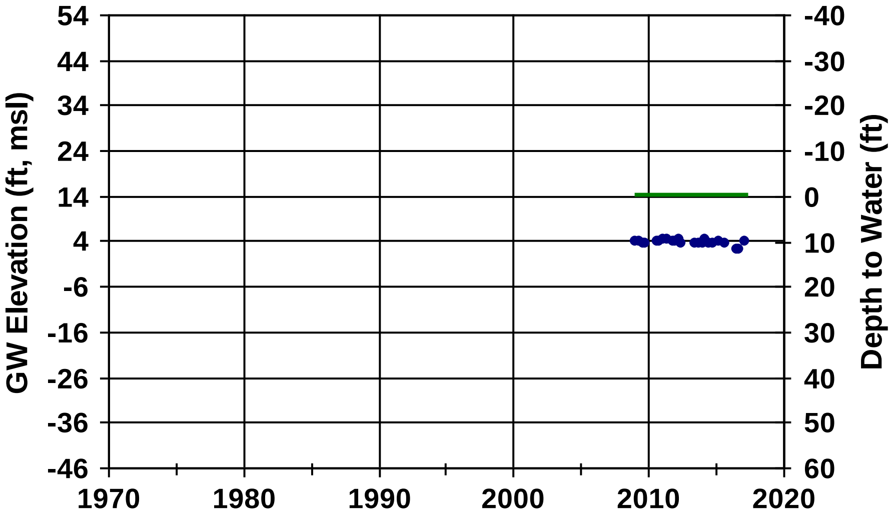


WellID: T0605514064MW7 RPE: 13.87 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

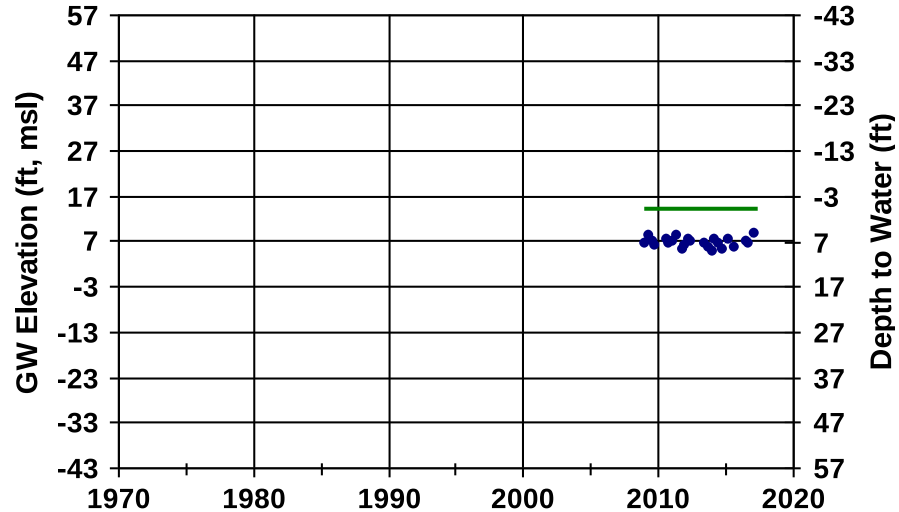


Measured Water Levels Questionable Measurements Reference Point Elevation

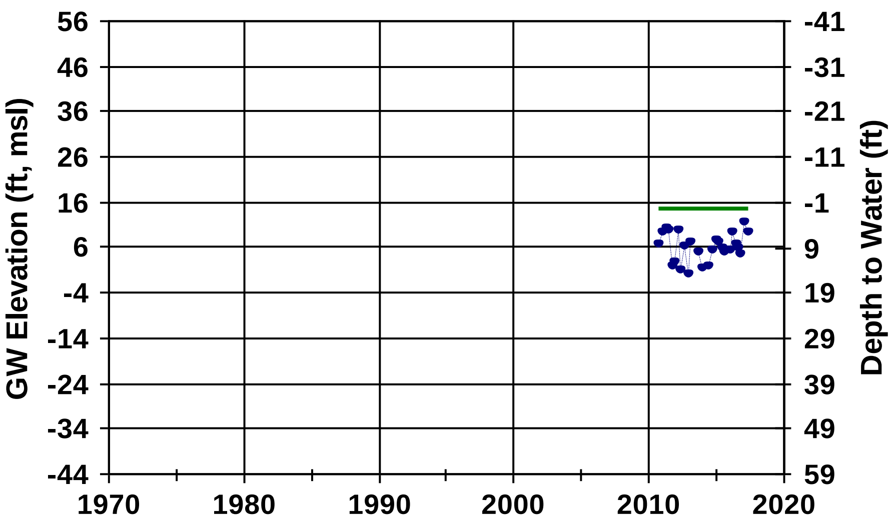
WellID: T0605514064MW8 RPE: 14.29 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



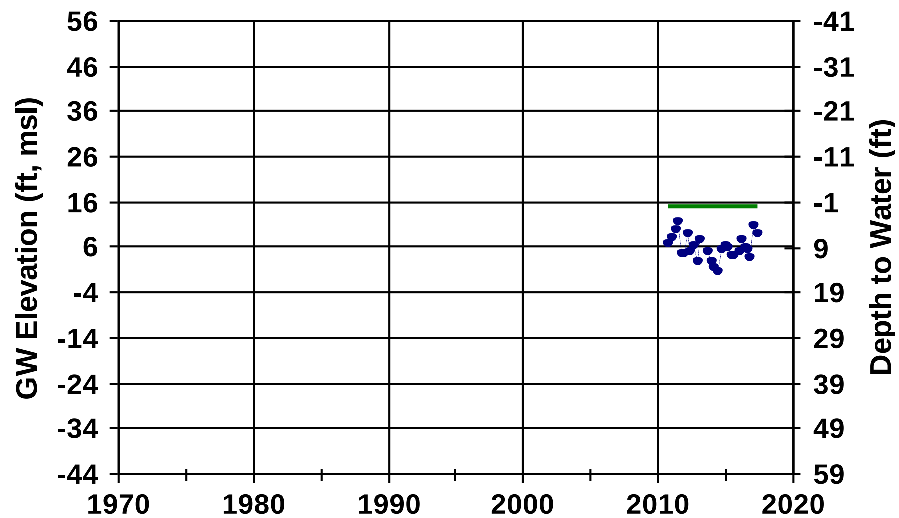
WellID: T0605514064MW9 RPE: 14.35 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: T0605514064OW1 RPE: 14.73 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

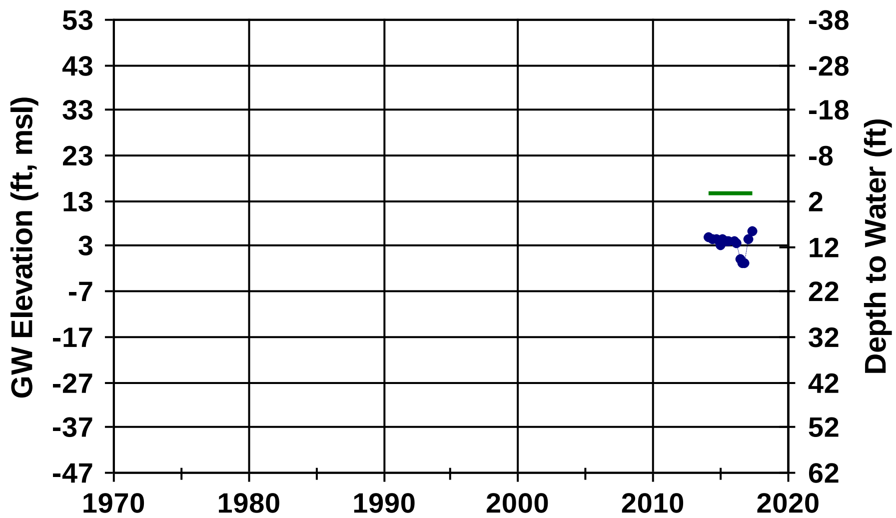


WellID: T0605514064OW2 RPE: 14.99 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

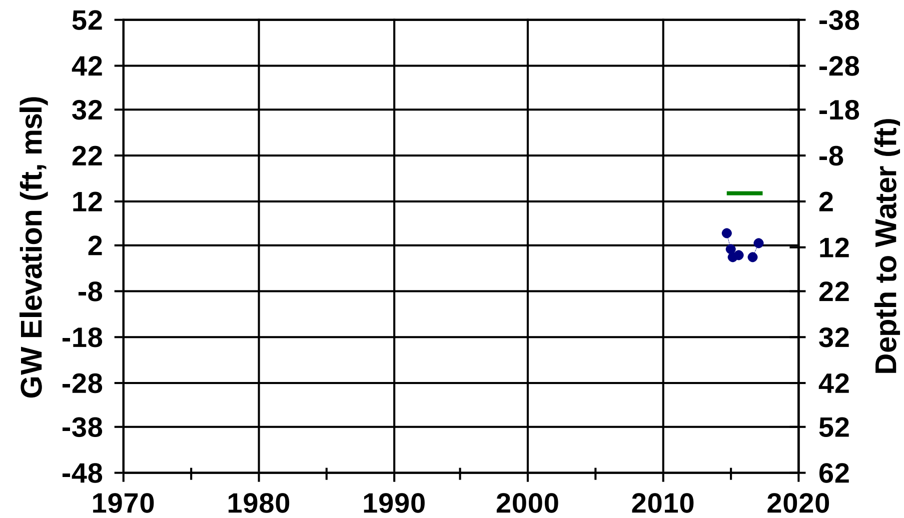


Measured Water Levels Questionable Measurements Reference Point Elevation

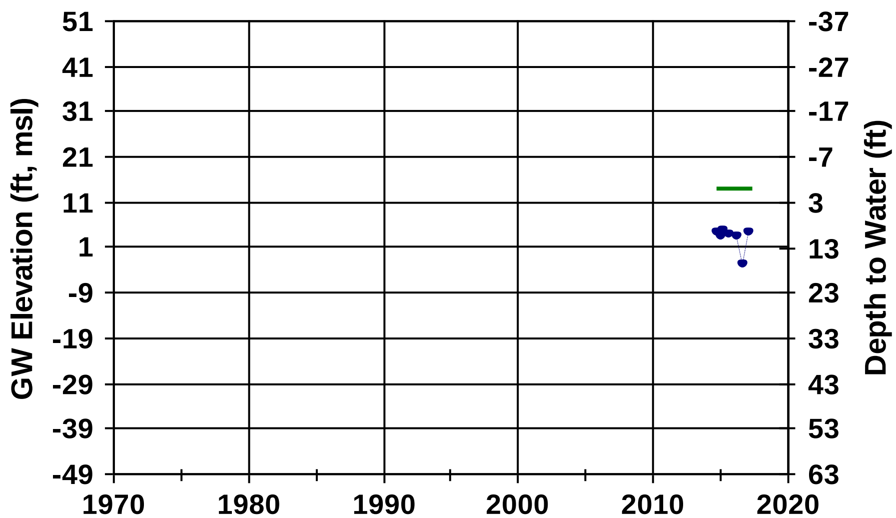
WellID: T0605514064OW3 RPE: 14.63 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017



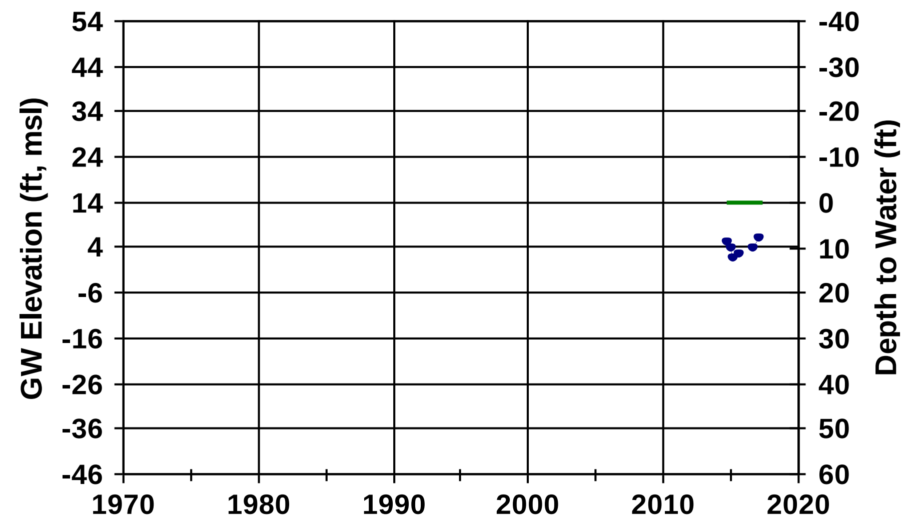
WellID: T0605514064RW1 RPE: 13.85 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017



WellID: T0605514064RW2 RPE: 14.17 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

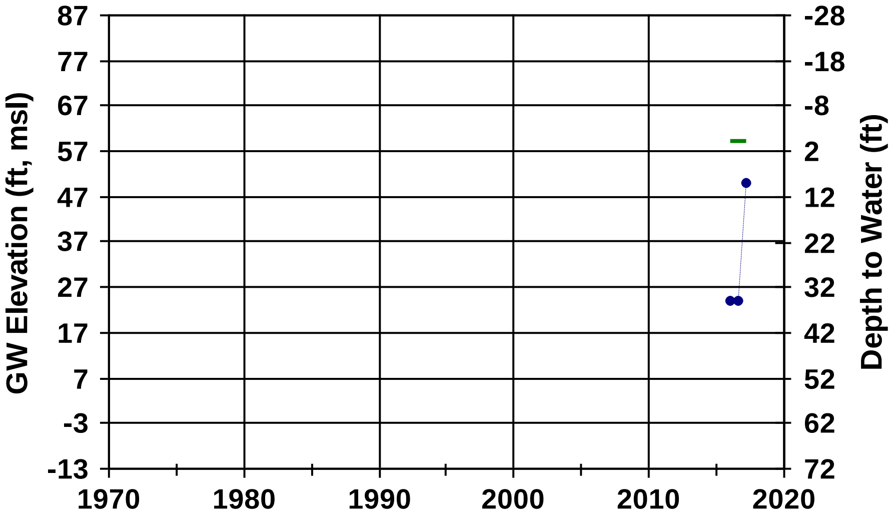


WellID: T0605514064RW3 RPE: 13.95 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 1/23/2017

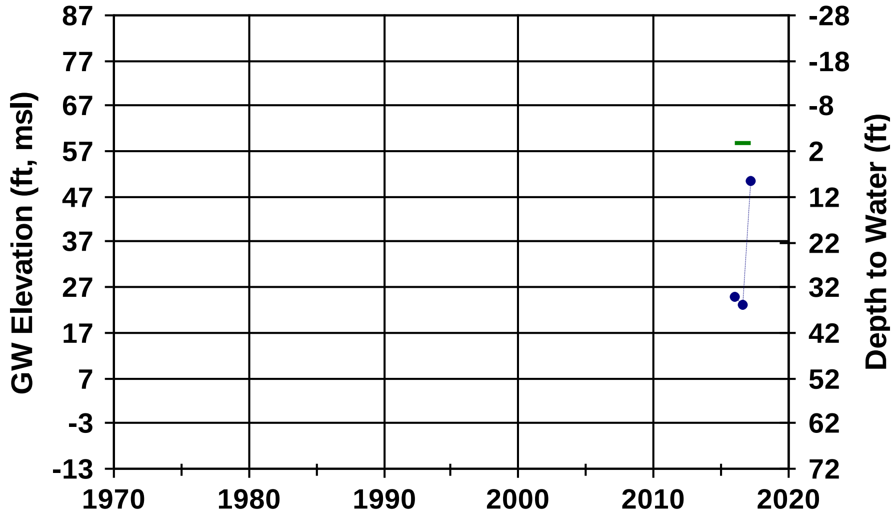


Measured Water Levels Questionable Measurements Reference Point Elevation

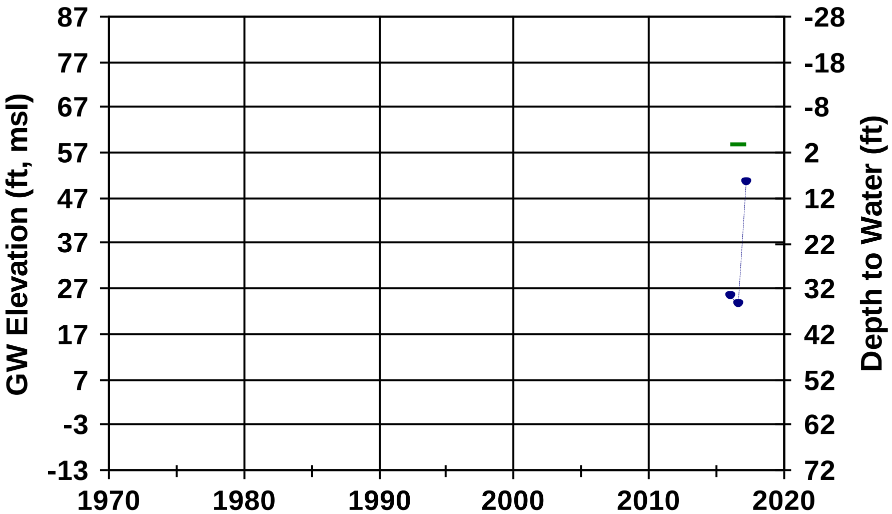
WellID: T0605547200AS-1 RPE: 59.19 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



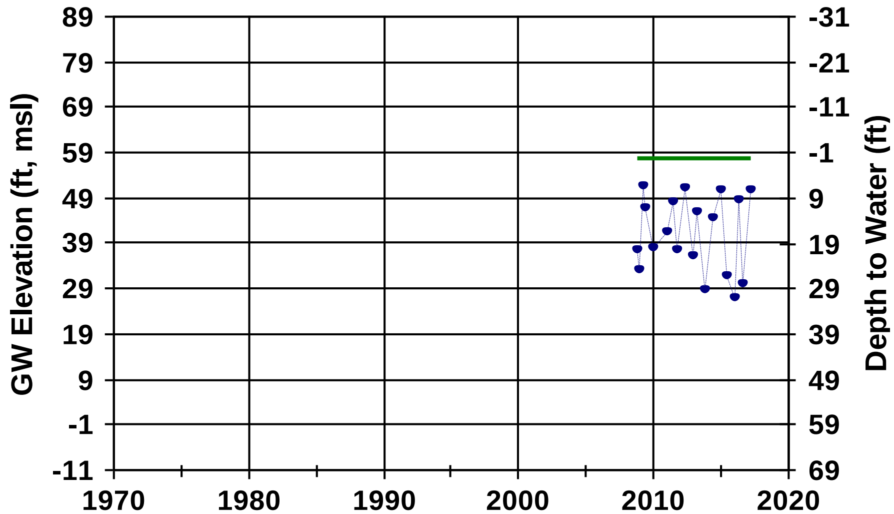
WellID: T0605547200AS-2 RPE: 58.9 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



WellID: T0605547200AS-3 RPE: 59.02 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

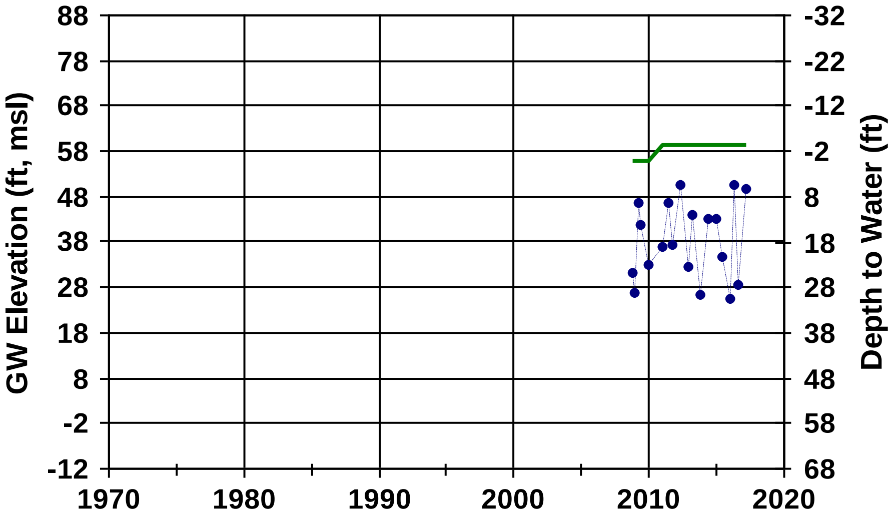


WellID: T0605547200MW-1 RPE: 60.54 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

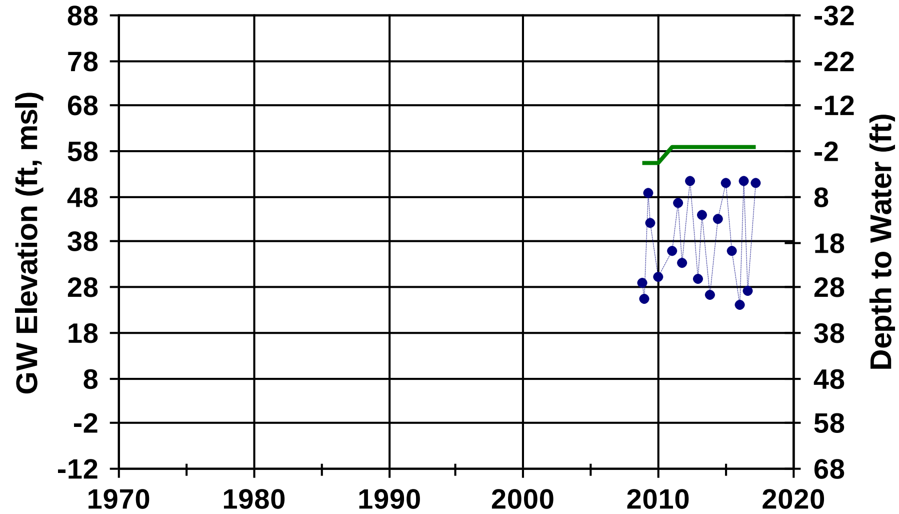


Measured Water Levels
Questionable Measurements
Reference Point Elevation

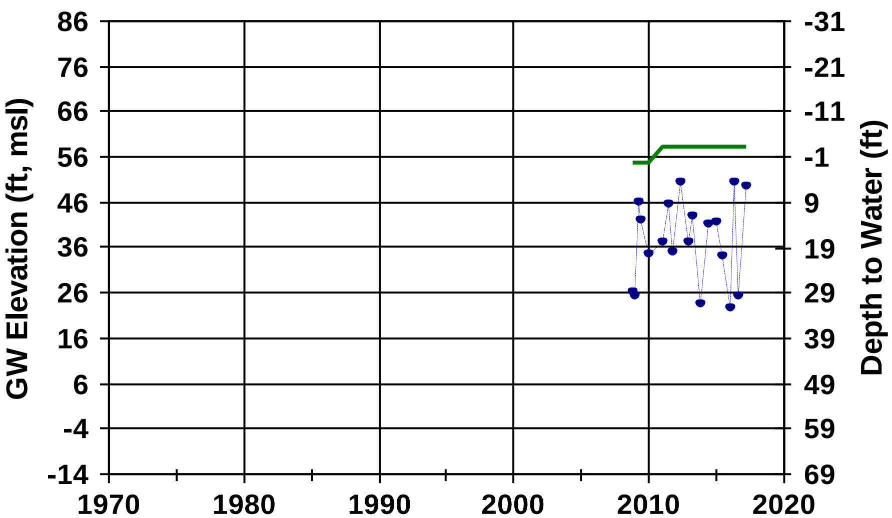
WellID: T0605547200MW-2 RPE: 55.91 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



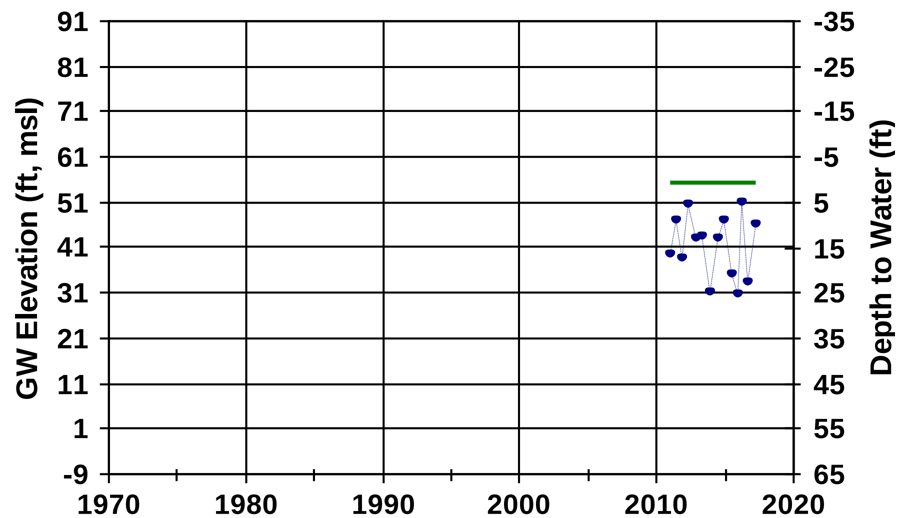
WellID: T0605547200MW-3 RPE: 55.59 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



WellID: T0605547200MW-4 RPE: 54.8 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

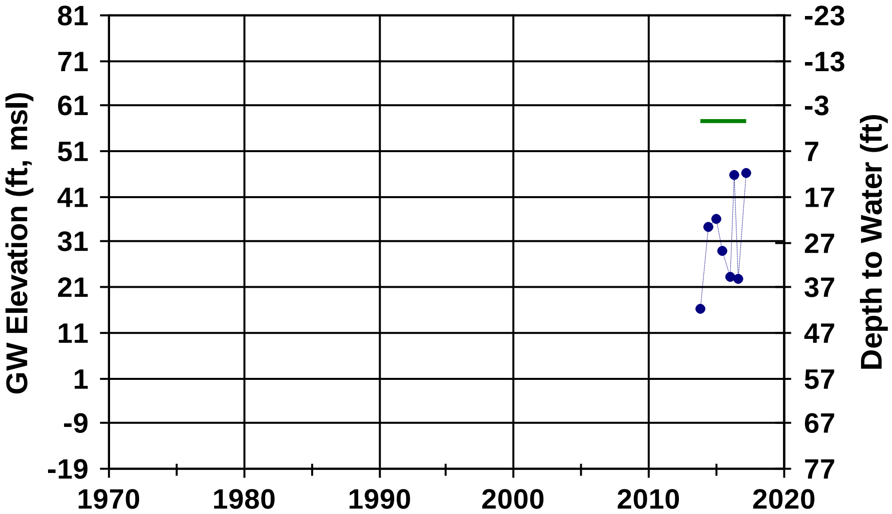


WellID: T0605547200MW-5 RPE: 55.5 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

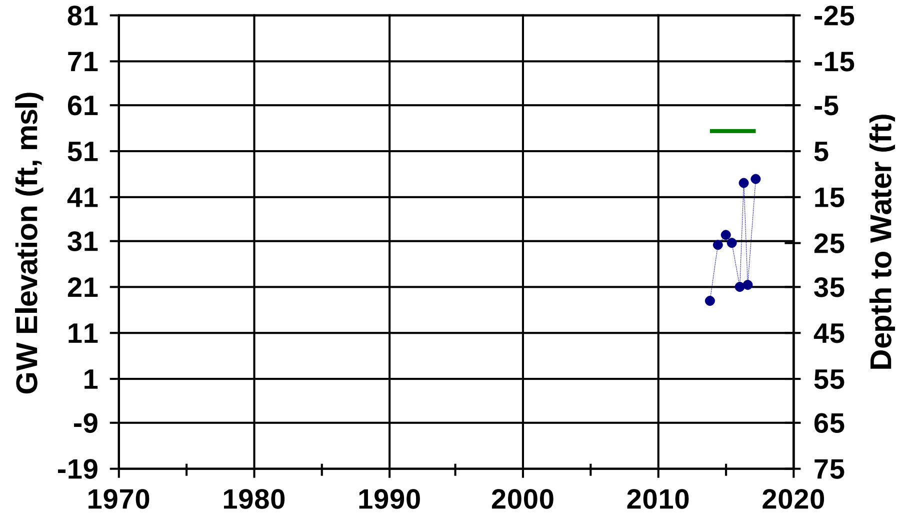


Measured Water Levels Questionable Measurements Reference Point Elevation

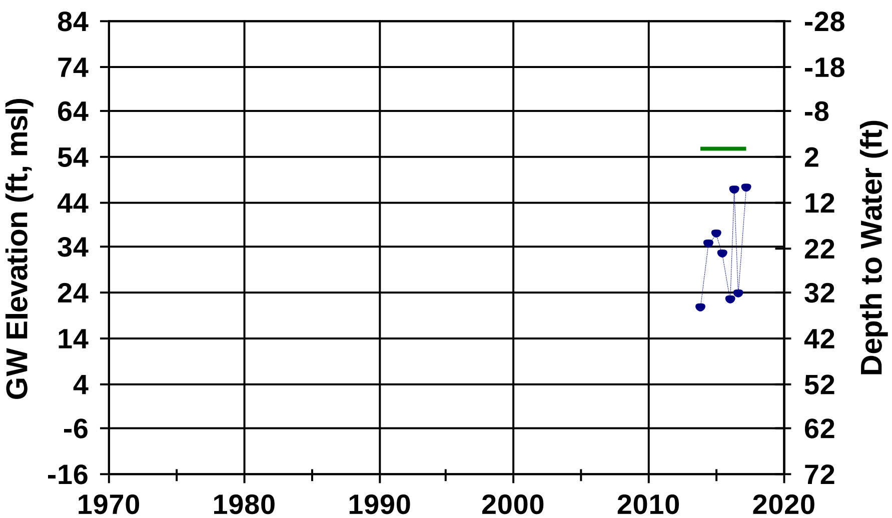
WellID: T0605547200MW-6D RPE: 57.7 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



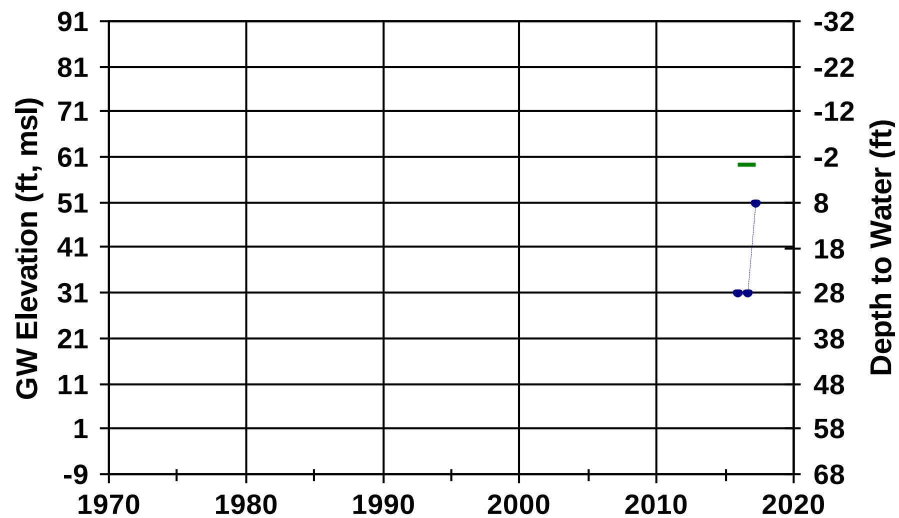
WellID: T0605547200MW-7D RPE: 55.63 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



WellID: T0605547200MW-8D RPE: 55.87 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

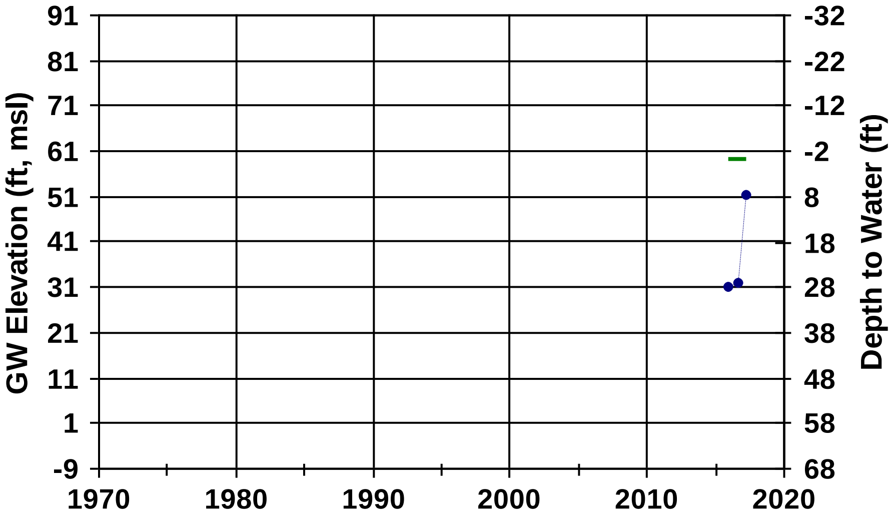


WellID: T0605547200SVE-1 RPE: 59.16 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017

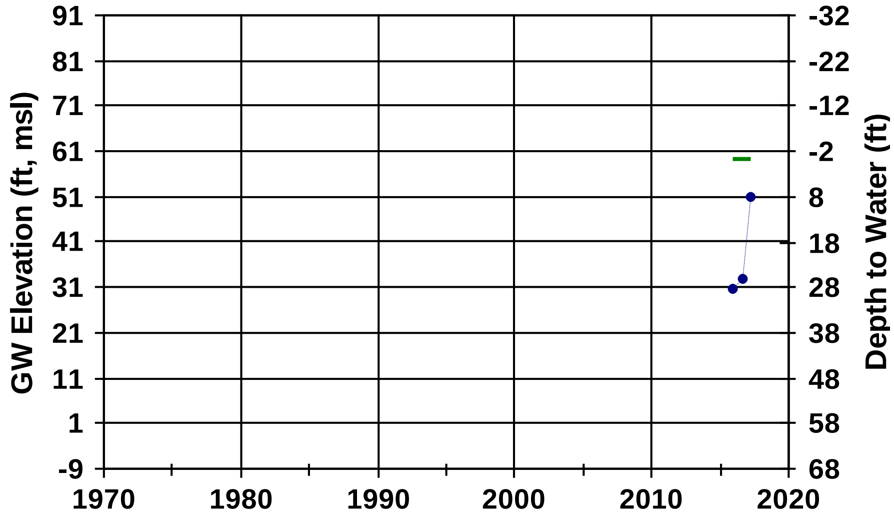


Measured Water Levels Questionable Measurements Reference Point Elevation

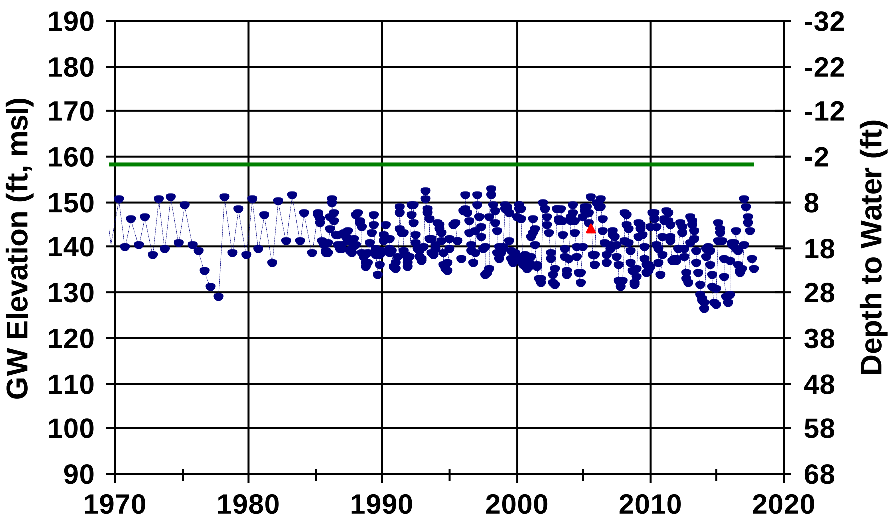
WellID: **T0605547200SVE-2** RPE: 59.43 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



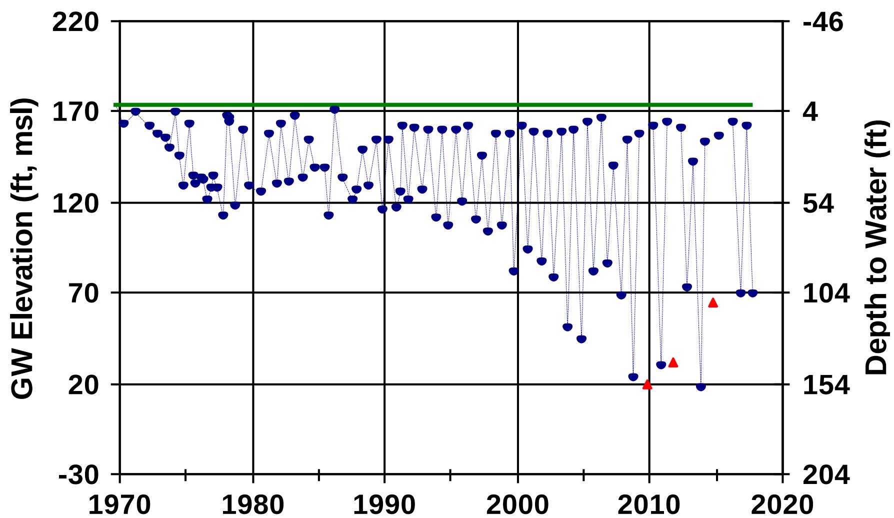
WellID: **T0605547200SVE-3** RPE: 59.33 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Napa Source: Geotracker Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/23/2017



WellID: **07N05W09Q002M** RPE: 158.24 ft, msl SWN: 007N005W09Q002
Subarea: Napa Valley Floor-St. Helena Source: DWR Aquifer Zone: Not Defined
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 9/25/2017

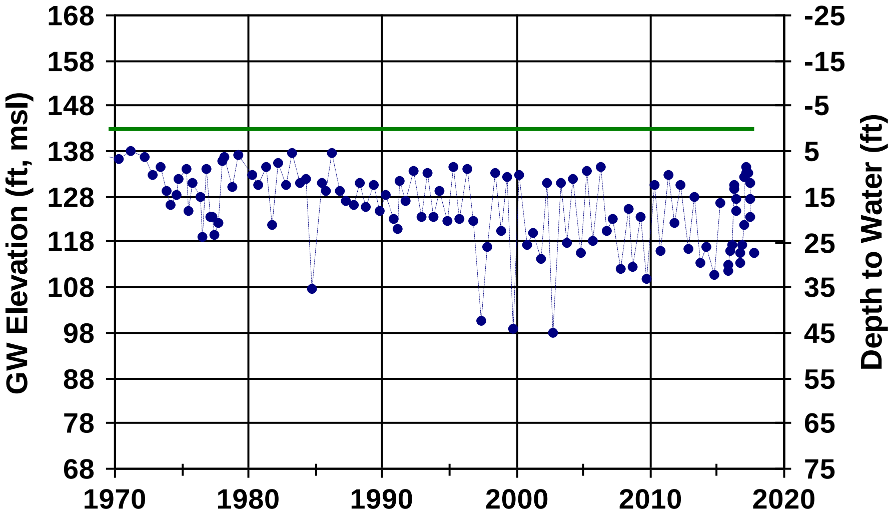


WellID: **NapaCounty-131** RPE: 173.5 ft, msl SWN: 007N005W16L001
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

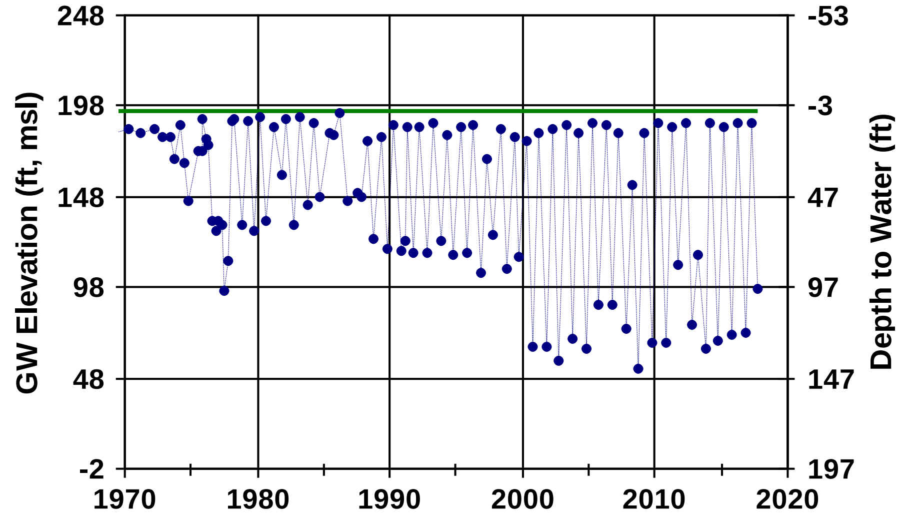


Measured Water Levels Questionable Measurements Reference Point Elevation

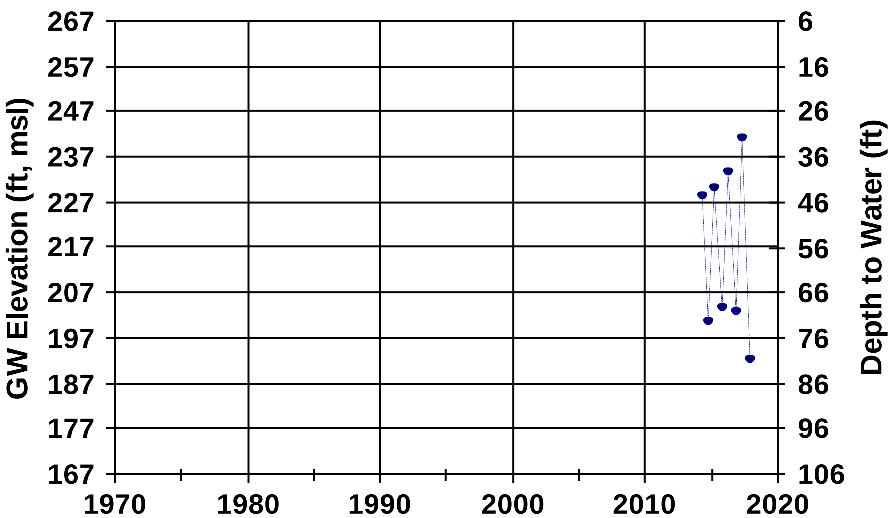
WellID: NapaCounty-132 RPE: 142.7 ft, msl SWN: 007N005W14B002
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Qa, Tsvab
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



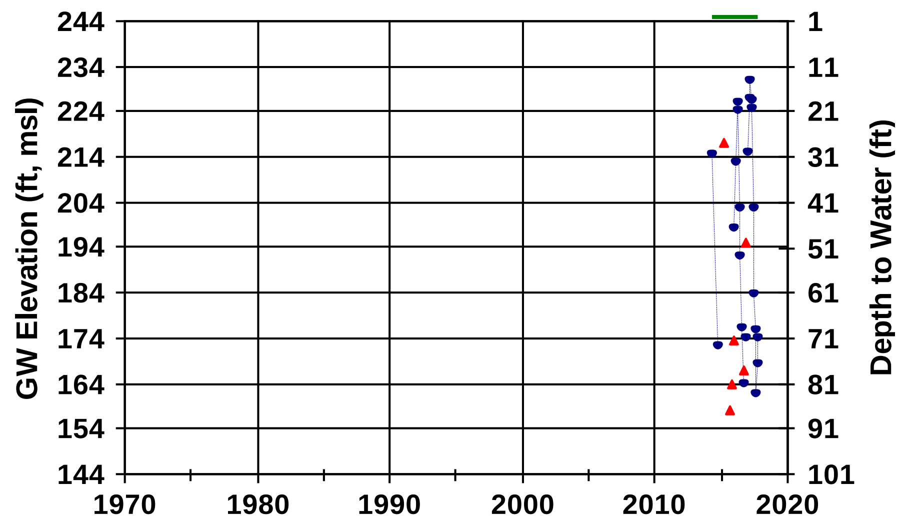
WellID: NapaCounty-138 RPE: 195.1 ft, msl SWN: 007N005W16N002
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



WellID: NapaCounty-169 RPE: 273.4 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/31/2017

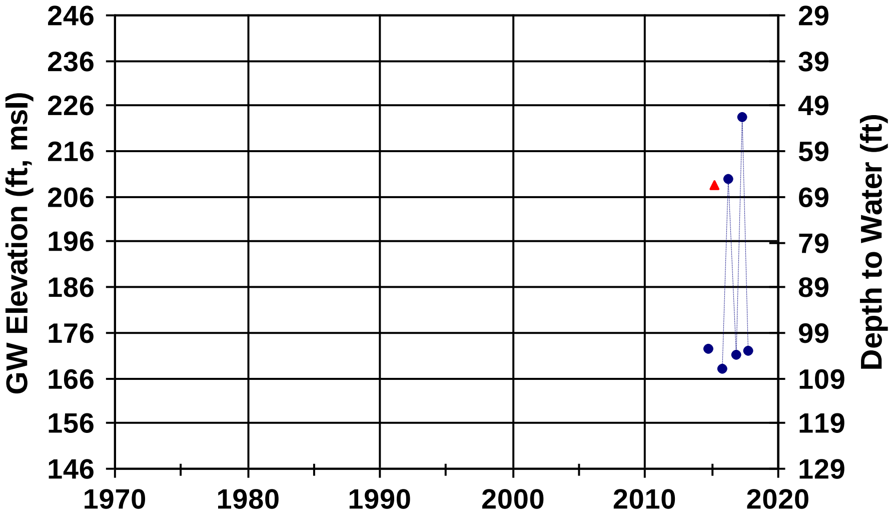


WellID: NapaCounty-171 RPE: 245.1 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Tst/s
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

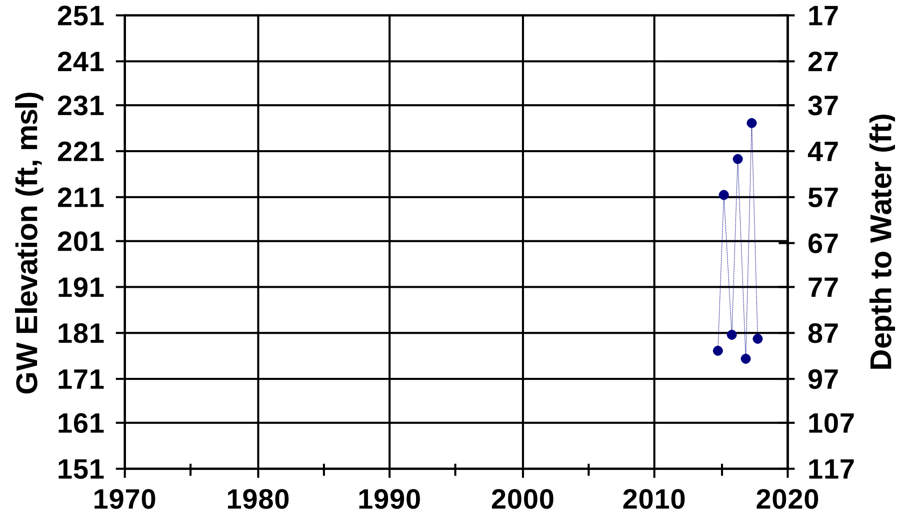


Measured Water Levels Questionable Measurements Reference Point Elevation

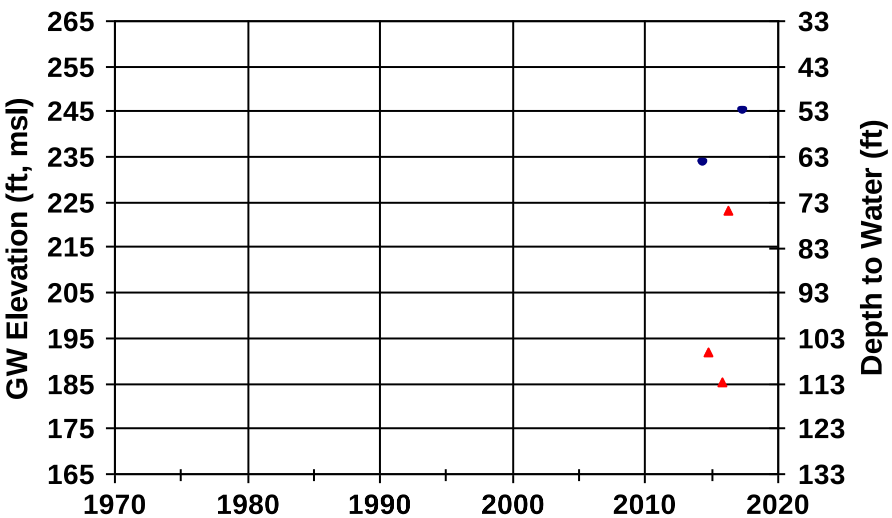
WellID: NapaCounty-172 RPE: 275.2 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/23/2017



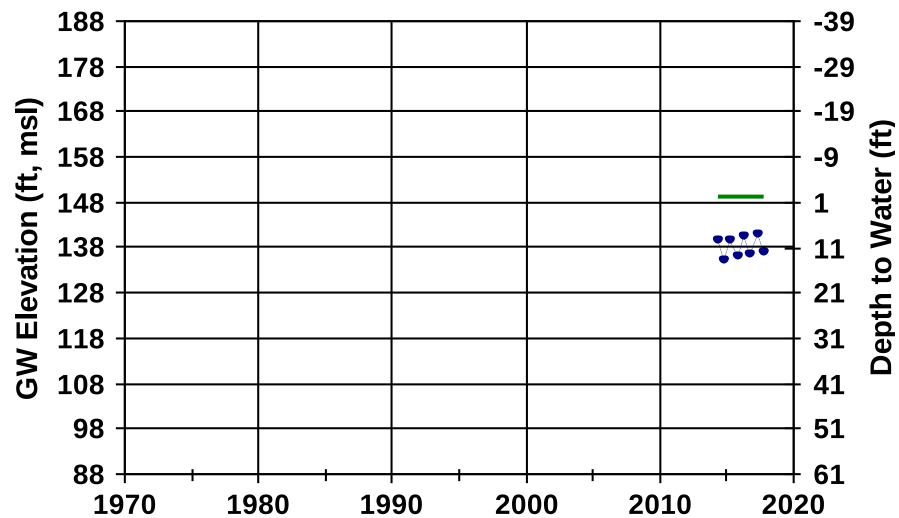
WellID: NapaCounty-173 RPE: 268.3 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/23/2017



WellID: NapaCounty-174 RPE: 298.2 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 4/26/2017

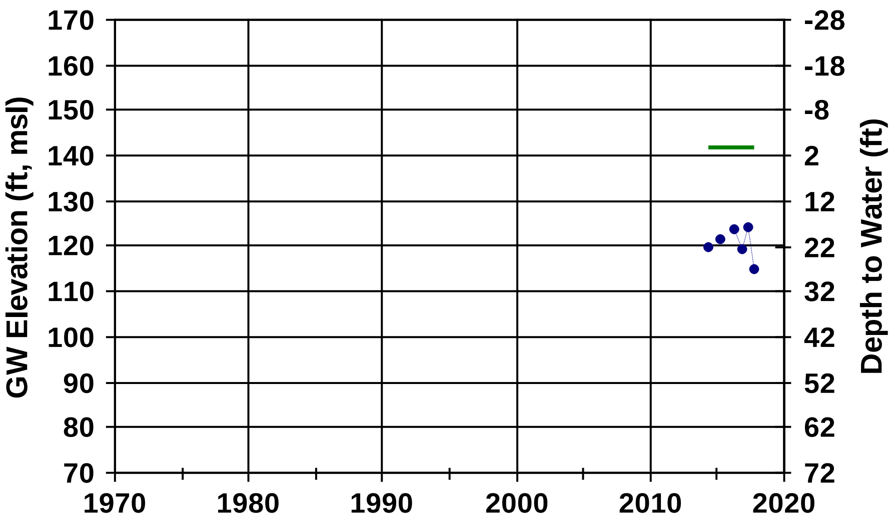


WellID: NapaCounty-177 RPE: 149.3 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

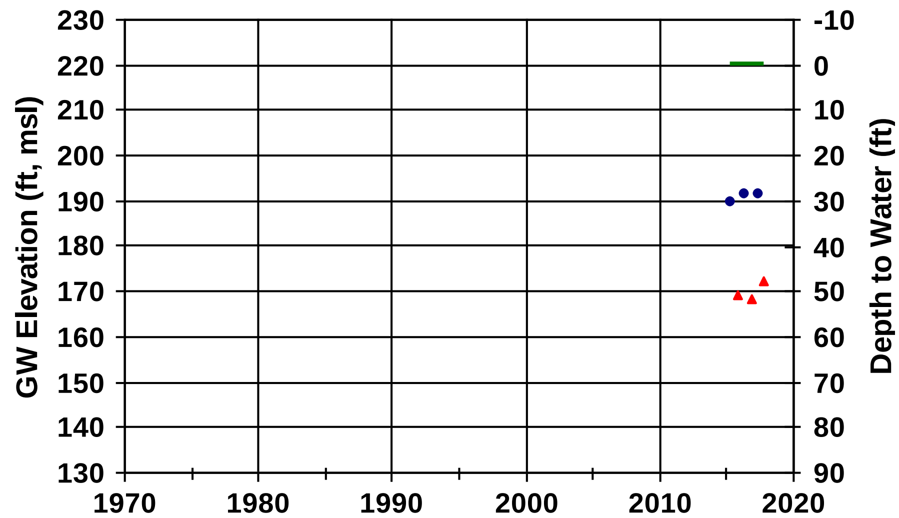


Measured Water Levels Questionable Measurements Reference Point Elevation

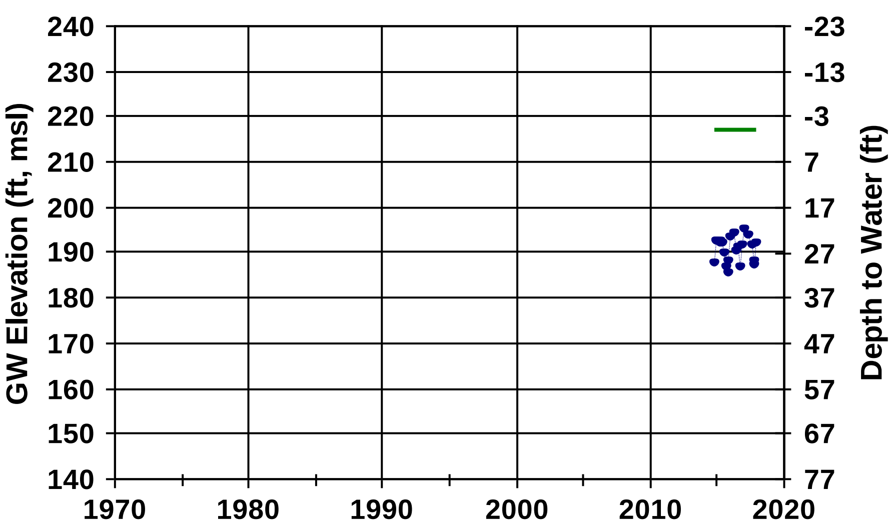
WellID: NapaCounty-204 RPE: 141.7 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



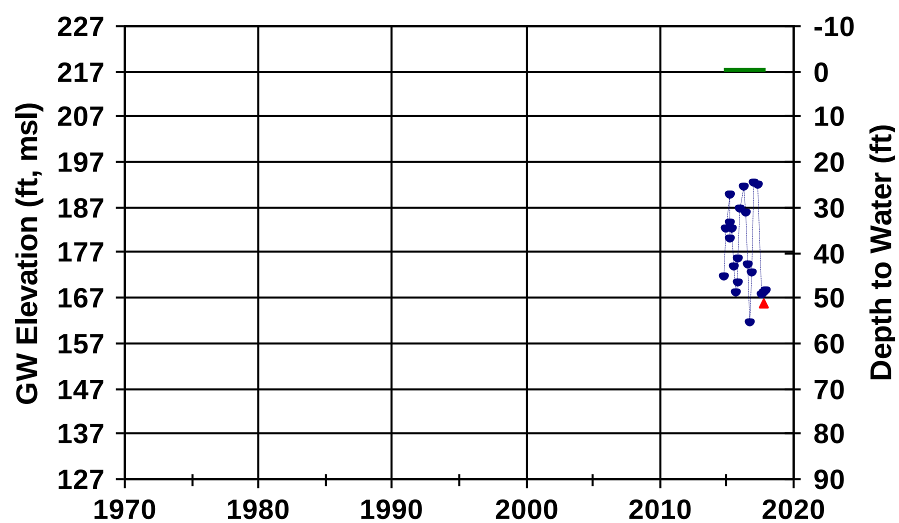
WellID: NapaCounty-212 RPE: 220.5 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/31/2017



WellID: NapaCounty-222s-swgw5 RPE: 217.07 ft, msl SWN: 08N05W30Q001M
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

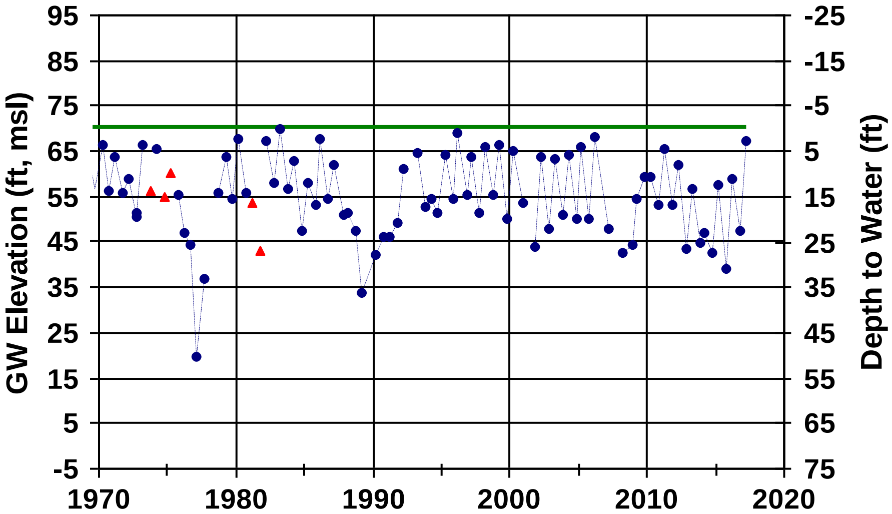


WellID: NapaCounty-223d-swgw5 RPE: 217.1 ft, msl SWN: 08N05W30Q002M
Subarea: Napa Valley Floor-St. Helena Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

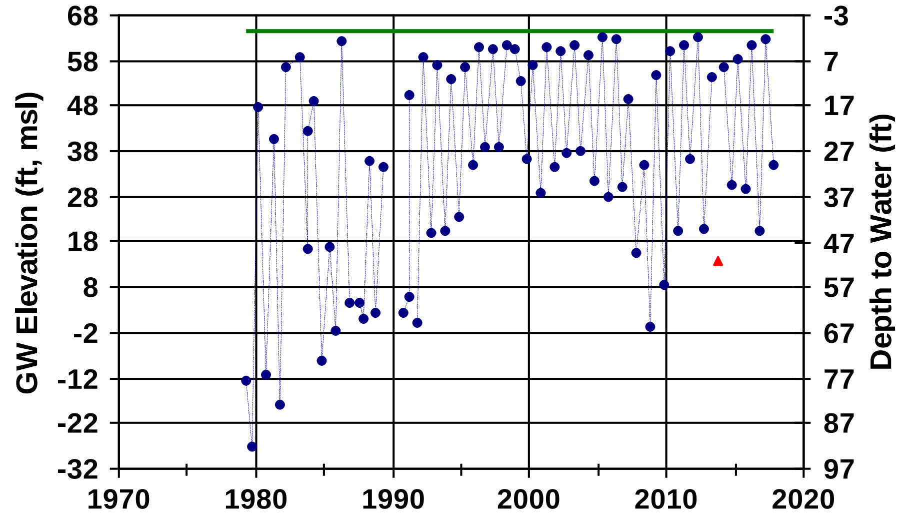


Measured Water Levels Questionable Measurements Reference Point Elevation

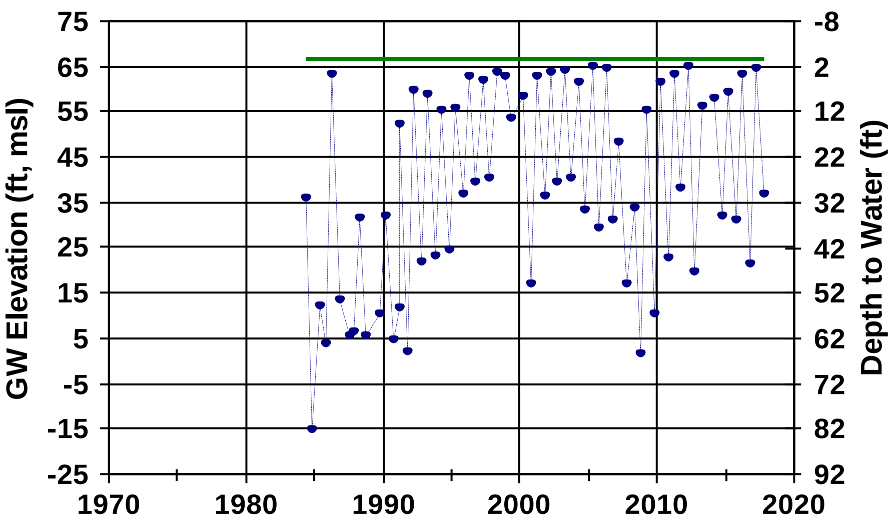
WellID: 06N04W17A001M RPE: 70.26 ft, msl SWN: 006N004W17A001
Subarea: Napa Valley Floor-Yountville Source: DWR Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 3/14/2017



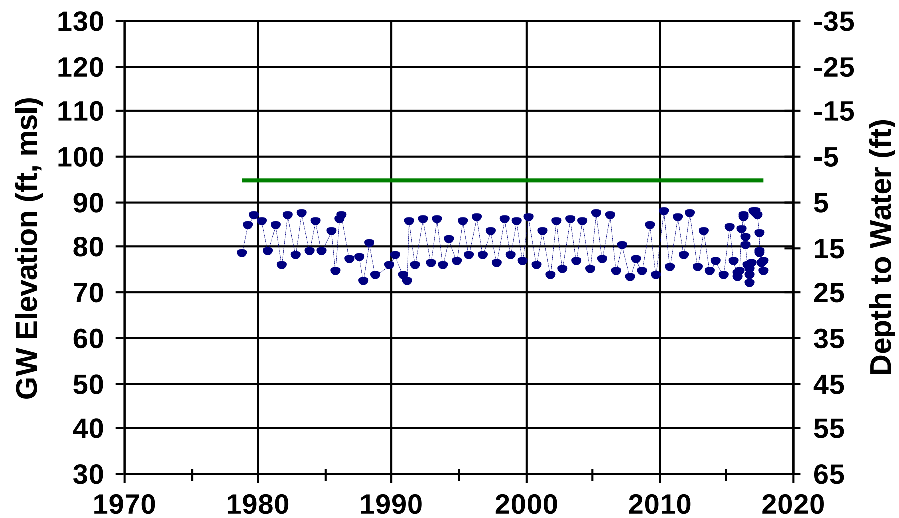
WellID: NapaCounty-125 RPE: 64.6 ft, msl SWN: 006N004W09Q001
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Tsva
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



WellID: NapaCounty-126 RPE: 66.7 ft, msl SWN: 006N004W09Q002
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Tsva
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

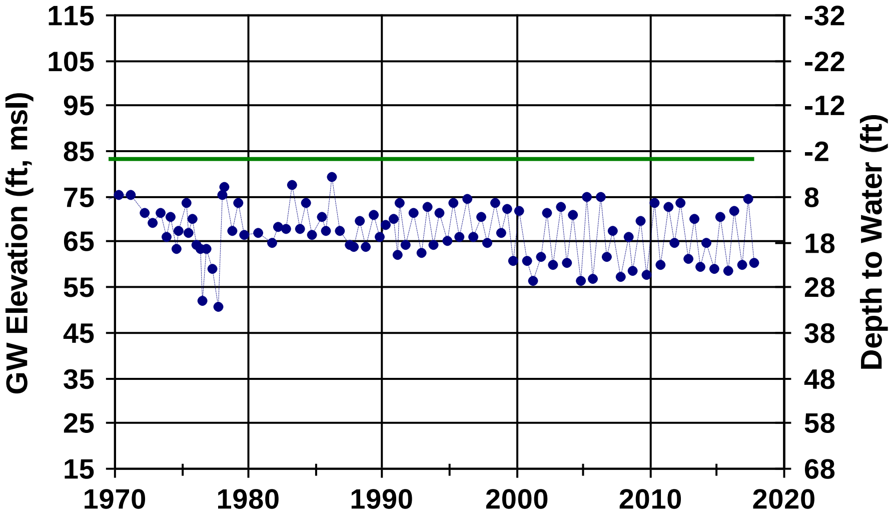


WellID: NapaCounty-133 RPE: 94.7 ft, msl SWN: 007N004W31M001
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017

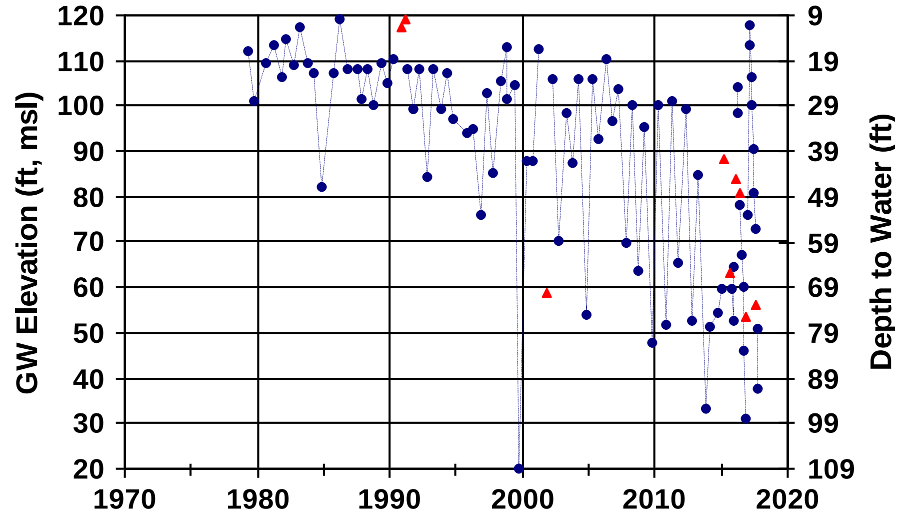


Measured Water Levels Questionable Measurements Reference Point Elevation

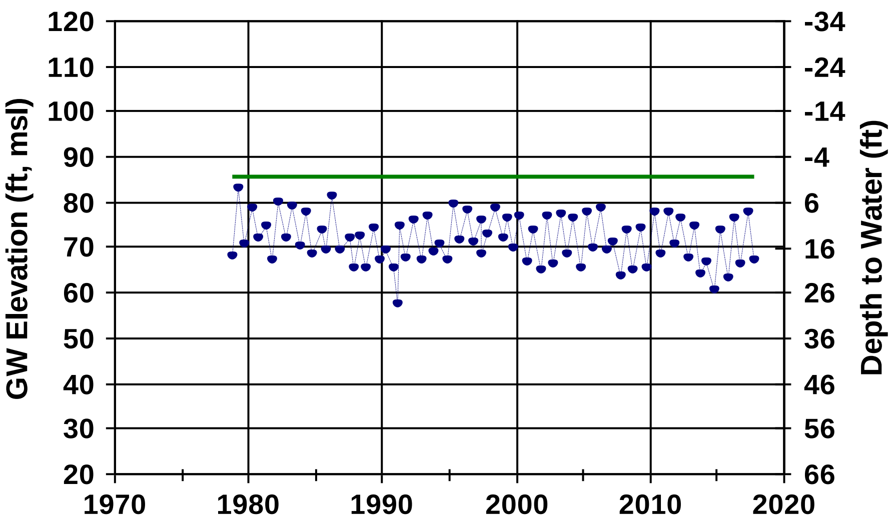
WellID: NapaCounty-134 RPE: 83.4 ft, msl SWN: 006N004W06L002
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/25/2017



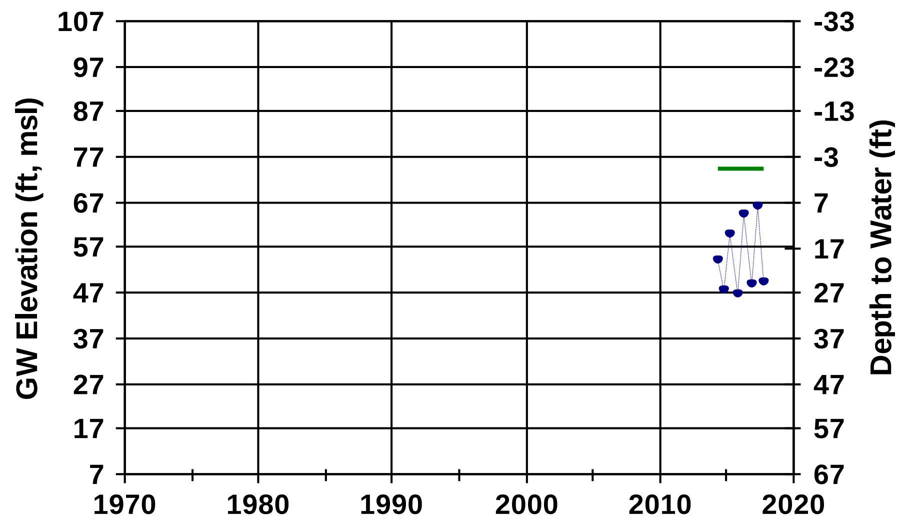
WellID: NapaCounty-135 RPE: 129.2 ft, msl SWN: 006N004W19B001
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa, Tsv
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017



WellID: NapaCounty-139 RPE: 85.8 ft, msl SWN: 006N004W17R002
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017

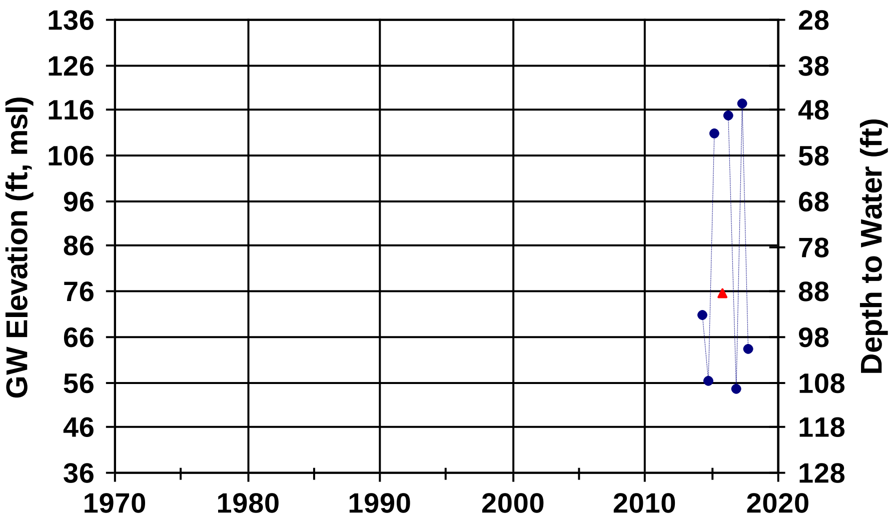


WellID: NapaCounty-179 RPE: 74.3 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017

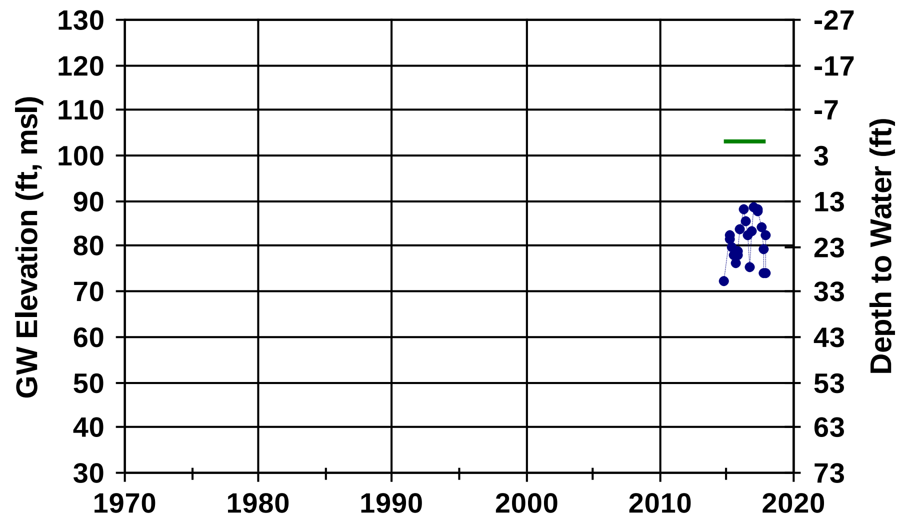


Measured Water Levels Questionable Measurements Reference Point Elevation

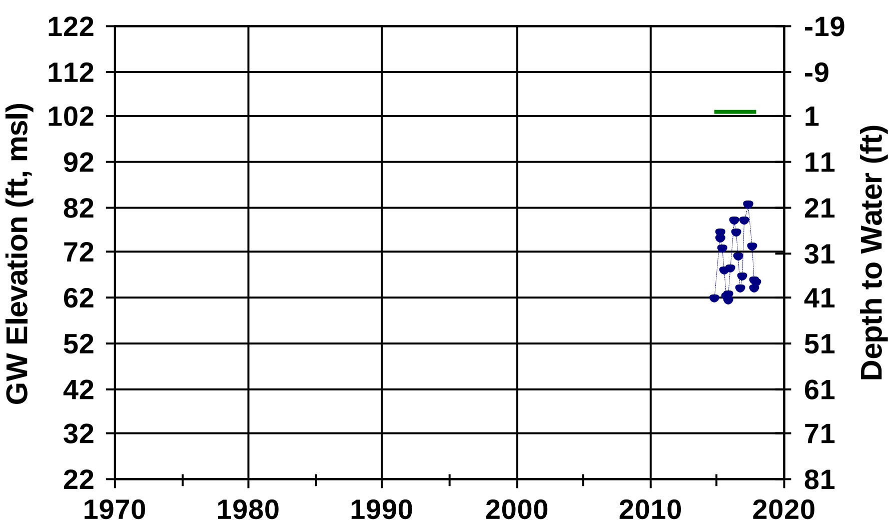
WellID: NapaCounty-181 RPE: 163.6 ft, msl SWN: Unknown
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Tsv
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/26/2017



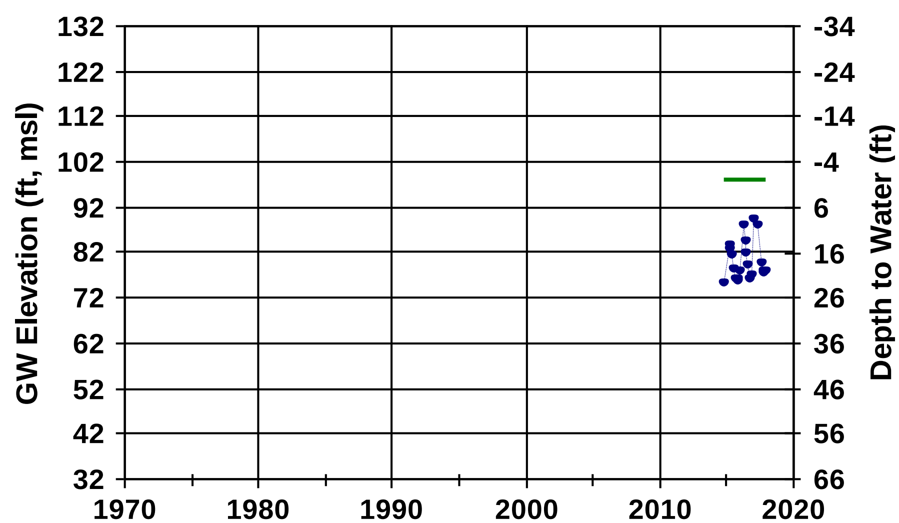
WellID: NapaCounty-216s-swgw2 RPE: 103.1 ft, msl SWN: 06N04W18J003M
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017



WellID: NapaCounty-217d-swgw2 RPE: 103.08 ft, msl SWN: 06N04W18J004M
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

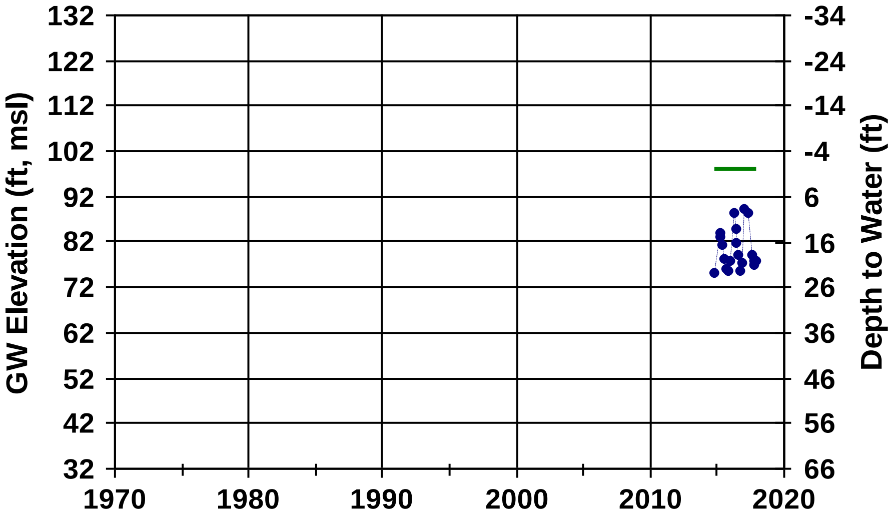


WellID: NapaCounty-220s-swgw4 RPE: 98.22 ft, msl SWN: 07N04W31D001M
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017

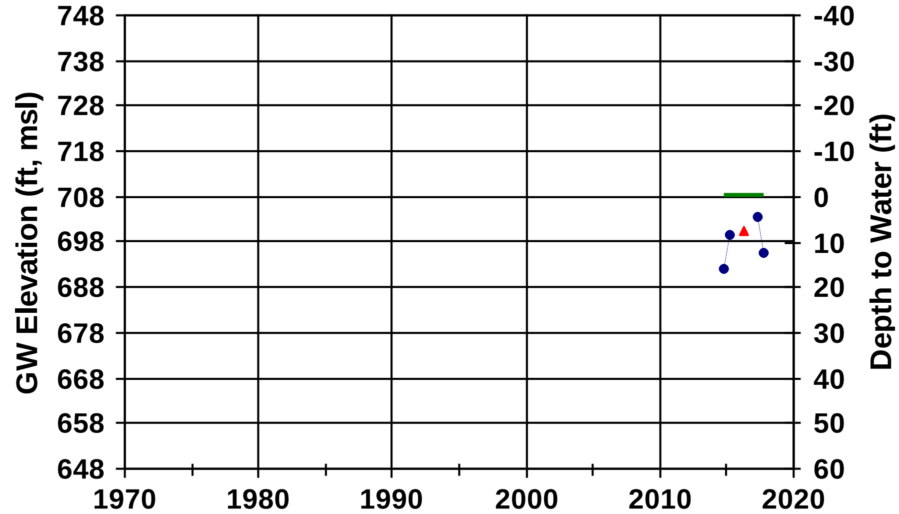


Measured Water Levels Questionable Measurements Reference Point Elevation

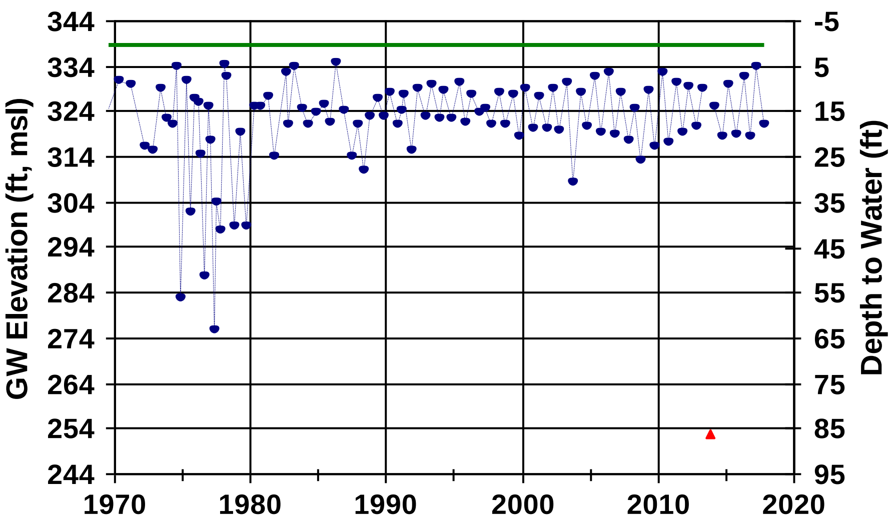
WellID: NapaCounty-221d-swgw4 RPE: 98.28 ft, msl SWN: 07N04W31D002M
Subarea: Napa Valley Floor-Yountville Source: NapaCounty Aquifer Zone: Qa
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 11/17/2017



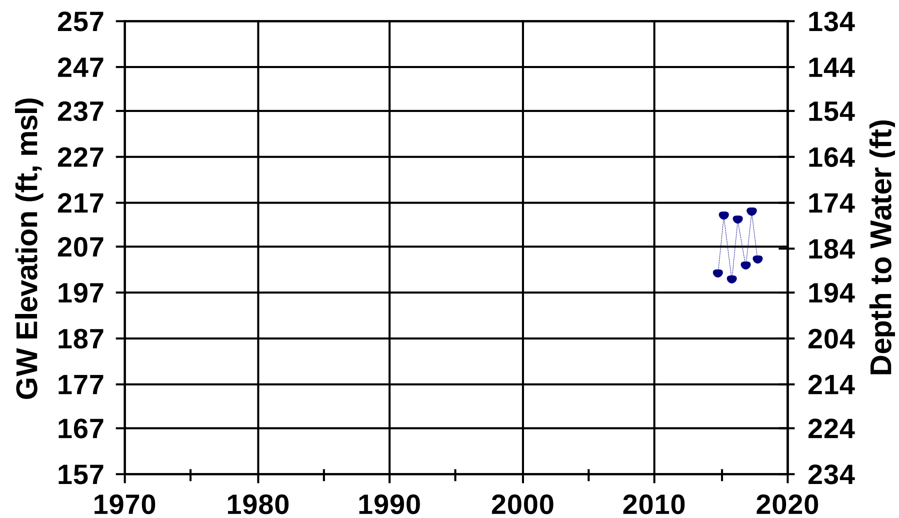
WellID: NapaCounty-211 RPE: 708.2 ft, msl SWN: Unknown
Subarea: Pope Valley Source: NapaCounty Aquifer Zone:
Groundwater Basin POPE VALLEY BASIN Last Msmt Date 10/3/2017



WellID: NapaCounty-129 RPE: 338.7 ft, msl SWN: 008N006W06L004
Subarea: Western Mountains Source: NapaCounty Aquifer Zone:
Groundwater Basin NAPA VALLEY SUBBASIN Last Msmt Date 10/3/2017



WellID: NapaCounty-213 RPE: 390.8 ft, msl SWN: Unknown
Subarea: Western Mountains Source: NapaCounty Aquifer Zone:
Groundwater Basin Not within a basin Last Msmt Date 10/23/2017



Measured Water Levels Questionable Measurements Reference Point Elevation

APPENDIX D

Napa County Procedure for
Measuring Groundwater Levels

NAPA COUNTY PROCEDURE FOR MEASURING

THE DEPTH TO WATER IN MONITORING AND PRODUCTION WELLS

Purpose

To obtain an accurate dated and timed measurement of the static depth to water in a well that can be converted into a water level elevation in reference to a commonly used reference datum (e.g., NAVD 1988). In this context, static means that the water level in the well is not influenced by pumping of the well. For comparability, measurements should be obtained according to an established schedule designed to capture times of both highest and lowest seasonal water level elevations. Also for comparability, measurements during a particular field campaign should be obtained consecutively and without delay within the shortest reasonable time.

Measurement Procedure

- If well is being pumped, do not measure; return later, but not sooner than 60 minutes and preferably after 24 hours (see below "Special Circumstances – Pumping Water Level on Arrival" for additional instructions).
- Turn on water level indicator signaling device and check battery by hitting the test button.
- Remove access plug or well cap from the well cover and lower probe (electric sounder) into the well.
- When probe hits water a loud "beep" will sound and signal light will turn red.
- Retract slightly until the tone stops.
- Slowly lower the probe until the tone sounds.
- Note depth measurement at rim (i.e., the surveyed reference point for water level readings) of well to the nearest 0.01 foot and rewind probe completely out of well.
- Remove excess water and lower probe once again into well and measure again.
- If difference is within ±0.02 foot of first measurement, record measurement.
- If difference is greater repeat the same procedure until three consecutive measurements are recorded within ± 0.02 foot.
- Rewind and remove probe from well and replace the access plug or well cap in the well cover.
- Clean and dry the measuring device/probe and continue to next well.

Special Circumstances

Oil Encountered in Well

If oil is detected in the well structure, the depth to the air-oil interface is measured. To obtain such a measurement, the electric sounder is used similar to the way chalked steel tapes were traditionally used for depth-to-water measurements.

1. Lower the cleaned probe well below the air-oil interface (e.g., 1 foot). Read and record the depth at the reference point (since this depth is chosen somewhat arbitrarily by the field technician, an even number can be chosen, e.g., 37.00 feet). This measurement is the length of cable lowered into the well and corresponds to a line that the oil leaves on the probe or cable (i.e., the oil inundation line). Above this line, smudges of oil may appear on the cable. Below this line, the cable/probe is completely covered with oil. If the probe is lowered too far, completely penetrates the oil, and is far submerged in the water below the oil, parts of the probe/cable below the oil inundation line may also appear smudgy.
2. Retrieve probe, identify and record the oil inundation line on the cable (e.g., 2.72 feet). This measurement does not reflect the thickness of the oil. It reflects the length of the cable below the air-oil interface.
3. Compute the depth to oil by subtracting the length of line below the air-oil interface from the corresponding measurement at the reference point: Depth to oil = 37.00 feet – 2.72 feet = 34.28 feet.

Since oil has a slightly smaller density than water, a depth-to-oil measurement will always be smaller than a corresponding depth-to-water measurement in the same well if oil were not present. Depth-to-oil measurements yield a reasonable approximation to depth-to-water measurements unless the oil thickness is great. For each foot of oil in the well casing, the depth-to-oil measurement will be approximately 0.12 foot smaller than a corresponding depth-to-water measurement if oil were not present.

Pumping Water Level on Arrival

If well is being pumped, do not measure. Return later when the water level has stabilized. Using past field notes, the field technician will use his/her experience to determine the appropriate duration necessary for static measurements. Upon returning to the well site (at a location where pumping was previously noted on the same day), the technician will measure the water level. The technician will have available historical water level data to determine whether the measurement is consistent with past measurements. If the initial measurement appears anomalous, the technician will measure water levels every 10 minutes over a period of 30 minutes.[1] If measurements vary significantly from past measurements (taking into account seasonal variations), the technician will note the circumstances (i.e., the date and time when the well was first visited, total time it was pumping (if known), when it was shutoff, when the

[1] During this period, if the groundwater level difference is greater than +/- 0.02 feet, repeat the same procedure until three consecutive measurements are recorded within +/- 0.02 feet.

technician returned, and subsequent water level measurements [on the same day, or as the case may be based on experience, the day immediately following]). Subsequent consideration of pumping effects at a site-specific well location will be addressed as necessary.

Recordation

1. Name of field technician
2. Unique identification of well
3. Weather and site conditions (e.g., clear, sunny, strong north wind, intense dust blowing over wellhead from nearby plowed field; dry ground, easy access)
4. Condition of well structure (e.g., well cap cracked – replaced with new one; wasp hive between well casing and well housing; no action, discuss with project manager)
5. Time and date of depth-to-water reading
6. Any other pertinent comments (e.g., sounder hangs up at 33 feet, thus no measurement; or: fifth measurement of ~55.68 feet in a row…residual water in end cap?; or: oil in well…measurement is depth to oil; or: intense sulfur odor upon opening well cap; or: nearby (west ~100 feet) irrigation well pumping)

CALIFORNIA STATEWIDE GROUNDWATER ELEVATION MONITORING
(CASGEM)

STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES

GROUND WATER LEVEL MEASUREMENTS

Monitoring Entity: Napa County
Monitoring Period:____
Measuring Agency Number: 3983
Measured By:____

STATE WELL NUMBER	COUNTY WELL ID	MSRMNT DATE	R.P. ELEVATION (NAVD88 ft)	DIST. R.P. TO WATER	METHOD OF WATER DEPTH MSRMNT	MSRMNT QUALITY CODES[1]	MSRMNT TIME	COMMENTS

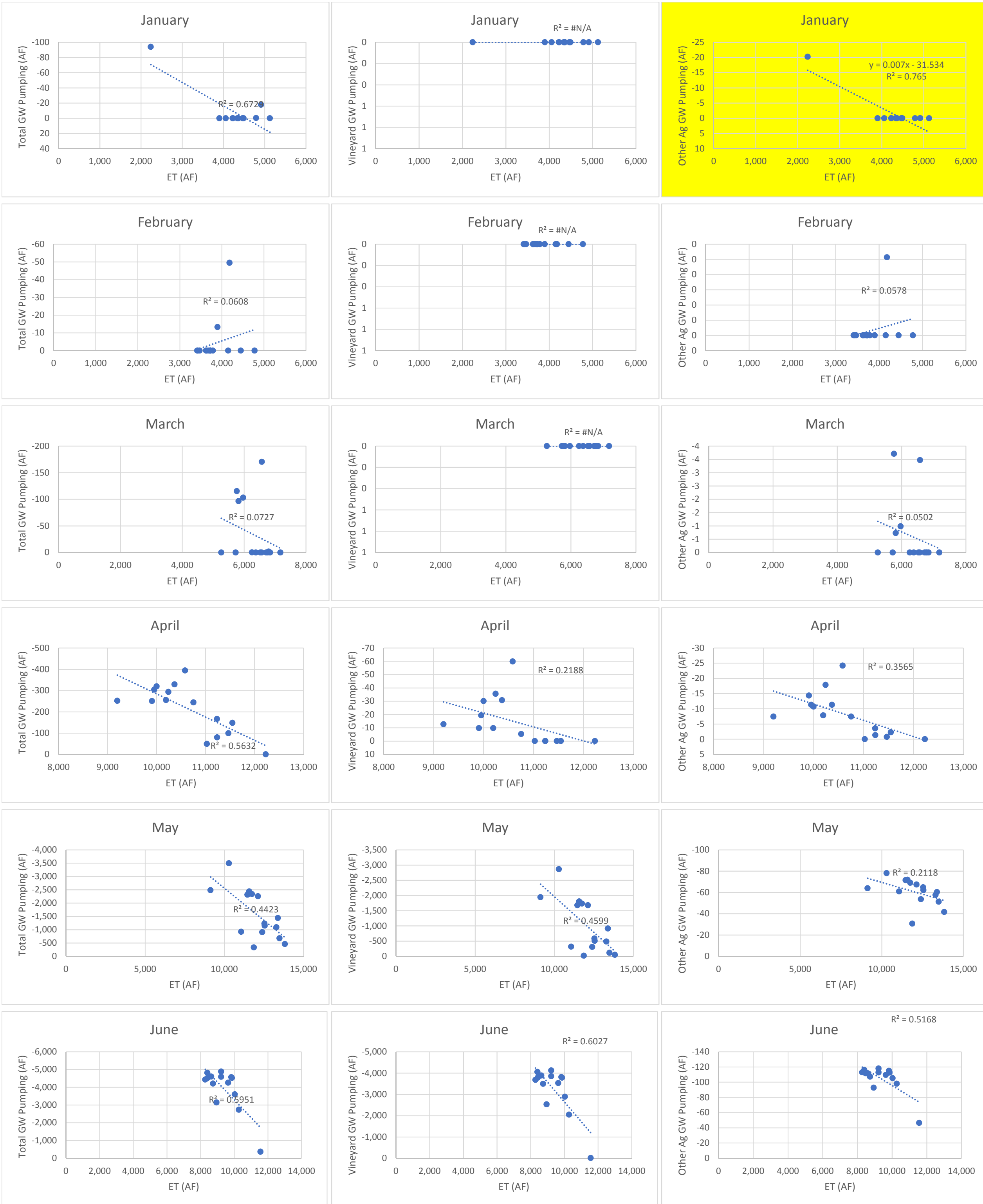
1 MEASUREMENT QUALITY CODES:

- If **no** measurement is taken, a specified "no measurement" code, must be recorded.
  0. Discontinued 1. Pumping 2. Pumphouse locked 3. Tape hung up 4. Can't get tape in casing 5. Unable to locate well 6. Well destroyed 7. Special 8. Casing leaking or wet 9. Temporarily inaccessible D. Dry well F. Flowing well
- If the quality of a measurement is **uncertain**, a "questionable measurement" code can be recorded.
  0. Caved or deepened 1. Pumping 2. Nearby pump operating 3. Casing leaking or wet 4. Pumped recently 5. Air or pressure gauge measurement 6. Other 7. Recharge operation at nearby well 8. Oil in casing 9. Acoustical sounder measurement

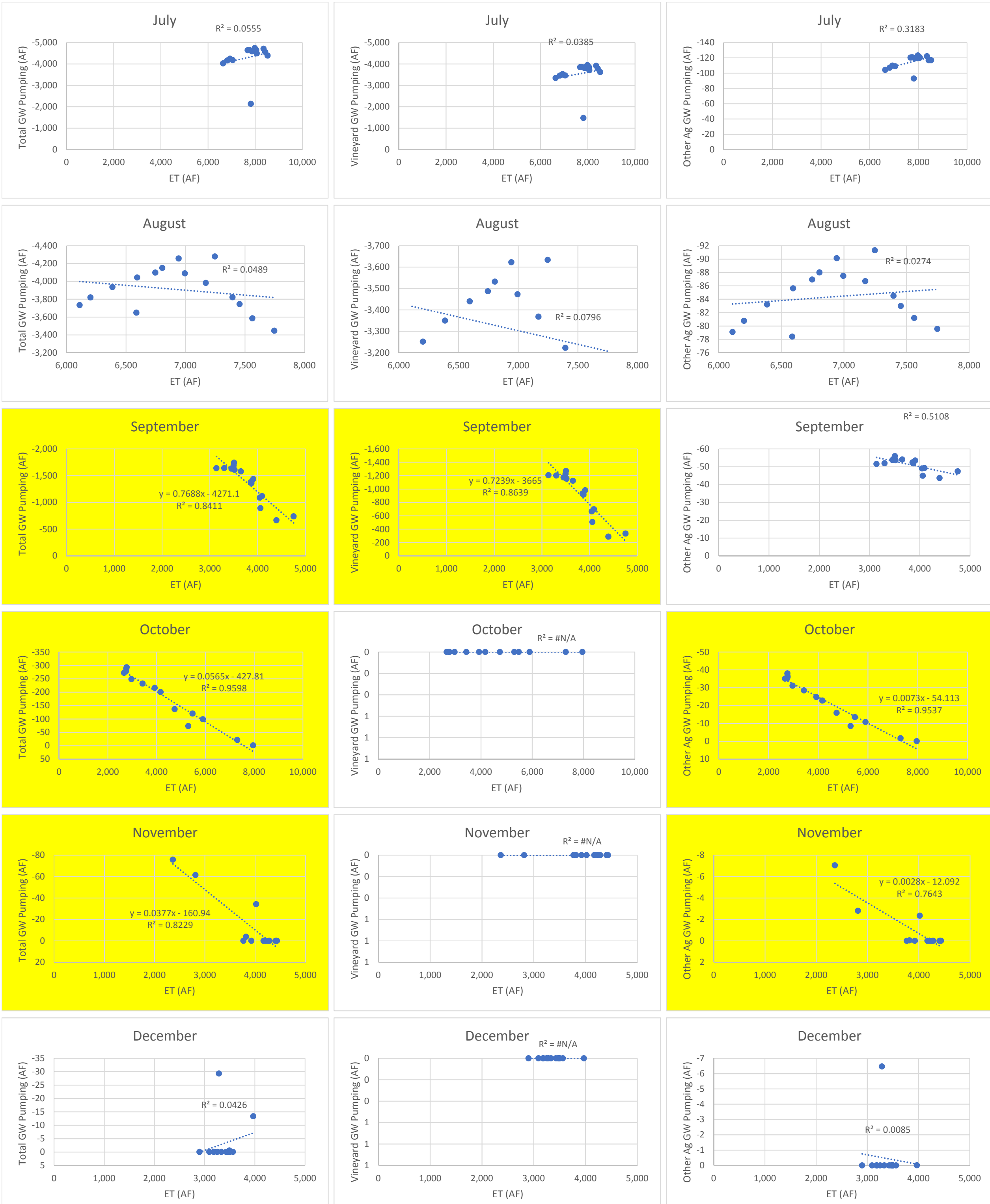
APPENDIX E

Linear Correlation Plots

Monthly Groundwater Components vs Evapotranspiration (Jan - June)

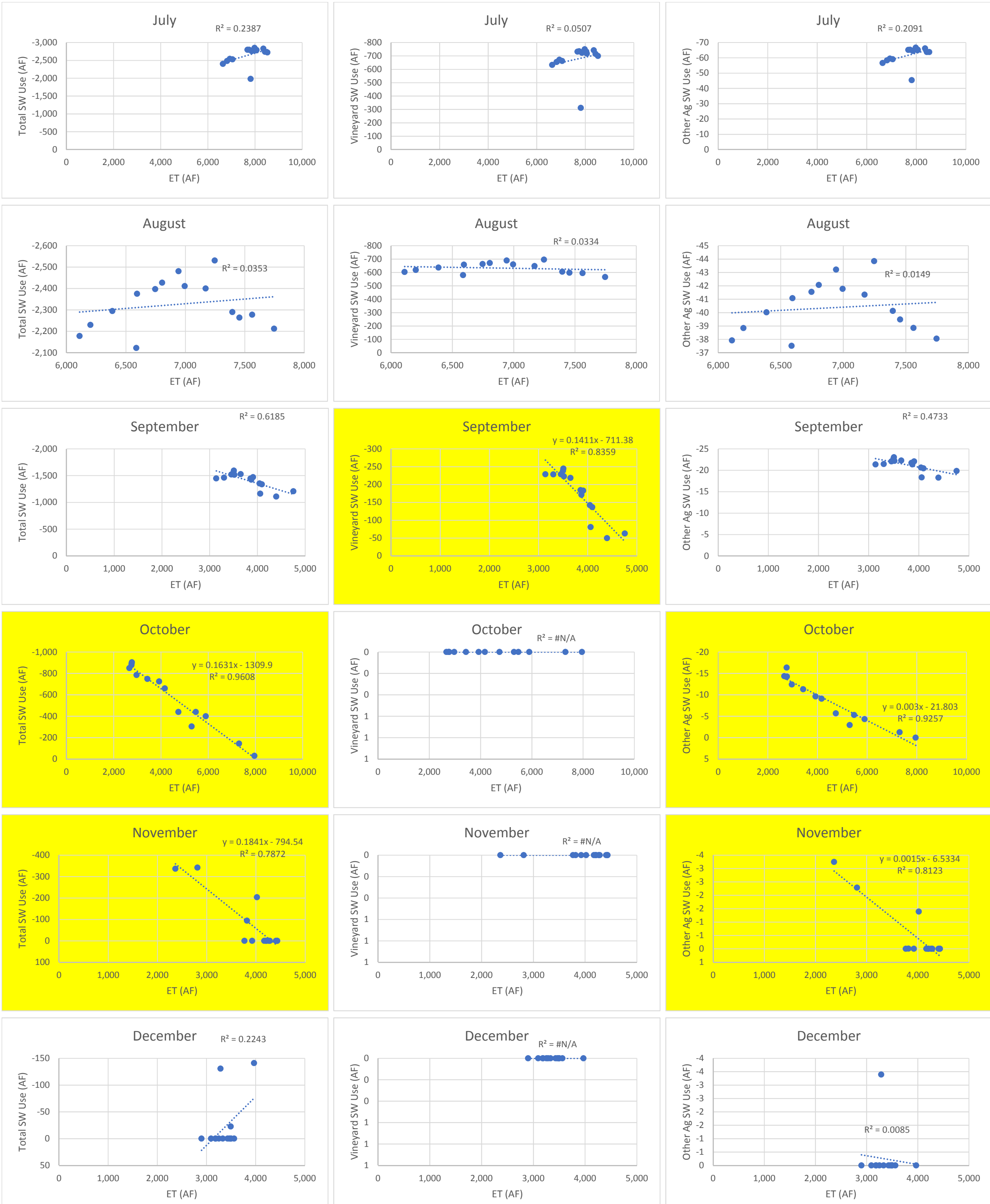


Monthly Groundwater Components vs Evapotranspiration (July - Dec)

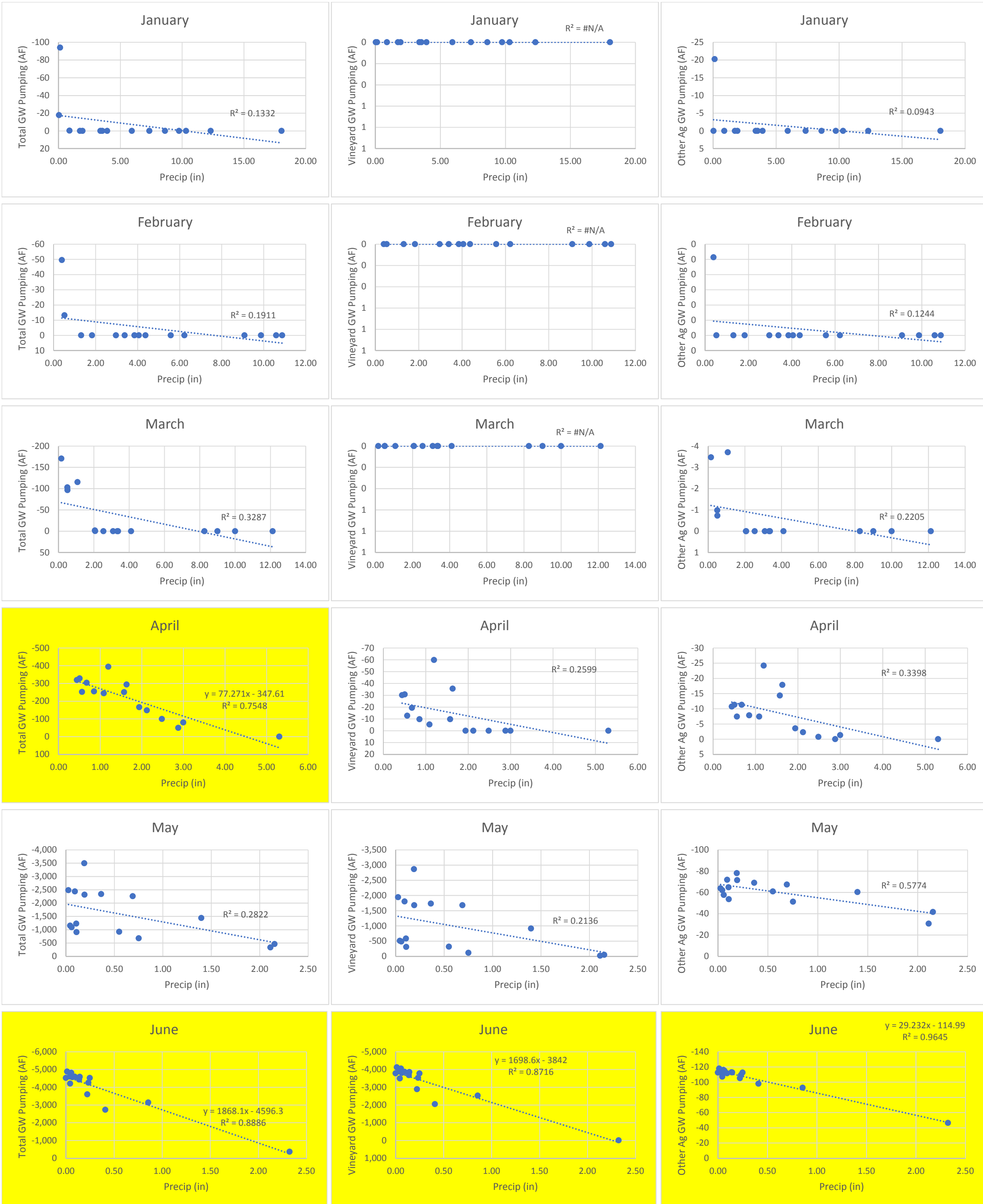


Monthly Surface Water Components vs Evapotranspiration (Jan - June)

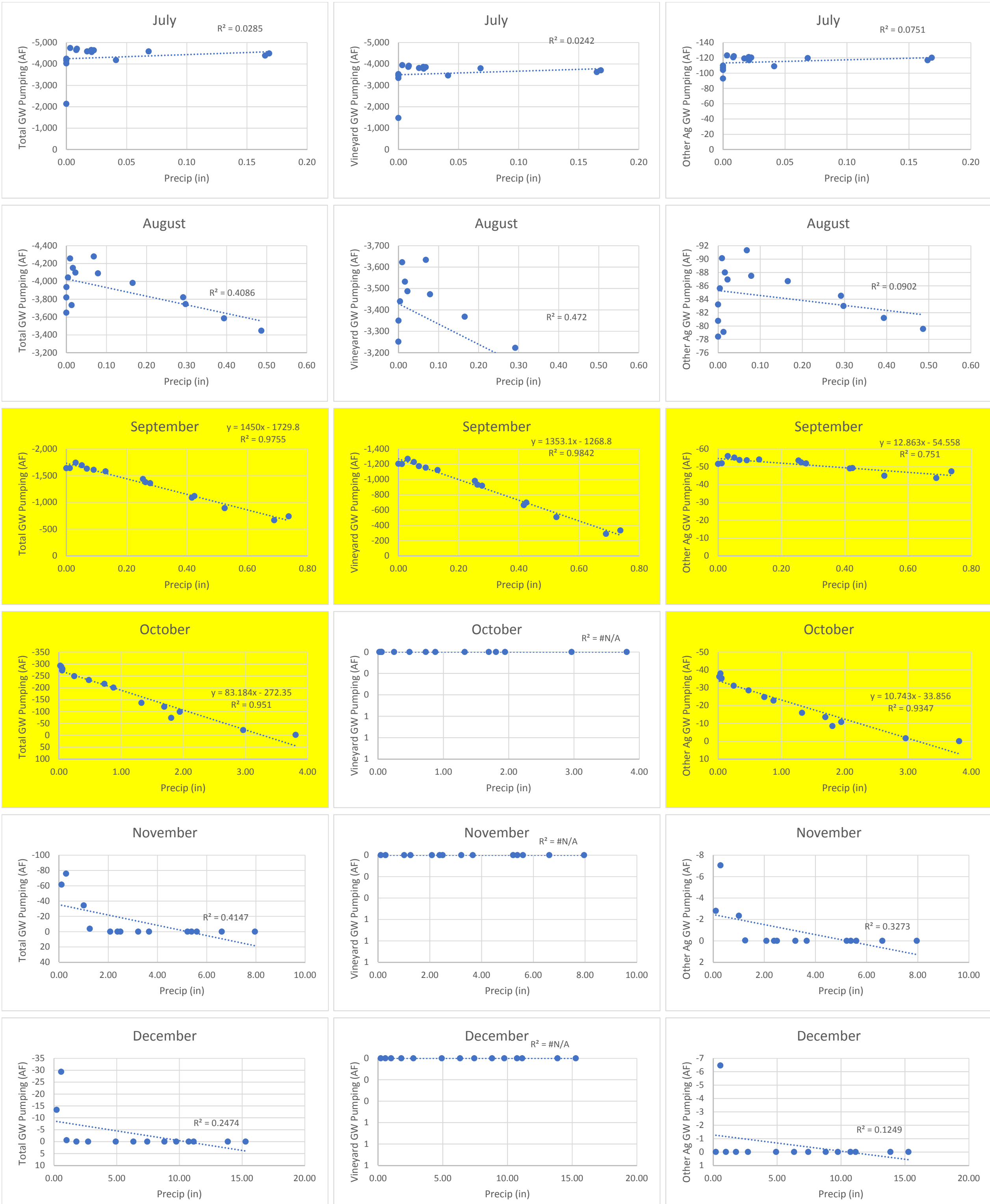
Monthly Surface Water Components vs Evapotranspiration (July - Dec)



Monthly Groundwater Components vs Precipitation (Jan - June)



Monthly Groundwater Components vs Precipitation (July - Dec)



Monthly Surface Water Components vs Precipitation (Jan - June)

Monthly Surface Water Components vs Precipitation (July - Dec)