Appendix 1-A

Central Sacramento County Groundwater Management Plan
(February 2006)

CENTRAL SACRAMENTO COUNTY

GROUNDWATER MANAGEMENT PLAN

FEBRUARY 2006

MWH

WATER FORUM

SACRAMENTO COUNTY WATER AGENCY

Members of the Central Sacramento County Groundwater Management Plan Task Force

The following participants are thanked for generously giving their time and effort in the oversight and preparation of the Central Sacramento County Groundwater Management Plan:

Agricultural Interests:

Denny Lewis *(Sacramento County Farm Bureau)*

Ronald Lowry (*Omochumne-Hartnell Water District)*

Larry Rodriguez (*Omochumne-Hartnell Water District)*

Agricultural/Residential Interests:

Stuart Helfand *(Ag/Res Resident)*

Ken Stroth *(Ag/Res Resident)*

Business Interests:

Ken Allred *(Building Industry Association/Chambers of Commerce)*

Environmental/Community Organizations Interests:

Mike Eaton *(The Nature Conservancy)*

Rick Bettis *(League of Woman Voters)*

Local Governments/Public Agencies Interests:

Clarence Korhonen *(City of Elk Grove)*

Jim Sequiera *(City of Elk Grove)*

Edwin Smith *(Southgate Recreation & Park District)*

Mel Johnson *(City of Sacramento)*

Herb Niederberger *(County of Sacramento)*

Ruben Robles *(Sacramento County Regional Sanitation District)*

Albert Stricker *(City of Rancho Cordova)*

Walter Sadler *(City of Folsom)*

Water Purveyor Interests:

Scott Fort *(Golden State Water Company)*

Dan Mizerski *(California-American Water Company)*

Mike Kenny *(Elk Grove Water Service)*

Darrell Eck (*Sacramento County Water Agency)*

California Department of Water Resources:

Mike Floyd

Eric Hong

Water Forum Successor Effort Staff:

Leo Winternitz

Jim McCormack

Eme Iturralde

Project Management Team:

Larry Norton *(Center for Collaborative Policy)*

Jim McCormack *(Water Forum)*

Anthony Saracino *(TNC)*

Darrell Eck *(SCWA)*

Jafar Faghih *(MWH)*

Jonathan Goetz *(MWH)*

Executive Summary

Executive Summary

Table of Contents

Page

Foreword ES-1
Introduction ES-1
Purpose of GMP ES-2
- What is required in a GMP? ES-2
- How does a GMP benefit the basin stakeholders? ES-2

Water Resources Setting ES-2
- Physical Setting ES-2
- The Central Basin ES-4
- How does the GMP address groundwater contamination problems in the Central Basin? ES-4
- Supply and Demand ES-4
- How much water supply does the Central Basin have? ES-4
- How are water demands calculated? ES-8

Management Plan Elements ES-8
- Basin Management Objectives ES-9
- Program Component Action Items ES-9

Plan Implementation ES-12
- BMO Trigger Point Activities ES-12
- Protection of Privately Owned Wells ES-12
- How is an existing private well protected? ES-12
- How is the private well owner kept notified of groundwater contamination clean-up efforts? ES-12
- Basin Governance Body ES-13
- Plan Implementation Costs ES-13

Executive Summary

FOREWORD

The Central Sacramento County Groundwater Basin stakeholders, in coordination with the Sacramento County Water Agency and the Water Forum Successor Effort have developed the Central Sacramento County Groundwater Management Plan (CSCGMP). The CSCGMP represents a critical step in establishing a framework for maintaining a sustainable groundwater resource for the various users overlying the basin in Sacramento County between the American and Cosumnes Rivers. It includes specific goals, objectives, and an action plan to provide a "road map" for the governance body as the steps necessary to manage the basin are taken in coordination with the various stakeholders. This Executive Summary is an outreach component of the CSCGMP that brings forth the essence of the CSCGMP in a similar format but in a condensed manner that still allows a basic level of understanding. The reader is encouraged to refer to the larger CSCGMP document if additional detail is needed.

INTRODUCTION

The CSCGMP is the result of over a decade of negotiations and agreements between stakeholders in the region. In 2000, the Water Forum Agreement (WFA) was signed by regional stakeholders, and the Water Forum Successor Effort (Successor Effort) was formed to continue forward in regional water supply planning.

The WFA laid the foundation for the Successor Effort. One of the responsibilities of the Successor Effort was to facilitate negotiations among stakeholders in the Central Sacramento County Groundwater Basin (Central Basin) that would lead to the creation of a groundwater basin governance body. This governance body would be responsible for the protection, health and long-term viability of the underlying groundwater as a sustainable resource for both current and future users. **Figure ES-1** shows the locations of the groundwater basins within Sacramento County.

Under the aegis of the Successor Effort, the Central Sacramento County Groundwater Forum (CSCGF) was formed in February 2002 to provide recommendations on a basin governance body to the Successor Effort. Following concurrence by the Successor Effort, this recommendation would be adopted by the appropriate agencies.

The CSCGF stakeholder interest groups included representatives in the following areas:

- Agricultural
- Agricultural Residential Groundwater Users
- Business Interests
- Environmental/Community Organizations
- Local Government/Public Agencies
- Water Purveyors

The total number of stakeholder representatives was approximately 40 people. These representatives met monthly for approximately three years at which time a decision was made to create an Advisory Committee, composed of CSCGF stakeholders, to develop a groundwater management plan for the Central Basin. The Advisory Committee spent approximately one year in developing the CSCGMP for adoption by the full CSCGF.

PURPOSE OF GMP

A Groundwater Management Plan (GMP) is a planning tool that assists overlying water providers in maintaining a safe, sustainable and high quality groundwater resource within a given groundwater basin. This CSCGMP is intended to be adaptive to changing conditions within the groundwater basin and will be updated and refined over time to reflect progress made in achieving the CSCGMP's objectives.

What is required in a GMP?

The GMP is a tool used to help ensure a long-term reliable water supply for rural domestic, agricultural, urban, business/industrial, environmental, and development uses in the region. The California Water Code (CWC) requires that a GMP contain numerous technical provisions which are briefly summarized as follows:

- An inventory of water supplies and a description of water uses within a given region. This information is summarized in a water balance showing overall water demands and available water supplies.
- Basin Management Objectives (BMOs) that are designed to protect and enhance the groundwater basin.
- Monitoring and management programs that ensure the BMOs are being met.
- Description of stakeholder involvement and public information plan and programs for the groundwater basin.

How does a GMP benefit the basin stakeholders?

The CSCGMP provides information related to planning activities currently taking place in the Central Basin. This information serves the following purposes:

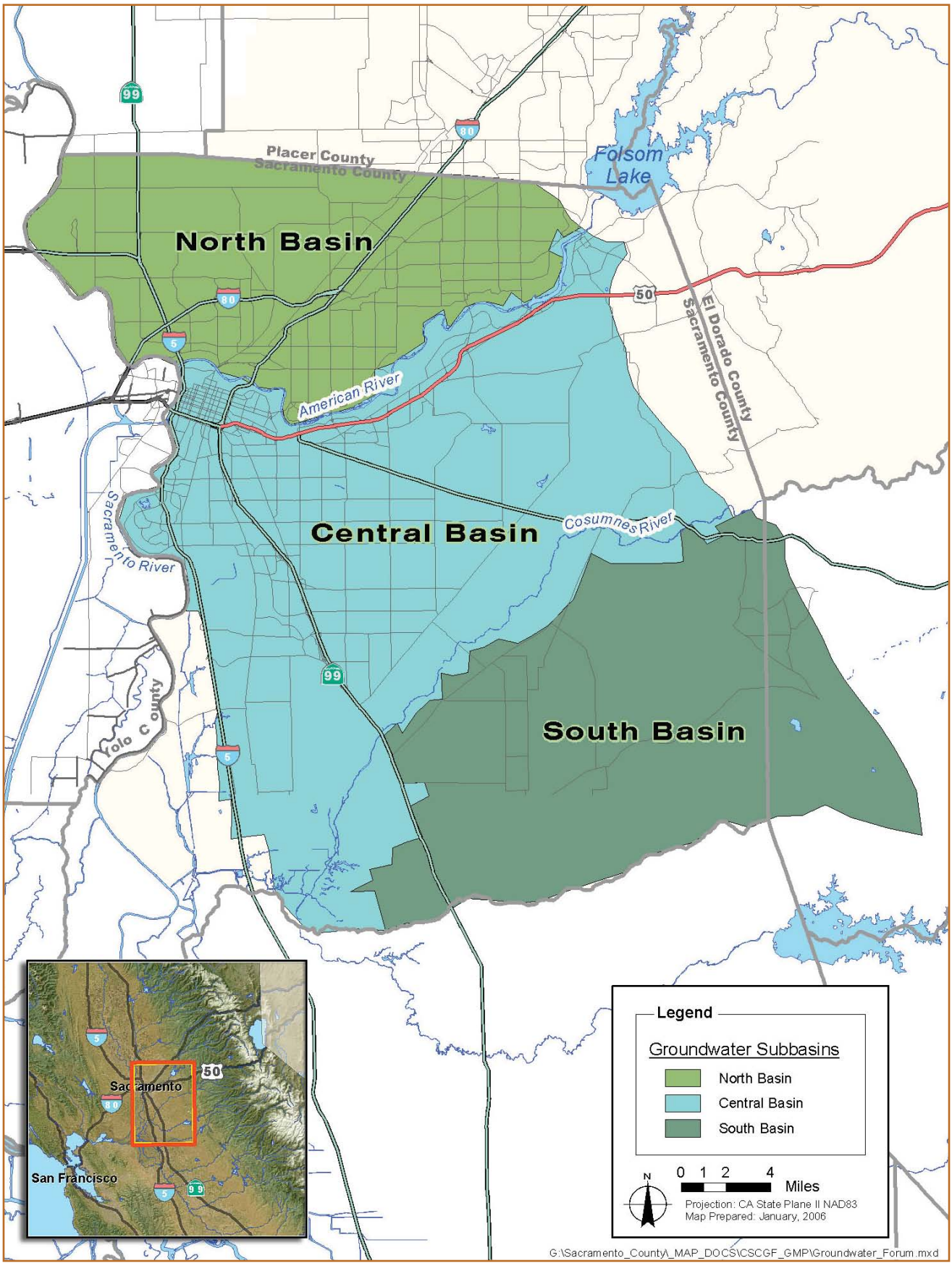
- It provides a management plan for the protection and preservation of groundwater resources.
- It underscores stakeholder interests and objectives.
- It ensures protection of groundwater quantity and quality.
- It assists in monitoring and maintaining groundwater elevations.

WATER RESOURCES SETTING

Physical Setting

Unique to Sacramento County are three major rivers each acting as a major source of recharge for the groundwater basin underlying the county. In some instances, the recharge process creates natural dividing lines along the rivers that can be used to delineate

Figure ES-1. Sacramento County Groundwater Basins



the individual sub-basins (i.e., North, Central, and South Basin as shown in **Figure ES-1**). Groundwater underlying the North Basin is currently managed by the Sacramento Groundwater Authority. Efforts are underway in the South Basin, led by the Southeast Sacramento County Agricultural Water Authority, to develop a groundwater management plan in accordance with the CWC and the provisions of the WFA.

The Central Basin

The Central Basin is made up of a variety of groundwater users (i.e., agriculture, agricultural residential, urban, and environmental). The Central Basin boundary was defined by the Sacramento County groundwater model that was used in the Water Forum process and took into account the hydrogeologic boundaries and the political boundaries of organized water purveyors/districts, cities (where they retail water within their boundaries), and the County of Sacramento.

In October 2004, the Sacramento County Water Agency (SCWA) adopted a GMP for the portion of the Central Basin that is served water through Zone 40 of the SCWA. The Zone 40 GMP was done to measure the effectiveness of the conjunctive use program outlined in the Zone 40 Water Supply Master Plan and for the purpose of seeking state grant funding to help finance large infrastructure projects that would benefit groundwater underlying the Central Basin. At the time of its adoption, the Zone 40 GMP recognized that a Central Basin GMP was necessary to meet the needs and interests of all the stakeholders in the Central Basin.

Groundwater underlying the Central Basin is contained within a shallow aquifer (Modesto Formation) and in a deep aquifer (Mehrten Formation). Groundwater is located from 20 to 100 feet below the ground surface depending on when and where the measurement is taken. The shallow aquifer is typically used for private domestic wells and typically requires no treatment. The deep aquifer is separated from the shallow aquifer by a discontinuous clay layer that serves as a semi-confining layer. The deep aquifer typically requires treatment for iron and manganese, which may cause mineral deposits and affect the taste of water. **Figure ES-2** contains a conceptual diagram of the aquifer.

Intensive use of groundwater over the past 60 years has resulted in a general lowering of groundwater elevations. Over time isolated groundwater depressions have grown and coalesced into a single cone of depression that is centered in the southwestern portion of the Central Basin (see **Figure ES-3** for Sacramento County Groundwater Elevations).

How does the CSCGMP address groundwater contamination problems in the Central Basin?

There are several sources of groundwater contamination within the Central Basin. These sources include: Mather Field, Aerojet, Boeing, the former Sacramento Army Depot, the Union Pacific railyards, and present and former landfills. The known extent of groundwater contamination and landfill sites are shown on **Figure ES-4**. The CSCGMP addresses the concerns well owners have regarding the potential for groundwater contamination threatening their wells.

Supply and Demand

The CSCGMP identifies available water supplies to meet the water demands of users within the basin. Water supplies include surface water, groundwater, recycled water, and remediated groundwater. Water demand is a result of rural, agricultural, private industrial, environmental, and urban activities. Demand reduction is being accomplished through water conservation measures identified in the WFA.

How much water supply does the Central Basin have?

Water supplies have been quantified in some detail in the CSCGMP. Availability and reliability of surface water is dependent on the particular contract or water right and the hydrologic year type (e.g., wet or dry years). **Figure ES-5** summarizes surface water supplies available to each of the surface water purveyors and

identifies the river source from which they originate. Based on existing and projected contract and water right entitlements, the total surface water supply available to the Central Basin is approximately 350,000 AF/year.

In addition to surface water supplies, the Water Forum determined the estimated long term average annual sustainable yield of groundwater from the Central Basin to be 273,000 acre-feet per year (AF/year). Currently, groundwater extractions are estimated to be 250,000 AF/year.

Recycled water use in the Central Basin is planned for up to 4,400 AF/year by 2030. The Sacramento Regional County Sanitation District is currently developing a Recycled Water Master Plan that will evaluate the feasibility of increased recycled water use in the County.

Water that is extracted for purposes of groundwater contamination clean-up activities is included in the overall sustainable yield of the Central Basin aquifer. In-basin use of remediated groundwater is an objective of the CSCGMP. This issue is addressed more fully in the Groundwater Contamination Monitoring and Collaboration Program summarized in the Plan Implementation section.

Figure ES-2. Hydrogeologic Cross Section

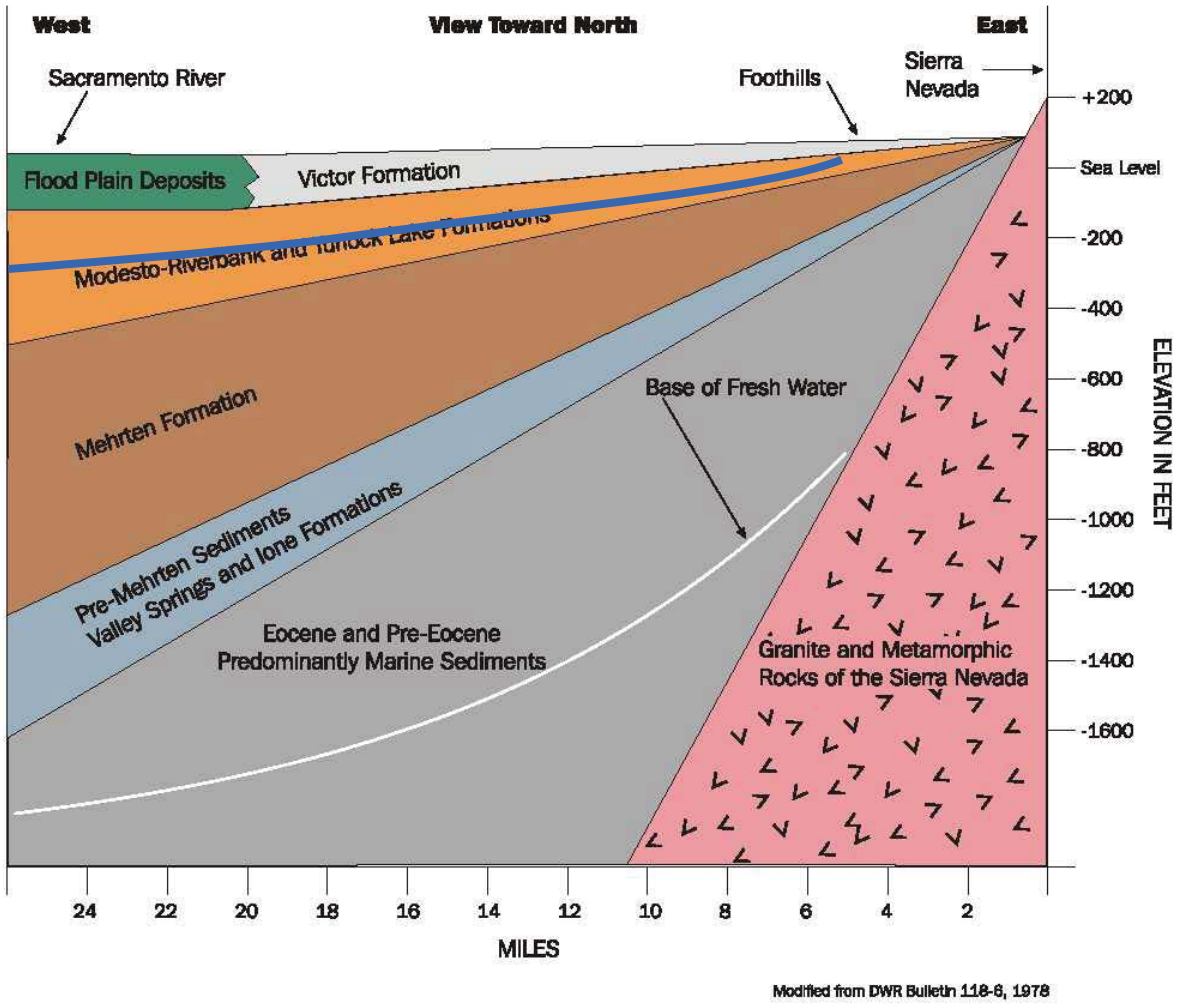


Figure ES-3. Spring 2004 Sacramento County Groundwater Elevation Contour Map

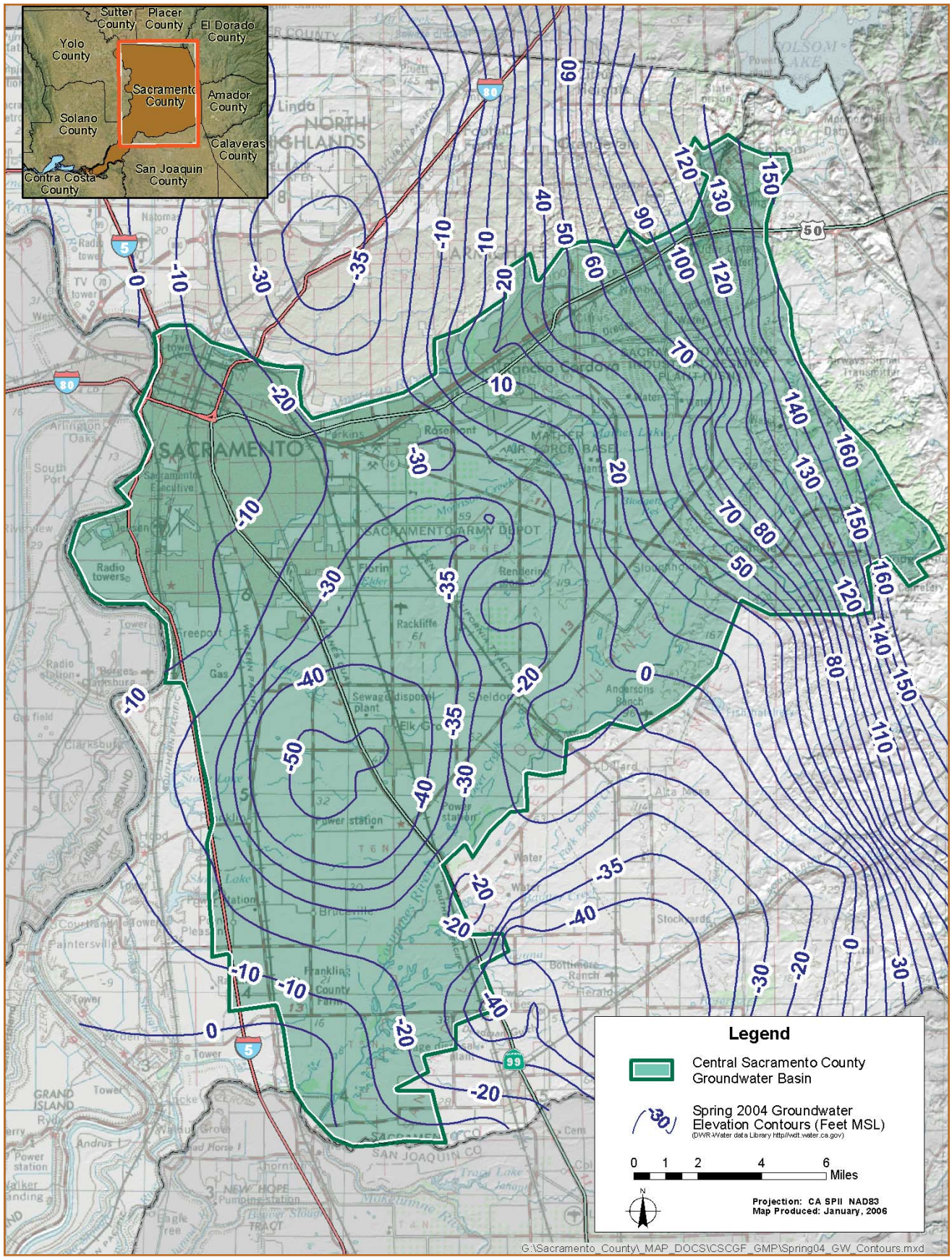
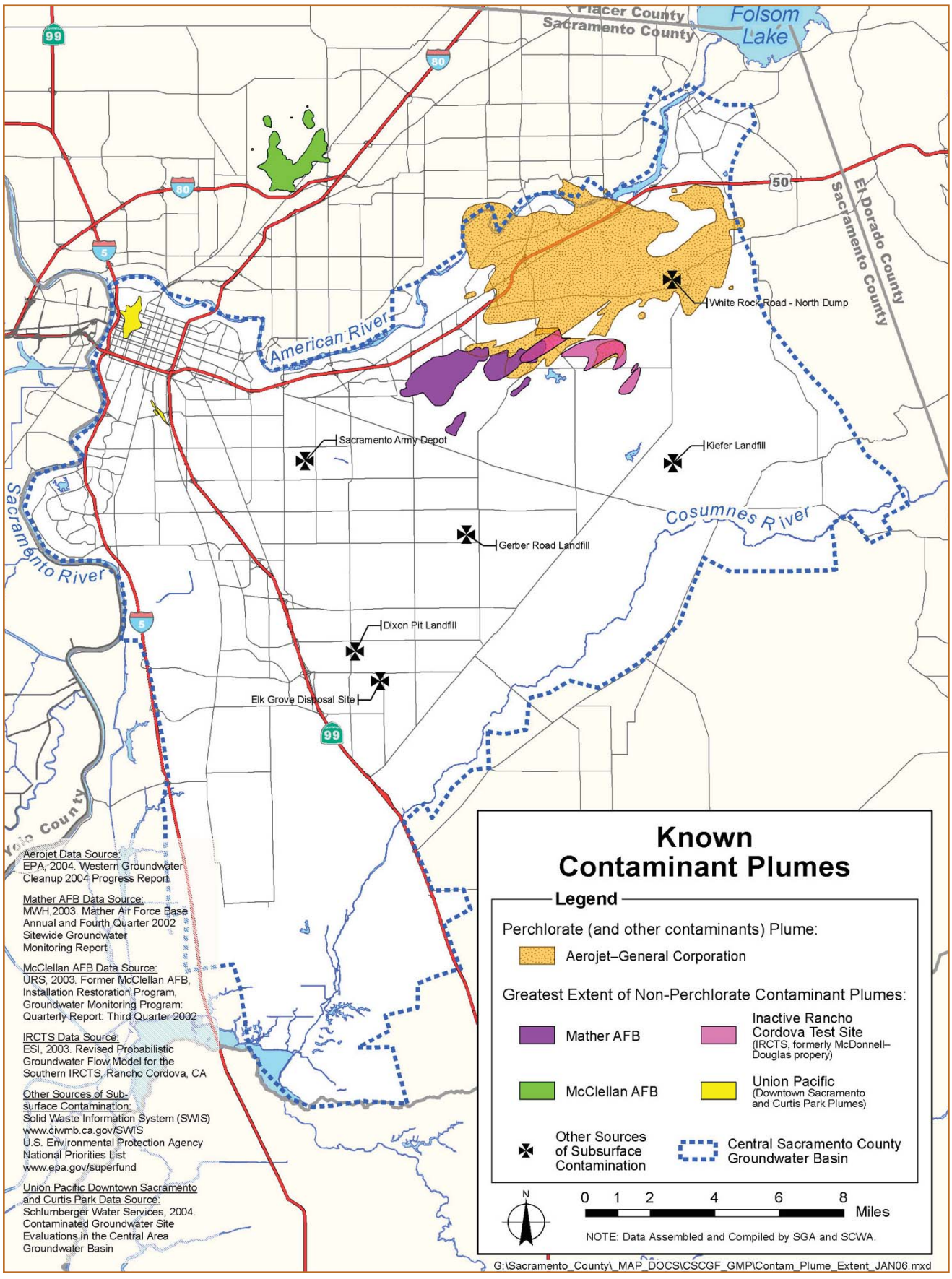


Figure ES-4. Known Extent of Contamination



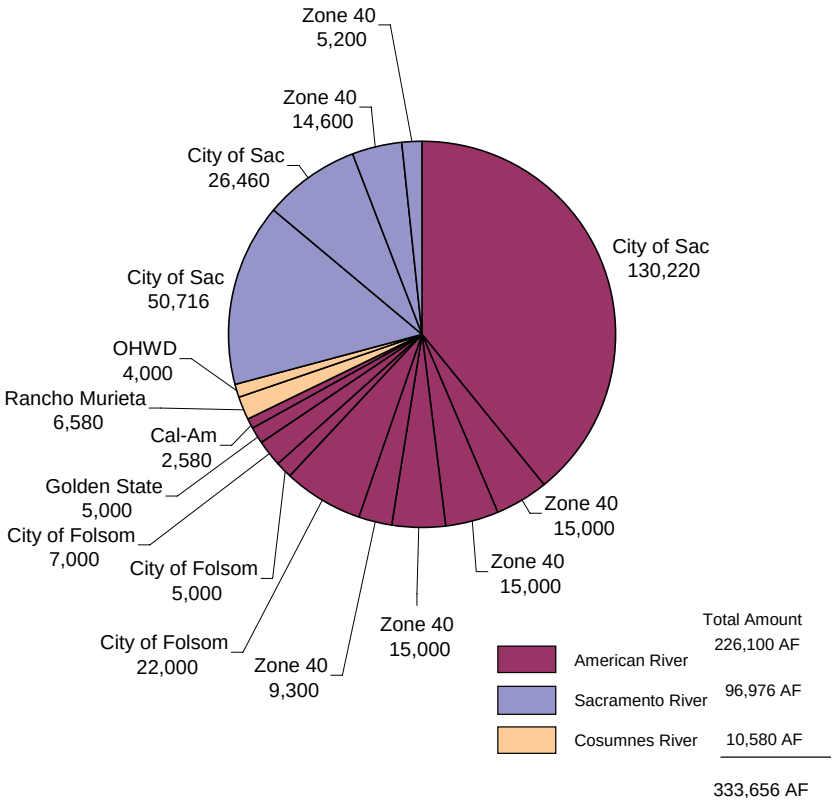
How are water demands calculated?

Water demands are determined using various methods based on identified uses of water. For instance, agricultural demands can vary significantly based on crop type. For agricultural-residential water users, demands are based on indoor usage, the amount of landscaped area around the home, and the amount of irrigated pasture for parcels that maintain livestock or other farm animals. Urban water demands are typically based on land use and zoning. Private industry and park district water demands are specific to the type of activity taking place at each site. Existing and future average annual water supply and demand is summarized in **Figure ES-6a and ES-6b** below. The graphs indicate that supplies meet demands and fluctuate depending on dry and wet hydrologic conditions, reflecting the conjunctive use of groundwater and surface water over the Central Basin by the various water purveyors and urban demand reductions during dry years. (In **Figure ES-6b**, conditions in 2030 demonstrate more clearly the results of existing and planned conjunctive use programs in full effect at that time). These demands also reflect the implementation of Best Management Practices (BMPs) for water conservation that are described in the WFA.

MANAGEMENT PLAN ELEMENTS

A goal of the CSCGMP is to ensure a viable groundwater resource for beneficial uses including water for purveyors, agricultural, agricultural residential, industrial, and municipal supplies that support the WFA's coequal objectives of providing a reliable and safe water supply and preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River. In addition, the CSCGMP recognizes the need to maintain and enhance flows in the Cosumnes River because of its ecological significance.

Figure ES-5. Summary of Surface Water Rights and Contracts



Basin Management Objectives

Basin Management Objectives (BMOs) are used to help achieve groundwater basin goals. Five BMOs provide the foundation for the CSCGMP:

1) Maintain a long-term average groundwater extraction rate of 273,000 AF/year.
2) Establish specific minimum groundwater elevations within all areas of the basin consistent with the Water Forum "Solution."
3) Protect against any potential inelastic land surface subsidence.
4) Protect against any adverse impacts to surface water flows.
5) Develop specific water quality objectives for several constituents of concern.

Each of these objectives is fully described in **Section 3** of the CSCGMP.

Program Component Action Items

The Program Components listed below provide specific action items that will be implemented to help achieve the Basin Management Objectives.

Stakeholder involvement - several means of achieving broad stakeholder participation in the management of the Central Basin will be used, including: 1) involving the public, 2) involving other agencies within and adjacent to the Central Basin, 3) using advisory committees, 4) developing relationships with state and federal agencies, and 5) pursuing a variety of partnership opportunities.

Monitoring program - a good monitoring program is capable of assessing the current status of the basin and predicting responses in the basin as a result of future management actions. The CSCGMP includes actions related to monitoring of groundwater elevations, groundwater quality, the potential for land surface subsidence resulting from groundwater extraction, and developing a better understanding of the relationship between surface water and groundwater along the American, Cosumnes, and Sacramento Rivers.

Groundwater quality protection - groundwater quality protection is critical to ensuring a sustainable groundwater resource. Groundwater quality protection includes: 1) the prevention of contamination from entering the groundwater basin, and 2) the remediation of existing contamination.

Groundwater sustainability - the CSCGMP seeks to maintain or increase the amount of groundwater stored in the basin over the long-term. The WFA's groundwater management element provides a framework by which the groundwater resource in the Sacramento County-wide basin can be protected and used in a sustainable manner.

Planning integration - it is important to integrate water management planning on a regional scale (i.e., the development of an Integrated Regional Water Management Plan). The WFA provides a regional conjunctive use framework with commitments from individual purveyors concerning groundwater and surface water operations, including limitations on surface water diversions from the lower American River during dry years.

Figure ES-6a. 2005 Annual Average Water Balance

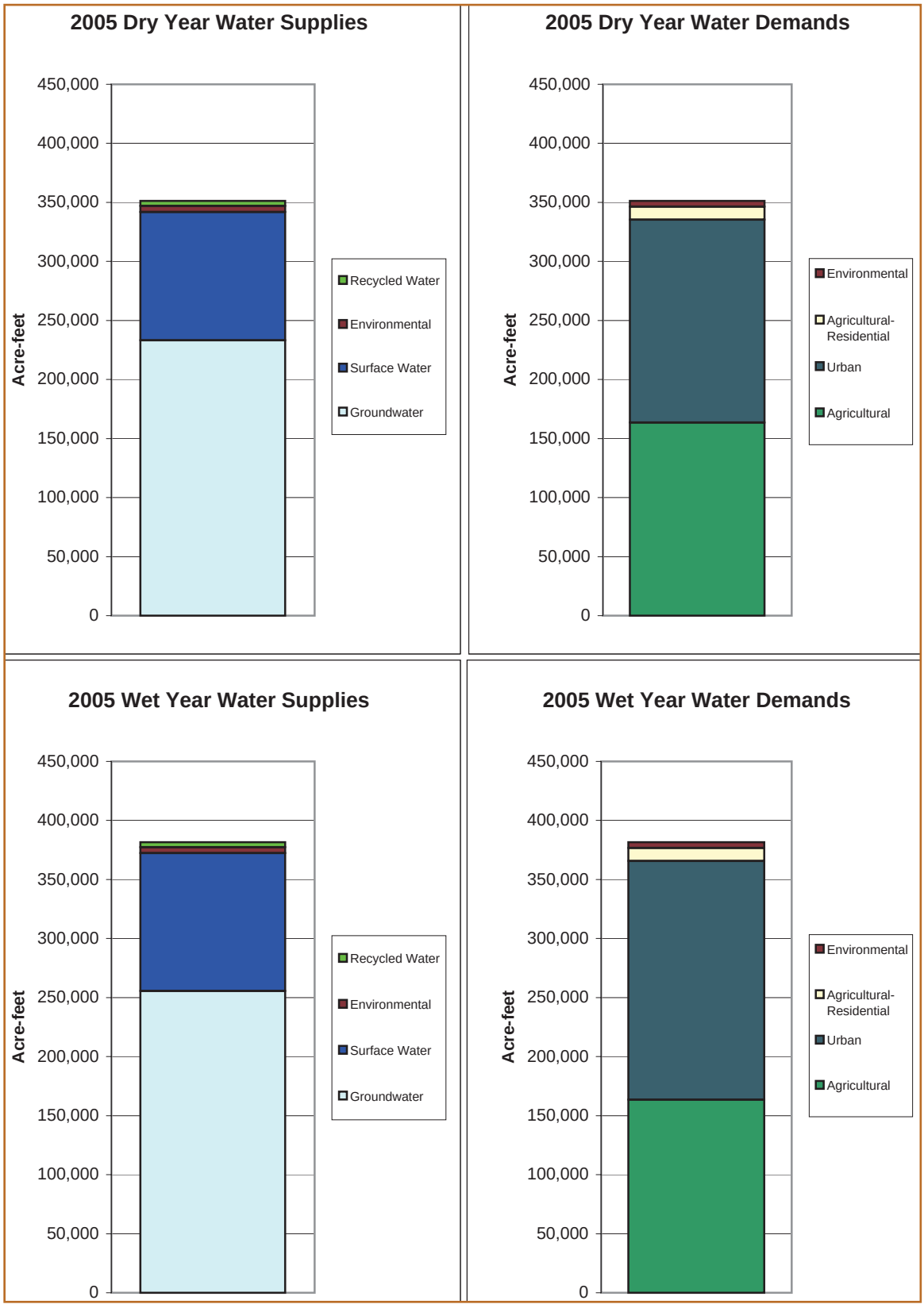
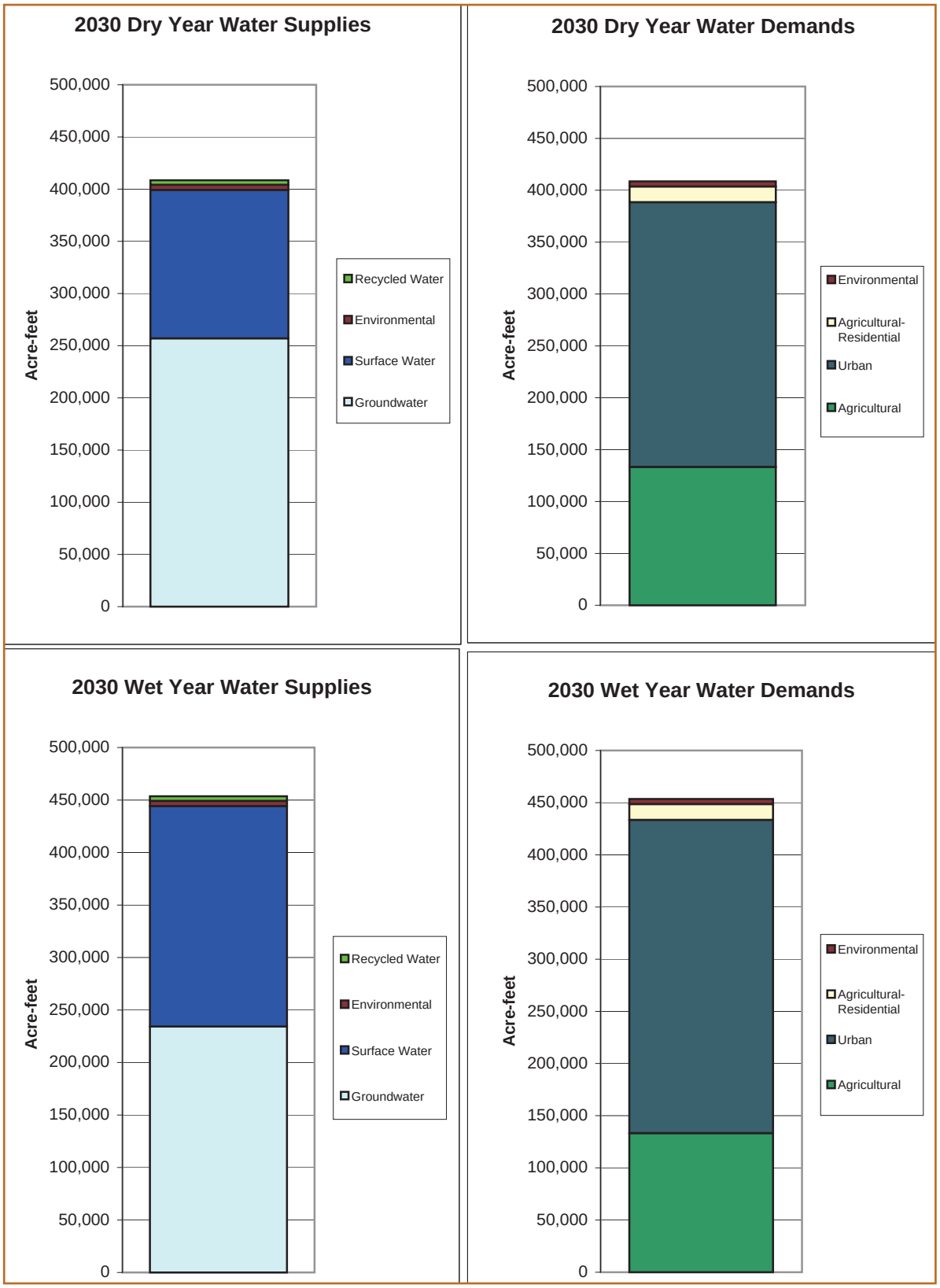


Figure ES-6b. 2030 Annual Average Water Balance



PLAN IMPLEMENTATION

An important element of a GMP is the establishment of trigger points and remedies necessary to fully implement the BMOs. Many of the remedies set forth in this GMP involve coordination with other local, state, and federal agencies. This coordination will begin upon adoption of the CSCGMP by the governance body.

BMO Trigger Point Activities

Trigger Point activities involve monitoring and assessing trends in the basin to determine the adequacy of the monitoring network for meeting the goals and objectives of the CSCGMP. These assessments will be made as new monitoring data become available for review by the basin governance body and results documented in an annual State of the Basin report. As mentioned in the introduction, this GMP is adaptive and relies on monitoring data, evaluation of remedies based on monitoring data and input from basin stakeholders. It requires that the basin be managed in a manner that makes the most practical sense in light of on-going collection and analysis of data.

Protection of Privately Owned Wells

The CSCGMP includes two programs that were negotiated by the stakeholders in the Central Sacramento County Groundwater Forum: the Well Protection Program and the Groundwater Contamination Monitoring and Collaboration Program.

How is an existing private well protected?

The Well Protection Program grew out of discussions that took place in the CSCGF and stems from the need to protect domestic and agricultural irrigation wells. Protection of existing privately owned wells is of fundamental importance to the stakeholders of the CSCGF. As part of this program, a trust fund will be put in place to cover costs of deepening or replacing any existing well that provides water for agricultural or domestic use that may be impacted by future development. The trust fund revenue will be generated from a fee assessed on every new building permit and permit to drill a new well. In 2005, the fee is estimated to be less than $100 per equivalent dwelling unit (e.g. single family home) within the basin.

How is the private well owner kept notified of groundwater contamination clean-up efforts?

The Groundwater Contamination Monitoring and Collaboration Program is focused on maintaining a clear line of communication between the designated Responsible Parties for groundwater contamination clean-up activities and private well owners. The program encourages the use of remediated groundwater in urbanized areas to keep the groundwater in the basin. This program also envisions the Regional Water Quality Control Board requiring designated Responsible Parties to survey private wells within 2,000 feet of any identified contamination plume. Assistance will also come from the Sacramento County Environmental Management Department (EMD). EMD is encouraged to exercise the strictest vigilance to ensure that all permitting

requirements are enforced and that, if requirements are not met, EMD will undertake whatever rigorous enforcement actions are effective.

Basin Governance Body

The governance body is responsible for implementing the actions contained within this CSCGMP. The governance body will initiate the trust fund of the Well Protection Program, take over its administration, and provide annual reporting on the program. In addition, it will pursue any grant opportunities available to the Central Basin and participate in the Integrated Regional Water Management Plan that is currently underway. This is a regional planning document that is a prerequisite if a region is to pursue Proposition 50 implementation grant monies. Lastly, the governance body will collect, evaluate, and report on all of the data and management activities that have been taken in the Central Basin once a year in a State-of-the-Basin Report.

Plan Implementation Costs

First year program startup costs are estimated at $280,000. This is essentially 1.2 full-time people working throughout the year on setting up monitoring programs, taking measurements, compiling data, and reporting data. Future program costs will be evaluated on an annual basis by the basin governance body.

GROUNDWATER MANAGEMENT PLAN

Foreword

The genesis of the Central Sacramento County Groundwater Management Plan (CSCGMP) stems from events that began in the early 1990s and continues to the present day. Foremost among these was the formation of the Sacramento Area Water Forum (Water Forum). At the culmination of the Water Forum process (1993 to 2000), a Water Forum Agreement (WFA) was signed by participating agencies (described in more detail in **Section 1**). After signing the WFA the Water Forum Successor Effort (Successor Effort) was formed to carry forward the work outlined in the WFA.

One of the objectives of the Successor Effort was the formation of a basin governance body for the Central Sacramento County Groundwater Basin (Central Basin). See **Figure 1-1** for the geographic location of the Central Basin and **Figure 1-2** for the location of existing organized water purveyors in the Central Basin. As a result, the Central Sacramento County Groundwater Forum (CSCGF) was established; each member or stakeholder of the CSCGF has an interest in the groundwater underlying the Central Basin (details of CSCGF membership are described further below). The stakeholders are listed as follows:

1. Local Government/Public Agencies Interests
2. Business Interests
3. Agricultural Interests
4. Agricultural/Residential Interests
5. Environmental/Community Organizations Interests
6. Water Purveyor Interests

In order to assist in the development of the basin governance body a recommendation was made to the CSCGF to first develop a groundwater management plan for the Central Basin. The stakeholders recognized that development of a groundwater management plan would help them focus on an appropriate structure for the basin governance body once they had an understanding of the responsibilities and requirements for implementing a groundwater management program. The CSCGF agreed by consensus to act on this recommendation and formed a smaller group of CSCGF stakeholders (GMP Task Force) that were tasked with developing the CSCGMP.

The CSCGMP is a tool that is designed to ensure a long-term reliable groundwater supply for beneficial use within the Central Basin. It should be noted that the CSCGMP is not a land use policy tool. However, it is understood that

a groundwater management plan may effect land use decisions simply through its influence on water use in a groundwater basin.

The structure of the CSCGMP is described below:

Section 1. Introduction. Describes the political and geographic setting and the activities taking place by water purveyors and interested stakeholders in the Central Basin.

Section 2. Water Resources Setting. Prior to managing a basin available water supplies have to be identified and quantified. In this section information is presented to assist the reader in understanding the availability of different water supplies and how they can be used within the Central Basin. This section provides a primer on the unique hydrogeology and setting within the Central Basin, it also provides an understanding of water quality issues and the groundwater and surface water infrastructure that is currently in-place. The relationship between water demands, water supplies, and land use are considered in the development of a water balance that examines current and future (2030) water supply needs.

Section 3. Components of the Groundwater Basin Management Plan. This section identifies the six components that constitute a groundwater management plan as described in the California Groundwater Management Guidelines (Groundwater Resources Association of California, Second Edition 2005). An important aspect of this section is the identification of Basin Management Objectives (BMOs) and the elements necessary for their implementation.

Section 4. Plan Implementation. Using the BMOs a set of threshold criteria (trigger points) have been developed to assist in reviewing and analyzing monitoring actions throughout the year. Once a trigger point is exceeded a recommended action takes place. Because the CSCGMP is based on adaptive management, trigger points and recommended actions can be changed by the basin management body. The section also includes a Well Protection Program that provides for the protection of domestic and agricultural and a Groundwater Contamination Collaboration Program to assist private well owners in understanding the risk of groundwater contamination to their wells.

Section 5. References. This section provides a compilation of references used in the development of the CSCGMP.

Table of Contents

Page

Section 1. Introduction 1-1
1.1 The Central Sacramento County Groundwater Management Plan 1-1
1.1.1 Water Forum as the Basis for the Central Sacramento County Groundwater Management Plan 1-4
1.2 North Sacramento County Groundwater Basin Activities 1-7
1.3 Central Sacramento County Groundwater Basin Activities 1-8
1.4 South Sacramento County Groundwater Basin Activities 1-8
1.5 Role of the Two Water Resources Managers in the Central Basin 1-10
1.5.1 Sacramento County Water Agency 1-10
1.5.2 City of Sacramento 1-10
1.6 Other Regional Management Efforts 1-11
1.6.1 Zone 40 Water Supply Master Plan and Environmental Documentation 1-11
1.6.2 The Freeport Regional Water Authority (FRWA) 1-11
1.6.3 The Nature Conservancy 1-12
1.6.4 Florin Resources Conservation District/Elk Grove Water Service 1-12
1.6.5 Southeast Sacramento County Agricultural Water Authority 1-13
1.6.6 Regional Water Authority 1-13
1.6.7 Sacramento Groundwater Authority 1-13
1.7 Authority To Prepare and Implement a GMP 1-13
1.8 CSCGMP Components 1-13
Section 2. Water Resources Setting 2-1
2.1 Water Use Under the Water Forum Agreement 2-1
2.1.1 Water Forum Agreement and Environmental Water 2-1
2.2 Surface Water Supplies 2-2
2.2.1 River Systems 2-4
2.2.2 Surface Water Quality 2-7
2.2.3 Major Surface Water Facilities Infrastructure 2-9
2.2.4 Surface Water Rights Defined 2-10
2.2.5 Surface Water Rights and Contract Entitlements Within the Central Basin 2-13
2.2.6 Surface Water Supply Summary 2-20
2.2.7 Other Available Surface Water Supplies 2-20
2.3 Groundwater Supplies 2-22
2.3.1 Overview of Hydrogeologic Setting 2-24
2.3.2 Hydrostatigraphy of the Central Basin 2-24
2.3.3 Understanding Groundwater Changes in the Central Basin 2-25
2.3.4 Groundwater Level Trends 2-27
2.3.5 Water Forum Groundwater Sustainable Yield 2-29
2.3.6 Groundwater Quality 2-30
2.3.7 Groundwater Facilities 2-33

2.3.8 Groundwater Rights 2-37
2.3.9 East Sacramento County Replacement Water Supply Project 2-37
2.4 Recycled Water Supplies 2-38
2.4.1 Recycled Water Facilities 2-39
2.4.2 Future Availability of Recycled Water Supplies 2-39
2.5 Water Demand and Land Use 2-40
2.5.1 Land Use 2-40
2.5.2 Water Demands 2-43
2.6 Water Balance 2-47
Section 3. Management Plan Elements 3-1
3.1 Introduction 3-1
3.1.1 BMO No. 1. Maintain long-term average groundwater extraction in the Central Sacramento County groundwater basin at or below 273,000 AF/year 3-2
3.1.2 BMO No. 2. Maintain specific groundwater elevations within all areas of the basin consistent with the Water Forum "solution" 3-2
3.1.3 BMO No. 3. Protect against any potential inelastic land surface subsidence by limiting subsidence to no more than 0.007 feet per 1 foot of drawdown in the groundwater basin 3-3
3.1.4 BMO No. 4. Protect against any adverse impacts to surface water flows in the American, Cosumnes, and Sacramento rivers 3-7
3.1.5 BMO No. 5. Water quality objectives 3-7
3.2 Program COMPONENT ACTION ITEMS 3-8
3.2.1 Component 1: STAKEHOLDER INVOLVEMENT 3-8
3.2.2 Component 2: MONITORING PROGRAM 3-11
3.2.3 Component 3: GROUNDWATER RESOURCE PROTECTION 3-16
3.2.4 Component 4: GROUNDWATER SUSTAINABILITY 3-19
3.2.5 Component 5: PLANNING INTEGRATION 3-21
3.3 Summary of Section 3 3-22
Section 4. Plan Implementation 4-1
4.1 Background 4-1
4.2 Specific Actions Based on Monitoring Results 4-1
4.3 Central Basin Well Protection Program 4-7
4.3.1 Background 4-7
4.3.2 Trust Fund Proposal 4-7
4.3.3 Fee Exemptions 4-7
4.3.4 Update to Fee Program 4-8
4.3.5 Authority to Collect Fees 4-8
4.3.6 Eligibility to Participate in Program 4-8
4.3.7 Eligibility for Claims 4-8
4.3.8 Sunset Provision 4-8
4.4 Groundwater Contamination Monitoring and Collaboration Program 4-9
4.4.1 Background 4-9
4.4.2 Program Components 4-9
4.5 Central Basin Reporting Methods 4-10
4.5.1 State of the Basin Report 4-10
4.6 Future Review of the GMP 4-10
4.7 Financing 4-10
4.7.1 Plan Implementation Costs 4-11
Section 5. References 5-1

FIGURES

Figure 1-1. Groundwater Basins in Sacramento County . . . 1-2
Figure 1-2. Water Purveyors In the Central Basin . . . 1-3
Figure 1-3. Location Map of Central Basin . . . 1-9
Figure 2-1. Major River Watersheds in the Central Basin . . . 2-3
Figure 2-2. Seasonal Exceedance Diagram for the Sacramento River at Freeport . . . 2-5
Figure 2-3. Exceedance Diagram of Projected Volume of Water from March to November for American River Unimpaired Inflow into Folsom Reservoir . . . 2-6
Figure 2-4. Seasonal Exceedance Diagram for Lower American River at Fairbairn Water Treatment Plant . . . 2-6
Figure 2-5. Seasonal Exceedance Diagram for Lower Cosumnes River (at or near Highway 99 crossing) . . . 2-8
Figure 2-6. Major Surface Water Infrastructure Facilities . . . 2-11
Figure 2-7. City of Sacramento 1969 to 1995 Combined American River and Sacramento River Surface Water Diversion to Central Basin . . . 2-16
Figure 2-8. U.S. Bureau of Reclamation 1969 to 1995 Surface Water Usage in Central Basin . . . 2-18
Figure 2-9. City of Folsom 1969 to 1995 Surface Water Usage in Central Basin . . . 2-18
Figure 2-10. Golden State Water Company 1969 to 1995 Surface Water Diversions in Central Basin . . . 2-19
Figure 2-11. Rancho Murieta CSD 1969 to 1995 Surface Water Usage in Central Basin . . . 2-21
Figure 2-12. OHWD 1969 to 1995 Surface Water Deliveries via the Folsom South Canal in Central Basin . . . 2-21
Figure 2-13. OHWD 1969 to 1995 Surface Water Usage from Cosumnes River and Deer Creek in Central Basin . . . 2-22
Figure 2-14. DWR Groundwater Subbasin . . . 2-23
Figure 2-15. Regional Geologic Cross Section . . . 2-25
Figure 2-16. Central Basin Recharge Sources . . . 2-26
Figure 2-17. Spring 2004 Groundwater Elevation Contour Map . . . 2-28
Figures 2-18A. Central Basin Groundwater Elevation Hydrographs Within SCWA Zone 40 . . . 2-31
Figures 2-18B. Central Basin Groundwater Elevation Hydrographs Outside SCWA Zone 40 . . . 2-32
Figure 2-19. Known Principal Contaminant Plumes . . . 2-34
Figure 2-20. Existing Production Wells . . . 2-36
Figure 2-21. Recycled Water Facilities . . . 2-41
Figure 2-22. 2000 and 2030 Distribution of Land Uses in the Central Basin (acres) . . . 2-43
Figure 2-23. 2000 General Land Use in the Central Basin . . . 2-45
Figure 2-24. 2030 General Land Use in the Central Basin . . . 2-46
Figure 2-25. Annual Average Water Balance for the Central Basin - 2005 Water Balance . . . 2-48
Figure 2-26. Annual Average Water Balance for the Central Basin - 2030 Water Balance . . . 2-49
Figure 3-1. Groundwater Elevation Contours for Lower Threshold . . . 3-4
Figure 3-2. Groundwater Elevation Contours for Upper Threshold . . . 3-5
Figure 3-3. Polygon Grid Used for Management of Groundwater Elevations . . . 3-6

TABLES

Table 1-1. Location of GMP Components . . . 1-14
Table 2-1. Existing Surface Water Rights/Contract Entitlements . . . 2-14
Table 2-2. Surface Water Diversions in the Central Basin from Zone 40 from 1995 to 2003 . . . 2-17
Table 2-3. Existing Purveyor “Larger” Production Wells . . . 2-35
Table 3-1. Summary of Action Items and How Each Applies to the BMOs . . . 3-23
Table 4-1. Monitoring Actions and Trigger Points . . . 4-3
Table 4-2. Estimate in Implementation of the GMP . . . 4-12
Table 4-3. Implementation Schedule . . . 4-13

APPENDICES

A. Summary of the process used for arriving at the long-term average annual sustainable yield of 273,000 AF/year that was negotiated by the Central Basin.
B. Summary of the development of Basin Management Objective #2 (Maintain specific groundwater elevations within all areas of the Central Basin consistent with the Water Forum solution).
C. Public Notices
D. Trial Balloon of Well Protection Program
E. Central Sacramento Count Groundwater Management Plan – Impact Analysis for Well Protection Program
F. Trial Balloon of Water Quality Collaboration Program

ABBREVIATIONS AND ACRONYMS

µg/L	micrograms per liter
AB	Assembly Bill
Aerojet	Aerojet-General Corporation
AF	acre-feet
AF/year	acre-feet per year
AFB	Air Force Base
AFRPA	Air Force Real Property Agency
ag/res	agricultural/residential
Agency Act	State of California Sacramento County Water Agency Act
ARWRI	American River Water Resources Investigation
ASR	aquifer storage and recovery
bgs	below ground surface
BMO	Basin Management Objective
BMP	best management practice
BVID	Brown's Valley Irrigation District
Cal-Am	California-American Water Company
CALFED	CALFED Bay-Delta Program
CCR	California Code of Regulations
Central Basin	Central Sacramento County Groundwater Basin
CEQA	California Environmental Quality Act
cfs	cubic feet per second
City	City of Sacramento
CMP	Sacramento Coordinated Water Quality Monitoring Program
COC	contaminant of concern
Cooperating Agencies	American River Basin Cooperating Agencies
CSCGF	Central Sacramento County Groundwater Forum
CSCGMP	Central Sacramento County Groundwater Management Plan
CSD	Community Service District
CSUS	California State University, Sacramento
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWC	California Water Code
DAU	Data Analysis Unit
Delta	Sacramento/San Joaquin Delta
DHS	California Department of Health Services
DMS	Data Management System
DTSC	State of California Department of Toxic Substance Control

DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection Program
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMD	Sacramento County Environmental Management Department
EPA	United States Environmental Protection Agency
FMS	Flow Management Standard
Folsom	City of Folsom
FRCD/EGWS	Florin Resource Conservation District/Elk Grove Water Service
GMP	Groundwater Management Plan
gpm	gallons per minute
GSWC	Golden State Water Company
GWNT	Groundwater Negotiation Team
ID	irrigation district
IGSM	Integrated Groundwater and Surface Water Model
InSAR	Interferometric Synthetic Aperture Radar
IRTCS	Inactive Rancho Cordova Test Site
JPA	Joint Powers Authority
LSCE	Luhdorff & Scalmanini Consulting Engineers
LUFT	leaking underground fuel tank
LUST	leaking underground storage tank
M&I	municipal and industrial
Mather AFB	Mather Air Force Base
McClellan AFB	McClellan Air Force Base
MCL	maximum contaminant level
MFP	Middle Fork Project
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
msl	mean sea level
NAWQA	National Water Quality Assessment
NCMWC	Natomas Central Mutual Water Company
NDMA	n-nitrosodimethylamine
NEPA	National Environmental Policy Act
NGS	National Geodetic Survey
NPDES	National Pollutant Discharge Elimination System
PBE	physical barrier effectiveness
PCA	potentially contaminating activities
PCE	tetrachloroethene

PCWA	Placer County Water Agency
PL	Public Law
PMT	Project Management Team
POU	Place of Use
PSA	Purveyor-Specific Agreement
Reclamation	United States Department of the Interior, Bureau of Reclamation
RWA	Regional Water Authority
RWQCB	Regional Water Quality Control Board
SACOG	Sacramento Area Council of Governments
SCWA	Sacramento County Water Agency
SCWC	Southern California Water Company
SGA	Sacramento Groundwater Authority
SMUD	Sacramento Municipal Utility District
SMWA	Sacramento Metropolitan Water Authority
SOP	standard operating procedure
SRCSD	Sacramento Regional County Sanitation District
SSCAWA	Southeast Sacramento County Agricultural Water Authority
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TDS	total dissolved solids
Title 22	California Code of Regulations, Title 22
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
Water Forum	Sacramento Area Water Forum
WD	water district
WEP	Water Efficiency Program
WFA	Water Forum Agreement
WPP	Well Protection Program
WSMP	Water Supply Master Plan
WTP	water treatment plant
WWTP	wastewater treatment plant
Zone 40	area within the Central Basin that includes Laguna, Vineyard, Elk Grove, and Rancho Cordova

Introduction

Section 1
Introduction

This section describes the CSCGMP, provides relevant background information, describes activities in the North, Central, and South Sacramento County groundwater basins, summarizes ongoing master planning in the context of various regional planning efforts taking place throughout the Sacramento County area, discusses the authority under which the CSCGMP is being prepared, and lists required and voluntary components of the CSCGMP.

1.1 THE CENTRAL SACRAMENTO COUNTY GROUNDWATER MANAGEMENT PLAN

In order to maintain a sustainable, high-quality groundwater resource for the users of the groundwater basin underlying the Central Basin (see **Figure 1-1**) the CSCGMP has been prepared to inform and guide the basin governance body, stakeholders and other interested parties in the management of the basin.

It is the intent of this document to quantify as much as practicable every aspect of the Central Basin including but not limited to: the historical context of the CSCGMP, a description of each stakeholders interest, projects and programs being implemented within the Central Basin by various stakeholders and regional partners, and the management and monitoring strategy to achieve a long-term sustainable yield from the basin. The CSCGMP also contains a Well Protection Program (WPP). The WPP is designed to protect private wells from going dry or becoming non-operable as a result of CSCGMP related activities. The Trial Balloon on Well Protection developed by the CSCGF outlines the premise of the WPP. The WPP is described in more detail in **Section 4**.

Described in the subsections below is the historical context of the CSCGMP. The reader will quickly understand that the concept of groundwater management of the Central Basin is not a new concept to this basin. Beginning from the time when wells were first dug by hand and then drilling technologies allowed for deeper and higher capacity yields from the basin, there has been data showing a consistent decline in groundwater elevations, spurring on management efforts at different stages in time and in different forums than that used in the development of this GMP. Because of the lengthy history, a synopsis of the more recent and more relevant events that have taken place is provided below.

Figure 1-1. Groundwater Basins in Sacramento County

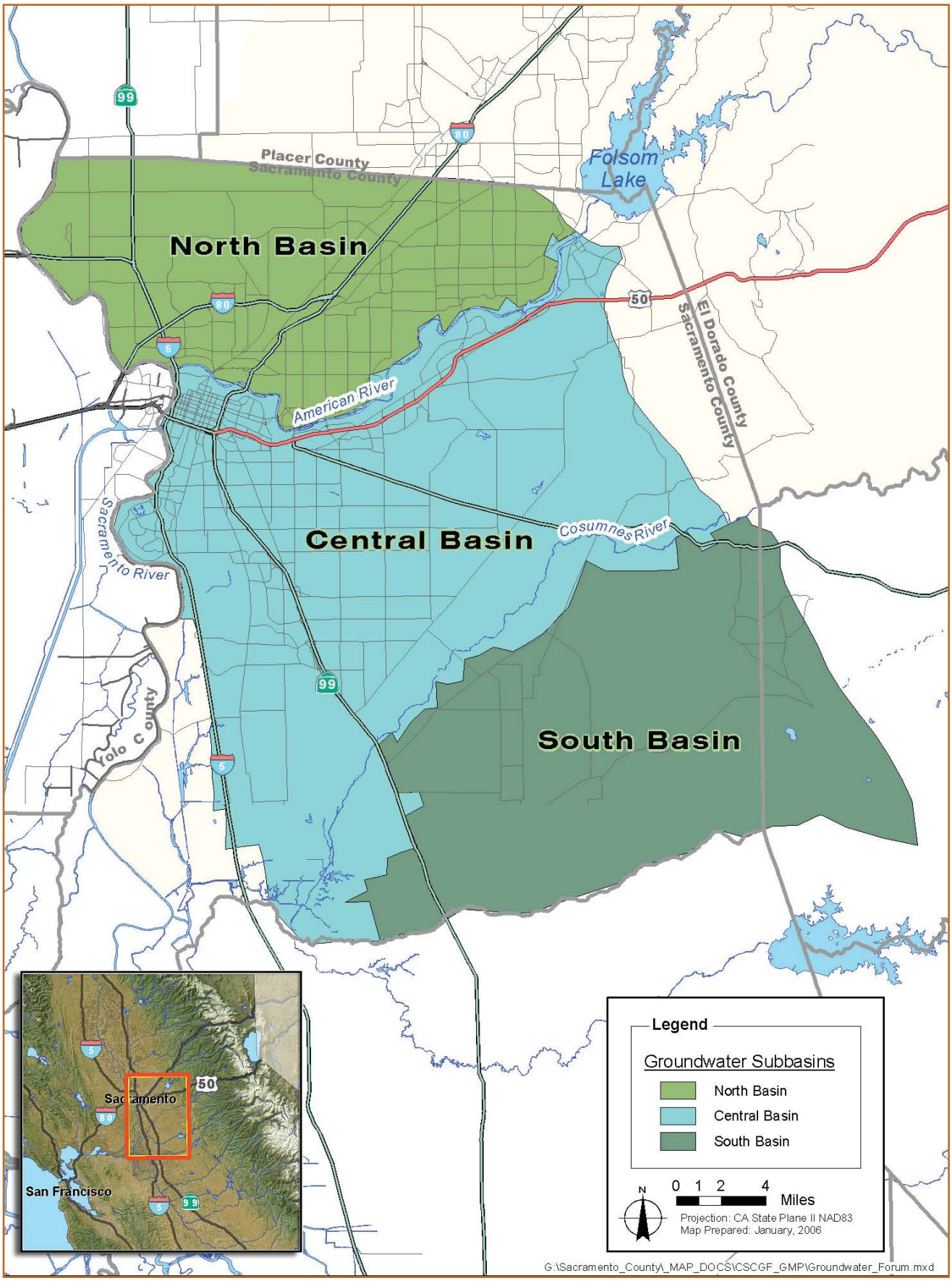
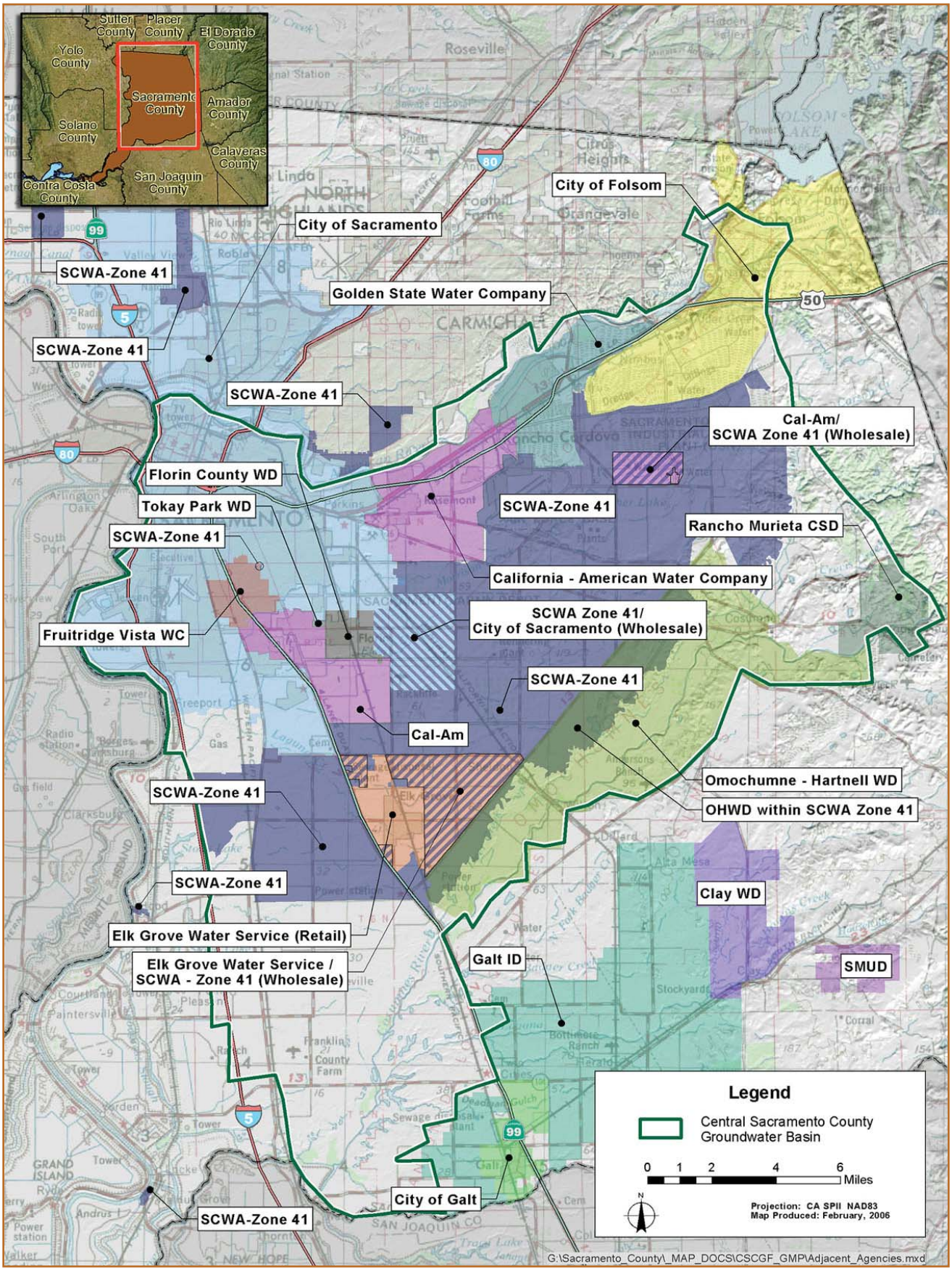


Figure 1-2. Water Purveyors In the Central Basin



1.1.1 Water Forum as the Basis for the Central Sacramento County Groundwater Management Plan

Beginning in 1993, the Water Forum process brought together a diverse group of stakeholders comprising business and agricultural leaders, citizens' groups, environmentalists, water managers, and local governments to evaluate available water resources and the future water needs of the Sacramento region, including communities from Sacramento, Placer and El Dorado counties. These stakeholders identified two coequal objectives to guide in the development of the WFA:

- Provide a reliable and safe water supply for the region's economic health and planned development through the year 2030
- Preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River

After a six year consensus-based stakeholder process, the WFA was completed. The WFA prescribes a regional conjunctive use program for the lower American River and connected groundwater basin. The Water Forum also completed an "Environmental Impact Report for the Water Forum Proposal" (State of California Clearinghouse Number 95082041). This document was certified by the two lead agencies of the Water Forum, the City and County of Sacramento, in December 1999.

One of the seven elements of the WFA is groundwater management. Implementation of this element includes adherence to an agreed-on long-term average annual pumping limit (sustainable yield) for each of the three geographic subareas of the groundwater basin within Sacramento County (see **Figure 1-1**): 131,000 acre-feet (AF) for the North Basin (north of the American River); 273,000 AF for the Central Basin (between the American and Cosumnes rivers); and 115,000 AF for the Galt or South Basin (south of the Cosumnes River). Any proposed water supply project or groundwater management structure must satisfy the groundwater conditions specified in the WFA for the 2030 projected level of development based on the 1993 Sacramento County General Plan.

In 2005, the County of Sacramento Planning Department, in partnership with the Sacramento Area Council of Governments (SACOG), released to the public conceptual land use plans for the next General Plan Update that will take development beyond 2030 and include the General Plans for the City of Sacramento, City of Folsom, City of Elk Grove, and the City of Rancho Cordova. This GMP recognizes that this effort is taking place and that it has direct and significant implications on groundwater management in the Central Basin; however, it is assumed that until the General Plan Update is adopted by the Sacramento County Board of Supervisors, this GMP will continue to reflect the current General Plan.

The WFA includes Purveyor-Specific Agreements (PSA) which define the benefits each water purveyor will receive as a stakeholder and actions each must take to receive these benefits. PSAs for the County of Sacramento/SCWA, City of Sacramento, and the Sacramento Municipal Utility District (SMUD) also describe commitments by the City of Sacramento, SMUD, and SCWA to address issues related to wheeling and wholesaling of surface water, Central Valley Project (CVP) water transfers, and dry year water supply.

1.1.1.1 Central Basin Signatories to the Water Forum Agreement

Excerpts from the WFA PSAs for Central Basin Water Purveyors signatory to the WFA follow (in some PSAs certain activities are or have already taken place or are included in adopted programs by the individual agencies.):

1.1.1.1.1 County of Sacramento/Sacramento County Water Agency

The **Sacramento County Water Agency (SCWA)** is responsible for providing wholesale water to an area within the Central Basin that includes the Laguna, Vineyard, Elk Grove and Rancho Cordova communities, and is commonly referred to as Zone 40. SCWA will divert firm and intermittent surface water from at, or near, the mouth of the American River or from the Sacramento River. SCWA will use groundwater and surface water conjunctively to meet water system demands.

A portion of Zone 40 is situated within the Place of Use (POU) for the City of Sacramento's American River water entitlements (see **Figure 1-3**). It is assumed that these entitlements would be used to serve significant portions, entirely or by conjunctive use, of this portion of Zone 40. Conditions for the use of this water will be consistent with the conditions outlined in the City of Sacramento's PSA related to diversions of American River water.

All signatories to the WFA endorse SCWA's PSA, which provides for constructing SCWA's water supply facilities identified in their Zone 40 Water Supply Master Plan. These facilities include a diversion structure at or near the mouth of the American River or on the Sacramento River, water treatment plants (WTP), pumping stations, wells, storage facilities, and transmission pipelines.

Stakeholder support is contingent on project-specific compliance with the California Environmental Quality Act (CEQA), and where applicable, the National Environmental Policy Act (NEPA), federal Endangered Species Act, California Endangered Species Act, and California Public Utilities Commission, and Local Area Formation Commission (LAFCO) approval.

1.1.1.1.2 City of Sacramento

The City of Sacramento (City) has rehabilitated its Fairbairn Water Treatment Plant (WTP) diversion facility and expanded its Fairbairn WTP treatment capacity by another 100 million gallons per day (mgd). This will allow the City to divert and treat an additional 155 cfs consistent with the terms described below. Concurrent with the expansion of the Fairbairn WTP, the City has also constructed other facilities such as expansion/rehabilitation of the Sacramento River WTP and river intake to assure that a reliable alternative supply (groundwater, pump-back, and/or diversion from the Sacramento River) is available when it is needed.

During periods when lower American River flows are sufficient (i.e., above the "Hodge" criteria, the City could fully use its increased diversion capacity at the Fairbairn WTP. In drier periods when lower American River flows are not sufficient (i.e., below the "Hodge" criteria), the City could not divert water from the American River for the full capacity of the Fairbairn WTP.

Additional diversions from the Sacramento River, and/or groundwater in the North Basin, also may be used by the City to meet 2030 demands.

Stakeholder support is contingent on project-specific compliance with the California Environmental Quality Act (CEQA), and where applicable, the National Environmental Policy Act (NEPA), federal Endangered Species Act, California Endangered Species Act, and California Public Utilities Commission, and Local Area Formation Commission (LAFCO) approval.

1.1.1.1.3 California-American Water Company (formerly Citizens Utility Company of California)

California-American Water Company (Cal-Am) has a number of service areas within the metropolitan area of Sacramento County. These service areas are located within the North Basin (identified as the North Area in the PSA) and the Central Basin (identified as the South County municipal and industrial (M&I) area and the City's American River water rights POU area in the PSA).

Cal-Am has contracted with the City to use 2,580 AF annually from the City's Fairbairn WTP and the Sacramento River WTP for use in its Southgate service area, which also is within the City's POU.

For other Cal-Am service areas within the POU (including the Arden area, portions of the suburban Rosemont

areas, and a portion of the Parkway area), when a contract with the City for delivery of surface water beyond the existing contract for the Southgate area is proposed, signatories to the WFA will meet in good faith with the objective of developing mutually acceptable provisions consistent with the two coequal objectives of the WFA.

Cal-Am will contract for use of a portion of the surface water provided through the County of Sacramento/SCWA for its service area in the south portion of Sacramento County. In addition, Cal-Am will continue to use groundwater to meet water supply needs in each of its service areas.

Stakeholder support is contingent on project-specific compliance with the California Environmental Quality Act (CEQA), and where applicable, the National Environmental Policy Act (NEPA), federal Endangered Species Act, California Endangered Species Act, and California Public Utilities Commission, and Local Area Formation Commission (LAFCO) approval.

1.1.1.1.4 City of Folsom

The City of Folsom (Folsom) will increase its average and wet year American River diversions from an agreed upon baseline amount of 20,000 AF to a 2030 level of 34,000 AF. In drier years, Folsom will divert and use a decreasing amount of surface water from 34,000 AF to 22,000 AF (or the equivalent, as described in the example below), in a three-stage stepped and ramped reduction in proportion to the decrease in the March through November unimpaired inflow (unimpaired inflow implies that there is no upstream storage occurring prior to water entering Folsom Reservoir) to Folsom Reservoir of 950,000 AF to 400,000 AF.

Under stage 1, Folsom will divert a decreasing amount, from 34,000 AF to 30,000 AF, in proportion to the decrease in March through November when the unimpaired inflow to Folsom Reservoir is greater than 870,000 AF but less than 950,000 AF.

Under stage 2, Folsom will divert a fixed amount of 27,000 AF when the March through November unimpaired inflow to Folsom Reservoir is greater than 650,000 AF but less than or equal to 870,000.

Under stage 3, Folsom will divert a fixed amount of 22,000 AF when the March through November unimpaired inflow to Folsom Reservoir is equal to or greater than 400,000 AF but less than or equal to 650,000 AF.

In the driest years, when the March through November unimpaired inflow to Folsom Reservoir is less than 400,000 AF, Folsom will reduce diversions (or the equivalency, as described in the example below) to 20,000 AF. Also, Folsom will reduce diversions in the driest years by encouraging additional, extraordinary conservation to reduce diversions to 18,000 AF.

As an example of how Folsom will meet its needs during drier and driest years, Folsom will reduce diversions by imposing additional conservation levels, and will continue to divert water from Folsom Reservoir for the balance of its needs. However, Folsom will enter into agreements with other suppliers that have access to both surface water and groundwater for an equivalent exchange of the amount of reduction in diversion needed by Folsom, as outlined above in the three stages of reduction. Under these arrangements, suppliers located north and possibly south of the American River will use groundwater in lieu of surface water equivalent to the amount that Folsom will continue to divert.

Stakeholder support is contingent on project-specific compliance with the California Environmental Quality Act (CEQA), and where applicable, the National Environmental Policy Act (NEPA), federal Endangered Species Act, California Endangered Species Act, and California Public Utilities Commission, and Local Area Formation Commission (LAFCO) approval.

1.1.1.1.5 Florin County Water District

Florin County Water District (FCWD) will use groundwater to meet its 2030 water demands. When a contract between the City and FCWD for delivery of surface water is proposed, signatories to the WFA will meet in good faith with the objective of developing mutually acceptable provisions consistent with the two coequal objectives of the WFA. FCWD is located within the POU for the City's American River entitlement.

Negotiations on specific conditions for delivery of surface water under this contract will be undertaken by the Water Forum Successor Effort and FCWD.

1.1.1.1.6 Omochumne-Hartnell Water District

At this time, the **Omochumne-Hartnell Water District (OHWD)** does not purvey water within the boundaries of the district. Private groundwater wells provide almost all of the water demands for the agricultural and rural residential community within OHWD. Surface water supplies are available to only a small number of agricultural users located adjacent to the Cosumnes River or Deer Creek. The unpredictable and limited nature of these waterways precludes the development of any significant surface water supplies.

Historically, OHWD has imported supplemental surface water from the Sly Park Unit of the CVP. Imports ranged from 800 to 5,300 AF per year (AF/year) from 1966 to 1974. After the completion of the Folsom South Canal (in the early 1970's) OHWD was only able to acquire supplemental water on an interim basis. Over the past 20 years, no reliable supplemental water has been made available from the Folsom South Canal.

OHWD currently maintains and operates four flashboard dams on the Cosumnes River to facilitate increased groundwater recharge from the river channel. The flashboard dams, which were historically operated to facilitate diversions, are now put in place in the early summer months when flows are receding to increase the wetted perimeter of the river channel and increase percolation to groundwater.

1.1.1.1.7 Golden State Water Company (formally Southern California Water Company)

Groundwater constitutes about 70 percent of the water supply for the portion of **Golden State Water Company (GSWC)**, south of the American River. Available groundwater supplies are conjunctively used with surface water with 5,000 AF of American River water entitlements diverted from the Folsom South Canal. GSWC has a Pre-1914 water right to 10,000 AF of American River water with 5,000 AF currently leased to the City of Folsom.

1.1.1.1.8 Aerojet-General and Other Self-Supplied Industries Through Business Interests

Aerojet-General Corporation (Aerojet) and other privately supplied industries have demonstrated a commitment to supporting reliable water supplies that will attract new industries and development to the community. The business community, as a signatory to the WFA, has agreed that they play a pivotal role in the region's water supply solution and should contribute to and support efforts that meet WFA goals.

1.2 NORTH SACRAMENTO COUNTY GROUNDWATER BASIN ACTIVITIES

The Water Forum process led to the establishment of the Sacramento Groundwater Authority (SGA). As an example of how a groundwater management plan is implemented, SGA is a governing body formed through a joint powers agreement. SGA uses the police powers of the cities of Sacramento, Citrus Heights, and Folsom, and the County of Sacramento to implement its adopted groundwater management plan. SCWA is a member

of SGA through SCWA's Zone 41 service area located north of the American River; the cities of Sacramento and Folsom and California-American and Golden State water companies also are SGA members.

1.3 CENTRAL SACRAMENTO COUNTY GROUNDWATER BASIN ACTIVITIES

As discussed previously, the WFA calls for an interest-based negotiation process to provide all segments of the community an opportunity to participate in developing a groundwater management structure for the Central Basin. This stipulation in the WFA led to the creation of CSCGF under the auspices of the Successor Effort.

Acting on behalf of the Successor Effort, the Sacramento City-County Office of Metropolitan Water Planning signed a Memorandum of Understanding with the California Department of Water Resources (DWR) and initiated the CSCGF. The CSCGF supports discussion among stakeholders representing all segments of the community with an interest in developing a groundwater basin management body and ultimately a groundwater management plan for the Central Basin. Stakeholders were selected through an area-wide assessment performed by the Successor Effort to identify concerns and develop a process for stakeholders to work together. Interviews were held with 94 stakeholders, resulting in the establishment of six interest groups: agriculture, agriculture/residential, business, environmental/community organizations, local governments/public agencies, and water purveyors. Each interest group is represented by five individuals who participate in the collaborative process known as the CSCGF.

1.4 SOUTH SACRAMENTO COUNTY GROUNDWATER BASIN ACTIVITIES

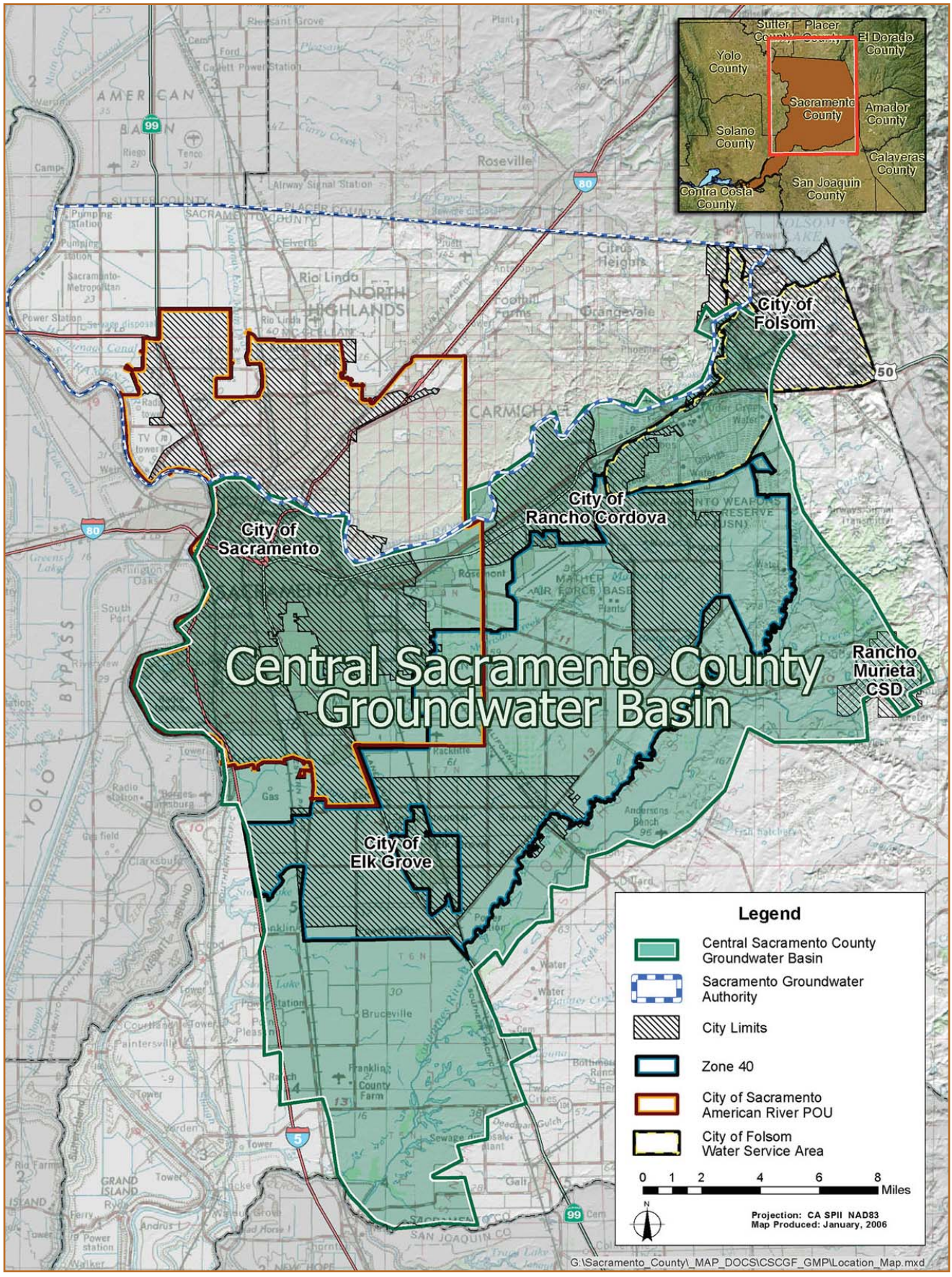
Groundwater-related activities south of the Cosumnes River are guided predominantly by the Southeast Sacramento County Agricultural Water Authority (SSCAWA). SSCAWA is a joint powers agency comprising three agricultural districts: OHWD, Galt Irrigation District, and Clay Water District.

The delineation of the Central Basin as determined by the WFA (see **Figure 1-3**) and the South Basin as reflected in SSCAWA's AB 3030 groundwater management plan adopted in 2002 (2002 GMP) are recognized as conflicting in the area of OHWD, which lies in both the Central and South Basins. Through cooperative participation in both groundwater basins, OHWD has acknowledged that activities which may take place within its boundaries can have a direct effect on both Central and South basins.

SSCAWA is working on updating the 2002 GMP to include additional local partners and to complete a more comprehensive groundwater management plan (South Sacramento County Groundwater Management Plan or SSCGMP) that can be integrated with the CSCGMP for the development of an Integrated Regional Water Management Plan (IRWMP) for the region south of the American River. New partners in the South Basin groundwater management plan include the City of Galt, Rancho Murieta Community Services District (also in the Central Basin), The Nature Conservancy (TNC), and SCWA. One of the primary objectives of the SSCGMP will be the development of a conjunctive use program that utilizes 15,000 AF of SMUD's CVP entitlement allocated to south Sacramento County agriculture through the WFA.

It has been demonstrated through real-time monitoring and scientific analysis that groundwater management programs adopted in the SSCAWA region and along the Cosumnes River corridor will have beneficial effects on the Central Basin (TNC and UC Davis, 2005). Recognizing this, a close working relationship between SSCAWA and the CSCGF has been developed to ensure that the interests and objectives of both basins are considered while developing their respective groundwater management plans. As a result of this relationship, SSCAWA, TNC, and SCWA have executed an agreement that actively investigates opportunities for flow restoration, conjunctive management, and enhanced recharge within the Cosumnes River corridor.

Figure 1-3. Location Map of Central Basin



1.5 ROLE OF THE TWO PRIMARY WATER RESOURCES MANAGERS IN THE CENTRAL BASIN

To understand how the CSCGMP fits into the various programs described in the following sections it is necessary to describe the role of the two primary water resources managers, the City of Sacramento and SCWA, and their respective goals.

1.5.1 Sacramento County Water Agency

SCWA was formed in 1952 by a special legislative act of the State of California: the Sacramento County Water Agency Act (Agency Act). The Agency Act defines SCWA's purposes including, but not limited to:

- Making water available for any beneficial use of lands and inhabitants
- Producing, storing, transmitting, and distributing groundwater in accordance with an approved Master Plan

SCWA's boundaries include all of Sacramento County (excluding the Cities of Folsom, Galt, Isleton, and Sacramento), and the agency is governed by a Board of Directors (ex officio, the Sacramento County Board of Supervisors). Under the Agency Act, the Board may contract with the federal government under reclamation laws with the same powers as irrigation districts, and may contract with the State of California and federal government with respect to the purchase, sale, and acquisition of water. SCWA also may construct and operate any required capital facilities.

Currently, several benefit zones exist within SCWA that are related to both water supply (Zone 13, Zone 40, Zone 41, and Zone 50) and drainage (Zone 11, Zone 12, and Zone 13). Each has a unique purpose and generates revenue internally for carrying out that purpose. Zone 40 is discussed in more detail in the following sections.

1.5.1.1 Zone 40

Historically, Zone 40 has relied on the underlying groundwater basin for agricultural, industrial, and residential water supplies. Over the past 10 years, Zone 40 has supplemented the use of groundwater supplies with surface water, recycled water, and education on and enforcement of water conservation. To address increasing demands for water in the region, SCWA updated and approved its Zone 40 Water Supply Master Plan (WSMP) in February 2005. As indicated in the WSMP, a primary role of Zone 40 is to meet growing urban water demands in a way that protects and maintains the groundwater basin and existing groundwater users. Through a policy that requires construction of groundwater wells to target portions of the underlying aquifer that are not used by private domestic wells, Zone 40 has developed approximately 40 mgd of groundwater capacity. All groundwater production is treated before distribution to retail and wholesale customers. Through firm surface water contracts with the US Bureau of Reclamation (Reclamation) and wheeling agreements with the City, Zone 40 currently has the ability to deliver 12,350 AF/year) of surface water. Zone 40 also delivers approximately 3 mgd of recycled water from SRCSD's Sacramento Regional Wastewater Treatment Plant (WWTP) to customers in the City of Elk Grove.

Zone 40 with its conjunctive use program (use of groundwater in conjunction with surface water) and recycled water from the Sacramento Regional County Sanitation District (SRCSD) is pivotal to the success of groundwater management in the Central Basin.

1.5.2 City of Sacramento

The City is a regional partner in that they provide surface water to areas within the Central Basin that are both inside and outside City boundaries. Through its American River water rights permit and settlement contract with Reclamation, the City's ability to deliver surface water extends to the American River POU boundary, as shown in **Figure 1-3**.

Through partnerships with retail purveyors the City wholesales its American River water to areas that historically have been solely dependent on groundwater. In the case of SCWA, the City currently provides surface water treatment and conveyance of a portion of SCWA's CVP contract water to the Laguna area of Zone 40. In

the future, the City plans to provide American River water to areas of Zone 40 located within the American River POU (see **Figure 1-3**).

The City's commitment to deliver surface water in a timely manner is and will continue to be critical in meeting the Central Basin's groundwater management objectives as described in **Section 3**. Maximizing the ability of the City to deliver surface water by establishing relationships with groundwater purveyors within the City's American River POU also is a critical goal of the CSCGMP.

1.6 OTHER REGIONAL MANAGEMENT EFFORTS

Over the past several decades, regional water supplies have been affected by the following:

- Extended drought and wet periods
- Increased push to dedicate surface water for environmental purposes
- Groundwater contamination cleanup efforts ordered by the United States Environmental Protection Agency (EPA), Central Valley Regional Water Quality Control Board (RWQCB), and California Department of Toxic Substance Control (DTSC)
- Declining groundwater levels
- Ongoing and potential impacts to surface water quality and groundwater quality

At the same time, demand for water in the region has continued to grow. To address these challenges, water purveyors in the region have invested substantial time and resources in a series of regional planning efforts. Planning efforts and agencies most relevant to CSCGMP include the following:

- Completion of the Zone 40 Water Supply Master Plan (SCWA, February 2005) and the Draft Environmental Impact Report for the 2002 Zone 40 Water Supply Master Plan (EDAW, November 2003)
- Creation and Implementation of the Freeport Regional Water Authority (FRWA)
- The Nature Conservancy (TNC)
- Southeast Sacramento County Agricultural Water Authority (SSCAWA)
- Regional Water Authority (RWA)
- Sacramento Groundwater Authority (SGA)
- Other ongoing activities related to groundwater cleanup and monitoring

These regional planning efforts are discussed further in the following subsections.

1.6.1 Zone 40 Water Supply Master Plan and Environmental Documentation

The Zone 40 WSMP identifies a study area (2030 study area) within Zone 40 that consists of existing and developing industrial, commercial, office, and residential land uses consistent with the City of Elk Grove and Rancho Cordova General Plans, and the Sacramento County 1993 General Plan.

Based on these General Plans, water demand is expected to be concentrated within the identified 2030 study area. However, developments can be proposed and approved anywhere within Zone 40 where they are consistent with the framework and requirements provided in the various General Plans, Community Plans, Comprehensive Plans, Specific Plans, and zoning and subdivision ordinances.

Three retail water purveyors provide service within Zone 40, these include: SCWA Zone 41, Florin Resource Conservation District (FRCD)/Elk Grove Water Service (EGWS), and Cal-Am. Zone 40 currently provides wholesale water to a portion of the FRCD/EGWS service area under the terms of the First Amended and Restated Master Water Agreement. It has been assumed that Cal-Am will purchase wholesale water supplies from Zone 40 to serve its Security Park franchise area located in the northern portion of Zone 40.

1.6.2 The Freeport Regional Water Authority (FRWA)

FRWA, a joint powers authority (JPA) developed between SCWA and East Bay Municipal Utilities District (EBMUD), is currently pursuing a project that will design and construct a diversion structure on the Sacramento River and a raw water pipeline between the diversion

structure and the Folsom South Canal. FRWA's efforts are focused in the following five areas: (1) formal state and federal environmental review; (2) public information and outreach; (3) detailed engineering studies and project design; (4) permitting and land acquisition; and (5) construction. The implementation process is expected to take up to four to five years, with actual construction beginning in 2006 and a target operational date of 2009.

While planning, design, and construction activities move forward on the FRWA facilities, Zone 40 will continue work on the surface water treatment plant, groundwater wells, groundwater treatment, raw and treated water transmission pipelines, and storage facilities necessary to fully implement SCWA's conjunctive use plan in the Central Basin.

1.6.3 The Nature Conservancy

The lower Cosumnes River watershed has been a major focus of conservation efforts in the Central Valley and is identified as a priority for ecosystem protection and restoration by both the California Bay-Delta Authority (formerly CALFED) and the USFWS Anadromous Fish Recovery Program, as well as in the Sacramento County General Plan.

The Cosumnes River channel and its associated floodplains are a major source of recharge for the Central Basin, and declining groundwater levels have adversely affected the river's salmon fishery and other environmental values. One of the goals of the WSMP environmental documentation was to assess the extent of impairment of Cosumnes River flows and aquatic values that has resulted from historic and ongoing groundwater pumping (both M&I and agricultural), and to explore programmatic opportunities for restoring and maintaining these aquatic values through integrated water management. The supporting documentation for this effort is included in the environmental documentation for the WSMP and subsequent studies included as a separate effort under the Water Forum Successor Effort and the Sacramento County Water Agency (WRIME, December 2005b).

The Cosumnes River conservation partnership includes federal, state, and local government, nonprofit land owners, and local water purveyors and sanitation districts. TNC has represented the Cosumnes River conservation partnership in the CSCGF. Because the ecological values of the Cosumnes River corridor have statewide significance, and the river presents opportunities for integrated water management, goals of the CSCGMP include the recognition, enhancement, and maintenance of the ecological values of the Cosumnes River.

1.6.4 Southeast Sacramento County Agricultural Water Authority

The SSCAWA is in the process of updating its 2002 GMP to include the remaining water management entities in the South Basin: Rancho Murieta CSD (also included in the Central Basin) and the City of Galt. While they have no authority to implement groundwater or surface water management programs, TNC is being included in the SSCGMP for the same reasons that they are included in the CSCGMP. These entities are developing an MOU as the first step to jointly preparing the SSCGMP. The MOU and resulting groundwater management plan will be structured to facilitate integration with the CSCGMP and development of an IRWMP for the region south of the American River.

The SSCGMP will focus on developing a conjunctive use program that optimizes the utilization of natural recharge areas associated with the Cosumnes River and explores opportunities for utilizing supplemental water supplies for recharge. The development of a viable conjunctive use program by the SSCAWA and its partners that protects and enhances groundwater resources for

local users and the environment can also contribute to management objectives defined in the CSCGMP.

1.6.5 Regional Water Authority

Regional Water Authority (RWA) represents a number of water supply interests and assists members in protecting and enhancing the reliability, availability, affordability, and quality of water resources. One of the principal missions of RWA is to help implement the conjunctive use program prescribed by the WFA. The RWA currently has 18 member agencies and three associate members, spanning Placer, Sacramento, and El Dorado counties.

1.6.6 Sacramento Groundwater Authority

SGA is a JPA created to manage groundwater in the North Basin (see **Figure 1-1**). SGA's formation in 1998 was a result of a coordinated effort by the Sacramento Metropolitan Water Authority (now RWA) and the Water Forum to establish an appropriate management structure for the North Basin.

SGA draws its authority from a JPA signed by the cities of Citrus Heights, Folsom, and Sacramento, and the County of Sacramento to exercise their common police powers to manage the underlying groundwater basin. With this authority, SGA manages the basin through representatives of 14 local water purveyors and representatives from the agricultural and self-supplied pumpers who serve as the Board of Directors.

At the core of the SGA's management responsibility is a commitment to not exceed the long-term average annual sustainable yield of the North Basin, which was estimated to be 131,000 AF in the WFA. To accomplish this objective and to provide a safe, reliable water supply for the North Basin, SGA adopted a groundwater management plan in December 2003.

1.6.7 On-going Groundwater Cleanup and Monitoring Related Activities

A number of on-going groundwater cleanup and monitoring activities currently underway within or adjacent to the Central Basin. Coordination among these efforts will be discussed in more detail later in **Section 3** and **4**. Many of the activities are in various states of clean-up. Activities closely related to CSCGMP groundwater management efforts include, but are not limited to, the following:

- Groundwater contamination investigation and remediation activities related to the former Mather Air Force Base, now called Mather Field.
- Groundwater contamination investigation and remediation activities related to operations at the Aerojet and McDonnell-Douglas (Boeing) facilities.
- Groundwater contamination investigation and remediation activities related to operations at the Kiefer Landfill, and other abandoned landfills within the Central Basin.
- Monitoring of groundwater levels and quality through participation in the DWR Well Monitoring Program.
- Monitoring of groundwater levels and quality at California State University, Sacramento (CSUS).
- Monitoring of groundwater quality by the United States Geological Survey (USGS) as part of its National Water Quality Assessment Program.
- Monitoring of site investigations and remediation efforts at known leaking underground storage tanks (LUST) coordinated by the Sacramento County Environmental Management Department (EMD) and the RWQCB.

1.7 AUTHORITY TO PREPARE AND IMPLEMENT A GMP

In order to initiate development of the CSCGMP, SCWA's Board of Directors held a public hearing and adopted Resolution of Intent (ROI) WA-2590 on April 19, 2005. In accordance with provisions of the California Water Code (CWC § 10753.4(a)) the CSCGMP must be adopted by the basin governance body within two years of adoption of the ROI.

1.8 CSCGMP COMPONENTS

The CSCGMP includes both required and voluntary components. **Table 1-1** lists these components and indicates the section(s) in which each component is addressed.

Table 1-1. Location of GMP Components

Description	Location in CSCGMP
A. CWC § 10750 et seq., Required Components[1]	
1. Documentation of public involvement statement.	Section 3.2.1.1
2. Basin management objectives (BMO).	Section 3.1
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping.	Section 3.2.2
4. Plan to involve other agencies located within groundwater basin.	Section 3.2.1.2
5. Adoption of monitoring protocols by basin stakeholders.	Section 3.2.2.5
6. Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118.	Figures 1-1, 1-2, 1-3, 2-27
7. For agencies not overlying groundwater basins, prepare GMP using appropriate geologic and hydrogeologic principles.	N/A
B. DWR's Recommended Components[2]	
1. Manage with guidance of advisory committee.	Section 3.2.1.3
2. Describe area to be managed under GMP.	Sections 1, 2
3. Create link between BMOs and goals and actions of GMP.	Section 3.3.4.2
4. Describe GMP monitoring program.	Section 3.2.2
5. Describe integrated water management planning efforts.	Section 3.2.5
6. Report on implementation of GMP.	Section 4.5.1
7. Evaluate GMP periodically.	Section 4.6
C. CWC § 10750 et seq., Voluntary Components[3]	
1. Control of saline water intrusion.	Section 3.2.3.6
2. Identification and management of wellhead protection areas and recharge areas.	Sections 3.2.3.3, 3.2.3.4
3. Regulation of the migration of contaminated groundwater.	Section 3.2.3.5
4. Administration of well abandonment and well destruction program.	Section 3.2.3.2
5. Mitigation of conditions of overdraft.	Section 3.2.4
6. Replenishment of groundwater extracted by water producers.	Section 3.1
7. Monitoring of groundwater levels and storage.	Sections 3.2.2.1, 3.2.4
8. Facilitating conjunctive use operations.	Sections 3.2.1.2, 3.2.4, 3.2.5
9. Identification of well construction policies.	Section 3.2.3.1
10. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	Sections 1.5, 1.6, 2.1, 2.2.3, 2.3.7, 2.3.9, 2.4, 3.2.4, 3.2.5, 4.3, 4.4
11. Development of relationships with federal and state regulatory agencies.	Section 3.2.1.4
12. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination.	Section 3.2.5

1 CWC § 10750 et seq. (seven required components). Recent amendments to the CWC § 10750 et seq. require GMPs to include several components to be eligible for the award of funds administered by DWR for the construction of groundwater projects or groundwater quality projects. These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003.

2 DWR Bulletin 118 (2003) components (seven recommended components).

3 CWC § 10750 et seq. (12 voluntary components). CWC § 10750 et seq. includes 12 specific technical issues that could be addressed in GMPs to manage a basin optimally and protect against adverse conditions.

Water Resources Setting

Section 2

Water Resources Setting

This section provides an in-depth review of available water supplies, their origins, and usage within the Central Basin. The review of each water supply includes a brief description of the local, state, and federal policies governing how that supply of water is used in the basin, and how these policies affect how much water is available from year to year. The section then describes the water demands associated with the identified land uses in the basin. Lastly, the water balance between supply and demand is described along with an examination of the different growth and water use scenarios that could occur in the region.

2.1 WATER USE UNDER THE WATER FORUM AGREEMENT

As summarized in **Section 1.1.1**, the Water Forum was formed in 1993 by a diverse group of water managers, business and agricultural leaders, environmentalists, citizen groups, and local governments in Sacramento. Local governments in Placer and El Dorado counties joined later. In the context of water supply availability in the Central Basin, it is vital to reiterate the importance of the Water Forum and the WFA as they relate to how surface and groundwater supplies were allocated and the importance of water conservation.

2.1.1 Water Forum Agreement and Environmental Water

The WFA included stakeholders representing most of the water interests in the Central Basin (i.e., some water purveyors elected not to participate or be signatory to the WFA). In April 2000, these stakeholders adopted and agreed to the principles set forth in the WFA. The WFA describes a conjunctive use program for the Central Basin to meet the region's water demands, and includes an updated Flow Management Standard (FMS) for the lower American River. The FMS essentially provides environmental protection for the lower American River while at the same time providing for increased water diversions by municipal purveyors. The Cosumnes River, which flows through the Central Basin, was evaluated in the Water Forum technical studies but was not considered to be impacted significantly by the WFA. Therefore, discussion and negotiation of issues for the Cosumnes River was not included in the Water Forum (See **Section 1.1.1**). The importance of environmental water on the Cosumnes River and the river's connection with groundwater are explained later in this section. The CSCGMP does not overlook the environmental water concerns of the American River, but

goes forward with the understanding that the American River was adequately addressed in the WFA.

A programmatic EIR for the WFA was completed in October 1999. The EIR indicated that the Water Forum Plan was the environmentally preferred alternative with significant and potentially significant impacts to the lower American River and Folsom Reservoir, including effects on certain fisheries, recreational opportunities, and cultural resources. Potential mitigation measures were identified as a part of the Habitat Mitigation Element of the WFA.

The seven elements of the Water Forum Plan preferred alternative (included as Section 3 of the WFA) are as follows:

1. Increased surface water diversions
2. Actions (e.g., conjunctive use, and water conservation) to meet customer's needs while reducing diversion impacts (on the lower American River) in drier years
3. Support for improved pattern of fishery flow releases from Folsom Reservoir
4. Lower American River habitat management
5. Water conservation
6. Groundwater management
7. Water Forum Successor Effort

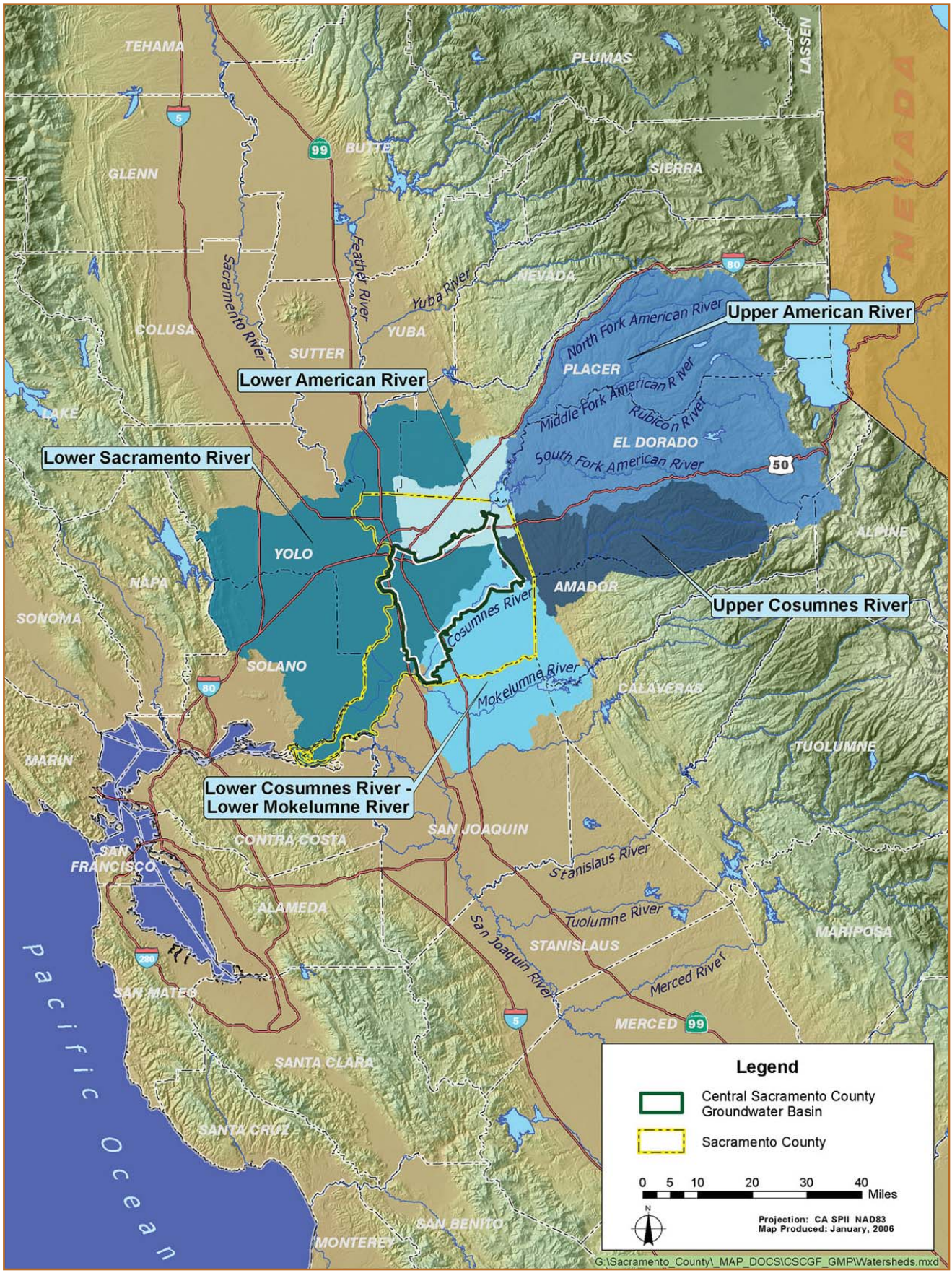
The following are examples of on-going regional projects/programs that are implementing parts of the WFA. These projects/programs are located primarily north of the American River.

1. **Placer County Water Agency (PCWA)/Sacramento Suburban Water District (SSWD) Groundwater Stabilization Project**. In August 1995, PCWA and SSWD entered into a 25-year contract to implement a groundwater stabilization project. PCWA agreed to supply Middle Fork of the American River Project (MFP) water to replace up to 29,000 AF/year of groundwater use by SSWD.
2. **American River Basin Cooperating Agencies (ARBCA) Regional Water Master Plan**. Water purveyors in southern Placer County and northern Sacramento County formed ARBCA and initiated work on implementing the type of regional conjunctive use program that was envisioned by the Water Forum. Under the auspices of this organization, conjunctive use pilot studies have been implemented and large-scale programs are being developed.
3. **PCWA American River Pump Station Project**. This project is a permanent pump station located near the former Auburn Dam site that provides year-round MFP water supply to PCWA. While the initial design capacity of the pump station is 100 cfs (maximum annual diversion of up to 35,500 AF), it has a potential ultimate diversion capacity of 225 cfs (100 cfs to accommodate additional PCWA demands of 35,000 AF and 25 cfs to meet Georgetown Divide Public Utility District's future needs).
4. **City of Sacramento Water Facilities Expansion Project**. The City has expanded its Fairbairn and Sacramento River WTPs to meet increasing demand in its service area. Expansion of the Sacramento River WTP will enable diversions to be shifted from the American River to the Sacramento River whenever the flow bypassing the expanded diversion at the Fairbairn WTP is less than the Hodge Flow criteria. While the City is not bound by Judge Hodge's 1990 decision, Environmental Defense Fund et al. v. East Bay Municipal Utility District, it has agreed to restrict diversions at the Fairbairn WTP when the Hodge Flow criteria apply as stipulated in the WFA.

2.2 SURFACE WATER SUPPLIES

Surface water for the Sacramento region comes from three major river watersheds; the Sacramento, American, and Cosumnes. The region also includes a portion of the Mokelumne River watershed south of the Cosumnes River (this area is technically not within the Central Basin). The Central Basin is roughly bound by the American River to the north, the Sacramento River to the west, the Cosumnes and Mokelumne Rivers to the south, and the Sierra foothills to the east (see **Figure 2-1**). The watershed areas for rivers identified on **Figure 2-1**, as well as the upland foothill regions, serve as the major source of groundwater recharge in the Central Basin. The role and mechanism of stream recharge to the aquifer is discussed more fully in **Section 2.3.3.1**.

Figure 2-1. Major River Watersheds in the Central Basin



2.2.1 River Systems

To understand the role of surface water as a major source of water in the Central Basin, it is important to have an overview of each surface water supply source. A description of each major river along with the current and future availability of water under different hydrologic conditions is provided below. Hydrologic conditions are an important consideration in determining the availability of surface water supplies. For example, in years when rainfall is low and snow pack is reduced, less surface water is available for storage behind dams. Lack of storage results in reduced availability of water for agriculture and urban supply requirements in dry months.

2.2.1.1 Exceedance Diagrams

The availability of surface water supplies often is presented in an exceedance diagram. In this type of diagram, the amount of water flowing in a particular surface water course is measured in terms of the percentage of time that a certain amount of water is expected to be present in that stream or river. Low flow or constrained conditions are most important; therefore, an interest always exists in how often a low-flow condition occurs during times of the year when high demands are expected (e.g., irrigation months). Exceedance curves represent average stream flows over the seasons of a particular year, and do not account for isolated storm events that produce instantaneous stream flow rates higher than the norm of any particular year.

2.2.1.2 Sacramento River Watershed

The Sacramento River watershed, upstream from the Central Basin, encompasses approximately 23,500 square miles and produces an average annual runoff of about 17,000,000 AF, as measured at the Freeport gauging station (below the confluence with the American River). Principal reservoirs regulating flows in the Sacramento River include Lake Shasta (storage capacity - 4,552,100 AF), located on the Sacramento River upstream from Redding; Trinity Lake (storage capacity - 2,448,000 AF), which regulates deliveries to the Sacramento River from the Trinity River watershed; Lake Oroville on the Feather River (storage capacity - 3,538,000 AF); and Folsom Reservoir on the American River (storage capacity - 975,000 AF).

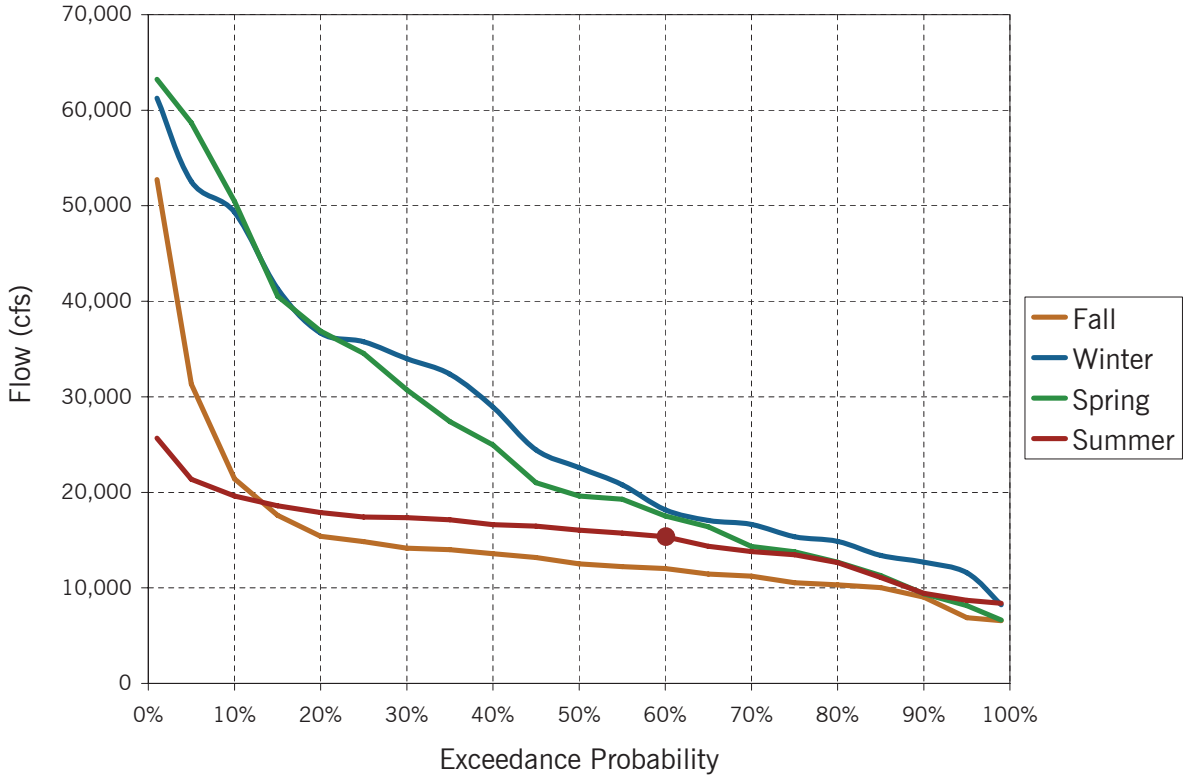
Based on 30 years of data records (1968 through 1998) and spanning a variety of water year types, individual monthly average flows in the Sacramento River have ranged from a low of 4,500 cfs in October 1978 to a maximum of 87,000 cfs in January 1997. Overall, average monthly flows for the 30 years of record range between 13,000 and 40,600 cfs, with the lowest flows occurring in October and highest flows in February. The 30-year average monthly flow during the wetter months of December through May is 32,200 cfs. During the typically drier months of June through November the average monthly flow is 16,500 cfs.

The exceedance diagram for the Sacramento River, based on 2020 forecasted conditions (this year is used in statewide surface water models), for each season is provided in **Figure 2-2**. Forecasted conditions project the operation of reservoirs and regulation of stream flows into the future while imposing 73 years of historical hydrology on this operational scheme. For example, **Figure 2-2** indicates that up to approximately 15,000 to 27,000 cfs of Sacramento River water flows through Freeport during the summer 60 percent of the time (see location of red dot on **Figure 2-2**). This is the general cutoff point for a dry year condition. The remaining 40 percent of the time, approximately 8,000 cfs to 15,000 cfs flows through Freeport. More important is that approximately 8,000 cfs is flowing in the Sacramento River in all seasons (100 percent of the time), even in the most critically dry conditions.

2.2.1.3 American River Watershed

The American River watershed encompasses approximately 1,900 square miles. Folsom Reservoir is the principal reservoir in the watershed with a capacity of 975,000 AF. Several smaller upstream reservoirs contribute 820,000 AF of storage capacity. Nimbus Dam impounds Lake Natoma, located immediately downstream from Folsom Dam, and regulates releases from Folsom Reservoir to the lower American River. The entrance facilities to the Folsom South Canal are located along the south shore of Lake Natoma immediately upstream from Nimbus Dam. The mean annual flow in the lower American River (1968 to 1998) is 3,300 cfs. The design capacity of the American River channel (for flood flows) is 115,000 cfs.

Figure 2-2. Seasonal Exceedance Diagram for the Sacramento River at Freeport



Two exceedance diagrams are provided for the American River (**Figure 2-3** and **Figure 2-4**). **Figure 2-3** relates to requirements in the WFA regarding where unimpaired inflow into Folsom Reservoir is evaluated. The WFA includes provisions for replacement water to the Lower American River in drier years from PCWA through reoperation of its MFP facilities to mitigate projected increases in American River diversions above the 1995 baseline condition. Replacement water is not needed when the projected March through November unimpaired inflow into Folsom Reservoir is more than 950,000 AF. When the projected unimpaired inflow is less than 400,000 AF, PCWA replacement water of 27,000 AF will be provided. When the projected unimpaired flow is between 950,000 AF and 450,000 AF, needed PCWA replacement water will be determined by linear interpolation between 0 and 27,000 AF. PCWA replacement water supplies cannot be diverted or stored until the replacement water flows through the lower reach of the American River to its confluence with the Sacramento River. **Figure 2-4** shows the lower American River at the Fairbairn WTP.

The resources of the lower American River and the land adjacent to the river (much of which is encompassed by the American River Parkway) are managed by a number of different agencies and organizations for a variety of purposes. One of the purposes of the WFA is to protect these resources and creatively partner with other resource managers to plan, fund, and implement projects that benefit the lower American River. The Water Forum monitors its success in five areas:

- Managing the lower American River to protect fish and river habitat
- Maintaining and/or improving habitats adjacent to the lower American River
- Meeting water quality goals and achieving regulatory standards for the lower American River
- Implementing lower American River levee stabilization and erosion control measures
- Communicating among lower American River stakeholders to inform and improve current and future management

Figure 2-3. Exceedance Diagram of Projected Volume of Water from March to November for American River Unimpaired Inflow into Folsom Reservoir

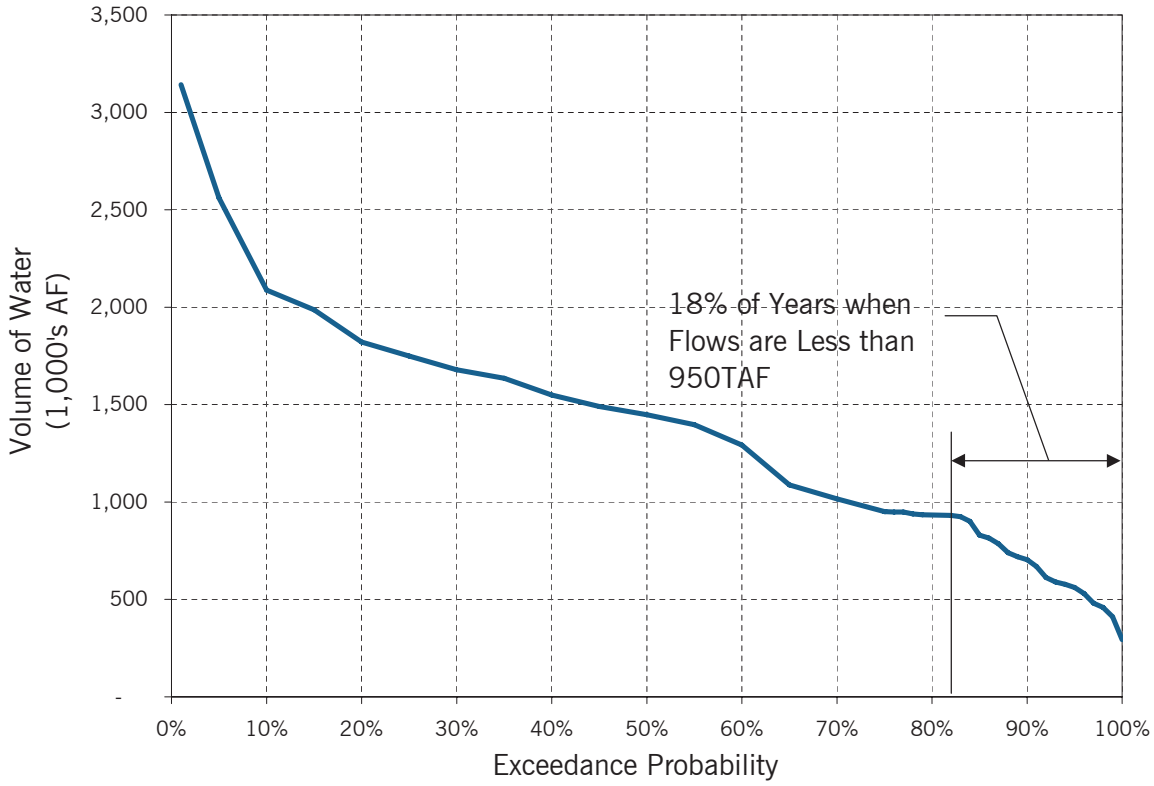
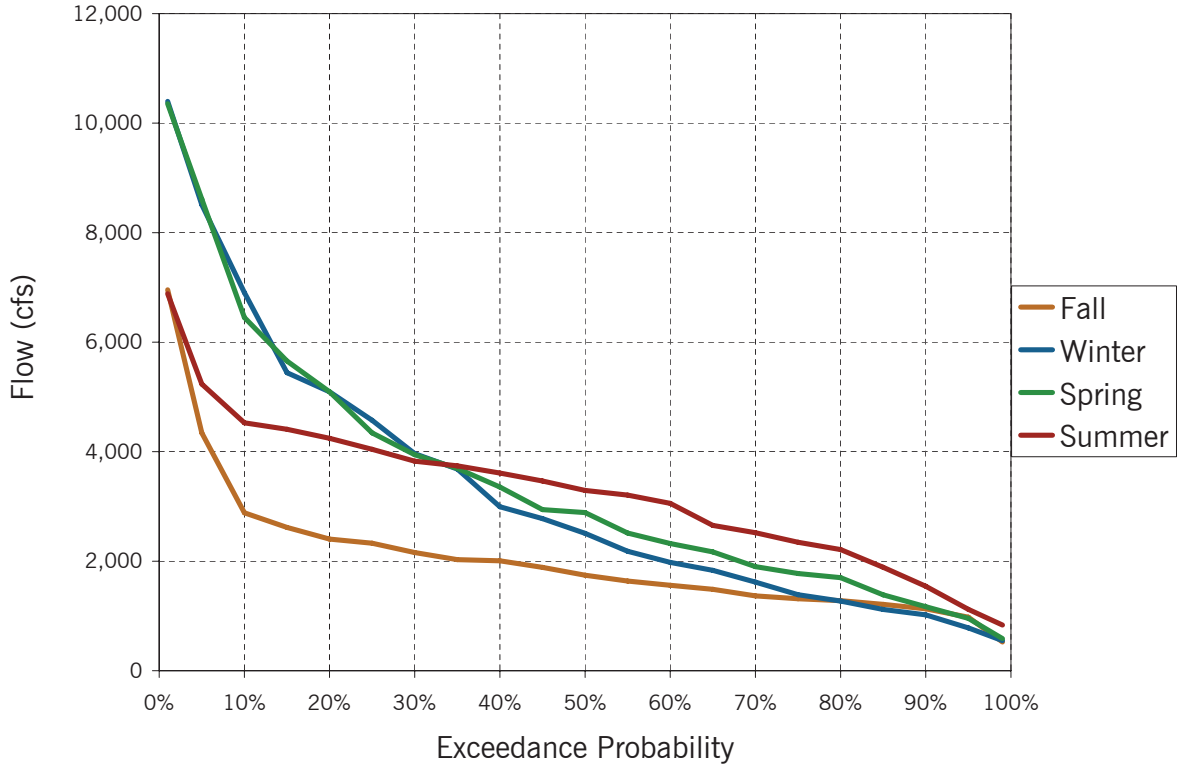


Figure 2-4. Seasonal Exceedance Diagram for Lower American River at Fairbairn Water Treatment Plant



2.2.1.4 Cosumnes River Watershed

The Cosumnes River watershed extends from its headwaters on the western slope of the Sierra Nevada to its confluence with the Mokelumne River. The Cosumnes River is one of the last major rivers in northern California with no major dam. Minor dams on the river are used more for recreational purposes than for water supply or flood control. The hydrology and use of the Cosumnes River have changed substantially over time. The river likely was the major source of surface water diversions for agriculture in the late 1800s prior to groundwater well technology becoming available and affordable. Until the 1940s, the Cosumnes River flowed year-round because it received a baseflow of water from an extensive floodplain aquifer (the aquifer was discharging water to the river). Historical data suggest that flow volumes in the lower reaches of the river decreased steadily from 1942 to 1982, with more frequent periods of very low or no flow. During September and October, flows in the river at Michigan Bar (the point which the river enters Sacramento County) are between 27 to 30 cfs. Currently, flows in the Cosumnes River cease in a 5- to 10-mile section of the river downstream from Michigan Bar (between Meiss Road and State Route 99) nearly every year at or before the end of the dry season (August through October). Studies using monitoring data and computer models have established a relationship between groundwater usage and river flows, leading to the conclusion that groundwater pumping is primarily responsible for the decline in fall river flows.

Since Cosumnes River flows are largely unregulated and considerable losses occur (in terms of percent of flow) to the groundwater system, the exceedance diagram in **Figure 2-5** is considerably different than those representing the Sacramento and American rivers. The diagram indicates a highly variable flow pattern for each season with flow primarily occurring in the winter and spring months and minimal flow in the summer and fall.

The ecological values of the Cosumnes River are of interest to many state, federal, and private institutions such as CALFED, Anadromous Fish Restoration Program, World Heritage Site, and TNC. Reduced flows in the Cosumnes River contribute to the degradation of fishery, wildlife, recreational, and aesthetic resources of the lower Cosumnes River. Water temperature also is an issue associated with flow impairment and poses a threat to the salmon fishery. These issues will be addressed more fully in the Basin Management Objectives outlined in **Section 3**.

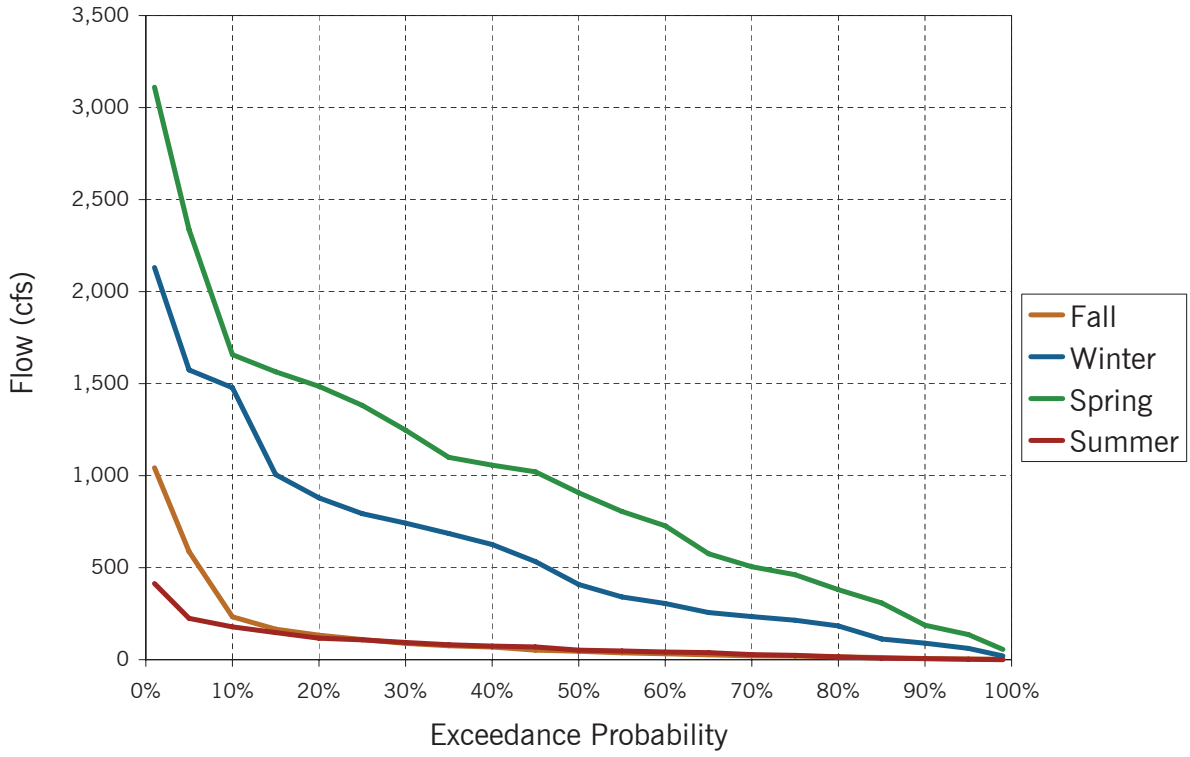
2.2.2 Surface Water Quality

The quality of surface water supplies is important when considering their use as a source of drinking water and agricultural supply. As a drinking water source, surface water must be of a high enough quality that it can be economically treated to meet all state and federal drinking water standards. For agriculture, past experience has shown that if certain constituents are present in applied surface water, such as salinity, these constituents can build up in the receiving soil over time, leaving the soil sterile and incapable of growing crops.

Based on the most current Watershed Sanitary Survey for the American and Sacramento rivers, both rivers are considered an excellent source of supply for drinking water in the Sacramento metropolitan area. These source waters can be readily treated to meet all California Code of Regulations (CCR) Title 22 drinking water standards using both conventional and direct filtration processes, including membranes. No persistent constituents are present in the raw water that require additional or more advanced water treatment processes. However, seasonal treatment requirements occur at times for rice herbicides found in the Sacramento River. These treatment requirements are addressed through chemical oxidation processes. High turbidities during storm events are a treatment challenge that can be managed by optimizing operations including adjusting chemical types and dosing schemes and by reducing plant flow (Montgomery Watson and Archibald & Wallberg, 2000).

Primary drinking water standards are set for constituents that cause adverse impacts to human health. Secondary drinking water standards are set for constituents that

Figure 2-5. Seasonal Exceedance Diagram for Lower Cosumnes River (at or near Highway 99 crossing)



cause unpleasing aesthetic impacts on water quality, and are not health-based standards. No chronic or persistent violations of primary or secondary drinking water standards have been reported in any treated surface water supply in the Sacramento area.

Like Sacramento area drinking water supplies, no known problems exist with surface water use for irrigation. No treatment or special considerations are typically given to agricultural diversions from rivers, with the exception of large river intakes and their ability to minimize fishery impacts. The subsections below address the drinking water aspects of each river and minor impacts associated with agricultural activities occurring upstream.

2.2.2.1 Sacramento River

Sacramento River water quality is largely influenced by a mass balance of water quality from upstream reservoir release operations, tributary flows (including the lower American River), agricultural runoff, subsurface drainage flows, and diversions with other impacts resulting from permitted discharges from M&I sources, urban runoff, and spills. In general, the quality of the Sacramento River is high in the vicinity of the Central Basin. Moderate amounts of alkalinity and minerals are present and low levels of disinfection by-product precursors. Turbidity levels in the Sacramento River are higher during the winter and early spring months, and are usually associated with reservoir releases or runoff from storm events. Very infrequent detections of organic chemicals occur, most of which are pesticides or herbicides from agricultural operations. Data collected to date indicate a low prevalence of *Giardia* and *Cryptosporidium* in the river, with protozoa only detected sporadically and at very low concentrations.

The characterization of Sacramento River water quality in the vicinity of the Central Basin is based on reports from the Sacramento River WTP (Sacramento River Watershed Sanitary Survey; 1995 Report and 2000 Update, prepared by MWH and Archibald & Wallberg).

The City diverts water from the Sacramento River at its Sacramento River WTP just downstream from the confluence with the American River. The City treats water using conventional treatment processes (i.e., flocculation, sedimentation, and filtration) with chlorine

disinfection. Treated water quality meets or exceeds all state and federal drinking water standards under current operations. The City includes corrosion control in its treatment of the water. Finished water is supplied to City customers both north and south of the American River (i.e., North Basin and Central Basin).

2.2.2.2 American River

Surface water quality in the American River is a function of the mass balance of water quality from tributary streams, diversions, minor agricultural return flows, subsurface drainage flows, with other impacts resulting from permitted discharges from M&I sources, urban runoff, and spills. In general, the quality of water in the American River is high from the river's headwaters to its confluence with the Sacramento River. It is low in alkalinity, low in disinfection by-product precursor materials, low in mineral content, and low in organic contamination. Limited data also indicate that the water is low in microbial contamination from *Giardia* and *Cryptosporidium*. Turbidity levels in the American River tend to be higher in the winter than summer because of higher flows associated with winter storms.

The City diverts water on the lower American River at the Fairbairn WTP just downstream from the Howe Avenue crossing. This water is also used by other water purveyors within the American River POU on a wholesale basis. The POU boundary in the Central Basin is shown in **Figure 1-3**. Water diverted at the plant undergoes conventional treatment and disinfection. The treated water meets or exceeds all state and federal drinking water standards under current operations (Archibald & Wallberg and MWH, 2003).

2.2.2.3 Cosumnes River

Water quality in the Cosumnes River watershed is affected primarily by land use and land cover. Monitoring data indicate that most of the river's nutrients and suspended sediments originate in the lower portion of the watershed below the Michigan Bar gauging station. Nutrient loading is strongly affected by a few point sources and non-point sources related to urbanized areas and agricultural activity (Ahearn and Dahlgren, 2000).

2.2.3 Major Surface Water Facilities Infrastructure

The distinction between surface water and groundwater facilities is sometimes difficult to make. In service areas that conjunctively use surface water and groundwater, the parts of the system that are attributed to surface water are the intake or diversion structure, the pipe that conveys the water from the intake structure to the WTP, the WTP itself, and the large conveyance pipelines that move treated surface water throughout the distribution system to the retail or wholesale customer.

The following sections describe existing and planned capital facilities that are, or will be, owned and operated by public and private water purveyors in the Central Basin. Major surface water diversions, untreated (raw) water conveyance, treatment, storage, and treated water conveyance systems are shown in **Figure 2-6**. The emphasis of this section will be on facilities that divert and convey surface water and on treatment capacity that is available today or in the near future that provides water to the Central Basin.

2.2.3.1 City of Sacramento

The City diverts surface water supply through two treatment plants, the Fairbairn WTP and the Sacramento River WTP. Both WTPs have recently been expanded. The Fairbairn WTP's treated water output capacity is 200 mgd and the Sacramento River WTP's output capacity is 160 mgd. Currently, the City maintains nine enclosed treated water storage reservoirs with a total storage capacity of 39 million gallons (MG), as shown in **Figure 2-6**.

2.2.3.2 SCWA Zone 40

Existing SCWA surface water facilities include the Franklin Intertie (see **Figure 2-6**), which supplies water to SCWA through the City. SCWA's wheeling agreement with the City provides up to 11 mgd of non-dedicated capacity that is diverted and treated at the City's Sacramento River WTP. SCWA's wheeling agreement with the City also provides for converting non-dedicated capacity to dedicated capacity in the

future (negotiations between SCWA and the City are currently taking place).

Planned SCWA diversions of surface water include a diversion structure located on the Sacramento River near the community of Freeport (see **Figure 2-6**), a raw water conveyance pipeline from the diversion structure to the central portion of Zone 40 (both constructed in partnership with EBMUD), a 100 mgd[4] (ultimate capacity) surface water treatment facility in the central portion of Zone 40, and appurtenant treated water conveyance pipelines. Other agreements currently in negotiation include expanded service from the City to the portion of Zone 40 that lies within the City's American River POU.

2.2.3.3 Golden State Water Company

Golden State Water Company provides water supply to its Cordova System in part with surface water treated at its 16 mgd Coloma and Pyrites WTPs. The Coloma and Pyrites WTPs divert American River water through a turnout on the Folsom South Canal.

2.2.3.4 City of Folsom

Folsom shares its surface water diversion facility at Folsom Reservoir with San Juan Water District and the City of Roseville. Folsom treats this water at the Folsom WTP, which is currently undergoing an expansion to a maximum capacity of 50 mgd. Folsom's water system includes eight treated water storage tanks with a total storage capacity of 19.5 MG and one raw water storage reservoir.

2.2.3.5 Rancho Murieta Community Services District (CSD)

Rancho Murieta CSD operates a surface water treatment plant located at the north end of Lake Clementia, with a total production rate of 3.5 mgd. The CSD relies on off-stream reservoirs using Cosumnes River water as their source of surface water. The majority of water is stored in the winter and spring months. The CSD also maintains two storage tanks with a total storage capacity of 4.2 MG.

2.2.3.6 Omochumne-Hartnell Water District

OHWD is the only organized agricultural water district with facilities to divert surface water within the Central Basin. While OHWD does not have surface water entitlements, they have historically operated four seasonal flashboard dams on the Cosumnes River to facilitate diversions by riparian water rights holders along the river. Diversions by riparian water rights holders are used on lands adjacent to the Cosumnes River and remain entirely within the Central Basin. The volume of water utilized by riparian users has decreased significantly over the past several decades. This is due to declining flows in the Cosumnes River during the irrigation season and the increasing use of drip irrigation for orchard and vineyards within the Cosumnes River and Deer Creek floodplain. As indicated previously, OHWD now operates their seasonal dams to facilitate groundwater recharge and only in limited instances are the impoundments formed by these dams used for diversions by riparian users.

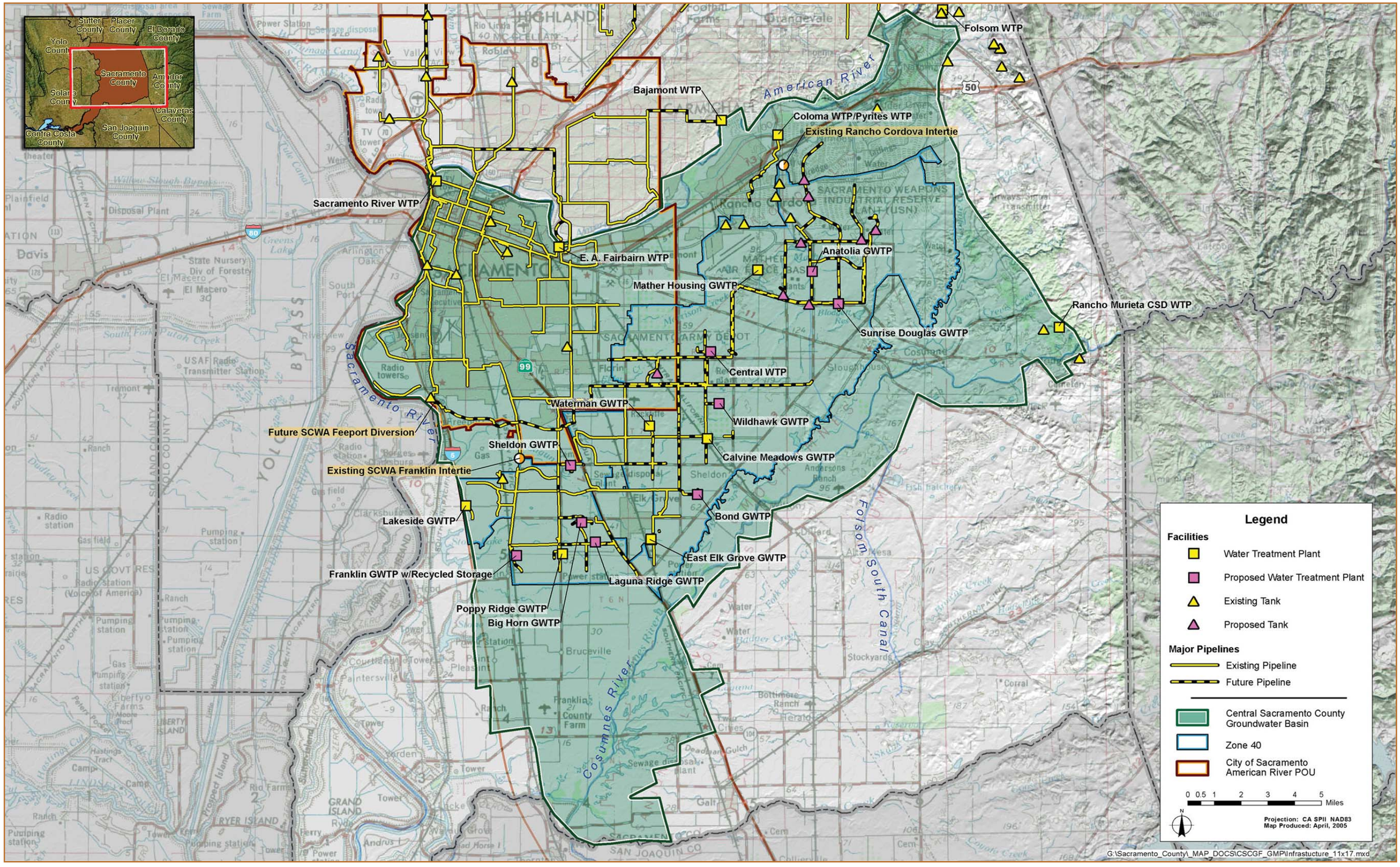
2.2.4 Surface Water Rights

The purpose of this section is to briefly discuss the different types of surface water rights as defined by state law. This section can be used as a resource when a water right is referred to in subsequent sections.

A surface water right is a legal right or contract entitlement to water that is generally not guaranteed in all hydrologic year types. In certain circumstances, water supply contracts are executed as a settlement proceeding which guarantee water supply availability, subject to certain stipulations, regardless of hydrologic year type. For this reason, it is important to understand which agencies have access to surface water, subject to certain constraints, as a component of groundwater management in the Central Basin. The different types of surface water rights and contract entitlements include the following:

[4] Fifteen mgd of this capacity is remediated groundwater discharged to the American River as part of the Eastern Sacramento County Replacement Water Supply Project, which is described more fully in the groundwater section.

Figure 2-6. Major Surface Water Infrastructure Facilities



Appropriative Right. This right is gained through diverting and using surface water for reasonable and beneficial use[5]. Because this right is not predicated on, and does not depend on, ownership of the land, the rights of an appropriator depend on actual physical control of the water (and since 1914, a permit for its beneficial use). The water stored by the state and Reclamation in reservoirs is through an appropriative water right. A CVP water contract is a contract with Reclamation that provides access to water that is stored and conveyed through CVP facilities. Typically, Reclamation allocates the water that is stored to municipal and agricultural water contract holders based on an estimate of the amount of water stored in Reclamation's reservoirs. This estimate is based on an estimate of watershed snow pack and potential runoff in the area tributary to Reclamation's reservoirs in March of every year.

Pre-1914 Water Right. The term "pre-1914 right" is often used in the context of a water right that is senior to most other water rights on a given stream.

USBR Settlement Water Contract. This water right is typically associated with riparian and Pre-1914 Water Right holders who settled under a contract agreement with Reclamation for water stored in a CVP reservoir that they normally would have received absent the reservoir.

Correlative Right. A correlative right has a mutual or reciprocal relationship to the rights of others, in the sense that the existence of one right necessarily implies the existence of the other right. For example, the rights of landowners adjacent to a stream (riparian) are correlative with all other landowners adjacent to the same stream.

Riparian Water Rights. Those who own property adjacent to a body of water possess the right to use the water from that body of water on the adjacent property for reasonable and beneficial uses. All riparian rights are correlative.

Area of Origin Water Rights. The California Water Code (CWC) contains a number of sections addressing certain rights, benefits, and obligations for upstream lands from which surface water originates. While discussed in a variety of informal venues, the "Area of Origin" provisions of the CWC have not yet been thoroughly tested and interpreted by the courts; therefore, no clear or definitive guidance exists regarding the application, interpretation, and functional operation of Area of Origin Statutes.

2.2.5 Surface Water Rights and Contract Entitlements Within the Central Basin

In **Section 2.2.4** the different types of surface water rights were briefly described. A basic understanding of surface water rights is important given the complexity of water right ownership, its quantity, and its reliability. The Integrated Groundwater Surface Water Model (IGSM) for Sacramento County is used to provide information on historical diversions (1968 to 1995) of surface water by each of the water providers. A graph of this usage is presented with each discussion. **Table 2-1** summarizes current water rights and contract entitlements in the Central Basin.

[5] Reasonable and beneficial use refers to Article X, Section 2, of the California Constitution, which requires that all water use be reasonable and beneficial. Beneficial uses include irrigation, domestic, M&I, hydroelectric power, recreation, and protection and enhancement of fish and wildlife. Reasonable use is more easily defined by what it is not: waste or unreasonable use. Reasonableness is determined based on circumstances and can vary, according to the California Supreme Court.

Table 2-1. Existing Surface Water Rights/Contract Entitlements

Surface Water Sources	Place of Use	Entitlements (AF/year)	Contracts from or to Other Purveyors (AF/year)
City of Sacramento (Amount Available to Central Basin) [1]			
Water Rights Permits/Reclamation Settlement Contract (American River)	American River POU	142,100	-2,580[1], -9,300[5]
Reclamation Settlement Contract (Sacramento River)	City of Sacramento	50,716	
Pre –1914 Water Right (Sacramento River)	Not Applicable	26,460	
SCWA Zone 40			
SMUD 1 Assignment (CVP Supply) [2]	Zone 40	15,000	-
SMUD 2 Assignment (CVP Supply) [3]	Zone 40	15,000	-
Fazio Water (PL 101-514 CVP Supply) [4]	Zone 40	22,000	-7,000[4]
Future Agreement with City of Sacramento (American River Settlement Contract)	American River POU (Zone 40)	-	9,300[5]
Future Appropriative Water Right [6] (American and/or Sacramento River)	Zone 40	14,600	-
Future Other Water Contract	Zone 40	5,200	
City of Folsom [7]			
Pre-1914 Water Right	City of Folsom	22,000	-
Agreement with GSWC (water right)	City of Folsom	-	5,000[8]
PL 101-514 contract with SCWA (CVP supply)	East area	-	7,000[4]
Golden State Water Company [8]			
Pre-1914 Water Right (American River)	Cordova System	10,000	-5,000[8]
California American Water Company [9]			
Reclamation Settlement Contract (American River)	American River POU (Southgate)	-	2,580[1]
Rancho Murieta Community Service District [10]			
Appropriative Water Right (Cosumnes River)	Rancho Murieta CSD	6,368	-
Omochumne – Hartnell Water District [11]			
Riparian Water Rights (Cosumnes River)	Agricultural Lands Along Cosumnes River	4,000	-
Total Surface Water Contracts in Central Basin	**Approximately**	**350,000**	

Sources: Sacramento River Water Reliability Study, Initial Alternatives Report, Main Report and Appendix A, Revised January 2005.

SCWA Zone 40 Groundwater Management Plan, adopted October 26, 2004.

Notes:

[1] The City has a Reclamation Settlement Contract for the American and Sacramento rivers for 245,000 and 81,800 AF/year (the amounts shown here indicate only what can be guaranteed; the actual water right is much higher), respectively, and a Pre-1914 Water Right for up to 54,000 AF/year (this amount is still under research). The amounts

Table 2-1. Existing Surface Water Rights/Contract Entitlements (continued)

shown in the table are the result of the total contract amounts being reduced in proportion to the area within the City Limits and the American River POU that are located within the Central Basin. These percentages amount to 58 and 62 percent, respectively. Also identified is a water sale contract with Cal-American (up to 2,580 AF/year) and a future water sale to SCWA's Zone 40 (up to 9,300 AF/year).

[2] SMUD 1 Assignment. Under the terms of a three-party agreement (SCWA, SMUD, and the City), and in accordance with SMUD's PSA, the City is providing surface water to SMUD for use at two of SMUD's cogeneration facilities. In turn, SMUD has assigned 15,000 AF/year of its CVP contract water to SCWA for M&I use. Because the cogeneration facilities are located within the City's American River POU, authorization by the State Water Resources Control Board (SWRCB) was not required.

[3] SMUD 2 Assignment. SMUD's PSA directs SMUD to assign a second 15,000 AF/year to SCWA and for SCWA to construct groundwater facilities necessary to meet SMUD's dry year water shortages of up to 10,000 AF/year. This CVP contract assignment is complete.

[4] CVP Water Public Law 101-514 ("Fazio" Water). In April 1999, SCWA obtained a CVP contract pursuant to PL 101-514 that provides a permanent water supply to SCWA Zone 40 of 15,000 AF/year and a 7,000 AF/year subcontract to Folsom.

[5] The City is committed to serving American River water to all areas located within the City's American River POU.

[6] Appropriative Water. SCWA has submitted an application to the SWRCB for appropriation of water from the American and Sacramento rivers (SCWA's Board authorized submittal of this application on May 30, 1995). The number shown is the expected long-term average use of the water and not the water right amount. This water is considered intermittent water that typically would be available during the winter months of normal or wet years.

[7] Does not include Section 215 water or water supplied by San Juan Water District.

[8] Golden State Water Company has access to Pre-1914 water through the Natomas Ditch Company and associated POU. A portion of this water is contracted to Folsom.

[9] Does not include a potential surface water supply for Rosemont Service Area.

[10] Rancho Murieta CSD's rights are governed by various appropriative rights and associated restrictions, maximum annual use, and maximum annual storage. The total contract yield varies from year to year.

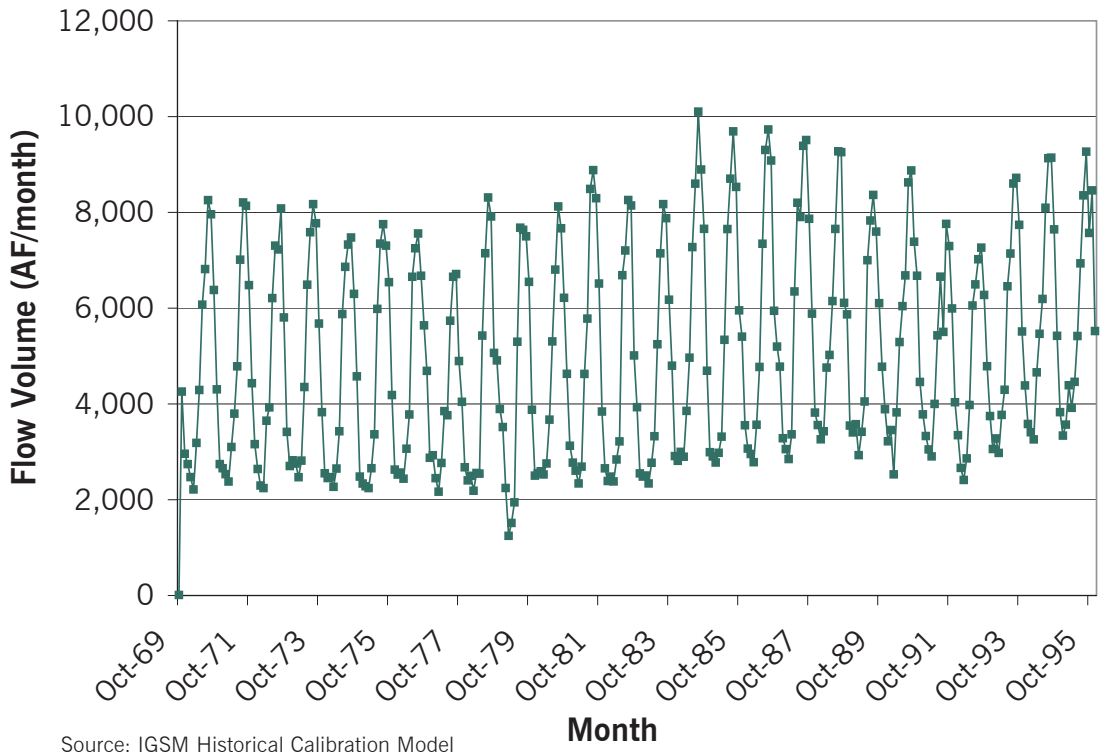
[11] OHWD contracted to the late 1970s with Reclamation for use of water stored at Sly Park Reservoir. Since the late 1970's OHWD has depended solely on riparian water supplies and infrequent supplemental purchase of spill water from the CVP, delivered through the Folsom South Canal. OHWD is assumed to continue to use riparian water rights of up to 4,000 AF/year (only because this value is assumed in the IGSM for diversions from the Cosumnes River to 1995, and because of the difficulty in accounting for riparian water use).

2.2.5.1 City of Sacramento

The City has water rights on both the Sacramento and American rivers. The City also has a settlement water contract with Reclamation that includes a delivery and storage schedule for use of their water entitlements. The City/Reclamation settlement agreement also incorporates an earlier SMUD contract with Reclamation. The City's current maximum water right/contract entitlements and existing surface water diversions are summarized in **Table 2-1**. Water available to the City's American River POU under its settlement contract is subject to a maximum annual diversion from the American River specified in the contract by a gradually increasing schedule. In 2030, the City's maximum diversion from the American River and Sacramento River is limited to 245,000 AF/year and 81,800 AF/year, respectively, under the City/Reclamation settlement contract. The City has agreed to limit its diversions under its settlement contract to not more than 225 cfs of Sacramento River water and not more than 675 cfs of American River water. In turn, Reclamation has guaranteed the availability of those amounts with no deficiencies in any hydrologic year-type.

As mentioned in **Section 2.1.1**, the WFA limits the City's American River diversions under certain flow conditions. The City may recover diversion reductions on the American River at its existing Sacramento River WTP. The City also may replace some of the water with Sacramento River water through a new intake at a future planned WTP located in North Natomas. The City's history of surface water use in the Central Basin is shown in **Figure 2-7**. Because the City's service area extends to both sides of the American River, and the water distribution system allows water to flow to either side, the information presented in this figure is only an approximation based on assumptions used in the IGSM. Based on the figure, very little change in the use of surface water has occurred over the period of record. Any change in surface water use would likely result in a change of the City's use of groundwater north of the American River, increased water conservation, and/or new growth.

Figure 2-7. City of Sacramento 1969 to 1995 Combined American River and Sacramento River Surface Water Diversion to Central Basin



Source: IGSM Historical Calibration Model

2.2.5.2 SCWA Zone 40

Currently, surface water meets approximately 12 percent of SCWA's Zone 40 water demands. SCWA's two CVP surface water contracts (termed "Fazio" and "SMUD" water) provide for two points of diversion, at or near the mouth of the American River, or just north of the community of Freeport on the Sacramento River.

SCWA has been diverting approximately 4,500 AF/year of surface water at the City's Sacramento River WTP. Under an existing wheeling agreement with the City this amount will increase to 12,350 AF/year. This water is treated and then wheeled through the City's conveyance facilities to a connection with Zone 40 facilities in Franklin Boulevard (Franklin Intertie) near the Sacramento Regional Waste Water Treatment Plant (WWTP) for use in the City of Elk Grove. Additionally, approximately 2,066 AF/year of interim surface water is used in the Mather/Sunrise portion of Zone 40; this interim surface water is purchased from Golden State Water Company as a short-term replacement for groundwater supplies lost as a result of groundwater contamination by Aerojet and Boeing. **Table 2-1** lists existing surface water supplies either acquired or currently being pursued. Each of the supplies is described in the table notes. Note that the CVP contracts have been acquired, whereas the appropriative water rights and other water rights or water contracts have not. **Table 2-2** summarizes water deliveries to Zone 40 through the Franklin Intertie with the City, beginning in 1995 with interim water supplies from Brown's Valley Irrigation District (BVID). After 1999 and into the future SCWA's "Fazio" water contract will be the sole supply of this water.

2.2.5.3 U.S. Bureau of Reclamation

U.S. Bureau of Reclamation (Reclamation), under contract with the United States Air Force and local farmers, supplied water from the Folsom South Canal to supply makeup water to a small lake located near the canal at Mather Field and for agricultural purposes. Diversions started in the late 1970s and ceased in the late 1980s because Reclamation restricted diversions as a result of the Central Valley Project Improvement Act[6] (CVPIA).

2.2.5.4 City of Folsom

Folsom's current water rights/contract entitlements are summarized in **Table 2-1**. Folsom has a Pre-1914 Water Right for up to 22,000 AF of American River water and a contract with Reclamation to deliver this water at a maximum rate of 38.8 mgd. An additional water entitlement is through a contract lease for 5,000 AF of Pre-1914 water rights with GSWC.

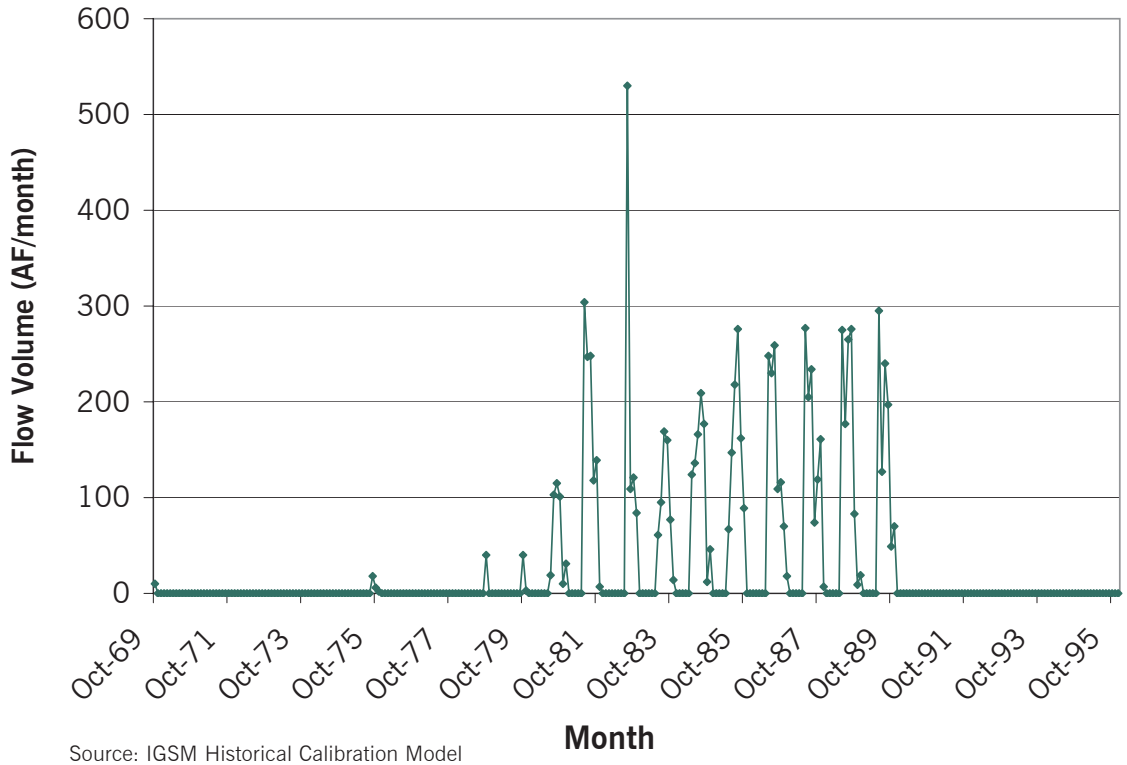
Folsom also has a subcontract with SCWA for 7,000 AF of American River water for delivery from Folsom Lake, as authorized by PL 101-514 (a portion of the "Fazio Water"). In addition, Folsom has a temporary contract with Reclamation for surplus water (often referred to as Section 215 water). Section 215 water is available on an intermittent basis only and is not storable in CVP facilities.

Table 2-2. Surface Water Diversions at the Franklin Intertie for Zone 40 from 1995 to 2003

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Contract Source	BVID	BVID	BVID	BVID	Fazio	Fazio	Fazio	Fazio	Fazio
Surface Water Use AF/year)	537	2,471	848	1,468	2,000	2,200	3,967	4,300	4,261

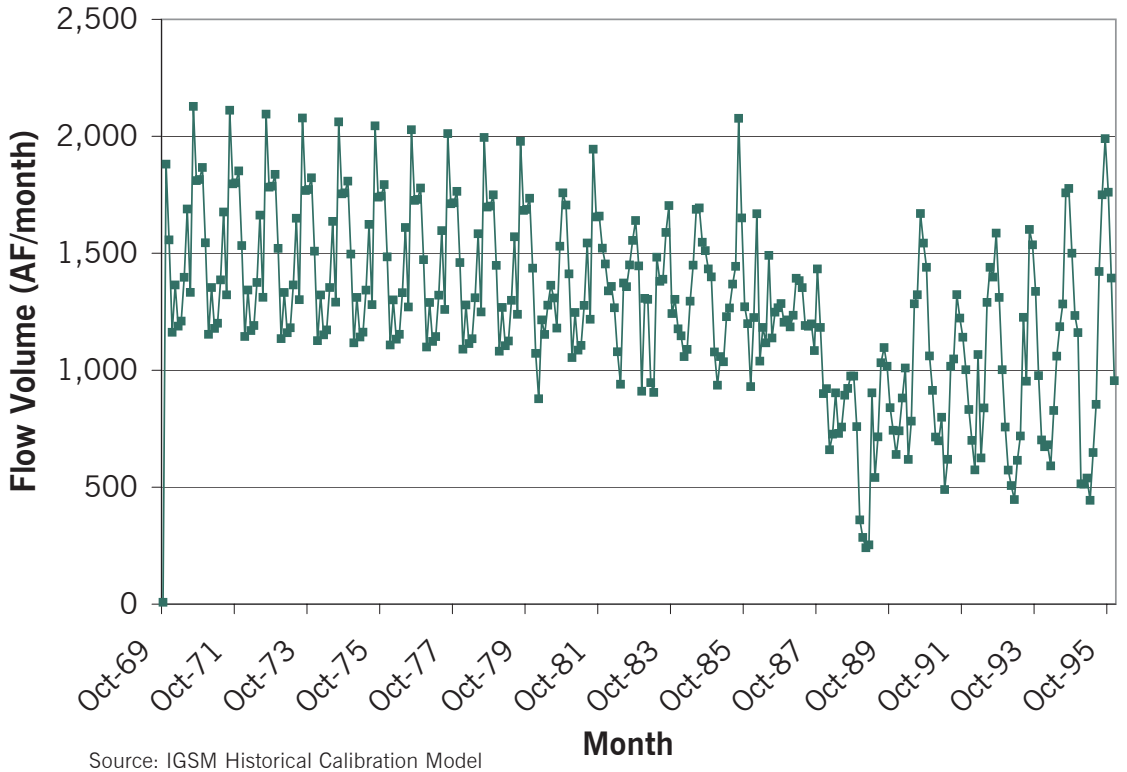
[6] The CVPIA made significant changes in the policies and administration of the project and redefined the purposes of the CVP to include the protection, restoration, and enhancement of fish, wildlife, and associated habitats, and to contribute to California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin River Delta Estuary.

Figure 2-8. U.S. Bureau of Reclamation 1969 to 1995 Surface Water Usage in Central Basin



Source: IGSM Historical Calibration Model

Figure 2-9. City of Folsom 1969 to 1995 Surface Water Usage in Central Basin



Source: IGSM Historical Calibration Model

The WFA limits Folsom's surface water diversions under certain hydrologic conditions (see **Section 1.1.1.1.4**). **Figure 2-9** provides a trace of the use of surface water by Folsom from 1969 to 1995. This figure shows a relatively stable use of surface water with a reduction during the 1987 drought period. Much of the growth that has occurred in Folsom over the past 10 years is not shown in this graph.

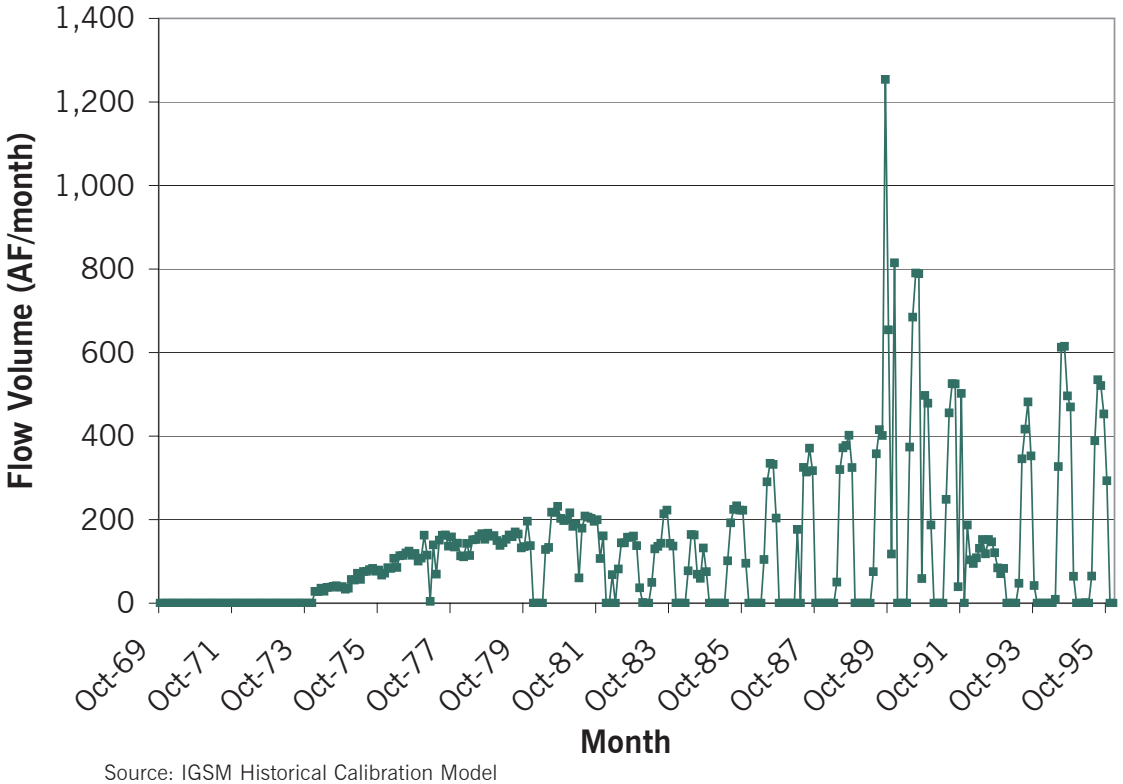
2.2.5.5 Golden State Water Company

GSWC has a 10,000 AF water right on the American River. This right and the Folsom's Pre-1914 Water Right for up to 22,000 AF of American River water are held in a co-tenancy agreement between the two purveyors. In 1994, Folsom and GSWC[7] entered into an agreement wherein GSWC agreed to sell Folsom 5,000 AF of water each year. GSWC diverts the remaining 5,000 AF/year of American River water from the Folsom South Canal for use in its Cordova System. GSWC's current water rights/contract entitlements are summarized in **Table 2-1**.

Figure 2-10 shows a buildup of surface water diversions to the Central Basin over the period of record due to growth and a higher reliance on surface water as a result of the loss of groundwater capacity from the contaminant plumes shown in **Figure 2-19**. Since 1995, GSWC has increased its capacity at the Coloma and Pyrites WTPs to 16 mgd to meet these higher demands.

SCWA purchases approximately 2,066 AF/year of interim surface water from GSWC for use in the Mather/Sunrise portion of Zone 40. This water serves as a short-term replacement for groundwater supplies lost as a result of groundwater contamination by Aerojet and Boeing.

Figure 2-10. Golden State Water Company 1969 to 1995 Surface Water Diversions in Central Basin



Source: IGSM Historical Calibration Model

[7] Southern California Water Company (SCWC), previously known as Arden-Cordova Water Service, held the water right at the time the agreement was signed. SCWC has since become Golden State Water Company.

2.2.5.6 California American Water Company

Cal-Am does not have direct access to surface water. SCWA has reached an agreement with Aerojet and Boeing to replace water supplies lost by SCWA, GSWC, and Cal-Am as a result of groundwater contamination caused by past operations. Once an agreement is signed with SCWA, the affected Cal-Am service areas could receive replacement water supplies as part of SCWA's East Sacramento County Replacement Water Supply Project. This replacement water will be considered a groundwater source of supply, which will be described further in **Section 2.3.9**. Additionally, the Cal-Am service area located within the City's POU has the potential to receive wholesale surface water supplies from the City of Sacramento.

2.2.5.7 Rancho Murieta Community Service District

Rancho Murieta CSD has appropriative water rights on the Cosumnes River of up to 6,368 AF/year for municipal and agricultural, recreational, industrial, environmental, and stock watering uses. However, because of various constraints, annual usage is only about 6,000 AF. Water is diverted from the Cosumnes River at Granlee's Dam and pumped into off-stream lakes Calero, Chesbro, and Clementia from November 1 until May 31 of each year. Minimum flows in the Cosumnes River must be 76 cfs at Michigan Bar before water can be diverted. Surface water use by Rancho Murieta over the time period of 1969 to 1995 is shown in **Figure 2-11**. This graph indicates the steep increase in diversions in relationship to increased development of the Rancho Murieta community and construction of residential development.

2.2.5.8 Omochumne-Hartnell Water District

Within OHWD landowners adjacent to the Cosumnes River and Deer Creek have riparian water rights. Agricultural diversions have fluctuated in the past, but more recently have stabilized at approximately 4,000 AF per year (riparian water usage is difficult to monitor given the number of diverters and unmonitored diversion points. The high variability of flows in both of these water ways cause a wide fluctuation in the volume of water diverted by riparian users. In some years the lack of stream flow during the irrigation season can reduce diversions to near zero.

Historically, riparian users have diverted water from either the Cosumnes River or Deer Creek. Supplemental water obtained from the CVP and conveyed to OHWD via the Folsom South Canal is released to either the Cosumnes River, where riparian users can make their diversions. **Figure 2-12** shows the historical deliveries to OHWD via the Folsom South Canal. **Figure 2-13** shows the historical diversion of surface water from the either the Cosumnes River or Deer Creek. The later years shown in **Figure 2-13** reflect the current level of diversions occurring within OHWD. Water demands for irrigation or other needs that are not met from surface water are met from groundwater sources.

2.2.6 Surface Water Supply Summary

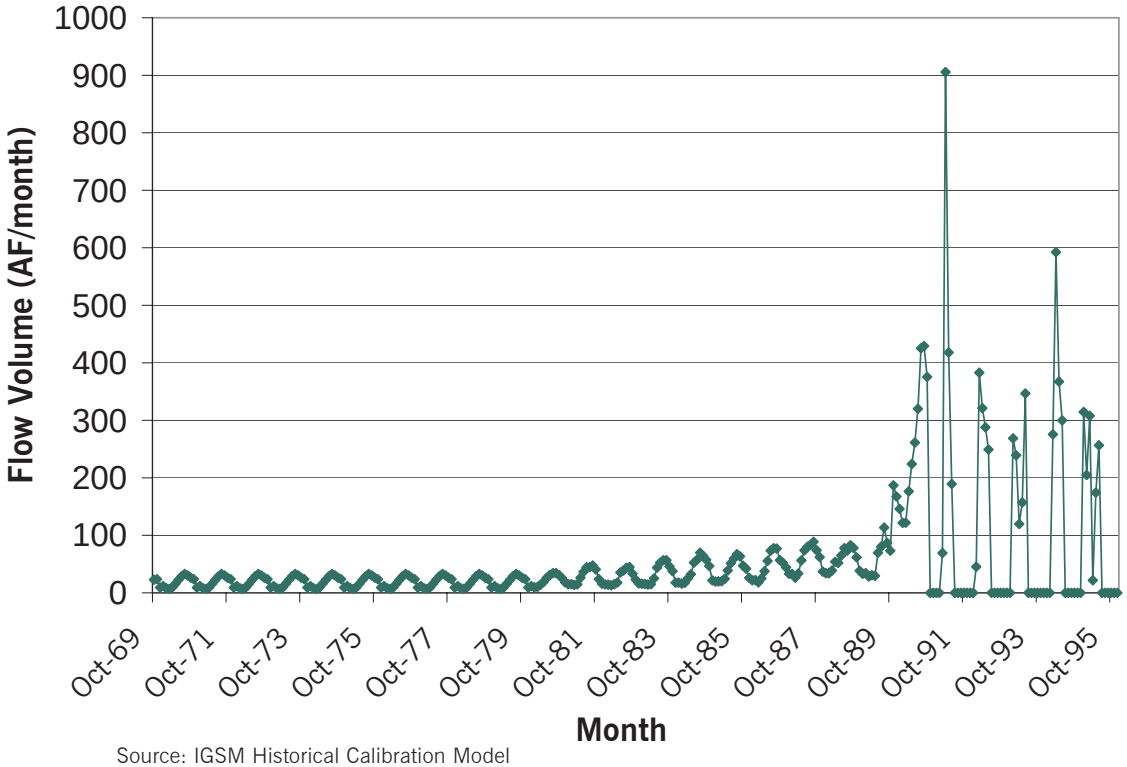
An overview of surface water supplies within the Central Basin is presented in a final water balance for the Central Basin on **Figures 2-25** and **2-26**. The figure shows that between 2005 and 2030, approximately 90,000 AF of additional surface water will be delivered to the Central Basin in wet years and approximately 30,000 AF in dry years.

The 2030 surface water supply shown in **Figure 2-26** should not be confused with the total amount of surface water available by contract to the basin given no curtailment in water contract amounts. Rather, the figure indicates the delivery of surface water based on municipal and agricultural demand patterns to meet the water demands of 2030. To make full use of all contract entitlements, would require above average rainfall, large offstream storage reservoirs to store the water for peak demand periods, and agreements to not use groundwater by purveyors who rely on groundwater to meet a portion or all of their water demands.

2.2.7 Other Available Surface Water Supplies

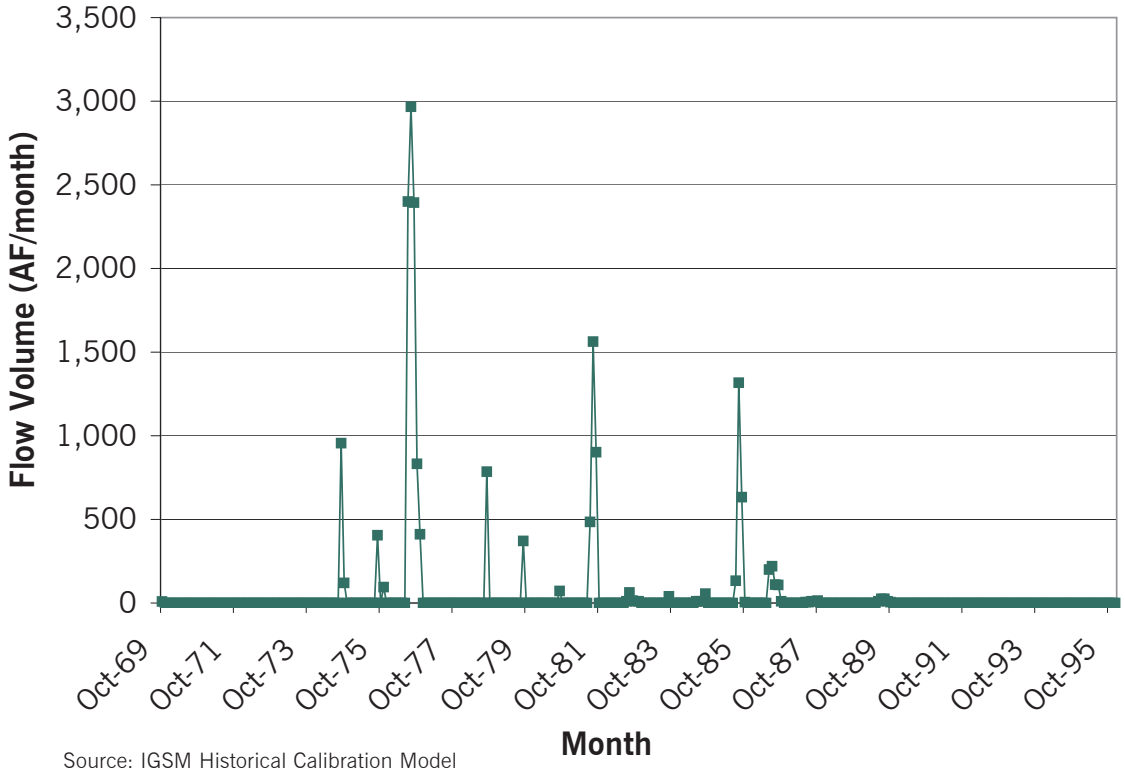
The availability of surface water supplies beyond those already under contract are not likely given the constraints and competition for water throughout the State of California. During critical year conditions, the

Figure 2-11. Rancho Murieta CSD 1969 to 1995 Surface Water Usage in Central Basin



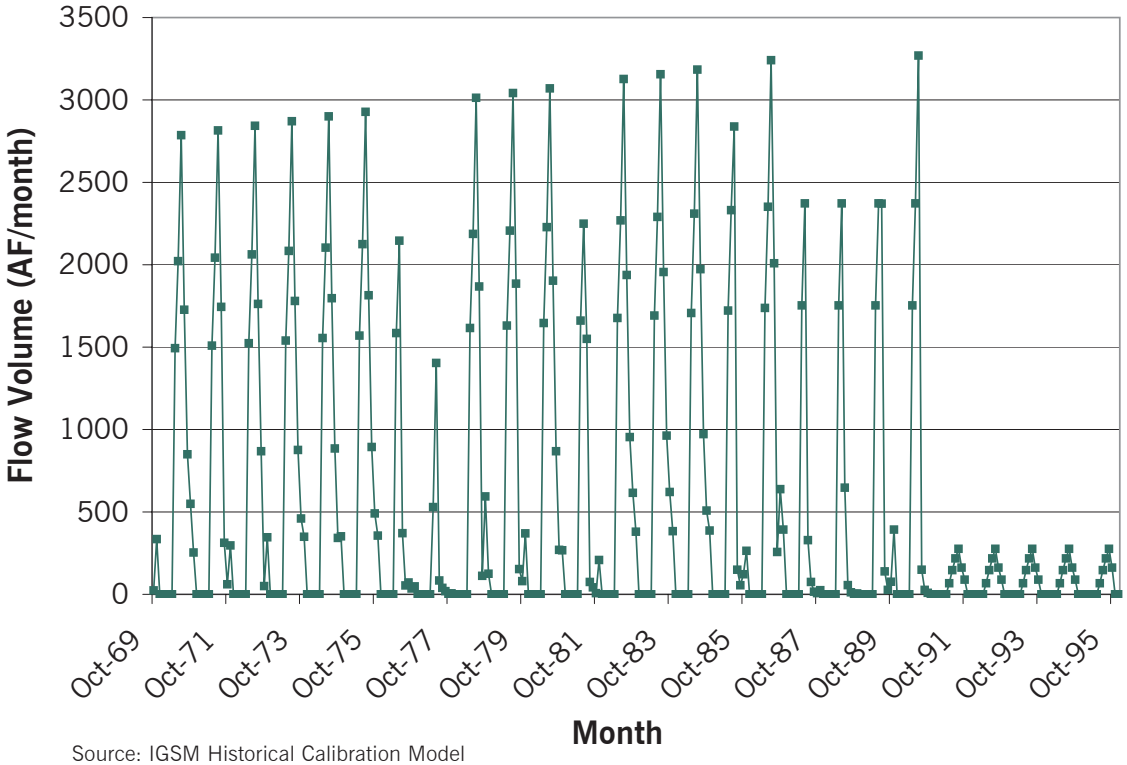
Source: IGSM Historical Calibration Model

Figure 2-12. OHWD 1969 to 1995 Surface Water Deliveries via the Folsom South Canal in Central Basin



Source: IGSM Historical Calibration Model

Figure 2-13. OHWD 1969 to 1995 Surface Water Usage from Cosumnes River and Deer Creek in Central Basin



Source: IGSM Historical Calibration Model

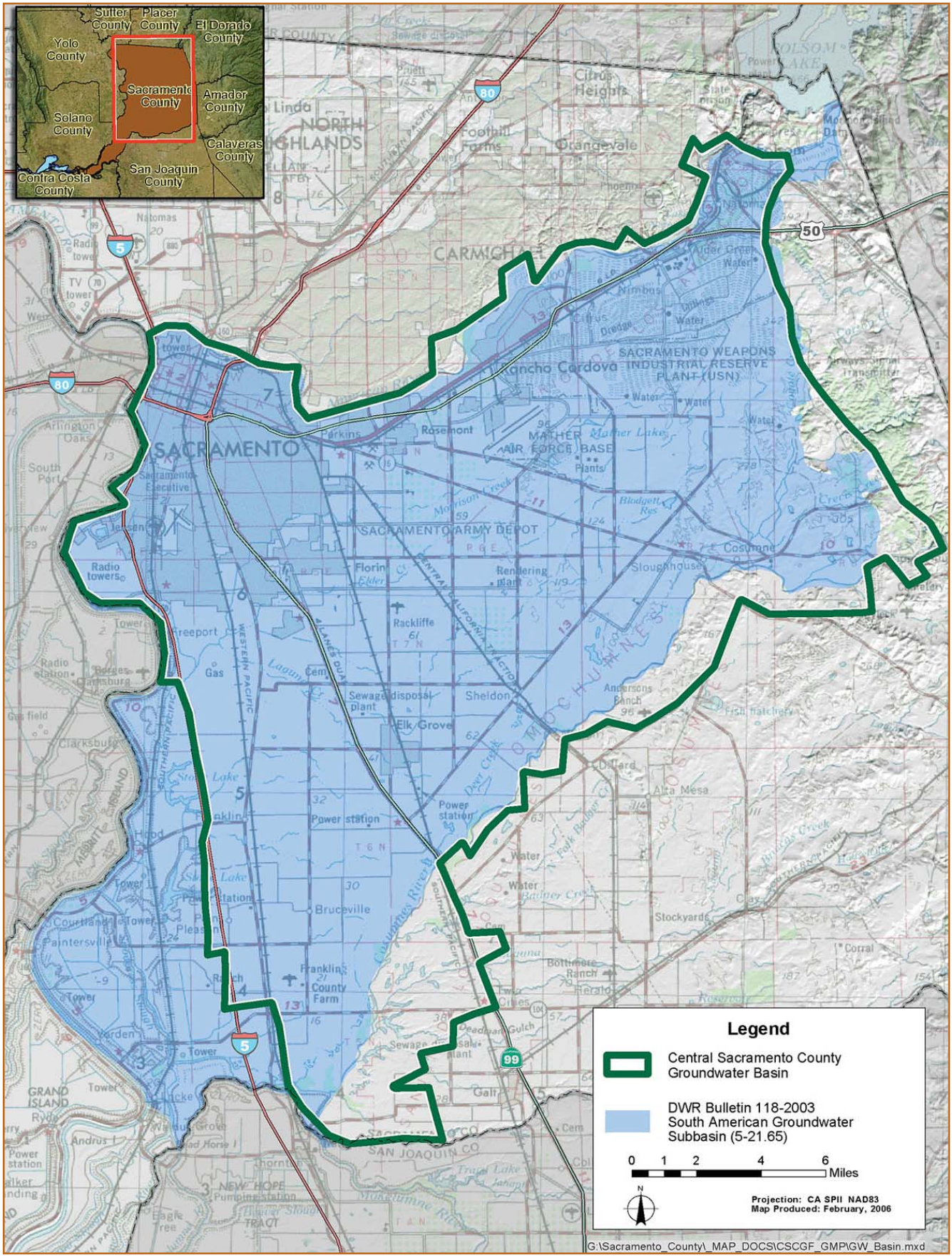
purchase of supplemental surface water from upstream Sacramento Valley water right holders may occur should those water right holders elect to fallow crops in return for compensation. SCWA has applied for an appropriative right on the Sacramento and American rivers for excess water. SCWA will most likely obtain this water right in 2008. Once appropriated, SCWA will use this water to meet municipal demands. SCWA also could potentially deliver water to agricultural areas that would have otherwise used groundwater, thus providing in-lieu recharge of the groundwater basin, or directly recharge the groundwater basin via recharge basins, and/or possibly treat and inject water with aquifer storage and recovery (ASR) wells. These options and strategies are discussed in later sections of this CSCGMP.

2.3 GROUNDWATER SUPPLIES

The groundwater basin underlying Sacramento County is divided into three subbasins, North, Central, and South, as shown in **Figure 1-1**. The Central Basin lies south of the American River, east of Interstate 5 and the Sacramento River, and north of the southern boundary of the OHWD and the Cosumnes and Mokelumne rivers. The eastern boundary of the Central Basin is approximately five to six miles west of the Sacramento County-El Dorado County boundary where the Sierra Nevada foothills begin to rise up from the Central Valley floor.

Essentially, the Central Basin boundary overlies State Department of Water Resources (DWR) South American Subbasin (DWR Bulletin 118-2003) (see **Figure 2-14**), however, the boundaries are slightly different because the Central Basin boundary was developed from the Sacramento County IGSM grid. An important artifact of this difference is that OHWD, which spans both sides of the Cosumnes River, lies entirely within the Central Basin for modeling purposes, but in fact half the district is in the Central Basin and the other half lies in the South Basin. This section provides a regional description of the geologic and hydrogeologic conditions of the underlying groundwater basin.

Figure 2-14. DWR Groundwater Subbasin



It is important to note that some municipal groundwater purveyors within the Central Basin did not actively participate in development of the CSCGMP. Rather than omit information relative to the Central Basin, the GMP Task Force obtained what information they could and have included it in this document. Because the CSCGMP is based on adaptive management, these stakeholders may participate, review, and provide data as part of the groundwater management plan program in the future.

2.3.1 Overview of Hydrogeologic Setting

The South American Subbasin, which the Central Basin is a portion, is defined as the area bounded on the west by the Sacramento River, on the north by the American River, on the south by the Cosumnes and Mokelumne rivers, and on the east by the Sierra Nevada Range. A full description about the South American Subbasin can be found on DWR's Web site (URL http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs _ desc/5-21.65.pdf). A summary of more relevant information is provided below:

- Surface area: 388 square miles (Central Basin: 386 square miles).
- The perennial rivers that surround the subbasin generally create a groundwater divide in the shallow subsurface. It is clear that interaction occurs between groundwater of adjacent subbasins at greater depths.
- Average annual precipitation in the basin ranges from about 14 inches along the western boundary to greater than 20 inches along the eastern boundary.
- The eastern basin boundary is defined by the uprising foothills of the Sierra Nevada, and is a north-south line extending from Folsom Reservoir south to the small community of Rancho Murieta. This represents the approximate edge of the alluvial basin, where little groundwater flows into or out of the groundwater basin from the Sierra Nevada foothills. The western portion of the subbasin consists of nearly flat floodplain deposits from the Sacramento, American, and Cosumnes rivers, and several small east side tributaries.

2.3.2 Hydrostatigraphy of the Central Basin

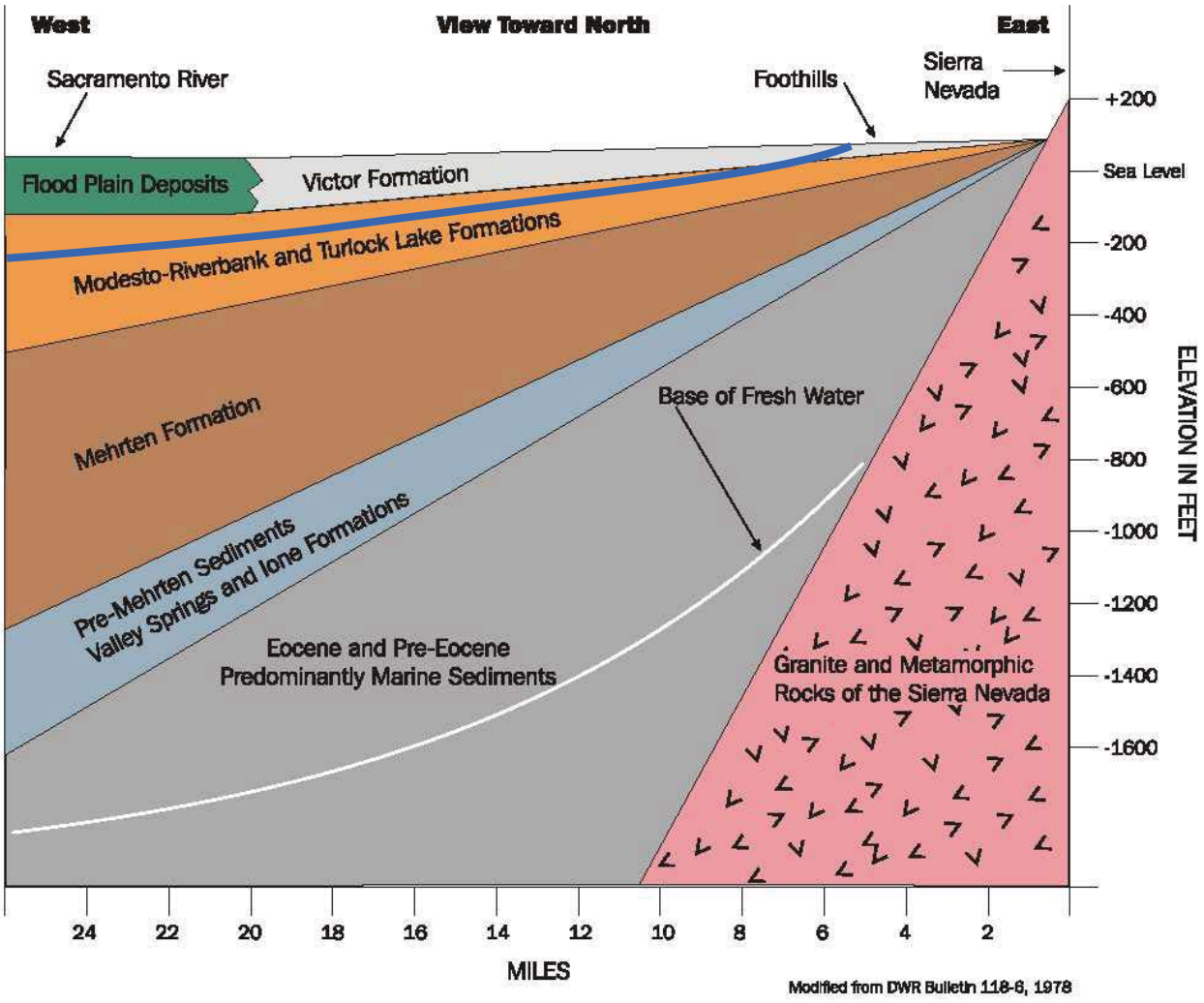
Bulletin 118-3 identifies and describes various geologic formations that constitute the water-bearing deposits underlying Sacramento County. These formations include an upper, unconfined aquifer system consisting of the Victor, Fair Oaks, and Laguna Formations (now known as the Modesto Formation), and a lower, semiconfined aquifer system consisting primarily of the Mehrten Formation, known for its fine black sands. These formations are shown in **Figure 2-15** and are typically composed of lenses of interbedded sand, silt, and clay, interlaced with coarse-grained stream channel deposits. **Figure 2-15** illustrates that these deposits form a wedge that generally thickens from east to west to a maximum thickness of about 2,500 feet under the Sacramento River. The Mehrten formation outcrops near the Sierra Foothills along the eastern Central Basin boundary and is typically characterized as a black sandy lens.

Groundwater in the Central Basin is generally classified as occurring in a shallow aquifer zone (Laguna or Modesto Formation) or in an underlying deeper aquifer zone (Mehrten Formation). Within the Central Basin, the shallow aquifer extends approximately 200 to 300 feet below the ground surface and, in general, water quality in this zone is considered to be good with the exception of arsenic detections in a few locations. The shallow aquifer is typically used for private domestic wells requiring no treatment unless high arsenic values are encountered, causing owners to possibly target other water-bearing strata.

The deep aquifer is separated from the shallow aquifer by a discontinuous clay layer that serves as a semiconfining layer for the deep aquifer. The base of the potable water portion of the deep aquifer averages approximately 1,400 feet below ground surface (bgs). Water in the deep aquifer typically has higher concentrations of total dissolved solids (TDS), iron, and manganese. Groundwater used in the Central Basin is supplied from both the shallow and deeper aquifer systems.

Older municipal wells and all domestic wells have been constructed in the shallow aquifer zone to avoid treatment.

Figure 2-15. Regional Geologic Cross Section



However, the policies and practices of SCWA in the Central Basin have led to the construction of larger municipal wells that target the Mehrten Formation where higher production rates can be achieved and less impact to private domestic wells would occur. This policy has in turn led to California Department of Health Services (DHS) requiring treatment of all municipal wells to meet primary and secondary drinking water quality standards.

2.3.3 Understanding Groundwater Changes in the Central Basin

Evaluating changes in aquifer conditions requires an understanding of the dynamic processes and interactions that are taking place as extractions and recharge of the aquifer occur. Conceptual models of the aquifer that describe induced recharge, aquifer storage, and differences between localized and regional effects on the aquifer are discussed below. These conceptual models are meant to clarify concepts; not all aspects of groundwater hydraulics are described. These models only apply to the Central Basin and adjoining basins within Sacramento County.

2.3.3.1 Groundwater Recharge Potential

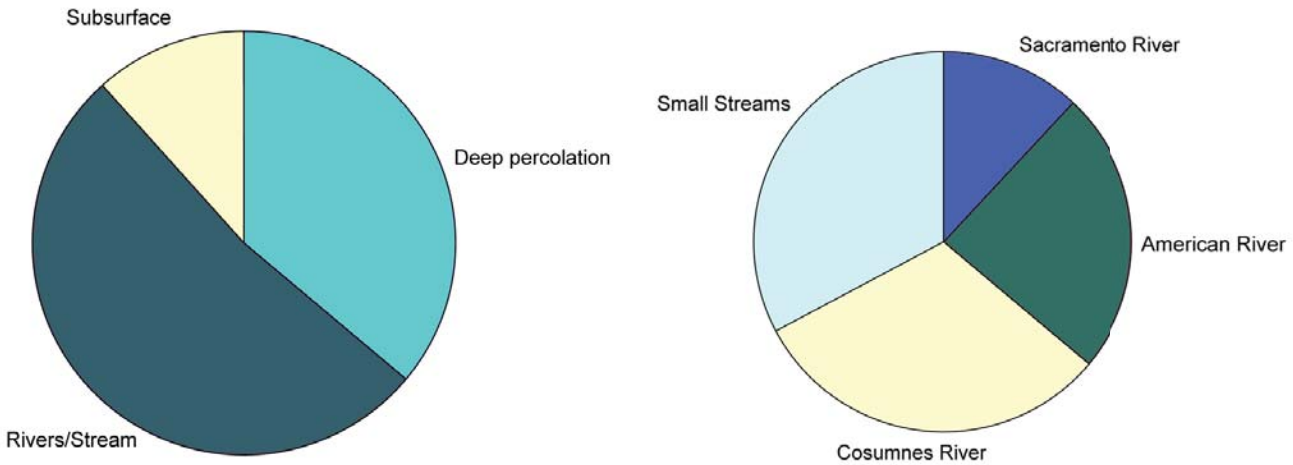
Groundwater in Central Sacramento County moves from sources of recharge to areas of discharge (as shown

in Figure 7 of the Conservation Element of the 1993 Sacramento County General Plan). Recharge of the local aquifer system occurs along active river and stream channels where extensive sand and gravel deposits exist, particularly along the American, Cosumnes, and Sacramento River channels. Additional recharge occurs along the eastern boundary of Sacramento County at the transition point from the consolidated rocks of the Sierra Nevada to the alluvial-deposited basin sediments. Recharge typically occurs through fractured granitic rock that makes up the Sierra Nevada foothills. This recharge is classified as subsurface recharge along with underground flow into and out of the Central Basin with adjacent groundwater basins. Other sources of recharge include deep percolation from applied surface water and precipitation. Induced recharge can occur from recharge basins and injection of water through ASR wells. The different sources of recharge and the approximate percentage that each provides to the Central Basin's overall natural recharge are provided in the pie chart shown in **Figure 2-16** below. The amount of natural recharge is important as it helps define when the basin is in a state of equilibrium and natural recharge roughly equals the amount of the groundwater extractions.

Changes in groundwater surface elevation (or piezometric surface) are a result of changes in groundwater extractions and can induce natural recharge at locations where rivers or streams and the aquifer are hydraulically connected. To the extent that a hydraulic connection exists, as groundwater conditions change, the slope or gradient of the groundwater surface may change as well. A steeper gradient away from the stream would induce higher recharge from the surface water source into the aquifer.

The rate of recharge from streams or rivers that are hydraulically disconnected from the groundwater surface is indifferent to changes in groundwater elevations or gradient. This is typically true with smaller streams where the groundwater surface is located far below the streambed. In such cases, surface water percolates through the unsaturated zone to the groundwater and its rate is a function of the aquifer materials underlying the streambed and the water level in the surface stream. The rate of infiltration under these conditions is not controlled by the change in elevation of the underlying groundwater. In the case of larger rivers, the American and Sacramento rivers are considered to be hydraulically connected and the Cosumnes River is considered to be hydraulically disconnected in the lower reaches of the

Figure 2-16. Central Basin Recharge Sources



river that flow through the Central Basin. The CSCGMP recognizes the importance of maintaining hydraulic connections with the larger river sources for sustainability of the groundwater supply, and the environmental benefits of keeping water flowing in the riverbed.

2.3.3.2 Localized Impacts of Groundwater Extraction

When extractions occur from a single well, a concentrated localized cone of depression is formed around the well. The shape and depth of the localized cone of depression depends on several factors including, but not limited to following: (1) the rate of extraction, (2) the presence of nearby sources of recharge and/or extraction, (3) aquifer transmissivity, (4) natural impervious barriers or earthquake faults, and (5) the "confined" or "unconfined" state of the aquifer, (i.e., storage coefficient). Over time, extraction from an unconfined aquifer can dewater the aquifer around the well. However, when extraction ceases, the water level within the aquifer can rebound to its preextraction condition over a relatively short period of time.

A confined or semi-confined aquifer behaves differently since the water is under pressure from a recharge source. Instead of dewatering the aquifer, a change in confining pressure occurs as a result of extractions; the aquifer remains saturated. In a confined aquifer, the pressure or piezometric surface elevation decline is more dramatic than in an unconfined aquifer; however, the recovery to pre-extraction conditions is typically much faster.

2.3.3.3 Regional Impacts of Groundwater Extraction

Large regional cones of depression can form in areas where multiple groundwater extraction wells are in operation. The location and shape of a regional cone of depression is influenced by the same factors as a single well. The regional cone of depression within the Central Basin is shown in **Figure 2-17**, as part of a water elevation contour map for spring 2004. This map was prepared using water elevation data from DWR's water data library available on-line at http://wdl.water.ca.gov. The map contours were determined using the Inverse Distance to a Power method.

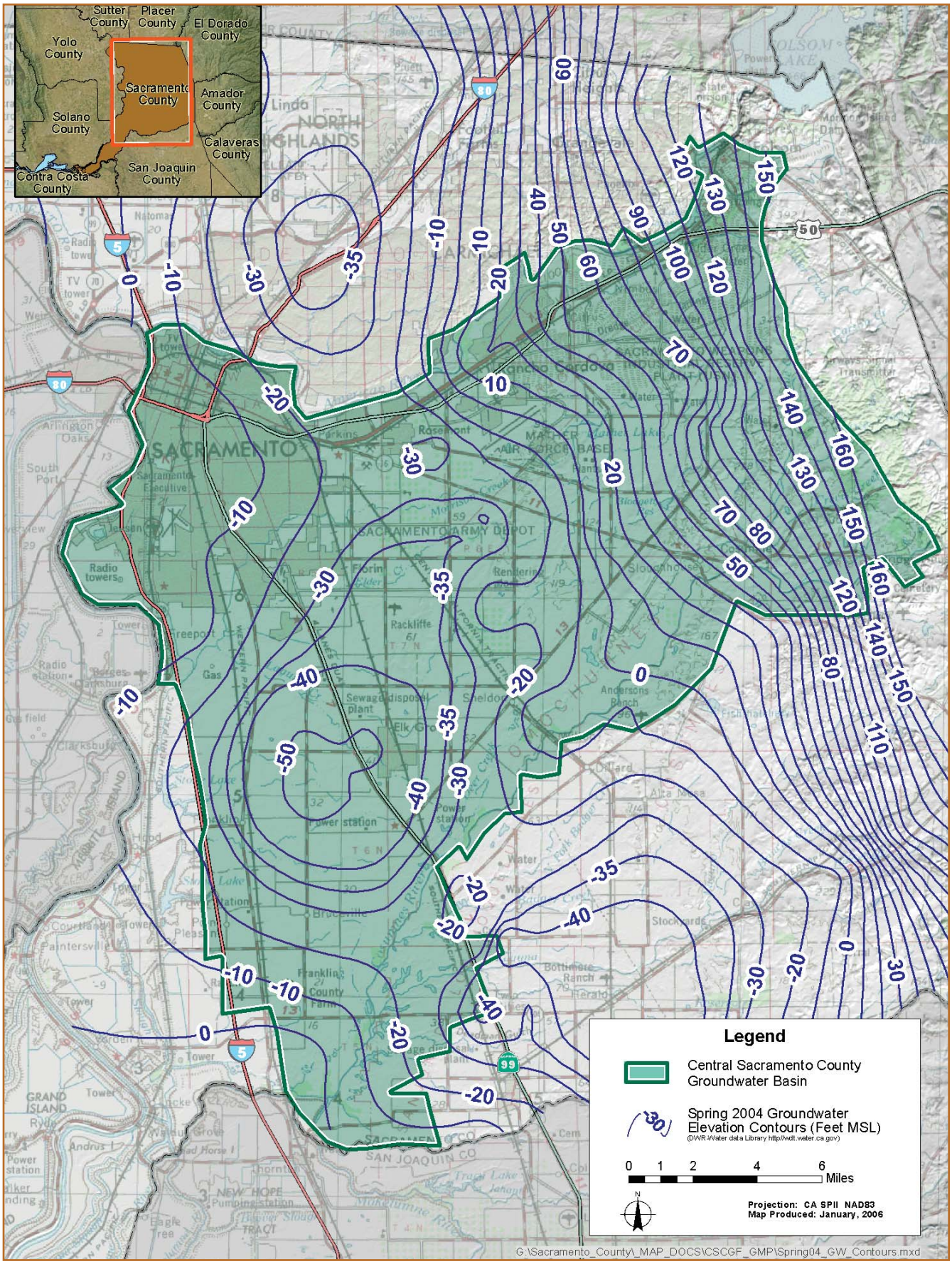
Fluctuations in regional cones of depression are measured over years and result from (1) changes in recharge and (2) changes in extractions from increasing and decreasing water demands. For example, a sequence of successive dry years can decrease the amount of natural recharge to the aquifer. If this is coupled with a coinciding increase in groundwater extraction, an imbalance is created between natural recharge and extractions. Consequently, groundwater elevations would decrease in response to this imbalance. Over time, the shape and location of the aquifer's regional cone of depression fluctuates.

Intensive use of the groundwater basin has resulted in a general lowering of groundwater elevations near the center (or centroid) of the basin away from the sources of recharge. As early as 1968, pumping depressions were evident in the Central Basin. These depressions have grown and coalesced into a single cone of depression centered in the southern portion of the Central Basin area, as shown in **Figure 2-17**.

2.3.4 Groundwater Level Trends

A review of 11 long-term hydrographs, shown in **Figure 2-18A** (within Zone 40) and **Figure 2-18B** (outside Zone 40), illustrates groundwater level trends through much of the Central Basin. Groundwater elevations generally declined consistently from the 1950s and 1960s to about 1980 on the order of 20 to 30 feet. From 1980 through 1983, water levels recovered by about 10 feet and remained stable until the beginning of the 1987 through 1992 drought. From 1987 until 1995, water levels declined by about 15 feet. From 1995 to 2003 most water levels recovered generally higher than levels prior to the 1987 through 1992 drought. Much of this recovery can be attributed to the increased use of surface water in the Central Basin, and the fallowing of previously irrigated agricultural lands transitioning into new urban development areas in accordance with the Sacramento County and City of Elk Grove General Plans. Below is a brief description of the hydrograph trends in different locations within the Central Basin (the geographic divisions were made to assist in the descriptions):

Figure 2-17. Spring 2004 Groundwater Elevation Contour Map



Southern Wells. The southern portion of the Central Basin extends from Interstate 5 to just east of Highway 99. Groundwater level trends in this area can be seen in hydrographs from DWR monitoring wells SWP-115, SWP-058, and SWP-054, shown in **Figure 2-18A**, and wells SWP-170, SWP-107, SWP-004, and SWP-063, shown in **Figure 2-18B**. The hydrographs for these wells show groundwater levels generally varying between 10 and 90 feet below mean sea level (msl).

Central Wells. The central portion of the Central Basin is the area between Highway 99 and Highway 16 (Jackson Highway). Groundwater level trends in this area can be seen in hydrographs from DWR monitoring wells SWP-121, SWP-124, SWP-125, SWP-128, SWP-188, shown in **Figure 2-18A**, and SWP-177, SWP-149, and SWP-154, shown in **Figure 2-18B**. The hydrographs for these wells show groundwater levels generally varying between 40 feet above to 40 feet below msl.

Northern Wells. The northern portion of the Central Basin is the area north of Highway 16 (Jackson Highway). The general trend of groundwater levels in this area is more stable than the other areas. Water level trends in this area can be seen in hydrographs from DWR monitoring wells SWP-255, SWP-202, and SWP-209, shown in **Figure 2-18A**, and SWP-185, SWP-250, and SWP-244, shown in **Figure 2-18B**. The hydrographs for these wells show declines of up to 40 feet since 1960.

2.3.5 Water Forum Groundwater Sustainable Yield

For each of the three groundwater subbasins in Sacramento County, the Water Forum Groundwater Negotiation Team (GWNT) developed an estimated long-term average annual pumping limit for meeting 2030 land and water use conditions (see **Section 1.1.1**). **Appendix A** provides a summary of the process used for developing the long-term average annual pumping limit of 273,000 AF/year that was negotiated for the Central Basin.

"Long-term average annual pumping limit" describes the hydrogeologic process under which groundwater can be pumped and not exceed average natural recharge over a long-term period of time. Under sustainable conditions, natural recharge is said to be able to make up for variations in the amount of pumping that occurs over the long-term, given wet and dry periods in the hydrologic record. As shown in **Figure 2-16**, natural recharge occurs primarily from streams, rainfall, and subsurface inflow.

To understand how the GWNT arrived at the 273,000 AF/year is a complex process that requires some discussion of the technical data that were developed to support that decision. Much of the data are based on evaluating future land and water use projections and describing the impacts associated with increased water demands, assuming that demand is met solely by groundwater. Comparing these results with existing conditions (1990 as the baseline) provided a level of impact that could be expected if groundwater pumping were increased beyond baseline conditions. In some cases, such as in the North Basin, the GWNT agreed that baseline levels of pumping were already at an acceptable level of impact.

Four quantifiable factors were used to determine the level of impact:

- Water quality degradation
- Dewatering of wells
- Higher cost of pumping
- Ground subsidence

Based on these four elements, a series of groundwater model runs quantified each condition in 10-year increments, beginning in 1990 and ending in 2030. Each model run was setup to reflect future land and water use conditions; then 70 years of historical hydrology were applied to each model run to determine how the aquifer might behave under wet and dry conditions.

After a comprehensive review and analysis of model data and real data, the GWNT concluded that using 2005 levels of groundwater pumping would provide the highest quantity of groundwater yield from the basin while minimizing impacts associated with the four elements of concern. By interpolating between 2000 and 2010, pumping at 2005 equates to a long-term average annual pumping limit of approximately 273,000 AF/year for the Central Basin.

2.3.6 Groundwater Quality

Water quality analysis of the aquifers underlying the Central Basin has shown that groundwater found in the upper aquifer system is of higher quality than that found in the lower aquifer system. This is principally because the lower aquifer system (specifically the Mehrten formation) contains higher concentrations of iron and manganese. The lower aquifer system also has higher concentrations of total dissolved solids (TDS), although this aquifer typically meets water quality standards as a potable water source. At depths of approximately 1,400 feet or greater (actual depth varies throughout the basin), the TDS concentration exceeds 2,000 milligrams per liter (mg/L) and groundwater is considered non-potable unless treated by reverse osmosis. Water from the upper aquifer (specifically the Laguna formation) generally does not require treatment (unless high arsenic values are encountered), other than disinfection for public drinking water systems.

2.3.6.1 Background Water Quality

Municipal wells meet all CCR Title 22 primary drinking water quality standards. A number of purveyor wells within the Central Basin exceed secondary drinking water standards for iron and manganese; many of these wells are treated to remove these constituents. Secondary standards were established for aesthetic concerns (e.g., staining of laundry and porcelain fixtures) and at elevated levels do not pose a health hazard. Arsenic concentrations in some wells exceed recently implemented (January 2006) federal drinking water standards of 10 micrograms per liter (μg/L); these regulations provide a timetable for compliance. Radon also has been detected in groundwater in the greater Sacramento area, although not at levels that exceed current drinking water standards.

This description of background water quality is based on data used to populate the Central Basin Data Management System (DMS). Groundwater quality data from monitoring activities between 1999 and 2003 were used to populate the DMS for portions of the Central Basin. The DMS can be used to query data and develop statistics and graphics for constituents of interest.

2.3.6.2 Total Dissolved Solids

TDS concentrations in most municipal wells are within secondary drinking water standards; therefore, TDS does not limit the potable use of groundwater.

2.3.6.3 Iron and Manganese

Iron and manganese are found in deeper municipal wells and treatment is required by DHS when a new well is constructed. Therefore, the presence of iron and manganese does not limit the potable use of groundwater. According to the DMS, iron concentrations range from nondetect (less than 10 μg/L) to 16,000 mg/L, although most wells have average values of less than 200 mg/L. Manganese concentrations range from nondetect (less than 2 mg/L) to 1,700 mg/L, although most wells have average values of less than 50 mg/L.

2.3.6.4 Arsenic

The U.S. Environmental Protection Agency (EPA) has adopted a revised MCL for arsenic of 0.010 mg/L, along with monitoring requirements, arsenic health effects language, and best available technologies for arsenic mitigation in public drinking water systems. The compliance date for the new MCL is January 23, 2006. Although DHS is in the process of adopting new regulations, it is unknown when the state regulations will be adopted. In the meantime, DHS plans to initiate implementation of the new federal requirements in January 2006.

DHS will require that untreated municipal wells that exceed the new arsenic standards be phased out of production or be treated to below the new 10 μg/L maximum concentration. The requirement does not apply to individual domestic wells. Water purveyor compliance through DHS will likely take place during 2006 within a set timeframe that the water purveyor can meet with DHS oversight. This provides for additional time to construct replacement facilities and close down existing wells that exceed the arsenic concentration, or, if needed, to meet the necessary treatment requirements.

Prior to the EPA ruling of 2004, arsenic concentrations of less than 50 μg/L were acceptable for potable

Figure 2-18A. Central Basin Groundwater Elevation Hydrographs Within SCWA Zone 40

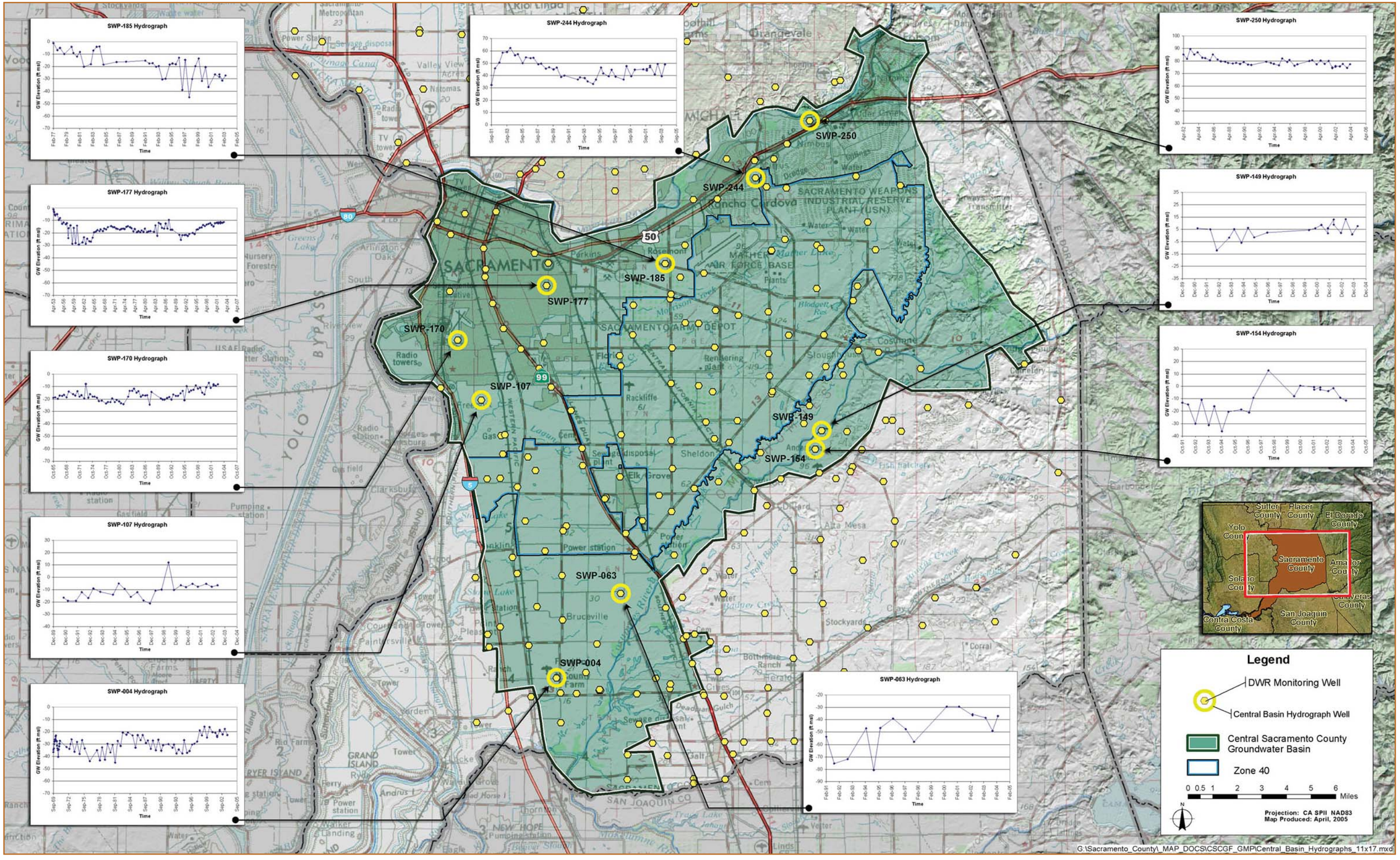
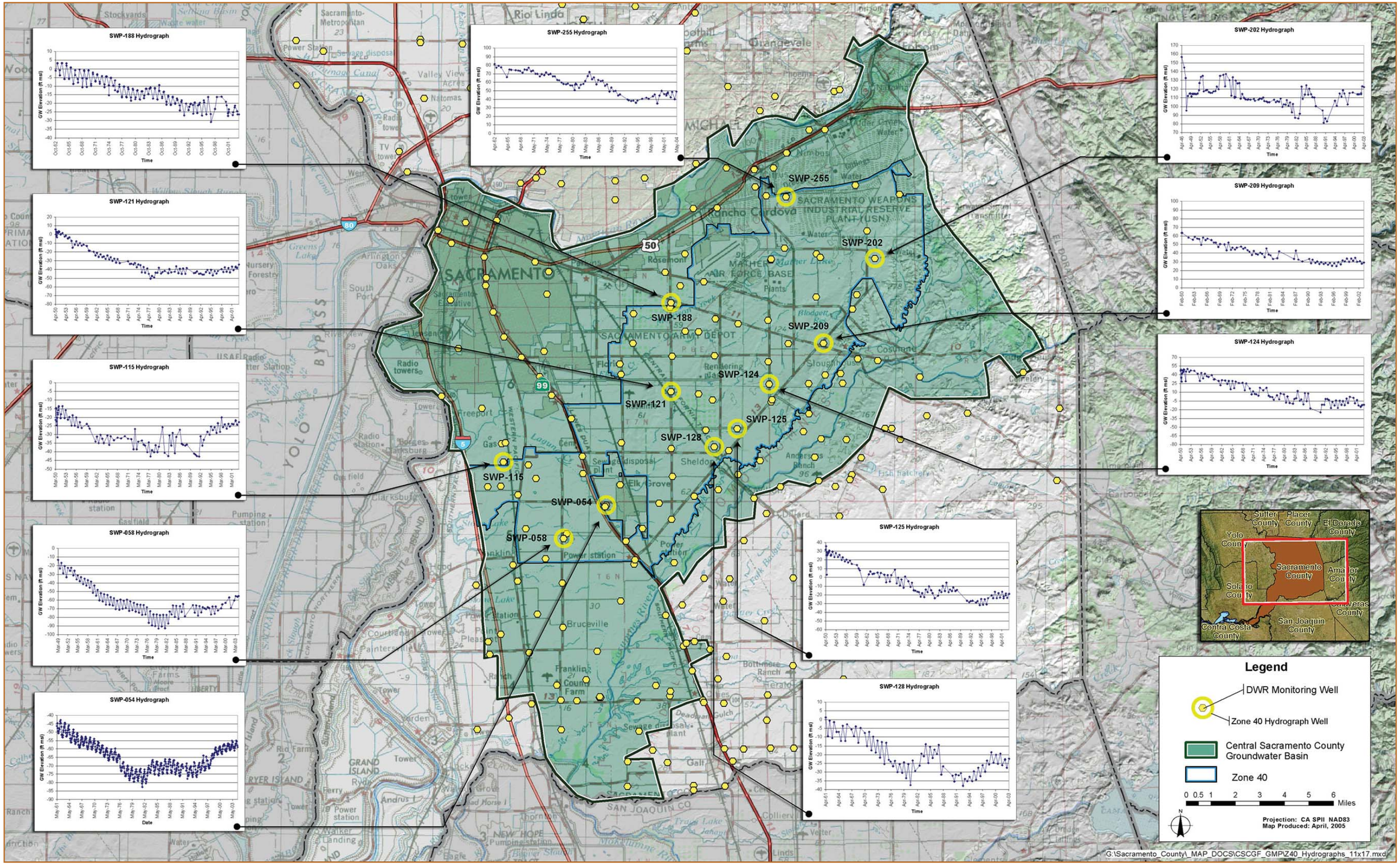


Figure 2-18B. Central Basin Groundwater Elevation Hydrographs Outside SCWA Zone 40



drinking water. Municipal wells within the Central Basin have historically met primary drinking water standards; therefore, arsenic has not limited the potable use of groundwater prior to December 2006.

2.3.6.5 Known "Principal" Contaminant Plumes

Principal groundwater contaminant plumes within or near the Central Basin are known to exist from source areas such as Mather Field, McClellan Air Force Base, Aerojet, Boeing, the former Army Depot, the former Southern Pacific and Union Pacific railyards, and various landfills. These plumes are shown on **Figure 2-19**. Contaminant plume data were collected from the following documents:

- MWH. Mather Air Force Base Annual and Fourth Quarter 2002 Sitewide Groundwater Monitoring Report. March 2003
- Aerojet Environmental Remediation. Aerojet General Corp Superfund Site Western Groundwater Cleanup 2004 Progress Report. 2004
- McDonnell Douglas/Boeing Environmental Remediation. McDonnell Douglas Sacramento Site, American River Study Area Groundwater Monitoring Results, April – June 2002. August 2002
- Disposal Sites. Integrated Waste Management Board.
- Environmental Simulations, Inc., Revised Probabilistic Groundwater Flow Model for the Southern IRCTS, Rancho Cordova, California. June 2003
- Groundwater Contamination Investigation for Central Basin 2004, Water Forum/Schlumberger Engineering)

Although other localized plumes exist in and around the Central Basin (e.g., small leaking under ground fuel tanks), the principal plumes shown in **Figure 2-19** are the largest and have the greatest current impact on existing groundwater use.

For the Mather Field plumes, the primary contaminants of concern (COC) are tetrachloroethylene (TCE), perchloroethylene (PCE), and carbon tetrachloride. The edges of Mather Field plume represent a composite COC concentration of 0.5 mg/L, which is one-tenth of the maximum contaminant level (MCL) for these constituents.

For the Aerojet and IRCTS plumes, the primary COCs are TCE, n-nitrosodimethylamine (NDMA), and perchlorate.

Leaking underground fuel tank (LUFT) sites also exist within the Central Basin. It is assumed that these sites can be fully remediated; however, an inventory of the number of sites, their locations, and their clean-up status is kept by the Sacramento County Environmental Management Department (EMD). The aggregate impact on groundwater quality from undetected contamination (e.g., MTBE) in the basin cannot be determined at this time and may ultimately be considerable. Methods to inventory these undetected contaminants will likely be done under the purview of EMD.

2.3.7 Groundwater Facilities

In municipal water systems that are "groundwater only," water is fed into the system by individual wells (direct feed wells) or by centralized groundwater treatment plant(s) (ranging in size from 1 mgd to 12 mgd) that treat water from several wells.

Large capacity municipal wells are shown in **Table 2-3** and **Figure 2-20**. Agricultural and private wells are not shown due to insufficient data on the location and size of each well. Typical municipal capital facilities for groundwater production capacity include groundwater extraction wells (including raw water piping from the wells to the treatment plant), treatment, at grade storage tanks, booster pumps, and transmission pipelines to the distribution system. Treatment plants typically remove iron, manganese, and some arsenic. Capacity of groundwater facilities by agencies participating in development of the CSCGMP are summarized below:

- The City currently operates two active municipal groundwater supply wells plumbed to its distribution system within the city limits south of the American River. These two wells represent about seven percent of the City's total groundwater pumping capacity of 30 mgd.
- SCWA has a combination of direct feed wells and groundwater treatment facilities. Groundwater treatment plant capacity ranges from approximately 2 mgd to 11 mgd.
- GSWC provides a portion of the water supply to its Cordova System with direct feed wells with a combined capacity of approximately 24 mgd. The Cordova System has been significantly impacted

Figure 2-19. Known Principal Contaminant Plumes

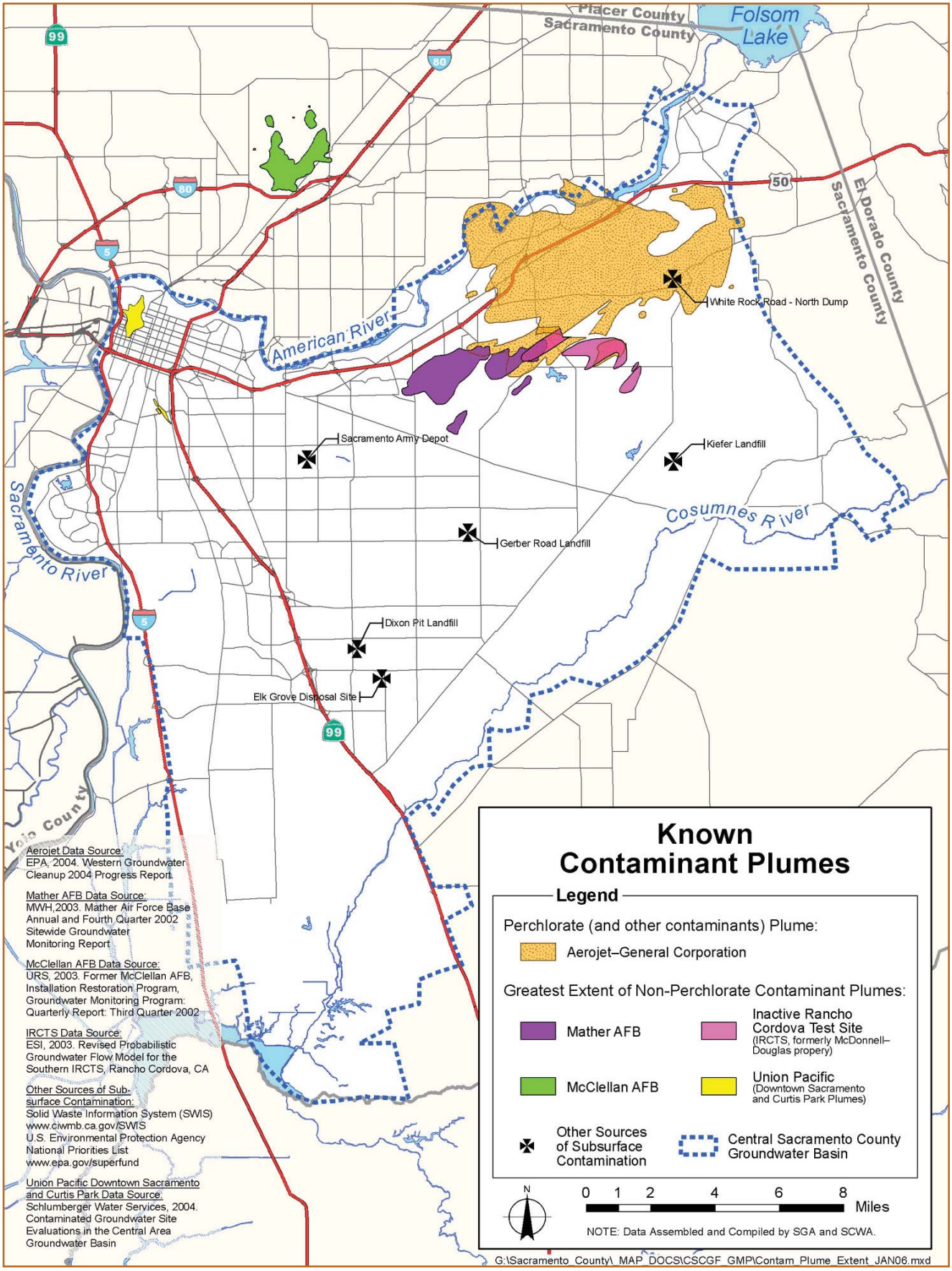
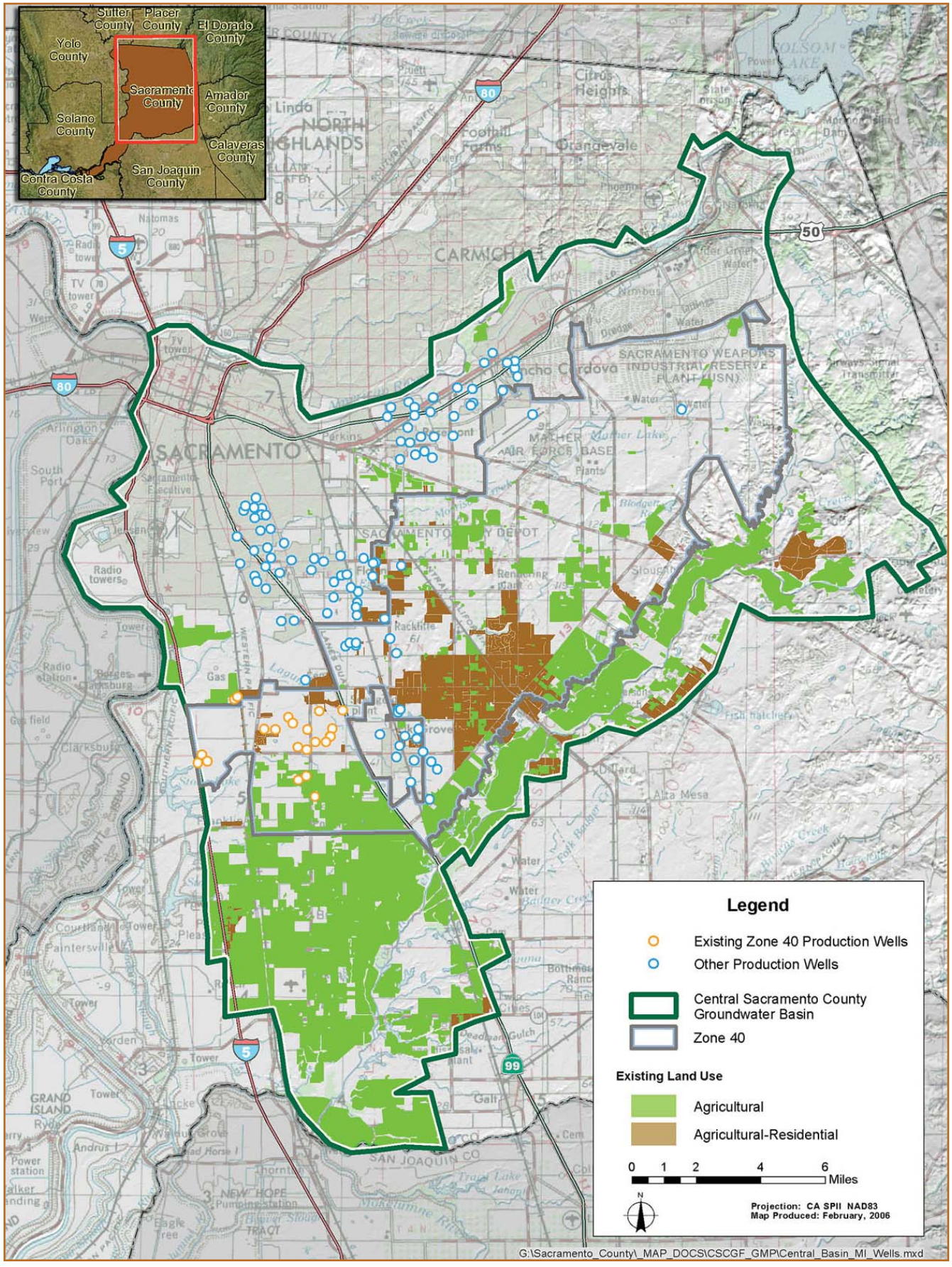


Table 2-3. Existing Purveyor "Larger" Production Wells

DMS Well ID	Well Name	State Well ID	Agency
134	WOODMAN	null	CAL-AM
135	SALMON F	null	CAL-AM
136	ROGUE RI	null	CAL-AM
137	WHITEWAT	null	CAL-AM
138	BUTTERFI	null	CAL-AM
139	FOLSOM/B	null	CAL-AM
153	CALDERA	null	CAL-AM
154	POINT REYES	null	CAL-AM
155	COLLEGE	null	CAL-AM
156	OAKEN BU	null	CAL-AM
157	SUTTERS	null	CAL-AM
158	WILDROSE	null	CAL-AM
159	TALLY HO #1	null	CAL-AM
160	SOUTHPORT	null	CAL-AM
161	WESTPORTER	null	CAL-AM
162	MOON BEAM	null	CAL-AM
163	TALLY HO #2	null	CAL-AM
164	SOUTHGATE	null	CAL-AM
165	A PARKWAY	null	CAL-AM
166	contaminated	null	CAL-AM
167	SKY PARKWAY	null	CAL-AM
168	contaminated	null	CAL-AM
169	abandoned	null	CAL-AM
170	STOCKER	null	CAL-AM
171	CONRAD D	null	CAL-AM
172	BRIGGS D	null	CAL-AM
173	LIPPI PARKWAY	null	CAL-AM
174	GERBER RD	null	CAL-AM
175	ROCKHURST	null	CAL-AM
177	ELSIE	null	CAL-AM
178	WILBUR #1	null	CAL-AM
179	WILBUR #2	null	CAL-AM
180	PARK SIT 2	null	CAL-AM
181	VINTAGEP #3	null	CAL-AM
182	LARCH CO SD #1	null	CAL-AM
183	LARCH CO #2	null	CAL-AM
244	CENTR	null	CAL-AM
246	CHETT	null	CAL-AM
249	COUNTRYSIDE1A	null	CAL-AM
250	COUNTRYSIDE #2	null	CAL-AM
255	EXPLO	null	CAL-AM
258	GOULD	null	CAL-AM
264	MALAG	null	CAL-AM
265	MARS	null	CAL-AM
266	MONTE	null	CAL-AM
267	NUT P	null	CAL-AM
273	ROCKI	null	CAL-AM
280	SWANS	null	CAL-AM
286	VINTAGE #1	null	CAL-AM
287	WEST	null	CAL-AM
289	WINCH	null	CAL-AM
436	FLORIN BOOSTER	null	CAL-AM
437	FLORINC	null	CAL-AM
438	FOLSOM-MH	null	CAL-AM
439	GOV CIRCLE	null	CAL-AM
440	RAFTCR	null	CAL-AM
441	ROSEMONT	null	CAL-AM
444	55TH ST	null	CAL-AM
448	PARKSITE#1(ELSIE1)	null	CAL-AM
477	POWER INN	null	CAL-AM
485	VINTAGE #2	null	CAL-AM
488	ISLETON #1	null	CAL-AM
489	ISLETON #2	null	CAL-AM
200	SAC-083	null	City of Sacramento
430	SAC-107	null	City of Sacramento
466	WELL	null	Elk Grove Fish and Habitat
467	WELL	null	Elk Grove Fish and Habitat
468	WELL	null	Elk Grove Fish and Habitat
303	MAIN	null	Elk Grove Water Service
304	MARVA	null	Elk Grove Water Service
305	WEBB	null	Elk Grove Water Service
306	EMERA	null	Elk Grove Water Service
307	EMERA	null	Elk Grove Water Service
308	PARKS	null	Elk Grove Water Service
309	WILLI	null	Elk Grove Water Service
310	POLHE	null	Elk Grove Water Service
311	FEICK	null	Elk Grove Water Service
312	DINO	null	Elk Grove Water Service
313	FALLB	null	Elk Grove Water Service
401	ADAMS	null	Elk Grove Water Service
492	HAMPTON VILLAGE	null	Elk Grove Water Service
321	DIANA	null	Florin County Water District
322	FLETC	null	Florin County Water District
323	FLORIN	null	Florin County Water District
324	FRENCH	null	Florin County Water District
325	KARA	null	Florin County Water District
326	MC COMBER	null	Florin County Water District
327	POWER INN	null	Florin County Water District
328	REESE #1	null	Florin County Water District
329	REESE #2	null	Florin County Water District
472	WEYAND	null	Florin County Water District
330	null	null	Fruitridg Vista Water District
331	null	null	Fruitridg Vista Water District
332	null	null	Fruitridg Vista Water District
333	null	null	Fruitridg Vista Water District
334	null	null	Fruitridg Vista Water District
335	null	null	Fruitridg Vista Water District
336	null	null	Fruitridg Vista Water District
337	null	null	Fruitridg Vista Water District
338	null	null	Fruitridg Vista Water District
339	null	null	Fruitridg Vista Water District
340	null	null	Fruitridg Vista Water District
341	null	null	Fruitridg Vista Water District
342	null	null	Fruitridg Vista Water District
343	null	null	Fruitridg Vista Water District
344	null	null	Fruitridg Vista Water District
452	AGGREGATE	null	Mather Air Force Base
184	VINTAGE PARK W-060	null	SCWA Zone 41
185	CAYMUS W-061	034/029-062	SCWA Zone 41
372	UNION INDUSTRIAL W-027	06N/06E-07Q02 M	SCWA Zone 41
373	SURVEY RD W-028	06N/06E-18A01 M	SCWA Zone 41
374	STOCKTON BL W-029	06N/06E-18J02 M	SCWA Zone 41
375	BRUCEVILLE W-040	06N/06E-18J02 M	SCWA Zone 41
376	SEASONS W-041	034/029-062	SCWA Zone 41
377	BANYON W-042	034/029-062	SCWA Zone 41
378	DUCK SLOUGH W-043	034/029-062	SCWA Zone 41
379	KILCONNELL W-044	034/029-062	SCWA Zone 41
380	ACROPOLIS W-045	034/029-062	SCWA Zone 41
381	ASHURST W-046	034/029-062	SCWA Zone 41
382	FEATHER CREEK W-047	034/029-062	SCWA Zone 41
383	WADENA W-048	034/029-062	SCWA Zone 41
384	SOARING OAKS W-049	034/029-062	SCWA Zone 41
385	BIG HORN SOUTH W-050	034/029-062	SCWA Zone 41
386	BIG HORN CENTER W-051	034/029-062	SCWA Zone 41
387	BIG HORN NORTH W-052	034/029-062	SCWA Zone 41
388	WHITE ROCK W-017	null	SCWA Zone 41
389	RECYCLE W-018	null	SCWA Zone 41
390	W-62 ANDAL	034/029-062	SCWA Zone 41
391	EQUINE W-063	034/029-062	SCWA Zone 41
396	3RD STREET W-019	06N/04E-14N01 M	SCWA Zone 41
397	HOOD-FRANKLIN RD (replace 398)	null	SCWA Zone 41
398	HOOD-FRANKLIN RD W-020	null	SCWA Zone 41
399	SWALE	null	SCWA Zone 41
447	OMEGA	null	SCWA Zone 41
483	WESTRAY W-064	034/029-062	SCWA Zone 41
484	SHELDON NORTH W-065	034/029-062	SCWA Zone 41
499	WATERMAN RD W-067	034/029-062	SCWA Zone 41
5172	null	null	SCWA Zone 41
5173	CALVINE MEADOWS W-066	null	SCWA Zone 41
5174	TILLOTSON W-068	null	SCWA Zone 41
5175	PERRY RANCH W-069	null	SCWA Zone 41
5176	DWIGHT RD RAW WATER WELL	null	SCWA Zone 41
5177	East Park W-073	null	SCWA Zone 41
5178	W. Stockton Blvd. W-074	null	SCWA Zone 41
5179	Legends W-076	null	SCWA Zone 41
5180	LW-78 POPPY RIDG	null	SCWA Zone 41
5181	LW-105 AZINGER	null	SCWA Zone 41
5182	LW-106 RODR CIR	null	SCWA Zone 41
5183	LW-109 TERRAZO	null	SCWA Zone 41
5184	LW-110 FERRAGAMO	null	SCWA Zone 41
5185	LW-113 BISHOP	null	SCWA Zone 41
5186	LW-114 WINDSOR D	null	SCWA Zone 41
5245	W-055	null	SCWA Zone 41
5246	W-056	null	SCWA Zone 41
5247	W-070	null	SCWA Zone 41
5248	W-075	null	SCWA Zone 41
5249	W-077	null	SCWA Zone 41
5250	W-007	null	SCWA Zone 41
5251	W-016	null	SCWA Zone 41
5252	W-020	null	SCWA Zone 41
5253	W-032	null	SCWA Zone 41
5254	W-081	null	SCWA Zone 41
5256	W-089	null	SCWA Zone 41
5257	W-099	null	SCWA Zone 41
5258	W-108	null	SCWA Zone 41
5259	W-B01	null	SCWA Zone 41
5260	W-B02	null	SCWA Zone 41
5261	W-B03	null	SCWA Zone 41
5262	W-DA	null	SCWA Zone 41
5263	W-M01	null	SCWA Zone 41
5264	W-T01	null	SCWA Zone 41
5265	W-T02	null	SCWA Zone 41
5266	W-T03	null	SCWA Zone 41
5267	W-T06	null	SCWA Zone 41

Note: "null" = no data

Figure 2-20. Existing Production Wells



by groundwater contamination from Aerojet and in some cases has installed well-head treatment to remove VOC contaminants prior to using groundwater as a potable supply.

- Cal-Am service areas are served primarily by direct feed groundwater wells within its service areas, but also has groundwater treatment facilities in its Parkway and Countryside systems. Cal-Am also is experiencing impacts from groundwater contamination from Mather, and in some cases, has installed well-head treatment such as carbon filters or air strippers to remove contaminants prior to using groundwater as potable supply. In addition, the Parkway and Countryside systems are believed to be potentially "at risk" of contamination due to past dry cleaner discharge of tetrachloroethene (PCE) into the sanitary sewer system.

2.3.8 Groundwater Rights

Since the groundwater basin underlying all of Sacramento County is not adjudicated, the rights to groundwater are based on the overlying water right of the property owner. Different types of groundwater rights are described more fully below.

Correlative Right. A correlative right has a mutual or reciprocal relationship to the rights of others, in the sense that the existence of one necessarily implies the existence of the other. For example, the rights of landowners in a given basin to extract groundwater are correlative with all other landowners in that basin.

Overlying Right. An overlying right is the right of a landowner to take water from the aquifer underneath their property for reasonable and beneficial use on the land overlying the aquifer. Overlying rights exist by virtue of land ownership.

Prescriptive right. A prescriptive right comes into existence only if a groundwater basin has no "surplus"[8] water available. Such a right is gained by appropriating nonsurplus water for a statutorily prescribed period.

Subordinate right. A subordinate right is one that is inferior to or secondary to a higher right.

Appropriative right. Appropriative rights to groundwater apply to pumpers who use water on nonoverlying lands. Most municipalities and agricultural water purveyors have appropriative rights to groundwater because they deliver groundwater to parcels they do not own, and in some cases to lands outside the basin. Appropriative use of groundwater is limited to water in excess of that required by overlying users. Unlike appropriative rights for use of surface water, no formal regulatory permitting process exists for appropriative use of groundwater.

Adjudication of a Groundwater Basin. Adjudication of a groundwater basin essentially removes the above mentioned rights to groundwater and the amount of water available to each groundwater pumper is allocated based on a court decision.

2.3.9 East Sacramento County Replacement Water Supply Project

Groundwater contamination emanating from the Aerojet project site, the Inactive Rancho Cordova Test Site (IRCTS), and the Mather Field site has significantly impacted groundwater resources in the Rancho Cordova area. In some instances, groundwater supplies have been impacted so severely that all wells within a purveyor's service area have been shut down. Typically, as an overlying appropriator, a municipal purveyor would use the underlying groundwater to serve homes and businesses that would be constructed within the purveyor's service area. However, because the underlying aquifer in much of the Rancho Cordova area is contaminated, this method of developing and delivering groundwater is unacceptable. Therefore, it is reasonable to consider a second approach to providing water. Aerojet and McDonnell-Douglas (Boeing) have been directed by various regulatory agencies to implement a groundwater remediation program that would stop the spread of contamination and perhaps remove it entirely. However, implementing the remedy will take a

[8] Surplus water is water in excess of environmental use and state and federal water projects.

significant amount of time and will not keep pace with the economic growth in the community.

Most of the current cleanup activities require extracting, treating, and discharging treated groundwater to a surface water body, primarily tributaries to the American River. This water then flows downstream through the Delta, resulting in a loss in the groundwater basin. A better use of this water would be to find a way to put it to beneficial use within the same groundwater basin that it is extracted from. The result would be that the overall impact of groundwater remediation would not affect the estimated long term average annual pumping limit of the basin. To achieve this objective, SCWA has entered into agreements with Aerojet and Boeing to ensure that the remediated groundwater does not leave the basin.

The project includes 1) extracting contaminated groundwater, 2) treating the contaminated groundwater to meet National Pollution Discharge Elimination System (NPDES) permit requirements, 3) discharging the treated groundwater to the American River, and 4) reusing the treated groundwater in the Central Basin. Reuse has been prioritized in the agreement as follows: 1) replacement of municipal groundwater supplies lost due to contamination, 2) water supply service to "Aerojet Lands," 3) new development in Zone 40, and 4) environmental uses.

Since the above agreements have been approved, additional agreements have been reached that more fully delineate how the replacement water will be used. These agreements include an agreement with EBMUD regarding use of the Folsom South Canal for delivery of replacement water supplies to GSWC and delivery of environmental water to the Cosumnes River, an agreement with SMUD on water quality in the Folsom South Canal, an agreement with GSWC for replacement water supply, and an agreement with TNC and SSCAWA on delivery of environmental water to the Cosumnes River. Currently, no agreement exists between SCWA and Cal-Am on how much water will be needed to meet their replacement water supply needs.

2.4 RECYCLED WATER SUPPLIES

Recycled water is a desirable source of water for outdoor landscape irrigation and other non-potable uses, especially in times of drought when surface water supplies are reduced and the groundwater system is being relied on more heavily to meet potable demands. For the Sacramento Region, use of recycled water provides an alternative to discharging treated wastewater from SRCSD's Sacramento Regional WWTP into the Sacramento River. Increasing use of recycled water may become a more cost-effective solution for SRCSD's 1.1 million ratepayers because wastewater regulations require ever higher treatment standards (and costs) for discharged effluent. Much of the need for higher quality water is because the background water quality of the river is already high in certain constituents from upstream agricultural and old mining activities. Significant discussion has occurred related to who "owns" the water once it is treated and discharged by SRCSD. The most current legal opinion is that the portion of wastewater stream that originated as groundwater in SRCSD's service area is owned by SRCSD and can be recycled (opinion referenced in Nolte, 2004). The surface water portion of the wastewater stream will likely continue to be discharged to the Sacramento River until further studies can be conducted to fully understand the impacts of a reduction in the amount of discharge

on downstream users and the Delta. However, since it is estimated that 50 percent of wastewater originates from a groundwater source, SRCSD will recycle up to 80 mgd, which is approximately half of the current average discharge flow to the Sacramento River, (SRCSD, 2005) This amount of recycled water is well above the SRCSD Board's adopted goal of recycling 30 to 40 mgd in the next 20 years.

The most commonly used recycled water is defined as wastewater that has been treated to tertiary standards that meet Title 22 of the California Code of Regulations (CCR). Recycled water treated to this level can be used for all outdoor irrigation demands in a community, including, parks, schools, street medians, residential front and backyard landscaping, public open space, and industrial uses such as cooling water. In addition, recycled water is commonly used for environmental purposes such as wetlands and habitat restoration.

In the Central Basin, SRCSD/SCWA have developed a recycled water pilot program that has been developed and is operational on a small scale. The 5 mgd project began as a pilot program to serve the communities of Laguna West, Lakeside, and Laguna Stonelake, and on-site needs of the Sacramento Regional WWTP. Recycled water is used in these communities for outdoor irrigation of public open space areas, commercial landscaping, schools, parks, and street medians. This pilot SRCSD Recycled Water Program is Phase 1 of a two-phase project.

Use of recycled water is regulated by DHS, SWRCB, RWQCB, and local EMD through a permitting process that minimizes the possibility for human contact either through cross connections with potable water supplies, or exposure to irrigation water from overspray or excess irrigation that drains off site.

Acceptance of recycled water as a source of water supply for the three communities has been very good. The future of recycled water in the Central Basin appears promising, especially because of the benefits recycled water brings to the region. SRCSD is currently developing a comprehensive Recycled Water Supply Master Plan that evaluates recycled water opportunities that could benefit the Central Basin, as well as other locations in the SRCSD service area. Recycled water can be provided to a community in one of two ways: first, through centralized treatment at the existing water recycling facility, or second, through satellite "polishing" plants that draw wastewater from large interceptor pipelines in the community, treat the wastewater to Title 22 standards, and provide the recycled water in the vicinity of the remote plant.

2.4.1 Recycled Water Facilities

Figure 2-21 depicts current and planned recycled water facilities in the Central Basin. A partnership between SCWA and SRCSD has led to construction and implementation of Phase 1 of the SRCSD Recycled Water Program. The Phase 1 service area consists of on-site uses at the Sacramento Regional WWTP complex and non-potable commercial and public landscape areas in the Laguna West, Lakeside, and Laguna Stonelake developments located within SCWA's service area immediately south of SRCSD's facility. The Phase 2 service area consists of the East Franklin and Laguna Ridge development areas located to the south and east of the Phase 1 system. Expansion of the SRCSD Recycled Water Program into the Phase 2 area requires a separate recycled water pipeline to be constructed from the Sacramento Regional WWTP to facilities owned and operated by SCWA. This work will be completed over the next several years. Much of the internal "purple" pipe distribution system is being constructed as part of new development.

2.4.2 Future Availability of Recycled Water Supplies

As mentioned, SRCSD is currently developing a comprehensive Recycled Water Master Plan as a future vision of recycled water in the community. Since much of the new growth taking place in Sacramento County is in the Central Basin, the opportunity appears favorable to expand the program in the Central Basin. The economic question of obtaining additional surface water supplies or making best use of recycled water supplies will be one of many factors in determining which areas are likely to move forward with recycled water. Other

factors include avoided cost of wastewater treatment, environmental benefits, long-term sustainability of regional water supplies, as well as other societal and long-term benefits. Areas with existing reliable surface water rights may not be as likely to use recycled water. However, installation of a recycled water distribution system with new development may be necessary in advance of recycled water availability to preserve the opportunity of using recycled water in the future. It has been shown that the "retrofit," or installation of a recycled water distribution system after development has occurred is likely to be economically infeasible. In areas where groundwater supplies are not readily available or constrained, recycled water often is seen as a long-term reliable source of supply.

Use of recycled water for agriculture and wetlands/habitat restoration to supplement groundwater supplies is being developed as another option. The resulting reduction in groundwater use may provide more sources of supply elsewhere in the Central Basin. Additional benefits can be achieved by placing recycled water infrastructure close enough to communities to bring recycled water to urban areas or for potential recharge basins.

2.5 WATER DEMAND AND LAND USE

Determining existing and future water demands is necessary to establish the adequacy of available water supplies (i.e., groundwater, surface water, and recycled water). In addition, raw, treated, and recycled water facility sizing and operation are directly influenced by projections of water demand. Water conservation also is an element of water demand and is considered in the development of demand estimates. This section describes land use and water demands in the Central Basin. Much of the information about land use and water demands is taken from the EIR for the Zone 40 WSMP, which developed land and water use data for 2000 and 2030 levels of development within the Central Basin. The WSMP EIR was used instead of earlier work done by the Water Forum because the WSMP EIR contains more recent land use surveys.

2.5.1 Land Use

Water demands are based on the type of use taking place on a piece of property. Based on the type of use, the amount of water considered for indoor uses and outdoor irrigation can vary. The groundwater aquifer is mostly affected by land use from the amount of rainfall and irrigation that is capable of deep percolating into the ground on the property versus what becomes surface water runoff leading to storm drain collection systems. Land uses within the Central Basin are classified into five categories:

- Agricultural land, consisting of areas greater than 5 acres and currently used for agricultural purposes.
- Agricultural-residential land, consisting of 2- to 5-acre parcels zoned for agricultural and residential uses.
- Urban land use, consisting of municipal, commercial, and industrial developed areas.
- Native vegetation/undeveloped land uses, consisting of areas that have not been developed. These areas also may be used in the spring and early summer as dry pasture for livestock grazing.
- Riparian vegetation land uses, consisting of areas along waterways that are typically within the floodplain of the waterway and are typically covered with dense native vegetation.

A graphical pie chart distribution of year 2000[9] and projected year 2030[10] land uses within the Central Basin is shown in **Figure 2-22** and described below. Spatial geographic distributions of 2000 and 2030 land uses in the basin are shown in **Figure 2-23** and **Figure 2-24**, respectively. Major anticipated changes in land use are the expansion of urban acreage by 64 percent, from 80,387 acres to 132,145 acres, while native vegetation/undeveloped acreage will decrease by 50 percent, from 101,692 acres to 50,440 acres (see **Figure 2-22**).

[9] Based on 2000 DWR land use survey for Sacramento County

[10] Based on 2000 DWR land use survey for Sacramento County, DWR detailed Analysis Unit (DAU) crop acreage estimates, and Sacramento County General Plan land use mapping, and 2002 Zone 40 WSMP EIR.

Figure 2-21. Recycled Water Facilities

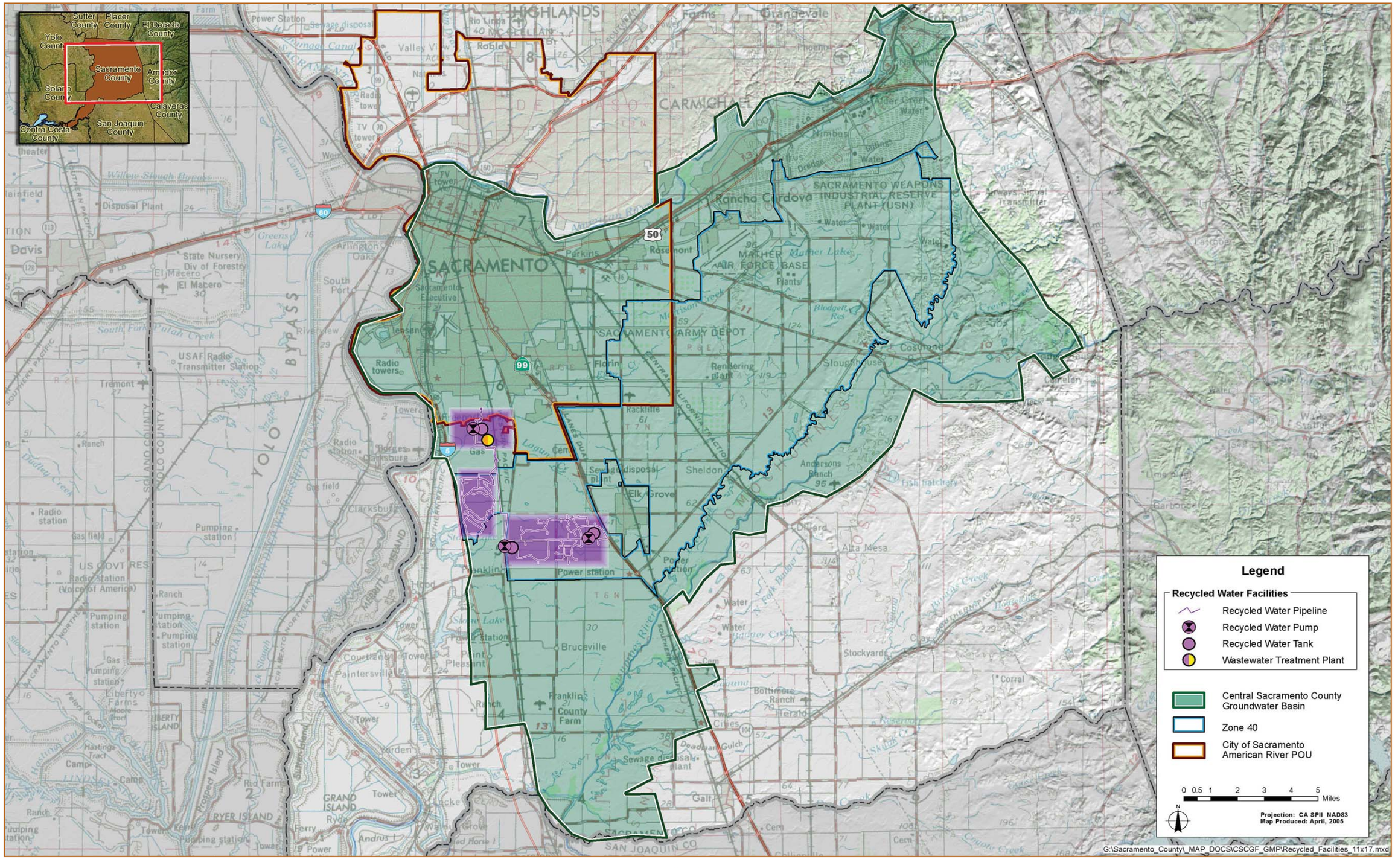
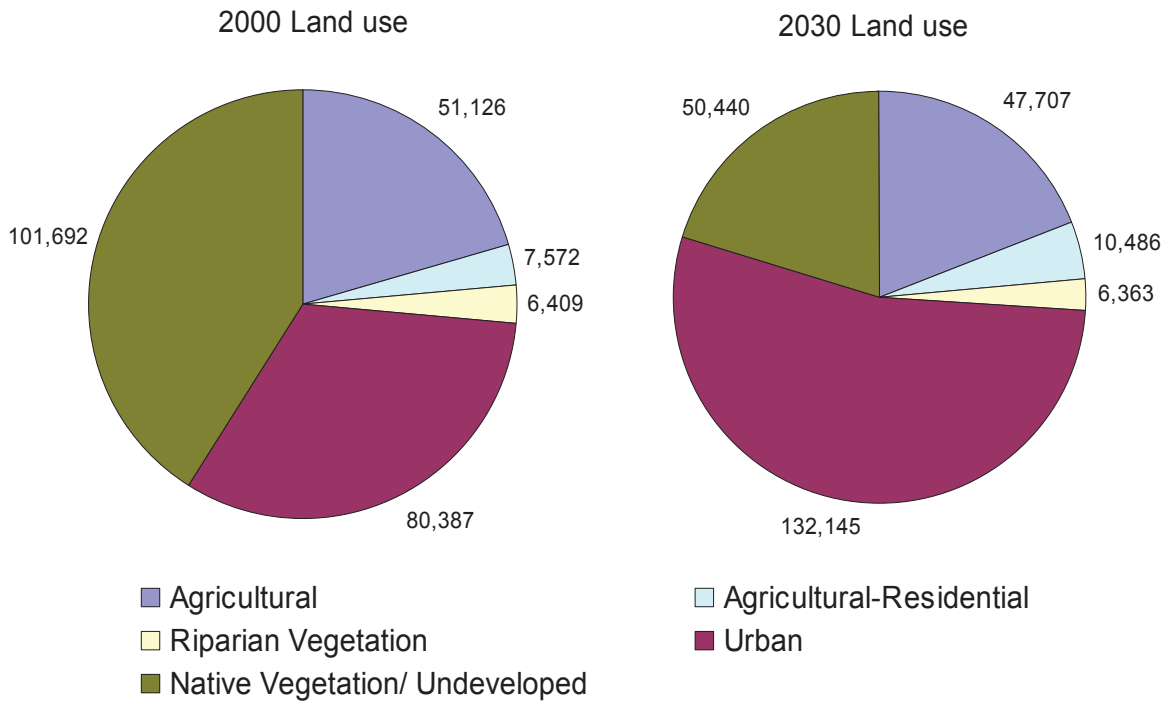


Figure 2-22. 2000 and 2030 Distribution of Land Uses in the Central Basin (acres)



2.5.2 Water Demands

Development of water demand information is important in describing the overall balance between available water supplies (i.e., surface water [see **Section 2.2**], groundwater [see **Section 2.3**], recycled water [see **Section 2.4**]) and demand. Water demand estimates are based on the land use data described above with refinements for land use differences in the urban category. These estimates are reported in four main categories: urban demands, agricultural demands, agricultural-residential demands, and environmental demands. Demands in these categories are calculated separately due to differences in land use and water application and the resulting variation in the amount of deep percolation and surface water runoff of applied irrigation and rainfall that can occur. **Figure 2-25** and **Figure 2-26** presents 2005 and 2030 estimated long-term average[11] water demands in the Central Basin. The bar chart shows an increase in annual water demands from 2005 to 2030 of approximately 70,000 AF in wet years and approximately 60,000 AF in dry years. Dry years have less of an increase due to water conservation.

2.5.2.1 Urban

An urban land use area is typically described being moderately to densely populated and provided with public services and infrastructure. In providing water service to an urban area, determining water demands includes the amount of water used both indoors and outdoors. In urban areas, water used indoors is discharged to a sewer collection system and then transported and treated at the Sacramento Regional WWTP. Treated effluent is then discharged either to the Sacramento River or diverted to the existing tertiary recycled water treatment plant to be reused to meet public and commercial irrigation needs in the Phase 1 recycled water service area.

Because water use practices change in urban areas as hydrologic conditions change over time, water use estimates require reviewing average water use over many

[11] Long-tern average estimates of water demand are developed based on a 74-year simulation using hydrologic condition data for the period 1922-1995. During each simulation run, land use remains unchanged at 2000 or 2030 levels of development.

years and then normalizing the water use to represent the design level of water use for water supply planning and facility designs.

Urban water demands also need additional refinement based on land use categories. Given the historical monitoring of water use for different land use categories, a separate water duty factor has been determined using statistical analysis of metered data for each of the major urban land use categories. Unit demand factors for each category are more fully described in a 1995 report completed for the Water Forum titled Estimate of Annual Water Demand within the Sacramento County-Wide Area (Boyle, 1995). This document is more commonly referred to as the Boyle Report.[12] The demand factors included in the Boyle Report are adjusted to reflect a 12 percent[13] conservation level in water demand for the 2000 level of development. The conservation factor used for 2030 urban water use is 25.6 percent, as per the WFA. After applying the conservation factors to each land use category, urban water demands at the 2005 (adjusted from the 2000 level of development are estimated as 202,292 AF/year, and 300,181 AF/year for the 2030 level of development. However in dry years, mandatory conservation efforts reduce these demands to 171,948 AF in 2005 and 255,154 AF in 2030.

2.5.2.2 Agricultural

No precise records of agricultural water demands in the Central Basin exist. However, agricultural water demands can be estimated through use of the Sacramento County IGSM, which can estimate consumptive crop water use. Using data for precipitation, crop acreage, soil moisture, field capacity, evapotranspiration, and irrigation efficiency, the Sacramento County IGSM calculates the estimated amount of applied water, how much water is consumptively used by the crop, and how much water enters the groundwater system. Long-term average annual water use is estimated at 163,454 AF per year for the 2005 level of development, which decreases to 133,275 AF per year for the 2030 level of development; this is a decrease in agricultural water use of an estimated 18 percent.

2.5.2.3 Agricultural-Residential

Agricultural-residential water demands are estimated using land use acreage and a demand factor of 1.44 AF/acre/year (Boyle Report, 1995). Since the Sacramento IGSM only reports urban and agricultural water uses, these two categories were used in combination to artificially reflect agricultural-residential uses by assigning 25 percent of the estimated agricultural-residential water demands to urban water use (2.7 AF/acre/year) and the remaining 75 percent to agricultural water use. The result for a typical 2-acre ranchette is approximately 1.4 AF/year assuming the agricultural portion is dry pasture (no applied water over 75 percent of the land area). Long-term average annual agricultural-residential water demands are estimated as 10,904 AF/year for the 2005 level of development, which increases to 15,100 AF/year for the 2030 level of development. Indoor water use is assumed to be a source of recharge to the groundwater basin through private septic and leach field systems.

2.5.2.4 Environmental Water

"Environmental water" has become a significant priority in the State's Water Supply Plan. One of the purposes of the CVPIA was to include water for the protection, restoration, and enhancement of fish, wildlife, and associated habitats. This effectively placed environmental water at the same level of priority as municipal, and possibly slightly higher than agricultural water uses.

While not discussed in the WFA, environmental water for the Cosumnes River is any water that provides ecosystem restoration or benefits along designated riparian areas. Discussions in previous sections described the interaction of the aquifer and the rivers, and the disconnect between the Cosumnes River and the regional aquifer. This disconnect caused late summer and fall flows in the river to recharge the groundwater basin, leaving no water in the river to support fisheries or riparian habitat. Unlike other water uses, environmental water use for the Cosumnes River is conceptual and

[12] Estimate of Annual Water Demand Within the Sacramento County-Wide Area (Boyle, May 1995)
[13] The 12 percent conservation value is prorated from the Water Forum's 25.6 percent level of conservation goal for 2030.

Figure 2-23. 2000 General Land Use in the Central Basin

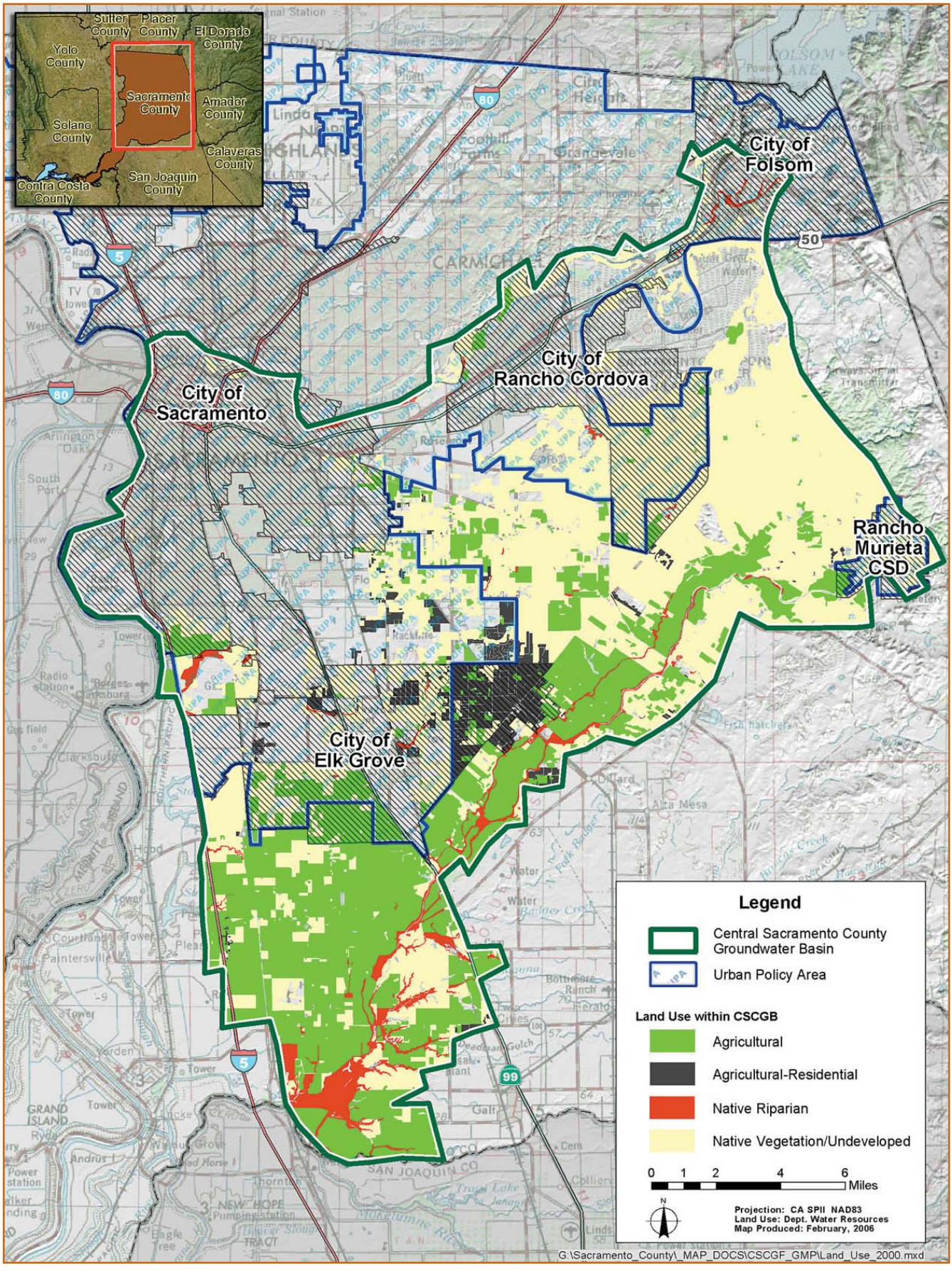
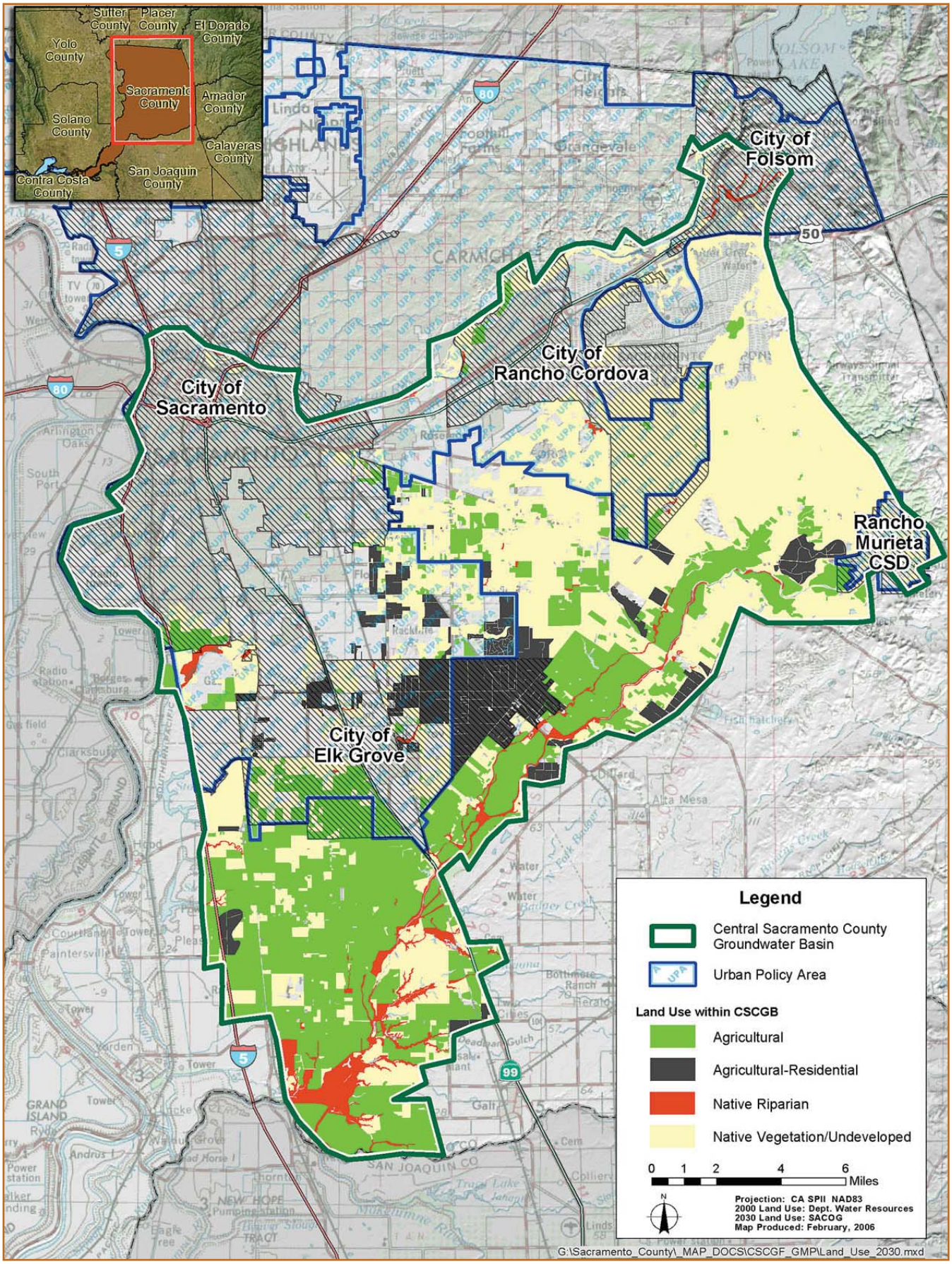


Figure 2-24. 2030 General Land Use in the Central Basin



subjective and is based on identifying problems and the amount of water needed to remedy the problems. For instance, water from the East Sacramento County Replacement Water Supply Project (see **Section 2.3.9**) provides a water supply during early fall to pre-wet the river prior to the first storm event to facilitate flow in the river when the first storm event occurs.

Environmental water requirements for other natural and restored streams in the area, such as the Upper Laguna Creek Multi-Functional Corridor, have not been defined. If environmental water needs are identified in the future they will be addressed by the basin governance body.

2.6 WATER BALANCE

In preceding sections, water supplies and demands were discussed based on information provided by participating water purveyors and information developed as part of the Water Forum process and the SCWA Zone 40 WSMP. Water supplies for the Central Basin come from surface water entitlements, groundwater, and recycled water. As shown in **Table 2-1**, the current estimated surface water entitlements for use in the Central Basin are 350,000 AF/year (assumes maximum availability of surface water in above normal to wet years, with no CVP reductions); the estimated long-term average groundwater pumping limit, as established by the WFA, is 273,000 AF/year; and the estimated recycled water supply is 4,400 AF/year. Therefore, the total estimated annual water supply for the Central Basin is 627,400 AF/year.

Current and projected future supplies and demands in the Central Basin also are shown in **Figure 2-25** and **Figure 2-26**. These demands are based on applied water for agriculture and delivered water for M&I use, which are greater than the actual amount of water consumed by these demand centers. For example, not all water applied to crops is used by the plants or evaporated – some of the water returns to the water supply, either through percolation to the groundwater table or through drainage return flow into the rivers. Similarly, not all of the water delivered to homes is consumed, as some of it flows through the sewer system (or leachfield) and some water used for landscaping percolates to the groundwater table. Although some modeling studies have been performed to help quantify the difference between applied/delivered water and consumed water, additional studies will be required (as discussed in the following sections of this report) prior to incorporating these data into Central Basin planning efforts.

Current and future water balances can be estimated by comparing supplies and demands for the Central Basin (**Figures 2-25** and **2-26**). Overall, the water balances show that supplies should be sufficient to meet both current and future demands to 2030. However, it is important to note that meeting water demands depends on more than simply having sufficient supplies. Meeting specific demands also requires the necessary infrastructure, as well as an appropriate institutional and political framework, to enable water resources in the Central Basin to be delivered and managed in a sustainable manner. In some cases, existing and future water wholesale agreements between various water purveyors will be necessary to move surface water supplies throughout the Central Basin[14]. Given the anticipated growth and potential environmental needs of the Central Basin, significant new infrastructure will be required as identified in the various water supply master plans for water purveyors with boundaries that lie within the Central Basin. The following chapters of this report present groundwater management objectives for the Central Basin and the programs and policies that will be developed to achieve these objectives.

[14] This specifically applies to purveyor areas within the City of Sacramento's American River POU and purveyor areas within Zone 40. See individual water supply master plans for the City of Sacramento and Zone 40 for specific information on how much water is planned for wholesale to affected water purveyors.

Figure 2-25. Annual Average Water Balance for the Central Basin - 2005 Water Balance

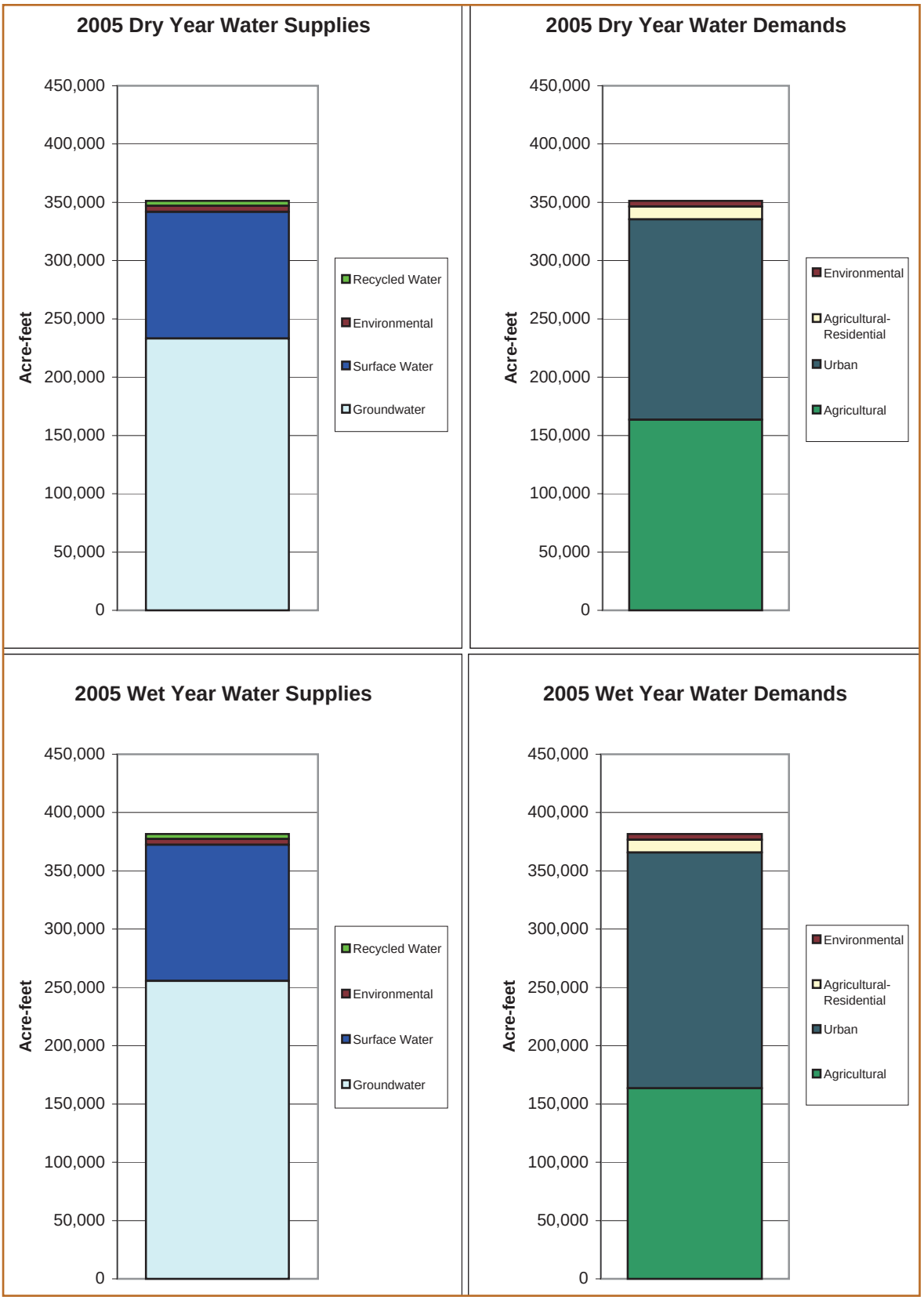
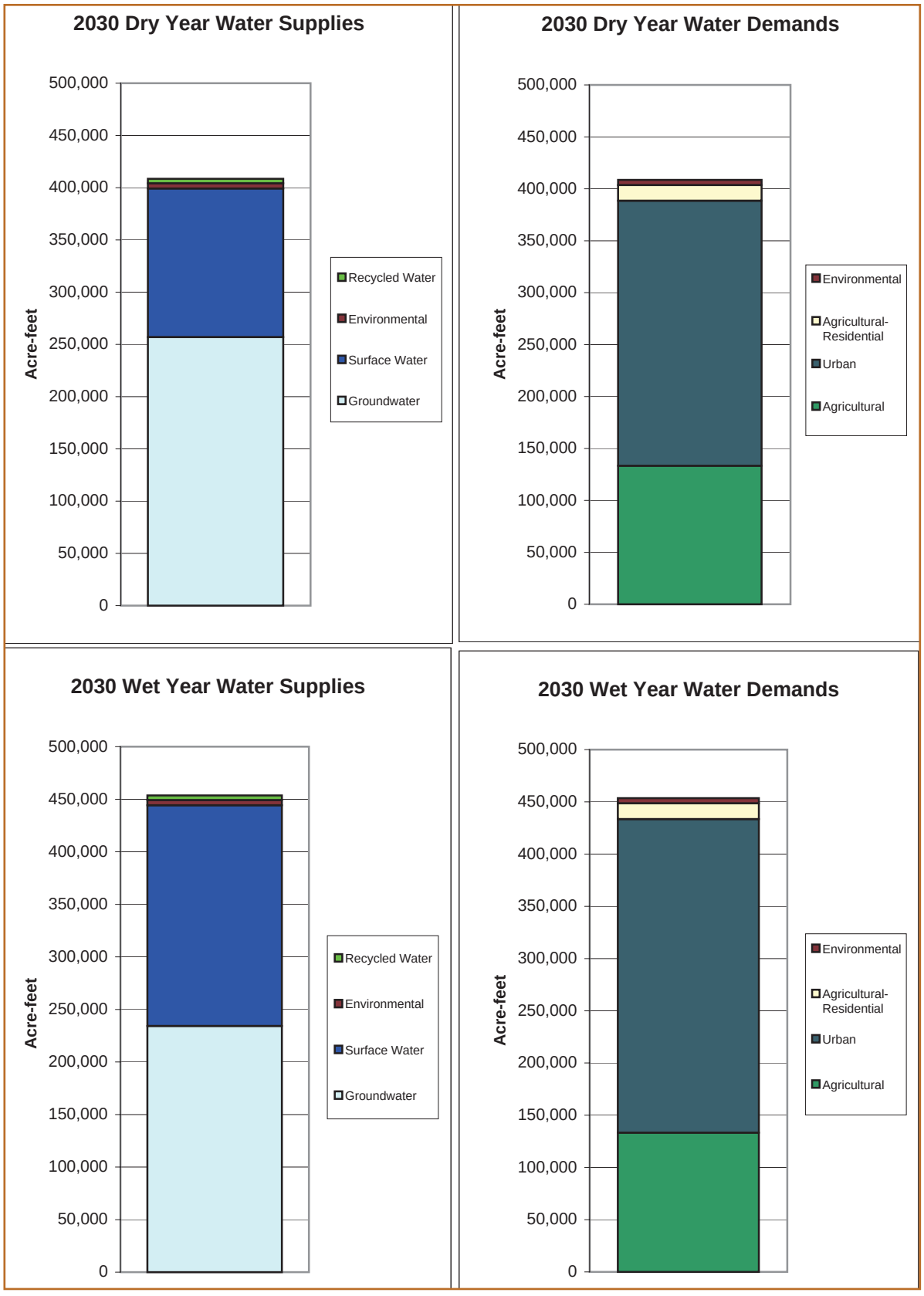


Figure 2-26. Annual Average Water Balance for the Central Basin - 2030 Water Balance



Management Plan Elements

Section 3

Management Plan Elements

This section discusses five BMOs proposed for the Central Basin based on feedback from basin stakeholders. Each BMO focuses on managing and monitoring the basin to benefit all groundwater users in the basin. The five BMOs are intended to be specific enough to result in numerical criteria for the basin, but also able to be modified or adapted to new information on groundwater basin behavior over time (as monitoring data are collected).

3.1 INTRODUCTION

A BMO has four main characteristics: 1) specific, measurable criteria that can be scientifically collected and established, 2) a clearly defined monitoring program that validates the BMO's performance, 3) a reporting method for monitoring data that identifies success or problems with the groundwater basin using early warning detection, and 4) programs that are available to remedy a problem in the groundwater basin, if one is determined to exist.

BMOs should have sufficiently specific numerical criteria so that implementation of the plan, through its monitoring and management programs, is scientifically defensible. For example, a BMO might have a criterion that groundwater elevations should not fall below 100 feet below ground surface in any location within a basin. A monitoring program could then be developed to measure groundwater elevations at key locations in the basin twice a year. These data would be entered into a database management system (DMS) that compares measured results to the BMO criterion to determine performance. A report would be generated to allow the governance body of the groundwater basin to evaluate the data, make a judgement on the level of concern, and, if needed, perform certain functions to remedy the problem (i.e., implement specific programs).

Because hydrologic and land use conditions change from year to year and exert differing stresses on aquifers, a remedy may or may not be applied in the area where a problem occurs. A good example is the regional cone of depression in the Central Basin. The regional cone is influenced by pumping throughout Sacramento County, including the North and South basins to a certain degree. Therefore, a problem in one management area may require actions in another management area(s) as a remedy.

3.1.1 BMO No. 1. Maintain the long-term average groundwater extraction rate at or below 273,000 AF/year.

The concept of "long-term average pumping limit" is discussed in **Section 2.3.5** and **Appendix A**. The CSCGMP defines "long-term average" as the average groundwater extraction from the basin calculated over a period of time. Said period of time commencing at the time of adoption of the CSCGMP to when the calculation is made. Each new year of data is added to the next and then averaged over the entire period of record. Agricultural groundwater extractions will be estimated based on land use and crop type every five years using DWR Land Use Surveys. Agricultural estimates remain constant for the five year period, unless specific information from this extraction amount is known during the respective 5-year intervals. An interpolation method also may be considered to adjust agricultural extractions in the intervening years.

For example, 2000 groundwater basin extraction data will be added to 2001 extraction data, which will be added to 2002 extraction data, etc., with urban extractions changing monthly and agricultural and other private well extractions likely changing only once every five years. The "long-term average" is the average of the total extraction over the period of record (i.e., 2000 to 2002 in this example).

The reason for using average groundwater extraction is that aquifer recharge varies depending on groundwater elevations. This variation stems from the effect the slope of the peizometric surface of the groundwater has on the natural recharge taking place from the rivers and subsurface inflow to the basin. The Water Forum recognized this variation when it selected 273,000 AF/year as an acceptable long-term average annual groundwater extraction rate. This decision recognized that the groundwater basin can be managed and maintained, on average, at an extraction rate that does not present undo risk to private and public well owners by dewatering wells, degrading water quality, creating ground subsidence, and adding cost to pumping groundwater from lower elevations.

3.1.2 BMO No. 2. Maintain specific groundwater elevations within all areas of the basin consistent with the Water Forum "solution"

Over time, extensive groundwater extraction by agriculture and more recently urbanization, have resulted in a persistent cone of depression in the southern Central Basin area. With the recent fallowing of some agricultural lands and importation of surface water into Zone 40, groundwater elevations at or near the cone of depression have stabilized and in some areas have recovered (see Hydrograph SWP-058 in **Figure 2-18A**). However, Water Forum studies indicate that with continued growth, coupled with dry hydrologic conditions, groundwater elevations can decrease to a point where adverse impacts may be seen. These impacts will occur to all groundwater users, ranging from increased energy costs to the need to deepen existing private and public wells or even constructing new wells.

As more surface water is delivered to users in the Central Basin by SCWA, the City of Sacramento, and other jurisdictions, groundwater elevations in the basin will rise in some areas of the basin more than others. Construction of SCWA Zone 40's Central WTP and interties with the City will provide the means to deliver more surface water to the basin and will allow the urbanized service area of Zone

40 to reduce groundwater extractions significantly. As urbanization proceeds according to the various land use authorities (the Cities of Sacramento, Elk Grove and Rancho Cordova and Sacramento County) General Plans, full implementation of the Zone 40 conjunctive use program will occur. As a conjunctive use program relies on the availability of surface water and groundwater during different hydrologic years full implementation of the program may result in a short-term drawdown in groundwater elevations below previous historical levels (this is a result of additional groundwater extraction during the drier and driest years). The intent of this BMO is to quantify overall groundwater elevations within the basin and to maintain an acceptable "operating range" for groundwater elevations throughout the basin.

A methodology for developing specific objectives to manage groundwater elevations requires a systematic, repeatable, and scientific basis. This methodology must define areas within the basin that are sufficiently distinct in hydrogeology, land use, groundwater and surface water use, and share some of the same institutional realities. The term "institutional reality" is defined as the ability of various jurisdictions or water purveyors to work together to develop and implement a program for a specific purpose. For example, an institutional reality might be the ability to implement a conjunctive use program involving all water purveyors having jurisdiction within the City's American River POU. Developing a program like this requires gaining the trust and commitment of the purveyors involved prior to establishing this area as a focus for management activities that would involve the higher use of POU water. The approach laid out below is intended to assist in the selection of areas that are sufficiently distinct and share many of the same goals and objectives.

An operating range for groundwater elevations in the basin has been developed by the Water Forum that define the upper and lower groundwater elevation threshold that will minimize the impacts stated above. For the range in values, two groundwater contour maps are provided in **Figure 3-1** and **Figure 3-2**. A polygon grid overlying the basin is used to implement and report on this BMO as shown in **Figure 3-3**. Each polygon is a 5 square mile management unit with lower and upper elevation attributes according to **Figure 3-1** and **Figure 3-2**, respectively. Monitoring wells are assigned to one or more polygons to compare actual groundwater elevations to the two reference points assigned to the polygon. In areas where there are insufficient wells to assign a single well to each polygon, a nearby well may be used as a surrogate until the basin governance body has either identified an existing monitoring well or constructs a new well for monitoring purposes. Achieving one well per polygon will take place over time as various priorities are satisfied and sufficient funding becomes available. A full discussion on the use of polygons is provided in **Appendix B**.

3.1.3 BMO No. 3. Protect against any potential inelastic land surface subsidence by limiting subsidence to no more than 0.007 feet per 1 foot of drawdown in the groundwater basin

Land subsidence can cause significant damage to essential infrastructure. Historic land surface subsidence within the Central Basin has been minimal, with no known significant impacts to existing infrastructure. Given historical trends, the potential for land surface subsidence from groundwater extraction in the Central Basin appears to be remote. However, the basin governance body intends to cooperate with adjacent groundwater management agencies such as SGA to monitor for potential land surface subsidence. If inelastic subsidence is documented in conjunction with declining groundwater elevations, the basin governance body will investigate and take appropriate actions to avoid adverse impacts. A limit of 0.007 feet per 1 foot of groundwater decline along survey control lines is considered to be the threshold at which implementation of mitigation programs may need to be implemented by the basin governance body.

Figure 3-1. Groundwater Elevation Contours for Lower Threshold

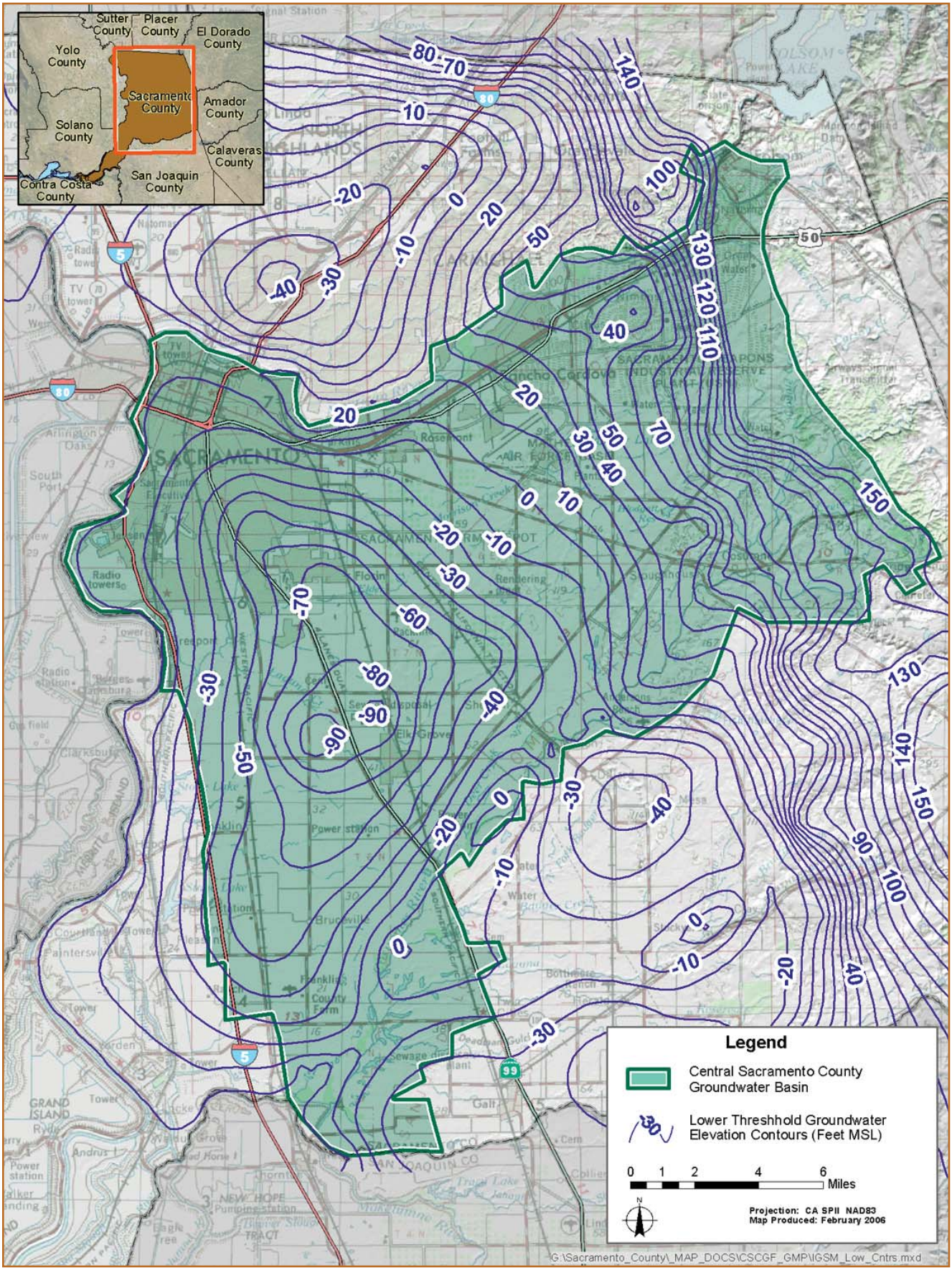


Figure 3-2 Groundwater Elevation Contours for Upper Threshold

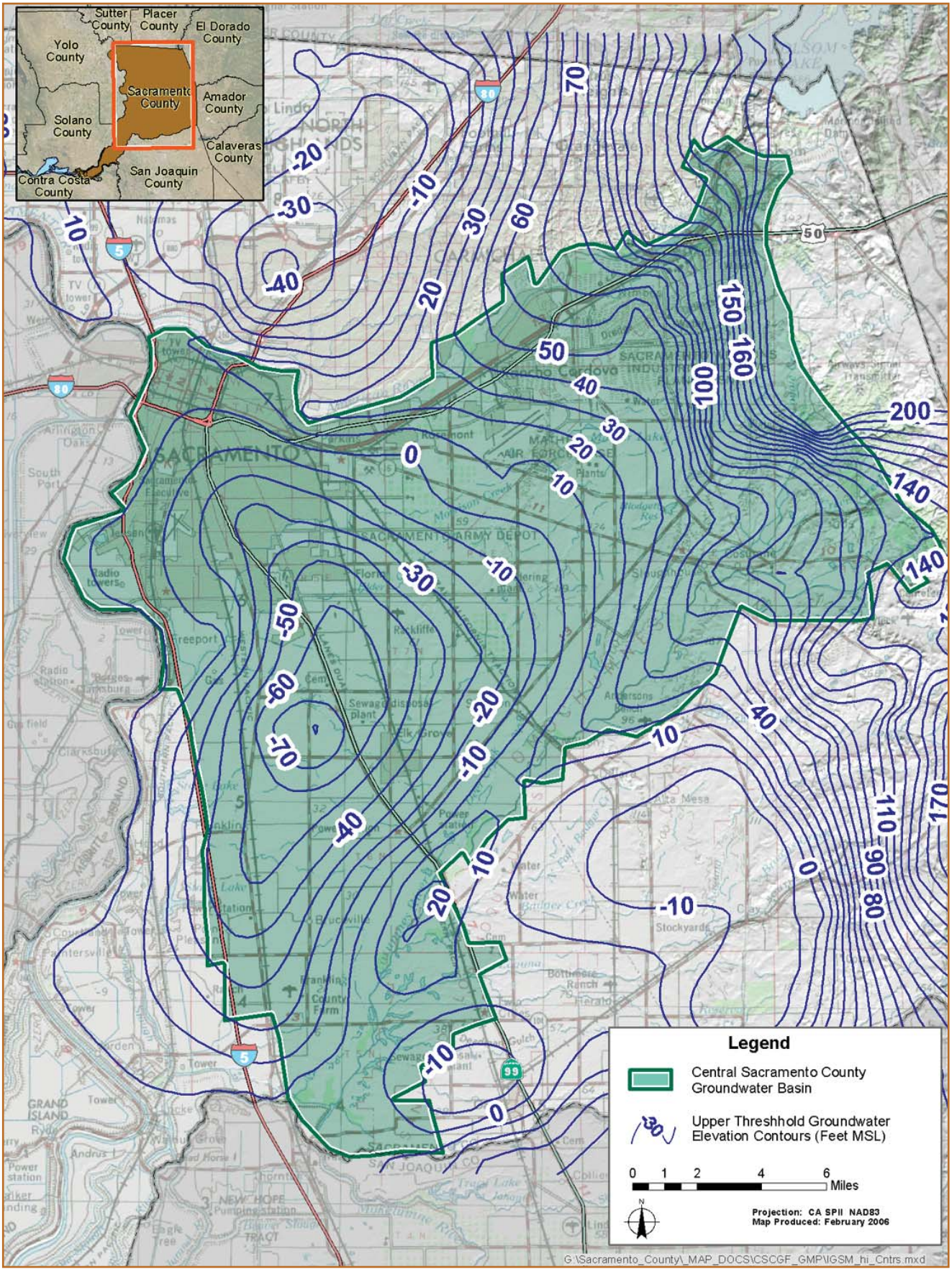
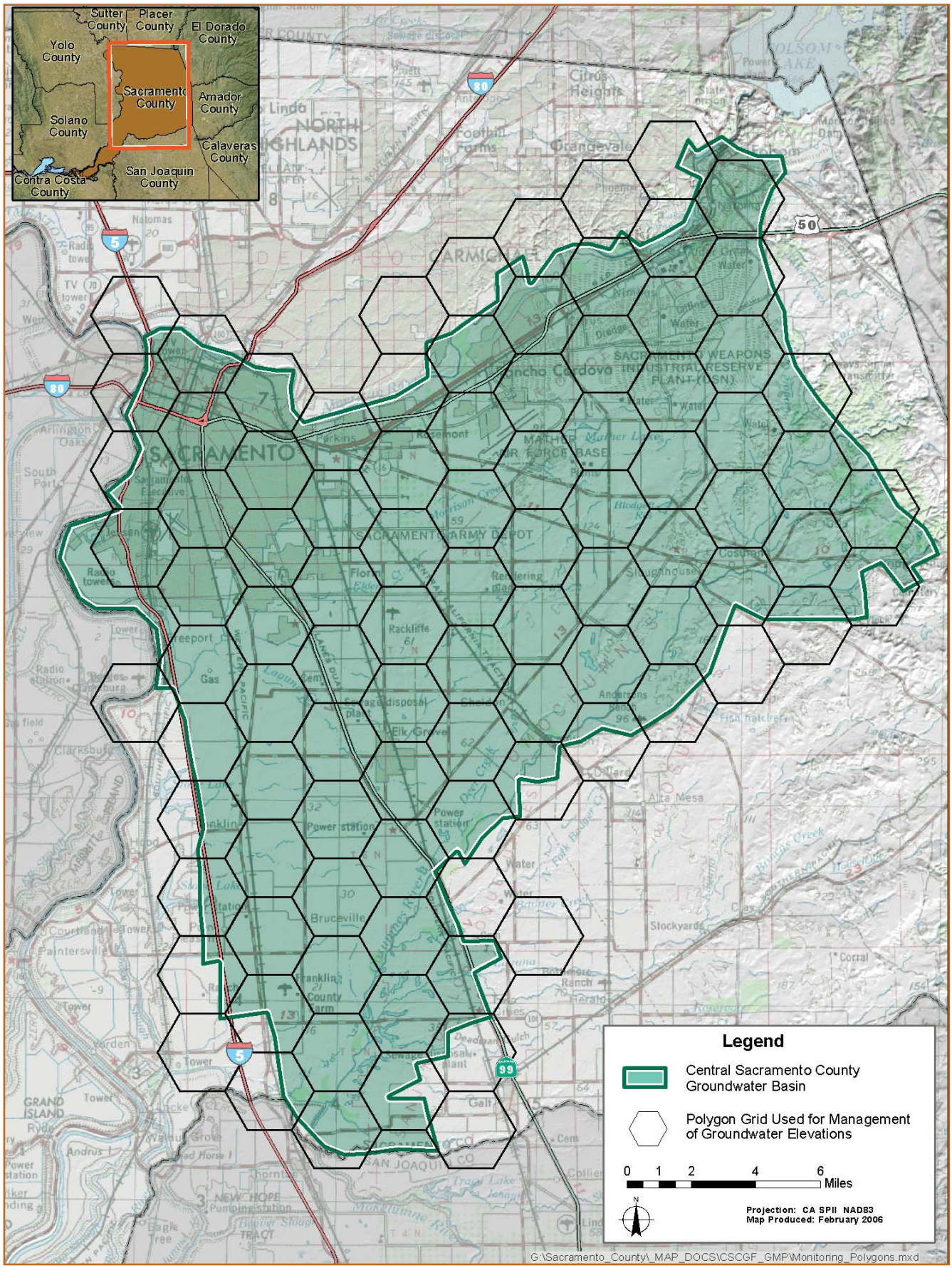


Figure 3-3 Polygon Grid Used for Management of Groundwater Elevations



3.1.4 BMO No. 4. Protect against any adverse impacts to surface water flows in the American, Cosumnes, and Sacramento rivers

Among other important uses, the American, Cosumnes, and Sacramento rivers provide habitat for a variety of fish and wildlife species. The basin management body is committed to the objectives of the WFA, which include preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River. Important elements of the WFA include commitments to reduce lower American River diversions during dry years and to not exceed the agreed on long-term average annual groundwater extraction of 273,000 AF/year. In addition, the CSCGMP incorporates monitoring and evaluation data in cooperation with SGA and others (if any) between groundwater pumping and adjacent river or stream flows.

The CSCGMP also includes goals to restore and preserve the fishery, wildlife, recreational, and aesthetic resources of the lower Cosumnes River and to assure a stable supply of water for agriculture in the lower Cosumnes River floodplain area. Another goal is to protect against adverse impacts to water quality resulting from interaction between groundwater in the basin and surface water flows in the American and Sacramento rivers. In most natural settings, groundwater is higher in TDS than most other constituents found in surface water. At the present time, the flow regime is such that groundwater is not discharging to the river systems (i.e., rivers within the Central Basin are termed as losing streams to the groundwater). It is possible that future actions could temporarily alter that condition. It is the intent of the CSCGMP that controllable operations of the groundwater system would not negatively impact the water quality of the area's rivers and streams. The basin governance body will seek to gain a better understanding, in cooperation with SGA and others, of the potential impacts of discharging local area groundwater to major rivers adjacent to the Central Basin.

The basin governance body shall coordinate with other responsible regional, county, and local agencies to ensure that surface water flows in the other natural and restored streams in the area are not adversely impacted as a result of implementation of the CSCGMP.

3.1.5 BMO No. 5. Water quality objectives

The following are water quality goals for the Central Basin:

1. Total Dissolved Solids (TDS) concentration of less than 1,000 mg/l

   The Central Basin is currently not threatened by salinity intrusion typically equated to concentrations of TDS from boundary influences. The upwelling of poor quality water from depths exceeding 2,000 feet is of primary concern and is typically addressed by constructing wells in a way that prevents poor quality water from reaching potable drinking water supplies. Monitoring of TDS is not only for detecting potential salinity intrusion from the deeper aquifer but also as a possible surrogate for other problems that may be occurring in the aquifer system such as naturally occurring salts or minerals that may pose a health risk.

   TDS is considered by DHS to be an aesthetic quality falling under the category of a Secondary Drinking Water Standard. The existing requirement for privately owned wells to collect this type of data at least once (a one-time monitoring requirement) was established some years ago to provide DHS staff with sufficient information to determine whether the water quality would be within an acceptable range for drinking purposes. "Acceptable" is a subjective term; however, DHS staff have sufficient field experience to identify sources that would be likely to pose problems (e.g., avoidance by consumers), even for nonresident consumers.

   Currently DHS lists a Secondary MCL for TDS of 1,000 mg/l. For purposes of the CSCGMP, this value will be used for purposes of taking action.

2. Nitrate (NO3) concentration of less than 45 mg/l

   The Central Basin has many land use types, and differing types of sewage disposal and agricultural fertilizer application. These activities could cause

nitrates to be introduced into the groundwater. DHS has set the Primary Drinking Water MCL for nitrate at 45 mg/l. Under this GMP, this should apply to both privately and publicly owned wells.

3. Volatile Organic Compounds (VOC)

   Various sources of VOCs exist within the basin including old landfills, wrecking yards, military bases, and research and development facilities. Significant concern exists regarding the movement of these compounds from the vadose or unsaturated zone to the saturated zone or aquifer. Once these compounds are mobilized in groundwater, their movement will depend on many different factors one of which could be management activities within the basin. A need exists to monitor VOC migration within the basin for the protection of public and private wells. A concentration limit is not identified for VOCs given that many constituents fall under this category. Any measurable trace of VOC in a private or public well should be considered significant and action should be taken in accordance with the programs identified in the CSCGMP and by the regulatory agencies having jurisdiction in addressing VOC contamination.

3.2 PROGRAM COMPONENT ACTION ITEMS

There are five program components with action items to assist in meeting the BMOs. They are as follows:

1. Stakeholder involvement
2. Monitoring program
3. Groundwater resource protection
4. Groundwater sustainability
5. Planning Integration

These components are described further in the following sections.

3.2.1 Component No. 1: STAKEHOLDER INVOLVEMENT

Management actions taken by the basin governance body may impact a broad range of individuals and agencies that have a stake in the successful management of the basin. Customers of the water purveyors may be most concerned about water rates or assurances that each time the tap is turned on a steady, safe stream of water is available. Industrial, agricultural, or agricultural-residential well owners will want their wells to be protected from dewatering, water quality degradation, and significantly higher energy costs. Furthermore, the degree to which the basin can achieve local supply reliability provides an opportunity to advance banking and exchange programs that could support state and federal water programs in meeting other water needs, particularly in drier years.

The basin governance body will pursue several means of achieving broad stakeholder participation in the management of the Central Basin including: 1) involving the public, 2) involving other agencies within and adjacent to the Central Basin, 3) using advisory committees, 4) developing relationships with state and federal water agencies, and 5) pursuing a variety of partnership opportunities.

3.2.1.1 Involving the Public

Groundwater in California is a public resource, and the basin governance body is committed to involving the public in implementing the CSCGMP. In accordance with CWC § 10753.2, a public hearing was held and a Resolution of Intent (WA-2590) to prepare a groundwater management plan for the Central Basin was adopted by the Board of Directors of the SCWA on April 19, 2005. Upon adoption of the resolution, the text of the resolution was published in the Sacramento Bee on April 27, 2005 and May 4, 2005 (**Appendix C**).

Development of the CSCGMP included representatives of interested basin stakeholders (see **Section 1.3**). Upon completion of the CSCGMP all required public notification will be made prior to adoption of the document by the basin governance body (note that this action may take place several months after completion of the GMP because the governance body will not be formally established until the fall of 2006. Within six months of adoption, the basin governance body, with the assistance of an advisory committee, will develop a Public Outreach

Plan (POP). The POP will include strategies for communicating with both internal and external audiences during implementation of the CSCGMP.

The Water Forum has posted on its web site (http://www.waterforum.org) a copy of the CSCGMP. The Water Forum will continue to use its web site to distribute information on CSCGMP implementation activities to the public until the basin governance body's web site is operational. The basin governance body will create a public outreach web site within one year of the adoption of the CSCGMP. Copies of the CSCGMP and the POP will be posted on this site.

Actions. The basin governance body will take the following actions:

- Continue efforts to encourage public participation in the implementation process as opportunities arise.
- Provide public notice and public comment periods on formal revisions to the CSCGMP.
- Develop a POP and periodically review the POP and take actions as appropriate while implementing the CSCGMP.
- Provide briefings to the Water Forum Successor Effort on CSCGMP implementation progress.
- Maximize outreach on CSCGMP activities including the use of the Water Forum web site and in the future a web site sponsored by the basin governance body.

3.2.1.2 Involving Other Agencies Within and Adjacent to the Central Basin

As was mentioned previously, development of the CSCGMP involved the participation of a number of different stakeholders. A list of the stakeholder groups can be found in **Section 3.2.1.3**. This list of participants does not cover all interests both within and adjacent to the basin that may be affected by implementation of the CSCGMP. Once implementation of the CSCGMP begins, the basin governance body will be responsible for informing and involving agencies and stakeholders in the activities conducted under the plan.

One interest inside the Central Basin is the Air Force Real Property Agency (AFRPA), which oversees remediation efforts of contaminated soil and groundwater at Mather Field. As a stakeholder and water purveyor at Mather Field, SCWA has had ongoing dialog both with the County of Sacramento Department of Economic Development and the AFRPA to discuss issues related to land use, wellhead protection, groundwater management, and remediation efforts at Mather Field.

Outside interests include SGA which adopted a groundwater management plan that covers the organized municipal water purveyors in north Sacramento County in December 2003. Other adjacent interested agencies and stakeholders include SSCAWA and TNC, which owns and maintains wetlands and agricultural lands along the Cosumnes River corridor. Representatives from SSCAWA and TNC participate as stakeholders in the CSCGF negotiations and in preparation of the CSCGMP.

Actions. The basin governance body will take the following actions:

- Maintain a high level of involvement by stakeholders in implementing the CSCGMP by continued participation with the various stakeholder groups described above.
- Provide copies of the adopted CSCGMP and subsequent annual reports to representatives of SGA, SSCAWA, TNC, CSCGF, San Joaquin County, and the Water Forum Successor Effort.
- Meet with representatives from SGA, SSCAWA, TNC, CSCGF, and the Water Forum Successor Effort, as needed.
- Coordinate meetings outside the CSCGF with agricultural and agricultural-residential self-supplied pumpers within the basin
- Coordinate meetings with self-supplied pumpers within the basin to inform them of the management responsibilities and activities relative to this plan.
- Coordinate CSCGMP activities and work to the extent practicable with adjacent groundwater management entities, water interest groups, and state and federal regulatory agencies that have jurisdiction in areas related to CSCGMP activities.

3.2.1.3 Using Advisory Committees

The CSCGF and the basin governance body will use advisory committees in developing and implementing the CSCGMP.

Prior to beginning development of the CSCGMP, a task force made up of stakeholders in the CSCGF was named as the Advisory Committee to guide development of the CSCGMP. The Advisory Committee formed a Project Management Team (PMT) to develop the CSCGMP and to present and solicit comments from the Advisory Committee on a monthly basis. The Advisory Committee updated the CSCGF on a quarterly basis during development of the CSCGMP.

The groups represented on the CSCGMP Advisory Committee included:

- Agricultural residential users
- Building Industry Association
- Cal-Am Water Company
- California Department of Water Resources
- City of Elk Grove
- City of Folsom
- City of Rancho Cordova
- City of Sacramento
- Elk Grove, Sacramento Metropolitan, and Rancho Cordova Chambers of Commerce
- Elk Grove Water Service
- Golden State Water Company
- League of Women Voters
- The Nature Conservancy
- Omochumne-Hartnell Water District
- Sacramento County
- Sacramento County Farm Bureau
- Sacramento County Water Agency
- Sacramento Regional County Sanitation District
- Southgate Recreation and Parks District
- Water Forum

Action. The basin governance body will take the following action:

- Following adoption of the CSCGMP, the basin governance body will discuss the continuation and composition of advisory committees that will provide guidance in the implementation of the plan.

3.2.1.4 Developing Relationships with State and Federal Agencies

Working relationships between the basin governance body and local, state, and federal regulatory agencies are critical in developing and implementing the various groundwater management strategies and actions detailed in the CSCGMP.

The PMT has established working relationships with local, state, and federal regulatory agencies (e.g., EMD, DHS, EPA, etc.) in the process of developing the CSCGMP.

Action. The basin governance body will take the following action:

- Continue to develop and establish working relationships with local, state, and federal regulatory agencies, as appropriate.

3.2.1.5 Pursuing Partnership Opportunities

The basin governance body is committed to facilitating partnership arrangements at the local, state, and federal levels. Over the past decade, the Sacramento area water community and other local leaders have made great strides in regional planning and collaboration on water issues. The WFA, which involved over 40 stakeholders and seven years of facilitated discussions, resulted in a regional framework to balance the competing demands for increased use of surface and groundwater with the environmental needs of the lower American River through 2030. Several important partnerships have been formed to implement the WFA as well as to provide benefits to water agencies, their customers, and other groundwater users. For example, SCWA, TNC, and SSCAWA are working cooperatively to enhance stream flows in the Cosumnes River.

While facilities necessary to implement and expand conjunctive use programs in the Central Basin have been identified in **Section 2**, the potential exists to expand these facilities on a basin-wide level to achieve broader regional and statewide benefits. These facilities, however, would require substantial resources. To investigate any further opportunities would require resources provided through partnerships with potential beneficiaries.

Actions. The basin governance body will take the following actions:

- Continue to promote partnerships that accomplish both local supply reliability and broader regional and statewide benefits.
- Continue to track grant opportunities to fund groundwater management activities and local water infrastructure projects.

3.2.2 Component No. 2: MONITORING PROGRAM

This section describes a monitoring program that is capable of assessing the current status of the basin, and predicting responses in the basin as a result of future management actions. The program includes monitoring groundwater elevations, monitoring groundwater quality, monitoring and assessing the potential for land surface subsidence resulting from groundwater extraction, and developing a better understanding of the relationship between surface water and groundwater along the American, Cosumnes, and Sacramento rivers. Also important is establishing monitoring protocols to ensure the accuracy and consistency of data collected. Finally, the monitoring program includes a tool (DMS, a.k.a. SHEDTOOL) for assembling and assessing groundwater-related data.

3.2.2.1 Groundwater Elevation Monitoring

The PMT has compiled a significant amount of historical groundwater level data measurements, extending from prior to 1950 through 2003, for the basin. Sources of this data include the following:

- DWR/SCWA
- USGS
- SMUD

DWR and SCWA have a program that collects biannual (spring and fall) groundwater level data from more than 150 wells throughout Sacramento County. SCWA uses these data to generate biannual groundwater contour maps for the county. However, because wells have been added and dropped from the program over time, it is difficult to compare a historic contour map with a recent one. For this reason, SGA, SCWA, and the basin governance body are establishing a standardized network of wells that combines those monitored by DWR, SCWA, SGA member water purveyors, and other sources. It is the intent of these parties that the wells comprising this program be maintained as a consistent long-term network that represents overall groundwater elevation conditions in the basin. **Appendix B** shows the wells currently proposed for this network. The wells were selected to provide uniform geographic coverage and are located in a series of polygons that cover the entire Central Basin.

The resulting grid, shown in **Appendix B**, includes approximately 90 polygons roughly about five square miles each. The proposed set of monitoring wells was selected from the DMS to represent water levels for as many polygons as possible. Individual wells were selected by the following methods:

- Giving preference to wells currently in DWR's and SCWA's monitoring program. These wells were selected because (1) they have long records of historic groundwater level data and are useful in assessing trends within the groundwater basins, (2) uniform protocols were used in measuring and recording the water level data, and (3) these are typically non-producing wells, so water level readings represent relatively static levels.
- Identifying other municipal and private wells with well construction information and long records of groundwater level data and giving preference to those wells with the lowest recent extraction volumes.

Actions. Additional actions by the basin governance body will include:

- Coordinate with DWR and others to identify an appropriate group of wells for monitoring for a spring 2007 set of groundwater elevation measurements.
- Coordinate with DWR and others to ensure that the selected wells are maintained as part of a long-term monitoring network.
- Coordinate with DWR to ensure that the timing of water level data collection by other agencies coincides within one month of DWR and SCWA data collection (currently DWR and SCWA collect water level data in the spring and fall).
- Coordinate with other agencies to ensure that needed water level elevations are collected and verify that uniform data collection protocols are used among the agencies.
- Coordinate with USGS to determine the potential for integrating USGS monitoring wells constructed for the NAWQA program into the SCWA and SGA monitoring network.
- Consider ways to fill gaps in the monitoring well network by identifying suitable existing wells or identifying opportunities for constructing new monitoring wells.
- Assess annually groundwater elevation trends and conditions based on the monitoring well network.
- Assess annually the adequacy of the groundwater elevation monitoring well network.
- Identify a subset of monitoring wells that will be monitored more frequently than twice annually to improve understanding of aquifer responses to pumping throughout the year.

3.2.2.2 Groundwater Quality Monitoring

Because many of the wells in the basin are used for public water supply, an extensive record of water quality data is available for most wells. Water purveyors have compiled available historic water quality data for constituents monitored as required by DHS under CCR Title 22. Sources of water quality data include the following:

- DWR
- Central Basin water purveyors
- USGS

This level of monitoring is sufficient under existing regulatory guidelines to ensure that the public is provided with a safe and reliable drinking water supply. Ultimately, it may be advisable to have in place a network of shallow (less than 200 feet deep) sentry wells to serve as an early warning system for contaminants that could make their way to greater depths in the basin where groundwater purveyors primarily extract groundwater. SCWA has been working with AFRPA to identify a subset of the sentry wells located in and around the Mather Field for integration into this monitoring effort. The basin governance body along with SCWA will also coordinate with EPA and the RWQCB, which oversees Aerojet and Boeing's remediation efforts and with EMD for the LUST cleanup efforts, to identify existing dedicated monitoring wells in the basin.

CCR Title 22 water quality reporting is required by DHS for each public drinking water source within the Central Basin. The Central Basin monitoring network includes these wells. The water quality monitoring well network may be expanded to include additional DWR, USGS, Mather Field, Aerojet, Boeing, RWQCB, and privately owned wells based on the outcome of coordination meetings with these agencies, businesses and various land owners.

Actions. The following actions will be taken by the basin governance body:

- Coordinate with cooperating agencies to verify that uniform protocols are used when collecting water quality data.
- Coordinate with USGS to obtain historic water quality data for NAWQA wells, determine timing and frequency of monitoring under USGS program, and discuss the potential for integrating USGS monitoring resources with other portions of the Central Basin monitoring network.
- Coordinate with local, state, and federal agencies to identify where wells may exist in areas with sparse groundwater quality data. Identify opportunities for collecting and analyzing water quality samples from those wells.
- Assess annually the adequacy of the groundwater quality monitoring well network..
- Coordinate with DWR on the groundwater quality data they collect.

3.2.2.3 Land Surface Elevation Monitoring

Subsidence of the land surface resulting from compaction of underlying formations affected by head (groundwater level) decline is a well-documented concern throughout much of the Central Valley. During a typical pumping season, changes in land surface elevation can be observed as a result of both elastic and inelastic subsidence in the underlying basin. Elastic subsidence results from the reduction of pore fluid pressures in the aquifer, and typically rebounds when pumping ceases or when groundwater is otherwise recharged resulting in increased pore fluid pressure. Inelastic subsidence occurs when pore fluid pressures decline to the point that fine-grained sediments such as clays consolidate, resulting in permanent compaction and reduced ability to store water in that portion of the aquifer. Other side effects may include damaged levees, canals, or pipes.

While some land surface subsidence is known to have occurred as a result of groundwater extraction west of the Sacramento River, the extent of subsidence east of the Sacramento River has been minimal. DWR maintains three subsidence monitoring stations in the Sacramento Valley.

Historical benchmark elevation data for the period from 1912 through the late 1960s obtained from the National Geodetic Survey (NGS) were used to evaluate land subsidence in north Sacramento County. From 1947 to 1969, the magnitude of land subsidence measured at benchmarks north of the American River ranged from 0.13 feet to 0.32 feet, with a general decrease in subsidence in a northeastward direction. This decrease is consistent with the geology of the area: formations along the eastern side of the Sacramento Valley are older than those on the western side and are subject to a greater degree of pre-consolidation, making them less susceptible to subsidence. The maximum documented land subsidence of 0.32 feet was measured at both benchmark L846, located approximately two miles northeast of the former McClellan AFB, and benchmark G846, located approximately one mile northeast of the intersection of Greenback Lane and Elkhorn Boulevard. Another land subsidence evaluation was performed in the Arden-Arcade area of Sacramento County from 1981 to 1991. Elevations of nine wells in the Arden-Arcade area were surveyed in 1981, 1986, and 1991. The 1986 results were consistently higher than the 1981 results; this was attributed to extremely high rainfall totals in early 1986 that recharged the aquifer and caused a rise in actual land surface elevations. The 1991 results were consistently lower than the 1986 results; this was attributed to five years of drought immediately preceding the 1991 measurements which caused depletion of the aquifer and resulting land surface subsidence. Comparison of eight of the locations indicates that seven benchmarks had lower elevations in 1991 than in 1981 and one benchmark had a higher elevation in 1991. Of the seven benchmarks with lower elevations in 1991, the maximum difference is 0.073 feet (less than one inch).

Whether this is inelastic subsidence is indeterminate from the data, but it is clear that the magnitude of the potential subsidence in the benchmarks between 1981 and 1991 was negligible.

Actions. While available data and reports indicate that land surface subsidence is not a problem in the Sacramento County area, the basin governance body is interested in pursuing additional possible actions to continue to monitor potential land surface subsidence especially in the Central Basin. Actions may include the following:

- Investigate the feasibility and costs of resurveying the wells in the Arden-Arcade area, which were last measured in 1991.
- Coordinate with USGS to ascertain the suitability of the use of Interferometric Synthetic Aperture Radar (InSAR) images of the Central Basin and the surrounding area. If the technology appears suitable, identify the costs of determining ground surface elevations and identify potential cost-sharing partners.
- Coordinate with other agencies, particularly the City and County of Sacramento and the NGS to determine if there are other suitable benchmark locations exist in the area to aid in analysis of potential land surface subsidence.

3.2.2.4 Surface Water Groundwater Interaction Monitoring

The interaction between groundwater and surface water has not been extensively evaluated in the Central Basin area. This is what is known:

- A recent draft decision by the SWRCB (2003) regarding the American River concluded that from Nimbus Dam to about 6,000 feet below the dam, groundwater elevations and surface water elevations were similar enough to each other that groundwater could be tributary to the American River. Beyond 6,000 feet down river from the dam, groundwater elevations are sufficiently lower than the river channel to conclude that the American River is a "losing" stream down to its confluence with the Sacramento River.
- Groundwater modeling has been used to estimate flow volumes between surface water and groundwater for various hydrologic conditions. California State University, Sacramento (CSUS) in cooperation with DWR has recently installed several monitoring wells in and adjacent to the American River to investigate groundwater interaction with the American River and how recent United States Army Corp of Engineers (USACE) levee reinforcement projects might have changed the surface water-groundwater flow relationships.
- In 1991, SRCSD, Sacramento County, and the City established the Sacramento Coordinated Water Quality Monitoring Program (CMP). Since that time, the CMP has monitored surface water quality for a variety of constituents, including trace elements at several locations on the American and Sacramento rivers. The CMP monitors the Sacramento River at the Freeport Bridge and the American River at Nimbus Dam.
- SCWA has completed an Memorandum of Agreement (MOA) with TNC and SSCAWA for the Management of Water and Environmental Resources associated with the lower Cosumnes River. This MOA reflects a desire to work together to actively investigate opportunities for flow restoration, conjunctive use management, and enhanced recharge within the Cosumnes River corridor.

Actions. The basin governance body will pursue actions to better understand the relationship between surface and groundwater in the Central Basin area, including the following:

- Work cooperatively with SGA, TNC, and OHWD to compile available stream gage data and information on tributary inflows and diversions from the American, Cosumnes, and Sacramento rivers to quantify net groundwater recharge or discharge between gages in the Central Basin area.
- Coordinate with local, state, and federal agencies to identify available surface water quality data from the American, Cosumnes, and Sacramento rivers proximate to the Central Basin area.

- Correlate groundwater level data from wells in the vicinity of river stage data to further establish whether the river and groundwater are in direct hydraulic connection, and if surface water is gaining or losing at those points.
- Continue to coordinate with local, state, and federal agencies and develop partnerships to investigate cost-effective methods that could be applied to better understand surface water-groundwater interaction along the American, Cosumnes and Sacramento rivers.
- Coordinate with CSUS, to analyze data obtained from recently constructed monitoring wells on the CSUS campus to better understand the relationship between groundwater basin and surface water flows at that location.

3.2.2.5 Protocols for Collection of Groundwater Data

Through the work completed as part of SGA's groundwater management plan, MWH has evaluated the accuracy and reliability of groundwater data collected by cooperating agencies within the Sacramento region (MWH, 2002). The evaluation indicated a significant range of techniques, frequencies and documentation methods for collection of groundwater level and groundwater quality data.

Although the groundwater data collection protocol may be adequate to meet the needs of individual agencies, the lack of consistency yields an incomplete picture of basinwide groundwater conditions. Other types of groundwater data collection protocols are included in **Sections 3.2.2.1** and **3.2.2.2** above.

Actions. To improve the comparability, reliability, and accuracy of groundwater data, the basin governance body will take the following actions:

- The governance body will develop within one year a standard operating procedure (SOP) for collection of water level data.
- Provide cooperating agencies with guidelines developed by DHS for the collection, pretreatment, storage, and transportation of water quality samples (DHS, 1995).
- Provide training on implementing the SOPs.

3.2.2.6 Data Management System

For the basin governance body to achieve its primary objective of sustaining the groundwater resource within the Central Basin, it was essential to develop a data storage and analysis tool, or DMS. The DMS was developed by MWH under contract with USACE. Other local sponsors included SGA and its member agencies, DWR, and SCWA.

The DMS is a public domain application developed in a Microsoft Visual Basic environment and is linked to a database containing Central Basin purveyor data. The DMS provides the end-user with ready access to both enter and retrieve data in either tabular or graphical formats. Security features in the DMS allow for access restrictions based on a variety of user permission levels.

Data in the DMS include the following:

- Well construction details
- Known locations of groundwater contamination and potentially contaminating activities (PCA)
- Long-term monitoring data on the following:
  - Monthly extraction volumes
  - Water elevations
  - Water quality
- Aquifer characteristics based on well completion reports and the Sacramento County IGSM.

The DMS allows viewing of regional trends in groundwater level and quality not previously available to stakeholders in the basin. The DMS has the capability of quickly generating well hydrographs and groundwater elevation contour maps using historic groundwater level data. The DMS allows the user to view water quality data for CCR Title 22 required constituents as a temporal concentration graph at a single well, or any constituent can be plotted with respect to concentration throughout the Central Basin area. Presentation of groundwater elevation and groundwater quality data in these ways will be useful for making groundwater basin management decisions.

SGA and the basin governance body will be establishing data transfer protocols so that groundwater data in the North and Central Basins (by cooperating agencies,

DWR, AFRPA, USGS, etc.) can be readily appended to the database and analyzed through the DMS. Annual summaries of groundwater monitoring data will be prepared using the analysis tools in the DMS and presented in an annual State of the Basin report (see **Section 4**). Once the DMS is fully populated and quality-control checked, a summary of existing basin conditions will be prepared. These initial summary analyses will be performed on at least an annual basis to assess the impacts of current and future management actions on the groundwater system.

Actions. To maintain and improve the usability of the DMS, the basin governance body will take the following actions:

- Continue to update the DMS with current water purveyor data.
- Make recommendations to MWH (or assigned DMS developer) on utilities to add to the DMS to increase its functionality.

3.2.3 Component No. 3: GROUNDWATER RESOURCE PROTECTION

The basin governance body considers groundwater resource protection a critical component in maintaining a sustainable groundwater resource. There are two aspects of groundwater resource protection, 1) preventing contamination from entering the groundwater, and 2) remediation of known contaminant plumes. Prevention measures include proper well construction and destruction practices, development of wellhead protection measures, and protection of recharge areas. Prevention also includes measures that prevent human activities and deleterious natural substances, such as saline water, from entering the groundwater system. Remediation includes any activity that removes and treats man made contaminants from the soil and the groundwater system.

3.2.3.1 Well Construction Policies

The Sacramento County Environmental Management Department (EMD) administers the well permitting program for Sacramento County. Standards for well construction are identified in Sacramento County Code No. SCC-1217 (County Well Ordinance), as amended on April 9, 2002. In addition to general well construction standards, Sacramento County has a policy of special review by appropriate regulatory agencies before granting a well permit within 2,000 feet of a known contaminant plume (referred to as Consultation Zones). Prohibitions have been established by various State regulatory agencies for drilling new public supply wells at Mather Field or near the Aerojet or Boeing facilities. As part of the development of the DMS, the extent of contaminant plumes associated with Mather Field, Aerojet, and Boeing were delineated for SGA and SCWA (see **Figure 2-19**).

Actions. The basin governance body will take the following actions:

- Ensure that appropriate Sacramento County and Central Basin implementation staff and consultants are provided a copy of the County Well Ordinance and understand proper well construction procedures.
- Adhere to Sacramento County's Consultation Zone and provide a copy of the boundary of the prohibition zones to appropriate agencies within the Central Basin.
- Provide a copy of the most recently delineated plume extents at Mather Field and Aerojet/Boeing to EMD and appropriate staff for their review and possible use.
- Coordinate with other groundwater users in the Central Basin to provide guidance, as appropriate, on well construction.
- Where feasible and appropriate, use subsurface geophysical tools prior to construction of the well to assist in well design.

3.2.3.2 Well Abandonment and Destruction Policies

EMD administers the well destruction program for Sacramento County. The standards for well destruction are identified in the County Well Ordinance. A concern of the basin governance body and EMD is that many abandoned supply wells have not been properly destroyed. As part of development of the DMS for SGA, DWR well records for all known wells in the North Basin were reviewed for reported destruction. Based on the information provided

each well was then rated based on the level of confidence that the well in question was actually destroyed properly. This information was then entered into the DMS.

Actions. The basin governance body will take the following actions:

- Complete a similar survey of abandoned and/or destroyed wells in the Central Basin and populate DMS with data.
- Ensure that all public and private agencies in the Central Basin are provided a copy of the County Well Ordinance and that they understand proper well destruction procedures, and support implementation of these procedures.
- Follow up with cooperating agencies and EMD on reported abandoned and/or destroyed wells to confirm the information collected from DWR.
- Obtain copies of any information on abandoned and/or destroyed wells in the Central Basin from EMD or other regulatory agencies to fill any gaps in the governance body's records.
- Meet with EMD to discuss ways to ensure that wells in the Central Basin are properly abandoned or destroyed.
- Obtain and review a copy of a "wildcat map" from California Division of Oil and Gas to ascertain the extent of historic gas well drilling operations in the area as these wells could function as conduits of contamination if not properly destroyed. It should be noted that EMD has no jurisdiction over gas wells.

3.2.3.3 Wellhead Protection Measures

Identification of wellhead protection areas is an element of the Drinking Water Source Assessment and Protection (DWSAP) program administered by DHS. DHS set a goal for all water systems statewide to complete Drinking Water Source Assessments by mid-2003. Most water purveyors in the basin have completed their required assessments by performing the three major elements required by DHS:

- Delineation of capture zones around sources (wells).
- Inventory of PCAs within protection areas.
- Vulnerability analysis to identify the PCAs to which the source is most vulnerable.

Delineation of capture zones includes using groundwater gradient and hydraulic conductivity data to calculate the surface area overlying the portion of the aquifer that contributes water to a well within specified time-of-travel periods. Typically, areas are delineated representing 2-, 5-, and 10-year time-of-travel periods. These protection areas must be managed to protect the drinking water supply from viral, microbial, and direct chemical contamination.

Inventories of PCAs include identifying potential origins of contamination to the drinking water source and protection areas. PCAs may consist of commercial, industrial, agricultural, and residential sites, or infrastructure sources such as utilities and roads. Depending on the type of source, each PCA is assigned a risk ranking, ranging from "very high" for such sources as gas stations, dry cleaners, and landfills, to "low" for such sources as schools, lakes, and non-irrigated cropland. Vulnerability analysis includes determining the most significant threats to the quality of the water supply by evaluating PCAs in terms of risk rankings, proximity to wells, and physical barrier effectiveness (PBE). PBE takes into account factors that could limit infiltration of contaminants including type of aquifer, aquifer material (for unconfined aquifers), pathways of contamination, static water conditions, hydraulic head (for confined aquifers), well operation, and well construction. The vulnerability analysis scoring system assigns point values for PCA risk rankings, PCA locations within wellhead protection areas, and well area PBE; the PCAs to which drinking water wells are most vulnerable are apparent once vulnerability scoring is complete.

PCA and capture zone information from the DWSAP will need to be added into the DMS. The DMS includes a feature that will automatically calculate wellhead protection areas if no data are available or if new well locations are proposed.

Actions. The basin governance body will take the following actions:

- Request that public water purveyor agencies within the Central Basin provide vulnerability summaries from the DWSAP to the basin

governance body to be used for guiding management decisions in the basin.

- Contact groundwater basin managers in other areas of the state for technical advice, effective management practices, and "lessons learned" regarding establishing wellhead protection areas.

3.2.3.4 Protection of Recharge Areas

Surface geology within and directly adjacent to the Central Basin's boundary was investigated as part of the 1993 Sacramento County General Plan for the purpose of delineating areas of potentially high recharge (as shown in Figure 7 of the Conservation Element of the 1993 Sacramento County General Plan). Much of the surface area considered to have the highest potential for recharge along the American River is developed. Other recharge areas identified in the Sacramento County General Plan include areas around and adjacent to the streams that flow along and across the Central Basin such as the Cosumnes River and Morrison stream group. Previous studies have also indicated that the abandoned aggregate mining pits north and south of Jackson Highway could be possible recharge locations. These pits typically extend 20 to 30 feet below ground surface and are mined to the clay layer that separates the Laguna Formation from the Mehrten Formation. Water introduced to these pits could deep percolate vertically through the interbedded clay lenses and horizontally through the pit walls into the Laguna formation. Flood waters, raw surface water, and perhaps treated recycled water can be discharged into these pits for year-round recharge. The RWQCB will need to provide regulatory approval prior to any use of these pits for recharge.

Another recharge location is along the Cosumnes River. The Cosumnes River overlies very transmissive soils, evidenced by the lack of river flow during certain times of year. Enhancing this recharge is already being considered through a pilot program (coordinated through the Water Forum, SCWA, TNC, and SSCAWA) that conveys American River water through the Folsom South Canal and then discharges it to the Cosumnes River at the canal crossing. It is hoped that this program will demonstrate an improvement in the fishery and riparian habitat along the Cosumnes River as well as provide enhanced recharge.

Action. The basin governance body will take the following action:

- Continue to work with mining companies, TNC, and SSCAWA to explore the possibilities for enhancing recharge into the Central Basin.

3.2.3.5 Control of the Migration and Remediation of Contaminated Groundwater

Major sources of contamination within the Central Basin are primarily from Mather Field, Aerojet, Boeing, and various active and inactive landfill sites. The extent of the groundwater contaminant plumes emanating from these sources are shown in **Figure 2-19**. Also of concern is localized contamination by industrial/commercial point sources such as dry cleaning facilities and numerous fuel stations throughout the basin.

While the basin governance body does not have the authority or responsibility for remediation of this contamination, it is committed to coordinating with responsible parties and regulatory agencies to stay informed on the status and disposition of known contamination in the basin. For example, information on known LUST sites has been collected from the EMD, the SWRCB, and the RWQCB and entered into the DMS. Also, SCWA has been in communication with AFRPA,

which is overseeing remediation efforts at Mather AFB (see **Section 3.2.2.2**).

Actions. The basin governance body will take the following actions:

- Coordinate with appropriate regulatory agencies (EMD, DTSC, EPA, and DHS) and known responsible parties to develop a network of monitoring wells to act as sentry wells for public supply wells.
- If detections occur in these monitoring wells, meet with the appropriate regulatory agencies and responsible parties to develop strategies to minimize the further spread of contaminants.
- Use the information on mapped contaminant plumes and LUST sites in developing groundwater extraction patterns and in locating future production or monitoring wells.
- Meet with representatives of EMD and RWQCB to establish a mutual understanding about the basin governance body's groundwater management responsibilities. Identify ways to have open and expedited communication with EMD regarding any new occurrences of LUSTs, particularly when contamination is believed to have reached the groundwater.

3.2.3.6 Control of Saline Water Intrusion

Saline water intrusion from the Sacramento/San Joaquin Delta (Delta) is not currently a problem in the Central Basin, and is not expected to become a problem in the future. Higher groundwater elevations associated with recharge from the American and Sacramento rivers have maintained a historical positive gradient, preventing significant migration of any saline water from the Delta into the Sacramento County region. These groundwater gradients will continue to serve to prevent any localized pumping depressions in the basin from inducing flow from the Delta into the Central Basin.

Actions. The basin governance body will take the following actions:

- Track the progression, if any, of saline water bodies moving toward the east from the Delta. Because this is a highly unlikely scenario, this action will be limited to communicating with DWR's Central District Office on a biennial basis to check for significant changes in TDS concentrations in wells. DWR has a regular program of sampling water quality in select production wells throughout the adjacent Solano, San Joaquin, and Yolo counties. This program will serve as an early warning system for potential saline water intrusion from the Delta.
- Observe TDS concentrations in municipal wells that are routinely sampled under CCR Title 22. These data will be readily available as part of the DMS and will be reported on in the annual State of the Basin report.
- Inform all stakeholders of the presence of the salinity interface and the approximate depth to the interface for their reference when locating potential wells. EMD, which issues well permits, is aware of the interface. SCWA will provide a map to EMD indicating the contour of the elevation of the base of fresh water in Sacramento County for its reference when issuing well permits.

3.2.4 Component No. 4: GROUNDWATER SUSTAINABILITY

To ensure a long-term viable supply of groundwater, the basin governance body seeks to maintain or increase the amount of groundwater stored in the basin over the long term. The WFA's groundwater management element provides a framework by which the groundwater resource in the Sacramento County-wide basin can be protected and used in a sustainable manner. As mentioned previously, the WFA estimated a long-term average annual pumping limit within the Central Basin of 273,000 AF/year. As discussed in **Section 2**, historic groundwater extractions have resulted in a net depletion of groundwater stored under the Central Basin area. To ensure a sustainable resource, SCWA continues to move forward with its conjunctive use program in Zone 40, including pursuit of additional surface water supplies, increased use of recycled water, and implementation of the WFA water conservation element. Current conjunctive use activities include the City/SCWA Franklin Intertie and continued development of the FRWA project that will bring additional surface water supplies into Zone 40. The

City also is considering optimizing the use of American River water within the POU boundaries. Lastly, SRCSD is looking at opportunities for use and possible in-lieu recharge of groundwater through use of recycled water for non-potable uses.

Conjunctive management is a program that includes both conjunctive use and the development of banking and exchange opportunities with local in-basin partners after local needs are met. Banking and exchange partnerships will result in increased surface water and perhaps revenue to pay for some of the necessary capital improvements to help sustain the resource. The basin governance body and SCWA are also interested in direct recharge and propose to investigate a variety of ways to recharge water into available storage space in the basin. Opportunities for direct recharge exist through the use of recharge basins (e.g., abandoned aggregate mining pits) or through a aquifer storage and recovery (ASR) program. The City of Roseville is currently implementing an ASR program where treated surface water is injected into the groundwater and then recovered in the summer months and dry years through groundwater wells. The success of this program will be monitored closely by the governance body.

Another recharge opportunity would provide raw or treated surface water to municipal and agricultural users in lieu of extracting groundwater. During the early phases of Zone 40's conjunctive use program, there is expected to be excess capacity in both the raw water pipeline from the FRWA project and the Central WTP that could be delivered through some type of conveyance to groundwater users.

Actions. The basin governance body will take the following actions:

- Continue to investigate conjunctive use opportunities within the Central Basin area. Groundwater users within the Central Basin will coordinate any recharge efforts.
- Continue to investigate opportunities for development of direct recharge facilities in addition to in-lieu recharge (e.g., injection wells or surface spreading facilities, through constructed recharge basins or in riverbeds or streambeds).

3.2.4.1 Demand Reduction

An important factor in maintaining the sustainable yield of the basin is by reducing demand for potable water supplies through conservation and the use of recycled water for landscape irrigation.

Water Conservation. RWA's efforts in developing and implementing a regional Water Efficiency Program (WEP) are well recognized by CSCGF. The WEP assists participants in meeting their water conservation agreements with the Water Forum, the California Urban Water Conservation Council, and CVPIA. The goal of the WFA is to achieve system-wide conservation of slightly more than 25 percent by 2030.

The basin governance body will work closely with the Water Forum Successor Effort and RWA to ensure that all applicable cost-effective BMPs are implemented in the Central Basin urban areas. The basin governance body shall develop BMPs for self-served agricultural and agricultural-residential water users. These BMPs will be based on applicable Reclamation and DWR data and recommendations.

Water Recycling. The SRCSD is developing a countywide Water Recycling Master Plan to provide up to 40 MGD of recycled water. SRCSD treats wastewater at its Sacramento Regional WWTP and is looking for ways to increase demand for tertiary treated or recycled water. Currently, SRCSD is treating approximately 5 mgd of recycled water and delivering it to nearby landscape irrigation users within the Laguna West, Lakeside and Laguna Stonelakes portion of Zone 40. SRCSD expects the capacity of that facility to increase to 10 mgd over the next few years to serve areas within the City of Elk Grove known at the East Franklin and Laguna Ridge development areas within Zone 40.

Actions. The basin governance body will take the following actions:

- Participate in RWA's WEP to ensure that Central Basin purveyor conservation efforts are focused and effective. For those who receive wholesale water supplies, the governance body of the Central Basin will ensure that they are informed of the benefits and regional importance of participating in the WEP.

- The basin governance body shall develop BMPs for self-served agricultural and agricultural-residential water users.
- Coordinate with SRCSD to investigate further opportunities for expanded use of recycled water throughout the Central Basin.

3.2.5 Component No. 5: PLANNING INTEGRATION

With the large number of water purveyors that serve the greater Sacramento area, the need to integrate water management planning on a regional scale is a high priority. Individual purveyors derive their supplies from the American River, Sacramento River, the groundwater basin, or some mix of these sources. Individual purveyor infrastructure systems are mostly independent; where interconnections do exist they are typically for emergency purposes only.

The WFA provides a regional conjunctive use framework with commitments from individual purveyors concerning groundwater and surface water operations, including limitations on surface water diversions from the lower American River during dry years. SCWA and others planning efforts seek to better integrate the individual plans of various entities to implement various elements of the WFA in keeping with the 2030 regional framework. Such integration also promotes operational efficiency, cost savings, and in some cases generates larger statewide-system benefits.

Some of the municipal groundwater purveyors that provide water service within the Central Basin have opted out of the Water Forum Process and the development of the CSCGMP. If these purveyors choose to participate in the future, then information relative to their water system will be added to the CSCGMP.

3.2.5.1 Existing Integrated Planning Efforts

Stakeholders in the Central Basin, such as SCWA, have already implemented integrated management in the region through cooperation with the City in treating and wheeling surface water (see **Section 2.2.3.2**), participation in the WEP (see **Section 3.2.4.1**), and the SRCSD recycled water program (see **Section 2.4**).

3.2.5.1.1 Urban Water Management Planning

Most urban purveyors in the Central Basin are required to prepare an Urban Water Management Plan. These plans, as defined by CWC § 10610 et seq., require public water suppliers with more than 3,000 customers, or who deliver more than 3,000 AF of water annually, to identify conservation and efficient water use practices to help ensure a long-term, reliable water supply. The basin governance body will encourage that all retail purveyors to submit plans to DWR.

3.2.5.1.2 DWSAP Program

The DWSAP Program is administered by DHS. The first step in completing a source protection program is to conduct a preliminary assessment. The assessment includes “delineation of the area around a drinking water source through which contaminants might move and reach the drinking water supply; an inventory of PCAs that might lead to the release of microbiological or chemical contaminants within the delineated area; and a determination of the PCAs to which the drinking water source is most vulnerable.” Refer to the following DHS web site for more details

on the DWSAP program: (http://www.dhs.ca.gov/ps/ddwem/dwsap/overview.htm).

These assessments only apply to agencies that deliver groundwater for public drinking water supply. Data from the assessments have or will be incorporated into the DMS.

3.2.5.1.3 Land Use Planning

Effective January 1, 2002, State Water Code Sections 10910-10915 (inclusive) (commonly known as SB 610) required that a water supplier take certain actions to confirm sufficiency of water supply as a condition to approval of new development projects. These actions involve the development of Water Supply Assessments and Written Verifications at the request of the land use authority. These documents provide an assurance that adequate water supplies are available before a project moves forward in gaining entitlements for development. The governance body will coordinate with and exchange information with all land use agencies within the area on a continuing basis to provide the latest information pertaining to activities taking place for the protection and availability of groundwater resources; however, the governance body will not be placed in a role of responding to SB 610 requests.

3.2.5.1.4 Integrated Groundwater and Surface Water Modeling

The basin governance body is interested in using and building on existing groundwater models for the Sacramento area. In the late 1990s, a range of groundwater extraction and recharge scenarios were simulated using the North American River and Sacramento County Combined IGSM. This model was originally developed for the American River Water Resources Investigation (ARWRI), conducted by Reclamation, and was later used for the Draft Water Forum Solution Model developed for the Water Forum. The Water Forum used the model in the development of a conjunctive use strategy for the groundwater basin underlying Sacramento County and southern Placer County. SGA recently updated the calibration model to run with the latest version of IGSM. Historical water budgets from 1970 to 1995 were developed and a comparison was provided of model results and actual measured values for groundwater elevations and streamflows over the calibration period. SCWA and SGA are pursuing having the hydrologic period extended from 1995 to 2000 and extending the planning model hydrologic period that is used for measuring effects of conjunctive use practices. Currently the hydrologic period extends from 1922 to 1995.

The reason for maintaining and updating the IGSM is because it forms the basis for the WFA and the Zone 40 WSMP environmental analyses. The basin governance body should be the custodian of the IGSM model because the model is used for regional planning by Reclamation and DWR for projects such as ARWRI, CVPIA, and the CALFED process and is a tool that is supported by the DMS. In addition, the model is a suitable tool to analize the effects of local projects on regional groundwater conditions.

Actions. The basin governance body will take the following actions:

- Prepare and adopt a formal integrated water management plan in accordance with CWC § 10540 et seq. The plan will include, but not be limited to, the elements listed above. The Central Basin governance body will seek to form an ad hoc committee with SCWA, RWA, SSCAWA, and TNC to determine which agency would be most appropriate to prepare that plan and to update and make use of the IGSM model.
- Review the Water Forum Land Use procedures and make recommendations on the type of role, if any, the basin governance body should take with respect to land use decisions within the basin.

3.3 SUMMARY OF SECTION 3

Table 3-1 below provides a summary of **Section 3** for quick reference and for use in further sections. The table correlates which activities are related to one or more BMOs.

Table 3-1. Summary of Action Items and How Each Applies to the BMOs

Action Items Related to BMO	BMO No. 1 Maintain the long-term average groundwater extraction rate at or below 273,000 AF/year	BMO No. 2 Maintain specific groundwater elevations within all areas of the basin consistent with the Water Forum "solution"	BMO No. 3 Protect against any potential inelastic land surface subsidence by limiting subsidence to no more than 0.007 feet per 1 foot of drawdown in the groundwater basin	BMO No. 4 Protect against any adverse impacts to surface water flows in the American, Cosumnes, and Sacramento rivers	BMO No. 5 Water quality objectives
Component No. 1 Stakeholder Involvement					
Involving the Public		✓		✓	✓
Involving Other Agencies Within & Adjacent to the Central Basin		✓	✓	✓	✓
Using Advisory Committees	✓	✓	✓	✓	✓
Developing Relationships with State and Federal Agencies	✓	✓	✓	✓	✓
Pursuing Partnership Opportunities			✓	✓	✓
Component No. 2 Monitoring Program					
Groundwater Elevation Monitoring		✓			
Groundwater Quality Monitoring					✓
Land Surface Elevation Monitoring			✓		
Surface Water Groundwater Interaction Monitoring				✓	
Protocols for Collection of Groundwater Data		✓			
Data Management System	✓	✓	✓	✓	✓
Component No. 3 Groundwater Resource Protection					
Well Construction Policies					✓
Well Abandonment and Destruction Policies					✓
Wellhead Protection Measures					✓
Protection of Recharge Areas					✓
Control of the Migration and Remediation of Contaminated Groundwater					✓
Control of Saline Water Intrusion					✓
Component No. 4 Groundwater Sustainability					
Demand Reduction (Water Conservation and Water Recycling	✓	✓	✓	✓	✓
Component No. 5 Planning Integration					
Existing Integrated Planning Efforts (Urban Water Management Planning, DWSAP Program, Land Use Planning, and Groundwater Modeling)	✓	✓	✓	✓	✓

Plan Implementation

Section 4
Plan Implementation

This section identifies needed monitoring, trigger points, and recommended steps necessary to fully implement the BMOs and action items presented in **Section 3**. Many of these steps involve coordination by the future basin governance body with other local, state and federal agencies. This coordination can take place within 6 months of the adoption of this CSCGMP by the governance body. Monitoring, assessing data trends, and reporting the state of the basin for the purpose of determining the adequacy of the management activities is a key process in this plan. Assessments in the value of monitoring and reporting activities will be made as new monitoring data become available for review by the Central Basin governance body. All results of the monitoring program and actions/decisions made by the governance body will be documented in an annual State of the Basin report. This section also considers the schedule and budget necessary to implement the CSCGMP.

4.1 BACKGROUND

Section 3 identified BMOs, plan components, and management actions (see **Table 3-1**) to implement the groundwater management plan. However, it did not define or identify specific actions that would be taken in the event the objectives of the BMOs were not being met. **Section 4** defines these specific actions by providing a set of "trigger points" in conjunction with recommended actions for each BMO. Associated steps based on exceeding a trigger point's established threshold are the next level of management activity to be undertaken by the governance body.

As mentioned in previous sections, determining and maintaining the health of the Central Basin is the governance body's foremost concern and is accomplished through data collection and evaluation, remedial and/or restorative actions if necessary, and reporting. Findings and the success or failure of steps taken to remedy a problem will comprise a good portion of the content of the annual State of the Basin report published by the basin governance body.

4.2 SPECIFIC ACTIONS BASED ON MONITORING RESULTS

The term "trigger point" as used in this section is defined as a condition in which a BMO has been breached at a defined level. Each trigger point has a corresponding recommended action that is linked to each level. The recommended action is dependent on the measurement taken and the BMO in

question. Individual trigger points are tied to monitoring actions such as groundwater level measurements, groundwater extraction calculations, water quality determinations, etc.

Once a trigger point has been reached, the basin governance body must decide on its course of action. For example, if groundwater levels begin to fall in basin polygon areas (discussed in **Section 3.1.2** and **Appendix B**) that had previously been identified as an area of concern, what action(s) should be taken by the basin governance body? In this case, the basin governance body would go to the trigger points that address potential lowering of groundwater levels in areas being impacted by groundwater pumping or by hydrologic conditions.

The actions that a trigger point might require for the "groundwater elevation" BMO (BMO No. 2) are described as follows:

Trigger Point 1. This initial alert stage informs the basin governance body and the overlying groundwater extractor(s) that a specific polygon area is being compromised. Activation of this trigger will only take place after conducting a thorough investigation into the cause of the condition.

Trigger Point 2. This stage assumes that the area has already gone through Trigger Point 1 actions and is at the next level of alert. This stage may require a reduction in pumping in predefined area(s) to bring the affected area back into compliance. Groundwater extractors within the affected area may not be the actual cause of decline.

Trigger Point 3. This stage indicates continuously declining groundwater levels in an area even during wet and normal hydrologic cycles. This would indicate that excessive pumping is the probable cause. Well owners with operating wells in the affected area(s) will be identified and notified of the basin condition in their area. An assessment will be levied against those owners who continue to pump at the higher level.

Trigger Point 4. If the recommended actions from the first three trigger points do not result in an improvement to the affected area(s), the basin governance body will need to consider what action it will take. In this example there appears to be two alternatives. The first is to consider whether a lower groundwater level in the area is acceptable. If lower groundwater levels are deemed acceptable, then the basin governance body has the ability to adapt to the real monitoring data and change the model-based thresholds for management in the area. If lower groundwater levels are deemed unacceptable, the second alternative would require finding supplemental water supplies and building the necessary infrastructure to deliver these supplies, for the area(s) and reduce pumping to allow groundwater levels to recover to acceptable levels. The cost of this last action will be exacted upon well owners with operating wells in the area that are contributing to the decline in groundwater levels.

This same process can be extrapolated for the average groundwater extraction rate, water quality, land subsidence, and aquifer stream interaction BMOs. The only difference in each trigger point is the measurement parameters and the set of actions and penalties. These are listed by BMO in **Table 4-1**. A full description of the BMOs, the methods of monitoring and management actions are provided in **Section 3**. **Table 4-1** provides the set of conditions that initiate change in how the basin is being managed and lays down the initial framework for penalties in the event trigger points are continuously exceeded.

Table 4-1. Monitoring Actions and Trigger Points

Monitoring Action	Trigger Points	Recommended Action
BMO No. 1. Maintain the long-term average groundwater extraction rate at or below 273,000 AF/year		
The term "long-term average" means averaging data over a long period of time. This will begin with completion of an accurate estimate of the current total groundwater extraction from the basin. Once completed, estimates will be made at least every five years. Five-year estimates will consist of agricultural and agricultural-residential data available through the DWR Land Use Survey, and data collected by the various purveyors (collected monthly and available on an annual basis). The collective data will then be used to compare estimated groundwater extractions and the BMO requirement of 273,000 AF/year. More frequent estimates can be made by assuming agriculture and agricultural-residential data remain relatively constant.	Trigger Point 1. Groundwater extractions for the basin have exceeded 273,000 AF for the previous year.	Evaluate and confirm the data. Look for opportunities to reduce pumping either through conservation, or education in water use and irrigation practices for urban, agricultural, and agriculture-residential.
	Trigger Point 2. Groundwater extractions for the basin have exceeded 273,000 AF for the previous two (2) years	Evaluate and confirm the data and include formal notification of the signatory governing bodies, local water purveyors and the agricultural community. Reduce pumping through importation of surface water where conveyance systems exist. In cases where infrastructure is not in place to convey alternative water supplies, reductions in pumping may be necessary until said facilities are in-place.
	Trigger Point 3. Groundwater extractions for the basin have exceeded 273,000 AF for the previous five (5) consecutive years	Evaluate and confirm data and include formal notification of the signatory governing bodies, local water purveyors and the agricultural community. Reduce pumping, acquire surface water entitlements to replace lost groundwater supplies, and construct conveyance facilities for surface water. Look for agreements with third parties and financing mechanisms to assist in infrastructure requirements. Initiate an extraction-rate-based funding mechanism over the entire basin.
	Trigger Point 4. Groundwater extractions for the basin have exceeded 273,000 AF for more than five (5) years.	Evaluate and confirm data and include formal notification of the signatory governing bodies, local water purveyors and the agricultural community. Conduct a mandatory examination of adequacy of long-term sustainable yield criteria and the actual effects on the basin with the higher groundwater yield. This may require a reassessment of the sustainable yield criteria, and possibly an increase, in accordance with basin governance body procedures. Consultation with the Water Forum Successor Effort will be required prior to taking this action.

Table 4-1. Monitoring Actions and Trigger Points (continued)

Monitoring Action	Trigger Points	Recommended Action
BMO No. 2. Maintain specific groundwater elevations within all areas of the basin consistent with the Water Forum "solution."		
A monitoring methodology to meet specific objectives in managing groundwater levels requires a systematic, repeatable, and scientific approach. The objective of this monitoring program is to take measurements from selected monitoring wells that have sufficient construction and hydrogeologic data. Wells will be assigned to represent the polygon areas defined in **Appendix B**, and may be grouped within the basin in areas that are sufficiently distinct in the makeup of hydrogeology and land use. Monitored groundwater levels for a well will be compared with the designated upper and lower groundwater level threshold for each polygon that is assigned to the well. The upper and lower thresholds are termed the "bandwidth" of the polygon.	Trigger Point 1. A 25 to 50 percent encroachment into the designated bandwidth of a polygon.	Alert stage that informs the basin governance body and the overlying groundwater extractor(s) that a specific polygon area is being compromised. Activation of this trigger will take place only after the cause of the condition is thoroughly investigated.
	Trigger Point 2. A 50 to 75 percent encroachment into the designated bandwidth of a polygon.	In the event groundwater level measurements hit Trigger Point 2 without first initiating Trigger Point 1, the recommended actions of Trigger Point 1 still apply. Additionally, this stage initiates a requirement to collect a fee to secure supplemental water supplies or to reduce pumping in a predefined area(s).
	Trigger Point 3. A 75 to 100 percent encroachment into the designated bandwidth of a polygon. This indicates continuously declining groundwater levels in an area even during wet and normal hydrologic cycles, indicating that excessive pumping is the probable cause.	Well owners with operating wells in the affected area(s) will be identified and notified of the basin's condition in their area. An assessment will be levied against those owners who continue to pump at the higher level. Every attempt will be made by the governance body to ameliorate the impact assessments to private domestic groundwater pumpers.
	Trigger Point 4. Over 100 percent encroachment into the designated bandwidth of a polygon.	If the recommended actions from the first three trigger points do not result in an improvement to the affected area(s), the basin governance body will need to consider which of two actions it will take. The first is to consider whether a lower groundwater level in the area is acceptable. If so, the basin governance body has the ability to adapt to the actual monitoring data and change the model-based thresholds for management in the area. If lower groundwater levels are deemed unacceptable, the second action would require finding supplemental water supplies and construct infrastructure for the area(s) and reduce pumping to allow groundwater levels to recover to acceptable levels. Fees in addition to Trigger Point 3 fees will be assessed to cover costs associated with this action.

Table 4-1. Monitoring Actions and Trigger Points (continued)

Monitoring Action	Trigger Points	Recommended Action
BMO No. 3. Protect against any potential inelastic land surface subsidence by limiting subsidence to no more than 0.007 feet per 1 foot of drawdown in the groundwater basin.		
If inelastic subsidence is documented in conjunction with declining groundwater levels, the basin governance body will investigate and take appropriate actions to avoid or mitigate adverse impacts. Subsidence should be measured and thought of as a long-term process. While some measurements have been made to determine the level of subsidence in the Sacramento area, some concern exists regarding the accuracy of the measurements and sufficiency of the data. The North and Central basins should collaborate to gain a better understanding of subsidence.	Trigger Point 1. Subsidence measured at less than 0.007 feet per foot of groundwater decline.	If subsidence is measured either in the North or Central basins, further study should be initiated to rule out any error in survey or survey markers. A measure of impacts, if any, should also be noted and weighed as to whether the impact is acceptable.
	Trigger Point 2. Subsidence measured at or above 0.007 feet per foot of groundwater decline.	Subsidence greater than the set limit is cause for concern and needs to be addressed by first assessing Trigger Point 1 data and then determining if the amount of subsidence can occur with acceptable impacts. If so, the criteria of 0.007 feet per foot of groundwater decline may be increased according to the data collected.
	Trigger Point 3. Data collected for ground subsidence has a high correlation with declines in groundwater elevations or if any structural damage is identified as being caused by subsidence.	The basin governance body needs to develop and implement a plan to reduce pumping, or by some other means, prevent dewatering of the aquifer in areas where inelastic subsidence is occurring. This may mean providing surface water or other supplemental water supplies to these areas or injection of surface water (or off-site groundwater) to replace groundwater that has been removed through extraction or in some manner has been prohibited from recharging the area of concern.
BMO No. 4. Protect against any adverse impacts to surface water flows in the American, Cosumnes, and Sacramento rivers.		
It is the intent of this plan that controllable operations of the groundwater system do not negatively impact the area's rivers and streams. The basin governance body will seek to gain a better understanding, in cooperation with SGA and others, of potential impacts of the discharge of local area groundwater to major rivers adjacent to the Central Basin. Water quality issues related to this type of discharge will be reported in the Annual State of the Basin Report. No Trigger Points are assigned to water quality issues as a result of groundwater discharges at this time.	Trigger Point 1. Monitoring of losses of river water to groundwater shows a 5 percent increase over the current loss rate based on total flow in the river.	Use the calibrated Sacramento County IGSM to identify where losses are likely occurring in the river(s). Identify and provide quantity of loss in the State of the Basin Report. Coordinate and consult any efforts with State DWR, SGA, TNC, and SSCAWA.
	Trigger Point 2. Monitoring of losses of river water to groundwater shows a 25 percent increase over the current loss rate based on total flow in the river.	Complete the same analysis as for Trigger Point 1 and begin to develop alternative management strategies that reduce the hydraulic gradient (or slope) of the groundwater pieziometric surface that is in contact with the river(s). Seek stakeholder approval and funding to implement a preferred alternative to begin managing the losses of surface water to the groundwater system.

Table 4-1. Monitoring Actions and Trigger Points (continued)

Monitoring Action	Trigger Points	Recommended Action
BMO No. 5. Water quality objectives		
Water quality objectives will include analyzing for total dissolved solids (TDS) (typically a measure of salinity), volatile organic compounds (VOC), and nitrates. Any violation exceeding the management criteria will require an action by the basin governance body.	Total Dissolved Solids	
	Trigger Point 1. Monitoring results of TDS exceed the secondary drinking water standard MCL of 1,000 mg/L.	Report the exceedance in the State of the Basin Report. If a health concern exists, the affected stakeholder(s) would be notified and arrangements made to remedy the problem.
	Trigger Point 2. High TDS levels believed to be coming from the deeper aquifer system.	A study will be conducted to determine if the increase in TDS is a result of groundwater well construction and extraction activities. Well construction may be a concern if high TDS water moves upward into the shallow aquifer due to the high piezometric surface of the deep aquifer. This condition "pushes" water into the shallow aquifer zone through a well or along the outside of a well. This condition also may occur through an improperly abandoned well that is screened in the deep aquifer.
	Volatile Organic Compounds	
	Trigger Point 1. Monitoring results of VOCs meet or exceed established maximum contaminant levels.	Report the exceedance in the State of the Basin Report. The affected stakeholder(s) and appropriate regulatory agencies would be notified and arrangements made to remedy the problem.
	Trigger Point 2. VOC monitoring results believed to be a result of normal basin pumping activities.	A study, in conjunction with appropriate regulatory agencies, will be conducted to determine the source of the contamination. If specific pumping activities are found to be the cause of contaminant migration, the appropriate regulatory agency will take the necessary steps to have the designated responsible party replace lost capacity and to protect other private and public wells from being contaminated.
	Nitrates	
	Trigger Point 1. Monitoring results of nitrates meet or exceed established the Primary Drinking Water Standard of 40 mg/l.	Report the exceedance in the State of the Basin Report. If a health concern exists, the affected stakeholder(s) would be notified and arrangements made to remedy the problem.
	Trigger Point 2. Source of nitrates believed to be a result of activities related to on-site wastewater disposal system management.	A study, in conjunction with the appropriate regulatory agencies, will be conducted to determine the source of the contamination. If on-site wastewater disposal systems are found to be the cause, a larger study of the impacted area may be warranted. Recommendations from these studies may necessitate an evaluation of design standards for on-site wastewater disposal systems county-wide.

4.3 CENTRAL BASIN WELL PROTECTION PROGRAM

The Central Basin Well Protection Program (WPP) is a result of negotiations that took place in the CSCGF. A copy of the negotiated Trial Balloon on Well Protection is included in **Appendix D**. Any differences between the Trial Balloon and this section are a result of the need to provide supplemental information and clarification for full implementation of the WPP. The basin governance body will be responsible for implementing this program.

4.3.1 Background

The WFA set the long-term average annual extraction of groundwater (i.e., sustainable yield) from the Central Basin at 273,000 acre-feet. When the Water Forum stakeholders negotiated this extraction volume for the basin, it was anticipated that this volume would result in a further decline in groundwater levels (approximately 50 feet in the deepest part of the cone of depression as measured in 1990). It was expected that such a decline would affect some existing domestic and agricultural wells. An update of the Impact Analysis (**Appendix E**) was recently completed. This update is based on groundwater model improvements and the Zone 40 WSMP. Results of this analysis show that the decline is not as severe as originally expected.

Protection of the Central Basin's groundwater resource and the domestic and agricultural wells located within the basin is of fundamental importance to the stakeholders of the CSCGF. Regarding the basin's long-term sustainable yield, the CSCGF was concerned that the continued decline in groundwater levels could result in the "dewatering" of some wells, particularly agricultural and agricultural-residential wells. Agricultural and agricultural-residential users have no alternative source of supply if their wells are dewatered, and current groundwater users should not have to subsidize future growth in the basin by paying the cost of deepening or replacing existing wells. To address this concern, it was proposed that a WPP be included as part of the groundwater management plan for the Central Basin.

4.3.2 Trust Fund Proposal

It is the responsibility of the basin governance body to develop specific details on operation of the well protection trust fund (trust fund). These details include, but are not limited to, the amount of a well protection fee, how the well protection fee will be collected, criteria for submitting a claim, claim verification, maximum amount paid per verified claimant, timeline between submission of claim and date of decision, etc.

All details related to the trust fund should be developed, and the WPP fully operational, within one year of the creation of the basin governance body. (NOTE: Development and implementation of the Central Basin WPP is not intended to modify or change any provisions of the North Vineyard Well Protection Program Agreement, or to relieve any party of their obligations as set forth in that agreement.) Some of the specific details of the trust fund are defined in the following subsections.

4.3.2.1 Creation of the Trust Fund

The purpose of the trust fund is to cover the cost of deepening or replacing existing agricultural or agricultural-residential wells that may be impacted by future development in the Central Basin area. As mentioned previously, funding for the trust fund will be provided through collection of a well protection fee. Well protection fees can be collected as part of the building permit process for new construction or as part of the well drilling permit process for a new well. The amount of the fee, how it will be collected, and how the trust fund should be administered will be determined by the basin governance body. The specifics of the fees, how much the fee should be, and who gets assessed will be determined within 6 months of adoption of the CSCGMP.

4.3.3 Fee Exemptions

Any property that is exclusively served by surface water is exempt from paying the well protection fee. Any well drilling permit application for a remediation well required by a regulatory compliance order and all monitoring wells are exempt from paying the well protection

fee. If an individual is obtaining both a building permit and applying to drill a new well on the same property, only one assessment should be made. For example, if a purveyor has paid the impact fee for a new well and is required to also get a building permit for appurtenant structures, the fee would only be assessed once.

4.3.4 Update to Fee Program

Once the well protection fee has been established by the governance body, a public notice and comment period will be conducted. The fee shall be indexed to the average of the Engineering News-Record (ENR) construction cost index for 20 U.S. cities and San Francisco when the WPP is adopted. Increases shall be determined by calculating an adjustment factor based on the index when the WPP is adopted, and the current index. Adjustments shall be made on an annual basis.

Throughout the life of the trust fund, the basin governance body should have the power to change the amount of the assessment by conducting a nexus study, including an impact analysis. This study would be initiated as a result of the findings of actuarial studies. An impact analysis was completed in December 2005 (see **Appendix E**).

4.3.5 Authority to Collect Fees

The basin governance body is responsible for collecting the well protection fee and administering the trust fund. Details of this authority will be determined as part of the process of establishing the basin governance body. The basin governance body should work cooperatively with permit-issuing authorities to see that fees are collected in an efficient manner.

4.3.6 Eligibility to Participate in Program

To establish eligibility for coverage under the program, existing wells must be registered with the basin governance body by the well owners. The basin governance body shall establish the terms and conditions under which a well shall be registered, and will develop a schedule and set a reasonable time limit by which to complete the registration process. The governance body shall make every reasonable attempt to inform all residents who may be eligible to participate in the WPP to register their well(s).

Once a well has been registered, coverage by the trust fund shall continue for as long as the fund remains active. Coverage of a well can be transferred for a particular property if ownership changes. Once a well has been registered, coverage by the trust fund shall continue for as long as the fund remains active. Coverage of well can be transferred on a particular property when there is a change in ownership.

4.3.7 Eligibility for Claims

The basin governance body will establish eligibility criteria for claims against the trust fund that are clearly defined and strictly related to a decline in groundwater level. Wells that have failed for reasons other than a decline in groundwater level, such as a structural failure or faulty motors or pumps, etc., will not be covered by the fund.

Any claim against the trust fund must be submitted to the basin governance body for review and verified by an independent source (e.g., hydrogeolologist, well service company, etc.) to be compensated by the fund. The verification cost will be funded by the trust fund.

4.3.8 Sunset Provision

No earlier than five years after implementing this program, nor later than the beginning of the eleventh year after surface water from the FRWA project is delivered to the Central Basin area, the basin management body shall conduct a comprehensive evaluation to determine whether a continuing need exists to maintain the trust fund. In conducting this evaluation, the basin management body shall consider the following factors:

- Groundwater levels
- Number of claims made against the trust fund
- Rate of claims filed over time (i.e., is the rate of claims increasing or decreasing)
- Status of urbanization (i.e., is further growth/development anticipated and, if yes, how will it affect water supply)

A decision on whether or not to continue the trust fund shall be reserved to the basin governance body.

If the basin governance body decides to terminate the program, any undisbursed money should be used for other activities consistent with the purposes of the CSCGMP (e.g., conservation, habitat mitigation, enhancement of groundwater recharge, etc.). For this to occur, the language establishing the trust fund must be consistent with the requirements set forth in Government Code, Section 1600.

4.4 GROUNDWATER CONTAMINATION MONITORING AND COLLABORATION PROGRAM

The Central Basin Groundwater Contamination Monitoring and Collaboration Program is a result of negotiations that took place in the CSCGF. A copy of the negotiated Trial Balloon is included in **Appendix F**. Any differences between the Trial Balloon and this section are a result of the need to provide supplemental information and clarification for full implementation of the program. The basin governance body will be responsible for implementing this program.

4.4.1 Background

Groundwater contamination and remediation of contaminated groundwater in the Central Basin must be addressed proactively. Water purveyors, regulatory agencies, responsible parties, and the Water Forum Successor Effort should meet on a regular basis to share information and develop strategies to collaborate on potential threats to drinking water sources and on cleanup activities.

These collaborative strategies should be designed to avoid negative impacts on all other water resources and water users.

4.4.2 Program Components

The components of the program focus on maintaining a policy of keeping remediated groundwater within the Central Basin through non-potable uses within newly developing areas and to maintain consistent outreach programs to private well owners to inform and collect data on groundwater cleanup efforts taking place within the region.

Program Component 1. Use of Remediated Groundwater in Urbanized Areas

The Water Forum Successor Effort and the basin governance body should commence a high-priority effort to convince Sacramento County and the cities of Elk Grove, Rancho Cordova, and Sacramento to adopt policies that encourage the use of remediated groundwater for non-potable purposes.

Program Component 2. Survey Private Wells for Potential Contamination

The Water Forum Successor Effort and the basin governance body should request that the RWQCB require responsible parties (i.e., parties who caused contamination) to survey private wells within 2,000 feet of any identified contaminant plume, and also require development of an appropriate monitoring plan for said wells. The monitoring plan shall be subject to review by the basin governance body and shall include the use of "sentinel" wells. The plan also should include information on frequency of sampling, reporting requirements, etc.

Program Component 3. Assistance of the Sacramento County Environmental Management Department

Sacramento County EMD is responsible for issuing well drilling permits and ensuring that the provisions of Sacramento County's well drilling ordinance are enforced. If the requirements of the ordinance are not met, EMD should undertake whatever rigorous enforcement actions are available and effective in the given circumstances.

The basin governance body will work with EMD to establish and maintain an information clearing house to assist individual well owners in addressing contamination concerns (e.g., sources for well testing services, substances to be tested for, cost, options if

contamination is found, etc.). As part of its responsibility for this information clearinghouse, the basin governance body should collaborate with the RWQCB to maintain up-to-date information on contamination sources in the Central Basin. Also, EMD should undertake a concerted effort to inform individual well owners of the importance of testing/monitoring water quality in their wells through a variety of public education tools, including (but not limited to) a brochure provided to all applicants as part of the well permitting procedure.

4.5 CENTRAL BASIN REPORTING METHODS

The basin governance body is responsible for reporting on the progress of implementing the CSCGMP in an annual State of the Basin report. At a minimum, the annual State of the Basin report will summarize groundwater conditions within the basin, and document groundwater management activities from the previous year. Much of the data used in developing the annual State of the Basin report will come from the monitoring data stored in the basin's DMS. The report also will detail the progress made on implementing the various action items described in **Section 3**.

4.5.1 State of the Basin Report

The annual State of the Basin report is an essential document that will provide detailed information to stakeholders and the general public on the current state of the Central Basin. This report will include the following:

- Reports on trigger points that were reached (if any) and actions that were taken to evaluate/mitigate the problem.
- An evaluation supported by monitoring results on whether management actions and trigger point actions are meeting the BMOs.
- Improved characterization of the basin through interpretation of new and historical data included in the DMS.
- Summary and interpretation of groundwater elevation data based on the polygon method outlined in **Appendix B**.
- Summary and interpretation of basin water quality, including a graphical presentation of how the sampling data compare with thresholds set in **Section 3.1.5** for the various water quality constituents.
- Update on implementation of the WPP and identification of fund reserves and any monies spent, including specific information on which wells were impacted and how the determination was made to expend program funds.
- Update on the Groundwater Contamination Monitoring and Collaboration Program, including actions taken throughout the year, and how those actions lead toward the stated goals of the CSCGMP.
- Summary of any component changes, including the addition or modification of BMOs (e.g., polygon thresholds for maximum and minimum groundwater elevations or thresholds for water quality concentrations) during the period covered by the report.

The annual State of the Basin report will be completed between April 1 and June 1 of each year and will cover conditions and activities completed through December 31 of the prior year.

4.6 FUTURE REVIEW OF THE GMP

The CSCGMP is intended to serve as a framework for the first regionally coordinated management effort in the Central Basin area. Updates by the basin governance body will be identified in the annual State of the Basin report described above. The CSCGMP is therefore intended to be a living document, and it will be important to evaluate all of the actions and objectives over time to determine how well they are meeting the overall specific goals. The basin governance body will reevaluate the entire CSCGMP within five years of adoption.

4.7 FINANCING AND SCHEDULE

The basin governance body is responsible for implementing the various programs as follows:

- Monitoring for groundwater quality or elevations in wells located outside participating water purveyor boundaries.

- Customization of the DMS interface.
- Preparation of annual reports.
- Adaptive updates of the CSCGMP.
- Update of data sets and recalibration/improvement of existing groundwater model (IGSM).
- Collection of additional subsidence data.
- Construction of monitoring wells where critical data gaps exist.
- Stream-aquifer interaction studies.
- Implementation of the CSCGMP action items in **Section 3**, including, but not limited to the following:
  - Ad-Hoc Advisory Committee coordination, as required.
  - Project management.
  - Implementation of broader regional conjunctive use program, including agriculture.
  - Development of Public Outreach Plan.
  - BMO monitoring procedures.
  - Survey of abandoned wells.
  - Obtain DWSAP dates.
  - Update DMS data.
- Develop details of administering WPP including outreach.
- Registering wells for the WPP.
- Implementation of the WPP.
- Implementation of the Groundwater Contamination Monitoring and Collaboration Program.
- Reevaluate CSCGMP every five years.

Table 4-2 provides an estimate of annual costs to operate the monitoring and reporting program according to the recommended trigger point actions described in **Section 3** and **Table 4-1** above. Other costs include implementation of remedies to problems, the WPP, and additional costs associated with the start-up of the first year of plan implementation. Table 4-3 shows an implementation schedule for the first two years.

4.7.1 Plan Implementation Costs

First year program startup costs are estimated at $280,000. This is essentially 1.2 full time people working throughout the year on setting up monitoring programs, taking measurements, compiling data, reporting data. Future program costs will be evaluated on an annual basis by the basin governance body.

Table 4-2. Estimate in Implementation of the GMP

Action Items Related to the adopted CSCGMP	Total Cost
Component No. 1 Stakeholder Involvement	
Involving the Public (Development of Public Outreach Plan)	$5,590
Involving Other Agencies Adjacent to the Central Basin	$7,405
Utilizing Advisory Committees	$9,605
Developing Relationships with State and Federal Agencies	$9,605
Pursuing Partnership Opportunities	$5,545
Subtotal	$37,750
Component No. 2 Monitoring Program	
Groundwater Elevation Monitoring	$20,974
Groundwater Quality Monitoring	$44,886
Land Surface Elevation Monitoring	$3,420
Surface Water Groundwater Interaction Monitoring	$5,310
Protocols for the Collection of Groundwater Data	$8,886
Data Management System	$23,418
Subtotal	$106,894
Component No. 3 Groundwater Resource Protection	
Well Construction Policies	$3,500
Well Abandonment and Destruction Policies	$3,500
Wellhead Protection Measures	$3,500
Protection of Recharge Areas	$3,500
Control of the Migration and Remediation of Contaminated Groundwater	$3,500
Control of Saline Water Intrusion	$1,062
Subtotal	$18,560
Component No. 4 Groundwater Sustainability	
Demand Reduction (Water Conservation and Water Recycling)	$2,148
Subtotal	$2,148
Component No. 5 Planning Integration	
Existing Integrated Planning Efforts (Urban Water Management Planning, DWSAP Program, Land Use Planning, and Groundwater Modeling)	$30,414
Subtotal	$30,414
Reporting	
Well Protection Program	$4,015
Water Quality Collaboration Program	$14,015
Completion of Annual State of the Basin Report	$50,684
Subtotal	$68,714
Subtotal	
Associated Project Costs (5%)	$13,224
Estimated Annual Total	**$277,704**

Table 4-3. Implementation Schedule

TASKS	2006			2007												2008											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monitoring for groundwater quality or elevations in wells located outside participating water purveyor boundaries						✓						✓						✓						✓			
Customization of the DMS interface	✓	✓	✓												✓												✓
Preparation of annual reports							✓	✓											✓	✓							
Adaptive updates of the CSCGMP									✓	✓											✓	✓					
Update of data sets and recalibration/improvement of existing groundwater model (IGSM)																									✓	✓	✓
Collection of additional subsidence data	Every Five Years																										
Apply for state/federal grant funding	✓	→																									
Construction of monitoring wells where critical data gaps exist																✓	→										
Stream-aquifer interaction studies																		✓	✓	✓							
Implementation of the CSC-GMP, including:																											
▪ Ad-Hoc Committee coordination, as required	✓	→																									
▪ Project management	✓	→																									
▪ Implementation of broader regional conjunctive use program, including agriculture	✓	→																									
▪ Development of Public Outreach Plan	✓	✓	✓																								
▪ BMO monitoring procedures			✓	✓	✓																						
▪ Survey of abandoned wells			✓	✓	✓																						
▪ Obtain DWSAP dates				✓	✓											✓	✓										
▪ Update DMS data							✓	✓					✓	✓					✓	✓					✓	✓	
Develop details of administering WPP	✓	✓	✓																								
Registering wells for the WPP	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓												
Implementation of the Groundwater Contamination Monitoring and Collaboration Program			✓	✓	✓																						
Revaluate CSCGMP	Every Five Years																										

References

Section 5

References

Aerojet Environmental Remediation. 2002. Aerojet Sacramento Site, American River Study Area Groundwater Monitoring Results. April – June 2002. August.

Ahearn, D., and R. Dahlgren. 2000. Evolution of Water Quality in the Cosumnes River Watershed: Are the Uplands Important? UC Davis Center for Watershed Sciences.

Archibald & Wallberg and MWH. 2003. American River Watershed Sanitary Survey, 2003 Update Report. December.

Boyle Engineering Corporation. 1995. Estimate of Annual Water Demand Within the Sacramento County-Wide Area. May.

Berkstresser, C.F., Jr. 1973. Base of Fresh Ground-Water – Approximately 3,000 micromhos - in the Sacramento Valley and Sacramento-San Joaquin Delta, California. U.S. Geological Survey Water-Resources Investigation 40-73, map.

California Department of Health Services. 1995. Collection, Pretreatment, Storage and Transportation of Water and Wastewater Samples. Fifth Edition. May.

California Department of Water Resources (DWR). 1974. Evaluation of Ground Water Resources: Sacramento County. Bulletin 118-3. July.

County of Sacramento. 1993. General Plan. December.

DWR. 1978. Evaluation of Ground Water Resources: Sacramento Valley. Bulletin 118-6. August.

DWR. 2003. California's Groundwater: Bulletin 118 – Update 2003. October.

Groundwater Resources Association of California. 2005. California Groundwater Management – A Resource for Future Generations. Second Edition.

Lucy & Company. 2003. Public Outreach Plan for Groundwater Management Program. June.

LSCE. 2002. In-Lieu Surface Water Use and Ground-Water Basin Conditions 2001, Northridge Service Area, Sacramento Suburban Water District. June.

Montgomery Watson. 1999. Regional Water Master Plan Phase I, Technical Memorandum 3: Summary of Existing Water Supplies.

Montgomery Watson and Archibald & Wallberg. 2000. Sacramento River Watershed Sanitary Survey, 2000 Update Report. December.

MWH. 2002. Data Management System, Task 4 Summary Memorandum, Evaluate Accuracy and Reliability of Groundwater Data. January.

MWH. 2003. Mather Air Force Base Annual and Fourth Quarter 2002 Sitewide Groundwater Monitoring Report. March.

MWH. 2004. SCWA Zone 40 Groundwater Management Plan. October 26.

MWH. 2005. Sacramento County Water Agency – Zone 40 Water Supply Master Plan. February.

MWH. 2005. Sacramento River Water Reliability Study, Initial Alternatives Report, Main Report and Appendix A, Revised. January.

Nolte and Associates, Inc. 1994. Sacramento County Water Reclamation Study Volume 1, August.

State Water Resources Control Board (SWRCB). 2003. Draft Order Denying Petition to Revise the Declaration of Fully Appropriated Streams to Allow Processing of Application to Appropriate Treated Groundwater Discharged into the Lower American River. May.

URS. 2003. Former McClellan Air Force Base, Installation Restoration Program, Groundwater Monitoring Program: Quarterly Report, Third Quarter, 2002. January.

WRIME. 2005a. Sacramento County Integrated Groundwater Surface Water Model (SACIGSM) Refinement and Update. Prepared for Sacramento County Department of Environmental Review and Assessment. July.

WRIME. 2005b. Central Sacramento County Management Plan – Impact Analysis for Well Protection Program. December.

CENTRAL SACRAMENTO COUNTY

GROUNDWATER MANAGEMENT PLAN

FEBRUARY 2006

MWH

WATER FORUM

SACRAMENTO COUNTY WATER AGENCY

Appendix 1-A

Central Sacramento County Groundwater Management Plan
(February 2006)

Appendices

Appendix A

Summary of the process used for arriving at the long-term average annual sustainable yield of 273,000 AF/year that was negotiated by the Central Basin.

Appendix A – Summary of the process used for arriving at the long-term annual average sustainable yield of 273,000 AF/year that was negotiated for the Central Basin

This appendix describes how the Groundwater Negotiation Team (GWNT) developed the long-term annual average sustainable yield for the Central Basin.

The first step taken was development of the baseline models. The buildup of water demands for each model is shown in **Figure A-1.** Groundwater extractions range from approximately 250,000 AF/year in 1990 to 350,000 AF/year in 2030. One additional demand condition was evaluated to consider if 1990 levels of water demand were sustained with 25 percent levels of water conservation applied. This demand condition is not represented in **Figure A-1** to avoid confusion, but is represented in each of the model result graphs that follow.

Figure A-1. Baseline Groundwater Demand Build-up in Central Basin

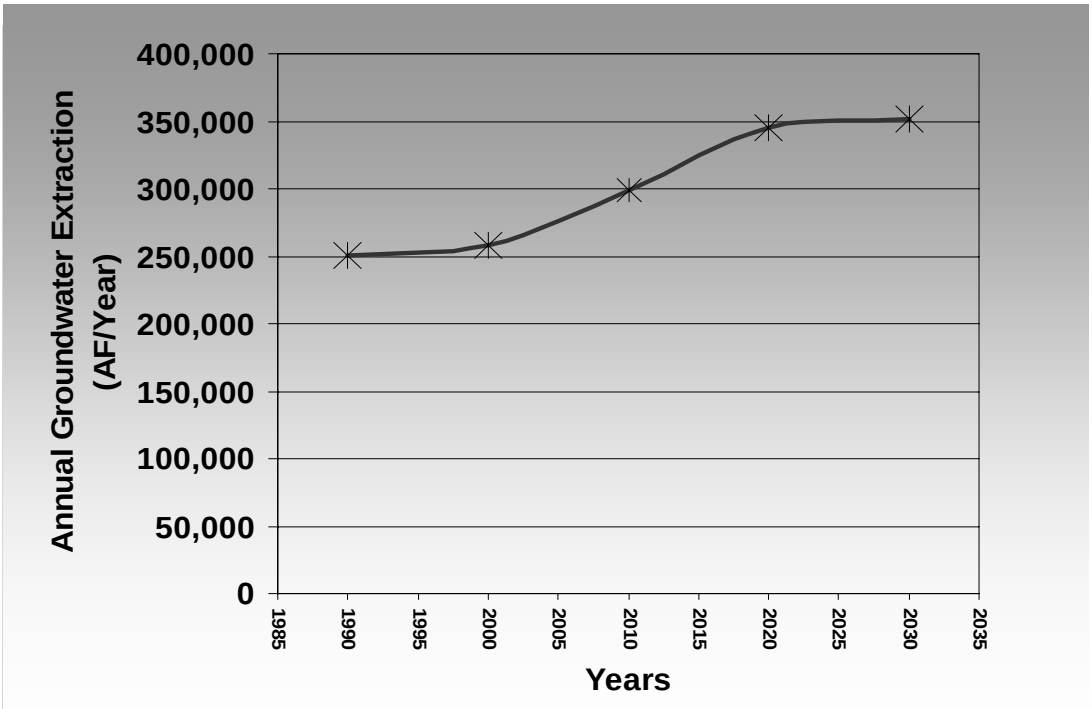
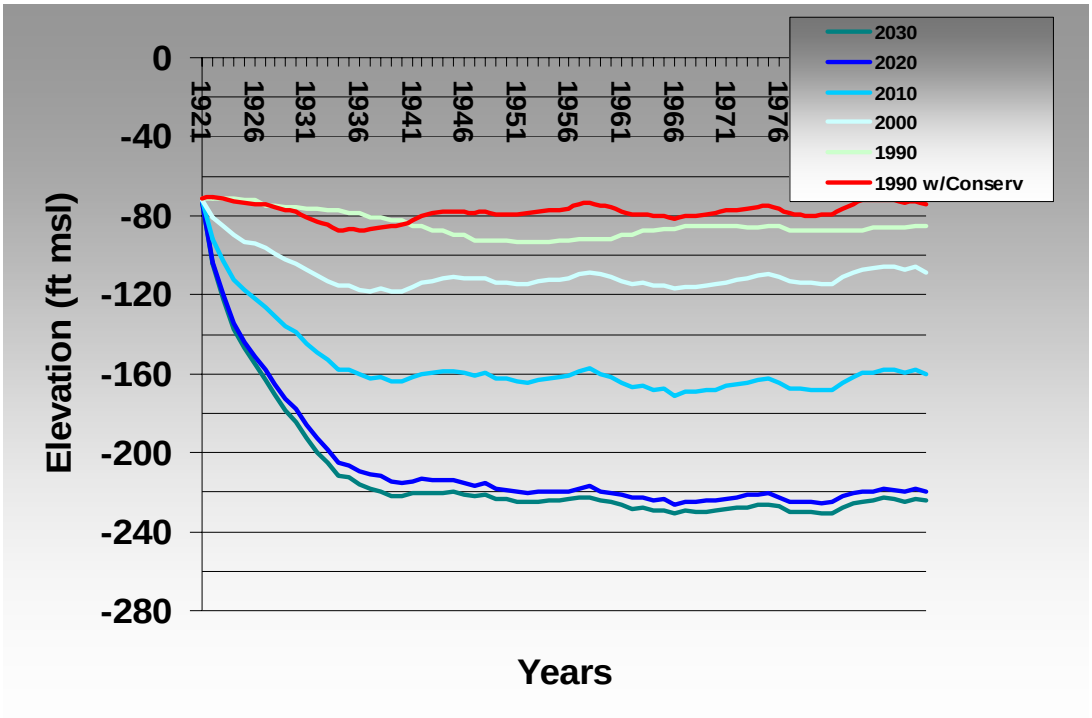


Figure A-2 illustrates the response of groundwater elevations to the simulated demands from the computer model using 70-years of historical hydrology for each 10-year growth increment. This collection of model runs comprises the baseline runs used for negotiation of the sustainable yield.

Each baseline model run begins at the same initial condition of approximately 73 feet below sea level (**Figure A-2)**. This initial condition simply represents a starting point and should not be construed as a measured groundwater elevation. It is only after 15 to 20 years in the model run that the model begins to reflect what the groundwater elevation pattern might look like under the varying hydrologic period. From the initial condition, the direction and severity of the groundwater elevation curve as it moves forward in time through the historical hydrologic years depends on the use of groundwater and the imposed land use conditions.

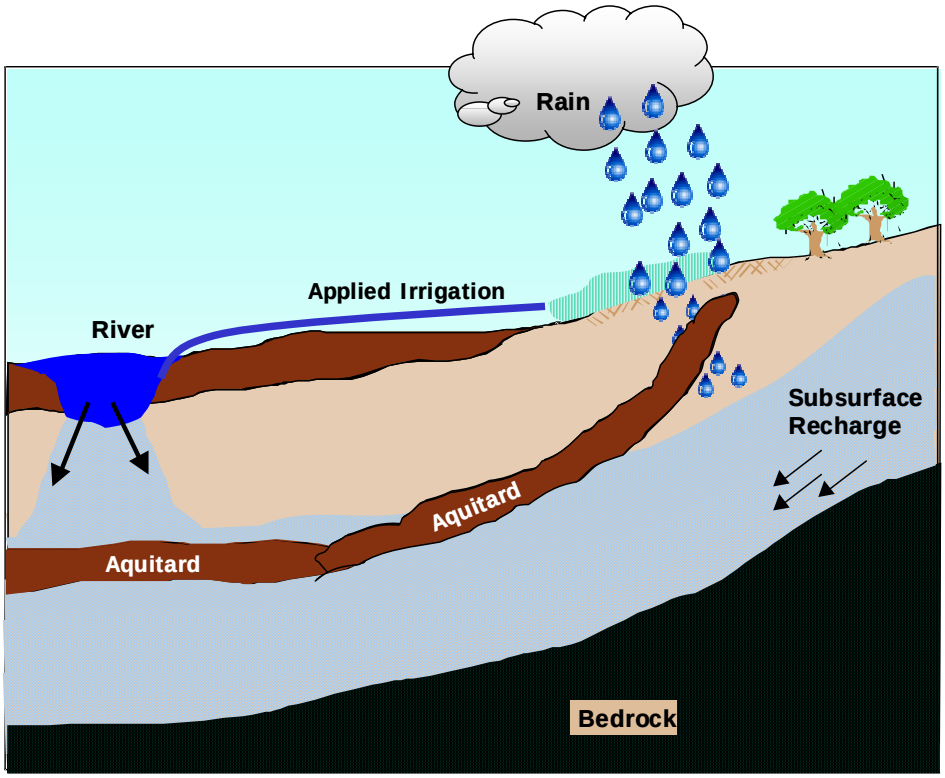
Figure A-2. Groundwater Elevation Trends for 10-Year Growth Increments



For instance, using the 2030 baseline run, the curve begins at initial conditions and quickly descends in about 15 years to approximately 220 feet below sea level and then stabilizes around this elevation for the remainder of the simulation. It is during the rapid drawdown period that the basin is said to be "out of balance" (i.e., pumping is greater than recharge). It is not until the curve flattens that natural recharge catches up with the higher rate of pumping. Higher rates of natural recharge occur predominantly through rivers that are hydraulically connected to the aquifer, such as the American and Sacramento Rivers. Recharge rates from the Cosumnes River do not increase significantly because it is not hydraulically connected over large reaches of the river bordering the Central Basin.

An illustration of a hydraulically connected river is shown in **Figure A-3** along with other sources of recharge. The slope of the groundwater surface from the river to the aquifer dictates how much recharge is occurring. The steep decline and then stabilization in **Figure A-2** is the result of river recharge going through this transition until the rate of recharge equals the rate of extraction (or pumping). Fluctuation in groundwater elevation after stabilization is the result of wet and dry year hydrology.

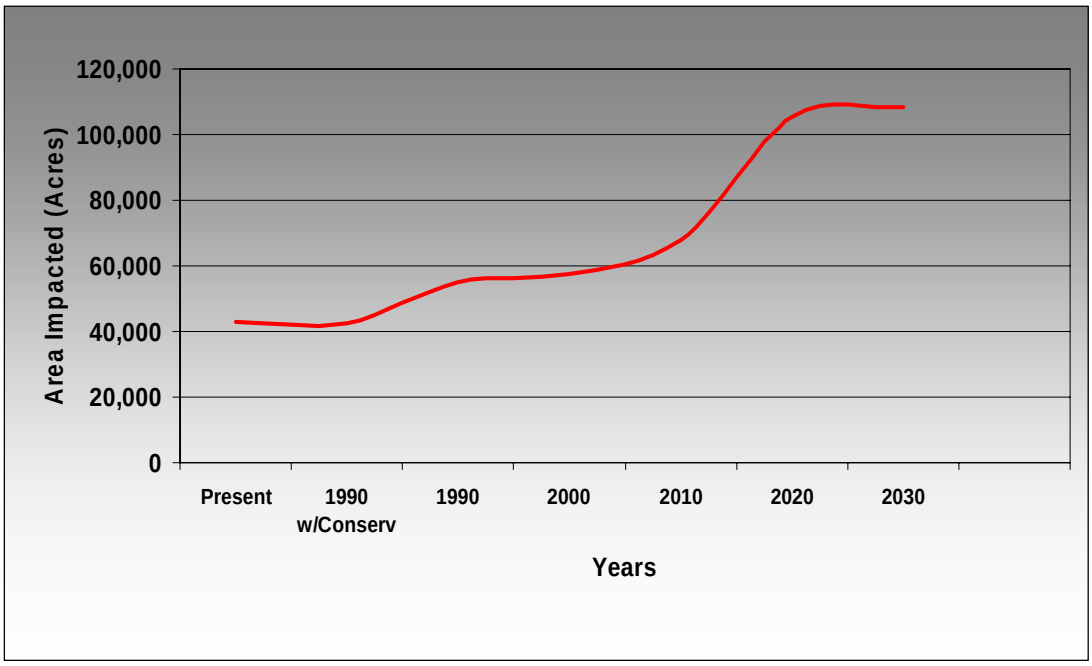
Figure A-3. Sources of Groundwater Recharge



Even though an extraction rate is sustainable, the impacts associated with it may not be acceptable to the overlying community. These impacts include water quality degradation, de-watering of wells, increased pumping costs, and ground subsidence. To address these issues, the GWNT statistically quantified these impacts for each of the baseline model runs.

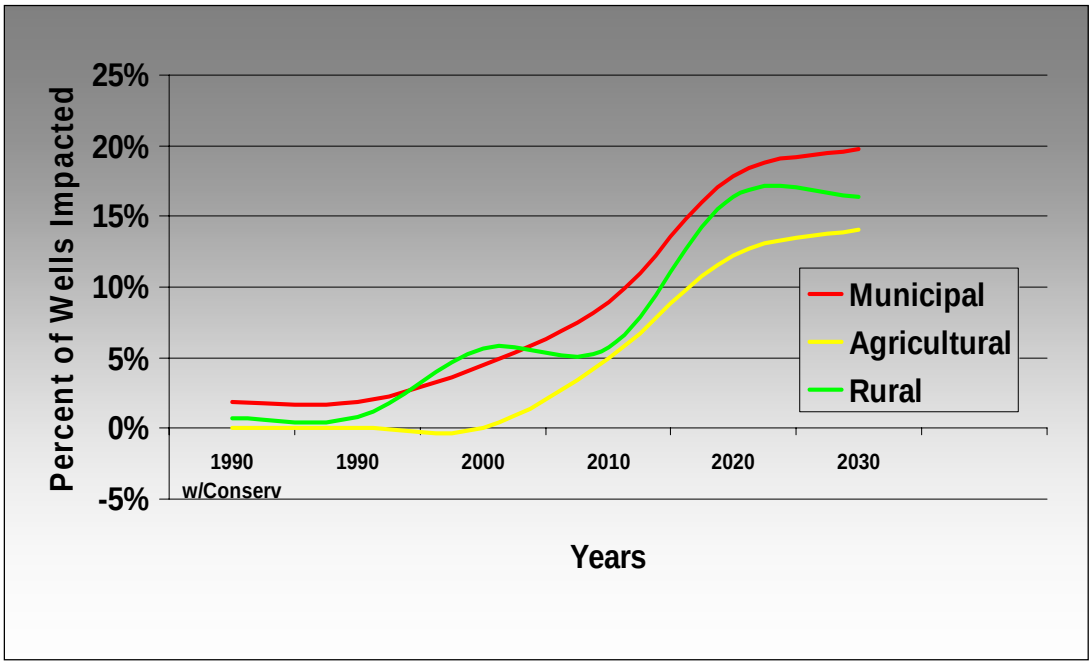
Water Quality Degradation – The amount of water quality degradation is measured by determining the land area that may currently be using water from the higher quality upper aquifer that could be impacted by lesser quality groundwater in the deeper aquifer. This occurs when groundwater levels in the upper aquifer decrease sufficiently to allow an upwelling of lower quality water from the lower aquifer. This could result in the need for private well owners to provide treatment for iron, manganese, total dissolved solids (or salinity), and possibly arsenic. **Figure A-4** shows the relationship between the baseline model runs and the amount of land area where water quality degradation "may" occur. Between 2000 and 2005 the curve remains relatively flat, after 2010 the amount of area potentially impacted increases significantly.

Figure A-4. Water Quality Degradation due to Pumping



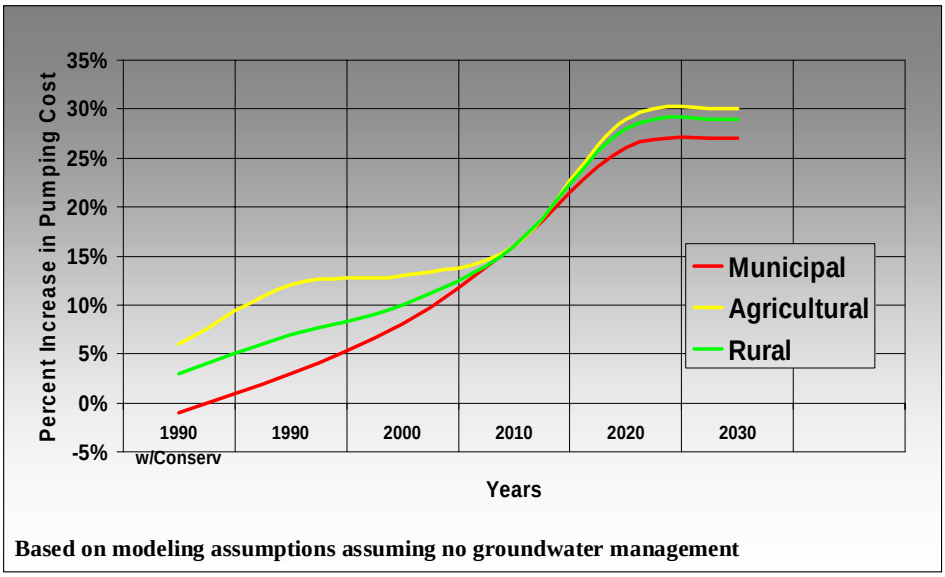
De-Watering of Wells – De-watering of a well occurs when groundwater levels drop below the depth of the well casing or screens. When this happens the well either needs to be deepened, the pump lowered, new screens constructed in the casing, or the well replaced. A sampling of wells was taken of each of the major groundwater users within 1-mile quadrants throughout the basin. For each well, the depth and location of the well was noted and then transferred to a groundwater level contour map for each baseline model run to determine if groundwater levels fell below the bottom of the well casing or screens. **Figure A-5** shows the percentage of wells impacted for each user category based on the baseline model runs. The rural and agricultural categories are of the highest interest given the shear quantity of wells and the expense a homeowner or farmer would bear to replace a well. Similar to water quality (**Figure A-4**) impacts, it is not until after 2010 that more than five percent of the rural and agricultural wells are impacted. The slight decrease in impacted rural wells between 2000 and 2010 is an artifact of the graphing utility and should be considered as little to no change in the percentage of wells impacted.

Figure A-5. Percent of Wells De-Watered by Lowering Groundwater Elevations



Increased Cost in Pumping - As groundwater levels fall, the energy it takes to pump the water to the ground surface with sufficient pressure to meet household and irrigation needs increases. In some cases, the water level may fall to the point where the pump is unable to lift water out of the well. In this circumstance, a new pump and motor may be required. Using the same sampling of wells as was used for the proceeding analysis, an accounting of the percent increase in the cost to pump was done for each user group. The result of this analysis is displayed in **Figure A-6** The agricultural line is relatively flat until 2010 and then it experiences a sharp increase. The other user groups steadily increase indicating a more uniform impact of lowered groundwater elevations across both municipal and rural users.

Figure A-6. Percent Increase in Pumping Cost by Lowering Groundwater Elevations



Based on modeling assumptions assuming no groundwater management

Land Subsidence - Land subsidence occurs when soils consolidate as water is removed from the soil matrix. The soil types underlying the Central Basin are not prone to subsidence. Benchmark studies over a 50+ year period indicate that the ratio of land subsidence to groundwater decline in the Central Basin is approximately 0.007 feet per foot of draw down. Based on the minimal amount of potential land subsidence, further evaluation was considered not necessary.

Appendix B

Summary of the development of Basin Management Objective #2 (Maintain specific groundwater elevations within all areas of the Central Basin consistent with the Water Forum solution).

Appendix B – Summary of the development of Basin Management Objective #2 (Maintain specific groundwater elevations within all areas of the Central Basin consistent with the Water Forum solution).

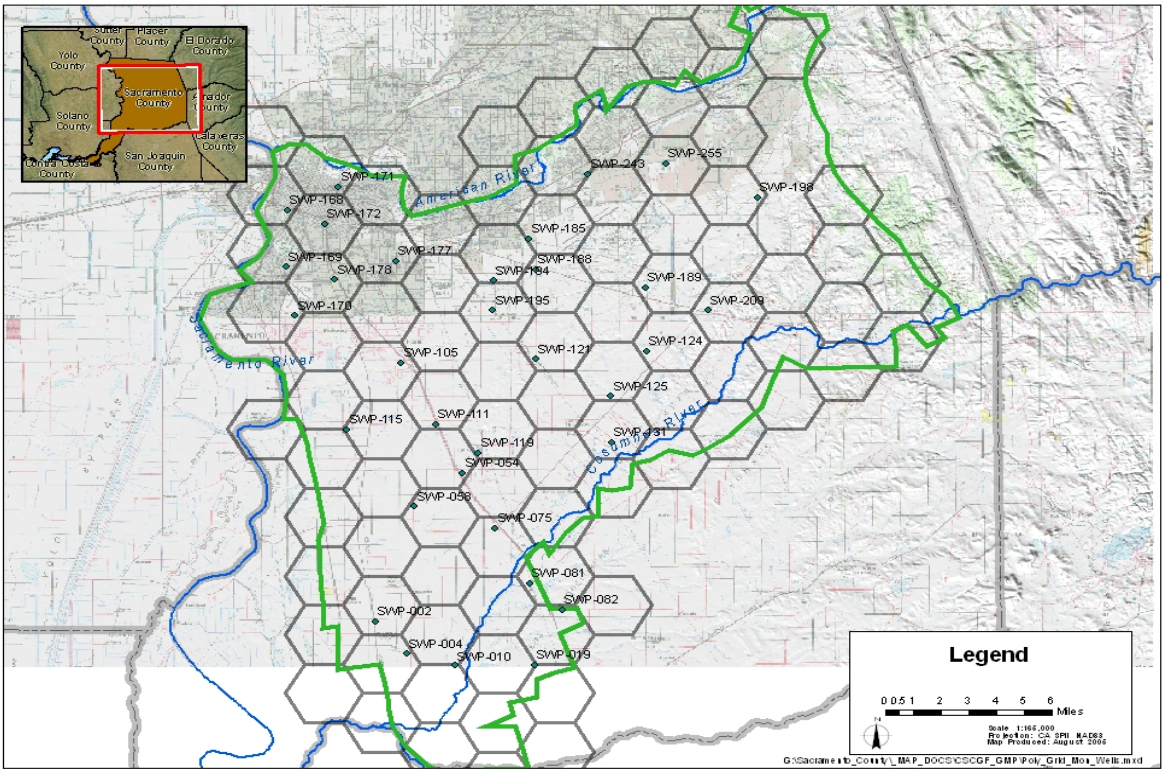
The following is a step-by-step description of how to the Central Basin will develop and/or update groundwater elevation thresholds. Thresholds will be established for upper and lower groundwater elevations throughout the Central Basin. Specific thresholds are summarized in **Section 3.1.1.1** of the CSCGMP.

Step 1. Define a polygon grid over the Central Basin that can be used as surrogate areas for possible management regions. This is done first to assist in understanding the basin's behavior at a relatively high level of resolution prior to possible aggregation of the areas based on meeting the objectives above.

The polygon grid used for the Central Basin is an extension of a similar grid used in the SGA GMP. This was done intentionally to allow for combining the monitoring results for both north and south of the American River knowing that each has the same level of resolution. The polygon grid is shown in **Figure B-1**. Each polygon represents an area of 3200 acres or 5 square miles.

Step 2. Locate a State Monitoring Well to represent each grid area based on the period of measurement record and the quality of the data. The period of record should include 1977 to 2003. Gaps in data should not exceed 1 year in time with monitoring at least twice a year, spring and fall. If no well meets this criterion, the location and/or perhaps the construction of a monitoring well will be necessary in the future. The location of selected wells is shown in **Figure B-1**.

Figure B-1. Polygons and Existing Monitoring Well Assignments



Step 3. Using the Water Forum Solution dataset in the Integrated Groundwater Surface Water Model[1] (IGSM) for 2030 conditions (Water Forum build-out), extract from the model, the hydrograph at the center of each polygon area. This is done to determine the ultimate behavior of the aquifer and then to compare the ultimate condition relative to existing groundwater elevations.

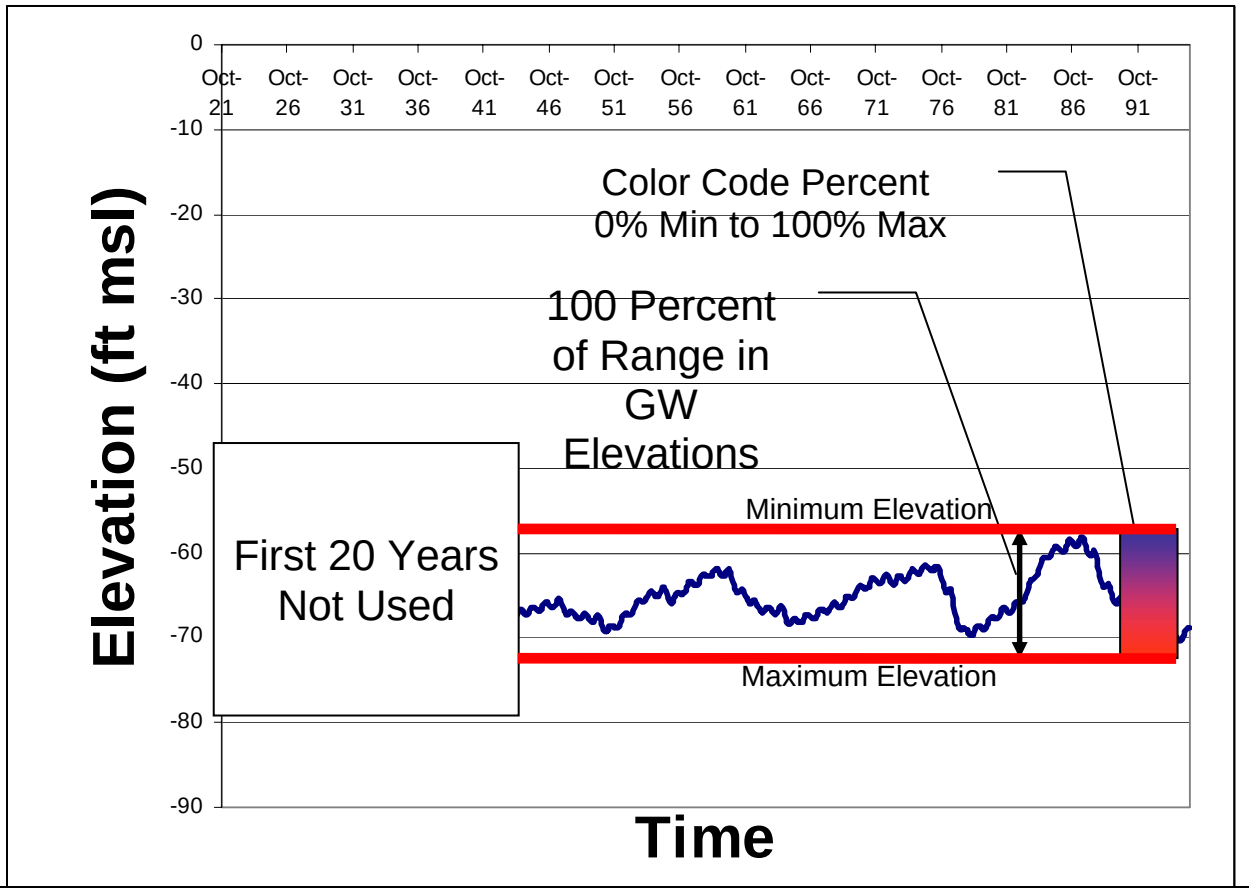
Step 4. Each of the real monitoring data hydrographs and model hydrographs will have a trace that shows groundwater elevations increasing in the wet months and decreasing in the dry months. The hydrographs also show the cumulative effect of multiple dry or wet years.

[1] The IGSM is a finite element, quasi three-dimensional, multi-layered model that integrates surface water and groundwater on a monthly time step. The IGSM was developed for use as a regional planning tool for large areas influenced by both surface water and groundwater. The tool is well-equipped to accommodate input and output of land use and water use data over large areas. Data input includes hydrogeologic parameters, land use, water demand, precipitation and other hydrologic parameters, boundary inflows, and historical water supply. For purposes of parameter definition and developing water budgets around physical and/or political boundaries, the IGSM divides Sacramento, Placer, Sutter, and San Joaquin counties into subregions. Each subregion is further divided into unique numbered elements varying from 200 to 800 acres in size. Overlying this grid is a coarse parametric grid utilized for specifying aquifer and other parameters.

For the model hydrographs, the maximum and minimum elevations are extracted from these hydrographs proceeding the first 20 years of model simulation to allow the groundwater basin to stabilize from initial conditions. The maximum and minimum values of model groundwater elevations are selected from each hydrograph. For instance, the lowest elevation may occur in the 1977 drought period and the maximum elevation may occur in the 1986 wet hydrology.

To normalize the data for the model data, the maximum and minimum elevation of each hydrograph are assumed to be equivalent to 100 percent of the operational range of the basin at that specific location within that polygon. This normalization is necessary to account for the fact that each polygon area has differing elevations due to the nature of the groundwater basin and the surface topography (i.e. the depth to groundwater in the eastern portion of the basin is less than the depth to groundwater in the southern Elk Grove portion of the basin). **Figure B-2** illustrates this process of defining the bandwidth of the model data and the percent rating using the high and low values. Five percent is added to the high elevation and subtracted from the low elevation to provide a small buffer that may show up in real-time monitoring but not in the model (e.g. monitoring wells located next to high producing wells that are running will be influenced by the localized cone of depression of the high producing wells showing a slight deviation from the actual regional groundwater elevation that is being measured).

Figure B-2. Methodology of Bandwidth based on Model Hydrograph



Importance of Bandwidth in Describing BMO Objectives

The bandwidth concept is important from the standpoint of judging whether the aquifer is within a management range; understanding that groundwater elevations fluctuate from month to month and from year to year depending on groundwater use and hydrologic conditions. The percentage indicator within the bandwidth becomes the index of performance and in setting management goals. Within the bandwidth itself, there can be various levels of warning and actions that take place based on each increasing level of warning. This concept is explained in step 6 where a framework for the BMO is defined.

Step 5. Three periods in the historical record are selected to represent a worst, best, and average case of groundwater conditions; these are 1977 (critical dry year), 1983 (very wet year), and 1979 (average year following 2 years after the 1977 drought period), respectively. The significance of 1977 is the combined behavior of increased groundwater extractions, reduced recharge from rivers and deep percolation, and cumulative effects of back to back dry years.

Underlying this information is the time element of how quickly does the groundwater elevation change in one polygon area versus another. For example, a polygon close to the river is influenced significantly by the river's recharge and will be affected almost immediately based on high or low flow river stages. In the dry years, polygons closest to the rivers experience the highest percentage of groundwater decline relative to the total bandwidth. Whereas, an area removed from the major recharge sources will not feel the full impact due to the time that it takes for river recharge to migrate to these areas. Groundwater movement is typically not more than 700 feet a year in the unconfined aquifer.

If the information described above is translated into a figure in terms of percent of the maximum and minimum or "bandwidth" values (e.g., a value from 0 to 100 percent), it becomes apparent that there are areas of similar aquifer behavior as shown in **Figure B-3** for 1977 conditions. One preferred representation of what is termed, "management zones" is shown in **Figure B-4** by the green boundary lines. The delineation of management zones takes into consideration not only the aquifer behavior but also the land use and surface water and groundwater use taking place within the basin. Additional thought in developing the zones was given based on **Figures B-5** and **Figure B-6** (described more fully below).

Aggregation of similar areas to form management zones is for purposes of monitoring and maintaining a net benefit to groundwater users over time as use of groundwater and surface water change, and land uses change over time. Aggregation is also necessary to avoid creating a management program that is cumbersome, costly, and perhaps not fully understood by the future governance body.

Figure B-3. Percentage of Groundwater Model Elevation Depth for 1977 Hydrology

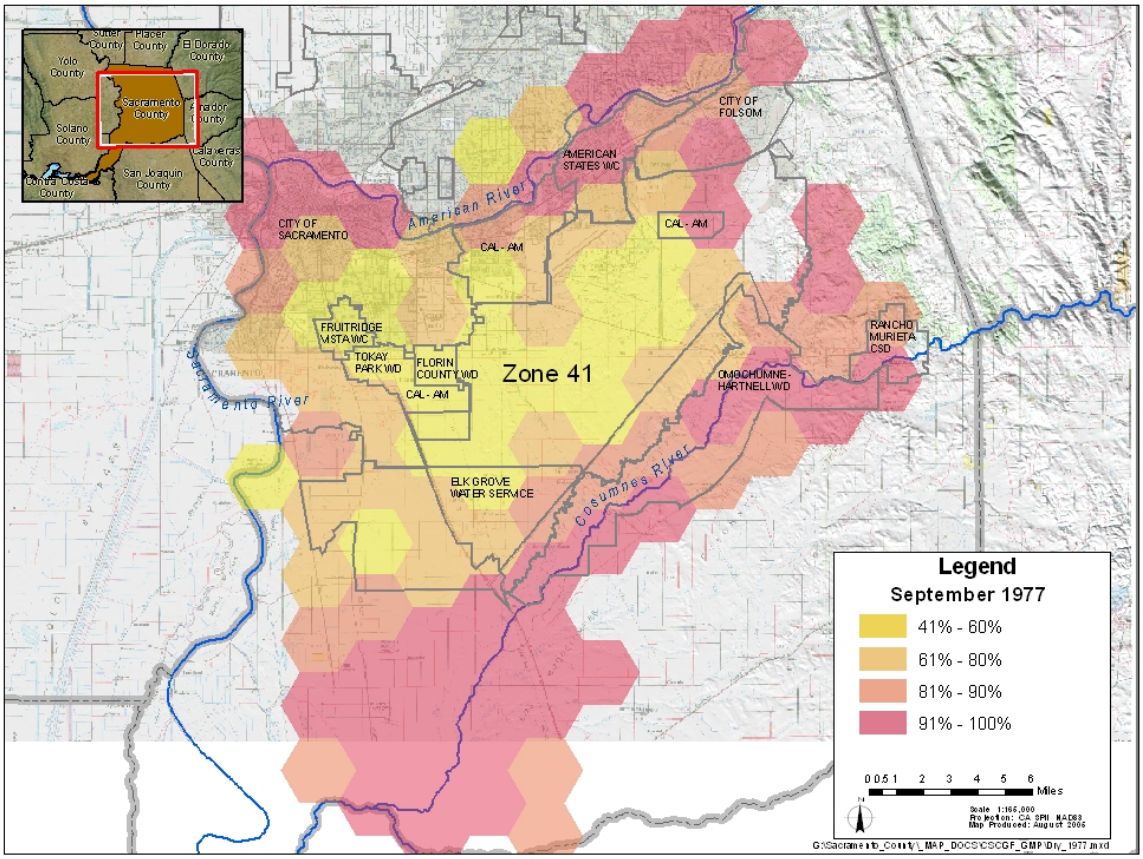
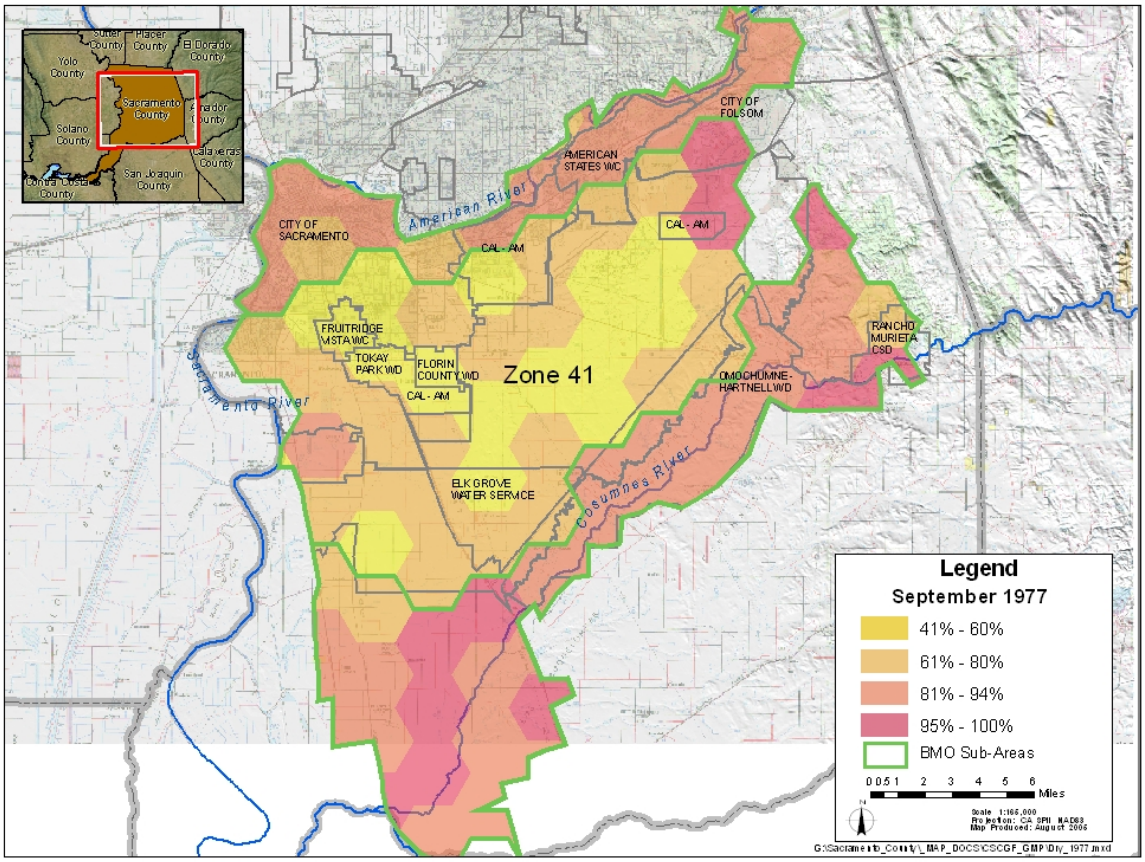


Figure B-4 suggests that within the Central Basin there be a north, central, and south management zone. The north and south zones are due to the obvious red polygons indicating areas with more sensitivity to drought conditions. The north zone is predominantly made up by the City of Sacramento, Cal-Am, and Golden State Water Company with both surface water and groundwater being used. Cal-Am is still dependent on groundwater and therefore is most affected by drought conditions.

The south zone is predominantly groundwater with agricultural and agricultural residential land uses with private wells and is deserving of being a focal point on groundwater management. Since this zone is also significantly affected by drought conditions, monitoring in this area is going to be extremely important to understand the full affect of changing conditions both in hydrology in the river recharge sources and land use changes both within the south zone and in the central zone.

Figure B-4. Groundwater Management Zone Delineation based on 1977 Hydrology



If **Figure B-4** (1977 critical year**)** is compared to **Figure B-5** (1983 wet year**)**, a similar pattern of recharge is evident along the rivers except that now there is an increase in the percent of bandwidth. The darker blue in **Figure B-5** (1983 wet year) represents percentages closest to the upper elevation of bandwidth for each polygon. The same aggregation is represented in **Figure B-5** to illustrate the logical separation of management zones.

The central zone is perhaps the most interesting in terms of how it behaves. **Figure B-6** (normal year) represents 1979 average hydrologic conditions two years after the 1977 extended drought condition and just before the wet period into 1983. This figure combines the time element of how long it takes for the effect of drought conditions to fully establish itself at the cone and how long it takes to recover. The central zone maintains a residual effect of the drought by the darker yellow polygons not changing significantly from 1977 to 1979 indicating 50 percent of the bandwidth, and from 1979 to 1983 with a similar pattern near the cone of depression. This implies that the central zone takes more time to react and recover; whereas, the north and south zones react quickly to hydrologic conditions where the polygons reduce from 90 percent in 1977 to 60 to 80 percent in 1979 and 10 percent in 1983.

Figure B-5. Percentage of Model Groundwater Elevation Depths for 1983 Hydrology

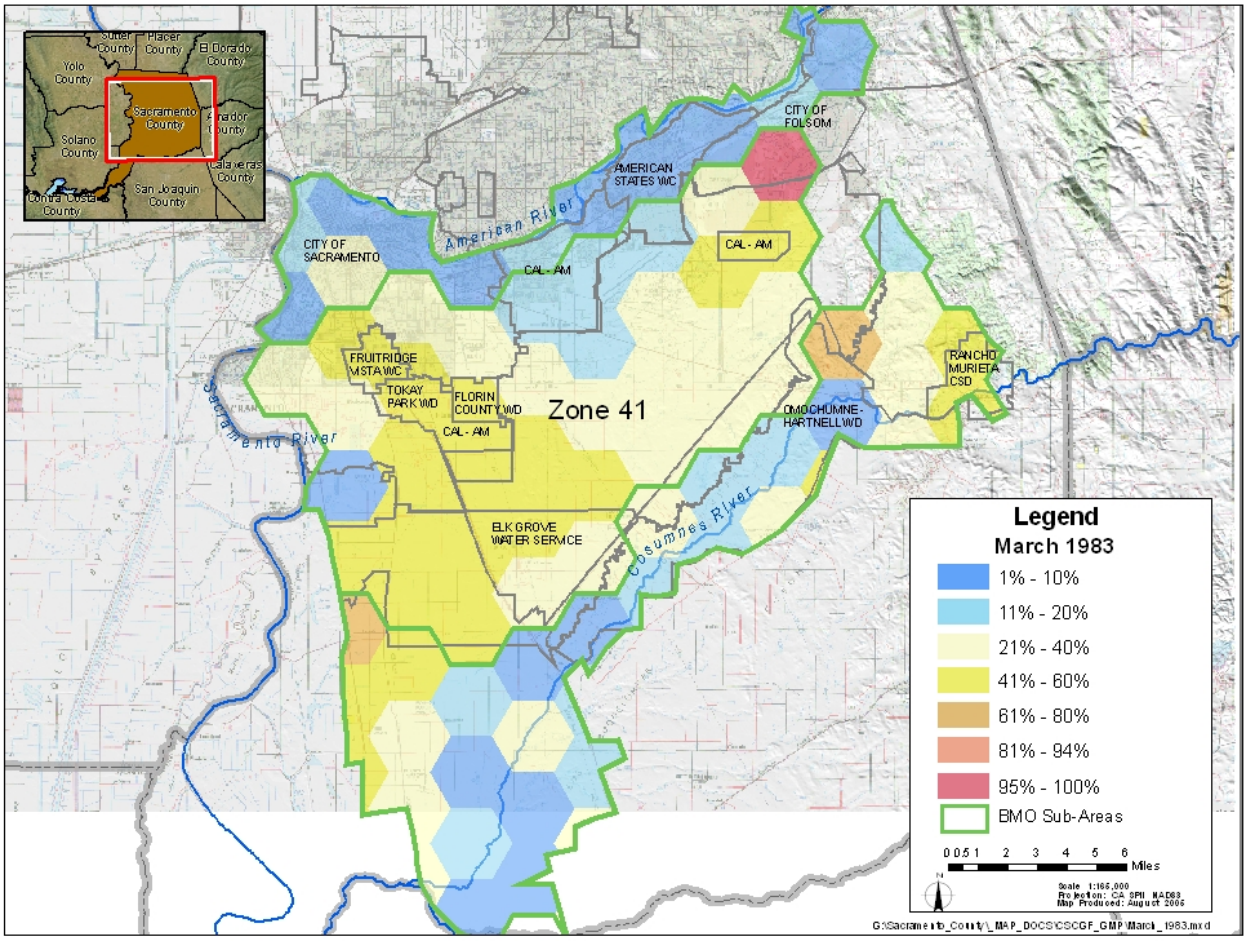
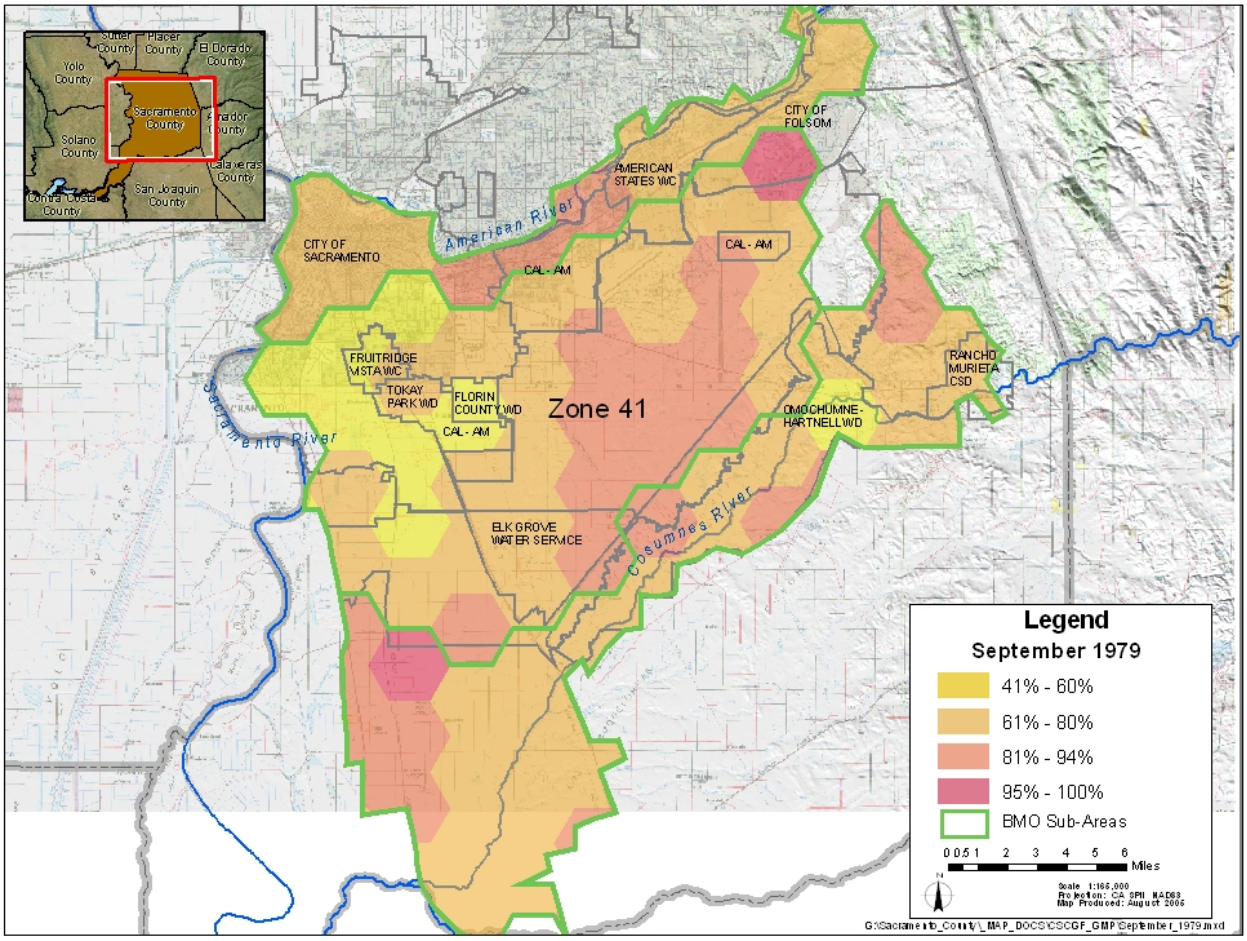


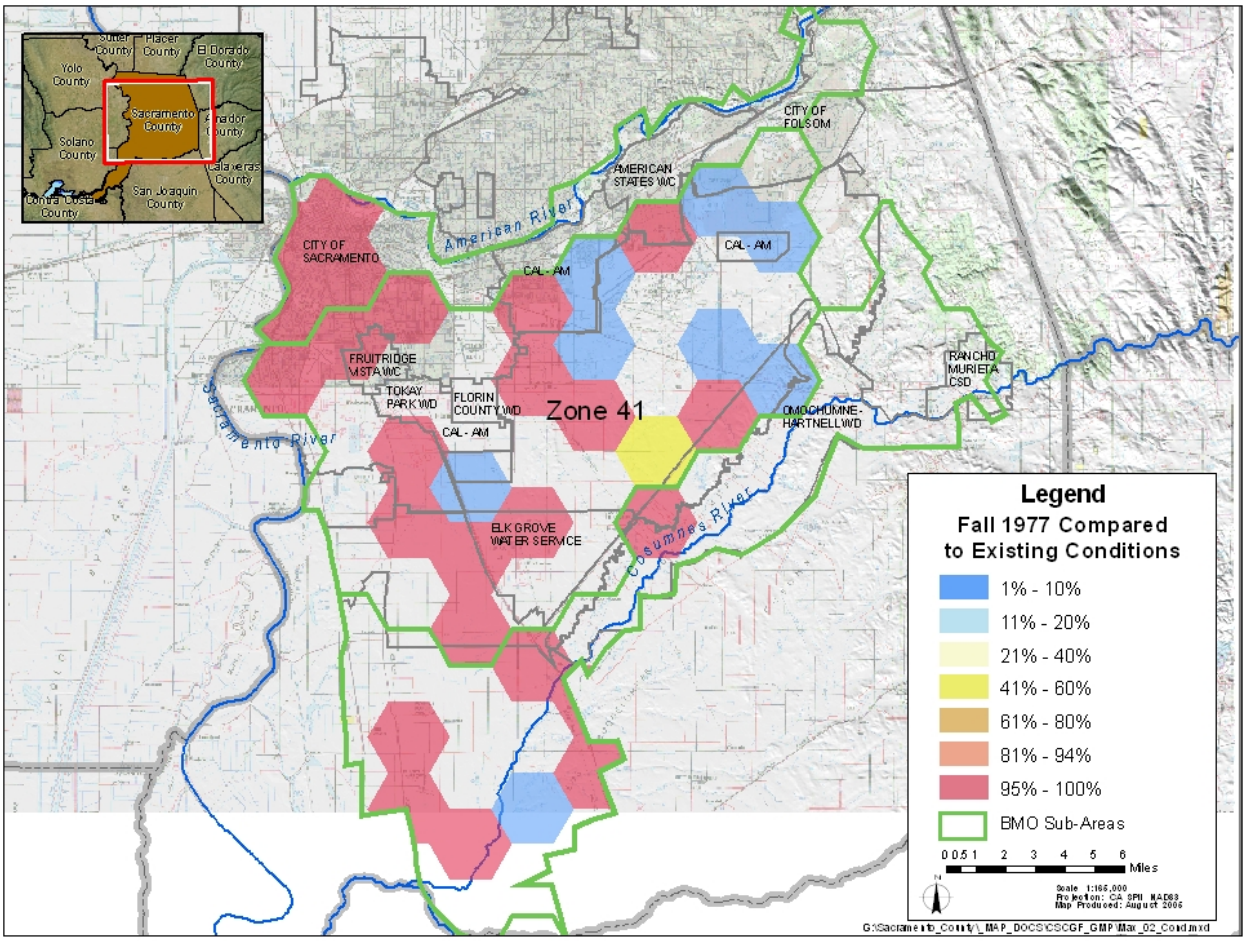
Figure B-6. Percentage of Model Groundwater Elevation Depths for 1979 Hydrology



Step 6. Ground-truthing the model data versus real data is necessary from the perspective of private well owners who currently realize a certain level of reliability in groundwater elevations and understand that during drought conditions there will be periods when groundwater elevations reach their lowest point with possible increase in energy costs and dewatering of wells. To achieve a sense of relative difference between the management objectives and current groundwater conditions, the bandwidth concept is applied to real monitoring data for the most recent measurement value as explained in Step 4 above.

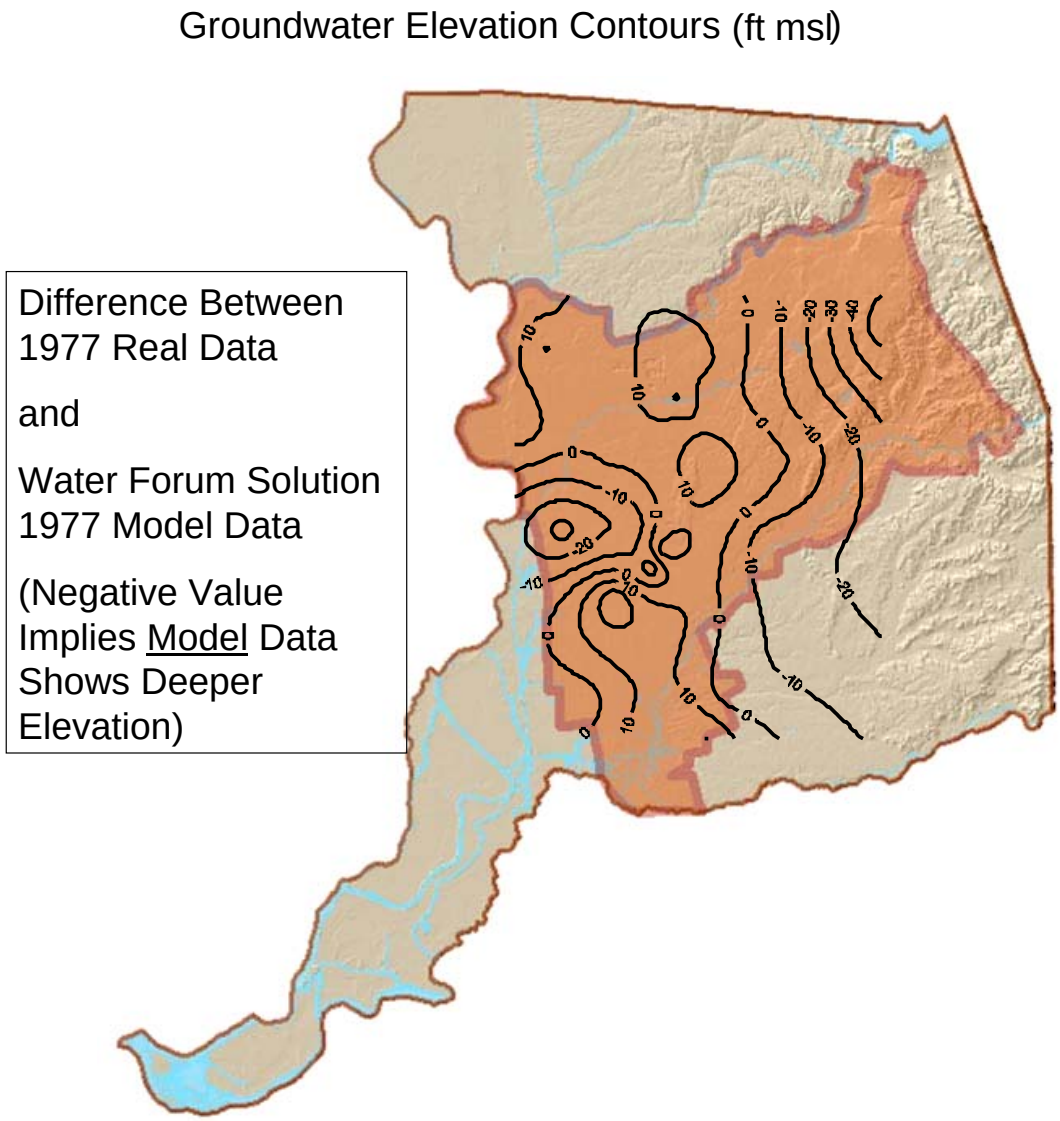
Figure B-7 provides a similar graph for 1977 conditions using real data to evaluate the lowest groundwater elevation relative to today's bandwidth and **Figure B-8** positions the 1977 real data on the model data and contours the difference. The expectation is that under the Water Forum Solution groundwater elevations do not exceed what actually occurred in 1977. If accidence does occur, **Figure B-7** provides, at a glance, the areas where accidence may occur which then provides the basin governance body to begin to understand future programs to mitigate for this event.

Figure B-7. Percentage of Real Groundwater Elevation Depths for 1977 Hydrology



Lastly, to look at the difference between the 1993 real data and the 1993 model data in a more absolute manner, a difference contour map is generated that indicates the probable increase or decrease that might be expected from the 2030 Water Forum Solution in the three management zones. Positive values in **Figure B-8** indicate a positive effect or higher groundwater elevation and a negative contour represents an area that may be impacted by the Water Forum Solution.

Figure B-8. Groundwater Elevation Difference Contours between Model and Real Data for 1977 Hydrology



Step 7. The next step is the development of a framework for monitoring and management of groundwater elevations for each management zone. The fundamental requirements of the framework are listed as follows:

- Provides for simple implementation;
- Allows for adaptive changes based on monitored data;
- Keeps the presentation of the data in a form that can be understood by all stakeholders;
- Allows for differing stages of attention requiring specific actions;
- The details of this framework are provided in **Section 4** (Plan Implementation) of the CSCGMP.

Appendix C
Public Notices

NO085 PUBLIC NOTICE

RESOLUTION NO. WA-2590

RESOLUTION OF INTENTION TO PREPARE A GROUNDWATER MANAGEMENT PLAN FOR THE CENTRAL GROUNDWATER BASIN OF SACRAMENTO COUNTY AND ADOPT A STATEMENT OF PUBLIC PARTICIPATION

WHEREAS, the stakeholders in the Central Sacramento County Groundwater Forum (hereinafter referred to as "Groundwater Forum") desire to develop a Groundwater Management Plan (hereinafter referred to as "GMP") in accordance with Section 10753 - 10753.10 of the California State Water Code (hereinafter referred to as "Water Code") and a groundwater management governance mechanism for the Central Sacramento County Groundwater Basin (hereinafter referred to as "Central Basin"); and
WHEREAS, development of a GMP would provide for the effective management of the groundwater resource; and
WHEREAS, the State Water Code requires that before a GMP can be prepared a local public agency with statutory authority adopt a Resolution of Intention; and
WHEREAS, the Groundwater Forum lacks the statutory authority to adopt a Resolution of Intention; and
WHEREAS, the Sacramento County Water Agency (hereinafter referred to as "Agency") was formed in 1952 by a special legislative act of the State of California (the Sacramento County Water Agency Act .hereinafter referred to as "Agency Act") and is a stakeholder in the Groundwater Forum; and
WHEREAS, under the Agency Act the Agency is to provide for the protection, preservation, and enhancement, for current and future beneficial uses, the groundwater resources in Sacramento County; and
WHEREAS, under the Agency Act the Agency is empowered to develop, adopt and implement a plan for the management of groundwater resources.
NOW, THEREFORE, the Board of Directors of the Sacramento County Water Agency resolves and determines as follows:

Section 1. The foregoing recitals are true and correct and this Board so finds and determines.
Section 2. The Agency will develop the groundwater management plan for the Central Basin. Upon completion of the GMP, the groundwater management governance mechanism developed by the stakeholders of the Groundwater Forum will adopt and implement the GMP. Among other components, the Central Basin groundwater management plan shall include the following components:

a. Basin Management Objectives;
b. Components relating to the monitoring and management of groundwater levels, groundwater banking, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping;
c. Monitoring protocols to track changes in conditions related to the components in paragraph (b) and to generate information for the purpose of meeting Basin Management Objectives and establishing effective management of groundwater;
d. A plan to involve other local agencies, water purveyors, and private well owners in the Central Basin in the development of the groundwater management plan;
e. A map depicting the Central Basin, as defined by California Department of Water Resources Bulletin No. 118 and the Groundwater Forum, other local agencies, and water purveyors in the Central Basin; and,
f. Rules related to implementation of the groundwater management plan.

Section 3. The Groundwater Forum will provide for public involvement in the development of the groundwater management plan. The Groundwater Forum's plan for public involvement shall include the following:

a. The formation of a Technical Review Committee and Policy Committee to guide development of the groundwater management plan;
b. Coordination and participation from the Water Forum;
c. Preparation of a Public Outreach Plan; and,
d. Public review and comment period and public hearings.

On a motion by Director Collin, and seconded by Director Nottoli, the foregoing resolution was passed and adopted by the Board of Directors of the Sacramento County Water Agency, State of California, this 19th day of April, 2005 with the following vote, to wit:

AYES: Directors, None
NOES: Directors, None
ABSENT: Directors, None
ABSTAIN: Directors, None

Roger Dickinson
Chair of the Board of Directors of the
Sacramento County Water Agency,
a district organized under the laws of the
State of California

ATTEST:
Clerk of the Board of Supervisors of Sacramento
County, California, and ex officio Secretary of theBoard of Directors
of Sacramento County
Water Agency

2Ti April 27 & May 4, 2005

Appendix D

Trial Balloon on Well Protection Program

CENTRAL SACRAMENTO COUNTY GROUNDWATER FORUM

Trial Balloon on a Well Protection Program: Final recommendations negotiated by the CSCGF

BACKGROUND

The Water Forum Agreement sets the long-term average annual extraction of groundwater (i.e., sustainable yield) in the Central Area at 273,000 acre-feet. At the time this figure was negotiated, it was anticipated that this sustainable yield would likely lead to a further decline in the groundwater level of approximately 50 feet in the deepest part of the existing cone of depression. Such a decline would undoubtedly affect some existing domestic and agricultural wells.

The protection of domestic and agricultural irrigation wells is of fundamental importance to the Agriculture and Agricultural/Residential Groundwater Users Interest Groups. Agriculturists and "ag/res" users have no alternative source of supply and they should not be required to subsidize future development by having to pay the cost of either deepening or replacing their existing wells. In order to address this concern, we propose that the following be included as part of the "solution package" concerning groundwater management in the Central Area.

RECOMMENDATIONS

The Central Sacramento County Groundwater Forum recommends:

1. The creation of a "well protection" trust fund.

2. The purpose of this fund shall be to cover the costs of deepening or replacing any *existing* well that provides water for agricultural or domestic use that may be impacted by future development in the Central Area. (The Central Area of the groundwater basin is bounded on the north by the American River, on the east by the Sierra foothills, on the south by the southern boundary of the Omochumne-Hartnell Water District and on the west by the Sacramento River and Interstate 5.)

3. This fund should be administered by whatever entity or authority is charged with the responsibility for managing groundwater in the Central Area.

4. The trust fund should be financed through:

- A fee assessed on every new building permit issued following a specified date (e.g., 30 days after establishment of an entity/authority to manage groundwater in the Central Area) ; and
- A fee assessed on any permit to drill a *new* well for any purpose, including agriculture, agricultural/residential, business, M & I supply, etc. However, an application to drill a remediation well required by a regulatory compliance order and all monitoring wells should be exempted from paying a fee.

5. Any property within the City of Sacramento that is served by surface water should be exempted from paying a fee on building permits to support the well protection trust fund.

6. The amount of the fee to be assessed on both building permits (for new construction) and new well applications should be determined by the groundwater management entity/authority. The well assessment should be based upon the diameter of the well. If an individual is obtaining both a building permit and applying to drill a new well on the same property, there should be one assessment only

7. Once an initial or interim fee has been determined and the well registration process has been completed (described in paragraph 10), the groundwater management entity/authority should undertake a nexus study including an impacts analysis and may subsequently revise the amount of the fee in light of the impacts analysis and the number of wells that have been registered.

8. Throughout the life of the trust fund, the groundwater management entity/authority should have the power to change the amount of the assessment, based upon then current actuarial studies.

9. Ultimate responsibility for the collection of these assessments should be vested in the groundwater management entity/authority. The authority should see that fees are collected in whatever manner it deems most efficient.

10. In order to be eligible for coverage by the fund, existing wells must be registered by the well-owner in a manner to be determined by the groundwater management entity/authority and within a schedule or time-limit to be established by the authority. The authority shall make every reasonable attempt to inform all residents who may be eligible to participate in the well protection program of the need to register their well.

11. Once a well has been registered, coverage by the well protection trust fund shall continue for as long as the fund is operational. Coverage of the well is not affected by a change in ownership of the property on which it is located.

12. Eligibility criteria for claims against the fund must be clearly defined and strictly related to a decline in groundwater level. Sub-standard wells, faulty motors or pumps, etc. will not be covered by the fund or eligible for consideration.

13. Any claim against the trust fund must be submitted to the entity/authority and verified by an independent source (e.g., a hydrologist, a well service company, etc.) in order to be paid by the fund.

14. The groundwater management entity/authority shall be responsible for working out the details of how the trust fund shall operate including but not limited to the amount of the fee to be assessed, how assessment fees are collected, criteria for submission of a claim, how a claim will be verified, amount to be paid for a verified claim, timeline between submission of claim and date of decision, etc.

15. At the time that the trust fund becomes operational, the groundwater management entity/authority should, on its own initiative or in conjunction with other appropriate agencies/organizations, undertake a vigorous campaign to educate all water users on the importance of conservation and recommend specific practices that can be implemented by agriculture and agricultural/residential pumpers.

16. Not earlier than five years nor later than the beginning of the eleventh year after water from the Freeport project becomes available for conjunctive use in the Central Area, the groundwater management entity/authority shall conduct a comprehensive review to determine whether there exists a continuing need to maintain a well protection trust fund. In conducting this review, the management entity/authority shall consider the following factors:
    - Groundwater levels;
    - The number of claims made against the trust fund;
    - The rate of claims filed over time: i.e., is the rate of claims increasing or decreasing;
    - Status of urbanization: i.e., is further growth/development anticipated and, if yes, how will it impact water supply.

    A decision on whether or not to continue the fund shall be reserved to the governing board or authority responsible for groundwater management in the Central Area.

17. If as a result of this comprehensive review, a decision is made to terminate the well protection plan but money has accumulated in the trust fund and has not been paid out to meet prior claims, any un-disbursed money should be used for other activities consistent with the purposes of a groundwater management plan or groundwater management authority in the Central Area: e.g., conservation, habitat mitigation, enhancement of groundwater recharge, etc. (In order for this to occur, the language establishing the trust fund must be consistent with the requirements set forth in Government Code, Section 1600.)

18. All details related to the fund should be worked out and the well protection program should become operational within one year of the creation of a groundwater management entity/authority in the Central Area.

NOTE: Nothing in this proposal is intended to modify or change any provisions in the North Vineyard Protection Agreement or to relieve any party of obligations set forth in that Agreement.

Appendix E

Central Sacramento County Groundwater Management Plan – Impact Analysis for Well Protection Program

WRIME Water Resources & Information Management Engineering, Inc.
tel. 916.564.2236 1451 River Park Drive Suite 142, Sacramento, CA, 95815
fax 916.564.1639 http://www.wrime.com • info@wrime.com

TECHNICAL MEMORANDUM

To:	Jim McCormack, Water Forum Darrell Eck, SCWA	CC:	Eric Hong, DWR
From:	Reza Namvar Ali Taghavi	**Date:**	December 30, 2005
Subject:	**Central Sacramento County Groundwater Management Plan – Impact Analysis for Well Protection Program**		
Project Reference:	**310.T01.00**		

EXECUTIVE SUMMARY

The Central Basin Well Protection Program is a result of negotiations that took place as part of the Central Sacramento County Groundwater Forum. Water demands to meet the build-out level of development in future land use and water use conditions in Central Basin could potentially change groundwater levels in various parts of the Central Basin. These changes in groundwater levels may have potential impact on existing agricultural and rural domestic wells. The impacted wells may require lowering of the pump bowls, deepening of the well, or replacement of the well. The well protection program is being developed for the Central Basin to provide funding for mitigation of any wells that may be impacted by a lowering of groundwater levels. This Technical Memorandum (TM) provides an estimate of the cost of the well protection program under three future scenarios.

The number of irrigation and rural domestic wells in the Central Basin is not known. Based on the 2000 land use conditions and water demand information, it is estimated that 235 agricultural and 5,903 rural domestic wells exist in the Central Basin. Using the 2030 land use conditions, it is estimated that the irrigation wells will decrease to 194 wells, while the rural domestic wells will increase to 8,175 wells. The land use, water supply, and water demand information presented in this TM were obtained from the Hydrologic and Modeling Analysis for Zone 40 Water Supply Master Plan study (WRIME, 2004).

The water levels for the three future scenarios were obtained from the recent Hydrologic and Modeling Analysis for Zone 40 Water Supply Mater Plan (WRIME, 2004), and the modeling work performed as part of the Impact Analysis for Well Protection study. These future scenarios are:

- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C – Reduced Surface Water Availability.

The "No Project" scenario represents the land and water use conditions based on the County's General Plan build-out level of development, and the corresponding firm water supply conditions.

The "Proposed Project" scenario represents the build-out conditions with the water supplies proposed under the Zone 40 WSMP. The Zone 40 WSMP was adopted in February 2005.

The "Reduced Surface Water Availability" scenario was simulated in this study to represent a 26,700 acre-feet / year (AFY) reduction in surface water diversion at Freeport to Zone 40 and increased groundwater pumping by 26,700 AFY in the Central Basin.

The simulated water levels were compared with the well bottom depth elevation data to obtain the number of impacted wells. The impact costs of changes in groundwater level include the cost of lowering the pump bowl, deepening the wells, or replacing the impacted wells.

The following table shows the impact cost of the three future scenarios.

Scenarios	Impacted Rural Domestic Wells	Impacted Agricultural Wells	Rural Domestic Wells Impact Cost	Agricultural Wells Impact Cost	Total Impact Cost
A - No Project	164	2	$560,000	$20,000	$580,000
B – Proposed Project	99	1	$423,000	$10,000	$433,000
C - Reduced Surface Water Availability	252	3	$1,097,000	$30,000	$1,127,000

The outline of the TM is presented below.

Executive Summary presents a summary of the TM findings.

1. Introduction provides some background on declining groundwater levels in the Central Basin, brief description of the alternatives, and the purpose of the TM.

2. Available Data provides details of available data that was used in this analysis.

3. Analysis of Well Inventory provides estimates of the number of agricultural and rural domestic wells in the Central Basin.

4. Impacted Wells provides estimates of the number of impacted agricultural and rural domestic wells in the Central Basin and the associated impact cost.

5. References lists the sources of information used in this analysis.

1. INTRODUCTION

Groundwater is a vital source of water for Central Sacramento County. In 2000, approximately 250,000 AF of groundwater was pumped in the Central Basin resulting in declining groundwater levels in some parts of the Central Basin.

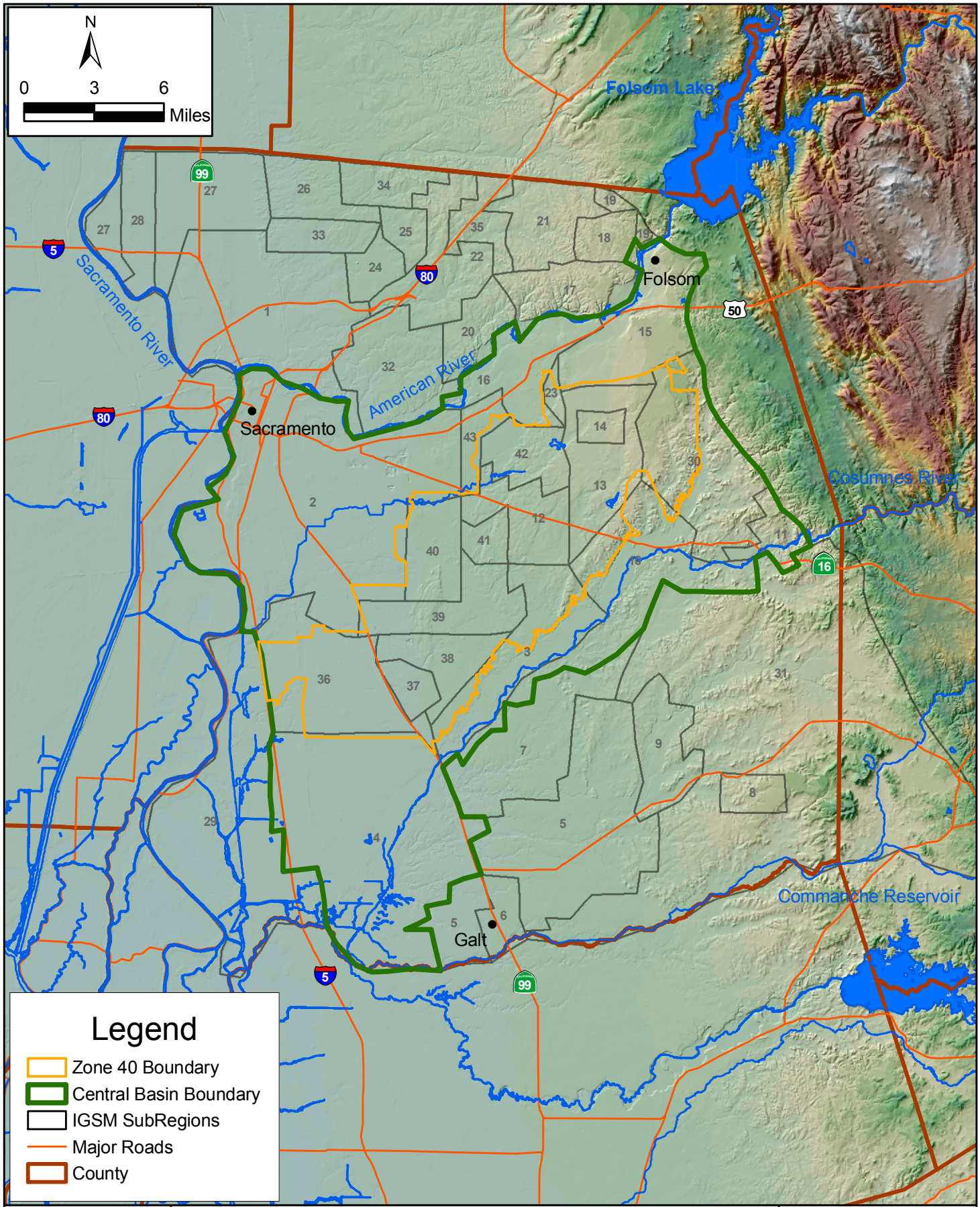
Anticipated urban water use is expected to increase the reliance on the groundwater aquifer and to lower groundwater levels. The Zone 40 Water Supply Master Plan (WSMP) project provides a conjunctive use program that consists of surface water, groundwater, and recycled water. As a result of the implementation of the WSMP groundwater levels in some parts of the Central Basin are expected to be lower than their current levels; however, higher than the future No Project conditions. Figure 1.1 shows the Zone 40 and the Central Basin.

Several water management scenarios including the Proposed Project were analyzed by WRIME (2004) using the Sacramento County Integrated Groundwater and Surface water Model (SACIGSM). A modified version of the Proposed Project scenario was also simulated as part of this study. The purpose of this scenario was to evaluate the worst-case scenario by analyzing the impact of reduced available surface water via the proposed Freeport diversion facilities, and maximum groundwater pumping in the Central Basin. The scenarios presented in this Technical Memorandum include:

- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C - Reduced Surface Water Availability.

All of the simulations indicate that groundwater levels in some parts of the Central Basin will decline in the future. Declining groundwater levels may have an adverse impact on existing wells in Central Basin. Some wells may need to be deepened while some others may have to be replaced.

The Well Protection Program has been developed for the Central Basin to provide funding for deepening or replacement of impacted wells. This Technical Memorandum (TM) presents the results of an analysis of the expected impact cost to agricultural and rural domestic wells in the Central Basin.



Central Sacramento Groundwater Basin
Well Impact Analysis

General Project Location

November 2005

Figure 1.1

2. AVAILABLE DATA

This study uses four categories of data for well impact analysis:

- Land Use Conditions,
- Water Demand,
- Well Depth, and
- Groundwater Levels.

The land use and water demand information are used to estimate the number of agricultural and rural domestic wells. The depth to groundwater at each well is compared to the depth to the bottom of the well to determine whether a well is impacted. The land use, water supply, and water demand information presented in this TM were obtained from the Hydrologic and Modeling Analysis for Zone 40 Water Supply Master Plan study (WRIME, 2004). The data sources and description of the available data is provided in the following subsections.

2.1 DATA SOURCES

The data for the well impact analysis was obtained from previous studies of Central Sacramento County, available databases, and interviews with local professionals. The data sources are presented below.

Sacramento County Groundwater Yield Analysis

A groundwater yield analysis including an evaluation of impacts and associated impact costs of increased groundwater withdrawals from the aquifer systems underlying the County of Sacramento was completed in 1997 for the SCWA (Montgomery Watson, 1997). The report consisted of two technical memorandums, TM1 Baseline Conditions and TM2 Impacts Analysis. The impacts and impact costs were based on the potential groundwater level changes for six Baseline Conditions. This study is commonly referred to as the 1997 Baseline Yield Analysis.

The 1997 Baseline Yield Analysis covers the northern, central, and southern areas of Sacramento County and investigates the impacts of lowering groundwater levels on groundwater quality, wells, land subsidence, and groundwater contamination. The replacement and additional pumping costs of the municipal, agricultural and rural domestic wells were evaluated on a reconnaissance level.

The numbers of agricultural and rural domestic wells in Central Sacramento County were estimated to be 324 and 4,955 wells, respectively. Depending on the simulated baseline condition, the number of agricultural wells impacted by additional groundwater level decline ranged from 0 to 54 wells. The number of impacted rural domestic wells ranged from 0 to 996 wells. The simulations with the highest groundwater pumping rates resulted in the highest number of impacted wells.

Distributions of agricultural and rural domestic well depth are provided in the technical memorandum of the 1997 Baseline Yield Analysis. However, the memorandum does not provide specific information about the location and depth of individual wells. The electronic files of the 1997 Baseline Yield Analysis provides well depth and location information for 964 wells in the Zone 40 area (Figure 2.1). No information was available in these electronic files for the wells outside the Zone 40 area.

DWR/USGS Well Log Database

The California Department of Water Resources (DWR), in cooperation with the United States Geological Survey (USGS), has developed a well log database for selected wells in the Central Sacramento County (DWR, 2005). This database has depth information for 92 wells in the Central Sacramento County. These wells are distributed over the entire central area (Figure 2.1).

Central Sacramento County Data Management System (DMS)

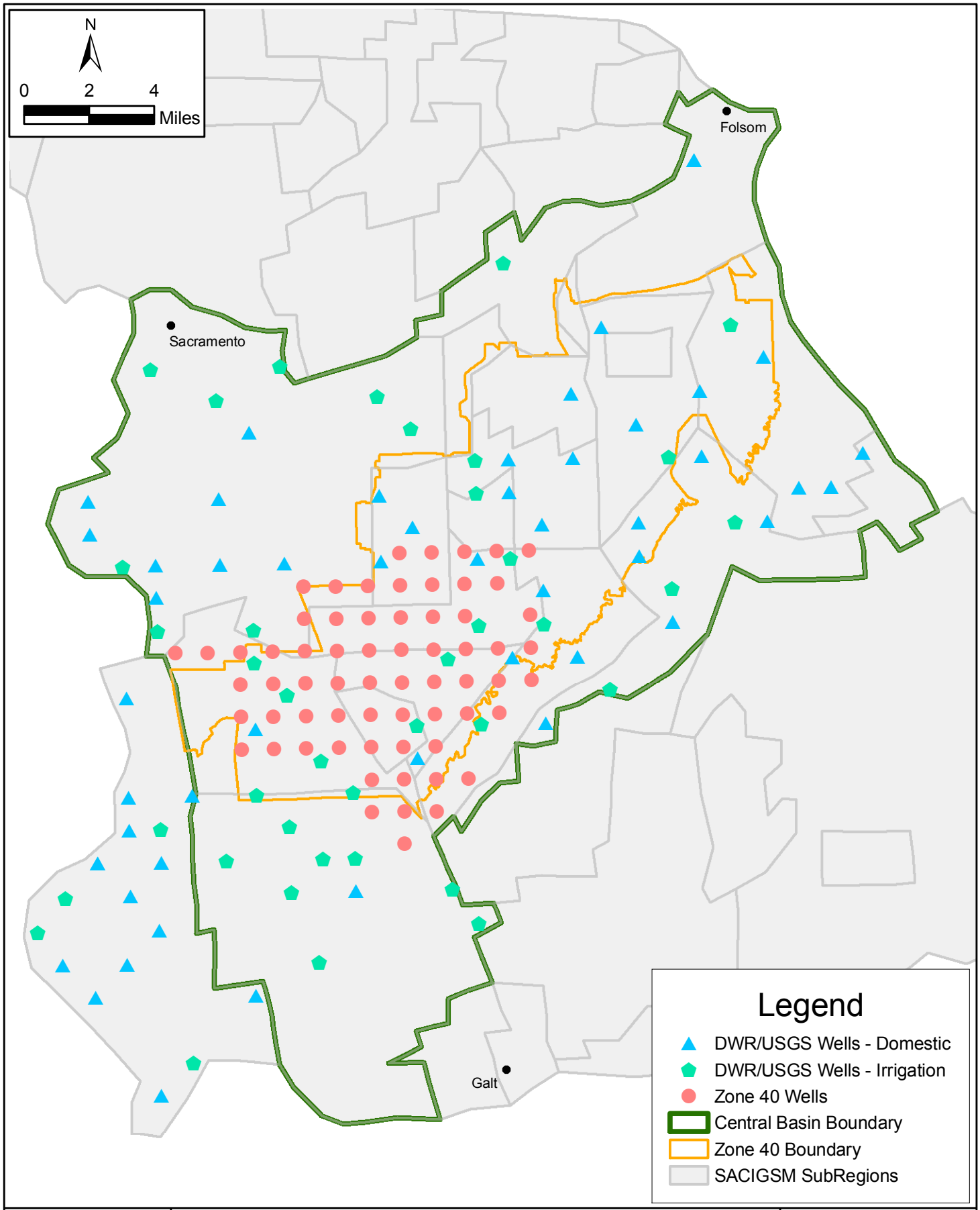
A database of 597 well logs in Central Sacramento County was obtained from MWH – Montgomery Watson Harza (MWH, 2005). However, this database contains only municipal and monitoring well information. Because this database does not provide information on irrigation and/or rural domestic wells, the database was not used in this study.

Hydrologic and Modeling Analysis for the Zone 40 Water Supply Master Plan

A hydrologic and modeling analysis was conducted for the Zone 40 WSMP (WRIME, 2004). Zone 40 was initially established in 1985 by the Sacramento County Water Agency to provide drinking water for the urbanizing unincorporated areas in the Laguna, Elk Grove, and Vineyard communities in Sacramento County.

The SACIGSM was used in the analysis of hydrologic effects of alternatives considered under the WSMP. The effects of water management alternatives were compared to two baseline conditions, 2000 and 2030 levels of development, reflecting existing conditions and ultimate buildout conditions. Table 2.1 presents the description of the alternatives. The Proposed Project represents the long-term effect of water demand and supply resulting from 2030 buildout conditions with additional surface water available and full reuse of remediated water. The Reduced Surface Water Availability scenario represents a 26,700 AFY reduction in available surface water from the FRWA diversion at Freeport and a 26,700 AFY increase in groundwater pumping in the Central Basin.

Water levels at selected irrigation and domestic wells were obtained from SACIGSM simulations for No Project, Project, and Reduced Surface Water Availability scenarios.



WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Location of Sample Wells

November 2005

Figure 2.1

Table 2.1 Descriptions of Model Scenarios

	2000 Baseline	A - No Project (2030 Baseline)	B - Proposed Project	C - Reduced Surface Water Availability
Land Use	DWR 2000 Land Use Survey (Agricultural = 53,000 acres, Urban = 86,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)	Projected 2030 Land Use (Agricultural = 45,000 acres, Urban = 137,000 acres)
Urban Water Demand	Based on DWR 2000 Land Use and a 12% level of conservation (205,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)	Based on projected 2030 Land Use and a 25.6% level of conservation (304,000 AFY)
Agricultural Demand	Based on crop type and the DWR 2000 crop acreages (171,600 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)	Based on crop type and estimated 2030 crop acreage (144,200 AFY)
Surface Water Supplies	Current supplies, estimated based on CALSIM II 2000 Baseline Condition simulation (128,100 AFY)	Increased to included 'firm water' supplies including 4,400 AFY of reclaimed water (194,800 AFY)	Increased to included 'firm water' supplies including 4,400 AFY of reclaimed water (194,300 AFY)	Reduced surface water diversion at Freeport to the Zone 40 area by 26,700 AFY (167,600 AFY)
Remediated Water	No Reuse	9,400 AFY is used in Zone 40, 5,000 AFY provided to augment Cosumnes River flow enhancement	100% Reuse (6,200 AFY reinjection, 5,000 AFY Cosumnes River flow enhancement, 18,800 AFY reuse)	100% Reuse (6,200 AFY reinjection, 5,000 AFY Cosumnes River flow enhancement, 18,800 AFY reuse)
Groundwater Pumping	Current Level of pumping (248,600 AFY)	Less pumping for agricultural demand, groundwater pumping to meet unsatisfied water demand (244,000 AFY)	Less pumping for agricultural demand, groundwater pumping to meet unsatisfied water demand (235,100 AFY)	Groundwater pumping in the Central area increased by 26,700 AFY (261,800 AFY)
Additional Supply Areas	None	None	North Vineyard, Zone 40 Uniform Pumping	North Vineyard, Zone 40 Uniform Pumping

2.2 IMPACT UNIT COSTS

The exact impact cost of each well will be different, however, representative average impact costs were used in this study to calculate the total impact cost. Current average costs for replacement of agricultural and rural domestic wells are $200,000 and $20,000, respectively (Ken Worster, 2005). The average replacement cost of agricultural and rural domestic wells in the 1997 Baseline Yield Analysis were $150,000 and $10,000, respectively. Assuming an annual inflation of 6%, the 2005 estimates for these costs are approximately $250,000 and $15,000. The impact unit cost estimates used in this study are presented in Table 2.2.

Table 2.2 – Impact unit cost estimates.

Impact	Cost Estimate	
	Agricultural Well	Rural Domestic Well
Pump Bowl Lowering	$10,000	$1,000
Well Deepening	$50,000	$5,000
Well Replacement	$220,000	$20,000

2.3 WELL DEPTH DATA

Well depth information for the agricultural and rural domestic wells in the Central Basin was obtained from the 1997 Baseline Yield Analysis and the DWR / USGS well log database. Table 2.3 presents the number of wells with bottom depth information that are available from these two sources. Figure 2.1 presents the location of the wells in Table 2.3.

Table 2.3 - Number of Wells in Central Basin With Bottom Depth Information.

Source	Well Type		Total
	Agricultural	Rural Domestic	
1997 Baseline Yield Analysis	189	775	964
DWR / USGS Databse	40	52	92
Total	**229**	**827**	**1056**

Agricultural wells are usually deeper than rural domestic wells. The distribution of depth of agricultural wells identified in Table 2.3 is illustrated in Figure 2.2. The agricultural wells are at least 80 feet deep and mostly range from 120 feet to 360 feet in depth. Eight wells are more than 600 feet in depth.

The distribution of depth of rural domestic wells identified in Table 2.3 is illustrated in Figure 2.3. The rural domestic wells are at least 60 feet deep and mostly range from 120 feet to 320 feet in depth.

Wells in the western part of the Central Basin pump from the upper aquifer (Layer 1 of SACIGSM), while wells in the eastern part pump from the lower aquifer (Layer 2 of SACIGSM). The location of the east-west SACIGSM cross-section and the locations of the wells are shown in Figure 2.4. Layer 1 thins out from west to east and occurs at lower depths in the eastern part of the Basin. The vertical distribution of pumping is illustrated in a SACIGSM cross-section (Figure 2.5).

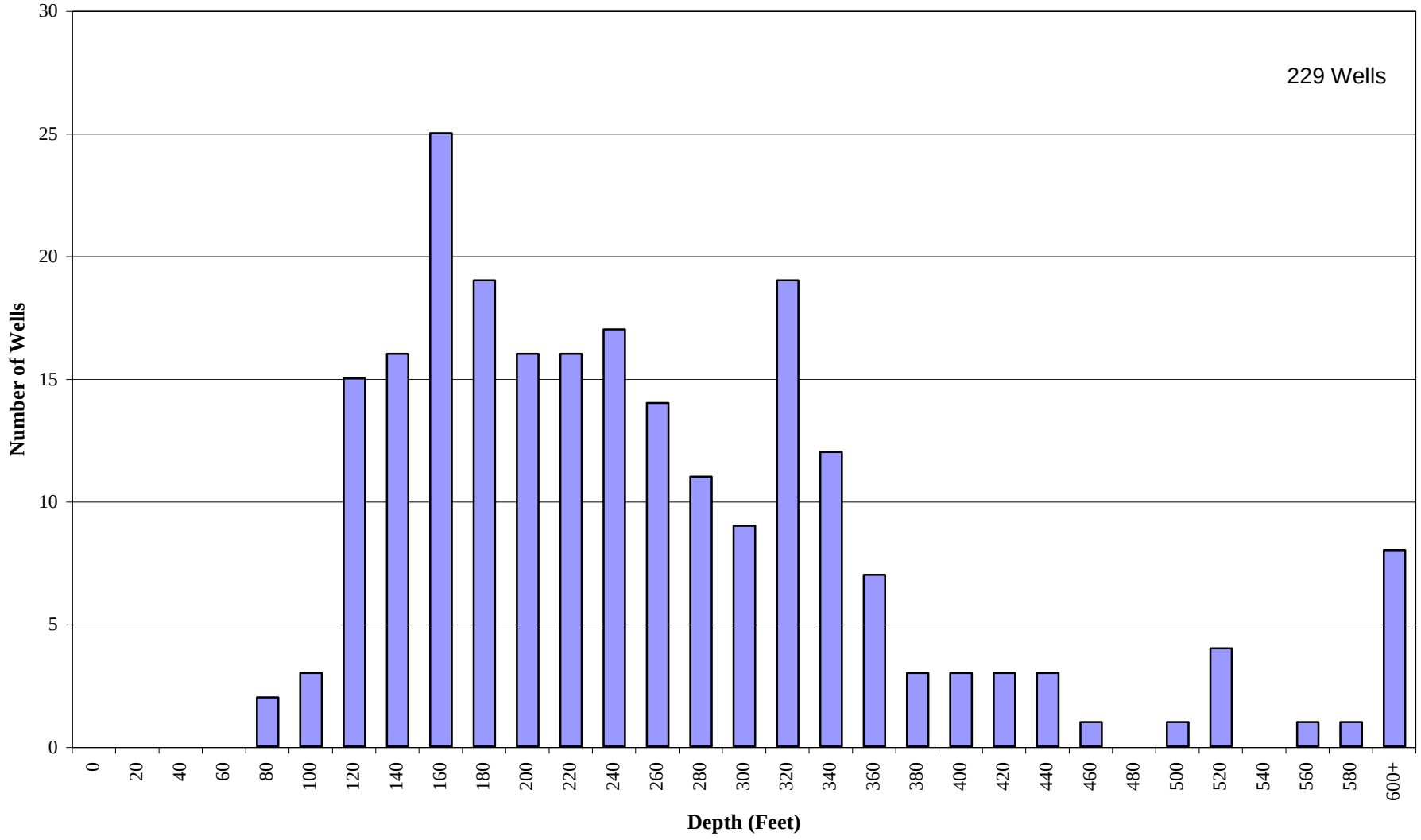
2.4 GROUNDWATER LEVELS

Groundwater levels at the location of the agricultural and rural domestic wells with available bottom depth data were obtained from WRIME's recent SACIGSM modeling analysis for Central Sacramento County (WRIME, 2004) and from a new SACIGSM simulation that was performed as part of this study for the Reduced Surface Water Availability scenario. Groundwater levels were compared with the well depth information to determine whether any well is impacted due to declining groundwater levels. The groundwater levels were obtained for the following scenarios:

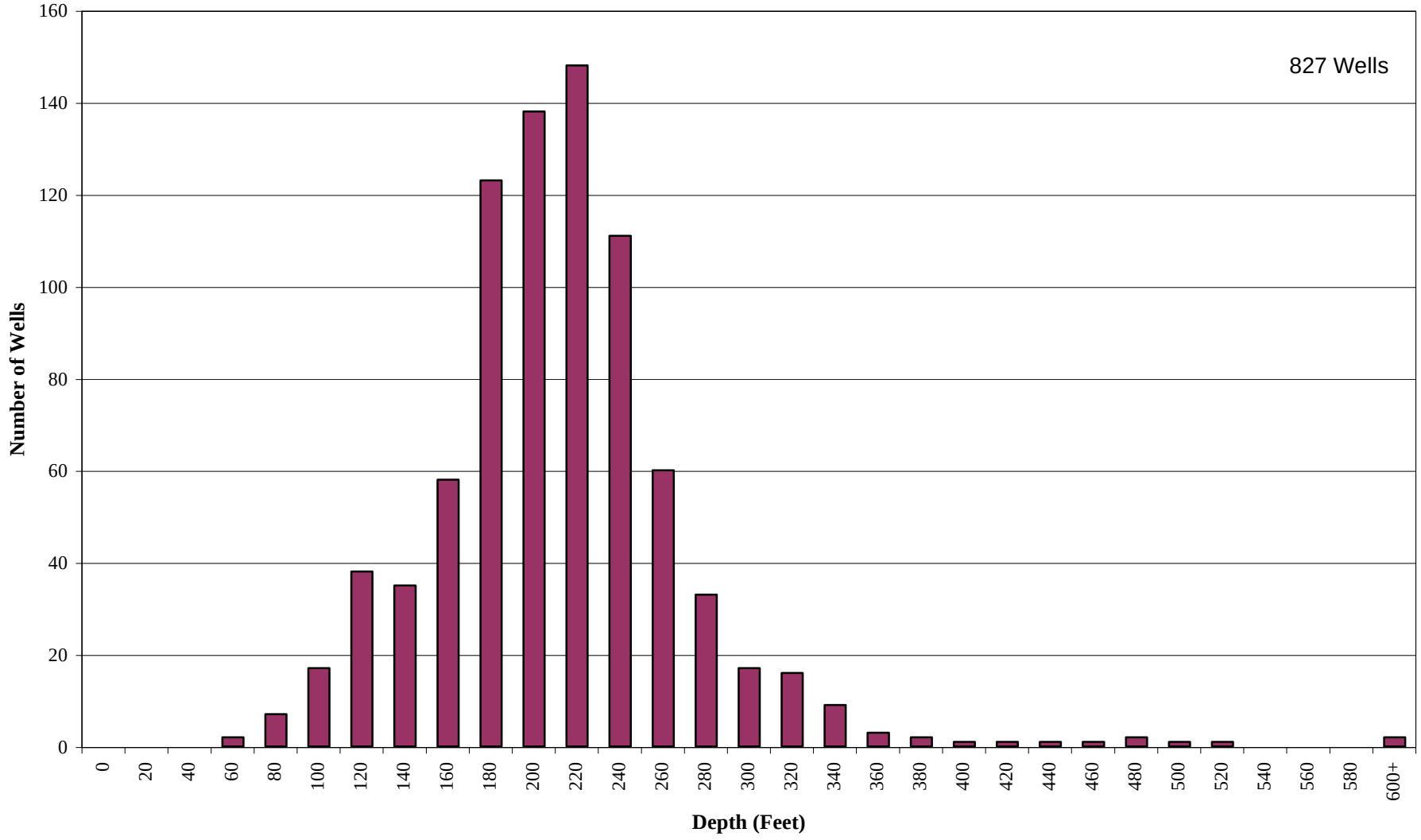
- A – No Project (Baseline 2030),
- B – Proposed Project, and
- C - Reduced Surface Water Availability.

The Reduced Surface Water Availability scenario was developed as part of this study to obtain groundwater levels for a situation where 26,700 AFY of the planned surface water diversion at Freeport would not be available for Zone 40 and the water supply deficiency would be met by an additional 26,700 AFY of groundwater pumping in the Central Basin. This scenario represents the worst case conditions in which the groundwater pumping in the Central Basin is at maximum rate of 261,800 AFY.

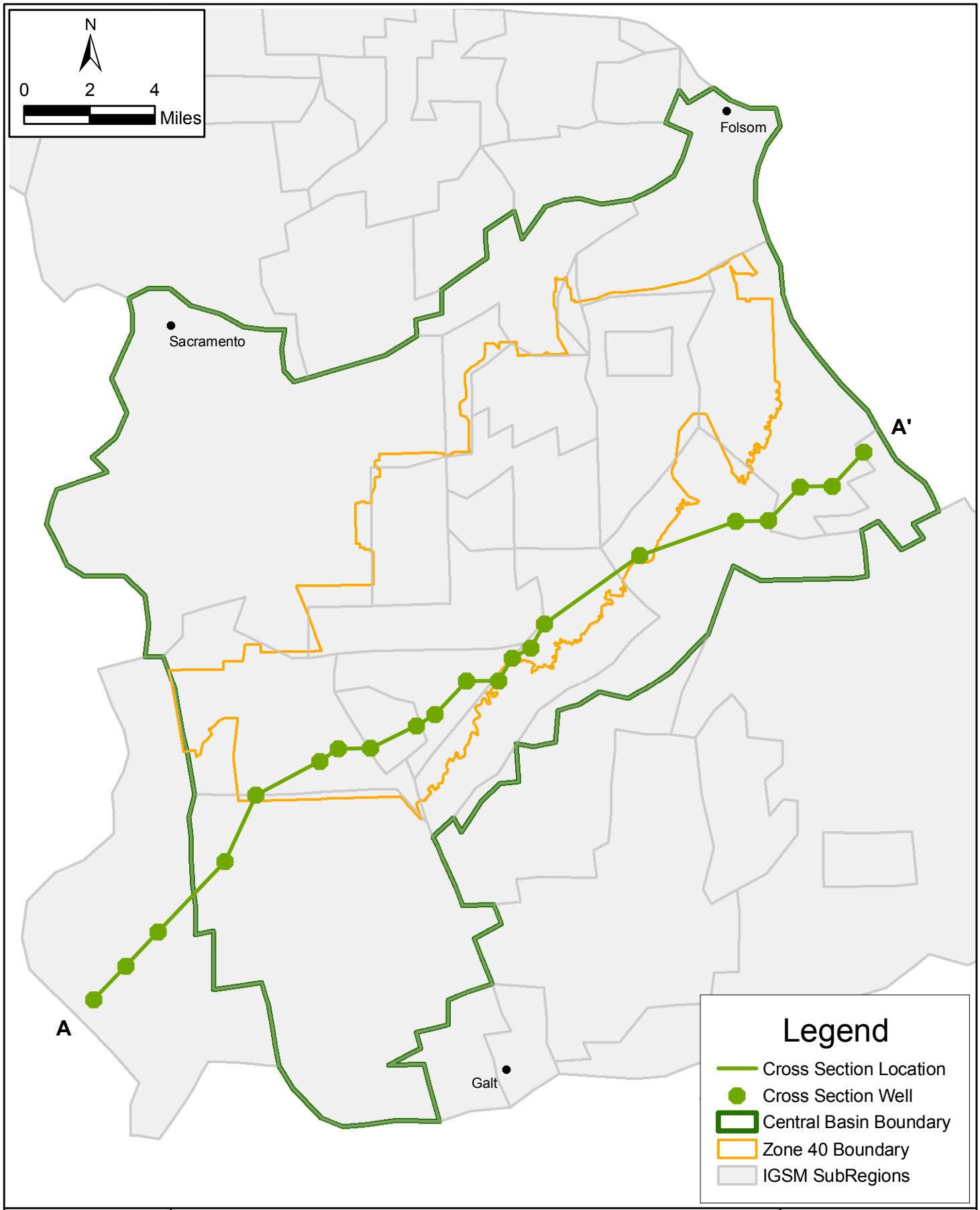
Groundwater levels from layers 1 and 2 were used in this study. Layer 1 is thicker in the western half of the Central Basin and most of the wells in the western half pump from Layer 1. In contrast, Layer 1 thins out in the eastern half and most of the wells in this half pump from layer 2 (Figure 2.5).



ORIME	Central Sacramento Groundwater Basin Well Impact Analysis	November 2005
	Agricultural Well Depth Distribution	FIGURE 2.2



ORIME	Central Sacramento Groundwater Basin Well Impact Analysis	November 2005
	Rural Domestic Well Depth Distribution	FIGURE 2.3

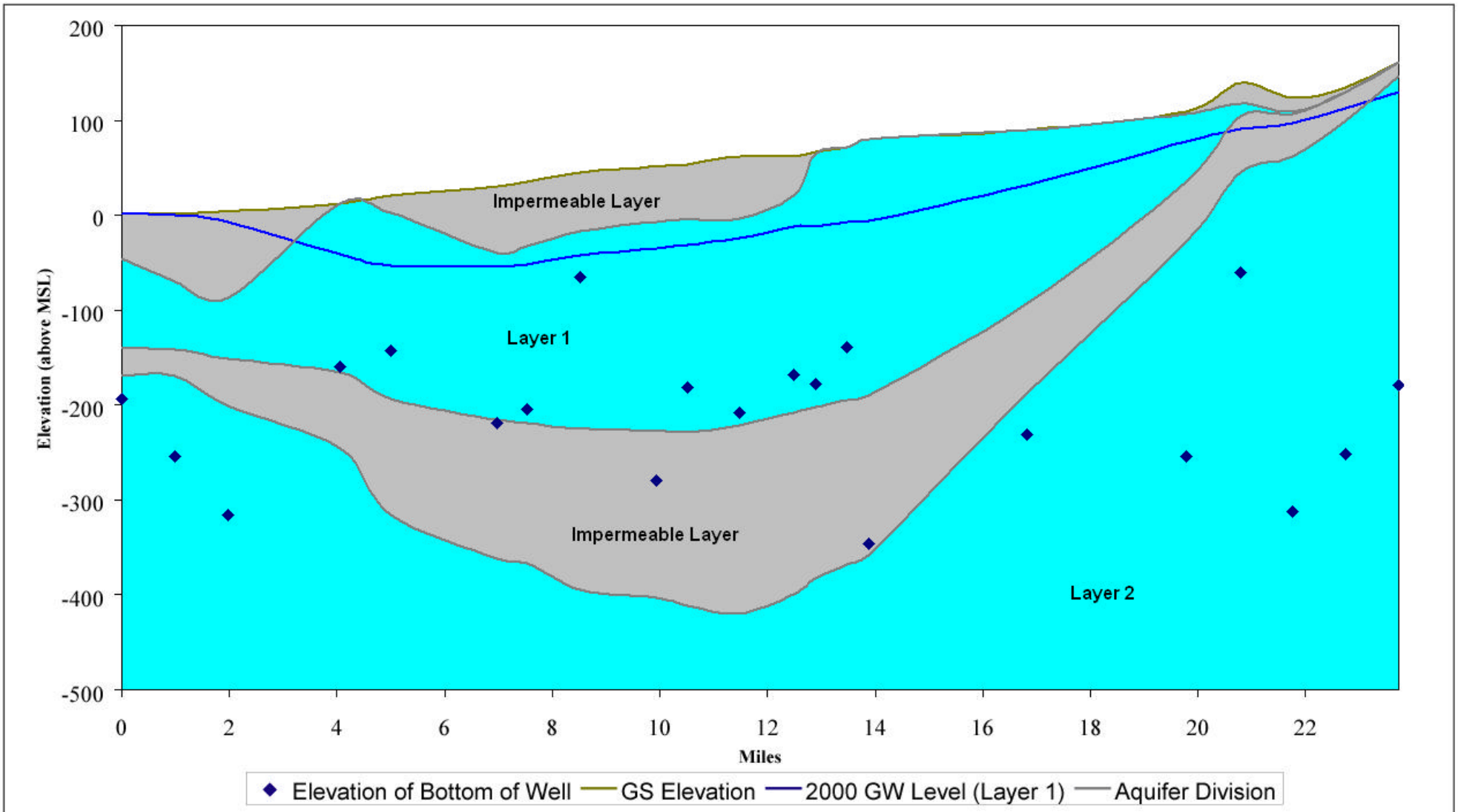


Central Sacramento Groundwater Basin
Well Impact Analysis

Location of East-West Cross Section

November 2005

Figure 2.4



ORIME

Central Sacramento Groundwater Basin Well Impact Analysis

Geologic Cross Section A - A'

November 2005

FIGURE 2.5

The No Project scenario represent groundwater levels at buildout (2030 level of development). The level of development represents a set of land use, water use, and water supply / demand conditions. The No Project scenario represent the long-term effect of buildout of the 2030 level of development with reduced agricultural demands and increased surface water supplies (Table 2.1). The No Project scenario provides a frame of reference for comparison of hydrologic impacts of various water management alternatives. The Proposed Project and the Reduced Surface Water Availability scenarios were analyzed under the 2030 level of development.

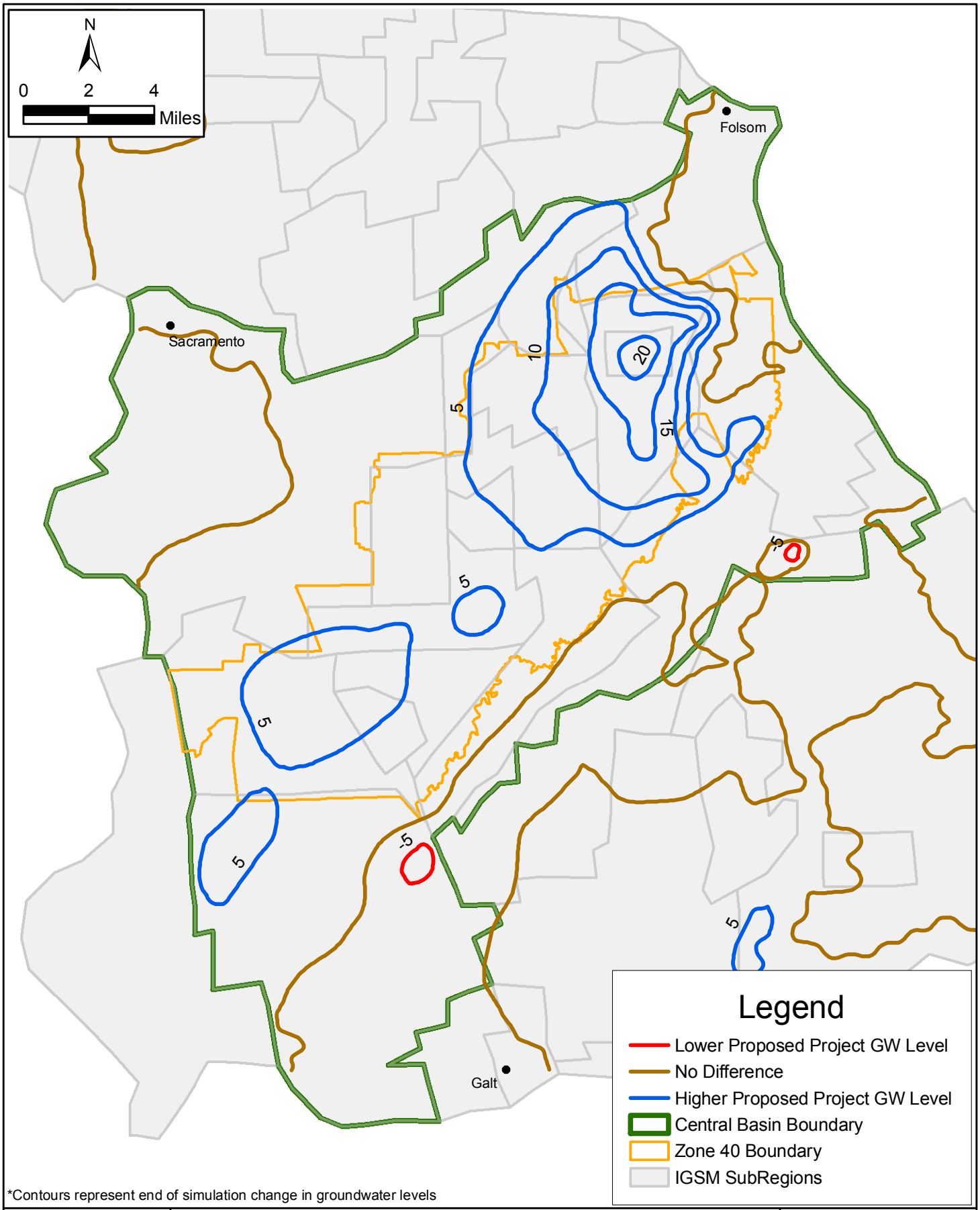
The groundwater levels of the Proposed Project scenario at the end of the simulation are compared to the groundwater levels of the No Project scenario (Figures 2.6 and 2.7). The blue contour lines represent areas with higher Proposed Project water levels than the No Project. The red contour lines indicate the Proposed Project water levels are lower than the No Project. The groundwater levels of the Reduced Surface Water Availability scenario at the end of the simulation are compared to the groundwater levels at the end of the No Project simulation (Figures 2.8 and 2.9). In the Reduced Surface Water Availability scenario water levels drop below the No Project water levels. The higher water level zone in the foothills is also limited to a smaller area. The comparison of the Reduced Surface Water Availability groundwater levels with the Proposed Project groundwater levels is presented in Figures 2.10 and 2.11. The groundwater levels of the Reduced Surface Water Availability scenario are lower than the Proposed Project water levels in all of the Central Basin. The maximum drop in water levels is observed in the western part of Zone 40 where less surface water is available for the Reduced Surface Water Availability scenario.

2.5 LAND USE CONDITIONS

The land use maps of the 2000 and projected 2030 conditions representing land use trends within the Sacramento County are presented in Figures 2.12 and 2.13 (WRIME, 2004). The land use data includes both the general land use and crop acreage to identify water use. The general land use conditions is divided into five classes of

- Agricultural land consisting of areas greater than 5 acres and used for agriculture;
- Agricultural-Residential consisting of 2- to 5-acre parcels zoned for agricultural and residential use;
- Urban consisting of municipal, commercial or industrial development;
- Native Vegetation / Undeveloped areas; and
- Riparian Vegetation consisting of areas along waterways.

The estimated acreage of general land use for the 2000 Baseline and 2030 Baseline are summarized in Table 2.4. The increase in urban and agriculture-residential acreages resulted from the conversion of agricultural land and the development of undeveloped land. The three



*Contours represent end of simulation change in groundwater levels

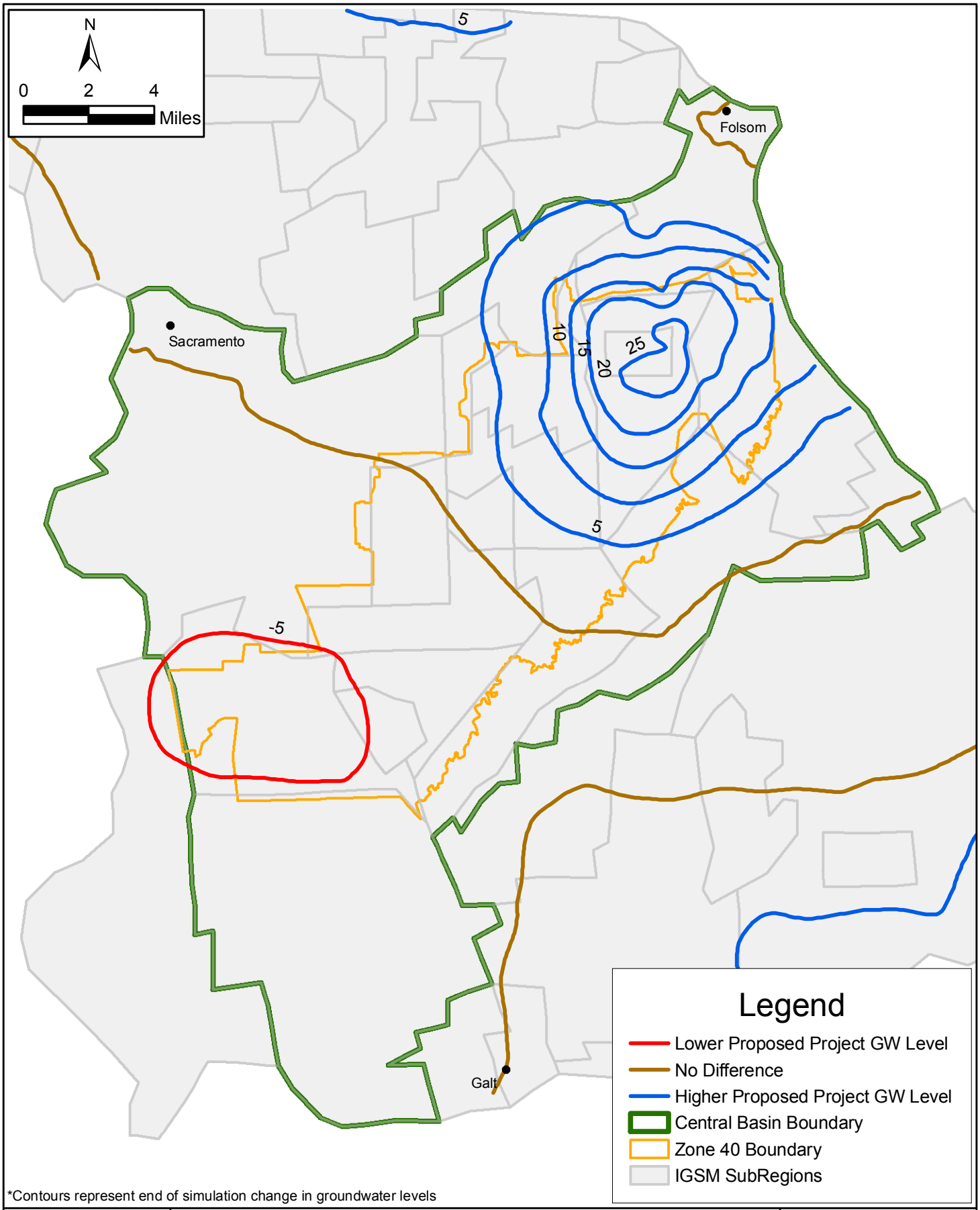
WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Comparison of Proposed Project and No Project GW Levels - Layer 1

November 2005

Figure 2.6



*Contours represent end of simulation change in groundwater levels

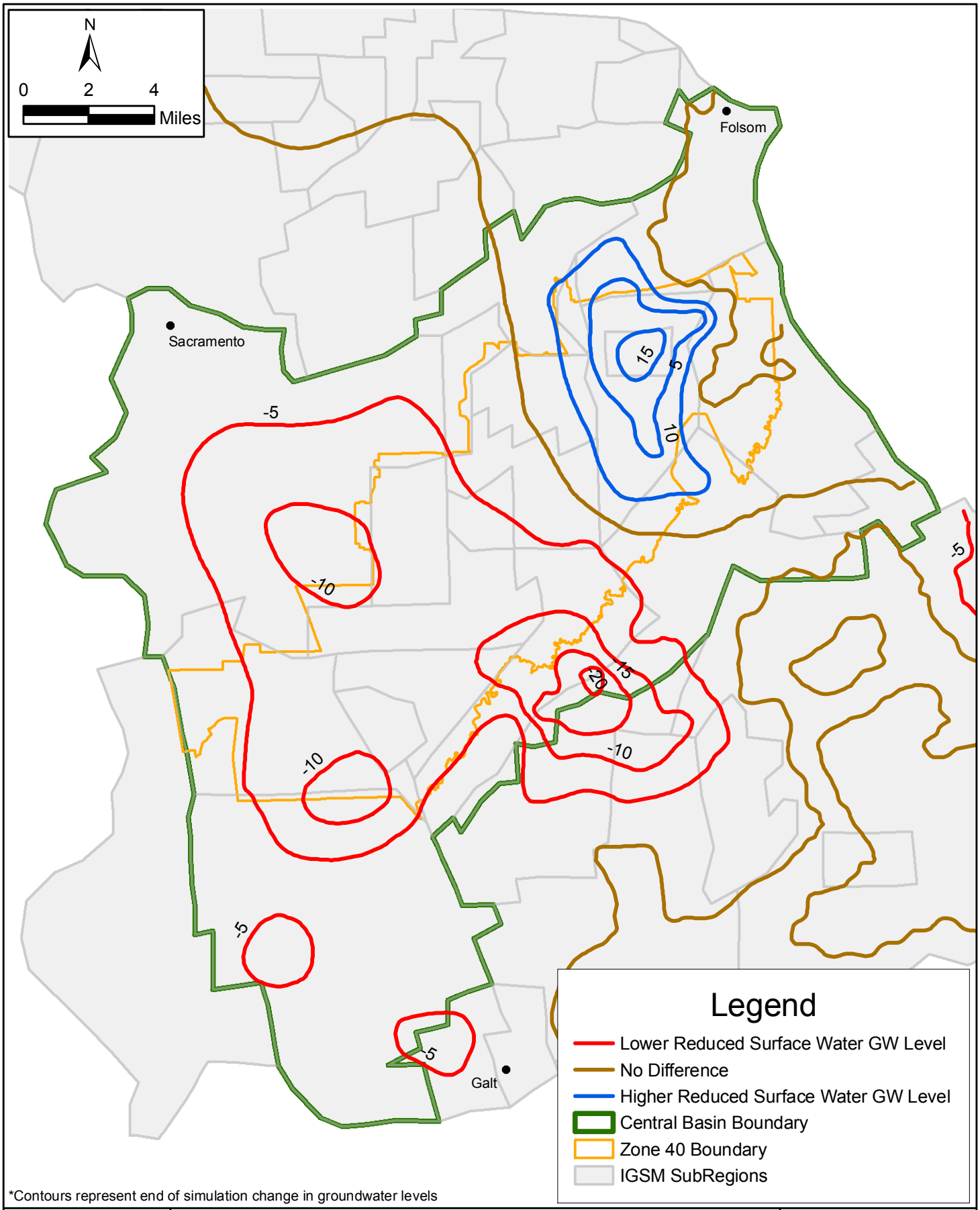
WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Comparison of Proposed Project and No Project GW Levels - Layer 2

November 2005

Figure 2.7



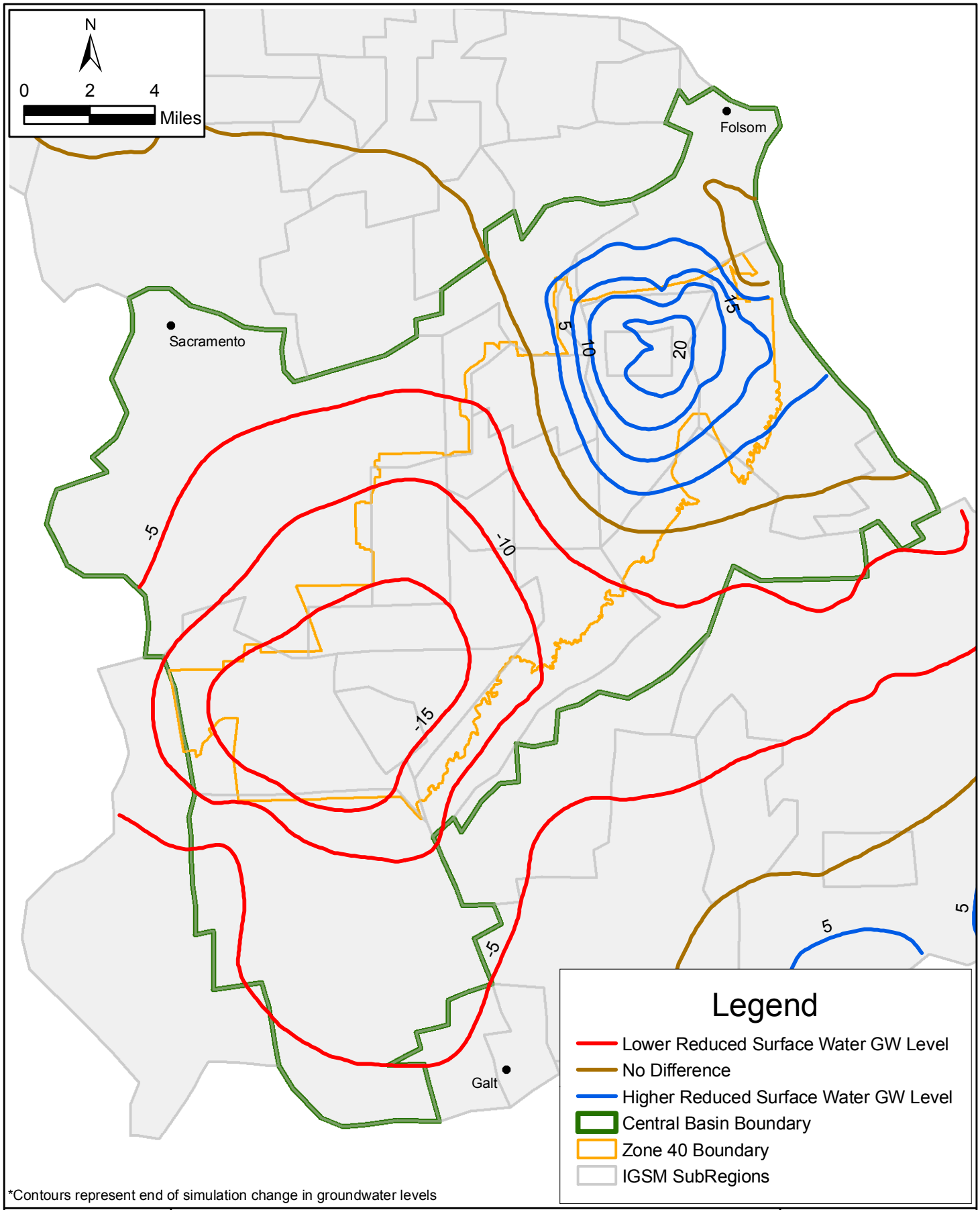
*Contours represent end of simulation change in groundwater levels

Central Sacramento Groundwater Basin
Well Impact Analysis

Comparison of Reduced Surface Water Availability and No Project GW Levels Layer 1

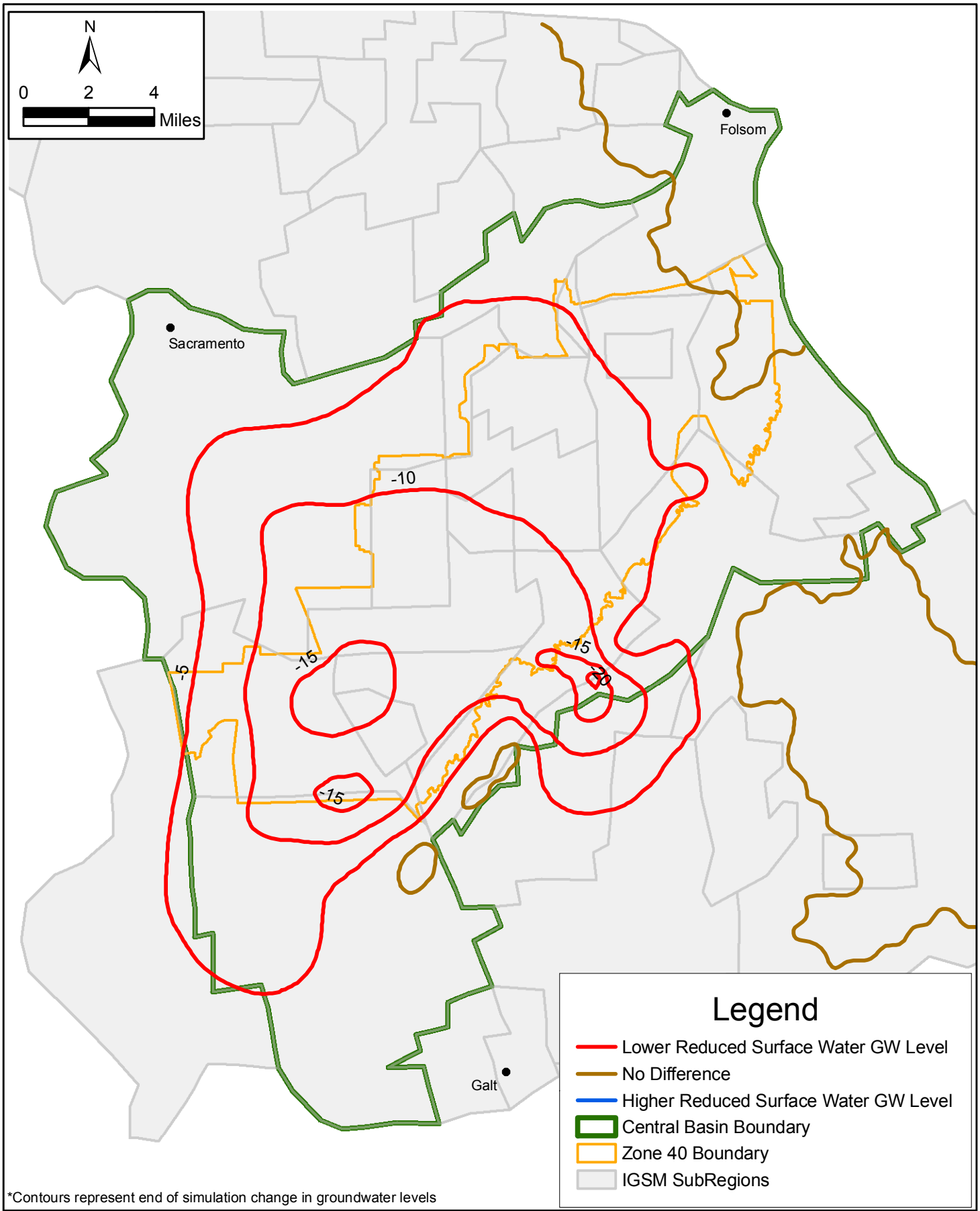
November 2005

Figure 2.8



*Contours represent end of simulation change in groundwater levels

WRIME	**Central Sacramento Groundwater Basin** **Well Impact Analysis** **Comparison of Reduced Surface Water Availability and No Project GW Levels** **Layer 2**	November 2005 Figure 2.9



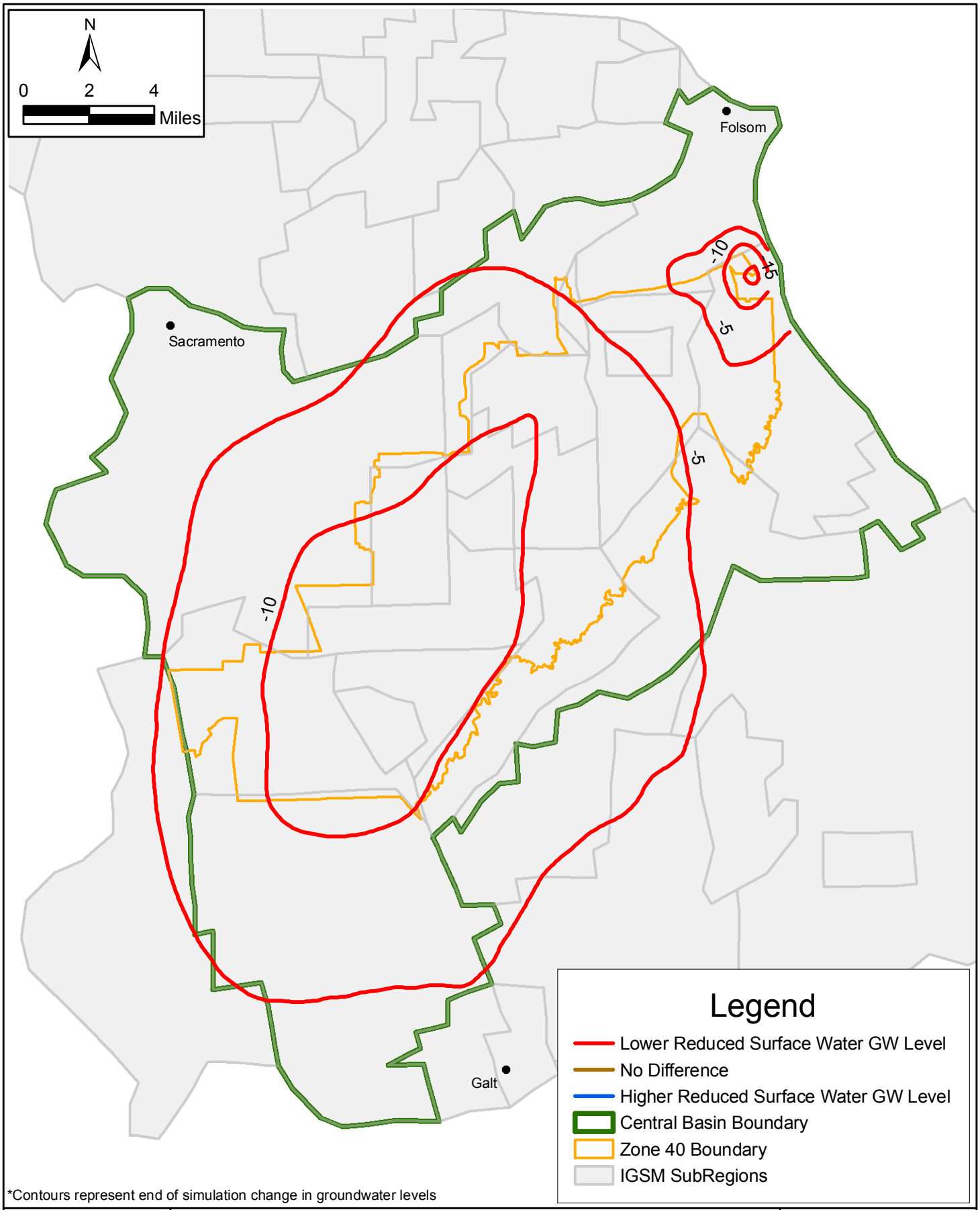
*Contours represent end of simulation change in groundwater levels

Central Sacramento Groundwater Basin
Well Impact Analysis

Comparison of Reduced Surface Water Availability and Proposed Project GW Levels - Layer 1

November 2005

Figure 2.10



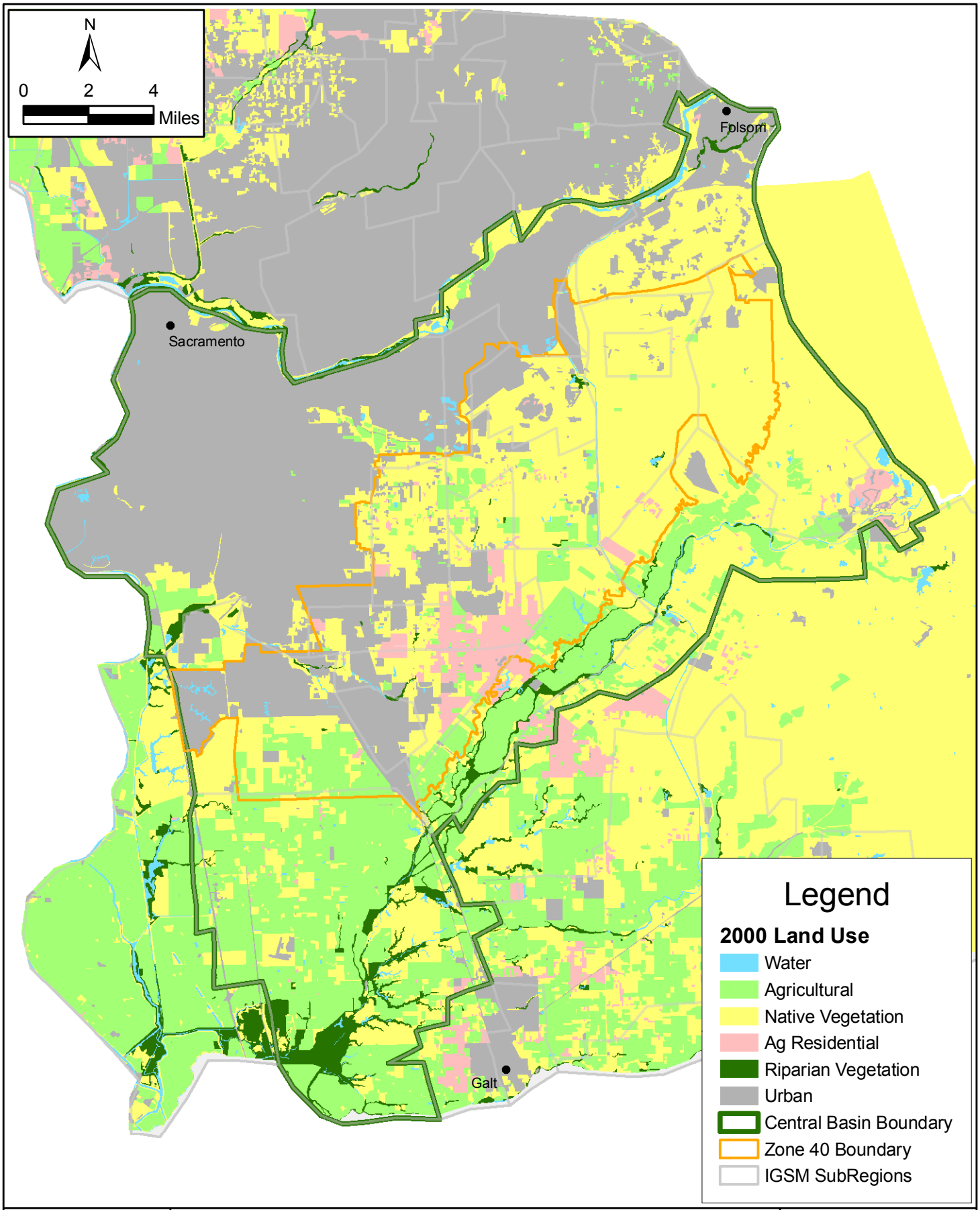
*Contours represent end of simulation change in groundwater levels

Central Sacramento Groundwater Basin
Well Impact Analysis

Comparison of Reduced Surface Water Availability and Proposed Project GW Levels - Layer 2

November 2005

Figure 2.11



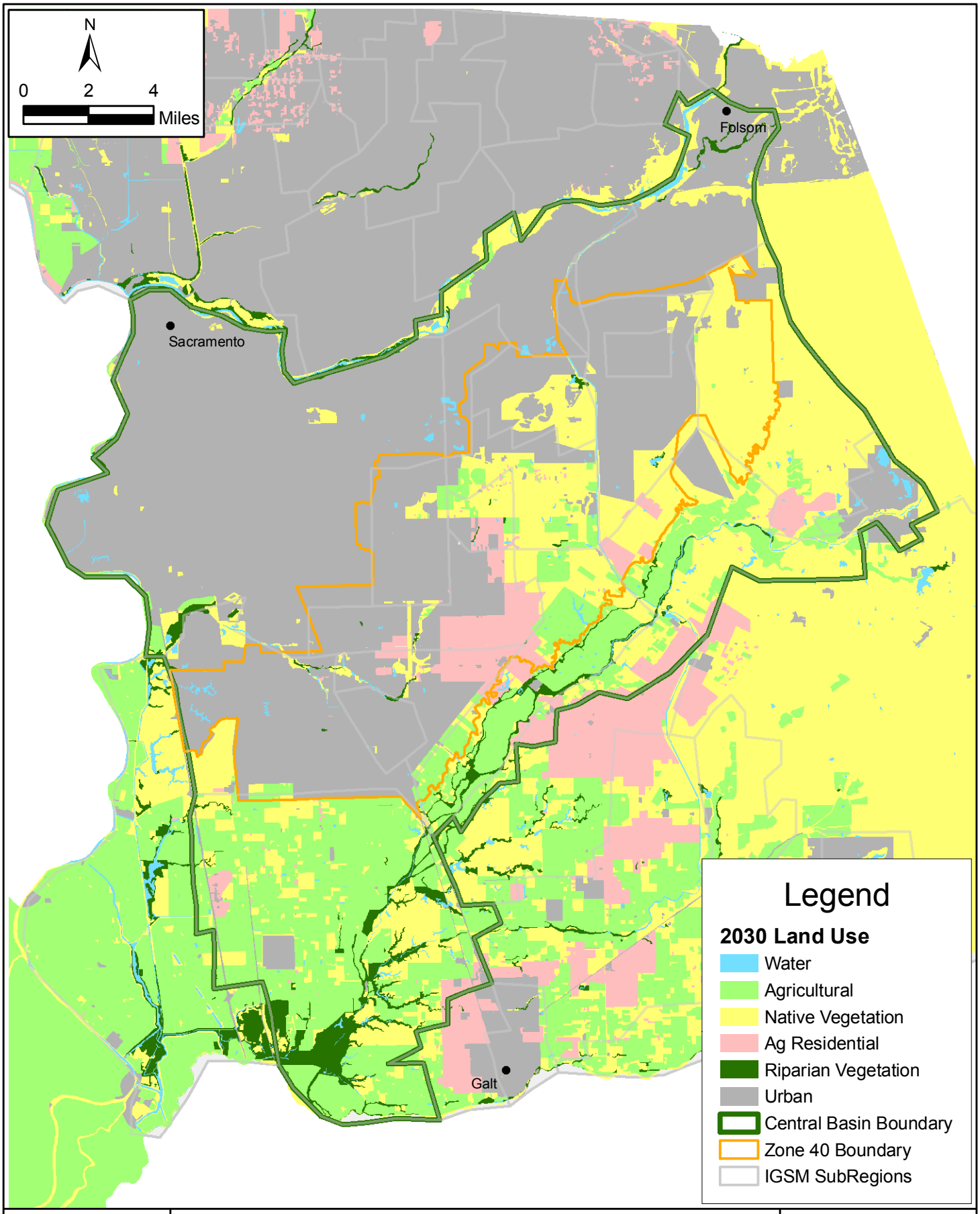
WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Year 2000 General Land Use

November 2005

Figure 2.12



Central Sacramento Groundwater Basin
Well Impact Analysis

Year 2030 General Land Use

November 2005

Figure 2.13

SACIGSM simulations (No Project, Proposed Project, and Reduced Surface Water Availability) are based on the estimated 2030 Baseline land use.

Table 2.4 Estimated Acreage of Land Use for the Central Basin (WRIME, 2004)

Class	Land Use, acres	
	2000	2030
Agriculture	51,126	39,492
Urban	80,387	132,263
Agriculture-Residential	7,572	10,486
Riparian Vegetation	6,409	6,363
Undeveloped / Native Vegetation	101,692	58,582
Total	**247,186**	**247,186**

2.6 WATER USE

Water use estimates are based on the land use data briefly described in the previous section (WRIME, 2004). Water use is divided into two categories of urban and agricultural uses. The water demands for each model subregion for 2000 and 2030 Baseline conditions are presented in Table 2.5. The 2000 Baseline urban water demand includes a 12 percent level of conservation, however, a 25.6 percent level of conservation is included in the 2030 Baseline urban water demand. The average annual agricultural demand in Zone 40 reduces from 28,400 AFY for the 2000 Baseline to 5,000 AFY for the 2030 Baseline.

2.7 WATER SUPPLY AVAILABILITY

The SACIGSM model scenarios are based on water supply availability from the following four sources:

- Surface Water Supplies;
- Recycled Water;
- Groundwater Supplies and;
- Groundwater Remediation and Reuse Options.

The surface water and groundwater supplies and remediation water reuse for each model subregion for No Project, Proposed Project, and Reduced Surface Water Availability scenarios are presented in Table 2.6. Groundwater pumping in Proposed Project is reduced by 9,400 AFY. The reduction in groundwater pumping is compensated by an additional 9,400 AFY of remediation water reuse. The surface water supply is reduced by 26,700 AFY for the Reduced Surface Water Availability simulation. The surface water reduction is accounted for by reducing the Freeport diversion by 26,700 AFY. Groundwater pumping is increased by 26,700 AFY to compensate for the surface water reduction.

Table 2.5 - 2000 and 2030 Baselines Water Demand (WRIME, 2004)

Subregion		2000 Baseline					2030 Baseline				
		Ag Acreage	Urban Acreage	AG Demand	Urban Demand	Total Water Demand	Ag Acreage	Urban Acreage	AG Demand	Urban Demand	Total Water Demand
Number	Name	(A)	(A)	(AF)	(AF)	(AF)	(A)	(AF)	(AF)	(AF)	(AF)
Central Area											
2	South Sacramento	1,440	46,525	3,912	116,296	120,208	386	50234	972	116006	116,978
3	Omochumne-Hartnell North	8,461	260	24,917	855	25,772	8388	137	24675	375	25,050
4	Southwest	27,132	1,048	84,623	1,201	85,824	26347	2284	82646	2181	84,827
10	Omochumne-Hartnell	6,132	720	20,260	1,215	21,475	6300	1277	21215	1796	23,011
11	Rancho Murieta	274	1,007	1,382	2,781	4,163	216	2178	1085	5011	6,096
12	Sunrise "A" – SCWA	1,341	721	5,715	927	6,642	1158	2482	4766	2659	7,425
15	City of Folsom	2	5,312	10	20,159	20,169	0	11697	0	32904	32,904
16	Arden Cordova	202	6,600	380	14,331	14,711	173	6929	303	12534	12,837
30	Fothills North	618	669	1,981	529	2,510	935	1825	3610	1202	4,812
37	EGWS	0	2,307	0	2,710	2,710	0	2590	0	2552	2,552
43	Rosemont – Cal Am	9	2,752	34	6,198	6,232	0	2990	0	5610	5,610
Total Central Area		**45,611**	**67,921**	**143,214**	**167,202**	**310,416**	**43,903**	**84,623**	**139,272**	**182,830**	**322,102**
Zone 40											
13	Sunrise Douglas – SCWA	96	230	145	115	259	713	8512	3012	17429	20,441
14	Security Park – Cal Am	1	86	5	381	384	11	1737	54	1455	1,509
23	Sunrise – SCWA	0	525	0	2,059	2,058	0	912	0	2059	2,059
36	Laguna / Franklin – SCWA	3,323	7,655	10,265	14,422	24,687	50	14228	154	35752	35,906
38	SCWA / EGWS Retail	1,558	1,760	7,209	6,185	13,394	53	5884	242	14308	14,550
39	Vineyard – SCWA	1,603	3,389	7,425	7,646	15,071	322	7533	1479	21988	23,467
40	N. Vineyard in POU - SCWA	540	1,978	1,644	4,444	6,088	0	5600	0	9929	9,929
41	N. Vineyard Out POU – SCWA	516	82	1,620	261	1,880	0	2351	0	7038	7,038
42	Mather	21	2,181	105	2,303	2,410	0	5755	0	11168	11,168
Total Zone 40		**7,658**	**17,886**	**28,418**	**37,816**	**66,233**	**1,149**	**52,512**	**4,941**	**121,126**	**126,067**
Grand Total		**53,269**	**85,807**	**171,632**	**205,018**	**376,649**	**45,052**	**137,135**	**144,213**	**303,956**	**448,169**

Table 2.6. Water Supplies for No Project, Proposed Project, and Reduced Surface Water Availability Scenarios

(RR=Remediation Reuse, GS=Groundwater, SW=Surface Water)

Subregion		A - No Project				B - Proposed Project				C - Reduced Surface Water Availability			
		GW	SW	RR	Total	GW	SW	RR	Total	GW	SW	RR	Total
Number	Name	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)
Central Area													
2	South Sacramento	28,590	88,388		116,978	28,590	88,388		116,978	32,070	88,388		120,458
3	Omochumne-Hartnell North	20,710	4,340		25,050	20,703	4,347		25,050	23,211	4,347		27,558
4	Southwest	84,827	0		84,827	84,827	0		84,827	95,075	0		95,075
10	Omochumne-Hartnell	16,441	6,570		23,011	16,441	6,570		23,011	18,433	6,570		25,003
11	Rancho Murieta	181	5,915		6,096	181	5,915		6,096	205	5,915		6,120
12	Sunrise "A" – SCWA	7,434	-9		7,425	7,503	-78		7,425	8,403	-78		8,325
15	City of Folsom	0	32,904		32,904	0	32,904		32,904	0	32,904		32,904
16	Arden Cordova	7,637	5,200		12,837	7,637	5,200		12,837	8,561	5,200		13,761
30	Fothills North	4,812	0		4,812	4,812	0		4,812	5,388	0		5,388
37	EGWS	2,552	0		2,552	2,552	0		2,552	2,864	0		2,864
43	Rosemont – Cal Am	5,610	0		5,610	5,610	0		5,610	6,282	0		6,282
Total Central Area		178,794	143,308	0	322,102	178,856	143,246	0	322,102	200,492	143,246	0	343,738
Zone 40													
13	Sunrise Douglas – SCWA	12,418	6,486	1,537	20,441	3,012	14,356	3,073	20,441	3,012	9,961	3,073	16,046
14	Security Park – Cal Am	839	542	128	1,509	54	1,198	257	1,509	54	831	257	1,142
23	Sunrise – SCWA	1,109	768	182	2,059	0	1,696	363	2,059	0	1,177	363	1,540
36	Laguna / Franklin – SCWA	17,831	15,314	2,761	35,906	18,504	11,880	5,522	35,906	20,292	3,984	5,522	29,798
38	SCWA / EGWS Retail	8,161	5,128	1,261	14,550	8,301	3,726	2,523	14,550	9,117	118	2,523	11,758
39	Vineyard – SCWA	13,647	7,882	1,938	23,467	13,447	6,144	3,876	23,467	14,827	601	3,876	19,304
40	N. Vineyard in POU - SCWA	733	9,141	55	9,929	2,033	7,785	111	9,929	2,093	7,785	111	9,989
41	N. Vineyard Out POU – SCWA	4,233	2,252	553	7,038	4,222	1,710	1,106	7,038	4,654	129	1,106	5,889
42	Mather	6,181	4,002	985	11,168	6,631	2,568	1,969	11,168	7,243	-248	1,969	8,964
Total Zone 40		65,152	51,515	9,400	126,067	56,204	51,063	18,800	126,067	61,292	24,339	18,800	104,431
Grand Total		**243,946**	**194,823**	**9,400**	**448,169**	**235,060**	**194,309**	**18,800**	**448,169**	**261,784**	**167,585**	**18,800**	**448,169**

3. ANALYSIS OF WELL INVENTORY

The exact number of agricultural and rural domestic wells in the Central Sacramento County is not known. In order to determine the potential impacts of lowering groundwater levels on these wells an analysis was performed to estimate the total number of wells in each model subregion. The following subsections present the methodology and the results of this analysis.

3.1. AGRICULTURAL WELLS

Agricultural wells are those wells that are primarily utilized for crop and pasture irrigation. The number of agricultural wells in the Central Sacramento County was estimated based on land use, water demand, and average well capacity.

The average well capacity of agricultural wells for Central Sacramento County is approximately 971 gallons per minute (MW, 1997). Agricultural wells are assumed to pump at the average capacity rate for 6 months each year and produce 772 AFY of water.

Agricultural water demand in each subregion is dependent on the acreage of land used for agricultural purposes and the estimated agricultural water duty. WRIME (2004) provided estimates of agricultural water demands of the subregions in Central Sacramento County for 2000 Baseline and 2030 Baseline conditions (Table 3.1).

The number of agricultural wells in each subregion is obtained by dividing the agricultural water demand by 772 AFY per well. The estimated number of agricultural wells in Central Sacramento County is presented in Table 3.1. Majority of the agricultural wells are in Omochumne-Hartnell North (Subregion 3), Southwest (Subregion 4), and Omochumne-Hartnell (Subregion 10) subregions along the Cosumnes River. The estimated total number of agricultural wells in Central Sacramento County with 2000 Baseline conditions is 235 wells and reduces to 194 wells with 2030 Baseline conditions.

3.2. RURAL DOMESTIC WELLS

Rural domestic wells are those wells that produce water for utilization at agricultural residential areas. The number of rural domestic wells in Central Sacramento County was estimated based on agricultural residential land use and average well capacity.

Rural domestic wells are assumed to pump, on the average, enough water for residential use and irrigation of 1.25 acres of land (MW, 1997). WRIME (2004) provided estimates of agricultural residential land use in the subregions in Central Sacramento County for 2000 Baseline and 2030 Baseline conditions (Table 3.2).

Table 3.1 – Estimated Number of agricultural wells in Central Sacramento County

Subregion		2000 Ag Water Demand	2030 Ag Water Demand	2000 Agricultural Wells	2030 Agricultural Wells
Number	**Name**	**(AF)**	**(AF)**	**(well)**	**(wells)**
Central Area					
2	South Sacramento	3,912	972	6	2
3	Omochumne-Hartnell North	24,917	24,675	33	32
4	Southwest	84,623	82,646	110	108
10	Omochumne-Hartnell	20,260	21,215	27	28
11	Rancho Murieta	1,382	1,085	2	2
12	Sunrise "A" – SCWA	5,715	4,766	8	7
15	City of Folsom	10	0	1	0
16	Arden Cordova	380	303	1	1
30	Fothills North	1,981	3,610	3	5
37	EGWS	0	0	0	0
43	Rosemont – Cal Am	34	0	1	0
Zone 40					
13	Sunrise Douglas – SCWA	145	3,012	1	4
14	Security Park – Cal Am	5	54	1	1
23	Sunrise – SCWA	0	0	0	0
36	Laguna / Franklin – SCWA	10,265	154	14	1
38	SCWA / EGWS Retail	7,209	242	10	1
39	Vineyard – SCWA	7,425	1,479	10	2
40	N. Vineyard in POU - SCWA	1,644	0	3	0
41	N. Vineyard Out POU – SCWA	1,620	0	3	0
42	Mather	105	0	1	0
	Total	**171,632**	**144,213**	**235**	**194**

Table 3.2 – Estimated number of rural domestic wells in Central Sacramento County

Subregion		2000 Ag Residential Land Use	2030 Ag Residential + General Plan Ag Residential Land Use	2000 Rural Domestic Wells	2030 Rural Domestic Wells
Number	Name	(Acres)	(AF)	(wells)	(wells)
	Central Area				
2	South Sacramento	9	1	8	1
3	Omochumne-Hartnell North	897	1,240	718	992
4	Southwest	195	868	156	695
10	Omochumne-Hartnell	804	2,367	644	1,894
11	Rancho Murieta	580	0	464	0
12	Sunrise "A" – SCWA	74	69	60	56
15	City of Folsom	21	4	17	4
16	Arden Cordova	0	0	0	0
30	Fothills North	143	1,018	115	815
37	EGWS	0	0	0	0
43	Rosemont – Cal Am	0	0	0	0
	Zone 40				
13	Sunrise Douglas – SCWA	9	0	8	0
14	Security Park – Cal Am	2	1	2	1
23	Sunrise – SCWA	0	0	0	0
36	Laguna/Franklin – SCWA	50	12	40	10
38	SCWA/EGWS Retail	1,953	1,720	1,563	1,376
39	Vineyard – SCWA	2,225	2,400	1,780	1,920
40	N. Vineyard in POU - SCWA	301	8	241	7
41	N. Vineyard Out POU – SCWA	87	511	70	409
42	Mather	28	0	23	0
	Total	**7,378**	**10,219**	**5,909**	**8,180**

The number of rural domestic wells in each subregion is obtained by dividing the agricultural residential land use by the area covered by each well (1.25 acres). The estimated number of rural domestic wells in Central Sacramento County is presented in Table 3.2. The majority of the rural domestic wells are in Omochumne-Hartnell North (Subregion 3), Southwest (Subregion 4), and Omochumne-Hartnell (Subregion 10), Rancho Murrieta (Subregion 11), SCWA / EGWS Retail (Subregion 38), Vineyard-SCWA (Subregion 39) subregions along Cosumnes River and in the middle of Zone 40. The estimated total number of rural domestic wells in Central Sacramento County with 2000 Baseline conditions is 5,909 wells and increases to 8,180 wells with 2030 Baseline conditions. This is due to increased acreage of agricultural residential land use in the 2030 Baseline conditions.

4. IMPACTED WELLS

Impacts associated with groundwater level decline analyzed in this study include pump bowl lowering, well deepening, and well replacement. The location of water level in relation to the pump bowl and the bottom of the well indicates the level of impact on a well. If the declining water levels remain above the pump bowl, the well would remain in operation. If the water levels drop below the pump bowl, depending on the magnitude of decline, the following impact categories or thresholds may be used:

- Threshold 1 – Lowering the pump bowl,
- Threshold 2 – Deepening the well, or
- Threshold 3 – Replacing the well.

The groundwater levels during the 26-year hydrologic sequence were analyzed at each well location, under each scenario. The lowest groundwater level over time was selected for comparison with the available well depth data. The above impact criteria were used to determine if a well is impacted by the particular scenario.

4.1. IMPACT CRITERIA

Threshold 1 – Lowering the Pump Bowl

If the groundwater level drops below the pump bowl then the pump cannot operate and the pump bowl should be lowered. However, there is a limit on how much the pump bowl could be lowered. The pump cannot operate at the bottom of the well and has to be at least 10 feet above the bottom of the well. The pump bowls are typically installed 50 feet above the bottom of the wells. Thus, the pump lowering threshold is used when the lowest groundwater level at a well location is between 50 feet above the bottom of the well to 10 feet above the bottom of the well. In this situation, it is assumed that the well remains operable and should not be deepened, however, the pump bowl needs to be lowered.

Threshold 2 – Deepening the Well

A well is expected to be deepened if the distance between the bottom of the well and the groundwater levels above the bottom of the well is less than 10 feet. By deepening the well, the pump bowl can be

lowered to a new operational depth. A well is considered a candidate for deepening if the lowest groundwater level at that well is between 10 feet above the bottom of the well and 30 feet below the bottom of the well. It is our understanding that most irrigation and domestic wells in Central Basin were drilled by cable-tool method. With cable-tool method the hole is usually drilled deeper than the casing to allow water to flow from bottom into the well. These wells could be deepened without significant technical difficulties.

Threshold 3 – Replacing the Well

If the lowest groundwater level at a well is 30 feet or more below the bottom of the well then, rather than deepening the well, it is economical to replace the well. The well replacement criterion is defined as the lowest groundwater levels to be more than 30 feet below the bottom of the well.

4.2. NUMBER OF IMPACTED WELLS

A well may be affected by multiple impacts. It may require pump bowl lowering at first, then require well deepening. If the water levels continue to drop then the well may need to be replaced. The analysis of this study assumes that only one type of impact will be applied to any well. The impact criteria will be evaluated for the lowest groundwater level at each well and the worst impact will be selected. The impact cost is based on the worst condition at each well and does not represent the sum of all possible impacts at the wells.

The wells with bottom depth elevations in each subregion of Central Sacramento County are the sample wells of each subregion (Figure 2.1 and Table 2.3). The estimated total numbers of agricultural and rural domestic wells are presented in Tables 3.1 and 3.2. These wells are the population wells of each subregion. The impact criteria are applied to the wells with bottom depth elevations (sample wells) of each subregion. The ratio of the impacted sample wells of each subregion to the total sample wells of that subregion is the subregion's impact ratio. The total number of impacted wells of any subregion is determined by multiplying the impact ratio of the subregion by the number of population wells of the subregion. The following equations were used to estimate the number of impacted wells:

$$\text{Impact Ratio } (IR_i) = (\text{Impacted Sample Wells})_i \;/\; (\text{Total Sample Wells})_i \text{ , and}$$

$$\text{Impacted Wells}_i = IR_i * (\text{Total Population Wells})_i \text{ ,}$$

where

i = subregion index.

The numbers of impacted agricultural and rural domestic wells for each threshold are presented in Table 4.1. For subregions with sample wells less than 10% of the population wells, the average impact ratio of the subregion and the neighboring subregions is used. The impact analysis was performed for agricultural and rural domestic wells independently. The locations of the impacted sample wells for

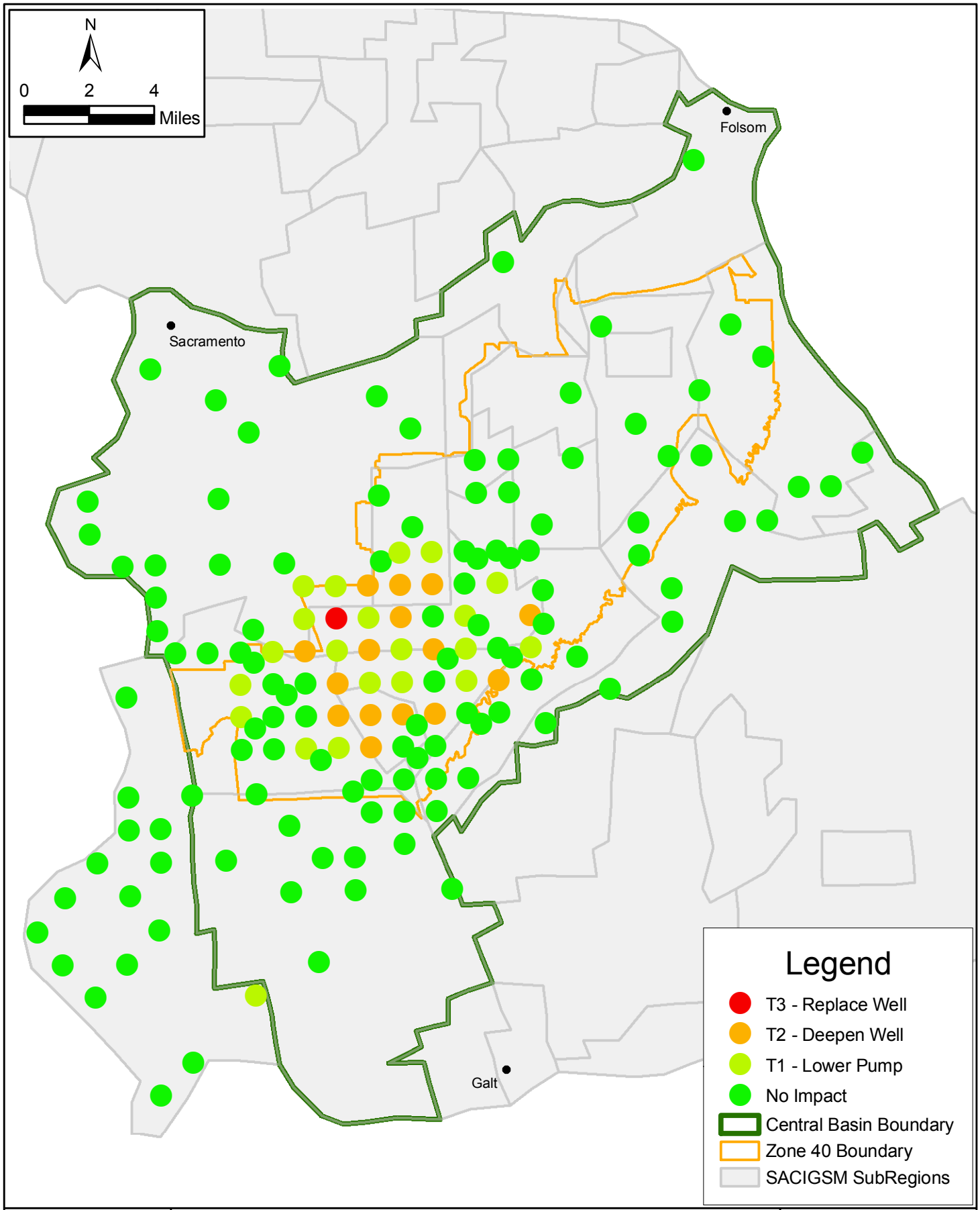
the three future scenarios are presented in Figures 4.1 to 4.3. Majority of the impacted sample wells occur in the southern parts of Zone 40.

Table 4.1 – Number of Impacted Wells

Impact Criteria	Agricultural Wells			Rural Domestic Wells		
	A-No Project	B–Proposed Project	C-Reduced Surface Water Availability	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
Lower Pump Bowl	2	1	3	95	48	142
Deepen Well	0	0	0	61	43	83
Replace Well	0	0	0	8	8	27
Total	**2**	**1**	**3**	**164**	**99**	**252**

4.3. IMPACT COST

The Well Protection Plan of Central Sacramento County covers the pump lowering, well deepening, and well replacement impact costs. The unit costs of the well deepening and well replacement are presented in Table 2.2. These unit costs are multiplied by the number of impacted wells from Table 4.1 to obtain the impact cost for the Central Sacramento County (Table 4.2). The Reduced Surface Water Availability scenario has the highest impact costs while the Proposed Project scenario result in the lowest impact cost. The reduced available surface water and increased groundwater pumping of the Reduced Surface Water Availability scenario result in $20,000 increase in impact cost of the agricultural wells and $674,000 increase in impact cost of the rural domestic wells.



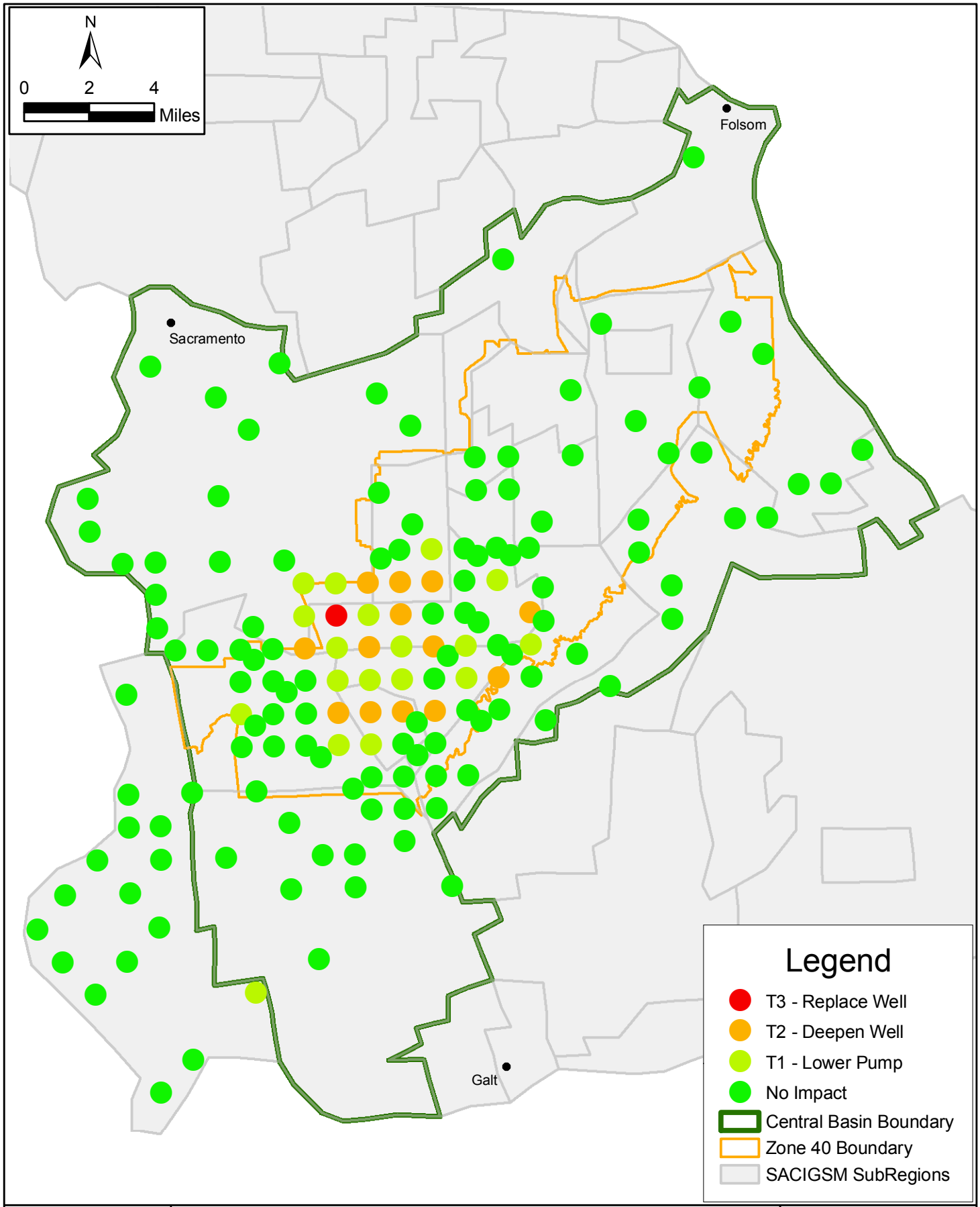
WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Location of Impacted Sample Wells Under No Project Scenario

November 2005

Figure 4.1



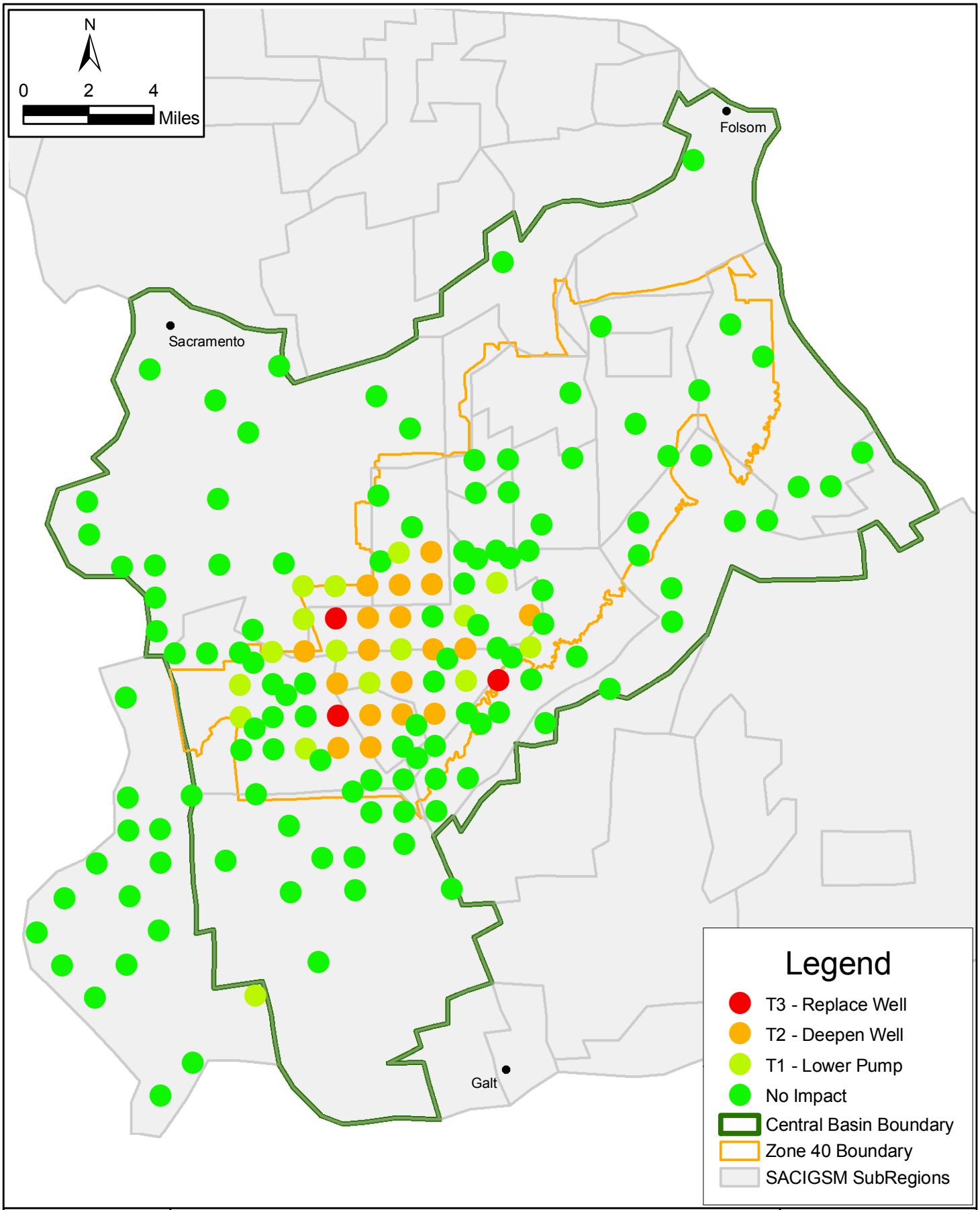
WRIME

Central Sacramento Groundwater Basin
Well Impact Analysis

Location of Impacted Sample Wells Under Proposed Project Scenario

November 2005

Figure 4.2



Central Sacramento Groundwater Basin
Well Impact Analysis

Location of Impacted Sample Wells Under Reduced Surface Water Availability Scenario

November 2005

Figure 4.3

TABLE 4.2 – AGRICULTURAL AND DOMESTIC RURAL WELLS IMPACT COSTS FOR THE CENTRAL SACRAMENTO COUNTY

Impact	Agricultural Wells			Rural Domestic Wells		
	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability	A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
Lower Pump Bowl	$20,000	$10,000	$30,000	$95,000	$48,000	$142,000
Deepen Well	0	0	0	$305,000	$215,000	$415,000
Replace Well	0	0	0	$160,000	$160,000	$540,000
Subtotal	**$20,000**	**$10,000**	**$30,000**	**$560,000**	**$423,000**	**$1,097,000**
				A-No Project	B-Proposed Project	C-Reduced Surface Water Availability
Total Impact Costs for Ag and Rural Domestic Wells				**$580,000**	**$433,000**	**$1,127,000**

5. REFERENCES

Feeney, Martin. 2005. *Personal communications.* Consulting Hydrogeologist.

Montgomery Watson. 1997. *Phase II – Groundwater Yield Analysis, Technical Memorandum No. 2 – Impacts Analysis.* Sacramento County Water Agency.

MWH. 2005. *Central Sacramento Well Log Database.*

Shatz, Richard. 2005. *Personal communications.* Bookman-Edmonston Consulting.

Worster, Ken. 2005. *Personal communications.* Brown and Caldwell.

WRIME. 2004. *Hydrologic and Modeling Analysis for Zone 40 Water Supply Master Plan*. Sacramento County Water Agency.

Appendix F

Trial Balloon on Water Quality Collaboration Program

CENTRAL SACRAMENTO COUNTY GROUNDWATER FORUM

Trial Balloon on Groundwater Contamination;
Final recommendations negotiated by the CSCGF

---

1. Groundwater contamination and remediation of contaminated groundwater in the Central Basin must be addressed *proactively*. Water purveyors, regulatory agencies, Responsible Parties* and the Water Forum Successor Effort should meet on a regular basis to share information and develop strategies to collaborate on drinking water supplies and cleanup activities. These collaborative strategies should be designed to minimize negative impacts on other water resources and water users. (*Responsible Parties are defined in federal legislation: 42 U.S.C. Sec. 9607 (a)).

   NOTE: At such time as the management entity for the Central Sacramento County Groundwater Basin has been established, representatives of that entity should also be included in these discussions.

2. The Water Forum Successor Effort should undertake a high priority effort to persuade Sacramento County, the cities of Elk Grove, Rancho Cordova and Sacramento (as well as the cities of Citrus Heights, Folsom and Galt) to adopt policies that encourage the use of remediated water for non-potable purposes. .

3. The Central Valley Regional Water Quality Control Board requires Responsible Parties to identify all wells within 2000 feet of any known plume of contamination in the Central Basin. For those wells that the responsible lead agency* has determined are threatened by contamination, that agency should require the Responsible Parties to implement a sampling plan for the impacted well(s), including frequency of sampling, chemicals, reporting requirements, etc. (* The

lead agency is that agency which is responsible for directing the mitigation activities associated with a specific contamination release.)

4. The Sacramento County Environmental Management Department (EMD) should establish and maintain an information clearing house to assist individual well owners in addressing contamination concerns: e.g., how to get a well tested, by whom, for what, options if contamination is found, etc. This should include use of a web-page where information can be found with links to other organizations such as the Water Forum.

5. EMD should undertake a concerted effort to inform individual well owners of the importance of testing/monitoring water quality in their wells through a variety of public education tools including (but not limited to) a brochure provided to all applicants as part of the well permitting procedure.

6. EMD should collaborate with the Central Valley Regional Water Quality Control Board and other regulatory agencies to maintain up-to-date information on contamination sources in the Central Basin.

7. The Environmental Management Department, which is responsible for permitting wells, should exercise the strictest vigilance to ensure that all requirements of the well ordinance are enforced. If requirements are not met, EMD should undertake whatever rigorous enforcement actions are available and effective in the given circumstances.

Appendix 1-B

Memorandum of Understanding Establishing a South American Subbasin SGMA Working Group and Identifying Cost Share Provisions for GSP Development (May 13, 2020)

Memorandum of Understanding
Establishing a South American Subbasin SGMA Working Group and Identifying Cost Share Provisions for GSP Development

This Memorandum of Understanding ("**MOU**") is entered into and effective this 13th day of May, 2020 by and among the County of Sacramento, a political subdivision of the State of California; Sacramento Central Groundwater Authority (SCGA), a joint powers authority; Northern Delta Groundwater Sustainability Agency (NDGSA), a joint powers authority; Omochumne-Hartnell Water District (OHWD), a California Water District; and Sloughhouse Resource Conservation District, (SRCD) a California Resource Conservation District. (each a "**Party**" and collectively, the "**Parties**.")

RECITALS

WHEREAS, the 2014 Sustainable Groundwater Management Act ("**SGMA**") empowers local agencies to adopt and implement groundwater sustainability plans ("**GSPs**") in order to provide for the sustainable management of groundwater basins; and

WHEREAS, SGMA recognizes and supports the primacy of local agencies in managing groundwater within their boundaries, and promotes coordination and collaboration among those local agencies in order to ensure sustainable groundwater management; and

WHEREAS, the Sacramento Valley- South American Sub-basin ("**Basin**") is an un-adjudicated groundwater basin that has been classified as a High Priority basin by the California Department of Water Resources ("**DWR**"), and which therefore must be governed by a GSP, or coordinated GSPs, no later than January 31, 2022; and

WHEREAS, each of the Parties is a local agency within the meaning of Water Code section 10721(m) with authority to adopt and implement a GSP in the Basin; and

WHEREAS, certain of the Parties have elected to serve as GSA in the same areas of the Basin, such that a condition of overlap exists in those service areas; and

WHEREAS, pursuant to County Resolution 2017-0201, the County of Sacramento has accepted responsibility for those portions of the Basin for which no exclusive GSA has been designated ("**Unmanaged Areas**"), such that the entire basin is included within the jurisdiction of a GSA; and

WHEREAS, Sacramento Central Groundwater Authority was awarded a grant under Proposition 1 and a grant under Prop 68 to fund the development of a GSP in the Basin; and

WHEREAS, it is the intent of the Parties to coordinate in the development and implementation of a single Basin-wide GSP; to provide a structure in which to collaborate and share costs in the development of that GSP; and to ensure that each Party appropriately bears the costs of GSP development in its own jurisdiction, and no others.

AGREEMENT

1. Definitions. The following terms shall have the following meanings.

(a) "Administrative Agency" means the entity designated under Section 8 of this MOU to administer the Grant, coordinate with consultants on behalf of the Parties and at the direction of the Working Group, and invoice costs pursuant to this MOU.

(b) "Basin" means the Sacramento Valley – South American Subbasin, as described in DWR Bulletin 118, Basin No. Basin 5-21.65.

(c) "GSA" means a Groundwater Sustainability Agency, established and authorizes pursuant to Water Code section 10723.8.

(d) "GSP" means a Groundwater Sustainability Plan developed under the Sustainable Groundwater Management Act.

(e) "Unmanaged Areas" means those portions of the Basin for which the County, in the absence of any other GSA election, has accepted responsibility as a GSA pursuant to County Resolution No. 2017-0201. For purposes of cost sharing and Working Group governance, the County's allocable area shall include only the Unmanaged Areas, excepting therefrom areas within SRCD/OHWD's jurisdiction.

(f) "Working Group" means the South American Subbasin Working Group, convened pursuant to this MOU for the purposes of developing and providing recommendations related to a SGMA-compliant GSP for the Basin.

2. **Term.** This MOU shall be effective upon signing and shall remain in full force and effect until the date upon which all of the Parties execute a document jointly amending or terminating the provisions of this MOU.

3. **Responsibilities of the Parties.** Each Party to this MOU shall be responsible for: providing timely responses and supporting information related to GSP development to the Working Group and Administrative Agency upon request; performing appropriate and coordinated outreach to other groundwater management entities and stakeholders within the Basin; promptly paying all invoiced costs as set forth in Exhibit A; and for considering and adopting a SGMA-compliant GSP over the area for which that Party serves as exclusive GSA, no later than January 31, 2022.

4. **Independent Consideration of the GSP.** The Parties expressly acknowledge that the Working Group is an advisory body intended to facilitate GSP development. The governing Board of each GSA is responsible for considering and adopting an appropriate GSP for its jurisdictional boundaries. Any Party may decline to adopt the GSP developed by the Working Group, or elect to proceed with development of its own GSP at that Party's expense. The decision not to adopt a GSP developed under this MOU shall not relieve a Party of its cost obligations pursuant to this MOU.

5. **Management Areas**. The parties recognize that the GSP may include distinct management areas to foster implementation and monitoring

6. **Establishment of the South American Subbasin SGMA Working Group.** Upon execution of this MOU, the Parties will convene the South American Subbasin SGMA Working Group ("**Working Group**"). Seats on the Working Group shall be allocated among the Parties as detailed in Exhibit A.

(a) The Working Group shall be responsible for sharing feedback from the Parties related to the GSP development; for developing the GSP for the Basin; and for making recommendations to the Parties regarding the adoption and development of the GSP.

(b) The Working Group will seek to make decisions through consensus. In the absence of a consensus, participants of the Working Group may be called upon to cast votes. Recommendations of the Working Group provided to the Parties shall include a report of the votes cast.

7. **Cost Sharing.** Shared costs of GSP development shall be allocated according to the proportions identified in Exhibit A. When any additional Party becomes a signatory to this MOU, the cost share proportions identified in Exhibit A shall be modified to appropriately distribute GSP development costs between the new and existing Parties, according to the formula identified in Exhibit A.

- In Kind Contributions are appropriate and recognized as satisfactory to meet the cost share requirements of a party to this agreement.

- Nothing in this MOU shall prevent a Party from voluntarily incurring its own costs related to GSP development, or from developing its own GSP or supporting materials at that Party's expense.

- Any in-kind contributions proposed to be substituted for monetary reimbursement of Assignable GSP Development Costs (Exhibit A) must be approved by the Administering Agency and, further, be consistent with the grant agreement between the Administering Agency and DWR.

8. **Responsibilities of the Administrative Agency.** The Administrative Agency shall be responsible for implementing the recommendations of the Working Group in GSP development; engaging and providing direction to consultants at the election and direction of the Working Group; and administering the grants for the benefit of the Basin. Costs of GSP development shall be distributed pursuant to Exhibit A and shall be recoverable by the Administrative Agency from the Parties in the proportions identified in Exhibit A.

(a) SCGA shall be initially designated as the Administrative Agency; this designation may be altered by the unanimous written consent of the Parties. The commitment

of the Administrative Agency to perform the designated functions under this Section is contingent upon the execution and performance of the cost sharing terms of this MOU.

9. **Invoicing and Payment of Shared GSP Development Cash Costs**. Costs of GSP development as set forth in Exhibit A, shall be invoiced to all Parties by the Administrative Agency, and paid by the invoiced Party within 90 days. A Party that fails to make payment within 90 days may be suspended from voting on Working Group recommendations until full payment of the past-due invoices is made. Activities of the Working Group will not be delayed under such an occurrence and costs incurred by the Working Group will still accrue to the Party as set forth in Exhibit A, during any period of non-payment.

10. **Basin Boundary Modifications**. To facilitate the efficient development of a GSP for the Basin, that Parties agree that no Party shall submit a request for Basin Boundary Modification of this Basin to DWR without the unanimous consent of the Parties, which consent shall not be unreasonably withheld.

11. **Withdrawal**. The intent of this agreement is for a spirit of working together for a single Basin-wide GSP. However, any party may unilaterally withdraw from this Agreement without causing or requiring termination of this Agreement by the following provisions.

a) The withdrawing Party shall provide the Working Group with thirty (30) days prior written notice.
b) The withdrawing Party shall be responsible for payment of its proportional share of costs and obligations associated with GSP development identified in Attachment A, up to the time of submission of the written notice of the withdrawal. Withdrawing party would be responsible for securing and funding consultants to develop and submit any amendments or revisions to the GSP required as a result of withdrawal.
c) The withdrawing party shall be responsible for securing SGMA compliance within its jurisdictional boundaries at its own expense, including as necessary, GSP development, coordination, and the cost of any additional requirements imposed by DWR or other regulatory agencies.

The withdrawing party shall be responsible for providing notice, maps and all other necessary information to the DWR and other GSAs regarding its change in status within 30 days of withdrawal.

12. **Resolution of Overlap: OHWD/SCGA**. Upon execution of this MOU, SCGA will modify its current overlapping GSA notification in OHWD's service area (SCGA-GSA-2) to exclude all of OHWD service area, except the area defined as the Kiefer Landfill. OHWD will modify their current overlapping GSA notification to exclude that area defined as Kiefer landfill. Modifications of each party will include all necessary geospatial information needed to identify the new service area boundary for each party. Immediately prior to modifying these notifications, SCGA and OHWD will attach separate letters to their existing notification

explaining why their notifications are being modified. OHWD will formally request that SCGA modify its governing joint powers agreement in order to remove OHWD's lands from SCGA's jurisdiction. SCGA will promptly request that the signatories to that agreement execute an amendment to that agreement to carry out the removal.

(a) For the term of plan development, Zone 13 funding currently provided to SCGA on behalf of OHWD shall be applied by SCGA as a credit toward any costs billed to OHWD under Section 7 of this MOU.

13. **Resolution of Overlap: OHWD/SRCD**. Upon execution of this MOU, SRCD will withdraw their overlapping GSA notification in OHWD's service area (SCGA-2). Immediately prior to withdrawing their notification, SRCD will attach a letter explaining why their current notification is being withdrawn.

14. **Resolution of Overlap and Redefining GSA Boundaries: SCGA/SRCD**. Upon execution of this MOU, SCGA and SRCD will modify their current GSA notifications for SCGA-GSA-3 to reflect this agreement. SCGA will modify their notice to describe and map an area of SCGA-GSA-3 that includes all lands to the eastern boundary of "Zone 40" (Urban limit), and all land within the limits of the Kiefer Landfill, as part of SCGAs GSA service area. SRCD will modify their current notification for SCGA-GSA-3 to describe and map an area east of the Zone 40 boundary and east of the OHWD boundary, and excluding Kiefer Landfill and Rancho Murieta CSD, as the SRCD GSA service area. All South American subbasin land within the Rancho Murieta Community Services District will remain a part of the Sacramento County GSA until such time that the RMCSD Board of Directors makes a formal decision to be included within the boundaries of another GSA. Notice modifications of each party will include all necessary geospatial information needed to identify the new service area boundary for each party. Sacramento County will need to modify their default notice for SCGA-GSA-3 to complete the process.

(a) For the term of plan development, Zone 13 funds collected within SRCDs GSA boundary shall be applied as a credit toward any costs billed to SRCD under Section 7 of this MOU.

15. **Disputes**. The Working Group is committed to working towards consensus in all decisions to be made regarding development of the GSP. With the help of a third-party facilitator, the Parties agree to put a good faith effort into transparently raising any concerns, understanding one another's interests, and working towards solutions that will adequately meet the needs of all Parties.

All claims, disputes, and controversies arising out of or in relation to the performance, interpretation, application, or enforcement of this agreement, including but not limited to breach thereof, shall be referred to mediation before, and as a condition precedent to, the initiation of any adjudicative action or legal proceeding, including arbitration. The Parties covenant that they will participate in the mediation in good faith. Mediation will be

conducted in Sacramento County, California, unless otherwise agreed to by the Parties in writing. The mediator shall be mutually selected.

16. **No Alternation of Water Rights**. Consistent with Water Code sections 10720.1(b), 10720.5 and 10726.8, nothing in this Agreement or in its implementation shall be construed to alter the existing water rights of the Parties.

GENERAL PROVISIONS

17. *Authority*. Each signatory of this MOU represents that s/he is authorized to execute this MOU on behalf of the Party for which s/he signs. Each Party represents that it has legal authority to enter into this MOU and to perform all obligations under this MOU.

18. *Amendment*. This MOU may be amended or modified only by a written instrument executed by each of the Parties.

19. *Jurisdiction and Venue*. This MOU shall be governed by and construed in accordance with the laws of the State of California, except for its conflicts of law rules. Any suit, action, or proceeding brought under the scope of this MOU shall be brought and maintained to the extent allowed by law in Sacramento County, California.

20. *Headings*. The paragraph headings used in this MOU are intended for convenience only and shall not be used in interpreting this MOU or in determining any of the rights or obligations of the Parties.

21. *Construction and Interpretation*. This MOU has been arrived at through negotiations and each Party has had a full and fair opportunity to revise the terms of this MOU. As a result, the normal rule of construction that any ambiguities are to be resolved against the drafting Party shall not apply in the construction or interpretation of this MOU.

22. *Entire Agreement*. This MOU constitutes the entire agreement of the Parties with respect to the subject matter of this MOU and supersedes any prior oral or written agreement, understanding, or representation relating to the subject matter of this MOU.

23. *Partial Invalidity*. If, after the date of execution of this MOU, any provision of this MOU is held to be illegal, invalid, or unenforceable under present or future laws effective during the term of this MOU, such provision shall be fully severable. However, in lieu thereof, there shall be added a provision as similar in terms to such illegal, invalid or unenforceable provision as may be possible and be legal, valid and enforceable.

24. *Successors and Assigns*. This MOU shall be binding on and inure to the benefit of the successors and assigns of the respective Parties. No Party may assign its interests in or obligations under this MOU without the written consent of the other Parties, which consent shall not be unreasonably withheld or delayed.

25. *Waivers*. Waiver of any breach or default hereunder shall not constitute a continuing waiver or a waiver of any subsequent breach either of the same or of another provision of this MOU and forbearance to enforce one or more of the remedies provided in this MOU shall not be deemed to be a waiver of that remedy.

26. *Attorneys' Fees and Costs*. In the event of a dispute between the Parties, each Party will pay their own attorneys' fees, expert witnesses' fees, costs of suit, and any other costs associated with the dispute.

27. *Necessary Actions*. Each Party agrees to execute and deliver additional documents and instruments and to take any additional actions as may be reasonably required to carry out the purposes of this MOU.

28. *Compliance with Law*. In performing their respective obligations under this MOU, the Parties shall comply with and conform to all applicable laws, rules, regulations and ordinances.

29. *Third Party Beneficiaries*. This MOU shall not create any right or interest in any non-Party or in any member of the public as a third party beneficiary.

30. *Counterparts*. This MOU may be executed in one or more counterparts, each of which shall be deemed to be an original, but all of which together shall constitute but one and the same instrument.

31. *Notices*. All notices, requests, demands or other communications required or permitted under this MOU shall be in writing unless provided otherwise in this MOU and shall be deemed to have been duly given and received on: (i) the date of service if served personally or served by electronic mail or facsimile transmission on the Party to whom notice is to be given at the address(es) provided below, (ii) on the first day after mailing, if mailed by Federal Express, U.S. Express Mail, or other similar overnight courier service, postage prepaid, and addressed as provided below, or (iii) on the third day after mailing if mailed to the Party to whom notice is to be given by first class mail, registered or certified, postage prepaid, addressed as follows:

EXHIBIT A: Working Group Membership & Cost Allocation

Party	Working Group Members	Assignable GSP Development Costs *
County of Sacramento	1 Representative	8% of agreed to amount Estimate= $88,247.36
Omochumne-Hartnell Water District	2 Representatives	17% of agreed to amount, to be paid first from Zone 13 funds during development of the GSP Estimate= $187,525.64
Sacramento Central Groundwater Authority	7 Representatives, including: • No more than 5 representatives that are signatories to the SCGA joint powers agreement; public water systems; commercial industrial self supplied interests; or sanitation districts. • At least 2 representatives of Agriculture, Ag-residential self supplied public agencies or Conservation Landowner interests	63% of agreed to amount Estimate= $694,947.96
Northern Delta Groundwater Sustainability Agency	1 Representative	8% of agreed to amount Estimate= $88,247.36
Sloughhouse Resource Conservation District	1 Representative	4% of agreed to amount, to be paid first from Zone 13 funds. Cash Cost estimate=$20,000

Sloughhouse RCD (Con't)		Zone 13 estimate= $25,000 Estimate= $ 44,123.68

. Assignable GSP development Costs are based on matching cost requirements of a Prop 1 grant funds (50% match) and Prop 68 grant fund (25% match).

IN WITNESS WHERE OF, the parties have caused this agreement to be duly executed upon signature.

Brad Van Loben Sels, Board Chairperson
Northern Delta Groundwater Sustainability Agency

Date

Kurt Kautz, Board Chairperson
Omochumne-Hartnell Water District

Date

Todd Eising, Board Chairperson
Sacramento Central Groundwater Authority

July 1st 2020
Date

Michael Peterson, Director
Sacramento County Department of Water Resources

Date

Jay Schneider, Chairperson
Sloughhouse Resource Conservation District

Date

South American
SUBBASIN

Appendix 1-C

Partnering Commitment + Guiding Principles
(May 22, 2020)

PARTNERING COMMITMENT + GUIDING PRINCIPLES
South American Subbasin (SASb) Groundwater Sustainability Plan Working Group
MAY 22, 2020

1.0 PURPOSE

These Principles for engagement and operation of the Groundwater Sustainability Plan (GSP) Working Group (Working Group) are intended to provide a framework of agreements among the members to work collaboratively, efficiently, and with the necessary dedication to promote the development, adoption and submission of a Sustainable Groundwater Management Act (SCGA) compliant GSP by the statutory deadline of January 31, 2022.

The Principles derive from and include by reference the *Memorandum of Understanding Establishing a South American Subbasin SGMA Working Group and Identifying Cost Share Provisions for GSP Development,* which is attached as Exhibit A.

2.0 GSP PARTIES

Following are the core parties responsible for delivering the SASb GSP:

Groundwater Sustainability Agencies' (GSAs) Boards of Directors

The five GSAs have respective Boards that have Working Group Members as assigned below.

Groundwater Sustainability Plan Working Group Membership

Northern Delta GSA – 1 member
- Erik Ringelberg, primary
- Chris Thomas, Alternate

Omochumne Hartnell Water District – 2 members
- Mike Wackman
- Mark Stretars
- Mark Wilson, Alternate

Sacramento Central Groundwater Authority (SCGA) – 7 members
- Todd Eising
- Paul Schubert
- Mark Madison
- Evan Jacobs
- Dave Ocenosak
- Ted Rauh
- Christine Thompson

Sacramento County – 1 member
- Linda Dorn
- Kerry Schmitz, Alternate

Sloughhouse Resource Conservation District – 1 member
- Austin Miller

- Herb Garmes, Alternate

GSP Administrating Agency

Sacramento Central Groundwater Authority

- John Woodling, Interim Executive Director, SCGA
- Bob Gardner
- Jonathan Goetz
- Ramon Roybal

Consultants Team

Larry Walker Associates

- Tom Grovhoug
- Laura Foglia
- Stephen Maples
    - **SEI**
        - Marisa Escobar
    - **KJ**
        - Sachi Itagaki
        - Jennifer Lau Larsen

Woodard & Curran

- Ali Taghavi
- Brian Van Lieden
- Jim Blanke
    - **Strategy Driver**
        - Ellen Cross
    - **HDR**
        - Shawn Koorn
        - Jafar Faghih

3.0 RESPONSIBILITIES

The primary responsibilities of each party to the GSP Team are identified below.

Respective GSAs' Boards

Each respective Board for the five GSAs will be responsible for:

- Ensuring appropriate communication and engagement is executed per the approved Communication and Engagement (C&E) Plan on behalf of their GSAs.
- Accepting interim milestone approvals to meet the mandated schedule of the Final GSP.
- Being informed about the GSP by their designated Working Group Members listed above.
- Informing their respective Working Group Members with their insights, perspectives, and opinions.
- Ultimately adopting an acceptable final GSP to deliver for DWR review by January 2022.

Working Group

The Working Group members shall be responsible for:

- Sharing feedback from their respective GSA's related to the GSP development.
- Making recommendations to their GSA regarding the consideration and adoption of the GSP.
- Providing or ensuring the provision of timely responses and supporting information related to GSP development to the Consultants, Working Group and Administrative Agency upon request in order to meet the state mandated GSP deadline.
- Performing and supporting appropriate and coordinated outreach to other stakeholders within the Basin.
- Ultimately delivering an acceptable GSP to all GSAs for adoption.

GSP Administrating Agency

SCGA Staff will be responsible for:

- Being the point of contact for the Working Group to coordinate with the Consultants.
- Overseeing the Consultants in the delivery of the GSP scope of work and budget per the contract.
- Ensuring grant obligations are met and reimbursements received.
- Delivering GSP priorities within the state mandated GSP schedule.

Consultants

Each member of the Consultant Team will be responsible for:

- Ensuring the delivery of the GSP Scope of Work on time and within the budget per the contract.

Collective Outreach and Engagement Responsibilities

To foster the consideration of the beneficial uses and users of groundwater in the subbasin, the Working Group members agree to the following:

- Parties are committed to an inclusive and transparent process that proactively seeks the engagement and input of potentially impacted parties as identified in SGMA. Parties will work to develop protocols for public engagement, both at public workshops and during regular Working Group meetings.
- Parties will work collectively to develop an agreed-upon outreach plan, but each GSA is responsible for helping to guide and implement efforts within their respective jurisdictions.
- Parties recognize the value in developing shared messages to ensure consistency; joint participation in outreach efforts is encouraged to foster consistency in message and concretely demonstrate the parties' coordinated effort.
- Parties recognize the need to conduct outreach in the near-term to better understand additional representation needs (e.g., environmental, tribal, riparian water users, overlying water users, disadvantaged communities (DACs) etc.) beyond the signatories to this agreement.

4.0 DECISION MAKING

Pursuant to the MOU, the Working Group will seek to make decisions through consensus. In the absence of a consensus, participants of the Working Group may be called upon to cast votes. Recommendations of the Working Group provided to the GSAs shall include a report of the votes cast.

With respect to voting procedures:

- Each Member commits to make a genuine effort to achieve consensus. Consensus is the preferred method for reaching agreement; voting is a last resort.
- Members from the OHWD GSA and SCGA GSA may vote by proxy provided in writing to another member from their respective GSA.
- Members who are the sole representative of their GSA (representing SRCD GSA, Sacramento County GSA and North Delta GSA) should identify an alternate to attend the meetings of the Working Group and vote on their behalf if they are unavailable.

5.0 SUCCESS FACTORS + BARRIERS TO SUCCESS + MITIGATING

SUCCESS	BARRIERS TO SUCCESS	MITIGATION
GOVERNANCE		
• Everyone is heard with equal voice and full participation	• Voting with an even number of participants	• Build consensus through discussion to envision success
• Understand flexibility and local needs – different demands for each	• Individual GSA Boards must buy in – waiting until the end or not knowing what has gone into the decision making will be problematic	• WG members needs to be the Liaisons and Advocates between the WG and the GSA Boards (e.g. build on successful MOU process that built trust)
• Understand where public will engage, actively outreach and communicate with them	• Public Meetings and how will play in with meetings and Boards	• Resolve issues of public meetings for the Working Group • Lay out public meeting schedule in C&E Plan
• Need to express positions of respective Boards of GSAs	• Understand that these are not personal or agency positions/decisions of the individuals; rather the position of the respective	• Need to articulate the nuances and technical challenges to the Boards • The decision by respective Boards will need to be carried forth

	GSA Boards	• Need to find consensus recommendations within the WG that can be carried to the Boards; but ultimately the Boards have the decision making authority. • Bring back the Boards' decisions and barriers to success • Have rigorous discussion with your respective Boards
• Working together to meet the schedule and any barriers to schedule	• Holding back information or barriers to success	• Possibly provide a Third Party outside of this group that is independent to help us if consensus process does not work
• Engage all interested parties / stakeholders including the public and electeds' early	• Dealing with mostly Staff vs Electeds on GSPWG – we may put together a good GSP but have uninformed participants that undermine the process.	• Need to make sure we bring the Electeds and other key stakeholders along and address concerns early (meet with them; educate them; same constituents)
STAKEHOLDERS		
• Getting Public Understanding	• Work with the public and provide a forum with the WG • Also provide a forum for the WG to work through issues before bringing to the public – we must work quickly and meaningfully while keeping the public informed and engaged at key milestones	• We should treat ourselves as an "ad hoc" – we need to build trust with the stakeholders and involve them in the GSP – need a mechanism so interested parties can "listen" through a mechanism so they know what is going on in the WG.
• Clearly state in the C&E Plan, how and when the public will be engaged	• Inconsistent messaging and engagement with the stakeholders	• Need to educate Public on how they will potentially benefit/be impacted and that we have a consistent

		message while building the GSP and distributed by all the Boards to set the stage for acceptance.
• A well informed public and stakeholders understand the process and can provide input	• Not bringing all the stakeholders along and not being transparent or providing the ability for input	• Set up an independent webpage that includes the technical documents / presentations / next meetings for the public
• Coordinating with adjacent basins to ensure there are no conflicts in information, sustainable criteria or actions	• Interbasin relationships, information or conflicts are not resolved.	• Need to find ways to coordinate alignment with adjacent basins so there are not differing answers / e.g. outcomes to the sustainable criteria
• Keep DWR engaged on the GSP process and asking them to observe so they know why and how we came up with our GSP to prevent any future obstacles	• DWR is not involved	• Engage Chelsea and new Grant Administrator engaged from the start (N American Subbasin with a co-worker) • Keep the Grant Administrator engaged
• Engage stakeholders in existing processes as much as possible with integrated messaging with ongoing efforts	• Competing messaging • Oversaturating stakeholders with engagement and messaging • Confusing stakeholders	• Leverage Regional San and County Ag as they are doing significant outreach to the Farming and Ag communities within the Recycled Water area and messaging on recycled water
TECHNICAL		
• Understand the goals of the GSP and what we want to implement	• Pulling in information into the GSP that we do not need to meet DWR obligations	• Need to NOT set up new requirements that are not defensible • Take DWR guidance that they have available
• Create actions that are implementable and measurable	• An unmeasurable Plan (e.g. GDEs) – lots of unmeasurable actions/requirements – careful not to tie our hands if we cannot implement the GSP	• GSP will establish measurable metrics and develop a plan to monitor success

• Need to build on work that has been completed within and adjacent to the Basin (basin boundary amendments)	• Starting from scratch	• Leverage all past work that is of value to expedite the GSP development
• Need to identify what we want in the GSP and <u>what do we want the GSP to do</u> – what will we implement and what is the objective to eliminate conflict going forward.	• Not knowing what we want to achieve, expanding beyond SGMA requirements/authorities, scope creep	Put in a mission, vision and <u>Sustainability Goal</u> related to the GSP so we accomplish what we want the Basin to do Understand the Alternative deficiencies to be addressed.
REGULATORY		
• Understand where GSP interfaces with land use	• How does land management authority work under GSP – without consideration of police powers for implementation	• Understand land use interface with GSP • Reconcile land use overlap (e.g. General Plans)
• Understand what regulatory impacts there are by SASb areas of concern	• Understand known groundwater contamination and remedial efforts and level of involvement of each GSA (e.g. Not in the N Delta GSA area)	• Need to address in GSP
SCHEDULE		
Need to get the job done and not let State take over	• Avoid State Water Board intervention	• Be responsive to the schedule – it matters
FUNDING		
• Ensure rate increases and funding mechanisms are coordinated	• Communicating rate changes ineffectively (218)	• Work with County aggressively to adopt a decision on 218 option or dual process to avoid confusion • Ensure HDR who is doing all the rates can coordinate the multiple processes.
COLLABORATION		
• Trustful, collaborative and transparent partnership	• Diminishing trust	• Continue the trust built from the MOU process to resolve the potential issues (Boundaries, governance,

		hard feelings) • Sloughhouse recent Board meeting reiterated the importance of trust and acknowledged it is growing and they are dedicated to the process • Create this as a "core value" and reinforce • Understand that trust and disagreement are not the same; so it is important that the GSP develops into something we can live with

6.0 GUIDING PRINCIPLES

Members agree to the following principles to inform and guide Working Group deliberations, foster constructive discussions, promote a clear and shared set of expectations, and encourage collaboration.

Support an Effective and Efficient Process

Rely on credible information. To foster effective dialogues, members agree to mutually support a transparent and inclusive process where parties commit to rely on credible data and clear criteria to inform decision-making and to draw on the advice of the Consultant Team selected to support its development of a GSP.

Craft a GSP that respects local jurisdictions while building subbasin-wide approach. Parties are committed to working together to develop an integrated and effective GSP, while respecting each GSA's interest and expertise to oversee implementation within its unique jurisdiction or distinct planning areas. Parties agree to move the GSP process forward through consensus to ensure GSP approval by all GSA Boards.

Build off existing structures, lessons learned and past work where practicable, to leverage past investments and make the best use of everyone's time and resources.

Build progress through incremental agreements. Participants will use preliminary agreements on issues as the basis for progress towards final agreement. The Working Group will revisit preliminary agreements when new information emerges and again when finalizing overall recommendations.

Dedicated Participation and Respectful Engagement

Commitment of Working Group members to practice and promote engaged preparation for and participation in scheduled meetings; timely response and input to communications and deliverables; and transparent and timely delivery of pertinent information.

Commitment to collaborate. All members agree to work together in a constructive manner to meet SGMA requirements based on a locally driven approach. No one is to benefit at the expense of others, and all parties agree to negotiate in good faith. Realize our collective teamwork is mandatory to move the GSP process forward and diversion from the process will put the GSP delivery at stake. Strive to reach consensus on positions of shared interest and proactively identify barriers for discussion and, where possible, resolution at the earliest opportunity.

Commitment of time. Strive to attend meetings consistently; we need everyone at the table throughout. Contribute your thoughts and share our time so everyone can participate.

Respect Others and the Process. Seek opportunities to share your perspectives and understand the perspectives of others; listen intently to what others are saying; be honest and fair, and as candid as possible. If you hear something you do not understand, ask questions to clarify. If you hear something you do not agree with, help people understand your concerns.

By signing below you acknowledge your intent to uphold the Partnering Agreement.

Agency Name: Sacramento Central Groundwater Authority

Ramon Royval, SCGA Staff — 6/4/2020

(Name and Title) (Date)

Agency Name: Omochumne Hartnell Water District

Mike Wackman — 6/1/2020

Mike Wackman, General Manager

(Name and Title) (Date)

Agency Name: Strategy Driver, Inc.

June 3, 2020

(Name and Title) (Date)

Agency Name: Norther Delta Groundwater Sustainability Agency

June 23, 2020

Erik Ringelberg – NDGSA Administrator

June 23, 2020

Chris Thomas – NDGSA Alternate

Agency Name: Woodard & Curran, Inc.

06/04/2020

(Name and Title) (Date)

Agency Name: Woodard & Curran, Inc.

06/03/2020

(Name and Title) (Date)

Agency Name: Sacramento Central Groundwater Authority / Golden State Water Co

Paul Schubert
General Manager

Paul T. Schubert
Digitally signed by Paul T. Schubert
Date: 2020.06.03 15:43:18 -07'00'

Agency Name: Larry Walker Associates

Thomas Grovhoug, Senior Executive

June 3, 2020

(Name and Title) (Date)

Agency Name: Sacramento County Groundwater Sustainability Agency

Linda Dorn, Environmental Program Manager — June 3, 2020

(Name and Title) (Date)

Agency Name: SACRAMENTO CENTRAL GROUNDWATER AUTHORITY

THEADORE M. RAUH BOARD MEMBER JUNE 2, 2020

(Name and Title) (Date)

Agency Name: Sloughhouse Resource Conservation District

6-1-20

Austin Miller
District Staff

June 1, 2020

Agency Name: SCGA STAFF

JOHN WOODLING 6/4/20

(Name and Title) (Date)

Agency Name: Omochumne-Hartnell Water District

Mark L Stretars June 1, 2020

(Name and Title) (Date)

Agency Name: Sloughhouse Resource Conservation District

Herb Garms
SRCD District Direc or

Date 6/23/20

Agency Name: Sac County Water Agency

6/23/20

(Name and Title) (Date)

Agency Name: Sacramento Central Groundwater Authority
Christine Thompson , Board of Directors

Public Agencies Self-Supplied June 4, 2020

(Name and Title) (Date)

Agency Name: California American Water

Evan Jacobs, Director of Regulatory Policy 6-5-20

Agency Name: Larry Walker Associates

Laura Foglia, Senior Engineer 06/03/2020

Agency Name: Florin Resource Conservation District/Elk Grove Water District

Mark J. Madison

June 5, 2020
Date

Agency Name: Sacramento Central Groundwater Authority

6/4/2020

Senior Civil Engineer (Date)

Agency Name: Sacramento Regional County Sanitation District

6/2/20

(Name and Title) (Date)

Dave Ocenosak
Principal Engineer

Agency Name: Sacramento Central Groundwater Authority

6/25/20

chairman

(Name and Title) (Date)

Agency Name: SCGA Staff

R. Gardner

6/29/2020

(Name and Title) (Date)

Bob Gardner P.E.
Associate Civil Engineer

Agency Name: OMOCHUMNE WATER DISTRICT

25 JUNE 2020

(Name and Title)

(Date)

MARK WILSON
OHWD BOARD MEMBER

South American
SUBBASIN

Appendix 1-D

Communication + Engagement Plan for the South American Subbasin (SASb) Groundwater Sustainability Plan (July 2020)

DRAFT

South American
SUBBASIN

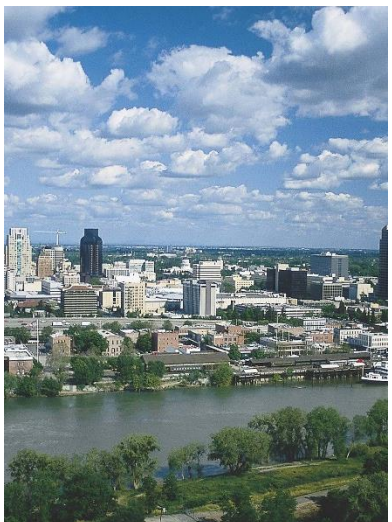
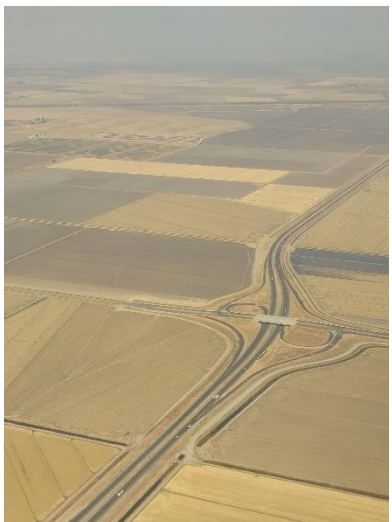
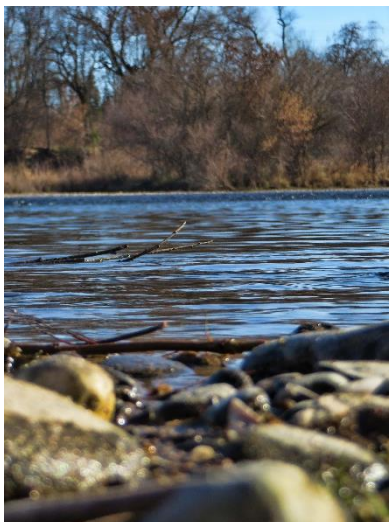
COMMUNICATION + ENGAGEMENT PLAN

FOR THE SOUTH AMERICAN SUBBASIN (SASb) GROUNDWATER SUSTAINABILITY PLAN

July 2020

SASb Groundwater Sustainability Agencies

- *Sacramento Central Groundwater Authority*
- *Northern Delta GSA*
- *Omochumne-Hartnell Water District*
- *Sacramento County*
- *Sloughhouse Resource Conservation District*
- *Reclamation District No. 551*

Abbreviations	Description
Ag-Res	Agricultural Residential
Board	GSA board of directors or other form of governing body (e.g. city council, board of supervisors)
C&E Plan	South American Subbasin (SASb), Sustainable Groundwater Management Act, Working Draft Communication and Engagement Plan
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
MOU	Memorandum of Understanding
GSP	Groundwater Sustainability Plan
GSPWG	Groundwater Sustainability Plan Working Group
PDF	Portable Document Format
SCGA	Sacramento Central Groundwater Authority
SGMA	Sustainable Groundwater Management Act
State Board	State Water Resources Control Board
SASb	South American Subbasin

DRAFT

Table of Contents

1.0 INTRODUCTION 5
2.0 GOALS AND OBJECTIVES 9
3.0 BENEFICIAL USES AND STAKEHOLDER GROUPS 11
4.0 GSAs' DECISION-MAKING PROCESS 12
5.0 HOW CAN INTERESTED PARTIES AND THE PUBLIC GET INVOLVED? 20
6.0 DESIRED OUTCOMES 22
7.0 COMMUNICATION + ENGAGEMENT TOOLS AND VENUES 24
8.0 TRACK AND EVALUATE COMMUNICATIONS AND ENGAGEMENT 30
9.0 SUMMARY 31
Appendix A. SASb Stakeholders Interviewed for the Stakeholder Assessment 33
Appendix B. Memorandum of Understanding Establishing a SASb SGMA Working Group and Identifying Cost Share Provisions for GSP Development 34
Appendix C. Statutory Requirements for SGMA 44
Appendix D. SASb Groundwater Website Portal 46
Appendix E. Partnership Commitment 49
Appendix F. Initial Interested Parties List 63
Appendix G. Disadvantaged Communities in the SASb 67
Appendix H. Native American Tribal Governments in the SASb 74
Appendix I. Preliminary Engagement Schedule 77
Appendix J. Example Public Notice 78
Appendix K. Meeting Feedback Form 80
Appendix L. Postcard Mailers 81
Appendix M. Interbasin Coordination under the Sustainable Groundwater Management Act 82
Appendix N. Media Contacts List 84

List of Figures

Figure 1. South American Subbasin is located within the larger Sacramento Valley Groundwater Basin ... 6
Figure 2. SASb GSA Boundaries 7
Figure 3. Role of SGMA in GSP Process 8
Figure 4. Participants in the GSP Development Process 12
Figure 5. Roles in the South American Subbasin 17
Figure 6. GSP Development Process 19
Figure 7. Effective Communication 21

List of Tables

Table 1. Communication and Engagement Plan SGMA Requirements 10
Table 2. SASb GSA Working Group Members 14
Table 3. GSA Board Meetings 20
Table 4. Groundwater Sustainability Agencies 24
Table 5. SASb GSA Boards' Regularly Scheduled Meetings 26
Table 6. Outreach Venues 27
Table 7. Basins Adjacent to the SASb 28
Table 8. Revision History 31

DRAFT

1.0 INTRODUCTION

This Communication and Engagement Plan (C&E Plan) was created in response to the Sustainable Groundwater Management Act (SGMA). The purpose of this C&E Plan is to assist the Groundwater Sustainability Agencies (GSAs) of the South American Subbasin (SASb) with stakeholder outreach and other related actions as required by SGMA. Its chapters identify key stakeholders and provide a high-level overview of near and long-term outreach and engagement strategies, tactics, and tools. The content of this C&E Plan was developed through discussions with GSA representatives and stakeholders during an interview process. See **Appendix A** for a list of the interviewees.

The Sacramento Central Groundwater Authority (SCGA) serves as the fiscal and administering entity that is developing the SASb Groundwater Sustainability Plan (GSP) under the guidance of a Working Group (WG). The GSPWG is governed by a Memorandum of Understanding (MOU) (**Appendix B**) adopted by the participating SASb GSAs.

SGMA Basics[1]

After decades of debate about groundwater management, California lawmakers adopted SGMA in 2014. This far-reaching law seeks to bring the state's critically important groundwater basins into a sustainable condition. The new regulatory landscape for groundwater management has created new obligations for groundwater users including municipal and agricultural water managers in the SASb. SGMA identifies six sustainability indicators, as shown below:

- Lowering Groundwater Levels
- Reduction of Storage
- Seawater Intrusion
- Degraded Quality
- Land Subsidence
- Depletions of Interconnected Surface Water

SGMA required by June 30, 2017, the formation of locally controlled GSAs in many of the state's groundwater basins, including the SASb. A GSA is responsible for developing and implementing a GSP. These plans assist the basins in meeting sustainability goals. The primary goal is to maintain sustainable yields without causing undesirable results.

GSAs & GSPs

Any local public agency that has water supply, water management, or land use responsibilities in a basin can decide to become a GSA. A single local agency can decide to become a GSA, or a combination of local agencies can decide to form a GSA by using either a Joint Power Authority, a memorandum of agreement, or another legal agreement. If no agency assumes the GSA role, the responsibility defaults to the County; however, the County may decline.

A GSP may be any of the following (California Water Code Section 10727[b]):

- A single plan covering the entire basin developed and implemented by one GSA
- A single plan covering the entire basin developed and implemented by multiple GSAs

[1] The text from this section of the C&E Plan was drawn directly from multiple DWR publications. See https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management

- Multiple plans developed and implemented by multiple GSAs that collectively cover the entire basin

Subject to California Water Code Section 10727.6, multiple plans implemented by multiple GSAs must be coordinated pursuant to a single coordination agreement that covers the entire basin.

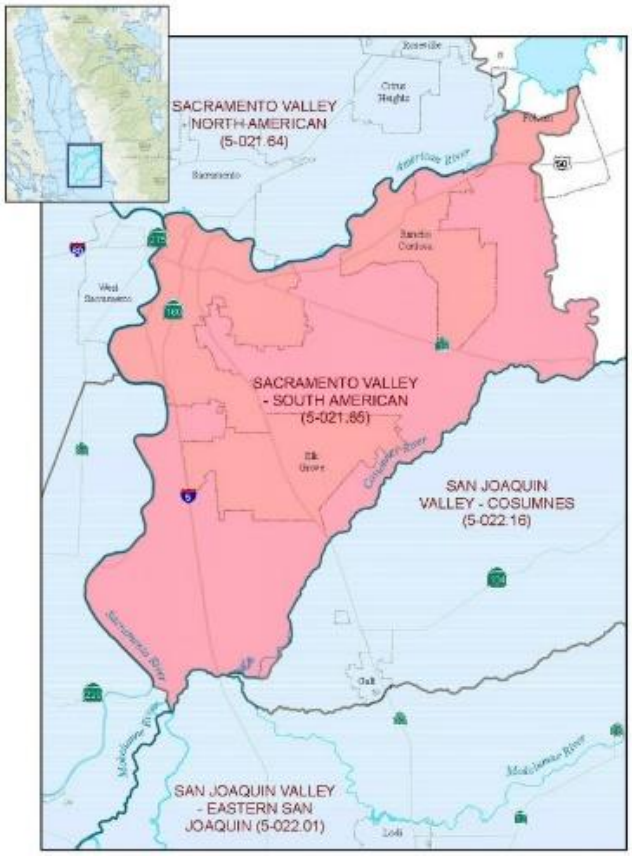


Figure 1. South American Subbasin is located within the larger Sacramento Valley Groundwater Basin

If local agencies are unable to form an approved GSA and/or prepare an approvable GSP in the required timeframe, then the basin or subbasin would be considered unmanaged. Unmanaged groundwater basins and subbasins are subject to State Water Resources Control Board oversight. This is true even if the vast majority of the basin or subbasin is covered by a plan. Should intervention occur, the State Water Resources Control Board is authorized to recover its costs.

SGMA and the SASb

The South American Subbasin is a high priority subbasin within the larger Sacramento Valley Groundwater Basin (**Figure 1**). A majority of the SASb is surrounded by rivers including the American River on the northern boundary, the Cosumnes and Mokelumne Rivers on the south, and the Sacramento River forming the western boundary. The eastern boundary is the only area not bounded by a river, located where the alluvial sediments of the groundwater basin give way to the foothills of the Sierra Nevada. The SASb shares boundaries with five adjacent subbasins, the Yolo Subbasin to the northwest, Solano Subbasin to the west, North American Subbasin to the north, and the Eastern San Joaquin and Cosumnes Subbasins to the south.

In 2014, California enacted SGMA requiring high and medium priority groundwater basins to develop a GSP to achieve a sustainable regime that balances pumping and recharge and considers the needs of all water users. The change in water management laws has created new obligations for groundwater users and water managers in the SASb. In accordance with SGMA, six GSAs were formed and under a collective Memorandum of Understanding (MOU) (Attachment B) in Spring of 2020, five of six of the GSAs agreed to develop one GSP for the SASb. While RD551 is currently not one of the MOU signatories, they are considering the option of merging their governance into one of the five GSAs listed below for the SASb GSP.

Following is a list of GSAs in the SASb as also depicted in **Figure 2** SASb GSP Map:

- County of Sacramento
- Northern Delta
- Omochumne-Hartnell Water District
- Reclamation District No. 551
- Sacramento Central Groundwater Authority
- Sloughhouse Resource Conservation District

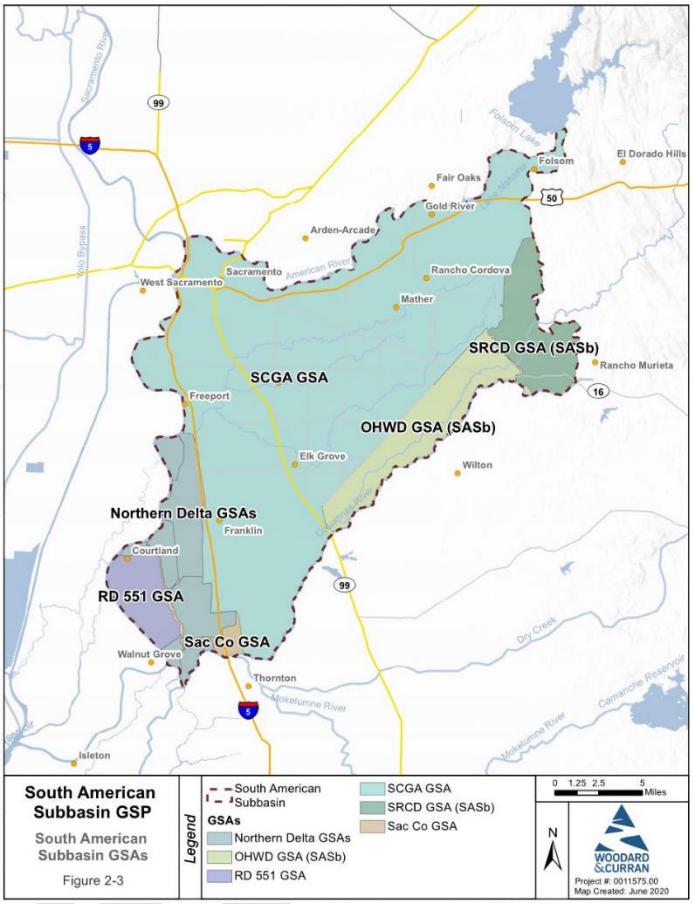


Figure 2. SASb GSA Boundaries

C+E Plan as a Roadmap

This C&E Plan serves as a roadmap to meet one of the statutory requirements of SGMA and the GSP Regulations as outlined in **Appendix C** and, more importantly, serves to facilitate common understanding and transparency of the GSP development process among the GSAs and interested parties throughout the GSP process. The GSAs will follow this plan to engage with and gather input from various Interested Parties to support GSP development. GSP information, meeting schedules, and useful links can be found at the SASb Groundwater Website at: www.sasbgroundwater.org. Anyone may register as an Interested Party to be notified of upcoming events and activities regarding GSP development. For more information on SASb Website, refer to **Appendix D**. **Figure 3 s**hows how GSP development will lead to a sustainable groundwater basin.

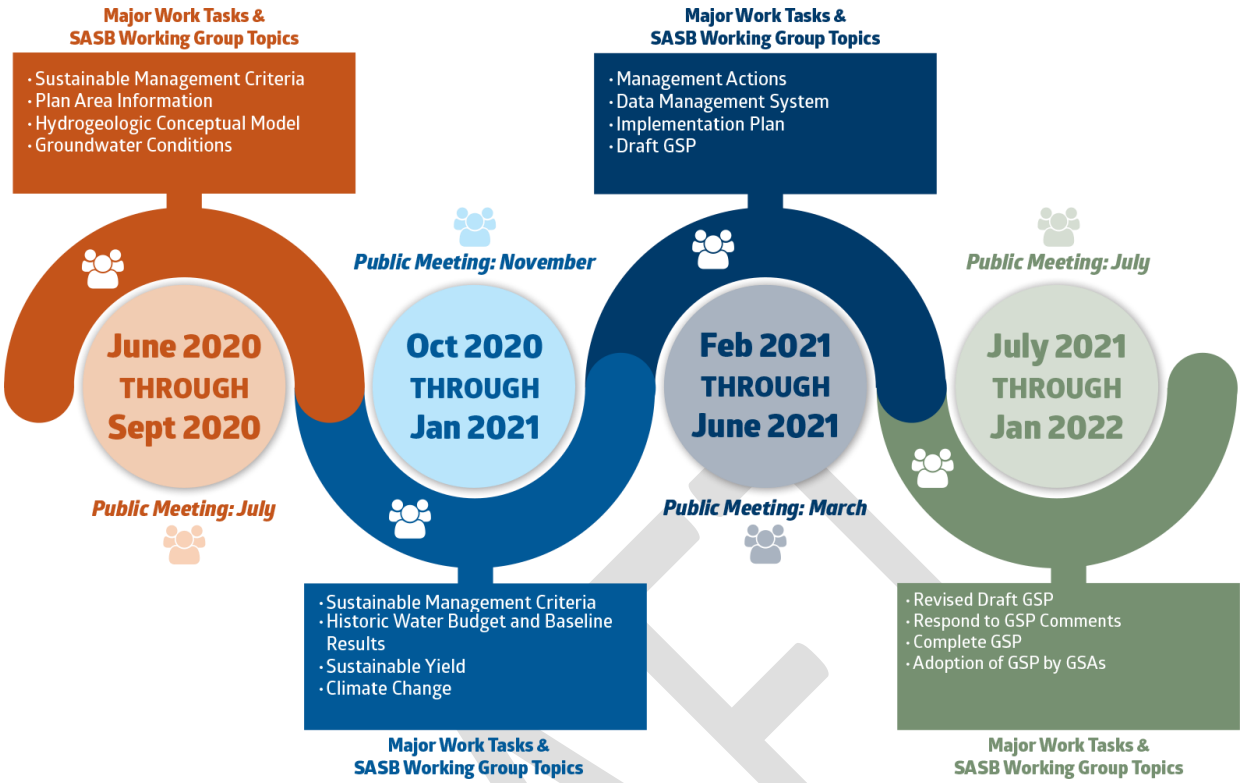


Figure 3. Role of SGMA in GSP Process

DRAFT

2.0 GOALS AND OBJECTIVES

The goal of the SASb communication and engagement efforts is to involve broad and diverse Interested Parties, including stakeholders, the public, and beneficial uses and users of groundwater throughout the GSP development process to ensure Interested Parties' concerns, issues, and aspirations are consistently understood and considered in the GSAs' decision-making process.

Under the umbrella of meeting the statutory requirements of SGMA and the GSP Regulations (**Table 1** below and **Appendix C**), the objectives of the SASb's engagement efforts are to:

- Educate Interested Parties about the importance of the GSP, what is and is not feasible, what must be accomplished, and how success will be measured.
- Ensure Interested Parties and beneficial users of water are able to contribute meaningful input, which is then considered in the decision-making process.
- Involve a diverse group of Interested Parties in the GSP process.
- Make public participation easy and accessible.

The GSAs represented by the GSPWG, are working together to develop a GSP, committed to safeguard our local groundwater resources through sustainable management and to preserve this invaluable water supply source for future generations. The GSAs are committed to work with Interested Parties to ensure that their concerns and inputs are considered in GSP development as outlined in the Partnership Agreement (**Appendix E**) including:

"To foster the consideration of the beneficial uses and users of groundwater in the SASb, the GSPWG members (Parties) agree to the following:

- Parties are committed to an inclusive and transparent process that proactively seeks the engagement and input of potentially impacted groups as identified in SGMA. Parties will work to develop protocols for public engagement, both at public workshops and during regular Working Group meetings.
- Parties will work collectively to develop an agreed-upon outreach plan, but each GSA is responsible for helping to guide and implement efforts within their respective jurisdictions.
- Parties recognize the value in developing shared messages to ensure consistency; joint participation in outreach efforts is encouraged to foster consistency in message and concretely demonstrate the Parties' coordinated effort.
- Parties recognize the need to conduct outreach in the near-term to better understand additional representation needs (e.g., environmental, tribal, riparian water users, overlying water users, disadvantaged communities (DACs) etc.) beyond the signatories to this agreement."

Table 1. Communication and Engagement Plan SGMA Requirements

Under the Sustainable Groundwater Management Act (SGMA) SASb ranked as a high priority basin[2], required to do the following per section (23 Cal. Code Regs. §354.10):

"Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and Interested Parties, including:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

(1) An explanation of the Agency's decision-making process.

(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of population within the basin. An explanation of the Agency's decision-making process.

(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions."

[2] Basin Prioritization is a technical process that utilizes the best available data and information to classify California's 515 groundwater basins into one of four categories high-, medium-, low-, or very low-priority. The technical process is based on eight components that are identified in the California Water Code Section 10933(b).

3.0 BENEFICIAL USES AND STAKEHOLDER GROUPS

SGMA stresses the importance of local groups to create local plans and ultimately to locally manage sustainable solutions. To achieve this, stakeholder input to consider beneficial groundwater uses and users of groundwater is imperative to support the GSP process and implementation. The SASb supports various agricultural activities (including but not limited to grazing, vineyards, and orchards); rural residential wells; municipal and industrial supply; aquatic ecosystems associated with rivers and streams, some of which provide habitat for threatened or endangered species, and groundwater dependent terrestrial ecosystems. While a more extensive list of Interested Parties is included in **Appendix F**, a summary of stakeholder groups is listed below.

- Cities
- County
- Large rural residential enclaves
- Agricultural Water Users
- Municipal Water Suppliers in Urban areas
- Industrial users
- Commercial users
- Remediation pumpers
- Natural ecosystems
- General public
- Land use authorities
- Private well owners
- Public agencies
- Environmental interests
- Disadvantaged Communities (DACs) (**Appendix G**)
- Native American Tribal interests (**Appendix H**)

California Water Code (CWC) §10723.4 requires GSAs to establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents. Any person may request, in writing, to be placed on the list of Interested Parties. Additionally, the GSAs developed the www.sasbgroundwater.org where any person may sign up to be added to the list of Interested Parties. **Appendix F** includes a list of Interested Parties identified at the time of GSA formation. The updated Interested Parties list, with individual registrants, is stored in the portal of the SASb website (**Appendix D**) will be available to DWR at the time of GSP submittal.

Diverse Outreach Practices

The GSPWG is committed to encouraging the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin. As such, outreach practices will be diverse as well, as outlined in **Section 7.0**.

4.0 GSAs' DECISION-MAKING PROCESS

The SASb GSAs are working together to meet SGMA requirements and will collaboratively prepare a single GSP by January 31, 2022. A GSP Working Group (WG) was established per the MOU (**Appendix A**) to provide recommendations related to development of the SASb GSP. GSP decision making and input is represented by the roles of the GSP Working Group, GSA Boards and Stakeholders as depicted in **Figure 4**.

Figure 4. Participants in the GSP Development Process

GSP Working Group

The SASb GSAs have formed a GSPWG of senior staff and governing board members to coordinate day-to-day planning activities and public outreach. This GSPWG comprises representatives from five of the six GSAs (See

DRAFT

Table 2). within the Subbasin and follows a consensus-based decision-making structure, where each member receives an equal voice. The GSPWG will hold two types of meetings, regularly scheduled working sessions to focus on the technical content and guidance to consultants working on the GSP as well as publicly noticed public meetings to allow stakeholders to engage and provide input prior to key GSP milestones throughout the process. GSA Board and Public meetings information can be found at http://www.sasbgroundwater.org/meetings.html.

DRAFT

Table 2. SASb GSA Working Group Members

Groundwater Sustainability Agencies	GSPWG Members	Date GSA Formed*
County of Sacramento https://waterresources.saccounty.net/Pages/SGMA.aspx	Linda Dorn Kerry Schmitz (Alternate)	April 11, 2017
Northern Delta GSA http://www.ndgsa.org	Erik Ringelberg Chris Thomas (Alternate)	Various
Omochumne-Hartnell Water District http://www.ohwd.org	Mike Wackman Mark Stretars Mark Wilson (Alternate)	April 24, 2016
Sacramento Central Groundwater Authority https://scgah2o.saccounty.net/Pages/default.aspx	Todd Eising Paul Schubert Mark Madison Evan Jacobs Dave Ocenosak Ted Rauh Christine Thompson	July 21, 2016
Sloughhouse Resource Conservation District http://sloughhousercd.org	Austin Miller Herb Garms (Alternate)	April 25, 2016

**Please see www.sasbgroundwater.org/home for links to GSA formation information.*

The GSPWG signed a Partnership Commitment (**Appendix E**) including principles for engagement and operation that are intended to provide a framework of commitments among the members to work collaboratively, efficiently, and with the necessary dedication to promote the development, adoption and submission of a SMGA compliant GSP by the statutory deadline of January 31, 2022.

The GSPWG is responsible for:

- Sharing feedback from their respective GSA's related to the GSP development
- Making recommendations to their respective GSA regarding the consideration and adoption of the GSP
- Providing or ensuring the provision of timely responses and supporting information related to GSP development to the Consultants upon request in order to meet the state mandated GSP deadline
- Performing and supporting appropriate and coordinated outreach to stakeholders within the Subbasin
- Ultimately delivering an acceptable GSP to all GSA Boards for adoption

The GSA Boards: The respective GSA's Boards assigned their GSPWG members to work on the day to day development of the GSP and stakeholder communication and engagement. The GSA Boards are responsible for:

- Ensuring appropriate communication and engagement is executed per the approved C&E Plan on behalf of their GSA
- Accepting interim milestone approvals to meet the mandated schedule the Final GSP
- Being informed about the GSP development by their designated GSPWG Members
- Informing their respective GSPWG Members with their insights, perspectives, and opinions

- Ultimately adopting an acceptable final GSP to deliver for DWR review by January 2022

As part of developing the GSP, the SASb GSAs will inform and involve stakeholders and Interested Parties within their own jurisdictions through their respective Board meetings and on their individual websites listed in

DRAFT

Table 2. The typical meeting frequency and locations for meetings of each GSA Board can be found at http://www.sasbgroundwater.org/meetings.html.

Additional Contributors to GSP Development

Interested Parties

Interested Parties can participate in public meetings and hearings, which are posted on the SASb Website, and communicate with GSPWG members to provide input, obtain information, and review and comment on GSP documents. An initial list of Interested Parties identified for the SASb at the time of GSA formation is provided in Error! Reference source not found.. Anyone may register as an Interested P arty via the SASb Website at http://www.sasbgroundwater.org/contact-us.html. Once registered, Interested Parties will receive invitations to meetings and workshops related the SASb GSP development. The Interested Party list is stored and maintained in the website portal database. Interested Parties are encouraged to sign up for information at http://www.sasbgroundwater.org/contact-us.html, and attend Public and GSA Board Meetings to learn more and provide input (see http://www.sasbgroundwater.org/meetings.html).

GSP Administrating Agency (Staff)

SCGA Staff will be responsible for:

- Being the point of contact for the Working Group to coordinate with the Consultants
- Overseeing the Consultants in the delivery of the GSP scope of work and budget per the contract
- Ensuring grant obligations are met and reimbursements received
- Delivering GSP priorities within the state mandated GSP schedule

GSP Consultants

A team of consultants will conduct technical studies and investigations, including groundwater modeling, and draft the GSP documents. GSP Staff will oversee the consultant work and provide direction to the consultants regarding GSP development. The consulting firms assisting with GSP development for the SASb are listed below.

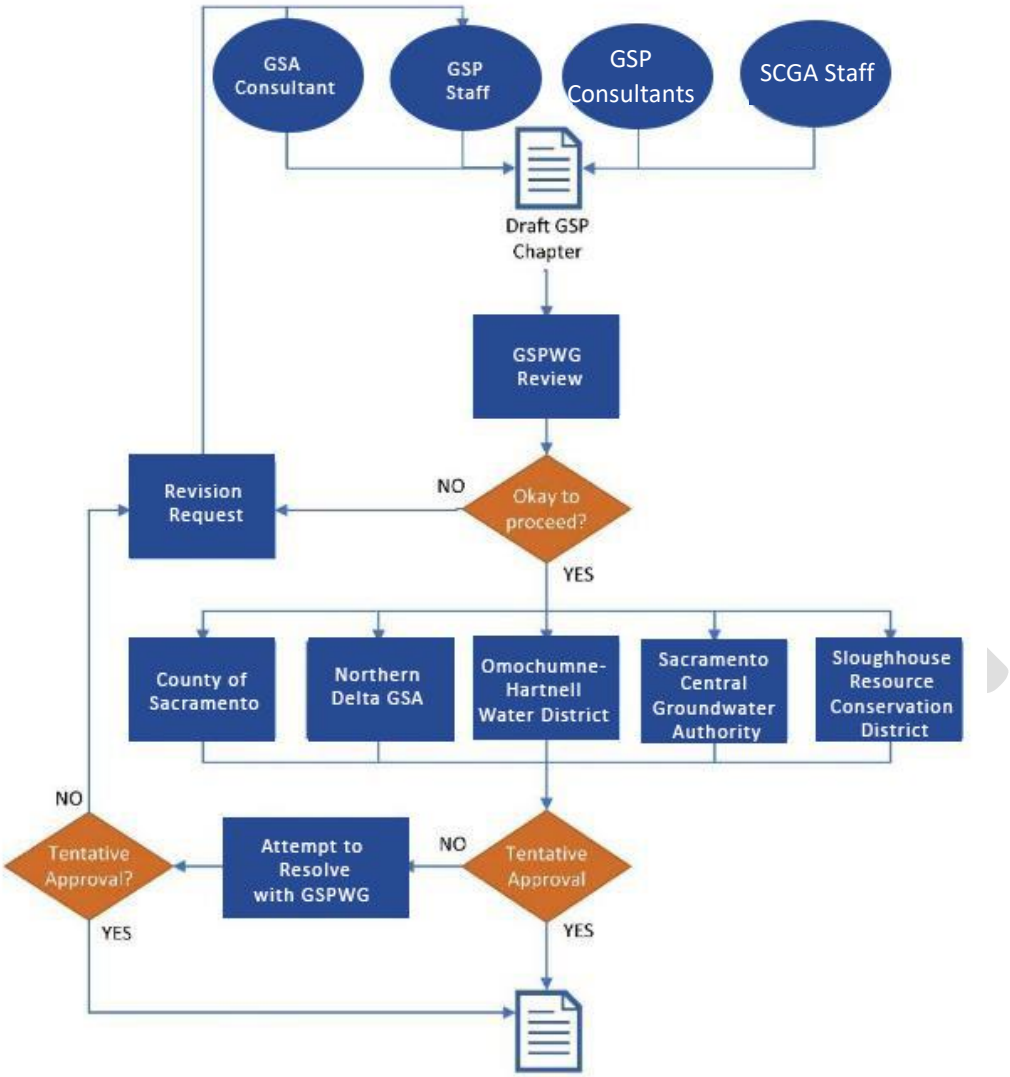
- Larry Walker Associates including Kennedy Jenks, and Stockholm Environmental Institute
- Woodard & Curran including Strategy Driver, Inc., and HDR Engineering

Decision-Making Steps

The GSP must be developed under a compressed schedule, as the final GSP is due to DWR by January 31, 2022. To ensure the GSP is delivered on time, decision-making during chapter development as well as for final approval must follow a streamlined process. A summary of the SASb roles and example actions for GSP development is depicted in **Figure 5**. The chapter and final approval processes are outlined in **Figure 6**.

Roles in South American Subbasin	Example Actions for GSP Development
Groundwater Sustainability Agency (GSA) Boards Northern Delta GSA; Omuchumnee Hartnell WD GSA; SCGA GSA; Sacramento County Board of Supervisors; Sloughhouse RCD GSA	• Ensuring execution of Communication and Engagement (C&E) Plan • Accepting interim milestone approvals • Being informed by Working Group • Informing Working Group on insights, perspectives, and opinions • Adopting and acceptable final GSP to deliver to DWR by January 2022
GSP Working Group (GSPWG) Northern Delta GSA – 1 Member; Omuchumnee Hartnell WD GSA – 2 Members; SCGA GSA – 7 Members; Sacramento County Board of Supervisors – 1 Member; Sloughhouse RCD GSA – 1 Member	• Sharing feedback from respective GSAs • Making recommendations to respective GSAs • Ensuring timely responses to consultants, GSPWG, and Administrating Agency • Performing coordinated outreach to stakeholders • Delivering and acceptable GSP to all GSAs for adoption
GSP Administrating Agency **SCGA Staff**	• Being the point of contact for Working Group to coordinate with consultants • Overseeing the consultants per the contact • Ensuring grant obligations are met and reimbursements received
Interested Parties	• Attend stakeholder workshops • Provide input regarding sustainable management criteria, projects, and programs • Participate in stakeholder surveys
GSP Consultants	• Ensuring the delivery of the GSP per the contract

Figure 5. Roles in the South American Subbasin


GSA Consultant
GSP Staff
GSP Consultants
SCGA Staff
Draft GSP Chapter
GSPWG Review
Okay to proceed?
NO
Revision Request
YES
County of Sacramento
Northern Delta GSA
Omochumne-Hartnell Water District
Sacramento Central Groundwater Authority
Sloughhouse Resource Conservation District
Tentative Approval
NO
Attempt to Resolve with GSPWG
Tentative Approval?
NO
YES
YES
GSP Chapter ready for Draft GSP, will be reviewed again at Draft GSP CC Review
(see GSP Approval Process flowchart)

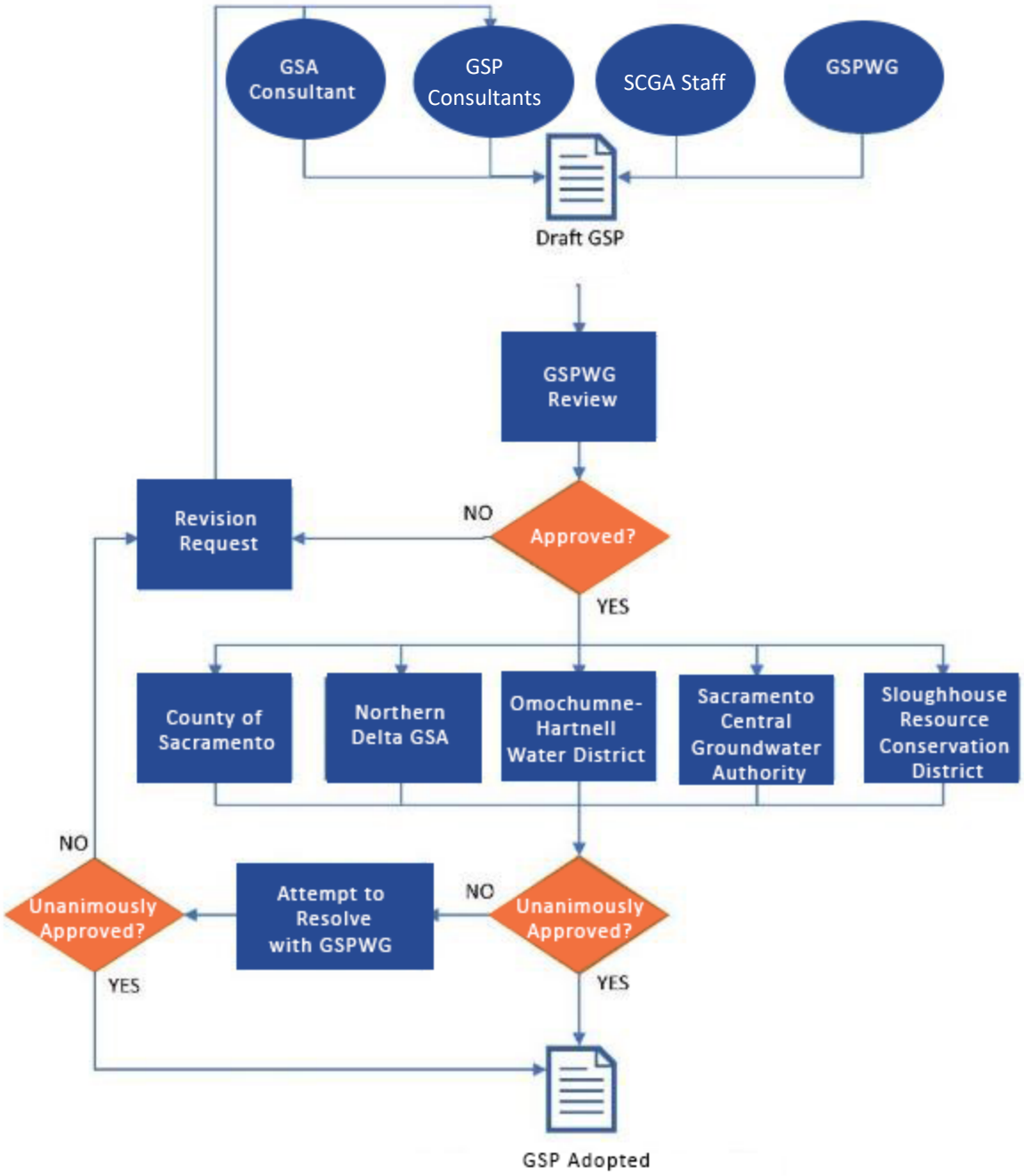


Figure 6. GSP Development Process

5.0 HOW CAN INTERESTED PARTIES AND THE PUBLIC GET INVOLVED?

Water is vital to the economy, the environment, and the quality of life in Sacramento County. While this precious resource is visible every day in the American, Sacramento and Cosumnes Rivers, water underground is no less important, providing about half of the region's water supply. Groundwater serves the needs of cities, farms and businesses and provides high quality drinking water to urban and rural residents, all while helping to sustain vital ecosystems. It is important that the SASb Interested Parties, public and beneficial users learn more about the SASb, how the GSAs in the SASb are responding to SGMA to develop a GSP, and how they can participate to promote the health and longevity of our shared and valued resource. Public and Interested Party participation is vital to the success of the GSP. A first step for Interested Parties to get involved is to sign up through the SASb website portal: http://www.sasbgroundwater.org/contact-us.html, and review the content on the GSA websites and attend GSA Board meetings listed on **Table 3** below. Meetings providing updates on the SASb GSP development are scheduled on a regular basis to inform the public and Interested Parties and provide opportunities to ask questions and make suggestions. These meetings are posted at http://www.sasbgroundwater.org/meetings.html and announced via email. See **Section 7.0** to learn more ways the GSAs are engaging Interested Parties and inviting participation.

Table 3. GSA Board Meetings

GSA	Meeting Frequency	Location
County of Sacramento	Meets on various Tuesdays and Wednesdays throughout the month	Sacramento County Board chambers, 700 H St, Sacramento, CA
Northern Delta	June & December each year	Walnut Grove Library, 14177 Market St., Walnut Grove, CA
Omochumne-Hartnell Water District	3rd Tuesday of each month at 10:00 am	Sacramento County Farm Bureau, 8970 Elk Grove Boulevard, Elk Grove, CA
Sacramento Central Groundwater Authority	2nd Wednesday of each month at 9:00 am	Elk Grove City Council chambers, 8400 Laguna Palms Way, Elk Grove, CA
Sloughhouse Resource Conservation District	2nd Wednesday of each month at 1:00 pm	Rancho Murieta CSD, 15160 Jackson Rd, Rancho Murieta, CA

The Department of Water Resources also provides information regarding the SGMA GSP process and can be accessed at the DWR SGMA Portal – https://sgma.water.ca.gov/portal/.

GSP Development Process

The GSP development process for the SASb shown in **Figure 7** outlines key tasks and their relationship in developing the GSP. These main tasks roughly follow what will ultimately be the GSP's chapters. GSP development will also include listing data gaps and how they will be filled during plan implementation, conducting technical studies, defining the subbasin's characteristics, accounting for current and planned groundwater uses, considering groundwater dependent ecosystems (GDEs), incorporating land use planning, and developing sustainable management criteria. **Appendix I** includes a preliminary schedule showing milestones and Interested Party engagement activities. As shown on the schedule, Public meetings will be held at regular intervals. GSA Board meetings are open to the public. Focused workshops will be held as needed with four scheduled on July 23, 2020; November 12, 2020; March 25, 2021 and July 15, 2021.Please consult http://www.sasbgroundwater.org/meetings.html for updates to the meeting schedule. In addition, GSP Staff will be available throughout the process to communicate

and engage with Interested Parties and the public. Interested Parties can be involved in GSP development by providing input throughout the process. Periodic updates and materials will be posted on the www.sasbgroundwater.org and presented at GSA Board meetings for Interested Parties review and comment.

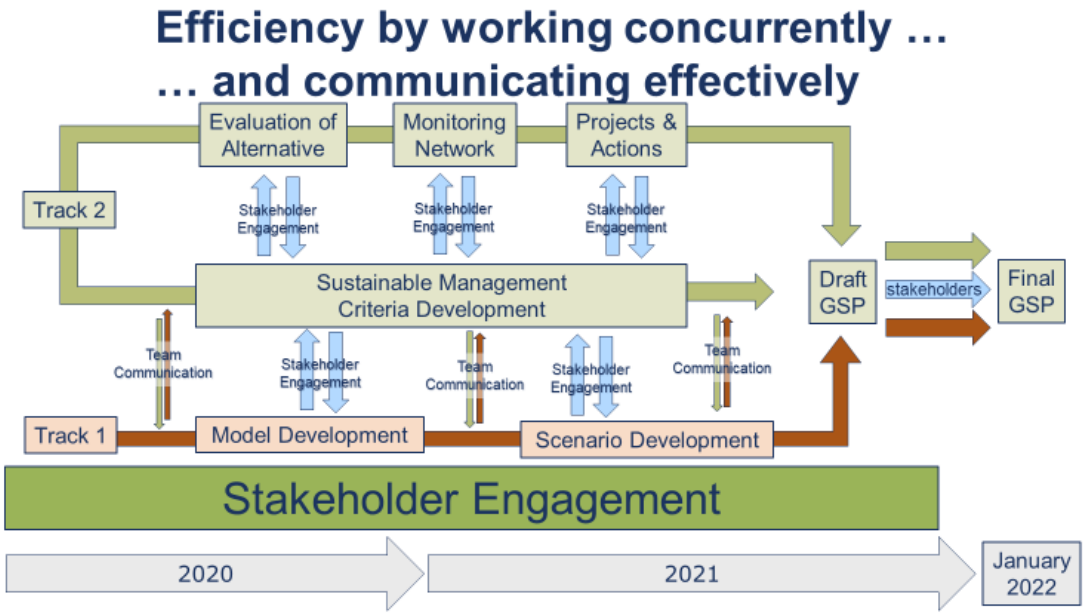


Figure 7. Effective Communication

6.0 DESIRED OUTCOMES

DWR suggests answering a series of questions when setting desired outcomes for GSP Interested Party outreach (https://water.ca.gov/Programs/Groundwater-Management/Assistance-and-Engagement). The questions and responses for the SASb are listed below.

What are we trying to accomplish?

We aim to make opportunities available for Interested Parties to provide input during development of the SASb GSP and ensure the GSP considers input from Interested Parties.

How will we know if we are successful?

We will be successful when various Interested Parties have opportunities to provide their input, ask questions, receive up-to-date information, and comment on GSP development and draft documents.

What are the challenges or barriers?

One of the challenges is making a complete list of Interested Parties and being able to effectively communicate with them. We will make every effort to reach a broad set of Interested Parties and expand the list. We will use several forms of communication and outreach such as: meetings, calendar updates with notification automatically sent to Interested Parties, radio and newspaper advertising, email blasts, and social media. For a list of media contacted regarding SASb events, see http://www.sasbgroundwater.org/meetings.html Error! Reference source not found..

Another challenge is meeting during COVID-19. We will be making every consideration to accommodate the Governor's Executive Order N-29-20 and will be meeting via teleconference as described further in Chapter 7.0.

What are the opportunities for communication and engagement?

Available communication and engagement opportunities for Interested Parties include public workshops and hearings, communication through individual GSA webpages, registration as an Interested Party or contact the http://www.sasbgroundwater.org/contact-us.html, correspondence, phone calls, emails, and engagement through the GSP Working Group and GSA Boards.

What is the timeframe?

GSP development began in Summer 2020 and will progress to adoption before January 31, 2022. During that period, Interested Party communication and engagement will be a continuous process, including the public review period for GSP approval. The Draft SASb GSP will be available for 90 days of review during Fall 2021.

When will public input be relevant?

During GSP development, public input will be most relevant when the GSAs are framing the scope of studies, setting sustainable management criteria, developing management actions, identifying groundwater-dependent ecosystems, collecting existing and planned groundwater use information, and during public review of the draft GSP prior to DWR approval. Workshops and/or surveys will be held during for public input when it is most relevant.

How will public input be used?

GSP Regulations (Section 355.4) require that GSAs consider the interests of the beneficial uses and users of groundwater in the subbasin. In addition, the GSAs will consider the effects on land use and property

interests of the GSP. Public input is essential in understanding and considering these interests and effects. During the GSP review and approval process, DWR will take public comments into account when determining whether interests within the subbasin have been considered in the development and implementation of the GSP (Section 353.8).

DRAFT

7.0 COMMUNICATION + ENGAGEMENT TOOLS AND VENUES

Interested Parties communication and engagement will take place throughout the subbasin and for GSA area-specific Interested Parties. Each GSA area may include a set of Interested Parties with specific interests relevant only to a particular GSA. Each GSA will decide required levels of communication for its own GSA area and engage with Interested Parties in its GSA area as appropriate.

For SASb-wide interests and issues, the GSP Working Group will communicate with all Interested Parties. The SASb GSAs are committed to encouraging the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin. Therefore, outreach will be conducted through multiple and varied venues. Descriptions of these venues follows:

SASb Groundwater Website:

Interested Parties are invited to register using the SASb Website Portal at http://www.sasbgroundwater.org/contact-us.html. Registrants will be invited by email to all activities regarding GSP development. Interested Parties may also register for upcoming events, and view materials from past events.

GSA Websites:

Each GSA hosts a website which is listed below as well as linked to www.sasbgroundwater.org. The webpages are designed to provide background information, maps, documents, status updates, useful links, contact information, and a means of communicating between the GSAs and the public.

Table 4. Groundwater Sustainability Agencies

Groundwater Sustainability Agencies / Websites
County of Sacramento https://waterresources.saccounty.net/Pages/SGMA.aspx
Northern Delta GSA http://www.ndgsa.org
Omochumne-Hartnell Water District http://www.ohwd.org
Reclamation District No. 551 https://waterresources.saccounty.net/stormready/Pages/Delta-Reclamation-Dist-551.aspx
Sacramento Central Groundwater Authority https://scgah2o.saccounty.net/Pages/default.aspx
Sloughhouse Resource Conservation District http://sloughhousercd.org

Public Meetings

Public Meetings: Four separate public meetings will be scheduled to update the public on the SASb GSP. The Public meetings are expected to be held mid-week and, in the evenings, so the public can more conveniently attend. In addition to the public, expected attendance includes: GSPWG members, SCGA Staff and Consultants. Meetings will be widely noticed (See **Appendix J** for an example) Tentatively scheduled meetings (please confirmed for meeting times and locations at http://www.sasbgroundwater.org/meetings.html) include:

- **2020: July 23 and November**

- **2021: March and July**

*Special Meetings as needed to cover time sensitive GSP topics will be held at Board meetings of each GSA, tentatively scheduled for:

- **2020: September**
- **2021: January, June, September, and November (GSP Adoption Meeting)**

*Please confirm dates and times at http://www.sasbgroundwater.org/meetings.html and local GSA Board meeting agendas)

COVID-19 Considerations

Please note that the SASb is following special precautions for COVID-19 pursuant to the Governor's Executive Order N-29-20, will be meeting via teleconference. We encourage meeting participants to join the meeting 10 minutes early. Note that we will use Zoom to share slides and other information during the meeting. Use the link below to join. If you have a microphone that you can use with your computer, it should be possible to both listen to, and participate in, the meeting through Zoom. If you do not have a microphone, or a headset with a microphone that plugs into your computer via USB port, you will need to call into the conference line to listen and comment, although you still should be able to view the meeting materials on Zoom. Please do not simultaneously use a microphone through Zoom and the telephone conference line. That combination results in audio problems for all participants. Please check the SASb Website for updates on meeting details.

To join the meeting:
https://zoom.us/j/97062255197?pwd=dWwySGlNOWMwWmU1UCsyeGtlbWpoQT09
You can also dial in using your phone
United States: +1 669 900 6833 US
Meeting ID: 970 6225 5197 Password: 936495

Public Surveys

Public surveys may be conducted when GSP development requires specific input from Interested Parties. One SASb Stakeholder Assessment was conducted in Spring 2020 where beneficial water users were interviewed and many of their suggestions on C&E were included as part of this C&E Plan. A list of interviewees in included as **Appendix A**.

Meeting feedback forms will be available to provide feedback about how workshops are conducted. An example of the meeting feedback form is provided in **Appendix K**.

GSA Board of Directors/Supervisors/Council Meetings

Each of the GSAs will have individual updates at their respective Board of Directors/Supervisors meetings, as shown in **Table 5**. GSP updates will be included as noticed per their respective meeting agendas that are published in advance. Stakeholders and members of the public may choose to comment at those meetings. SCGA GSA reports regular SASb GSP updates at the SCGA Board Meeting, while the other GSAs provide GSP updates as needed. Please confirm individual GSA Board agendas for SASb GSP updates through their respective websites (**Table 4**, above).

Table 5. SASb GSA Boards' Regularly Scheduled Meetings

GSA	Meeting Frequency	Location
County of Sacramento	2nd Tuesday of each month at 9:30 am	Sacramento County Board Chambers, 700 H St, Sacramento, CA
Northern Delta	June & December each year	Walnut Grove Library, 14177 Market St., Walnut Grove, CA
Omochumne-Hartnell Water District	3rd Tuesday of each month at 10:00 am	Sacramento County Farm Bureau, 8970 Elk Grove Boulevard, Elk Grove, CA
Sacramento Central Groundwater Authority	2nd Wednesday of each month at 9:00 am	Elk Grove City Council chambers, 8400 Laguna Palms Way, Elk Grove, CA
Sloughhouse Resource Conservation District	2nd Wednesday of each month at 1:00 pm	Rancho Murieta CSD, 15160 Jackson Rd, Rancho Murieta, CA

*As of July 2020, all GSAs are holding online meetings. Details can be found at their respective websites.

Outreach Venues

GSA representatives have identified a list of potential outreach venues in the SASb, shown in **Table 6** below. Note that this is only an initial list of outreach venues. The GSAs will continue to expand this list and develop a full Outreach Venues Database and uploaded to the SASb Website Portal.

Table 6. Outreach Venues

Organization/Event Name	Type of Organization/ Event	Location
Sacramento County Farm Bureau	Agricultural	City of Sacramento
Sacramento Metro Chamber of Commerce	Commercial	City of Sacramento
Rancho Murieta Community Service Center	Civic/Community	Community of Rancho Murieta
Wilton Community Center	Civic/Community	Community of Wilton
Earth Day	Event	Multiple locations throughout SASb
Farmers Market	Other	Sacramento County (Multiple)
Sacramento County Association of Realtors	Other	Multiple locations throughout SASb
Vineyard Community Planning Advisory Council	Civic/Community	Sacramento County
Sheldon Community Association	Civic/Community	City of Elk Grove Community of Sheldon
Greater Sheldon Road Estates Homeowners Association	Civic/Community	City of Elk Grove Community of Sheldon

**Outreach at many of these venues may be limited subject to COVID-19 restrictions of the State of California and County of Sacramento*

Email

Email blasts (emails to the entire list of Interested Parties) will be sent when there is significant information to communicate regarding GSP development. For example, email blasts are sent when Public Meetings or Special Meetings are scheduled.

Individual emails will also be sent to invite known Interested Party groups to participate. For example, letters were sent via email to local Native American Tribal governments, Ag-Res communities and small water system users inviting participation in the GSP process. Small community water systems within the SASb will also be identified and communicated with individually.

Postal Mail

Postal mail will be utilized to reach areas of the groundwater basin that may not otherwise be informed of GSP activities. For example, a postcard (**Appendix L**) was mailed to Interested Parties throughout the SASb to notify Interested Parties to register on the SASb Website Portal, since the existing contact lists for several of the GSAs included postal addresses, but not email addresses. The postcard invited these

known Interested Parties to register their email address online with the SASb Website. This postcard is also available through Next Door and Facebook per many of the GSPWG organizations as well as provided as inserts into water bills.

Spanish Language Materials

The California Department of Health Care Services has identified threshold languages for which services and information should be available for the services they provide. A threshold language is defined as one that has been identified as the primary language, as indicated on the Medi-Cal Enrollment Data System of 3,000 beneficiaries or five percent of the beneficiary population, whichever is lower, in an identified geographic area. In Sacramento County those languages are Spanish, Vietnamese, Cantonese, Russian, and Hmong. Up to 13 languages are recognized by the Sacramento County Office of Education. The most recent Census information indicates 34% of the people in Sacramento County, CA speak a non-English language. In 2018, the most common non-English language spoken in Sacramento County, CA was Spanish. 14.1% of the overall population of Sacramento County, CA are native Spanish speakers. Sacramento County Voter information is provided in English, Spanish and Chinese. Through the Stakeholder Assessment and interviews with the GSPWG, it was determined that targeted communications would be provided to Spanish speakers including the following:

- Postcard in Spanish to advertise http://www.sasbgroundwater.org/meetings.html
- Web page on in Spanish http://www.sasbgroundwater.org/espanol.html
- Fact Sheet on SASb GSP

If there is significant demand, additional translation services will be provided for the SASb GSP process.

Adjacent Basin Meetings

Members of adjacent basins are welcome to participate in regularly scheduled Public or GSA Board meetings as well as special meetings. In addition, coordination between adjacent basins and individual GSAs will occur as needed. Interagency Agreements are included in **Appendix M**. The names and GSP deadlines for basins adjacent are shown in **Table 7**.

Table 7. Basins Adjacent to the SASb

Adjacent Basin	Basin Prioritization	GSP Due Date
North American	High	January 31, 2022
Cosumnes	High	January 31, 2022
Yolo	High	January 31, 2022
Solano	High	January 31, 2022
East San Joaquin	Critically Over drafted	January 31, 2020

Public Hearings

Notices of public hearings are published in a variety of media, including radio and local newspapers, informing the public on meeting information, subject, and how to provide comments prior to decision-

making. Public hearings will also be noticed through the www.sasbgroundwater.org and media list (**Appendix N**). At a minimum, a Public Hearing will be held when adopting or amending the GSP.

DRAFT

8.0 TRACK AND EVALUATE COMMUNICATIONS AND ENGAGEMENT

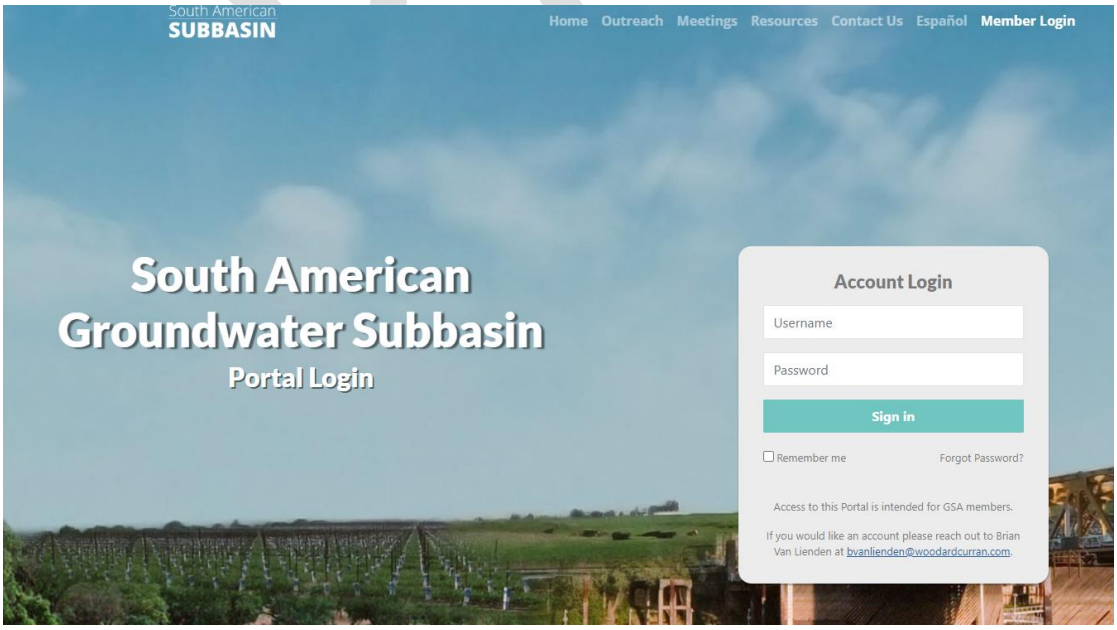
The SASb Website Portal (see **Appendix D**) tracks communications and engagement efforts for the SASb GSAs.

The SASb Website Portal serves as a repository for information about public meetings and Interested Parties. It tracks outreach efforts by the GSAs in its database, storing meeting attendance information, logging targeted outreach, and hosting the Interested Parties list.

Tool administrators can generate reports about meetings related to GSP planning. The reports include items such as attendance sheets, RSVPs, agendas, summary notes, handouts, and presentations. Reports such as these will be included with the final SASb GSP as submitted to DWR.

GSAs continually evaluate communications and engagement efforts as they are executed following this C&E Plan. This evaluation is conducted through GSP Working Group, GSA Staff, and GSP Consultant observations, as well as through feedback from Interested Parties via online surveys and meeting feedback forms **(Appendix K)**. The GSP Working Group, GSA Staff, and GSP Consultants will assess need and update this C&E Plan, as necessary.

The SASb Portal is the primary tool for tracking communication and engagement in the South American Subbasin. Above is a view of the Administrator's dashboard, where site administrators can post events, upload documents, and generate reports regarding communication and engagement.



9.0 SUMMARY

Interested Parties communication and outreach activities are essential in GSP development. Only through effective communication and outreach, will we be able to ensure Interested Parties' concerns, issues, and aspirations are consistently understood and considered in the GSAs' decision-making process. Moreover, the C&E Plan process will be ongoing, starting with GSP development and through implementation of the approved GSP for the SASb. As in GSP development, periodic reviews and adjustments of the C&E Plan process may be necessary. The goal is to develop and implement a robust Interested Parties C&E process so we may achieve sustainability in managing our valuable shared groundwater resource for future generations. **Table 8** below shows the updates to the C&E Plan.

Revision History

Table 8. Revision History

Revision/ Section Title #	Date of Release	Author	Summary of Changes
Final Working Draft	July 22, 2020	SCGA Staff / SDI	This is a living document expected to be adjusted adapted as new information emerges.

APPENDICES

Appendix A. SASb Stakeholders Interviewed for the Stakeholder Assessment 33
Appendix B. Memorandum of Understanding Establishing a SASb SGMA Working Group and Identifying Cost Share Provisions for GSP Development 34
Appendix C. Statutory Requirements for SGMA 44
Appendix D. SASb Groundwater Website Portal 46
Appendix E. Partnership Commitment 49
Appendix F. Initial Interested Parties List 63
Appendix G. Disadvantaged Communities in the SASb 67
Appendix H. Native American Tribal Governments in the SASb 74
Appendix I. Preliminary Engagement Schedule 77
Appendix J. Example Public Notice 78
Appendix K. Meeting Feedback Form 80
Appendix L. Postcard Mailers 81
Appendix M. Interbasin Coordination under the Sustainable Groundwater Management Act 82
Appendix N. Media Contacts List 84

DRAFT

Appendix A. SASb Stakeholders Interviewed for the Stakeholder Assessment

Stakeholders Interviewed

Name	Affiliation
Suzanne Pecci	Agricultural-Residential Representative for County of Sacramento on SCGA Board
Lynn Wheat	Agricultural-Residential Representative
Lindsey Liebig	Farm Bureau
Nancy Myers	Laguna Creek Watershed
Erik Ringelberg	Northern Delta GSA
Archie James	Omochumne-Hartnell Water District
Mike Wackman	Omochumne-Hartnell Water District
Dave Ocenosak	Regional San
Terrie Mitchell	Regional San
Todd Eising	City of Folsom
Paul Schubert	Golden State Water
Darrell Eck	Sacramento Central Groundwater Authority GSA
Ramon Roybal	Sacramento Central Groundwater Authority GSA
Linda Dorn	Sacramento County GSA
Ted Rauh	SCGA Conservation Landowner Representative
Bill Myers	Sheldon Community Association
Austin Miller	Sloughhouse RCD
Barbara Washburn	Sloughhouse RCD

Appendix B. Memorandum of Understanding Establishing a SASb SGMA Working Group and Identifying Cost Share Provisions for GSP Development

Memorandum of Understanding
Establishing a South American Subbasin SGMA Working Group and Identifying Cost Share Provisions for GSP Development

This Memorandum of Understanding ("**MOU**") is entered into and effective this 13th day of May, 2020 by and among the County of Sacramento, a political subdivision of the State of California; Sacramento Central Groundwater Authority (SCGA), a joint powers authority; Northern Delta Groundwater Sustainability Agency (NDGSA), a joint powers authority; Omochumne-Hartnell Water District (OHWD), a California Water District; and Sloughhouse Resource Conservation District, (SRCD) a California Resource Conservation District. (each a "**Party**" and collectively, the "**Parties**.")

RECITALS

WHEREAS, the 2014 Sustainable Groundwater Management Act ("**SGMA**") empowers local agencies to adopt and implement groundwater sustainability plans ("**GSPs**") in order to provide for the sustainable management of groundwater basins; and

WHEREAS, SGMA recognizes and supports the primacy of local agencies in managing groundwater within their boundaries, and promotes coordination and collaboration among those local agencies in order to ensure sustainable groundwater management; and

WHEREAS, the Sacramento Valley- South American Sub-basin ("**Basin**") is an un-adjudicated groundwater basin that has been classified as a High Priority basin by the California Department of Water Resources ("**DWR**"), and which therefore must be governed by a GSP, or coordinated GSPs, no later than January 31, 2022; and

WHEREAS, each of the Parties is a local agency within the meaning of Water Code section 10721(m) with authority to adopt and implement a GSP in the Basin; and

WHEREAS, certain of the Parties have elected to serve as GSA in the same areas of the Basin, such that a condition of overlap exists in those service areas; and

WHEREAS, pursuant to County Resolution 2017-0201, the County of Sacramento has accepted responsibility for those portions of the Basin for which no exclusive GSA has been designated ("**Unmanaged Areas**"), such that the entire basin is included within the jurisdiction of a GSA; and

WHEREAS, Sacramento Central Groundwater Authority was awarded a grant under Proposition 1 and a grant under Prop 68 to fund the development of a GSP in the Basin; and

WHEREAS, it is the intent of the Parties to coordinate in the development and implementation of a single Basin-wide GSP; to provide a structure in which to collaborate and share costs in the development of that GSP; and to ensure that each Party appropriately bears the costs of GSP development in its own jurisdiction, and no others.

AGREEMENT

1. Definitions. The following terms shall have the following meanings.

(a) "Administrative Agency" means the entity designated under Section 8 of this MOU to administer the Grant, coordinate with consultants on behalf of the Parties and at the direction of the Working Group, and invoice costs pursuant to this MOU.

(b) "Basin" means the Sacramento Valley – South American Subbasin, as described in DWR Bulletin 118, Basin No. Basin 5-21.65.

(c) "GSA" means a Groundwater Sustainability Agency, established and authorizes pursuant to Water Code section 10723.8.

(d) "GSP" means a Groundwater Sustainability Plan developed under the Sustainable Groundwater Management Act.

(e) "Unmanaged Areas" means those portions of the Basin for which the County, in the absence of any other GSA election, has accepted responsibility as a GSA pursuant to County Resolution No. 2017-0201. For purposes of cost sharing and Working Group governance, the County's allocable area shall include only the Unmanaged Areas, excepting therefrom areas within SRCD/OHWD's jurisdiction.

(f) "Working Group" means the South American Subbasin Working Group, convened pursuant to this MOU for the purposes of developing and providing recommendations related to a SGMA-compliant GSP for the Basin.

2. **Term.** This MOU shall be effective upon signing and shall remain in full force and effect until the date upon which all of the Parties execute a document jointly amending or terminating the provisions of this MOU.

3. **Responsibilities of the Parties.** Each Party to this MOU shall be responsible for: providing timely responses and supporting information related to GSP development to the Working Group and Administrative Agency upon request; performing appropriate and coordinated outreach to other groundwater management entities and stakeholders within the Basin; promptly paying all invoiced costs as set forth in Exhibit A; and for considering and adopting a SGMA-compliant GSP over the area for which that Party serves as exclusive GSA, no later than January 31, 2022.

4. **Independent Consideration of the GSP.** The Parties expressly acknowledge that the Working Group is an advisory body intended to facilitate GSP development. The governing Board of each GSA is responsible for considering and adopting an appropriate GSP for its jurisdictional boundaries. Any Party may decline to adopt the GSP developed by the Working Group, or elect to proceed with development of its own GSP at that Party's expense. The decision not to adopt a GSP developed under this MOU shall not relieve a Party of its cost obligations pursuant to this MOU.

5. **Management Areas**. The parties recognize that the GSP may include distinct management areas to foster implementation and monitoring

6. **Establishment of the South American Subbasin SGMA Working Group.** Upon execution of this MOU, the Parties will convene the South American Subbasin SGMA Working Group ("**Working Group**"). Seats on the Working Group shall be allocated among the Parties as detailed in Exhibit A.

(a) The Working Group shall be responsible for sharing feedback from the Parties related to the GSP development; for developing the GSP for the Basin; and for making recommendations to the Parties regarding the adoption and development of the GSP.

(b) The Working Group will seek to make decisions through consensus. In the absence of a consensus, participants of the Working Group may be called upon to cast votes. Recommendations of the Working Group provided to the Parties shall include a report of the votes cast.

7. **Cost Sharing.** Shared costs of GSP development shall be allocated according to the proportions identified in Exhibit A. When any additional Party becomes a signatory to this MOU, the cost share proportions identified in Exhibit A shall be modified to appropriately distribute GSP development costs between the new and existing Parties, according to the formula identified in Exhibit A.

- In Kind Contributions are appropriate and recognized as satisfactory to meet the cost share requirements of a party to this agreement.

- Nothing in this MOU shall prevent a Party from voluntarily incurring its own costs related to GSP development, or from developing its own GSP or supporting materials at that Party's expense.

- Any in-kind contributions proposed to be substituted for monetary reimbursement of Assignable GSP Development Costs (Exhibit A) must be approved by the Administering Agency and, further, be consistent with the grant agreement between the Administering Agency and DWR.

8. **Responsibilities of the Administrative Agency.** The Administrative Agency shall be responsible for implementing the recommendations of the Working Group in GSP development; engaging and providing direction to consultants at the election and direction of the Working Group; and administering the grants for the benefit of the Basin. Costs of GSP development shall be distributed pursuant to Exhibit A and shall be recoverable by the Administrative Agency from the Parties in the proportions identified in Exhibit A.

(a) SCGA shall be initially designated as the Administrative Agency; this designation may be altered by the unanimous written consent of the Parties. The commitment

of the Administrative Agency to perform the designated functions under this Section is contingent upon the execution and performance of the cost sharing terms of this MOU.

9. **Invoicing and Payment of Shared GSP Development Cash Costs**. Costs of GSP development as set forth in Exhibit A, shall be invoiced to all Parties by the Administrative Agency, and paid by the invoiced Party within 90 days. A Party that fails to make payment within 90 days may be suspended from voting on Working Group recommendations until full payment of the past-due invoices is made. Activities of the Working Group will not be delayed under such an occurrence and costs incurred by the Working Group will still accrue to the Party as set forth in Exhibit A, during any period of non-payment.

10. **Basin Boundary Modifications**. To facilitate the efficient development of a GSP for the Basin, that Parties agree that no Party shall submit a request for Basin Boundary Modification of this Basin to DWR without the unanimous consent of the Parties, which consent shall not be unreasonably withheld.

11. **Withdrawal**. The intent of this agreement is for a spirit of working together for a single Basin-wide GSP. However, any party may unilaterally withdraw from this Agreement without causing or requiring termination of this Agreement by the following provisions.

a) The withdrawing Party shall provide the Working Group with thirty (30) days prior written notice.
b) The withdrawing Party shall be responsible for payment of its proportional share of costs and obligations associated with GSP development identified in Attachment A, up to the time of submission of the written notice of the withdrawal. Withdrawing party would be responsible for securing and funding consultants to develop and submit any amendments or revisions to the GSP required as a result of withdrawal.
c) The withdrawing party shall be responsible for securing SGMA compliance within its jurisdictional boundaries at its own expense, including as necessary, GSP development, coordination, and the cost of any additional requirements imposed by DWR or other regulatory agencies.

The withdrawing party shall be responsible for providing notice, maps and all other necessary information to the DWR and other GSAs regarding its change in status within 30 days of withdrawal.

12. **Resolution of Overlap: OHWD/SCGA**. Upon execution of this MOU, SCGA will modify its current overlapping GSA notification in OHWD's service area (SCGA-GSA-2) to exclude all of OHWD service area, except the area defined as the Kiefer Landfill. OHWD will modify their current overlapping GSA notification to exclude that area defined as Kiefer landfill. Modifications of each party will include all necessary geospatial information needed to identify the new service area boundary for each party. Immediately prior to modifying these notifications, SCGA and OHWD will attach separate letters to their existing notification

explaining why their notifications are being modified. OHWD will formally request that SCGA modify its governing joint powers agreement in order to remove OHWD's lands from SCGA's jurisdiction. SCGA will promptly request that the signatories to that agreement execute an amendment to that agreement to carry out the removal.

(a) For the term of plan development, Zone 13 funding currently provided to SCGA on behalf of OHWD shall be applied by SCGA as a credit toward any costs billed to OHWD under Section 7 of this MOU.

13. **Resolution of Overlap: OHWD/SRCD**. Upon execution of this MOU, SRCD will withdraw their overlapping GSA notification in OHWD's service area (SCGA-2). Immediately prior to withdrawing their notification, SRCD will attach a letter explaining why their current notification is being withdrawn.

14. **Resolution of Overlap and Redefining GSA Boundaries: SCGA/SRCD**. Upon execution of this MOU, SCGA and SRCD will modify their current GSA notifications for SCGA-GSA-3 to reflect this agreement. SCGA will modify their notice to describe and map an area of SCGA-GSA-3 that includes all lands to the eastern boundary of "Zone 40" (Urban limit), and all land within the limits of the Kiefer Landfill, as part of SCGAs GSA service area. SRCD will modify their current notification for SCGA-GSA-3 to describe and map an area east of the Zone 40 boundary and east of the OHWD boundary, and excluding Kiefer Landfill and Rancho Murieta CSD, as the SRCD GSA service area. All South American subbasin land within the Rancho Murieta Community Services District will remain a part of the Sacramento County GSA until such time that the RMCSD Board of Directors makes a formal decision to be included within the boundaries of another GSA. Notice modifications of each party will include all necessary geospatial information needed to identify the new service area boundary for each party. Sacramento County will need to modify their default notice for SCGA-GSA-3 to complete the process.

(a) For the term of plan development, Zone 13 funds collected within SRCDs GSA boundary shall be applied as a credit toward any costs billed to SRCD under Section 7 of this MOU.

15. **Disputes.** The Working Group is committed to working towards consensus in all decisions to be made regarding development of the GSP. With the help of a third-party facilitator, the Parties agree to put a good faith effort into transparently raising any concerns, understanding one another's interests, and working towards solutions that will adequately meet the needs of all Parties.

All claims, disputes, and controversies arising out of or in relation to the performance, interpretation, application, or enforcement of this agreement, including but not limited to breach thereof, shall be referred to mediation before, and as a condition precedent to, the initiation of any adjudicative action or legal proceeding, including arbitration. The Parties covenant that they will participate in the mediation in good faith. Mediation will be

conducted in Sacramento County, California, unless otherwise agreed to by the Parties in writing. The mediator shall be mutually selected.

16. **No Alternation of Water Rights.** Consistent with Water Code sections 10720.1(b), 10720.5 and 10726.8, nothing in this Agreement or in its implementation shall be construed to alter the existing water rights of the Parties.

GENERAL PROVISIONS

17. *Authority*. Each signatory of this MOU represents that s/he is authorized to execute this MOU on behalf of the Party for which s/he signs. Each Party represents that it has legal authority to enter into this MOU and to perform all obligations under this MOU.

18. *Amendment*. This MOU may be amended or modified only by a written instrument executed by each of the Parties.

19. *Jurisdiction and Venue*. This MOU shall be governed by and construed in accordance with the laws of the State of California, except for its conflicts of law rules. Any suit, action, or proceeding brought under the scope of this MOU shall be brought and maintained to the extent allowed by law in Sacramento County, California.

20. *Headings*. The paragraph headings used in this MOU are intended for convenience only and shall not be used in interpreting this MOU or in determining any of the rights or obligations of the Parties.

21. *Construction and Interpretation*. This MOU has been arrived at through negotiations and each Party has had a full and fair opportunity to revise the terms of this MOU. As a result, the normal rule of construction that any ambiguities are to be resolved against the drafting Party shall not apply in the construction or interpretation of this MOU.

22. *Entire Agreement*. This MOU constitutes the entire agreement of the Parties with respect to the subject matter of this MOU and supersedes any prior oral or written agreement, understanding, or representation relating to the subject matter of this MOU.

23. *Partial Invalidity*. If, after the date of execution of this MOU, any provision of this MOU is held to be illegal, invalid, or unenforceable under present or future laws effective during the term of this MOU, such provision shall be fully severable. However, in lieu thereof, there shall be added a provision as similar in terms to such illegal, invalid or unenforceable provision as may be possible and be legal, valid and enforceable.

24. *Successors and Assigns*. This MOU shall be binding on and inure to the benefit of the successors and assigns of the respective Parties. No Party may assign its interests in or obligations under this MOU without the written consent of the other Parties, which consent shall not be unreasonably withheld or delayed.

25. *Waivers*. Waiver of any breach or default hereunder shall not constitute a continuing waiver or a waiver of any subsequent breach either of the same or of another provision of this MOU and forbearance to enforce one or more of the remedies provided in this MOU shall not be deemed to be a waiver of that remedy.

26. *Attorneys' Fees and Costs*. In the event of a dispute between the Parties, each Party will pay their own attorneys' fees, expert witnesses' fees, costs of suit, and any other costs associated with the dispute.

27. *Necessary Actions*. Each Party agrees to execute and deliver additional documents and instruments and to take any additional actions as may be reasonably required to carry out the purposes of this MOU.

28. *Compliance with Law*. In performing their respective obligations under this MOU, the Parties shall comply with and conform to all applicable laws, rules, regulations and ordinances.

29. *Third Party Beneficiaries*. This MOU shall not create any right or interest in any non-Party or in any member of the public as a third party beneficiary.

30. *Counterparts*. This MOU may be executed in one or more counterparts, each of which shall be deemed to be an original, but all of which together shall constitute but one and the same instrument.

31. *Notices*. All notices, requests, demands or other communications required or permitted under this MOU shall be in writing unless provided otherwise in this MOU and shall be deemed to have been duly given and received on: (i) the date of service if served personally or served by electronic mail or facsimile transmission on the Party to whom notice is to be given at the address(es) provided below, (ii) on the first day after mailing, if mailed by Federal Express, U.S. Express Mail, or other similar overnight courier service, postage prepaid, and addressed as provided below, or (iii) on the third day after mailing if mailed to the Party to whom notice is to be given by first class mail, registered or certified, postage prepaid, addressed as follows:

EXHIBIT A: Working Group Membership & Cost Allocation

Party	Working Group Members	Assignable GSP Development Costs *
County of Sacramento	1 Representative	8% of agreed to amount Estimate= $88,247.36
Omochumne-Hartnell Water District	2 Representatives	17% of agreed to amount, to be paid first from Zone 13 funds during development of the GSP Estimate= $187,525.64
Sacramento Central Groundwater Authority	7 Representatives, including: • No more than 5 representatives that are signatories to the SCGA joint powers agreement; public water systems; commercial industrial self supplied interests; or sanitation districts. • At least 2 representatives of Agriculture, Ag-residential self supplied public agencies or Conservation Landowner interests	63% of agreed to amount Estimate= $694,947.96
Northern Delta Groundwater Sustainability Agency	1 Representative	8% of agreed to amount Estimate= $88,247.36
Sloughhouse Resource Conservation District	1 Representative	4% of agreed to amount, to be paid first from Zone 13 funds. Cash Cost estimate=$20,000

Sloughhouse RCD (Con't)		Zone 13 estimate= $25,000 Estimate= $ 44,123.68

. Assignable GSP development Costs are based on matching cost requirements of a Prop 1 grant funds (50% match) and Prop 68 grant fund (25% match).

9

Attachment 2

IN WITNESS WHERE OF, the parties have caused this agreement to be duly executed upon signature.

7-15-20

Brad Van Loben Sels, Board Chairperson
Northern Delta Groundwater Sustainability Agency

Date

7/1/20

Kurt Kautz, Board Chairperson
Omochumne-Hartnell Water District

Date

July 1st 2020

Todd Eising, Board Chairperson
Sacramento Central Groundwater Authority

Date

7/7/20

Michael Peterson, Director
Sacramento County Department of Water Resources

Date

6-16-20

Jay Schneider, Chairperson
Sloughhouse Resource Conservation District

Date

Appendix C. Statutory Requirements for SGMA

Statutory Requirements

Legislative/Regulatory Requirement	Legislative/Regulatory Section Reference	C&E Plan Section
Publish public notices and conduct public meetings when establishing a GSA, adopting or amending a GSP, or imposing or increasing a fee.	SGMA Sections 10723(b), 10728.4, and 10730(b)(1).	7.0
Maintain a list of, and communicate directly with, Interested Parties.	SGMA Sections 10723.4, 10730(b)(2), and 10723.8(a)	3.0/Appx F
Consider the interests of all beneficial uses and users of groundwater.	SGMA Section 10723.2	3.0/Appx F
Provide a written statement describing how Interested Parties may participate in plan development and implementation, as well as a list of Interested Parties, at the time of GSA formation.	SGMA Sections 10723.8(a) and 10727.8(a)	4.0
Encourage active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin.	SGMA Section 10727.8(a)	7.0
Understand that any federally recognized Indian Tribe may voluntarily agree to participate in the planning, financing, and management of groundwater basins – refer to DWR's Engagement with Tribal Governments Guidance Document for Tribal recommended communication procedures.	SGMA 10720.3(c)	7.0
Description of beneficial uses and users of groundwater in the basin	GSP Regulations §354.10	3.0/Appx F

List of public meetings at which the Plan was discussed or considered	GSP Regulations §354.10	Appendix D
Comments regarding the Plan received by the Agency and a summary of responses	GSP Regulations §354.10	N/A at time of publication
A communication section that includes the following (GSP Regulations §354.10):		
Explanation of the Agency's decision-making process	GSP Regulations §354.10	4.0
Identification of opportunities for public engagement and discussion of how public input and response will be used	GSP Regulations §354.10	7.0
Description of how the Agency encourages active involvement of diverse social, cultural, and economic elements of the population within the basin	GSP Regulations §354.10	7.0
The method the Agency will follow to inform the public about progress implementing the Plan, including the status of projects and actions	GSP Regulations §354.10	7.0

DRAFT

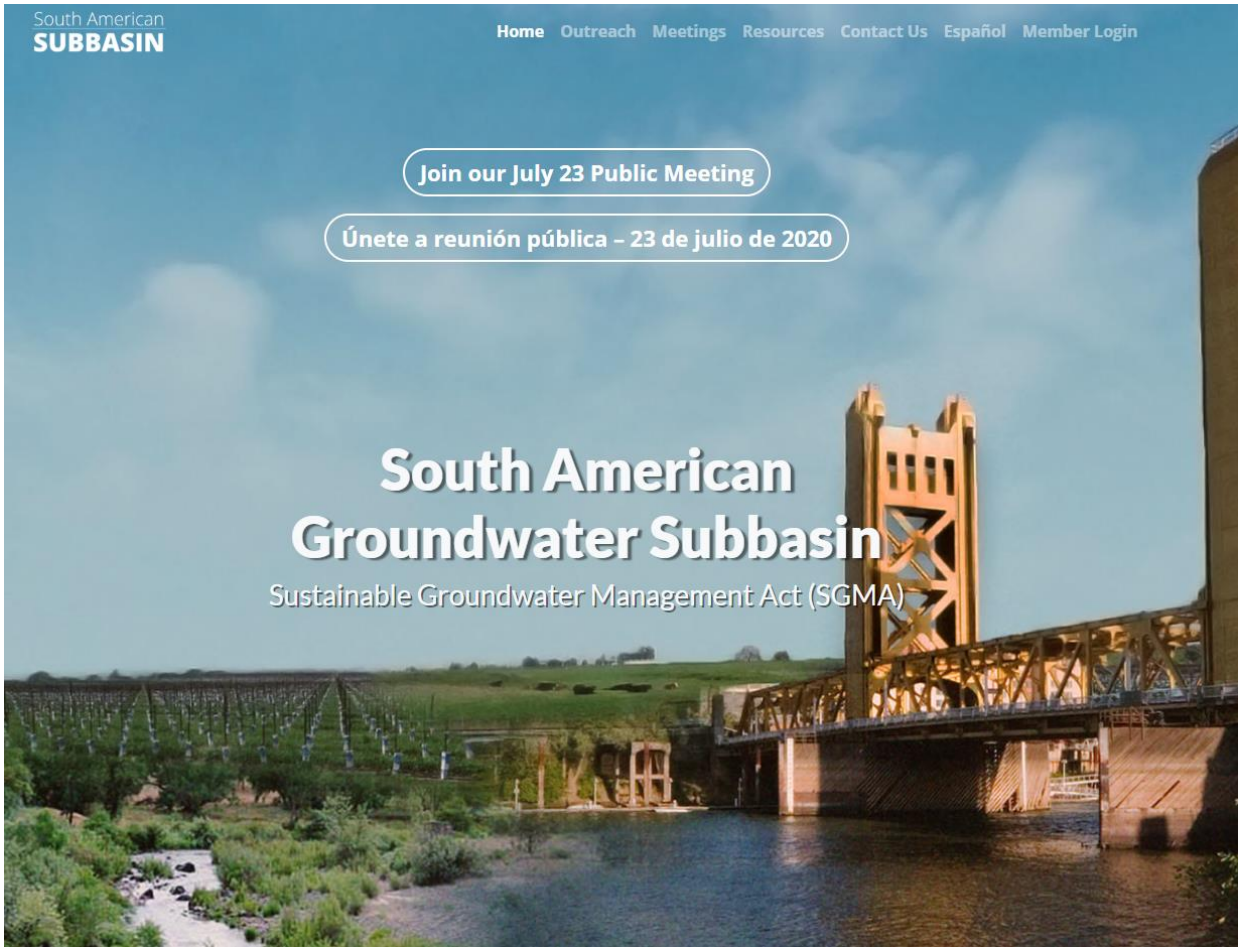
Appendix D. SASb Groundwater Website Portal

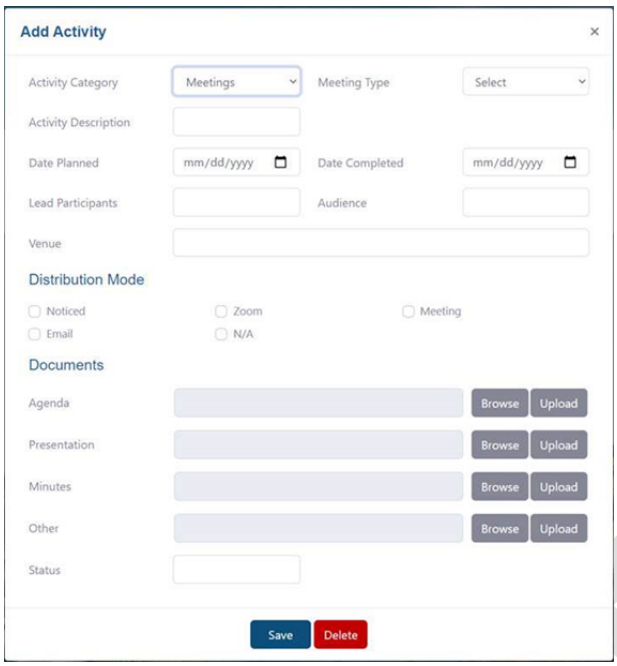
The SASb Website Portal (http://www.sasbgroundwater.org/contact-us.html) is a web-based outreach tool for SASb GSAs to post events and automatically inform Interested Parties about GSP development. Interested Parties can visit the website to register their email address to stay informed about upcoming activities.

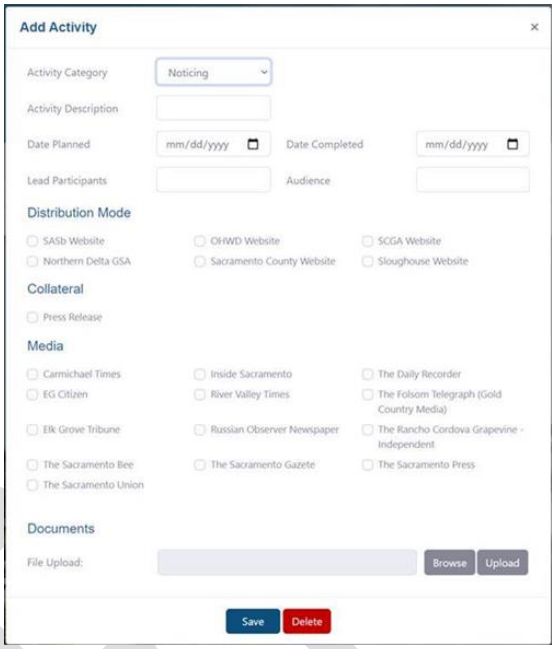
The SASb Website Portal serves as a repository for GSA information about SASb meetings, communications, and Interested Parties. It tracks outreach efforts by the GSAs; storing meeting attendance information as practical with COVID-19 teleconferencing limitations, logging targeted outreach, and hosting the Interested Parties list.

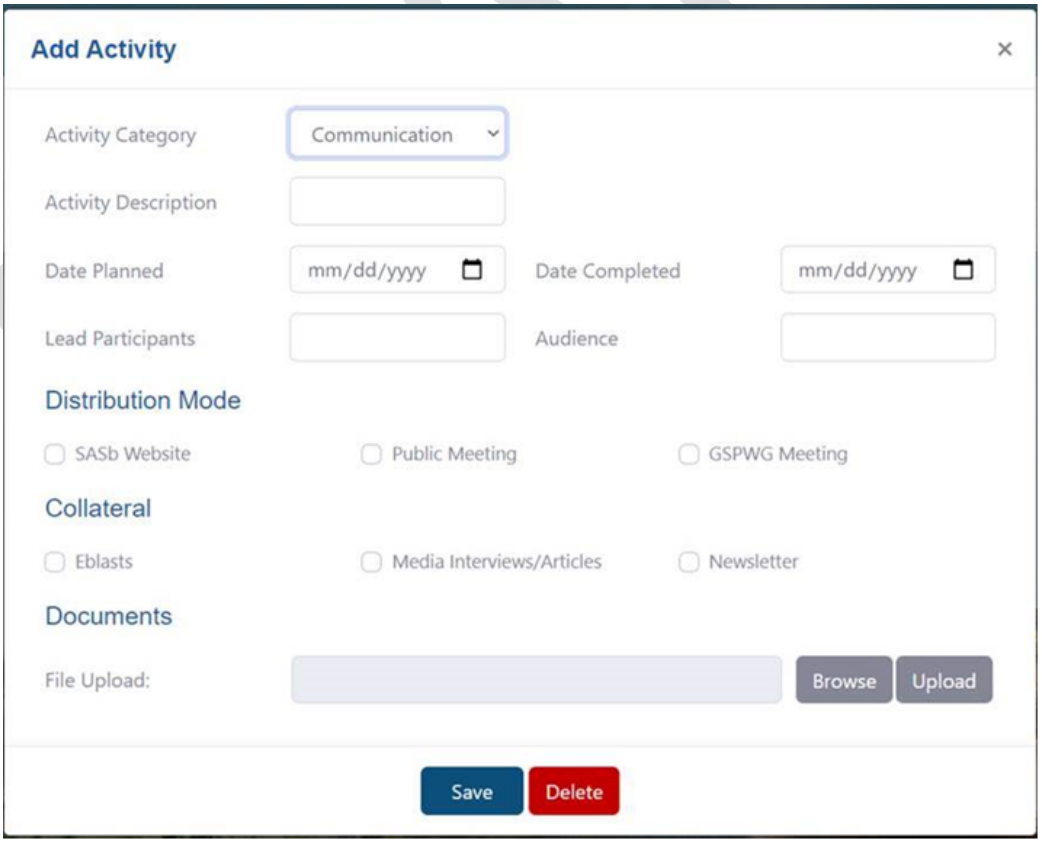
Tool administrators can generate reports about all GSP outreach activities. The reports include items such as attendance sheets, RSVPs, agendas, meeting summaries, handouts, and presentations.

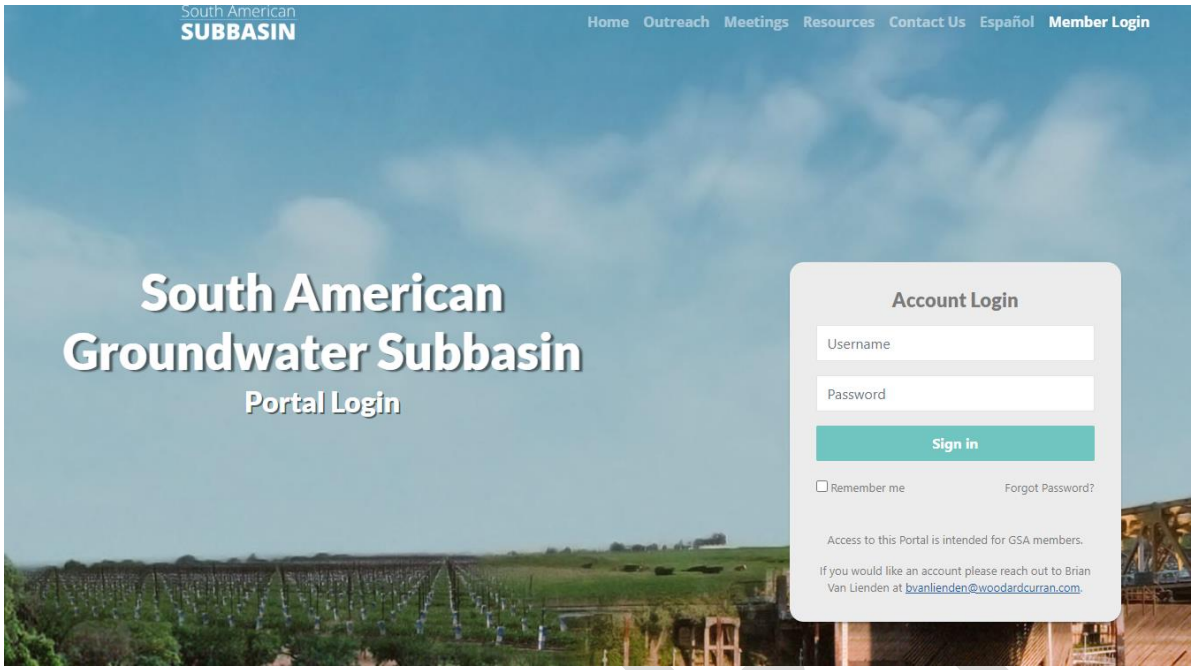
SASbgroundwater.org Home Page, Contact Registration and Portal Pages

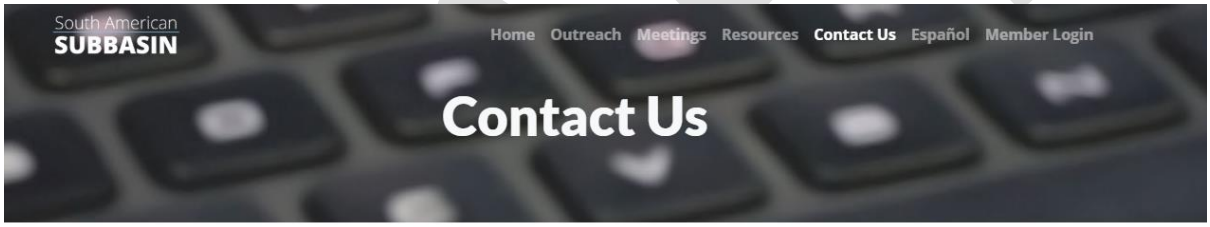



Add Activity
Activity Category
Meetings
Meeting Type
Select
Activity Description
Date Planned
mm/dd/yyyy
Date Completed
mm/dd/yyyy
Lead Participants
Audience
Venue
Distribution Mode
Noticed
Zoom
Meeting
Email
N/A
Documents
Agenda
Presentation
Minutes
Other
Status
Browse
Upload
Save
Delete


Add Activity
Activity Category
Noticing
Activity Description
Date Planned
mm/dd/yyyy
Date Completed
mm/dd/yyyy
Lead Participants
Audience
Distribution Mode
SASb Website
OHWD Website
SCGA Website
Northern Delta GSA
Sacramento County Website
Sloughouse Website
Collateral
Press Release
Media
Carmichael Times
Inside Sacramento
The Daily Recorder
EG Citizen
River Valley Times
The Folsom Telegraph (Gold Country Media)
Elk Grove Tribune
Russian Observer Newspaper
The Rancho Cordova Grapevine - Independent
The Sacramento Bee
The Sacramento Gazete
The Sacramento Press
The Sacramento Union
Documents
File Upload:
Browse
Upload
Save
Delete


Add Activity
Activity Category
Communication
Activity Description
Date Planned
mm/dd/yyyy
Date Completed
mm/dd/yyyy
Lead Participants
Audience
Distribution Mode
SASb Website
Public Meeting
GSPWG Meeting
Collateral
Eblasts
Media Interviews/Articles
Newsletter
Documents
File Upload:
Browse
Upload
Save
Delete





Reach us by email at info@sasbgroundwater.org

GSAs in the South American Subbasin Region

Northern Delta GSA

Omochumne-Hartnell Water District

Reclamation District #551

Sacramento Central Groundwater Authority

Sacramento County

Sloughhouse Resource Conservation

Appendix E. Partnership Commitment

South American SUBBASIN

PARTNERING COMMITMENT + GUIDING PRINCIPLES
South American Subbasin (SASb) Groundwater Sustainability Plan Working Group
MAY 22, 2020

1.0 PURPOSE

These Principles for engagement and operation of the Groundwater Sustainability Plan (GSP) Working Group (Working Group) are intended to provide a framework of agreements among the members to work collaboratively, efficiently, and with the necessary dedication to promote the development, adoption and submission of a Sustainable Groundwater Management Act (SCGA) compliant GSP by the statutory deadline of January 31, 2022.

The Principles derive from and include by reference the *Memorandum of Understanding Establishing a South American Subbasin SGMA Working Group and Identifying Cost Share Provisions for GSP Development,* which is attached as Exhibit A.

2.0 GSP PARTIES

Following are the core parties responsible for delivering the SASb GSP:

Groundwater Sustainability Agencies' (GSAs) Boards of Directors

The five GSAs have respective Boards that have Working Group Members as assigned below.

Groundwater Sustainability Plan Working Group Membership

Northern Delta GSA – 1 member
- Erik Ringelberg, primary
- Chris Thomas, Alternate

Omochumne Hartnell Water District – 2 members
- Mike Wackman
- Mark Stretars
- Mark Wilson, Alternate

Sacramento Central Groundwater Authority (SCGA) – 7 members
- Todd Eising
- Paul Schubert
- Mark Madison
- Evan Jacobs
- Dave Ocenosak
- Ted Rauh
- Christine Thompson

Sacramento County – 1 member
- Linda Dorn
- Kerry Schmitz, Alternate

Sloughhouse Resource Conservation District – 1 member
- Austin Miller

1

- Herb Garmes, Alternate

GSP Administrating Agency

Sacramento Central Groundwater Authority

- John Woodling, Interim Executive Director, SCGA
- Bob Gardner
- Jonathan Goetz
- Ramon Roybal

Consultants Team

Larry Walker Associates

- Tom Grovhoug
- Laura Foglia
- Stephen Maples
  - **SEI**
    - Marisa Escobar
  - **KJ**
    - Sachi Itagaki
    - Jennifer Lau Larsen

Woodard & Curran

- Ali Taghavi
- Brian Van Lieden
- Jim Blanke
  - **Strategy Driver**
    - Ellen Cross
  - **HDR**
    - Shawn Koorn
    - Jafar Faghih

3.0 RESPONSIBILITIES

The primary responsibilities of each party to the GSP Team are identified below.

Respective GSAs' Boards

Each respective Board for the five GSAs will be responsible for:

- Ensuring appropriate communication and engagement is executed per the approved Communication and Engagement (C&E) Plan on behalf of their GSAs.
- Accepting interim milestone approvals to meet the mandated schedule of the Final GSP.
- Being informed about the GSP by their designated Working Group Members listed above.
- Informing their respective Working Group Members with their insights, perspectives, and opinions.
- Ultimately adopting an acceptable final GSP to deliver for DWR review by January 2022.

Working Group

2

The Working Group members shall be responsible for:

- Sharing feedback from their respective GSA's related to the GSP development.
- Making recommendations to their GSA regarding the consideration and adoption of the GSP.
- Providing or ensuring the provision of timely responses and supporting information related to GSP development to the Consultants, Working Group and Administrative Agency upon request in order to meet the state mandated GSP deadline.
- Performing and supporting appropriate and coordinated outreach to other stakeholders within the Basin.
- Ultimately delivering an acceptable GSP to all GSAs for adoption.

GSP Administrating Agency

SCGA Staff will be responsible for:

- Being the point of contact for the Working Group to coordinate with the Consultants.
- Overseeing the Consultants in the delivery of the GSP scope of work and budget per the contract.
- Ensuring grant obligations are met and reimbursements received.
- Delivering GSP priorities within the state mandated GSP schedule.

Consultants

Each member of the Consultant Team will be responsible for:

- Ensuring the delivery of the GSP Scope of Work on time and within the budget per the contract.

Collective Outreach and Engagement Responsibilities

To foster the consideration of the beneficial uses and users of groundwater in the subbasin, the Working Group members agree to the following:

- Parties are committed to an inclusive and transparent process that proactively seeks the engagement and input of potentially impacted parties as identified in SGMA. Parties will work to develop protocols for public engagement, both at public workshops and during regular Working Group meetings.
- Parties will work collectively to develop an agreed-upon outreach plan, but each GSA is responsible for helping to guide and implement efforts within their respective jurisdictions.
- Parties recognize the value in developing shared messages to ensure consistency; joint participation in outreach efforts is encouraged to foster consistency in message and concretely demonstrate the parties' coordinated effort.
- Parties recognize the need to conduct outreach in the near-term to better understand additional representation needs (e.g., environmental, tribal, riparian water users, overlying water users, disadvantaged communities (DACs) etc.) beyond the signatories to this agreement.

3

4.0 DECISION MAKING

Pursuant to the MOU, the Working Group will seek to make decisions through consensus. In the absence of a consensus, participants of the Working Group may be called upon to cast votes. Recommendations of the Working Group provided to the GSAs shall include a report of the votes cast.

With respect to voting procedures:

- Each Member commits to make a genuine effort to achieve consensus. Consensus is the preferred method for reaching agreement; voting is a last resort.
- Members from the OHWD GSA and SCGA GSA may vote by proxy provided in writing to another member from their respective GSA.
- Members who are the sole representative of their GSA (representing SRCD GSA, Sacramento County GSA and North Delta GSA) should identify an alternate to attend the meetings of the Working Group and vote on their behalf if they are unavailable.

5.0 SUCCESS FACTORS + BARRIERS TO SUCCESS + MITIGATING

SUCCESS	BARRIERS TO SUCCESS	MITIGATION
GOVERNANCE		
• Everyone is heard with equal voice and full participation	• Voting with an even number of participants	• Build consensus through discussion to envision success
• Understand flexibility and local needs – different demands for each	• Individual GSA Boards must buy in – waiting until the end or not knowing what has gone into the decision making will be problematic	• WG members needs to be the Liaisons and Advocates between the WG and the GSA Boards (e.g. build on successful MOU process that built trust)
• Understand where public will engage, actively outreach and communicate with them	• Public Meetings and how will play in with meetings and Boards	• Resolve issues of public meetings for the Working Group • Lay out public meeting schedule in C&E Plan
• Need to express positions of respective Boards of GSAs	• Understand that these are not personal or agency positions/decisions of the individuals; rather the position of the respective	• Need to articulate the nuances and technical challenges to the Boards • The decision by respective Boards will need to be carried forth

4

	GSA Boards	• Need to find consensus recommendations within the WG that can be carried to the Boards; but ultimately the Boards have the decision making authority. • Bring back the Boards' decisions and barriers to success • Have rigorous discussion with your respective Boards
• Working together to meet the schedule and any barriers to schedule	• Holding back information or barriers to success	• Possibly provide a Third Party outside of this group that is independent to help us if consensus process does not work
• Engage all interested parties / stakeholders including the public and electeds' early	• Dealing with mostly Staff vs Electeds on GSPWG – we may put together a good GSP but have uninformed participants that undermine the process.	• Need to make sure we bring the Electeds and other key stakeholders along and address concerns early (meet with them; educate them; same constituents)
STAKEHOLDERS		
• Getting Public Understanding	• Work with the public and provide a forum with the WG • Also provide a forum for the WG to work through issues before bringing to the public – we must work quickly and meaningfully while keeping the public informed and engaged at key milestones	• We should treat ourselves as an "ad hoc" – we need to build trust with the stakeholders and involve them in the GSP – need a mechanism so interested parties can "listen" through a mechanism so they know what is going on in the WG.
• Clearly state in the C&E Plan, how and when the public will be engaged	• Inconsistent messaging and engagement with the stakeholders	• Need to educate Public on how they will potentially benefit/be impacted and that we have a consistent

5

		message while building the GSP and distributed by all the Boards to set the stage for acceptance.
• A well informed public and stakeholders understand the process and can provide input	• Not bringing all the stakeholders along and not being transparent or providing the ability for input	• Set up an independent webpage that includes the technical documents / presentations / next meetings for the public
• Coordinating with adjacent basins to ensure there are no conflicts in information, sustainable criteria or actions	• Interbasin relationships, information or conflicts are not resolved.	• Need to find ways to coordinate alignment with adjacent basins so there are not differing answers / e.g. outcomes to the sustainable criteria
• Keep DWR engaged on the GSP process and asking them to observe so they know why and how we came up with our GSP to prevent any future obstacles	• DWR is not involved	• Engage Chelsea and new Grant Administrator engaged from the start (N American Subbasin with a co-worker) • Keep the Grant Administrator engaged
• Engage stakeholders in existing processes as much as possible with integrated messaging with ongoing efforts	• Competing messaging • Oversaturating stakeholders with engagement and messaging • Confusing stakeholders	• Leverage Regional San and County Ag as they are doing significant outreach to the Farming and Ag communities within the Recycled Water area and messaging on recycled water
TECHNICAL		
• Understand the goals of the GSP and what we want to implement	• Pulling in information into the GSP that we do not need to meet DWR obligations	• Need to NOT set up new requirements that are not defensible • Take DWR guidance that they have available
• Create actions that are implementable and measurable	• An unmeasurable Plan (e.g. GDEs) – lots of unmeasurable actions/requirements – careful not to tie our hands if we cannot implement the GSP	• GSP will establish measurable metrics and develop a plan to monitor success

6

• Need to build on work that has been completed within and adjacent to the Basin (basin boundary amendments)	• Starting from scratch	• Leverage all past work that is of value to expedite the GSP development
• Need to identify what we want in the GSP and what do we want the GSP to do – what will we implement and what is the objective to eliminate conflict going forward.	• Not knowing what we want to achieve, expanding beyond SGMA requirements/authorities, scope creep	Put in a mission, vision and Sustainability Goal related to the GSP so we accomplish what we want the Basin to do Understand the Alternative deficiencies to be addressed.
REGULATORY		
• Understand where GSP interfaces with land use	• How does land management authority work under GSP – without consideration of police powers for implementation	• Understand land use interface with GSP • Reconcile land use overlap (e.g. General Plans)
• Understand what regulatory impacts there are by SASb areas of concern	• Understand known groundwater contamination and remedial efforts and level of involvement of each GSA (e.g. Not in the N Delta GSA area)	• Need to address in GSP
SCHEDULE		
Need to get the job done and not let State take over	• Avoid State Water Board intervention	• Be responsive to the schedule – it matters
FUNDING		
• Ensure rate increases and funding mechanisms are coordinated	• Communicating rate changes ineffectively (218)	• Work with County aggressively to adopt a decision on 218 option or dual process to avoid confusion • Ensure HDR who is doing all the rates can coordinate the multiple processes.
COLLABORATION		
• Trustful, collaborative and transparent partnership	• Diminishing trust	• Continue the trust built from the MOU process to resolve the potential issues (Boundaries, governance,

7

		hard feelings) • Sloughhouse recent Board meeting reiterated the importance of trust and acknowledged it is growing and they are dedicated to the process • Create this as a "core value" and reinforce • Understand that trust and disagreement are not the same; so it is important that the GSP develops into something we can live with

6.0 GUIDING PRINCIPLES

Members agree to the following principles to inform and guide Working Group deliberations, foster constructive discussions, promote a clear and shared set of expectations, and encourage collaboration.

Support an Effective and Efficient Process

Rely on credible information. To foster effective dialogues, members agree to mutually support a transparent and inclusive process where parties commit to rely on credible data and clear criteria to inform decision-making and to draw on the advice of the Consultant Team selected to support its development of a GSP.

Craft a GSP that respects local jurisdictions while building subbasin-wide approach. Parties are committed to working together to develop an integrated and effective GSP, while respecting each GSA's interest and expertise to oversee implementation within its unique jurisdiction or distinct planning areas. Parties agree to move the GSP process forward through consensus to ensure GSP approval by all GSA Boards.

Build off existing structures, lessons learned and past work where practicable, to leverage past investments and make the best use of everyone's time and resources.

Build progress through incremental agreements. Participants will use preliminary agreements on issues as the basis for progress towards final agreement. The Working Group will revisit preliminary agreements when new information emerges and again when finalizing overall recommendations.

Dedicated Participation and Respectful Engagement

8

Commitment of Working Group members to practice and promote engaged preparation for and participation in scheduled meetings; timely response and input to communications and deliverables; and transparent and timely delivery of pertinent information.

Commitment to collaborate. All members agree to work together in a constructive manner to meet SGMA requirements based on a locally driven approach. No one is to benefit at the expense of others, and all parties agree to negotiate in good faith. Realize our collective teamwork is mandatory to move the GSP process forward and diversion from the process will put the GSP delivery at stake. Strive to reach consensus on positions of shared interest and proactively identify barriers for discussion and, where possible, resolution at the earliest opportunity.

Commitment of time. Strive to attend meetings consistently; we need everyone at the table throughout. Contribute your thoughts and share our time so everyone can participate.

Respect Others and the Process. Seek opportunities to share your perspectives and understand the perspectives of others; listen intently to what others are saying; be honest and fair, and as candid as possible. If you hear something you do not understand, ask questions to clarify. If you hear something you do not agree with, help people understand your concerns.

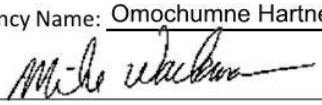
By signing below you acknowledge your intent to uphold the Partnering Agreement.

Agency Name: Sacramento Central Groundwater Authority

Ramon Royval, SCGA Staff — 6/4/2020

(Name and Title) (Date)

Agency Name: Omochumne Hartnell Water District



6/1/2020

Mike Wackman, General Manager

(Name and Title) (Date)

Agency Name: Strategy Driver, Inc.

June 3, 2020

(Name and Title) (Date)

9

Agency Name: Norther Delta Groundwater Sustainability Agency

June 23, 2020

Erik Ringelberg – NDGSA Administrator

June 23, 2020

Chris Thomas – NDGSA Alternate

Agency Name: Woodard & Curran, Inc.

06/04/2020

(Name and Title) (Date)

Agency Name: Woodard & Curran, Inc.

06/03/2020

(Name and Title) (Date)

Agency Name: Sacramento Central Groundwater Authority / Golden State Water Co

Paul Schubert
General Manager

Paul T. Schubert Digitally signed by Paul T. Schubert Date: 2020.06.03 15:43:18 -07'00'

Agency Name: Larry Walker Associates

June 3, 2020

Thomas Grovhoug, Senior Executive

(Name and Title) (Date)

Agency Name: Sacramento County Groundwater Sustainability Agency

Linda Dorn, Environmental Program Manager — June 3, 2020

(Name and Title) (Date)

Agency Name: SACRAMENTO CENTRAL GROUNDWATER AUTHORITY

THEADORE MURAUH BOARD MEMBER JUNE 2, 2020

(Name and Title) (Date)

Agency Name: Sloughhouse Resource Conservation District

6-1-20

Austin Miller
District Staff

June 1, 2020

Agency Name: SCGA STAFF

JOHN WOODLING 6/4/20

(Name and Title) (Date)

Agency Name: Omochumne-Hartnell Water District

Mark L Stratton June 1, 2020

(Name and Title) (Date)

Agency Name: Sloughhouse Resource Conservation District

Herb Garms
SRCD District Direc or

6/23/20
Date

Agency Name: Sac County Water Agency

6/23/20

(Name and Title) (Date)

Agency Name: Sacramento Central Groundwater Authority
Christine Thompson , Board of Directors

Public Agencies Self-Supplied June 4, 2020

(Name and Title) (Date)

Agency Name: California American Water

Evan Jacobs, Director of Regulatory Policy 6-5-20

Agency Name: Larry Walker Associates

Laura Foglia, Senior Engineer 06/03/2020

Agency Name: Florin Resource Conservation District/Elk Grove Water District

Mark J. Madison — June 5, 2020 (Date)

Agency Name: Sacramento Central Groundwater Authority

6/4/2020 (Date)

Senior Civil Engineer

Agency Name: Sacramento Regional County Sanitation District

6/2/20 (Date)

(Name and Title)

Dave Ocenosak
Principal Engineer

Agency Name: Sacramento Central Groundwater Authority

6/25/20 (Date)

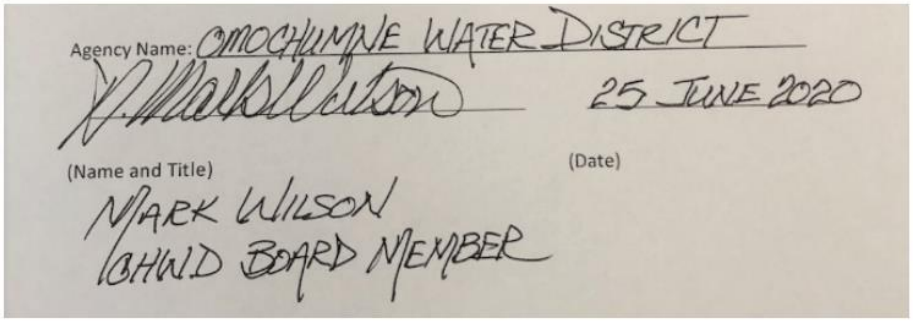
(Name and Title)

Agency Name: SCGA Staff

R. Gardner — 6/29/2020 (Date)

(Name and Title)

Bob Gardner P.E.
Associate Civil Engineer


Agency Name: OMOCHUMNE WATER DISTRICT

25 JUNE 2020

(Name and Title)

(Date)

MARK WILSON
OHWD BOARD MEMBER

Appendix F. Initial Interested Parties List

Pursuant to the California Water Code Section 10723.2, the SASb GSAs will consider the interest of all beneficial uses and users of groundwater when developing and implementing the SASb GSP.

The five SASb MOU GSAs developed lists of Interested Parties and submitted those lists to DWR at the time of GSA formation and augmented the list since that time. A compiled list of those submissions is provided below. This initial list, plus individuals who expressed interest in receiving updates about GSP development via the SASb website, will be imported into the website portal (presented in Appendix D) launched in July 2020. The SASb website portal will notify the Interested Parties list via email when GSP-related events are scheduled in the SASb. The list continues to grow as additional Interested Parties self-register or are otherwise identified.

Agency

- City of Elk Grove
- City of Folsom
- City of Rancho Cordova
- City of Sacramento
- Sacramento County
- Sacramento Central Groundwater Authority
- Florin Resource Conservation District/ Elk Grove Water District
- Lower Cosumnes Resource Conservation District
- Omochumne-Hartnell Water District
- Florin County Water District
- Rancho Murieta Community Services District
- Reclamation District 800
- Reclamation District 1002
- Sacramento County Water Agency
- Sacramento Regional County Sanitation District
- Sloughhouse Resource Conservation District
- Southgate Recreation and Park District

Water Corporations Regulated by PUC or a Mutual Water Company

- California-American Water Company
- Fruitridge Vista Water Company
- Golden State Water Company
- Tokay Park Water Company

Agricultural Users

- Agricultural landowners (individuals)_
- Wine Grape Growers Association
- Sacramento County Farm Bureau
- Southeast Sacramento County Agricultural Water Authority

Domestic Well Owners

- Individual rural residential/suburban landowners

Other Users

- East Lawn Cemetery
- Elk Grove Cosumnes Cemetery District
- St. Joseph's Catholic Cemetery
- Calvary Catholic Cemetery
- St. Mary's Catholic Cemetery
- Greater Sacramento Muslim Cemetery
- Sacramento Historic Cemetery
- Quiet Haven Memorial Park
- Sacramento Pet Cemetery
- Camellia Memorial Lawn
- Odd Fellows Lawn Cemetery
- Building Industry Association
- California Association of Resource Conservation Districts
- California State University, Sacramento

Public Water Systems

- El Dorado Mobile Home Park
- Sequoia Water Assoc
- Travel Lodge Mobile Home Park
- Cozy Villa MHP
- Tokay Park Water Co
- Holiday Mobile Village
- Twin Palms Motel
- El Dorado West MHP
- Plantation Mobile Home Park
- Freeport Marina Inc
- Laguna Village RV Park
- Westerner Mobile Home Park
- Locke Water Works Co
- Delta Crossing MHP

Golf Courses

- Valley Hi Country Club
- Bradshaw Ranch Golf Course
- Mather Golf Course
- Wildhawk Golf Course

Federal, State, Regional

- Department of Water Resources
- State Water Resources Control Board
- US Bureau of Reclamation
- US Fish and Wildlife Service
- California Fish and Wildlife Service
- Central Valley Regional Water Quality Board
- North Delta Water Agency
- Solano County Water Agency

DRAFT

- San Joaquin County Flood Control and Water Conservation District
- Yolo County Flood Control and Water Conservation District
- Regional Water Authority
- Sacramento Groundwater Authority

Local Land Use Planning Agencies/Adjacent GSAs

- City of Elk Grove
- City of Folsom
- City of Rancho Cordova
- City of Sacramento
- County of Sacramento

Environmental Users of Groundwater

- Various agencies on this list address environmental concerns related to groundwater and the SASb GSAs will work with them to consider and protect such interests, including but not limited to the additional organizations cited.
- Stone Lakes National Wildlife Refuge
- Sacramento Valley Conservancy
- The Nature Conservancy
- Cosumnes River Preserve
- Cosumnes Coalition
- Delta Meadows State Park

Tribal Governments

- Wilton Rancheria
- Buena Vista Rancheria Mewuk Indians
- Ione Band of Miwok Indians
- Nashville Enterprise Miwok-Maidu-Nishinam Tribes
- Shingle Springs Brand of Miwok Indians
- Tsi Akim Maidu
- United Auburn Indian Community of the Auburn Rancheria
- Colfax-Todds Valley Consolidated Tribe
- Yocha Dehe Wintun Nation

Disadvantaged Communities

- Environmental Justice Coalition for Water
- Florin Census-Designated Place (CDP) DAC
- Lemon Hill CDP DAC
- Parkway CDP DAC
- Fruitridge Pocket CDP DAC
- Freeport CDP DAC

Remediation Stakeholders

- Aerojet Rocketdyne
- Mather Airforce Base (Former)
- Sacramento Army Depot
- Sacramento County Refuse

Entities Monitoring and Reporting Groundwater in the Basin

- Various of the agencies and water companies listed above collect and report groundwater data including at the County and State level (CASGEM)
- Sacramento Central Groundwater Authority
- Sacramento County Water Agency

DRAFT

Appendix G. Disadvantaged Communities in the SASb

This appendix provides documentation for the contacts made by the Groundwater Sustainability Plan (GSP) Consultant Team in the South American Sub-basin (SASb) to assemble a list of Interested Parties from Disadvantaged Communities (DAC). Thee contacts were the first step in outreach to DACs to enable engagement and involvement in the SASb GSP development effort. The focus of the outreach is to DACs which are beneficial users of groundwater in the SASb, i.e. communities which rely on either individual domestic wells or small public water systems that use groundwater as a source of supply.

The following contacts were made:

DAC Organizations Contacted

Organization
Community Water Center
Sacramento County Environmental Management Department
Sacramento River Funding Area DAC Involvement Grant
American River Basin IRWM
Leadership Council for Justice and Accountability
California Rural Water Association
Center for Race, Poverty, and the Environment
Environmental Justice Coalition for Water
Sacramento County
Sacramento Water Forum

The following list of DAC areas in SASb was compiled using information from the DWR Water Tool, DAC Boundaries-Places, 2016. These areas overlap with the water supply entity jurisdictions that are shown in the maps below:

1. **Florin Census-designated Place (CDP) DAC**
   - Water District 1: Florin County Water District
   - Water District 2: Sacramento County Water District
   - Water District 3: City of Sacramento
   - Water District 4: California American Water Company
   - Water District 5: California American Water Company
   - Water District 6: California American Water Company
   - Water District 7: California American Water Company
2. **Parkway CDP DAC**
   - Water District 1: California American Water Company
   - Water District 2: City of Sacramento
3. **Lemon Hill CDP DAC**
   - Water District 1: California American Water Company
   - Water District 2: City of Sacramento
4. **Fruitridge Pocket CDP DAC**
   - Water District 1: California American Water Company

- Water District 2: City of Sacramento

5. **Franklin CDP DAC**
   - Water District 1: Sacramento County Water District
6. **Freeport CDP DAC**
   - Water District 1: Appears to be between Rec District No 307 and North Delta Water Agency

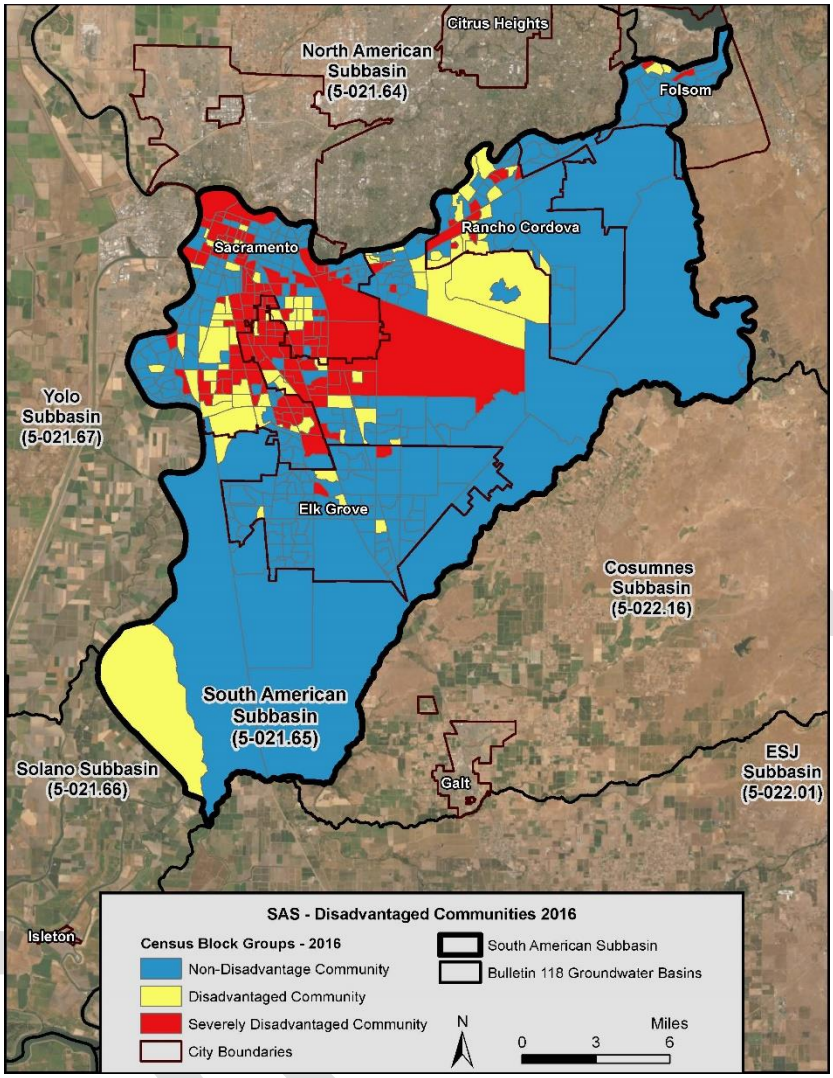
The 2018 American River Basin IRWMP Update shows the following Water Agencies also overlay these DAC Boundaries:

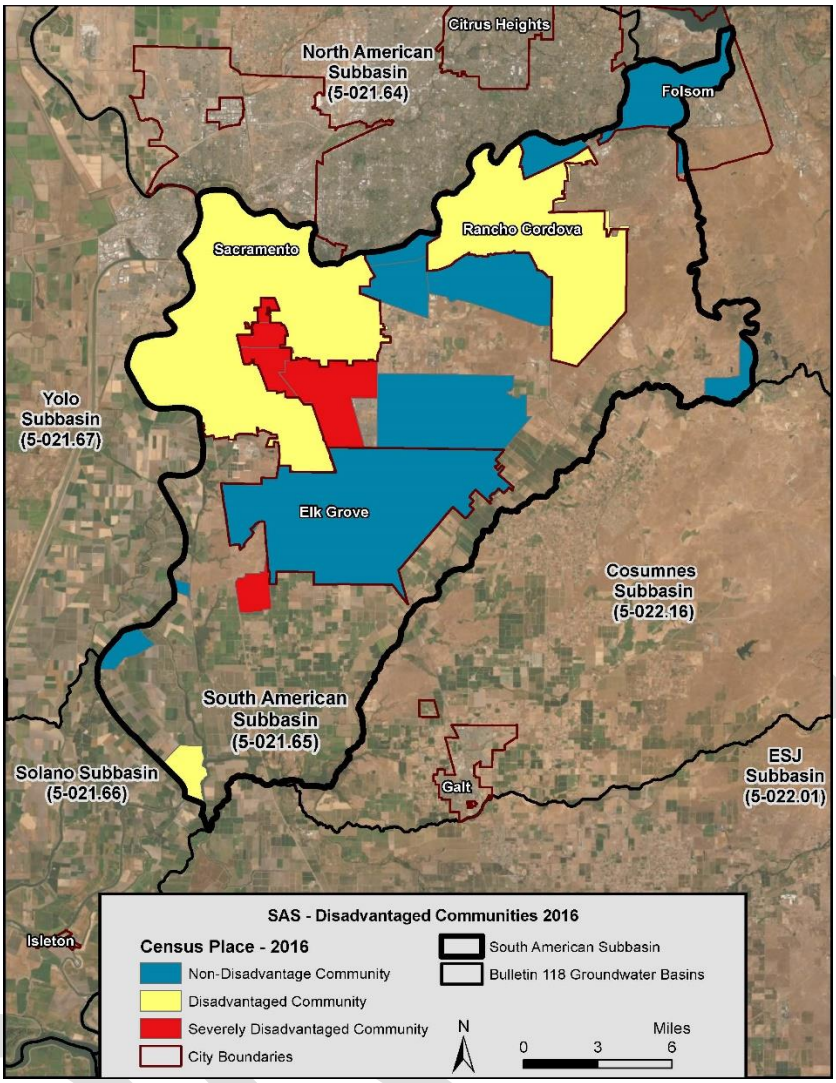
- Golden State Water Company
- California American Water Company
- Sacramento County Water Agency- Zone 41
- Tokay Park Water District

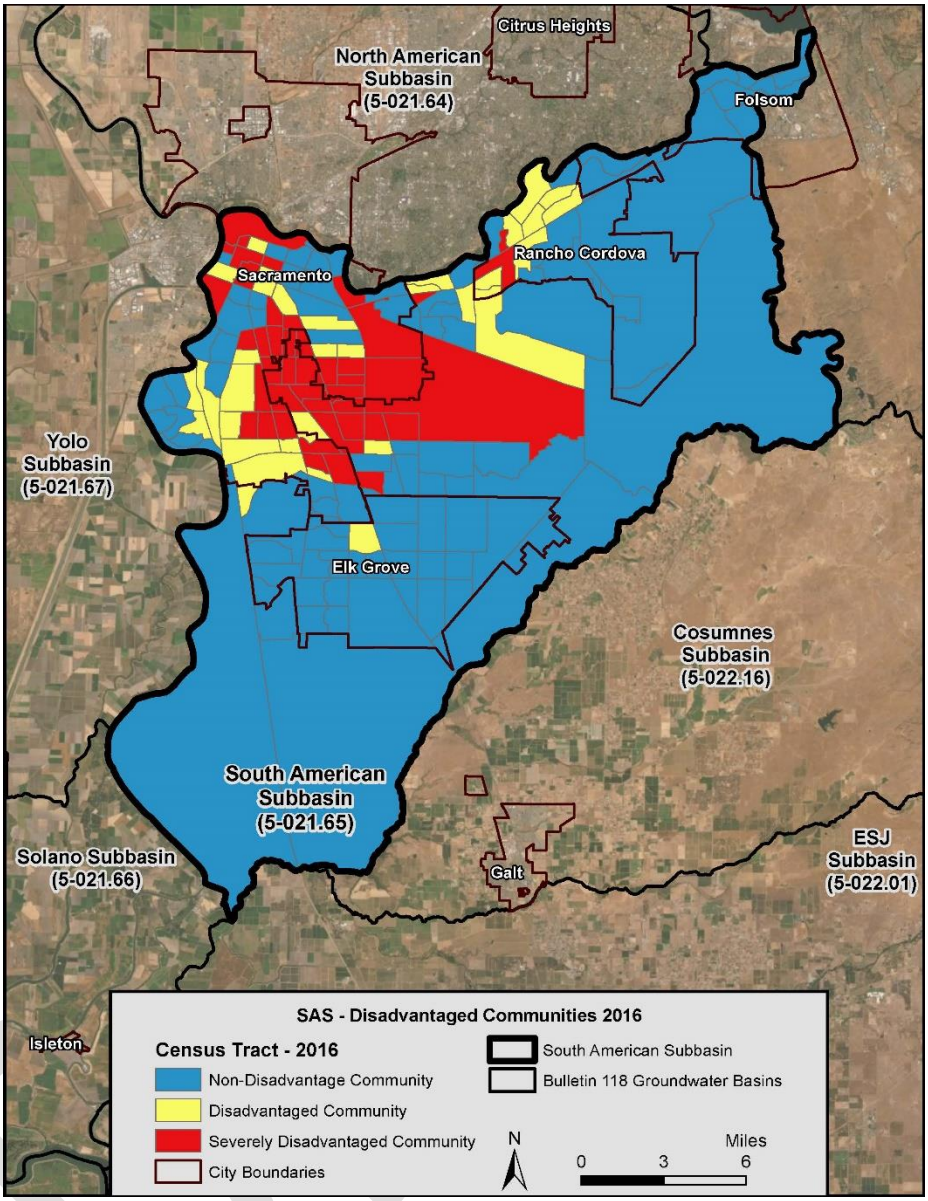
Three maps, depicted below, were prepared showing DACs in the SASb using information available from the DWR Water Tool, DAC Boundaries-Places, 2016. From the organizations above, a list of potentially Interested Parties was developed which will be used in outreach to DACs in accordance with the C&E Plan.

DRAFT

DACs in the SASb




Citrus Heights
North American Subbasin (5-021.64)
Folsom
Rancho Cordova
Sacramento
Yolo Subbasin (5-021.67)
Elk Grove
Cosumnes Subbasin (5-022.16)
South American Subbasin (5-021.65)
Solano Subbasin (5-021.66)
Galt
ESJ Subbasin (5-022.01)
Isleton
SAS - Disadvantaged Communities 2016
Census Place - 2016
Non-Disadvantage Community
Disadvantaged Community
Severely Disadvantaged Community
City Boundaries
South American Subbasin
Bulletin 118 Groundwater Basins
N
Miles
0
3
6


Citrus Heights
North American Subbasin (5-021.64)
Folsom
Rancho Cordova
Sacramento
Yolo Subbasin (5-021.67)
Elk Grove
Cosumnes Subbasin (5-022.16)
South American Subbasin (5-021.65)
Solano Subbasin (5-021.66)
Galt
ESJ Subbasin (5-022.01)
Isleton
SAS - Disadvantaged Communities 2016
Census Tract - 2016
Non-Disadvantage Community
Disadvantaged Community
Severely Disadvantaged Community
City Boundaries
South American Subbasin
Bulletin 118 Groundwater Basins
N
Miles
0
3
6

DRAFT

Sacramento Central Groundwater Authority
Managing Groundwater Resources in Central Sacramento County

827 7th St, Rm 301
Sacramento, CA 95814

Tel: (916) 874-6851
Fax: (916) 874-5698
www.scgah2o.org

John Woodling
Interim Executive Director

California-American Water Company
City of Elk Grove
City of Folsom
City of Rancho Cordova
City of Sacramento
County of Sacramento
Florin Resource Conservation District/Elk Grove Water Service
Golden State Water Company
Omochumne-Hartnell Water District
Rancho Murieta Community Services District
Sacramento Regional County Sanitation District
Agricultural Representative
Agricultural-Residential Representative
Commercial/Industrial Representative
Conservation Landowners
Public Agencies/Self-Supplied Representative

July 13, 2020

To: DAC
xxxxx
xxxxx
xxxx, CA, 9xxxx

Subject: Notice of Intent to Prepare a Groundwater Sustainability Plan (GSP) in the South American Subbasin (SASb)

Dear Chairperson xxxxx,

On behalf of Groundwater Sustainability Agencies (GSAs) representing the South American Subbasin (SASb), we are writing to notify you that a Groundwater Sustainability Plan (GSP) for the SASb is under development as required by the Sustainable Groundwater Management Act (SGMA) (California Water Code Section 10720 et seq). The plan will be developed in accordance with SGMA regulations, in concert with local stakeholders and beneficial users of water in the SASb, and must be approved by the six GSA Boards and submitted to the California Department of Water Resources by January 31, 2022.

SASb GSAs
Northern Delta
Omochumne-Hartnell Water District (OHWD)
Sacramento Central Groundwater Authority (SCGA)
Sacramento County
Sloughhouse Resource Conservation District
Reclamation District 551

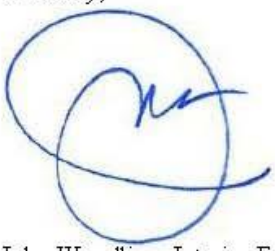
Water is vital to the economy, the environment, and the quality of life for all residents in Sacramento County. While this precious resource is visible every day in the American, Sacramento and Cosumnes Rivers, water that is underground is no less important, providing about half of the region's water supply. Groundwater in the South American Subbasin (SASb) serves the needs of cities, farms, businesses and tribes, and provides high quality drinking water to urban and rural residents, all while helping to sustain vital ecosystems. Your interest and input is essential to developing a plan to sustainably manage the SASb so our groundwater can satisfy your needs and all other needs in perpetuity.

A preliminary Communication and Engagement Plan for the development of the SASb GSP is being developed and will be available soon at www.sasbgroundwater.org. This plan will include a schedule of public meetings and other meetings that will take place during GSP preparation and describes the overall schedule for GSP preparation. The first public meeting (a remote meeting with web-based access) will occur on July 23, 2020 from 6 pm to 8 pm.

SGMA requires that special attention be given to outreach and engagement with disadvantaged communities potentially impacted by decisions made in the GSP development process. We are especially interested in connecting with individuals or communities who are served by domestic wells or small public water systems that operate wells.

If you wish to meet with the GSP Consultant Team members who are assisting in the development of the GSP, please notify the SASb Facilitator below and we will arrange a time for a meeting. To be included on the list of Interested Parties to receive further information on ways to meaningfully participate in the SASb GSP development process, please register at the following web address: sasbgroundwater.org and feel free to contact our Public Outreach Facilitator, Ellen Cross, with any questions or comments by email at crosse@strategydriver.com or by phone at (510) 316-9657.

Sincerely,



John Woodling, Interim Executive Director
Sacramento Central Groundwater Authority

cc: Groundwater Sustainability Plan Working Group
Ellen Cross, Strategy Driver, Inc.

Appendix H. Native American Tribal Governments in the SASb

Native American Tribal entities are included as part of the SASb outreach. The following list of Tribal Governments were contacted in advance of Public Meeting #1 scheduled for July 23, 2020.

- Wilton Rancheria
- Buena Vista Rancheria Mewuk Indians
- Ione Band of Miwok Indians
- Nashville Enterprise Miwok-Maidu-Nishinam Tribes
- Shingle Springs Brand of Miwok Indians
- Tsi Akim Maidu
- United Auburn Indian Community of the Auburn Rancheria
- Colfax-Todds Valley Consolidated Tribe
- Yocha Dehe Wintun Nation

DRAFT

Sacramento Central Groundwater Authority
Managing Groundwater Resources in Central Sacramento County

827 7th St, Rm 301
Sacramento, CA 95814

Tel: (916) 874-6851
Fax: (916) 874-5698
www.scgah2o.org

John Woodling
Interim Executive Director

California-American Water Company
City of Elk Grove
City of Folsom
City of Rancho Cordova
City of Sacramento
County of Sacramento
Florin Resource Conservation District/Elk Grove Water Service
Golden State Water Company
Omochumne-Hartnell Water District
Rancho Murieta Community Services District
Sacramento Regional County Sanitation District
Agricultural Representative
Agricultural-Residential Representative
Commercial/Industrial Representative
Conservation Landowners
Public Agencies/Self-Supplied Representative

July 7, 2020

To: Tribal Nation
Chairperson
xxxxx
xxxx, CA, 9xxxx

Transmitted via email: xxxxxxx

Subject: Notice of Intent to Prepare a Groundwater Sustainability Plan (GSP) in the South American Subbasin (SASb)

Dear Chairperson xxxxx,

On behalf of Groundwater Sustainability Agencies (GSAs) representing the South American Subbasin (SASb), we are writing to notify you that a Groundwater Sustainability Plan (GSP) for the SASb is under development as required by the Sustainable Groundwater Management Act (SGMA) (California Water Code Section 10720 et seq). The plan will be developed in accordance with SGMA regulations, in concert with local stakeholders and beneficial users of water in the SASb, and must be approved by the six GSA Boards and submitted to the California Department of Water Resources by January 31, 2022.

SASb GSAs

Northern Delta

Omochumne-Hartnell Water District (OHWD)

Sacramento Central Groundwater Authority (SCGA)

Sacramento County

Sloughhouse Resource Conservation District

Reclamation District 551

Water is vital to the economy, the environment, and the quality of life for all residents in Sacramento County. While this precious resource is visible every day in the American, Sacramento and Cosumnes Rivers, water that is underground is no less important, providing about half of the region's water supply. Groundwater in the South American Subbasin (SASb) serves the needs of cities, farms, businesses and tribes, and provides high quality drinking water to urban and rural residents, all while helping to sustain vital ecosystems. Your interest and input is essential to developing a plan to sustainably manage the SASb so our groundwater can satisfy your needs and all other needs in perpetuity.

SGMA allows any federally recognized Indian tribe to voluntarily participate in the preparation or administration of a GSP. A federally recognized tribe's actions during

participation will be based on the tribe's independent sovereign authority and not the authorities that SGMA provides to local agencies. Regardless of whether a tribe opts to coordinate their groundwater management with SGMA implementation, SGMA requires GSAs to consider the interests of all beneficial uses and users of groundwater, including tribes.

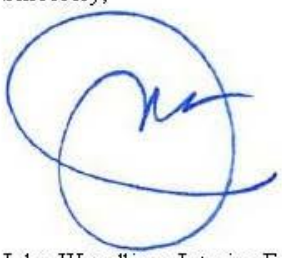
For more information on Tribal Government Engagement with GSAs, please see the Guidance Document on Sustainable Groundwater Management prepared by the California Department of Water Resources Sustainable Groundwater Management Program Tribal Advisory Group.

(https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/GuidanceDocumentforSustainableManagementofGroundwaterEngagementwithTribalGovernments_ay_19.pdf).

A preliminary Communication and Engagement Plan for the development of the SASb GSP is being developed and will be available soon at www.sasbgroundwater.org. This plan will include a schedule of public meetings and other meetings that will take place during GSP preparation and describes the overall schedule for GSP preparation. The first public meeting (a remote meeting with web-based access) will occur on July 23, 2020 from 6 pm to 8 pm.

To be included on the list of Interested Parties to receive further information on ways to meaningfully participate in the SASb GSP development process, please register at the following web address: sasbgroundwater.org. If you wish to meet with the GSP Consultant Team who are assisting in the development of the GSP, or have any questions or comments please contact our Public Outreach Facilitator, Ellen Cross by email at crosse@strategydriver.com or by phone at (510) 316-9657.

Sincerely,



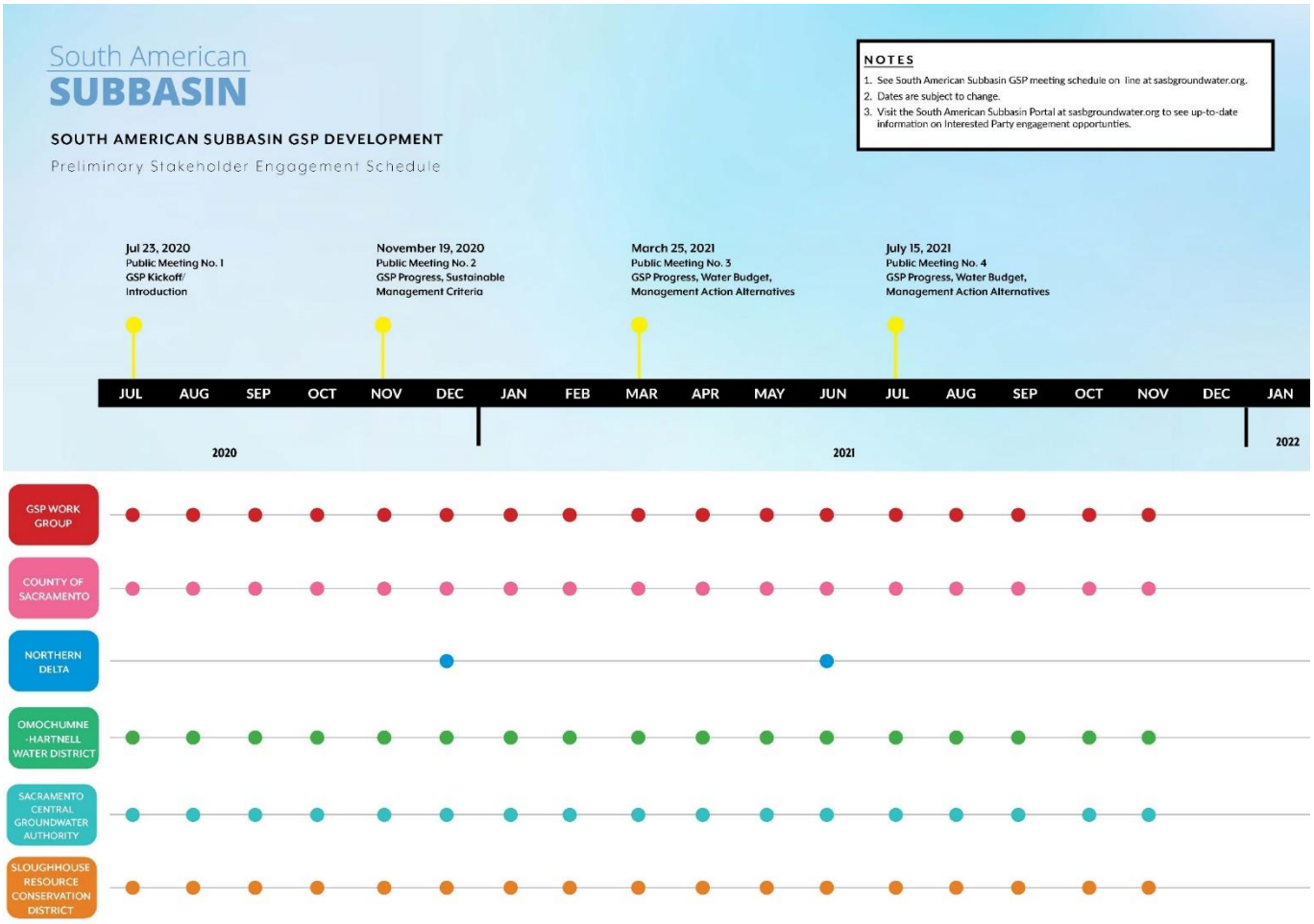
John Woodling, Interim Executive Director
Sacramento Central Groundwater Authority

cc: Groundwater Sustainability Plan Working Group
Ellen Cross, Strategy Driver, Inc.

Page **2** of **2**

Appendix I. Preliminary Engagement Schedule

Preliminary Engagement Schedule



Appendix J. Example Public Notice

Date: July 6, 2020

Contact: Ramon Roybal (916) 874-6826, RoybalR@SacCounty.NET

https://scgah2o.saccounty.net/Pages/default.aspx

SOUTH AMERICAN SUBBASIN GROUNDWATER SUSTAINABILITY PLAN - PUBLIC WORKSHOP – July 23, 2020 – The South American Subbasin (SASb) Groundwater Sustainability Plan (GSP) Working Group, on behalf of five Groundwater Sustainability Agencies (GSAs), invites groundwater basin users and interested community members to attend a public workshop to initiate the development of a GSP for the SASb in accordance with the requirements of the Sustainable Groundwater Management Act (SGMA). The SASb is located in Sacramento County between the American and Cosumnes Rivers.

Why Groundwater Sustainability Matters?

Join us and learn about the condition and future health of your groundwater subbasin. Participate in the process to understand what needs to be done to protect the quality and availability of this valuable resource. Learn why maintaining a sustainable groundwater subbasin matters to the economy, environment, and quality of life of our urban and rural communities. We need your input - join us July 23rd!

The workshop will provide an opportunity to learn more about the following topics and provide initial input on:

- SGMA and the schedule for GSP development for the SASb
- Opportunities for public engagement in the decision-making process for the GSP
- Introduction to the SASb Groundwater Sustainability Agencies' (GSAs) Working Group
- Sustainability Goals and Sustainable Management Criteria

To indicate your interest and access the agendas and materials for the Public Meeting, please visit sasbgroundwater.org. Please note that during the development of the GSP, the GSAs also will hold their regular public Board Meetings, a schedule for which can be viewed at the website.

The GSP Working Group will host a public workshop on:

Thursday, July 23, 2020 from 6:00 pm to 8:00 pm

https://zoom.us/j/97062255197?pwd=dWwySGlNOWMwWmU1UCsyeGtlbWpoQT09

The public can call in at (669) 900 6833

Meeting ID: 970 6225 5197 Password: 936495

The GSPWG includes representation from five of the GSAs:

- Sacramento Central Groundwater Authority
- Northern Delta GSA
- Omochumne-Hartnell Water District
- Sacramento County
- Sloughhouse Resource Conservation District

Note: Pursuant to the Governor's Executive Order N-29-20 and given the state of emergency regarding the threat of COVID-19, the meeting will be held via teleconference.

- We encourage members and participants to join the meeting 10 minutes early. Note that we will use Zoom to share slides and other information during the meeting. Use the link above to join. If you have a microphone that you can use with your computer, it should be possible to both listen to, and participate in, the meeting through Zoom. If you do not have a microphone, or a headset with a microphone that plugs into your computer via USB port, you will need to call into the conference line to listen and comment, although you still should be able to view the meeting materials on Zoom. Please do not simultaneously use a microphone through Zoom and the telephone conference line. That combination results in audio problems for all participants.

Our free news notifications are not a substitute for official means of notification where such exist. You can view or update your subscriptions at any time on your User Profile Page by just using your email address. For questions or assistance, contact subscriberhelp.govdelivery.com. Unsubscribe.

Appendix K. Meeting Feedback Form

South American SUBBASIN

SASb Meeting Survey

SASb Meeting Survey

Please provide feedback to improve our communication and engagement process.

Name: _____

Contact: _____

Date: _____

Survey Questions

Survey Question	Please Select One
1) Information provided was useful and understandable?	Yes ☐ No ☐
2) Meeting noticing was timely, informative about location, and meeting topic(s)?	Yes ☐ No ☐
3) Opportunity to comment was provided?	Yes ☐ No ☐
4) Can we contact you regarding your survey to follow up?	Yes ☐ No ☐

Other SGMA topics and information of interest to you: _____

_____

_____

_____

Other Suggestions on communication and engagement that would be helpful for the SGMA process:

_____

_____

_____

_____

_____

_____

DRAFT

Appendix L. Postcard Mailers

Postcards in English and Spanish sent to announce the SASb GSP Public Workshop

JOIN THE DISCUSSION

In accordance with the Sustainable Groundwater Management Act (SGMA), a Groundwater Sustainability Plan (GSP) is being developed for the South American Subbasin (SASb). Your local GSP Working Group invites you to participate as an Interested Party and to be notified about events concerning GSP preparation.

SASBGROUNDWATER.ORG

Indicate your interest and learn more about the first public meeting on July 23rd!

Sent on behalf of the SASb GSP Working Group representing the SASb Groundwater Sustainability Agencies:

- County of Sacramento
- Northern Delta
- Omochumne-Hartnell Water District
- Sacramento Central Groundwater Authority
- Sloughhouse Resource Conservation District

Why You Should Be Involved

Join us and learn about the condition and future health of your groundwater subbasin. Participate in the process to understand what needs to be done to protect the quality and availability of this valuable resource. Learn why maintaining a sustainable groundwater subbasin matters to the economy, environment, and quality of life of our urban and rural communities.

We need your input- join us July 23rd!

JOIN OUR FIRST PUBLIC MEETING

for the South American Subbasin (SASb) Groundwater Sustainability Plan

JULY 23, 2020

SASBGROUNDWATER.ORG

ÚNASE A LA CONVERSACIÓN

De acuerdo con la Ley de Manejo Sostenible de Aguas Subterráneas (SGMA por sus siglas en inglés), se está desarrollando un Plan de Sostenibilidad de Aguas Subterráneas (GSP por sus siglas en inglés) para la subcuenca sur de American River (SASb por sus siglas en inglés).

El grupo de trabajo local para el GSP le invita a participar como una Parte Interesada para que pueda recibir notificaciones sobre eventos relacionados con la preparación del GSP.

SASBGROUNDWATER.ORG

¡Inscríbase hoy y aprenda más sobre la primera junta pública agendada para este 23 de julio!

Enviado por parte del grupo de trabajo del SASb GSP, que representa a los siguientes cinco Agencias de Sostenibilidad de Aguas subterráneas:

- County of Sacramento
- Northern Delta
- Omochumne-Hartnell Water District
- Sacramento Central Groundwater Authority
- Sloughhouse Resource Conservation District

¿Por qué te deberías involucrar?

Únase con nosotros y aprenda de las condiciones actuales y futuras de nuestra subcuenca de aguas subterráneas. Participe en el proceso para entender mejor lo que se requiere para proteger la calidad y disponibilidad de este recurso vital. Descubra por qué el mantenimiento sostenible de la subcuenca es importante para una mejor economía, medio ambiente, y calidad de vida en nuestras comunidades tanto urbanas como rurales.

¡Le necesitamos en este proceso el 23 de julio!

ÚNETE A NUESTRA PRIMERA REUNIÓN PÚBLICA

para le Plan de Sustentablidad Aguas Subterráneas de la Sub-cuenca South American

23 de julio de 2020

SASBGROUNDWATER.ORG

Appendix M. Interbasin Coordination under the Sustainable Groundwater Management Act

Agencies preparing a Groundwater Sustainability Plan (GSP) under SGMA are encouraged to work with other agencies in adjacent basins to facilitate exchange of technical information, assist with preparation of GSPs, coordinate basin boundary modifications, and conduct outreach to regional stakeholders.

Interbasin coordination is also important to ensure that implementation of a GSP will not adversely affect an adjacent basin's ability to implement is GSP or impede its ability to achieve its sustainability goal. GSAs may develop a voluntary Interbasin Agreement to establish compatible sustainability goals and understanding regarding the fundamental elements of each agency's GSP. Interbasin agreements should facilitate the exchange of technical information between agencies and include a process to resolve disputes concerning the interpretation of that information. (23 CCR § 357.2). A summary of elements to be included in an interbasin agreement is provided below.

DRAFT

Interbasin Coordination Agreement Checklist

	Interbasin Coordination Agreement Element	CA Code of Regulations
General Information		
☐	Identity of each basin participating in and covered by the terms of the agreement.	23 CCR § 357.2 (a)(1)
☐	A list of the Agencies or other public agencies or other entities with groundwater management responsibilities in each basin.	23 CCR § 357.2 (a)(2)
☐	A list of the Plans, Alternatives, or adjudicated areas in each basin.	23 CCR § 357.2 (a)(3)
Technical Information		
☐	An estimate of groundwater flow across basin boundaries, including consistent and coordinated data, methods and assumptions.	23 CCR § 357.2 (b)(1)
☐	An estimate of stream-aquifer interactions at boundaries.	23 CCR § 357.2 (b)(2)
☐	A common understanding of the geology and hydrology of the basins and the hydraulic connectivity as it applies to the Agency's determination of groundwater flow across basin boundaries and description of the different assumptions utilized by different Plans and how the Agencies reconciled those differences.	23 CCR § 357.2 (b)(3)
☐	Sustainable management criteria and a monitoring network that would confirm that no adverse impacts result from the implementation of the Plans of any party to the agreement. If minimum thresholds or measurable objectives differ substantially between basins, the agreement should specify how the Agencies will reconcile those differences and manage the basins to avoid undesirable results. The Agreement should identify the differences that the parties consider significant and include a plan and schedule to reduce uncertainties to collectively resolve those uncertainties and differences.	23 CCR § 357.2 (b)(4)
Conflict Resolution		
☐	A description of the process for identifying and resolving conflicts between Agencies that are parties to the agreement.	23 CCR § 357.2 (c)
Submission to DWR		
☐	Interbasin agreements submitted to the Department shall be posted on the Department's website.	23 CCR § 357.2 (d)

Appendix N. Media Contacts List

Press releases regarding GSP development public workshops are sent to the following media contacts.

Media Contacts

Newspaper Name	Website Link
Carmichael Times	http://carmichaeltimes.com/contact/index.php
EG Citizen	http://www.egcitizen.com/site/contact.html
Elk Grove Tribune	https://elkgrovetribune.com/contact/
Inside Sacramento	https://insidesacramento.com/events/
River Valley Times	https://www.mondotimes.com/1/world/us/5/8437/16348
Russian Observer Newspaper	https://www.russianamericanmedia.com/contact-us/
The Daily Recorder	https://www.dailyrecorder.news/home.cfm
The Folsom Telegraph (Gold Country Media)	https://goldcountrymedia.com/live-content/the-folsom-telegraph/ https://goldcountrymedia.com/live-content/contact/
The Rancho Cordova Grapevine-Independent	http://ranchocordovaindependent.com/contact/index.php
The Sacramento Bee	https://www.sacbee.com/customer-service/contact-us/#navlink=mi_footer
The Sacramento Gazette	https://www.sacgazette.com/
The Sacramento Observer	https://sacobserver.com/contact-us/
The Sacramento Press	https://sacramentopress.com/contact/
The Sacramento Union	https://sacunion.com/

South American
SUBBASIN

Appendix 1-E

Outreach Report (as of 10/21/2021)

Outreach report as of 10.12.2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
General GSP	Initial Notification of GSP Development for SASb	DWR SGMA Portal	SCGA staff	General Public	N/A	7/7/2020
General GSP	Initial Notification of GSP Development for SASb to County/Cities/CA PUC	USPS/Email	SCGA staff	Sacramento County BOS, Cities of Sacramento/Elk Grove/Folsom/Rancho Cordova, CA PUC	6	7/7/2020
General GSP	Noticing of SASb GSP Development to Tribal Representatives	USPS/Email	SCGA staff	Tribal contacts	14	7/9/2020
General GSP	Noticing of SASb GSP Development to DACs	USPS/Email	SCGA staff	DAC contacts	18	7/15/2020
General GSP	Additional Notification (to corrected address) to Locke Water Works as a DAC Regarding GSP Development	USPS	SCGA staff	Locke Water Works	1	7/22/2020
General GSP	Press Release via Sacramento County Public Information Office Announcing GSP Development	Sacramento County Public Information Office	C&E Coordinator	General Public	N/A	7/6/2020
General GSP	Availability of Public Draft - South American Subbasin Groundwater Sustainability Plan	SASb Email Distribution list/SASb website/USPS to Tribal contacts and DACs	SCGA staff	Interested Parties/Stakeholders/Tribal contacts/DACs	N/A	6/24/2021
General GSP	90-day notice of SASb GSP consideration for adoption by GSAs	Mailed via USPS and Email to County BOS/County Executive/City Councils and City Managers for Sacramento, Elk Grove, Folsom, and Rancho Cordova	SCGA staff	Municipal jurisdictions	N/A	9/3/2021
Sacramento Central Groundwater Authority (SCGA)	Discussion of GSP development schedule	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	10/9/2019
SCGA	Discussion of GSP development schedule	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	12/11/2019

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SCGA	Contract to develop GSP for SASb. GSP development schedule update	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	2/5/2020
SCGA	Contract to develop GSP for SASb. GSP development schedule update. Status report on MOU for development of SASb GSP.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	3/11/2020
SCGA	GSP development schedule update. Status report on MOU for development of SASb GSP. Report on C&E plan for SASb.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	4/8/2020
SCGA	GSP development schedule update. Adoption of MOU for development of SASb GSP.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	5/13/2020
SCGA	GSP development update. Status report of MOU for development of SASb GSP.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	7/8/2020
SCGA	GSP Working Group public kickoff meeting	Postcard sent via email and published in Farm Bureau newspaper mailed to members	Sacramento County Farm Bureau	Sacramento County Farm Bureau members	N/A	7/8/2020
SCGA	GSP Working Group public kickoff meeting	City of Rancho Cordova public website	City of Rancho Cordova	City of Rancho Cordova Interested Parties/Stakeholders/Public	N/A	7/9/2020
SCGA	SGMA/GSP requirements	City of Rancho Cordova department meeting	City of Rancho Cordova staff	City Rancho Cordova department heads and City Manager	N/A	7/10/2020
SCGA	GSP Working Group public kickoff meeting	Golden State Water Company email dist. list	Golden State Water Company staff	Golden State Water Company interested parties/customers	N/A	7/10/2020
SCGA	GSP Working Group public kickoff meeting	California American Water Company social media channels	California American Water Company staff	California American Water Company interested parties/customers	N/A	7/13/2020
SCGA	GSP Working Group public kickoff meeting	Elk Grove Water District website	Elk Grove Water District staff	Elk Grove Water District interested parties/customers	N/A	7/14/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SCGA	Individual follow up with large Acreage Ag members within the basin to ensure attendance and awareness of 7/23/20 GSP public kickoff meeting	N/A	Sacramento County Farm Bureau staff	Sacramento County Farm Bureau members	N/A	7/15/2020
SCGA	SGMA/GSP update	City of Rancho Cordova "Monday Memo"	City of Rancho Cordova staff	Rancho Cordova City Council members	N/A	7/20/2020
SCGA	Reminder of July 23, 2020 SASb GSP public kickoff meeting.	social media event invites, posts and reminder email	Sacramento County Farm Bureau staff	Sacramento County Farm Bureau members	N/A	7/22/2020
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	8/12/2020
SCGA	Authorize The Interim Executive Director To Enter Into Amended Contracts With Larry Walker Associates And Woodard & Curran To Complete The Proposition 1 And Proposition 68 Grant Scopes Of Work For GSP Completion.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	9/3/2020
SCGA	Postcard Announcing GSP Working Group public meeting #2	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/Public	N/A	10/12/2020
SCGA	Announcement of Public Meeting #2 to SCGA Interested Party List	Email	SCGA staff	Interested Parties/Stakeholders	N/A	10/13/2020
SCGA	Promotion of Public Meeting #2	planned E-blasts & social media accounts	Sacramento County Farm Bureau staff	Sacramento County Farm Bureau members/ Interested Parties	N/A	10/14/20 10/28/20 11/5/2020
SCGA	GSP development update. Groundwater Sustainability Plan Consultant Contract Amendments	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	10/14/2020
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	12/9/2020
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	2/10/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SCGA	English and Spanish postcards announcing public meeting #3 to SCGA interested parties without email addresses	USPS	SCGA staff	Interested Parties	N/A	3/3/2021
SCGA	English and Spanish postcards announcing SASb GSPWG public meeting #3	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/public	N/A	3/4/2021
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	3/10/2021
SCGA	Noticed SASb Working Group public meeting.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	3/25/2021
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	4/14/2021
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	5/12/2021
SCGA	Notification of SASb WG Mtg #15	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/P	N/A	5/12/2021
SCGA	Notification of SASb WG Mtg #16	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/P	N/A	6/16/2021
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	6/22/2021
SCGA	Availability of public draft SASb GSP	Link to document on SCGA website homepage	SCGA staff	Interested Parties/Stakeholders/Public	N/A	6/23/2021
SCGA	Notification of availability of Public Draft SASb GSP	SCGA Email Dist. List	SCGA staff	Interested Parties/Stakeholders	N/A	6/24/2021
SCGA	English and Spanish postcards announcing SASb GSPWG public meeting #4	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/Public	N/A	6/28/2021
SCGA	English and Spanish postcards announcing public meeting #4 to SCGA interested parties without email addresses	USPS	SCGA staff	Interested Parties	N/A	6/28/2021
SCGA	Notification of SASb WG Mtg #17	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/Public	N/A	7/14/2021
SCGA	Noticed SASb Working Group public meeting.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	7/15/2021
SCGA	GSP development update. Vulnerable well protection program.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	8/11/2021
SCGA	Notification of SASb WG Mtg #18	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/Public	N/A	8/17/2021
SCGA	Notification of SASb WG Mtg #19	Posted to SCGA website	SCGA staff	Interested Parties/Stakeholders/Public	N/A	9/15/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SCGA	GSP development update.	SCGA Board Meeting	SCGA staff	Interested Parties/Stakeholders	N/A	10/13/2021
SCGA	GSP development updates.	Monthly presentations	SCGA Conservation Landowner Representative	Habitat 2020 and executive committee members of ECOS	N/A	January 2020-October 2021
Omochumne-Hartnell Water District (OHWD)	Mailing to all residences in the OHWD water district about the July 23, 2020 GSP development public meeting	USPS	OHWD staff	Stakeholders	N/A	7/9/2020
OHWD	Mailing to all residences in the OHWD GSA about the March 25, 2021 GSP development public meeting	USPS	OHWD staff	Stakeholders	N/A	3/11/2021
OHWD	Mailing to all residences in the OHWD GSA about the November 5, 2020 GSP development public meeting	USPS	OHWD staff	Stakeholders	N/A	10/24/2020
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	12/15/2020
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	1/19/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	2/16/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	3/16/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	4/20/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	5/18/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	6/15/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	7/20/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	8/17/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	9/21/2021
OHWD	SASb GSP development	OHWD Board Meeting	OHWD staff	Interested Parties/Stakeholders	N/A	10/19/2021
Sloughhouse Resource Conservation District (SRCD)	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	7/8/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	8/12/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	9/9/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	10/14/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	11/11/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	12/9/2020
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	1/13/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	2/10/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	3/10/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	4/14/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	5/12/2021
SRCD	Ag. Res. Public Workshop Announcement	SRCD E-Mailing List	SRCD Staff	Interested Parties/Stakeholders	112	5/20/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	6/9/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	7/14/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	8/11/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	8/25/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	9/8/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	9/22/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	10/13/2021
SRCD	SASb GSP Development	SRCD Board Meeting	SRCD Staff	Interested Parties/Stakeholders	N/A	10/20/2021
County of Sacramento (County)	Adopt Sacramento County Groundwater Management Principles To Ensure Local Compliance With The Sustainable Groundwater Management Act Of 2014	Sacramento County Board of Supervisors	County staff	General Public	N/A	11/10/2015
County	Adopt Sacramento County Groundwater Management Principles To Ensure Local Compliance With The Sustainable Groundwater Management Act Of 2014 (Continued From November 10, 2015 Item No. 40)	Sacramento County Board of Supervisors	County staff	General Public	N/A	3/22/2016
County	Sustainable Groundwater Management Act Update	Sacramento County Board of Supervisors	County staff	General Public	N/A	4/5/2016
County	Update On Compliance With The Sustainable Groundwater Management Act In Sacramento County	Sacramento County Board of Supervisors	County staff	General Public	N/A	12/13/2016
County	Report Back On Implementation Of The Sustainable Groundwater Management Act And Funding Resources To Assist With Activities In The Sub-Basins (December 13 2016; Item 56)	Sacramento County Board of Supervisors	County staff	General Public	N/A	3/1/2017

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
County	Public Hearing To Consider Adopting A Resolution Accepting Groundwater Sustainability Agency Responsibility For Subbasin Areas Within Sacramento County Remaining Unmanaged On June 30, 2017	Sacramento County Board of Supervisors	County staff	General Public	N/A	4/11/2017
County	Accept GSA Responsibility For Overlap Areas In Sacramento County In The Event That The Alternative Submittal Is Withdrawn Or Denied	Sacramento County Board of Supervisors	County staff	General Public	N/A	9/26/2017
County	Update On Compliance With The Sustainable Groundwater Management Act	Sacramento County Board of Supervisors	County staff	General Public	N/A	12/17/2019
County	Update On Compliance With The Sustainable Groundwater Management Act	Sacramento County Board of Supervisors	County staff	General Public	N/A	10/20/2020
County	Postcard announcing 7/23/20 public meeting to all parcels in Sacramento County GSA area	USPS	County staff	Stakeholders	N/A	7/15/2020
South American Subbasin Working Group (SASb WG)	**SASb WG Mtg #1**: introductions, expectations, success factors, barriers to success, guiding principles and Partnering Commitment	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	5/15/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #2**: Management / Governance, Overview of Draft Master Meeting Schedule, Continued Sustainability Goal discussions, Received updates on CoSANA Model and data needs, Requested data and information for incorporation in model, C&E Near Term Priorities	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	6/5/2020
SASb WG	**SASb WG Mtg #3**: Management / Governance, introductory information regarding Water Quality Sustainable Management Criteria (SMC) development process, a preliminary list of constituents of concern (COCs), available data for COCs in the SASb, options regarding SMC development, and input needed from the GSP WG, Discussed preparations for first Public meeting, Presented new SASb GSP (sasbgroundwater.org) website, Reminded GSPWG members of their obligation to disseminate materials for the first public meeting and convey information back to their respective GSA	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	6/26/2020
SASb WG	Website to inform public about GSP development	SASb Website	GSP consultant	General Public	N/A	7/1/2020
SASb WG	GSP Working Group public kickoff meeting	Press release via Sacramento County Public Information Office	Sacramento County Public Information Officer	General Public	N/A	7/6/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	GSP Working Group public kickoff meeting	Sacramento County Go Delivery Email Bulletin	SCGA staff	Interested Parties	5,600	7/7/2020
SASb WG	Postcard Announcing GSPWG Public Kickoff/Website	USPS/Email/SASb Website	GSP consultant staff	Interested Parties/Stakeholders/DACs/Tribal Contacts/General public	N/A	7/7/2020
SASb WG	**SASb WG Mtg #4**: Discussed status of Reclamation District (RD) No. 551 participation in the GSP process, status of negotiations with Northern Delta GSA, Water Quality Sustainable Management Criteria (SMC) development, options regarding SMC development, reviewed monitoring network options, reviewed available information on domestic well densities in SASb, Discussed outreach efforts by GSPWG members to distribute notices for the public meeting. Discussed GSPWG member participation in public meeting, Reviewed functionality of sasbgroundwater.org website portal	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	7/17/2020
SASb WG	**Public Meeting #1**: Management / Governance, Communication & Engagement, Introduction to Groundwater Sustainability Plan, GSP Development Schedule, Overview of GSP Content	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	7/23/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	SASb WG Mtg #5: Discussed Public's request to attend GSP Working Group Meetings, GSPWG decided to open meetings, Ag-Res Public Meeting scheduled from 6:00 pm to 7:30 pm on August 6th	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	8/3/2020
SASb WG	**SASb Ag-Res Public Meeting**: Public Meeting #1 (July 23rd) Follow Up - GSP Working Group Inclusion • Modeling Workshop • Other Topics raised during meeting Requested Ag-Res Topics • Groundwater Levels • Ag-Res as beneficial users and uses • Communications & Engagement with AgRes Interested Parties	GSP Working Group Meeting	Administrative/GSP consultant staff	Ag-res stakeholders/Interested Parties/subbasin stakeholders	N/A	8/6/2020
SASb WG	**SASb WG Mtg #6**: Discussed the fact that Reclamation District (RD) No. 551 has recently joined Northern Delta Groundwater Sustainability Agency (GSA) as an Associate member, climate change information, Hydrogeologic Conceptual Model, Surface Water Depletion, Discussed outcomes from the special Ag-Res meeting	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	8/21/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #7**: schedule for production and review of draft GSP chapters, Inter-basin coordination meetings, Groundwater Conditions, development of the CoSANA model, climate change methodology, Surface Water Depletion, Groundwater Dependent Ecosystems	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	9/11/2020
SASb WG	GSP Working Group public meeting #2	Press release via Sacramento County Public Information Office	Sacramento County Public Information Officer	General Public	N/A	10/13/2020
SASb WG	GSP Working Group public meeting #2	Sacramento County Go Delivery Email Bulletin	SCGA staff	Interested Parties	5,650	10/13/2020
SASb WG	English and Spanish postcard Announcing GSP Working Group public meeting #2	USPS/Email/SASb Website	GSP consultant staff	Interested Parties/Stakeholders/DACs/Tribal Contacts/General public	N/A	10/13/2020
SASb WG	GSP Working Group public meeting #2	SASb Email dist. list	SCGA staff	Interested Parties	N/A	10/13/2020
SASb WG	SASb WG Mtg #8: need to integrate the efforts in the Cosumnes and SASb in addressing surface water depletions and Groundwater Dependent Ecosystems, CoSANA model, historic water budget and baseline assumptions, Monitoring Network for the Surface Water Depletion (SWD) and GDE sustainability indicators	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	10/16/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**Public Meeting #2**: SGMA GSP Process, GSA Formation History, Decision Making - Roles & Responsibilities, GSP Schedule and status, CoSANA Mode, Ag-Res Water Budget, SGMA requirements for GSP, Entities with Land Use Authority in SASb, – Opportunities for Interactions with Land Use Agency Entities	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	11/5/2020
SASb WG	**SASb WG Mtg #9**: key decisions that will need to be made during the development of the GSP, projected water demands and sources of supply, Monitoring Network for groundwater levels, SMC for groundwater levels, Comments received from the public during the GSPWG meeting, Lisa Beutler of Stantec introduced to assist with public outreach elements of the C&E Plan.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	11/12/2020

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #10**: status of key decisions to be made during the development of the GSP, draft GSP review process, development of governance structure and plan for GSP implementation, CoSANA model baseline assumptions, presentation was provided regarding the analytical approach being used to assess the vulnerability of shallow wells to changes in groundwater level, screening process that has been used to determine candidate wells for inclusion in a proposed groundwater level monitoring network	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	12/11/2020
SASb WG	Notification of SASb WG Mtg #11	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	1/13/2021
SASb WG	**SASb WG Mtg #11**: results of CoSANA modeling work to describe current and projected water budgets for the SASb, projects and management actions, analysis of interconnected surface waters (ISWs) and groundwater dependent ecosystems (GDEs) in the SASb.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	1/15/2021
SASb WG	Notification of SASb WG Mtg #12	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	2/17/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #12**: proposed option for setting Sustainable Management Criteria (SMC) for groundwater (GW) levels, projects and management actions that will be considered in the GSP and in the development of scenarios to be modeled using the CoSANA model, CoSANA modeling work to describe the impact of several Demand Reduction scenarios, status report was provided on the technical studies being formed to identify and assess groundwater dependent ecosystems.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	2/19/2021
SASb WG	Announcement of GSP Working Public Meeting #3	Press release via Sacramento County Public Information Office	Sacramento County Public Information Officer	General Public	N/A	3/3/2021
SASb WG	Announcement of GSP Working Public Meeting #3	Sacramento County Go Delivery Email Bulletin	SCGA staff	Interested Parties	5,550	3/3/2021
SASb WG	GSP Working Group public meeting #3	SASb Email dist. list	SCGA staff	Interested Parties	N/A	3/2/2021
SASb WG	English and Spanish postcard Announcing GSP Working Group public meeting #3	USPS/Email/SASb Website	GSP consultant staff	Interested Parties/Stakeholders/DACs/Tribal Contacts/General public	N/A	3/3/2021
SASb WG	Notification of SASb WG Mtg #13	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	3/17/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #13**: comments on Section 1 and Sections 2.1 and 2.2 of the draft GSP that were circulated in January, 2021, Projects and Management Actions, g Sustainable Management Criteria (SMC) for groundwater (GW) levels, e status of inter-basin coordination meetings with the groups that are now preparing GSPs for the Yolo, Solano, Cosumnes and North American subbasins	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	3/19/2021
SASb WG	GSP Working Group public meeting #3 - Reminder	SASb Email dist. list	SCGA staff	Interested Parties	N/A	3/22/2021
SASb WG	**Public Meeting #3**: Why the South American Subbasin (SASb) GSP Matters – SASb boundary – Sustainable Groundwater Management Act, Groundwater Sustainability Agency (GSA) Formation History, Decision Making - Roles & Responsibilities, GSP Schedule and status, Current and Projected Groundwater Conditions, Projects and Management Actions, Presentation on GSP Implementation - SGMA requirements, GSP Implementation Costs, Possible Agricultural-Residential (Ag-Res) survey, Upcoming special meetings: Farm Bureau and Ag-Res groups	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	3/25/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	Notification of SASb WG Mtg #14	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	4/14/2021

SASb WG	**SASb WG Mtg #14**: GSP Master Meeting Schedule; proposed response to comments received from GSPWG members on Section 1 and Sections 2.1 and 2.2 of the draft GSP, status report was provided regarding the work by SCGA staff and facilitators from Stantec to develop a governance structure and cost sharing plan for GSP implementation, status report was also provided indicating that the consultant team was working on a structure for a shallow well protection program to be considered as a proposed element of the GSP; history and current status of the basin with regard to groundwater storage volumes and groundwater levels; presentation of future projected conditions; overview of the materials contained in the draft of Section 3 of the GSP; overview of the work that is ongoing by SCGA to set rates to cover GSP implementation costs; presentation on Harvest Water Project; GSA representatives were reminded to be documenting all communication and engagement activities that are occurring at their GSAs, including Board meetings.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	4/16/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	Notification of SASb WG Mtg #15	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	5/12/2021

SASb WG	**SASb WG Mtg #15:** GSP Master Meeting Schedule; GSPWG members were reminded to provide comments on the draft of GSP Section 3; status report regarding the consultant team and SCGA staff efforts to develop a structure for a shallow/vulnerable well protection program to be considered as a proposed management action under the GSP; review of performed to date to assess future projected conditions, review of the status of modeling scenarios developed and run using the CoSANA model to assess the influence of planned Projects and Management Actions on future conditions of groundwater storage and level in the SASb; overview of the materials contained in the draft of Sections 4 and 5 of the GSP; summary of the GDE technical analysis; Harvest Water Project benefits and proposed measurable objectives and interim milestones as requested for incorporation into the GSP to reflect future improvements to groundwater levels in the project area and to help ensure that the Harvest Water project benefits will be maintained; GSA representatives were reminded to be documenting all GSP	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	5/14/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
	communication and engagement activities that are occurring at their GSAs, including Board meetings.					
SASb WG	Notification of SASb AG Res/ Vulnerable Well Owner Special Workshop	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	5/20/2021
SASb WG	**SGMA & GSP 101, Subbasin Status, SASb - AG Res/ Shallow Well Owner Implications, Introduction**: Approaches for Maintaining Reliability, GSP Implementation & Fiscal Impacts & Next Steps	Ag-res/Vulnerable well owner Groundwater Sustainability Workshop	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	5/25/2021
SASb WG	Notification of SASb WG Mtg #16	SASb Email dist. list	SCGA staff	Interested Parties/Stakeholders	N/A	6/16/2021

SASb WG	**SASb WG Mtg #16**: GSP Master Meeting Schedule, proposed response to comments received from GSPWG members on Section 1 and Sections 2.1 and 2.2 of the draft GSP prior to the meeting, status report was also provided indicating that the consultant team was working on a structure for a shallow well protection program to be considered as a proposed element of the GSP, review the work performed to date to assess the history and current status of the basin with regard to groundwater storage volumes and groundwater levels, future projected conditions, overview of the materials contained in the draft of Section 3 of the GSP - Sustainable Management Criteria for groundwater levels, groundwater storage, stream depletion and groundwater quality, overview of the work that by SCGA to set rates to cover GSP implementation costs, e status of inter-basin coordination meetings with the groups that are now preparing GSPs for the Yolo, Solano, Cosumnes and North American subbasins, GSA representatives were reminded to be documenting all	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	6/18/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
	communication and engagement activities that are occurring at their GSAs, including Board meetings.					
SASb WG	Announcement of GSP Working Public Meeting #4	Sacramento County Go Delivery Email Bulletin	SCGA staff	Interested Parties	5,460	6/28/2021
SASb WG	GSP Working Group public meeting #4	SASb Email dist. list	SCGA staff	Interested Parties	N/A	6/28/2021
SASb WG	English and Spanish postcards announcing SASb GSPWG public meeting #4	USPS/Email/SASb Website	GSP consultant staff	Interested Parties/Stakeholders/DACs/Tribal Contacts/General public	N/A	6/28/2021
SASb WG	Announcement of GSP Working Public Meeting #4	Press release via Sacramento County Public Information Office	Sacramento County Public Information Officer	General Public	N/A	7/13/2021
SASb WG	Reminder announcement of GSP Working Public Meeting #4	Sacramento County Go Delivery Email Bulletin	SCGA staff	Interested Parties	5,460	7/13/2021
SASb WG	Reminder of GSP Working Group public meeting #4	SASb Email dist. list	SCGA staff	Interested Parties	N/A	7/13/2021
SASb WG	Posting of SASb WG Mtg #17	SASb Email dist. list	SCGA staff	Interested Parties	N/A	7/14/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**Public Meeting #4**: GSP Master Meeting Schedule, SGMA Overview - Groundwater Sustainability Agencies (GSAs) and GSPs, Medium Priority GSP Schedule, Sustainability Indicators; GSP – Highlights of Key Elements - CoSANA model, Water Budgets and GW Levels, PMAs – planned, Model scenarios – future conditions/climate change - basin is sustainable into the future, Shallow/vulnerable well analysis, Monitoring network – SMC; GSP Implementation by GSAs - Monitoring/reporting, 5-year GSP updates, Ongoing outreach and engagement, Coordination – other basins, land use entities, water supply entities, water bank, Vulnerable well protection – monitoring, mitigation, Fees; Questions, Comments and Discussion Related to GSP Section 5; Well Monitoring and Well Protection Concepts.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	7/15/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #17**: GSP Master Meeting Schedule, reminder that the draft GSP was released for public and GSPWG comment on June 18. Comment deadline was August 18 to allow the consultant team time to address comments in a final draft GSP; elements of a Shallow/Vulnerable Well Protection Program as a SASb GSP management action; re-visited the GSP implementation actions described in Section 5 of the draft GSP and asked that GSAs carefully consider those actions and associated costs; e development of a sustainable yield estimate; discussed in the ongoing inter-basin coordination meetings; GSA representatives were reminded to be documenting all GSP communication and engagement activities that are occurring at their GSAs, including Board meetings; review of topics covered and input received at the fourth SASb GSP public meeting held on July 15th	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	7/16/2021
SASb WG	Posting of SASb WG Mtg #18	SASb Email dist. list	SCGA staff	Interested Parties	N/A	8/17/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #18**: GSP Master Meeting Schedule, review of revised Section 4.7.1 in the draft GSP which describes the elements of a Shallow/Vulnerable Well Protection Program as a SASb GSP management action; summarized the major comments received to date on the draft GSP; development of the data management system; update on inter-basin coordination meetings; GSA representatives were reminded by Lisa Beutler to be documenting all GSP communication and engagement activities that are occurring at their GSAs, including Board meetings.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	8/20/2021
SASb WG	Posting of SASb WG Mtg #19	SASb Email dist. list	SCGA staff	Interested Parties	N/A	9/15/2021

Jurisdiction	Topics covered in outreach	Outreach Method	Presenter	Audience	#	Date
SASb WG	**SASb WG Mtg #19**: GSP Master Meeting Schedule, Post GSP Implementation, Governance Process –Status & Schedule, GSA Board meetings to consider GSP; GSP Implementation – Well Protection Program – comments received on revised text in Section 4; Major Comments received on Draft GSP – proposed responses; Inter-basin Coordination update; C&E Near Term Priorities – Outreach tracking by GSAs; Upcoming October 11 small group introductory meeting – volunteer monitoring network for Ag-Res wells.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	9/17/2021
SASb WG	Posting of SASb WG Mtg #20	SASb Email dist. list	SCGA staff	Interested Parties	N/A	10/13/2021
SASb WG	**SASb WG Mtg #20:** Post GSP Implementation Governance Process - Draft MOU content, Schedule; GSA Board meetings to consider/approve Final GSP – RD 551 check-in; Final GSP Production – Status Report; CoSANA Model report/appendix; Inter-basin Coordination update; C&E implementation - Outreach tracking by GSAs – Additions to Draft Table; Report back from October 11 small group introductory meeting – volunteer monitoring network for Ag-Res wells.	GSP Working Group Meeting	Administrative/GSP consultant staff	Interested Parties/Stakeholders	N/A	10/15/2021
				TOTAL	152	

Appendix 1-F

DWR Groundwater Sustainability Plan Elements Guide

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
§ 354.			**Introduction to Plan Contents**					
			This Article describes the required contents of Plans submitted to the Department for evaluation, including administrative information, a description of the basin setting, sustainable management criteria, description of the monitoring network, and projects and management actions.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
SubArticle 1.			**Administrative Information**					
§ 354.2.			**Introduction to Administrative Information**					
			This Subarticle describes information in the Plan relating to administrative and other general information about the Agency that has adopted the Plan and the area covered by the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.4.			**General Information**					
			Each Plan shall include the following general information:					
(a)			An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.	34:63	ES			
(b)			A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.	423:432	6.0			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
§ 354.6.			**Agency Information**					
			When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:					
(a)			The name and mailing address of the Agency.	70:74	1.4.1.1:1.4.1.6			
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.	74:76	1.4.2.1:1.4.2.3			
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.	74	1.4.2.1			
(d)			The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.	76:77	1.4.3			
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.	416:418,418:419	5.2,5.4		5-2	
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.8, 10727.2, and 10733.2, Water Code.					
§ 354.8.			**Description of Plan Area**					
			Each Plan shall include a description of the geographic areas covered, including the following information:					
(a)			One or more maps of the basin that depict the following, as applicable:					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.	84:88	2.1,2.1.1:2.1.2	2.1-1:2.1-3		1) Figure 2.1-1 shows the general SASb plan area. 2) Figure 2.1-2 shows the SASb subbasin and other adjacent basins. 3) Figure 2.1-3 shows the GSAs in the SASb.
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.	86,88	2.1.2.1	2.1-3		1) Figure 2.1-3 shows map of other Agencies within the basin.
	(3)		Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.	89,91,94	2.1.2.1, 2.1.2.3, 2.1.2.5	2.1-4, 2.1-6	2.1-2	1) Figure 2.1-6 shows Federal and State lands in the SASb. 2) Figure 2.1-4 shows cities and counties in the SASb. 3) Table 2.1-2 lists the municipal water purveyors of the SASb in year 2018.
	(4)		Existing land use designations and the identification of water use sector and water source type.	93:101, 259:266	2.1.2.6, 2.1.4, 2.4.2.1:2.4.2.2	2.1.6:2.1-8, 2.4-3:2.4-8	2.1-2, 2.1-5, 2.4-2:2.4-8	1) Figure 2.1-7 shows the agricultural land use designations. 2) Figure 2.1-8 shows land use by water use and water source type. 3) Figure 2.1-5 shows the regional watersheds. 4) Table 2.1-2 lists the municipal water purveyors of the SASb in year 2018.
	(5)		The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.	97:101	2.1.2.7	2.1-9:2.1-11		1) Figure 2.1-9 shows number/depth of DOMESTIC wells in SASb. 2) Figure 2.1-10 shows number/depth of PRODUCTION wells in SASb. 3) Fgure 2.1-11 shows number/depth of PUBLIC wells in SASb.
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.	86:89	2.1, 2.1.1:2.1.2, 2.1.2.1	2.1-1:2.1-4		1) Figure 2.1-1 shows the general SASb plan area. 2) Figure 2-2 shows the SASb subbasin and other adjacent basins. 3) Figure 2-3 shows map of other Agencies within the basin. 4) Figure 2-4 shows cities and counties in the SASb.
(c)			Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.	101:151	2.1.4:2.1.12	2.1-12:2.1-28	2.1-5:2.1-23	
(d)			A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.	136:142	2.1.9			
(e)			A description of conjunctive use programs in the basin.	141,187:188,368:384	2.1.9.9, 2.3, 4.3:4.5	4-2:4-5	4-1	
(f)			A plain language description of the land use elements or topic categories of applicable general plans that includes the following:					
	(1)		A summary of general plans and other land use plans governing the basin.	142:143,407	2.1.10, 5.0		2.1-18:2.1-22	
	(2)		A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects	407	5.0			

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.	407	5.0			
	(4)		A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.	139	2.1.9.6			1) The Sacramento County Environmental Management Wells Program is responsible for authorizing the construction, modification, repair, inactivation, or destruction of wells in Sacramento County This has been amended to clarify that this is performed "via a permit and inspection process"
	(5)		To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.	N/A				No known impacts of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.	N/A				All plan elements are discussed in the GSP.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10720.3, 10727.2, 10727.4, 10733, and 10733.2, Water Code.					
§ 354.10.			**Notice and Communication**					
			Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:					
(a)			A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.	78:81	1.5.3,1.5.3. 1:1.5.3.2		1-3	This information is addressed in section 1.5, where various means of communication such as public meetings, surveys, mail, emails, and public hearings were utilized to reach groups throughout the SASb.
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.	81, 746	1.5.3.2		1-4	1) Table 1-4 lists the individual GSA websites, meeting frequency, and meeting dates. 2) Appendix I-E
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.	794				Appendix 1-G
(d)			A communication section of the Plan that includes the following:					
	(1)		An explanation of the Agency's decision-making process.	77:78	1.5.2			
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.	78:81	1.5			
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.	78:81	1.5			
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.	78:81	1.5			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.8, 10728.4, and 10733.2, Water Code					
SubArticle 2.			**Basin Setting**					
§ 354.12.			**Introduction to Basin Setting**					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.14.			**Hydrogeologic Conceptual Model**					
(a)			Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.	153:187	2.2			
(b)			The hydrogeologic conceptual model shall be summarized in a written description that includes the following:					
	(1)		The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.	153	2.2.1			
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	172:173	2.2.5.1			
	(3)		The definable bottom of the basin.	173	2.2.5.3			
	(4)		Principal aquifers and aquitards, including the following information:					
		(A)	Formation names, if defined.	173:174	2.2.6, 2.2.6.1:2.2.6.2			
		(B)	Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.	172:176	2.2.5:2.2.6			
		(C)	Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.	156:176	2.2.3:2.2.6			
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	176	2.2.7			
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	173:174, 97	2.2.6, 2.2.6.1:2.2.6.2, 2.1.2.7	2.1-9:2.1-11		1) Figure 2.1-9 shows number/depth of DOMESTIC wells in SASb. 2) Figure 2.1-10 shows number/depth of PRODUCTION wells in SASb. 3) Fgure 2.1-11 shows number/depth of PUBLIC wells in SASb.
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model	184:187	2.2.9			
(c)			The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.	161:167	2.2.3.1	2.2-33:2.2-39		1) The cross sections derived from the CoSANA model layers are shown individually in Figures 2.2-33 to Figures 2.2-39.
(d)			Physical characteristics of the basin shall be represented on one or more maps that depict the following:					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		Topographic information derived from the U.S. Geological Survey or another reliable source.	180	2.2.8.1	2.2-42		1) Figure 2.2-42 shows the SASb topography
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	162:163		2.2-34:2.2-35		1) Figure 2.2-6 shows cross section D-D'. 2) Figure 2.2-7 shows cross section H-H'.
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	185:186	2.2.8.4	2.2-45:2.2-46		1) Figure 2.2-45 shows soils of the SASb. 2) Figure 2.2-46 shows the hydrologic soil groups
	(4)		Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.	183	2.2.8.4	2.2-44		1) Figure 2.2-44 shows recharge areas, seeps, and springs
	(5)		Surface water bodies that are significant to the management of the basin.	181	2.2.8.2	2.2-43		1) Figure 2.2-43 shows SASb surface water bodies.
	(6)		The source and point of delivery for imported water supplies.	179	2.2.8			1) There are no imported water supplies
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10733, and 10733.2, Water Code.					
§ 354.16.			**Groundwater Conditions**					
			Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:					
(a)			Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:					
	(1)		Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.	209:217	2.3.1	2.3-19:2.3-26		1) Figures 2.3-19:2.3-24 show groundwater elevations for Fall 1977, Fall 1986, Fall 2005, and Fall 2015. 2) Figures 2.3-23:2.3-26 show seasonal groundwater contour maps for both elevation and depth to water for Fall 2019 and Spring 2019.
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	197:207	2.3.1	2.3-6:2.3-18		1) Figure 2.3-6 shows location of wells with measured groundwater levels since 2018. 2) Figures 2.3-7:2.3-14 show hydrographs of groundwater levels from 1970 to 2020 in selected wells. 3) Figure 2.3-15 shows multiple completion wells. 4) Figures 2.3-16:2.3-20 show combined and cluster well hydrographs.
(b)			A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.	218	2.3.2	2.3-27		1) Figure 2.3-27 shows Groundwater Storage by Year, Water Year Type, and Cumulative Water Volume
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	218:219	2.3.3			1) Seawater intrusion is not considered to be a problem for the SASb.
(d)			Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.	219:233, 118:136	2.3.4, 2.1.8	2.3-28:2.3-38, 2.1-18		1) Figures 2.3-30:2.3-40 show data for nitrate, TDS, arsenic, hexavalent chromium, and PFAS 2) Figure 2.1.18 shows the known contaminant plumes known since 2008.
(e)			The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	234:236	2.3.5	2.3-39:2.3-40		1) land subsidence is not known to be a historically or currently significant in the SASb. Figures 2.3-39:2.3-40 show vertical displacement

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(f)			Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	236:238	2.3.6	2.3-45		1) Figure 2.3-45 shows seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches. The black line represents historical to near present-day conditions.
(g)			Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	241:244	2.3.7	2.3-47		1) Figure 2.3-47 shows GDE likelihood classification of potential GDEs from 2005-2018.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, and 10733.2, Water Code.					
§ 354.18.			**Water Budget**					
(a)			Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.	245:274	2.4			
(b)			The water budget shall quantify the following, either through direct measurements or estimates based on data:					
	(1)		Total surface water entering and leaving a basin by water source type.	245:251	2.4.1	2.4-1		1) Figure 2.4-1 shows the sources of water entering and leaving the SASb
	(2)		Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.	245:251	2.4.1	2.4-1		1) Figure 2.4-1 shows the sources of water entering and leaving the SASb
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	245:251	2.4.1	2.4-1		1) Figure 2.4-1 shows the sources of water entering and leaving the SASb
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.	188:207, 259:263	2.3.1, 2.4.2.1	2.3-6:2.3-18	2.4-8	1) Figure 2.3-6 shows location of wells with measured groundwater levels since 2018. 2) Figures 2.3-7:2.3-14 show hydrographs of groundwater levels from 1970 to 2020 in selected wells. 3) Figure 2.3-15 shows multiple completion wells. 4) Figures 2.3-16:2.3-18 show combined and cluster well hydrographs. 1) Table 2.4-8 lists the groundwater storage and change in groundwater storage as a function of water year type (i.e., dry, wet, etc.)
	(5)		If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.	320:321	3.3.2			The basin has historically avoided overdraft.
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.	266	2.4.2.1		2.4-8	1) Table 2.4-8 lists the groundwater storage and change in groundwater storage as a function of water year type (i.e., dry, wet, etc.)
	(7)		An estimate of sustainable yield for the basin.	274:279	2.5.2			
(c)			Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.	263:266	2.4.2.2	2.4-6:2.4-8		1) Figures 2.4-6:2.4-8 show the current inflows and outflows of the SASb for stream and canal systems, land surface system, and groundwater system.
	(2)		Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:					
		(A)	A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.	259:263	2.4.2.1	2.4-3:2.4-5		1) Figures 2.4-3:2.4-5 show the historical inflows, outflows, and water budget of the SASb for stream and canal systems, land surface system, and groundwater system.
		(B)	A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.	259:263	2.4.2.1	2.4-3:2.4-5		1) Figures 2.4-3:2.4-5 show the historical inflows, outflows, and water budget of the SASb for stream and canal systems, land surface system, and groundwater system.
		(C)	A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.	259:263	2.4.2.1		2.4-8	1) Table 2.4-8 shows that is an overall increase in groundwater storage averaged over 10 years.
	(3)		Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:					
		(A)	Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.	249:251, 267:273	2.4.1.3.3, 2.4.2.3, 2.4.2.4	2.4-9:2.4-14	2.4-1	1) Baseline conditions are summarized in Table 2.4-1. 2) Figures 2.4-9:2.4-11 show projected conditions for water resources without climate change impacts. 3) Figures 2.4-12:2.4-14 show projected conditions for water resources with climate change impacts.
		(B)	Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.	249:251, 267:273	2.4.1.3.3, 2.4.2.3, 2.4.2.4	2.4-9:2.4-14	2.4-1	1) Baseline conditions are summarized in Table 2.4-1. 2) Figures 2.4-9:2.4-11 show projected conditions for water resources without climate change impacts. 3) Figures 2.4-12:2.4-14 show projected conditions for water resources with climate change impacts.

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(C)	Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.	249:251, 267:273	2.4.1.3.3, 2.4.2.3, 2.4.2.4	2.4-9:2.4-14	2.4-1	1) Baseline conditions are summarized in Table 2.4-1. 2) Figures 2.4-9:2.4-11 show projected conditions for water resources without climate change impacts. 3) Figures 2.4-12:2.4-14 show projected conditions for water resources with climate change impacts.
(d)			The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:					
	(1)		Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.	267:273	2.4.2:2.4.2.1		2.4-5:2.4-7	1) Tables 2.4-2:2.4-4 shows the historical, current, and projected water budget (with and without climate change) considering all inflows and outflows of all water resources.
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.	251:255, 263:266	2.4.2, 2.4.2.2		2.4-5:2.4-7	1) Tables 2.4-2:2.4-4 shows the historical, current, and projected water budget (with and without climate change) considering all inflows and outflows of all water resources.
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.	251:255, 267:273	2.4.2, 2.4.2.3:2.4.2.5		2.4-5:2.4-7	1) Tables 2.4-2:2.4-4 shows the historical, current, and projected water budget (with and without climate change) considering all inflows and outflows of all water resources.
(e)			Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.	251:274	2.4.1:2.4.2			1) This section describes the assumptions associated with water budget projection using the best available information. Water budget projection was performed using the CoSANA model, a fully integrated surface and groundwater flow model that covers the entire South American Subbasin as well as the adjoining North American and Cosumes Subbasins
(f)			The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.	248:249	2.4.1.2			1) The CoSANA model, a fully integrated surface and groundwater flow model that covers the entire South American Subbasin as well as the adjoining North American and Cosumes Subbasins, was used to develop the water budget.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10727.6, 10729, and 10733.2, Water Code.					
§ 354.20.			**Management Areas**					
(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.	N/A				Currently no additional management areas are needed to facilitate plan implementation.

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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.	N/A				Currently no additional management areas are needed to facilitate plan implementation.
	(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.	N/A				Currently no additional management areas are needed to facilitate plan implementation.
	(3)		The level of monitoring and analysis appropriate for each management area.	N/A				Currently no additional management areas are needed to facilitate plan implementation.
	(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.	N/A				Currently no additional management areas are needed to facilitate plan implementation.
(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.	N/A				Currently no additional management areas are needed to facilitate plan implementation.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
SubArticle 3.			**Sustainable Management Criteria**					
§ 354.22.			**Introduction to Sustainable Management Criteria**					
			This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.24.			**Sustainability Goal**					
			Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.	281:282	3.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10727, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.26.			**Undesirable Results**					
(a)			Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.	282:294	3.2			
(b)			The description of undesirable results shall include the following:					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.	283:284, 287, 288:289, 291,293	3.2.1.1, 3.2.2.1, 3.2.3.2, 3.2.4.1, 3.2.5.1			
	(2)		The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.	284:285,287,288:289, 291:292,293:294	3.2.1.2, 3.2.2.2, 3.2.3.1, 3.2.4.2, 3.2.5.2			
	(3)		Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.	285:286, 287, 289, 291	3.2.1.3, 3.2.2.3, 3.2.3.3, 3.2.4.3, 3.2.5.3			
(c)			The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.	N/A				1) Minimum thresholds discussed in Section 3.3. 2) Criteria to define minimum thresholds defined sections 3.2.1.2, 3.2.2.2, 3.2.3.1, 3.2.4.2, 3.2.5.2.
(d)			An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.	280	3.0			1) Seawater intrusion does not apply to the SASb
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.28.			**Minimum Thresholds**					
(a)			Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.	294:325	3.3			
(b)			The description of minimum thresholds shall include the following:					
	(1)		The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.	294:325	3.3.1:3.3.5			
	(2)		The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.	294:325	3.3.1:3.3.5			
	(3)		How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.	294:317	3.3.1.1:3.3.1-2			
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.	317, 321:323	3.3.1.3, 3.3.3			

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(5)		How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.	294:325	3.3.1:3.3.5			
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.	317, 321:323	3.3.1.3, 3.3.3			
(c)			Minimum thresholds for each sustainability indicator shall be defined as follows:					
	(1)		Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:					
		(A)	The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.	297:315	3.3.1.2	3-1:3-6, 3-8, 3-11:3-12		1) Figure 3-1 shows MTs, MOs, and IMs at 8 example RMPs in the GSP groundwater elevation monitoring network. 2) Figure 3-2 shows Seasonal, 4 year running mean interpolated groundwater elevations in the South American Subbasin from spring 2005 to fall 2019. 3) Figure 3-3 shows Seasonal summary of interpolated groundwater elevations. 4) Figure 3-4 shows Groundwater elevation measured at all 37 RMPs in the Basin. 5) Figure 3-5 shows the impact of projected groundwater management and climate change on vulnerable wells. 6) Figure 3-6 shows impact of projected groundwater management and climate change on GDE areas. 7) Figure 3-8 shows impact of projected groundwater management and climate change on ISW reach length. 8) Figure 3-11 shows seasonally averaged ISW depletion estimated by CoSANA at ISW designed reaches.
		(B)	Potential effects on other sustainability indicators.	320:321, 323:324	3.3.2, 3.3.4			1) Groundwater level is directly related to groundwater storage and ISW depletion and be used as a proxy for these indicators.
	(2)		Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.	320:321	3.3.2	3-16		1) Figure 3-16 shows the impact of projected groundwater management and climate change on groundwater storage.
	(3)		Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:					
		(A)	Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.	N/A				1) Seawater intrusion does not apply to the SASb
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.	N/A				1) Seawater intrusion does not apply to the SASb

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(4)		Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.	321:323	3.3.3		3-5	1) Maximum Threshold for Degraded Groundwater Quality is discussed instead of minimum threshold for degraded groundwater quality. 2) Table 3-5 shows Constituents of concern and the associated maximum thresholds. Maximum thresholds also include no more than 10% of wells exceeding the maximum threshold for concentration listed here.
	(5)		Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:					
		(A)	Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.	324:325	3.3.5			
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.	234:236	2.3.5	2.3-39: 2.3-40		1) Figure 2.3-41 shows land subsidence from data for 2005 - 2020 from single CGPS (Continuous Global Positioning System) station in the Subbasin (UNAVCO station #P274).
	(6)		Depletions of Interconnected Surface Water. 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. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:					
		(A)	The location, quantity, and timing of depletions of interconnected surface water.	307:312	3.3.1.2	3-7, 3-10:3-11	3-3	1) Figure 3-7 shows probable ISW and Probable Disconnected stream nodes. 2) Figure 3-10 shows probable ISW reaches by name, Probable Disconnected reaches, and GSAs in the Basin. 3) Figure 3-11 shows seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches. 4) Table 3-3 shows October - December simulated streamflow for the American, Cosumnes, and the Sacramento rivers under current conditions (baseline) and projected scenarios.
		(B)	A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.	248:249	2.4.1.2			1) The CoSANA model, a fully integrated surface and groundwater flow model that covers the entire South American Subbasin as well as the adjoining North American and Cosumes Subbasins, was used to develop the water budget.

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(d)			An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.	320:321,323:324	3.3.2, 3.3.4			1) Groundwater level is directly related to groundwater storage and ISW depletion and be used as a proxy for these indicators.
(e)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.	280	3.0			1) Seawater intrusion does not apply to the SASb
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10733, 10733.2, and 10733.8, Water Code.					
§ 354.30.			**Measurable Objectives**					
(a)			Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.	316, 325:334	3.3.1.3, 3.4		3-4, 3-6	1) Table 3-4 lists the IM, MO for groundwater level decline, storage, and ISW depletion. 2) Table 3-6 lists the MO's for degraded groundwater quality. 3) Seawater intrusion is not significant in the SASb. 4) Land is not significant in the SASb and the MO is to maintain current ground surface elevations.
(b)			Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.	316, 325:334	3.3.1.3, 3.4	3-17:3-21	3-4, 3-6	1) Table 3-4 lists the IM, MO for groundwater level decline, storage, and ISW depletion. 2) Table 3-6 lists the MO's for degraded groundwater quality. 3) Seawater intrusion is not significant in the SASb. 4) Land is not significant in the SASb and the MO is to maintain current ground surface elevations.
(c)			Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.	316	3.3.1.3		3-4	1) Table 3-4 lists the operational flexibility for groundwater level decline, storage, and ISW depletion. Operational flexibility is not applicable for groundwater quality, land subsidence, and seawater intrusion.
(d)			An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.	320:321,323:324	3.3.2, 3.3.4			1) Groundwater level is directly related to groundwater storage and ISW depletion and be used as a proxy for these indicators.
(e)			Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.	325:334, 411:413	3.4, 5.1.5			
(f)			Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.	N/A				1) There are no additonal plan elements to discuss
(g)			An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.	N/A				1) There are no MO's established that exceed the reasonable margin of operational flexibility.

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					
SubArticle 4.			**Monitoring Networks**					
§ 354.32.			**Introduction to Monitoring Networks**					
			This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.34.			**Monitoring Network**					
(a)			Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.	335:355	3.5.1:3.5.2	3-26:3-28		
(b)			Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:					
	(1)		Demonstrate progress toward achieving measurable objectives described in the Plan.	335:355	3.5.1:3.5.2			
	(2)		Monitor impacts to the beneficial uses or users of groundwater.	335:355	3.5.1:3.5.2			
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.	335:355	3.5.1:3.5.2			
	(4)		Quantify annual changes in water budget components.	335:355	3.5.1:3.5.2			
(c)			Each monitoring network shall be designed to accomplish the following for each sustainability indicator:					
	(1)		Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:					
		(A)	A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.	337:355	3.5.2	3-21:3-22		1) Figure 3-21 shows monitoring network for groundwater level, storage, and ISW depletion sustainability indicators. 2) Figure 3-22 shows Density of monitoring locations in the upper and lower zone of the principal aquifer.
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.	340	3.5.2	3-23		1) Figure 3-23 Monitoring frequency for representative monitoring points in the network for level, storage, and ISW depletion.
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.	320:321,323:324	3.3.2, 3.3.4			1) Groundwater level is directly related to groundwater storage and ISW depletion and be used as a proxy for these indicators.

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.	280	3.0			1) Seawater intrusion does not apply to the SASb
	(4)		Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.	341:348	3.5.2	3-24:3-28	3-7:3-8	1) Figures 3-24:3-26 show the water quality monitoring wells in the upper and lower aquifer. 2) Tables 3-7:3-8 list information regarding the upper and lower aquifer layer water quality monitoring wells
	(5)		Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.	353:354	3.5.2			1) Subsidence is not a significant concern for the Subbasin
	(6)		Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:					
		(A)	Flow conditions including surface water discharge, surface water head, and baseflow contribution.	327:329,339:355	3.5.2	3-17:3-19, 3-23	3-9	1) Figures 3-17:3-19 show ISW monitoring locations. 2) Figure 3-23 shows monitoring frequency for representative monitoring points in the network for level, storage, and ISW depletion. 2) Table 3-9 lists stream gauge monitoring locations in the basin that collected 15 minute interval data.
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.	N/A				No rivers in the SASb have been shown to cease flowing.
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.	355	3.5.2		3-9	1) Table 3-9 lists stream gauge monitoring locations in the basin that collected 15 minute interval data.
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.	N/A				1) Groundwater level is used as a proxy for ISW depletion
(d)			The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.	330	3.5.2	3-21		1) Figure 3-21 shows monitoring network for groundwater level, storage, and ISW depletion sustainability indicators covering 92% lateral coverage of the network. Groundwater level is used as a proxy for ISW depletion.
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.	337:355	3.5.2			
(f)			The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:					
	(1)		Amount of current and projected groundwater use.	335:337	3.5.1			

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.	340,345:348	3.5.2	3-23, 3-26:3-28	3-7, 3-8	1) Figure 3-22 shows the density of monitoring locations in the upper and lower zone of the principal aquifer for groundwater level and storage and ISW depletion. 2) Figures 3-25:3-26 show monitoring locations in the upper and lower zones for water quality.
	(3)		Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.	335:338	3.5.1			
	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.	335:338	3.5.1			1) Wells with a historical record dating past 2005 were prioritized as monitoring candidates.
(g)			Each Plan shall describe the following information about the monitoring network:					
	(1)		Scientific rationale for the monitoring site selection process.	335:338	3.5.1	3-22		1) Figure 3-22 shows the general framework for monitoring site selection
	(2)		Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.	360	3.5.4			
	(3)		For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.	317, 322, 342	3.3.1.3, 3.3.3, 3.4.3		3-4, 3-5:3-6	1) Table 3-4 lists the MT, MO, and IM for groundwater level decline, storage, and ISW depletion. 2) Land subsidence and seawater intrusion are not significant in the subbasin. 3) Table 3-5 lists the MTs for water quality. 4) Table 3-6 shows the measurable objectives for nitrogen and specific conductivity at the selected wells within the Subbasin. 5) IMs are not applicable for water quality.
(h)			The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.	317, 330, 332, 340:341, 351:352	3.3.1.3, 3.4.3, 3.5.2	3-21, 3-23:3-24	3-4, 3-6:3-8	1) Figure 3-21 shows monitoring network for groundwater level and storage, and ISW depletion. 2) Figure 3-23 shows the monitoring frequency for groundwater level and storage, and ISW depletion. 3) Figure 3-24 shows the location of water quality monitoring wells. 4) Table 3-4 lists the monitoring wells used for groundwater level and storage, and ISW depletion. 5) Table 3-6 lists the wells for water quality monitoring. 6) Tables 3-7:3-8 lists the measurement history and frequency for water quality.
(i)			The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.	355:360	3.5.3			
(j)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.	N/A				1) Seawater intrusion does not apply to the SASb. 2) Land subsidence is not expected to be a signficiant concern to the SASb

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, 10728, 10733, 10733.2, and 10733.8, Water Code					
§ 354.36.			**Representative Monitoring**					
			Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:					
(a)			Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.	316, 341	3.3.1.3, 3.4.3		3-4, 3-6	1) Table 3-4 lists the RMPs groundwater level and storage, and ISW depletion. 2) Table 3-7 lists the RMPs for water quality.
(b)			(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:					
	(1)		Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.	320:321, 323:324	3.3.2, 3.3.4			1) Groundwater level is directly related to groundwater storage and ISW depletion and be used as a proxy.
	(2)		Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.	316	3.3.1.3		3-4	1) Table 3-4 lists the operational flexibility for groundwater level decline, storage, and ISW depletion. Operational flexibility is not applicable for groundwater quality, land subsidence, and seawater intrusion.
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.	335:337	3.5.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2 and 10733.2, Water Code					
§ 354.38.			**Assessment and Improvement of Monitoring Network**					
(a)			Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.	360:362	3.5.5			
(b)			Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.	316,337:355,347,352,360:362	3.3.1.3, 3.5.2, 3.5.5	3-27	3-4	1) Figure 3-27 shows the data gaps to be addressed for monitoring wells, stream gauges. 2) Table 3-4 shows monitoring wells with some historical data gaps
(c)			If the monitoring network contains data gaps, the Plan shall include a description of the following:					
	(1)		The location and reason for data gaps in the monitoring network.	316, 337:355, 347,352, 360:362	3.3.1.3, 3.5.2, 3.5.5	3-27	3-4	1) Figure 3-27 shows the data gaps to be addressed for monitoring wells, stream gauges. 2) Table 3-4 shows monitoring wells with some historical data gaps
	(2)		Local issues and circumstances that limit or prevent monitoring.	316,337:355,347,352,360:362	3.3.1.3, 3.5.2, 3.5.5	3-27	3-4	1) Figure 3-27 shows the data gaps to be addressed for monitoring wells, stream gauges. 2) Table 3-4 shows monitoring wells with some historical data gaps

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(d)			Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.	316,337:355, 347,352,360:362	3.3.1.3, 3.5.2, 3.5.5	3-27	3-4	1) Figure 3-27 shows the data gaps to be addressed for monitoring wells, stream gauges. 2) Table 3-4 shows monitoring wells with some historical data gaps
(e)			Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:					
	(1)		Minimum threshold exceedances.	316, 360:362	3.3.1.3, 3.5.5			In Development
	(2)		Highly variable spatial or temporal conditions.	316, 337:355,360:362	3.3.1.3, 3.5.2, 3.5.5	3-25, 3-26, 3-27, 3-28, 3-70	3-7, 3-8, 3-9	In Development
	(3)		Adverse impacts to beneficial uses and users of groundwater.	337:355	3.5.2	3-24		In Development
	(4)		The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.	316	3.3.1.3			In Development
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10728.2, 10733, 10733.2, and 10733.8, Water Code					
§ 354.40.			**Reporting Monitoring Data to the Department**					
			Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.					
SubArticle 5.			**Projects and Management Actions**					
§ 354.42.			**Introduction to Projects and Management Actions**					
			This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.44.			**Projects and Management Actions**					
(a)			Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.	363:366	4.0			
(b)			Each Plan shall include a description of the projects and management actions that include the following:					
	(1)		A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:					

Article 5.			Plan Contents for South American Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(A)	A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.	365:368	4.2	4-1		Figure 4-1 shows the process of identifying, screening, evaluating, and selecting PMAs
		(B)	The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.	371, 375,379	4.4.1.2, 4.4.2.2, 4.4.3.2			
	(2)		If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.	320:321	3.3.2	3-16		The basin has historically avoided overdraft.
	(3)		A summary of the permitting and regulatory process required for each project and management action.	371, 375,379	4.4.1.3, 4.4.2.3, 4.4.3.3			
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.	371, 375,379	4.4.1.4, 4.4.2.4, 4.4.3.4			1) General status of all PMAs listed in Appendix 4-A
	(5)		An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.	371, 375,380	4.4.1.5, 4.4.2.5, 4.4.3.5			1) Additional project benefit information is listed in Appendix 4-B
	(6)		An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.	372,376,380	4.4.1.6, 4.4.2.6, 4.4.3.6			
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.	372,376,380	4.4.1.7, 4.4.2.7, 4.4.3.7			
	(8)		A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.	372,376,380:381, 413:415,416:417	4.4.1.8, 4.4.2.8, 4.4.3.8, 5.1.6, 5.2, 5.4, 5.5		5-1, 5-2	1) Table 5-2 lists the proposed funding mechanisms for proposed management actions 2)Table 5-2 lists a summary of the GSP implementation costs.
	(9)		A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.	372,376,381	4.4.1.9, 4.4.2.9, 4.4.3.9			
(c)			Projects and management actions shall be supported by best available information and best available science.	365:368	4.2		4-1	Figure 4-1 shows the process of identifying, screening, evaluating and selecting PMAs
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.	365:368	4.2		4-1	Figure 4-1 shows the process of identifying, screening, evaluating and selecting PMAs
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

Appendix 1-G

Public Comment Log

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
1	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	General			The Department is writing to support ecosystem preservation in compliance with SGMA and its implementing regulations based on Department expertise and best available information and science. The Department recognizes and appreciates the effort of the GSAs to thoroughly and quantitatively consider all beneficial users of groundwater in the subbasin, and the draft GSP includes thoughtful analysis of modeled scenarios to evaluate the identified management criteria for undesirable results. However, the Department disagrees with the GSP's assessment of what impacts constitute an unreasonable impact for environmental users and believes the GSP could improve its methods for identifying environmental users of groundwater and establish more protective management criteria. Accordingly, the Department recommends that South American Subbasin GSAs address the following comments before submitting the GSP to the Department of Water Resources (DWR).	Comment noted.
2	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	General			In conclusion, the draft GSP thoughtfully discusses all beneficial uses and users of groundwater, provides detailed characterization of groundwater conditions in the basin, and incorporates robust modeling of future scenarios; however, the GSP can further refine its management criteria to better avoid potential impacts to GDEs and ISW, and provide additional detail for planned projects and management actions. The Department recommends that the South American Subbasin GSAs address the above comments before GSP submission to DWR to best prepare for the following regulatory criteria for plan evaluation: 1. The assumptions, criteria, findings, and objectives, including the sustainability goal, undesirable results, minimum thresholds, measurable objectives, and interim milestones are not reasonable and/or not supported by the best available information and best available science. [23 CCR § 355.4(b)(1)] (See Comments #1, 2, 3, 4, 5) 2. The GSP does not identify reasonable measures and schedules to eliminate data gaps. [23 CCR § 355.4(b)(2)] (See Comment #6) 3. The interests of the beneficial uses and users of groundwater in the basin, and the land uses and property interests potentially affected by the use of groundwater in the basin, have not been considered. [23 CCR § 355.4(b)(4)] (See Comments #1, 3, 4, 5) 4. The projects and management actions are not feasible and/or not likely to prevent undesirable results and ensure that the basin is operated within its sustainable yield. [23 CCR § 355.4(b)(5)] (See Comment #7)	Comment noted and addressed in other comment items.
3	Clean Water Action/Clean Water Fund Union of Concerned Scientists Audubon California Local Government Commission The Nature Conservancy	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan E.J. Remson & Melissa M. Rohde	8/10/2021	Overall	See attached letter for comments regarding specific attachments		Based on our review, we have significant concerns regarding the treatment of key beneficial users in the Draft GSP and consider the GSP to be insufficient under SGMA. We highlight the following findings: 1. Beneficial uses and users are not sufficiently considered in GSP development. a. Human Right to Water considerations are not sufficiently incorporated. b. Public trust resources are not sufficiently considered. c. Impacts of Minimum Thresholds, Measurable Objectives and Undesirable Results on beneficial uses and users are not sufficiently analyzed. 2. Climate change is not sufficiently considered. 3. Data gaps are not sufficiently identified and the GSP needs additional plans to eliminate them. 4. Projects and Management Actions do not sufficiently consider potential impacts or benefits to beneficial uses and users. Our specific comments related to the deficiencies of the South American Subbasin Draft GSP along with recommendations on how to reconcile them, are provided in detail in Attachment A. Please refer to the enclosed list of attachments for additional technical recommendations: Attachment A GSP Specific Comments Attachment B SGMA Tools to address DAC, drinking water, and environmental beneficial uses and users	Specific comments addressed in other sections.
4	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			Conceptually, the GSPD includes two conservative assumptions that deserve clarification. First, regarding the projected impacts from pending climate change, the selection of the 'central tendency' climate forecast understates the impacts of climate change on future water supply and demand, which would have a negative impact on the SAS's sustainability. The GSPD should clearly describe the climate change study, its assumptions, and the arguments for and against using the central tendency forecast. Second, the GSPD does not include demand reduction as a Project and, therefore, does not reduce groundwater demand resulting from the associated water conservation and efficiency actions and programs that are expected to take place. These demand reducing programs should be described along with the logic for not including them in this GSP. The effect is to potentially overstate future groundwater pumping in the SAS. We urge that: 1) the GSPD include a more robust discussion of the climate change forecast, and 2) both climate assessment and demand reduction approaches be reassessed and included in a future GSP annual report to DWR or, at a minimum, in the 2025 GSP update.	Comment noted. Implementation of the GSP includes consideration of updates to the CoSANA model in light of changing conditions or additional data.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
5	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			We are concerned about how GDEs are impacted by the Sustainable Management Criteria. We acknowledge that the GSPD presents a comprehensive assessment of both interconnected surface water (ISW) and Groundwater Dependent Ecosystems (GDE) based on current science. However, new information was presented recently (Lewis and Burgy 1964 study) to the GSP Working Group suggesting the root depth analysis used for GDEs should use a depth of 80 feet, not the 30 feet used in the GSPD. In addition, The Nature Conservancy (TNC) is about to publish a study indicating root depths for certain oak species are 25 meters. Also, a recent TNC study identifies the inability of oak woodlands to reproduce when ground water levels are too low. Therefore, a determination of appropriate root depths to maintain GDEs should be included as a priority Management Action in the final GSP.	This 80 ft metric concerns one paper from 1964 that studied injected isotope tracers (particles moving through the subsurface) in a fractured rock aquifer in hilly topography on (n = 15) trees. Results are specific to geology and do not hold for a relatively flat, alluvial, aquifer-aquitard system. Reproducible, recent results are needed for a system comparable to the SASb.
6	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			We are concerned about the measures being taken to protect GDEs. While we understand the rationale behind the three-year trigger for ISW, we believe another approach is necessary for the protection of GDEs. If groundwater levels fall below the root zone for three years before any action is taken, then the need for action has passed because the plants located in the area of concern will already be dead. We urge further work in this area and that the final document include more protective measures for GDEs; or if further study is needed, this be identified as a high priority Management Action.	The GSP identifies undesirable results for GDEs not when groundwater levels are below the root zone for 3 years, but rather, when the area of GDEs decreases below 44% (2012-2016 groundwater levels), or when the GDE ”greenness” measured by satellites declines below historically observed values. In other words, GDEs won’t shrink or dry out beyond what we’ve previously seen in the basin. Importantly, GDE area and greenness has improved since the past drought, indicating the ability to come back from those groundwater lows. Furthermore, projected management and climate change are expected to impact GDE area by -3 to +4 %, with a median impact slightly greater than 0, largely due to PMA near GDEs (Firgue 3-6).
7	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			Finally, with respect to communicating, we recommend that that monitoring data be presented to the public in a form that allows local property owners to track information from sampling events that are of immediate interest to them. We suggest that the GSAs incorporate telemetry into the well monitoring program so that results can be recorded on a real-time basis. This will allow for more frequent sampling if the need arises.	Section 3.5.3 summarizes the protocols for data collection and monitoring. Section 3.5. assesses and provides recommendations for improving the monitoring network, including installation of telemetry and data loggers, as well as protocols for data management. As part of the implementation of the GSP, the monitoring network will also be reassessed regularly for adequacy in tracking Subbasin conditions.
8	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			The Group 2 project list should be expanded to include a priority list of water purveyor projects that best contribute to the sustainable management of the basin. Water purveyors have a significant list of system connectivity, conjunctive use, and recharge projects. We recognize that the GSAs have no direct authority over any of these projects, but it is important to send a signal to the water purveyors and the public at large regarding which projects fit best with the management of the SAS and what completion priority each project has with respect to attaining subbasin sustainability.	Additional projects and management actions may be developed, discussed, and considered for inclusion into the GSP update by the GSAs as part of the implementation phase of the GSP.
9	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			Finally, we note the important insights made possible by research and monitoring that guides Project development so that both recharge and ecological value are increased. An example is the investment made by OHWD and SAFCA to work with research teams to fully understand the site characteristics and to identify all the opportunities for both principal aquifer recharge and flood protection, and ecological uplift. This information will enhance funding opportunities and support effective and responsible groundwater banking. We encourage SAS GSAs efforts to support individual GSA projects like this, and suggest including a thorough description of the many benefits of the project in the DGSP.	Additional projects and management actions may be developed, discussed, and considered for inclusion into the GSP update by the GSAs as part of the implementation phase of the GSP.
10	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			This Section also contains Management Action. We endorse the concept of a Shallow/ Vulnerable Well Protection Program and the Well Permit Coordination actions. The GSPD should specify responsibilities and timeframes for these Actions’ development, funding, and implementation. Additionally, we recognize that the Shallow/Vulnerable Well Protection Program is still in the formative stage and offer these suggestions: The Program should focus on shallow wells (domestic and agricultural) that become dry resulting from MT exceedance, and should not apply to localized dry well conditions. We support efforts to engage the local agricultural and residential landowners in the development of the program. We suggest that the GSPD’s initial focus include voluntary, private well owner data gathering and coordination. We recommend that the GSPD include enough information about the effort to support any subsequent funding opportunities from outside sources. The tie between shallow wells and conjunctive use/recharge should also be assessed as part of program development and implementation. Additionally, with enhanced private well owner monitoring, these well owners will have information they can use to carry out their own water conservation efforts.	Management actions are not all equally developed. The information provided is what was available at the time of the development of the GSP.
11	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			The GSPD’s Management Actions section should be expanded to include specific lists of work, studies, and monitoring system improvements, including the responsible GSA(s). The same level of detail should be included in Management Action write-ups for the additional monitoring system improvements (including those we have recommended) noted as needed to be performed within the GSPD. The GSAs may find it difficult to plan and budget for these Actions unless they are called out in the final GSP that is approved by the GSAs. We believe the GSPD’s Management Actions section should be expanded to include the following additional Management Actions: (see the next 2 rows)	Management actions are not all equally developed. The information provided is what was available at the time of the development of the GSP.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
12	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			1) A Management Action should commission a climate impacts assessment that results in revised climate impact inputs for the five-year GSP update. This new climate impacts assessment should build upon the American River Basin Study used as the basis for the current GSPD analysis. The yet-to-be-published American River Basin Study is expected to include over 60 climate forecasts and the version that the GSPD uses is based on climate information and forecasts do not reflect the region's recent climate experience and the latest climate forecasts. Fortunately, the local agencies who helped fund the study have briefed the Water Forum and others on its findings and have indicated that the American River Basin Study does have climate data that is more reflective of current conditions and these newer forecasts. The study's project managers have advised that the study's forecasting models can be run with that information. Given the repeated references in the GSPD to the importance of the impacts of climate change on basin management, a new assessment should be conducted so that it is available in time for a future annual update to DWR or, by the latest, the next plan update in five years. To that end, the GSAs should reach out now to the other subbasin GSAs, RWA and the Water Forum to develop an agreement to perform that work so that it can be included in the region's three GSP updates. The same inputs should be used in the next round of UWMPs and by the RWA and Water Forum in their planning efforts. ECOS and RWA are members of the Water Forum and participate in the Water Forum 2 renegotiation process, which is committed to actions that lead to the Region's water supplies being able to best adapt to climate change. This includes how groundwater is a significant, sustainable resource for providing for our water needs - both for people and the environment. We believe that the Water Forum 2 process, and successor efforts, should help in the development of studies linking our water supply with future	Addition of these studies and analyses, including updates to the CoSANA model will be considered during the implementation phase of the GSP.
13	Environmental Council of Sacramento (ECOS)		6/18/2021	Overall			2) A Management Action should direct the GSAs to develop a policy and procedure for reviewing, formally commenting on, and approving (when appropriate) groundwater transfers, water banking activities including the accounting framework, and conjunctive use operations. The document should include GSA ongoing monitoring and management responsibilities in each area, and how costs for these activities are recovered. The policy and procedure should lay out how water banking and recharge programs will be implemented in the SAS including governance, water accounting, banking and recharge operations, and SAS banking premiums of water left in the SAS, over and above deposits, to adjust for natural storage loss, environmental premiums, and basin supply enhancement. Some Projects (Harvest Water Project and OHWD) are investments that enhance the subbasin's storage and provide multiple benefits for the subbasin. These efforts contribute to subbasin sustainability and the ability to utilize the subbasin for transfers, conjunctive use, and water banking. The policy and procedure should address how these types of Projects are able to participate in transfers, conjunctive use, and water banking operations, and/or other transactions that add value to their basin contributions.	Additional projects and management actions may be developed, discussed, and considered for inclusion into the GSP update by the GSAs as part of the implementation phase of the GSP.
14	Huhtamaki Foodservice, Inc.	Amy Steinfeld	8/17/2021	General			In 1963, Huhtamaki began production of groundwater from two water supply wells on the Property for overlying use in Huhtamaki's consumer products manufacturing operations From 1990 until 2005, the volume of water pumped by Huhtamaki ranged from 200,000 to 3.5 million gallons per day (MGD) or 220 to 3,900 acre-feet per year (AFY). In 2001, groundwater pumping ranged between 300,000 and 1.5 MGD (335 to 1,680 AFY). In 2002, at a time when its production process was using approximately 600,000 to 750,000 gallons per day (approximately 672 to 840 AFY), Huhtamaki was forced to temporarily pause all groundwater production after third-party groundwater pollution from operations on a neighboring property caused elevated levels of the contaminant tetrachloroethylene (PCE) in groundwater beneath the Property.2 During this interim period, Huhtamaki was forced to connect to the local municipal water system (California-American Water's (Cal-Am) Parkway System) as an interim water supply to replace groundwater supplies. Clean-up efforts are ongoing, and Huhtamaki intends to resume groundwater production from the Subbasin once groundwater quality conditions improve.	Comment noted
15	Sacramento Regional County Sanitation District (Regional San)	Terrie Mitchell	8/18/2021	General			We appreciate the GSP incorporating Harvest Water as a project and management action that contributes to the sustainability of the basin. Regional San is developing Harvest Water to provide a safe and reliable supply of tertiary-treated recycled water for agricultural uses, reducing the need for groundwater pumping in the region, supporting habitat protection and enhancement efforts, and providing near-term benefits to the Sacramento-San Joaquin Delta.	Comment noted.
16	Sacramento Regional County Sanitation District (Regional San)	Terrie Mitchell	8/18/2021	General			We believe Harvest Water is an exceptional opportunity to proactively restore and manage groundwater, while improving stream flows in the lower Cosumnes River, enhancing riparian habitats and wetlands, sustaining prime agricultural lands, and improving regional water supply reliability through conjunctive use. By delivering recycled water in-lieu of groundwater pumping, Harvest Water will increase groundwater storage by approximately 245,000 acre-feet within 10 years. This in-lieu recharge is expected to raise groundwater levels up to 35 feet in the center of the Harvest Water Program area, and 15 to 25 feet in other parts of the groundwater basin in the vicinity of the Program.	Comment noted.
17	Sacramento Regional County Sanitation District (Regional San)	Terrie Mitchell	8/18/2021	General			The GSP's measurable objectives for groundwater levels incorporate the estimated increases in groundwater levels in the vicinity of the Harvest Water Program. We believe this is not only appropriate, but vital to ensuring that the on-going management of groundwater in the basin supports the success of the Harvest Water Program. Regional San plans to continue our involvement in GSP development and implementation to ensure that Harvest Water benefits are realized in the form of elevated groundwater levels, protection of groundwater dependent ecosystems, and the related ecological benefits. We are available to provide additional information on the Harvest Water Program as needed and look forward to continuing our involvement as the GSP is adopted and implemented.	Comment noted.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
18		Carl Werder	7/5/2021	Overall			General comment: Section 1 is currently 204 pages and more pages to be added. Other sections are less than 100 pages. Recommend dividing Section 1 into two parts or adding another section. Same for appendix 2-B, it is two big at 459 pages to be useful. May want to divide the basin into four or five areas of hydrographs.	Comment noted
19		Lynn Wheat Wheat91@yahoo.com	8/18/2021	General			As a 34 year resident of Elk Grove and active participant in local government, it was only after another community member began sharing information with me on SCGA meetings and the GSP, did I begin attending meetings and reading documents--and it was only after taking these steps did I begin to understand the importance in developing and implementing a plan. Were it not for the community member reaching out to me and discussing the GSP and meetings of the various GSA's would I have had any idea of the future of water in our area. This document suggested there has been extensive outreach. I believe the final GSP document needs to further elaborate on "extensive". Many in my community have no idea what will be required of them in the future and the cost burden of implementing the various projects. How have the members of the SCGA board been communicating to the general public they represent? I had requested the City of Elk Grove communicate with the residents in a manner which would peak curiosity; what will be required of the residents? Will residents be required to reduce use and carry the financial obligations of program implementation imposed by increasing fees, taxes and water bills? As a resident of Elk Grove, I pay taxes and fees to the City of Elk Grove, Elk Grove Water District, and Sacramento County Sanitation District. All are members of SCGA who contribute monies to support the functions of SCGA. There will be costs to implementing the programs and the costs should be clearly estimated and defined within the GSP. Who will cover the costs? How will the cost burden be distributed? Will there be equity in sharing the burden of the costs? What about "Unknown" costs of programs and facilities. "Costs of facilities and activities uncertain and will be developed as	Comment noted. See Section 1 and Appendix 1-E for summaries of public outreach and noticing. See Section 5 for discussion on implementation funding.
20		Lynn Wheat Wheat91@yahoo.com	8/18/2021	General			What will the quality of local groundwater be when GSP projects are implemented? Will there be significant changes to the quality of the water and treatment process? Will our groundwater become contaminated? What will be the estimated costs of treating the water to make it drinkable and meeting minimal State/EPA standards? The GSP needs to evaluate this and include it in the document. It is of no value to have water available that is more contaminated and harmful to the health and environment of the region and therefore unusable.	Comment noted. See Section 4. PMAs are in various levels of development, and details are provided as available. All projects will be required to obtain applicable state and federal environmental clearances as well as other permits as required.
21		Suman Singha, PhD	8/16/2021	General			It is heartening to learn that there is no significant aquifer drawdown in the SASb and future management should ensure long term sustainability.	Comment noted
22		Suman Singha, PhD	8/16/2021	General			It is equally heartening to learn that the contaminant plumes at Mather AFB, Aerojet and Kiefer Landfill are being closely monitored and that the remediation plans are working.	Comment noted
23		Suman Singha, PhD	8/16/2021	General			However, I do have a major concern that the CoSANA projections are based on past and current parameters. Given that climate change is a reality, I believe the model should also include a protracted/severe drought scenario that has the potential of occurring; especially when we consider the 20- and 50-year timelines for the plan.	Comment noted. Implementation of the GSP includes consideration of updates to the CoSANA model in light of changing conditions or additional data.
24		Suman Singha, PhD	8/16/2021	General			Although outside the scope of this report, I believe we need to start considering water as a finite and precious resource. Change in consumer behavior regarding water conservation and usage is going to be an important component of this. Part of this should include tiered pricing for water. Action on this is needed at all levels, else the scenario playing out in Mendocino will no longer be the exception but the rule.	Comment noted

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comments
1	Environmental Council of Sacramento (ECOS)		6/18/2021	Executive Summary			The Executive Summary (ES) does not adequately include the impacts and importance of climate change on SAS sustainability even though this information is found in the body of the GSPD. The ES focuses on the need for a plan to address human water needs, but the SGMA makes it clear that environmental groundwater needs must also be addressed. The ES also focuses on past plans and actions, and while these contribute to why we are engaged in a GSPD, the ES should focus on the future. Terms and concepts should be better defined, along with their relevance to groundwater assessments and planning. For example, “groundwater conditions”, “conceptual model”, and “water budget” need definitions/relevance narratives for the lay reader. Many readers may only read the ES, so it is important that the ES communicate effectively. Our specific comments on the GSPD’s technical work, conclusions, and findings are discussed in the following section reviews.	Executive Summary has been modified, in part, to address comment. The detail requested is provided in later sections of the GSP (Sections 2,3,4 and 5).
2	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	Executive Summary	IX	129	Please revise the first sentence of the Kiefer Landfill Description, contained within Table ES-2, as follows: "The Kiefer Landfill is a 1,084-acre site with an active class III ~~300~~ 335-acre solid waste disposal site that is owned and operated by Sacramento County." Source info for revision: Page 2 of https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2016-0013.pdf The number was adjusted upward by 30 acres to account for recently opened landfill Module M4.	Edit accepted
3	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	Executive Summary	IX	129	We would prefer that the last sentence of the Kiefer Landfill Description (within Table ES-2), which lists the number of monitoring wells, be removed, as these details are more properly provided in Section 2. If this sentence must be retained within the Executive Summary, then it should be revised as follows: "Currently, the monitoring network at Kiefer consists of ~~23~~ 65 monitoring wells." If the sentence is retained, the numbers of monitoring wells for the Mather and Aerojet sites (570 and 2000, respectively) should also be listed within this table. Source info for revision to number of wells: Page 10 of https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2016-0013.pdf	Edit accepted

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comments
1	Huhtamaki Foodservice, Inc.	Amy Steinfeld	8/17/2021	Section 1.5.3.1			The Draft Plan list of SASb Beneficial Uses and Users (Section 1.5.3.1) does not include "commercial" or "industrial" uses of groundwater as beneficial uses within the Subbasin. Although the Draft Plan mentions these types of uses elsewhere and in the Sustainability Goal (see, e.g., Plan, § 3.1, App. 1-D), "commercial" and/or "industrial" uses should be added to this list. (See Wat. Code, §§ 10723.2, 10727.2(b)(2); Cal. Code Regs., tit 23, § 354.10(a).)	Water uses listed in 1-D have been added to 1.5.3.1
2	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/10/2021	Appendix 1D	69-71		Provide a map of tribal lands in the subbasin. The GSP states (p. 2-10): "The only tribal land that falls within the SASb is located south of Elk Grove near the intersection of Kammerer Road and Hwy 99." However no map, acreage, or population is provided.	Although we do not provide maps, acreage, or population counts, tribal governments and entities were contacted during engagement and outreach (detailed in Appendix 1D) and are involved in ongoing communication and outreach. Tribal groups involved in ongoing C&E include: Wilton Rancheria, Buena Vista Rancheria Mewuk Indians, Ione Band of Miwok Indians, Nashville Enterprise Miwok-Maidu-Nishinam Tribes, Shingle Springs Brand of Miwok Indians, Tsi Akim Maidu, United Auburn Indian Community of the Auburn Rancheria, Colfax-Todds Valley Consolidated Tribe, Yocha Dehe Wintun Nation.
3	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/12/2021				Provide the population of each identified DAC and include details on the population dependent on groundwater for their domestic water use.	Although we do not provide population counts of DACs, DAC groups were contacted during engagement and outreach (detailed in Appendix 1D) and are involved in ongoing communication and outreach. DAC-representative groups involved in ongoing C&E include: Environmental Justice Coalition for Water, Florin Census-Designated Place (CDP) DAC, Lemon Hill CDP DAC, Parkway CDP DAC, Fruitridge Pocket CDP DAC, Freeport CDP DAC. The GSP comprehensively evaluates impacts to domestic wells - which may be used by DACs - and finds them to be minimal (Appendix 3A).
4	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/16/2021	Appendix 1D			Describe efforts to engage with stakeholders during the GSP *implementation* phase in the Stakeholder Communication and Engagement Plan. Refer to Attachment B for specific recommendations on how to actively engage stakeholders during all phases of the GSP process.	The GSAs are in the process of developing an implementation MOU that includes public engagement provisions. The GSAs will follow DWR guidance in stakeholder engagement during implementation (i.e., public notices and meetings before amending a GSP or prior to imposing or increasing a fee, and ongoing efforts to encourage active involvement).
5	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/17/2021	Appendix 1D			Describe efforts to consult and engage with tribes within the subbasin. Refer to the DWR guidance entitled Engagement with Tribal Governments for specifics on how to consult with tribes.	We received a list of potentially interested tribes after making a direct request to the Native American Heritage Commission. Contact was made with all of the listed tribes and those that indicated interest were added to the subbasin outreach lists. However, we will maintain ongoing communication with tribes following DWR guidance in stakeholder engagement during implementation.
6		Carl Werder	7/5/2021	Section 1			Section 1, -- This section offers nothing but a rehash of existing documentation concerning the GSP process, therefore no comment	Noted. No changes made.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
1	Ag/Res resident	Amelia Vankeuren	8/17/2021	2	102	1577	Section 2.2.7 Natural Water Quality Characterization only summarizes older groundwater quality data (pre-2016) in public supply wells, which tend to be deeper than shallow domestic wells. The summary in this section should also incorporate the more recent data downloaded from the GAMA Groundwater Information System Data Download in 2020 (as mentioned on page 2-142) as that would include shallow well information from the 2017 GAMA Sacramento-Metro Study Unit - Shallow Assessment.	The document was developed using the data that was available at the time it was written. More recent data can be reported in Annual Reports to be submitted after the GSP is completed.
2	Ag/Res resident	Amelia Vankeuren	8/17/2021	2	125	1938	The declining trend in groundwater levels in the eastern portion of the subbasin is highly concerning. "Not well understood" declines of 40 ft over 50 years are unacceptable, particularly as well 244 is relatively close to an area with a high concentrations of shallow domestic wells.	Comment noted. The text has been edited to clarify the discussion of groundwater elevations in this section.
3	Ag/Res resident	Amelia Vankeuren	8/17/2021	2	132	2019	The hydrographs for the 4 shallower wells show that the shallow aquifer groundwater elevation is generally 30 ft higher than the deeper aquifer wells, so there is a strong downward vertical gradient. The shift from an upward vertical gradient in other locations in the subbasin to the downward vertical gradient in Elk Grove suggests that the deeper aquifer is being heavily exploited in this location. Why is this downward gradient not mentioned in the summary of this section?	Comment noted. The text has been edited to clarify the discussion of groundwater elevations in this section.
4	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.1.3 Description of Beneficial Uses and Users of Groundwater	page 2-19		1. Comment #1 Beneficial Uses and Users (Plan Area and Basin Setting, 2.1.3 Description of Beneficial Uses and Users of Groundwater, page 2-19): The GSP does not specifically identify environmental uses and users as beneficial users of groundwater in the subbasin. a. Issue: The GSP defines beneficial uses of groundwater in the subbasin as municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply. GSAs are required to consider all beneficial uses of groundwater, including environmental uses [Water Code 10723.2(e)]. b. Recommendation: The Department recommends revising the Section 2.1.3 description of beneficial uses and users to more accurately describe all groundwater users in the subbasin, similar to the more inclusive description of environmental beneficial users included in Section 1.5.3.1 (page 1-14).	Environmental uses has been added as a beneficial use.
5	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.2 Hydrogeologic Conceptual Model, 2.4 Water Budget			2. Comment #2 CoSANA Model (Plan Area and Basin Setting, 2.2 Hydrogeologic Conceptual Model, 2.4 Water Budget): The GSP does not include sufficient detail on CoSANA model development. a. Issue: The GSP states that "The CoSANA model and model layers are described in detail in the Model Development technical memorandum" (page 2-78) and that "Additional information on the data and assumptions used to develop the CoSANA model is included as an appendix to the GSP" (page 2-172). However, neither of these documents are included with the draft GSP. b. Recommendation: The Department recommends the technical information referenced regarding CoSANA model development be included to facilitate careful review of the GSP.	The CoSANA model appendix has now been provided for review
6	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.3.6 Interconnected Surface Water Systems, starting page 2-159			3. Comment #3 Interconnected Surface Waters (Plan Area and Basin Setting, 2.3.6 Interconnected Surface Water Systems, starting page 2-159): GSP identification of interconnected surface waters (ISW), defined by 23 CCR § 351(o) as surface water hydraulically connected "at any point" to the underlying aquifer, is based on a methodology that relies on a narrower definition of ISW than the definition included in the regulations and that risks misidentifying surface waters as disconnected. a. Issues: i. ISW Identification: The methodology for identifying a surface water reach as interconnected requires a majority of CoSANA stream nodes to be connected for a season in order to be considered ISW (line 2358, Appendix_3-C). However, this methodology applies a narrower definition of interconnected surface waters than 23 CCR § 351(o), which defines surface water as ISW if the surface water is hydraulically connected to groundwater "at any point." Therefore, surface water reaches that have connected nodes, regardless of whether those nodes represent a majority for a given season, meet the definition of interconnected surface water and should be evaluated accordingly in the GSP. Additionally, the GSP applies this ISW identification methodology inconsistently by identifying the Cosumnes River approximately between Deer Creek and Twin Cities Road as a data gap due to "sub-seasonal connection" (line 2366). The GSP does not discuss whether other surface waters throughout the basin were evaluated for sub-seasonal connections. 23 CCR § 351(o) does not require connection to last for the duration of a season for a reach to be interconnected. ii. Streamflow Depletion: The GSP states that increased streamflow will increase the hydraulic gradient and therefore increase ISW depletion (page 3-11, line 397).	(i) We agree with the reviewer that correctly classifying ISW is very important. For this reason, we conservatively include entire reaches when a majority of nodes are interconnected for at least 1 of 22 seasons evaluated in the historical record from 2005-2018 (Appendix 3-C, Figure 24). Unlike the reviewer suggests, this classification system actually leads to more surface water being considered ISW (compare subplots A and B in Figure 24) than if we only classified ISW at the nodal level. This increases ISW protection under SGMA because it includes portions of surface water that may actually be disconnected. We believe it reasonable that "interconnection" is an average state during a season and disagree with the reviewer that the scant evidence of sub-seasonal connection along the Cosumnes River between Deer Creek and Twin Cities Road should be considered "interconnection". Out of an abundance of caution we classify this section a "Data Gap" and seek to study whether the scant evidence of sub-seasonal connection in a small number of wells may be the result of air entrapment, perched aquifer dynamics, or another essential function that supports ISW. Bear in mind: groundwater conditions in this reach show persistent disconnection from 2005-2018. The GSP's decision to call this a Data Gap and to coordinate with environmental groups and the neighboring Cosumnes basin on studying this reach is taken out of an abundance of caution. Furthermore, scant evidence from high frequency 15-minute data suggests that a few days in the past 10 years groundwater levels sharply increased above river stage in the Cosumnes Data Gap. Notably, these groundwater level increases occur in wells more than a mile from the river - it is highly unlikely this these pulse events propagate to the river, and they may well represent air entrapment following floodplain inundation, or perched aquifer heads. This data is simply not available across all surface water reaches in the basin, nor is it necessary in locations
7	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.3.6 Interconnected Surface Water Systems, starting page 2-159			b. Recommendations: i. ISW Identification: The Department recommends revising the methodology for identifying ISW so that surface water reaches that are connected at any node, regardless of whether the nodes reach the majority threshold or are connected for a full seasonal duration, are considered ISW. The reach of the Cosumnes River between Deer Creek and Twin Cities Road should be classified as ISW, rather than as a data gap. Additionally, the GSP should provide additional clarification on the sub-seasonal interconnection analysis and whether other surface water reaches in the subbasin similarly demonstrated short term interconnectedness. ii. Streamflow Depletion: The Department recommends clarifying that increased streamflow may increase the rate of stream water seeping from ISW into the underlying aquifer; but increased streamflow will not necessarily cause greater depletion of surface waters.	(i) As previously stated, we maintain that the methodology for classifying ISW is conservative and includes many more persistently disconnected surface water nodes with no strong evidence of connection as ISW because they exist on reaches where a majority of nodes experience at least 1 season of interconnection of out the 22 evaluated (Appendix 3-C, Figure 24). The reach of the Cosumnes River between Deer Creek and Twin Cities Road is persistently disconnected for all 22 seasons evaluated from 2005-2018. We include it as a Data Gap out of an abundance of caution and due to scant evidence from high frequency 15-minute data that suggests a few days in the past 10 years when groundwater levels sharply increased. Notably, these groundwater level increases occur in wells more than a mile from the river - it is highly unlikely this these pulse events propagate to the river, and they may well represent air entrapment following floodplain inundation, or perched aquifer heads. We maintain that this area is best classified as a Data Gap, and have plans for additional monitoring, interbasin coordination, and outreach to conclusively determine the location, timing, and magnitude of ISW (should data show that it exists) in this region. (ii) This point is well taken and the section has been clarified.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
8	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.3.7 Groundwater Dependent Ecosystems, starting page 2-164			4. Comment #4 Groundwater Dependent Ecosystems (Plan Area and Basin Setting, 2.3.7 Groundwater Dependent Ecosystems, starting page 2-164): GDE identification, required by 23 CCR § 354.16(g), is based on methods that risk exclusion of ecosystems that may depend on groundwater. a. Issues: i. Depth to Groundwater: Methods applied to the Natural Communities Commonly Associated with Groundwater dataset to eliminate potential GDEs may exclude deep rooted vegetation. The GSP removes potential GDEs with a depth to groundwater greater than 30 feet; however, mature Valley Oak (Quercus lobata) can access groundwater up to 80 feet below the ground surface (Howard 1992, Lewis & Burgy, 1964). The use of a 30-foot threshold may incorrectly exclude Valley Oak communities within the subbasin from further consideration as a GDE. ii. Special Status Species: Though Appendix 3-B of the GSP references a compiled resource of GDE beneficial uses and users, the annotated list of species and their groundwater dependence (Appendix E to Appendix 3-B) has not been included for review with this draft GSP.	(i) The consultant team has reviewed the study in question (Lewis and Burgy, 1964) and does not find merit in the results. The study concerns an isotope-tracer study in a fractured rock aquifer in hilly topography using a small sample (n = 15) of trees. These results are highly specific to geology (i.e., isotope transport in fractured rock and alluvium are not at all comparable), and hydraulics (i.e., topographic driven flow patterns in mountainous regions are much different than those in relatively flat valley floors). Moreover, other literature reviewed by TNC suggest rooting depths of around 30 feet. The scientific de-merits outlined above give cause to not consider an 80 foot rooting depth parameter, and hence, we maintain the GDE study carried out the Freshwater Trust for the SASb (see technical Memo 3B (groundwater dependent ecosystems). (ii) This appendix is now included.
9	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Plan Area and Basin Setting, 2.3.7 Groundwater Dependent Ecosystems, starting page 2-164			b. Recommendations: i. Depth to Groundwater: The Department recommends the GSP update the methodology for GDE identification to reflect accurate maximum rooting depth specifically for Valley Oak communities. The Department recommends use of the NCAAG, field verification, and/or other local data to identify the locations of Valley Oak within the subbasin. For those areas, the GDE analysis should apply a threshold of 80 feet below the ground surface as the maximum potential depth at which the potential GDE could access groundwater. The Department accepts the use of a 30-foot threshold as sufficiently conservative for other potential GDEs within the subbasin that likely do not contain Valley Oak. ii. Special Status Species: The Department recommends including the list of GDE environmental users of groundwater within an appendix to the GSP.	(i-ii) addressed in the response to Comment No. 8.
10	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			We find the introductory materials to be duplicative of the material presented in Section 1 of the Draft GSP and do not materially contribute to the technical presentation of the South American Subbasin's (SASb) Sustainable Yield under SGMA. If there is reference to the former level of 273,000 AFY within this section of the GSP analysis, then a full technical analysis of why the basin sustainable level has changed from 273,000 AFY as late as last year to the new sustainable average level of 235,000 AFY should be included. One can only conclude that moving from a 20-year-old single value to a range that has a substantially lower midpoint, is the result of improved data and analysis carried out as part of the GSP process. In addition, there is an omission in the several paragraphs that discuss the uncertainties associated with the analysis underpinning the Sustainable Yield Estimate. These paragraphs neglect to mention the uncertainty posed by climate change. In our earlier comments on the draft GSP, we pointed out the importance of thoroughly documenting the climate change analysis that underpins the GSP analysis including the basis for the Sustainable Yield estimates.	The Background section was included because it provides context for how the GSP's sustainable yield estimate relates to previous Basin management. The remainder of the section provides a discussion of why the new value of 235,000 AFY is recommended.
11	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			We find that the materials meant to describe how the Sustainable Yield estimates were determined and why 235,000 AFY is the average sustainable yield, are not sufficiently explanatory for the lay person. The presentation needs to explain how the range of pumping was developed and, using one or more of the charts, identify what the points on these charts mean, and why and how the X and Y axis are developed. Also, if 0 change in groundwater storage is the desired point (as presented in figures 2.5.2(a & b) why is there no X and Y axis lining up on figure c and what is the significance of the negative value under the corresponding point of 235,000 AFY?	The section narrative has been revised to make more clear that the range of pumping shown by year type is meant to be descriptive of typical operational patterns and was not meant to be prescriptive.
12	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			We do not find a compelling analysis that determines why a range of pumping between 210,000 AFY and 270,000 AFY is acceptable. Also, there is no description of what "various year types" are, who determines them, and how are they factored into basin management. If this analysis is dependent on past years weather and hydraulic conditions projected forward, then an additional caution is warranted given that more recent conditions are tending to diverge from the past. It is not apparent from the analysis presented whether the SASb could withstand successive years like the past two continuing for another one or two years while being operated on the premise that 270,000 AFY can be withdrawn from the basin without Sustainable Yield consequences. More information is needed to put context around the "year types" and the GSAs' management responsibilities vis a vis the SASb's Sustainable Yield.	The section narrative has been revised to explain what is meant by year types (i.e. Sacramento River Index) and to make more clear that the range of pumping shown by year type is meant to be descriptive of typical operational patterns and was not meant to be prescriptive.
13	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			The document presents a table of annual pumping levels which it asserts, if adhered to, would ensure the SASb is managed so that its Sustainable Yield is maintained. However, there is no description of monitoring or management actions the GSAs will engage in to ensure that the SASb is not drawn down in such a fashion that its Sustainable Yield is negatively impacted. The GSP should include Management Actions to ensure that SASb pumping is managed not to exceed these pumping levels. In addition, there is no base line calculation for the storage level in 2015. It seems obvious that this value is needed so that the Sustainable Yield can be monitored and managed. There is five years of known data that can be used to develop and track the SASb's Sustainable Yield.	The pumping levels by water year are reflective of an average of 235,000 AFY, and are meant to provide guidelines for operational flexibility to implement water supply projects and to manage year-to-year weather variability. Under projected conditions with the PMAs, there is not a projection of overdraft in the SASb. However, additional adaptive management strategies can be used to maintain long-term sustainability of the basin. These do not necessarily need to be explicitly included in the GSP.
14	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			We believe that Management Actions are needed in at least two areas. First, there is a need to manage data and annually report the amount of annual pumping and how that volume relates to the SASb's sustainability including the Sustainable Yield. This work also needs to include coordination with the Water Forum, The Regional Water Authority, and the Bureau of Reclamation regarding forecasts of current and future "water years". This coordination will allow the GSAs to better understand if any management actions (e. g. possible pumping restrictions or demand management actions) are needed to maintain basin sustainability.	The pumping levels by water year are reflective of an average of 235,000 AFY, and are meant to provide guidelines for operational flexibility to implement water supply projects and to manage year-to-year weather variability. Under projected conditions with the PMAs, there is not a projection of overdraft in the SASb. However, additional adaptive management strategies can be used to maintain long-term sustainability of the basin. These do not necessarily need to be explicitly included in the GSP.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
15	Environmental Council of Sacramento (ECOS)	Ralph Propper & Robert Burness	6/18/2021	Section 2.5			A second Management Action includes the establishment of agreements with the water purveyors who plan to utilize the basin's groundwater for conjunctive use so that their pumping levels are consistent with figure 2.5-3. Agreements that match pumping levels with "water years" will assist the GSAs in exercising their responsibilities under SGMA. Similar agreements will be needed with those purveyors and others who carry out water banking operations.	The pumping levels by water year are reflective of an average of 235,000 AFY, and are meant to provide guidelines for operational flexibility to implement water supply projects and to manage year-to-year weather variability. Under projected conditions with the PMAs, there is not a projection of overdraft in the SASb. However, additional adaptive management strategies can be used to maintain long-term sustainability of the basin. These do not necessarily need to be explicitly included in the GSP.
16	Environmental Council of Sacramento (ECOS)		6/18/2021	Section 2			Section 2 also discusses water purveyor supply and demand numbers. The GSPD provides information from published 2015 Urban Water Management Plans (UWMP). The water purveyors subsequently published their 2020 UWMPs. These plans include updated information including actual supply and demand numbers for 2020, as well as forecasts for future water demand based on current local land use plans. The base numbers for 2020 are actual water supply and demand for that year and will not change so these 2020 UWMP numbers should be included in the final GSP. Understanding future groundwater demand is a critical component in the subbasin's water budget and in assuring management actions will have the desired effects in achieving SAS sustainability. Additionally, including 2020 supply and demand numbers as benchmarks improves the accuracy of assessments conducted to determine the effectiveness of purveyor demand reduction programs. Also, the next five-year GSP update should be based on 2025 UWMP demand numbers and programs. Therefore, the GSAs should engage in GSP planning and coordination for the next five-year update to ensure the latest water purveyor numbers are provided in advance of the draft and included in the final 2025 GSP update.	Table 2.1-23 has been updated to included data from the 2020 UWMPs
17	Environmental Council of Sacramento (ECOS)		6/18/2021	Section 2			Section 2 encompasses a compendium of information about the SAS. While we understand that the existing monitoring well system depends on existing wells and monitoring programs of the GSAs and other organizations, we urge those deficiencies noted in the system be corrected and that plans be developed, and resources set aside to further the coverage of both the shallow and deep portions of the primary aquifer. In addition, time and experience may necessitate additional monitoring associated with ISW and GDE protection. Finally, the existing monitoring system needs to be assessed to determine if it is sufficient to monitor future groundwater banking operations. If additional wells and monitoring are needed, their installation, operation and maintenance costs should be incorporated within the water banking program and borne by its participants.	Section 3.5.3 summarizes the protocols for data collection and monitoring. Section 3.5. assesses and provides recommendations for improving the monitoring network, including installation of telemetry and data loggers, as well as protocols for data management. As part of the implementation of the GSP, the monitoring network will also be reassessed regularly for adequacy in tracking Subbasin conditions.
18	Huhtamaki Foodservice, Inc.	Amy Steinfeld	8/17/2021	Section 2.4			The Water Budget (Section 2.4) should account for Huhtamaki's historical and projected groundwater use within the Subbasin. This section does not present granular detail about groundwater use by commercial and industrial users, but rather estimates urban water demand based on 2015 Urban Water Management Plans (UWMPs) and agricultural demand through land use mapping. (See Plan, §§ 2.4.1.3.1, 2.4.1.3.2, 2.4.1.3.3.) Accordingly, the Water Budget may not capture large-scale commercial and industrial users, such as Huhtamaki, unless those users are accounted for within the UWMPs.3 As described above, Huhtamaki holds an overlying right to the Subbasin, has previously pumped groundwater from the Subbasin, and plans to resume groundwater pumping when the quality of its water is satisfactory. We thus recommend that the Final Plan assess the groundwater production of commercial and industrial users that may not be included in the UWMPs and incorporate this production into the Water Budget and other sections of the Plan.	The water budgets included in CoSANA reflect the data that was available at the time the model was developed. Updates can be considered for the 2025 GSP Update.
19	Huhtamaki Foodservice, Inc.	Amy Steinfeld	8/17/2021	Section 2.4.3 Section 5.4 Section 2.1.6			The Draft Plan indicates that three sections are missing: (1) Sustainability Yield Estimate (Section 2.4.3); (2) Funding Sources and Mechanism (Section 5.4); and (3) Interconnected Surface Water Monitoring (Section 2.1.6). The public and stakeholders must have the opportunity to review and comment on these sections prior to approval of the Final Plan by the groundwater sustainability agencies. (Cal. Code Regs., tit 23, § 355.4(b)(10); Plan, App. 1-D, p. 16.) Because these are fundamental sections of the Plan, we request that these sections be posted for review and comment as soon as possible.	These sections have now been provided for review
20	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.1	2-51	628	Please revise as follows: "Currently, the monitoring network at Kiefer consists of ~~23~~ 65 monitoring wells." Source info for revision: Page 10 of https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2016-0013.pdf	Change has been made
21	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.1	2-51	630	Please revise as follows: "The infiltration basin pilot study was successful~~ly~~, and the County ~~is currently awaiting~~ has received approval for permanent use" Source info for revision: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2015-0012_noas/r5-2015-0012-062.pdf	Change has been made
22	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.2	2-51	638	Please revise quantities (AFY) in Table 2.1-16, Kiefer Groundwater Pumping, as follows: 2010 1,099; 2011 1,142; 2012 391; 2013 518; 2014 507; 2015 460; 2016 380; 2017 475; 2018 599; 2019 650; Average 622. Source info for revision: Spreadsheet data previously supplied to Woodard & Curran for CoSANA model on 6/11/2020	Change has been made
23	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.5	2-53	678	Please revise quantity (AFY) in Table 2.1-17 for Kiefer to 622 AFY. Source info for revision: See Line No. 638 comment above.	Change has been made
24	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18	2-36	346	Please revise the estimated Remediation Water Use for Kiefer Landfill to 612 AF/year for the 2018 Water Year. Source info for revision: Spreadsheet data previously supplied to Woodard & Curran for CoSANA model on 6/11/2020	Change has been made

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
25	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3	2-49	590-592	Please revise these lines to reflect the most recent regulatory orders, as follows: "The CVRWQCB carries out Kiefer Landfill remediation under WDR Order ~~R5-2007~~ R5-2016-0013. Additional information can be found here: https://www.waterboards.ca.gov/centralvalley/board_decisions/~~tentative orders/0708/kiefer/kiefer wdr.~~adopted_orders/sacramento/r5-2016-0013.pdf"	Change has been made
26	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3	2-49	593	Please revise this line as follows: "The Kiefer Landfill is a 1,084-acre site with an active class III ~~300~~ 335-acre solid waste disposal site..." Source info for revision: See Page 2, Finding No. 6 of https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2016-0013.pdf The number was adjusted upward by 30 acres to account for recently opened landfill Module M4.	Change has been made
27	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3	2-49	603	Please revise this sentence as follows: "Sacramento County was issued a ~~tentative order~~Order No. 89-207 to install a network of monitoring wells." Source info for revision: CVRWQCB Order No. 89-207, copy available upon request. Please also note that Tentative Orders are not issued and not enforceable.	Change has been made
28	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.1	2-51	618	Please revise the sentence that is fully contained on this line as follows: "Approximately ~~375,000~~ 650,000 gallons of water are treated each day." Source info for revision: last sentence of 3rd paragraph of Page 2 of: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2015-0012_noas/r5-2015-0012-062.pdf ("The Discharger proposes an average and maximum discharge to the infiltration basin at approximately 450 and 900 gpm, respectively, which are flows expected from the groundwater extraction and treatment system.")	Change has been made
29	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.1	2-51	619	Please revise "rate of 1,000 gallons per minute" to "rate of up to 1,000 gallons per minute" Reason: Please see revisions to historical pumping rates which follow below (Line 638 comments), which show that the 1000 gpm level is rarely attained.	Change has been made
30	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.3.3	2-52	642-648	These figures appear to have been extracted from a 2009 report. In 2015 (the last time that these figures were estimated), the numbers for VOCs remaining in Zone A were 90 pounds and for Zone B were 13 pounds. The 2015 annual report is available on Geotracker (see Section 10.7 for total VOC mass estimates). Also, in line 648, "2000" should be replaced with "1995", as 1995 is the reference year for the groundwater cleanup that is used in all reports and orders.	Change has been made
31	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	2.18.4	2-52	665-667	There are about ten other landfills listed on Geotracker (https://geotracker.waterboards.ca.gov) that overlay the SASb. Two of these (28th Street and L & D Landfills) are in corrective action.	The list has been updated
32	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/13/2021	Figure 2.3-46 and throughout Section 3			While the GSP clearly identifies data gaps and their locations, we recommend that the GSP considers any segments with data gaps as *potential* ISWs and clearly marks them as such on maps provided in the GSP.	No action is taken.
33	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/25/2021	Section 2			Provide more information regarding the selection of the American River Basin Study and the methods through which climate change is incorporated, since this is a different method than the use of climate change factors suggested by DWR.	This rationale has been clarified and improved in the text.
34	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/26/2021	Section 2			Integrate climate change, including extremely wet and dry scenarios, into all elements of the projected water budget to form the basis for development of sustainable management criteria and projects and management actions.	This change is not taken, but the rationale for selecting the central tendency has been made more clear.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
35	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/27/2021	Section 2			Calculate sustainable yield based on the projected water budget with climate change incorporated.	The sustainable yield estimate utilizes the climate change scenarios that were analyzed for the GSP, along with the other modeling scenarios. The data does not indicate that climate change will significantly change the basin sustainable yield.
36	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/28/2021	Section 2			Incorporate climate change scenarios into projects and management actions.	We agree this is important, and evaluate a scenario that includes both climate change and PMAs.
37	Carl Werder		7/5/2021	Section 2	Page 135	Figure 2.3-18	Page 135 of 204, Figure 2.3-18., This hydrograph of wells 262 and 263 shows a steady decline in the groundwater table as a result of over pumping for remediation efforts and over reliance of groundwater in the Vineyard area. This decline must be clearly addressed as the current drop in the water table is not sustainable. Action needs to be clearly stated in this document as to how this decline will be stopped prior to any reporting to DWR. And how soon projects will be up and running to rectify this ongoing problem.	The proposed projects and timing of implementation are described in Section 4
38	Carl Werder		7/5/2021	Section 2	Page 33	line 212	Page 33 of 204, line 212., Recommend adding internet location for DWR so that the reader of this document can obtain additional information concerning their individual wells.	This has been added
39	Carl Werder		7/5/2021	Section 2	Page 60	line 678, Table 2.1-17	Page 60 of 204, line 678, Table 2.1-17., This table uses an average but fails to show how many years to determine this average? Also, since this document shows numbers in Table 2.1-13 for 2018 why add additional numbers. It would be best to stay with either a year or a specified average throughout this GSP.	The table is a roll-up of the previous 3 tables that show the average from 2010-2019.
40	Carl Werder		7/5/2021	Section 2	Page 36	line 242, Table 2.1-10	Page 36 of 204, line 242, Table 2.1-10., Each of these SCGA well locations are shown in hydrograph format so as to show how some areas have declining water tables and others that have improved water tables. The problems with this draft document is that on pages 35 and 36 there is no reference to Appendix 2-B Hydrographs and the hydrographs in Appendix 2-B do not show either the Local Designation or State Well Number. In fact there are 459 hydrographs in appendix 2-B numbered in order. This appendix needs to be divided up into groups so as to allow the reader of this document to find a specific well. This seems to me to be a case of putting out so much information (459 hydrographs) and poor referencing of hydrographs so that the declining well locations are buried.	The well locations for the hydrographs in Appendix 2-B are shown on Figure 2.3-6. It will also be available in an easy-to access format in the Subbasin Data Management System.
41	Carl Werder		7/5/2021	Section 2	Page 203	Line 2936	Page 203 of 204, Line 2936., Very disappointed that this section has yet to be completed. This is the real meat of this section one. Everything else in this section one is just a repeat of existing documents providing nothing new to the reader. Please forward this section to me via email as soon as it becomes available.	Section has now been made available for review
42	Carl Werder		7/5/2021	Section 2	Page 43	line 346, Table 2.1-13	Page 43 of 204, line 346, Table 2.1-13., This table for 2018 shows a total remediation groundwater extraction of 34,322 AF/yr and Aerojet alone extracting 26,075 AF/yr. However, on page 189 of 204, Table 2.4-7, remediation amount is only 21,000 AF/yr over a period of nine years and yet it goes up over a period from 1970. This makes no sense and appears to be deflecting the fact that remediation efforts contribute to reducing recharging of the groundwater in the Vineyard area.	The numbers have been checked and updated
43	Carl Werder		7/5/2021	Section 2	Page 59	line 607	Page 59 of 204, line 607., The words “small decline” are subjective and the word ‘small’ should be deleted as this is an opinion with no bases in fact.	This sentence has been removed
44	Carl Werder		7/5/2021	Section 2	Page 60	line 705 and 706	Page 60 of 204, line 705 and 706., The yield number of 273,000 AF/yr is a negotiated settlement amount that has no bases in fact. This was pointed out by DWR in their rejection of the SCGA Alternative. Therefore, I recommend that any reference to this number be deleted from this GSP.	The yield amount from the Water Forum Agreement is provided for historical context
45	Carl Werder		7/5/2021	Section 2	Page 14	line 78, Table 2.1-2	Section 2. – Page 14 of 204, line 78, Table 2.1-2., Why is this document using 2018 Water Year and not 2019 or a better picture of distributed water would be a three year average.	2018 was the last year where all data was available at the time the document was developed
46	Suman Singha, PhD		8/16/2021	Section 2	2-194	2908	I believe the word should be “with” not “without”	Change has been made
47	Suman Singha, PhD		8/16/2021	Section 2		Table 2.1-7 and Figure 2.1-12	Table 2.1-7 CDEC Flow Stations in SASb lists 4 active and 1 inactive sensor. The corresponding Figure 2.1-12 lists 5 active and 3 inactive sensors; with one active sensor being outside the SASb.	Thin shown the Section 3.2

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
1	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	20	566	Allowing the minimum threshold at some representative monitoring points to be set lower than the 2015 low is unacceptable. Model simulations of projected conditions with climate change and PMA should not be allowed to serve as the minimum threshold. The purpose of SGMA is to ensure sustainability of the subbasin. If projected conditions with climate change and PMA result in groundwater levels lower than the 2015 low, then additional management actions must be taken in order to raise groundwater levels to at least the level of the 2015 low. It is unacceptable and disingenuous just lower the minimum threshold so that existing PMA are sufficient to not exceed the minimum threshold.	The reviewer's opinion is that SMC should not be set lower than the 2015 groundwater level. SGMA requires GSAs to evaluate the impact of SMC on beneficial users of groundwater. There is no one "historical" water year that guarantees the avoidance of impacts to beneficial users, and it is incorrect that significant and undesirable results are avoided if groundwater levels fall below those recorded in an arbitrary year. SGMA requires quantitative assessments of the impacts to beneficial users observed at MTs (evidenced by comment letters to Paso Robles and Cayuma GSPs). Thus, this plan acknowledges that the environment, domestic users, agricultural users, industrial users, and municipal users all require groundwater. Then, it sets MTs at levels that avoid significant and unreasonable impacts to these users of groundwater. The plan forecasts the avoidance of impacts to beneficial users (summarized in Section 3.3.1.2, and in technical Appendices 3A, 3B, and 3C).
2	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	7	109	Localized undesirable results such as this would likely not exceed the sustainable management criterion of 25% of representative monitoring wells being below the minimum threshold for three consecutive years. How will beneficial users be protected from localized undesirable results?	Our analyses suggest that even if 100% of wells reach MTs, significant and unreasonable impacts to wells are avoided. However, in an abundance of caution, the GSP advances a well protection program in Section 4.7.1 and a budget item in Section 5 to provide coordination, monitoring, outreach, a well census, and rehabilitation funds. Annual reporting and ongoing monitoring efforts, coupled with the well protection program will protect well users from localized undesirable results.
3	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	8	151	Wells that are currently functioning and become impacted due to lowering of groundater levels must be included in this count even if the wells are not listed in the DWR Well Completion Report database (as is the case for many older domestic wells). That is, even if a well is not listed on the DWR Well Completion Report database, if it is impacted it will be considered as contributing to the undesirable result threshold.	The GSP will always use the "best available information", which at this time is the DWR WCR database. As the well census yields more accurate well location information, these data will be used.
4	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	661	Both the 31 or 40 year retirement age for wells is inappropriate. My own domestic well is 47 years old and still functions quite well. Most of the other homes in my Ag/Res area were also built in the 1970s and still have original functioning wells. By assuming that older wells are not active, functional wells are being inappropriately removed from the domestic well count.	We thank the reviewer for this comment. Well impact analyses were re-run using a 50 year retirement age and found an additional 6 wells were impacted, and the count of active wells increased to about 1300 (compared to around 400-800). Thus, forecasted well impact appear insensitive to well retirement age. Importantly, these results to not change the definition of significant and unreasonable impacts to wells occurring at 5% of impacted wells. We keep the text as-is because using lower well retirement age results in a more conservative count of wells required to reach 5%. If a larger retirement age is used for GSP planning purposes - as the reviewer suggests - then the number of wells required to trigger a significant and unreasonable impact is also increased (5% of 1300 wells is 65 wells, but 5% of 400 wells is only 20 wells). Thus, using a larger retirement age in the GSP planning process may make it difficult to more rapidly respond to a well impact situation should it occur. Moreover, we point out that the reviewer's well is one sample. Retirement ages of 31 and 40 years are suggested by peer-reviewed literature that use thousands of samples (Gailey et al., 2019; Pauloo et al., 2020), and which are more appropriate until better data is uncovered in the well census.
5	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	654	The DWR Well Completion Report database that provides the basis for the number of active domestic wells is woefully incomplete, particularly for older wells (prior to 1990). My 1974 fully functioning domestic well is not included in the database, nor are many of my neighbors' wells. I live in a section of Elk Grove that is specifically zoned for Ag/Res small parcels and each residence has its own well, but many of these wells are not shown on the database. I've heard that Sacramento County well records prior to 1990 are a mess and not digitized, so weren't included in the database. In order to get a better count of active domestic wells and a more representative depth estimate of those wells, a well census should be conducted.	We fully agree with the reviewer and a well census is already proposed as part of the well protection program (Section 4.7.1). This effort will begin during the first year of SGMA implementation.
6	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	general	If 2-3% of domestic wells are impacted, the number of domestic wells impacted will be much higher than the 7 estimated by the climate change + PMA simulation. This is due to the incomplete nature of the DWR Well Completion Report database. The database is missing many older wells (pre-1990) that are still functioning, so the number of active domestic wells is undercounted. Also, newer wells tend to be drilled deeper than the older wells were, so the depth of domestic wells appear deeper and thus less vulnerable than they actually are.	This is not necessarily true. If older wells are indeed missing from the DWR WCR database, these wells are more likely to be shallower due to their age, and thus inactive anyway. As presented in working group meeting 10 (December 11, 2020), average domestic well depth in the SASb increased by a factor of 3 between 1940 and 2020. Nonetheless, the WCR represents our best available information on well construction and we must use it. In an abundance of caution, and acknowledging potential limitations in the data, a well census is planned, alongside a well protection program that involves monitoring, coordination, and rehabilitation funds.
7	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	675	Well rehabilitation costs is estimated based on the number of wells that will need to be deepened due to the water level declining to below 30 feet above the bottom of the well. However, there may be many more wells that are impacted due to the water level falling below the minimum level above the pump. These wells will need to have their pump lowered in order to maintain productivity. Lowering the pump is substantially cheaper than deepening a well, but may be much more common and thus contribute substantially to the cost of the program. It must be made clear that lowering of pumps in impacted wells is also covered in the Shallow/Vulnerable Well Protection Program	"Pump lowering" is now mentioned in the identified line. The authors wish to make it known that "well rehabilitation" and "well impacts" are used throughout the plan instead of "well replacement" and "well failure" to account for exactly the kind of lower-cost rehabilitation to impacted wells that the reviewer points out.
8	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	677	This cost is likely a gross underestimate because 1) it ignores the cost of lowering pumps which may be much more commonly needed than deepening wells, and 2) the number of wells that may be impacted is underestimated due to the fact that the DWR Well Completion Report database only includes a fraction of active wells and is skewed younger and deeper than the actual active well population.	(1) The model referenced by Pauloo et al (2021), EKI (2020) and Gailey (2019) actually does internalize the cost of pump lowering and well deepening. (2) Impacted well counts increase by about 6 when using a 50 year retirement ages, and thus costs are not substantially different than those reported in the GSP. Importantly, uncertainty and potential missing data that inform these models should be recognized. The GSP acknowledges this in the form of a well protection program with coordination, monitoring, a well census, and a well rehabilitation fund to mitigate impacts caused by unsustainable groundwater use.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
9	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	27	681	Estimated well impacts and associated rehabilitation costs were shared during public meetings, but the public response and feedback has not been properly addressed. During public meetings, Ag/Res residents brought up the incomplete nature of the DWR Well Completion Report database and the inappropriate 31-40 year old retiremet age for domestic wells, but neither of those issues were addressed.	Concerns about the retirement age parameter have been addressed in additional analysis that suggests only minimal additions to impacted well count that are still on the order of 1% of wells impacted. We elect to keep well retirement ages as-is so that the count of wells impacted to trigger undesirable results stays low (5% of 1300 wells is 65 wells, but 5% of 400 wells is only 20 wells). Section 4.7.1 details a well protection plan which includes a management action of improving well data in the region. This will drive more accurate well impact models. At the same time, a well rehabilitation fund will be built up to protect well users from unintended impacts.
10	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	31	745	Again, allowing the minimum threshold to be set lower than the 2015 low is unacceptable. Model simulations of projected conditions with climate change and PMA should not be allowed to serve as the minimum threshold. The purpose of SGMA is to ensure sustainability of the subbasin. If projected conditions with climate change and PMA result in conditions worse than the 2015 low, then additional management actions must be taken. It is unacceptable and disingenuous just lower the minimum threshold so that existing PMA are sufficient to not exceed the minimum threshold.	The reviewer's opinion is that SMC should not be set lower than the 2015 groundwater level. SGMA requires GSAs to evaluate the impact of SMC on beneficial users of groundwater. There is no one "historical" water year that guarantees the avoidance of impacts to beneficial users, and it is incorrect that significant and undesirable results are avoided if groundwater levels fall below those recorded in an arbitrary year. SGMA requires quantitative assessments of the impacts to beneficial users observed at MTs (evidenced by comment letters to Paso Robles and Cayuma GSPs). Thus, this plan acknowledges that the environment, domestic users, agricultural users, industrial users, and municipal users all require groundwater. Then, it sets MTs at levels that avoid significant and unreasonable impacts to these users of groundwater. The plan forecasts the avoidance of impacts to beneficial users (summarized in Section 3.3.1.2, and in technical Appendices 3A, 3B, and 3C).
11	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	81	1610	Rather than using "best professional judgement" to ensure that groundwater samples are representative of ambient groundwater, sampler collectors should use standard protocol from USGS National Field Manual for the Collection of Water-Quality Data, which specifies allowable fluctuation in pH, temperature, electrical conductivity, turbidity, etc.	Thank you for the recommendation, the recommended change has been incorporated.
12	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	65	1362	Public supply wells tend to be deeper than domestic wells. Will groundwater quality measurements from these wells actually be representative of groundwater quality in domestic wells? Most domestic well users do not monitor groundwater quality on a regular basis, but could be the first affected by water quality changes. Some domestic well owners (like myself) might be willing to allow regular sampling from our wells in order to get better spatial and depth coverage for monitoring efforts.	Two water quality monitoring networks are proposed for the basin: an upper aquifer network, and a lower aquifer network. A combination of municipal and monitoring wells of various depths will be utilized for these networks. In short, the deeper public supply wells will be used to characterize the lower zone, and the shallower monitoring and domestic wells will monitor the upper zone. As shown in Table 3-7, 11 wells have been selected to monitor the upper aquifer zone, and 10 wells have been selected to monitor the lower aquifer zone. This equates to roughly 36% of the upper aquifer layer being monitored (Figure 3-25), and roughly 47% of the lower aquifer layer being monitored (Figure 3-26). It is noted that these coverages are only estimates, as there is no official guidance on the required number of wells to monitor a basin of this size and pumping rate. Additionally, the monitored coverage will be increased in the future with wells incorporated to fill spatial data gaps, as well as existing wells within Regional San's Harvest Water Project. So, although deeper public supply wells may not necessarily be representative of shallower domestic wells, the proposed monitoring network contains an adequate assortment of well depths, sufficiently characterizes basin conditions, and is capable of being upgraded if spatial gaps are determined. Thank you for the interest in volunteering your well. Private wells were considered, but the team is hesitant to include these wells in the network as the data will be part of public, long-term record, and the goal is for these locations to be monitored 40+ years.
13	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	60	1306	The monitoring network only achieves 92% spatial coverage when combining data from both aquifers. The upper aquifer only has 70% spatial coverage and the lower aquifer only 50% coverage. There is a large spatial gap, particularly in the upper aquifer, near the center of the subbasin to the north and south of Elk Grove. Additional wells should be added to the monitoring network in those locations to fill the spatial data gap. These locations are particularly important to monitor due to the high density of domestic wells in the rural estates of Elk Grove.	The RMP network for groundwater level includes 45 wells which is nearly triple the amount required by DWR for a basin of the acreage and pumping capacity of the SASb (n = 16). The SASb has one principal aquifer (Section 2) with shallow and deep zones. Monitoring networks are designed to follow the zones of production from this principal aquifer. We maintain that together, the monitoring network is sufficient and representative.
14	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	66	1388	The water quality monitoring network should also include wells with a history of arsenic measurement. Figure 2.3-36 showed many shallow wells with arsenic exceeding the EPA MCL. Changes in groundwater levels and flow directions due to groundwater management could mobilize arsenic into other shallow wells such as those used for domestic purposes. Even if arsenic is naturally occurring and being mobilized from sediments, changes in groundwater flow and chemistry (i.e., changes in oxidation-reduction potential) could mobilize arsenic into the water.	While we agree that water quality monitoring should be conducted for arsenic, the historical assortment of constituents monitored at wells within the basin makes inclusion of wells monitored for arsenic, as well as TDS and N, hard to include in the network. Therefore, efforts will be made to ensure wells have historical record of arsenic measurements, but this cannot be guaranteed.
15	Ag/Res resident	Amelia Vankeuren	8/17/2021	3	68	Figure 3-24	There are huge spatial gaps in the groundwater quality monitoring network. This is highly concerning given the concentration of domestic wells in the upper aquifer. Most domestic well users do not measure groundwater quality except when buying or selling a house, so changes in water quality in this aquifer (e.g., increases in nitrate or arsenic) could go undetected for years and cause significant health impacts.	Monitoring coverage of the shallow aquifer is planned to be expanded in the near future. Wells from Aerojet's network in the northern portion of the Subbasin, and wells located within Regional San's Harvest Water Project area in the southern portion of the Subbasin, will be added to expand coverage. The northwestern portion of the Subbasin covers urban areas with no known issues related to nitrate or TDS, and therefore no expansion is planned for that region at this time. As shown in Table 3-7, 11 wells have been selected to monitor the upper aquifer zone, and 10 wells have been selected to monitor the lower aquifer zone. This equates to roughly 36% of the upper aquifer layer being monitored (Figure 3-25), and roughly 47% of the lower aquifer layer being monitored (Figure 3-26). It is noted that these coverages are only estimates, as there is no official guidance on the required number of wells to monitor a basin of this size and pumping rate.
16	Ag/Res resident	Amelia Vankeuren	8/17/2021	Appendix 3-A	18	Figure 7	The projected conditions with PMA and climate change result in a decline of groundwater levels to 15 ft below the Fall 2015 low along a north-south oriented line at the center of the subbasin. This amount of decline is unacceptable, particularly given the high concentration of domestic wells that fall in that zone of groundwater level depletion near Elk Grove. While it appears that most domestic wells were still functioning during the 2012-2016 drought, an additional decline of 15 ft may impact many domestic wells in that area and require well rehabilitation in the form of pump lowering or well deepening. Additional PMA should be planned in order to prevent the projected groundwater level declines in the center of the subbasin.	Our modeling suggests that even in this situation, an additional 15 feet of decline in this area is unlikely to impact wells to a significant and unreasonable degree (see Figure 15 in this appendix). PMA are developed around a well protection program to fund rehabilitation, to run a volunteer monitoring program, to coordinate with local community members, and to fill data gaps to better model well impacts.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
17	Ag/Res resident	Amelia Vankeuren	8/17/2021	Appendix 3-A	25	Figure 13	The range of domestic well total completed depths determined from the DWR Well Completion Report database is likely deeper the actual range of depths in active domestic wells. The database is incomplete, particularly for wells installed prior to 1990, many of which are still in use in rural communities that were built in the 1970s and 1980s like those near Elk Grove. The older wells that are not listed on the database tend to be shallower than the newer wells that are listed. The Greater Sheldon Rural Estates Homeowners Association has been collecting well information from its members and has found that there may be significantly more wells in the more vulnerable 150-200 ft depth range than Figure 13 suggests.	As part of the well protection program and ongoing annual reporting and monitoring, the GSP will incorporate the best available information into the SGMA planning process, which can include the well information collected by GSREHA. Until then, this plan uses the best available information.
18	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria; 3.3.1, 3.4.1 Groundwater Levels and 3.3.4, 3.4.4 Depletions of Interconnected Surface Water			5. Comment #5 Sustainable Management Criteria (Sustainable Management Criteria; 3.3.1, 3.4.1 Groundwater Levels and 3.3.4, 3.4.4 Depletions of Interconnected Surface Water): Groundwater level and interconnected surface water sustainable management criteria (SMC) may not protect against undesirable results for fish and wildlife beneficial uses and users of groundwater and interconnected surface waters. a. Issues: i. Minimum Thresholds: Minimum thresholds (MTs) for groundwater levels, and by proxy, for depletions of interconnected surface water, are not likely to prevent undesirable results for environmental beneficial uses and users of groundwater and interconnected surface water. The GSP assumes that conditions that have previously occurred in the basin did not lead to significant and unreasonable impacts to beneficial users of groundwater, relying on a circa 2015 baseline. At this baseline, which occurred towards the end of an extended period of dry from 2012 to 2016 (including two back-to-back Sacramento Valley critically dry water years in 2014 and 2015), wherein groundwater extraction increased to replace more than 70% of lost agricultural water supplies (Lund 2018), it is probable that vegetated and aquatic GDEs were experiencing adverse impacts due to combined groundwater depletion and reduced surface water availability. These adverse impacts included stressed or dying riparian vegetation, poor instream habitat availability, and increased water temperatures (DFW 2019). The GSP contends that only groundwater conditions that worsen beyond historic lows would constitute an undesirable result. However, GSPs must first evaluate potential adverse impacts to beneficial uses and users and determine at what groundwater levels those impacts would occur, and then set minimum thresholds accordingly. Defaulting to the post-2015 low groundwater level as minimum thresholds because similar	The comment contends that ISW and GDEs may have experienced significant and unreasonable impacts during the period circa 2015, but does not state or quantify what those impacts were. Without this information, it is difficult to assess the validity of this claim. Moreover, in contrast to what the reviewer states, MTs in this plan do not default to post-2015 lows, but rather are based on projected groundwater level change due to water use, projects and management actions, and climate change. Next, impacts to beneficial users are at these projected groundwater levels were assessed and found to be below ranges defined as significant and unreasonable by the GSAs. Avoiding impacts to beneficial users is at the core of this GSP, and we refer the reviewer to technical appendices 3A-3C, which detail the methods and results for impacts to wells, ISW, and GDEs. To summarize results here: quantified impacts to beneficial users were less than limits that the working group defined as significant and unreasonable. For instance, in the worst case scenario evaluated ("climate change with no PMA") domestic wells impacted by 1-2%. MTs are in fact set higher than these levels (i.e., at the scenario "climate change with PMA"), leading to even less well impact. Furthermore, at projected MTs, ISW reach length is may decline by 2.6% relative to 2015 conditions, and late fall baseflow to streams - important for spawning migration and habitat - will stay roughly the same, and may increase depending on the severity of climate change in the basin. Finally, GDE area is estimated to change by -3% to + 4% depending on the impacts of climate change, meaning that a low severity scenario actually leads to an increase in GDE area over the SGMA management horizon. Therefore, we maintain that the SMC set herein protect beneficial users of groundwater to quantifiable degrees and do not classify as "significant and unreasonable".
19	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria; 3.3.1, 3.4.1 Groundwater Levels and 3.3.4, 3.4.4 Depletions of Interconnected Surface Water			ii. Undesirable Results: The GSP metrics for declaring an undesirable result for the chronic lowering of groundwater, and by proxy, the depletion of interconnected surface water, may not sufficiently protect environmental beneficial users of groundwater. The GSP requires 25% of representative monitoring wells in the subbasin to fall below their MTs for three consecutive years before identifying an undesirable result to GDEs or ISW. While environmental users are adapted to sustain short-term lowering of groundwater levels during dry periods, environmental users may not be able to sustain extended periods of reduced groundwater access that would result from allowing groundwater levels to fall to historic lows for three consecutive years. The scenarios analyzed in the GSP showed that climate change impacts are likely to be most acutely felt by interconnected surface waters and GDEs that rely on shallower groundwater (line 559). By the time an undesirable result is declared, and management actions are triggered in response to the undesirable result, environmental users will have already experienced significant stress and potentially irreversible mortality.	As described in comment 18, in a theoretical and unlikely worst-case scenario in which all MTs are simultaneously reached across the entire basin was used to estimate impacts to ISW, GDE, and wells. Results suggest that these impacts are minimal and below thresholds determined by the GSAs as significant and unreasonable. Moreover, actual impacts would be even less if 25% of RMPs reach their MTs (versus the 100% of RMPs that we stress-tested our SMC against). To be clear, MTs have been carefully set and iteratively defined with respect to analyses of impacts to beneficial users such that they avoid "significant and unreasonable impacts", not "all impacts whatsoever".
20	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria; 3.3.1, 3.4.1 Groundwater Levels and 3.3.4, 3.4.4 Depletions of Interconnected Surface Water			b. Recommendations: i. Minimum Thresholds: The Department recommends the GSP reselect minimum thresholds that would better protect environmental uses and users of groundwater, rather than defaulting to the historical low groundwater levels for the subbasin. ii. Undesirable Results: The Department recommends the GSP reconsider the 3-year duration of groundwater levels below MTs required to constitute an undesirable result, recognizing that extended durations of groundwater inaccessibility for environmental users will likely lead to adverse impacts that cannot be easily reversed when groundwater levels recover. At a minimum, the Department recommends identifying physical triggers (e.g., declining Normalized Difference Vegetation Index (NDVI) signals) and associated management actions (e.g., demand reduction) to mitigate localized patterns of lowering groundwater or depleted ISW that can be implemented before the third consecutive year of MT exceedances. These interim action triggers will help preempt irreversible losses and undesirable results, instead of waiting for three years before deciding a trend is unacceptable. Protective MT criteria and/or interim action triggers are particularly important if anticipated supply augmentation PMAs are not implemented in a timely or predictable manner (see Comment #6).	These comments are well taken. (i) MTs are not, as the reviewer states, set to historic lows, but rather based on a simulation of our best-available information of forecasted groundwater pumping, PMAs, and climate change. In some locations, MTs are lower than historic lows, and in other locations, MTs are higher than historic lows. Importantly, across all scenarios tested, significant and undesirable results are avoided if 100% of RMPs reach their MTs, thus 255 of RMPs reaching MTs is conservative. (ii) In the abundance of caution, we have already implemented what the reviewer recommends in this second bullet point. We direct the reviewer to table 3-2, which lists criteria for GDE area and GDE NDVI set at historical minima, that when reached trigger the identification of significant and undesirable results for GDEs. These findings are elaborated upon in Technical Appendix 3B (Freshwater Trust, 2020), and importantly allow the identification of unprecedented impacts to GDEs even if RMPs do not register the identification of undesirable results.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
21	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria, 3.3 Minimum Thresholds, 3.4 Measurable Objectives and Interim Milestones, 3.5 Assessment and Improvement of the Monitoring Network			Comment #6 Monitoring Networks (Sustainable Management Criteria, 3.3 Minimum Thresholds, 3.4 Measurable Objectives and Interim Milestones, 3.5 Assessment and Improvement of the Monitoring Network): The GSP is inconsistent in identifying data gaps and plans for improvement of the monitoring network. a. Issue: i. Shallow Groundwater Monitoring: Existing shallow groundwater monitoring wells may not be sufficient to characterize groundwater level trends as they relate to potential GDEs within the subbasin. The GSP identified the need for additional shallow groundwater data near both surface waters and natural communities commonly associated with groundwater (2.2.9, line 1738); while the GSP later discusses plans to install paired monitoring wells and stream gauges (3.5.5, line 1735), there is no further discussion of the plan to collect additional shallow groundwater data near GDEs. ii. Representative Monitoring Points: While Table 3-4 (page 3-36) includes the geographic coordinates of the representative monitoring points (RMP), the points are not explicitly identified on any of the maps that display the RMP thresholds. iii. Groundwater Elevation Mapping: The maps in Section 3 that display groundwater levels of minimum thresholds (Figures 3-13 and 3-17; beginning on page 3-37) and measurable objectives (Figures 3-15 and 3-18) utilize elevations above mean sea level. Without a reference to the ground surface elevation, it is difficult to determine the depth of groundwater levels below ground surface and evaluate potential impacts to groundwater dependent ecosystems and interconnected surface water.	We are confused by the reviewer's comment, because all of the items that are reportedly missing are in fact present in the public draft of the GSP. First, we maintain that the RMP network is sufficient, that data gaps are consistently identified, and that plans for improvement of the groundwater level network are clearly outlined (Section 3.3.1.3, Figure 3-28), described in Section 4 (PMAs), and budgeted for in Section 5. (i) Shallow monitoring wells adequately cover GDE areas in the basin (compare Figures 3-23, 3-24 with Figure 3-7). There are no plans to collect additional shallow groundwater measurements near GDEs because enough are present. In fact, the 45 RMPs is nearly triple DWR recommendations for a basin of this size and pumping (n = 16). Finally, the additional monitoring alluded to in the comment for ISW is a separate issue: to better understand surface and groundwater interactions near ISW data gaps. Given the co-location of ISW and GDEs, these monitoring networks will also aid in GDE monitoring. (ii) The point is well taken, and Figure 3-14 now shows RMP ids and locations. (iii) The point is well taken and RMP MOs and MTs are now shown with as elevation and depth to groundwater in Figures 3-15, 3-17, 3-19, and 3-20. Moreover, Figure 3-5 now shows all hydrographs as depth to groundwater.
22	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria, 3.3 Minimum Thresholds, 3.4 Measurable Objectives and Interim Milestones, 3.5 Assessment and Improvement of the Monitoring Network			iv. ISW Data Gaps: The GSP states “reaches of the Cosumnes River approximately between Deer Creek and Twin Cities Rd. … are considered a data gap for planning purposes, and more research and inter-basin coordination is needed to determine the nature of surface groundwater interactions in this region. It is expected that by the next plan update (2027), a revised determination of ISW in this area will be developed” (page 3-29). The GSP describes how other data gaps, such as the lack of well perforation data, “will be addressed in future fieldwork during the GSP implementation period” (page 3-55). The GSP proposes that “additional stream gage and continuous monitoring will be installed in the area” to address the data gaps (page 3-79); however, the proposed monitoring network (displayed in Figure 3-21 on page 3-58) does not include any indicators for interconnected surface water near the stretch of the Cosumnes River that has been identified as a data gap. In particular, the two representative monitoring points closest to this area are proposed to only monitor groundwater level and groundwater storage, but not ISW. v. ISW Monitoring: Figure 3-21 (page 3-58) identifies interconnected surface waters in the far northeast portion of the subbasin. However, the representative monitoring points closest to these interconnected surface waters are proposed only to monitor groundwater level and groundwater storage, but not ISW.	(iv) As detailed in the ISW technical memo (Appendix 3C), and as emphasized in "Addressing Regional Surface Water Depletions in California: A PROPOSED APPROACH FOR COMPLIANCE WITH THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT" (EDF, 2018) groundwater monitoring locations should be sufficiently spaced away from ISW to avoid near-stream hydraulic influences in the groundwater level signal. To serve as an adequate monitoring point for ISW depletion, a monitoring well should represent changes in the expanding cone of depression that will eventually surpass the well's location and propagate to the steam, thereby capturing a portion of its streamflow. Thus, we disagree with the reviewer that points proximal to streams should be included based on their proximity alone, and refer them to Figure 34 of Technical Appendix 3C and EDF (2018). Our analysis suggests selecting monitoring wells between 3000 and 9000 feet from streams, consistent with EDF (2018) recommendations to position wells beyond 2000 feet from streams: "To indicate incipient streamflow depletion, therefore, water-level measurements in this zone, which for purposes here is estimated to be between 0 and 2000 feet for most Central Valley conditions, are not useful. (p. 8)". The two wells the reviewer suggests should monitor for ISW are in fact too close to the stream to be useful, but the one that we select is sufficiently spaced, and hence, used as an ISW RMP. Furthermore, we maintain that existing and planned monitoring in the Cosumnes River ISW data gap is sufficient. Paired, continuous, 15 minute groundwater level and streamflow data are collected at the upper and lower end of the Cosumnes River data gap, with plans to install an additional stream gage (Figure 3-29). (v) Please refer to the response above in (iv).
23	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Sustainable Management Criteria, 3.3 Minimum Thresholds, 3.4 Measurable Objectives and Interim Milestones, 3.5 Assessment and Improvement of the Monitoring Network			b. Recommendation: i. Shallow Groundwater Monitoring: Consistent with the GSP’s acknowledgement of the need for additional shallow groundwater monitoring, the Department recommends the GSAs propose a specific plan for installing a discrete number of additional shallow groundwater monitoring wells near GDEs. The Department recommends using the list of GDE-associated beneficial users (not available for review, see Comment #3(ii)) to identify locations of GDE communities within the subbasin that are most likely to support special status species. GDEs that support special status species, or that are most vulnerable to reduced access to lowered groundwater levels (e.g., have limited surface water supply), should be prioritized for siting additional shallow groundwater monitoring wells. ii. Representative Monitoring Points: The Department recommends providing an identification number to each RMP listed in Table 3-4 and including a map identifying the location of each of the RMPs. iii. Groundwater Elevation Mapping: The Department recommends including ground surface elevation and groundwater depth below ground surface for the included maps. iv. ISW Data Gaps: The Department recommends that the GSP include specific gage and monitoring well plans and locations to address the data gap on the Cosumnes River. v. ISW Monitoring: The Department recommends that all interconnected surface waters are adequately monitored.	(i) RMPs that monitor shallow groundwater conditions (Figure 3-23 and 3-24) overlap with GDEs (3-6). Moreover, a robust plan to monitor changes in GDE area and NDVI are in place and we are confident in the GSP's ability to protect these beneficial users of groundwater. (ii) This comment has been addressed with a revised Table 3-4 and Figure 3-13. (iii) This has been addressed in Figures 3-15, 3-17, 3-19, and 3-20. (iv) This is already addressed in Section 3.5 (Figure 3-29) with commensurate PMAs in Section 4 and budget in Section 5. (v) In addition to groundwater level monitoring at carefully selected shallow aquifer monitoring wells, in an abundance of caution, the GSP also monitors for changes in the late fall spawning migration exceedance flow, and the ISW reach length. The Department's concerns are heard, and all efforts are being made to protect ISW.
69	Environmental Council of Sacramento (ECOS)		6/18/2021	Section 3			Section 3 effectively communicates the analysis done to comply with the requirements of SGMA and we concur with the proposed Sustainability Goal. However, we are concerned about the use of 2015 storage and water levels as the triggers in the Sustainable Management Criteria. The document implies that we can drop below 2015 levels for three consecutive years before any action is taken. However, under this approach, the GSPD does not comply with the SGMA provisions that direct conditions not to worsen below the 2015 base year. A more prudent approach would be to set the trigger levels higher so that action can be taken when water and storage levels initially reach the 2015 mark. The result of analysis presented in the GSPD makes it possible to adjust the Minimum Thresholds to levels that would require action when the actual 2015 values are reached.	In contrast to what the reviewer states, MTs are not all below 2015 levels. In fact, some are above 2015 levels, some are near 2015 levels, and some are below (Figure 3-4 and 3-5 in Section 3, and Figure 21 in the ISW technical Appendix). MTs are allowed to decline below 2015 levels, provided the avoidance of significant and unreasonable impacts to beneficial users of groundwater, which we demonstrate in three technical appendices to Section 3 and summarize in the Section 3 (see Section 3.3.1.2). Finally, we do not set trigger thresholds as the reviewer states at 2015 storage and levels. In fact, we do not set triggers at all. Rather, we use the identification of undesirable results as triggers for action and rely on PMAs to address them. Furthermore, the monitoring network and SMC tracking ensures continuous awareness of groundwater conditions in the basin, and GSAs will coordinate actions to address negative trends in the basin if and when they emerge as identified by the monitoring network, the SMC, and the onus of responsibility to continually evaluate groundwater conditions for annual reports and plan updates.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
24	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	3.4.3	3-51	1119	Regarding Table 3-6, L10008601447-MW-13 is a background well for Elk Grove Landfill and currently exceeds the Measurable Objective for Specific Conductivity. As this well is offsite and upgradient of the landfill and does not exceed any Water Quality Protection Standards for the landfill as specified by the CVRWQCB, achievement of the MOs would require action on the part of private landowners (Hilltop Cemetery) and public districts (Cosumnes CSD) and these other parties may wish to dispute or comment on the MOs, which are well below maximum thresholds. Without such input, the MO for Specific Conductivity should be increased to at least 580 umhos/cm, the current level of the Water Quality Protection Standard, and above the current Specific Conductivity of 538 umhos/cm. See Geotracker for further info.	This comment is well received and highlights the fact that MOs for specific wells must be reviewed at this time.
25	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	3.4.3	3-51	1119	Regarding Table 3-6, L10007396297-MW-40B is a downgradient well for Kiefer Landfill and this well currently exceeds the Measurable Objective for Specific Conductivity. However, this well does not exceed any Water Quality Protection Standards for the landfill, the Specific Conductivity is well below maximum thresholds, and no corrective action has been indicated for this location by the CVRWQCB, other than VOC treatment by air stripping (which does not reduce Specific Conductivity). Therefore, the Measurable Objective for Specific Conductivity for this well should be increased to at least the level of the Water Quality Protection Standard, which is set by statistical analysis of background wells and has varied between 480 and 512 umhos/cm in recent years. See latest monitoring reports on Geotracker for further info.	This comment is well received and highlights the fact that MOs for specific wells must be reviewed at this time.
26	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	3.5.2	3-71	Table 3-8	Please change GSA for Well ID L10007396297-MW-40B from OHWD to SCGA. Reference: SCGA MOU dated 5/13/2020 removing Kiefer Landfill from OHWD GSA.	Change incorporated.
27	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	Appendix 3-D	NA	Table A-1	Please change GSA for all Kiefer Landfill wells from OHWD to SCGA. Reference: SCGA MOU dated 5/13/2020 removing Kiefer Landfill from OHWD GSA.	Change incorporated.
28	Sacramento County Department of Waste Management & Recycling	Mike Koza	8/17/2021	Appendix 3-D	NA	Table A-1	Well depth to upper limit of screened interval for Kiefer Landfill well L10007396297-MW-38B is incorrect. Please use well depth to screen of 170 feet, as reported in Appendix B of 2020 annual monitoring report on Geotracker.	Change incorporated.
29	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			Issue 1: The number of functioning domestic wells The 5400 acres within the city of Elk Grove zoned Agricultural Residential, a fifth of its land area, at present contain over 1,200 occupied residences, all of them dependent for water on roughly the same number of domestic wells. This may be the principal dense concentration of domestic wells in the SCGA area, and perhaps one of the largest in the South American subbasin. Virtually all these wells are fully functioning and currently supply their associated residences with adequate water. The dramatic growth of this area, including in planned developments, dates back to at least the 1970s and 80s. Hundreds of wells over 30 or 40 years old, with some over 50, are maintained by their owners and are without visible deterioration.	The number of assumed active wells in our modeling efforts is controlled by an assumed "retirement age" parameter, which we have evaluated at 50 years in response to these comments. This raises the number of assumed active wells to around 1300, in line with the reviewer's suggestion. However, the true retirement age is likely to be lower than 50 years, consistent with the reviewer's claim that the DWR WCR database undercounts wells (thus a larger retirement age is required in order to increase the active well count to 1300). Well impact analyses re-run using a 50 year retirement age found an additional 6 wells were impacted, and the count of active wells increased to about 1300 (compared to around 400-800). Thus, forecasted well impact appear insensitive to well retirement age. Importantly, these results to not change the definition of significant and unreasonable impacts to wells occurring at 5% of impacted wells. We keep the text as-is because using lower well retirement age results in a more conservative count of wells required to reach 5%. If a larger retirement age is used for GSP planning purposes - as the reviewer seems to imply - then the number of wells required to trigger a significant and unreasonable impact is also increased (5% of 1300 wells is 65 wells, but 5% of 400 wells is only 20 wells). Thus, using a larger retirement age in the GSP planning process may make it difficult to more rapidly respond to a well impact situation should it occur. Moreover, we point out that retirement ages of 31 and 40 years are suggested by peer-reviewed literature that use thousands of samples (Gailey et al., 2019; Pauloo et al., 2020), and which are more appropriate until better data is uncovered in the planned well census (Sections 4.7.1 and 5).
30	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			(Issue 1 continued) The area water table and geological formations have been so stable that competently constructed wells have faced few threats. Well and pump purveyors serving our area say that residential well failures are rare. The Ag-Res area is subject to both City of Elk Grove and Sacramento County governance, plus community vigilance from CC&Rs and our two long active neighborhood associations established to monitor and defend the quality of rural life. This is not an environment in which a rash of well failures would go unnoticed. All observable evidence suggests that our domestic wells of all ages are generally performing adequately; we see no evidence to the contrary.	Our modeling is consistent with what the reviewer notes. Wells have no record of being impacted during recent historical lows (i.e., 2012-2016, DWR, MyDryWaterSupply), and our analysis of well impacts using peer-reviewed methods (Gailey et al., 2019; Paulo et al., 2020) suggests the avoidance of significant and unreasonable impacts. It is the intent of the well protection program in the GSP (Section 4.7.1) to not let well impacts go unnoticed. This is achieved by a volunteer monitoring program, coordination with a well advisory group, a well census, and a rehabilitation fund.
31	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			(Issue 1 continued) It is therefore with some surprise and puzzlement that we find in the recently released SASb draft Groundwater Sustainability Plan, particularly in Appendix 3-A, the suggestion that residential wells should be attributed an expected functional lifetime of something around 30 or 40 years, with the implication being that older wells should not be counted as viable or provided protection. If applied to Elk Grove, that policy could exclude hundreds of obviously functioning wells unproblematically providing water to their residences. Obviously, nobody knows the actual life span of our Elk Grove rural area domestic wells, since virtually all, including some several decades old, are still functioning and have not yet begun to peter out. There is no evidence on which to base a life expectancy estimate until we begin to see a failure pattern that has yet to appear. The only logical policy at this time is to accept the valid presence of all domestic wells in the Elk Grove rural residential area for both identification and protection. This will considerably raise what we understand to be the current SASb estimate of only around 700 eligible wells in the entire subbasin---only two thirds the number we observe just within the city limits of Elk Grove alone.	The reviewer is mistaken that the 30-40 year old retirement age parameter discredits older wells from being protected. The GSP at this time makes no distinction as to what wells are protected, but rather, creates a broad well protection program (Section 4.7.1) that includes among other provisions, a well rehabilitation fund. As the reviewer notes, no one knows the actual life span of a domestic well in the Elk Grove rural area. Retirement ages of 31 and 40 are used to address uncertainty in this parameter while still using the best available information (Pauloo et al., 2020; Gialey et al., 2019). A well census is designed as part of the well protection program to improve understanding of wells. Moreover, a well impact model was re-run with a retirement age parameter of 50 years, which brings the active well count closer to 1400, and increases well impacts by only 6 wells. As stated before, the 1% impact ratio is constant, but we elect to maintain retirement ages as-is in Section 3 and Appendix 3-A because a lower active well count results in a lower trigger threshold in terms of the count of impacted wells required to identify an undesirable result (5% of 1400 wells is 65 wells, but 5% of 400 wells is 20 wells). We hope that this conservative management threshold, coupled with the well protection program, gives the review confidence in the GSP.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
32	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			(Issue 1 continued) Curious about how the Subbasin working group could have come up with an estimate so obviously at odds with observable fact in our Elk Grove rural area, we consulted one of the main databases they cite---a website of well completion reports maintained by DWR. An initial look at the site suggests to us that the data it contains are so incomplete and so biased toward new wells that these data probably are worse than useless. Given the lack of credible evidence supporting any imputed average well life span in our Elk Grove rural area, plus strong prima facie evidence that virtually all wells of all ages, over 1,100 in number, are still working acceptably, we request that every well serving an occupied residence be counted as functional. There simply is no empirical justification for doing otherwise. The burden of proof is clearly on those who would impose a well lifespan criterion.	We have investigated the DWR WCR database and actually find the opposite. Please review slide 11 in Working Group presentation # 10 (December 11, 2020). The distribution of well completion dates shows no systematic bias towards well completion date. In fact, more older wells are represented compared to new wells. This makes sense because WCRs need to be tabulated and entered into the database, so we expect some lag time for new wells to enter the system. We disagree with the reviewer's comment that these data are "worse than useless" and instead offer that although limited, they are the "best available information" at the time of GSP writing. It is infeasible for the GSP to collect information on all domestic wells at the present moment, but the GSP takes management actions (Section 4.7.1) to improve well completion data through a well census during the first year of plan implementation. In an abundance of caution, the GSP also provides monitoring, coordination, and a rehabilitation fund.
33	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			Issue 2: Minimum Threshold The draft GSP proposes setting a subbasin-wide minimum threshold groundwater level equivalent to the groundwater level in the fall of 2015, a year of severe drought. That level is not the same everywhere relative to current groundwater levels, this year also being a severe drought year. We have not found a recorded 2015 groundwater level for the Elk Grove rural residential area, but anecdotal evidence from well and pump purveyors and other observers suggests that the groundwater level in 2015 was so close to the current ground level in 2021 that the difference is negligible. In the absence of solid evidence of a substantial difference, we propose that the groundwater level as measured in fall of 2021--under effects from the current drought---be adopted as the official recognized minimum threshold pertaining to the Elk Grove rural residential area. It is important to have a solid beginning point measurement, for the Elk Grove rural residential area is projected (Appendix 3-A, p. 17) to suffer some of the subbasin's most pronounced groundwater level decline (15 feet) even after accounting for project and management actions to retain water.	Groundwater level trends may be highly localized and influenced by a variety of hydrogeologic factors, however, the reviewer's claim that 2015 levels are close to 2021 levels at the scale of Elk Grove, or at a regional scale are inaccurate. Groundwater level data from the DWR, SCGA, OHWD, and UCD strongly suggest that, on average, levels were around 12 feet lower comparing 2019 and 2021 (slides 33-34, Working Group presentation #10, December 11, 2020). Moreover, setting MTs at present day levels, which may avoid significant and unreasonable impacts to domestic well users, would certainly cause significant and unreasonable impacts to municipal users of water - the GSP must avoid impacts to all beneficial users of groundwater as per the stated Sustainability Goal (Section 3.1). Thus, this GSP models impacts to domestic wells assuming all MTs are reached and finds a low impact proportion of around 1-2%, irrespective of well retirement age. Nonetheless, in the abundance of caution, please refer to the well protection program (Section 4.7.1).
34	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			One of the reasons for this especially severe decline is that the Elk Grove rural residential area does not substantially benefit from any such project or management action now planned. Nor are there any announced intentions to reinforce the especially impacted aquifers in this area. Hence, some of SCGA's, and the subbasin's, greatest groundwater table decline is projected to occur precisely at the location of its largest and most dense collection of shallow domestic wells, with no remedial action at the spot even considered. This is a recipe for looming disaster, and one practical means to help prevent it is to designate a minimum threshold for this area no deeper than the current water table at the time the GSP is proposed.	The reviewer's claim that Elk Grove does not benefit from planned PMAs is inaccurate. The Harvest Water and regional conjunctive use programs collectively are modeled to increase the groundwater level by around 6-12 feet in the Elk Grove area (technical Appendix 3A, Figure 8) compared to projected groundwater conditions without PMAs.
35	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			Issue 3: Well monitoring The large cluster of domestic wells and variety of conditions in the Elk Grove rural residential area suggest a need for denser well monitoring than is currently being considered for the subbasin as a whole. It is generally agreed between our associations and the technical working group advising the draft GSP that such enhanced monitoring will be useful, and that it must be conducted through organized community effort in communication with SCGA and perhaps whatever team is working across the subbasin. Because of the specificity of our area of interest---the designated rural residential area established within the city limits of Elk Grove---we have decided to organize under our auspices an independent community well monitoring project within and limited to the Elk Grove rural residential area, of course maintaining communication and cooperation with SCGA and related technical staff as appropriate.	We cannot agree more with the reviewer that local-scale well monitoring is needed, and in fact the GSP supports an even more dense monitoring effort through a volunteer monitoring network (compared to the RMP network) and coordination with a well advisory committee that can relate this information to the GSAs (Section 4.7.1).
36	Sheldon Community Association Greater Sheldon Road Estates Homeowners Association	William Myers Shirley Peters	7/21/2021	Appendix 3-A			Issue 4: Well protection program We request that any GSP adopted by SCGA and submitted for approval to DWR include the guarantee of a well protection program that deepens or replaces free of cost to owners all domestic wells within the Elk Grove rural residential area in which groundwater levels are judged in danger of sinking to levels less than 30 feet above the bottom of the existing well. Since at the time of this writing all known domestic wells in this area are functioning adequately with proper groundwater access, and since it is unlikely that the net water use of domestic well owners as a group surpasses the total rainfall they typically receive on their Ag Res acreage in a season, and since future conditions of groundwater availability and quality are likely to reflect management policies, practices and decisions taken by SCGA, that agency should from the date its GSP enters into force be responsible for maintaining full access of each and every Elk Grove rural residential area well to a sufficient groundwater supply. Well owners are responsible for maintaining well structure and equipment in good repair.	Precipitation as a benchmark for de minimis extraction is ill advised: groundwater inputs are not - as the reviewer suggests - controlled directly by precipitation, but rather, net deep percolation from imported and diverted surface water and runoff, and subsurface interflow. The metric that this GSP adopts quantifies the proportion of wells impacted (5%) after which significant and unreasonable impacts are identified, with no restriction on using the well rehabilitation fund (Section 4.7.1) prior to the identification of such results.
37	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/10/2021	Appendix 1D	69-71		Provide a map of tribal lands in the subbasin. The GSP states (p. 2-10): "The only tribal land that falls within the SASb is located south of Elk Grove near the intersection of Kammerer Road and Hwy 99." However no map, acreage, or population is provided.	Although we do not provide maps, acreage, or population counts, tribal governments and entities were contacted during engagement and outreach (detailed in Appendix 1D) and are involved in ongoing communication and outreach. Tribal groups involved in ongoing C&E include: Wilton Rancheria, Buena Vista Rancheria Mewuk Indians, Ione Band of Miwok Indians, Nashville Enterprise Miwok-Maidu-Nishinam Tribes, Shingle Springs Brand of Miwok Indians, Tsi Akim Maidu, United Auburn Indian Community of the Auburn Rancheria, Colfax-Todds Valley Consolidated Tribe, Yocha Dehe Wintun Nation.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
38	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/11/2021				Include a map showing domestic well locations and average well depth across the subbasin.	These are present in Technical Appendix 3C (Figures 10, 13, 14).
39	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/12/2021				Provide the population of each identified DAC and include details on the population dependent on groundwater for their domestic water use.	Although we do not provide population counts of DACs, DAC groups were contacted during engagement and outreach (detailed in Appendix 1D) and are involved in ongoing communication and outreach. DAC-representative groups involved in ongoing C&E include: Environmental Justice Coalition for Water, Florin Census-Designated Place (CDP) DAC, Lemon Hill CDP DAC, Parkway CDP DAC, Fruitridge Pocket CDP DAC, Freeport CDP DAC. The GSP comprehensively evaluates impacts to domestic wells - which may be used by DACs - and finds them to be minimal (Appendix 3A).
40	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/13/2021	Figure 2.3-46 and throughout Section 3			While the GSP clearly identifies data gaps and their locations, we recommend that the GSP considers any segments with data gaps as *potential* ISWs and clearly marks them as such on maps provided in the GSP.	No action is taken.
41	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/14/2021				The GSP states that a complete list of special status species is presented in Appendix E of the GSP, but this was not included in the public review draft. We recommend that the GSP includes a clear description of the fauna (e.g., birds, fish, amphibians) and flora (e.g., plants) that are dependent on GDEs within the GDE section of the GSP (see Attachment C of this letter for a list of freshwater species located in the South American subbasin). Also note any threatened or endangered species.	This will be included on the website ASAP and we will coordinate with the Freshwater Trust to see to this.
42	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/15/2021				Refer to Attachment B for more information on TNC's plant rooting depth database. Deeper thresholds are necessary for plants that have reported maximum root depths that exceed the averaged 30 feet threshold, such as valley oak (Quercus lobata). We recommend that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to-groundwater threshold of 80 feet should be used instead of the 30 feet threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater.	The consultant team has reviewed the study in question (Lewis and Burgy, 1964) and does not find merit in the results. The study concerns an isotope-tracer study in a fractured rock aquifer in hilly topography using a small sample (n = 15) of trees. These results are highly specific to geology (i.e., isotope transport in fractured rock and alluvium are not at all comparable), and hydraulics (i.e., topographic driven flow patterns in mountainous regions are much different than those in relatively flat valley floors). Moreover, other literature reviewed by TNC suggest rooting depths of around 30 feet. The scientific de-merits outlined above give cause to not consider an 80 foot rooting depth parameter, and hence, we maintain the GDE study carried out the Freshwater Trust for the SASb (see technical Memo 3B (groundwater dependent ecosystems).
43	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/16/2021	Appendix 1D			Describe efforts to engage with stakeholders during the GSP *implementation* phase in the Stakeholder Communication and Engagement Plan. Refer to Attachment B for specific recommendations on how to actively engage stakeholders during all phases of the GSP process.	The GSAs are in the process of developing an implementation MOU that includes public engagement provisions. The GSAs will follow DWR guidance in stakeholder engagement during implementation (i.e., public notices and meetings before amending a GSP or prior to imposing or increasing a fee, and ongoing efforts to encourage active involvement).

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
44	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/17/2021	Appendix 1D			Describe efforts to consult and engage with tribes within the subbasin. Refer to the DWR guidance entitled Engagement with Tribal Governments for specifics on how to consult with tribes.	We received a list of potentially interested tribes after making a direct request to the Native American Heritage Commission. Contact was made with all of the listed tribes and those that indicated interest were added to the subbasin outreach lists. However, we will maintain ongoing communication with tribes following DWR guidance in stakeholder engagement during implementation.
45	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/18/2021	Section 3			Describe direct and indirect impacts on DACs and tribes when defining undesirable results for chronic lowering of groundwater levels.	Undesirable results are defined with respect to domestic, industrial, agricultural, municipal, and environmental users. DACs are already considered by inclusion in these user groups (particularly domestic users).
46	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/19/2021	Section 3			Evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs and tribes.	Analysis of reaching 100% of MTs at all RMPs suggest the avoidance of significant and undesirable results to domestic wells. Thus impacts to all user groups - which include DACs - are already considered.
47	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/20/2021	Section 3			Describe direct and indirect impacts on DACs and tribes when defining undesirable results for degraded water quality. For specific guidance on how to consider domestic water users, refer to "Guide to Protecting Water Quality Under the Sustainable Groundwater Management Act."	Undesirable results are defined with respect to domestic, industrial, agricultural, municipal, and environmental users. DACs are already considered by inclusion in these user groups (particularly domestic users).
48	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/21/2021	Section 3			Evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs and tribes.	Groundwater quality MTs suggest the avoidance of significant and undesirable results for all users. Thus impacts to all user groups - which include DACs - are already considered.
49	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/22/2021	Sections 2 and 3			Section 2.3.4 (Groundwater quality) discusses TDS, however Section 3.3.3 (Maximum threshold for degraded groundwater quality) discusses specific conductivity. Choose one measurement to describe salinity and use it consistently throughout the GSP.	The groundwater quality section (Section 2.3.4) uses analysis of Total Dissolved Solids (TDS), as opposed to specific conductivity, to evaluate salinity levels in the Subbasin as this data is historically abundant for the subbasin. Section 3.3.3 (Maximum threshold for degraded groundwater quality) discusses specific conductivity, as opposed to TDS, for the reason that specific conductivity can be measured with an in-situ probe, while TDS requires laboratory results. This ease of measurement will enable easier collection of salinity data for the subbasin moving forward. We understand that disconnect arises with use of the different methods, but feel that the historic analysis available through TDS data, and the future ease of measurements available through probe measurements of specific conductivity, outweigh any potential disconnect.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
50	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/23/2021	Section 3			The plan only sets minimum thresholds and measurable objectives for nitrates and specific conductivity. The GSP should set SMC for the additional COCs in the subbasin (arsenic, iron, and manganese) and ensure they align with drinking water standards.	Analysis of the available data for arsenic, iron, and manganese does show that exceedances of these constituents occur throughout the Subbasin. Arsenic is different from iron and manganese for the reason that there are public health risks associated with elevated arsenic concentrations, as opposed to the aesthetic considerations that arise due to elevated concentrations of iron and manganese. Further analysis of elevated concentrations of these constituents reveals that exceedances of the Maximum Contaminant Level (MCL), and Secondary Maximum Contaminant Levels (SMCLs) occur within regions that are served water by Municipal Community Water Systems (this analysis will be presented in an upcoming draft). The monitoring and treatment of these constituents should be sufficient to protect the beneficial users of groundwater. As part of the updated GSP Draft, it is not proposed that SMC be set for these constituents, but instead proposed that the three constituents be included in the two monitoring networks proposed by the GSP (the GSP Water Quality Monitoring Network, and the Community Monitoring Effort). This monitoring data will then be evaluated, and if deemed necessary, SMC will be set in the next GSP update in 2027.
51	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/24/2021	Section 3			When defining undesirable results for chronic lowering of groundwater levels and depletions of interconnected surface waters, provide specifics on what biological responses (e.g., extent of habitat, growth, recruitment rates) would best characterize a significant and unreasonable impact to GDEs. Undesirable results to environmental users occur when 'significant and unreasonable' effects on beneficial users are caused by groundwater conditions in the subbasin. Thus, potential impacts on environmental beneficial uses and users need to be considered when defining undesirable results9 in the subbasin. Defining undesirable results is the crucial first step before the minimum thresholds can be determined.	See Technical Appendix 3B and Section 3's Table 3-2 (The Freshwater Trust, 2020). GDE area and NDVI declining below historical observed levels are used as quantitative metrics to define when significant and unreasonable impacts occur.
52	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/25/2021	Section 2			Provide more information regarding the selection of the American River Basin Study and the methods through which climate change is incorporated, since this is a different method than the use of climate change factors suggested by DWR.	This rationale has been clarified and improved in the text.
53	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/26/2021	Section 2			Integrate climate change, including extremely wet and dry scenarios, into all elements of the projected water budget to form the basis for development of sustainable management criteria and projects and management actions.	This change is not taken, but the rationale for selecting the central tendency has been made more clear.
54	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/27/2021	Section 2			Calculate sustainable yield based on the projected water budget with climate change incorporated.	The sustainable yield estimate utilizes the climate change scenarios that were analyzed for the GSP, along with the other modeling scenarios. The data does not indicate that climate change will significantly change the basin sustainable yield.
55	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/28/2021	Section 2			Incorporate climate change scenarios into projects and management actions.	We agree this is important, and evaluate a scenario that includes both climate change and PMAs.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
56	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/29/2021	Section 3			Provide maps that overlay monitoring well locations with the locations of DACs, domestic wells, and tribal areas to clearly identify potentially impacted areas. Ensure that existing and proposed representative monitoring sites adequately cover DAC, domestic well, and tribal portions of the subbasin.	We provide both maps of monitoring well locations (Section 3.3.1.3) and DACs (Appendix 1D, page 69). Analysis of reaching 100% of MTs at all RMPs suggest the avoidance of significant and undesirable results to domestic wells. Thus impacts to all user groups - which include DACs - are already considered.
57	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/30/2021	Section 3			Provide specific steps to fill data gaps relating to representative monitoring sites that lack historical data or well screen information for wells on private lands.	A management action to fill the described data gaps has been provided in Section 4 and a budgetary item has been provided in Section 5.
58	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/31/2021	Section 3			Determine what ecological monitoring can be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the subbasin. The GSP (Appendix 3-B) describes GDE analyses using NDVI. Describe more fully if NDVI will be used to assess impacts to GDEs during the GSP implementation phase.	Groundwater level monitoring and NDVI monitoring will occur throughout the implementation period.
59	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	9/1/2021	Section 4			For DACs, include a discussion of whether potential impacts to water quality from projects and management actions could occur. For example, groundwater recharge projects can have potential negative impacts to water quality which could cause undesirable results to drinking water beneficial users. Ensure that appropriate monitoring and mitigation aspects are included in the project development plans for recharge projects. Refer to Appendix B for drinking water well impact mitigation guidance.	The project proponents for each project included in the GSP will be responsible for monitoring water quality effects of their projects and for mitigating any potential impacts. These aspects will be addressed as the projects are implemented.
60	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	9/2/2021	Section 4			Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.	Currently planned PMA substantially improve groundwater elevations (Appendix 3A, Figure 8) and avoid undesirable results. PMA also include regional conjunctive use, which incorporate climate and water delivery uncertainties.
61	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/11/2021				Include a map showing domestic well locations and average well depth across the subbasin.	These are present in Technical Appendix 3C (Figures 10, 13, 14).

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
62	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/14/2021				The GSP states that a complete list of special status species is presented in Appendix E of the GSP, but this was not included in the public review draft. We recommend that the GSP includes a clear description of the fauna (e.g., birds, fish, amphibians) and flora (e.g., plants) that are dependent on GDEs within the GDE section of the GSP (see Attachment C of this letter for a list of freshwater species located in the South American subbasin). Also note any threatened or endangered species.	This will be included on the website ASAP and we will coordinate with the Freshwater Trust to see to this.
63	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/15/2021				Refer to Attachment B for more information on TNC's plant rooting depth database. Deeper thresholds are necessary for plants that have reported maximum root depths that exceed the averaged 30 feet threshold, such as valley oak (Quercus lobata). We recommend that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to-groundwater threshold of 80 feet should be used instead of the 30 feet threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater.	The consultant team has reviewed the study in question (Lewis and Burgy, 1964) and does not find merit in the results. The study concerns an isotope-tracer study in a fractured rock aquifer in hilly topography using a small sample (n = 15) of trees. These results are highly specific to geology (i.e., isotope transport in fractured rock and alluvium are not at all comparable), and hydraulics (i.e., topographic driven flow patterns in mountainous regions are much different than those in relatively flat valley floors). Moreover, other literature reviewed by TNC suggest rooting depths of around 30 feet. The scientific de-merits outlined above give cause to not consider an 80 foot rooting depth parameter, and hence, we maintain the GDE study carried out the Freshwater Trust for the SASb (see technical Memo 3B (groundwater dependent ecosystems).
64	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/18/2021	Section 3			Describe direct and indirect impacts on DACs and tribes when defining undesirable results for chronic lowering of groundwater levels.	Undesirable results are defined with respect to domestic, industrial, agricultural, municipal, and environmental users. DACs are already considered by inclusion in these user groups (particularly domestic users).
65	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/19/2021	Section 3			Evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs and tribes.	Analysis of reaching 100% of MTs at all RMPs suggest the avoidance of significant and undesirable results to domestic wells. Thus impacts to all user groups - which include DACs - are already considered.
66	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/20/2021	Section 3			Describe direct and indirect impacts on DACs and tribes when defining undesirable results for degraded water quality. For specific guidance on how to consider domestic water users, refer to "Guide to Protecting Water Quality Under the Sustainable Groundwater Management Act."	Undesirable results are defined with respect to domestic, industrial, agricultural, municipal, and environmental users. DACs are already considered by inclusion in these user groups (particularly domestic users).
67	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/21/2021	Section 3			Evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs and tribes.	Groundwater quality MTs suggest the avoidance of significant and undesirable results for all users. Thus impacts to all user groups - which include DACs - are already considered.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
68	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/22/2021	Sections 2 and 3			Section 2.3.4 (Groundwater quality) discusses TDS, however Section 3.3.3 (Maximum threshold for degraded groundwater quality) discusses specific conductivity. Choose one measurement to describe salinity and use it consistently throughout the GSP.	The groundwater quality section (Section 2.3.4) uses analysis of Total Dissolved Solids (TDS), as opposed to specific conductivity, to evaluate salinity levels in the Subbasin as this data is historically abundant for the subbasin. Section 3.3.3 (Maximum threshold for degraded groundwater quality) discusses specific conductivity, as opposed to TDS, for the reason that specific conductivity can be measured with an in-situ probe, while TDS requires laboratory results. This ease of measurement will enable easier collection of salinity data for the subbasin moving forward. We understand that disconnect arises with use of the different methods, but feel that the historic analysis available through TDS data, and the future ease of measurements available through probe measurements of specific conductivity, outweigh any potential disconnect.
69	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/23/2021	Section 3			The plan only sets minimum thresholds and measurable objectives for nitrates and specific conductivity. The GSP should set SMC for the additional COCs in the subbasin (arsenic, iron, and manganese) and ensure they align with drinking water standards.	Analysis of the available data for arsenic, iron, and manganese does show that exceedances of these constituents occur throughout the Subbasin. Arsenic is different from iron and manganese for the reason that there are public health risks associated with elevated arsenic concentrations, as opposed to the aesthetic considerations that arise due to elevated concentrations of iron and manganese. Further analysis of elevated concentrations of these constituents reveals that exceedances of the Maximum Contaminant Level (MCL), and Secondary Maximum Contaminant Levels (SMCLs) occur within regions that are served water by Municipal Community Water Systems (this analysis will be presented in an upcoming draft). The monitoring and treatment of these constituents should be sufficient to protect the beneficial users of groundwater. As part of the updated GSP Draft, it is not proposed that SMC be set for these constituents, but instead proposed that the three constituents be included in the two monitoring networks proposed by the GSP (the GSP Water Quality Monitoring Network, and the Community Monitoring Effort). This monitoring data will then be evaluated, and if deemed necessary, SMC will be set in the next GSP update in 2027.
70	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/24/2021	Section 3			When defining undesirable results for chronic lowering of groundwater levels and depletions of interconnected surface waters, provide specifics on what biological responses (e.g., extent of habitat, growth, recruitment rates) would best characterize a significant and unreasonable impact to GDEs. Undesirable results to environmental users occur when 'significant and unreasonable' effects on beneficial users are caused by groundwater conditions in the subbasin. Thus, potential impacts on environmental beneficial uses and users need to be considered when defining undesirable results9 in the subbasin. Defining undesirable results is the crucial first step before the minimum thresholds can be determined.	See Technical Appendix 3B and Section 3's Table 3-2 (The Freshwater Trust, 2020). GDE area and NDVI declining below historical observed levels are used as quantitative metrics to define when significant and unreasonable impacts occur.
71	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/29/2021	Section 3			Provide maps that overlay monitoring well locations with the locations of DACs, domestic wells, and tribal areas to clearly identify potentially impacted areas. Ensure that existing and proposed representative monitoring sites adequately cover DAC, domestic well, and tribal portions of the subbasin.	We provide both maps of monitoring well locations (Section 3.3.1.3) and DACs (Appendix 1D, page 69). Analysis of reaching 100% of MTs at all RMPs suggest the avoidance of significant and undesirable results to domestic wells. Thus impacts to all user groups - which include DACs - are already considered.
72	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/30/2021	Section 3			Provide specific steps to fill data gaps relating to representative monitoring sites that lack historical data or well screen information for wells on private lands.	A management action to fill the described data gaps has been provided in Section 4 and a budgetary item has been provided in Section 5.
73	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	8/31/2021	Section 3			Determine what ecological monitoring can be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the subbasin. The GSP (Appendix 3-B) describes GDE analyses using NDVI. Describe more fully if NDVI will be used to assess impacts to GDEs during the GSP implementation phase.	Groundwater level monitoring and NDVI monitoring will occur throughout the implementation period.
74		Carl Werder	7/5/2021	Section 3	Page 7	Lines 104 and 105	Section 3 – Page 7 of 85, Lines 104 and 105., This sentence should include remediation as a major use of groundwater in the basin since they extract approximately 30,000 AF/yr.	We see the reviewer's perspective, but technically remediated groundwater is either returned to the groundwater system (and hence not consumed), or consumed for one of the already mentioned uses including agricultural, domestic, industrial, and municipal categories. Thus, we keep the text as-is.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
75		Carl Werder	7/5/2021	Section 3	Page 14	Line 363	Page 14 of 85, Line 363., Introduction of a new project called "Harvest Water Project '' without any explanation of what this is or maybe I missed it? Need to refer reader to Section 4.4.1 at this location.	This comment is well taken, and the requested cross-reference has been made.
76		Carl Werder	7/5/2021	Section 3	Page 32	Line 791, Table 3-3	Page 32 of 85, Line 791, Table 3-3., The 50th percentile column has figures carried out to the hundredths while all other columns are not. Recommend dropping the decimal point figures in this column.	This comment is also well taken, and the requested rounding has been made.
77		Carl Werder	7/5/2021	Section 3	Page 40	Line 852, Table 3-4	Page 40, Line 852, Table 3-4., It is assumed that the 'Well ID' in this table is DWR's, but again it would be better to add SCGA's numbers to locate the hydrograph that goes with the information in the table.	This comment suggests using the shorter, more easily-readable well IDs associated with SCGA well IDs in the SMC table. Unfortunately, not all DWR state well IDs are also SCGA wells. Hence, we revise the entire ordering to be consistent with a direction (south to north) and a more easily readable scheme ("RMP_number"). See updated Figures 3-4 and 3-5.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
1	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	4.4.1			8. Comment #8 Water Storage Investment Program, Harvest Water Project: The Department's dedicated Water Storage Investment Program (WSIP) staff have completed additional review of the GSP's inclusion of the Harvest Water Project as a PMA and provide the following comments for GSA consideration. a. Background: In July 2018, the Sacramento Regional County Sanitation District (Regional San) received a maximum conditional eligibility determination of $287.5 million from the California Water Commission for the public benefits to be provided by the Harvest Water Program. The California Water Commission is administering funds dedicated by Proposition 1 through the WSIP for public benefits associated with water storage projects. The Department is the administering agency for public ecosystem benefits. As required by regulations, to receive funding, the Department will be contracting with Regional San for administration of Harvest Water's proposed ecosystem benefits to riparian, wetland, Greater sandhill crane, and vernal pool habitats, as well as increased Cosumnes River flows. More specifically, three of Harvest Water's proposed public ecosystem benefits are dependent upon increasing groundwater levels: enhancement of riparian habitat, enhancement of wetland habitat, and increased flows in the Cosumnes River to support fall-run Chinook salmon. The implementation of the GSP and the resultant groundwater levels in the subbasin will influence Harvest Water's ability to increase groundwater levels within their project area to elevations necessary for these public ecosystem benefits. The WSIP contract between the Department and Regional San will constitute a long-term commitment by the Harvest Water Program to administer public ecosystem benefits for the life of the project, estimated during the WSIP application process to be 84 years.	See response to comment No. 3
2	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	4.4.1			b. Issues: i. Groundwater Levels: The GSP states the Harvest Water project is expected to restore "depleted groundwater levels up to 35 feet within 15 years" (page 4-8) but elsewhere states "model simulations indicate groundwater levels will increase upwards of 25 feet in the main recharge zone" (page 3-44). The GSP also notes that the measurable objectives for eight of the representative monitoring points "within or near the Harvest Water recharge project" are increased to reflect "an aspirational goal of increasing groundwater levels in the southern SASb" (page 3-44). ii. Measurement Frequency: The GSP states "All wells will collect at least biannual measurements… Wells in or adjacent to the Harvest Water Recharge management zone will collect monthly measurements" (page 3-57). However, Figure 3-23 (page 3-60) indicates that most of the RMPs near the Harvest Water program area will be monitored biannually (indicated by the green dots) while other areas will be monitored on a 15-minute frequency. This mapping leaves the reader to guess which of these "biannual" RMPs will be monitored on a monthly frequency. iii. Model Assumptions: The GSP describes only limited assumptions utilized to model the Harvest Water project (page 4-21).	See response to comment No. 3
3	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	4.4.1			c. Recommendations: i. Groundwater Levels: The GSP should clarify expected groundwater levels in the Harvest Water program area and their relation to minimum thresholds and measurable objectives. Further, the GSP should explicitly describe how GSP implementation will meet these aspirational goals, which will support Harvest Water's groundwater elevation targets. ii. Measurement Frequency: For the sake of clarity, the GSP should indicate which RMPs will be monitored more frequently than biannually. iii. Model Assumptions: Due to the importance of this project in the subbasin, the GSP should more thoroughly describe the inputs and assumptions utilized when modeling Harvest Water. Specific topics on which the GSP should elaborate include: 1. The locations of in-lieu recharge and winter application recharge. 2. The total volume of water delivered to the subbasin. Specifically, the volume of the in-lieu net recharge (22,500 Acre Feet per Year [AFY]) and the winter application (8,750 AFY) do not correctly sum to the total delivery volume (41,250 AFY). 3. Restrictions to delivery of recycled water imposed by the 2019 Wastewater Change Petition. 4. Project ramp-up timing (i.e., as the project ramps up delivery volumes from startup to full operation).	i. The description of expected benefits described in Section 4.4 comes from available documentation for the Harvest Water Project, and may differ from the results of modeling simulated for the GSP due to differences in project or baseline assumptions. Refinements of groundwater level benefits for the project will be developed by the Harvest Water program going forward. ii. We apologize for the confusion. The RMP network (Figure 3-23) shows biannual well monitoring within and near Harvest Water; these wells will be monitored biannually as part of the GSP for comparison to SMC and assessment of the avoidance of significant and unreasonable impacts to beneficial users. Importantly, monthly monitoring is not necessary or required for GSP purposes in the South American Subbasin. However, the Harvest Water Program may incorporate additional monitoring wells and may incorporate higher frequency monitoring, to the extent necessary to support the needs of that program. The GSAs have coordinated with Regional San on the Harvest Water Program during GSP development and anticipate future data sharing so that data collected under the Harvest Water Program can be incorporated into analyses for GSP purposes, to the extent relevant. iii. The information provided is sufficient for purposes of describing the model simulation performed for the GSP. For more detailed assumptions regarding potential project parameters and operations, please refer to documentation developed by the Harvest Water program.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
4	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Project and Management Actions (PMA); 4.6 Results of Model Scenarios; starting page 4-20		page 4-20	7. Comment #7 Project and Management Actions (Project and Management Actions (PMA); 4.6 Results of Model Scenarios; starting page 4-20): Projects and management actions that would support demand management in the subbasin lack specificity. a. Issue: The modeled project and management action scenarios presented in the GSP include two demand management scenarios that would involve reductions in both urban and agricultural water use (Table 4-3). Though the GSP provides detailed explanations for the three supply augmentation scenarios included in the PMA modeling, similar specificity is not provided for demand reduction scenarios. The GSP states that 2020 urban water management plans, developed by water supply agencies within the subbasin, are anticipated to lead to increased conservation and encourage demand management scenarios (line 786). However, as water management plan specifics are not provided, it is unclear whether it is reasonable for the GSP to assume that these plans will be able to collectively meet the demand reductions modeled in Scenario 1 and 2, or when and how they would be implemented within the subbasin. PMA Scenario 5, which includes implementation of the Harvest Water, Omochumne-Hartnell Water District (OHWD) Recharge, and Regional Conjunctive Use projects (Table 4-4, Scenario 5) results in an annual net storage change deficit of 100 acre-feet per year with climate change. Should any of the three projects encounter delays or result in less than the projected benefit to groundwater storage volumes, annual subbasin storage deficits could increase significantly. Only six of the 172 potential projects and management actions presented in Appendix 4-A are categorized as demand management; the lack of specificity for how and when these demand reduction actions would be implemented within the subbasin could delay implementation and undermine the subbasin's ability to achieve sustainability goals, particularly if the expected	See response to Comment 23 for Section 3. If, in the future, the need for demand management arises, the GSA may consider demand management as a management action under a revised GSP.
5	California Department of Fish and Wildlife	Kevin Thomas	8/17/2021	Project and Management Actions (PMA); 4.6 Results of Model Scenarios; starting page 4-20		page 4-20	b. Recommendation: The Department recommends detailing when and how demand reduction projects and management actions would be implemented to meet the targets outlined in Scenarios 1 and 2. Add specific measures that would lead to initiation of demand reduction actions should planned projects within the basin fail to provide the necessary benefit to groundwater levels in the subbasin.	Failure to meet SMC and avoid undesirable results could lead to further exploration of demand management and/or implementation of additional recharge projects as an element of the GSP. These triggering mechanisms will be evaluated annually and considered in 5-year updates to the GSP. Best available information does not indicate that such actions will be necessary.
6	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4			Section 4. Projects and Management Action, 4.1 History and Context 8. Regional Water Reliablity Plan prepared for Regional Water Authority— 2019 Neither a discussion of the RWA Reliability Plan nor an overview of the general concepts of water banking were provided in the Public Outreach and Engagement Meetings or workshops conducted by SCGA or OHWD . It is my understanding water banking is an overarching goal in the SASb for both SCGA, and OHWD. There is the potential to partcipate in a regional water bank in the SASb facilitated by staffing of SCGA by SGA and RWA which is currently under consideration.. In my opinion there was suffficient time and opportunity for the public to be informed about water banking in the SASb, but the conversation seem to get stuck on SGMA 101 The public requires an overview of water banking before GSP adoption.	Regional water banking discussions are ongoing among key players in the North Amercian and South Amercian subbasins. A complete public process will occur as those plans become more detailed. Discussions of water banking were described in GSPWG meetings and are described in Section 4 and Appendix 4-A. Text has been added to Section 4 to provide greater clarity regarding the management action in the GSP which calls for action by the GSAs to work with the parties involved in regional water banking discussion to develop a regional water bank and associated accounting system. This measure was widely supported by GSPWG members and public participants in public meetings.
7	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4.2			4.2 Projects and Managements Actions under SGMA. In my understanding, recycled water projects, recharge projects,conjunctive use and water banking are the basis for achieving sustainability in the SASb . Water quality implications of these innovative new concepts and projects were not appropriately disclosed to the large community of shallow well owners whose wells could potentially be impacted by poor water quality resulting from implementing these projects. Recently, in attempting to compare recent water tests results from our private well to wells locations similar to my ag res parcel, directly adjacent to agriculture, I found there were no monitoring wells in the SASb monitoring network or the GAMA network with which I could compare results. A monitoring network, of shallow wells including water quality monitoring is a data gap in the GSP that needs to be addressed. Exisiting water moniitoring data, including water quality data needs to be readily accessible to owners of shallow wells. GSAs that are participating in groundwater level monitoring and/or water quality monitoring programs through the State Water Board, DWR or any County or State Agency must be be required as Public Agencies to be transparent and share their data with the public by making it readily accessible to the public on their websites. An good example is the UC Davis Well Monitoring project in OHWD. Water quality should be as an element of the shallow well monitoring network PMA with wells located in a variety of areas throughout the rural area in the SASb. Shallow monitoring wells should be included in GSP annual reports and the five year update of the GSP as the data is gathered and quantified and made available for inclusion.	Modifications were made to Section 4 to describe the activities associated with a well protection program in greater detail, including additional data collection for groundwater levels and groundwater quality in shallow wells in the SASb. A volunteer monitoring network is described in Section 4 as a vehicle for implementation of such data collection activities.
8	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4.4.1			4.4.1 Harvest Water Harvest Water is an innovative and costly recycled water project, in my opinion, designed for agriulture and enviornmental interests with targeted outreach to specific participants and potential participants in the Harvest Water program. There is no evidence of significant outreach to the general public by the public agencies involved since 2011 to the present as the design and construction phases begin. An overview of Harvest Water Program by Regional San introduced the project to the General Public in the last few Public Enegagement and Outreach Meetings, There are lots of moving parts to the project and the public has not been made aware of the entire scope tof he Harvest Water Program and financing for the project.	The Harvest Water project has moved forward over the past decade with broad-based support among State and local agencies and stakeholders. A public engagement program has been conducted for Harvest Water, including development and adoption of a program-level and project-level EIR conforming to CEQA requirements by Sacramento REgional County Sanittion Distrct (Regional San). REsponsbility for continued public outreach and engagement rests with Regional San as he implementing agency for Harvest Water.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
9	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4.4.3			Section 4.4.3 Regional Conjunctive Use Program 4.4.3.8 Estimated Cost and Funding Funding of these highly innovative concepts and innovative technologies planned for the SASb carry big price tags for construction,operated and ongoing maintenance. Transparency has been lacking from GSAs planning and developing these projects and more detailed information is required in this GSP for public review and comment. Public/Private Partnerships as potential funding mechanisms for development and operation of many of these projects in the planning stages has not been discussed in Public Outreach and Engaagement meetings . It is my opinion Public/private partnerships are required o be addressed as a matter of The Public Trust.	The regional conjunctive use project described in the GSP and modeled using the CoSANA model will be implemented by the individual entities described in Section 4 of the GSP. These entities have performed similar projects over the past several decades and will be responsible for following applicable regulatory requirements, meeting public outreach requirements and acquiring funding for continued implementation of conjunctive use projects in the SASb. GSAs will communicate and coordinate with these water supply agencies, as described in the GSP, but will not bear the direct burden of implementation.
10	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4.4			4.4 Near Term Projects Additional detail and nformation needs to be provided in the GSP for public review and comment which would include proposed funding sources. For instance the Interconnection between the City of Folsom and Omochumne-Hartnell Water District at the Folsom South Canal Project. The public should be provided more than a few words about this project which a review of public records and LAFCo documents in, my opinion, indicate proposed construction and operation of a direct potable reuse recycled water facility in OHWD. At least those of us in the district should know about this project.	Prior to implementation of specific elements of the regional conjunctive use project, the implementing agencies (in this case, the City of Folsom and OHWD) will need to fulfill all regulatory, CEQA and public notification requirements. Some of these projects are at the concept level where additional detail is unavailable. In general, detailed descriptions of the elements of the regional conjunctive use project are beyond the scope of the GSP.
11	Community Member	Suzanne Pecci (916) 893-3139 slpecci@aol.com	8/18/2021	Section 4.7			Section 4.7 Management Actions 4.7.1 Shallow/vulnerable Well Protection Program There is a large ag res presence in the SASb dependent on private individual shallow wells as their sole source of drinking water. Through Public Outreach and Engagement SCGA successfully reached a large number of these irural residents who expressed their great interest in having a Shallow Well Protection Program. There have beenn numerous presentations at Public Engagement Meetings, Ag res Workshops and at a recent SCGA Board meeting to articulate the many decisions and considerations that have to be addressed in developing a Well Potection plan, including the lack of funding. There has been no decision by the GSAs in the SASb to move forward with at Well protection Plan for the ag res wells owners. I understand in order to be funded in the GSP, there has to be an identified Project . I suggest this section of the GSP be amended to include: a formal decision by SCGA and the affected GSAs in the SASb supporting development of a Well Protection Plan Framework; a Project framework be developed for inclusion in the current GSP that includes application for grant funding currently available from DWR and a request for technical support and funding from DWR for development of a Pilot Well Protection Plan for the SASb.	As noted by the commenter, significant time and energy has been spent in GSPWG and public meetings to discuss inclusion of a well protection program in the GSP. The result of those discussions is captured in Section 4 of the GSP, where a commitment to implement a mangement action and the process to develop and a framework for the program is described at a level of detail acceptable to members of the GSPWG.
12	Environmental Council of Sacramento (ECOS)		6/18/2021	Section 4			Section 4 provides complete discussions of the Projects contemplated as part of the GSP. However, we believe that water purveyor and Agriculture demand reduction should be added. The GSPD discusses a 10% demand reduction programs for water purveyors and Agriculture. While time may not be sufficient to redo the analysis to incorporate these programs, they should be described in the GSPD and included in the next GSP five-year update as Group 1 and 2 projects.	See response to Comment No. 69 for Section 3. Demand reduction is anticipated to occur in the future through actions by others, but has not been assumed in Scenarios 4 and 5 described in Section 4. Since demand reduction is planned to occur through the implementation of UWMPs by urban water purveyors in the SASb, the results described in Scenarios 4 and 5 are conservative estimates of future conditions.
13	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	9/1/2021	Section 4			For DACs, include a discussion of whether potential impacts to water quality from projects and management actions could occur. For example, groundwater recharge projects can have potential negative impacts to water quality which could cause undesirable results to drinking water beneficial users. Ensure that appropriate monitoring and mitigation aspects are included in the project development plans for recharge projects. Refer to Appendix B for drinking water well impact mitigation guidance.	The project proponents for each project included in the GSP will be responsible for monitoring water quality effects of their projects and for mitigating any potential impacts. These aspects will be addressed as the projects are implemented.
14	The Nature Conservancy Audubon California Local Government Commission Union of Concerned Scientists Clean Water Action	Ngodoo Atume J. Pablo Ortiz-Partida, Ph.D. Samantha Arthur Danielle V. Dolan EJ Remson Melissa M. Rohde	9/2/2021	Section 4			Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.	Currently planned PMA substantially improve groundwater elevations (Appendix 3A, Figure 8) and avoid undesirable results. PMA also include regional conjunctive use, which incorporate climate and water delivery uncertainties.
15		Carl Werder	7/5/2021	Section 4	Page 6	Line 64	Section 4 – Page 6 of 44, Line 64., Again the 273,000 AF is a red flag. By using the words, “development of a sustainable yield value of 273,000 AF” makes it sound as though this number was based on some criteria. It was not, it was simply negotiated between parties such as developers and environmental folks. Recommend deleting this part of the sentence.	Information pertaining to the development and utilization of the existing sustainable yield estimate is a matter of record. A new sustainable yield figure has been developed for the SASb based on consideration of the SMC described in Section 3. The basis for this estimate and the methodology used in its derivation is described in Section 2.
16		Carl Werder	7/5/2021	Section 4	Page 6	Lines 66 and 67	Page 6 of 44, Lines 66 and 67., It should also be pointed out that the 2006 Groundwater Management Plan has in it action plans if the criteria is exceeded and in 15 years not once has any of these actions been taken.	As required by SGMA, the GSP for the SASb clearly outlines the SMC and monitoring network that will be implemented to ensure that undesirable results do not occur. The GSP outlines the process that will be used to address problems that may arise in the attainment of SMC at representative monitoring points in the SASb. Past performance in implementing the 2006 GMP is not indicative of future actions taken by GSA under this GSP.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
17		Lynn Wheat Wheat91@yahoo.com	8/18/2021	4.4.1			Will the new urban areas be using recycled water for domestic use? Will this project be adding additional future drinking water for the region? Is this in the conceptual stage? I have presented this question at SCGA meetings and what I heard is that SCGA is not a land use agency. How can there be coordination between land use agencies and SCGA if the GSP is not based on updated General Plans of the cities and counties? How can this be a transparent process when the agencies involved in serving Elk Grove are not coordinating meetings to reach out to the ratepayers in a meaningful understandable way? Ratepayers are Stakeholders and have not been identified as such in the draft GSP. However, ratepayers have been identified as a financial source for the funding of projects.	Section 4.4.1 provides a description of the Harvest Water Project, which is in the design phase. The recycled water will be provided for agricultural uses. Regional San is in the process of fulfilling all permitting requirements for the construction and operation of the Harvest Water. As described in Section 5.1.4, implementation of the GSP includes coordinating activities with other GSAs and other entities such as those with land use jurisdiction, and the GSAs will need to develop governance and communication processes to support these activities.

Comment No.	Commenting Organization	Comment By	Date of Comment	Section/ Appendix #	PDF Page Number	PDF Line Number or Figure Number	Comment	Response to Comment
1	Community Member	Suzanne Pecci	8/18/2021	Section 5			Section 5 Plan Implementation The governace structure for the 5 GSAs in the SAsb has not been successfully negotiated after 6 years of meetings, 2x2s, ad hoc committees., MOUs… At this point in time when the 60 day period of public review is closied the GSP is missing a governance agreement, a funding structure, a framework for managment and coordination for shared projects ,as well as funding plans for individual GSAs for public review and comment, Section 5 —Plan Implementation is reliant on these agreements between the 5 GSP. The public requires a public review and comment period on these essential agreements. Finally, a few comments on the August 17, 2021 OHWD Board Meeting Agenda item 7 .Expansion —a public discussion of OHWD possibly pursuing in the coming months an expansion of its GSA boundaries through DWR —annexation of thousands of acres of agricultural land currently in SCGA territory going through the LAFCo process in the next few months, including CEQA, —-a transfer of assessments and fees recently levied by SCGA for the area —and the removal of the Ag Director position from the SCGA Board ——-all being done in conjunction with the review and response to the GSP draft comments,approval and adoption of the current GSP and DWR final plan submittal by the end of January 2022 —and OHWD pursuing these actions at this time seems a distraction and, in my opinion, jeopordizes tthe SASb GSP process that is at a critical juncture. The discussion of 22,000 - 33,000 acres being added to OHWD, and even the idea of crossing into San Joaquin County adds a whole new dimension to “Local Control.” There was an OHWD comment that ‘this expansion could make us very powerful ‘ leads me to question SGMA’s intent with respect to Local Control. and was the intent really to facilitate power and not to facilitate public	Discussions among the GSAs in the SASb regarding the governance structure and funding contributios for GSP implementation have been ongoing for most of 2021. The MOU developed by the GSAs will be submitted to DWR with the GSP.
2	Environmental Council of Sacramento (ECOS)		6/18/2021	Section 5			Section 5 needs to be strengthened with the additional Projects and Actions we recommend. If the GSP does not include the full list of Projects and Actions that need to be accomplished, then those left off the Plan’s published list will likely not be addressed.	This comment was addressed in response to comments on Section 4, where projects and management actions were thoroughly described.
3	Huhtamaki Foodservice, Inc.	Amy Steinfeld	8/17/2021	Section 2.4.3 Section 5.4 Section 2.1.6			The Draft Plan indicates that three sections are missing: (1) Sustainability Yield Estimate (Section 2.4.3); (2) Funding Sources and Mechanism (Section 5.4); and (3) Interconnected Surface Water Monitoring (Section 2.1.6). The public and stakeholders must have the opportunity to review and comment on these sections prior to approval of the Final Plan by the groundwater sustainability agencies. (Cal. Code Regs., tit 23, § 355.4(b)(10); Plan, App. 1-D, p. 16.) Because these are fundamental sections of the Plan, we request that these sections be posted for review and comment as soon as possible.	The draft Section 2 subsection describing the sustainable yield estimate was posted on the SASb website for public review in September 1, 2021. The draft section was discussed and refined at publicly accessible GSPWG meetings in August and September, 2021. The final GSP includes this publicly vetted subsection. The other sections noted by the commenter are included in the final GSP and will be considered in the public process for GSP approval by each of the GSA Boards.
4		Lynn Wheat Wheat91@yahoo.com	8/18/2021	5.1.6			5.1.6 Projects are group 1, group 2 and group 3. What are the projects under each grouping? Understandably the Projects are further discussed in another area of the document. How about listing the projects in the Executive Summary? Projects in group 3 are supplemental and in a “conceptual stage”. What are the concepts being contemplated? A description of the “conceptual stage” lends transparency to this document. Funding by the individual entities and sponsors should be included.	The breakdown of projects into categories 1, 2 and 3 is described in Section 4 of the final GSP.
5		Lynn Wheat Wheat91@yahoo.com	8/18/2021	5.1.7			5.1.7 Continuation of education, outreach and engagement should and needs to include property owners and ratepayers.	The GSP acknowledges and supports the need for ongoing outreach to property owners and stakeholders after approval of the GSP. A budget estimate is provided for continued outreeach by GSAs in Section 5.
6		Lynn Wheat	8/18/2021	5.2.2			5.2.2 Needs to include the costs for each GSA. The GSP should be able to give an estimate of the “unknown” costs for the potential projects or infrastructure need. This needs to be a transparent process with the financial obligations defined. Harvest Water Project is still seeking an additional $100 million in funding. An area within the Harvest Water Project will be urbanized under Elk Grove City’s general plan and will not remain Agricultural. This needs to be discussed in the GSP as I understand Harvest Water is to bring recycled water to area farmers easing groundwater pumping.	Estimates for costs to be incurred by GSAs in their normal conduct of business and estimates for costs to be shared by the GSAs in implementing the GSP are included in Section 5. Apportionment of these costs to each GSA is being addressed in the GSP implementation MOU being developed by the GSAs. Distribution of individual GSP costs to landowners and groundwater users in each GSA will be determined by each GSA. This information is not available for inclusion in the GSP.

Appendix 2-A

Divisions of Geologic Time – Major Chronostratigraphic and Geochronologic Units (US Geological Survey, March 2007)

USGS
science for a changing world

Divisions of Geologic Time—Major Chronostratigraphic and Geochronologic Units

Introduction.—Effective communication in the geosciences requires consistent uses of stratigraphic nomenclature, especially divisions of geologic time. A geologic time scale is composed of standard stratigraphic divisions based on rock sequences and calibrated in years (Harland and others, 1982). Over the years, the development of new dating methods and refinement of previous ones have stimulated revisions to geologic time scales.

Since the mid-1990s, geologists from the U.S. Geological Survey (USGS), State geological surveys, academia, and other organizations have sought a consistent time scale to be used in communicating ages of geologic units in the United States. Many international debates have occurred over names and boundaries of units, and various time scales have been used by the geoscience community.

New time scale.—Since the publication by the USGS of the 7th edition of "Suggestions to Authors" (STA7; Hansen, 1991), no other time scale has been officially endorsed by the USGS. For consistency purposes, the USGS Geologic Names Committee (GNC; see box for members) and the Association of American State Geologists (AASG) developed **Divisions of Geologic Time** (fig. 1). The **Divisions of Geologic Time** is based on the time scale in STA7 (Hansen, 1991, p. 59) and updates it with the unit names and boundary age estimates ratified by the International Commission on Stratigraphy (ICS). Scientists should note that other published time scales may be used, provided that these are specified and referenced (for example, Palmer, 1983; Harland and others, 1990; Haq and Eysinga, 1998; Gradstein and others, 2004). Advances in stratigraphy and geochronology require that any time scale be periodically updated. Therefore, the **Divisions of Geologic Time** is dynamic and will be modified as needed to include accepted changes of unit names and boundary age estimates.

The **Divisions of Geologic Time** shows the major chronostratigraphic (position) and geochronologic (time) units; that is, eonothem/eon to series/epoch divisions. Workers should refer to the ICS time scale (Ogg, 2004) for stage/age terms. Most systems of the Paleozoic and Mesozoic are subdivided into series utilizing the terms "Lower," "Middle," and "Upper." The geochronologic counterpart terms for subdivisions of periods are "Early," "Middle," and "Late." The international geoscience community is applying names to these subdivisions based on stratigraphic sections at specific localities worldwide. All series/epochs of the Silurian and Permian have been named. Although the usage of these names is preferred, "lower/early," "middle," and "upper/late" are still acceptable as informal units (lowercase) for these two systems/periods. Also the Upper Cambrian has been named "Furongian" in the ICS time scale. However, the GNC will not recognize this name and include it in the **Divisions of Geologic Time** until all series/epochs of the Cambrian are named.

Cenozoic.—There has been much controversy related to subdivisions of the Cenozoic, particularly regarding retention or rank of the terms "Tertiary" and "Quaternary." Although some stratigraphers have suggested that these terms be abandoned, the issue remains unresolved. If the terms are retained, there will need to be agreement on the status of the Quaternary as a system/period or subsystem/subperiod. Another controversial issue is the position of the base of the Quaternary; is it at the base of the Pleistocene or within the upper Pliocene? These positions have age estimates of 1.8 Ma and 2.6 Ma, respectively (see box for age terms). Until a decision is made on the subdivisions of the Cenozoic, the **Divisions of Geologic Time** will follow the general structure of the time scale in STA7 (Hansen, 1991) in accepting the use of the terms "Tertiary" and "Quaternary" and the equivalence of the bases of the Quaternary and Pleistocene. The map symbols "T" (Tertiary) and "Q" (Quaternary) have been used on geologic maps for more than a century and are widely used today.

Precambrian.—For many years, the term "Precambrian" was used for the division of time older than the Phanerozoic. For consistency with the time scale in STA7 (Hansen, 1991), the term "Precambrian" is considered to be informal and without specific stratigraphic rank (although it is capitalized).

Map colors.—Geologic maps utilize color schemes based on standards that are related to the time scale. Two different schemes are used, one by the Commission for the Geologic Map of the World (CGMW) and another by the USGS. Colors typically shown on USGS geologic maps have been used in a standard fashion since the late 1800s and recently have been published in the digital cartographic standard for geologic map symbolization (Federal Geographic Data Committee, Geologic Data Subcommittee, 2006). The GNC decided in 2006 that the USGS colors should be used for large-scale and regional geologic maps of the United States. For international maps or small-scale maps (for instance, 1:5 million) of the United States or North America, the GNC recommends the use of the international colors. Specifications for the USGS colors are in Federal Geographic Data Committee, Geologic Data Subcommittee (2006), and those for the CGMW colors are in Gradstein and others (2004).

Acknowledgments.—This Fact Sheet benefited from thoughtful reviews by John Repetski (USGS) and Donald E. Owen (Lamar University, Beaumont, Tex., and North American Commission on Stratigraphic Nomenclature).

By U.S. Geological Survey Geologic Names Committee

Members of the Geologic Names Committee of the U.S. Geological Survey, 2006

Randall C. Orndorff (chair), Nancy Stamm (recording secretary), Steven Craigg, Terry D'Erchia, Lucy Edwards, David Fullerton, Bonnie Murchey, Leslie Ruppert, David Soller (all of the USGS), and Berry (Nick) Tew, Jr. (State Geologist of Alabama).

Age Terms

The age of a stratigraphic unit or the time of a geologic event may be expressed in years before present (before A.D. 1950). The "North American Stratigraphic Code" (North American Commission on Stratigraphic Nomenclature, 2005) recommends abbreviations for ages in SI (International System of Units) prefixes coupled with "a" for annum: ka for kilo-annum, 10^3 years; Ma for mega-annum, 10^6 years; and Ga for giga-annum, 10^9 years. Duration of time should be expressed in millions of years (m.y.). For example, deposition began at 85 Ma and continued for 2 m.y.

References Cited

Federal Geographic Data Committee, Geologic Data Subcommittee, 2006, FGDC digital cartographic standard for geologic map symbolization: Federal Geographic Data Committee Document Number FGDC–STD–013–2006, 290 p., 2 pls., available online at http://ngmdb.usgs.gov/fgdc_gds/.

Gradstein, Felix, Ogg, James, and Smith Alan, eds., 2004, A geologic time scale 2004: Cambridge, U.K., Cambridge University Press, 589 p., 1 pl.

Hansen, W.R., ed., 1991, Suggestions to authors of the reports of the United States Geological Survey, seventh edition [STA7]: Reston, Va., U.S. Geological Survey, 289 p. (Also available online at http://www.nwrc.usgs.gov/lib/lib_sta.htm.)

Haq, B.U., and Eysinga, F.W.B., van, eds., 1998, Geological time table (5th ed.): Amsterdam, Elsevier, 1 sheet.

Harland, W.B., Armstrong, R.L. Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G., 1990, A geologic time scale, 1989: Cambridge, U.K., Cambridge University Press, 263 p.

Harland, W.B., Cox, A.V., Llewellyn, P.G., Picton, C.A.G., Smith A.G., and Walters, R.W., 1982, A geologic time scale: Cambridge, U.K., Cambridge University Press, 131 p.

North American Commission on Stratigraphic Nomenclature, 2005, North American stratigraphic code: American Association of Petroleum Geologists Bulletin, v. 89, no. 11, p. 1547–1591. (Also available online at http://ngmdb.usgs.gov/Info/NACSN/Code2/code2.html.)

Ogg, James, comp., 2004, Overview of global boundary stratotype sections and points (GSSPs): International Commission on Stratigraphy, available online at http://www.stratigraphy.org/gssp.htm.

Palmer, A.R., comp., 1983, The Decade of North American Geology [DNAG] 1983 geologic time scale: Geology, v. 11, no. 9, p. 503–504.

For more information, please contact:

Randall C. Orndorff, U.S. Geological Survey
908 National Center, 12201 Sunrise Valley Drive
Reston, VA 20192
E-mail: rorndorf@usgs.gov

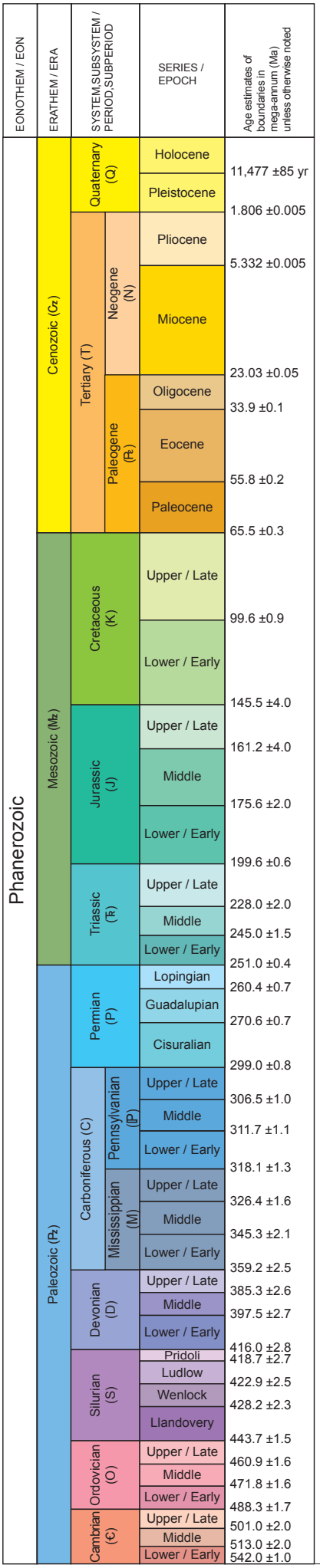


Figure 1. Divisions of Geologic Time approved by the U.S. Geological Survey Geologic Names Committee, 2006. The chart shows major chronostratigraphic and geochronologic units. It reflects ratified unit names and boundary age estimates from the International Commission on Stratigraphy (Ogg, 2004). Map symbols are in parentheses.

Appendix 2-B

CoSANA: An Integrated Water Resources Model of the Cosumnes, South American, and North American Groundwater Subbasins

CoSANA

An Integrated Water Resources Model of the Cosumnes, South American, and North American Groundwater Subbasins

NOVEMBER 2021

WOODARD &CURRAN

CoSANA:
An Integrated Water Resources Model
of the
Cosumnes, South American, and North American
Groundwater Subbasins

November 2021

801 T Street
Sacramento, CA 95811
916.999-8700

woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS

WOODARD &CURRAN

TABLE OF CONTENTS

SECTION **PAGE NO.**

EXECUTIVE SUMMARY **ES-1**

1. INTRODUCTION **1-1**

1.1 Goals of Model Development 1-1
1.2 Cosumnes, South American, and North American Subbasins 1-2
1.3 Collaborative and Open Environment 1-6
1.4 Model Platform and Historical Modeling of the Region 1-6
1.5 Report Organization 1-8

2. MODEL DEVELOPMENT **2-1**

2.1 Model Input Data 2-1
2.2 Simulation Period and Temporal Discretization 2-2
2.3 Model Grid and Subregions 2-2
2.4 Stream Configuration and Inflow 2-10
2.5 Surface Drainage Pattern 2-15
2.6 Precipitation 2-17
2.7 Land Use and Cropping Patterns 2-19
2.8 Evapotranspiration 2-29
2.9 Root Zone Soil Parameters 2-31
2.10 Geologic Structure and Model Layering 2-33
2.10.1 Model Layer Development and Approach 2-33
2.10.2 Model Layer Definition 2-34
2.11 Tributary Watersheds 2-45
2.12 Boundary Conditions 2-46
2.12.1 General Head 2-46
2.12.2 Small Watersheds 2-46
2.12.3 Constrained Head 2-46
2.13 Initial Conditions 2-46

3. WATER SUPPLY AND DEMAND DATA **3-1**

3.1 Water Supply 3-1
3.1.1 Surface Water Supply 3-1
3.1.2 Groundwater Pumping 3-5
3.2 Urban Water Demand and Supply 3-5
3.2.1 North American Subbasin 3-7
3.2.1.1 California American Water Company (Antelope) 3-7
3.2.1.2 California American Water Company (Arden) 3-7
3.2.1.3 California American Water Company (Lincoln Oaks) 3-7
3.2.1.4 California American Water Company (West Placer) 3-7
3.2.1.5 Carmichael Water District 3-7
3.2.1.6 Citrus Heights Water District 3-7
3.2.1.7 Del Paso Manor Water District 3-7
3.2.1.8 Fair Oaks Water District 3-7
3.2.1.9 Golden State Water Company (Arden) 3-8
3.2.1.10 City of Lincoln 3-8
3.2.1.11 Orange Vale Water Company 3-8
3.2.1.12 Placer County Water Agency (City of Rocklin Retail Service Area) 3-8

3.2.1.13 Rio Linda / Elverta Community Water District....3-8
3.2.1.14 City of Roseville....3-8
3.2.1.15 Sacramento Suburban Water District....3-8
3.2.1.16 City of Sacramento....3-8
3.2.1.17 Sacramento International Airport....3-9
3.2.1.18 San Juan Water District....3-9
3.2.1.19 Sacramento County Water Agency (Arden Park Vista)....3-9
3.2.1.20 Sacramento County Water Agency (Northgate)....3-9
3.2.2 South American Subbasin....3-9
3.2.2.1 California American Water Company (Fruitridge - formerly Fruitridge Vista Water Company)....3-9
3.2.2.2 California American Water Company (Parkway)....3-9
3.2.2.3 California American Water Company (Security Park)....3-9
3.2.2.4 California American Water Company (Suburban Rosemont)....3-9
3.2.2.5 Elk Grove Water District (Service Area 1)....3-10
3.2.2.6 Florin County Water District....3-10
3.2.2.7 City of Folsom....3-10
3.2.2.8 Golden State Water Company (Cordova)....3-10
3.2.2.9 Rancho Murieta Community Service District....3-10
3.2.2.10 City of Sacramento....3-10
3.2.2.11 Sacramento County Water Agency (Hood)....3-10
3.2.2.12 Sacramento County Water Agency (Laguna Vineyard)....3-10
3.2.2.13 Sacramento County Water Agency (Mather)....3-10
3.2.3 Cosumnes Subbasin....3-10
3.2.3.1 Amador County Water Agency (Camanche Village)....3-11
3.2.3.2 Amador County Water Agency (Ione)....3-11
3.2.3.3 City of Galt....3-11
3.2.3.4 Rancho Murieta Community Service District....3-11
3.2.4 Fish Farms....3-11
3.2.5 Galt Wastewater Treatment Plant Effluent....3-11
3.3 Agricultural Water Demand and Supply....3-11
3.3.1 Rural-Residential Pumping....3-12
3.3.2 Agricultural Pumping....3-12
3.3.3 Agricultural Groundwater Substitution Transfers....3-12
3.4 Remediation Pumping....3-15

4. MODEL CALIBRATION AND SENSITIVITY ANALYSIS....4-1

4.1 Calibration Goals....4-1
4.2 Calibration Process....4-2
4.2.1 Water Budget Calibration....4-3
4.2.1.1 Land and Water Use Budget....4-3
4.2.1.2 Groundwater Budget....4-13
4.2.2 Groundwater Level Calibration....4-16
4.2.3 Streamflow Calibration....4-36
4.2.4 Small Watershed Calibration....4-42
4.3 Calibration Statistics and Goodness of Fit....4-42
4.4 Final Calibration Parameters....4-44
4.5 Model Features, Strengths, and Limitations....4-50
4.5.1 Spatial Extent and Resolution....4-50
4.5.2 Temporal Scale....4-50
4.5.3 Geology and Hydrogeology....4-50

4.5.4 Land Use Data 4-50
4.5.5 Water Demand Estimates 4-50
4.5.6 Water Supply Data 4-51
4.5.7 Groundwater Pumping Estimates 4-51
4.5.8 Water Budgets 4-51
4.5.9 Groundwater Flow and Levels 4-51
4.5.10 Streamflows 4-52
4.6 Modeling Uncertainties 4-52
4.6.1 Structural Uncertainties 4-52
4.6.2 Data Uncertainties 4-53
4.6.3 Calibration Uncertainties 4-53
4.6.4 Application Uncertainties 4-53
4.7 Sensitivity Analysis 4-54
4.7.1 Metrics of the Sensitivity Analysis 4-54
4.7.2 Results of the Sensitivity Analysis 4-54

5. BASELINE CONDITIONS 5-1

5.1 Current Conditions Baseline 5-1
5.1.1 Hydrology 5-1
5.1.1.1 Precipitation 5-1
5.1.1.2 Evapotranspiration 5-2
5.1.1.3 Stream Inflow 5-2
5.1.1.4 Hydrologic Year Types 5-2
5.1.2 Initial Conditions 5-3
5.1.3 Boundary Conditions 5-5
5.1.4 Land Use 5-5
5.1.5 Urban Demand and Supply 5-11
5.1.5.1 North American Subbasin 5-11
5.1.5.2 South American Subbasin 5-12
5.1.5.3 Cosumnes Subbasin 5-12
5.1.5.4 Fish Farms 5-12
5.1.6 Agricultural Demand and Supply 5-13
5.1.6.1 Rural-Residential Pumping 5-13
5.1.6.2 Galt Wastewater Treatment Plant Effluent 5-13
5.1.6.3 Agricultural Groundwater Substitution Transfers 5-13
5.1.7 Remediation Operations 5-13
5.1.8 Results 5-13
5.1.8.1 Land and Water Use Budget 5-14
5.1.8.2 Groundwater Budget 5-17
5.2 Projected Conditions Baseline 5-19
5.2.1 Hydrologic Period 5-19
5.2.2 Land Use 5-19
5.2.3 Urban Demand and Supply 5-27
5.2.3.1 North American Subbasin 5-27
5.2.3.2 South American Subbasin 5-31
5.2.3.3 Cosumnes Subbasin 5-33
5.2.3.4 Fish Farms 5-33
5.2.4 Agricultural Demand and Supply 5-34
5.2.4.1 Galt Wastewater Treatment Plant Effluent 5-34
5.2.4.2 Rural Residential 5-34
5.2.4.3 Agricultural Groundwater Substitution Transfers 5-34

5.2.5 Remediation Operations 5-34
5.2.6 Results 5-34
5.2.6.1 Land and Water Use Budget 5-34
5.2.6.2 Groundwater Budget 5-38
5.3 Projected Conditions Baseline with Climate Change 5-40
5.3.1 Hydrologic Period 5-40
5.3.1.1 Methodology 5-40
5.3.1.2 Precipitation 5-41
5.3.1.3 Stream Inflow 5-45
5.3.1.4 Evapotranspiration 5-47
5.3.2 Land Use 5-48
5.3.3 Urban Demand and Supply 5-48
5.3.4 Agricultural Demand and Supply 5-48
5.3.5 Remediation Operations 5-48
5.3.6 Results 5-49
5.3.6.1 Land and Water Use Budget 5-49
5.3.6.2 Groundwater Budget 5-51
5.3.7 Sensitivity Analysis: Hot-Dry Scenario 5-53
6. SUMMARY AND RECOMMENDATIONS 6-1
6.1 Summary 6-1
6.2 Recommendations 6-1
7. REFERENCES 7-1

TABLES

Table 1-1: Groundwater Sustainability Agencies by Subbasin 1-2
Table 1-2: SacIWRM History and Application 1-7
Table 2-1: CoSANA Input Data 2-1
Table 2-2: CoSANA Subregions 2-4
Table 2-3: CoSANA Streams and Tiers 2-11
Table 2-4: Stream Inflows 2-13
Table 2-5: Land Use Categories 2-20
Table 2-6: Sources of Data for Land Use Coverages 2-21
Table 3-1: Summary of CoSANA Well Pumping by Urban Purveyor 3-5
Table 3-2: Summary of Agricultural Groundwater Substitution Transfer Pumping 3-15
Table 3-3: Summary of CoSANA Remediation Operations: 3-15
Table 4-1: Land and Water Use Budget Demand and Supply Mix (Average Annual for the Period WY 1995-2018) 4-9
Table 4-2: Summary of CoSANA Groundwater Budget (Average Annual for the Period WY 1995-2018) 4-14
Table 4-3: Summary of CoSANA Stream Calibration Gages 4-37
Table 4-4: Range of Aquifer Parameter Values 4-44
Table 5-1: Hydrologic Water Year Types 5-3
Table 5-2: CCBL Average Annual Land and Water Use Budget 5-14
Table 5-3: CCBL Average Annual Groundwater Budget 5-17
Table 5-4: Proposed New Developments 5-21
Table 5-5: PCBL Average Annual Land and Water Use Budget 5-35
Table 5-6: PCBL Average Annual Groundwater Budget 5-38
Table 5-7: Percent Change in Annual Climatic and Hydrologic Indicators in the American River Basin Study* 5-41
Table 5-8: PCBL with Climate Change Average Annual Land and Water Use Budget 5-49
Table 5-9: PCBL with Climate Change Average Annual Groundwater Budget 5-51

Table 5-10: Comparison Groundwater Budgets of CoSANA Climate Change Models to the Projected Conditions Baseline 5-53

FIGURES

Figure 1-1: Model Area and Groundwater Subbasin Boundaries 1-3
Figure 1-2: Major Water Purveyors 1-4
Figure 1-3: Groundwater Sustainability Agencies 1-5
Figure 2-1: Features Used to Create Model Grid 2-3
Figure 2-2: CoSANA Model Grid 2-7
Figure 2-3: Alignment with Neighboring Model Grids 2-8
Figure 2-4: CoSANA Subregions 2-9
Figure 2-5: CoSANA Streams 2-12
Figure 2-6: CoSANA Stream Inflow Gage Locations 2-14
Figure 2-7: CoSANA Drainage Network 2-16
Figure 2-8: CoSANA Average Annual Precipitation 2-18
Figure 2-9: CoSANA Average Annual Precipitation with Statistics 2-19
Figure 2-10: 1995 Land Use Coverage 2-22
Figure 2-11: 2005 Land Use Coverage 2-23
Figure 2-12: 2015 Land Use Coverage 2-24
Figure 2-13: Annual Land Use for CoSANA 2-25
Figure 2-14: Annual Land Use for North American Subbasin 2-26
Figure 2-15: Annual Land Use for South American Subbasin 2-27
Figure 2-16: Annual Land Use for Cosumnes Subbasin 2-28
Figure 2-17: Average Monthly Evapotranspiration by Land Use Type, Major Field and Row Crops 2-30
Figure 2-18: Average Monthly Evapotranspiration by Land Use Type, Orchards and Vineyards 2-30
Figure 2-19: Average Monthly Evapotranspiration by Land Use Type, Urban, Native, and Riparian 2-31
Figure 2-20: USDA Hydrologic Soil Groups 2-32
Figure 2-21: Thickness of Layer 1 2-35
Figure 2-22: Thickness of Layer 2 2-36
Figure 2-23: Thickness of Layer 3 2-37
Figure 2-24: Thickness of Layer 4 2-38
Figure 2-25: Thickness of Layer 5 2-39
Figure 2-26: CoSANA Cross Sections 2-40
Figure 2-27: CoSANA Cross Section A-A' 2-41
Figure 2-28: CoSANA Cross Section B-B' 2-41
Figure 2-29: CoSANA Cross Section C-C' 2-41
Figure 2-30: CoSANA Cross Section D-D' 2-42
Figure 2-31: CoSANA Cross Section E-E' 2-42
Figure 2-32: CoSANA Cross Section F-F' 2-42
Figure 2-33: CoSANA Cross Section G-G' 2-43
Figure 2-34: CoSANA Cross Section H-H' 2-43
Figure 2-35: CoSANA Cross Section I-I' 2-43
Figure 2-36: CoSANA Cross Section J-J' 2-44
Figure 2-37: CoSANA Cross Section K-K' 2-44
Figure 2-38: CoSANA Cross Section L-L' 2-44
Figure 2-39: Tributary Watersheds 2-45
Figure 2-40: Initial Conditions, Groundwater Heads, Fall 1989 2-47
Figure 3-1: CoSANA NASb Surface Water Delivery Schematic 3-2
Figure 3-2: CoSANA SASb Surface Water Delivery Schematic 3-3
Figure 3-3: CoSANA CoSb Surface Water Delivery Schematic 3-4

Figure 3-4: Locations of Urban Groundwater Production Wells 3-6
Figure 3-5: Locations of Agricultural Groundwater Substitution Transfer Pumping Wells 3-14
Figure 3-6: Locations of Remediation Pumping Wells 3-16
Figure 4-1: CoSANA Calibration Process 4-2
Figure 4-2: CoSANA Field Capacity 4-4
Figure 4-3: CoSANA Wilting Point 4-5
Figure 4-4: CoSANA Total Porosity 4-6
Figure 4-5: CoSANA Saturated Soil Hydraulic Conductivity 4-7
Figure 4-6: CoSANA Ponded Crop Saturated Soil Hydraulic Conductivity 4-8
Figure 4-7: CoSANA Agricultural Land and Water Use Budget 4-9
Figure 4-8: NASb Agricultural Land and Water Use Budget 4-10
Figure 4-9: SASb Agricultural Land and Water Use Budget 4-10
Figure 4-10: CoSb Agricultural Land and Water Use Budget 4-11
Figure 4-11: CoSANA Model Urban Land and Water Use Budget 4-11
Figure 4-12: NASb Urban Land and Water Use Budget 4-12
Figure 4-13: SASb Urban Land and Water Use Budget 4-12
Figure 4-14: CoSb Urban Land and Water Use Budget 4-13
Figure 4-15: CoSANA Groundwater Budget 4-14
Figure 4-16: NASb Groundwater Budget 4-15
Figure 4-17: SASb Groundwater Budget 4-15
Figure 4-18: CoSb Groundwater Budget 4-16
Figure 4-19: Number of Observations for Calibration Wells 4-17
Figure 4-20: Period of Record for Calibration Wells 4-18
Figure 4-21: CoSANA Groundwater Level Contours – Spring 1998 (End of Wet Period) 4-20
Figure 4-22: CoSANA Groundwater Level Contours – Fall 2015 (End of Drought Period) 4-21
Figure 4-23: CoSANA Groundwater Level Contours – Fall 2018 (End of Simulation) 4-22
Figure 4-24: Location of Sample Hydrographs 4-23
Figure 4-25: CoSANA Groundwater Level Hydrograph – Hydrograph #1 4-24
Figure 4-26: CoSANA Groundwater Level Hydrograph – Hydrograph #2 4-24
Figure 4-27: CoSANA Groundwater Level Hydrograph – Hydrograph #3 4-25
Figure 4-28: CoSANA Groundwater Level Hydrograph – Hydrograph #4 4-25
Figure 4-29: CoSANA Groundwater Level Hydrograph – Hydrograph #5 4-26
Figure 4-30: CoSANA Groundwater Level Hydrograph – Hydrograph #6 4-26
Figure 4-31: CoSANA Groundwater Level Hydrograph – Hydrograph #7 4-27
Figure 4-32: CoSANA Groundwater Level Hydrograph – Hydrograph #8 4-27
Figure 4-33: CoSANA Groundwater Level Hydrograph – Hydrograph #9 4-28
Figure 4-34: CoSANA Groundwater Level Hydrograph – Hydrograph #10 4-28
Figure 4-35: CoSANA Groundwater Level Hydrograph – Hydrograph #11 4-29
Figure 4-36: CoSANA Groundwater Level Hydrograph – Hydrograph #12 4-29
Figure 4-37: CoSANA Groundwater Level Hydrograph – Hydrograph #13 4-30
Figure 4-38: CoSANA Groundwater Level Hydrograph – Hydrograph #14 4-30
Figure 4-39: CoSANA Groundwater Level Hydrograph – Hydrograph #15 4-31
Figure 4-40: CoSANA Groundwater Level Hydrograph – Hydrograph #16 4-31
Figure 4-41: CoSANA Groundwater Level Hydrograph – Hydrograph #17 4-32
Figure 4-42: CoSANA Groundwater Level Hydrograph – Hydrograph #18 4-32
Figure 4-43: CoSANA Groundwater Level Hydrograph – Hydrograph #19 4-33
Figure 4-44: CoSANA Groundwater Level Hydrograph – Hydrograph #20 4-33
Figure 4-45: CoSANA Groundwater Level Hydrograph – Hydrograph #21 4-34
Figure 4-46: CoSANA Groundwater Level Hydrograph – Hydrograph #22 4-34
Figure 4-47: CoSANA Groundwater Level Hydrograph – Hydrograph #23 4-35
Figure 4-48: CoSANA Groundwater Level Hydrograph – Hydrograph #24 4-35

Figure 4-49: CoSANA Groundwater Level Hydrograph – Hydrograph #25 4-36
Figure 4-50: Stream Gage Locations 4-38
Figure 4-51: CoSANA Streambed Hydraulic Conductivity 4-39
Figure 4-52: Streamflow Hydrograph for Sacramento River at Freeport, Simulated and Observed 4-40
Figure 4-53: Sacramento River at Freeport Streamflow Exceedance, Simulated and Observed 4-40
Figure 4-54: Stage for Cosumnes River at McConnell, Simulated and Observed 4-41
Figure 4-55: Cosumnes River at McConnell Stage Exceedance, Simulated and Observed 4-41
Figure 4-56: Residual histogram for the CoSANA Model 4-43
Figure 4-57: Scatter Plot of CoSANA Simulated versus Observed Values 4-43
Figure 4-58: Distribution of CoSANA Layer 1 Horizontal Hydraulic Conductivity (K_H) 4-45
Figure 4-59: Distribution of CoSANA Layer 2 Horizontal Hydraulic Conductivity (K_H) 4-46
Figure 4-60: Distribution of CoSANA Layer 3 Horizontal Hydraulic Conductivity (K_H) 4-47
Figure 4-61: Distribution of CoSANA Layer 4 Horizontal Hydraulic Conductivity (K_H) 4-48
Figure 4-62: Distribution of CoSANA Layer 5 Horizontal Hydraulic Conductivity (K_H) 4-49
Figure 4-63: Sensitivity of Groundwater Level Residual Statistics in NASb 4-55
Figure 4-64: Sensitivity of Groundwater Level Residual Statistics in SASb 4-55
Figure 4-65: Sensitivity of Groundwater Level Residual Statistics in CoSb 4-56
Figure 5-1: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation 5-2
Figure 5-2: Initial Groundwater Levels for CoSANA Baseline Models 5-4
Figure 5-3: Current Conditions Baseline Land Use 5-6
Figure 5-4: Current Conditions Baseline Land Use for CoSANA 5-7
Figure 5-5: Current Conditions Baseline Land Use for North American Subbasin 5-8
Figure 5-6: Current Conditions Baseline Land Use for South American Subbasin 5-9
Figure 5-7: Current Conditions Baseline Land Use for Cosumnes Subbasin 5-10
Figure 5-8: Annual Agricultural Water Demand and Supply – North American Subbasin, Current Conditions Baseline 5-14
Figure 5-9: Annual Agricultural Water Demand and Supply – South American Subbasin, Current Conditions Baseline 5-15
Figure 5-10: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline 5-15
Figure 5-11: Annual Urban Water Demand and Supply – North American Subbasin, Current Conditions Baseline 5-16
Figure 5-12: Annual Urban Water Demand and Supply – South American Subbasin, Current Conditions Baseline 5-16
Figure 5-13: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline 5-17
Figure 5-14: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Current Conditions Baseline 5-18
Figure 5-15: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Current Conditions Baseline 5-18
Figure 5-16: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Current Conditions Baseline 5-19
Figure 5-17: Projected Land Use and Proposed New Developments 5-22
Figure 5-18: Projected Conditions Baseline Land Use for CoSANA 5-23
Figure 5-19: Projected Conditions Baseline Land Use for North American Subbasin 5-24
Figure 5-20: Projected Conditions Baseline Land Use for South American Subbasin 5-25
Figure 5-21: Projected Conditions Baseline Land Use for Cosumnes Subbasin 5-26
Figure 5-22: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline 5-35
Figure 5-23: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline 5-36
Figure 5-24: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline 5-36
Figure 5-25: Annual Urban Water Demand and Supply – North American Subbasin, Projected Conditions Baseline 5-37

Figure 5-26: Annual Urban Water Demand and Supply – South American Subbasin, Projected Conditions Baseline.... 5-37
Figure 5-27: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline 5-38
Figure 5-28: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline 5-39
Figure 5-29: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline 5-39
Figure 5-30: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline 5-40
Figure 5-31: Annual Precipitation with and without Climate Change 5-43
Figure 5-32: Average Monthly Precipitation with and without Climate Change 5-44
Figure 5-33: Annual Folsom Reservoir Releases to American River with and without Climate Change 5-45
Figure 5-34: Monthly Average Folsom Reservoir Releases to American River 5-46
Figure 5-35: Exceedance Chart for the Monthly Folsom Reservoir Releases to American River 5-46
Figure 5-36: Annual Potential Evapotranspiration for Pasture 5-47
Figure 5-37: Monthly Average Potential Evapotranspiration for Pasture 5-48
Figure 5-38: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline with Climate Change 5-49
Figure 5-39: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline with Climate Change 5-50
Figure 5-40: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change 5-50
Figure 5-41: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline with Climate Change 5-51
Figure 5-42: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline with Climate Change 5-52
Figure 5-43: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change 5-52

APPENDICES

Appendix A: Model Surface Water Deliveries
Appendix B: Remediation Pumping by Entity
Appendix C: Subregion Land and Water Use Budgets
Appendix D: Stream Reach Budgets
Appendix E: Subregion Groundwater Budgets
Appendix F: Calibration Hydrographs
Appendix G: Baseline Conditions Demand and Supply Tables
Appendix H: Baseline Conditions Land and Water Use Budgets
Appendix I: Baseline Conditions Groundwater Budgets
Appendix J: Baseline Conditions Sample Hydrographs

ABBREVIATIONS

2070CT	2070 Central Tendency
2070HD	2070 Hot and Dry
AFY	acre-feet per year
ARBS	American River Basin Study
ASR	aquifer storage and recovery
ASTM	American Standard Testing Method
AWMP	Agricultural Water Management Plan
C2VSimFG	California Central Valley Groundwater-Surface Water Simulation Model
Cal Am	California American Water Company
CalSIMETAW	California Simulation of Evapotranspiration of Applied Water
CASGEM	California Statewide Groundwater Elevation Monitoring
CDEC	California Data Exchange Center
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CoSANA	Cosumnes-South American-North American Integrated Water Resources Model
CoSb	Cosumnes Subbasin
CSD	Community Services District
CWD	community water district
DEM	digital elevation model
DWR	California Department of Water Resources
ESJ	Eastern San Joaquin Groundwater Subbasin
ET	evapotranspiration
ET_o	reference ET
ET_c	crop coefficient
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
GWMP	City of Sacramento's 2017 Groundwater Master Plan
ID	irrigation district; identifier
IDC	IWFM Demand Calculator
IGSM	Integrated Groundwater and Surface Water Model
IWFM	Integrated Water Flow Model
JVID	Jackson Valley Irrigation District
METRIC	Mapping Evapotranspiration at High Resolution with Internalized Calibration
NASb	North American Subbasin
NRCS	Natural Resource Conservation Service
PCWA	Placer County Water Agency
PRISM	Precipitation-Elevation Regressions on Independent Slopes Model
Reclamation	United States Bureau of Reclamation
RMCSD	Rancho Murieta Community Services District
RMSE	root mean square error
RWA	Regional Water Authority
SacIWRM	Sacramento Area Integrated Water Resources Model
SAFCA	Sacramento Area Flood Control Agency
SASb	South American Subbasin
SCGA	Sacramento Central Groundwater Authority
SCWA	Sacramento County Water Agency
SGA	Sacramento Groundwater Authority
SGMA	Sustainable Groundwater Management Act

SMUD	Sacramento Municipal Utility District
SSCAWA	Southeast Sacramento County Agricultural Water Authority
SSURGO	Soil Survey Geographic Database
STATSGO2	Digital General Soil Map of the United States
SVSim	Sacramento Valley Groundwater-Surface Water Simulation Model
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WA	water agency
WC	water company
WD	water district
WDL	Water Data Library
WY	water year
YGM	Yuba Groundwater Model

ACKNOWLEDGEMENTS

The Cosumnes-South American-North American Integrated Water Resources Model (CoSANA) was developed in a collaborative effort with representatives of the North American Subbasin (NASb), South American Subbasin (SASb), and the Cosumnes Subbasin (CoSb). This collaborative approach spanning three subbasins improves the ability for local water managers and stakeholders to use CoSANA to for a range of regional planning efforts.

Funding of the CoSANA model was also a collaborative effort, with contributions from the Sacramento Groundwater Authority (SGA), Regional Water Authority (RWA), Sacramento Central Groundwater Authority (SCGA), Sacramento Area Flood Control District (SAFCA), and Southeast Sacramento County Agricultural Water Authority (SSCAWA). Contributions from SGA, SSCAWA, Sacramento Water Forum, Sacramento County, and the seven groundwater sustainability agencies (GSAs) represented by the Cosumnes Subbasin Sustainable Groundwater Management Act (SGMA) Working Group supported by grants from the California Department of Water Resources' Proposition 1, Round 2 Sustainable Groundwater Planning Grant Program

A technical committee consisting of working groups from each of the three subbasins provided technical support and quality assurance throughout the model development. Working groups included agencies and consultant teams representing the NASb, SASb, and CoSb with knowledge of the area. Participation by representatives of regional water agencies and GSA representatives, including SGA, RWA, SCGA, SAFCA, SSCAWA and the Sacramento Water Forum, allowed for incorporation of information related to stakeholders within those organizations and beyond. Further progress was shared at meetings associated with development of groundwater sustainability plans (GSPs) to gain additional input and information.

Model development was led by RWA and supported by input and efforts of many entities and their consultants, including:

- RWA/SGA
  - Rob Swartz
  - Monica Garcia
- SCGA
  - John Woodling
  - Ramon Roybal
  - Bob Gardner
- The Sacramento Water Forum
  - Tom Gohring
- SAFCA
  - Gary Bardini
- Department of Water Resources
  - Can Dogrul
  - Tyler Hatch
  - Tariq Kadir
- Each GSA within the North American, South American, and Cosumnes Subbasins and their representatives
- Many other water purveyor and remediation site representatives that provided information to better simulate their areas and operations.

Woodard & Curran was the lead consultant for development of the CoSANA model with substantial assistance from stakeholders, subbasin representatives, and their consultants. The Woodard & Curran project team included:

- Ali Taghavi
- Jim Blanke
- Sebastien Poore
- Sara Miller
- Sevim Onsoy
- Brian Van Lienden
- Sercan Ceyhan
- Mesut Cayar

Other consultants who contributed to the model development included:

- EKI Environment and Water
  - John Fio
  - Dave Leighton
  - Christina Lucero
- GEI Consultants
  - Jonathan Goetz
  - Richard Shatz
- Larry Walker Associates
  - Laura Foglia
  - Rich Pauloo
- MBK Engineers
  - Lee Bergfeld
  - Angela Bezzone
  - Kyle Knutson

The CoSANA team is grateful for the many entities that provided assistance or data to characterize the groundwater and surface water systems in the greater Sacramento region, including many urban water purveyors, agricultural entities, environmental groups, GSA representatives, managers of contamination remediation operations, project proponents, private domestic and rural residential well owners. The team is also appreciative of the California Department of Water Resources for their assistance in implementing the CoSANA model on the Integrated Water Flow Model (IWFM) platform.

EXECUTIVE SUMMARY

CoSANA, the Cosumnes-South American-North American, Integrated Water Resources Model, is a regional integrated water resources model developed as an upgrade and enhancement of the existing Sacramento Area Integrated Water Resources Model (SacIWRM). The enhanced integrated groundwater and surface water simulation capabilities afforded by CoSANA are intended to assist in a broad range of water management activities in the Sacramento Region. CoSANA is built on the Integrated Water Flow Model (IWFM) framework, which is specifically designated in Sustainable Groundwater Management Act (SGMA) Groundwater Sustainability Plans (GSP) regulations as being supported by the California Department of Water Resources for water budget development within GSPs. The model is developed with specific features to support development of sustainable groundwater management strategies and policies and compliance with SGMA, as well as to support the planning and implementation of regional conjunctive use and water banking efforts and other water management activities.

CoSANA at a Glance

Model area: North American, South American, and Cosumnes Groundwater Subbasins

Modeling Platform: IWFM

Layering: 5 layers representing major formations to the base of fresh water

Elements: 24,171 elements with an average element area of 37 acres

Stream system: 27 simulated streams with 51 reaches

Land Use: 24 land use types, including 20 agricultural crops

Water Supply: Surface water, groundwater, and recycled water supply to agricultural and urban water purveyors

Remediation Pumping: Groundwater extraction and cleanup at 4 remediation sites

Hydrologic period: Water Years 1970-2019 on a monthly time step

Stakeholder participation was a key component in the development of CoSANA, which enabled the model development team to work in a collaborative and transparent environment and to obtain the local data necessary to develop a detailed model, gain input and insight from those most knowledgeable about the subbasins, and to gain stakeholder buy-in, which is necessary for broad regional acceptance. Outreach activities included coordination with representatives of regional water agencies and groundwater sustainability agencies, including the Regional Water Authority, Sacramento Groundwater Authority, Sacramento Central Groundwater Authority, Sacramento Area Flood Control Agency, Southeast Sacramento County Agricultural Water Authority, and the Sacramento Water Forum. Further, progress was shared at meetings associated with development of GSPs for each of the three subbasins to gain additional input and information.

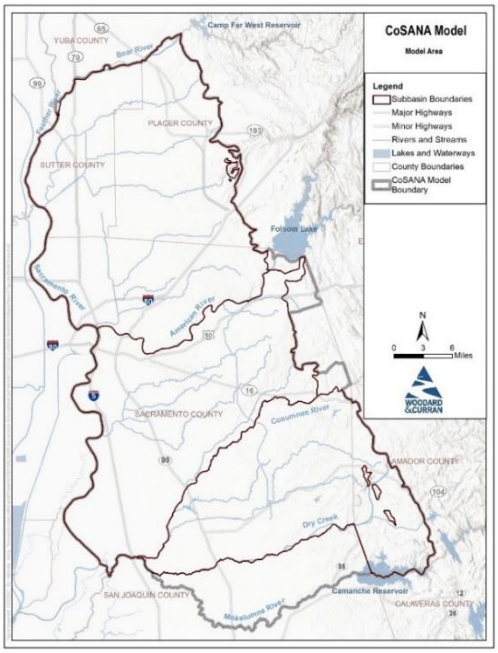


Figure ES-1: Model Area

ES.1 Model Area

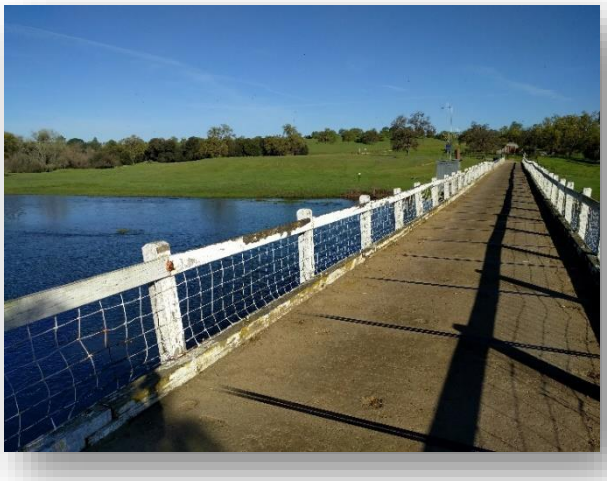
The model area covers nearly 900,000 acres (approximately 1,400 square miles) and is bounded in the north by the Bear River, in the south by the Mokelumne River, in the west by the Sacramento River, and in the east by the Sierra Nevada foothills. This area includes the entirety of the North American, South American, and Cosumnes Groundwater Subbasins. Portions of the Eastern San Joaquin Subbasin are included for consistency with past efforts but are not updated or calibrated to the same level as the North American, South American, and Cosumnes Subbasins. The physical model boundaries are shown in Figure ES-1.

CoSANA performs calculations related to water flow by breaking down the model area into smaller areas both horizontally and with depth. This is known as discretization. Smaller areas and more layers allow for more detailed modeling, but optimal discretization is found by weighing these benefits against limitations of data availability and computational power. The CoSANA model grid contains 24,171 finite elements and 22,274 nodes with an average element area of 37 acres. The overall node spacing is 1,170 feet on average with a maximum of 2,210 feet and a minimum of 300 feet. Smaller node spacing is present near streams and near areas of significant groundwater contamination, where more accurate calculations are called for. The subsurface is characterized by five model layers representing the different geologic conditions from the ground surface to the shallower of the bedrock or base of fresh water. These layers represent:

- Layer 1: Recent alluvium and the Riverbank Formation
- Layer 2: Laguna Formation
- Layer 3 Mehrten Formation
- Layer 4: Valley Springs Formation
- Layer 5: Ione Formation

The development of CoSANA included collection and compilation of a broad range of data related to land use, water use, hydrologic conditions, and hydrogeologic conditions, including:

- Geologic stratification
- Aquifer parameters
- Stream configuration
- Stream flows
- Small watersheds
- Precipitation
- Land use
- Evapotranspiration
- Soil properties
- Population
- Per capita water use
- Groundwater pumping
- Groundwater levels
- Surface water deliveries
- Boundary conditions
- Initial conditions



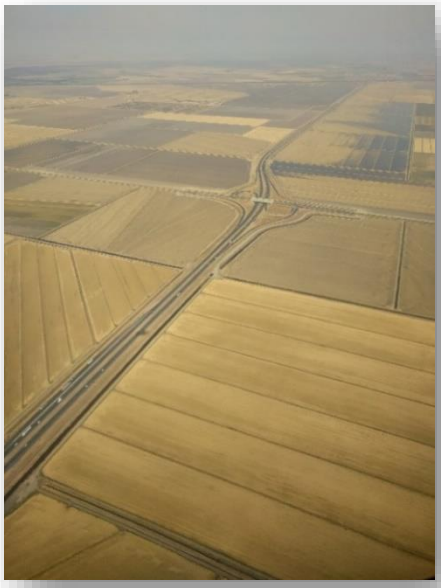
These and other datasets were developed based on local data, state databases, and federal databases and provided as input to CoSANA, on a monthly time step.

ES.2 Historical Simulation and Model Calibration

The CoSANA model simulates historical conditions in the basin for the period of water years 1970 through 2018 (October 1, 1969 through September 30, 2018). While the modeling time period begins in water year 1970, consistent with the SacIWRM, the focus of this modeling effort was water years 1990 – 2018, which includes substantially more refined data than the earlier years. Water years 1990 – 1994 are used as a warm-up period for the model, and water years 1995-2018 are used for model calibration. Additionally, the entire period of water year 1970-2018 is then used to perform a verification of the model performance over longer hydrologic period.

The simulation of historical conditions is intended to both help better understand and quantify the groundwater flow system and to calibrate the overall groundwater model. The calibration process involves comparison of simulated and observed data combined with adjustments to certain parameters. Data related to groundwater levels, streamflows, and water budgets were incorporated into the calibration process. Parameter adjustments were made within certain tolerance ranges that are reflective of the uncertainties associated with each parameter. The calibration process included both manual calibration by reviewing results and making appropriate adjustments as needed to reflect the long-term trends and short-term seasonal changes in observed data. Additionally, the PEST software package was employed to refine the calibration results by adjusting the soil, aquifer, and stream parameters within a reasonable range and distribution to achieve a better match between observed and simulated data. In this manner, the model is able to improve estimates for parameters lacking comprehensive data, such as agricultural groundwater production or certain aquifer parameters, resulting in better overall model performance.

ES.3 Baseline Simulations



Baseline simulations were developed to represent a set of pre-established hydrologic, land and water use, water demand, water supply, and basin operational conditions. In addition to providing valuable information on the groundwater flow system, these baselines can be implemented to evaluate effects of particular projects or management actions. The baselines incorporate 50 years of hydrology (water years 1970 – 2019) to meet SGMA requirements and to provide climatic variability necessary to assess future projects and management actions. Baseline simulations were developed for four different conditions:

- **Current Conditions:** The CoSANA Current Conditions Baseline (CCBL) is a representation of long-term average conditions assuming that a recent level of development and water demand persists over a long-term period of hydrologic conditions.
- **Projected Conditions:** The CoSANA Projected Conditions Baseline (PCBL) is a representation of the projected land and water use conditions of 2040, applied to the same long-term hydrologic conditions. Projected conditions are generally based on information from land use agencies and from Urban Water Management Plans or other planning documents from water purveyors.
- **Projected Conditions with Climate Change:** The CoSANA Projected Conditions Baseline with Climate Change (PCBL with Climate Change) shares many of the same inputs as the PCBL, but with additional factors to incorporate potential climate change conditions. Climate change conditions are represented through incorporation of information on 2070 Central Tendency (2070CT) conditions as documented by the US Bureau of Reclamation in the American River Basin Study (ARBS). In addition to the 2070CT, sensitivity of the model results and groundwater levels and storage was evaluated using a 2070 Hot and Dry (2070HD) climate scenario from the ARBS.

ES.4 Simulated Groundwater Conditions

Groundwater conditions associated with the historical simulation and the baseline simulations are presented in the report as contour maps, hydrographs, and water budgets. A summary-level groundwater budget for the three groundwater subbasins in the model area is presented in Table ES-1, below. This groundwater budget shows positive change in storage for the historical conditions, Current Conditions Baseline, and Projected Conditions Baseline, and a negative change in storage for the Projected Conditions with Climate Change Baseline (based on 2070CT). Generally, positive change in storage is associated with rising groundwater levels as the system seeks a new equilibrium with the surface water system and surrounding subbasins, while negative change in storage is associated with declining groundwater levels.

Table ES-1: Groundwater Budgets for the Combined North American, South American, and Cosumnes Subbasins

Model Version	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Boundary Flows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
Historical (1995–2018)	667,460	428,359	206,837	18,335	7,003*	11,302	26,702
CCBL	643,595	413,447	188,397	16,758	33,656	8,147	16,768
PCBL	685,501	396,714	230,109	16,402	36,561	8,726	2,969
PCBL+ Climate Change	726,028	377,207	261,089	16,427	40,481	11,378	-19,486

Note: all values presented in acre-feet per year (AFY)

CoSANA provides substantial detail that can allow for disaggregating these results spatially and temporally. For instance, as shown in Table ES-2, the North American Subbasin shows the most positive change in storage and the Cosumnes Subbasin shows the most negative change in storage, with values for the South American Subbasin in the middle. Similar differences exist within the subbasins as well, with areas receiving surface water and/or using little groundwater having generally more positive change in storage and groundwater levels and areas using more groundwater and/or receiving little surface water having generally more negative change in storage and groundwater levels. Groundwater conditions and model output are complex, and substantial detail is presented in the main report.

Table ES-2: Estimates of Average Change in Groundwater Storage by Subbasin

Model Version	North American Subbasin (AFY)	South American Subbasin (AFY)	Cosumnes Subbasin (AFY)	Total (AFY)
Historical (1995–2018)	26,661	5,551	-5,510	26,702
CCBL	14,843	2,158	-233	16,768
PCBL	5,390	-1,128	-1,293	2,969
PCBL+ Climate Change	-3,502	-6,222	-9,762	-19,486

ES.5 Recommendations

Like the SacIWRM before it, the CoSANA model is intended to be a living model, with refinements and updates occurring over time to meet the changing needs of the region and to incorporate the latest conditions, data, and modeling platforms. During the development of the model, several items were identified for future refinements to improve the capability of CoSANA to be a long-term defensible and reliable water resources model for the area, as listed below with additional detail in the main report.

- Continue collaboration and engagement with local GSAs, water purveyors, groundwater users, and water managers
- Collaborate with DWR
- Develop a model update schedule
- Enhance representation of variability of potential evapotranspiration
- Map Soil Survey Geographic Database (SSURGO) rootzone parameters directly to CoSANA
- Refine surface water deliveries in the North American and South American Subbasins
- Improve inflow estimates for tributary streams
- Improve return flow routing within IFWM and CoSANA
- Improve data and simulation of Auburn Ravine flows
- Develop improved rating tables for major streams
- Improve simulation of complex water systems
- Improve data for Mather AFB remediation operations
- Improve model information and data sets on the eastern areas

ES.6 Summary

The CoSANA model is built upon the previous SacIWRM by migrating to the IWFM platform, providing finer resolution spatially and with depth, and by refining and extending the data incorporated into the model. CoSANA provides a robust, comprehensive, defensible model for assessing water resources conditions in the Sacramento Region through integrated modeling of land surface, groundwater, and surface water conditions using detailed local and regional data and the most widely accepted modeling platform. This includes simulation under historical, current, projected, and projected with climate change conditions. The tool is well calibrated and ready to be used in various water supply and management studies and is flexible enough to be updated and refined to meet future needs of the region, including implementation of sustainable groundwater management strategies, regional water accounting and allocation frameworks, evaluation of well protection plans and programs, and regional conjunctive use and projects assessments, including the regional water bank.

1. INTRODUCTION

The North American, South American, and Cosumnes Groundwater Subbasins are simulated under a unified model to provide a regional integrated water resources model suitable for a variety of regional water management needs. With a comprehensive long-term hydrologic period, robust and accurate water supply and use data for urban water purveyors, land use and cropping patterns based on the latest statewide and regional land use surveys, geologic and hydrogeologic information based on the statewide numerical and texture models, and surface water hydrologic data, The Cosumnes-South American-North American Integrated Water Resource Model, or CoSANA, is a comprehensive integrated water resources model to serve the North and South American and Cosumnes groundwater subbasins. CoSANA incorporates all relevant data from the Sacramento Area Integrated Water Resources Model (SacIWRM).

1.1 Goals of Model Development

The primary goal of development of CoSANA is to have a robust, technically sound, publicly accepted analytical computer tool that simulates the details of the integrated land surface system; stream and river system; and groundwater hydrologic and hydrogeologic system in the model area for use in regional water management.

This goal represents continuation of successful use of the SacIWRM, which was implemented for numerous diverse water management efforts over three decades. Updating, refining, and modernizing SacIWRM into the new state-of-the-art CoSANA platform has a goal of providing a technical and analytical tool through conducting the work in a collaborative and open environment to gain regional acceptance in the water community of the greater Sacramento region. Together, the tool and regional acceptance can allow for a broad, regional, consistent modeling approach that can provide defensible, robust, consistent results in a more efficient manner.

While CoSANA is intended to assist in a broad range of water management activities in the area, the model is developed with specific features to support development of sustainable groundwater management strategies and policies and compliance with the Sustainable Groundwater Management Act (SGMA), as well as to support the planning and implementation of regional conjunctive use and water banking efforts.

CoSANA is used for the development of the groundwater sustainability plans (GSPs) for North American Subbasin (NASb), South American Subbasin (SASb), and Cosumnes Subbasin (CoSb), including work related to:

- Hydrogeologic conceptual model
- Sustainable management criteria
- Water budgets and sustainable yield
- Monitoring networks
- Projects and management actions to achieve sustainability
- Outreach, reporting, and ongoing analysis

CoSANA is also intended to support work associated with a Sacramento regional water bank, including:

- Identification of benefits and impacts
- Water bank accounting
- Quantification of losses
- Integration with surface water reservoir operations models
- FloodMAR opportunities assessment and design
- Outreach, reporting, and ongoing analysis

CoSANA is developed to support analysis of a broad range of regional water management efforts.

1.2 Cosumnes, South American, and North American Subbasins

CoSANA simulates the North American (5-021.64), South American (5-021.65), and Cosumnes (5-022.16) Groundwater Subbasins, along with a small portion of the Eastern San Joaquin (ESJ) (5-022.01) Groundwater Subbasin. The focus of the model is the NASb, SASb, and CoSb subbasins, with less detail provided for the ESJ Subbasin. Figure 1-1 shows the model domain and the boundaries of the associated subbasins. Portions outside of the groundwater subbasins were included in the model area to avoid breaking up larger urban areas, including the City of Folsom and Rancho Murieta Community Services District (RMCSD). The model area includes portions of Amador, Placer, Sacramento, San Joaquin, and Sutter Counties. The CoSANA model domain is similar to the SacIWRM model domain, with some differences due to changes in groundwater subbasin boundaries.

NASb and SASb are categorized as high priority groundwater subbasins and CoSb is categorized as a medium priority groundwater subbasin under the California Statewide Groundwater Elevation Monitoring (CASGEM) program. None of these three subbasins are identified by the California Department of Water Resources (DWR) as critically overdrafted. As such, groundwater sustainability agencies (GSAs) in these three subbasins must develop GSPs by January 31, 2022 that detail how each subbasin will be managed in a sustainable manner by 2042. CoSANA is developed to assist in that process.

Table 1-1 lists 17 GSAs covering the NASb, SASb, and CoSb Subbasins. The GSAs include the major urban water purveyors, agricultural water purveyors, or other agencies which supply water or have land use authority within the subbasin. The water purveyors are shown in Figure 1-2 and the GSAs are shown in Figure 1-3.

Table 1-1: Groundwater Sustainability Agencies by Subbasin

Subbasin	GSA
North American Subbasin	Reclamation District 1001
	Sacramento Groundwater Authority
	South Sutter Water District
	Sutter County
	West Placer County
South American Subbasin	Sacramento County
	Northern Delta
	Omochumne-Hartnell Water District
	Sacramento Central Groundwater Authority
	Sloughhouse Resource Conservation District
Cosumnes Subbasin	Amador County Groundwater Management Authority
	City of Galt
	Clay Irrigation District
	Galt Irrigation District
	Omochumne-Hartnell Water District
	Sacramento County
	Sloughhouse Resource Conservation District

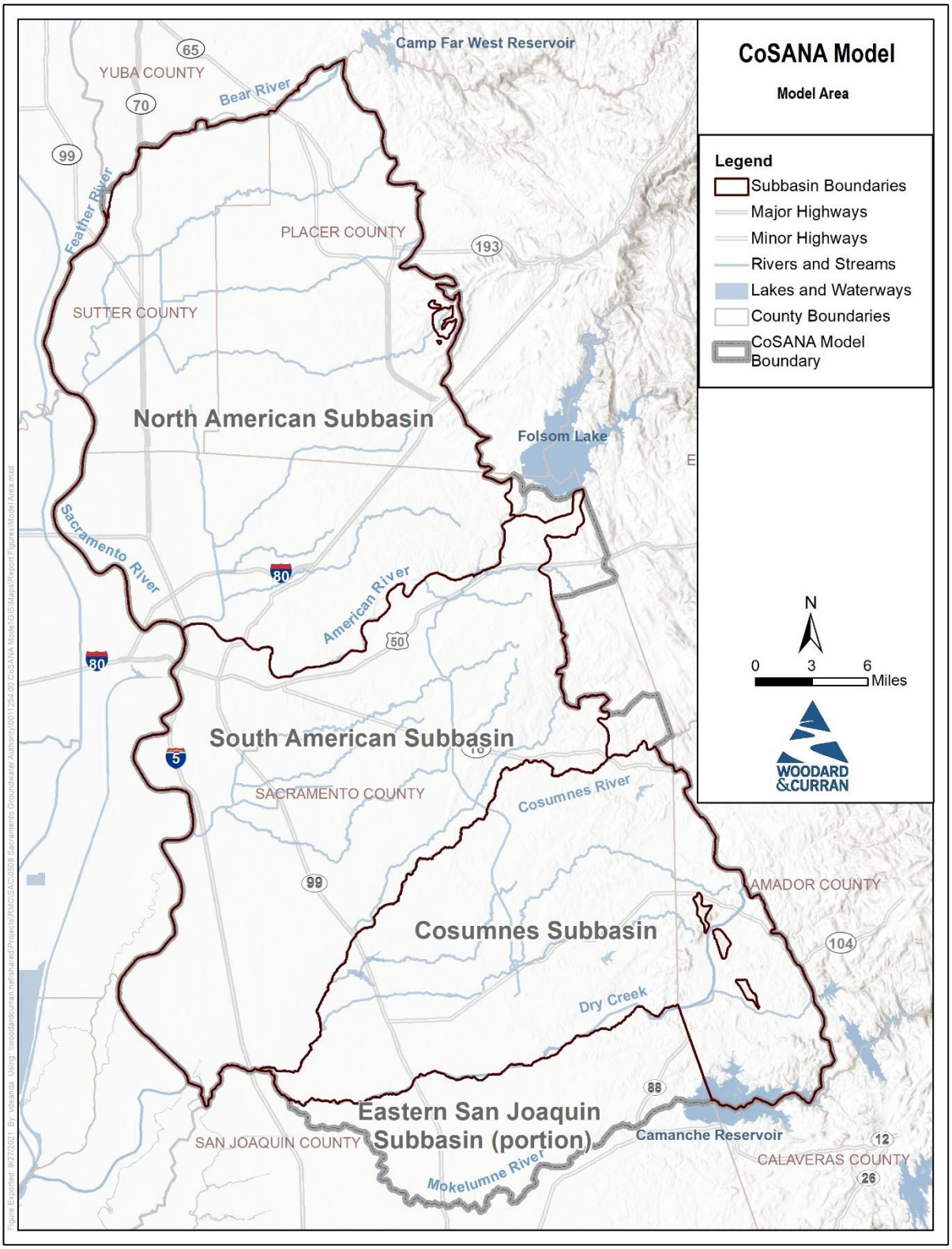


Figure 1-1: Model Area and Groundwater Subbasin Boundaries

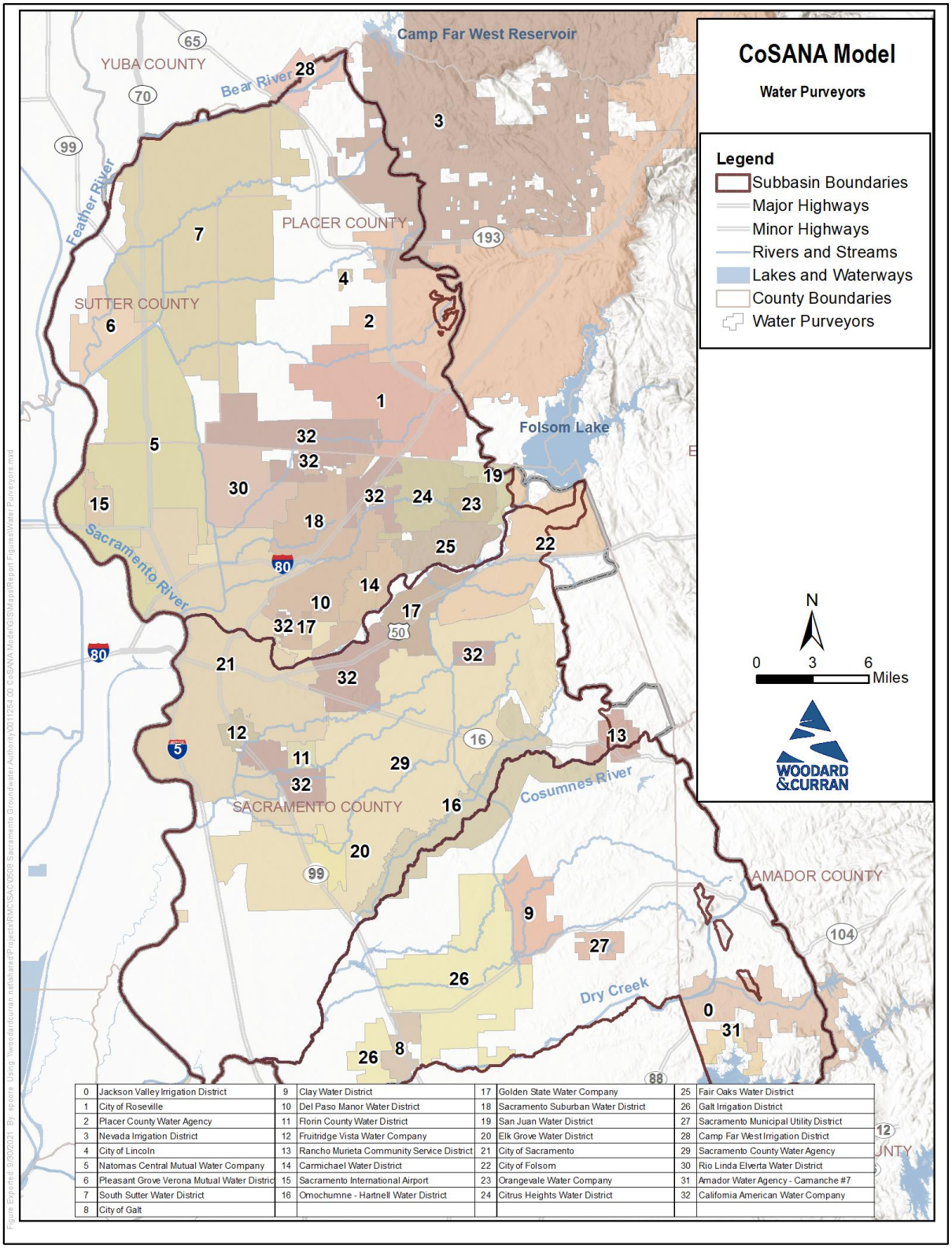


Figure 1-2: Major Water Purveyors

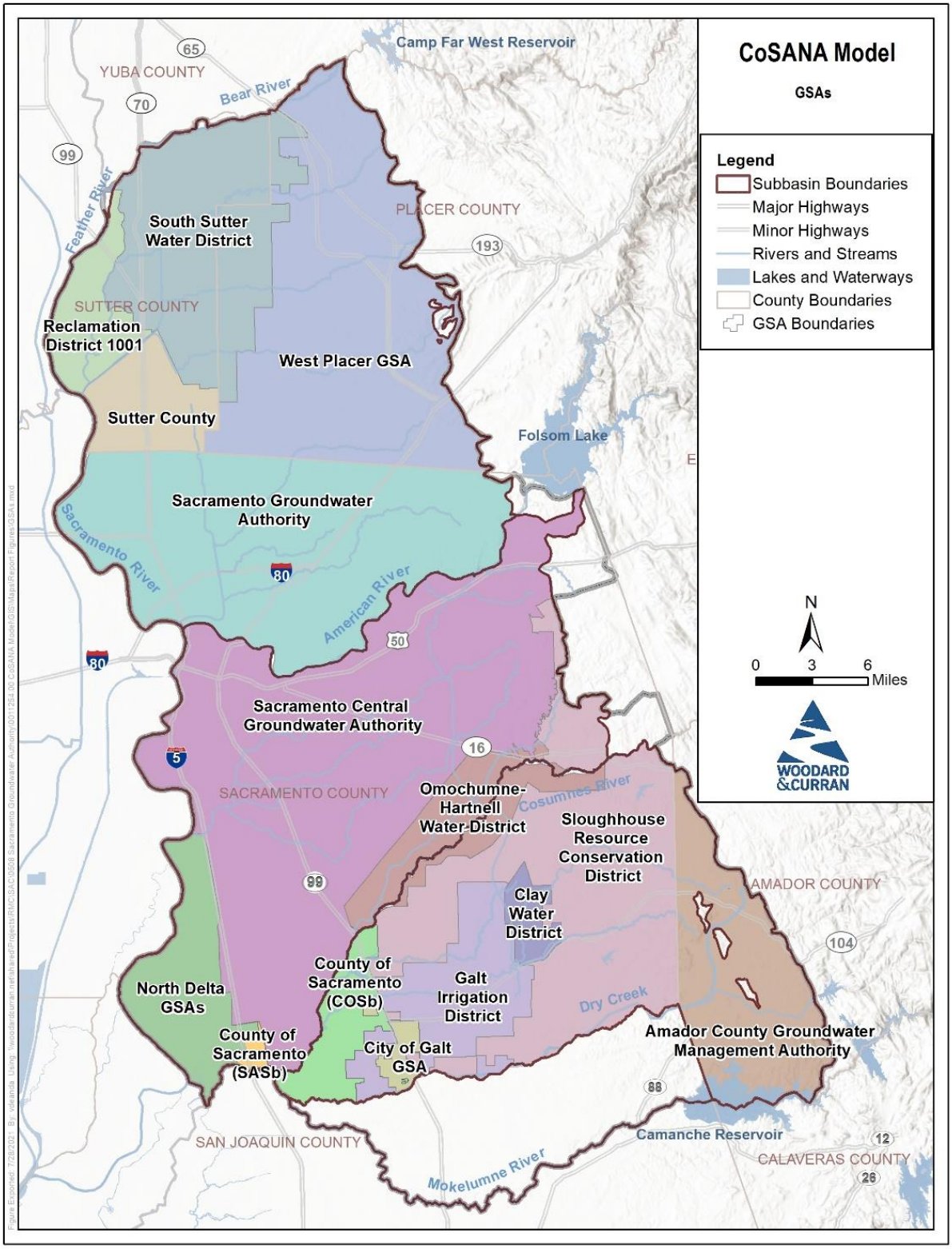


Figure 1-3: Groundwater Sustainability Agencies

1.3 Collaborative and Open Environment

Model development was conducted in a collaborative and open environment and was coordinated with various entities representing the three groundwater subbasins, including Sacramento Groundwater Authority (SGA), Sacramento Central Groundwater Authority (SCGA), Sacramento Area Flood Control Agency (SAFCA), Sacramento County, Regional Water Authority (RWA), the Sacramento Water Forum, the Cosumnes Subbasin SGMA Working Group (referred to as the "Working Group"), GSAs, and associated consultants.

The development of CoSANA took place in an open and transparent process and in a collaborative environment, with regular meetings between technical and working group members discussing model technical specifics and sharing model data, assumptions, data analysis and development, calibration approach and process, as well as interim and final results. The modeling team additionally met with local agencies individually to review model data and gather additional information to support refining model and data assumptions during model development.

Participation by representatives of regional water agencies and GSA representatives, including SGA, RWA, SCGA, SAFCA, Southeast Sacramento County Agricultural Water Authority (SSCAWA), the Sacramento Water Forum, and the Cosumnes Subbasin Working Group allowed for incorporation of information related to stakeholders within those organizations and associated subbasins. Further, progress was shared at meetings associated with development of GSPs for each of the three subbasins to gain additional input and information. These presentations provided details on the goals and progress of CoSANA development and also served as a method to request information and data from stakeholders.

In addition to coordination activities during development of the CoSANA model, the completed model was compared to models in the surrounding subbasins to assess consistency. The assessment focused primarily on subsurface flows, although other components, including stream seepage, were also reviewed. The assessment included meetings with modeling representatives from surrounding subbasins, including the Yolo, Yuba, and Solano Subbasins. Subsurface flows were found to be similar in magnitude, although in some cases in opposite directions. These differences were not considered substantial enough to impact the ability to use model results for management purposes within the GSP. This is due to the relatively small differences in comparison to other components of the groundwater budget and due to the calibrated nature of the models, where small differences in subsurface flows may be balanced out by similar differences in other calibrated components of the model. Coordination is expected to continue in the future, where information gained by recent modeling in the various subbasins can be incorporated into future refinements of CoSANA and the neighboring models to reduce the differences and improve model performance.

1.4 Model Platform and Historical Modeling of the Region

SacIWRM and predecessor models have been used to simulate and analyze the North American, South American, and Cosumnes Subbasins since 1992. The models have contributed to many regional and local studies, including supporting the Water Forum Agreement and implementation of groundwater management plans (Table 1-2). SacIWRM was developed based on the Integrated Groundwater and Surface Water Model (IGSM) code, developed in the early 1990s by DWR and the United States Bureau of Reclamation (Reclamation) to simulate Central Valley operations. SacIWRM underwent six major upgrades since first being developed, with the last major update to the northern portion of the model in 2007 and to the central portion in 2016. SacIWRM includes data from 1970 through 2011 and is still in active use for various projects.

CoSANA is developed by porting and refining the data from the older model SacIWRM into the newer DWR code that replaced IGSM in the early 2000s, called Integrated Water Flow Model (IWFM). IWFM is an open-source, finite element simulation code that supports triangular and quadrilateral elements (Dogrul et al., 2017a). It is specifically designated in the GSP regulations as being supported by DWR for water budget development within GSPs. It is also the code used for DWR's California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG), which supports SGMA activities throughout the Central Valley at the regional scale (Brush et al., 2013; DWR, 2020). The IWFM Demand Calculator (IDC) is the stand-alone root zone component of IWFM that simulates land surface and root zone

flow processes (Dogrul et al., 2017b). It calculates agricultural and urban water demands using inputs including climate conditions, soil parameters, and land use types and distribution. It can be run separately or combined with IWFM. IDC was run combined with IWFM, and data development and results in this documentation are included as part of overall IWFM datasets and results.

The model area covers 888,548 acres and is bounded in the north by the Bear River, in the south by the Mokelumne River, in the west by the Sacramento River, and in the east by the Sierra Nevada foothills. The physical model boundaries are shown in Figure 1-1.

Table 1-2: SacIWRM History and Application

Year	Study
1992	City-wide Model
1993	County-wide Model
1996	American River Water Resources Investigation
1996	Northridge Conjunctive Use Study
1996	Rio Linda Water Supply Analysis
1996	Hydrology Update
1996	Water Forum- Basin Yield
1999	Sunrise Douglas Water Supply Analysis
1999	Zone 40 (North Vineyard Well Field)
2000	American River Basin Cooperating Agencies Studies
2002	Aerojet Surface Water Discharge Permit
2004	Zone 40 Water Supply Master Plan Update
2005	Natomas Central Mutual Water Company Impacts Assessment
2005	Rio Del Oro Impacts Study
2007	Sutter Measure M Impact Study
2007	Sun Creek Development
2008	Model Comprehensive Update
2009	SCGA Well Protection Program
2009	Cosumnes River Hydrologic Study
2010	RWA Water Accounting Framework
2011	The Nature Conservancy (TNC) Reservoir Re-Operation Study
2012	South County Recycled Water Feasibility Study
2012	TNC Conjunctive Use Study
2012	TNC/California Water Foundation Central Valley Hydrologic Study
2014	TNC Groundwater Banking Feasibility
2015	SCGA Biennial Groundwater Management Plan Report
2016	Sacramento Regional County Sanitation District Climate Change Assessment & Environmental Impact Report Support
2017	Harvest Water, Water Storage Investment Program, City of Sacramento Groundwater Master Plan
2018	Dynamic linkage with the Yolo IGSM
2020	Grandpark Specific Plan Development

1.5 Report Organization

The remainder of this report is organized as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 describes the historical model development, including the design of the model grid, layering, and input data for the root zone, groundwater, surface water, and land surface modules.
- Chapter 3 describes model input data for water supply and demand. Assumptions associated with agricultural and urban water use are described in this chapter.
- Chapter 4 describes the methodology used for the calibration of model parameters. Final parameters used in the model are provided along with model results and comparisons to observed data. This chapter also includes a sensitivity analysis of model results with perturbed input parameters.
- Chapter 5 describes the baseline conditions. The Current Conditions Baseline (including the input data for water supply and demand and the model results), Projected Conditions Baseline (including the land use, water supply and demand data used and the model results), and Projected Conditions with Climate Change Baseline (including the hydrologic data used and the model results) are described in this chapter.
- Chapter 6 presents a summary of the report and provides recommendations for future activities.
- Chapter 7 presents a list of references used in this report.

2. MODEL DEVELOPMENT

This section presents the source and analysis of input data used in the development of CoSANA. This includes spatial and temporal information for hydrologic, hydrogeologic, water use, water supply, and operations data sets included in the model, as well as physical settings, parameters, and assumptions.

2.1 Model Input Data

IWFM model files and corresponding major data sources used in the development of CoSANA are presented in Table 2-1 along with the report sections where the model data and data sources are described.

Table 2-1: CoSANA Input Data

Major Data Category	Minor Data Category	Data Source	Report Section
Hydrogeological Data	Geologic Stratification	Local information	2.10
	Aquifer Parameters	USGS texture model	4.5.3
Stream Data	Stream Configuration	C2VSim SVSim SacIWRM Local information	2.4
	Stream Inflow	USGS & CDEC stream gages Local information	2.4
	Calibration Gages	USGS & CDEC stream gages	4.2.3
Hydrological Data	Precipitation	PRISM & CalSIMETAW	2.6
Agricultural Water Demand	Land Use	DWR county surveys CropScape DWR statewide mapping Local information	2.7
	Evapotranspiration	C2VSim METRIC Local information	2.8
	Soil Properties	SSURGO STATSGO2	2.9
Urban Water Demand	Population	U.S. Census Bureau tract data	3.3.1
	Per Capita Water Use	Local information California Water Plan	3.2
Water Supply	Groundwater Pumping	Local information SacIWRM	3.1.2
	Surface Water Deliveries	Local information SacIWRM	3.1.1
Other	Boundary Conditions	C2VSim Local information	2.12
	Initial Conditions	Water Data Library	2.13
	Small Watersheds	C2VSim	2.11
	Calibration Wells	DWR Local information	4.2.2

Abbreviations: C2VSim: California Central Valley Groundwater-Surface Water Simulation Model; CalSIMETAW: California Simulation of Evapotranspiration of Applied Water; CDEC: California Data Exchange Center; DWR: California Department of Water Resources; METRIC: Mapping Evapotranspiration at High Resolution with Internalized Calibration; SacIWRM: Sacramento Integrated Water Resources Mode; PRISM: Precipitation-Elevation Regressions on Independent Slopes Model; SSURGO: Soil Survey Geographic Database; STATSGO2:Digital General Soil Map of the United States; SVSim: Sacramento Valley Groundwater-Surface Water Simulation Model; USGS: United States Geological Survey

2.2 Simulation Period and Temporal Discretization

The CoSANA model simulates the historical conditions in the basin for the period of water years (WY) 1970 through 2018 (October 1, 1969 through September 30, 2018). Monthly data was used as model input, and the model simulation uses a monthly time step. Model output can be reported on a monthly or annual time increment, as needed.

Model data development efforts were divided into two periods, as follows:

- WY 1970-1989 – The data for this period is primarily mapped over from SacIWRM. As such, CoSANA inherits the spatial and temporal resolution of SacIWRM. As much of the source data for land use, water use, and water supply are not readily available in digital form, the mapped data from SacIWRM was used without substantial refinement. However, the hydrologic data sets, including rainfall and streamflows, are refined based on the latest sources of data.
- WY 1990-2018 – The data for this period is much more refined, as digital source data are used in development of the model input data. Additionally, the groundwater level and streamflow observation data are available in a more consistent quality and format. Therefore, this period is used for the WY 1995-2018 model calibration period, plus a WY 1990-1994 warm up period. Further discussion on calibration period selection is provided in the model calibration section of the report.

Beyond the two time periods, the entirely of the WY 1970-2018 period is used for verification of consistency of model simulation, long-term water budgets, long-term trends in groundwater levels and stream-aquifer interaction, and long-term trends in the groundwater storage changes. WY 2019 is added to the baselines to achieve 50 years of hydrology as required by SGMA (see Section 5).

2.3 Model Grid and Subregions

A model grid provides a discrete geographic representation of the physical, hydrologic, hydrogeologic, jurisdictional, land use, water use, and water supply features at a small enough size to support the basis for robust mathematical representation of the features and the inter-relationship between various components of the system.

A grid network was developed for the CoSANA model, based on principles of finite element numerical analysis, to reflect hydrological, hydrogeological, physical, jurisdictional, and operational conditions in the groundwater subbasins represented in CoSANA. The finite element grid for CoSANA was developed using Aquaveo's GMS-Groundwater Modeling System software with spatial processing using Esri's ArcGIS. The grid includes quadrilateral and triangular elements based on selected input lines and control points. Features included in the development of the model grid are shown in Figure 2-1 and include:

- Streams
- GSA boundaries
- Water purveyor boundaries
- County boundaries
- Areas of groundwater contamination
- Geological features
- Model grids in neighboring subbasins

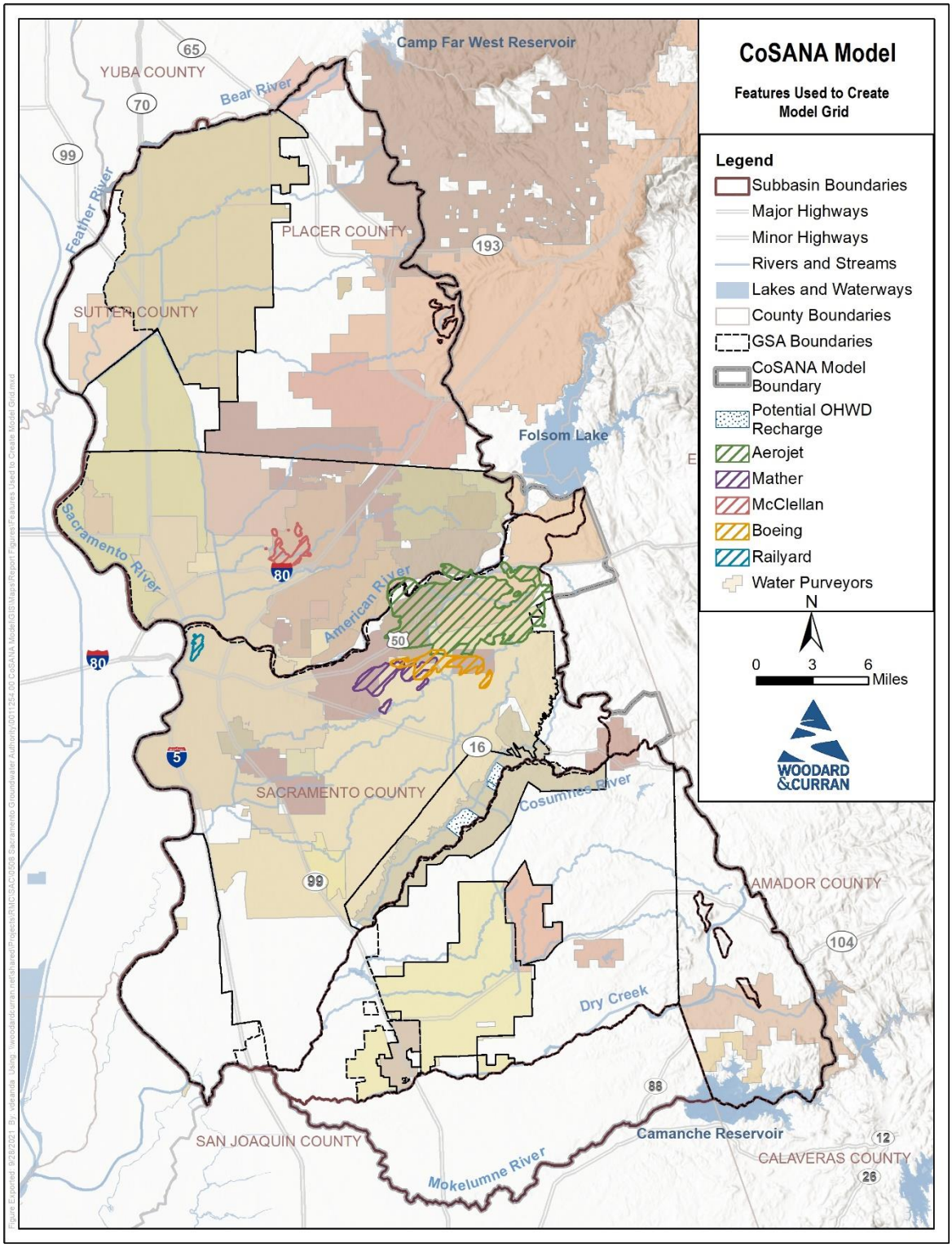


Figure 2-1: Features Used to Create Model Grid

The CoSANA model grid contains 24,171 elements and 22,274 nodes with an average element area of 37 acres (Figure 2-2). The node discretization interval for most features was set at 2,000 feet with more refined spacing in specific areas, such as near streams (described below) and areas of significant groundwater contamination (1,000 feet spacing for the Mather, Aerojet, and McClellan areas). The overall node spacing was 1,170 feet on average with a maximum of 2,210 feet and a minimum of 300 feet.

Streams in the model domain were separated into three tiers, described further in Section 2.4. The first two tiers are simulated in the model. Tier 3 streams are minor streams that are included in the model grid for drainage routes but are not directly modeled in CoSANA.

Border model nodes were aligned with the model grids for the Yuba Groundwater Model (YGM), which is directly adjacent and also uses the IWFM platform, to improve the potential for future direct interaction with this model (Figure 2-3). Node spacing along other boundaries for other neighboring models, including the Yolo and Eastern San Joaquin models were used as guidelines, however, CoSANA provides smaller node spacing along these boundaries compared to the neighboring models. There was no direct coordination on node spacing along the boundaries bordering the Solano or Sutter Subbasins.

The southern boundary of CoSANA is the Mokelumne River, which provides coverage for the Cosumnes Subbasin and a portion of the Eastern San Joaquin Subbasin, as well as a hydrologic boundary. The Cosumnes Subbasin is covered by both CoSANA and the Eastern San Joaquin Subbasin model (Eastern San Joaquin Water Resources Model). Generally, the CoSANA model has limited focus on the Eastern San Joaquin Subbasin, and the Eastern San Joaquin model has limited focus on the Cosumnes Subbasin. The CoSANA node spacing is refined along the Mokelumne River and the data and information in CoSANA's representation of the Cosumnes Subbasin is refined by the Cosumnes Subbasin GSAs and consultants. The Cosumnes Subbasin GSAs used CoSANA in development of their GSP.

The model elements are grouped into 87 model subregions (Figure 2-4) that are used to organize input data and to report standard model water budget output. Subregions were delineated using boundaries of cities, water agencies, GSAs, subbasins, and counties. A listing of model subregions, including the associated subbasin and the number of model elements they contain, is provided in Table 2-2.

Table 2-2: CoSANA Subregions

Subregion Number	Subregion Name	Groundwater Subbasin	Number of Elements
1	Camp Far West ID	North American	142
2	Sutter Co. 1	North American	12
3	South Sutter WD GSA	North American	1296
4	Placer County WA	North American	997
5	Nevada ID	North American	161
6	Lincoln	North American	235
7	RD1001	North American	359
8	Pleasant Grove Verona MWC	North American	162
9	Sutter Co. 2	North American	60
10	Natomas MWC (Sutter Co.)	North American	252
11	Sutter Co. 3	North American	76
12	Roseville SOI	North American	42
13	City of Roseville	North American	478
14	Cal Am (West Placer)	North American	166
15	Natomas MWC (Sacramento Co.)	North American	423

Subregion Number	Subregion Name	Groundwater Subbasin	Number of Elements
16	Sacramento International Airport	North American	48
17	Metro Air Park	North American	26
18	Sac Co. 1	North American	63
19	Sac Co. 2	North American	27
20	Sac County WA (Northgate 880)	North American	13
21	Rio Linda Elverta	North American	221
22	Sac Co. 3	North American	16
23	Cal Am (Antelope)	North American	55
24	Cal Am (Lincoln Oaks)	North American	92
25	Citrus Heights WD	North American	171
26	San Juan WD (Placer Co.)	North American	29
27	San Juan WD (Sacramento Co.)	North American	88
28	Orange Vale WC	North American	73
29	Lake Natoma/Mississippi Bar	North American	116
30	Fair Oaks WD	North American	354
31	Carmichael WD	North American	297
32	Sacramento Suburban WD (North)	North American	471
33	Sacramento Suburban WD (South)	North American	293
34	Del Paso Manor WD	North American	18
35	Golden State WC Arden	North American	21
36	Cal Am (Arden)	North American	27
37	Sac County WA (Arden Park Vista)	North American	76
38	City of Sacramento (North)	North American	777
39	City of Sacramento (South)	South American	1212
40	Cal Am (Suburban Rosemont)	South American	410
41	Sac Co. 4	South American	33
42	Golden State WC (Cordova)	South American	548
43	Sac Co. 5	South American	111
44	City of Folsom	South American (partial)	869
45	Cal Am (Security Park)	South American	76
46	Fruitridge Vista WC	South American	46
47	Florin County WD	South American	31
48	Cal Am (Parkway)	South American	98
49	Sac Co. 6	South American	104
50	Sac County WA (North/Central)	South American	1451
51	Sac County WA (South)	South American	240
52	Elk Grove WD (Service Area 2 - Intertie)	South American	97
53	Elk Grove WD (Service Area 1 - GW)	South American	62
54	Cosumnes River West	South American	734
55	RD744	South American	76
56	Franklin Drainage District	South American	197

Subregion Number	Subregion Name	Groundwater Subbasin	Number of Elements
57	RD813	South American	70
58	RD755	South American	22
59	RD1002	South American	94
60	RD551	South American	272
61	RD369	South American	36
62	RD2110	South American	88
63	Sac Co. 7	South American	54
64	Rancho Murieta (North)	South American (partial)	244
65	Sloughhouse RCD (North)	South American	422
66	OHWD (South American Subbasin)	South American	990
67	OHWD (Cosumnes Subbasin)	Cosumnes	601
68	Rancho Murieta (South)	Cosumnes	87
69	Sloughhouse RCD (East)	Cosumnes	1219
70	Wilton	Cosumnes	255
71	Sloughhouse RCD (West)	Cosumnes	254
72	Galt ID (East)	Cosumnes	615
73	Clay WD	Cosumnes	125
74	Clay	Cosumnes	67
75	SMUD Rancho Seco	Cosumnes	50
76	Cosumnes River South	Cosumnes	308
77	Galt ID (West)	Cosumnes	78
78	Sac Co. 8	Cosumnes	408
79	City of Galt	Cosumnes	86
80	Sloughhouse RCD (South)	Cosumnes	35
81	Amador Co. 1	Cosumnes	443
82	Ione	Cosumnes	44
83	Jackson ID	Cosumnes	213
84	Camanche	Cosumnes	355
85	Amador County WA	Cosumnes	57
86	Mokelumne	Eastern San Joaquin	1944
87	City of Galt WWTP	Cosumnes	7

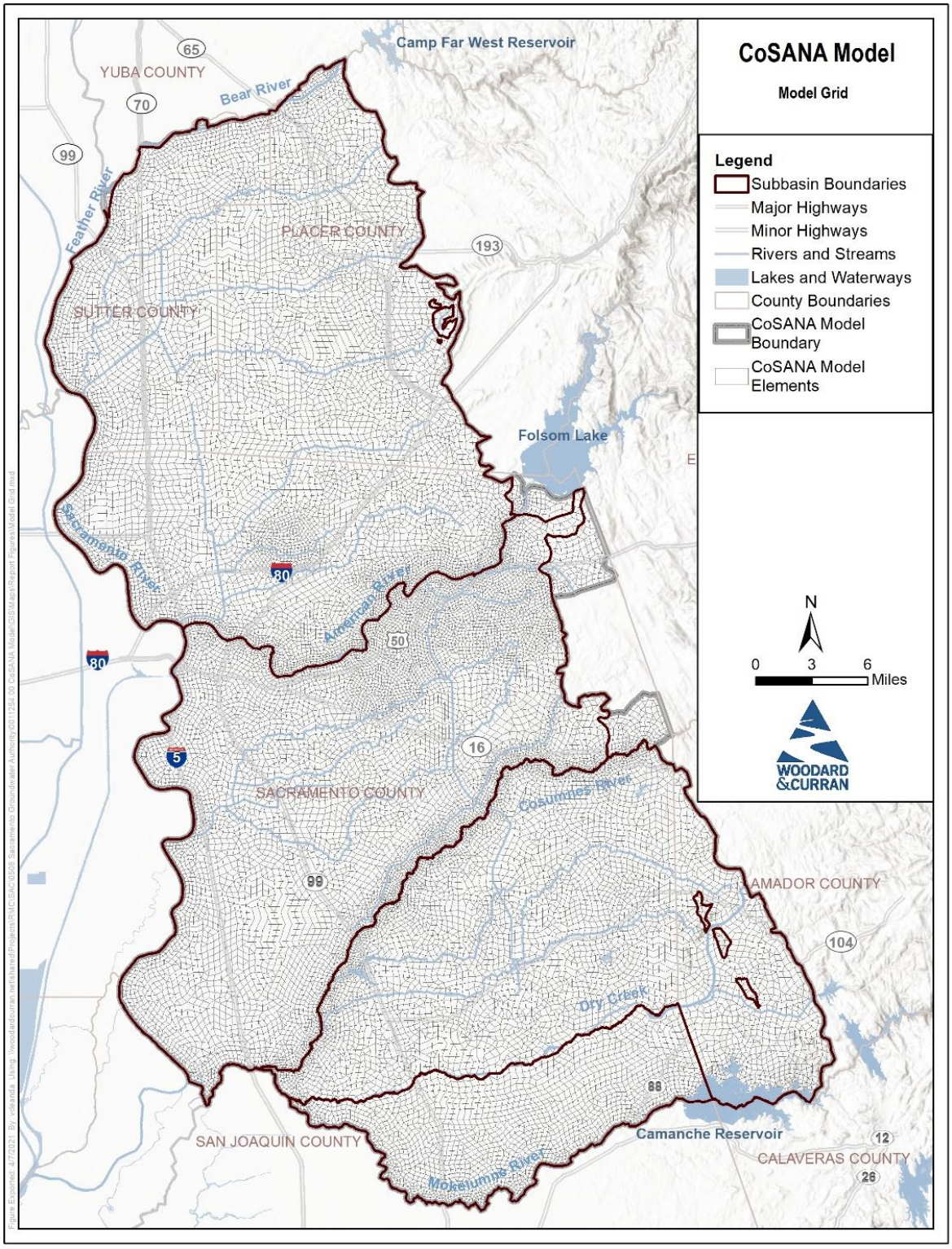


Figure 2-2: CoSANA Model Grid

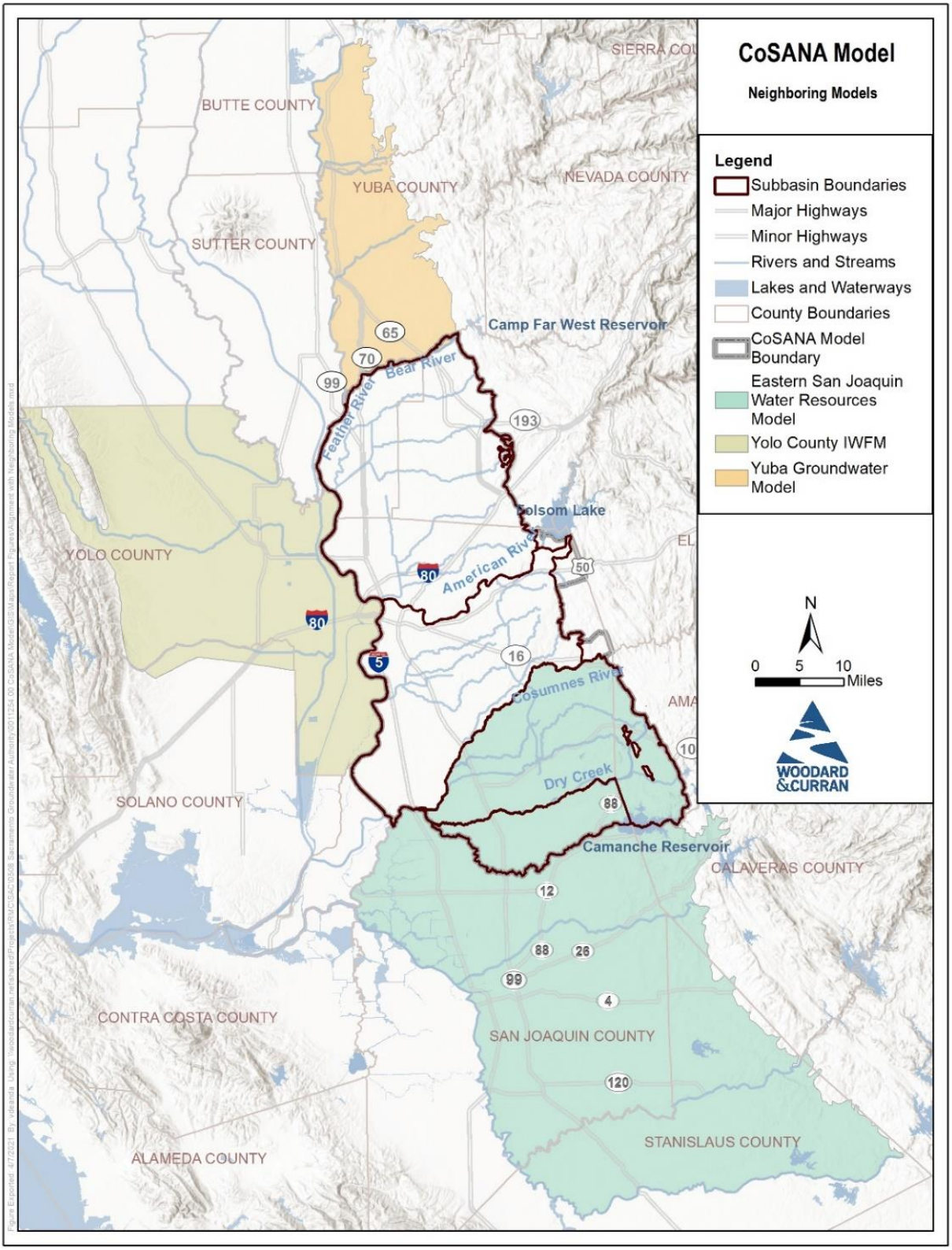


Figure 2-3: Alignment with Neighboring Model Grids

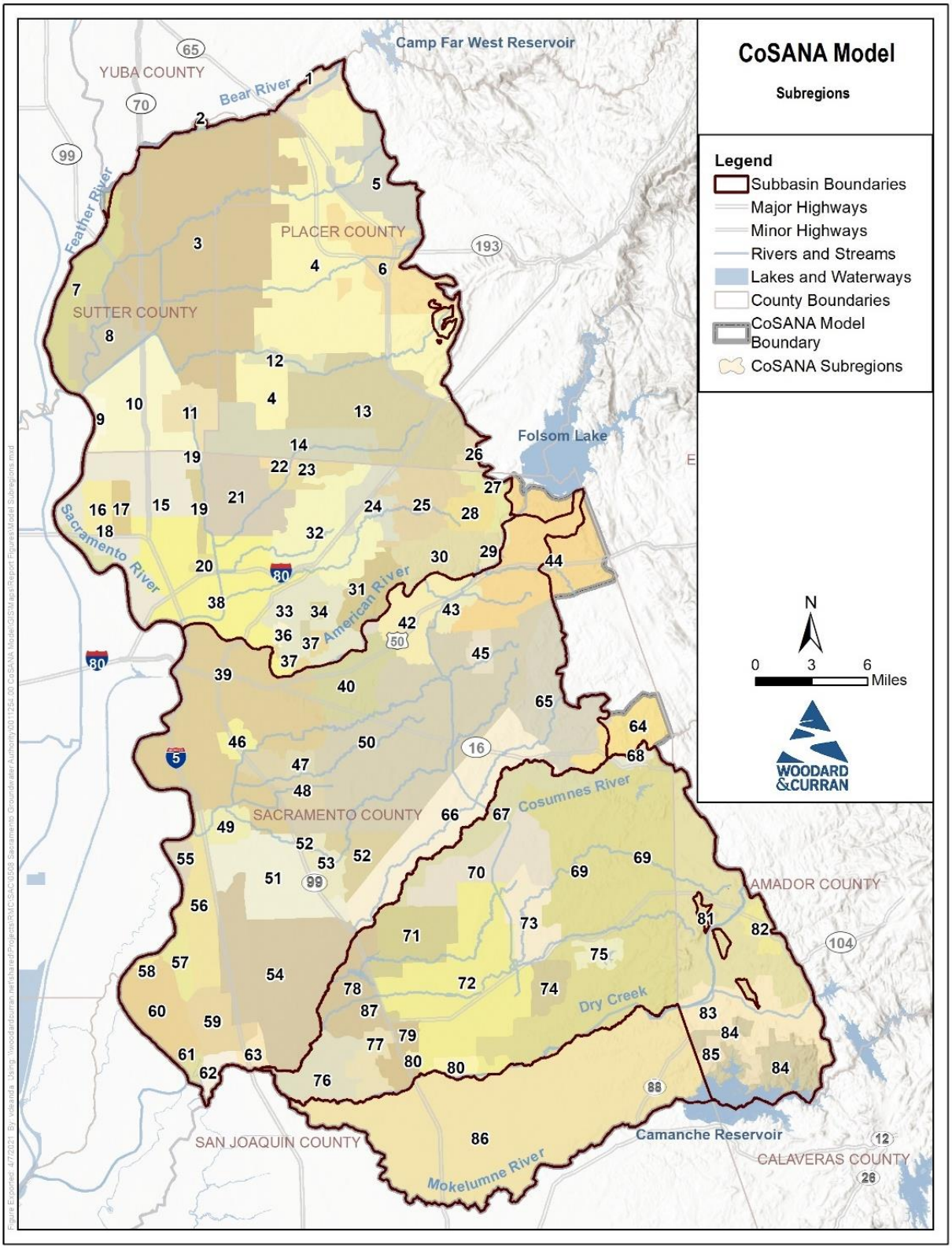


Figure 2-4: CoSANA Subregions

2.4 Stream Configuration and Inflow

Model hydrology is represented by 51 modeled stream reaches representing 27 streams, rivers, and canals, which are largely defined to start and/or end at confluences. Streams in the model domain are separated into three tiers, as shown in Table 2-3 and Figure 2-5. The discretization interval for stream node spacing and buffers included around the streams to transition from the finer to coarser node spacing vary based on the tier, as follows:

- Tier 1 includes major streams and were discretized to 750 feet (Cosumnes and American Rivers) or 1,000 feet (Sacramento, Feather, Bear, and Mokelumne Rivers). The fine level of discretization allows for better representation of surface water-groundwater interaction. A buffer, the distance within which the finer discretization is applied, of 5,280 feet (1 mile) was applied.
- Tier 2 represents important streams with standard feature discretization intervals (largely 2,000 feet). Exceptions included Deer Creek with discretization of 1,250 feet and a 2,640 feet (0.5 mile) buffer and Folsom South Canal with discretization of 1,500 feet and a 5,280 feet (1 mile) buffer.
- Tier 3 includes minor streams and drainages, and were not simulated as streams, but included for drainage routes (discussed further in section 2.5). Discretization for these streams was standard (largely 2,000 feet). While these hydrologic features represent drainage and conveyance water courses in the model, they are not directly used as simulated streams in the model due to lack of sufficient information such as channel geometry and streamflow records.

The streams and creeks are represented in the model by 2,388 stream nodes. The number of stream nodes and their refined resolution provide an increased level of accuracy when depicting stream-groundwater interaction. Physical channel characteristics, including the stream invert elevation, channel width, and stream flow rating tables, were obtained from the closest C2VSimFG stream nodes, SacIWRM, and United States Geological Survey (USGS) digital elevation models (DEM).

Time series of stream inflow data is available from 7 USGS gaging stations, additionally several tier 2 streams in the NASb use inflows developed by MBK Engineers or model derived flows from C2VSimFG or YGM. Table 2-4 presents stream input data and Figure 2-6 shows available stream gage locations.

Table 2-3: CoSANA Streams and Tiers

Stream	Groundwater Subbasin	Stream Tier
American River	North American	1
Arcade Creek	North American	2
Auburn Ravine	North American	2
Bear River	North American	1
Cross Canal	North American	2
Curry Creek	North American	3
Dry Creek	North American	2
East Side Canal	North American	2
Feather River	North American	1
Magpie Creek	North American	2
Natomas East Drain	North American	2
Ping Slough	North American	3
Pleasant Grove Creek	North American	2
Racoon Creek	North American	2
Sacramento River	North American	1
South Branch Pleasant Grove Creek	North American	3
Alder Creek	South American	2
American River	South American	1
Beacon Creek	South American	2
Buffalo Creek	South American	2
Cosumnes River	South American	1
Deer Creek	South American	2
Elder Creek	South American	2
Folsom South Canal	South American	2
Laguna Creek	South American	2
Morrison Creek	South American	2
Sacramento River	South American	1
Arkansas Creek	Cosumnes	3
Badger Creek	Cosumnes	2
Brown's Creek	Cosumnes	3
Cosumnes River	Cosumnes	1
Deadman Gulch	Cosumnes	3
Dry Creek	Cosumnes	2
Folsom South Canal	Cosumnes	2
Griffith Creek	Cosumnes	3
Hadselville Creek	Cosumnes	2
Jackson Creek	Cosumnes	2
Laguna Creek	Cosumnes	2
Mokelumne River	Cosumnes	1
North Fork Badger Creek	Cosumnes	3
Rolling Draw	Cosumnes	3
Skunk Creek	Cosumnes	3
Sutter Creek	Cosumnes	3
Willow Creek	Cosumnes	3
Windmill Draw	Cosumnes	3

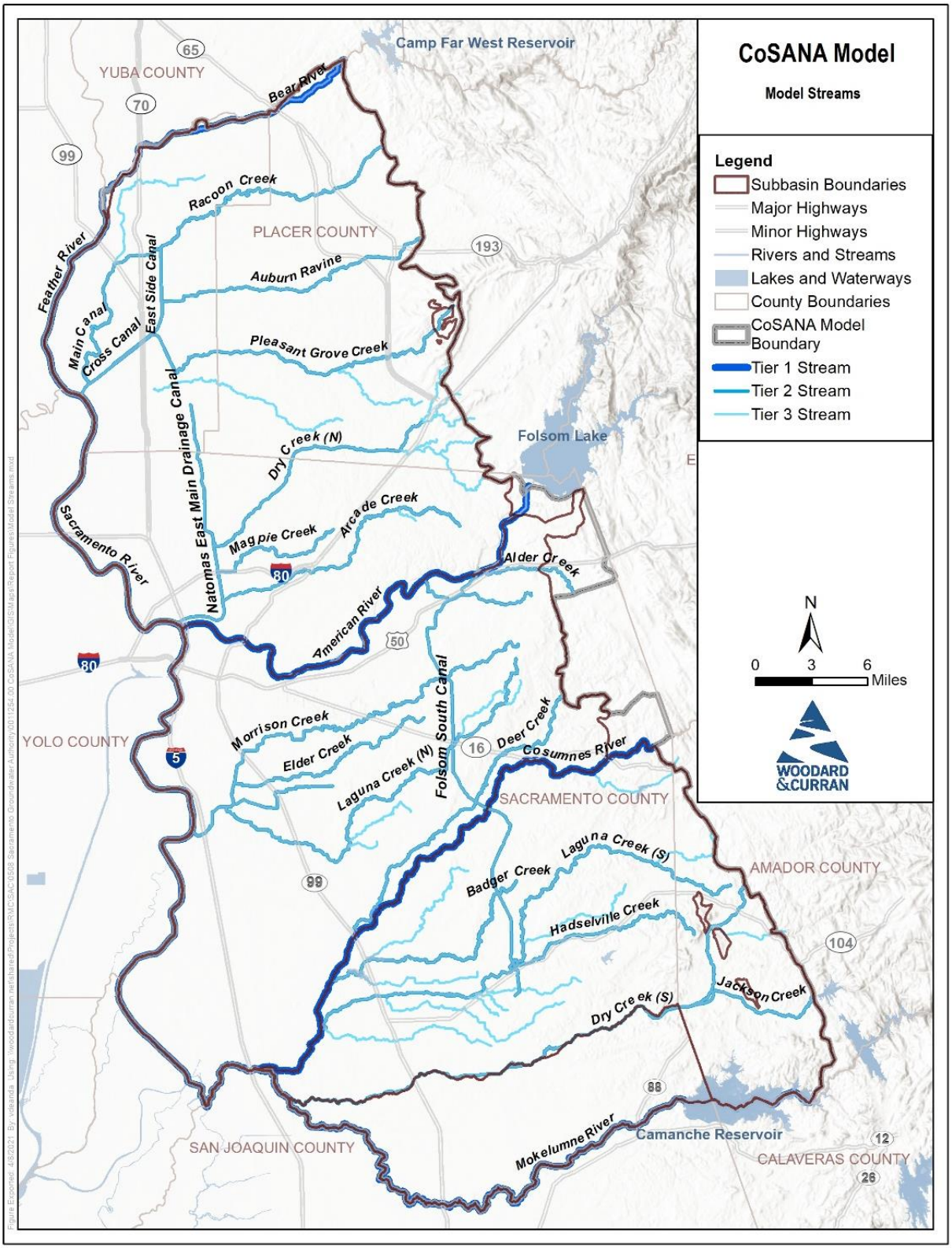


Figure 2-5: CoSANA Streams

Table 2-4: Stream Inflows

Stream	Stream Node	Source	Gage Name	Period of Record (WY)	Average Annual Streamflow (acre-feet)
Sacramento River	155	USGS	Sacramento River near Verona (USGS Gage 11425500)	1929 - 2021	14,461,848
American River	734	USGS	American River at Fair Oaks (USGS Gage 11446500)	1904 - 2021	2,745,469
Cosumnes River	1490	USGS	Cosumnes River at Michigan Bar (USGS Gage 11335000)	1907 - 2021	396,807
Mokelumne River	2080	USGS	Mokelumne River below Camanche Dam (USGS Gage 11323500)	1905 - 2020	568,754
Bear River	1	USGS	Bear River near Wheatland (USGS Gage 11424000)	1928 - 2021	325,546
Raccoon Creek	158	MBK Engineers	Raccoon Creek	1976 - 2018	28,848
Auburn Ravine	248	MBK Engineers	Auburn Ravine	1976 - 2018	19,353
Pleasant Grove Creek	301	MBK Engineers	Pleasant Grove Creek	1976 - 2018	28,827
Dry Creek[1]	502	MBK Engineers	Dry Creek (North American Subbasin)	1976 - 2018	35,944
Feather River	86	YGM	Feather River	1987 - 2015	5,314,464
Dry Creek[1]	1911	C2VSimFG	Dry Creek (Cosumnes Subbasin)	1970 - 2015	30,020
Jackson Creek	1936	JVID	Jackson Creek below Lake Amador Dam	1980 – 2009, 2017 – 2019	7,198
Morrison Creek	1024	USGS	Morrison Cr near Sacramento	1997 - 2017	15,158
Laguna Creek (SASb)	1169	USGS	Laguna Cr. near Elk Grove	1995 - 2018	8,336

C2VSimFG = California Central Valley Groundwater-Surface Water Simulation Fine Grid Model
JVID = Jackson Valley Irrigation District
USGS = United States Geological Survey
YGM = Yuba Groundwater Model
[1] There are two distinct streams named "Dry Creek" within the model domain: one in the North American Subbasin, and one in the Cosumnes Subbasin

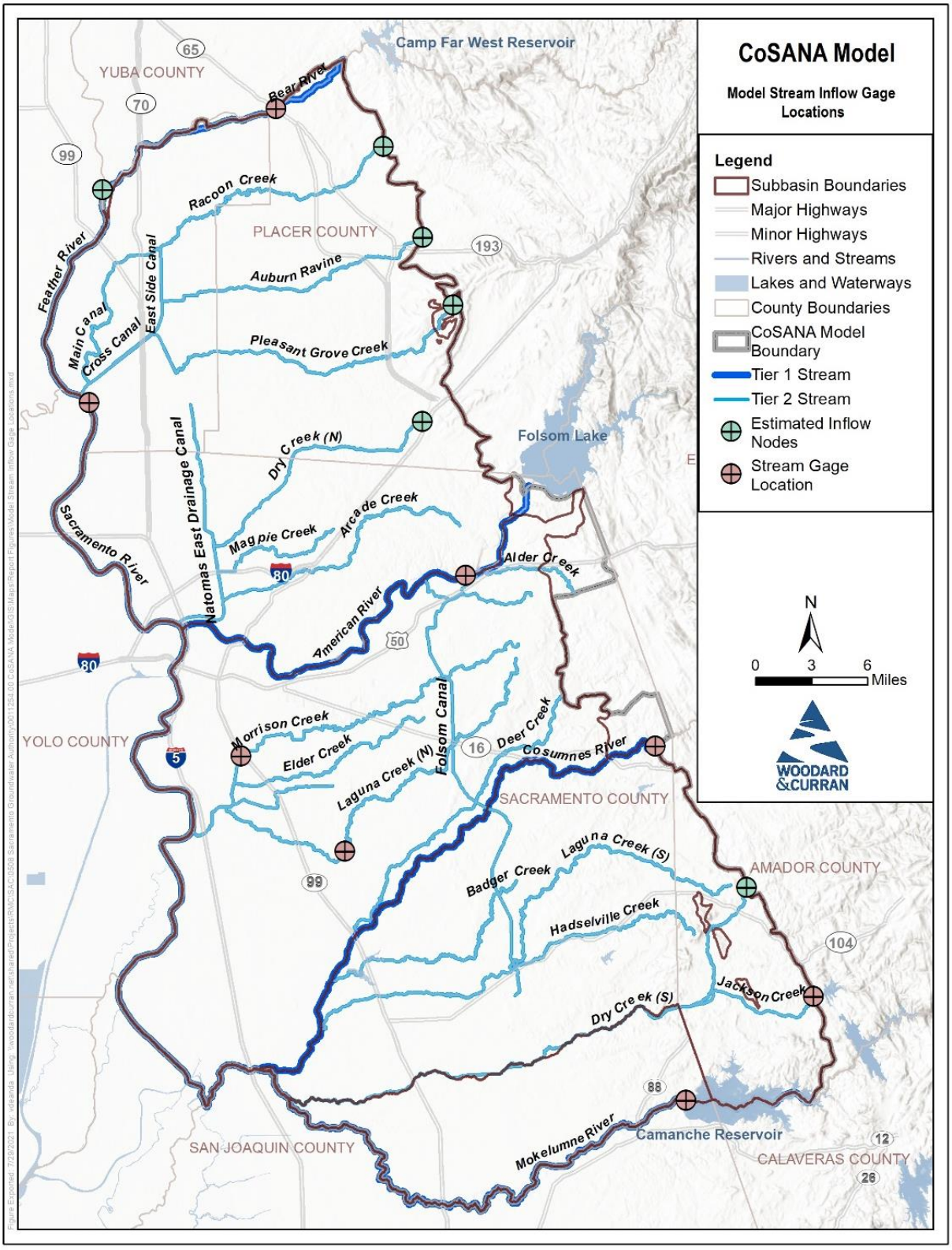


Figure 2-6: CoSANA Stream Inflow Gage Locations

2.5 Surface Drainage Pattern

Surface water drainage (e.g., runoff from rainfall and excess applied water) for each model element is assigned to a stream node representing where the drainage ultimately flows to. These drainage patterns were delineated using the USGS Watershed Boundary Dataset for 12-digit hydrologic units, also called subwatersheds. Each 12-digit hydrologic unit located within the model boundaries was associated with the model stream node it ultimately drained into through both visual analysis as well as information provided on the subwatersheds. Elements falling within the hydrologic units were assigned to the model stream node indicating the ultimate surface water drainage direction. Additional refinement was done along the Cosumnes River to simulate where agricultural return flow would return to the stream with more precision. A total of 62 unique stream nodes receive surface water drainage in CoSANA from 58 subwatersheds. Figure 2-7 shows these stream nodes and the subwatersheds mapped to the model elements.

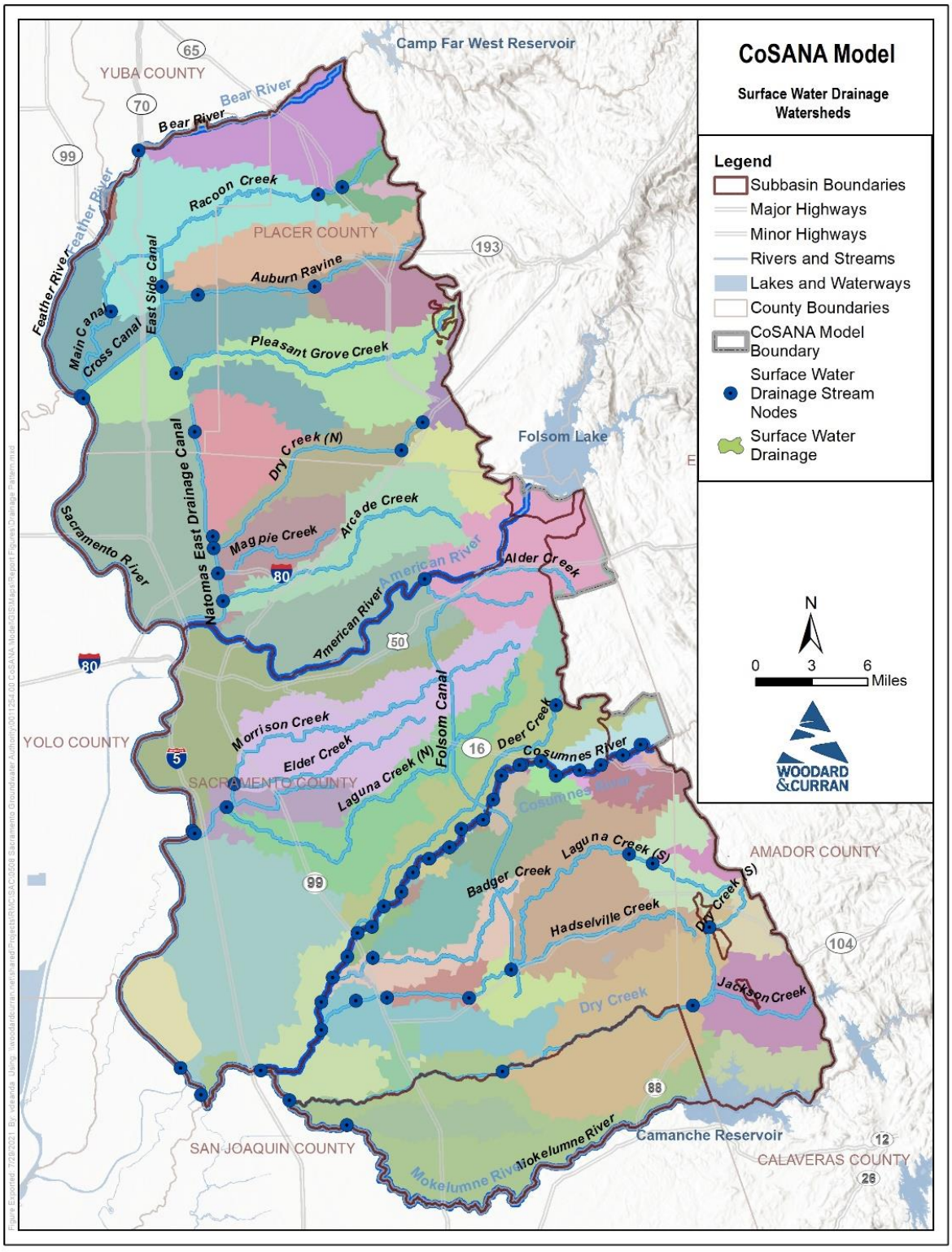


Figure 2-7: CoSANA Drainage Network

2.6 Precipitation

Rainfall data for the model area was derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) database used in the DWR's CALSIMETAW (California Simulation of Evapotranspiration of Applied Water) model. The database contains daily precipitation data from October 1, 1921, to September 30, 2018, on an 800-meter grid throughout the model area. CoSANA has monthly rainfall data defined for every model element in order to preserve the spatial distribution of the monthly rainfall. Each of the model elements was mapped to the nearest PRISM reference node and the resulting average annual precipitation is shown in Figure 2-8.

Figure 2-9 shows the annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area. For the 1995-2018 calibration period, the minimum precipitation was in 2007 with 11.0 inches, while the maximum occurred in 1998 with 34.4 inches, the average annual precipitation over this period was 20.1 inches. Based on the Sacramento Valley Water Year Index, there were 3 critical, 5 dry, 5 below normal, 3 above normal, and 8 wet years.

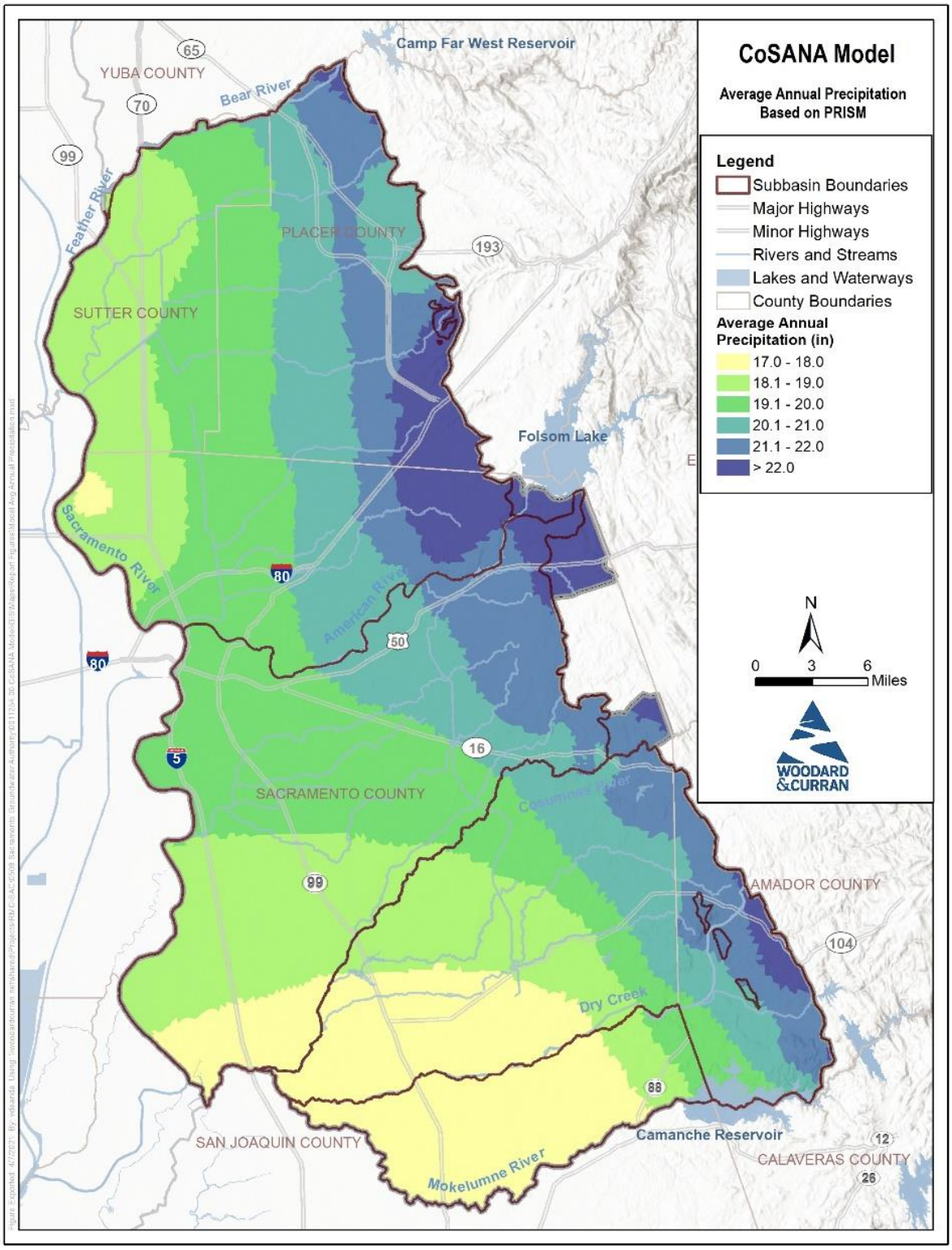


Figure 2-8: CoSANA Average Annual Precipitation

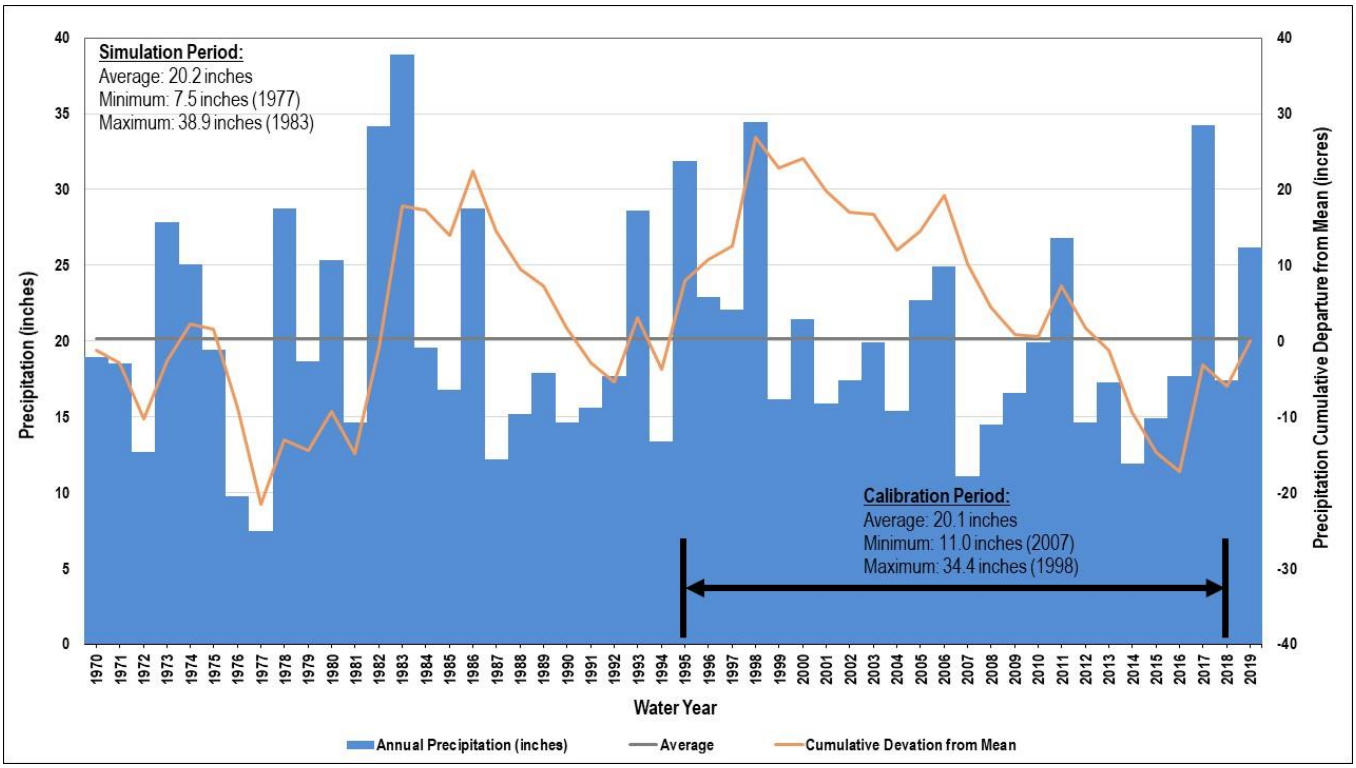


Figure 2-9: CoSANA Average Annual Precipitation with Statistics

2.7 Land Use and Cropping Patterns

Land use and cropping patterns are major data sets that drive the estimation of water demand for agricultural water use as well as rainfall runoff and deep percolation conditions throughout the model area. Land use surveys were used to map the agricultural crops into 4 general land use types and 20 irrigated crop categories, consistent with C2VSimFG, and as shown in Table 2-5. The digital land use surveys were mapped to each of the model elements, so as each model element contains all information to estimate the agricultural, native, and riparian water demand on a monthly time step. All irrigated crop categories except for rice are simulated as non-ponded crops, meaning they are grown without standing water. Rice is simulated as both no decomposition and flooded decomposition to represent the current understanding of local rice growing practices. Assumptions of rice decomposition practices were based on local information and estimated as proportion of rice acreage each year that underwent no decomposition or flooded decomposition. This information aligns with rice practices simulated in other models, including the Yuba Groundwater Model and C2VSimFG. Table 2-5 lists the land use categories. The crop categories are nearly identical to those in C2VSimFG, the only difference being CoSANA has one category of tomatoes, whereas C2VSimFG has two.

Table 2-5: Land Use Categories

Land Use Type	Model Category
Irrigated Crops	Grain
	Cotton
	Sugar Beets
	Corn
	Dry Beans
	Safflower
	Other Field Crops
	Alfalfa
	Pasture
	Tomato
	Cucurbits
	Onions & Garlic
	Potatoes
	Other Truck Crops
	Almonds & Pistachios
	Other Deciduous
	Citrus & Subtropical
	Vineyards
	Idle
	Rice
Other Land Use	Urban Landscape Water Surface Riparian Vegetation Native Vegetation

Spatial land use data were used to specify land use types and crop acreages for each model element for each year. The three major reference sources include DWR county land use surveys, DWR Statewide Crop Mapping, and CropScape. As crop categories were not consistent across all the land use data sources, individual mappings matched up each crop type to the appropriate model land use category. These data were available for different years for different counties. To approximate the land use across the entire model area, digital land use coverages were created from multiple datasets covering different years. These three snapshot years of land use coverage are assumed to represent conditions for 1995, 2005, and 2015 using data from a year close to that snapshot year (see Table 2-6). Linear interpolation was used represent land use for years between snapshot years. As no land use data for 2005 was available for Amador and San Joaquin Counties, land use in elements in those areas was linearly interpolated between 1995 and 2015.

Table 2-6: Sources of Data for Land Use Coverages

Data Source	Coverage Area	Year
1995 Land Use Coverage		
DWR Land Use Survey	Sutter County	1998
DWR Land Use Survey	Placer County	1994
DWR Land Use Survey	Sacramento County	1993
DWR Land Use Survey	San Joaquin County	1996
DWR Land Use Survey	Amador County	1997
2005 Land Use Coverage		
DWR Land Use Survey	Sutter County	2004
Local Information	Placer County	2009
DWR Land Use Survey	Sacramento County	2000
2015 Land Use Coverage		
DWR Statewide Crop Mapping	Sutter and Placer Counties (except for urban in Placer County)	2014
CropScape	Urban extent for Roseville-Lincoln	2015
DWR Land Use Survey	Sacramento County	2015
DWR Statewide Crop Mapping	San Joaquin and Amador Counties	2014

Land use development methodologies differed between DWR county land use surveys and DWR statewide crop mapping for 2014. Because the 2014 survey focused only on irrigated and urban areas, areas such as roads or strips between fields or buildings were assumed to be undeveloped or unirrigated land. This created issues in interpolation where longstanding rice fields would be shown as growing smaller and developed urban footprints were decreasing in acreage. In order to preserve the accuracy and refinement of the 2014 dataset, a reduction of 5% was applied to land use acreages developed from DWR county surveys assumed to represent 1995 and 2005. This 5% was estimated based on analysis of differences in estimated crop acreages for parcels known to be cultivated in both 1995 and 2015. Additionally, interpolation in dense urban areas was adjusted to have urban acreage remain the same or increase over time, to avoid erroneous reductions in urban land due to survey methodologies. Further refinement was also performed in the Elk Grove area to more accurately capture the timing of some of the large-scale agricultural-to-urban land use conversions in that area.

Refinement was also performed to capture drought-period fallowing. Growers indicated they fallowed fields in areas of Sutter and Placer Counties during 2014 in response to drought; these same fields were mostly returned to crops after the drought. The 2014 statewide survey categories for these idle plots were overwritten with 2016 and 2017 CropScape data to better reflect the total crop acreage in Sutter and Placer Counties for interpolation purposes. The idled acreage was added back in for the year 2014 after interpolation between the compositive areas was performed.

Figure 2-10, Figure 2-11, and Figure 2-12 show the spatial distribution of the land use coverages for CoSANA for 1995, 2005, and 2015. Figure 2-13 through Figure 2-16 show the annual cropping patterns for the entire CoSANA and individual subbasins.

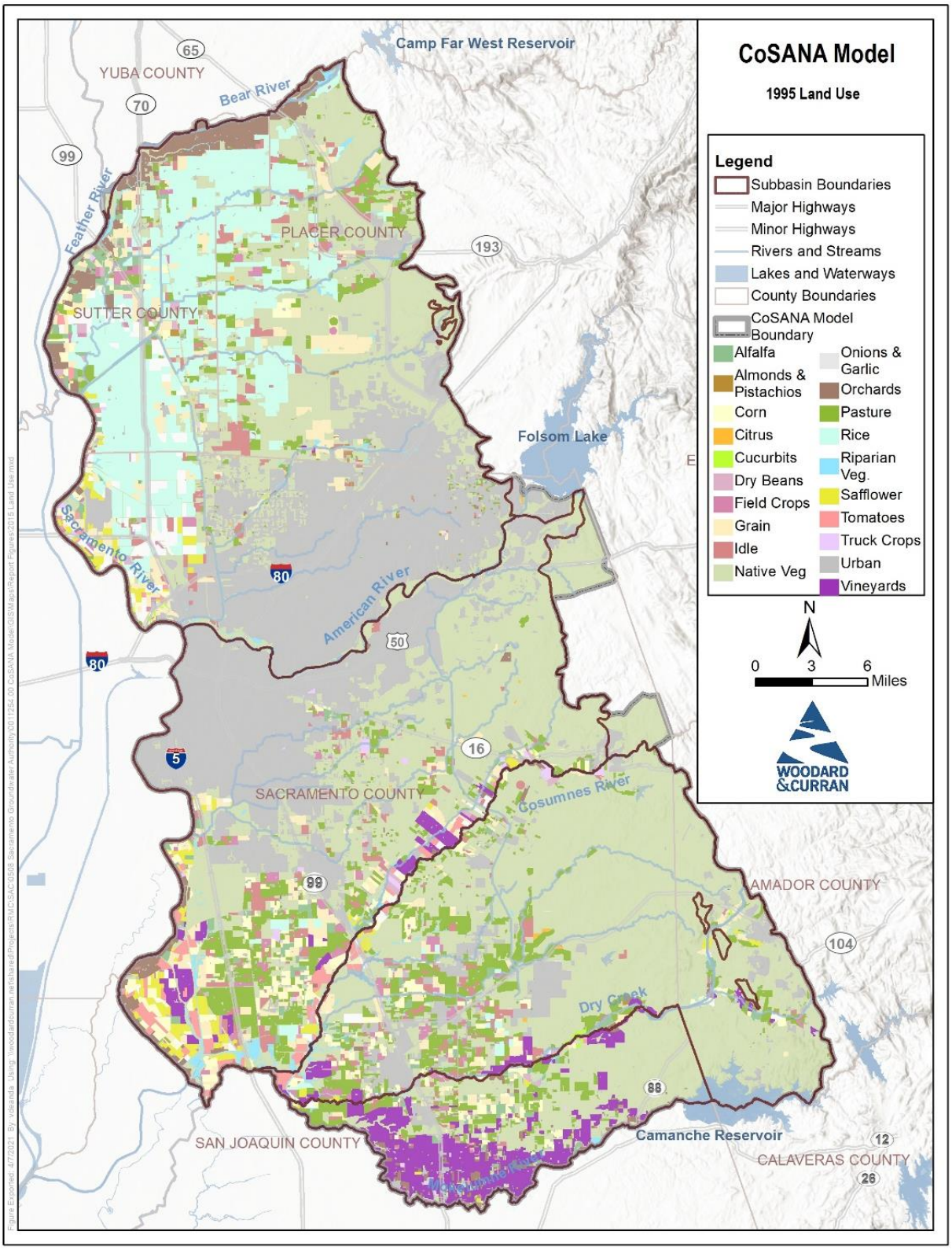


Figure 2-10: 1995 Land Use Coverage

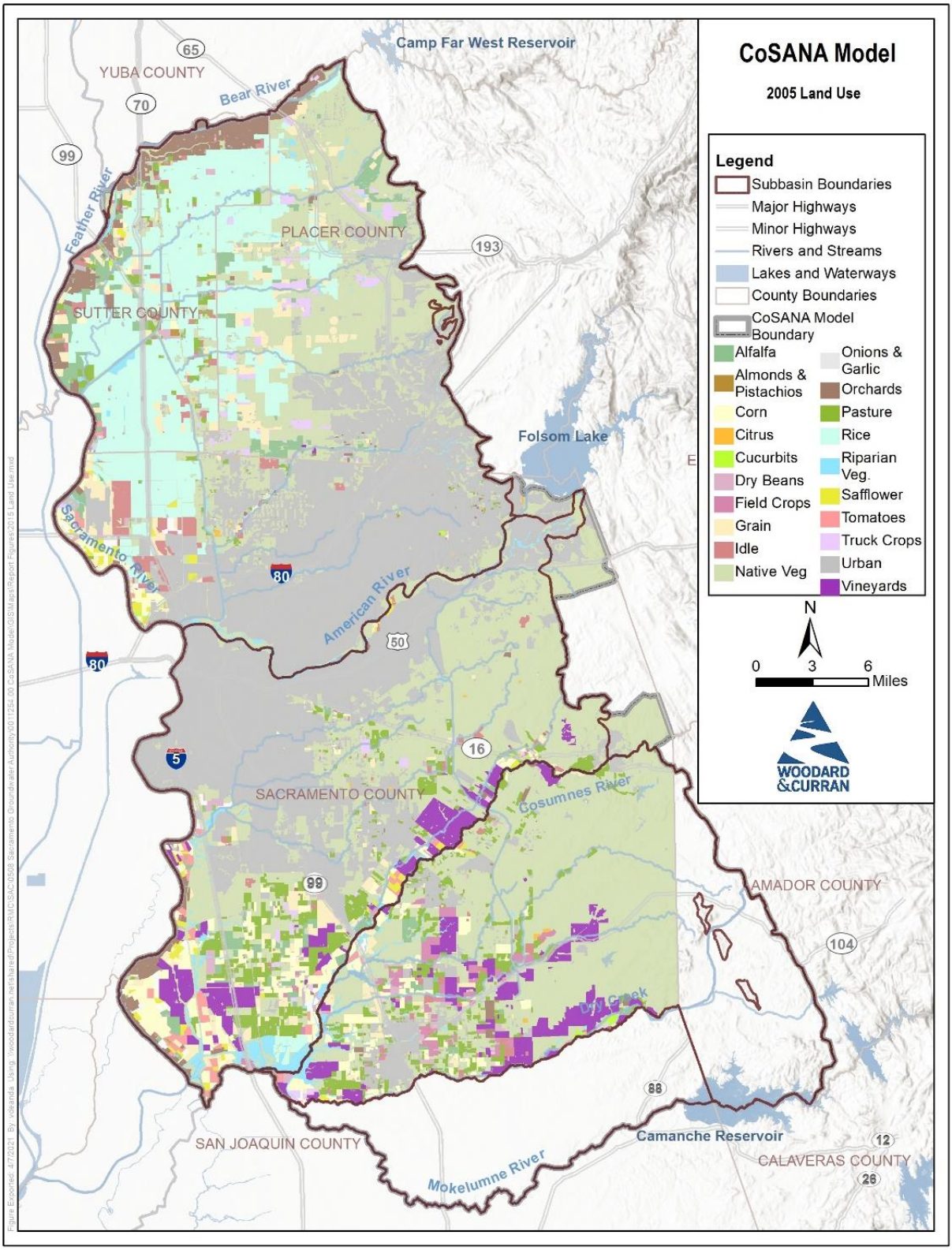


Figure 2-11: 2005 Land Use Coverage

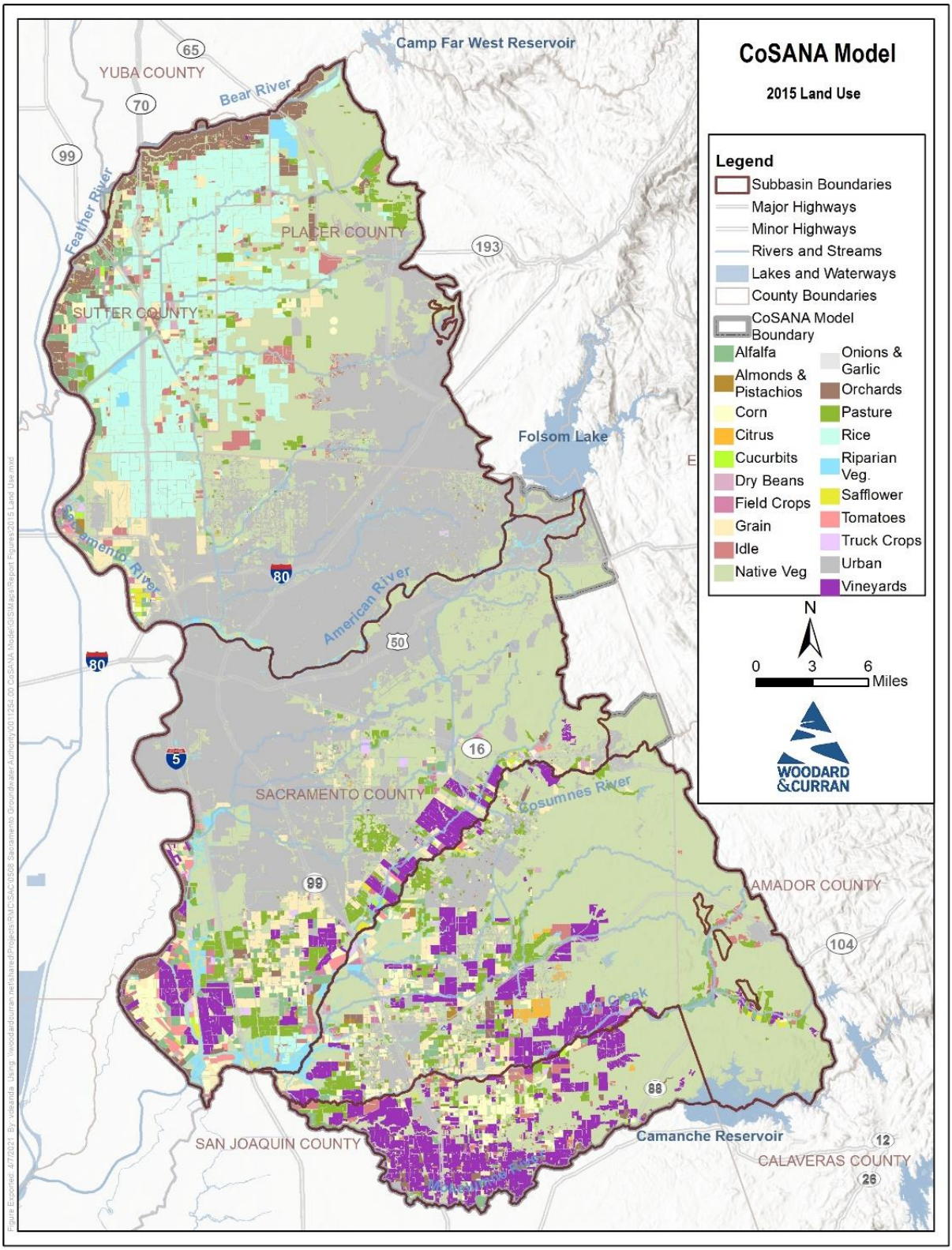


Figure 2-12: 2015 Land Use Coverage

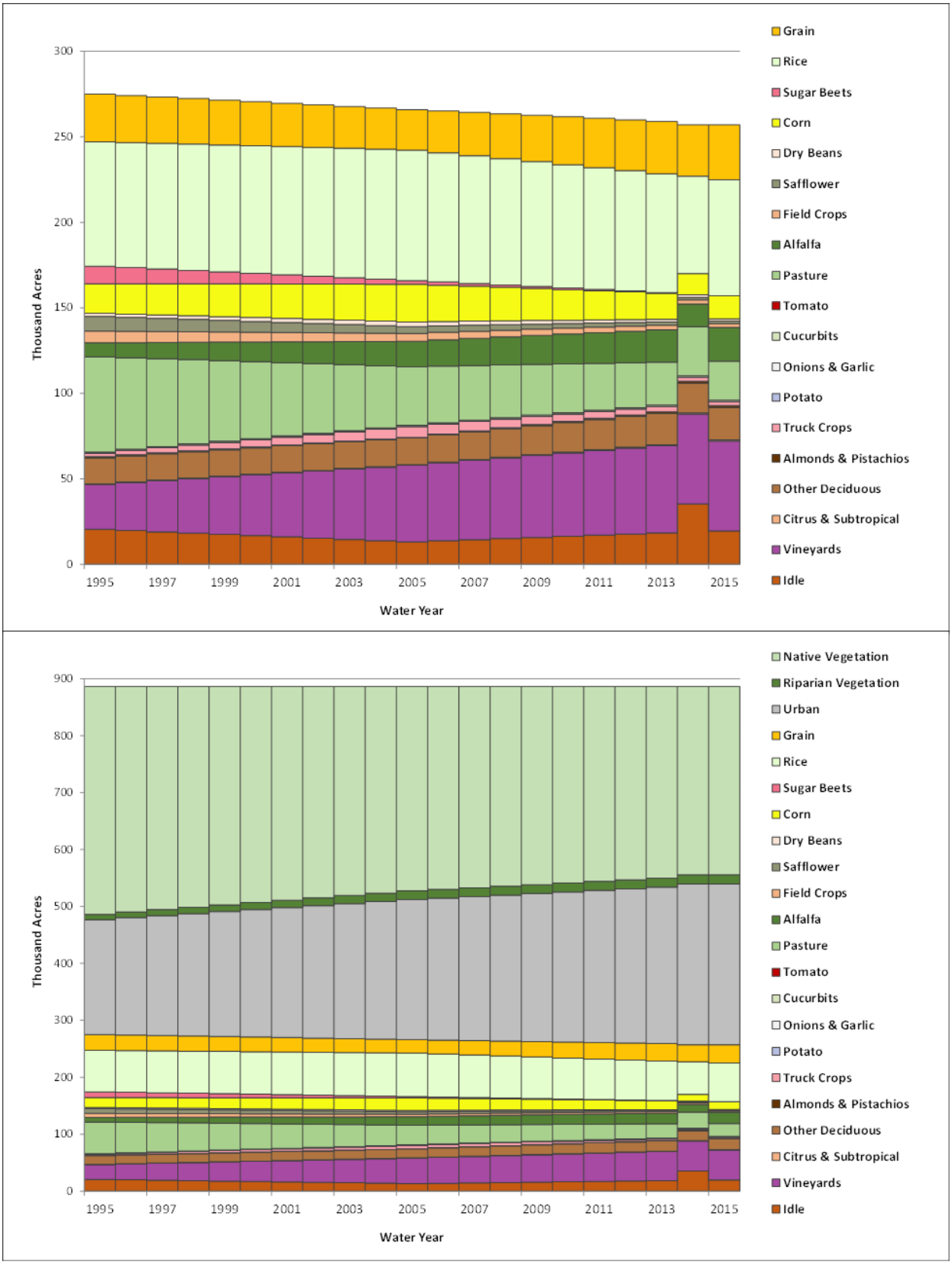


Figure 2-13: Annual Land Use for CoSANA

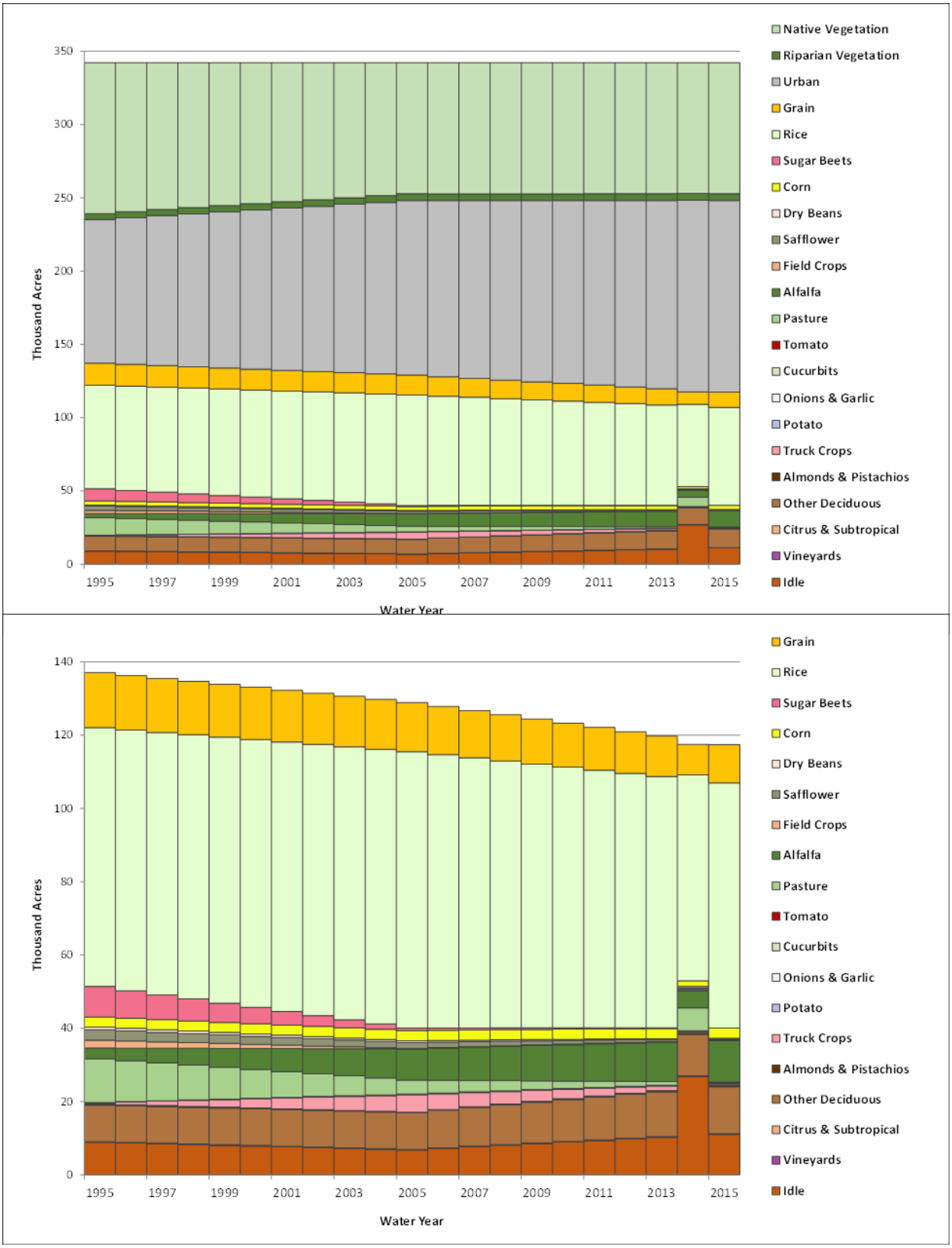


Figure 2-14: Annual Land Use for North American Subbasin

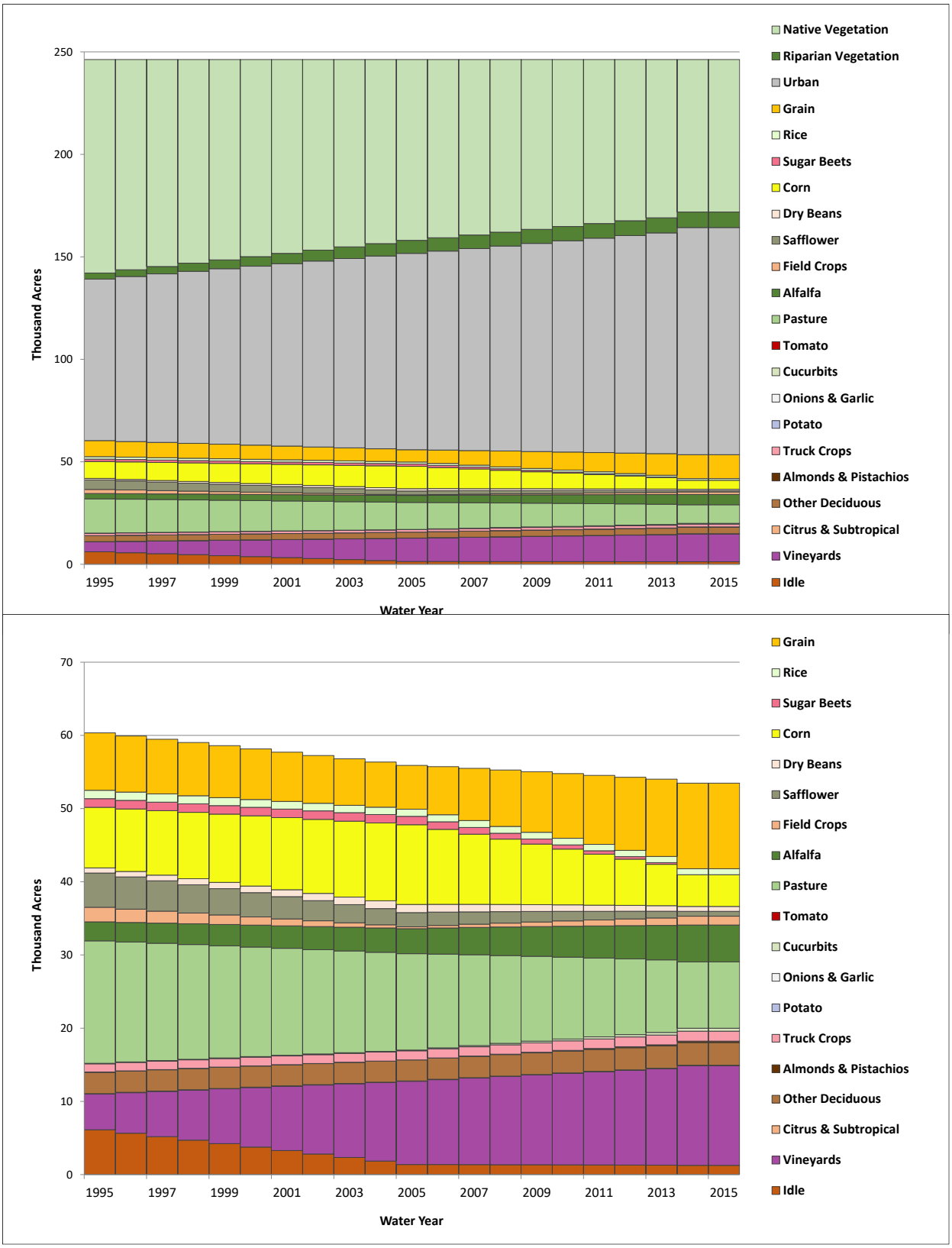


Figure 2-15: Annual Land Use for South American Subbasin

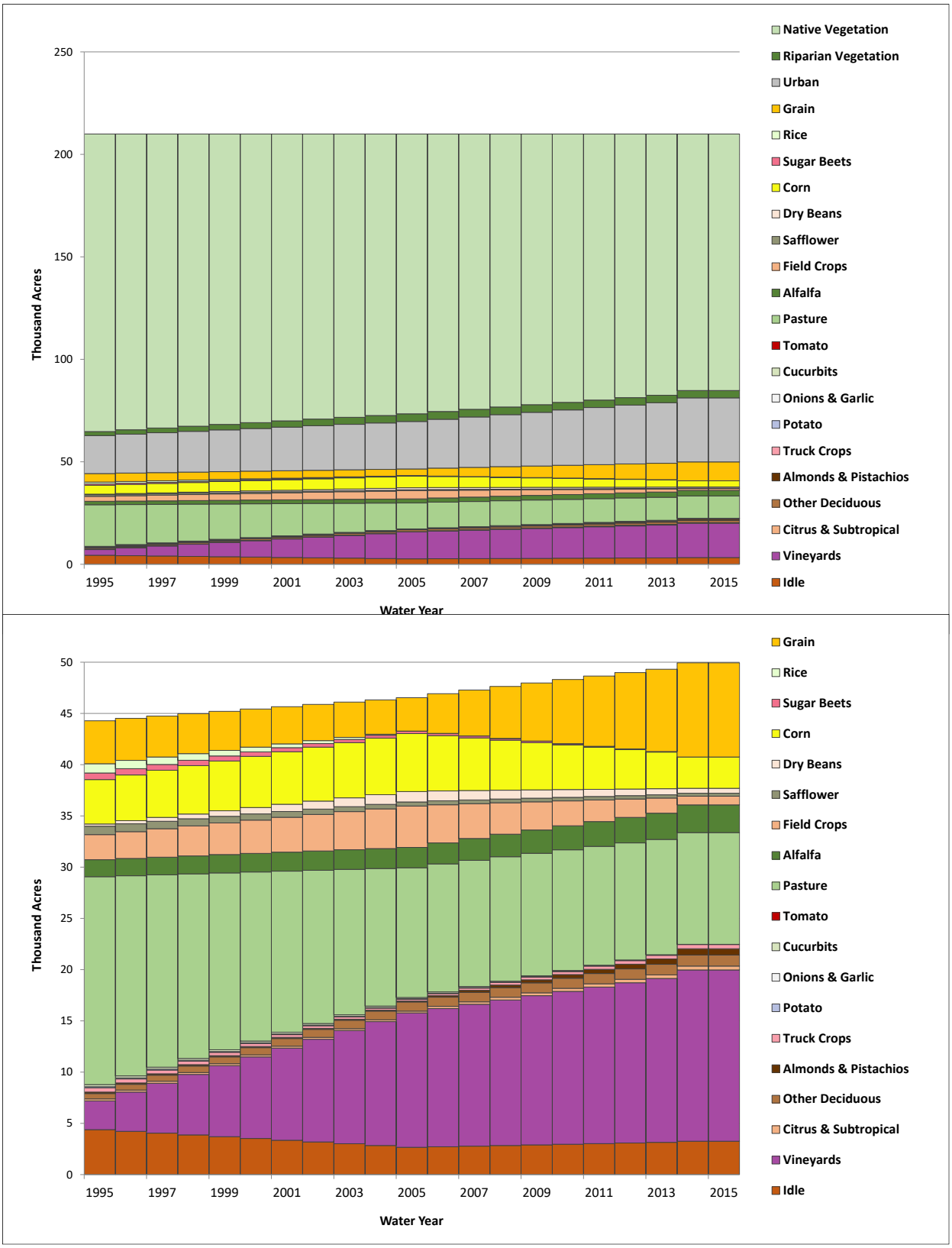


Figure 2-16: Annual Land Use for Cosumnes Subbasin

Land use trends in the North American Subbasin for 1995 through 2015 show decreases in total and irrigated agricultural acreage, with about 137,900 irrigated acres in 1995 and about 117,700 acres in 2015. During this same period, urban area increases from about 98,000 acres to about 130,800 acres. The increased urban area is due to both conversion of agricultural lands to urban areas, as well as conversion of native vegetation areas to urban. Most of the urban growth occurs in the Placer County area of the subbasin. In terms of irrigated acreages, decreases are observed in grain, rice, sugar beets, safflower, other field crops, and alfalfa/pasture. These decreases are due to urbanization and grower crop choices. The only irrigated crop showing substantial increases in acreage are orchards.

Land use trends in the South American Subbasin for 1995 through 2015 show decreases in total and irrigated agricultural acreage, with about 65,000 irrigated acres in 1995 and about 55,800 acres in 2015. During this same period, urban area increases from about 78,800 acres to about 110,800 acres. Increased urban area is due to both conversion of agricultural lands to urban areas, as well as conversion of native vegetation areas to urban. Most urban growth is observed to occur in the Elk Grove and Rancho Cordova areas. In terms of irrigated acreage, decreases are observed in corn, safflower, alfalfa/pasture, and tomatoes. These decreases are due to urbanization and grower crop choices. The largest increases in agricultural acreage are seen with the growth of grain and vineyards.

Land use trends in the Cosumnes Subbasin for 1995 through 2015 show increases in total and irrigated agricultural acreage, with about 45,200 irrigated acres in 1995 and about 50,200 acres in 2015. During this same period, urban area increases from about 18,500 acres to about 31,300 acres. Both urban and agricultural growth occur largely as a result of conversion of native vegetation areas. The majority of urban growth occurs as rural residential development in the Wilton area. In terms of irrigated acreage, decreases are observed in field crops (sugar beets, corn, safflower, and other field crops), and alfalfa/pasture. These decreases are due to urbanization and grower crop choices. Increases are observed in grain and permanent crops such as orchards and vineyards.

2.8 Evapotranspiration

Evapotranspiration (ET) is an important factor in demand estimation for crops and native vegetation. Every CoSANA land use type and crop category, as well as the small-stream watersheds, are assigned monthly values for the entire simulation period, which provides the monthly and annual hydrologic variability in ET estimates for the period of simulation.

The starting ET values through September 2015 were derived from C2VSimFG values for the C2VSimFG Subregion 7, which represents the NASb and was chosen as being most representative of the agricultural practices of the greater Sacramento region as modeled in CoSANA. Additional modifications were made during model calibration to the rice ET based on local information. Also, grain, vineyards, field crops, and safflower ET was updated using typical year monthly crop evapotranspiration information developed by the Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo by DWR's CIMIS (California Irrigation Management Information System) Zone. CIMIS zones represent areas with similar long-term average reference ET (ET_o) values, there are in total 18 zones to represent ET variability across California (https://cimis.water.ca.gov/App_Themes/images/ etozonemap.jpg). CoSANA uses average data for both Zone 12 and Zone 14.

To extend this data to 2018, ET_o data were downloaded for CIMIS station 131 (Fair Oaks). Monthly crop coefficient (ET_c) data for the extended period were estimated using the ratio of ET_o between annual data and the 2015 data.

Of 20 agricultural land uses in CoSANA, 7 crop types account for nearly 95% of irrigated cropland (for the 2015 land use survey). The monthly ET requirements of these crops are shown in Figure 2-17, Figure 2-18, and Figure 2-19, as well as for urban, riparian vegetation, and native vegetation land use types. Annual ET demands for the major land use types are 19.0 inches/year for grain, 29.7 inches/year for corn, 47.6 inches/year for alfalfa, 49.8 inches/year for pasture, 45.6 inches/year for orchards, 30.4 inches/year for vineyards, 32.3 inches/year for rice, 42.9 inches/year for urban, 18.2 inches/year for native vegetation, and 63.4 inches/year for riparian vegetation.

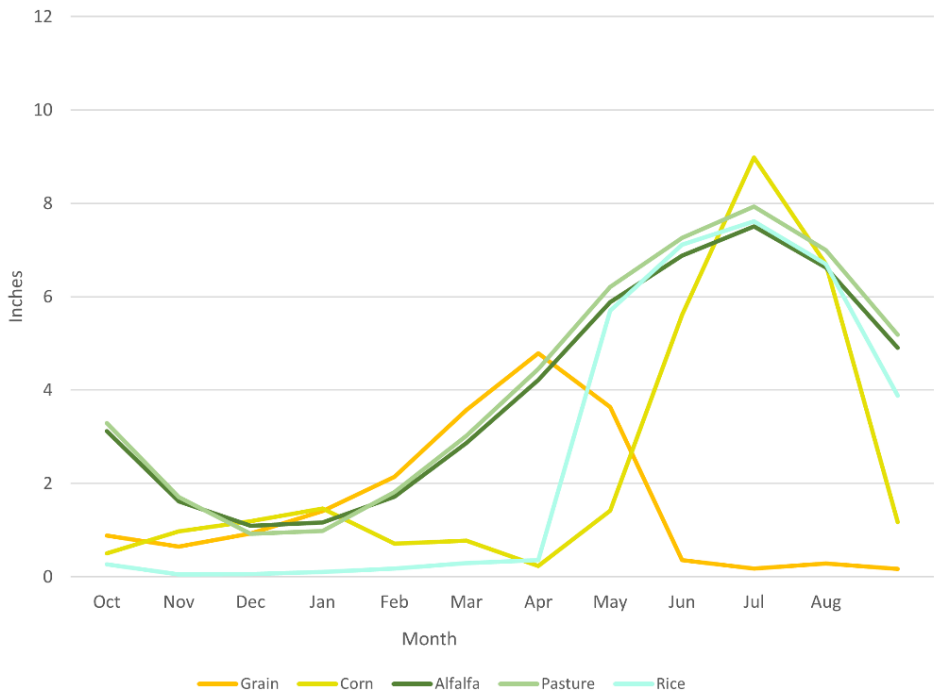


Figure 2-17: Average Monthly Evapotranspiration by Land Use Type, Major Field and Row Crops

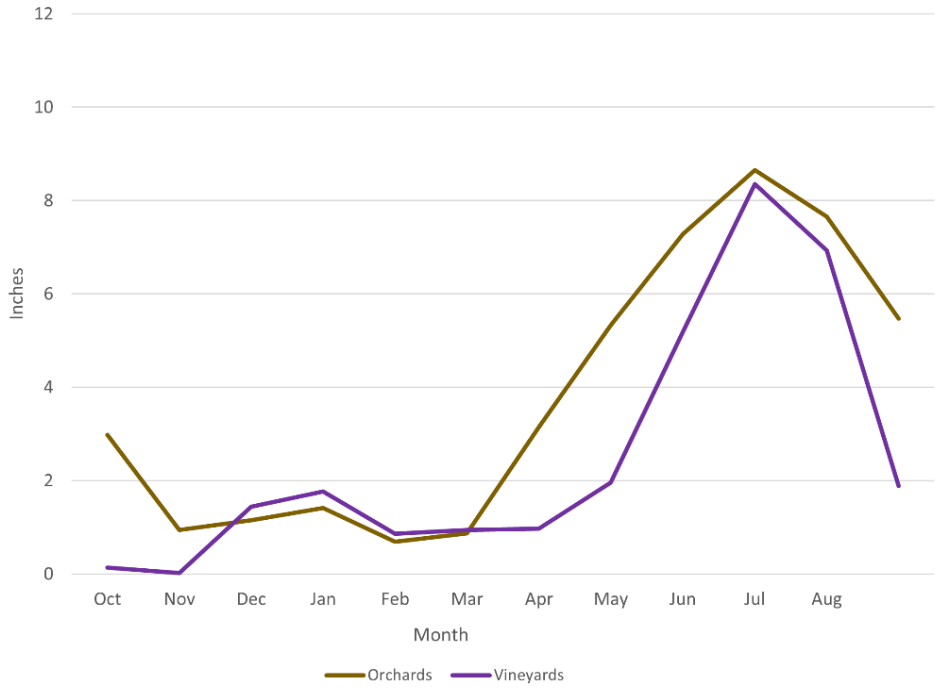


Figure 2-18: Average Monthly Evapotranspiration by Land Use Type, Orchards and Vineyards

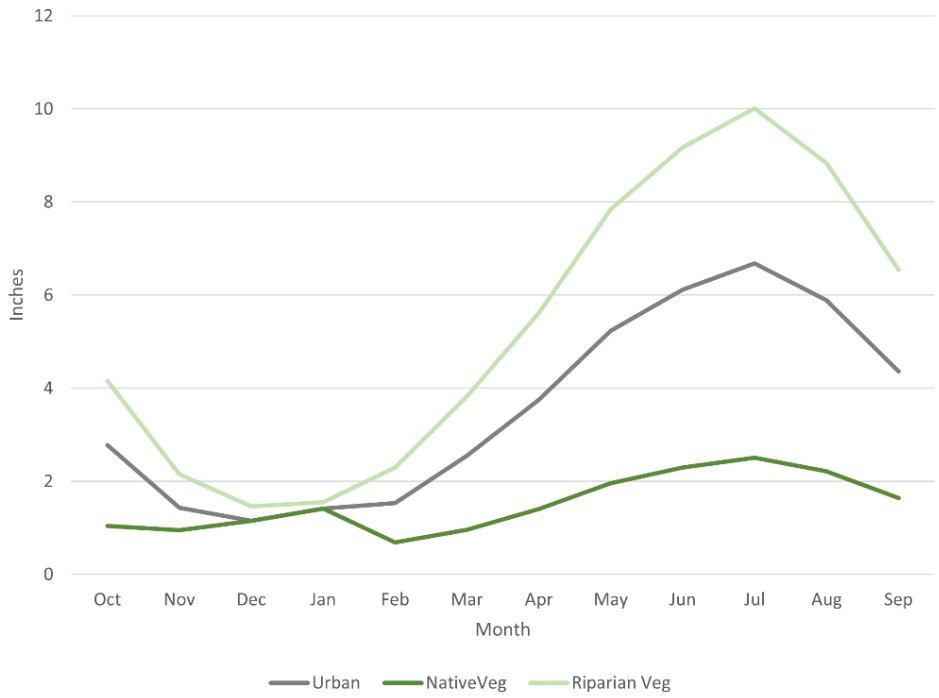


Figure 2-19: Average Monthly Evapotranspiration by Land Use Type, Urban, Native, and Riparian

2.9 Root Zone Soil Parameters

The soil properties specified in CoSANA are field capacity, wilting point, total porosity, saturated hydraulic conductivity, and pore size distribution index. The soil properties are used to calculate rainfall runoff and infiltration through the soil zone for each model element. Data from C2VSimFG was used to populate the five soil properties for each model element. The soil parameters were modified during the calibration process; the final soil parameter values and their spatial distributions are discussed and shown in figures in Section 0.

Model elements are also associated with the four hydrologic soil groups according to their runoff potential and infiltration characteristics. CoSANA elements with their corresponding hydrologic soil group are shown in Figure 2-20. The United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS; USDA NRCS, 2007) defines these hydrological soil groups as follows:

- Soils in Group A have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam, or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- Soils in Group B have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

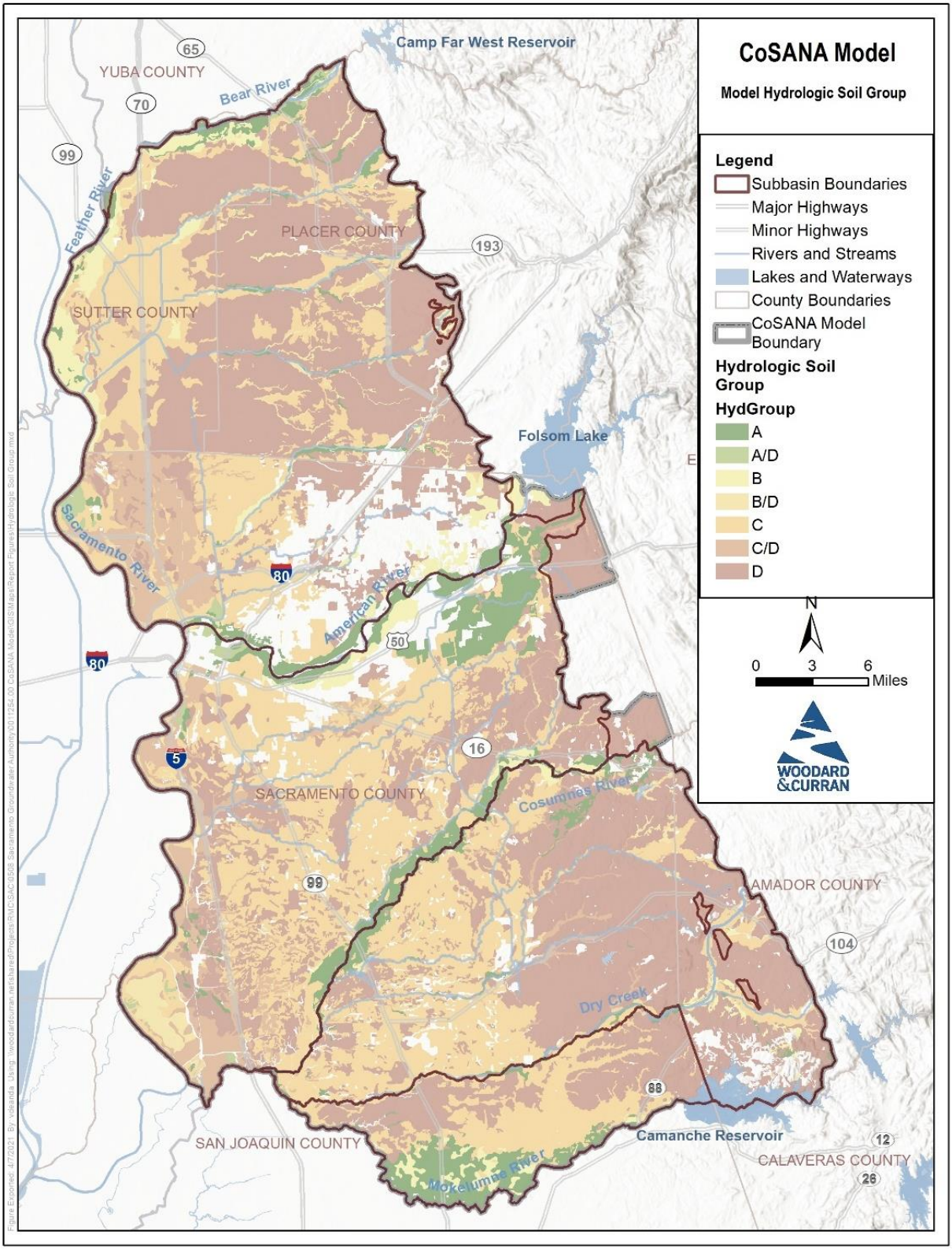


Figure 2-20: USDA Hydrologic Soil Groups

- Soils in Group C have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- Soils in Group D have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential.

2.10 Geologic Structure and Model Layering

The following section highlights development and refinement of CoSANA stratigraphy.

2.10.1 Model Layer Development and Approach

Layering for a groundwater model is guided by many factors, several of which are described as follows:

- Hydrostratigraphy of the study area. The thickness and extent of model layers and the overall extent and depth of the model was developed based on available geologic and hydrogeologic reports, including available maps and cross-sections, to reflect the physical system being simulated. Information from neighboring subbasins was also considered for consistency with the modeling efforts in those areas.
- Stream-aquifer interaction. CoSANA will support the investigation of stream-aquifer interaction in the modeled subbasins, notably for the American, Sacramento, and Cosumnes Rivers. This requires a realistic and accurate representation of the aquifer, pumping volumes, and pumping locations and a grid that is discretized sufficiently fine horizontally and vertically. Representing the recent alluvium and Riverbank Formation as a separate layer provided a finer vertical discretization underneath and around the streams.
- Available information on screen/perforation depths for monitoring and production wells. If available, information on the vertical distribution of pumping is used to layer the model such that it corresponds to the depths at which those stresses occur. At present, there is limited information on the vertical distribution of well screens and perforations in the study area, particularly for private agricultural and domestic wells. Furthermore, many wells in the area were constructed with long sections of perforation or open boring, making it difficult to determine the elevations of greatest groundwater production.
- Importance of vertical gradients and the availability of vertically distributed head data. There are several multi-completion monitoring wells installed in the study area. At the most there are only five completions in an individual well cluster. Vertical discretization beyond that level would require estimation of parameters that control vertical movement of water (e.g., vertical hydraulic conductivity) that could not be evaluated by comparison of simulated and observed data.
- Model run time. All other considerations being equal, model run times will increase with the number of layers that are used. Run time was identified as an important consideration early in the planning process for CoSANA due to the benefits seen from faster model run time for SacIWRM. The ability to perform many model runs quickly is a desired outcome in the model development, particularly when iterative modeling scenarios are performed.

The selection of the number of layers and their elevations requires balancing these factors and the overall objectives of the project.

2.10.2 Model Layer Definition

The subsurface is characterized in CoSANA by five model layers representing the different geology from the ground surface to the shallower of bedrock or the base of fresh water. The ground surface elevation, the upper boundary of the topmost layer, is based on the USGS DEM at a resolution of 30 meters. Descriptions of each of the model layers are listed below, from top to bottom. DWR's Bulletin 118-3 (1974) and data from the Western Placer County Groundwater Management Plan (Roseville, City of, et al., 2007) provided cross sections that were used to support development of all layers, while surficial geology maps (California Geological Survey 2009, 2011) were used primarily to support the extent of layers at the surface. Figures 23-27 show the extent and thickness of each model layer as described below.

- Layer 1 represents the recent alluvium and Riverbank Formation. Layer 1 is up to 188 feet thick and is generally constrained to be at least 30 feet thick. This layer was developed using California Geological Survey (2009; 2011), DWR's Bulletin 118-3 (1974), and data from the Western Placer County Groundwater Management Plan (Roseville, City of, et al., 2007) (Figure 2-21).
- Layer 2 corresponds to the Laguna Formation. Layer 2 is up to 502 feet thick and is generally constrained to be at least 50 feet thick (Figure 2-22).
- Layer 3 corresponds to the Mehrten Formation. Layer 3 is up to 1,487 feet thick and is generally constrained to be at least 50 feet thick (Figure 2-23).
- Layer 4 corresponds to the Valley Springs Formation. Layer 4 is up to 824 feet thick and is generally constrained to be at least 50 feet thick (Figure 2-24). The bottom of the Valley Springs Formation was supported by the work of Page (1974) in addition to the sources described earlier.
- Layer 5 corresponds to the portion of the Ione Formation that is above the base of fresh groundwater. Base of fresh water is defined based on Berkstresser (1973) and represents the depth where electrical conductivity is approximately 3,000 microsiemens per centimeter. Very few borings penetrate far below the base of freshwater, and it is expected that very little pumping occurs from this depth. Layer 5 is up to 795 feet thick and is generally constrained to be at least 50 feet thick (Figure 2-25).

A set of cross-sections were developed to show model stratigraphy in various locations and are presented as an overview map and 12 cross sections in Figure 2-26 through Figure 2-38.

Within each model layer, CoSANA aquifer parameters were estimated based on the texture dataset of the Sacramento Valley (DWR, 2018a). Aquifer parameters assigned to pilot point locations covering the model domain were distributed to model nodes using the sediment-based texture information to provide the spatial variability of parameters.

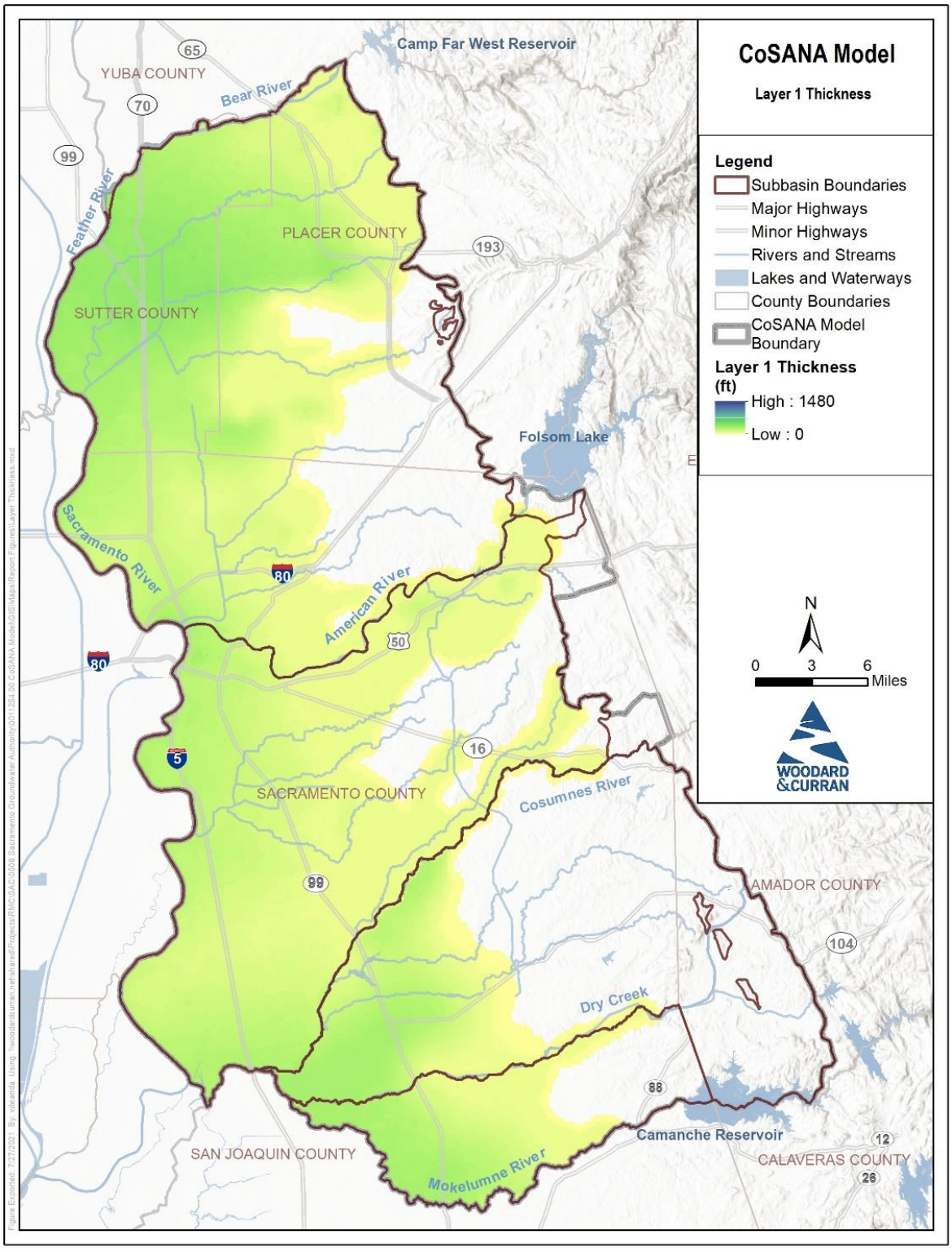


Figure 2-21: Thickness of Layer 1

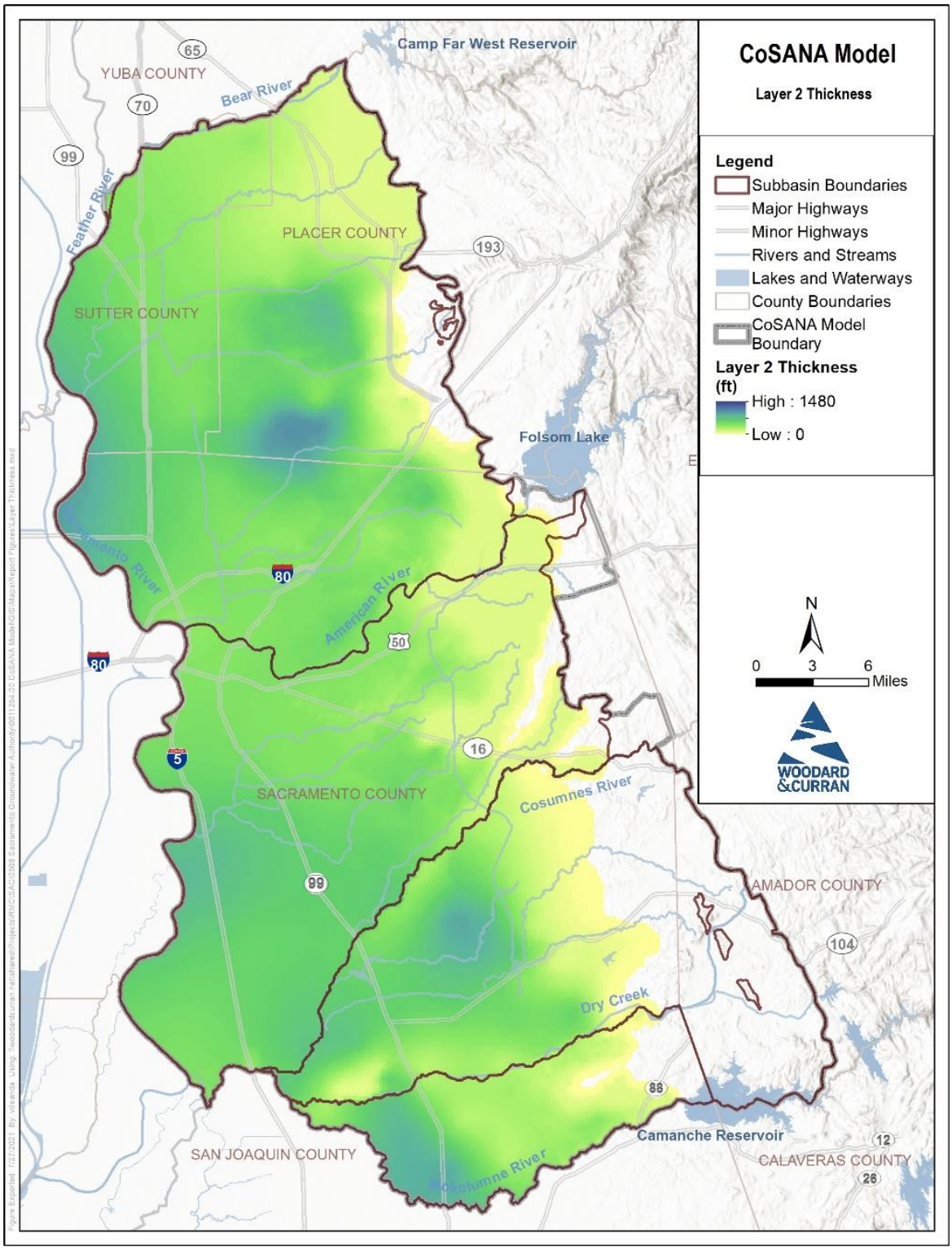


Figure 2-22: Thickness of Layer 2

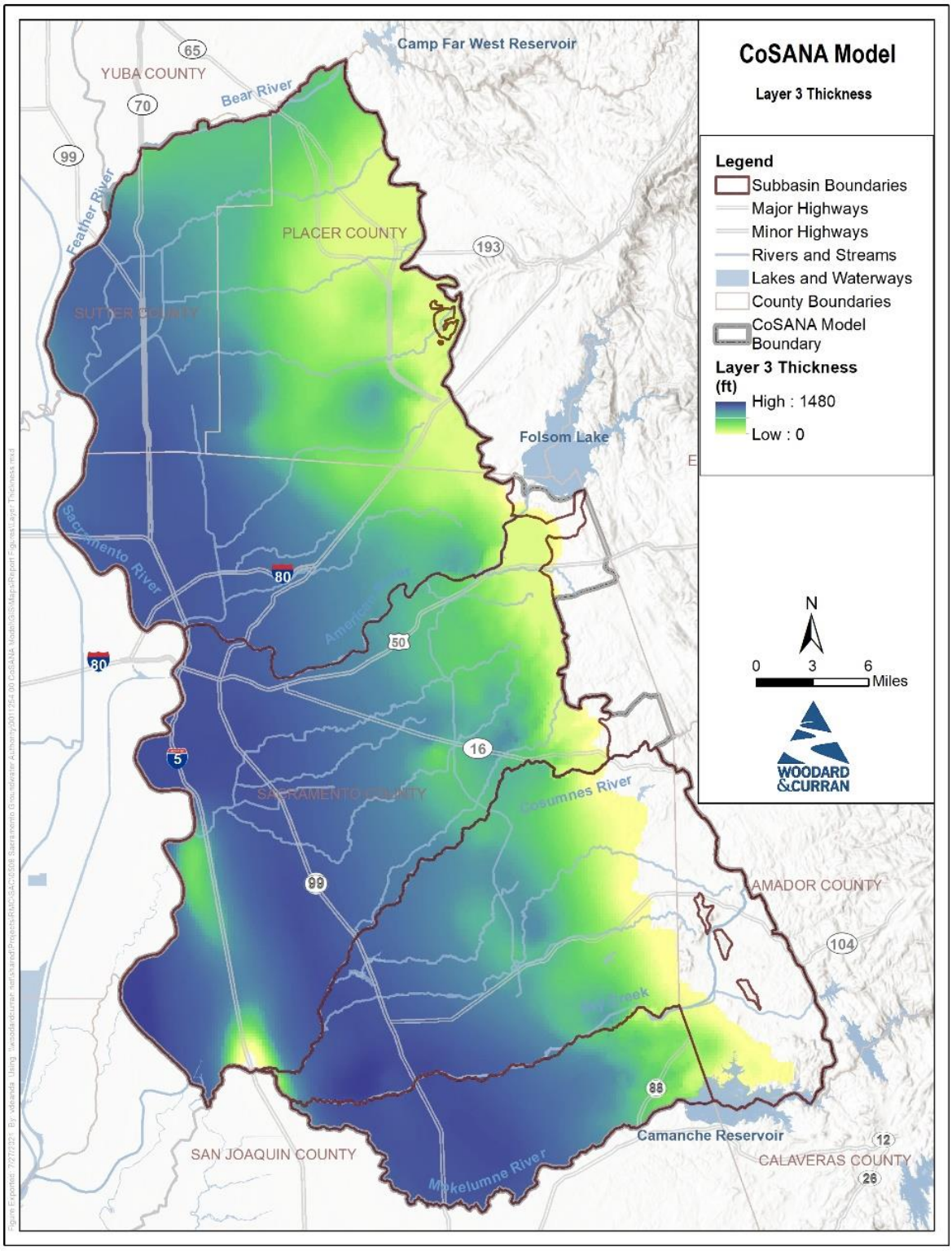


Figure 2-23: Thickness of Layer 3

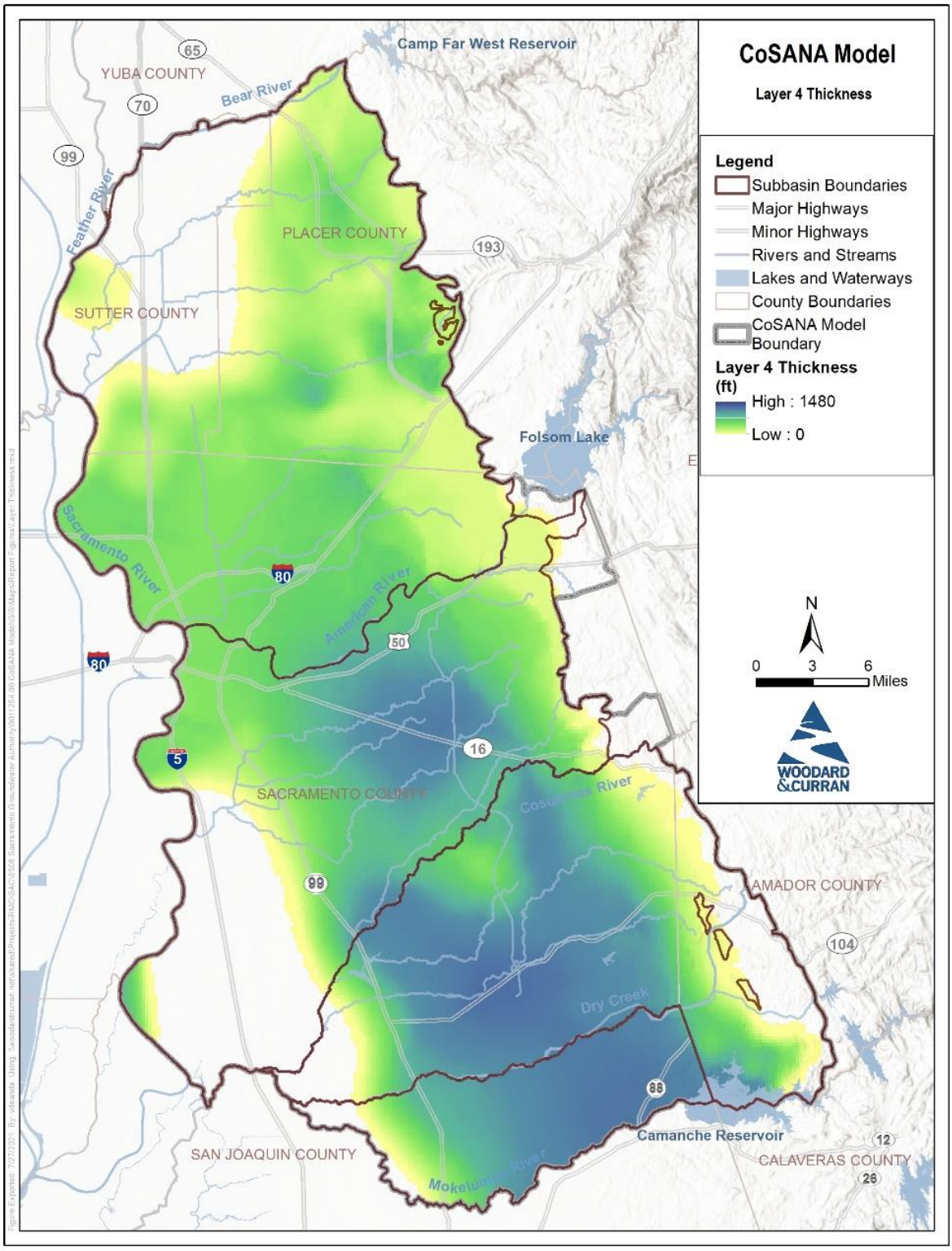


Figure 2-24: Thickness of Layer 4

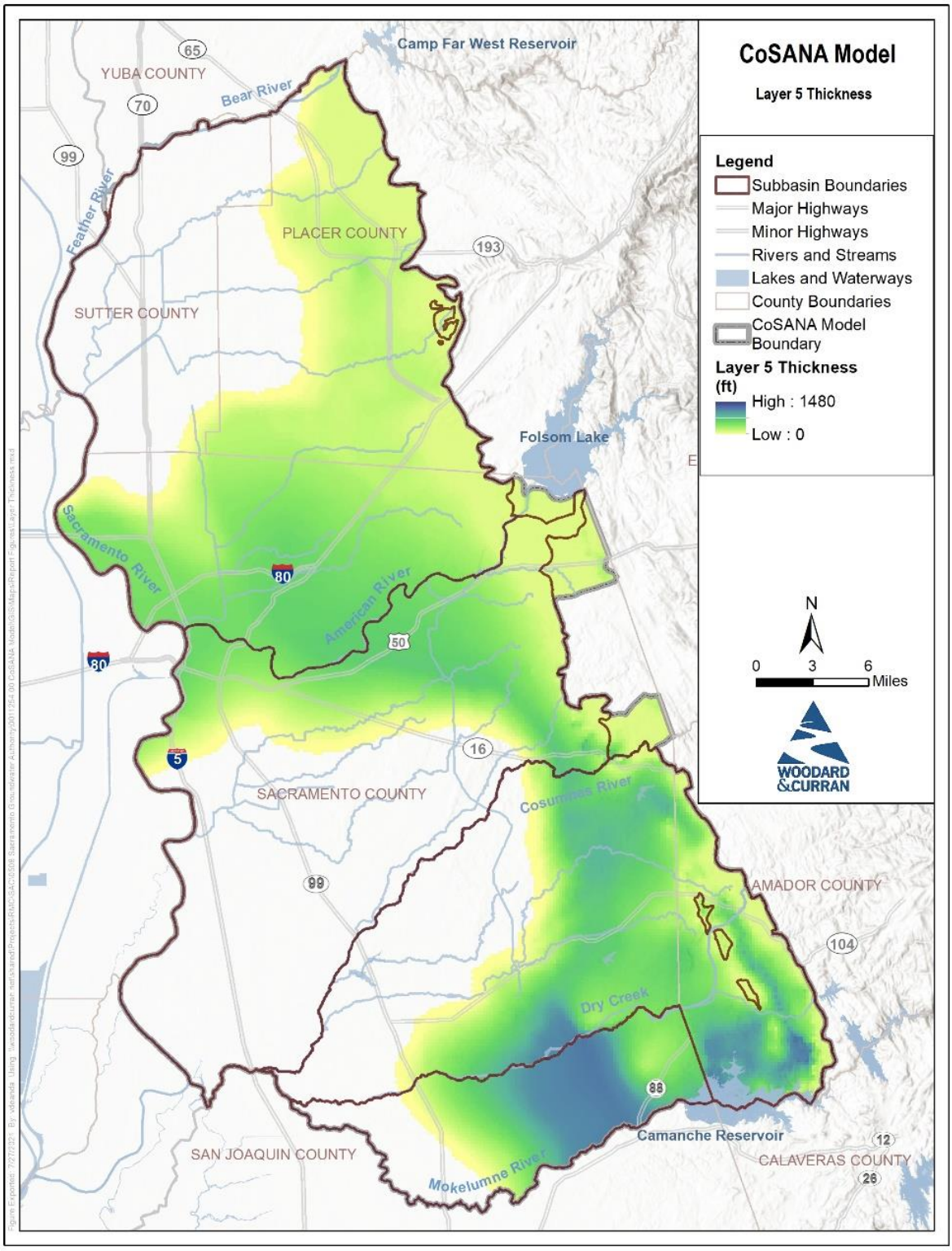


Figure 2-25: Thickness of Layer 5

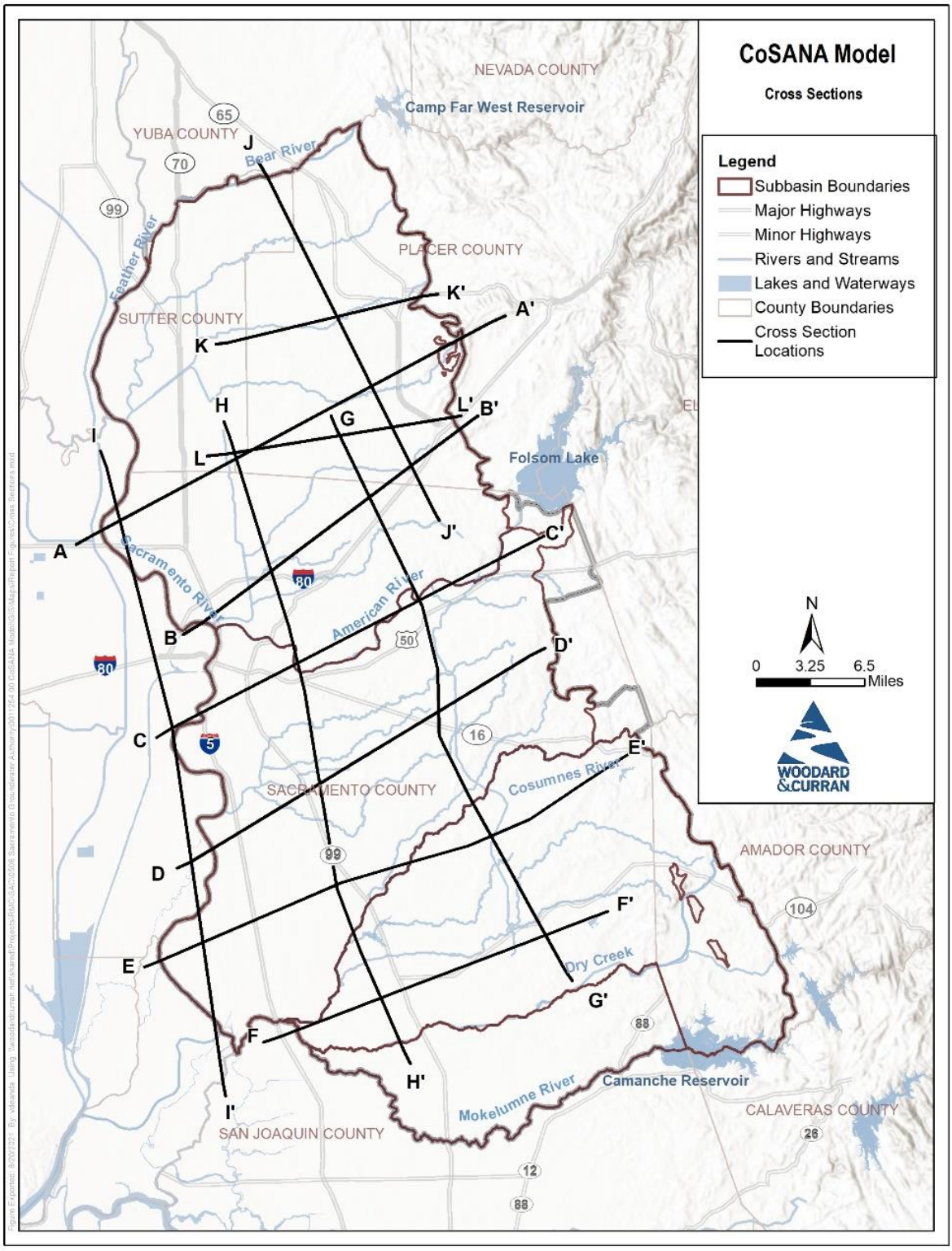


Figure 2-26: CoSANA Cross Sections

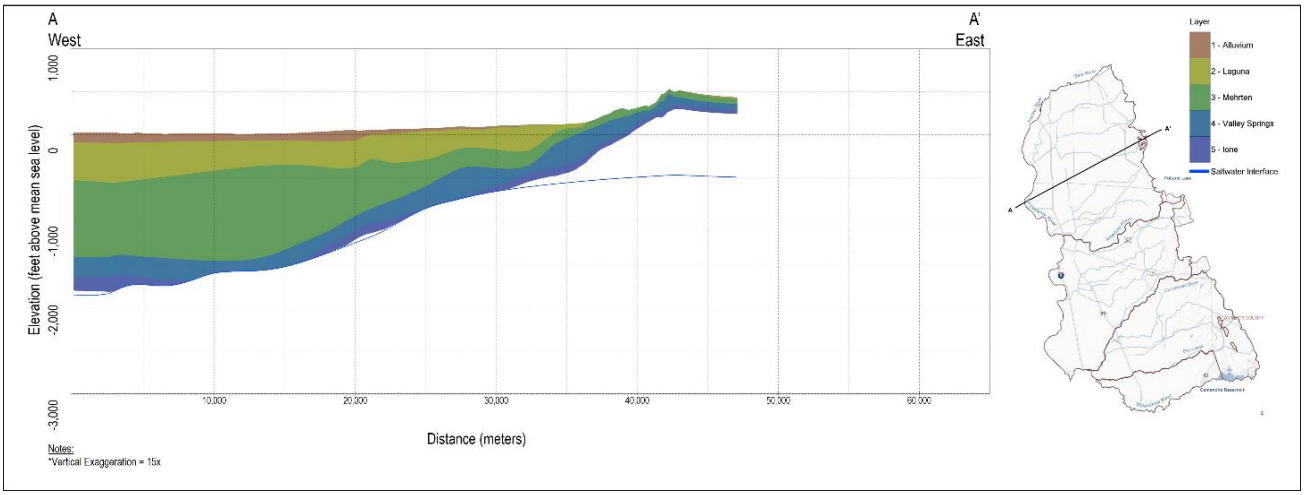


Figure 2-27: CoSANA Cross Section A-A'

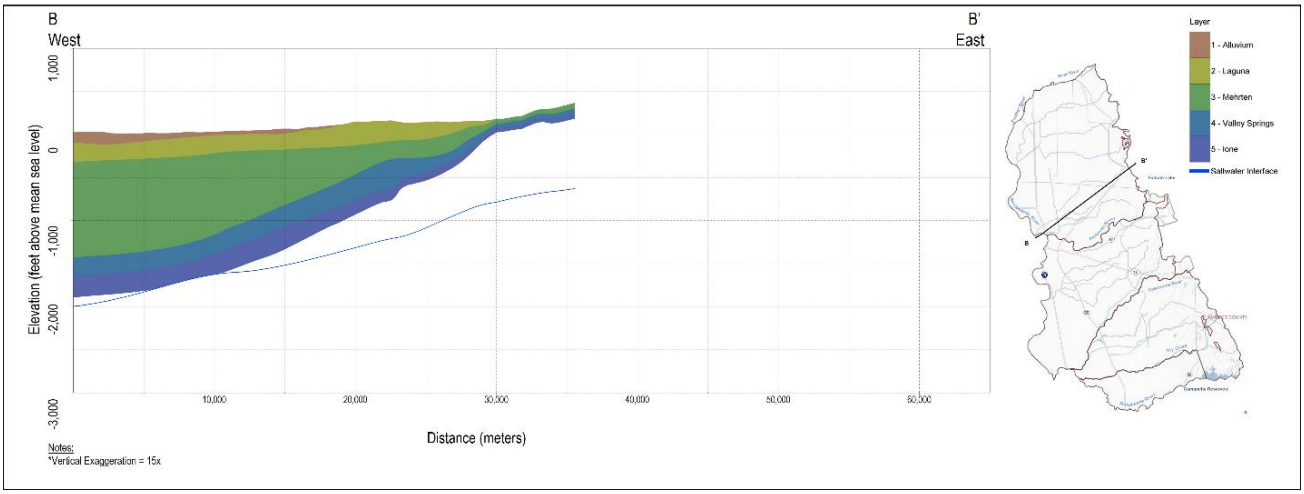


Figure 2-28: CoSANA Cross Section B-B'

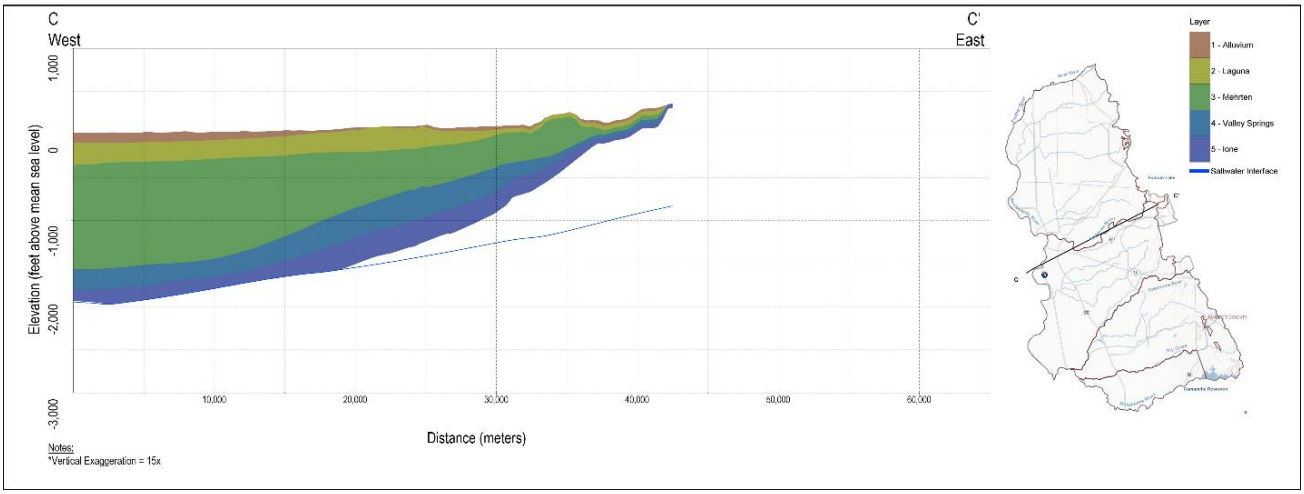


Figure 2-29: CoSANA Cross Section C-C'

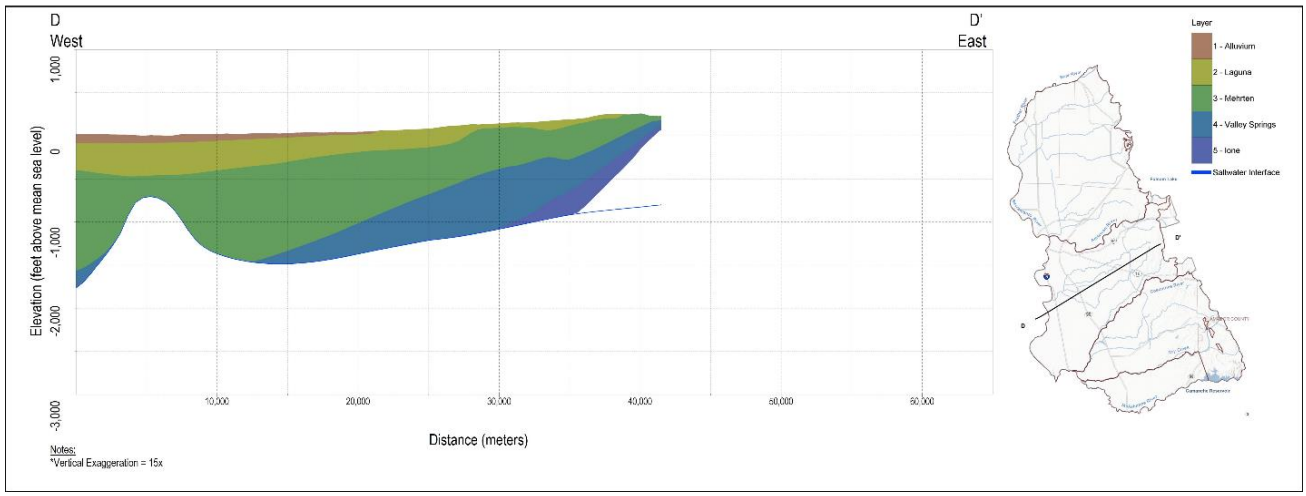


Figure 2-30: CoSANA Cross Section D-D'

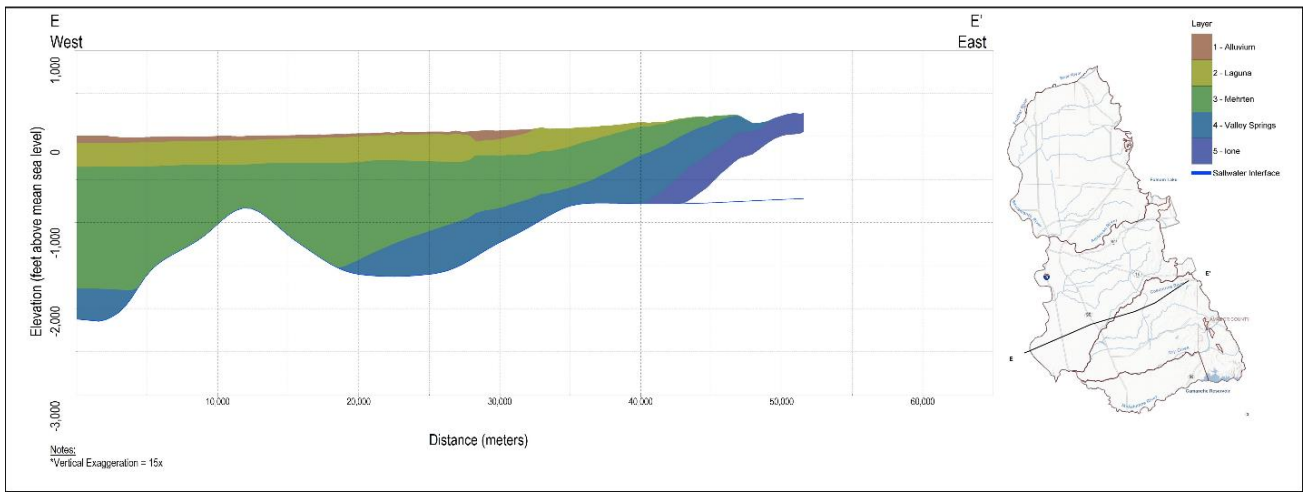


Figure 2-31: CoSANA Cross Section E-E'

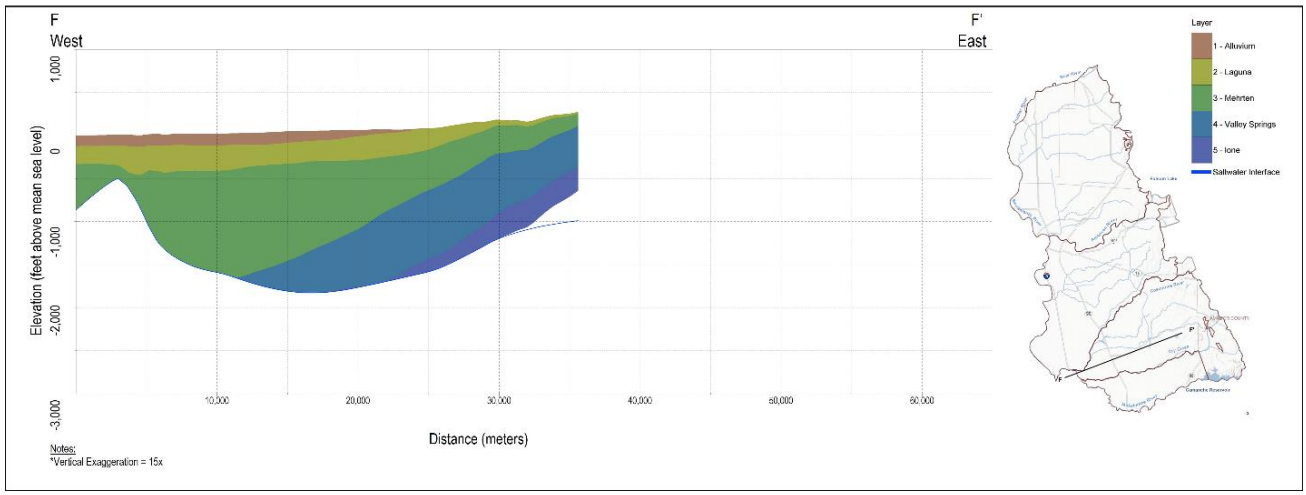


Figure 2-32: CoSANA Cross Section F-F'

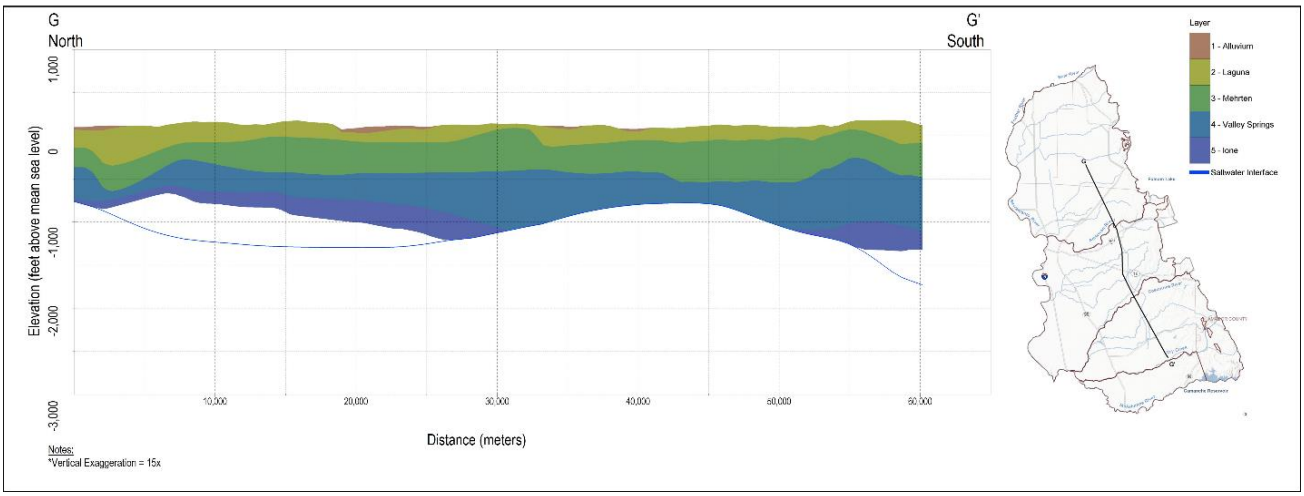


Figure 2-33: CoSANA Cross Section G-G'

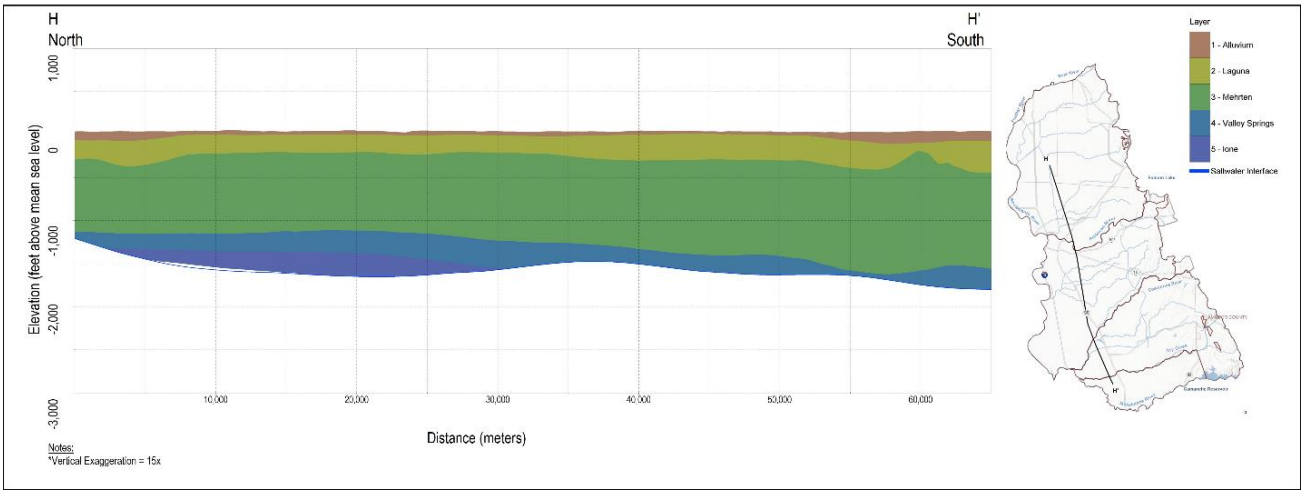


Figure 2-34: CoSANA Cross Section H-H'

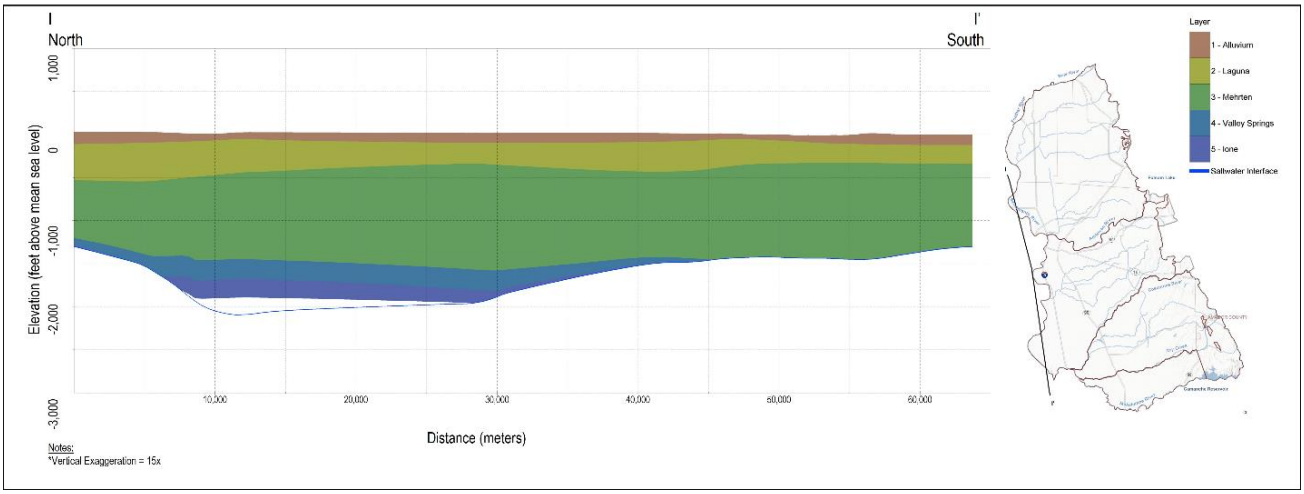


Figure 2-35: CoSANA Cross Section I-I'

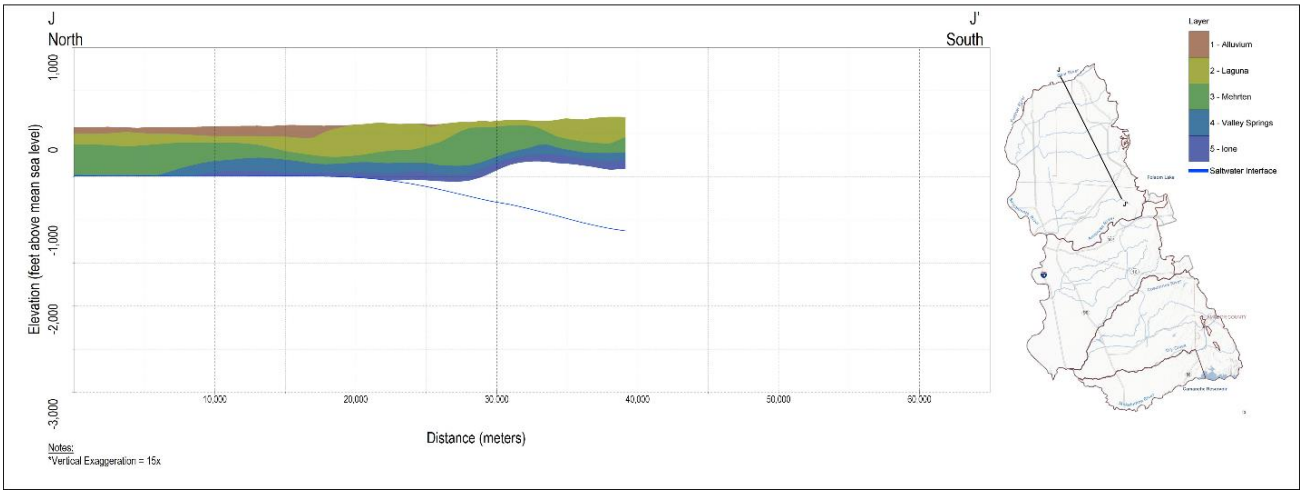


Figure 2-36: CoSANA Cross Section J-J'

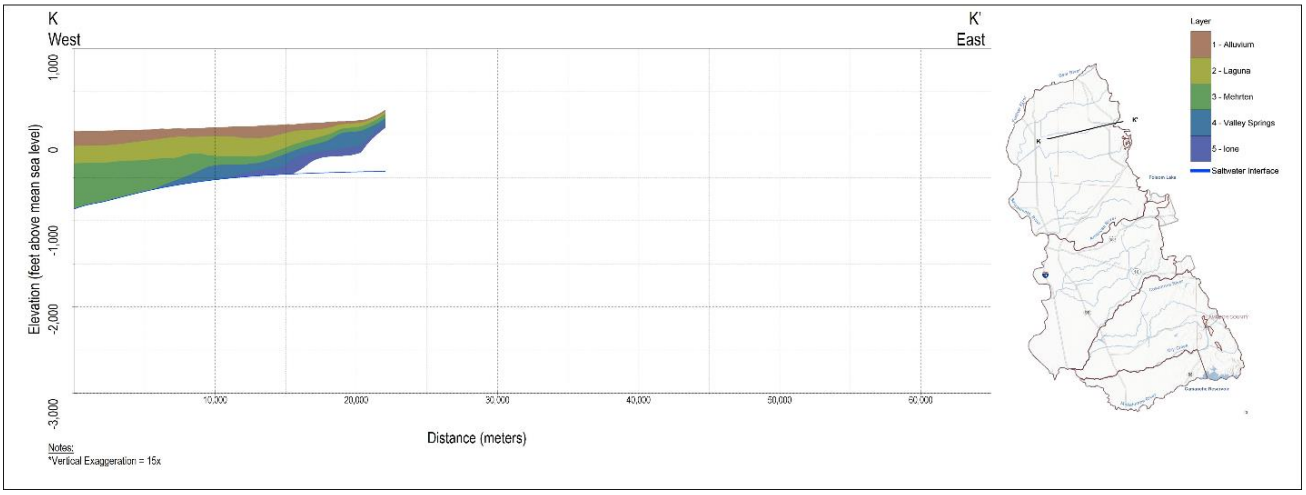


Figure 2-37: CoSANA Cross Section K-K'

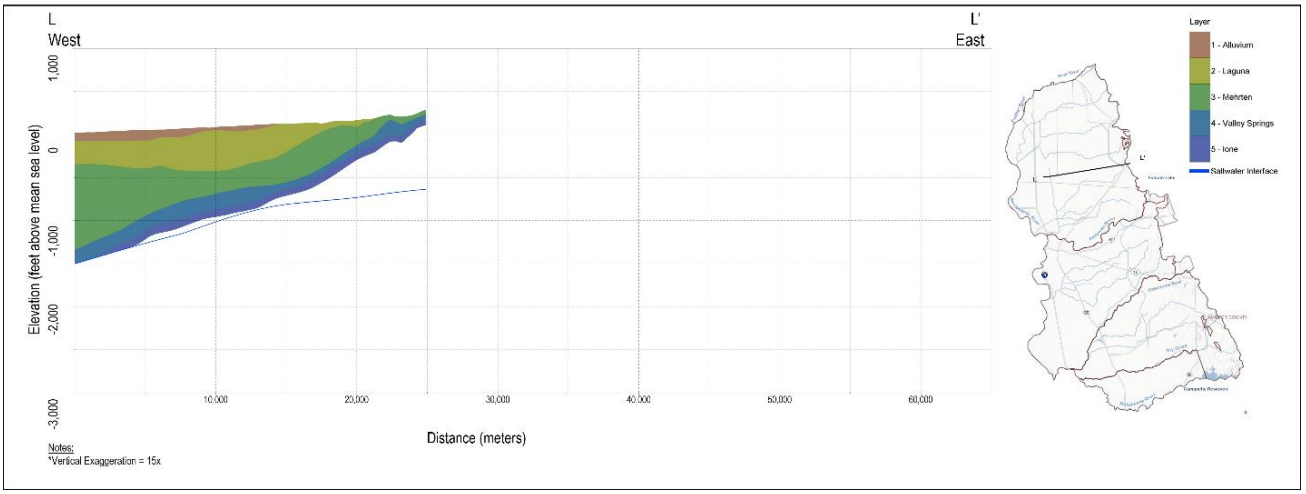


Figure 2-38: CoSANA Cross Section L-L'

2.11 Tributary Watersheds

The inflow from the eastern boundary of the model (i.e., Sierra Nevada foothills) originates from tributary watersheds, including both gaged and ungaged watersheds. The simulation of runoff and inflows from the gaged watersheds (i.e., stream inflows into the model) was discussed in Section 2.4. The simulation of surface and subsurface flows from the ungaged watersheds is explained in this section.

CoSANA simulates the ungaged eastern inflow using 32 small watersheds (Figure 2-39), based on the latest version of C2VSimFG. Flow from ungaged small watersheds is estimated based on precipitation rates and characteristics assigned to each identified ungaged watershed, again based on parameters from C2VSimFG. A portion of flow from the small watershed enters the model area as surface runoff and flows to simulated streams. The remaining small watershed flow contributes as subsurface boundary flow to the groundwater system.

All subsurface inflows from these small watersheds are routed to model Layer 5 along specified groundwater nodes, with a defined maximum percolation rate at each node. Excess flows that do not infiltrate to groundwater enter the simulated streams at specified locations, delineated using the USGS Watershed Boundary Dataset (HUC12 watersheds).

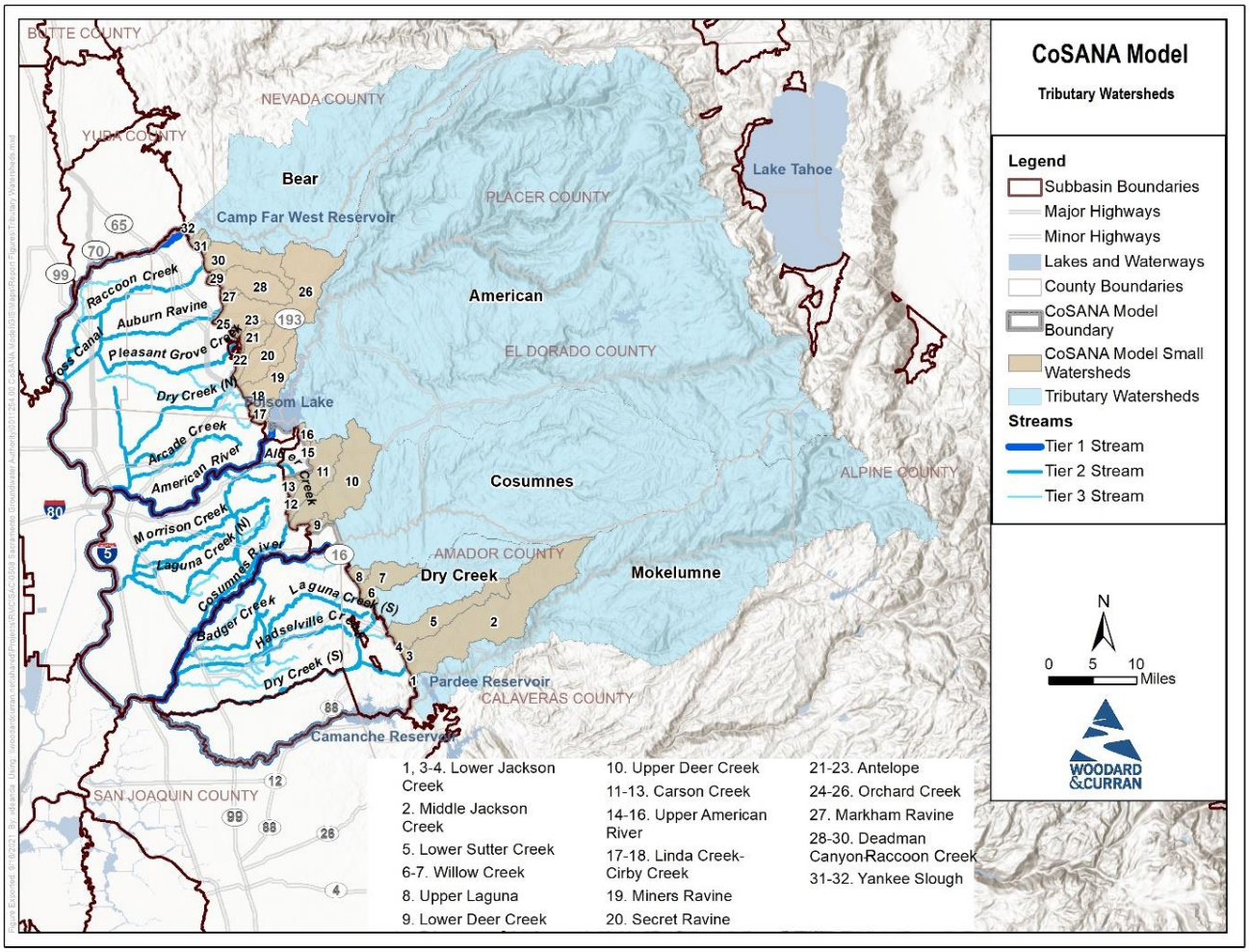


Figure 2-39: Tributary Watersheds

2.12 Boundary Conditions

Boundary conditions define the subsurface inflows for the northern, western, and southern borders of the model. The following boundary conditions are set in CoSANA:

2.12.1 General Head

Time-series general-head boundary conditions representing groundwater levels outside of the model area were defined for all active layers for 713 boundary nodes on the northern, western, and southern limits (i.e., along Bear River, Sacramento River, and Mokelumne River). General head boundary conditions, for each model node that it is defined, use a defined conductance and a reference groundwater level time series at a location outside the model domain with a known distance. The conductance values at the boundary condition nodes were calculated from the horizontal hydraulic conductivity, distance to the reference point, layer thickness, and the length of the boundary section represented by each node.

Groundwater level time-series data at a distance of approximately 3,000 feet from the boundary were extracted from the C2VSimFG model. The extracted values were compared with observed groundwater elevations from DWR's Water Data Library (WDL) and modified to better fit the observed elevations by trend and bias correction while protecting the spatial variation provided by C2VSimFG.

2.12.2 Small Watersheds

As discussed in the previous section, subsurface inflows and surface runoff contributions along the eastern boundary of model are represented using small watersheds.

2.12.3 Constrained Head

Additional boundary conditions were defined to simulate known water elevations for Camanche Reservoir. Seepage from Camanche Reservoir was represented by constrained head boundary conditions for the uppermost layer of the 228 groundwater nodes representing the reservoir elevations.

2.13 Initial Conditions

Groundwater heads for each model node and each layer at the beginning of the calibration simulation (October 1, 1989) were developed using DWR's WDL database. Over 815 wells with data were analyzed for use in building the initial groundwater heads. Due to the availability of data in different wells, a hierarchy of data was used to compile sufficient coverage over the model domain for development of initial conditions:

- Fall 1989 (August through October) where available
- Extended Fall 1989 (July through November)
- Surrounding years data, averaged (Fall 1988 or Fall 1990)
- Surrounding two years data, averaged (Fall 1987 or Fall 1991)
- Other timeframes were selected by examining hydrographs and groundwater level trends
- Where all above unavailable outside of the model boundary, depth to water was extrapolated

Observation data were interpolated to develop a raster representing initial groundwater levels over the model domain. Due to the lack of construction information for many of the WDL monitoring locations, the groundwater heads described above are used for all layers. The model "warm up" period from WY1989 to WY1994 allows the model time to equilibrate the groundwater conditions to smooth any issues that might arise from lack of data or erroneous data. The initial conditions for CoSANA representing October 1, 1989 are shown in Figure 2-40.

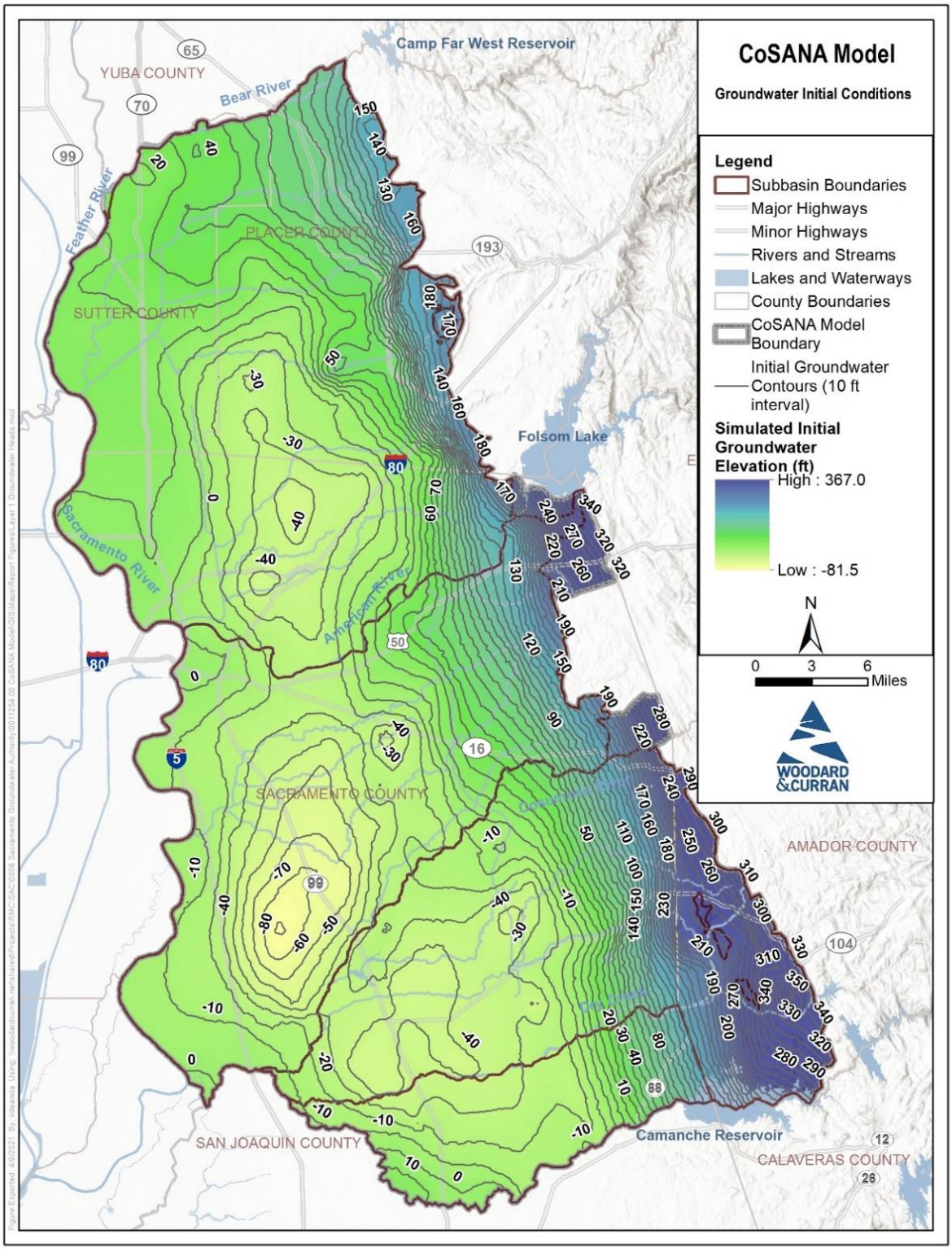


Figure 2-40: Initial Conditions, Groundwater Heads, Fall 1989

3. WATER SUPPLY AND DEMAND DATA

The following sections describe the data and methodology for developing CoSANA water demand and supply input data. Typically, agricultural and urban supplies are specified in IWFM's groundwater pumping and surface water diversion data, and agricultural and urban demands are calculated using the IWFM IDC. In the case of CoSANA, the urban demands for historical period were provided for each one of the urban water purveyors and were input in the model directly.

3.1 Water Supply

Both the agricultural demands estimated by IDC and the urban demands are primarily met through the IWFM representation of surface water diversions and groundwater pumping. Other sources of water simulated in IWFM to meet demand include recycled water, remediated (reuse) water, precipitation, and existing moisture in the soil.

3.1.1 Surface Water Supply

Historical surface water diversions for the simulation period were compiled from a combination of sources discussed in more detail in Sections 3.2 and 3.3, including gage data, water rights reports, Urban Water Management Plans (UWMPs), Agricultural Water Management Plans (AWMPs), and other sources. Some diversions were estimated based on historical demands. A summary of diversions simulated in the model is provided in Appendix A, along with the actual percentage of diverted water that is delivered after the delivery losses are accounted for. Delivery losses comprise recoverable losses (i.e., seepage along delivery and unlined canals) and non-recoverable losses (i.e., evaporation from canals).

Many diversions provide water across two or more model subregions, so deliveries are assigned to a group of elements representing the delivery area, rather than a subregion. Diversions are either assigned to a stream node near the point of diversion or they are treated as imports if the point of diversion is outside model area. Figure 3-1 to Figure 3-3 show schematic diagrams of the surface water delivery system simulated in CoSANA.

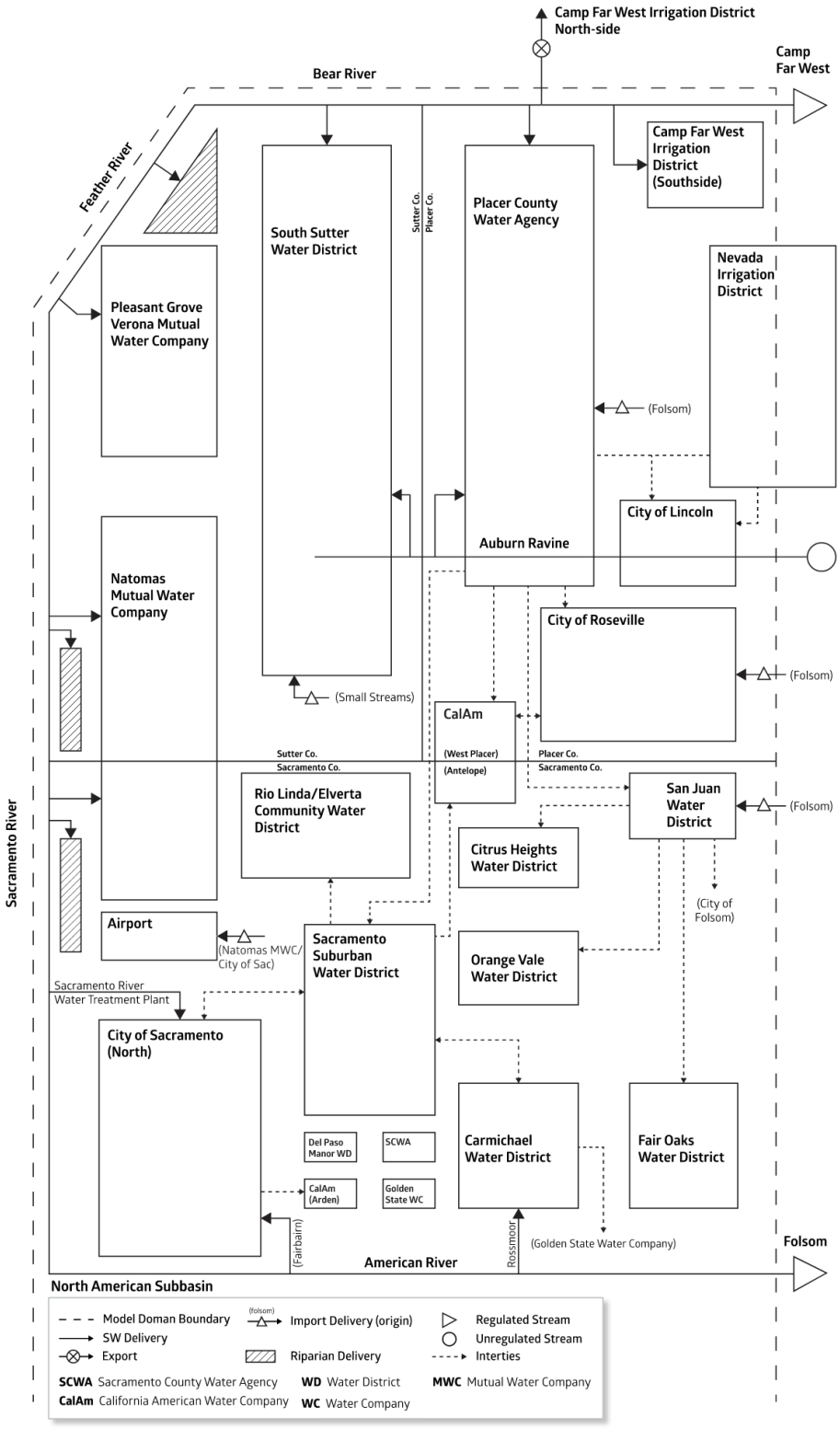


Figure 3-1: CoSANA NASb Surface Water Delivery Schematic

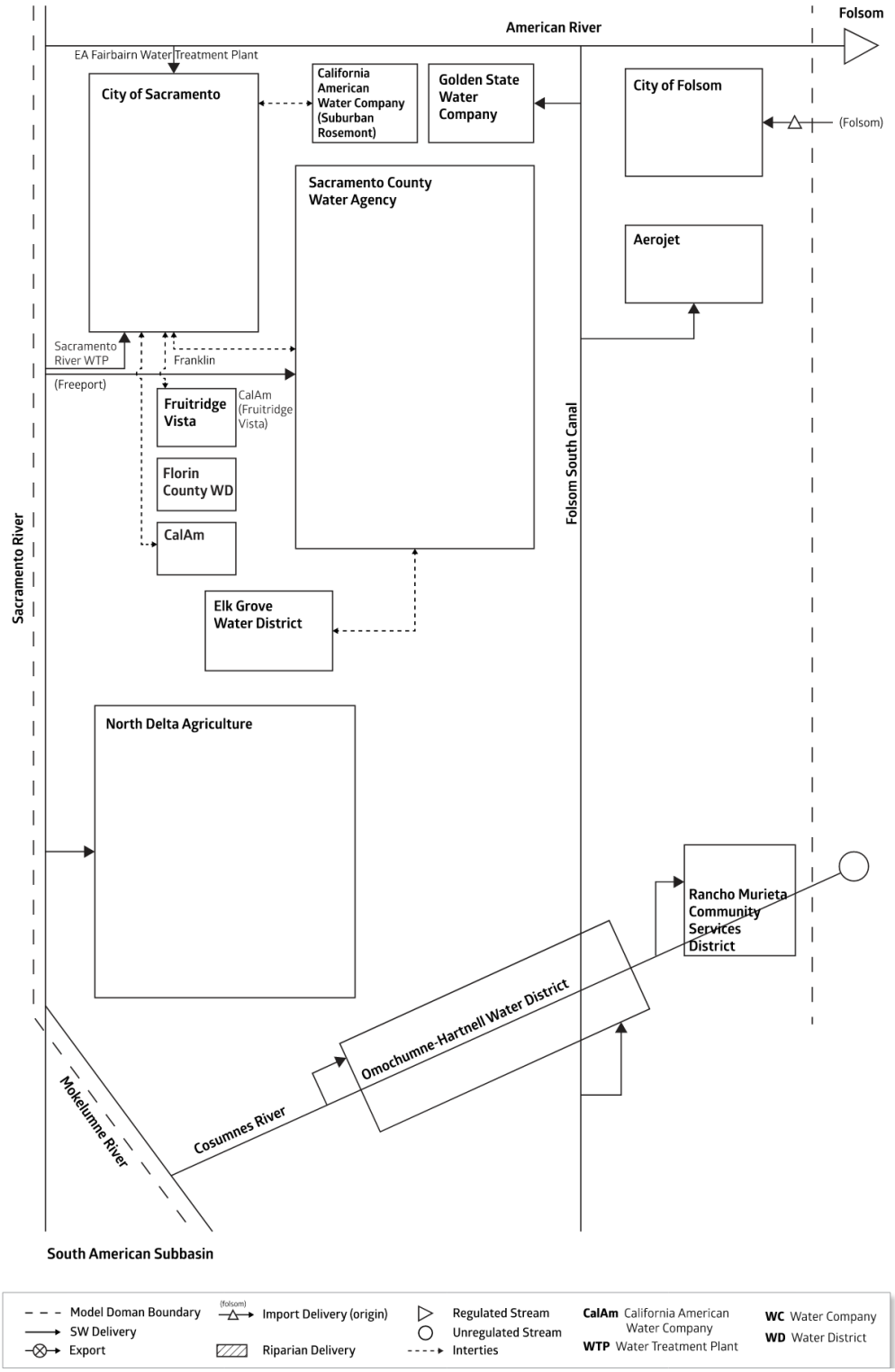


Figure 3-2: CoSANA SASb Surface Water Delivery Schematic

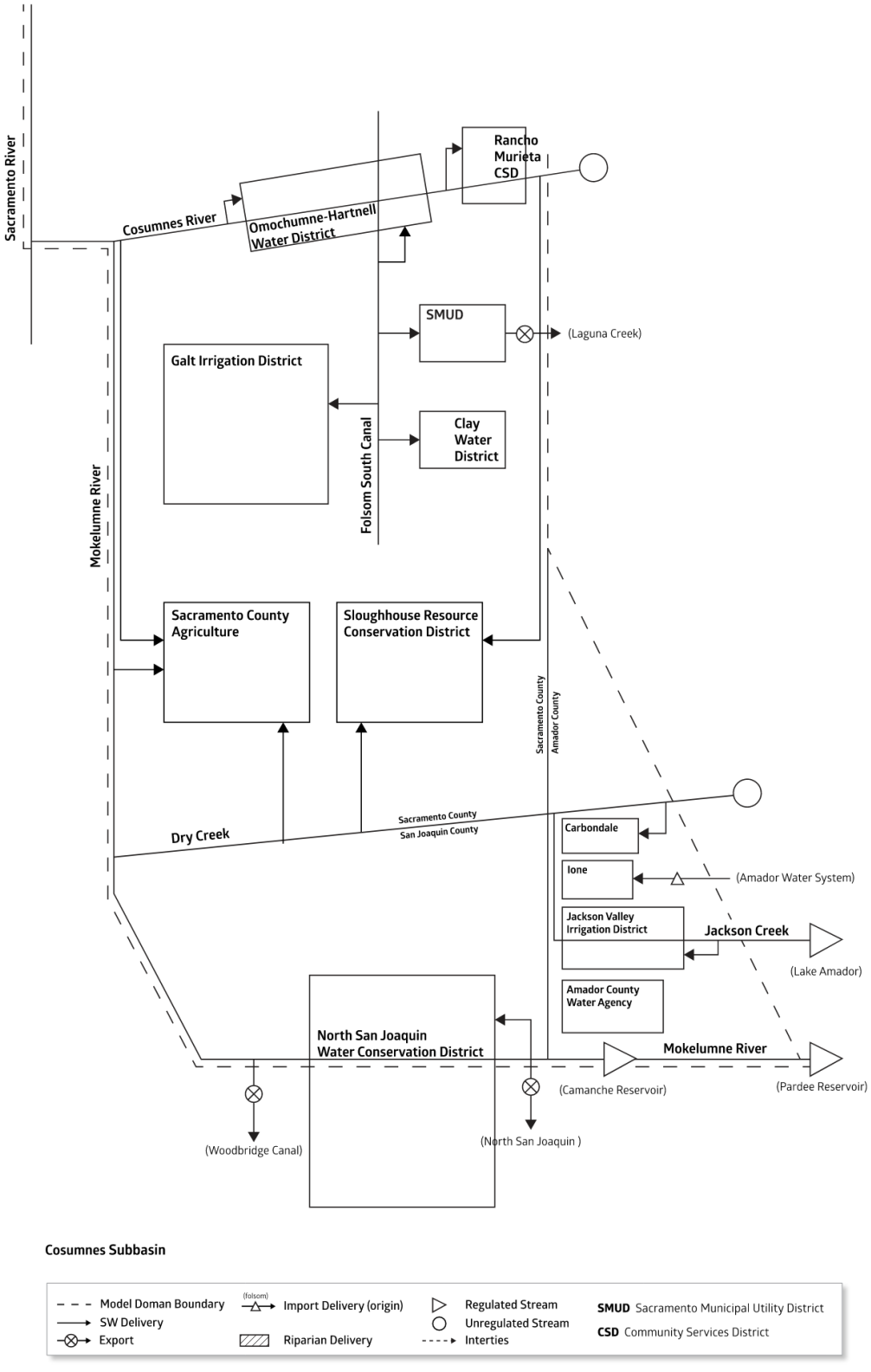


Figure 3-3: CoSANA CoSb Surface Water Delivery Schematic

3.1.2 Groundwater Pumping

Groundwater pumping within CoSANA is separated into pumping by wells and pumping by elements. The former largely includes agency-operated wells that deliver groundwater to a public water supply system, as well as groundwater contamination remediation operations where data are available by well. The latter includes estimated agricultural and domestic (including rural residential) groundwater pumping.

Where available, pumping data are specified on a monthly basis throughout the historical simulation period. Data provided typically included well locations, total depth, screen perforation depth, use (agricultural, urban, or remediation) and historical monthly pumping records. Agricultural and rural residential pumping volumes are not typically known and were estimated by the model to meet demands not satisfied through other sources (e.g., well pumping and surface water deliveries.)

3.2 Urban Water Demand and Supply

Urban demands are provided by the urban water purveyors for the historical model period. The monthly urban demands are directly inputted into the model for each urban purveyor.

It was assumed that an annual average of 60% of urban water is used indoors and 40% is used outdoors. CoSANA uses monthly fractions for indoor and outdoor use, with the majority of urban water demand due to indoor activities from November through March and up to 60% of urban water used outdoors for the remainder of the year. Assumed monthly fractions for City of Galt indoor and outdoor use were adjusted to better match those reported by the City of Galt.

Table 3-1 lists the number of wells by type and purveyor included in CoSANA. Figure 3-4 shows the locations of the urban pumping wells in CoSANA, including those shown in Table 3-1 and some additional smaller users including Sacramento International Airport, fish farms, and others.

Table 3-1: Summary of CoSANA Well Pumping by Urban Purveyor

Purveyor	Number of Municipal Pumping Wells	Average Annual Municipal Pumping (WY 1995-2018, acre-feet)
California American Water Company	135	39,666
Cal Am (formerly Fruitridge Vista WC)	20	4,220
Camanche Village (Amador County WA)	6	258
Carmichael WD	17	4,025
Citrus Heights WD	14	987
City of Galt	25	4,716
City of Lincoln	5	717
City of Roseville	6	18
City of Sacramento	68	20,427
Del Paso Manor WD	10	1,536
Elk Grove WD	17	5,144
Fair Oaks WD	12	1,262
Florin County WA	10	2,624
Golden State WC	33	9,897
Orange Vale WC	2	0
Rio Linda Elverta CWD	13	2,990
Sacramento County WA	118	27,510
Sacramento Suburban WD	119	29,905
Total Average Annual Pumping (acre-feet)		155,902

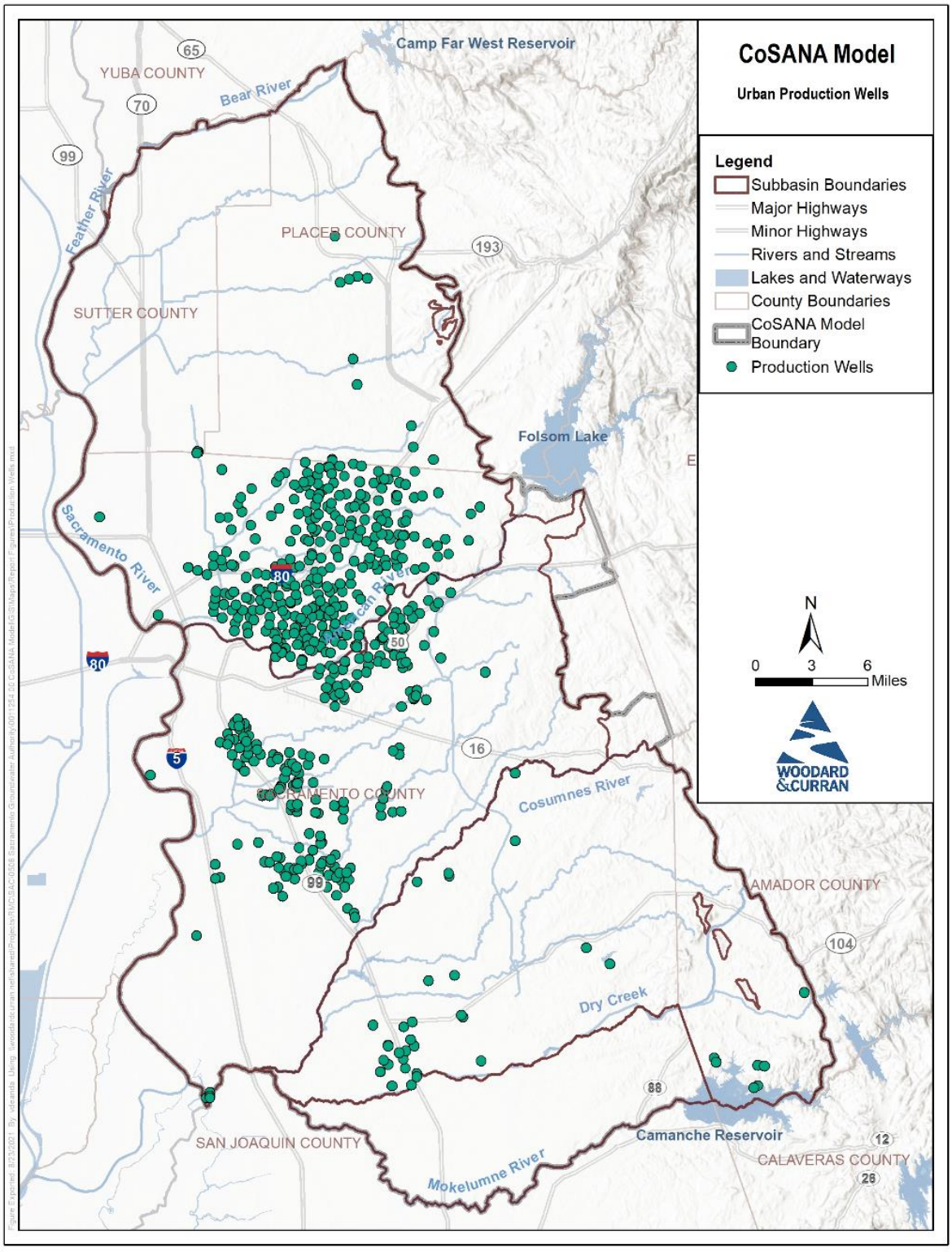


Figure 3-4: Locations of Urban Groundwater Production Wells

The following sections provide a brief description of water supplies for each of the urban water purveyors in each Subbasin.

3.2.1 North American Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors within the NASb. Averages presented are for the calibration period, WY 1995-2018. RWA (M. Garcia, personal communication, August 29, 2019) provided data for many of the individual entities listed below.

3.2.1.1 California American Water Company (Antelope)

California American Water Company (Cal Am) Antelope receives an average of 170 acre-feet per year (AFY) of surface water supplied via an intertie with Sacramento Suburban Water District (WD). Groundwater supply meets remaining demand with an average of 5,621 AFY. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.1.2 California American Water Company (Arden)

Cal Am Arden is primarily supplied by groundwater, an average of 2,830 AFY, with approximately 2 AFY being met by surface water supplied by the City of Sacramento. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.1.3 California American Water Company (Lincoln Oaks)

Cal Am Lincoln Oaks receives an average of 245 AFY of surface water supplied via an intertie with Sacramento Suburban WD. Groundwater supply meets remaining demand, with an average of 8,869 AFY. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.1.4 California American Water Company (West Placer)

Cal Am West Placer service area supply includes 725 AFY of surface water sourced from Placer County Water Agency (PCWA). RWA provided data for 2011-2018. Data prior to 2011 is estimated based on annual data provided by GEI Consultants (R. Shatz, personal communication, March 5, 2020).

3.2.1.5 Carmichael Water District

Carmichael WD uses an average 7,155 AFY of surface water from the American River and 4,080 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.6 Citrus Heights Water District

Citrus Heights WD supply includes 16,015 AFY of surface water sourced from San Juan WD and 952 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.7 Del Paso Manor Water District

Supply for Del Paso Manor WD is met entirely by groundwater pumping from district wells and averages 1,549 AFY. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.8 Fair Oaks Water District

Fair Oaks WD supplies include an average of 11,145 AFY of surface water received from San Juan WD and 1,183 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.9 Golden State Water Company (Arden)

Golden State Water Company (WC) Arden supply includes an average of 1,169 AFY of groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.10 City of Lincoln

On average, 6,218 AFY of the City of Lincoln's water supply comes from surface water supplied by PCWA and Nevada Irrigation District. The remaining 739 AFY of supply is provided by groundwater production from city wells. Data for 2008-2018 was provided by the City of Lincoln. Data for 2005 to 2008 is estimated based on annual data from the City of Lincoln UWMPs (2010, 2015). Data prior to 2005 is from SacIWRM

3.2.1.11 Orange Vale Water Company

Orange Vale WC on average receives 4,191 AFY of surface water sourced from San Juan WD. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.12 Placer County Water Agency (City of Rocklin Retail Service Area)

PCWA serves the City of Rocklin for retail customers. Remaining portions of PCWA's service area within the model are served by other retail water purveyors or are self-supplied by groundwater. Supply to the City of Rocklin is on average 4,578 AFY, based on data from PCWA (R. Cox, personal communication, July 17, 2019) for WY 2016-2018. All demand is assumed to be met by surface water. Lacking other data sources, data from 2016 was used for previous years.

3.2.1.13 Rio Linda / Elverta Community Water District

Rio Linda/Elverta CWD is primarily supplied by groundwater pumping, averaging 3,010 AFY. The remaining 5 AFY is from surface water sourced from an intertie with the City of Sacramento. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.14 City of Roseville

The City of Roseville receives, on average, 27,943 AFY of surface water sourced from Folsom Reservoir, with the remaining 126 AFY of supply met by groundwater pumping from city wells. Data were provided by the City of Roseville for 1986-2018. Gaps in data existed for 1999-2000 and 2008-2009; these were filled by interpolating data from surrounding years. Data prior to 1986 is from SacIWRM. Data from the City of Roseville also included details on groundwater injection as part of the city's aquifer storage and recovery program.

3.2.1.15 Sacramento Suburban Water District

Sacramento Suburban WD supply mix includes 32,396 AFY of groundwater production from district wells and 10,024 AFY from surface water sourced via intertie with PCWA and the City of Sacramento. Data sources include SacIWRM (to 2004), and RWA (after 2004).

3.2.1.16 City of Sacramento

The City of Sacramento receives on average 97,488 AFY of surface water from their water treatment plants on the American and Sacramento Rivers. Remaining demand is met by groundwater production from city wells that averages 20,225 AFY. This demand is spread across both the NASb and the SASb. Data sources include SacIWRM (to 2004), and RWA (after 2004).

3.2.1.17 Sacramento International Airport

The Sacramento International Airport receives on average 175 AFY from the City of Sacramento (based on data from RWA). Remaining demand of 968 AFY is assumed to be met by groundwater (based on SacIWRM demand).

3.2.1.18 San Juan Water District

San Juan WD average supply is estimated to be 5,196 AFY within the model area and is met entirely by surface water from Folsom Lake. This is based on retail data for the district supplied by RWA (after 2004) and assumes that 37% of the districts retail service area is within the CoSANA boundary. Data prior to 2004 is based on SacIWRM.

3.2.1.19 Sacramento County Water Agency (Arden Park Vista)

Demand for the Sacramento County Water Agency (SCWA) Arden Park Vista service area averages 3,911 AFY and is met entirely by groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.1.20 Sacramento County Water Agency (Northgate)

Supply for the SCWA Northgate service area averages 940 AFY and is met entirely by groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

3.2.2 South American Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors located within the SASb.

3.2.2.1 California American Water Company (Fruitridge - formerly Fruitridge Vista Water Company)

Cal Am Fruitridge Vista is serviced almost entirely by groundwater production from Cal Am wells. Some small surface water transfers are reported, which average to 1 AFY. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

3.2.2.2 California American Water Company (Parkway)

Cal Am Parkway receives on average 592 AFY of surface water delivered via an intertie with the City of Sacramento; the remaining 10,699 AFY is supplied from groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.2.3 California American Water Company (Security Park)

Cal Am Security Park averages 31 AFY demand, met by groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area level data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.2.4 California American Water Company (Suburban Rosemont)

Cal Am Suburban Rosemont receives on average 110 AFY of surface water delivered via an intertie with the City of Sacramento, with the remaining 12,296 AFY supplied from groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area level data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

3.2.2.5 Elk Grove Water District (Service Area 1)

Supply for Elk Grove WD Service Area 1 averages 5,189 AFY and is met by groundwater production from district wells. Data sources include SacIWRM (to 2009) and Elk Grove Water District (after 2009).

3.2.2.6 Florin County Water District

Florin County WD supply averages 2,623 AFY, entirely sourced by groundwater production from district wells. Data is from SacIWRM. Actual production values are not known for this area, and demand is estimated.

3.2.2.7 City of Folsom

The City of Folsom has an average demand of 20,451 AFY, with 100% of its supply coming from surface water diverted from Folsom Lake. Data sources include SacIWRM (to 2011) and RWA (after 2011).

3.2.2.8 Golden State Water Company (Cordova)

Golden State WC Cordova receives on average 6,287 AFY of surface water, primarily from water diverted from the American River via the Folsom South Canal. The remaining 8,977 AFY of demand is met by groundwater production from Golden State wells. Data sources include SacIWRM (to 2011) and RWA (after 2011).

3.2.2.9 Rancho Murieta Community Service District

Rancho Murieta CSD supply averages to 1,833 AFY, which is fully met by surface water diverted from the Cosumnes River. This is based on data on the number of service connections and water use from the 2006 Rancho Murieta Community Services District Integrated Water Master Plan and the 2010 Update.

3.2.2.10 City of Sacramento

(See North American Subbasin)

3.2.2.11 Sacramento County Water Agency (Hood)

SCWA Hood service area has an average demand of 47 AFY which is supplied by groundwater production from agency wells. Data sources include SacIWRM (to 2011) and RWA (after 2011).

3.2.2.12 Sacramento County Water Agency (Laguna Vineyard)

SCWA Laguna Vineyard service area (including Elk Grove WD Service Area 2) has an average supply mix of 17,340 AFY of groundwater production from agency wells, 3,314 AFY of surface water primarily sourced from the Sacramento River, and 232 AFY of recycled water. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

3.2.2.13 Sacramento County Water Agency (Mather)

SCWA Mather service area average supply mix that includes 3,958 AFY of groundwater production from agency wells, and 233 AFY surface water primarily sourced from the Sacramento River via the Vineyard Surface Water Treatment Plant. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

3.2.3 Cosumnes Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors located within the CoSb.

3.2.3.1 Amador County Water Agency (Camanche Village)

Amador County WA Camanche Village service area has an average supply of 257 AFY which is met 100% by groundwater production from agency wells. Data sources include monthly pumpage from four Camanche wells and two Camanche north shore wells, as reported by Amador County Water Agency (G. Mancebo, personal communication, April 29, 2019).

3.2.3.2 Amador County Water Agency (Ione)

Amador County WA supply to the City of Ione averages 2,130 AFY which is entirely surface water. Ione supply was estimated from reported wastewater treatment plant flows and population. Data sources include treated wastewater flows from Amador Water Agency (B. Cook, personal communication, December 9, 2019) and population data from the California Department of Finance.

3.2.3.3 City of Galt

The City of Galt has an average supply of 4,737 AFY, which comes entirely from groundwater production from municipal wells. Data sources include monthly pumpage from a total of 18 wells, as reported by the City of Galt (M. Clarkson, personal communication, March 22, 2019).

3.2.3.4 Rancho Murieta Community Service District

(see South American Subbasin section)

3.2.4 Fish Farms

The 2011 South Basin Groundwater Management Plan reported that there is approximately 11,000 AFY pumping to supply water to fish farms in the Cosumnes Subbasin. This annual pumping estimate was allocated to six fish farms based on the relative area of each fish farm and the annual pumping rate was converted to monthly rates in proportion to monthly ET_o rates. Inspection of aerial photos in Google Earth was used to determine when each fish farms was developed and when pumping from each fish farm was likely to have begun.

3.2.5 Galt Wastewater Treatment Plant Effluent

All effluent and stormwater from the City of Galt is routed to the wastewater treatment plant, where it is ultimately either released to Skunk Creek (tributary of Laguna Creek) or used for irrigation of surrounding fields. The 2011 South Basin Groundwater Management Plan (South Area Water Council, 2011) reported that the City of Galt applies an average of approximately 700 AFY to fields for irrigation. The wastewater treatment plant came online in 1983. As such, a variable monthly application rate based on an assumed monthly supply requirement was specified for 1983 through 2019.

3.3 Agricultural Water Demand and Supply

Agricultural water demand is the amount of irrigation water that is required to satisfy the crop evapotranspiration requirement and to meet other irrigation practices. IDC is designed to estimate the agricultural water demand for each model element through consumptive use methodology. IDC dynamically calculates crop demand at each model time step based on factors including crop type, crop evapotranspiration, rainfall, hydrologic soil type, and irrigation practices. The IDC calculations rely on model input data for historical crop acreage, irrigation practices (e.g., return and reuse fractions, irrigation period), soil moisture requirements, effective rainfall (the portion of rainfall available for crop consumptive use), crop evapotranspiration, and localized soil parameters. These data were compiled, analyzed, synthesized, and processed for input in CoSANA.

Precipitation, land use, evapotranspiration, and soil properties are discussed in the relevant sections in Chapter 2. The irrigation period, using data from C2VSimFG, defines irrigation as either on or off for each crop and for each month of

the model simulation period. Most trees are assumed irrigated from April through October, vineyards from April through November, most field crops from May through September, and most truck crops from April through September. Crops with irrigation assumed year-round include citrus and subtropical trees, irrigated pasture, and alfalfa. Fractions to represent return flow (i.e., irrigation flow following the model drainage pattern discussed in Section 2.5) and reuse (i.e., the fraction of applied irrigation water to be reused for irrigation) are based on data from C2VSimFG. All non-ponded CoSANA agricultural lands are assigned a 5% return flow and 1% reuse factor. Rice during the growing season is assigned an average 13% return flow and an average 9% reuse factor, with variability depending on the month of the year. Riceland when flooded for decomposition in the non-growing season is assigned an average 9% return flow and an average 6% reuse factor, also with variability depending on the month of the year. Urban landscape areas are assumed to have 0% return flow and 0% reuse.

3.3.1 Rural-Residential Pumping

Private groundwater pumping quantities on an individual well basis are largely unknown; therefore, private rural-residential pumping in CoSANA is estimated by IWFM on an element basis. Water demands at each relevant element are used to calculate pumping necessary to meet the urban demand estimated by IDC after water purveyor pumping and surface water has been distributed.

The perforation interval, which dictates the layers a simulated well extracts water from, were assigned separately to the domestic (i.e., rural residential) and agricultural wells. Rural residential wells used a statistical analysis of perforation interval developed for C2VSimFG. Perforation interval data were compiled by DWR using data from the CASGEM and Online System for Well Completion Reports databases. Simulated perforation intervals were assigned as the 5th and 95th percentiles of the well perforation interval data for each township/range block.

Demand for rural residential areas, or areas outside of those supplied by a public water system, was based on estimated population and water consumption outside of areas supplied by a public water system. To estimate demand in these areas, the areas themselves were isolated spatially by removing all areas served by a public water system. Population density for the rural residential areas is developed based on census tract data, and estimated per capita water use is developed for a typical household based on information from the California Water Plan (DWR, 2018b).

For the rural-residential area within the CoSb, outdoor water use was estimated from per-parcel water demand and approximate total number of rural-residential parcels. The estimated average per-parcel outdoor water demand is 2.5 AFY based on a detailed inspection of land use for 10 random parcels. Visual inspection of Google Earth aerial photographs identified approximately 3,200 rural-residential parcels, resulting in an average annual outdoor water use of 8,000 AFY. All indoor water use was assumed to return to the subsurface through septic systems and was therefore not explicitly modeled.

3.3.2 Agricultural Pumping

Private groundwater pumping volumes, location, and pumping depth for agricultural water supplies are largely unknown, though aggregate estimates for private pumping are often included in planning documents (e.g., AWMPs, groundwater management plans). Therefore, agricultural pumping in CoSANA is estimated by IWFM on an element basis. Water demand at each relevant element is used to calculate any additional pumping necessary to meet the agricultural demand estimated by IDC after public water system pumping and surface water has been distributed.

3.3.3 Agricultural Groundwater Substitution Transfers

CoSANA includes 55 agricultural groundwater substitution transfer pumping wells, shown in Figure 3-5. All agricultural groundwater substitution transfer pumping operations occur in the NASb and include Pleasant Grove Verona MWC (PGVMWC) and Natomas MWC (NMWC). South Sutter WD also operates a transfer program that is similar in many respects to a groundwater substitution transfer. Transfer pumping volumes are known for PGVMWC and NMWC on a well-by-well basis. The volume of groundwater pumped is assumed to be applied to meet agricultural demand in the

respective service areas. South Sutter WD transfer wells and pumping volumes are not known, but it is assumed that a reduction in surface water deliveries to the service area creates increased pumping demand, resulting in transfer pumping operations. A summary of agricultural transfer pumping wells in CoSANA is shown in Table 3-2.

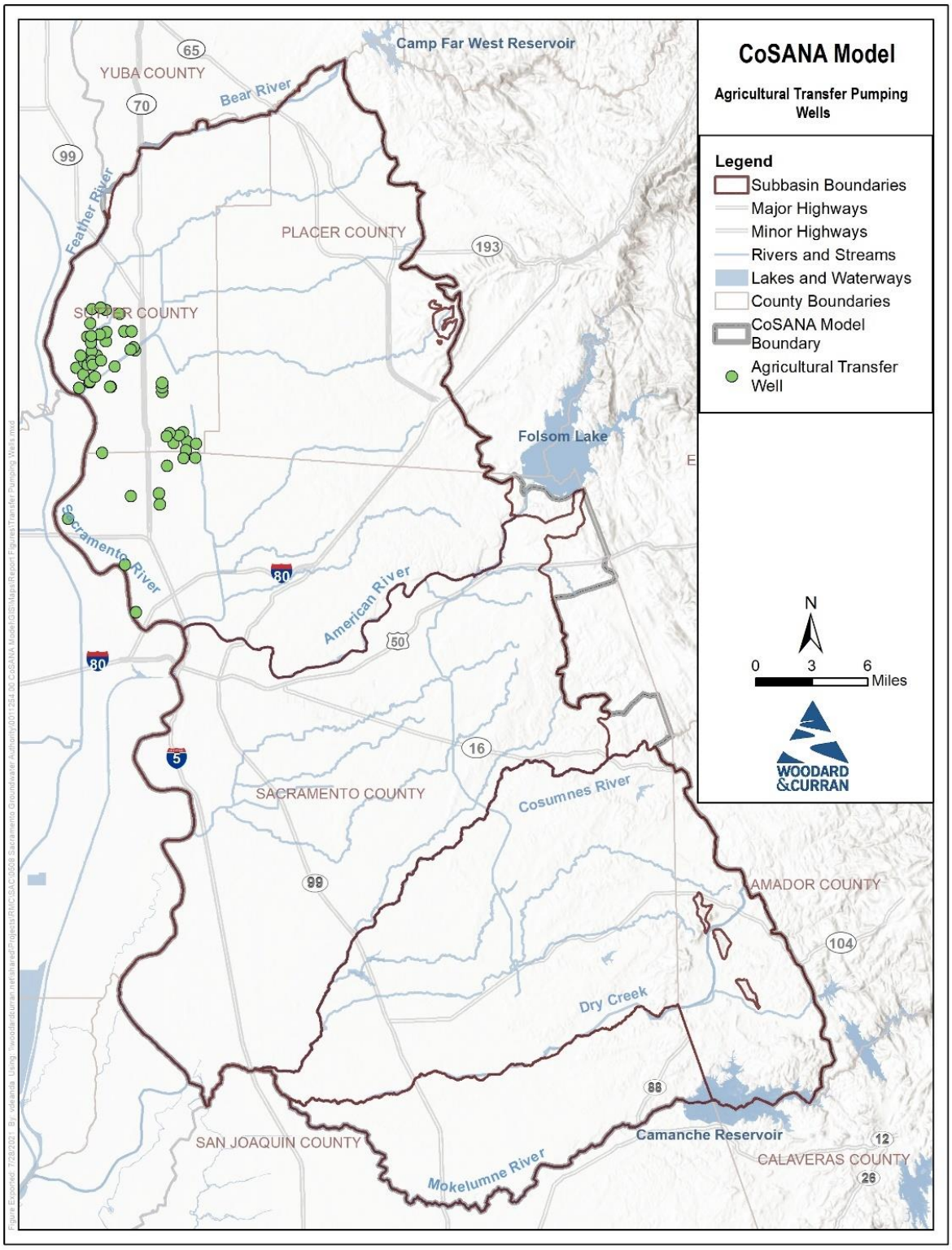


Figure 3-5: Locations of Agricultural Groundwater Substitution Transfer Pumping Wells

Table 3-2: Summary of Agricultural Groundwater Substitution Transfer Pumping

Agency	Number of Groundwater Transfer Pumping Wells	Number of Simulated Transfer Years	Average Annual Pumping in a Transfer Year WY 1995-2018, (acre-feet)
Pleasant Grove Verona MWC	30	6	7,668
Natomas MWC	25	4	8,412
Total Average Annual Pumping (acre-feet)			16,080

3.4 Remediation Pumping

CoSANA includes 344 remediation wells (Figure 3-6) simulating remediation operations for Aerojet/IRCTS, McClellan AFB, Mather AFB, and Kiefer landfill. Data for Aerojet and IRCTS operations were provided by Aerojet (personal communication, J. Fourie, January 16, 2020); McClellan AFB remediations data were provided by McClellan AFB (G. Yuki, personal communication, October 23, 2020) and AECOM (P. Graff, personal communication, October 10, 2020); Mather AFB data were developed based on annual reports; data for Kiefer Landfill operations were provided by Sacramento County (M. Koza, personal communication, June 11, 2020). Remediation pumping volumes by entity are shown in Table 3-3. An annual summary of remediation pumping volumes by extraction entity is provided in Appendix B. Further, annual simulated pumping volumes for the major remediation efforts in the CoSANA model area are summarized by subregion in the land and water use budgets in Appendix C.

Table 3-3: Summary of CoSANA Remediation Operations:

Remediation Area (Subbasin)	Number of Groundwater Remediation Pumping Wells	Average Annual Remediation Pumping (WY 1995-2018, acre-feet)
Aerojet/IRCTS (NASb)	15	1,970
Aerojet/IRCTS (SASb)	190	19,703
Kiefer Landfill (SASb)	15	969
Mather AFB (SASb)	4	207
McClellan AFB (NASb)	113	1,899
Total Average Annual Pumping (acre-feet)		24,748

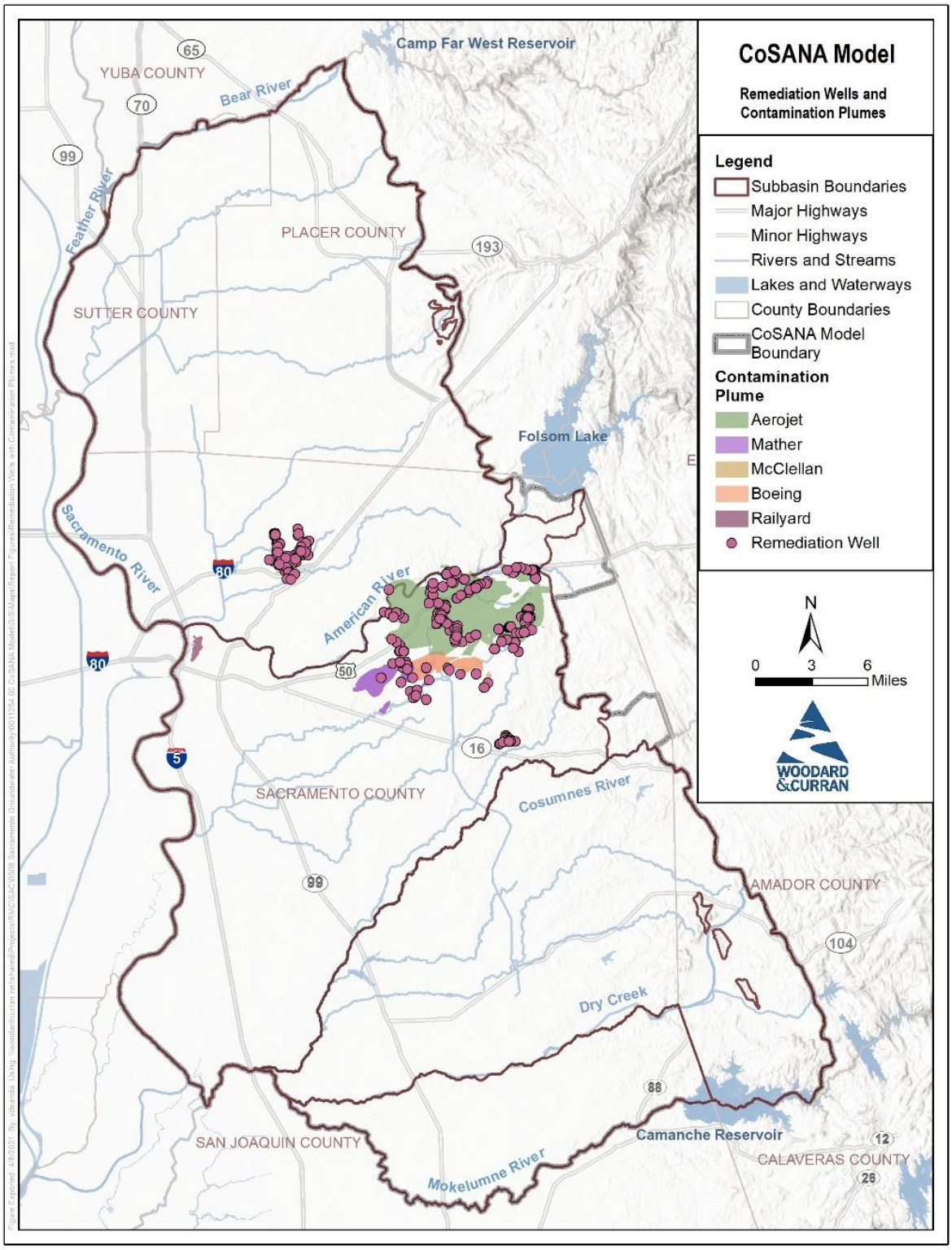


Figure 3-6: Locations of Remediation Pumping Wells

4. MODEL CALIBRATION AND SENSITIVITY ANALYSIS

CoSANA model is an integrated water resources model developed to simulate the integrated nature of the various components of the hydrologic system. Model calibration is an important part of model development, performed to meet the following objectives:

- Develop water budgets that properly represent various geographic scales, including the subbasin, GSA, and subregion scales, at both monthly and annual time scales,
- Represent the regional distribution of groundwater conditions, as well as the seasonal and long-term trends in groundwater levels at target calibration wells,
- Represent appropriate level of stream-aquifer interaction by simulating the modeled streams in such a way that the monthly and long-term streamflows at specific gaging stations properly represent the observed stream flow or stream stage data,
- Properly represent the interbasin flows across the boundaries internal to the CoSANA between the three subbasins modeled, as well as those between the neighboring subbasins outside the model area, in specific, Yuba, Yolo, Solano, and Eastern San Joaquin Subbasins.

Due to the complexities of calibrating an integrated water resources model, a hybrid approach for calibration was utilized to perform a manual calibration on initial water budgets and regional groundwater conditions and an automated calibration using PEST (Doherty, 2015) to achieve a refinement of the calibrated parameters that would result in a more accurate simulation. This calibration approach and process is similar to that used for calibration of the Central Valley's C2VSimFG, with special focus and attention to the regional and local data sets and information.

4.1 Calibration Goals

The goals of model calibration are to:

1. Represent the physical understanding of the model parameters within a range of reported values
2. Obtain a reasonable representation of water budgets for each of the hydrologic systems modeled (i.e., land and water use, stream flow, and groundwater budgets)
3. Achieve a reasonable general pattern of groundwater levels and flow directions
4. Optimize the agreement between simulated results and observed values for short-term seasonal and long-term trends in groundwater levels at selected calibration well
5. Optimize the agreement between simulated results and observed streamflow hydrographs or stream stage gages at selected gaging stations.

These goals are achieved through careful review of model input data and adjustments to model parameters. The model results also provide insight to key components of the groundwater basin including historical recharge, subsurface flows, gains/losses from/to streams and changes in groundwater storage.

CoSANA was calibrated to local data and knowledge, surface water flows, groundwater levels, and groundwater contours. The sources used include local knowledge (mainly gathered during the GSP Working Groups meetings), AWMPs, UWMPs, other local planning efforts, observed groundwater levels and associated contours, and observed streamflow data.

Due to uncertainty in the initial conditions, a "warm up" period is included to allow groundwater levels to stabilize. As previously noted, CoSANA includes data starting in October 1969 (WY 1970). To reduce run time, the model used for the historical calibration begins in October 1989 (WY 1990). The CoSANA calibration period begins after a five-year warm up period, in October 1994, and ends in September 2018; thus, the full period for model calibration is WY 1995 through 2018 (24 years).

4.2 Calibration Process

The calibration process is conducted as shown in Figure 4-1 and as described in the following subsections.

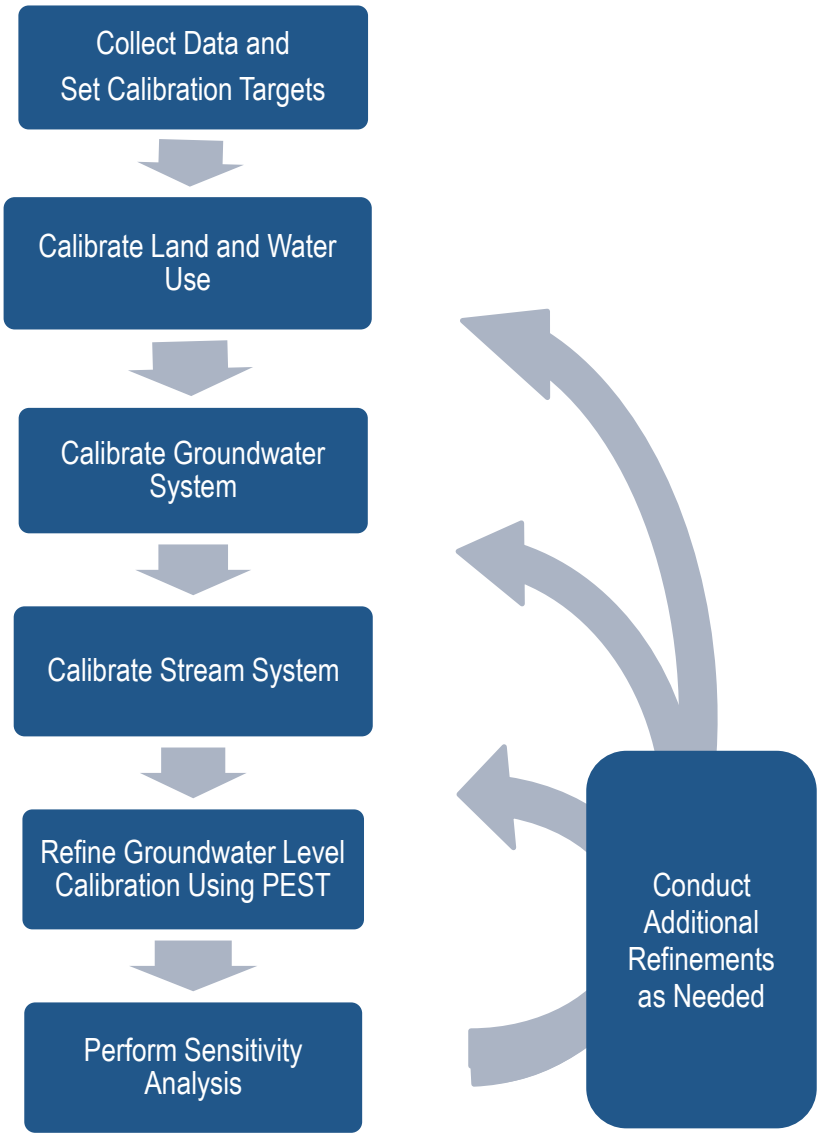


Figure 4-1: CoSANA Calibration Process

4.2.1 Water Budget Calibration

Water budgets are calibrated to improve the accuracy of the representation of the hydrologic characteristics of the groundwater basin. A water budget balances supplies, demands, and any subsequent change in storage occurring within that specific portion of the hydrologic cycle. IWFM automatically outputs budgets at the subregion scale for processes involving groundwater, the surface layer, streams, the root zone, small watersheds, and the unsaturated zone. IWFM can output budgets down to a single element or any specific grouping of elements.

During this step of the calibration process, model results are reviewed and summarized into monthly and annual (by water year) budgets. The primary budgets reviewed for calibration are the groundwater budget and the land and water use budget. Other budgets, notably the stream budget (see Appendix D), are also reviewed as part of the calibration process. After extensive budget analysis, key model datasets and parameters are adjusted, particularly groundwater aquifer parameters, to better match local budgets from local agricultural water purveyors and local planning efforts. The CoSANA water budget results are summarized in the following sections.

4.2.1.1 Land and Water Use Budget

The land and water use budget represents the balance of the IDC-calculated water demands with the water supplied and includes two different versions, agricultural and urban. Both the agricultural and urban versions include the same components that make up the water balance:

- Demands:
  - Demand (either agricultural or urban)
  - Surplus (if applicable)
- Supplies:
  - Groundwater pumping
  - Surface water deliveries (including recycled water deliveries)
  - Shortage (if applicable)

As part of the calibration of the land and water use budget, root zone parameters are adjusted as needed to achieve reasonable estimates of agricultural demand and to develop the components of a balanced root zone budget. IDC calibration serves as the foundation of the IWFM calibration for agricultural areas, as demand estimated often translates directly to groundwater pumping, which is the primary stress on the groundwater system. To adjust agricultural demand, element-level root zone parameters, particularly the soil hydraulic conductivity and the pore size distribution index, were adjusted in accordance with the hydrologic soil group and subregion. Spatial representation of these calibrated parameters is shown in Figure 4-2 through Figure 4-6. The IDC model was calibrated to achieve an irrigation efficiency of approximately 68% to 72%, consistent with agricultural water use values reported by irrigation districts in their AWMPs, as well as data from DWR's California Agricultural Water Use Model and California Water Plan.

The average annual water demand and supply mix used to meet the demand is summarized in Table 4-1. The average annual simulated land and water use budgets for the calibration period are presented in Figure 4-7 through Figure 4-14, showing the agricultural and urban demands and supplies in CoSANA both model wide and by subbasin. Additional detail on the Land and Water Use budget is included in Appendix C.

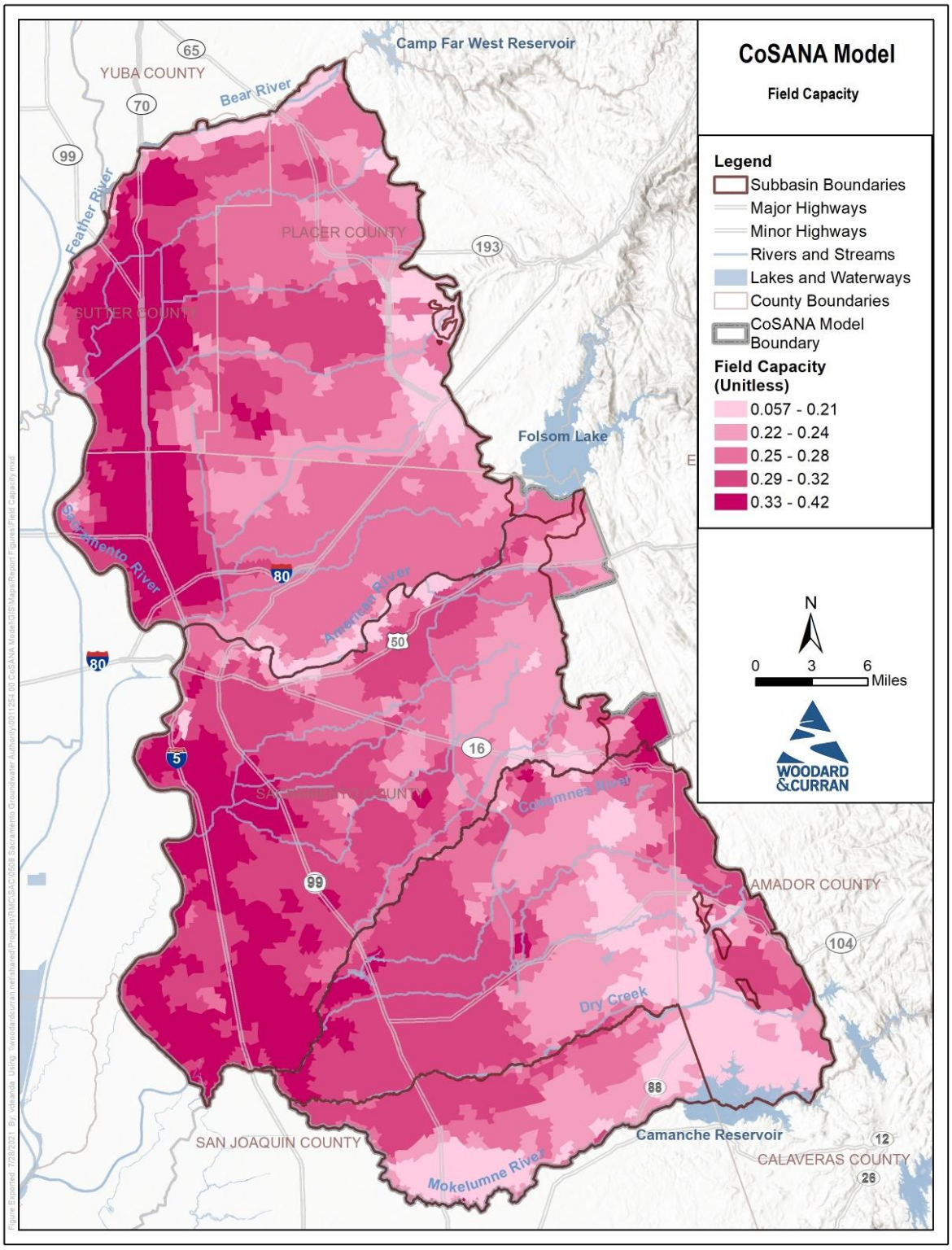


Figure 4-2: CoSANA Field Capacity

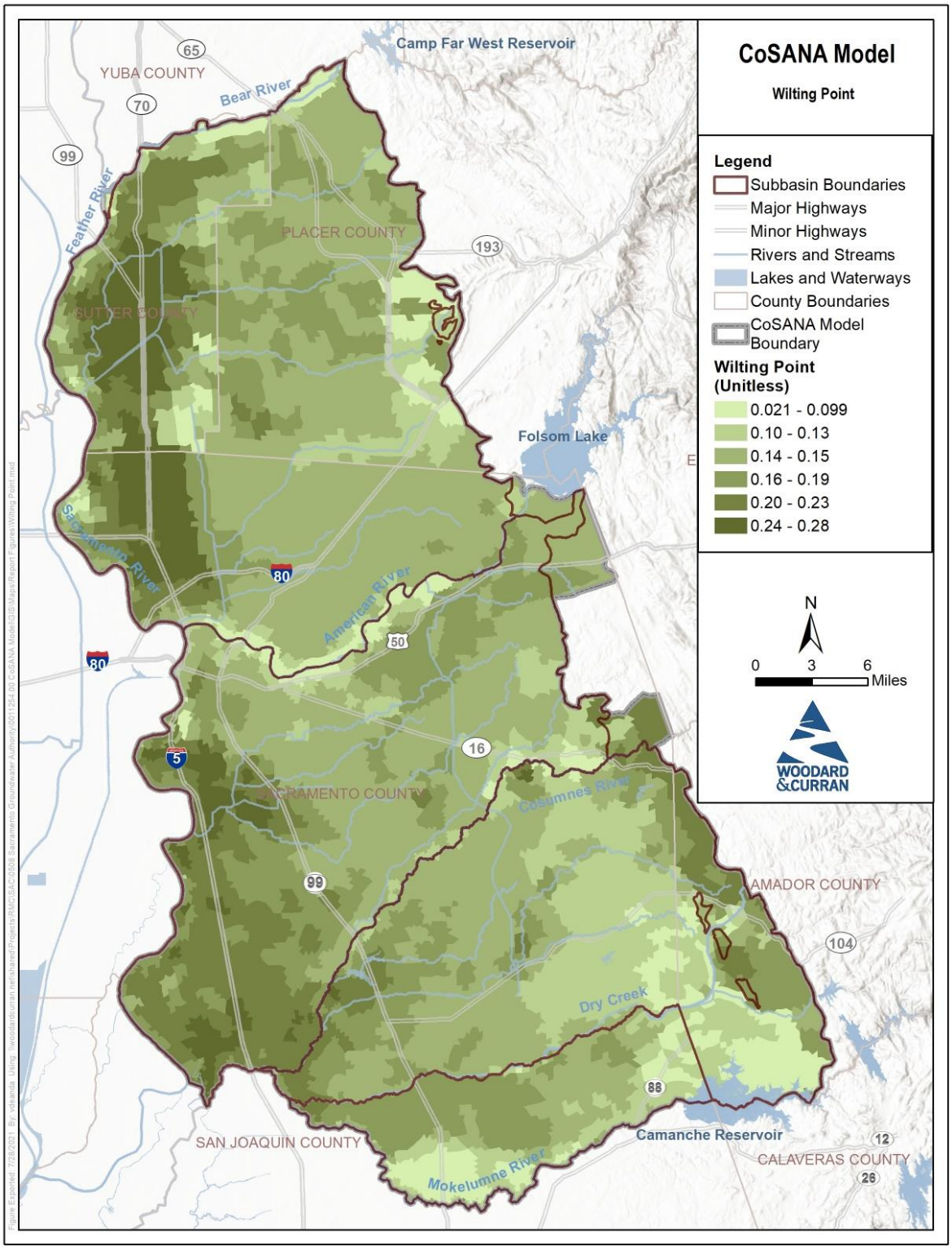


Figure 4-3: CoSANA Wilting Point

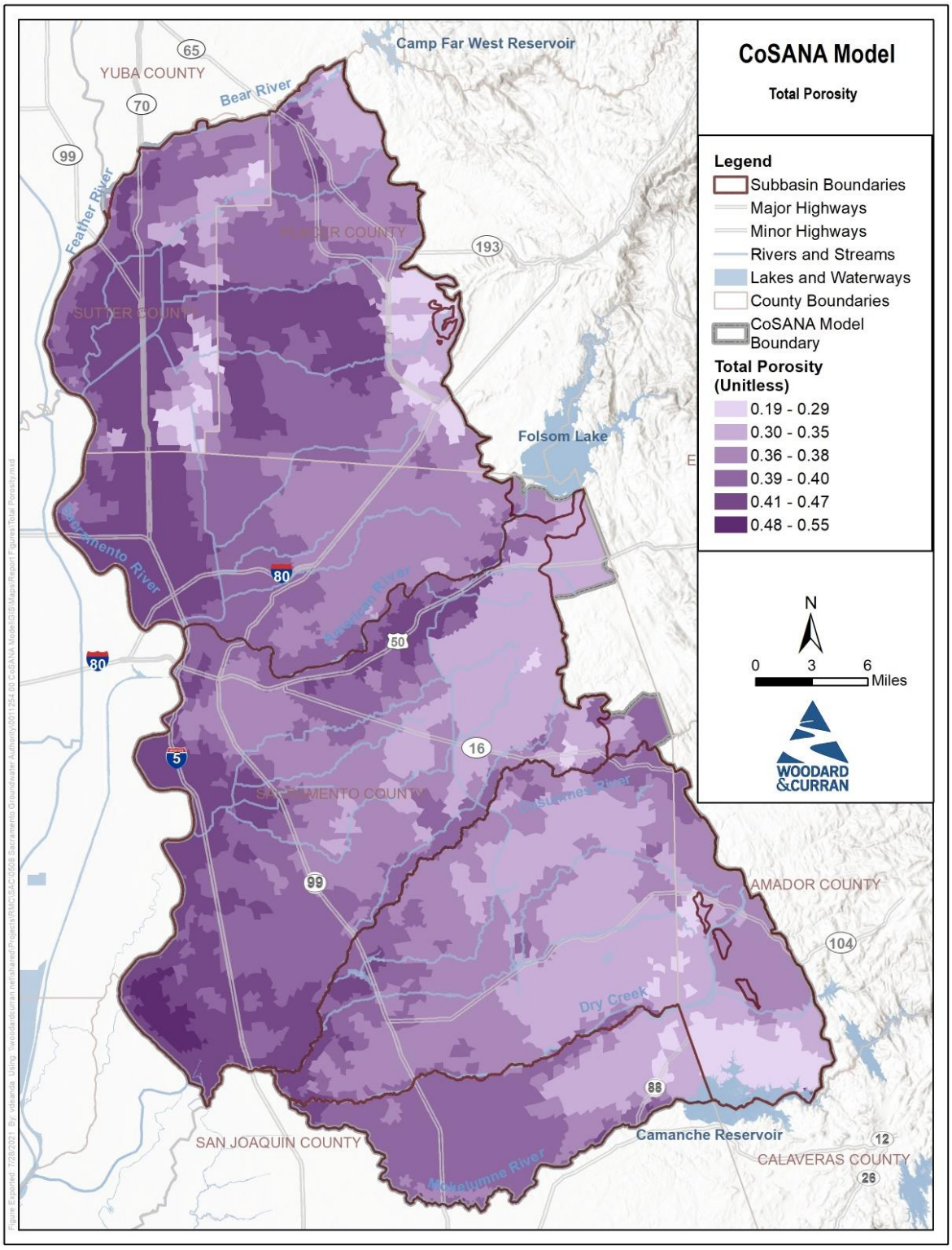


Figure 4-4: CoSANA Total Porosity

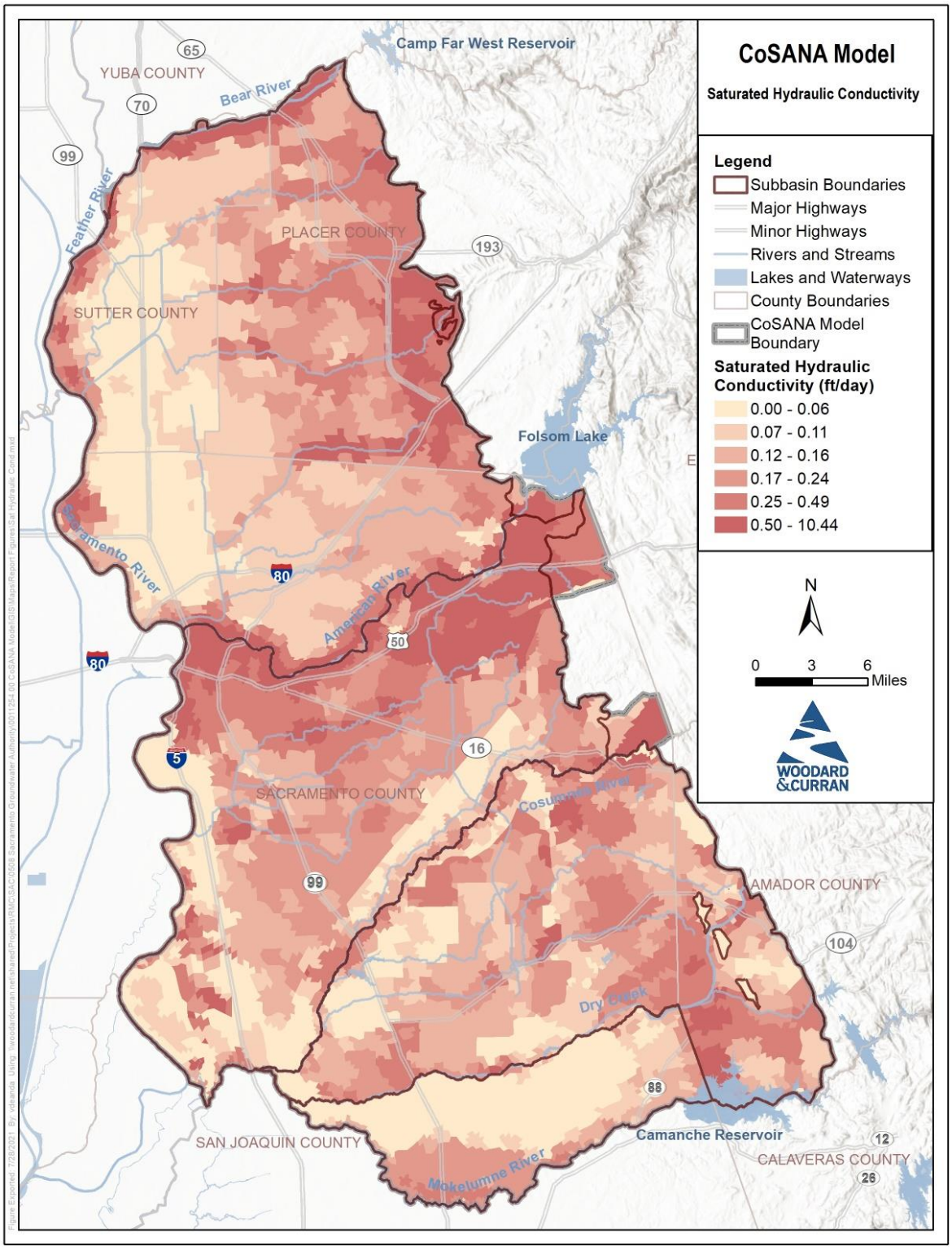


Figure 4-5: CoSANA Saturated Soil Hydraulic Conductivity

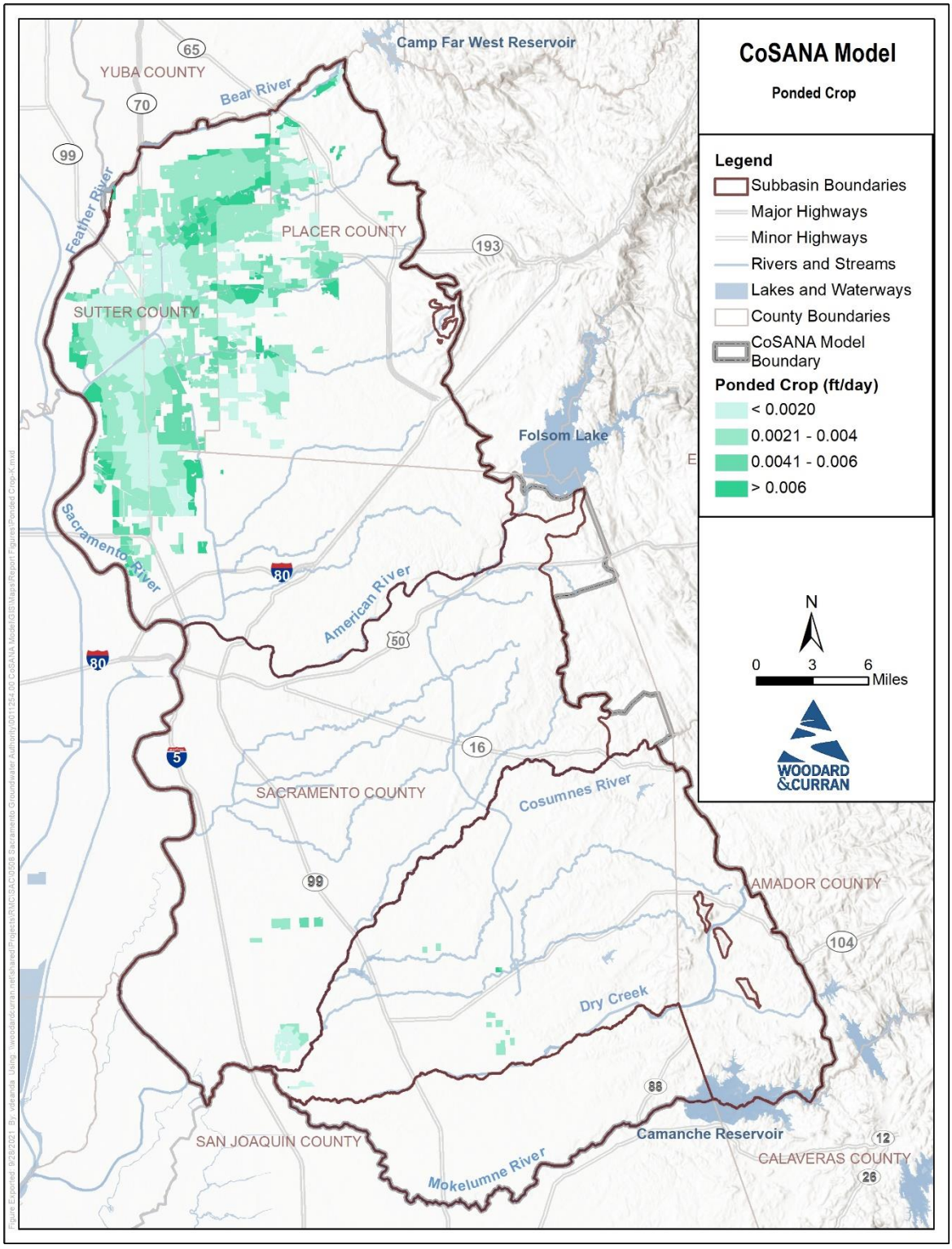
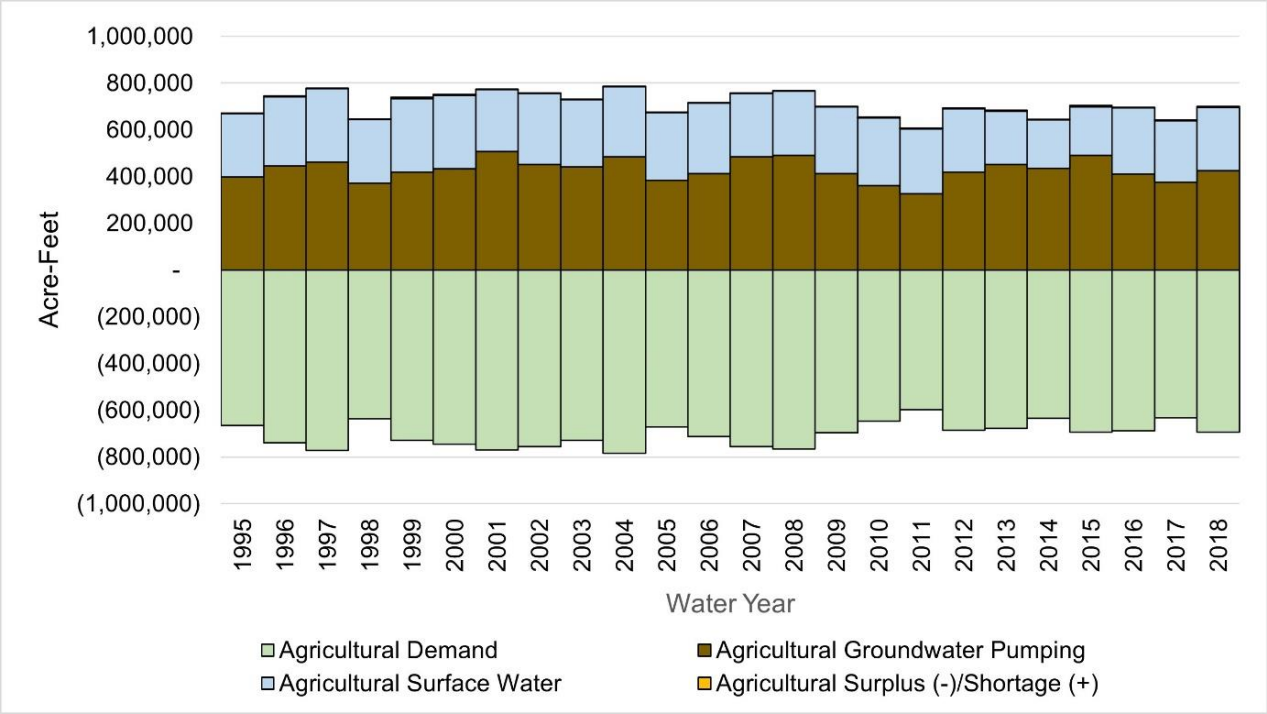


Figure 4-6: CoSANA Ponded Crop Saturated Soil Hydraulic Conductivity

Table 4-1: Land and Water Use Budget Demand and Supply Mix
(Average Annual for the Period WY 1995-2018)

Subbasin	Ag. Demand (AFY)	Ag. Ground-water Use (AFY)	Ag Surface Water Deliveries (AFY)	Urban Demand (AFY)	Urban Ground-water Use (AFY)	Urban Surface Water Deliveries (AFY)	Urban Recycled Water (AFY)	Remediation Pumping (AFY)
NASb	410,136	205,563	207,225	215,951	91,263	124,687	0	3,869
SASb	160,694	116,397	44,667	182,760	93,515	89,324	232	20,879
CoSb	132,690	107,167	25,576	26,861	22,881	2,417	0	0
Total	**703,520**	**429,127**	**277,468**	**425,572**	**207,659**	**216,428**	**232**	**24,748**

Note: Small differences exist between total supplies and total demands. These shortages and surpluses are delivered and applied regardless of the demand specified in the model. Surpluses tend to result in deep percolation. Remediation pumping is not considered part of demand in the L&WU budget but is shown for information purposes. CoSANA total is a summation of the three subbasins (NASb, SASb, and CoSb) and excludes areas in the Eastern San Joaquin subbasin and areas outside of B118 subbasins.



Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins

Figure 4-7: CoSANA Agricultural Land and Water Use Budget

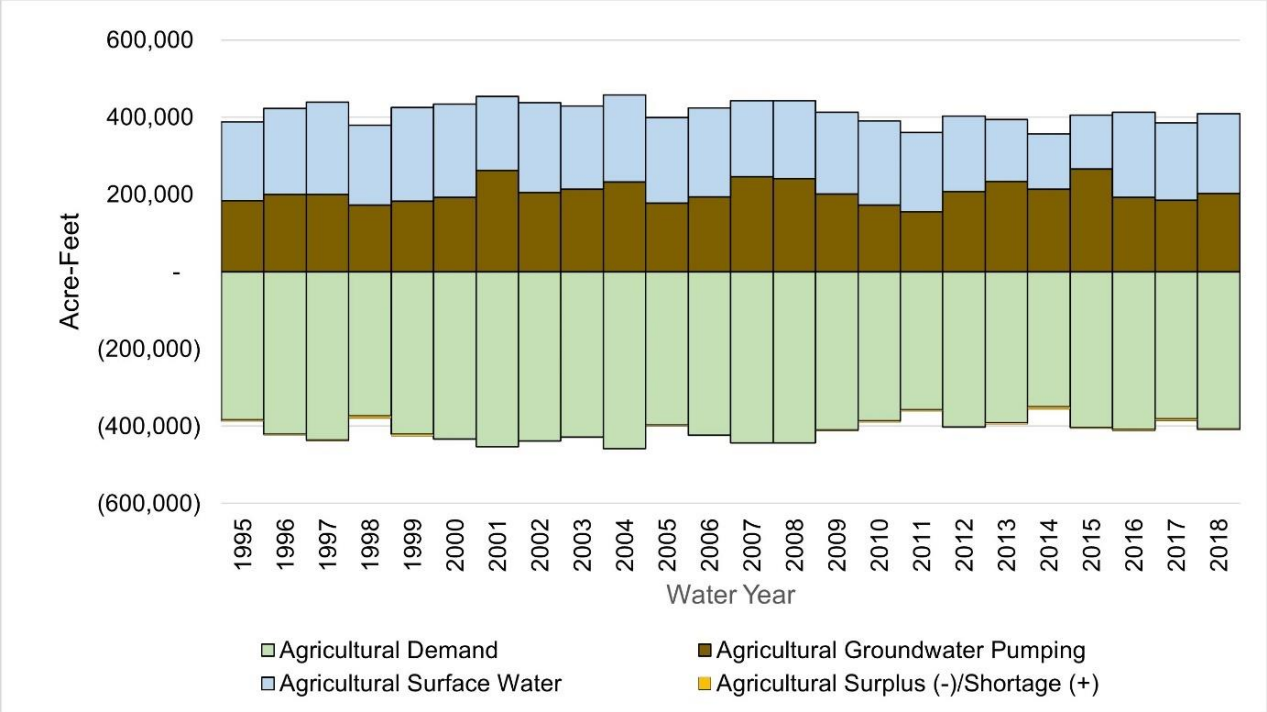


Figure 4-8: NASb Agricultural Land and Water Use Budget

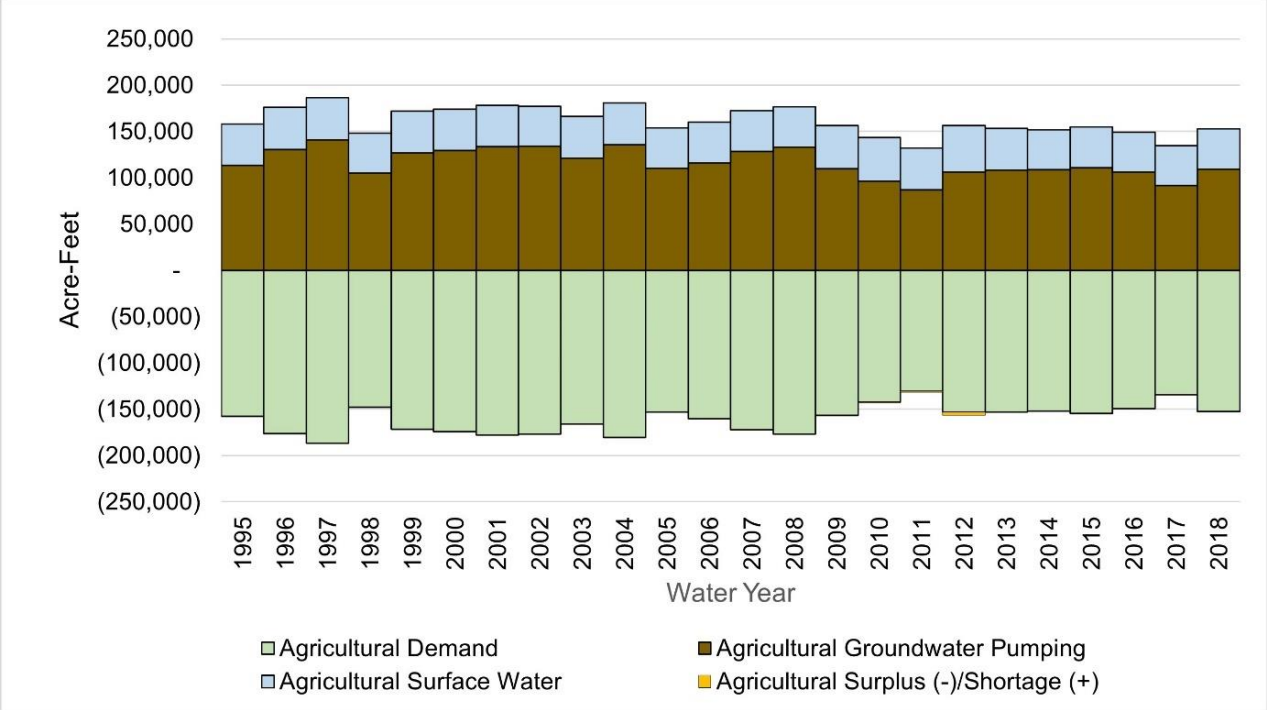


Figure 4-9: SASb Agricultural Land and Water Use Budget

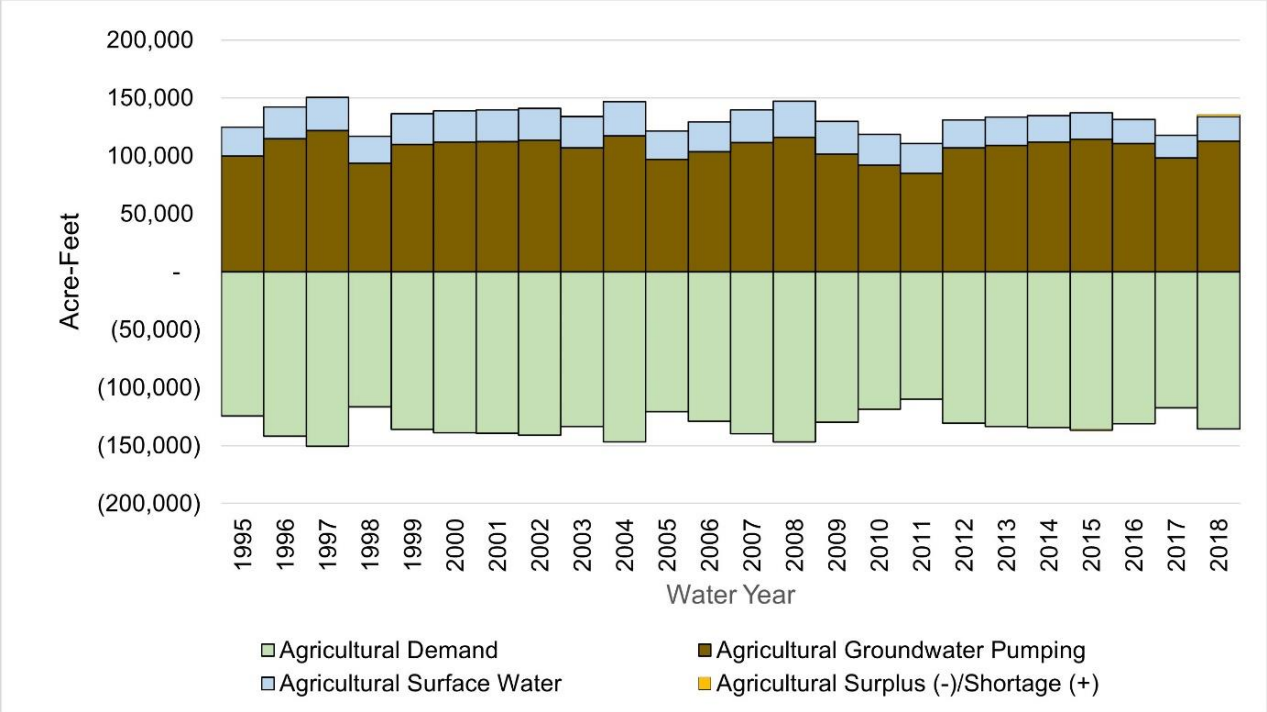
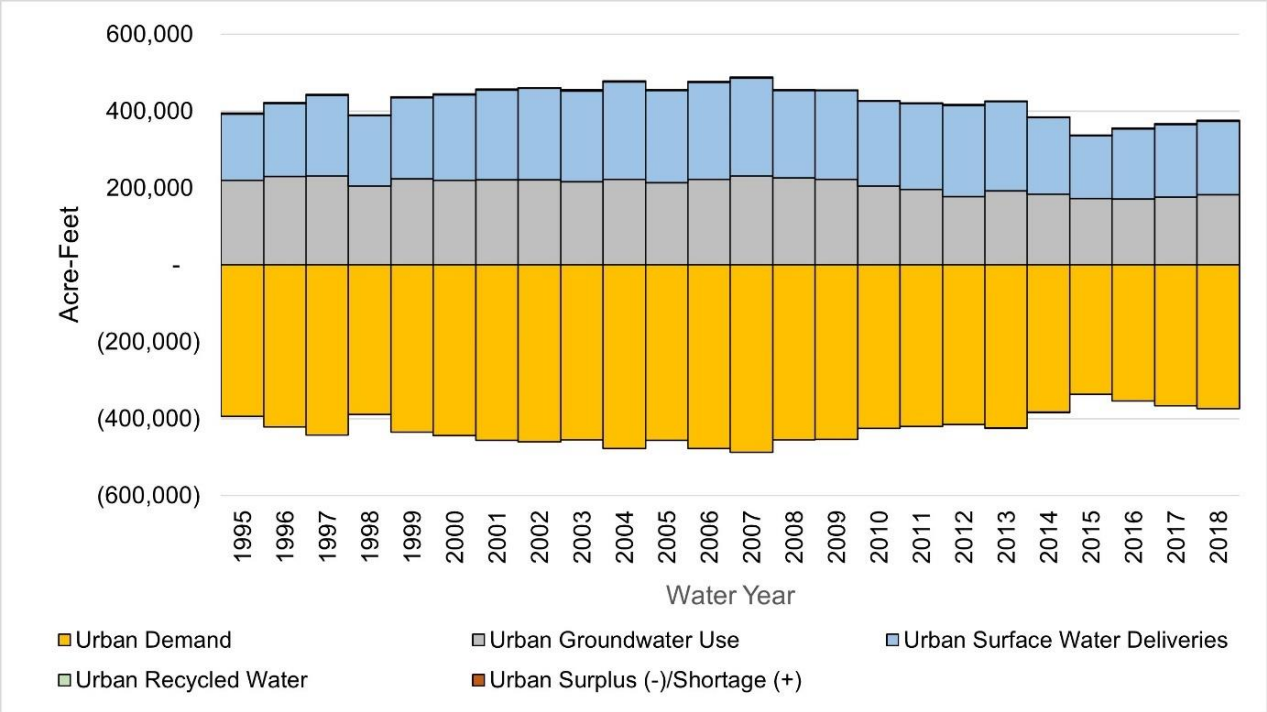


Figure 4-10: CoSb Agricultural Land and Water Use Budget



Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins

Figure 4-11: CoSANA Model Urban Land and Water Use Budget

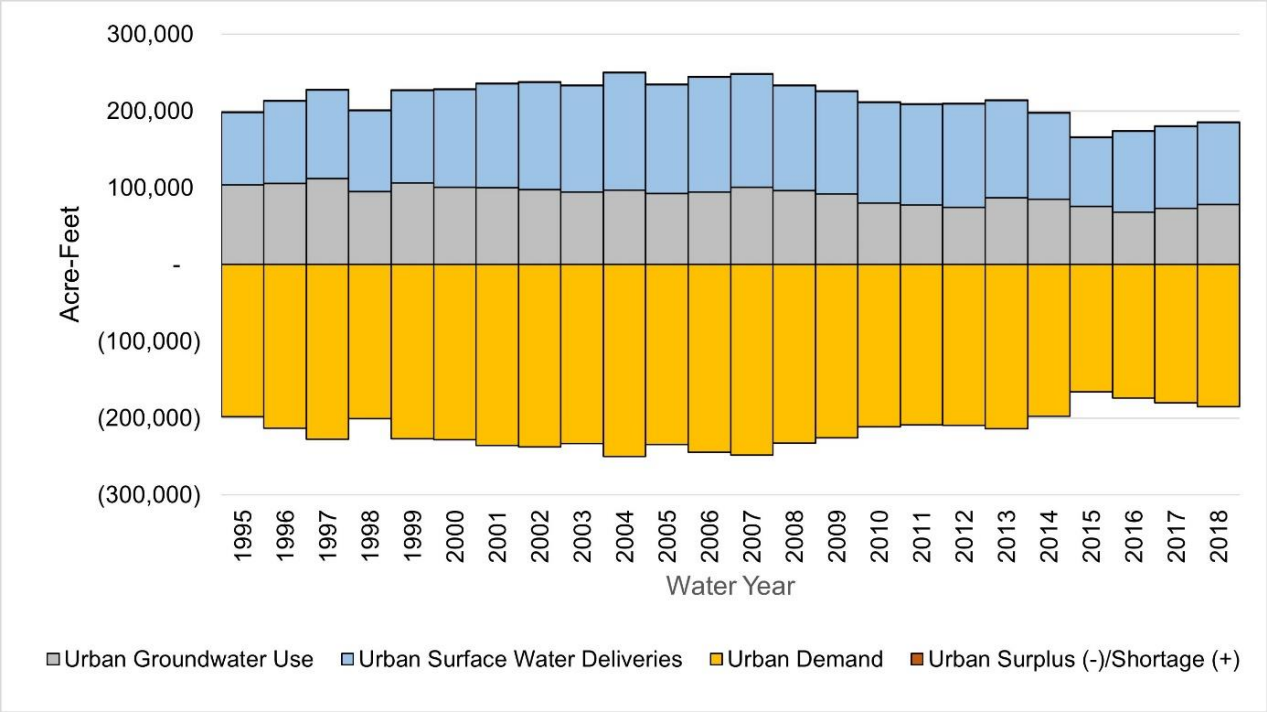


Figure 4-12: NASb Urban Land and Water Use Budget

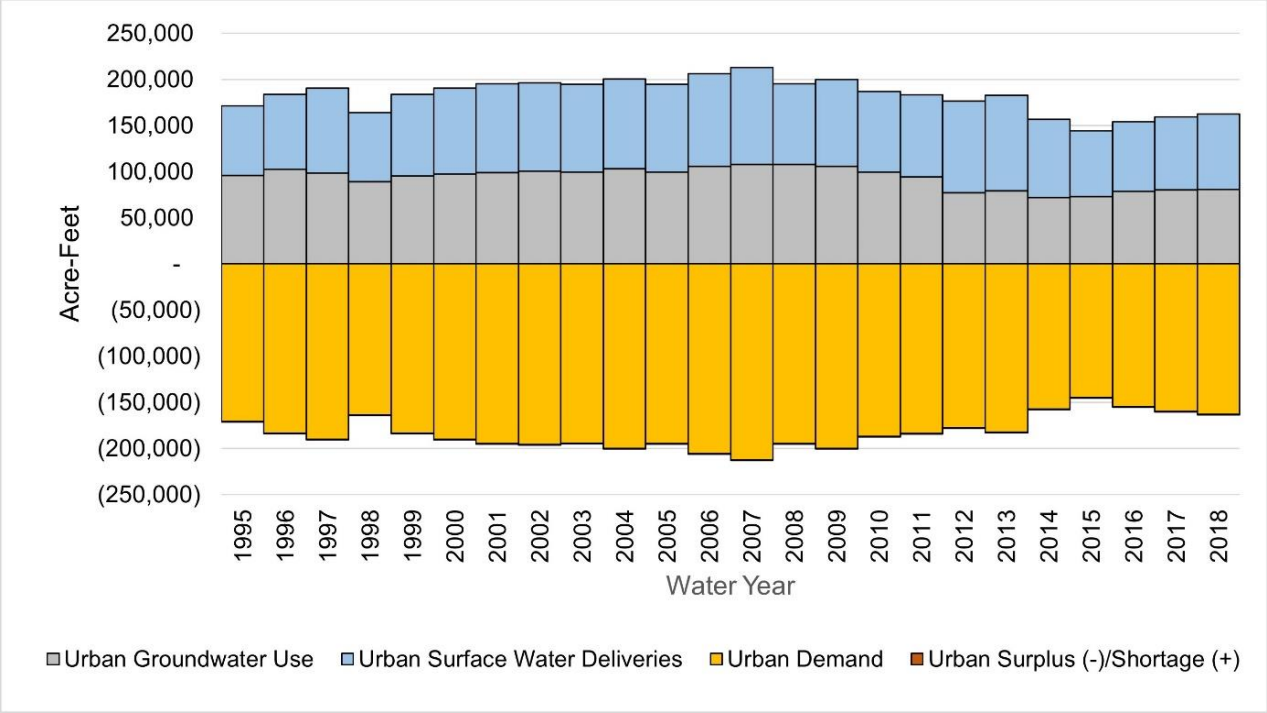
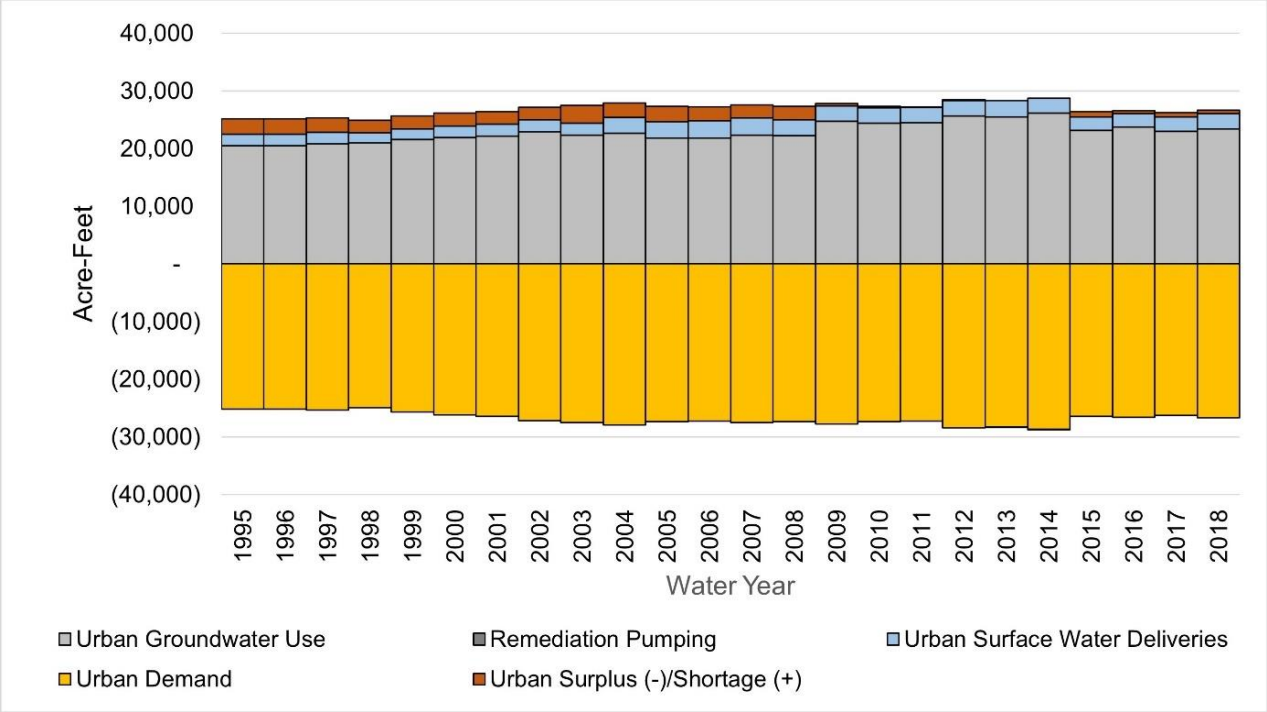


Figure 4-13: SASb Urban Land and Water Use Budget



Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.

Figure 4-14: CoSb Urban Land and Water Use Budget

4.2.1.2 Groundwater Budget

The groundwater budget quantifies inflows and outflows from the groundwater system. The primary components of the groundwater budget, corresponding to the major hydrologic processes affecting groundwater flow in the model area, are:

- Inflows:
  - Deep percolation (from rainfall and irrigation applied water)
  - Gain from stream (recharge due to stream seepage)
  - Recharge (from other sources such as irrigation canal seepage and recharge ponds)
  - Boundary inflow (from outside the model area)
  - Net subsurface inflow (from adjacent subregions)
- Outflows:
  - Groundwater pumping
  - Loss to stream (outflow to streams and rivers)
  - Boundary outflow (to outside the model area)
  - Subsurface outflow (to adjacent subregions)
- Change in groundwater storage (positive indicates withdrawal from groundwater storage, and negative indicates contribution to groundwater storage)

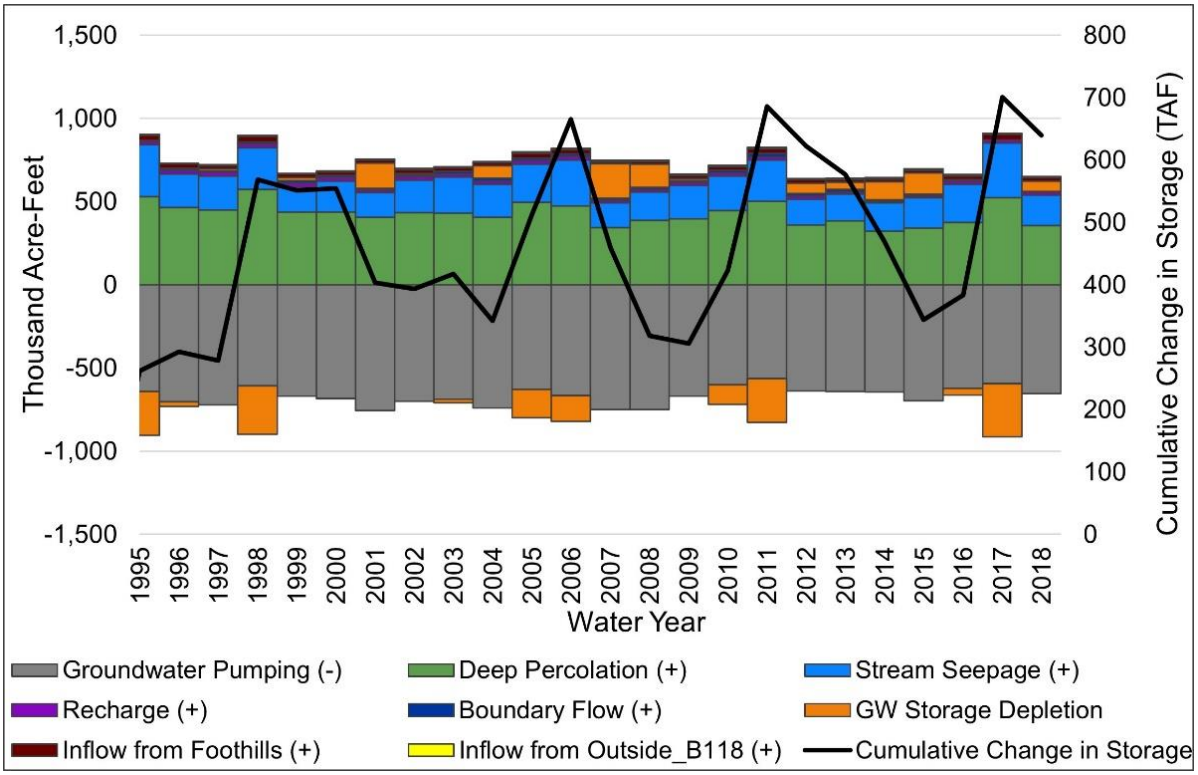
The groundwater budgets, including cumulative change in storage, are summarized in Table 4-2 and shown in Figure 4-15 through Figure 4-18 for three subbasins combined and for the NASb, SASb, and CoSb, respectively. Though results vary area to area, the primary sources of groundwater inflows are deep percolation and interaction with the model streams.

Subregion-level budgets are provided in Appendix E.

Table 4-2: Summary of CoSANA Groundwater Budget
(Average Annual for the Period WY 1995-2018)

Subbasin	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Subsurface Inflow (AFY)	Boundary Flows (AFY)	Change in Storage (AFY)
NASb	315,794	189,988	85,907	18,320	18,220	30,019	26,661
SASb	221,618	130,317	101,953	15	-8,884	3,769	5,551
CoSb	130,048	108,054	18,977	0	-2,333	-162	-5,510
Total	**667,460**	**428,359**	**206,837**	**18,335**	**7,003***	**11,302**	**26,702**

Note: CoSANA total is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins.
* The model-wide subsurface inflow value includes subsurface flows to and from areas outside of the combined NASb, SASb, and CoSb area.



Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins

Figure 4-15: CoSANA Groundwater Budget

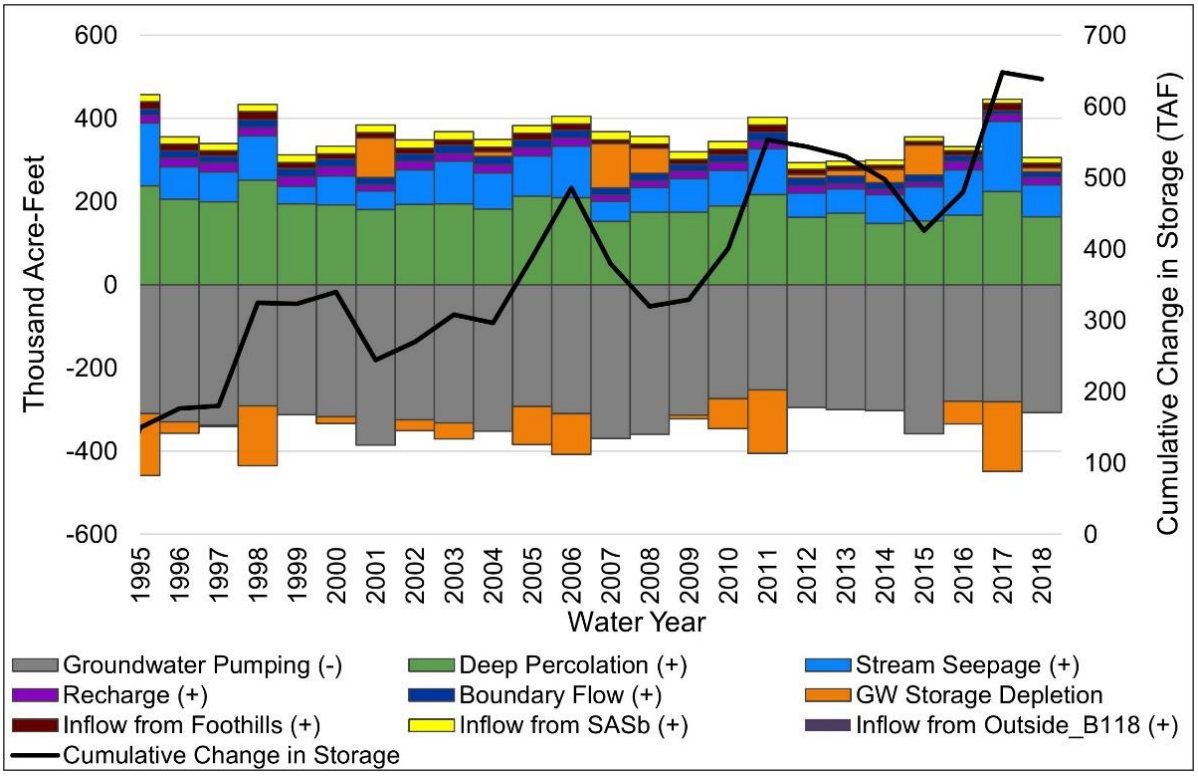


Figure 4-16: NASb Groundwater Budget

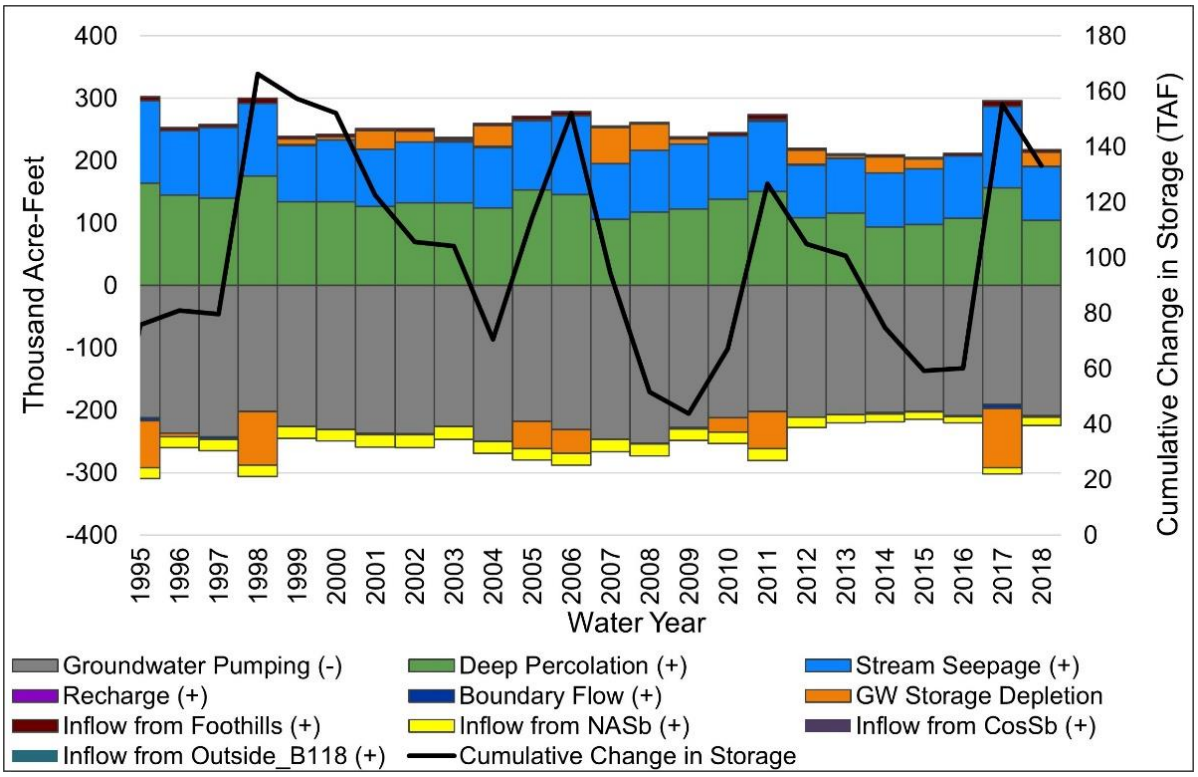


Figure 4-17: SASb Groundwater Budget

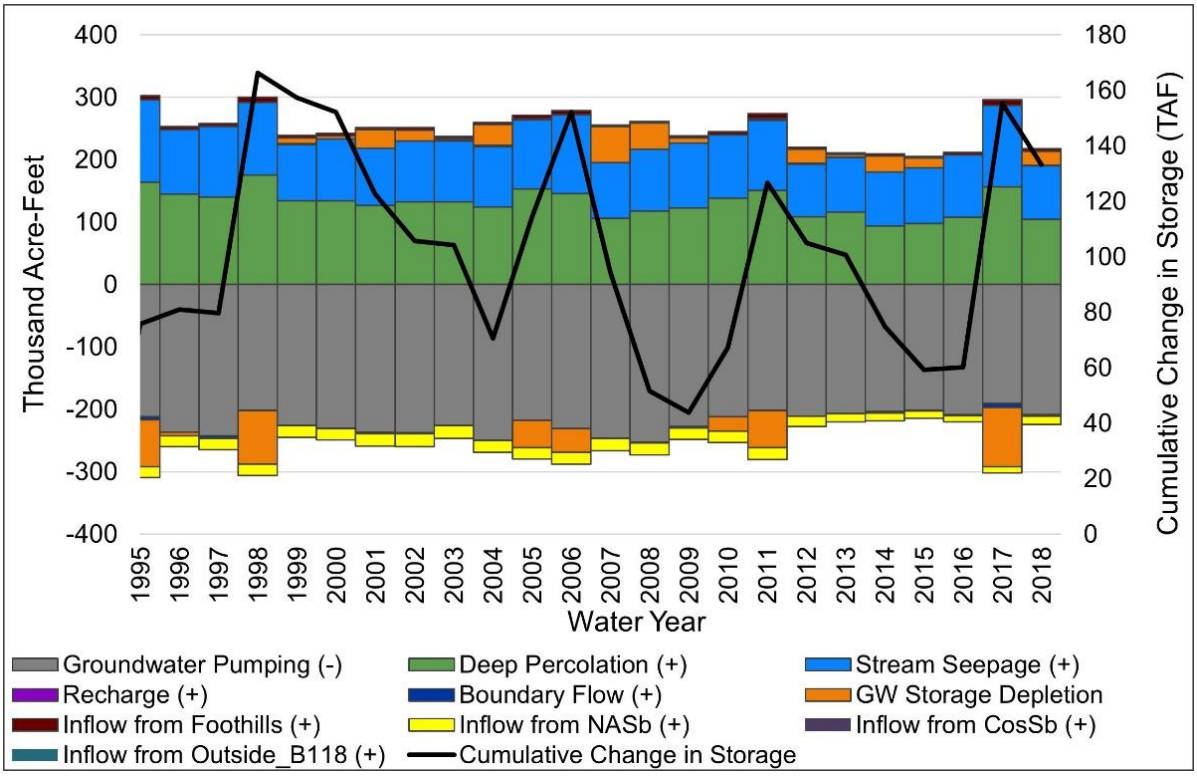


Figure 4-18: CoSb Groundwater Budget

4.2.2 Groundwater Level Calibration

Groundwater levels are calibrated to achieve acceptable agreement between the simulated and observed values (in this case, groundwater levels at the calibration wells). Within CoSANA, over 1,600 wells were evaluated for developing groundwater observation locations (calibration wells) to allow CoSANA's calibration at both a regional and local scale. Data for these wells were obtained from DWR's CASGEM program, DWR's Water Data Library, and local monitoring data from Aerojet, Elk Grove Water District, The Nature Conservancy, and the University of California - Davis. The calibration wells were selected based on their period of record, availability of observation data, spatial distribution across the model, representative nature of the data, and trends of nearby wells. After a review of the available observation data, a working set of 761 wells was selected to be used for the calibration process.

The groundwater level calibration process included both manual refinements to the model as well as automated calibration using the PEST software package. The set of 761 wells with associated observations was used to perform PEST calibration. Of the identified 761 wells, a refined subset of 403 wells that are considered representative of the long-term conditions of groundwater levels both at a local and regional scale were selected for analysis in each PEST run. The location and number of observations for the full set of 761 wells are shown in Figure 4-19, the period of record for each of these wells is shown in Figure 4-20. Maps showing the locations of each of the 403 wells in the subset and calibration hydrographs are shown in Appendix F.

With the observation data identified, a preliminary manual calibration was performed to adjust the water budgets, primarily the land and water use budgets and the small watershed budgets, to have a reasonable starting point for calibrating the aquifer parameters. Simulated groundwater levels are calibrated to observed levels through adjustments to hydrogeologic parameters or aquifer parameters including hydraulic conductivity, specific storage, and specific yield (discussed in Section 4.4). Input datasets were also refined where the calibration process identified issues. The goal of groundwater level calibration is to achieve the maximum agreement between simulated and observed groundwater elevations at calibration wells while maintaining reasonable values for aquifer parameters.

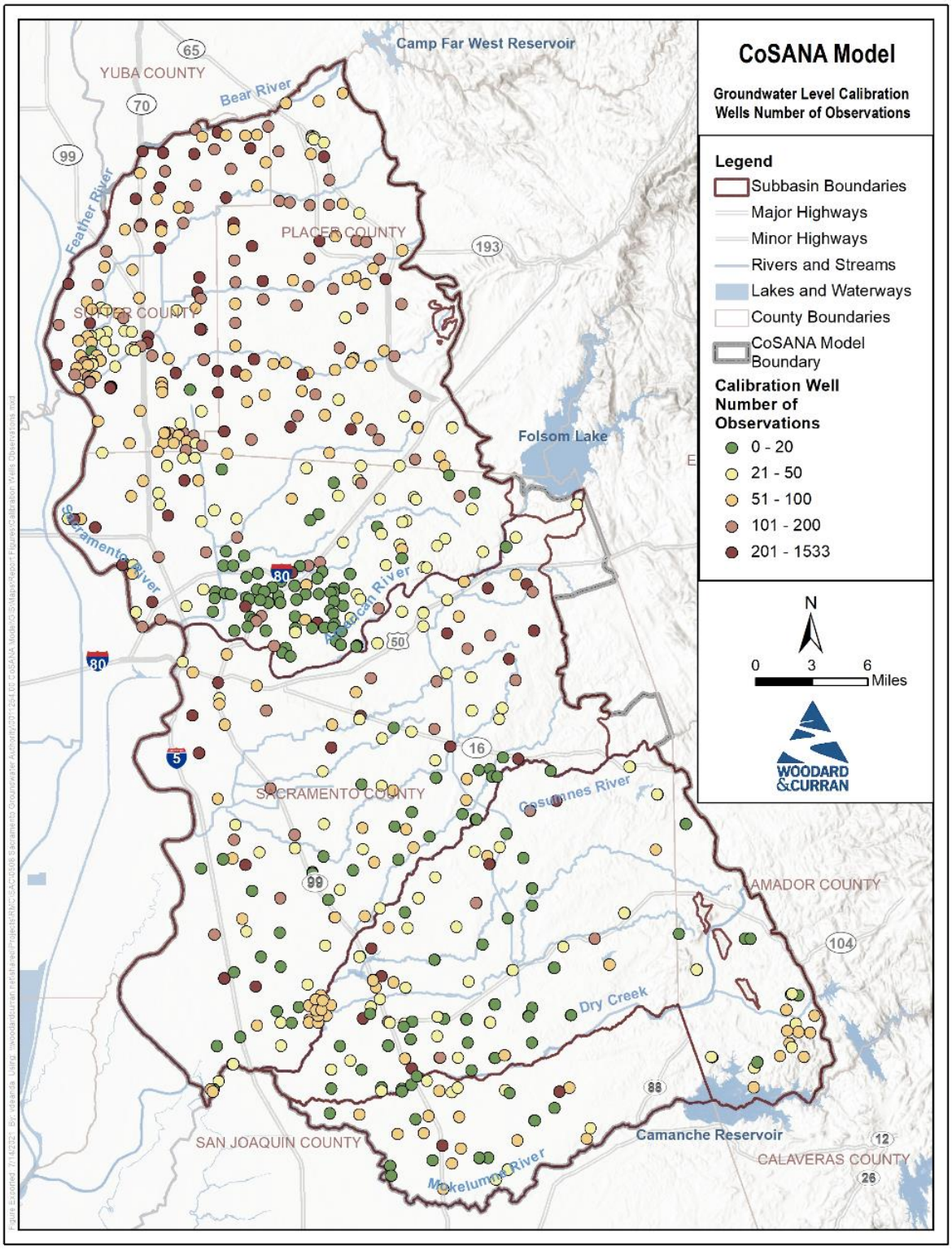


Figure 4-19: Number of Observations for Calibration Wells

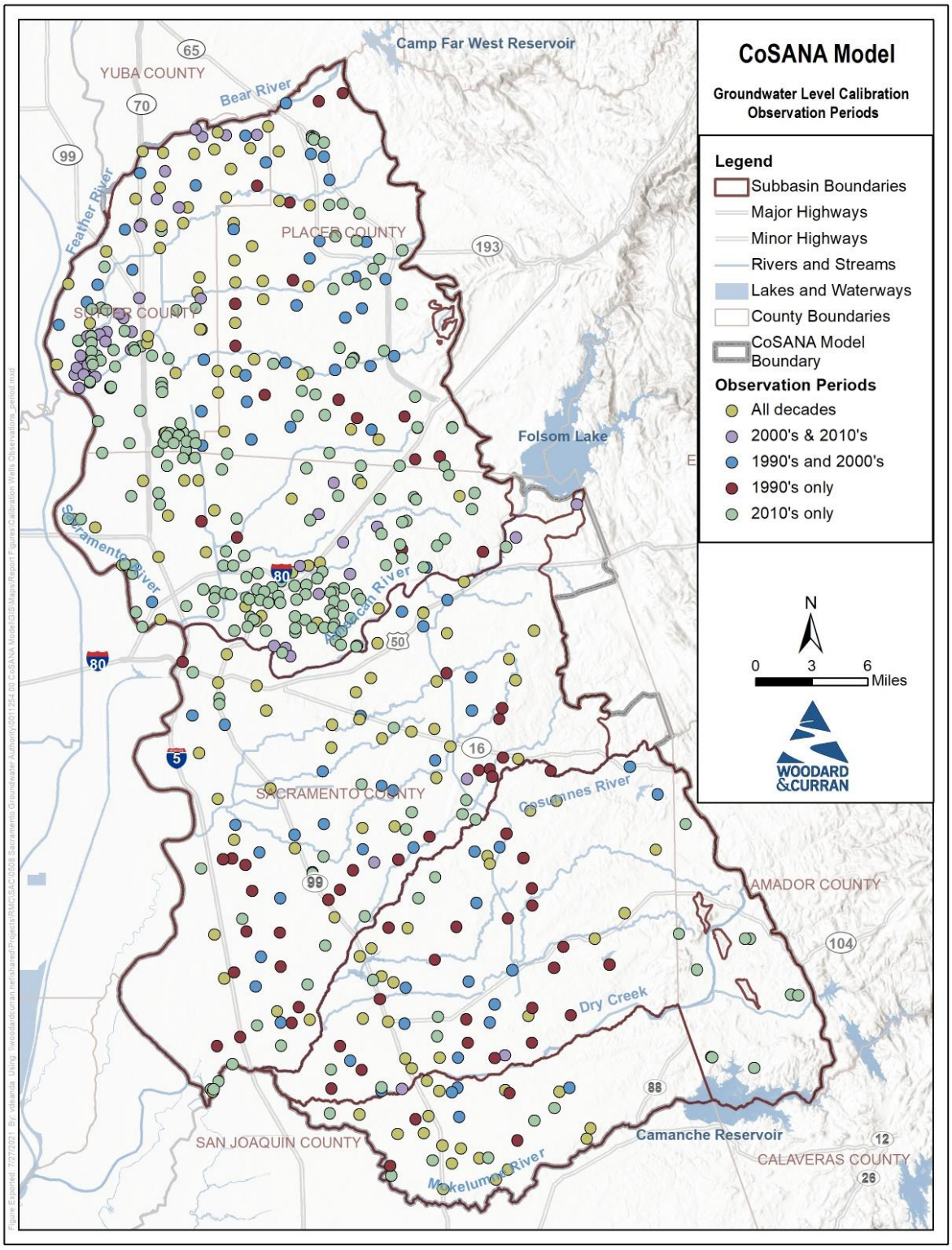


Figure 4-20: Period of Record for Calibration Wells

The automated parameter estimation tool, PEST, was used to assist in refinement of aquifer parameters to improve model calibration. PEST-assisted calibration is performed to interact with CoSANA via input and output files and iteratively modifies parameter values to reduce an objective function representative of the model residual error. These modifications are made within identified bounds of reasonable values for each parameter. PEST-assisted calibration focused on the aquifer parameters such as horizontal and vertical conductivities and storage parameters.

Between PEST-assisted calibration iterations, the modeling team revisited the land system and small watershed budgets and made manual adjustments where needed, until calibration goals were met.

Simulated groundwater level contours and observed values for calibration wells are shown in Figure 4-21, Figure 4-22, and Figure 4-23 for spring 1998, fall 2015, and fall 2018, respectively. Simulated groundwater level hydrographs and observations for selected wells (locations shown in Figure 4-24) are shown in Figure 4-25 through Figure 4-49. Simulated values represent the layers screened at that well, except for 7223 and 7224 which do not have screened interval information.

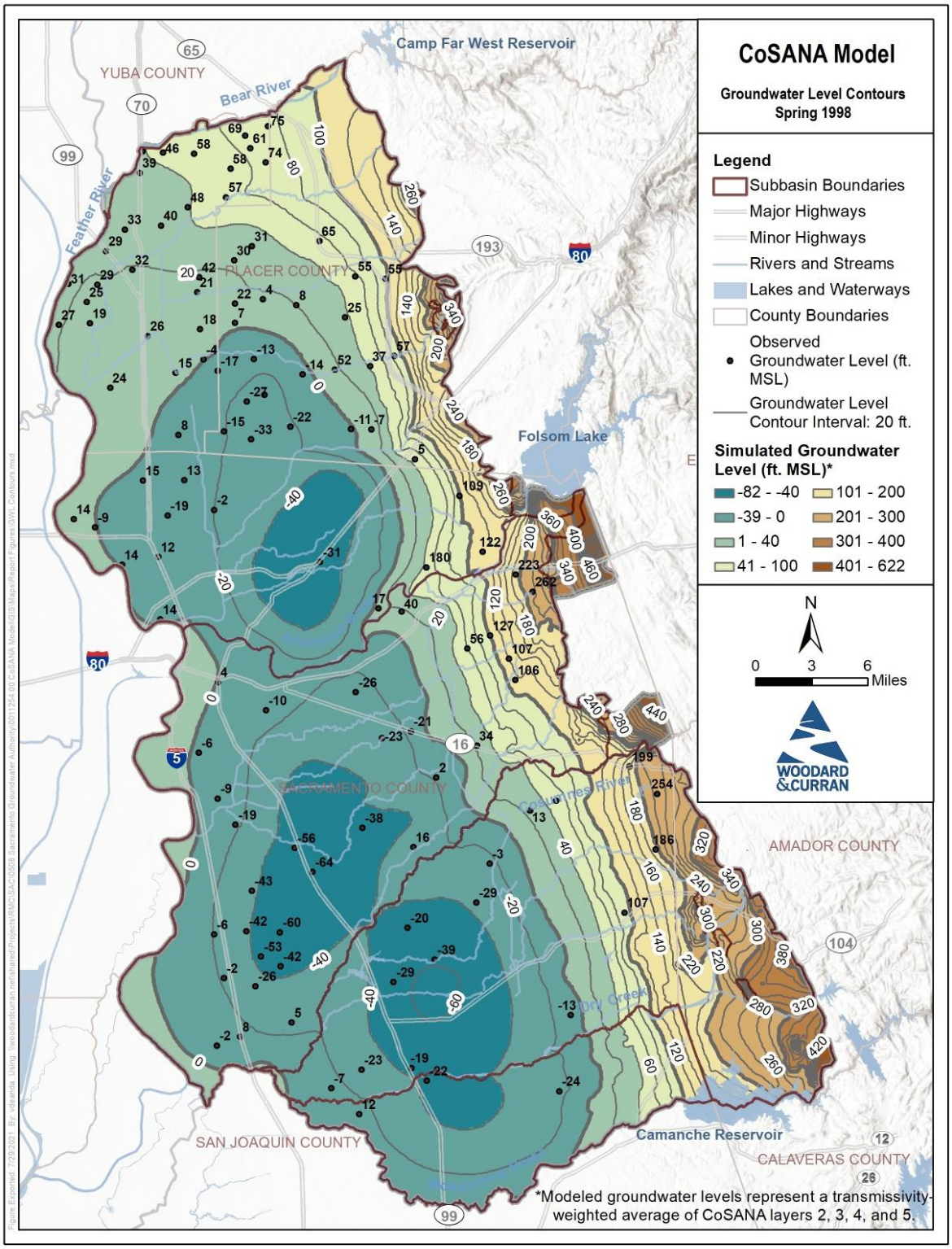


Figure 4-21: CoSANA Groundwater Level Contours – Spring 1998 (End of Wet Period)

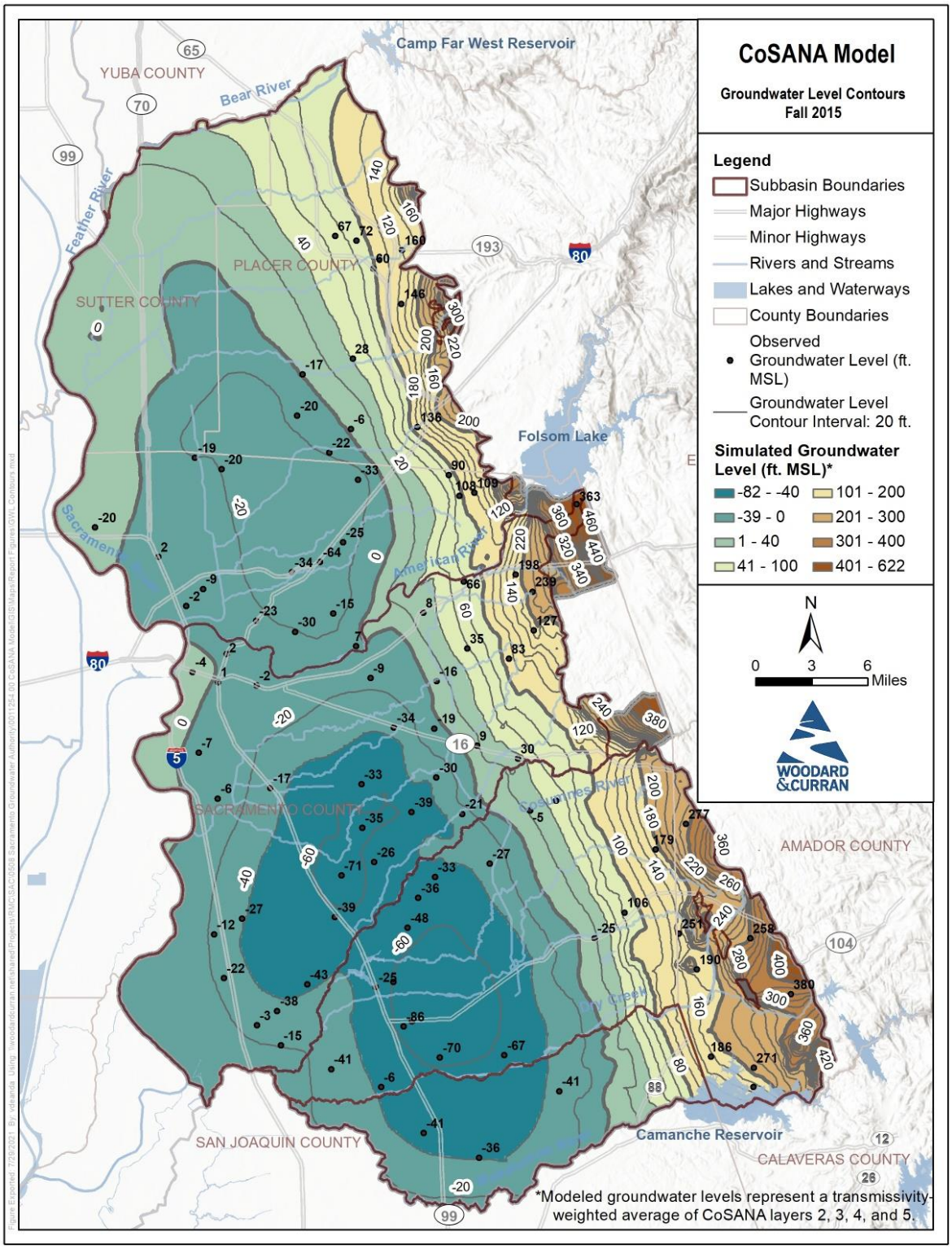


Figure 4-22: CoSANA Groundwater Level Contours – Fall 2015 (End of Drought Period)

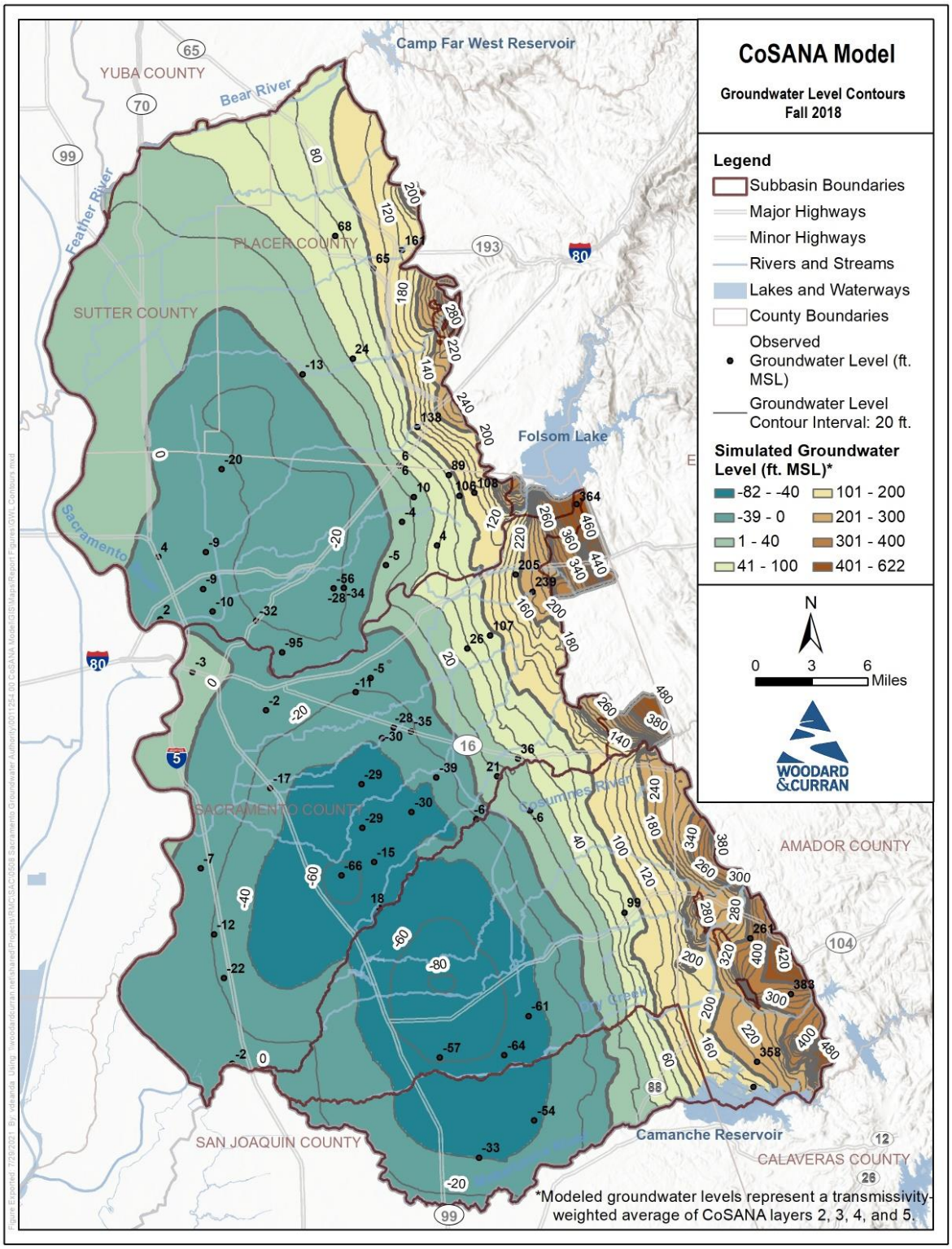


Figure 4-23: CoSANA Groundwater Level Contours – Fall 2018 (End of Simulation)

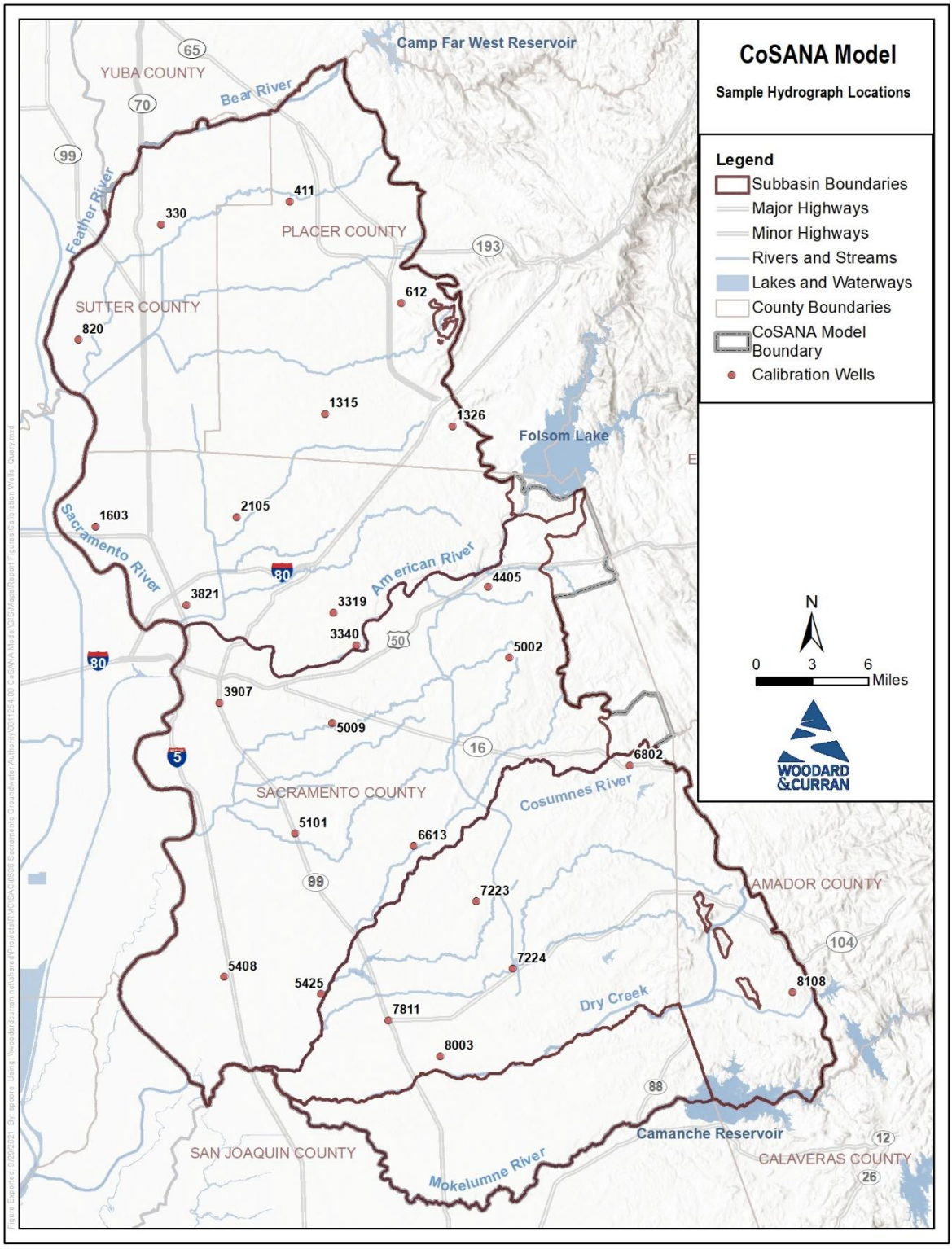


Figure 4-24: Location of Sample Hydrographs

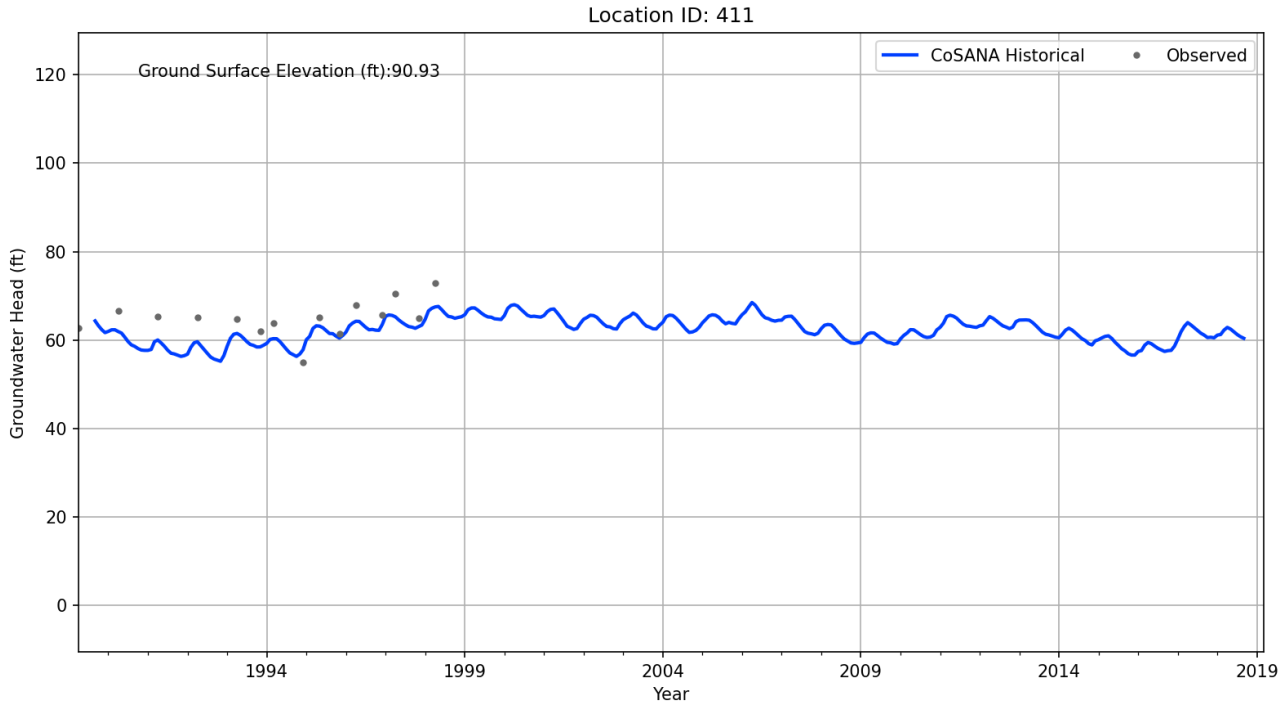


Figure 4-25: CoSANA Groundwater Level Hydrograph – Hydrograph #1

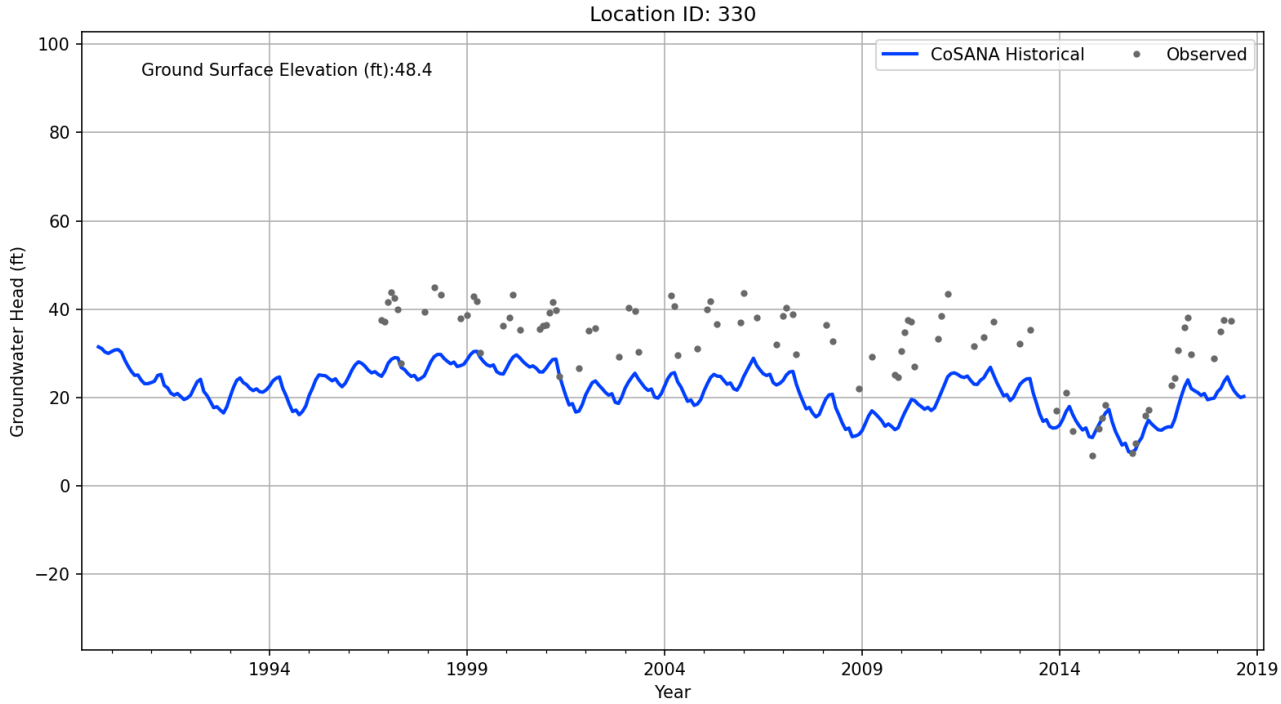


Figure 4-26: CoSANA Groundwater Level Hydrograph – Hydrograph #2

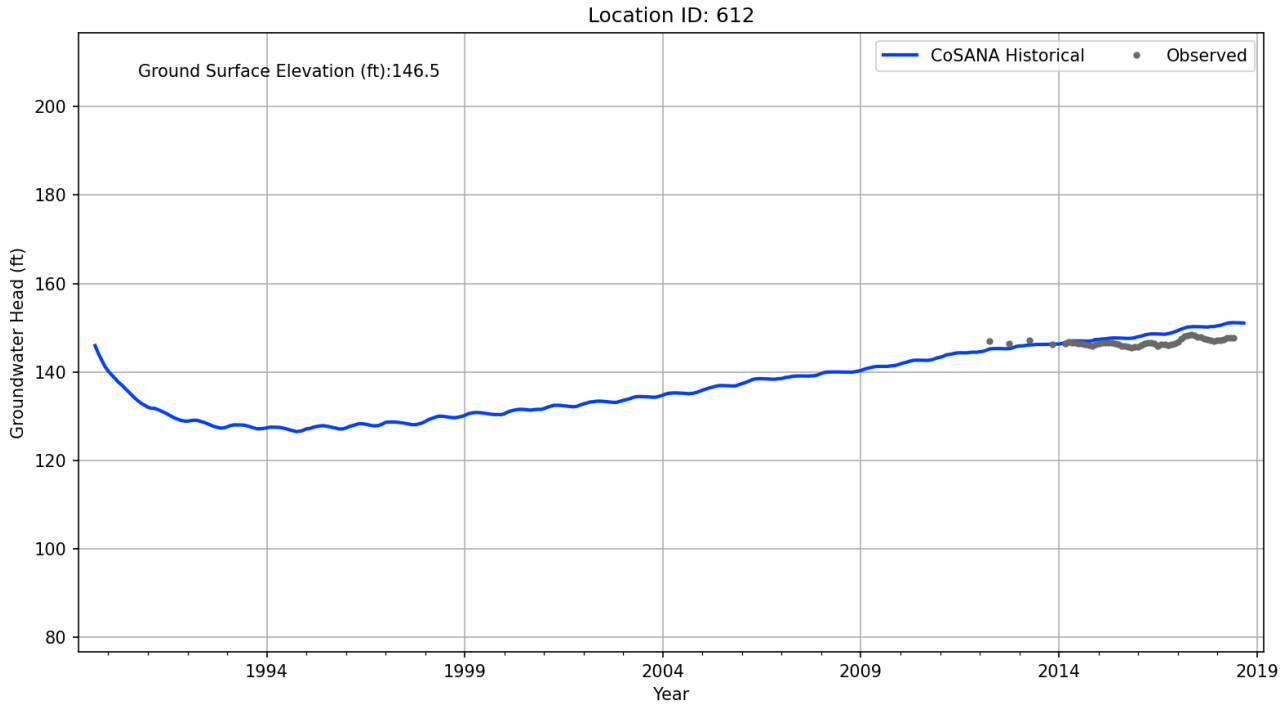


Figure 4-27: CoSANA Groundwater Level Hydrograph – Hydrograph #3

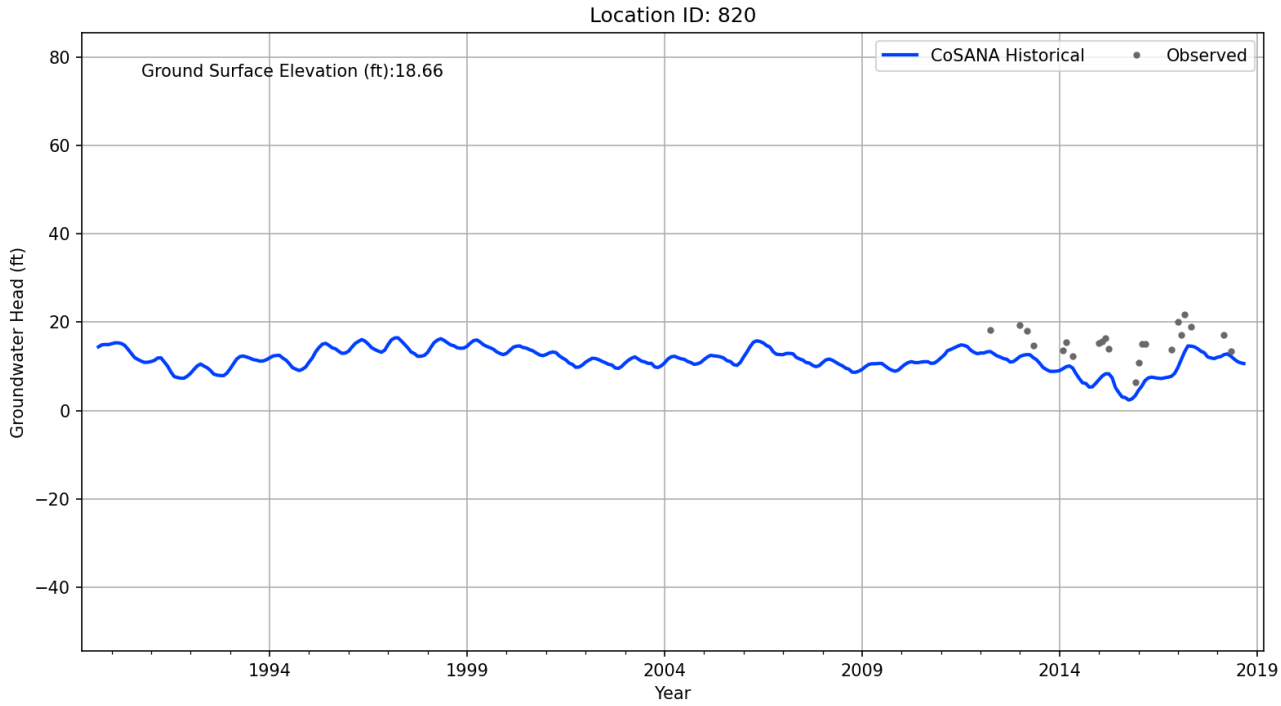


Figure 4-28: CoSANA Groundwater Level Hydrograph – Hydrograph #4

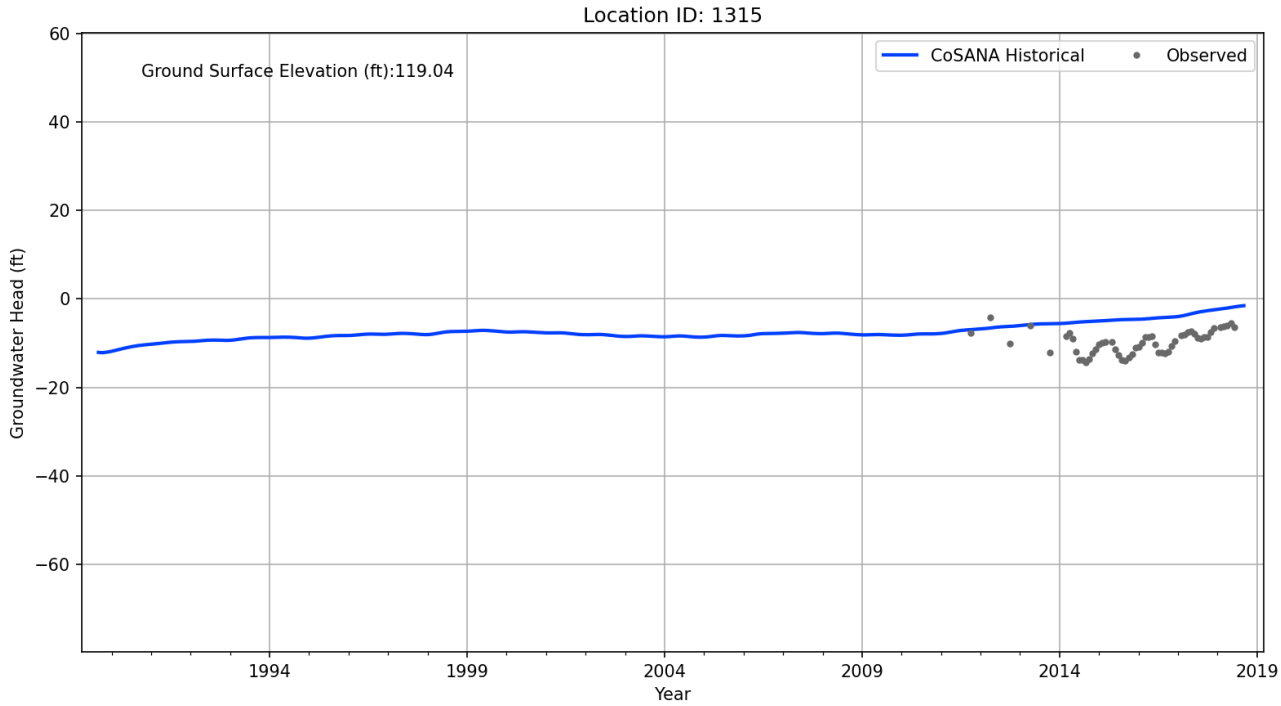


Figure 4-29: CoSANA Groundwater Level Hydrograph – Hydrograph #5

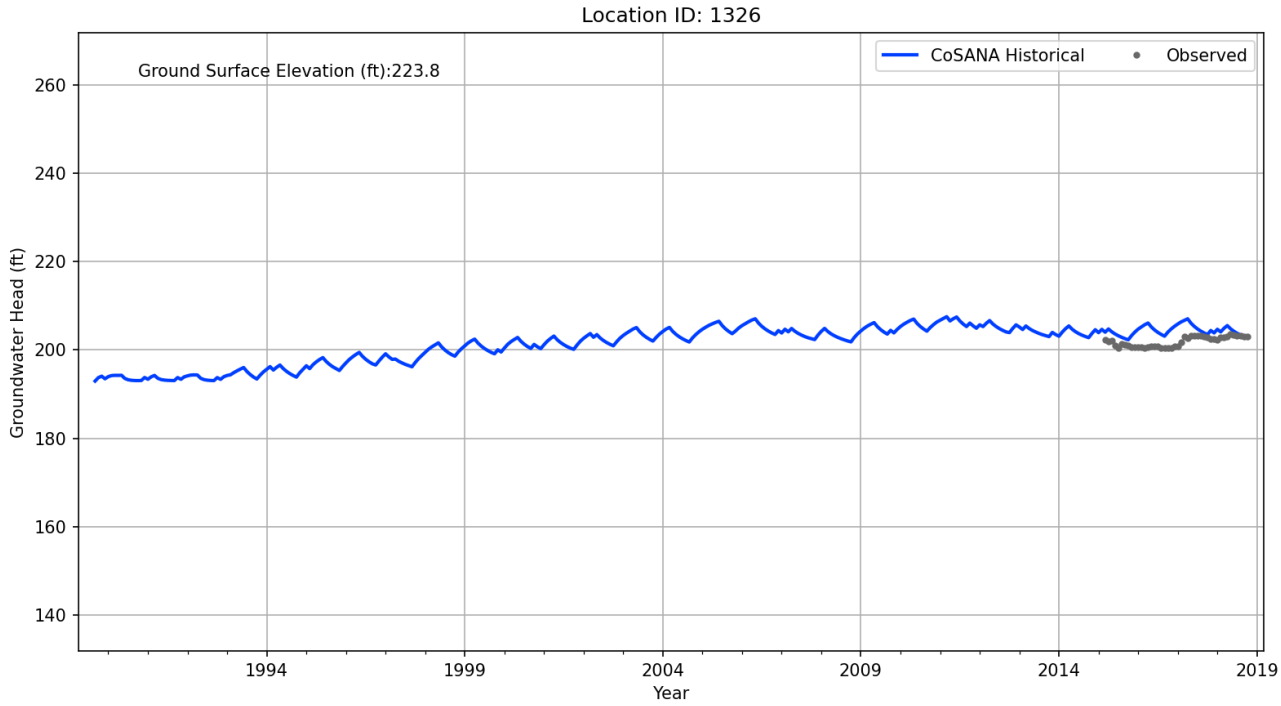


Figure 4-30: CoSANA Groundwater Level Hydrograph – Hydrograph #6

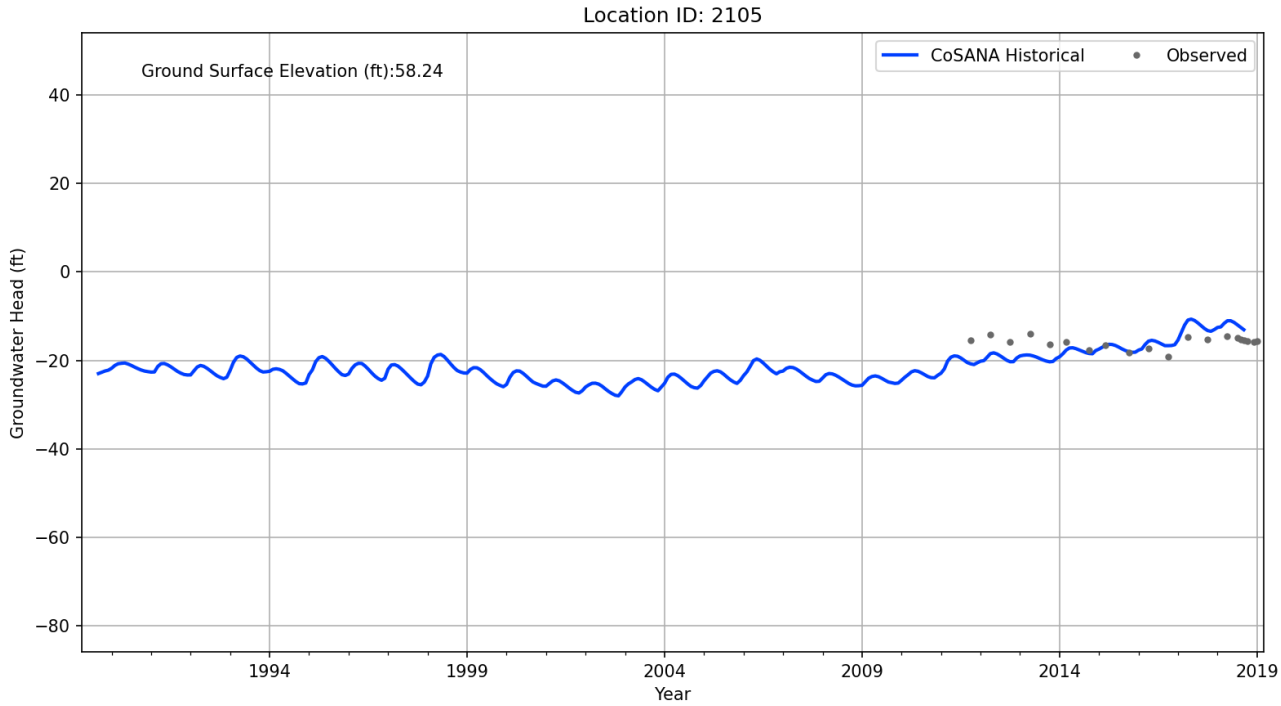


Figure 4-31: CoSANA Groundwater Level Hydrograph – Hydrograph #7

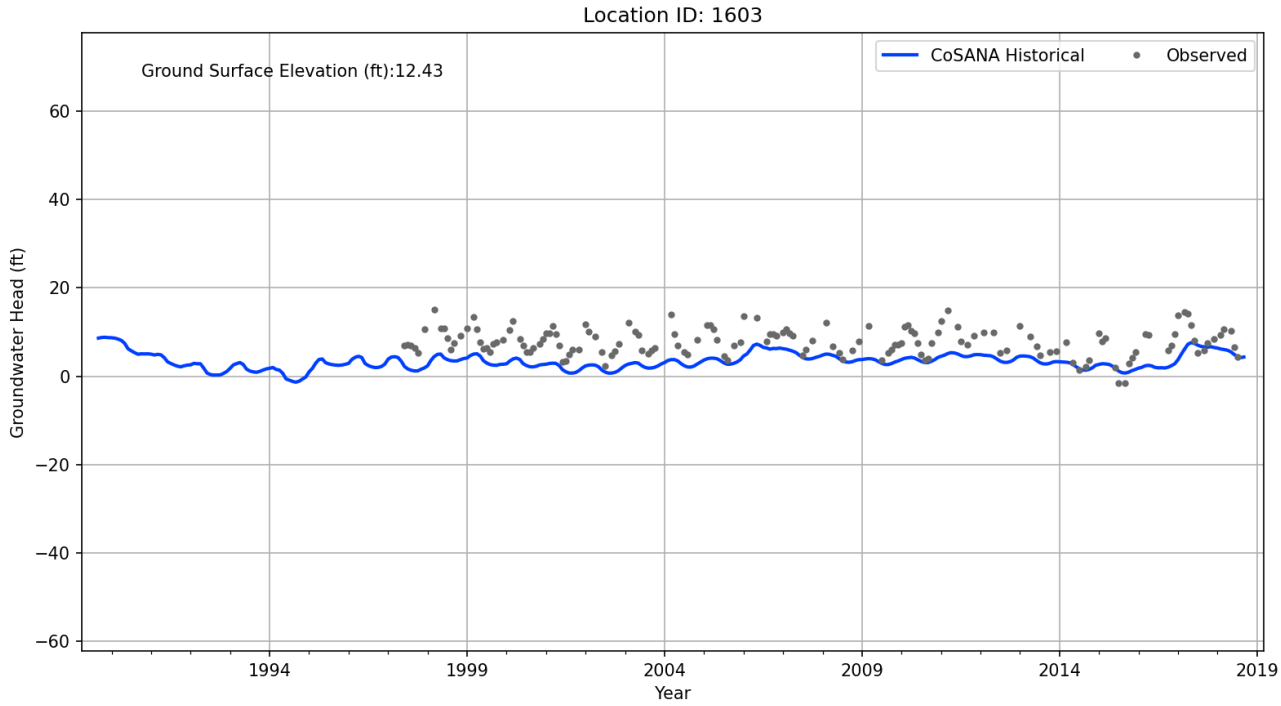


Figure 4-32: CoSANA Groundwater Level Hydrograph – Hydrograph #8

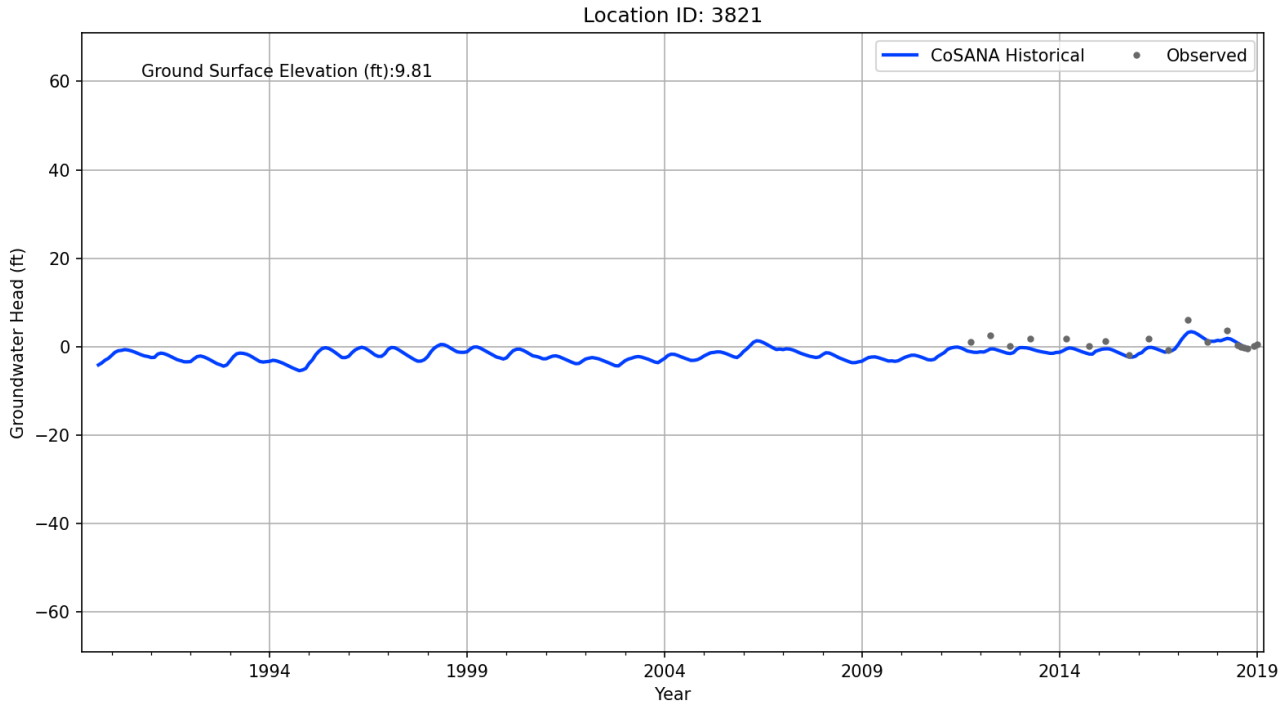


Figure 4-33: CoSANA Groundwater Level Hydrograph – Hydrograph #9

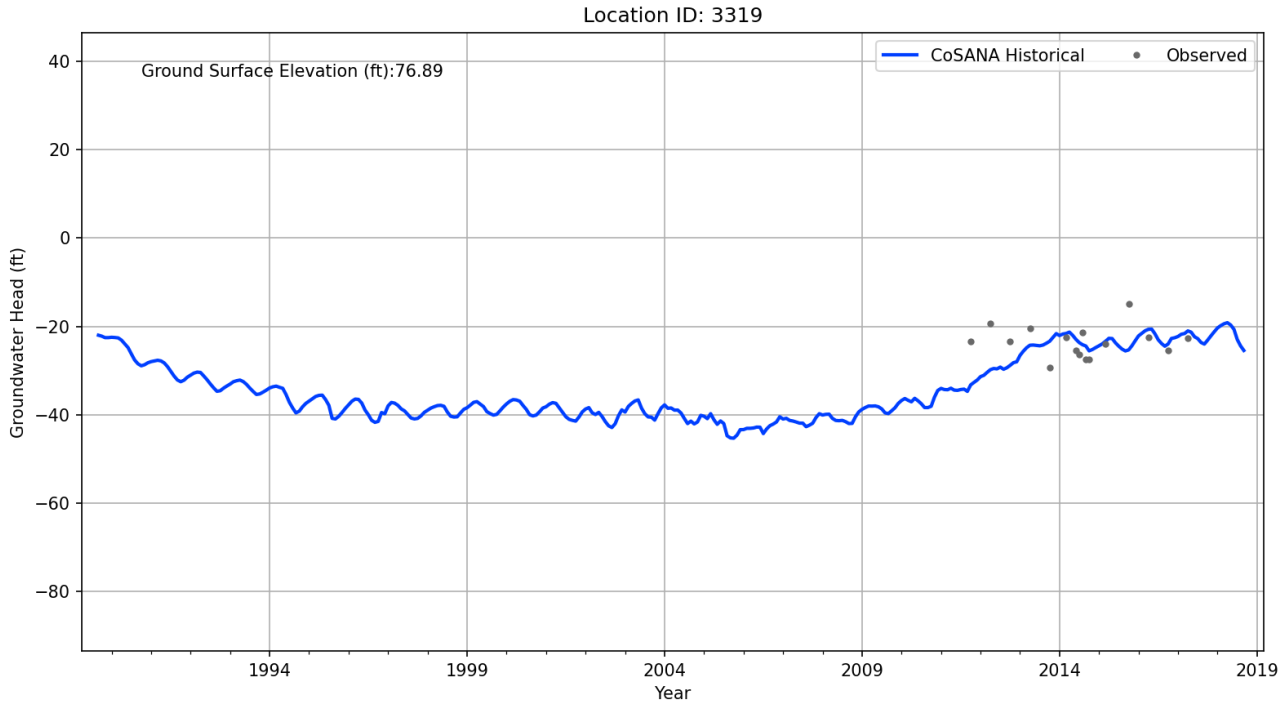


Figure 4-34: CoSANA Groundwater Level Hydrograph – Hydrograph #10

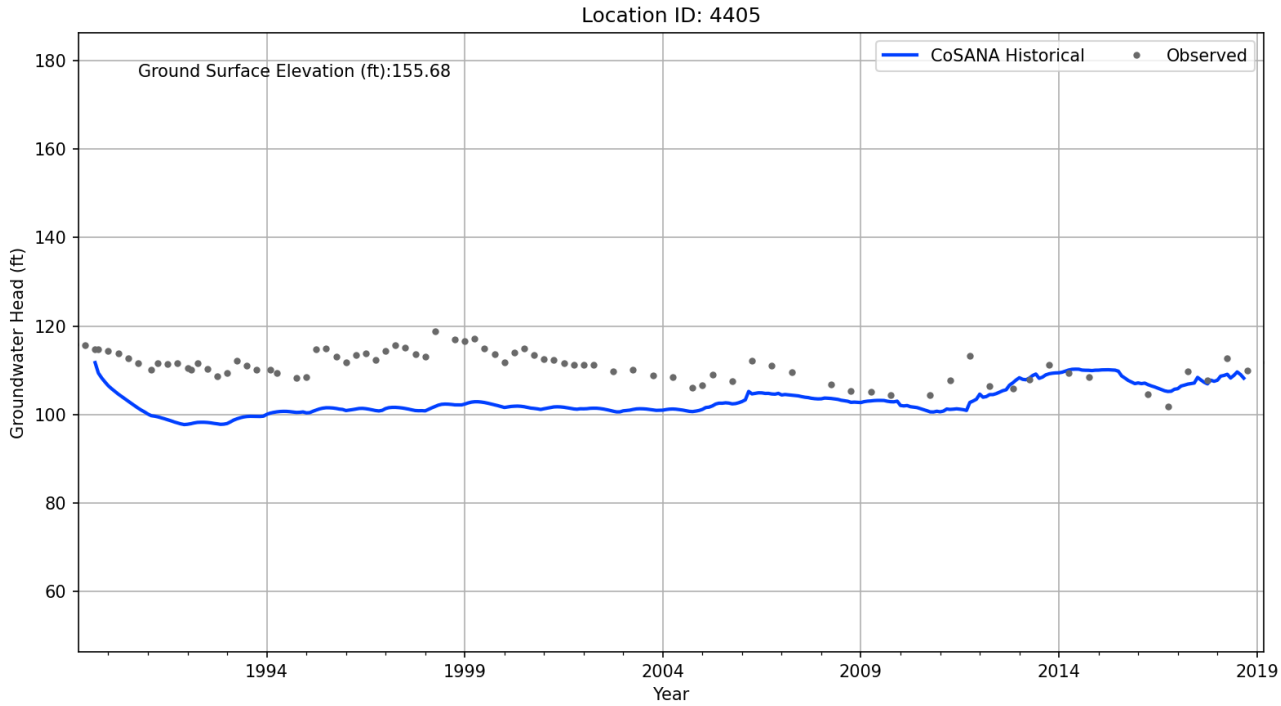


Figure 4-35: CoSANA Groundwater Level Hydrograph – Hydrograph #11

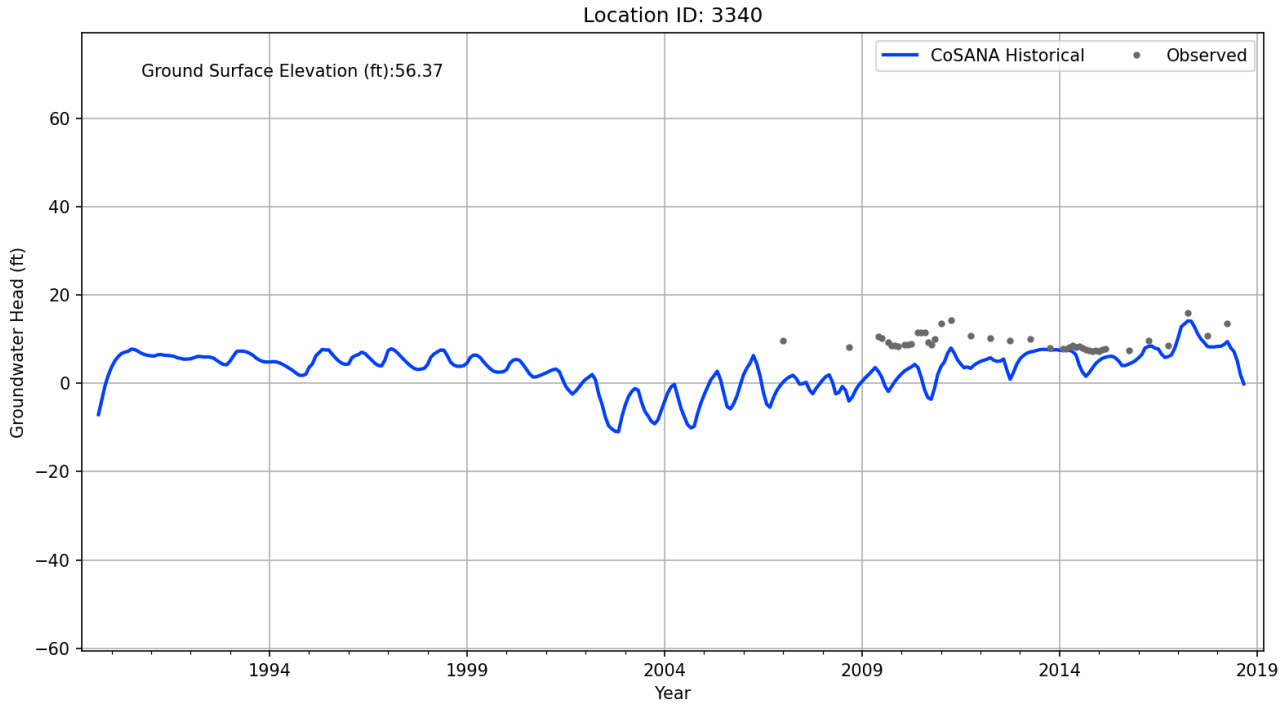


Figure 4-36: CoSANA Groundwater Level Hydrograph – Hydrograph #12

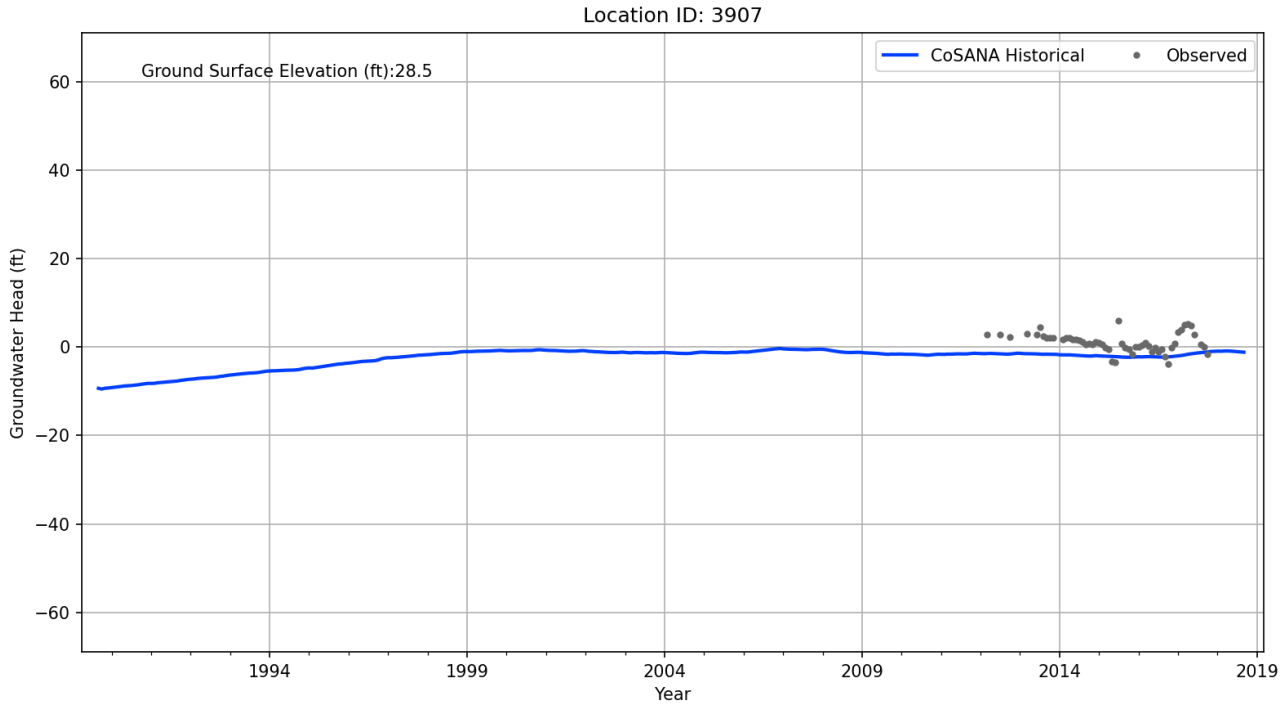


Figure 4-37: CoSANA Groundwater Level Hydrograph – Hydrograph #13

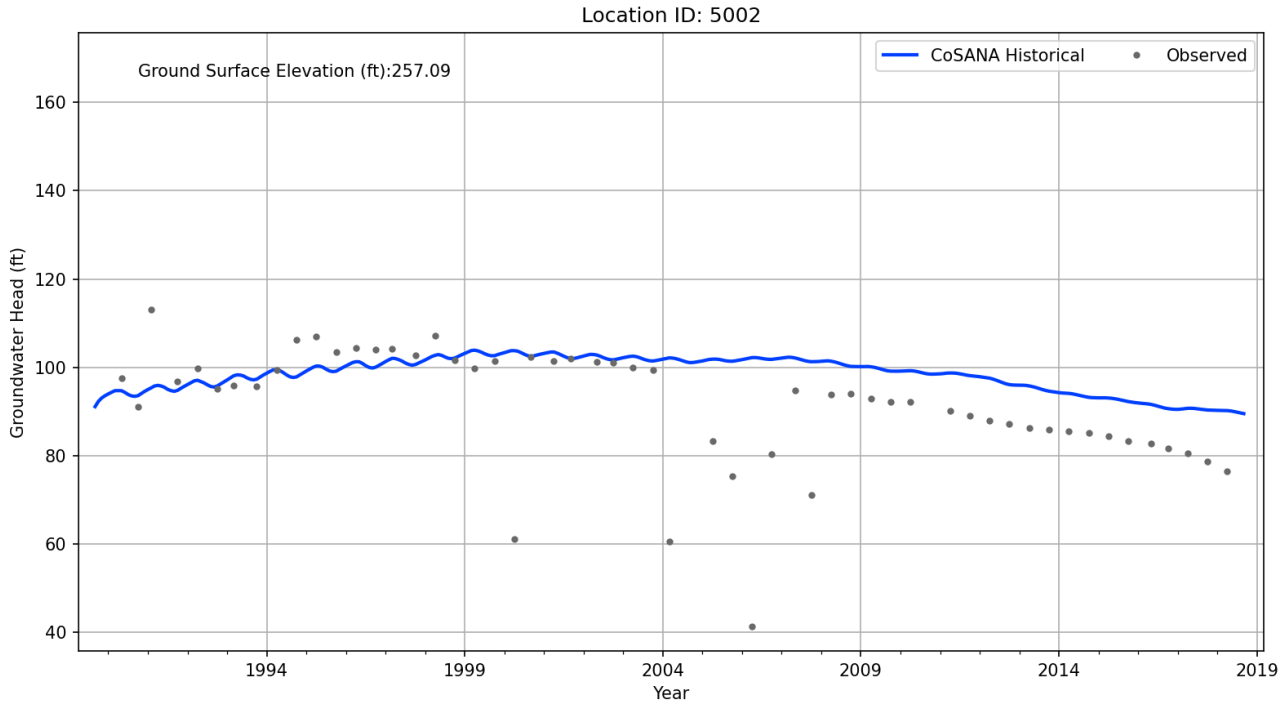


Figure 4-38: CoSANA Groundwater Level Hydrograph – Hydrograph #14

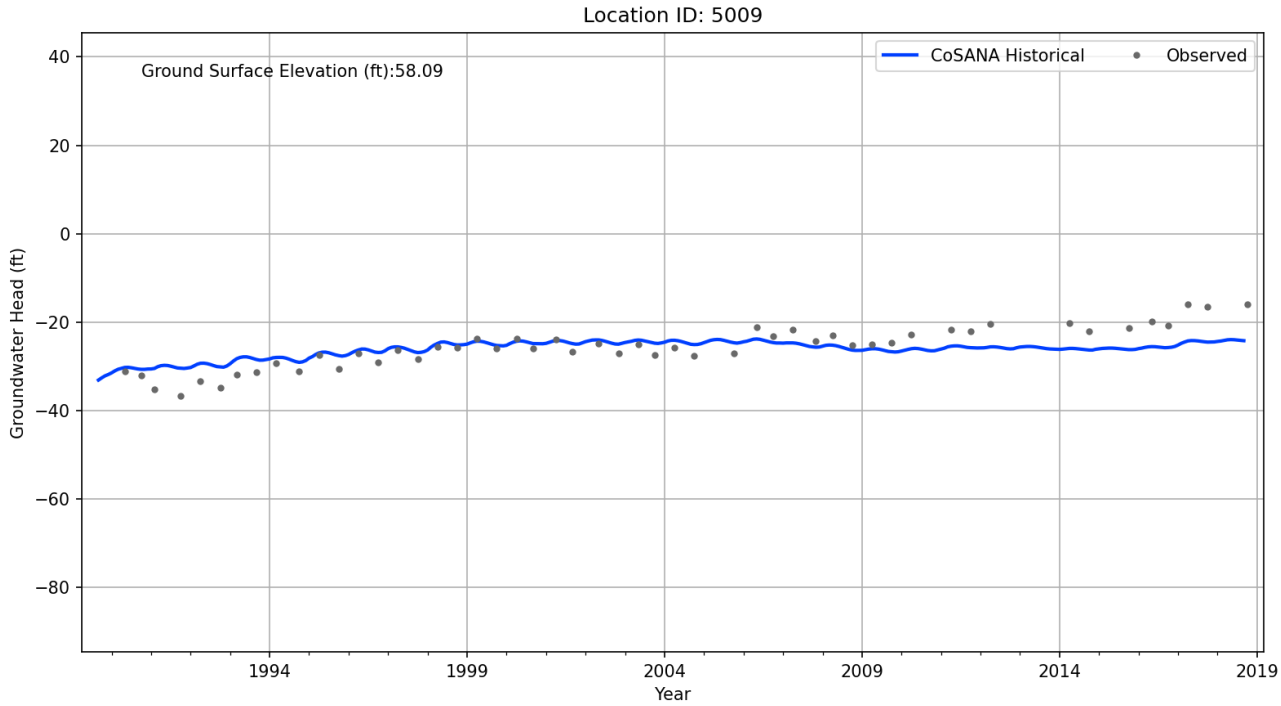


Figure 4-39: CoSANA Groundwater Level Hydrograph – Hydrograph #15

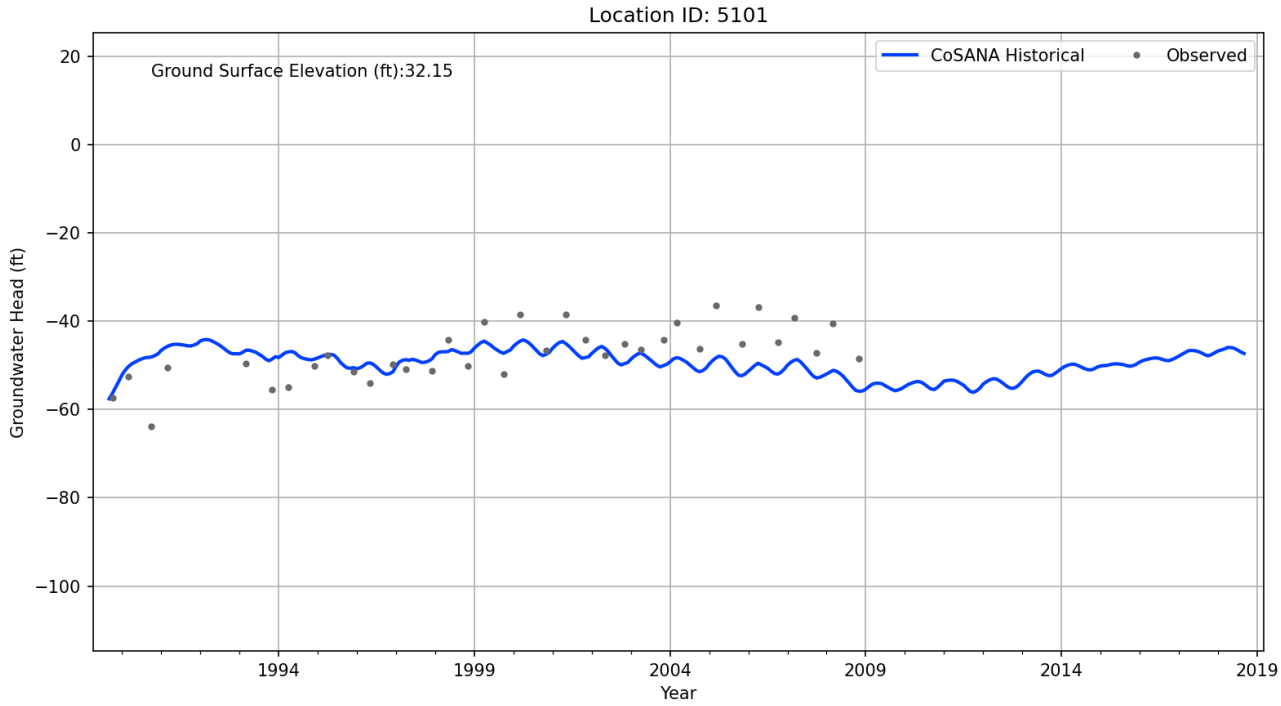


Figure 4-40: CoSANA Groundwater Level Hydrograph – Hydrograph #16

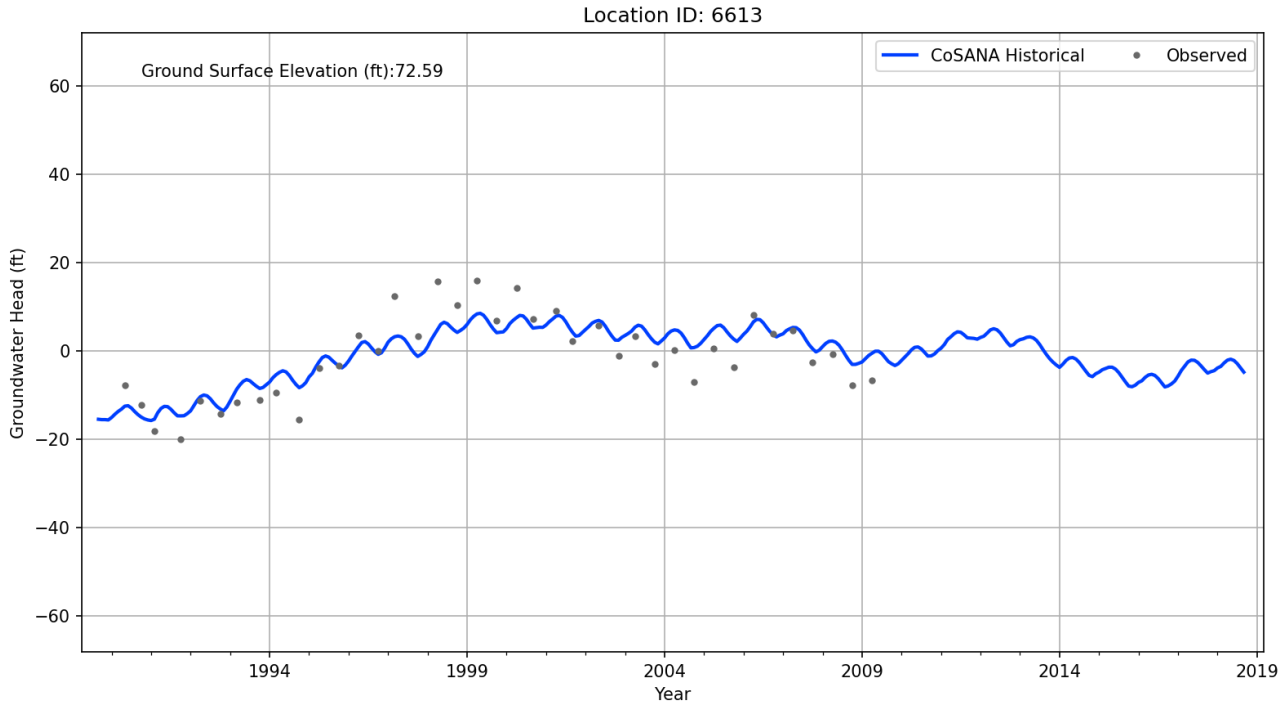


Figure 4-41: CoSANA Groundwater Level Hydrograph – Hydrograph #17

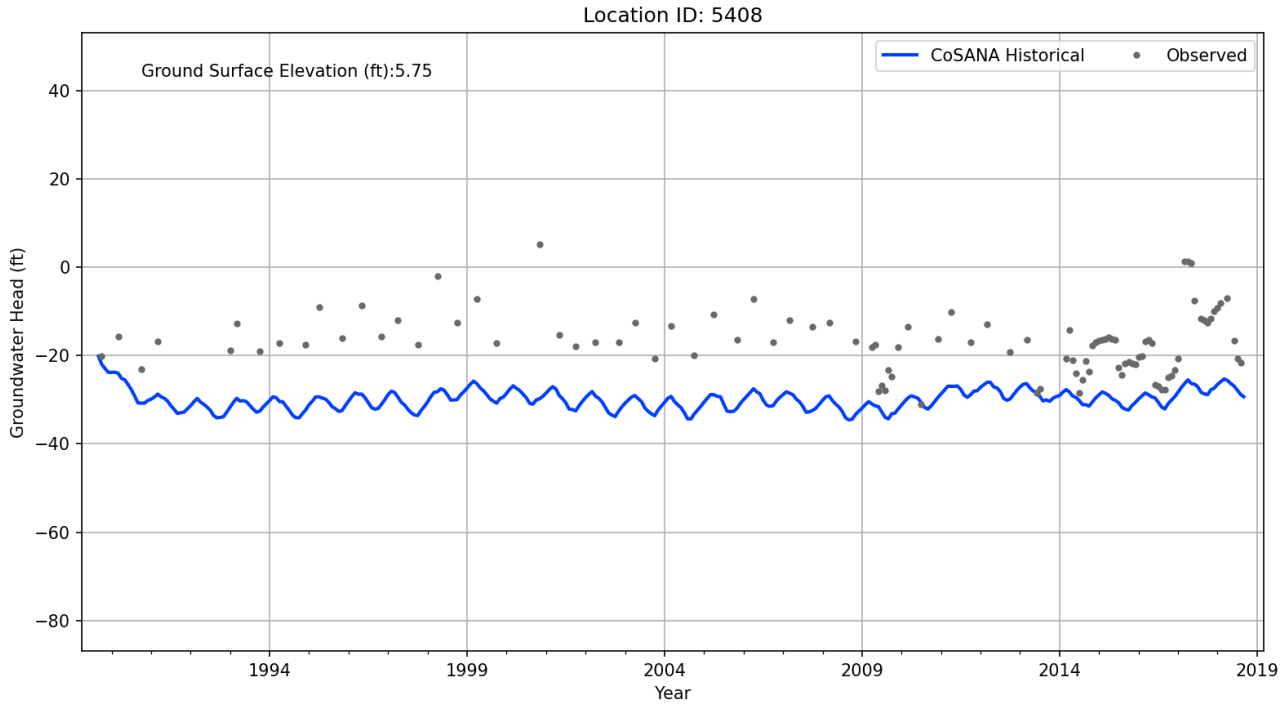


Figure 4-42: CoSANA Groundwater Level Hydrograph – Hydrograph #18

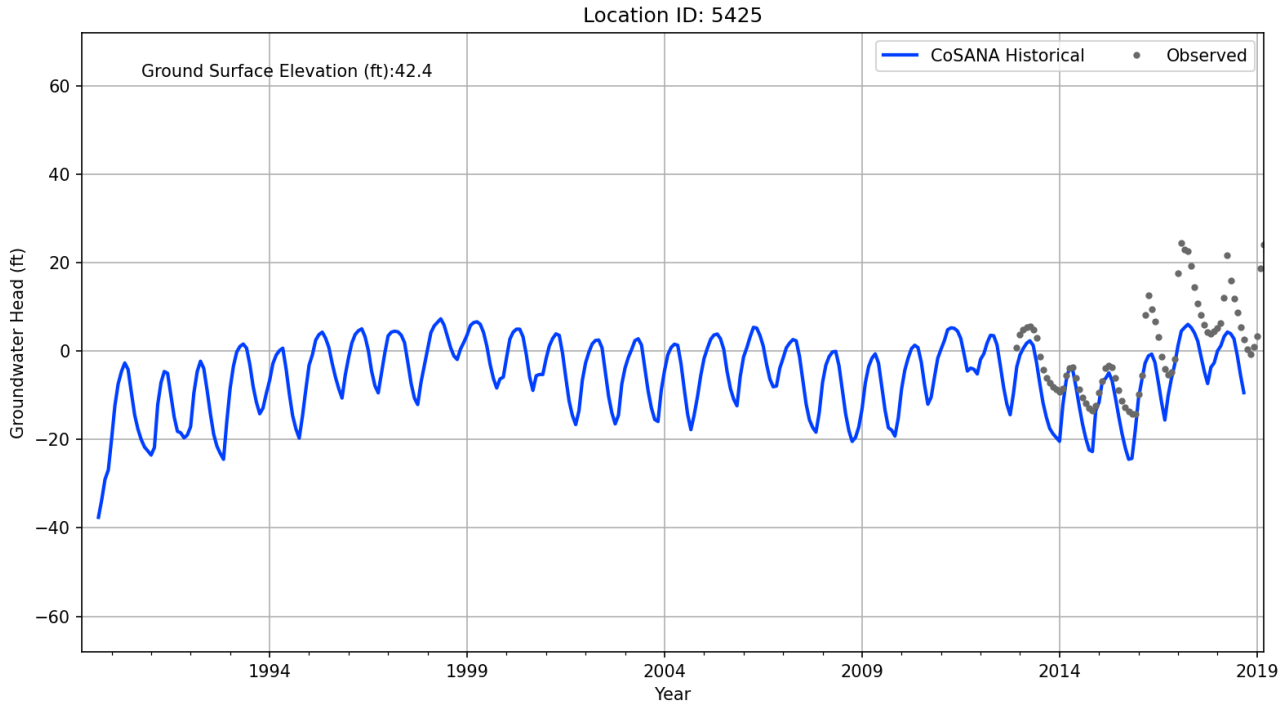


Figure 4-43: CoSANA Groundwater Level Hydrograph – Hydrograph #19

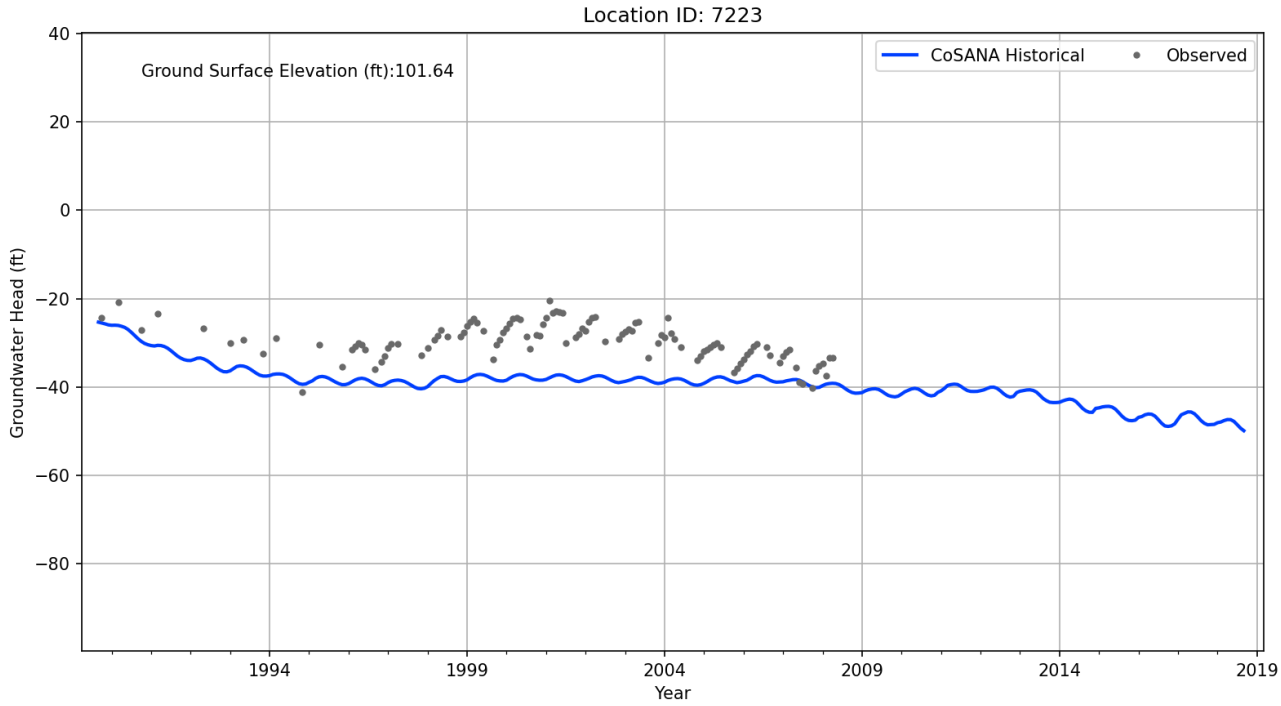


Figure 4-44: CoSANA Groundwater Level Hydrograph – Hydrograph #20

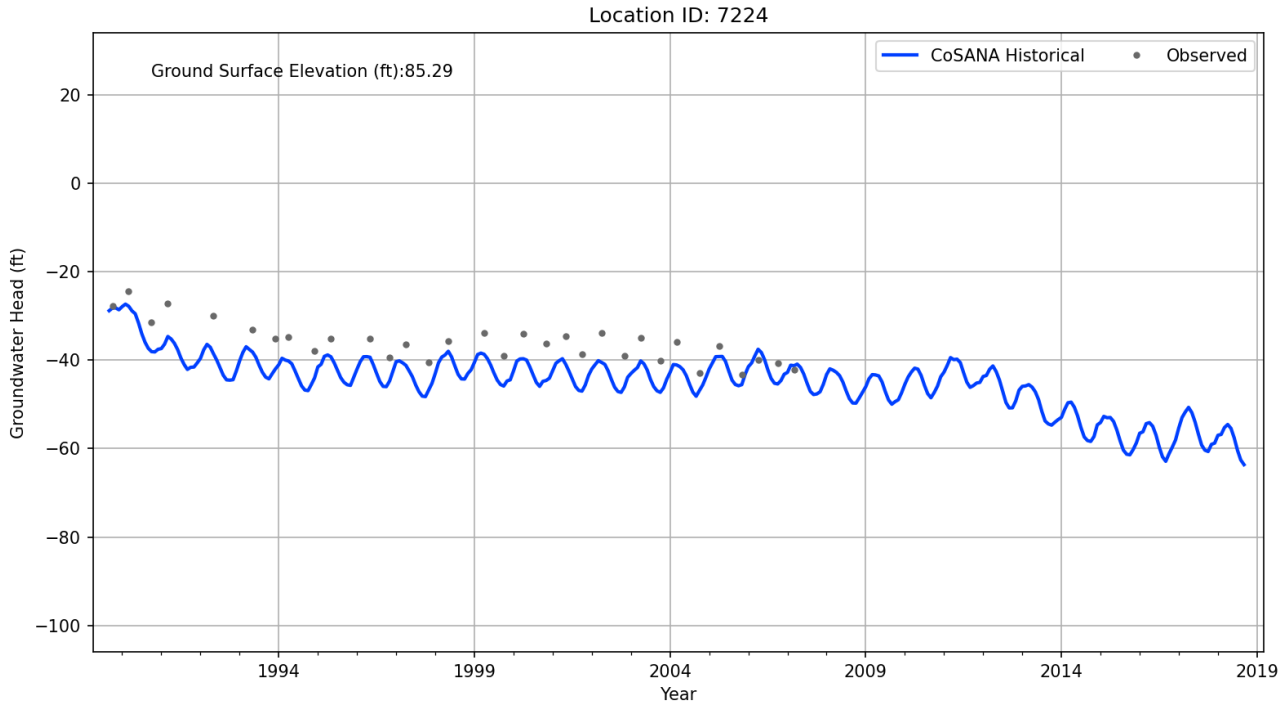


Figure 4-45: CoSANA Groundwater Level Hydrograph – Hydrograph #21

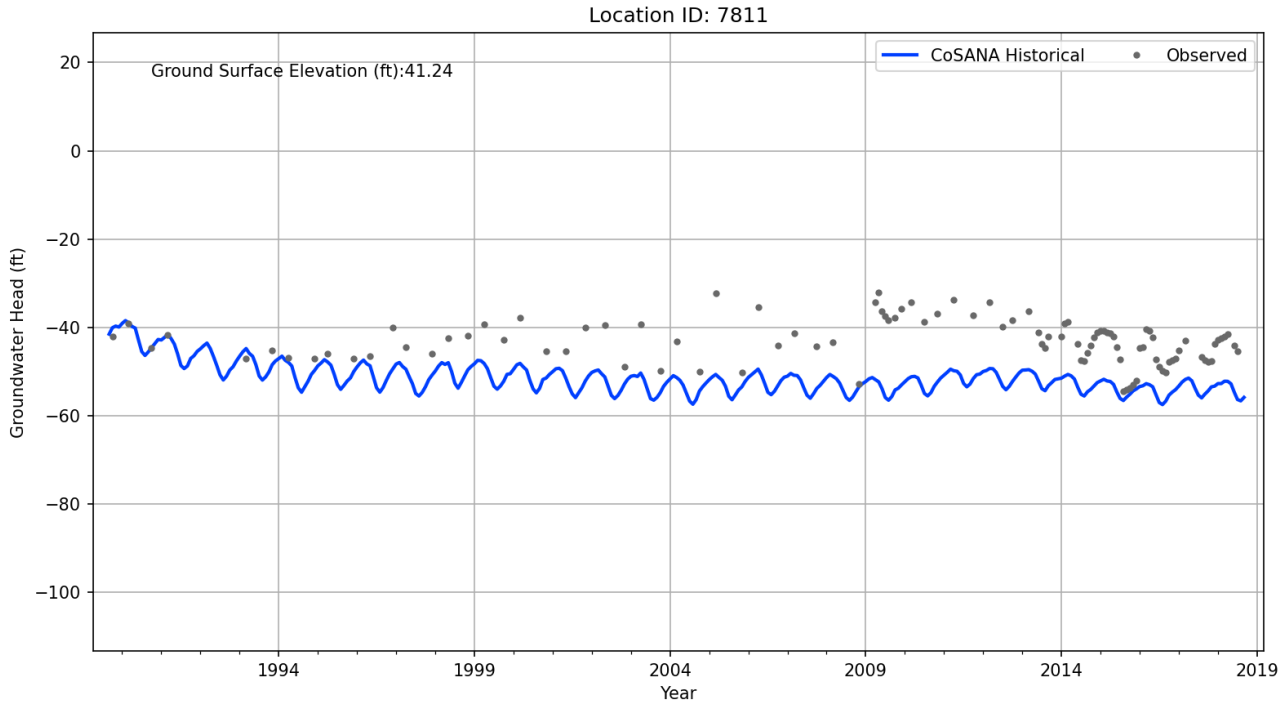


Figure 4-46: CoSANA Groundwater Level Hydrograph – Hydrograph #22

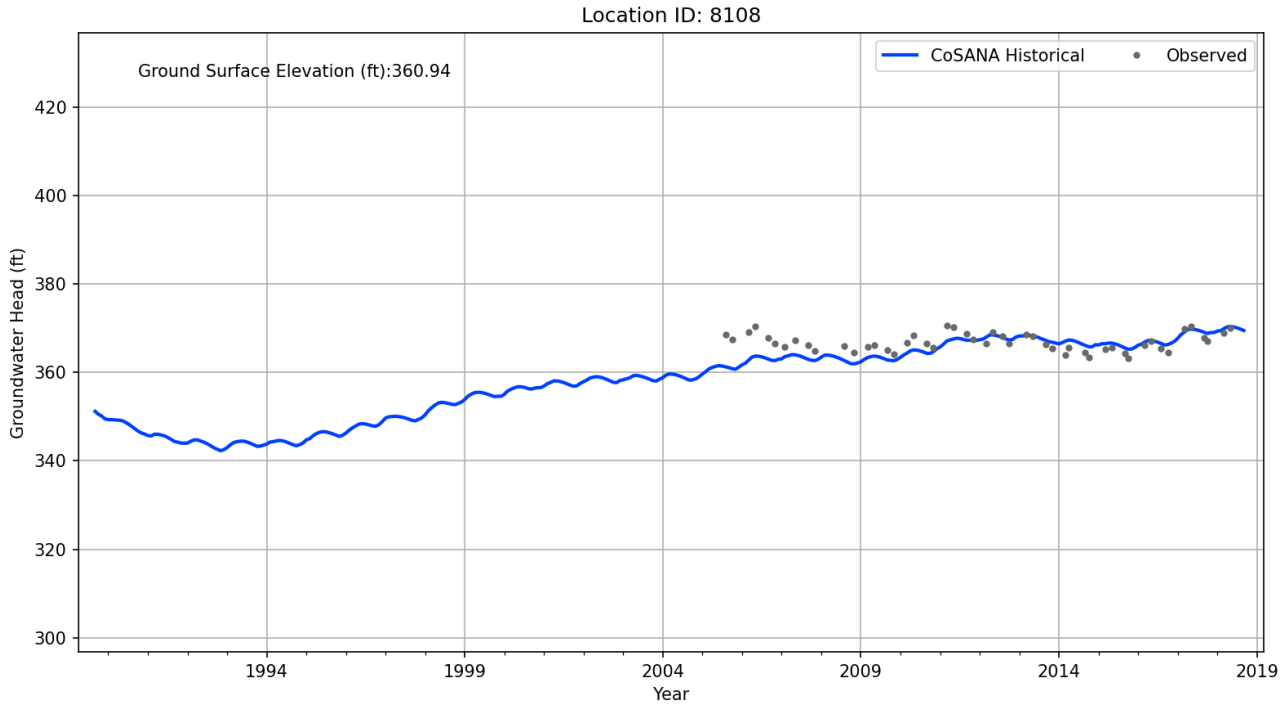


Figure 4-47: CoSANA Groundwater Level Hydrograph – Hydrograph #23

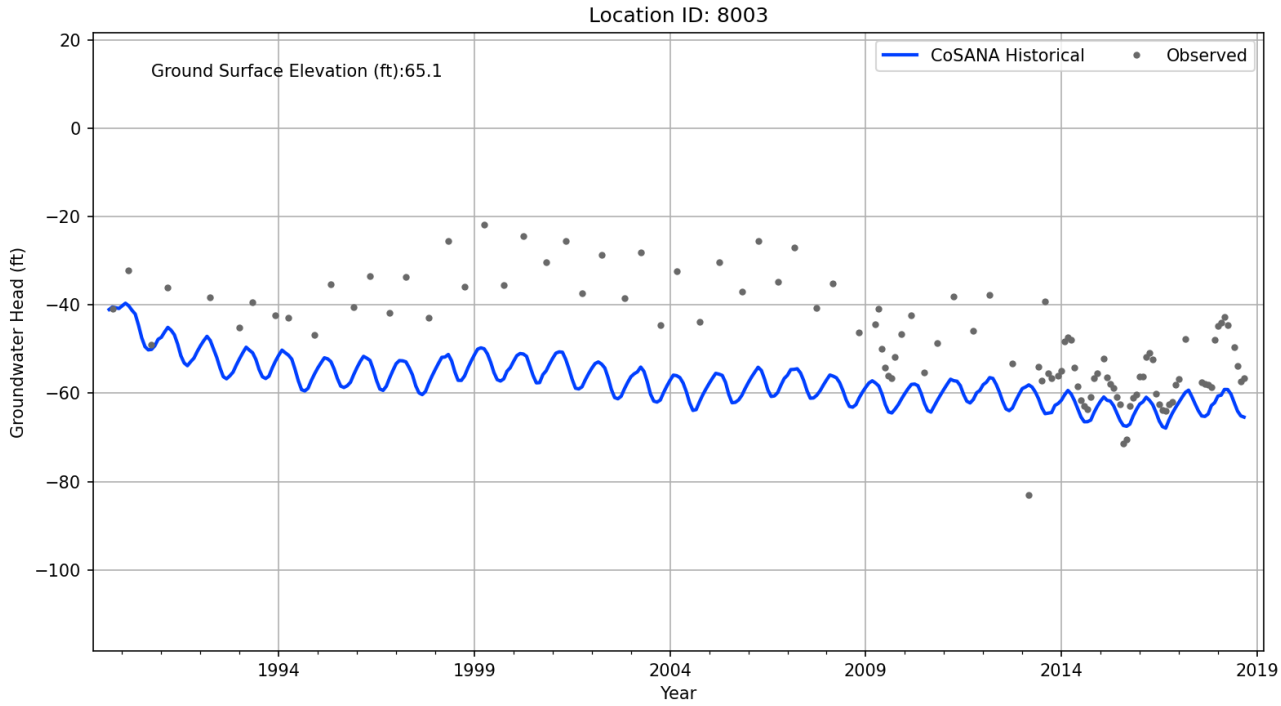


Figure 4-48: CoSANA Groundwater Level Hydrograph – Hydrograph #24

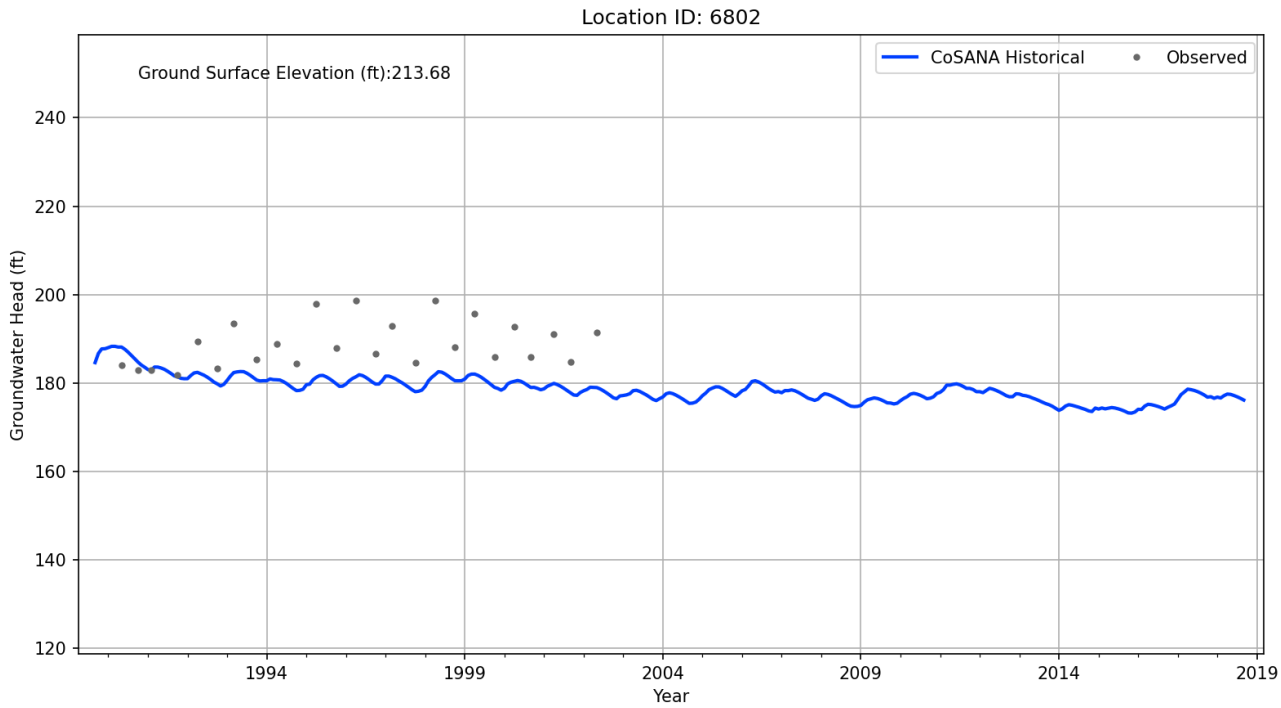


Figure 4-49: CoSANA Groundwater Level Hydrograph – Hydrograph #25

4.2.3 Streamflow Calibration

Similar to the process for groundwater levels, streamflows are calibrated to achieve reasonable agreement between the simulated and observed values (in this case, streamflows at the gaging stations). Streamflow gaging stations near the eastern boundary of the model are often used for inflow data (see Section 2.4). Other streamflow gaging stations are downstream of these inflow points and associated observed streamflow data can be compared to simulated streamflow in the calibration process. The comparison assists in modifications to parameters associated with stream aquifer interaction.

Streamflow calibration is primarily performed by comparing the simulated streamflow with local data from 15 stream gages (Table 4-3 and Figure 4-50). Data for these gages came from USGS or the California Data Exchange Center (CDEC).

Table 4-3: Summary of CoSANA Stream Calibration Gages

Stream	Stream Node	Description	Agency	Station ID	Period of Record
American River	895	American R at H St Bridge	CA DWR	CDEC ID: HST	1986 - Present
Arcade Creek	619	Arcade Cr at Winding Way	Sacramento County	CDEC ID: AMC	1995 - Present
Arcade Creek	625	Arcade Cr near Del Paso Heights	USGS	11447360	1995 - Present
Arcade Creek	600	Arcade Cr at Sunrise Blvd	Sacramento County Dep't Public Works	CDEC ID: ARD	1997 - Present
Bear River	49	Bear R at Pleasant Grove Rd	CA DWR	CDEC ID: BPG	2005 - Present
Cosumnes River	1667	Cosumnes R at McConnell, CA	USGS	11336000	1941 to 1982
Dry Creek (NASb)	510	Dry Cr at Vernon St. Bridge	City of Roseville	CDEC ID: VRS	1995 - Present
Dry Creek (CoSb)	1998	Dry Cr near Galt	USGS	11329500	1926 - 1997
Feather River	107	Feather R near Nicolaus	CA DWR	CDEC ID: NIC	1984 - Present
Laguna Creek (SASb)	1202	Laguna Cr near Eagles Nest Rd.	Sacramento County	CDEC ID: EGN	1996 - Present
Mokelumne River	2212	Mokelumne R at Woodbridge	EBMUD	CDEC ID: WBR	1997 - Present
Morrison Creek	1105	Morrison Cr at Mack Rd	Sacramento Dep't Public Works	CDEC ID: MCM	1998 - 2009
Sacramento River	947	Sacramento R at I St Bridge	CA DWR	CDEC ID: IST	1984 - Present
Sacramento River	1020	Sacramento R at Freeport	USGS	11447650	1948 - Present

Streamflow calibration included refinement of the streambed hydraulic conductivity originally from C2VSim. The calibrated streambed hydraulic conductivity is shown in Figure 4-51. Simulated streamflows were compared with observed records, and exceedance charts were also used to check the model performance when simulating high and low flows at each gage location. Calibration results for the Sacramento River at Freeport are shown in Figure 4-52 and Figure 4-53. Calibration results for the Cosumnes River at McConnell are shown in Figure 4-54 and Figure 4-55 (note that stage data but not flow data are available at McConnell).

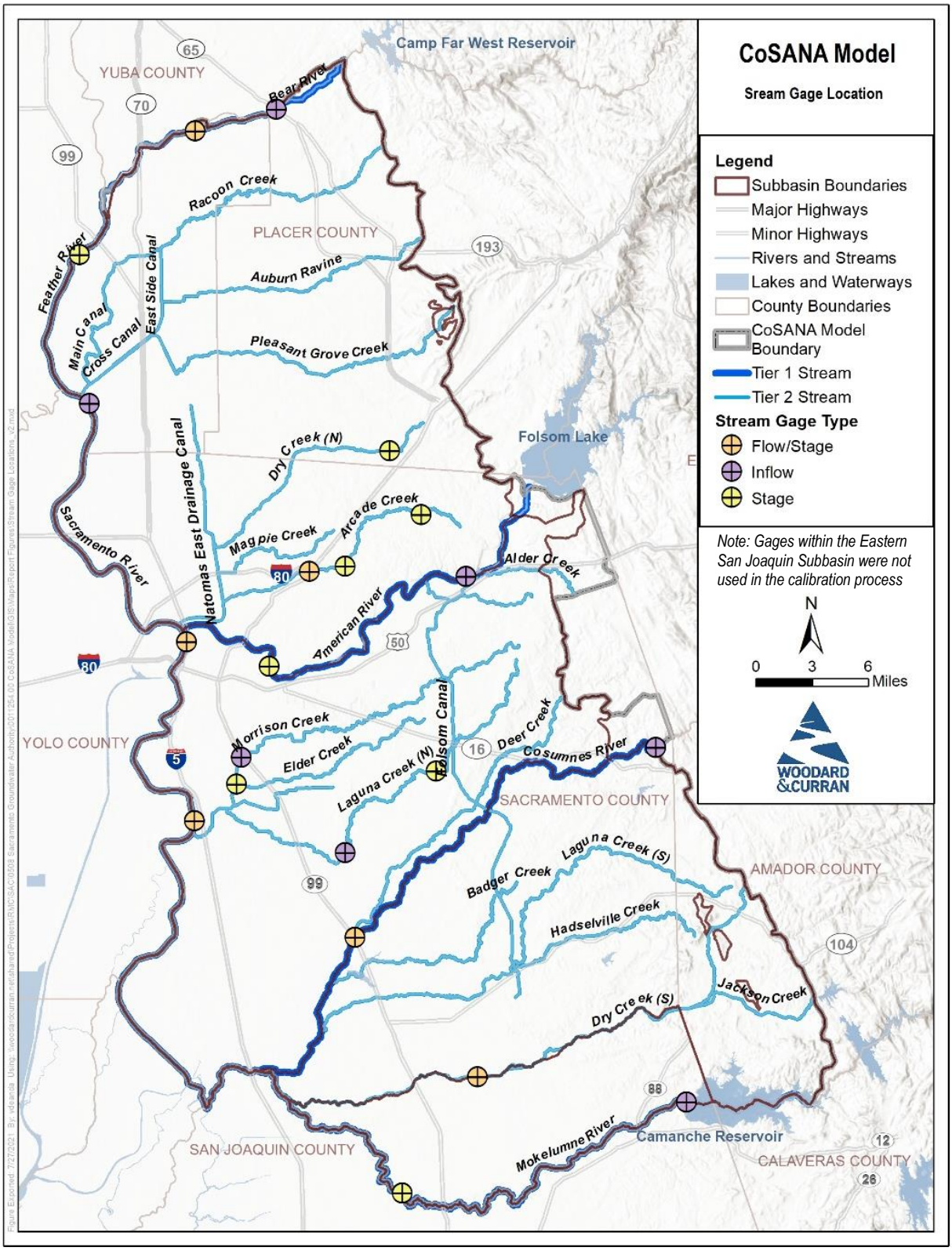


Figure 4-50: Stream Gage Locations

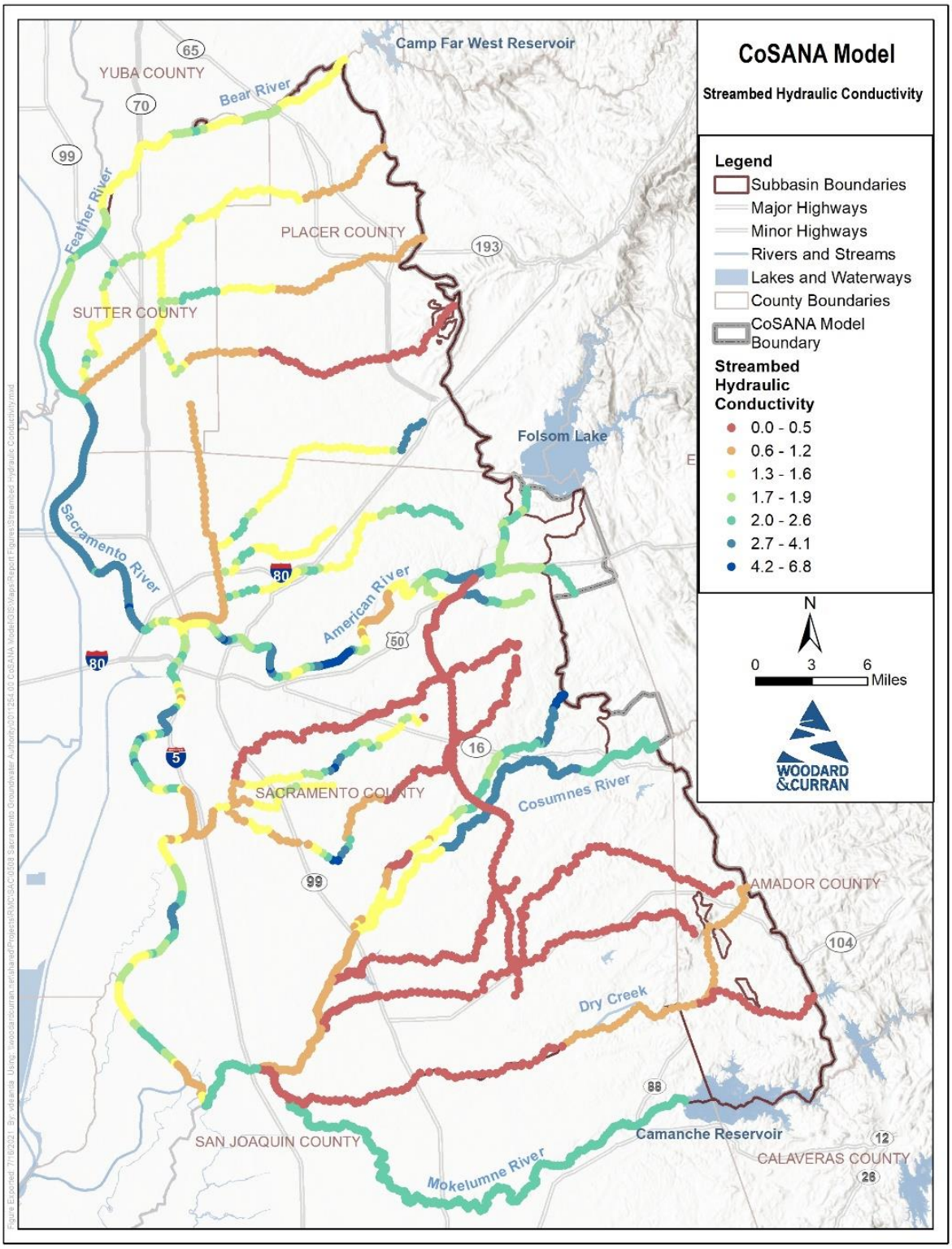


Figure 4-51: CoSANA Streambed Hydraulic Conductivity

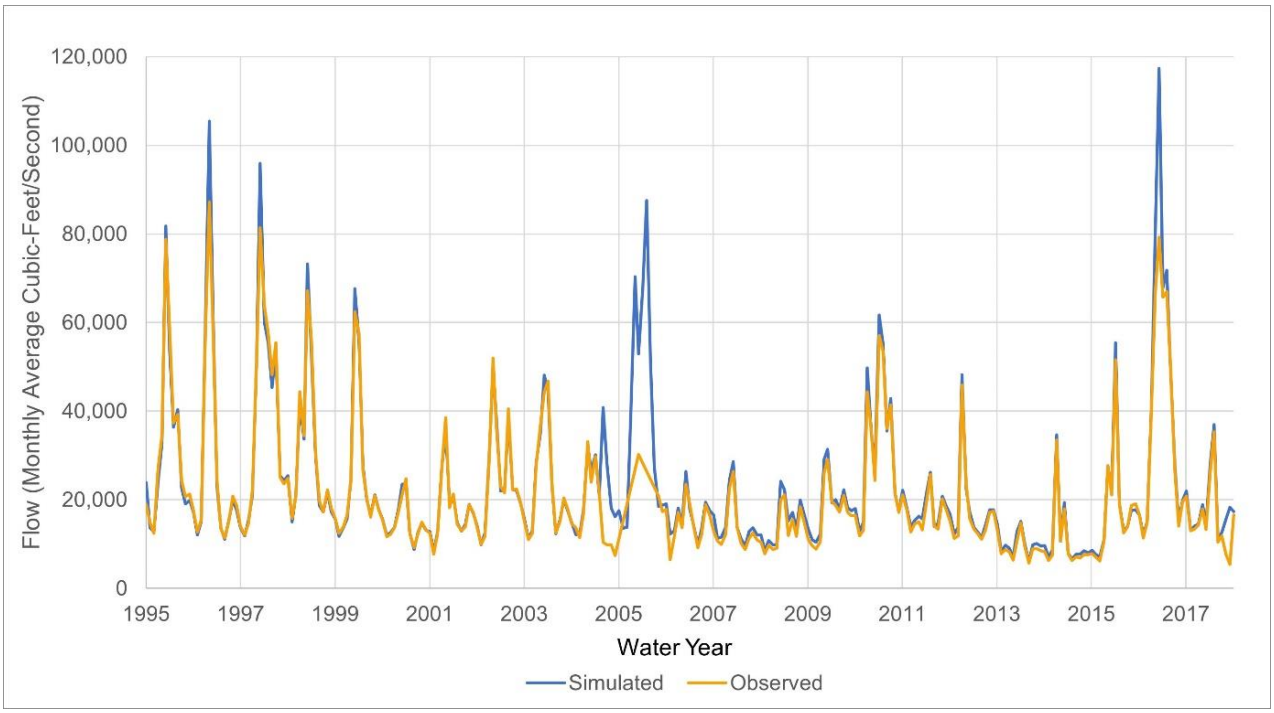


Figure 4-52: Streamflow Hydrograph for Sacramento River at Freeport, Simulated and Observed

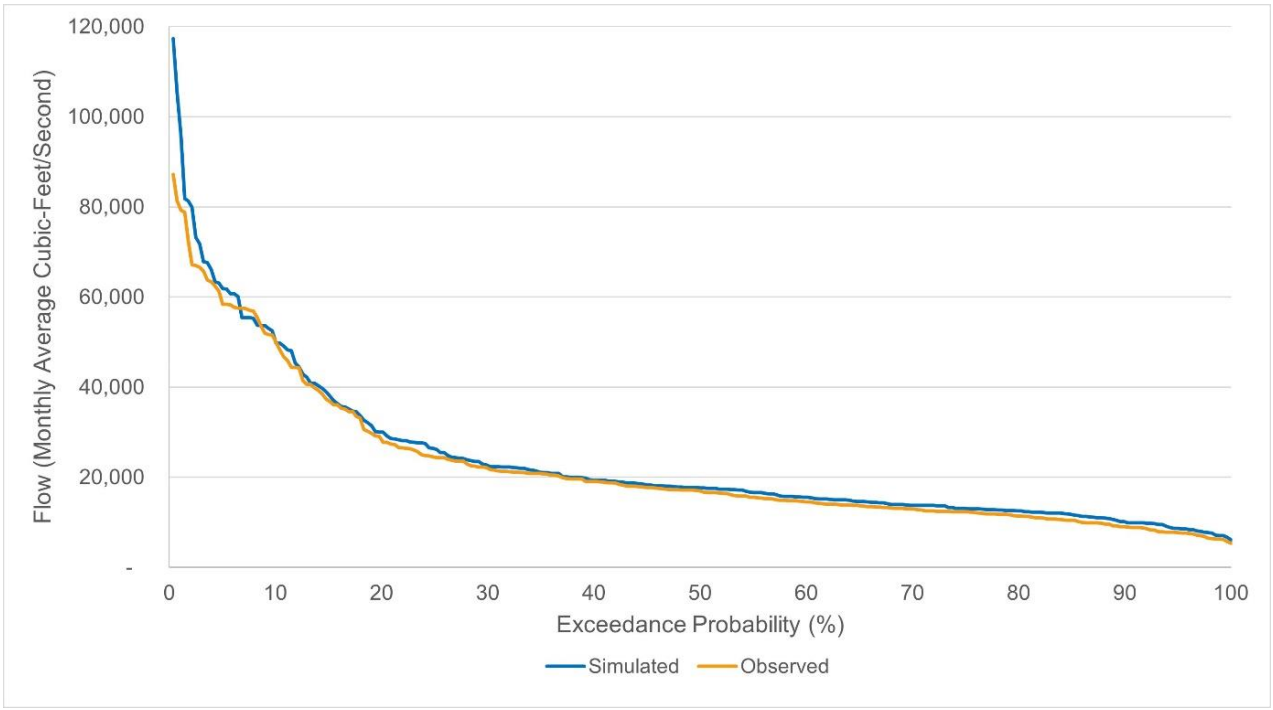


Figure 4-53: Sacramento River at Freeport Streamflow Exceedance, Simulated and Observed

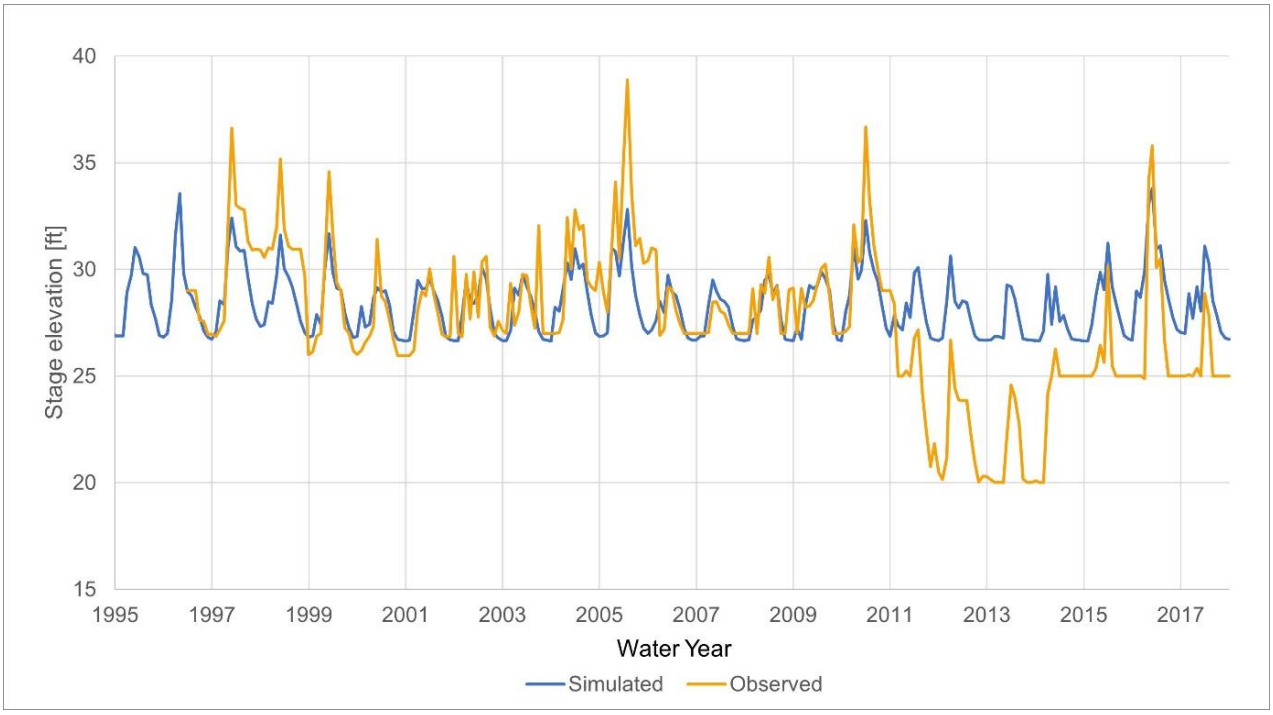
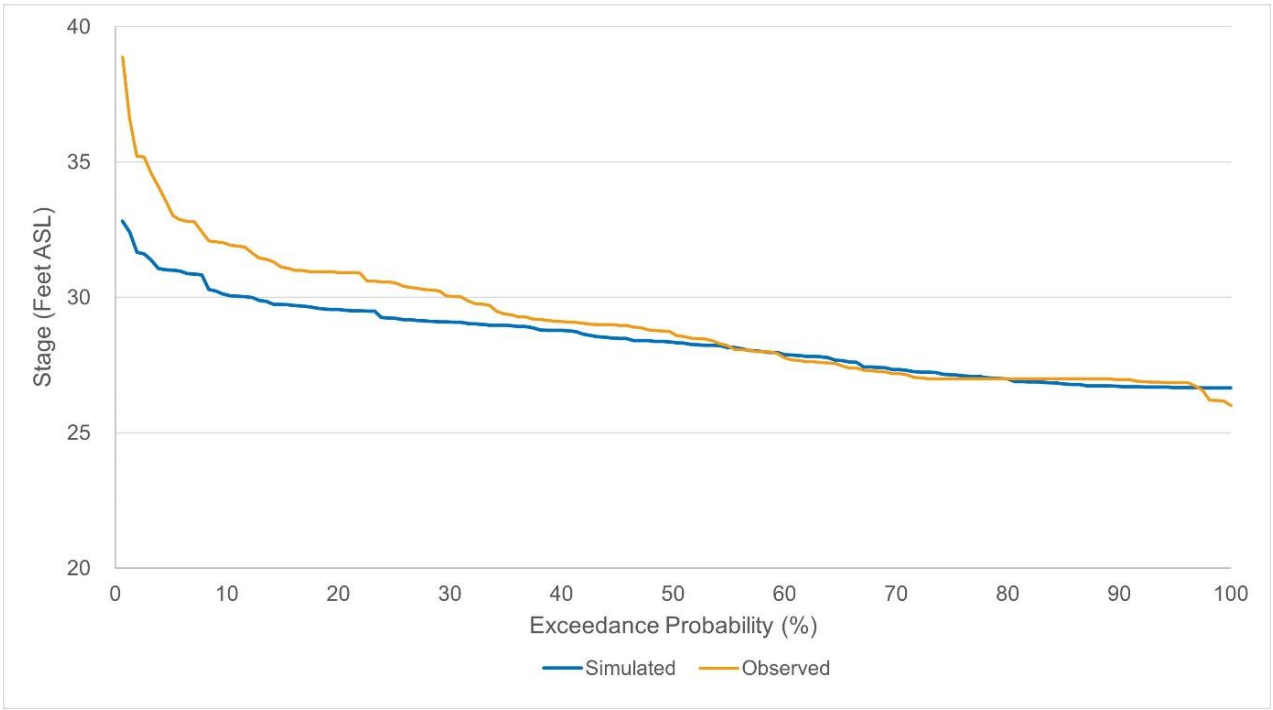


Figure 4-54: Stage for Cosumnes River at McConnell, Simulated and Observed



Note: due to apparent vertical datum issues (shown in Figure 4 53) the above exceedance chart shows data from only Mar-1997 to Sept-2010

Figure 4-55: Cosumnes River at McConnell Stage Exceedance, Simulated and Observed

4.2.4 Small Watershed Calibration

As discussed in Section 2.11, small watersheds are used to simulate inflows into the model from ungaged watersheds. The small watershed contributions are split between surface water runoff that enters the stream system, percolation that occurs during transport to the streams, and baseflow entering the groundwater system at the model boundary. Groundwater level hydrographs along the model boundary selected for groundwater level calibration (Section 4.2.2) were referenced to confirm and edit, as necessary, the various parameters of the small watersheds.

The distribution of small watershed inflows between surface runoff, percolation, and baseflow is primarily driven by the maximum recharge rate and recession coefficients. The recession coefficient governs how much of the total water enters the system as surface water and groundwater. The maximum recharge controls the percolation from runoff. Observed groundwater hydrographs along the model boundary were used to assess how much watersheds contributed to groundwater levels with a focus on seasonal fluctuations. Parameter adjustments were implemented across the small watersheds to maintain reasonable groundwater elevations and streamflows. Additionally, some small watersheds were turned off where additional data were available to characterize the inflows.

There is considerable uncertainty in subsurface conditions and nature of hydraulic interactions between the small watersheds adjacent and upslope to the Cosumnes Subbasin. Two small watersheds adjacent to Cosumnes Subbasin were set to zero area to minimize adjacent flooding of the Foothills Subarea (flooding refers the condition when model-calculated water levels exceed land surface). As Jackson Creek is controlled by Lake Amador dam, it was instead specified as a stream inflow. The Lower Sutter Creek watershed area is the next largest contributing small watershed whose surficial geology is composed of Jurassic-age bedrock, and therefore was assumed that no baseflow or subsurface percolation to groundwater occurs from this watershed. Even with these specifications, model-calculated water budgets and groundwater levels indicated additional data and model refinements are needed to improve reliability in this portion of the Cosumnes Subbasin.

4.3 Calibration Statistics and Goodness of Fit

The CoSANA calibration was primarily assessed using two metrics: groundwater level trends and the correlation between simulated and observed groundwater levels. In addition to quantifiable metrics, the CoSANA calibration included comparisons and modifications to result in regional groundwater flow directions and water budgets that are consistent with available information on observed conditions and consistent with the understanding of basin conditions by stakeholders.

Statistics related to the differences between simulated and observed groundwater levels were evaluated relative to the American Standard Testing Method (ASTM) standard. The “Standard Guide for Calibrating a Groundwater Flow Model Application” (ASTM D5981) states that “the acceptable residual should be a small fraction of the head difference between the highest and lowest heads across the site.” The residual is defined as the simulated head minus the observed head. An analysis of all calibration water levels within the model indicated the presence of a range in groundwater levels of approximately 500 feet. Using 10 percent as the small fraction, the acceptable residual level would be 50 feet. The calibration exceeds that standard, as shown by the following statistics.

- 56% of observed groundwater levels are within +/- 10 feet of its respective simulated values
- 83% of observed groundwater levels are within +/- 20 feet of its respective simulated values
- 94% of observed groundwater levels are within +/- 30 feet of its respective simulated values

The residual histogram for the CoSANA is shown in Figure 4-56. Additionally, a scatter plot of simulated versus observed values is shown in Figure 4-57.

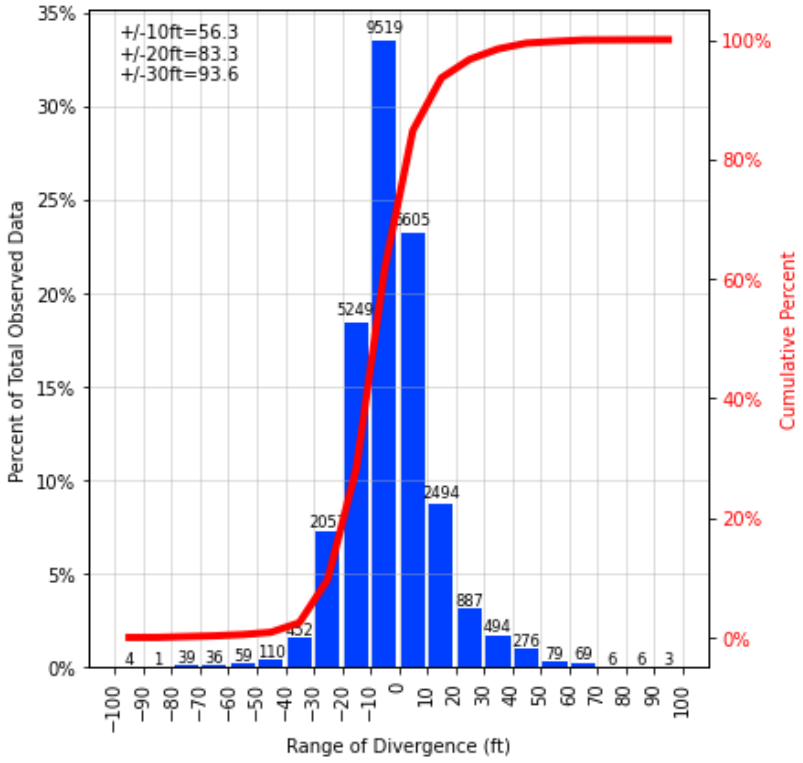
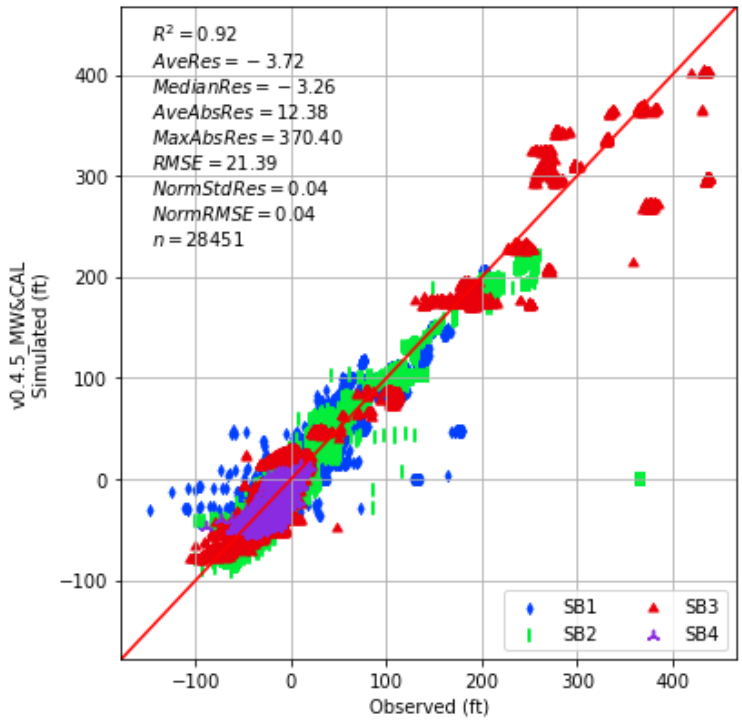


Figure 4-56: Residual histogram for the CoSANA Model



Note: SB1 = NASb, SB2 = SASb, SB3 = CoSb, SB4 = Eastern San Joaquin Subbasin

Figure 4-57: Scatter Plot of CoSANA Simulated versus Observed Values

4.4 Final Calibration Parameters

The parameters resulting from the calibration process are listed in Table 4-4. The spatial distribution of horizontal hydraulic conductivity is presented in Figure 4-58 through Figure 4-62.

Table 4-4: Range of Aquifer Parameter Values

Data		Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Horizontal Hydraulic Conductivity (ft/day)	Minimum	2.1	1.9	0.65	0.58	0.33
	Average	33.9	24.1	16.3	14.1	10.2
	Maximum	108.3	86.8	51.9	42.0	37.6
Vertical Hydraulic Conductivity (ft/day)	Minimum	0.012	0.0066	0.00045	0.0020	0.0012
	Average	0.99	0.73	0.19	0.42	0.35
	Maximum	4.6	5.2	2.0	2.6	2.3
Specific Storage (1/ft)	Minimum	2.67×10^{-6}	1.88×10^{-6}	1.54×10^{-6}	1.15×10^{-6}	9.80×10^{-6}
	Average	6.30×10^{-5}	6.40×10^{-5}	5.95×10^{-5}	6.09×10^{-5}	7.52×10^{-5}
	Maximum	4.73×10^{-4}	4.59×10^{-4}	4.68×10^{-4}	4.91×10^{-4}	4.96×10^{-4}
Specific Yield (unitless)	Minimum	0.057	0.068	0.056	0.073	0.052
	Average	0.13	0.12	0.13	0.13	0.11
	Maximum	0.24	0.22	0.24	0.24	0.22
Transmissivity (ft^2/day)	Minimum	0.64	0.067	0.077	0.25	0.23
	Average	2,765	5,128	9,679	3,489	1,726
	Maximum	15,005	24,090	69,562	17,019	11,078

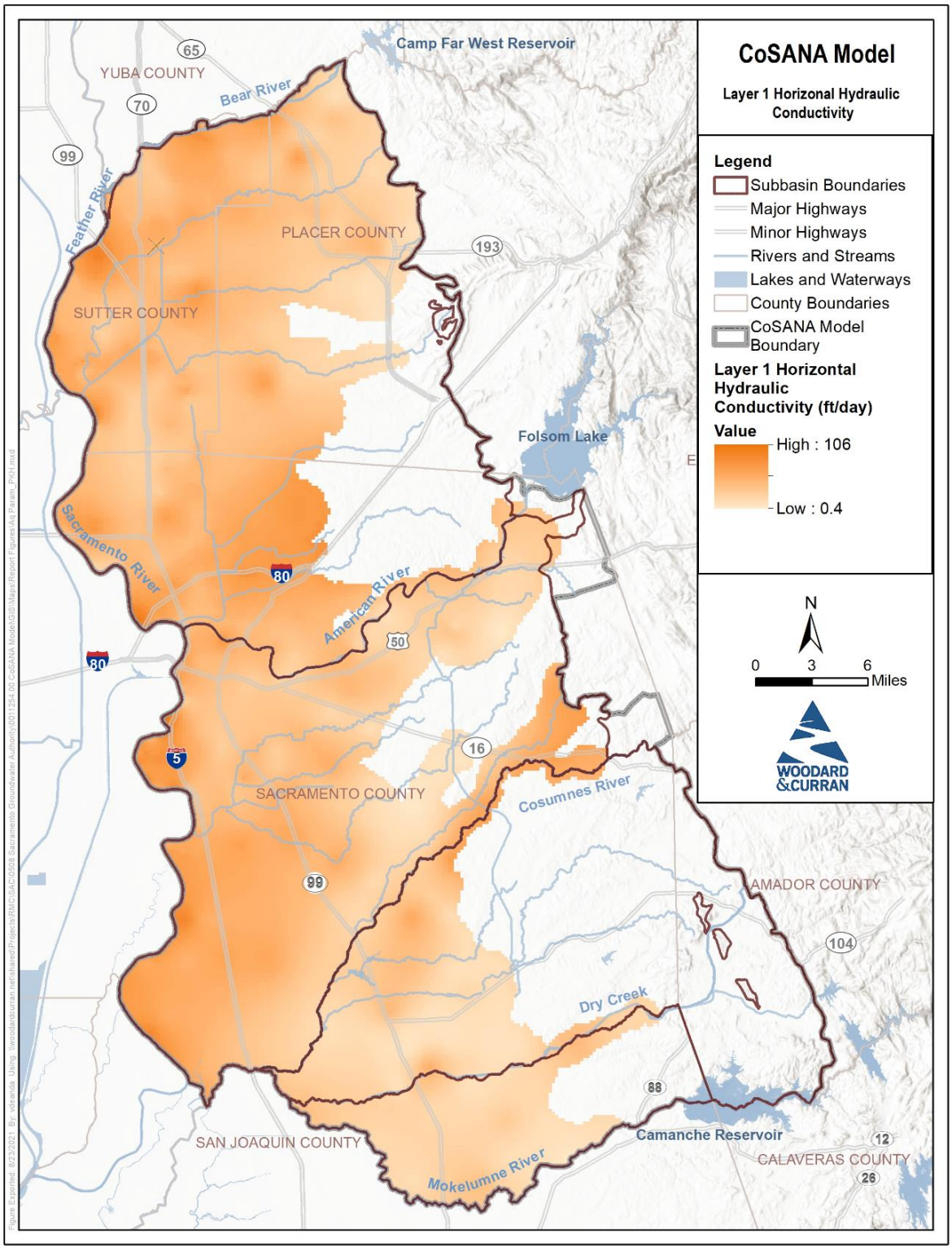


Figure 4-58: Distribution of CoSANA Layer 1 Horizontal Hydraulic Conductivity (K_H)

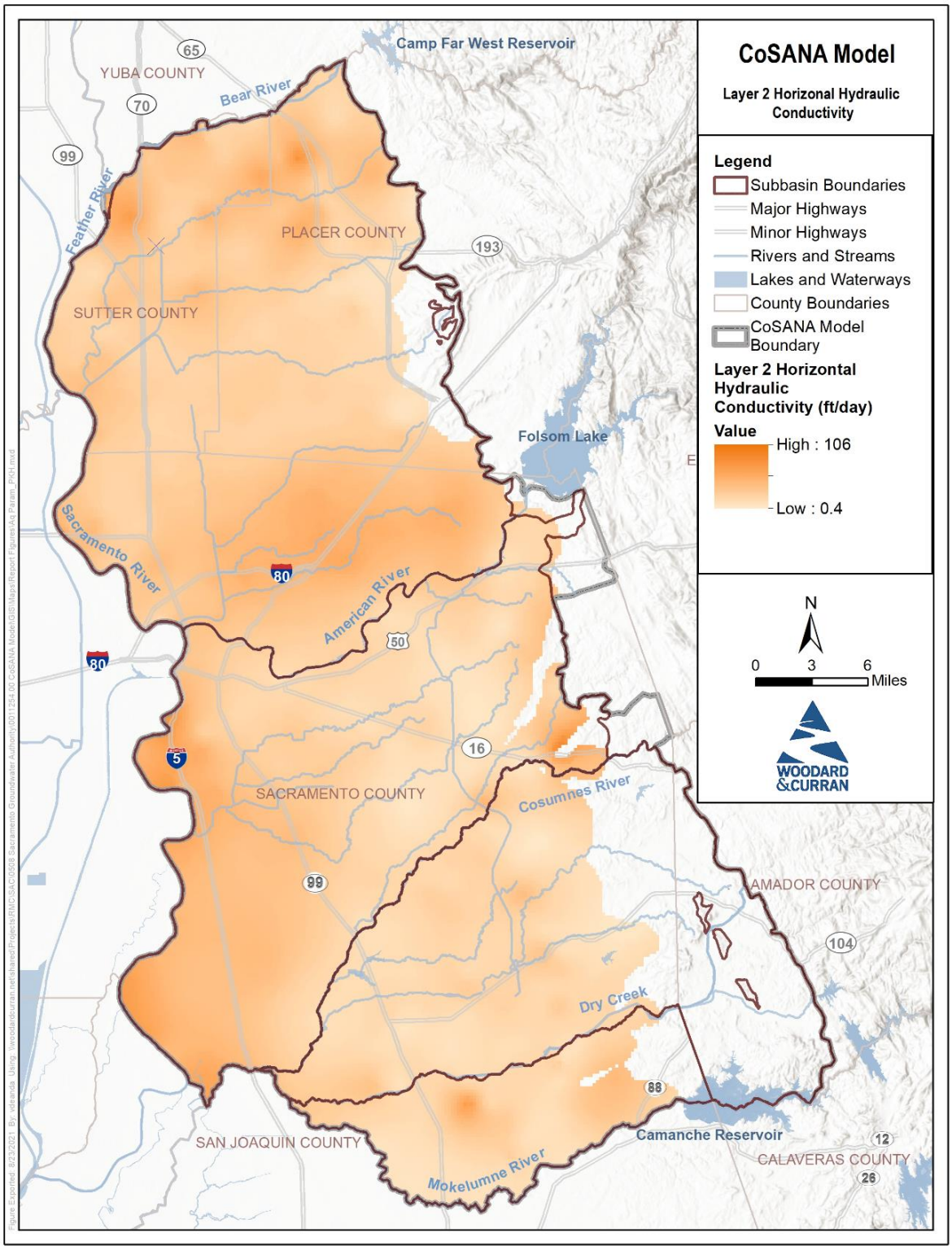


Figure 4-59: Distribution of CoSANA Layer 2 Horizontal Hydraulic Conductivity (K_H)

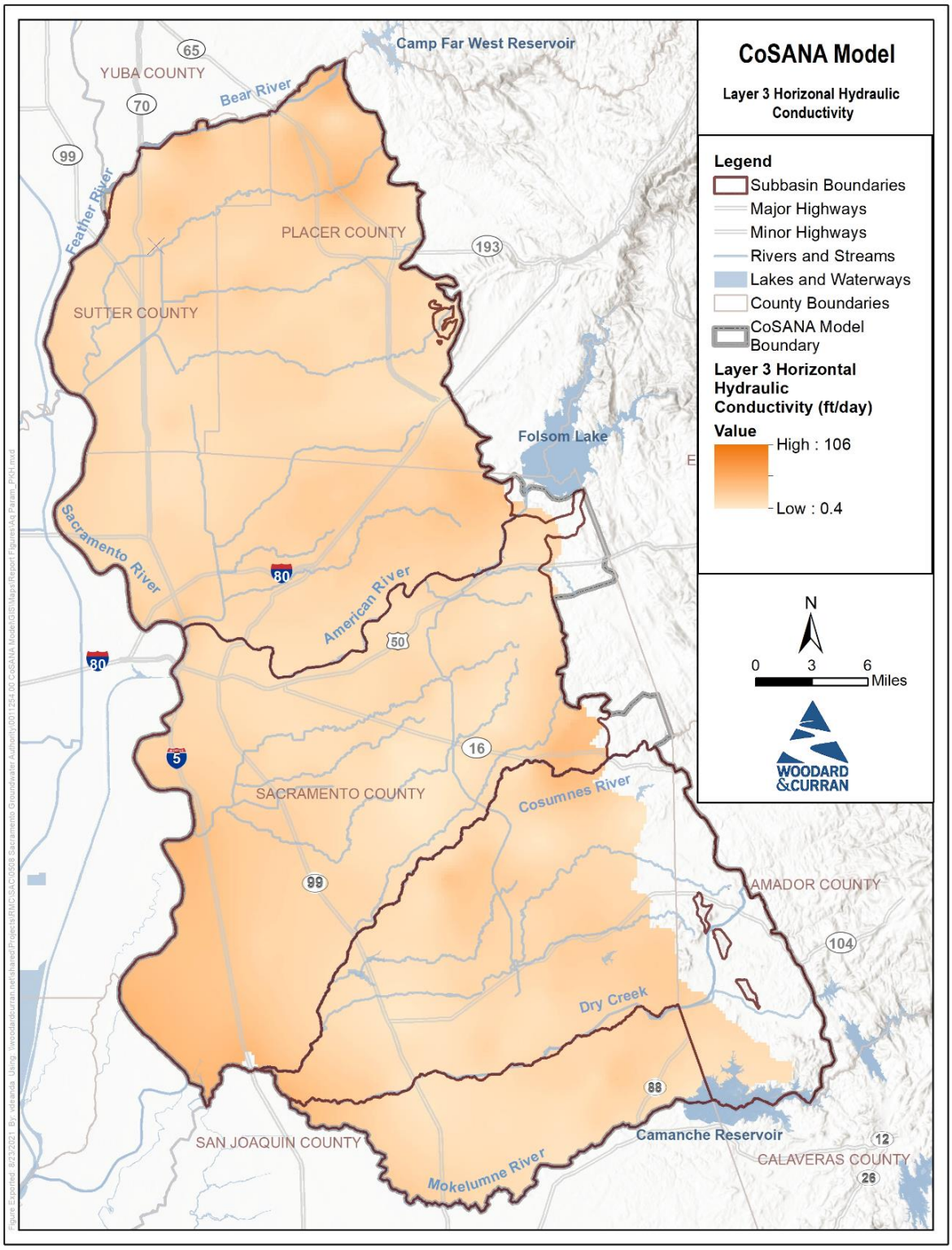


Figure 4-60: Distribution of CoSANA Layer 3 Horizontal Hydraulic Conductivity (K_H)

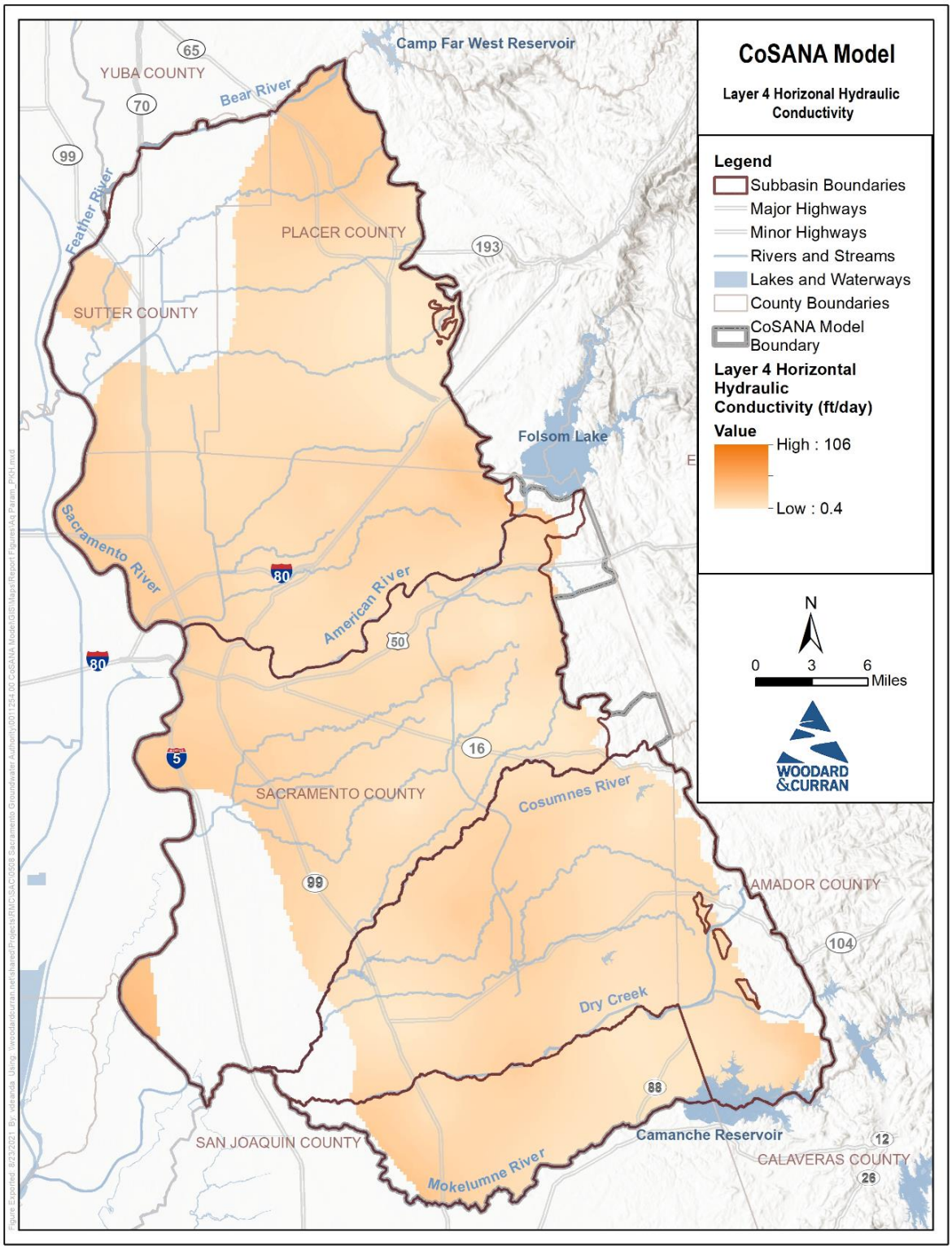


Figure 4-61: Distribution of CoSANA Layer 4 Horizontal Hydraulic Conductivity (K_H)

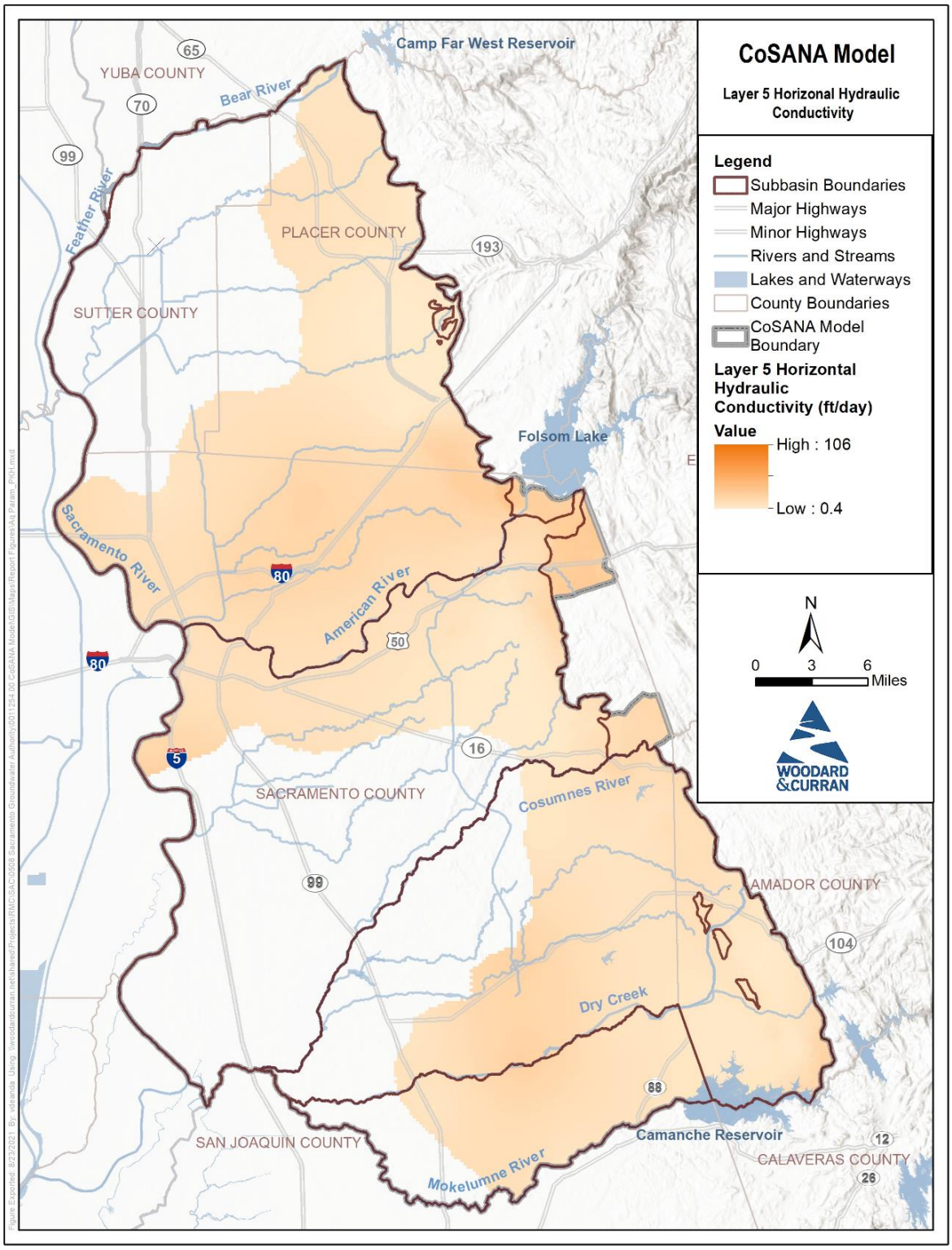


Figure 4-62: Distribution of CoSANA Layer 5 Horizontal Hydraulic Conductivity (K_H)

4.5 Model Features, Strengths, and Limitations

CoSANA has been developed based on years of integrated model development expertise and experience for the Sacramento area, including the SacIWRM and other groundwater planning and analysis efforts in the area. As such, the model data sets, conceptual representation of the groundwater system, the interaction with the surface water and land surface processes, and model calibration conditions are built on a strong foundation and reflect the experience and expertise of hydrologic and hydrogeologic conditions and modeling in the area. Having said that, the model has certain limitations that are outlined as follows:

4.5.1 Spatial Extent and Resolution

The accuracy of the model simulation is a function of spatial resolution of the data, as well as spatial discretization of the finite elements. As the spatial data such as land use or soil conditions are mapped to the elements, the size of elements reflect the accuracy of the underlying data sets as mapped. Much of the spatial data has been reviewed and verified against available statewide and local data available. The model is calibrated to target levels based on the spatial resolution in the model. However, when using the model for local scale analysis and modeling, the experienced user is encouraged to perform further validation of the underlying spatial data prior to use of the model for analysis of projects or management actions.

4.5.2 Temporal Scale

CoSANA includes monthly hydrologic data for the period WY 1970-2018. The model is calibrated for the period WY 1995-2018. Additionally, the model simulations are verified for the entirety of the period WY 1970-2018 for long-term trends and short -term seasonal conditions for groundwater levels and groundwater storage. The monthly time step is a reasonable one for a regional model and reflects the resolution of much of the recorded and reported data. However, the monthly time step at times may pose limitations for simulation of some of the model features, such as streamflows during high and peak flows. This is not of major concern as the regional model context and utilization of model for most long-term water supply planning needs is not affected by this limitation.

4.5.3 Geology and Hydrogeology

CoSANA includes an updated aquifer stratigraphy based on available maps and cross sections. CoSANA also uses the aquifer texture model used in C2VSimFG and SVSim (DWR, 2018a), which is based on the USGS aquifer texture data. The texture data is used in the model calibration and distribution of aquifer properties based on a field level set of lithologic log information. The details of the texture model affect the model performance and calibration in simulation of the various hydrogeologic conditions. The user is reminded to consider variabilities and uncertainties in the texture model as the model results are being interpreted and used for policy and planning purposes.

4.5.4 Land Use Data

Land use is one of the key data sets that affect water demand estimation as well as rainfall runoff, infiltration, and recharge conditions. This data set was developed based on numerous DWR county-level land use surveys, land use and cropping data available from the recent statewide DWR land use surveys, and local sources. This information was assembled, analyzed, and discrepancies were reconciled, which resulted in annual crop data by each model element. Mapping of land use data from various maps to element level within the model and temporal interpolation of land use changes between years of available data may introduce inaccuracies that need to be considered in evaluation of land use conditions at smaller spatial scales, such as parcel level, and for years in between dates of source data.

4.5.5 Water Demand Estimates

Water demands in the model are estimated for three user categories, urban purveyors, agricultural entities, and rural residential areas. The urban demands are based on the reported water supply and demand data from the urban purveyors. The agricultural demand estimates are based on respective model data sets and calibration of the model

for each agricultural area. While care has been given to estimation of agricultural water use estimates, and the results have been shared and reviewed by the agricultural entities within the model area, inaccuracies in the source data or those mapped to the model may introduce inaccurate estimates in certain conditions. The rural residential water use estimates have also been shared and presented to the representatives of the rural residential water users at a number of public workshops. In general, the model user is encouraged to validate the estimates with additional local data and is also requested to share their findings with the model developers for future refinements of the model.

4.5.6 Water Supply Data

The surface water delivery data set in the model is one of the most reliable data sets as it is provided by the purveyors. However, some surface water diversions by the agricultural entities are subject to more uncertainty, which affects the model simulation results. Local entities are encouraged to review the surface water delivery data and provide feedback to the model developers as issues arise or inaccuracies are identified.

4.5.7 Groundwater Pumping Estimates

CoSANA includes groundwater wells for all urban purveyors and groundwater pumping rates are, with a few exceptions, provided by the urban purveyors. The model includes estimated monthly groundwater pumping by each model element for the agricultural water use and rural residential users. Agricultural groundwater pumping is estimated as the balance of agricultural demand estimates and surface water that is available to meet the demand for each element and at each model time step. The contamination remediation groundwater extractions are based on data supplied by the entity performing the remediation and are assumed to be accurate. However, these remediation systems are complex, and some details of extraction and the fate of extracted water may be missing or inaccurate. Notably, details on individual well pumping volumes and injection volumes at Mather are not known, although overall pumping and injection volumes are incorporated into CoSANA. Where data were not available, values have been estimated for the model to the best of the model development team's knowledge.

4.5.8 Water Budgets

CoSANA provides detailed water budgets at each model element, which, when aggregated, can provide water budgets for a selected geographic area representing a subregion, subbasin, water/irrigation district, a GSA, or other geographies. The model water budgets have been verified for major model subregions against data and information available from local sources. Additionally, the subbasin-scale model water budgets have been reviewed and verified by the respective technical staff and/or representatives of the GSAs to check the accuracy and reliability of the water budgets for GSP use. When using the CoSANA for more detailed analysis, the user is encouraged to verify the water budgets for reasonableness and consistency with local data and information.

4.5.9 Groundwater Flow and Levels

CoSANA has been calibrated against long-term groundwater trends and seasonal groundwater level changes at approximately 761 wells throughout the model area. The calibration process included adjustments to model input data and/or parameters to ensure that reasonable water budgets are achieved for each model subregion, and long-term simulated groundwater levels match the observed levels within acceptable tolerances. Subsequently, an automated calibration process using PEST was performed to further refine the model calibration by adjusting the aquifer hydraulic properties throughout the model domain. The process of automated calibration also used aquifer texture data for spatial distribution of aquifer parameters. Inaccuracies in observation and reported groundwater levels may influence the quality of calibration. Further, lack of detailed well construction information in many of the calibration wells limited the ability to use data at those sites to properly calibrate the model with depth.

4.5.10 Streamflows

CoSANA simulates streamflows many rivers and streams, including the Sacramento, American, and Cosumnes Rivers. CoSANA stream budgets have been developed and reviewed for several key stream reaches, including reaches along the major river reaches. Additional care has been given to the nature of stream-aquifer interaction to allow proper representation of the stream reaches that potentially have hydraulic connection to the groundwater system, as well as reaches that are gaining or losing. In specific, published information by various non-governmental organizations, such as TNC have been used in model calibration. The quantity and quality of data on the physical nature, extent, and rate of stream-aquifer interaction is, in general, low throughout the state. The Sacramento region and the CoSANA model area is not an exception to this lack of quality data, despite improvements over the past decades. Government agencies and non-governmental organizations are encouraged to allocate additional research to this area for better representation of the nature, extent, and conditions of stream-aquifer relationship.

4.6 Modeling Uncertainties

A model is a numerical representation of physical process and inherently possesses uncertainties that affect the calibration, performance, and results of the model. Integrated hydrologic models are complex models that involve simulation of complex physical systems and interrelationships and require many different types of data, each of which may be available at different temporal and spatial scales. Uncertainties in the performance of an integrated hydrologic model can arise from uncertainties in how the physical processes are conceptualized and formulated, inaccuracies in the underlying data, calibration process and eventually the assumptions used in applications of the model to evaluate projects, including projections of future conditions. The following are additional details on each of these uncertainty categories.

4.6.1 Structural Uncertainties

First set of model uncertainties can arise due to the structural framework of the model, which can include:

- Representation of Physical Features- In order to properly represent natural conditions, the physical and natural features need to be well understood so that they can be conceptualized in a simplified manner for development of theoretical formulations.
- Theoretical Concepts and Representation of the Natural and Physical Systems- This type of uncertainty can be attributed to the conceptualization of the physical and natural systems in the form of mathematical functions and formulas that govern the movement of groundwater and surface water systems and the interrelation of these systems. These formulas are typically referred to as governing equations for each of the hydrologic or hydrogeologic features modeled.
- Formulation, Code Development, Solution Techniques, and Assumptions- The governing equations are typically so complex that analytical solutions to these equations are either not available or are so simplified that they would add to the inaccuracies in the representation of complex hydrologic systems. Therefore, numerical solutions are employed, including finite element or finite difference techniques, which require their own set of assumptions. Computer software is used to implement the theoretical formulations.
- Model Spatial and Temporal Resolution- The governing equations representing the natural and/or physical systems are either solved at two levels:
    - Lumped solution- At this level, the formulation represents a lumped parameter system, and the solution will be for an aggregated system at the large scale. This aggregated and lumped scale can be both for the spatial and temporal scale of the problem. Lumped level solutions are typically employed in conditions where there is a lack of accurate information or where the system is small enough that further spatial or temporal breakdown of the system is not possible due to lack of data and information.

- Distributed Solution- At this level, the system is subdivided in further spatial resolution to take advantage of spatial variability in the data and information that is available at smaller scales. Additionally, the solution to the formulation of the system is also subdivided in smaller temporal scales, such as a monthly or daily time step, so that short-term and long-term variability in the data over time is properly represented in the solution.

4.6.2 Data Uncertainties

This category of uncertainty is related to the data and information that is used and employed in development of a model.

- Data and Information Accuracy, Data Gaps, and Estimates- Collection and compilation of data for natural and physical systems, including precipitation, streamflow, land use, cropping patterns, population, water use, crop evapotranspiration, soil conditions, groundwater levels, streamflow, surface water use, groundwater pumping, infrastructure, facilities, and operations all include a certain level of inaccuracy and uncertainty. This uncertainty is exacerbated when data gaps and inconsistencies exist. The methodology used to identify and fill data gaps can introduce levels of uncertainty.
- Data Spatial and Temporal Resolution- In addition to the above, the spatial and temporal resolution of data may contain inaccuracies and uncertainties that would affect the data that are used in the model.

4.6.3 Calibration Uncertainties

- Estimates of Hydrologic and Hydrogeologic Parameters- Often, data and/or information for specific parameters that are used to represent the governing equations in the model may not be available. In these circumstances, the modeler uses professional judgement, or adopts conditions from similar areas, which may introduce uncertainties and inaccuracies in model simulations.
- Calibration Approach, Target Characteristics, and Accuracy- Model calibration requires certain quality, consistency, and care, so that the model properly represents the natural and physical conditions observed in the field. In addition to the quality and uncertainties in data and methodologies, the approach employed, tools and techniques used, and experience and expertise of the model developer affects the quality of model calibration and accuracy of the results. Often, the calibration targets are prone to uncertainty or lack of information. For example, information on the depth of the screened interval, as well as pumping rate and depth at the well, whether the recorded groundwater level reflects static or pumping conditions, and whether a well is under the influence from other nearby wells or a nearby stream can have significant bearing on the approach and quality of the calibration.

4.6.4 Application Uncertainties

- Assumptions and Project Applications, Including Data Projections and Forecasting Methods- It is imperative that model application be defined and considered in such a way that is supported by model calibration. Assumptions on a model application to analyze a particular project can often be generalized with little knowledge of the conditions. For example, significant uncertainties exist with respect to the following data, which can affect the quality and results of the model output for planning and policy making:
  - Hydrologic conditions and rainfall patterns
  - Land use and cropping patterns
  - Population and water use
  - Water supply conditions
  - Climate change conditions

While modeling uncertainties need to be considered in use and application of models for evaluation of project conditions for potential impacts, benefits, and design of plans and facilities, the model should be considered a reasonably robust tool to support the major decisions, including GSPs, projects and management actions, and sustainability analysis.

4.7 Sensitivity Analysis

Sensitivity analysis is a way of investigating how sensitive certain model results are to changes in certain model parameters. A sensitive parameter is when the simulation results are greatly affected by changes in that parameter within its valid range. Conversely, an insensitive parameter means the changes in that parameter within its valid range do not affect the simulation results greatly.

Model parameters that are sensitive can be the largest sources of error and uncertainty when not precisely measured and well understood. For this reason, sensitivity analysis is an important step of the model calibration process. The sensitivity analysis serves the following purposes:

- To improve the understanding of input-output relationships
- To quantify the impact of inaccuracies in model parameters
- To evaluate the stability and robustness of the model
- To understand the overall range of accuracy of the model results

For these purposes, the following set of calibration parameters were selected for investigation under CoSANA Model sensitivity analysis:

- Aquifer horizontal hydraulic conductivity (PKH) changed globally by factors of 0.5, 0.67, 1.5, 2.0
- Aquifer vertical hydraulic conductivity (PL) changed globally by factors of 0.5, 0.67, 1.5, 2.0
- Specific yield (PN) changed globally by factors of 0.8, 1.2
- Specific storage (PS) changed globally by factors of 0.1, 0.2, 5, 10
- Streambed conductivity (CSTRM) changed globally by factors of 0.2, 0.5, 2.0, 5.0
- Small watersheds curve number (CNS) changed globally by -10, -5, 5, 10
- General head boundary condition head time series (BHTS) changed globally by -10, 10 feet

4.7.1 Metrics of the Sensitivity Analysis

In the process of evaluating the sensitivity of model results to certain parameter changes, the results from the sensitivity runs were analyzed for the NASb, SASb, and CoSb and compared to the calibrated model in terms of the groundwater residual statistics.

The changes to the input parameters for sensitivity analysis were made globally. Therefore, the changes in the model performance should be considered on a global scale. An improvement in the model performance based on changes in one parameter at a global scale does not necessarily mean improvements in the overall model performance and/or calibration, as the model is calibrated to a number of target parameters, only some of which may be included in the performance assessment during the sensitivity analysis. The residual statistics for this sensitivity analysis was used as the performance indicator.

4.7.2 Results of the Sensitivity Analysis

Figure 4-63, Figure 4-64, and Figure 4-65 present the relative change in the three groundwater level residual statistics used in the evaluation of model calibration performance for 10 sensitive parameters in NASb, SASb, and CoSb respectively. These three statistics are:

- Root mean square error (RMSE): This statistic is a measure of how spread out the residuals are.
- Average residual: This statistic measures how inaccurate simulation results are with respect to the corresponding observations on average.

- Correlation coefficient (R2): This statistic is a measure of the strength of the linear relationship between the simulated and observed pairs.

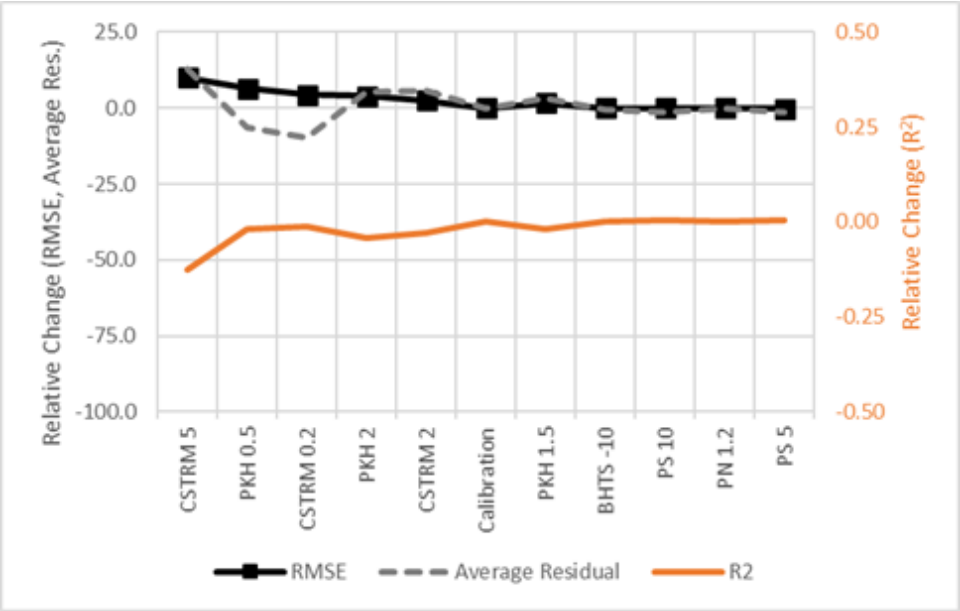


Figure 4-63: Sensitivity of Groundwater Level Residual Statistics in NASb

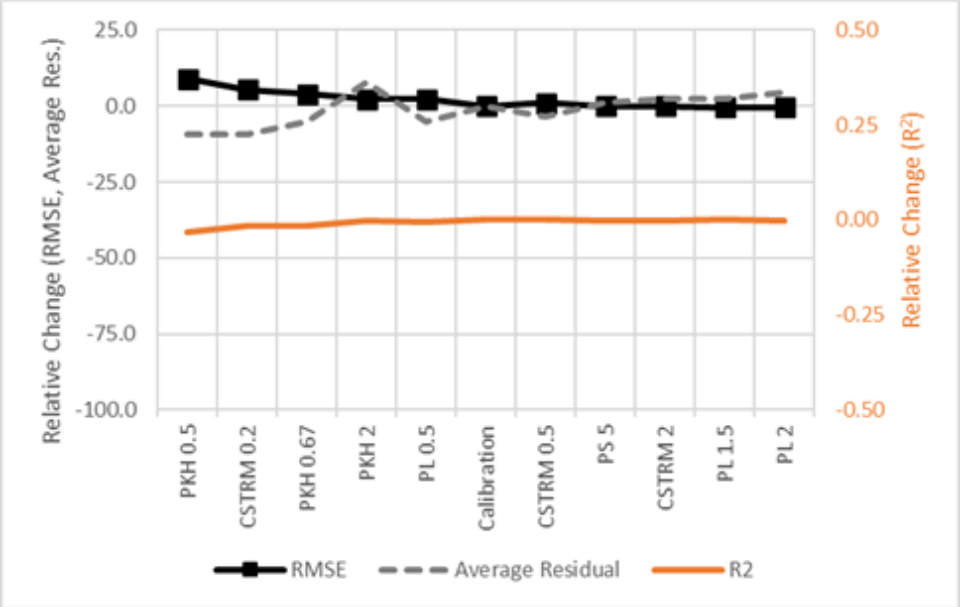


Figure 4-64: Sensitivity of Groundwater Level Residual Statistics in SASb

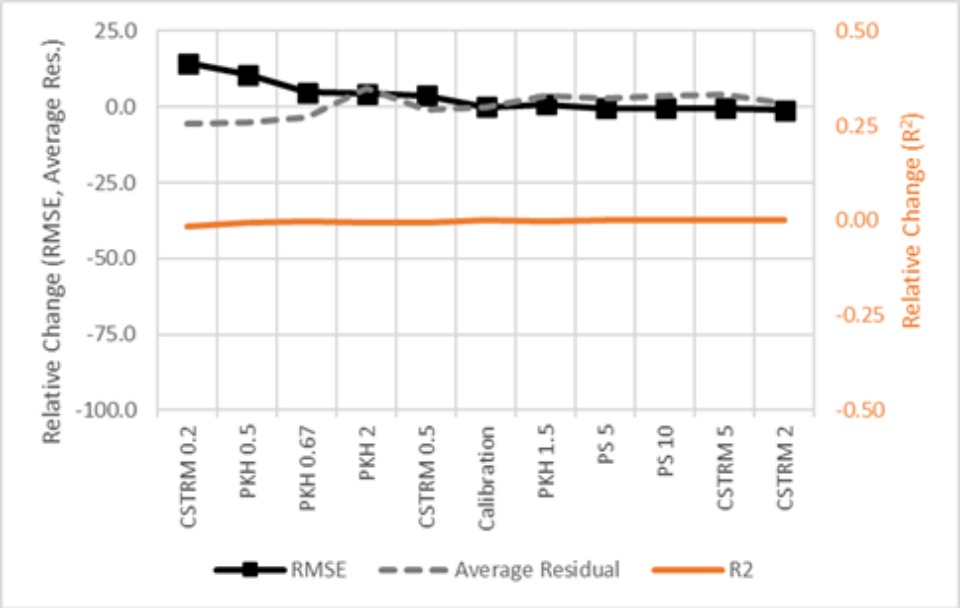


Figure 4-65: Sensitivity of Groundwater Level Residual Statistics in CoSb

None of the sensitivity runs resulted in a significant improvement in these statistics for any of the subbasins. This means that the model is stable and that the calibration is at or near an optimal point when global parameter changes are considered.

5. BASELINE CONDITIONS

Integrated hydrologic and water resources models are used to evaluate effects, benefits, and impacts of particular projects and management actions under a set of baseline conditions. These baseline conditions can represent a set of pre-established hydrologic, land and water use, water demand, water supply, and basin operational conditions. As part of the development of the GSPs for the NASb, SASb, and CoSb, three sets of baseline conditions have been defined for the CoSANA model. These represent the current, projected, and projected under climate change baseline conditions.

Following are descriptions of the assumptions and results for each of these baseline scenarios.

5.1 Current Conditions Baseline

The CoSANA Current Conditions Baseline (CCBL) is a representation of long-term average conditions assuming that a recent level of development and water demand persists over a long-term period of hydrologic conditions. Initial groundwater levels and soil conditions in the CCBL represent those at the end of the simulation period of the historical CoSANA (representing September 30, 2018).

5.1.1 Hydrology

The CCBL uses a 50-year historical hydrology from water years (WY) 1970 through 2019 (October 1, 1969 through September 30, 2019) for precipitation, evapotranspiration, and streamflow.

5.1.1.1 Precipitation

Precipitation in the historical simulation, discussed in Section 2.6, uses the PRISM database for the entire period of record. The precipitation used in the historical simulation was extended through WY 2019 for use in the CCBL. The average CCBL precipitation across the entire model area is 20.2 inches, with a minimum of 7.5 inches in WY 1977 and a maximum of 38.9 inches in WY 1983.

Figure 5-1 graphically illustrates the cumulative departure of the spatially averaged rainfall within the CoSANA model area. The figure includes bars displaying annual precipitation for each water year from WY 1970 through 2019 and a horizontal line representing the long-term mean precipitation of 20.2 inches. The cumulative departure from mean precipitation is displayed as a line that highlights wet periods with upward slopes (positive departure) and dry periods with downward slopes (negative departure). More severe events are shown by steeper slopes and greater changes.

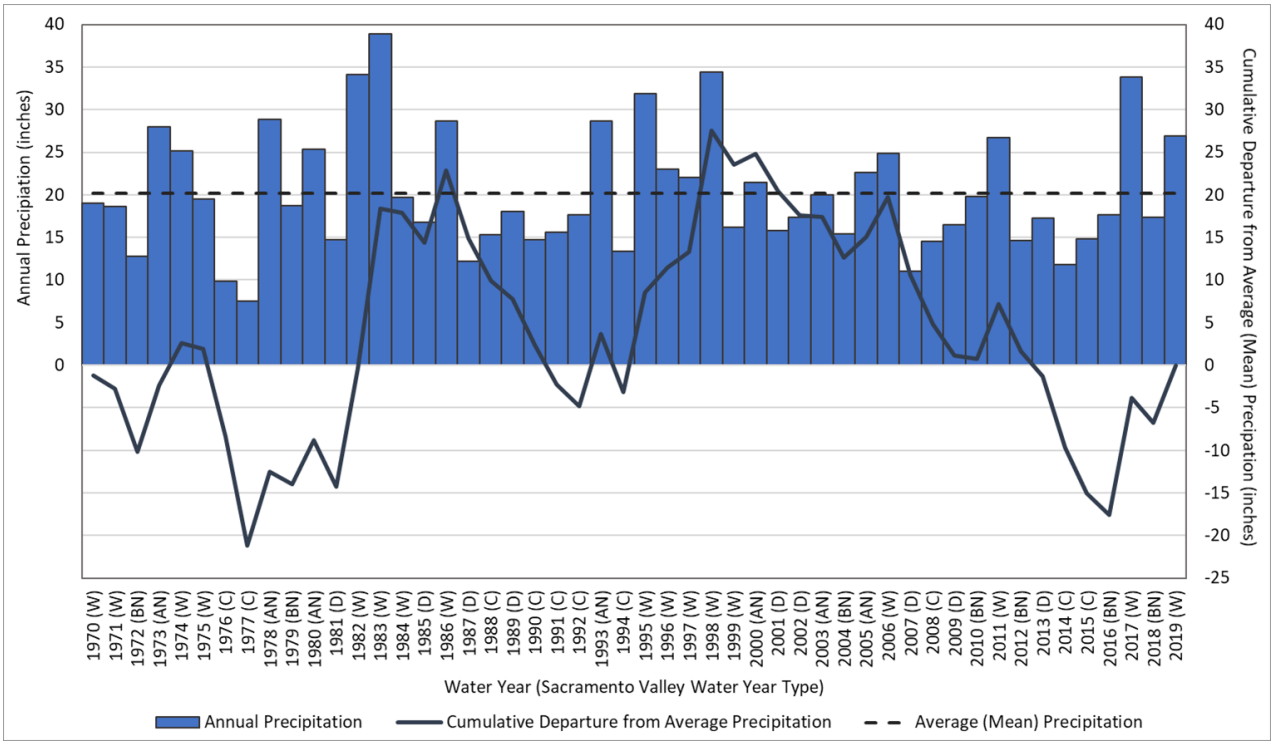


Figure 5-1: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation

5.1.1.2 Evapotranspiration

As discussed in Section 2.8, the crop ET requirement was based on values from regional modeling (C2VSimFG) and associated CIMIS Zones 12 and 14. The ET used in the historical simulation was extended through WY 2019 for use in the CCBL.

5.1.1.3 Stream Inflow

As discussed in Section 2.4, stream inflows are from stream gaging stations at the upstream area of CoSANA river reaches. The stream inflow points and gaging stations are described in Section 2.4 and listed in Table 2-4. As the CCBL uses the historical hydrologic conditions as the basis for planning the baseline conditions, the stream inflows used in the historical simulation were extended through WY 2019 for use in the CCBL.

5.1.1.4 Hydrologic Year Types

The 50 years of the CCBL, from WY 1970 through 2019, represent a range of hydrologic conditions, as identified by the water year types in the Sacramento Valley Water Year Hydrologic Classification, which classifies water years 1901 through 2020 as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), and Critical (C) based on inflows to major reservoirs or lakes. A description of how this index is calculated and the specific data used to calculate this index is available online from CDEC at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST. In the 50 years of hydrology used in the CCBL, there are 10 Critical years, 9 Dry years, 7 Below Normal years, 7 Above Normal years, and 17 Wet years.

To facilitate assumptions for baseline water supplies and demands, these five water year types were simplified into three water year types. Critical and Dry years are combined into one category in the baseline water year types (called Dry years), Above Normal and Below Normal years are also combined into one category (Normal years), and Wet years remain in one category (called Wet years). With this breakdown, the three baseline water year types have a

distribution of 19 Dry years, 14 Normal years, and 17 Wet years. These baseline water year types (Table 5-1) are used in the remainder of the CCBL data development and results discussion.

Table 5-1: Hydrologic Water Year Types

Baseline Year	Water Year	Sacramento Valley Water Year Hydrologic Classification	Baseline Year Type		Baseline Year	Water Year	Sacramento Valley Water Year Hydrologic Classification	Baseline Year Type
1	1970	Wet	Wet		26	1995	Wet	Wet
2	1971	Wet	Wet		27	1996	Wet	Wet
3	1972	Below Normal	Normal		28	1997	Wet	Wet
4	1973	Above Normal	Normal		29	1998	Wet	Wet
5	1974	Wet	Wet		30	1999	Wet	Wet
6	1975	Wet	Wet		31	2000	Above Normal	Normal
7	1976	Critical	Dry		32	2001	Dry	Dry
8	1977	Critical	Dry		33	2002	Dry	Dry
9	1978	Above Normal	Normal		34	2003	Above Normal	Normal
10	1979	Below Normal	Normal		35	2004	Below Normal	Normal
11	1980	Above Normal	Normal		36	2005	Above Normal	Normal
12	1981	Dry	Dry		37	2006	Wet	Wet
13	1982	Wet	Wet		38	2007	Dry	Dry
14	1983	Wet	Wet		39	2008	Critical	Dry
15	1984	Wet	Wet		40	2009	Dry	Dry
16	1985	Dry	Dry		41	2010	Below Normal	Normal
17	1986	Wet	Wet		42	2011	Wet	Wet
18	1987	Dry	Dry		43	2012	Below Normal	Normal
19	1988	Critical	Dry		44	2013	Dry	Dry
20	1989	Dry	Dry		45	2014	Critical	Dry
21	1990	Critical	Dry		46	2015	Critical	Dry
22	1991	Critical	Dry		47	2016	Below Normal	Normal
23	1992	Critical	Dry		48	2017	Wet	Wet
24	1993	Above Normal	Normal		49	2018	Below Normal	Normal
25	1994	Critical	Dry		50	2019	Wet	Wet

5.1.2 Initial Conditions

The initial conditions for the 50-year CCBL are defined as the groundwater, surface water, and hydrologic conditions for the end of WY 2018 from the end of simulation of the CoSANA historical model. Figure 5-2 shows a map of initial groundwater levels used in the CCBL. The initial conditions for the CCBL are also used for other baseline models.

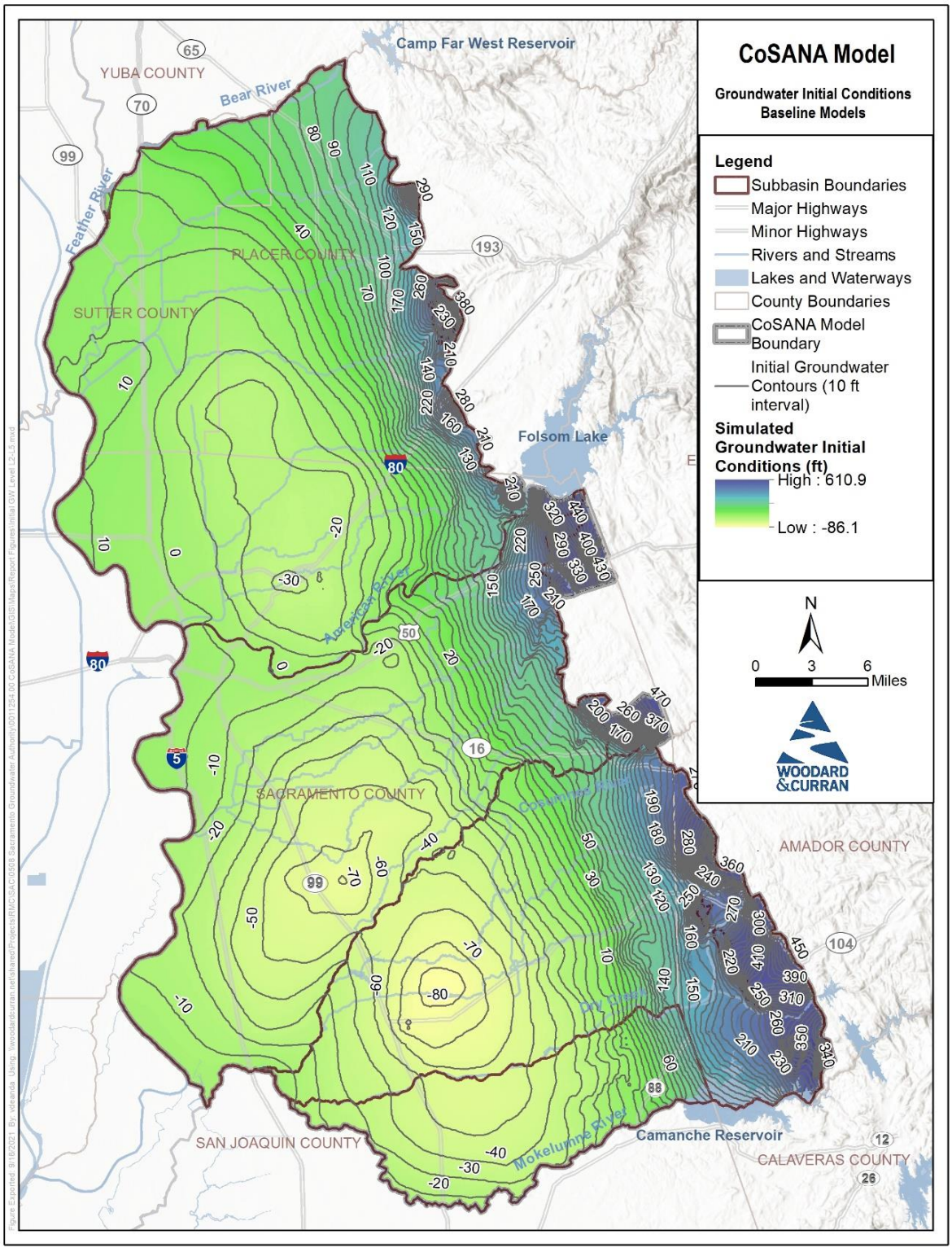


Figure 5-2: Initial Groundwater Levels for CoSANA Baseline Models

5.1.3 Boundary Conditions

CCBL boundary conditions are based on an average for each baseline water year type (normal, wet, and dry) during the last 10 years of the historical simulation (WY 2009-2018). This averaging is applied to the constrained head boundary conditions that represent Lake Camanche in the southeast corner of the model, and the general head boundary conditions that represent groundwater levels to the north, south, and west of the model boundary. Water year type averaging is not applied to the small watersheds form the eastern boundary of the model, as these are driven by hydrology (precipitation and evapotranspiration.) Further detail of how boundary conditions are applied in CoSANA are provided in Section 2.12.

5.1.4 Land Use

The CCBL used the land use from the last year of the historical simulation, discussed in Section 2.7. The last year of the historical simulation represents the digital land use coverage developed to represent 2015 (see Figures 15-21). As also described in Section 2.7, certain lands regarded as temporarily fallowed due to drought were represented as their typical land use for purposes of historical interpolation and for purposes of the CCBL. Minor changes to specified land use conditions were made to account for recent changes. Land use in Sutter County and Placer County was updated to incorporate recent conversions of rice fields to orchards. In the Cosumnes Subbasin, the land use was updated to incorporate recent conversion of vineyards or pasture to almonds and native land to agricultural and urban uses. A spatial representation of the CCBL land use is shown in Figure 5-3. The time-series of land use for the CoSANA CCBL is shown in Figure 5-4, highlighting the constant nature of land and water use in the baseline conditions. Figure 5-5 through Figure 5-7 show time-series of land use for the NASb, SASb, and CoSb, respectively.

.

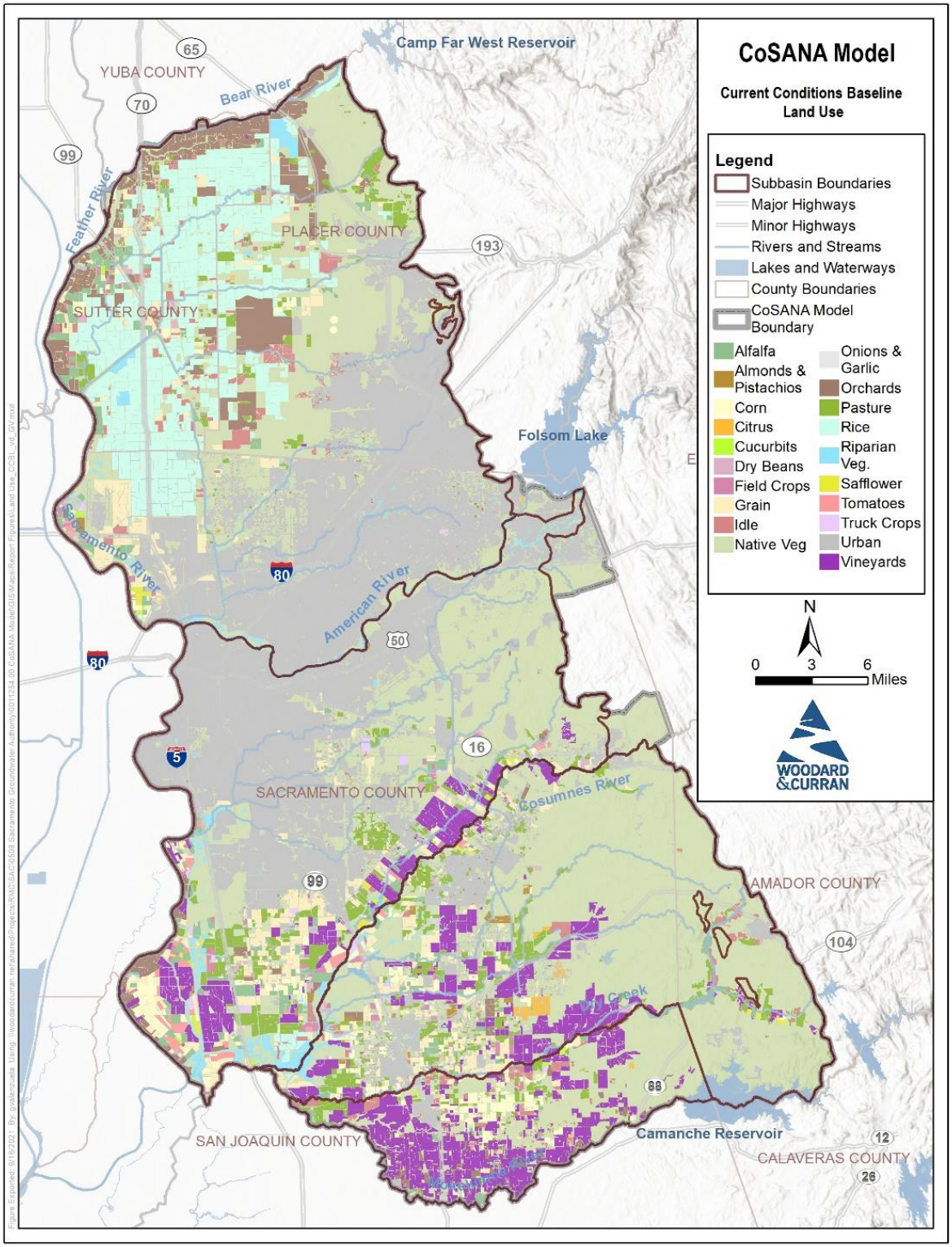


Figure 5-3: Current Conditions Baseline Land Use

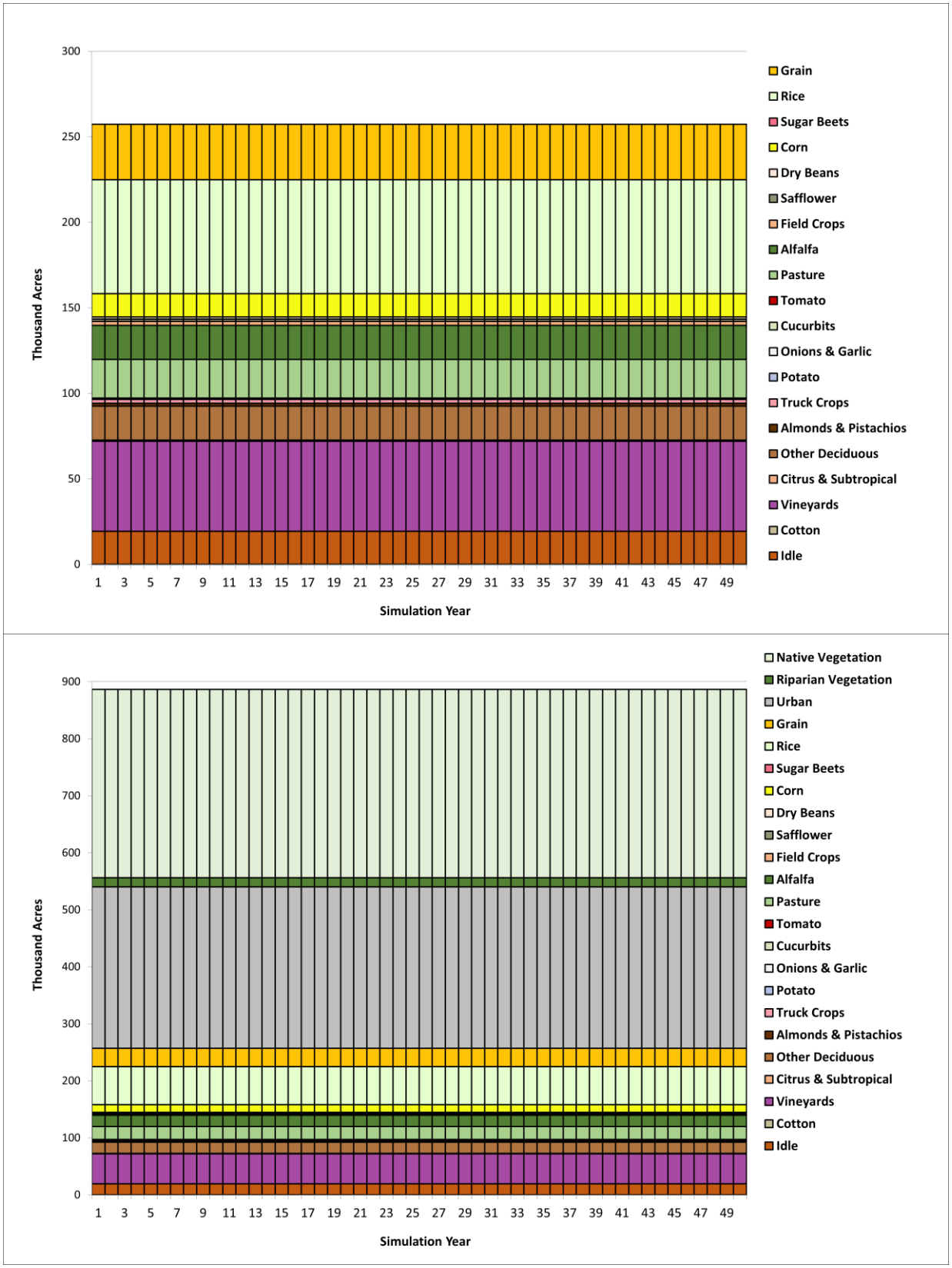


Figure 5-4: Current Conditions Baseline Land Use for CoSANA

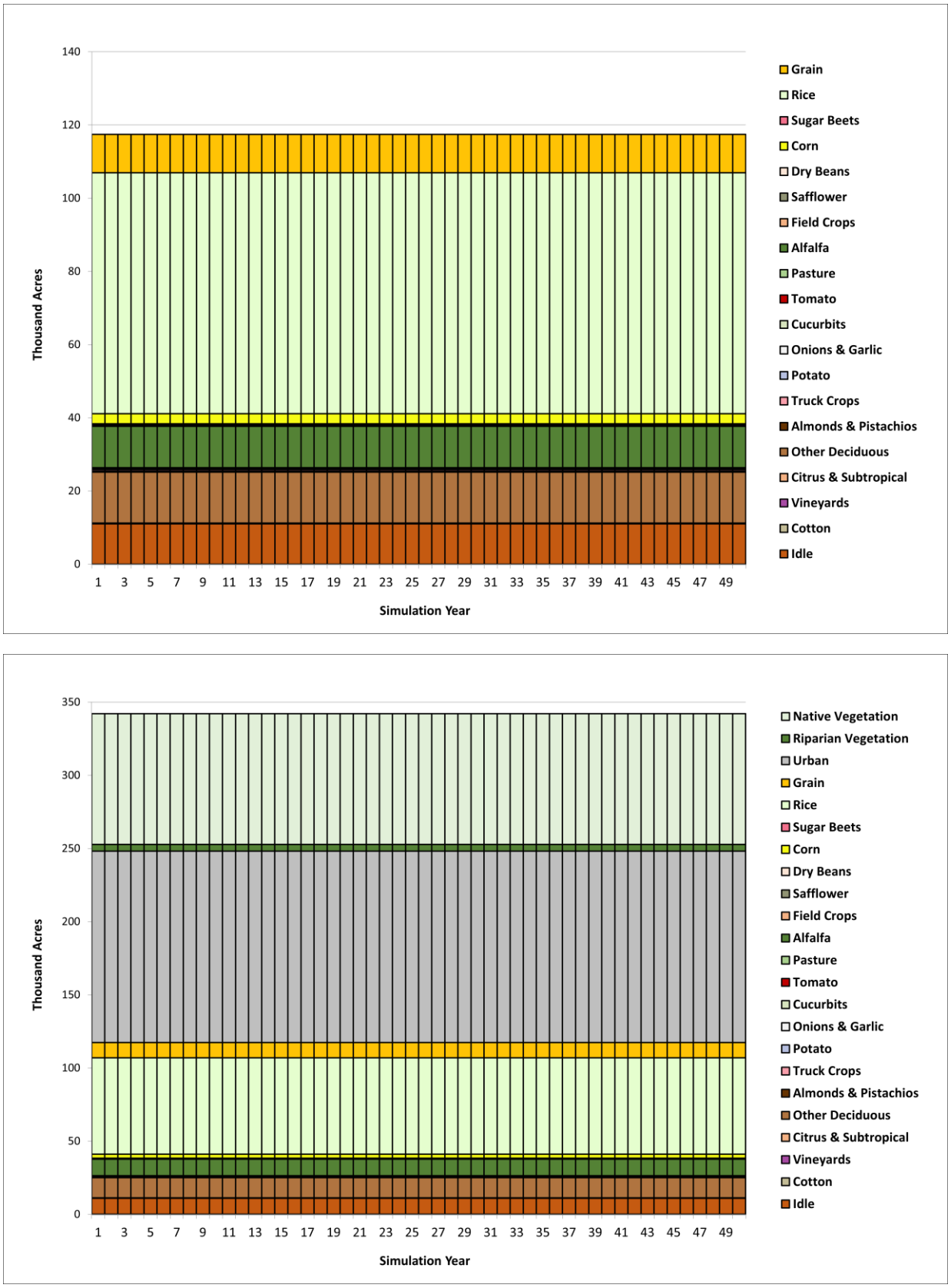


Figure 5-5: Current Conditions Baseline Land Use for North American Subbasin

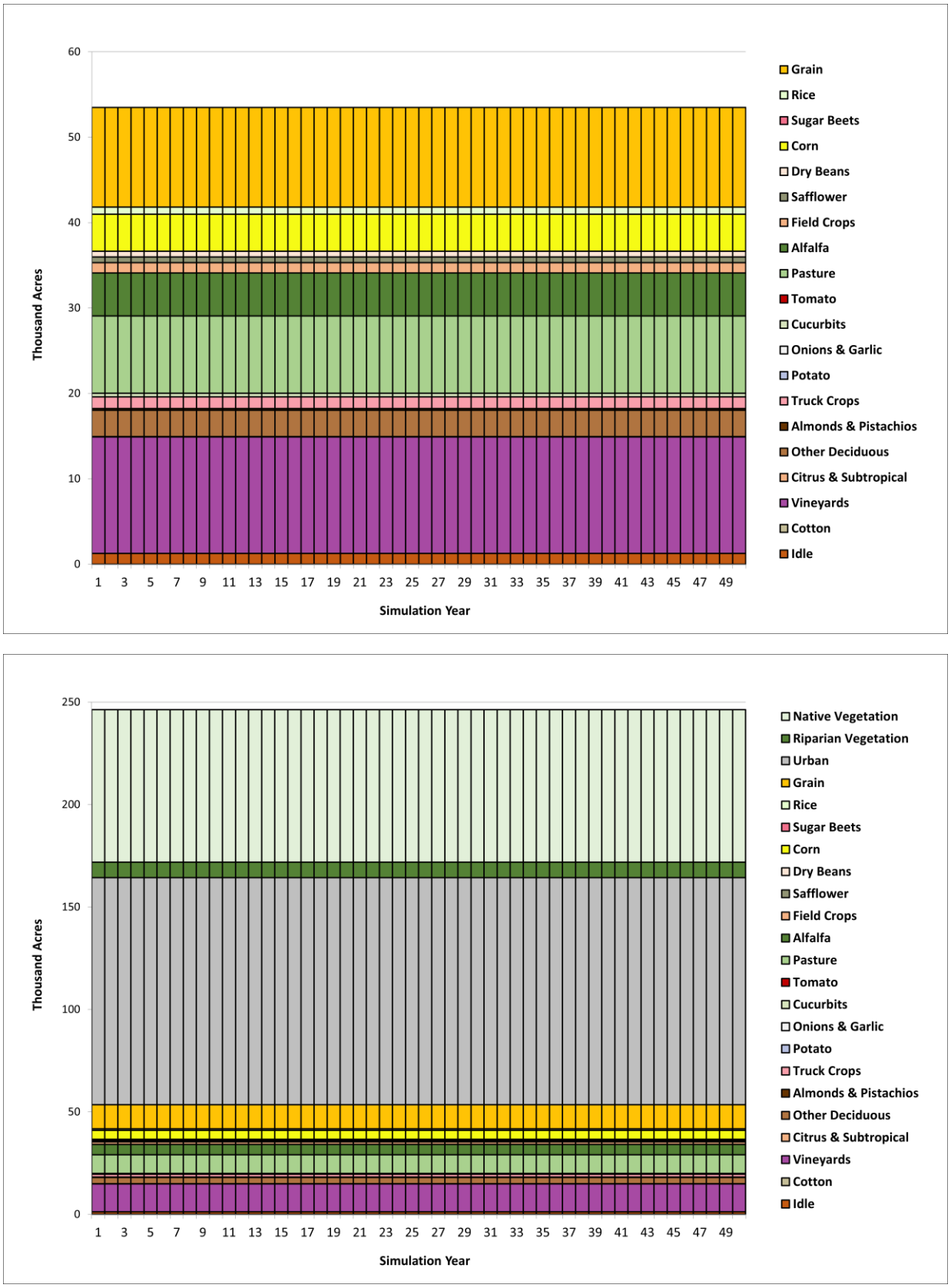


Figure 5-6: Current Conditions Baseline Land Use for South American Subbasin

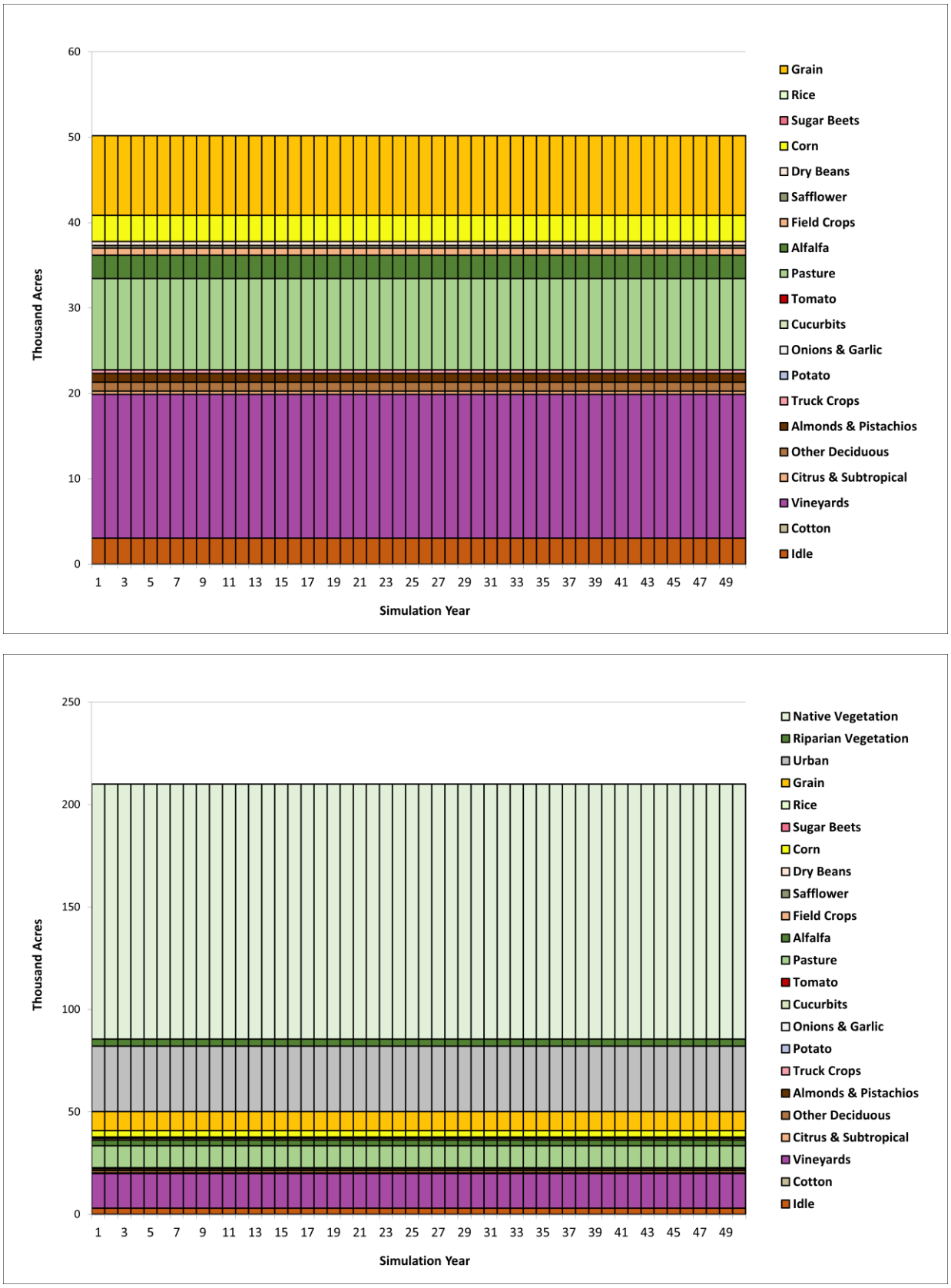


Figure 5-7: Current Conditions Baseline Land Use for Cosumnes Subbasin

5.1.5 Urban Demand and Supply

Urban demand is represented for each urban area based on supply data. Like the CoSANA historical model, each baseline assumes that urban supply (combined groundwater, surface water, and other sources such as recycled water) is equal to urban demand.

Urban water supply, including surface water deliveries, groundwater pumping, recycled water, and remediated water, are all calculated using the method described below, unless exceptions are listed in the individual purveyor sections that follow. To estimate CCBL water supply, the information for the last 10 years of the historical simulation (WY 2009 through 2018) was averaged by the three baseline water year types (normal, wet, and dry) described in Section 5.1.1.4. WY 2009 through 2018 contains four normal years (2010, 2012, 2016, and 2018), two wet years (2011 and 2017), and 4 dry years (2009, 2013, 2014, and 2015). Appendix G shows subregion/purveyor urban demand and supply for each entity for the three WY types (normal, wet, and dry). The water supply conditions for these three baseline year types were applied to the 50 years of hydrology within the CCBL.

For urban groundwater pumping, a well was assumed active in the CCBL if there was historical recorded pumping in WY 2016-2018. Average pumping by baseline year type was distributed in the CCBL to all active wells by purveyor based on their proportion of the historical simulation purveyor totals.

As previously noted, urban demand and supply were calculated using averages developed from the last 10 years of the historical simulation for all agencies except those specified otherwise in the following subsections.

5.1.5.1 North American Subbasin

The following subsections present demand and supply assumptions for purveyors within the North American Subbasin whose assumptions are different from the standard methodology outlined above.

5.1.5.1.1 City of Sacramento

City of Sacramento's demand was based on the last 10 years of the historical simulation. Demand varies slightly with water year types from 34,702 AFY for wet years to 35,274 AFY for dry years. Approximately 35% of the demand was assumed to be in the NASb portion of the model, based on urban area.

The City of Sacramento's current supplies include groundwater pumping and surface water supplies that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 Groundwater Master Plan (GWMP) (City of Sacramento, 2017). Groundwater pumping assumptions for the CCBL were consistent with the Future Conditions Baseline scenario developed in the 2017 GWMP, based on the discussions with the City of Sacramento (B. Ewart, personal communication, December 2020). Monthly pumping assumptions by each well were incorporated into the CCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Groundwater pumping in the NASb varies from 6,989 AFY during wet years to 41,841 AFY during driest years. Demand after groundwater pumping was assumed to be supplied by surface water.

The City of Sacramento also has specific wells that supply certain larger parks and green areas within the city. These irrigation wells are simulated using six representative irrigation wells that pump 2,400 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the NASb and the remaining half in the SASb.

5.1.5.1.2 Sacramento County Water Agency (Arden Park Vista and Northgate)

Due to changing supply conditions over the last 10 years of the historical simulation, the SCWA service areas of Northgate and Arden Park Vista in the CCBL use groundwater pumping from WY 2018 for normal and dry baseline years and WY 2019 for wet baseline years.

5.1.5.2 South American Subbasin

The following subsections present demand and supply assumptions for purveyors within the South American Subbasin whose assumptions are different from the standard methodology.

5.1.5.2.1 City of Sacramento

The discussion also applies to the portion of the City of Sacramento that lies within the South American Subbasin; the portion within the NASb was discussed above in Section 5.1.5.1. Groundwater pumping in the SASb by the city varies from 1,761 AFY during wet years to 11,885 AFY during driest years, based on the Future Conditions Baseline scenario developed in the 2017 GWMP and the discussions with the City of Sacramento (B. Ewart, personal communication, December 2020). Monthly pumping assumptions by each well and by each water year type were incorporated into the CCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Demand after groundwater pumping was assumed to be supplied by surface water.

5.1.5.2.2 Sacramento County Water Agency (Hood, Laguna Vineyard, and Mather)

Due to changing supply conditions over the last 10 years of the historical simulation, including construction of the Vineyard Surface Water Treatment Plant (online in WY 2011), the SCWA service areas of Hood, Laguna Vineyard, and Mather in the CCBL use surface water deliveries, groundwater pumping, recycled water, and remediated water from WY 2018 for normal and dry baseline years and WY 2019 for wet baseline years.

5.1.5.3 Cosumnes Subbasin

The following subsections present demand and supply assumptions for purveyors within the Cosumnes Subbasin whose assumptions are different from the standard methodology.

5.1.5.3.1 City of Galt

The average historical groundwater production for WY 2015-2018 for the City of Galt was used to estimate groundwater pumping for all CCBL years. This pumping occurs at six active wells.

5.1.5.3.2 City of Ione

To estimate CCBL surface water supply to the City of Ione, the average for WY 2015-2018 was used for all CCBL years.

5.1.5.3.3 Camanche Village

To estimate CCBL groundwater pumping water supply for Camanche Village from six active wells, the average for WY 2015-2018 was used for all CCBL years.

5.1.5.3.4 Sacramento Municipal Utility District

The imported Central Valley Project water from the American River via the Folsom South Canal to the Sacramento Municipal Utility District (SMUD) facility uses the average for WY 2015-2018 for all CCBL years.

5.1.5.4 Fish Farms

In the North American Subbasin, four wells were used to simulate 3,480 AFY of pumping for Sterling Caviar, which is located near the Sutter/Sacramento County line just east of Highway 99.

Groundwater pumping at fish farms in the South American Subbasin and Cosumnes Subbasin uses the average for WY 2015-2018 for all CCBL years.

5.1.6 Agricultural Demand and Supply

Agricultural demand in the CCBL is calculated within the model using land use, evapotranspiration, precipitation, and other information, as described for the historical simulation in Section 3.3.

Agricultural supply in the CCBL made of up primarily of surface water deliveries and groundwater pumping. Surface water deliveries are based on water year types (normal, wet, and dry) averages calculated using the last 10 years of the historical simulation (WY 2009-2018). Demand not met by surface water is assumed to be met by groundwater pumping, which is pumped within the associated model element, rather than coming from specific agricultural pumping wells.

5.1.6.1 Rural-Residential Pumping

Rural residential pumping for the current conditions baseline is assumed to be the same as the historical model for water year 2018. Refer to Section 3.3.1 in the historical model documentation.

5.1.6.2 Galt Wastewater Treatment Plant Effluent

The reclaimed water use from the Galt Wastewater Treatment Plant (WWTP) uses the average for WY 2015-2018 for all CCBL years, regardless of baseline water year type.

5.1.6.3 Agricultural Groundwater Substitution Transfers

Pumping associated with agricultural water transfers occurs in three entities in the North American Subbasin: Natomas Mutual Water Company (NMWC), Pleasant Grove-Verona Mutual Water Company (PGVMWC), and South Sutter Water District. NMWC and PGVMWC participate in groundwater substitution transfers under certain conditions. South Sutter Water District is different from the other two, as they transfer water based on a hybrid approach. The water made available is released from storage in Camp Far West Reservoir. Generally, a similar volume of groundwater is pumped by private well owners within the district. This volume is not directly measured and is assumed to be slightly less than the amount released from storage. This is represented in the CCBL by delivering less surface water during dry years than normal or wet years, with averages calculated using the data from the last 10 years of the historical simulation. The groundwater pumping is calculated internally in the model and therefore automatically adjusts for years with less or more surface water.

For NMWC and PGVMWC, historical groundwater substitution transfer pumping data was provided for water years 2020 and 2021 (2019 was not a transfer year). For the CCBL estimates of groundwater substitution transfer pumping, dry year averages were calculated using historical data for WY 2012-2021. During this 10-year period, all groundwater substitution transfer pumping occurs in the five dry years (2013, 2014, 2015, 2020, and 2021). The estimated dry year transfer pumping for NMWC and PGVMWC was distributed among all transfer wells in the same proportion as in the historical data. The surface water deliveries to NMWC and PGVMWC in the CCBL are adjusted based on the amount of dry year transfer pumping.

5.1.7 Remediation Operations

Remediation operations for Mather, McClellan, Kiefer, and Aerojet, discussed for the historical simulation in Section 3.4, in the CCBL are held constant at the WY 2018 level of pumping for the entire CCBL. The number and location of the remediation wells is assumed to remain the same as in the historical simulation. Mather remediation pumping is set at 209 AFY, McClellan remediation pumping is set at 2,409 AFY, Kiefer remediation pumping is set at 621 AFY, and Aerojet remediation pumping is set at 32,040 AFY.

5.1.8 Results

This section provides a summary of the CoSANA CCBL results.

5.1.8.1 Land and Water Use Budget

The land and water use budget provides details on the urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, or remediation pumping). Average annual CCBL model results by groundwater subbasin are shown in Table 5-2. Annual agricultural water demand and supply by subbasin are shown in Figure 5-8 through Figure 5-10. Annual urban demand and supply by subbasin are shown in Figure 5-11 through Figure 5-13. Appendix H includes model subregion land and water use budgets for the baselines.

Table 5-2: CCBL Average Annual Land and Water Use Budget

Subbasin	Ag. Demand (AFY)	Ag. Ground-Water Use* (AFY)	Ag Surface Water Deliveries (AFY)	Urban Demand (AFY)	Urban Ground-Water Use** (AFY)	Urban Surface Water Deliveries (AFY)	Urban Recycled Water (AFY)	Remediation Pumping (AFY)
NASb	392,619	206,201	188,962	200,913	83,319	117,596	-	5,515
SASb	142,961	98,369	44,804	174,487	79,948	93,871	856	29,765
CoSb	126,838	105,049	21,458	27,520	22,825	2,483	-	-
Total	**662,418**	**409,619**	**255,224**	**402,920**	**186,092**	**213,950**	**856**	**35,280**

Note:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

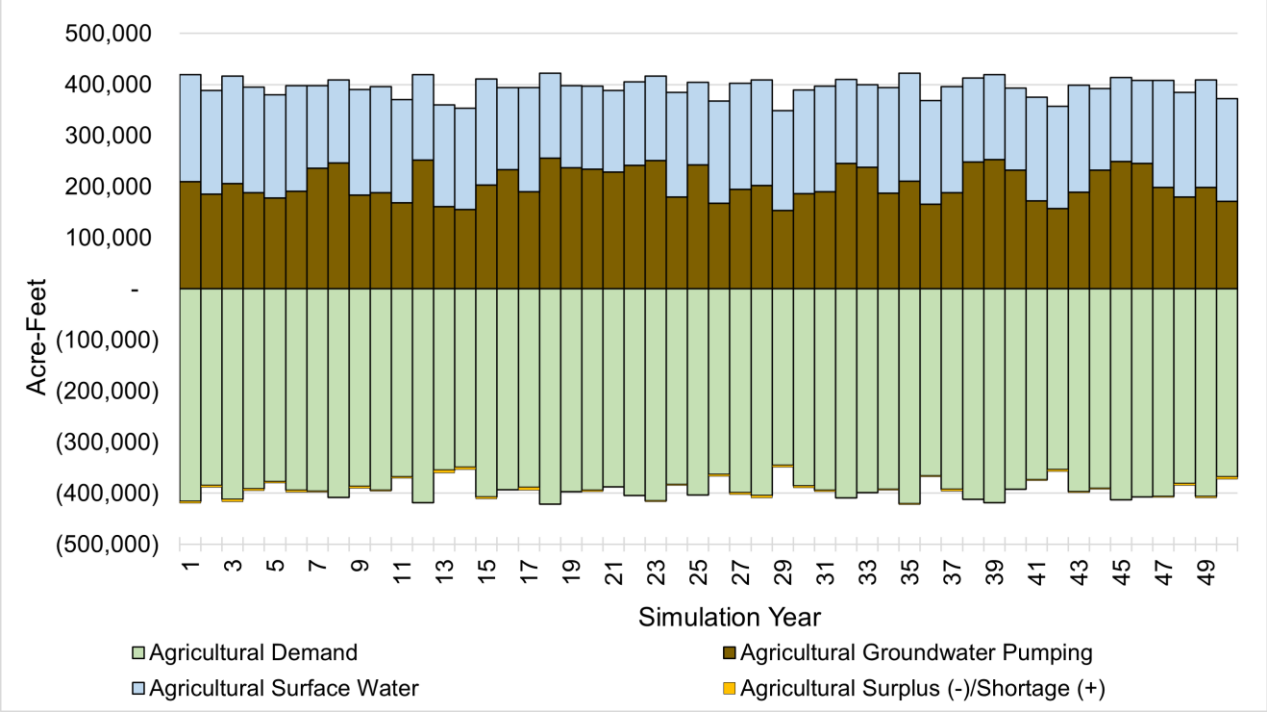


Figure 5-8: Annual Agricultural Water Demand and Supply – North American Subbasin, Current Conditions Baseline

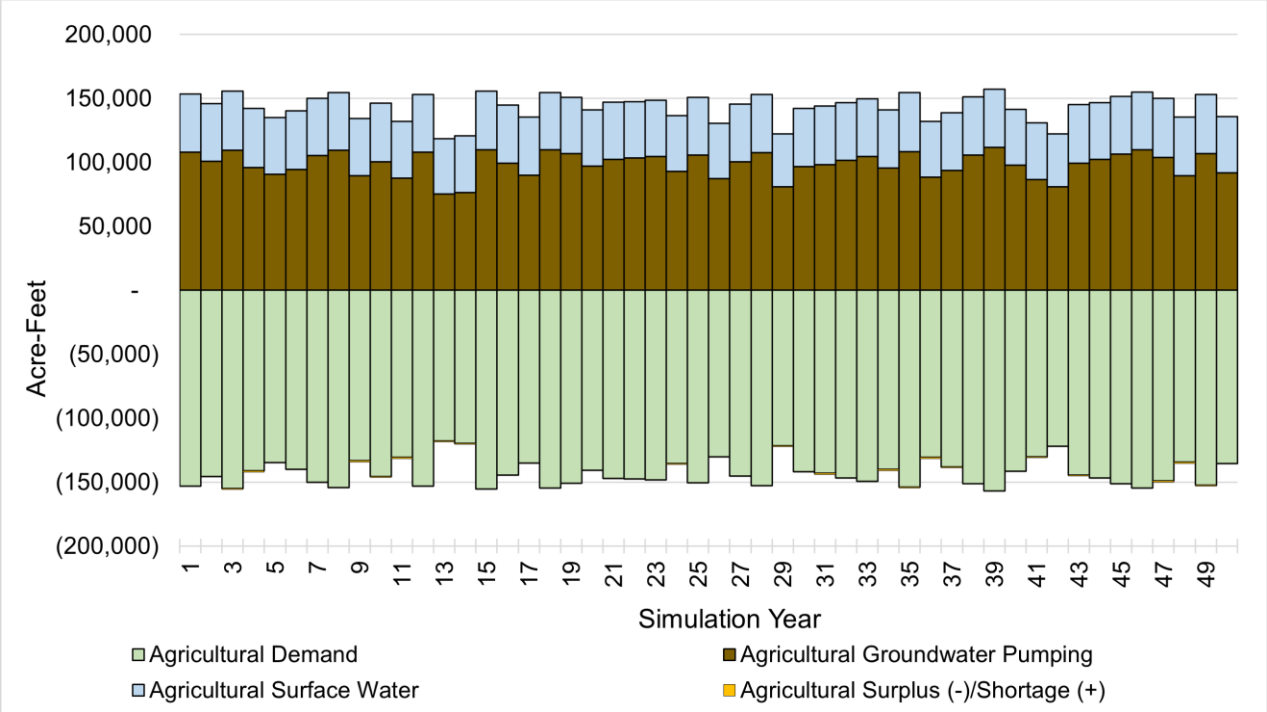


Figure 5-9: Annual Agricultural Water Demand and Supply – South American Subbasin, Current Conditions Baseline

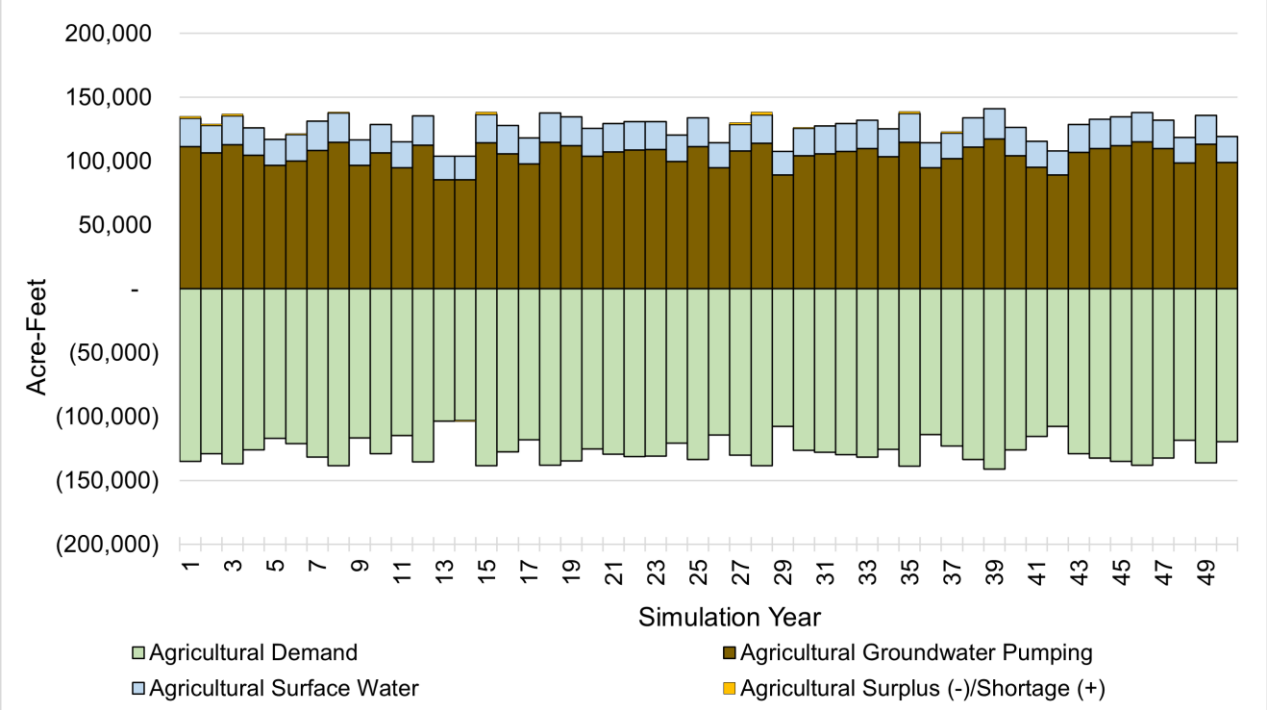


Figure 5-10: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline

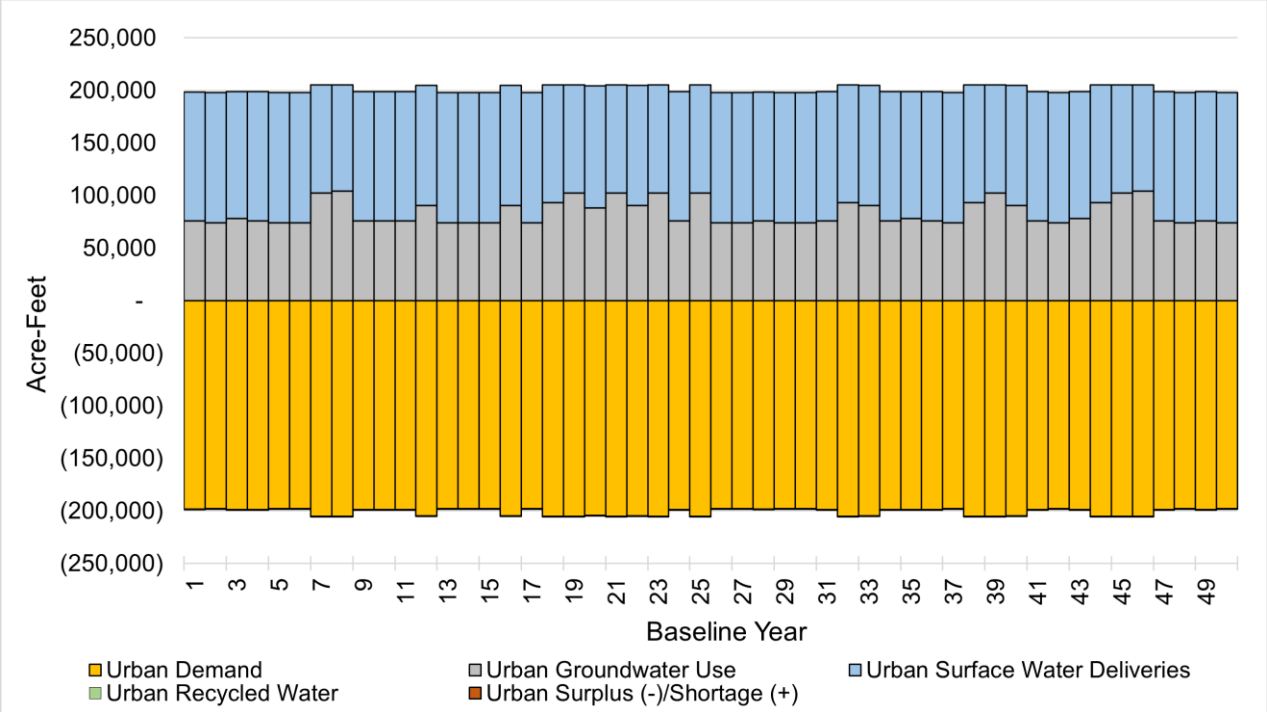


Figure 5-11: Annual Urban Water Demand and Supply – North American Subbasin, Current Conditions Baseline

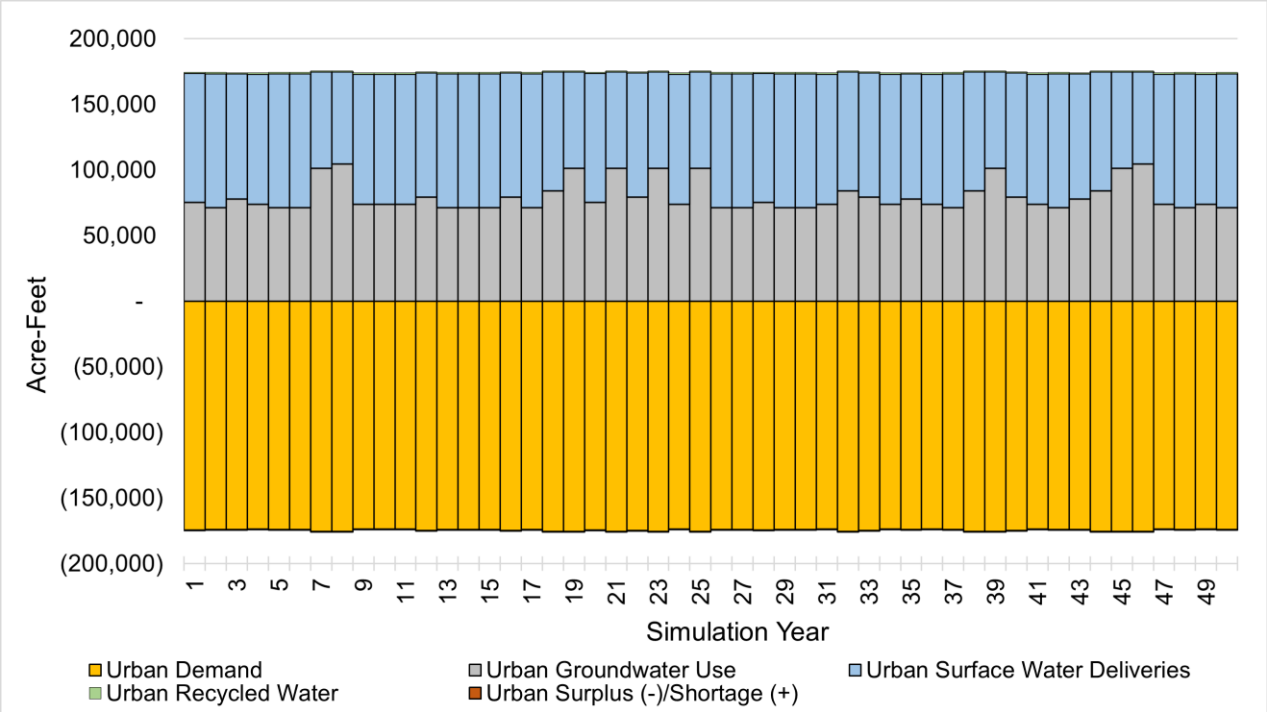
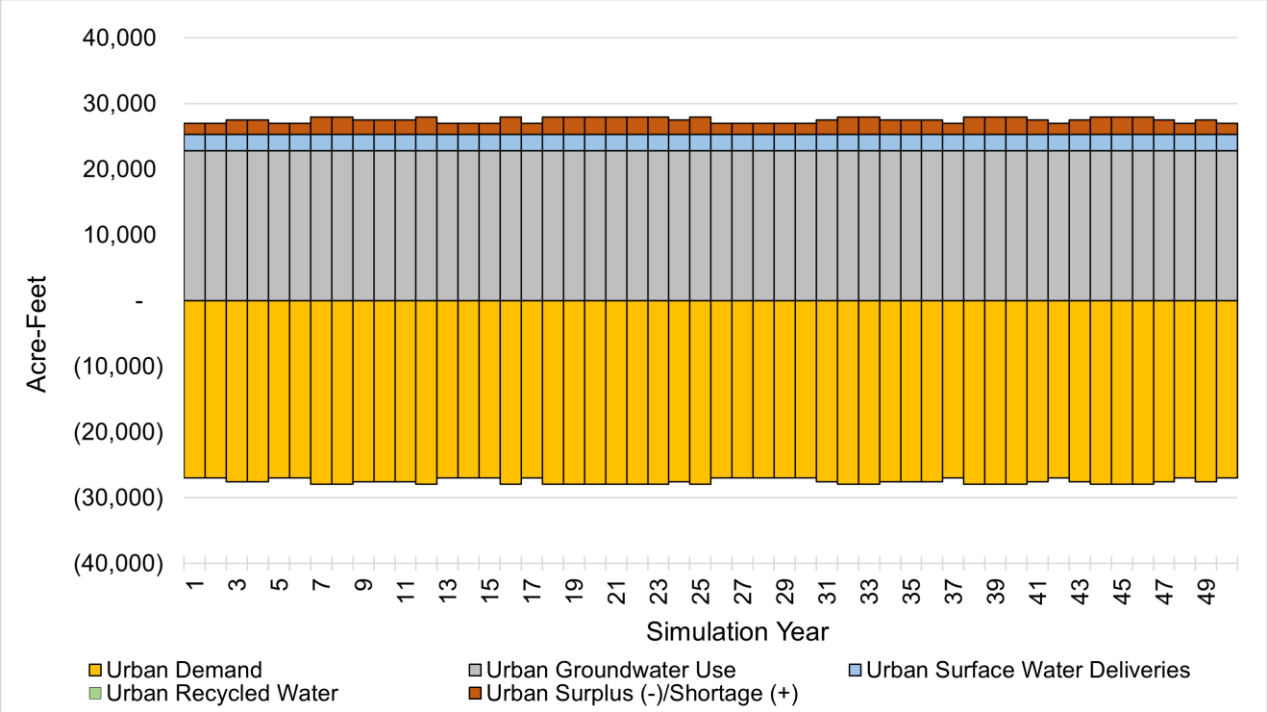


Figure 5-12: Annual Urban Water Demand and Supply – South American Subbasin, Current Conditions Baseline



Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.

Figure 5-13: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline

5.1.8.2 Groundwater Budget

The groundwater budget provides all inflows and outflows to the groundwater aquifer system. Average annual CCBL model results by groundwater subbasin are shown in Table 5-3. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-14 through Figure 5-16. Appendix I includes model subregion groundwater budgets for the baselines. Appendix J includes a set of sample hydrographs for the baseline models.

Table 5-3: CCBL Average Annual Groundwater Budget

Subbasin	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Boundary Flows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
NASb	303,094	183,468	81,494	16,732	28,125	8,161	14,843
SASb	212,626	120,915	91,328	26	4,089	-1,573	2,158
CoSb	127,875	109,064	15,575	0	1,442	1,559	-233
Total	**643,595**	**413,447**	**188,397**	**16,758**	**33,656**	**8,147**	**16,768**

Note: Boundary Flows term includes flow between areas outside of the CoSANA model domain and baseflow from small watersheds. Subsurface Inflows includes flow between the simulated subbasins in CoSANA and areas outside of Bulletin 118 subbasins.

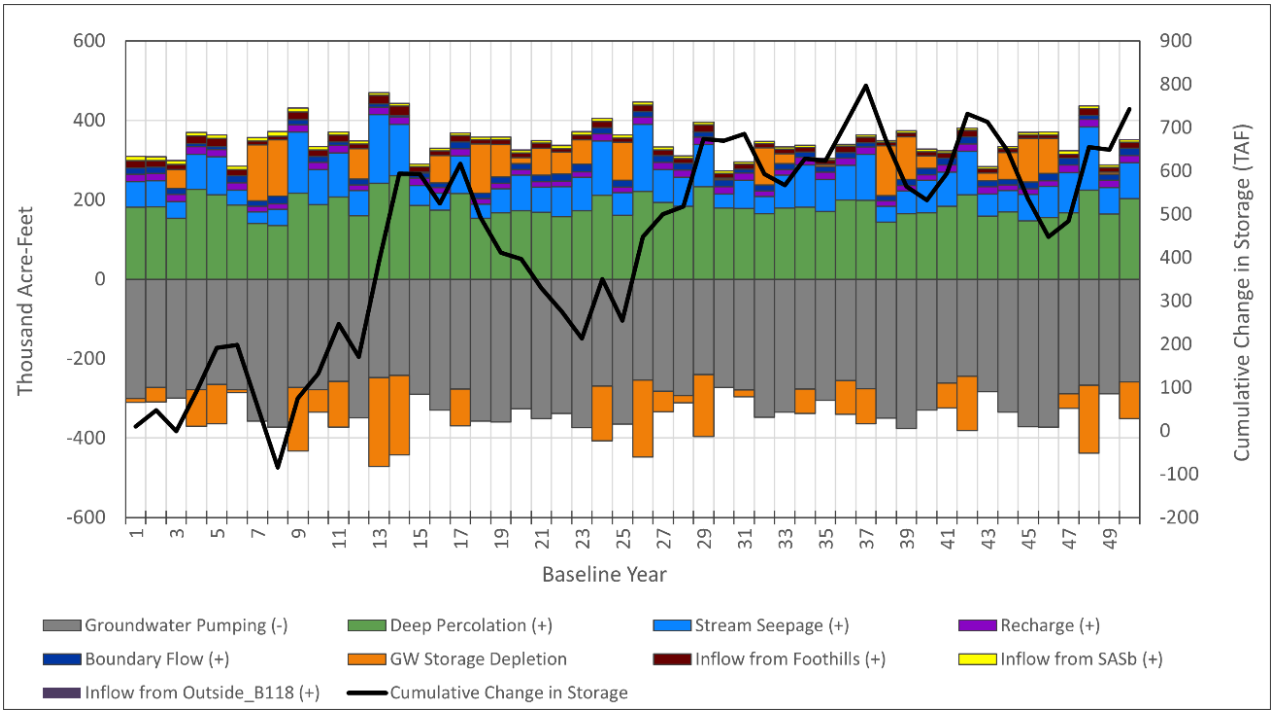


Figure 5-14: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Current Conditions Baseline

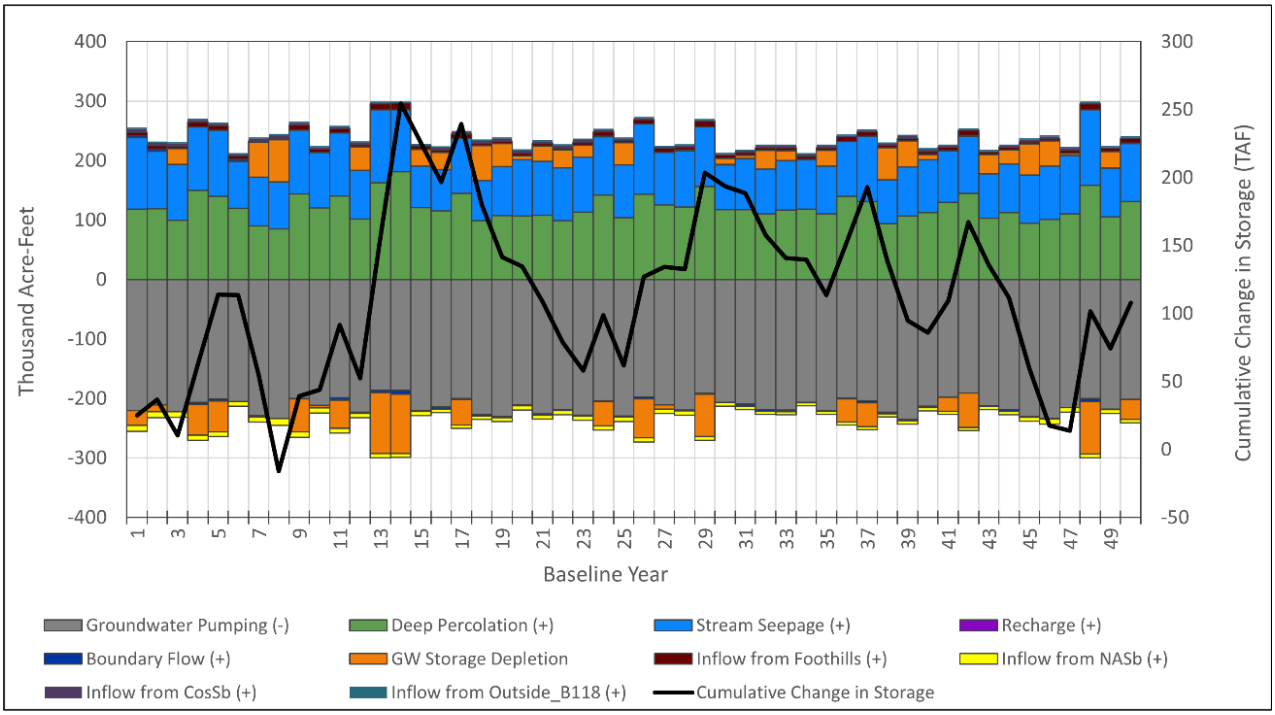


Figure 5-15: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Current Conditions Baseline

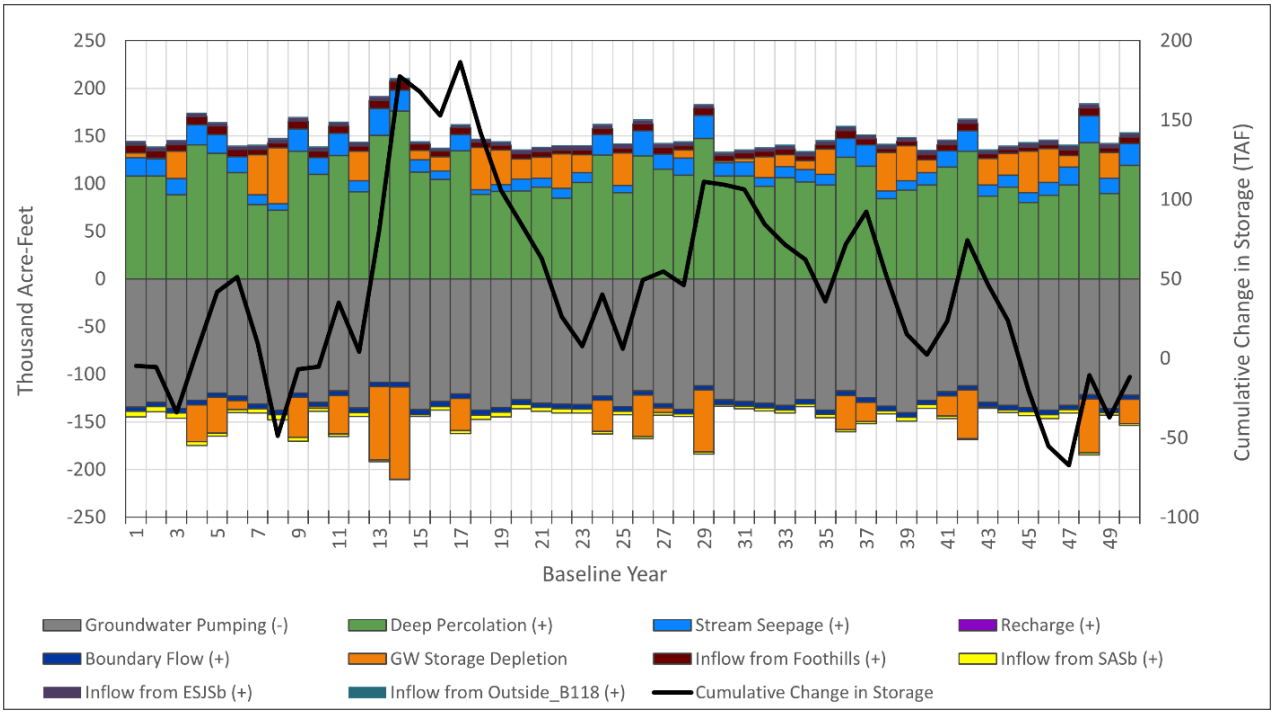


Figure 5-16: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Current Conditions Baseline

5.2 Projected Conditions Baseline

The CoSANA Projected Conditions Baseline (PCBL) is a representation of the projected land and water use conditions of 2040, or the closest information available from planning documents. This section presents the key data sources and assumptions used to develop the PCBL and provides the model results. Initial groundwater levels and soil conditions in the PCBL represent those at the end of the simulation period of the historical CoSANA (September 30, 2018).

5.2.1 Hydrologic Period

The PCBL uses the 50-year historical hydrology from WY 1970 through 2019 (October 1, 1969 through September 30, 2019) for precipitation, evapotranspiration, and streamflow. This is the same as for the CCBL, discussed in Section 5.1. The hydrologic year types discussed in Section 5.1.1.4 are used in the PCBL to develop projected water demands and supplies.

5.2.2 Land Use

The PCBL incorporates the proposed new developments to reflect the 2040 land use conditions or the closest data available from planning documents. The existing land use data for 2015 conditions used in the CCBL were modified to incorporate the future projected urban footprint. The urban footprint for the proposed new developments, urban demand, and urban supply projections including the new developments were incorporated into the model, as further explained below.

Table 5-4 lists the proposed new developments incorporated into the PCBL. A total of 62 proposed new developments were identified, including 34 in the NASb, 25 in the SASb, and 3 in CoSb. In the CoSb, urban land was expanded around existing developed areas, as projected in planning documents.

The main data source for identifying the new developments in Sacramento County was information and GIS files provided by the Sacramento County Office of Planning and Environmental Review (T. Smith, personal communication, October 2020). In addition, public information available from the Sacramento Area Council of Governments (SACOG) was also collected and reviewed for identifying and confirming the developments within Placer and Sutter Counties. Placer County also reviewed the list of the new developments and provided inputs (J. Byous, personal communication, December 2020). Information was also available for many of the developments in Sutter and Placer Counties (R. Shatz, personal communication, December 2020).

The majority of the new developments in the NASb are located in Placer County near the City of Rocklin (Sunset Ranchos and Clover Valley), City of Lincoln (SUD A, SUD B, SUD C, Village 1, Village 2, Village 3, Village 4, Village 5, Village 6, and Village 7), City of Roseville (Amoruso Ranch, Creekview, HP Campus Oaks, North Area, Northwest Roseville, Sierra Vista, Sun City Roseville [or Del Webb] and West Roseville Specific Plans), and Cal-Am West Placer (Placer Vineyards Specific Plans East and West and Riolo Vineyards). Other proposed developments include the Placer Ranch and Regional University in Placer County, Sutter Pointe in Sutter County; and Grandpark Specific Plan, Elverta, Greenbrier, Panhandle, Northborough, and Upper Westside in Sacramento County.

The majority of the proposed new developments in the SASb are located within the SCWA service areas (Arboretum, Jackson Township, Laguna Ridge, Ranch at Sunridge, Rio del Oro (partially in the Cal-Am service area), Southeast Planning Area (Meridian), Sterling Meadows, SunCreek, SunRidge, Vineyards, Cordova Hills, Florin Vineyard Gap, Mather South, NewBridge, North Vineyard Station, Vineyard Springs, Lent Ranch, and West Jackson Highway Master Plan). Other proposed developments are located around or within the City of Folsom (Easton, Folsom South Area, and Glenborough), Rancho Murieta Community Service District (Rancho Murieta), and Elk Grove Water District (Triangle).

In the CoSb, urban land in the City of Galt was expanded based on 2030 projections in the City's General Plan, and areas in the vicinity of Ione ("Urban Planning Area") and Camanche Village ("Rural Residential") were expanded based on Amador County's General Plan. The footprint of the Buena Vista Rancheria was converted from native to urban.

The proposed new developments and future land use conditions are shown in Figure 5-17. The time-series of land use for the CoSANA PCBL is shown in Figure 5-18, highlighting the constant nature of land and water use in the baseline conditions. Figure 5-19 through Figure 5-21 show time-series of land use for the NASb, SASb, and CoSb, respectively.

Table 5-4: Proposed New Developments

Proposed Development Name	ID		Proposed Development Name	ID
Village 4	1		Greenbriar	32
SUD A	2		Panhandle	33
Village 3	3		Upper Westside	34
Village 5	4		Westborough	35
SUD B	5		Easton	36
Village 2	6		Glenborough	37
Village 1	7		Folsom South Area	38
Village 6	8		Rio Del Oro	39
Village 7	9		Mather South	40
SUD C	10		Ranch At Sunridge	41
Sunset Ranchos	11		SunRidge	42
Amoruso Ranch Specific Plan	12		SunCreek	43
Clover Valley	13		Cordova Hills	44
Placer Ranch	14		West Jackson Highway Master Plan	45
Creekview	15		Jackson Township	46
West Roseville	16		NewBridge	47
North Area Specific Plan	17		Arboretum	48
Sun City Roseville	18		Rancho Murrieta	49
HP Campus Oaks	19		Florin-Vineyard	50
Sierra Vista Specific Plan	20		North Vineyard Station	51
North Area Specific Plan 2	21		Delta Shores	52
Northwest Roseville Specific Plan	22		Vineyards	53
Sutter Pointe	23		Vineyard Springs	54
Regional University	24		Triangle	55
Riolo Vineyards	25		Laguna Ridge	56
Placer Vineyards Specific Plan (east)	26		Southeast Planning Area (Meridian)	57
Placer Vineyards Specific Plan (west)	27		Sterling Meadows	58
Dry Creek-West Placer Community Plan	28		Lent Ranch	59
Grandpark Specific Plan	29		Galt Sphere of Influence	60
Elverta Specific Plan	30		Camanche Village Rural Residential	61
Northborough Boundary	31		Ione Urban Planning Area	62

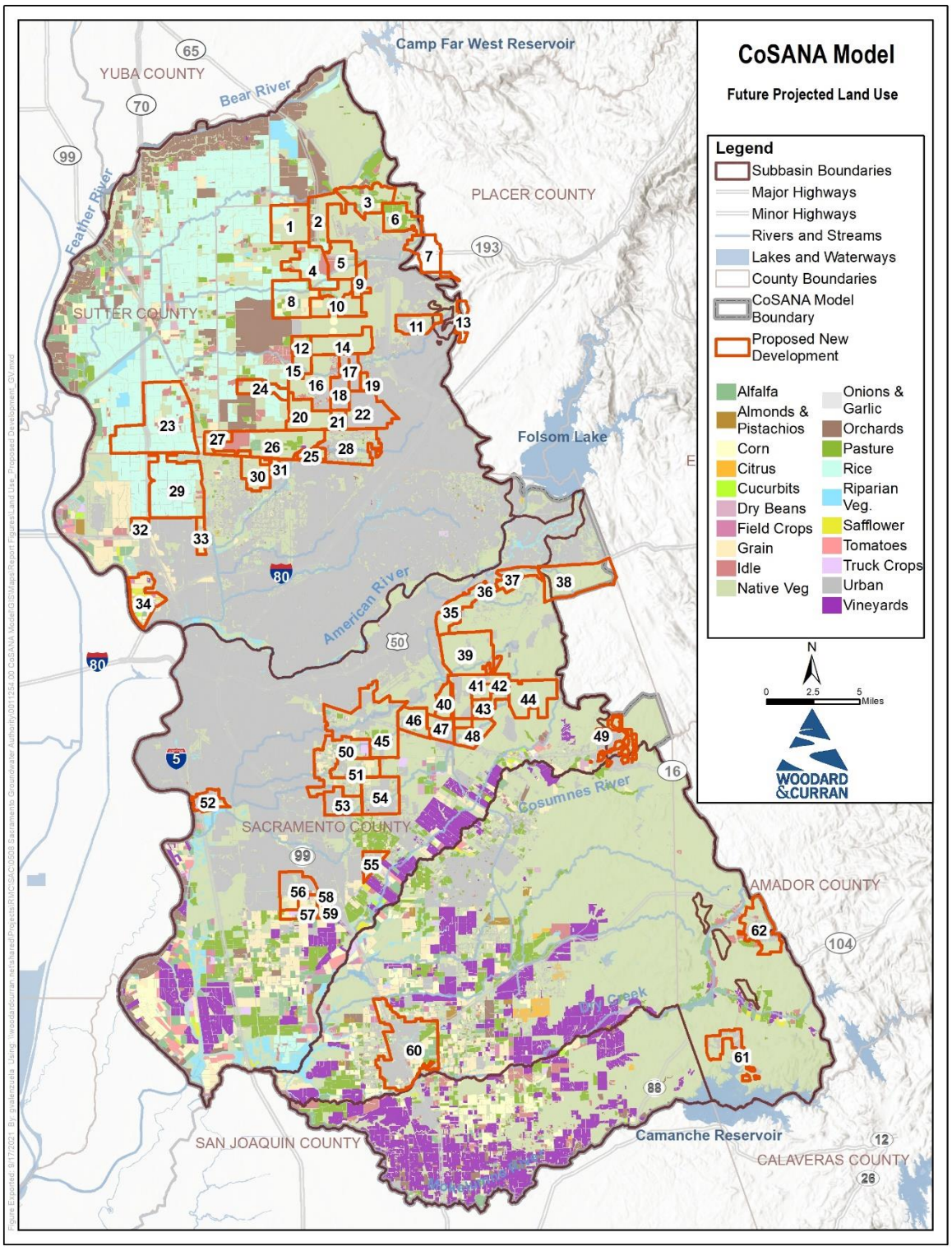


Figure 5-17: Projected Land Use and Proposed New Developments

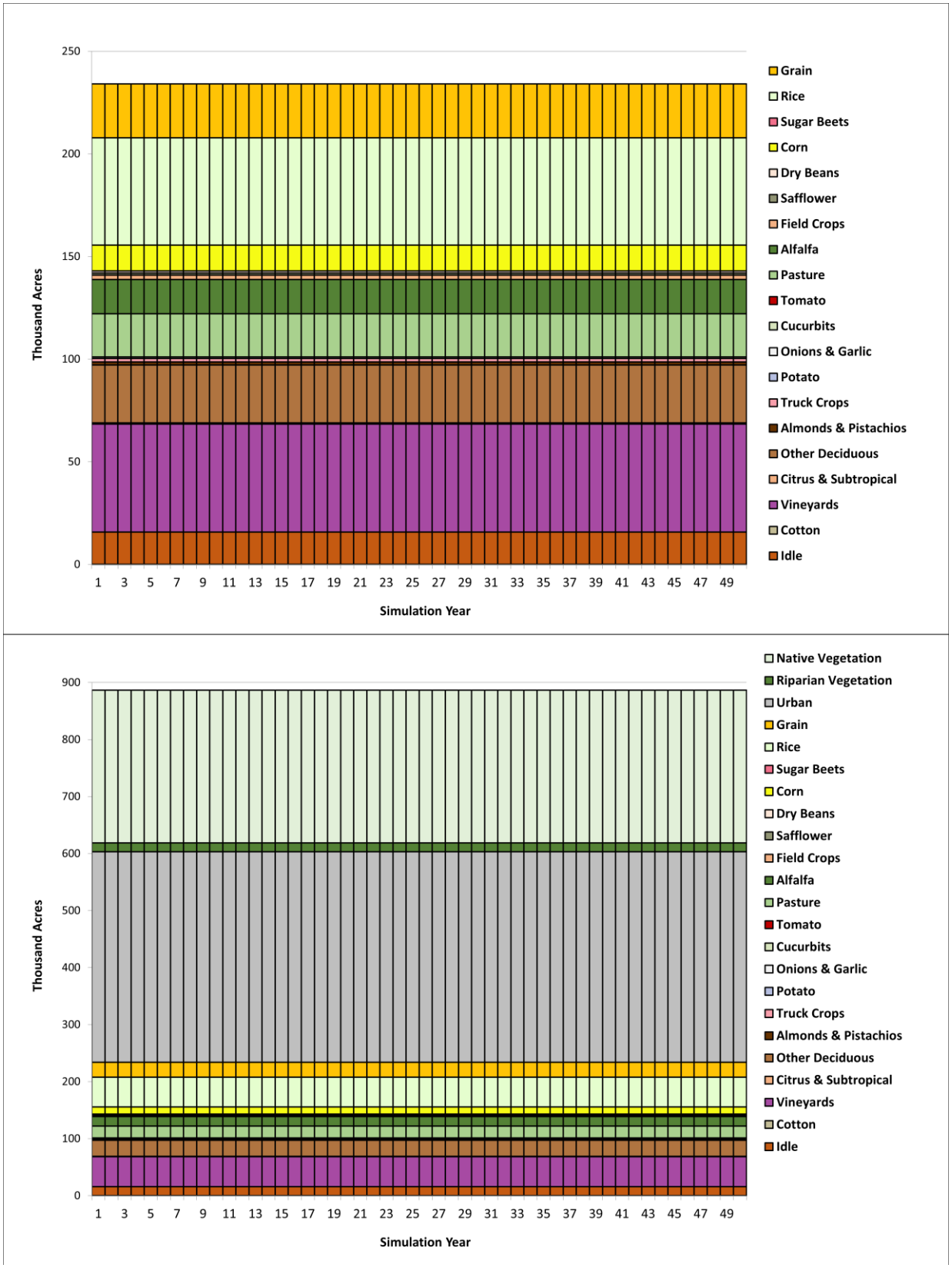


Figure 5-18: Projected Conditions Baseline Land Use for CoSANA

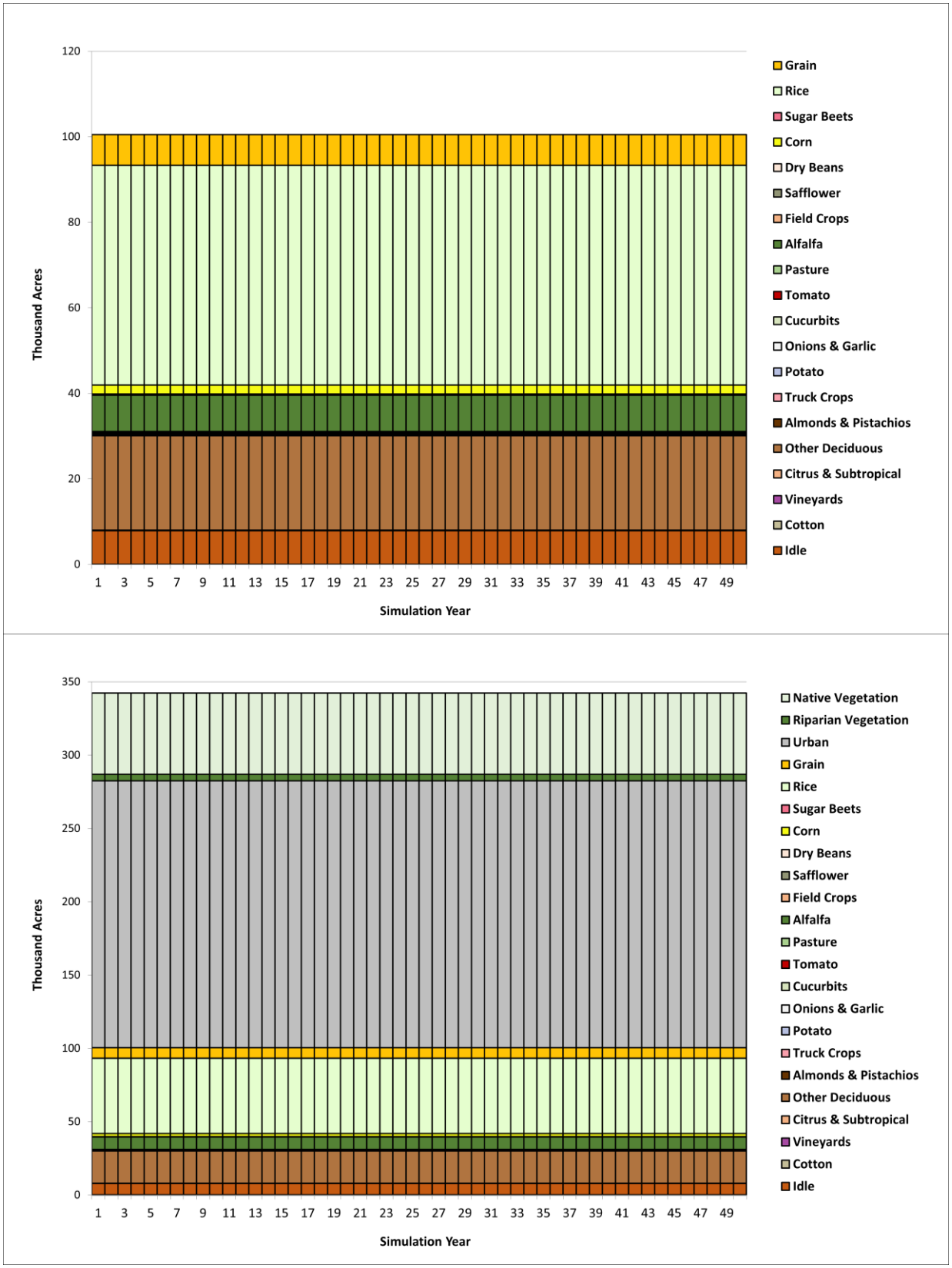


Figure 5-19: Projected Conditions Baseline Land Use for North American Subbasin

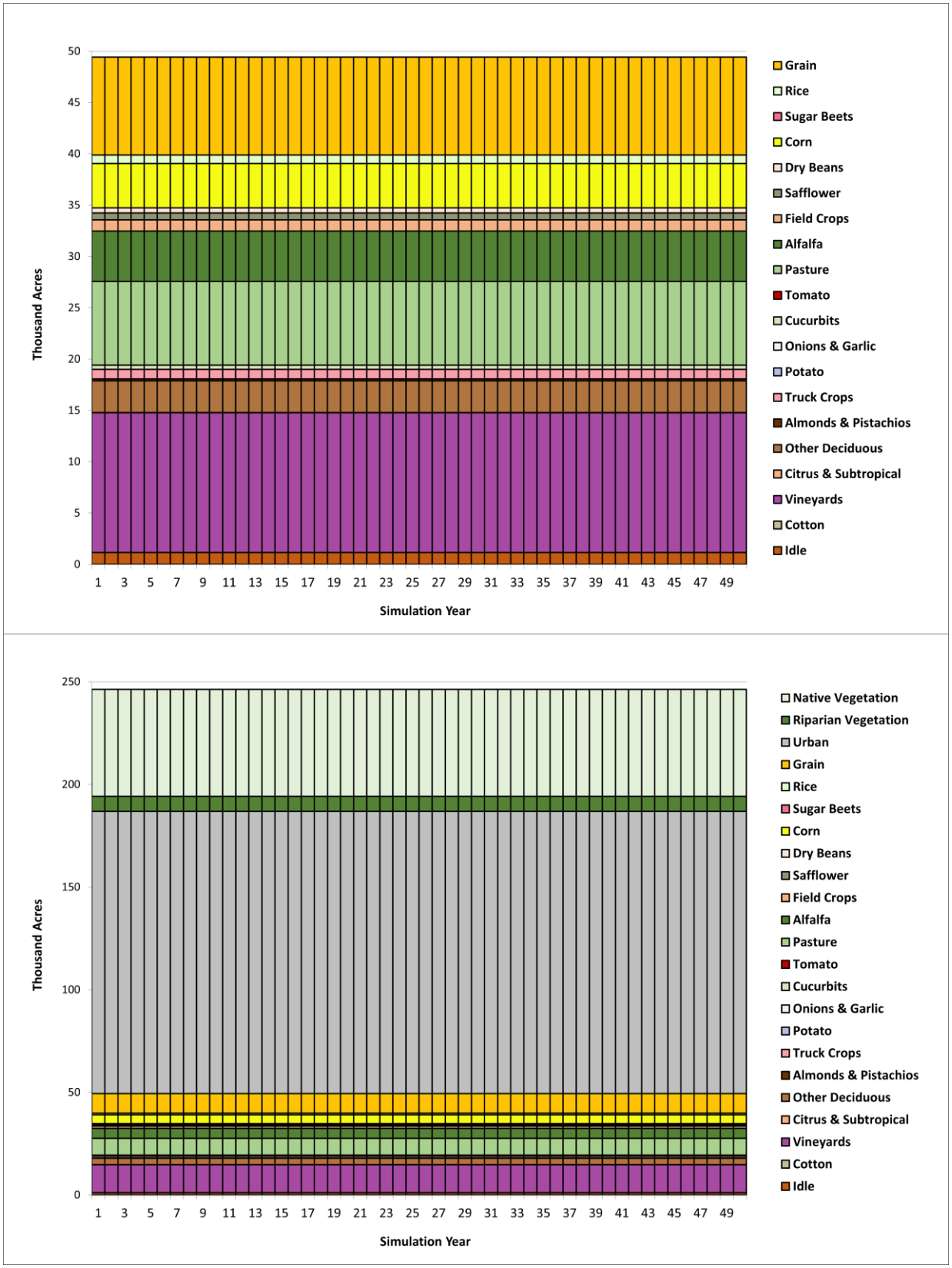


Figure 5-20: Projected Conditions Baseline Land Use for South American Subbasin

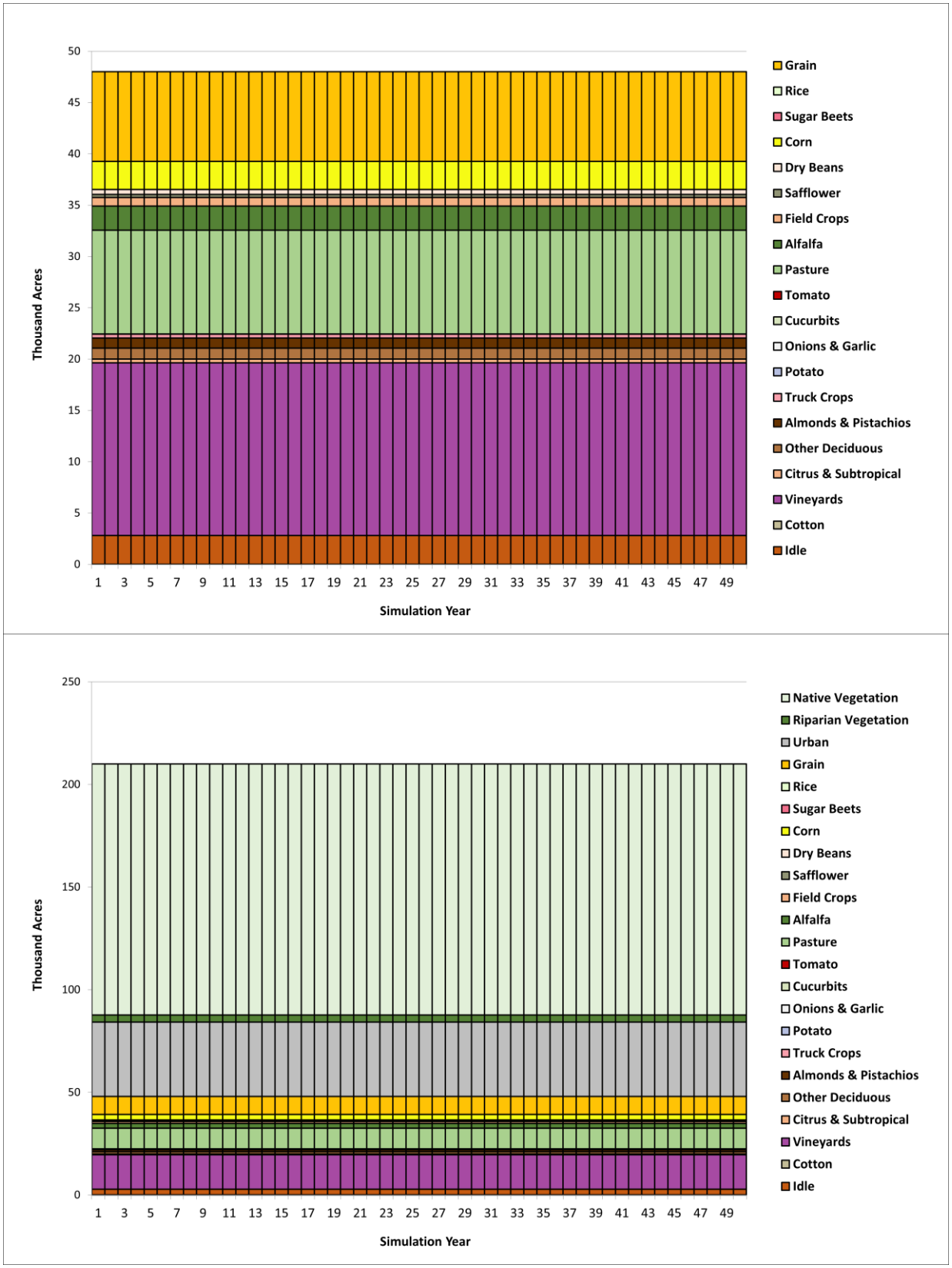


Figure 5-21: Projected Conditions Baseline Land Use for Cosumnes Subbasin

5.2.3 Urban Demand and Supply

Urban water demand in the PCBL is generally reflective of 2040 conditions. Demand and supply projections were generally available for 2040 conditions; when data for 2040 was not readily available, 2035 projections were used as the latest information. Water demand and supply assumptions are based on the 2015 UWMPs, general plans, other planning documents, or most current information provided by purveyors. Note that the 2020 UWMPs were not available at the time of model development. Appendix G presents the annual average demand and supply assumptions used in the PCBL by three water year types for each purveyor and five water year types for the City of Sacramento. Urban demand and supply projections were defined by three water year types for wet, normal, and dry conditions, using the same water year types as in the CCBL. All dry year projections were assumed to be single dry year projections based on the information available. Projections for wet years were assumed to be the same as normal conditions when wet year projections were unavailable. For the purpose of the modeling, supply was assumed to meet the demand with no surplus.

2015 UWMPs and other planning and environmental permitting documents were reviewed to estimate demand and supply sources for the proposed developments. Review of the publicly available information suggested that demand and supply projections were generally included in the purveyors' projected demand and supply estimates as reported in the 2015 UWMPs with the exception of two new developments - Sutter Pointe and Grandpark Specific Plans. Sutter Pointe and Grandpark Specific Plans were assumed to be on a mix of groundwater pumping and surface water supplies based on available documentation. It was assumed that all new developments in Placer County would be on surface water supplies.

This section briefly describes the demand and supply assumptions used in the PCBL for each purveyor. Similar to the approach in the CCBL, demand and supply information is described for purveyors grouped by the three subbasins NASb, SASb, and CoSb.

5.2.3.1 North American Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL within the NASb.

5.2.3.1.1 Placer County Water Agency – Rocklin Retail Area

- **Demand**: The City of Rocklin's future demand of 18,942 AFY was based on the Placer County Water Agency's 2015 UWMP (Table 4-9; PCWA, 2016) with a partial demand estimated and incorporated into the PCBL to represent the portion of the City of Rocklin within the model domain. It is estimated that approximately 33% of the City of Rocklin's demand was within the model area. Demand was adjusted by water year type based on the trends seen in the CCBL, with slightly lower demand during dry years than normal and wet years.

- **Supply**: All future demand was assumed to be met by surface water.

5.2.3.1.2 City of Lincoln

- **Demand**: 2040 demand projections were 20,336 AFY for normal and wet years and 20,947 AFY for dry years, based on the 2015 UWMP (Table 4-6 and Table 7-2) (City of Lincoln, 2016a).

- **Supply**: Demand was assumed to be met by 3,300 AFY of groundwater pumping, 6,063 AFY of recycled water, and the remaining demand met by surface water. These values were based on the Water Master Plan (Tables 3-10 and 3-11; City of Lincoln, 2016b) and the latest information available (R. Shatz, personal communication, December 2020). The City of Lincoln's proposed future wells to support the proposed developments were incorporated into the PCBL.

5.2.3.1.3 City of Roseville

- **Demand**: The 2040 demand projection was based on the 2015 UWMP (City of Roseville, 2016) and information provided by the City of Roseville (T. Joseph, personal communication, December 2020). Demand was assumed at 56,865 AFY during normal and wet years and reduced to 46,708 AFY during dry years, which accounts for a reduction of 11,677 AFY through water conservation.

- **Supply**: Demand was assumed to be met by 5,958 AFY of recycled water in all years, based on the 2015 UWMP (Table 6-11); the remaining demand was assumed to be met by surface water and the city's aquifer storage and recovery (ASR) program. The PCBL incorporated the ASR program at buildout with 15 ASR wells operating and included well information (well IDs, well locations, and well screens) and annual extraction and injection schedules provided by the City of Roseville. With the ASR program, the city assumes no net take on groundwater supply over the long-term, based on the following ASR operations by water year types:

    - During dry years, the City of Roseville's ASR wells extract 6,907 AFY of groundwater.

    - During wet years, the City of Roseville recharges groundwater through injection of 6,200 AFY of surface water into aquifer.

    - During normal and wet years, ASR wells pump a small volume of 25 AFY for maintenance.

5.2.3.1.4 California American Water Company (West Placer, Antelope, Lincoln Oaks, and Arden)

- **Demand**: A 2035 demand projection was developed for each service area based on the 2015 UWMP (Table 4-2; Cal-Am, 2016). Demand remains the same in all water year types.

- **Supply:** Supply projections by service area were based on the 2015 UWMP as follows:

    - West Placer was assumed to be all surface water provided to Cal-Am by the wholesaler, PCWA.

    - Antelope and Lincoln Oaks were assumed to be on surface water from Sacramento Suburban WD (only during normal and wet years) and groundwater pumping. The 2,000 AFY of surface water supply was assumed to be distributed as 60% to Antelope and 40% to Lincoln Oaks (2015 UWMP Table 5-9); the remaining supply comes from groundwater.

    - The City of Sacramento supply of 4,831 AFY was distributed between Arden (NASb), Parkway (SASb), and Suburban Rosemont (SASb) based on the 2015 UWMP (Table 5-9).

5.2.3.1.5 Sacramento International Airport

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.

- **Supply**: Demand was assumed to be met by surface water and groundwater, proportional to the volumes in 2017 and 2018.

5.2.3.1.6 Rio Linda / Elverta Community Water District

- **Demand**: A 2035 demand projection of 7,462 AFY for normal and wet years (Table 4-2) and 8,208 AFY for dry years (Table 7-3) was assumed based on the 2015 UWMP (RLECWD, 2016).

- **Supply**: Demand was assumed to be met by groundwater, similar to the CCBL conditions (UWMP Table 6-9).

- **Proposed Development**: The PCBL incorporates the Elverta and Northborough Specific Plans, which are located outside of the RLECWD's current service area.

5.2.3.1.7 Sacramento Suburban Water District

- **Demand**: A 2040 demand projection of 41,304 AFY was assumed based on the 2015 UWMP (Table 3-5) (Sacramento Suburban WD, 2016). Demand remains the same for all water year types.

- **Supply**: Demand was assumed be met by a maximum groundwater pumping of 35,000 AFY during dry years, based on the 2015 UWMP (Table 5-11); the remaining demand was assumed to come from surface water. For normal and wet years, the groundwater and surface water supply mix was assumed to be proportional to CCBL conditions.

5.2.3.1.8 Citrus Heights Water District

- **Demand**: 2035 demand was assumed as 18,210 AFY for normal and wet years and 15,478 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-3; Citrus Heights Water District, 2016).

- **Supply**: Demand was assumed be met by 900 AFY of groundwater pumping, with the remaining demand from San Juan WD surface water, based on the 2015 UWMP (Table 6-9).

5.2.3.1.9 Orange Vale Water Company

- **Demand**: 2035 demand was assumed as 4,981 AFY for normal and wet years and 4,234 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-3; Orange Vale Water Company, 2016).

- **Supply**: Demand was assumed be met by San Juan WD surface water, similar to the CCBL.

5.2.3.1.10 San Juan Water District

- **Demand**: A 2040 demand projection of 19,393 AFY was assumed for retail demand, based on the 2015 UWMP (Table 4-2b; SJWD, 2016).

- **Supply**: Demand was assumed to be met by surface water, based on the 2015 UWMP (Table 6-9).

5.2.3.1.11 City of Sacramento

- **Demand**: A 2040 demand projection of 161,029 AFY was assumed based on the 2015 UWMP (Table 4-2) (City of Sacramento, 2016). Demand remains the same for all water year types. Approximately 35% of the demand was assumed to be in the NASb portion of the model, based on urban area.

- **Supply**: Supply projections include groundwater pumping and surface water supplies that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 GWMP (City of Sacramento, 2017). Groundwater pumping assumptions were consistent with the Maximum Groundwater Use scenario developed in the 2017 GWMP, based on the discussions with the City of Sacramento. Monthly pumping assumptions by each well were incorporated into the PCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Groundwater pumping in the NASb varies from 11,553 AFY during wet years to 38,261 AFY during driest years. Demand after groundwater pumping was assumed to be supplied by surface water. The City of Sacramento also has specific wells that supply some of the larger parks and green areas within the city boundaries. These irrigation wells are simulated using six representative irrigation wells that pump 2,200 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the NASb and the remaining half in the SASb.

5.2.3.1.12 Sacramento County Water Agency (Arden Park Vista and Northgate)

- **Demand**: 2045 demand projections for Arden Park Vista and Northgate were based on the Draft 2020 UWMP (Tables 4-10(b) and 4-10(c)) provided by SCWA and input from SCWA (M. Grinstead, personal communication, April 2021).
- **Supply**: Arden Park Vista and Northgate were assumed to be on groundwater, similar to the CCBL conditions.

5.2.3.1.13 Del Paso Manor Water District

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.
- **Supply**: Demand was assumed to be met by groundwater, similar to the CCBL.

5.2.3.1.14 Golden State Water Company (Arden)

- **Demand**: Demand for the Arden service area was assumed to remain the same as in the CCBL conditions.
- **Supply**: Arden service area was assumed to be on groundwater, consistent with the CCBL conditions.

5.2.3.1.15 Carmichael Water District

- **Demand**: A 2040 demand projection was assumed as 10,334 AFY for normal and wet years and 10,851 AFY for dry years, based on the 2015 UWMP (Table 4-6 and Table 7-2) (Carmichael Water District, 2016).
- **Supply**: Demand was assumed to be met by groundwater pumping and surface water, proportional to the CCBL conditions.

5.2.3.1.16 Fair Oaks Water District

- **Demand**: A 2035 demand projection of 12,726 AFY was assumed based on the 2015 UWMP (Table 4-2) (Fair Oaks Water District, 2016).
- **Supply**: Demand was assumed to be met by groundwater pumping and surface water, proportional to the CCBL conditions.

5.2.3.1.17 Sutter Pointe

- **Demand**: A demand projection of 15,786 AFY was assumed, based on the Phase 2+B proposed water supply program from the *Supplement to the Water Supply Assessment for Lakeside at Sutter Pointe* (Golden State Water Company, 2020).
- **Supply**: Demand was assumed to be met by a mixture of groundwater pumping and surface water. Groundwater pumping is assumed to meet 10,919 AFY of demand, and surface water is assumed to meet the remaining 4,867 AFY of demand.

5.2.3.1.18 Grandpark

- **Demand**: A demand projection of 12,030 AFY was assumed, based on build out projections for the project (K. Giberson, pers comm. Feb 14, 2019).
- **Supply**: Demand was assumed to be met by a mixture of groundwater pumping and surface water. Groundwater pumping is assumed to meet 2,407 AFY of demand during normal and wet years, and 3,007 AFY

of demand during dry years. Surface water is assumed to meet 9,623 AFY of demand during normal and wet years, and 9,395 AFY of demand during dry years.

5.2.3.2 South American Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL for the purveyors located within the SASb. All new developments were assumed to be on supplies projected by the purveyors.

5.2.3.2.1 City of Sacramento

- **Demand**: As described above in Section 5.2.3.1.11, a city-wide 2040 demand projection of 161,029 AFY was assumed, based on the 2015 UWMP (Table 4-2) (City of Sacramento, 2016). Approximately 65% of the demand was assumed to be in the SASb portion of the model, based on urban area.

- **Supply**: As with the NASb, supply projections include groundwater pumping and surface water that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 GWMP (City of Sacramento, 2017). Groundwater pumping follows the Maximum Groundwater Use scenario specified in the 2017 GWMP. Based on the specific well pumping assumptions, groundwater pumping in the SASb varies from 12,749 AFY during wet years to 43,029 AFY during driest years. Remaining demand after groundwater pumping was assumed to be supplied by recycled water (1,000 AFY) and surface water. As described above in Section 5.2.3.1.11, the City of Sacramento also has specific wells that supply some parks and green areas within the city boundaries. These irrigation wells are simulated using six representative irrigation wells that pump 2,600 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the SASb.

5.2.3.2.2 California American Water Company (Suburban Rosemont, Security Park, and Parkway)

- **Demand**: As described above in Section 5.2.3.1.4 for Cal Am service areas within the NASb, demand projections reflect the 2035 conditions based on the 2015 UWMP (Tables 4-2) (Cal-Am, 2016). Demand remains the same in all water year types.

- **Supply:** Supply projections by service area were based on the 2015 UWMP as follows:

    - Security Park was assumed to be all on groundwater and served water from SCWA, similar to the CCBL conditions.

    - As described above in Section 5.2.3.1.4, surface water supply from the City of Sacramento was distributed between Arden (NASb), Parkway (SASb), and Suburban Rosemont (SASb), based on the 2015 UWMP (Table 5-9). Remaining demand is met by groundwater from Cal Am wells.

5.2.3.2.3 California American Water Company (former Fruitridge Vista Water Company)

- **Demand**: A 2035 demand projection of 4,957 AFY was assumed, based on the discussions with Cal-Am.

- **Supply**: Supply projections include local groundwater pumping and surface water wholesale supply from the City of Sacramento, with 50% of demand met by groundwater and the remaining 50% of demand met by surface water.

5.2.3.2.4 Golden State Water Company (Cordova)

- **Demand**: A 2040 demand projection of 19,572 AFY was assumed for the Cordova service area, based on the 2015 UWMP (Table 4-4) (GSWC, 2016).

- **Supply**: Cordova's supply projections include groundwater pumping of 9,752 AFY, 5,000 AFY of remediated water from the Aerojet Granted Water Supply, and 5,000 AFY of American River diversion from Folsom South Canal, as reported in the 2015 UWMP (Table 6-12).

5.2.3.2.5 City of Folsom

- **Demand**: A 2040 demand projection was assumed as 29,923 AFY for normal and wet years and 30,819 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-2) (City of Folsom, 2016).

- **Supply**: City of Folsom supply was assumed all surface water, as with the CCBL conditions.

5.2.3.2.6 Florin County Water District

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.

- **Supply**: Demand was assumed to be met by groundwater, consistent with CCBL conditions.

5.2.3.2.7 Sacramento County Water Agency (Hood, Laguna Vineyard, and Mather)

- **Demand**: The 2045 demand projection for Hood was based on the Draft 2020 UWMP (Table 4-10[e]), provided by SCWA and input from SCWA (M. Grinstead, personal communication, April 2021). Demand projections for Laguna Vineyard and Mather reflect 2052 conditions based on the 2021 Zone 40 Water Supply Master Plan Amendment (Tables B-6, B-7, and B-8) (SCWA, 2021), and discussions with SCWA (M. Grinstead, personal communication, April 2021). Laguna Vineyard in the PCBL represents the South Service Area and Central Service Area; and Mather represents the North Service Area.

- **Supply**: Hood was assumed to be on groundwater, consistent with the CCBL. Supply projections for Laguna Vineyard and Mather reflect 2052 conditions based on a mix of groundwater, surface water, recycled water, and remediated water, as reported in the 2021 Zone 40 Master Plan Amendment (Tables B-6, B-7, and B-8). Recycled water of 1,700 AFY would be available in the Laguna Vineyard demand area (South Service Area) and remediated water of 8,900 AFY would be available every year.

5.2.3.2.8 Elk Grove Water District

- **Demand**: A 2045 demand projection was assumed be 8,080 AFY for normal and wet years and includes demand both for Service Area 1 and Service Area 2 based on the 2015 UWMP (Table 4-6; EGWD, 2016). Dry year demand projection was assumed to 8,323 AFY based on the 2015 UWMP (Table 7-2) and was assumed to be distributed to Service Area 1 and Service Area 2 proportional to demand in normal and wet years in the two service areas.

- **Supply**: The 2015 UWMP does not break future supply projections into groundwater and surface water supplies by service areas. It was assumed Service Area 1 was served with groundwater and Service Area 2 served with a mix of groundwater and surface water by SCWA.

5.2.3.2.9 Rancho Murieta Community Service District

- **Demand**: Demand for the entire service area was assumed to be 3,477 AFY based on a medium growth projection of 3,659 AFY at buildout with 20% reduction (or 2,927 AFY potable demand) and additional recycled water demand of approximately 550 AFY, based on the information available from the Rancho Murieta Community Services District's (CSD) 2010 Integrated Water Master Plan Update (Figure ES-1, Table 2-3, and Table 3-2; Rancho Murieta CSD, 2010). Approximately 32% of demand falls within the SASb based on urban area.

- **Supply**: Demand was assumed to be met by surface water for potable demand and recycled water of 550 AFY for golf course irrigation.

5.2.3.3 Cosumnes Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL for the purveyors located within the CoSb.

5.2.3.3.1 Rancho Murieta Community Service District

Several proposed developments were identified within the Rancho Murieta CSD and incorporated into the PCBL. Note that the majority of the developments would occur outside of the three subbasins but within the model boundary.

- **Demand**: As described above in Section 5.2.3.2.9, total demand was assumed to be 3,477 AFY. Approximately 22% of the demand falls within the CoSb based on urban area, compared to 32% within the NASb. The remaining demand of 46% falls outside of the NASb, SASb and CoSb, but within the model boundary.
- **Supply**: As described above in Section 5.2.3.2.9, demand was assumed to be met by surface water for potable demand and recycled water.

5.2.3.3.2 City of Galt

- **Demand**: A 2040 groundwater demand projection of 7,663 AFY was assumed based on the 2015 UWMP (Table 4-3; City of Galt, 2016).
- **Supply**: Demand was assumed to be met by groundwater with pumping distributed between six active CCBL wells proportional to their historical maximum annual yield. Dry year supply projections were assumed to be the same as normal year supplies.

5.2.3.3.3 Amador County Water Agency

- **Demand**: 2040 demand projections were updated based on supply assumptions, as discussed below, and distributed to the expanded urban land use areas.
- **Supply**: Supply projections include surface water and recycled water for the City of Ione and groundwater, surface water, and recycled water for Camanche Village. CCBL City of Ione surface water supply was doubled based on the projected demand increases from the Amador Water Agency 2015 UWMP; there was no change to the recycled water use relative to the CCBL. CCBL groundwater pumping for Camanche Village from the four active wells was doubled based on expansion and development of currently vacant parcels (Dunn Environmental, 2012). CCBL groundwater pumping for Camanche North Shore from the two active wells was increased by a total of 11 AFY based on a projected maximum daily treated water demand increase from the *Camanche Area Regional Water Supply Plan Feasibility Study and Conceptual Design* (RMC Water and Environment, 2012). Specified groundwater pumping to three wells operated by the Buena Vista Rancheria are based on reported May 2019-April 2020 pumping, in which the seasonal average pumping rates were distributed to associated months.

5.2.3.3.4 Sacramento Municipal Utility District

No change in demand or supply relative to the CCBL.

5.2.3.4 Fish Farms

No change in demand or supply relative to the CCBL.

5.2.4 Agricultural Demand and Supply

Agricultural demand and supply in the PCBL is similar to the discussion in the CCBL (Section 5.1.6), with demand being driven by the land use changes in the PCBL discussed in Section 5.2.2 and much of the supply being internally calculated within the model or based on the last 10 years of the historical simulation.

5.2.4.1 Galt Wastewater Treatment Plant Effluent

No change in treatment plant effluent use relative to the CCBL.

5.2.4.2 Rural Residential

Refer to section 3.3.1 in the historical model report for a description of the methodology used to estimates rural residential pumping.

Rural residential demand in the PCBL version of CoSANA accounts for the urbanization of areas that would lead to a decrease in the rural residential population. It is assumed that the projected urbanization of areas previously used for agricultural purposes would result in a decline in rural residential population, and therefore demand. These areas are subsequently served by an urban water purveyor.

In the CoSb, rural residential demand was assumed to increase as a result of projected population increases. Assuming a rural residential population, and associated demand increase of 1% per year, total projected annual groundwater consumption was estimated to be 9,448 AFY and was proportionally distributed monthly as specified in the CCBL.

5.2.4.3 Agricultural Groundwater Substitution Transfers

As discussed for the CCBL, two purveyors engage in agricultural groundwater substitution transfer pumping in the NASb: NMWC and PGVMWC, Additionally, South Sutter Water District operates a transfer program that behaves very similarly to a groundwater substitution transfer. South Sutter Water District uses a hybrid approach to groundwater substitution transfer pumping similar to the CCBL model. Dry year decreases of surface water deliveries from Camp Far West Reservoir are offset by an increase in groundwater pumping.

For NMWC and PGVMWC, agricultural transfer pumping was assumed to occur in 16 years of the baseline (15 of the 19 dry years and one normal year), with timing and pumping volumes based on information included in the Long-Term Water Transfer (LTWT) EIS/R (Reclamation, 2019). The estimated transfer pumping for NMWC and PGVMWC was distributed among all transfer wells in the same proportion as in the historical data. NMWC surface water deliveries are automatically adjusted to meet total agricultural demand, and PGVMWC surface water deliveries are estimated using the last 10 years of historical simulation data, reduced by the amount of agricultural transfer pumping estimated to occur in the PCBL.

5.2.5 Remediation Operations

Information about future remediation operations is not available, so remediation operations in the PCBL are the same as in the CCBL, discussed in Section 5.1.7.

5.2.6 Results

This section provides a summary of the CoSANA PCBL results.

5.2.6.1 Land and Water Use Budget

The land and water use budget provides details on the urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, and remediation pumping). Average annual PCBL model results by groundwater subbasin are shown in Table 5-5. Annual agricultural water demand and

supply by subbasin are shown in Figure 5-22 through Figure 5-24. Annual urban demand and supply by subbasin are shown in Figure 5-25 through Figure 5-27. Appendix H includes model subregion land and water use budgets.

Table 5-5: PCBL Average Annual Land and Water Use Budget

Subbasin	Ag. Demand (AFY)	Ag. Ground-Water Use* (AFY)	Ag Surface Water Deliveries (AFY)	Urban Demand (AFY)	Urban Ground-Water Use** (AFY)	Urban Surface Water Deliveries (AFY)	Urban Recycled Water (AFY)	Remediation Pumping (AFY)
NASb	349,317	202,228	149,868	328,654	108,492	220,161	-	5,515
SASb	135,956	91,599	44,369	301,060	116,385	167,661	17,200	29,765
CoSb	121,676	99,886	21,460	30,168	28,445	3,943	-	-
Total	**606,949**	**393,713**	**215,697**	**659,882**	**253,322**	**391,765**	**17,200**	**35,280**

Note:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

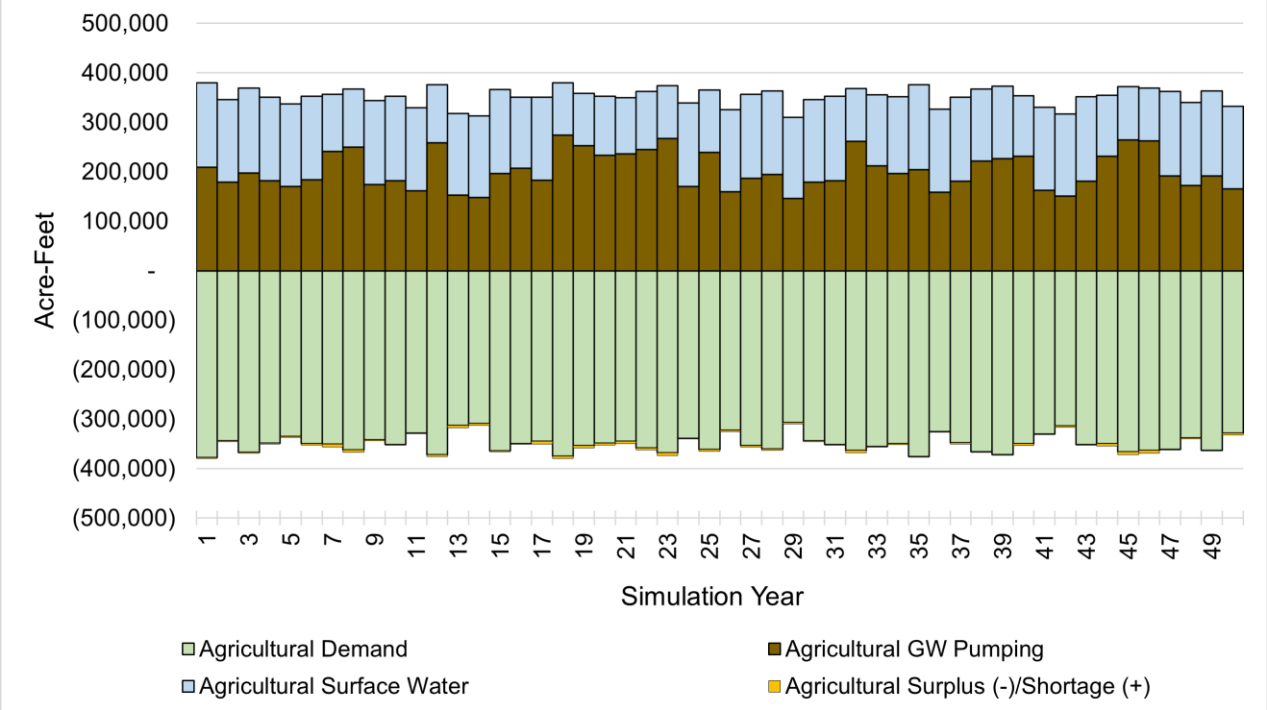


Figure 5-22: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline

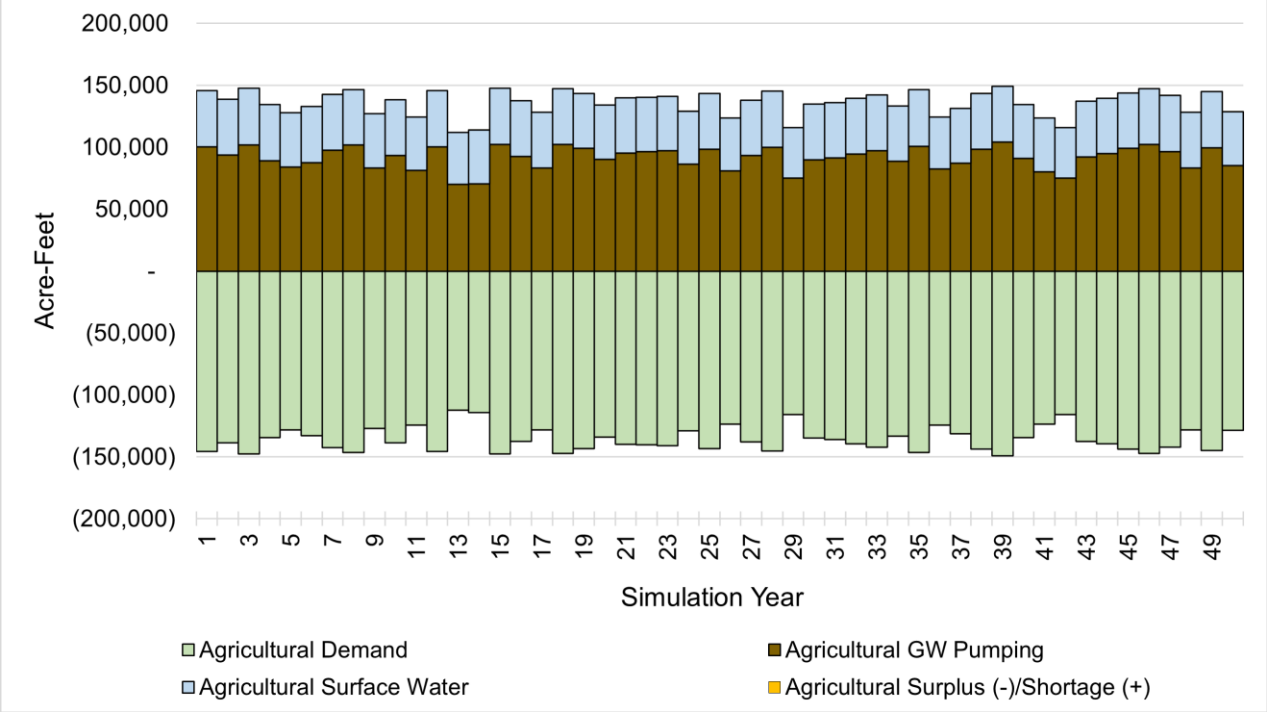


Figure 5-23: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline

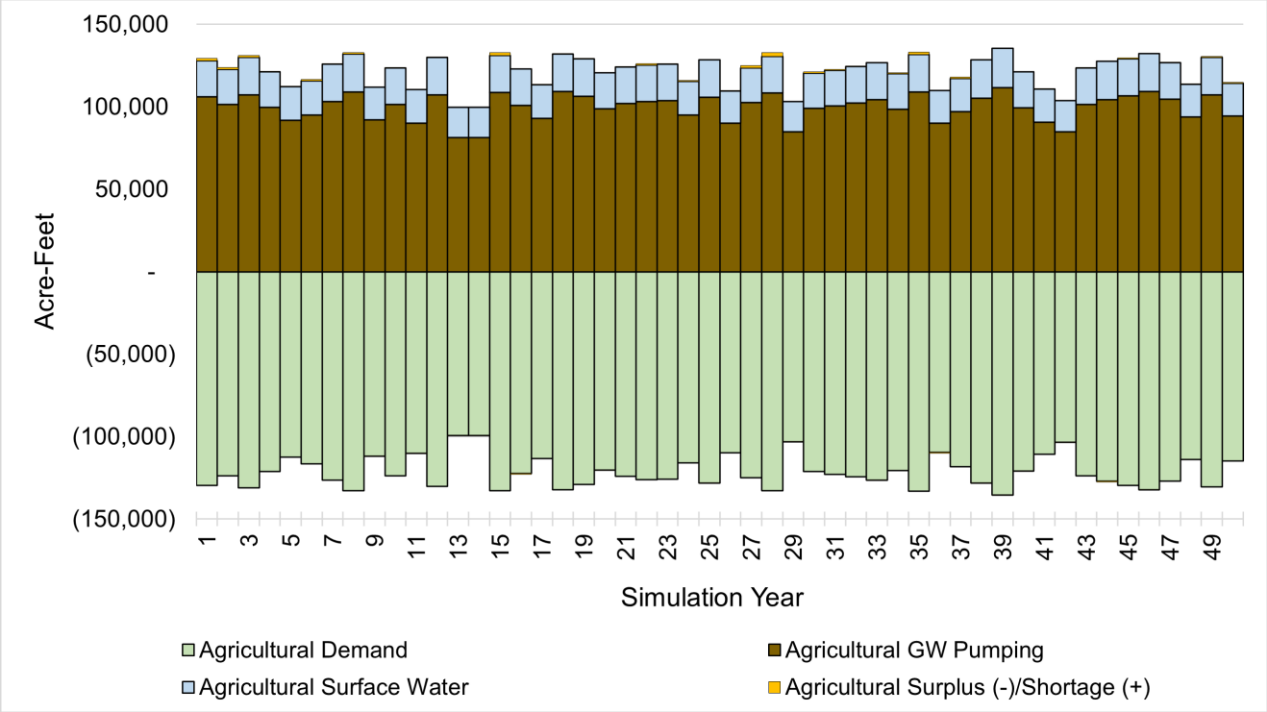


Figure 5-24: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline

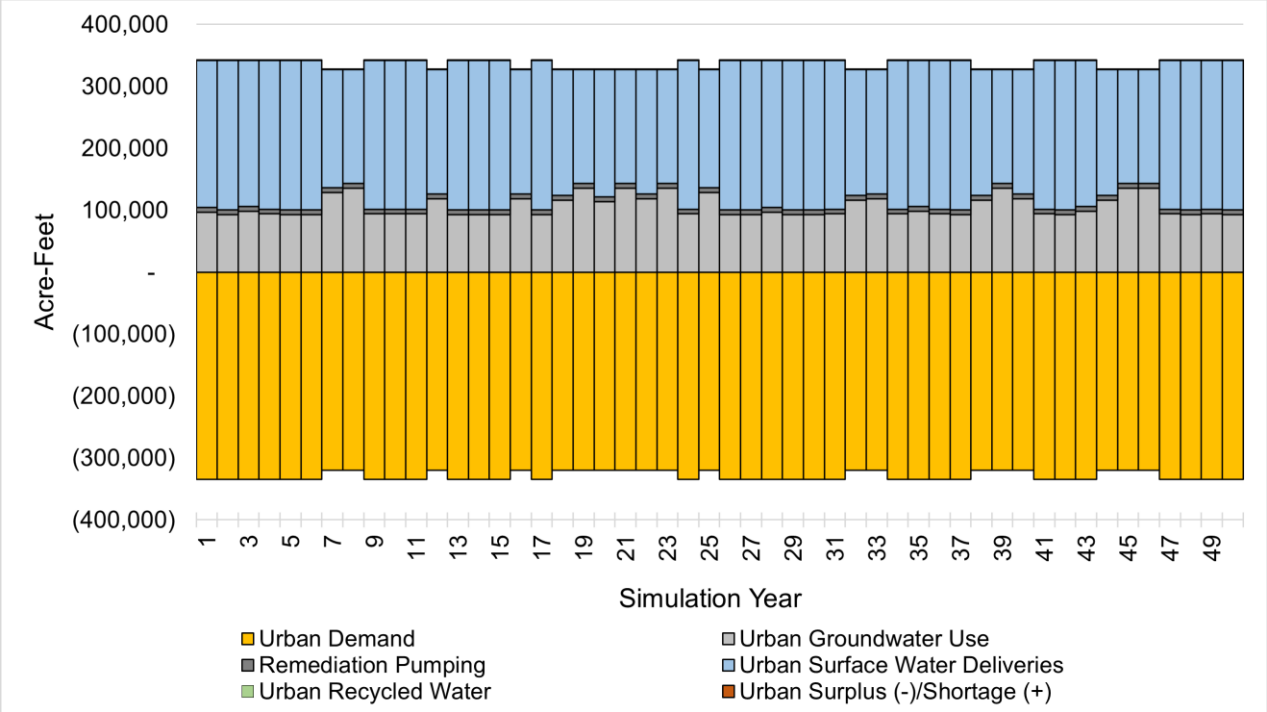


Figure 5-25: Annual Urban Water Demand and Supply – North American Subbasin, Projected Conditions Baseline

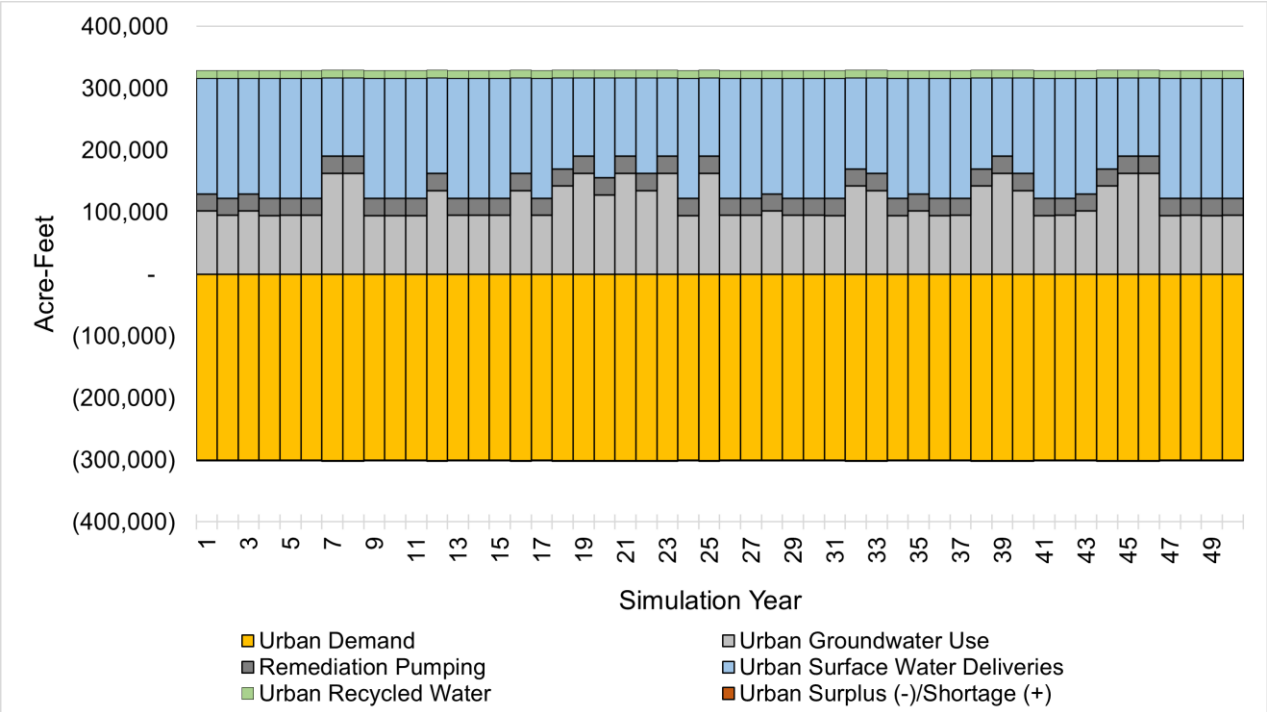
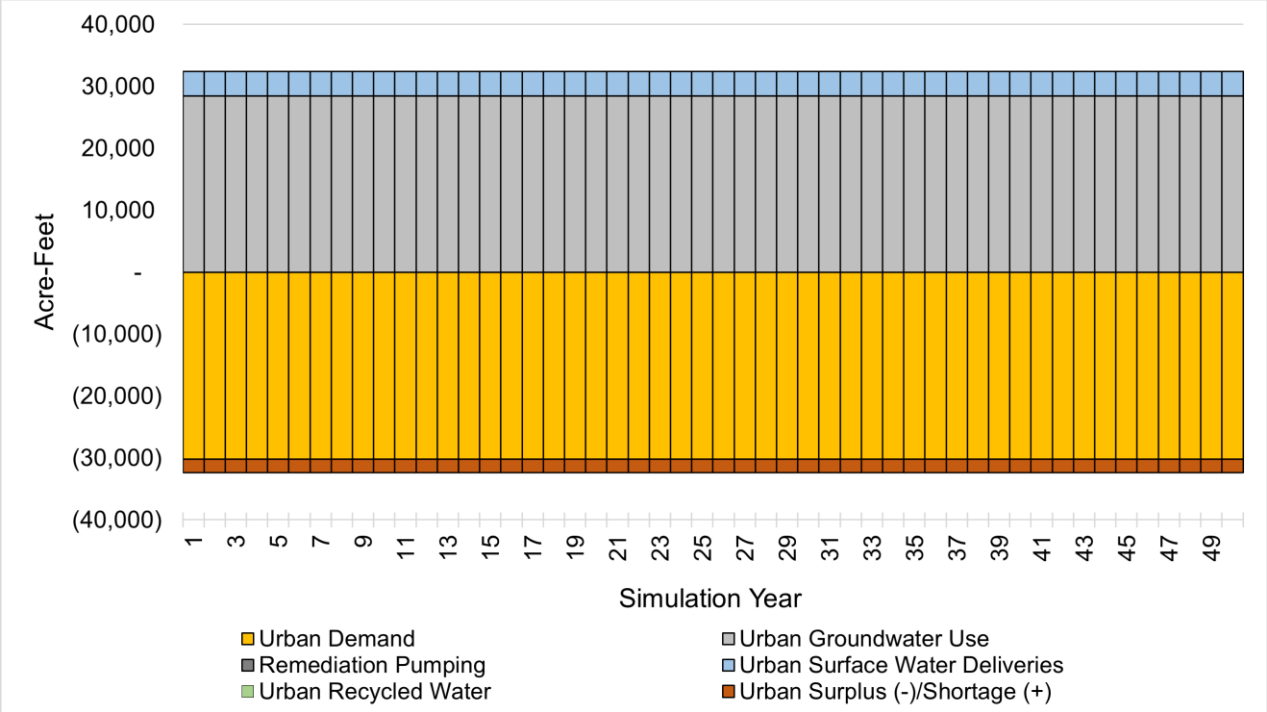


Figure 5-26: Annual Urban Water Demand and Supply – South American Subbasin, Projected Conditions Baseline



Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.

Figure 5-27: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline

5.2.6.2 Groundwater Budget

The groundwater budget summarizes all inflows and outflows to the groundwater aquifer system. Average annual PCBL model results by groundwater subbasin are shown in Table 5-6. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-28 through Figure 5-30. Appendix I includes model subregion groundwater budgets. Appendix J includes a set of sample hydrographs for the baseline models.

Table 5-6: PCBL Average Annual Groundwater Budget

Subbasin	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Boundary Flows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
NASb	323,167	167,424	107,950	16,376	30,140	6,710	5,390
SASb	234,003	121,313	105,665	26	4,886	986	-1,128
CoSb	128,332	107,977	16,494	0	1,536	1,030	-1,293
Total	**685,501**	**396,714**	**230,109**	**16,402**	**36,561**	**8,726**	**2,969**

Note: Boundary Flows term includes flow between areas outside of the CoSANA model domain and baseflow from small watersheds. Subsurface Inflows includes flow between the simulated subbasins in CoSANA and areas outside of Bulletin 118 subbasins.

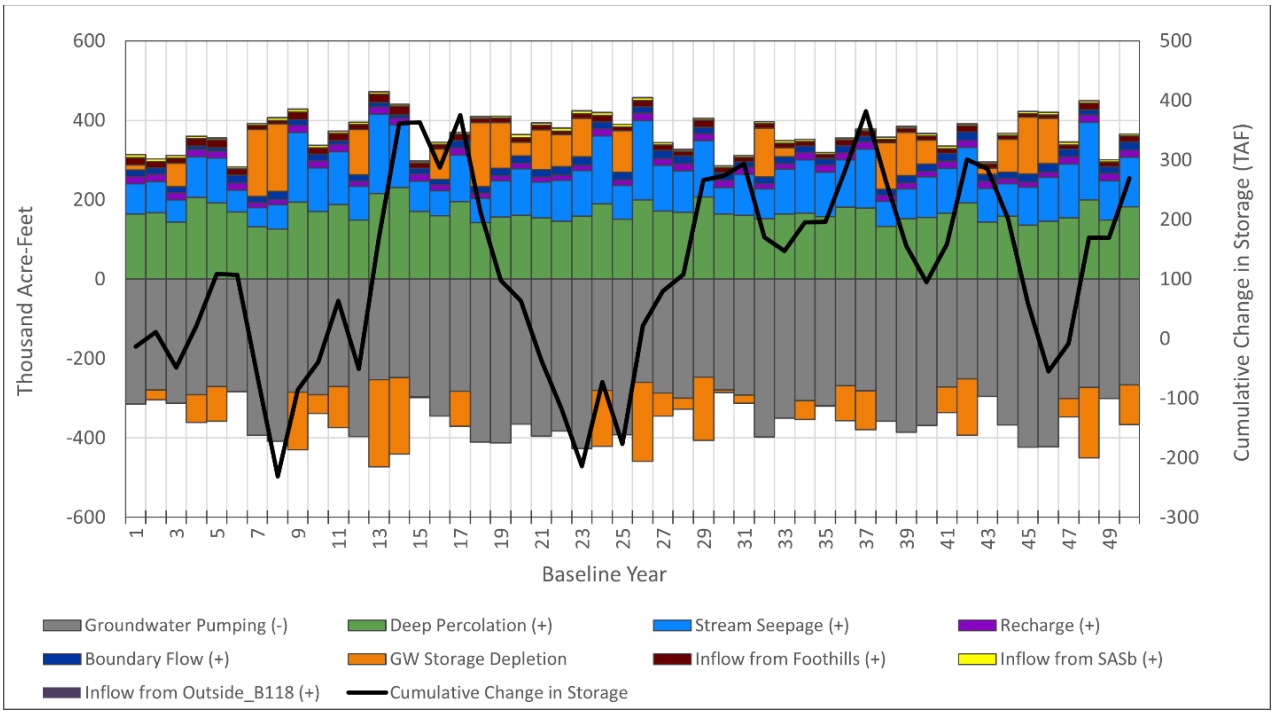


Figure 5-28: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline

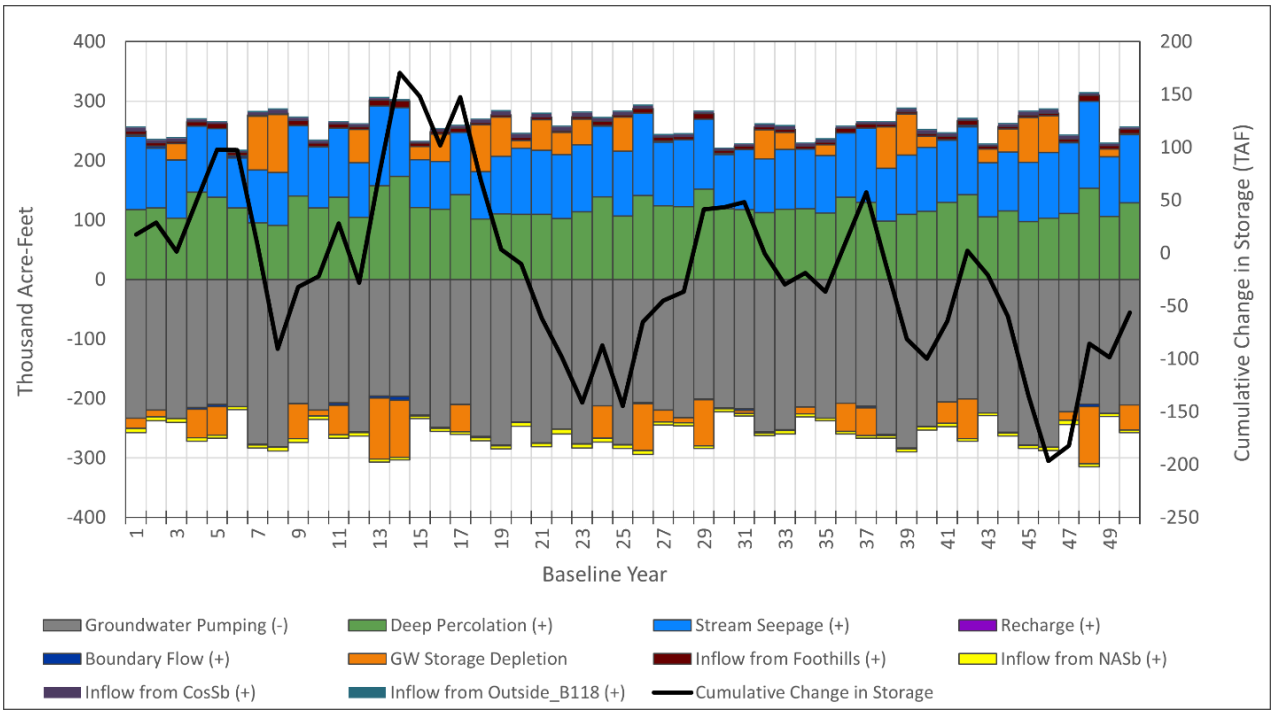


Figure 5-29: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline

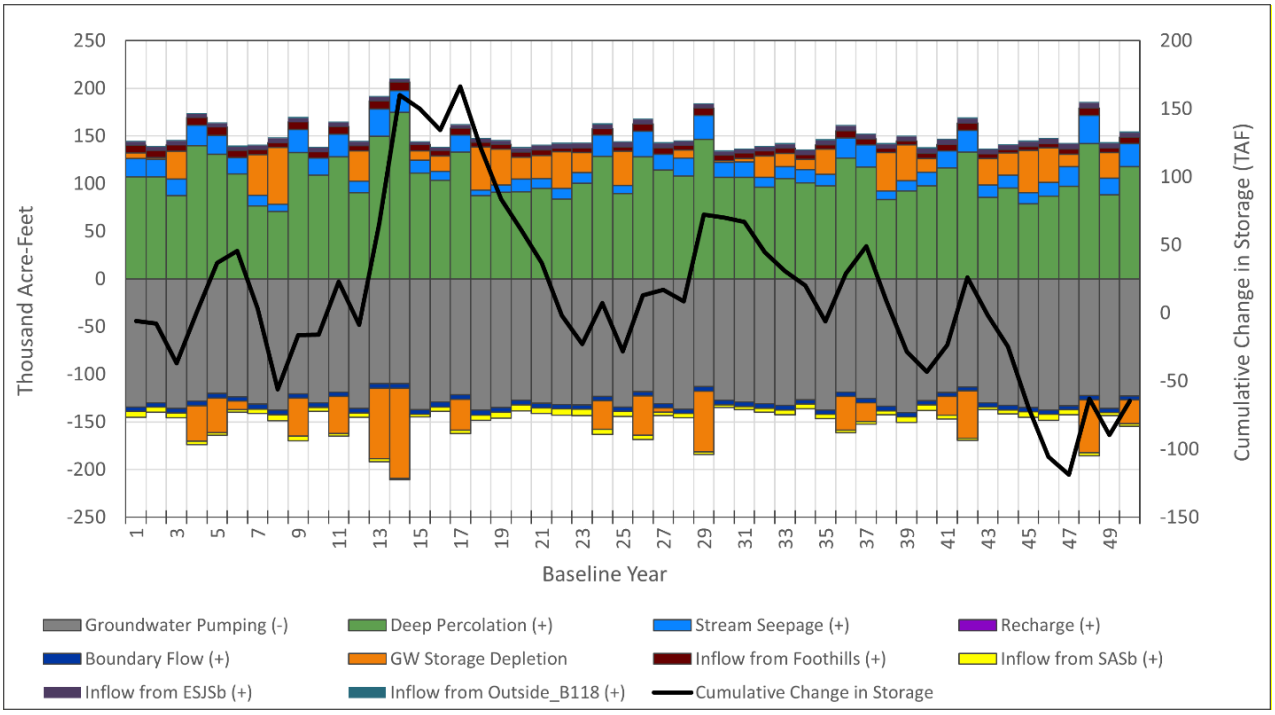


Figure 5-30: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline

5.3 Projected Conditions Baseline with Climate Change

The CoSANA Projected Conditions Baseline with Climate Change (PCBL with Climate Change) shares many of the same inputs as the PCBL, but with additional factors to incorporate potential climate change conditions. These conditions affect the hydrologic cycle as changes in precipitation and temperature. In the CoSANA model files, the change in precipitation is incorporated by the precipitation rate and stream inflow inputs while the change in temperature is reflected by the change in evapotranspiration rate and stream inflow inputs. Changes in water use are incorporated by estimation of agricultural water demands within CoSANA based on changes in precipitation and evapotranspiration. Urban water use is assumed to remain unchanged, based on assumed changes in conservation and landscape choices.

5.3.1 Hydrologic Period

The hydrologic period used for the projected conditions baseline with climate change is the same as the projected conditions baseline (WY 1970 to 2019), modified according to the methodology explained below to incorporate climate change conditions.

5.3.1.1 Methodology

In order to incorporate climate change conditions, precipitation, stream inflow, and evapotranspiration time series data from the projected conditions baseline are modified using the findings from the American River Basin Study (ARBS; Reclamation, in press). ARBS aims to examine the water management challenges around the American River Basin under recent changes in conditions, regulatory requirements, and the science of climate change. Towards this goal, ARBS provides regional climate change data with improved resolution that can be used with other modeling and planning studies.

ARBS used 64 downscaled climate projections with 1/16-degree grid resolution from 32 global climate models under RCP4.5 and RCP8.5 emissions scenarios. These 64 scenarios are then evaluated for three future periods (2040-2069, 2055-2084, and 2070-2099) and grouped into five climate scenarios based on percentiles of projected changes to simulate possible temperature and precipitation effects: Warm-Wet, Warm-Dry, Hot-Wet, Hot-Dry, and Central-Tendency.

The ensemble of climate models used in the study found clear trends with projected temperature changes. Precipitation trends were not found to be as consistent with around half of the projections indicating an increase in precipitation, and the other half indicating a decrease in precipitation.

Upon evaluation of these climate scenarios, the Central Tendency scenario for the 2055-2084 period, also commonly called as 2070CT conditions, was selected for groundwater sustainability planning because it was determined that it has the highest probability and likelihood to be experienced. Other climate scenarios are subject to significantly more uncertainty and less likely to occur. Additionally, to assess uncertainty and the effects of a possible extreme condition, the 2055-2084 Hot-Dry (2070HD) scenario was also simulated, with results presented in Section 5.3.7.

In ARBS, the downscaled climate variables of the scenarios were then used with the Variable Infiltration Capacity (VIC) hydrology model to simulate hydrologic conditions at the land surface. VIC uses a spatial grid that covers the entire CoSANA model domain. This grid was used to resample the precipitation time series from 2070CT and 2070HD conditions to the CoSANA model grid and for the small watersheds using area weighted averaging.

ARBS uses the outputs from the VIC model to develop corresponding inputs to the operations model CalSim 3.0 that covers the entire Sacramento and San Joaquin River Basins. One of those inputs is the evapotranspiration rates for each crop type. For the PCBL with Climate Change scenarios in CoSANA, evapotranspiration time series input from the PCBL were perturbed with the perturbation factors calculated between the 2070CT and 2070HD climate change scenarios and the 2015 baseline scenario for each crop type averaged across the CoSANA domain. Additionally, stream inflow time series input at six locations (Sacramento River at Verona, Folsom Reservoir releases, Cosumnes River, Camanche Reservoir release, Bear River, and Feather River) were replaced with the simulated flows by CalSim 3.0 in ARBS.

A summary comparison table of the ARBS historical baseline hydrology and percent changes to different system components in the 2070CT and 2070HD is shown in Table 5-7.

Table 5-7: Percent Change in Annual Climatic and Hydrologic Indicators in the American River Basin Study*

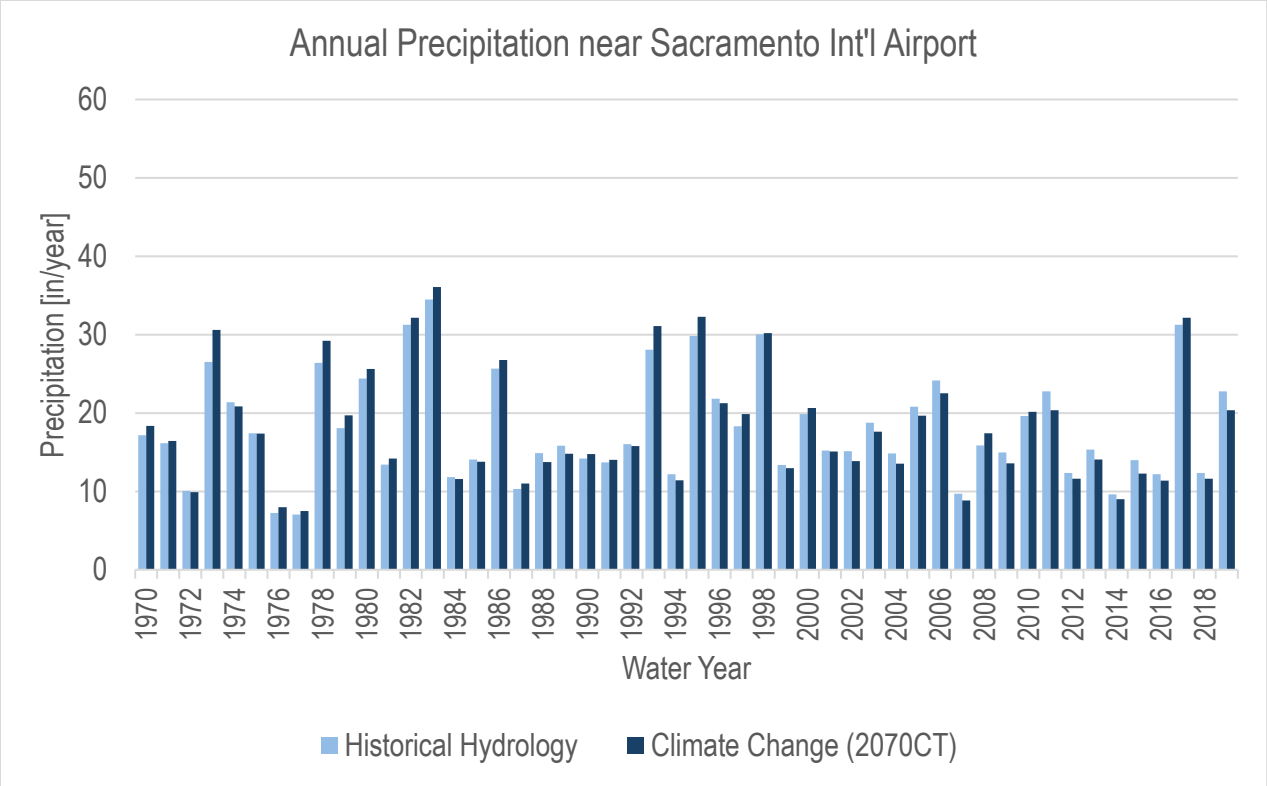
Climate Scenario	Precipitation	Temperature (average)	Potential Evapotranspiration	Runoff
Historical Observations (1915-2015 average)	38.2 inches	54.8^{0}F	42.8 inches	1,458,000 AFY
2070 Central-Tendency	-3%	+11%	+10%	-6%
2070 Hot and Dry	-9%	+14%	+12%	-13%

* The values are for the entire American River Basin Study area and are based on Table 2-4 in the study report.

5.3.1.2 Precipitation

Annual precipitation near Sacramento International Airport and on the small watershed areas are shown in Figure 5-31 for with- and without-climate change conditions for comparison purposes. As a result of the 2070CT climate change conditions, average annual precipitation increased from 17.5 inches to 17.8 inches on the valley floor and increased from 30.6 inches to 30.9 inches on the small watersheds.

Figure 5-32 illustrates the changes in average monthly precipitation before and after climate change conditions are applied. For both the valley floor and the small watersheds, a slight shift in the distribution of precipitation can be observed.



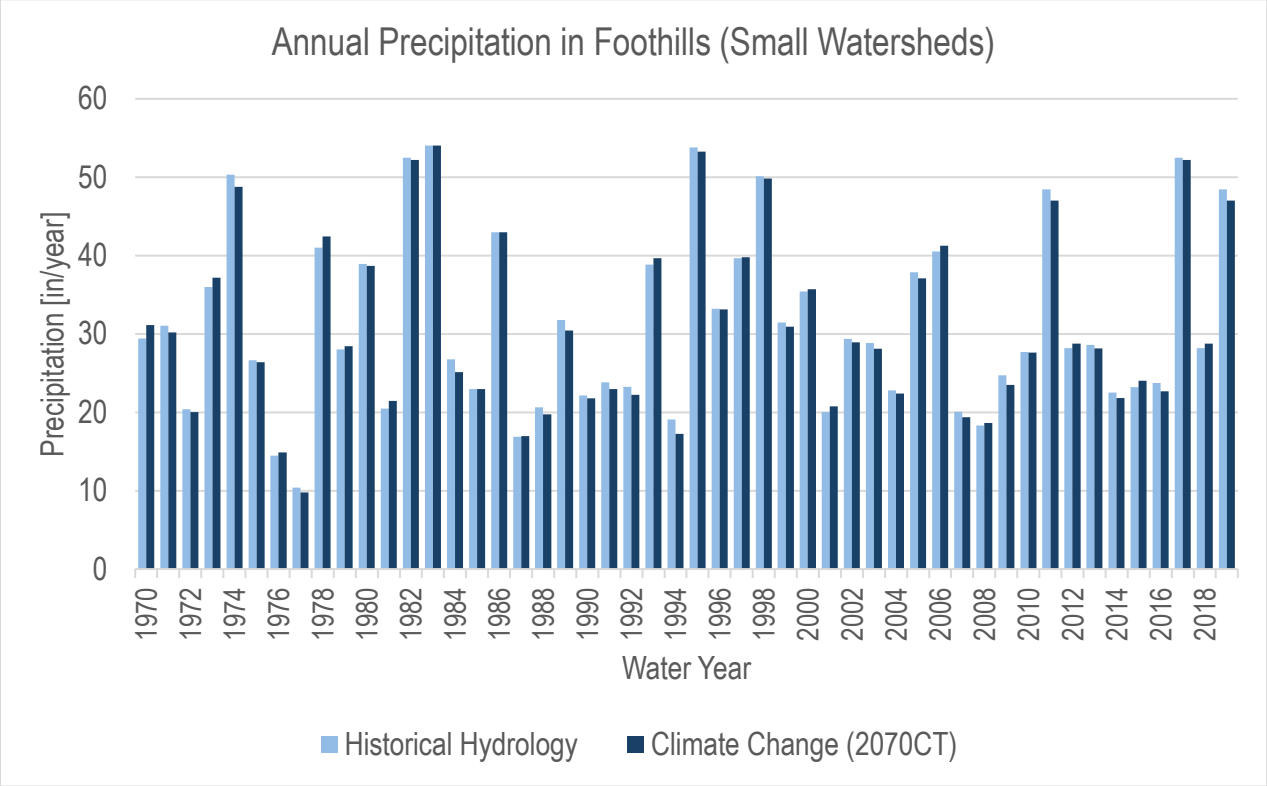
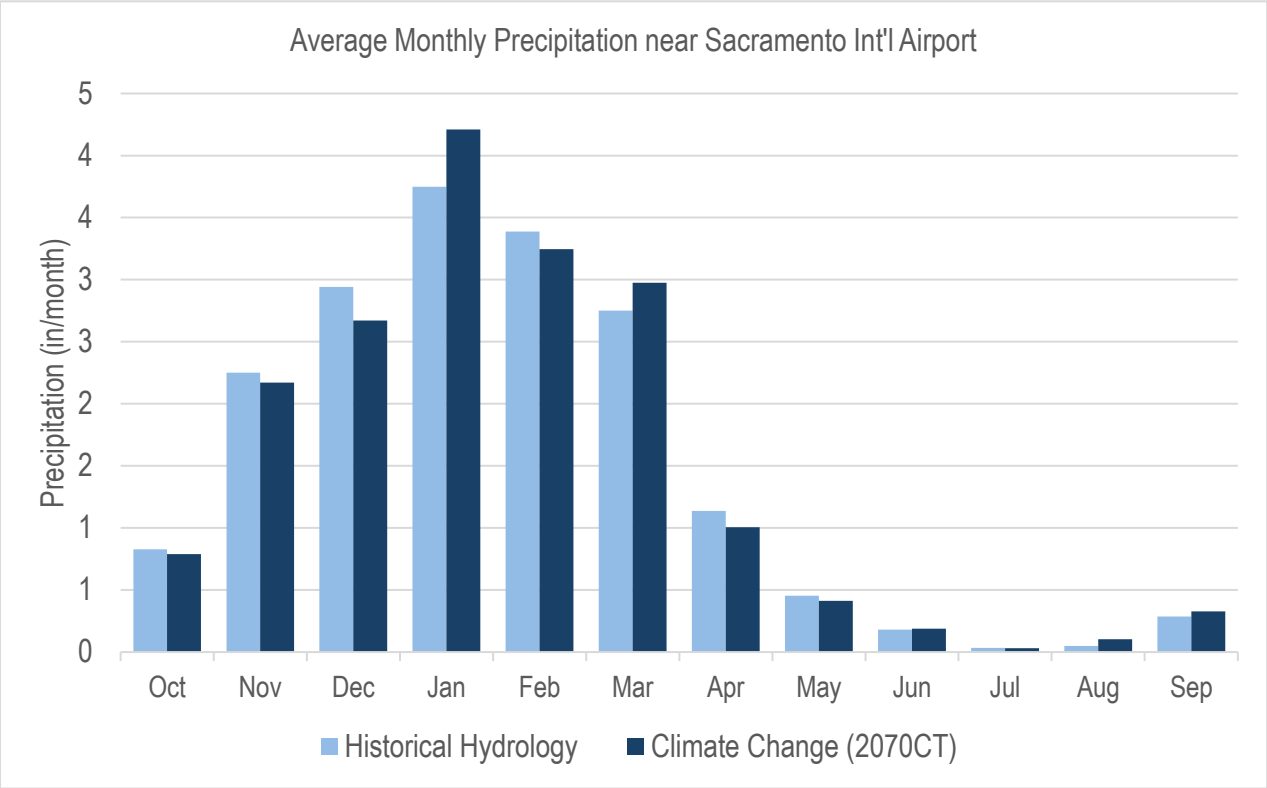


Figure 5-31: Annual Precipitation with and without Climate Change



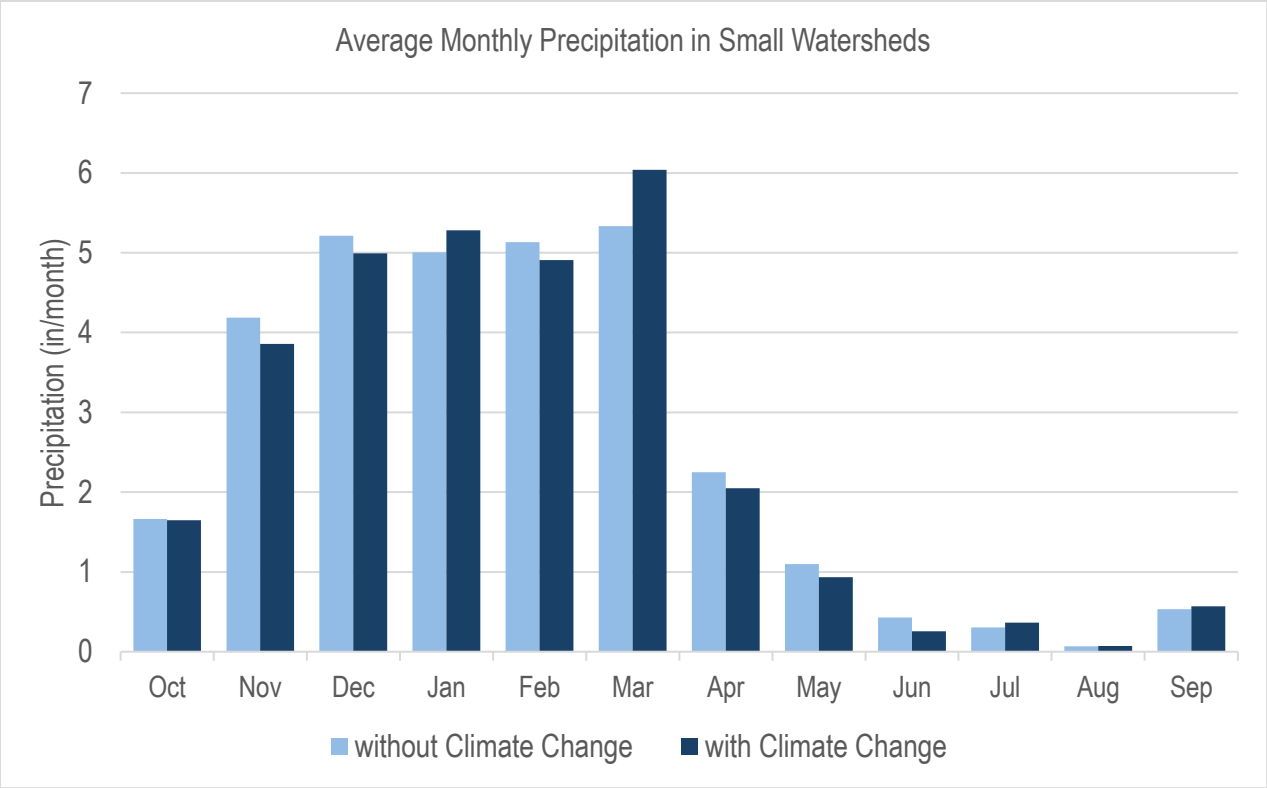


Figure 5-32: Average Monthly Precipitation with and without Climate Change

5.3.1.3 Stream Inflow

Major stream flows entering to the CoSANA domain were modified to accommodate the climate change according to 2070CT conditions. In Figure 5-33, American River releases from the Folsom Reservoir are shown with and without climate change for comparison purposes. As a result of the 2070CT climate change conditions, average annual stream flow on the American River below Folsom Reservoir is decreased from around 3,500 cubic feet per second (cfs) to around 3,000 cfs.

Figure 5-34 illustrates the changes in average monthly stream inflow before and after climate change conditions are applied. According to this chart average flows in early winter and late spring decrease, while March flows increase.

An exceedance chart comparing the monthly Folsom Reservoir Release to American River is given in Figure 5-35 According to this chart, peak monthly flows show an increase in probability, while the probability of lower flows show a slight decrease.

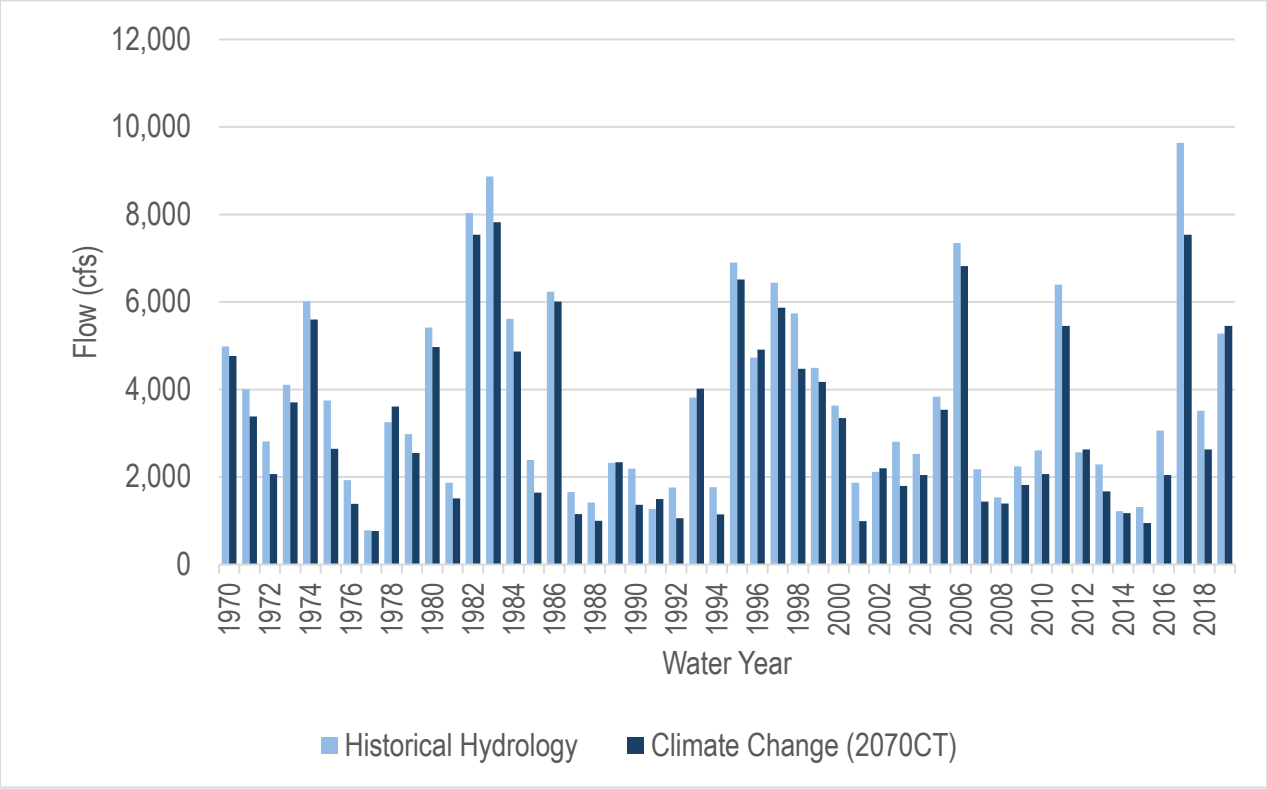


Figure 5-33: Annual Folsom Reservoir Releases to American River with and without Climate Change

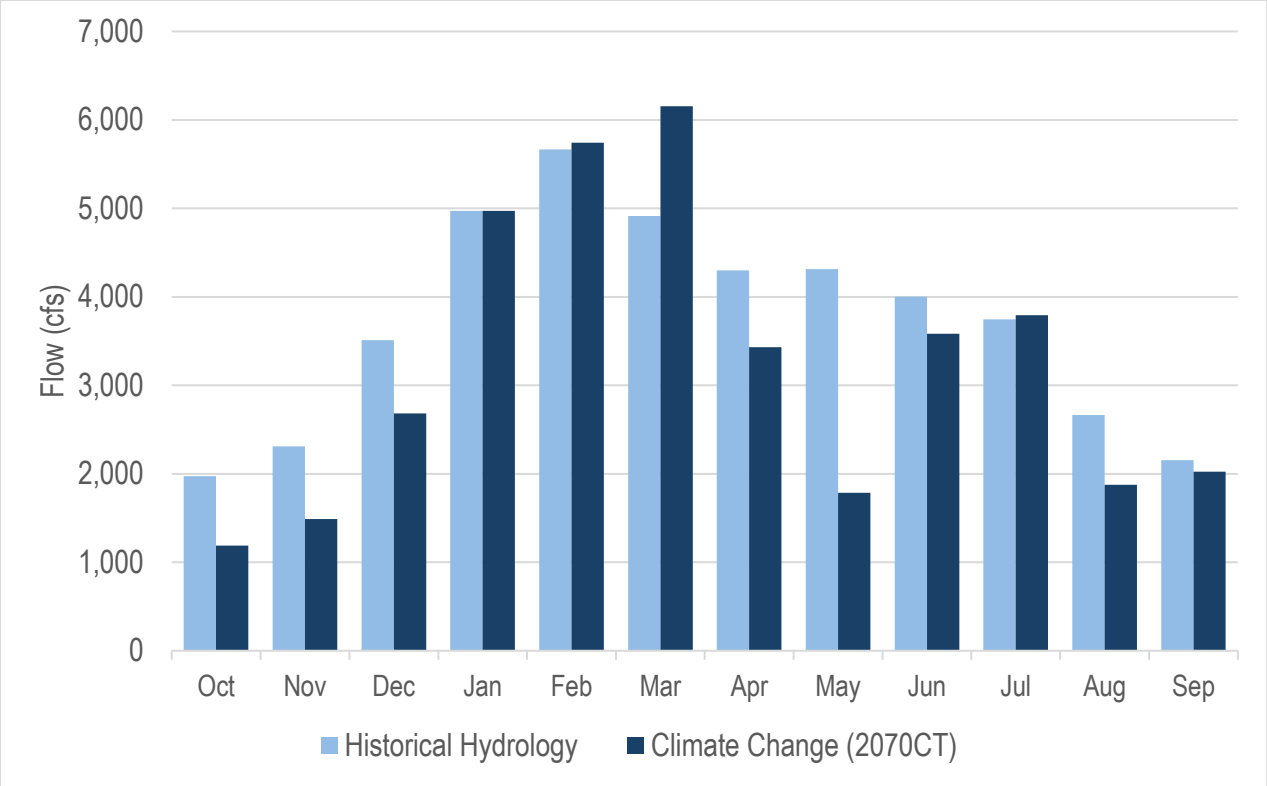


Figure 5-34: Monthly Average Folsom Reservoir Releases to American River

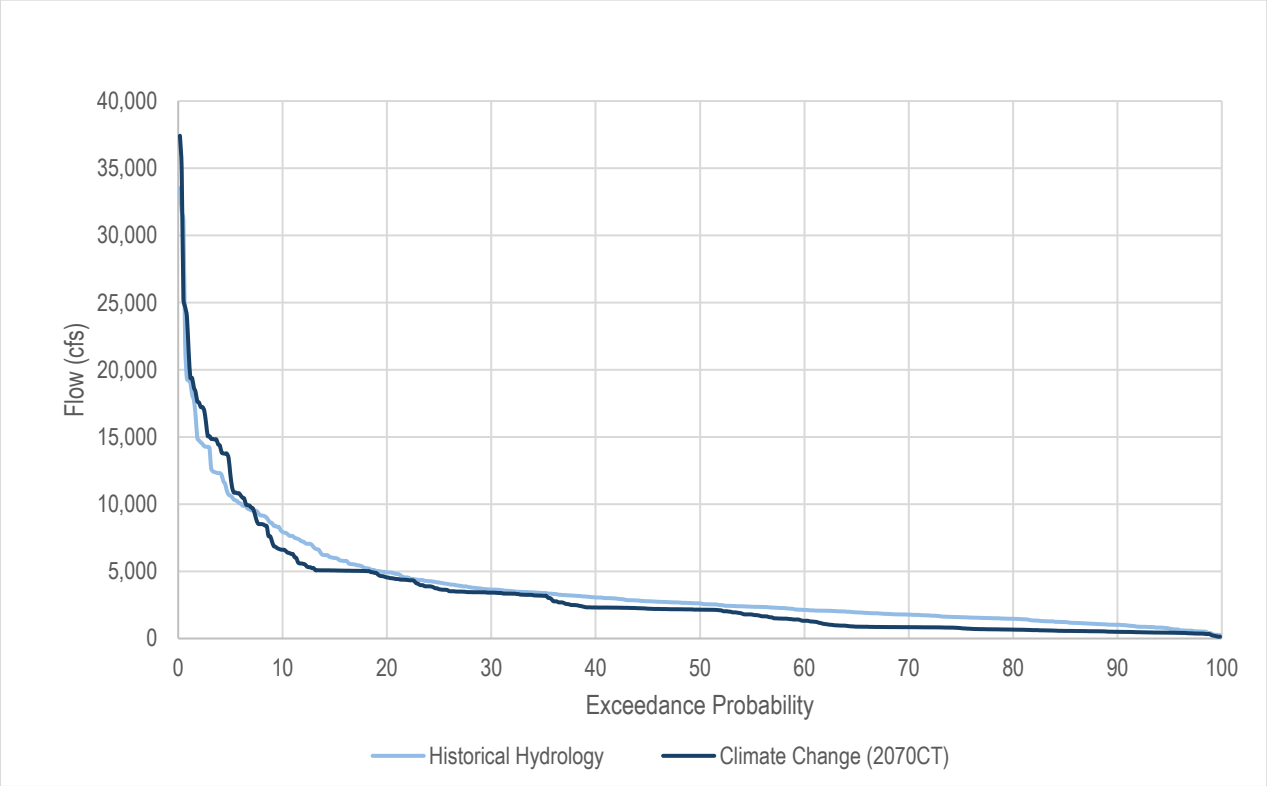


Figure 5-35: Exceedance Chart for the Monthly Folsom Reservoir Releases to American River

5.3.1.4 Evapotranspiration

Potential evapotranspiration time series data for each land cover type in CoSANA were modified to accommodate climate change according to 2070CT conditions. 2070CT conditions predict higher temperature than historical conditions which will result in higher potential evapotranspiration rates. Annual potential evapotranspiration for pasture over the valley floor is shown in Figure 5-36 for with- and without-climate change conditions for comparison purposes. Among all the land cover types defined in CoSANA, pasture was chosen here for its similarity to the reference evapotranspiration. As a result of the 2070CT climate change conditions, average annual potential evapotranspiration for pasture is expected to increase from 49.9 inches to 54.6 inches. Figure 5-37 illustrates the changes in average monthly potential evapotranspiration for pasture before and after climate change conditions are applied.

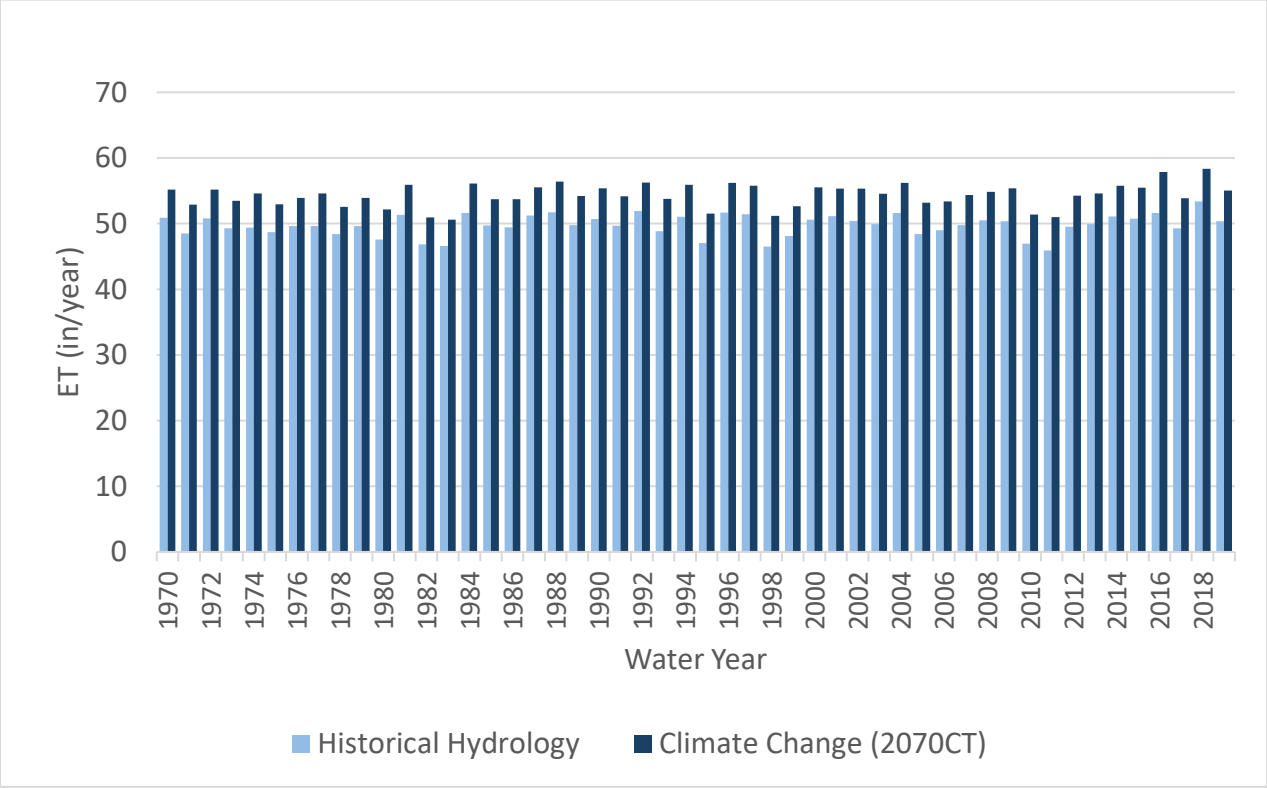


Figure 5-36: Annual Potential Evapotranspiration for Pasture

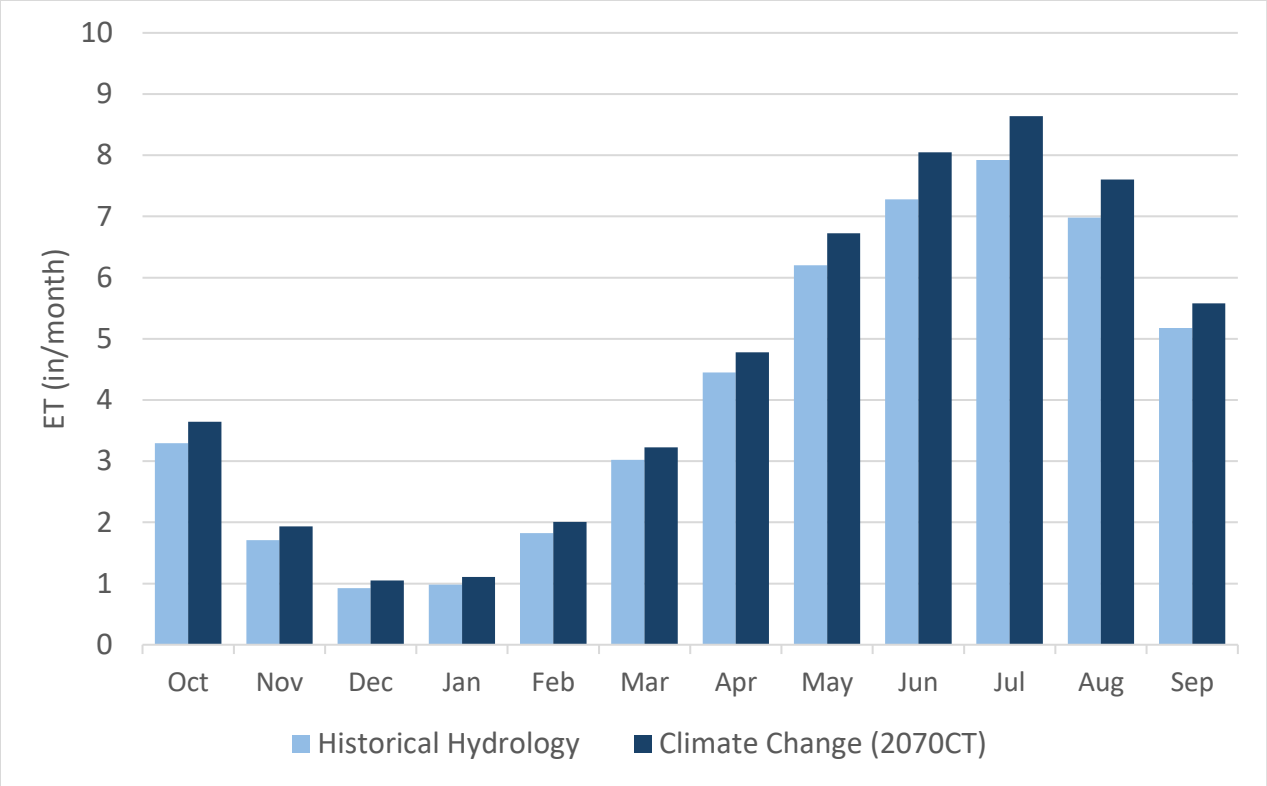


Figure 5-37: Monthly Average Potential Evapotranspiration for Pasture.

5.3.2 Land Use

The PCBL with Climate Change land use is the same as the PCBL, described in Section 5.2.2.

5.3.3 Urban Demand and Supply

The PCBL with Climate Change urban demand and supply is the same as the PCBL, described in Section 5.2.3. It is noted that water demands for urban landscape will increase with increasing ET under climate change, however demand and supply remain unchanged in the baseline due to likely changes in ordinances and likely changes in landscaping practices.

5.3.4 Agricultural Demand and Supply

The PCBL with Climate Change agricultural demand and supply is based on the PCBL, described in Section 5.2.4. The agricultural demand under the climate change conditions is impacted by the effect of climate change on the hydrology, notably evapotranspiration, which increases demands. The increased supply needed to meet this demand is typically met by additional groundwater pumping.

5.3.5 Remediation Operations

Information about future remediation operations is not available, so remediation operations in the PCBL with Climate Change are the same as in the CCBL, discussed in Section 5.1.7.

5.3.6 Results

This section provides a summary of the CoSANA PCBL with Climate Change results.

5.3.6.1 Land and Water Use Budget

The land and water use budget provides details on urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, and remediation pumping). Average annual PCBL with Climate Change model results by groundwater subbasin are shown in Table 5-8. Annual agricultural water demand and supply by subbasin are shown in Figure 5-38 through Figure 5-40. As discussed in Section 5.3.3, urban demand and supply for the PCBL with Climate Change are the same as the PCBL; refer to Figure 5-25 through Figure 5-27 for urban land and water use budgets. Appendix H includes model subregion land and water use budgets.

Table 5-8: PCBL with Climate Change Average Annual Land and Water Use Budget

Subbasin	Ag. Demand (AFY)	Ag. Ground-Water Use* (AFY)	Ag Surface Water Deliveries (AFY)	Urban Demand (AFY)	Urban Ground-Water Use** (AFY)	Urban Surface Water Deliveries (AFY)	Urban Recycled Water (AFY)	Remediation Pumping (AFY)
NASb	372,286	222,061	152,544	328,654	108,492	220,161	-	5,515
SASb	148,520	103,348	45,178	301,060	116,385	167,661	17,200	29,765
CoSb	132,348	108,831	22,744	30,168	28,445	3,943	-	-
Total	**653,154**	**434,240**	**220,466**	**659,882**	**253,322**	**391,765**	**17,200**	**35,280**

Notes:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

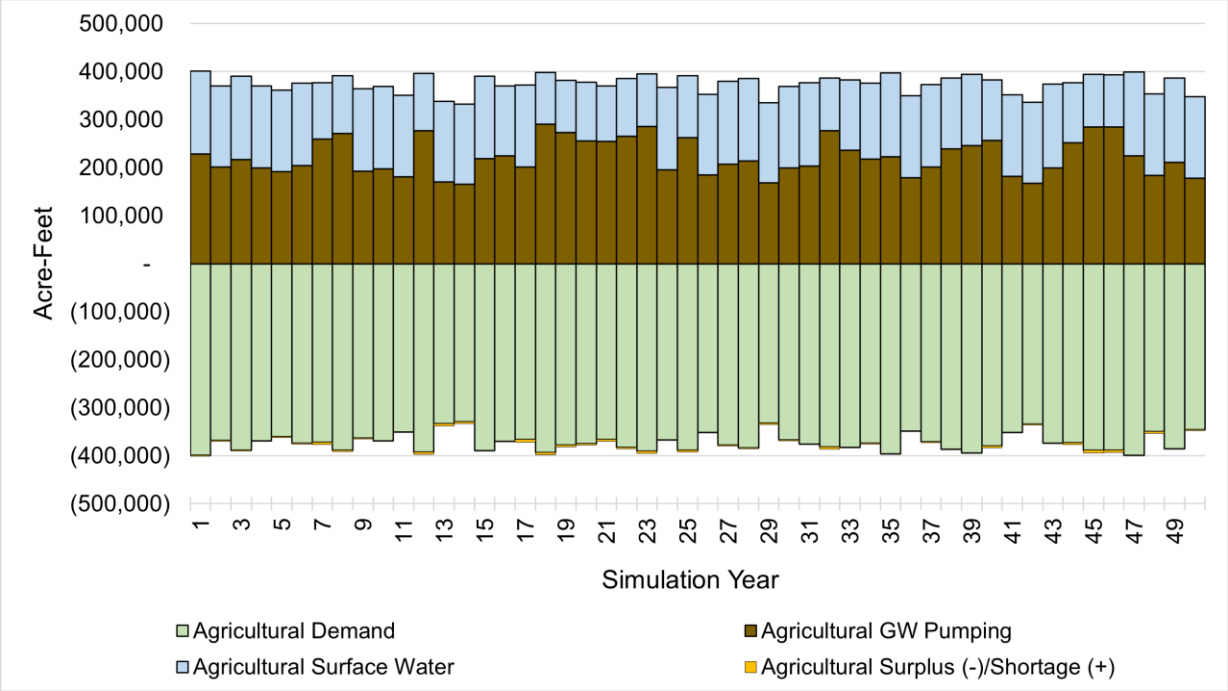


Figure 5-38: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline with Climate Change

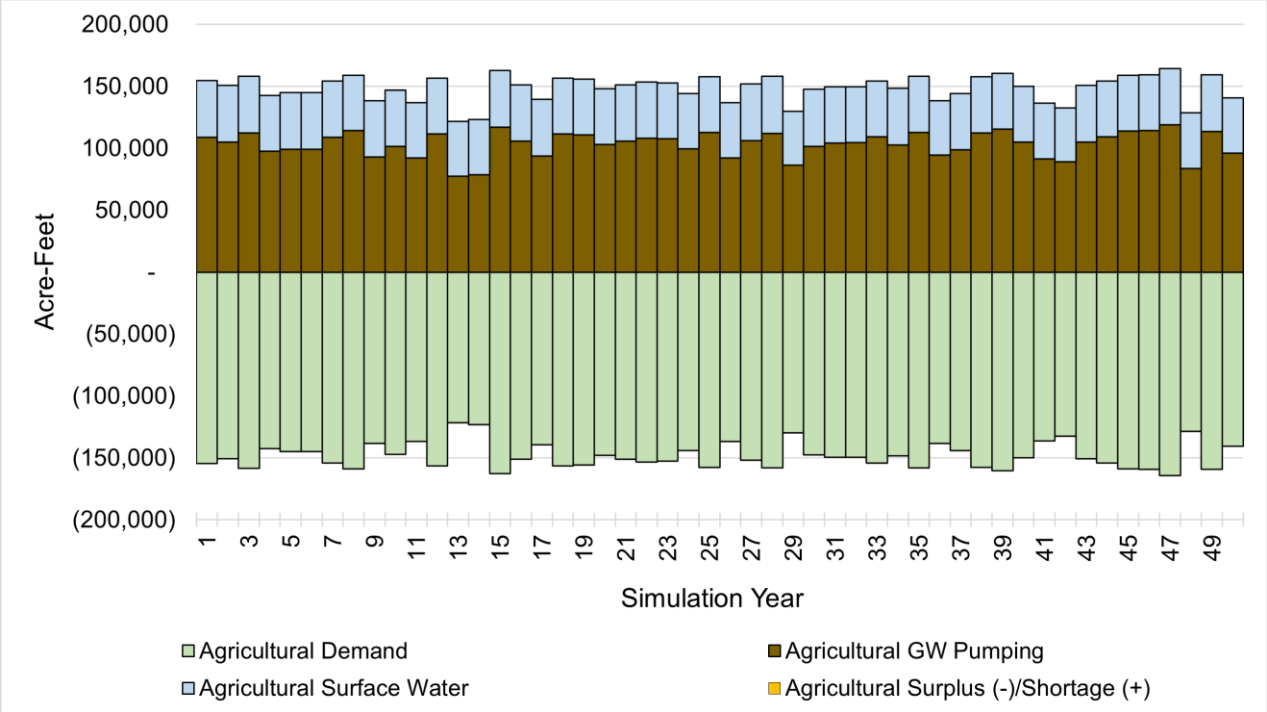


Figure 5-39: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline with Climate Change

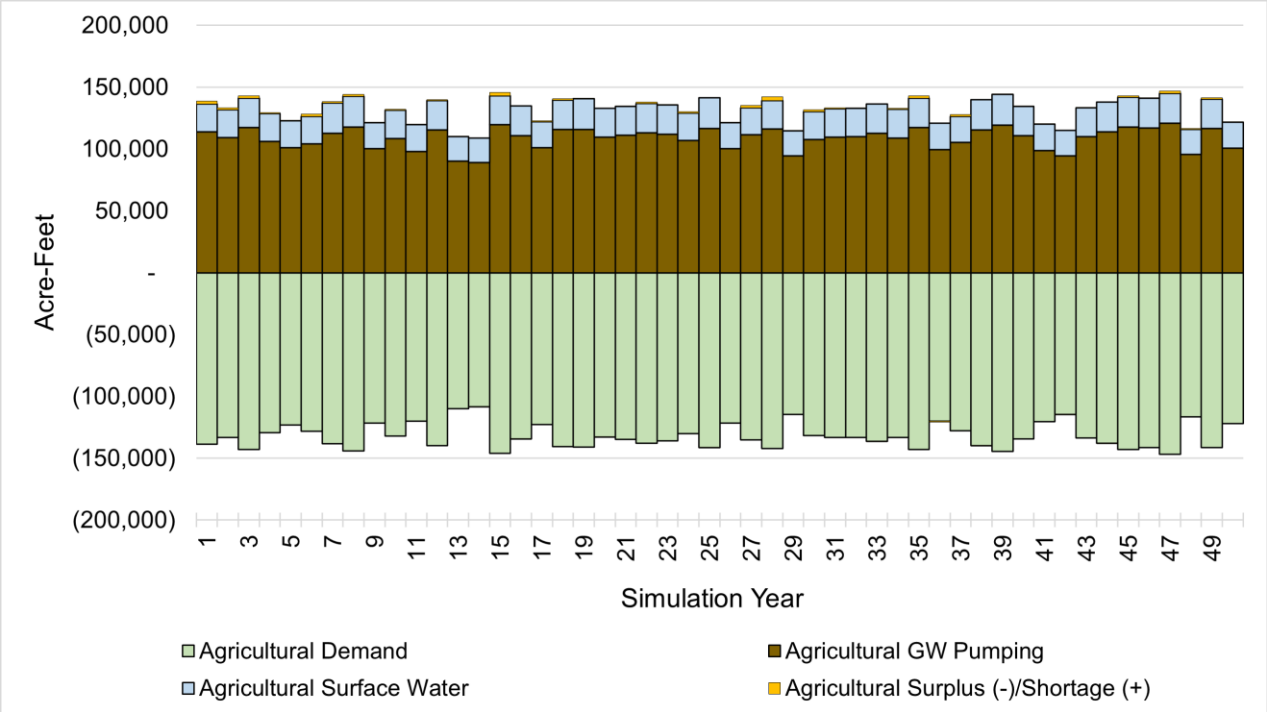


Figure 5-40: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change

5.3.6.2 Groundwater Budget

The groundwater budget provides all inflows and outflows to the groundwater aquifer system. Average annual PCBL with Climate Change model results by groundwater subbasin are shown in Table 5-9. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-41 through Figure 5-43. Appendix I includes model subregion groundwater budgets. Appendix J includes a set of sample hydrographs for the baseline models.

Table 5-9: PCBL with Climate Change Average Annual Groundwater Budget

Subbasin	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Boundary Flows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
NASb	343,000	160,987	122,181	16,401	32,744	7,228	-3,502
SASb	245,752	114,730	118,164	26	6,198	411	-6,222
CoSb	137,276	101,490	20,744	0	1,540	3,739	-9,762
Total	**726,028**	**377,207**	**261,089**	**16,427**	**40,481**	**11,378**	**-19,486**

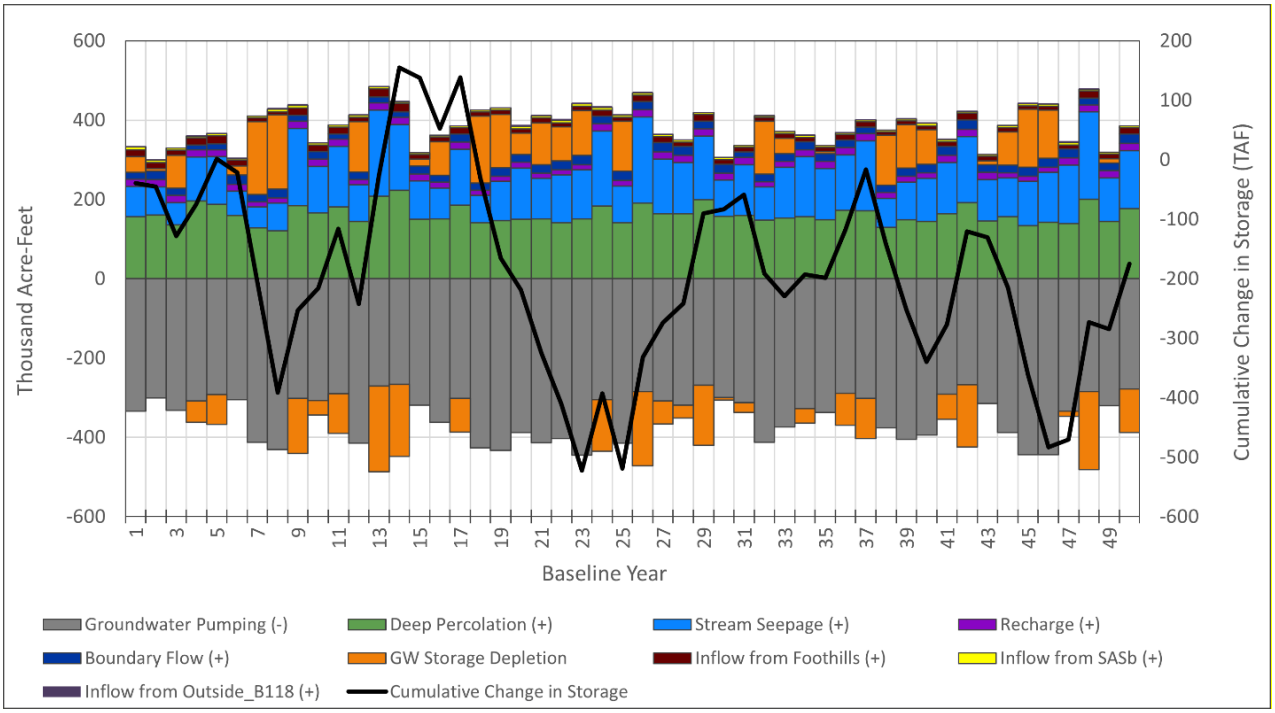


Figure 5-41: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline with Climate Change

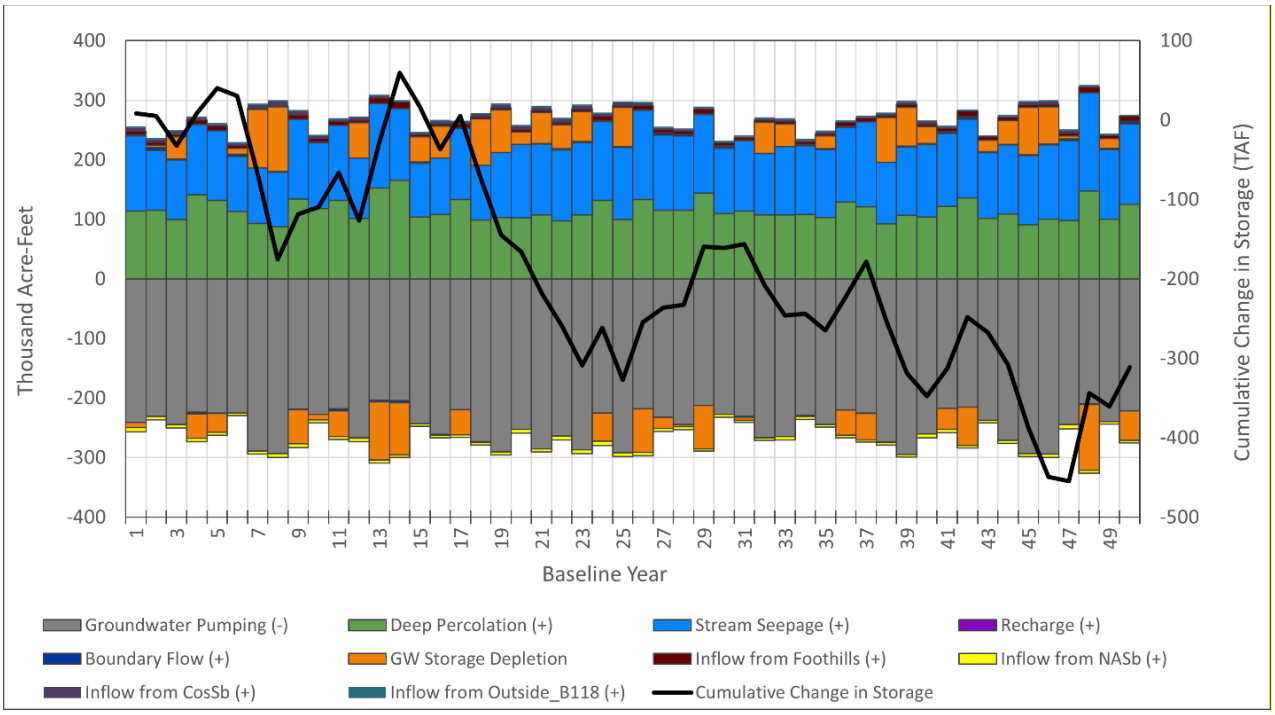


Figure 5-42: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline with Climate Change

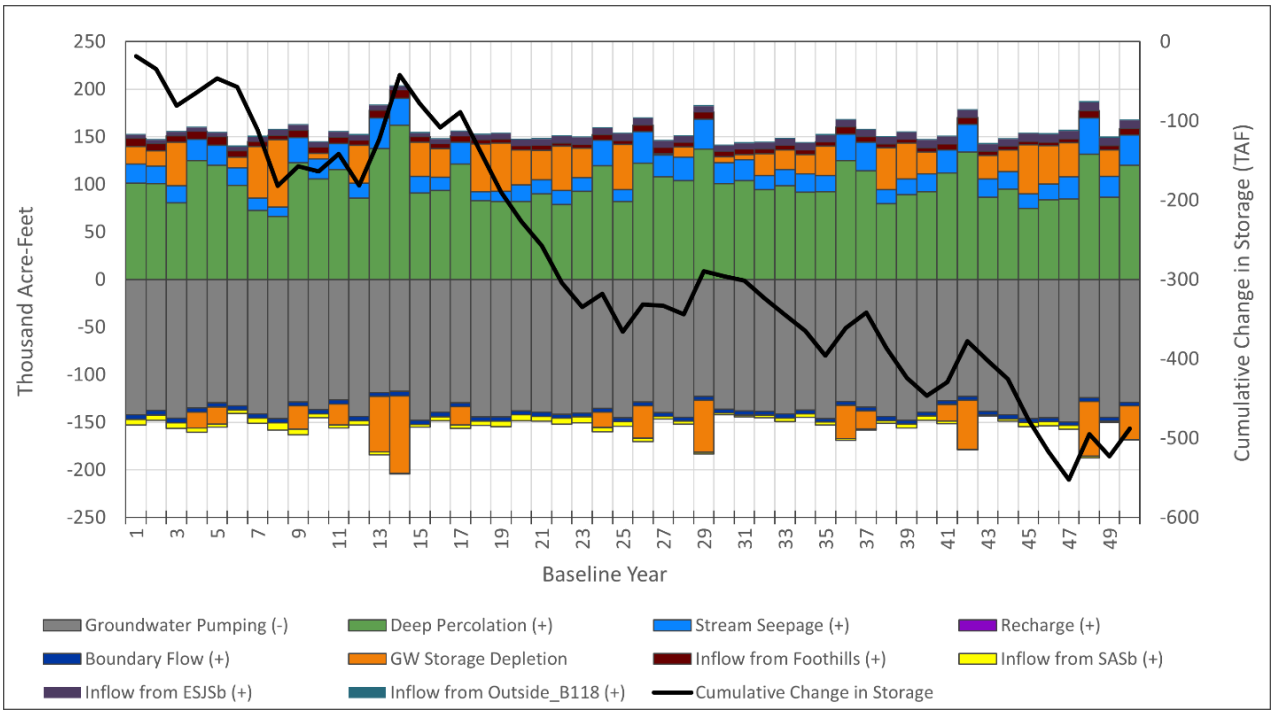


Figure 5-43: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change

5.3.7 Sensitivity Analysis: Hot-Dry Scenario

The 2070HD scenario was analyzed as an extreme case to determine the potential effects of the 2070HD scenario on the groundwater and surface water systems. 2070HD simulates lower overall precipitation, and higher temperature, than the 2070CT. A comparison of groundwater budgets (summation of the 3 subbasins, does not include areas outside of NASb, SASb, and CoSb) can be seen in Table 5-10 below.

Table 5-10: Comparison Groundwater Budgets of CoSANA Climate Change Models to the Projected Conditions Baseline

Model Version	Subbasin	Pumping (AFY)	Deep Percolation (AFY)	Gain from Stream (AFY)	Recharge from Canals (AFY)	Boundary Flows (AFY)	Subsurface Inflow (AFY)	Change in Storage (AFY)
PCBL	NASb	323,167	167,424	107,950	16,376	30,140	6,710	5,390
PCBL	SASb	234,003	121,313	105,665	26	4,886	986	-1,128
PCBL	CoSb	128,332	107,977	16,494	0	1,536	1,030	-1,293
PCBL	**Total**	**685,501**	**396,714**	**230,109**	**16,402**	**36,561**	**8,726**	**2,969**
PCBL+CC (2070CT)	NASb	343,000	160,987	122,181	16,401	32,744	7,228	-3,502
PCBL+CC (2070CT)	SASb	245,752	114,730	118,164	26	6,198	411	-6,222
PCBL+CC (2070CT)	CoSb	137,276	101,490	20,744	0	1,540	3,739	-9,762
PCBL+CC (2070CT)	**Total**	**726,028**	**377,207**	**261,089**	**16,427**	**40,481**	**11,378**	**-19,486**
PCBL+CC (2070HD)	NASb	351,979	155,616	128,609	16,410	33,728	7,482	-10,179
PCBL+CC (2070HD)	SASb	250,445	110,570	122,767	26	7,058	614	-9,409
PCBL+CC (2070HD)	CoSb	140,677	97,337	22,515	0	1,439	4,838	-14,545
PCBL+CC (2070HD)	**Total**	**743,100**	**363,524**	**273,892**	**16,436**	**42,224**	**12,934**	**-34,133**

As shown in Table 5-10, the 2070HD scenario leads to an overall increase in pumping of approximately 2% above the 2070CT, this is largely due to increased evapotranspiration causing an increase in agricultural demand. Decreases in deep percolation are largely attributable to decreasing precipitation. Increases in stream seepage, boundary flows, and subsurface flows are all due to lower groundwater levels being observed in the 2070HD scenario.

6. SUMMARY AND RECOMMENDATIONS

6.1 Summary

The CoSANA model is built upon the previous SacIWRM by migrating to the IWFM platform, providing finer resolution spatially and with depth, and by refining and extending the data incorporated into the model. CoSANA provides a robust, comprehensive, defensible model for assessing water resources conditions in the Sacramento region through integrated modeling of land surface, groundwater, and surface water conditions using detailed local and regional data and the DWR-supported IWFM modeling platform. This includes simulation under historical, current, projected, and projected with climate change conditions. The tool is well calibrated and ready to be used in various water supply and management studies and includes flexibility for updates and refinements to meet future needs of the region.

CoSANA simulates historical hydrology for the water year 1970 – 2018 on a monthly time step, with a focused calibration period of water years 1995 – 2018. Model calibration is based on water budgets, regional groundwater level and flow trends, groundwater level elevations at designated calibration wells, streamflows at selected stream gaging stations, interaction between the stream and the aquifer system along major river courses, surface and subsurface flow contributions from the tributary watersheds to the east, and subsurface flow directions and rates among the three groundwater subbasins within the model.

Three baseline scenarios are developed to support SGMA activities, development of the GSPs within the three subbasins, and other potential water resources planning needs. The Current Conditions Baseline, Projected Conditions Baseline, and Projected Conditions with Climate Change Baseline allow for assessment of water budgets under respective hydrologic, land and water use, and operations conditions and also facilitate analysis of future projects and management activities. The baselines incorporate 50 years of hydrology (1970-2019) to meet SGMA requirements and to provide climatic uncertainty based on 2070 Central Tendency climate change to assess future projects and management actions. A sensitivity analysis was also performed to assess the groundwater conditions under the 2070 Hot and Dry climate conditions.

6.2 Recommendations

CoSANA is intended to be a living model, which would evolve over time for better and more accurate representation of the surface and groundwater systems in the greater Sacramento area. Model refinements and updates need to take place on a regular basis to ensure the most recent and best representation of the changing needs of the region and to incorporate the latest conditions, data, and modeling platforms. During the development of the model, several items were identified for future refinements to improve the capability of CoSANA:

- **Continue collaboration and engagement with local GSAs, water purveyors, groundwater users, and water managers**. Continue working with local agencies and groundwater users in the region to further understand the local operations of the groundwater system and improve representation of groundwater users in the CoSANA.
- **Collaborate with DWR.** The fine grid version of C2VSim as well as the SVSim were developed by DWR to evaluate the integrated surface water and groundwater conditions at a regional scale, and to assess surface water-groundwater interaction and stream depletions at regional scale. CoSANA, being a local scale model with significantly more detail data and information provides a much better platform for evaluation of stream-aquifer interaction for the Sacramento area. It would be important to support the DWR in increasing the accuracy of the regional groundwater conditions in the fine grid C2VSim and SVSim, so that the regional scale results and policy decisions are consistent with the analysis at the local scale. It is therefore recommended that coordination occur with DWR to provide data and information for further refinement and update of the C2VSimFG and SVSim in the CoSANA area.
- **Develop model update schedule.** In order to keep the CoSANA up-to-date and current for analysis of water resources and especially for supporting SGMA implementation, it is recommended that the model

hydrology and land and water use data be updated and used for preparation of the GSP Annual Reports on an annual basis. It is further recommended that the model be updated for other major data sets, as well as enhanced for additional features every 5 years. This 5-year update would include an update of the model calibration and would be developed for use in the 5-year GSP updates for the three subbasins in the model area.

- **Enhance representation of variability of potential evapotranspiration**. The current version of the IDC used for estimation of the consumptive use of crops in the CoSANA uses monthly potential ET values that are uniform across the model domain. Future refinements are recommended to incorporate spatial variability of ET.
- **Map Soil Survey Geographic Database (SSURGO) rootzone parameters directly to CoSANA:** CoSANA used C2VSim rootzone parameters mapped to the CoSANA grid. Due to the difference in grid resolution, this may lead to a loss of detail on the original rootzone parameters. Remapping of the rootzone parameters should be considered to improve this resolution.
- **Refine surface water deliveries in NASb/SASb:** Some surface water diversions have limited detail on the delivery area, with some of this water sent to the appropriate subregion, but not specifically to the delivery area. Additional information on delivery areas is recommended for incorporation into CoSANA, including those in OHWD, and PCWA zone 5.
- **Improve inflow estimates for tributary streams:** Tributary streams were found to have a substantial effect on simulation of groundwater levels during calibration. Improvements could include flow measurements on small streams and/or developing improved regression analyses. Some tributary streams are not connected to a small watershed or receive very little flow from the small watershed simulation (for example: Magpie Creek and Arcade Creek in NASb, Elder Creek in SASb). Finally, subsurface conditions and simulated inflows from small watersheds east of the Cosumnes Subbasin require refinement to address model-calculated water levels that are significantly above land surface (flooded conditions).
- **Improve return flow routing within IWFM and CoSANA:** IWFM allows only one location for return flows, thus surface runoff must be routed to the same stream node as urban wastewater. In much of the Sacramento region, urban wastewater is routed to the Sacramento Regional Wastewater Treatment Plant northwest of Elk Grove. However, surface runoff is typically routed to the nearest surface water course. Coordination with DWR's IWFM development team is recommended to allow flexibility to route these differently according to the physical system.
- **Improve data and simulation of Auburn Ravine flows:** Auburn Ravine has complex operations that include inflows and diversions from several different entities. Currently, CoSANA simulation of Auburn Ravine flows is based on a regression analysis that uses flows from nearby Dry Creek. Though these may represent a reasonable estimate of natural flows that could occur in Auburn Ravine, this analysis does not capture any of the operational flows that occur through the ravine. There is a streamflow gage that is installed in Auburn Ravine, but the gage does not read flows above 200 cfs and therefore cannot be used to develop model inflows. It is recommended that streamflow measurements be taken on Auburn Ravine to either provide a data series for model input or to allow for an improved regression.
- **Develop improved rating tables for major streams:** many of the major stream rating tables are based on C2VSim/SVSim (Sacramento Valley Groundwater-Surface Water Simulation Model) rating tables from a flood study. These rating tables are heavily biased towards high flows that rarely occur in the model. The lower first or second interval includes almost all of the flows observed in a 10-point rating table. This results in the model not having much stage sensitivity, which may affect groundwater / surface water interaction as well as calibration of flow and stage. It is recommended that future efforts to develop rating tables include more focus on low flow conditions that are important for water resource management.
- **Improve simulation of complex water systems:** CoSANA incorporates substantial detail on complex public water systems. In some cases, additional detail on where water is produced, how much water is

lost in transmission, and where water is used can improve the simulation and improve the ease of reporting data from the model. This is typically most relevant to larger public water systems with mixed surface water and groundwater supplies and those systems that utilize interties or perform transfers.

- **Improve data for Mather AFB remediation operations:** Pumping data was received, but well location information is not known. Incorporation of the locations of wells could improve simulation of remediation operations.
- **Improve model information and data sets on the eastern areas:** The model geologic, hydrogeologic, and land use information for the eastern areas of the model near the foothills will need to be further enhanced, once additional data are collected. Such data may include boring logs, groundwater data, or geophysical data such as from airborne electromagnetic surveys. Model calibration will need to be improved upon collection of additional groundwater level data from the representative monitoring wells on the east side.

7. REFERENCES

Amador Water Agency, 2016. 2015 Urban Water Management Plan. Prepared by RMC Water and Environment. June.

Berkstresser, C.F. Jr., 1973. *Base of Fresh Ground Water – Approximately 3,000 Micromhos – in the Sacramento Valley and Sacramento-San Joaquin Delta, California*. December. Accessed online at https://pubs.er.usgs.gov/publication/wri7340.

Brush, Charles F, Emin C Dogrul, and Tariq N Kadir, 2013. *Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG*. accessed online at http://baydeltaoffice.water.ca.gov/modeling/hydrology/C2VSim/download/C2VSim_Model_Report_2016-03_vR374.pdf.

California American Water (Cal-Am), 2016. Final 2015 Urban Water Management Plan for the Northern Division-Sacramento District. Prepared by Water System Consulting, Inc. June 30.

California Geological Survey, 2009. Preliminary Geologic Map of the Lodi 30' x 60' Quadrangle, California.

California Geological Survey, 2011. Preliminary Geologic Map of the Sacramento 30' x 60' Quadrangle, California.

Carmichael Water District, 2016. 2015 Urban Water Management Plan. Prepared by Tully & Young. Final June 27.

Citrus Heights Water District, 2016. 2015 Urban Water Management Plan. Prepared by J. Crowley Group Water Resources Planning and Policy. June.

City of Folsom, 2016. 2015 Urban Water Management Plan. Prepared by Tully & Young. June.

City of Galt, 2016. 2015 Urban Water Management Plan Update. Prepared by Carollo Engineers. July.

City of Lincoln, 2016a. Final 2015 Urban Water Management Plan. Prepared by Tully & Young.

City of Lincoln, 2016b. Water Master Plan, Public review Draft. Prepared by Tully & Young. November.

City of Roseville, 2016. Final 2015 Urban Water Management Plan. Prepared by West Yost Associates Consulting Engineers. May.

City of Sacramento, 2016. 2015 Urban Water Management Plan. Prepared by West Yost Associates Consulting Engineers. June.

City of Sacramento, 2017. Groundwater Master Plan Final Report. Prepared by RMC Water and Environment, a Woodard & Curran Company. December.

Dogrul, Emin C., Tariq N. Kadir, and Charles F. Brush, 2017a. *Integrated Water Flow Model Theoretical Documentation (IWFM-2015), Revision 630*. accessed online at http://baydeltaoffice.water.ca.gov/modeling/hydrology/IWFM/IWFM-2015/v2015_0_630/downloadables/IWFM-2015.0.630_Theoretical Documentation.pdf.

Dogrul, Emin C., Tariq N. Kadir, and Charles F. Brush, 2017b. *DWR Technical Memorandum: Theoretical Documentation and User's Manual for IWFM Demand Calculator (IDC-2015)*, Revision 63. Bay-Delta Office, California Department of Water Resources. accessed online at http://baydeltaoffice.water.ca.gov/modeling/hydrology/IDC/IDC-2015/v2015_0_63/index_ IDCv2015_0_63.cfm.

Doherty, J., 2015. *Calibration and Uncertainty Analysis for Complex Environmental Models*. Watermark Numerical Computing, Brisbane, Australia. ISBN: 978-0-9943786-0-6.

Dunn Environmental, 2012 *Groundwater Supply Study and Integrated Regional Groundwater Management Plan for the Lake Camanche Water Improvement District No. 7*. June.

DWR, 1974. *Evaluation of Ground Water Resources: Sacramento County.* Bulletin 118-3. July.

DWR, 2018a. *Sacramento Valley Groundwater-Surface Water Simulation Model Technical Memorandum 1B*. April.

DWR, 2018b. *California Water Plan*. June. accessed online at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2018/Final/California-Water-Plan-Update-2018.pdf.

DWR, 2020. *California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid (C2VSimFG): Development and Calibration Version 1.0*. December. accessed online at https://data.cnra.ca.gov/dataset/b313f4b2-1f5a-4028-9680-277cc04f6ded/resource/4f904e97-a47b-4138-81df-9b74bd952948/download/c2vsimfg-report-draft-clean_12072020_adaaccessible.pdf.

Fair Oaks Water District, 2016. 2015 Urban Water Management Plan. Prepared by Peterson Brustad Inc. Engineering Consulting. June.

Golden State Water Company, 2016. 2015 Urban Water Management Plan Cordova. Prepared by Kennedy/Jenks Consultants. June.

Golden State Water Company, 2020. *Supplement to the Water Supply Assessment for Lakeside at Sutter Pointe.* Prepared by Holland Knight and Wood Rodgers. October.

Orange Vale Water Company, 2016. 2015 Urban Water Management Plan. Prepared by J. Crowley Group Water Resources Planning and Policy. June.

Page, 1974. *Base and Thickness of the Post Eocene Continental Deposits in the Sacramento Valley, California.* USGS Water-Resources Investigations 45-73. September. accessed online at https://pubs.usgs.gov/wri/1973/0045/report.pdf.

Placer County Water Agency (PCWA), 2016. 2015 Urban Water Management Plan. Prepared by Tully & Young. June.

RMC Water and Environment, 2012. *Camanche Area Regional Water Supply Plan Feasibility Study and Conceptual Design.* January.

Rancho Murieta Community Services District, 2010. 2010 Integrated Water Supply Master Plan Update. Prepared by Brown and Caldwell. October.

Rio Linda / Elverta Community Water District, 2016. 2015 Urban Water Management Plan. Prepared by J. Crowley Group Water Resources Planning and Policy. June.

Roseville, City of, City of Lincoln, Placer County Water Agency, California American Water Company, 2007. *Western Placer County Groundwater Management Plan*. November.

Sacramento County Water Agency (SCWA), 2021. Draft Zone 40 Water Supply Master Plan Amendment. Prepared by Brown and Caldwell. January.

Sacramento Suburban Water District, 2016. 2015 Urban Water Management Plan. Prepared by Brown and Caldwell. June.

San Juan Water District, 2016. Final 2015 Urban Water Management Plan. Prepared by Kennedy/Jenks Consultants. June.

South Area Water Council, 2011.South Basin Groundwater Management Plan. Prepared by RBI and WRIME. October.

U.S. Bureau of Reclamation, 2019. *Long-Term Water Transfer EIS/R*. September.

U.S. Bureau of Reclamation, in press. *American River Basin Study*.

USDA NRCS, 2007. *National Engineering Handbook*, Part 630 Hydrology, Chapter 7, Hydrologic Soil Groups. May. accessed online at https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba.

APPENDIX A: MODEL SURFACE WATER DELIVERIES

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
1	North-Side Bear River Diversion - Import to Camp Far West ID for Agriculture	Import	Subregion 1	Agriculture	0.14	0.04	1	5,888	SacIWRM	
2	Bear River Diversions - Import to South Sutter WD for Agriculture	Import	Subregion 3	Agriculture	0.14	0.04	1	93,421	SacIWRM, MBK	
3	Auburn Ravine Diversions to South Sutter WD for Agriculture	Auburn Ravine	Subregion 3	Agriculture	0.14	0.04	1	1,529	MBK	
4	Small Stream Diversions - Import to South Sutter WD for Agriculture	Import	Subregion 3	Agriculture	0	0	1	331	MBK	
5	Auburn Ravine Diversions to Zone 5 - Import to Placer County Water Agency for Agriculture	Import	Subregion 4	Agriculture	0.14	0.04	1	9,998	SacIWRM, Placer County Water Agency	
6	Hemphill Canal - Import to Nevada Irrigation District for Agriculture	Import	Subregion 5	Agriculture	0.07	0.02	0.25	19,583	C2VSim, Nevada Irrigation District	Estimated portion of volume coming into model area
7	Auburn Ravine Diversions - Import to Nevada Irrigation District for Agriculture	Import	Subregion 5	Agriculture	0.07	0.02	0.25	3,497	C2VSim, Nevada Irrigation District	Estimated portion of volume coming into model area
8	From PCWA/NID Intertie - Import to City of Lincoln for Urban	Import	Subregion 6	Urban	0	0	1	6,218	SacIWRM, City of Lincoln	
9	Feather River Riparian Diversions for Agriculture	Feather River	Subregion 7	Agriculture	0.12	0.03	1	11,000	SacIWRM	
10	Sacramento River Diversions to Pleasant Grove Verona MWC for Agriculture	Sacramento River Upstream Cross Canal	Subregion 8	Agriculture	0.12	0.03	1	14,528	C2VSim, USBR	
11	Sacramento River Riparian Diversions below Feather River confluence for Agriculture	Sacramento River Upstream Natomas East Drain	Subregion 9	Agriculture	0.12	0.03	1	1,260	SacIWRM	
12	Natomas Mutual Water Company USBR Diversions for Agriculture	Sacramento River Upstream Natomas East Drain	Element group representing / NMWC	Agriculture	0.01	0.0033	1	61,850	SacIWRM, Natomas Mutual Water Company	
13	NOT USED	N/A	Out of model	Agriculture	0	0	0	0	N/A	Not used
14	Folsom Diversions - Import to City of Roseville for Urban	Import	Subregion 13	Urban	0	0	1	27,943	City of Roseville	
15	From PCWA Intertie - Import to City of Roseville for Urban	Import	Subregion 13	Urban	0	0	1	0	N/A	Placeholder, no data
16	From PCWA Intertie - Import to Cal-Am West Placer for Urban	Import	Subregion 14	Urban	0	0	1	725	RWA, GEI	
17	Import to Sacramento Int'l Airport for Urban	Import	Subregion 16	Urban	0	0	1	175	SacIWRM, RWA	
18	Sacramento River Riparian Imports near Sacramento Int'l Airport	Import	Subregion 18	Agriculture	0	0	1	3,124	SacIWRM	
19	Import to Rio Linda Elverta CWD from SSWD Intertie for Urban	Import	Element group representing / Rio Linda Elverta CWD Service Area	Urban	0	0	1	5	RWA	
20	From SSWD Intertie - Import to Cal-Am Antelope for Urban	Import	Subregion 23	Urban	0	0	1	170	RWA	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
21	From SSWD Intertie - Import to Cal-Am Lincoln Oaks for Urban	Import	Subregion 24	Urban	0	0	1	245	RWA	
22	Folsom Diversions Via SJWD Intertie - Import to Citrus Heights WD for Urban	Import	Subregion 25	Urban	0	0	1	16,015	RWA, SacIWRM	
23	From PCWA Intertie - Import to San Juan WD for Urban	Import	Subregion 26	Urban	0	0	1	0	N/A	Placeholder, no data
24	Total Folsom Diversions Inc. Wholesale - Import to San Juan WD for Urban	Import	Out of model	Urban	0	0	1	33,020	RWA	
25	Retail Only - Import to San Juan WD for Urban	Import	Element group representing / SAN JUAN WD RETAIL AREA	Urban	0	0	0.37	14,043	RWA, SacIWRM	
26	Sac Suburban North District Total GW Production	Import	Subregion 32	Urban	0	0	1	16,044	RWA	
27	From SSWD Intertie - Import to San Juan WD for Urban	Import	Subregion 26	Urban	0	0	1	0	N/A	Placeholder, no data
28	From PCWA Intertie - Import to San Juan WD for Urban	Import	Subregion 26	Urban	0	0	1	0	N/A	Placeholder, no data
29	Folsom Diversions via SJWD Intertie - Import to Orange Vale WC for Urban	Import	Subregion 28	Urban	0	0	1	4,191	RWA, SacIWRM	
30	Folsom Diversions Via SJWD Intertie - Import to Fair Oaks WD for Urban	Import	Subregion 30	Urban	0	0	1	11,145	RWA, SacIWRM	
31	American River Diversions to Carmichael WD for Urban	American River	Subregion 31	Urban	0	0	1	7,155	RWA, SacIWRM	
32	From Sac Suburban Intertie - Import to Carmichael WD for Urban	Import	Subregion 31	Urban	0	0	1	0	N/A	Placeholder, no data
33	From CHWD Intertie - Import to Carmichael WD for Urban	Import	Subregion 31	Urban	0	0	1	0	N/A	Placeholder, no data
34	Sac Suburban North District Imports - Import to Sac Suburban North for Urban	Import	Subregion 32	Urban	0	0	1	8,987	RWA, SacIWRM	
35	From City of Sac Intertie - Import to Sac Suburban South for Urban	Import	Subregion 33	Urban	0	0	1	1,037	RWA	
36	From SSWD SSA Intertie - Import to City of Sacramento for Urban	Import	Element group representing / CITY OF SACRAMENTO	Urban	0	0	1	161	RWA	
37	From PCWA - Import to City of Rocklin for Urban	Import	Element group representing Rocklin	Urban	0	0	1	4,578	Placer County Water Agency	
38	Metro Air Park - Import to Metro Air Park for Urban	Import	Subregion 17	Urban	0	0	1	0	N/A	Placeholder, no data
39	From City of Sac Intertie - Import to Cal-Am Arden for Urban	Import	Subregion 36	Urban	0	0	1	2	RWA, SacIWRM	
40	City of Sacramento - American River Diversions to City of Sacramento for Urban	American River	Out of model	Urban	0	0	1	48,211	RWA	
41	City of Sacramento - Sacramento River Diversions to City of Sacramento for Urban	Sacramento River Upstream Morrison Crk	Out of model	Urban	0	0	1	52,300	RWA	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
42	City of Sacramento - Retail SW Delivery Volumes - Import to City of Sacramento for Urban	Import	Element group representing / CITY OF SACRAMENTO	Urban	0	0	1	97,195	RWA, SacIWRM	
43	Sac Suburban South District Total GW Production - Import to Sac Suburban South for Urban	Import	Subregion 33	Urban	0	0	1	16,351	RWA, SacIWRM	Represents total GW production for service area
44	NOT USED - Import for Agriculture	Import	Out of model	Agriculture	0	0	0	470	N/A	
45	Arcade American River Diversions to Arcade for Urban	American River Upstream Sacramento R.	Subregion 39	Urban	0	0	1	132	SacIWRM	
46	From City of Sac Intertie - Import to Cal-Am Suburban Rosemont for Urban	Import	Subregion 40	Urban	0	0	1	85	RWA	
47	FSC/American River Diversions - Import to Golden State Water Company Cordova for Urban	Import	Subregion 42	Urban	0	0	1	5,922	SacIWRM, RWA	FSC operations not currently simulated
48	From Carmichael WD - Import to Golden State Water Company Cordova for Urban	Import	Subregion 42	Urban	0	0	1	366	RWA	
49	Aerojet FSC Diversions - Import to Aerojet FSC for Urban	Import	Out of model	Urban	0	0	1	1,083	SacIWRM	FSC operations not currently simulated
50	Folsom Diversions, Estimated Prior to 1983 - Import to City of Folsom for Urban	Import	Subregion 44	Urban	0	0	1	20,451	SacIWRM, RWA	
51	SJWD Intertie) - Placeholder No Dat - Import to City of Folsom for Urban	Import	Subregion 44	Urban	0	0	1	0	N/A	Placeholder, no data
52	From SCWA Intertie - Import to Cal-Am Security Park for Urban	Import	Subregion 45	Urban	0	0	1	0	N/A	Placeholder, no data
53	From City of Sac Intertie - Import to Fruitridge Vista WC for Urban	Import	Subregion 46	Urban	0	0	1	1	RWA	
54	From City of Sac Intertie - Import to Cal-Am Parkway for Urban	Import	Subregion 48	Urban	0	0	1	592	RWA	
55	GW Imports - Import to SCWA - Arden Park Vista for Urban	Import	Subregion 37	Urban	0	0	1	3,911	SacIWRM, RWA, SCWA	Represents total GW production for service area
56	SW Imports - Import to SCWA - Arden Park Vista for Urban	Import	Subregion 37	Urban	0	0	1	0	N/A	Represents total SW delivered to service area
57	RW Imports - Import to SCWA - Arden Park Vista for Urban	Import	Subregion 37	Urban	0	0	1	0	N/A	Represents total RW for service area
58	GW Imports - Import to SCWA - Hood for Urban	Import	Element group representing SCWA - Hood	Urban	0	0	1	47	SacIWRM, RWA, SCWA	Represents total GW production for service area
59	SW Imports - Import to SCWA - Hood for Urban	Import	Element group representing SCWA - Hood	Urban	0	0	1	0	SacIWRM, RWA, SCWA	Represents total SW delivered to service area
60	RW Imports - Import to SCWA - Hood for Urban	Import	Element group representing SCWA - Hood	Urban	0	0	1	0	SacIWRM, RWA, SCWA	Represents total RW for service area

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
61	GW Imports - Import to SCWA - Northgate for Urban	Import	Subregion 20	Urban	0	0	1	940	SacIWRM, RWA, SCWA	Represents total GW production for service area
62	SW Imports - Import to SCWA - Northgate for Urban	Import	Subregion 20	Urban	0	0	1	0	SacIWRM, RWA, SCWA	Represents total SW delivered to service area
63	RW Imports - Import to SCWA - Northgate for Urban	Import	Subregion 20	Urban	0	0	1	0	SacIWRM, RWA, SCWA	Represents total RW for service area
64	GW Imports - Import to SCWA - Laguna Vineyard for Urban	Import	Element group representing SCWA - South and Central Service Areas (including Elk Grove)	Urban	0	0	1	17,340	SacIWRM, RWA, SCWA	Represents total GW production for service area
65	SW Imports - Import to SCWA - Laguna Vineyard for Urban	Import	Element group representing SCWA - South and Central Service Areas (including Elk Grove)	Urban	0	0	1	3,314	SacIWRM, RWA, SCWA	Represents total SW delivered to service area
66	RW Imports - Import to SCWA - Laguna Vineyard for Urban	Import	Element group representing SCWA - South and Central Service Areas (including Elk Grove)	Urban	0	0	1	232	SacIWRM, RWA, SCWA	Represents total RW for service area
67	GW Imports - Import to SCWA Mather for Urban	Import	Element group representing SCWA - NSA	Urban	0	0	1	3,958	SacIWRM, RWA, SCWA	Represents total GW production for service area
68	SW Imports - Import to SCWA Mather for Urban	Import	Element group representing SCWA - NSA	Urban	0	0	1	233	SacIWRM, RWA, SCWA	Represents total SW delivered to service area
69	RW Imports - Import to SCWA Mather for Urban	Import	Element group representing SCWA - NSA	Urban	0	0	1	0	SacIWRM, RWA, SCWA	Represents total RW for service area
70	North Delta WA Ag Diversions - Import to North Delta WA for Agriculture	Import	Element group representing NDWA	Agriculture	0	0	1	43,072	SacIWRM	
71	Cosumnes River diversion 1 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions to for Agriculture	Cosumnes River Upstream Mokolumne R. / EKI	Element group representing CosSb_4	Agriculture	0	0	1	356	eWRIMS	
72	Cosumnes River diversion 2 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions to for Agriculture	Cosumnes River Upstream Laguna Crk /EKI	Element group representing CosSb_4	Agriculture	0	0	1	4	eWRIMS	
73	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_1	Agriculture	0	0	1	752	eWRIMS	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
74	East Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_3	Agriculture	0	0	1	103	eWRIMS and Mark Stretars	
75	Cosumnes River diversion 3 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions for Agriculture	Cosumnes River Upstream Badger Crk / EKI	Element group representing CosSb_4	Agriculture	0	0	1	1,119	eWRIMS	
76	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_1	Agriculture	0	0	1	1,143	eWRIMS	
77	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_1	Agriculture	0	0	1	130	eWRIMS	
78	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_1	Agriculture	0	0	1	307	eWRIMS	
79	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_1	Agriculture	0	0	1	2,153	eWRIMS	
80	Cosumnes Subbasin Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_2	Agriculture	0	0	1	354	eWRIMS	
81	East Subregion for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Element group representing CosSb_3	Agriculture	0	0	1	42	eWRIMS	
82	Cos and S Am Subbasins for Urban	Cosumnes River Upstream Deer Crk / EKI	Out of model	Urban	0	0	1	3,755	eWRIMS	
83	Dry Creek diversion for ag use in element group 7 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk	Out of model	Agriculture	0	0	1	432	eWRIMS	
84	Dry Creek diversion for ag use in element group 8 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk	Out of model	Agriculture	0	0	1	2,238	eWRIMS	
85	Dry Creek diversion 1 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk / EKI	Element group representing CosSb_9	Agriculture	0	0	1	31	eWRIMS	
86	Dry Creek diversion 2 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk	Element group representing CosSb_9	Agriculture	0	0	1	62	eWRIMS	
87	Dry Creek diversion 3 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk	Element group representing CosSb_9	Agriculture	0	0	1	3	eWRIMS	
88	Dry Creek diversion 4 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture	Dry Creek Upstream Jackson Crk	Element group representing CosSb_9	Agriculture	0	0	1	1	eWRIMS	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
89	Dry Creek diversion 1 for ag use in element group 5 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_5	Agriculture	0	0	1	5,398	eWRIMS	
90	East Subregion to for Agriculture	Dry Creek Upstream Mokolumne R.	Element group representing CosSb_6	Agriculture	0	0	1	413	eWRIMS	
91	East Subregion for Agriculture	Dry Creek Upstream Mokolumne R.	Element group representing CosSb_6	Agriculture	0	0	1	59	eWRIMS	
92	Dry Creek diversion 2 for ag use in element group 5 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_5	Agriculture	0	0	1	547	eWRIMS	
93	East Subregion for Agriculture	Dry Creek Upstream Mokolumne R.	Element group representing CosSb_6	Agriculture	0	0	1	19	eWRIMS	
94	Dry Creek diversion 3 for ag use in element group 5 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_5	Agriculture	0	0	1	1,748	eWRIMS	
95	Dry Creek diversion 4 for ag use in element group 5 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_5	Agriculture	0	0	1	1,748	eWRIMS	
96	Dry Creek diversion 5 for ag use in element group 5 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_5	Agriculture	0	0	1	1,748	eWRIMS	
97	East Subregion for Agriculture	Badger Creek	Element group representing CosSb_15	Agriculture	0	0	1	10	eWRIMS	
98	West Subregion for Agriculture	Badger Creek	Element group representing CosSb_12	Agriculture	0	0	1	35	eWRIMS	
99	Laguna Creek diversion for ag use in element group 21 within Clay WD subregion for Agriculture	Laguna Creek (Cosumnes Subbasin)	Element group representing CosSb_21	Agriculture	0	0	1	301	eWRIMS	
100	East Subregion for Agriculture	Laguna Creek (Cosumnes Subbasin)	Element group representing CosSb_11	Agriculture	0	0	1	362	eWRIMS	
101	East Subregion for Agriculture	Laguna Creek (Cosumnes Subbasin)	Element group representing CosSb_11	Agriculture	0	0	1	3	eWRIMS	
102	East Subregion for Agriculture	Laguna Creek (Cosumnes Subbasin)	Element group representing CosSb_10	Agriculture	0	0	1	49	eWRIMS	
103	Jackson Creek diversion for ag use in element group 14 within Jackson ID subregion - Import for Agriculture	Import	Element group representing CosSb_14	Agriculture	0	0	1	10,558	eWRIMS	
104	Mokelumne River diversion 1 for ag use in element group 16 within Cosumnes River South subregion for Agriculture	Dry Creek Upstream Mokolumne R. / EKI	Element group representing CosSb_16	Agriculture	0	0	1	2,376	eWRIMS	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
105	Mokelumne River diversion 2 for ag use in element group 16 within Cosumnes River South subregion for Agriculture	Mokolumne River Upstream Cosumnes R.	Element group representing CosSb_16	Agriculture	0	0	1	436	eWRIMS	
106	Mokelumne River diversion 3 for ag use in element group 16 within Cosumnes River South subregion to for Agriculture	Mokolumne River Upstream Cosumnes R.	Element group representing CosSb_16	Agriculture	0	0	1	232	eWRIMS	
107	Mokelumne River diversion 4 for ag use in element group 16 within Cosumnes River South subregion for Agriculture	Mokolumne River Upstream Cosumnes R.	Element group representing CosSb_16	Agriculture	0	0	1	933	eWRIMS	
108	Mokelumne River diversion 5 for ag use in element group 16 within Cosumnes River South subregion for Agriculture	Mokolumne River Upstream Cosumnes R.	Element group representing CosSb_16	Agriculture	0	0	1	4	eWRIMS	
109	Mokelumne River diversion 6 for ag use in element group 16 within Cosumnes River South subregion for Agriculture	Mokolumne River Upstream Cosumnes R.	Element group representing CosSb_16	Agriculture	0	0	1	141	eWRIMS	
110	East Subregion - Import for Agriculture	Import	Element group representing CosSb_19	Agriculture	0	0	1	1,263	eWRIMS	
111	East Subregion - Import for Agriculture	Import	Element group representing CosSb_17	Agriculture	0	0	1	651	eWRIMS	
112	East Subregion - Import for Agriculture	Import	Element group representing CosSb_18	Agriculture	0	0	1	142	eWRIMS	
113	Diversion from unmodeled stream or spring for ag use in OHWD Cosumnes Subbasin subregion - Import for Agriculture	Import	Subregion 67	Agriculture	0	0	1	232	eWRIMS	
114	East Subregion - Import for Agriculture	Import	Subregion 69	Agriculture	0	0	1	200	eWRIMS	
115	Diversion from unmodeled stream or spring for ag use in Wilton subregion - Import for Agriculture	Import	Subregion 70	Agriculture	0	0	1	11	eWRIMS	
116	Diversion from unmodeled stream or spring for ag use in Sloughhouse RCD West subregion - Import for Agriculture	Import	Subregion 71	Agriculture	0	0	1	133	eWRIMS	
117	Diversion from unmodeled stream or spring for ag use in Galt ID East subregion - Import for Agriculture	Import	Subregion 72	Agriculture	0	0	1	10	eWRIMS	
118	Diversion from unmodeled stream or spring for ag use in SMUD Rancho Seco subregion - Import for Agriculture	Import	Subregion 75	Agriculture	0	0	1	455	eWRIMS	
119	Diversion from unmodeled stream or spring for ag use in Cosumnes River South subregion - Import for Agriculture	Import	Subregion 76	Agriculture	0	0	1	5	eWRIMS	

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
120	Diversion from unmodeled stream or spring for ag use in Amador Co. 1 subregion - Import for Agriculture	Import	Subregion 81	Agriculture	0	0	1	217	eWRIMS	
121	Diversion from unmodeled stream or spring for ag use in Jackson ID subregion - Import for Agriculture	Import	Subregion 83	Agriculture	0	0	1	91	eWRIMS	
122	Diversion from unmodeled stream or spring for ag use in Comanche subregion - Import for Agriculture	Import	Subregion 84	Agriculture	0	0	1	80	eWRIMS	
123	Diversion from unmodeled stream or spring for ag use in Amador County WA subregion - Import or Agriculture	Import	Subregion 85	Agriculture	0	0	0	3	eWRIMS	
124	East Subregion - Import to for Agriculture	Import	Element group representing CosSb_20	Agriculture	0	0	1	150	eWRIMS	
125	Cosumnes Subbasin Subregion - Import for Agriculture	Import	Subregion 67	Agriculture	0	0	1	180	SacIWRM	
126	East Subregion - Import for Agriculture	Import	Subregion 72	Agriculture	0	0	1	1,128	SacIWRM	
127	Tailwater Reuse from fish farms for ag use in Clay WD subregion - Import to for Agriculture	Import	Subregion 73	Agriculture	0	0	1	150	SacIWRM	
128	East) Subregion - Import for Agriculture	Import	Subregion 69	Agriculture	0	0	1	300	SacIWRM	
129	Import to Ione for local surface water supply - Import for Urban	Import	Subregion 82	Urban	0	0	1	1,878	SacIWRM	
130	Recoverable Loss from Rancho Seco Export Water to Laguna Creek - Import for Agriculture	Import	Out of model	Agriculture	0	0	0	12,028	SacIWRM	
131	NOT USED - Import for Agriculture	Import	Out of model	Agriculture	0	0	0	786	N/A	
132	Cosumnes Subbasin) Subregion to O-H for Agriculture	Folsom South Canal (South of Cosumnes R.)	Subregion 67	Agriculture	0	0	0.34	0	SacIWRM	
133	South American) Subregion to O-H for Agriculture	Folsom South Canal (South of Cosumnes R.)	Subregion 66	Agriculture	0	0	0.66	0	SacIWRM	
134	East Subregion to Galt ID for Agriculture	Folsom South Canal (South of Cosumnes R.)	Subregion 72	Agriculture	0	0	1	2,279	SacIWRM	
135	Clay ID FSC diversions to Clay ID subregion to Clay ID for Agriculture	Folsom South Canal (South of Cosumnes R.)	Subregion 73	Agriculture	0	0	1	1,051	SacIWRM	
136	SMUD FSC diversions to SMUD Rancho Seco subregion to SMUD FSC for Agriculture	Folsom South Canal (South of Cosumnes R.)	Subregion 75	Agriculture	0	0	1	14,615	SacIWRM	
137	SCWA Freeport Diversions for Mather and Vineyard SW Supply	Sacramento River at Freeport	Out of model	Urban	0	0	1	3,154	RWA	Retail delivery handled with Divs 65, 68

Model Diversion ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion 1995-2018 (acre-feet)	Data Source	Notes
					RL	NL	Delivery			
138	Deer Creek diversion to SRCD to Deer Creek for Agriculture	Deer Creek	Subregion 65	Agriculture	0	0	1	29	eWRIMS	
139	Deer Creek diversions to OHWD to Deer Creek for Agriculture	Deer Creek	Subregion 66	Agriculture	0	0	1	175	eWRIMS	
140	Cosumnes River diversion to RMCSD area Ag to Cosumnes River for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Subregion 64	Agriculture	0	0	1	570	eWRIMS	
141	Cosumnes River diversions to OHWD to Cosumnes River for Agriculture	Cosumnes River Upstream Deer Crk / EKI	Subregion 66	Agriculture	0	0	1	1,388	eWRIMS	
142	Not Used	Import	N/A	N/A	1	0	1	0	N/A	
143	Diversion from water stored in Loch Lane for at use, adjusted to meet demand	Import	Element group representing / CosSb_22	Agriculture	0	0	1	2,670	eWRIMS	
144	Galt WWTP flows through Laguna Creek to Galt WWTP for Agriculture	Laguna Creek (Cosumnes Subbasin)	Element group representing / Galt WWTP	Agriculture	0	0	1	700	South Basin Groundwater Management Plan, Robertson-Bryan Inc. and WRIME, 2011	
145	Rancho Murieta diversion from stored water to meet estimated demand. - Import to Rancho Murieta for Urban	Import	Element group representing CosSb_13	Urban	0	0	1	1,833	RMCSD	

RL: Recoverable Loss
NL: Non-recoverable Loss

APPENDIX B: REMEDIATION PUMPING BY ENTITY

Water Year	Aerojet Remediation (NASb) (acre-feet)	Aerojet Remediation (SASb) (acre-feet)	Kiefer Landfill Remediation (acre-feet)	Mather Air Force Base Remediation (acre-feet)	McClellan Air Force Base Remediation (acre-feet)
1995	0	14,568	102	157	745
1996	0	15,189	468	209	1,145
1997	0	14,672	517	209	1,157
1998	270	16,916	898	209	1,167
1999	2,018	14,586	870	209	1,032
2000	1,900	12,747	1,500	209	2,020
2001	1,672	13,297	1,339	209	1,440
2002	1,583	12,657	1,793	209	1,105
2003	1,551	15,267	1,531	209	1,098
2004	1,695	18,682	1,622	209	1,569
2005	1,953	17,591	1,333	209	1,446
2006	2,069	18,892	1,280	209	2,272
2007	2,382	19,568	1,555	209	2,838
2008	2,287	21,786	1,391	209	2,743
2009	2,093	21,383	1,321	209	2,386
2010	2,424	24,938	1,111	209	2,369
2011	2,674	26,618	1,141	209	2,406
2012	3,394	26,058	575	209	2,483
2013	2,125	18,808	488	209	2,394
2014	2,479	21,932	522	209	2,317
2015	2,689	20,137	494	209	2,213
2016	3,482	28,274	375	209	2,432
2017	3,430	29,362	422	209	2,395
2018	3,105	28,935	621	209	2,409
Average WY 1995-2018	**1,970**	**19,703**	**969**	**207**	**1,899**

APPENDIX C: SUBREGION LAND AND WATER USE BUDGETS

Historical Water Use Budget Summary, Annual Average for WY 1995 - 2018

Subregion	Description	Ag Area	Ag Demand	Ag Water Duty	Urban Area	Urban Demand	Urban Water Duty	Total Water Demand	Total Ag Water Supply (Acre-Feet/Year)		Total Urban Water Supply (Acre-Feet/Year)			Total Supply (Acre-Feet/Year)	Remediation Operations	
		(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acre-Feet)	GW Production	SW Deliveries	GW Use	SW Deliveries	Other Supply[2]		Extraction	Injection
1	Camp Far West ID	1,760	9,327	5.3	169	150	0.9	9,477	4,472	4,990	150	-	-	9,612	-	-
2	Sutter Co. 1	147	643	4.4	2	1	0.4	644	643	-	1	-	-	644	-	-
3	South Sutter WD GSA	52,398	183,202	3.5	1,962	1,490	0.8	184,693	103,768	80,796	1,490	-	-	186,055	-	-
4	Placer County WA[1]	12,243	31,383	2.6	7,202	8,308	1.2	39,692	22,996	8,473	3,730	4,578	-	39,778	-	-
5	Nevada ID	3,168	11,467	3.6	482	397	0.8	11,864	6,030	5,770	397	-	-	12,196	-	-
6	Lincoln[1]	527	1,275	2.4	4,573	6,958	1.5	8,233	1,275	-	739	6,218	-	8,233	-	-
7	RD1001 [1]	7,476	28,604	3.8	371	165	0.4	28,769	19,039	9,565	165	-	-	28,769	-	-
8	Pleasant Grove Verona MWC	6,813	23,943	3.5	99	45	0.5	23,988	12,036	12,633	45	-	-	24,714	-	-
9	Sutter Co. 2	985	3,447	3.5	87	39	0.5	3,486	2,278	1,169	39	-	-	3,486	-	-
10	Natomas MWC (Sutter Co.)	11,694	41,428	3.5	436	197	0.5	41,625	717	40,744	197	-	-	41,658	-	-
11	Sutter Co. 3	2,912	9,152	3.1	440	289	0.7	9,441	9,152	-	289	-	-	9,441	-	-
12	Roseville SOI	1,127	3,037	2.7	44	105	2.4	3,141	3,037	-	105	-	-	3,141	-	-
13	City of Roseville	488	623	1.3	16,617	28,069	1.7	28,692	623	-	126	27,943	-	28,692	-	-
14	Cal Am (West Placer)	3,223	6,459	2.0	2,146	725	0.3	7,184	6,459	-	-	725	-	7,184	-	-
15	Natomas MWC (Sacramento Co.)	13,037	41,942	3.2	1,357	2,973	2.2	44,915	687	41,291	2,973	-	-	44,951	-	-
16	Sacramento International Airport	946	893	0.9	1,621	1,143	0.7	2,037	893	-	968	175	-	2,037	-	-
17	Metro Air Park	1,643	1,458	0.9	37	-	0.0	1,458	1,458	-	-	-	-	1,458	-	-
18	Sac Co. 1	928	1,896	2.0	139	604	4.3	2,500	100	1,796	604	-	-	2,500	-	-
19	Sac Co. 2	793	2,636	3.3	141	17	0.1	2,653	2,636	-	17	-	-	2,653	-	-
20	Sac County WA (Northgate 880)	43	52	1.2	792	940	1.2	992	52	-	940	-	-	992	-	-
21	Rio Linda Elverta	630	905	1.4	5,873	8,941	1.5	9,846	905	-	8,936	5	-	9,846	-	-
22	Sac Co. 3	327	250	0.8	214	335	1.6	584	250	-	335	-	-	584	-	-
23	Cal Am (Antelope)	4	8	1.8	2,664	5,790	2.2	5,798	8	-	5,621	170	-	5,798	-	-
24	Cal Am (Lincoln Oaks)	3	8	2.3	4,254	9,114	2.1	9,122	8	-	8,869	245	-	9,122	-	-
25	Citrus Heights WD	66	262	3.9	7,706	16,967	2.2	17,229	262	-	952	16,015	-	17,229	-	-
26	San Juan WD (Placer Co.)	41	18	0.4	1,130	1,817	1.6	1,835	18	-	-	1,817	-	1,835	-	-
27	San Juan WD (Sacramento Co.)	79	246	3.1	2,043	3,378	1.7	3,624	246	-	-	3,378	-	3,624	-	-
28	Orange Vale WC	119	618	5.2	2,839	4,191	1.5	4,809	618	-	-	4,191	-	4,809	-	-
29	Lake Natoma/Mississippi Bar	1	35	36.0	128	-	0.0	35	35	-	-	-	-	35	-	-
30	Fair Oaks WD	97	284	2.9	6,159	12,328	2.0	12,611	284	-	1,183	11,145	-	12,611	1,401	-
31	Carmichael WD	0	0	3.5	5,255	11,234	2.1	11,234	0	-	4,080	7,155	-	11,234	568	-
32	Sacramento Suburban WD (North)	154	74	0.5	13,736	25,031	1.8	25,105	74	-	16,130	8,902	-	25,105	1,843	-
33	Sacramento Suburuban WD (South)	-	-	0.0	7,765	17,388	2.2	17,388	-	-	16,387	1,001	-	17,388	-	-
34	Del Paso Manor WD	-	-	0.0	614	1,549	2.5	1,549	-	-	1,549	-	-	1,549	-	-
35	Golden State WC Arden	-	-	0.0	496	1,169	2.4	1,169	-	-	1,169	-	-	1,169	-	-
36	Cal Am (Arden)	-	-	0.0	640	2,832	4.4	2,832	-	-	2,830	2	-	2,832	-	-
37	Sac County WA (Arden Park	-	-	0.0	1,348	3,911	2.9	3,911	-	-	3,911	-	-	3,911	-	-
38	City of Sacramento (North)	3,522	4,546	1.3	17,106	37,754	2.2	42,300	4,546	-	6,459	31,296	-	42,300	56	-
	Total NASb	127,396	410,120	120	118,685	216,346	58	626,466	205,605	207,227	91,384	124,961	-	629,177	3,869	-
39	City of Sacramento (South)	735	1,230	1.7	35,588	79,828	2.2	81,058	1,146	84	13,767	66,193	-	81,190	-	-
40	Cal Am (Suburban Rosemont)	291	938	3.2	7,186	12,381	1.7	13,318	938	-	12,296	110	-	13,343	131	-
41	Sac Co. 4	65	29	0.4	15	-	0.0	29	29	-	-	-	-	29	-	-
42	Golden State WC (Cordova)	72	76	1.1	6,310	15,264	2.4	15,341	76	-	8,977	6,287	-	15,341	4,422	-
43	Sac Co. 5	-	-	0.0	269	3	0.0	3	-	-	-	3	-	3	7,351	-
44	City of Folsom[1]	53	55	1.1	9,505	20,451	2.2	20,507	35	-	-	20,451	-	20,487	3,137	-
45	Cal Am (Security Park)	-	-	0.0	171	31	0.2	31	-	-	31	0	-	31	48	-
46	Fruitridge Vista WC	-	-	0.0	1,894	4,224	2.2	4,224	-	-	4,387	1	-	4,388	-	-
47	Florin County WD	1	4	3.9	1,369	2,623	1.9	2,628	4	-	2,623	-	-	2,628	-	-
48	Cal Am (Parkway)	5	11	1.9	5,007	11,291	2.3	11,302	11	-	10,699	592	-	11,302	-	-
49	Sac Co. 6	463	898	1.9	1,056	57	0.1	955	598	300	57	-	-	955	-	-
50	Sac County WA (North/Central)	4,080	11,378	2.8	12,881	16,425	1.3	27,803	11,378	-	14,874	1,435	92	27,779	4,819	207
51	Sac County WA (South)	3,303	8,188	2.5	7,996	11,375	1.4	19,564	8,188	-	9,397	1,851	128	19,564	-	-
52	Elk Grove WD (2 - Intertie Service Area)	639	1,717	2.7	2,374	3,430	1.4	5,147	1,717	-	2,833	558	38	5,147	-	-
53	Elk Grove WD (1 - GW Service Area)	33	115	3.5	2,934	5,189	1.8	5,305	115	-	5,189	-	-	5,305	-	-
54	Cosumnes River West	18,072	56,004	3.1	1,824	4,533	2.5	60,536	51,495	4,509	4,533	-	-	60,537	-	-
55	RD744	1,294	2,738	2.1	102	60	0.6	2,798	702	2,036	60	-	-	2,798	-	-
56	Franklin Drainage District	2,825	8,515	3.0	250	158	0.6	8,673	3,180	5,336	125	33	-	8,674	-	-
57	RD813	2,075	4,676	2.3	82	48	0.6	4,724	1,287	3,389	33	15	-	4,724	-	-
58	RD755	354	1,497	4.2	26	16	0.6	1,513	520	978	16	-	-	1,513	-	-
59	RD1002	4,303	10,037	2.3	254	166	0.7	10,203	2,889	7,148	166	-	-	10,203	-	-
60	RD551	7,927	22,522	2.8	423	245	0.6	22,767	6,062	16,462	245	-	-	22,768	-	-
61	RD369	108	382	3.5	37	23	0.6	406	130	252	23	-	-	406	-	-
62	RD2110	1,401	2,033	1.5	52	28	0.5	2,061	409	1,624	28	-	-	2,061	-	-
63	Sac Co. 7	306	680	2.2	88	94	1.1	773	176	504	94	-	-	773	-	-
64	Rancho Murieta (North) [1]	381	1,239	3.2	1,098	1,415	1.3	2,654	740	499	153	1,262	-	2,654	-	-
65	Sloughouse RCD (North)	575	1,318	2.3	631	616	1.0	1,934	1,290	28	584	31	-	1,934	-	-
66	OHWD (Sth American Subbasin)	9,592	24,431	2.5	2,469	1,970	0.8	26,401	23,282	1,517	1,554	431	-	26,784	969	-
	Total SASb	58,954	160,714	62	101,890	191,942	33	352,656	116,398	44,668	92,742	99,252	258	353,318	20,879	207
67	OHWD (Cosumnes Subbasin)	2,633	7,608	2.9	1,049	975	0.9	8,583	5,202	2,407	1,053	-	-	8,661	-	-
68	Rancho Murieta (South)	4	20	4.7	365	465	1.3	485	6	14	-	412	-	432	-	-
69	Sloughouse RCD (East)	8,331	21,515	2.6	1,303	1,322	1.0	22,838	19,813	1,702	109	128	-	21,752	-	-
70	Wilton	1,018	3,611	3.5	3,502	2,742	0.8	6,353	3,600	11	4,352	-	-	7,963	-	-
71	Sloughouse RCD (West)	4,111	10,694	2.6	324	242	0.7	10,936	10,562	132	8	-	-	10,701	-	-
72	Galt ID (East)	14,401	41,762	2.9	6,071	5,336	0.9	47,098	38,080	3,682	9,526	-	-	51,288	-	-
73	Clay WD	1,918	7,109	3.7	172	479	2.8	7,588	5,634	1,474	-	-	-	7,109	-	-
74	Clay	61	180	2.9	2,805	1,945	0.7	2,126	180	-	1,903	-	-	2,084	-	-
75	SMUD Rancho Seco	21	36	1.7	137	138	1.0	174	-	36	7	-	-	43	-	-
76	Cosumnes River South	4,405	12,174	2.8	191	315	1.6	12,488	9,159	3,046	-	-	-	12,205	-	-
77	Galt ID (West)	1,847	5,355	2.9	1,331	1,222	0.9	6,577	5,355	-	707	-	-	6,062	-	-
78	Sac Co. 8	2,882	6,480	2.2	623	924	1.5	7,404	5,124	1,356	165	-	-	6,645	-	-
79	City of Galt	182	361	2.0	3,035	4,650	1.5	5,011	361	-	4,737	-	-	5,099	-	-
80	Sloughouse RCD (South)	1,034	2,418	2.3	320	497	1.6	2,915	2,418	-	56	-	-	2,474	-	-
81	Amador Co. 1	1,812	3,278	1.8	1,832	2,530	1.4	5,809	1,259	2,018	0	-	-	3,277	-	-
82	Ione	153	425	2.8	1,109	2,130	1.9	2,555	425	0	-	1,878	-	2,303	-	-
83	Jackson ID	2,693	9,258	3.4	361	456	1.3	9,713	-	9,018	-	-	-	9,018	-	-
84	Camanche	63	-	0.0	133	164	1.2	164	-	-	76	-	-	76	-	-
85	Amador County WA	0	-	0.0	199	245	1.2	245	-	-	181	-	-	181	-	-
87	Galt WWTP	148	209	1.4	57	88	1.5	297	-	698	-	-	-	698	-	-
	Total CoSb	47,717	132,494	49	24,918	26,866	26	159,360	107,180	25,594	22,881	2,417	-	158,072	-	-
86	Mokelumne	34,664	79,056	2.3	3,200	4,222	1.3	83,278	79,056	-	4,222	-	-	83,278	-	-
	Total Other	34,664	79,056	2.3	3,200	4,222	1.3	83,278	79,056	-	4,222	-	-	83,278	-	-
	CoSANA Grand Total (NASb, SASb, CoSb)	234,067	703,329	231	245,493	435,154	116	1,138,482	429,183	277,488	207,008	226,630	258	1,140,568	24,748	207

Footnotes:
1. Subregion includes areas that fall outside of DWR B118 subbasin boundaries
2. Other Supply includes recycled water deliveries

APPENDIX D: STREAM REACH BUDGETS

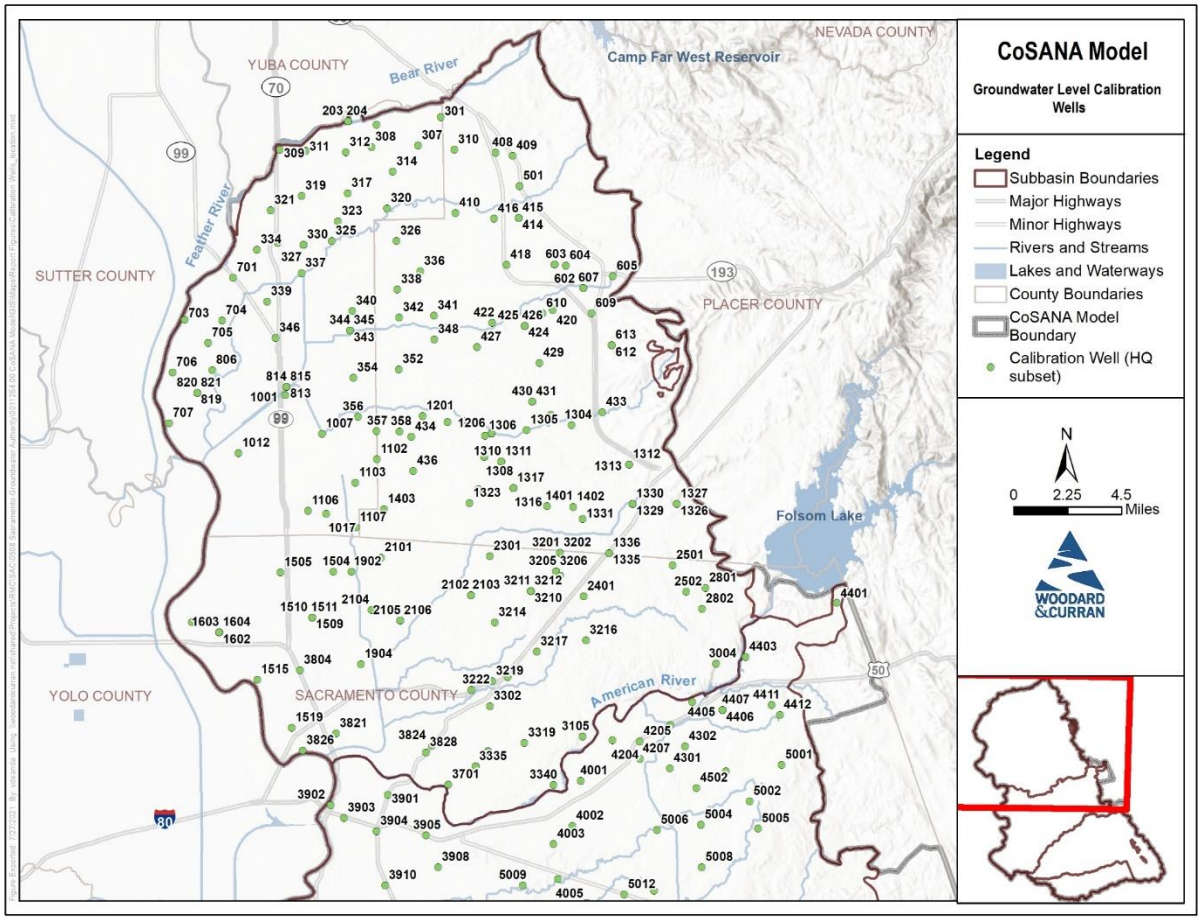
Reach Number	Reach Description	Upstream Inflow (acre-feet)	Downstream Outflow (acre-feet)	Tributary Inflow (acre-feet)	Runoff (acre-feet)	Return Flow (acre-feet)	Gain from Groundwater (acre-feet)	Riparian ET (acre-feet)	Runoff (acre-feet)	Diversion Shortage (acre-feet)
1	Bear River	325,762	362,711	1,587	15,179	3,535	16,654	0	0	0
2	Feather River	5,680,692	5,643,013	0	0	0	-26,679	0	11,000	0
3	Sacramento River Upstream Cross Canal	14,471,419	14,512,137	0	31,663	8,137	15,455	0	14,528	0
4	Racoon Creek (formerly Coon Creek)	28,867	73,106	21,978	35,599	7,876	-21,201	0	0	0
5	East Side Canal I	0	21,499	334	17,074	4,405	-307	0	0	0
6	Auburn Ravine	19,365	26,950	0	13,451	3,115	-7,449	0	1,528	1
7	East Side Canal II	48,450	47,304	0	0	0	-1,146	0	0	0
8	Pleasant Grove Creek	28,846	76,604	386	38,745	12,405	-3,773	0	0	0
9	Pleasant Grove Creek Canal	76,604	73,288	0	0	0	-3,321	0	0	0
10	Cross Canal 1	120,591	114,705	0	0	0	-5,881	0	0	0
11	Cross Canal 2	187,811	189,809	0	0	0	1,998	0	0	0
12	Sacramento River Upstream Natomas East Drain	14,701,946	14,624,027	0	0	0	6,551	0	84,471	0
13	Natomas East Drain Upstream Dry Crk	0	128,860	0	86,007	50,192	-7,347	0	0	0
14	Dry Creek (North American Subbasin)	35,968	47,216	2,438	16,213	7,721	-15,123	0	0	0
15	Natomas East Drain Upstream Magpie Crk	47,216	96,191	0	30,091	20,647	-1,752	0	0	0
16	Magpie Creek	2,470	1,915	0	0	0	-554	0	0	0
17	Natomas East Drain Upstream Arcade Crk	98,107	155,478	0	34,602	26,267	-3,498	0	0	0
18	Arcade Crk	0	0	0	0	0	0	0	0	0
19	Natomas East Drain Upstream Sacramento R.	155,478	147,333	0	0	0	-8,144	0	0	0
20	Sacramento River Upstream American R.	14,771,360	14,777,536	0	0	0	6,176	0	0	0
21	Alder Creek	0	3,728	999	0	0	2,729	0	0	0
22	Buffalo Creek	7,203	53,112	0	32,572	16,776	-3,438	0	0	0
23	American River Upstream Alder Crk	2,747,286	2,754,396	409	0	0	6,700	0	0	0
24	American River Upstream Buffalo Crk	2,758,124	2,750,442	0	0	0	-7,682	0	0	0
25	American River Buffalo Crk to H St Bridge	2,815,189	2,718,995	0	0	0	-40,829	0	55,365	0
26	American River Upstream Sacramento R.	2,718,995	2,736,106	0	0	0	17,242	0	132	0
27	Sacramento River Upstream Morrison Crk	17,513,642	17,502,205	0	42,933	35,792	-34,708	0	55,453	0
28	Morrison Creek Upstream Elder Crk	17,995	77,197	0	41,487	20,118	-2,388	0	0	0
29	Elder Creek	0	0	0	0	0	0	0	0	0
30	Morrison Creek Upstream Beacon Crk	77,197	74,208	0	0	0	-2,989	0	0	0
31	Beacon Creek	0	57	0	0	0	57	0	0	0
32	Morrison Creek Upstream Laguna Crk	74,265	111,174	0	28,492	9,394	-970	0	0	0
33	Laguna Creek (South American Subbasin)	8,342	2,940	0	0	0	-5,402	0	0	0
34	Morrison Creek Upstream Sacramento R.	114,114	134,109	0	11,790	7,076	1,133	0	0	0
35	Sacramento River Upstream Mokolumne Confluence	17,636,315	17,649,814	0	38,822	12,907	-38,209	0	0	0
36	Deer Creek	1,214	104,376	87,005	23,491	2,701	-9,833	0	197	6
37	Cosumnes River Upstream Deer Crk	397,070	409,057	0	25,669	3,406	-8,031	1,239	7,818	197
38	Cosumnes River Upstream Badger Crk	513,433	505,527	0	662	182	-7,340	640	769	0
39	Badger Creek	0	6,524	0	6,425	486	199	579	0	45
40	Cosumnes River Upstream Laguna Crk	512,051	522,840	0	17,105	1,617	-7,584	340	4	0
41	Laguna Creek (Cosumnes Subbasin)	21,012	96,118	17,138	52,214	7,685	1,003	1,544	1,388	0
42	Cosumnes River Upstream Mokolumne R.	618,958	617,231	0	8,449	2,085	-10,375	1,817	68	0
43	Dry Creek Upstream Jackson Crk	30,040	53,117	0	19,708	1,448	4,570	0	2,649	75
44	Jackson Creek	30,295	36,670	804	0	0	5,570	0	0	0
45	Dry Creek Upstream Mokolumne R.	89,787	119,068	0	46,628	6,563	-18,302	1,614	3,955	505
46	Mokolumne River Upstream Dry Crk	569,130	534,845	0	5,415	1,306	-41,001	0	0	0
47	Mokolumne River Upstream Cosumnes R.	653,913	649,754	0	0	0	-3,591	281	290	0
48	Mokolumne River Upstream Sacramento R. Confluence	1,266,985	1,278,877	0	0	0	11,894	0	0	0
49	Folsom South Canal (North of Cosumnes R.)	0	0	0	0	0	0	0	0	0
50	Folsom South Canal (South of Cosumnes R.)	0	0	0	0	0	0	0	0	0
51	Hadselville Creek	12,039	11,985	0	0	0	-27	27	0	0

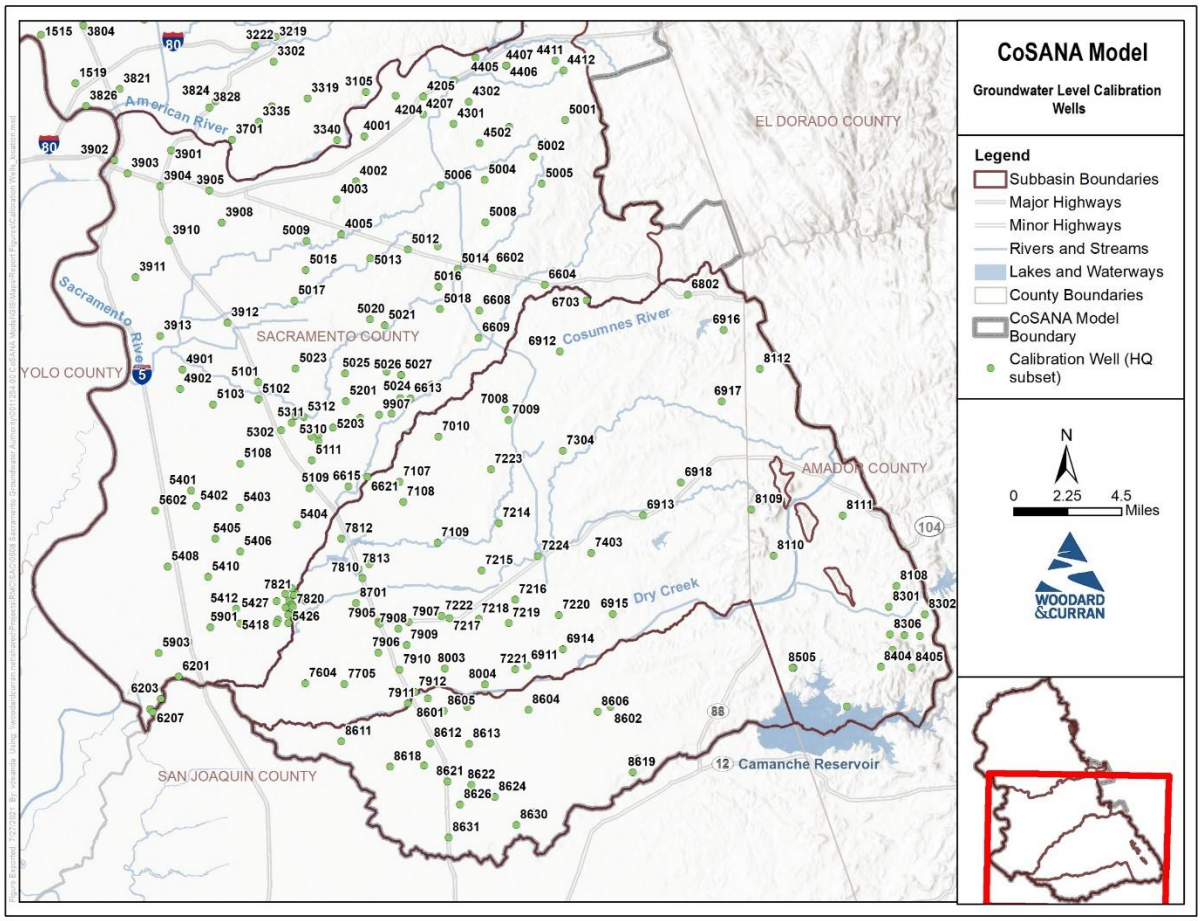
APPENDIX E: SUBREGION GROUNDWATER BUDGETS

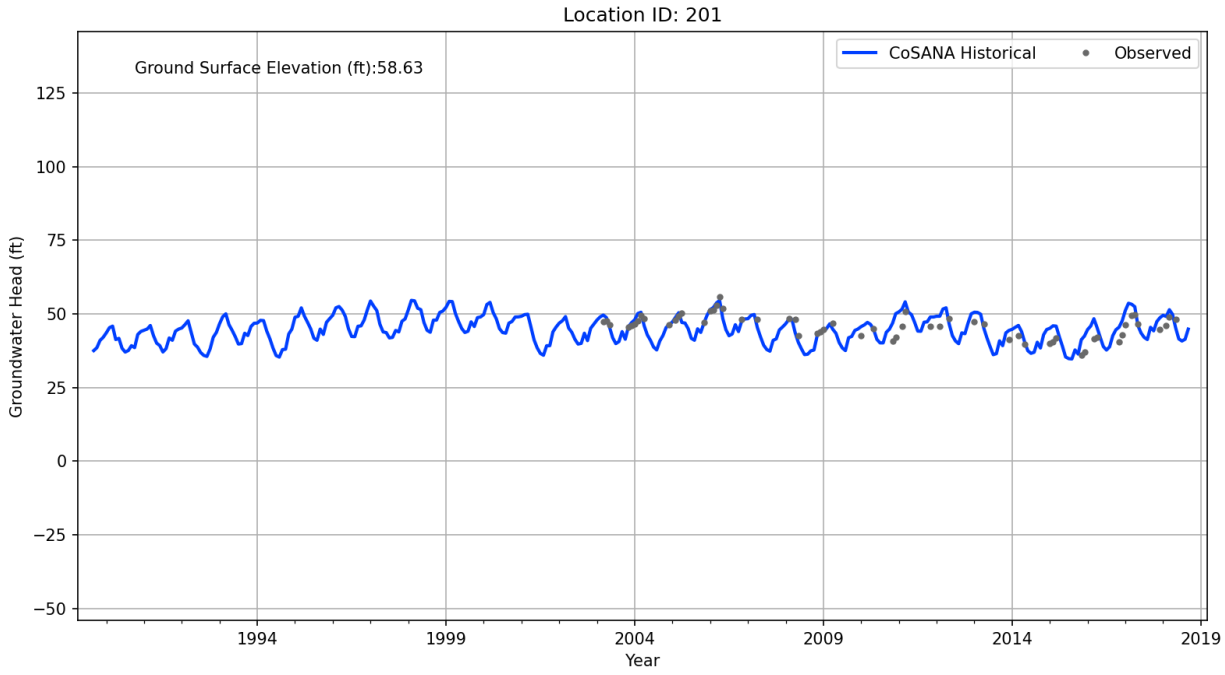
Historical Groundwater Budget Summary, Annual Average for WY 1995 - 2018							
Subregion	**Description**	**Deep Percolation**	**Gain from Stream**	**Recharge (Recoverable Loss)**	**Boundary Inflow**	**Net Subsurface Inflow**	**Pumping**
		(Acre-Feet)	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*
North American Subbasin							
1	Camp Far West ID	6,135	-5,792	699	2,385	1,193	4,622
2	Sutter Co. 1	309	19	0	1,042	-723	644
3	South Sutter WD GSA	53,729	24,620	11,265	3,832	12,707	105,258
4	Placer County WA	32,625	3,435	1,186	1,469	-4,129	26,874
5	Nevada ID	7,990	850	1,616	4,455	-8,249	6,426
6	Lincoln	6,143	933	0	505	-1,859	1,866
7	RD1001	15,990	3,411	1,148	741	-1,978	19,204
8	Pleasant Grove Verona MWC	5,444	2,754	1,516	0	2,447	12,081
9	Sutter Co. 2	1,438	-2,571	140	1,429	1,889	2,318
10	Natomas MWC (Sutter Co.)	7,966	5,839	306	72	-10,265	3,933
11	Sutter Co. 3	3,321	938	0	0	5,114	9,441
12	Roseville SOI	1,287	1,178	0	0	1,043	3,141
13	City of Roseville	5,768	6,041	145	2,486	-8,724	749
14	Cal Am (West Placer)	4,747	4,279	0	0	-1,597	6,465
15	Natomas MWC (Sacramento Co.)	11,773	-3,535	514	4,246	-8,920	3,477
16	Sacramento International Airport	1,060	0	0	0	982	1,862
17	Metro Air Park	878	0	0	0	745	1,468
18	Sac Co. 1	964	-2,655	0	4,068	-1,619	704
19	Sac Co. 2	1,336	2,281	0	0	-242	3,286
20	Sac County WA (Northgate 880)	77	603	0	0	238	846
21	Rio Linda Elverta	2,156	5,736	0	0	2,732	9,840
22	Sac Co. 3	231	793	0	0	-356	584
23	Cal Am (Antelope)	618	663	0	0	4,262	5,134
24	Cal Am (Lincoln Oaks)	618	0	0	0	8,459	8,402
25	Citrus Heights WD	1,760	0	0	476	-292	1,680
26	San Juan WD (Placer Co.)	434	0	0	1,159	-1,751	18
27	San Juan WD (Sacramento Co.)	649	-488	0	811	-931	246
28	Orange Vale WC	1,338	0	0	0	-1,018	618
29	Lake Natoma/Mississippi Bar	1,516	-4,959	0	30	3,461	35
30	Fair Oaks WD	2,910	5,159	0	0	-5,449	2,877
31	Carmichael WD	1,165	6,118	0	0	-1,996	4,906
32	Sacramento Suburban WD (North)	2,802	53	0	0	16,599	17,456
33	Sacramento Suburuban WD (South)	954	7,379	0	0	9,721	17,166
34	Del Paso Manor WD	84	0	0	0	1,550	1,549
35	Golden State WC Arden	45	0	0	0	956	931
36	Cal Am (Arden)	481	0	0	0	1,492	1,901
37	Sac County WA (Arden Park	237	991	0	0	1,819	2,896
38	City of Sacramento (North)	4,793	19,148	0	1,130	1,947	25,074
Total NASb		191,772	83,222	18,535	30,336	19,257	315,980
South American Subbasin							
39	City of Sacramento (South)	16,041	15,444	0	1,403	-28,141	3,252
40	Cal Am (Suburban Rosemont)	1,950	7,140	0	0	4,865	13,511
41	Sac Co. 4	301	2,827	0	0	-3,093	29
42	Golden State WC (Cordova)	6,644	14,347	0	0	-7,641	13,361
43	Sac Co. 5	1,939	0	0	0	5,527	7,351
44	City of Folsom	17,068	-2,544	0	2,135	-10,936	3,171
45	Cal Am (Security Park)	1,608	37	0	0	-1,613	79
46	Fruitridge Vista WC	306	235	0	0	3,194	3,621
47	Florin County WD	158	0	0	0	2,209	2,315
48	Cal Am (Parkway)	857	303	0	0	9,845	10,762
49	Sac Co. 6	1,228	3,807	0	228	-4,544	655
50	Sac County WA (North/Central)	18,508	3,649	207	0	8,510	32,290
51	Sac County WA (South)	5,692	203	0	0	14,360	19,306
52	Elk Grove WD (2 - Intertie Service Area)	1,525	1,066	0	0	1,132	3,758
53	Elk Grove WD (1 - GW Service Area)	493	632	0	0	6,665	7,568
54	Cosumnes River West	23,325	11,899	0	0	21,878	56,028
55	RD744	885	6,948	0	-718	-6,346	762
56	Franklin Drainage District	3,383	6,324	0	-205	-6,030	3,365
57	RD813	1,648	3,037	0	-91	-3,265	1,320
58	RD755	549	1,415	0	-249	-1,180	535
59	RD1002	3,199	0	0	0	-115	3,055
60	RD551	8,934	6,259	0	-1,397	-7,491	6,307
61	RD369	441	2,023	0	-201	-2,110	153
62	RD2110	865	-745	0	516	-197	437
63	Sac Co. 7	407	1,342	0	29	-1,507	270
64	Rancho Murieta (North)	5,053	-1,984	0	0	-1,382	893
65	Sloughouse RCD (North)	4,971	93	0	2,791	-5,805	1,874
66	OHWD (Sth American Subbasin)	11,701	15,439	15	64	-969	25,837
Total SASb		139,681	99,195	222	4,307	-14,179	221,865
Cosumnes Subbasin							
67	OHWD (Cosumnes Subbasin)	5,590	5,181	0	0	-4,272	6,255
68	Rancho Murieta (South)	1,070	-1,843	0	0	768	6
69	Sloughouse RCD (East)	22,178	3,548	0	1,116	-9,591	19,922
70	Wilton	4,641	45	0	0	3,051	7,953
71	Sloughouse RCD (West)	4,099	381	0	0	5,687	10,570
72	Galt ID (East)	20,192	1,970	0	0	23,121	47,606
73	Clay WD	3,514	1,115	0	0	629	5,634
74	Clay	1,051	3	0	0	733	2,084
75	SMUD Rancho Seco	473	0	0	0	-666	7
76	Cosumnes River South	4,860	9,984	0	-523	-5,018	9,159
77	Galt ID (West)	2,736	776	0	0	2,631	6,062
78	Sac Co. 8	4,301	8,367	0	0	-7,323	5,289
79	City of Galt	1,744	668	0	0	2,623	5,099
80	Sloughouse RCD (South)	1,225	993	0	0	224	2,474
81	Amador Co. 1	13,266	-5,448	0	3,367	-8,492	1,259
82	Ione	1,513	0	0	0	-602	425
83	Jackson ID	8,648	-6,775	0	507	-2,429	0
84	Camanche	5,130	0	0	-4,621	-1,420	81
85	Amador County WA	1,477	0	0	5	-1,559	176
87	Galt WWTP	344	0	0	0	-352	0
Total CoSb		108,054	18,964	0	-149	-2,255	130,062
Other							
86	Mokelumne	29,317	49,564	0	3,650	-2,823	83,278
Total Other		29,317	49,564	0	3,650	-2,823	83,278
CoSANA Total (NASb, SASb, CoSb)		439,507	201,381	18,757	34,495	2,823	667,907

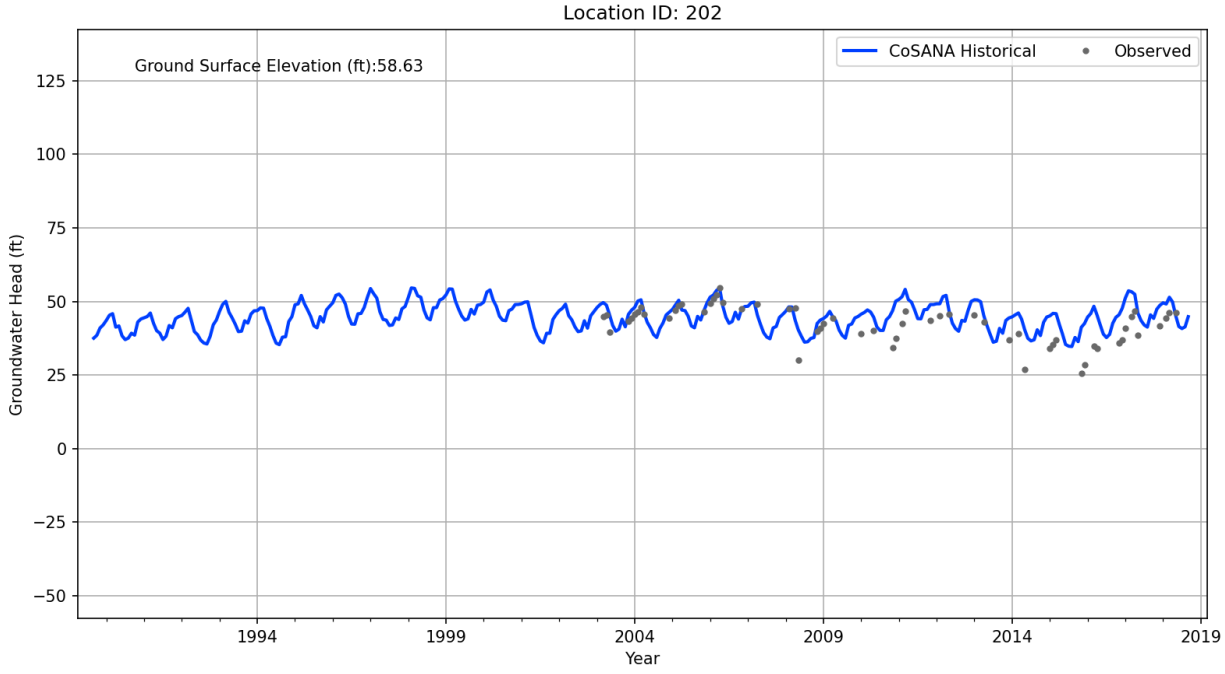
APPENDIX F: CALIBRATION HYDROGRAPHS

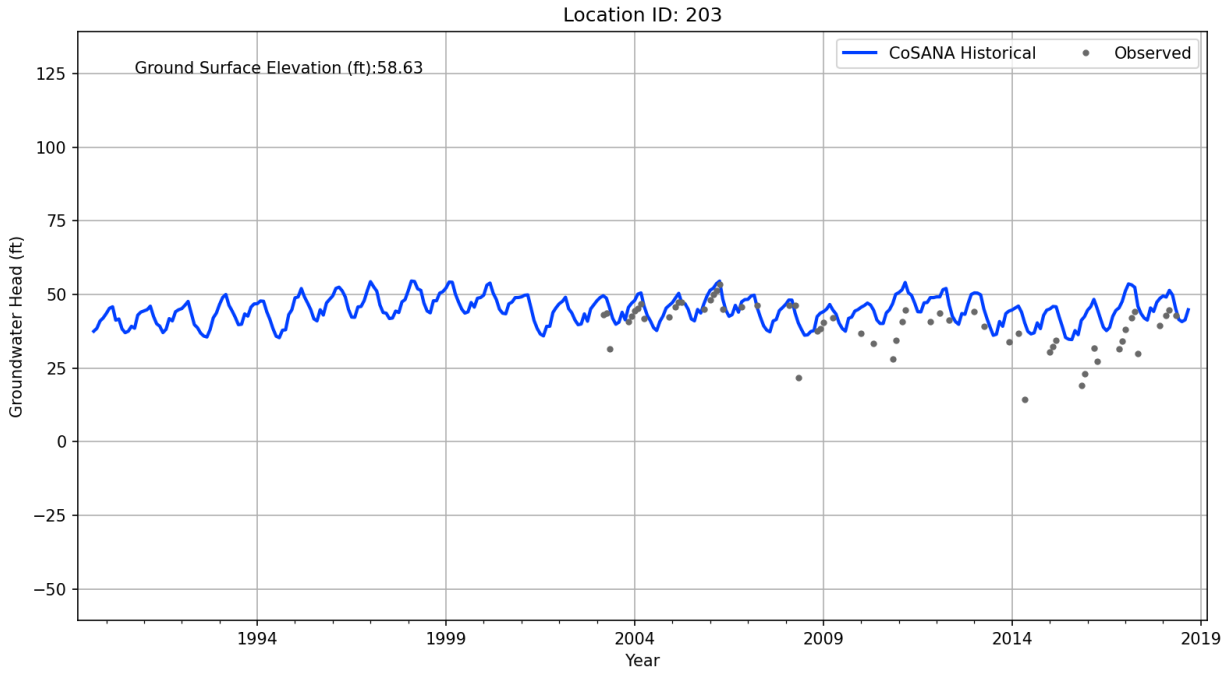
Note: *hydrographs developed for this appendix use a transmissivity-weighted average of layers 2 through 5 for simulated groundwater heads.*

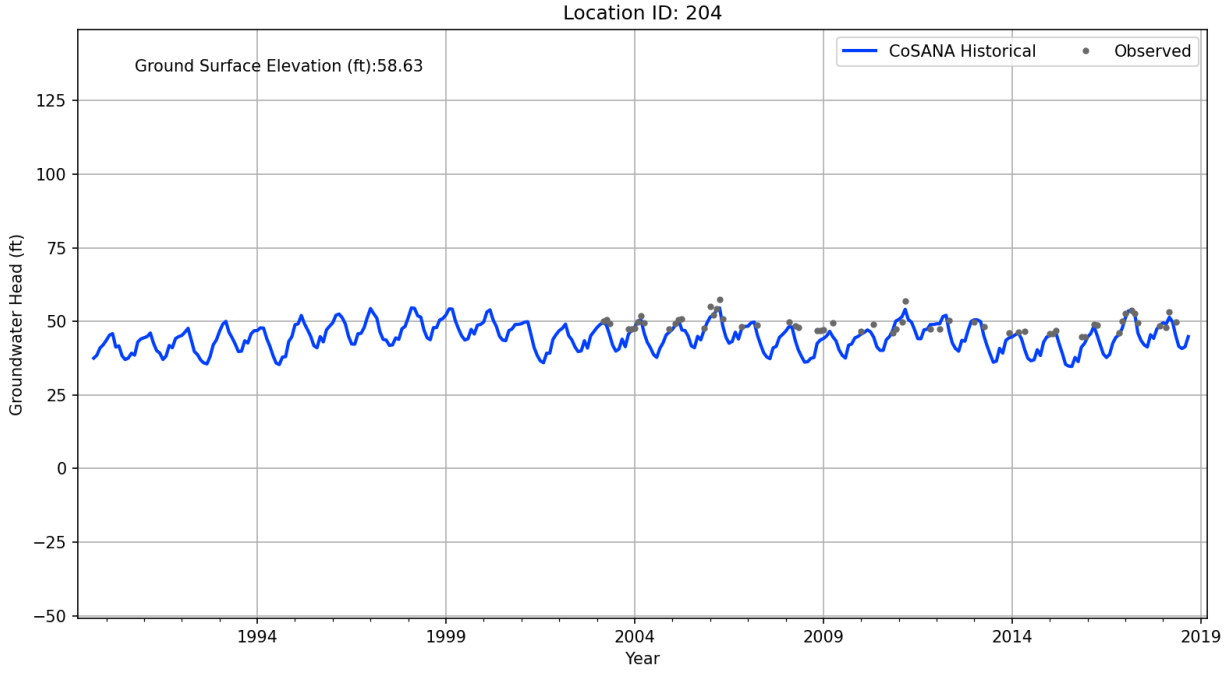


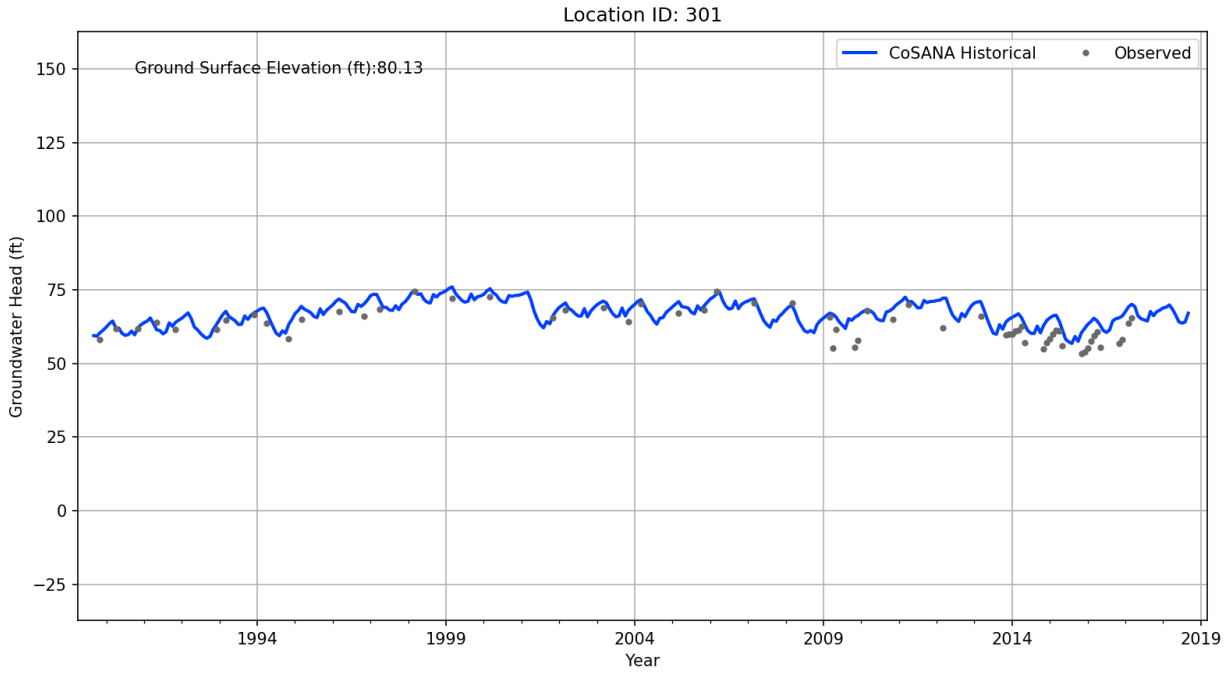

CoSANA Model
Groundwater Level Calibration Wells
Legend
Subbasin Boundaries
Major Highways
Minor Highways
Rivers and Streams
Lakes and Waterways
County Boundaries
CoSANA Model Boundary
Calibration Well (HQ subset)
N
0 2.25 4.5 Miles
WOODARD &CURRAN
EL DORADO COUNTY
SACRAMENTO COUNTY
YOLO COUNTY
AMADOR COUNTY
SAN JOAQUIN COUNTY
American River
Sacramento River
Cosumnes River
Dry Creek
Camanche Reservoir

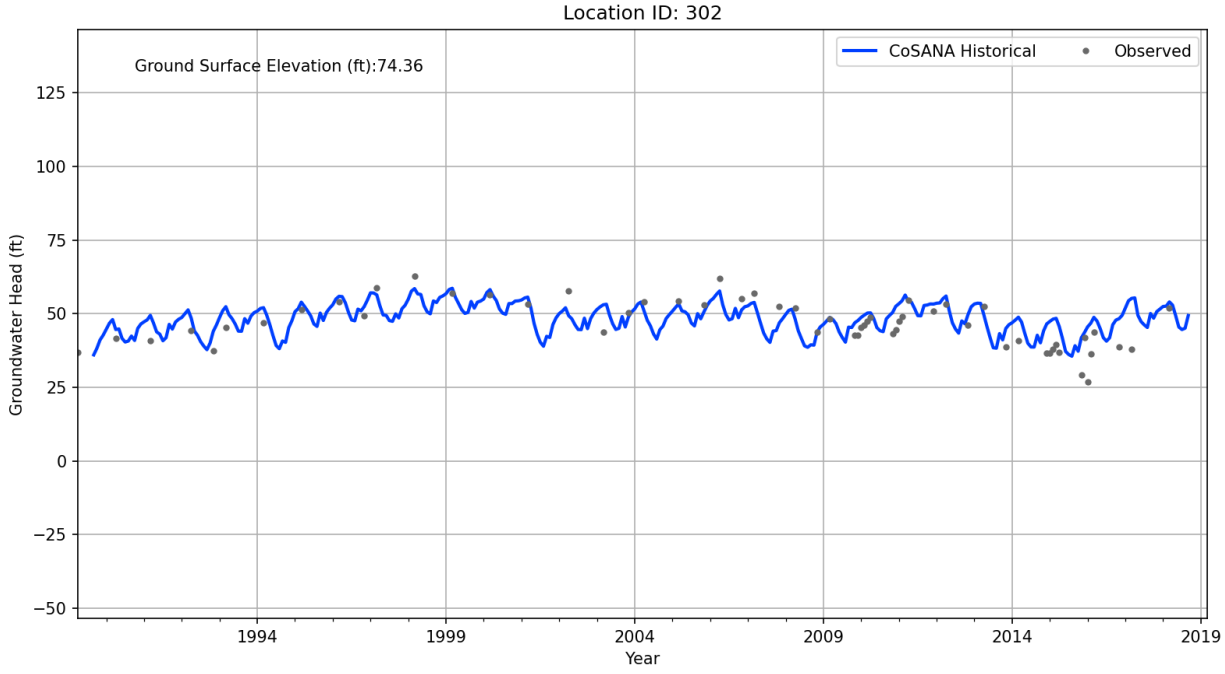

Location ID: 201
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

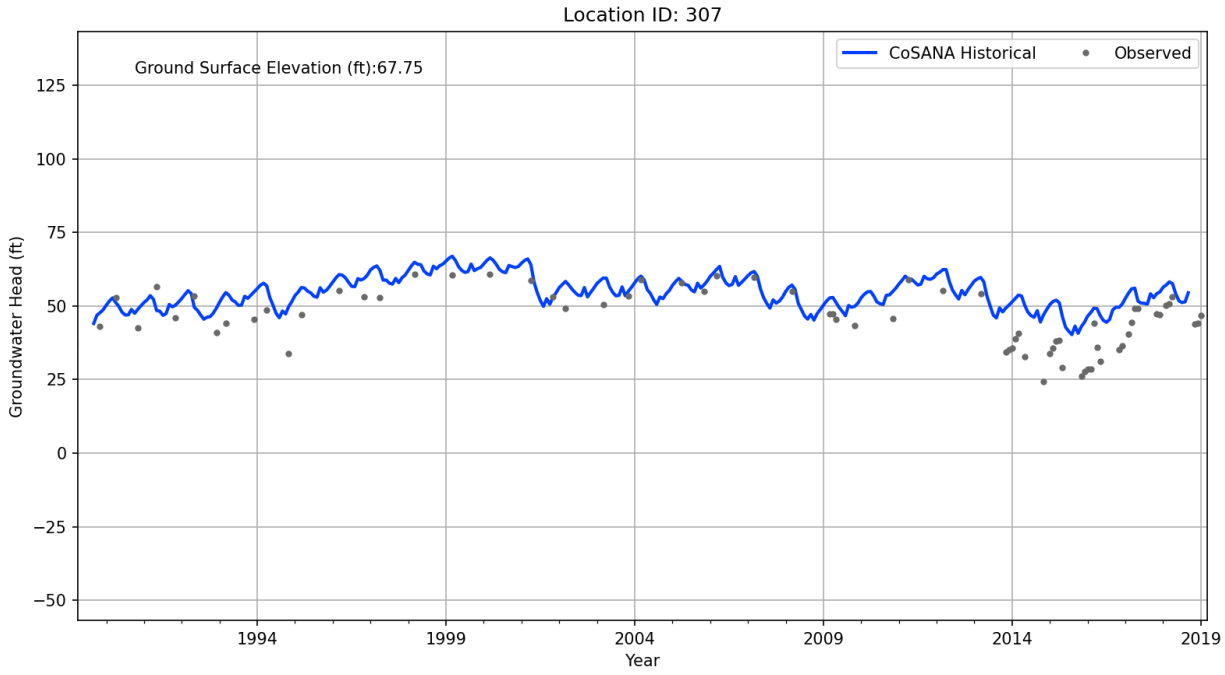

Location ID: 202
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

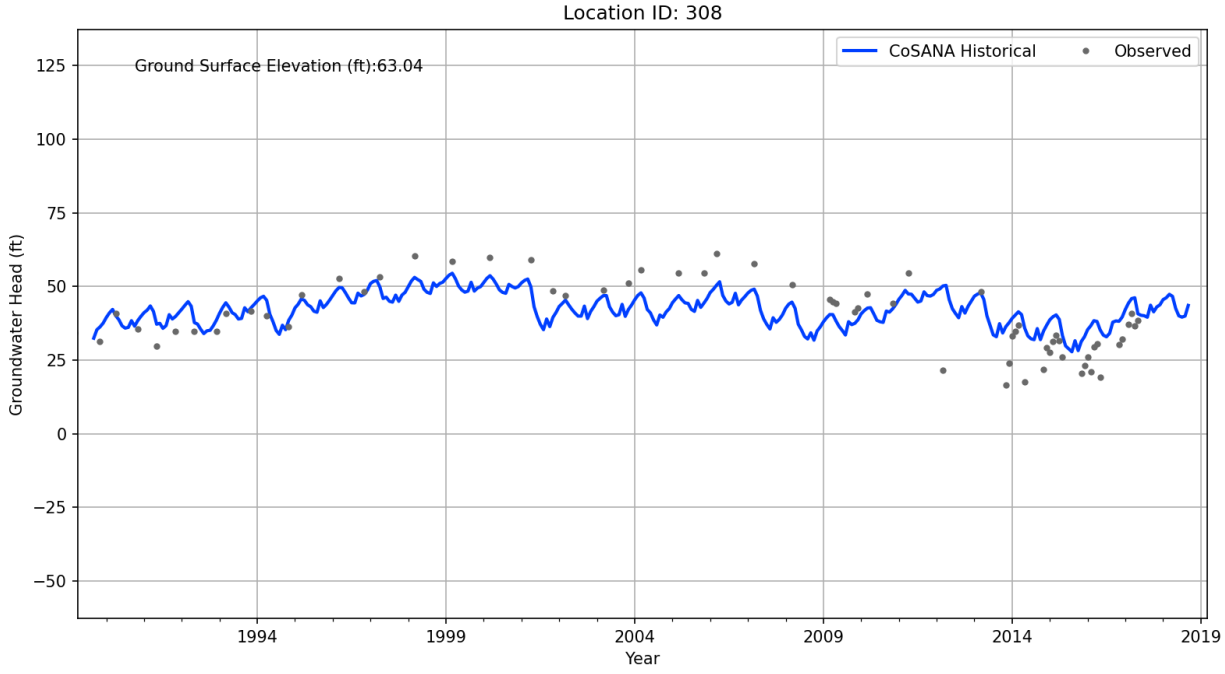

Location ID: 203
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

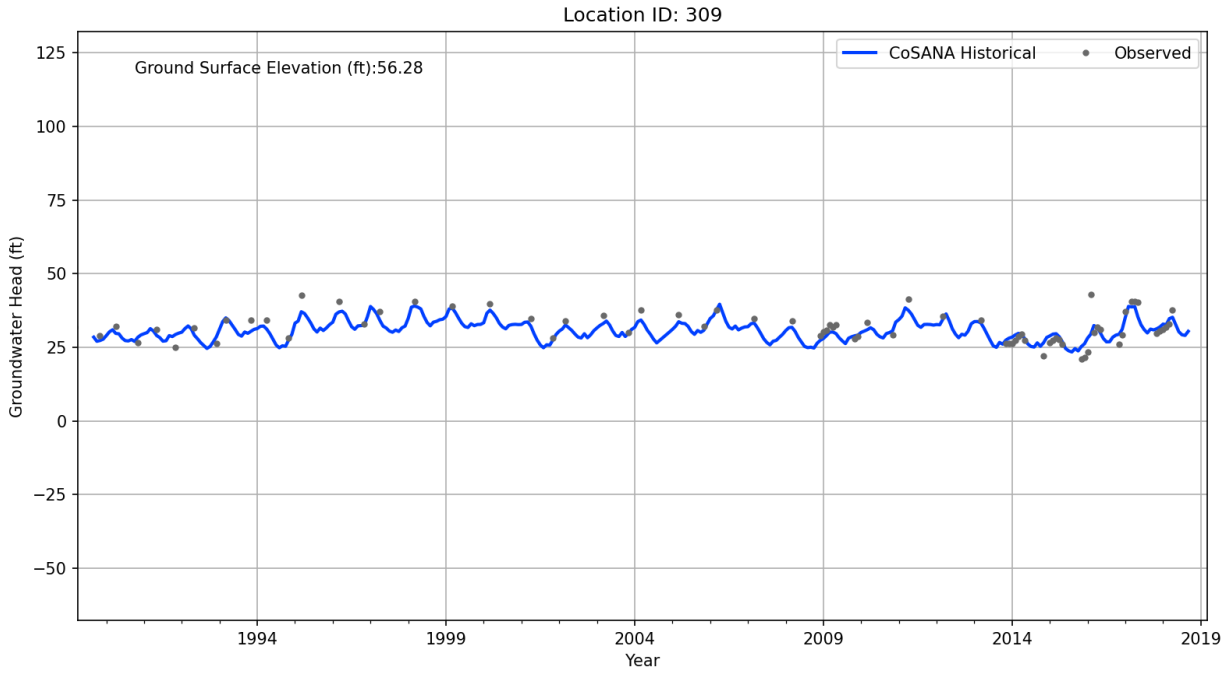

Location ID: 204
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

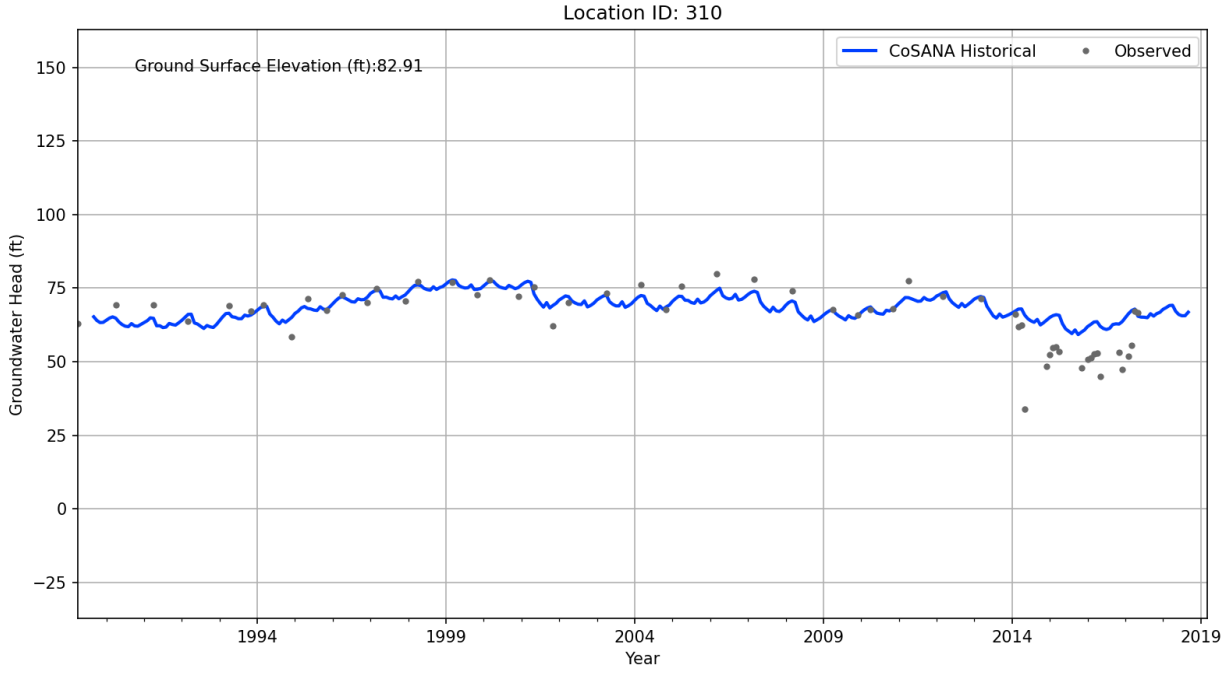

Location ID: 301
Ground Surface Elevation (ft):80.13
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

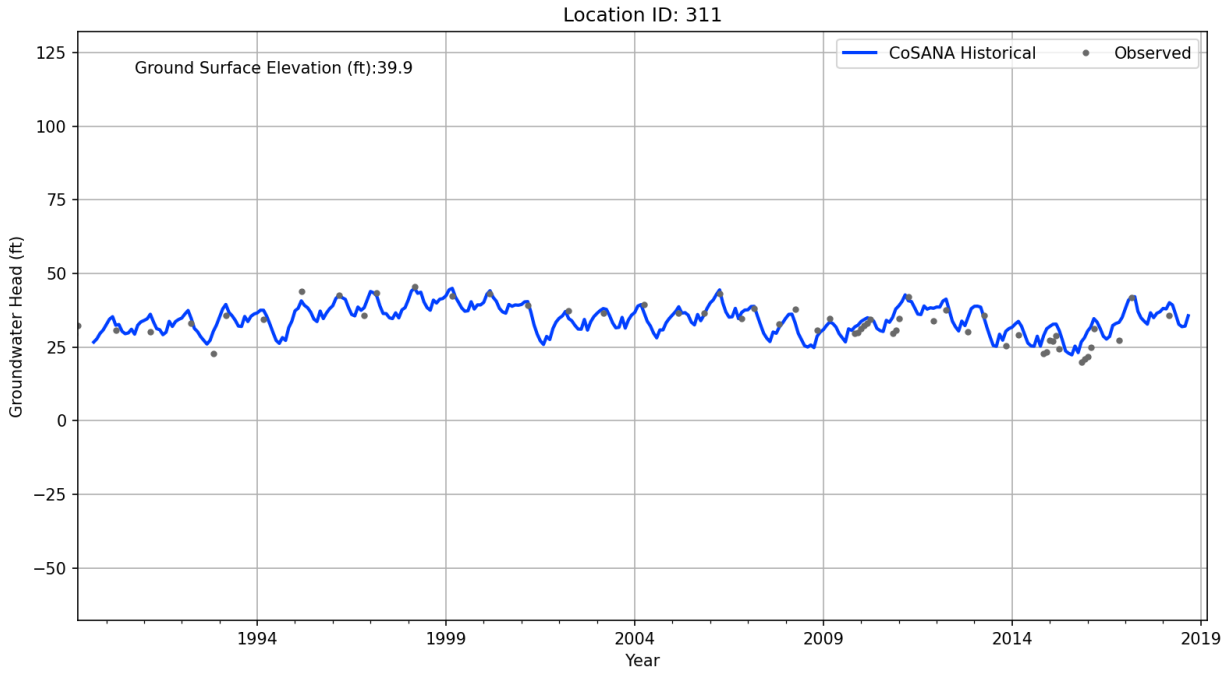

Location ID: 302
Ground Surface Elevation (ft):74.36
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

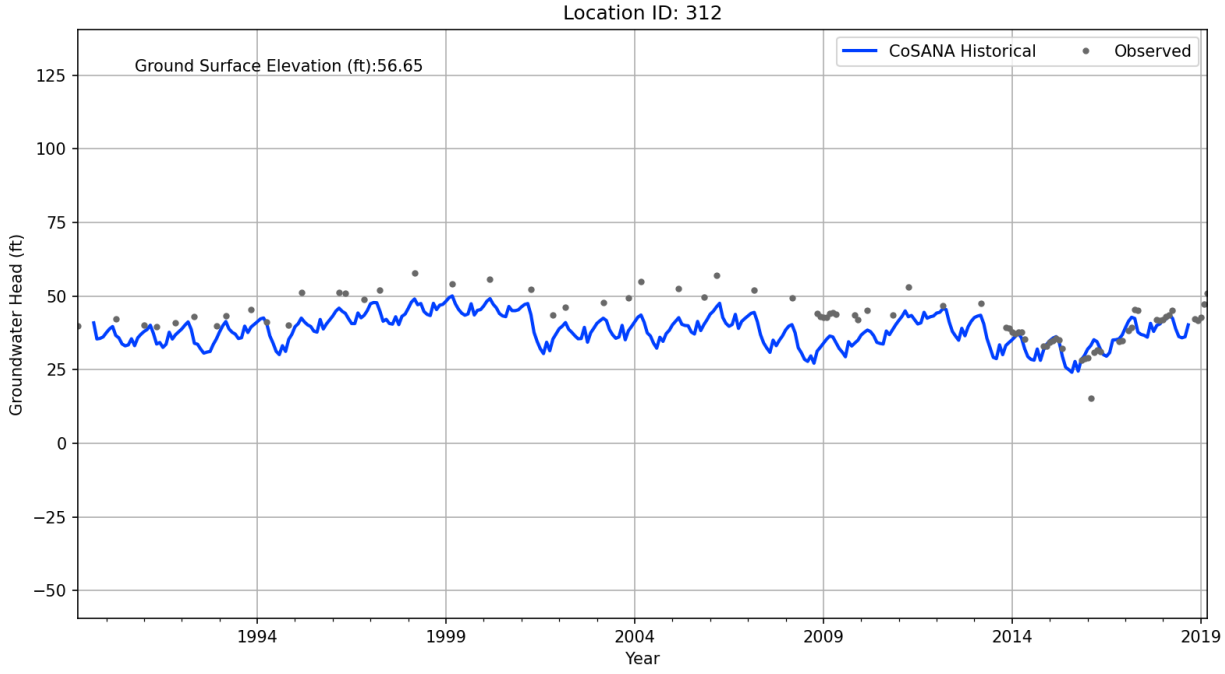

Location ID: 307
Ground Surface Elevation (ft):67.75
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

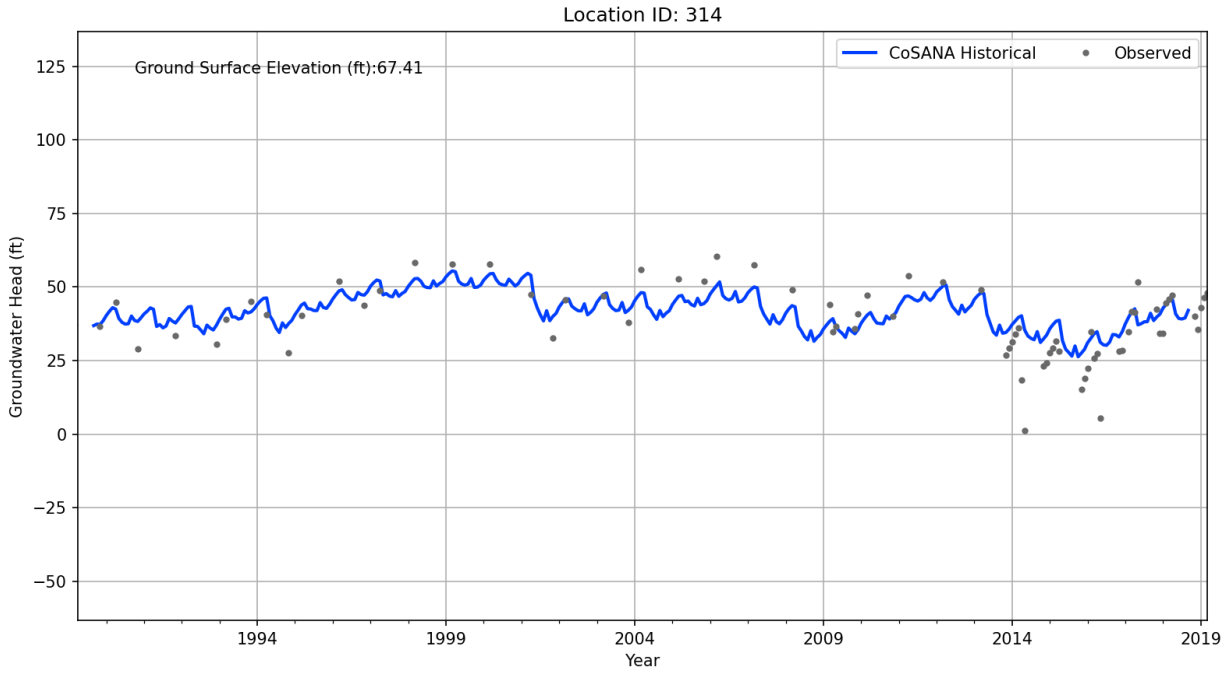

Location ID: 308
Ground Surface Elevation (ft):63.04
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

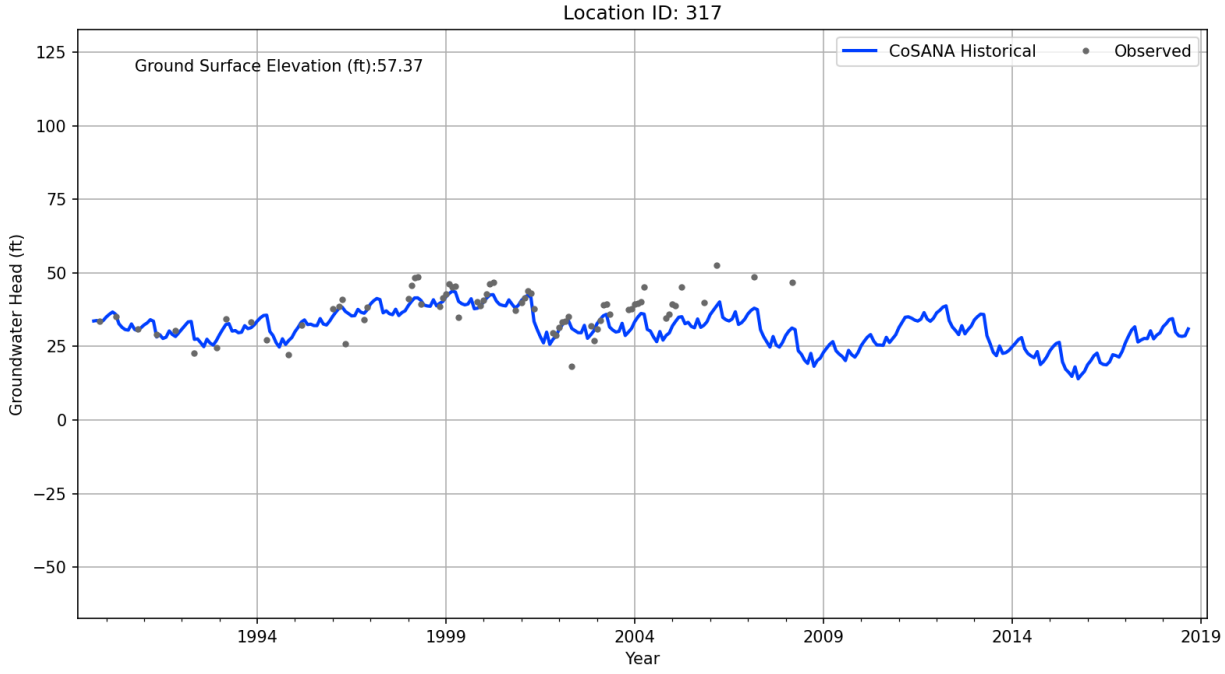

Location ID: 309
Ground Surface Elevation (ft):56.28
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

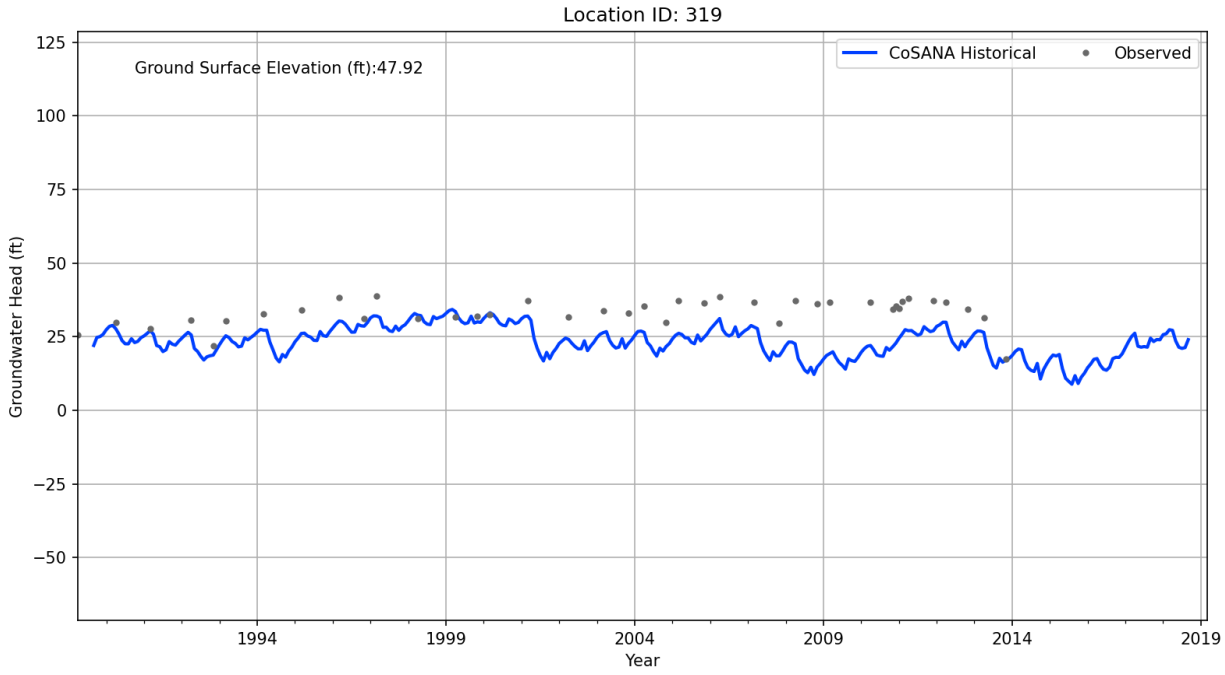

Location ID: 310
Ground Surface Elevation (ft):82.91
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

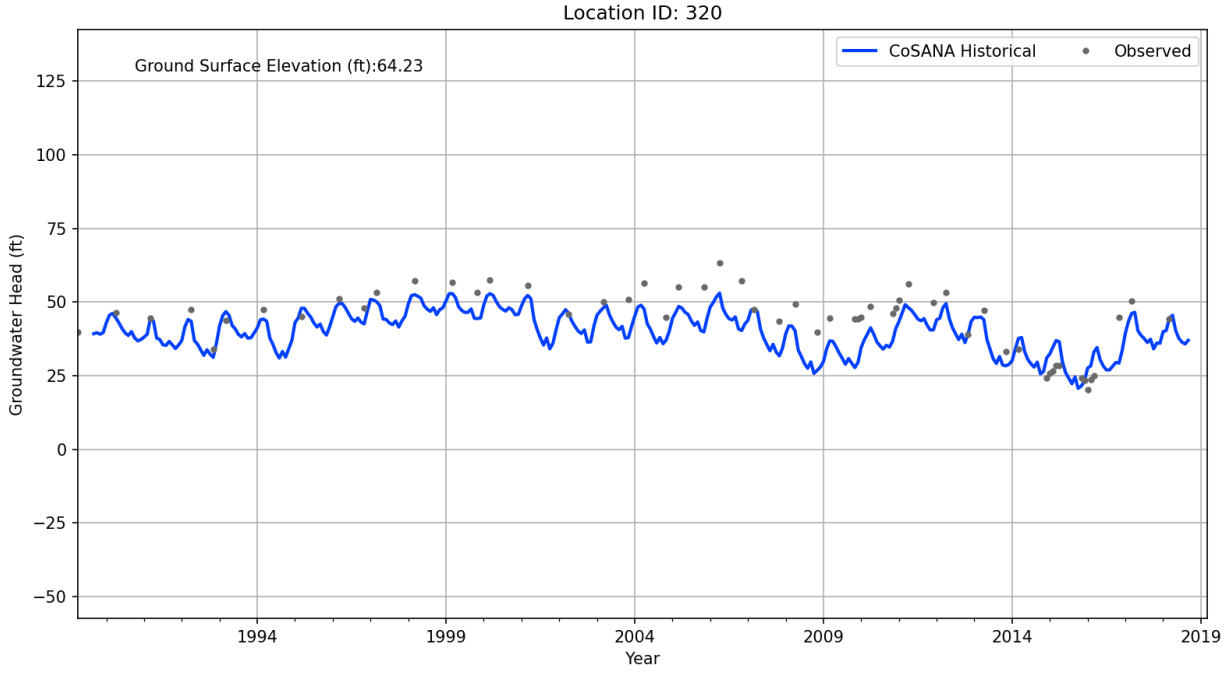

Location ID: 311
Ground Surface Elevation (ft):39.9
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

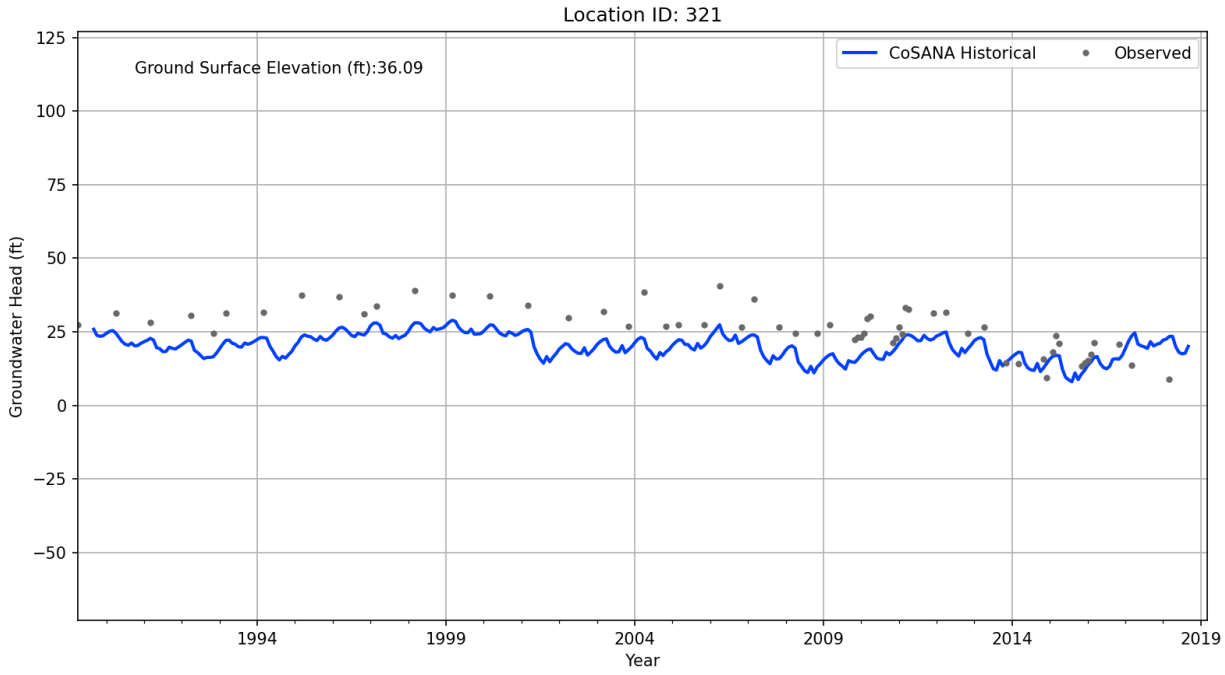

Location ID: 312
Ground Surface Elevation (ft):56.65
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

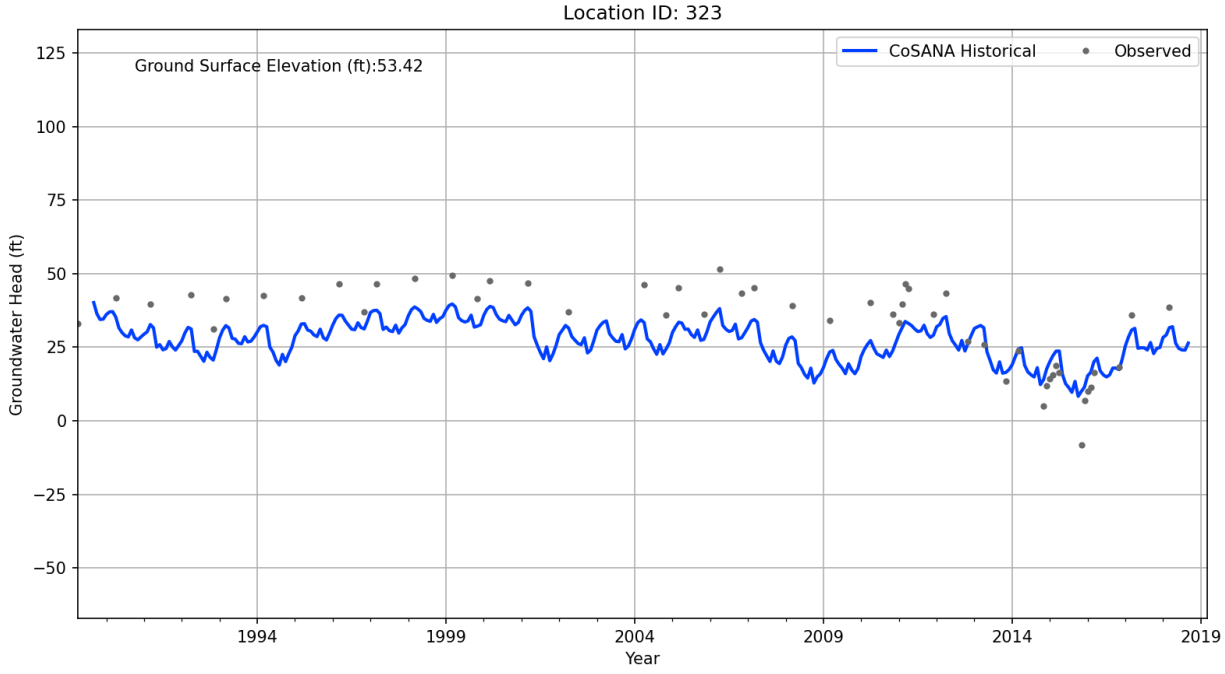

Location ID: 314
Ground Surface Elevation (ft):67.41
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

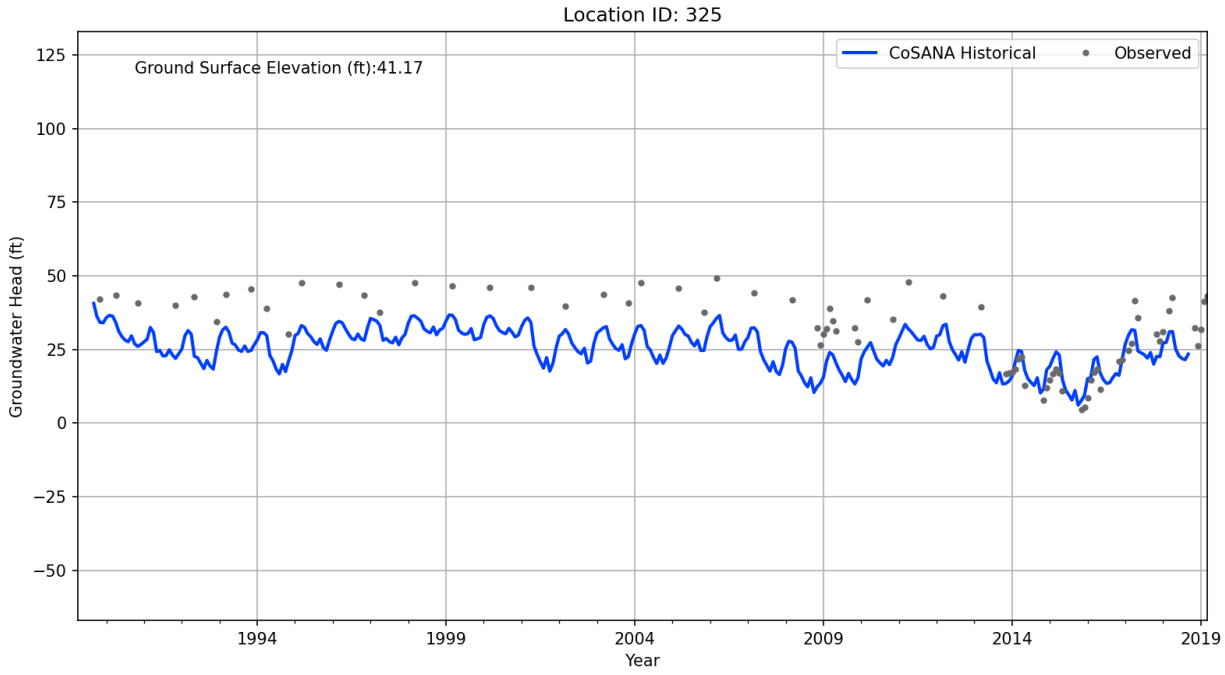

Location ID: 317
Ground Surface Elevation (ft):57.37
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

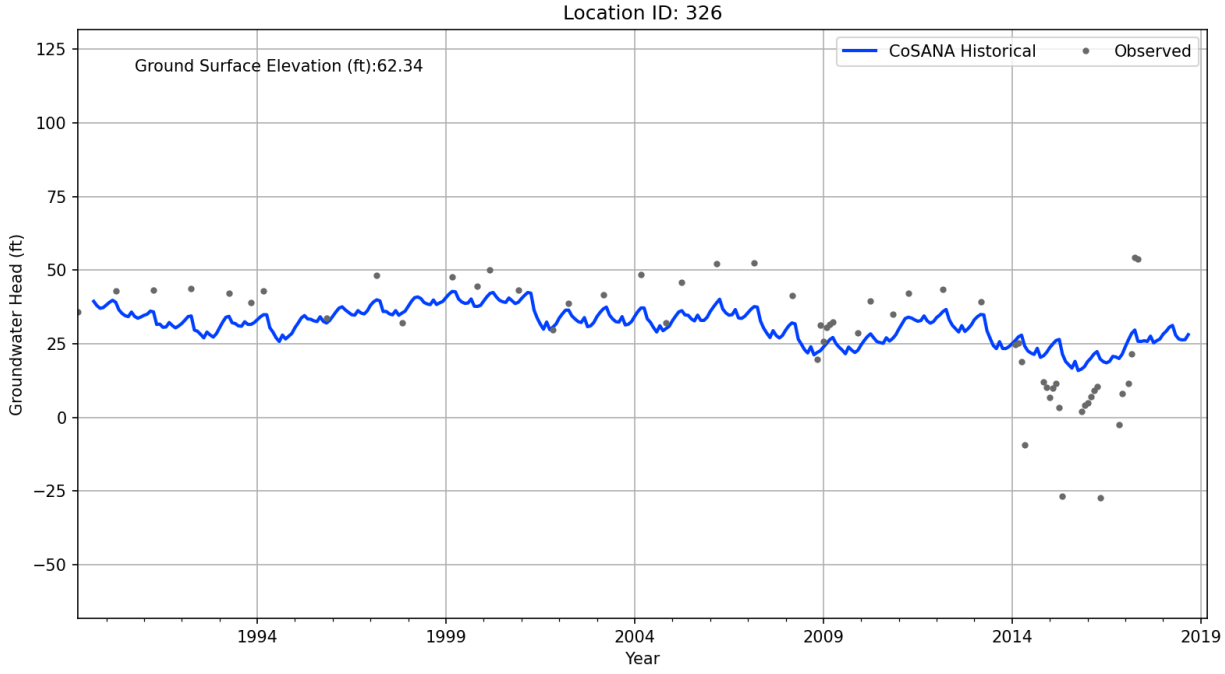

Location ID: 319
Ground Surface Elevation (ft):47.92
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

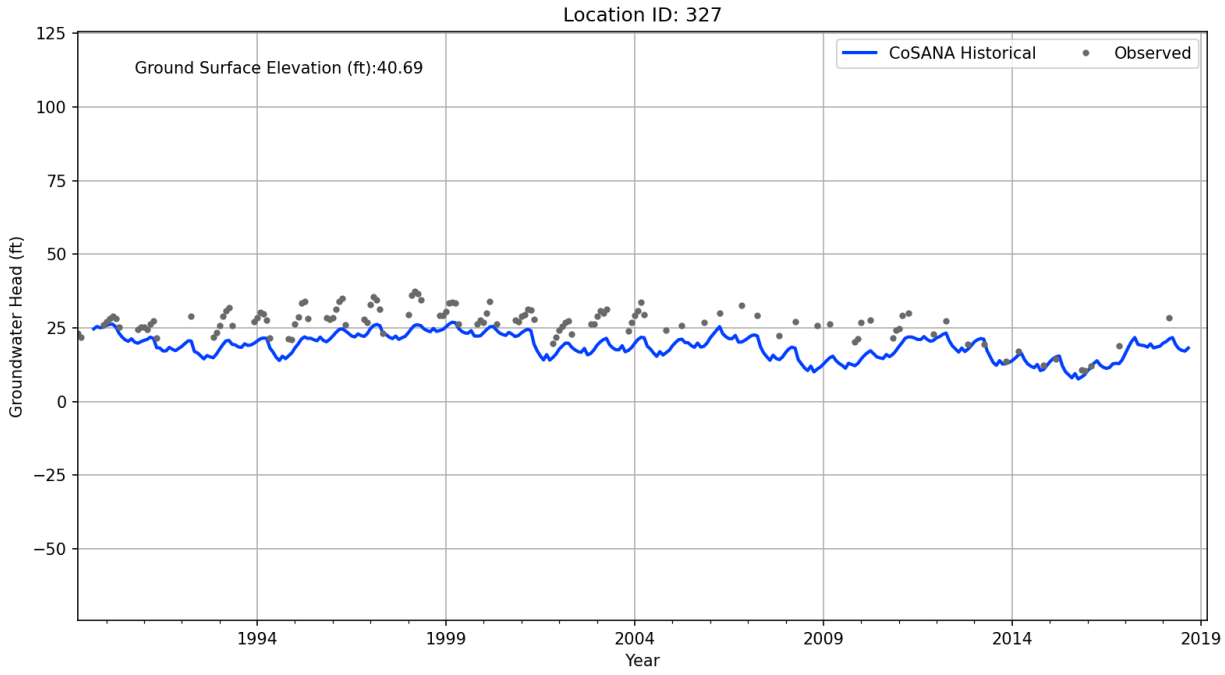

Location ID: 320
Ground Surface Elevation (ft):64.23
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

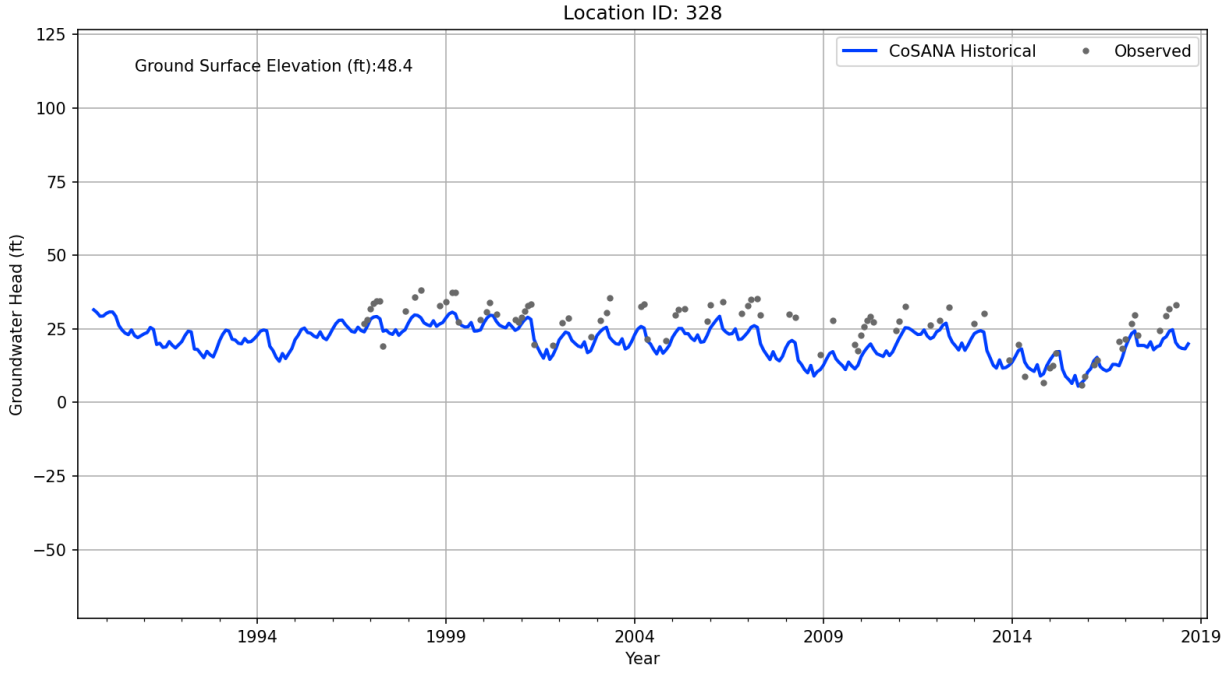

Location ID: 321
Ground Surface Elevation (ft):36.09
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

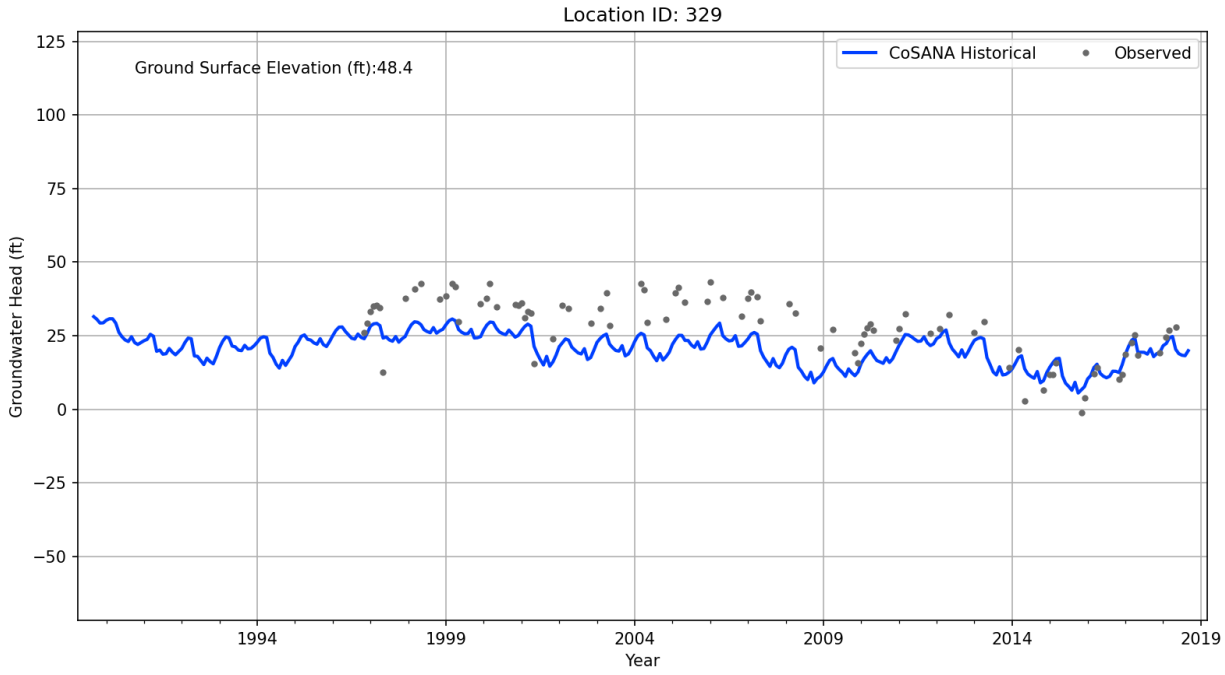

Location ID: 323
Ground Surface Elevation (ft):53.42
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

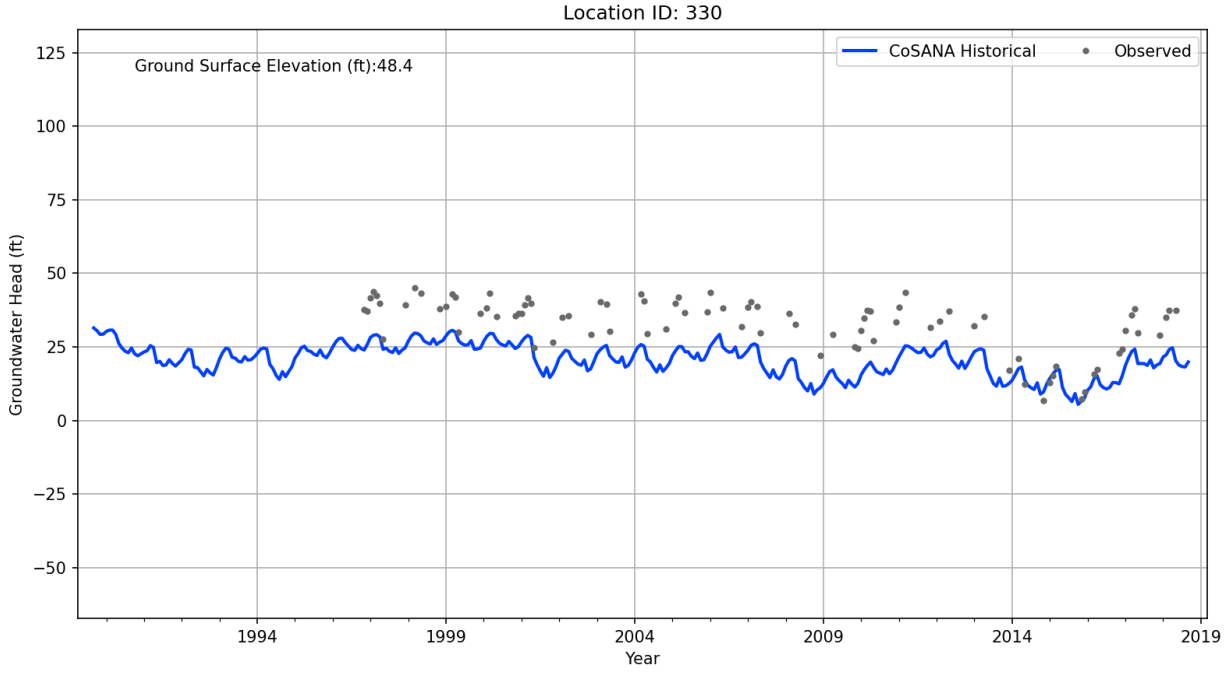

Location ID: 325
Ground Surface Elevation (ft):41.17
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

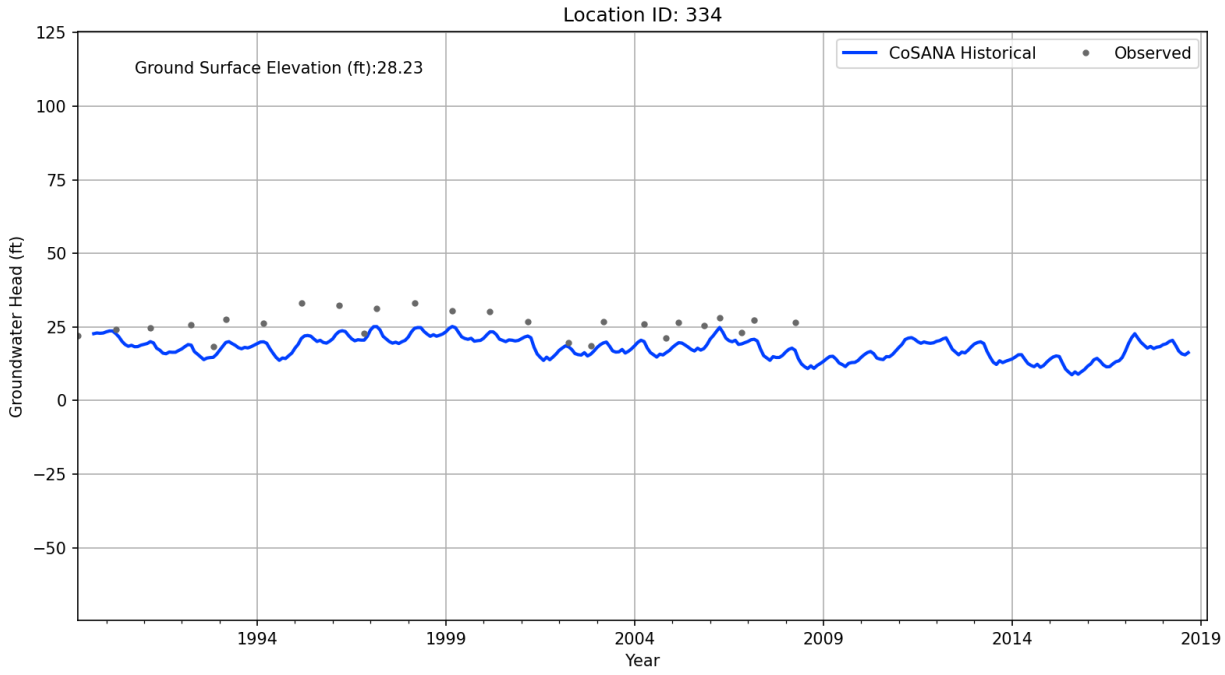

Location ID: 326
Ground Surface Elevation (ft):62.34
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

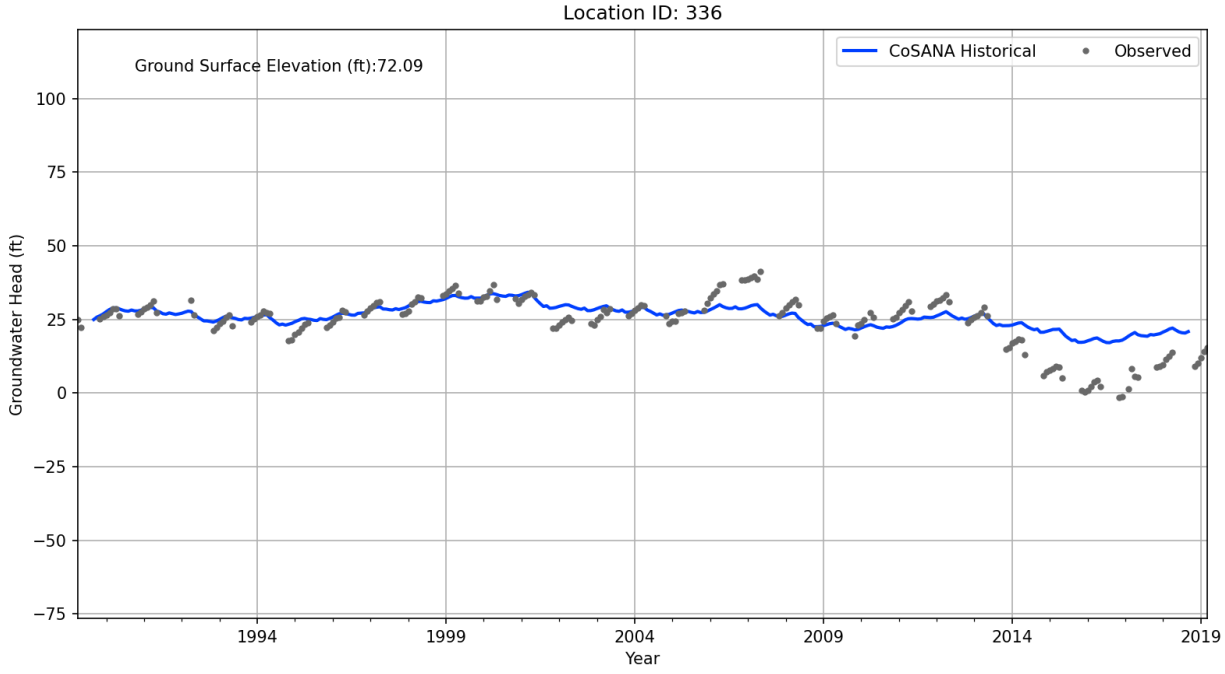

Location ID: 327
Ground Surface Elevation (ft):40.69
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

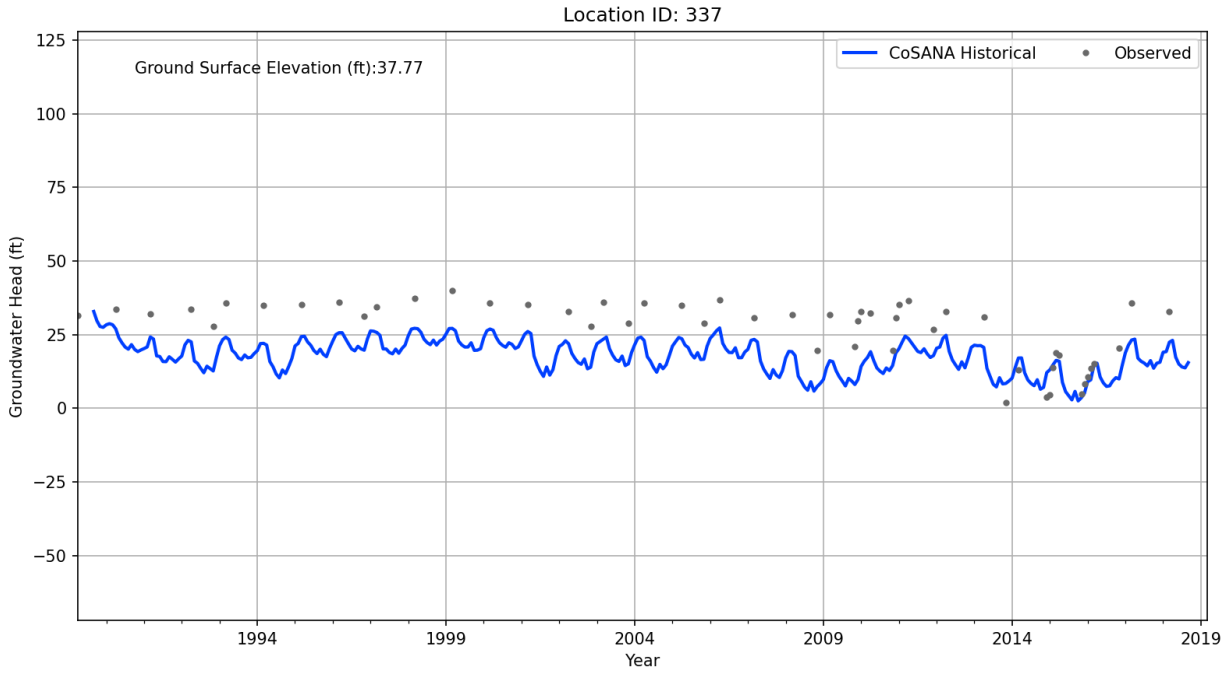

Location ID: 328
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

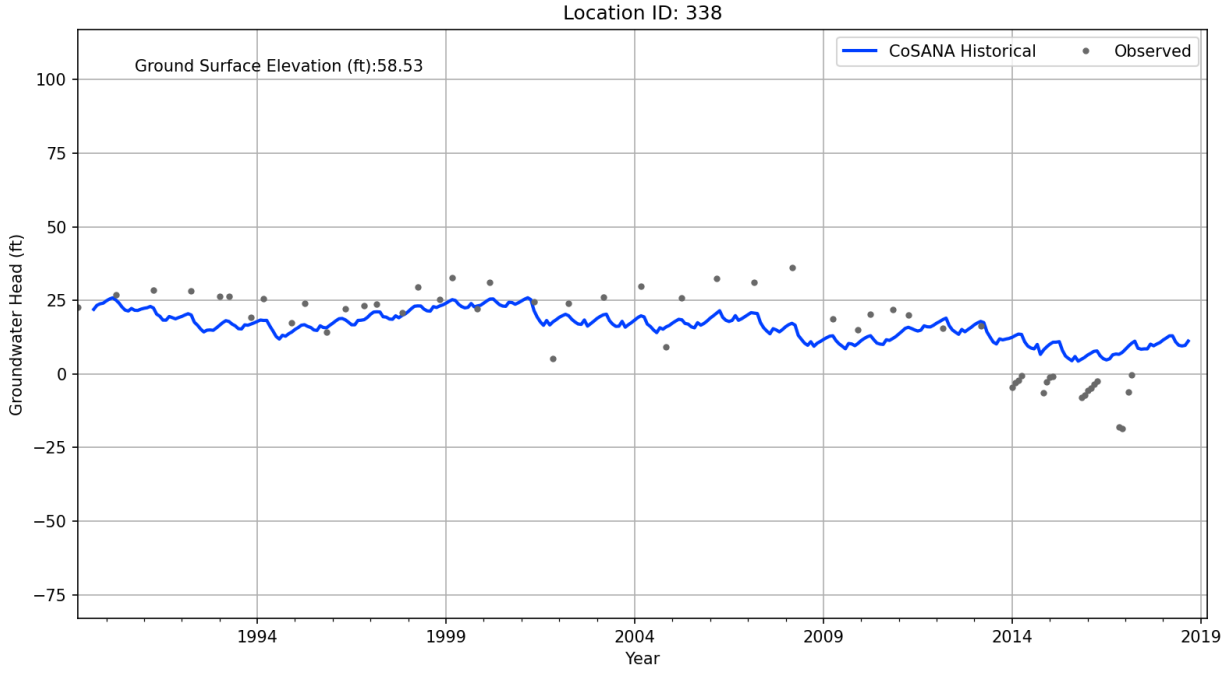

Location ID: 329
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

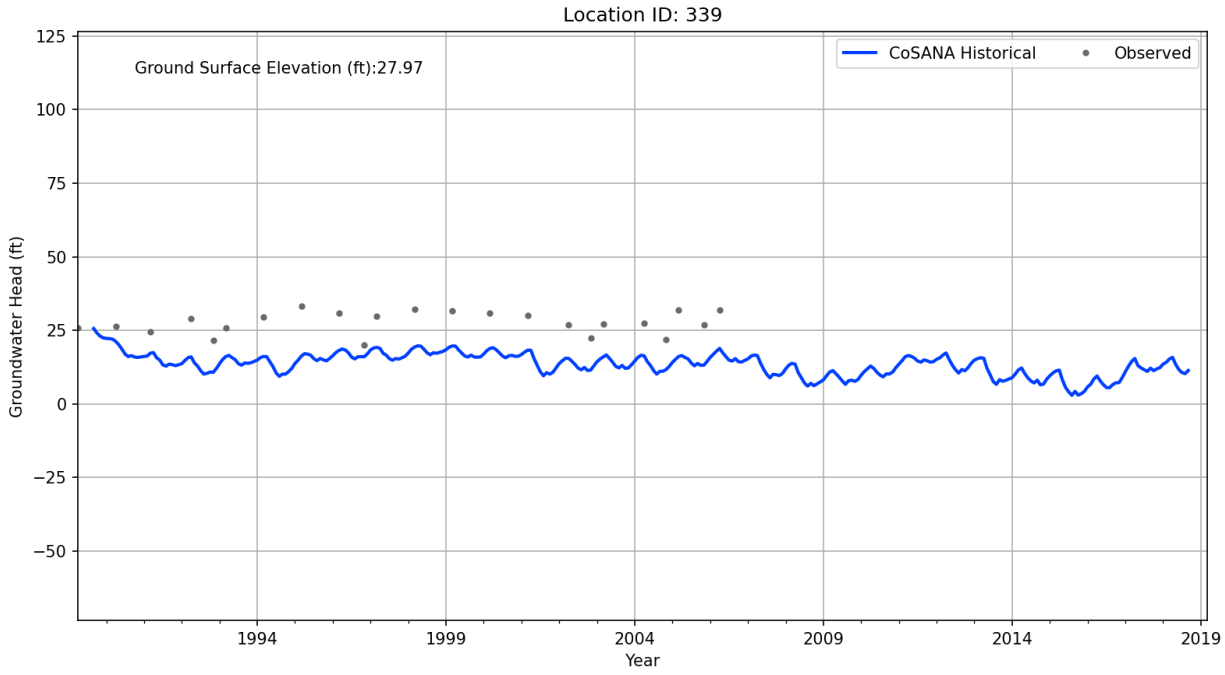

Location ID: 330
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

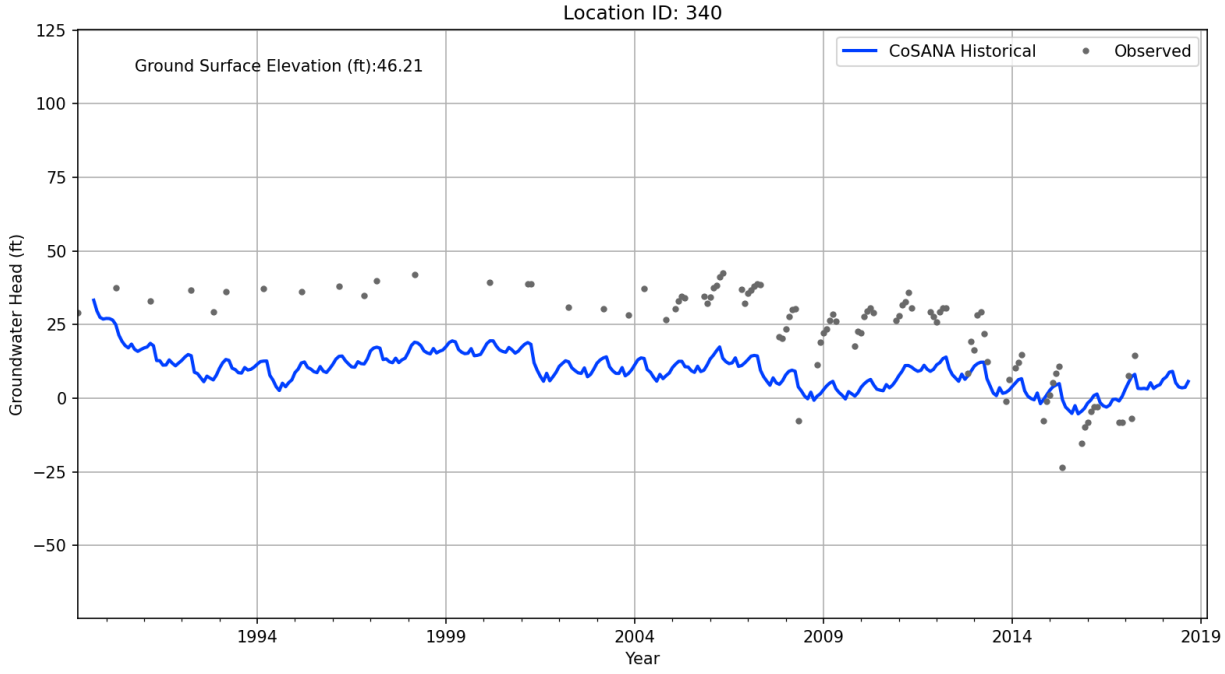

Location ID: 334
Ground Surface Elevation (ft):28.23
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

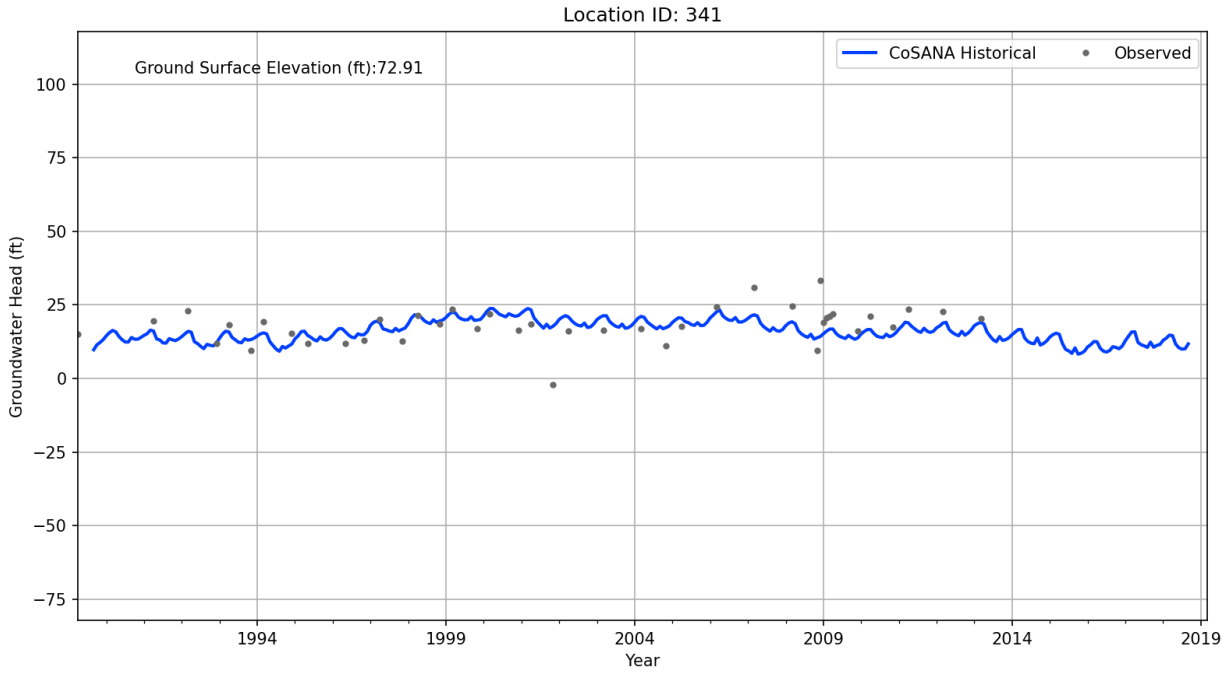

Location ID: 336
Ground Surface Elevation (ft):72.09
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

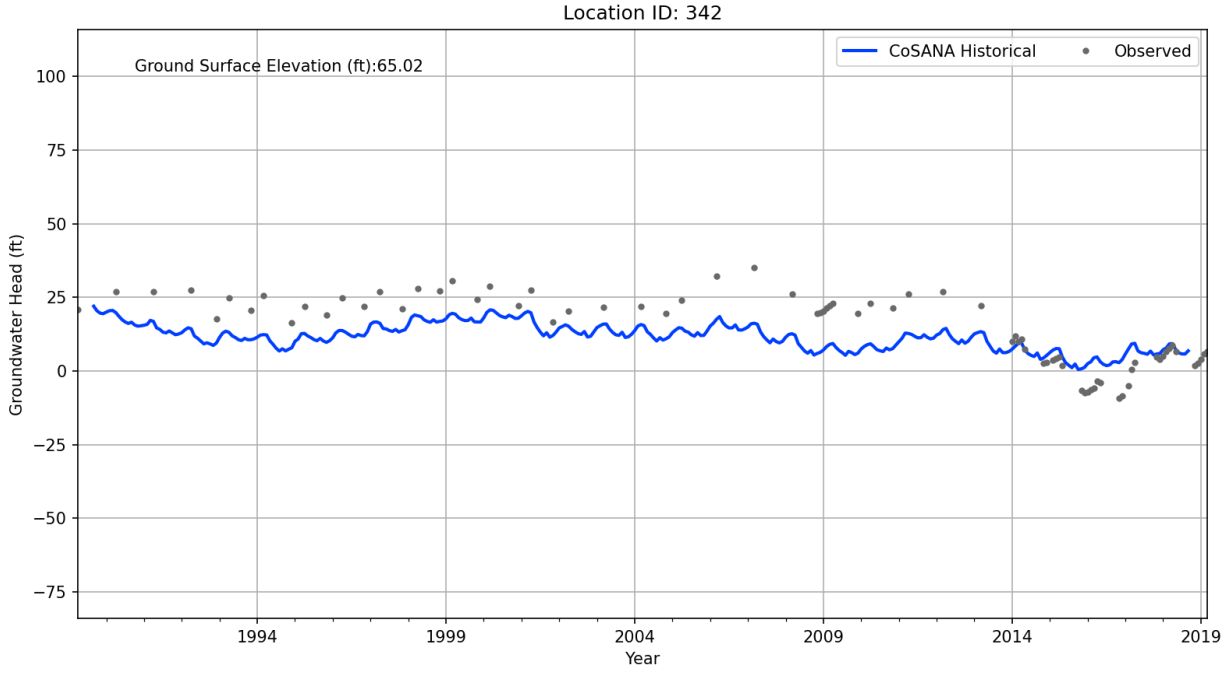

Location ID: 337
Ground Surface Elevation (ft):37.77
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

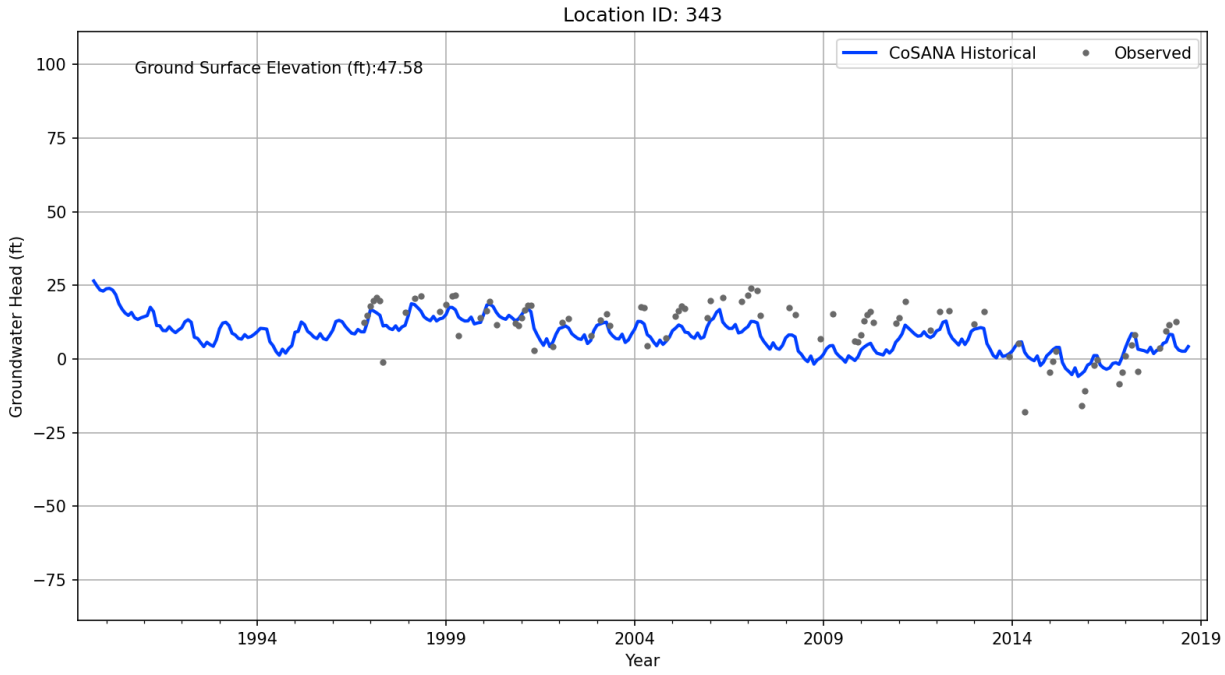

Location ID: 338
Ground Surface Elevation (ft):58.53
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

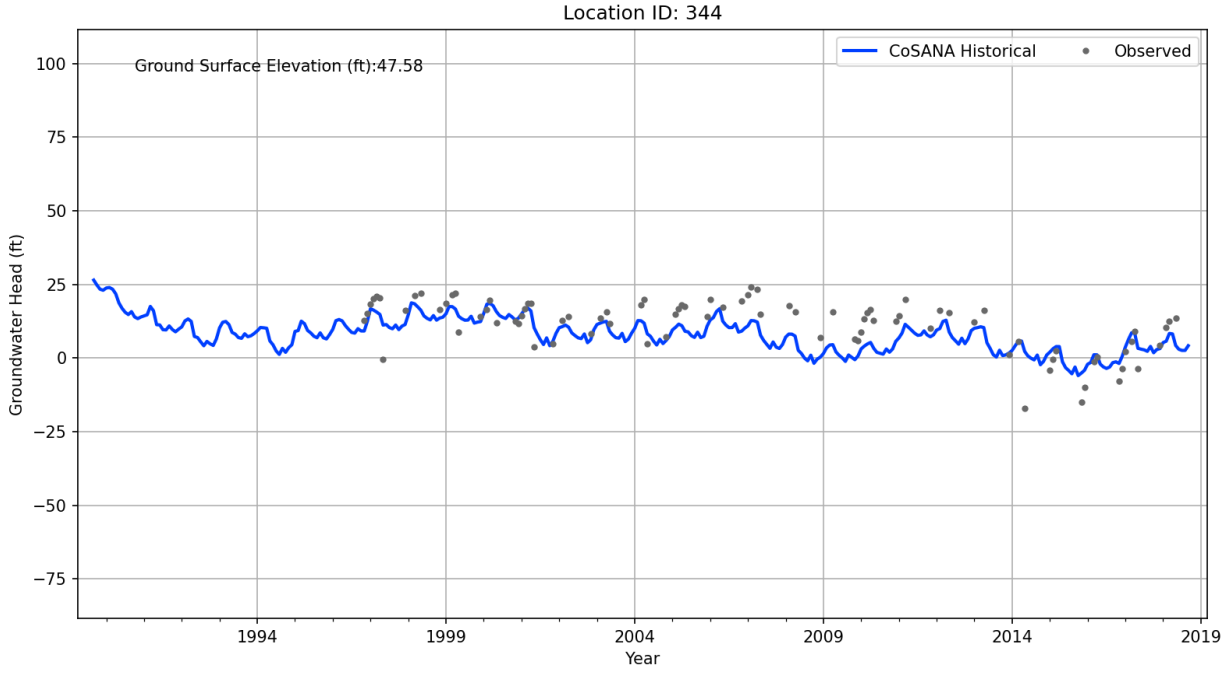

Location ID: 339
Ground Surface Elevation (ft):27.97
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

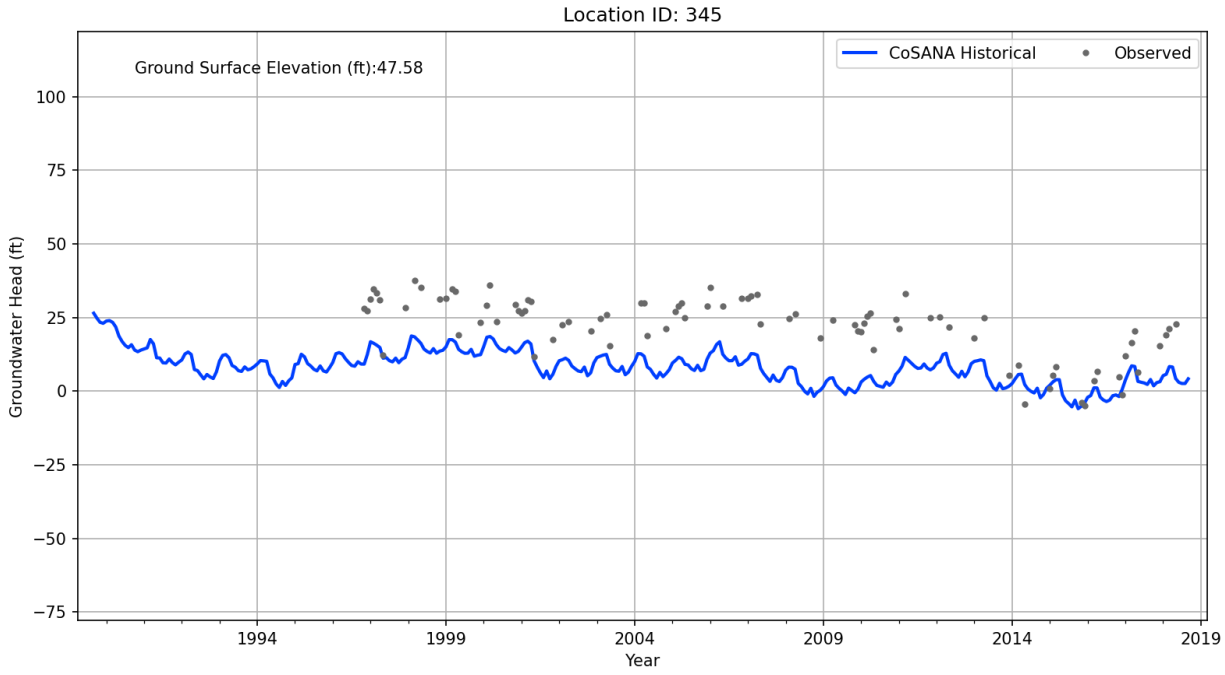

Location ID: 340
Ground Surface Elevation (ft):46.21
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

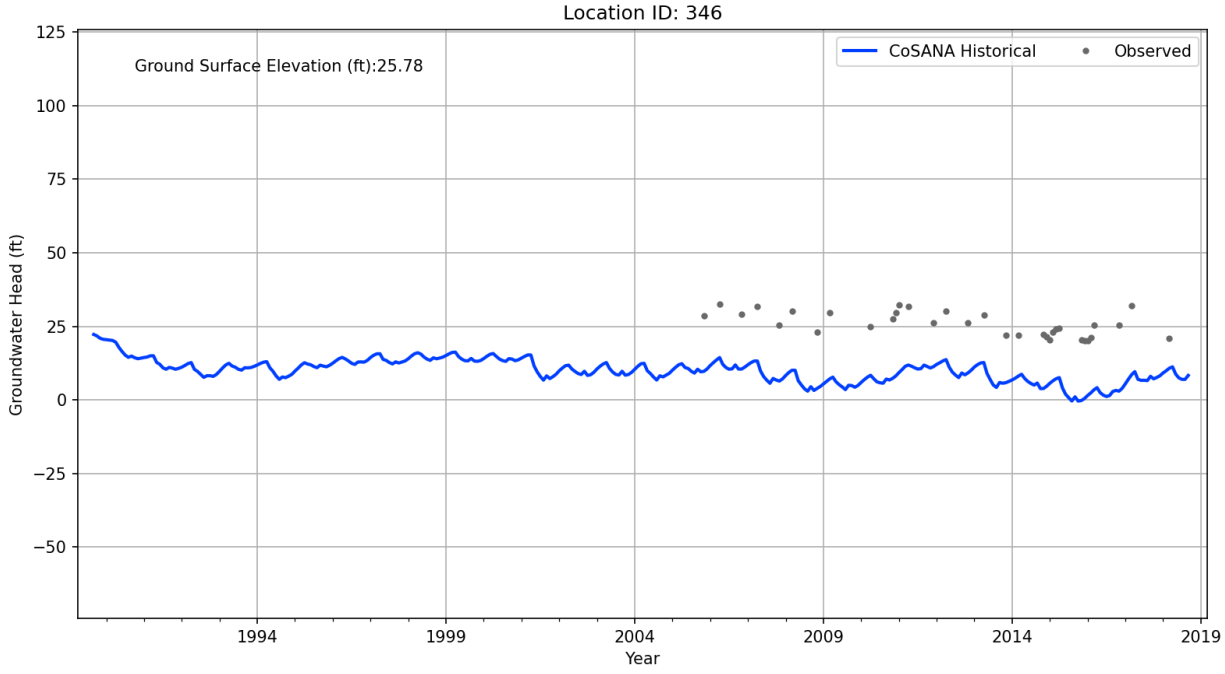

Location ID: 341
Ground Surface Elevation (ft):72.91
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

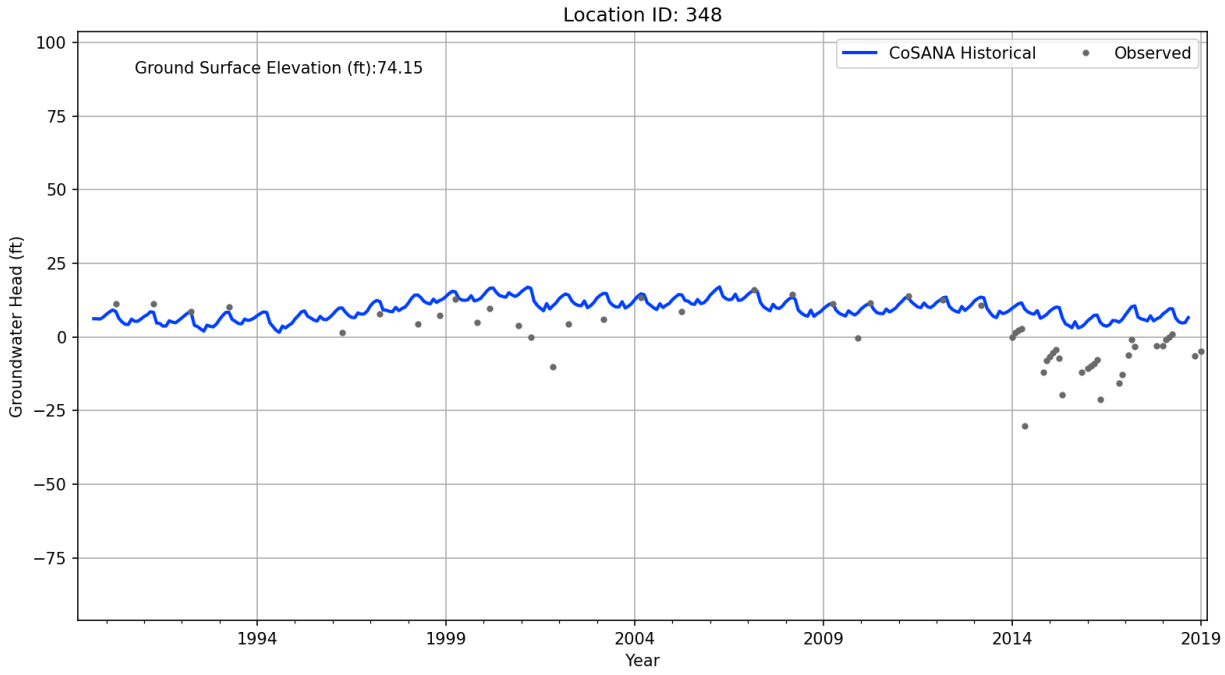

Location ID: 342
Ground Surface Elevation (ft):65.02
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

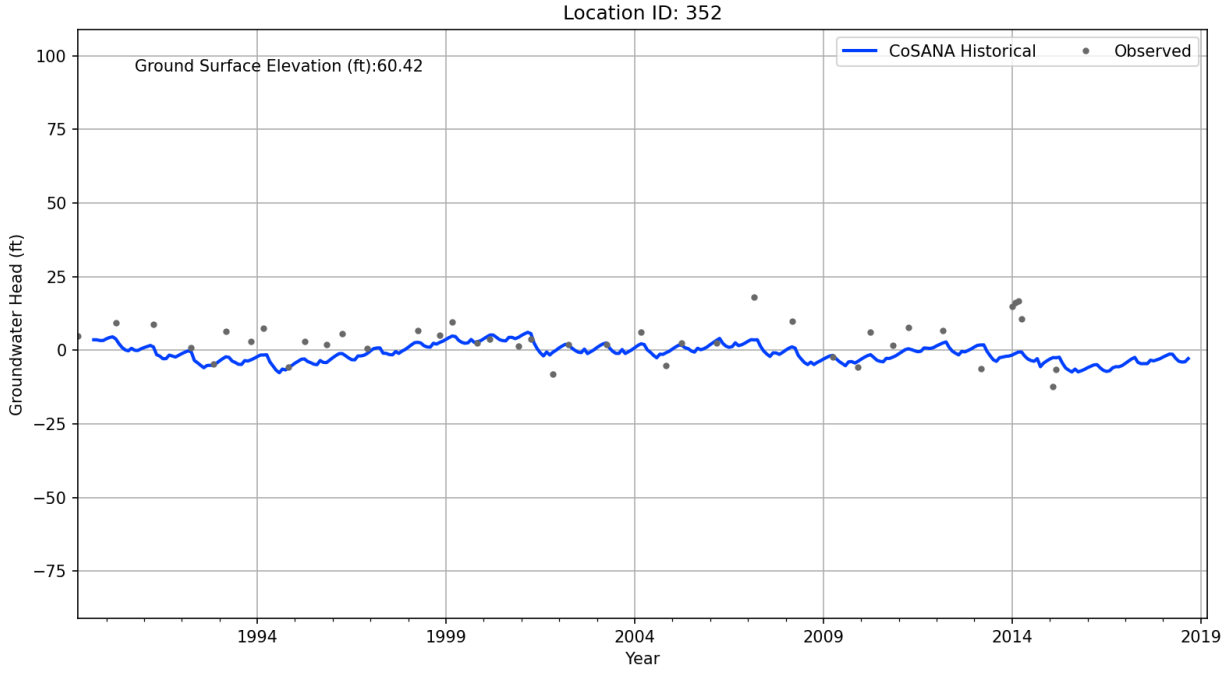

Location ID: 343
Ground Surface Elevation (ft):47.58
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

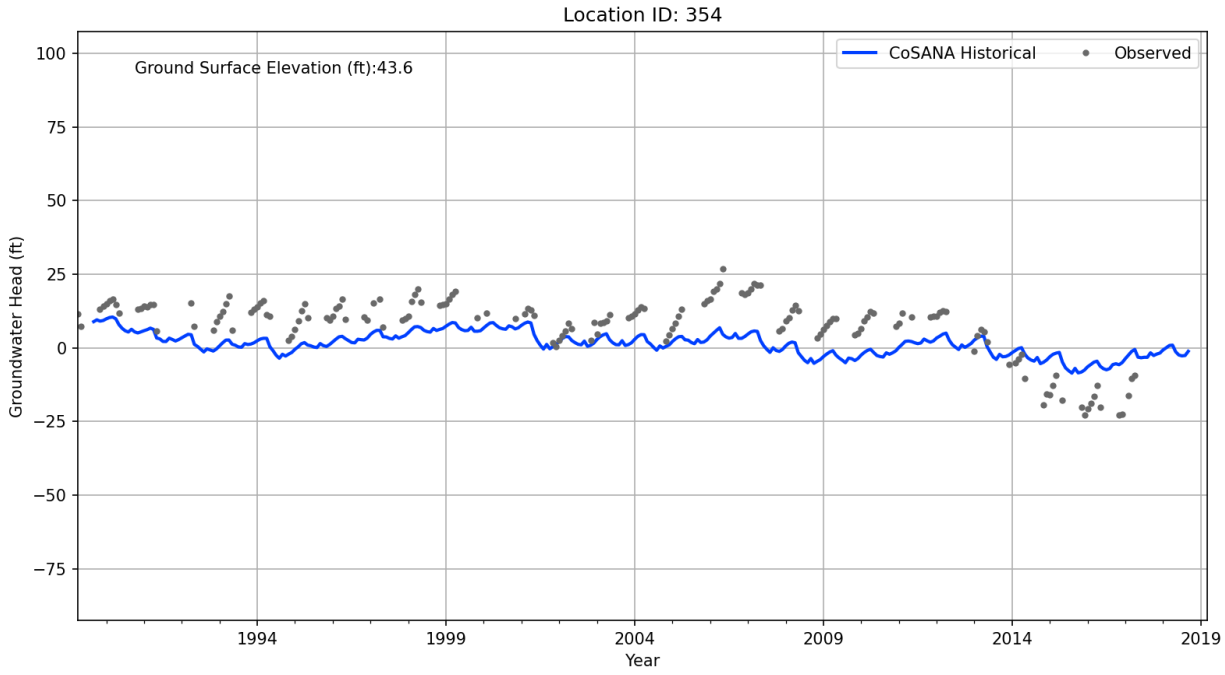

Location ID: 344
Ground Surface Elevation (ft):47.58
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

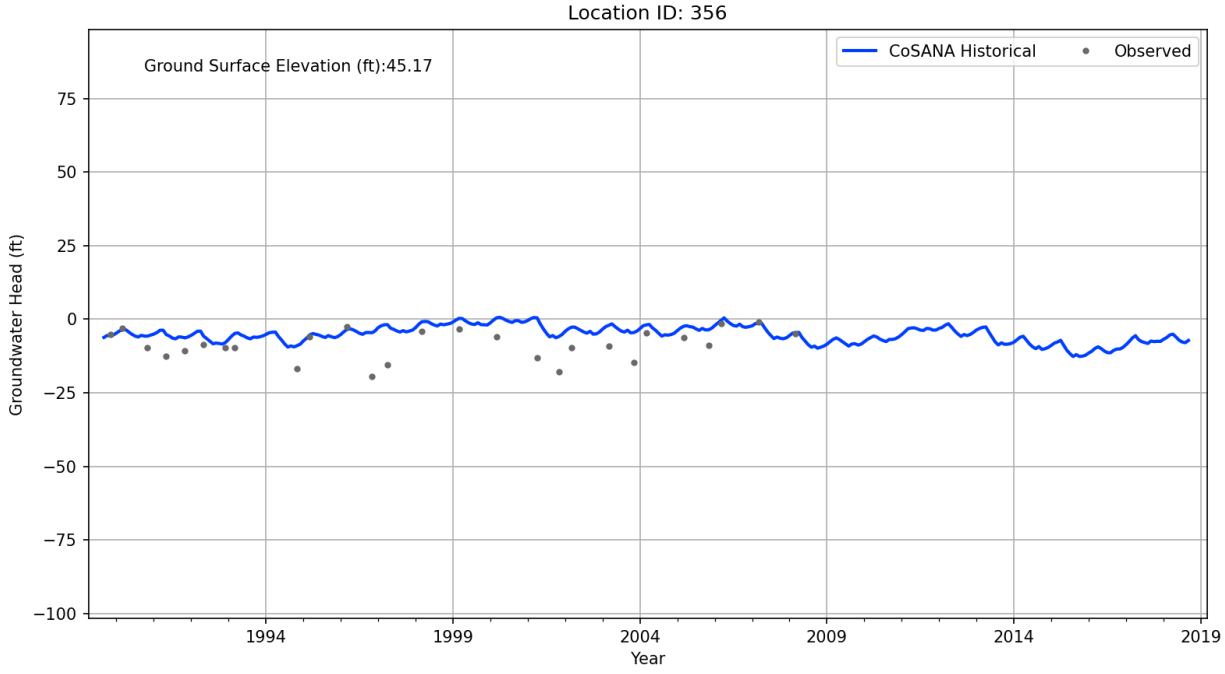

Location ID: 345
Ground Surface Elevation (ft):47.58
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

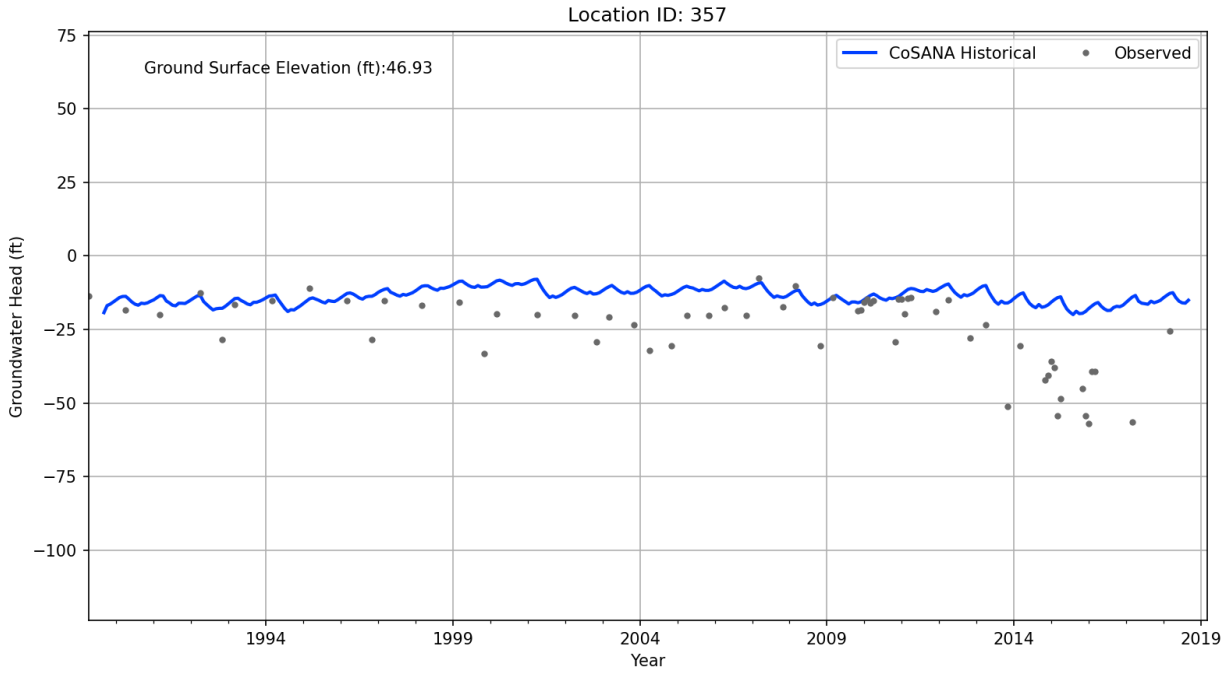

Location ID: 346
Ground Surface Elevation (ft):25.78
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

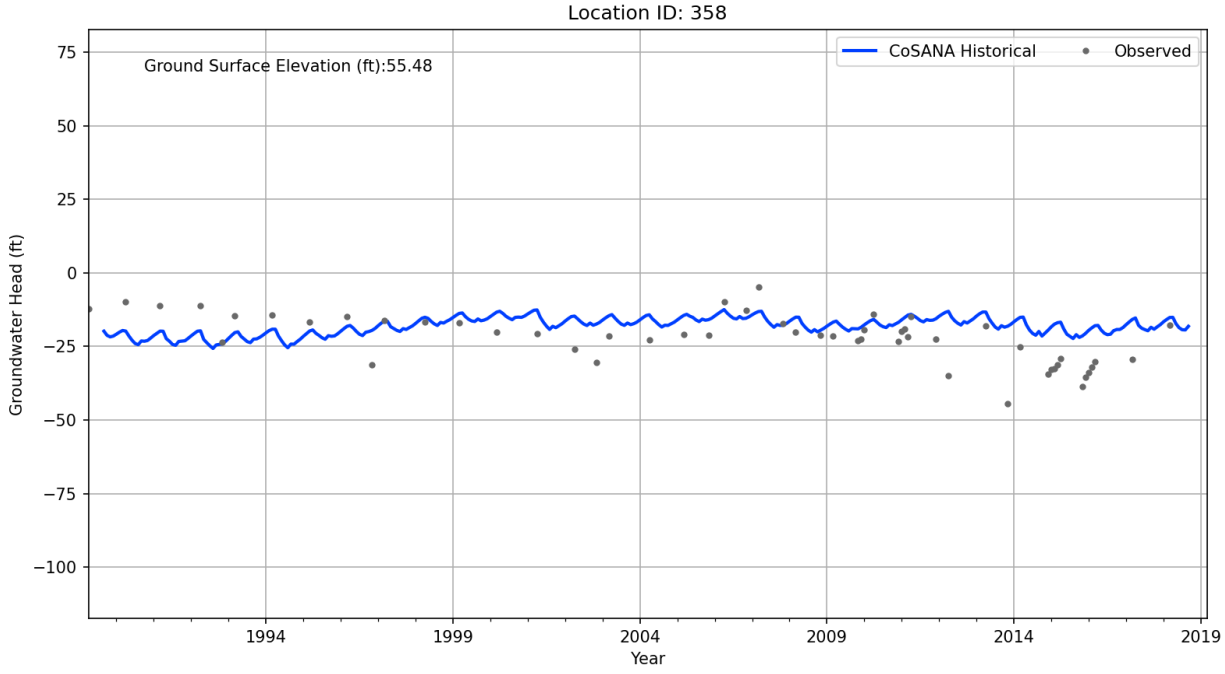

Location ID: 348
Ground Surface Elevation (ft):74.15
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

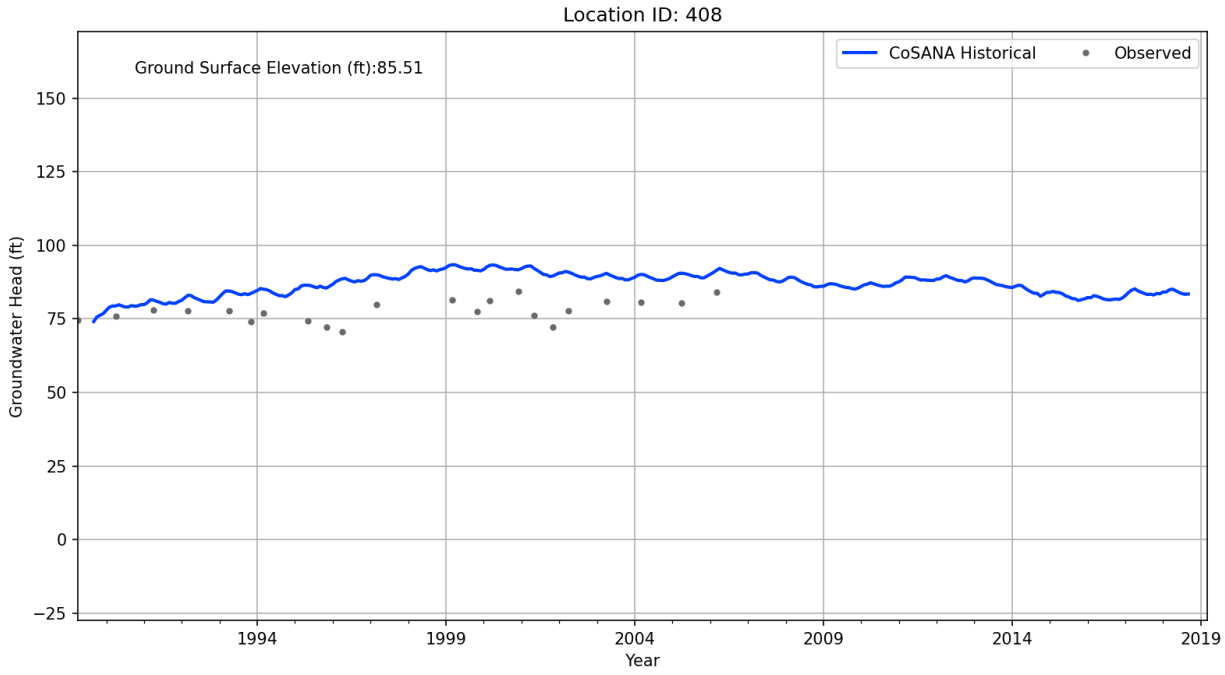

Location ID: 352
Ground Surface Elevation (ft):60.42
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

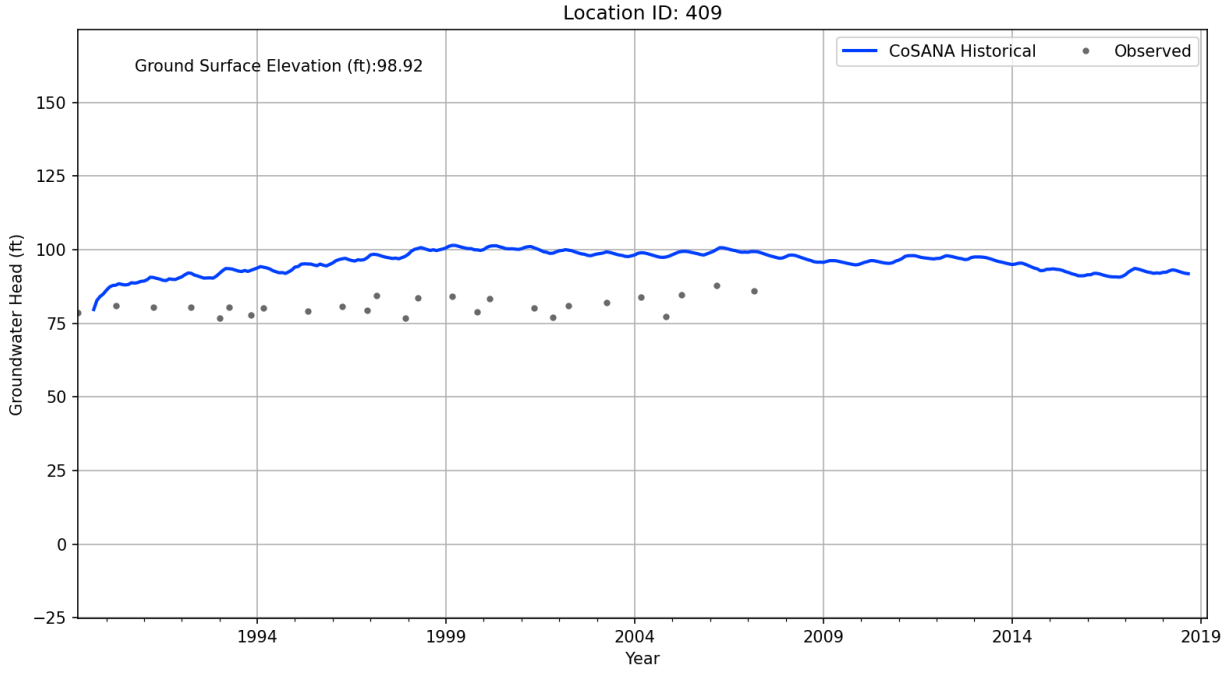

Location ID: 354
Ground Surface Elevation (ft):43.6
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

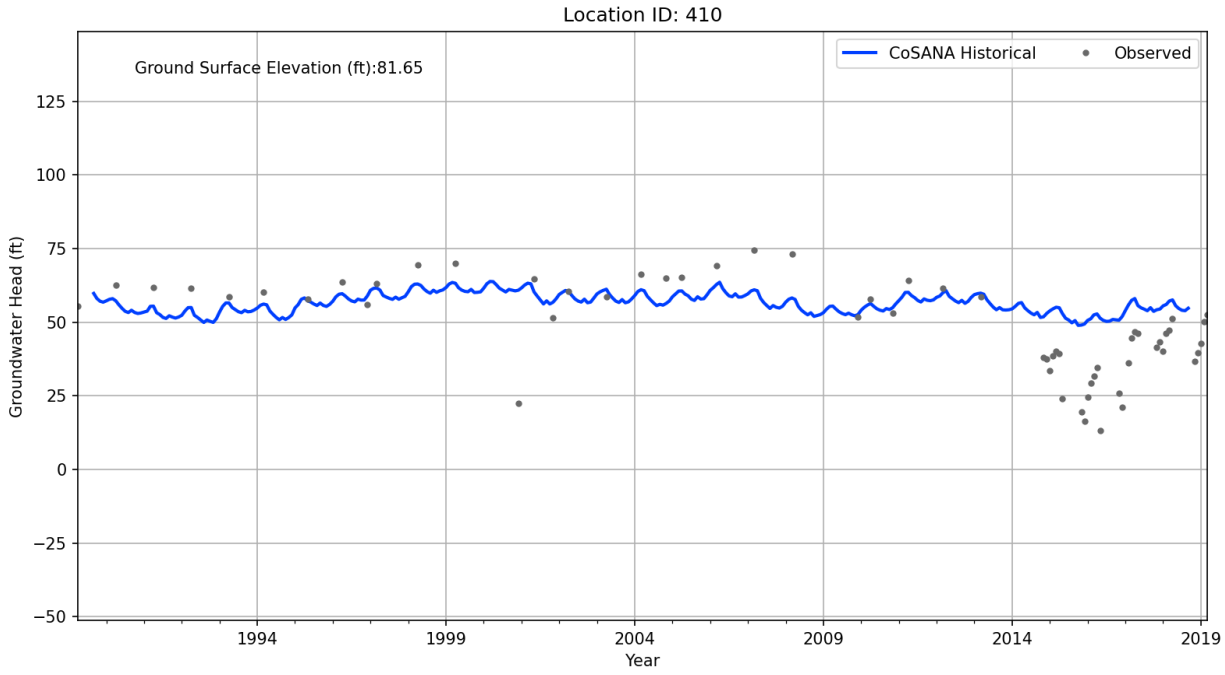

Location ID: 356
Ground Surface Elevation (ft):45.17
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

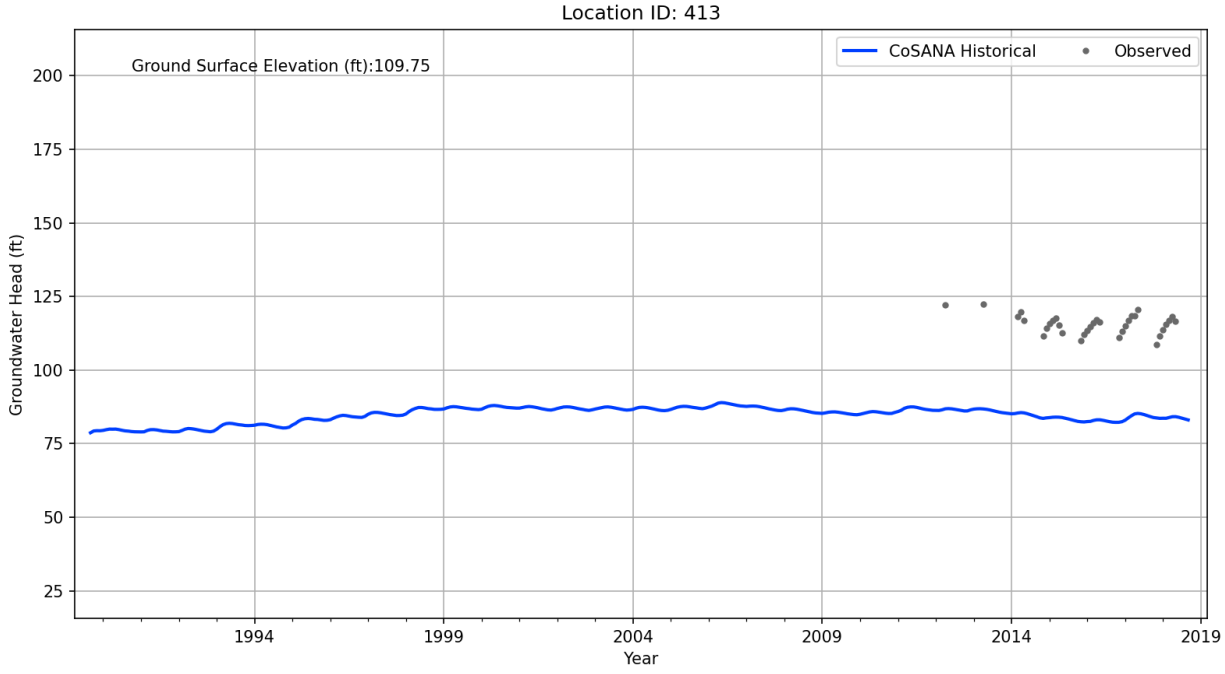

Location ID: 357
Ground Surface Elevation (ft):46.93
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

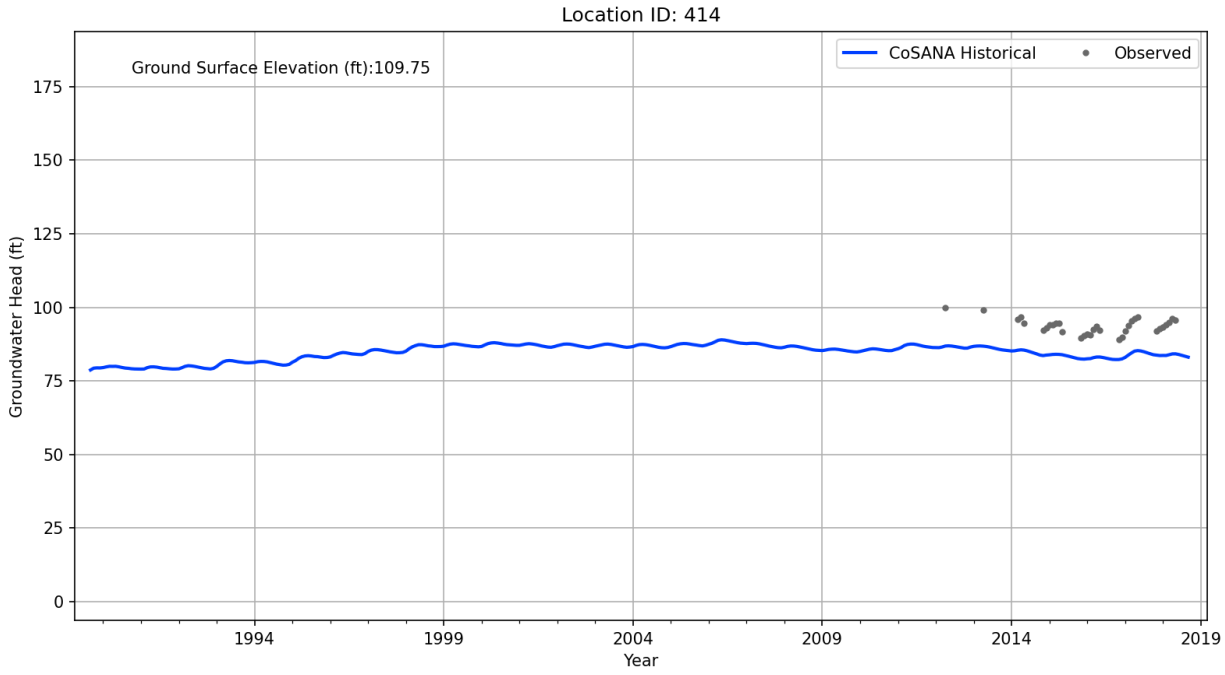

Location ID: 358
Ground Surface Elevation (ft):55.48
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

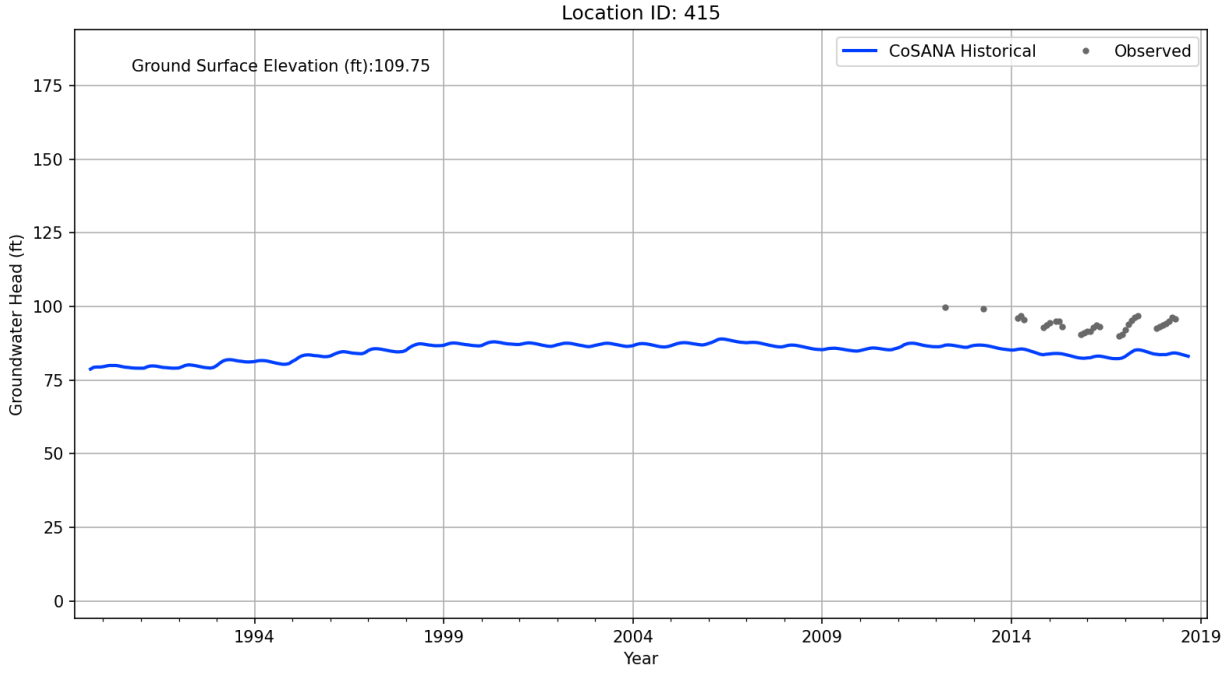

Location ID: 408
Ground Surface Elevation (ft):85.51
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

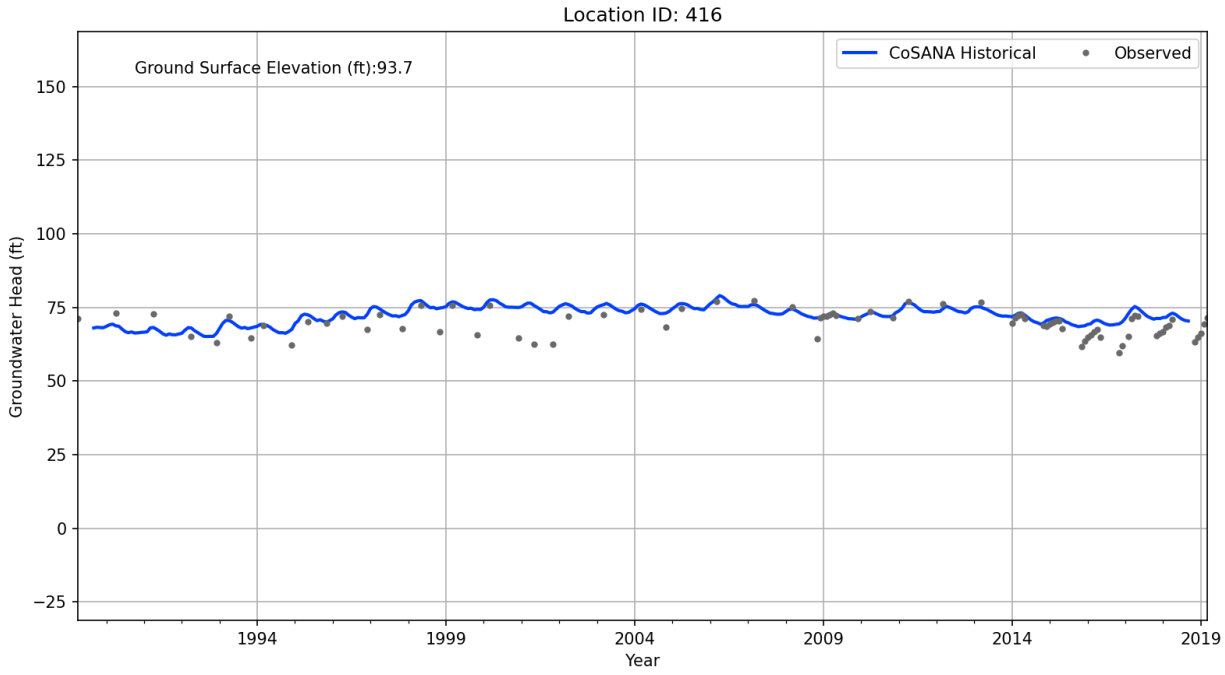

Location ID: 409
Ground Surface Elevation (ft):98.92
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

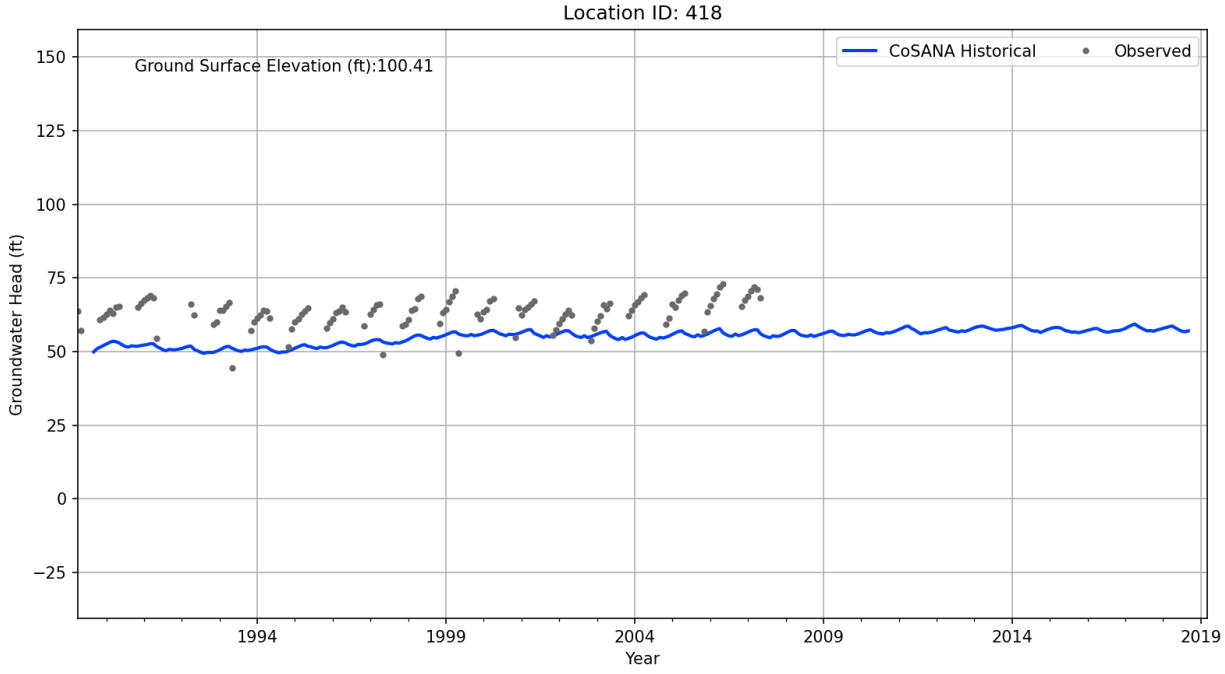

Location ID: 410
Ground Surface Elevation (ft):81.65
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

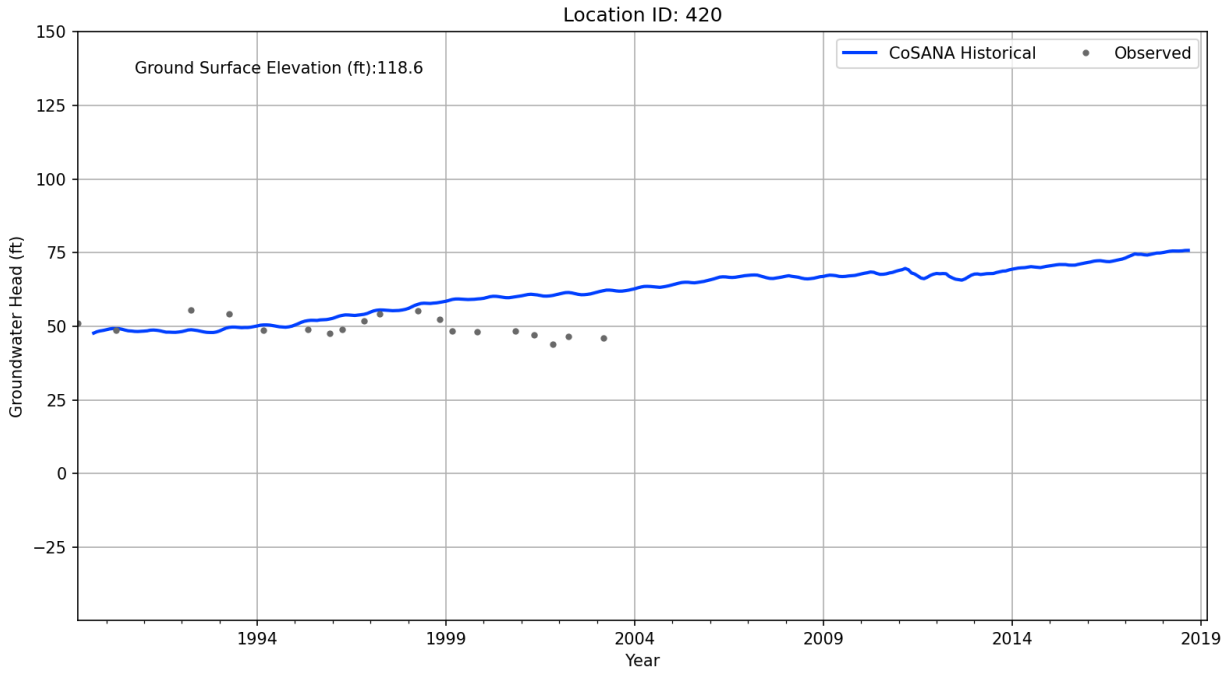

Location ID: 413
Ground Surface Elevation (ft):109.75
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year

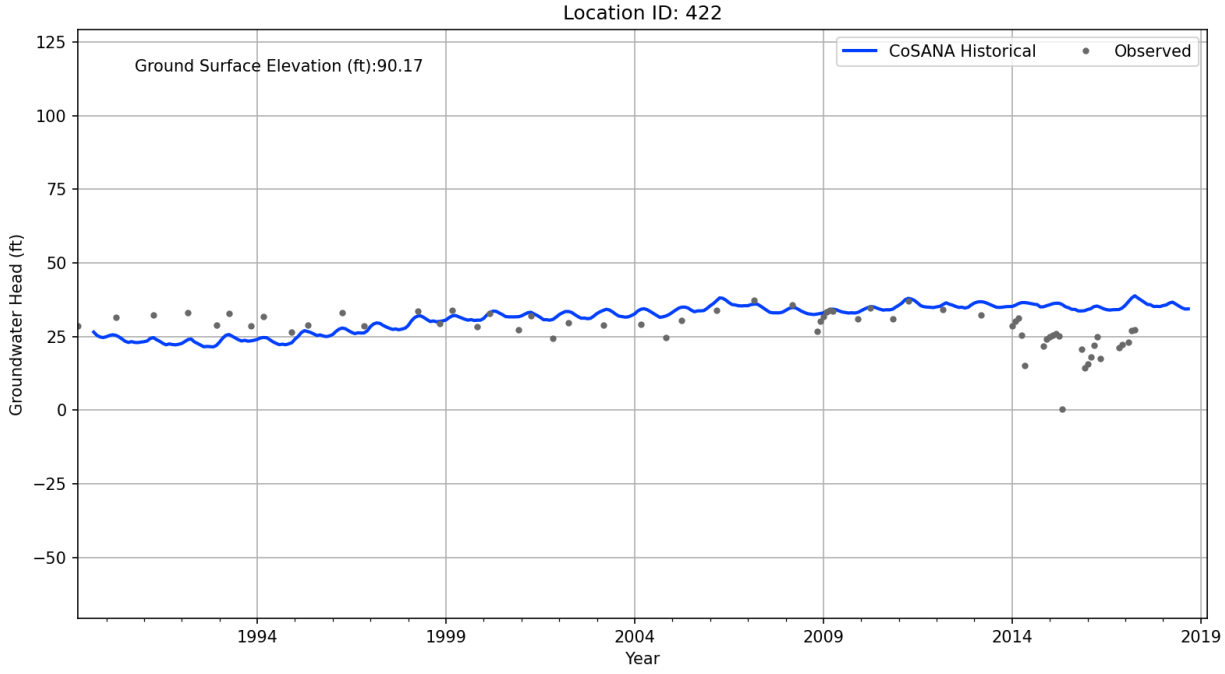

Location ID: 414
Ground Surface Elevation (ft):109.75
CoSANA Historical
Observed
Groundwater Head (ft)
Year
0
25
50
75
100
125
150
175
1994
1999
2004
2009
2014
2019

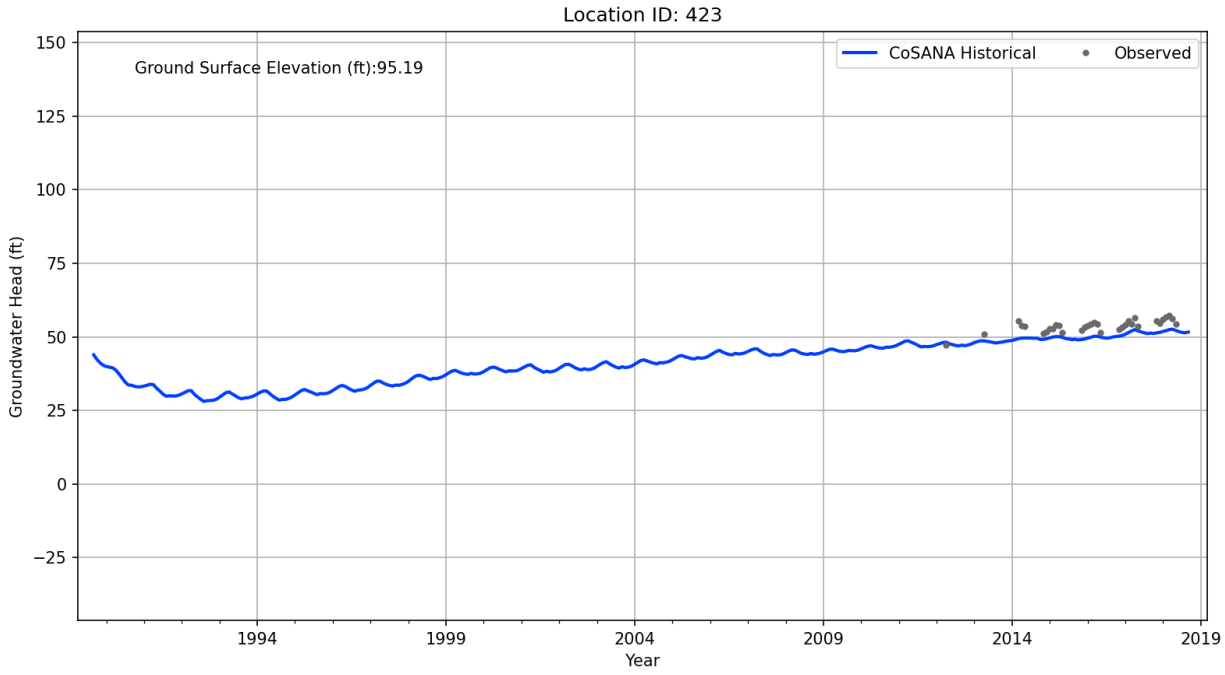

Location ID: 415
Ground Surface Elevation (ft):109.75
CoSANA Historical
Observed
Groundwater Head (ft)
Year
0
25
50
75
100
125
150
175
1994
1999
2004
2009
2014
2019

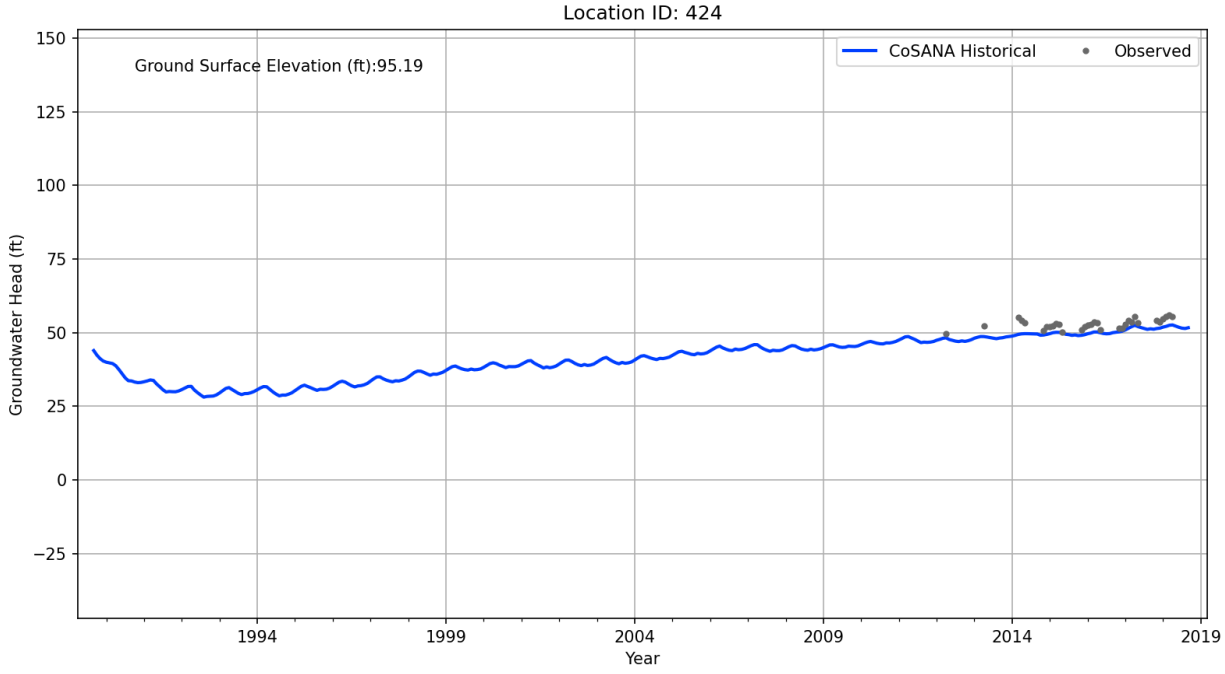

Location ID: 416
Ground Surface Elevation (ft):93.7
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

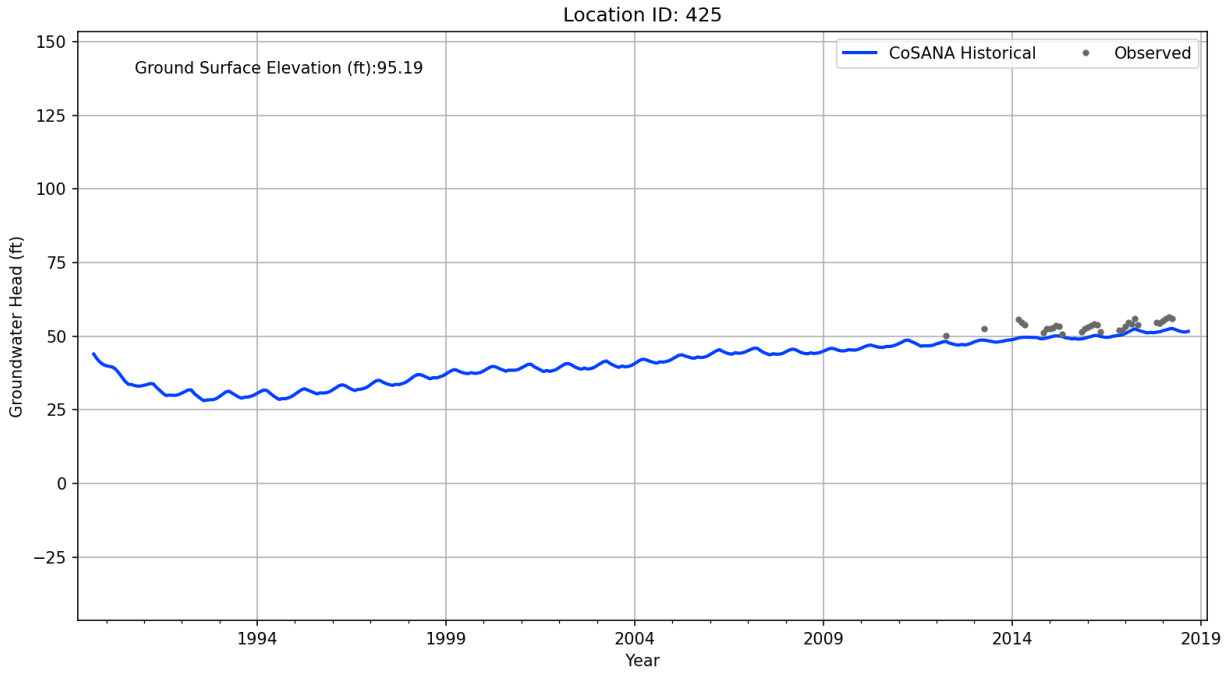

Location ID: 418
Ground Surface Elevation (ft):100.41
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

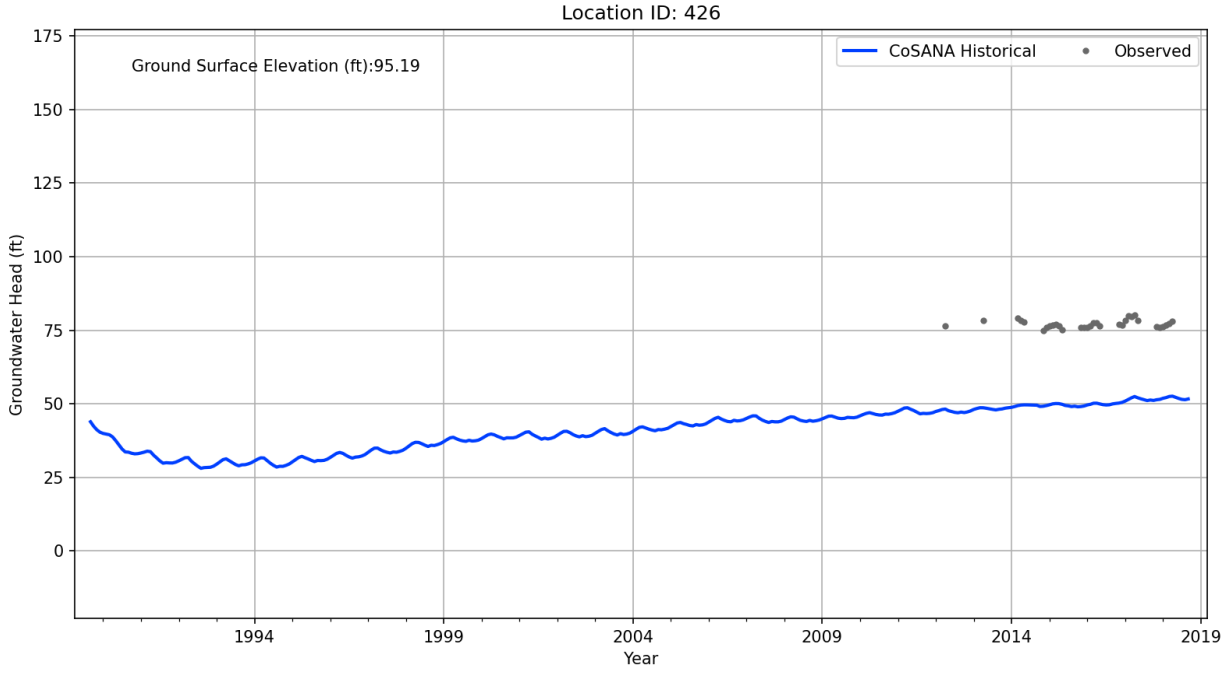

Location ID: 420
Ground Surface Elevation (ft):118.6
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

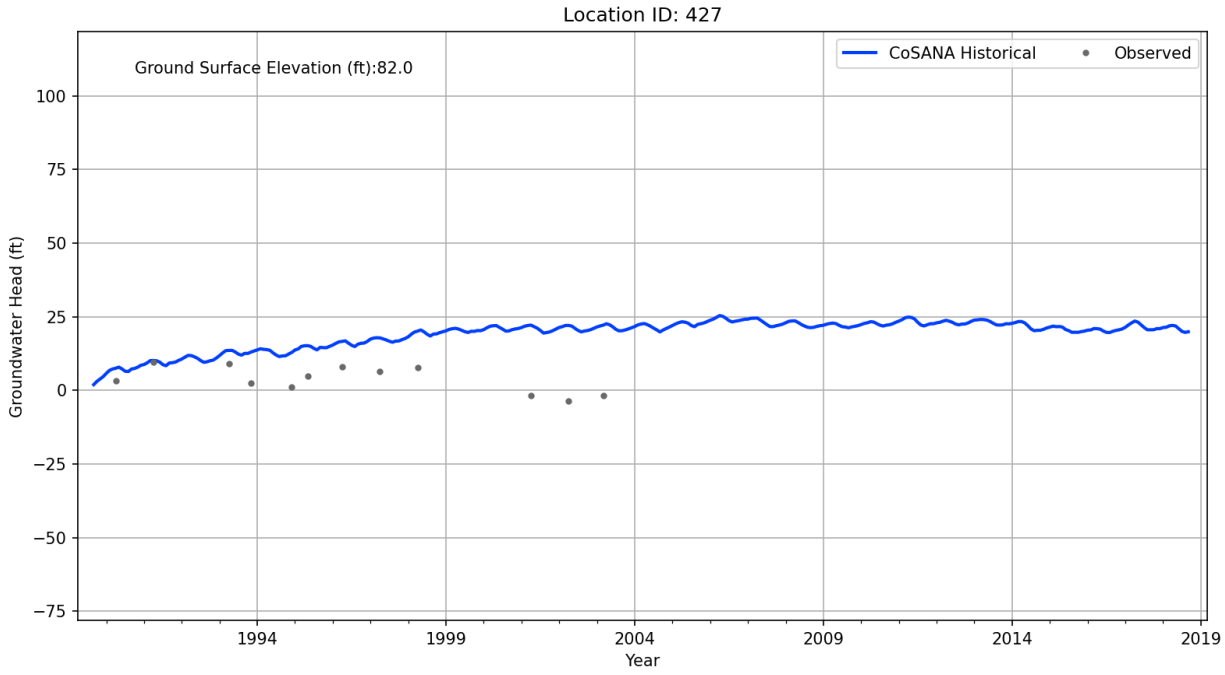

Location ID: 422
Ground Surface Elevation (ft):90.17
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

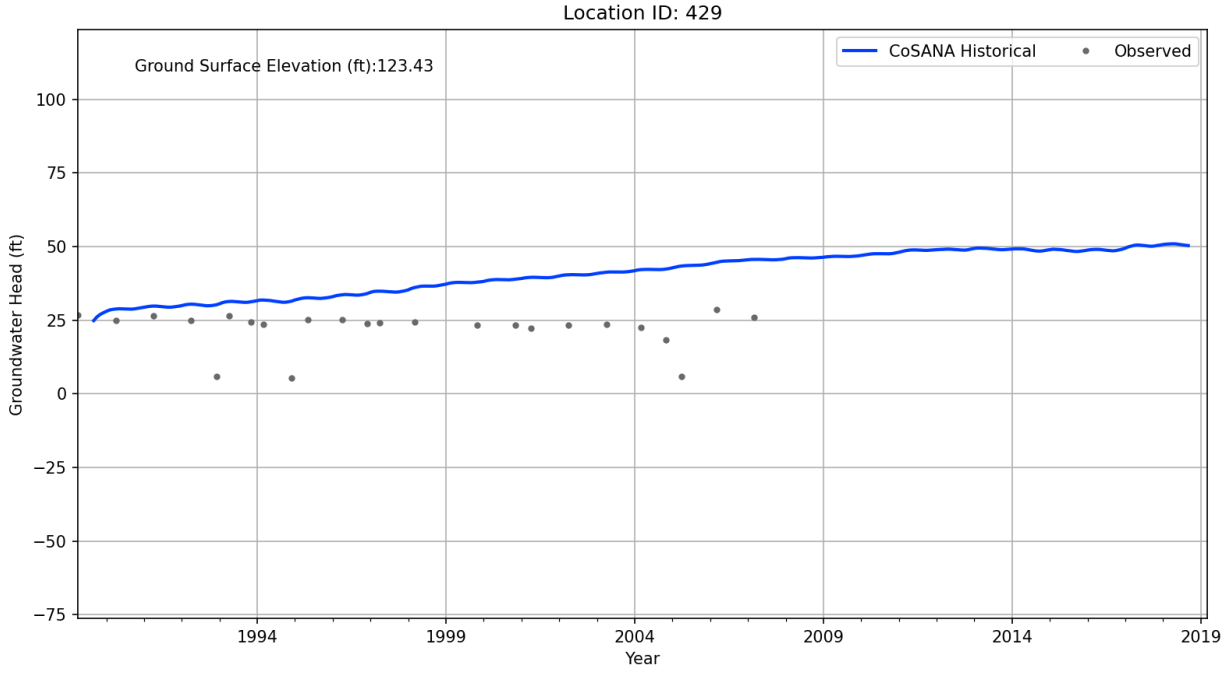

Location ID: 423
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

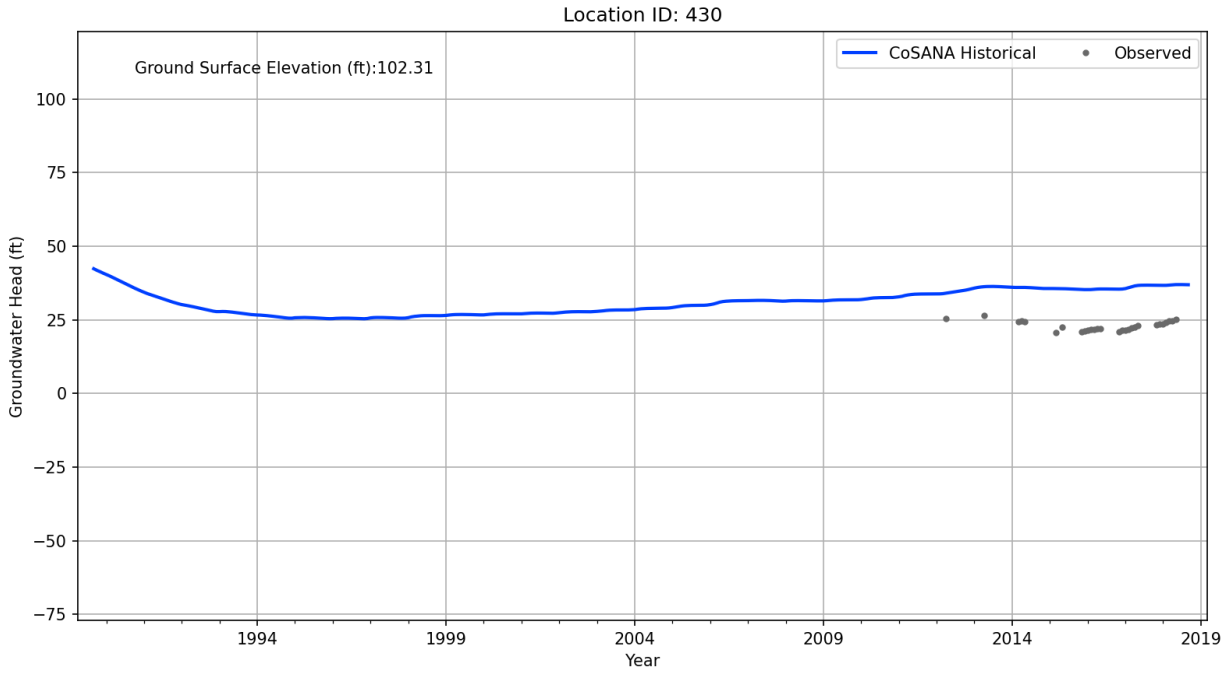

Location ID: 424
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

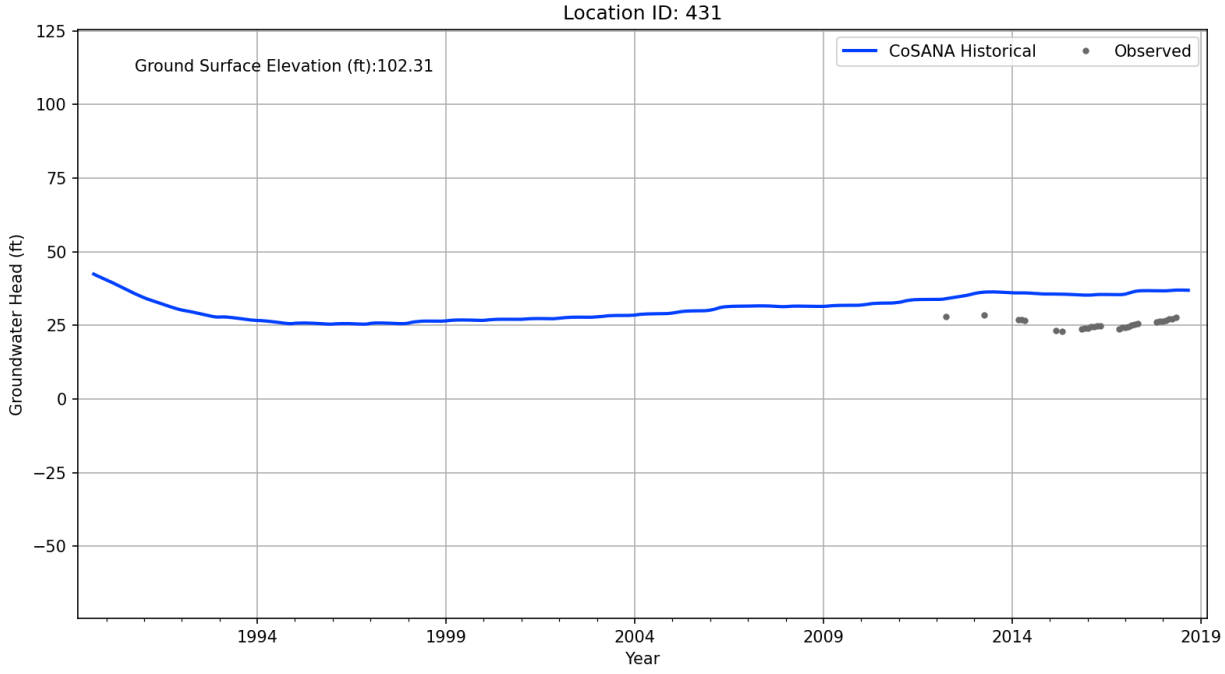

Location ID: 425
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

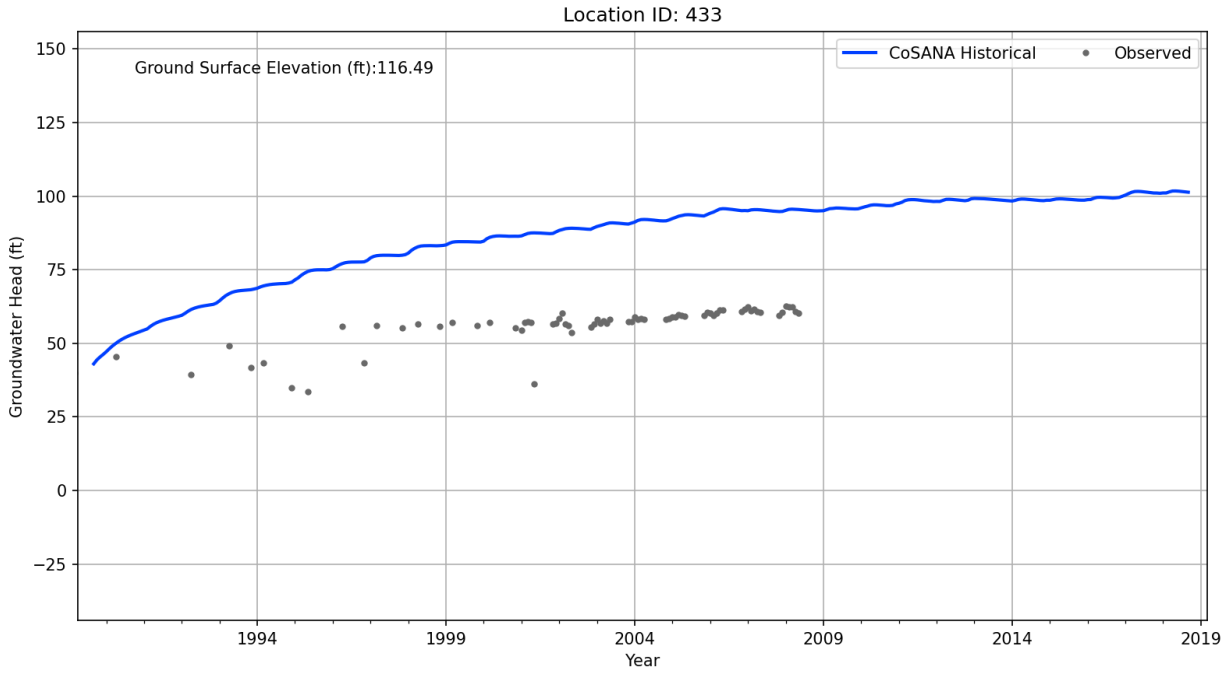

Location ID: 426
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

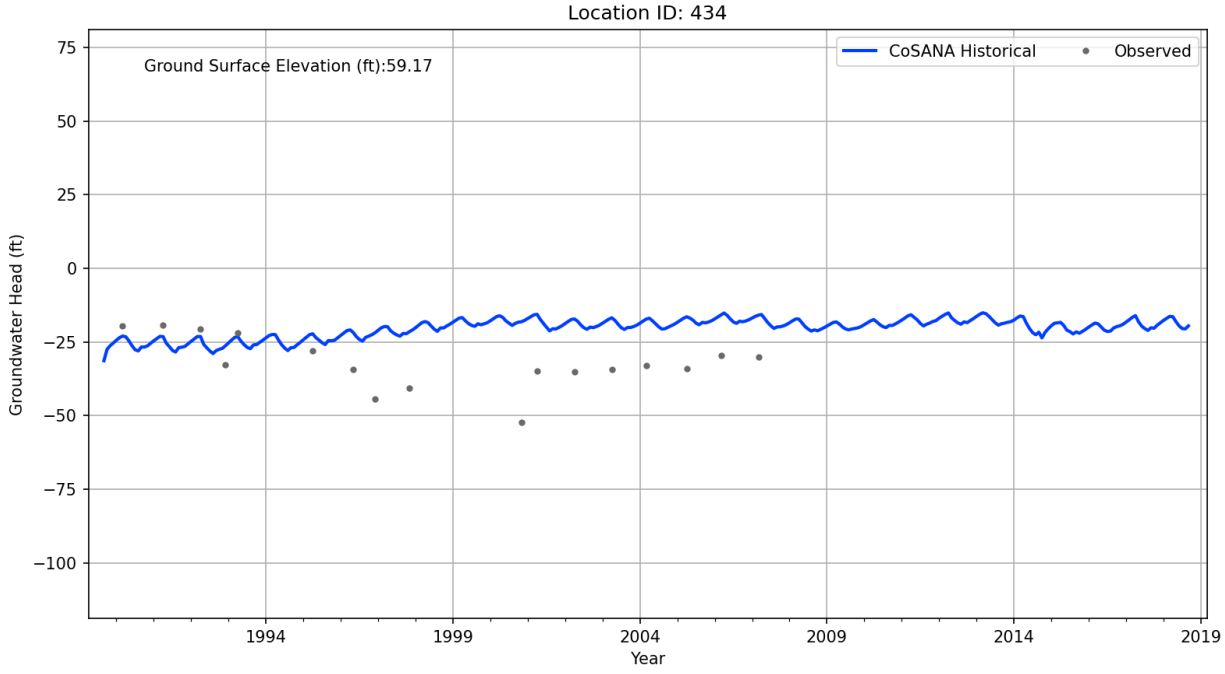

Location ID: 427
Ground Surface Elevation (ft):82.0
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

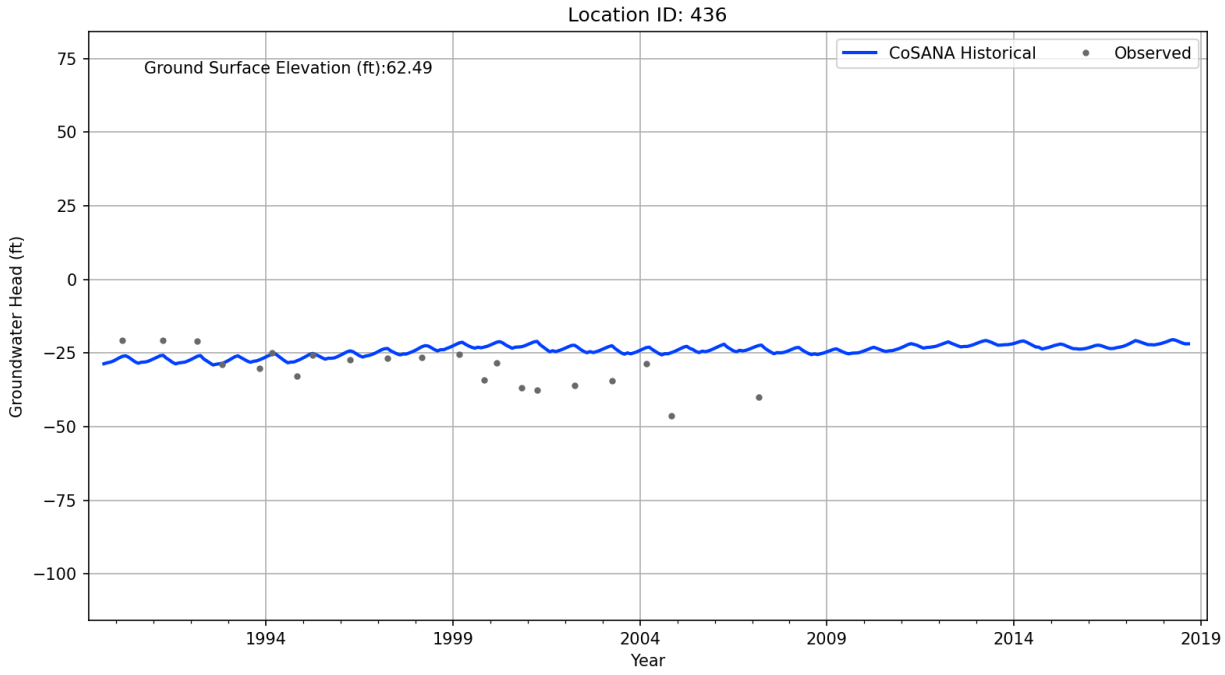

Location ID: 429
Ground Surface Elevation (ft):123.43
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

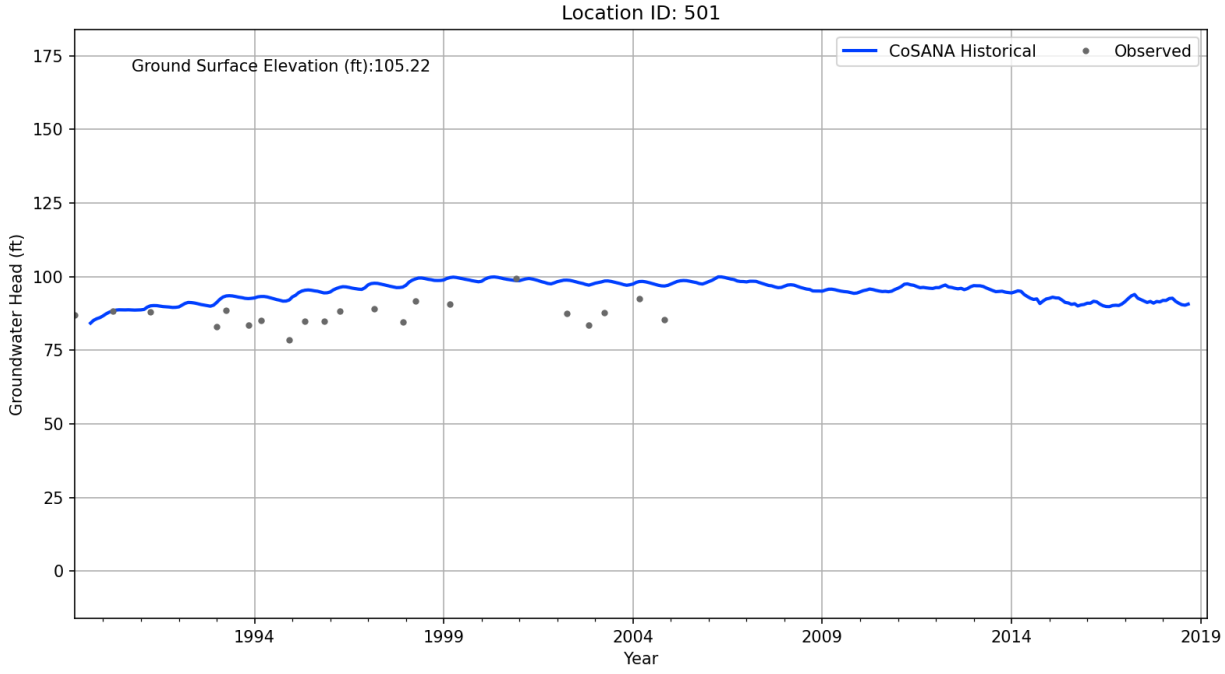

Location ID: 430
Ground Surface Elevation (ft):102.31
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

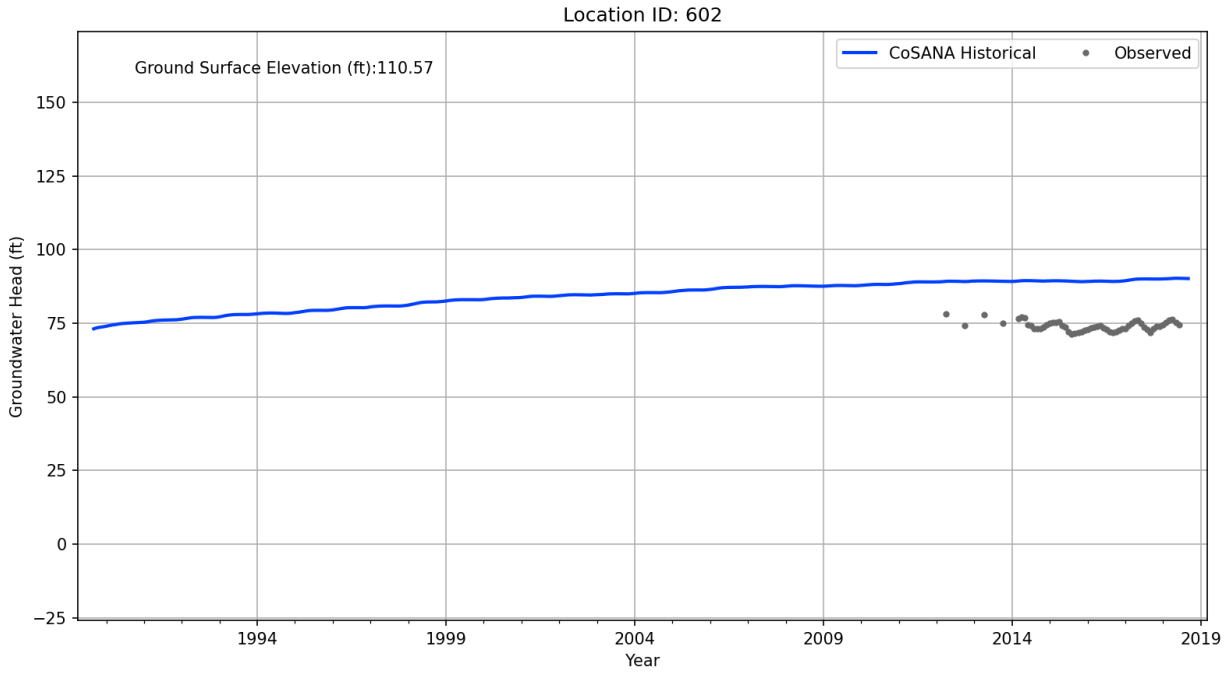

Location ID: 431
Ground Surface Elevation (ft):102.31
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

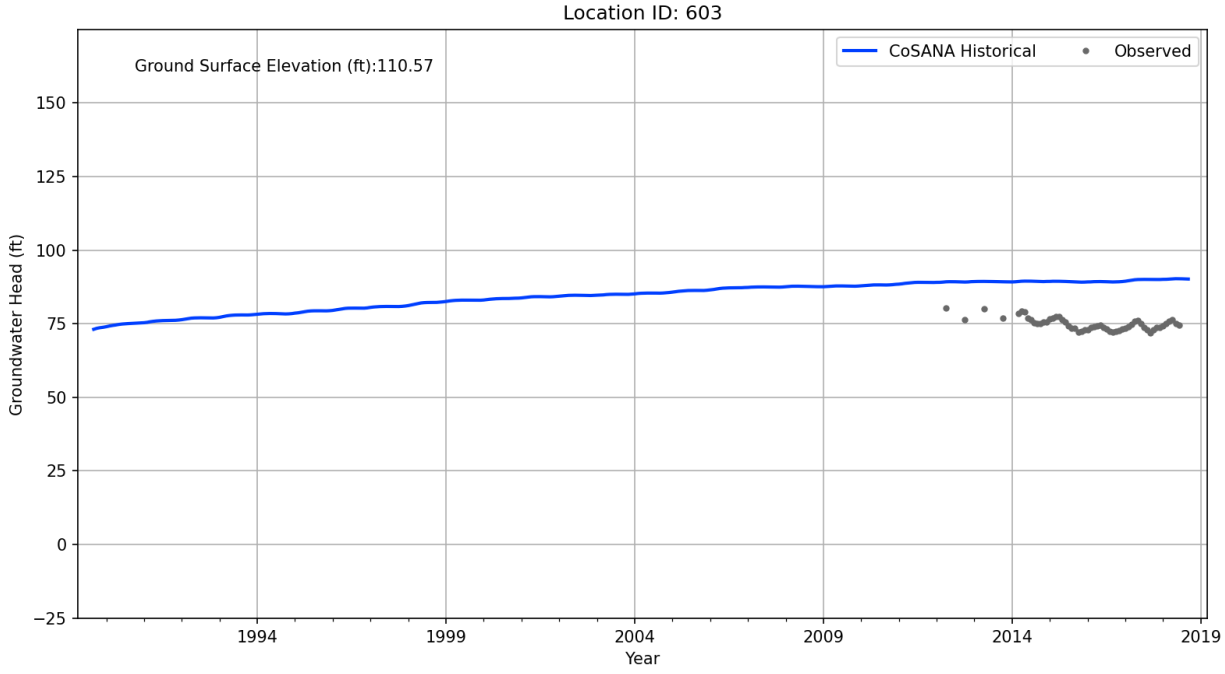

Location ID: 433
Ground Surface Elevation (ft):116.49
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

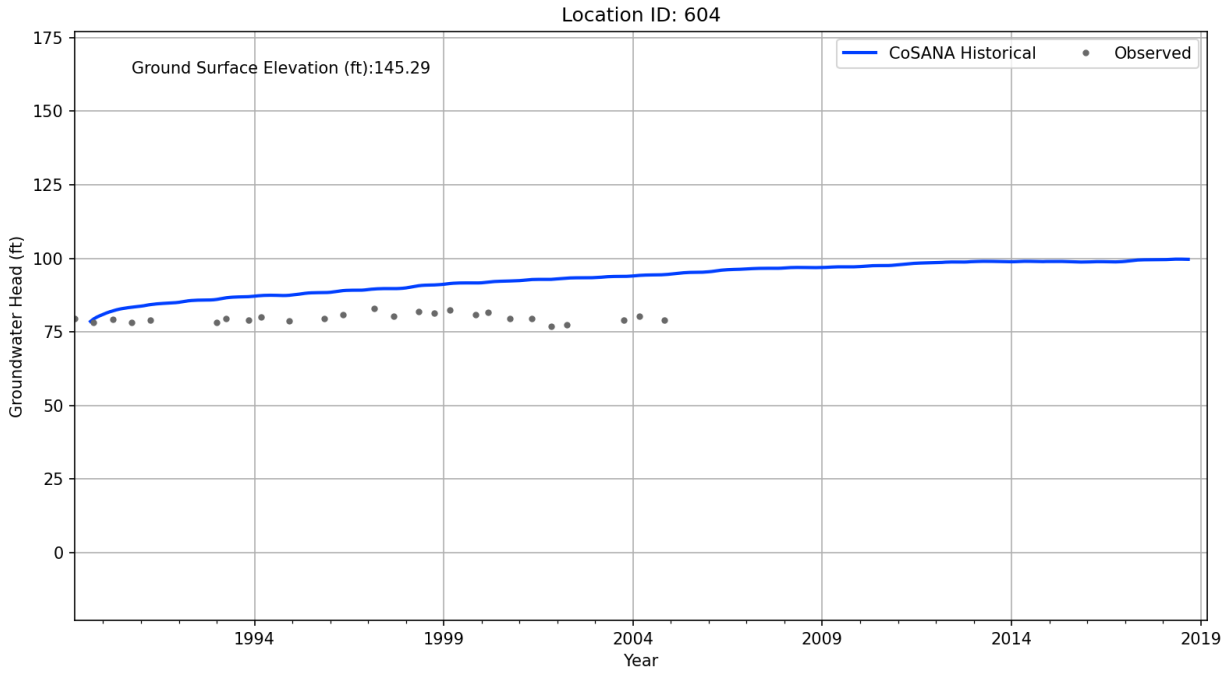

Location ID: 434
Ground Surface Elevation (ft):59.17
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

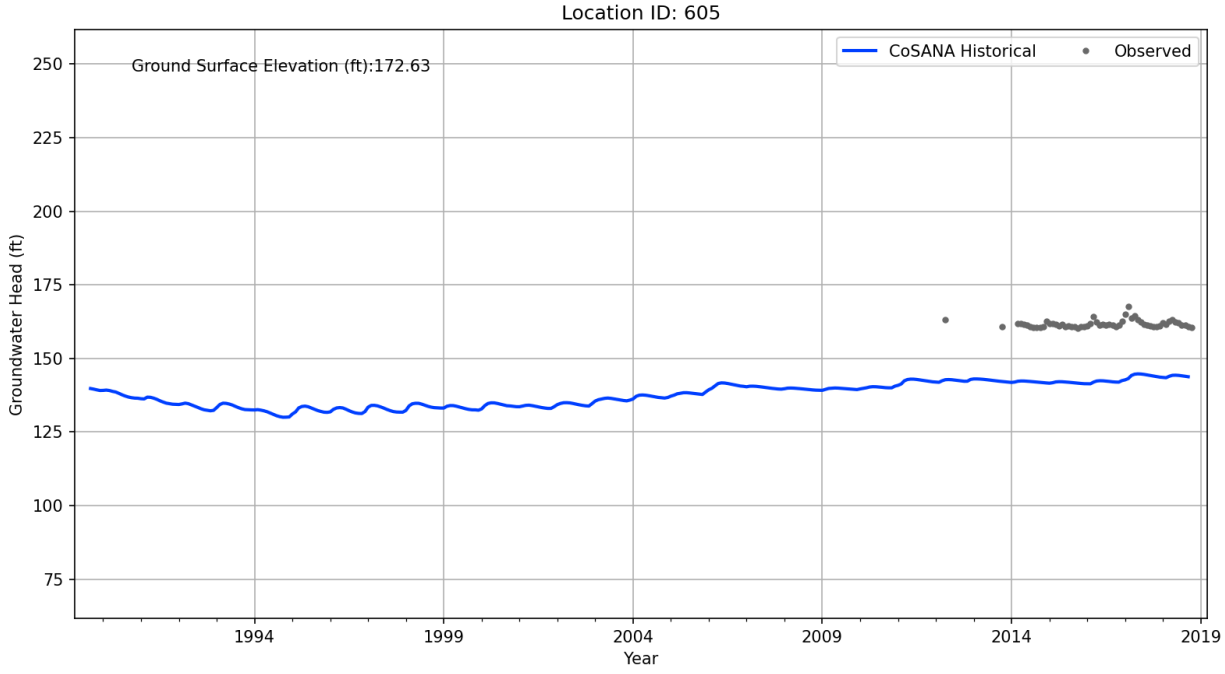

Location ID: 436
Ground Surface Elevation (ft):62.49
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

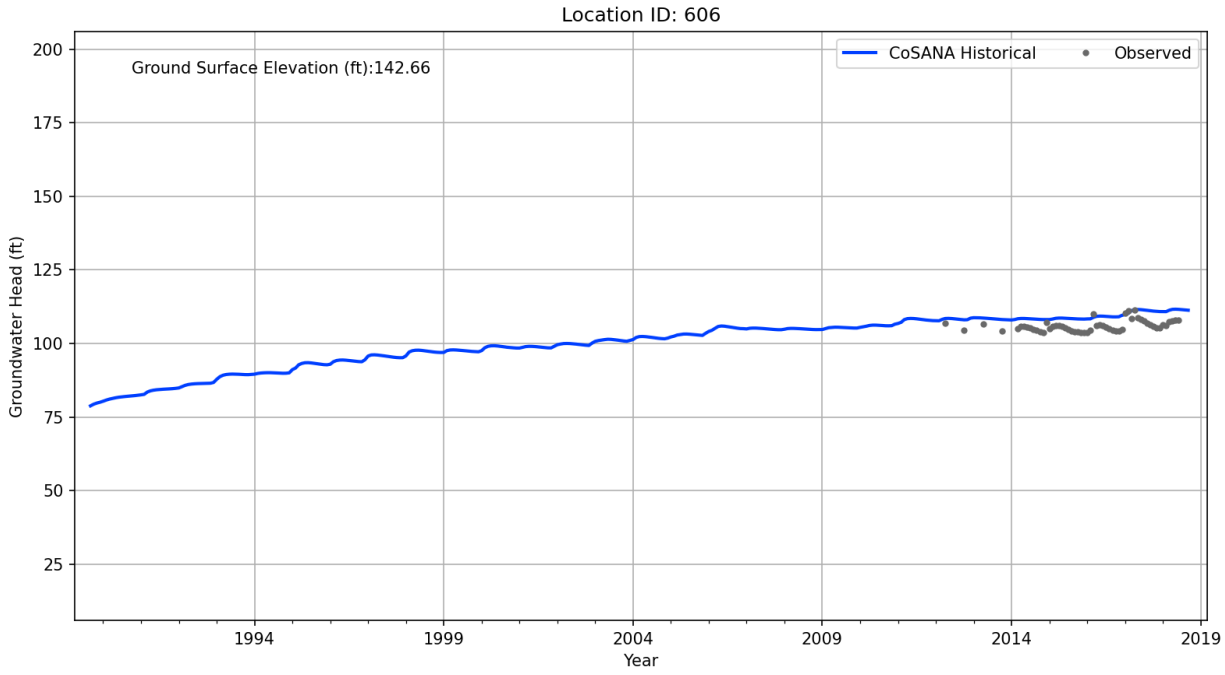

Location ID: 501
Ground Surface Elevation (ft):105.22
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

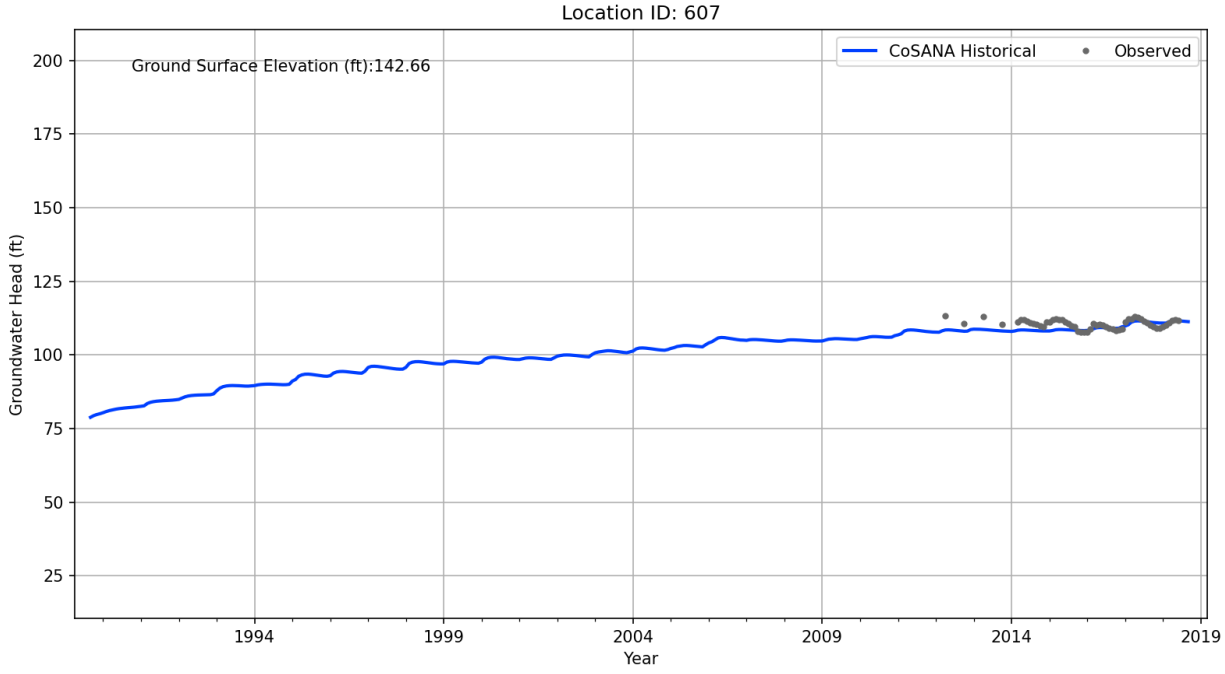

Location ID: 602
Ground Surface Elevation (ft):110.57
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

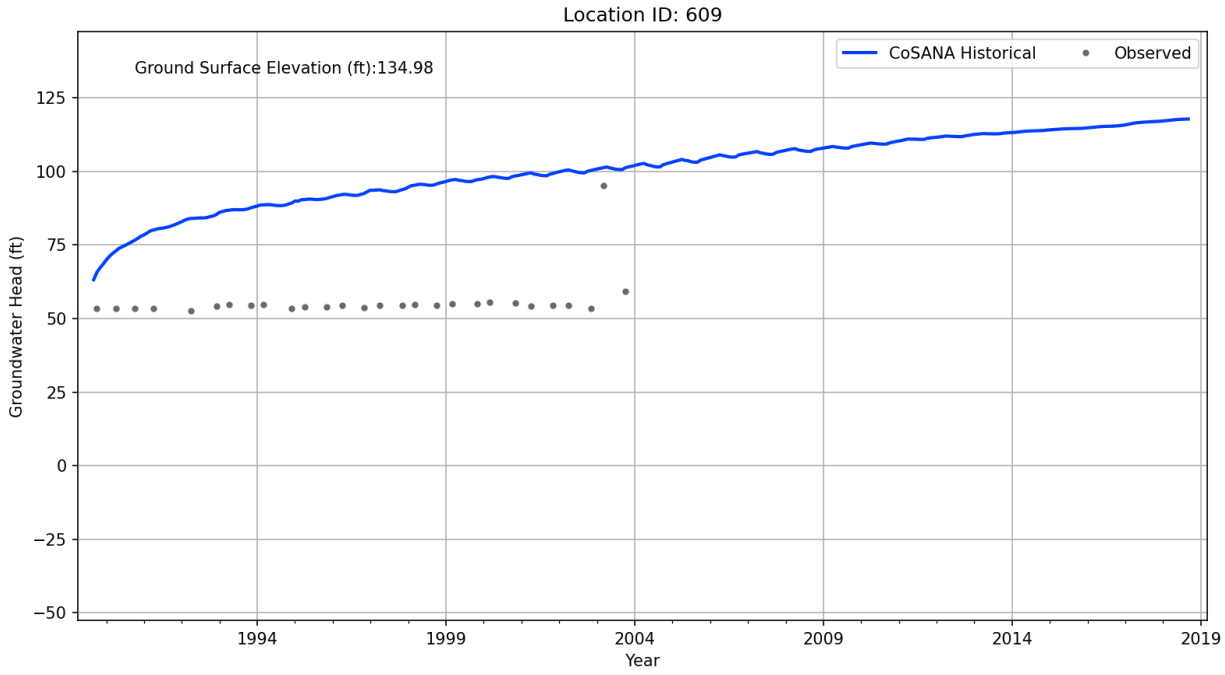

Location ID: 603
Ground Surface Elevation (ft):110.57
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

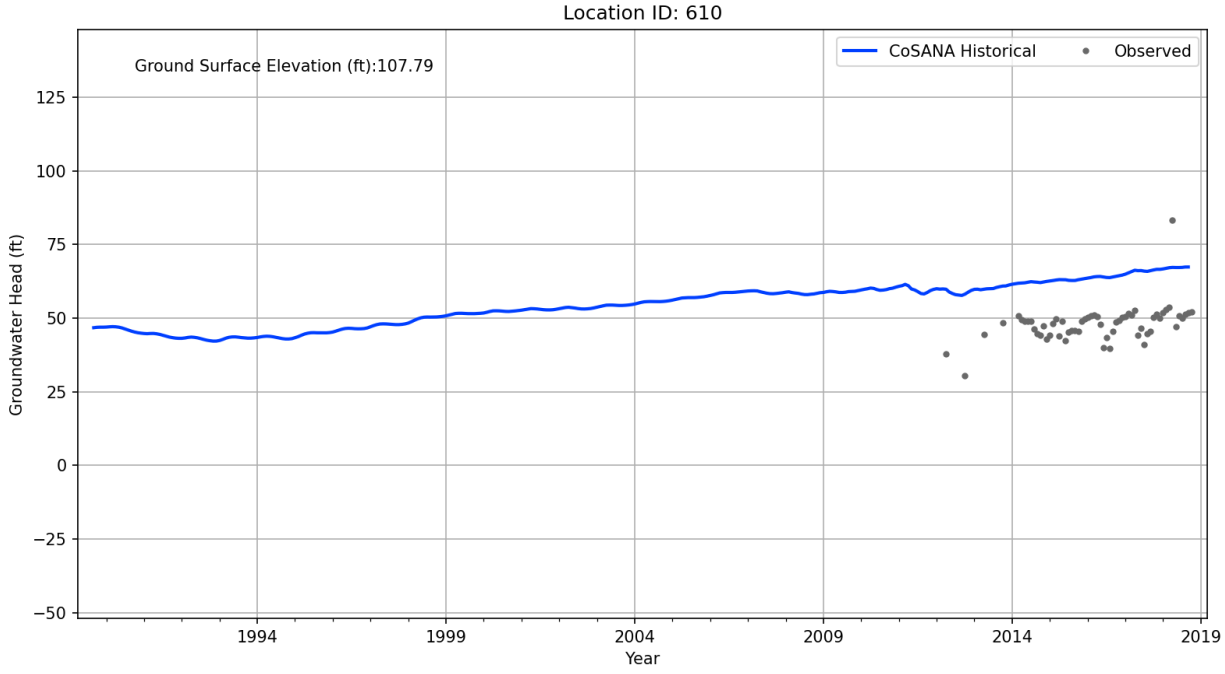

Location ID: 604
Ground Surface Elevation (ft):145.29
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

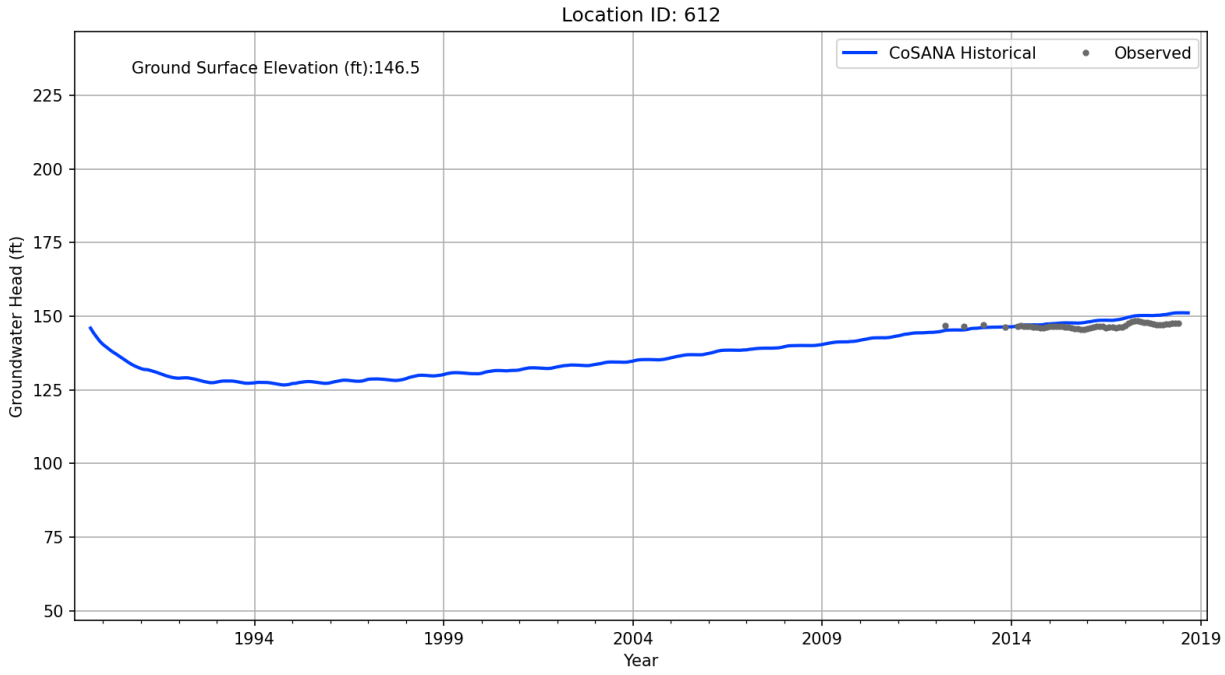

Location ID: 605
Ground Surface Elevation (ft):172.63
CoSANA Historical
Observed
Groundwater Head (ft)
250
225
200
175
150
125
100
75
1994
1999
2004
2009
2014
2019
Year

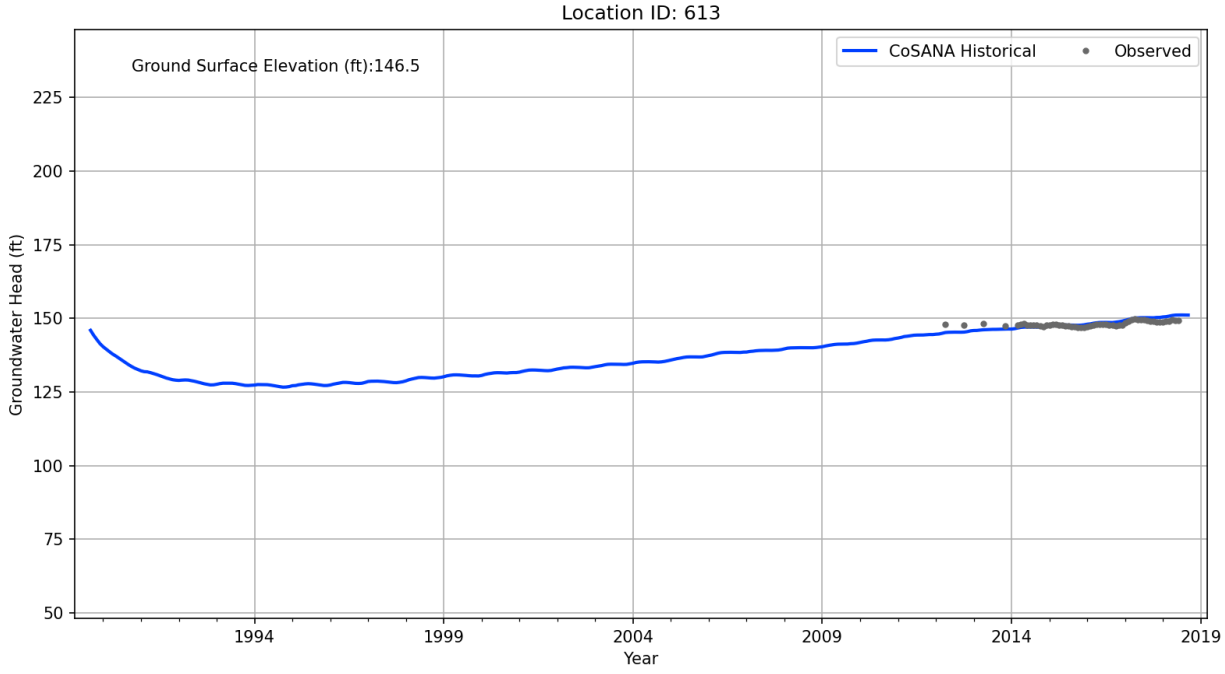

Location ID: 606
Ground Surface Elevation (ft):142.66
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

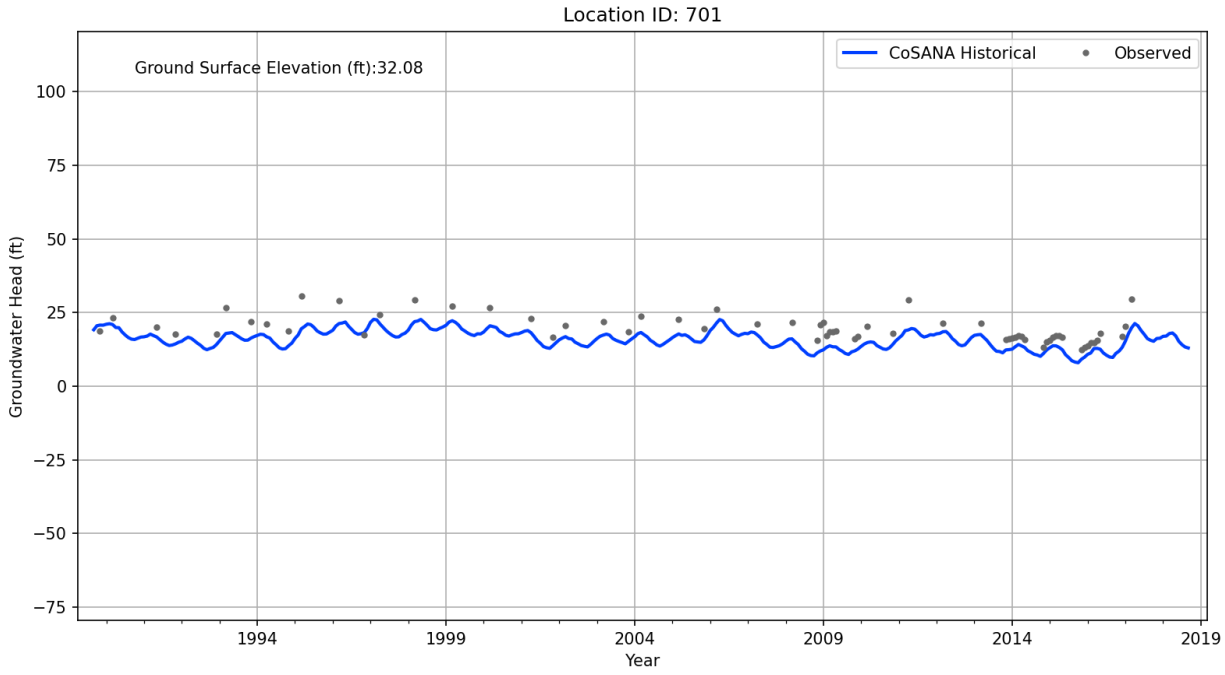

Location ID: 607
Ground Surface Elevation (ft):142.66
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

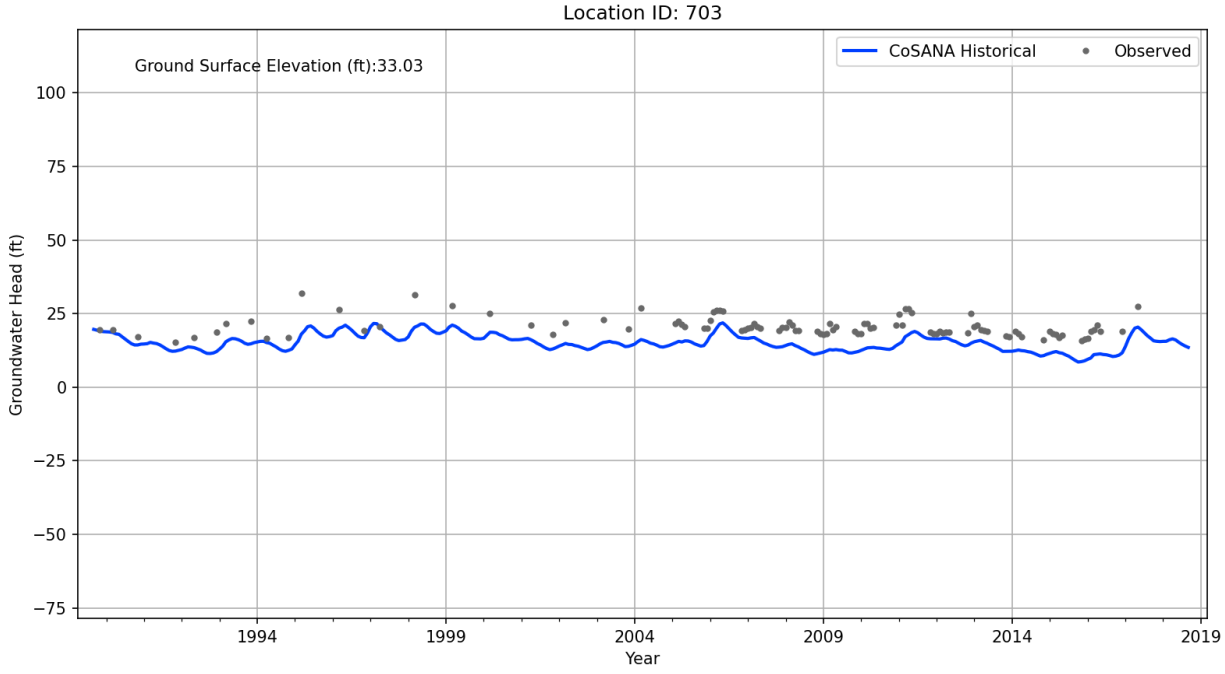

Location ID: 609
Ground Surface Elevation (ft):134.98
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

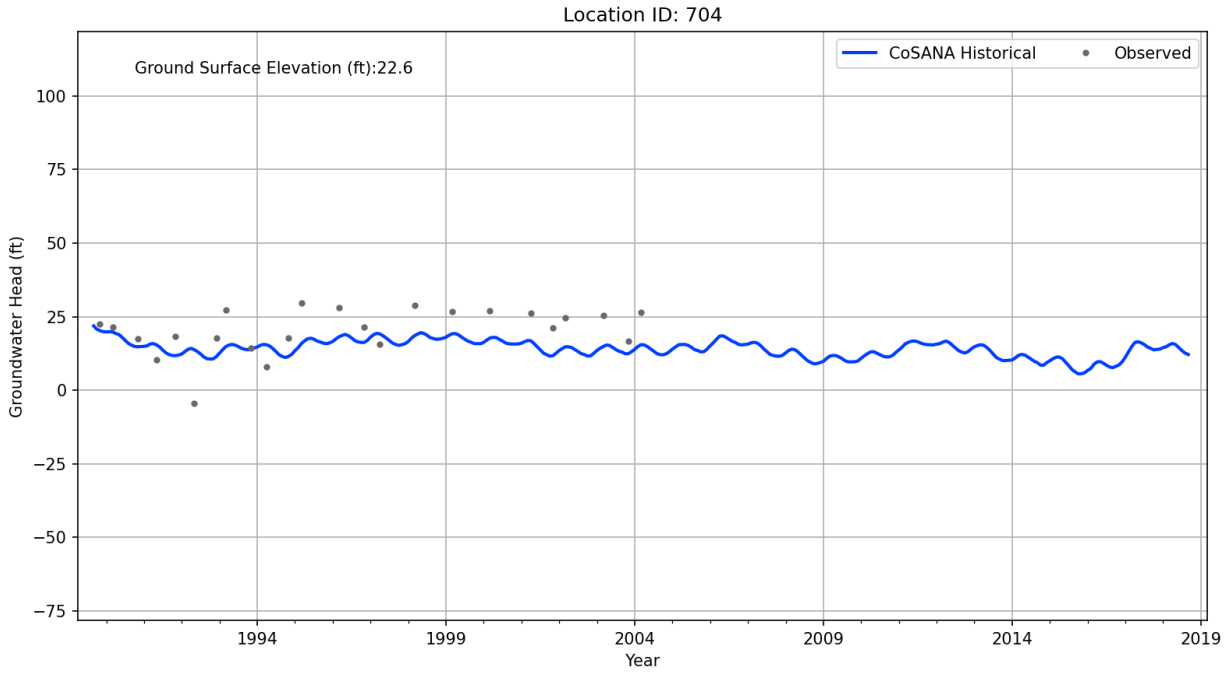

Location ID: 610
Ground Surface Elevation (ft):107.79
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

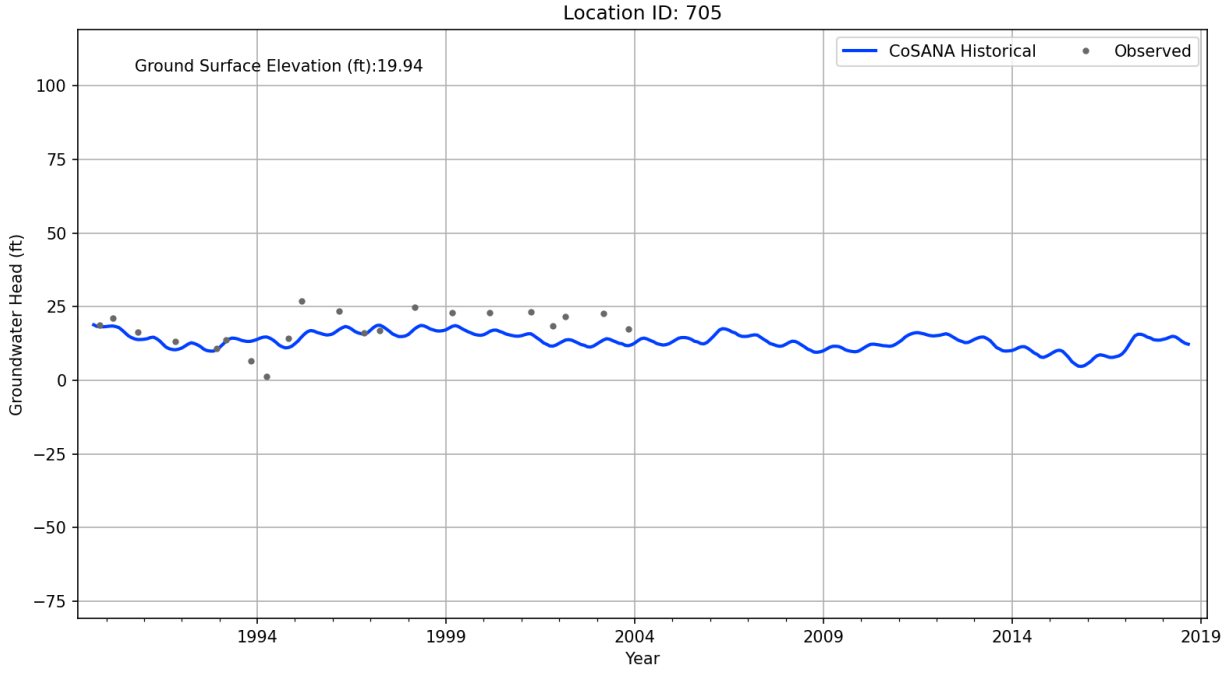

Location ID: 612
Ground Surface Elevation (ft):146.5
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

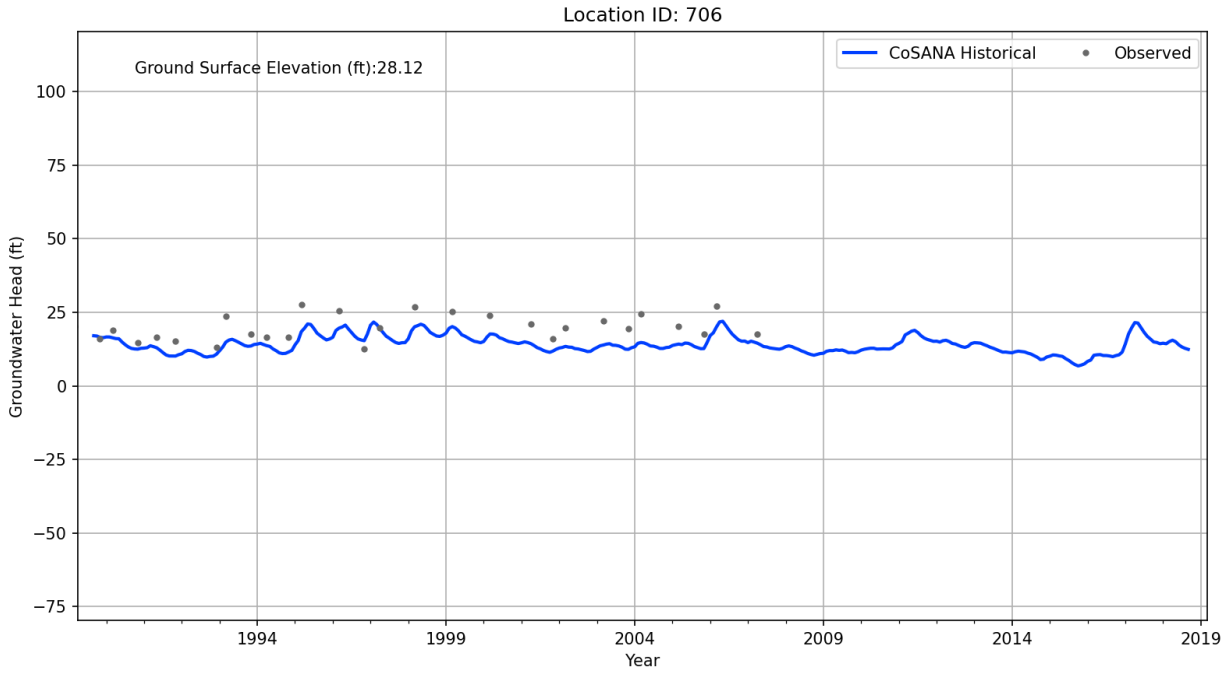

Location ID: 613
Ground Surface Elevation (ft):146.5
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

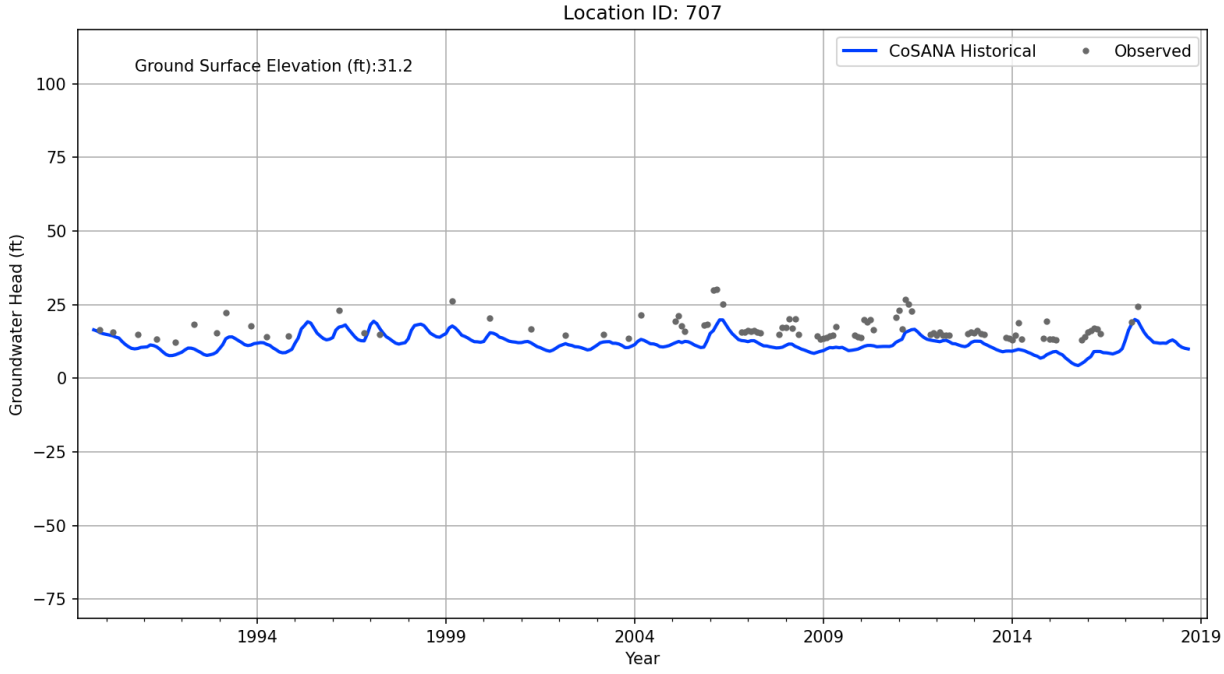

Location ID: 701
Ground Surface Elevation (ft):32.08
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

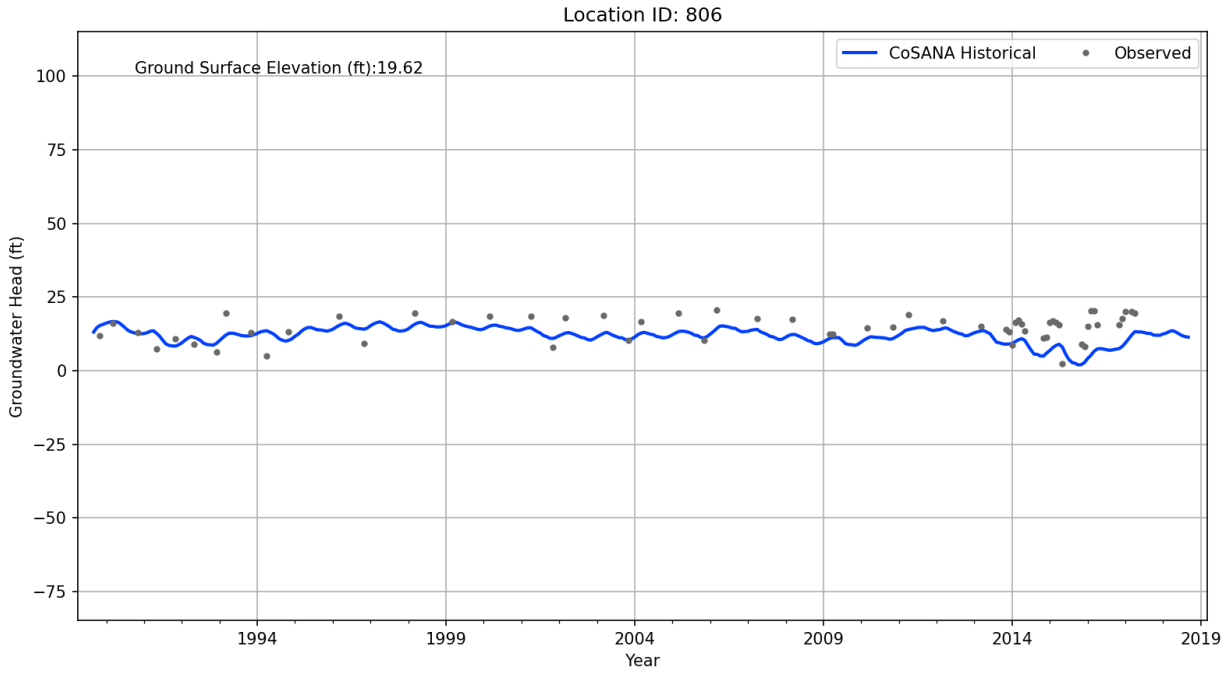

Location ID: 703
Ground Surface Elevation (ft):33.03
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

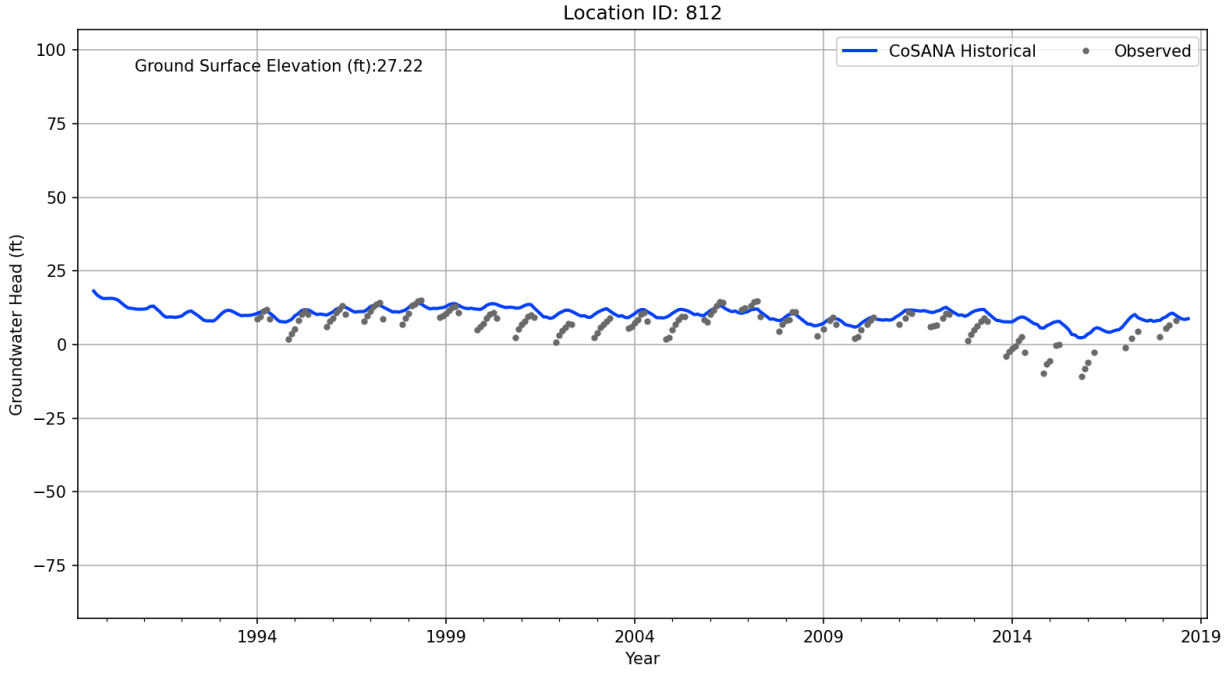

Location ID: 704
Ground Surface Elevation (ft):22.6
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

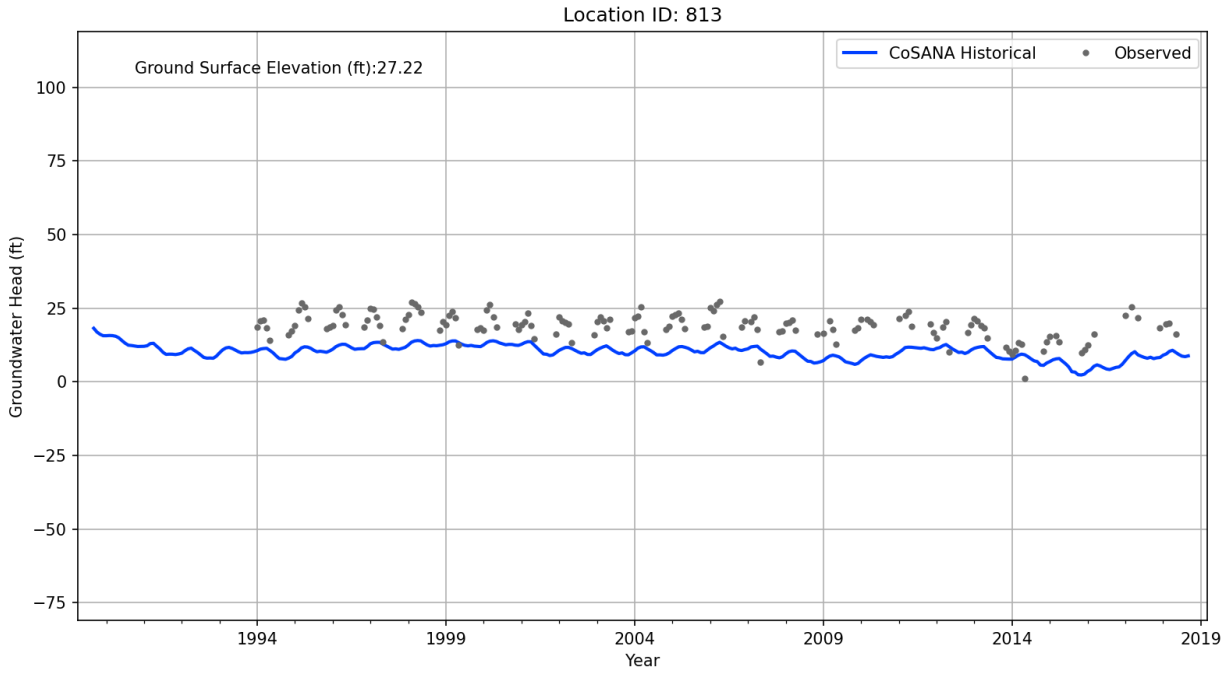

Location ID: 705
Ground Surface Elevation (ft):19.94
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

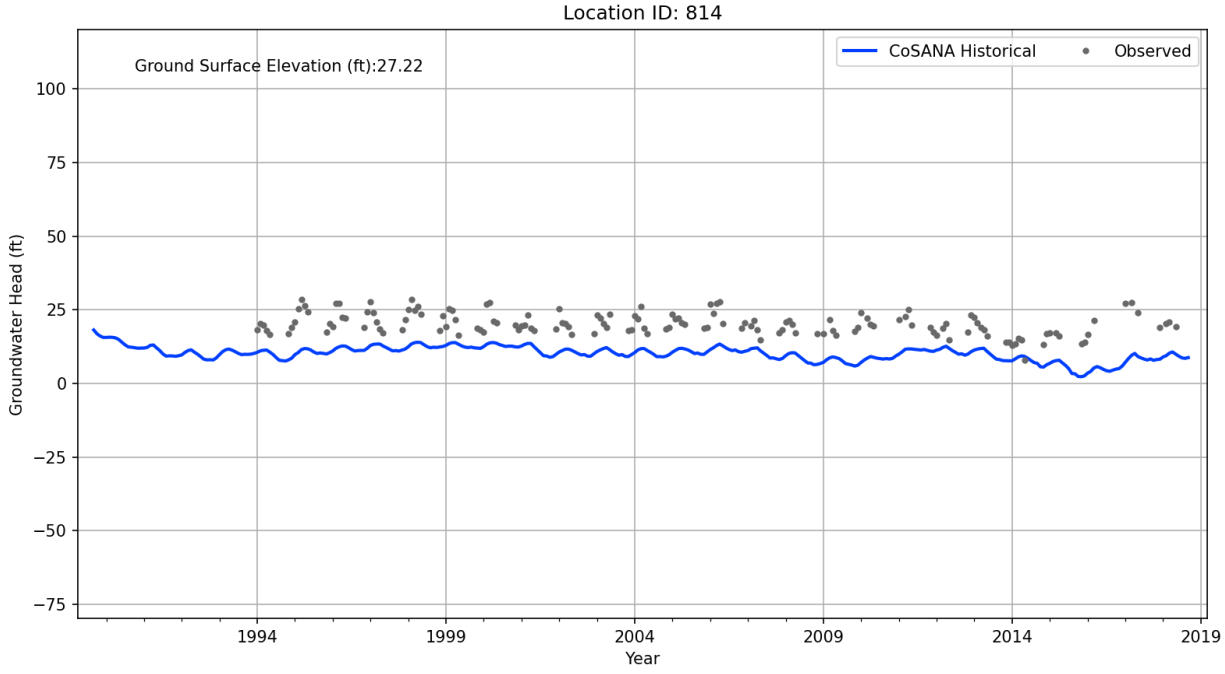

Location ID: 706
Ground Surface Elevation (ft):28.12
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

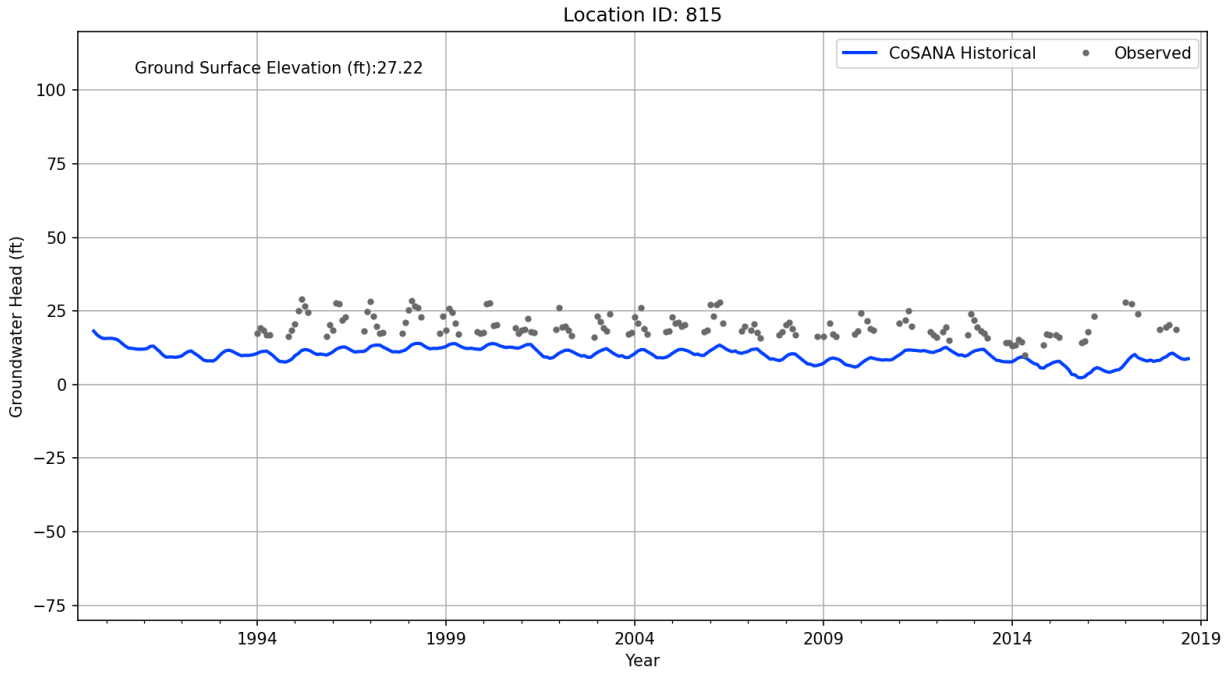

Location ID: 707
Ground Surface Elevation (ft):31.2
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

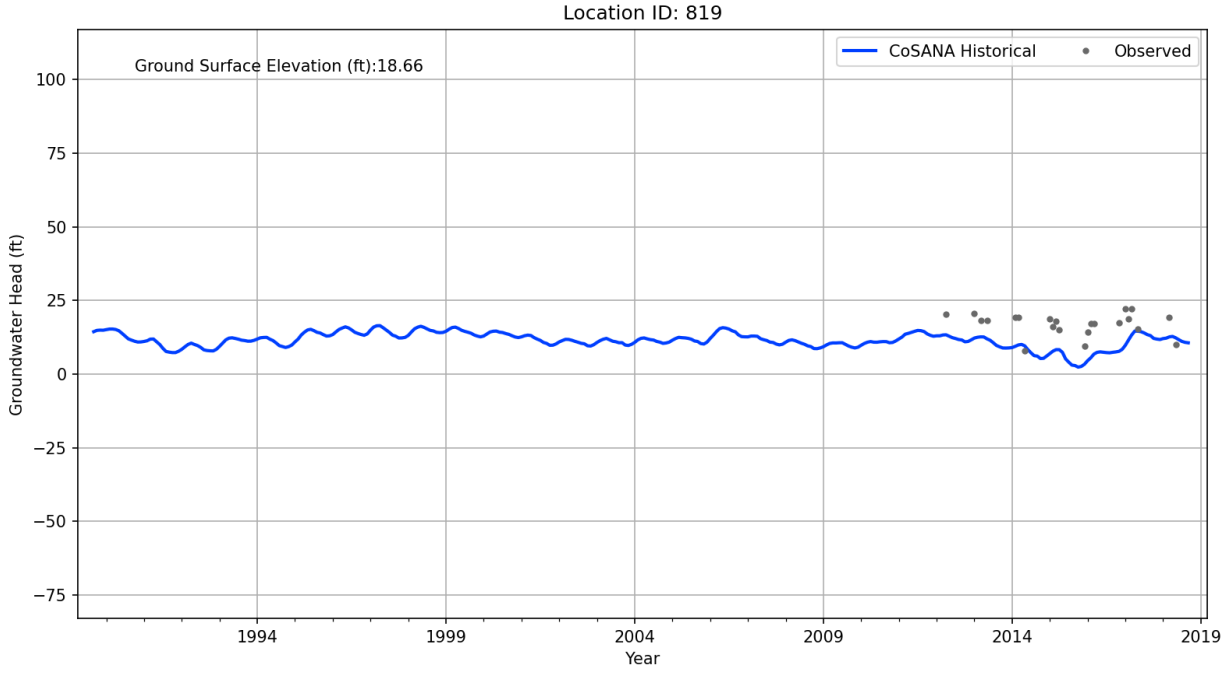

Location ID: 806
Ground Surface Elevation (ft):19.62
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

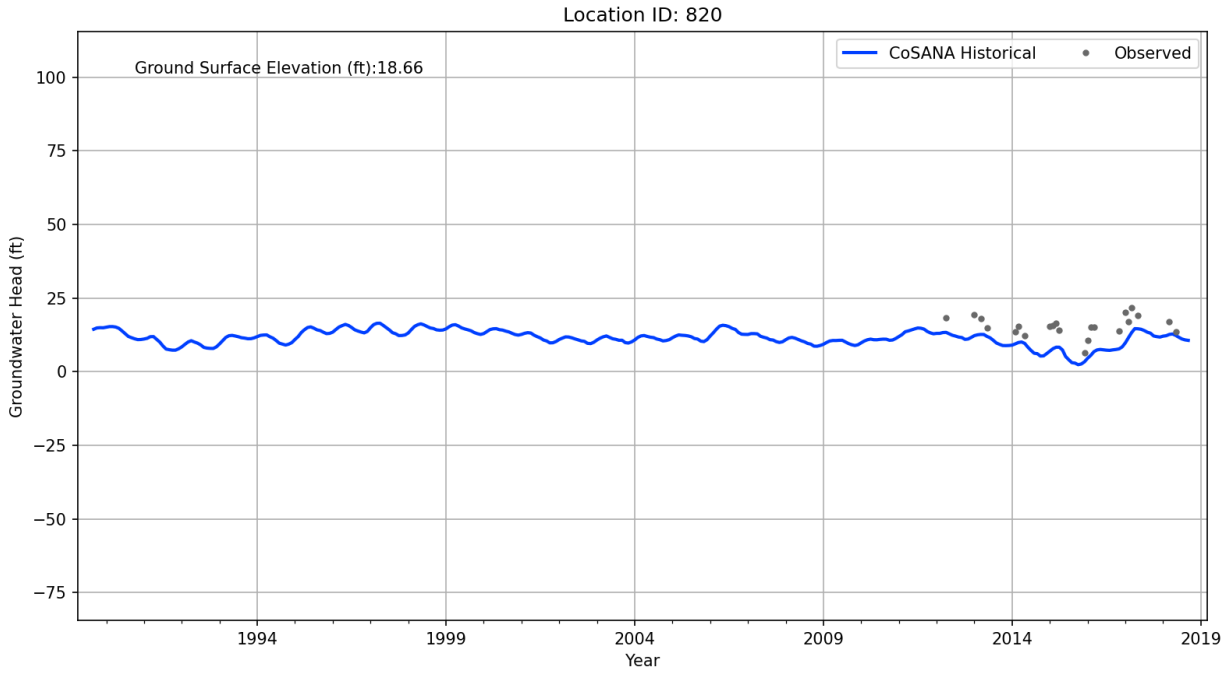

Location ID: 812
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

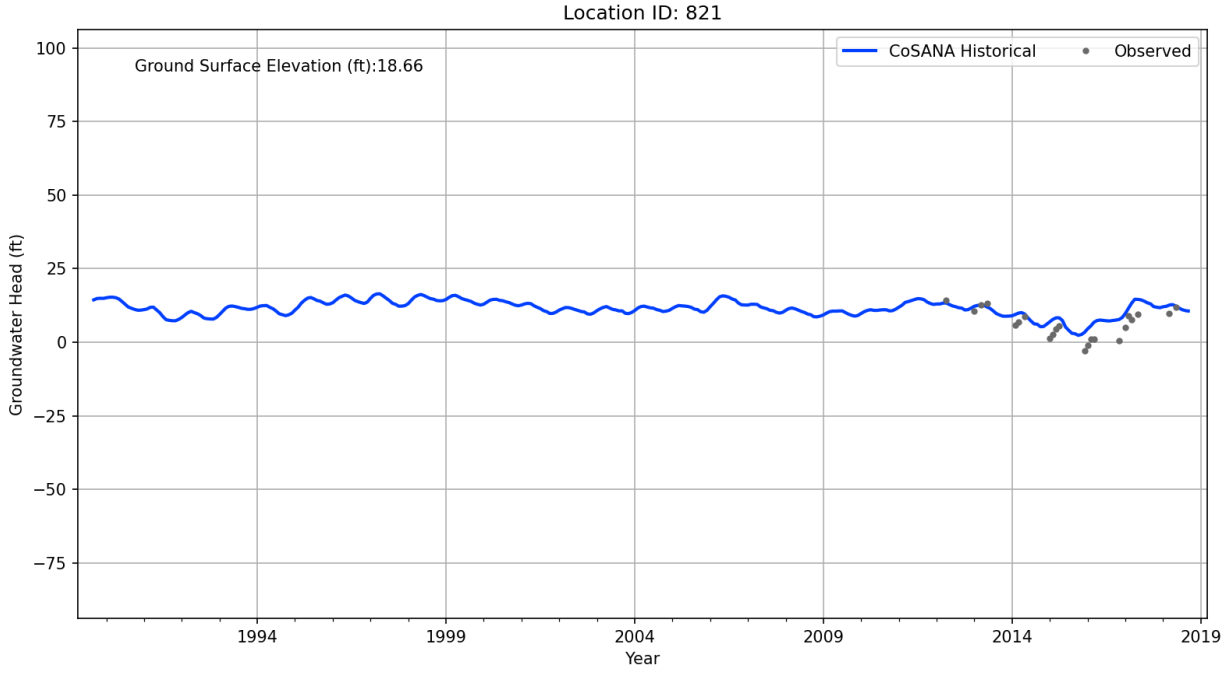

Location ID: 813
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

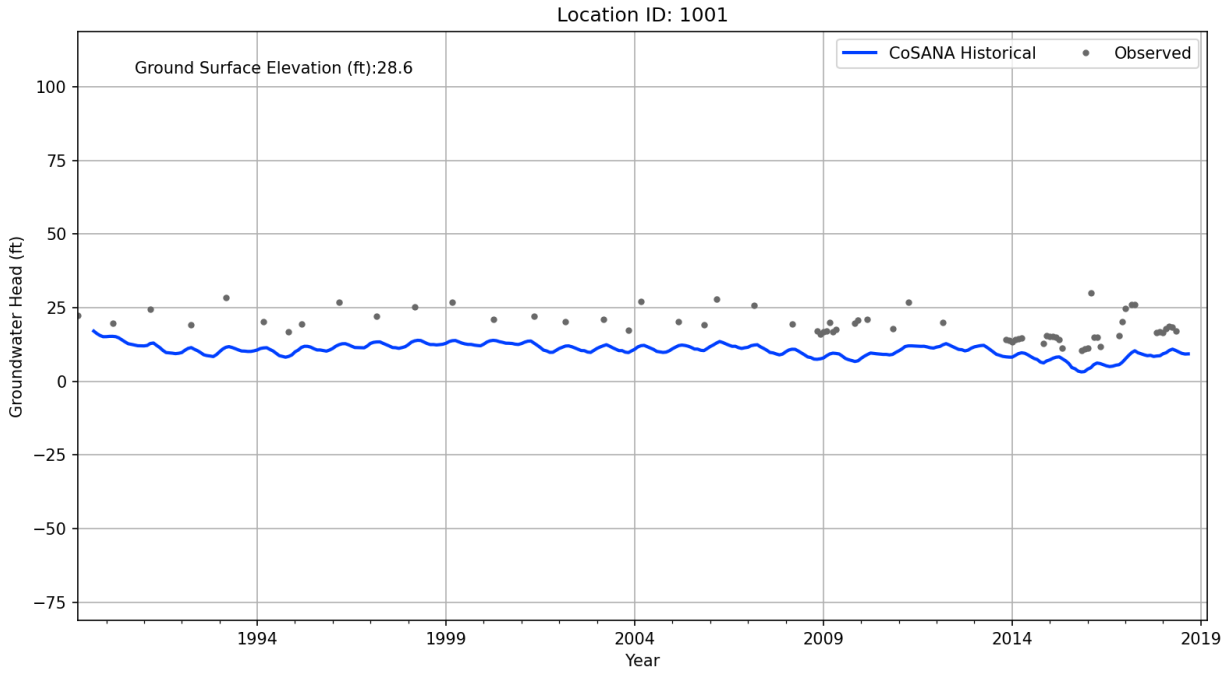

Location ID: 814
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

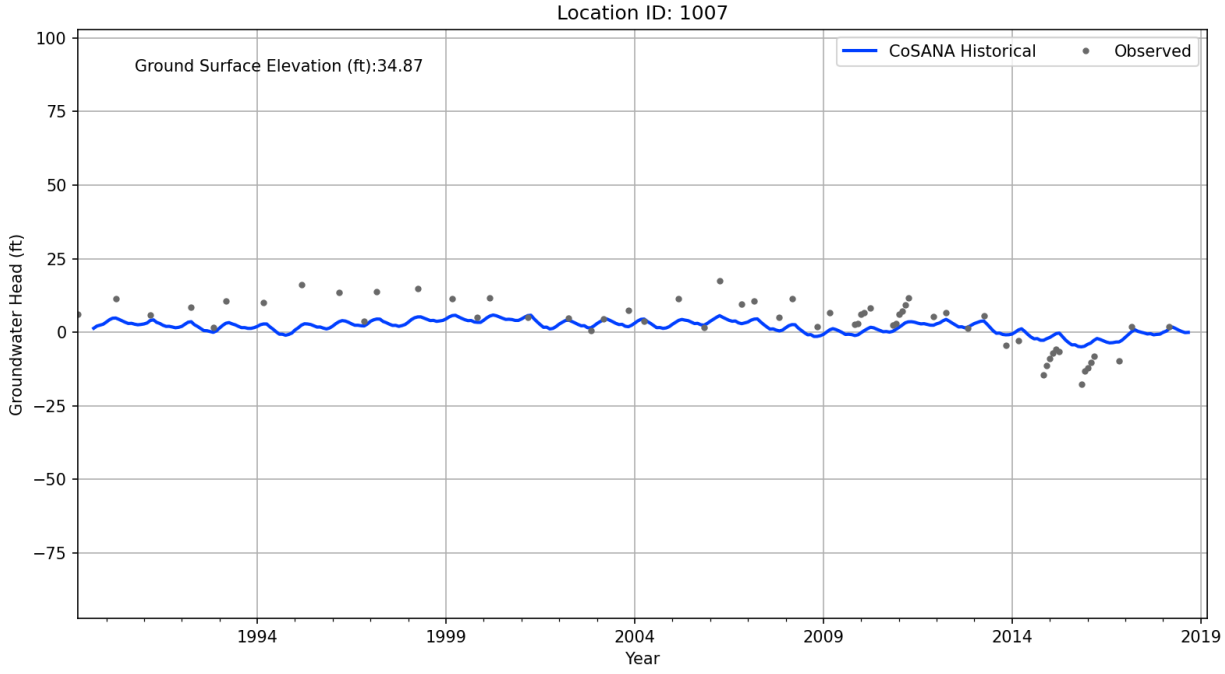

Location ID: 815
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

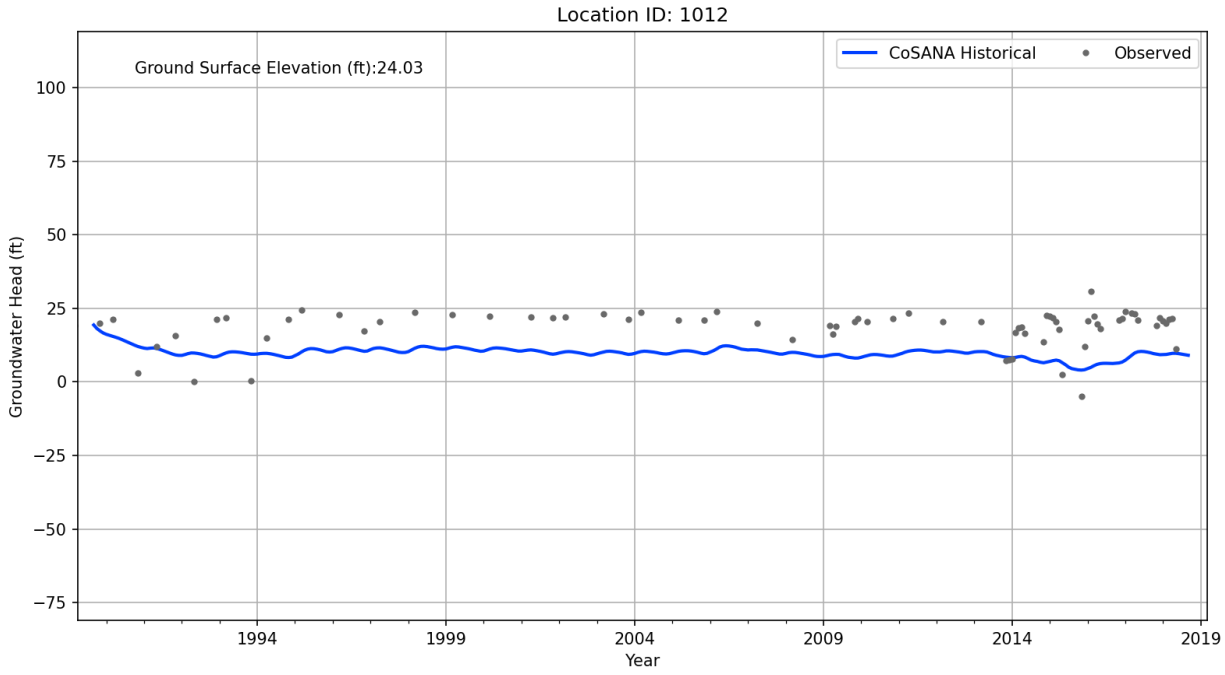

Location ID: 819
Ground Surface Elevation (ft):18.66
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

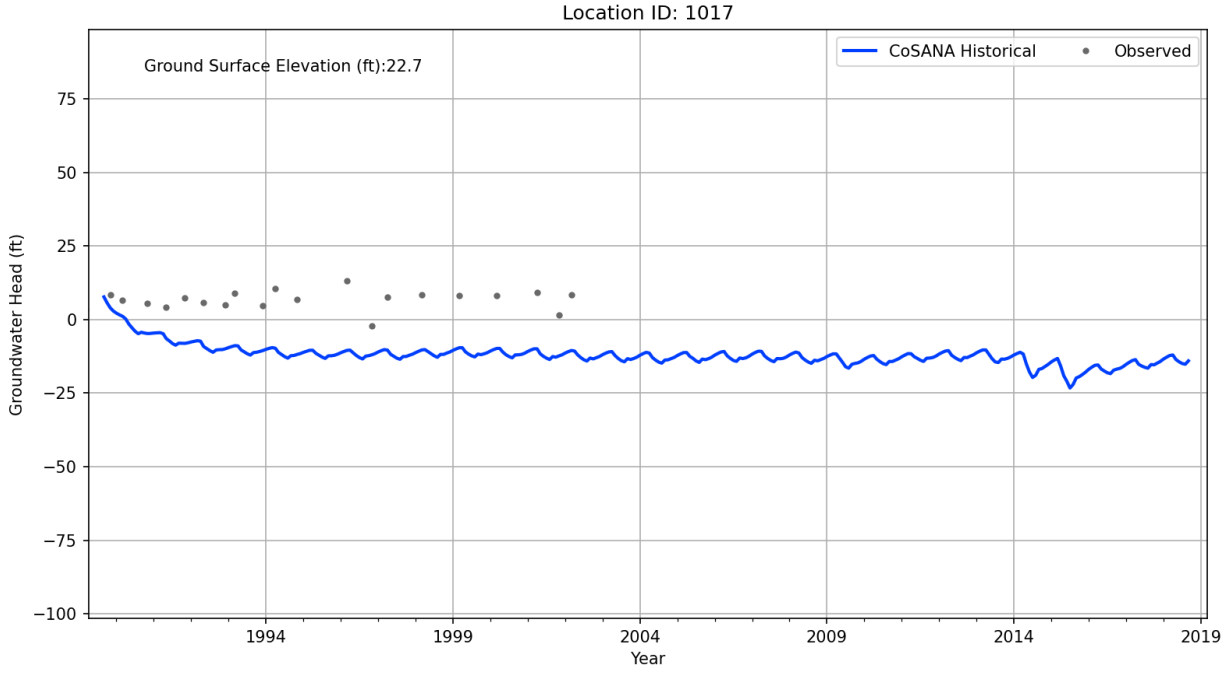

Location ID: 820
Ground Surface Elevation (ft):18.66
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

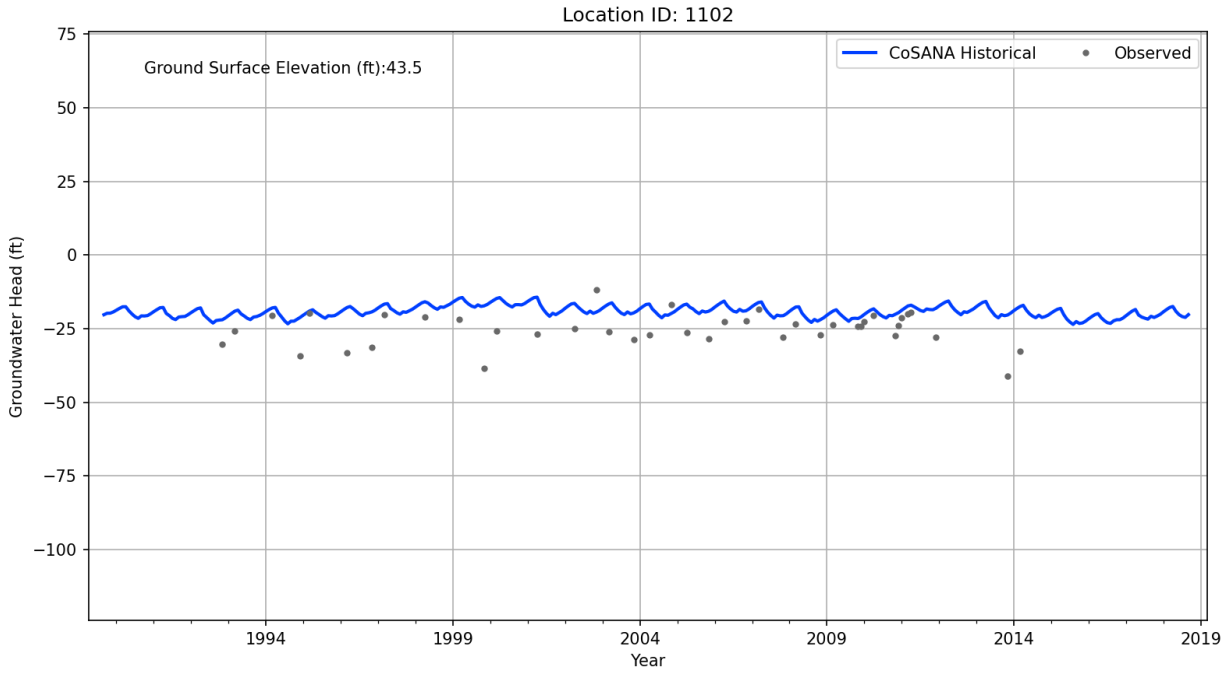

Location ID: 821
Ground Surface Elevation (ft):18.66
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

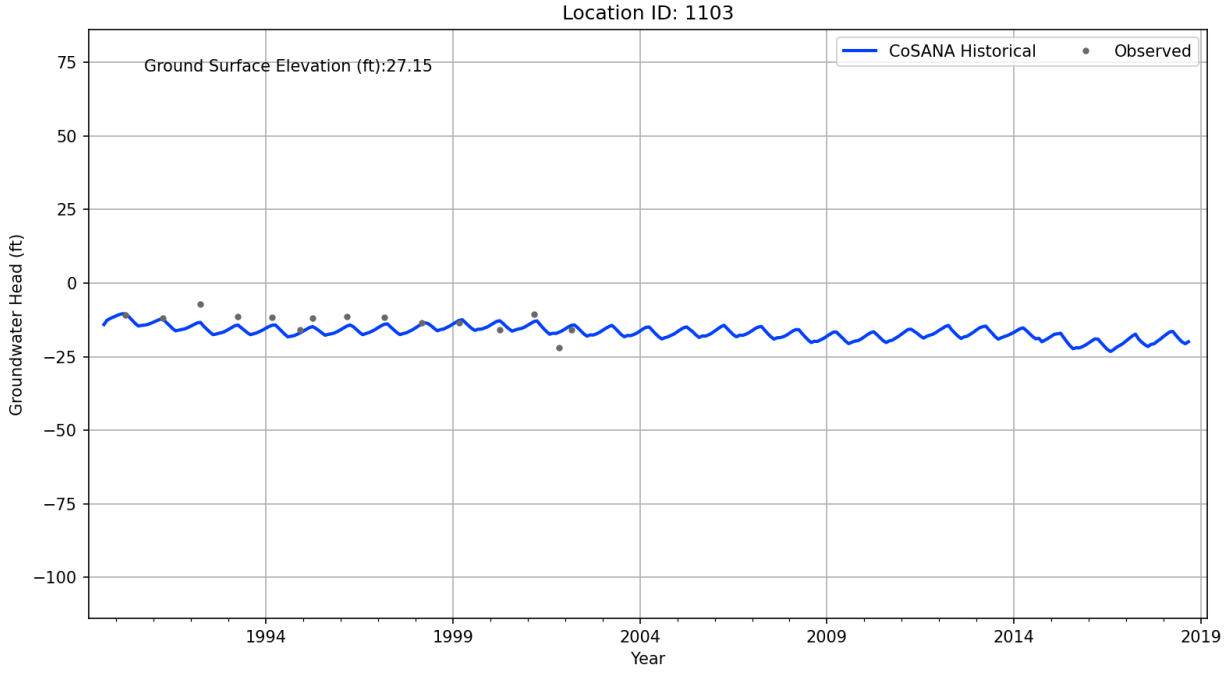

Location ID: 1001
Ground Surface Elevation (ft):28.6
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

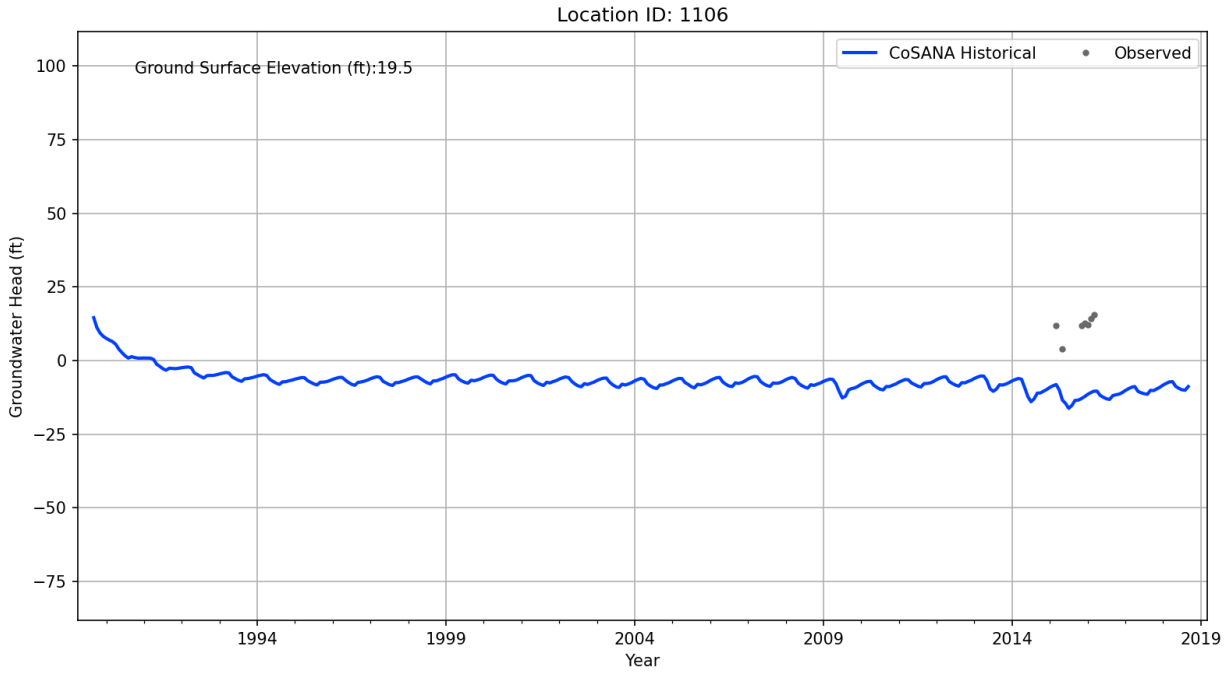

Location ID: 1007
Ground Surface Elevation (ft):34.87
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

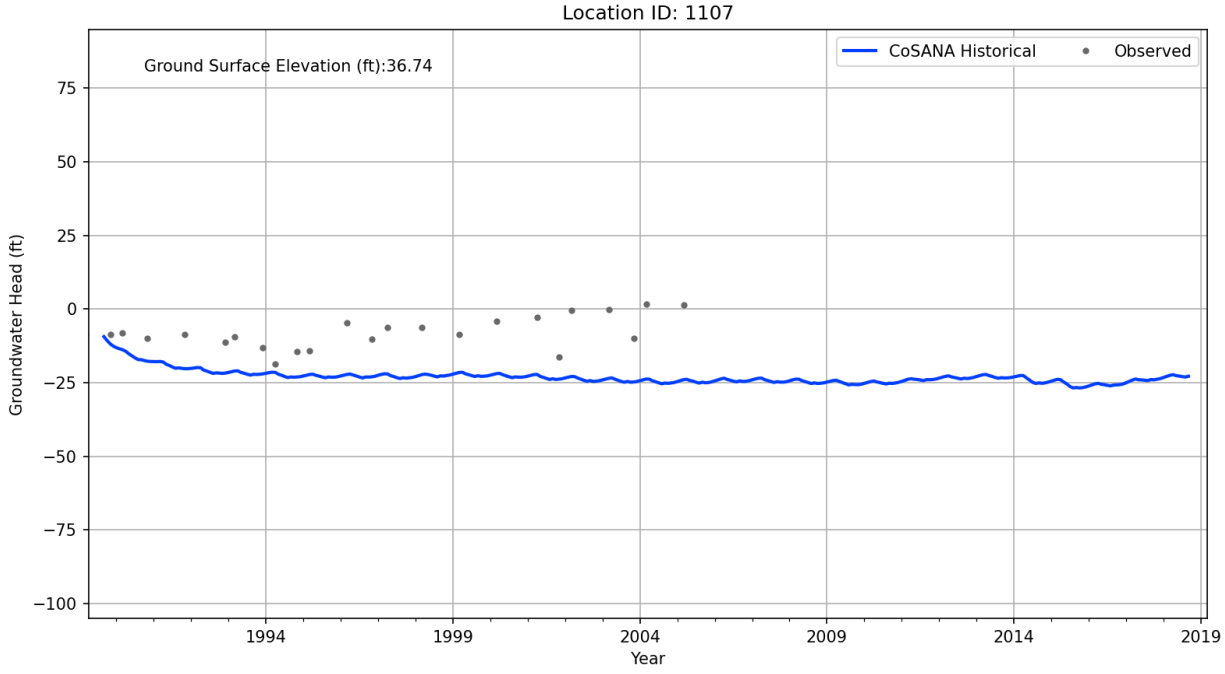

Location ID: 1012
Ground Surface Elevation (ft):24.03
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

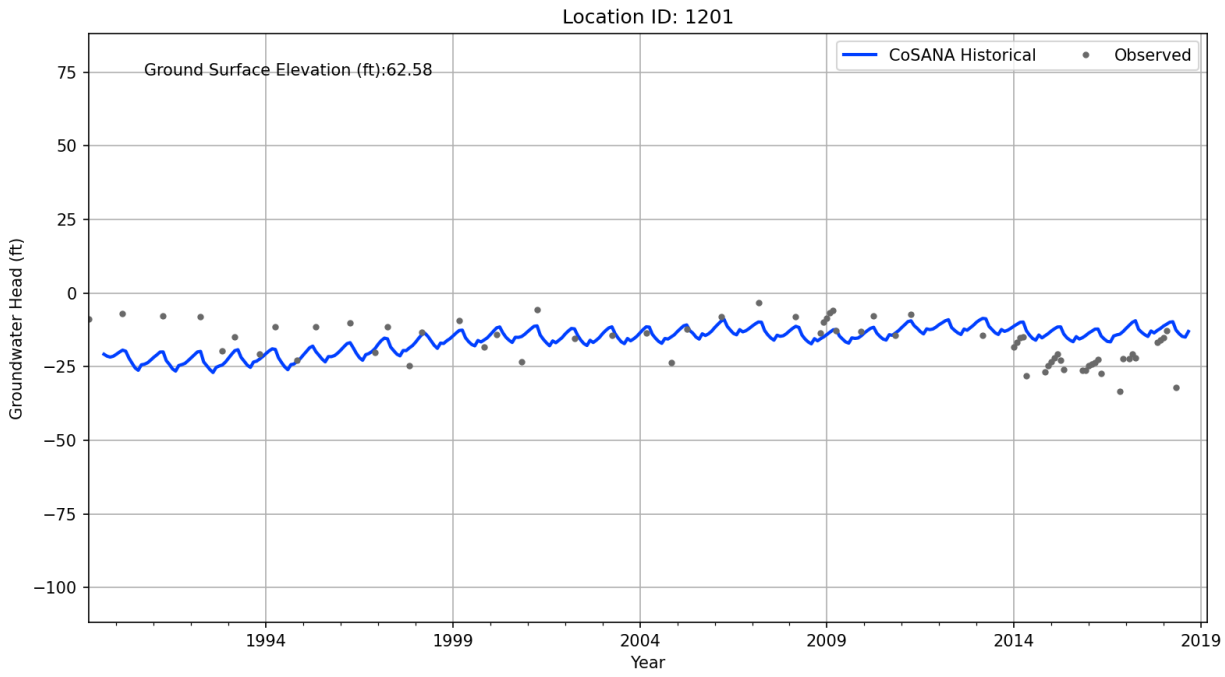

Location ID: 1017
Ground Surface Elevation (ft):22.7
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

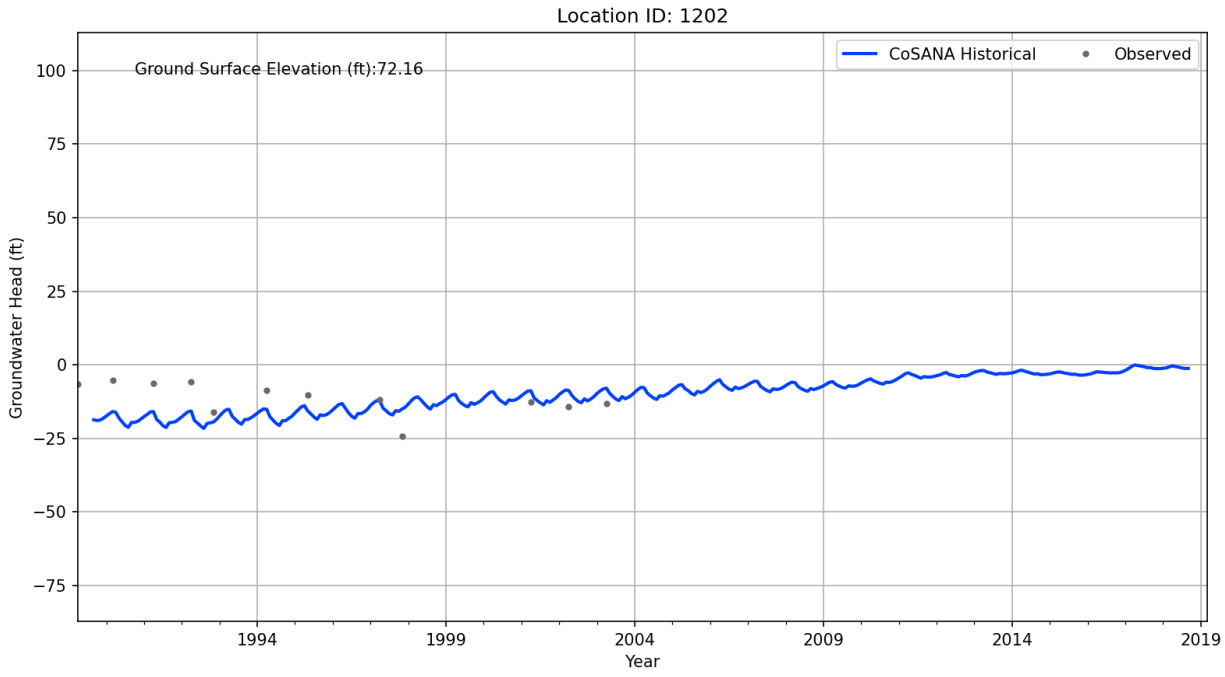

Location ID: 1102
Ground Surface Elevation (ft):43.5
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

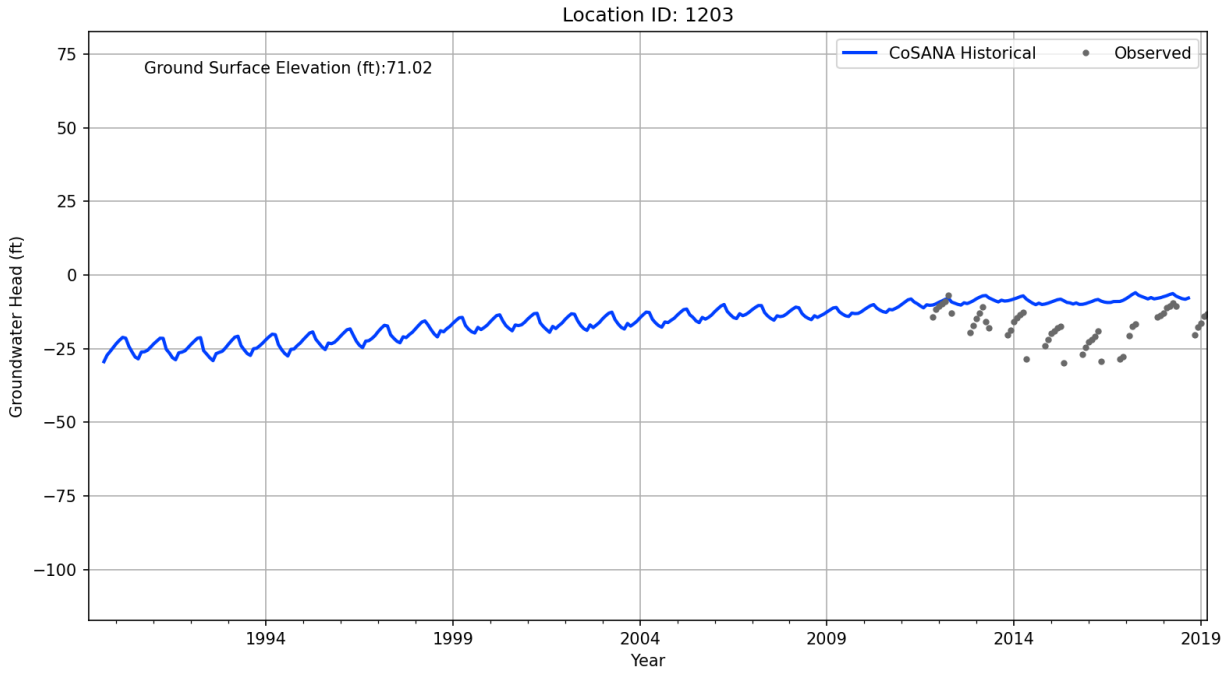

Location ID: 1103
Ground Surface Elevation (ft):27.15
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

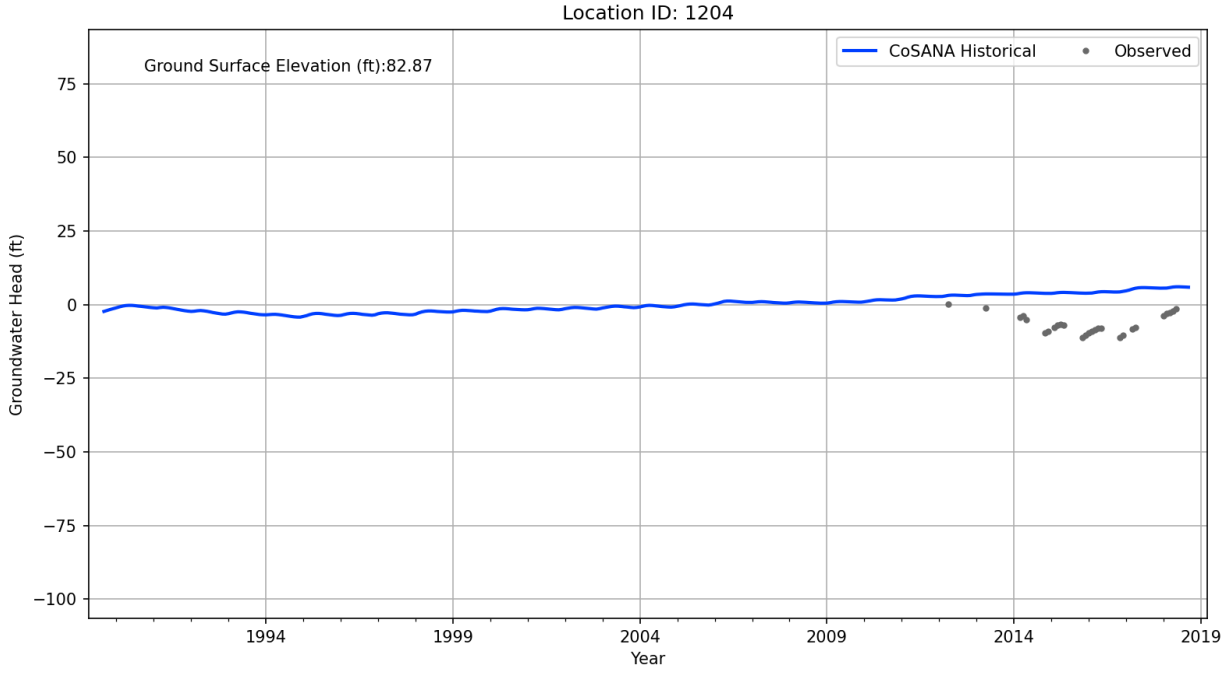

Location ID: 1106
Ground Surface Elevation (ft):19.5
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

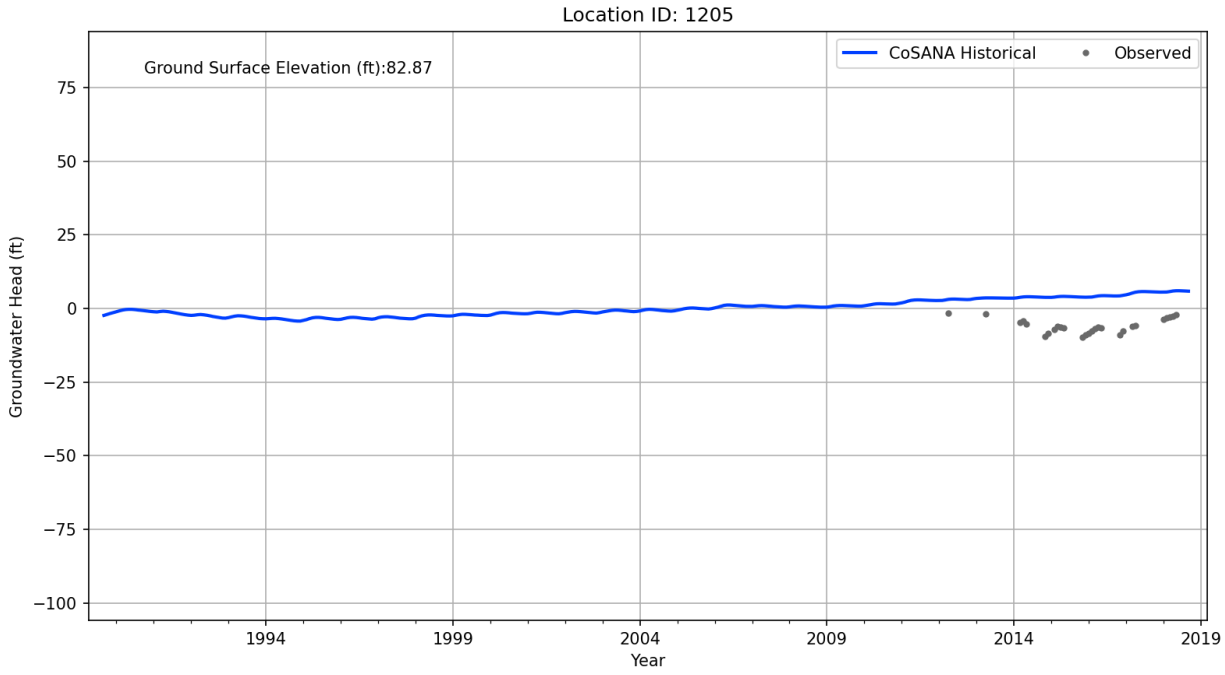

Location ID: 1107
Ground Surface Elevation (ft):36.74
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

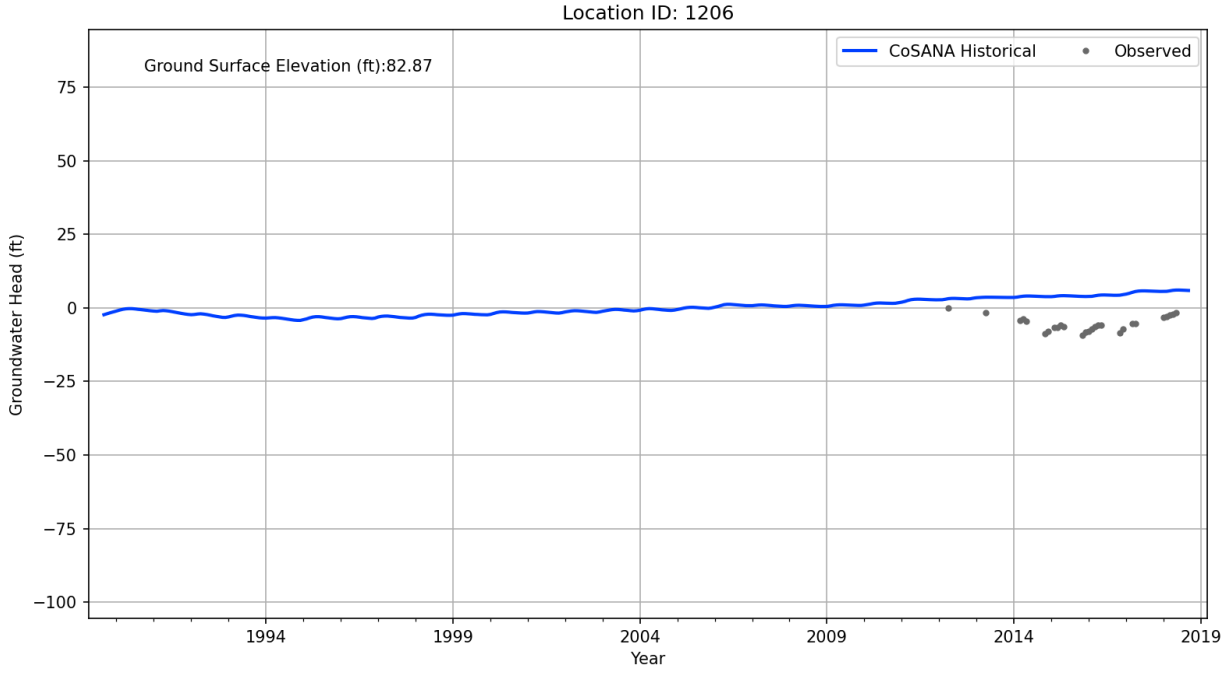

Location ID: 1201
Ground Surface Elevation (ft):62.58
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

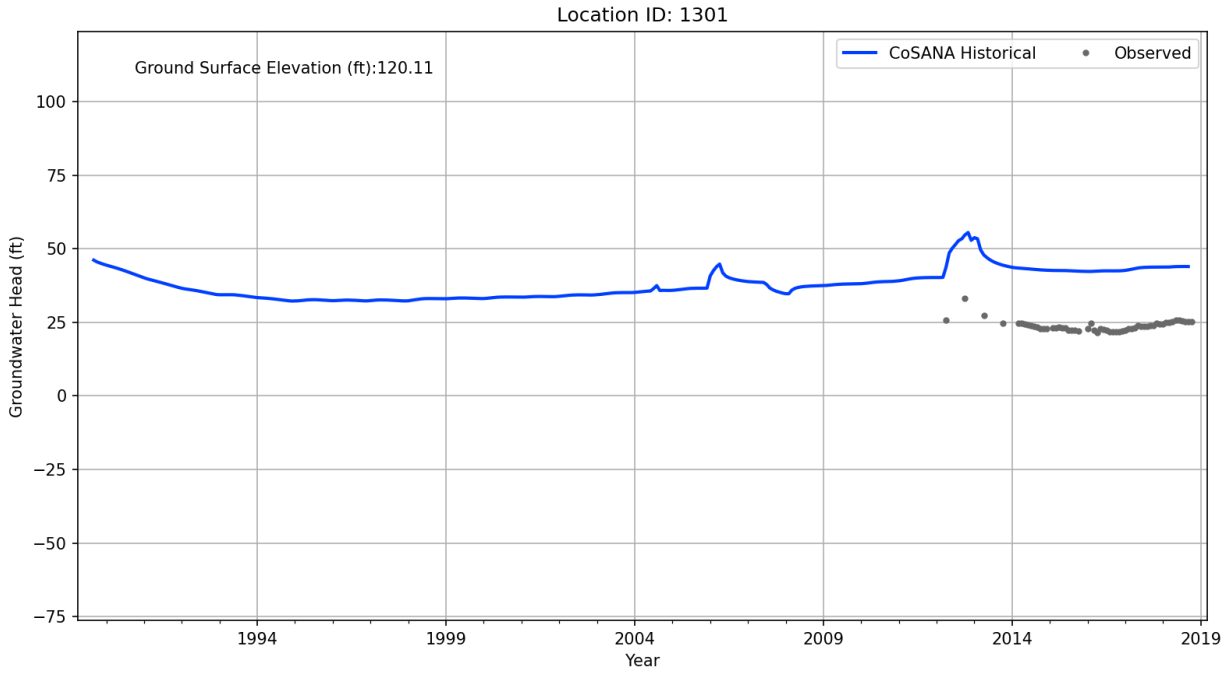

Location ID: 1202
Ground Surface Elevation (ft):72.16
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

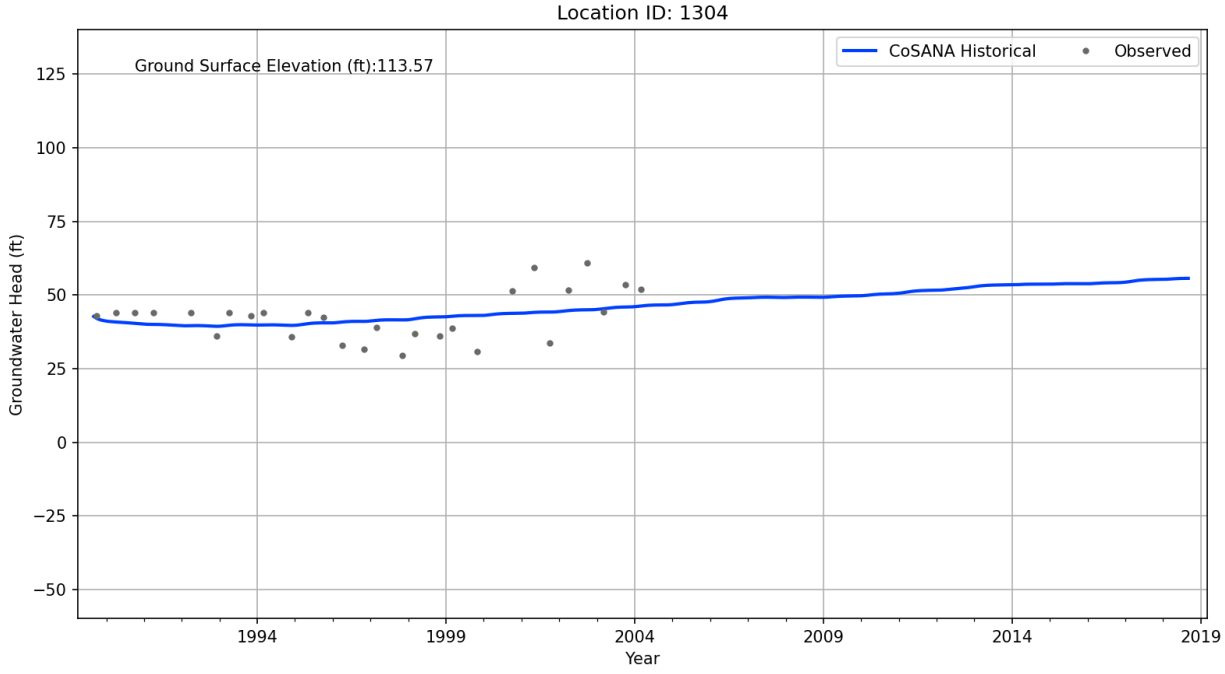

Location ID: 1203
Ground Surface Elevation (ft):71.02
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

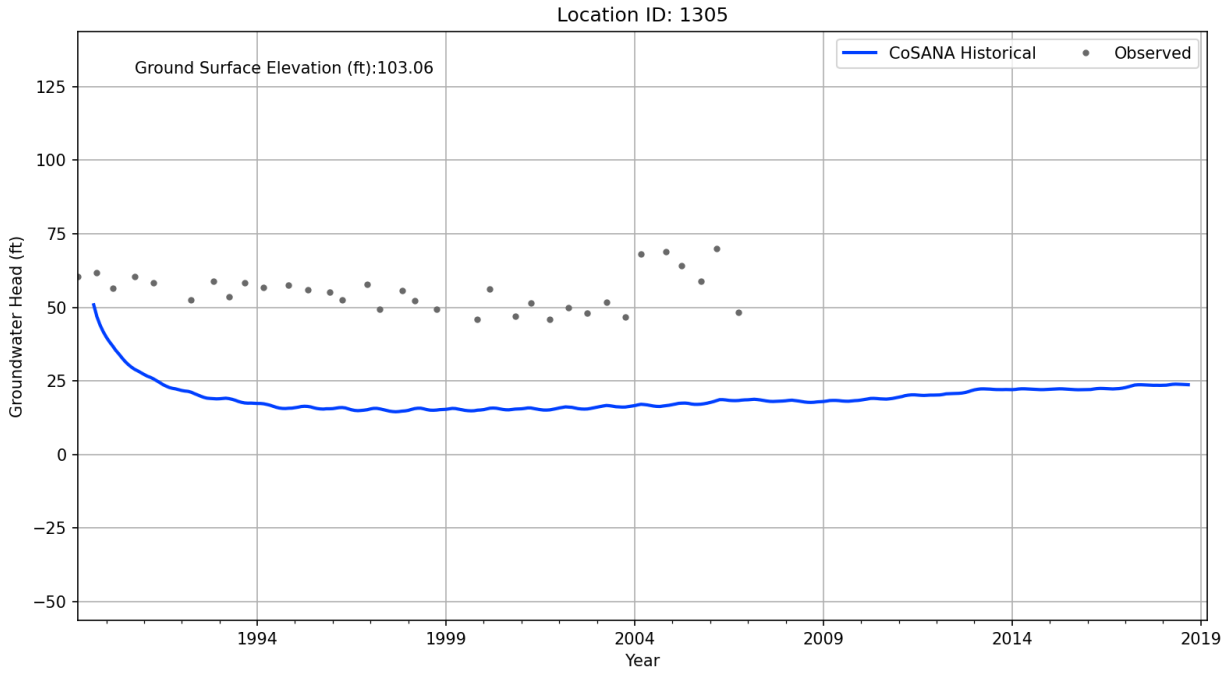

Location ID: 1204
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

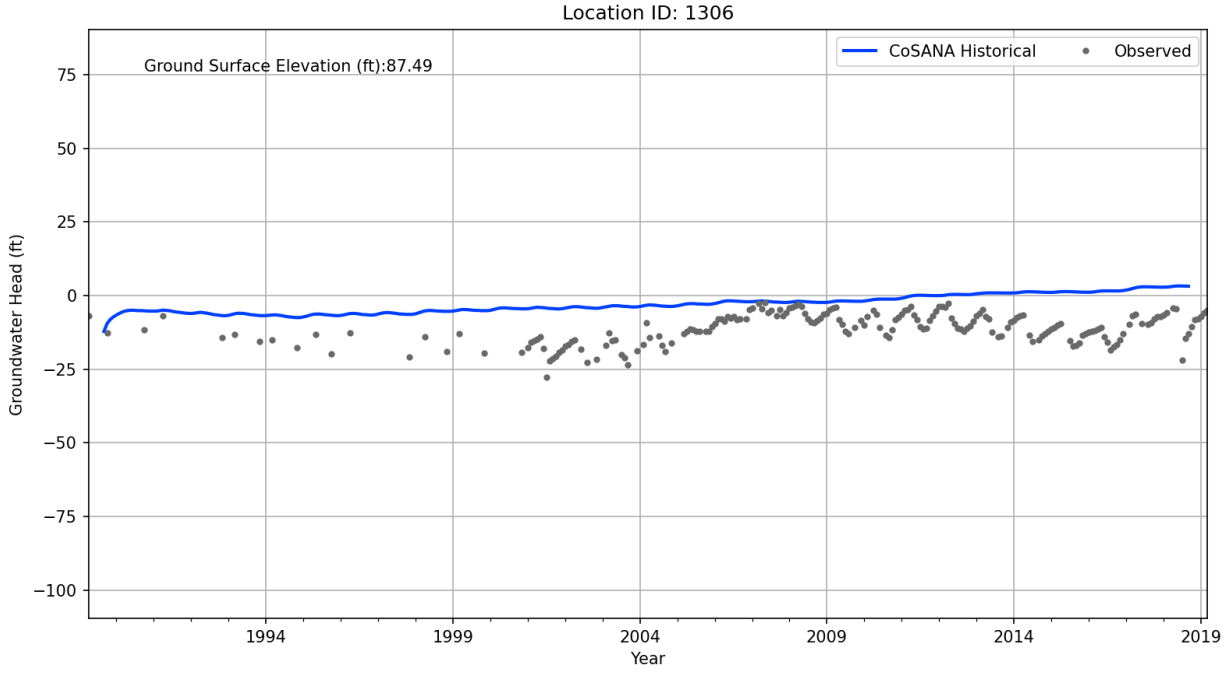

Location ID: 1205
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

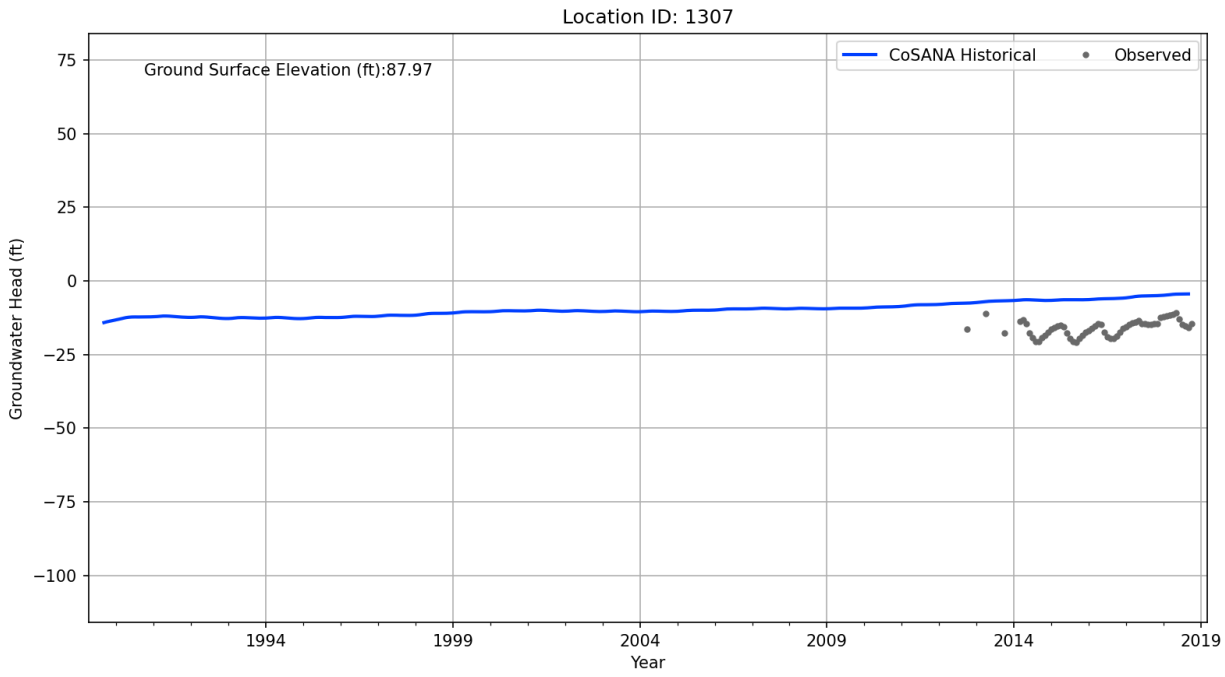

Location ID: 1206
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

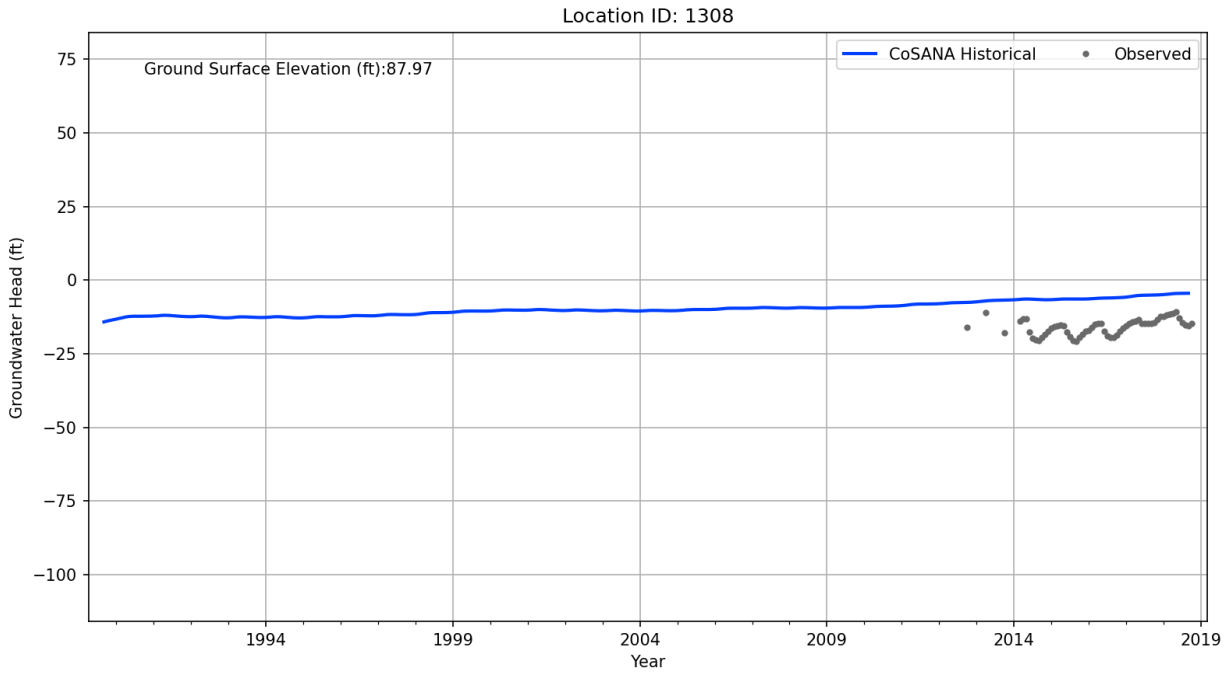

Location ID: 1301
Ground Surface Elevation (ft):120.11
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

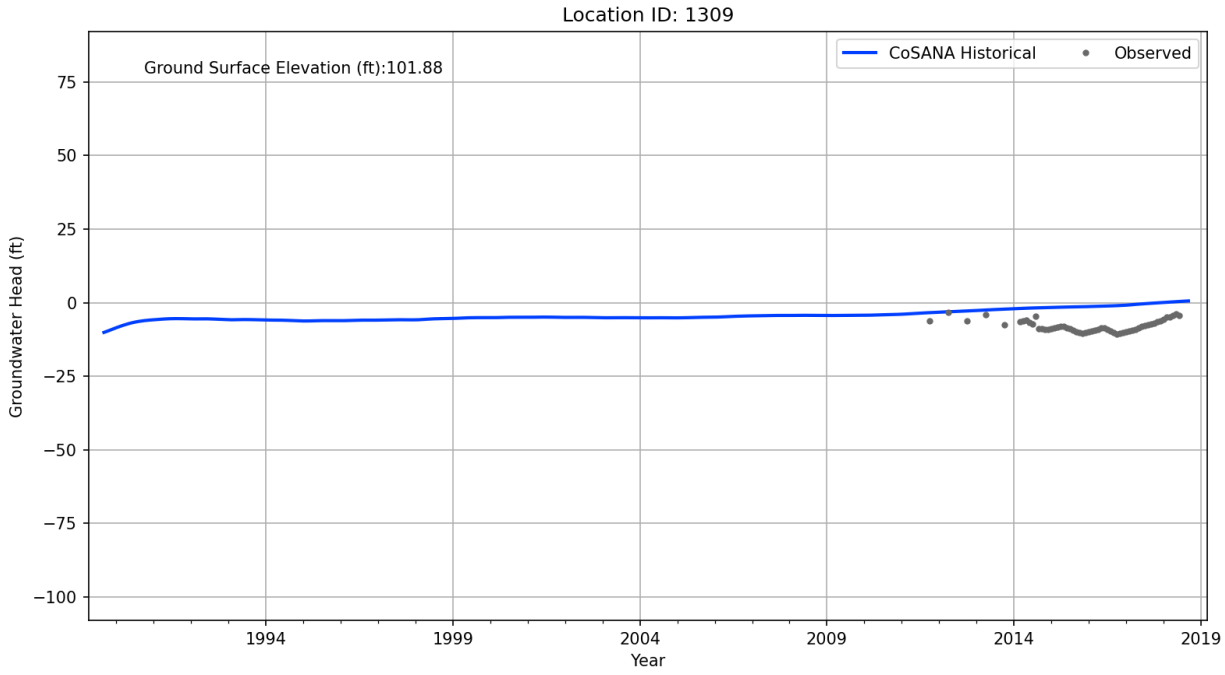

Location ID: 1304
Ground Surface Elevation (ft):113.57
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

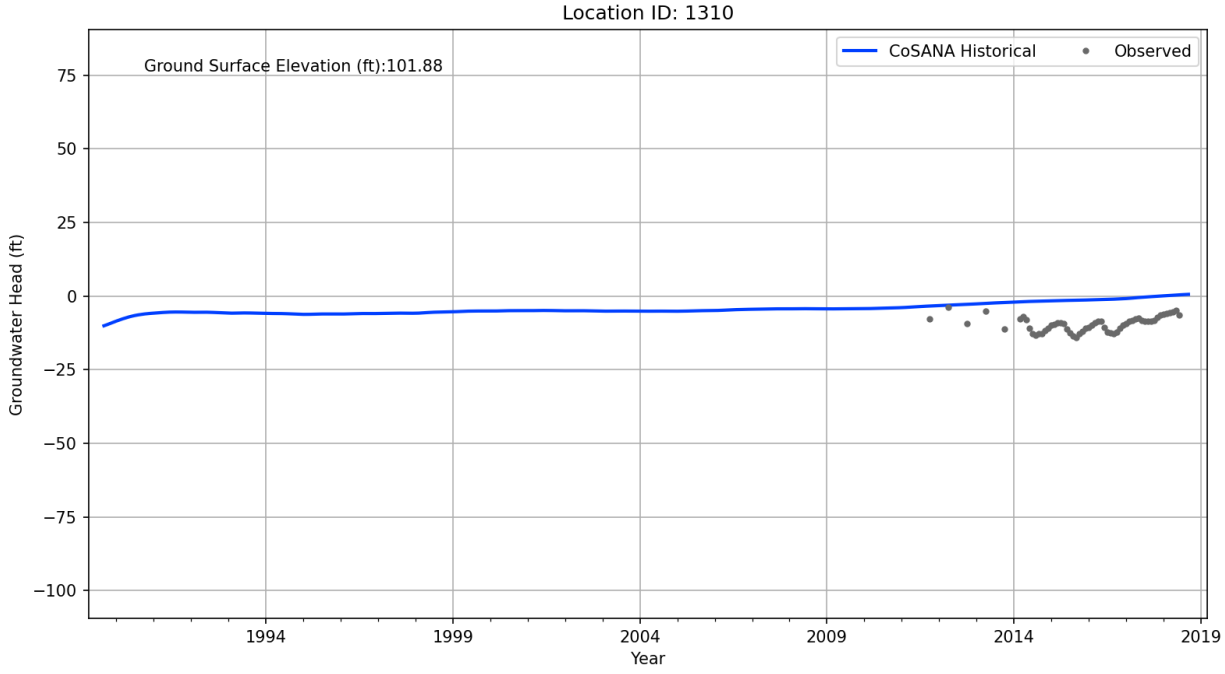

Location ID: 1305
Ground Surface Elevation (ft):103.06
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

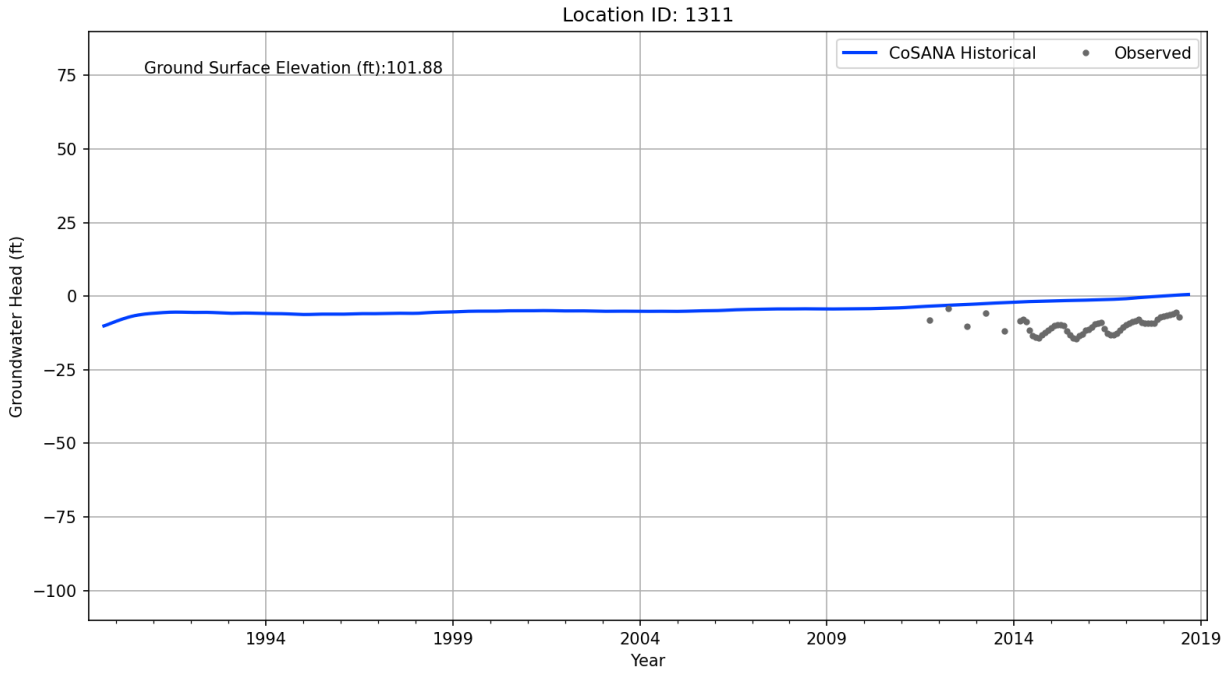

Location ID: 1306
Ground Surface Elevation (ft):87.49
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

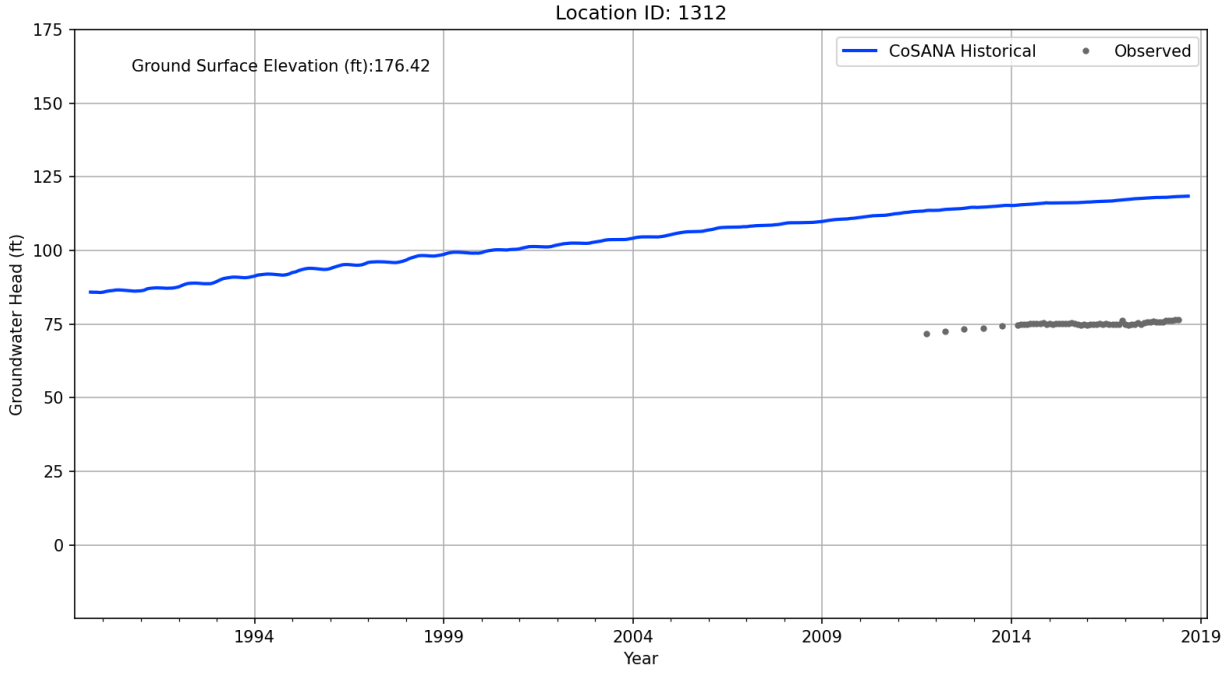

Location ID: 1307
Ground Surface Elevation (ft):87.97
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

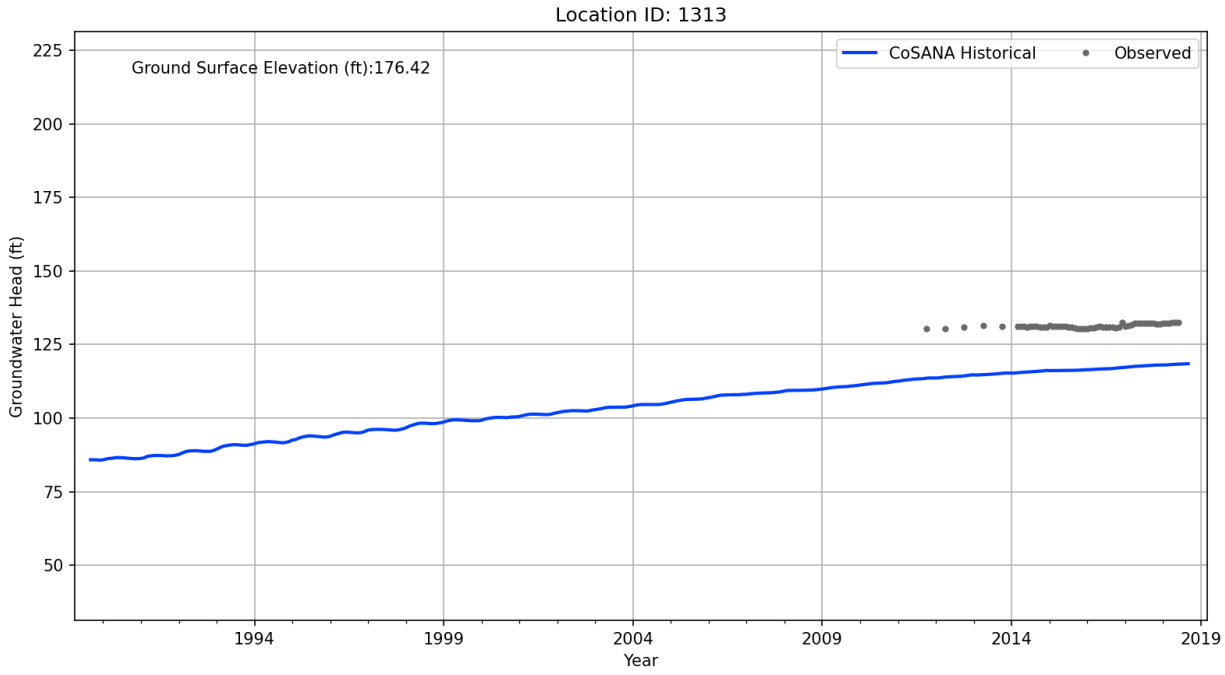

Location ID: 1308
Ground Surface Elevation (ft):87.97
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

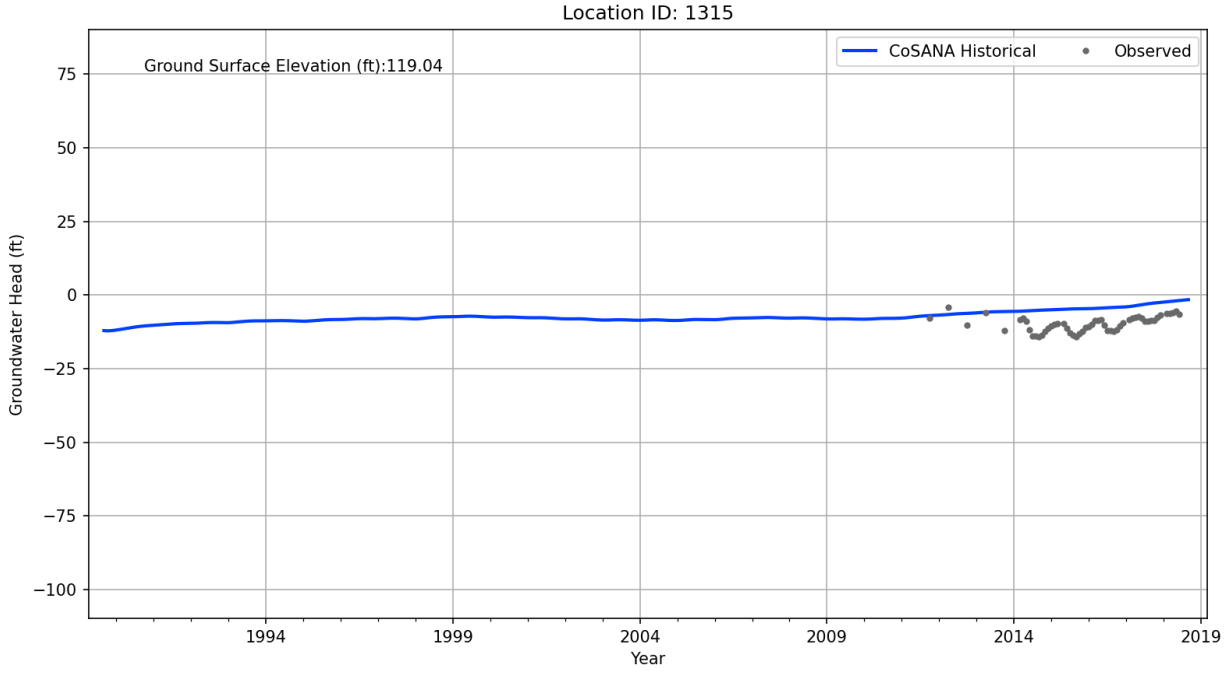

Location ID: 1309
Ground Surface Elevation (ft):101.88
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

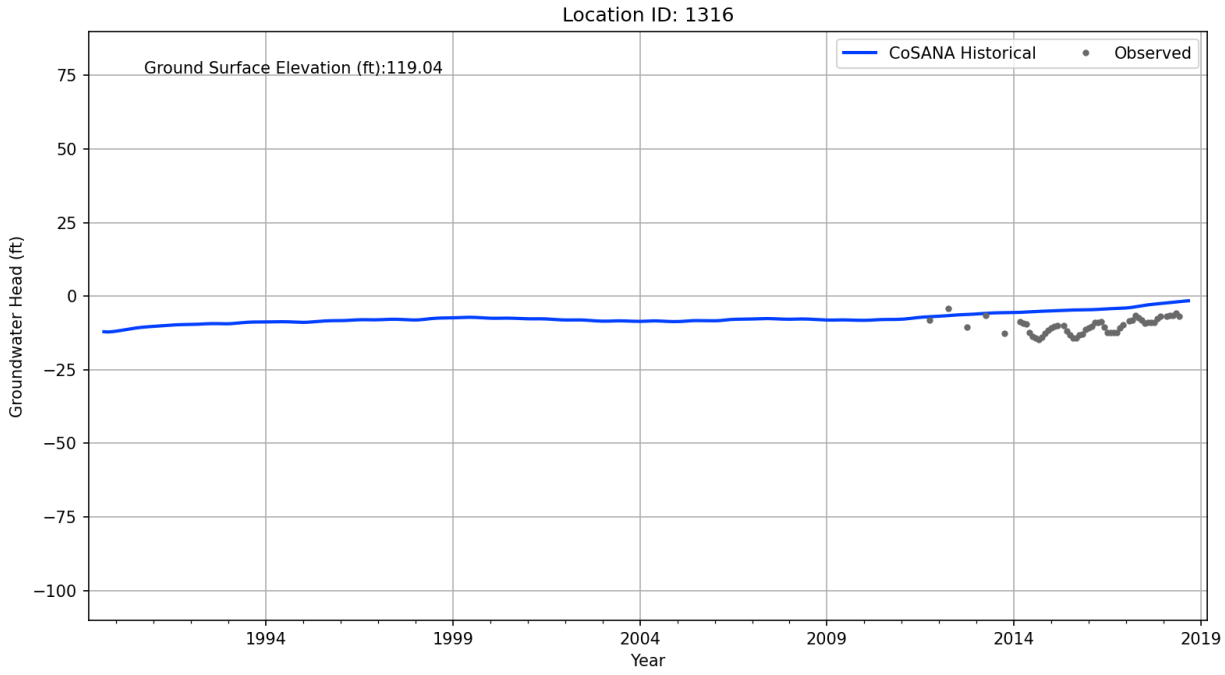

Location ID: 1310
Ground Surface Elevation (ft):101.88
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

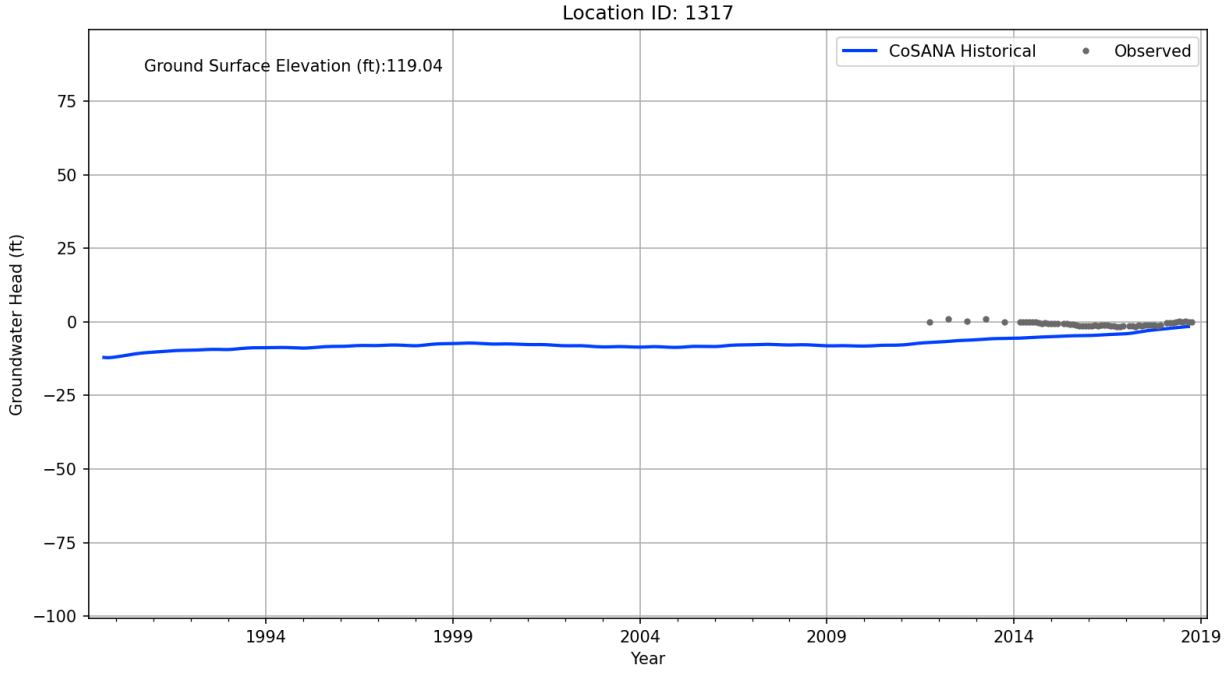

Location ID: 1311
Ground Surface Elevation (ft):101.88
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

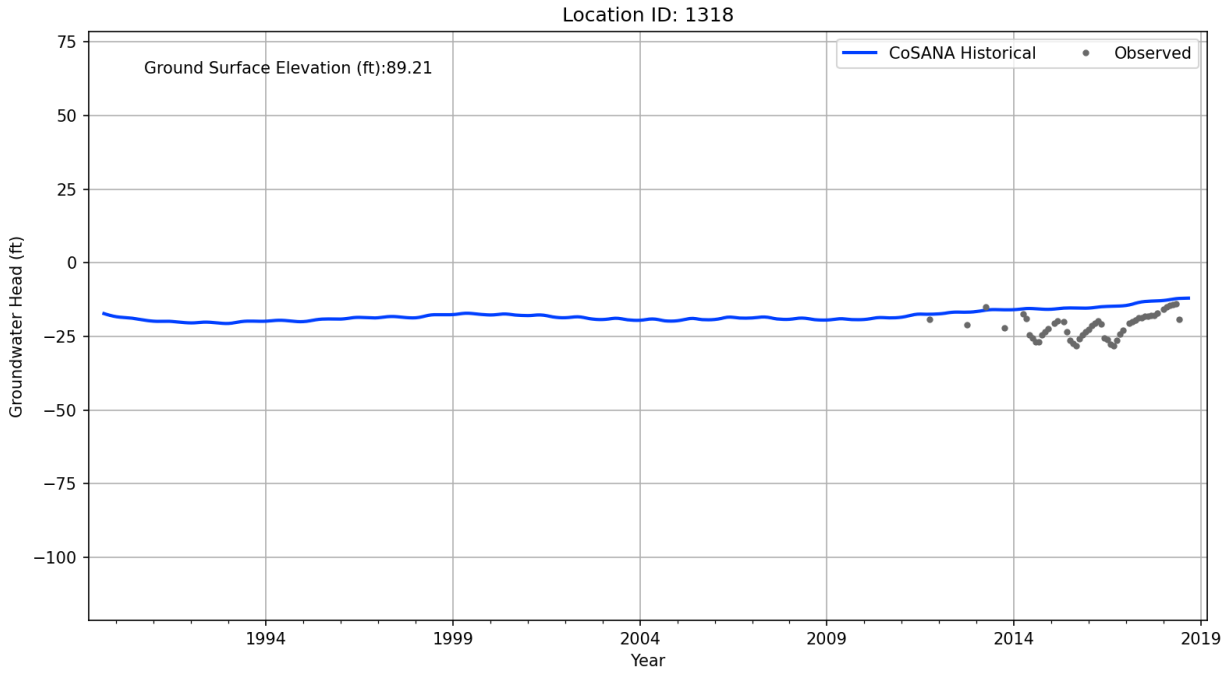

Location ID: 1312
Ground Surface Elevation (ft):176.42
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

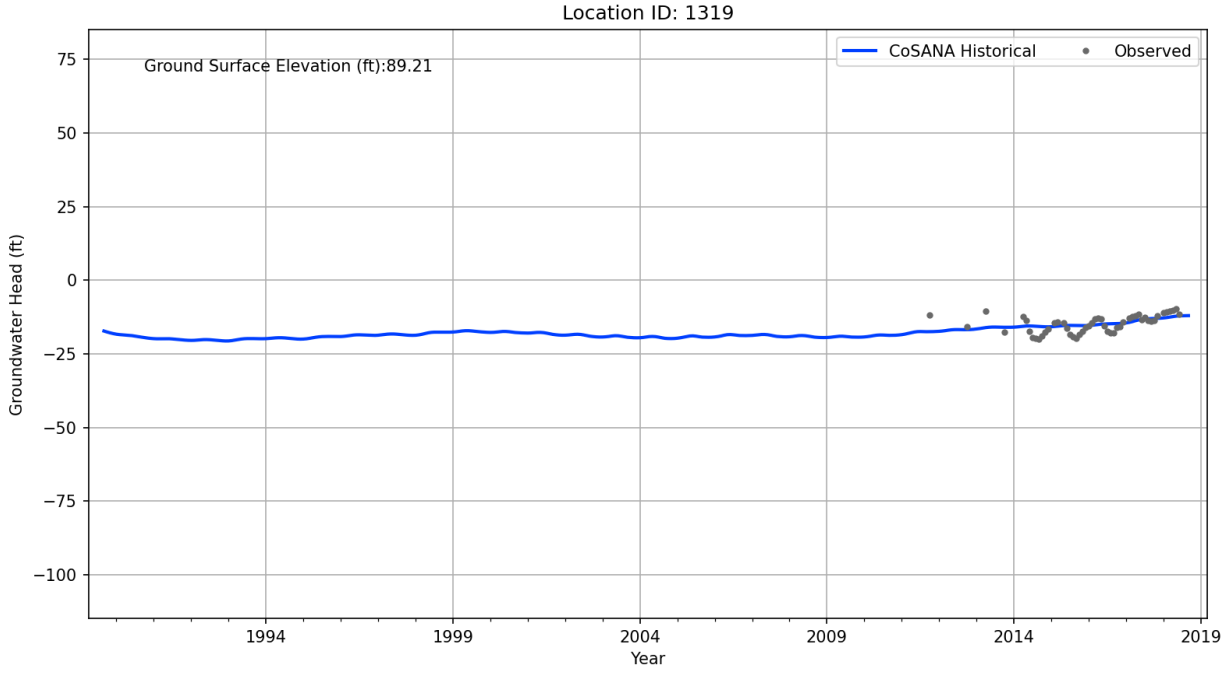

Location ID: 1313
Ground Surface Elevation (ft):176.42
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

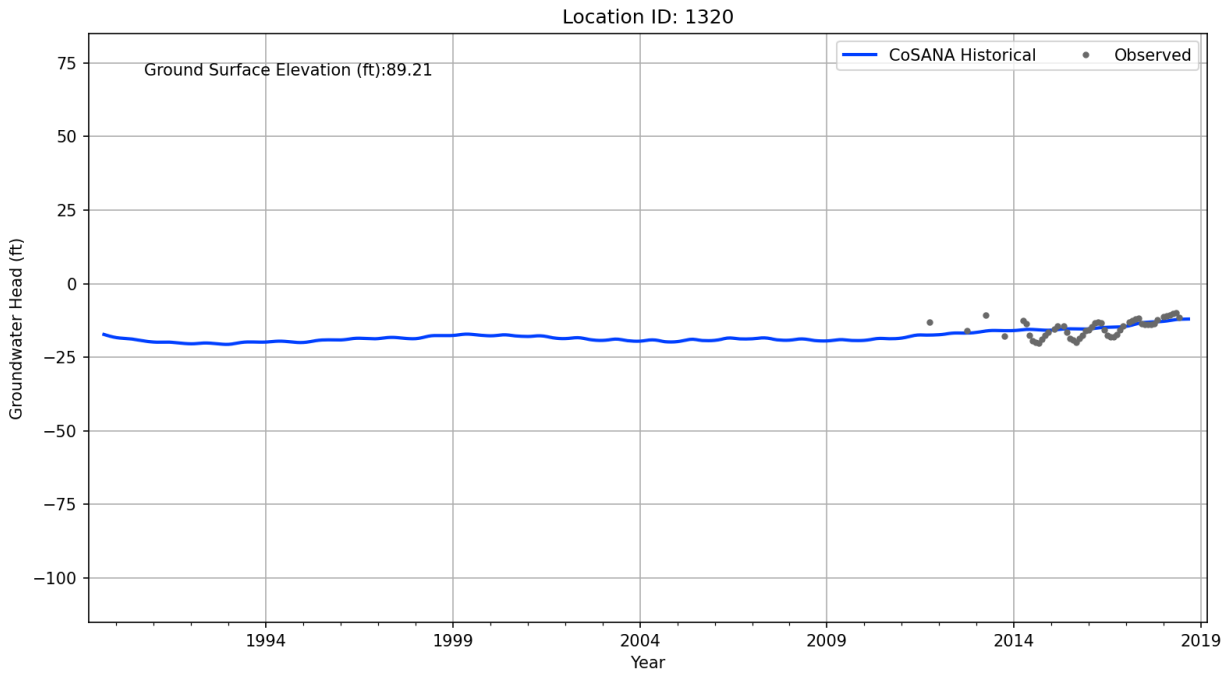

Location ID: 1315
Ground Surface Elevation (ft):119.04
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

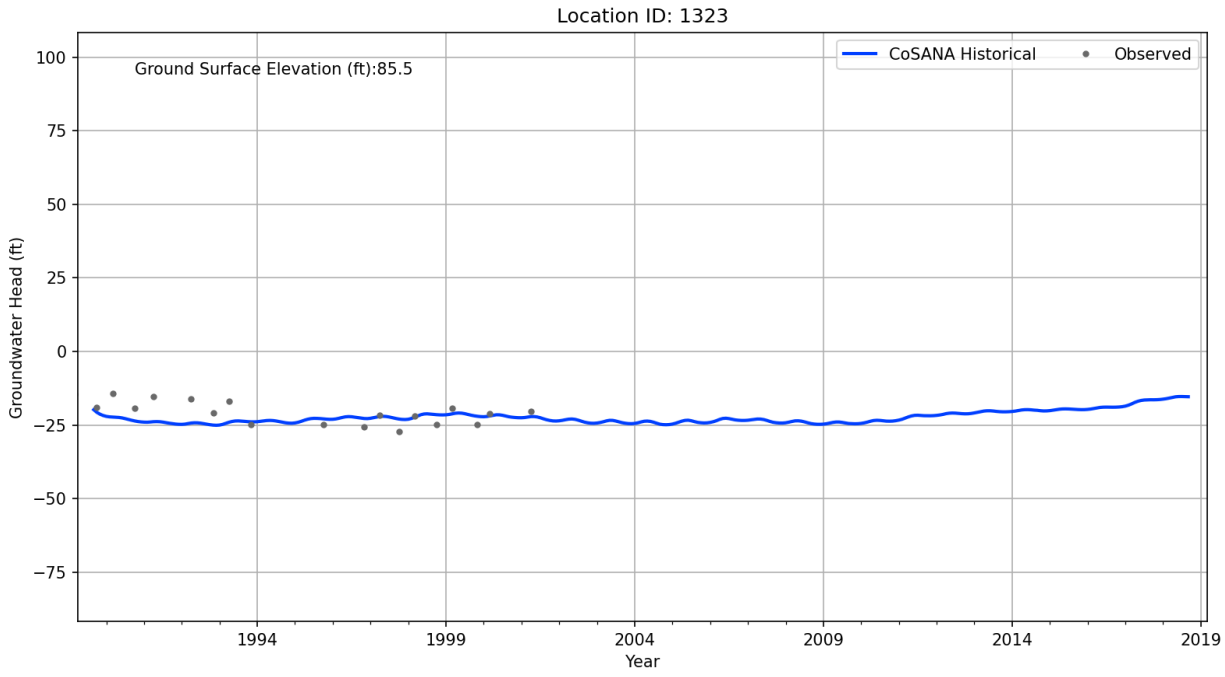

Location ID: 1316
Ground Surface Elevation (ft):119.04
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

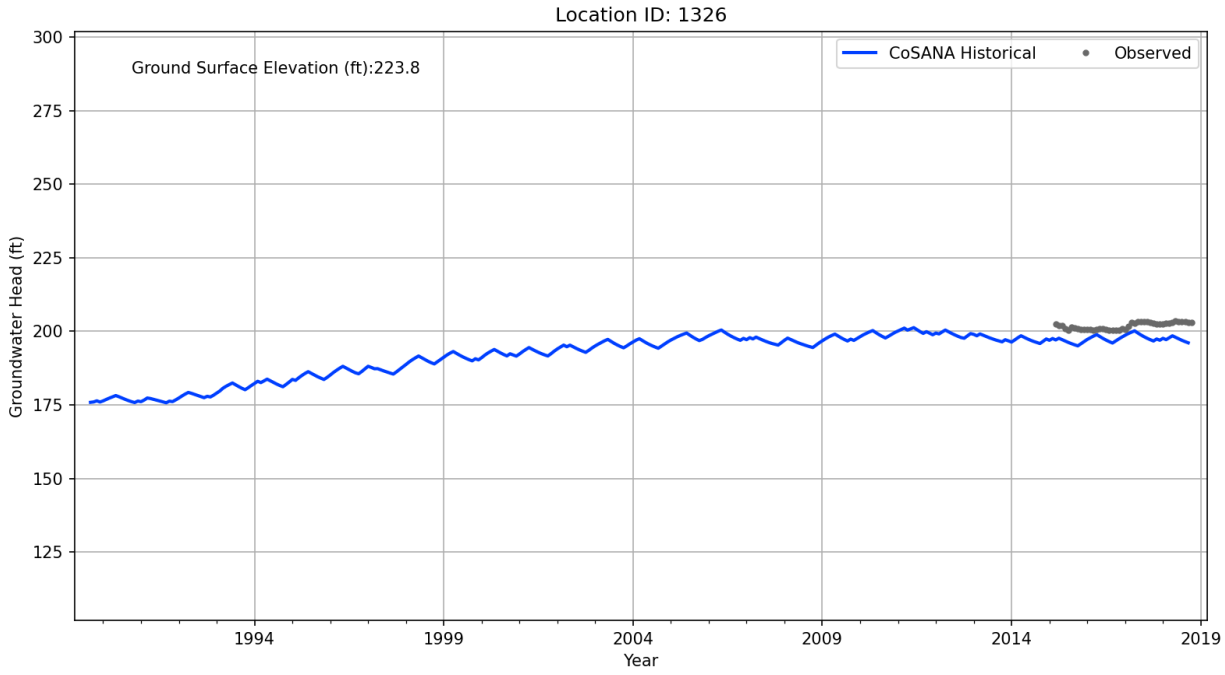

Location ID: 1317
Ground Surface Elevation (ft):119.04
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

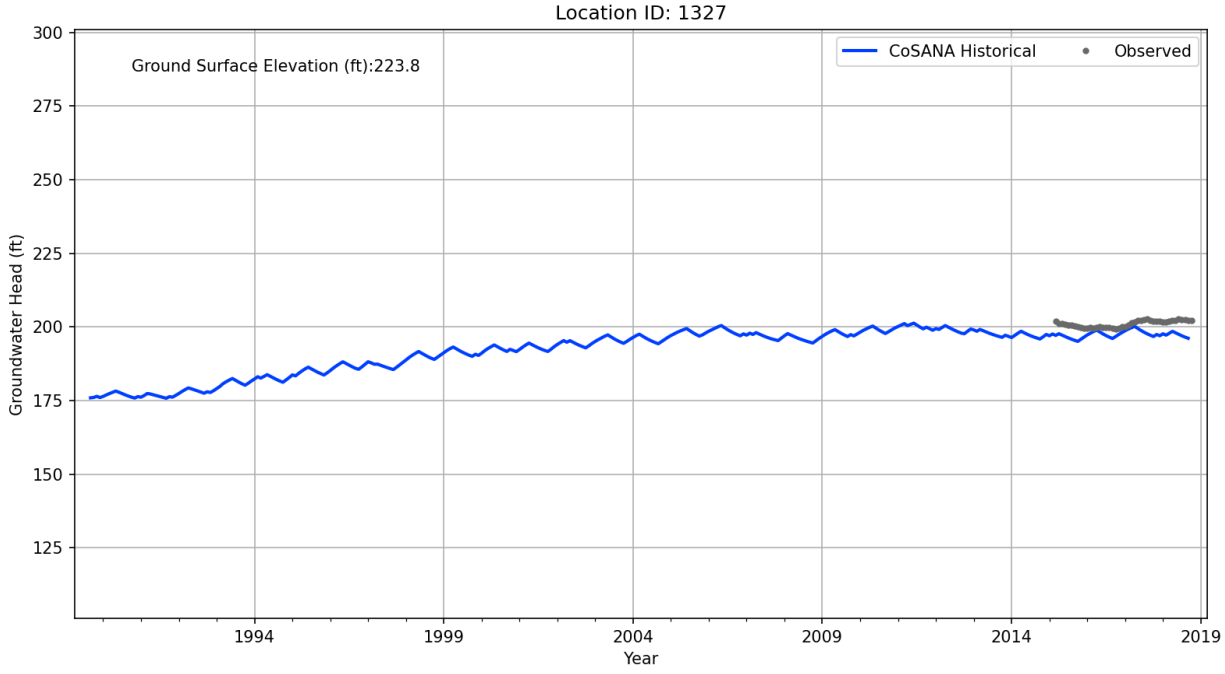

Location ID: 1318
Ground Surface Elevation (ft):89.21
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

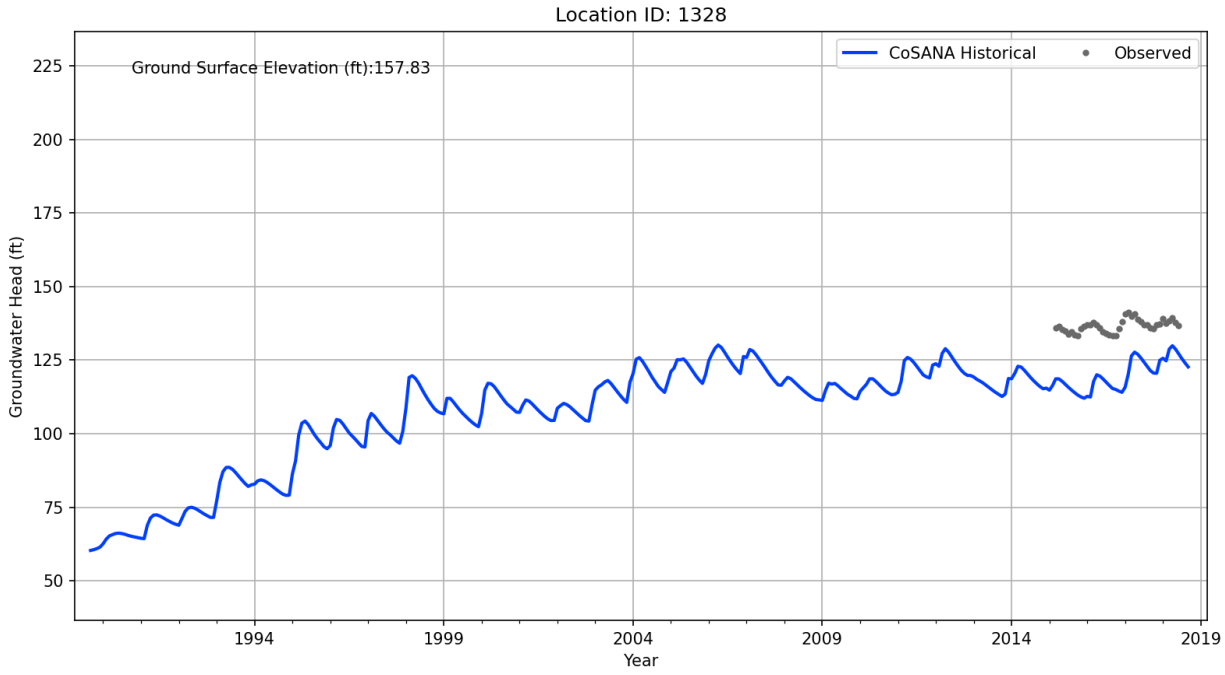

Location ID: 1319
Ground Surface Elevation (ft):89.21
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

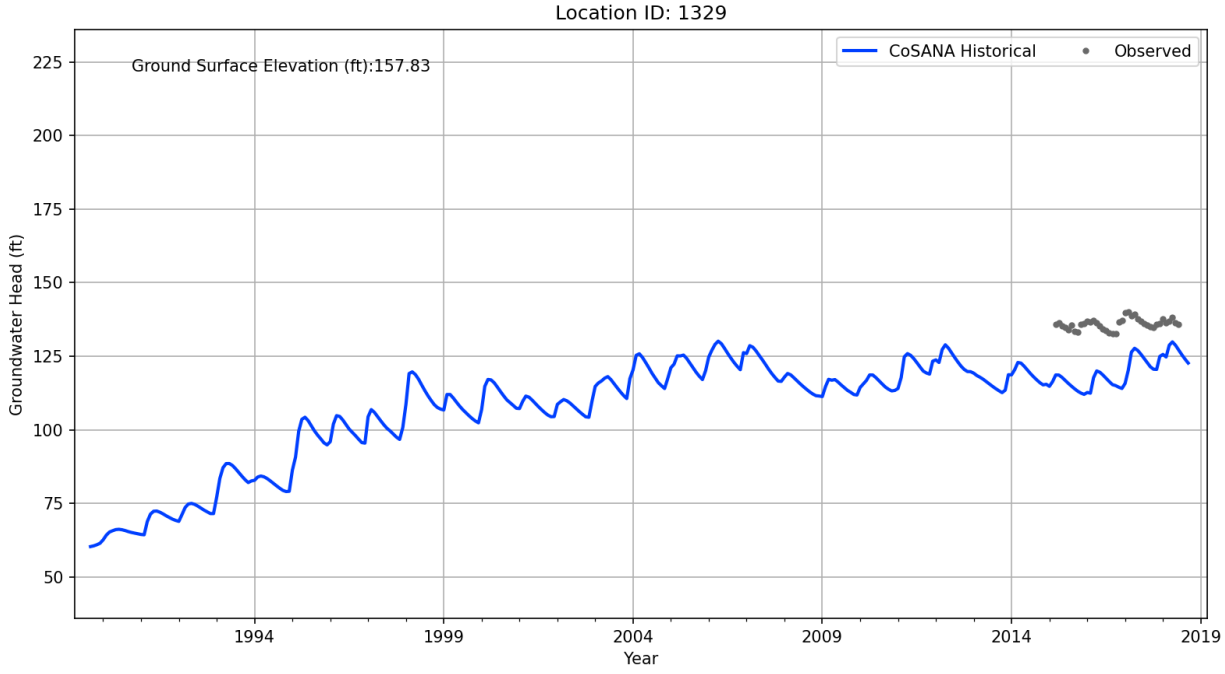

Location ID: 1320
Ground Surface Elevation (ft):89.21
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

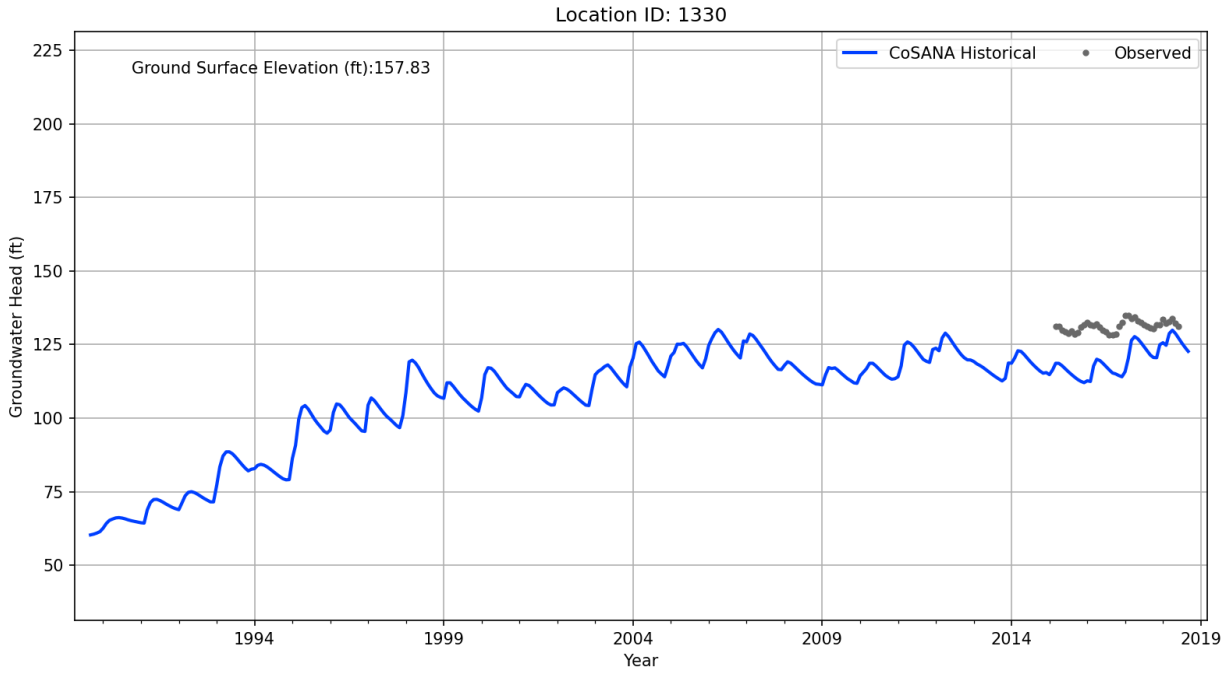

Location ID: 1323
Ground Surface Elevation (ft):85.5
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

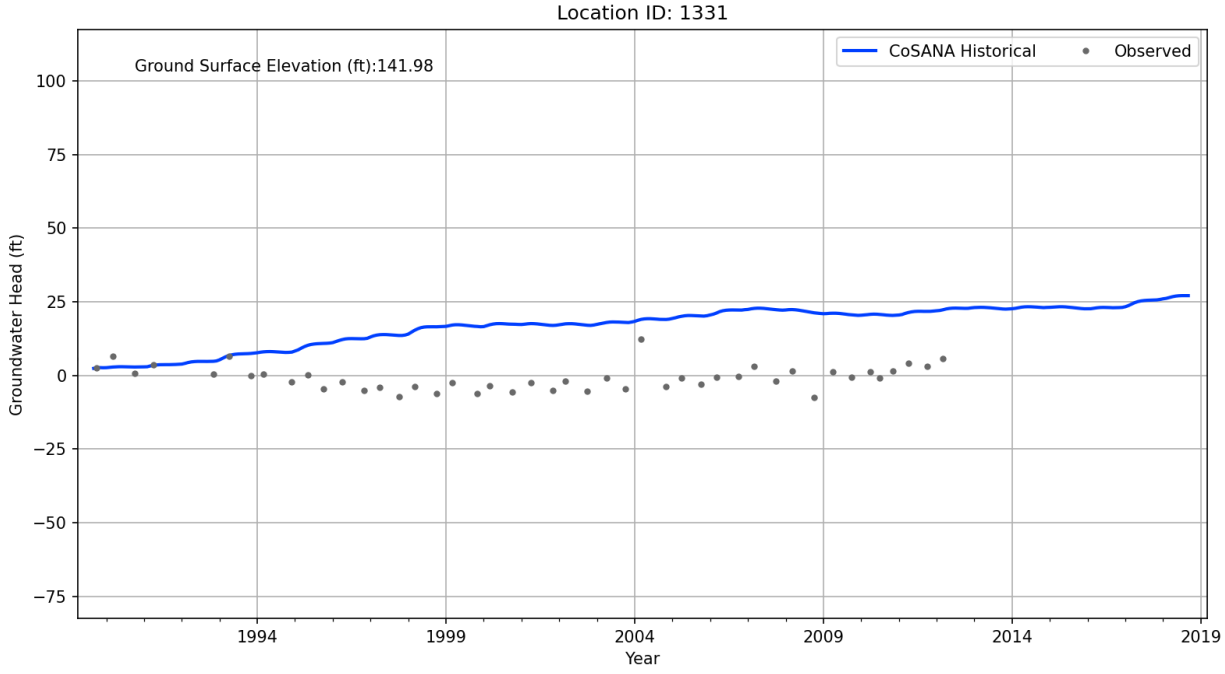

Location ID: 1326
Ground Surface Elevation (ft):223.8
CoSANA Historical
Observed
Groundwater Head (ft)
300
275
250
225
200
175
150
125
1994
1999
2004
2009
2014
2019
Year

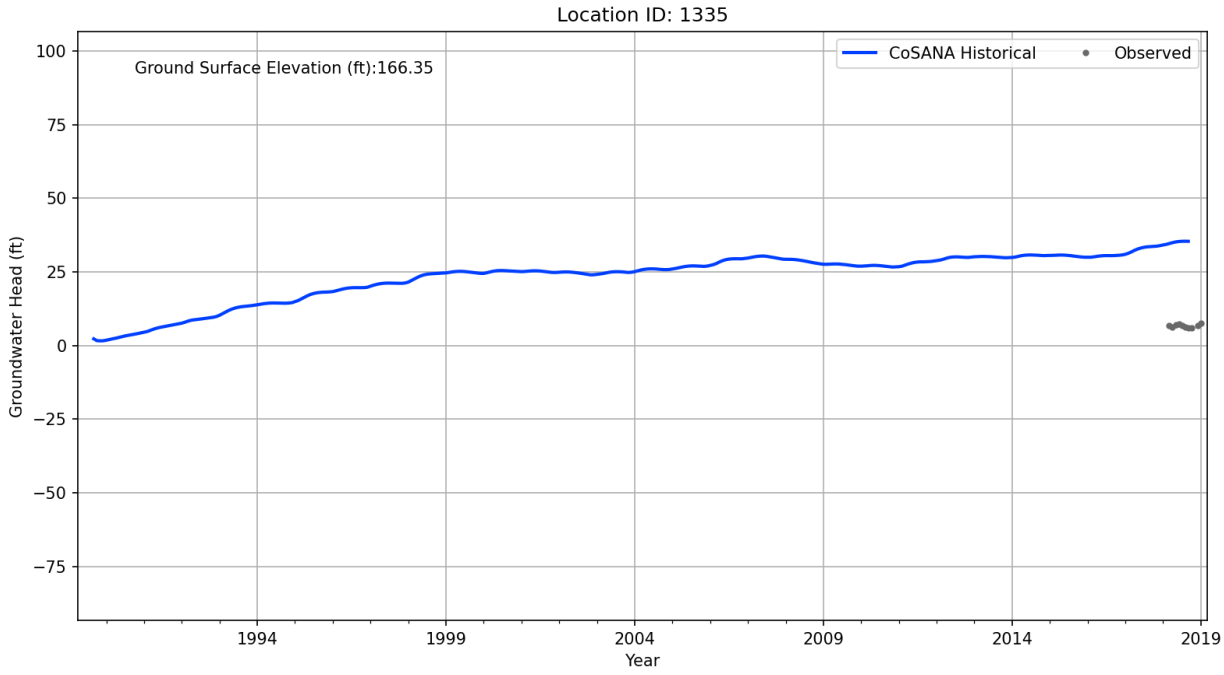

Location ID: 1327
Ground Surface Elevation (ft):223.8
CoSANA Historical
Observed
Groundwater Head (ft)
300
275
250
225
200
175
150
125
1994
1999
2004
2009
2014
2019
Year

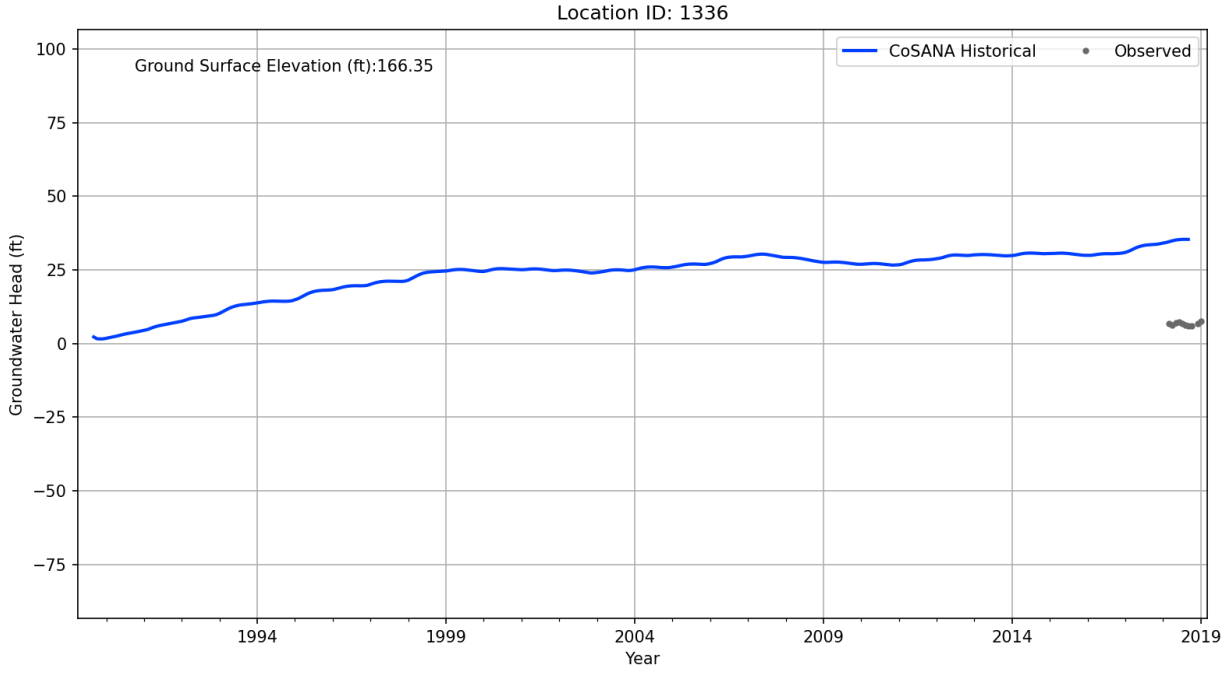

Location ID: 1328
Ground Surface Elevation (ft):157.83
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

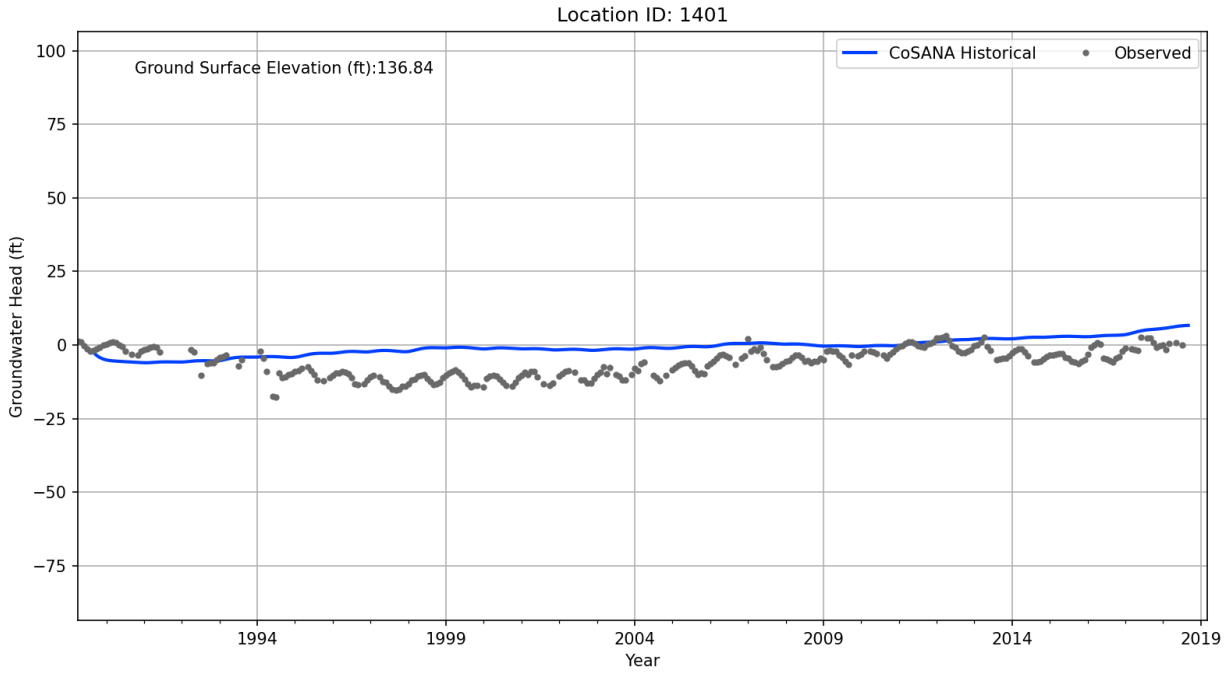

Location ID: 1329
Ground Surface Elevation (ft):157.83
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

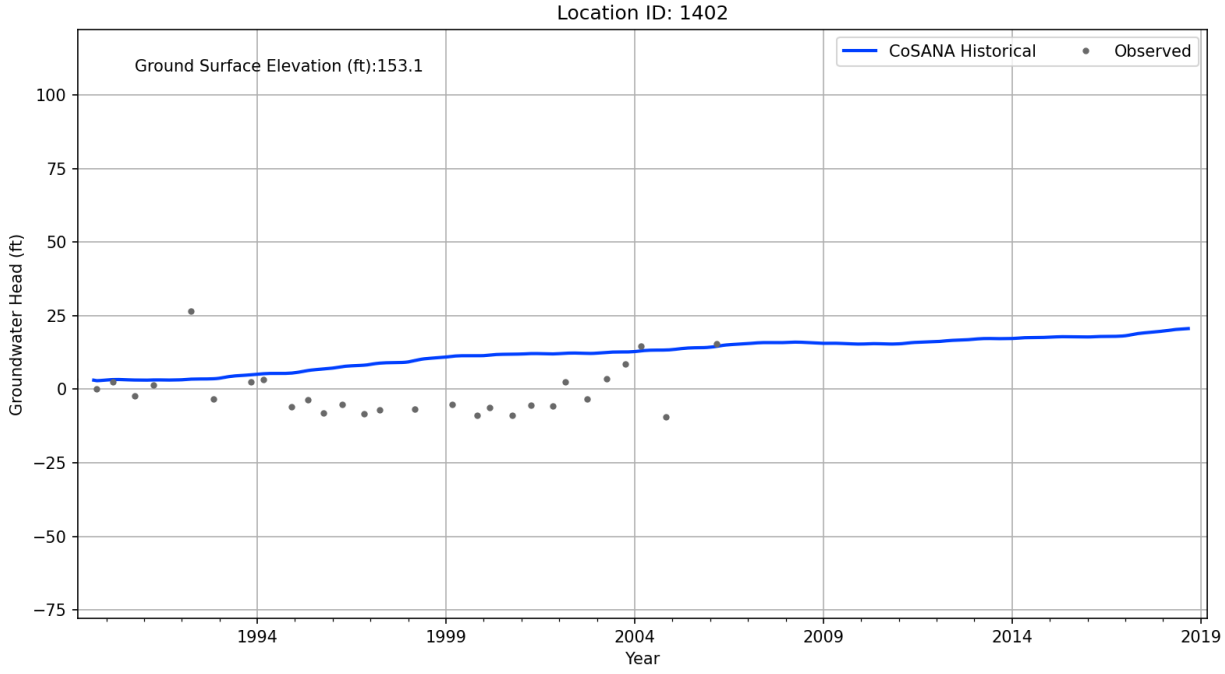

Location ID: 1330
Ground Surface Elevation (ft):157.83
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

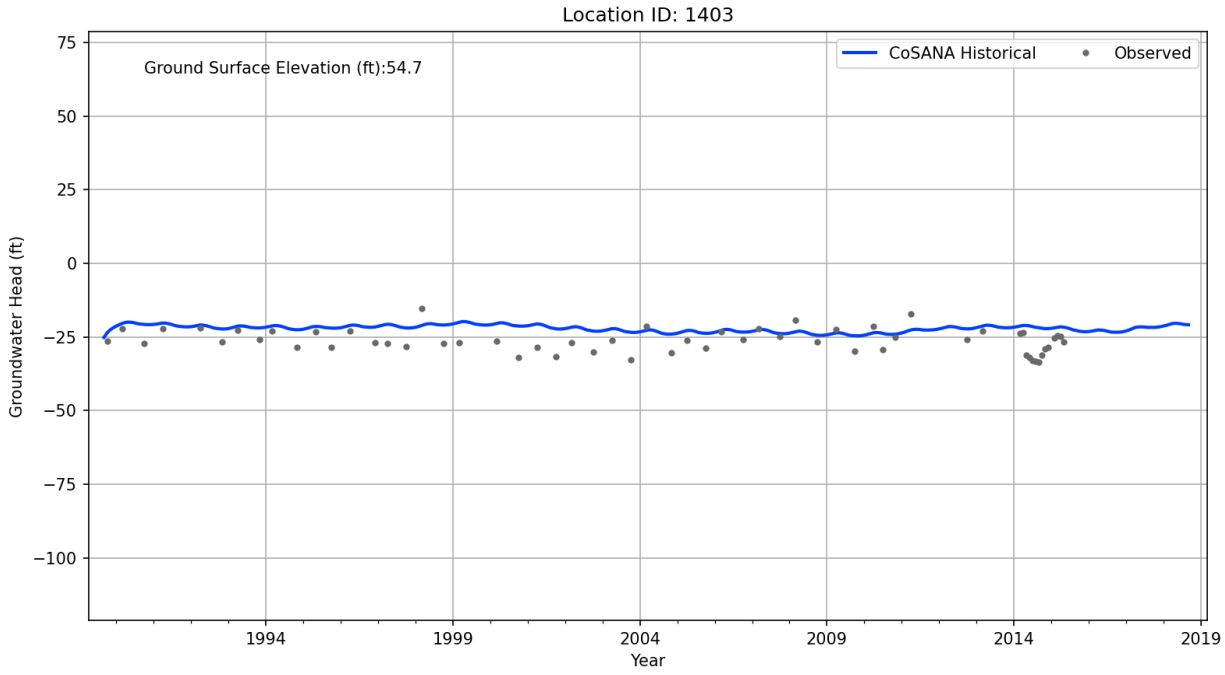

Location ID: 1331
Ground Surface Elevation (ft):141.98
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

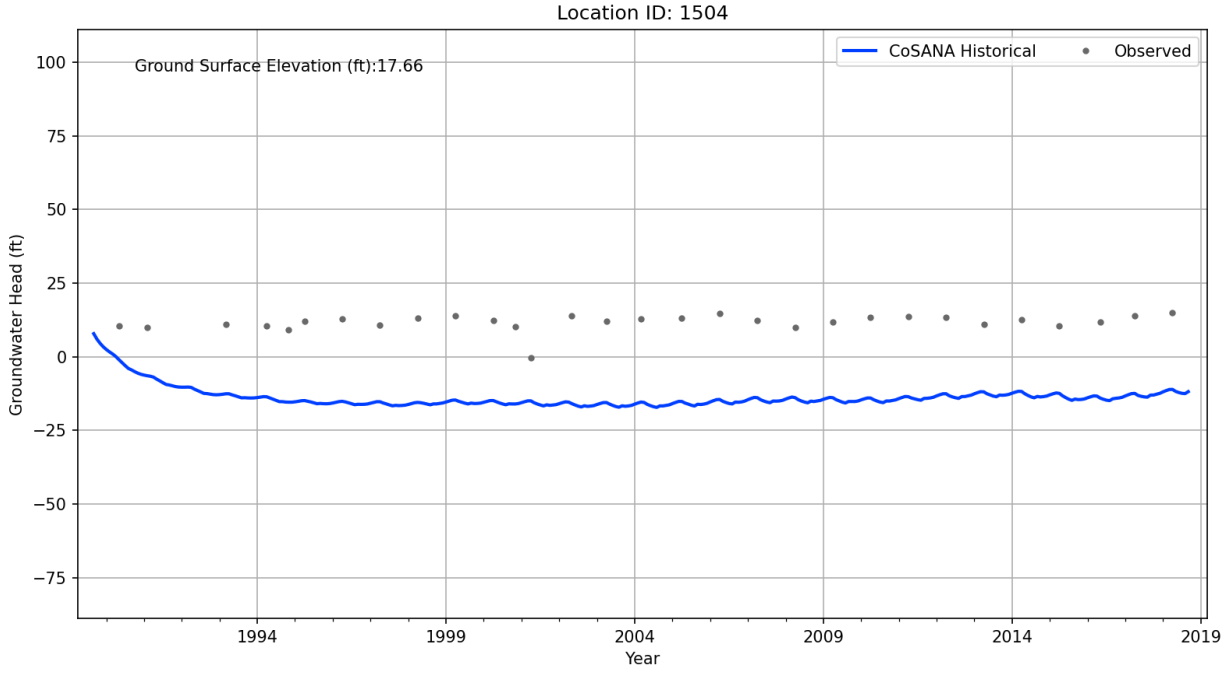

Location ID: 1335
Ground Surface Elevation (ft):166.35
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

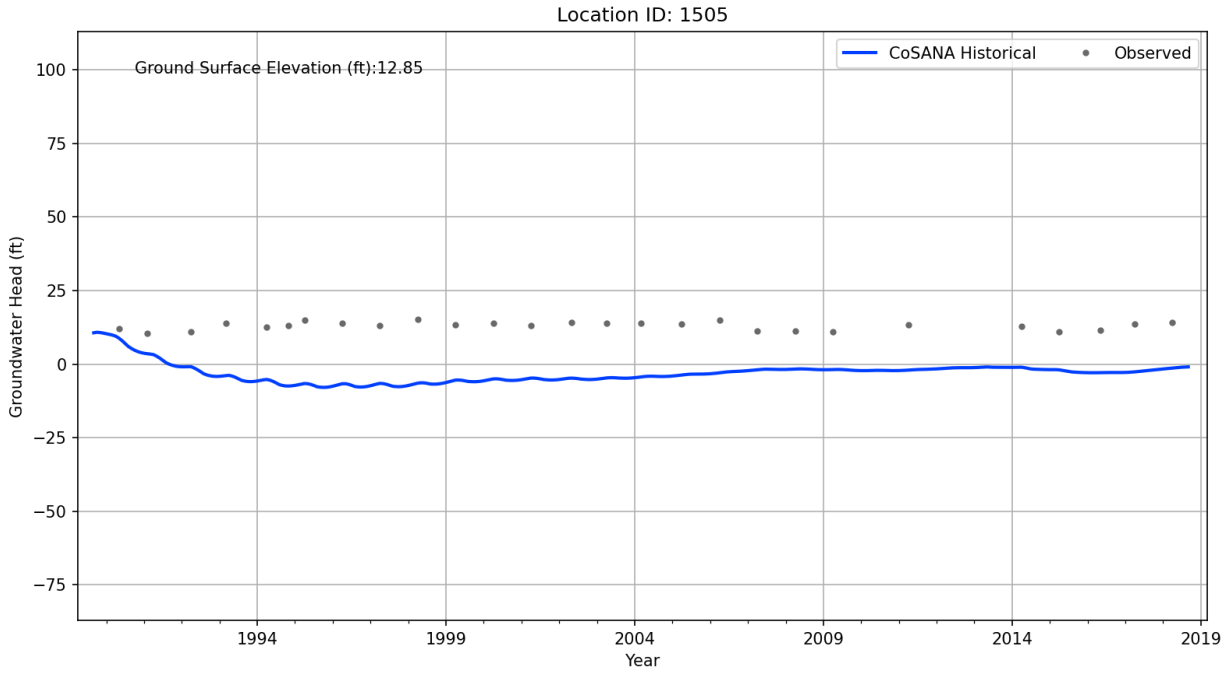

Location ID: 1336
Ground Surface Elevation (ft):166.35
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

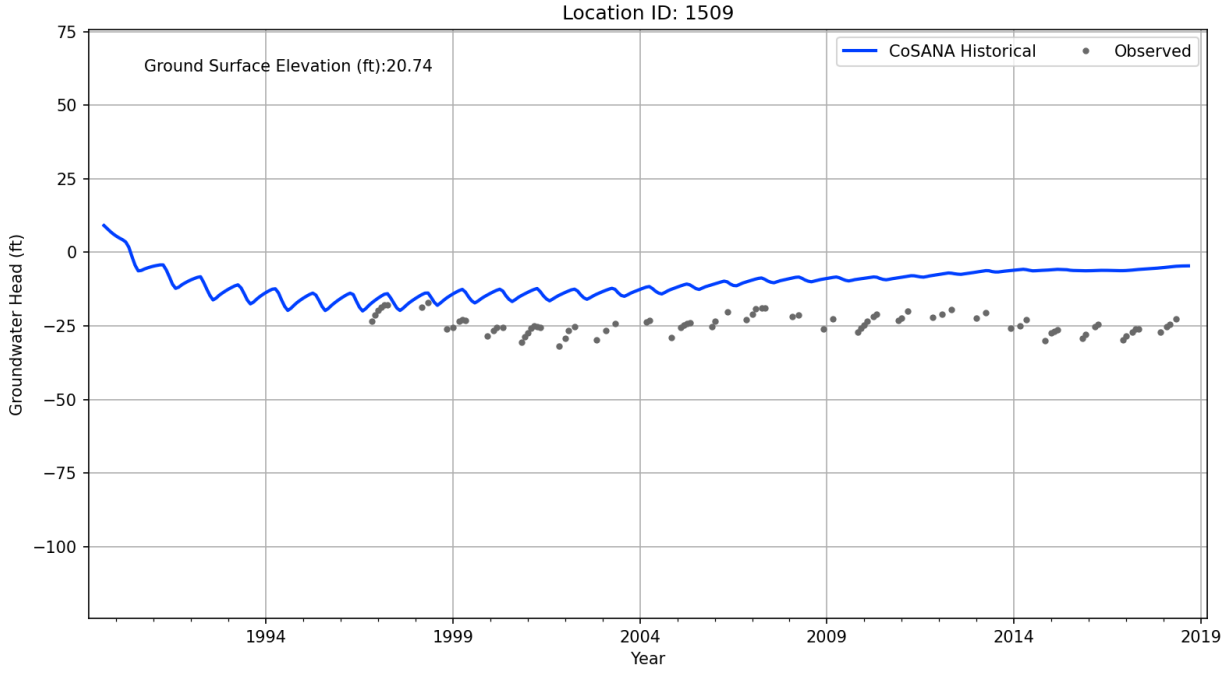

Location ID: 1401
Ground Surface Elevation (ft):136.84
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

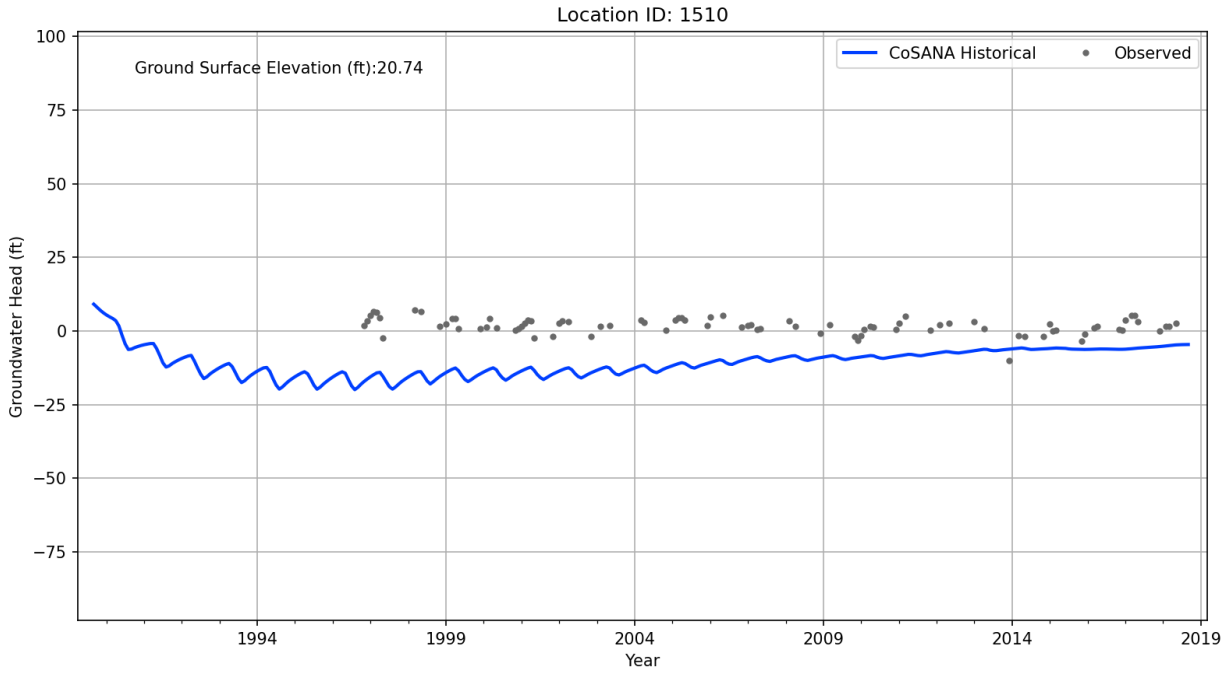

Location ID: 1402
Ground Surface Elevation (ft):153.1
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

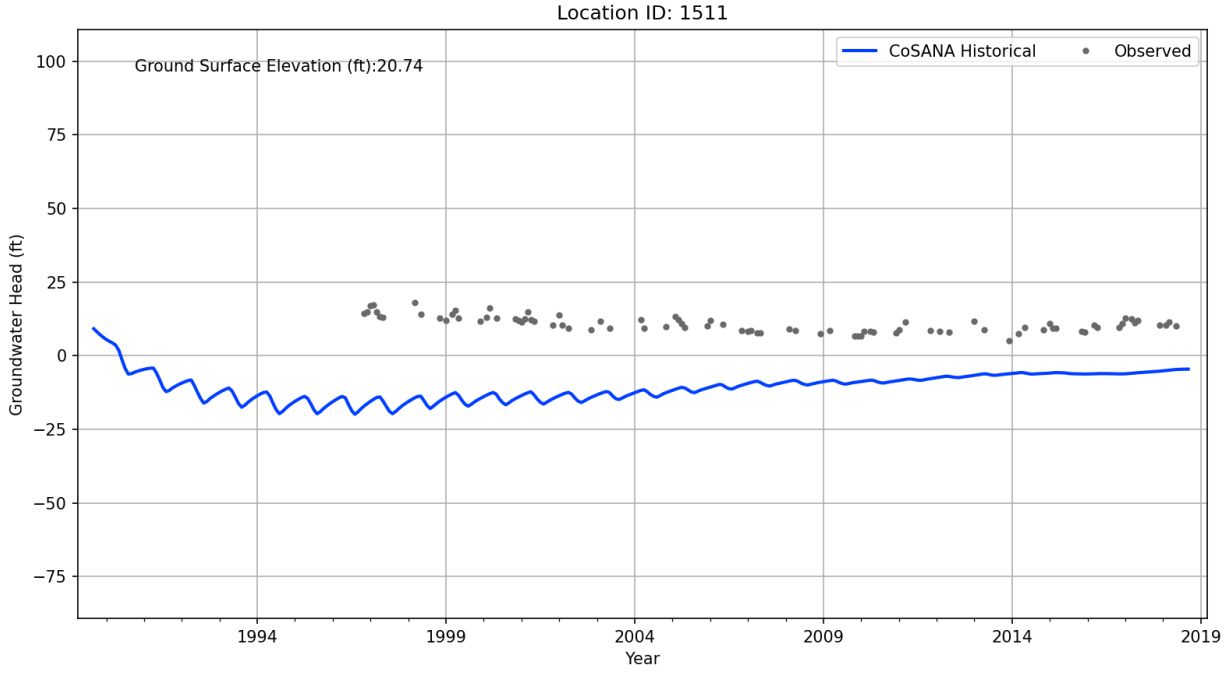

Location ID: 1403
Ground Surface Elevation (ft):54.7
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

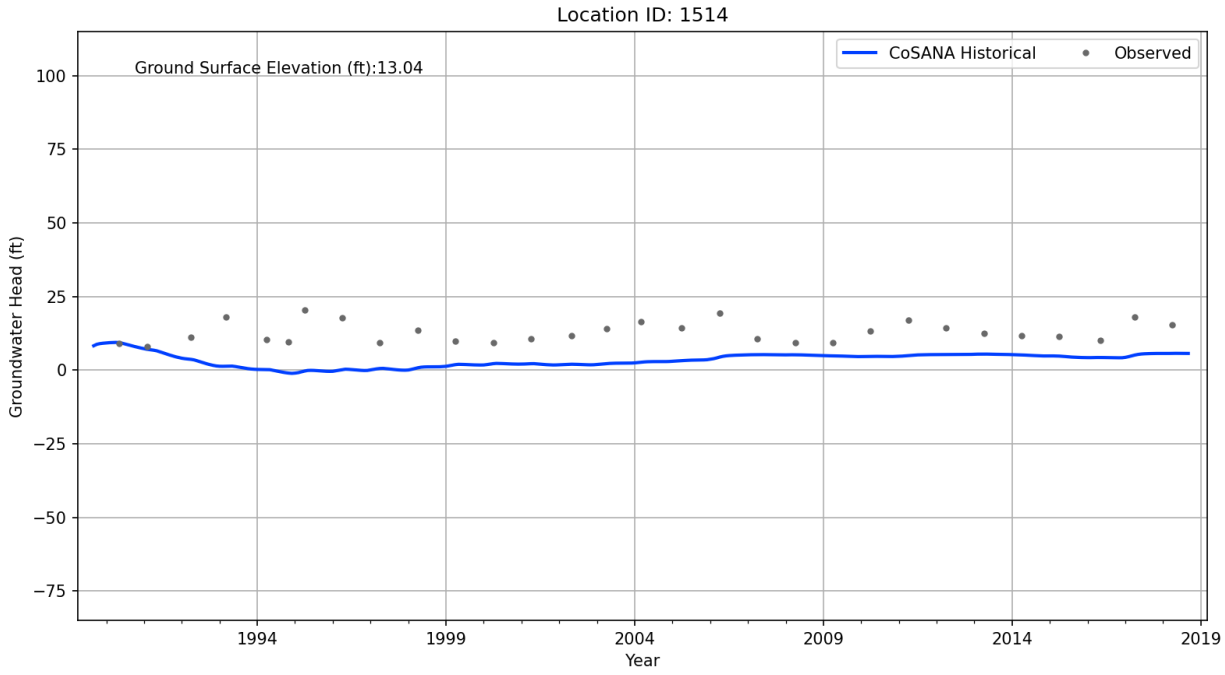

Location ID: 1504
Ground Surface Elevation (ft):17.66
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

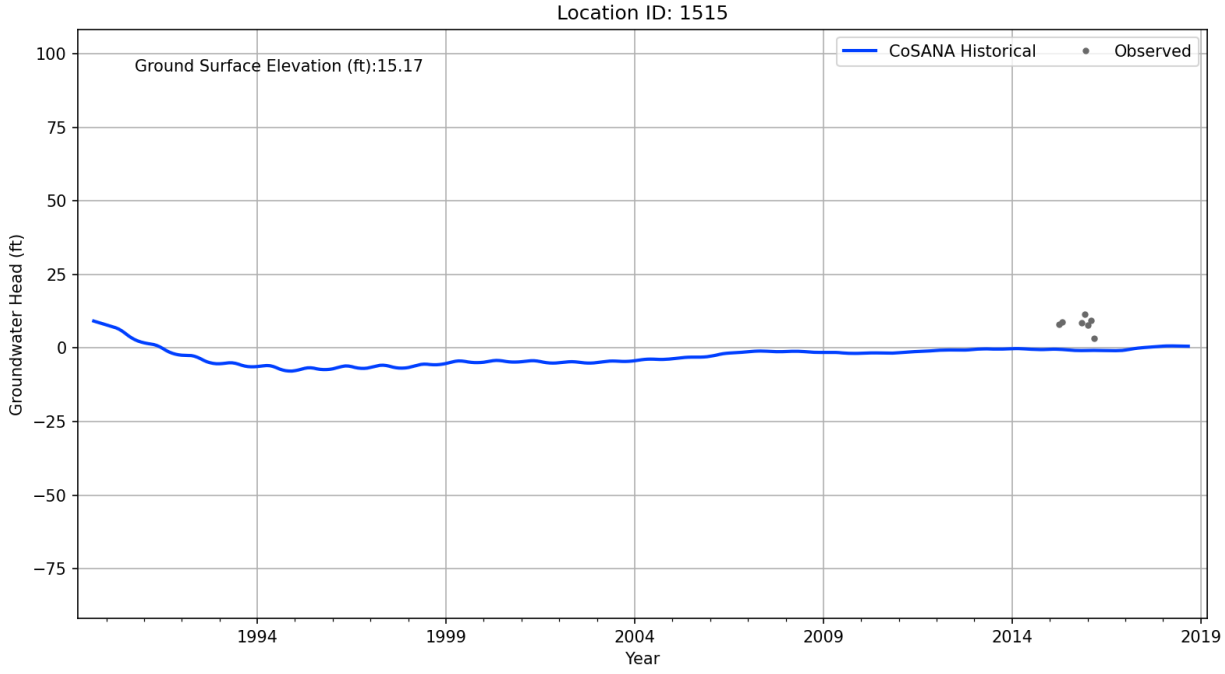

Location ID: 1505
Ground Surface Elevation (ft):12.85
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

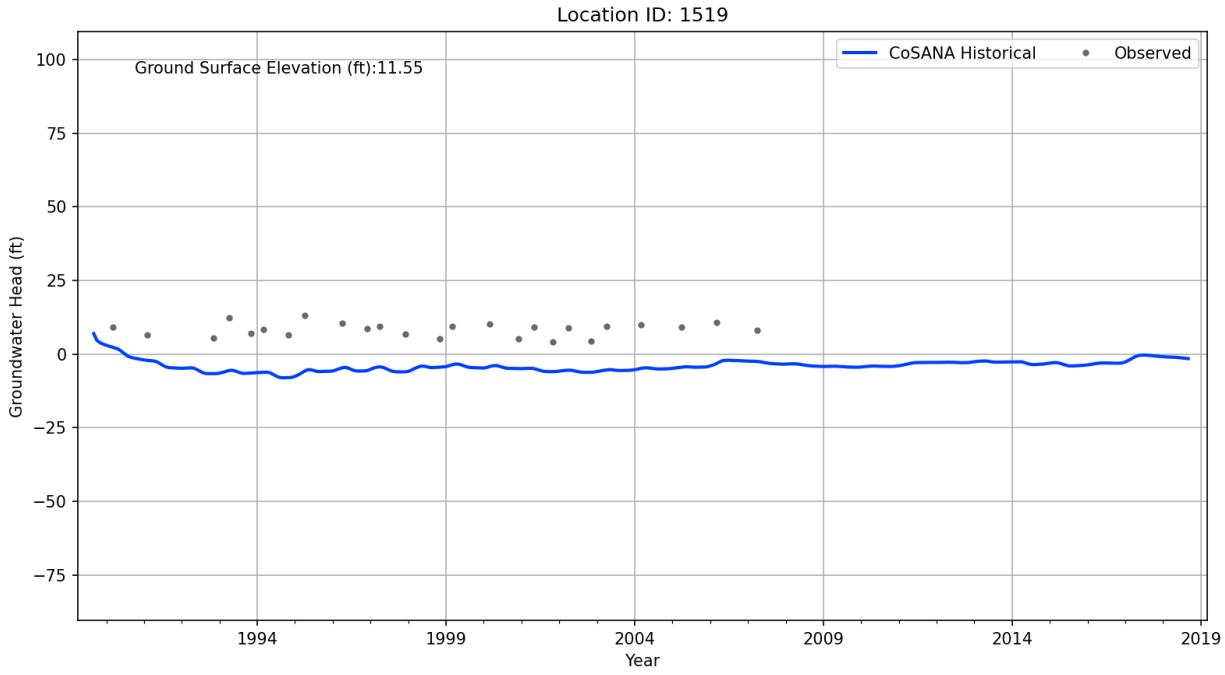

Location ID: 1509
Ground Surface Elevation (ft):20.74
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

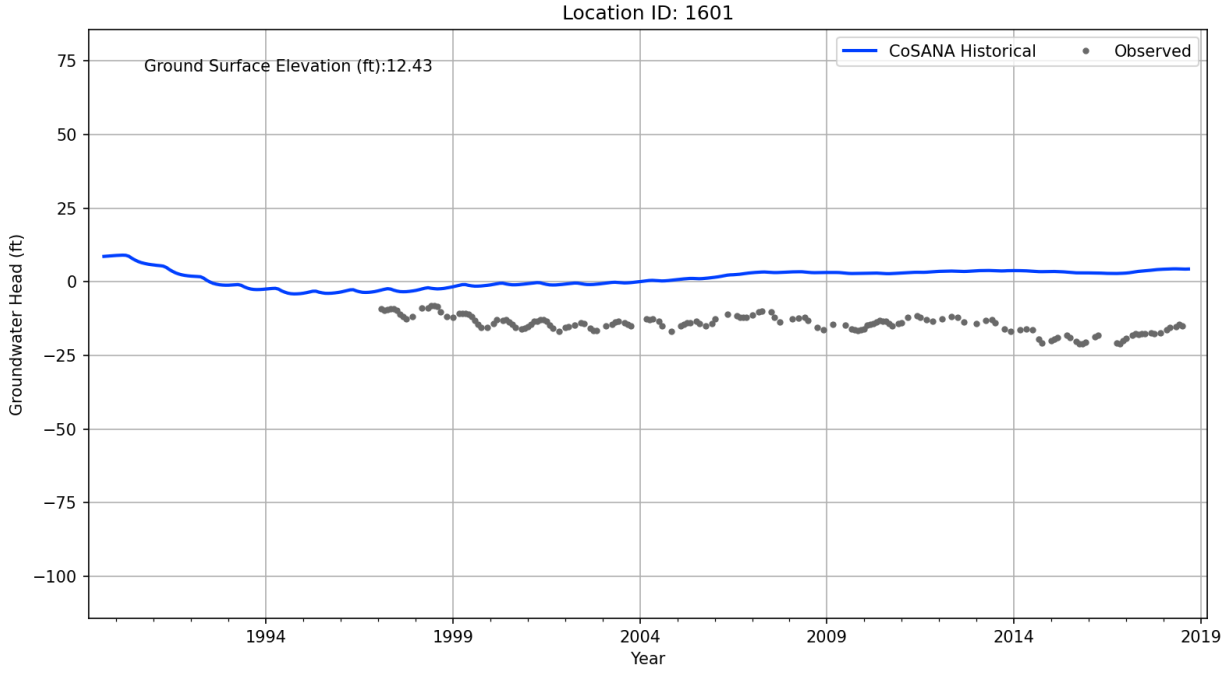

Location ID: 1510
Ground Surface Elevation (ft):20.74
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

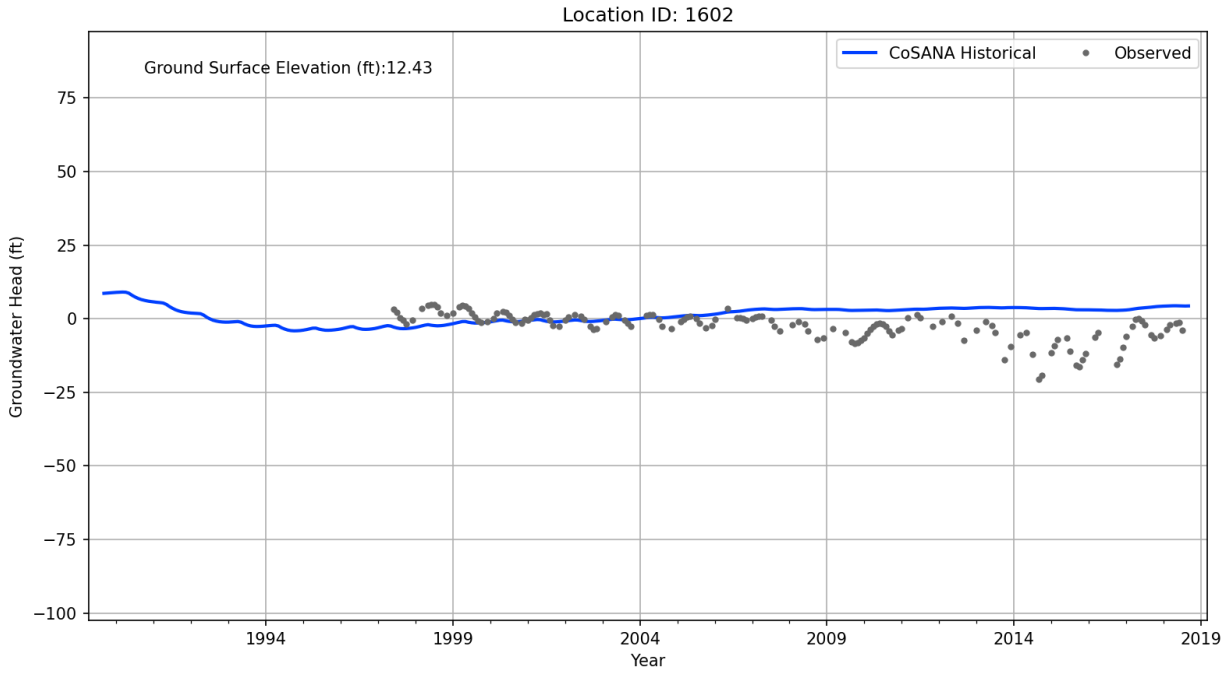

Location ID: 1511
Ground Surface Elevation (ft):20.74
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

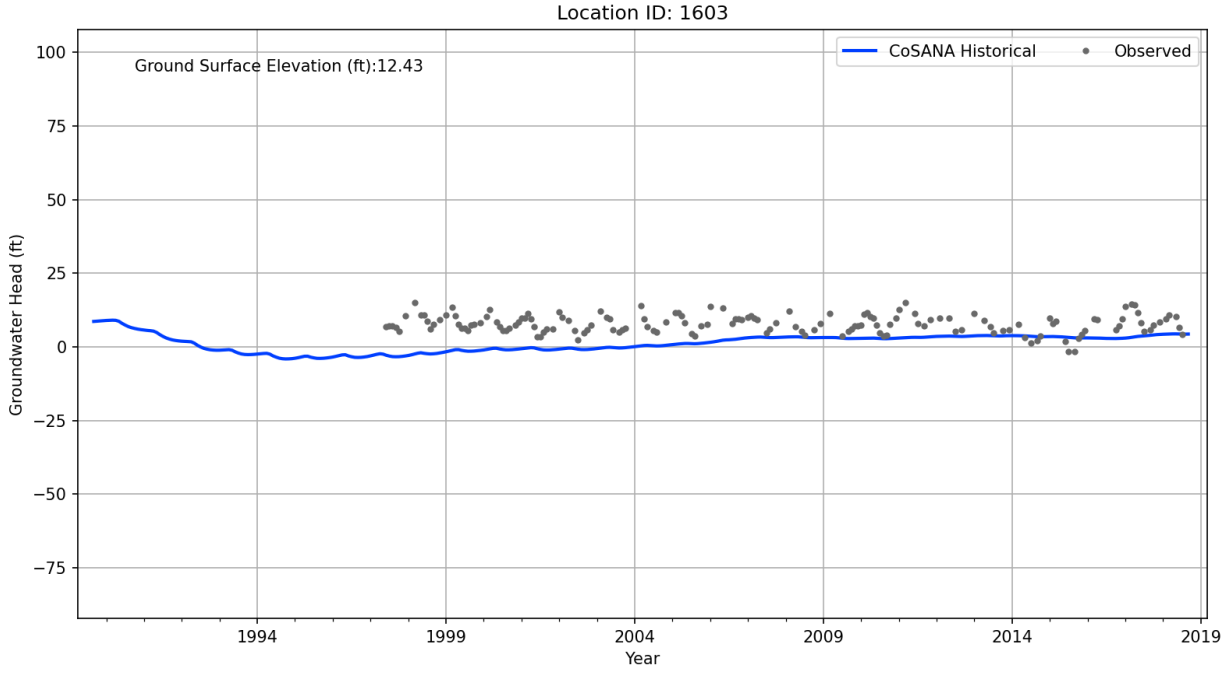

Location ID: 1514
Ground Surface Elevation (ft):13.04
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

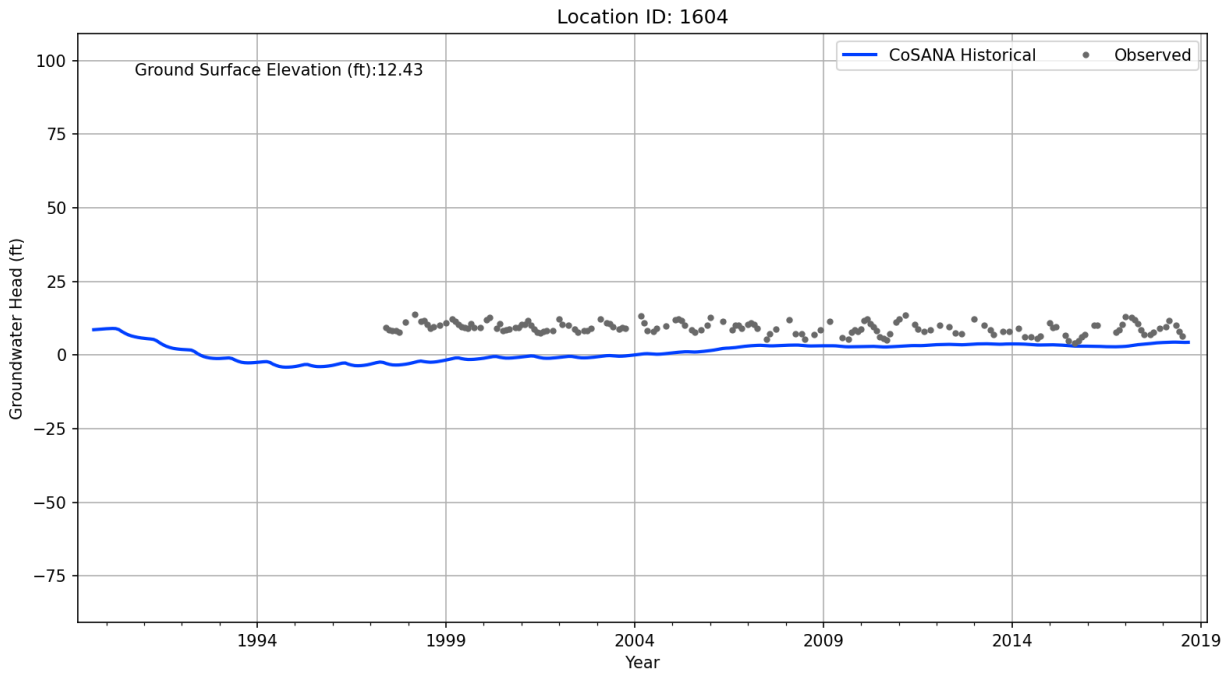

Location ID: 1515
Ground Surface Elevation (ft):15.17
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

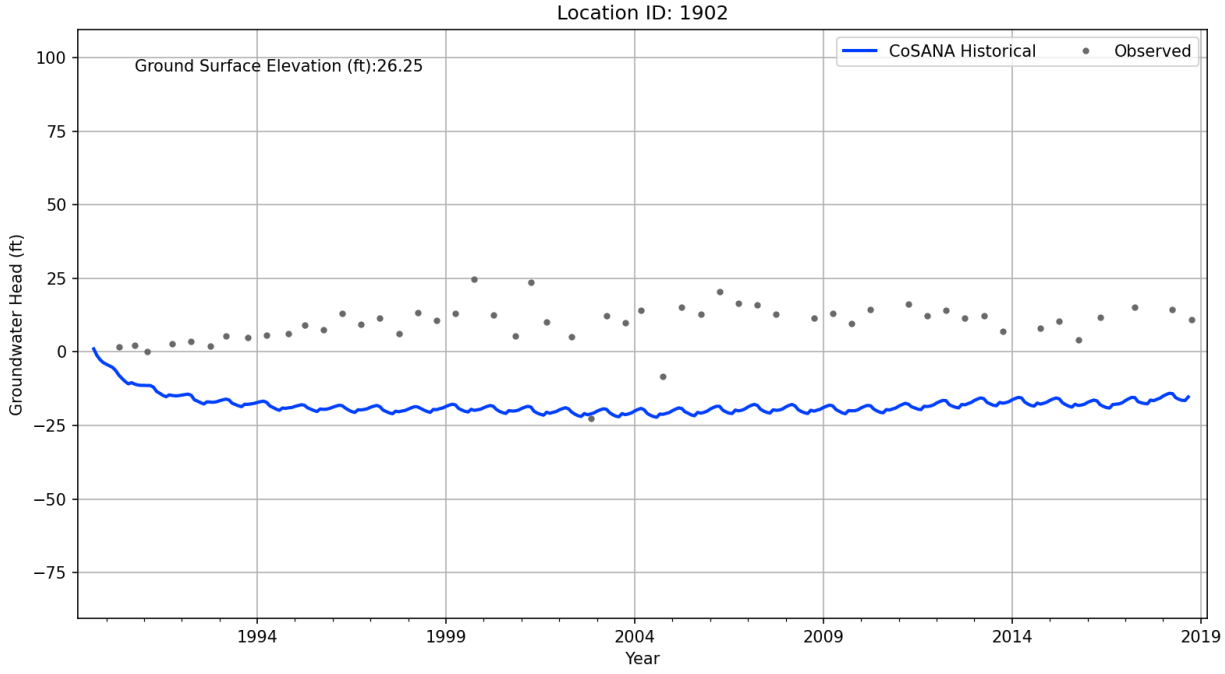

Location ID: 1519
Ground Surface Elevation (ft):11.55
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

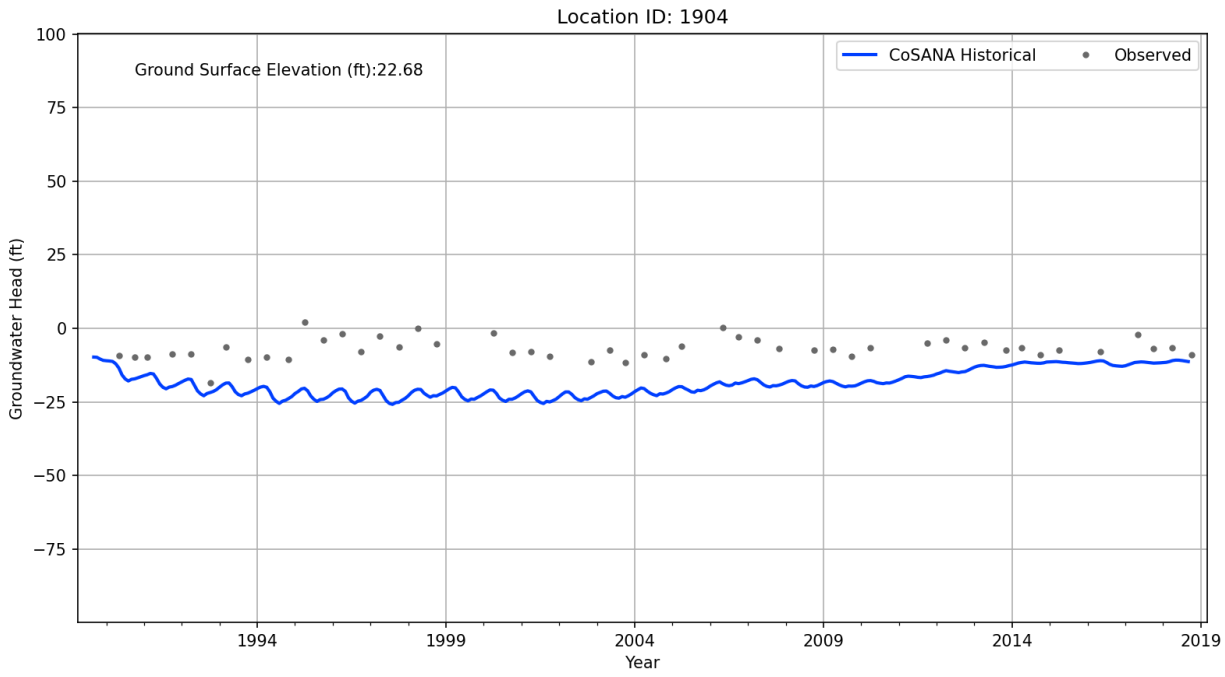

Location ID: 1601
Ground Surface Elevation (ft):12.43
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

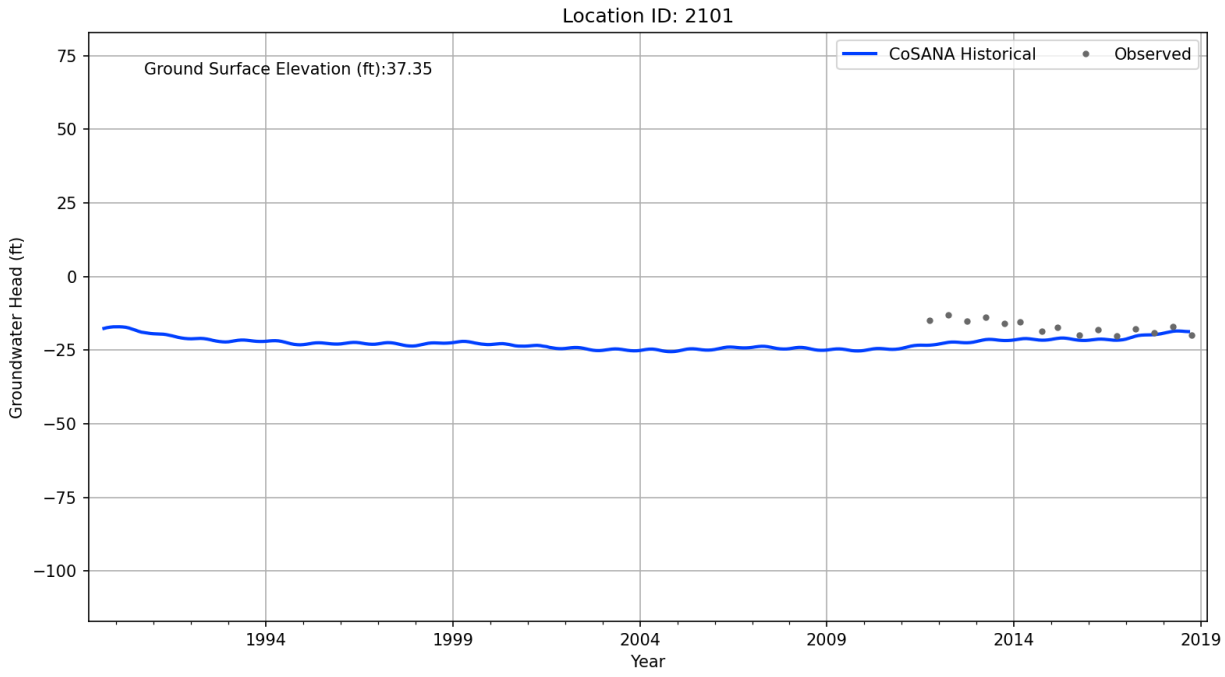

Location ID: 1602
Ground Surface Elevation (ft):12.43
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

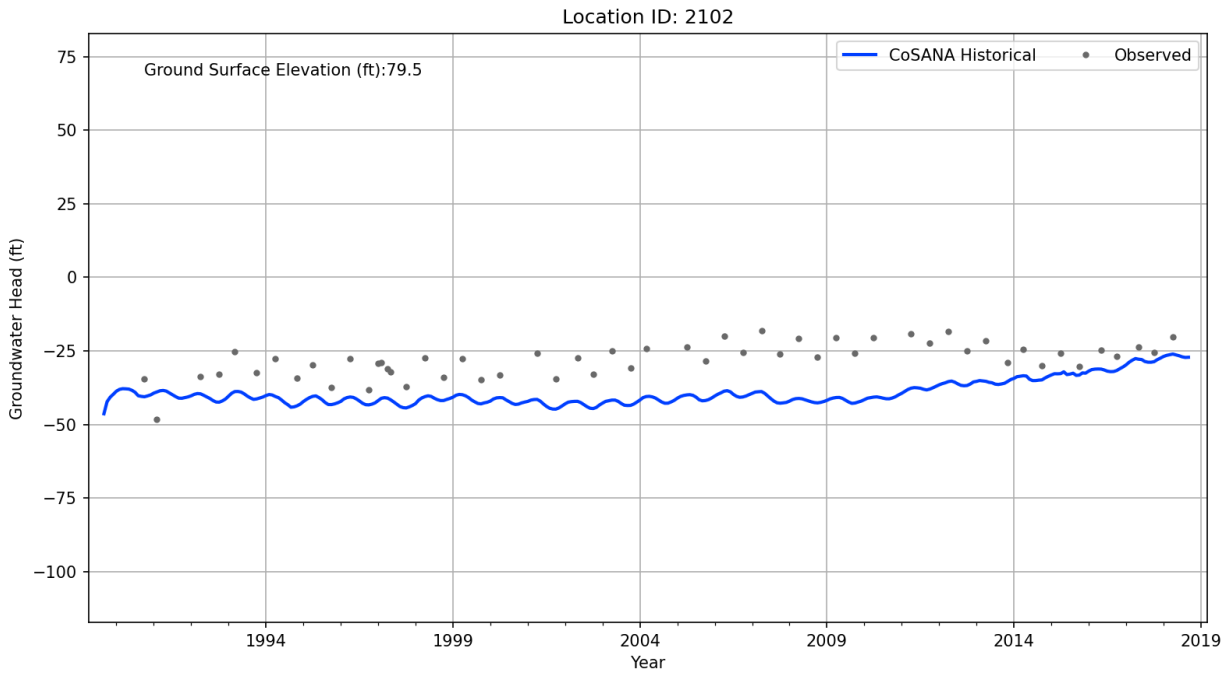

Location ID: 1603
Ground Surface Elevation (ft):12.43
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

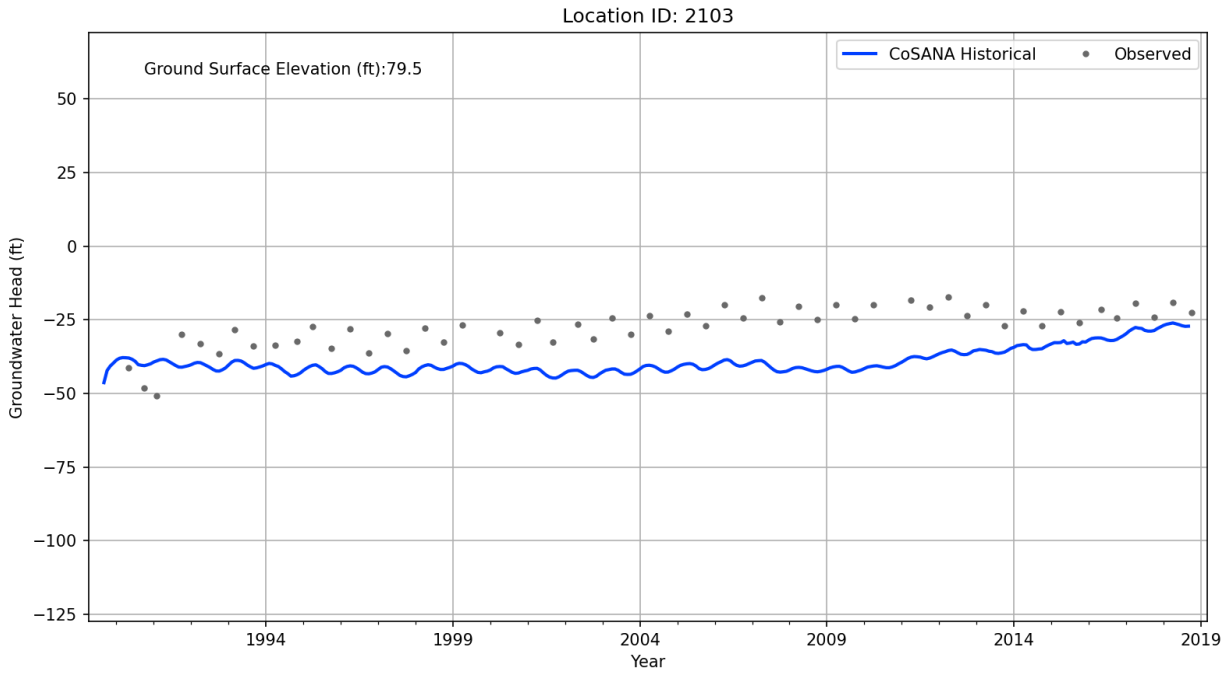

Location ID: 1604
Ground Surface Elevation (ft):12.43
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

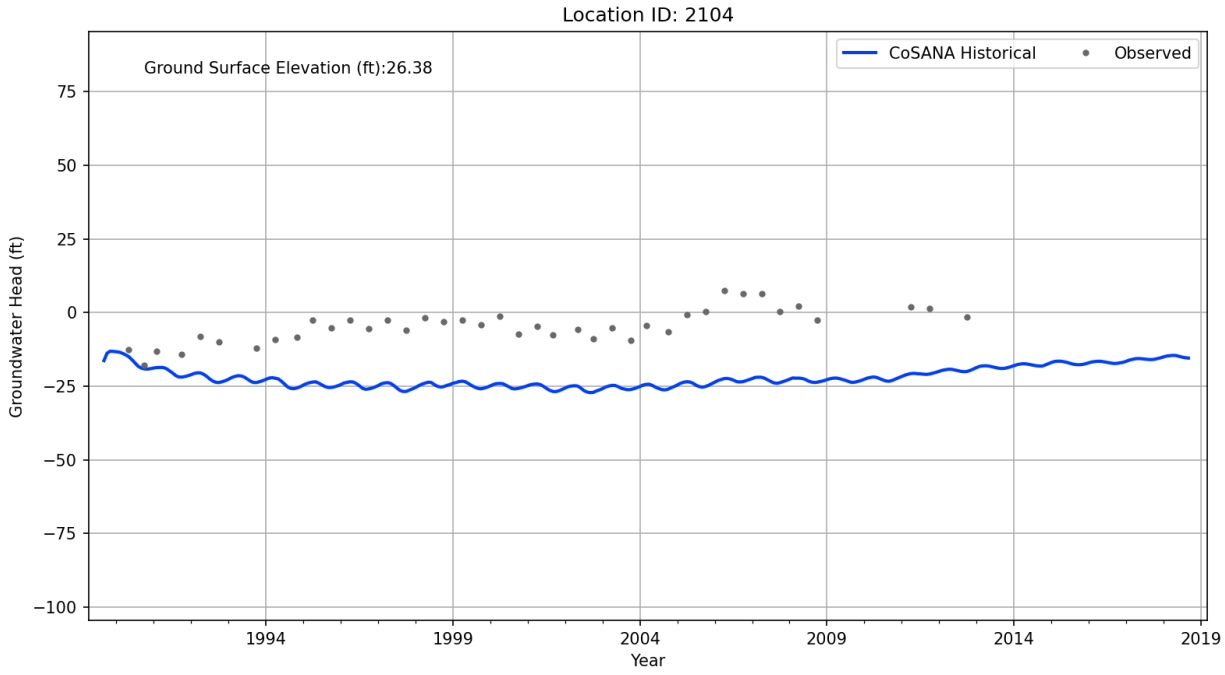

Location ID: 1902
Ground Surface Elevation (ft):26.25
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

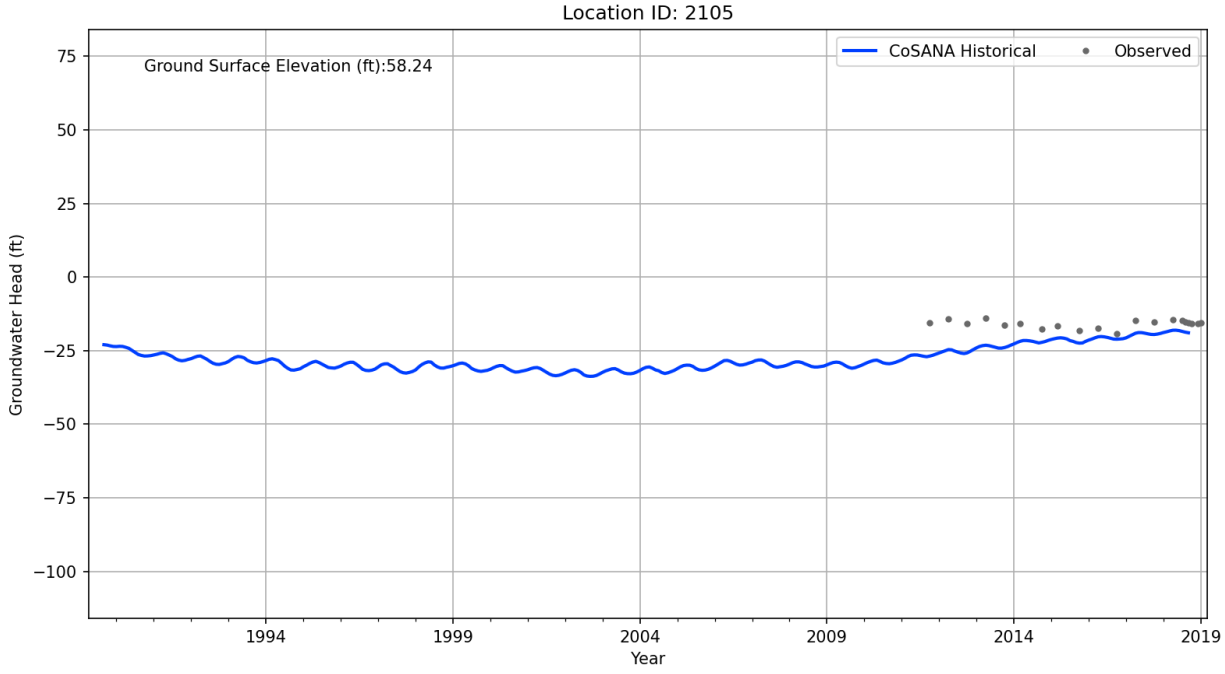

Location ID: 1904
Ground Surface Elevation (ft):22.68
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

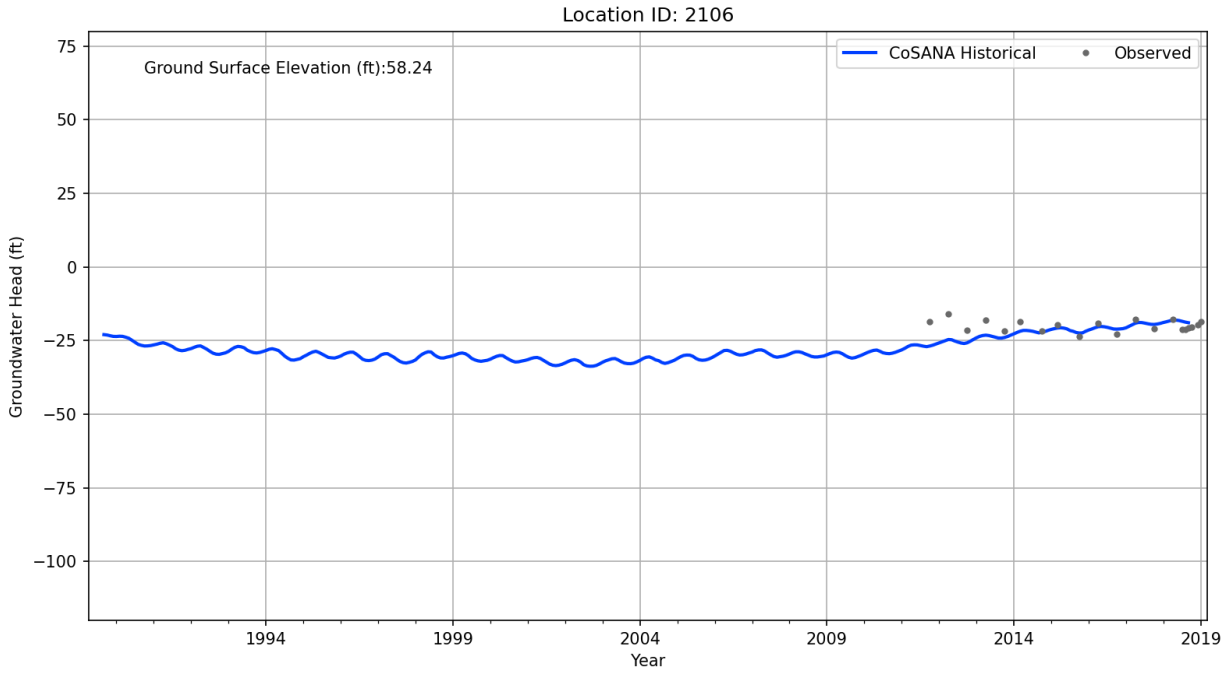

Location ID: 2101
Ground Surface Elevation (ft):37.35
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

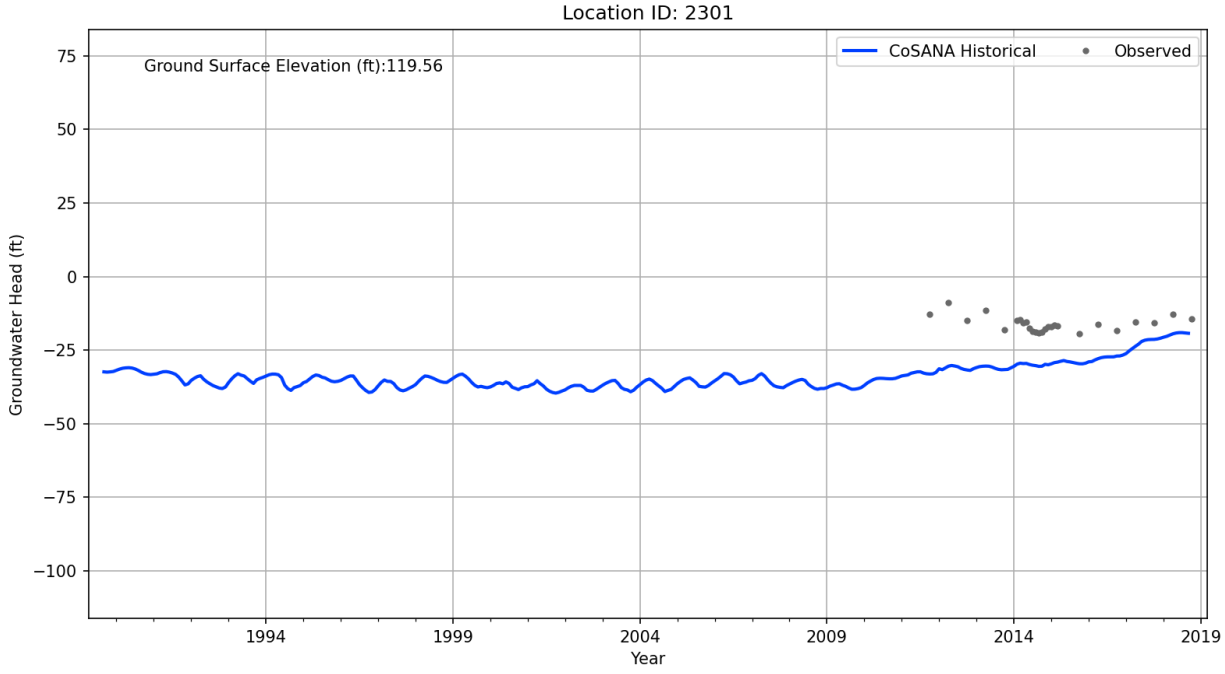

Location ID: 2102
Ground Surface Elevation (ft):79.5
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

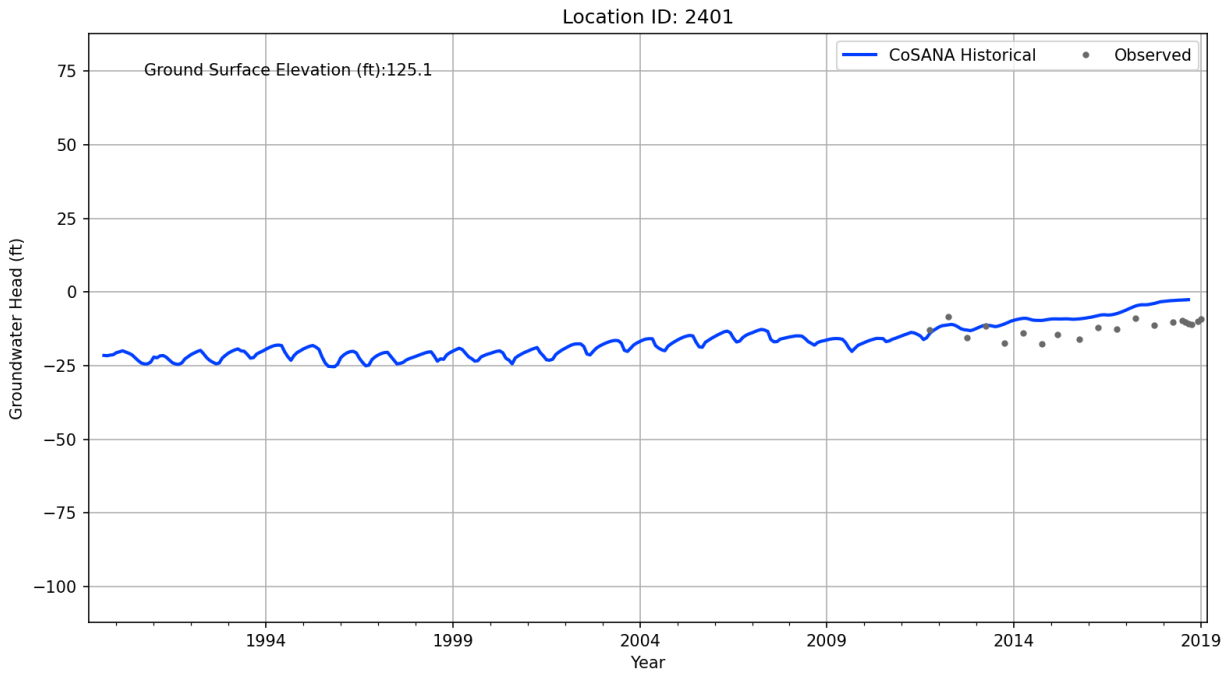

Location ID: 2103
Ground Surface Elevation (ft):79.5
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

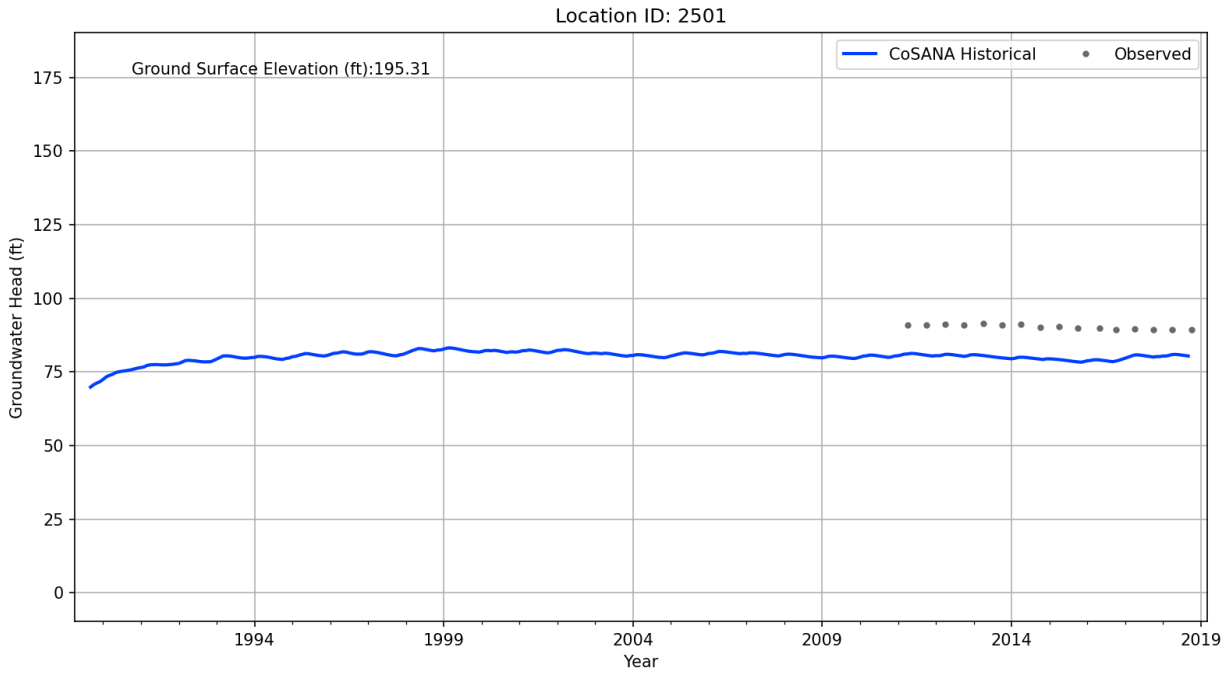

Location ID: 2104
Ground Surface Elevation (ft):26.38
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

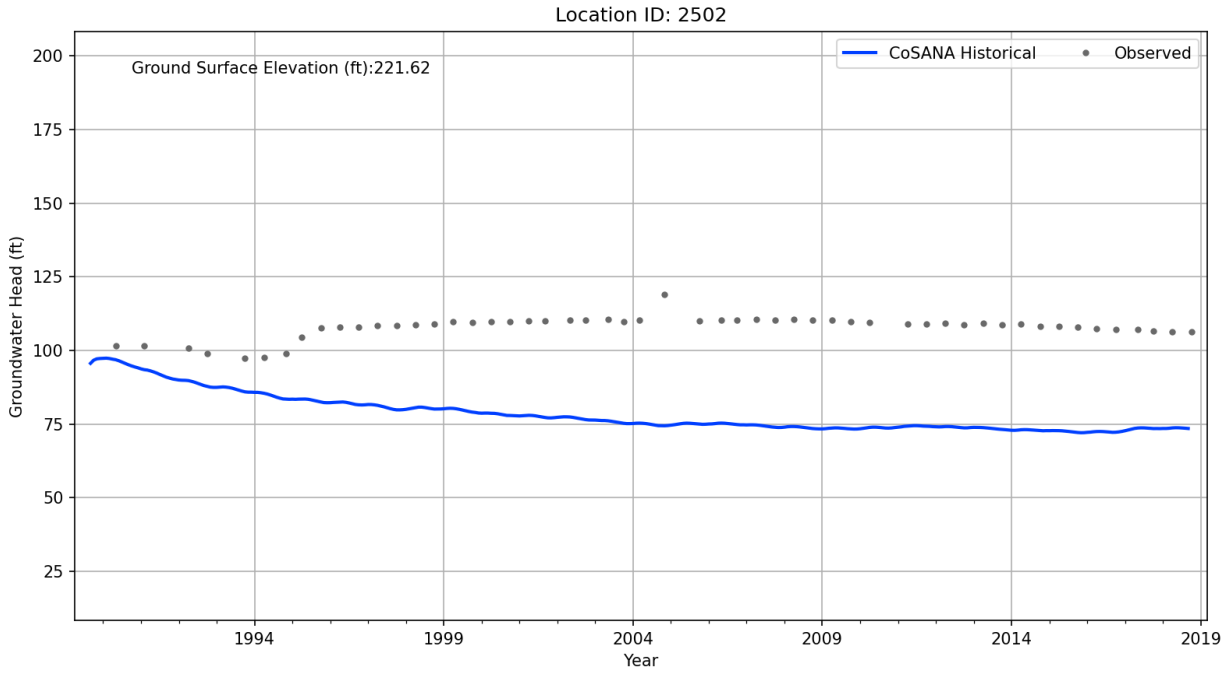

Location ID: 2105
Ground Surface Elevation (ft):58.24
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

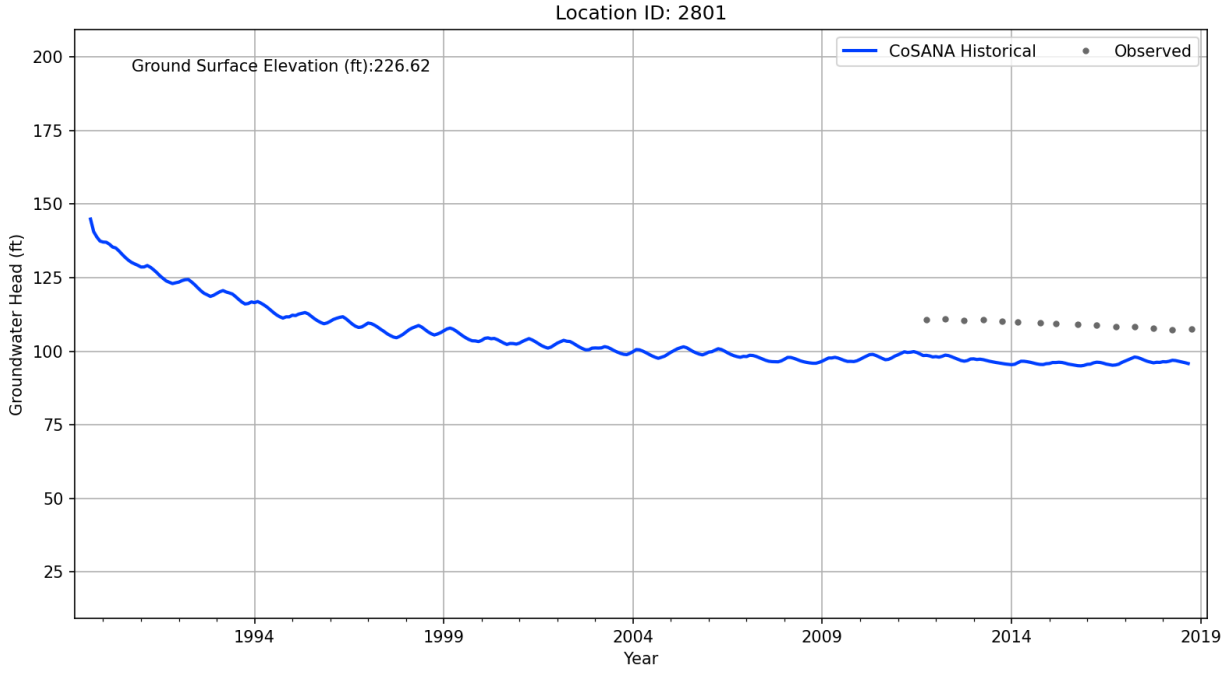

Location ID: 2106
Ground Surface Elevation (ft):58.24
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

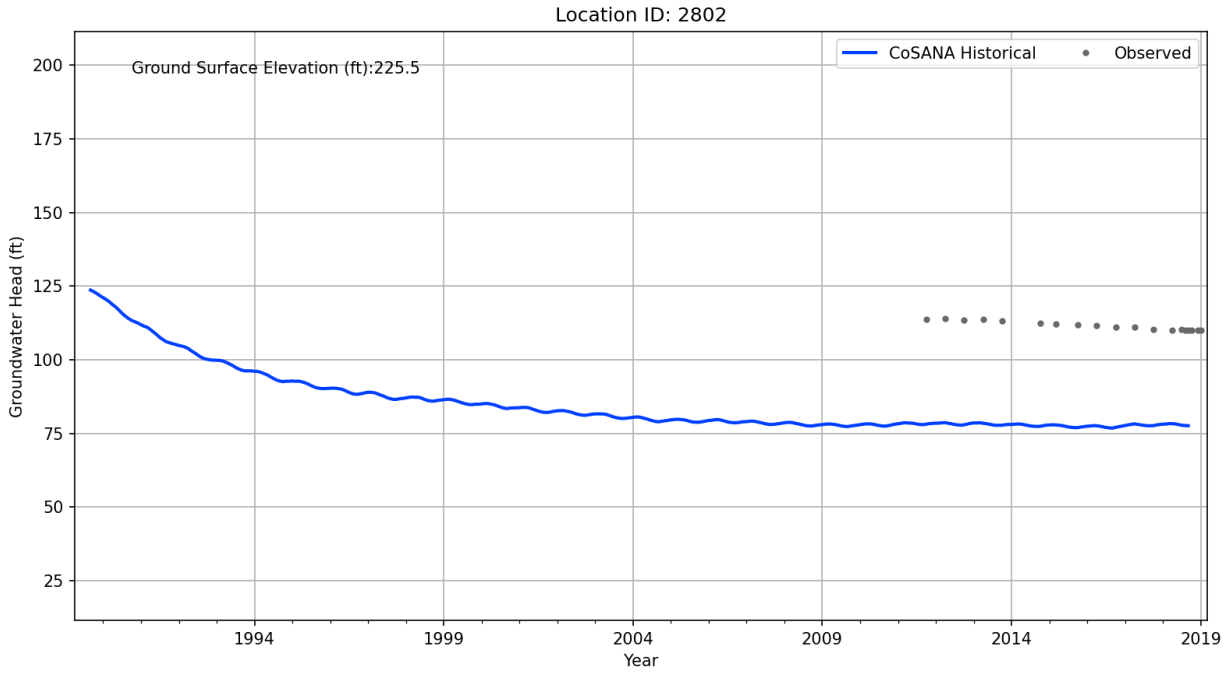

Location ID: 2301
Ground Surface Elevation (ft):119.56
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

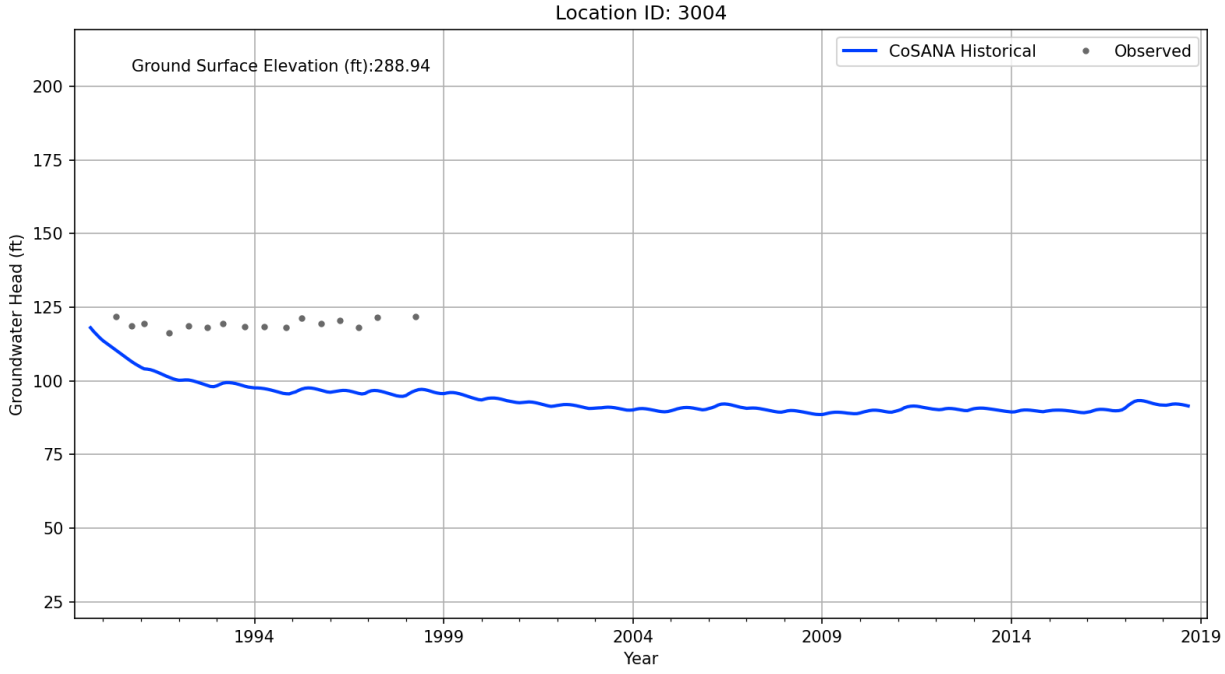

Location ID: 2401
Ground Surface Elevation (ft):125.1
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

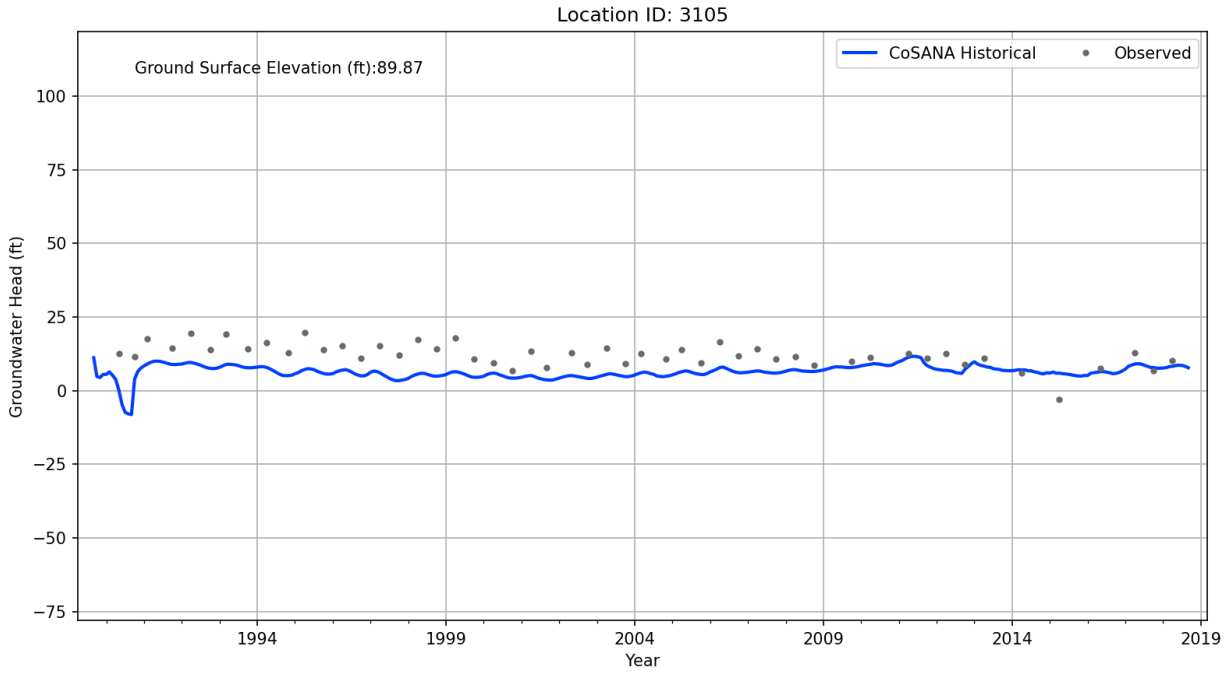

Location ID: 2501
Ground Surface Elevation (ft):195.31
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

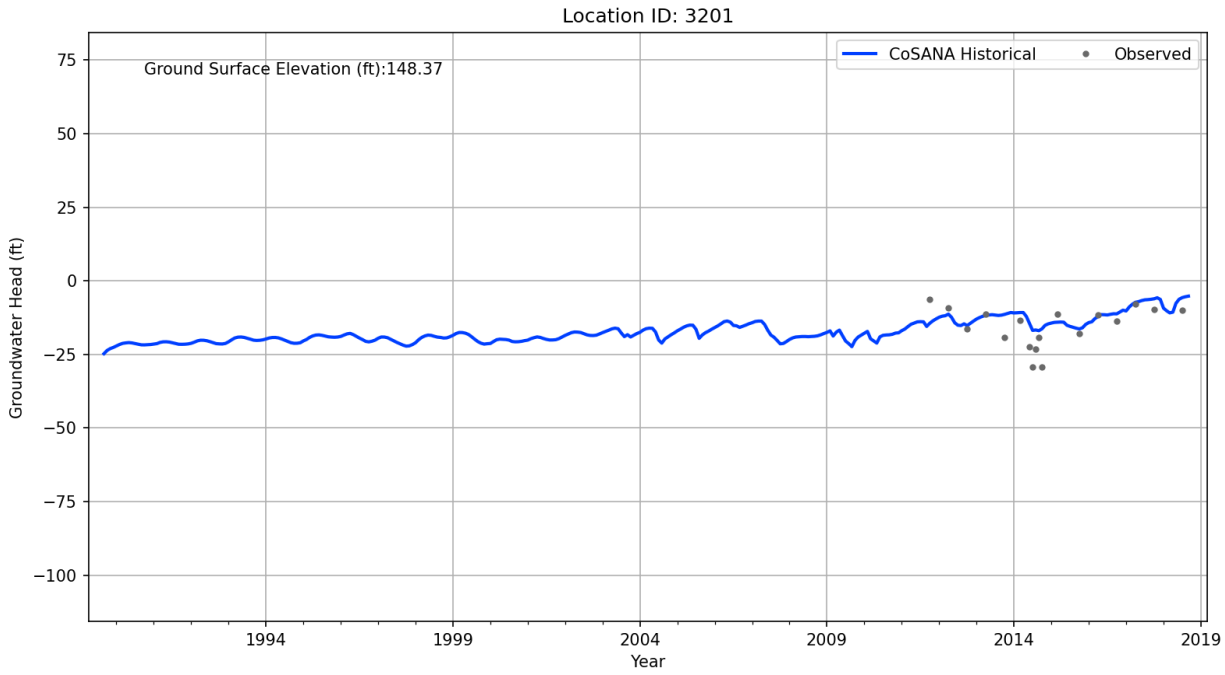

Location ID: 2502
Ground Surface Elevation (ft):221.62
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

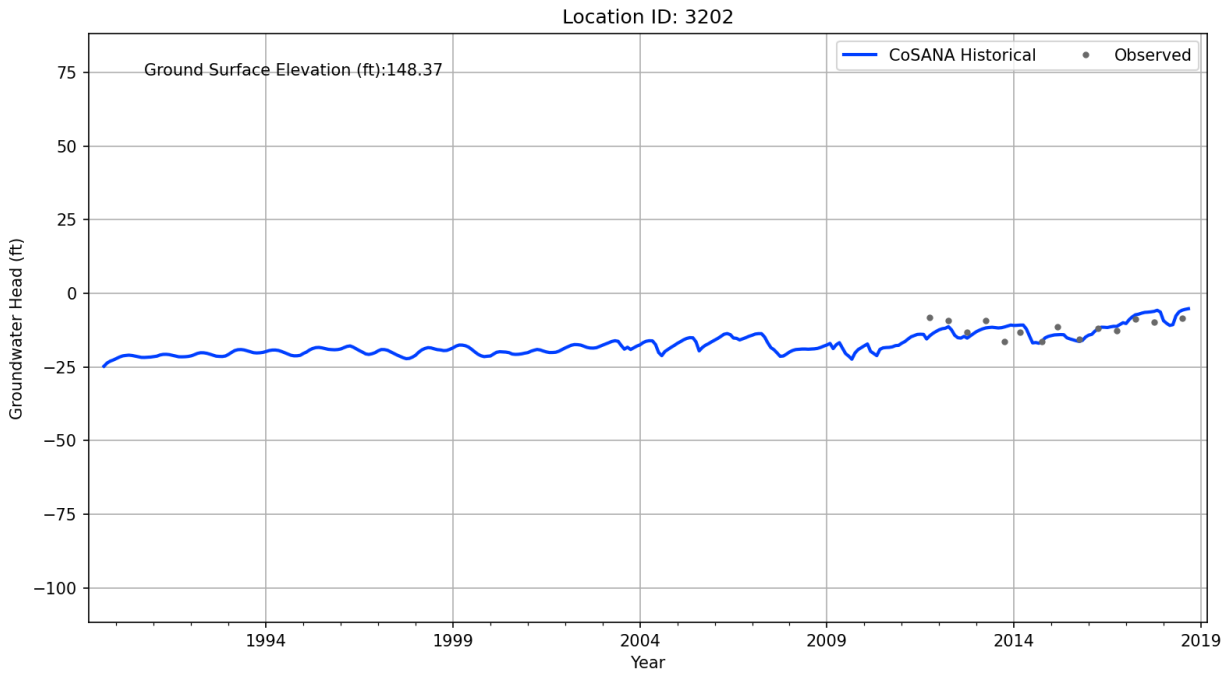

Location ID: 2801
Ground Surface Elevation (ft):226.62
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

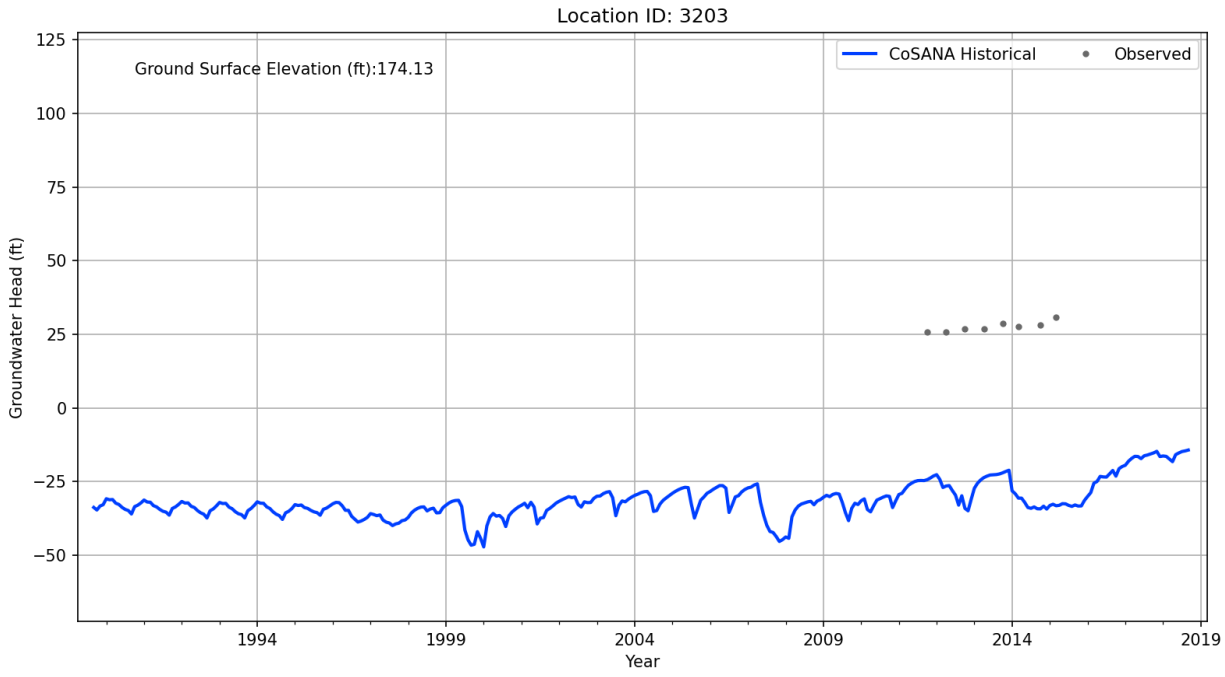

Location ID: 2802
Ground Surface Elevation (ft):225.5
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

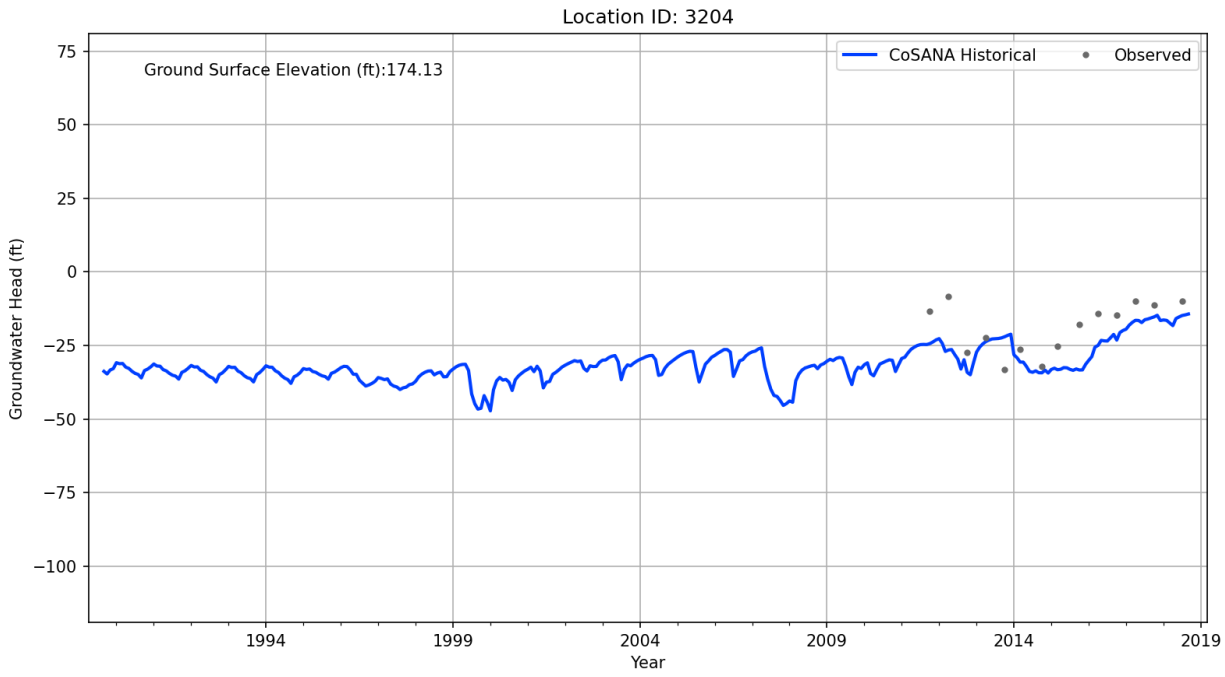

Location ID: 3004
Ground Surface Elevation (ft):288.94
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

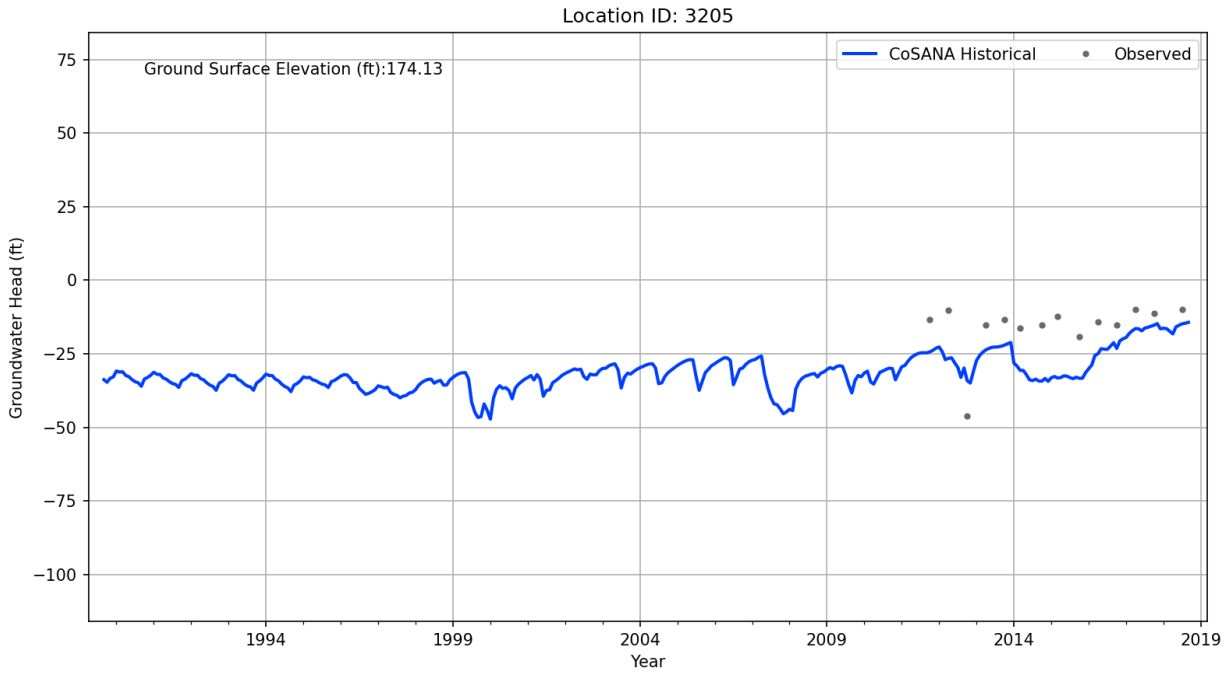

Location ID: 3105
Ground Surface Elevation (ft):89.87
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

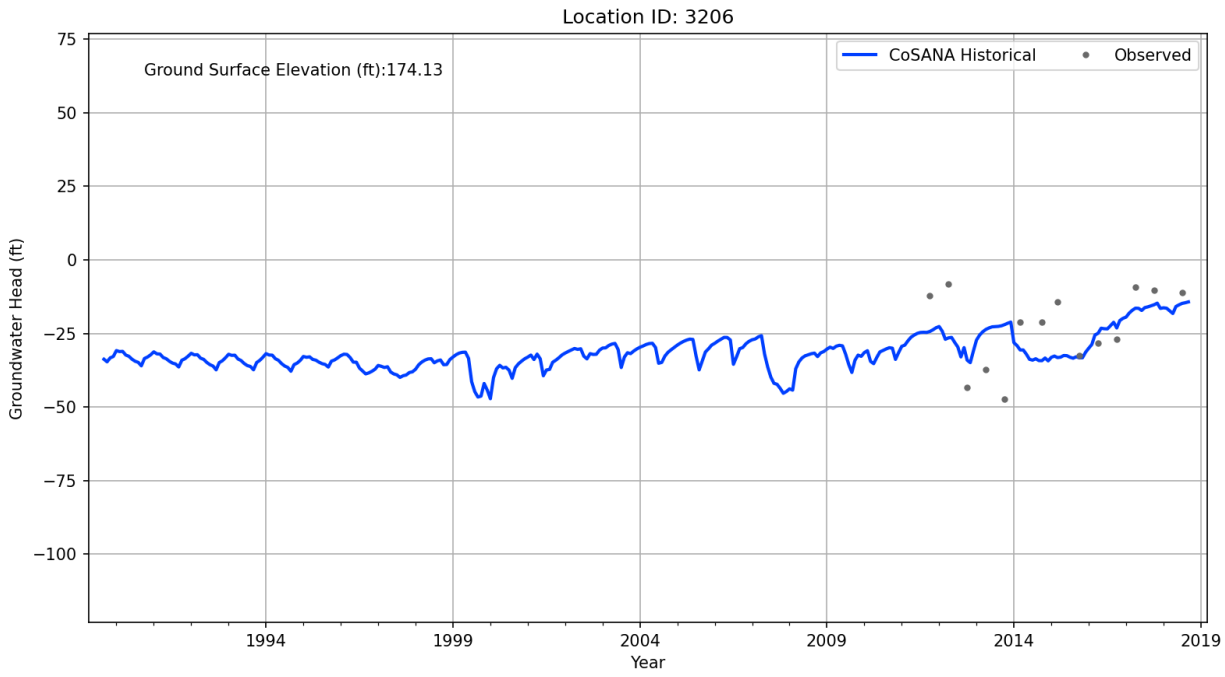

Location ID: 3201
Ground Surface Elevation (ft):148.37
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

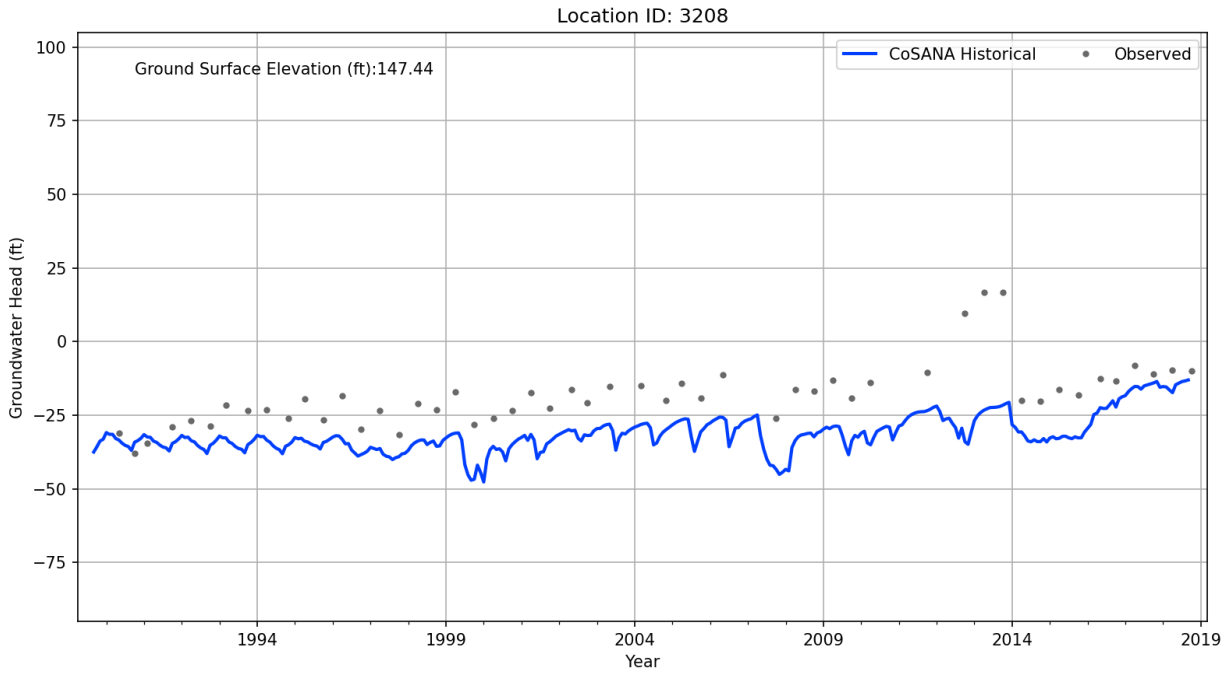

Location ID: 3202
Ground Surface Elevation (ft):148.37
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

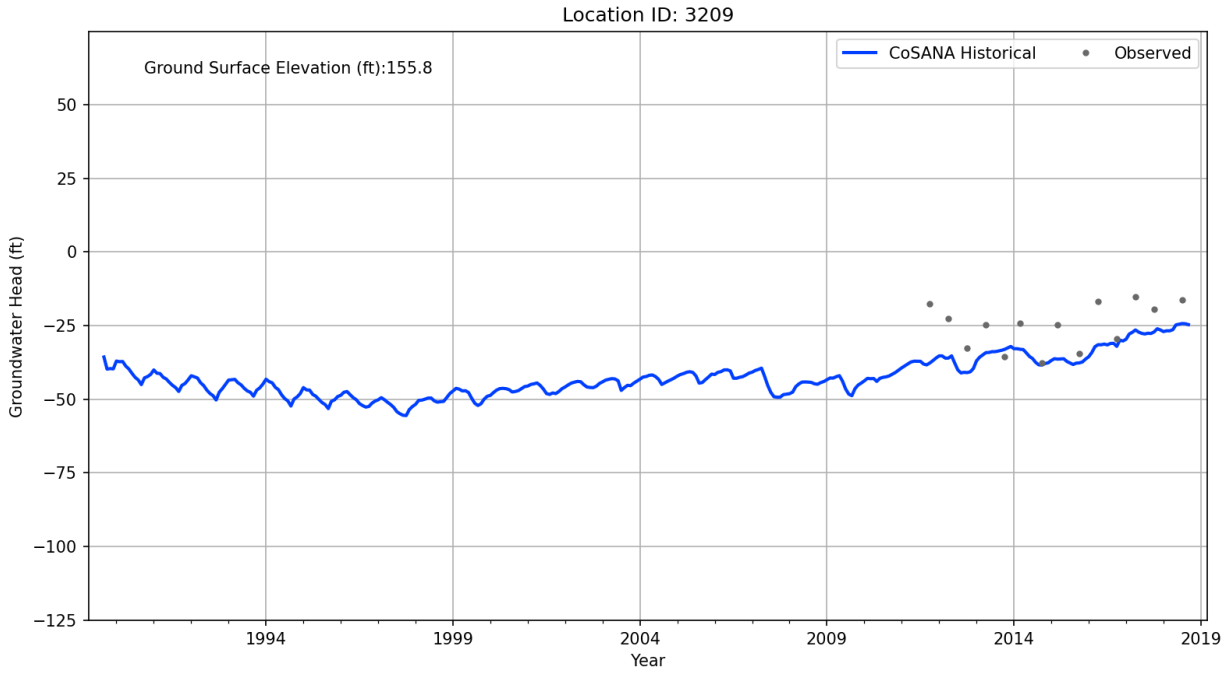

Location ID: 3203
Ground Surface Elevation (ft):174.13
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

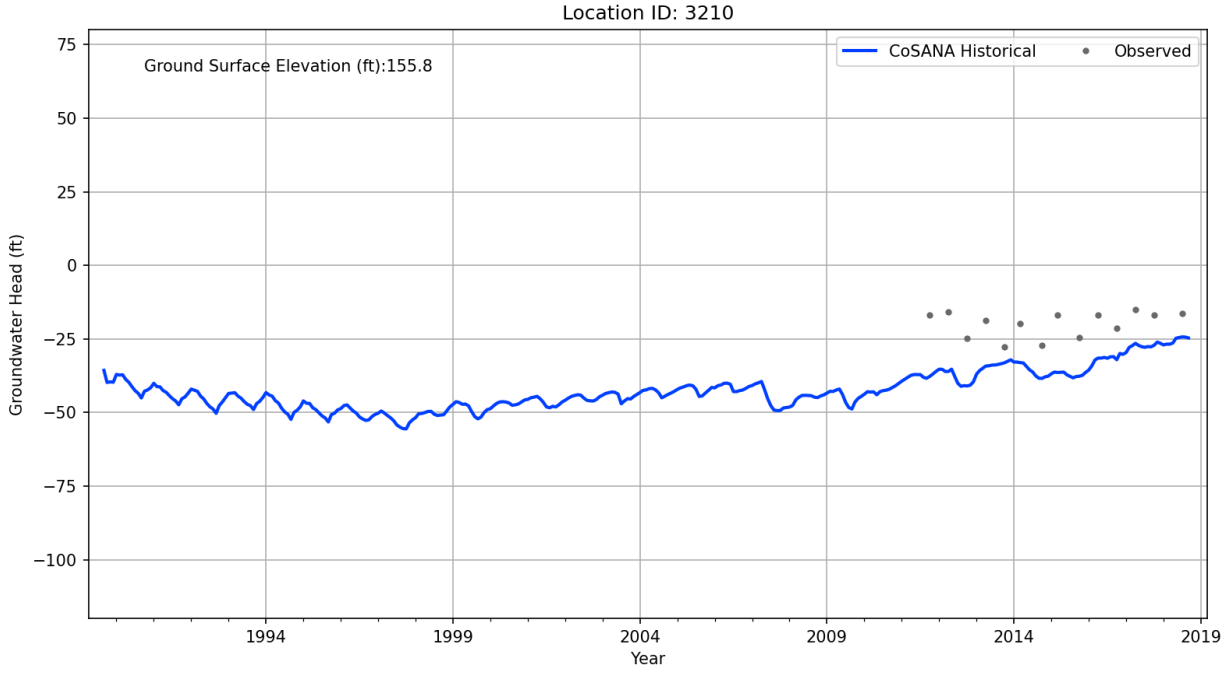

Location ID: 3204
Ground Surface Elevation (ft):174.13
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

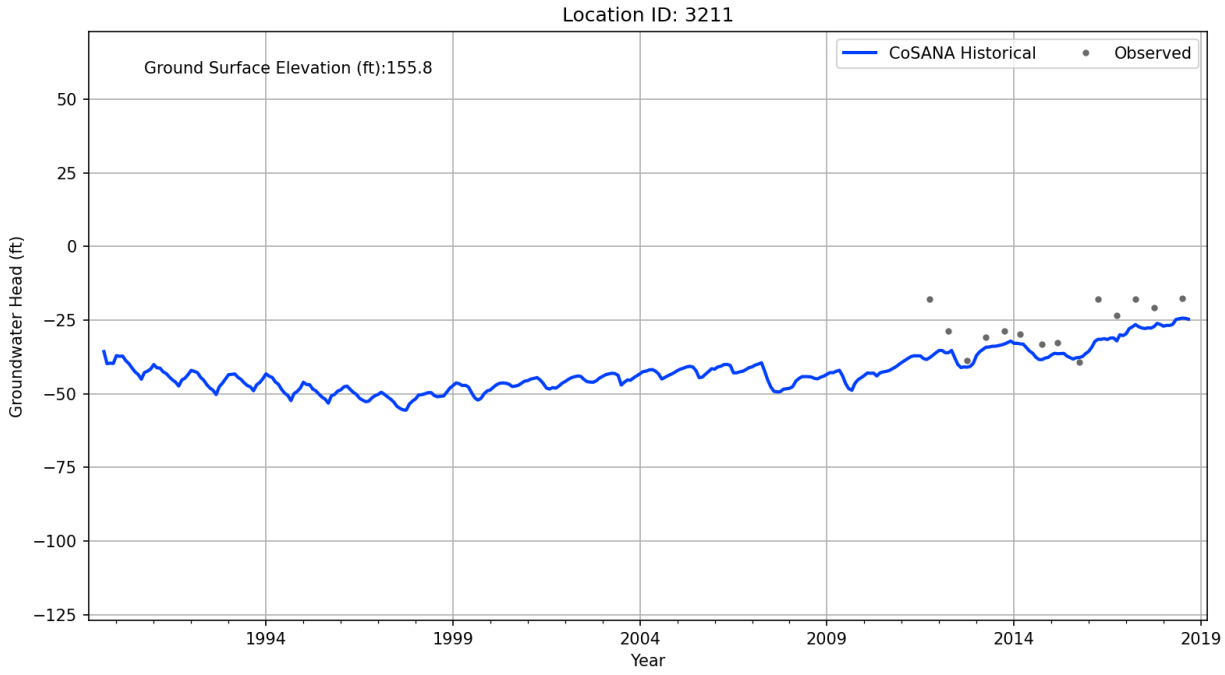

Location ID: 3205
Ground Surface Elevation (ft):174.13
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

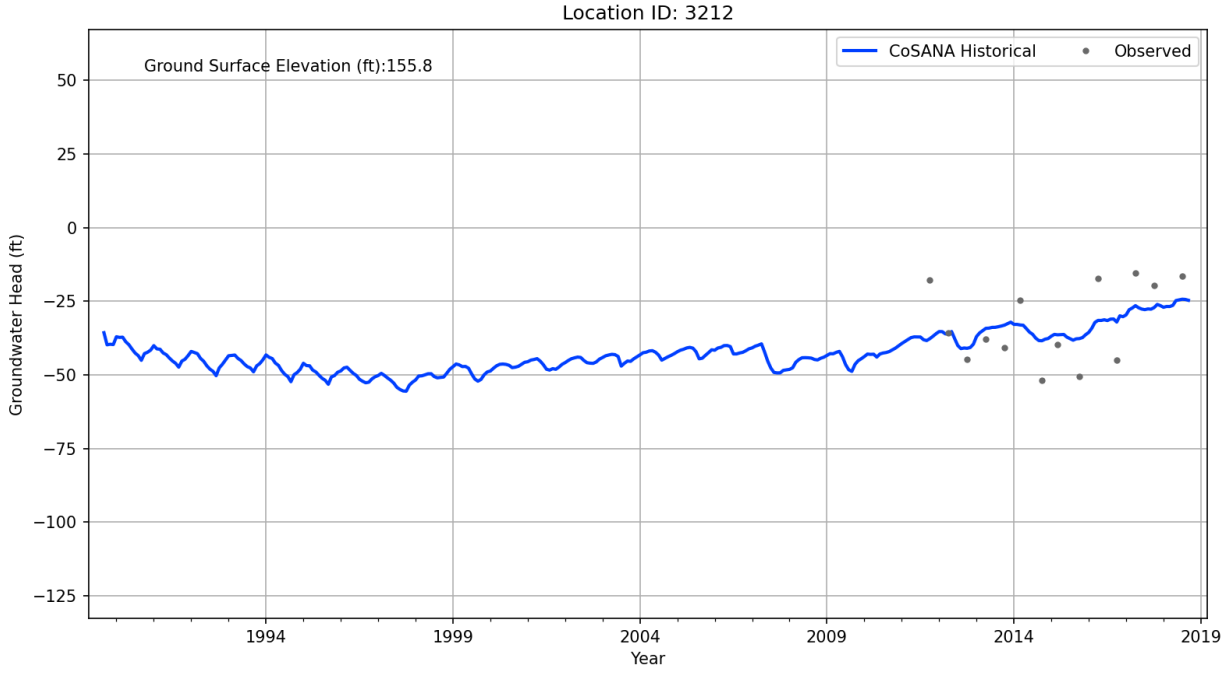

Location ID: 3206
Ground Surface Elevation (ft):174.13
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

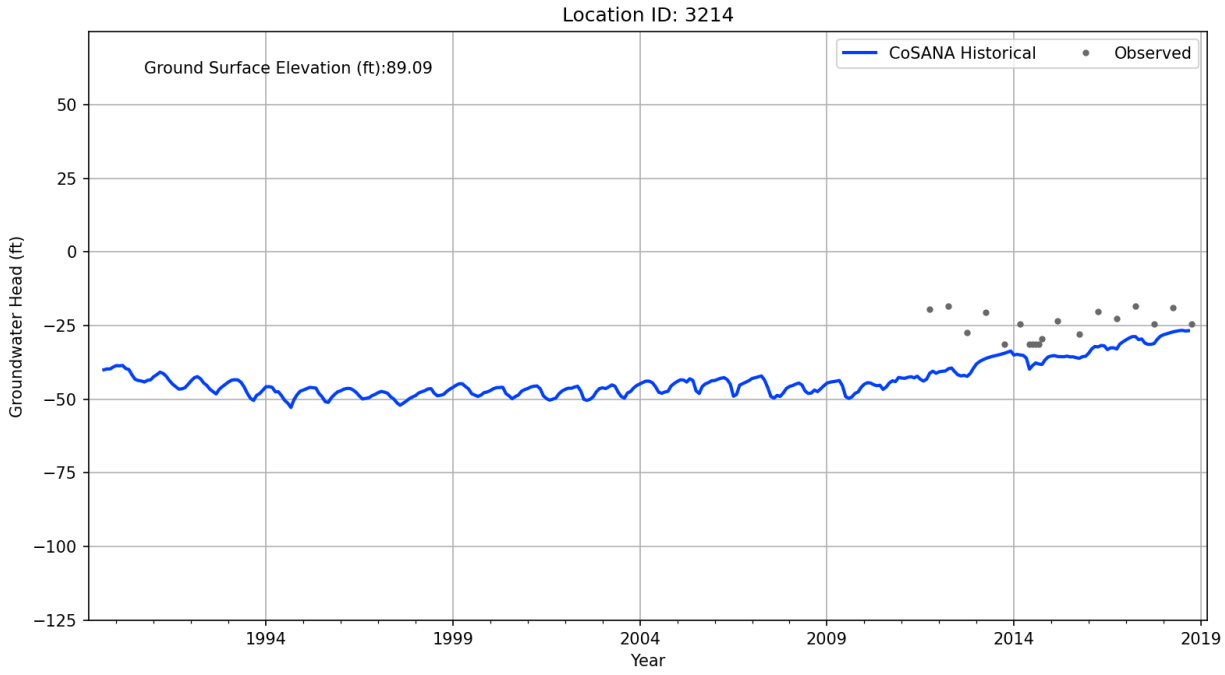

Location ID: 3208
Ground Surface Elevation (ft):147.44
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

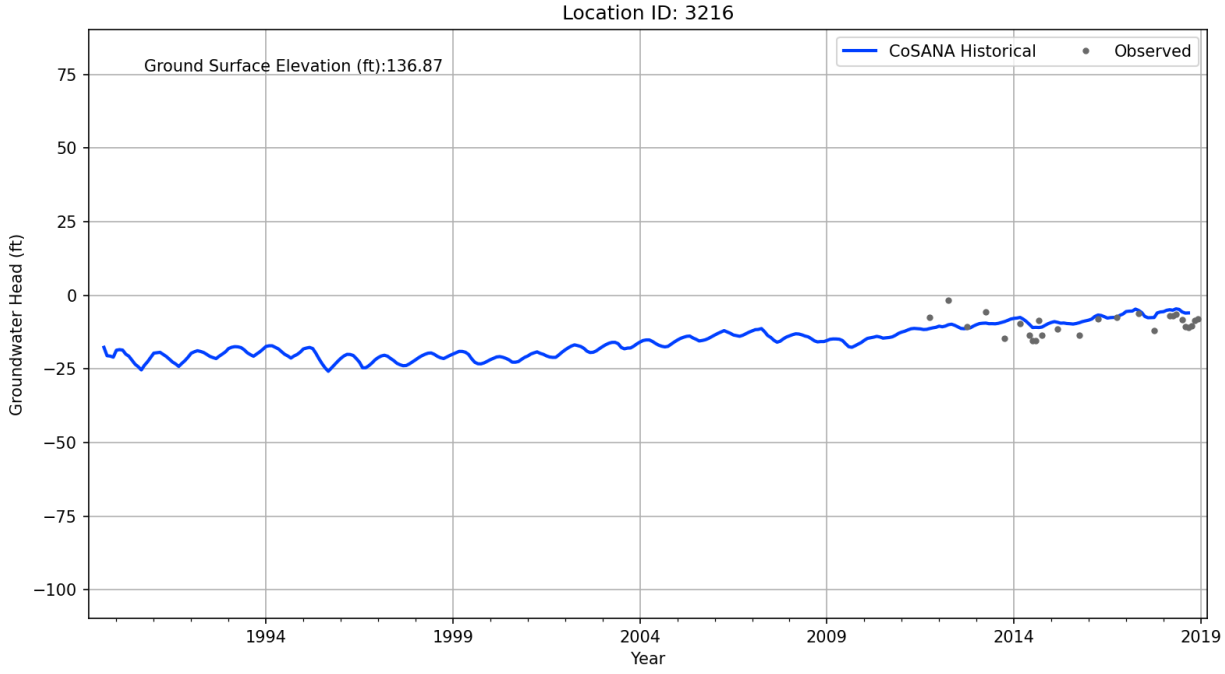

Location ID: 3209
Ground Surface Elevation (ft):155.8
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

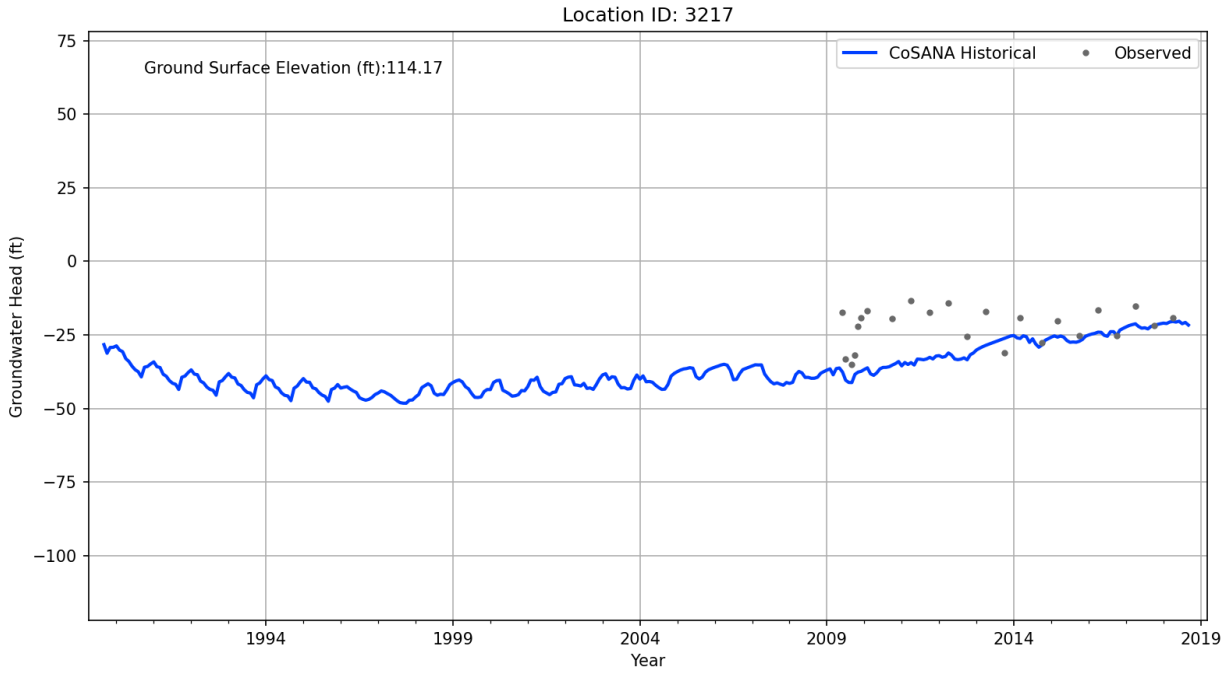

Location ID: 3210
Ground Surface Elevation (ft):155.8
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

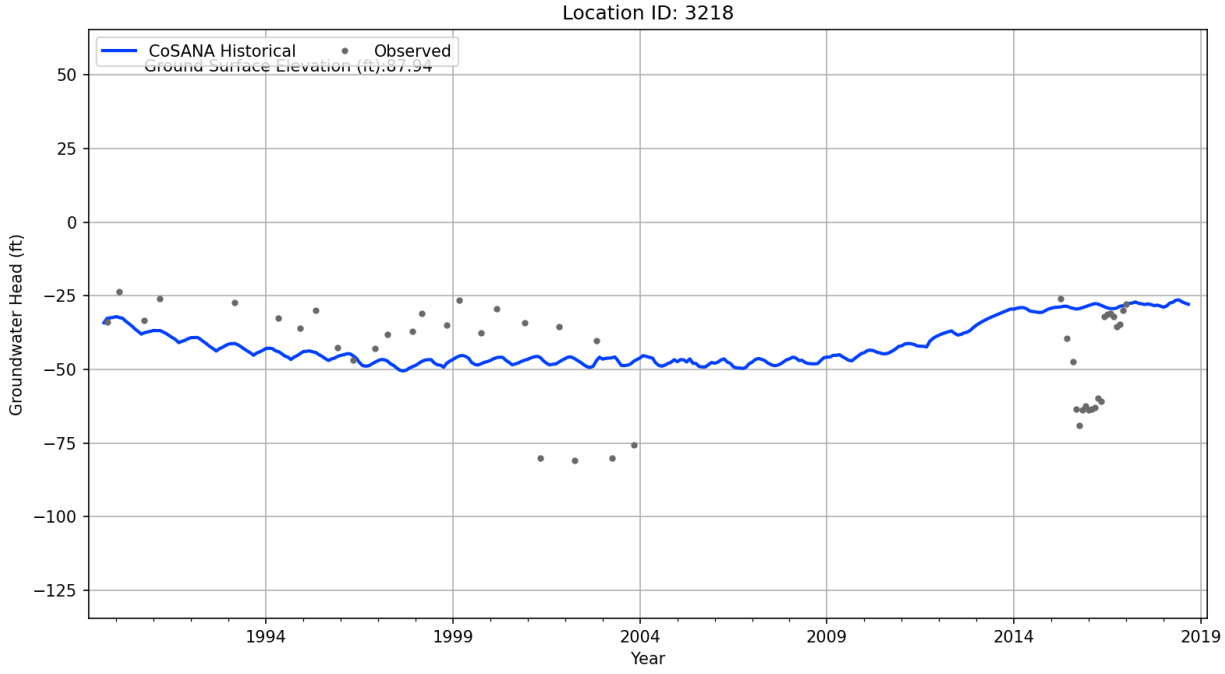

Location ID: 3211
Ground Surface Elevation (ft):155.8
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

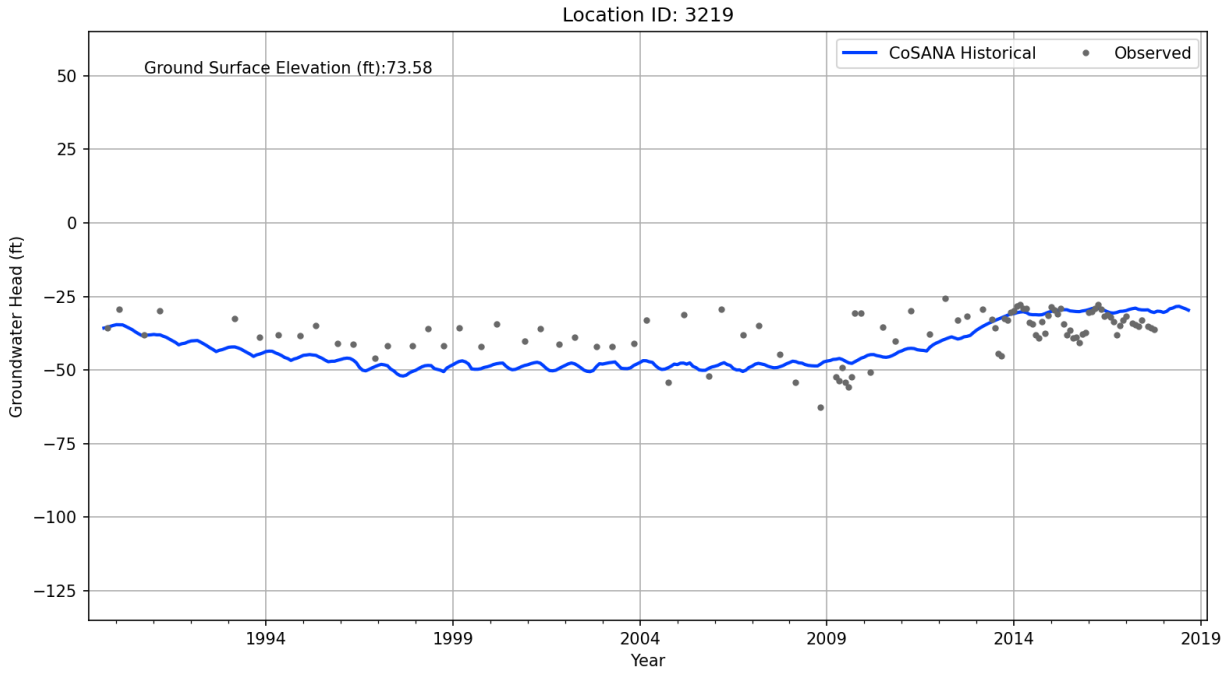

Location ID: 3212
Ground Surface Elevation (ft):155.8
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

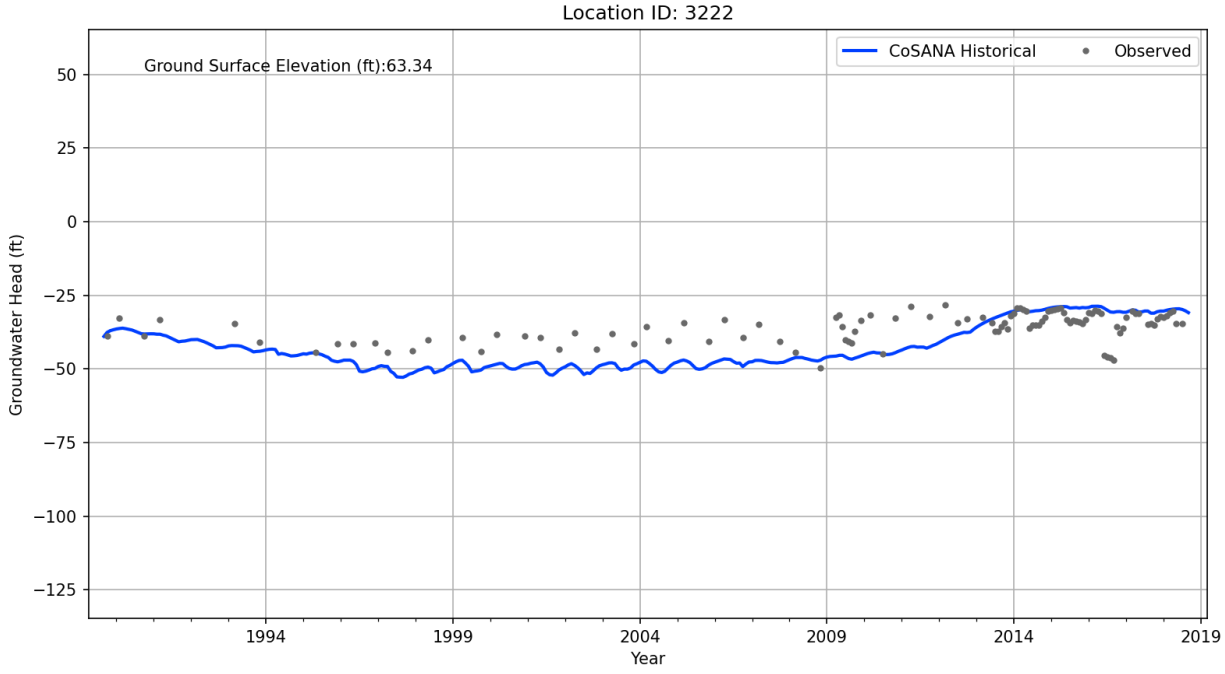

Location ID: 3214
Ground Surface Elevation (ft):89.09
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

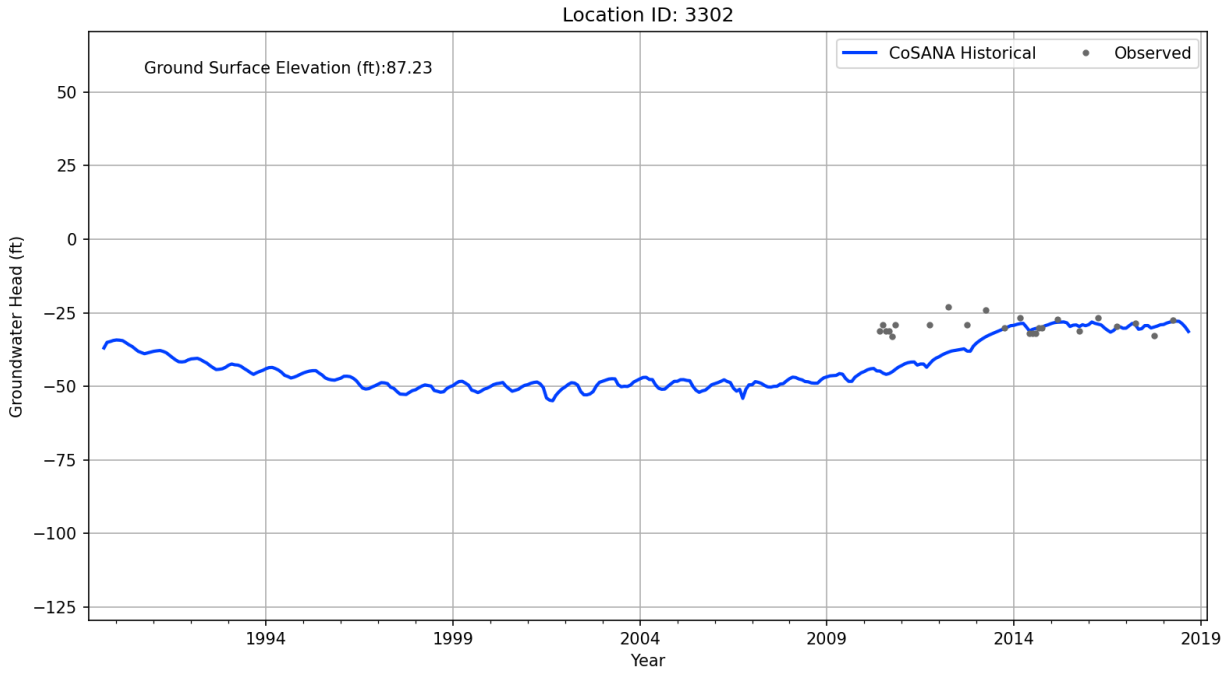

Location ID: 3216
Ground Surface Elevation (ft):136.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

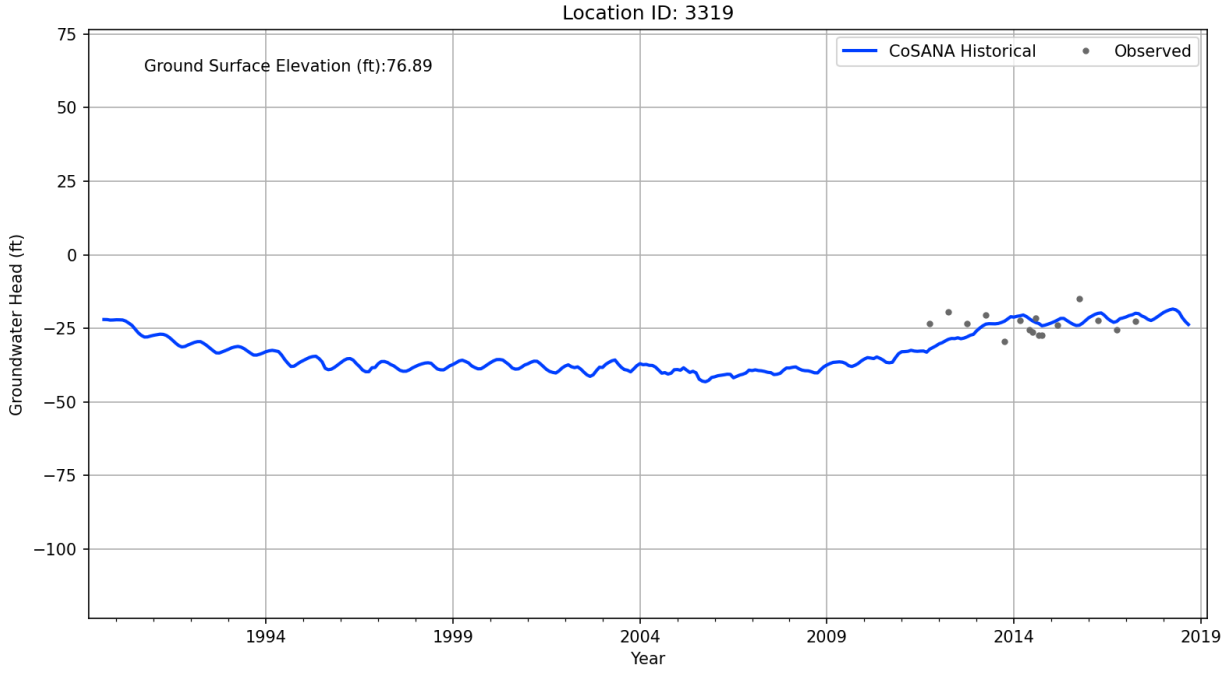

Location ID: 3217
Ground Surface Elevation (ft):114.17
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

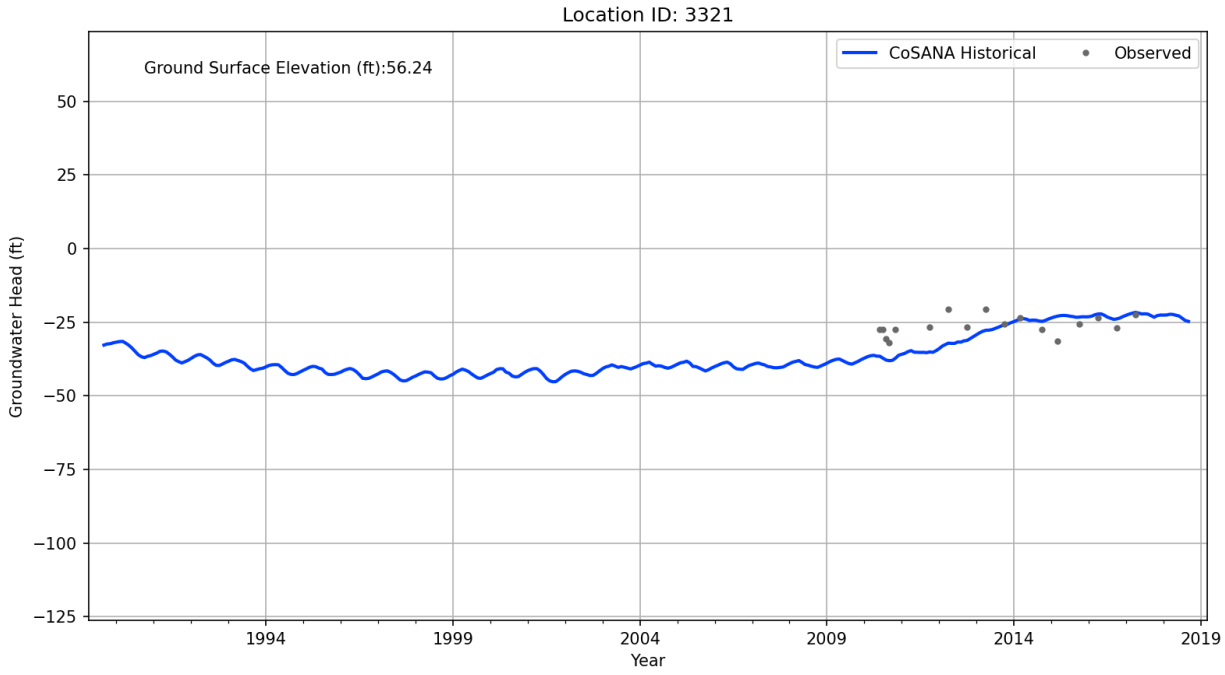

Location ID: 3218
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

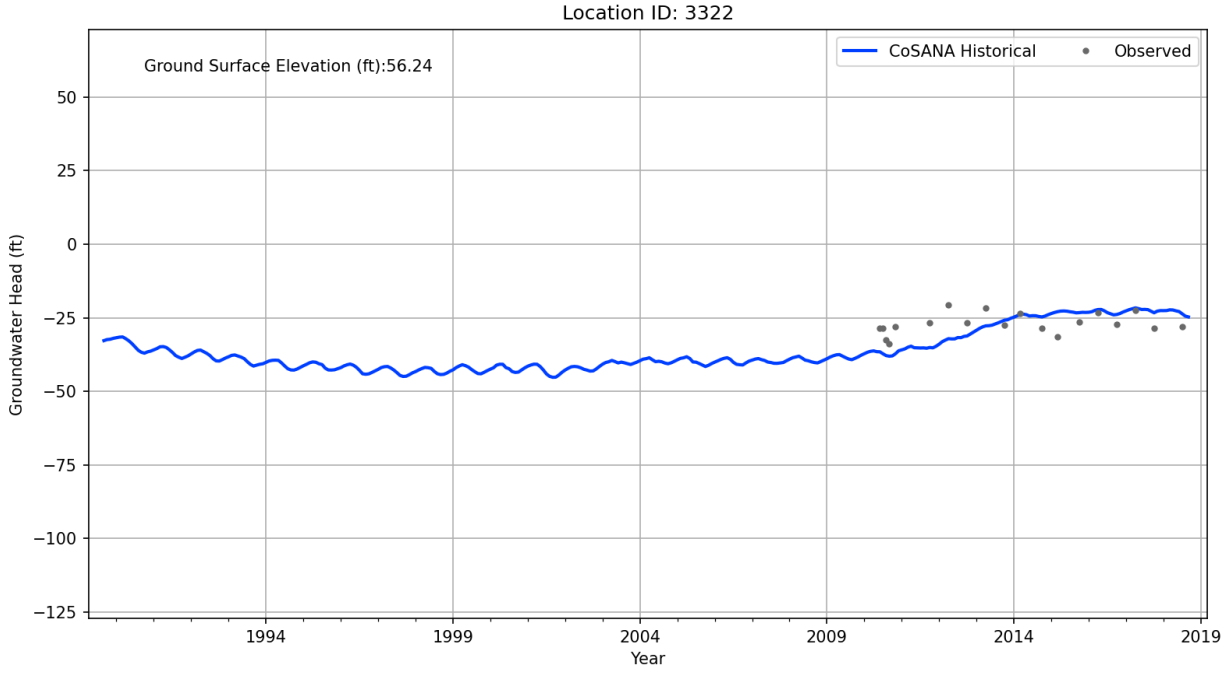

Location ID: 3219
Ground Surface Elevation (ft):73.58
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

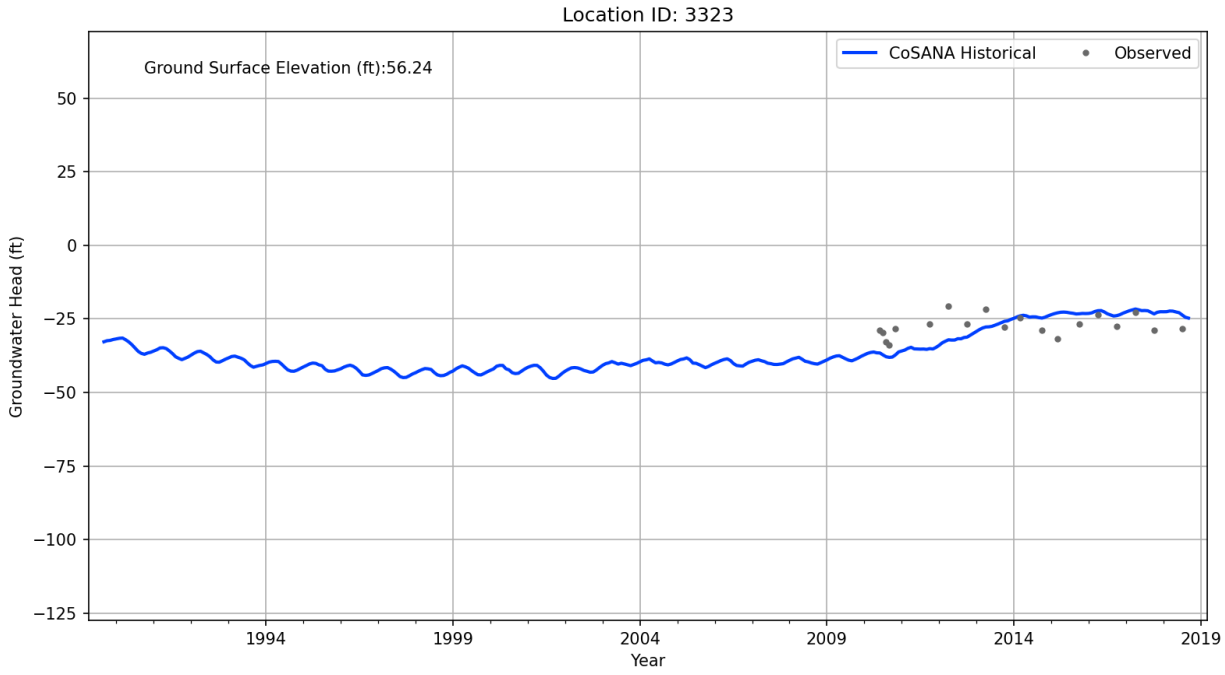

Location ID: 3222
Ground Surface Elevation (ft):63.34
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

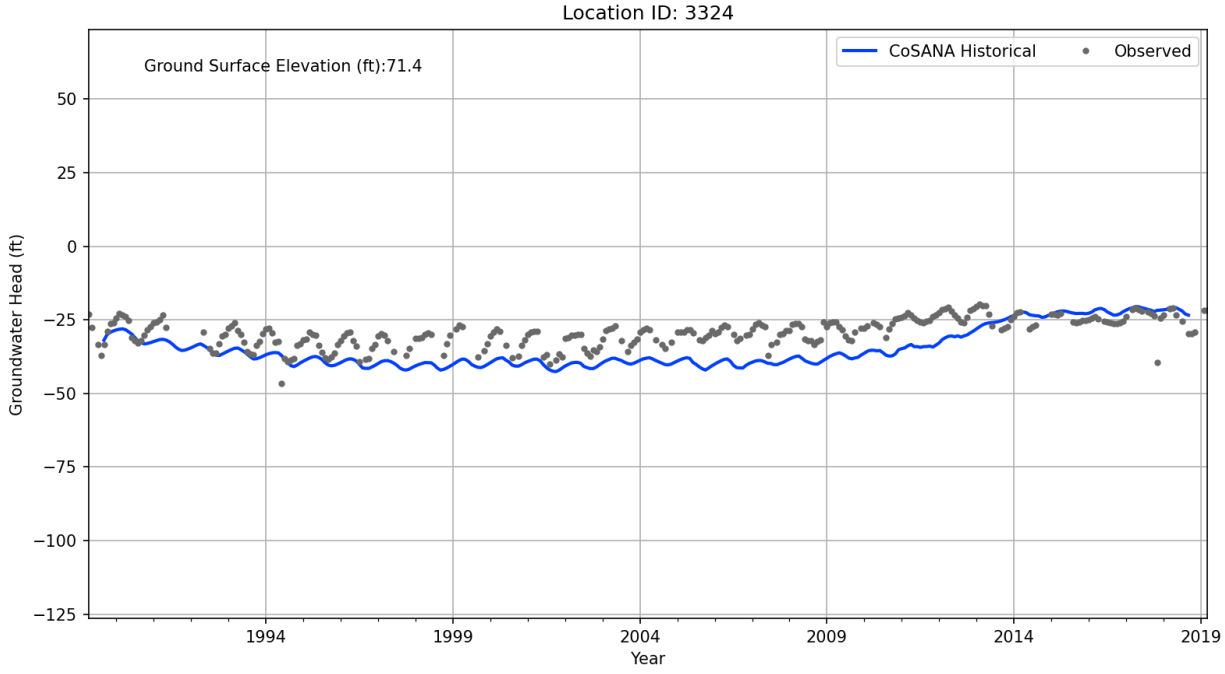

Location ID: 3302
Ground Surface Elevation (ft):87.23
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

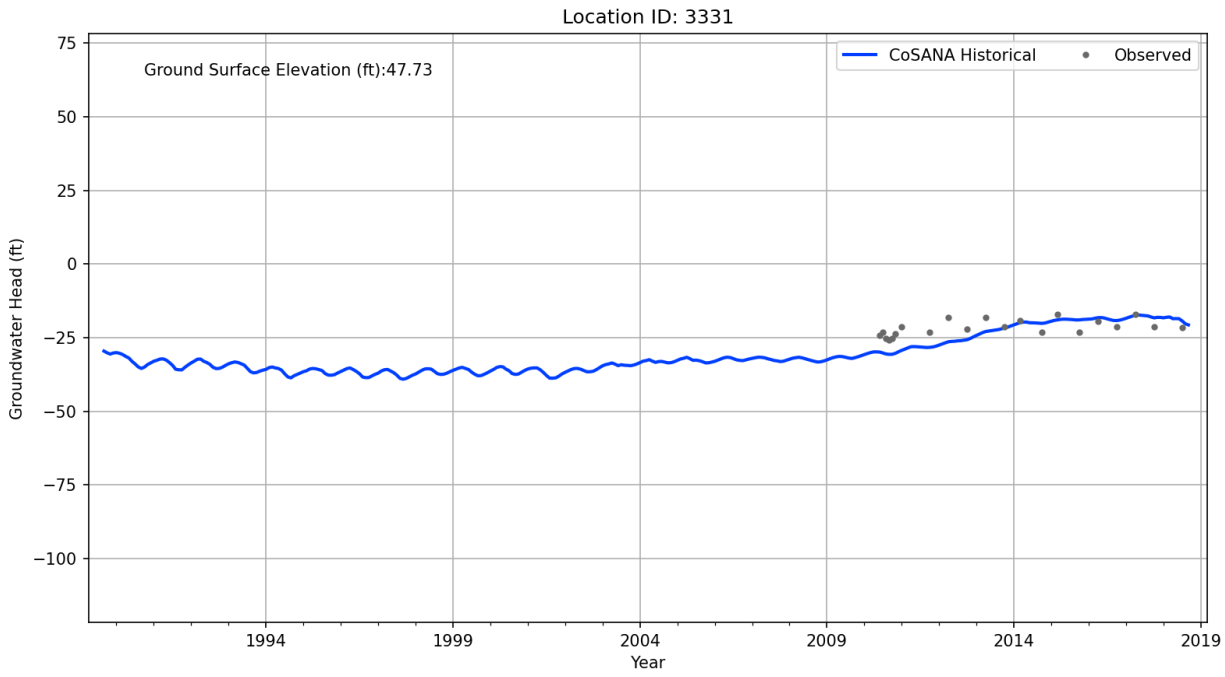

Location ID: 3319
Ground Surface Elevation (ft):76.89
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

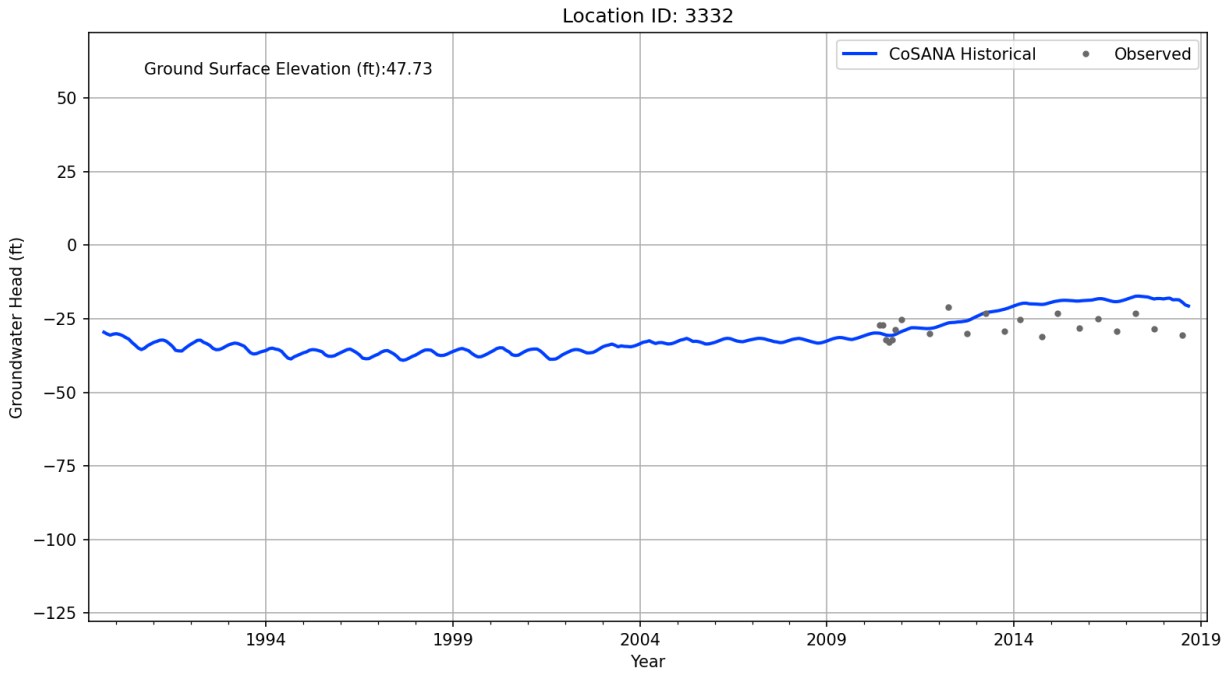

Location ID: 3321
Ground Surface Elevation (ft):56.24
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

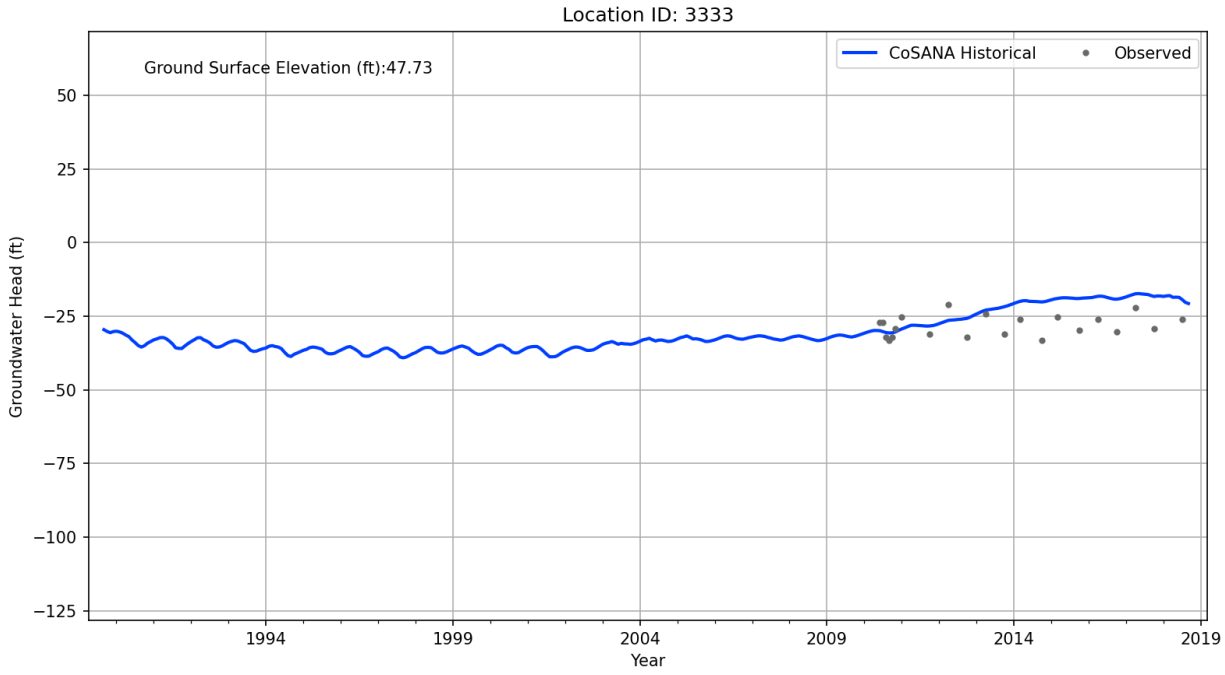

Location ID: 3322
Ground Surface Elevation (ft):56.24
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

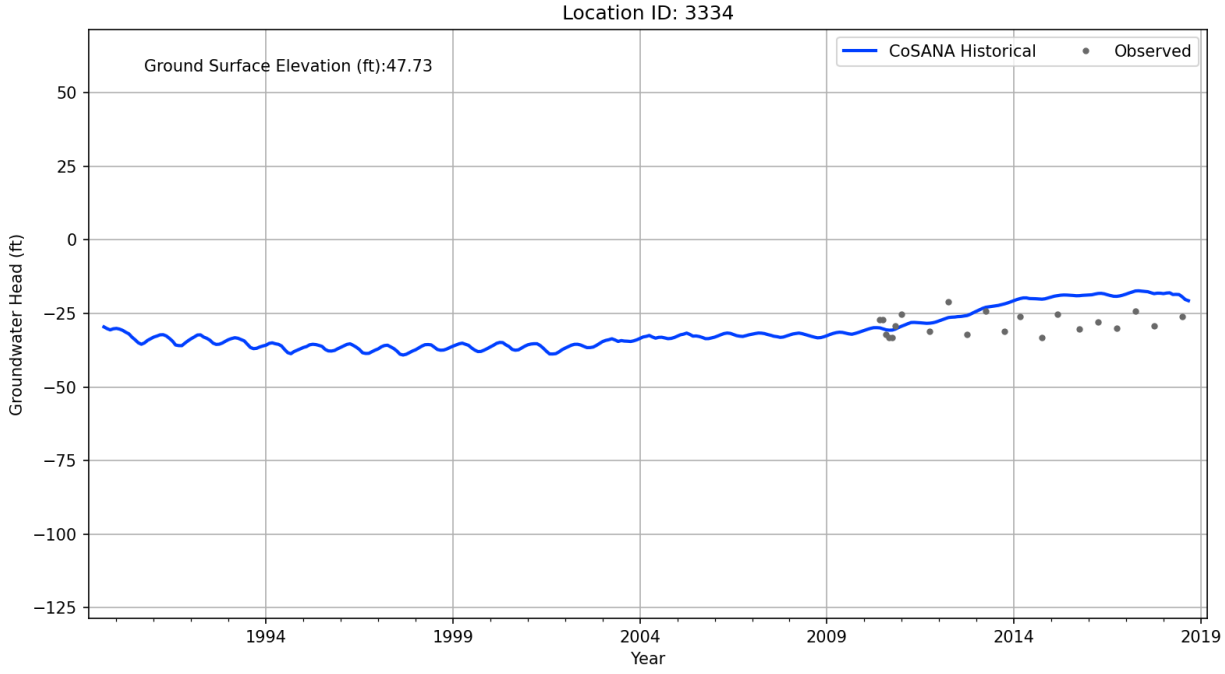

Location ID: 3323
Ground Surface Elevation (ft):56.24
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

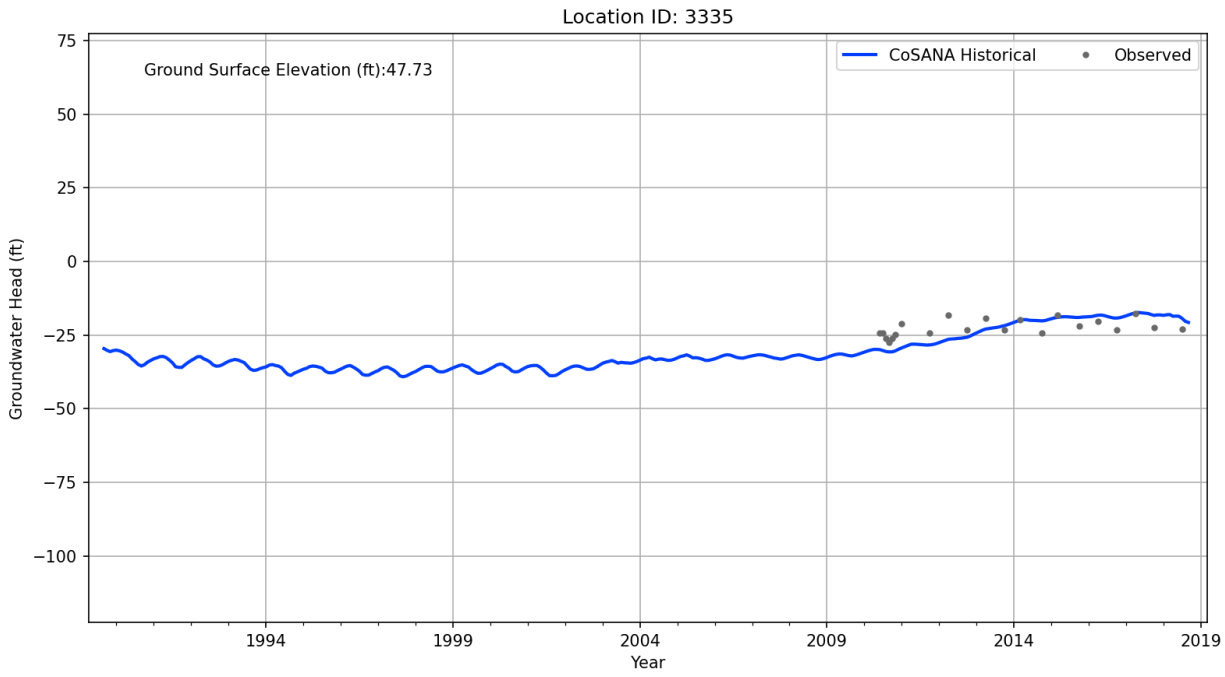

Location ID: 3324
Ground Surface Elevation (ft):71.4
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

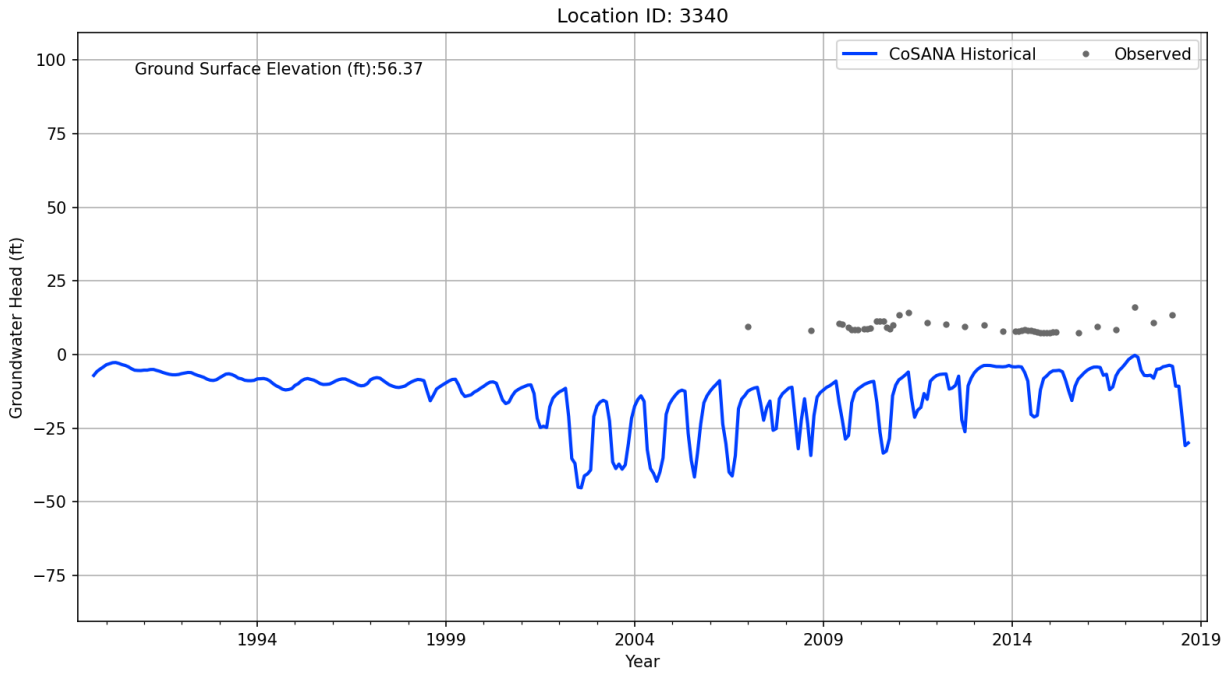

Location ID: 3331
Ground Surface Elevation (ft):47.73
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

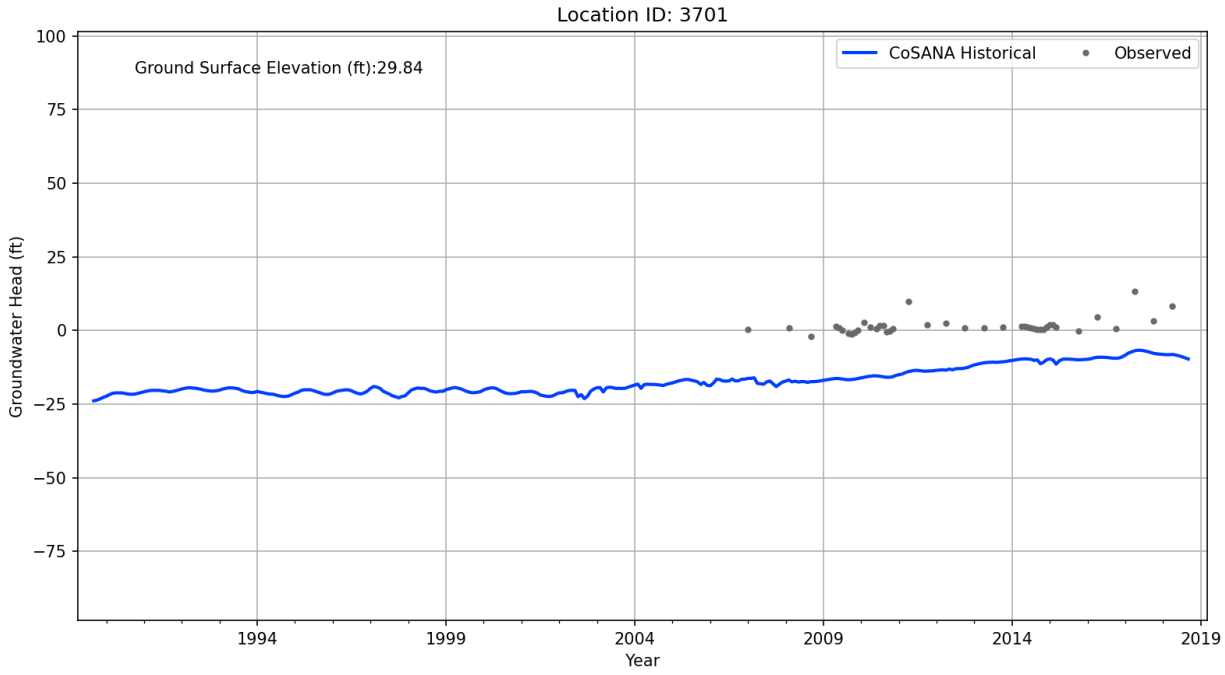

Location ID: 3332
Ground Surface Elevation (ft):47.73
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

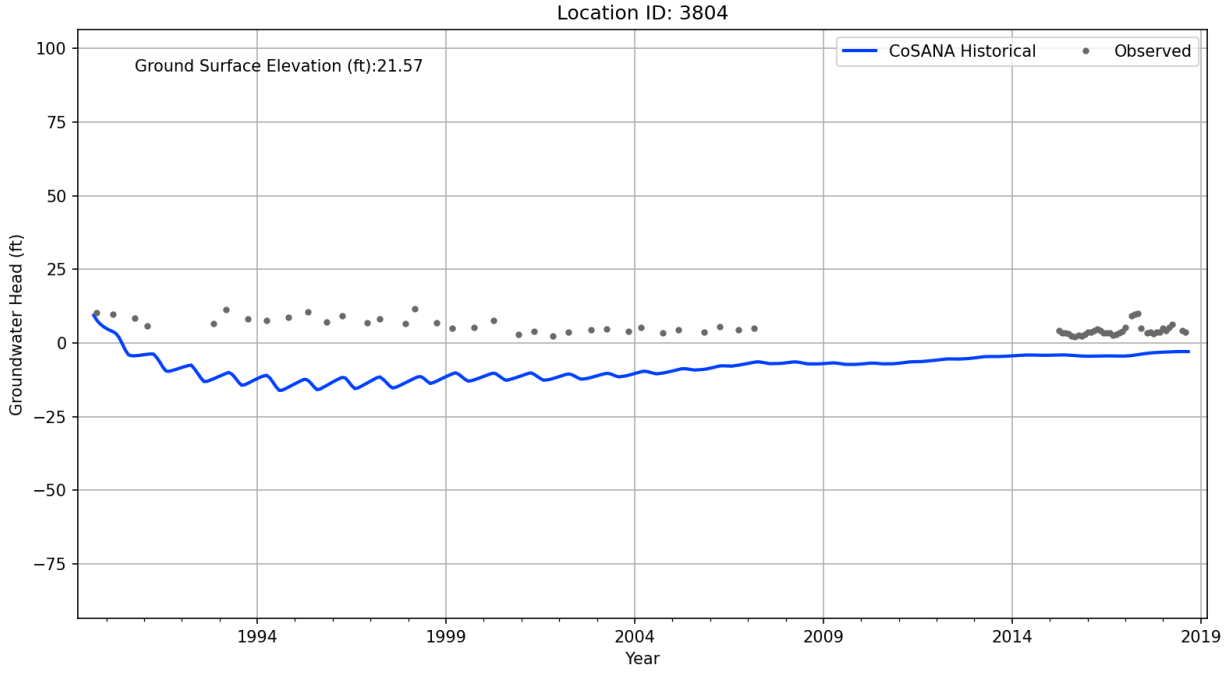

Location ID: 3333
Ground Surface Elevation (ft):47.73
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

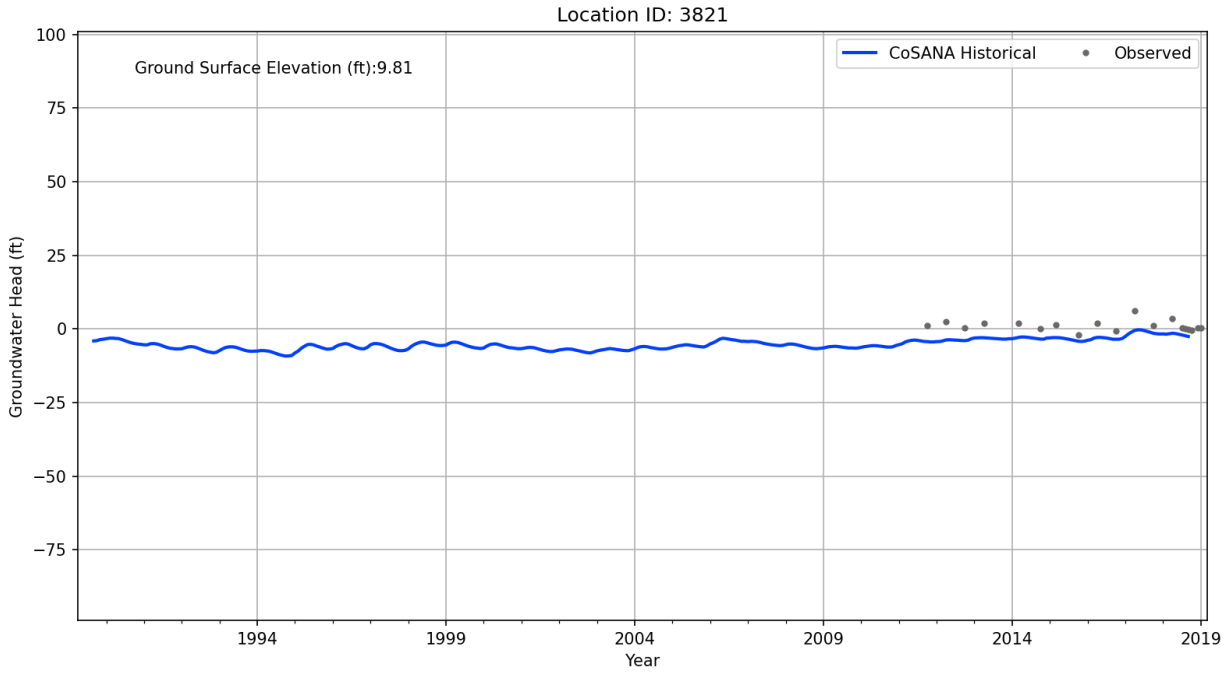

Location ID: 3334
Ground Surface Elevation (ft):47.73
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

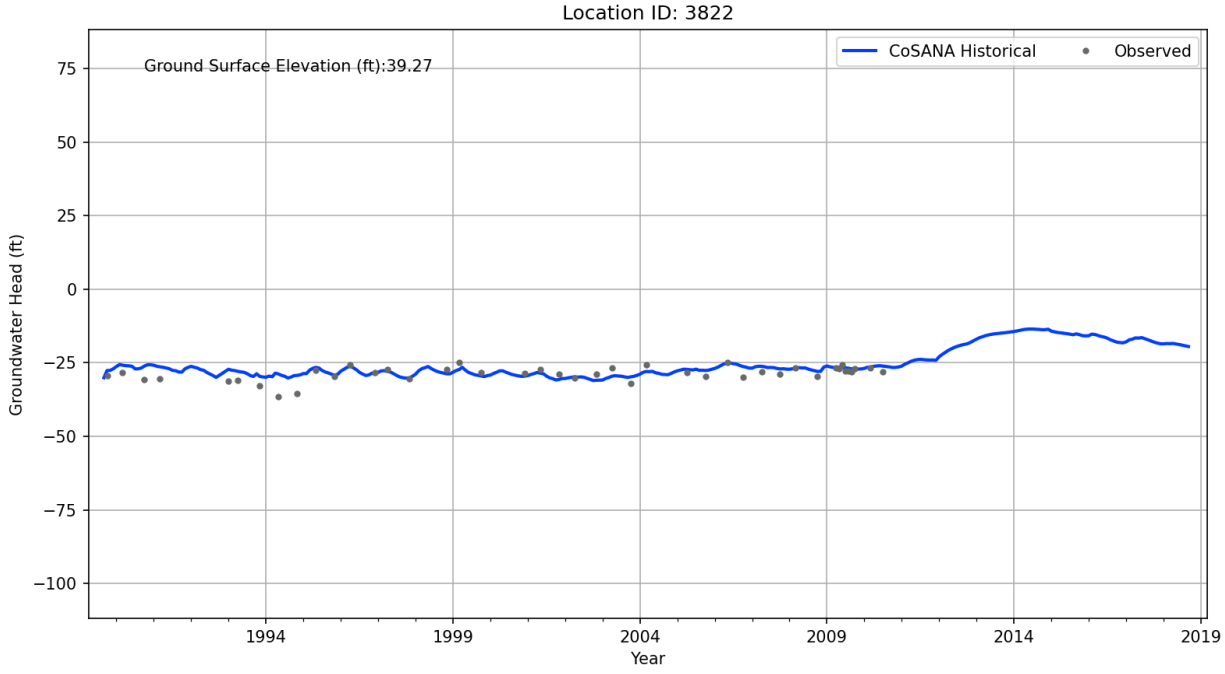

Location ID: 3335
Ground Surface Elevation (ft):47.73
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

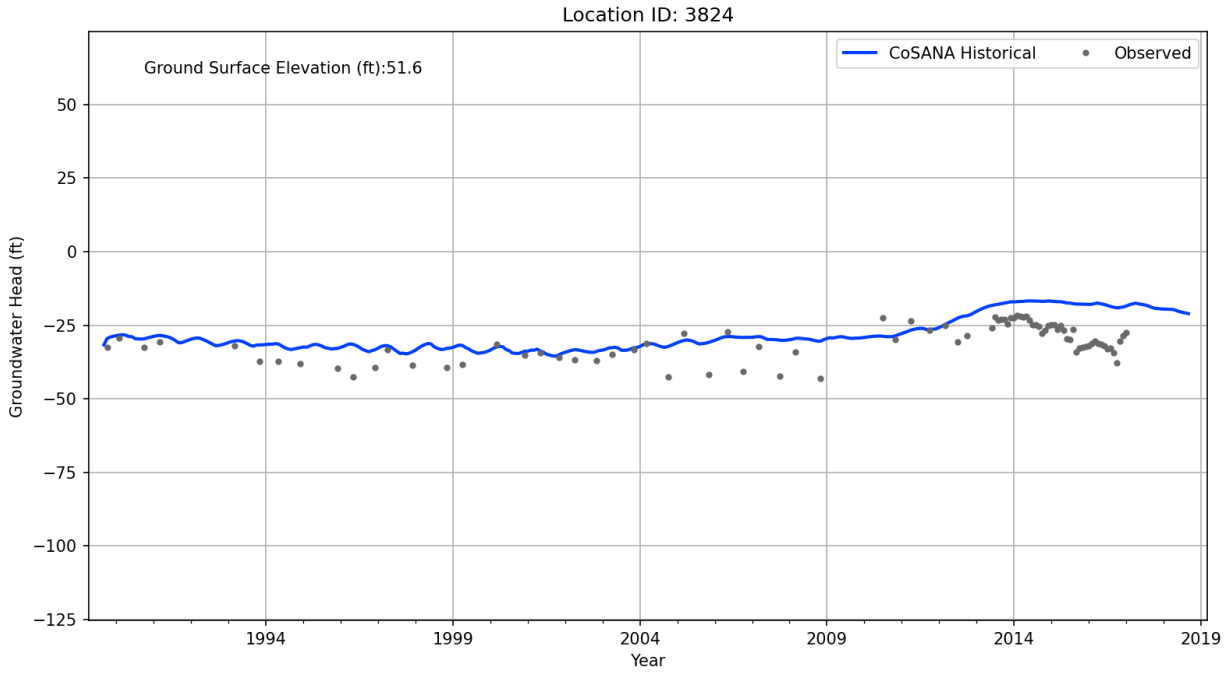

Location ID: 3340
Ground Surface Elevation (ft):56.37
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

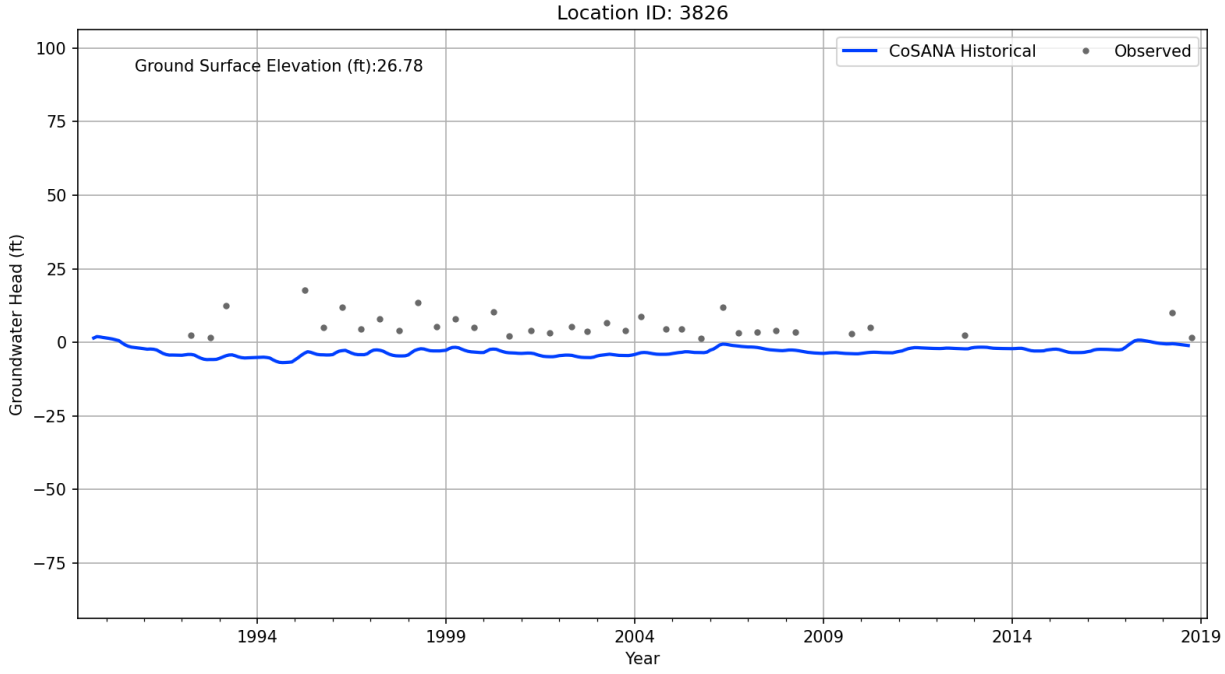

Location ID: 3701
Ground Surface Elevation (ft):29.84
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

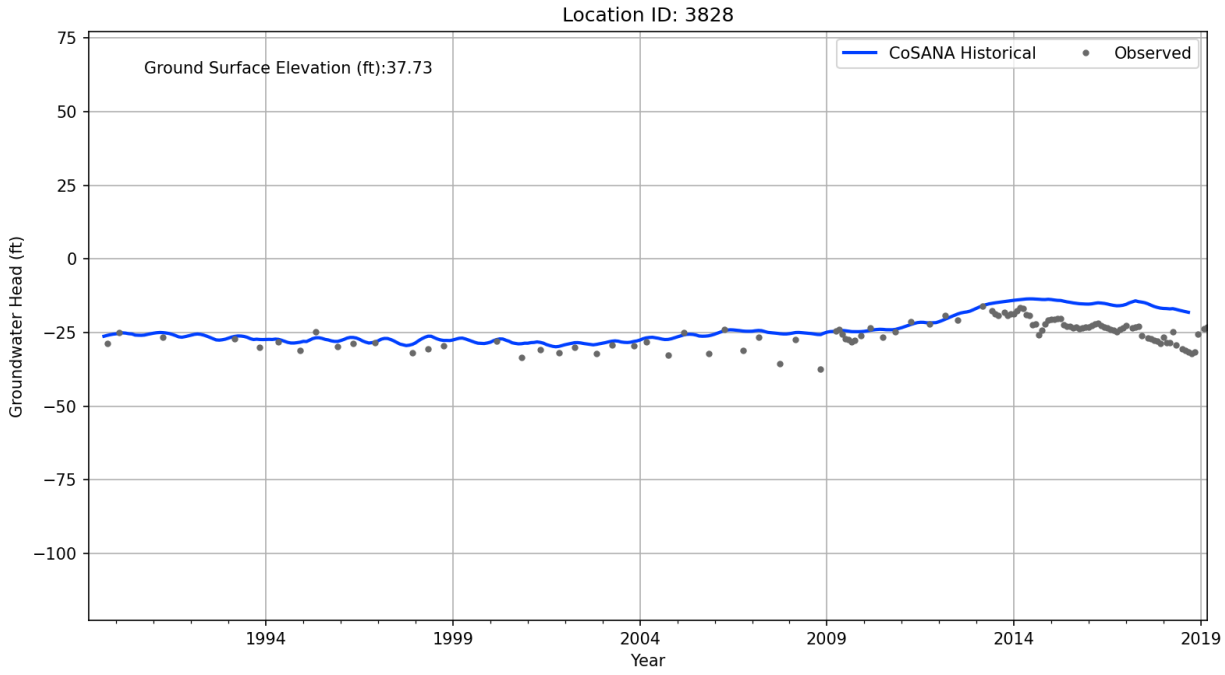

Location ID: 3804
Ground Surface Elevation (ft):21.57
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

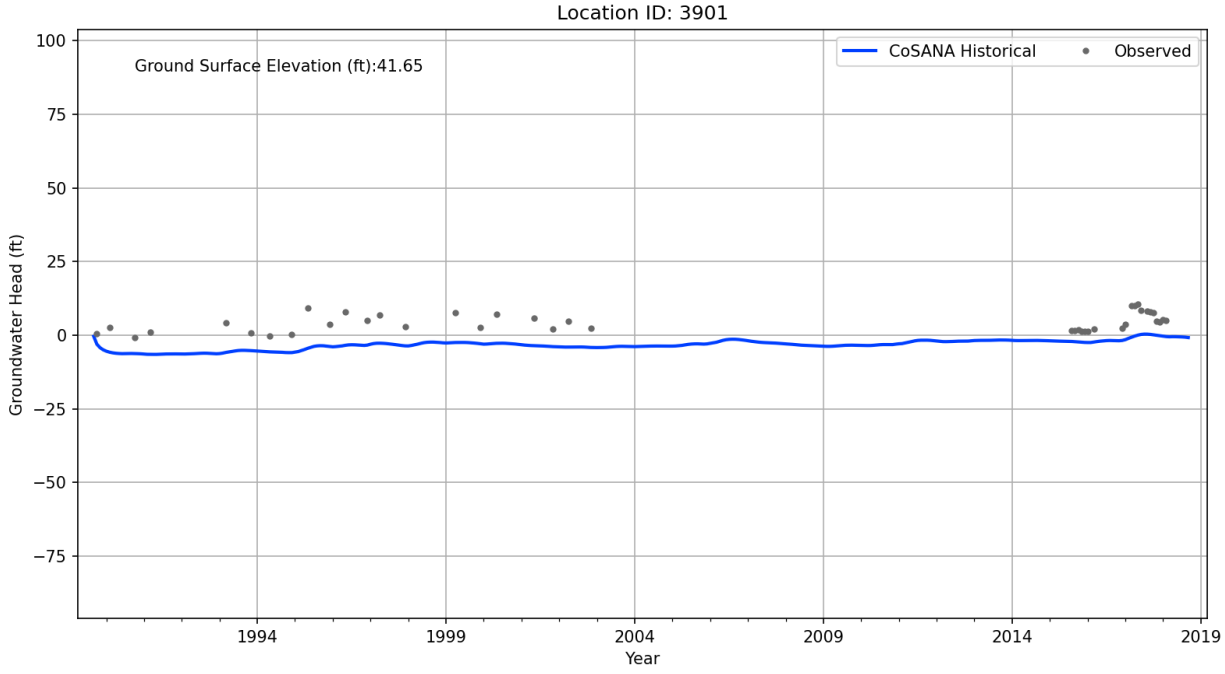

Location ID: 3821
Ground Surface Elevation (ft):9.81
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

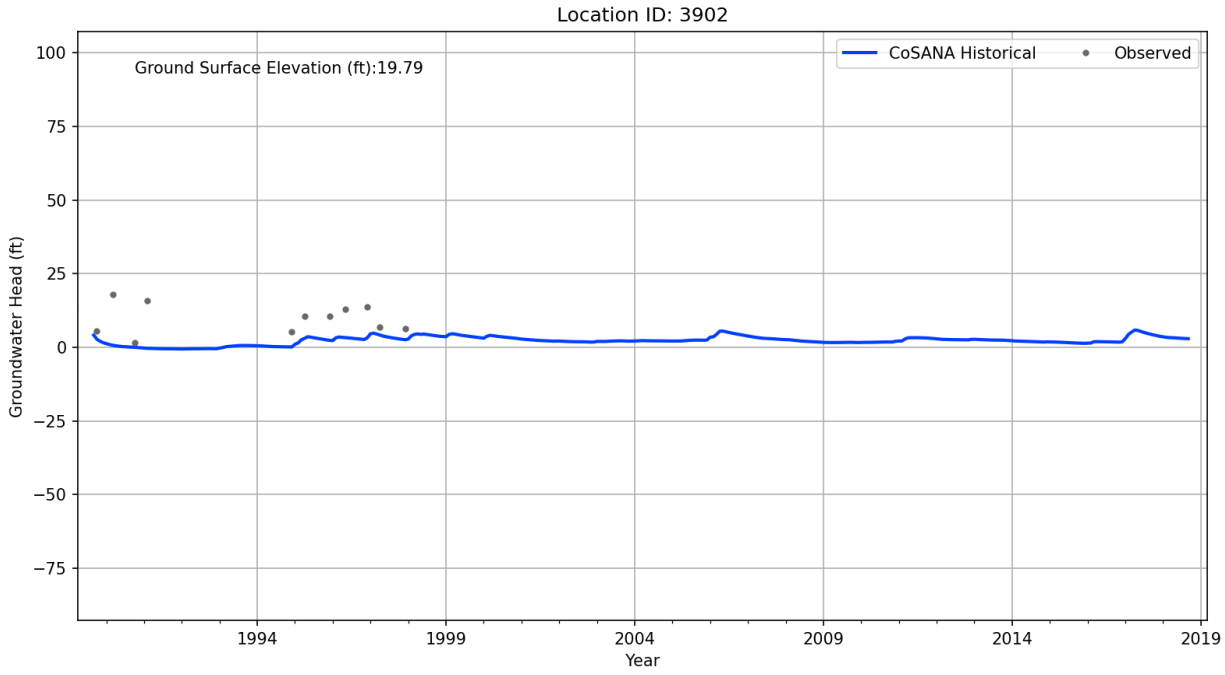

Location ID: 3822
Ground Surface Elevation (ft):39.27
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

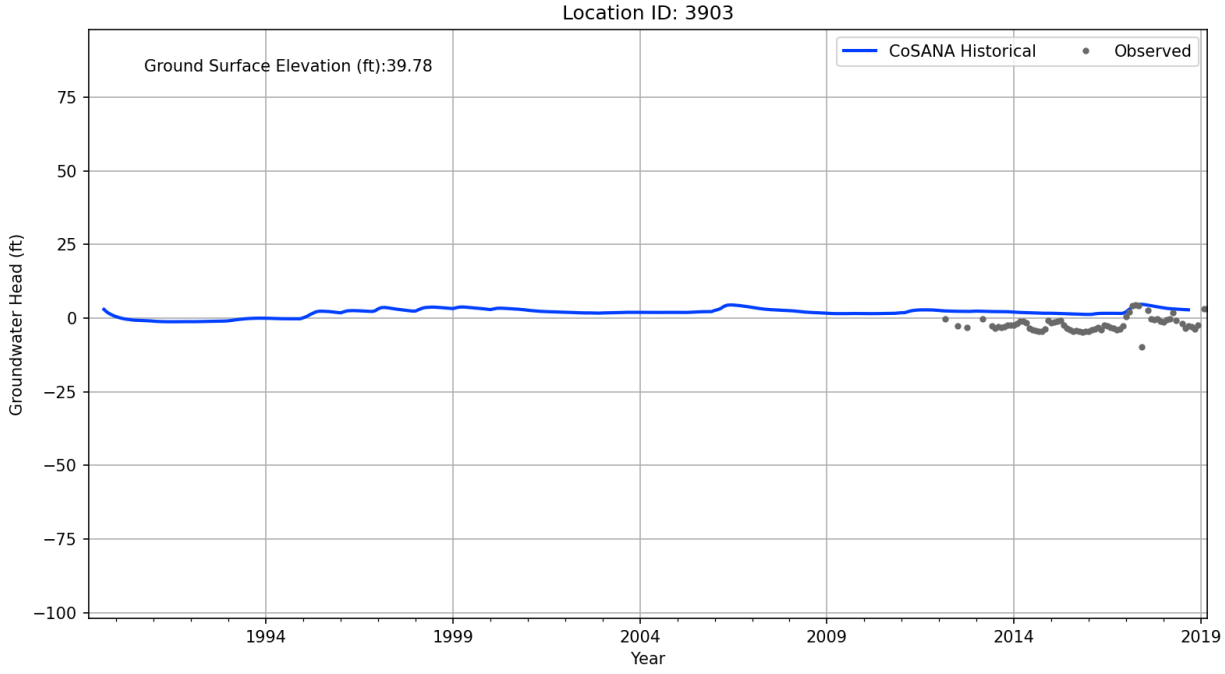

Location ID: 3824
Ground Surface Elevation (ft):51.6
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

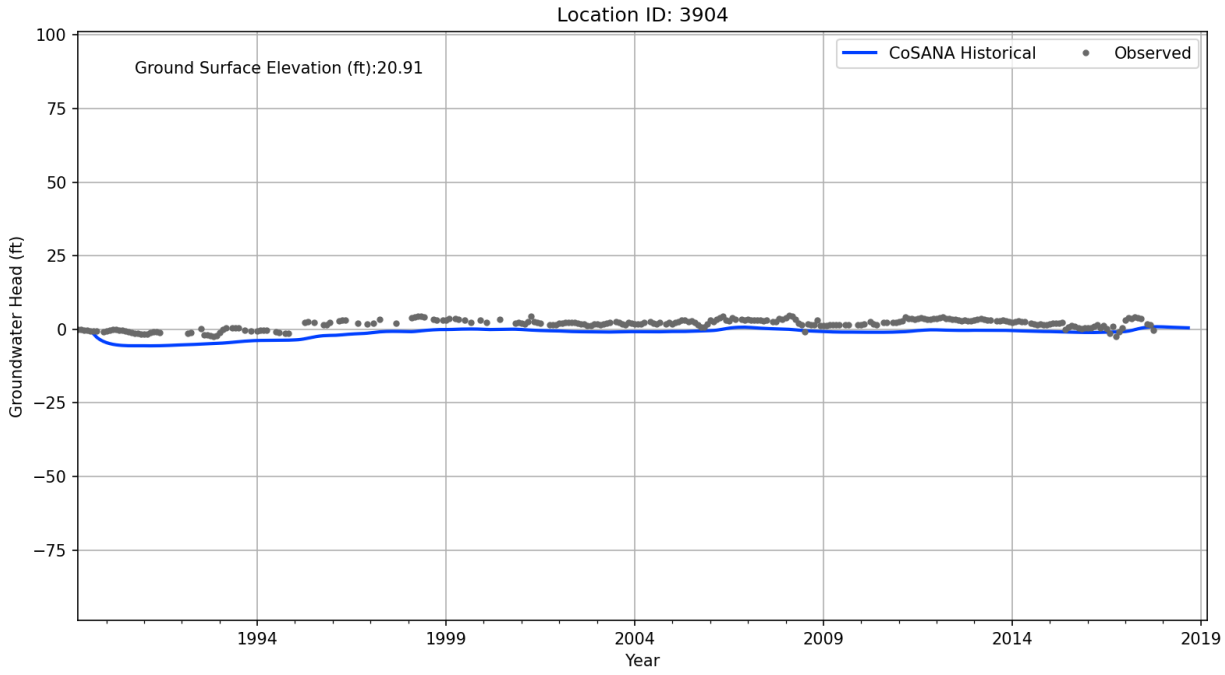

Location ID: 3826
Ground Surface Elevation (ft):26.78
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

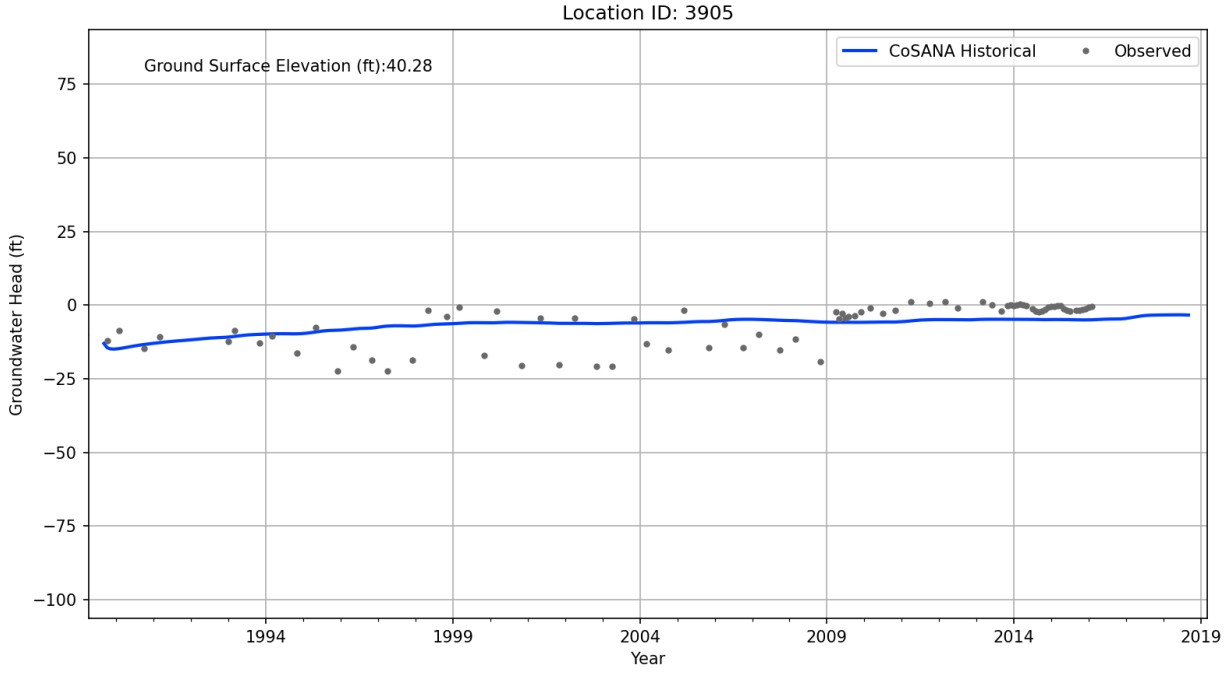

Location ID: 3828
Ground Surface Elevation (ft):37.73
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

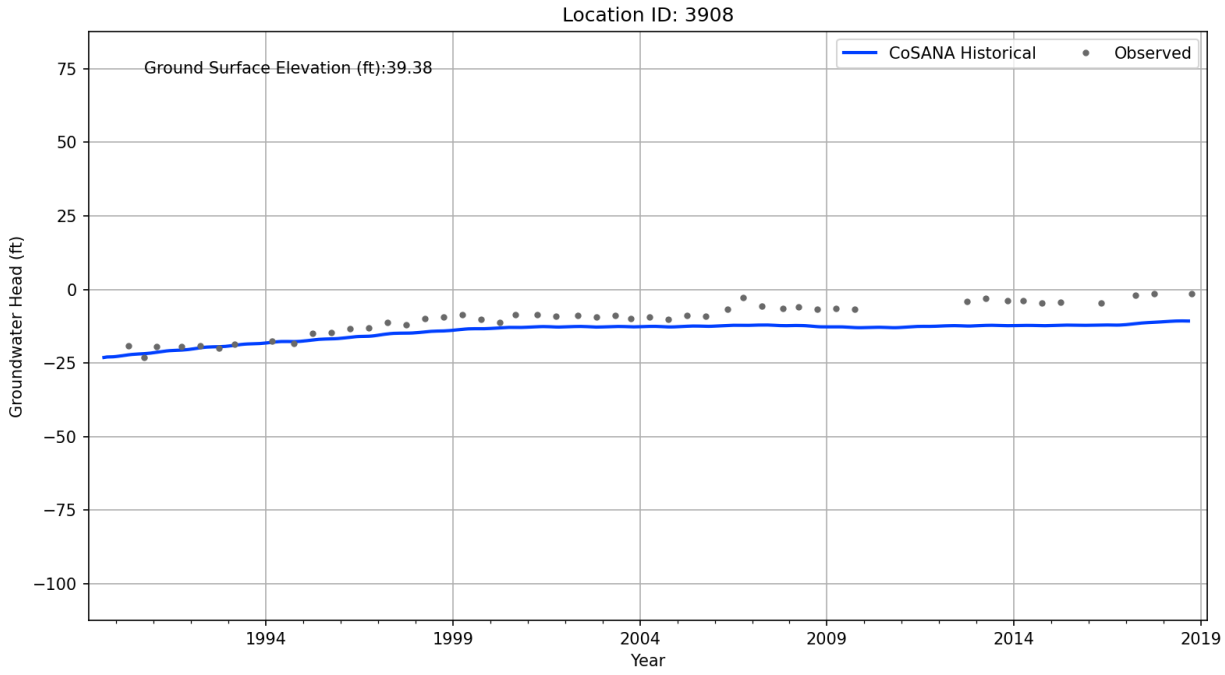

Location ID: 3901
Ground Surface Elevation (ft):41.65
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

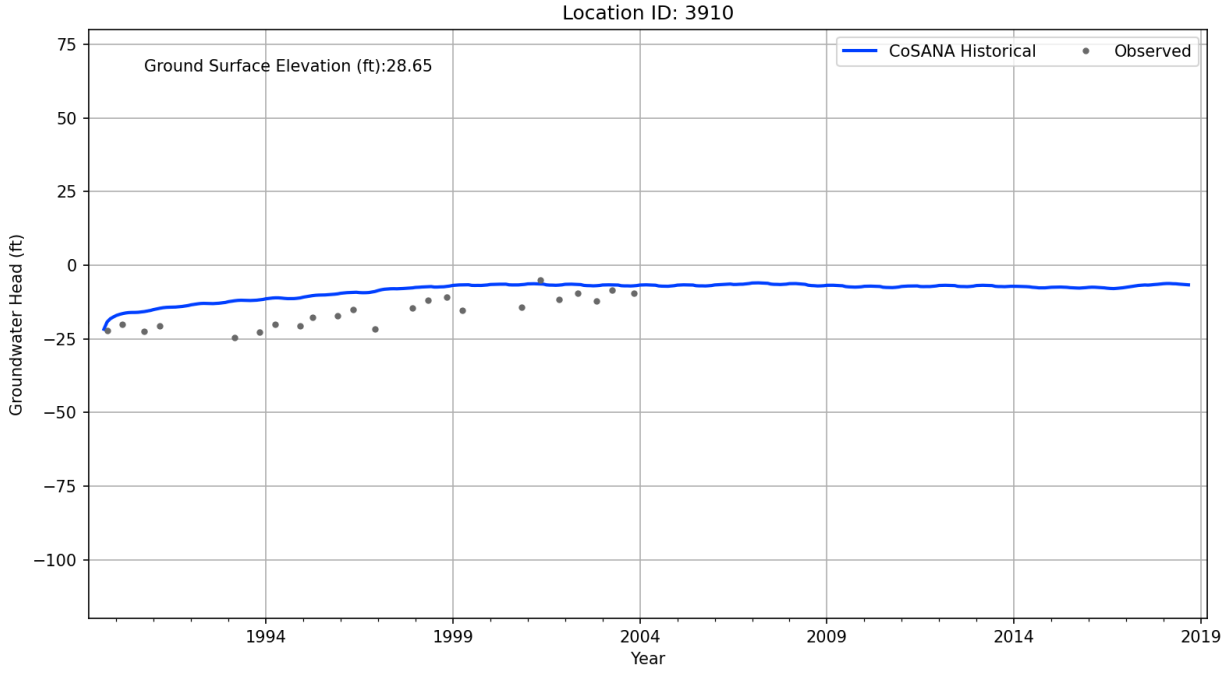

Location ID: 3902
Ground Surface Elevation (ft):19.79
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

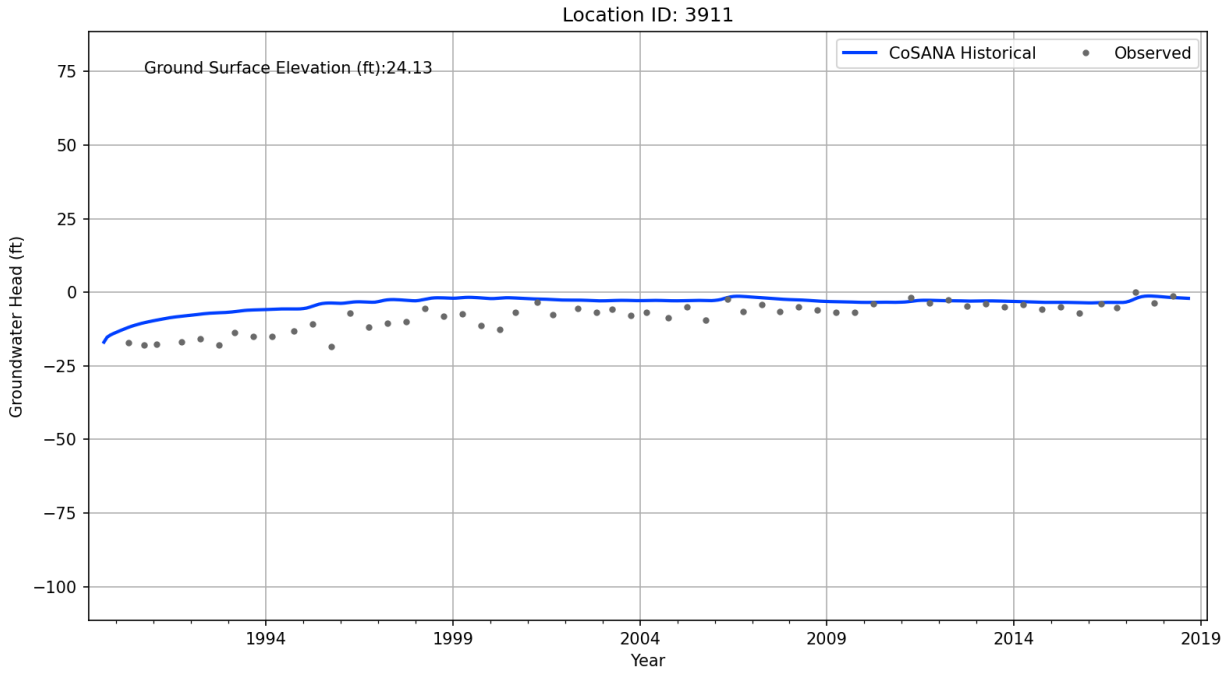

Location ID: 3903
Ground Surface Elevation (ft):39.78
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

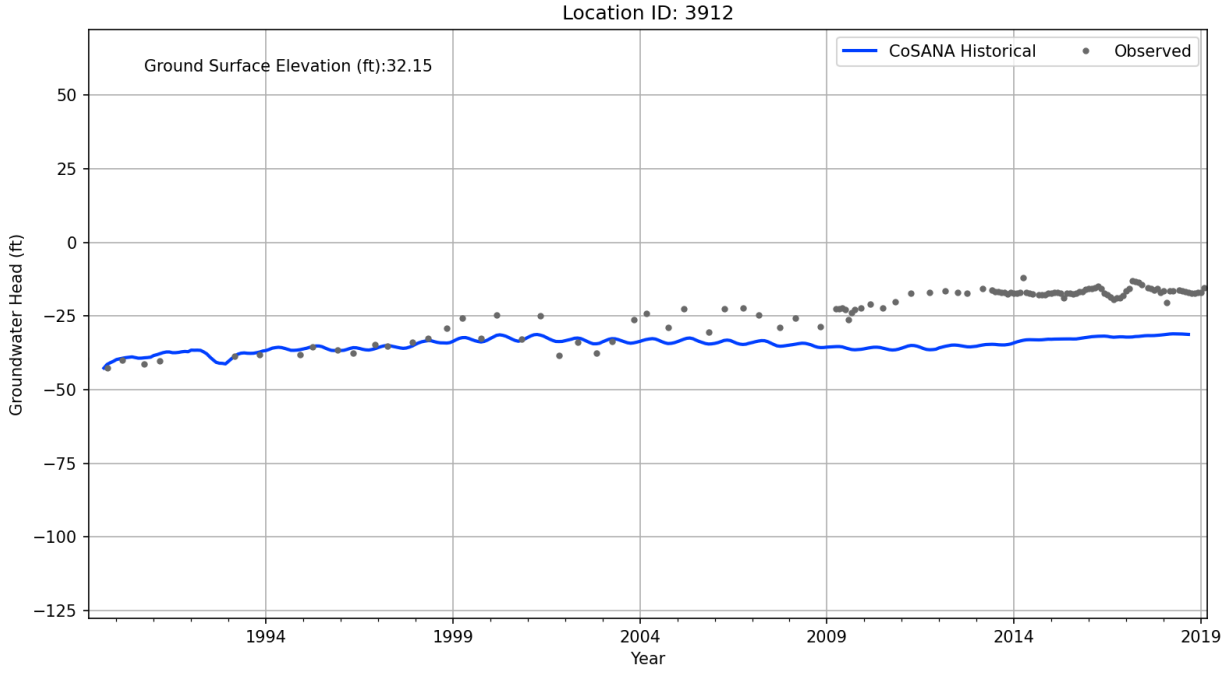

Location ID: 3904
Ground Surface Elevation (ft):20.91
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

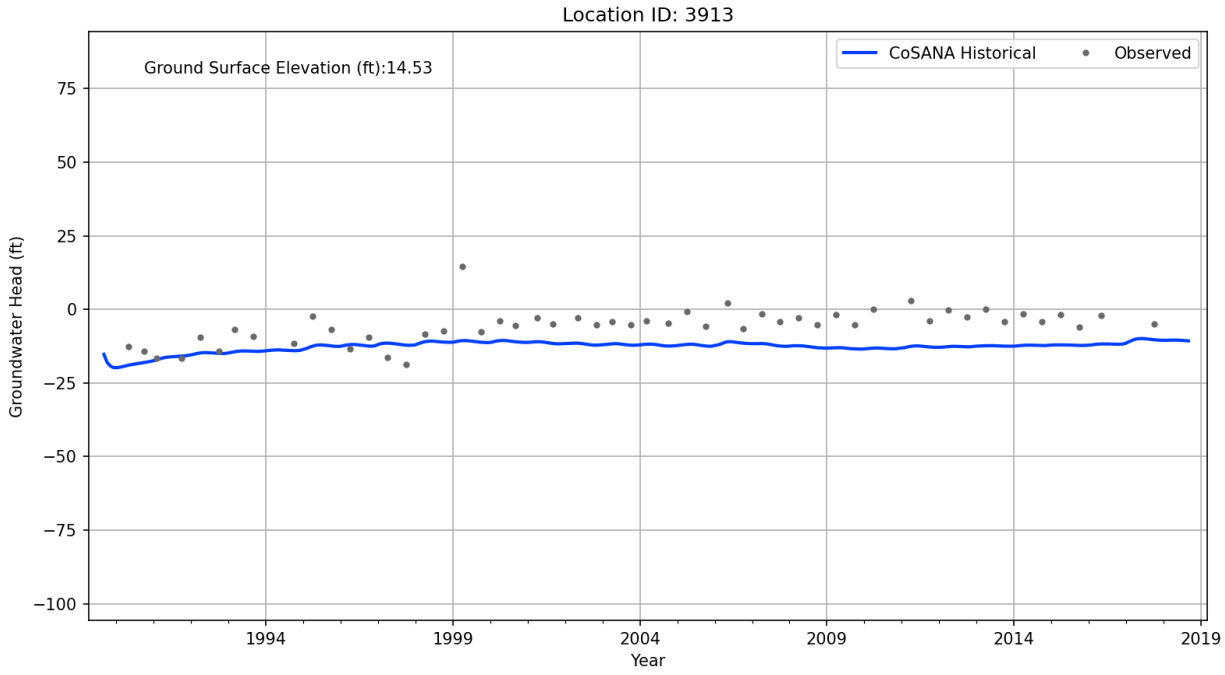

Location ID: 3905
Ground Surface Elevation (ft):40.28
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

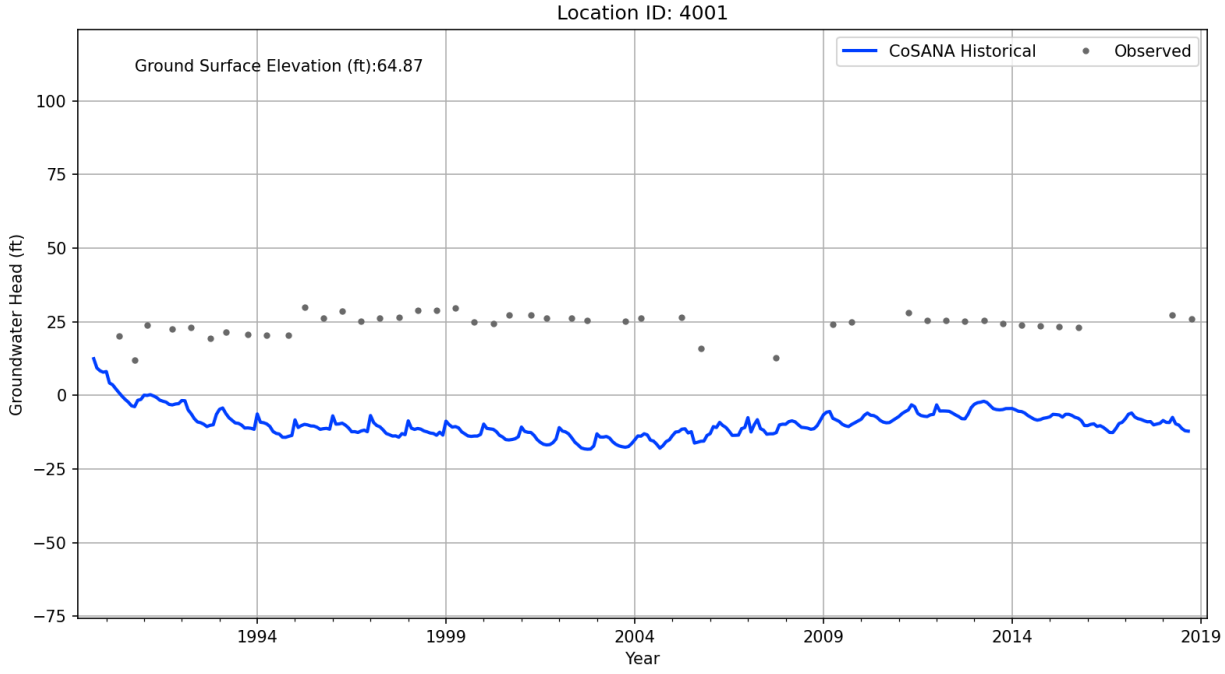

Location ID: 3908
Ground Surface Elevation (ft):39.38
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

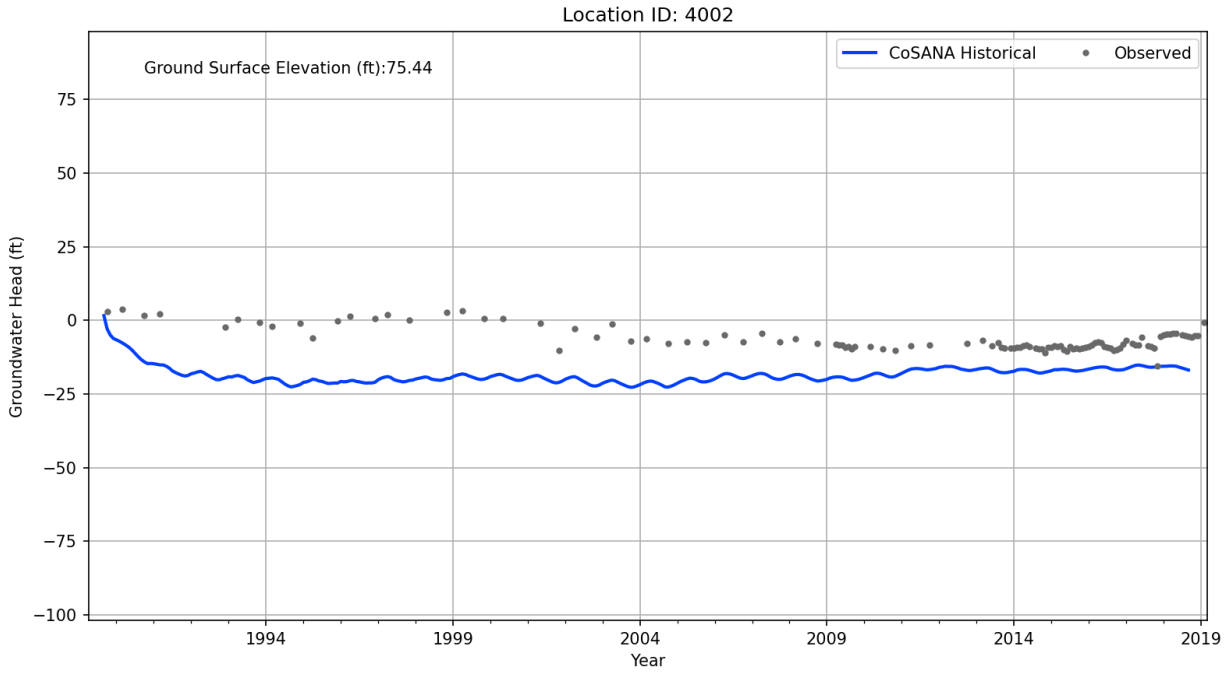

Location ID: 3910
Ground Surface Elevation (ft):28.65
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

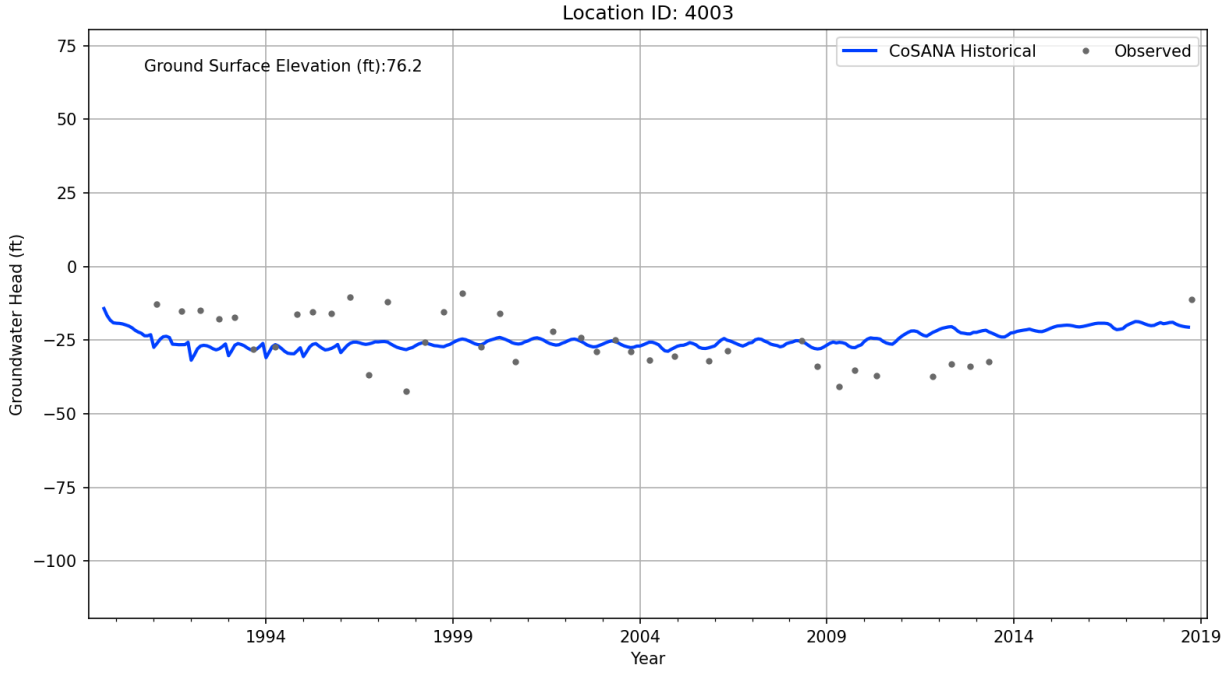

Location ID: 3911
Ground Surface Elevation (ft):24.13
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

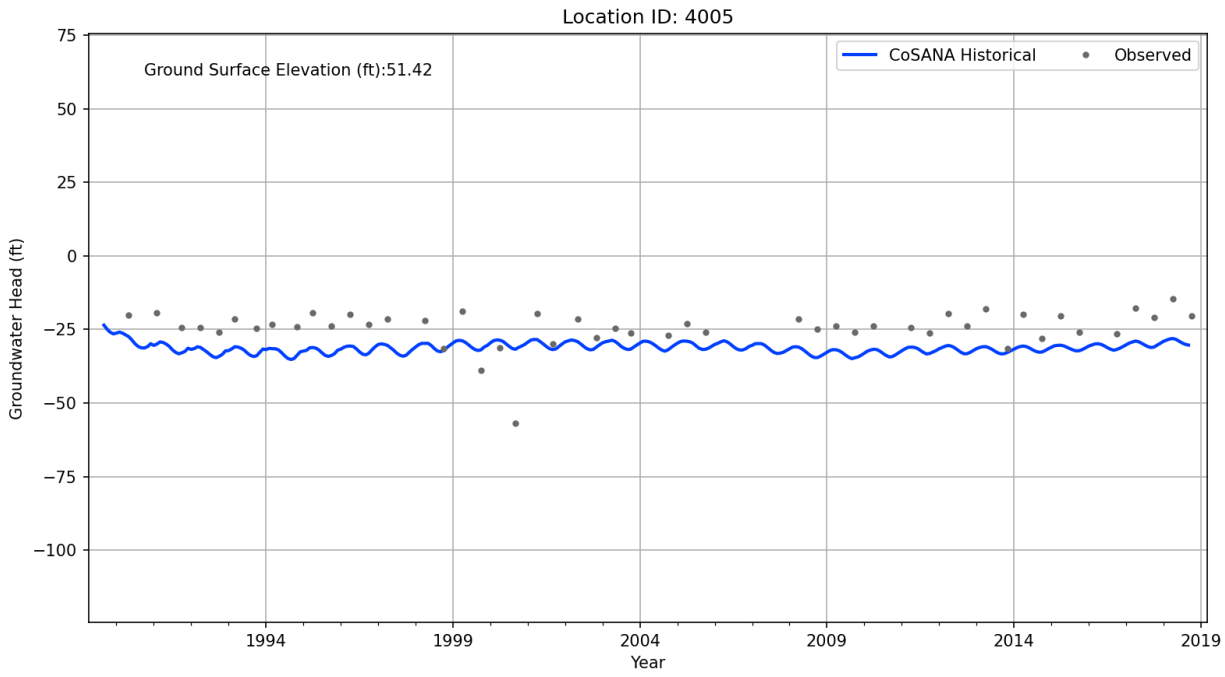

Location ID: 3912
Ground Surface Elevation (ft):32.15
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

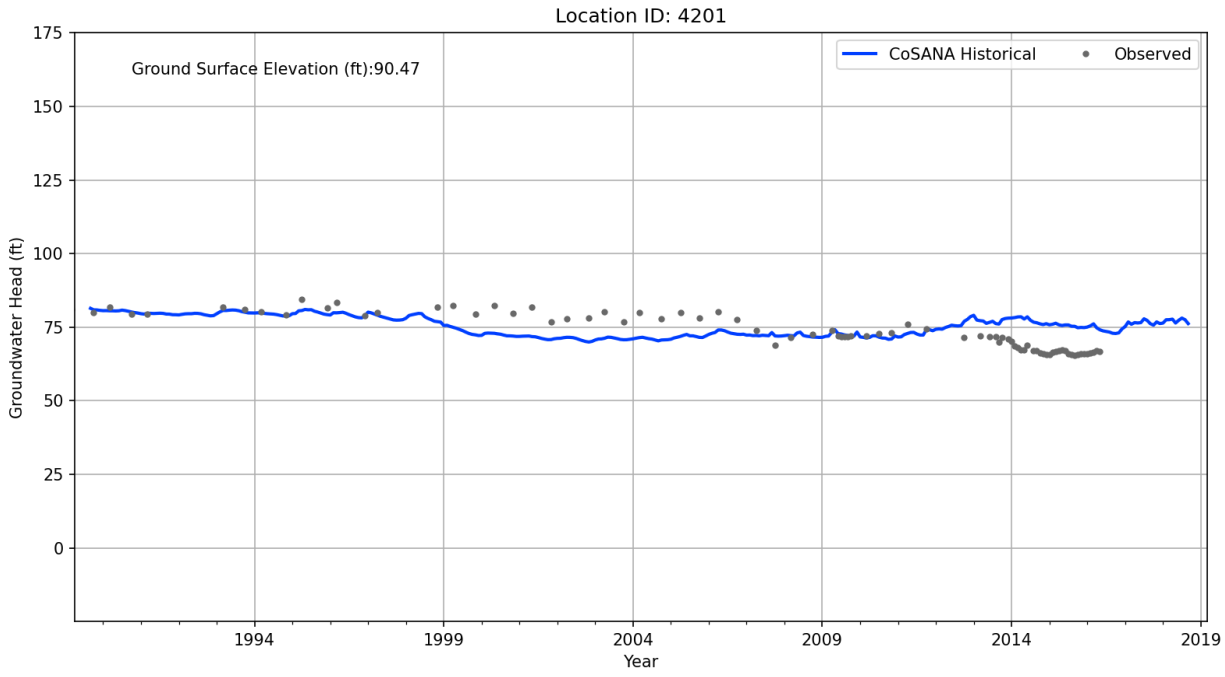

Location ID: 3913
Ground Surface Elevation (ft):14.53
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

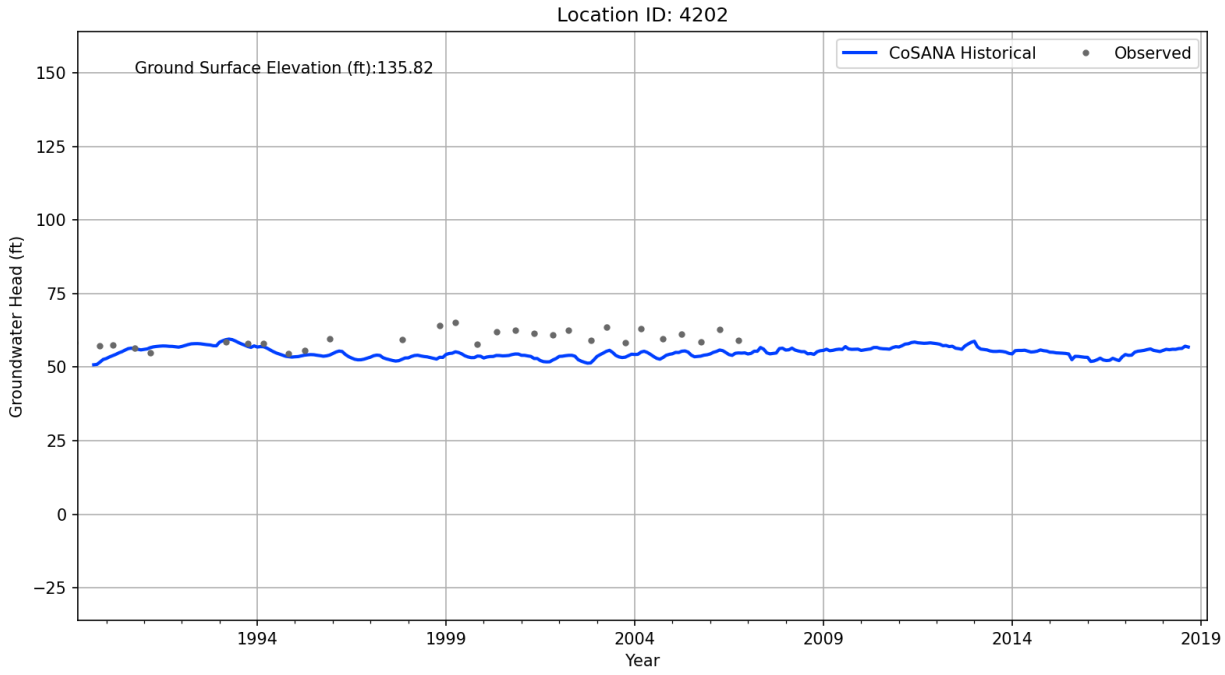

Location ID: 4001
Ground Surface Elevation (ft):64.87
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

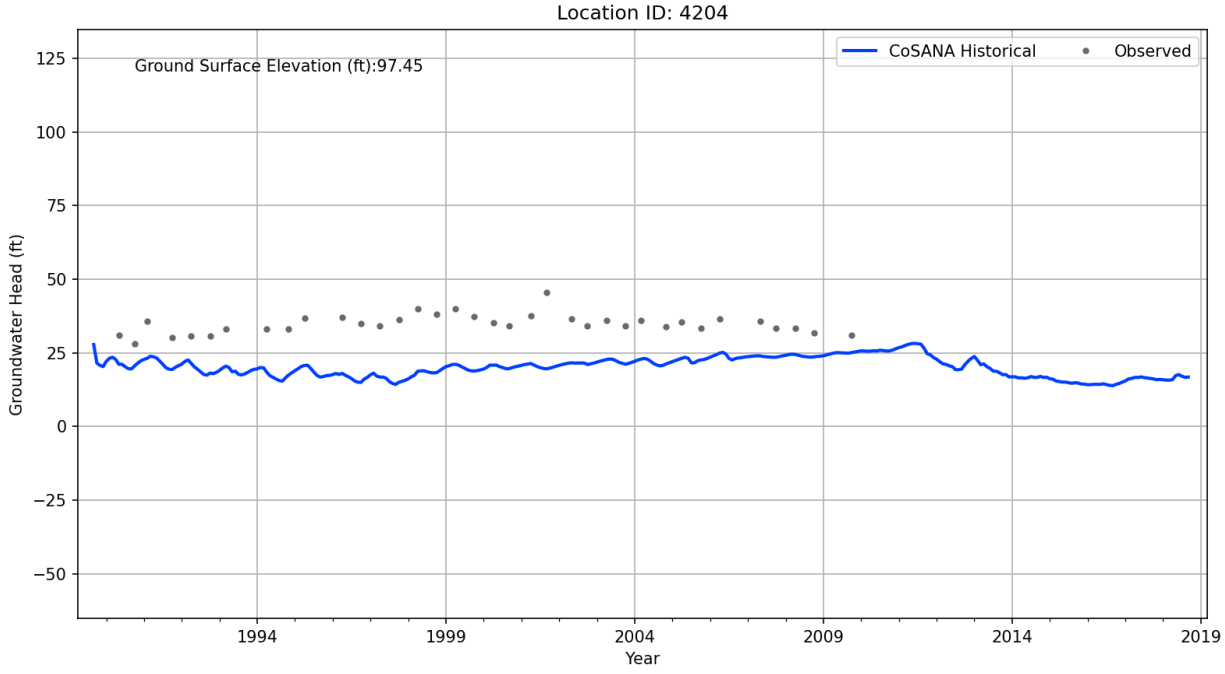

Location ID: 4002
Ground Surface Elevation (ft):75.44
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

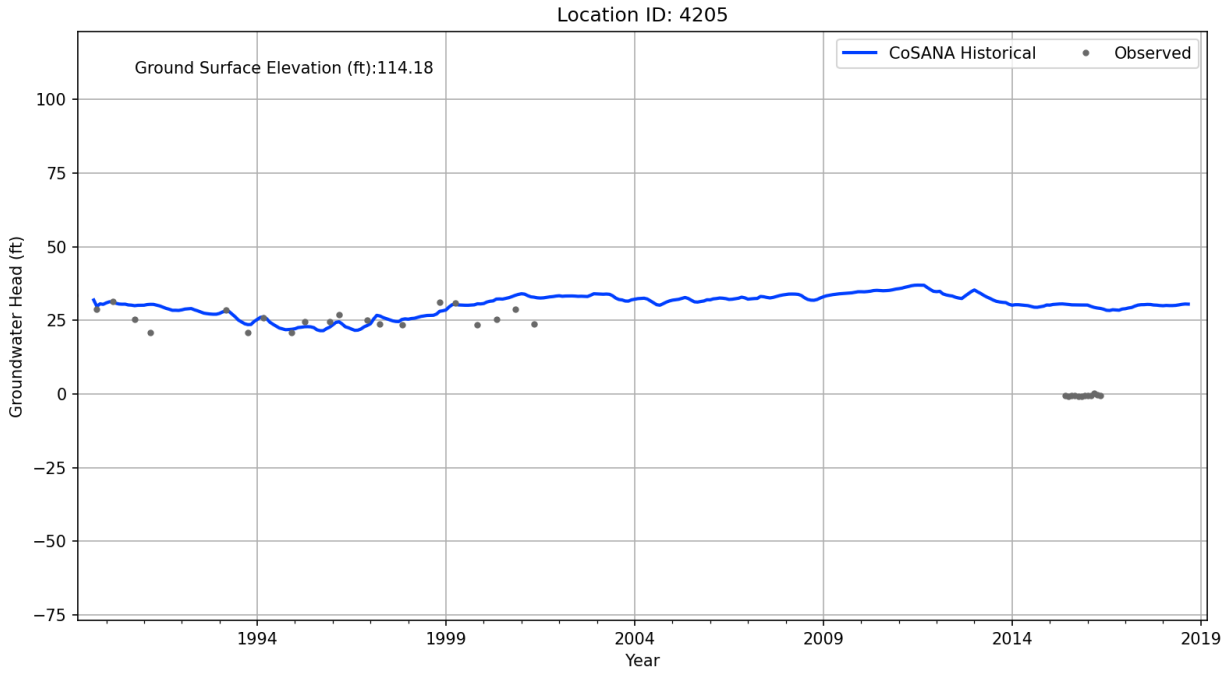

Location ID: 4003
Ground Surface Elevation (ft):76.2
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

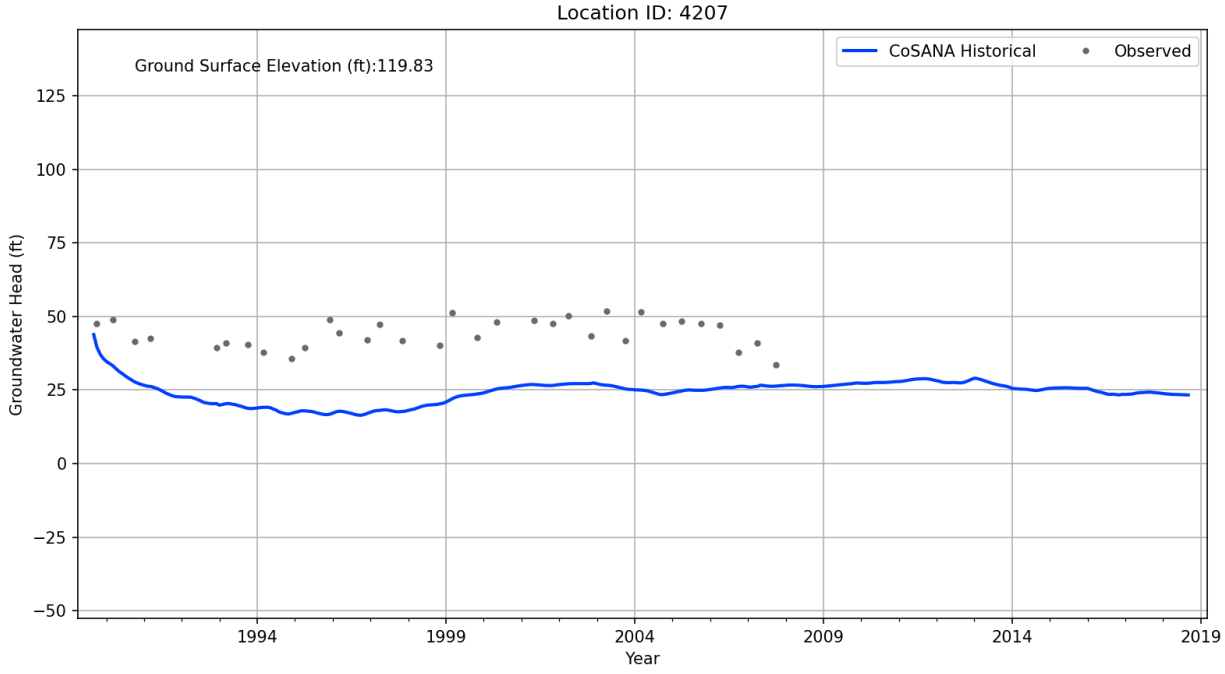

Location ID: 4005
Ground Surface Elevation (ft):51.42
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

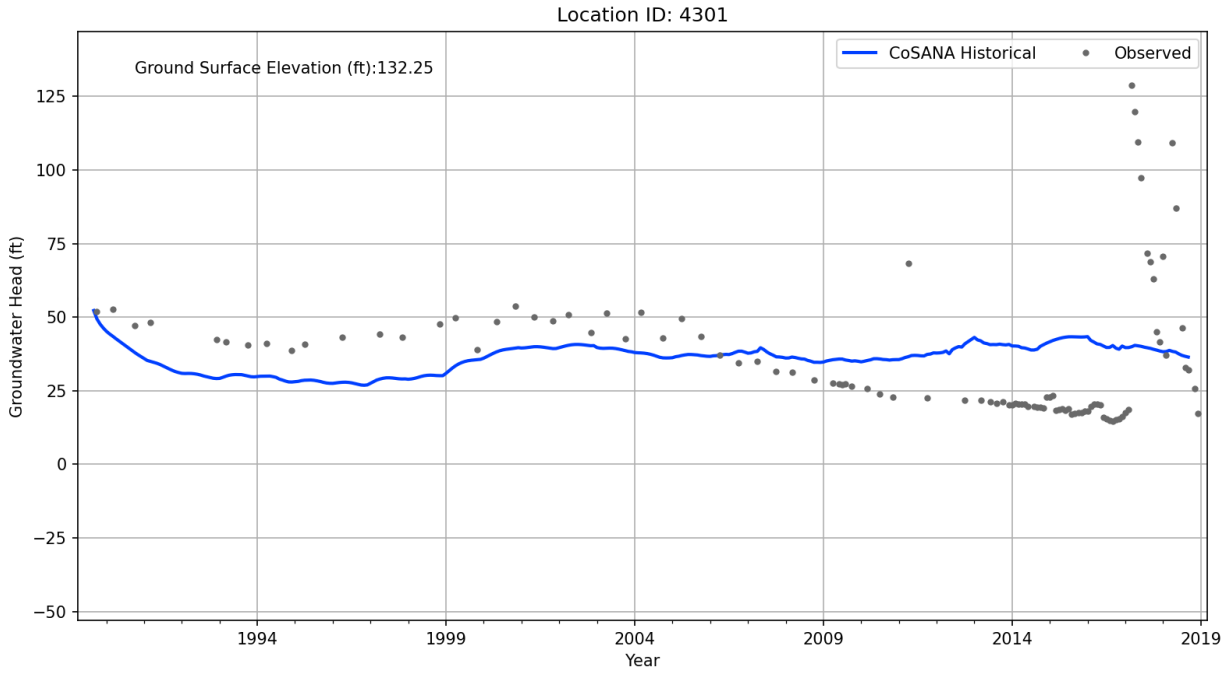

Location ID: 4201
Ground Surface Elevation (ft):90.47
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year

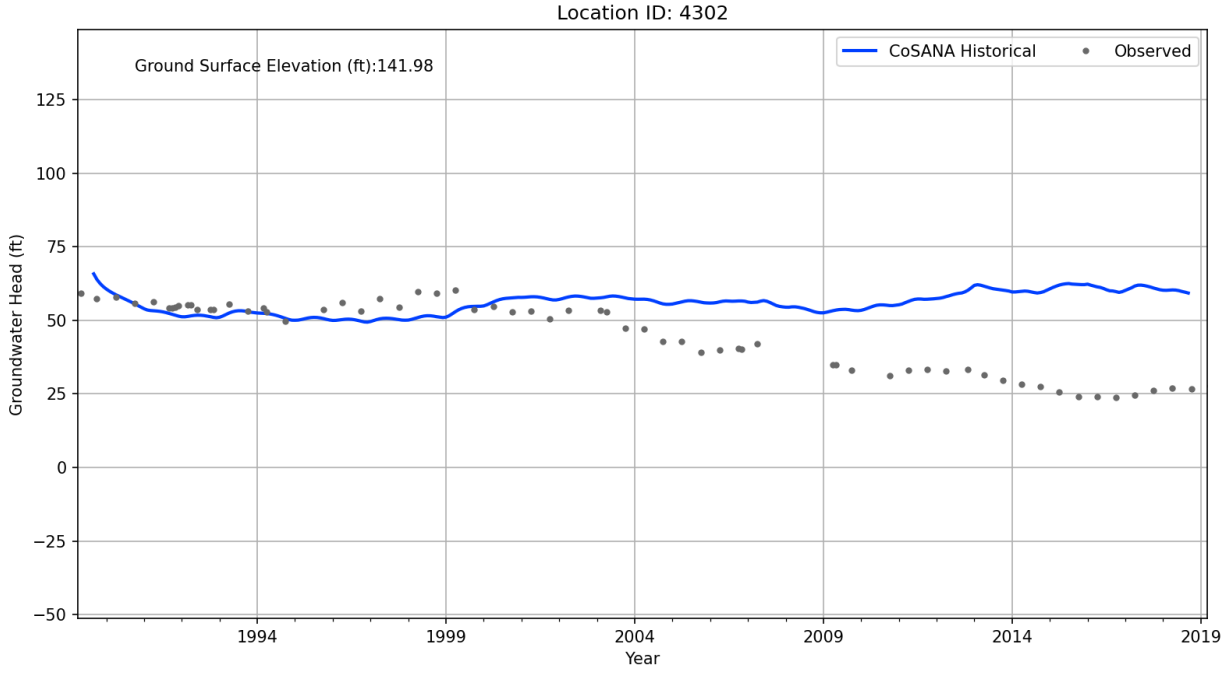

Location ID: 4202
Ground Surface Elevation (ft):135.82
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

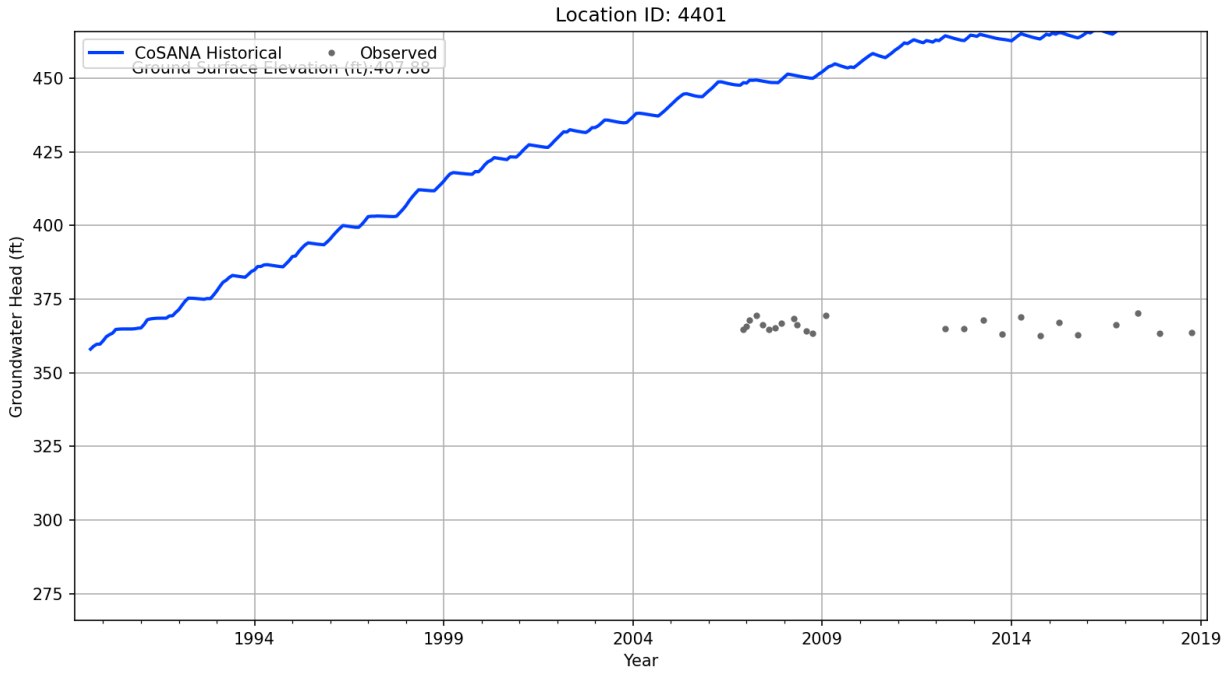

Location ID: 4204
Ground Surface Elevation (ft):97.45
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

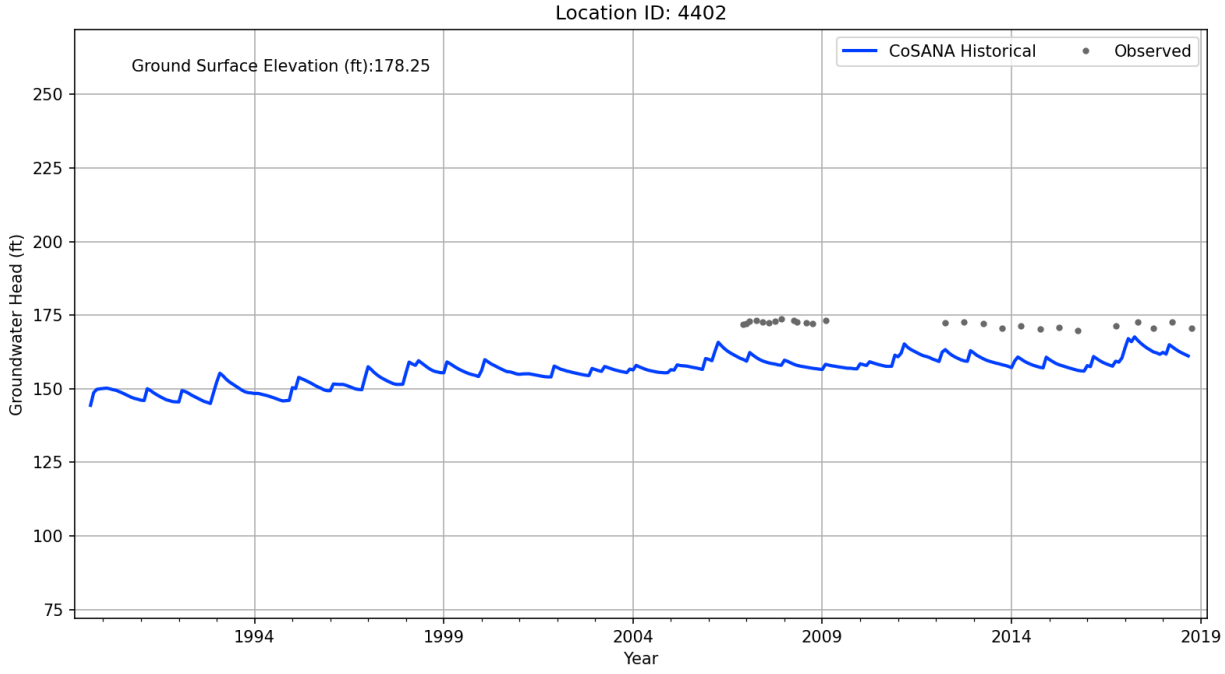

Location ID: 4205
Ground Surface Elevation (ft):114.18
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

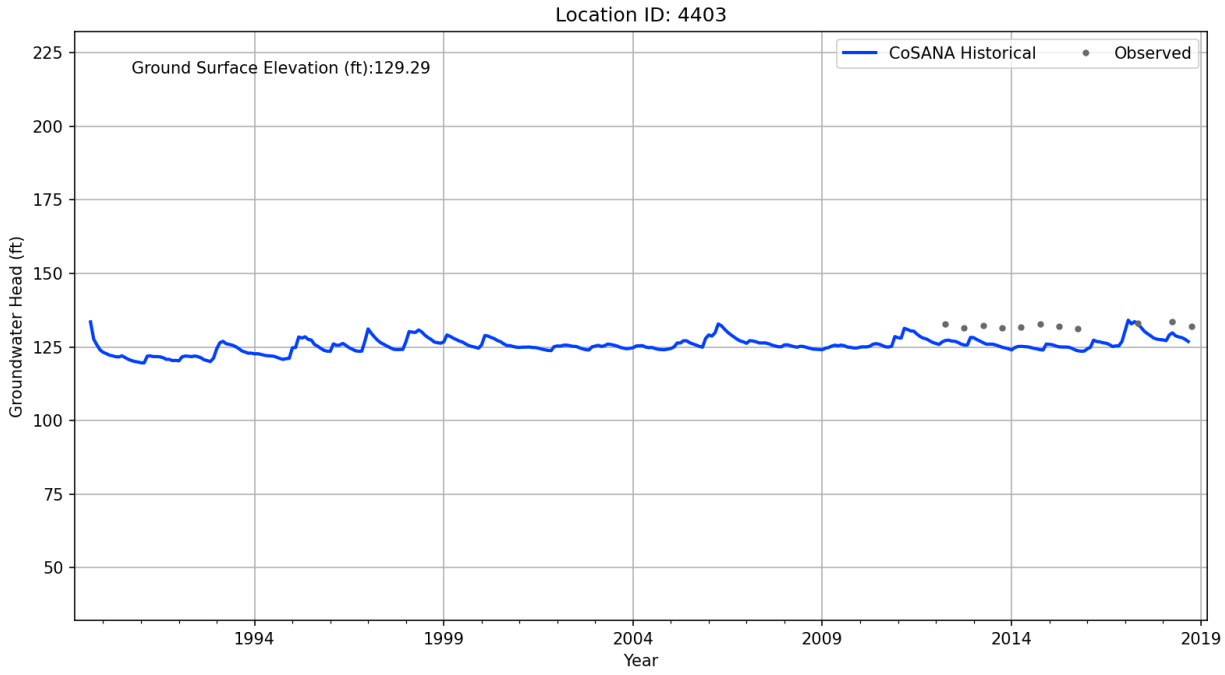

Location ID: 4207
Ground Surface Elevation (ft):119.83
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

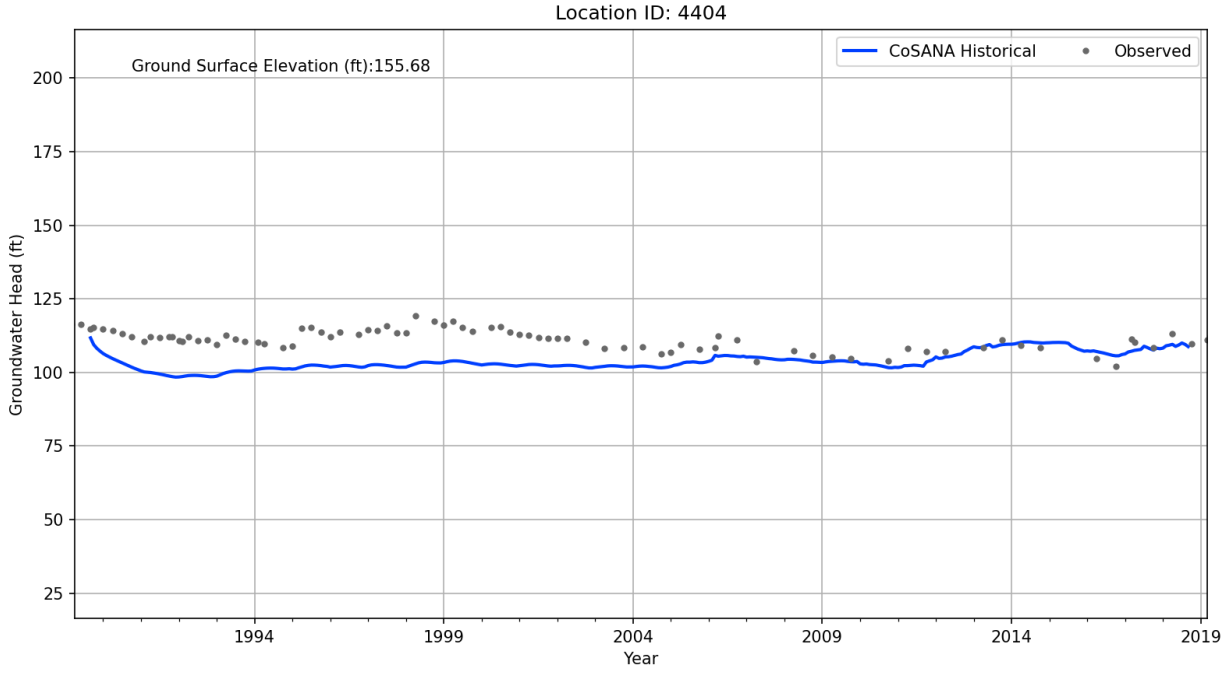

Location ID: 4301
Ground Surface Elevation (ft):132.25
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

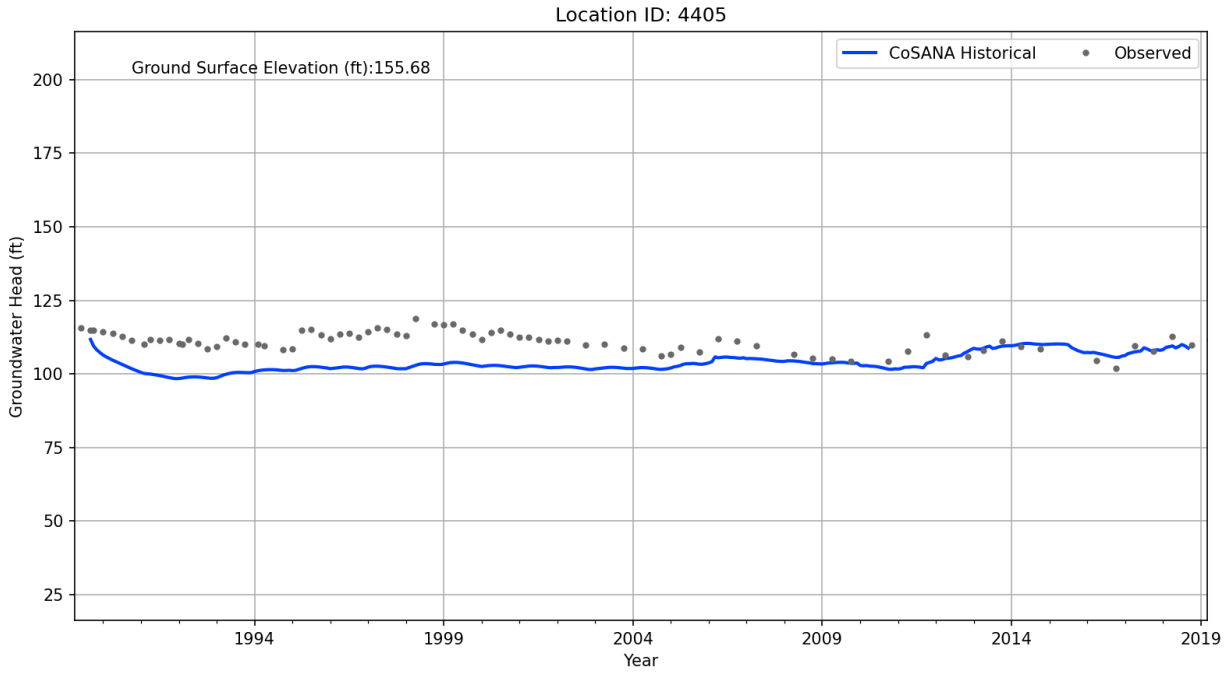

Location ID: 4302
Ground Surface Elevation (ft):141.98
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

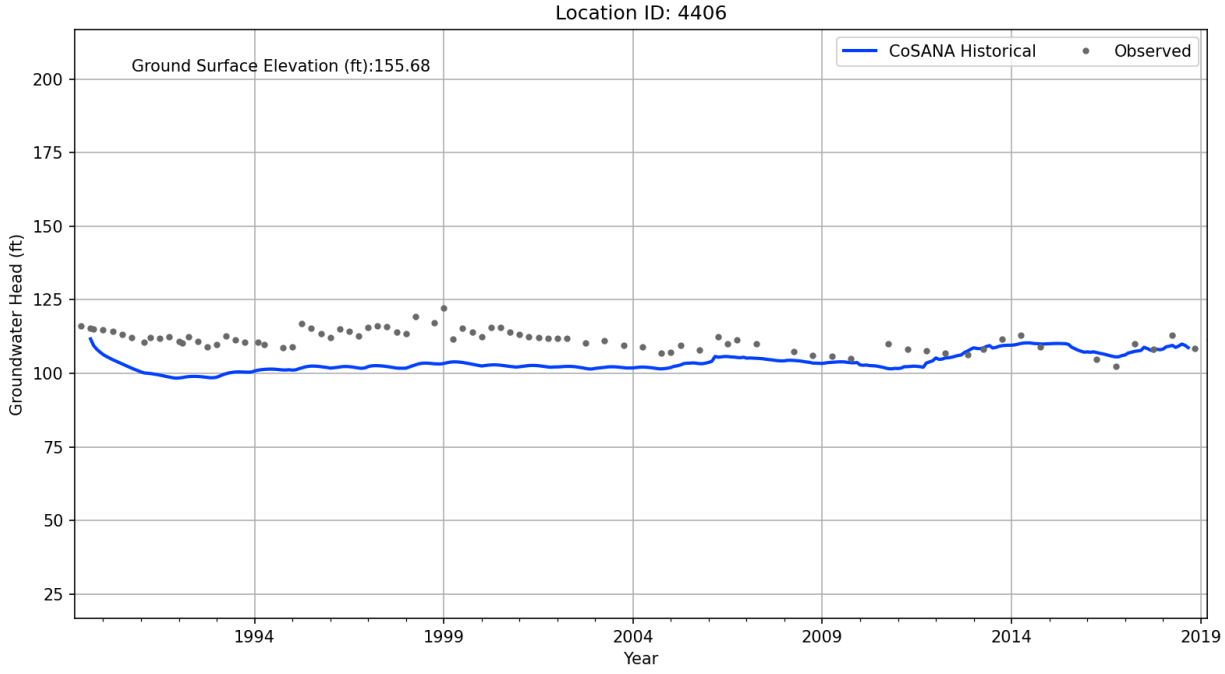

Location ID: 4401
CoSANA Historical
Observed
Ground Surface Elevation (ft):407.88
Groundwater Head (ft)
450
425
400
375
350
325
300
275
1994
1999
2004
2009
2014
2019
Year

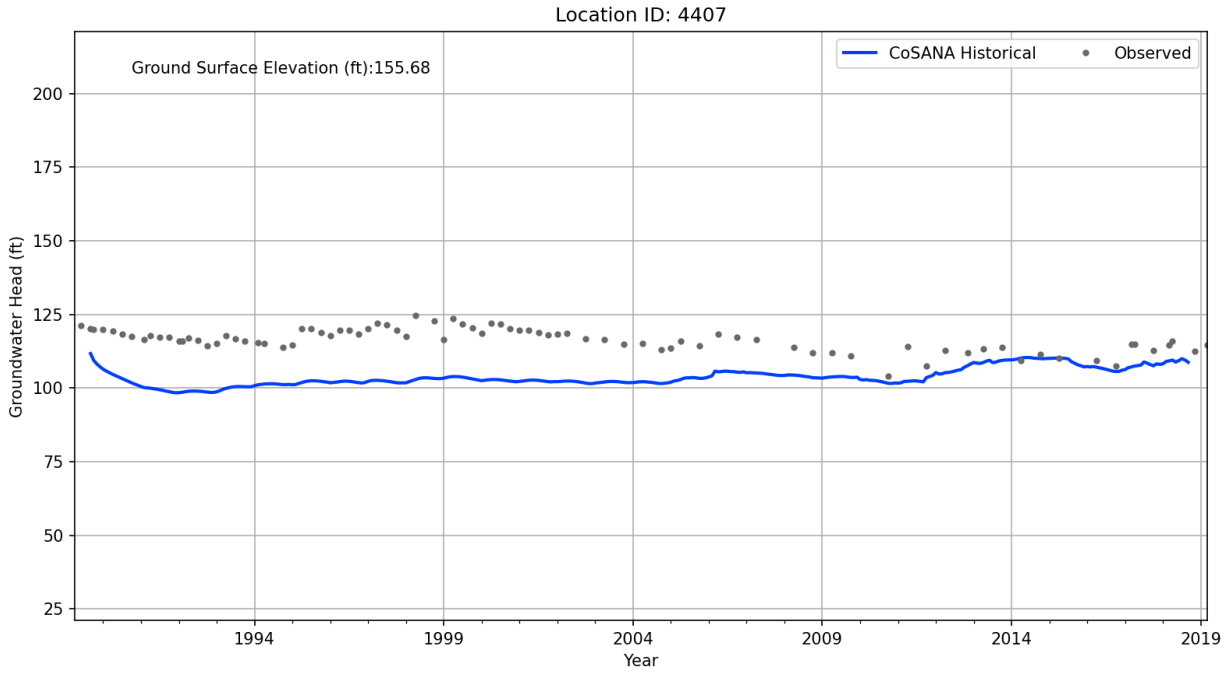

Location ID: 4402
CoSANA Historical
Observed
Ground Surface Elevation (ft):178.25
Groundwater Head (ft)
250
225
200
175
150
125
100
75
1994
1999
2004
2009
2014
2019
Year

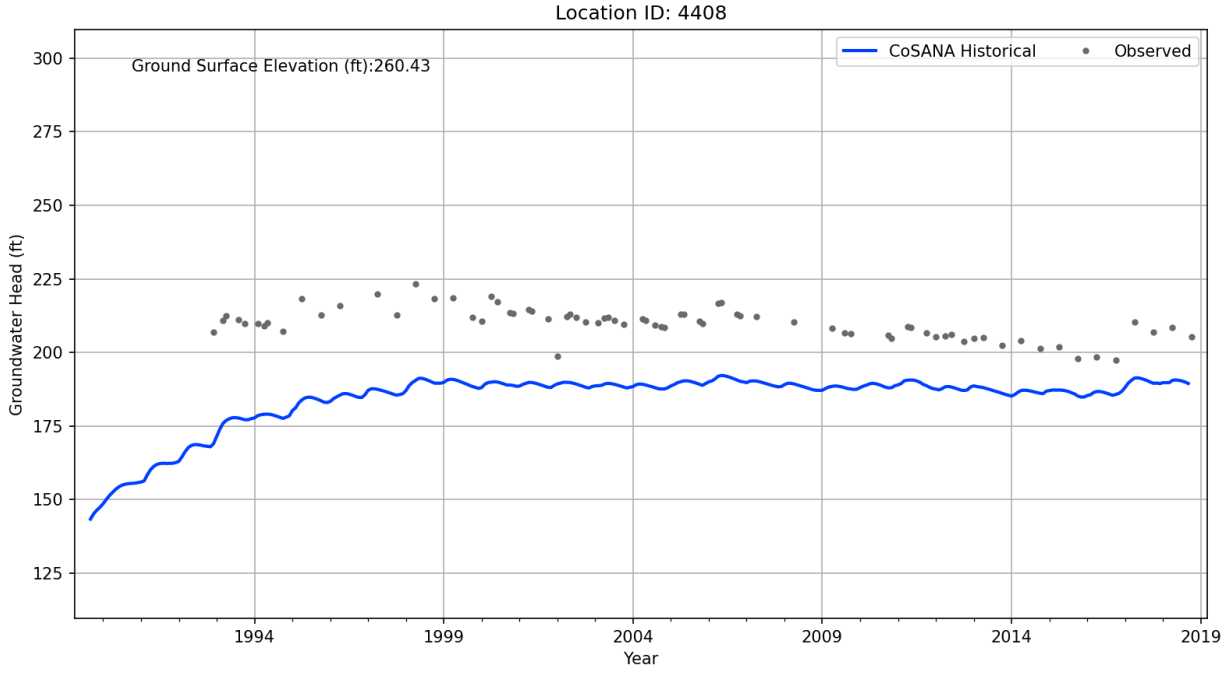

Location ID: 4403
Ground Surface Elevation (ft):129.29
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

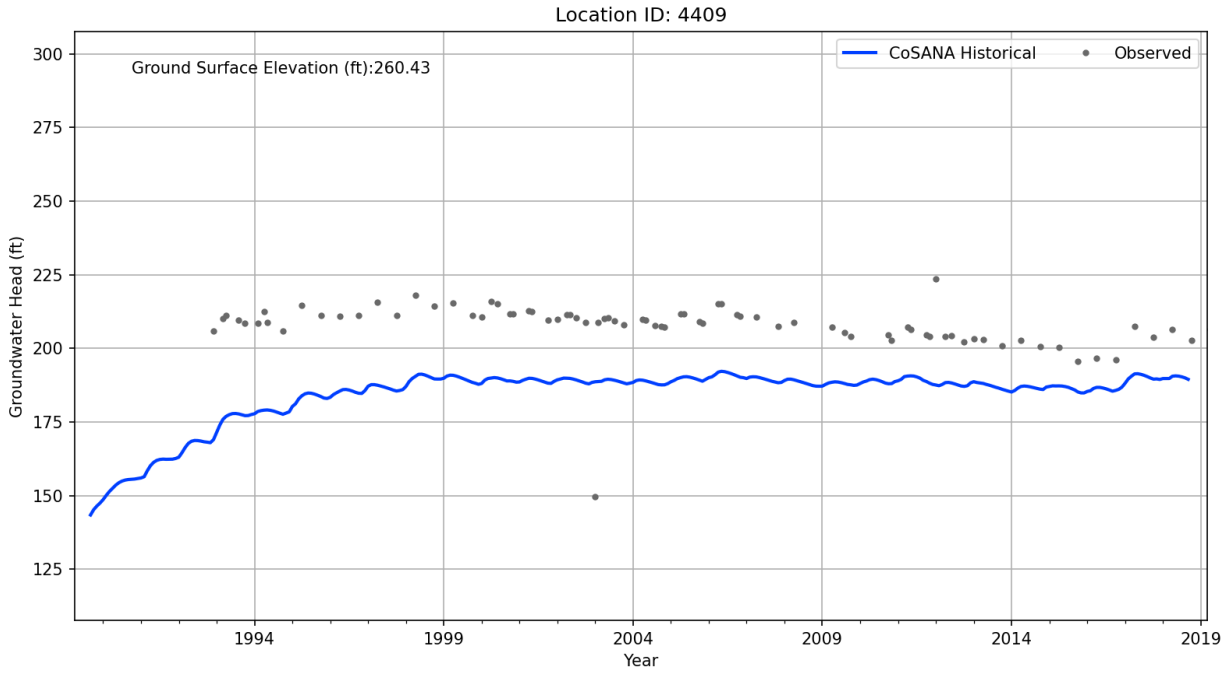

Location ID: 4404
Ground Surface Elevation (ft):155.68
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year

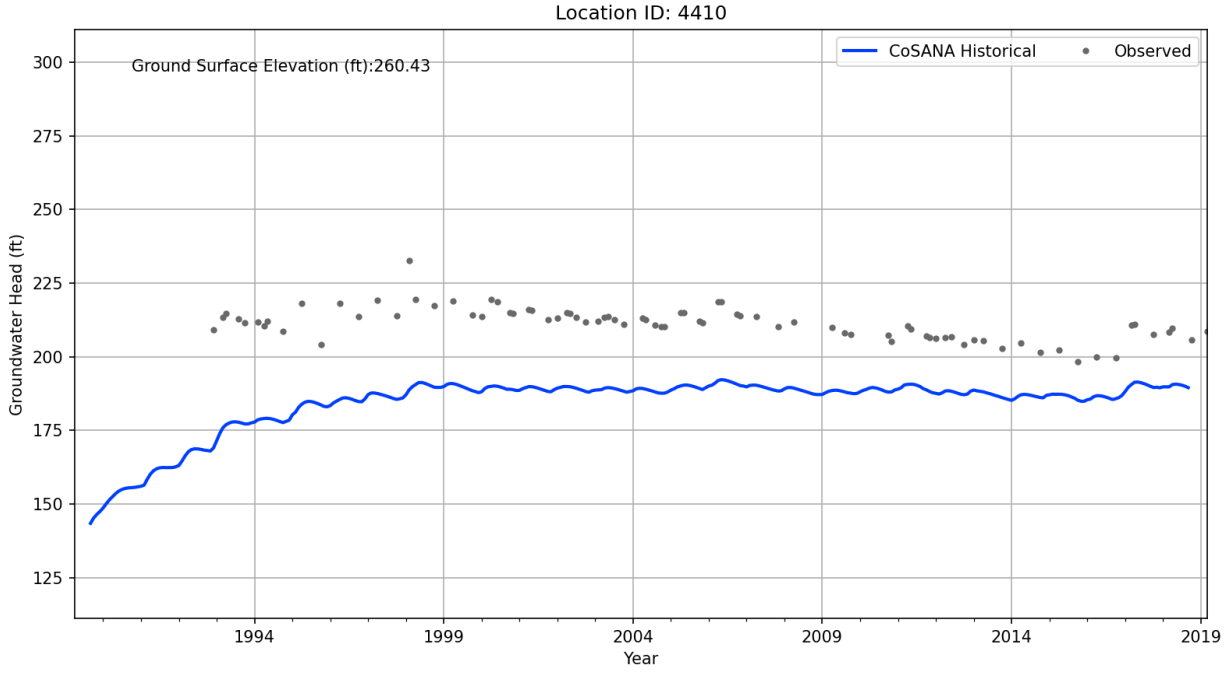

Location ID: 4405
Ground Surface Elevation (ft):155.68
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year

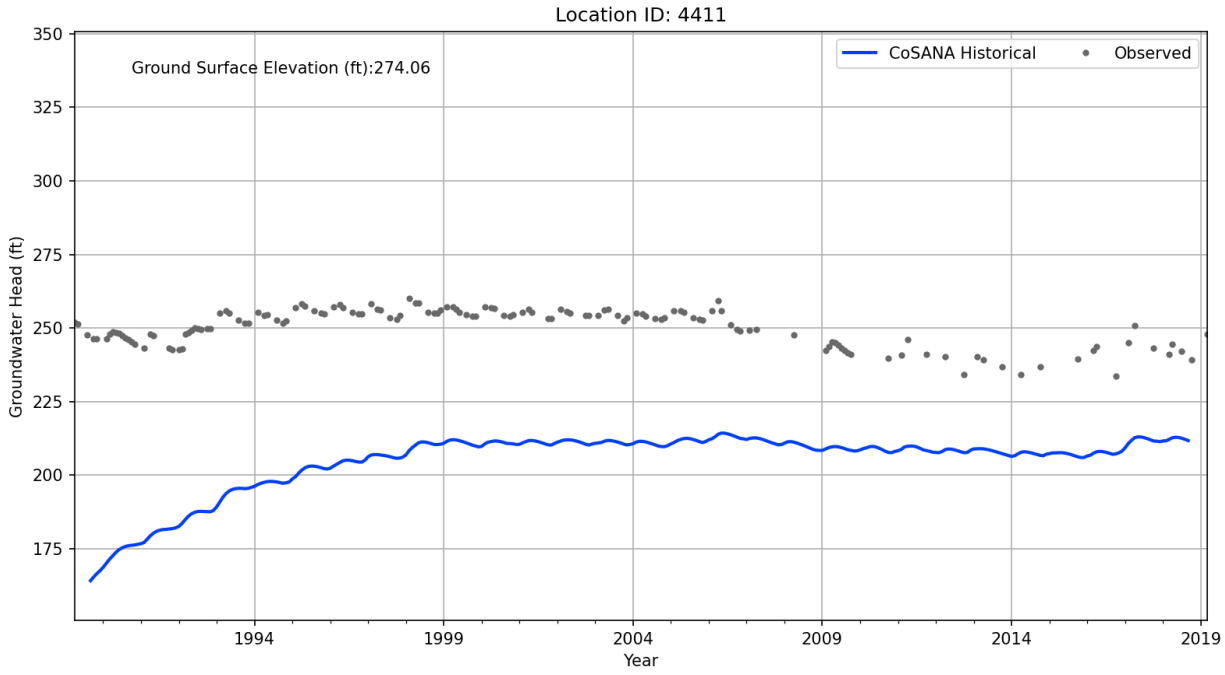

Location ID: 4406
Ground Surface Elevation (ft):155.68
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year

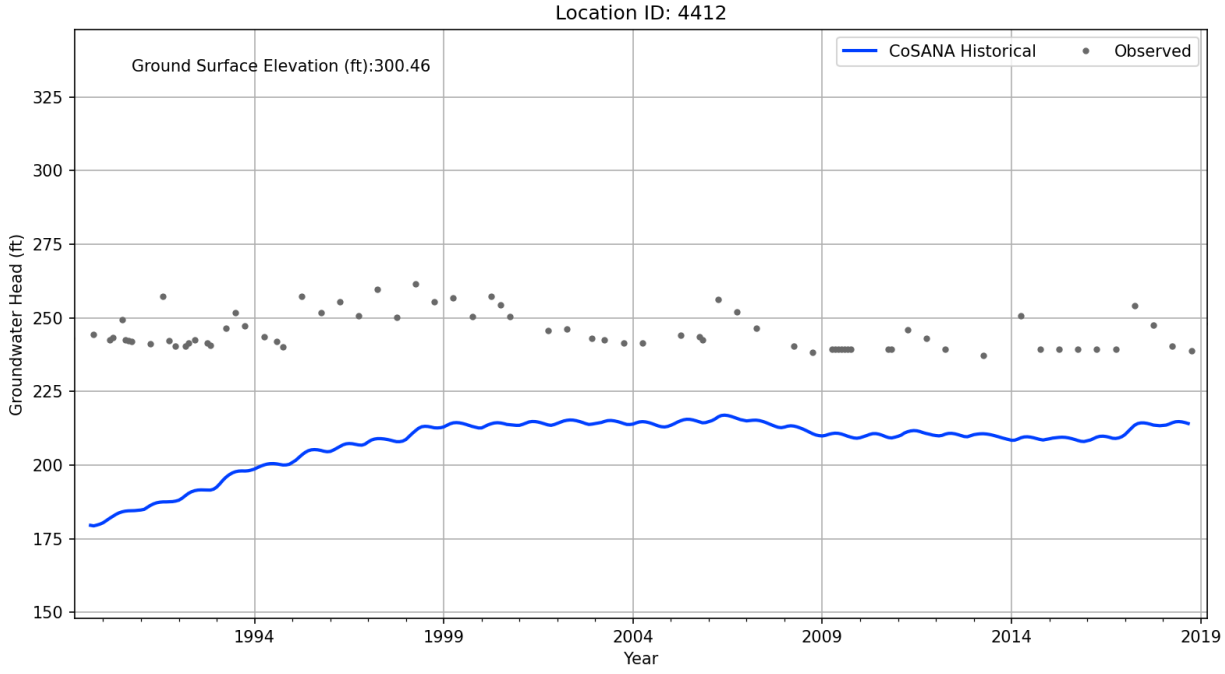

Location ID: 4407
Ground Surface Elevation (ft):155.68
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

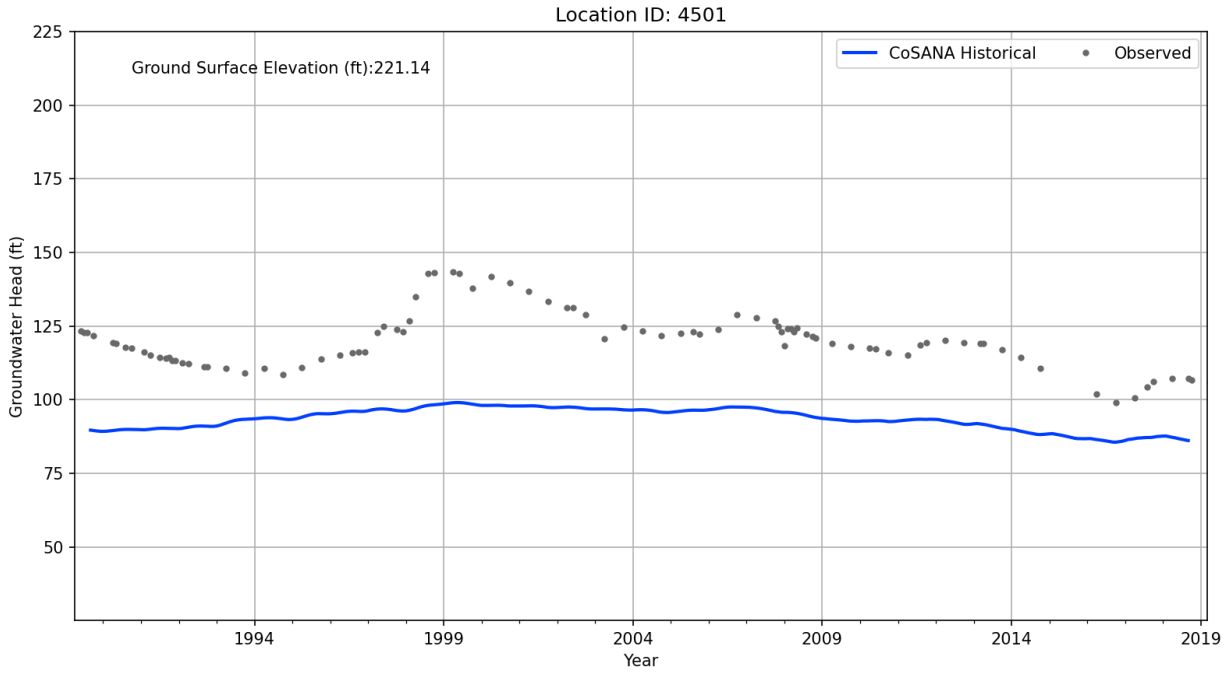

Location ID: 4408
Ground Surface Elevation (ft):260.43
CoSANA Historical
Observed
Groundwater Head (ft)
Year
300
275
250
225
200
175
150
125
1994
1999
2004
2009
2014
2019

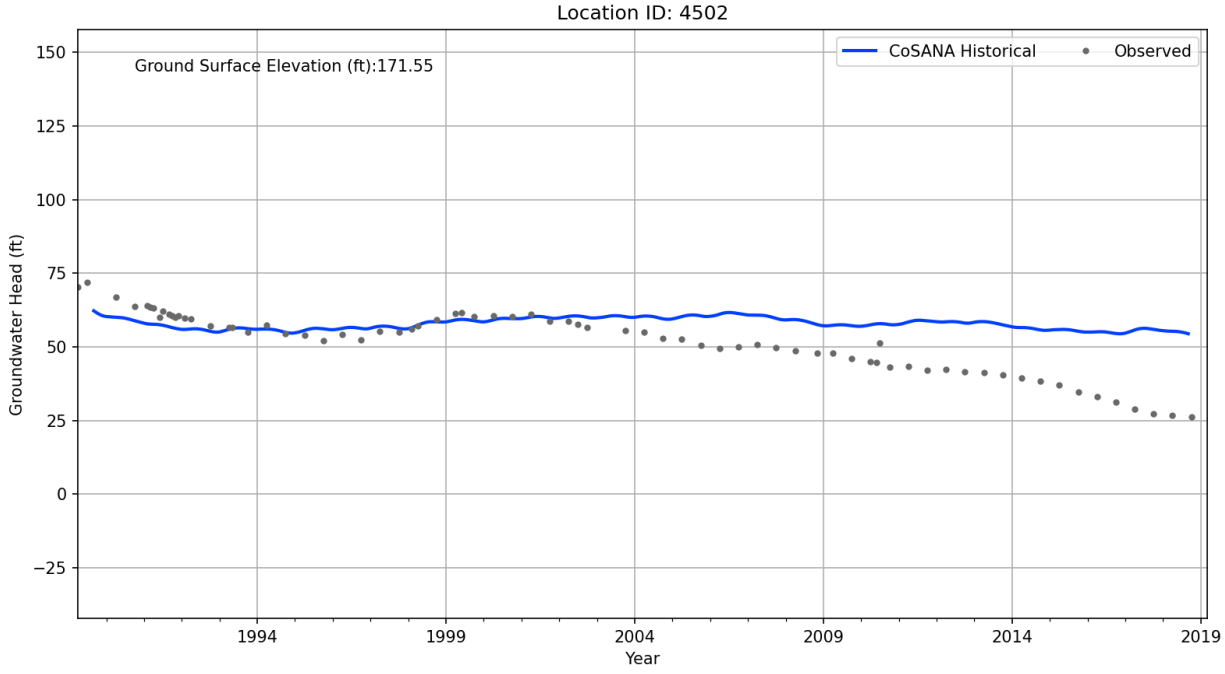

Location ID: 4409
Ground Surface Elevation (ft):260.43
CoSANA Historical
Observed
Groundwater Head (ft)
Year
300
275
250
225
200
175
150
125
1994
1999
2004
2009
2014
2019

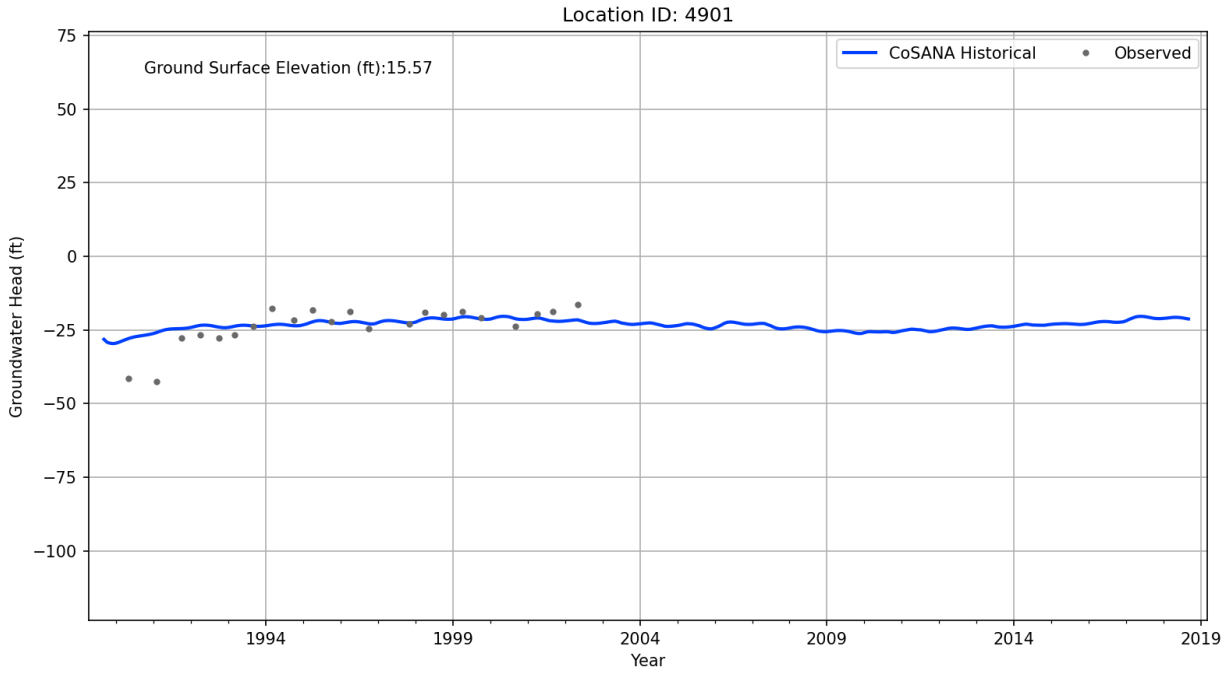

Location ID: 4410
Ground Surface Elevation (ft):260.43
CoSANA Historical
Observed
Groundwater Head (ft)
Year
300
275
250
225
200
175
150
125
1994
1999
2004
2009
2014
2019

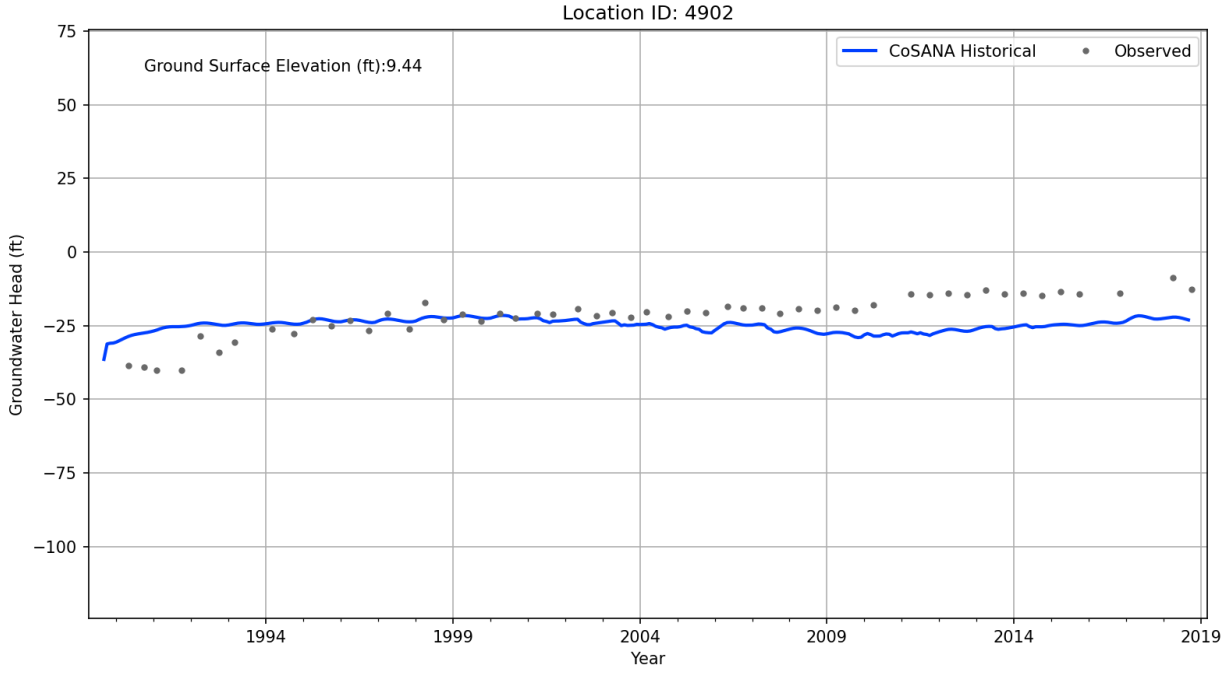

Location ID: 4411
Ground Surface Elevation (ft):274.06
CoSANA Historical
Observed
Groundwater Head (ft)
Year
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019

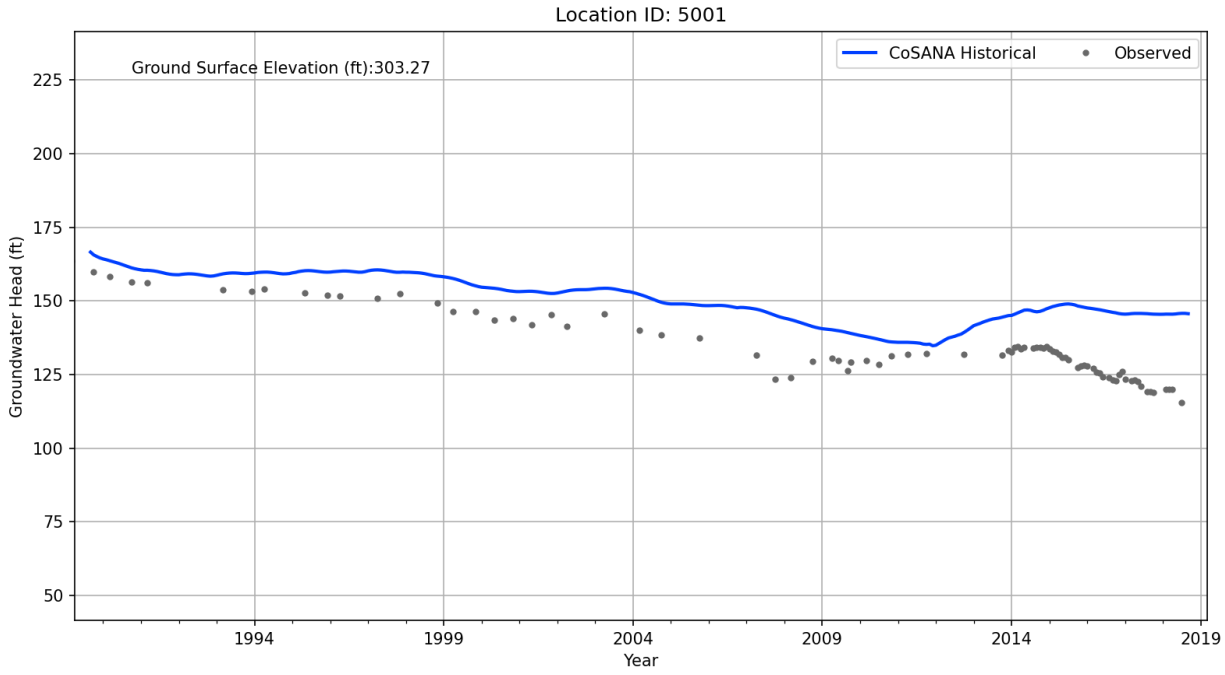

Location ID: 4412
Ground Surface Elevation (ft):300.46
CoSANA Historical
Observed
Groundwater Head (ft)
Year
325
300
275
250
225
200
175
150
1994
1999
2004
2009
2014
2019

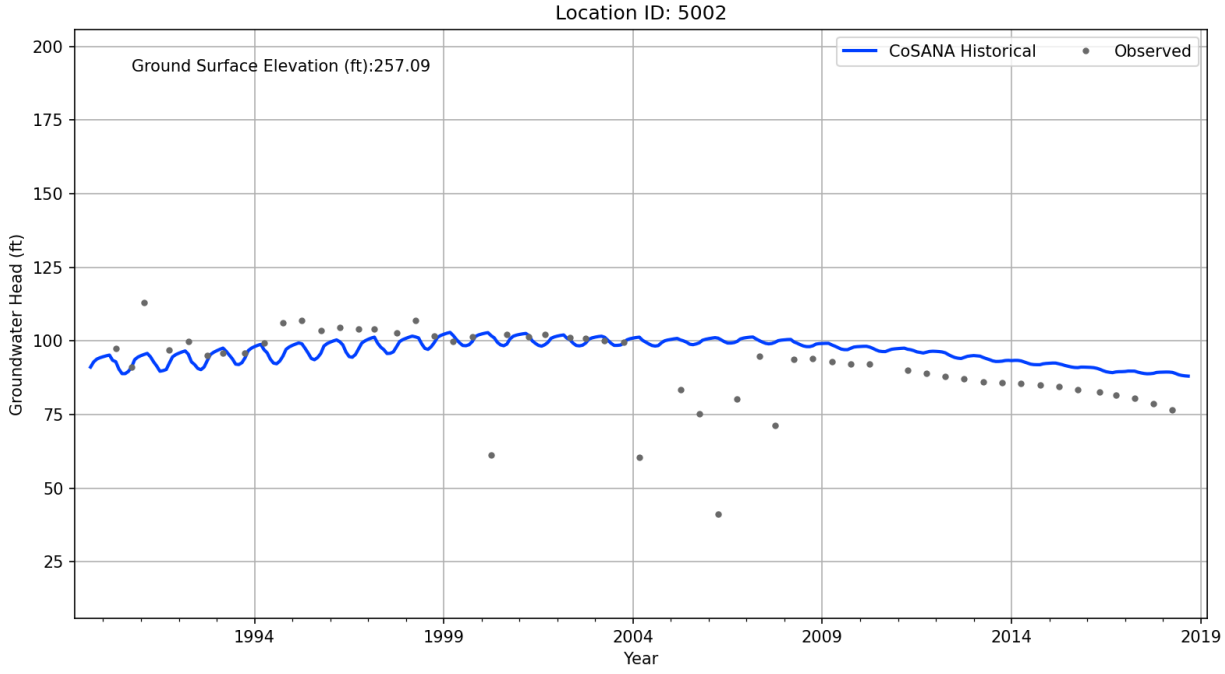

Location ID: 4501
Ground Surface Elevation (ft):221.14
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

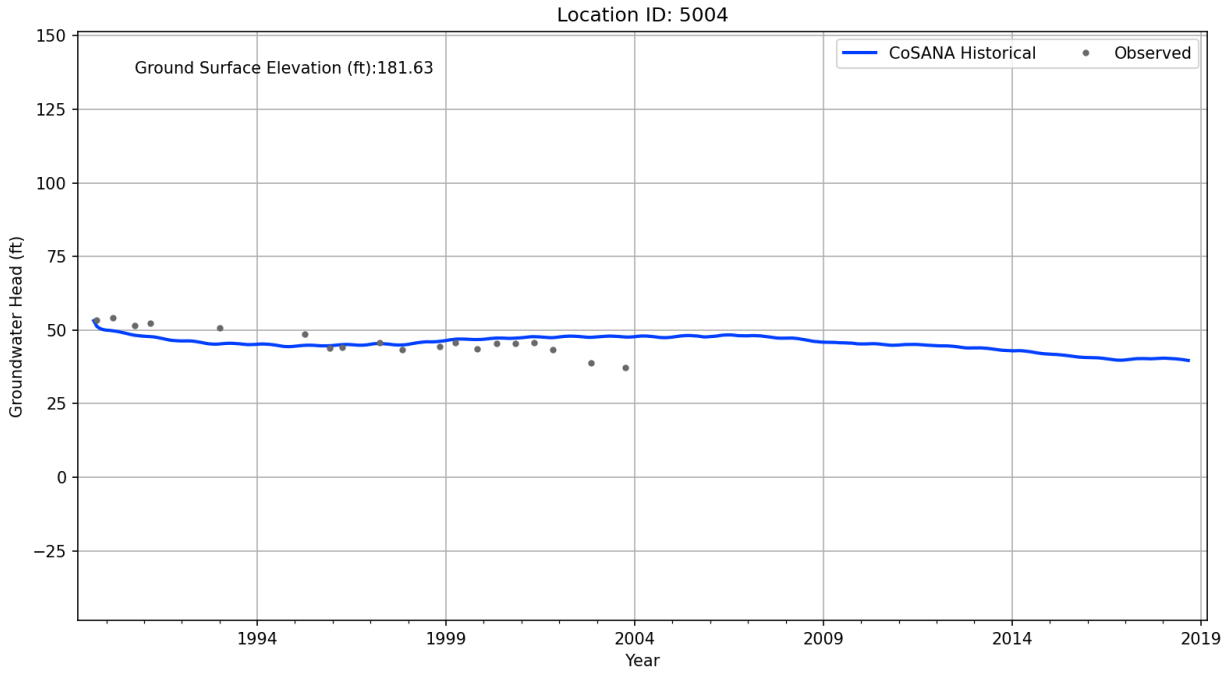

Location ID: 4502
Ground Surface Elevation (ft):171.55
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

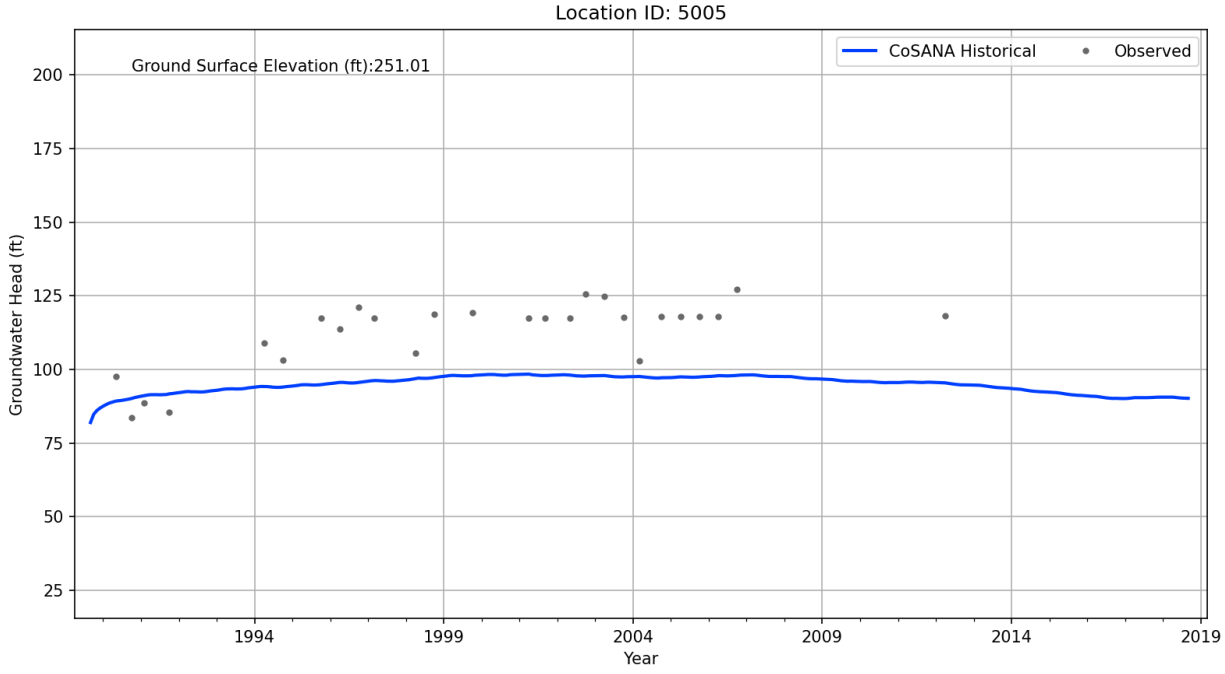

Location ID: 4901
Ground Surface Elevation (ft):15.57
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

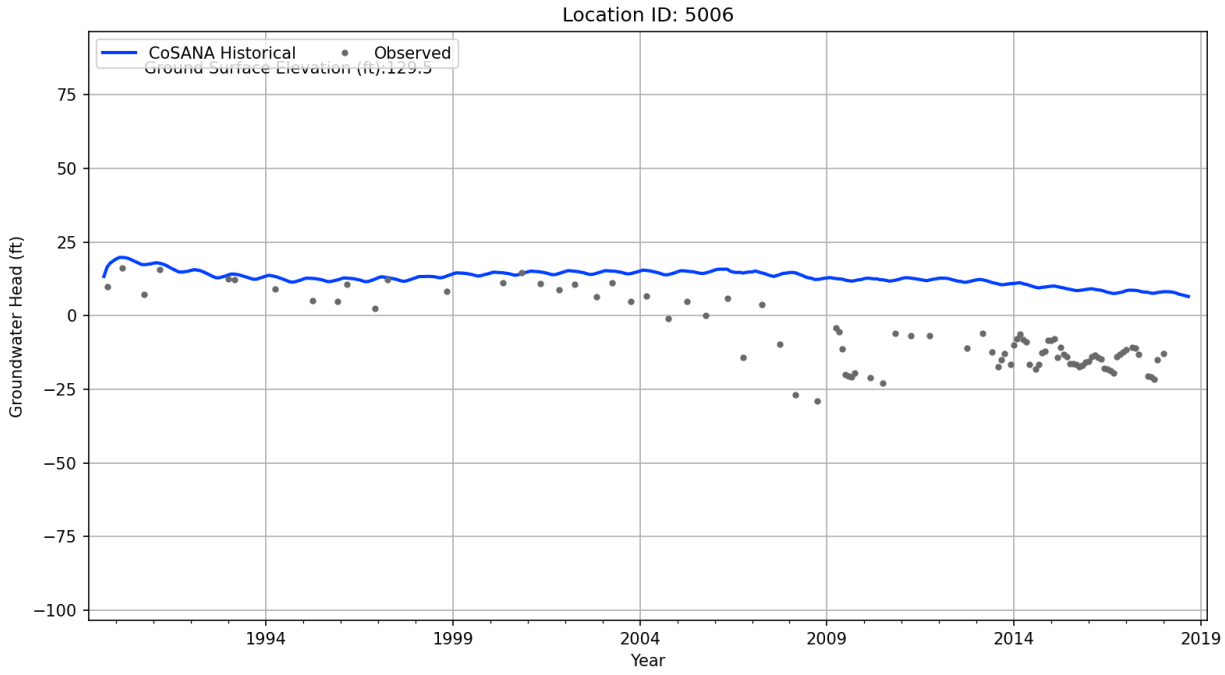

Location ID: 4902
Ground Surface Elevation (ft):9.44
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

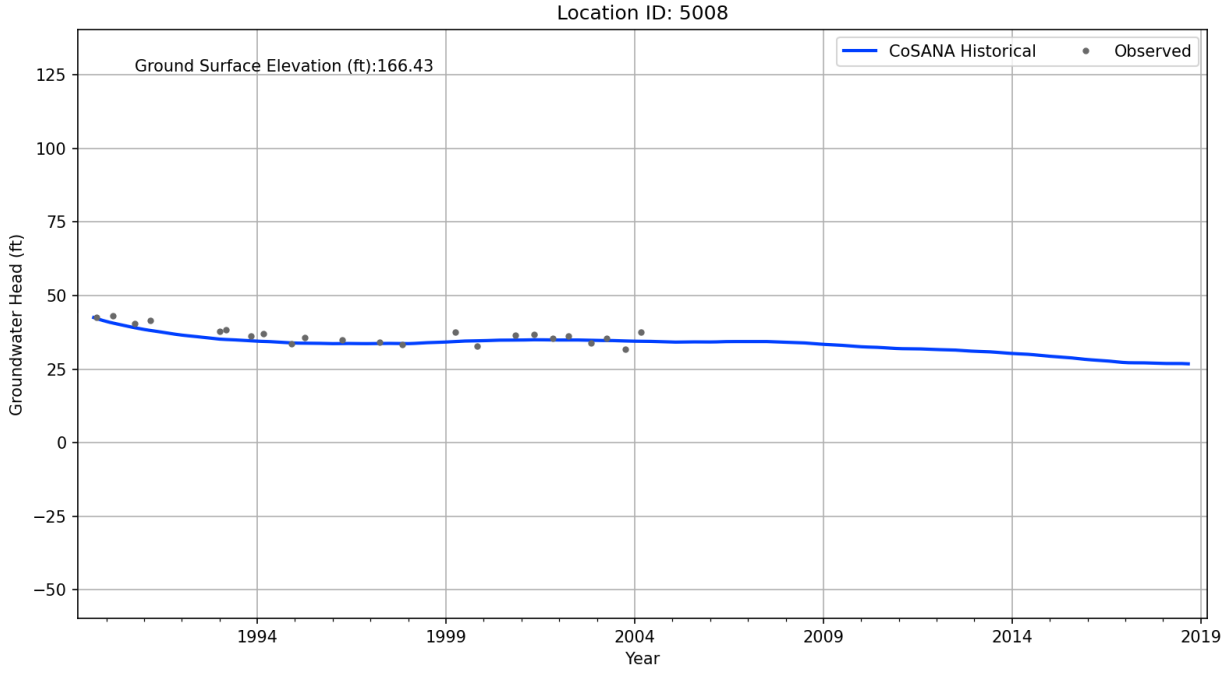

Location ID: 5001
Ground Surface Elevation (ft):303.27
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

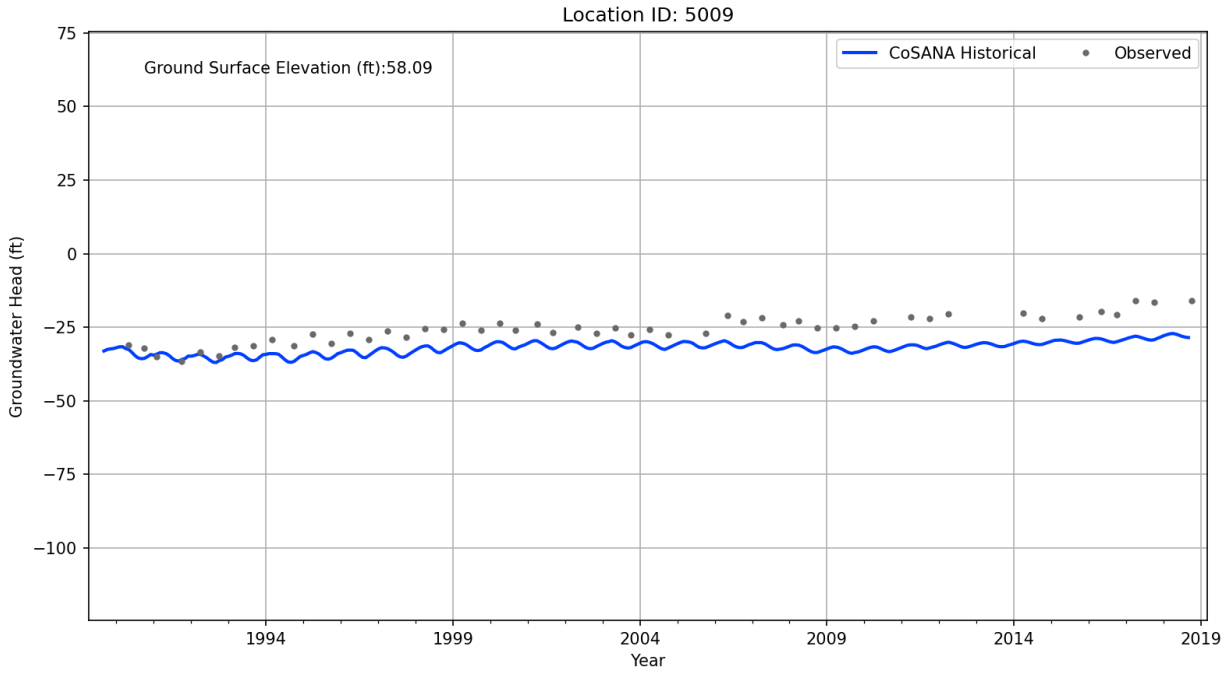

Location ID: 5002
Ground Surface Elevation (ft):257.09
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year

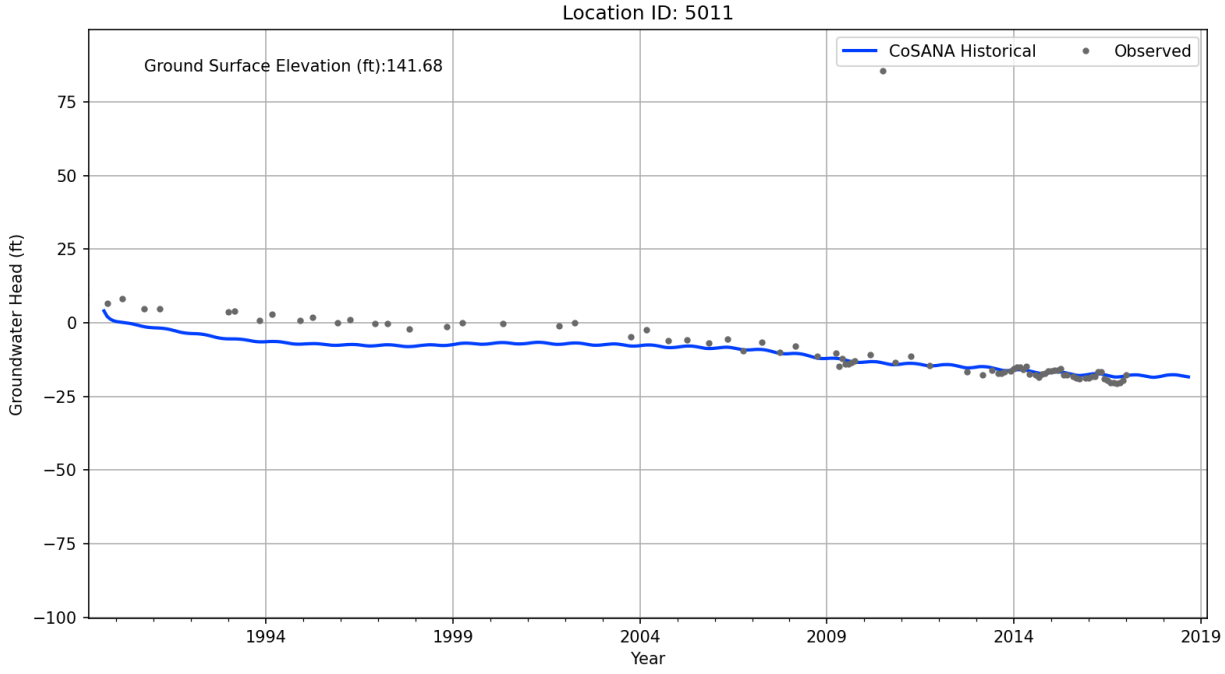

Location ID: 5004
Ground Surface Elevation (ft):181.63
CoSANA Historical
Observed
Groundwater Head (ft)
Year
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019

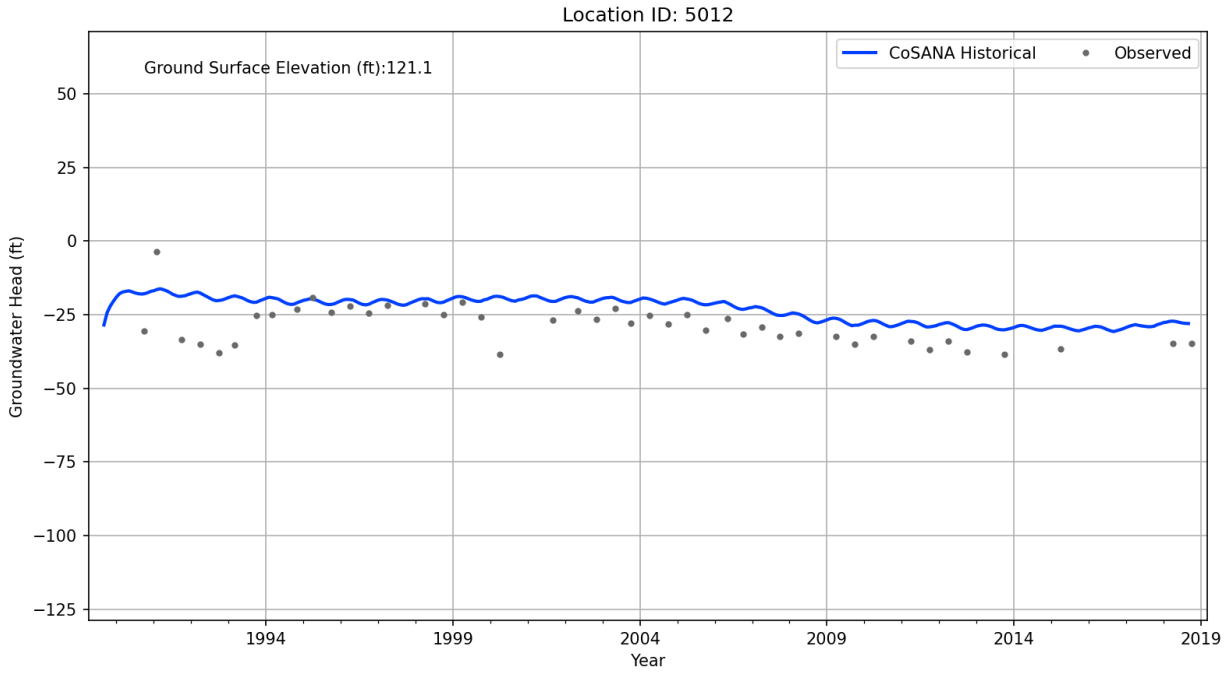

Location ID: 5005
Ground Surface Elevation (ft):251.01
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

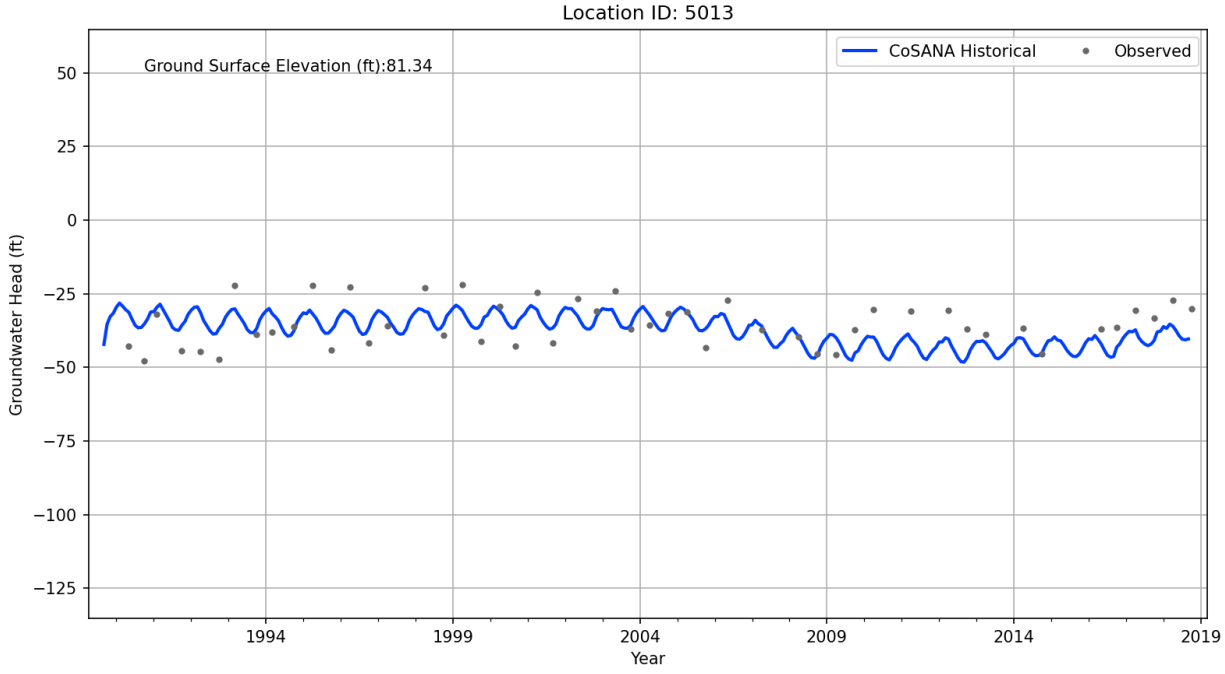

Location ID: 5006
CoSANA Historical
Observed
Ground Surface Elevation (ft):129.5
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

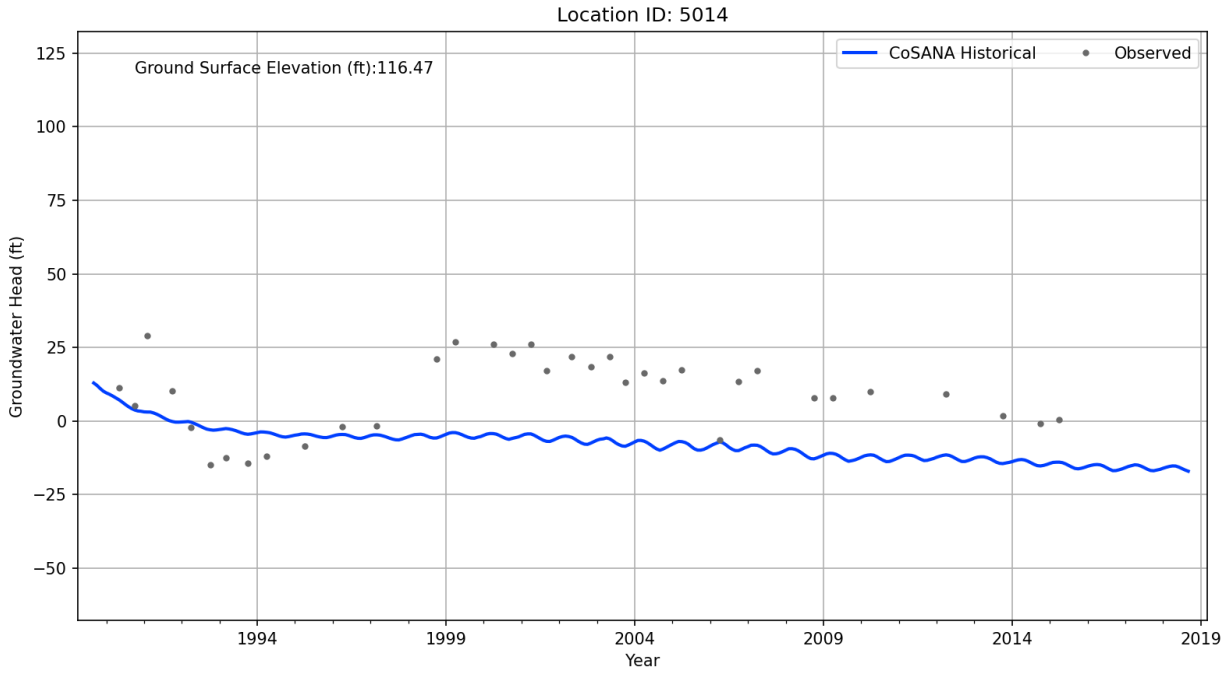

Location ID: 5008
CoSANA Historical
Observed
Ground Surface Elevation (ft):166.43
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

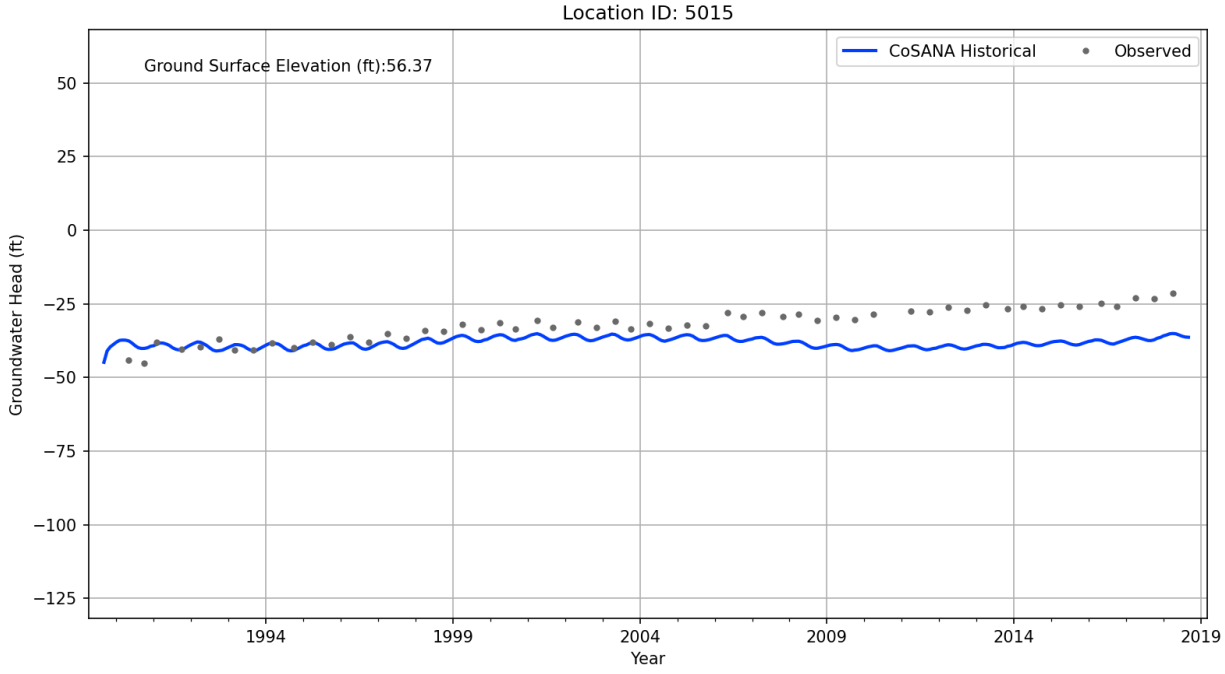

Location ID: 5009
Ground Surface Elevation (ft):58.09
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

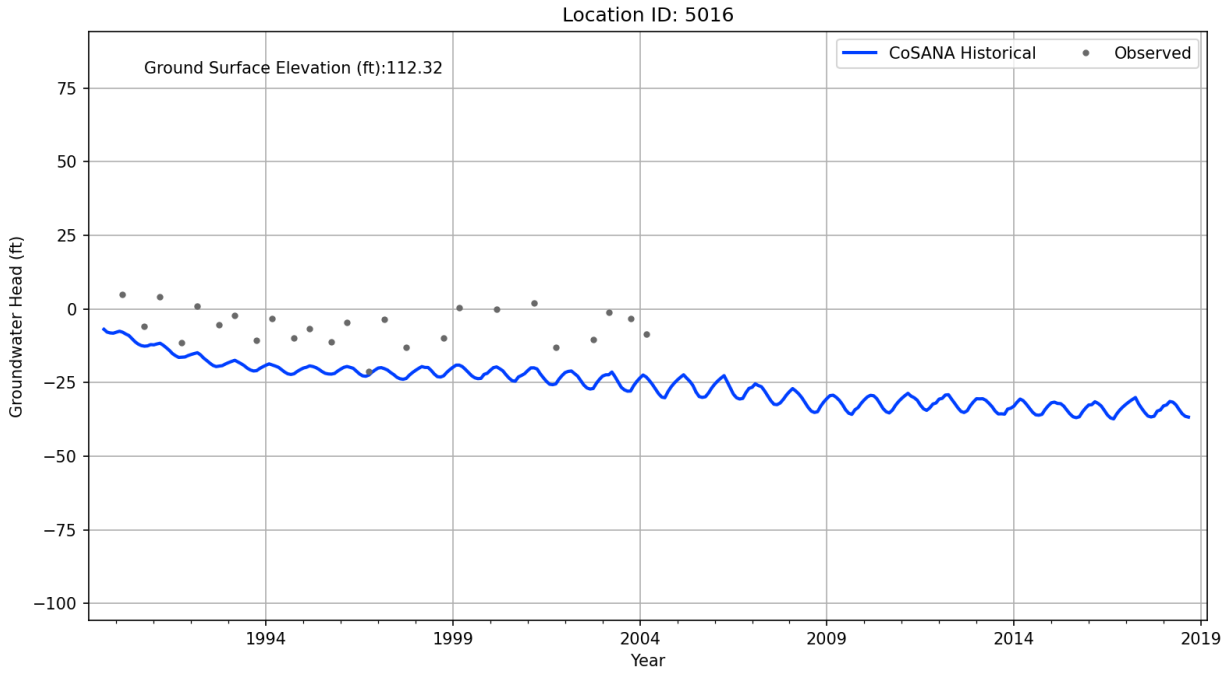

Location ID: 5011
Ground Surface Elevation (ft):141.68
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

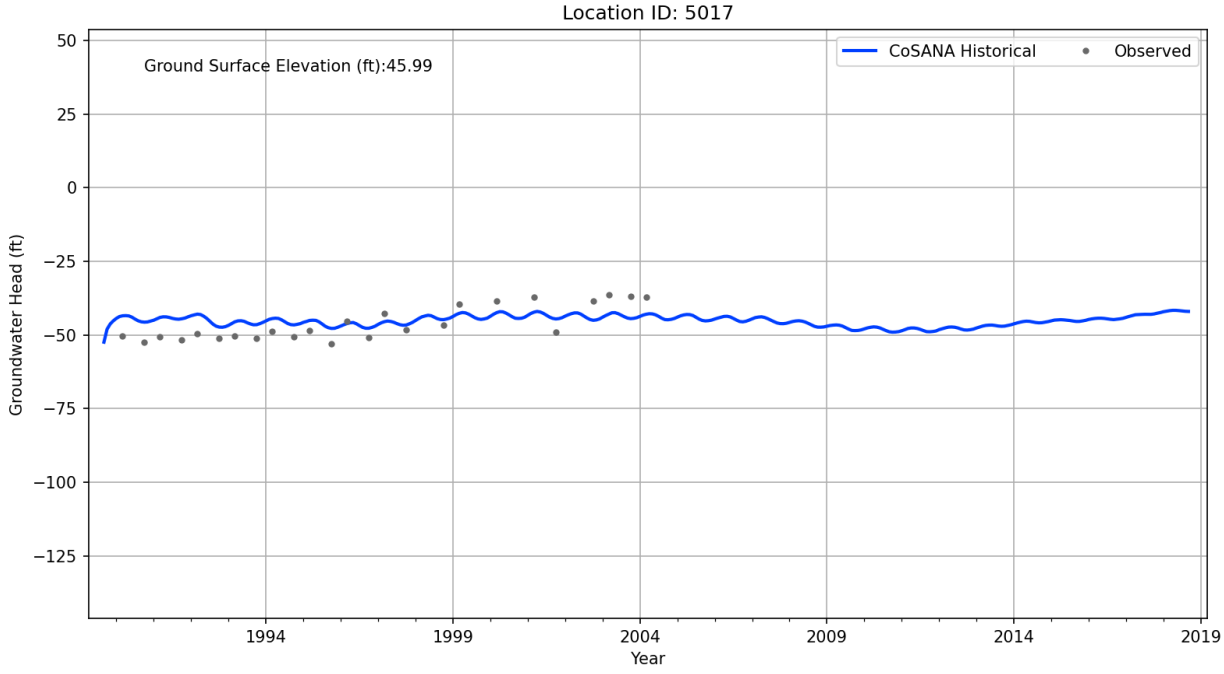

Location ID: 5012
Ground Surface Elevation (ft):121.1
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

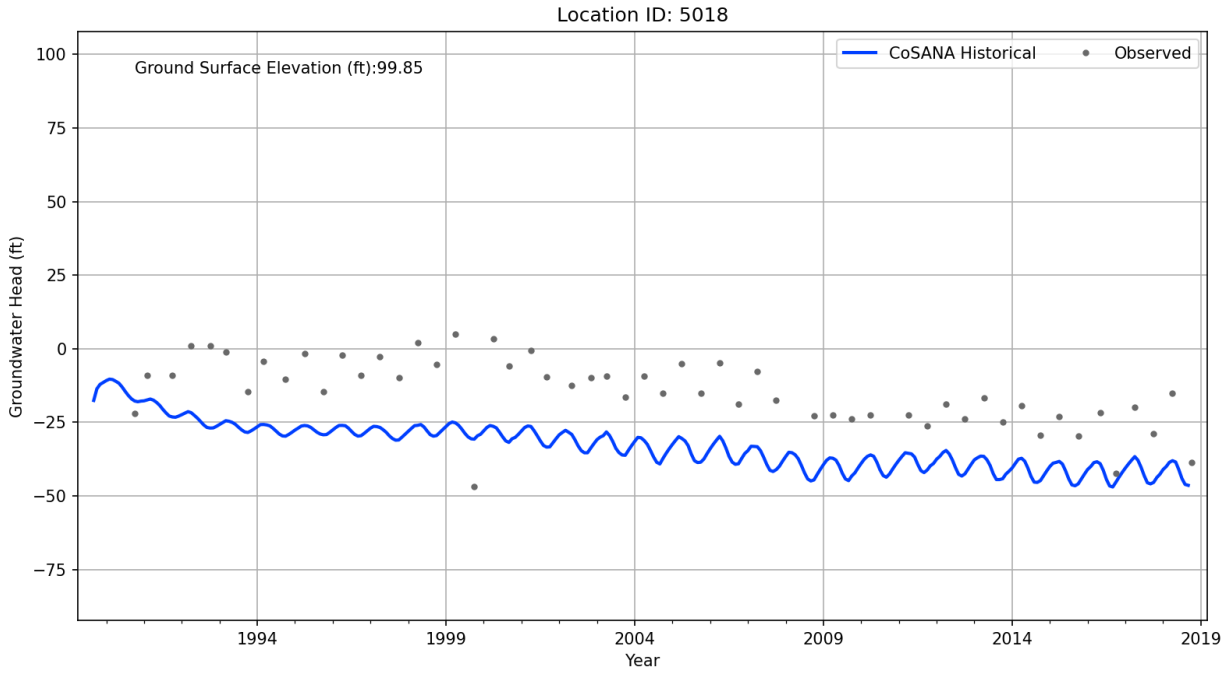

Location ID: 5013
Ground Surface Elevation (ft):81.34
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

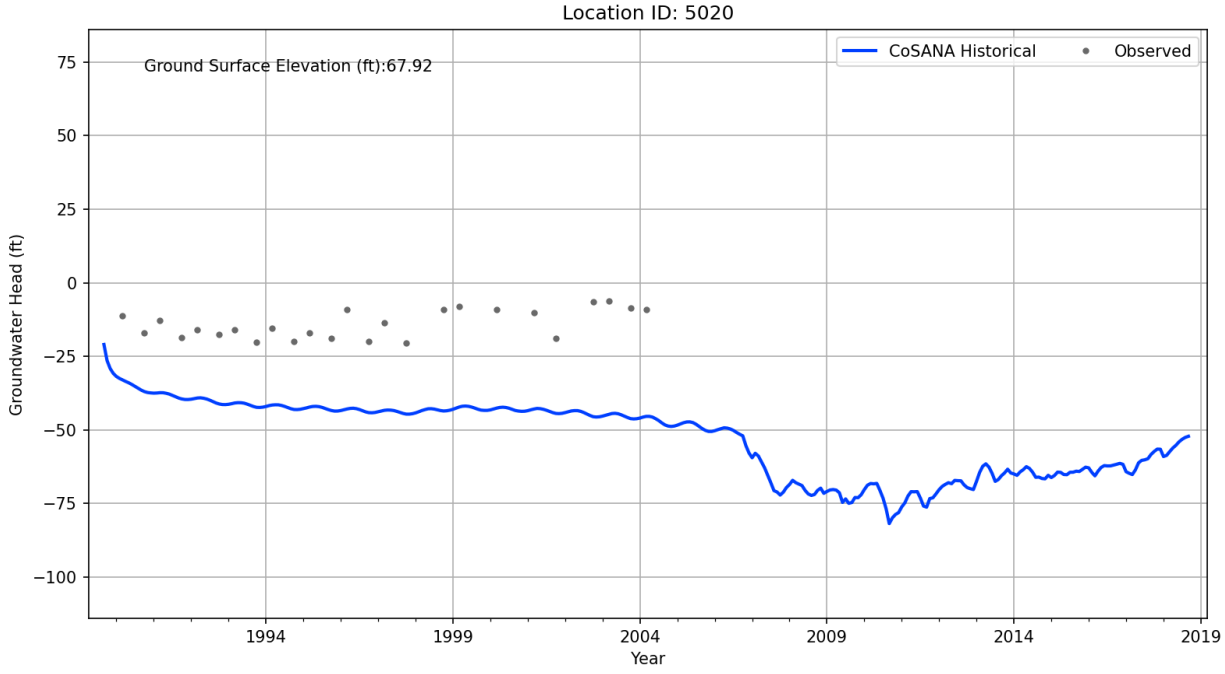

Location ID: 5014
Ground Surface Elevation (ft):116.47
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

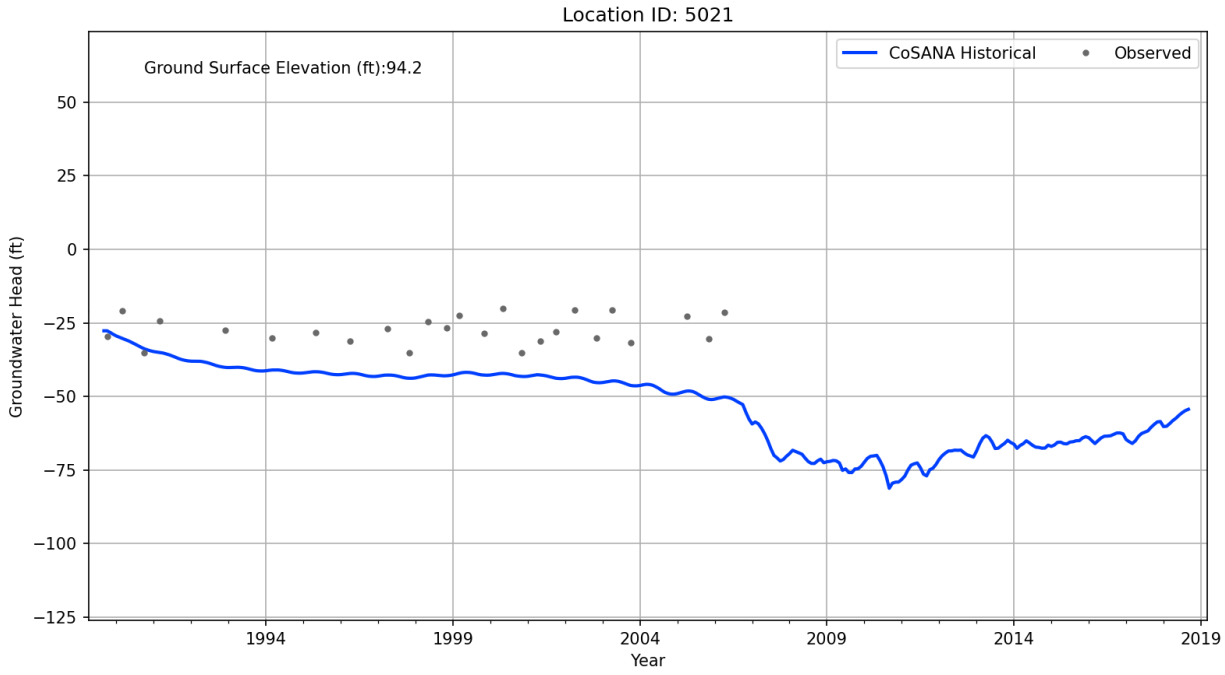

Location ID: 5015
Ground Surface Elevation (ft):56.37
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

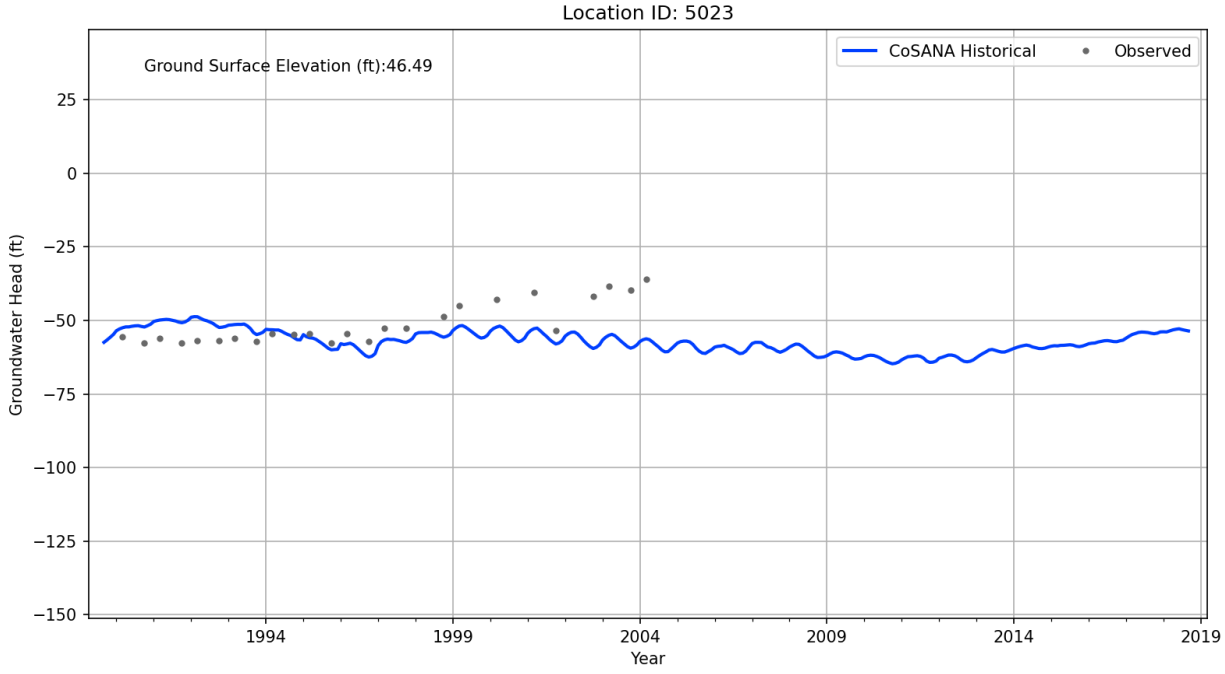

Location ID: 5016
Ground Surface Elevation (ft):112.32
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

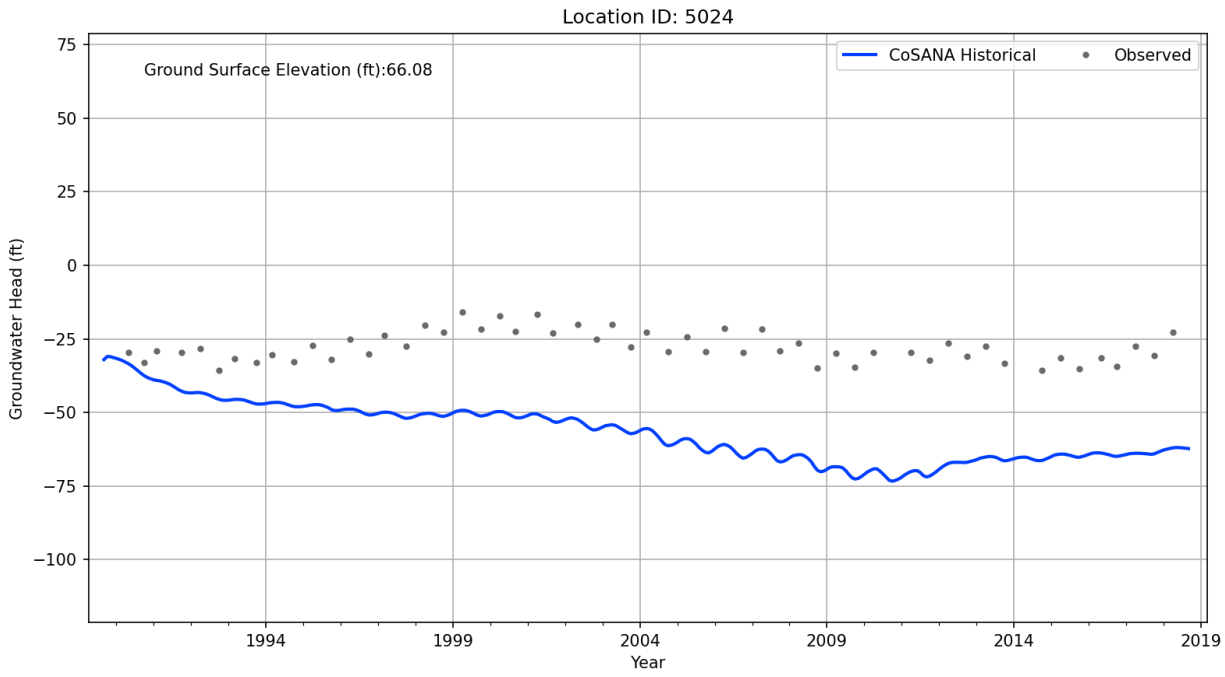

Location ID: 5017
Ground Surface Elevation (ft):45.99
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

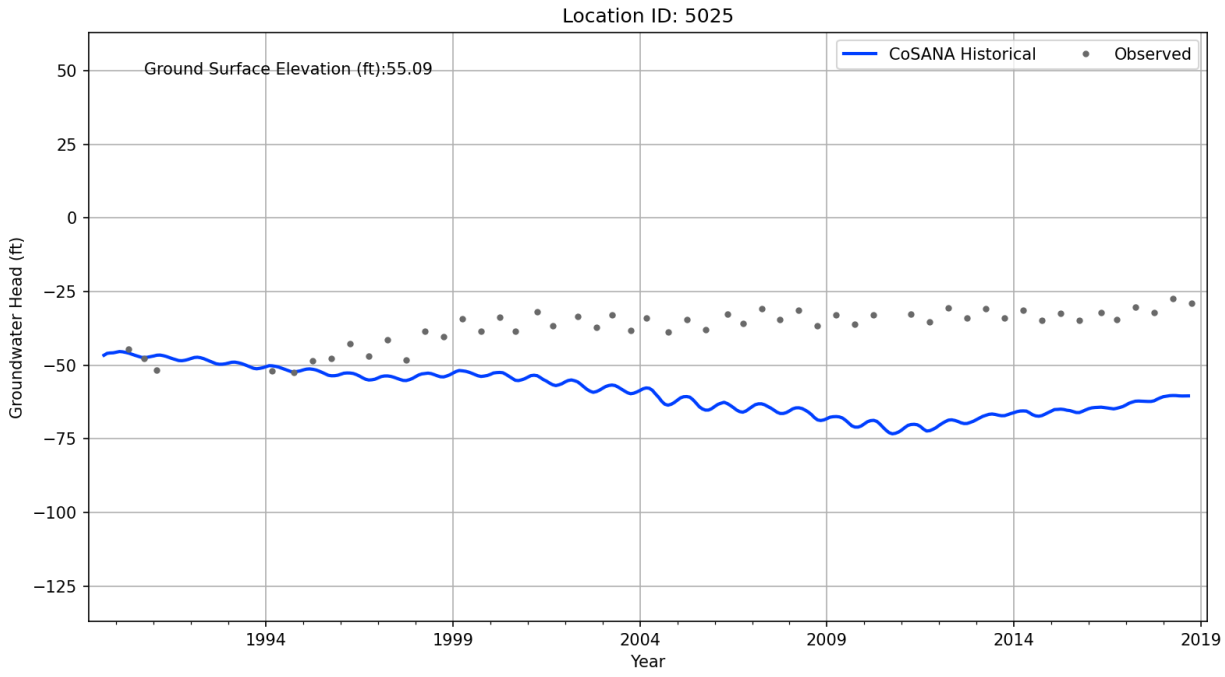

Location ID: 5018
Ground Surface Elevation (ft):99.85
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

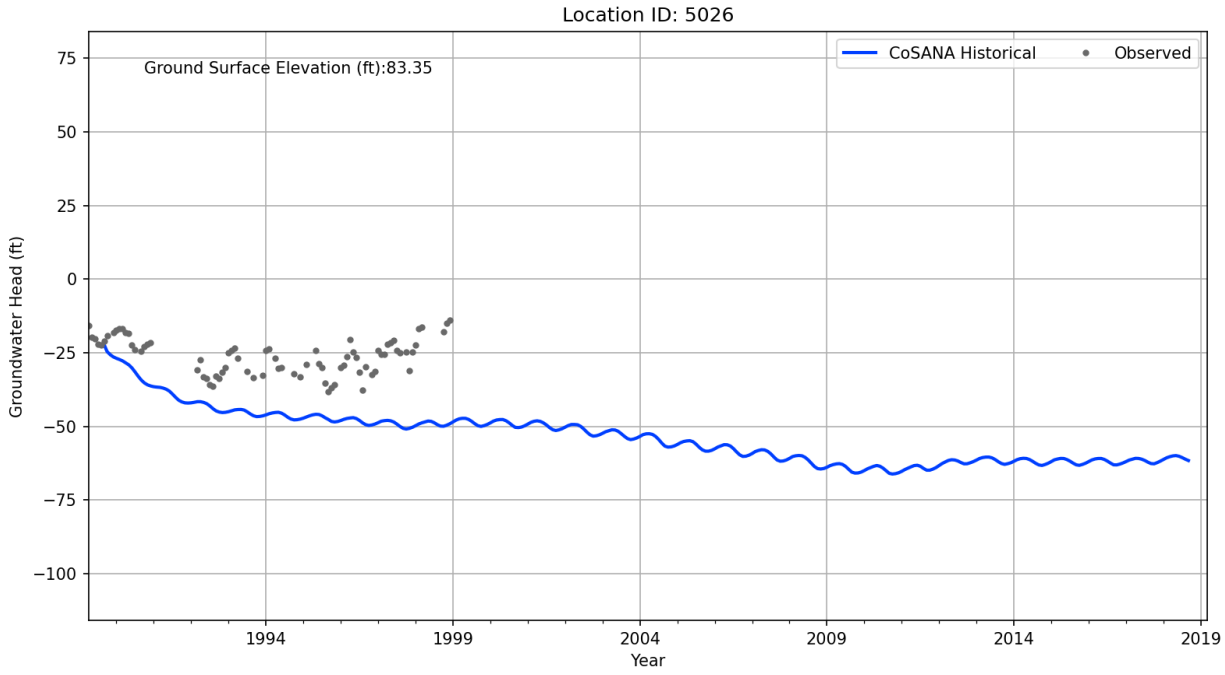

Location ID: 5020
Ground Surface Elevation (ft):67.92
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

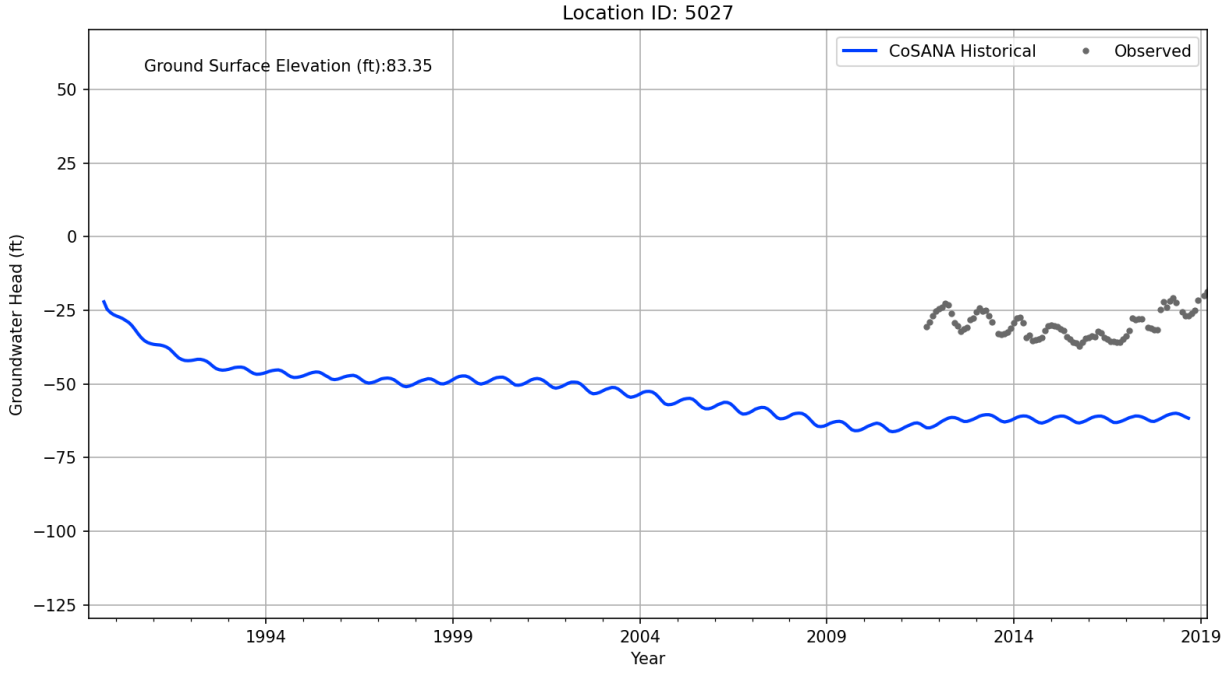

Location ID: 5021
Ground Surface Elevation (ft):94.2
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

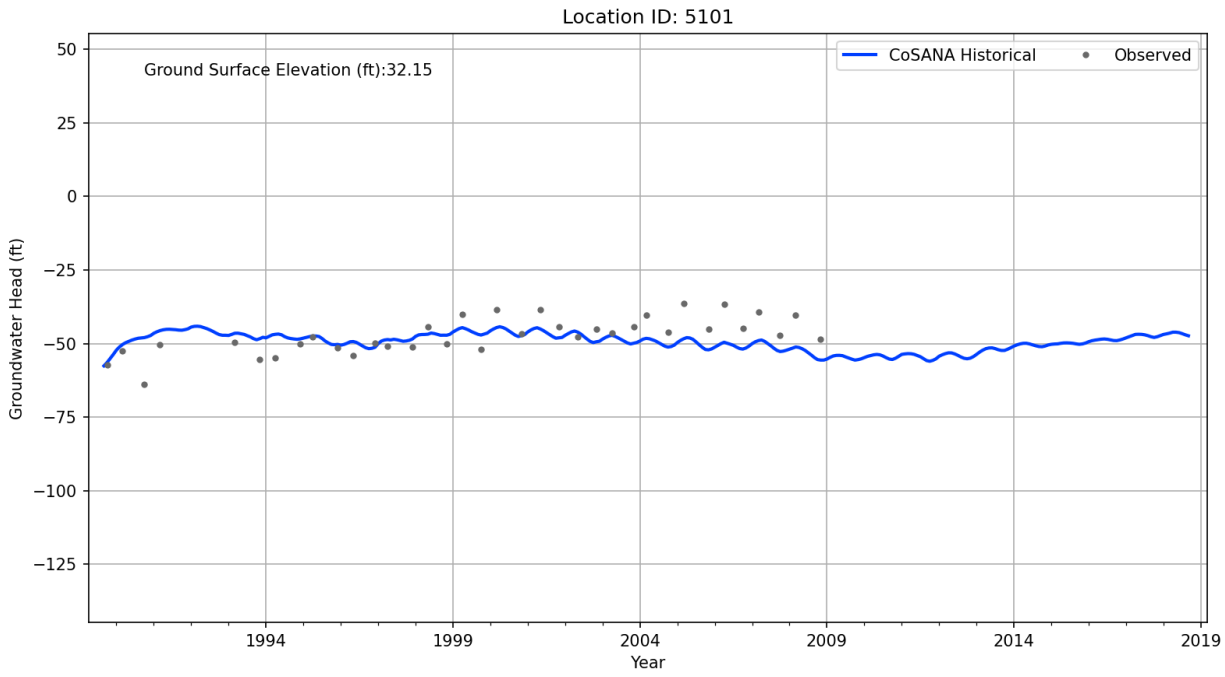

Location ID: 5023
Ground Surface Elevation (ft):46.49
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

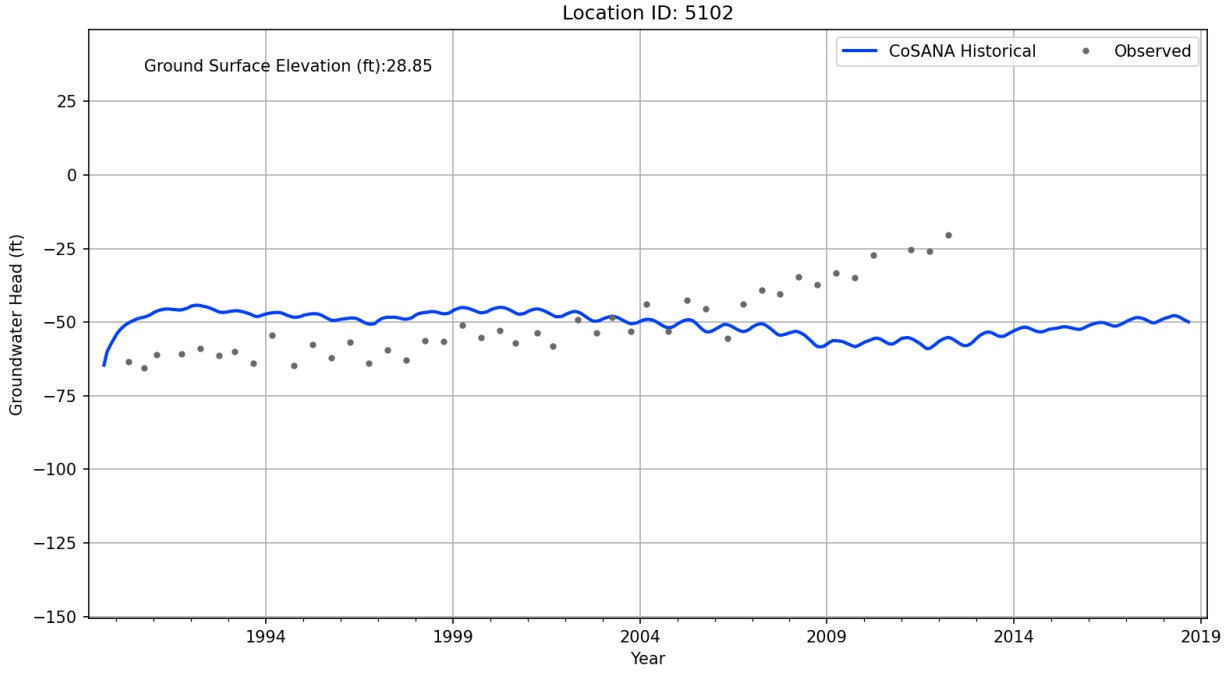

Location ID: 5024
Ground Surface Elevation (ft):66.08
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

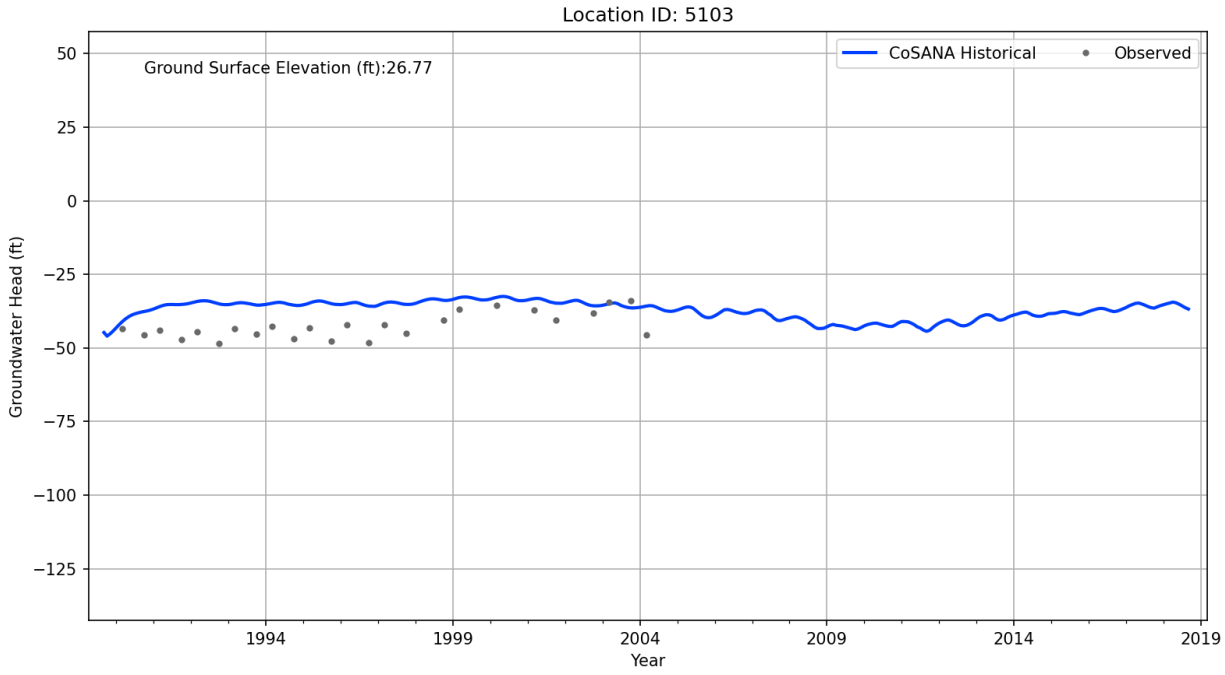

Location ID: 5025
Ground Surface Elevation (ft):55.09
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

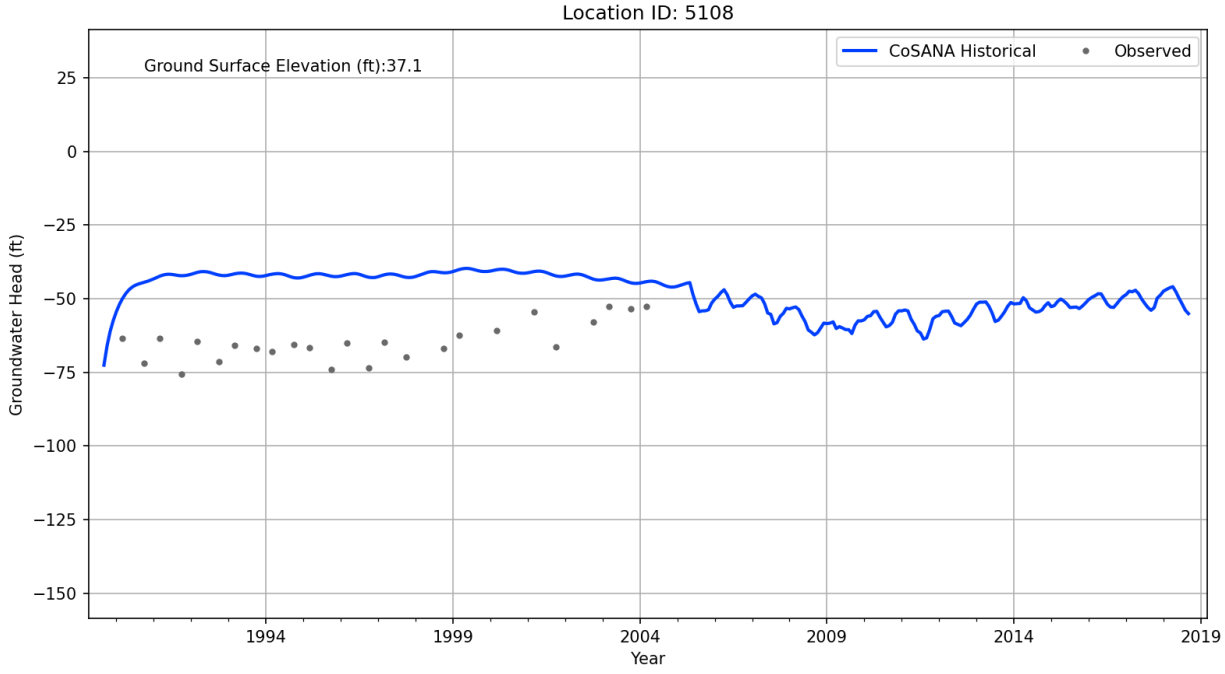

Location ID: 5026
Ground Surface Elevation (ft):83.35
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

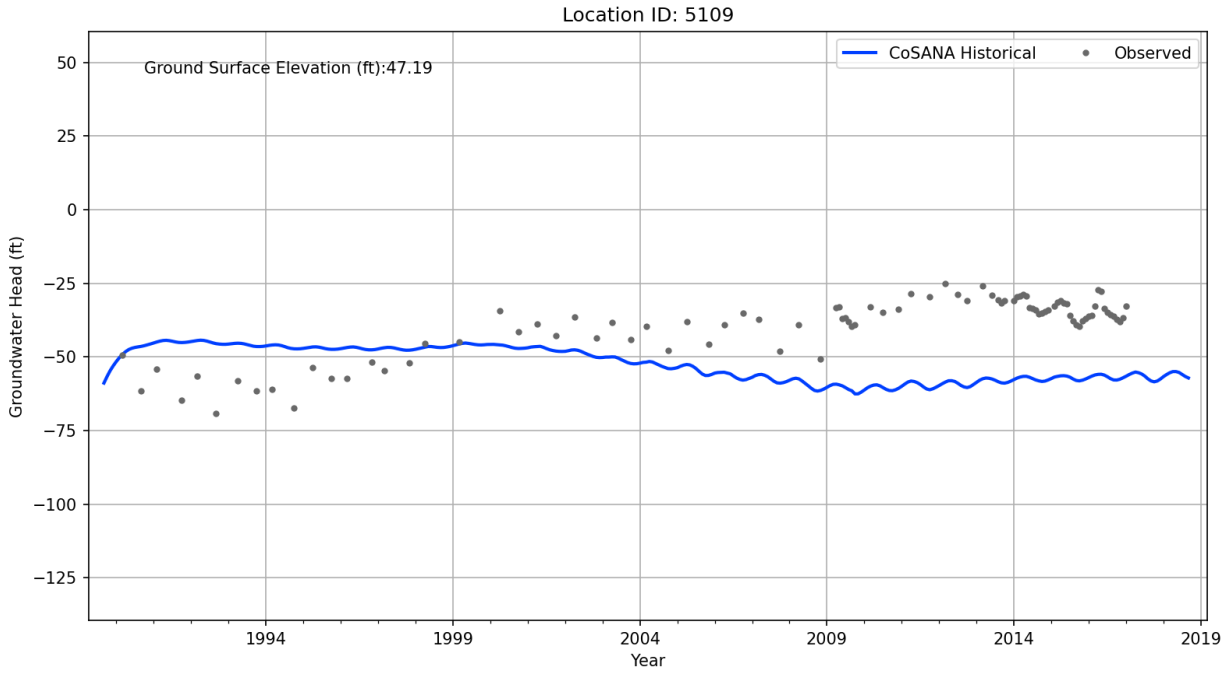

Location ID: 5027
Ground Surface Elevation (ft):83.35
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

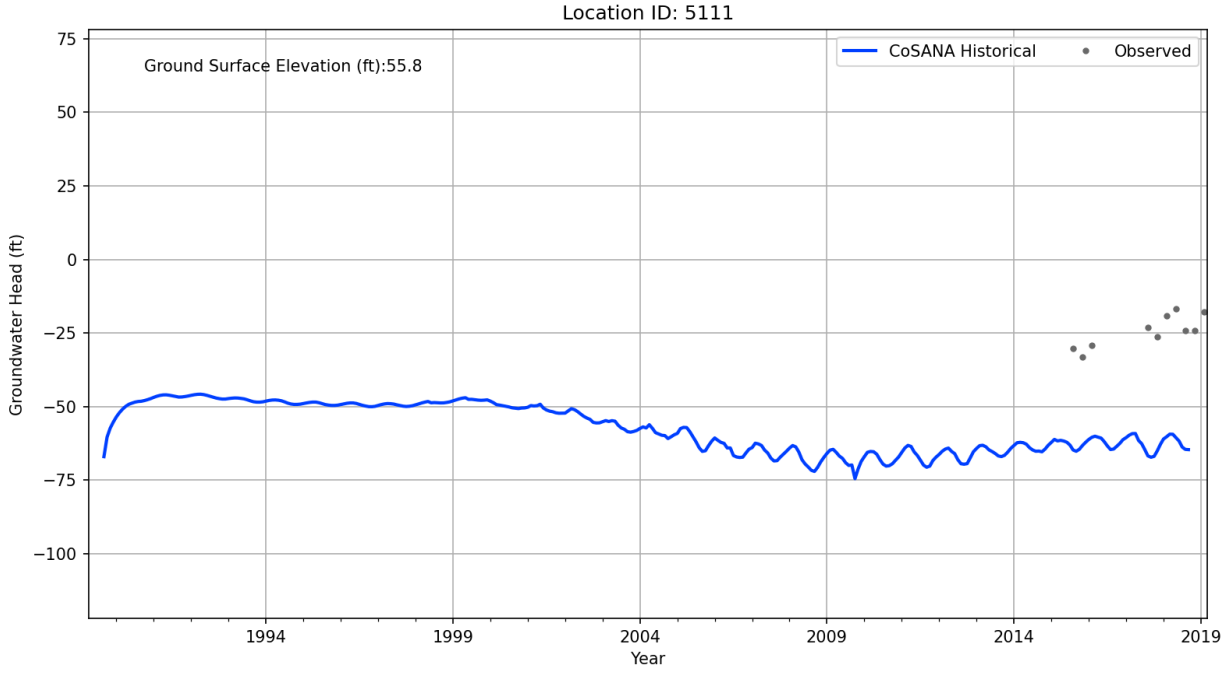

Location ID: 5101
Ground Surface Elevation (ft):32.15
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

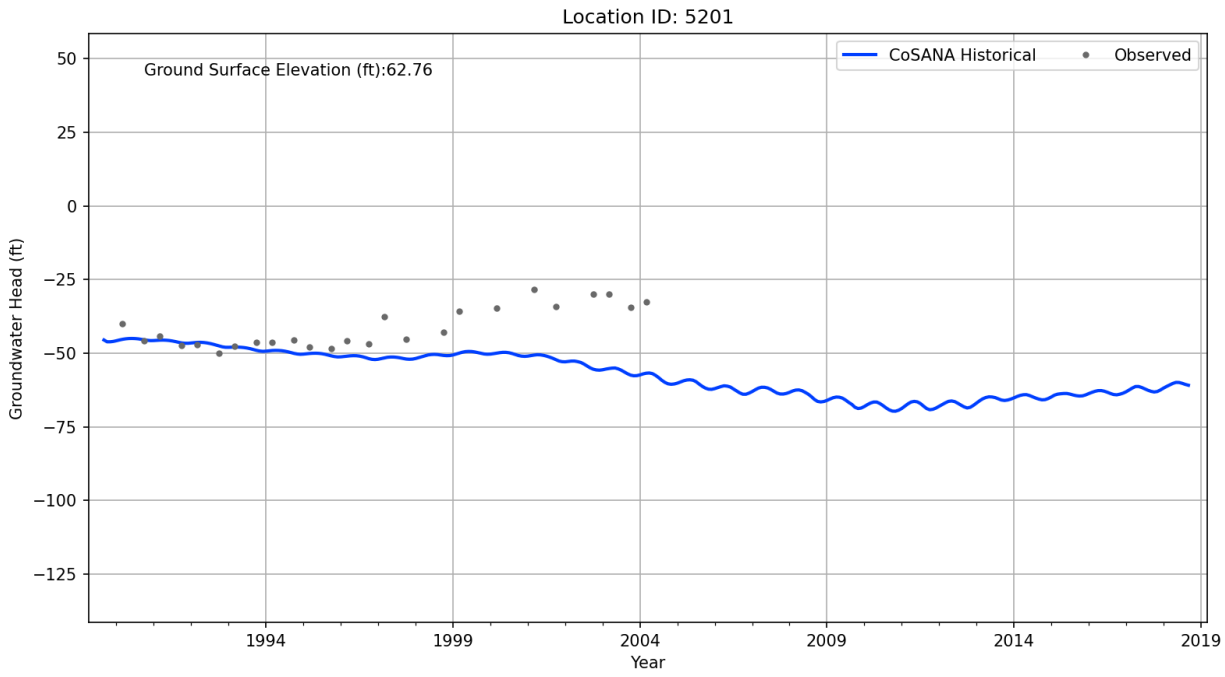

Location ID: 5102
Ground Surface Elevation (ft):28.85
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

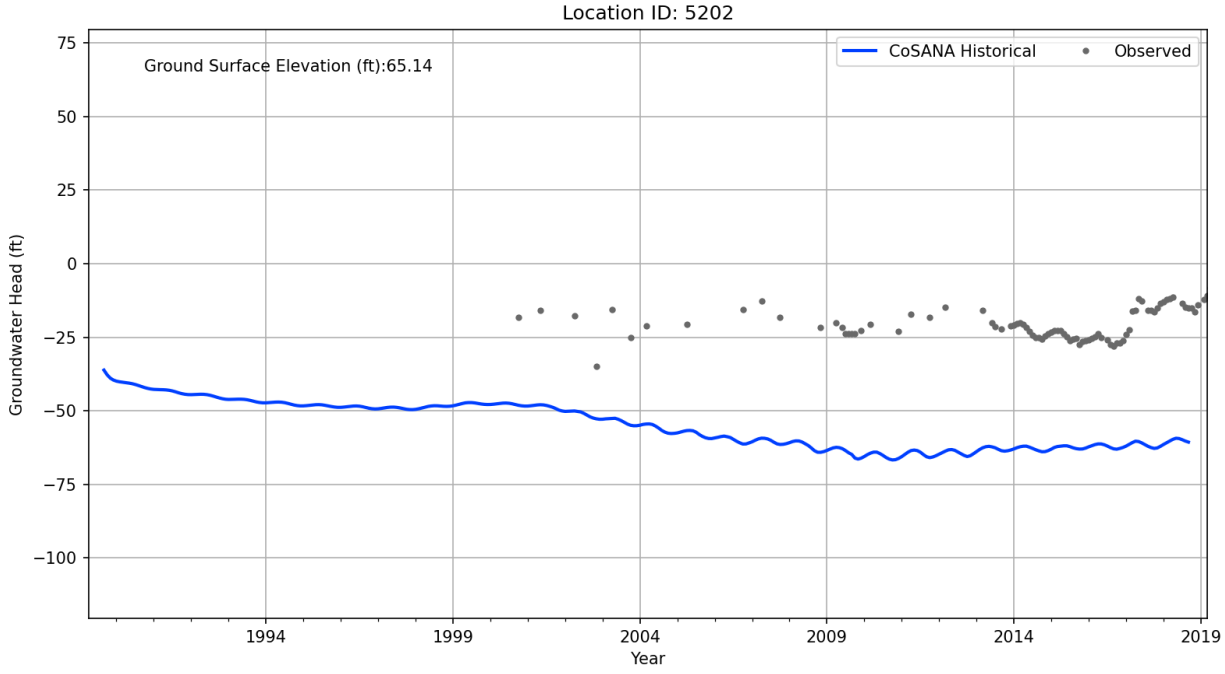

Location ID: 5103
Ground Surface Elevation (ft):26.77
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

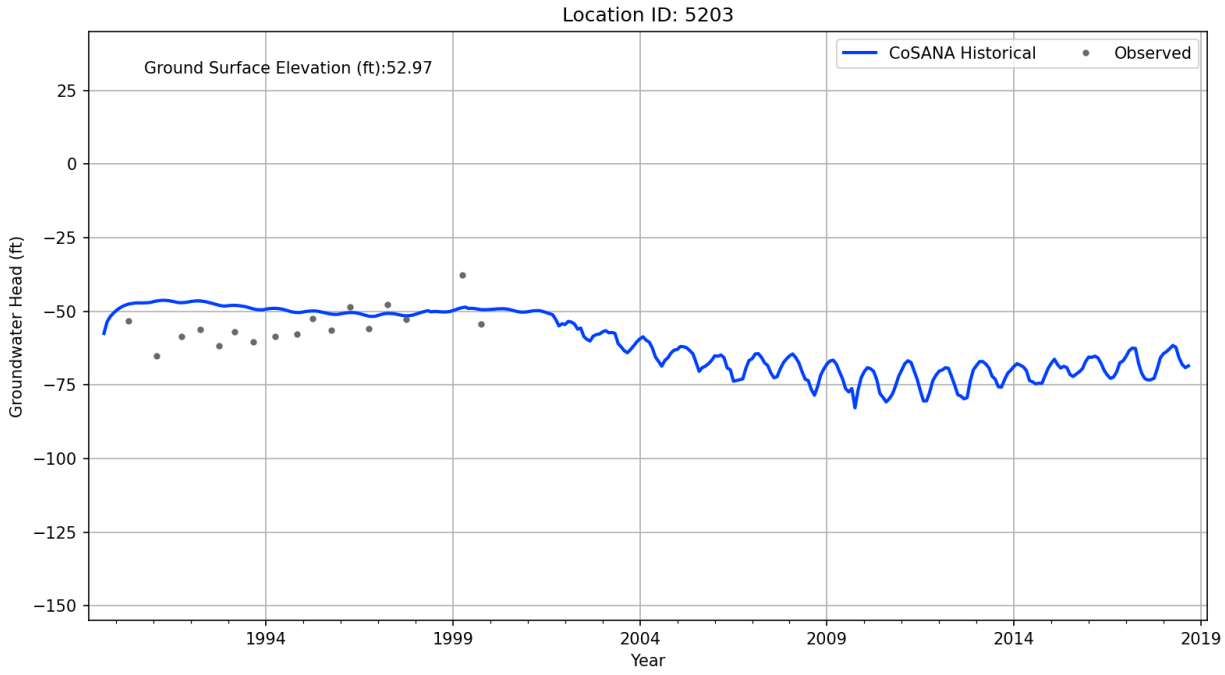

Location ID: 5108
Ground Surface Elevation (ft):37.1
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

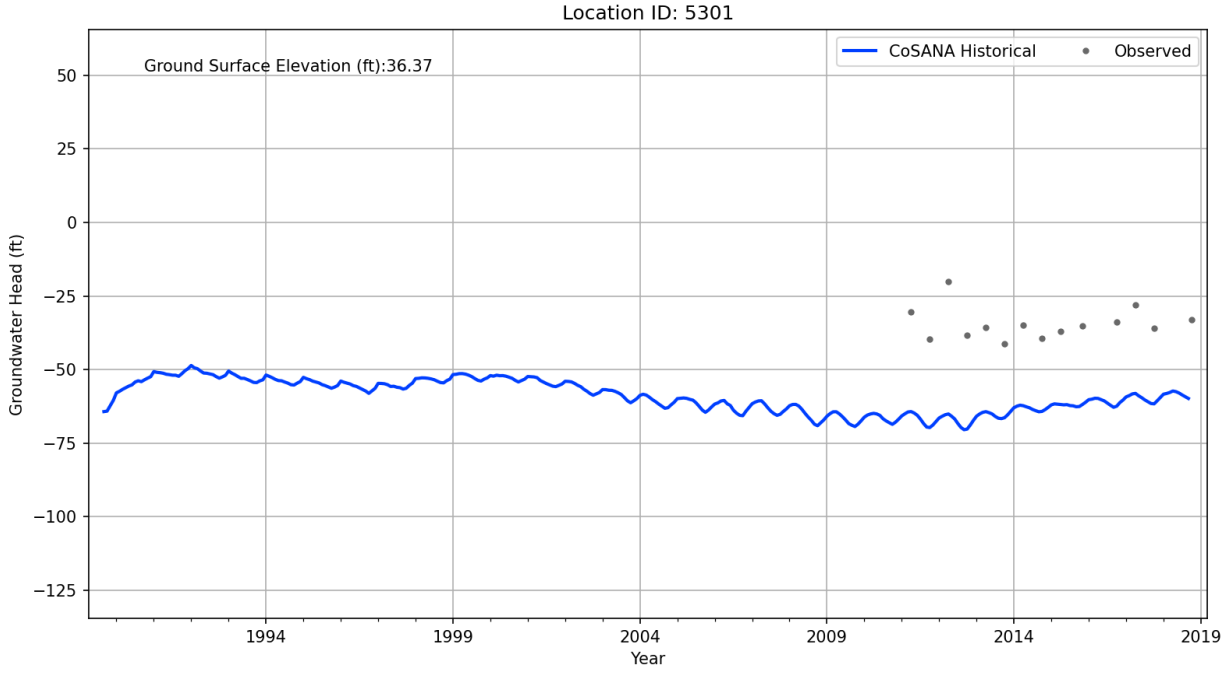

Location ID: 5109
Ground Surface Elevation (ft):47.19
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

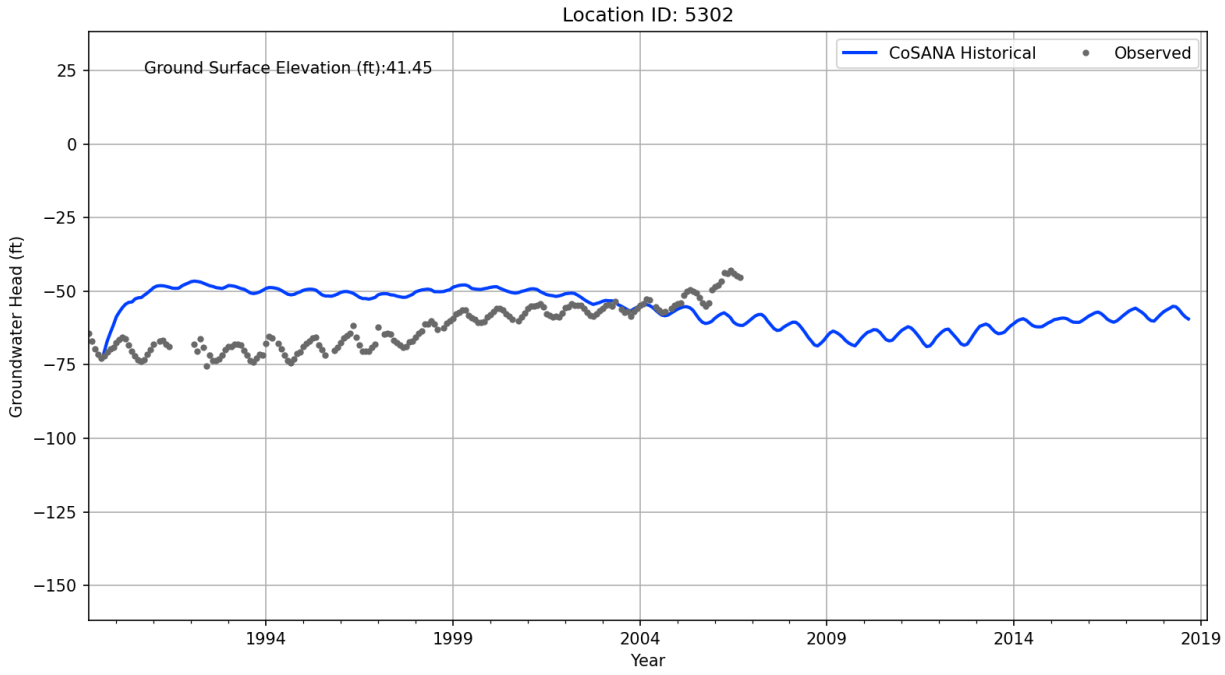

Location ID: 5111
Ground Surface Elevation (ft):55.8
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

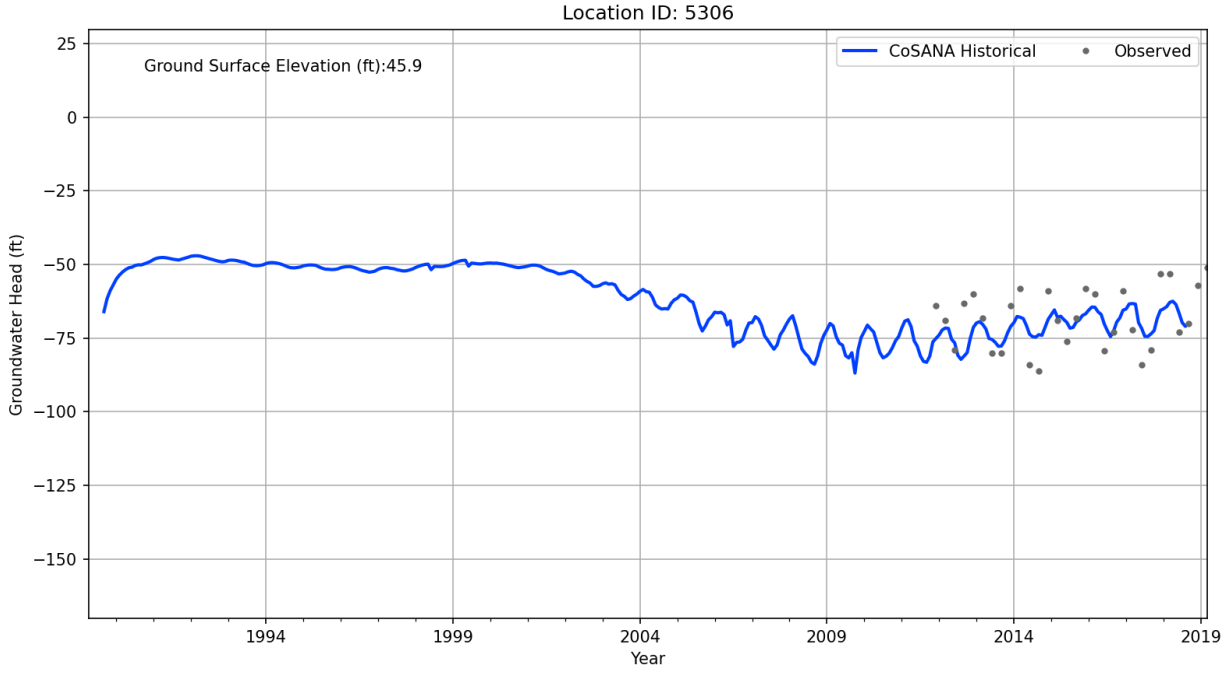

Location ID: 5201
Ground Surface Elevation (ft):62.76
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

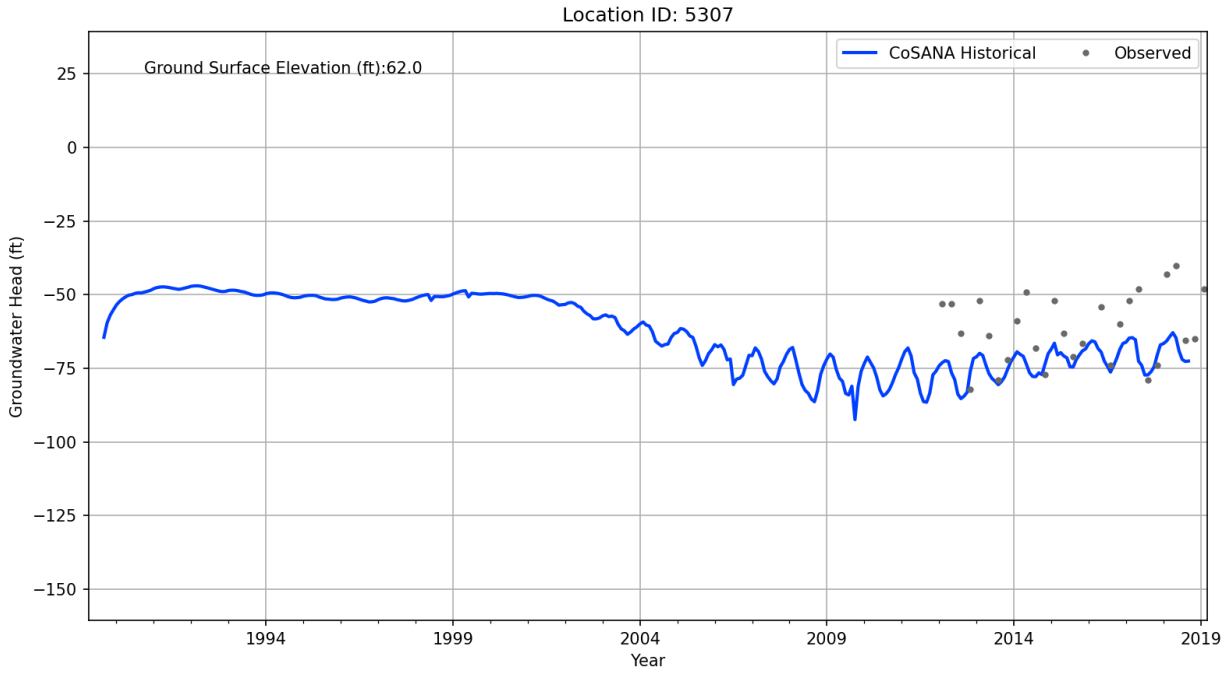

Location ID: 5202
Ground Surface Elevation (ft):65.14
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

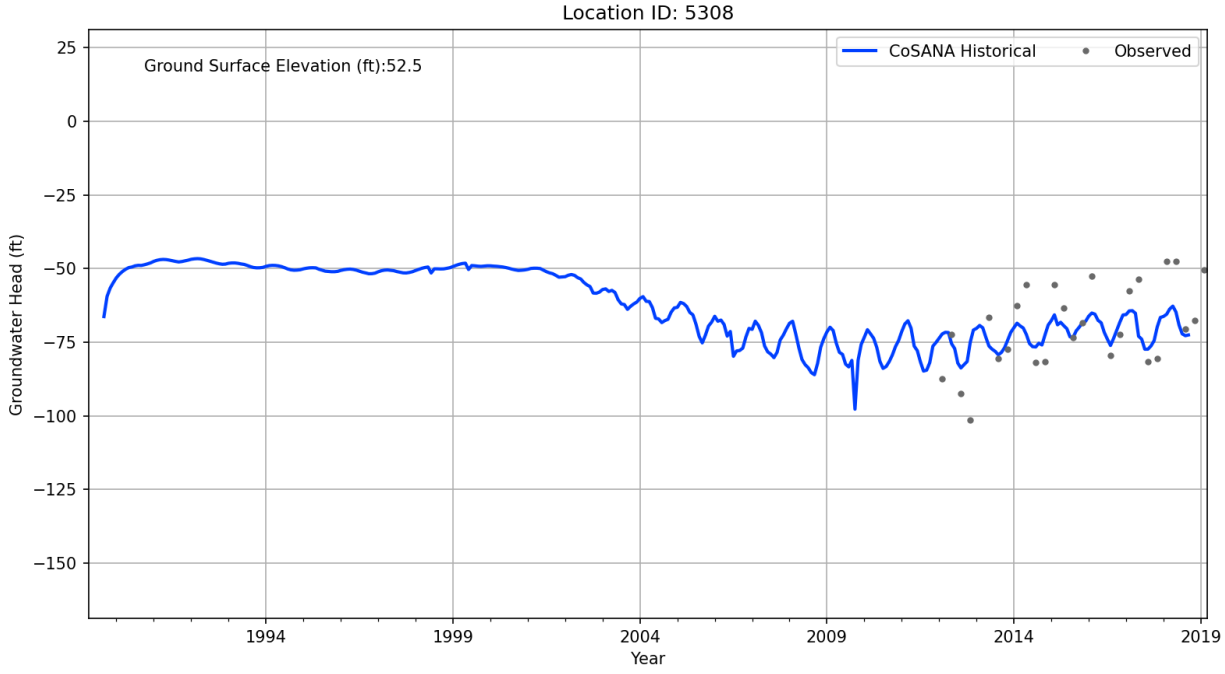

Location ID: 5203
Ground Surface Elevation (ft):52.97
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

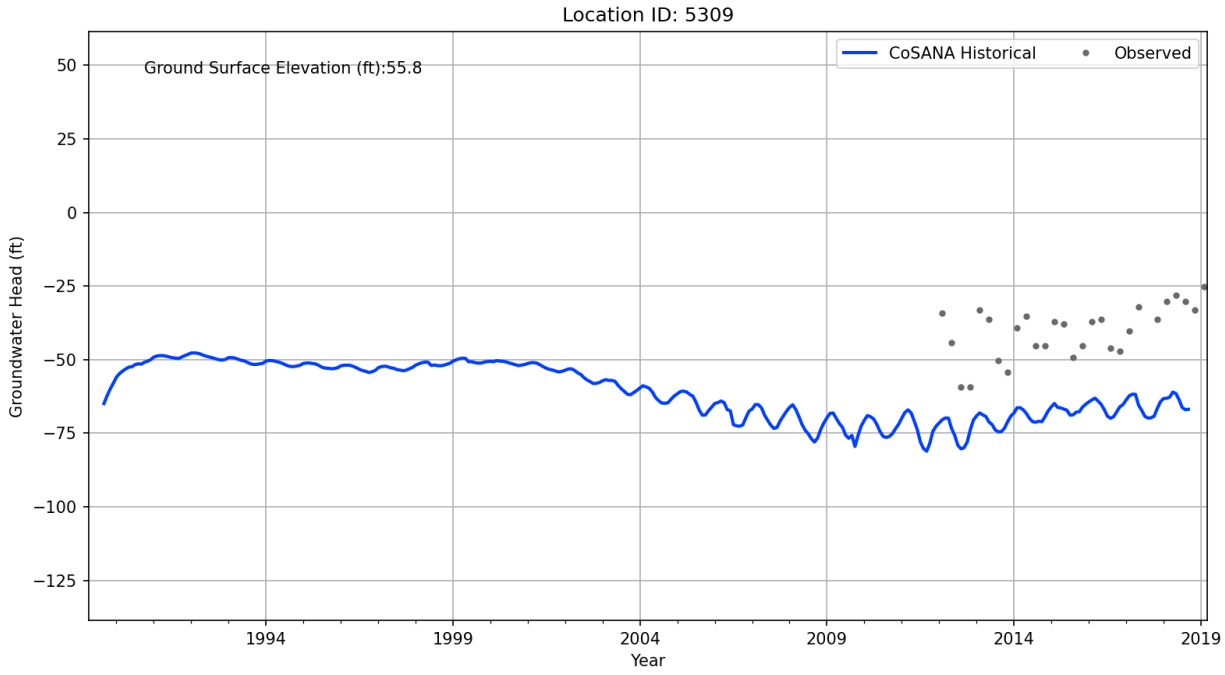

Location ID: 5301
Ground Surface Elevation (ft):36.37
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

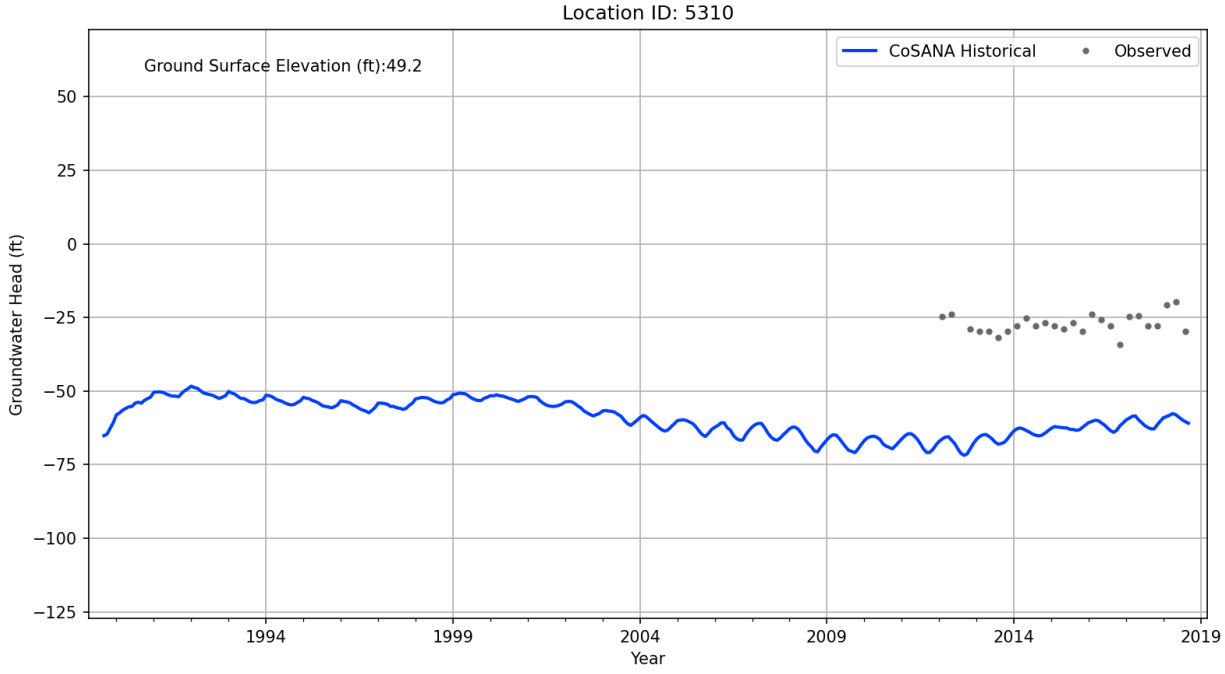

Location ID: 5302
Ground Surface Elevation (ft):41.45
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

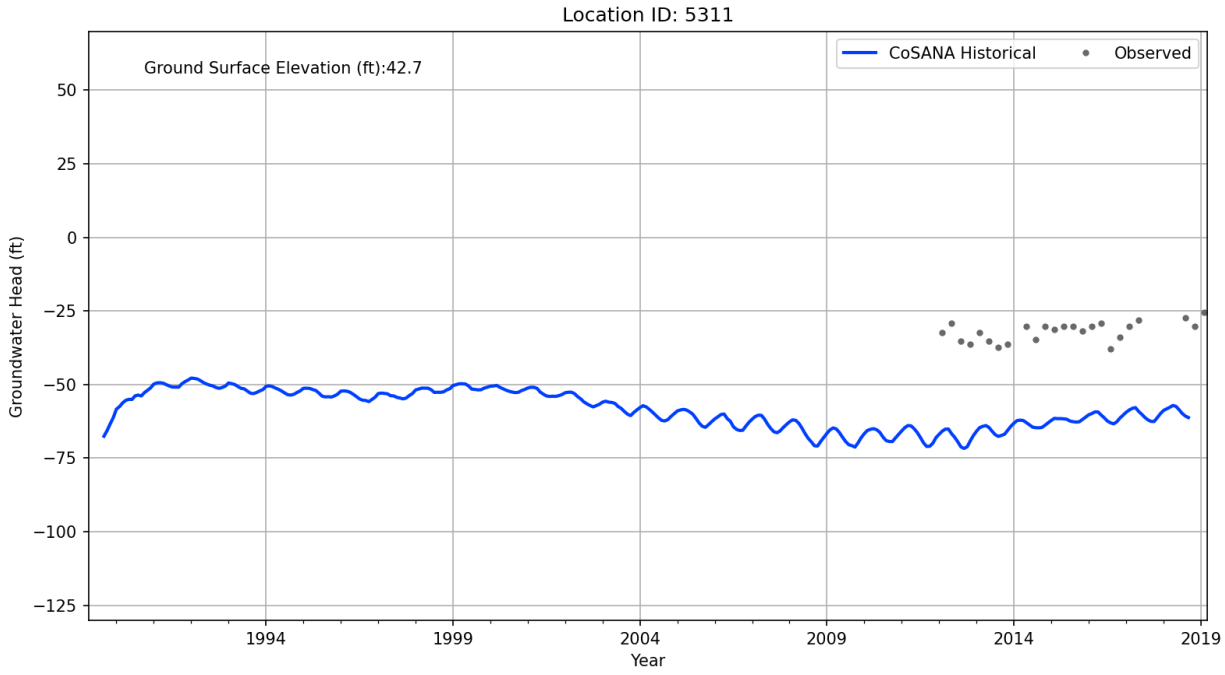

Location ID: 5306
Ground Surface Elevation (ft):45.9
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

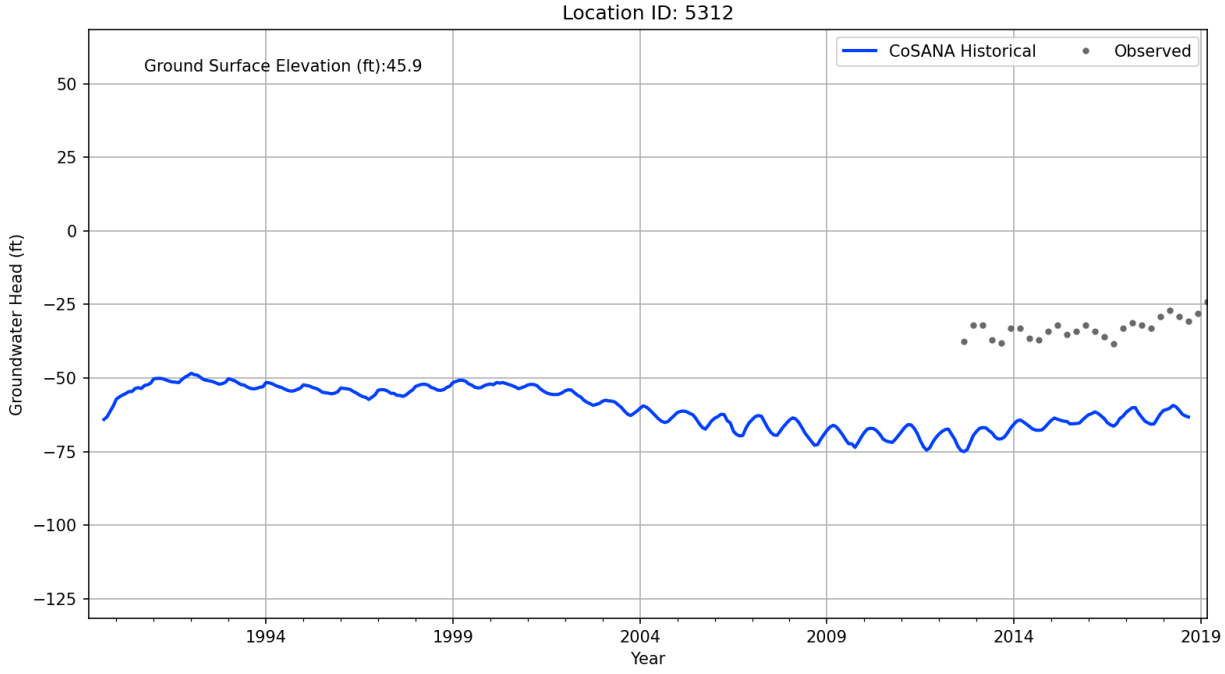

Location ID: 5307
Ground Surface Elevation (ft):62.0
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

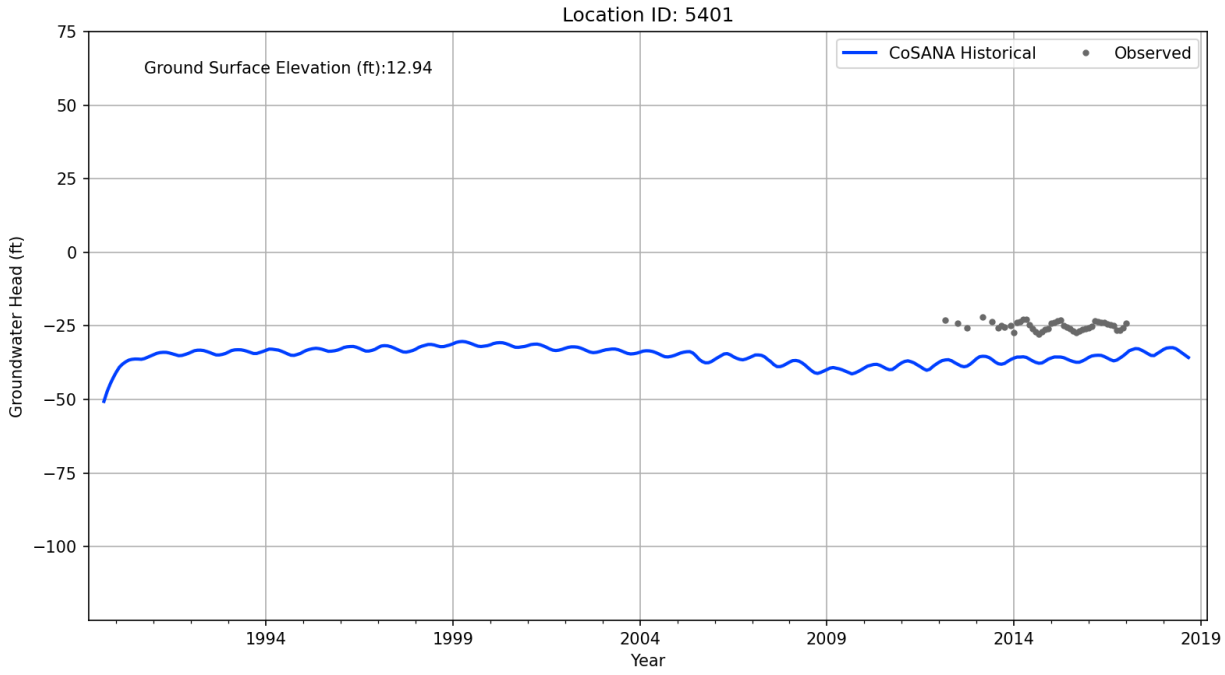

Location ID: 5308
Ground Surface Elevation (ft):52.5
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

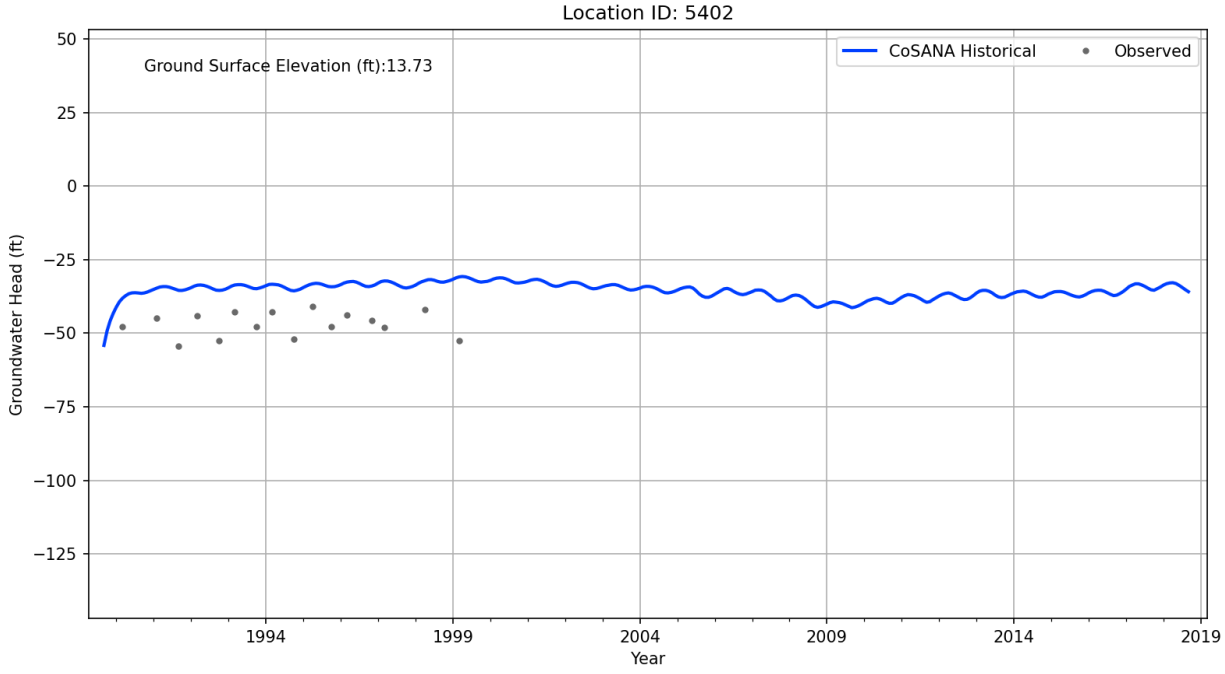

Location ID: 5309
Ground Surface Elevation (ft):55.8
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

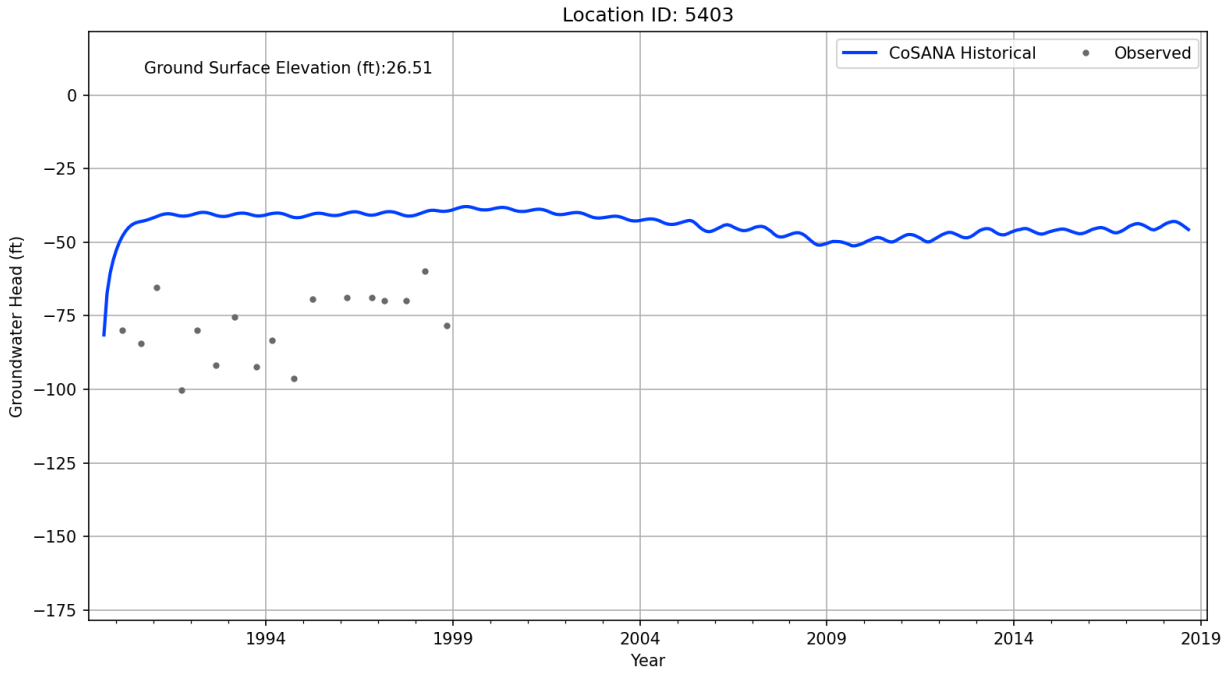

Location ID: 5310
Ground Surface Elevation (ft):49.2
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

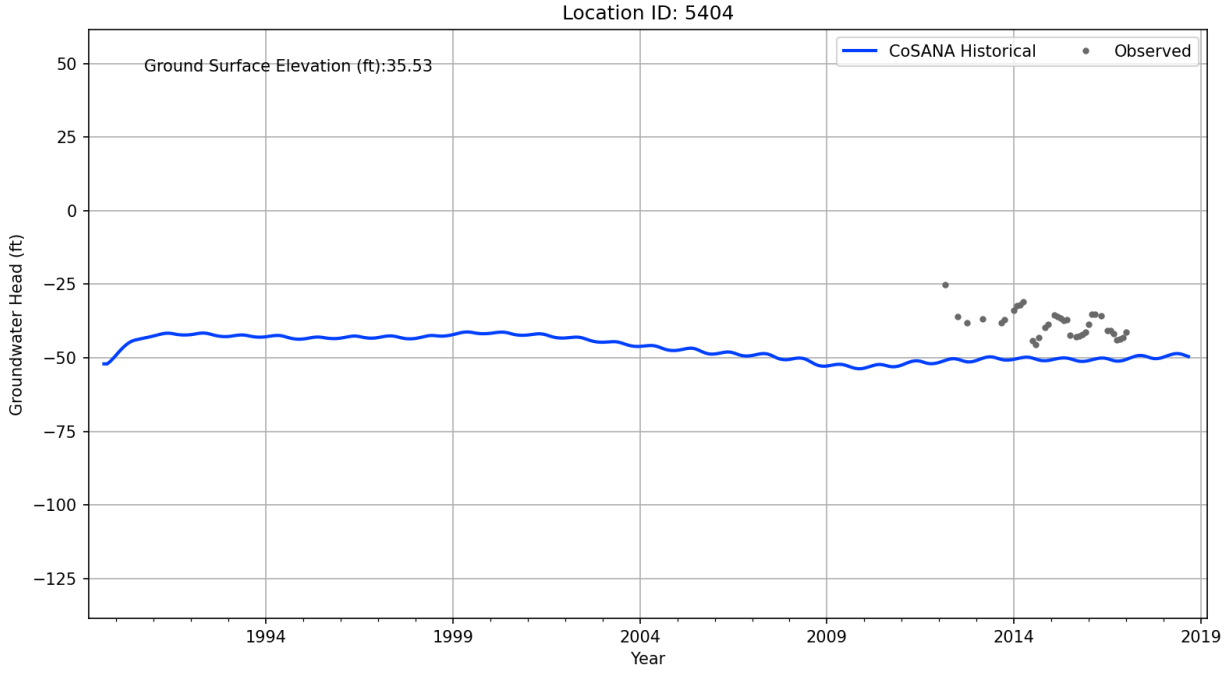

Location ID: 5311
Ground Surface Elevation (ft):42.7
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

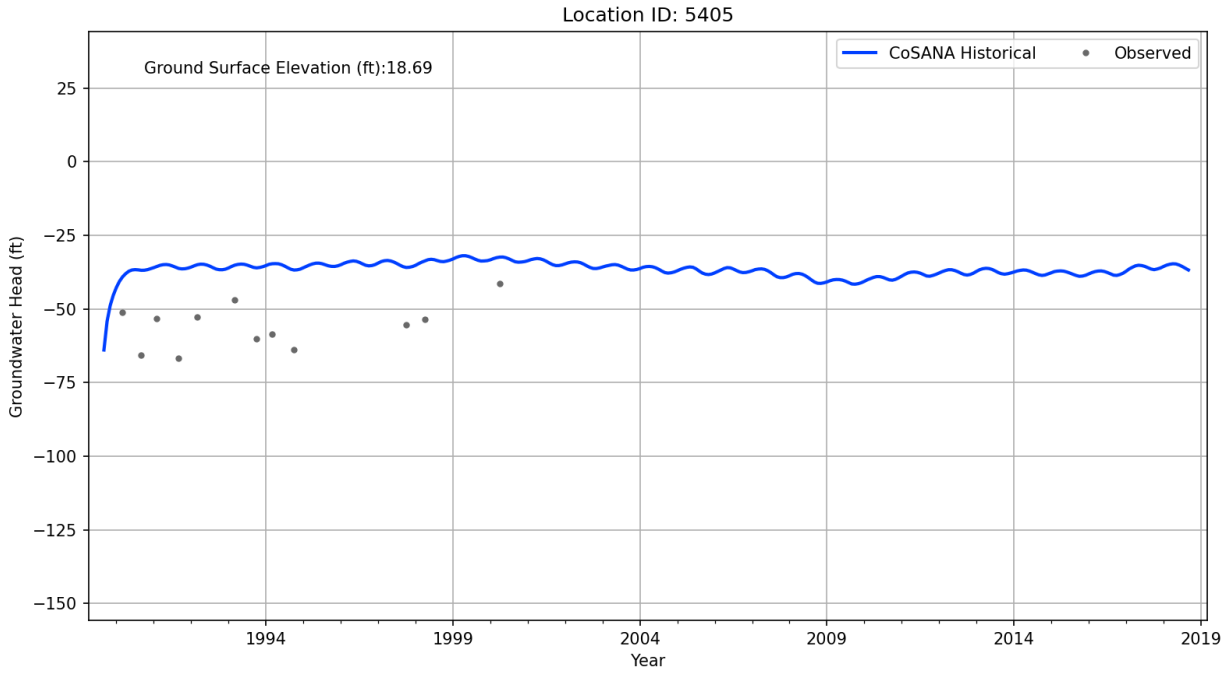

Location ID: 5312
Ground Surface Elevation (ft):45.9
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

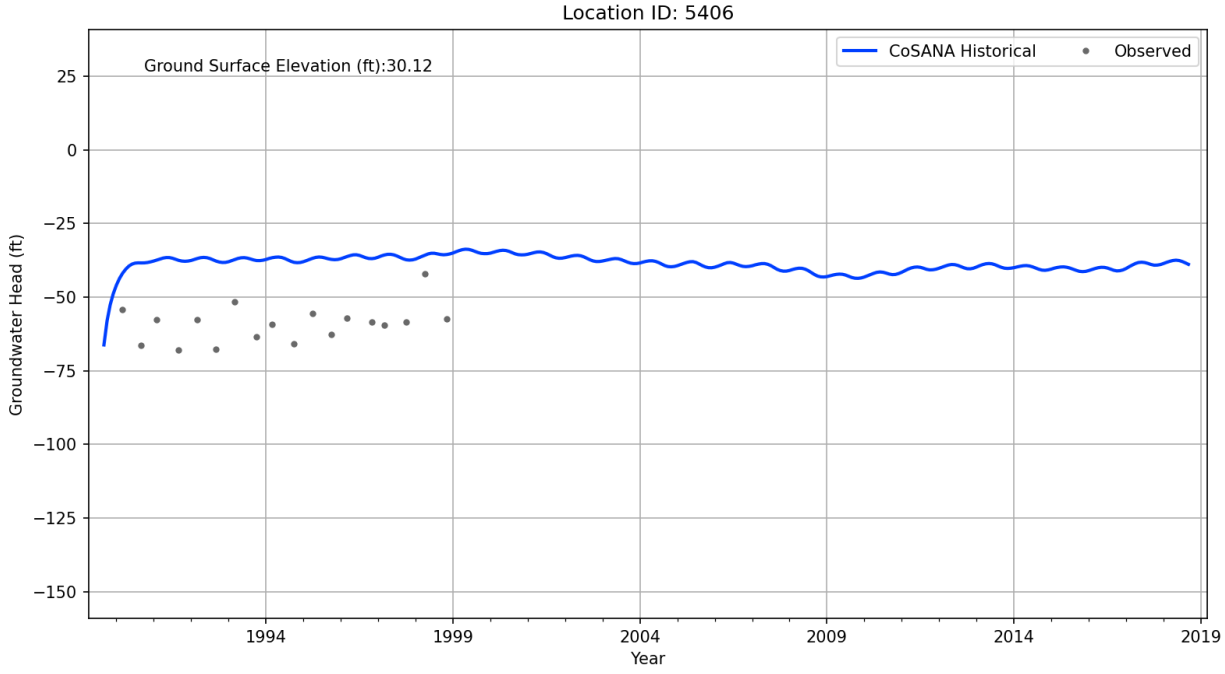

Location ID: 5401
Ground Surface Elevation (ft):12.94
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

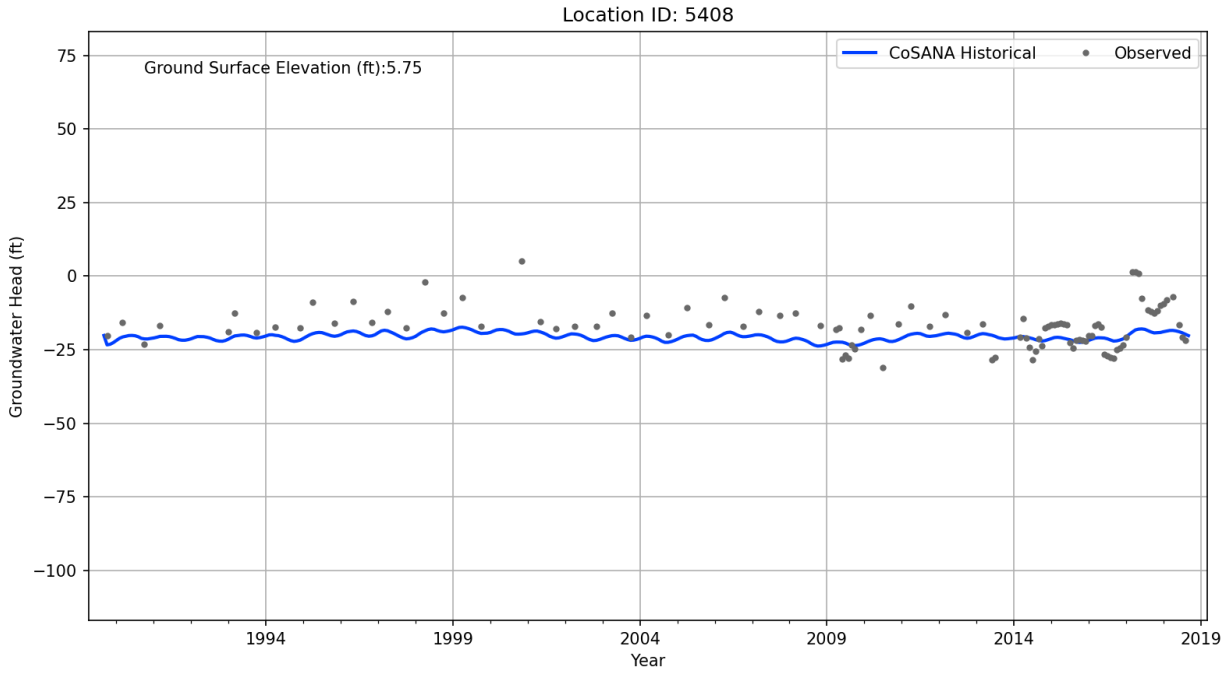

Location ID: 5402
Ground Surface Elevation (ft):13.73
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

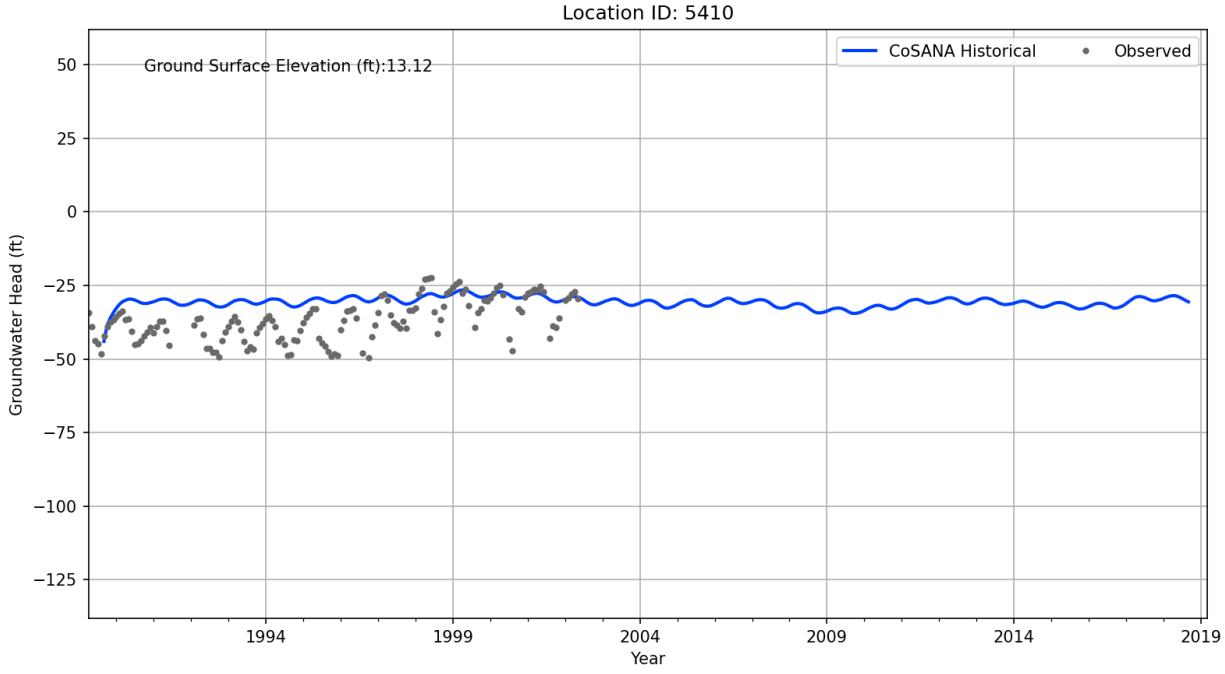

Location ID: 5403
Ground Surface Elevation (ft):26.51
CoSANA Historical
Observed
Groundwater Head (ft)
0
−25
−50
−75
−100
−125
−150
−175
1994
1999
2004
2009
2014
2019
Year

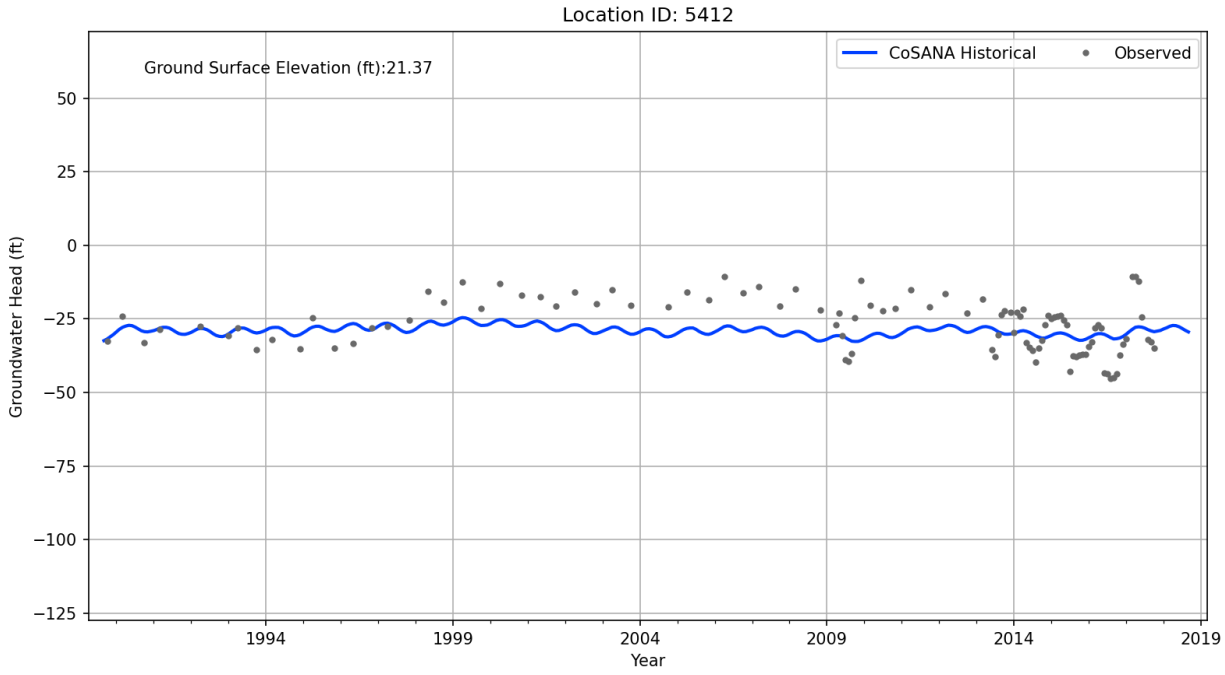

Location ID: 5404
Ground Surface Elevation (ft):35.53
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

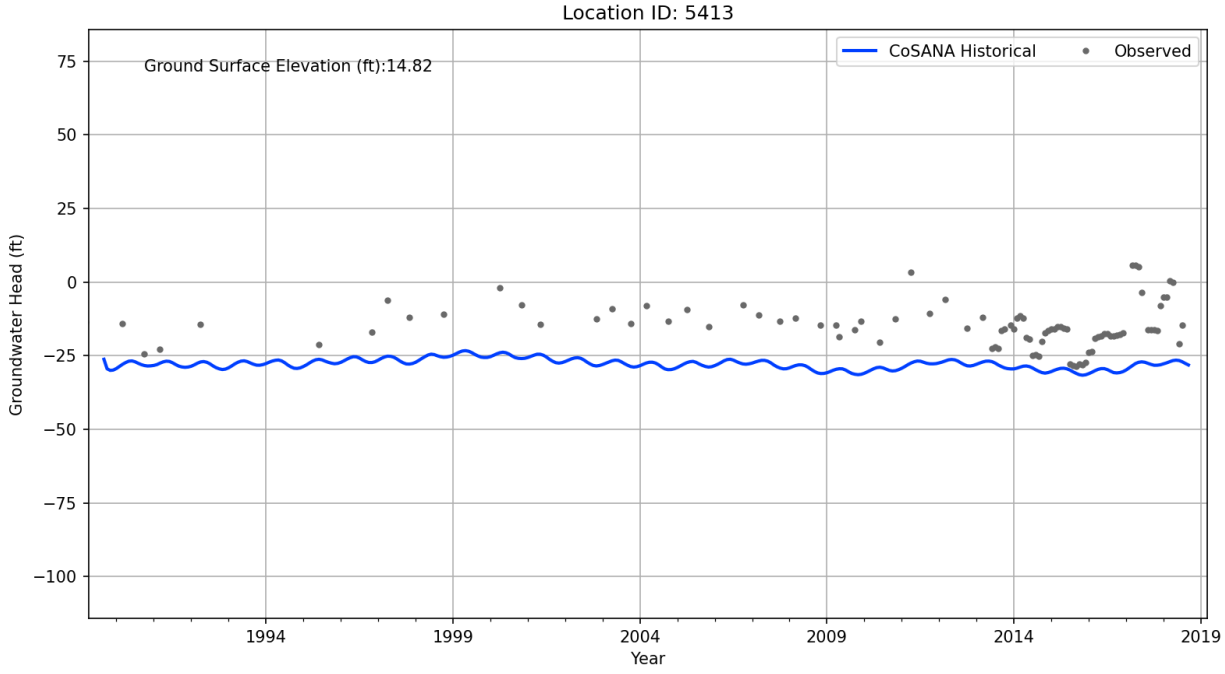

Location ID: 5405
Ground Surface Elevation (ft):18.69
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

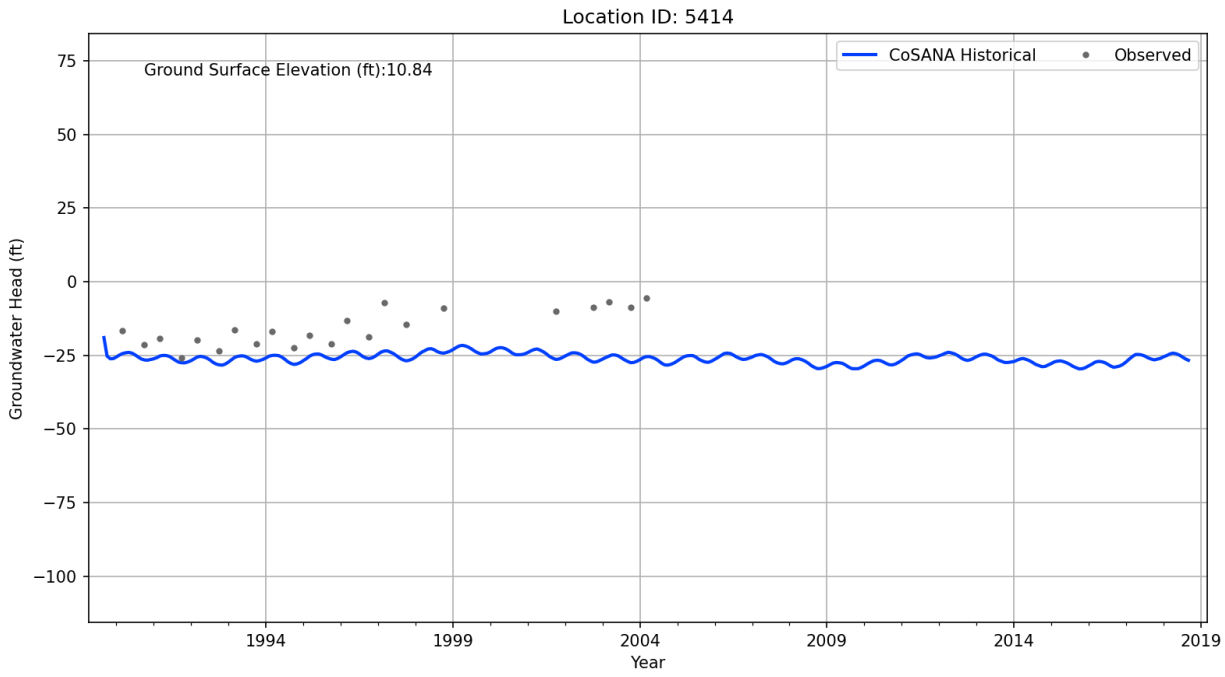

Location ID: 5406
Ground Surface Elevation (ft):30.12
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

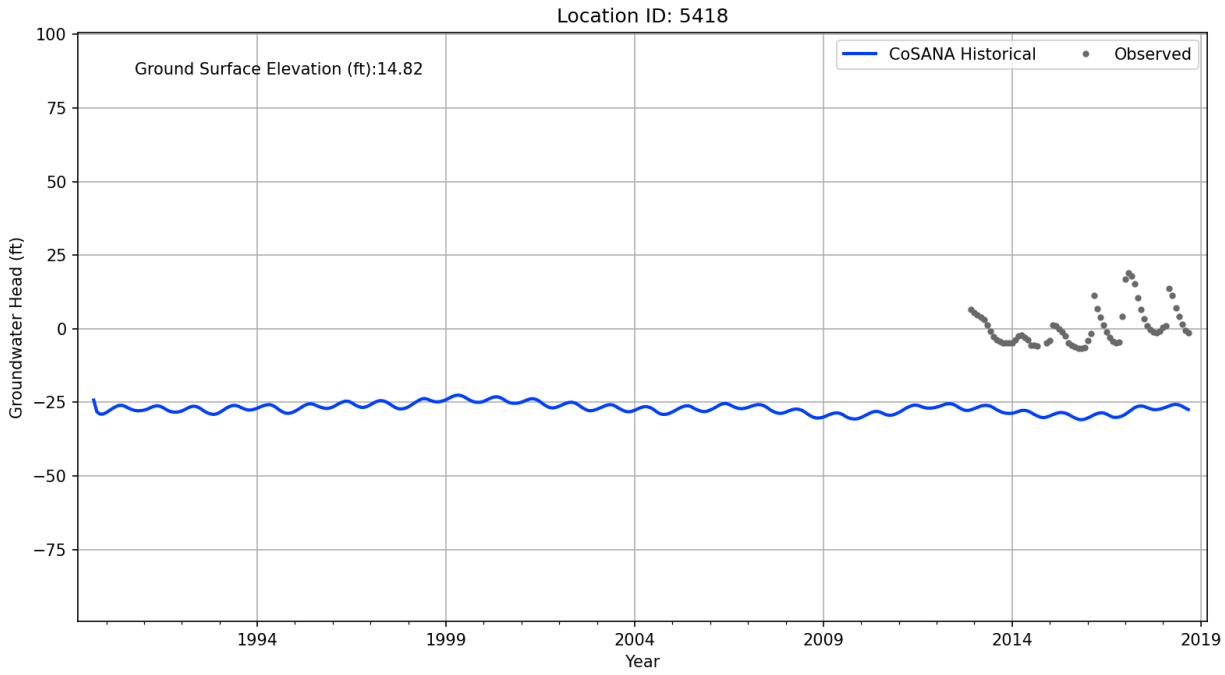

Location ID: 5408
Ground Surface Elevation (ft):5.75
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

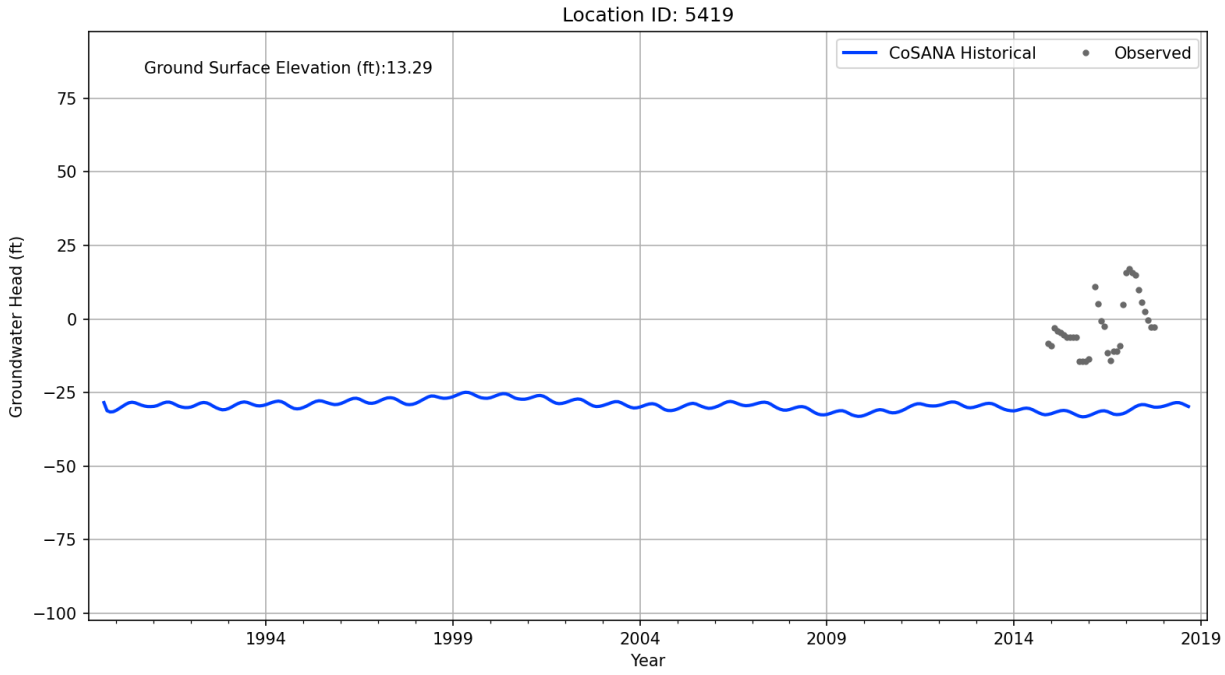

Location ID: 5410
Ground Surface Elevation (ft):13.12
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

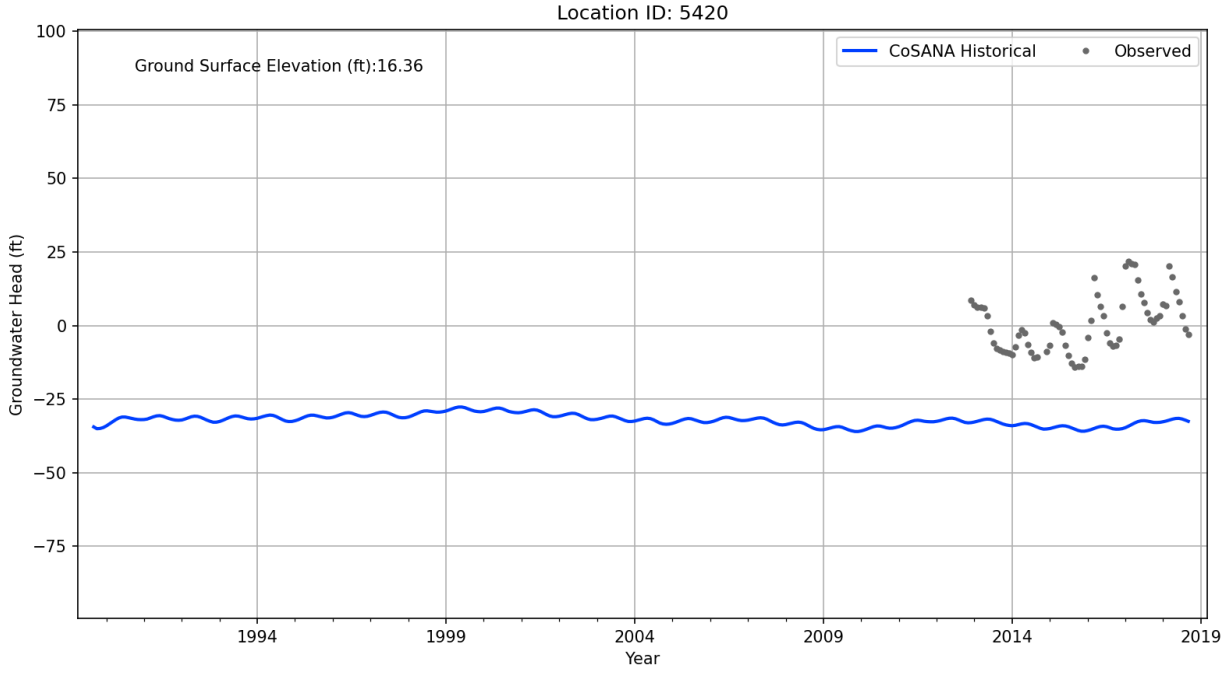

Location ID: 5412
Ground Surface Elevation (ft):21.37
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

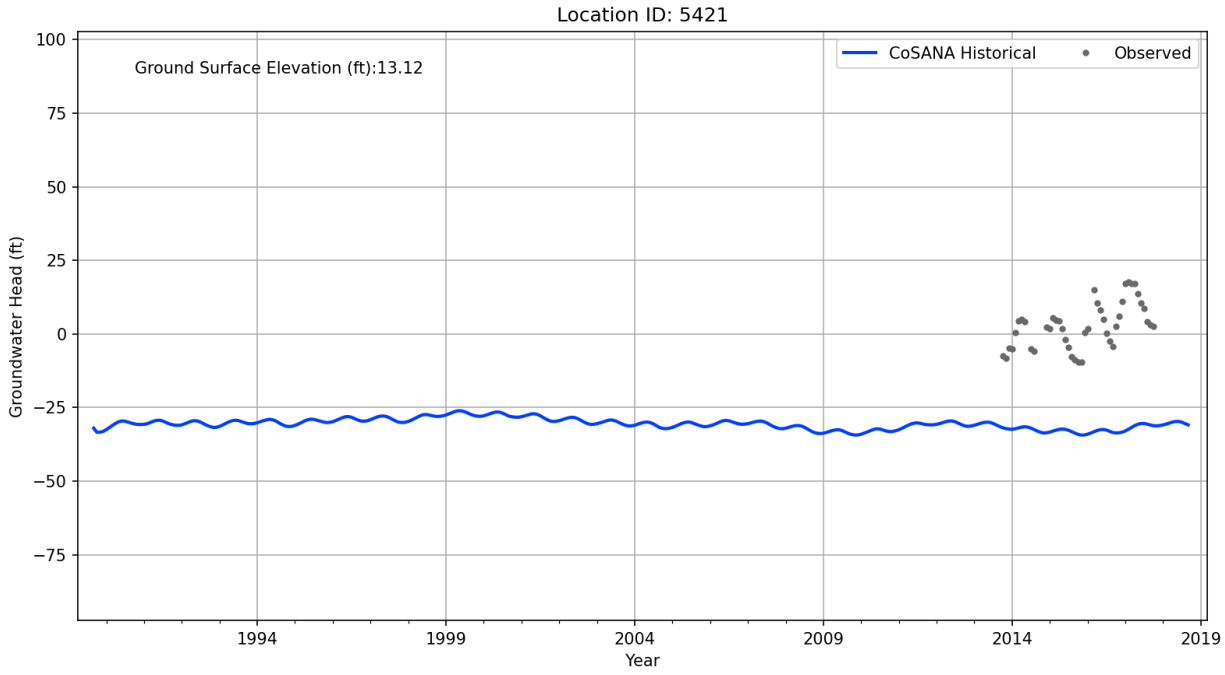

Location ID: 5413
Ground Surface Elevation (ft):14.82
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

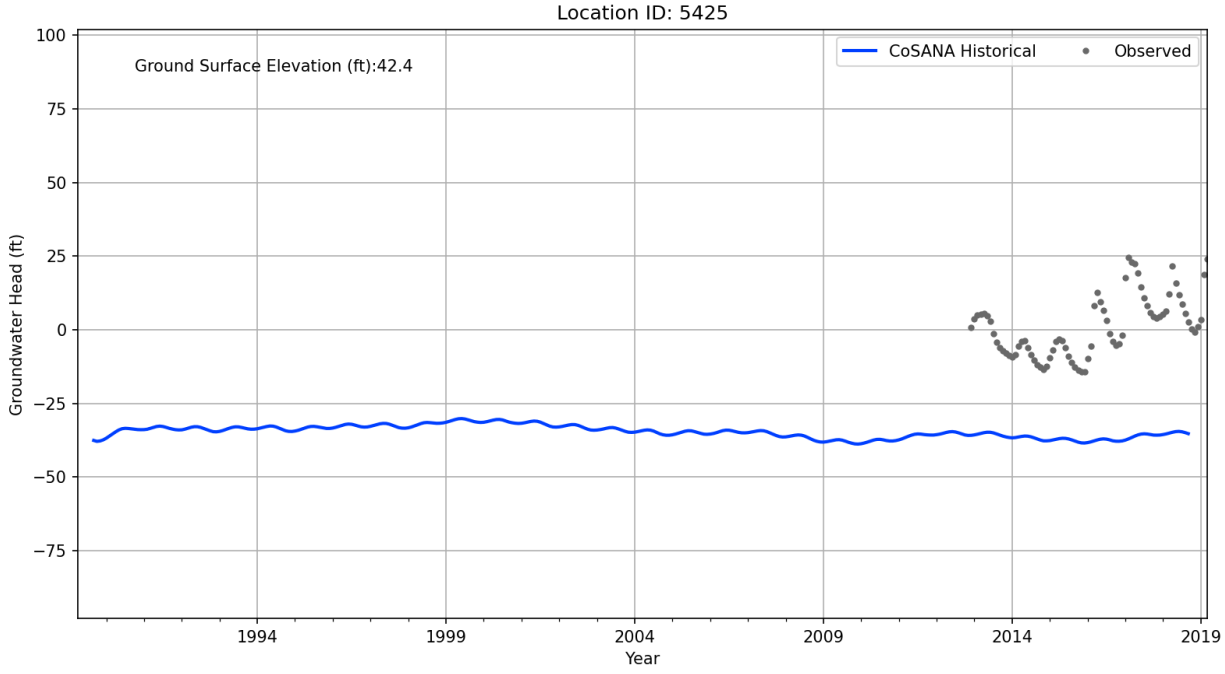

Location ID: 5414
Ground Surface Elevation (ft):10.84
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

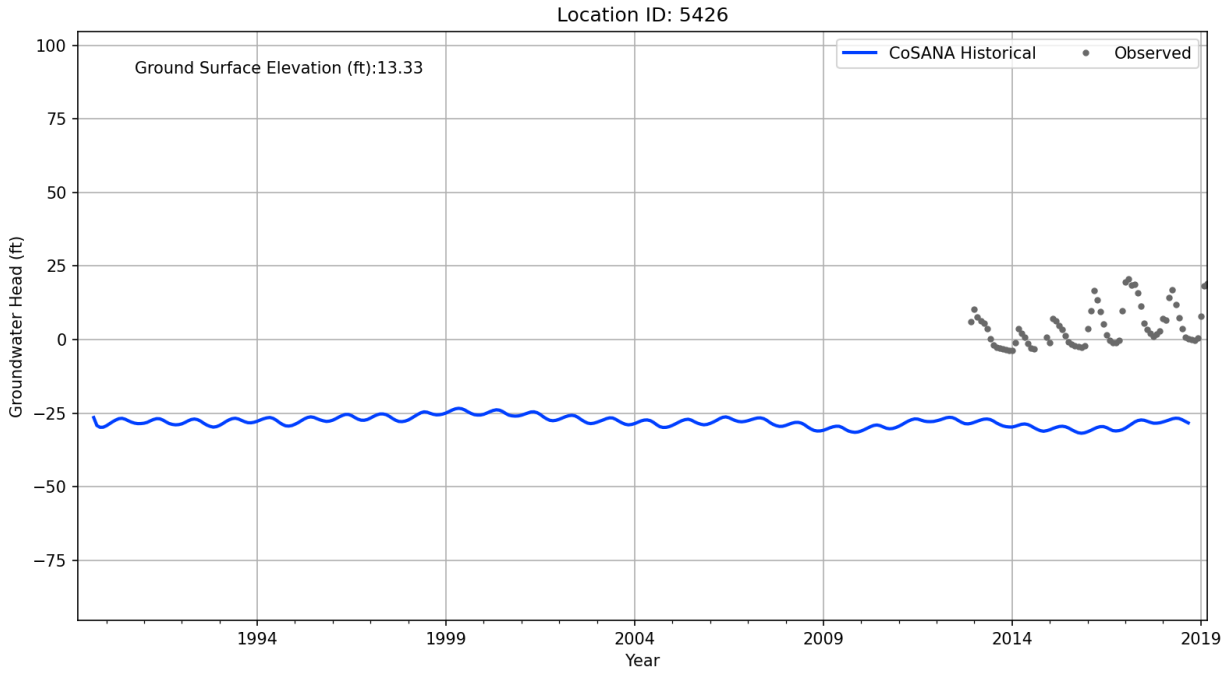

Location ID: 5418
Ground Surface Elevation (ft):14.82
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

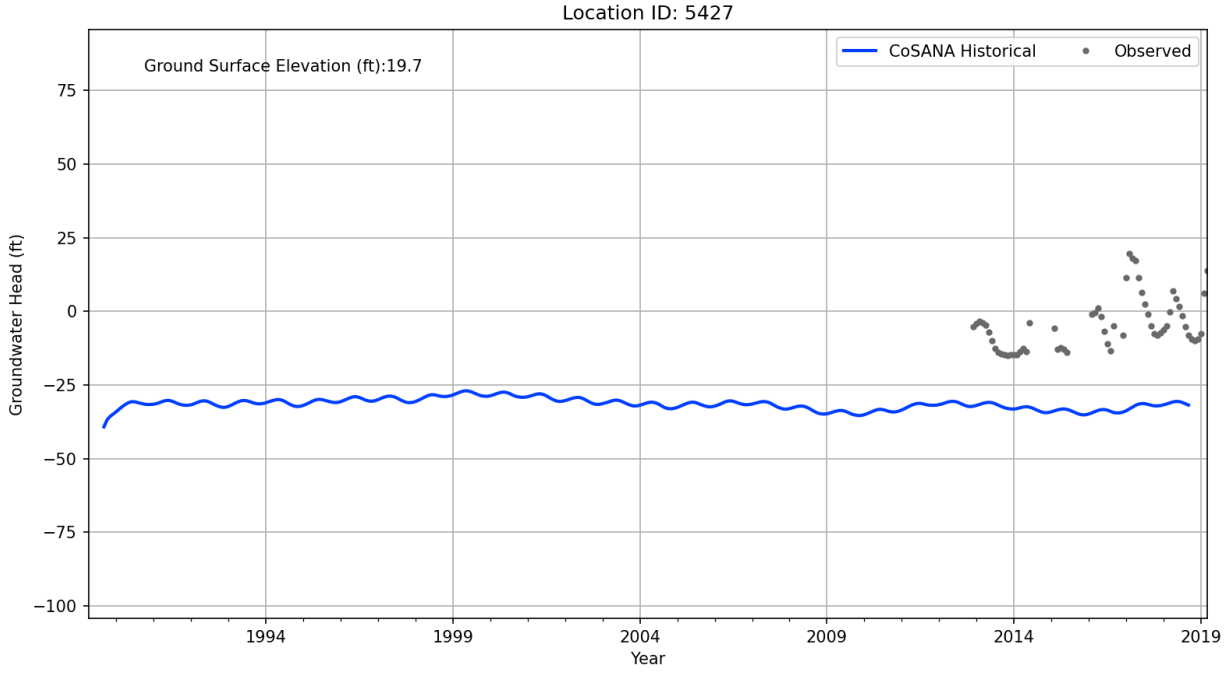

Location ID: 5419
Ground Surface Elevation (ft):13.29
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

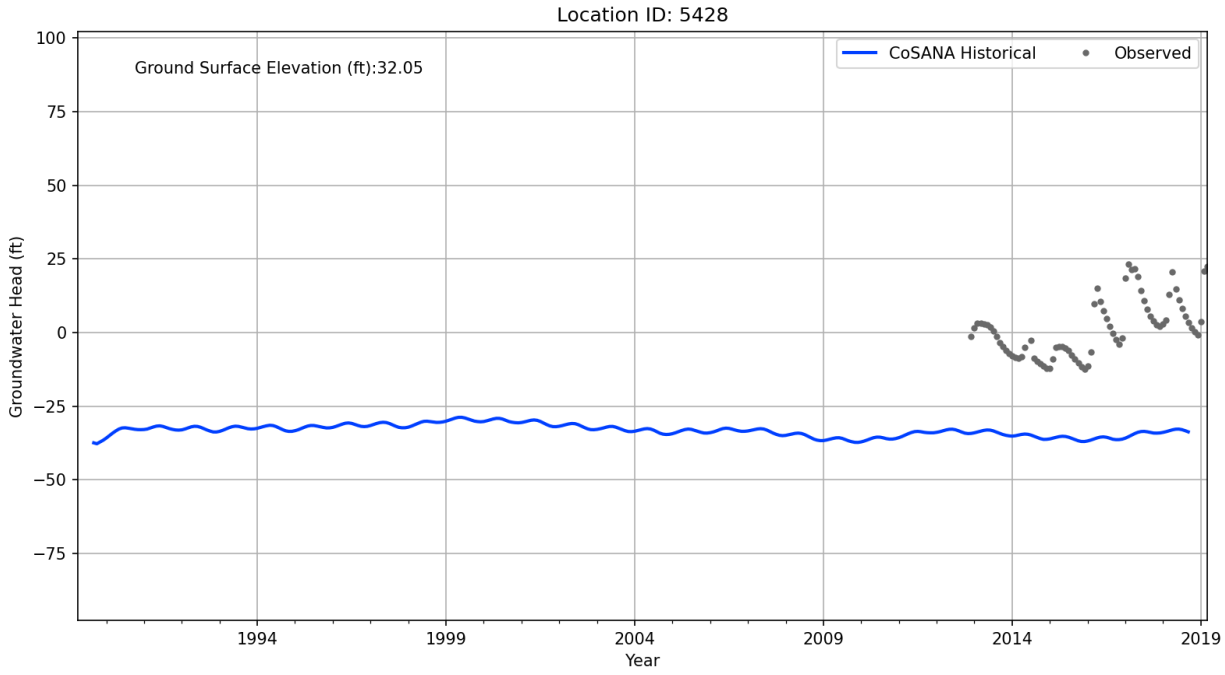

Location ID: 5420
Ground Surface Elevation (ft):16.36
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

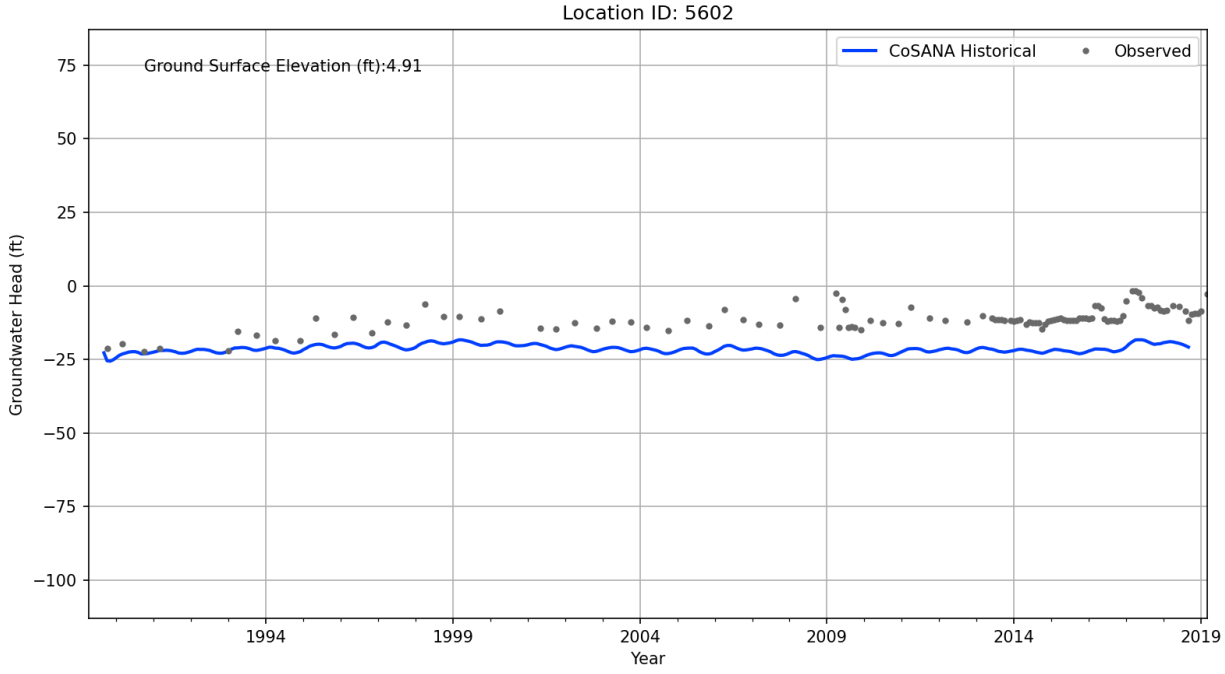

Location ID: 5421
Ground Surface Elevation (ft):13.12
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

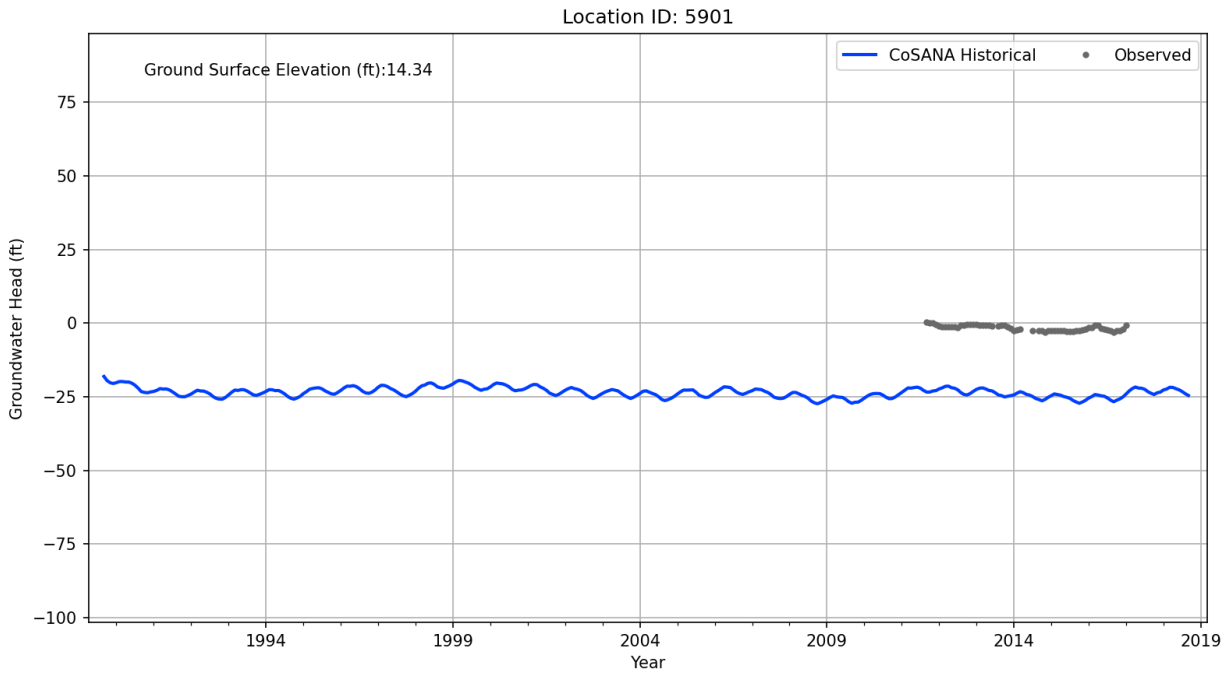

Location ID: 5425
Ground Surface Elevation (ft):42.4
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

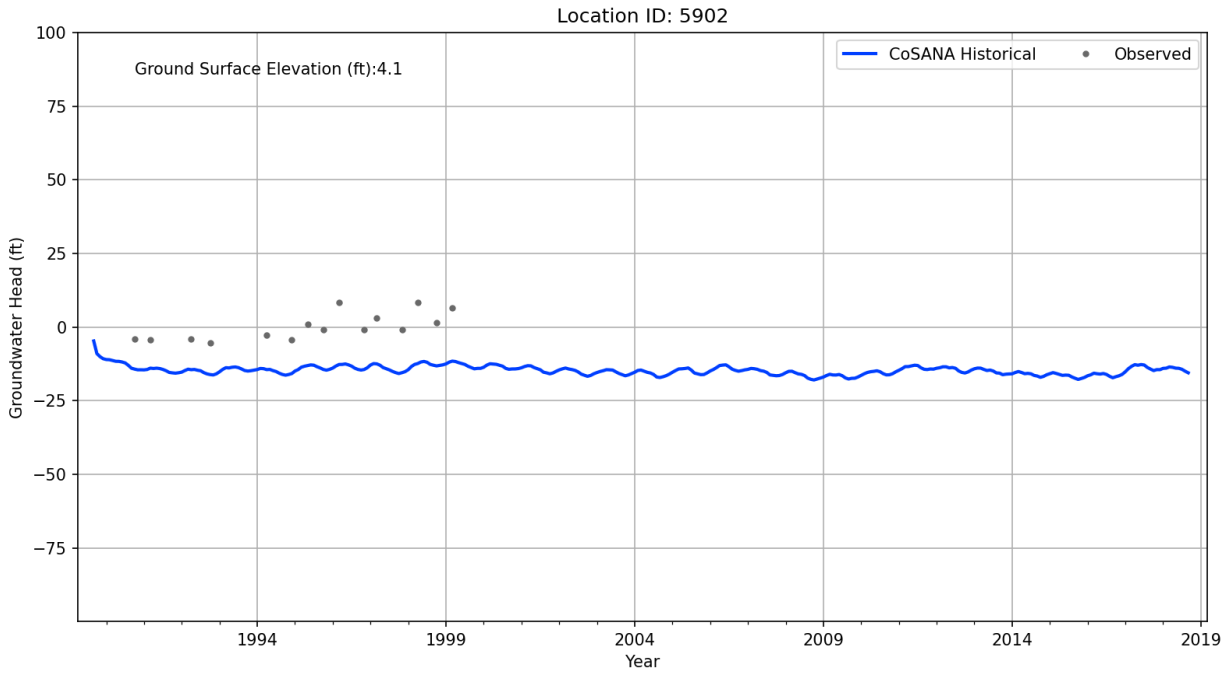

Location ID: 5426
Ground Surface Elevation (ft):13.33
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

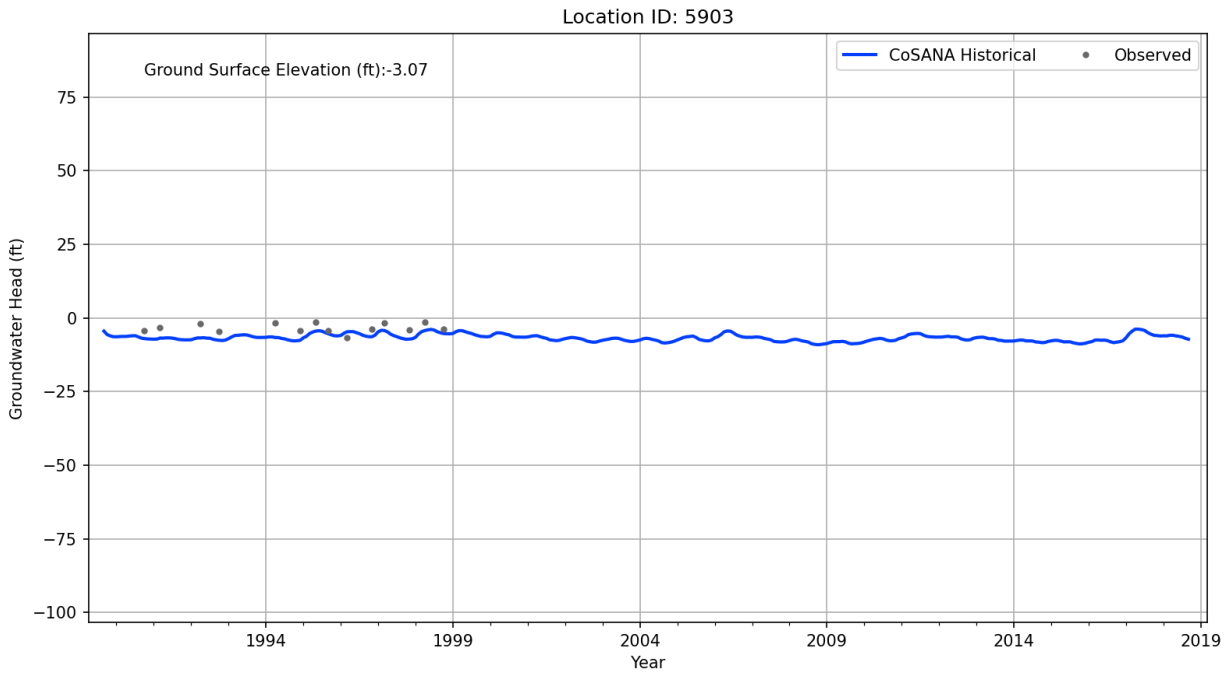

Location ID: 5427
Ground Surface Elevation (ft):19.7
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

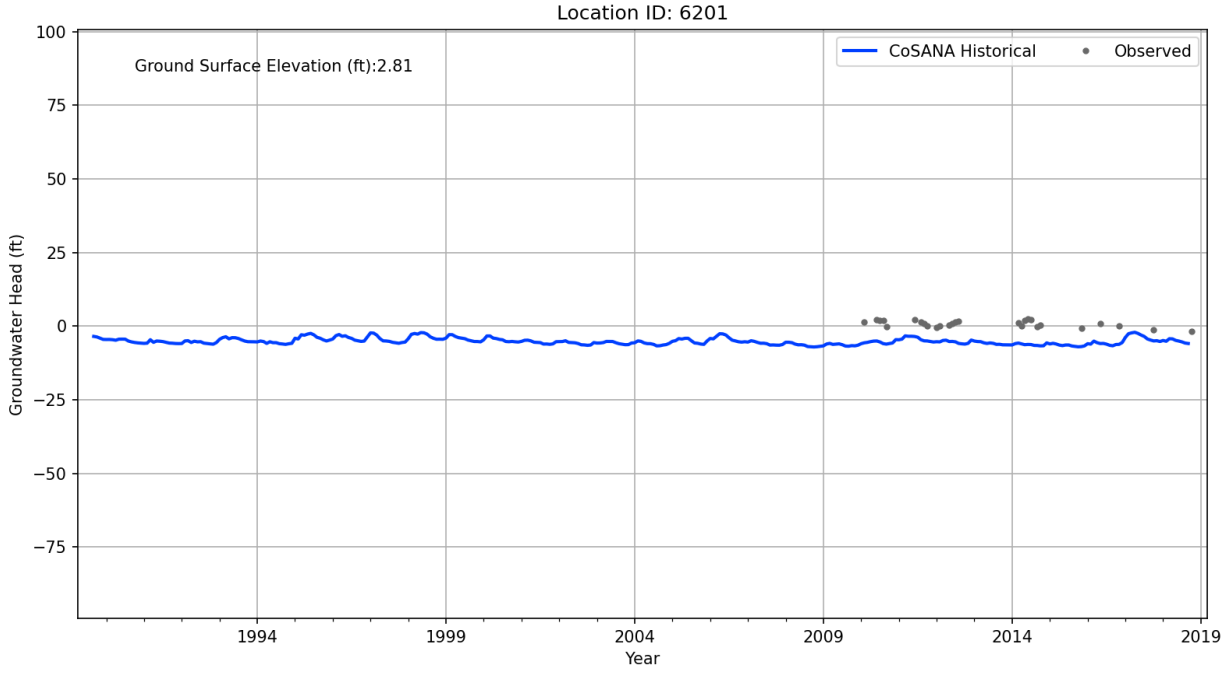

Location ID: 5428
Ground Surface Elevation (ft):32.05
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

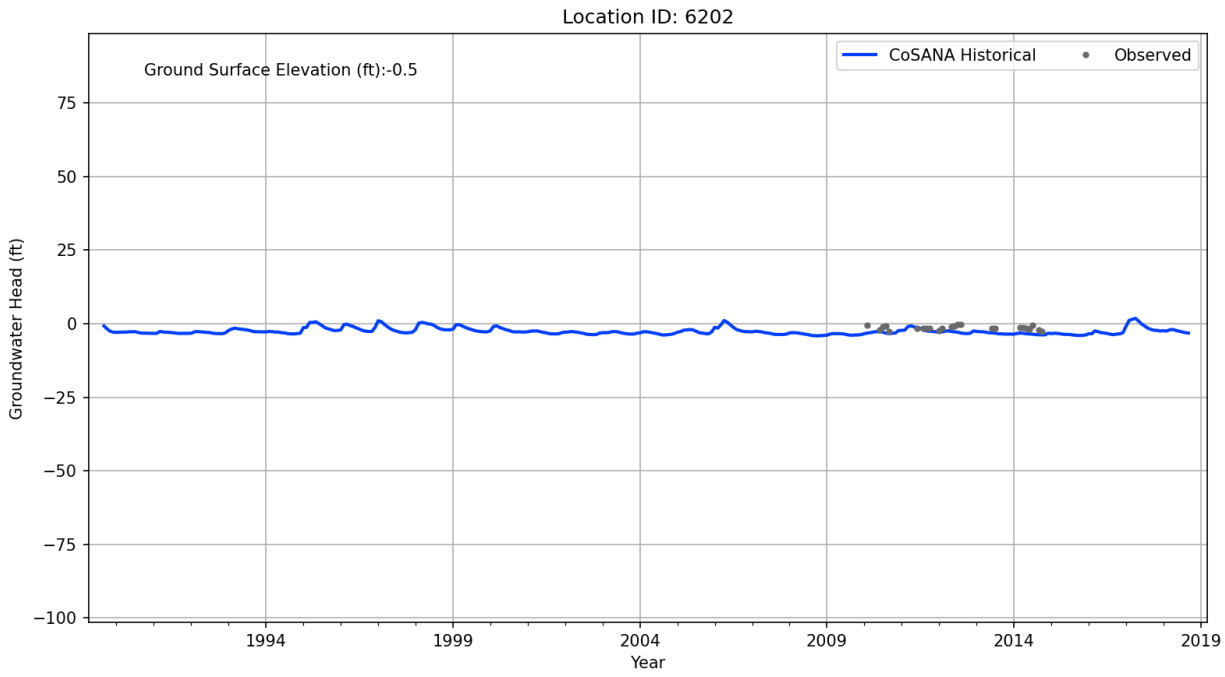

Location ID: 5602
Ground Surface Elevation (ft):4.91
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

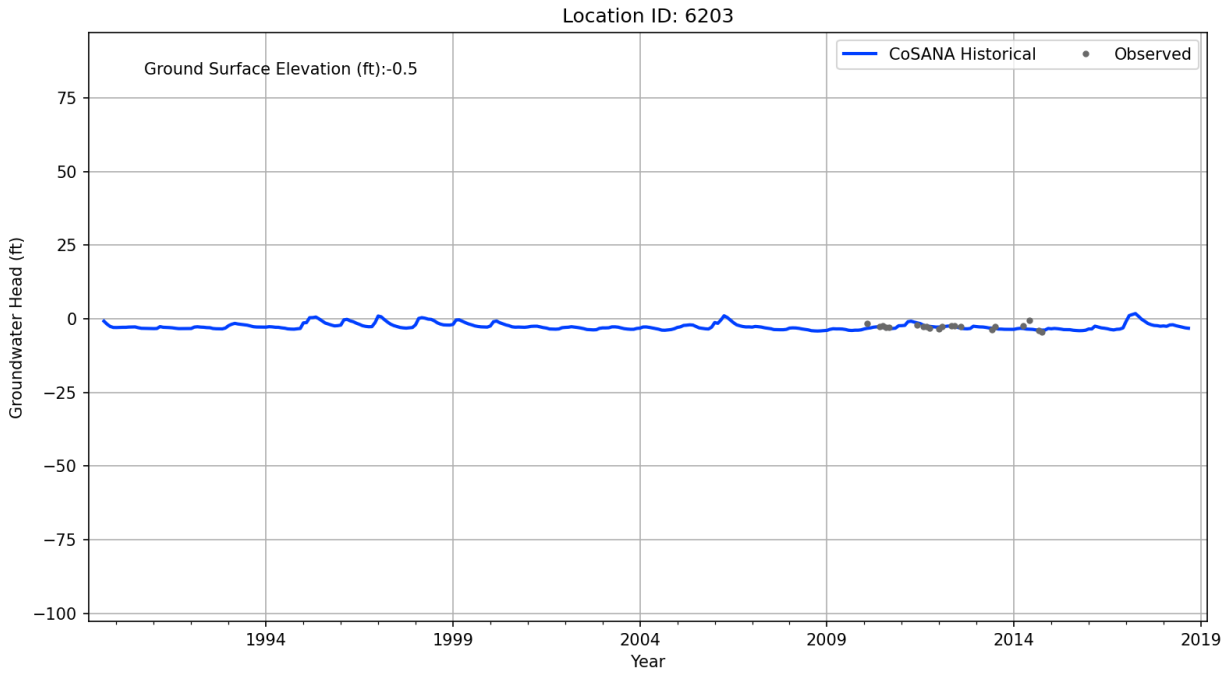

Location ID: 5901
Ground Surface Elevation (ft):14.34
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

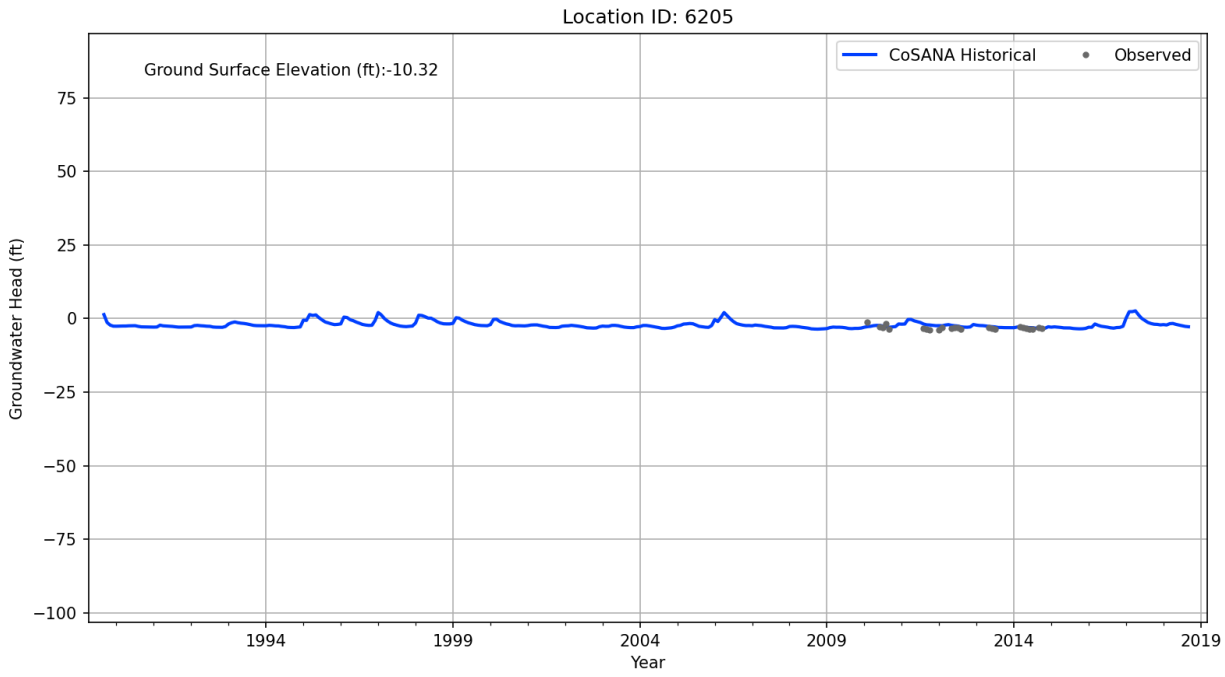

Location ID: 5902
Ground Surface Elevation (ft):4.1
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

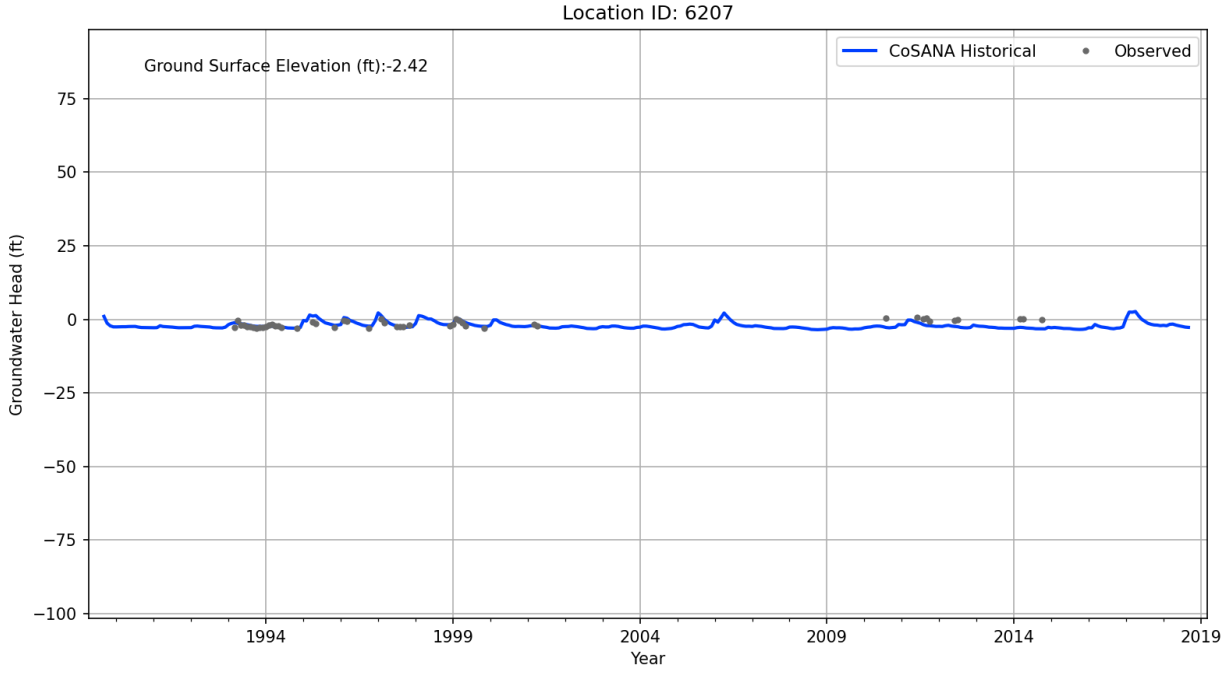

Location ID: 5903
Ground Surface Elevation (ft):-3.07
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

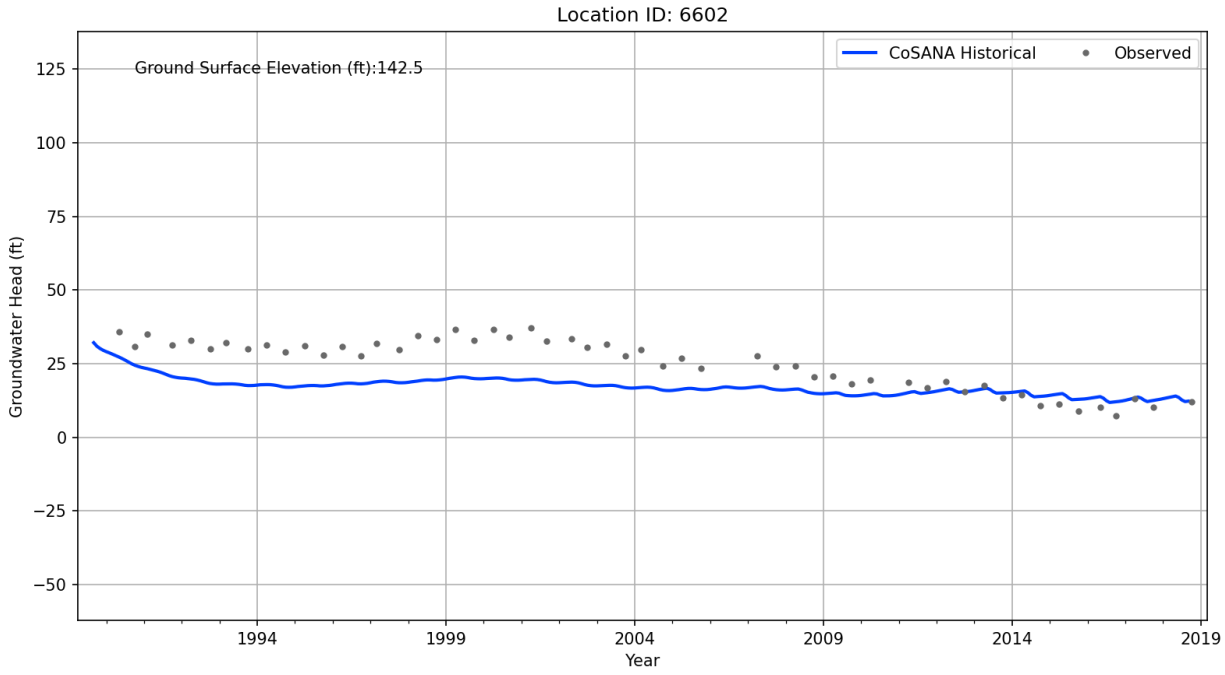

Location ID: 6201
Ground Surface Elevation (ft):2.81
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

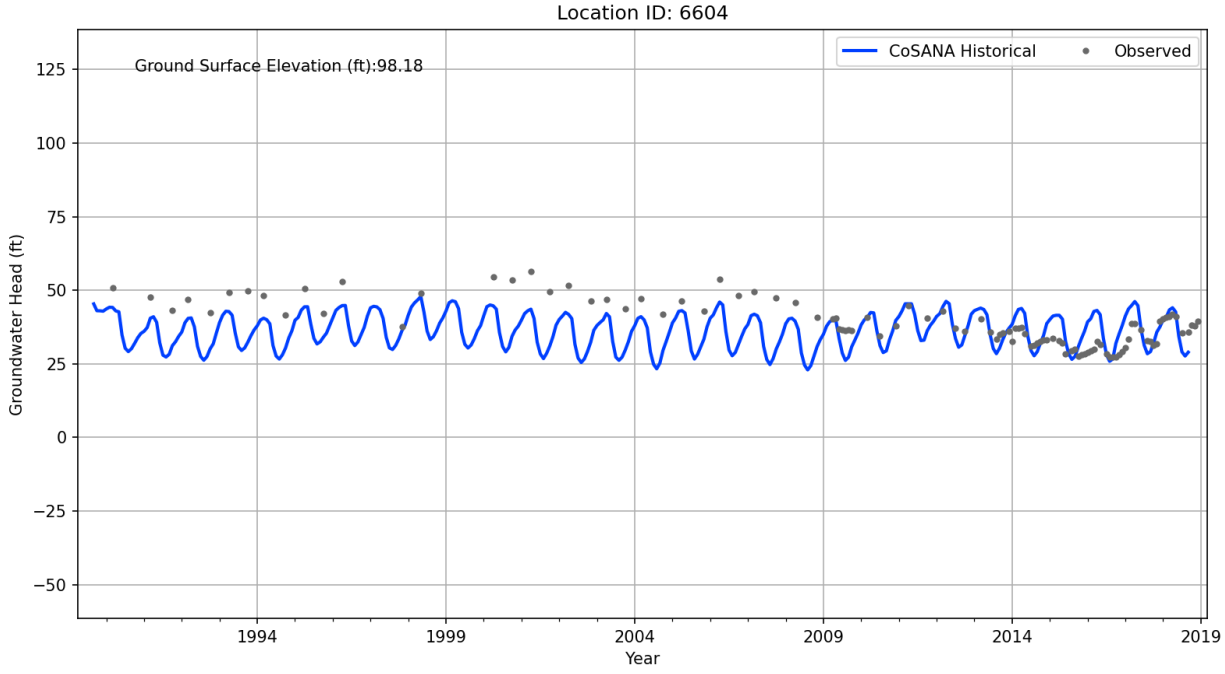

Location ID: 6202
Ground Surface Elevation (ft):-0.5
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

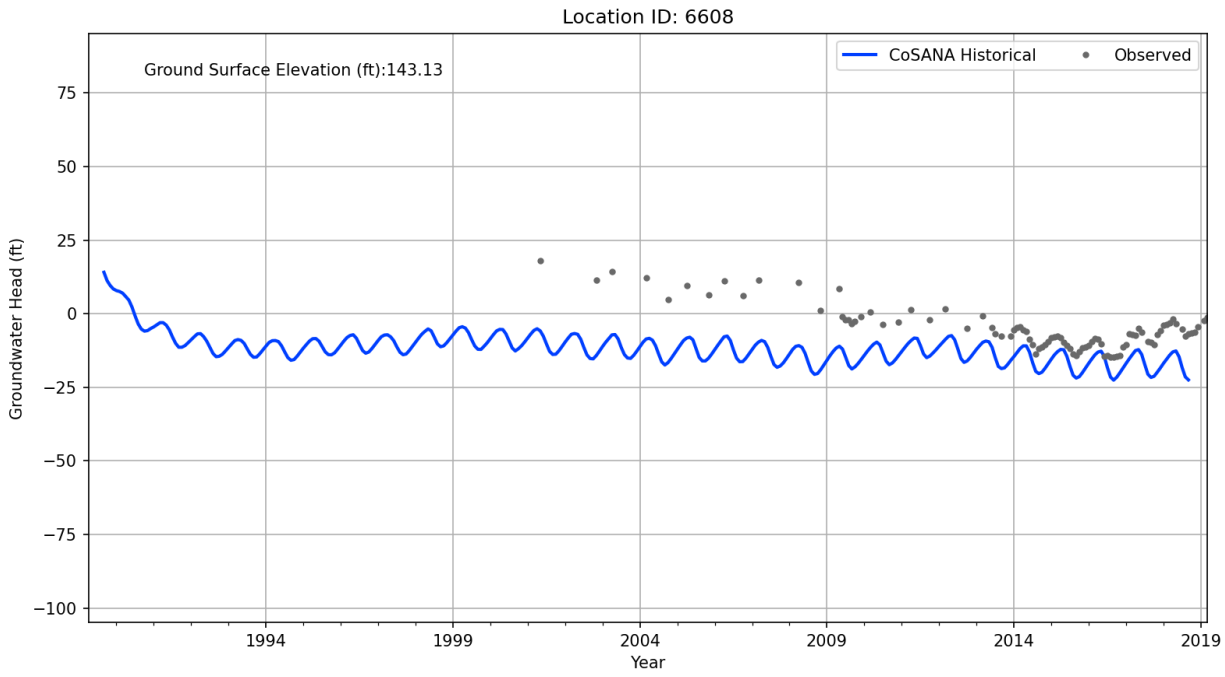

Location ID: 6203
Ground Surface Elevation (ft):-0.5
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

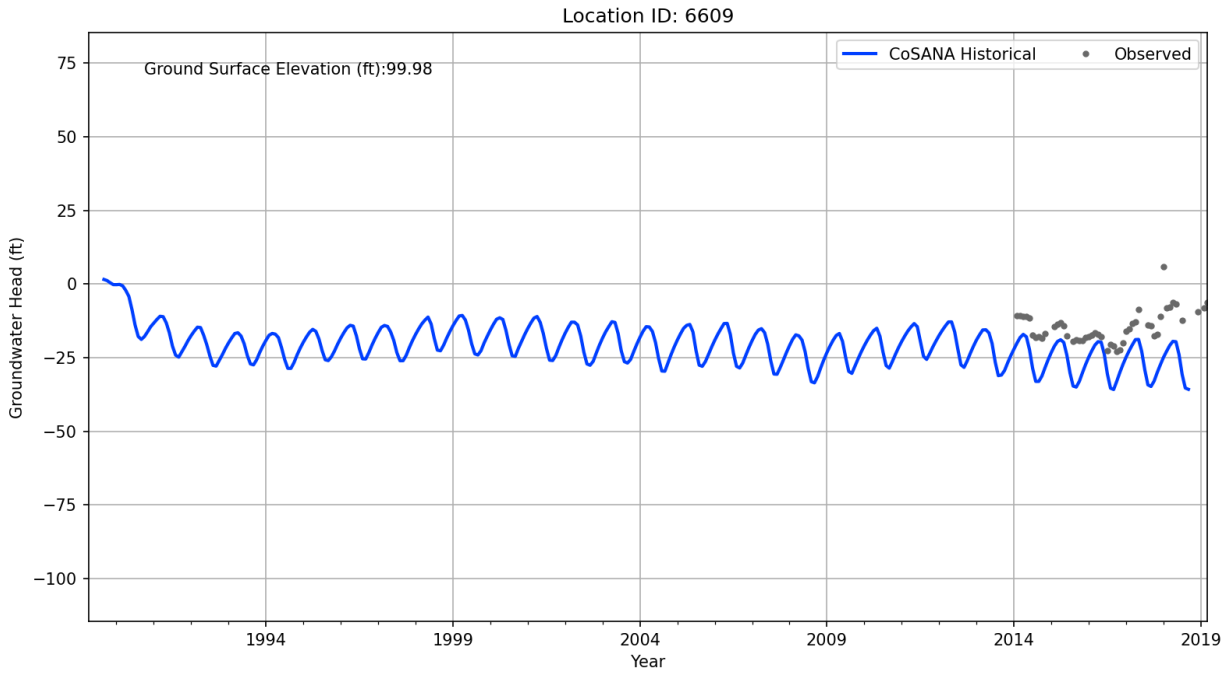

Location ID: 6205
Ground Surface Elevation (ft):-10.32
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

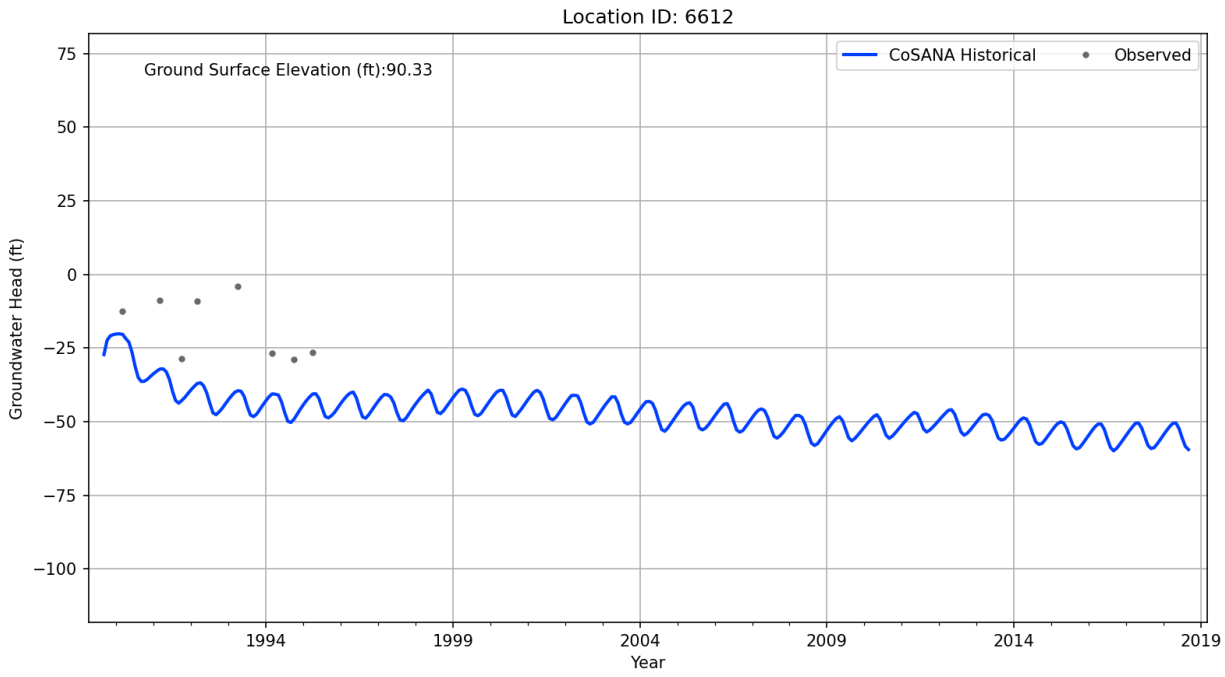

Location ID: 6207
Ground Surface Elevation (ft):-2.42
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

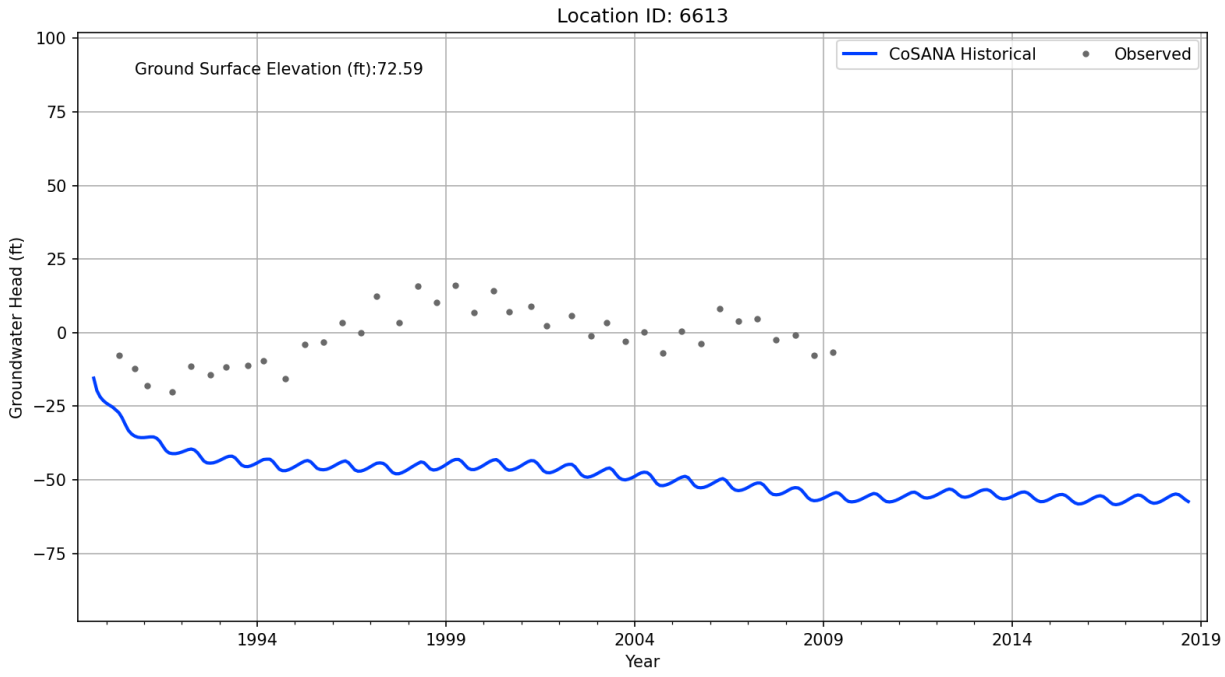

Location ID: 6602
Ground Surface Elevation (ft):142.5
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

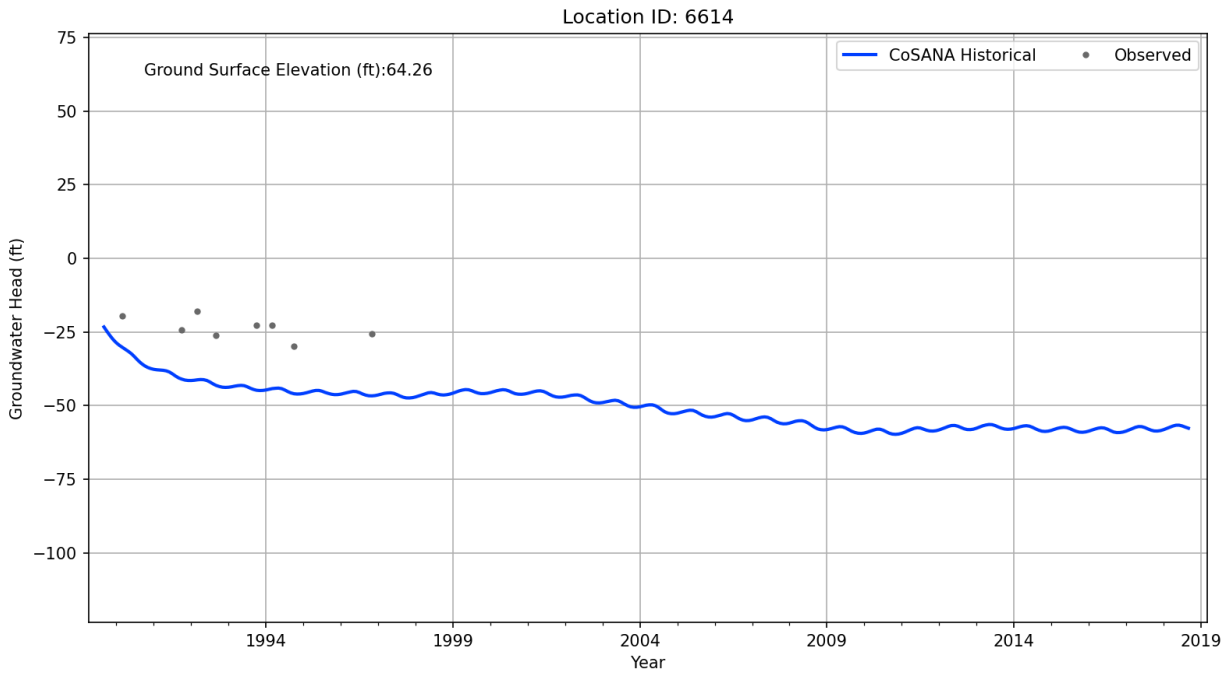

Location ID: 6604
Ground Surface Elevation (ft):98.18
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

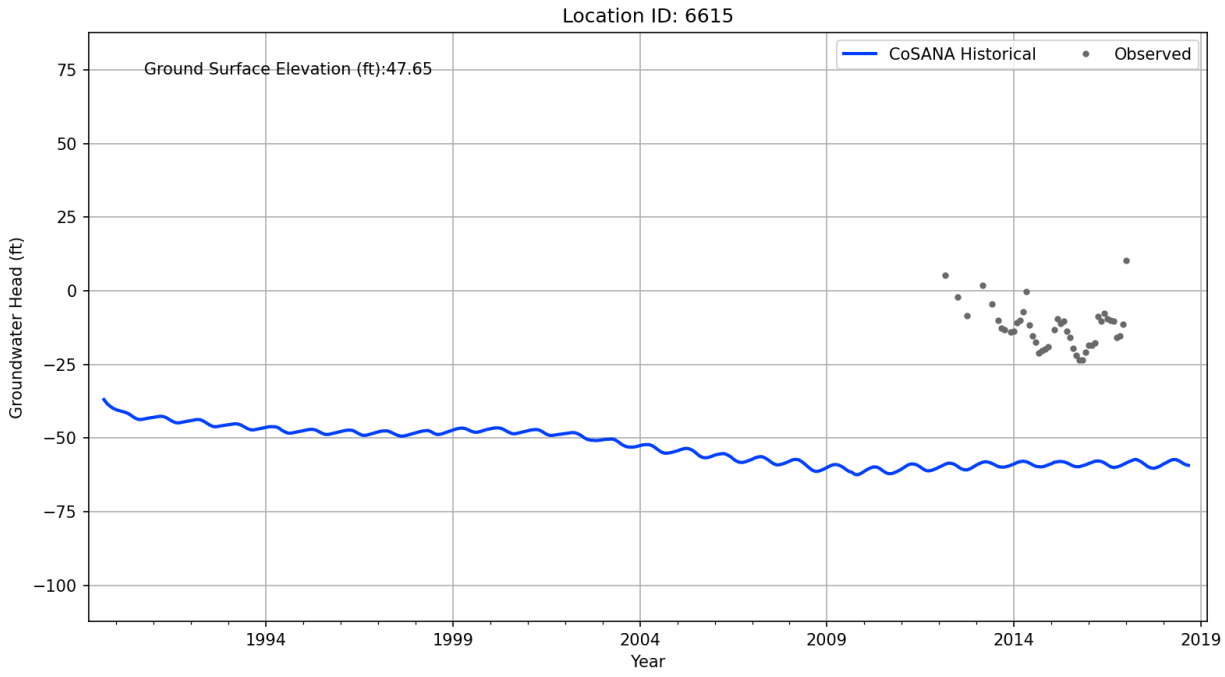

Location ID: 6608
Ground Surface Elevation (ft):143.13
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

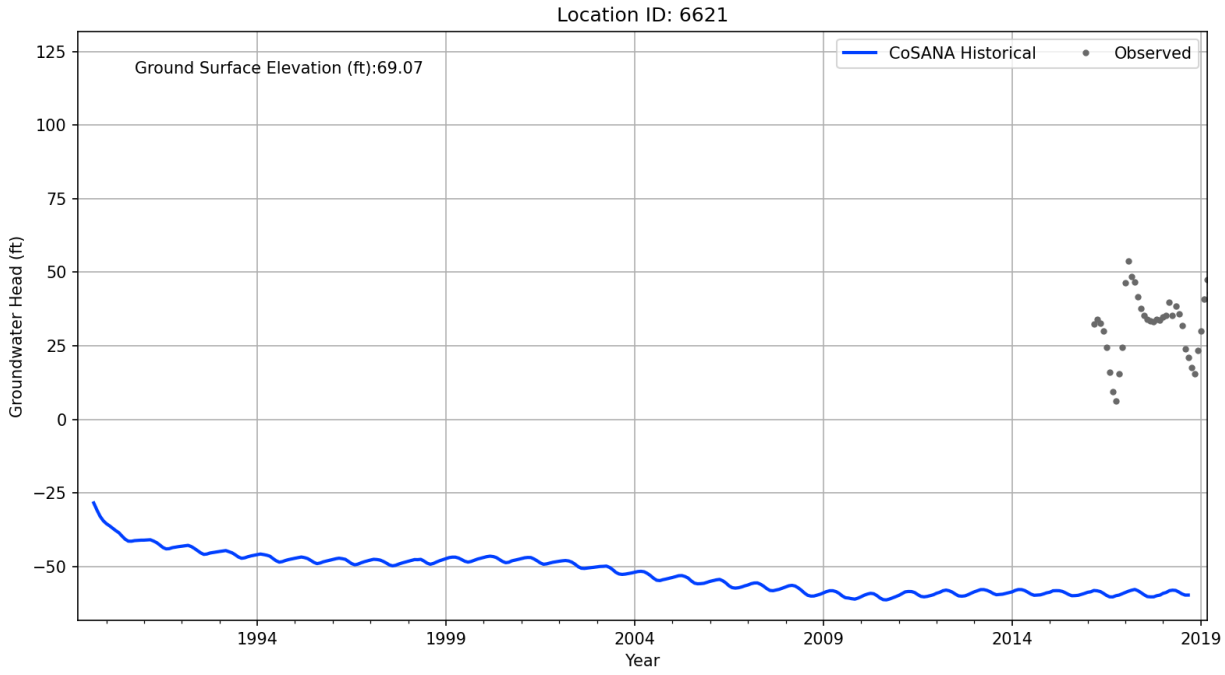

Location ID: 6609
Ground Surface Elevation (ft):99.98
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

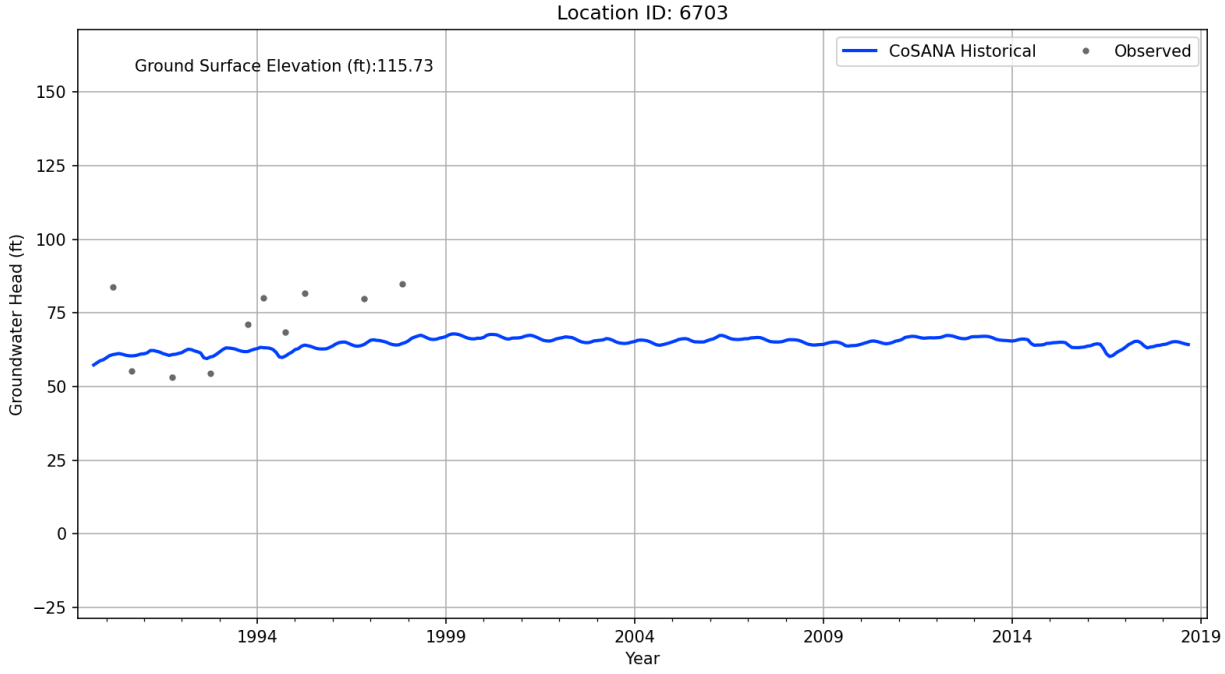

Location ID: 6612
Ground Surface Elevation (ft):90.33
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

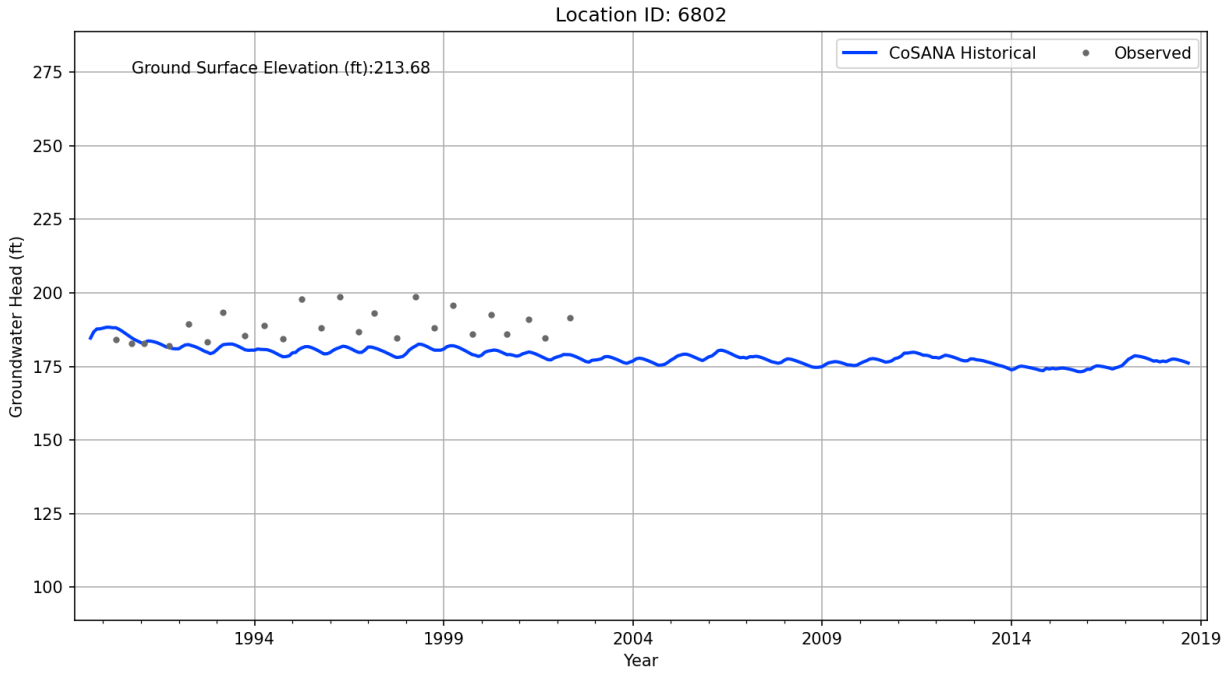

Location ID: 6613
Ground Surface Elevation (ft):72.59
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

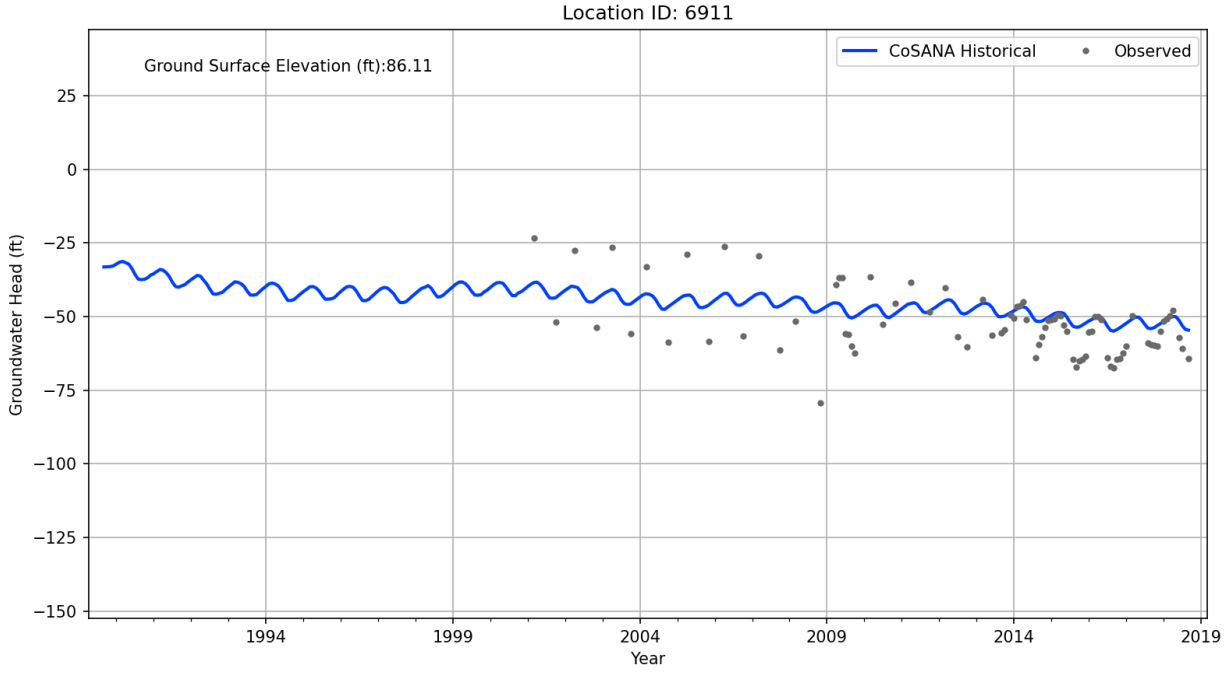

Location ID: 6614
Ground Surface Elevation (ft):64.26
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

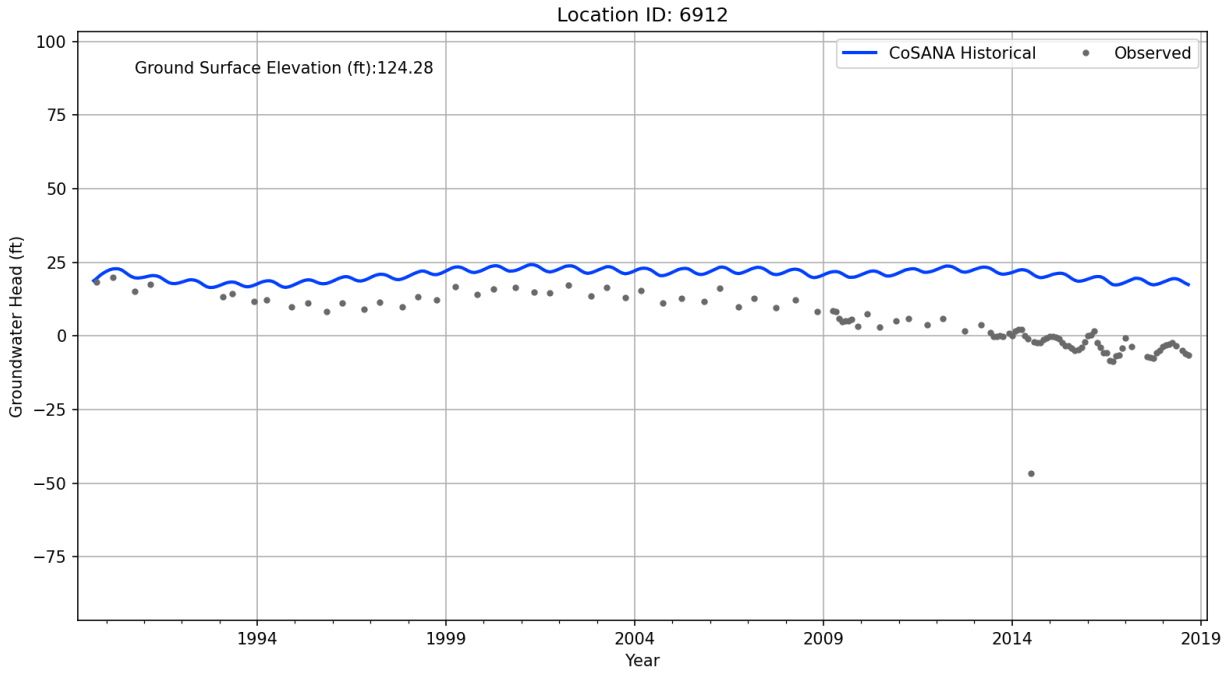

Location ID: 6615
Ground Surface Elevation (ft):47.65
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

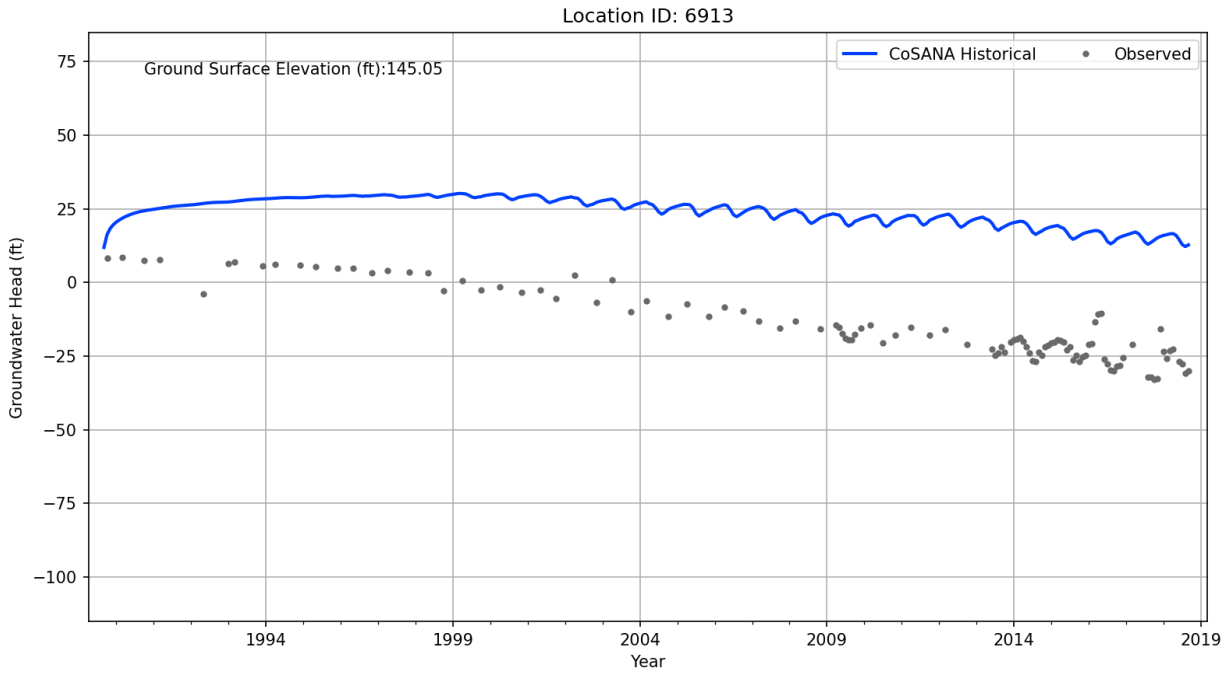

Location ID: 6621
Ground Surface Elevation (ft):69.07
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

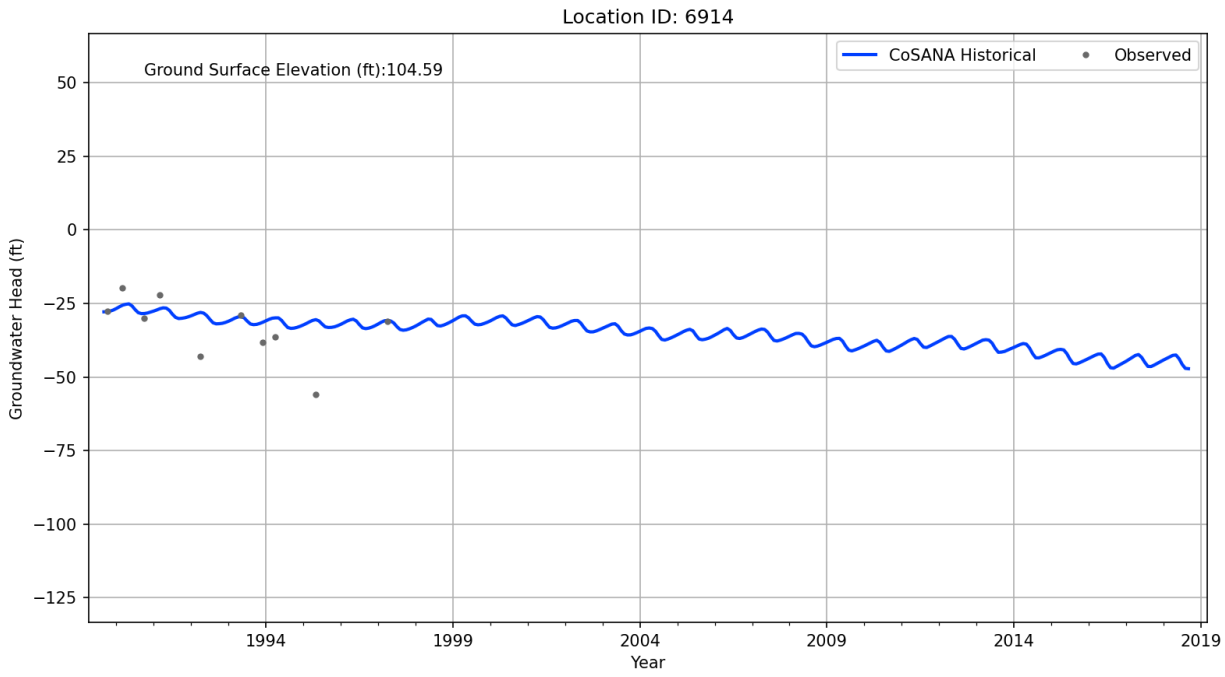

Location ID: 6703
Ground Surface Elevation (ft):115.73
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

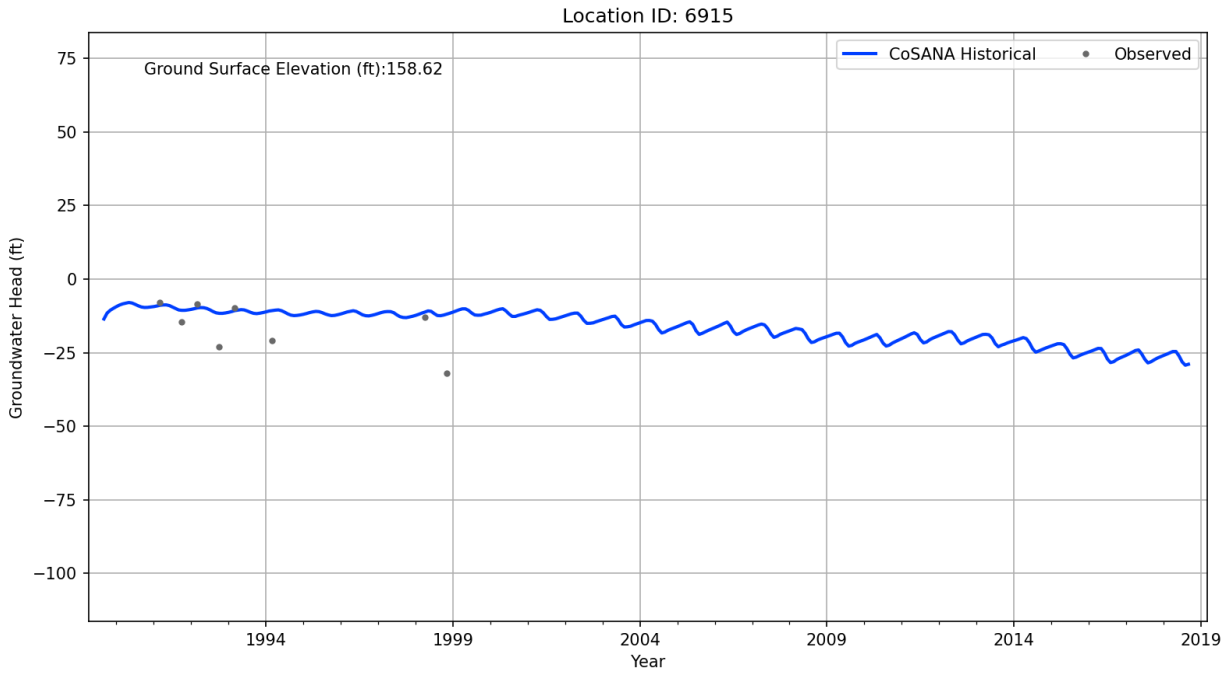

Location ID: 6802
Ground Surface Elevation (ft):213.68
CoSANA Historical
Observed
Groundwater Head (ft)
275
250
225
200
175
150
125
100
1994
1999
2004
2009
2014
2019
Year

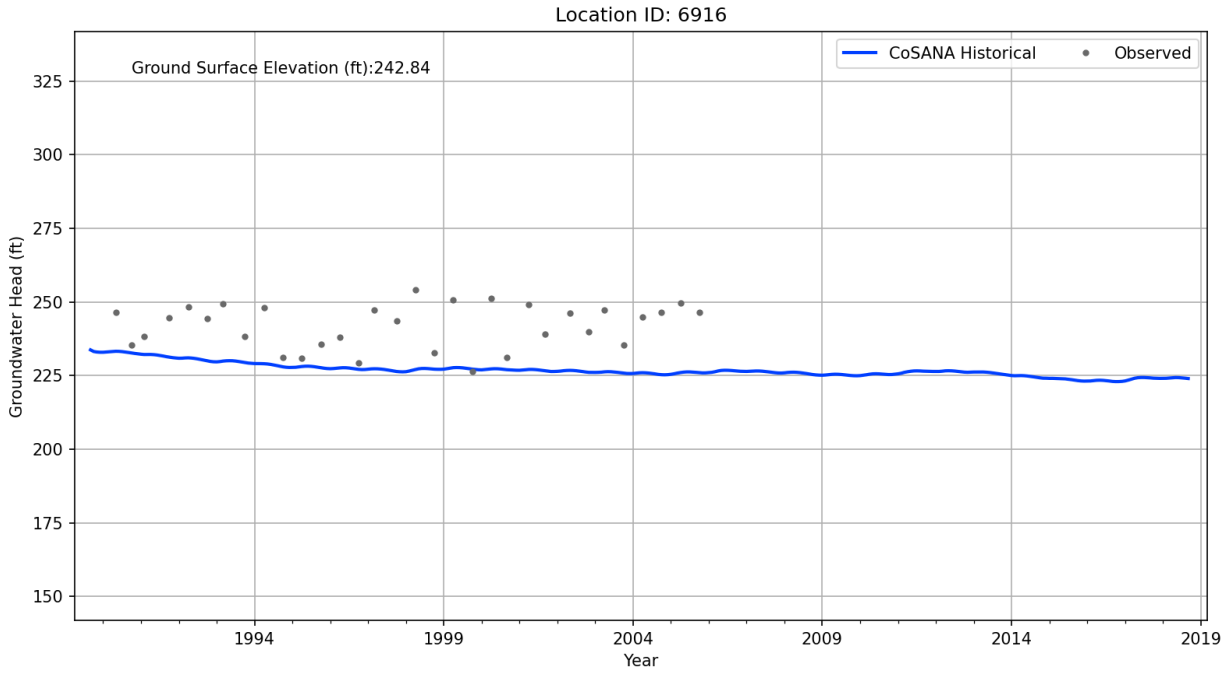

Location ID: 6911
Ground Surface Elevation (ft):86.11
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

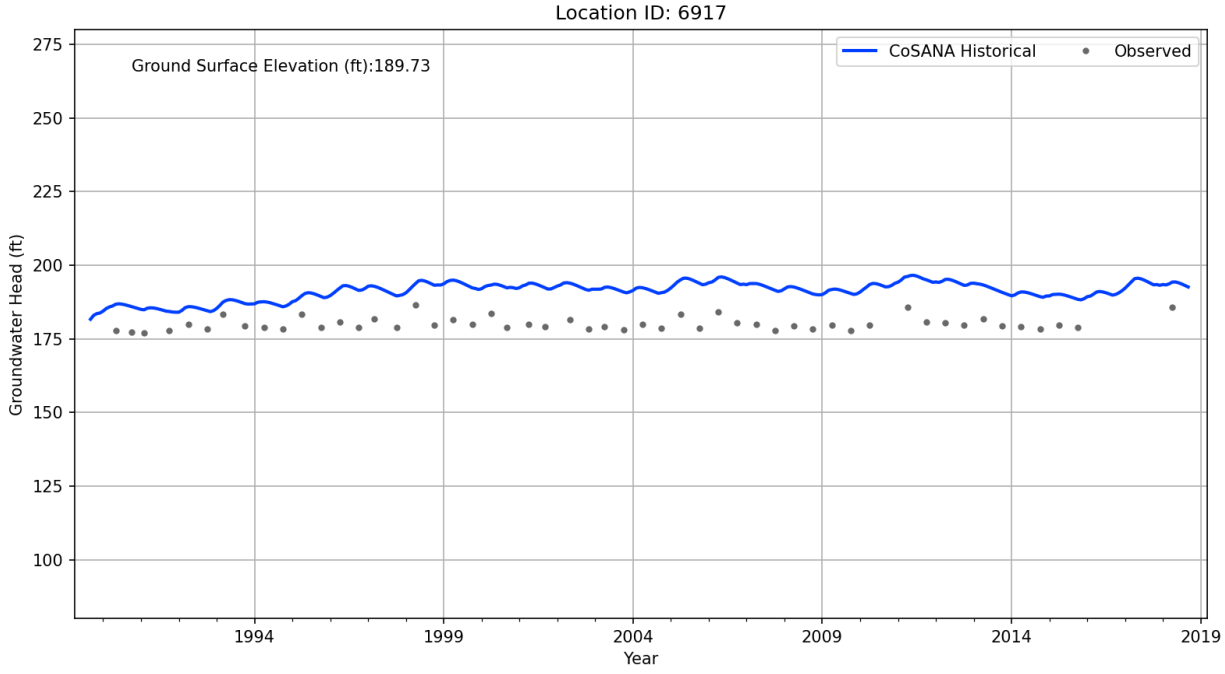

Location ID: 6912
Ground Surface Elevation (ft):124.28
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

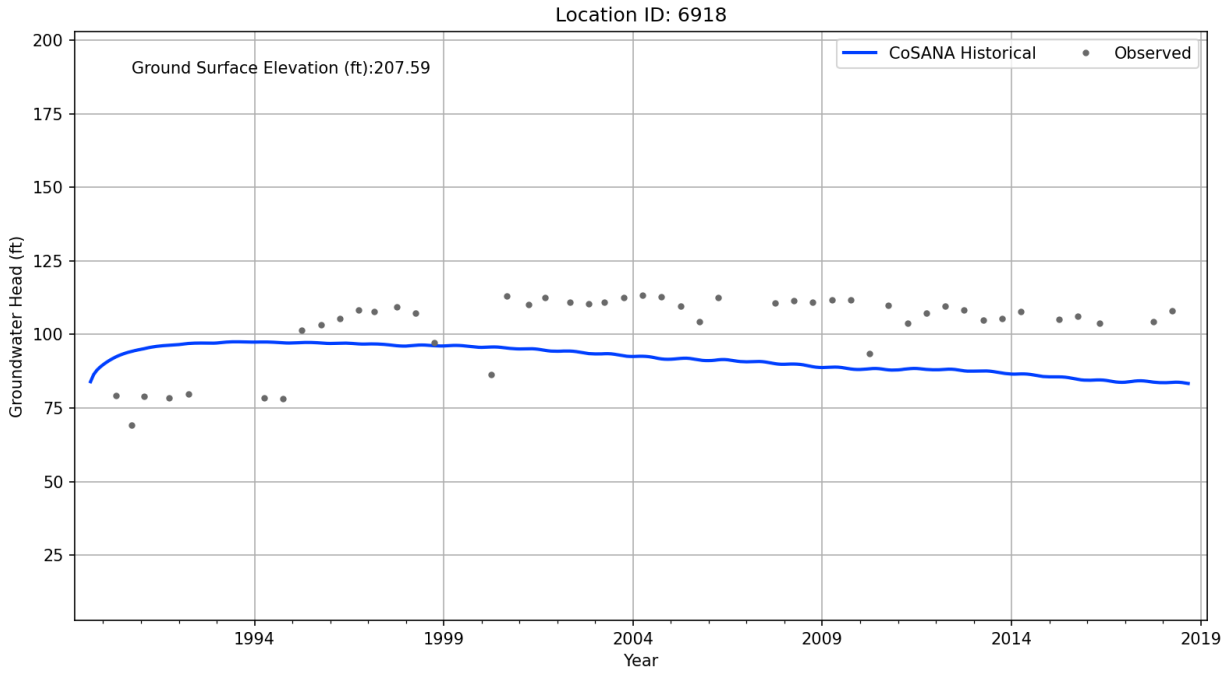

Location ID: 6913
Ground Surface Elevation (ft):145.05
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

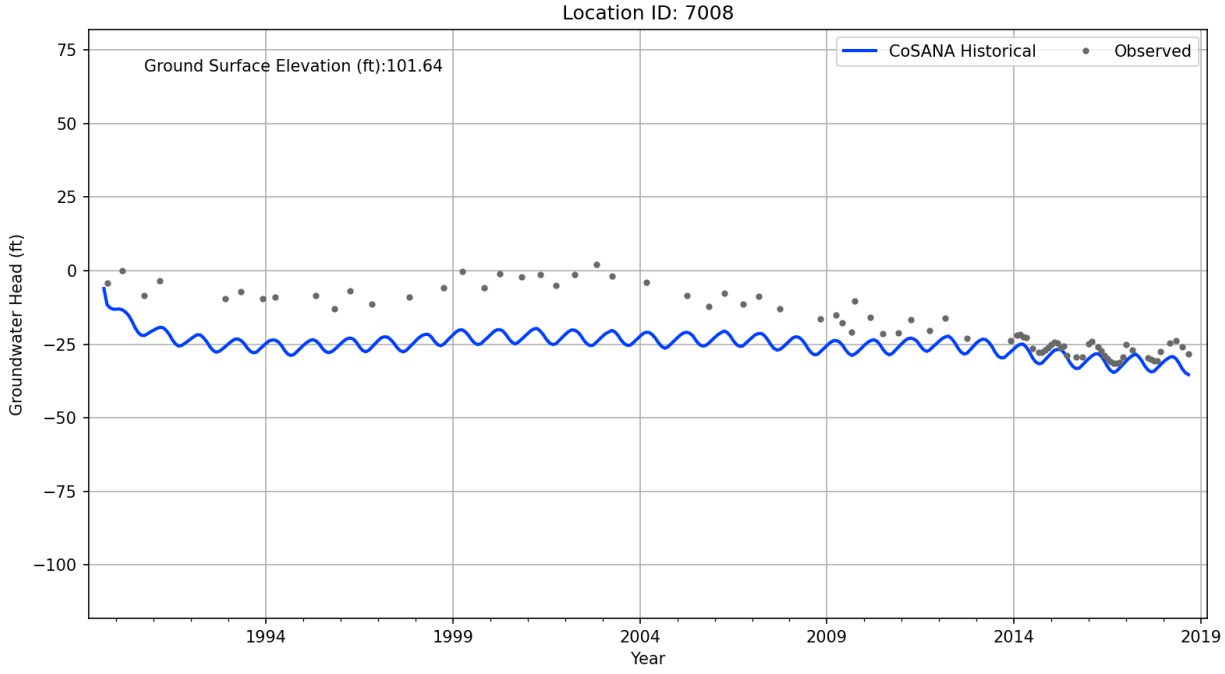

Location ID: 6914
Ground Surface Elevation (ft):104.59
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

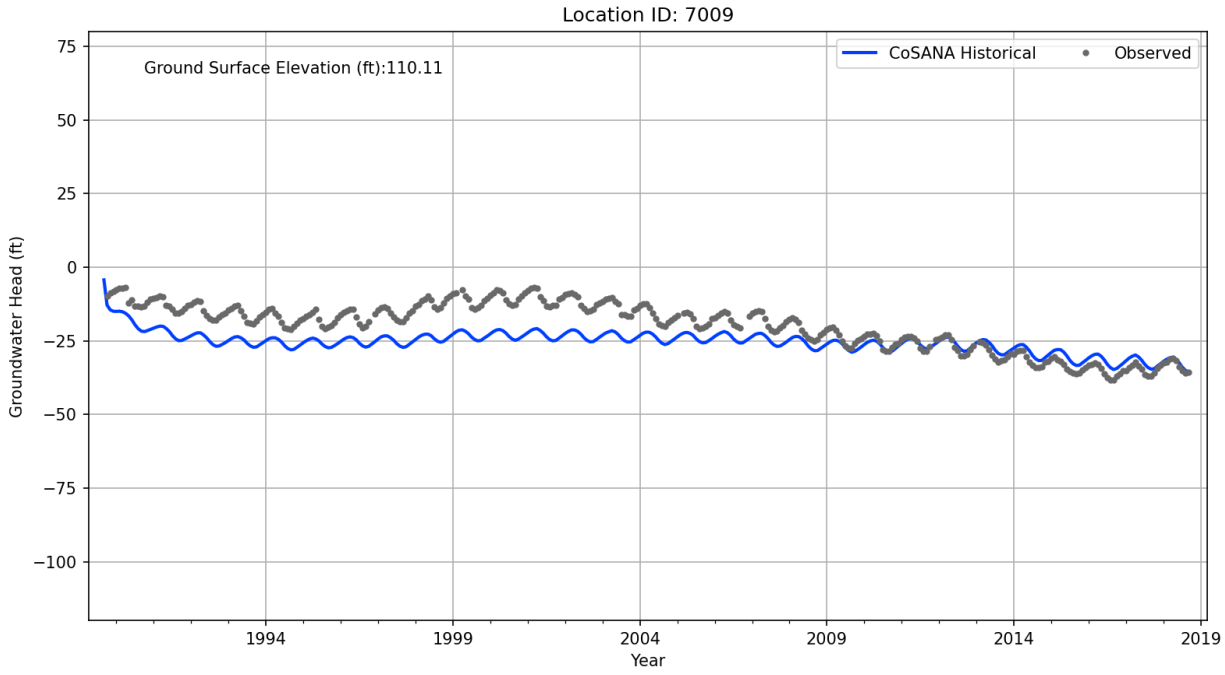

Location ID: 6915
Ground Surface Elevation (ft):158.62
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

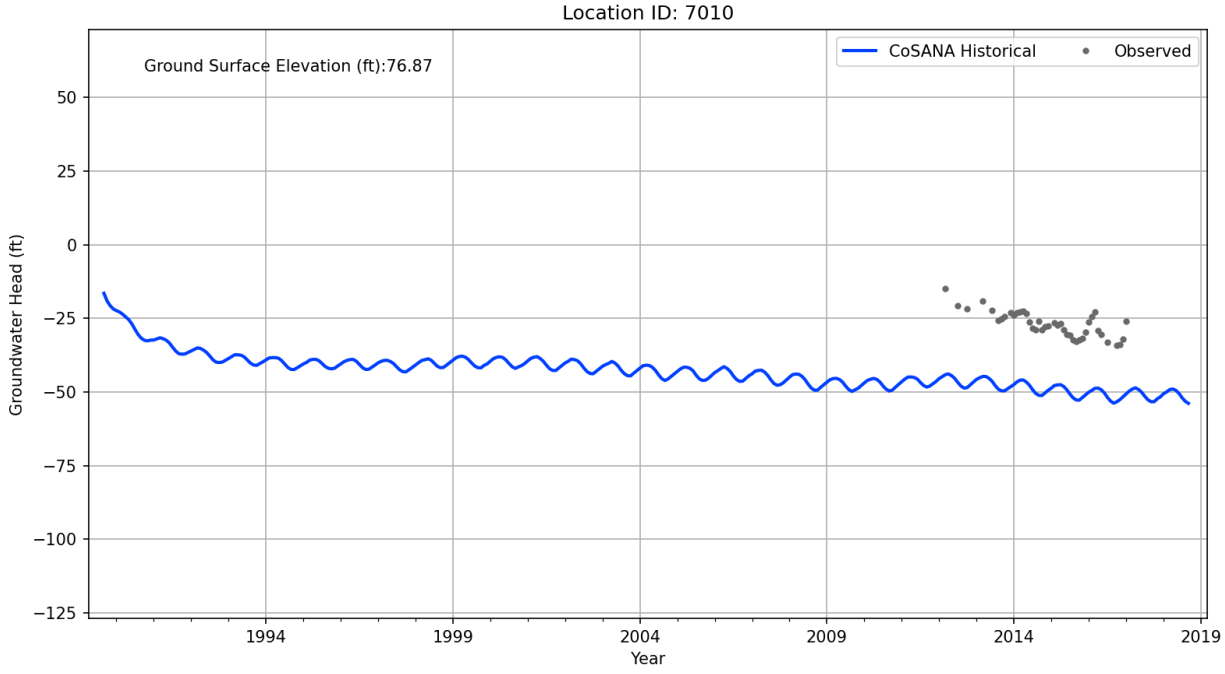

Location ID: 6916
Ground Surface Elevation (ft):242.84
CoSANA Historical
Observed
Groundwater Head (ft)
325
300
275
250
225
200
175
150
1994
1999
2004
2009
2014
2019
Year

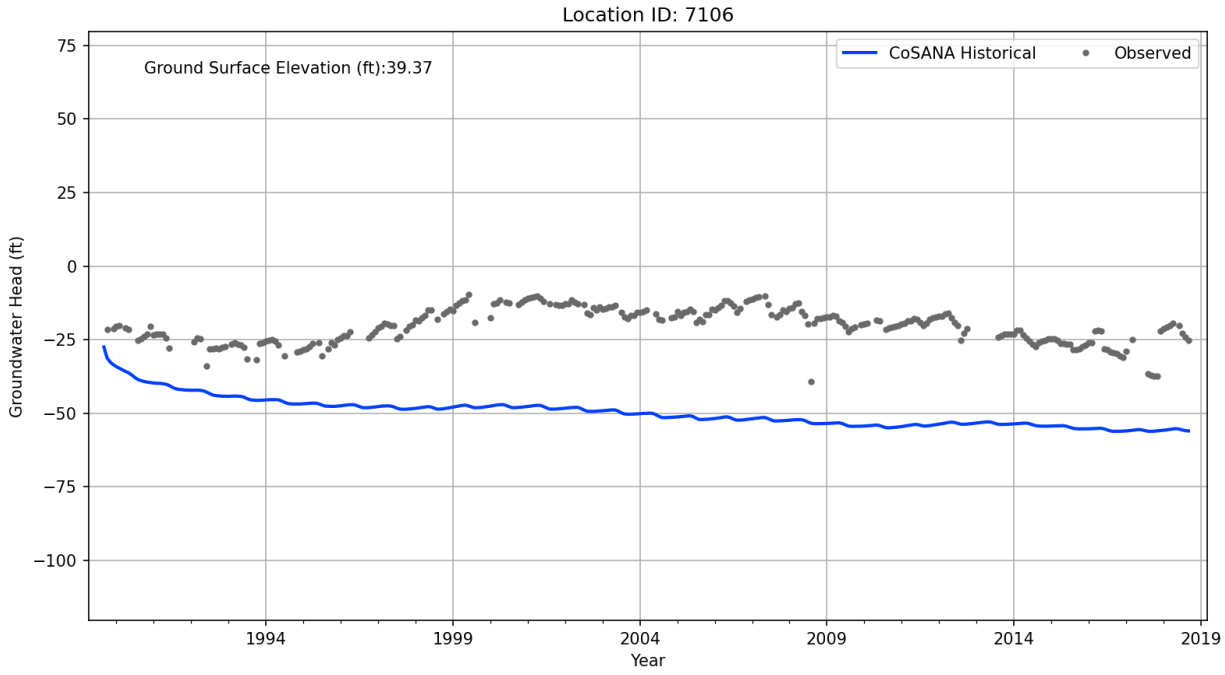

Location ID: 6917
Ground Surface Elevation (ft):189.73
CoSANA Historical
Observed
Groundwater Head (ft)
275
250
225
200
175
150
125
100
1994
1999
2004
2009
2014
2019
Year

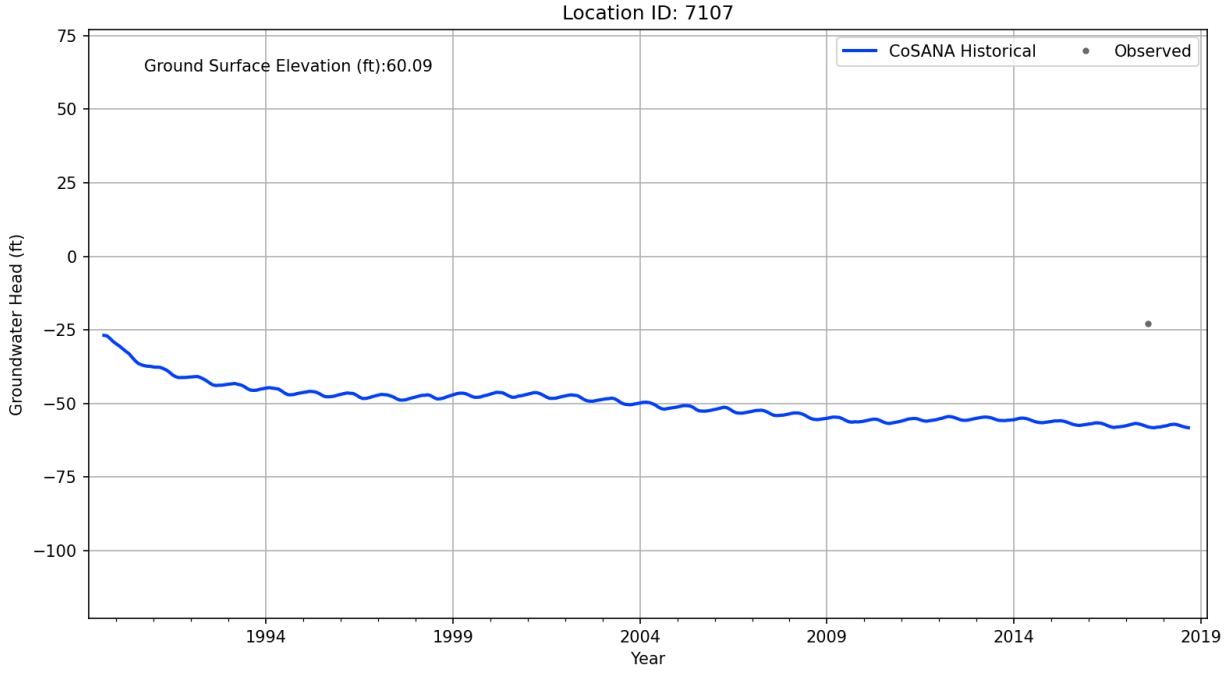

Location ID: 6918
Ground Surface Elevation (ft):207.59
CoSANA Historical
Observed
Groundwater Head (ft)
Year
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019

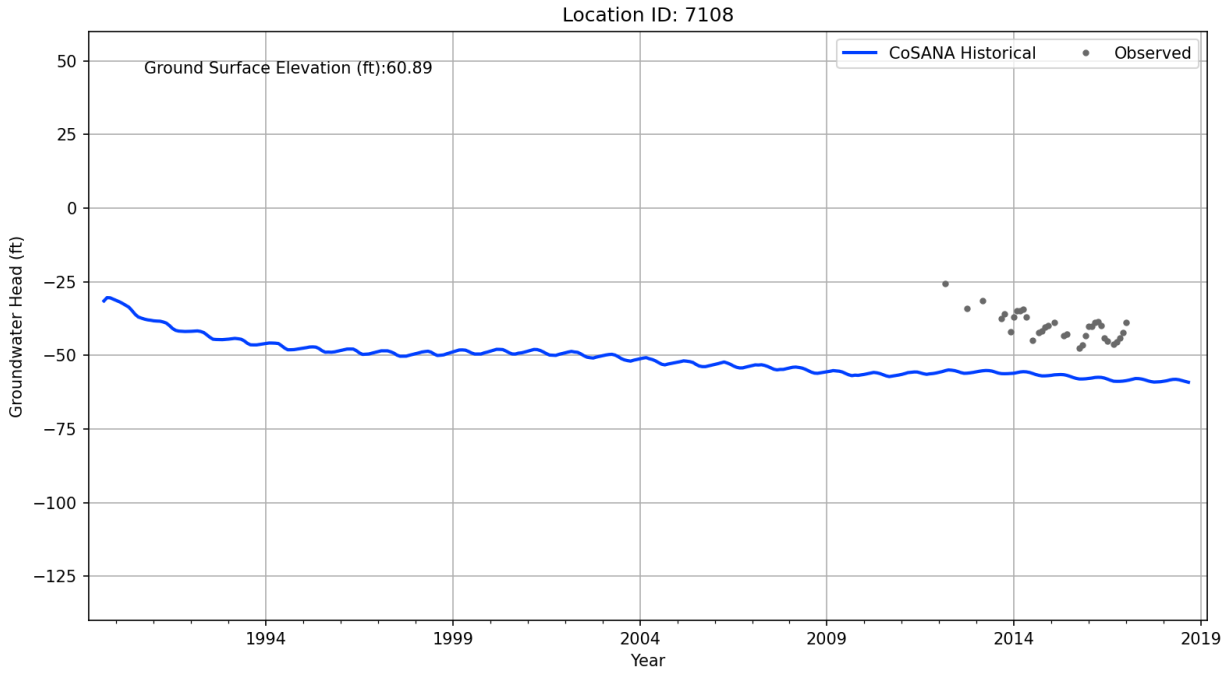

Location ID: 7008
Ground Surface Elevation (ft):101.64
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

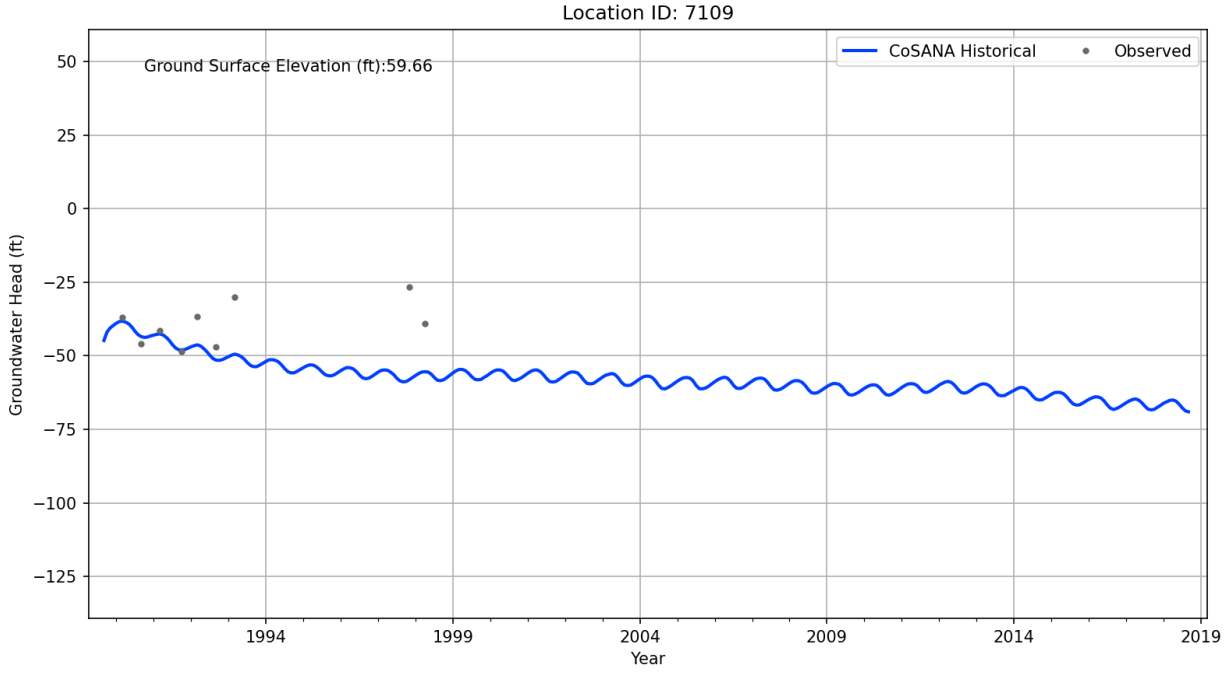

Location ID: 7009
Ground Surface Elevation (ft):110.11
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

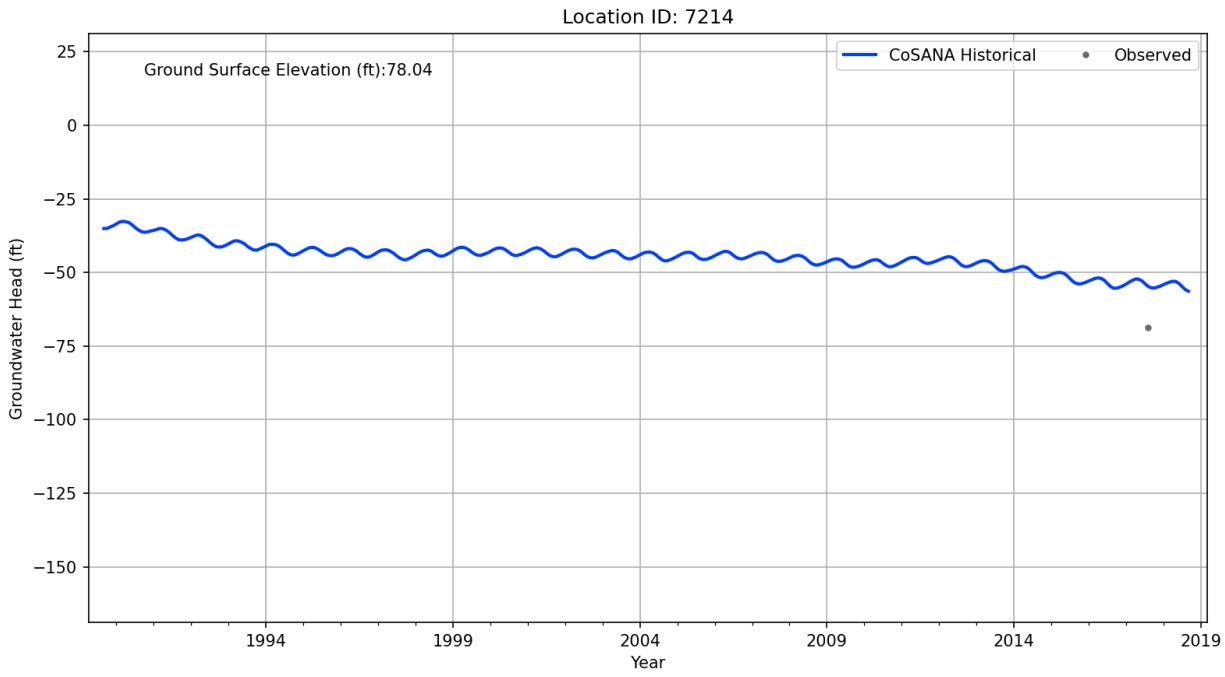

Location ID: 7010
Ground Surface Elevation (ft):76.87
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

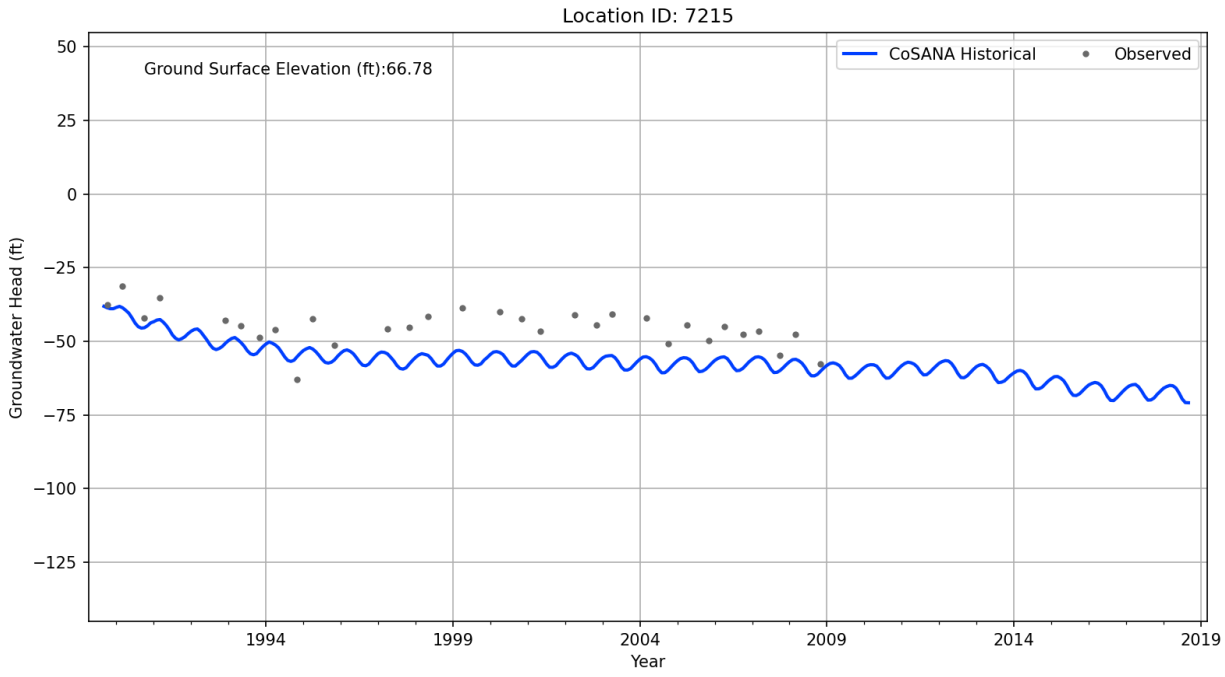

Location ID: 7106
Ground Surface Elevation (ft):39.37
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

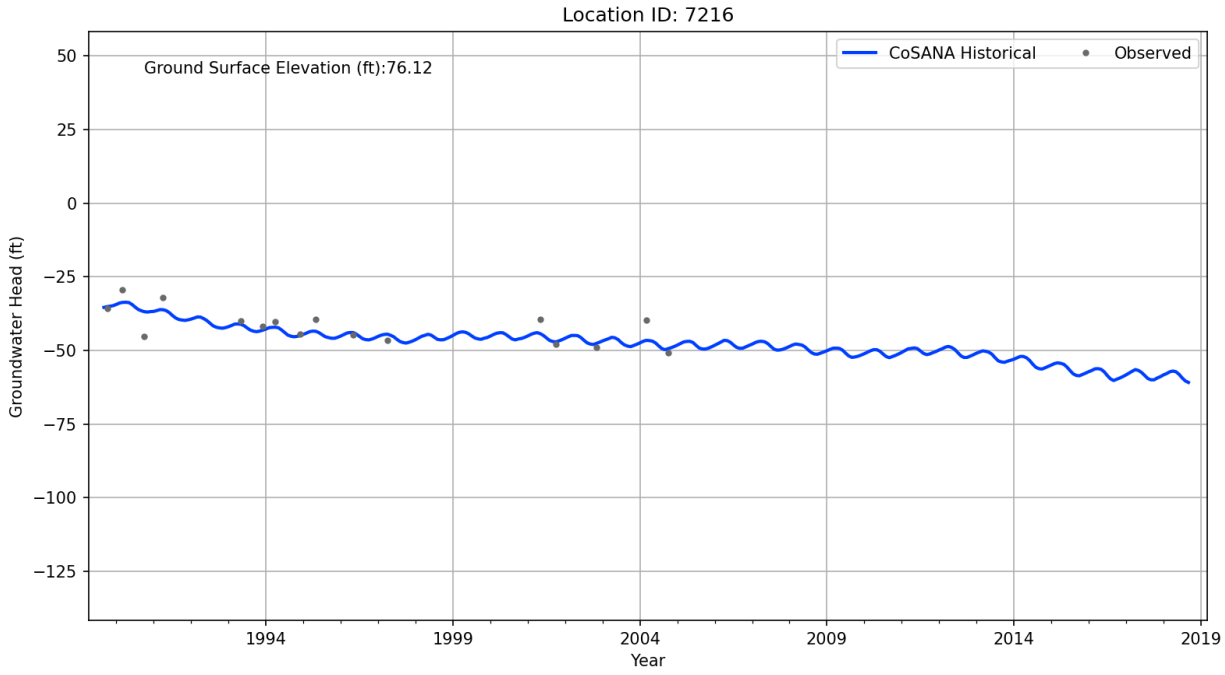

Location ID: 7107
Ground Surface Elevation (ft):60.09
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

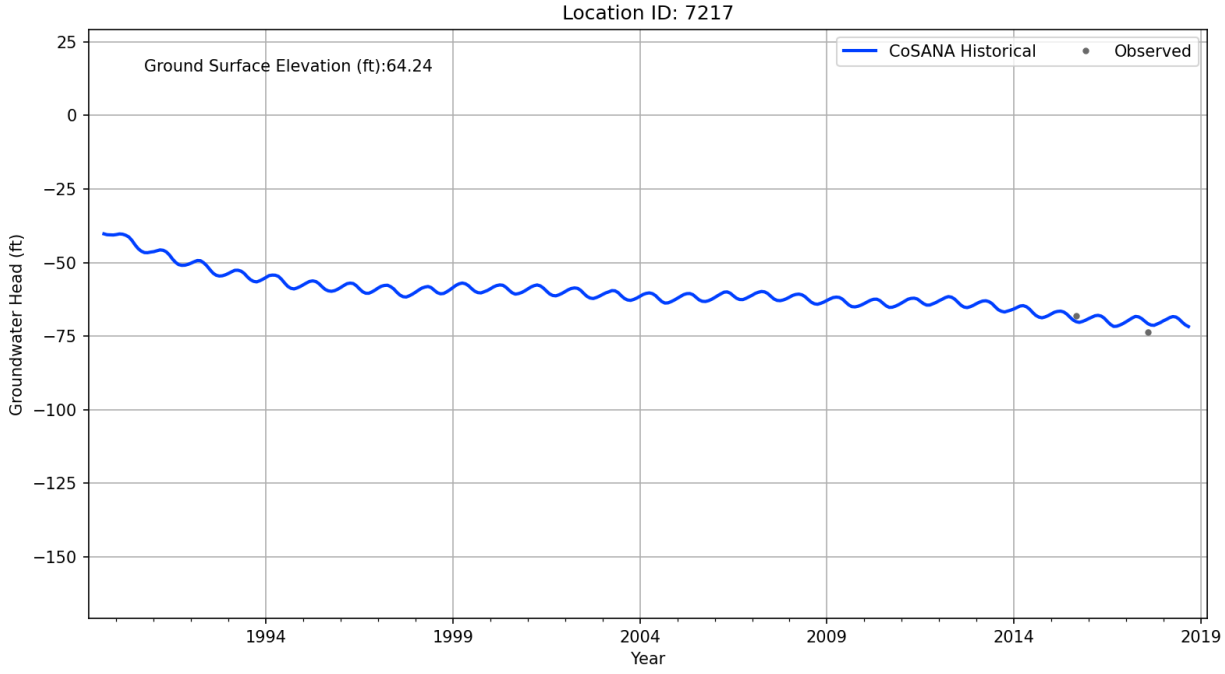

Location ID: 7108
Ground Surface Elevation (ft):60.89
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

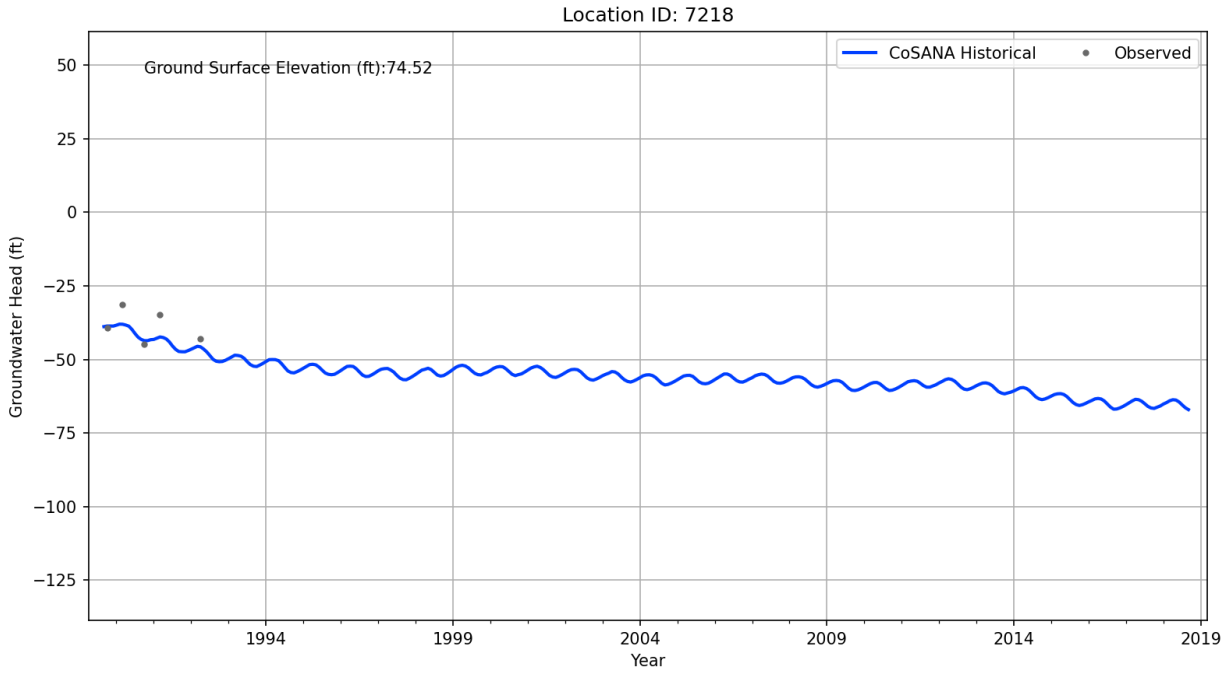

Location ID: 7109
Ground Surface Elevation (ft):59.66
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

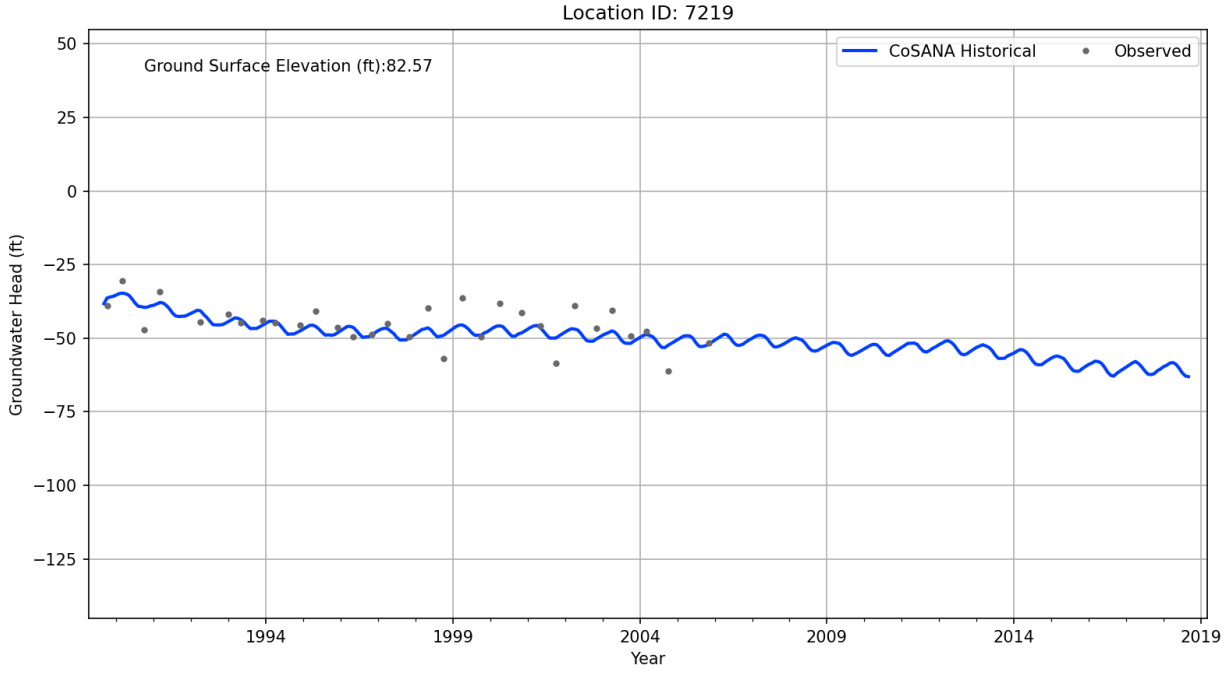

Location ID: 7214
Ground Surface Elevation (ft):78.04
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

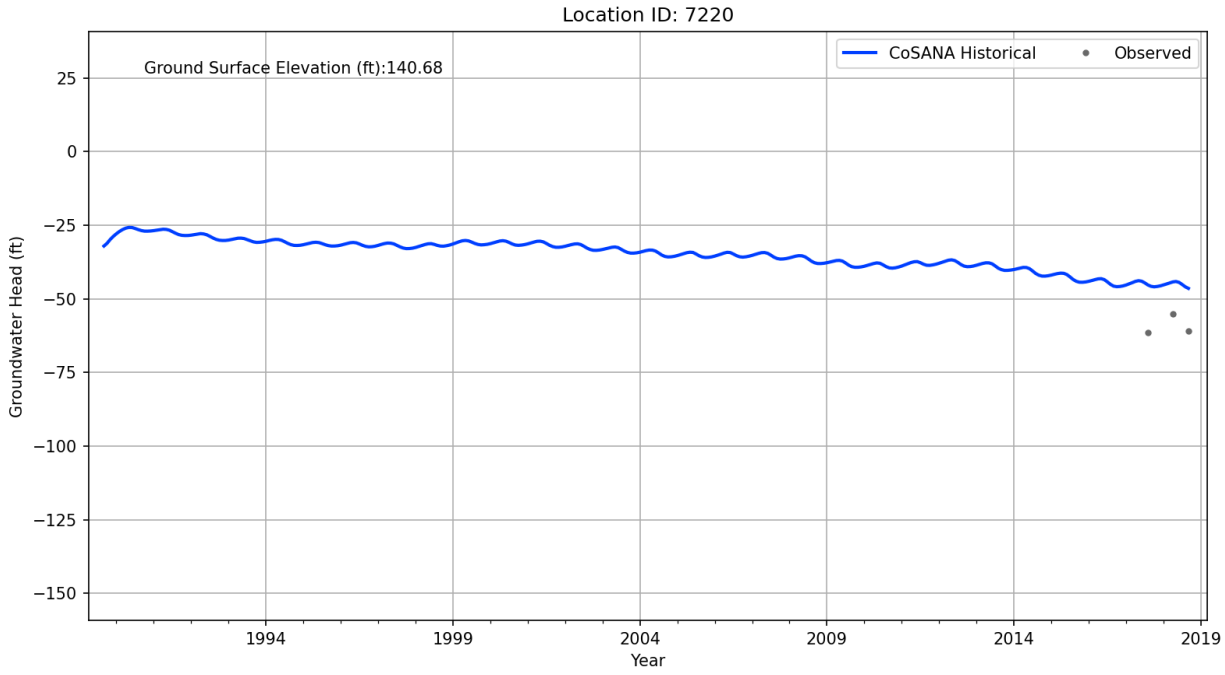

Location ID: 7215
Ground Surface Elevation (ft):66.78
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

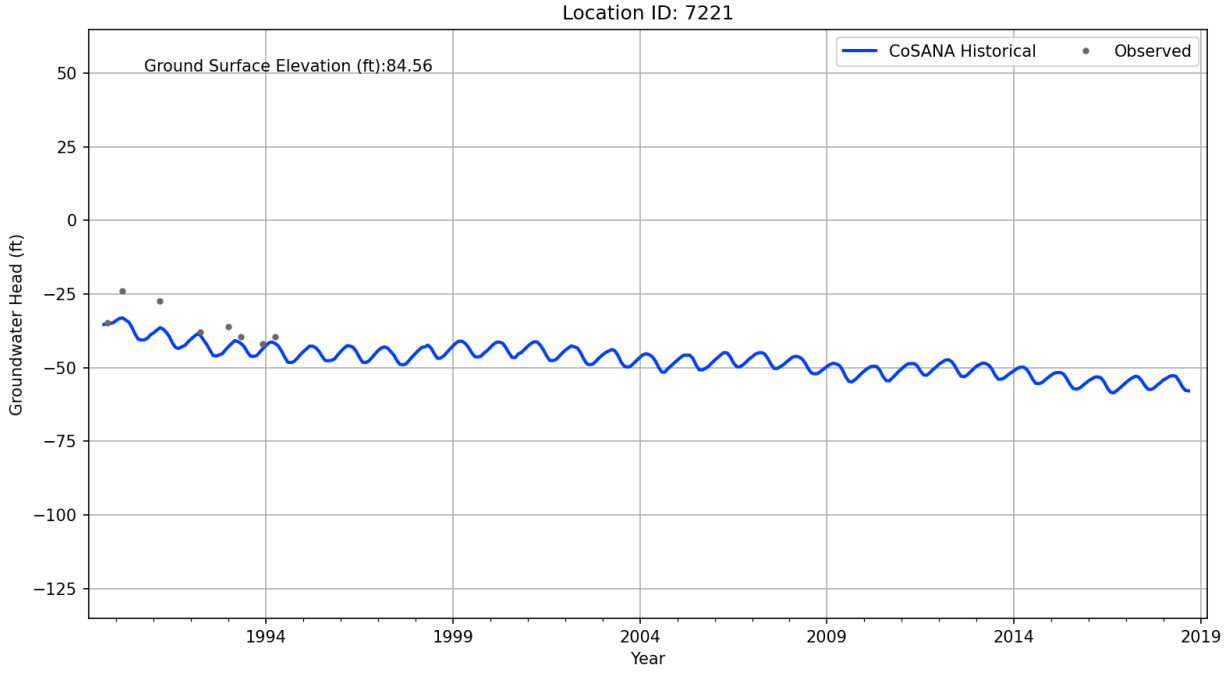

Location ID: 7216
Ground Surface Elevation (ft):76.12
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

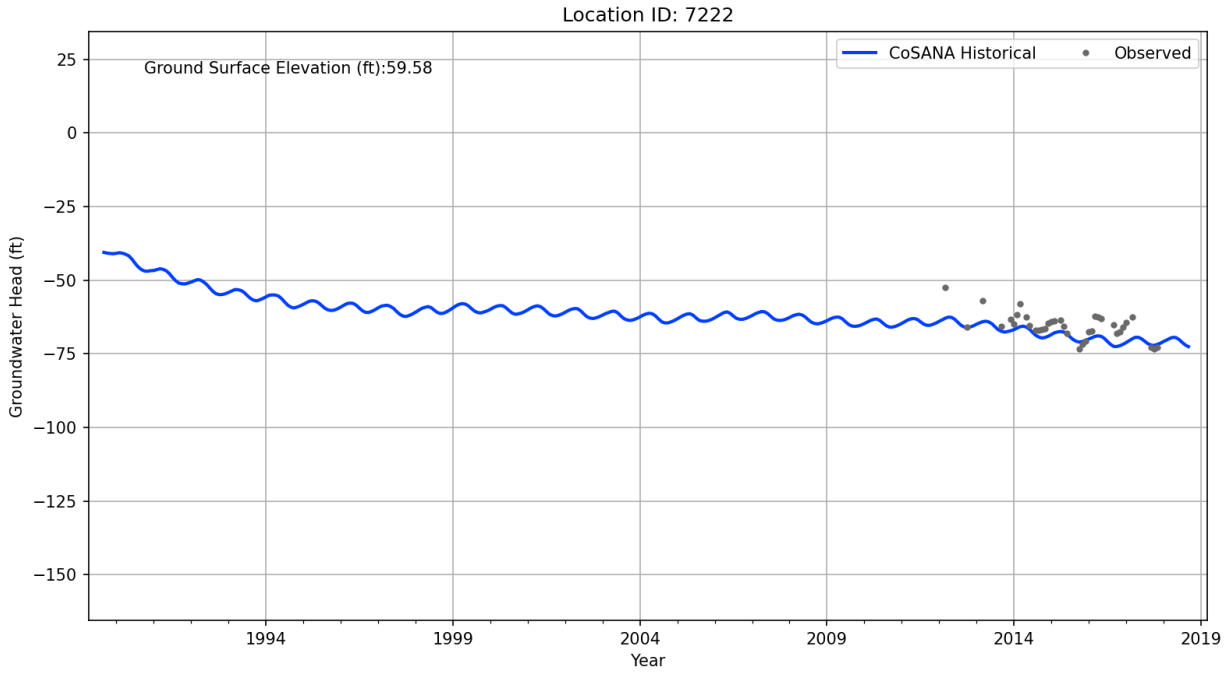

Location ID: 7217
Ground Surface Elevation (ft):64.24
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

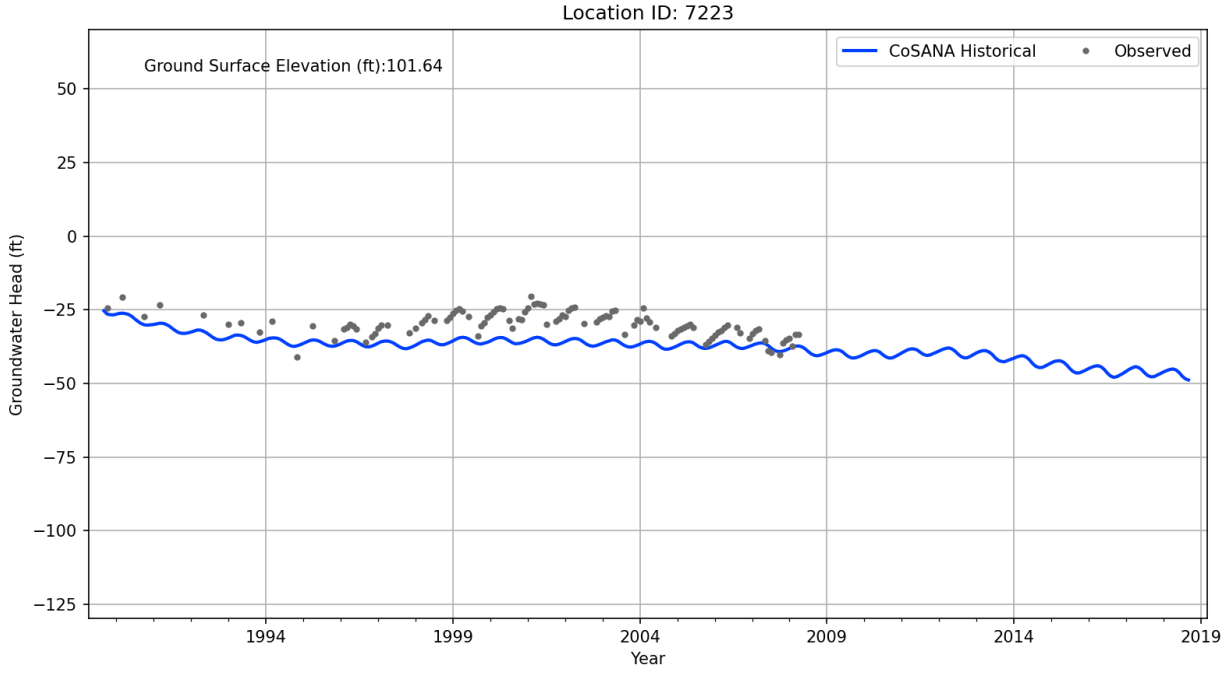

Location ID: 7218
Ground Surface Elevation (ft):74.52
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

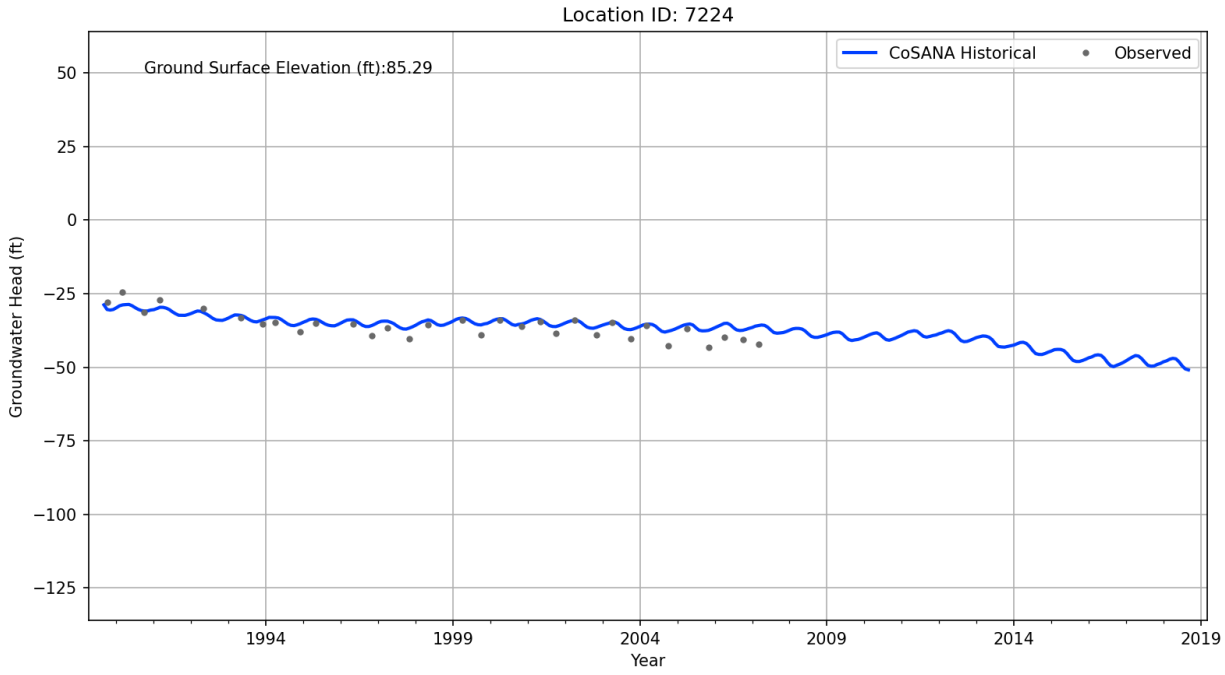

Location ID: 7219
Ground Surface Elevation (ft):82.57
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

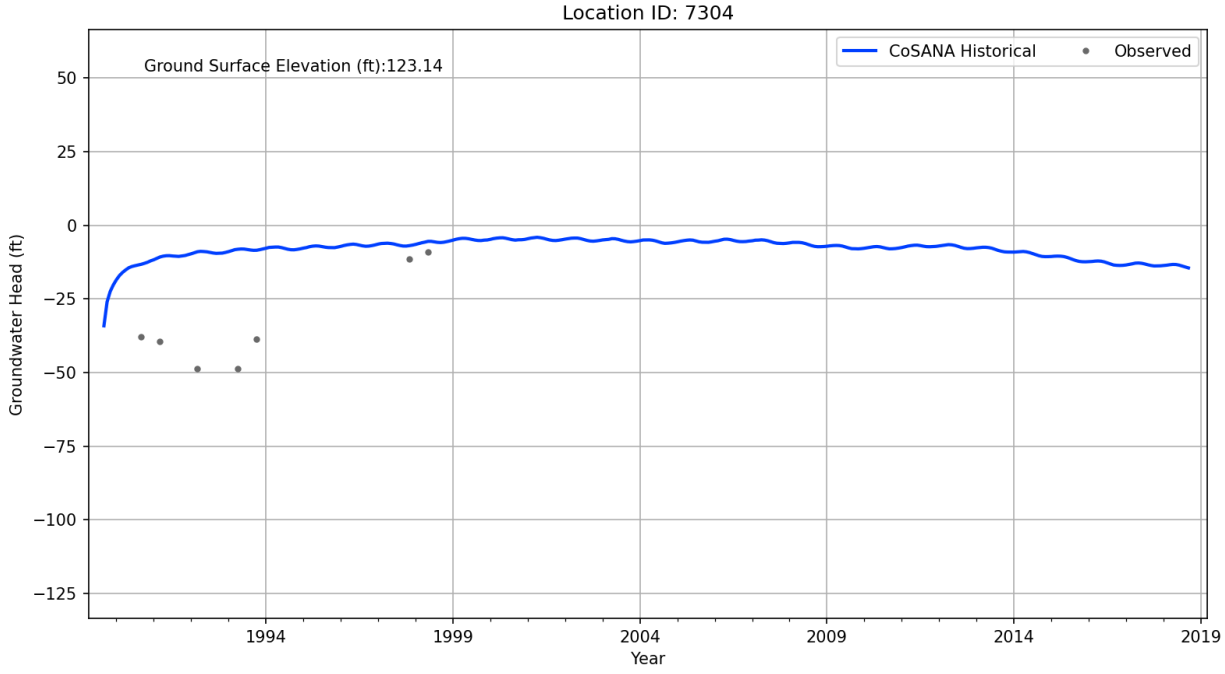

Location ID: 7220
Ground Surface Elevation (ft):140.68
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

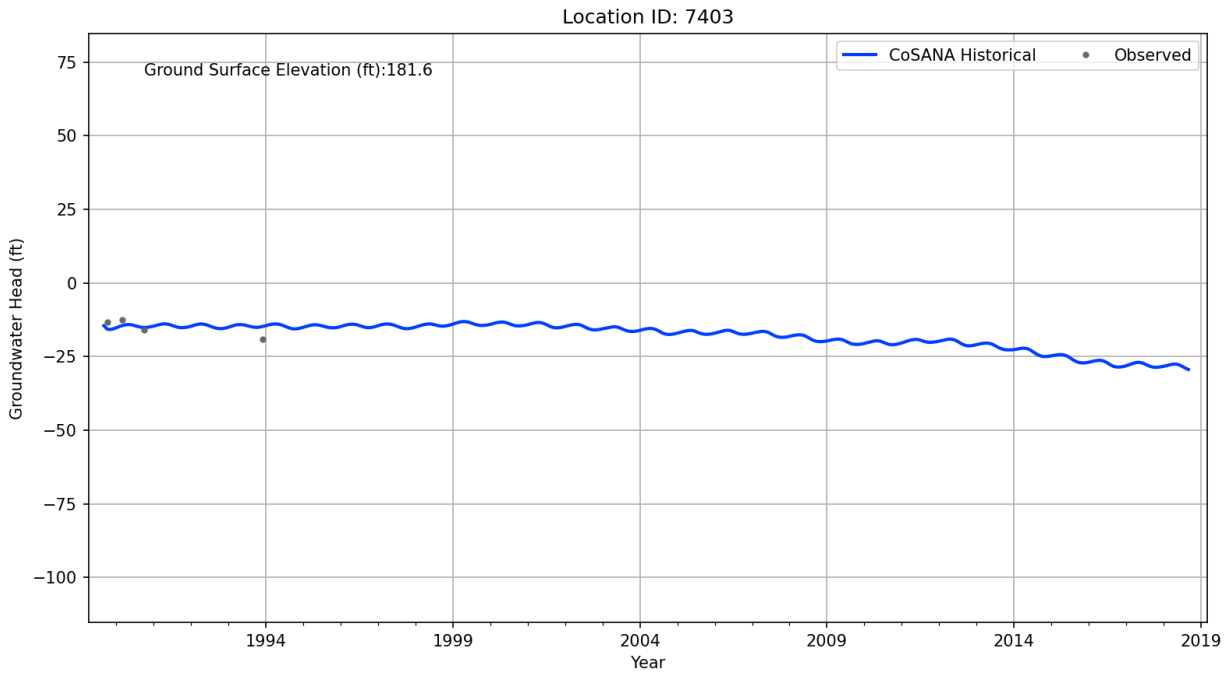

Location ID: 7221
Ground Surface Elevation (ft):84.56
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

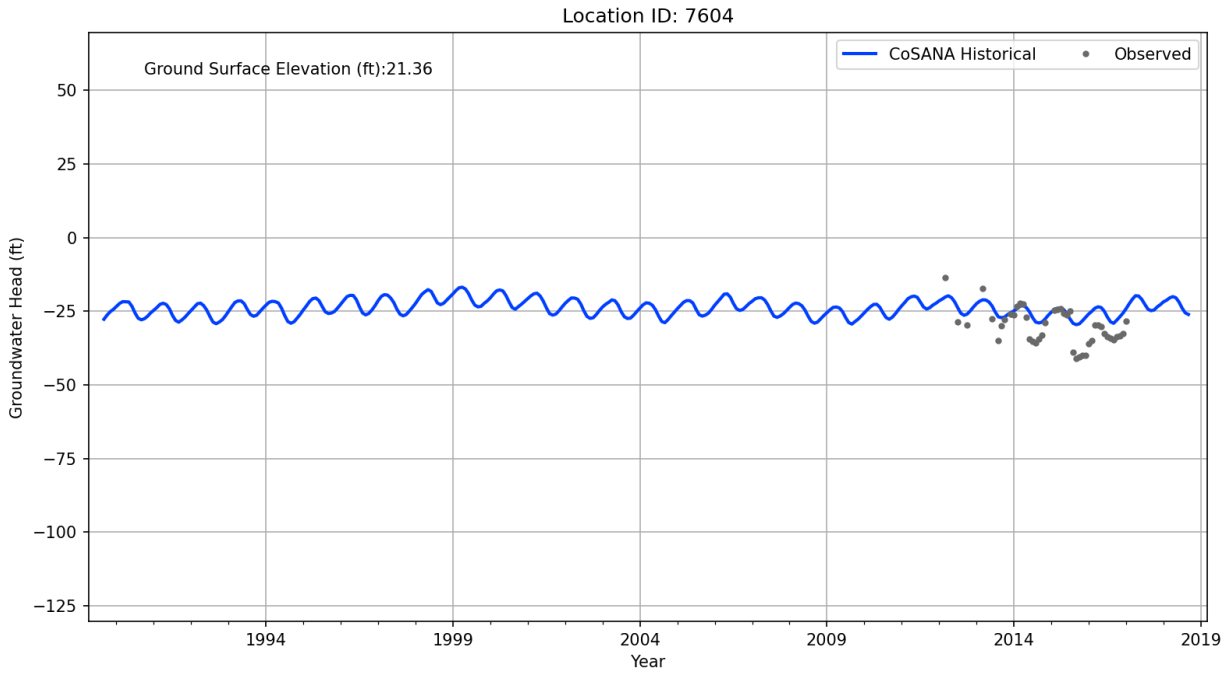

Location ID: 7222
Ground Surface Elevation (ft):59.58
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

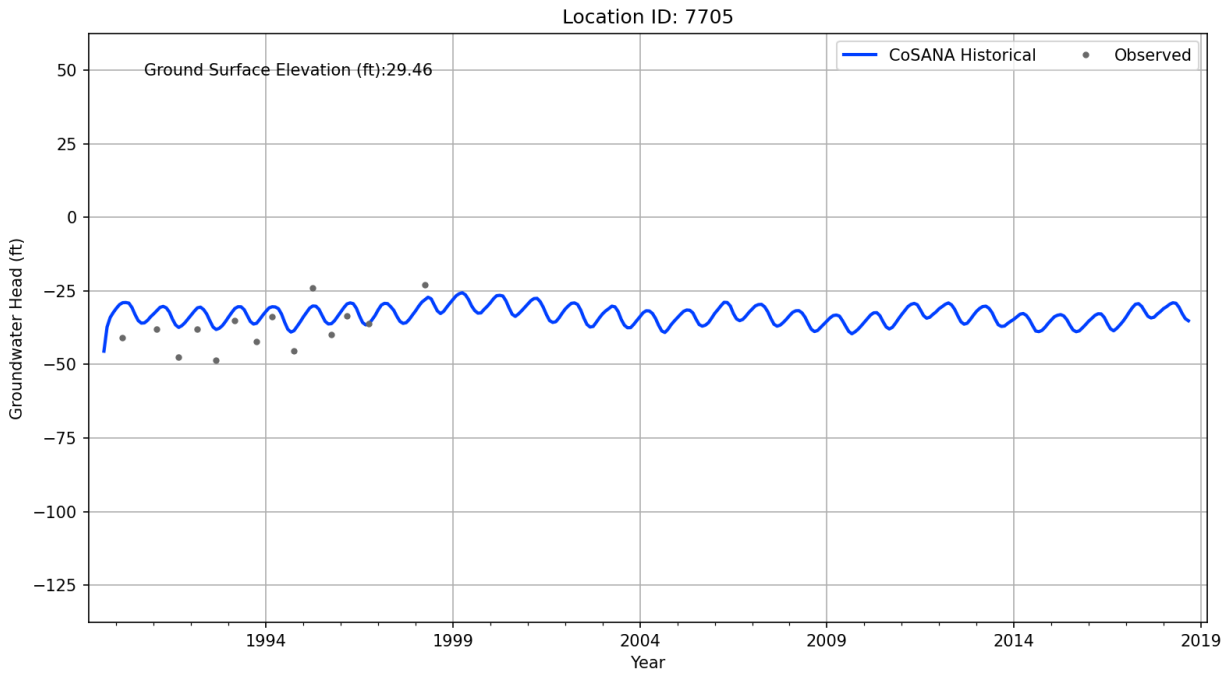

Location ID: 7223
Ground Surface Elevation (ft):101.64
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

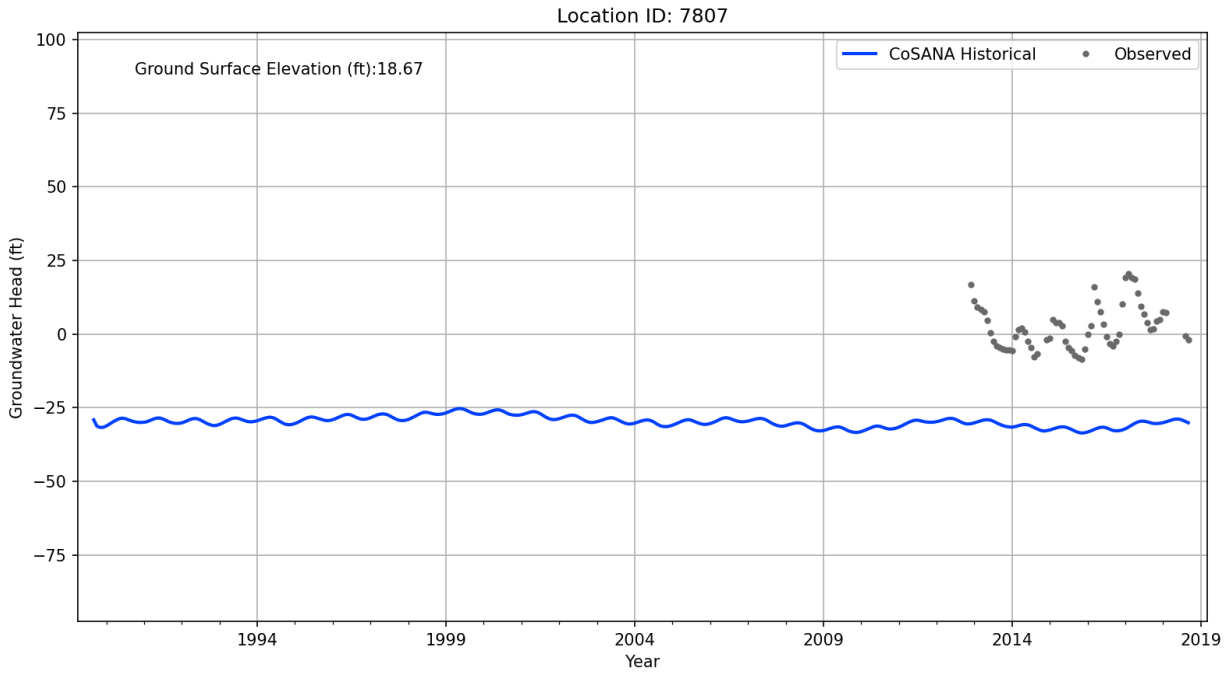

Location ID: 7224
Ground Surface Elevation (ft):85.29
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

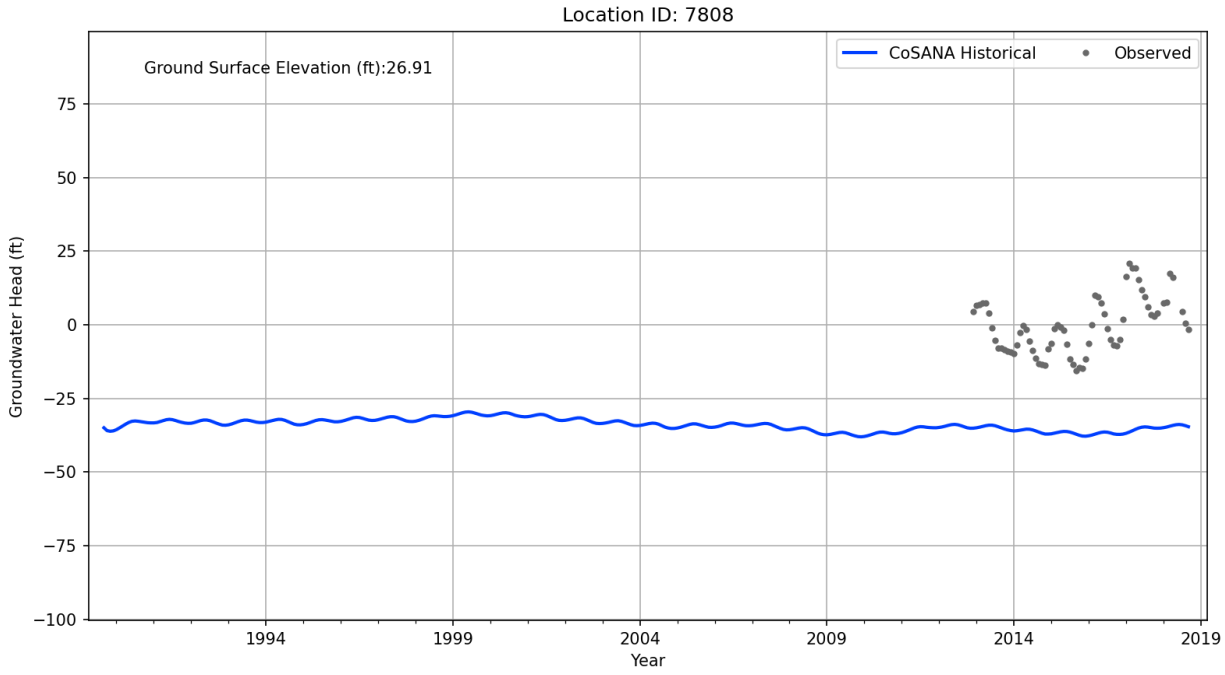

Location ID: 7304
Ground Surface Elevation (ft):123.14
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

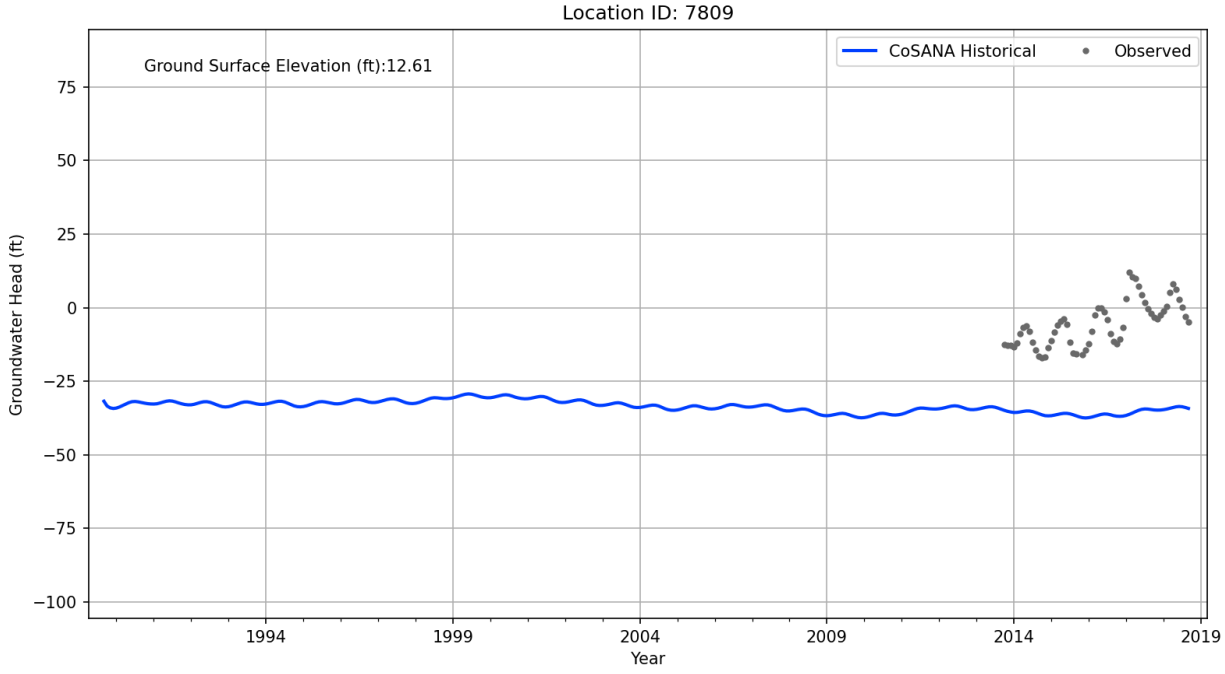

Location ID: 7403
Ground Surface Elevation (ft):181.6
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

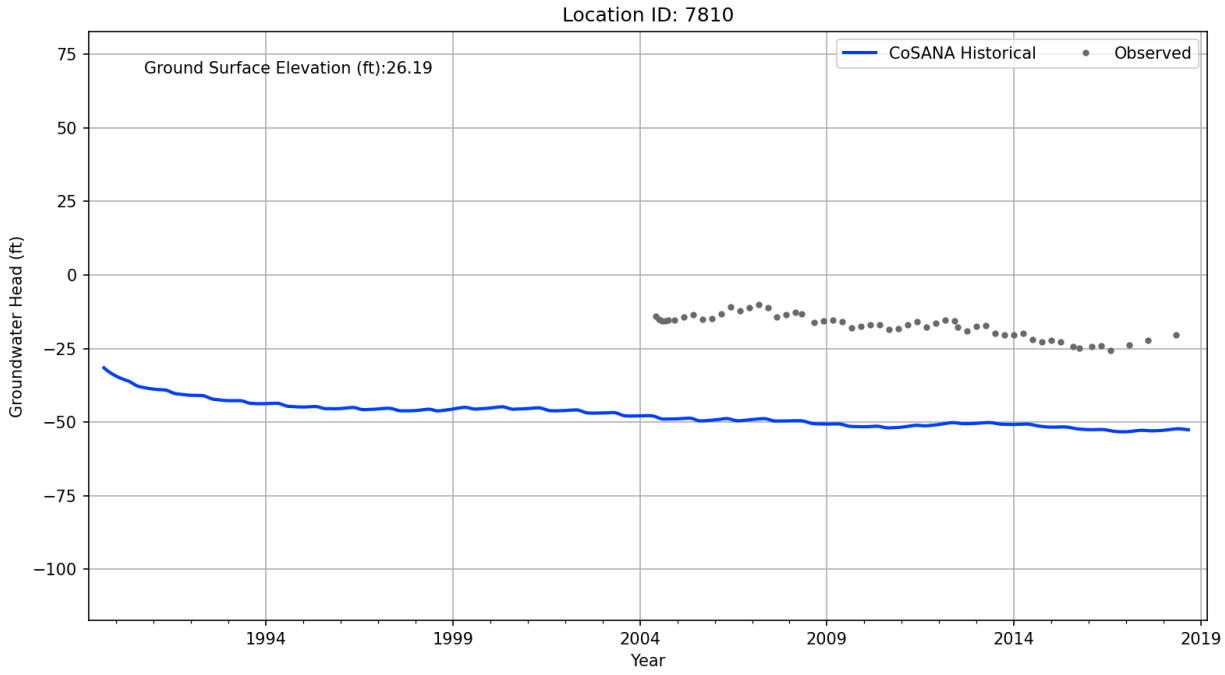

Location ID: 7604
Ground Surface Elevation (ft):21.36
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

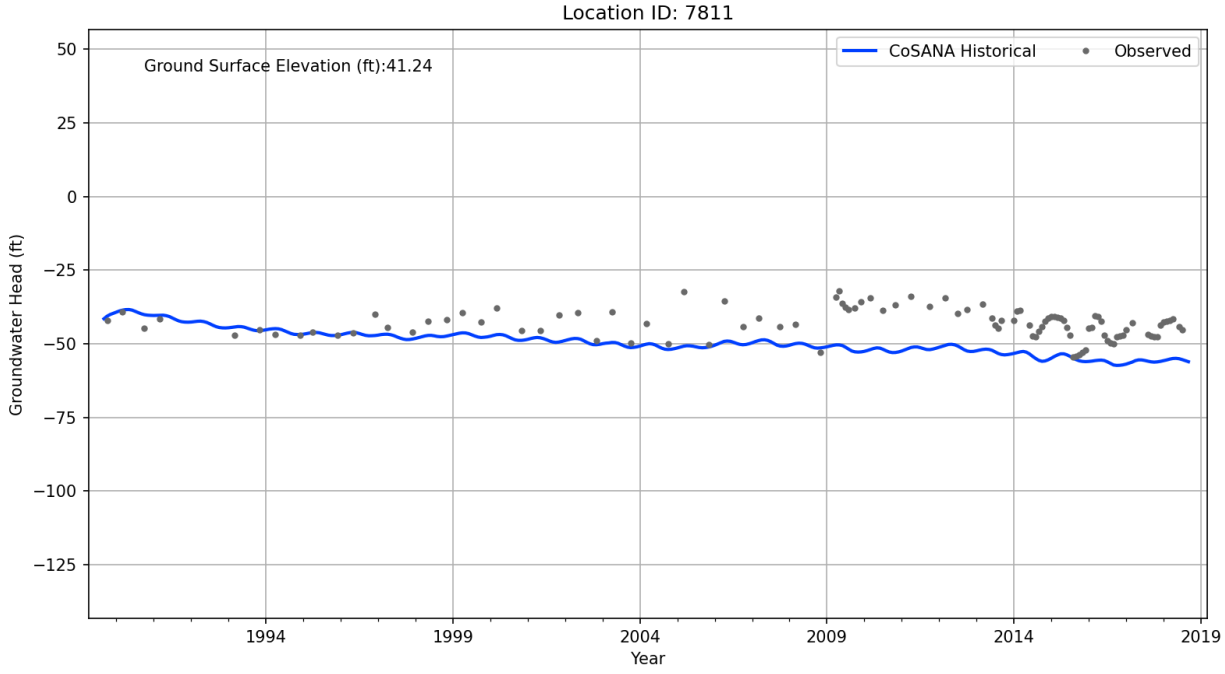

Location ID: 7705
Ground Surface Elevation (ft):29.46
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

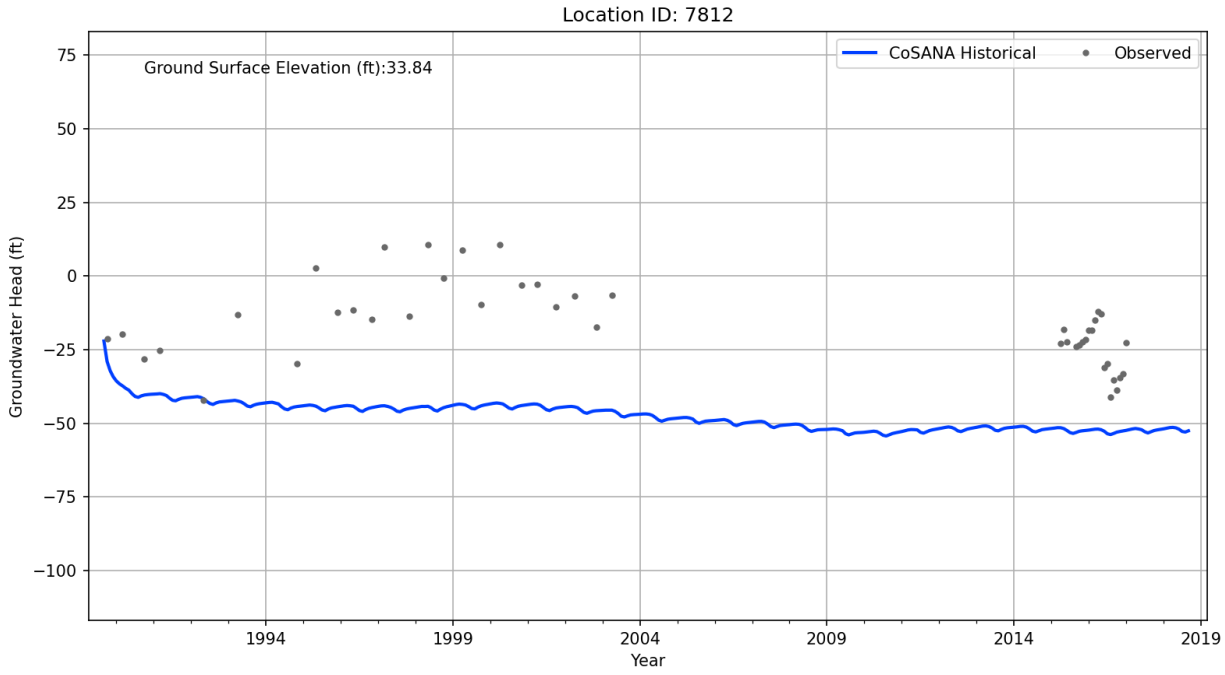

Location ID: 7807
Ground Surface Elevation (ft):18.67
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

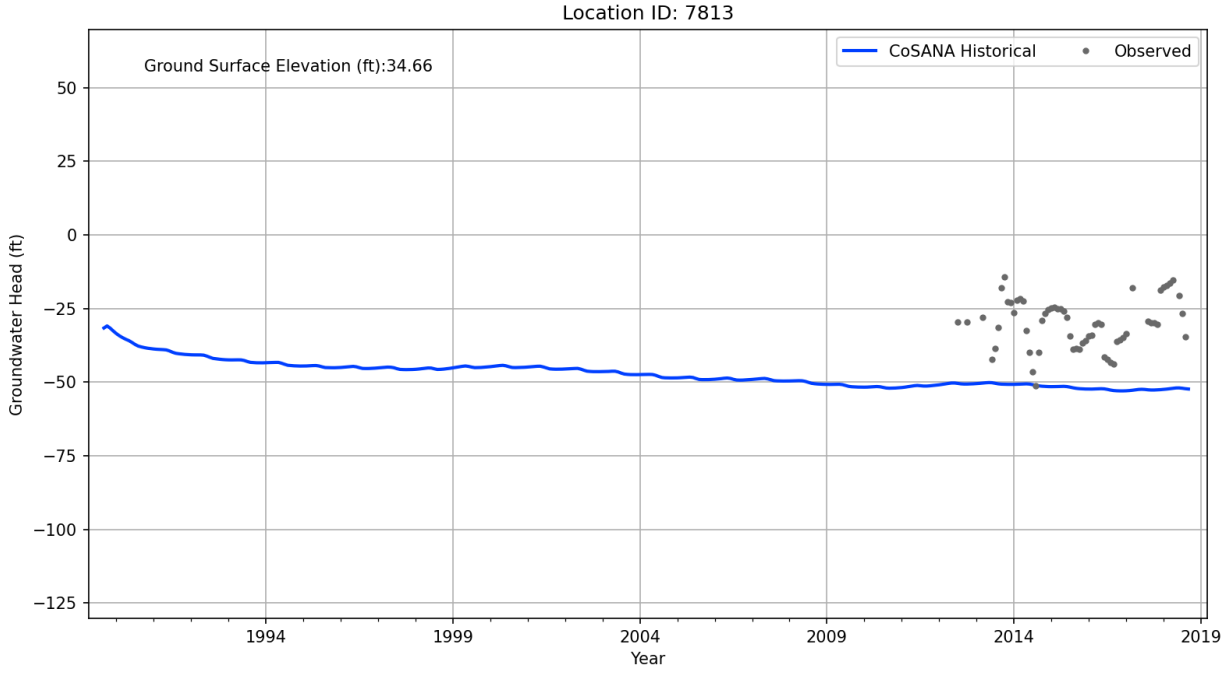

Location ID: 7808
Ground Surface Elevation (ft):26.91
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

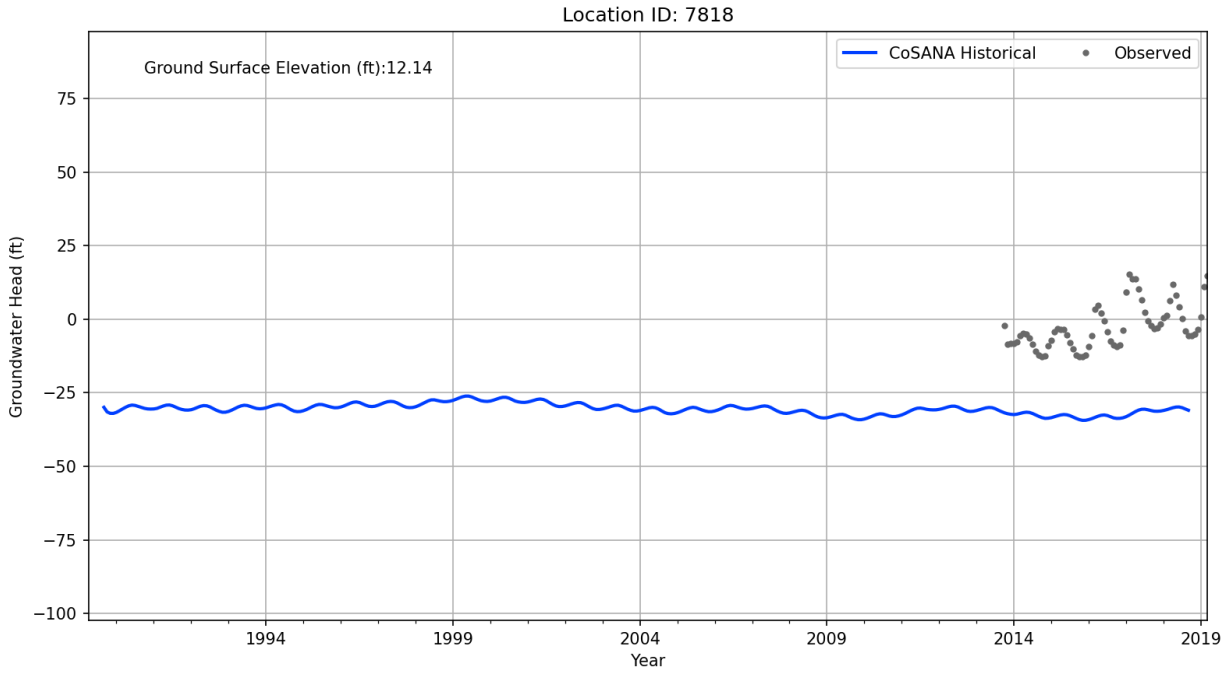

Location ID: 7809
Ground Surface Elevation (ft):12.61
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

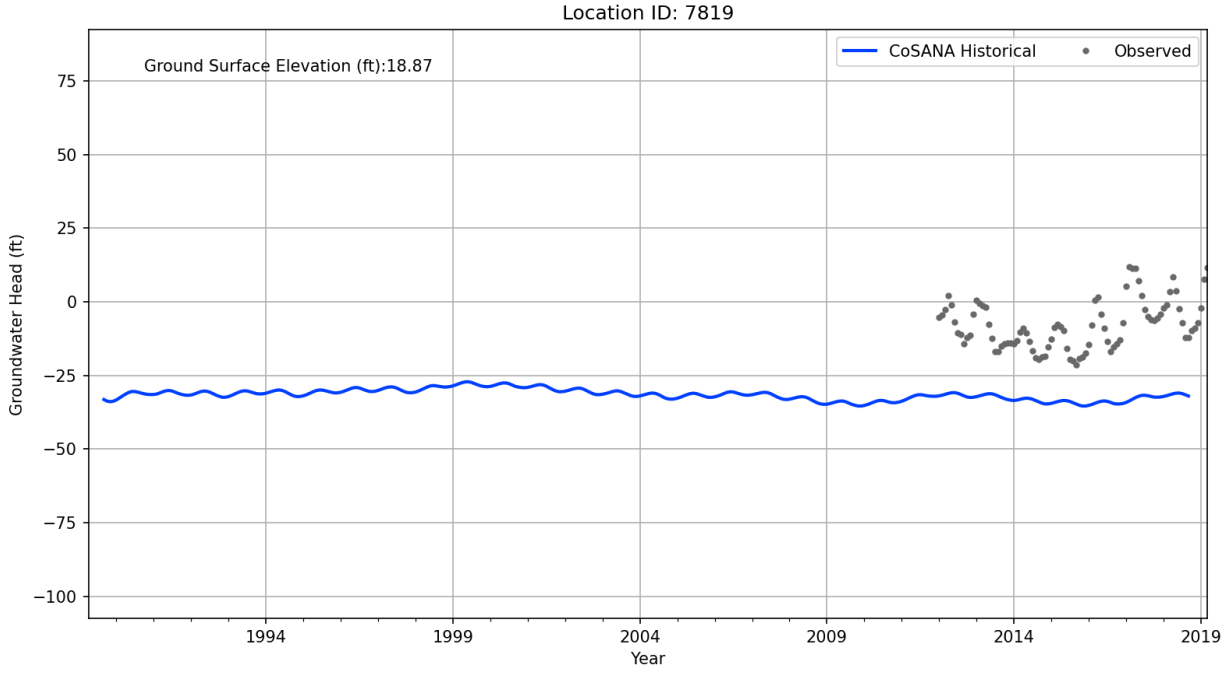

Location ID: 7810
Ground Surface Elevation (ft):26.19
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

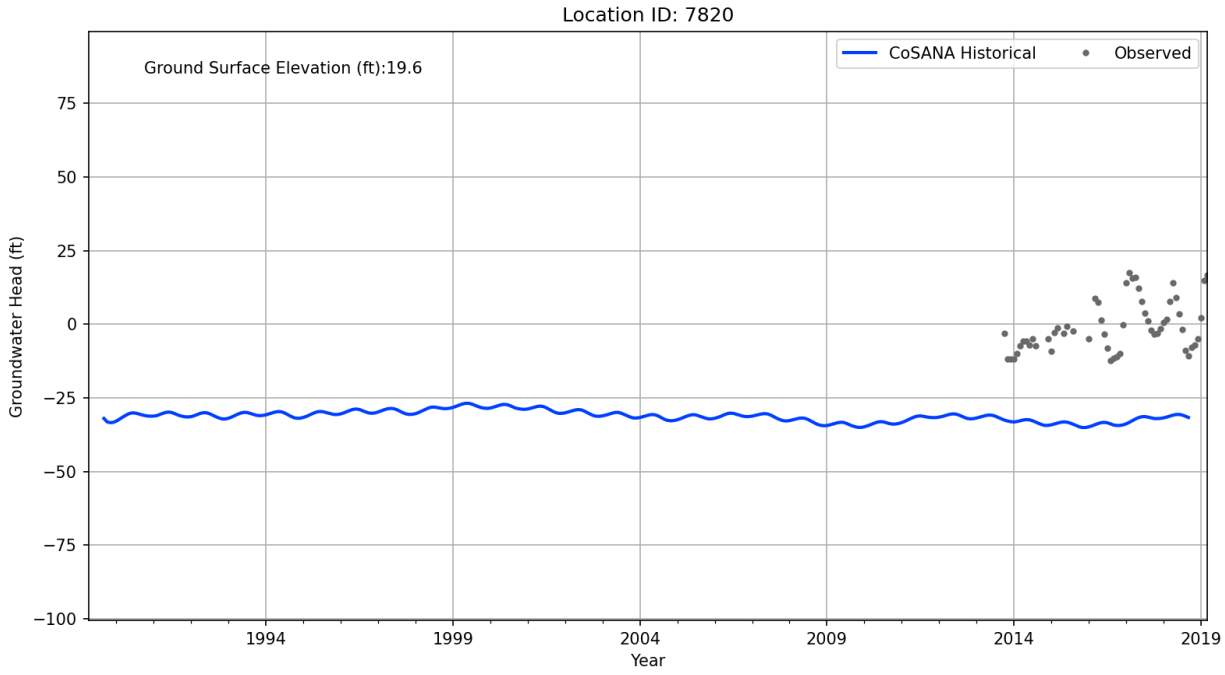

Location ID: 7811
Ground Surface Elevation (ft):41.24
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

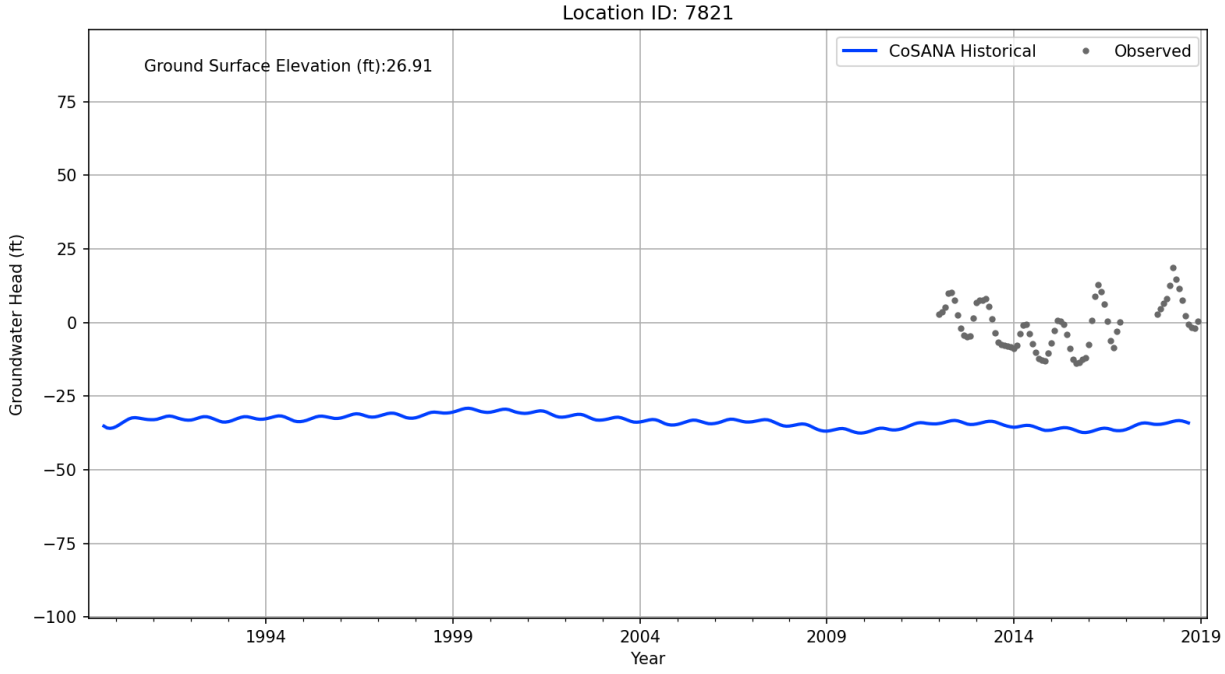

Location ID: 7812
Ground Surface Elevation (ft):33.84
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

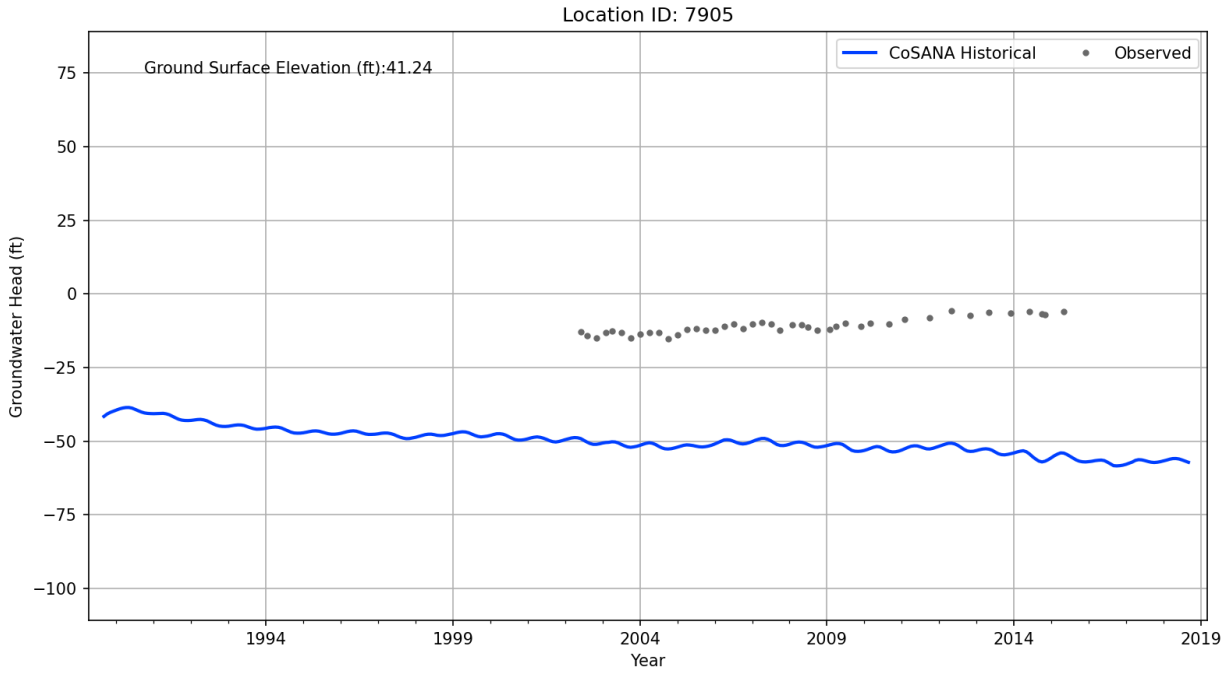

Location ID: 7813
Ground Surface Elevation (ft):34.66
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

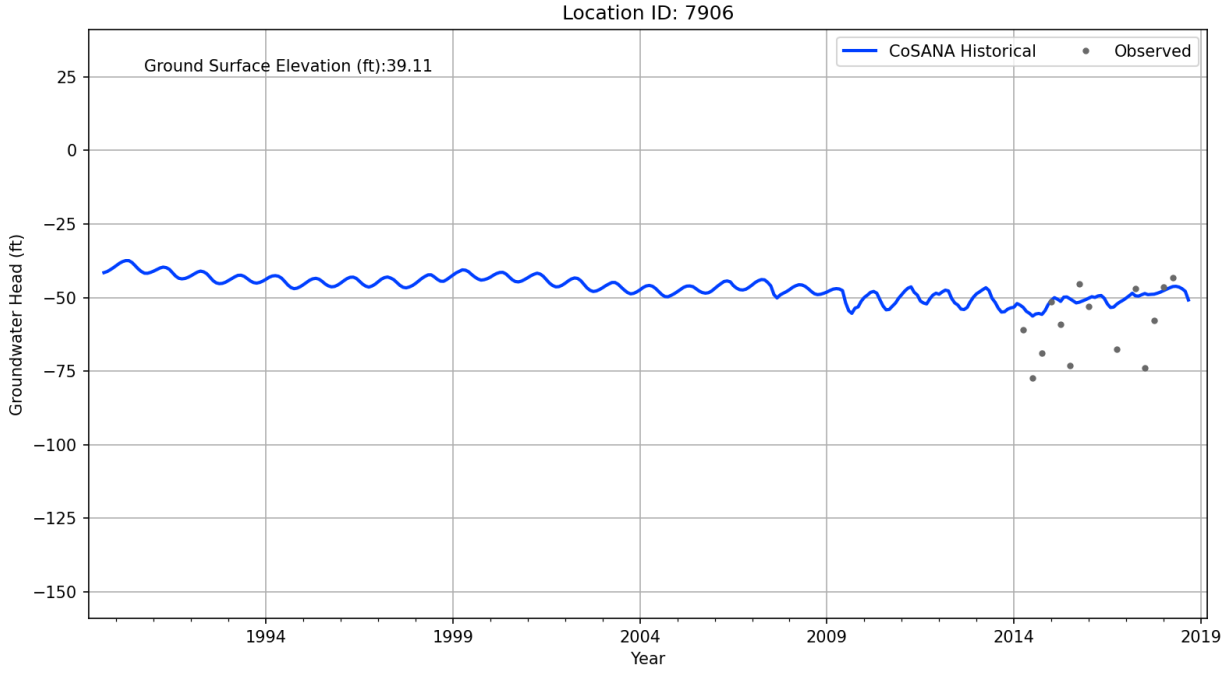

Location ID: 7818
Ground Surface Elevation (ft):12.14
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

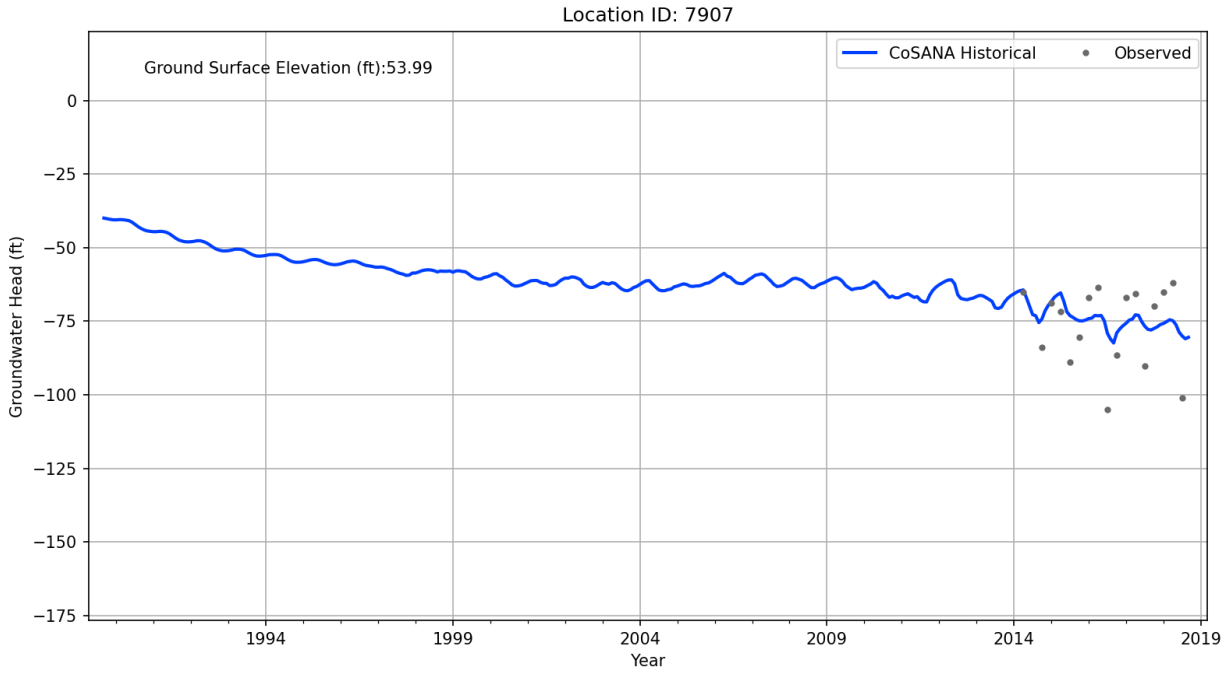

Location ID: 7819
Ground Surface Elevation (ft):18.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

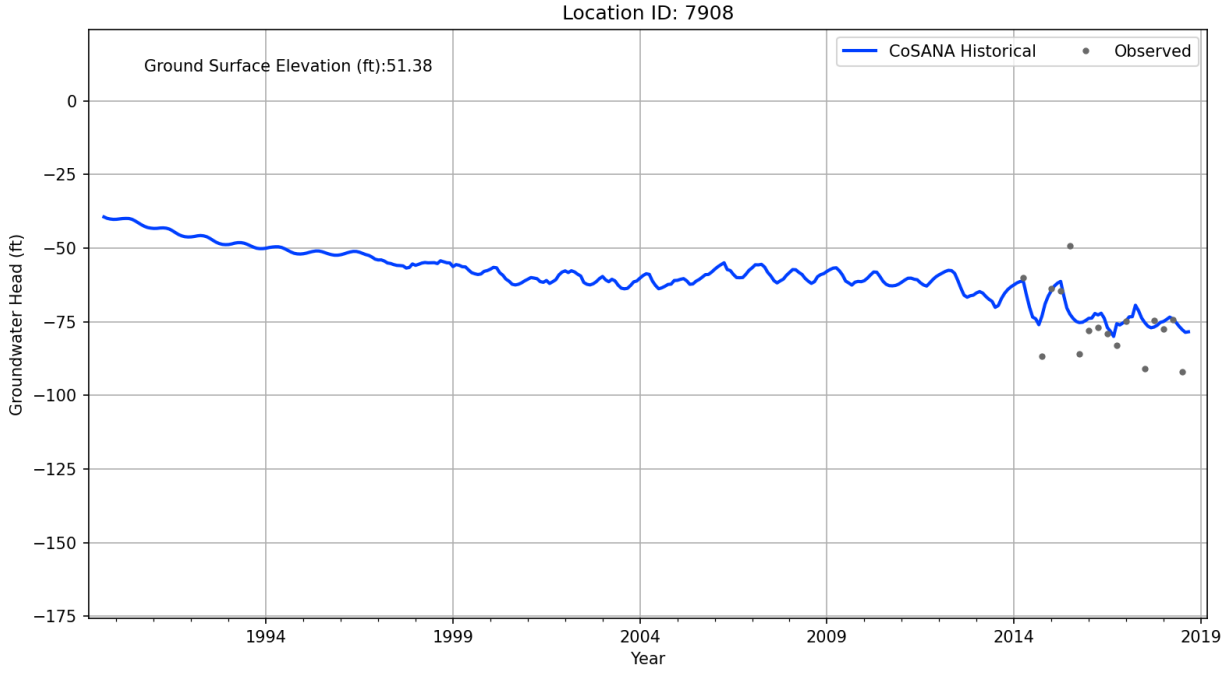

Location ID: 7820
Ground Surface Elevation (ft):19.6
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

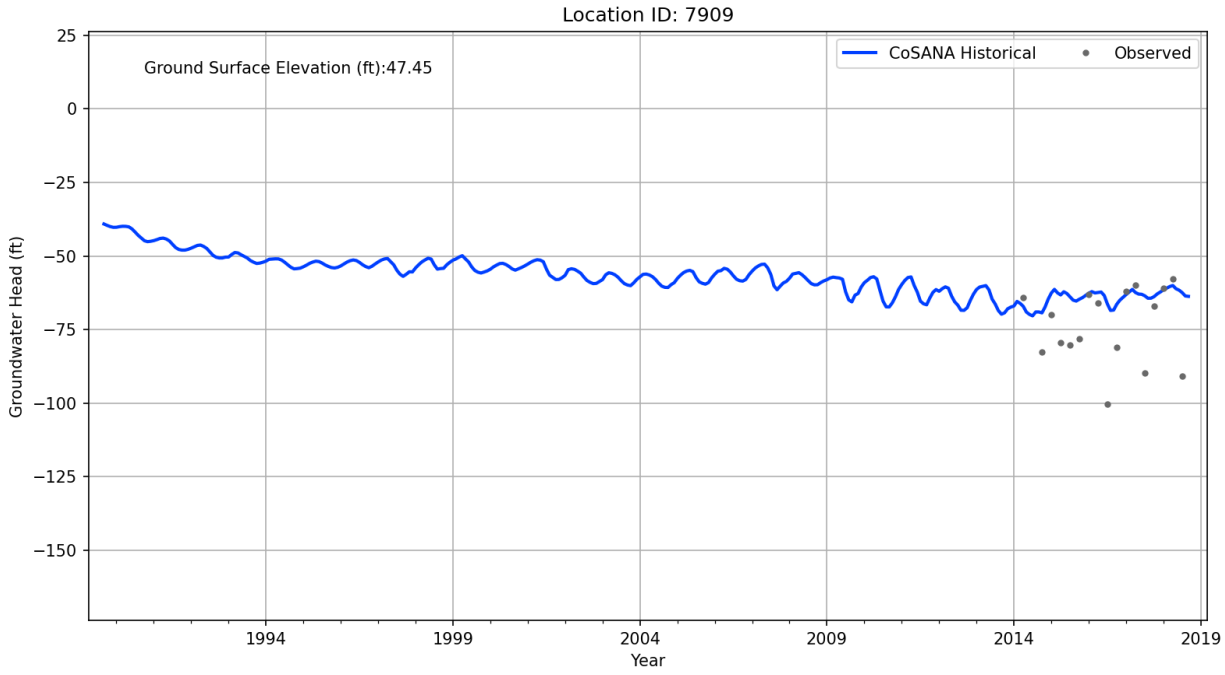

Location ID: 7821
Ground Surface Elevation (ft):26.91
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

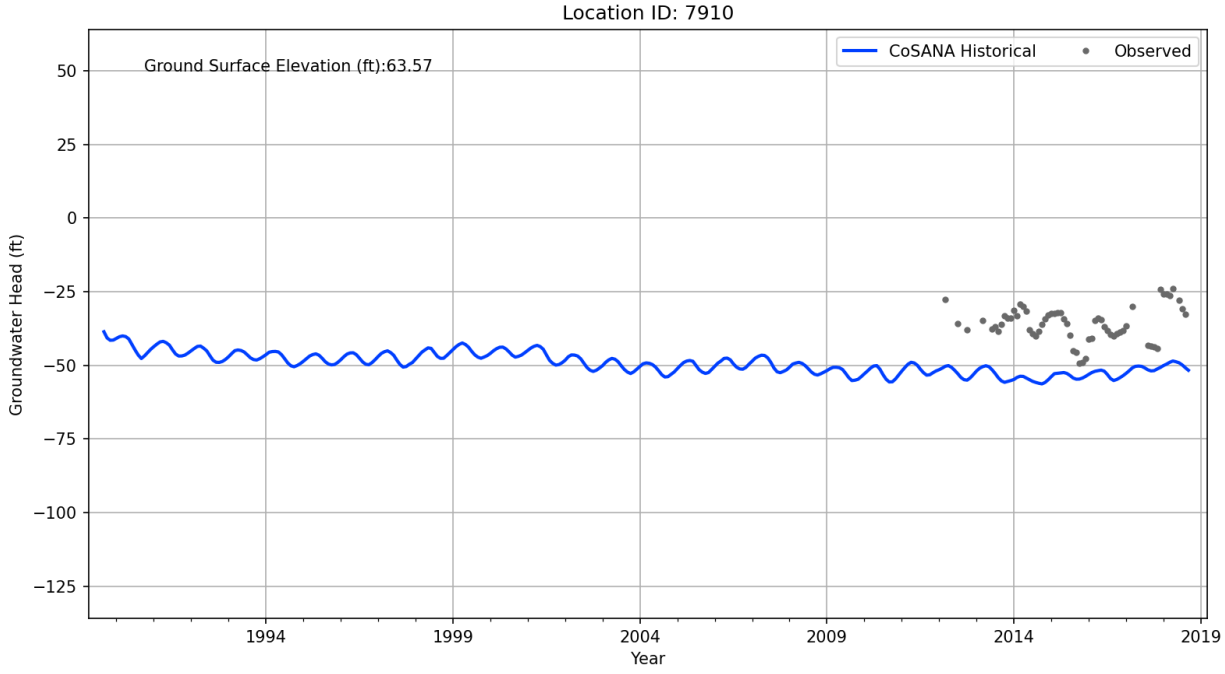

Location ID: 7905
Ground Surface Elevation (ft):41.24
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

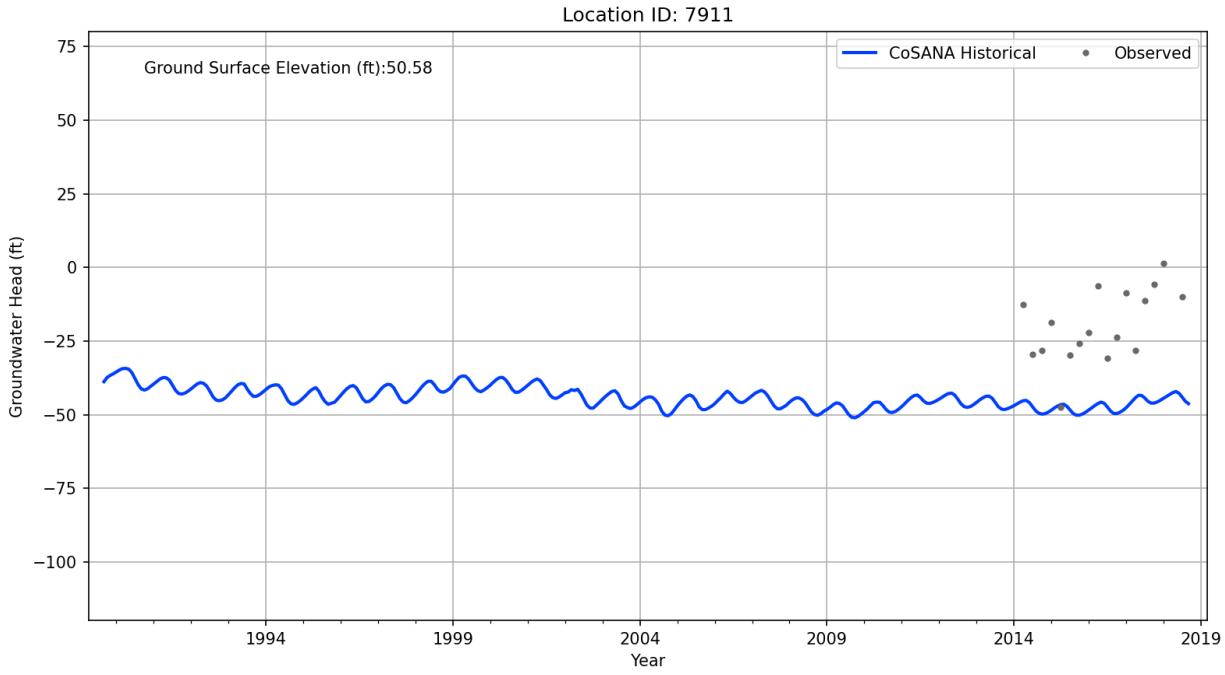

Location ID: 7906
Ground Surface Elevation (ft):39.11
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

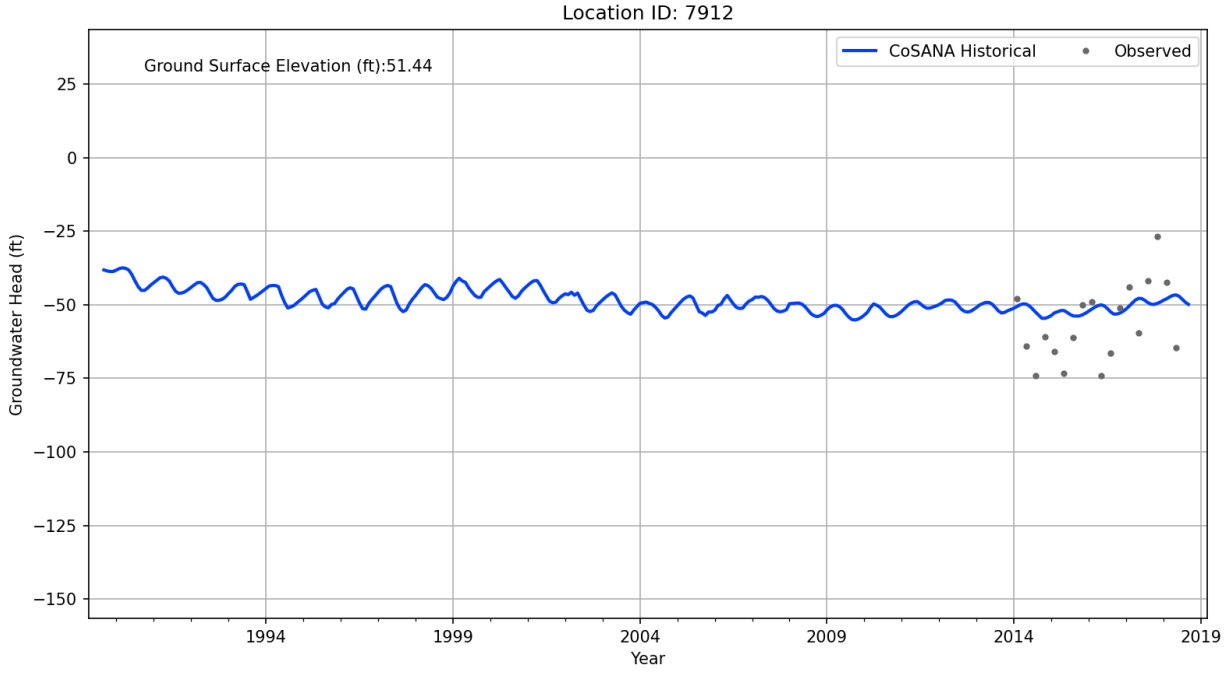

Location ID: 7907
Ground Surface Elevation (ft):53.99
CoSANA Historical
Observed
Groundwater Head (ft)
0
−25
−50
−75
−100
−125
−150
−175
1994
1999
2004
2009
2014
2019
Year

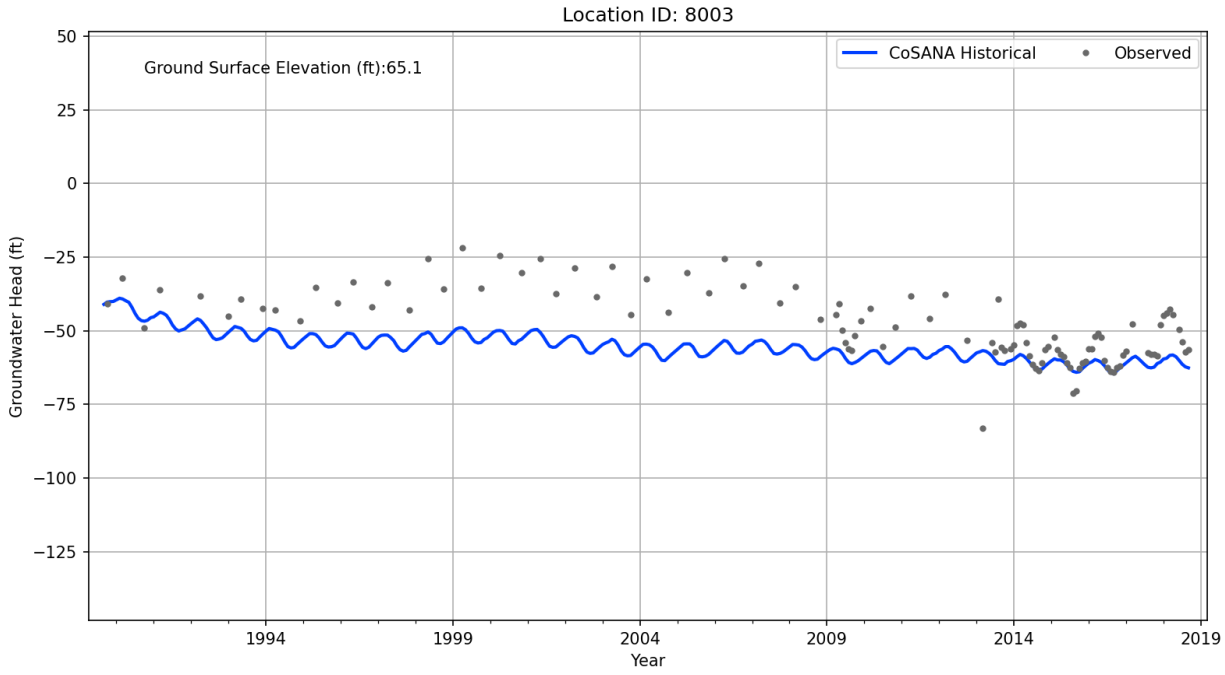

Location ID: 7908
Ground Surface Elevation (ft):51.38
CoSANA Historical
Observed
Groundwater Head (ft)
0
−25
−50
−75
−100
−125
−150
−175
1994
1999
2004
2009
2014
2019
Year

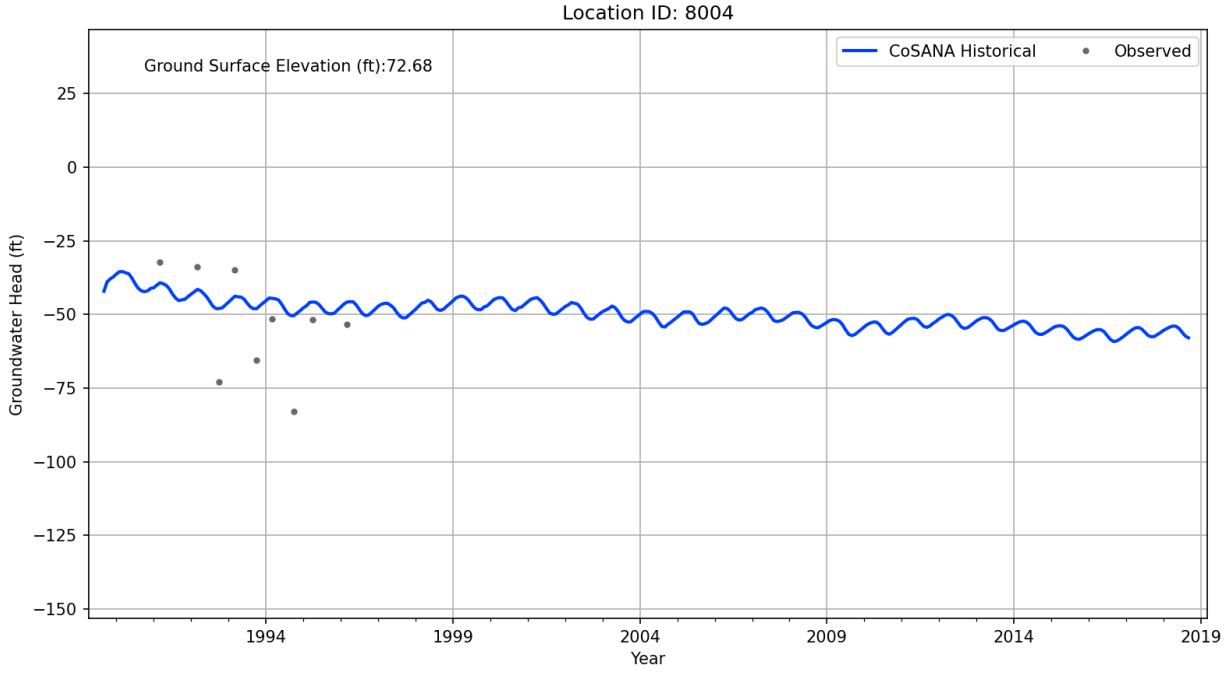

Location ID: 7909
Ground Surface Elevation (ft):47.45
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

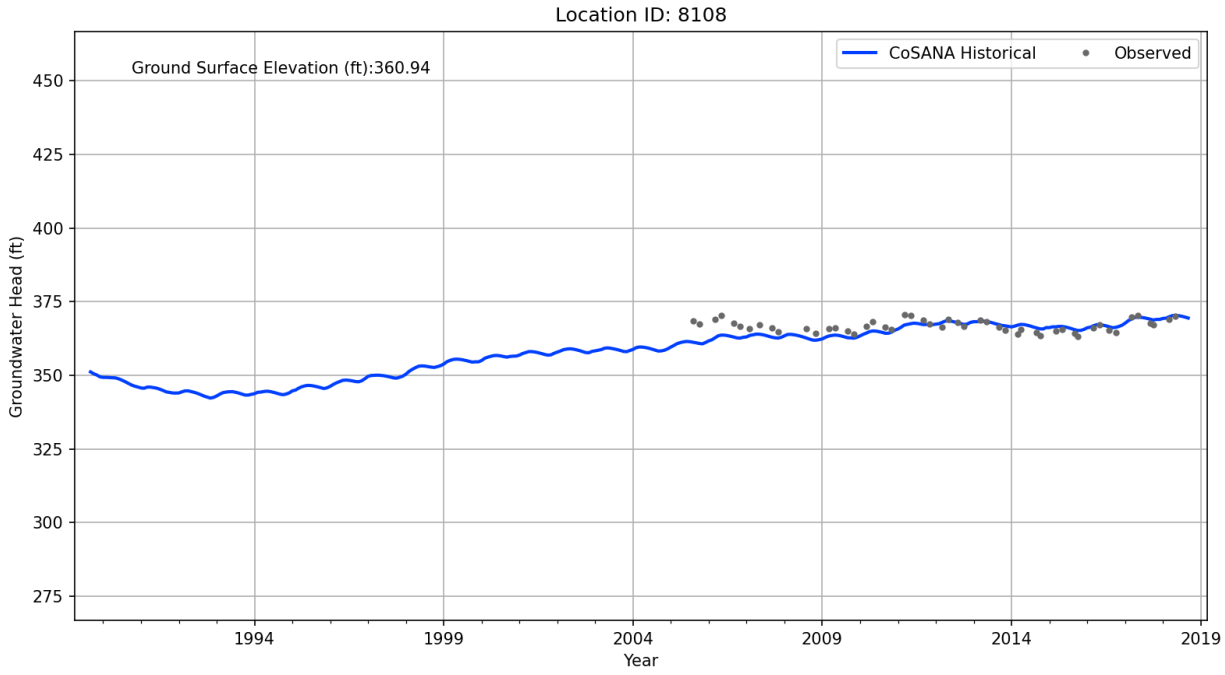

Location ID: 7910
Ground Surface Elevation (ft):63.57
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

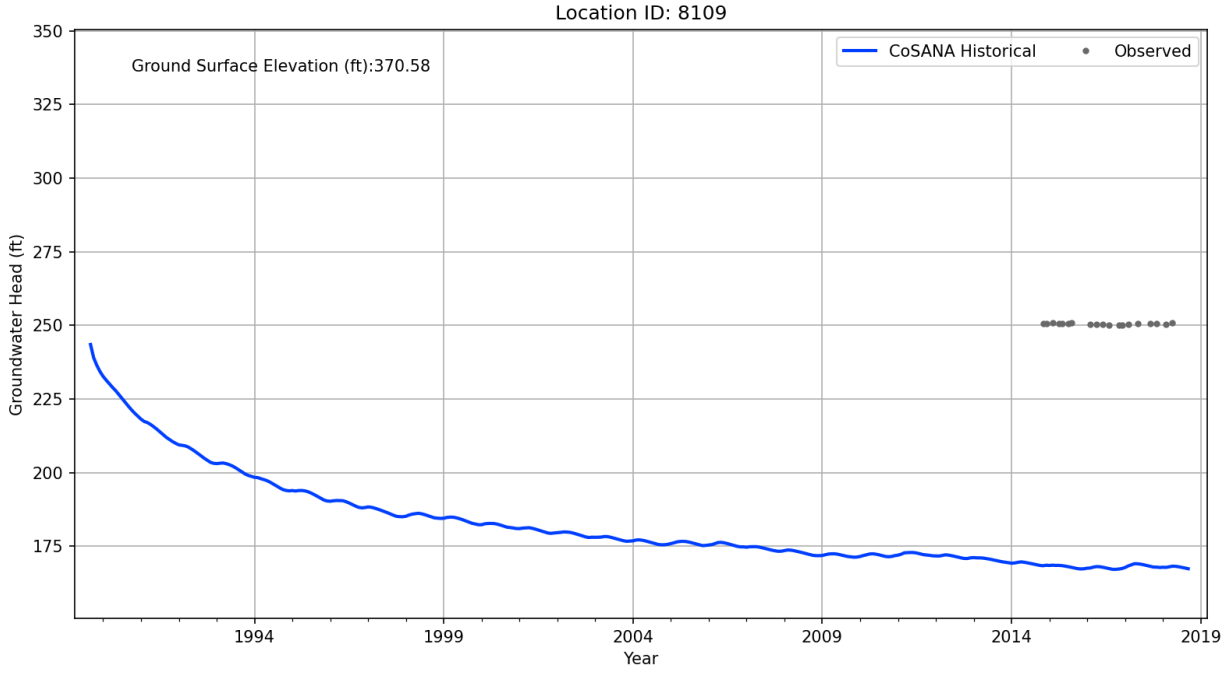

Location ID: 7911
Ground Surface Elevation (ft):50.58
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

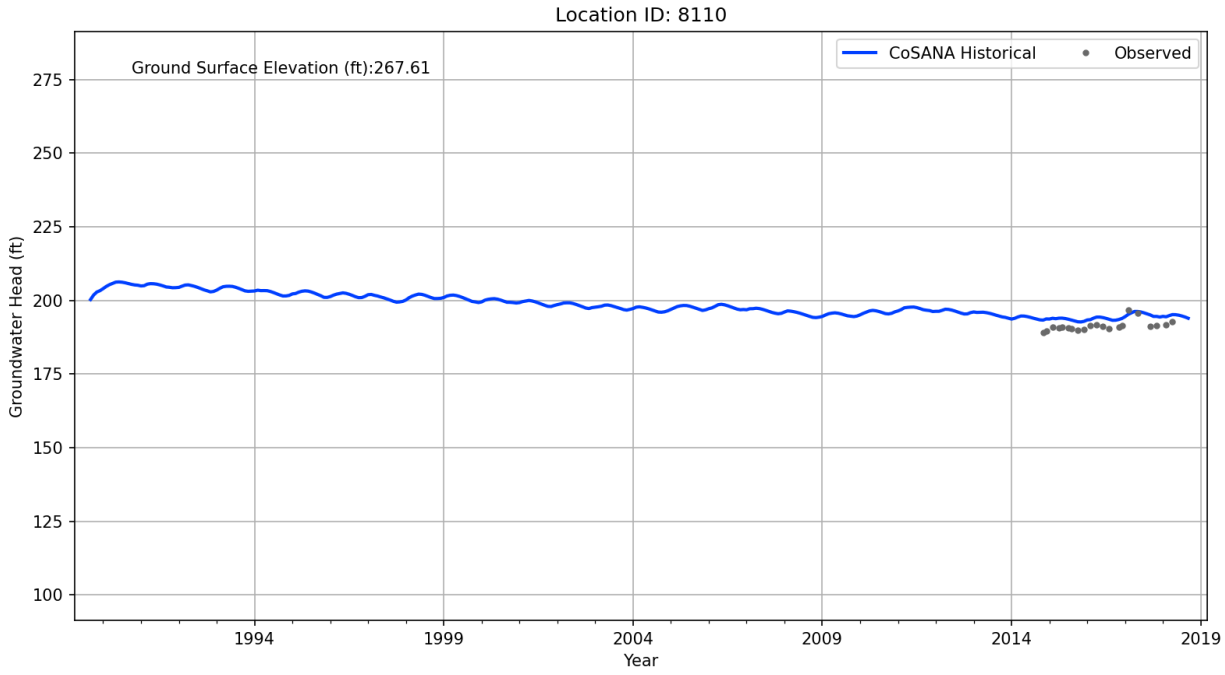

Location ID: 7912
Ground Surface Elevation (ft):51.44
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

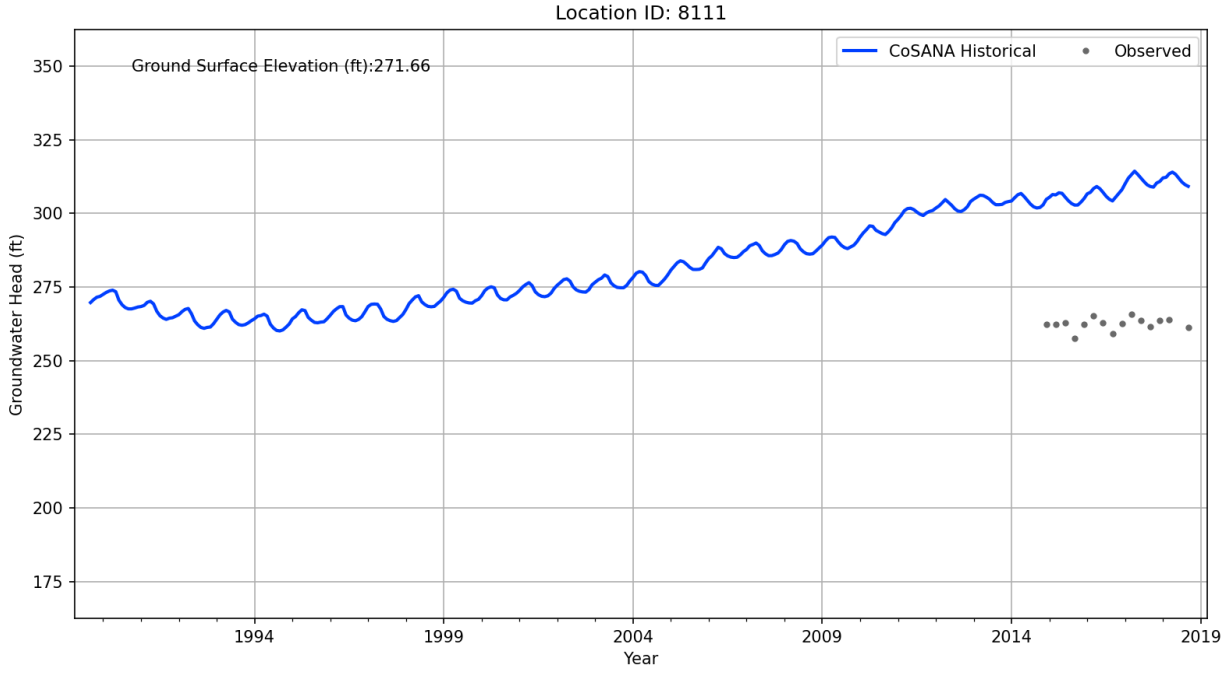

Location ID: 8003
Ground Surface Elevation (ft):65.1
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

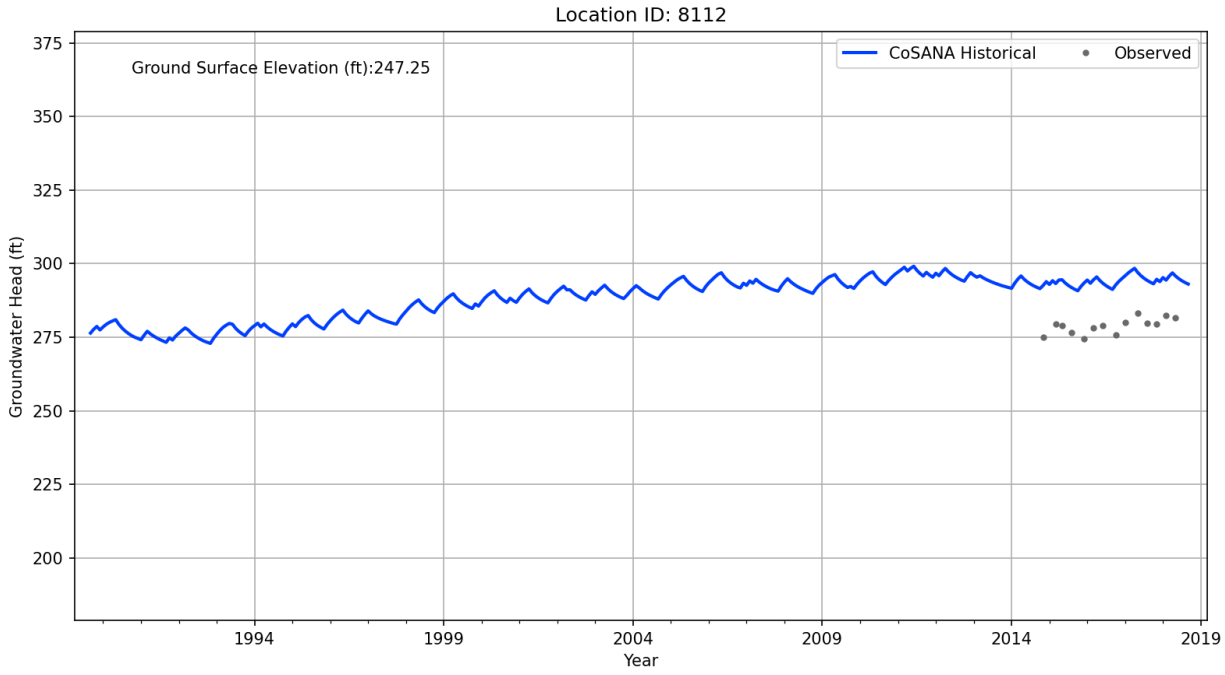

Location ID: 8004
Ground Surface Elevation (ft):72.68
CoSANA Historical
Observed
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

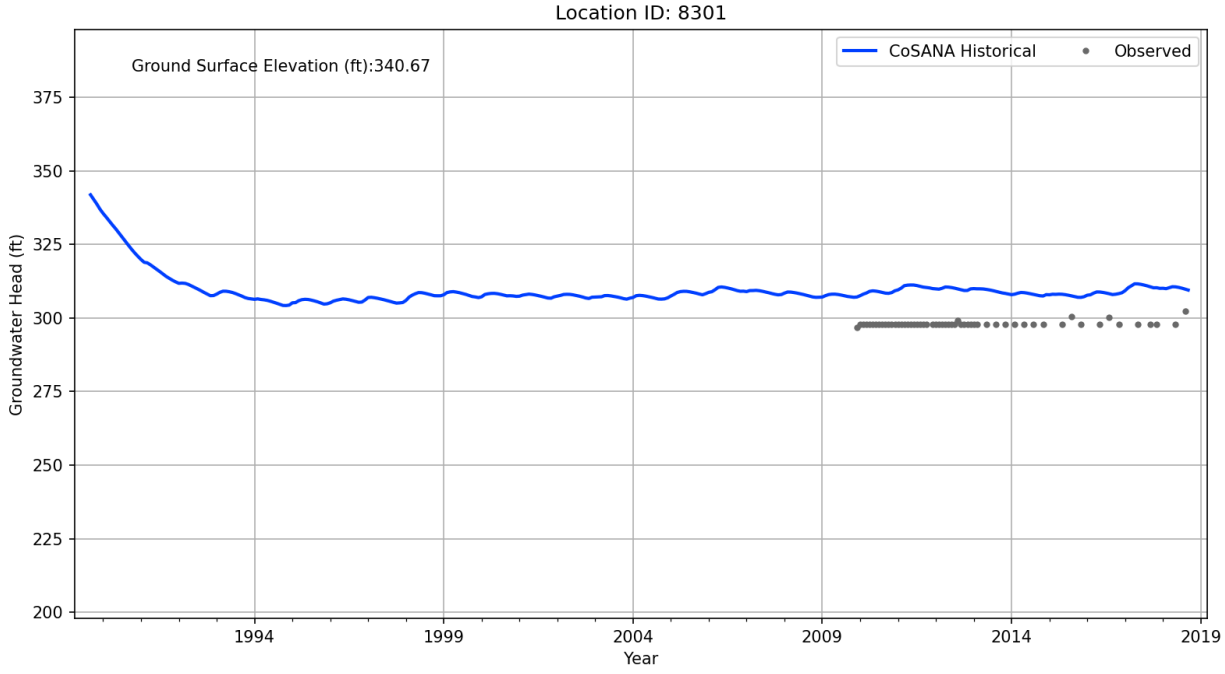

Location ID: 8108
Ground Surface Elevation (ft):360.94
CoSANA Historical
Observed
Groundwater Head (ft)
450
425
400
375
350
325
300
275
1994
1999
2004
2009
2014
2019
Year

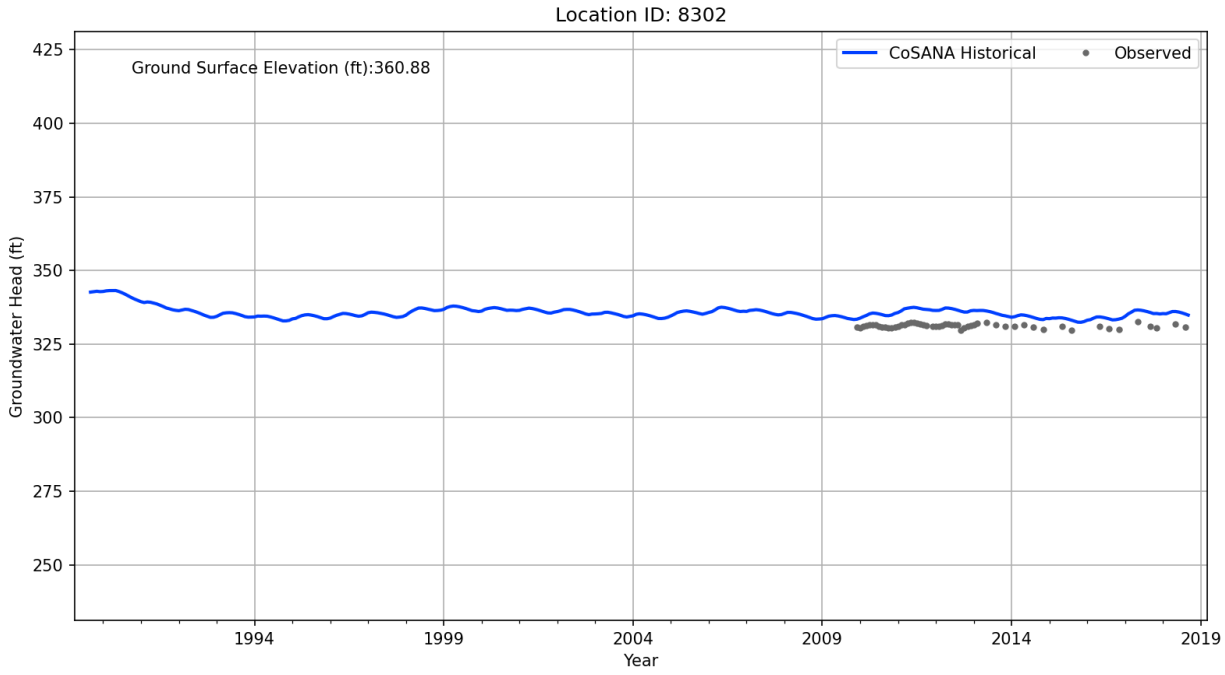

Location ID: 8109
Ground Surface Elevation (ft):370.58
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

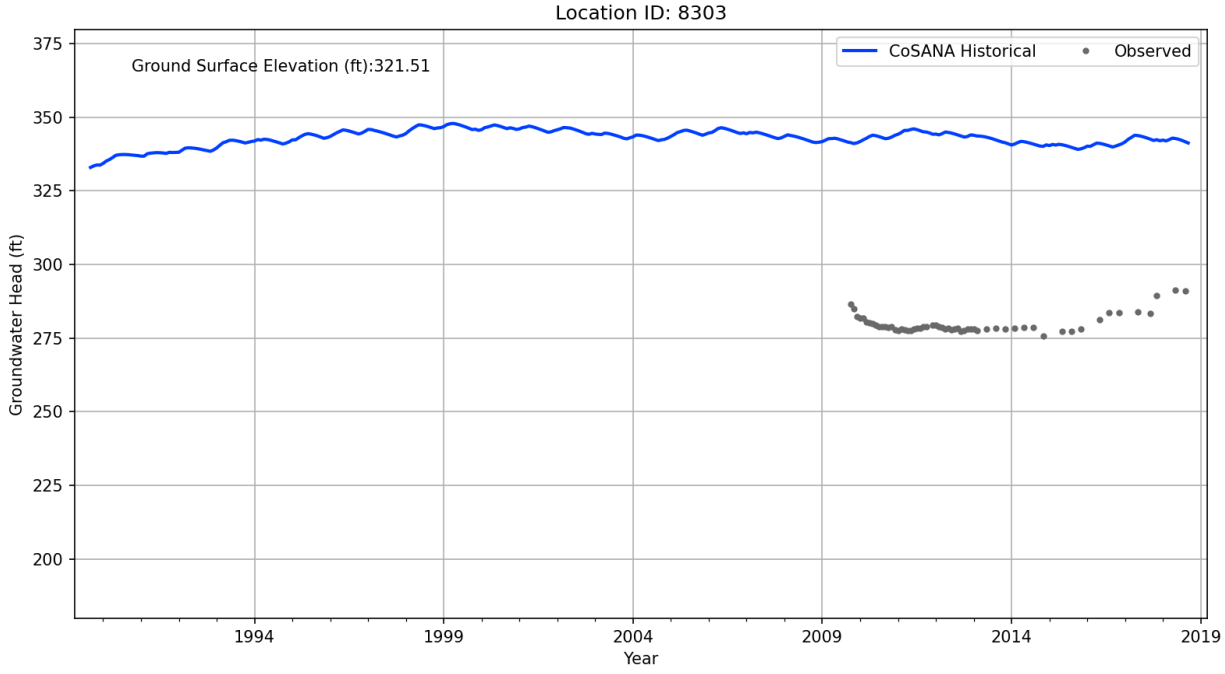

Location ID: 8110
Ground Surface Elevation (ft):267.61
CoSANA Historical
Observed
Groundwater Head (ft)
275
250
225
200
175
150
125
100
1994
1999
2004
2009
2014
2019
Year

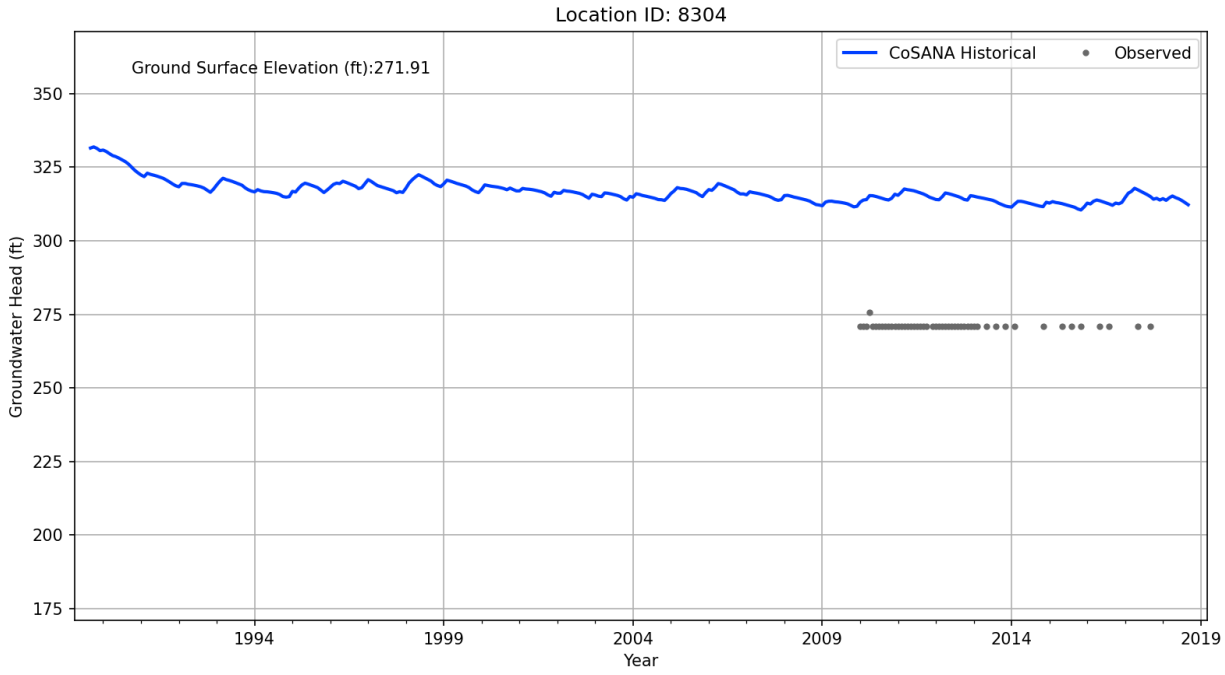

Location ID: 8111
Ground Surface Elevation (ft):271.66
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

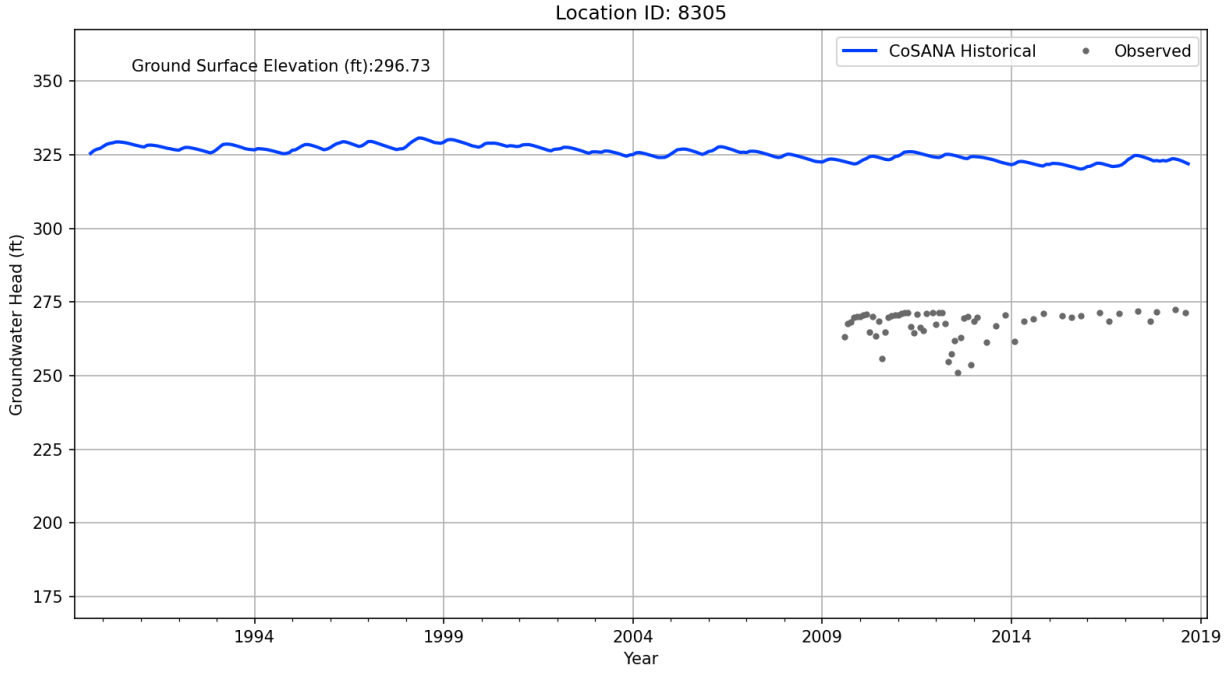

Location ID: 8112
Ground Surface Elevation (ft):247.25
CoSANA Historical
Observed
Groundwater Head (ft)
375
350
325
300
275
250
225
200
1994
1999
2004
2009
2014
2019
Year

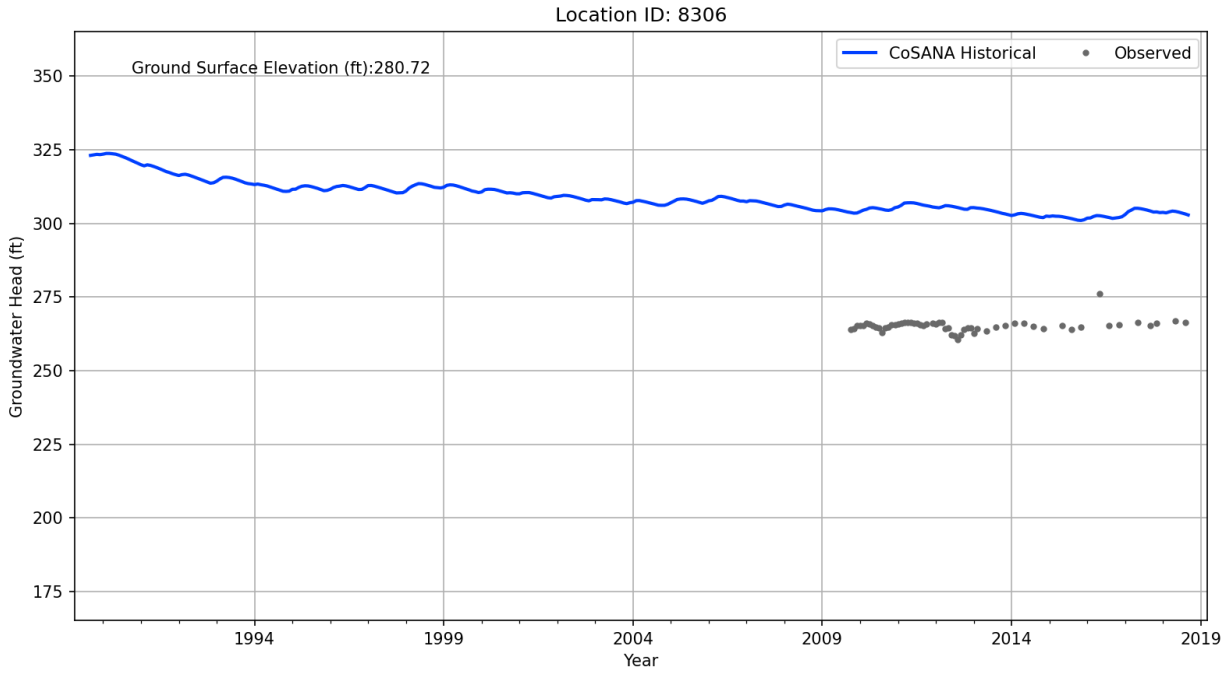

Location ID: 8301
Ground Surface Elevation (ft):340.67
CoSANA Historical
Observed
Groundwater Head (ft)
375
350
325
300
275
250
225
200
1994
1999
2004
2009
2014
2019
Year

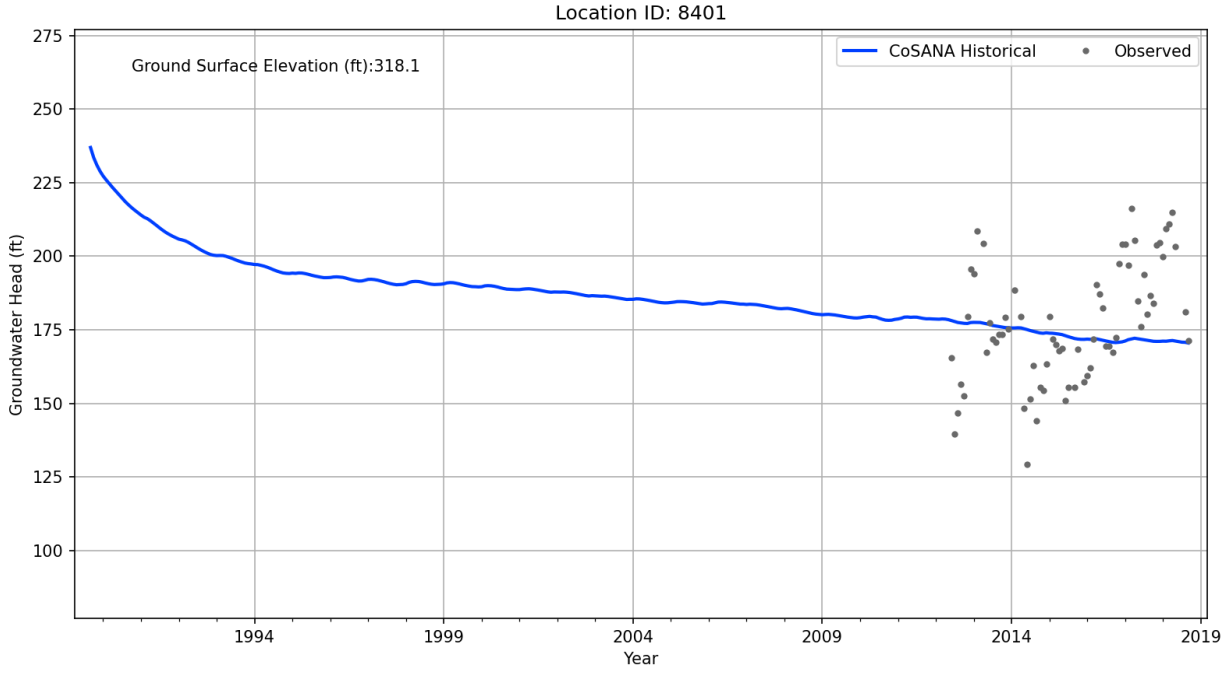

Location ID: 8302
Ground Surface Elevation (ft):360.88
CoSANA Historical
Observed
Groundwater Head (ft)
425
400
375
350
325
300
275
250
1994
1999
2004
2009
2014
2019
Year

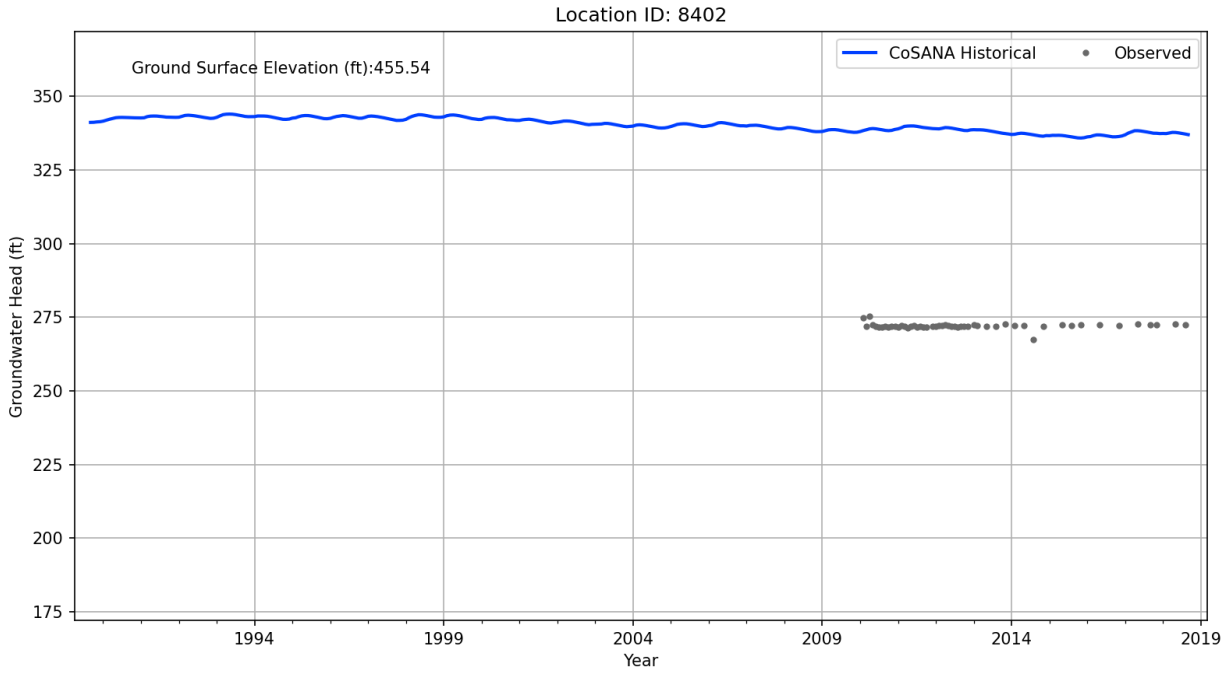

Location ID: 8303
Ground Surface Elevation (ft):321.51
CoSANA Historical
Observed
Groundwater Head (ft)
375
350
325
300
275
250
225
200
1994
1999
2004
2009
2014
2019
Year

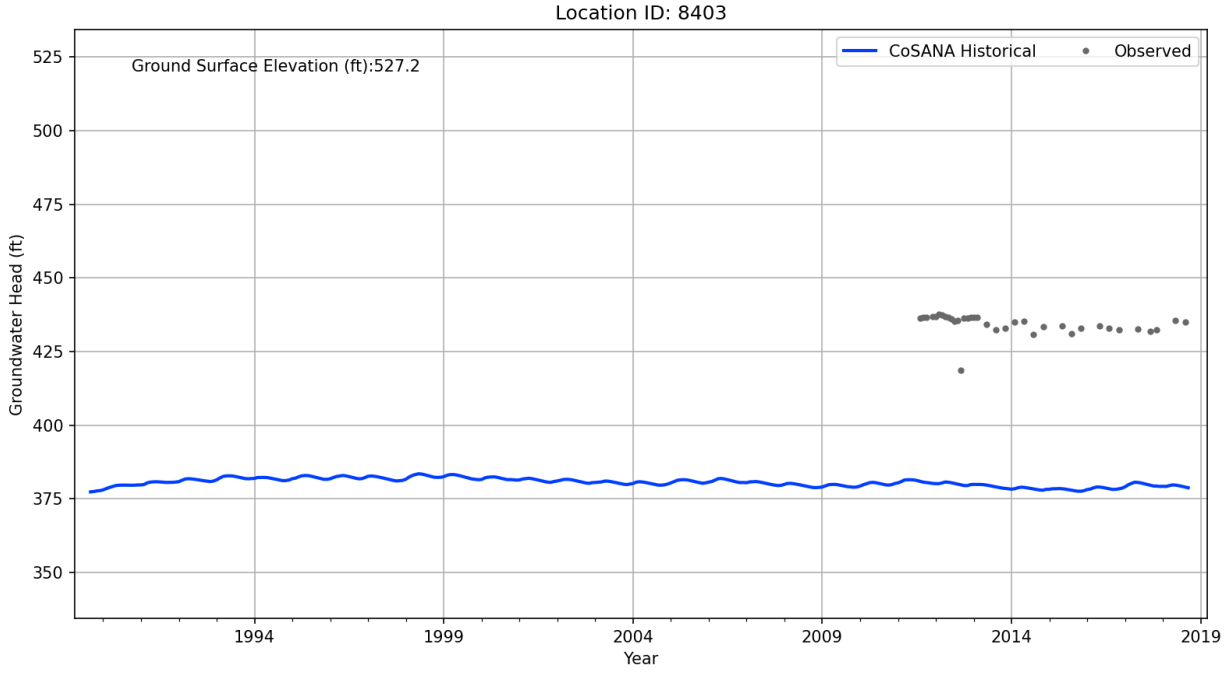

Location ID: 8304
Ground Surface Elevation (ft):271.91
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

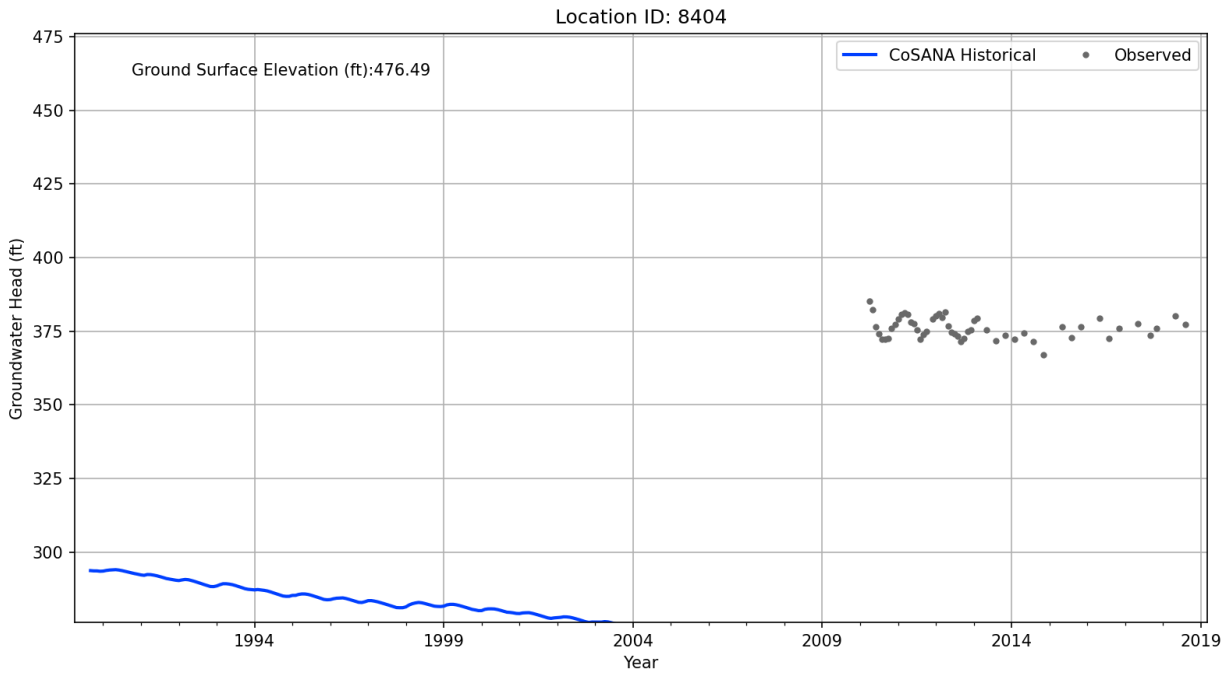

Location ID: 8305
Ground Surface Elevation (ft):296.73
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

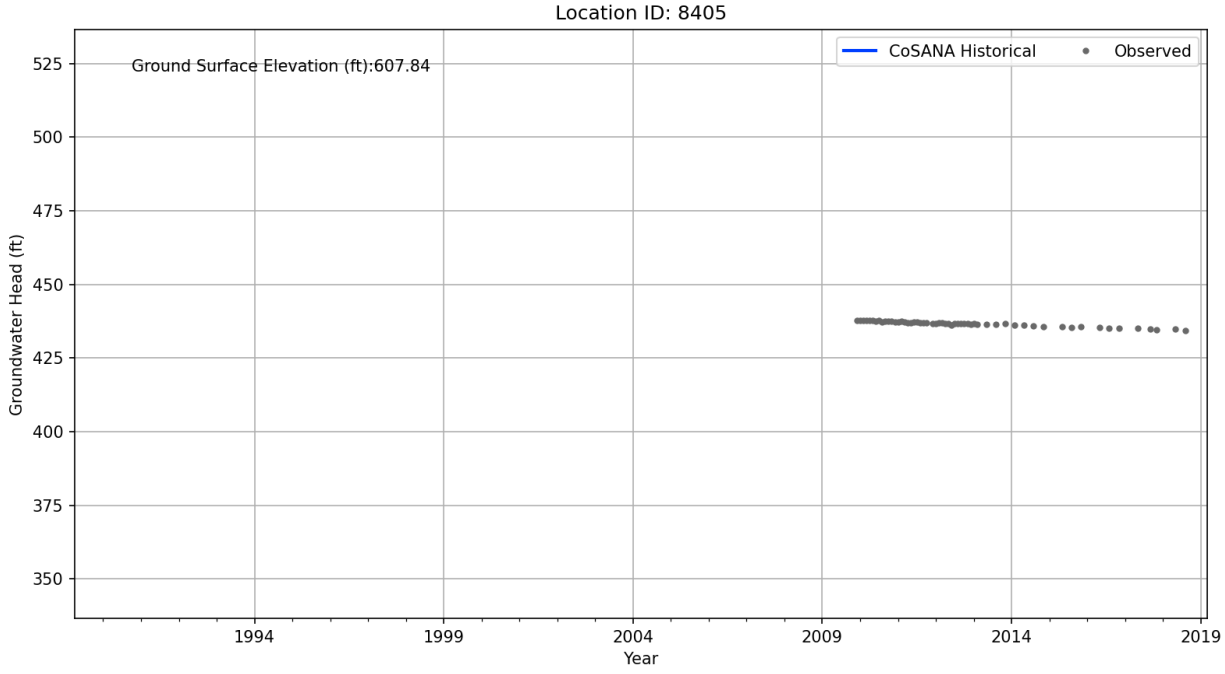

Location ID: 8306
Ground Surface Elevation (ft):280.72
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

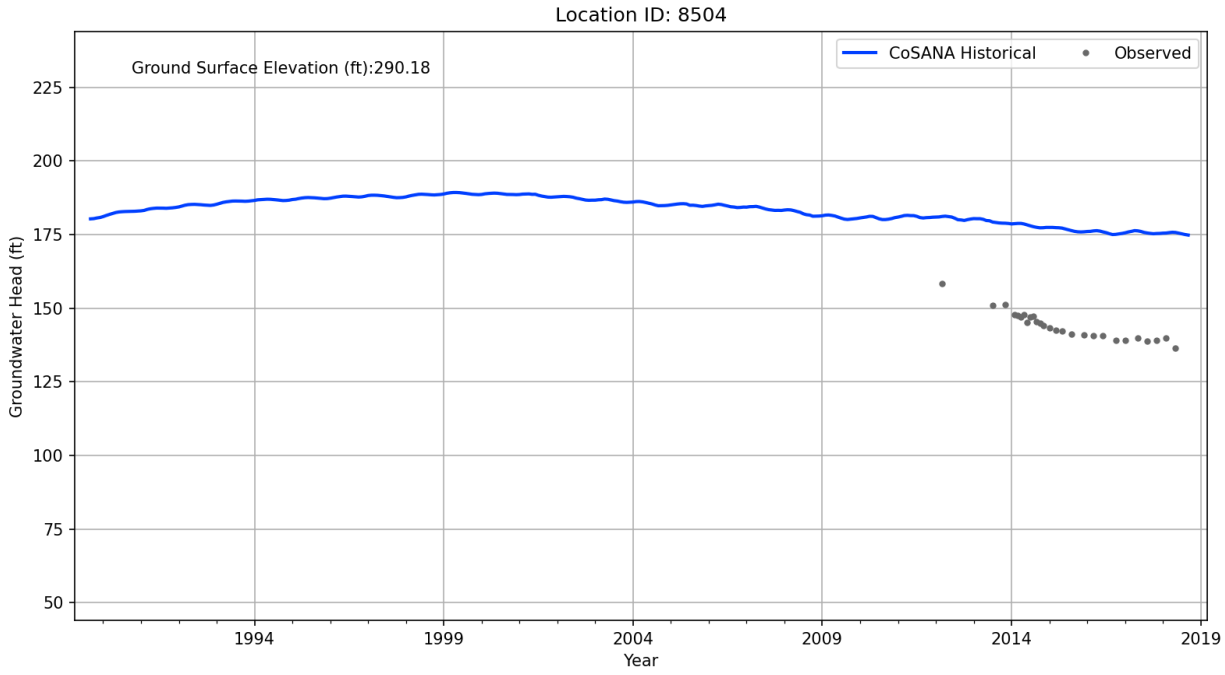

Location ID: 8401
Ground Surface Elevation (ft):318.1
CoSANA Historical
Observed
Groundwater Head (ft)
275
250
225
200
175
150
125
100
1994
1999
2004
2009
2014
2019
Year

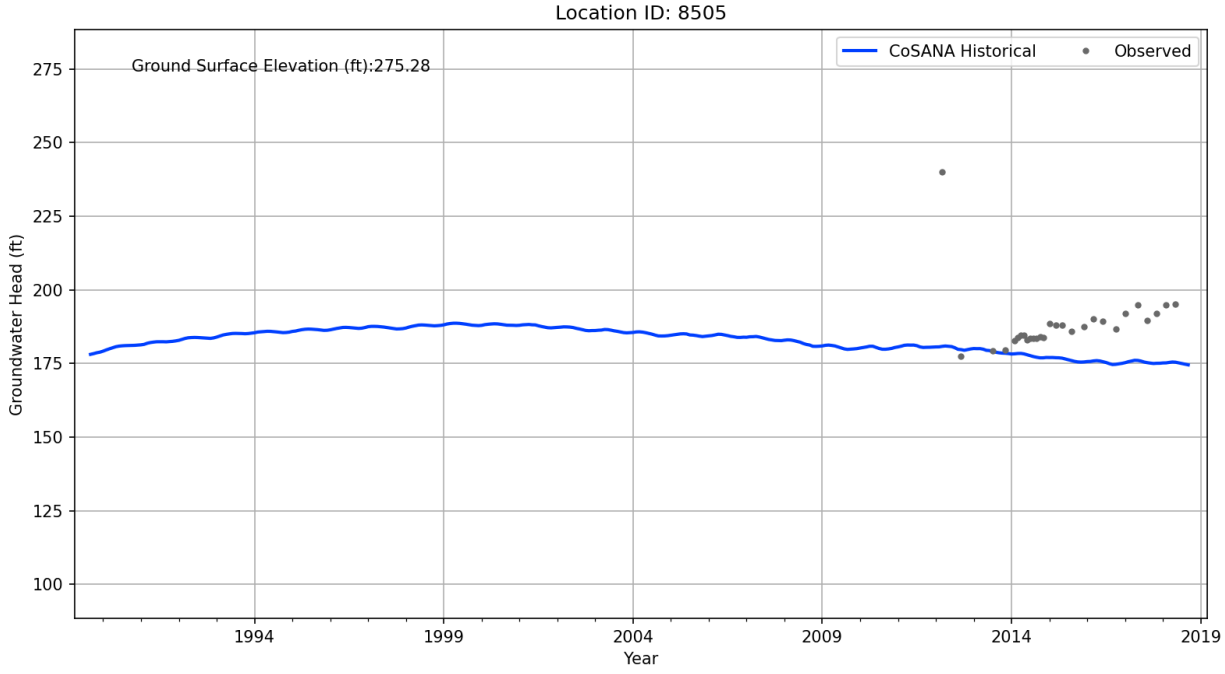

Location ID: 8402
Ground Surface Elevation (ft):455.54
CoSANA Historical
Observed
Groundwater Head (ft)
350
325
300
275
250
225
200
175
1994
1999
2004
2009
2014
2019
Year

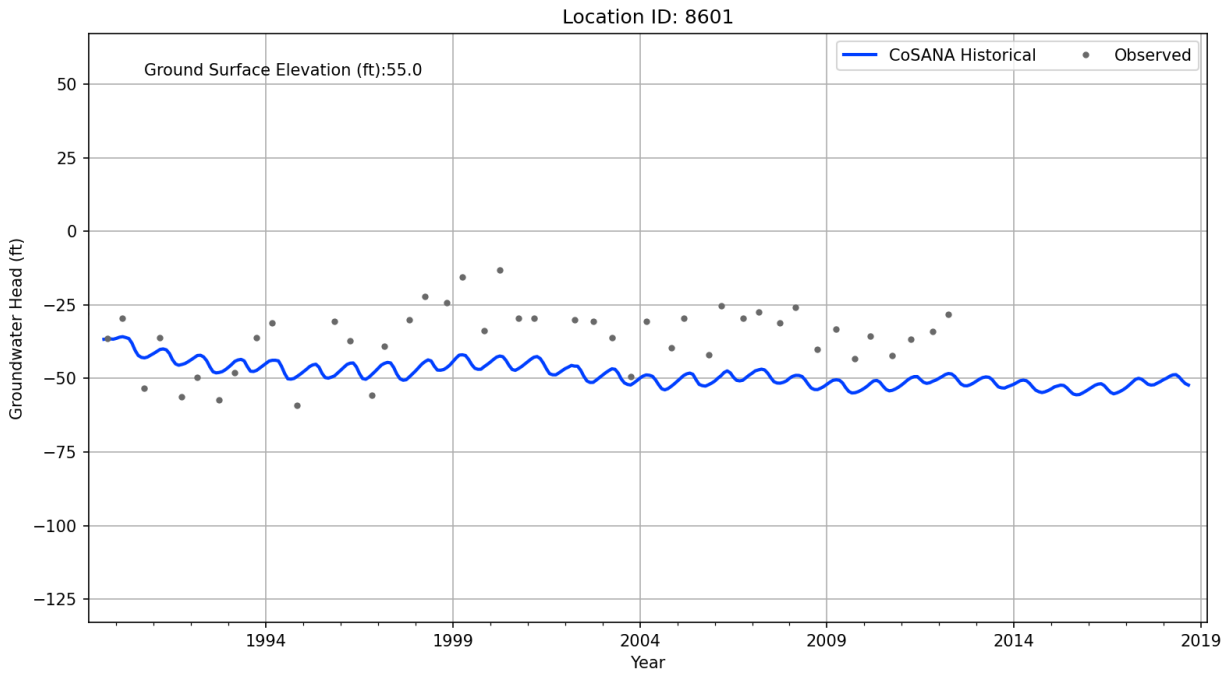

Location ID: 8403
Ground Surface Elevation (ft):527.2
CoSANA Historical
Observed
Groundwater Head (ft)
525
500
475
450
425
400
375
350
1994
1999
2004
2009
2014
2019
Year

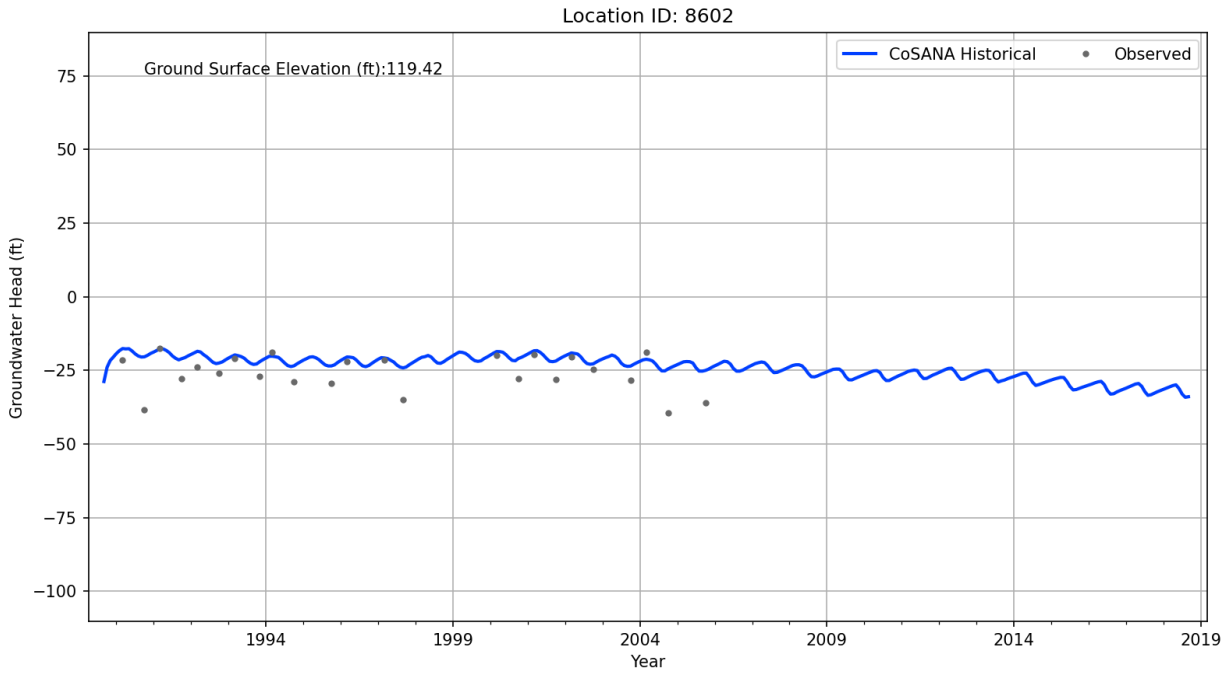

Location ID: 8404
Ground Surface Elevation (ft):476.49
CoSANA Historical
Observed
Groundwater Head (ft)
475
450
425
400
375
350
325
300
1994
1999
2004
2009
2014
2019
Year

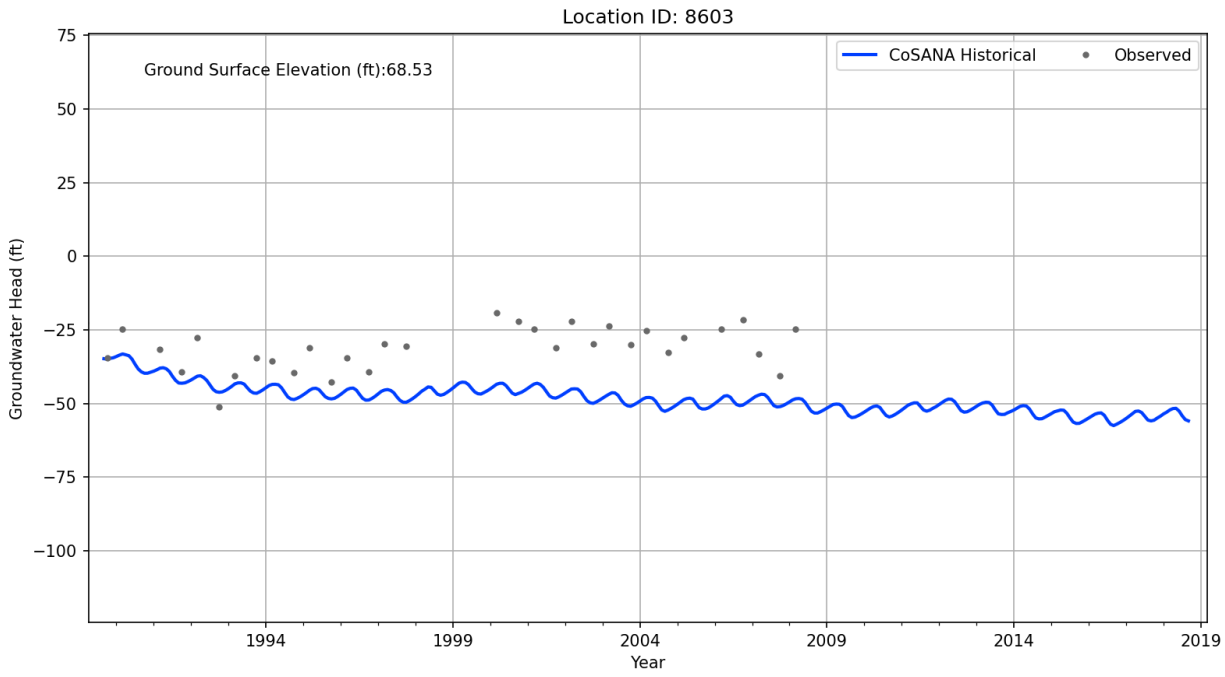

Location ID: 8405
Ground Surface Elevation (ft):607.84
CoSANA Historical
Observed
Groundwater Head (ft)
525
500
475
450
425
400
375
350
1994
1999
2004
2009
2014
2019
Year

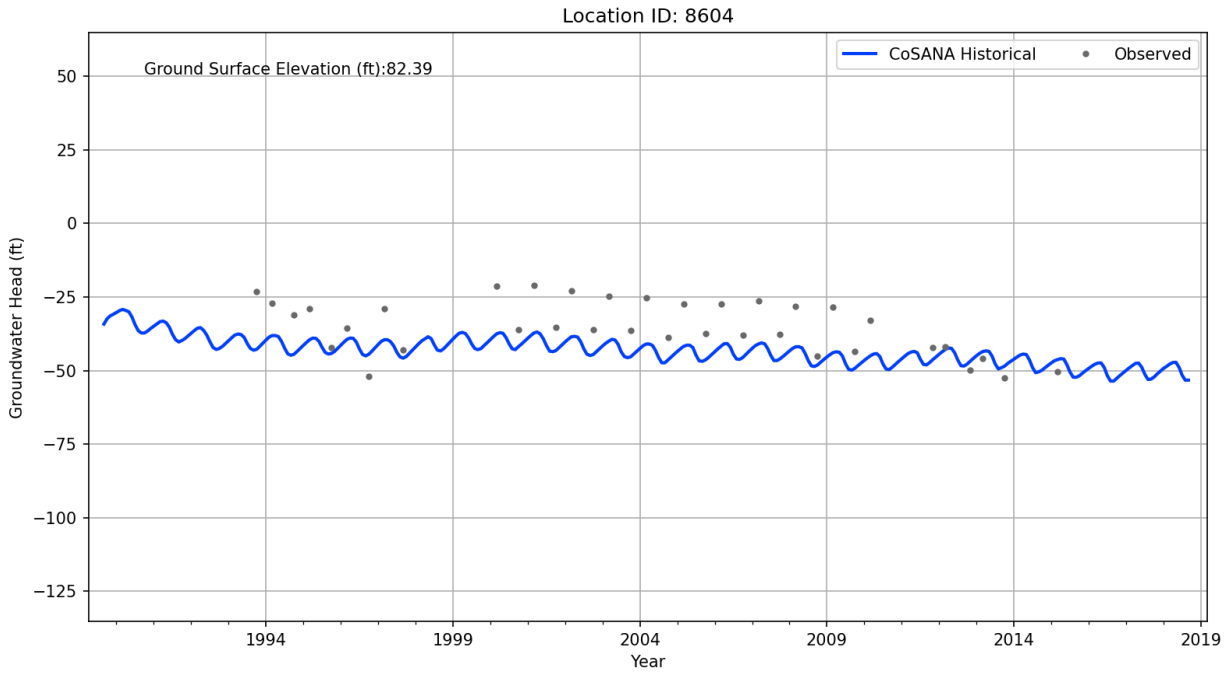

Location ID: 8504
Ground Surface Elevation (ft):290.18
CoSANA Historical
Observed
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

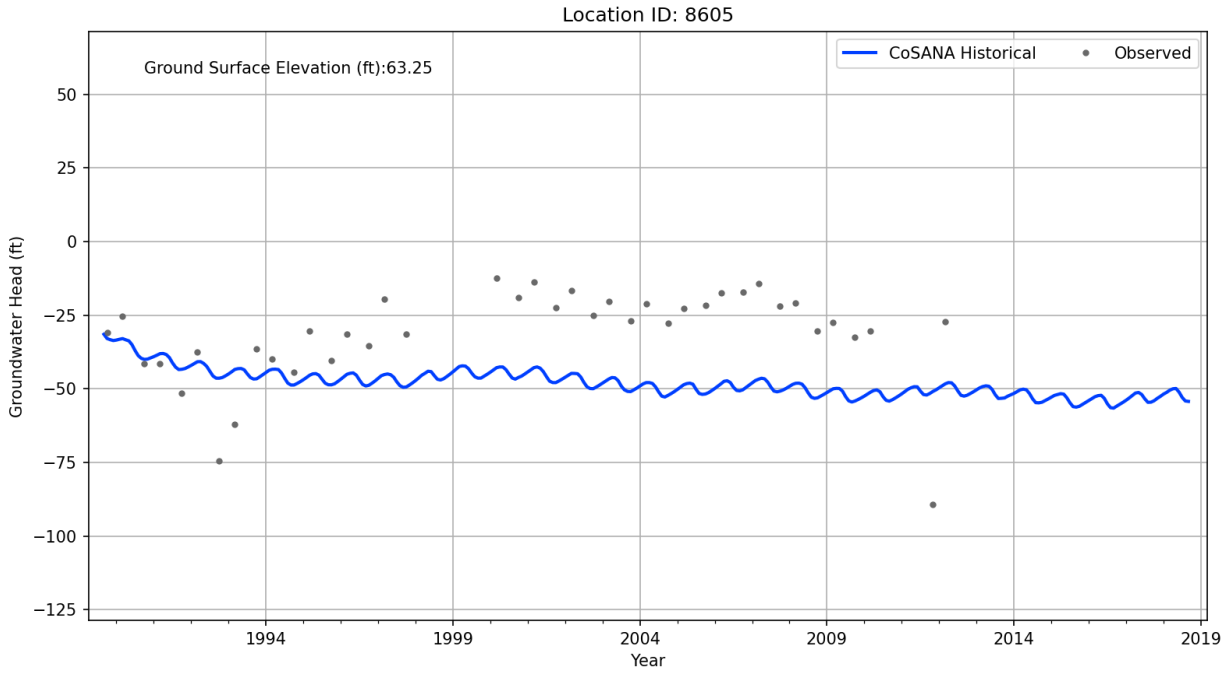

Location ID: 8505
Ground Surface Elevation (ft):275.28
CoSANA Historical
Observed
Groundwater Head (ft)
275
250
225
200
175
150
125
100
1994
1999
2004
2009
2014
2019
Year

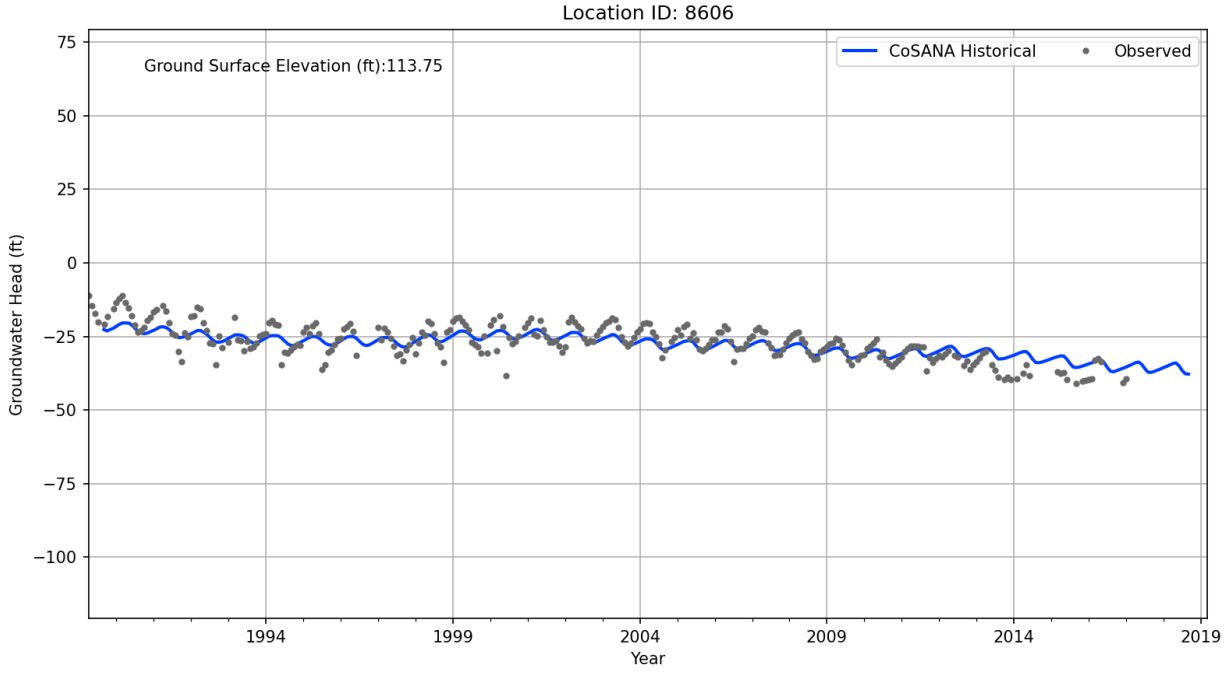

Location ID: 8601
Ground Surface Elevation (ft):55.0
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

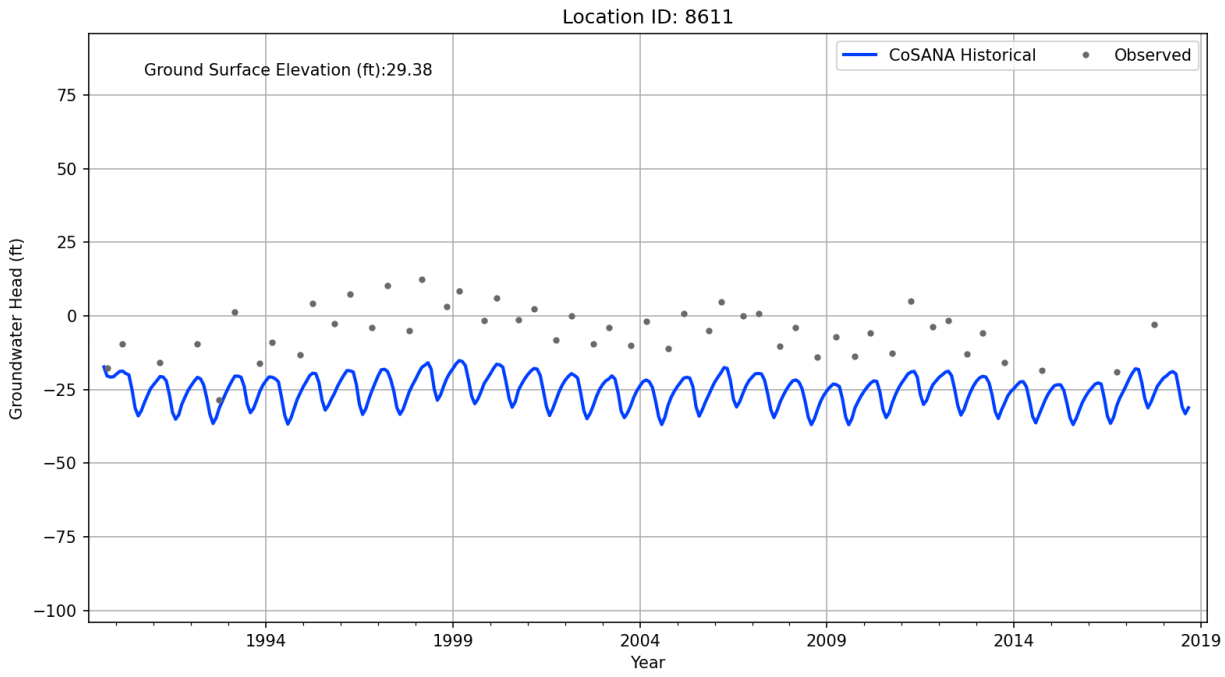

Location ID: 8602
Ground Surface Elevation (ft):119.42
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

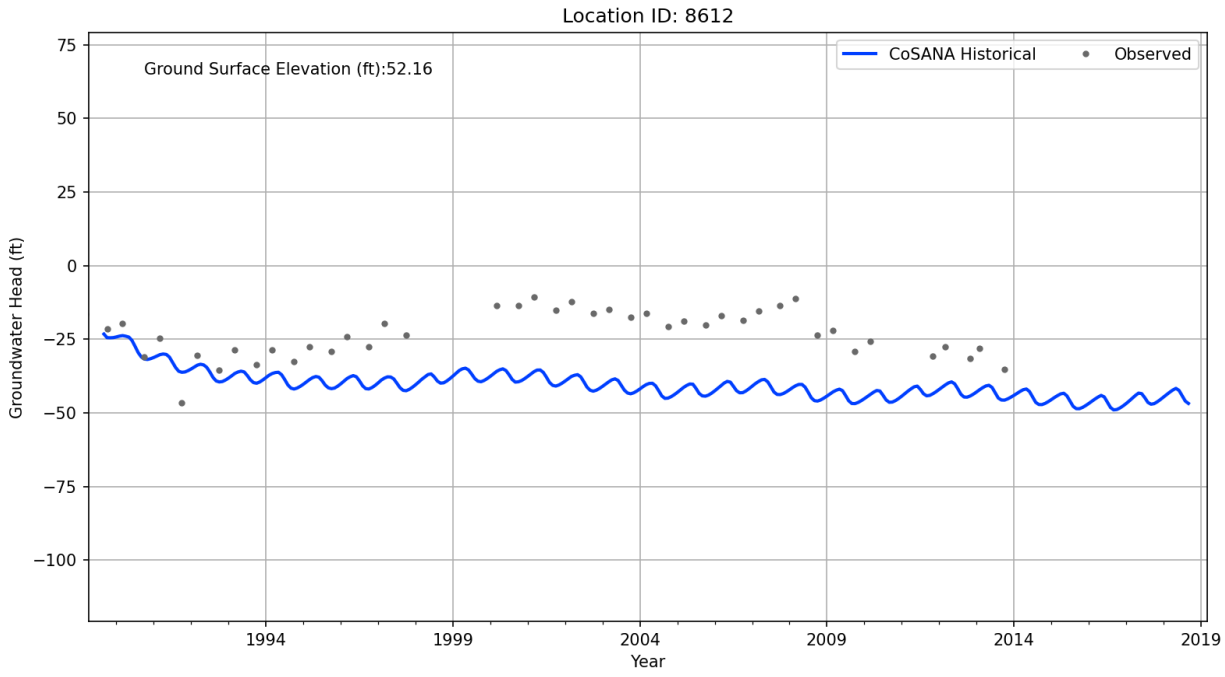

Location ID: 8603
Ground Surface Elevation (ft):68.53
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

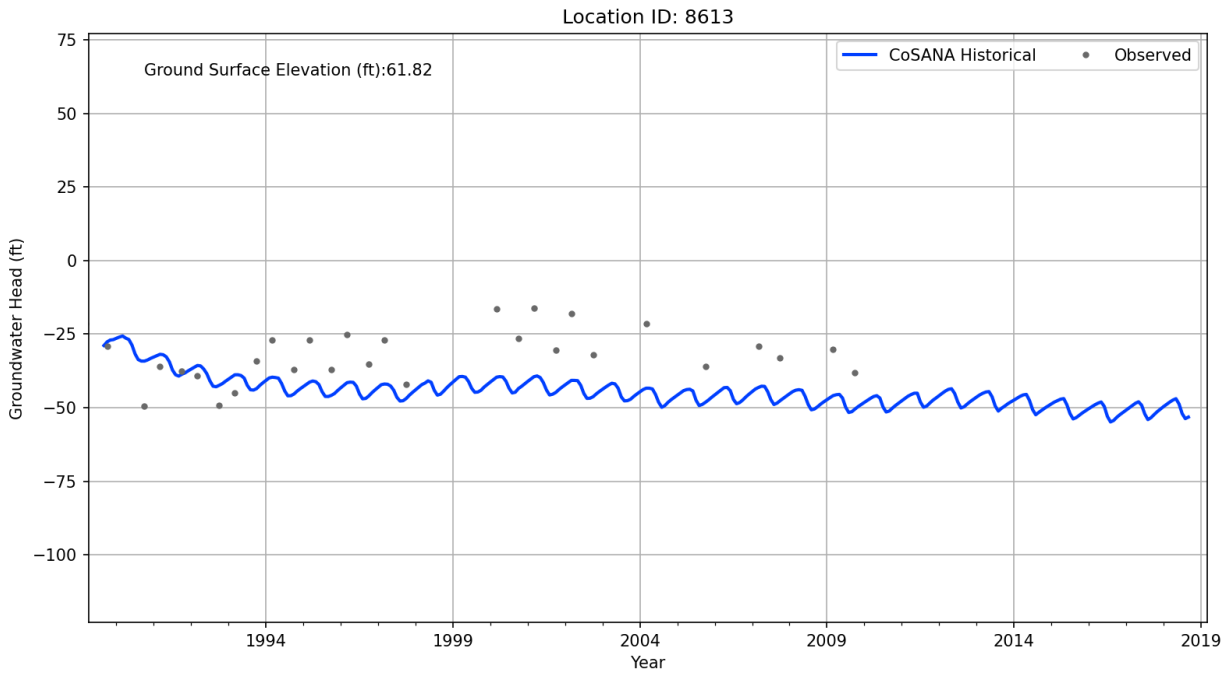

Location ID: 8604
Ground Surface Elevation (ft):82.39
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

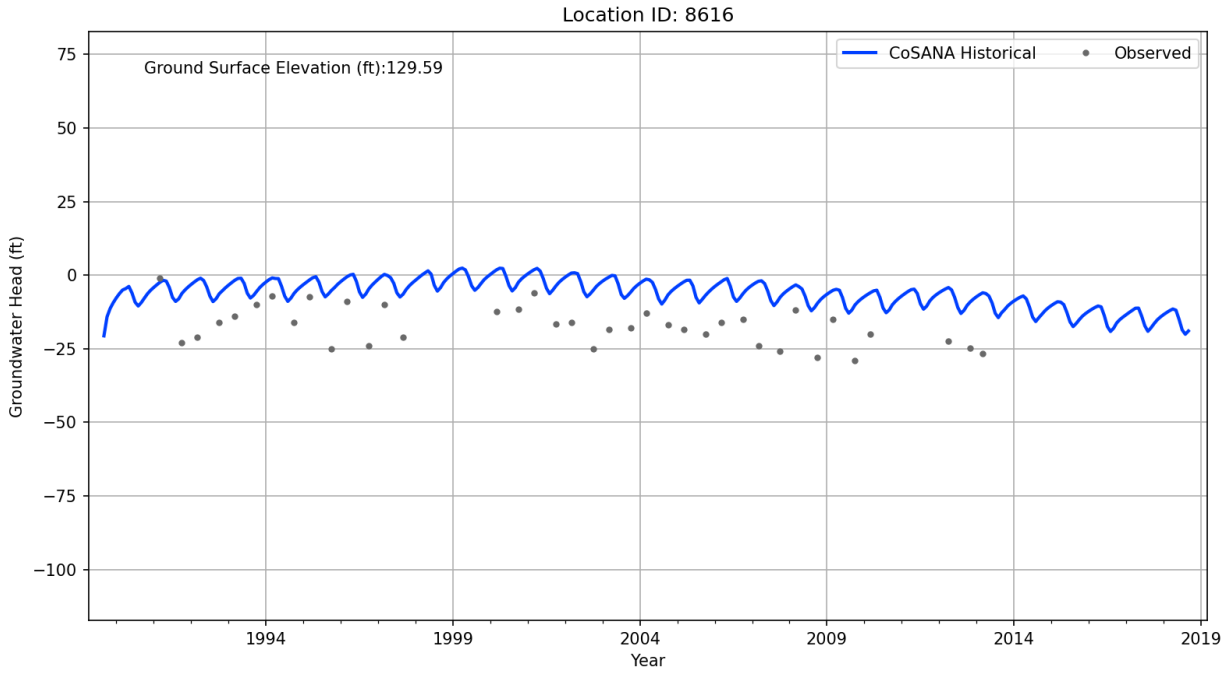

Location ID: 8605
Ground Surface Elevation (ft):63.25
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

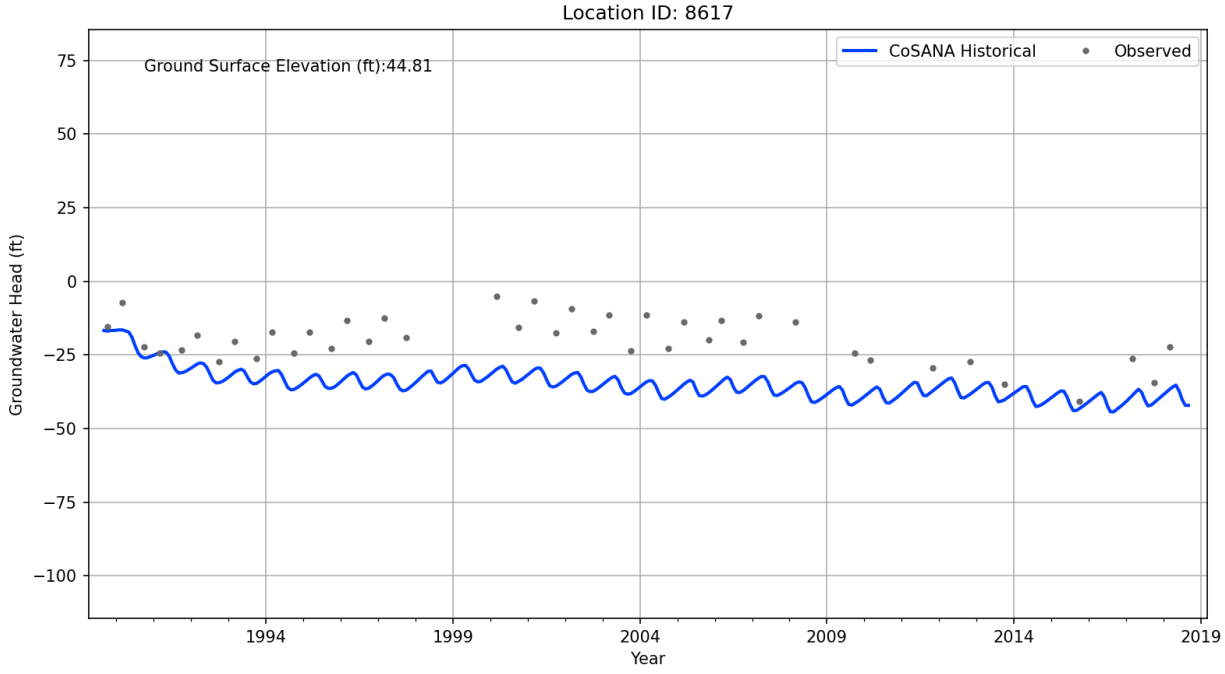

Location ID: 8606
Ground Surface Elevation (ft):113.75
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

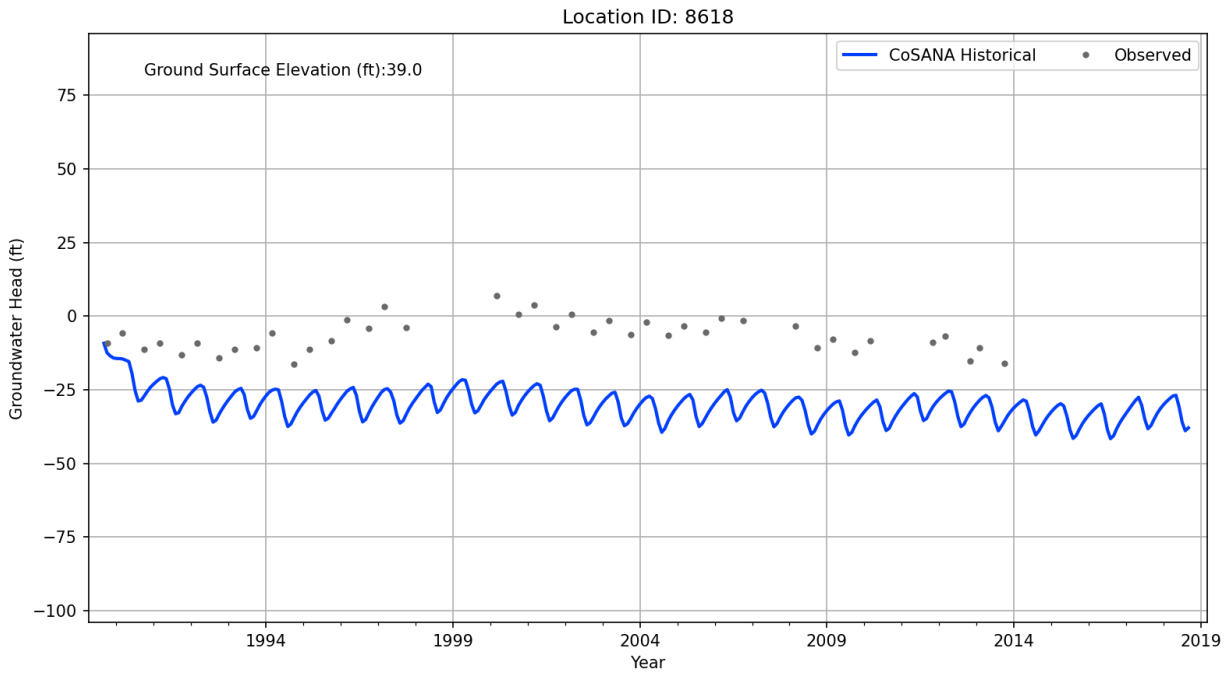

Location ID: 8611
Ground Surface Elevation (ft):29.38
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

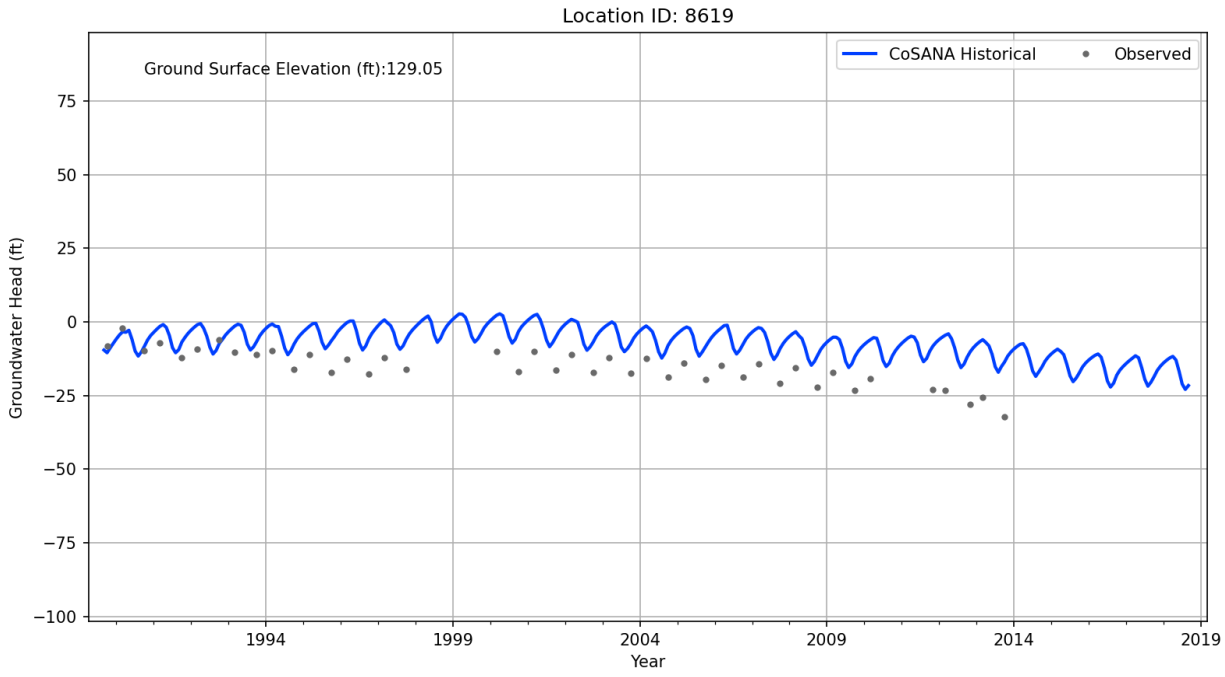

Location ID: 8612
Ground Surface Elevation (ft):52.16
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

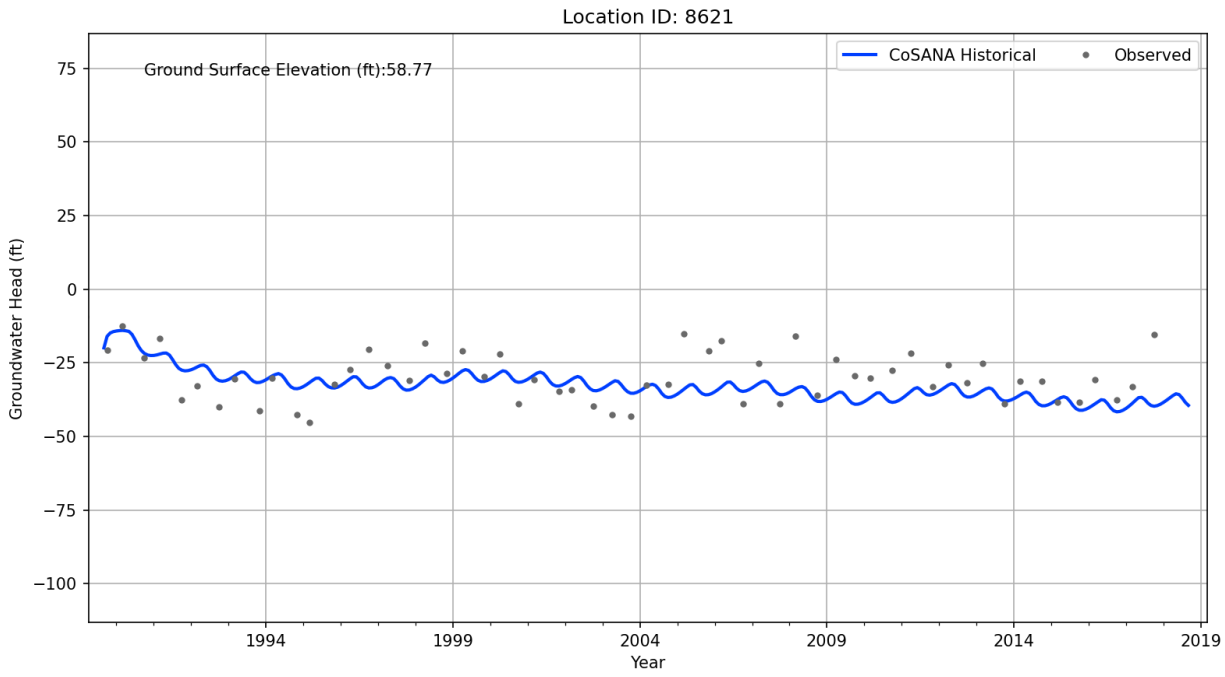

Location ID: 8613
Ground Surface Elevation (ft):61.82
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

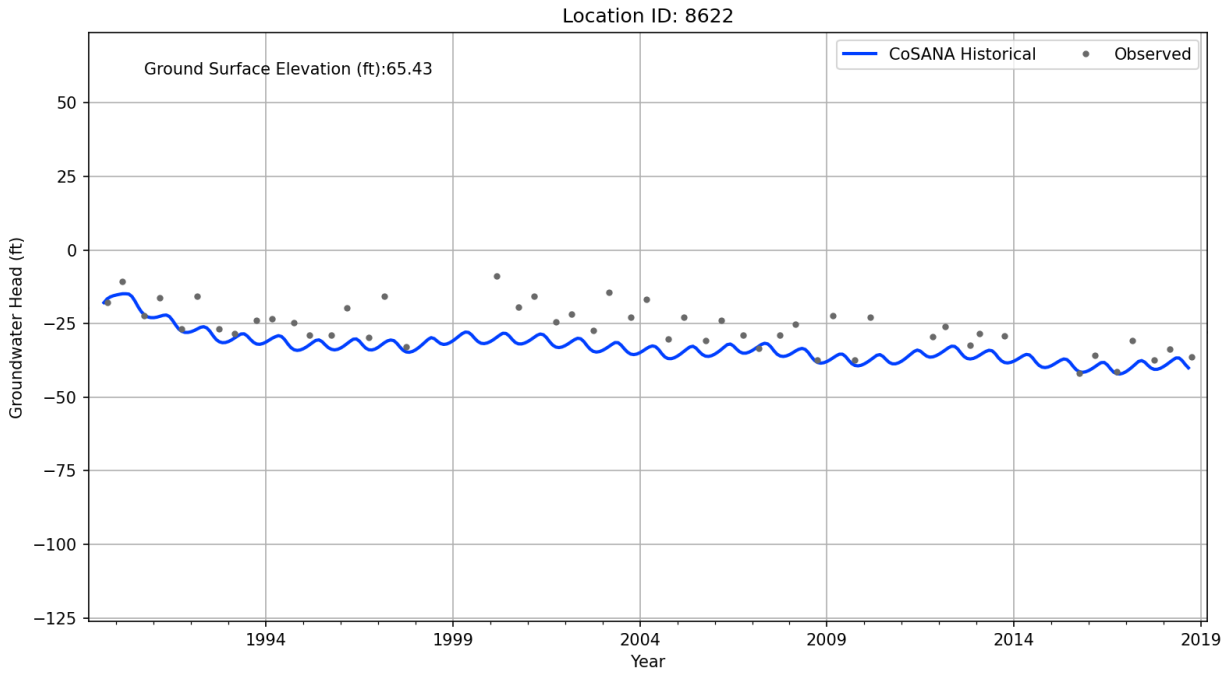

Location ID: 8616
Ground Surface Elevation (ft):129.59
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

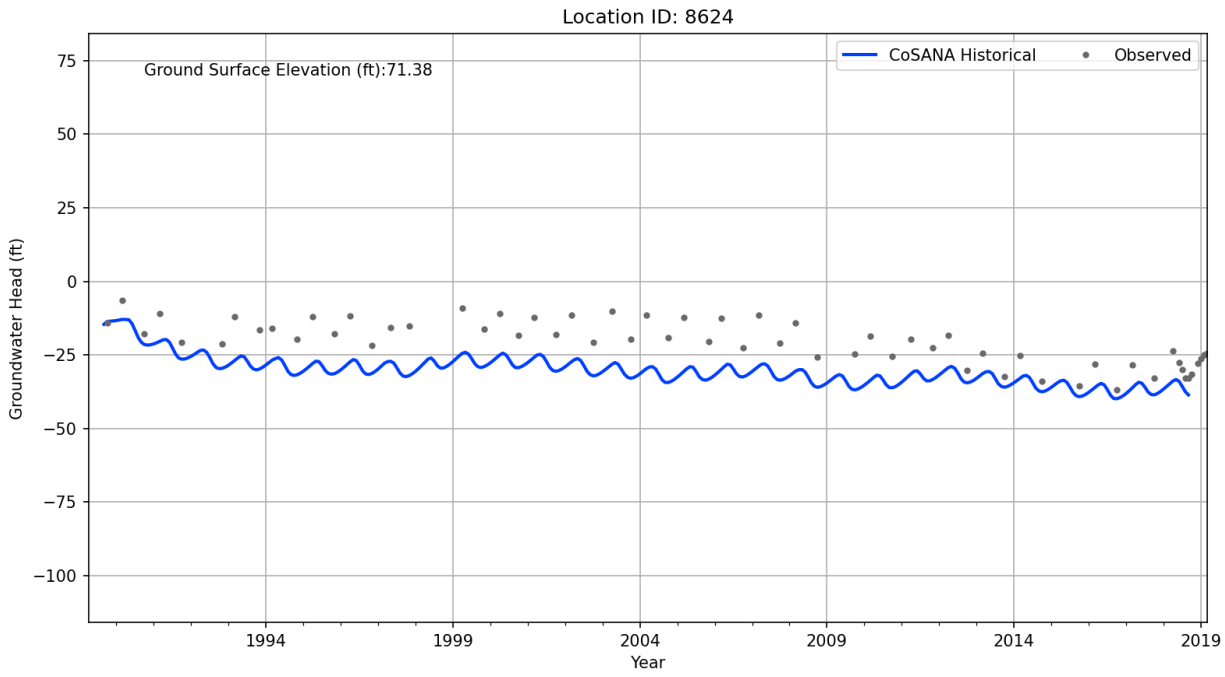

Location ID: 8617
Ground Surface Elevation (ft):44.81
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

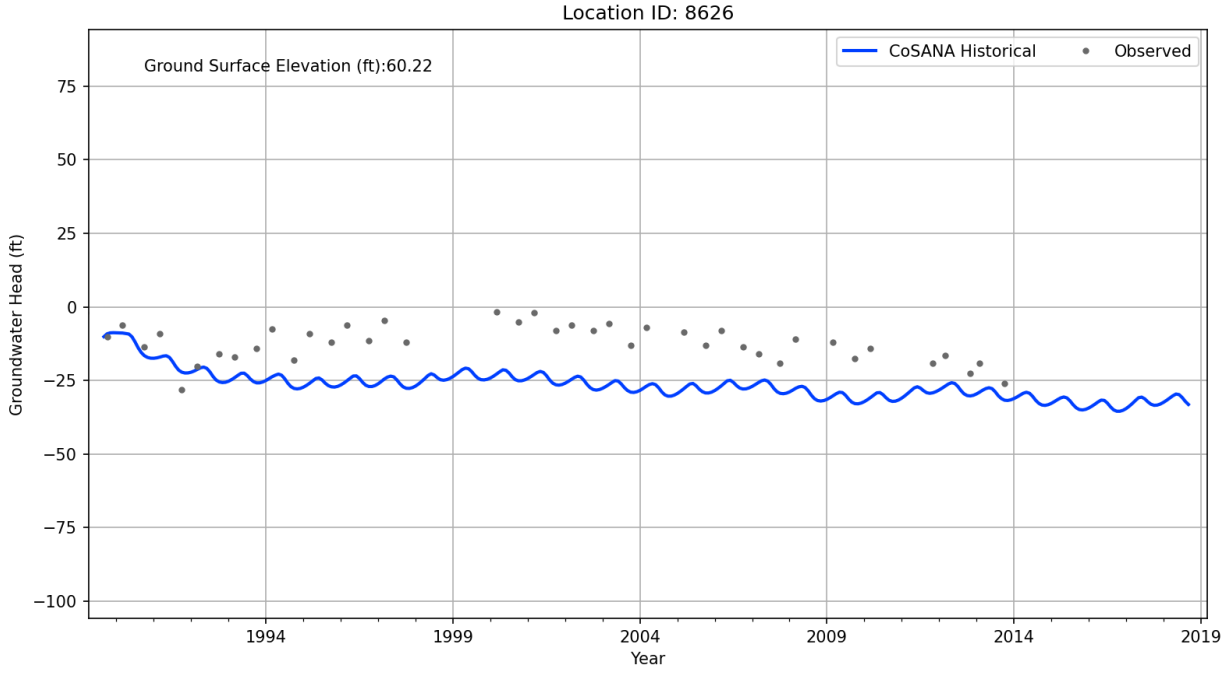

Location ID: 8618
Ground Surface Elevation (ft):39.0
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

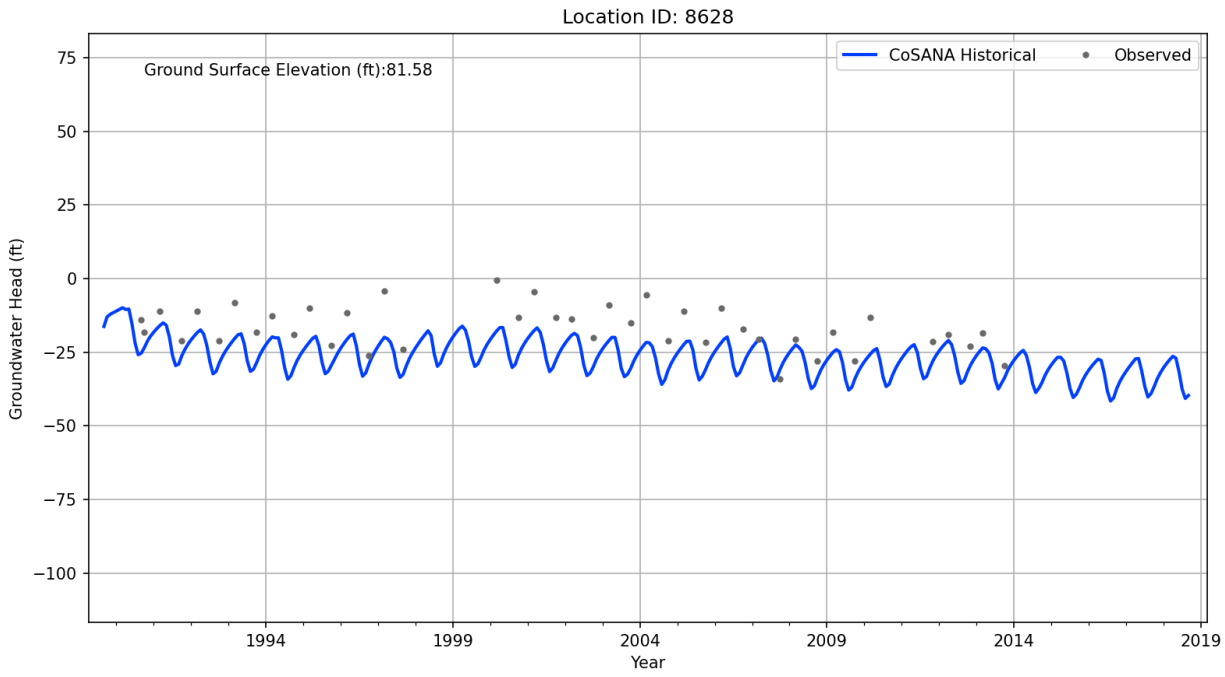

Location ID: 8619
Ground Surface Elevation (ft):129.05
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

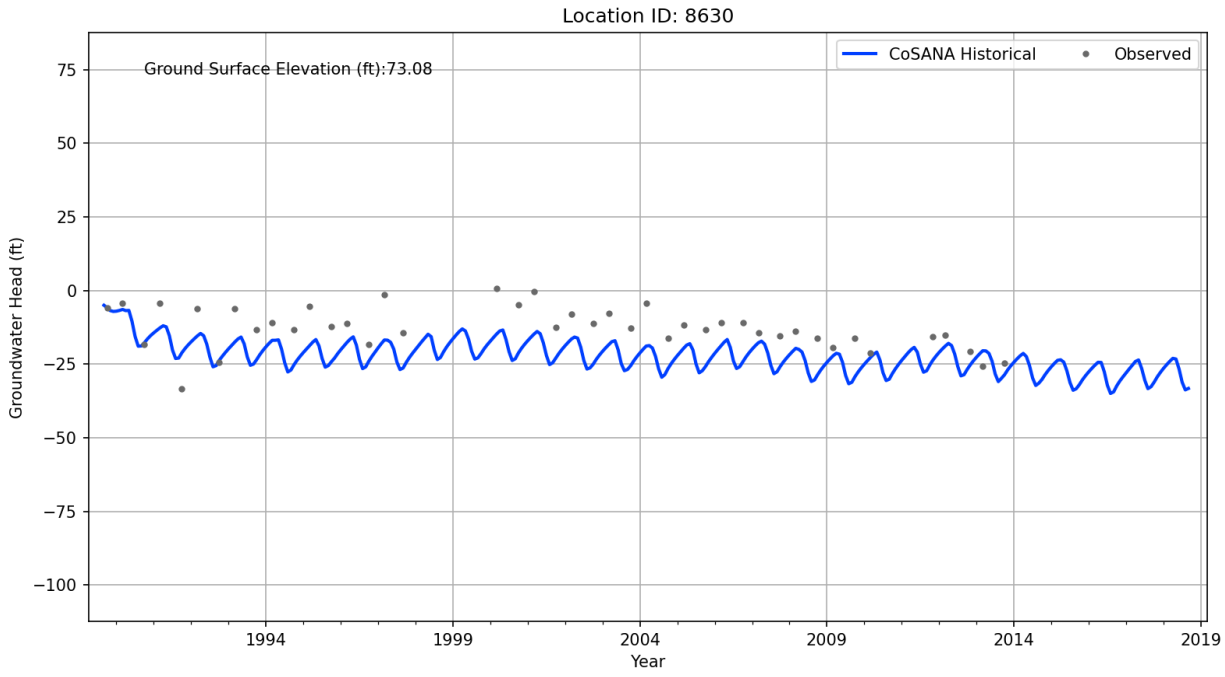

Location ID: 8621
Ground Surface Elevation (ft):58.77
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

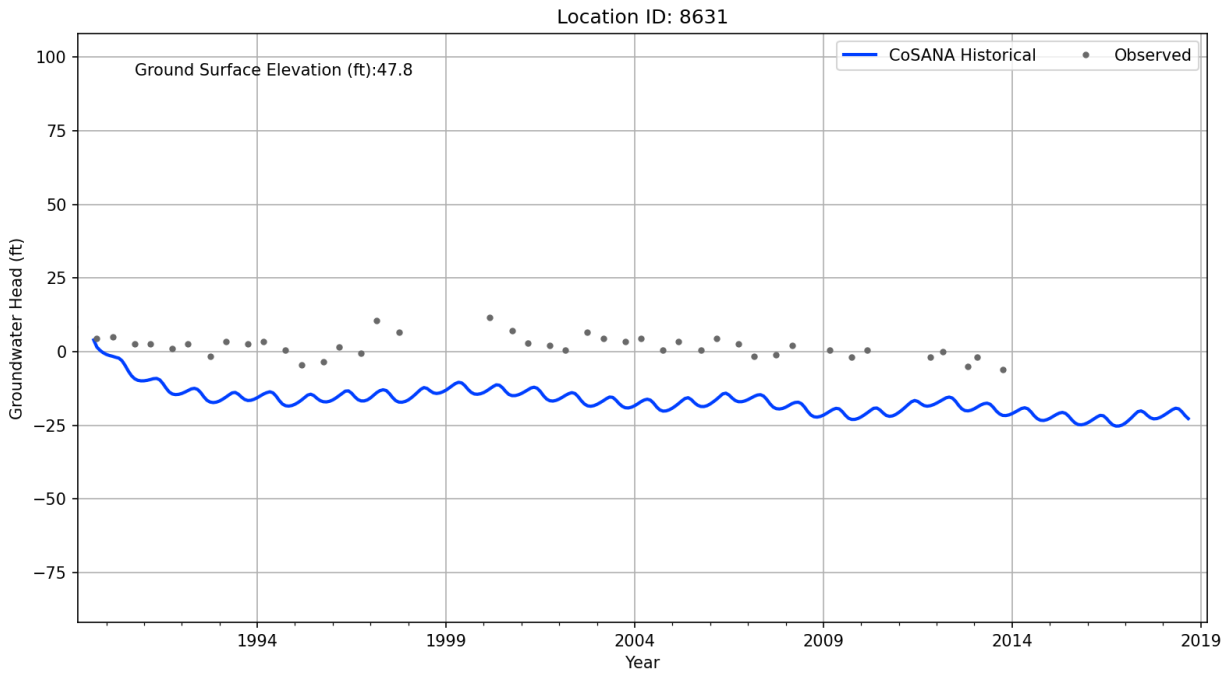

Location ID: 8622
Ground Surface Elevation (ft):65.43
CoSANA Historical
Observed
Groundwater Head (ft)
50
25
0
−25
−50
−75
−100
−125
1994
1999
2004
2009
2014
2019
Year

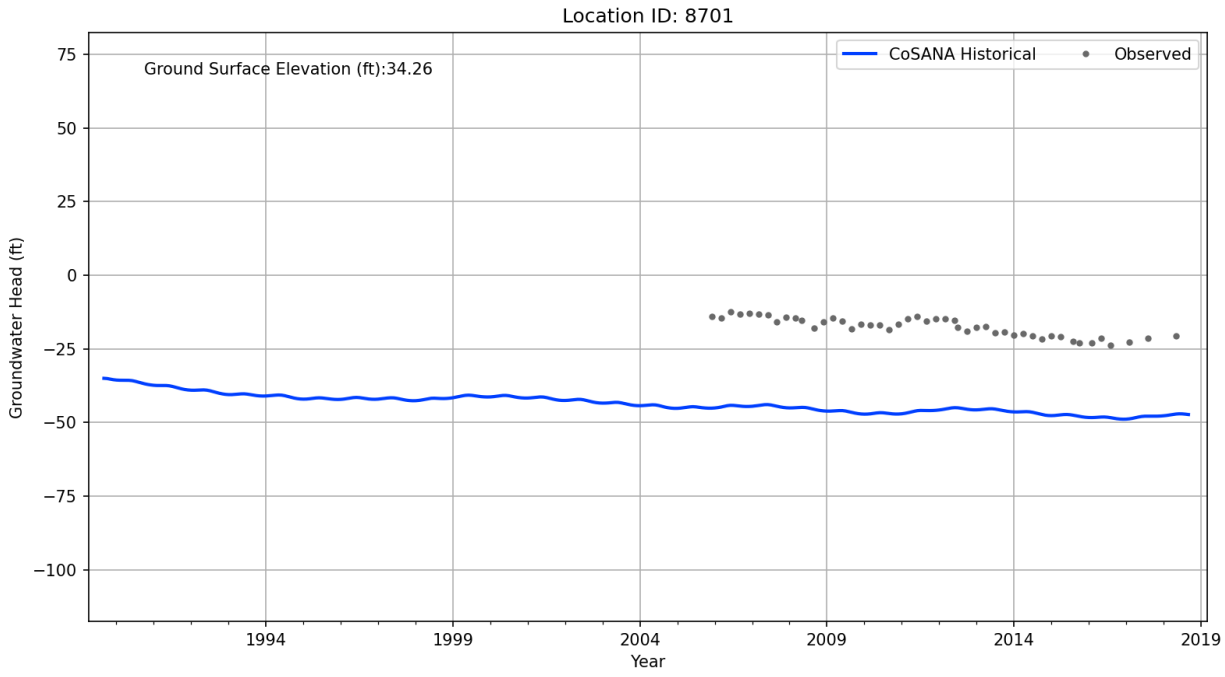

Location ID: 8624
Ground Surface Elevation (ft):71.38
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

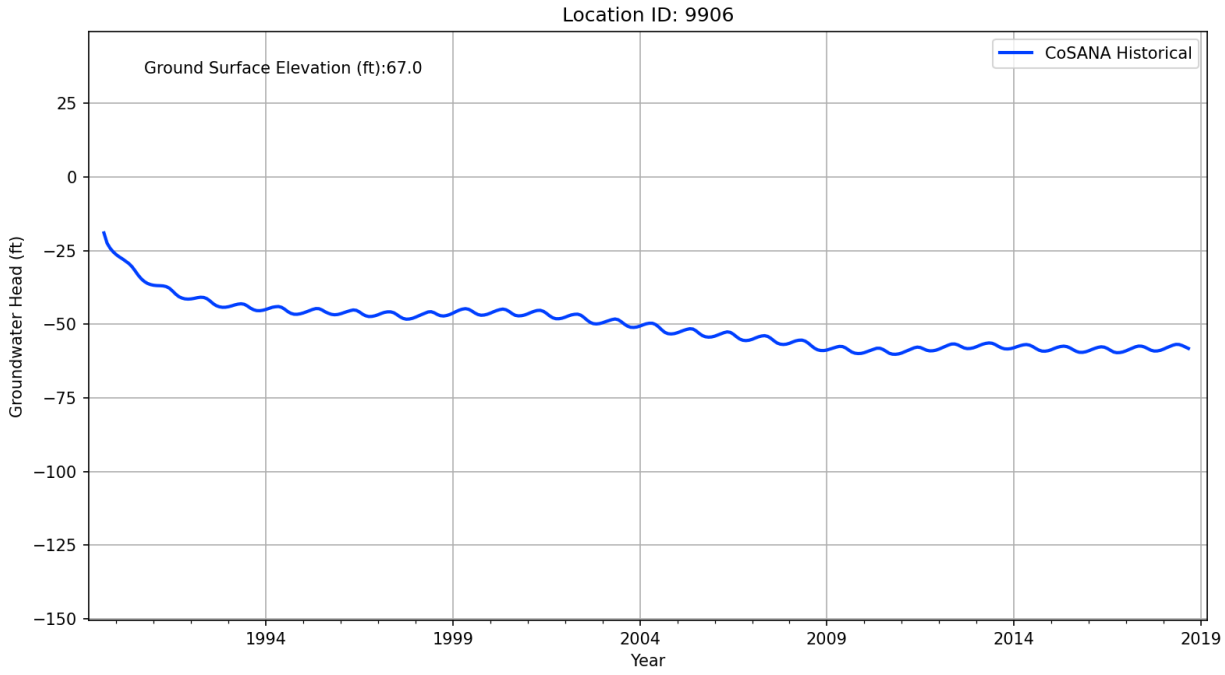

Location ID: 8626
Ground Surface Elevation (ft):60.22
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

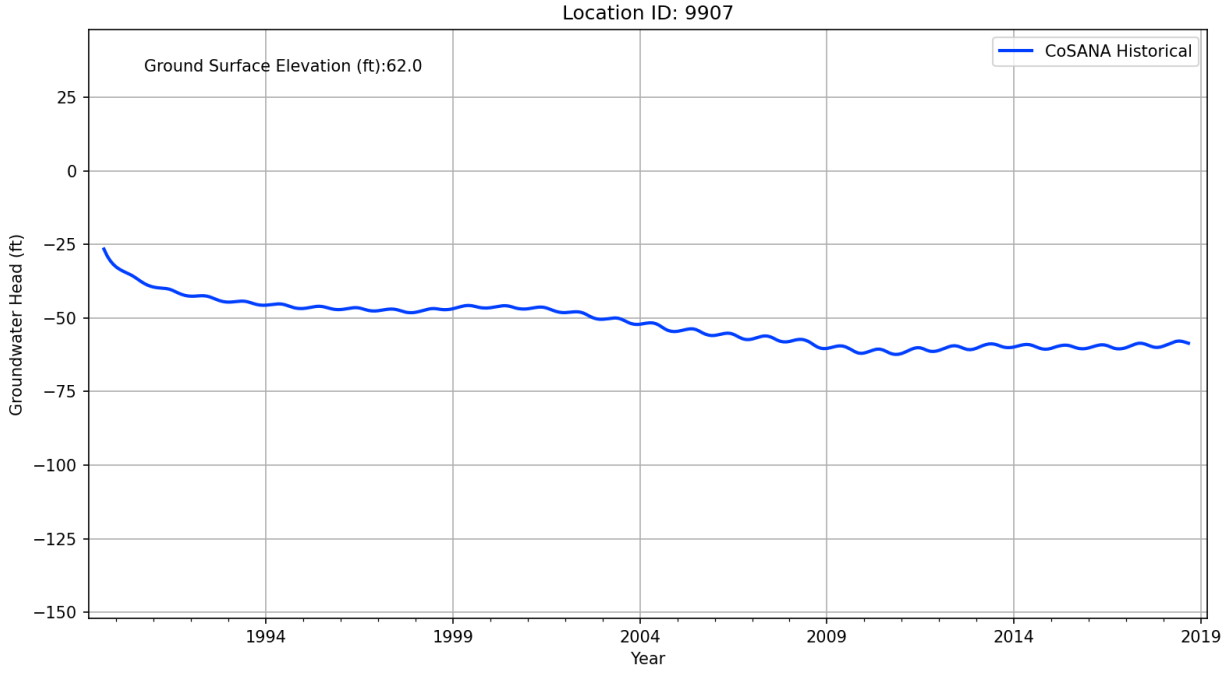

Location ID: 8628
Ground Surface Elevation (ft):81.58
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 8630
Ground Surface Elevation (ft):73.08
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 8631
Ground Surface Elevation (ft):47.8
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 8701
Ground Surface Elevation (ft):34.26
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 9906
Ground Surface Elevation (ft):67.0
CoSANA Historical
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year


Location ID: 9907
Ground Surface Elevation (ft):62.0
CoSANA Historical
Groundwater Head (ft)
25
0
−25
−50
−75
−100
−125
−150
1994
1999
2004
2009
2014
2019
Year

APPENDIX G: BASELINE CONDITIONS DEMAND AND SUPPLY TABLES

CalAm Antelope

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	4,282	4,556	4,950	4,629	5,225	5,225	5,225	5,225
Groundwater	3,728	3,907	4,944	4,251	4,025	4,025	5,225	4,481
Surface Water	554	648	6	378	1,200	1,200	0	744
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	4,282	4,556	4,950	4,629	5,225	5,225	5,225	5,225

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Arden

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,421	1,459	1,509	1,467	1,606	1,606	1,606	1,606
Groundwater	1,408	1,459	1,509	1,464	1,123	1,123	1,123	1,123
Surface Water	13	0	0	4	483	483	483	483
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	1,421	1,459	1,509	1,467	1,606	1,606	1,606	1,606

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Fruitridge Vista

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	4,244	4,055	4,142	4,141	6,609	6,609	6,609	6,609
Groundwater	4,238	4,054	4,141	4,139	6,609	6,609	6,609	6,609
Surface Water	6	1	0	2	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	4,244	4,055	4,142	4,141	6,609	6,609	6,609	6,609

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Lincoln Oaks

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	6,826	6,395	7,770	7,038	6,213	6,213	6,213	6,213
Groundwater	6,131	5,504	7,766	6,539	5,413	5,413	6,213	5,717
Surface Water	695	891	4	499	800	800	0	496
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	6,826	6,395	7,770	7,038	6,213	6,213	6,213	6,213

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Parkway

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	9,266	8,629	9,538	9,153	16,604	16,604	16,604	16,604
Groundwater	8,821	8,148	8,979	8,652	14,430	14,430	14,430	14,430
Surface Water	445	482	560	501	2,174	2,174	2,174	2,174
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	9,266	8,629	9,538	9,153	16,604	16,604	16,604	16,604

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Security Park

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	10	7	15	11	97	97	97	97
Groundwater	9	7	15	11	0	0	15	6
Surface Water	1	0	0	0	97	97	82	91
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	10	7	15	11	97	97	97	97

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm Suburban Rosemont

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	8,278	7,958	9,616	8,678	13,227	13,227	13,227	13,227
Groundwater	8,139	7,936	9,255	8,494	11,053	11,053	11,053	11,053
Surface Water	139	22	360	183	2,174	2,174	2,174	2,174
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	8,278	7,958	9,616	8,678	13,227	13,227	13,227	13,227

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

CalAm West Placer

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,059	1,011	1,042	1,036	6,819	6,819	6,819	6,819
Groundwater	0	0	0	0	0	0	0	0
Surface Water	1,059	1,011	1,042	1,036	6,819	6,819	6,819	6,819
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	1,059	1,011	1,042	1,036	6,819	6,819	6,819	6,819

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Camanche Village (ACWA)

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	293	296	286	292	1,415	1,415	1,483	1,441
Groundwater	293	296	286	292	420	420	420	420
Surface Water	0	0	0	0	681	681	749	707
Recycled Water/ Remediated Water	0	0	0	0	314	314	314	314
Total Supply	293	296	286	292	1,415	1,415	1,483	1,441

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Carmichael WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	8,984	8,871	9,311	9,070	10,334	10,334	10,851	10,530
Groundwater	1,919	1,977	2,403	2,123	2,207	2,303	2,801	2,465
Surface Water	7,065	6,894	6,908	6,947	8,127	8,031	8,050	8,065
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	8,984	8,871	9,311	9,070	10,334	10,334	10,851	10,530

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Citrus Heights WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	12,370	12,130	13,083	12,559	18,210	18,210	15,478	17,172
Groundwater	1,179	748	1,126	1,012	900	900	900	900
Surface Water	11,191	11,382	11,957	11,547	17,310	17,310	14,578	16,272
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	12,370	12,130	13,083	12,559	18,210	18,210	15,478	17,172

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Del Paso Manor WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,300	1,334	1,361	1,335	1,214	1,214	1,214	1,214
Groundwater	1,300	1,334	1,361	1,335	1,214	1,214	1,214	1,214
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	1,300	1,334	1,361	1,335	1,214	1,214	1,214	1,214

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Elk Grove Water District

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	9,080	8,744	9,388	9,083	8,081	8,081	8,323	8,173
Groundwater	4,305	4,158	4,625	4,376	4,598	4,598	4,736	4,650
Surface Water	4,775	4,586	4,764	4,707	3,483	3,483	3,587	3,523
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	9,080	8,744	9,388	9,083	8,081	8,081	8,323	8,173

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Elk Grove Water District surface water supply shown is from SCWA supplied intertie. These volumes may include a mix of sources (groundwater, surface water, and recycled water) that are unknown. For the purposes of this table, these volumes are all shown as surface water.

Fair Oaks WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	10,518	10,322	10,676	10,511	12,726	12,726	12,726	12,726
Groundwater	1,983	2,222	1,416	1,849	2,399	2,399	1,688	2,129
Surface Water	8,535	8,100	9,260	8,663	10,327	10,327	11,038	10,597
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	10,518	10,322	10,676	10,511	12,726	12,726	12,726	12,726

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Florin County WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645
Groundwater	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Folsom, City of

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	21,235	21,329	20,445	20,967	29,923	29,923	30,819	30,263
Groundwater	0	0	0	0	0	0	0	0
Surface Water	21,235	21,329	20,445	20,967	29,923	29,923	30,819	30,263
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	21,235	21,329	20,445	20,967	29,923	29,923	30,819	30,263

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Galt, City of

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	4,841	4,286	5,452	4,884	8,266	8,266	8,266	8,266
Groundwater	4,841	4,286	5,452	4,884	7,663	7,663	7,663	7,663
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	603	603	603	603
Total Supply	4,841	4,286	5,452	4,884	8,266	8,266	8,266	8,266

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Grandpark

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	0	0	0	0	12,030	12,030	12,030	12,030
Groundwater	0	0	0	0	2,407	2,407	3,007	2,635
Surface Water	0	0	0	0	9,623	9,623	9,023	9,395
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	0	0	0	0	8,021	8,021	8,021	8,021

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Golden State WC Arden

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	942	937	1,016	968	942	937	1,016	968
Groundwater	942	937	1,016	968	942	937	1,016	968
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	942	937	1,016	968	942	937	1,016	968

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Golden State WC Cordova

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	14,780	16,099	14,162	14,994	19,752	19,752	19,752	19,752
Groundwater	5,499	4,762	5,210	5,139	9,752	9,752	9,752	9,752
Surface Water	9,281	11,337	8,952	9,855	5,000	5,000	5,000	5,000
Recycled Water/ Remediated Water	0	0	0	0	5,000	5,000	5,000	5,000
Total Supply	14,780	16,099	14,162	14,994	19,752	19,752	19,752	19,752

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Projected remediated water includes groundwater previously pumped for remediation activities.

Ione, City of (ACWA)

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	2,434	2,448	2,256	2,371	11,744	11,744	11,676	11,718
Groundwater	0	0	0	0	0	0	0	0
Surface Water	2,434	2,448	2,256	2,371	10,794	10,794	10,726	10,768
Recycled Water/ Remediated Water	0	0	0	0	950	950	950	950
Total Supply	2,434	2,448	2,256	2,371	11,744	11,744	11,676	11,718

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Lincoln, City of

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	9,314	9,094	9,470	9,298	20,336	20,336	20,947	20,568
Groundwater	1,136	1,607	864	1,193	3,297	3,297	3,297	3,297
Surface Water	8,177	7,487	8,606	8,105	10,972	10,972	11,584	11,205
Recycled Water/ Remediated Water	0	0	0	0	6,063	6,063	6,063	6,063
Total Supply	9,314	9,094	9,470	9,298	20,332	20,332	20,944	20,565

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Orange Vale WC

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	4,075	3,905	4,217	4,071	4,981	4,981	4,234	4,697
Groundwater	0	0	0	0	0	0	0	0
Surface Water	4,075	3,905	4,217	4,071	4,981	4,981	4,234	4,697
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	4,075	3,905	4,217	4,071	4,981	4,981	4,234	4,697

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

PCWA (Regional Univ. and Placer Ranch)

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	0	0	0	0	6,805	6,805	6,805	6,805
Groundwater	0	0	0	0	0	0	0	0
Surface Water	0	0	0	0	6,805	6,805	6,805	6,805
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	0	0	0	0	6,805	6,805	6,805	6,805

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Placer County WA (Rocklin)

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	4,774	4,706	4,521	4,655	8,841	8,749	8,496	8,679
Groundwater	0	0	0	0	0	0	0	0
Surface Water	4,774	4,706	4,521	4,655	8,841	8,749	8,496	8,679
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	4,774	4,706	4,521	4,655	8,841	8,749	8,496	8,679

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Rancho Murietta CSD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,833	1,833	1,833	1,833	3,477	3,477	3,477	3,477
Groundwater	0	0	0	0	0	0	0	0
Surface Water	1,833	1,833	1,833	1,833	2,927	2,927	2,927	2,927
Recycled Water/ Remediated Water	0	0	0	0	550	550	550	550
Total Supply	1,833	1,833	1,833	1,833	3,477	3,477	3,477	3,477

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Rio Linda Elverta CWD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	2,563	2,489	2,672	2,579	7,462	7,462	8,208	7,745
Groundwater	2,562	2,489	2,670	2,578	7,462	7,462	8,208	7,745
Surface Water	1	0	2	1	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	2,563	2,489	2,672	2,579	7,462	7,462	8,208	7,745

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Roseville, City of

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	28,834	28,177	30,779	29,349	65,615	65,615	52,666	60,694
Groundwater	9	2	7	6	25	25	4,734	1,814
Surface Water	28,826	28,174	30,771	29,344	59,632	59,632	41,974	52,922
Recycled Water/ Remediated Water	0	0	0	0	5,958	5,958	5,958	5,958
Total Supply	28,834	28,177	30,779	29,349	65,615	65,615	52,666	60,694

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Sacramento International Airport

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,138	1,133	1,133	1,134	1,144	1,144	1,144	1,144
Groundwater	763	785	877	814	673	673	673	673
Surface Water	376	348	255	320	471	471	471	471
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	1,138	1,133	1,133	1,134	1,144	1,144	1,144	1,144

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Sacramento, City of

Values shown in acre-feet/year

	Current *						Projected **					
Year Type	**Normal**	**Wet**	**Dry**	**Drier-Critical**	**Driest**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**Drier-Critical**	**Driest**	**50-yr Average**
Total Demand	104,096	98,465	89,879	100,782	100,782	96,779	162,029	162,029	162,029	162,029	162,029	162,029
Groundwater	14,942	8,750	22,287	48,952	53,726	15,628	35,864	24,302	47,690	81,290	81,290	36,427
Surface Water	89,154	89,715	67,592	51,830	47,056	81,151	125,165	136,727	113,339	79,739	79,739	124,602
Recycled Water/ Remediated Water	0	0	0	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000
Total Supply	104,096	98,465	89,879	100,782	100,782	96,779	162,029	162,029	162,029	139,000	139,000	162,029

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

City of Sacramento has an estimated 2,200 AFY of additional pumping from irrigation wells that provide water to parks, schools, etc.

Sac Suburban

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	35,262	37,206	35,990	36,200	41,304	41,304	41,304	41,304
Groundwater	23,586	22,005	33,212	26,706	27,627	24,428	35,000	29,341
Surface Water	11,676	15,202	2,779	9,494	13,677	16,876	6,304	11,963
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	35,262	37,206	35,990	36,200	41,304	41,304	41,304	41,304

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

San Juan WD

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	12,437	11,631	12,509	12,190	19,393	19,393	19,393	19,393
Groundwater	0	0	0	0	0	0	0	0
Surface Water	12,437	11,631	12,509	12,190	19,393	19,393	19,393	19,393
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	12,437	11,631	12,509	12,190	19,393	19,393	19,393	19,393

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

SCWA Arden

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	3,402	3,349	3,402	3,384	3,217	3,217	3,217	3,217
Groundwater	3,402	3,349	3,402	3,384	3,217	3,217	3,217	3,217
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	3,402	3,349	3,402	3,384	3,217	3,217	3,217	3,217

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

SCWA Hood

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	82	75	82	79	31	31	31	31
Groundwater	82	75	82	79	31	31	31	31
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	82	75	82	79	31	31	31	31

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

SCWA Laguna Vineyard

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	24,331	24,734	24,343	24,473	68,900	68,900	68,900	68,900
Groundwater	13,910	13,315	13,910	13,707	20,200	20,200	51,900	32,246
Surface Water	9,569	10,556	9,580	9,909	36,500	36,500	4,800	24,454
Recycled Water/ Remediated Water	853	863	853	856	12,200	12,200	12,200	12,200
Total Supply	24,331	24,734	24,343	24,473	68,900	68,900	68,900	68,900

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

SCWA remediated water is assumed to be split 25% to Mather service area and 75% to Laguna Vineyard service area

SCWA Mather

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	5,363	5,624	5,363	5,452	34,900	34,900	34,900	34,900
Groundwater	1,742	1,673	1,742	1,719	0	0	1,100	418
Surface Water	3,621	3,951	3,621	3,733	34,900	34,900	33,800	34,482
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	5,363	5,624	5,363	5,452	34,900	34,900	34,900	34,900

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

SCWA remediated water is assumed to be split 25% to Mather service area and 75% to Laguna Vineyard service area

SCWA Northgate

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	1,423	1,205	1,423	1,349	1,365	1,365	1,365	1,365
Groundwater	1,423	1,205	1,423	1,349	1,365	1,365	1,365	1,365
Surface Water	0	0	0	0	0	0	0	0
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	1,423	1,205	1,423	1,349	1,365	1,365	1,365	1,365

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

Sutter Pointe

Values shown in acre-feet/year

	Current *				Projected **			
Year Type	**Normal**	**Wet**	**Dry**	**50-yr Average**	**Normal**	**Wet**	**Dry**	**50-yr Average**
Total Demand	0	0	0	0	15,786	15,786	15,786	15,786
Groundwater	0	0	0	0	10,919	10,919	10,919	10,919
Surface Water	0	0	0	0	4,867	4,867	4,867	4,867
Recycled Water/ Remediated Water	0	0	0	0	0	0	0	0
Total Supply	0	0	0	0	15,786	15,786	15,786	15,786

Notes:

* Current Condition Baseline information for each hydrologic year type was extracted based on the last 10 years of historical operations or the current use and facilities when available. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

** Projected Condition Baseline information is based on latest planning documents for each purveyor (2015 UWMPs, GWMPs, Water Supply Master Plans etc.). Projected demands are assumed to account for each entity's conservation targets. 50-year average projection reflects 50-year hydrologic projected conditions based on the water supplies and demands for each respective hydrologic year type.

APPENDIX H: BASELINE CONDITIONS LAND AND WATER USE BUDGETS

Current Conditions Baseline Water Use Budget Summary, Annual Average over 50-year Simulation

Subregion	Description	Ag Area	Ag Demand	Ag Water Duty	Urban Area	Urban Demand	Urban Water Duty	Total Water Demand	Total Ag Water Supply (Acre-Feet/Year)		Total Urban Water Supply (Acre-Feet/Year)			Total Supply (Acre-Feet/Year)	Remediation Operations	
		(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acre-Feet)	GW Production	SW Deliveries	GW Use	SW Deliveries	Other Supply[2]		Extraction	Injection
1	Camp Far West ID	1,806	10,115	5.6	176	120	0.7	10,235	5,462	4,653	120	-	-	10,235	-	-
2	Sutter Co. 1	147	629	4.3	2	1	0.4	630	629	-	1	-	-	630	-	-
3	South Sutter WD GSA	51,339	183,798	3.6	2,094	2,044	1.0	185,842	109,495	76,260	2,044	-	-	187,799	-	-
4	Placer County WA[1]	10,653	29,617	2.8	9,186	11,101	1.2	40,718	23,214	6,415	6,446	4,655	-	40,730	-	-
5	Nevada ID	3,180	12,719	4.0	581	394	0.7	13,113	8,387	4,489	394	-	-	13,271	-	-
6	Lincoln[1]	372	91	0.2	6,577	9,298	1.4	9,390	91	-	1,193	8,106	-	9,390	-	-
7	RD1001 [1]	7,436	30,324	4.1	416	164	0.4	30,488	20,759	9,565	164	-	-	30,488	-	-
8	Pleasant Grove Verona MWC	6,667	23,324	3.5	101	40	0.4	23,364	12,521	11,216	40	-	-	23,777	-	-
9	Sutter Co. 2	904	3,238	3.6	88	35	0.4	3,272	2,063	1,175	35	-	-	3,272	-	-
10	Natomas MWC (Sutter Co.)	11,136	41,377	3.7	442	175	0.4	41,552	2,113	39,267	175	-	-	41,555	-	-
11	Sutter Co. 3	2,991	9,780	3.3	456	343	0.8	10,123	9,780	-	343	-	-	10,123	-	-
12	Roseville SOI	904	1,040	1.2	46	180	3.9	1,220	1,040	-	180	-	-	1,220	-	-
13	City of Roseville	512	202	0.4	20,005	29,349	1.5	29,551	202	-	6	29,344	-	29,552	-	-
14	Cal Am (West Placer)	2,211	4,122	1.9	2,514	1,037	0.4	5,158	4,122	-	-	1,037	-	5,158	-	-
15	Natomas MWC (Sacramento Co.)	11,732	37,038	3.2	1,882	3,562	1.9	40,600	2,168	34,874	3,562	-	-	40,604	-	-
16	Sacramento International Airport	526	130	0.2	1,669	1,134	0.7	1,264	130	-	814	321	-	1,264	-	-
17	Metro Air Park	1,578	-	0.0	71	-	0.0	-	-	-	-	-	-	-	-	-
18	Sac Co. 1	832	1,096	1.3	165	606	3.7	1,702	43	1,052	606	-	-	1,702	-	-
19	Sac Co. 2	803	2,086	2.6	194	21	0.1	2,107	2,086	-	21	-	-	2,107	-	-
20	Sac County WA (Northgate 880)	-	-	0.0	837	1,349	1.6	1,349	-	-	1,349	-	-	1,349	-	-
21	Rio Linda Elverta	515	801	1.6	6,094	8,590	1.4	9,391	801	-	8,589	1	-	9,391	-	-
22	Sac Co. 3	335	167	0.5	227	345	1.5	512	167	-	345	-	-	512	-	-
23	Cal Am (Antelope)	3	7	2.3	2,679	4,629	1.7	4,636	7	-	4,251	378	-	4,636	-	-
24	Cal Am (Lincoln Oaks)	9	20	2.3	4,285	7,038	1.6	7,058	20	-	6,539	499	-	7,058	-	-
25	Citrus Heights WD	12	50	4.3	7,744	12,559	1.6	12,609	50	-	1,012	11,547	-	12,610	-	-
26	San Juan WD (Placer Co.)	82	-	0.0	1,409	1,808	1.3	1,808	-	-	-	1,808	-	1,808	-	-
27	San Juan WD (Sacramento Co.)	47	89	1.9	2,106	2,702	1.3	2,792	89	-	-	2,702	-	2,792	-	-
28	Orange Vale WC	50	278	5.5	2,900	4,071	1.4	4,349	278	-	-	4,071	-	4,349	-	-
29	Lake Natoma/Mississippi Bar	3	97	35.9	140	-	0.0	97	97	-	-	-	-	97	-	-
30	Fair Oaks WD	75	240	3.2	6,204	10,511	1.7	10,751	240	-	1,849	8,663	-	10,751	1,229	-
31	Carmichael WD	-	-	0.0	5,264	9,070	1.7	9,070	-	-	2,123	6,947	-	9,070	1,876	-
32	Sacramento Suburban WD (North)	25	56	2.2	13,845	21,660	1.6	21,716	56	-	14,242	7,418	-	21,717	2,300	-
33	Sacramento Suburuban WD (South)	-	-	0.0	7,773	14,540	1.9	14,540	-	-	12,464	2,076	-	14,540	-	-
34	Del Paso Manor WD	-	-	0.0	614	1,335	2.2	1,335	-	-	1,335	-	-	1,335	-	-
35	Golden State WC Arden	-	-	0.0	496	968	2.0	968	-	-	968	-	-	968	-	-
36	Cal Am (Arden)	-	-	0.0	641	1,467	2.3	1,467	-	-	1,464	4	-	1,467	-	-
37	Sac County WA (Arden Park	-	-	0.0	1,350	3,384	2.5	3,384	-	-	3,384	-	-	3,384	-	-
38	City of Sacramento (North)	1,258	200	0.2	19,767	35,728	1.8	35,928	200	-	7,261	28,467	-	35,928	110	-
	Total NASb	118,141	392,731	109	131,039	201,360	51	594,091	206,311	188,966	83,319	118,044	-	596,640	5,515	-
39	City of Sacramento (South)	262	130	0.5	36,584	66,122	1.8	66,253	45	86	13,438	52,684	-	66,252	-	-
40	Cal Am (Suburban Rosemont)	211	575	2.7	7,563	8,677	1.1	9,252	575	-	8,494	205	-	9,274	508	-
41	Sac Co. 4	5	25	4.7	23	-	0.0	25	25	-	-	-	-	25	-	-
42	Golden State WC (Cordova)	8	27	3.3	6,459	14,994	2.3	15,021	27	-	5,139	9,855	-	15,021	10,981	-
43	Sac Co. 5	-	-	0.0	286	3	0.0	3	-	-	-	3	-	3	6,245	-
44	City of Folsom[1]	103	50	0.5	11,146	20,967	1.9	21,017	34	-	-	20,967	-	21,001	2,443	-
45	Cal Am (Security Park)	-	-	0.0	218	11	0.1	11	-	-	11	0	-	11	233	-
46	Fruitridge Vista WC	-	-	0.0	1,894	4,141	2.2	4,141	-	-	4,302	2	-	4,304	-	-
47	Florin County WD	2	10	4.0	1,380	2,645	1.9	2,655	10	-	2,645	-	-	2,655	-	-
48	Cal Am (Parkway)	7	3	0.4	5,162	9,153	1.8	9,156	3	-	8,652	501	-	9,157	-	-
49	Sac Co. 6	183	493	2.7	1,127	49	0.0	542	137	357	49	-	-	542	-	-
50	Sac County WA (North/Central)	3,581	8,940	2.5	17,404	21,456	1.2	30,395	8,940	-	14,039	7,065	330	30,374	8,733	207
51	Sac County WA (South)	2,225	3,237	1.5	10,542	15,858	1.5	19,095	3,237	-	7,450	7,943	465	19,095	-	-
52	Elk Grove WD (2 - Intertie Service Area)	676	1,470	2.2	3,225	4,852	1.5	6,322	1,470	-	2,279	2,430	142	6,322	-	-
53	Elk Grove WD (1 - GW Service Area)	18	1	0.0	3,074	4,376	1.4	4,377	1	-	4,376	-	-	4,377	-	-
54	Cosumnes River West	17,598	49,046	2.8	2,597	6,220	2.4	55,266	44,813	4,233	6,220	-	-	55,266	-	-
55	RD744	1,240	2,400	1.9	146	64	0.4	2,464	605	1,795	64	-	-	2,464	-	-
56	Franklin Drainage District	2,654	9,111	3.4	344	189	0.5	9,299	3,442	5,670	134	55	-	9,300	-	-
57	RD813	2,053	4,826	2.4	166	90	0.5	4,916	1,361	3,466	65	24	-	4,916	-	-
58	RD755	354	1,515	4.3	39	17	0.4	1,532	502	1,012	17	-	-	1,532	-	-
59	RD1002	4,060	9,611	2.4	423	222	0.5	9,833	2,483	7,129	222	-	-	9,834	-	-
60	RD551	7,767	21,698	2.8	683	301	0.4	21,999	5,464	16,236	301	-	-	22,001	-	-
61	RD369	92	376	4.1	39	17	0.4	393	121	255	17	-	-	393	-	-
62	RD2110	1,358	1,649	1.2	97	43	0.4	1,692	281	1,368	43	-	-	1,693	-	-
63	Sac Co. 7	254	635	2.5	98	105	1.1	740	151	483	105	-	-	740	-	-
64	Rancho Murieta (North) [1]	368	676	1.8	1,189	1,342	1.1	2,018	435	248	111	1,231	-	2,026	-	-
65	Sloughouse RCD (North)	722	1,633	2.3	903	574	0.6	2,207	1,594	39	545	29	-	2,208	-	-
66	OHWD (Sth American Subbasin)	10,099	24,772	2.5	3,345	1,985	0.6	26,757	22,821	2,431	1,420	588	-	27,261	621	-
	Total SASb	55,900	142,907	59	116,154	184,473	28	327,380	98,577	44,808	80,139	103,584	938	328,046	29,765	207
67	OHWD (Cosumnes Subbasin)	2,885	7,427	2.6	1,718	1,236	0.7	8,664	4,863	2,566	1,230	-	-	8,659	-	-
68	Rancho Murieta (South)	5	30	5.5	441	494	1.1	524	15	15	-	448	-	479	-	-
69	Sloughouse RCD (East)	9,647	22,821	2.4	1,872	1,383	0.7	24,204	21,177	1,644	122	124	-	23,068	-	-
70	Wilton	1,200	3,929	3.3	5,748	3,278	0.6	7,207	3,918	11	5,077	-	-	9,006	-	-
71	Sloughouse RCD (West)	4,261	9,306	2.2	490	256	0.5	9,562	9,182	125	6	-	-	9,312	-	-
72	Galt ID (East)	15,282	38,926	2.5	7,847	5,284	0.7	44,210	37,395	1,531	10,545	-	-	49,471	-	-
73	Clay WD	1,989	7,680	3.9	230	424	1.8	8,104	7,237	443	-	-	-	7,680	-	-
74	Clay	130	358	2.8	2,805	1,427	0.5	1,785	358	-	1,403	-	-	1,761	-	-
75	SMUD Rancho Seco	19	60	3.1	196	126	0.6	186	43	17	7	-	-	67	-	-
76	Cosumnes River South	4,231	10,943	2.6	329	465	1.4	11,408	8,293	2,651	-	-	-	10,944	-	-
77	Galt ID (West)	1,728	4,654	2.7	1,542	1,117	0.7	5,771	4,654	-	600	-	-	5,254	-	-
78	Sac Co. 8	2,693	5,929	2.2	697	799	1.1	6,728	5,410	518	131	-	-	6,059	-	-
79	City of Galt	197	216	1.1	3,206	4,777	1.5	4,993	216	-	3,413	-	-	3,629	-	-
80	Sloughouse RCD (South)	1,051	1,417	1.3	376	514	1.4	1,931	1,417	-	42	-	-	1,459	-	-
81	Amador Co. 1	1,900	2,863	1.5	1,832	2,418	1.3	5,282	858	2,003	0	-	-	2,861	-	-
82	Ione	147	14	0.1	1,128	2,371	2.1	2,385	14	0	-	1,911	-	1,925	-	-
83	Jackson ID	2,842	9,699	3.4	387	493	1.3	10,192	-	9,329	19	-	-	9,348	-	-
84	Camanche	81	-	0.0	325	240	0.7	240	-	-	87	-	-	87	-	-
85	Amador County WA	1	-	0.0	603	315	0.5	315	-	-	144	-	-	144	-	-
87	Galt WWTP	156	27	0.2	72	107	1.5	135	-	630	-	-	-	630	-	-
	Total CoSb	50,447	126,301	43	31,841	27,524	21	153,825	105,049	21,484	22,825	2,483	-	151,842	-	-
86	Mokelumne	35,660	75,590	2.1	3,287	4,606	1.4	80,196	75,590	-	4,606	-	-	80,196	-	-
	Total Other	35,660	75,590	2.1	3,287	4,606	1.4	80,196	75,590	-	4,606	-	-	80,196	-	-
	CoSANA Grand Total (NASb, SASb, CoSb)	224,487	661,939	212	279,035	413,358	100	1,075,297	409,937	255,259	186,284	224,111	938	1,076,528	35,279	207

Footnotes:
1. Subregion includes areas that fall outside of DWR B118 subbasin boundaries
2. Other Supply includes recycled water deliveries

Projected Conditions Baseline Water Use Budget Summary, Annual Average over 50-year Simulation

Subregion	Description	Ag Area	Ag Demand	Ag Water Duty	Urban Area	Urban Demand	Urban Water Duty	Total Water Demand	Total Ag Water Supply (Acre-Feet/Year)		Total Urban Water Supply (Acre-Feet/Year)			Total Supply (Acre-Feet/Year)	Remediation Operations	
		(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acre-Feet)	GW Production	SW Deliveries	GW Use	SW Deliveries	Other Supply[2]		Extraction	Injection
1	Camp Far West ID	1,807	10,113	5.6	177	101	0.6	10,214	5,459	4,653	101	-	-	10,214	-	-
2	Sutter Co. 1	147	629	4.3	2	1	0.4	629	629	-	1	-	-	629	-	-
3	South Sutter WD GSA	52,244	188,092	3.6	2,715	2,044	0.8	190,136	112,897	76,258	1,626	418	-	191,198	-	-
4	Placer County WA[1]	9,028	30,832	3.4	27,745	32,735	1.2	63,567	24,418	6,415	6,187	26,545	-	63,565	-	-
5	Nevada ID	1,481	6,536	4.4	4,231	3,433	0.8	9,969	2,243	4,489	765	2,667	-	10,164	-	-
6	Lincoln[1]	348	91	0.3	6,738	5,657	0.8	5,749	91	-	907	4,750	-	5,748	-	-
7	RD1001 [1]	7,436	30,319	4.1	416	167	0.4	30,486	20,754	9,565	167	-	-	30,486	-	-
8	Pleasant Grove Verona MWC	6,668	23,216	3.5	101	41	0.4	23,257	12,374	11,533	41	-	-	23,947	-	-
9	Sutter Co. 2	904	3,237	3.6	88	35	0.4	3,272	2,062	1,175	35	-	-	3,272	-	-
10	Natomas MWC (Sutter Co.)	6,336	23,929	3.8	5,699	11,492	2.0	35,421	3,662	20,320	7,979	3,512	-	35,473	-	-
11	Sutter Co. 3	1,424	4,445	3.1	2,344	4,577	2.0	9,021	4,445	-	3,222	1,355	-	9,021	-	-
12	Roseville SOI	1,104	2,081	1.9	1,056	2,530	2.4	4,612	2,081	-	188	2,342	-	4,612	-	-
13	City of Roseville	99	60	0.6	23,599	56,637	2.4	56,697	60	-	1,692	54,945	-	56,698	-	-
14	Cal Am (West Placer)	1,528	5,318	3.5	9,158	6,782	0.7	12,101	5,318	-	-	6,782	-	12,101	-	-
15	Natomas MWC (Sacramento Co.)	5,920	17,315	2.9	8,209	17,108	2.1	34,423	3,683	14,413	5,345	11,763	-	35,204	-	-
16	Sacramento International Airport	526	130	0.2	1,669	1,144	0.7	1,274	130	-	673	471	-	1,274	-	-
17	Metro Air Park	1,578	-	0.0	71	-	0.0	-	-	-	-	-	-	-	-	-
18	Sac Co. 1	832	1,096	1.3	165	568	3.5	1,664	43	1,052	568	-	-	1,664	-	-
19	Sac Co. 2	31	61	1.9	1,652	3,710	2.2	3,770	61	-	865	2,845	-	3,770	-	-
20	Sac County WA (Northgate 880)	-	-	0.0	837	1,365	1.6	1,365	-	-	1,365	-	-	1,365	-	-
21	Rio Linda Elverta	447	772	1.7	7,215	10,323	1.4	11,095	772	-	10,323	-	-	11,095	-	-
22	Sac Co. 3	36	129	3.5	652	1,064	1.6	1,193	129	-	1,064	-	-	1,193	-	-
23	Cal Am (Antelope)	3	5	2.0	2,706	5,225	1.9	5,230	5	-	4,481	744	-	5,230	-	-
24	Cal Am (Lincoln Oaks)	9	20	2.3	4,285	6,213	1.4	6,233	20	-	5,717	496	-	6,233	-	-
25	Citrus Heights WD	12	50	4.3	7,744	17,172	2.2	17,222	50	-	900	16,272	-	17,222	-	-
26	San Juan WD (Placer Co.)	82	-	0.0	1,409	2,876	2.0	2,876	-	-	-	2,876	-	2,876	-	-
27	San Juan WD (Sacramento Co.)	47	89	1.9	2,106	4,299	2.0	4,389	89	-	-	4,299	-	4,389	-	-
28	Orange Vale WC	50	277	5.5	2,899	4,697	1.6	4,975	277	-	-	4,697	-	4,975	-	-
29	Lake Natoma/Mississippi Bar	3	97	35.9	140	-	0.0	97	97	-	-	-	-	97	-	-
30	Fair Oaks WD	75	240	3.2	6,204	12,726	2.1	12,966	240	-	2,129	10,597	-	12,966	1,229	-
31	Carmichael WD	-	-	0.0	5,264	10,530	2.0	10,530	-	-	2,465	8,065	-	10,530	1,876	-
32	Sacramento Suburban WD (North)	25	56	2.2	13,846	24,848	1.8	24,904	56	-	15,597	9,251	-	24,904	2,300	-
33	Sacramento Suburuban WD (South)	-	-	0.0	7,773	16,456	2.1	16,456	-	-	13,744	2,712	-	16,456	-	-
34	Del Paso Manor WD	-	-	0.0	614	1,214	2.0	1,214	-	-	1,214	-	-	1,214	-	-
35	Golden State WC Arden	-	-	0.0	496	969	2.0	969	-	-	968	-	-	968	-	-
36	Cal Am (Arden)	-	-	0.0	641	1,606	2.5	1,606	-	-	1,123	483	-	1,606	-	-
37	Sac County WA (Arden Park	-	-	0.0	1,350	3,217	2.4	3,217	-	-	3,217	-	-	3,217	-	-
38	City of Sacramento (North)	806	191	0.2	20,363	55,977	2.7	56,168	191	-	13,955	42,022	-	56,168	110	-
	Total NASb	101,036	349,428	115	182,377	329,539	59	678,967	202,338	149,872	108,625	220,911	-	681,745	5,515	-
39	City of Sacramento (South)	122	24	0.2	36,875	101,356	2.7	101,381	24	1	25,256	76,100	-	101,381	-	-
40	Cal Am (Suburban Rosemont)	56	185	3.3	8,045	17,439	2.2	17,624	185	-	11,053	6,386	-	17,624	508	-
41	Sac Co. 4	5	25	4.7	23	-	0.0	25	25	-	-	-	-	25	-	-
42	Golden State WC (Cordova)	8	27	3.3	6,459	19,752	3.1	19,779	27	-	9,752	10,000	-	19,779	10,981	-
43	Sac Co. 5	-	-	0.0	1,815	2,863	1.6	2,863	-	-	-	2,863	-	2,863	6,245	-
44	City of Folsom[1]	75	50	0.7	15,728	27,405	1.7	27,455	34	-	-	27,405	-	27,439	2,443	-
45	Cal Am (Security Park)	-	-	0.0	1,770	3,408	1.9	3,408	-	-	6	3,402	-	3,408	233	-
46	Fruitridge Vista WC	-	-	0.0	1,894	4,957	2.6	4,957	-	-	2,642	2,478	-	5,120	-	-
47	Florin County WD	-	-	0.0	1,399	2,692	1.9	2,692	-	-	2,645	47	-	2,692	-	-
48	Cal Am (Parkway)	-	-	0.0	5,252	17,084	3.3	17,084	-	-	14,430	2,654	-	17,084	-	-
49	Sac Co. 6	183	493	2.7	1,141	60	0.1	553	136	357	60	-	-	553	-	-
50	Sac County WA (North/Central)	1,607	4,573	2.8	34,073	64,917	1.9	69,489	4,573	-	22,962	35,099	6,856	69,489	8,733	207
51	Sac County WA (South)	531	1,261	2.4	12,689	27,243	2.1	28,504	1,261	-	12,130	10,524	4,589	28,504	-	-
52	Elk Grove WD (2 - Intertie Service Area)	582	1,226	2.1	3,470	7,451	2.1	8,676	1,226	-	3,317	2,878	1,255	8,676	-	-
53	Elk Grove WD (1 - GW Service Area)	18	1	0.0	3,074	4,650	1.5	4,651	1	-	4,650	-	-	4,651	-	-
54	Cosumnes River West	17,599	49,045	2.8	2,597	4,968	1.9	54,013	44,805	4,240	4,968	-	-	54,014	-	-
55	RD744	1,240	2,400	1.9	146	78	0.5	2,478	601	1,799	78	-	-	2,479	-	-
56	Franklin Drainage District	2,654	9,111	3.4	344	185	0.5	9,295	3,431	5,680	163	21	-	9,296	-	-
57	RD813	2,053	4,826	2.4	166	89	0.5	4,915	1,354	3,473	80	10	-	4,916	-	-
58	RD755	354	1,514	4.3	39	21	0.5	1,535	500	1,014	21	-	-	1,535	-	-
59	RD1002	4,060	9,611	2.4	423	271	0.6	9,882	2,468	7,144	271	-	-	9,883	-	-
60	RD551	7,767	21,697	2.8	683	368	0.5	22,065	5,432	16,268	368	-	-	22,068	-	-
61	RD369	92	376	4.1	39	21	0.5	397	121	255	21	-	-	397	-	-
62	RD2110	1,358	1,649	1.2	97	52	0.5	1,702	278	1,371	52	-	-	1,702	-	-
63	Sac Co. 7	254	635	2.5	98	128	1.3	763	151	484	128	-	-	763	-	-
64	Rancho Murieta (North)[1]	367	675	1.8	1,945	2,837	1.5	3,512	433	249	182	2,655	-	3,519	-	-
65	Sloughouse RCD (North)	722	1,632	2.3	2,903	4,233	1.5	5,866	1,594	39	752	3,481	-	5,866	-	-
66	OHWD (Sth American Subbasin)	10,098	24,867	2.5	3,354	2,403	0.7	27,271	22,876	1,997	1,598	829	-	27,299	621	-
	Total SASb	51,804	135,904	57	146,542	316,931	40	452,836	91,537	44,372	117,584	186,834	12,700	453,027	29,765	207
67	OHWD (Cosumnes Subbasin)	2,885	7,427	2.6	1,718	1,234	0.7	8,661	4,861	2,568	1,321	-	-	8,750	-	-
68	Rancho Murieta (South)	5	30	5.5	441	633	1.4	663	15	15	-	583	-	614	-	-
69	Sloughouse RCD (East)	9,647	22,821	2.4	1,872	1,325	0.7	24,145	21,177	1,644	144	167	-	23,132	-	-
70	Wilton	1,200	3,929	3.3	5,748	3,631	0.6	7,560	3,918	11	5,574	-	-	9,503	-	-
71	Sloughouse RCD (West)	4,199	9,219	2.2	641	434	0.7	9,653	9,095	125	235	-	-	9,455	-	-
72	Galt ID (East)	14,125	35,219	2.5	9,175	6,681	0.7	41,900	33,688	1,531	12,889	-	-	48,108	-	-
73	Clay WD	1,990	7,680	3.9	230	301	1.3	7,981	7,237	443	-	-	-	7,680	-	-
74	Clay	130	358	2.8	2,805	1,673	0.6	2,031	358	-	1,653	-	-	2,011	-	-
75	SMUD Rancho Seco	19	60	3.1	196	105	0.5	165	43	17	7	-	-	67	-	-
76	Cosumnes River South	4,232	10,943	2.6	329	480	1.5	11,422	8,292	2,651	-	-	-	10,944	-	-
77	Galt ID (West)	1,562	4,294	2.7	1,753	1,480	0.8	5,774	4,294	-	1,139	-	-	5,433	-	-
78	Sac Co. 8	2,473	5,526	2.2	967	1,120	1.2	6,646	5,008	518	536	-	-	6,062	-	-
79	City of Galt	27	78	2.9	3,428	4,000	1.2	4,078	78	-	3,912	-	-	3,990	-	-
80	Sloughouse RCD (South)	822	964	1.2	677	784	1.2	1,748	964	-	546	-	-	1,510	-	-
81	Amador Co. 1	1,870	2,864	1.5	1,918	2,677	1.4	5,541	858	2,003	0	277	-	3,138	-	-
82	Ione	10	-	0.0	2,216	2,340	1.1	2,340	-	-	-	2,915	-	2,915	-	-
83	Jackson ID	2,842	9,699	3.4	400	549	1.4	10,247	-	9,329	17	-	-	9,346	-	-
84	Camanche	81	-	0.0	452	215	0.5	215	-	-	120	-	-	120	-	-
85	Amador County WA	0	-	0.0	1,184	429	0.4	429	-	-	353	-	-	353	-	-
87	Galt WWTP	156	27	0.2	72	84	1.2	111	-	630	-	-	-	630	-	-
	Total CoSb	48,275	121,140	45	36,220	30,173	19	151,314	99,886	21,487	28,445	3,943	-	153,761	-	-
86	Mokelumne	35,662	75,582	2.1	3,286	4,632	1.4	80,214	75,582	-	4,632	-	-	80,214	-	-
	Total Other	35,662	75,582	2.1	3,286	4,632	1.4	80,214	75,582	-	4,632	-	-	80,214	-	-
	CoSANA Grand Total (NASb, SASb, CoSb)	201,115	606,472	216	365,138	676,644	118	1,283,116	393,760	215,731	254,654	411,687	12,700	1,288,532	35,279	207

Footnotes:
1. Subregion includes areas that fall outside of DWR B118 subbasin boundaries
2. Other Supply includes recycled water deliveries

Projected Conditions Baseline with Climate Change Water Use Budget Summary, Annual Average over 50-year Simulation

Subregion	Description	Ag Area	Ag Demand	Ag Water Duty	Urban Area	Urban Demand	Urban Water Duty	Total Water Demand	Total Ag Water Supply (Acre-Feet/Year)		Total Urban Water Supply (Acre-Feet/Year)			Total Supply (Acre-Feet/Year)	Remediation Operations	
		(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acres)	(Acre-Feet)	(Acre-Feet/Acre)	(Acre-Feet)	GW Production	SW Deliveries	GW Use	SW Deliveries	Other Supply[2]		Extraction	Injection
1	Camp Far West ID	1,807	10,632	5.9	177	101	0.6	10,733	5,979	4,653	101	-	-	10,733	-	-
2	Sutter Co. 1	147	672	4.6	2	1	0.4	673	672	-	1	-	-	673	-	-
3	South Sutter WD GSA	52,244	200,075	3.8	2,715	2,044	0.8	202,119	124,690	76,246	1,626	418	-	202,980	-	-
4	Placer County WA[1]	9,028	33,233	3.7	27,745	32,735	1.2	65,967	26,818	6,415	6,187	26,545	-	65,965	-	-
5	Nevada ID	1,481	6,965	4.7	4,231	3,433	0.8	10,397	2,637	4,489	765	2,667	-	10,558	-	-
6	Lincoln[1]	348	98	0.3	6,738	5,657	0.8	5,755	98	-	907	4,750	-	5,754	-	-
7	RD1001 [1]	7,436	32,241	4.3	416	167	0.4	32,408	22,676	9,565	167	-	-	32,408	-	-
8	Pleasant Grove Verona MWC	6,668	24,847	3.7	101	41	0.4	24,887	13,800	11,533	41	-	-	25,373	-	-
9	Sutter Co. 2	904	3,469	3.8	88	35	0.4	3,504	2,286	1,183	35	-	-	3,504	-	-
10	Natomas MWC (Sutter Co.)	6,336	25,410	4.0	5,699	11,492	2.0	36,901	3,663	21,795	7,979	3,512	-	36,949	-	-
11	Sutter Co. 3	1,424	4,750	3.3	2,344	4,577	2.0	9,326	4,750	-	3,222	1,355	-	9,326	-	-
12	Roseville SOI	1,104	2,229	2.0	1,056	2,530	2.4	4,759	2,229	-	188	2,342	-	4,759	-	-
13	City of Roseville	99	63	0.6	23,599	56,637	2.4	56,700	63	-	1,692	54,945	-	56,700	-	-
14	Cal Am (West Placer)	1,528	5,790	3.8	9,158	6,782	0.7	12,572	5,790	-	-	6,782	-	12,572	-	-
15	Natomas MWC (Sacramento Co.)	5,920	18,453	3.1	8,209	17,108	2.1	35,561	3,691	15,528	5,345	11,763	-	36,327	-	-
16	Sacramento International Airport	526	139	0.3	1,669	1,144	0.7	1,283	139	-	673	471	-	1,283	-	-
17	Metro Air Park	1,578	-	0.0	71	-	0.0	-	-	-	-	-	-	-	-	-
18	Sac Co. 1	832	1,190	1.4	165	568	3.5	1,757	48	1,142	568	-	-	1,757	-	-
19	Sac Co. 2	31	64	2.0	1,652	3,710	2.2	3,774	64	-	865	2,845	-	3,774	-	-
20	Sac County WA (Northgate 880)	-	-	0.0	837	1,365	1.6	1,365	-	-	1,365	-	-	1,365	-	-
21	Rio Linda Elverta	447	842	1.9	7,215	10,323	1.4	11,166	842	-	10,323	-	-	11,166	-	-
22	Sac Co. 3	36	140	3.9	652	1,064	1.6	1,204	140	-	1,064	-	-	1,204	-	-
23	Cal Am (Antelope)	3	6	2.2	2,706	5,225	1.9	5,231	6	-	4,481	744	-	5,231	-	-
24	Cal Am (Lincoln Oaks)	9	22	2.5	4,285	6,213	1.4	6,235	22	-	5,717	496	-	6,235	-	-
25	Citrus Heights WD	12	54	4.7	7,744	17,172	2.2	17,226	54	-	900	16,272	-	17,226	-	-
26	San Juan WD (Placer Co.)	82	-	0.0	1,409	2,876	2.0	2,876	-	-	-	2,876	-	2,876	-	-
27	San Juan WD (Sacramento Co.)	47	97	2.1	2,106	4,299	2.0	4,396	97	-	-	4,299	-	4,396	-	-
28	Orange Vale WC	50	294	5.9	2,899	4,697	1.6	4,991	294	-	-	4,697	-	4,991	-	-
29	Lake Natoma/Mississippi Bar	3	98	36.2	140	-	0.0	98	98	-	-	-	-	98	-	-
30	Fair Oaks WD	75	257	3.4	6,204	12,726	2.1	12,984	257	-	2,129	10,597	-	12,983	1,229	-
31	Carmichael WD	-	-	0.0	5,264	10,530	2.0	10,530	-	-	2,465	8,065	-	10,530	1,876	-
32	Sacramento Suburban WD (North)	25	62	2.4	13,846	24,848	1.8	24,910	62	-	15,597	9,251	-	24,910	2,300	-
33	Sacramento Suburuban WD (South)	-	-	0.0	7,773	16,456	2.1	16,456	-	-	13,744	2,712	-	16,456	-	-
34	Del Paso Manor WD	-	-	0.0	614	1,214	2.0	1,214	-	-	1,214	-	-	1,214	-	-
35	Golden State WC Arden	-	-	0.0	496	969	2.0	969	-	-	968	-	-	968	-	-
36	Cal Am (Arden)	-	-	0.0	641	1,606	2.5	1,606	-	-	1,123	483	-	1,606	-	-
37	Sac County WA (Arden Park	-	-	0.0	1,350	3,217	2.4	3,217	-	-	3,217	-	-	3,217	-	-
38	City of Sacramento (North)	806	209	0.3	20,363	55,977	2.7	56,186	209	-	13,955	42,022	-	56,186	110	-
	Total NASb	101,036	372,398	121	182,377	329,539	59	701,937	222,172	152,548	108,625	220,911	-	704,255	5,515	-
39	City of Sacramento (South)	122	26	0.2	36,875	101,356	2.7	101,383	26	1	25,256	76,100	-	101,383	-	-
40	Cal Am (Suburban Rosemont)	56	196	3.5	8,045	17,439	2.2	17,635	196	-	11,053	6,386	-	17,635	508	-
41	Sac Co. 4	5	27	5.1	23	-	0.0	27	27	-	-	-	-	27	-	-
42	Golden State WC (Cordova)	8	29	3.5	6,459	19,752	3.1	19,781	29	-	9,752	10,000	-	19,781	10,981	-
43	Sac Co. 5	-	-	0.0	1,815	2,863	1.6	2,863	-	-	-	2,863	-	2,863	6,245	-
44	City of Folsom[1]	75	54	0.7	15,728	27,405	1.7	27,459	32	-	-	27,405	-	27,438	2,443	-
45	Cal Am (Security Park)	-	-	0.0	1,770	3,408	1.9	3,408	-	-	6	3,402	-	3,408	233	-
46	Fruitridge Vista WC	-	-	0.0	1,894	4,957	2.6	4,957	-	-	2,642	2,478	-	5,120	-	-
47	Florin County WD	-	-	0.0	1,399	2,692	1.9	2,692	-	-	2,645	47	-	2,692	-	-
48	Cal Am (Parkway)	-	-	0.0	5,252	17,084	3.3	17,084	-	-	14,430	2,654	-	17,084	-	-
49	Sac Co. 6	183	559	3.1	1,141	60	0.1	618	190	368	60	-	-	618	-	-
50	Sac County WA (North/Central)	1,607	4,981	3.1	34,073	64,917	1.9	69,897	4,981	-	22,962	35,099	6,856	69,897	8,733	207
51	Sac County WA (South)	531	1,377	2.6	12,689	27,243	2.1	28,620	1,377	-	12,130	10,524	4,589	28,620	-	-
52	Elk Grove WD (2 - Intertie Service Area)	582	1,333	2.3	3,470	7,451	2.1	8,784	1,333	-	3,317	2,878	1,255	8,784	-	-
53	Elk Grove WD (1 - GW Service Area)	18	1	0.1	3,074	4,650	1.5	4,651	1	-	4,650	-	-	4,651	-	-
54	Cosumnes River West	17,599	53,472	3.0	2,597	4,968	1.9	58,440	49,159	4,313	4,968	-	-	58,440	-	-
55	RD744	1,240	2,637	2.1	146	78	0.5	2,716	804	1,834	78	-	-	2,716	-	-
56	Franklin Drainage District	2,654	9,945	3.7	344	185	0.5	10,129	4,202	5,743	163	21	-	10,130	-	-
57	RD813	2,053	5,335	2.6	166	89	0.5	5,424	1,787	3,548	80	10	-	5,425	-	-
58	RD755	354	1,642	4.6	39	21	0.5	1,662	624	1,018	21	-	-	1,662	-	-
59	RD1002	4,060	10,637	2.6	423	271	0.6	10,908	3,281	7,356	271	-	-	10,908	-	-
60	RD551	7,767	23,766	3.1	683	368	0.5	24,134	7,291	16,477	368	-	-	24,135	-	-
61	RD369	92	409	4.4	39	21	0.5	430	152	257	21	-	-	430	-	-
62	RD2110	1,358	1,825	1.3	97	52	0.5	1,877	407	1,417	52	-	-	1,877	-	-
63	Sac Co. 7	254	704	2.8	98	128	1.3	832	207	497	128	-	-	832	-	-
64	Rancho Murieta (North)[1]	367	731	2.0	1,945	2,837	1.5	3,568	476	260	182	2,655	-	3,574	-	-
65	Sloughouse RCD (North)	722	1,760	2.4	2,903	4,233	1.5	5,993	1,721	39	752	3,481	-	5,993	-	-
66	OHWD (Sth American Subbasin)	10,098	27,030	2.7	3,354	2,403	0.7	29,434	24,981	2,053	1,598	829	-	29,461	621	-
	Total SASb	51,804	148,475	62	146,542	316,931	40	465,406	103,283	45,182	117,584	186,834	12,700	465,583	29,765	207
67	OHWD (Cosumnes Subbasin)	2,885	8,048	2.8	1,718	1,234	0.7	9,282	5,302	2,747	1,321	-	-	9,370	-	-
68	Rancho Murieta (South)	5	32	5.9	441	633	1.4	665	16	17	-	583	-	616	-	-
69	Sloughouse RCD (East)	9,647	24,790	2.6	1,872	1,325	0.7	26,115	23,102	1,689	144	167	-	25,102	-	-
70	Wilton	1,200	4,246	3.5	5,748	3,631	0.6	7,877	4,235	11	5,574	-	-	9,820	-	-
71	Sloughouse RCD (West)	4,199	10,057	2.4	641	434	0.7	10,491	9,932	125	235	-	-	10,293	-	-
72	Galt ID (East)	14,125	38,178	2.7	9,175	6,681	0.7	44,859	36,639	1,538	12,889	-	-	51,067	-	-
73	Clay WD	1,990	8,332	4.2	230	301	1.3	8,633	7,886	446	-	-	-	8,332	-	-
74	Clay	130	387	3.0	2,805	1,673	0.6	2,061	387	-	1,653	-	-	2,040	-	-
75	SMUD Rancho Seco	19	66	3.4	196	105	0.5	171	47	19	7	-	-	73	-	-
76	Cosumnes River South	4,232	11,994	2.8	329	480	1.5	12,473	9,084	2,924	-	-	-	12,008	-	-
77	Galt ID (West)	1,562	4,670	3.0	1,753	1,480	0.8	6,150	4,670	-	1,139	-	-	5,809	-	-
78	Sac Co. 8	2,473	5,969	2.4	967	1,120	1.2	7,089	5,433	536	536	-	-	6,505	-	-
79	City of Galt	27	83	3.1	3,428	4,000	1.2	4,082	83	-	3,912	-	-	3,995	-	-
80	Sloughouse RCD (South)	822	1,047	1.3	677	784	1.2	1,831	1,047	-	546	-	-	1,592	-	-
81	Amador Co. 1	1,870	3,126	1.7	1,918	2,677	1.4	5,804	968	2,155	0	277	-	3,400	-	-
82	Ione	10	-	0.0	2,216	2,340	1.1	2,340	-	-	-	2,915	-	2,915	-	-
83	Jackson ID	2,842	10,410	3.7	400	549	1.4	10,959	-	9,934	17	-	-	9,951	-	-
84	Camanche	81	-	0.0	452	215	0.5	215	-	-	120	-	-	120	-	-
85	Amador County WA	0	-	0.0	1,184	429	0.4	429	-	-	353	-	-	353	-	-
87	Galt WWTP	156	32	0.2	72	84	1.2	116	-	632	-	-	-	632	-	-
	Total CoSb	48,275	131,469	49	36,220	30,173	19	161,642	108,831	22,773	28,445	3,943	-	163,992	-	-
86	Mokelumne	35,662	83,220	2.3	3,286	4,632	1.4	87,852	83,220	-	4,632	-	-	87,852	-	-
	Total Other	35,662	83,220	2.3	3,286	4,632	1.4	87,852	83,220	-	4,632	-	-	87,852	-	-
	CoSANA Grand Total (NASb, SASb, CoSb)	201,115	652,342	231	365,138	676,644	118	1,328,986	434,286	220,503	254,654	411,687	12,700	1,333,830	35,279	207

Footnotes:
1. Subregion includes areas that fall outside of DWR B118 subbasin boundaries
2. Other Supply includes recycled water deliveries

APPENDIX I: BASELINE CONDITIONS GROUNDWATER BUDGETS

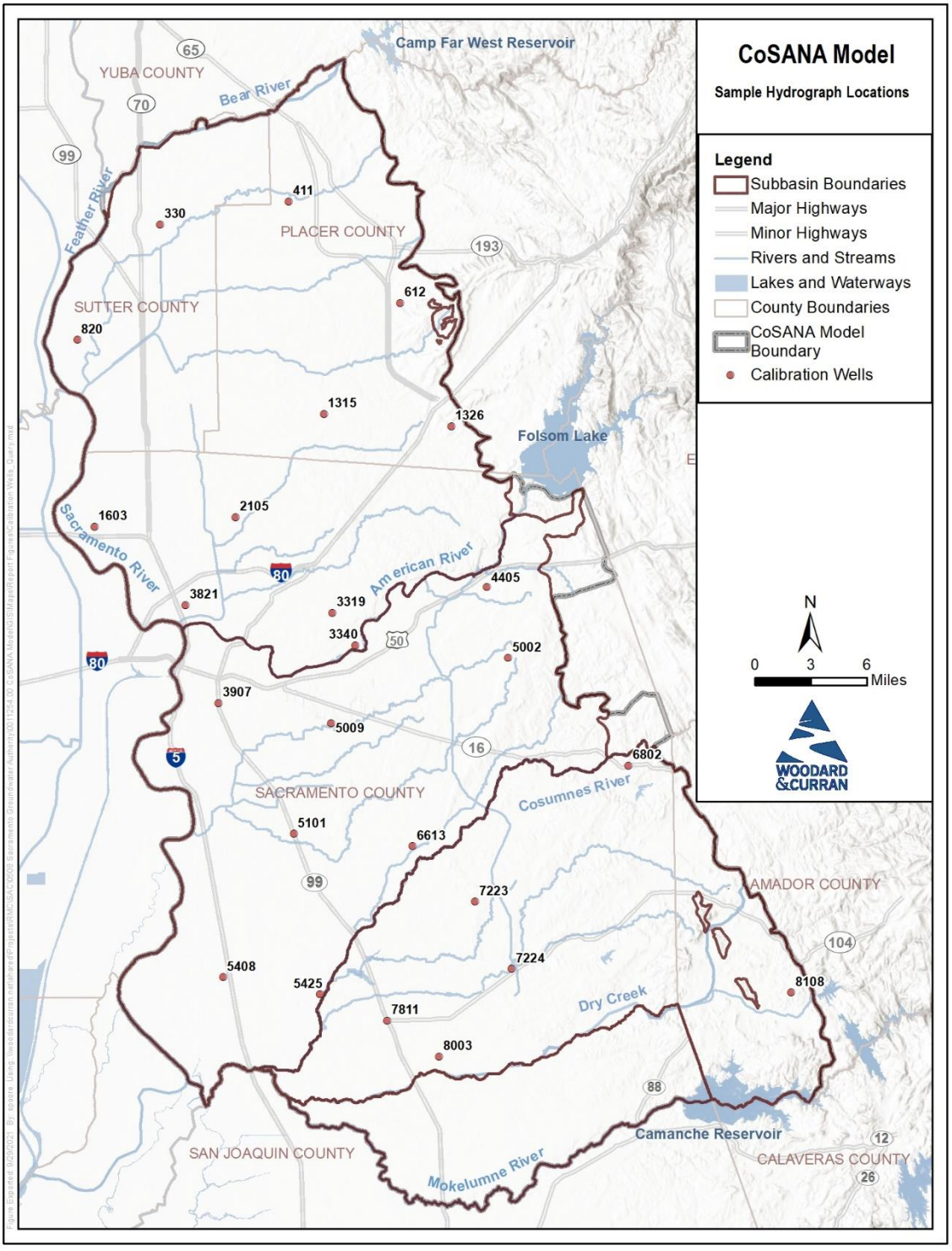
Current Conditions Baseline Groundwater Budget Summary, Annual Average over 50-year Simulation							
Subregion	**Description**	**Deep Percolation**	**Gain from Stream**	**Recharge (Recoverable Loss)**	**Boundary Inflow**	**Net Subsurface Inflow**	**Pumping**
		(Acre-Feet)	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*
North American Subbasin							
1	Camp Far West ID	6,458	-4,879	651	2,526	834	5,582
2	Sutter Co. 1	312	23	0	1,232	-937	630
3	South Sutter WD GSA	54,557	26,635	10,625	4,478	16,746	111,539
4	Placer County WA	32,195	2,096	898	1,539	-3,198	29,899
5	Nevada ID	8,411	776	1,257	4,345	-6,277	8,782
6	Lincoln	5,464	640	0	504	-4,060	1,046
7	RD1001	16,678	6,067	1,148	-86	-2,764	20,923
8	Pleasant Grove Verona MWC	5,013	3,705	1,346	0	2,564	12,561
9	Sutter Co. 2	1,351	-2,512	141	945	2,150	2,098
10	Natomas MWC (Sutter Co.)	7,920	6,075	277	46	-8,615	5,586
11	Sutter Co. 3	3,461	917	0	0	5,931	10,123
12	Roseville SOI	1,059	1,146	0	0	-715	1,220
13	City of Roseville	5,082	5,202	210	2,758	-9,643	208
14	Cal Am (West Placer)	4,628	4,071	0	0	-3,453	4,130
15	Natomas MWC (Sacramento Co.)	9,916	-3,968	465	2,663	-3,906	5,140
16	Sacramento International Airport	736	0	0	0	161	944
17	Metro Air Park	477	0	0	0	-457	31
18	Sac Co. 1	733	-3,297	0	3,897	-709	649
19	Sac Co. 2	1,188	2,090	0	0	-344	2,849
20	Sac County WA (Northgate 880)	61	585	0	0	70	696
21	Rio Linda Elverta	2,194	5,392	0	0	2,387	9,390
22	Sac Co. 3	164	754	0	0	-344	512
23	Cal Am (Antelope)	567	629	0	0	2,949	3,903
24	Cal Am (Lincoln Oaks)	523	0	0	0	6,174	6,359
25	Citrus Heights WD	1,417	0	0	460	-176	1,263
26	San Juan WD (Placer Co.)	380	0	0	1,566	-2,057	0
27	San Juan WD (Sacramento Co.)	567	-589	0	825	-773	89
28	Orange Vale WC	1,187	0	0	0	-868	278
29	Lake Natoma/Mississippi Bar	1,590	-5,831	0	34	4,313	97
30	Fair Oaks WD	2,746	4,824	0	0	-4,113	3,317
31	Carmichael WD	1,032	5,622	0	0	-2,545	3,999
32	Sacramento Suburban WD (North)	2,691	50	0	0	11,769	13,785
33	Sacramento Suburuban WD (South)	866	6,342	0	0	5,791	12,843
34	Del Paso Manor WD	75	0	0	0	1,270	1,335
35	Golden State WC Arden	33	0	0	0	772	800
36	Cal Am (Arden)	92	0	0	0	1,382	1,464
37	Sac County WA (Arden Park	203	766	0	0	1,650	2,611
38	City of Sacramento (North)	3,252	14,463	0	727	-1,197	16,734
Total NASb		185,281	77,793	17,017	28,461	9,761	303,413
South American Subbasin							
39	City of Sacramento (South)	13,704	12,643	0	842	-21,062	5,940
40	Cal Am (Suburban Rosemont)	1,529	6,147	0	0	2,224	9,911
41	Sac Co. 4	286	2,527	0	0	-2,785	25
42	Golden State WC (Cordova)	6,482	12,851	0	0	-3,452	15,892
43	Sac Co. 5	1,947	0	0	0	4,280	6,245
44	City of Folsom	16,480	-3,463	0	2,155	-12,339	2,475
45	Cal Am (Security Park)	1,583	38	0	0	-1,424	244
46	Fruitridge Vista WC	299	278	0	0	2,982	3,550
47	Florin County WD	161	0	0	0	2,134	2,288
48	Cal Am (Parkway)	660	359	0	0	7,943	8,919
49	Sac Co. 6	969	3,022	0	254	-4,025	185
50	Sac County WA (North/Central)	16,795	4,020	209	0	15,652	37,013
51	Sac County WA (South)	3,686	213	0	0	11,379	15,038
52	Elk Grove WD (2 - Intertie Service Area)	1,302	1,192	0	0	1,805	4,229
53	Elk Grove WD (1 - GW Service Area)	390	668	0	0	5,823	6,835
54	Cosumnes River West	21,988	10,970	0	0	18,478	51,033
55	RD744	837	6,390	0	-773	-5,730	669
56	Franklin Drainage District	3,404	5,872	0	-252	-5,133	3,626
57	RD813	1,594	2,833	0	-134	-2,774	1,426
58	RD755	552	1,312	0	-283	-1,036	519
59	RD1002	3,060	0	0	0	-280	2,705
60	RD551	8,754	5,686	0	-1,517	-6,924	5,765
61	RD369	433	1,947	0	-216	-2,013	138
62	RD2110	746	-919	0	495	19	324
63	Sac Co. 7	358	1,221	0	26	-1,342	256
64	Rancho Murieta (North)	4,945	-2,429	0	0	-1,821	546
65	Sloughouse RCD (North)	5,139	-606	0	3,948	-6,007	2,140
66	OHWD (Sth American Subbasin)	11,901	15,290	26	64	-2,207	24,862
Total SASb		129,985	88,059	235	4,610	-7,634	212,799
Cosumnes Subbasin							
67	OHWD (Cosumnes Subbasin)	5,611	5,146	0	0	-4,615	6,093
68	Rancho Murieta (South)	1,081	-2,163	0	0	1,095	15
69	Sloughouse RCD (East)	23,460	3,256	0	1,183	-7,110	21,299
70	Wilton	4,917	48	0	0	3,963	8,995
71	Sloughouse RCD (West)	4,059	361	0	0	4,768	9,187
72	Galt ID (East)	20,225	1,975	0	0	25,568	47,940
73	Clay WD	3,489	1,189	0	0	2,464	7,237
74	Clay	1,074	3	0	0	618	1,761
75	SMUD Rancho Seco	490	0	0	0	-496	50
76	Cosumnes River South	4,753	9,282	0	-561	-5,145	8,293
77	Galt ID (West)	2,506	785	0	0	1,989	5,254
78	Sac Co. 8	4,149	7,799	0	0	-6,412	5,541
79	City of Galt	1,489	675	0	0	1,487	3,629
80	Sloughouse RCD (South)	964	997	0	0	-496	1,459
81	Amador Co. 1	13,631	-6,996	0	4,477	-9,734	858
82	Ione	1,367	0	0	0	-1,088	14
83	Jackson ID	8,808	-6,794	0	538	-2,476	0
84	Camanche	5,218	0	0	-4,190	-1,146	60
85	Amador County WA	1,457	0	0	6	-1,324	190
87	Galt WWTP	316	0	0	0	-317	0
Total CoSb		109,064	15,562	0	1,453	1,591	127,874
Other							
86	Mokelumne	30,689	51,058	0	1,834	-3,718	80,196
Total Other		30,689	51,058	0	1,834	-3,718	80,196
CoSANA Total (NASb, SASb, CoSb)		424,331	181,414	17,252	34,525	3,718	644,087

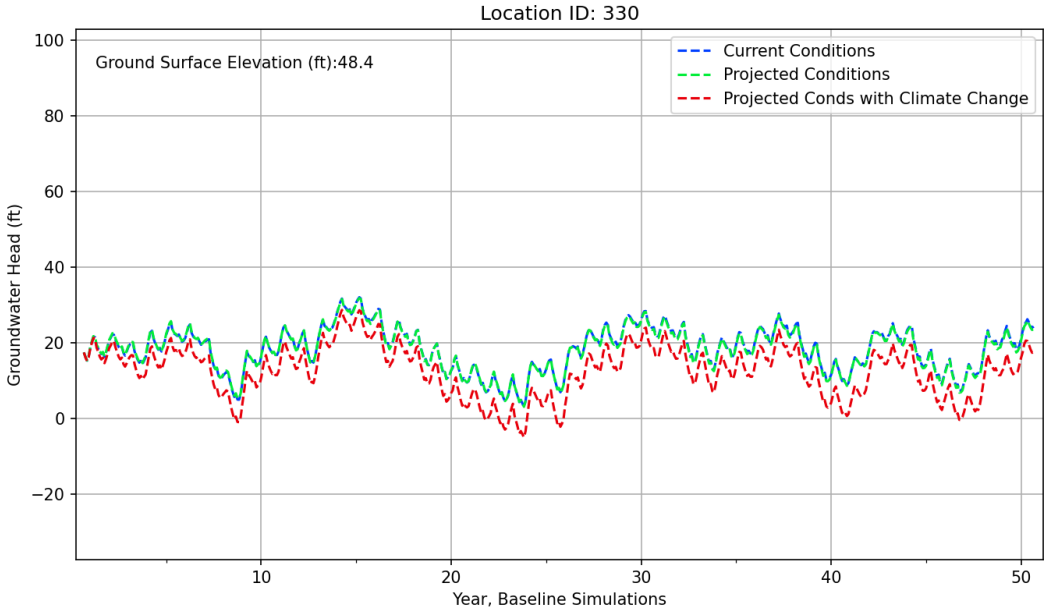
Projected Conditions Baseline Groundwater Budget Summary, Annual Average over 50-year Simulation							
Subregion	**Description**	**Deep Percolation**	**Gain from Stream**	**Recharge (Recoverable Loss)**	**Boundary Inflow**	**Net Subsurface Inflow**	**Pumping**
		(Acre-Feet)	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*
North American Subbasin							
1	Camp Far West ID	6,456	-4,691	651	2,549	603	5,560
2	Sutter Co. 1	312	63	0	1,246	-991	629
3	South Sutter WD GSA	54,699	31,313	10,625	4,579	13,738	114,443
4	Placer County WA	27,668	2,366	898	1,539	912	30,955
5	Nevada ID	6,315	702	1,257	4,345	-9,688	2,499
6	Lincoln	5,087	561	0	504	-3,418	1,187
7	RD1001	16,677	6,369	1,148	-40	-3,119	20,921
8	Pleasant Grove Verona MWC	5,152	5,551	1,384	0	376	12,414
9	Sutter Co. 2	1,351	116	141	1,340	-899	2,098
10	Natomas MWC (Sutter Co.)	4,579	8,640	130	70	1,220	15,205
11	Sutter Co. 3	1,690	1,136	0	0	4,552	7,667
12	Roseville SOI	1,244	1,143	0	0	-177	2,198
13	City of Roseville	5,939	5,388	2,108	2,758	-11,668	1,874
14	Cal Am (West Placer)	2,555	4,419	0	0	-1,515	5,327
15	Natomas MWC (Sacramento Co.)	6,500	-1,579	218	3,491	-2,793	6,635
16	Sacramento International Airport	737	0	0	0	-67	803
17	Metro Air Park	477	0	0	0	-525	52
18	Sac Co. 1	728	-2,650	0	4,361	-1,872	611
19	Sac Co. 2	113	2,768	0	0	-1,490	1,451
20	Sac County WA (Northgate 880)	61	656	0	0	877	1,614
21	Rio Linda Elverta	1,974	6,391	0	0	3,372	11,959
22	Sac Co. 3	95	818	0	0	-582	330
23	Cal Am (Antelope)	590	684	0	0	2,881	4,111
24	Cal Am (Lincoln Oaks)	490	0	0	0	5,224	5,562
25	Citrus Heights WD	1,712	0	0	460	-775	1,125
26	San Juan WD (Placer Co.)	461	0	0	1,566	-2,125	0
27	San Juan WD (Sacramento Co.)	662	-577	0	825	-879	89
28	Orange Vale WC	1,240	0	0	0	-946	277
29	Lake Natoma/Mississippi Bar	1,590	-5,522	0	34	4,002	97
30	Fair Oaks WD	2,921	6,048	0	0	-5,354	3,598
31	Carmichael WD	1,117	6,445	0	0	-3,261	4,342
32	Sacramento Suburban WD (North)	2,849	50	0	0	14,001	16,878
33	Sacramento Suburuban WD (South)	919	7,507	0	0	7,330	15,864
34	Del Paso Manor WD	67	0	0	0	1,134	1,214
35	Golden State WC Arden	33	0	0	0	757	800
36	Cal Am (Arden)	75	0	0	0	1,042	1,123
37	Sac County WA (Arden Park	194	1,061	0	0	1,949	3,227
38	City of Sacramento (North)	3,884	19,364	0	861	-3,804	20,646
Total NASb		169,212	104,540	18,560	30,488	8,023	325,385
South American Subbasin							
39	City of Sacramento (South)	17,819	18,440	0	1,275	-17,061	21,111
40	Cal Am (Suburban Rosemont)	1,969	7,265	0	0	2,923	12,392
41	Sac Co. 4	286	2,902	0	0	-3,168	25
42	Golden State WC (Cordova)	7,385	14,630	0	0	-1,909	20,280
43	Sac Co. 5	1,519	0	0	0	4,664	6,245
44	City of Folsom	14,874	-2,446	0	2,155	-11,968	2,475
45	Cal Am (Security Park)	1,422	38	0	0	-1,297	239
46	Fruitridge Vista WC	358	278	0	0	1,519	2,191
47	Florin County WD	160	0	0	0	2,049	2,278
48	Cal Am (Parkway)	1,228	359	0	0	12,848	14,625
49	Sac Co. 6	969	4,316	0	279	-5,357	196
50	Sac County WA (North/Central)	13,944	4,021	209	0	9,034	28,197
51	Sac County WA (South)	3,114	213	0	0	14,449	17,670
52	Elk Grove WD (2 - Intertie Service Area)	1,318	1,192	0	0	2,960	5,497
53	Elk Grove WD (1 - GW Service Area)	404	668	0	0	5,579	6,664
54	Cosumnes River West	21,470	11,391	0	0	17,120	49,774
55	RD744	837	7,064	0	-709	-6,460	679
56	Franklin Drainage District	3,404	6,558	0	-180	-5,152	4,401
57	RD813	1,594	3,174	0	-82	-3,167	1,433
58	RD755	552	1,417	0	-252	-1,170	521
59	RD1002	3,061	0	0	0	-263	2,739
60	RD551	8,756	6,090	0	-1,426	-7,399	5,800
61	RD369	433	2,014	0	-205	-2,088	141
62	RD2110	746	-769	0	512	-143	331
63	Sac Co. 7	359	1,322	0	29	-1,427	279
64	Rancho Murieta (North)	4,871	-2,372	0	0	-1,756	615
65	Sloughouse RCD (North)	4,881	-339	0	3,948	-5,913	2,346
66	OHWD (Sth American Subbasin)	11,612	15,651	26	64	-2,214	25,095
Total SASb		129,345	103,077	235	5,407	-4,767	234,238
Cosumnes Subbasin							
67	OHWD (Cosumnes Subbasin)	5,622	5,276	0	0	-4,737	6,182
68	Rancho Murieta (South)	1,109	-2,126	0	0	1,030	15
69	Sloughouse RCD (East)	23,465	3,320	0	1,183	-7,361	21,321
70	Wilton	4,980	48	0	0	4,283	9,492
71	Sloughouse RCD (West)	4,052	371	0	0	4,557	9,096
72	Galt ID (East)	19,433	1,984	0	0	22,831	44,622
73	Clay WD	3,489	1,187	0	0	2,414	7,237
74	Clay	1,108	3	0	0	812	2,011
75	SMUD Rancho Seco	490	0	0	0	-509	50
76	Cosumnes River South	4,753	9,573	0	-546	-5,472	8,292
77	Galt ID (West)	2,440	791	0	0	1,627	4,854
78	Sac Co. 8	4,095	8,071	0	0	-7,133	5,092
79	City of Galt	1,448	680	0	0	5,597	7,737
80	Sloughouse RCD (South)	856	1,005	0	0	-871	983
81	Amador Co. 1	13,634	-6,968	0	4,477	-9,790	858
82	Ione	1,279	0	0	0	-1,040	0
83	Jackson ID	8,806	-6,733	0	538	-2,539	17
84	Camanche	5,208	0	0	-4,112	-1,224	94
85	Amador County WA	1,396	0	0	6	-1,094	379
87	Galt WWTP	316	0	0	0	-318	0
Total CoSb		107,977	16,481	0	1,547	1,063	128,332
Other							
86	Mokelumne	30,691	51,342	0	2,032	-4,319	80,214
Total Other		30,691	51,342	0	2,032	-4,319	80,214
CoSANA Total (NASb, SASb, CoSb)		406,534	224,098	18,795	37,442	4,319	687,954

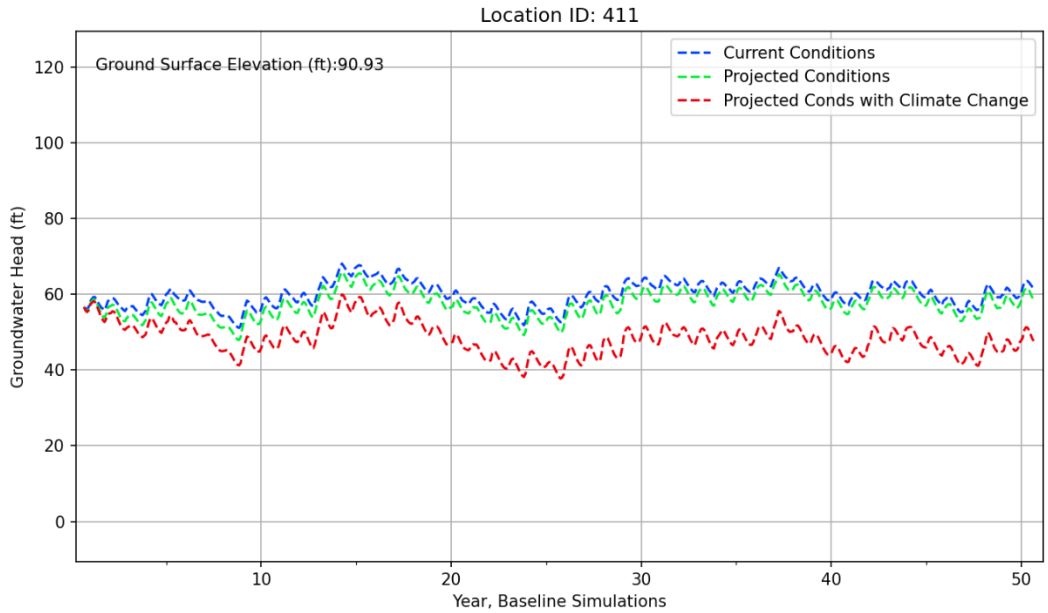
Projected Conditions Baseline with Climate Change Groundwater Budget Summary, Annual Average over 50-year Simulation							
Subregion	**Description**	**Deep Percolation**	**Gain from Stream**	**Recharge (Recoverable Loss)**	**Boundary Inflow**	**Net Subsurface Inflow**	**Pumping**
		(Acre-Feet)	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*	*(Acre-Feet)*
North American Subbasin							
1	Camp Far West ID	6,384	-3,554	651	2,802	-206	6,080
2	Sutter Co. 1	309	228	0	1,320	-1,184	673
3	South Sutter WD GSA	53,890	37,614	10,623	4,994	17,602	126,237
4	Placer County WA	26,028	2,902	898	1,483	2,003	33,355
5	Nevada ID	6,157	732	1,257	4,278	-9,411	2,892
6	Lincoln	4,928	664	0	483	-3,730	1,193
7	RD1001	16,409	7,802	1,148	1,380	-3,857	22,843
8	Pleasant Grove Verona MWC	5,050	8,165	1,384	0	-773	13,840
9	Sutter Co. 2	1,311	372	142	1,545	-1,108	2,321
10	Natomas MWC (Sutter Co.)	4,513	9,390	139	79	313	15,205
11	Sutter Co. 3	1,613	1,126	0	0	4,776	7,972
12	Roseville SOI	1,193	1,131	0	0	-155	2,345
13	City of Roseville	5,481	5,491	2,108	2,677	-12,114	1,877
14	Cal Am (West Placer)	2,330	4,464	0	0	-1,276	5,799
15	Natomas MWC (Sacramento Co.)	6,269	-1,584	234	3,962	-3,219	6,644
16	Sacramento International Airport	685	0	0	0	-33	812
17	Metro Air Park	426	0	0	0	-492	52
18	Sac Co. 1	671	-2,612	0	4,558	-2,055	616
19	Sac Co. 2	96	2,742	0	0	-1,480	1,455
20	Sac County WA (Northgate 880)	56	663	0	0	866	1,614
21	Rio Linda Elverta	1,708	6,397	0	0	3,469	12,029
22	Sac Co. 3	88	827	0	0	-595	341
23	Cal Am (Antelope)	520	691	0	0	2,870	4,111
24	Cal Am (Lincoln Oaks)	442	0	0	0	5,186	5,564
25	Citrus Heights WD	1,558	0	0	438	-737	1,130
26	San Juan WD (Placer Co.)	431	0	0	1,460	-2,016	0
27	San Juan WD (Sacramento Co.)	618	-548	0	772	-823	97
28	Orange Vale WC	1,193	0	0	0	-926	294
29	Lake Natoma/Mississippi Bar	1,600	-5,291	0	34	3,762	98
30	Fair Oaks WD	2,761	6,285	0	0	-5,475	3,615
31	Carmichael WD	1,024	6,582	0	0	-3,363	4,342
32	Sacramento Suburban WD (North)	2,480	50	0	0	14,128	16,883
33	Sacramento Suburuban WD (South)	797	7,717	0	0	7,148	15,864
34	Del Paso Manor WD	58	0	0	0	1,134	1,214
35	Golden State WC Arden	29	0	0	0	756	800
36	Cal Am (Arden)	66	0	0	0	1,045	1,123
37	Sac County WA (Arden Park	163	1,101	0	0	1,925	3,227
38	City of Sacramento (North)	3,413	19,844	0	990	-4,170	20,664
Total NASb		162,749	119,391	18,585	33,255	7,782	345,219
South American Subbasin							
39	City of Sacramento (South)	16,708	19,971	0	1,635	-18,250	21,113
40	Cal Am (Suburban Rosemont)	1,758	7,462	0	0	2,813	12,402
41	Sac Co. 4	266	2,940	0	0	-3,188	27
42	Golden State WC (Cordova)	7,090	14,997	0	0	-2,062	20,282
43	Sac Co. 5	1,478	0	0	0	4,683	6,245
44	City of Folsom	14,446	-2,148	0	2,013	-11,789	2,475
45	Cal Am (Security Park)	1,391	38	0	0	-1,303	239
46	Fruitridge Vista WC	311	278	0	0	1,542	2,191
47	Florin County WD	136	0	0	0	2,038	2,278
48	Cal Am (Parkway)	1,051	359	0	0	12,906	14,625
49	Sac Co. 6	913	5,011	0	302	-5,991	250
50	Sac County WA (North/Central)	13,021	4,022	209	0	9,027	28,605
51	Sac County WA (South)	2,803	213	0	0	14,509	17,786
52	Elk Grove WD (2 - Intertie Service Area)	1,193	1,192	0	0	2,963	5,605
53	Elk Grove WD (1 - GW Service Area)	352	668	0	0	5,513	6,664
54	Cosumnes River West	20,558	12,903	0	0	20,076	54,127
55	RD744	770	7,865	0	-605	-7,101	882
56	Franklin Drainage District	3,213	7,420	0	-49	-5,292	5,172
57	RD813	1,478	3,923	0	44	-3,524	1,867
58	RD755	522	1,961	0	-127	-1,689	644
59	RD1002	2,885	0	0	0	647	3,552
60	RD551	8,342	8,551	0	-968	-8,129	7,658
61	RD369	395	2,387	0	-141	-2,459	173
62	RD2110	667	-80	0	647	-765	460
63	Sac Co. 7	316	1,758	0	59	-1,807	334
64	Rancho Murieta (North)	4,788	-2,129	0	0	-1,887	658
65	Sloughouse RCD (North)	4,624	217	0	3,782	-6,084	2,473
66	OHWD (Sth American Subbasin)	11,032	15,967	26	60	-633	27,200
Total SASb		122,508	115,747	235	6,653	-5,232	245,986
Cosumnes Subbasin							
67	OHWD (Cosumnes Subbasin)	5,341	5,815	0	0	-4,966	6,623
68	Rancho Murieta (South)	1,095	-2,043	0	0	958	16
69	Sloughouse RCD (East)	21,910	3,688	0	1,094	-6,550	23,246
70	Wilton	4,623	45	0	0	4,353	9,809
71	Sloughouse RCD (West)	3,778	409	0	0	4,969	9,934
72	Galt ID (East)	18,352	1,928	0	0	24,803	47,573
73	Clay WD	3,368	1,112	0	0	2,873	7,886
74	Clay	977	3	0	0	744	2,040
75	SMUD Rancho Seco	448	0	0	0	-594	54
76	Cosumnes River South	4,481	11,014	0	-404	-6,143	9,084
77	Galt ID (West)	2,241	767	0	0	2,072	5,230
78	Sac Co. 8	3,795	8,781	0	0	-7,484	5,517
79	City of Galt	1,277	659	0	0	5,614	7,742
80	Sloughouse RCD (South)	777	974	0	0	-790	1,065
81	Amador Co. 1	13,068	-6,388	0	4,209	-9,703	968
82	Ione	1,194	0	0	0	-1,002	0
83	Jackson ID	8,289	-6,033	0	485	-2,765	17
84	Camanche	4,849	0	0	-3,840	-1,251	94
85	Amador County WA	1,316	0	0	7	-1,046	379
87	Galt WWTP	311	0	0	0	-330	0
Total CoSb		101,490	20,732	0	1,552	3,763	137,276
Other							
86	Mokelumne	27,801	53,146	0	9,567	-6,313	87,852
Total Other		27,801	53,146	0	9,567	-6,313	87,852
CoSANA Total (NASb, SASb, CoSb)		386,746	255,871	18,820	41,460	6,313	728,482

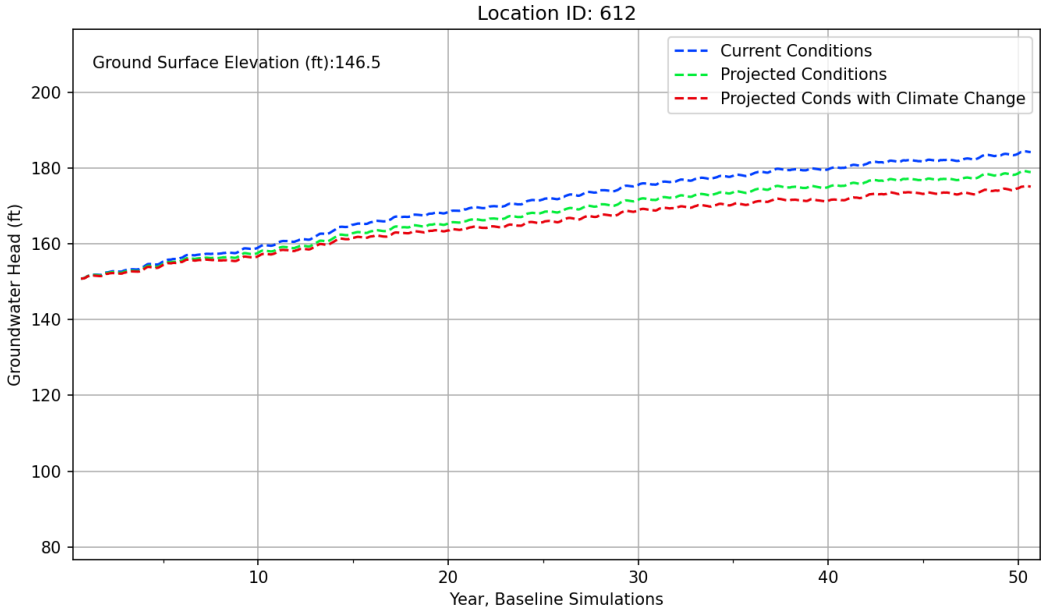
APPENDIX J: BASELINE CONDITIONS SAMPLE HYDROGRAPHS

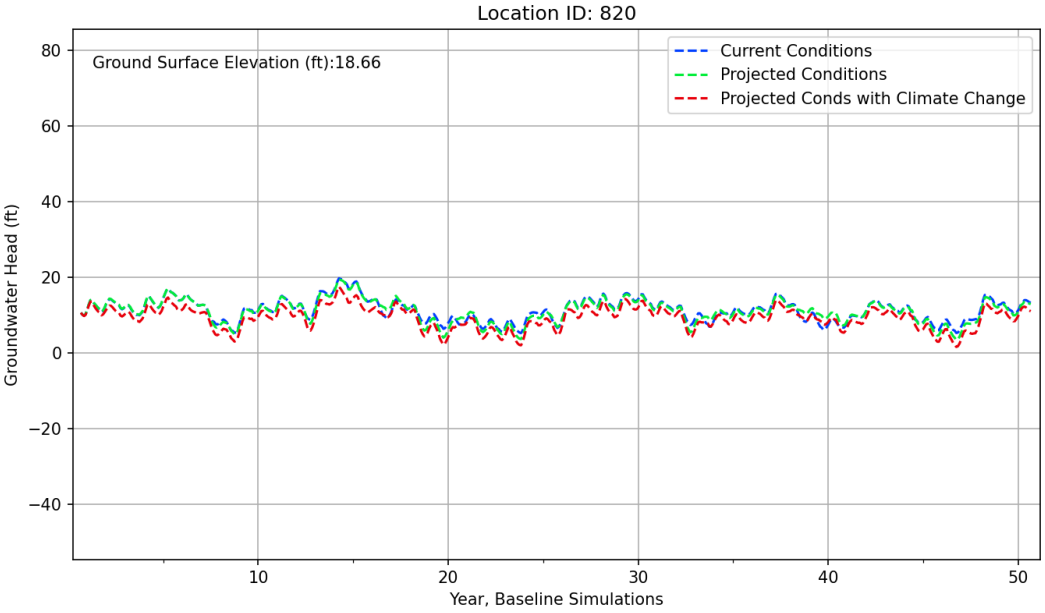
Note: *Simulated values represent the layers screened at that well, except for 7223 and 7224 which do not have screen interval information.*

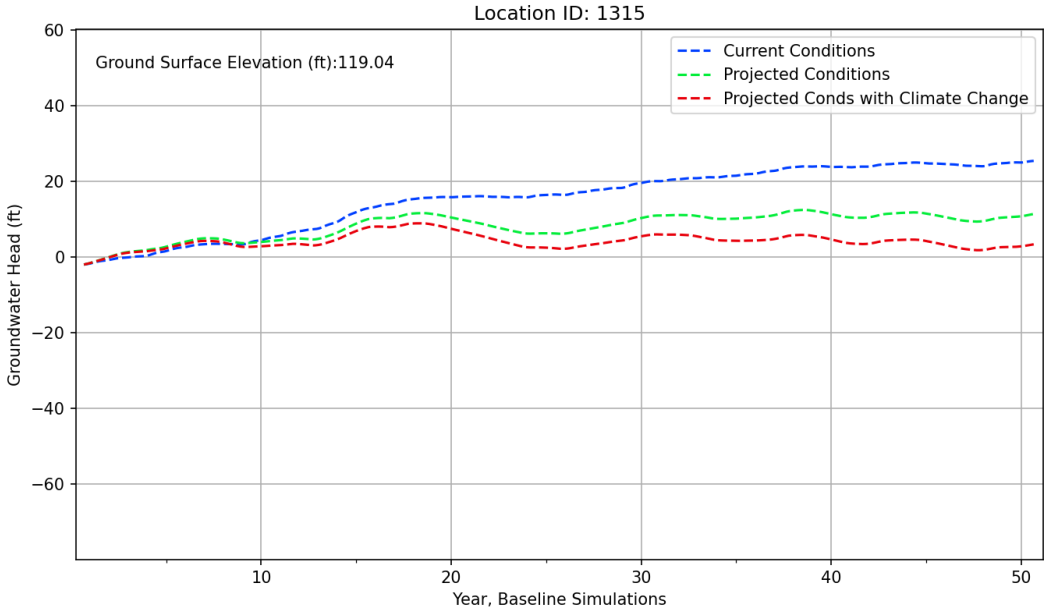


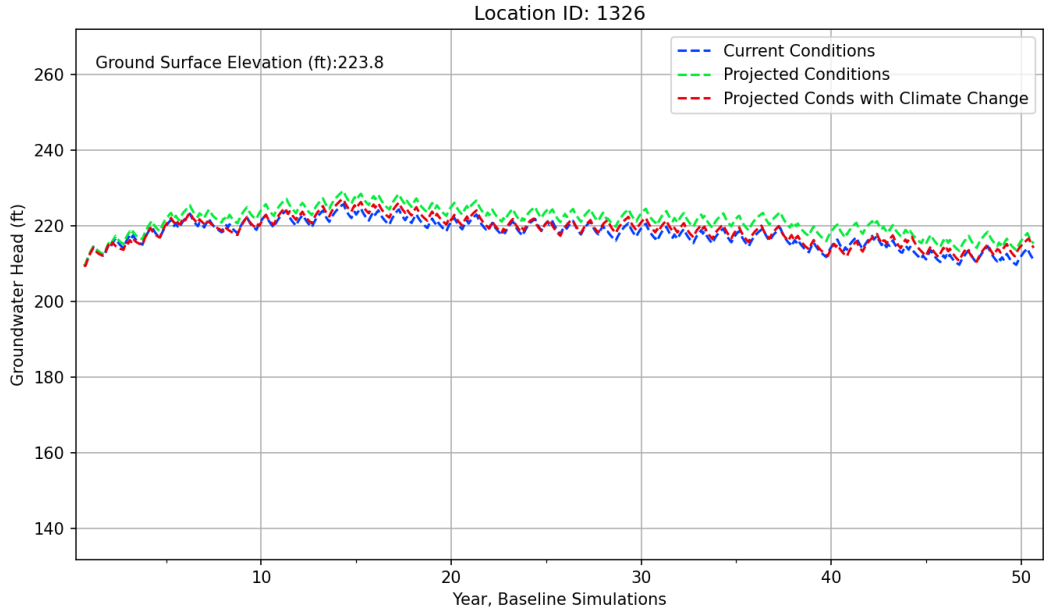

Location ID: 330
Ground Surface Elevation (ft):48.4
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
Year, Baseline Simulations

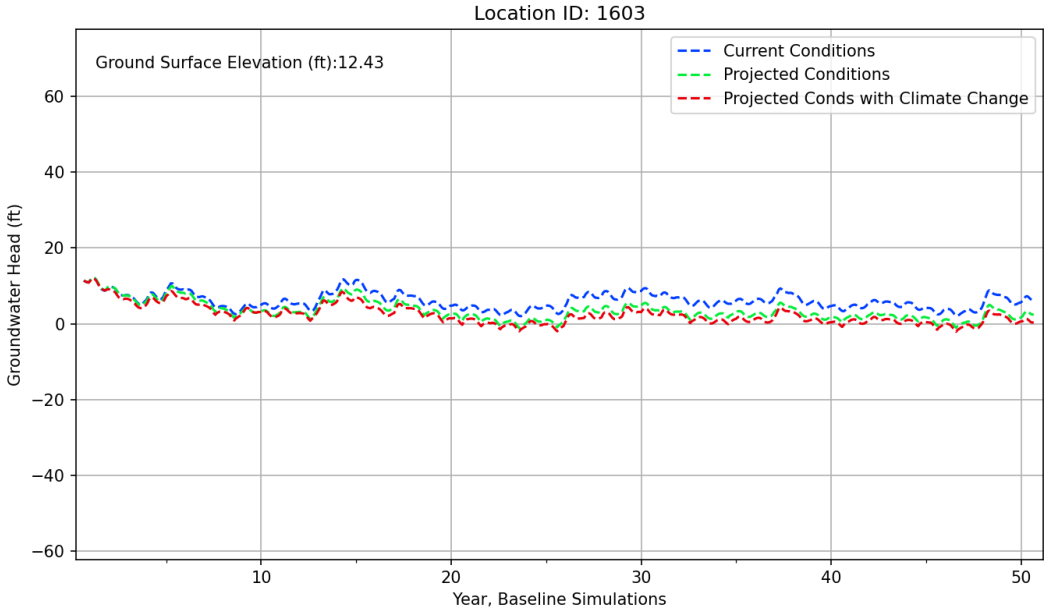

Location ID: 411
Ground Surface Elevation (ft):90.93
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
Year, Baseline Simulations

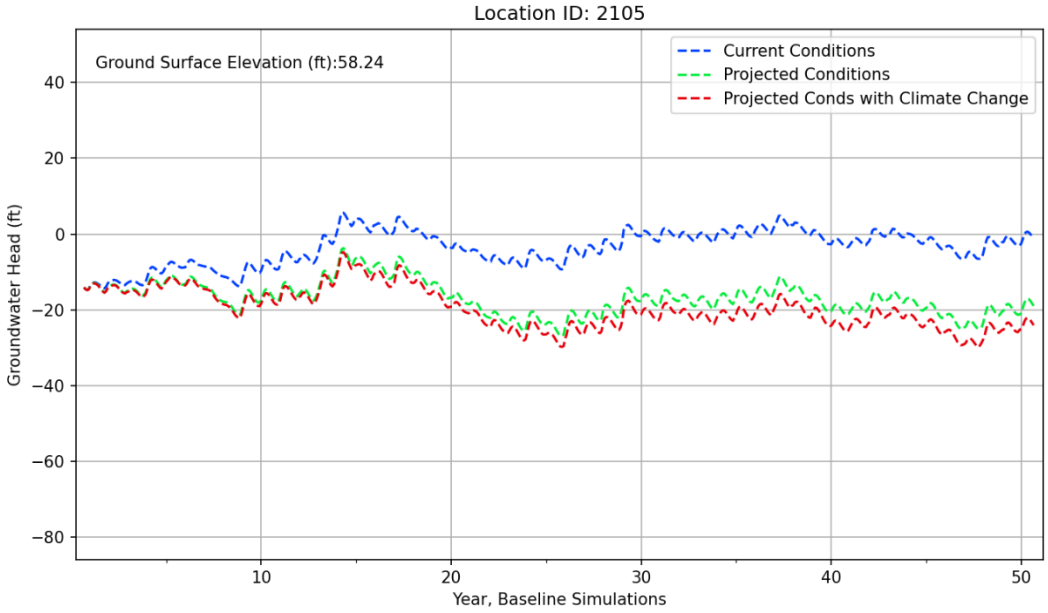

Location ID: 612
Ground Surface Elevation (ft):146.5
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
200
180
160
140
120
100
80
10
20
30
40
50
Year, Baseline Simulations

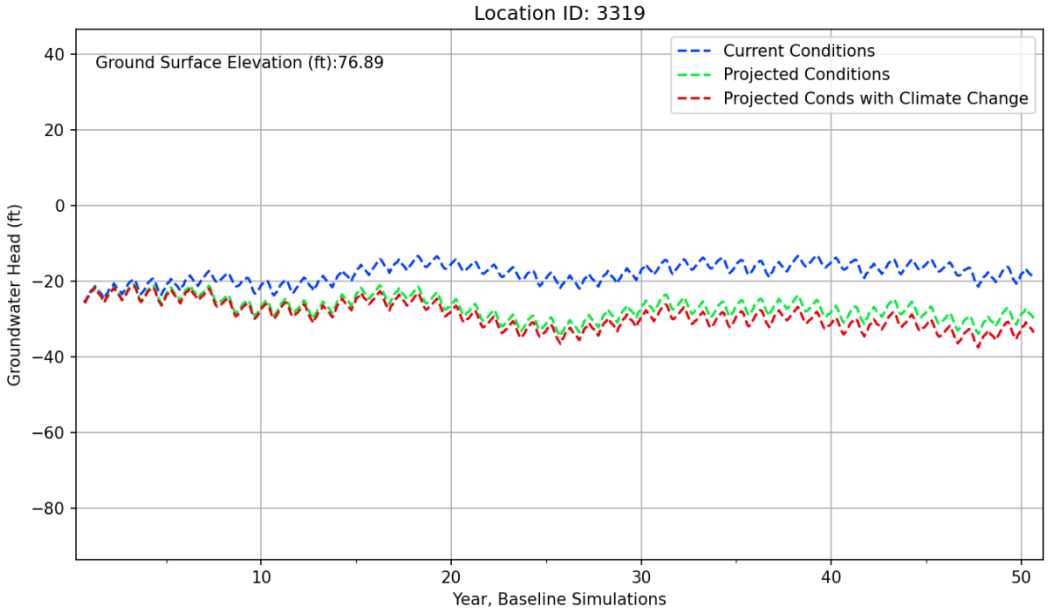

Location ID: 820
Ground Surface Elevation (ft):18.66
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
80
60
40
20
0
−20
−40
10
20
30
40
50
Year, Baseline Simulations

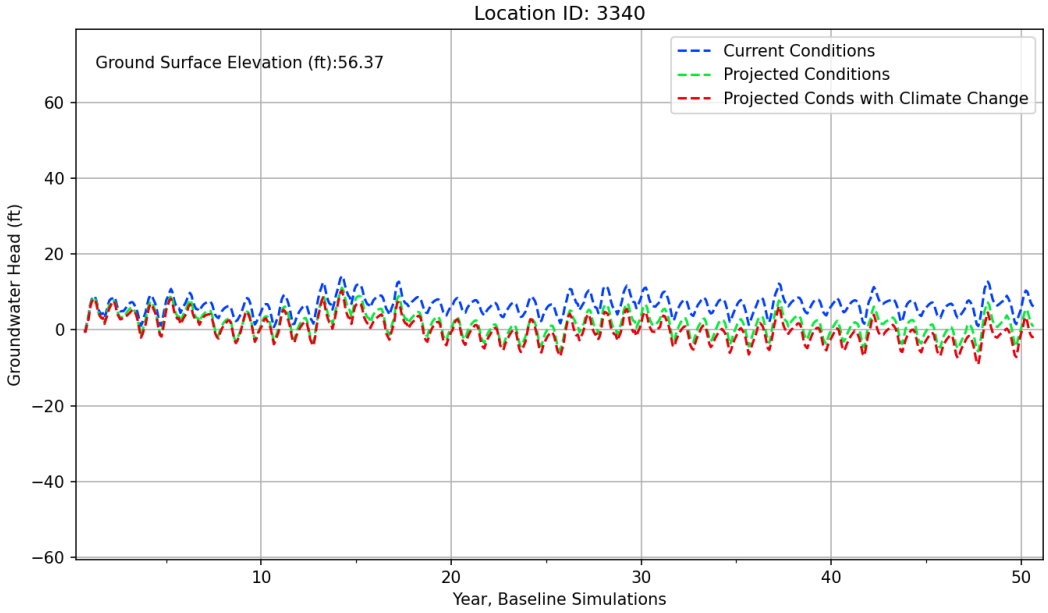

Location ID: 1315
Ground Surface Elevation (ft):119.04
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

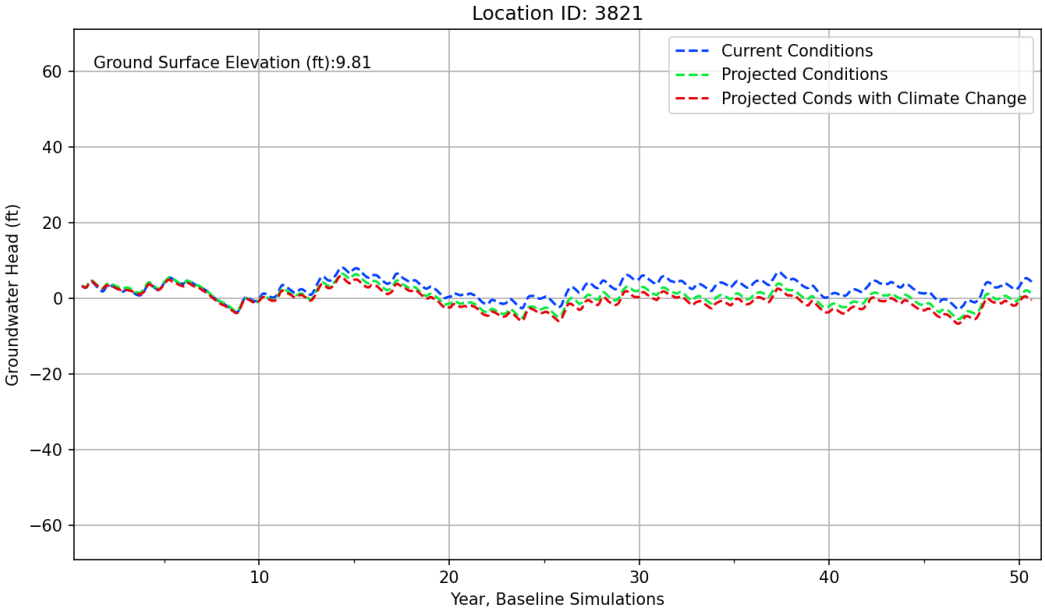

Location ID: 1326
Ground Surface Elevation (ft):223.8
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
260
240
220
200
180
160
140
10
20
30
40
50
Year, Baseline Simulations

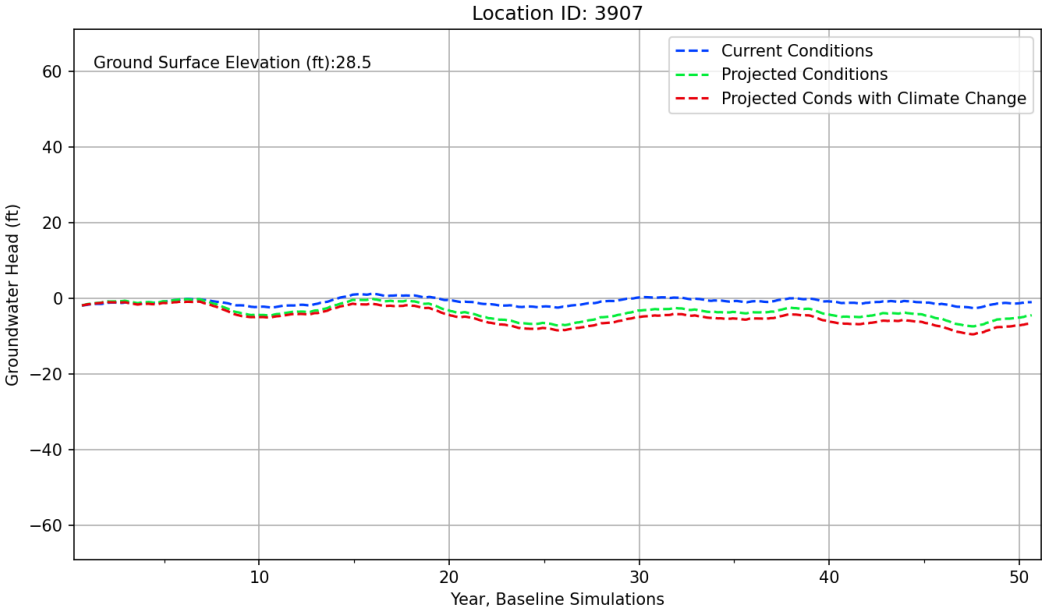

Location ID: 1603
Ground Surface Elevation (ft):12.43
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

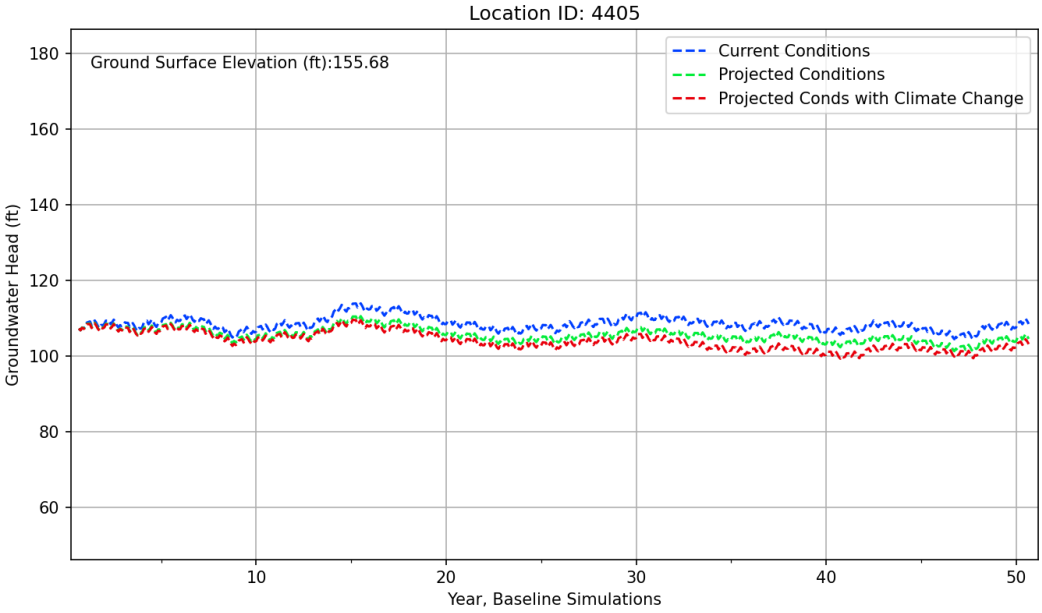

Location ID: 2105
Ground Surface Elevation (ft):58.24
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
40
20
0
−20
−40
−60
−80
10
20
30
40
50
Year, Baseline Simulations

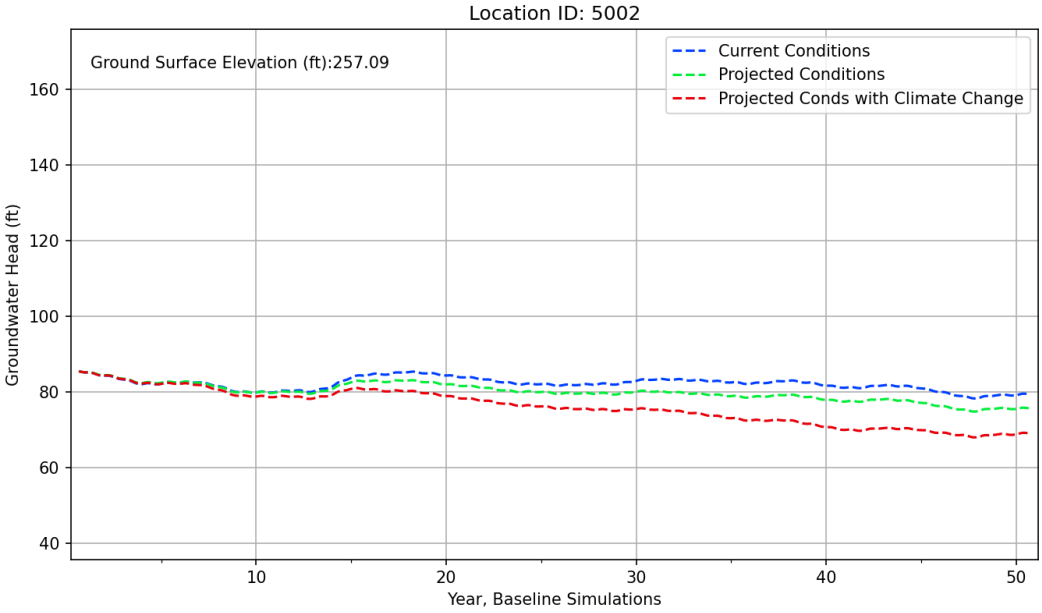

Location ID: 3319
Ground Surface Elevation (ft):76.89
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
40
20
0
−20
−40
−60
−80
10
20
30
40
50
Year, Baseline Simulations

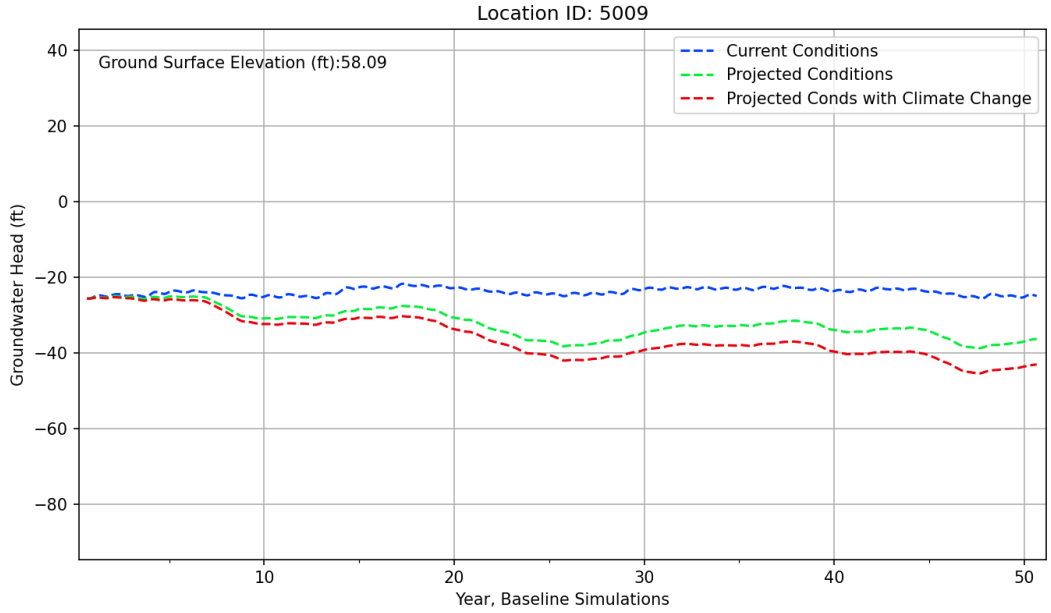

Location ID: 3340
Ground Surface Elevation (ft):56.37
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

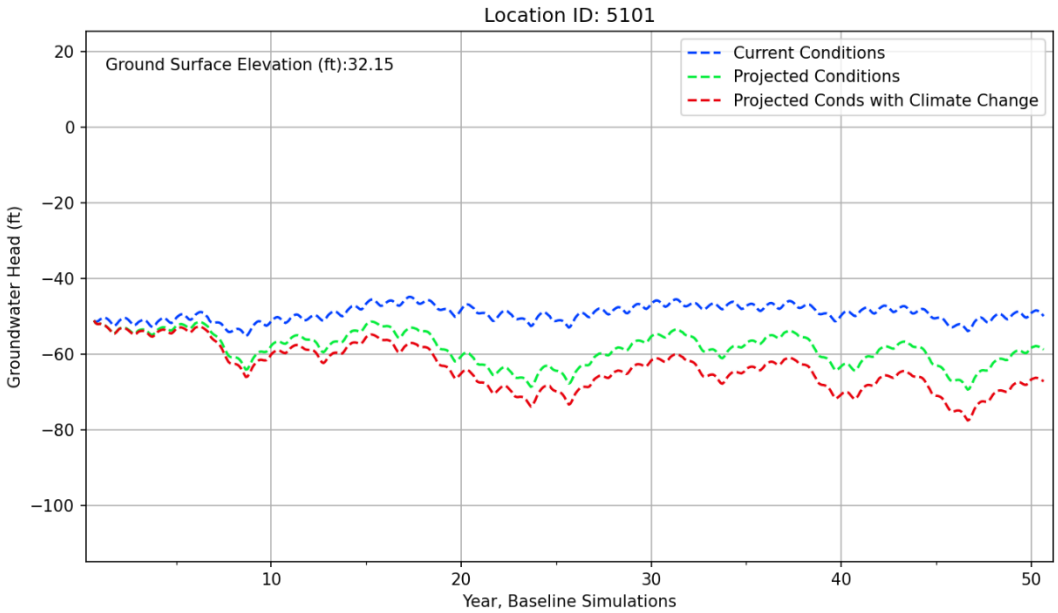

Location ID: 3821
Ground Surface Elevation (ft):9.81
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

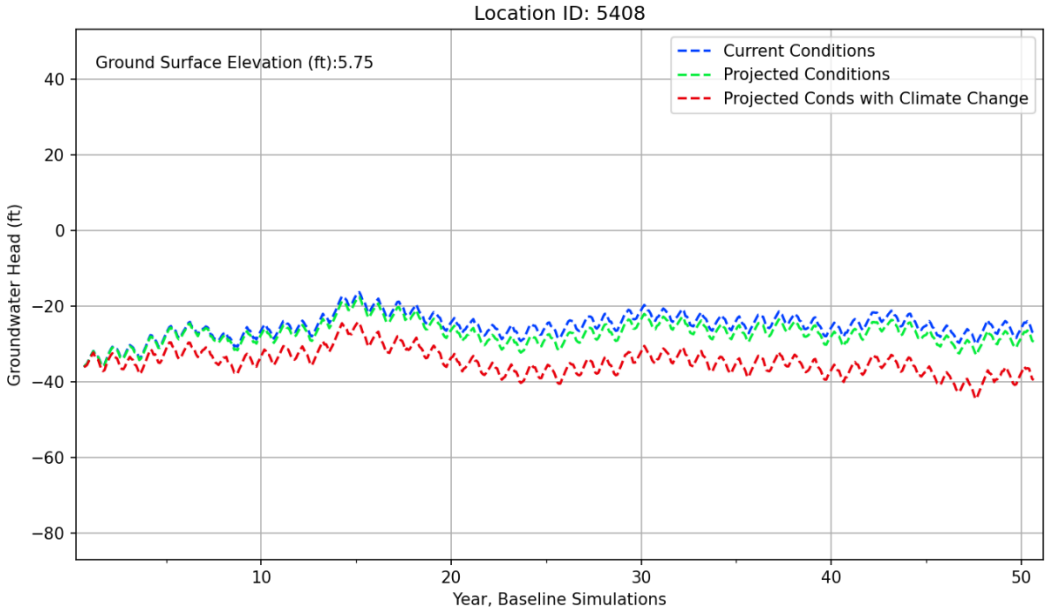

Location ID: 3907
Ground Surface Elevation (ft):28.5
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

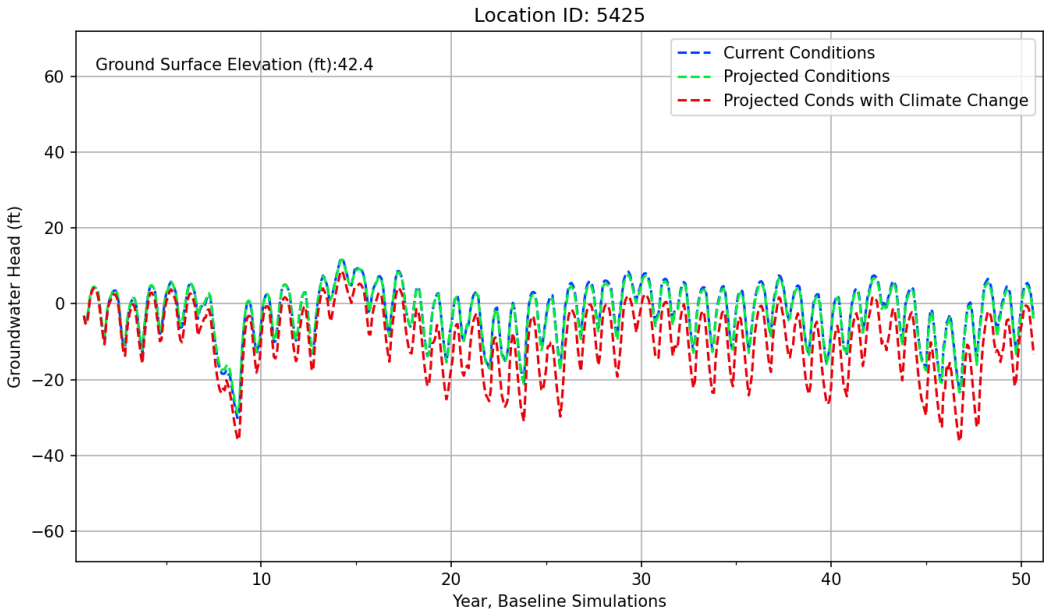

Location ID: 4405
Ground Surface Elevation (ft):155.68
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
180
160
140
120
100
80
60
10
20
30
40
50
Year, Baseline Simulations

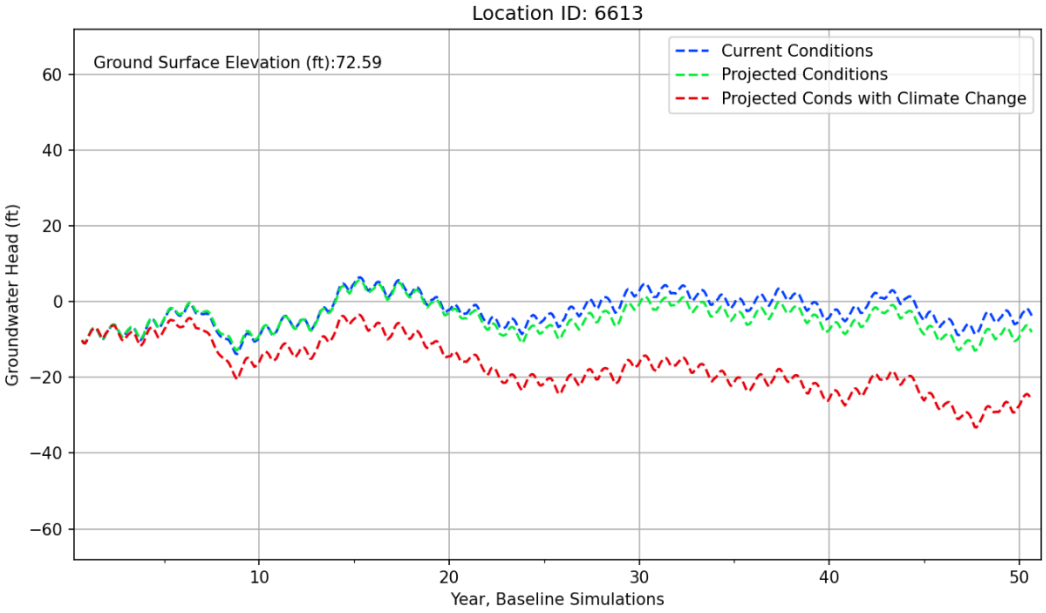

Location ID: 5002
Ground Surface Elevation (ft):257.09
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
160
140
120
100
80
60
40
10
20
30
40
50
Year, Baseline Simulations

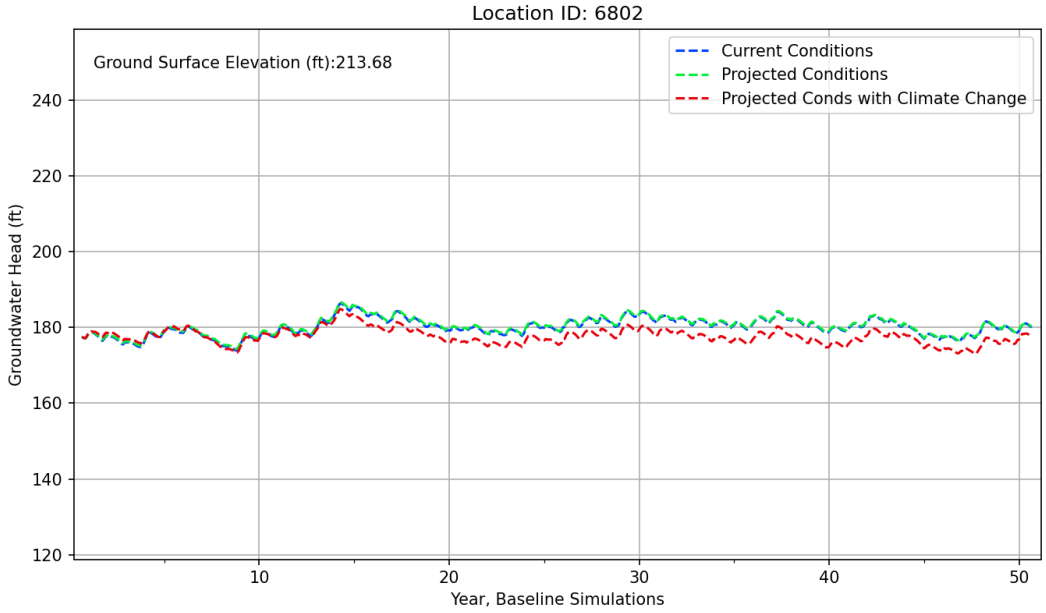

Location ID: 5009
Ground Surface Elevation (ft):58.09
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
40
20
0
−20
−40
−60
−80
10
20
30
40
50
Year, Baseline Simulations

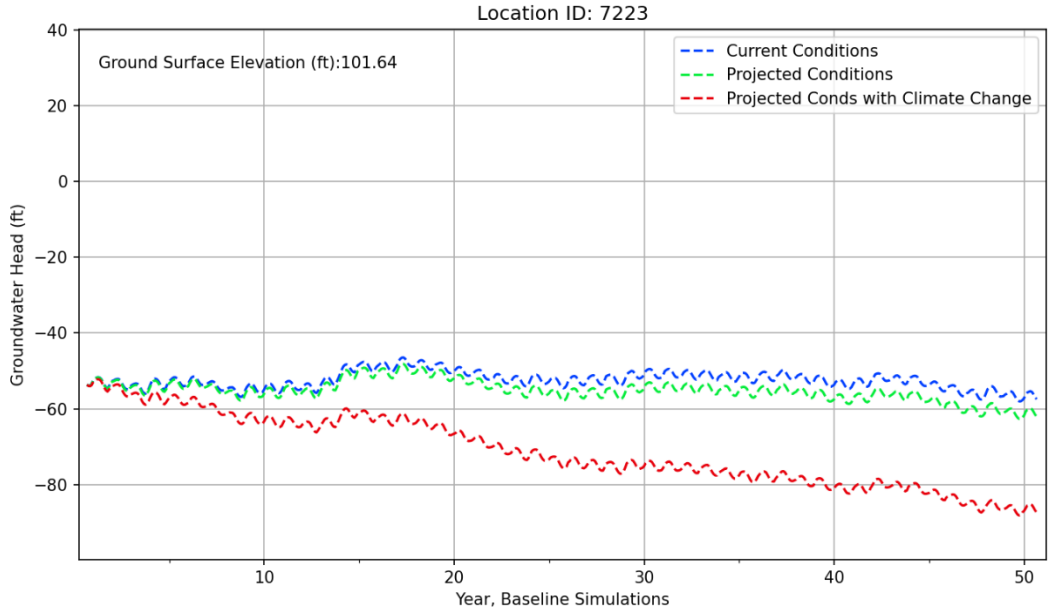

Location ID: 5101
Ground Surface Elevation (ft):32.15
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
20
0
−20
−40
−60
−80
−100
10
20
30
40
50
Year, Baseline Simulations

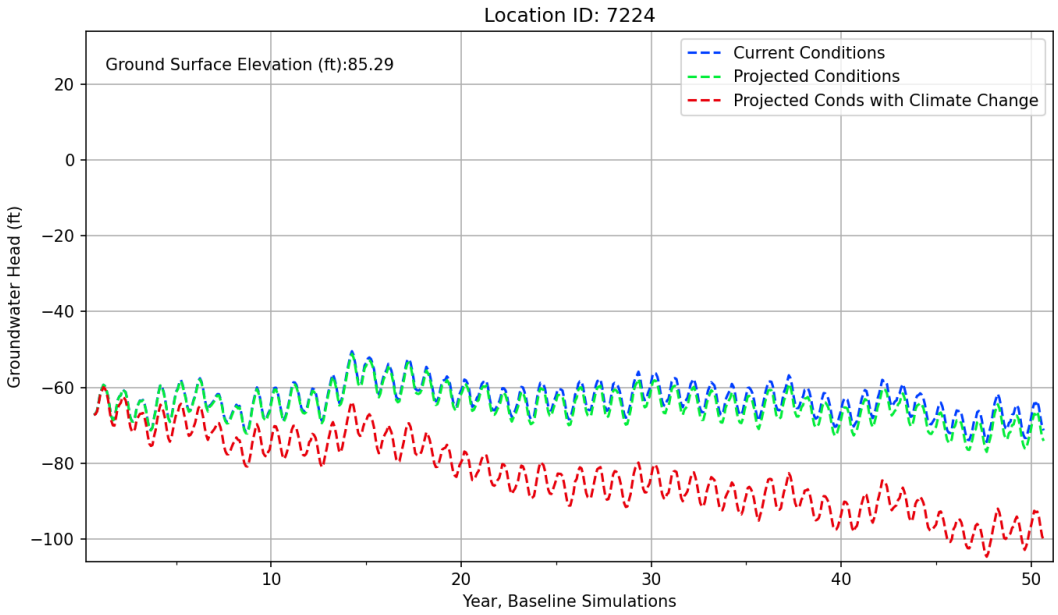

Location ID: 5408
Ground Surface Elevation (ft):5.75
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
40
20
0
−20
−40
−60
−80
10
20
30
40
50
Year, Baseline Simulations

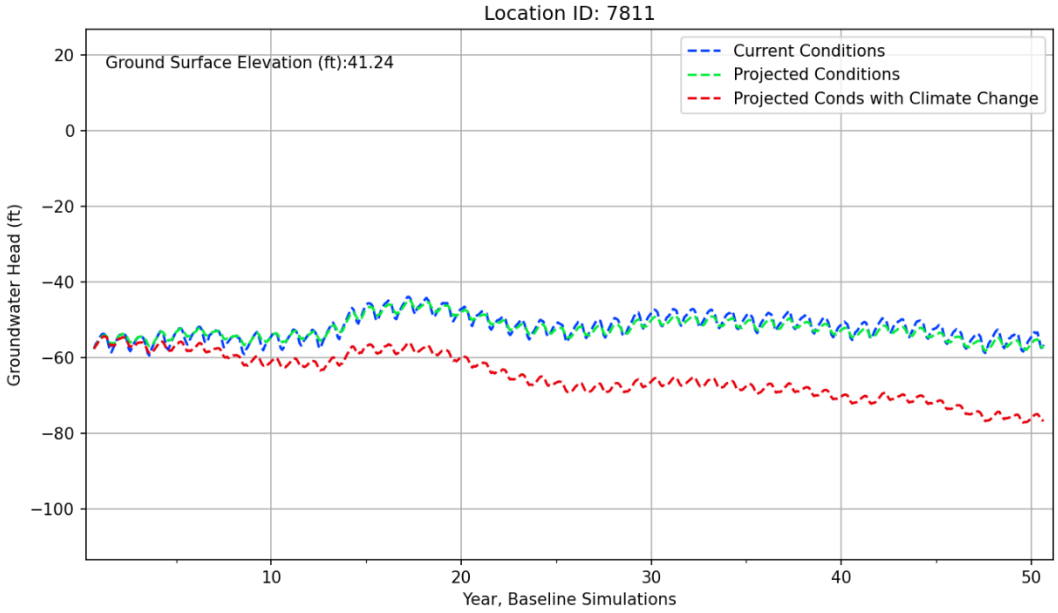

Location ID: 5425
Ground Surface Elevation (ft):42.4
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

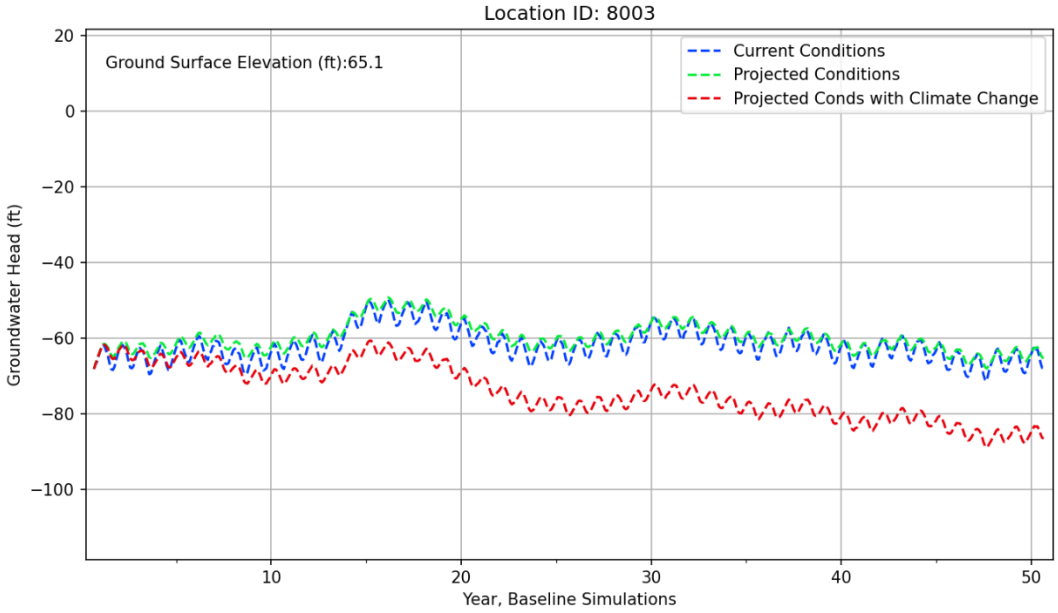

Location ID: 6613
Ground Surface Elevation (ft):72.59
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
60
40
20
0
−20
−40
−60
10
20
30
40
50
Year, Baseline Simulations

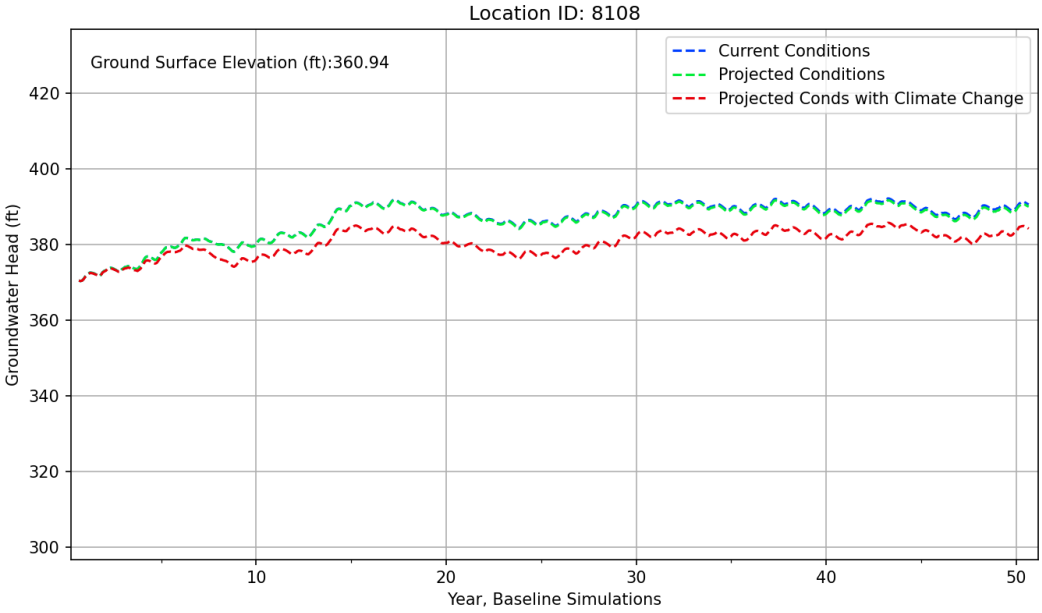

Location ID: 6802
Ground Surface Elevation (ft):213.68
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
240
220
200
180
160
140
120
10
20
30
40
50
Year, Baseline Simulations

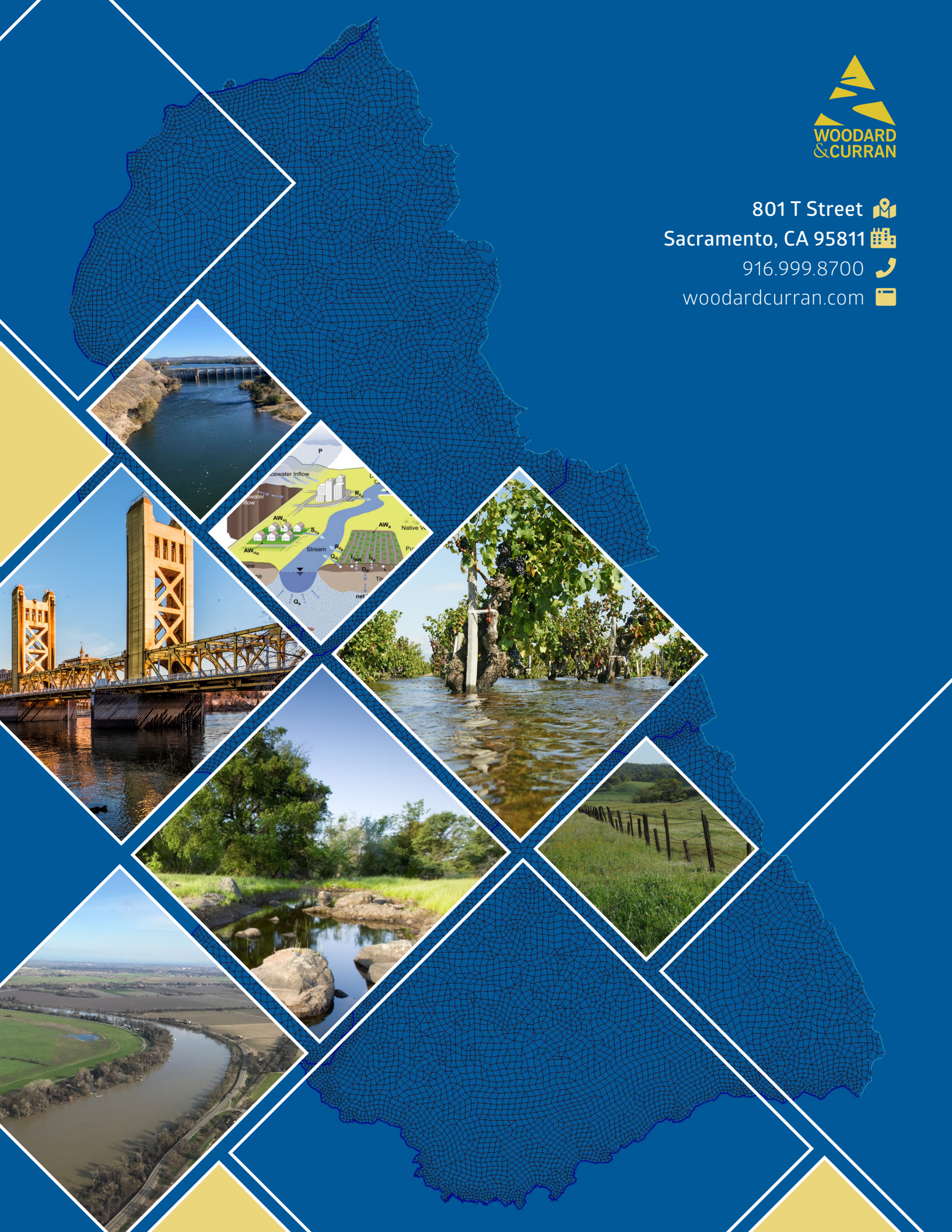

Location ID: 7223
Ground Surface Elevation (ft):101.64
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
40
20
0
−20
−40
−60
−80
10
20
30
40
50
Year, Baseline Simulations


Location ID: 7224
Ground Surface Elevation (ft):85.29
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
20
0
−20
−40
−60
−80
−100
10
20
30
40
50
Year, Baseline Simulations


Location ID: 7811
Ground Surface Elevation (ft):41.24
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
20
0
−20
−40
−60
−80
−100
10
20
30
40
50
Year, Baseline Simulations


Location ID: 8003
Ground Surface Elevation (ft):65.1
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
20
0
−20
−40
−60
−80
−100
10
20
30
40
50
Year, Baseline Simulations

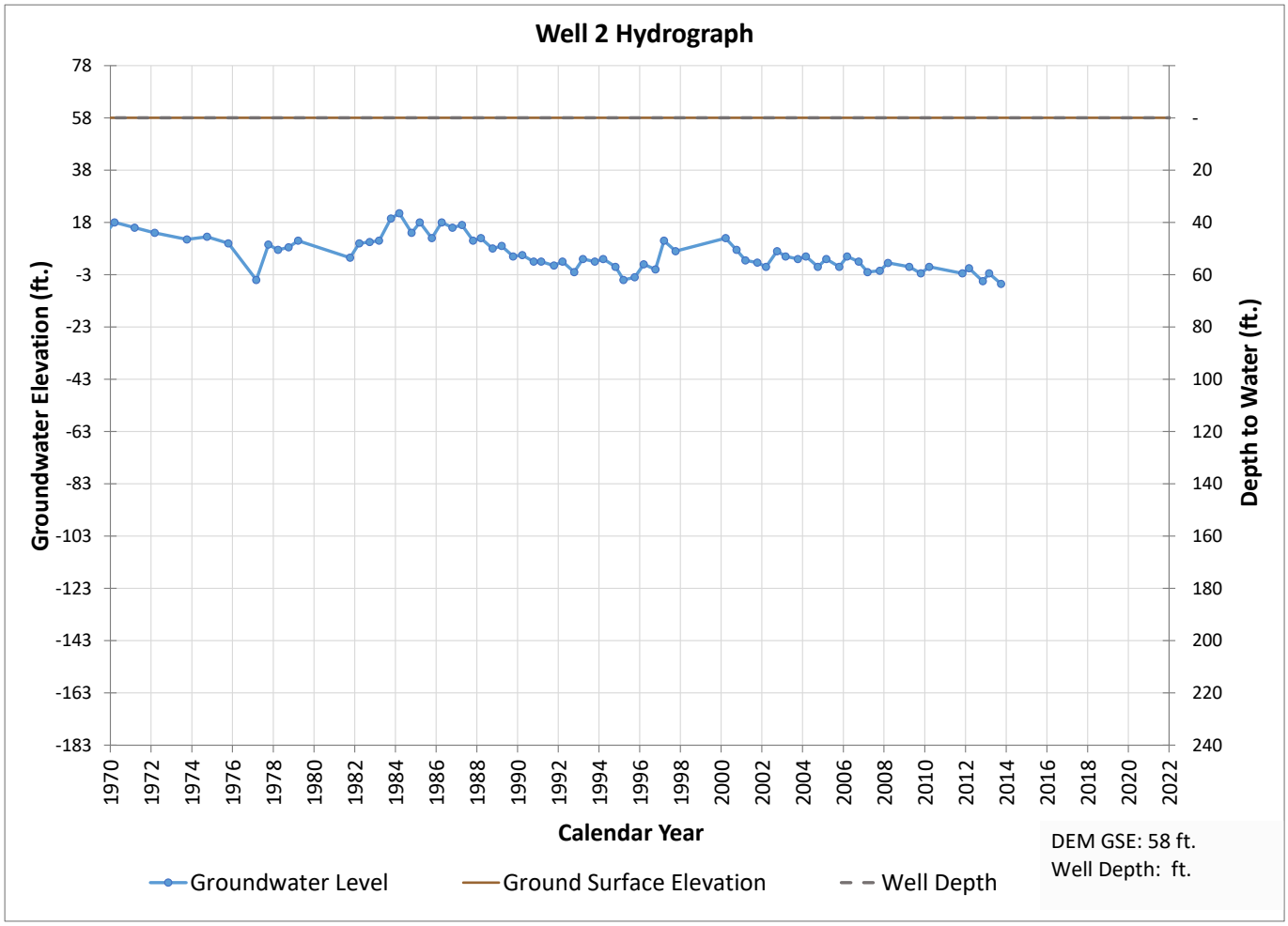

Location ID: 8108
Ground Surface Elevation (ft):360.94
Current Conditions
Projected Conditions
Projected Conds with Climate Change
Groundwater Head (ft)
420
400
380
360
340
320
300
10
20
30
40
50
Year, Baseline Simulations

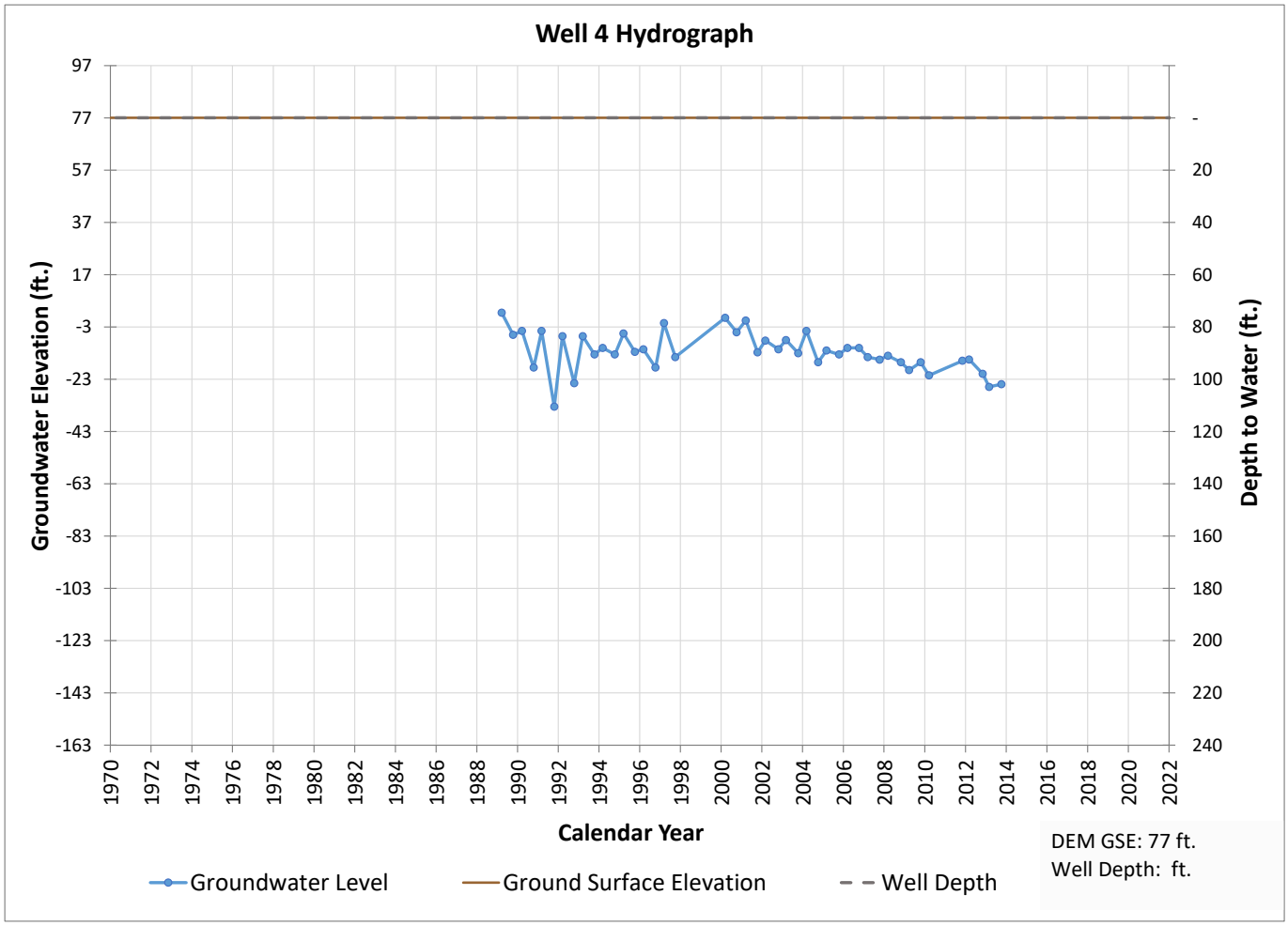


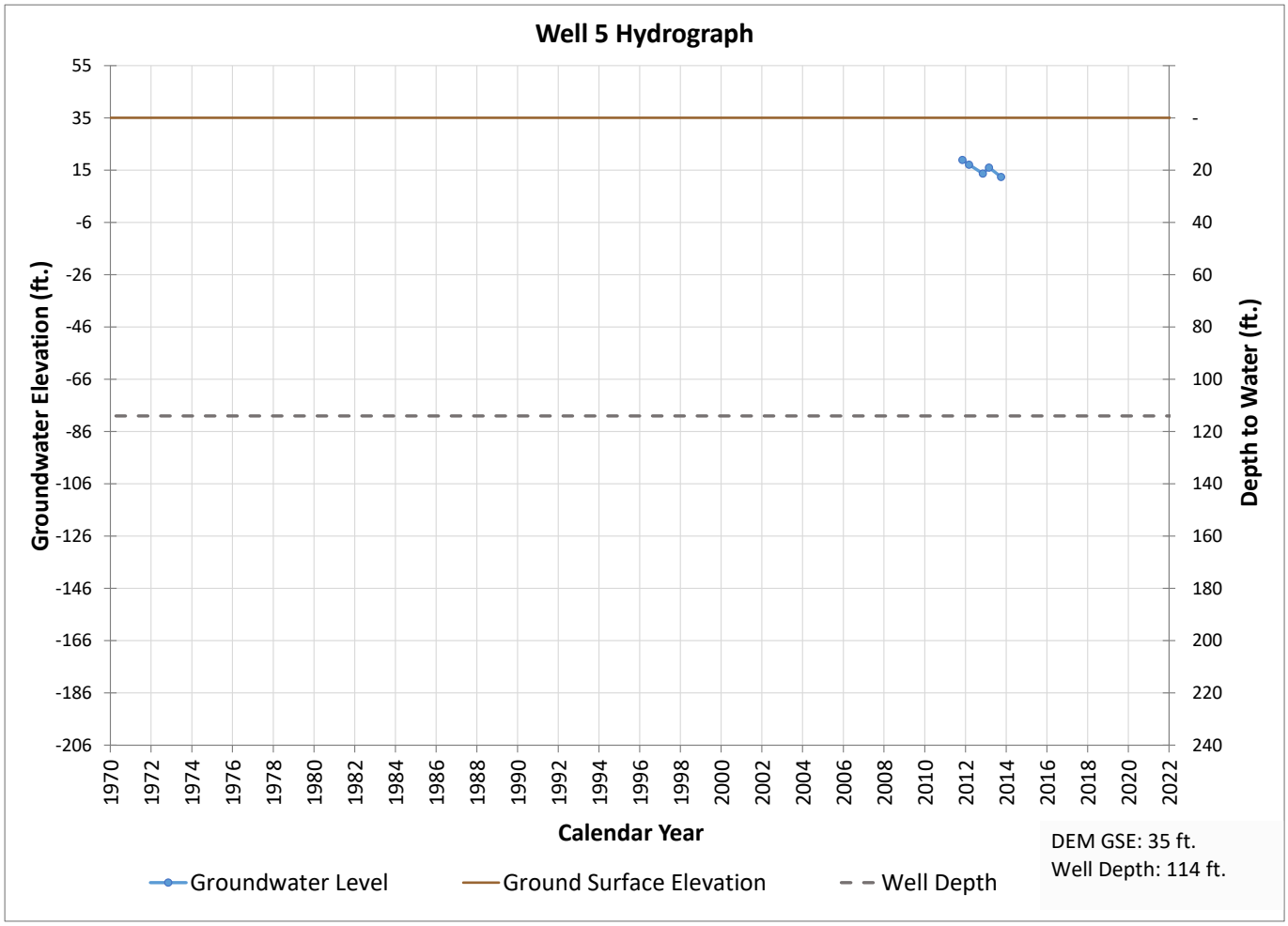
801 T Street
Sacramento, CA 95811
916.999.8700
woodardcurran.com

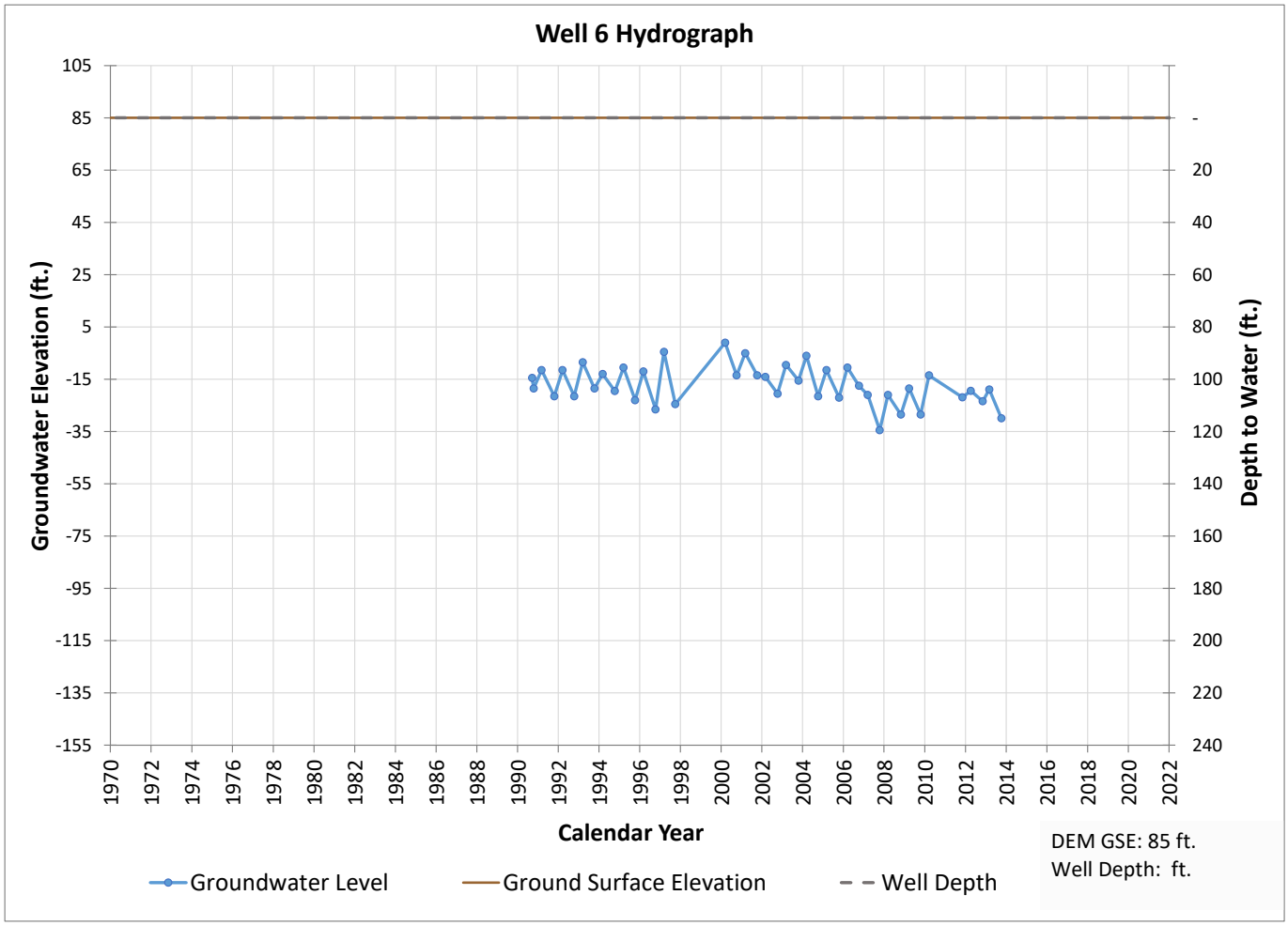
Appendix 2-C

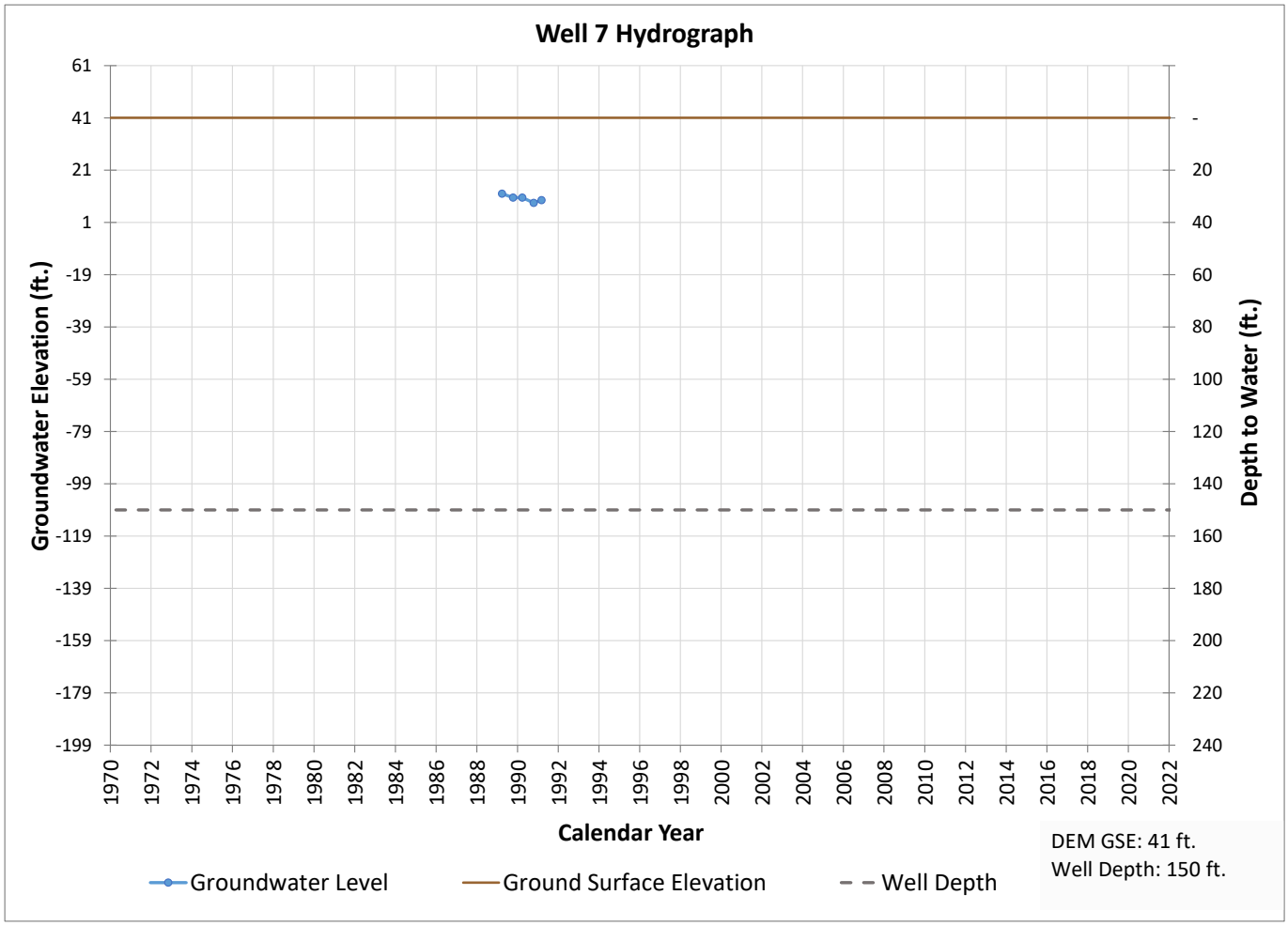
Groundwater Hydrographs

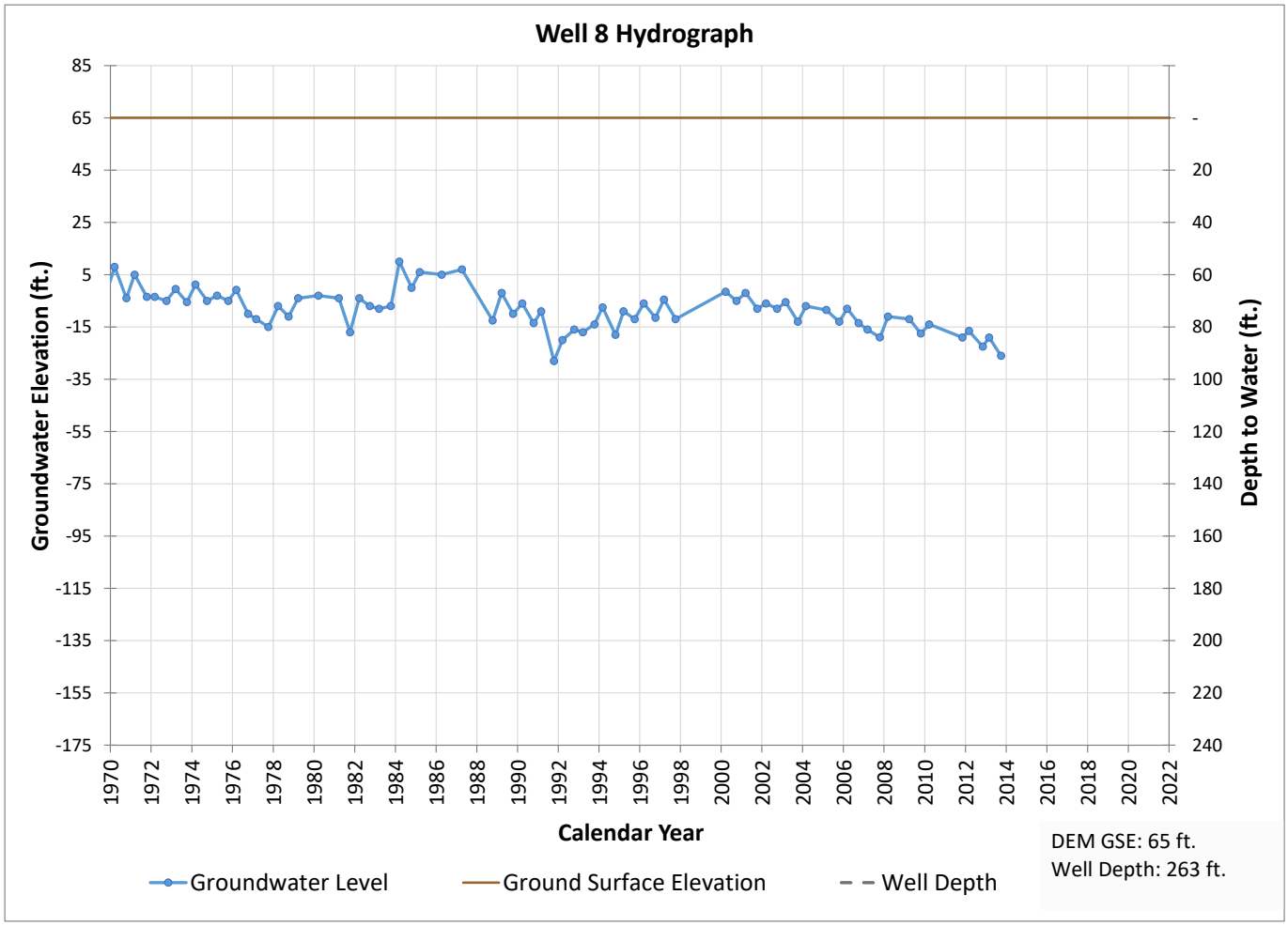

Well 2 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
78
58
38
18
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 58 ft.
Well Depth: ft.

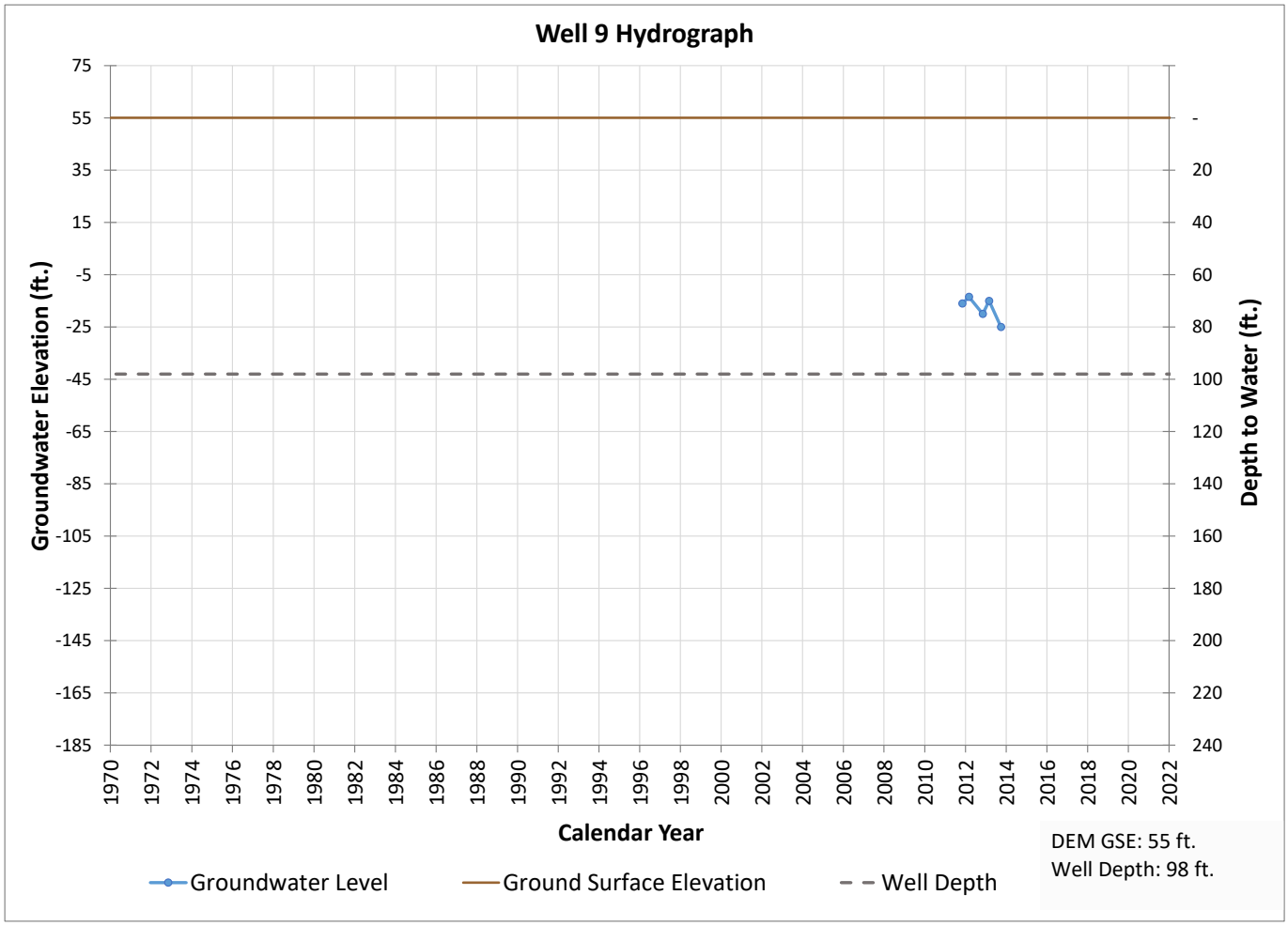

Well 4 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: ft.

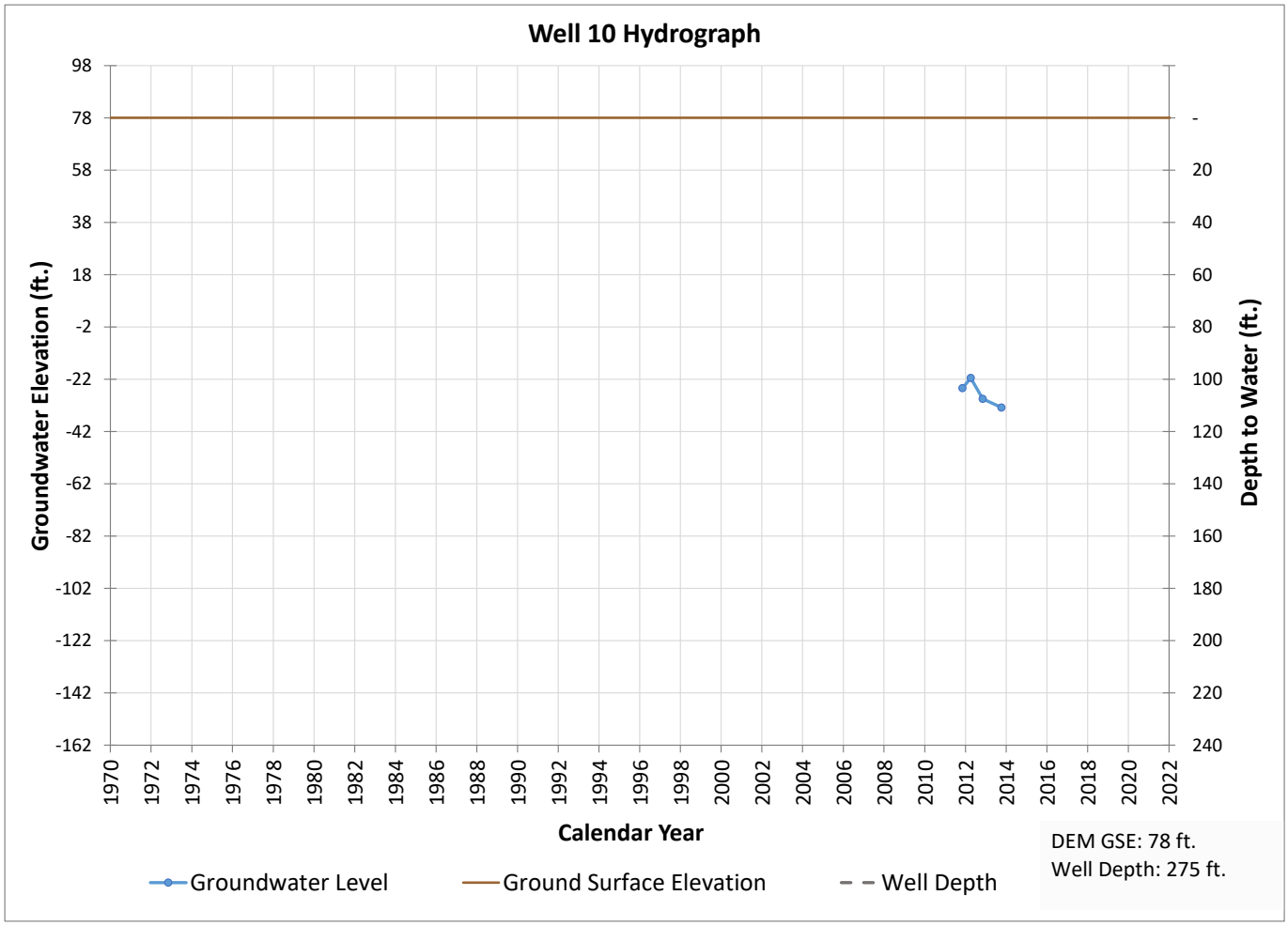

Well 5 Hydrograph
Groundwater Elevation (ft.)
55
35
15
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 35 ft.
Well Depth: 114 ft.

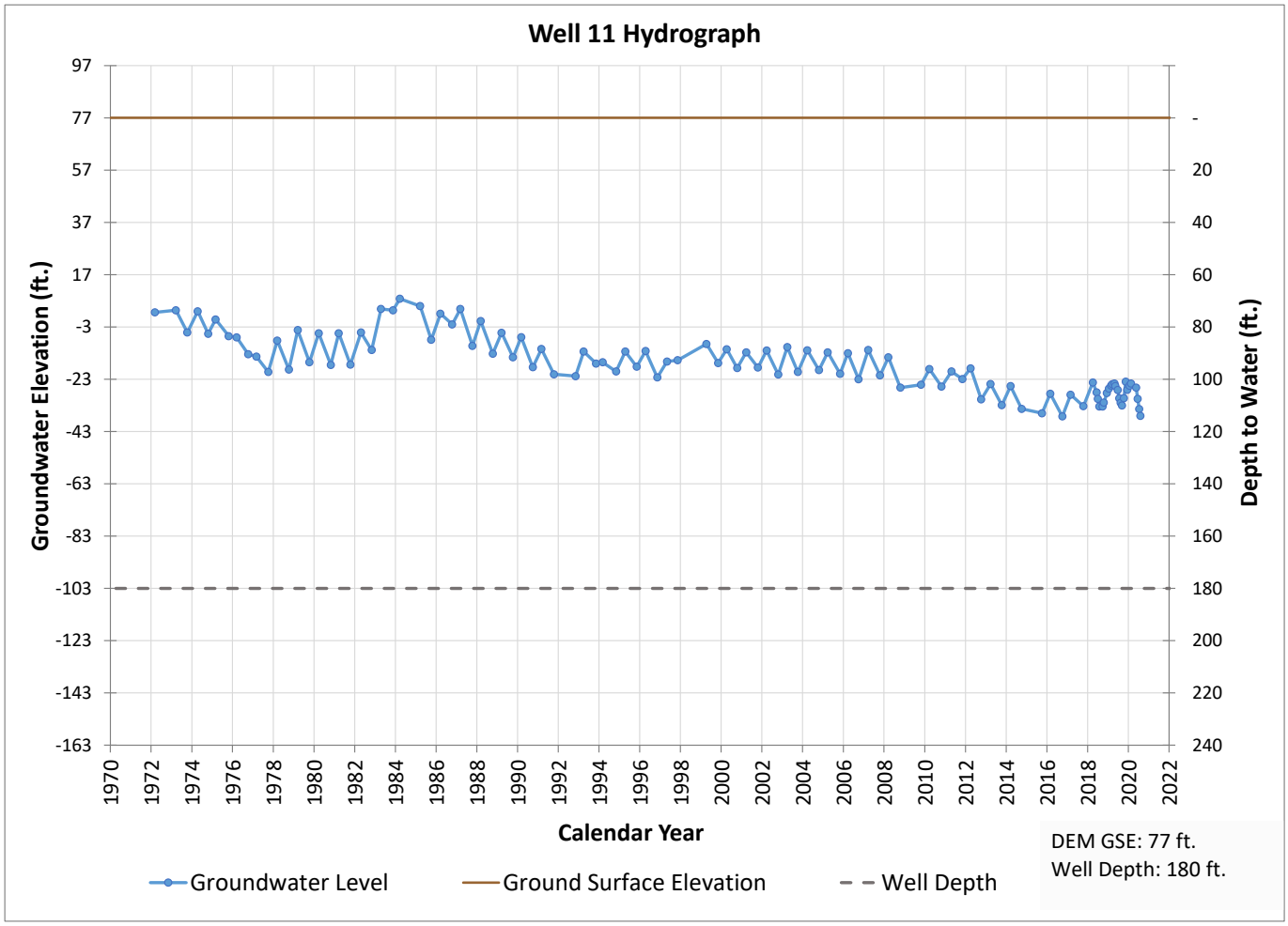

Well 6 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
105
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 85 ft.
Well Depth: ft.

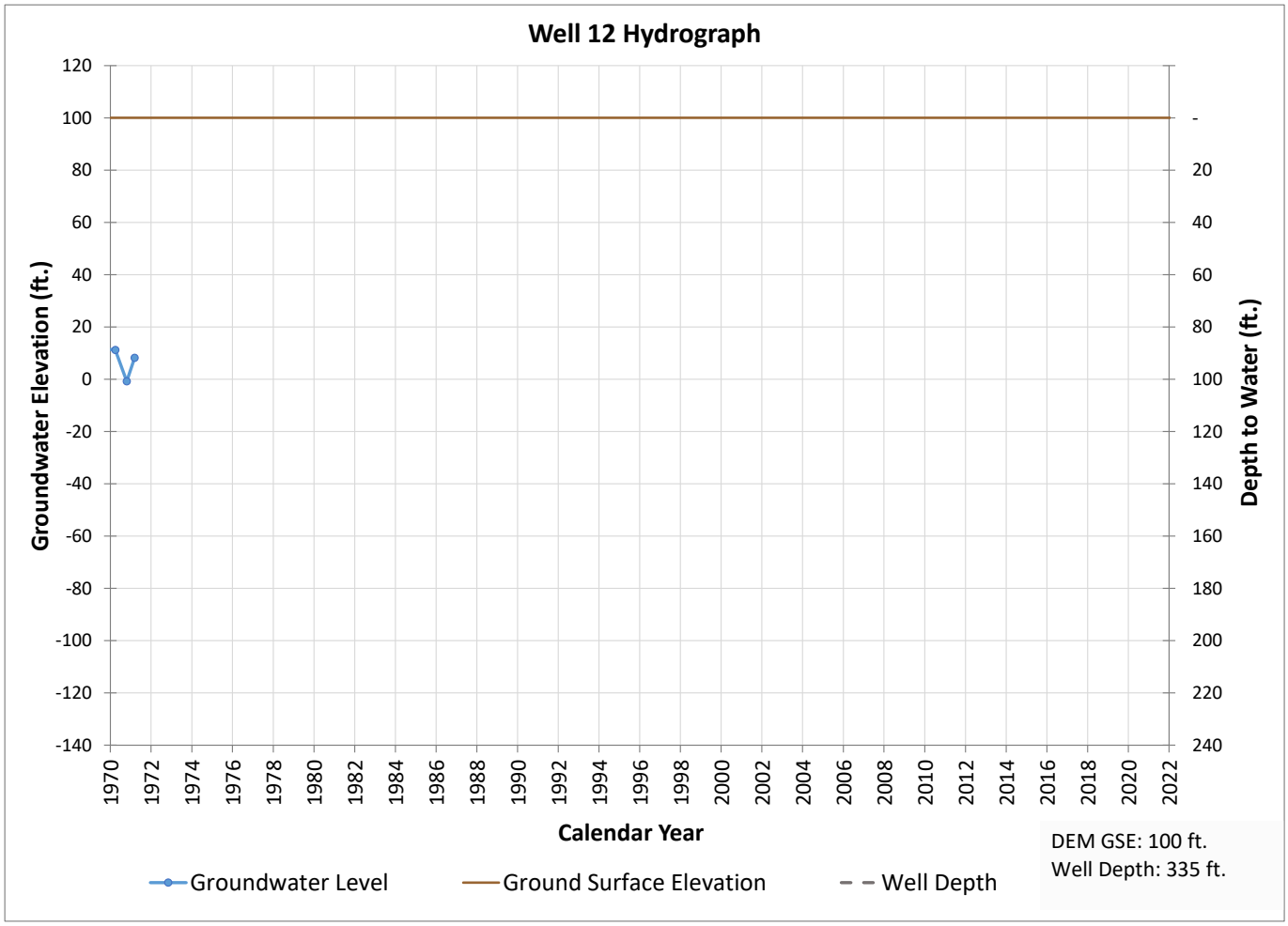

Well 7 Hydrograph
Groundwater Elevation (ft.)
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 41 ft.
Well Depth: 150 ft.

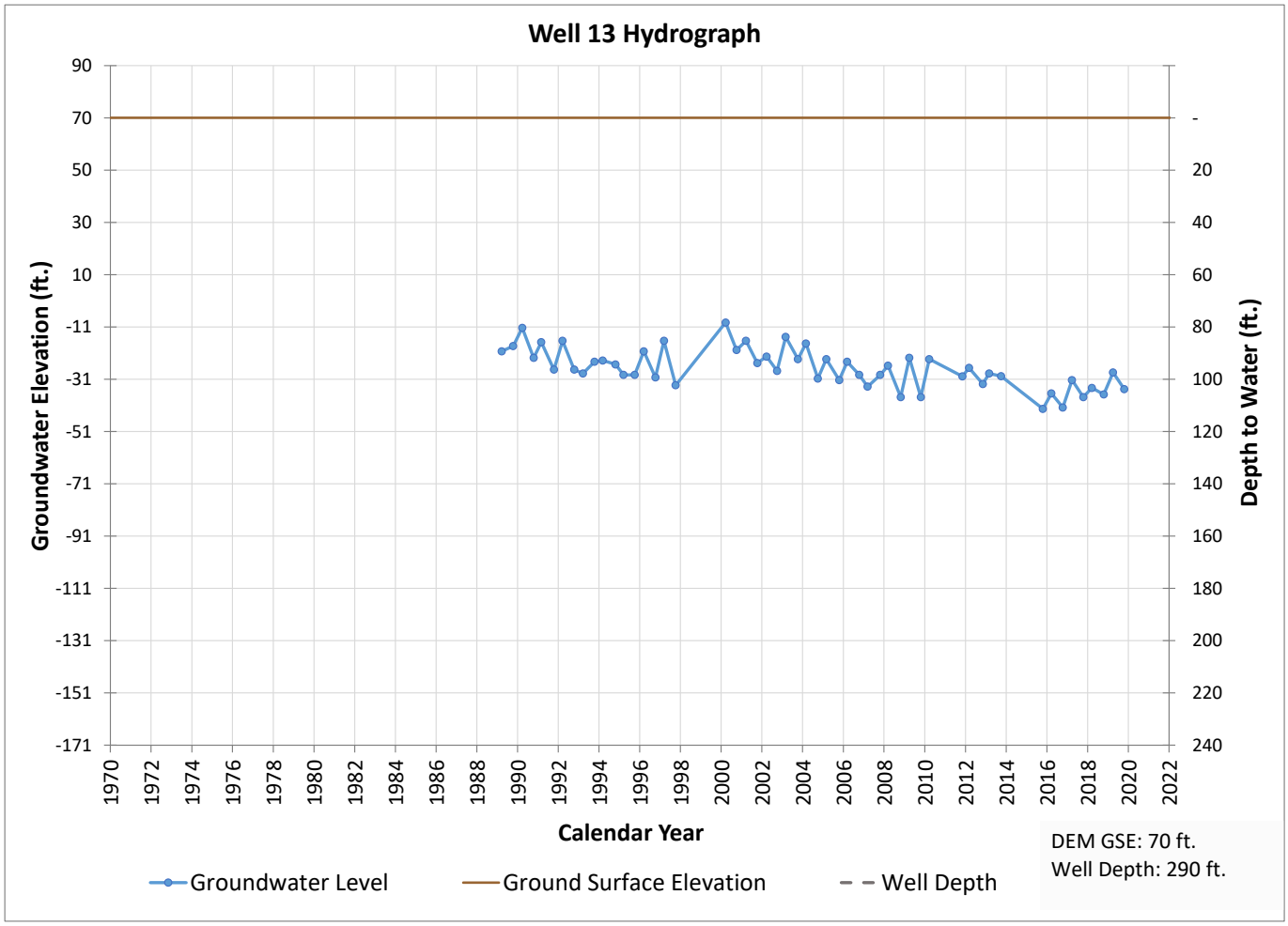

Well 8 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 65 ft.
Well Depth: 263 ft.

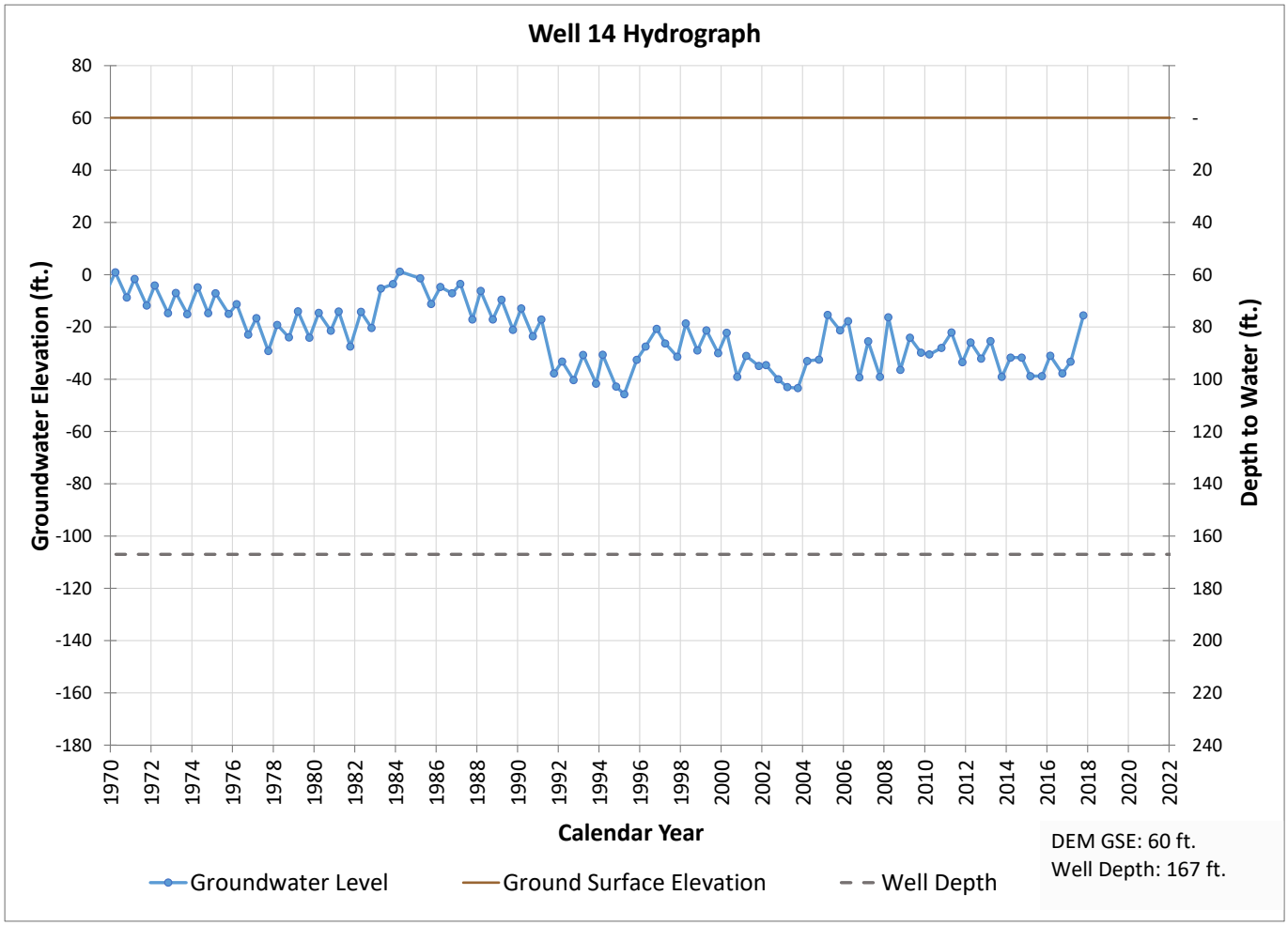

Well 9 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 55 ft.
Well Depth: 98 ft.

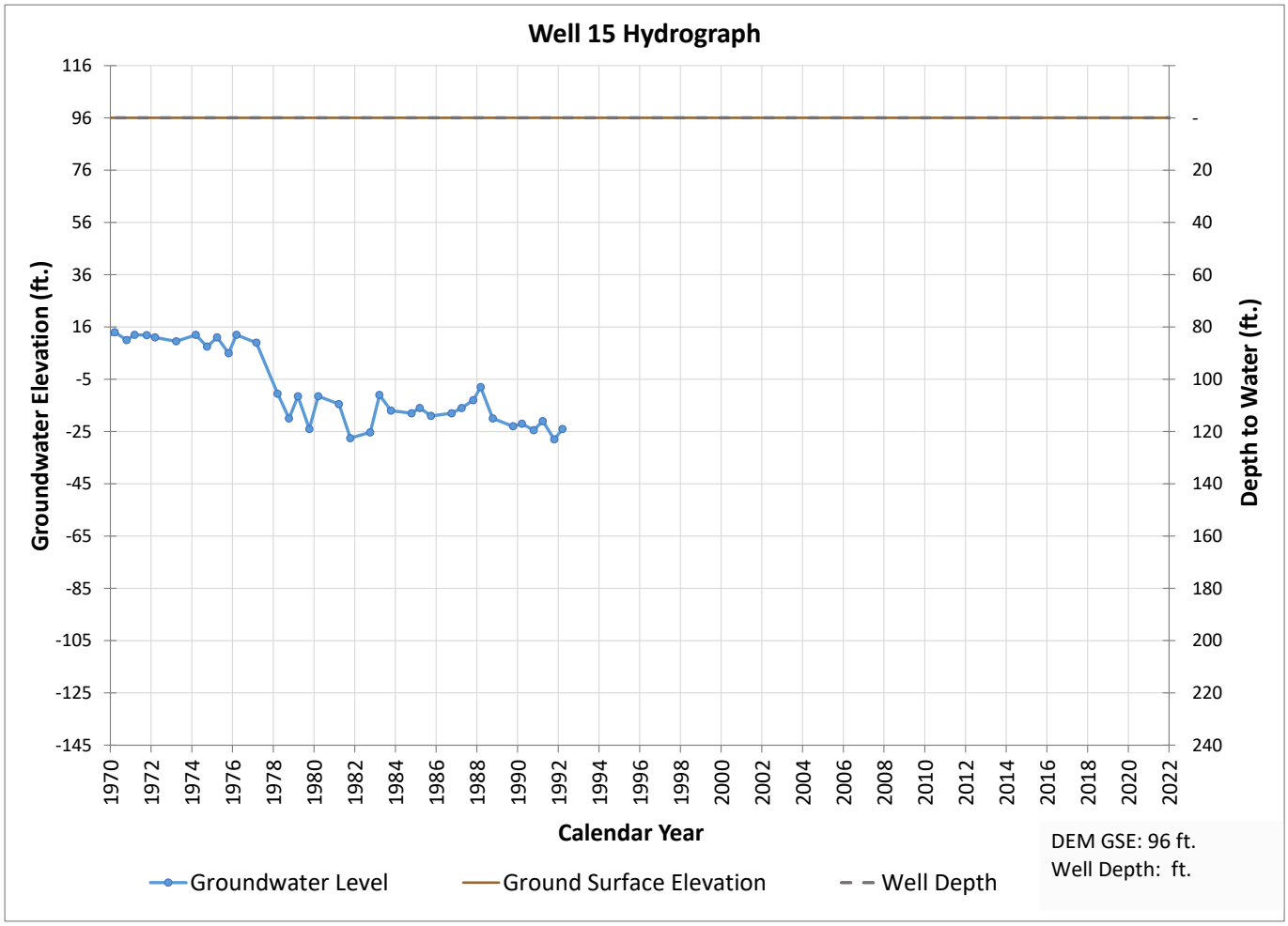

Well 10 Hydrograph
Groundwater Elevation (ft.)
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 78 ft.
Well Depth: 275 ft.

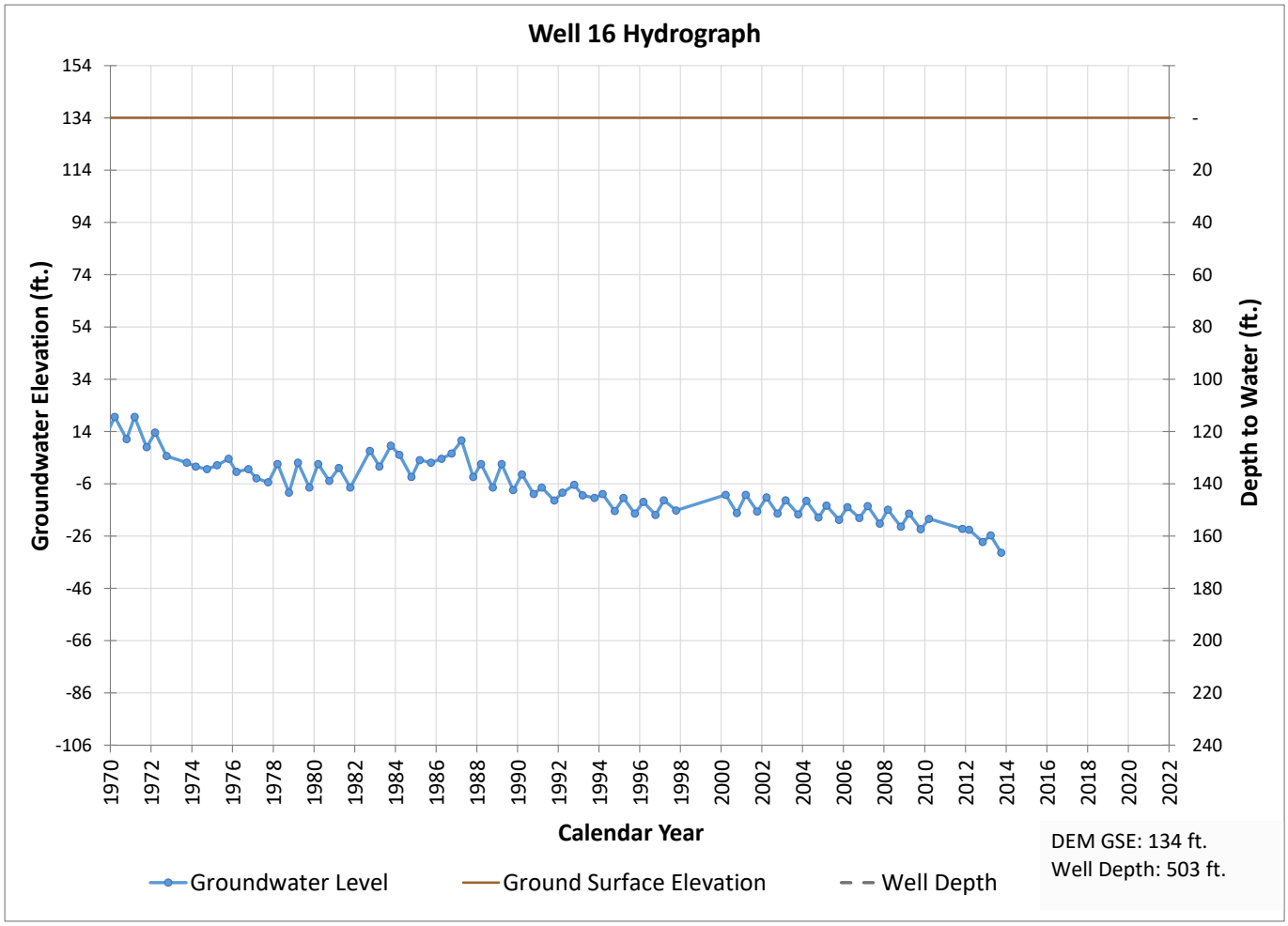

Well 11 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: 180 ft.

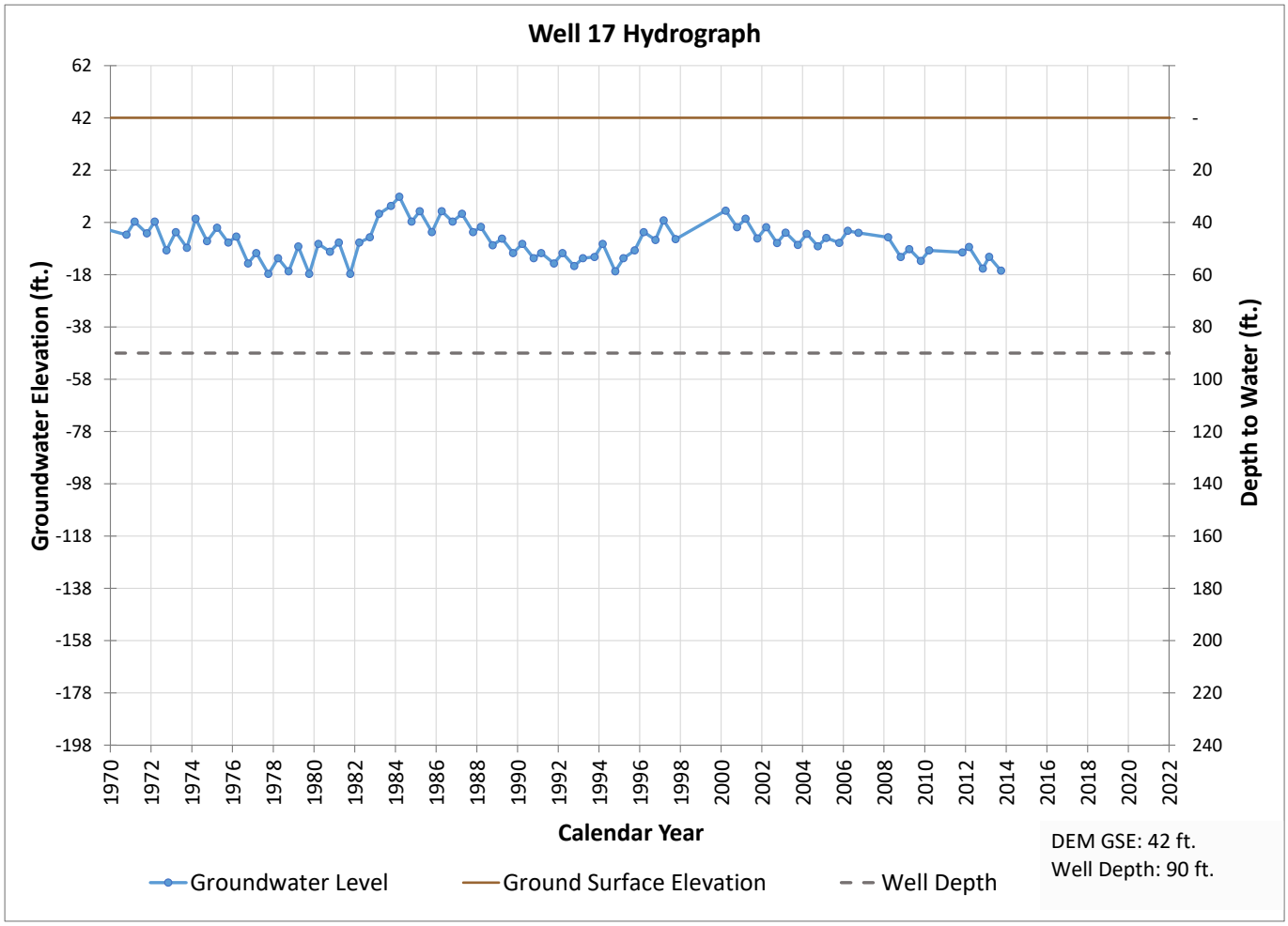

Well 12 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 100 ft.
Well Depth: 335 ft.

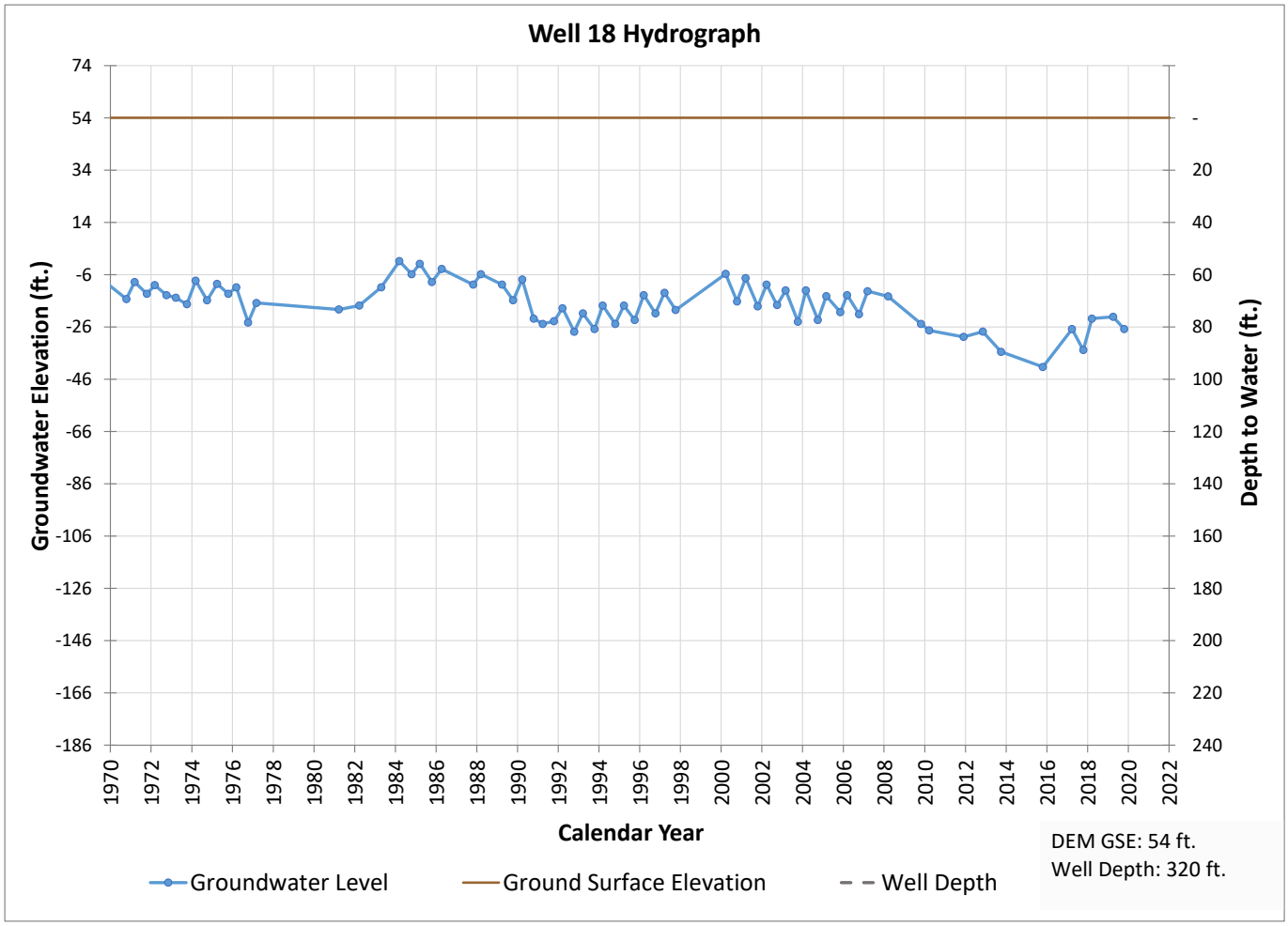

Well 13 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
90
70
50
30
10
-11
-31
-51
-71
-91
-111
-131
-151
-171
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 70 ft.
Well Depth: 290 ft.

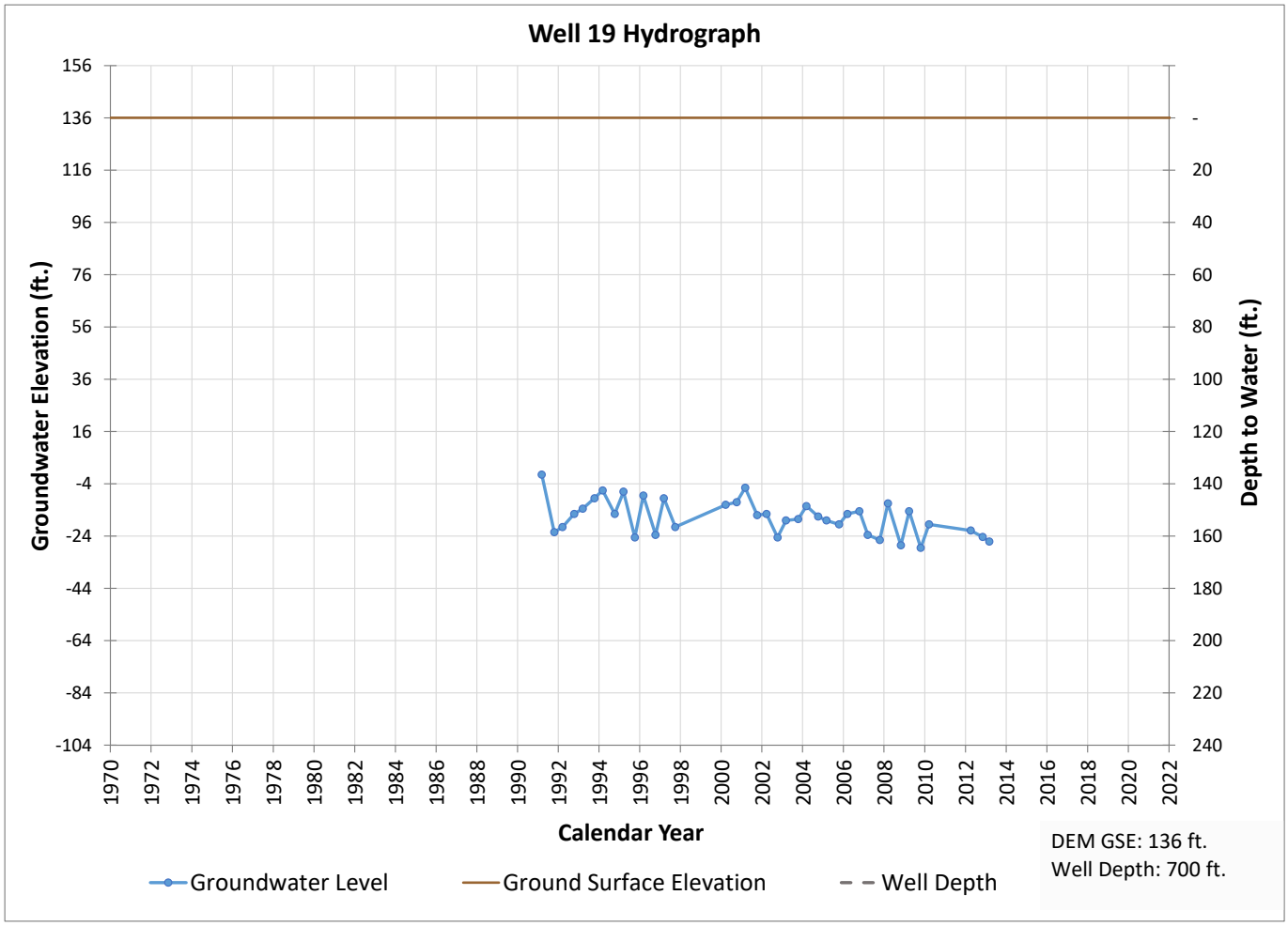

Well 14 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 60 ft.
Well Depth: 167 ft.

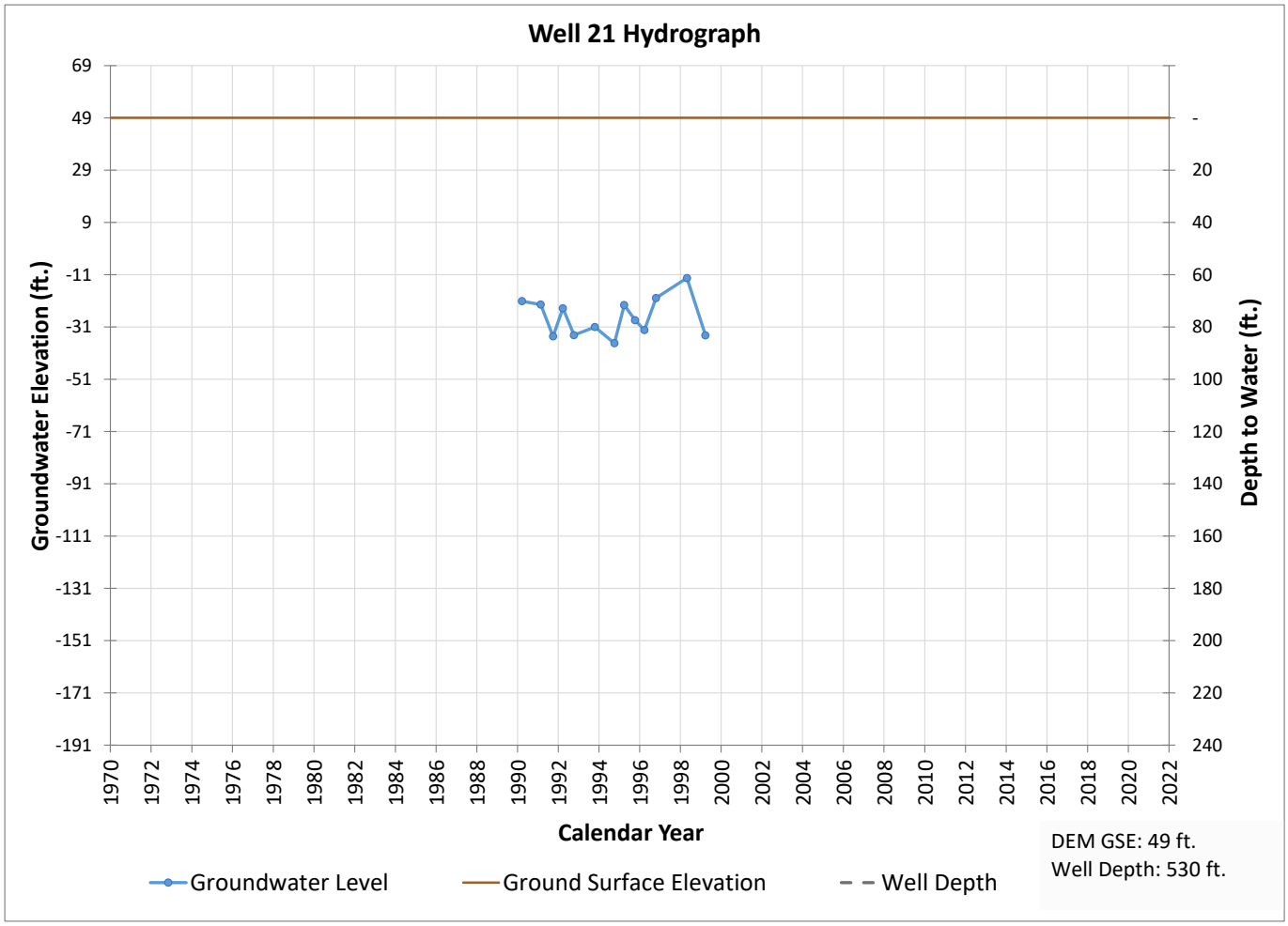

Well 15 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
116
96
76
56
36
16
-5
-25
-45
-65
-85
-105
-125
-145
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 96 ft.
Well Depth: ft.

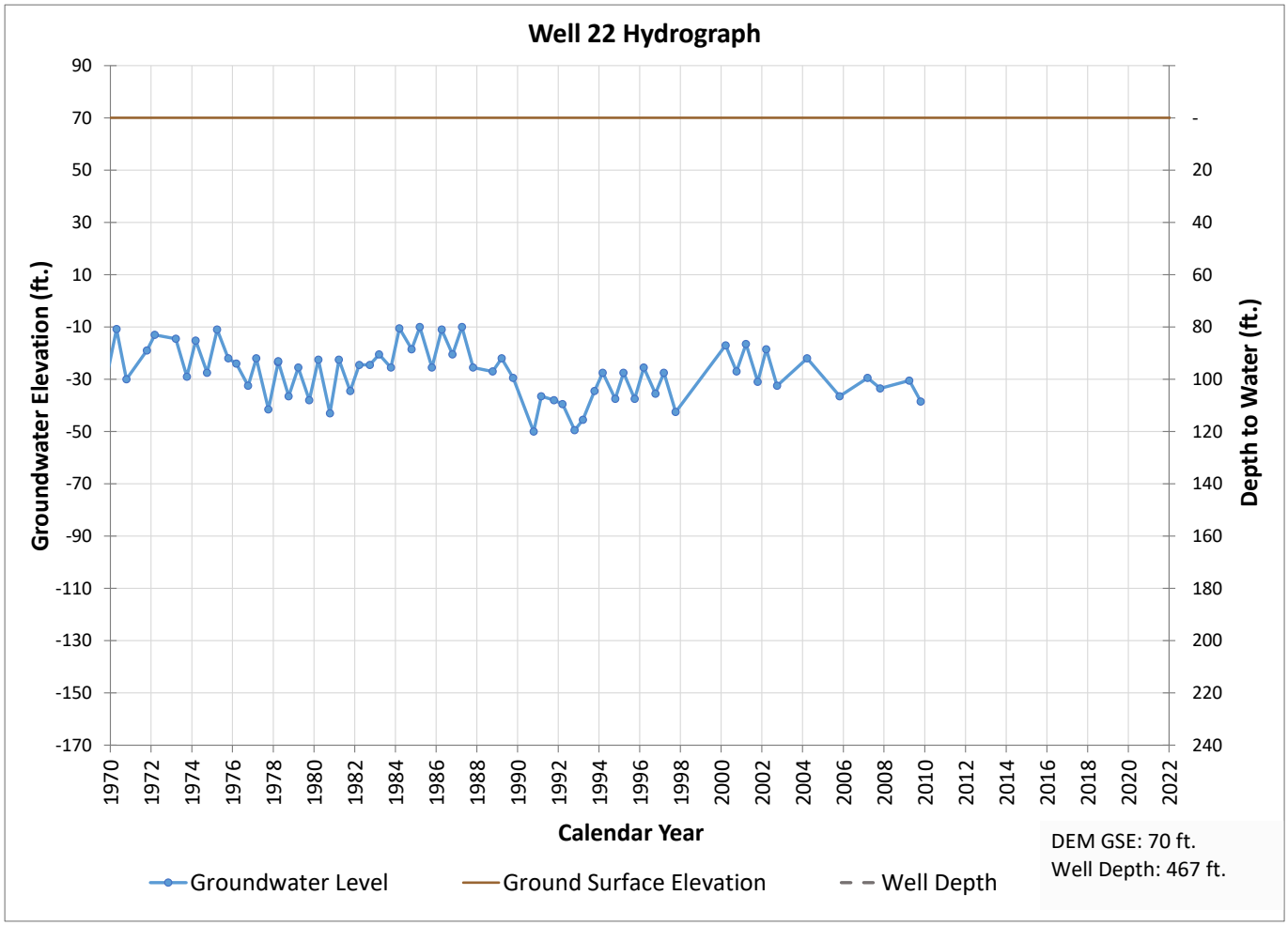

Well 16 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
154
134
114
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 134 ft.
Well Depth: 503 ft.

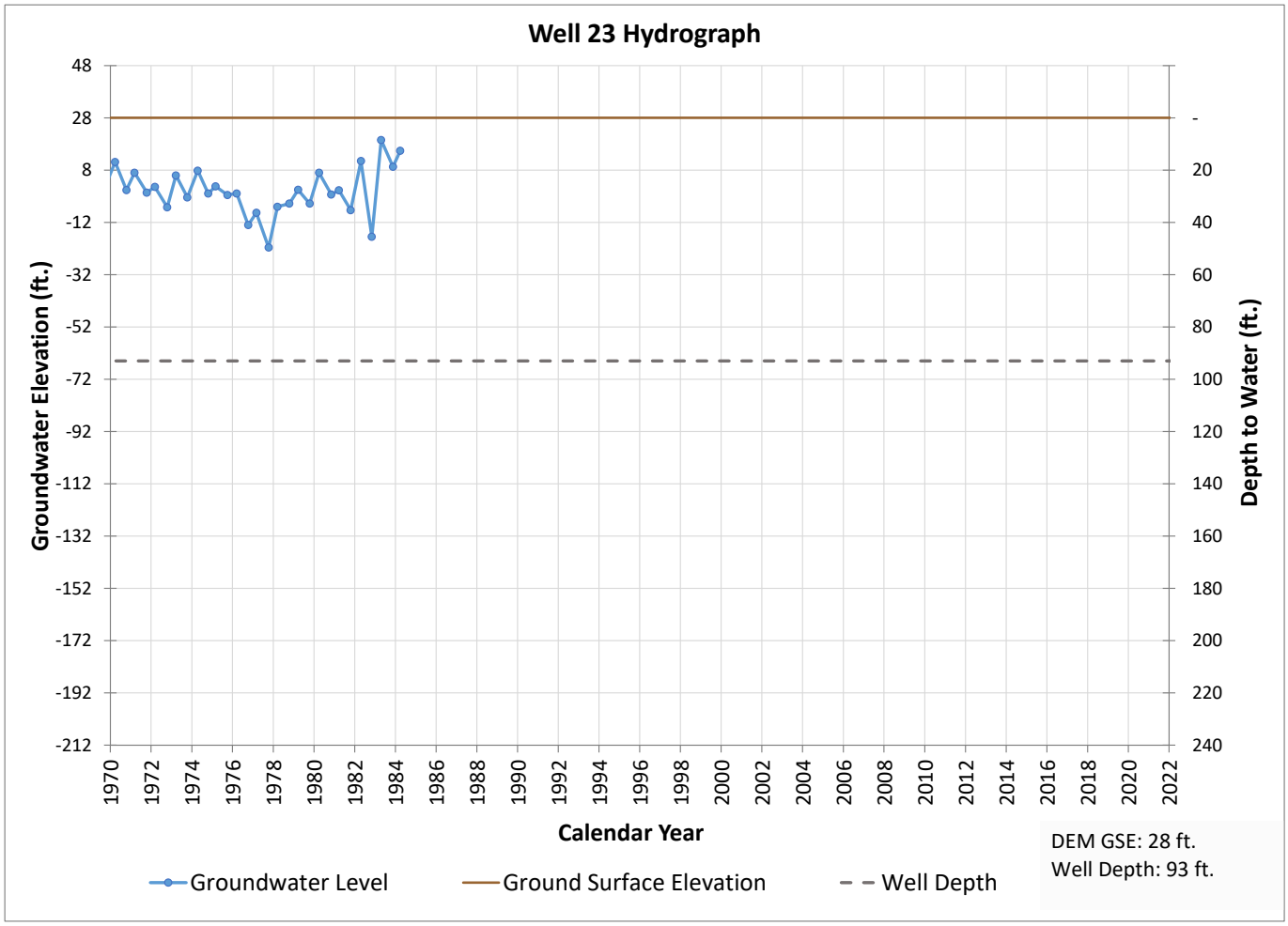

Well 17 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: 90 ft.

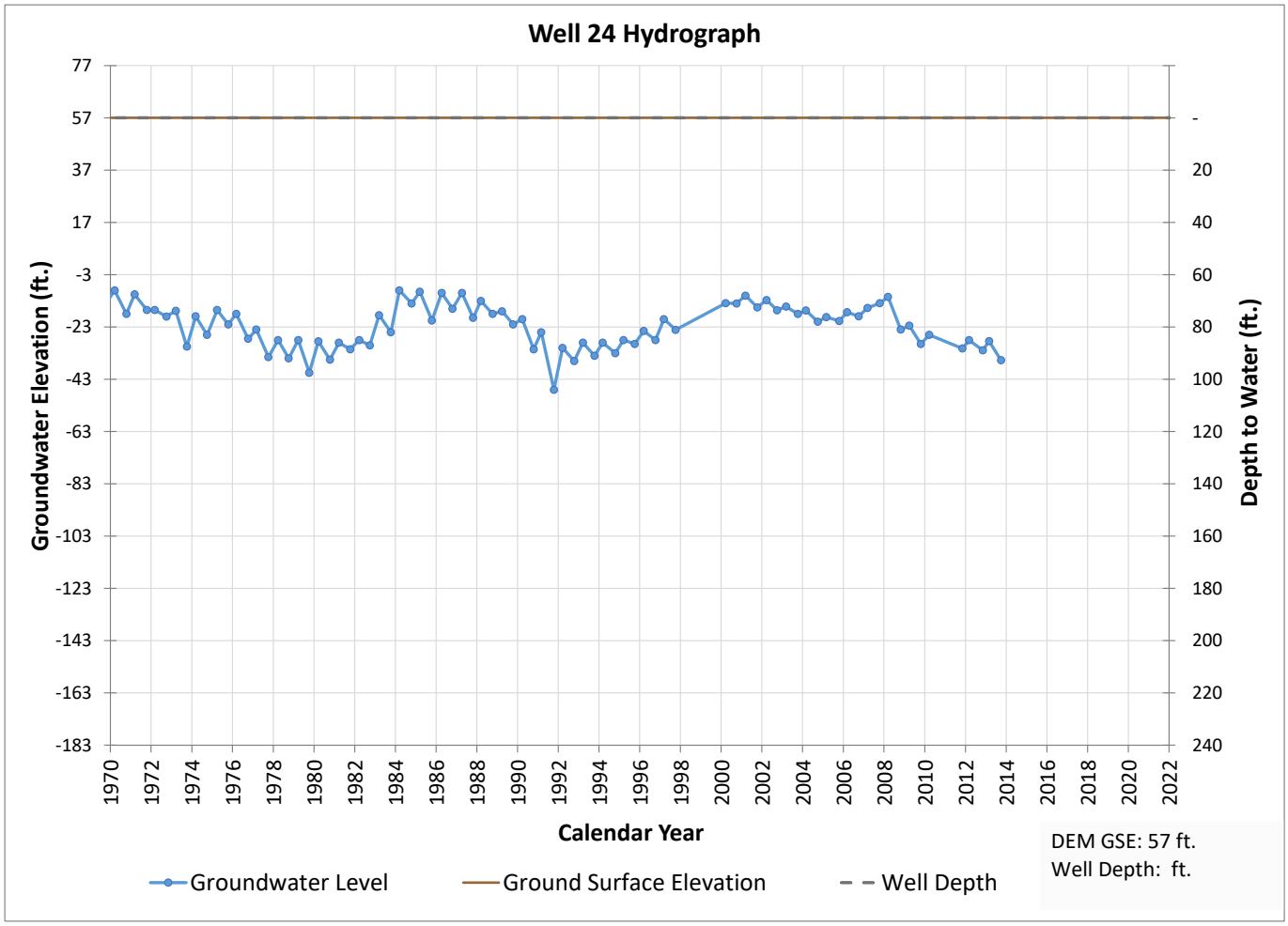

Well 18 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 320 ft.

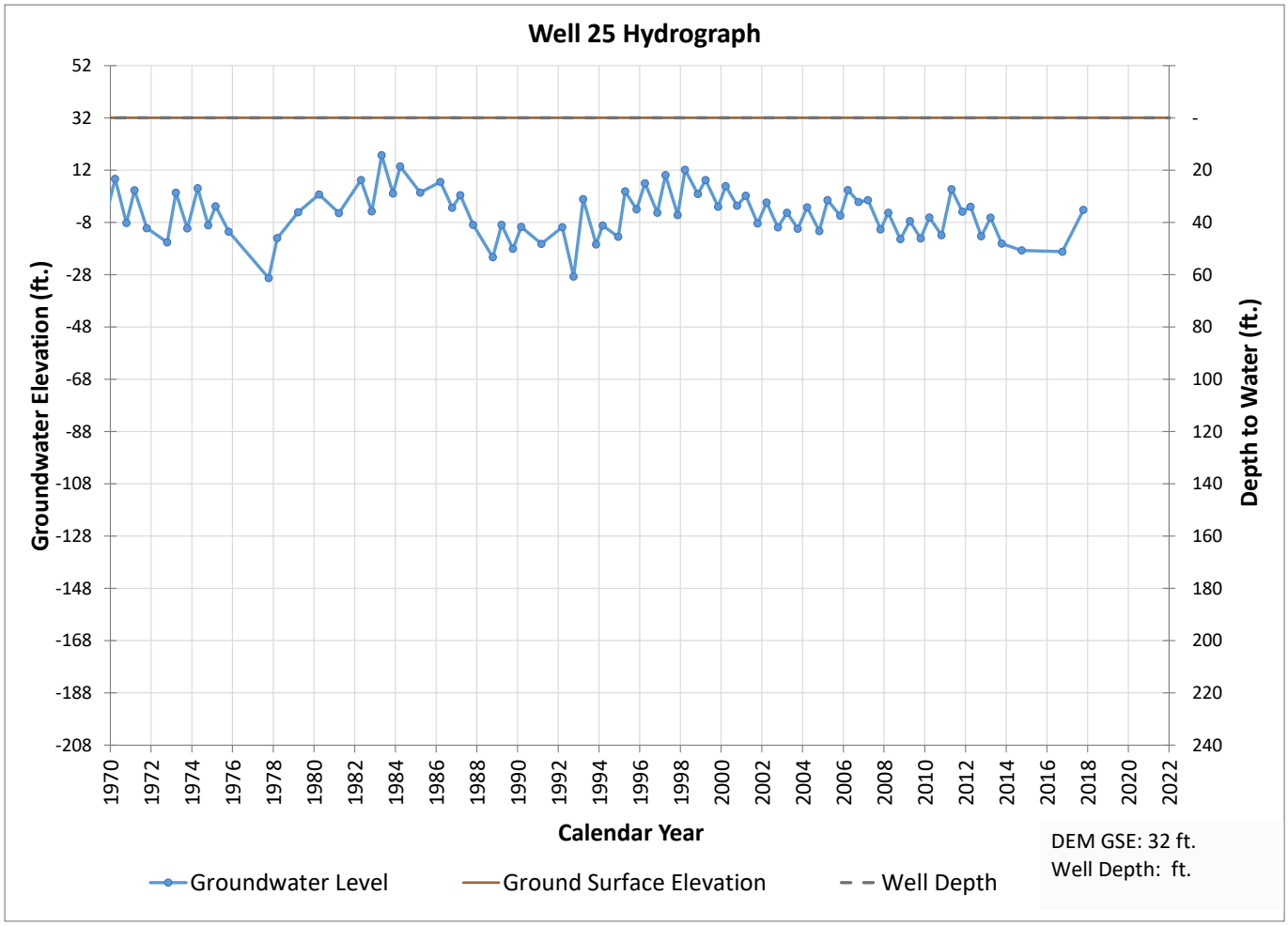

Well 19 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
156
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 136 ft.
Well Depth: 700 ft.

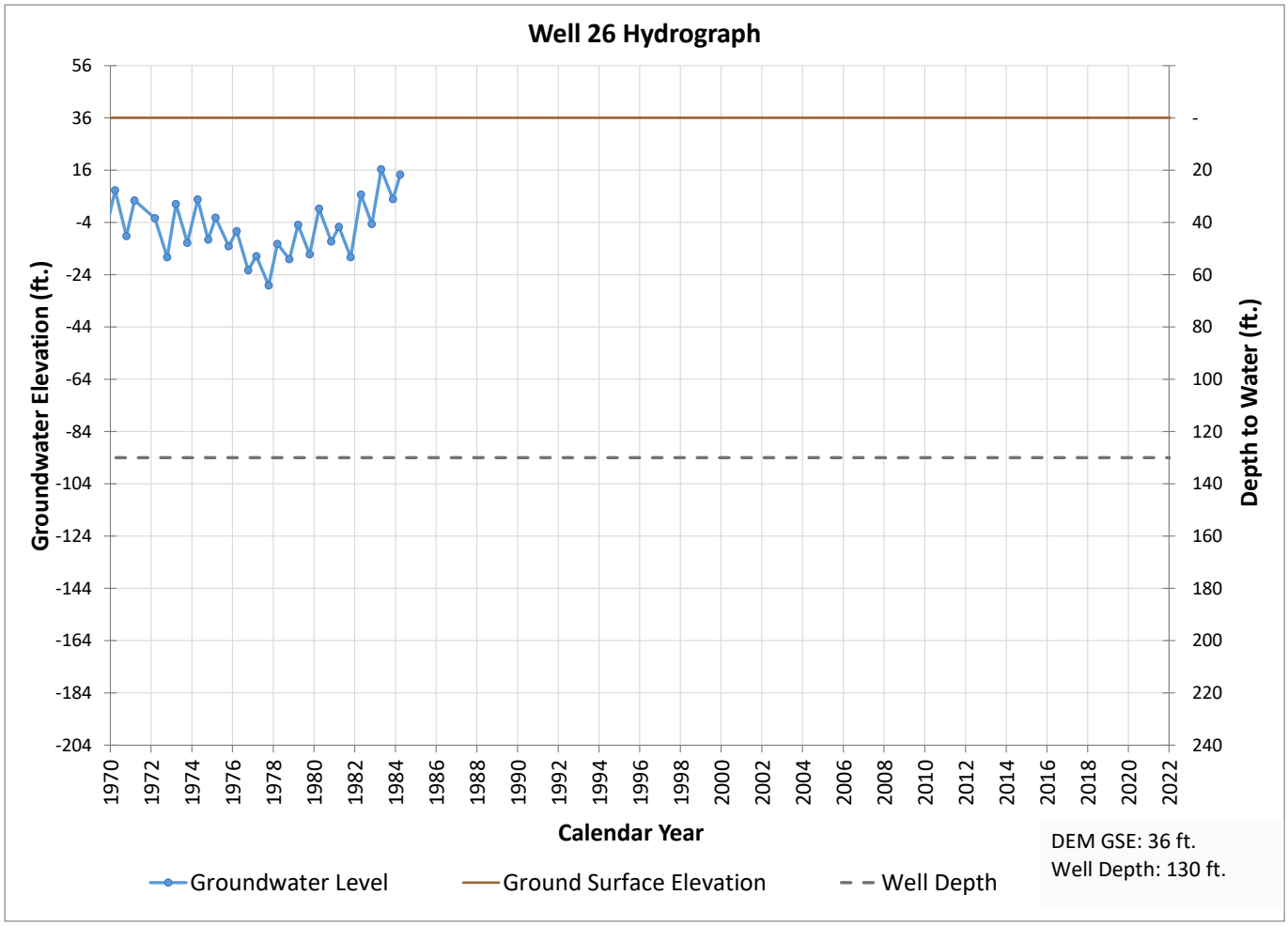

Well 21 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: 530 ft.

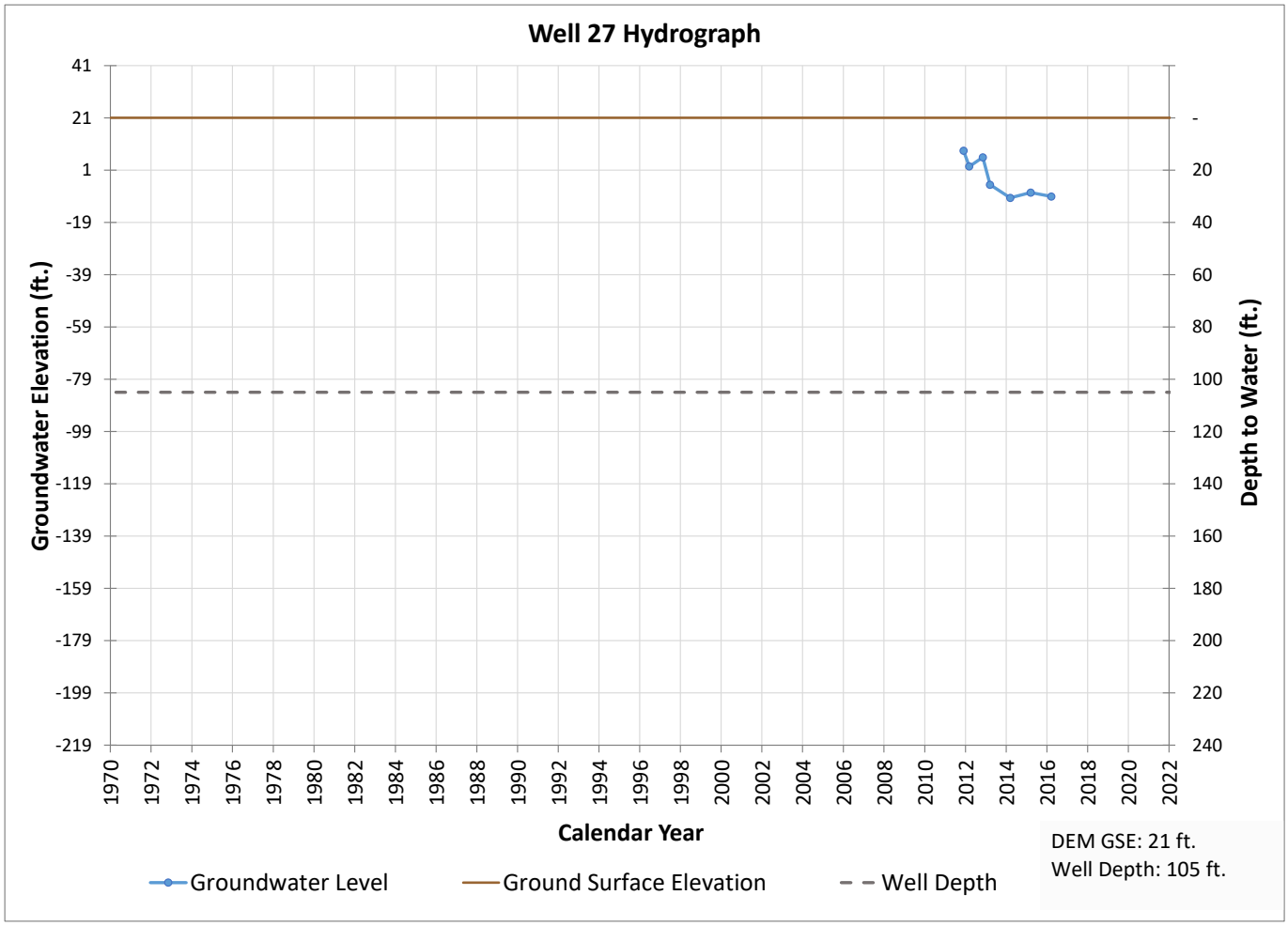

Well 22 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
90
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 70 ft.
Well Depth: 467 ft.

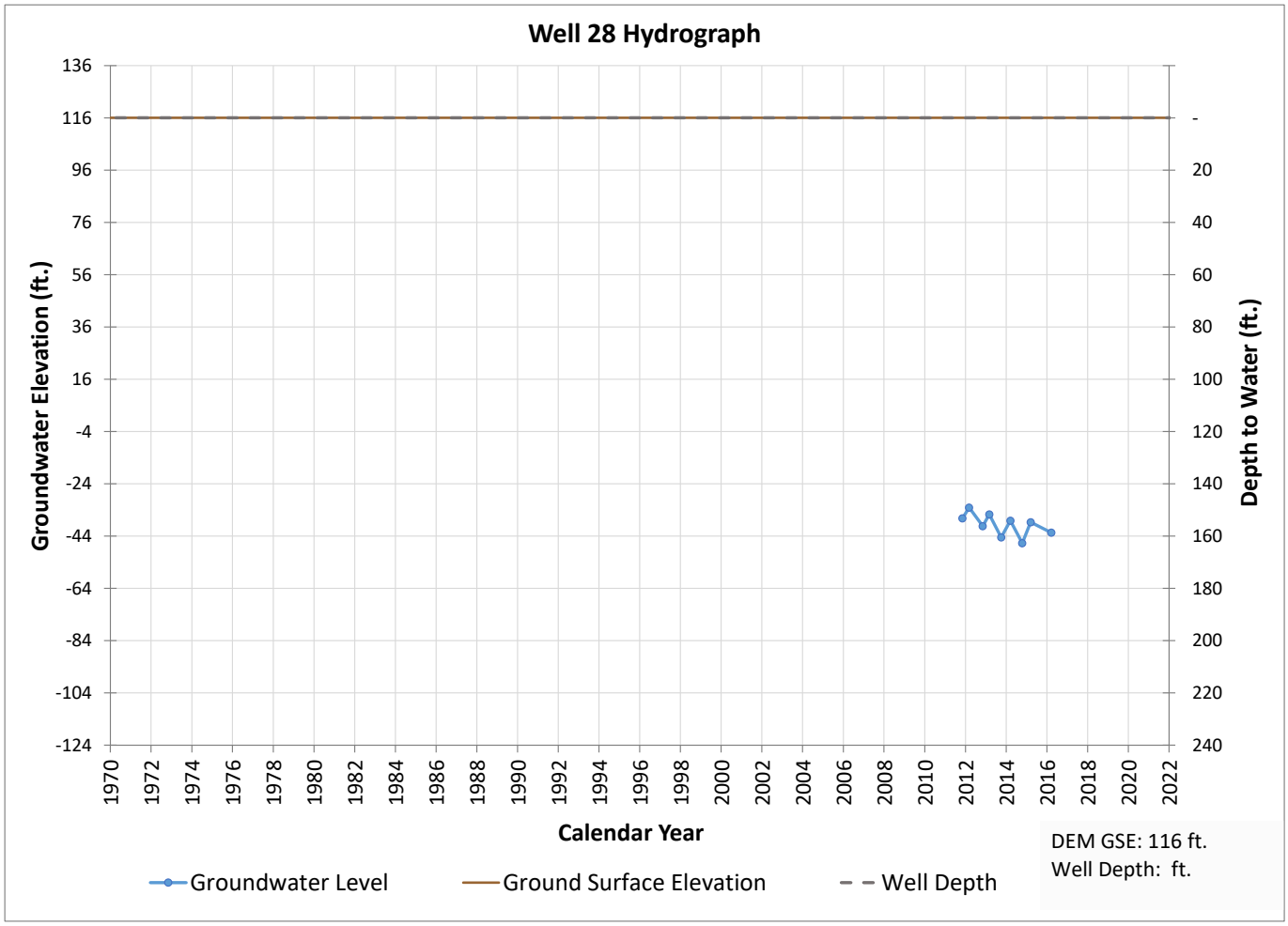

Well 23 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 28 ft.
Well Depth: 93 ft.

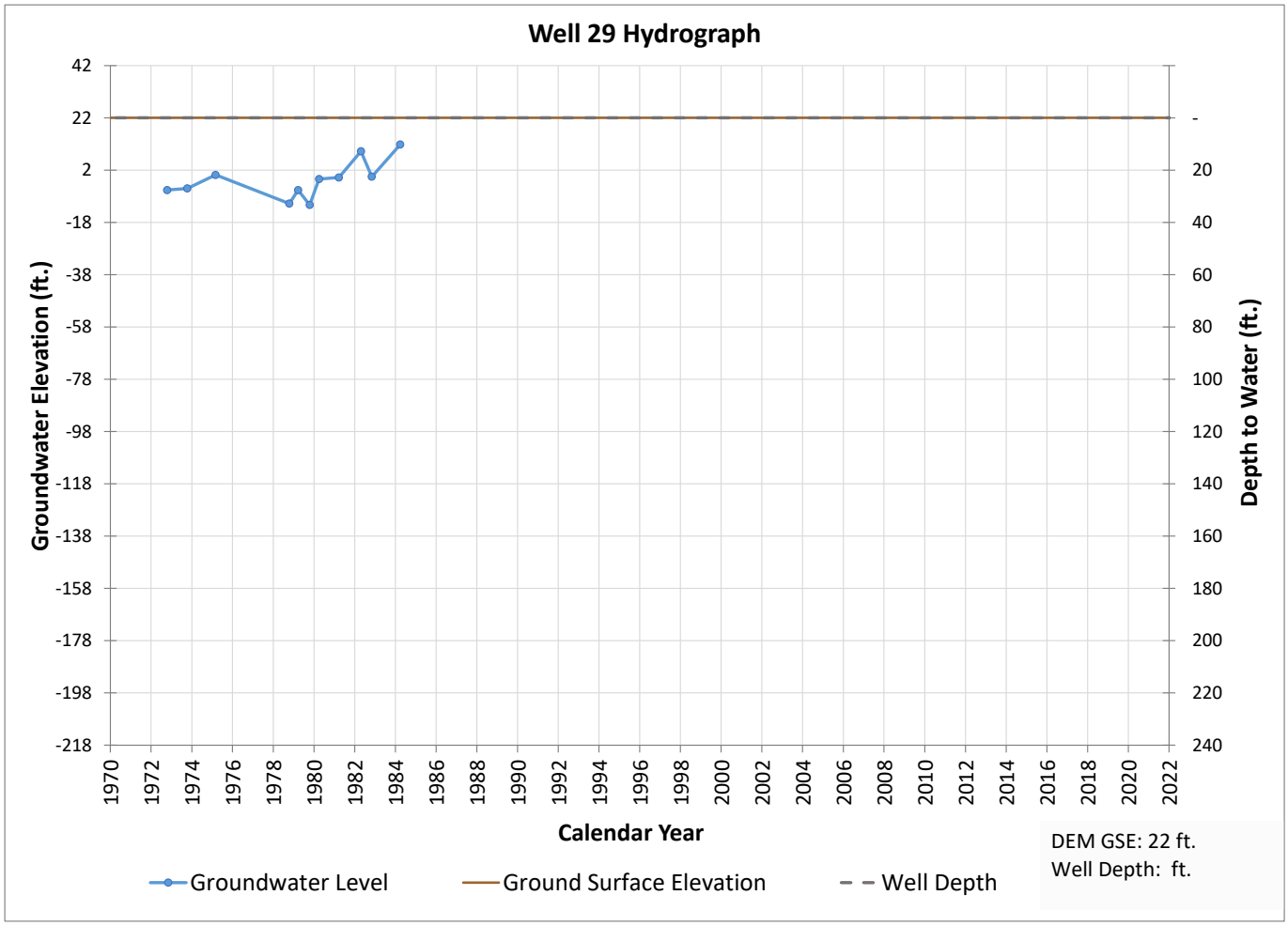

Well 24 Hydrograph
Groundwater Elevation (ft.)
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 57 ft.
Well Depth: ft.

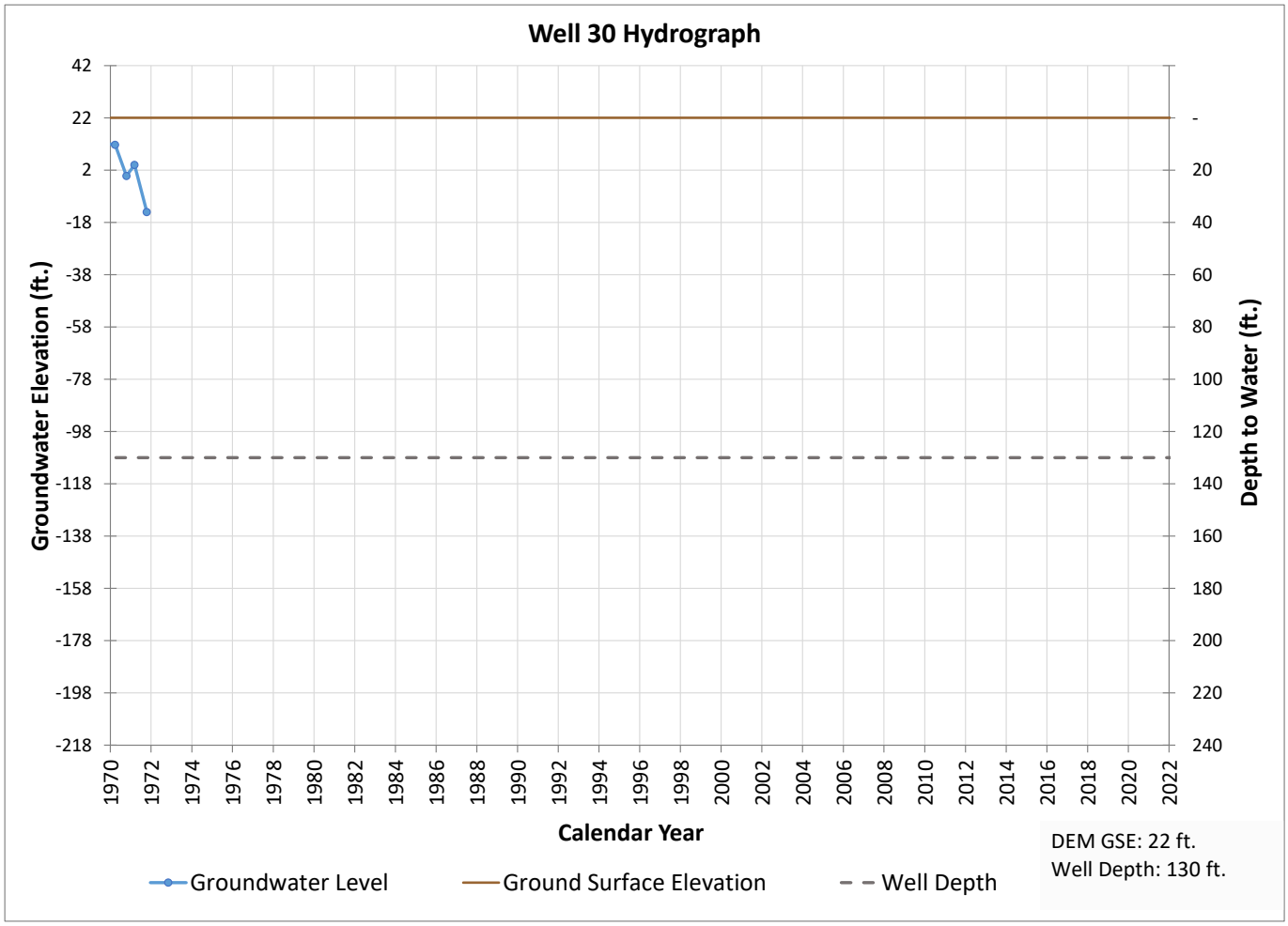

Well 25 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: ft.

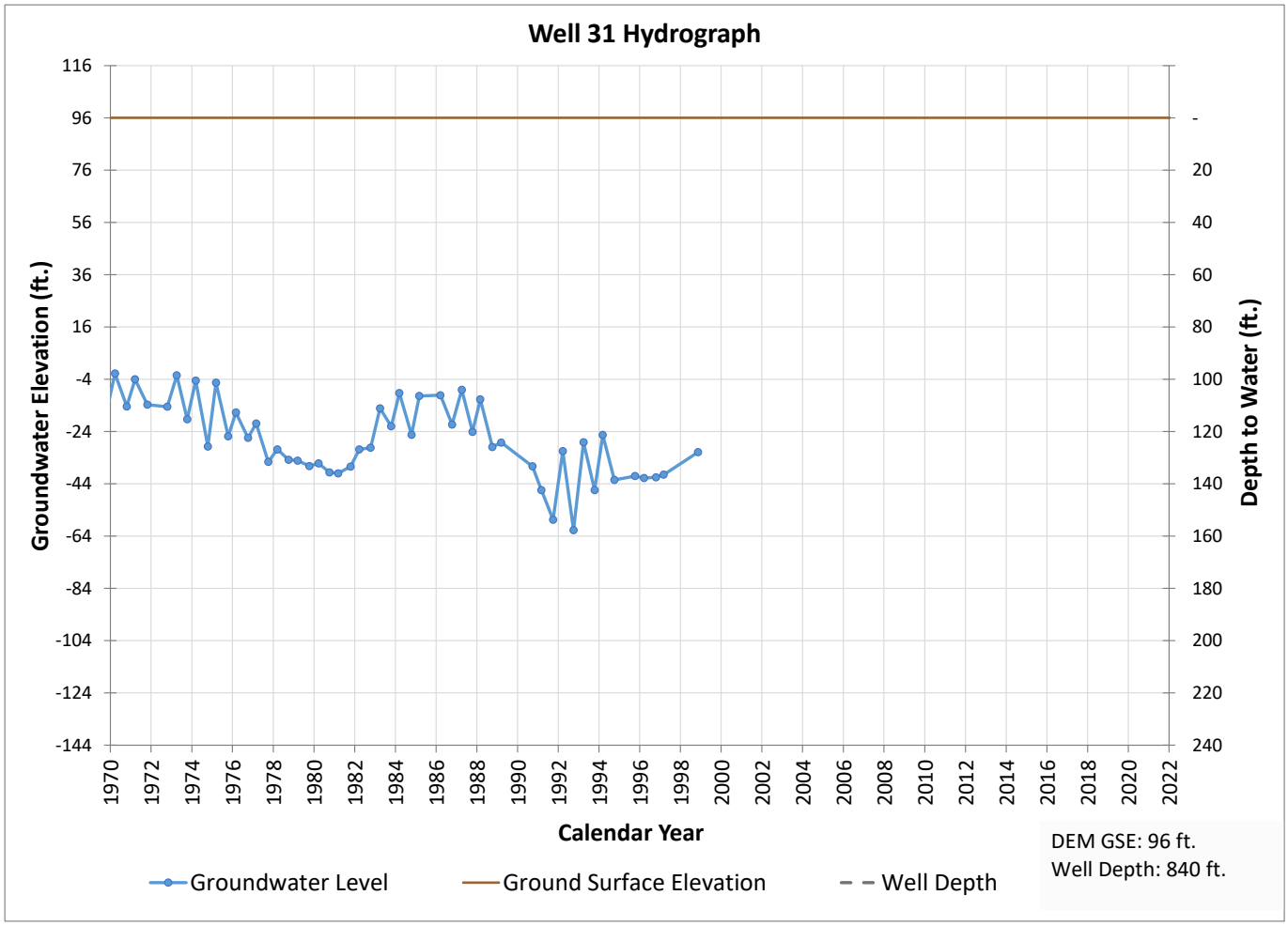

Well 26 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 36 ft.
Well Depth: 130 ft.

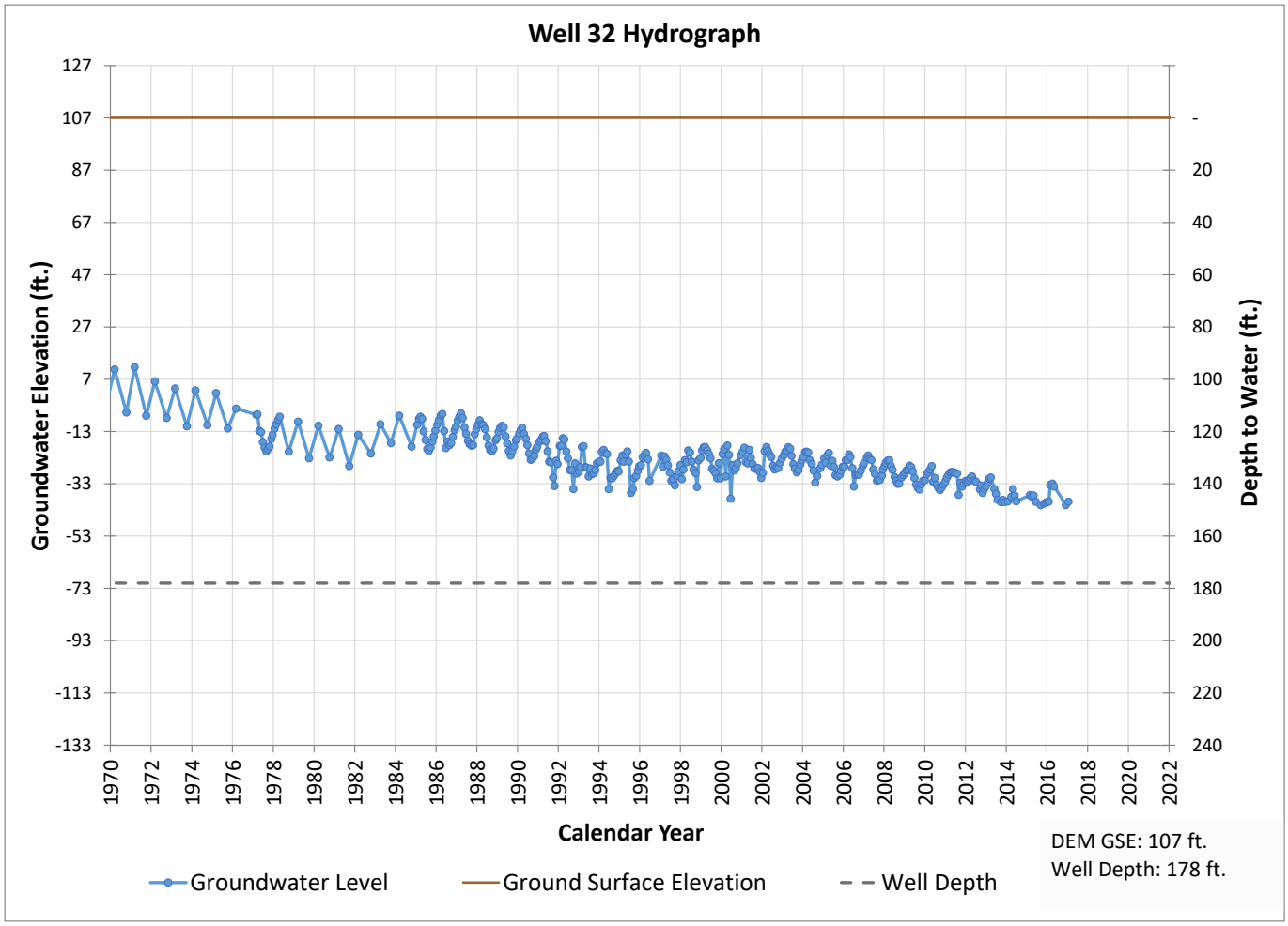

Well 27 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
-219
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 21 ft.
Well Depth: 105 ft.

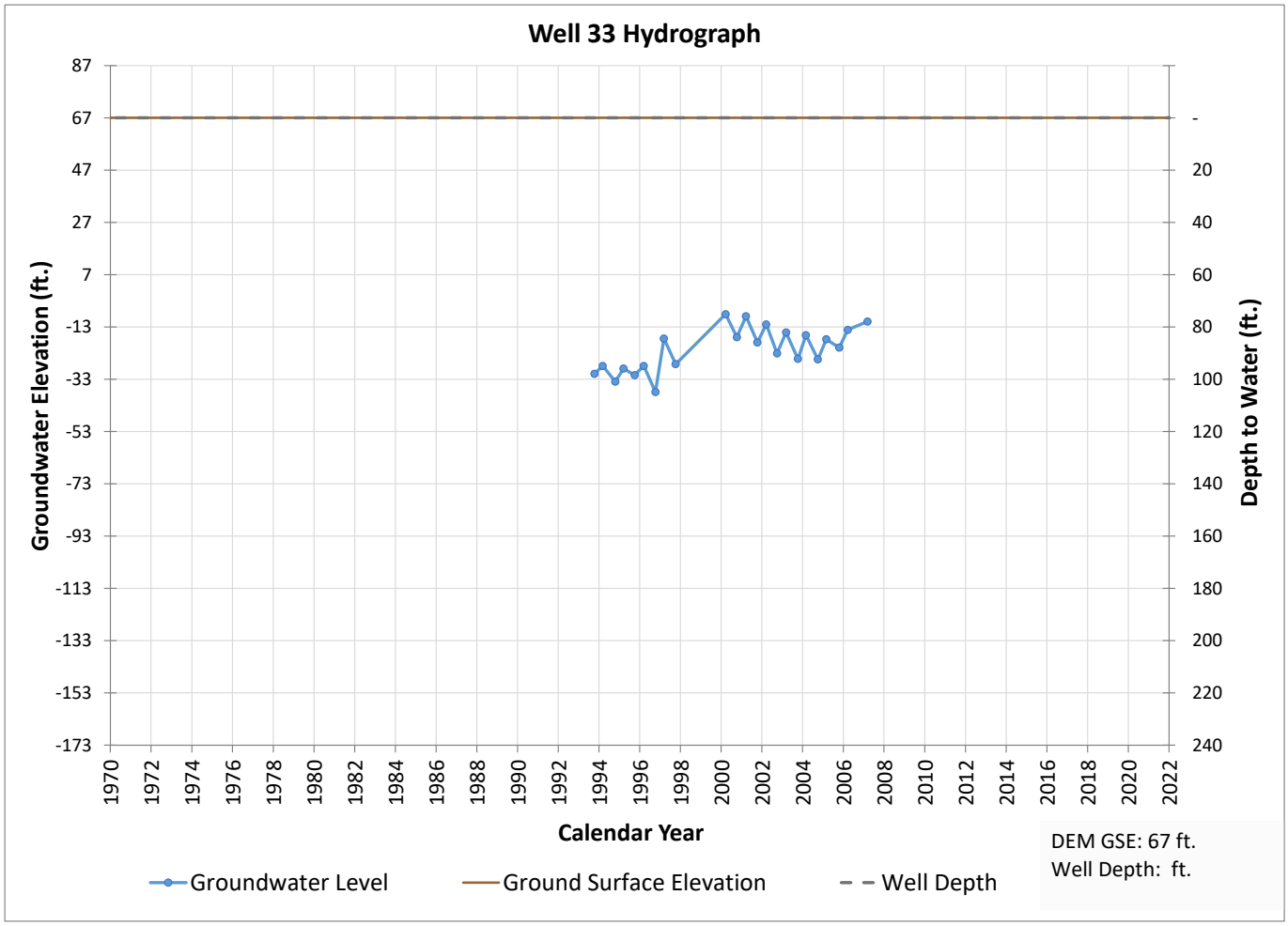

Well 28 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 116 ft.
Well Depth: ft.

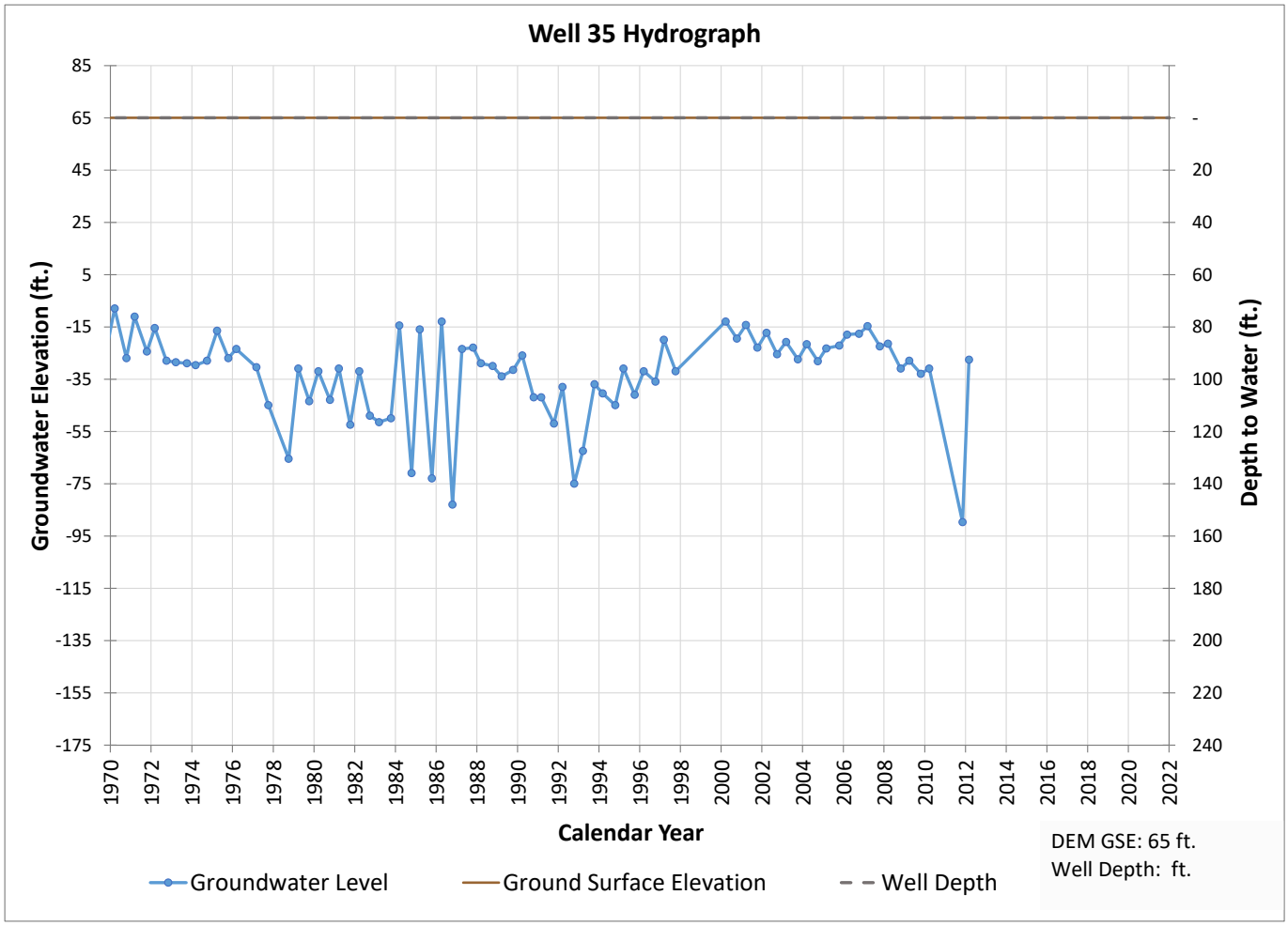

Well 29 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: ft.

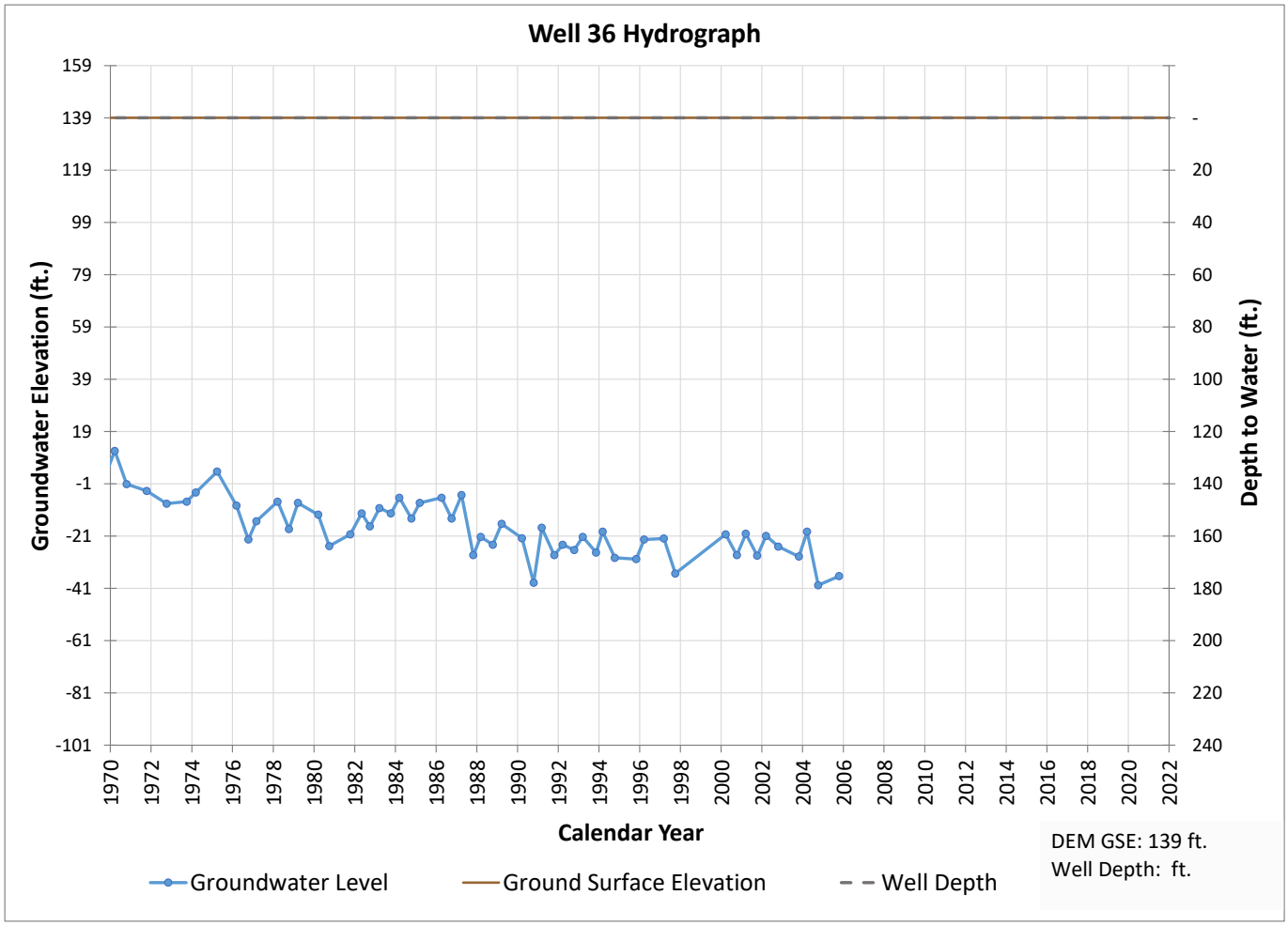

Well 30 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: 130 ft.

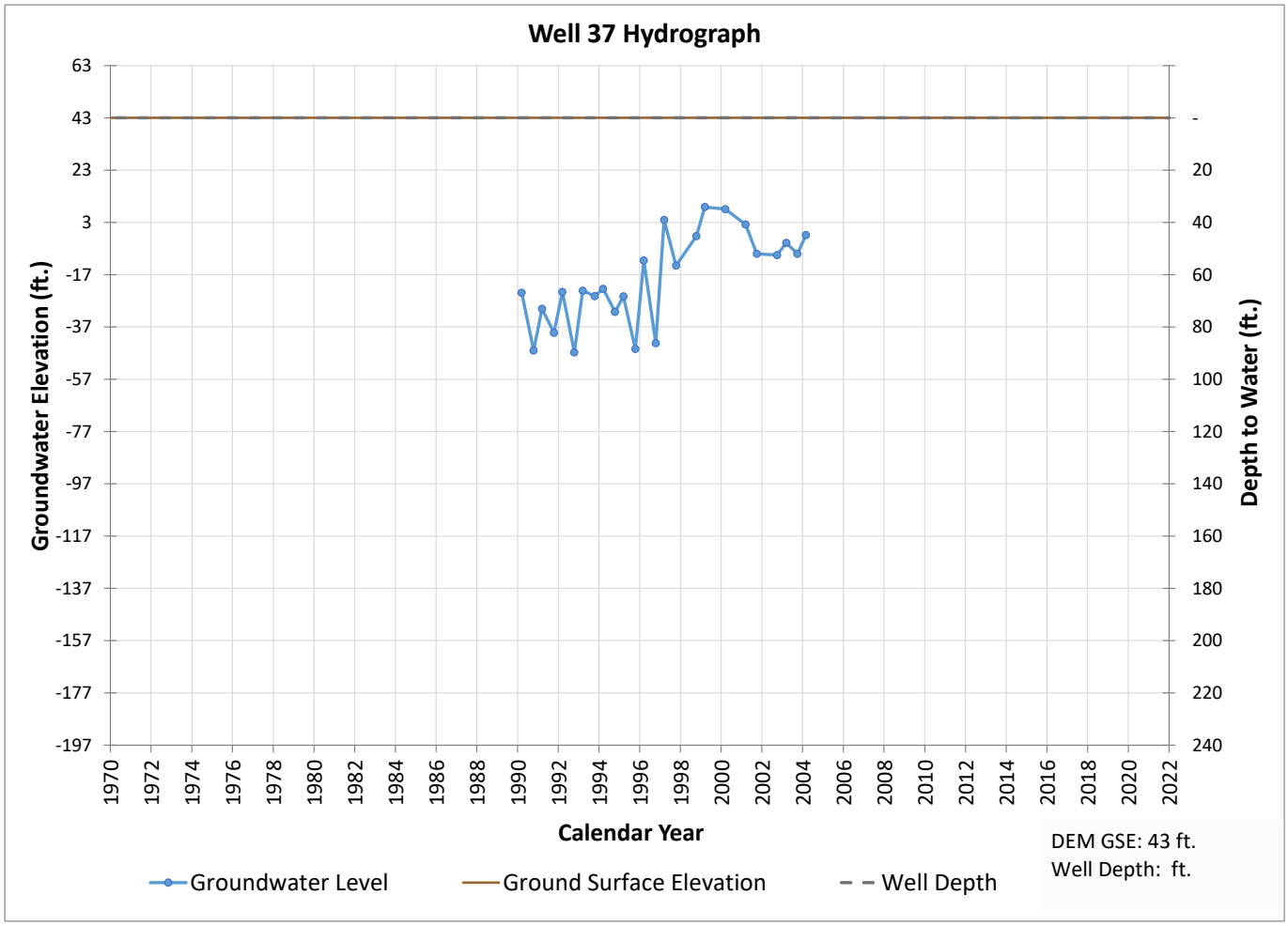

Well 31 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 96 ft.
Well Depth: 840 ft.

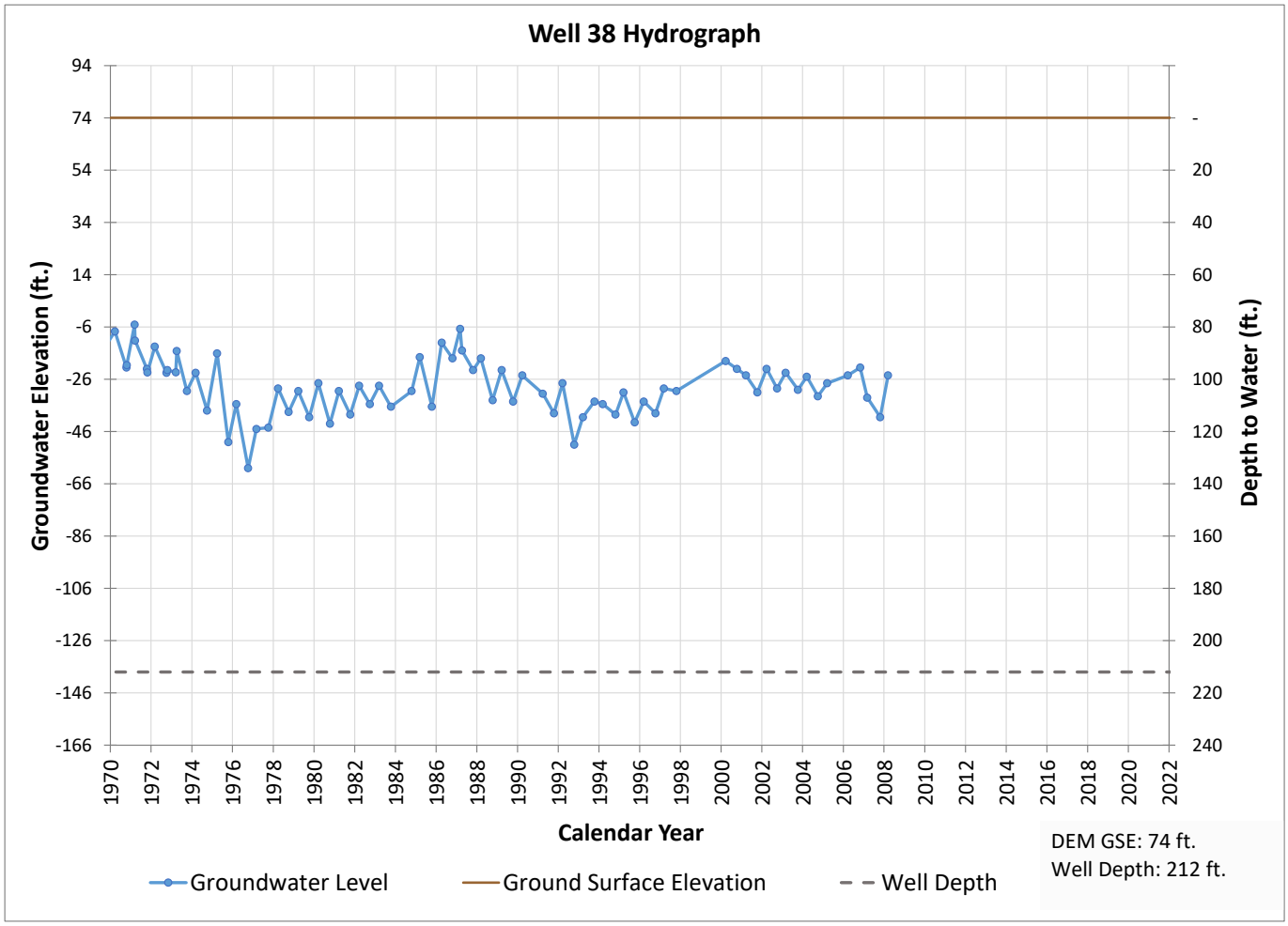

Well 32 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 107 ft.
Well Depth: 178 ft.

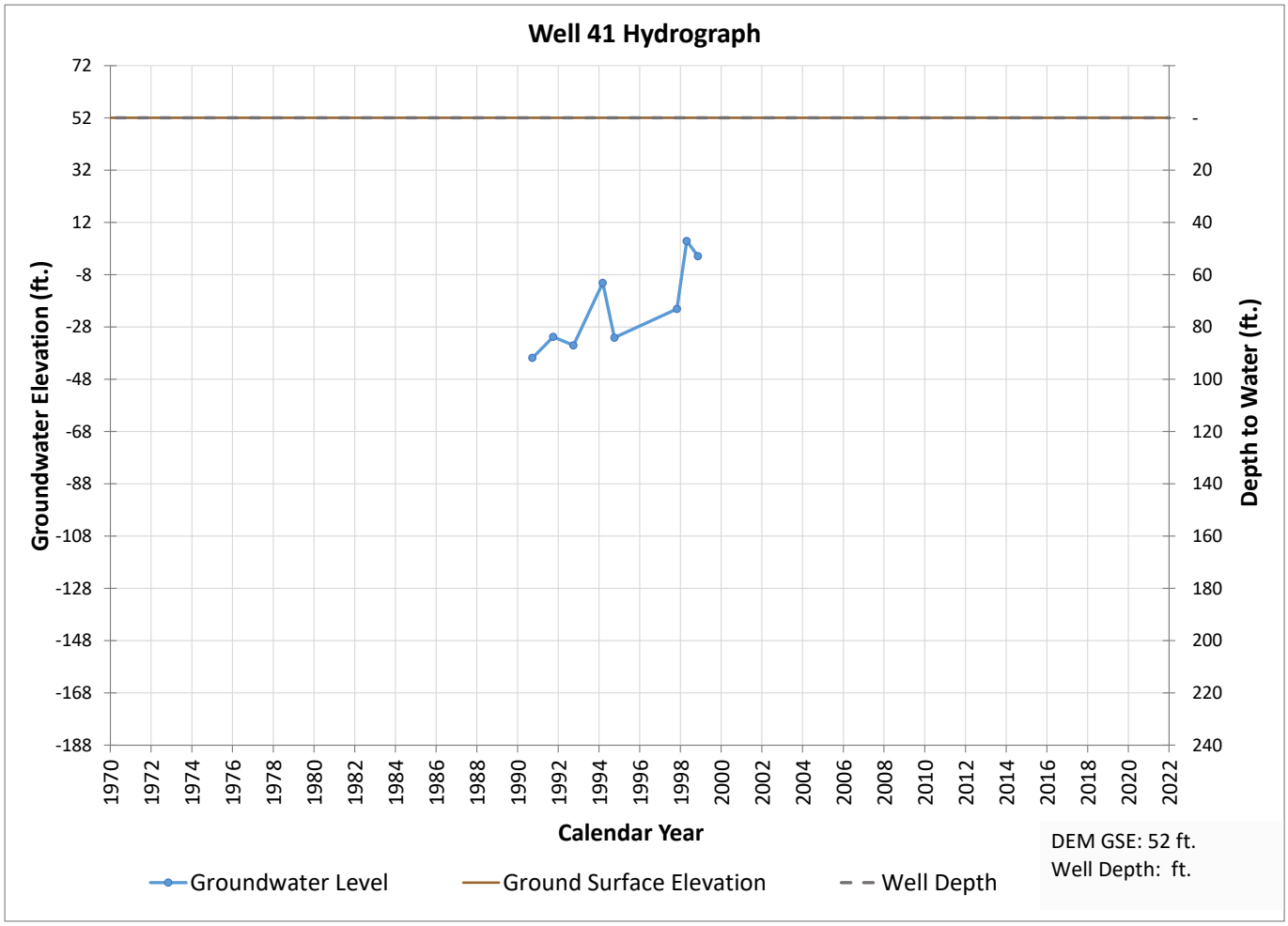

Well 33 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: ft.

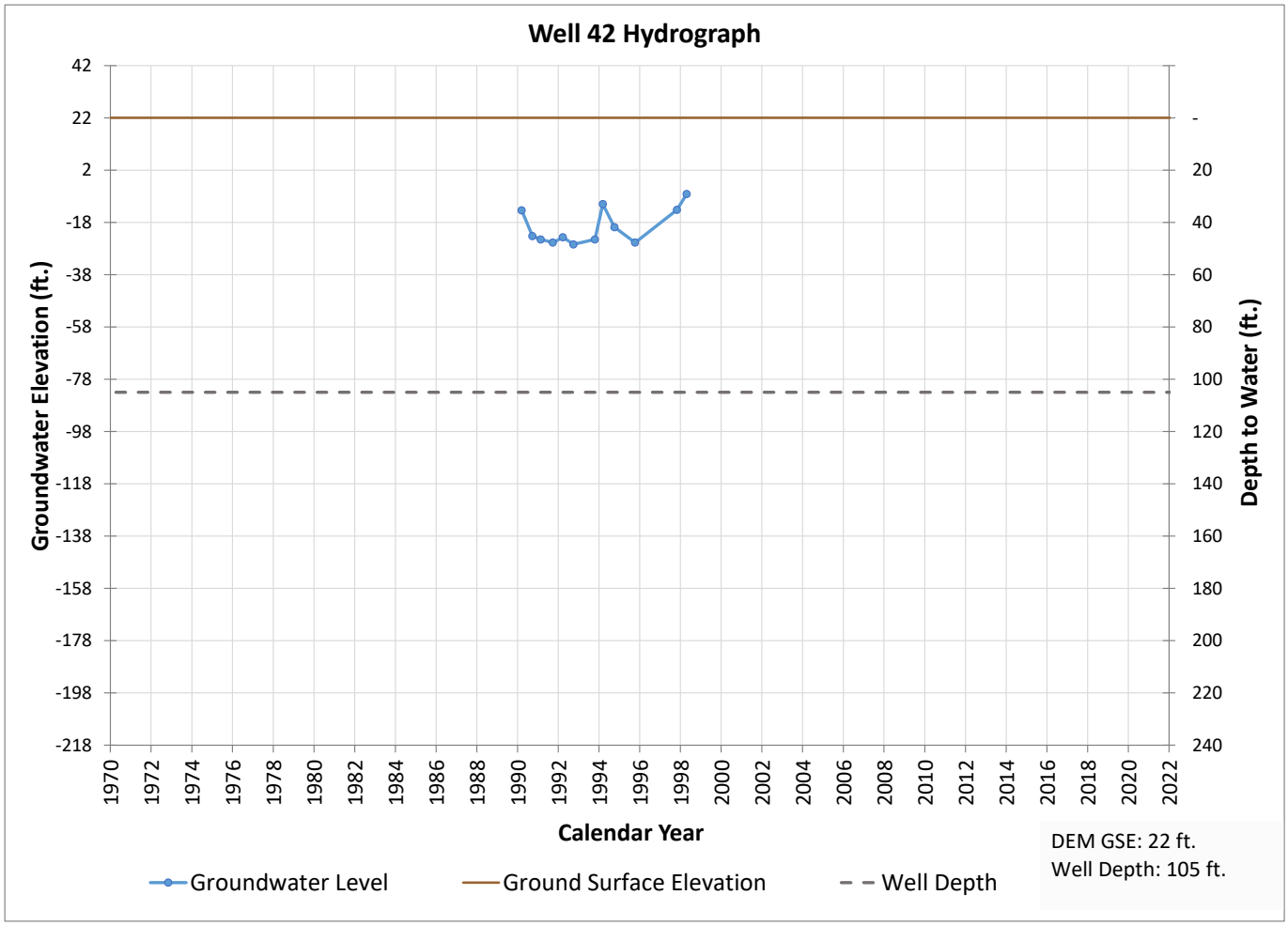

Well 35 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 65 ft.
Well Depth: ft.

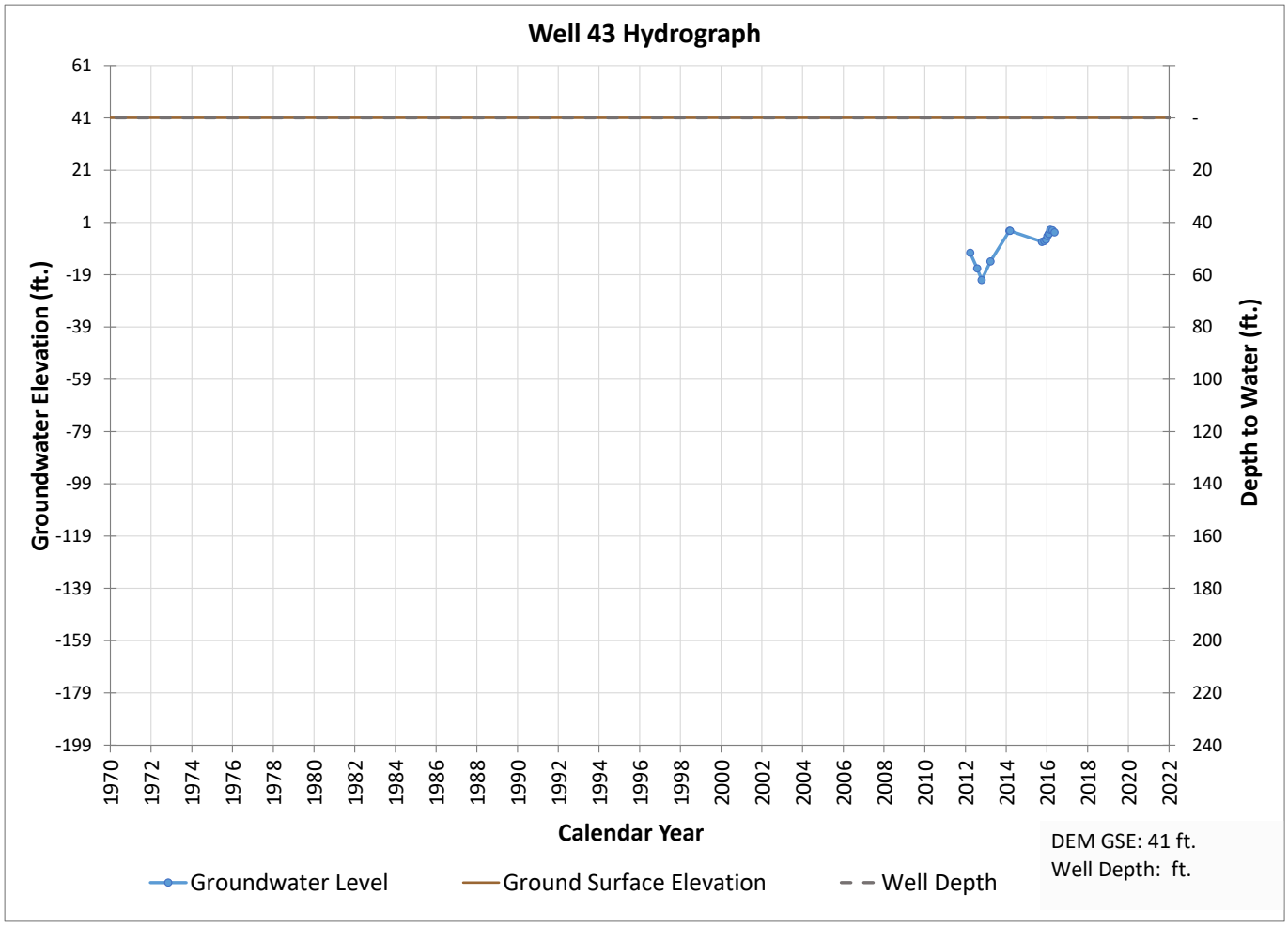

Well 36 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
159
139
119
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 139 ft.
Well Depth: ft.

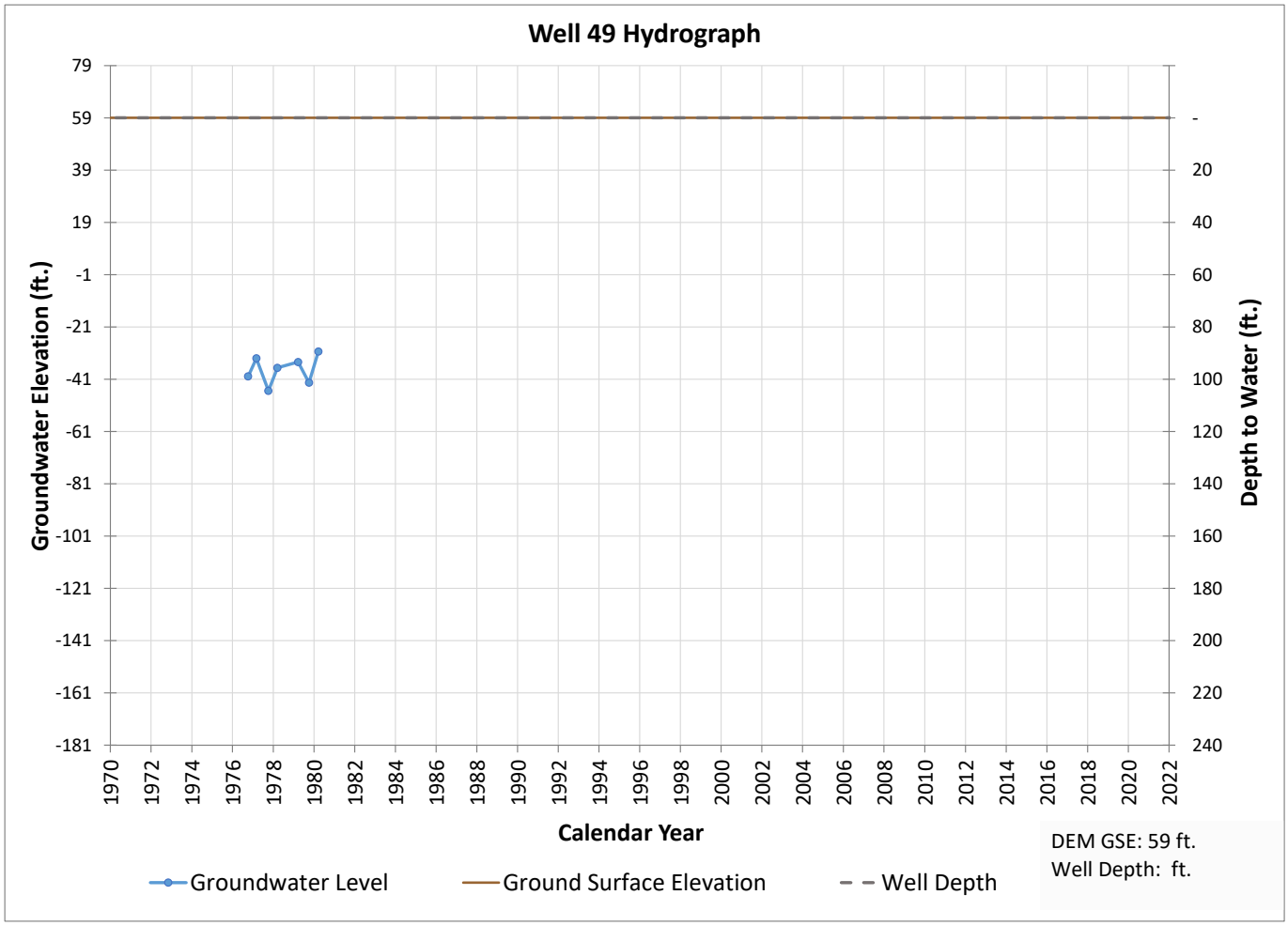

Well 37 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: ft.

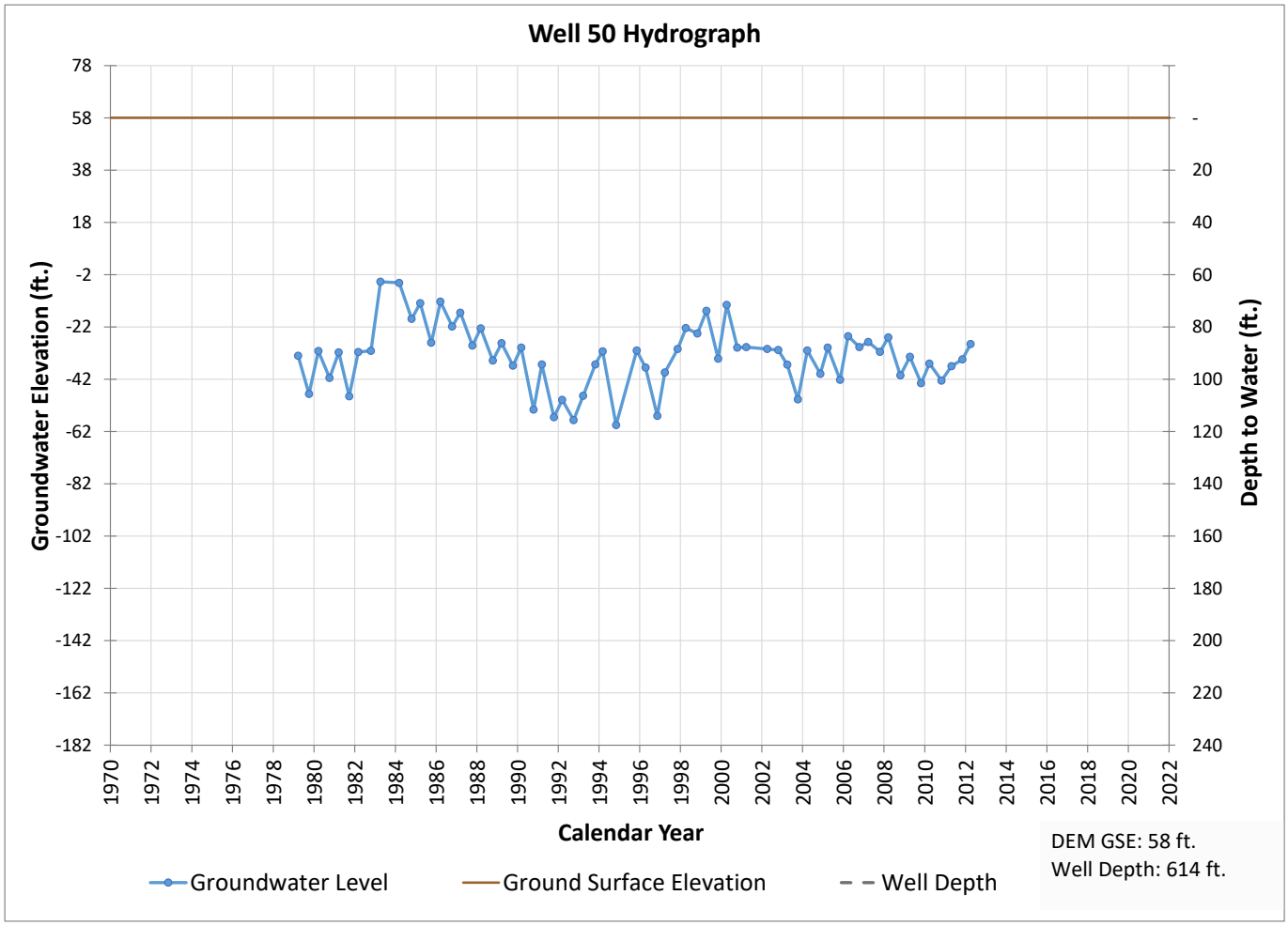

Well 38 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 74 ft.
Well Depth: 212 ft.

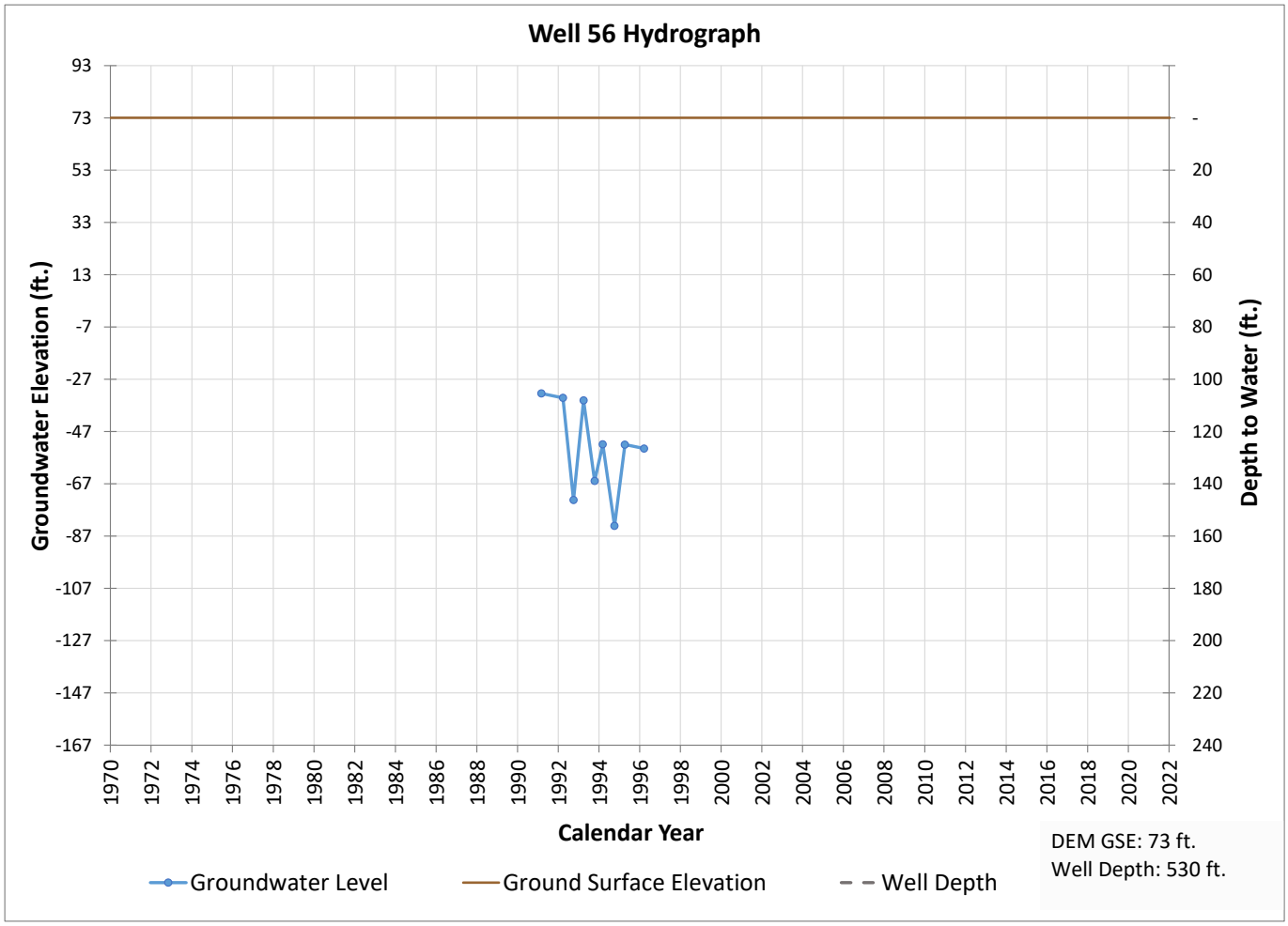

Well 41 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: ft.

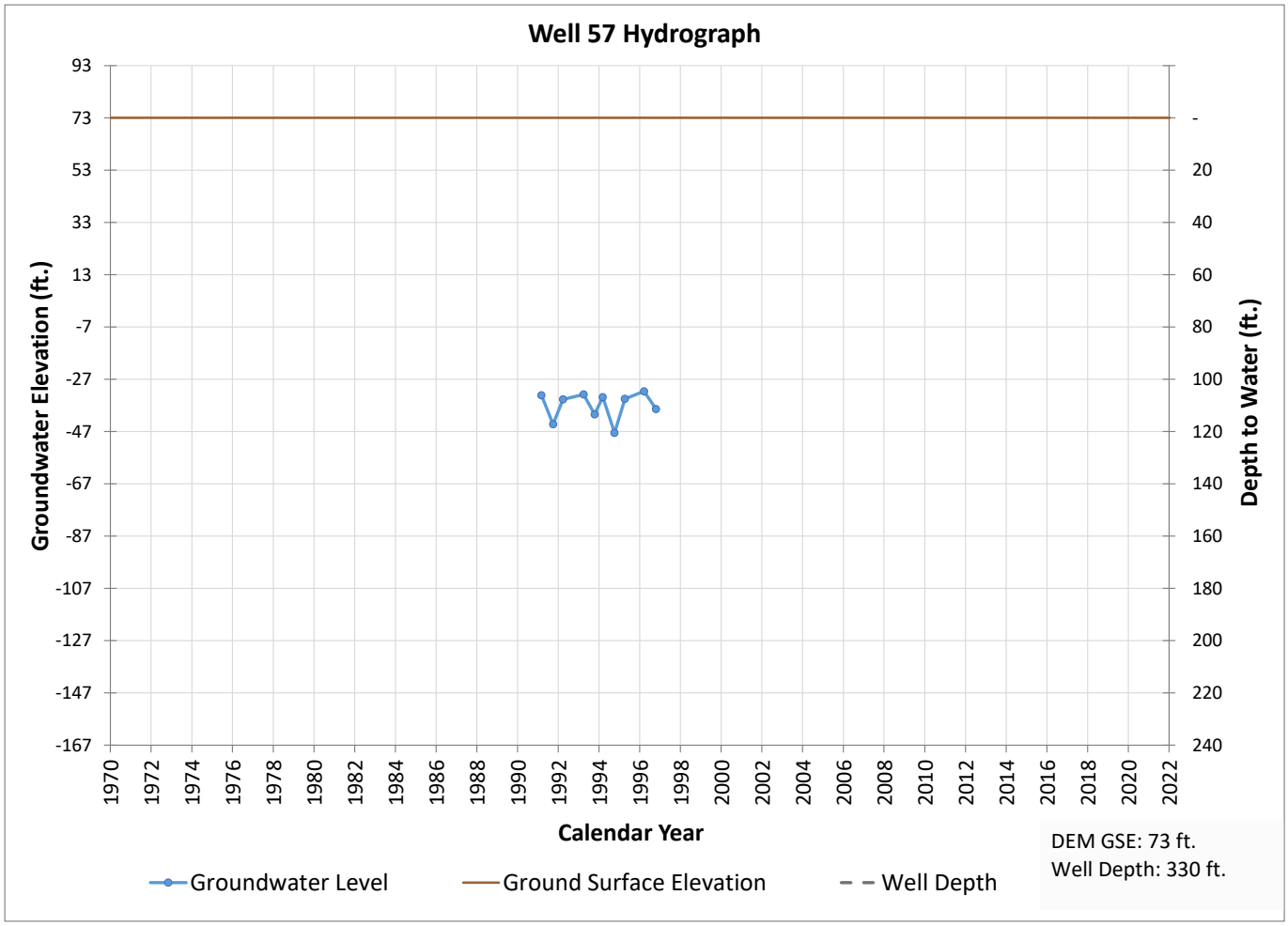

Well 42 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: 105 ft.

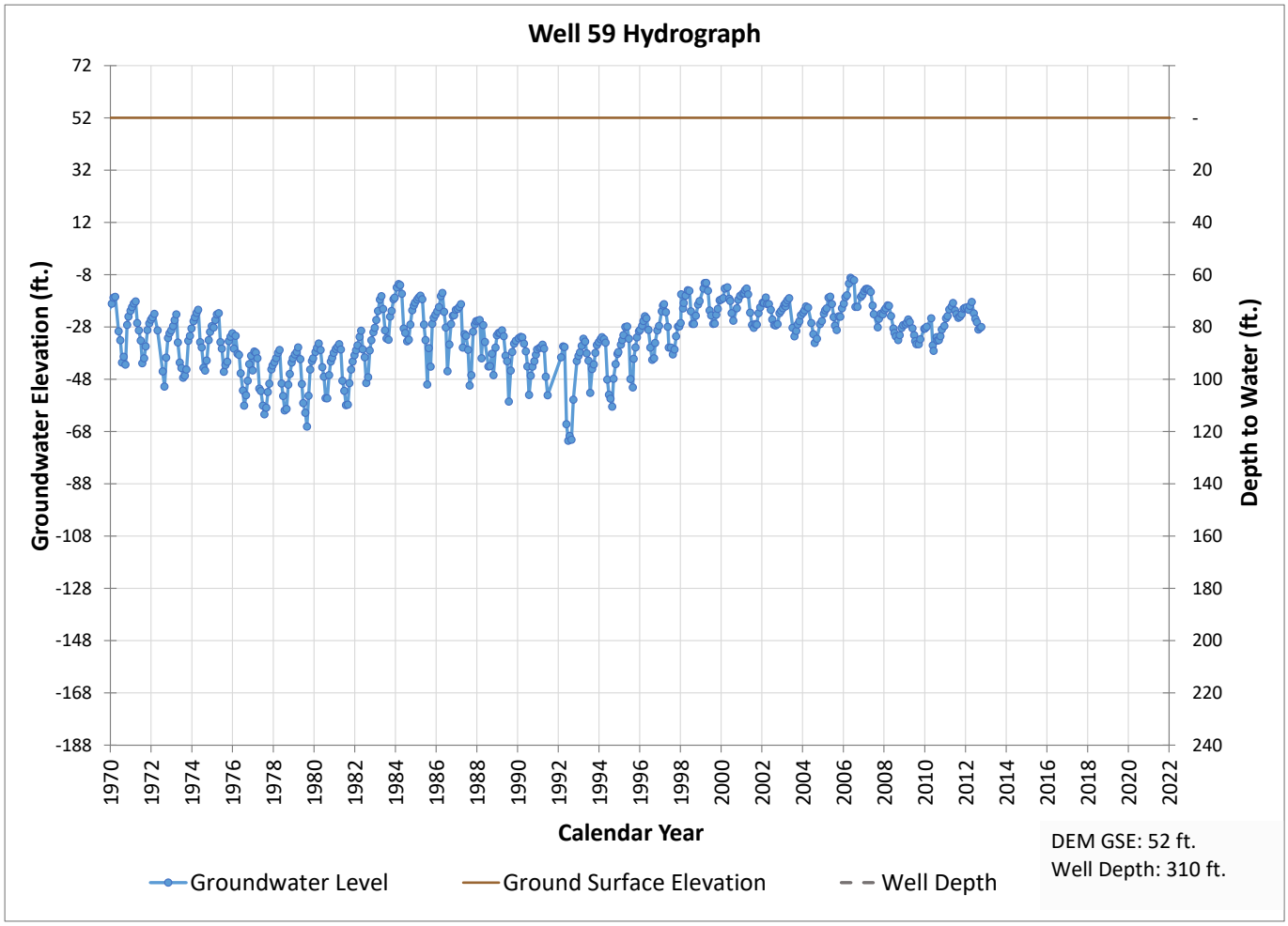

Well 43 Hydrograph
Groundwater Elevation (ft.)
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 41 ft.
Well Depth: ft.

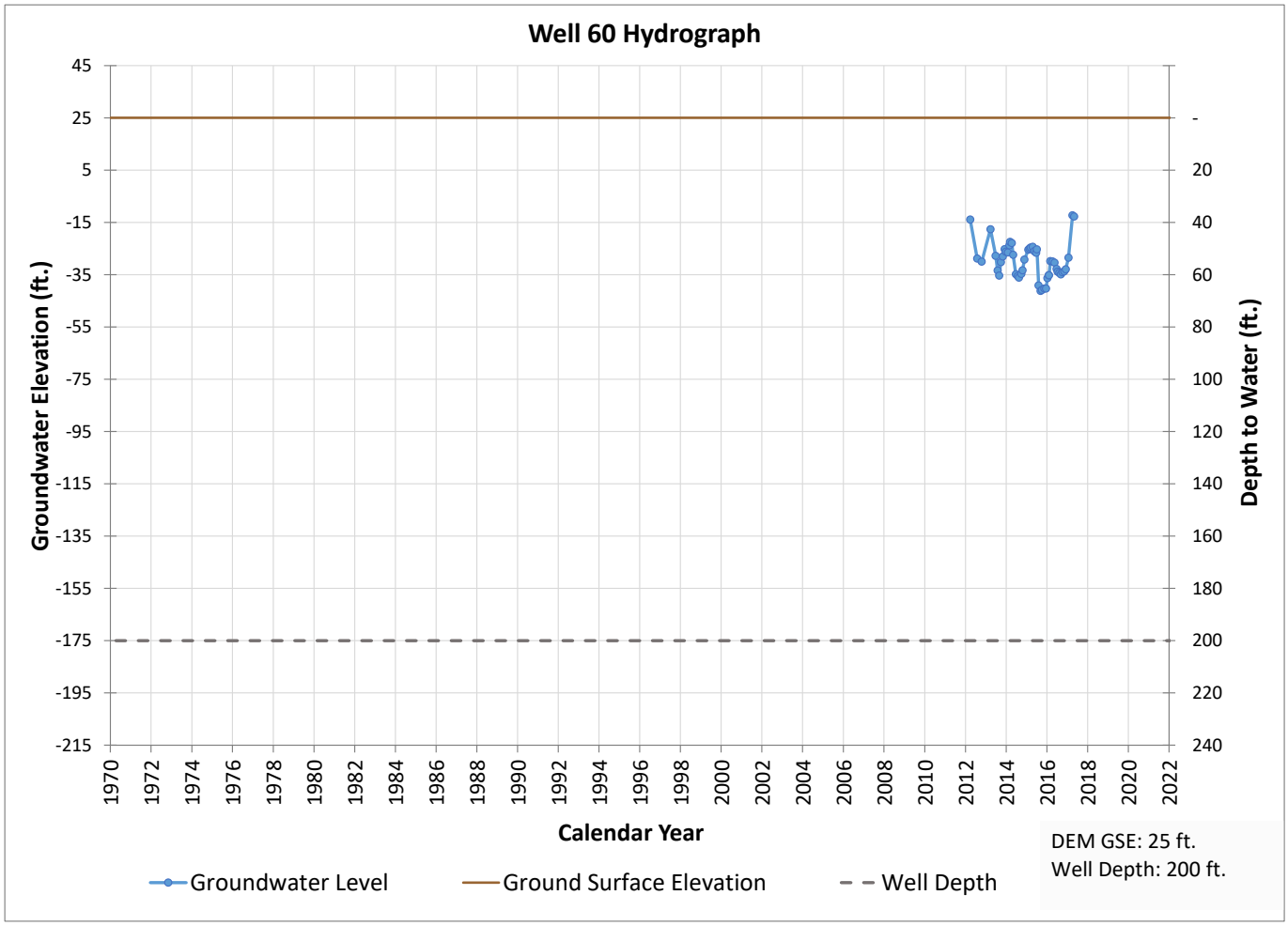

Well 49 Hydrograph
Groundwater Elevation (ft.)
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 59 ft.
Well Depth: ft.

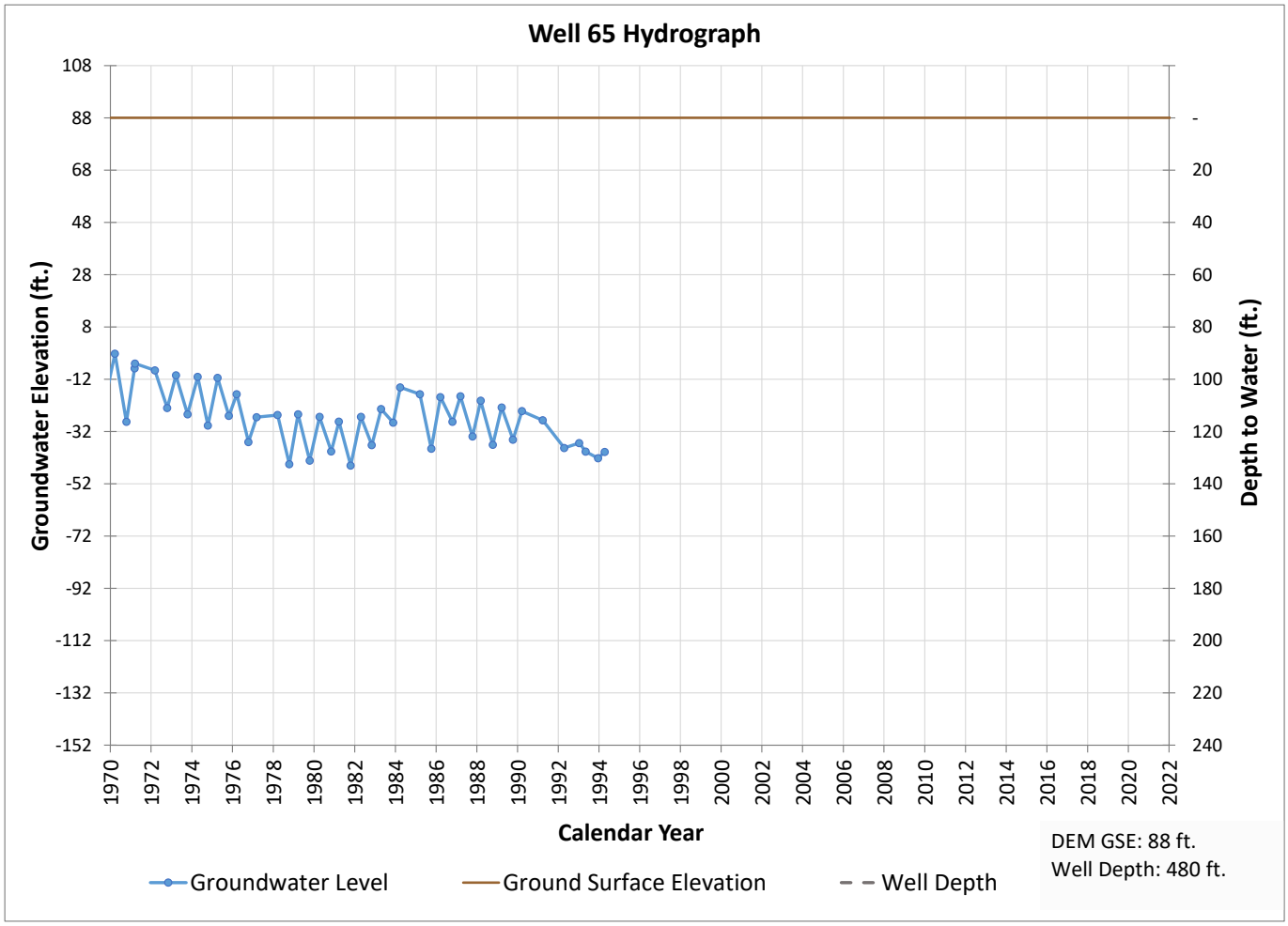

Well 50 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 58 ft.
Well Depth: 614 ft.

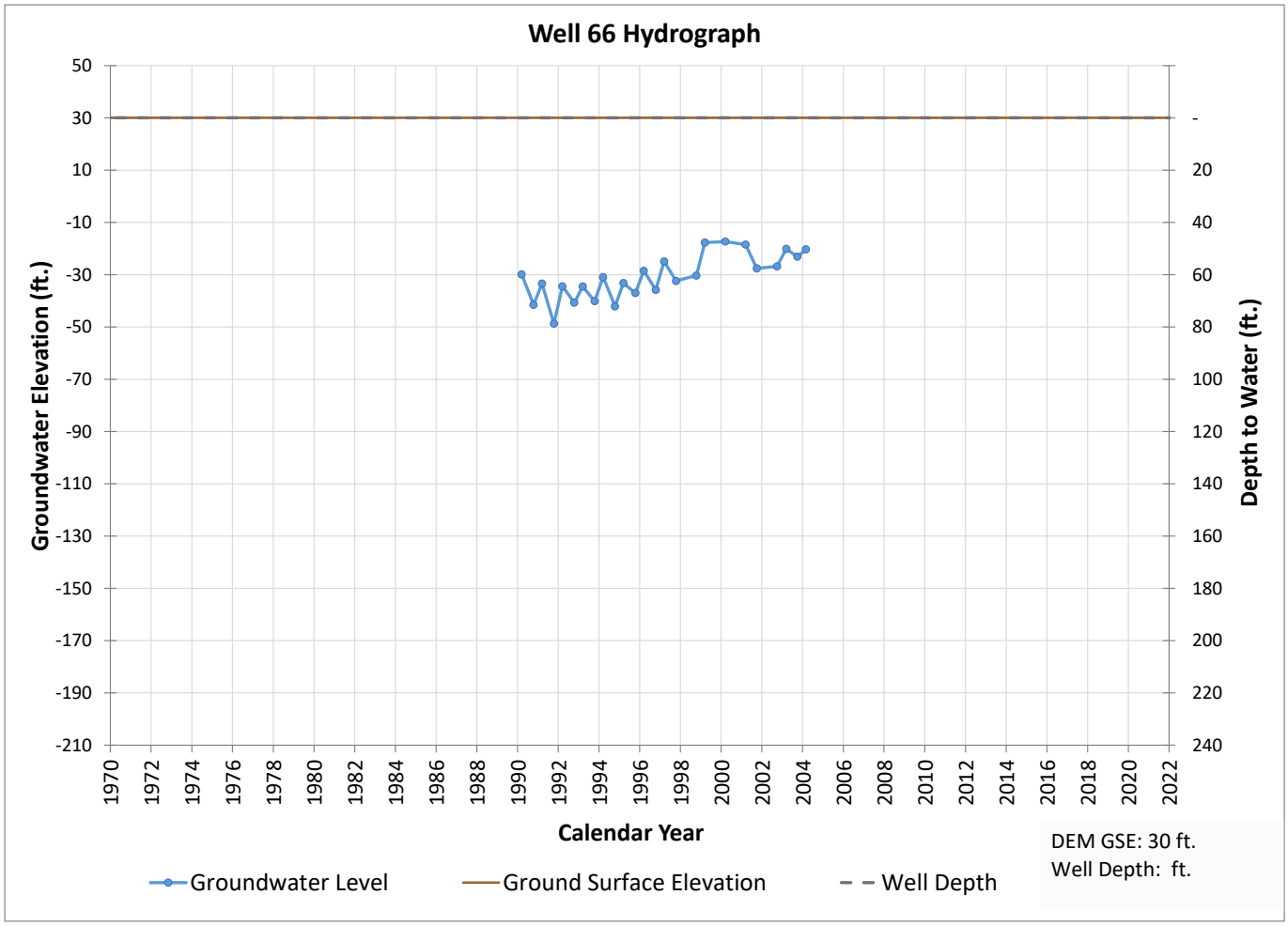

Well 56 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 73 ft.
Well Depth: 530 ft.

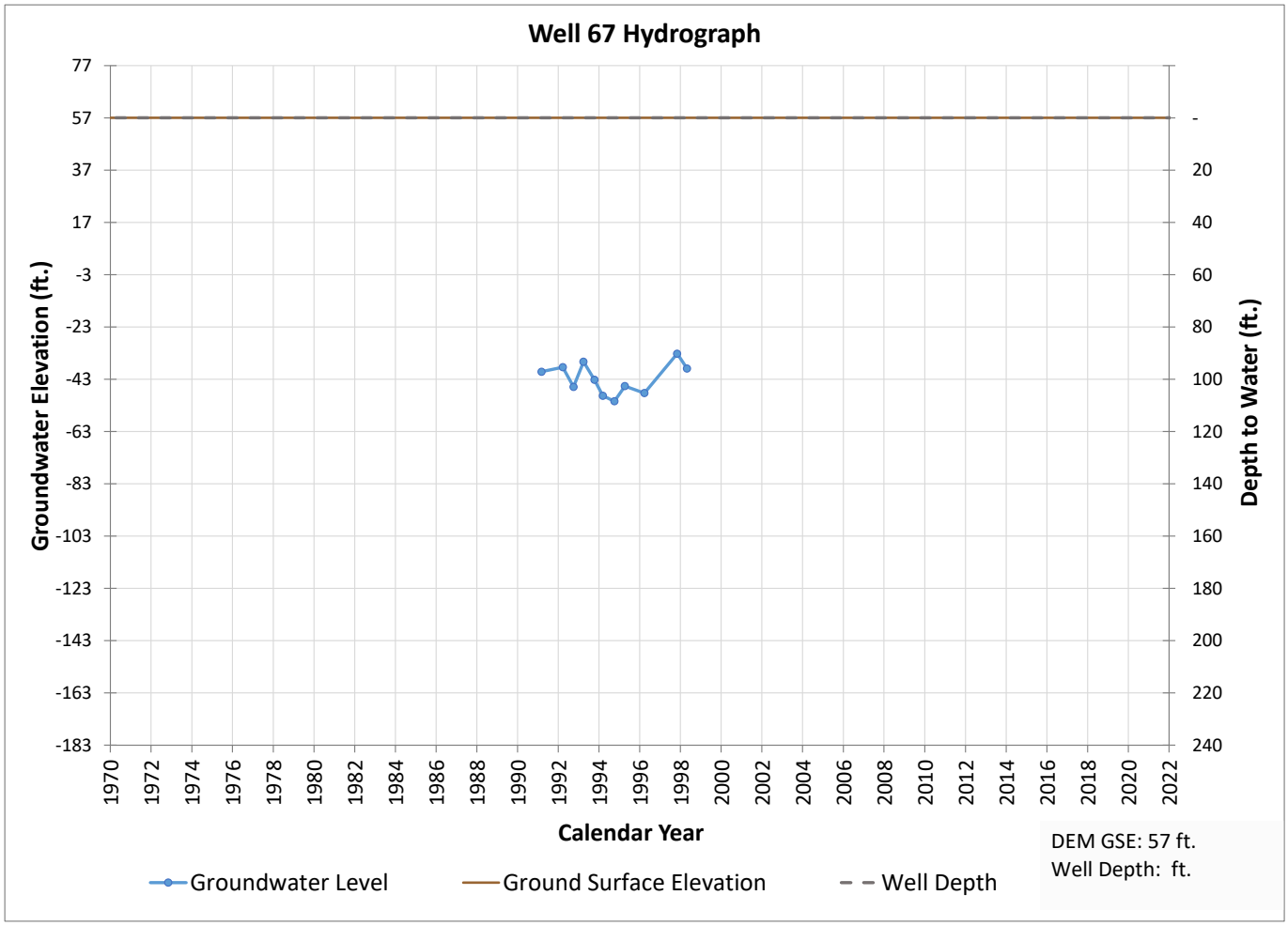

Well 57 Hydrograph
Groundwater Elevation (ft.)
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 73 ft.
Well Depth: 330 ft.

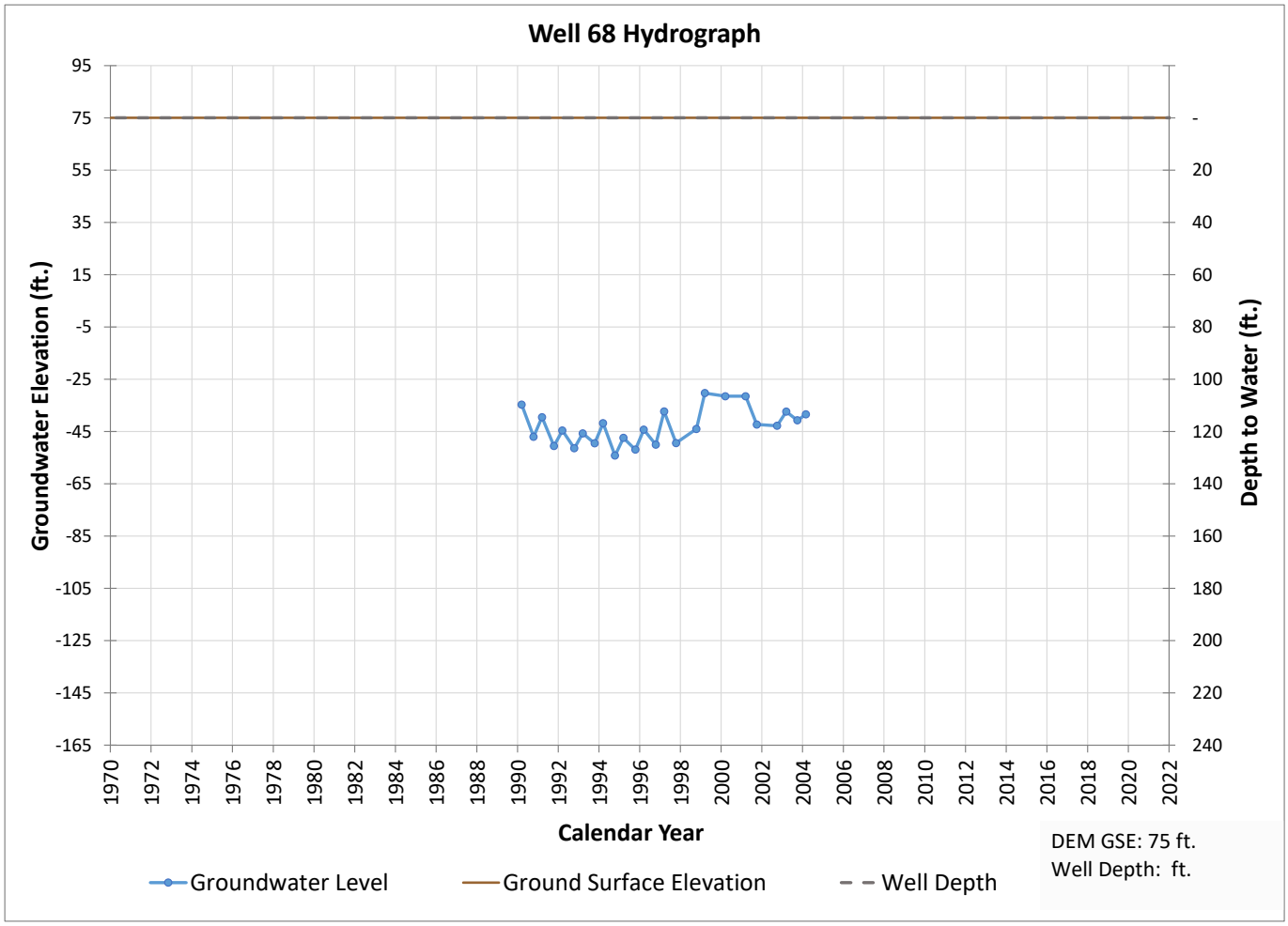

Well 59 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: 310 ft.

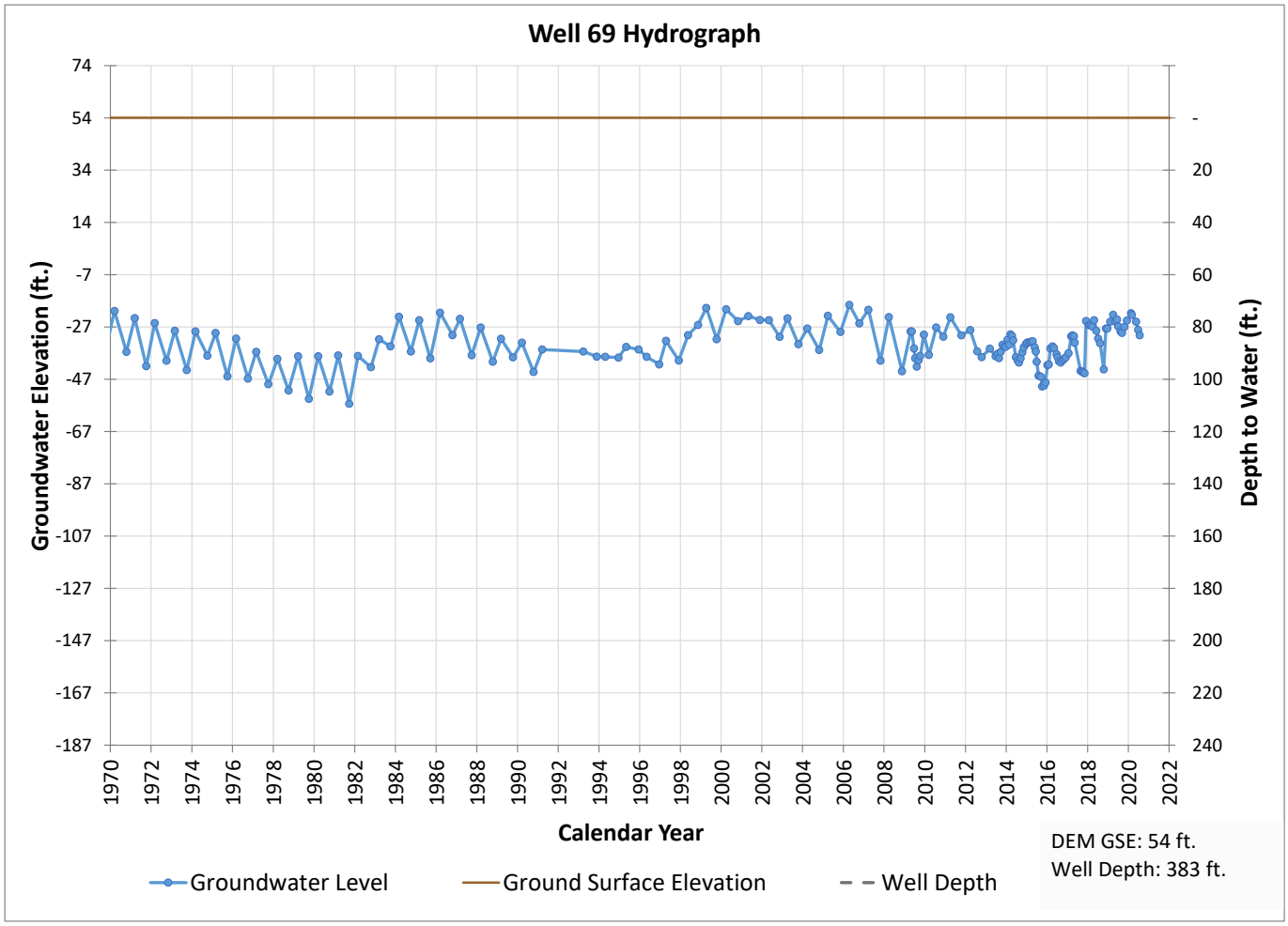

Well 60 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-195
-215
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 25 ft.
Well Depth: 200 ft.

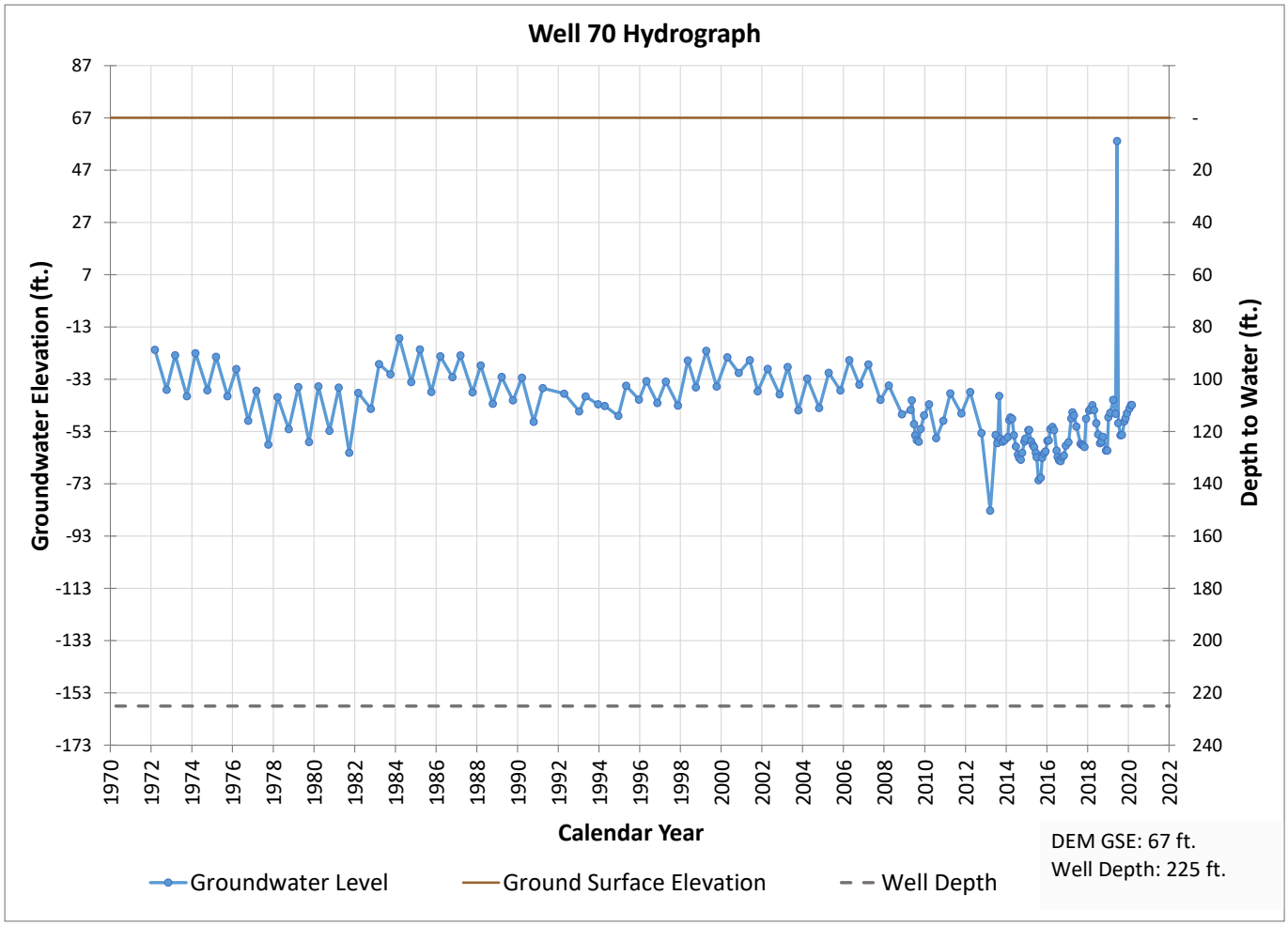

Well 65 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 88 ft.
Well Depth: 480 ft.

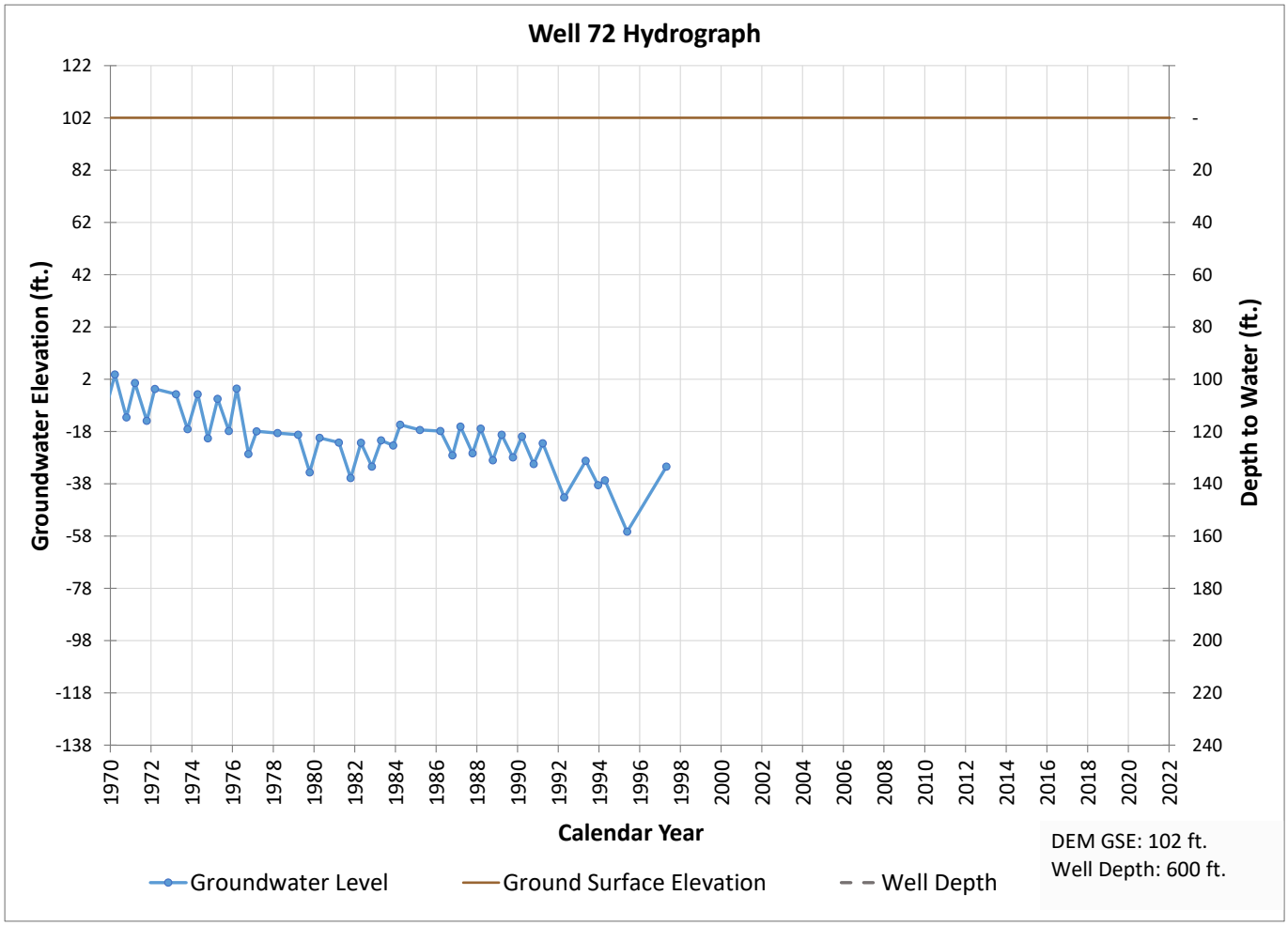

Well 66 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 30 ft.
Well Depth: ft.

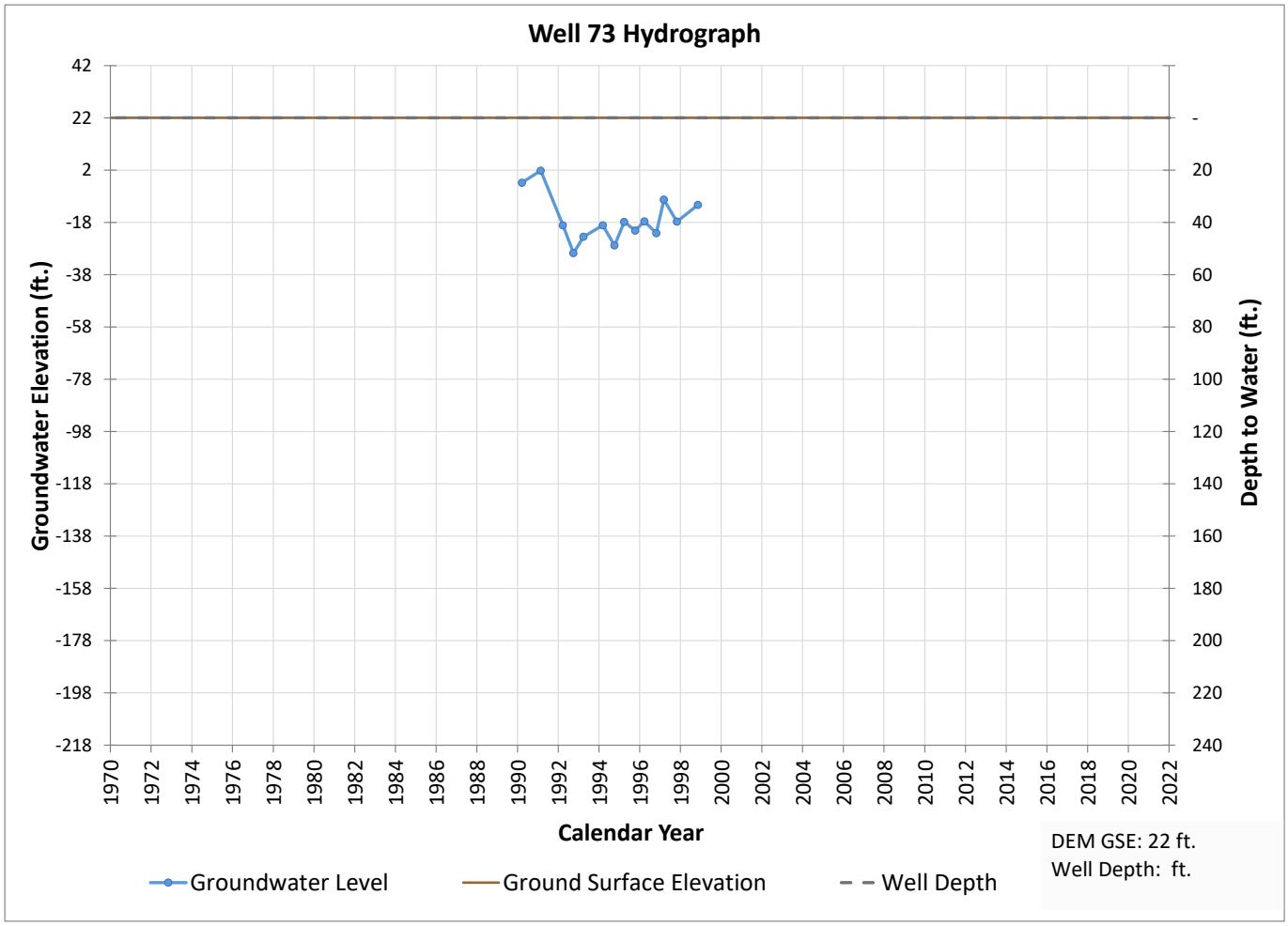

Well 67 Hydrograph
Groundwater Elevation (ft.)
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 57 ft.
Well Depth: ft.

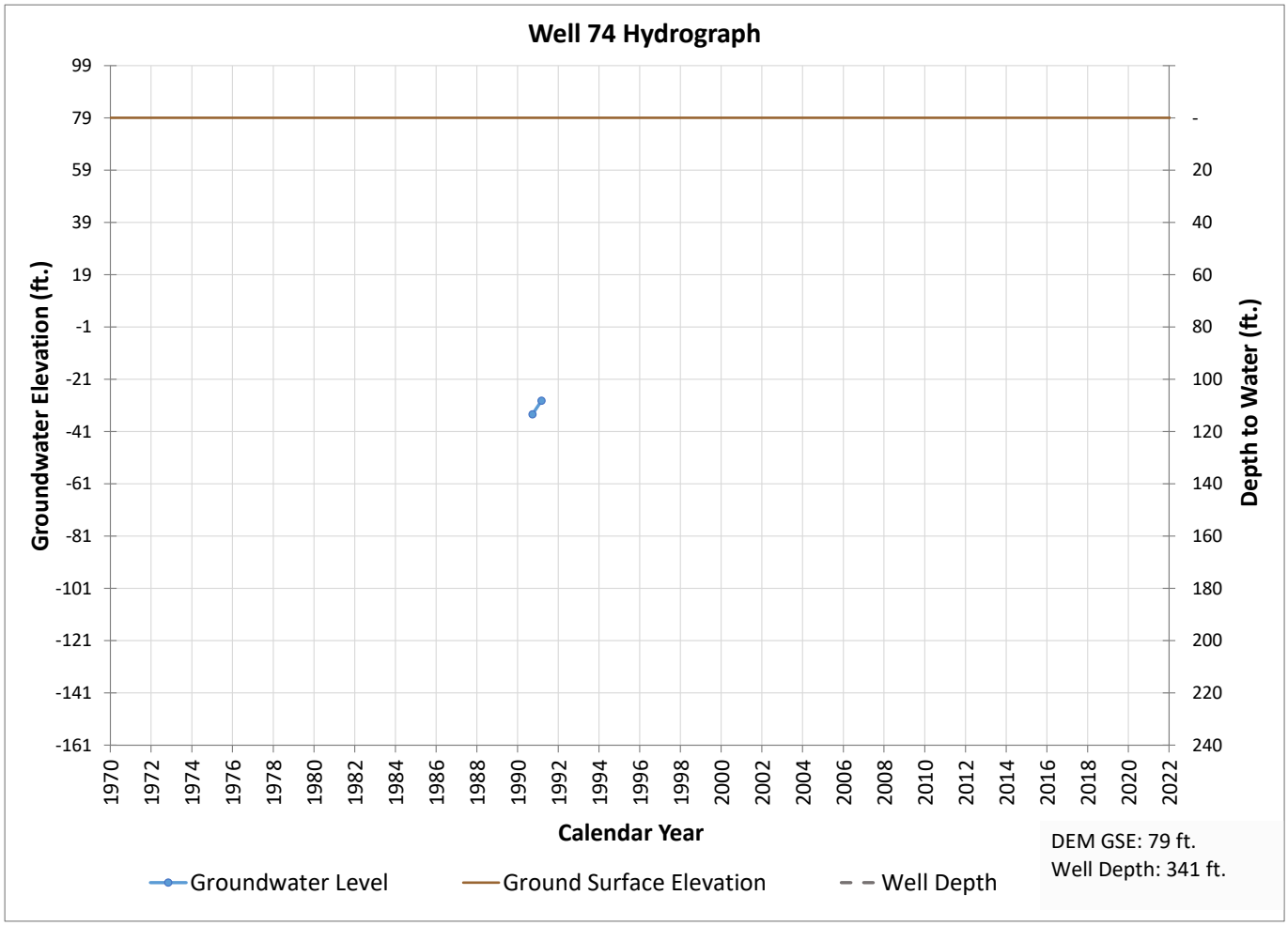

Well 68 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 75 ft.
Well Depth: ft.

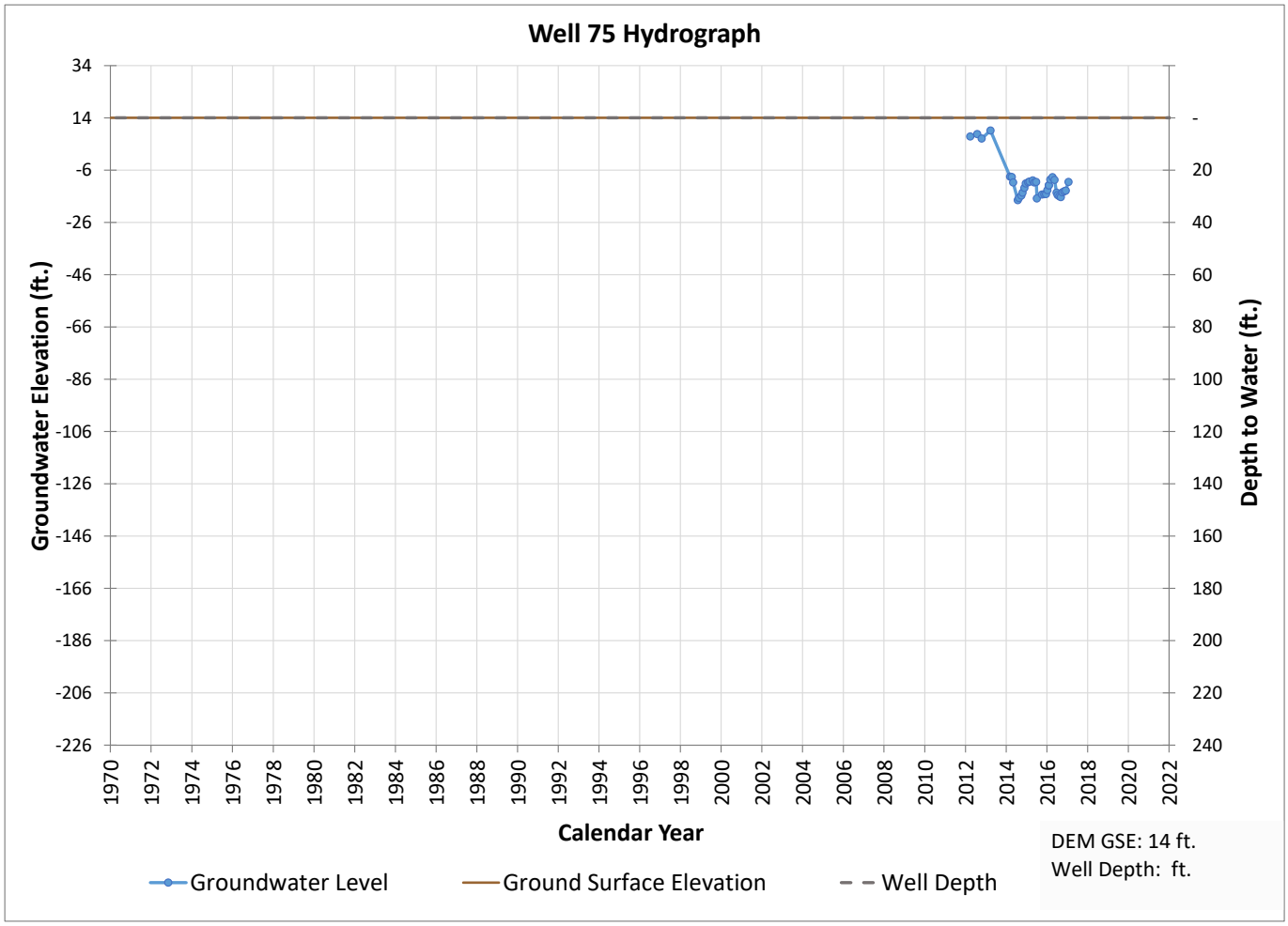

Well 69 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 383 ft.

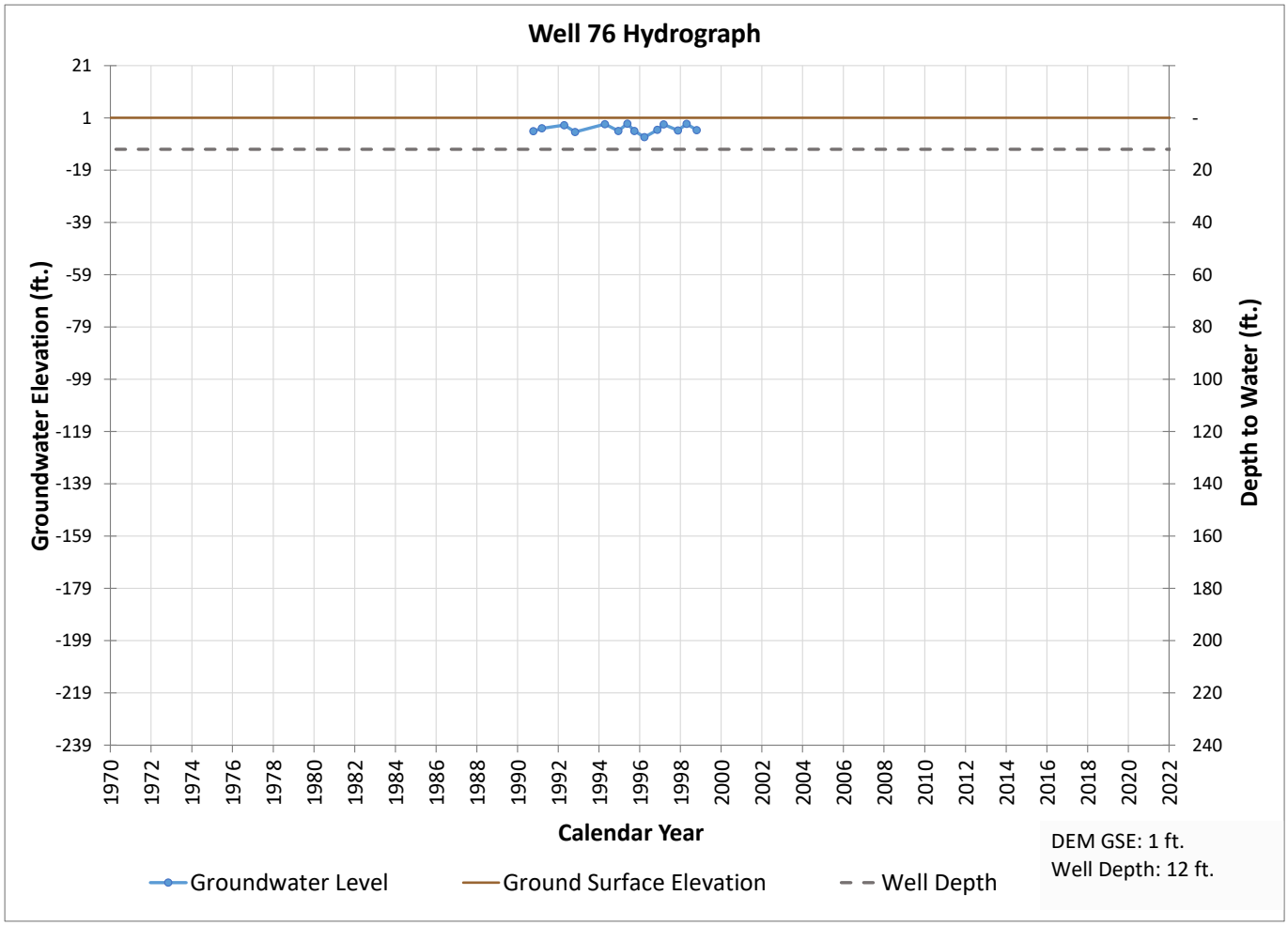

Well 70 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: 225 ft.

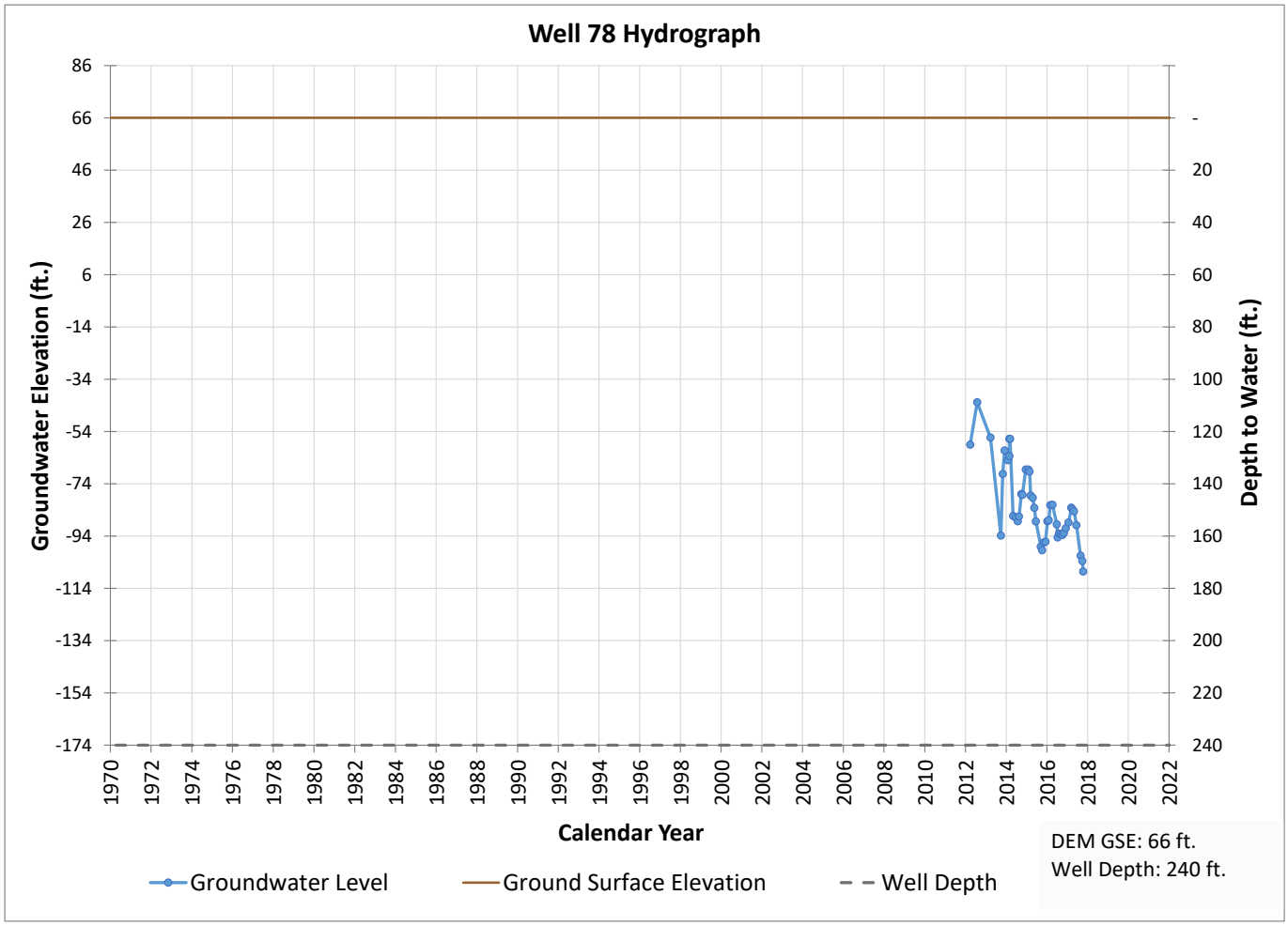

Well 72 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: 600 ft.

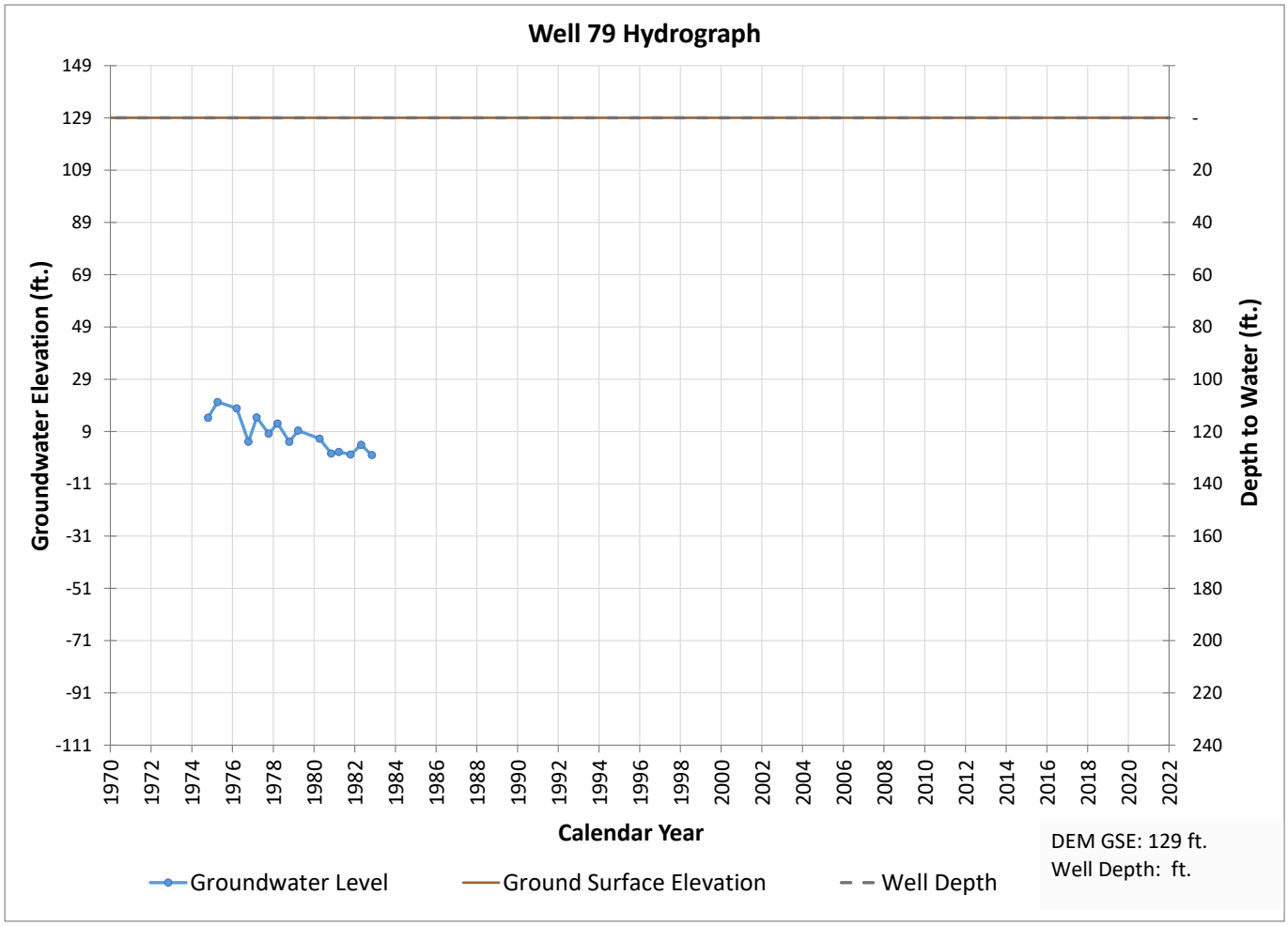

Well 73 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: ft.

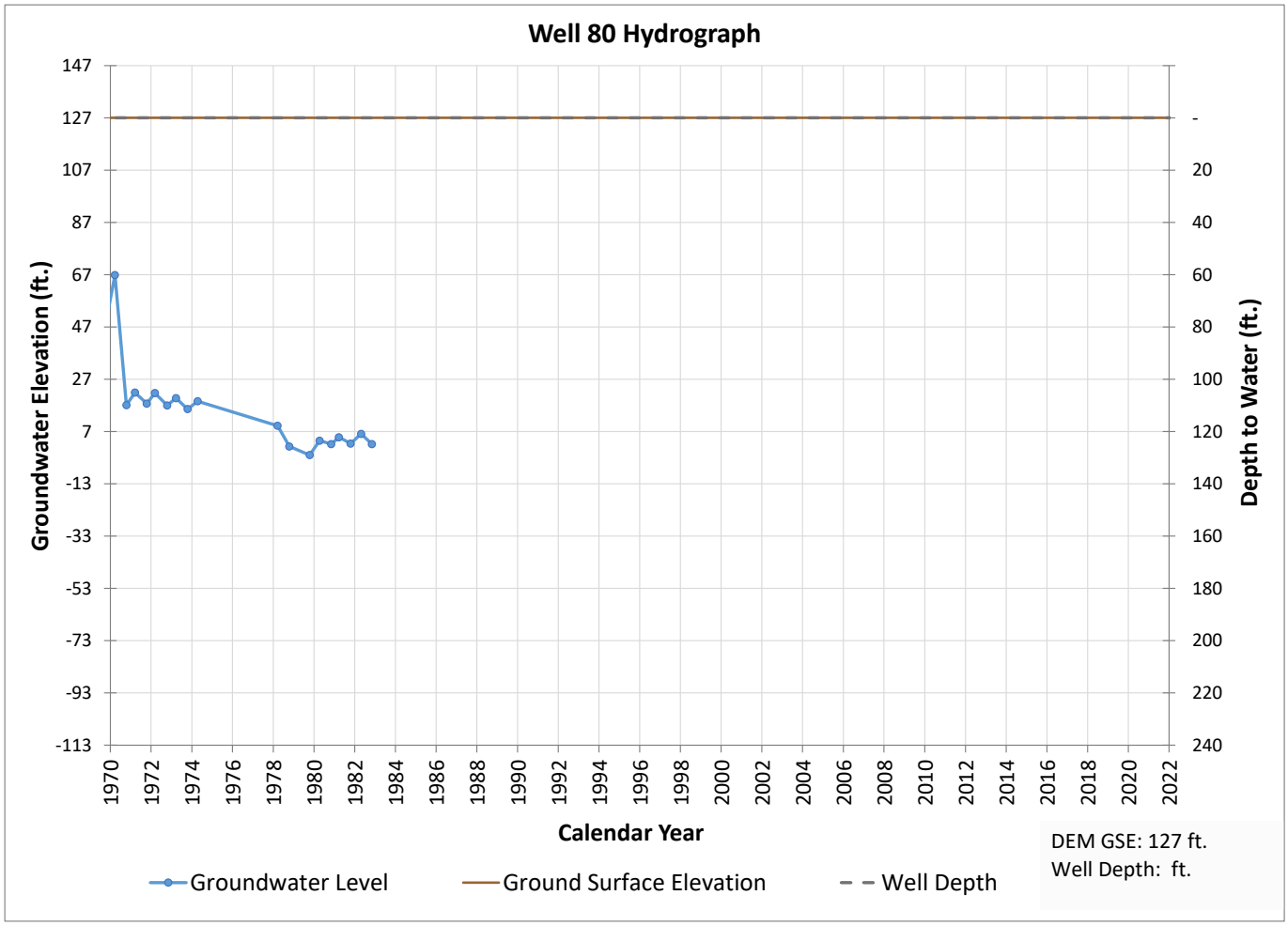

Well 74 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 79 ft.
Well Depth: 341 ft.

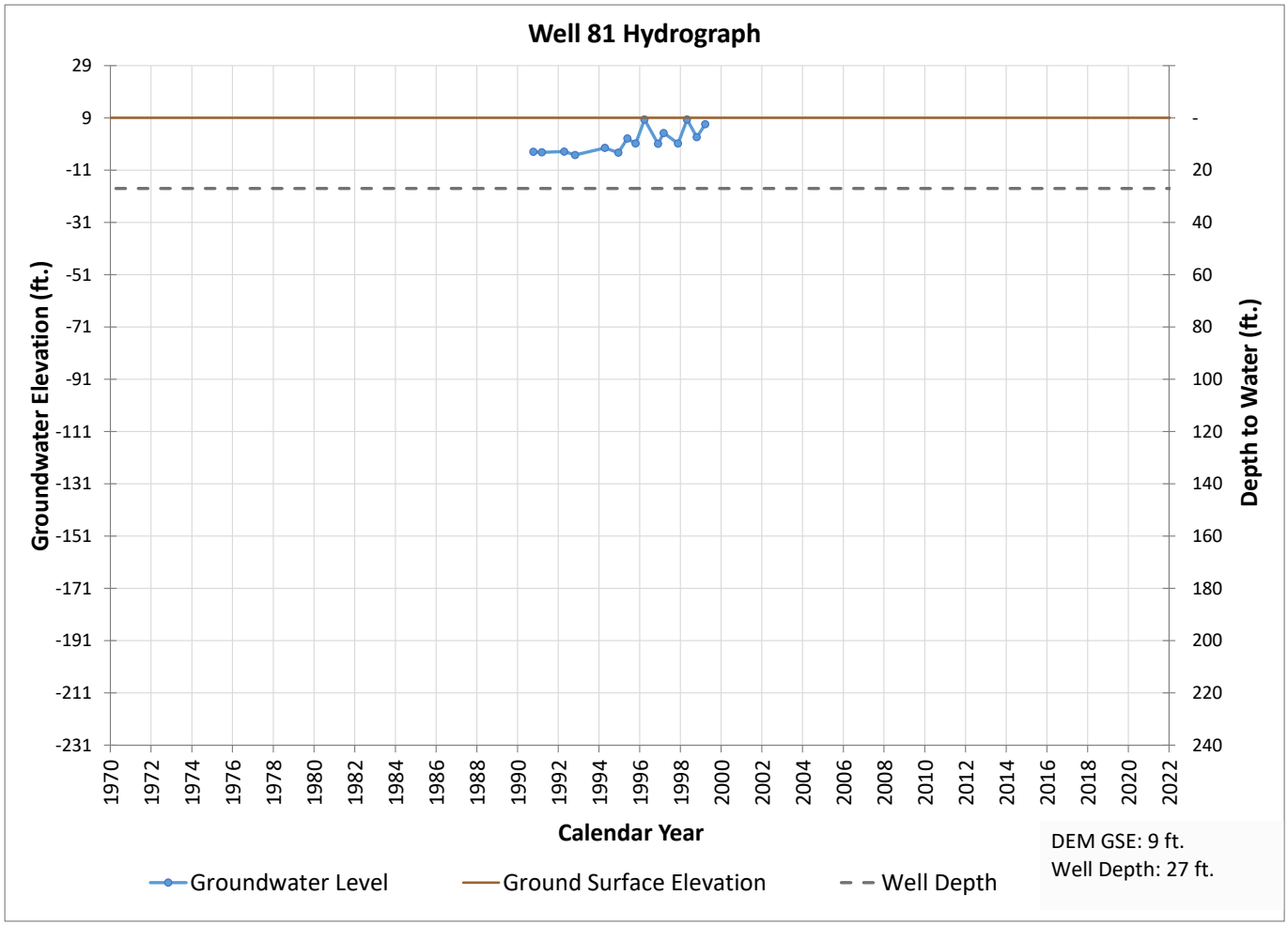

Well 75 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
-226
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 14 ft.
Well Depth: ft.

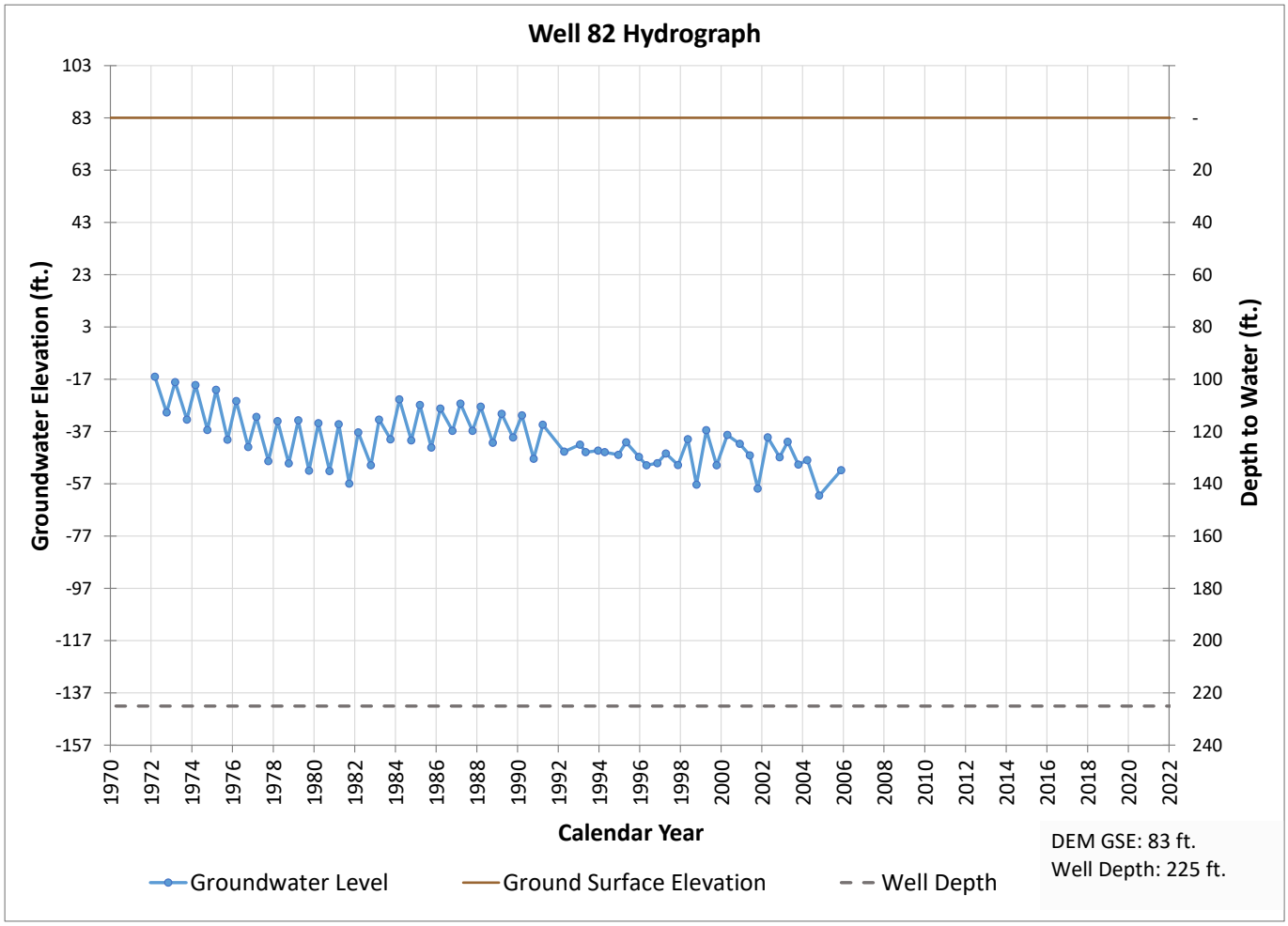

Well 76 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
-219
-239
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 1 ft.
Well Depth: 12 ft.

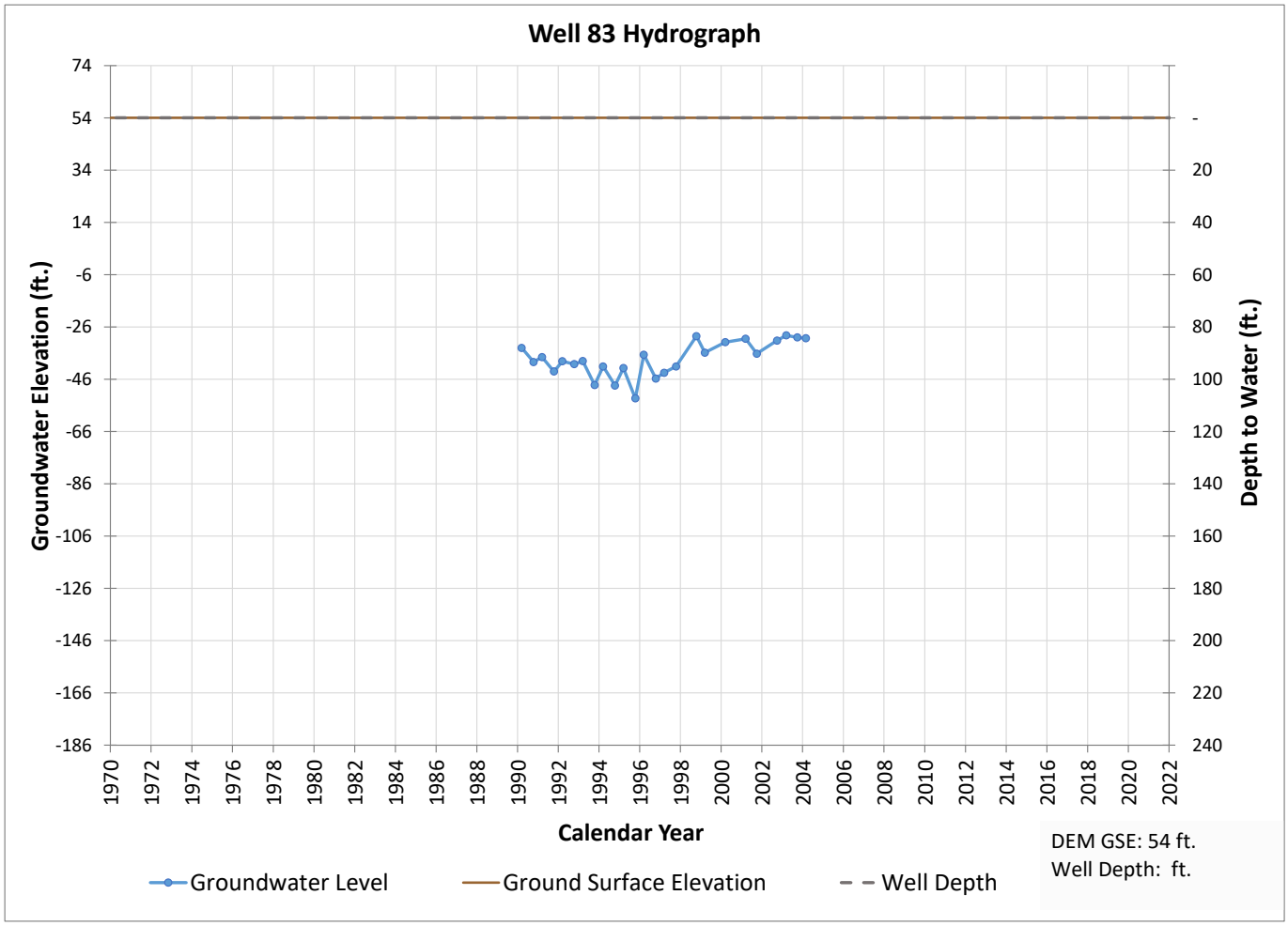

Well 78 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 66 ft.
Well Depth: 240 ft.

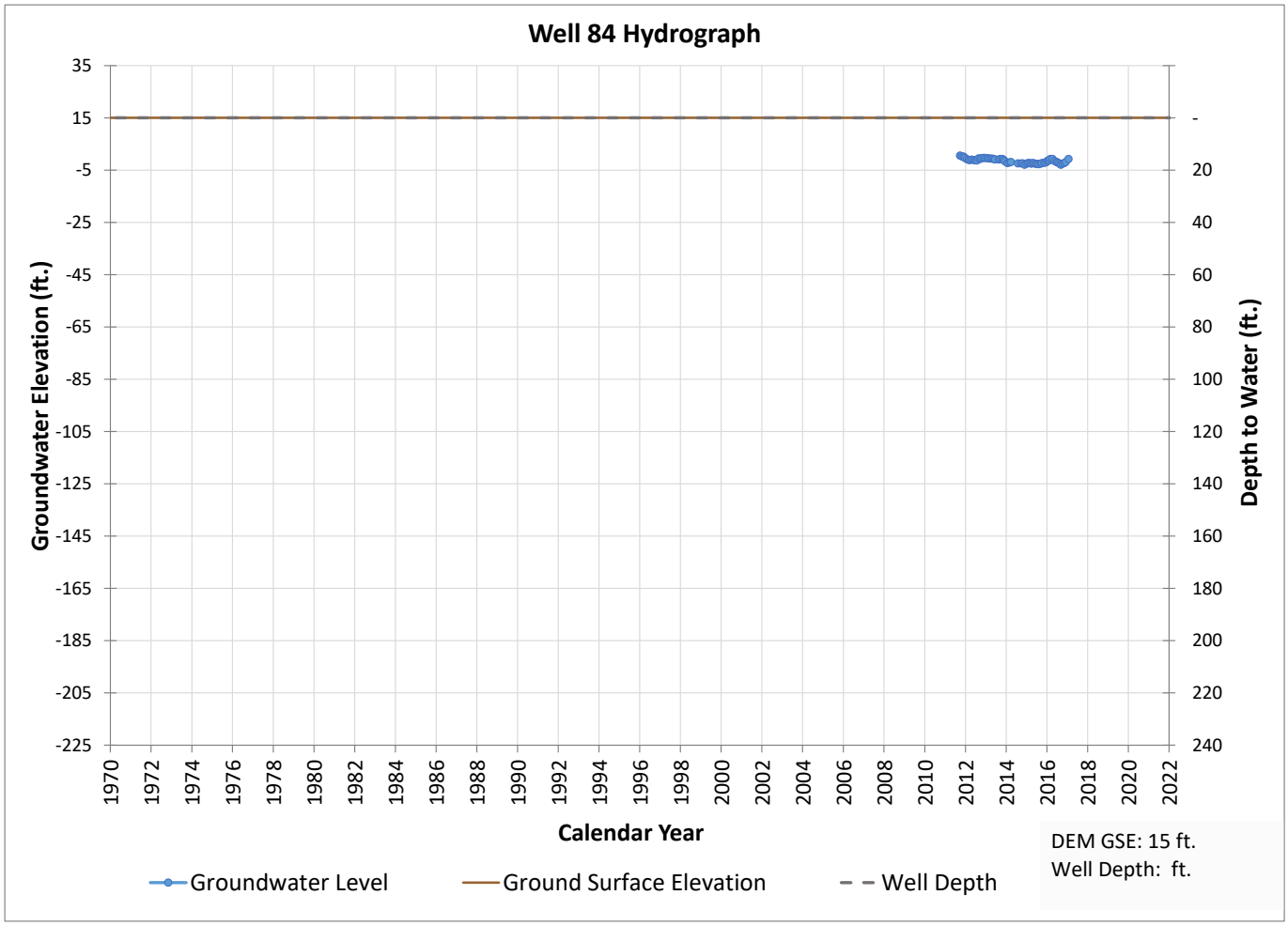

Well 79 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
149
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 129 ft.
Well Depth: ft.

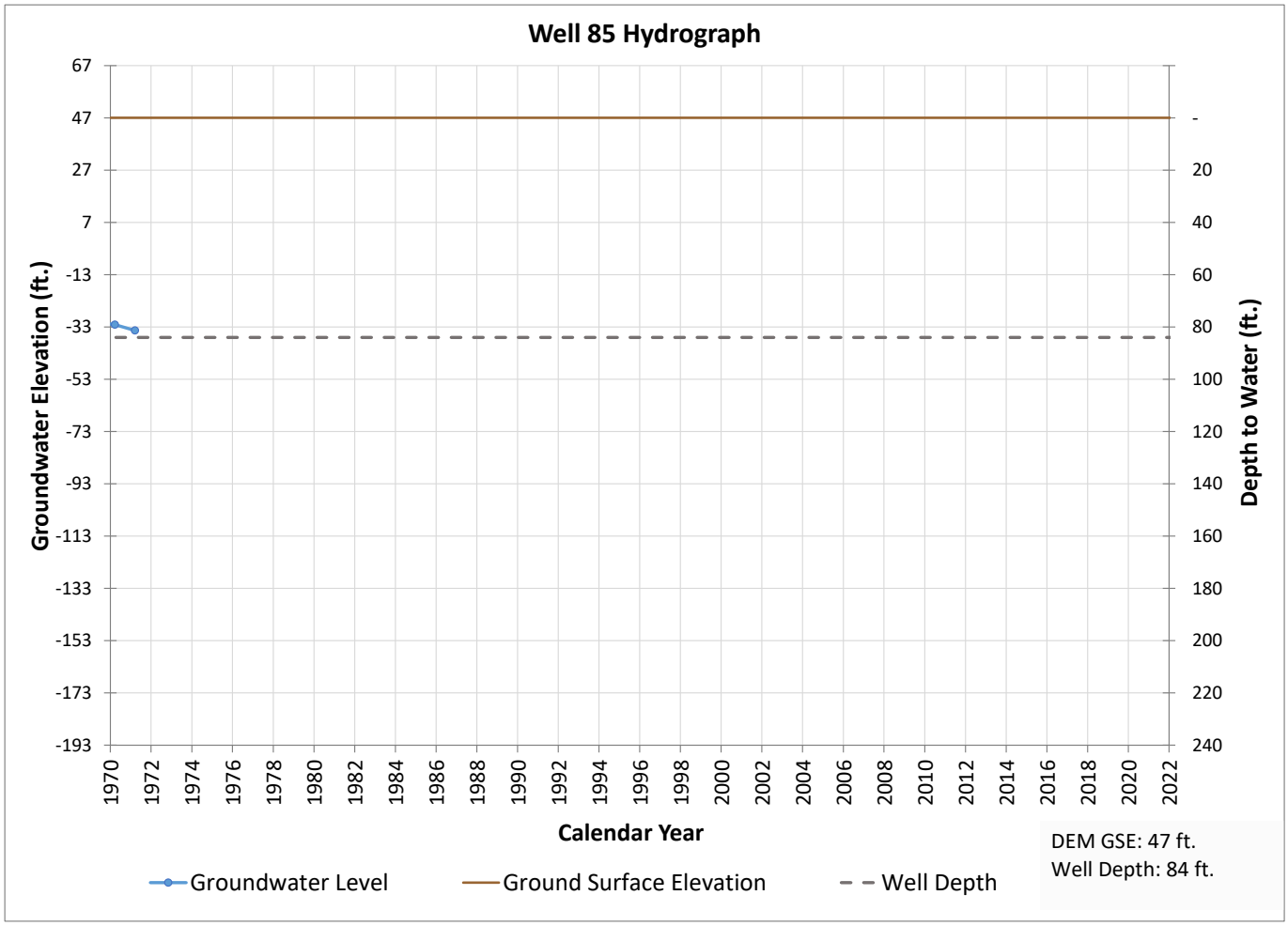

Well 80 Hydrograph
Groundwater Elevation (ft.)
147
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 127 ft.
Well Depth: ft.

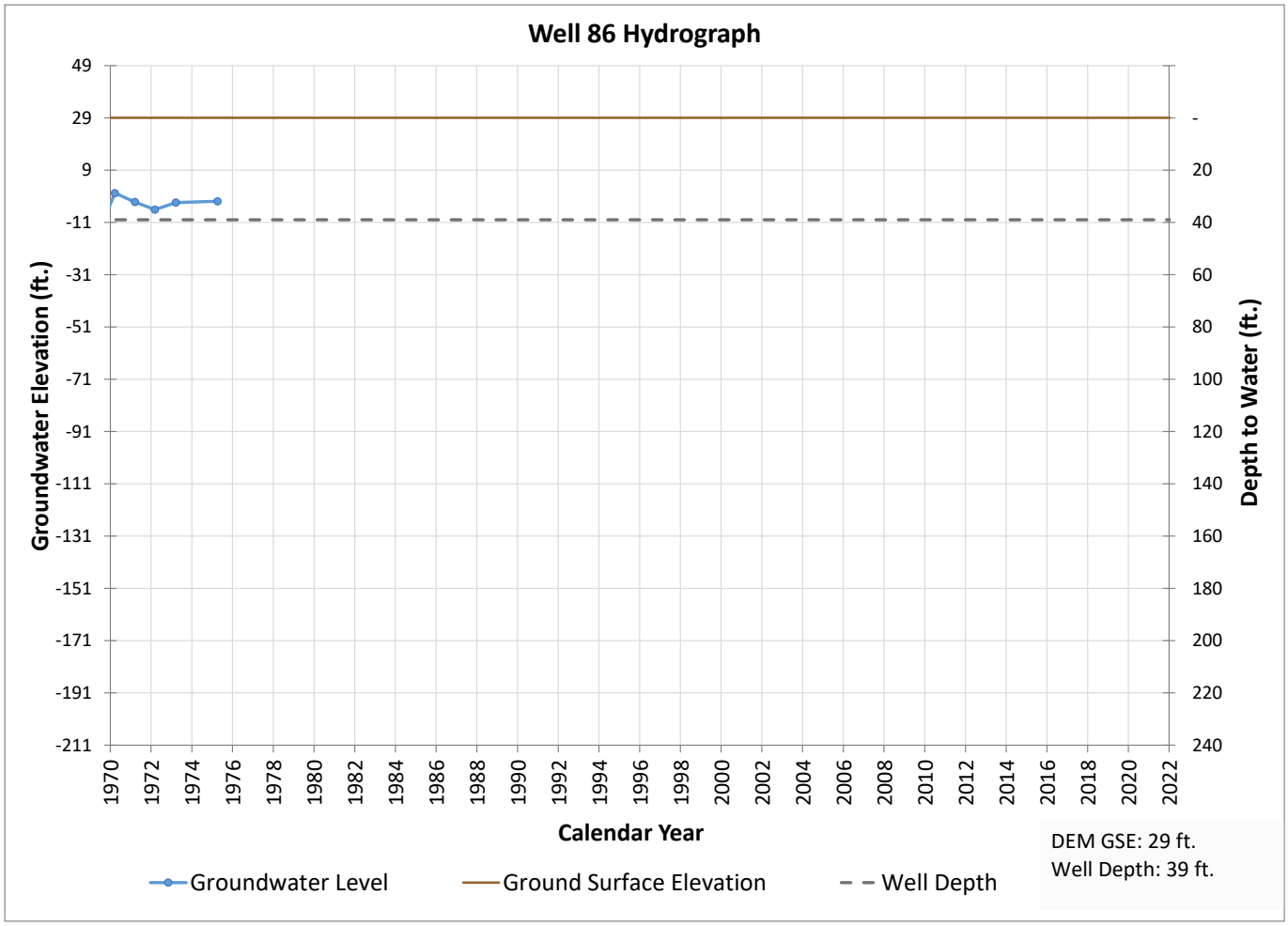

Well 81 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-231
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 9 ft.
Well Depth: 27 ft.

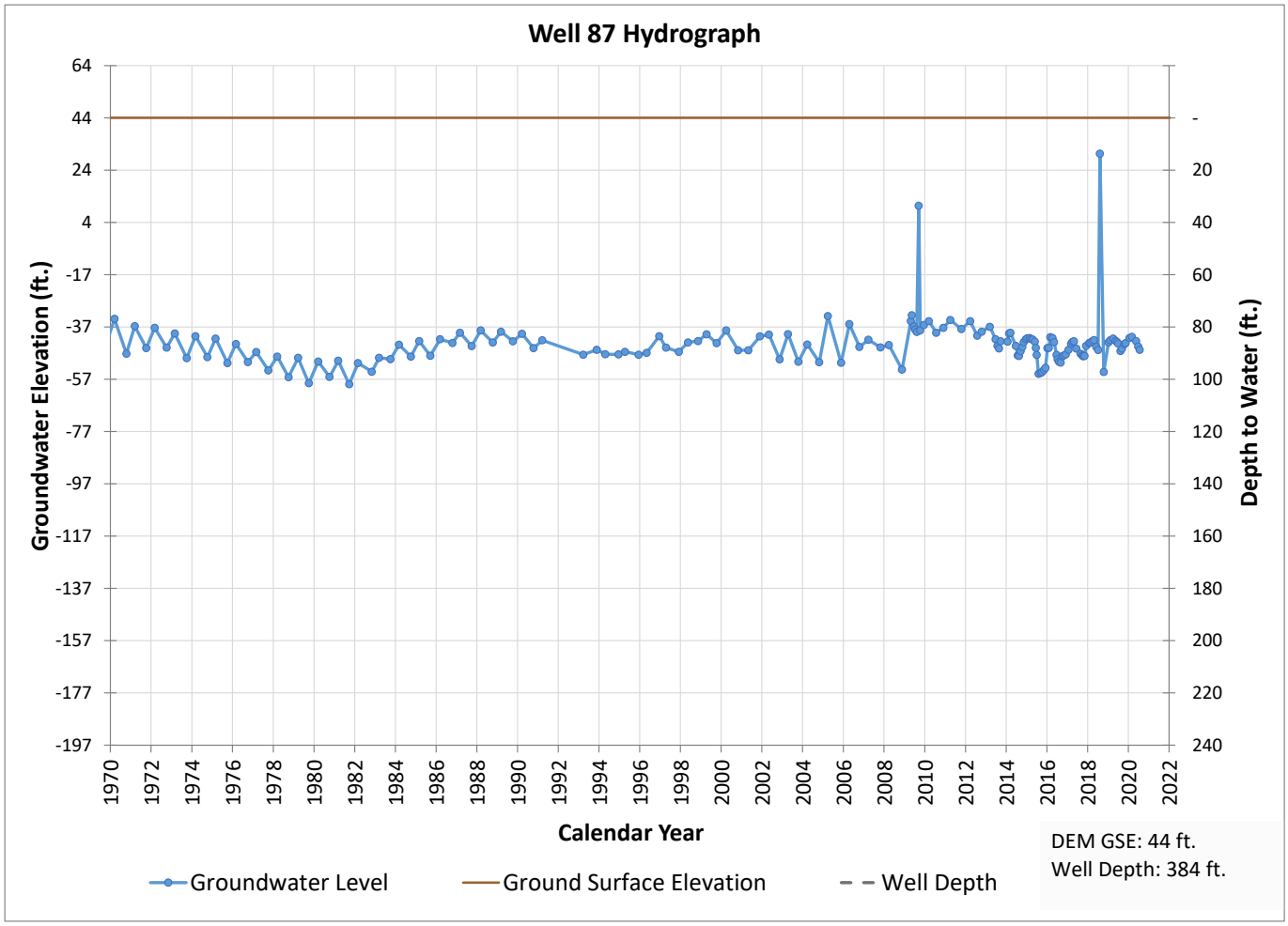

Well 82 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
103
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 83 ft.
Well Depth: 225 ft.

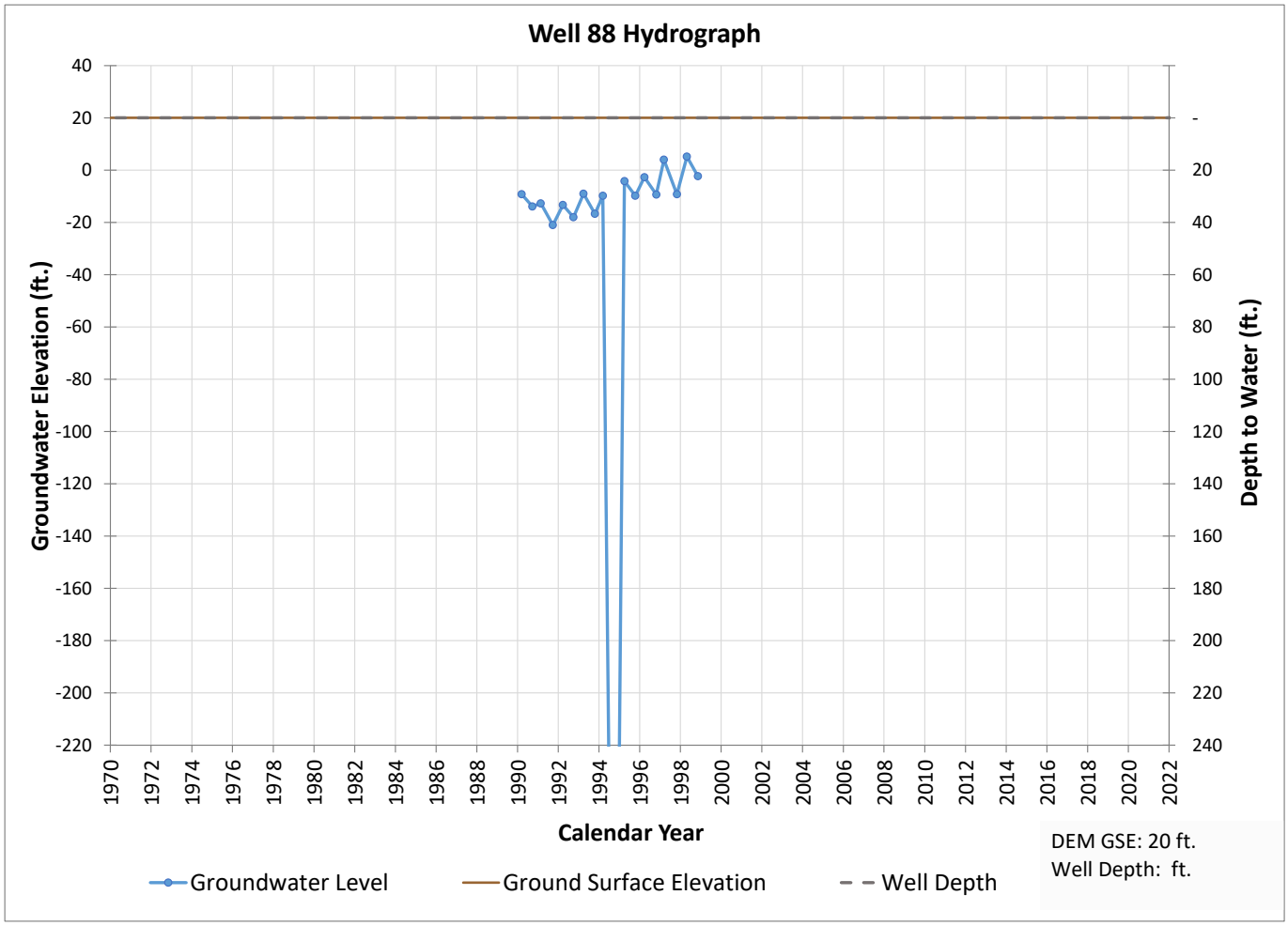

Well 83 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: ft.

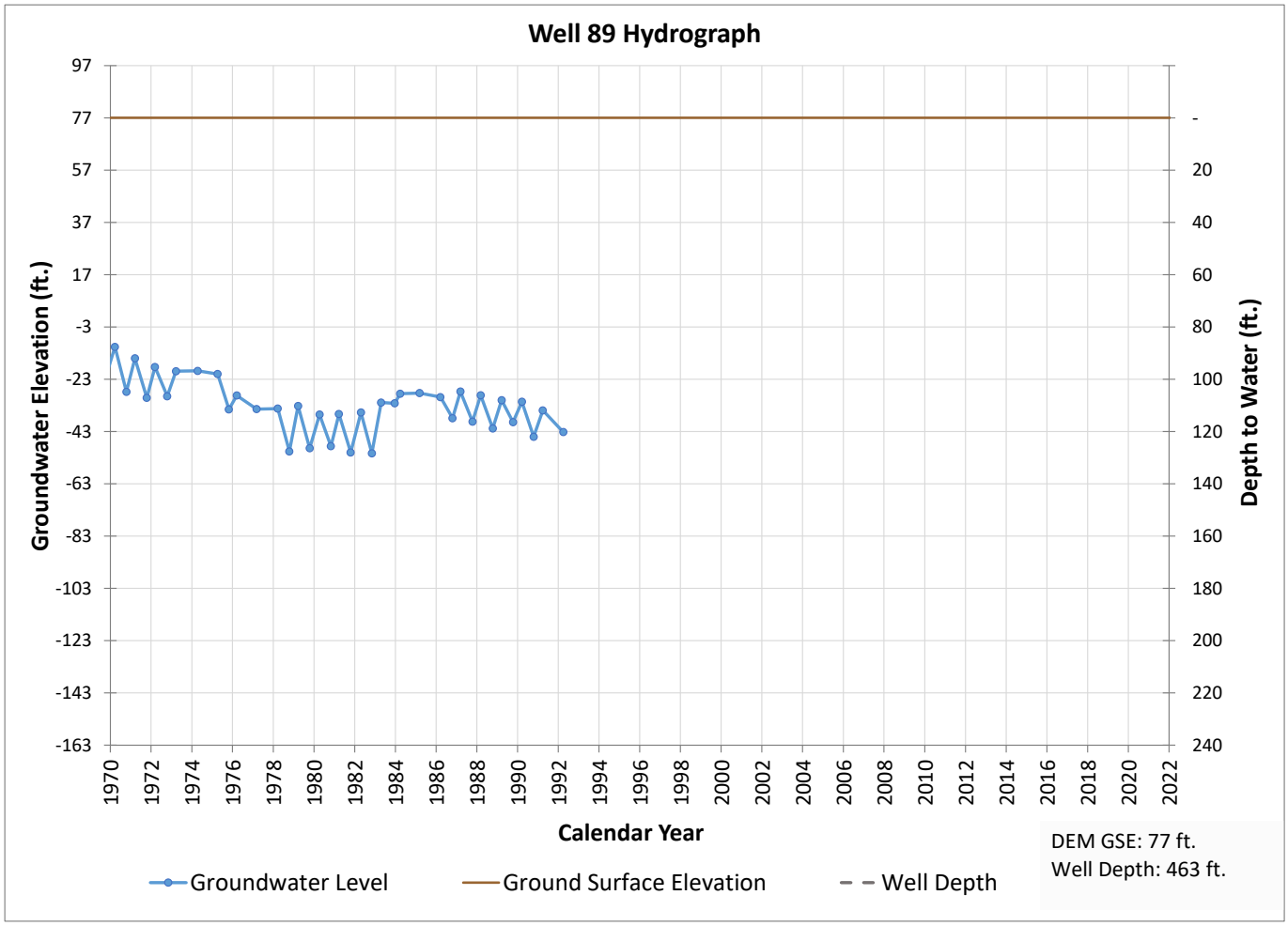

Well 84 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-225
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 15 ft.
Well Depth: ft.

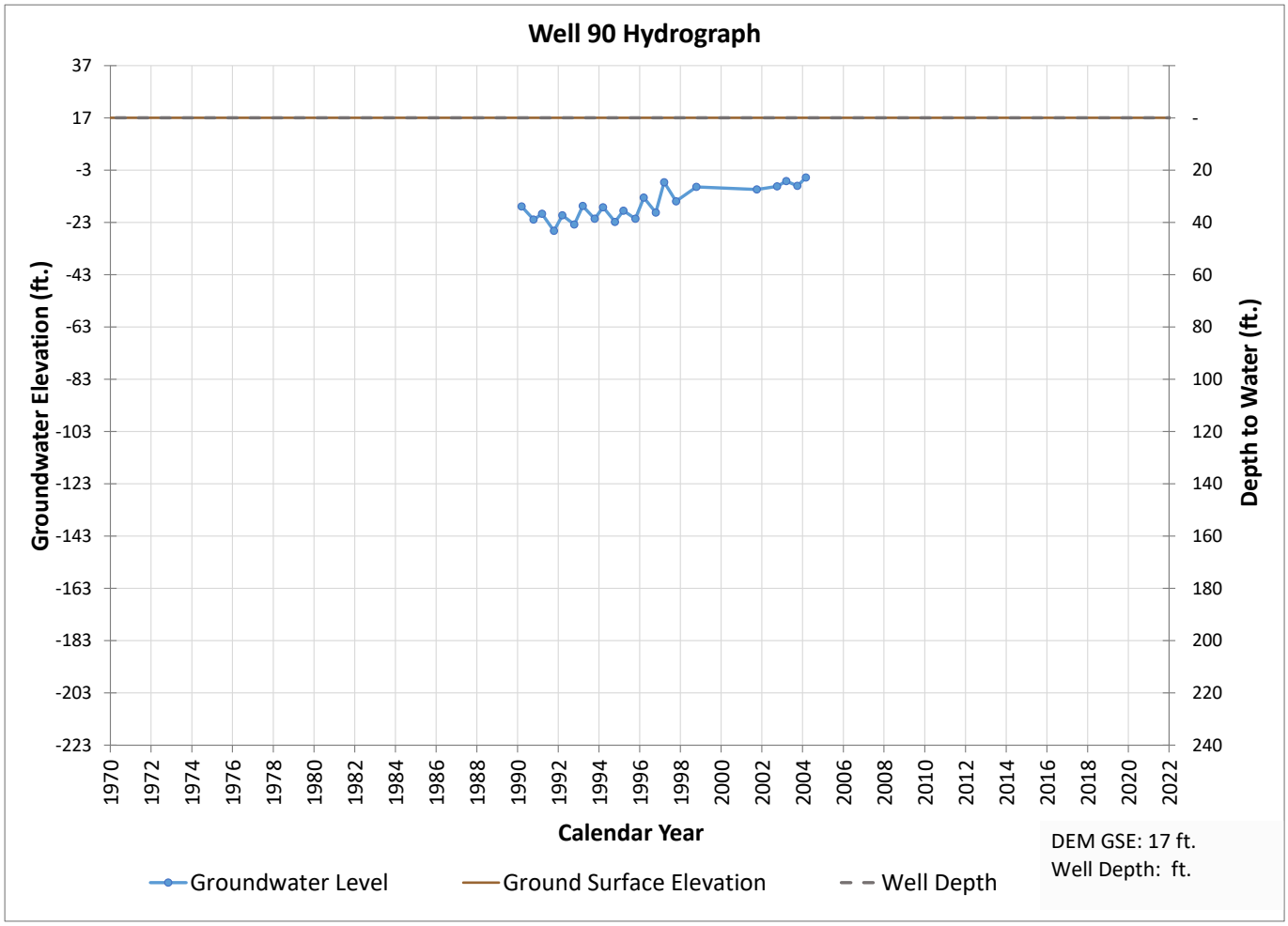

Well 85 Hydrograph
Groundwater Elevation (ft.)
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 47 ft.
Well Depth: 84 ft.

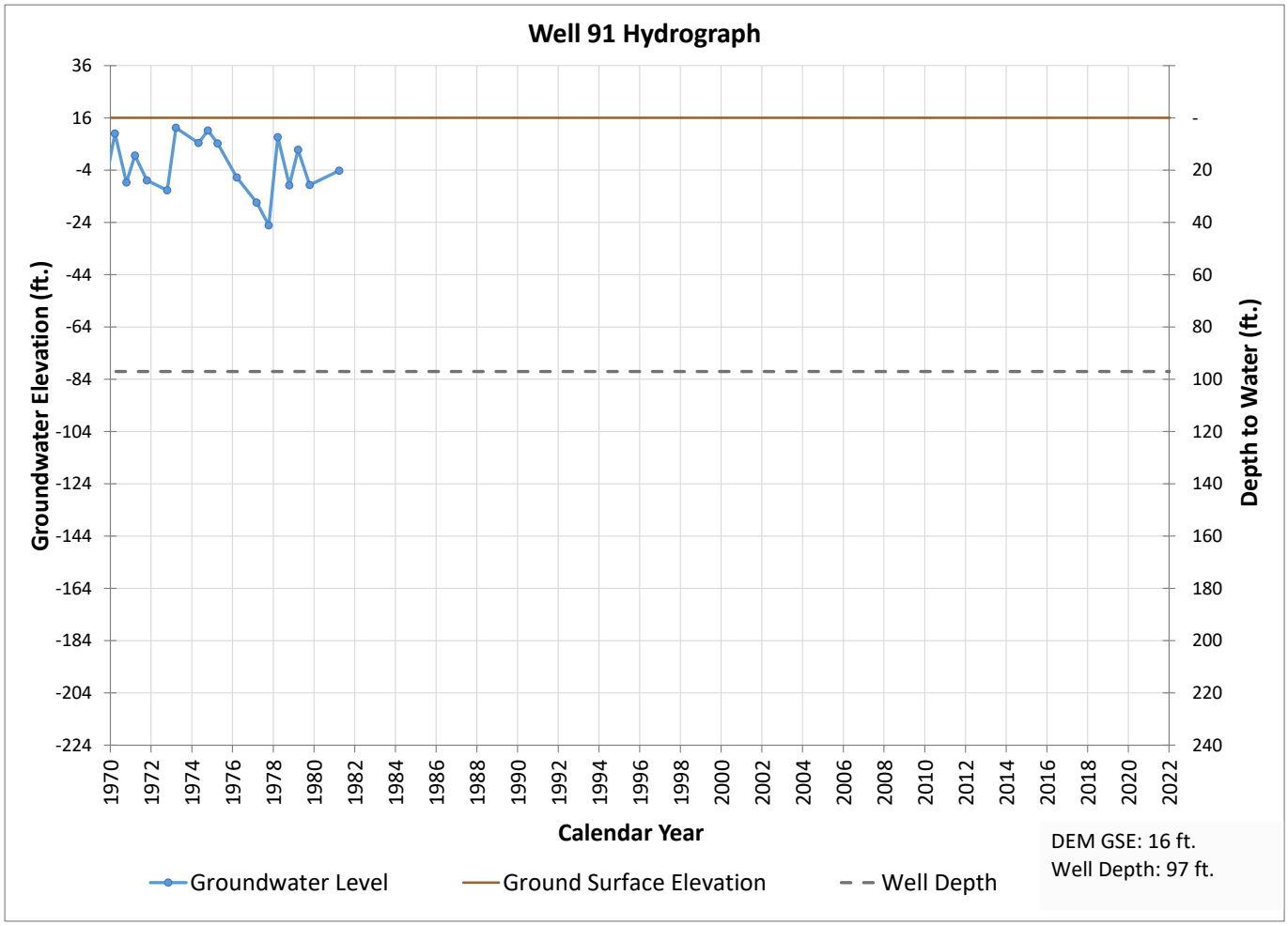

Well 86 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 39 ft.

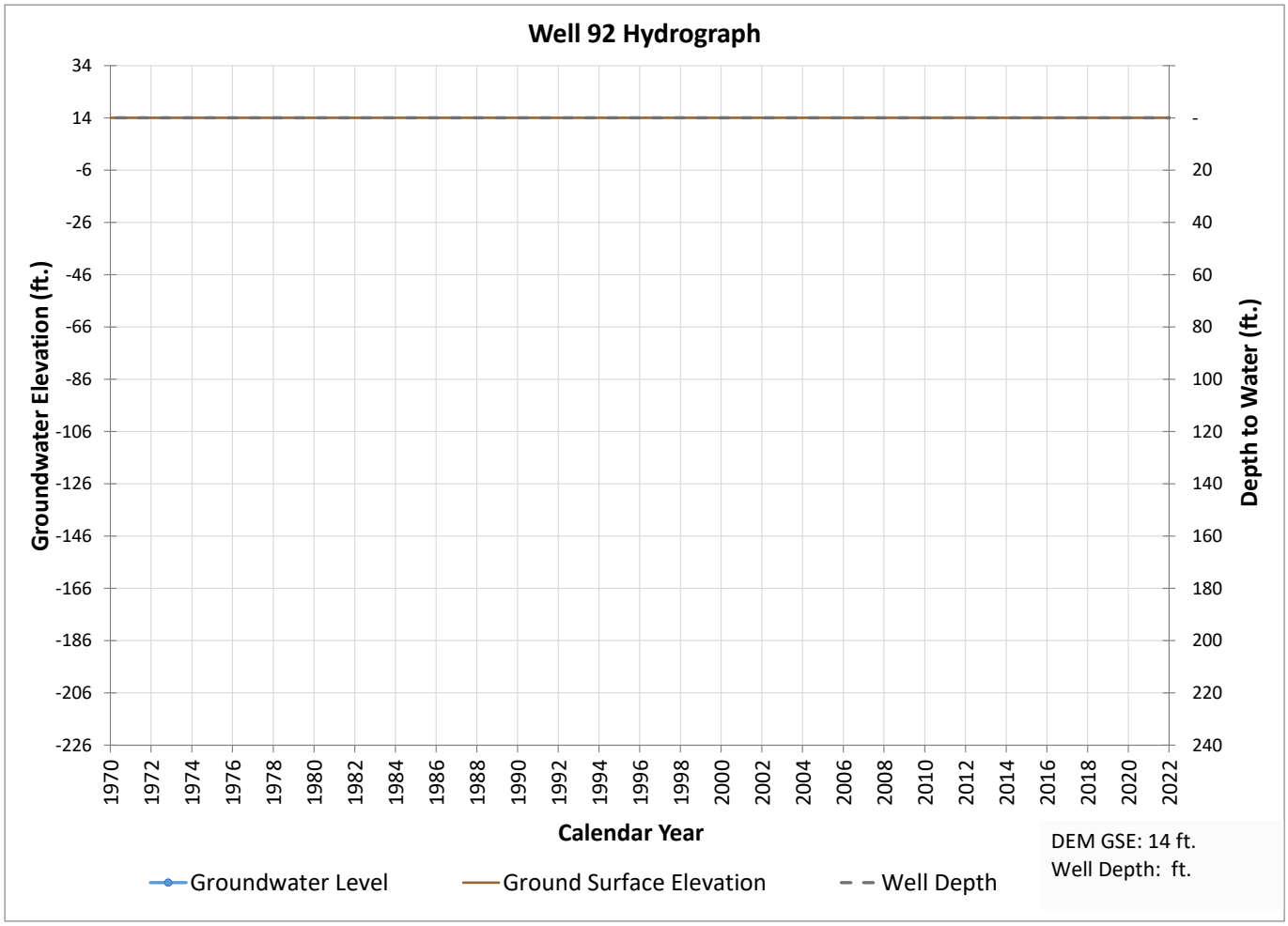

Well 87 Hydrograph
Groundwater Elevation (ft.)
64
44
24
4
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 44 ft.
Well Depth: 384 ft.

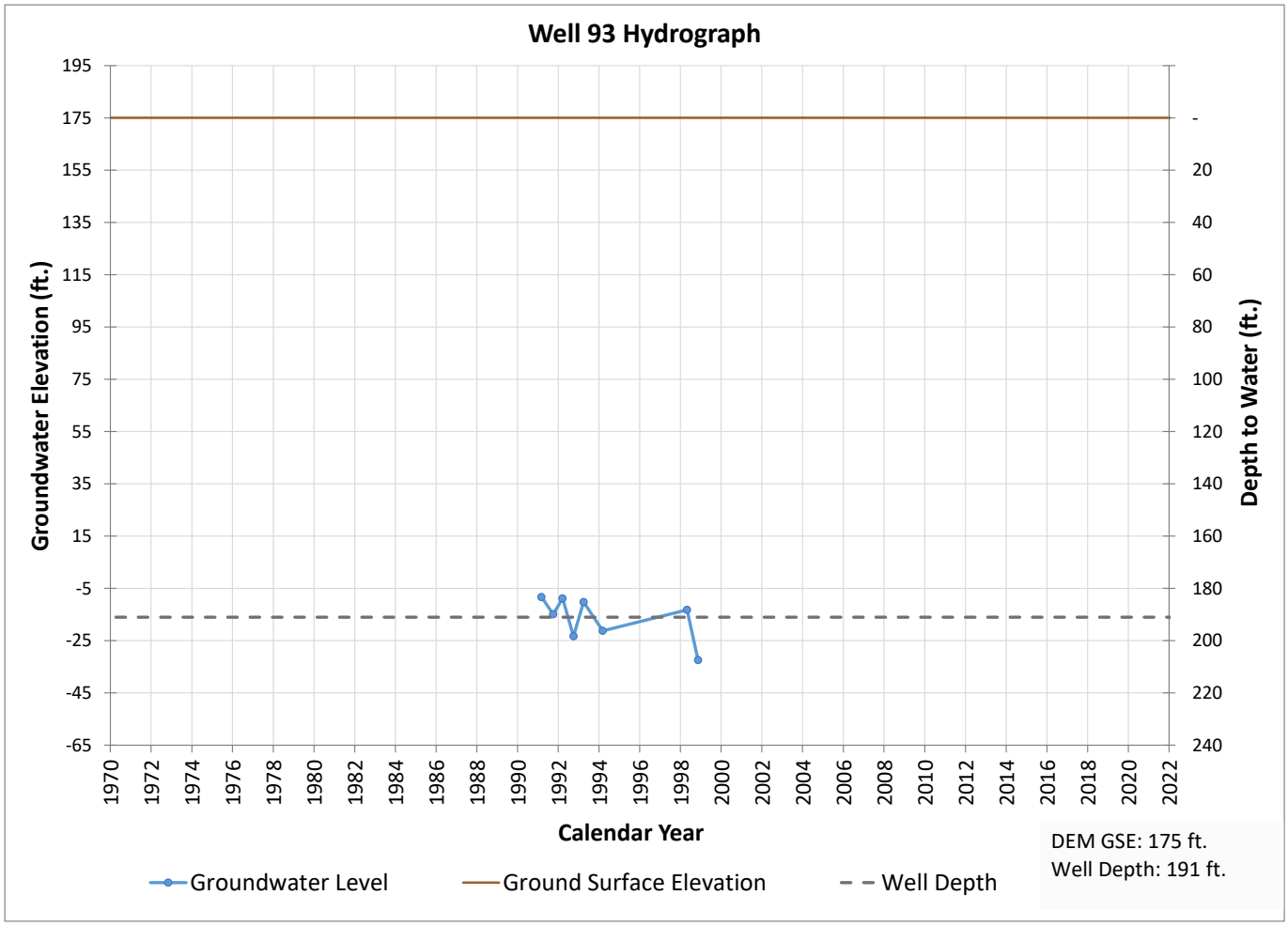

Well 88 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: ft.

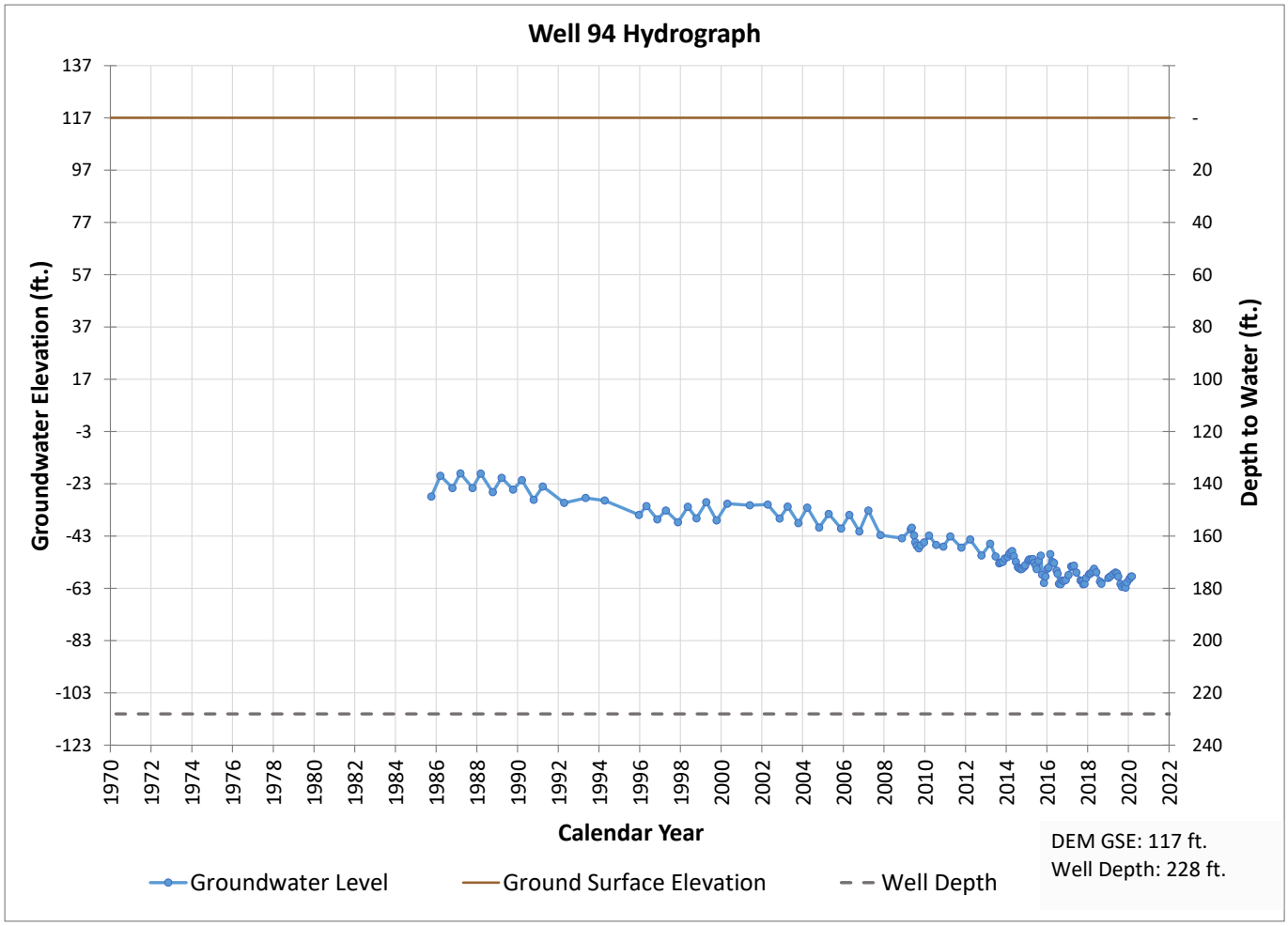

Well 89 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: 463 ft.

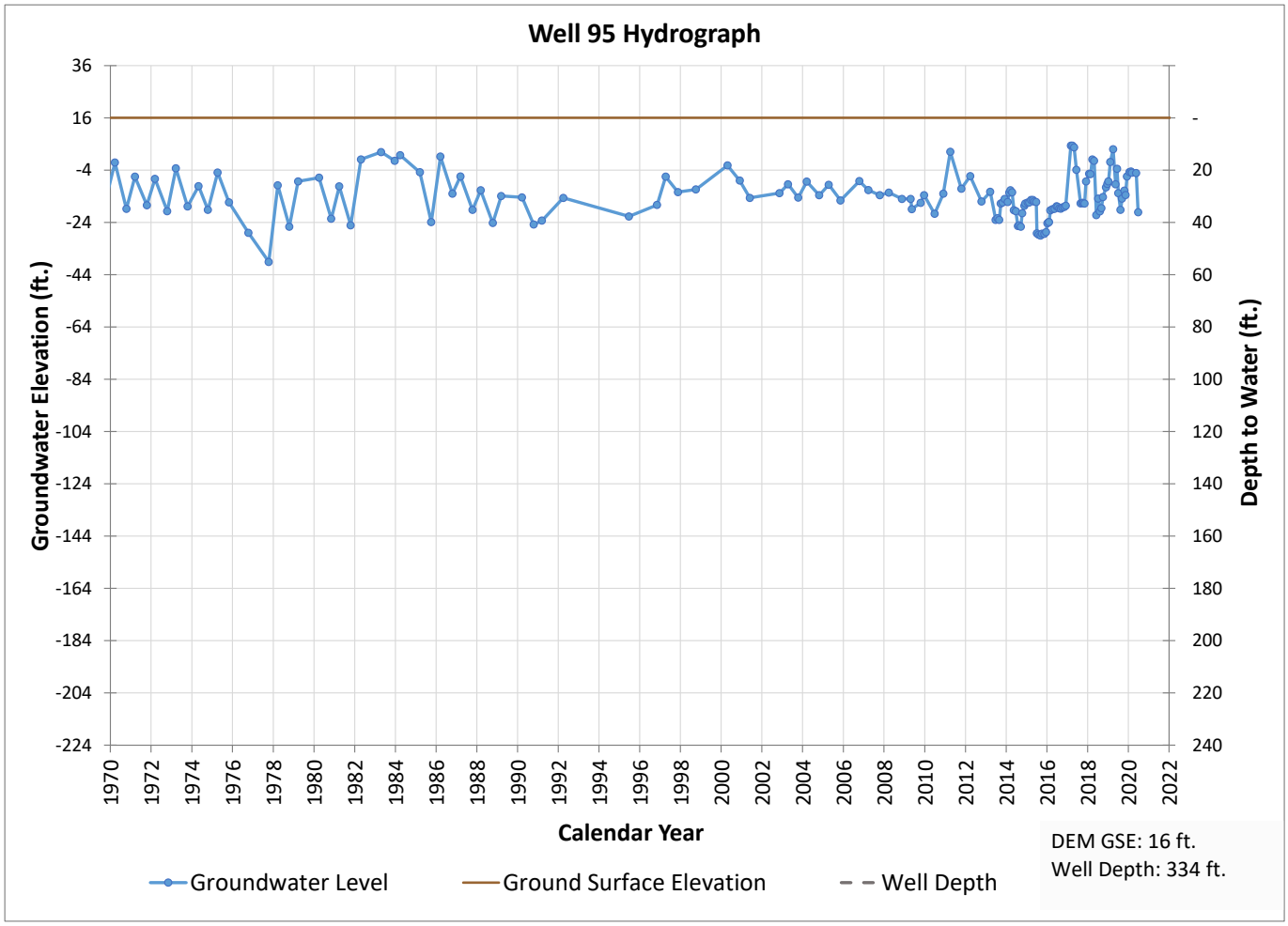

Well 90 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
-223
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 17 ft.
Well Depth: ft.

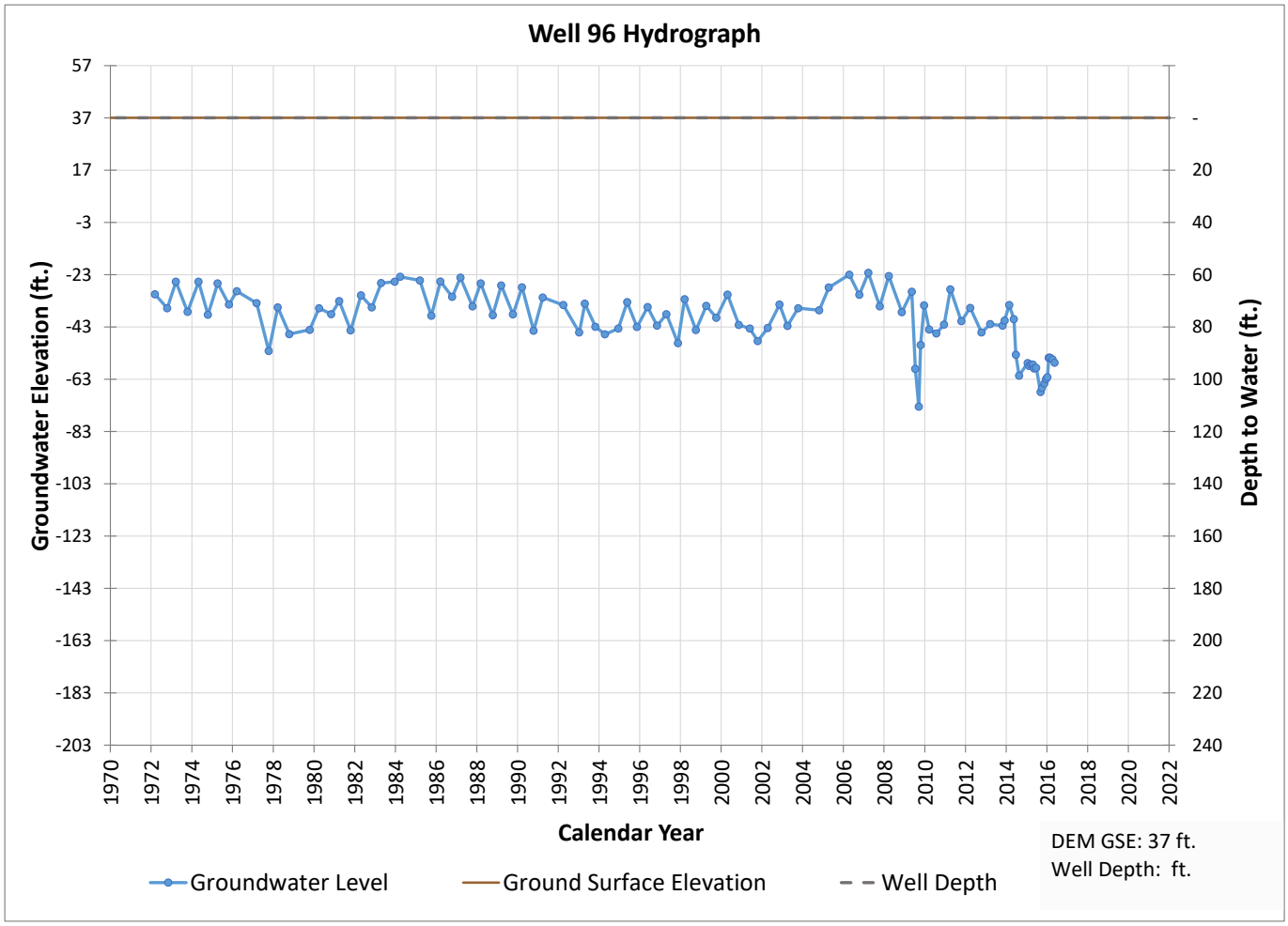

Well 91 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: 97 ft.

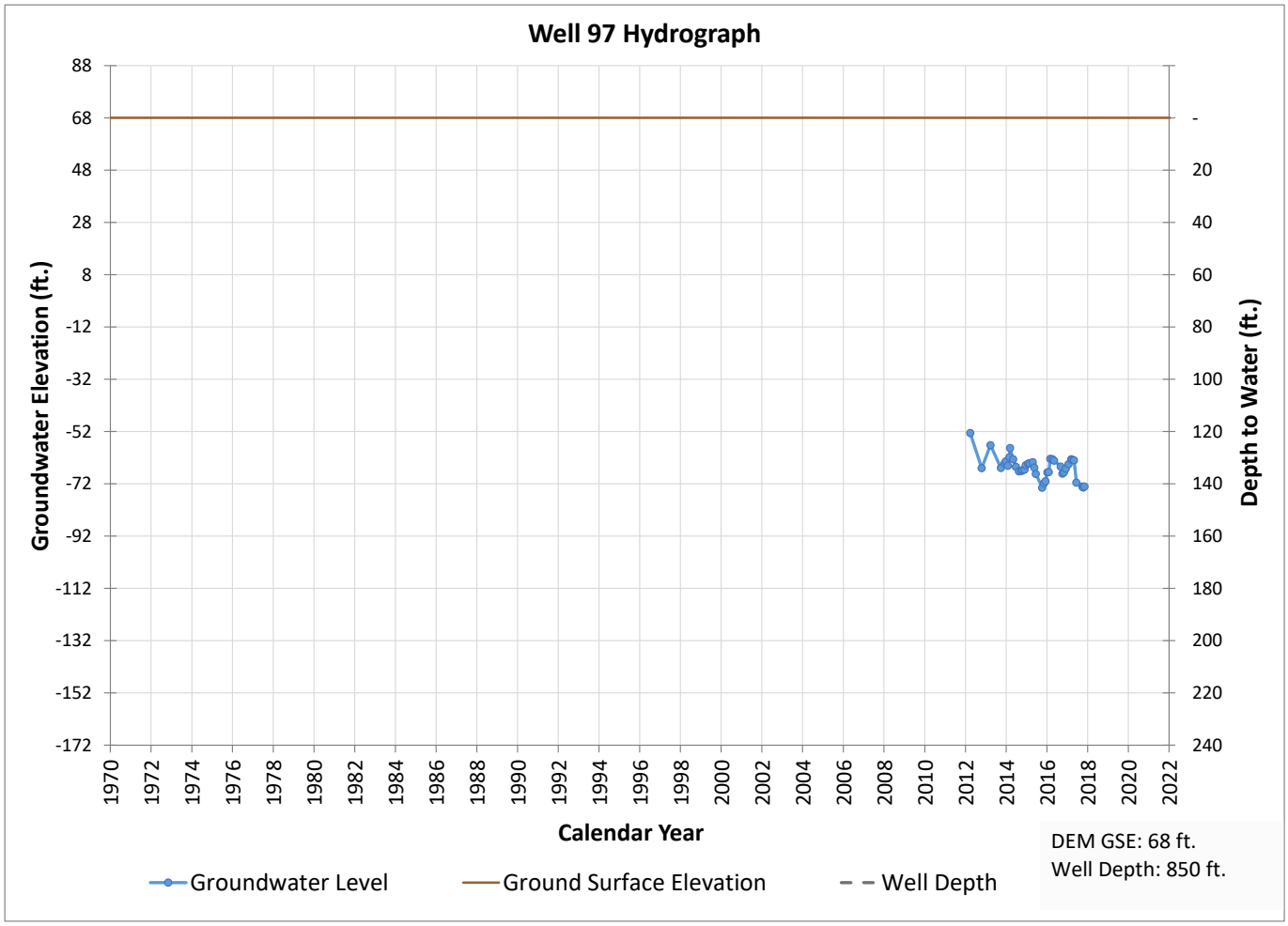

Well 92 Hydrograph
Groundwater Elevation (ft.)
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
-226
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 14 ft.
Well Depth: ft.

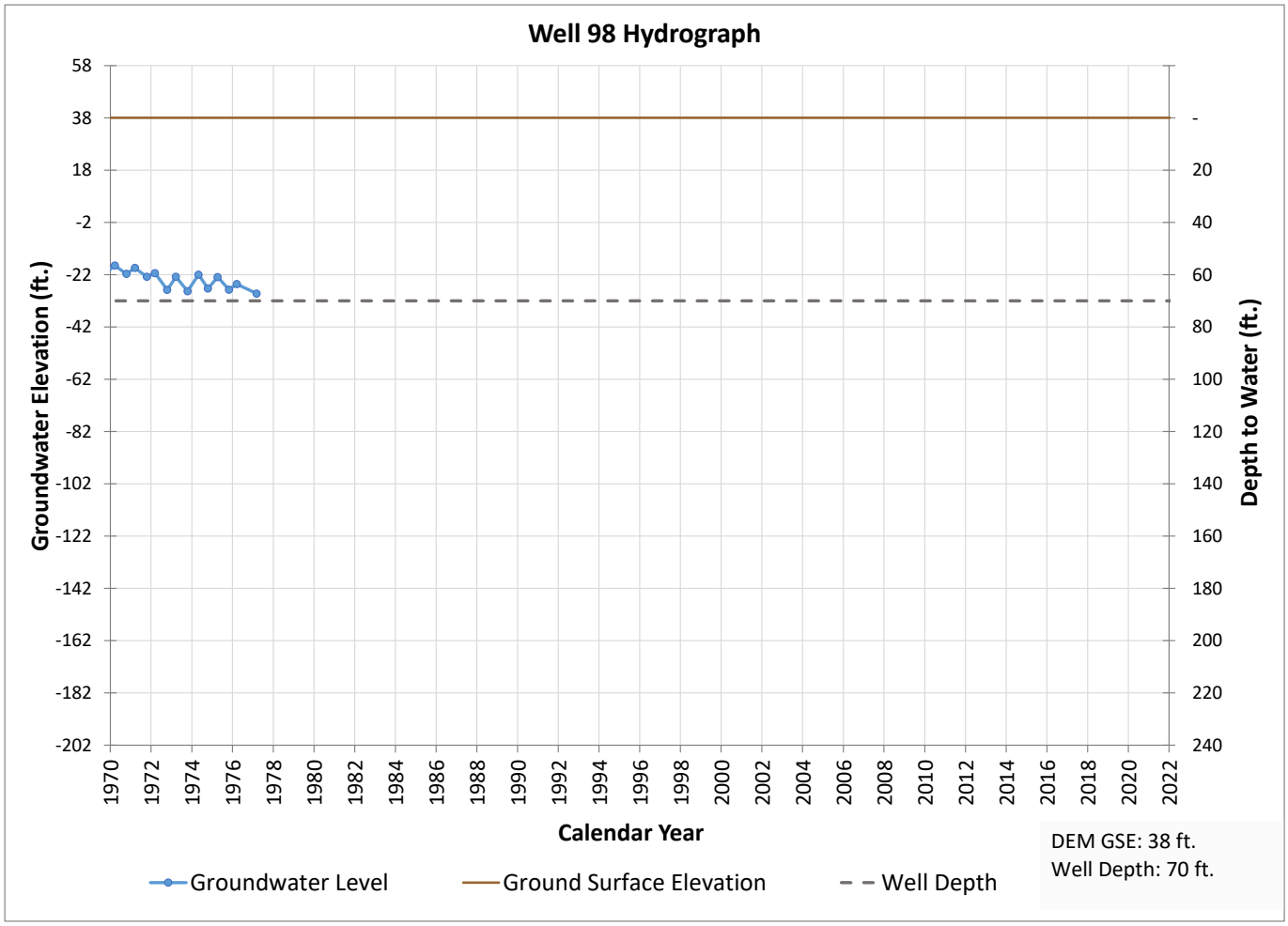

Well 93 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
195
175
155
135
115
95
75
55
35
15
-5
-25
-45
-65
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 175 ft.
Well Depth: 191 ft.

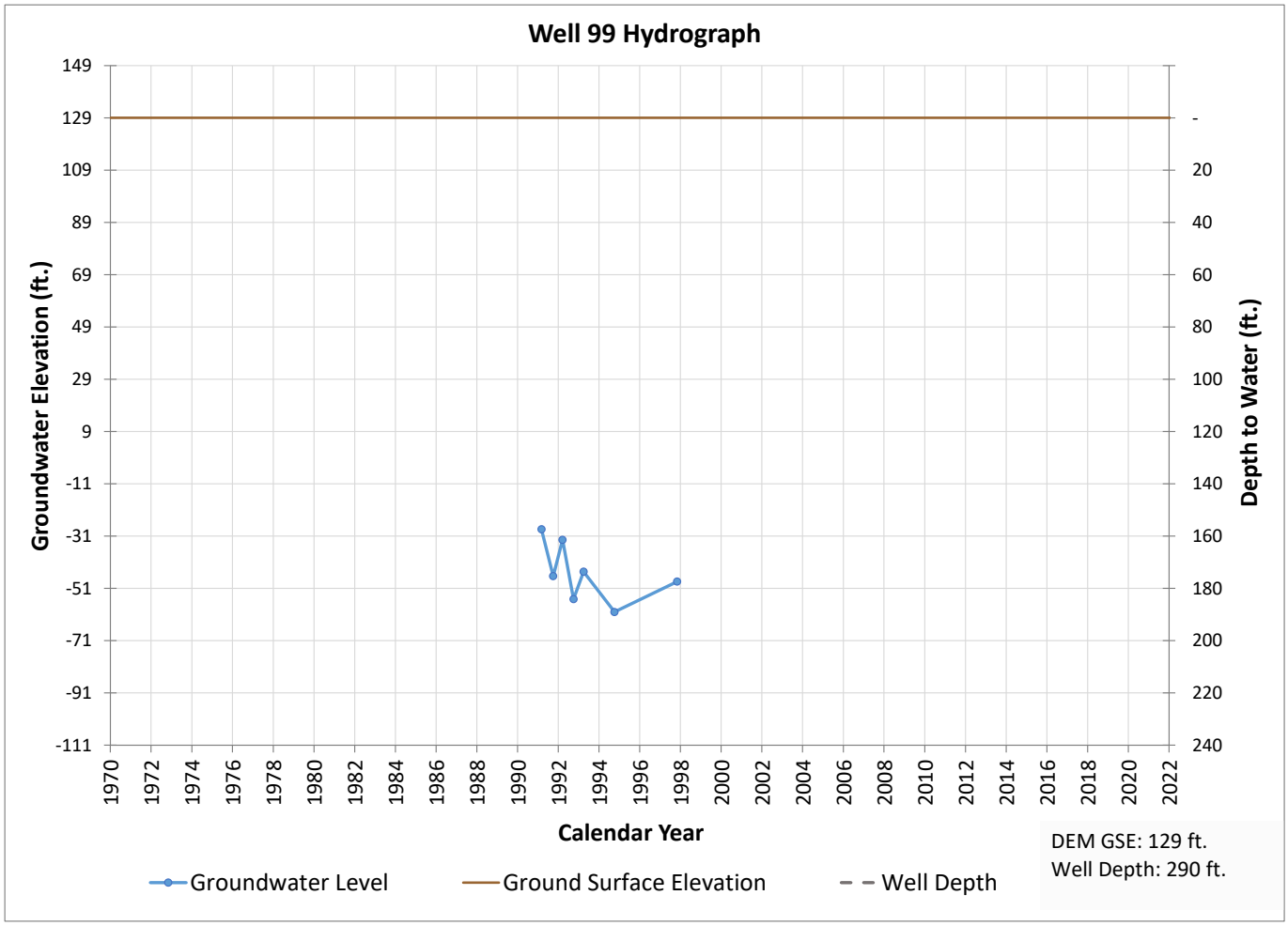

Well 94 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 117 ft.
Well Depth: 228 ft.

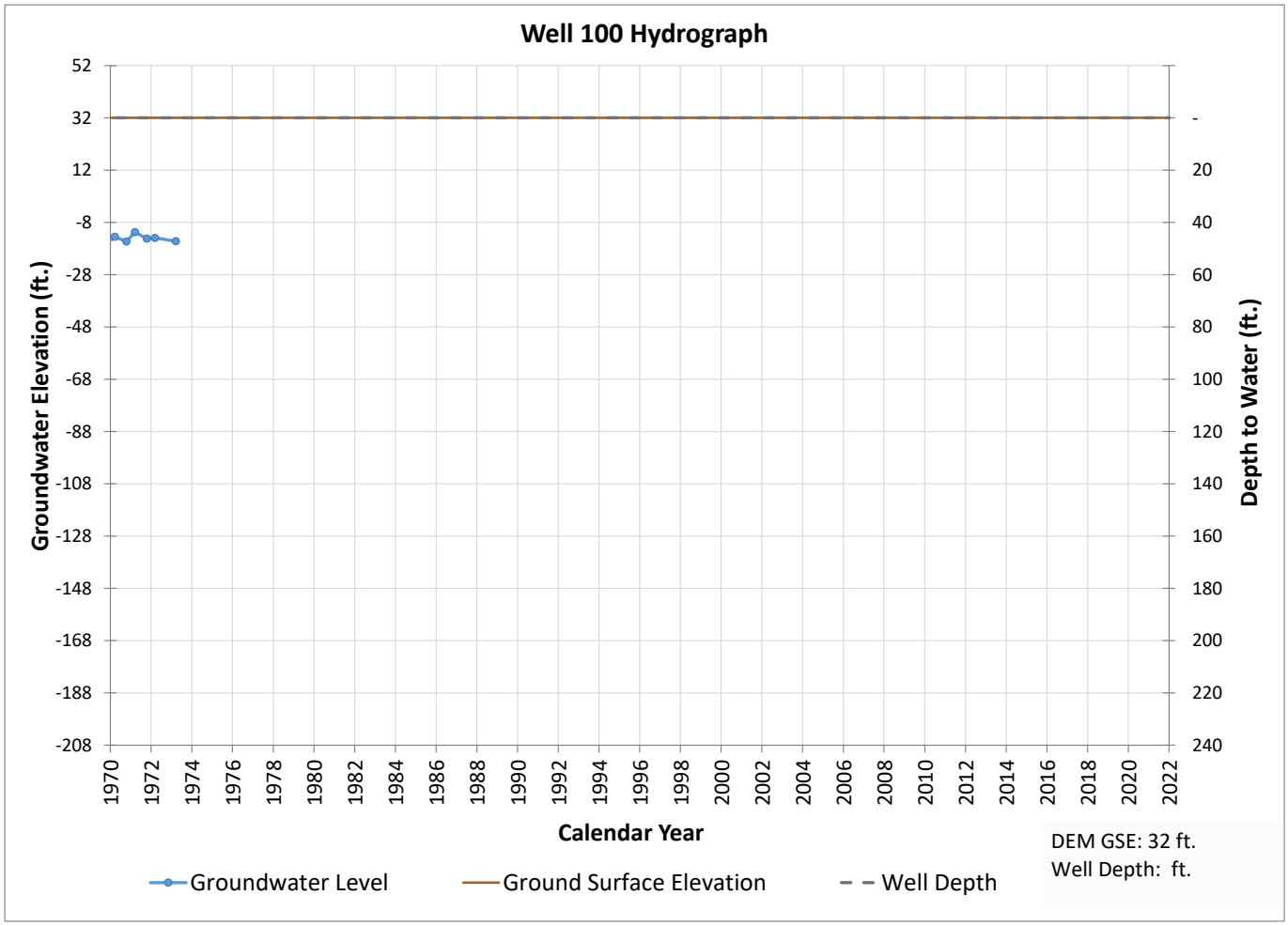

Well 95 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: 334 ft.

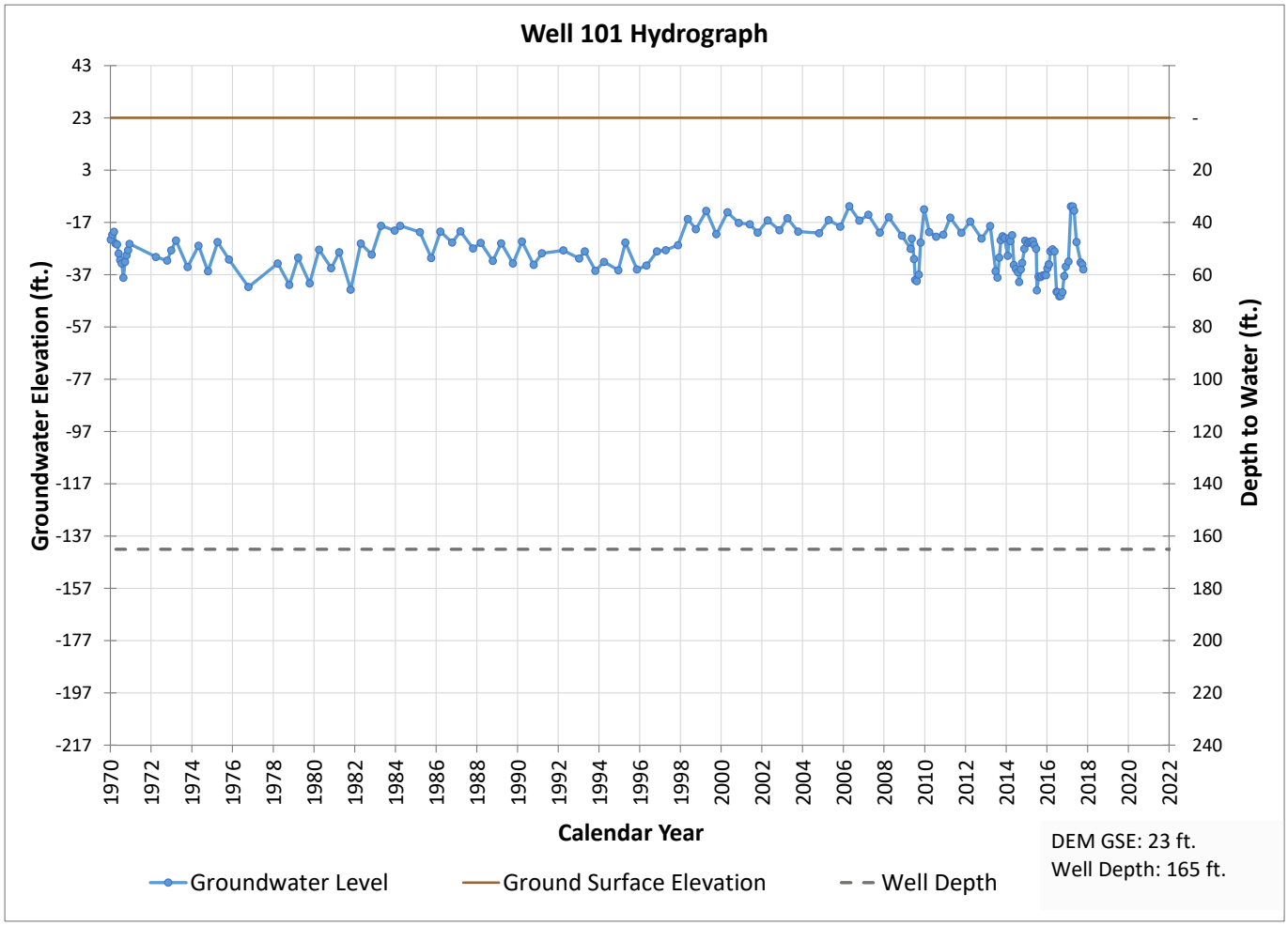

Well 96 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 37 ft.
Well Depth: ft.

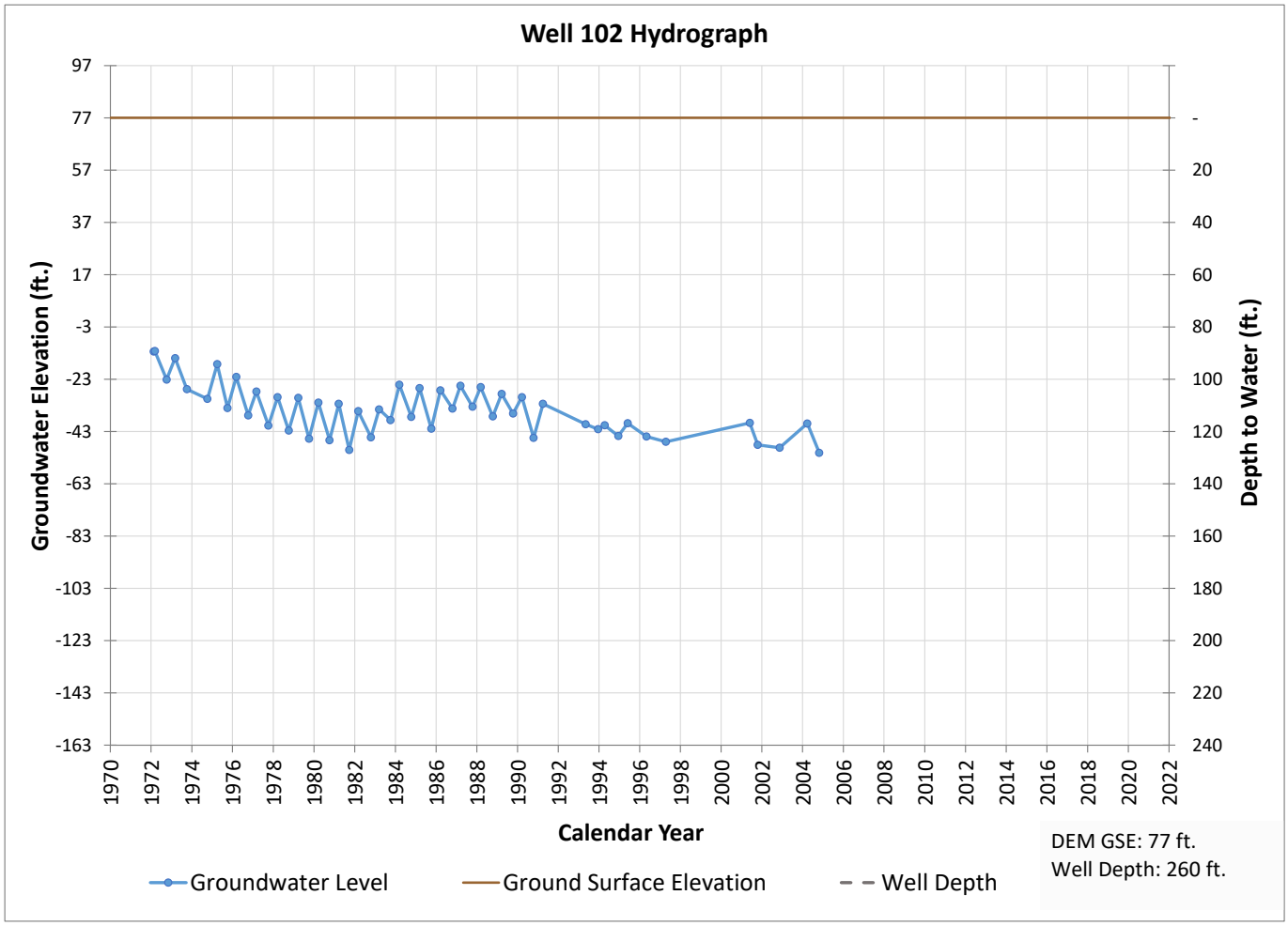

Well 97 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 68 ft.
Well Depth: 850 ft.

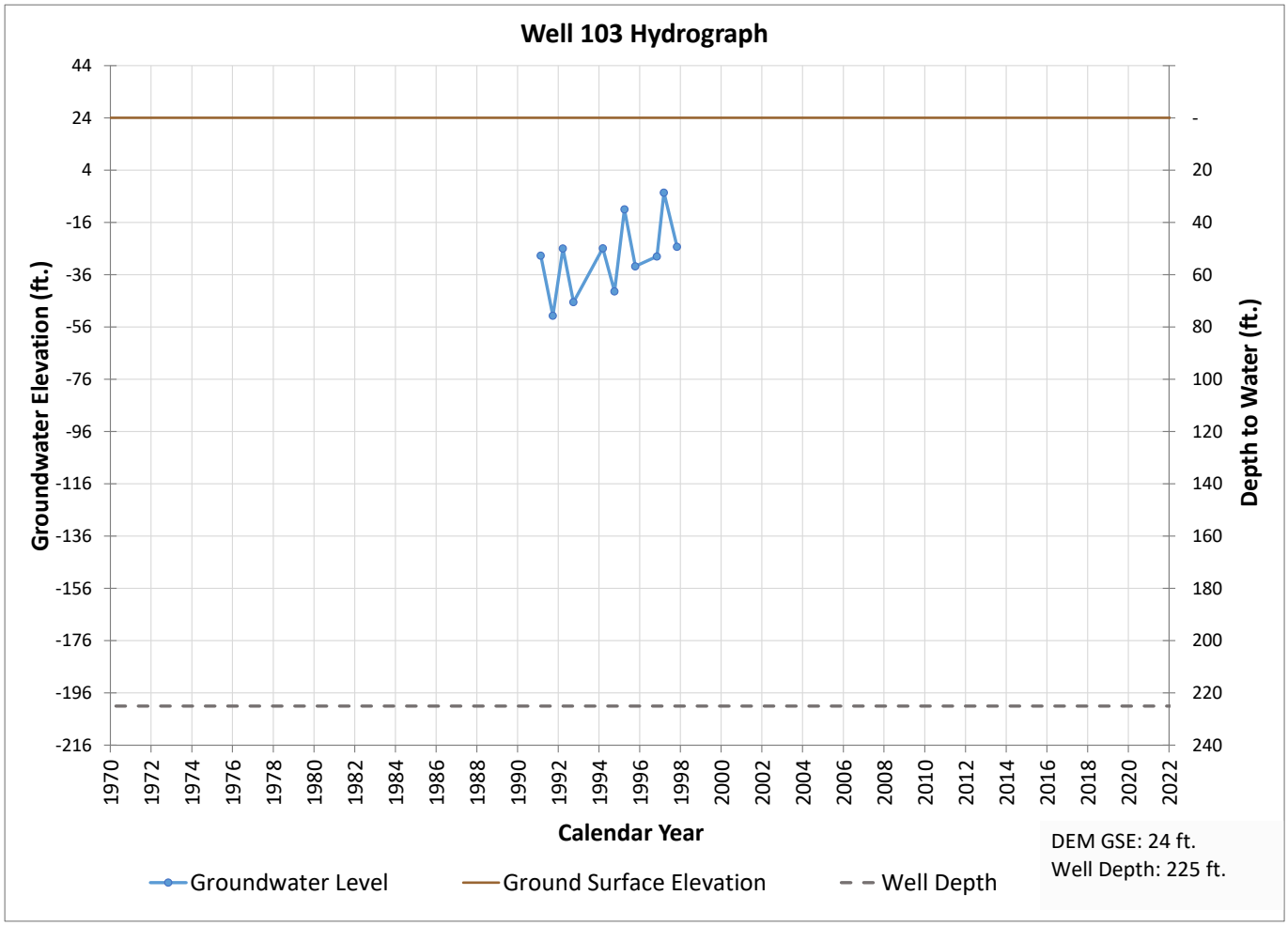

Well 98 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 38 ft.
Well Depth: 70 ft.

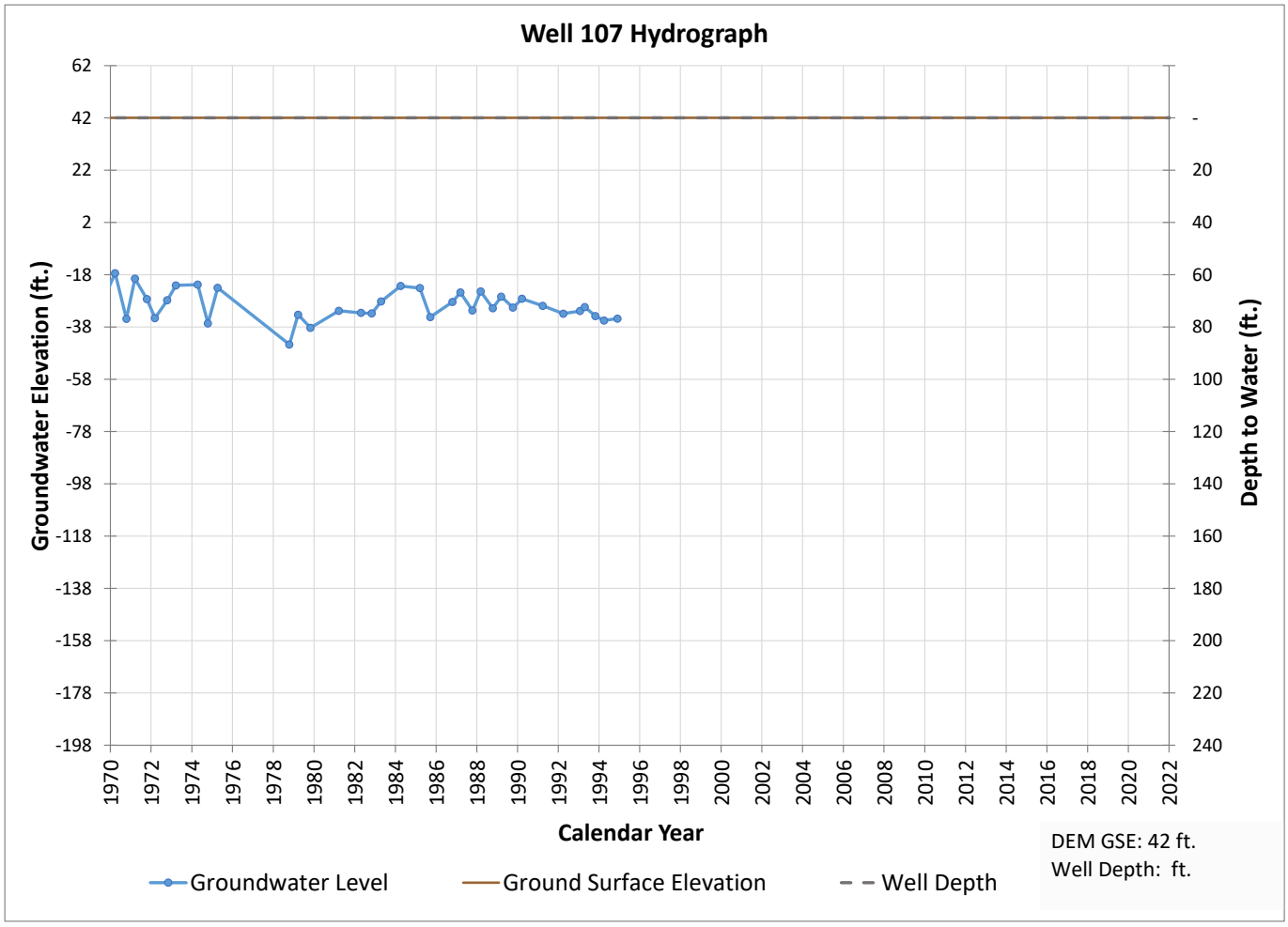

Well 99 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
149
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 129 ft.
Well Depth: 290 ft.

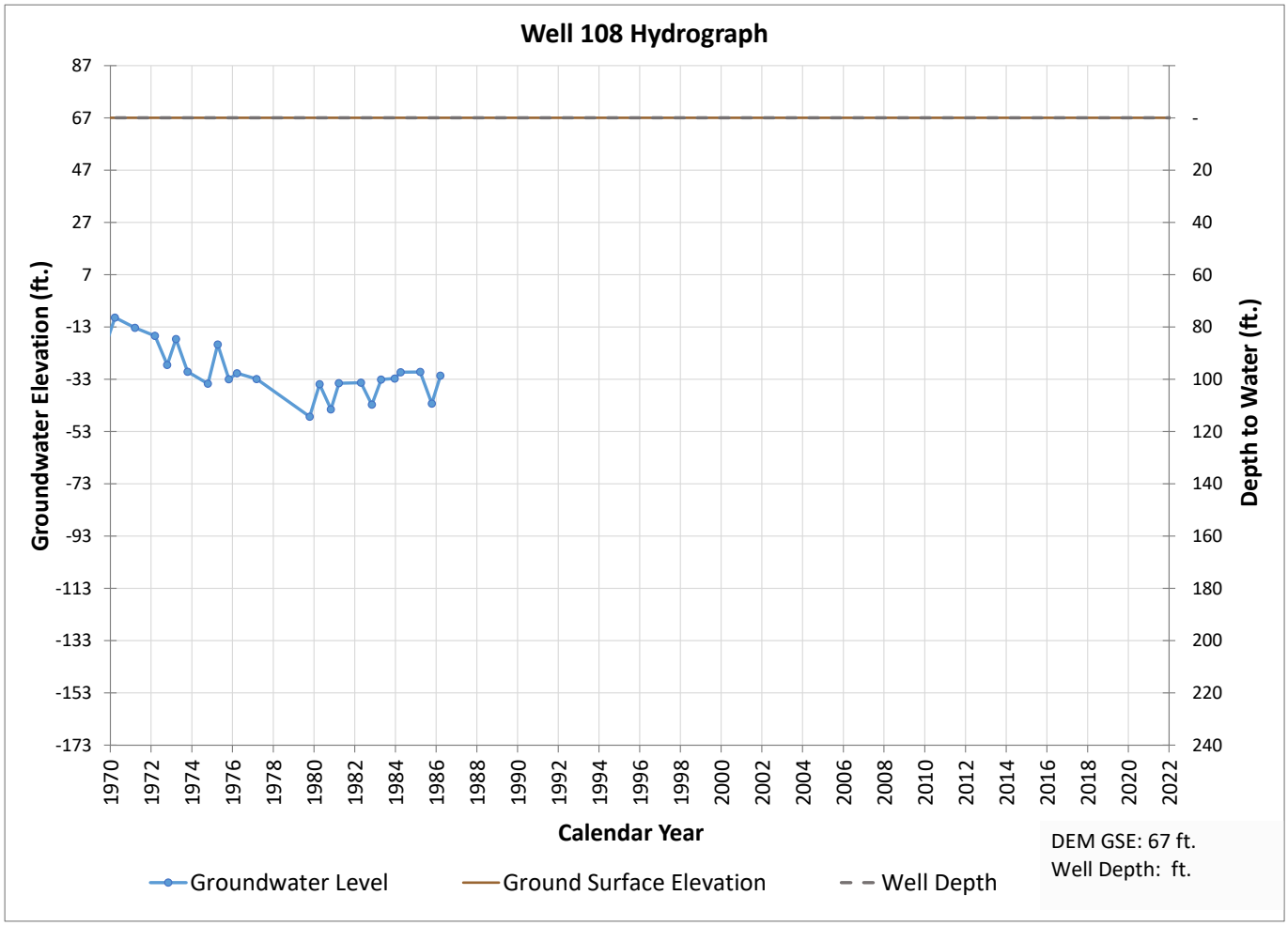

Well 100 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: ft.

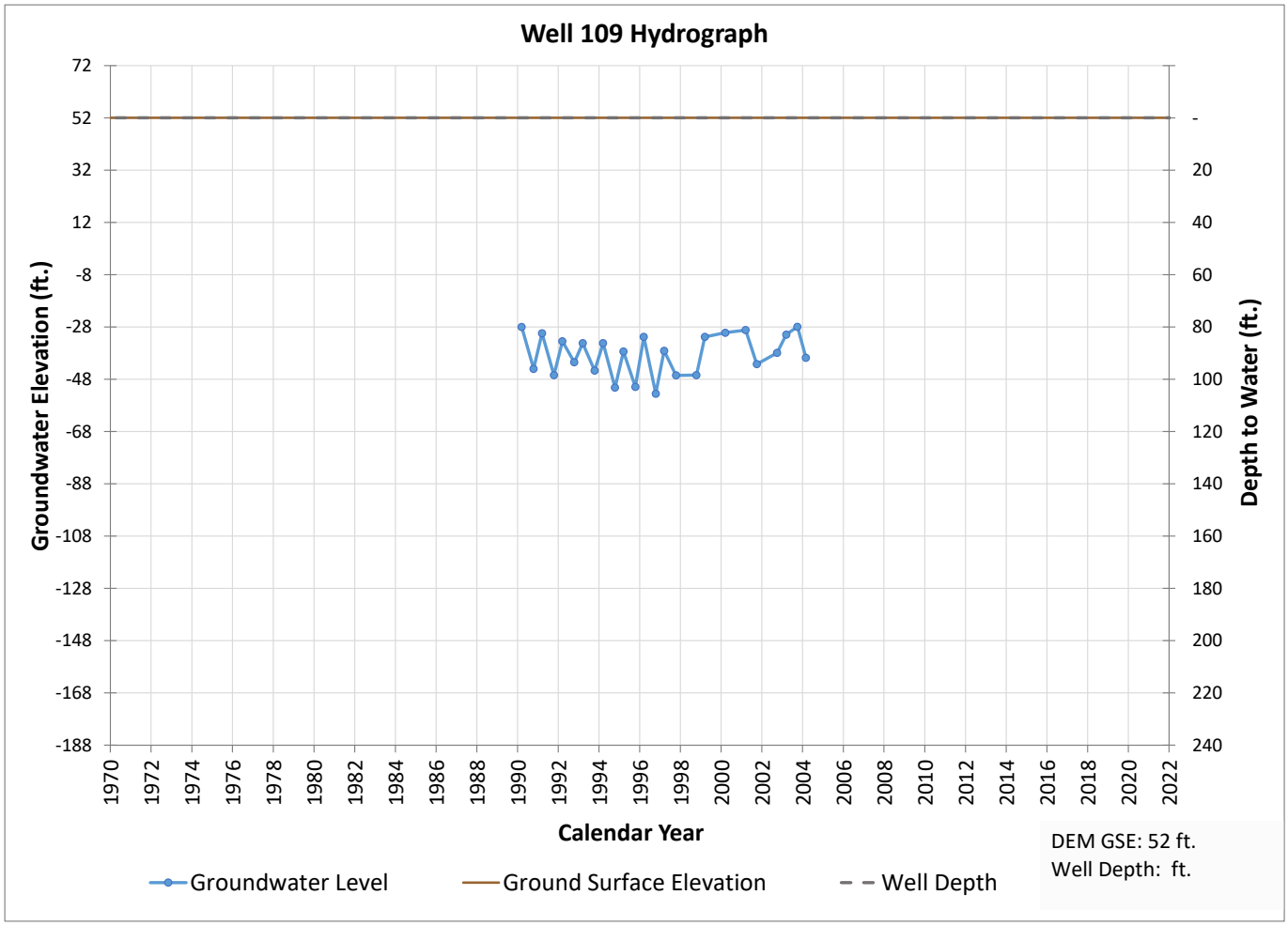

Well 101 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: 165 ft.

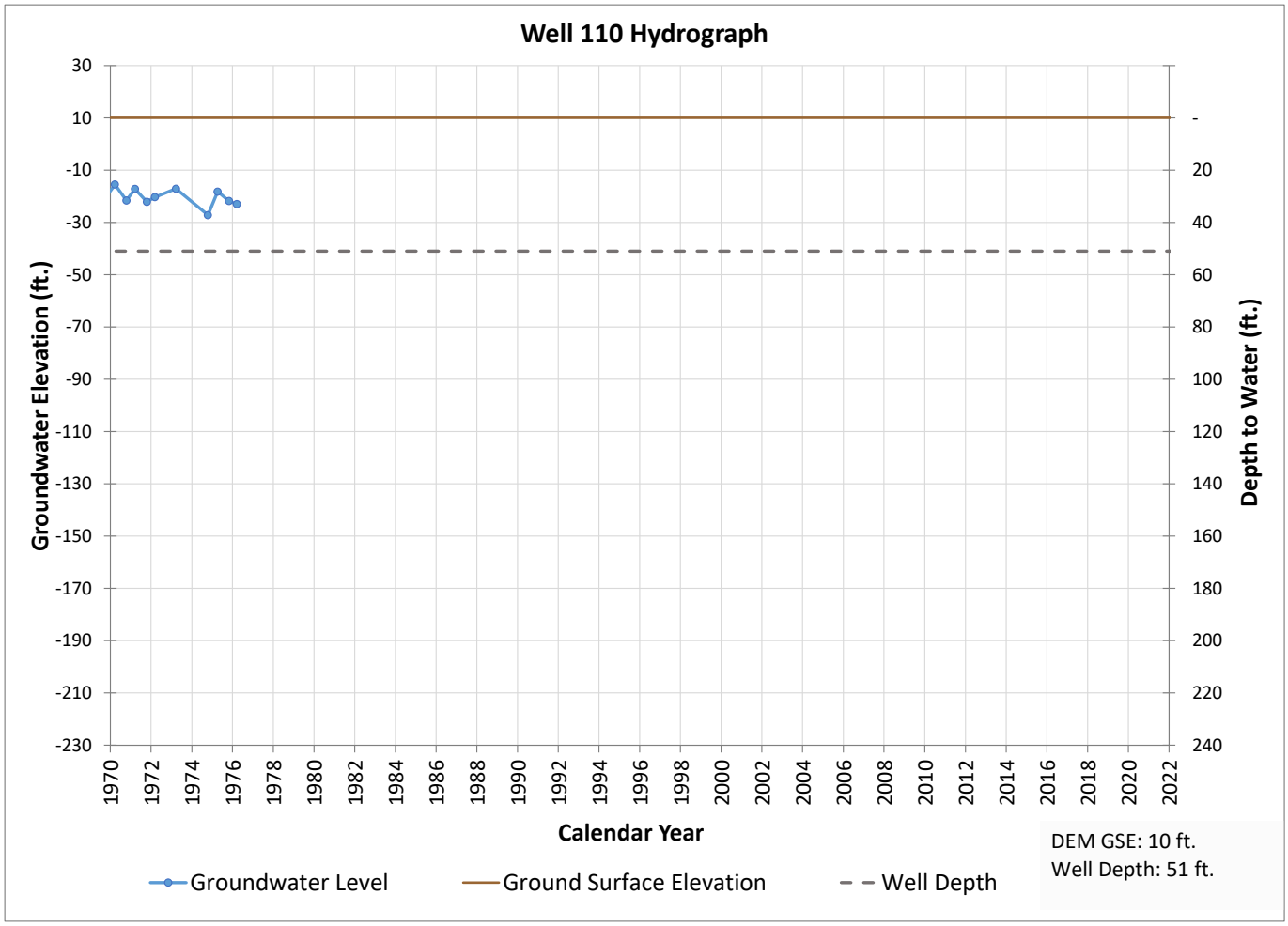

Well 102 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: 260 ft.

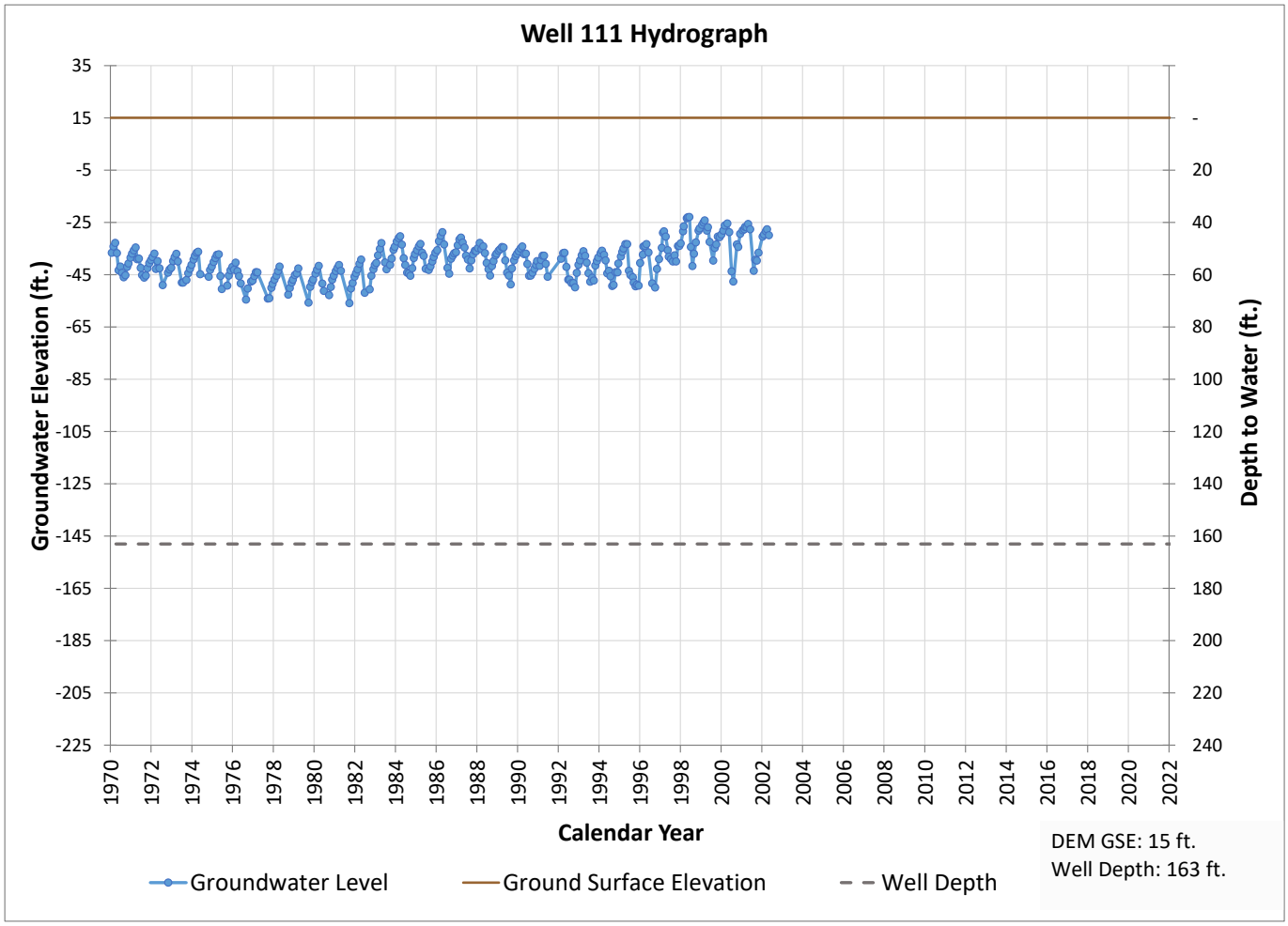

Well 103 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
-216
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 24 ft.
Well Depth: 225 ft.

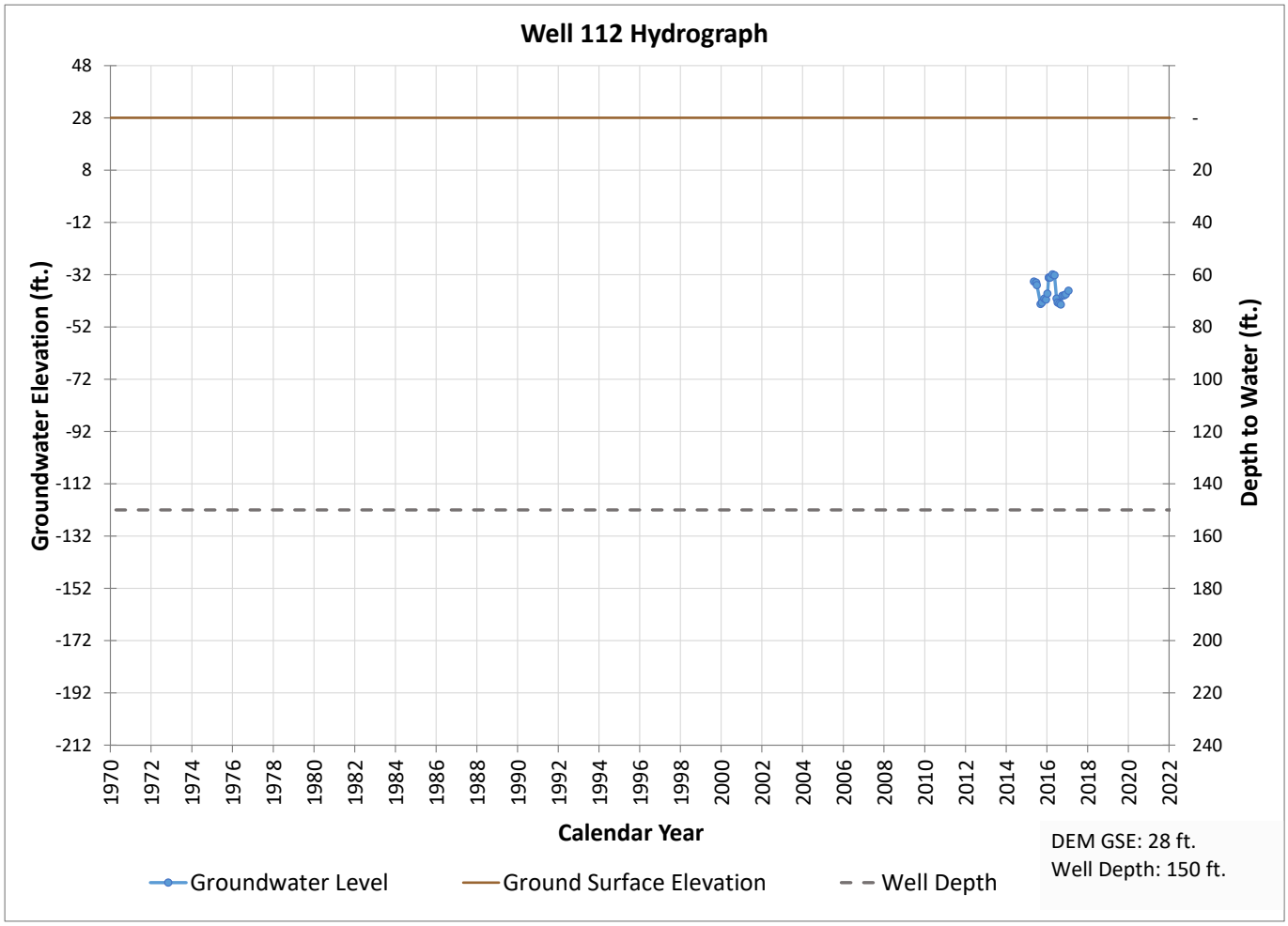

Well 107 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: ft.

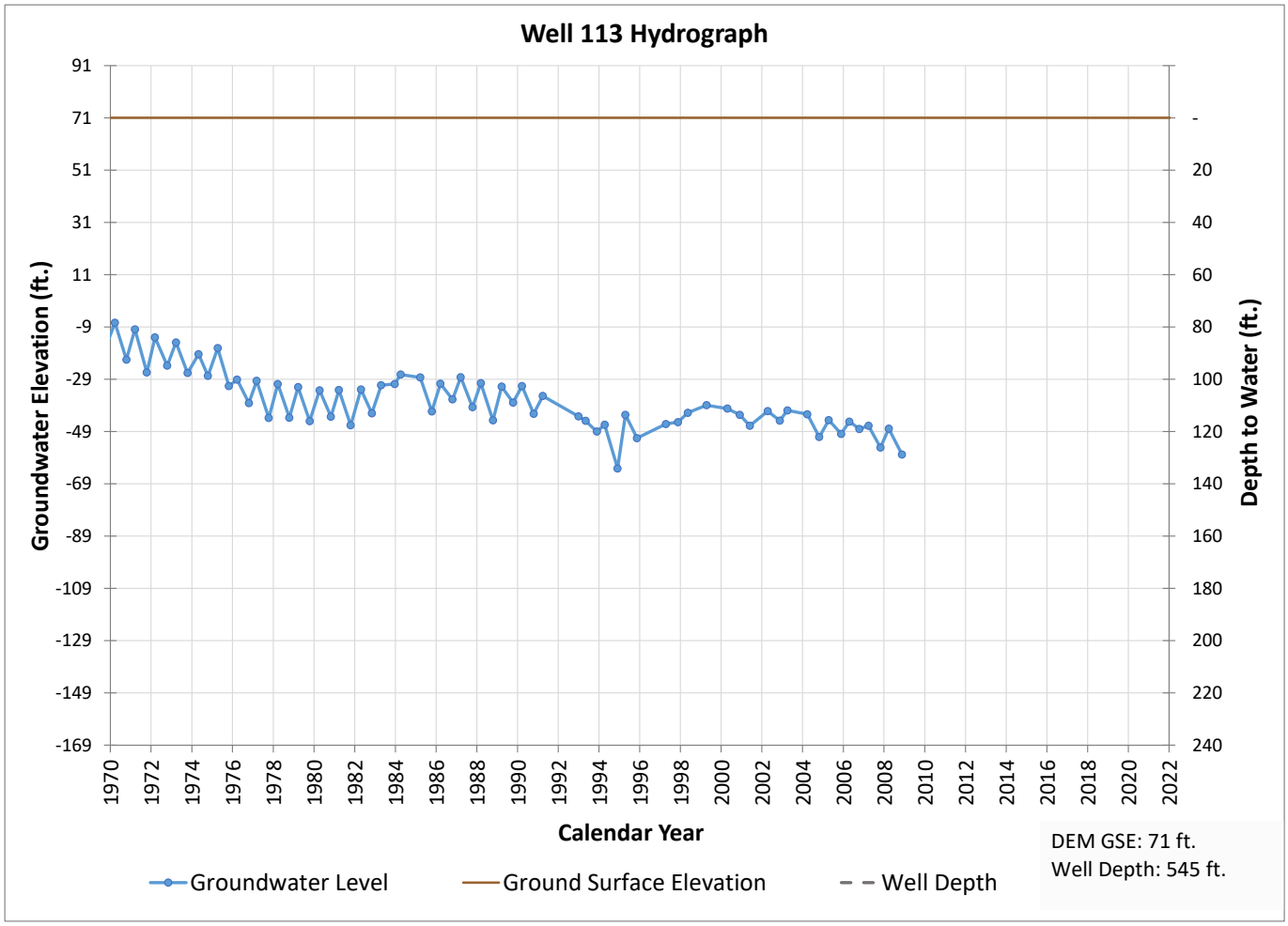

Well 108 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: ft.

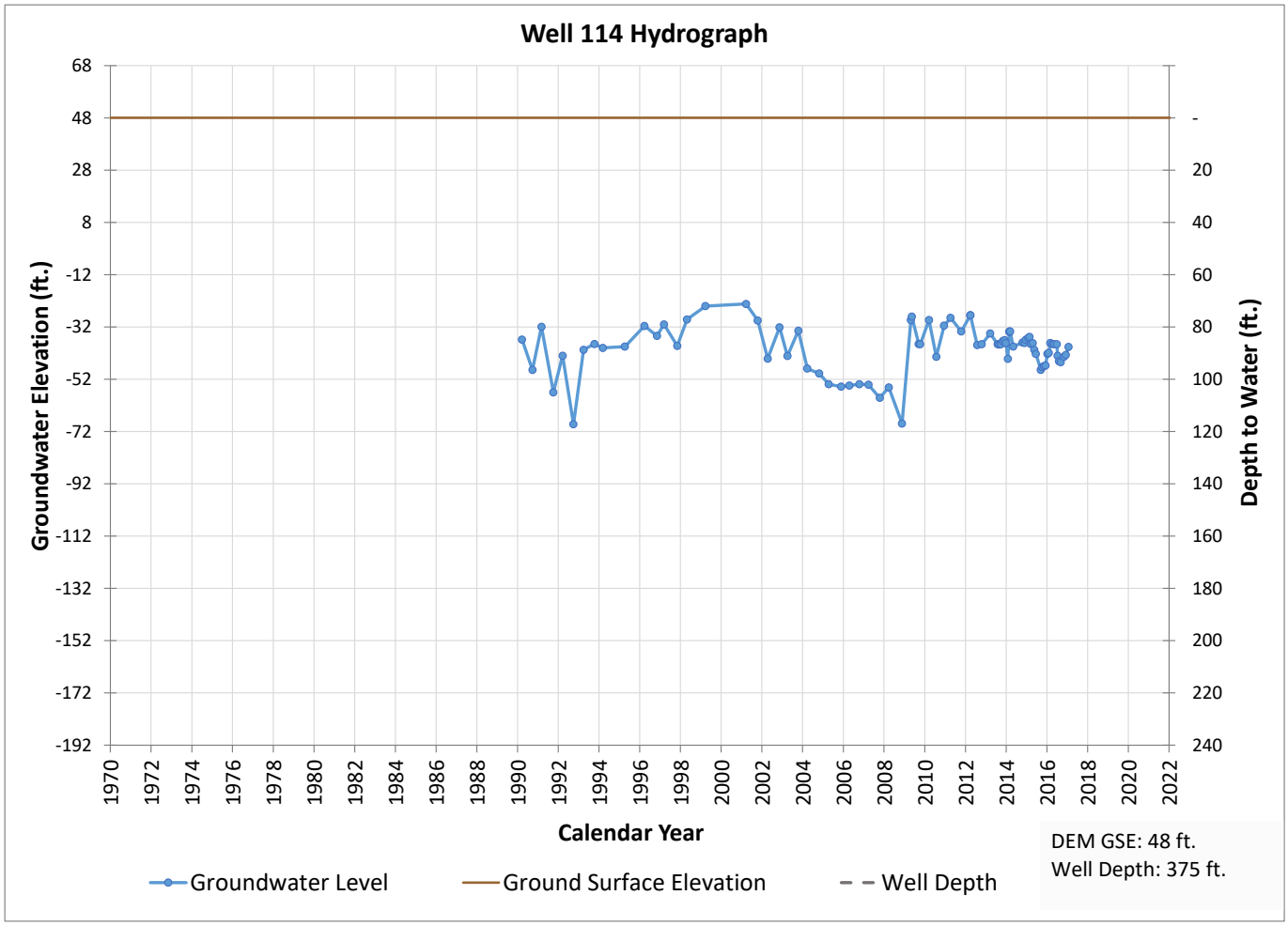

Well 109 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: ft.

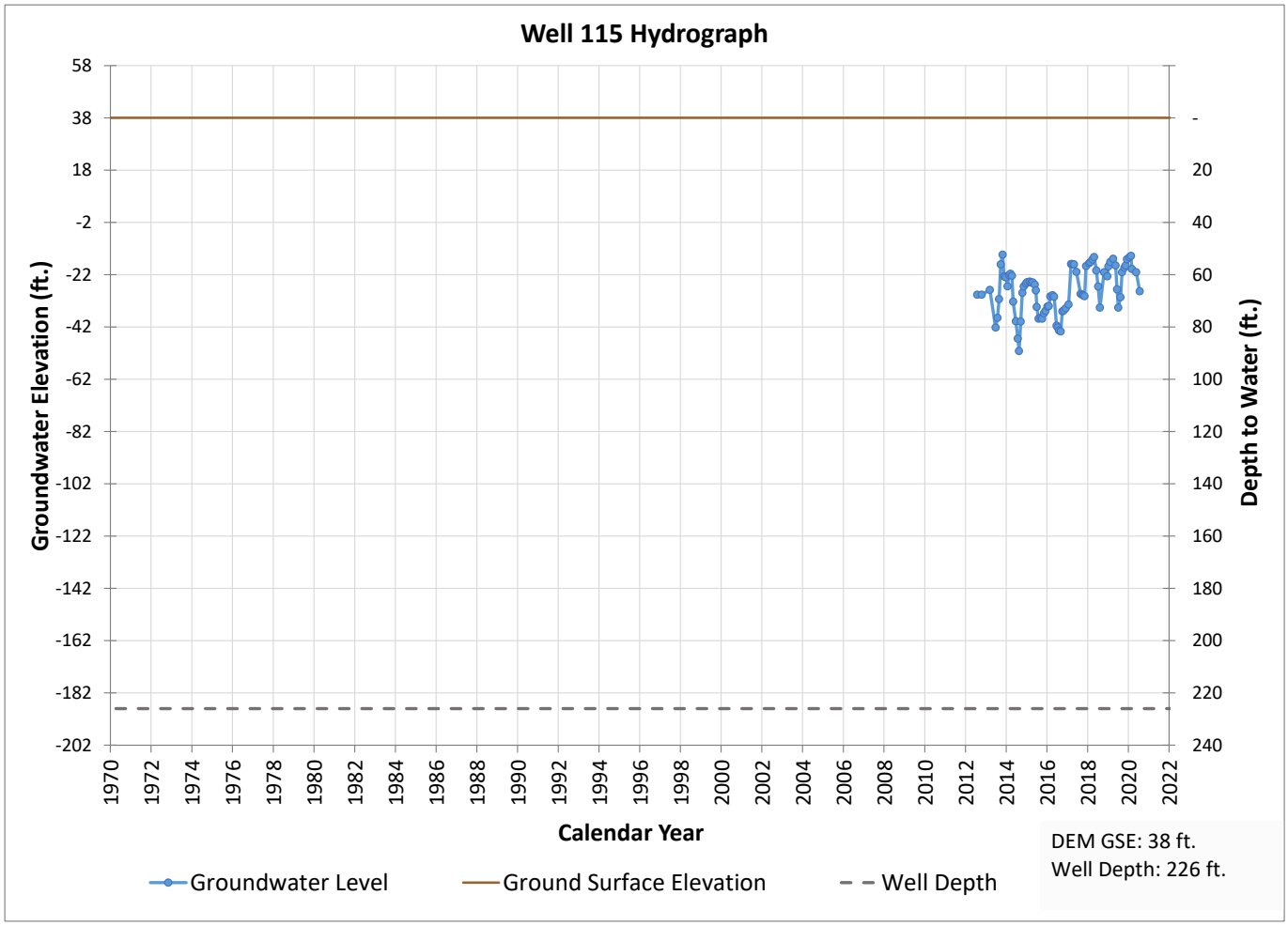

Well 110 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 10 ft.
Well Depth: 51 ft.

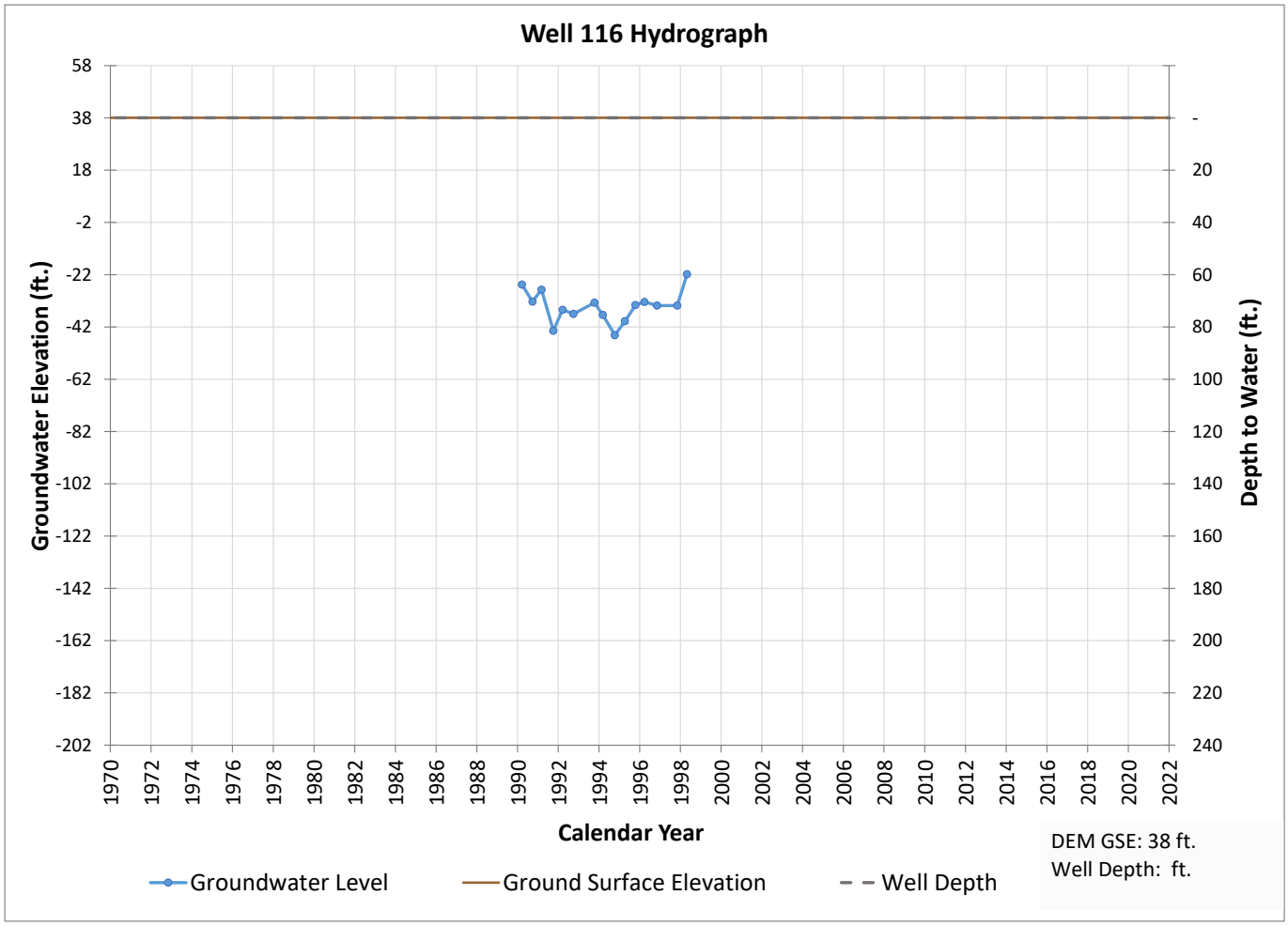

Well 111 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-225
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 15 ft.
Well Depth: 163 ft.

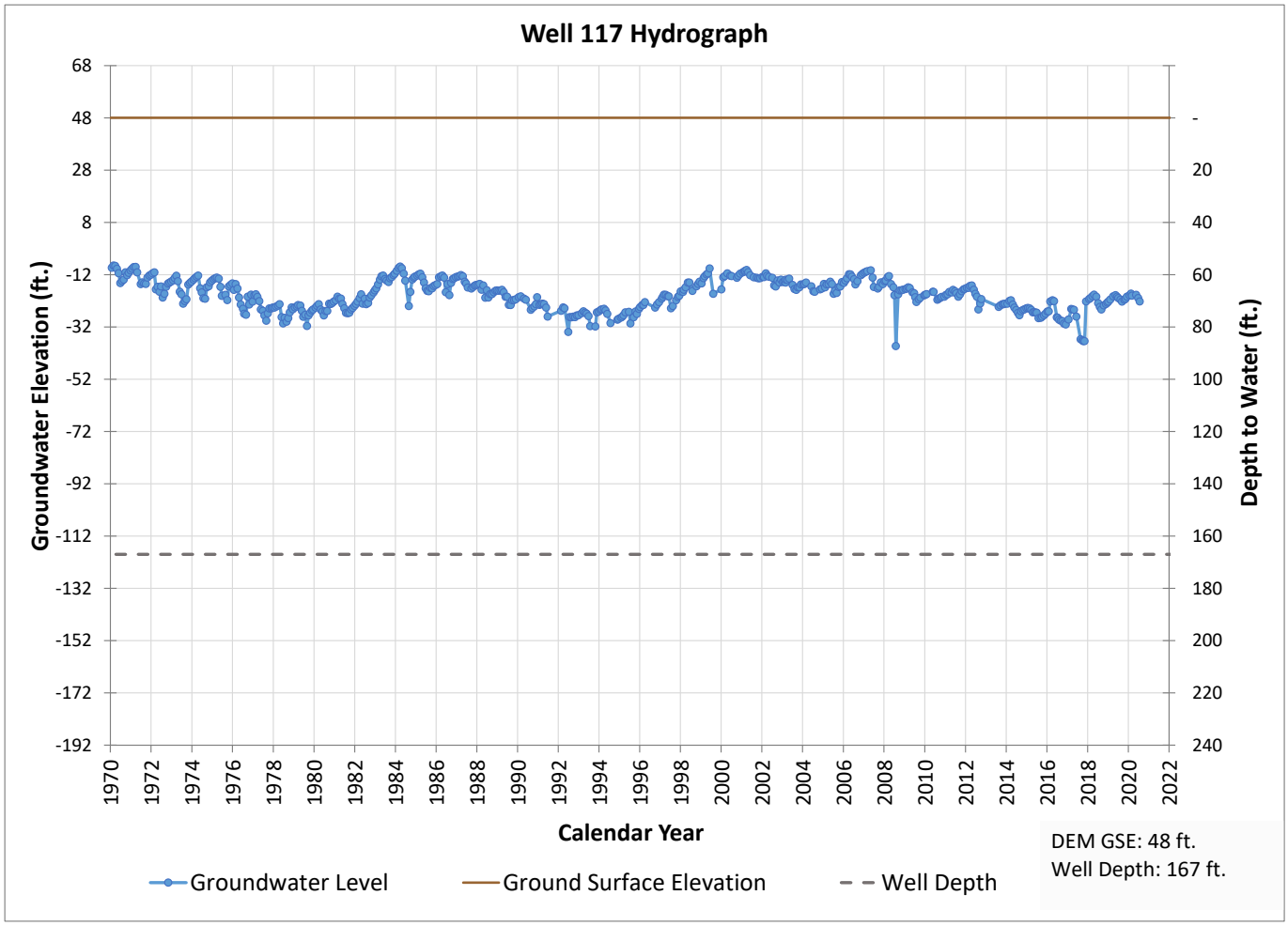

Well 112 Hydrograph
Groundwater Elevation (ft.)
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 28 ft.
Well Depth: 150 ft.

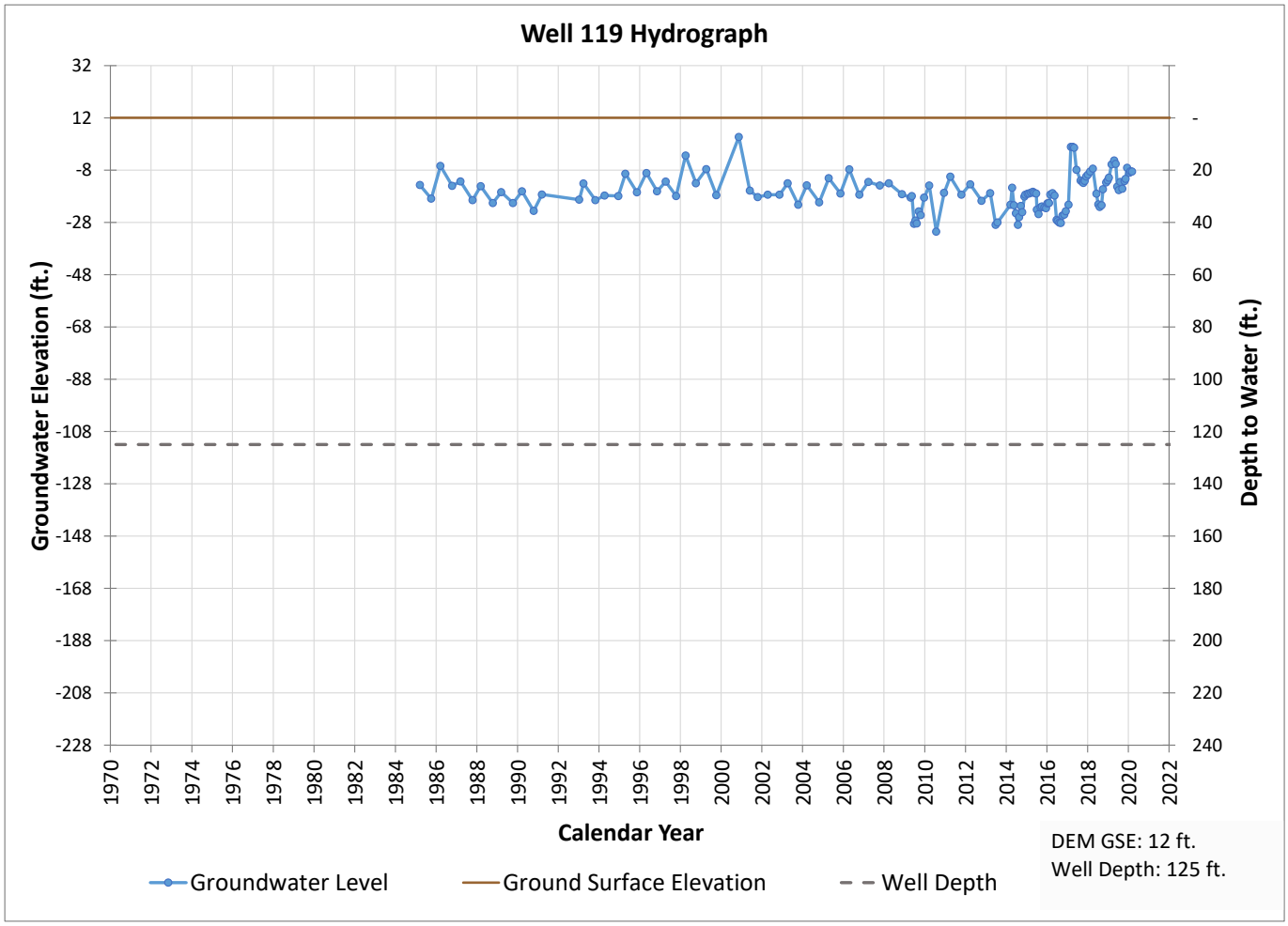

Well 113 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 71 ft.
Well Depth: 545 ft.

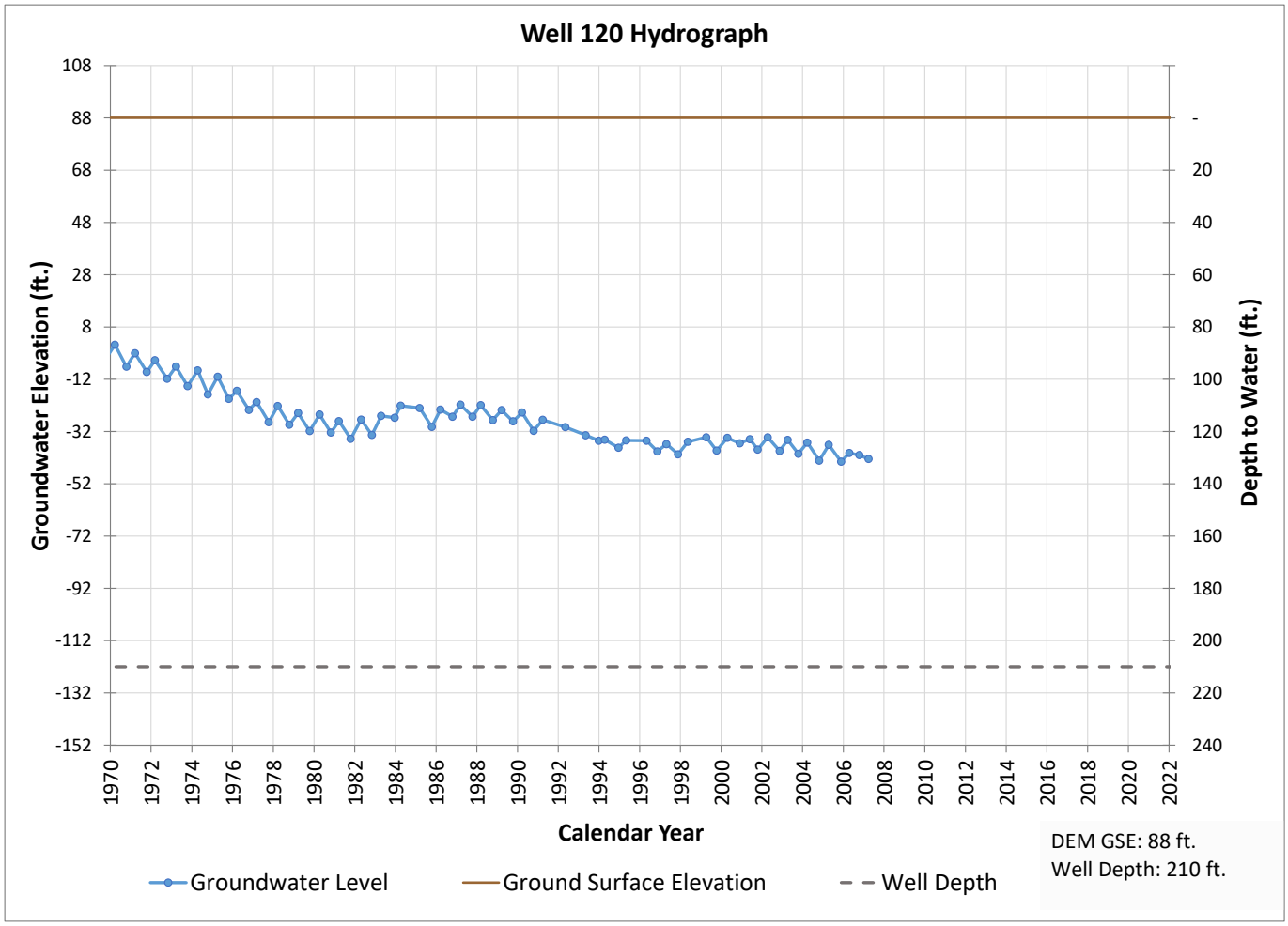

Well 114 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 48 ft.
Well Depth: 375 ft.

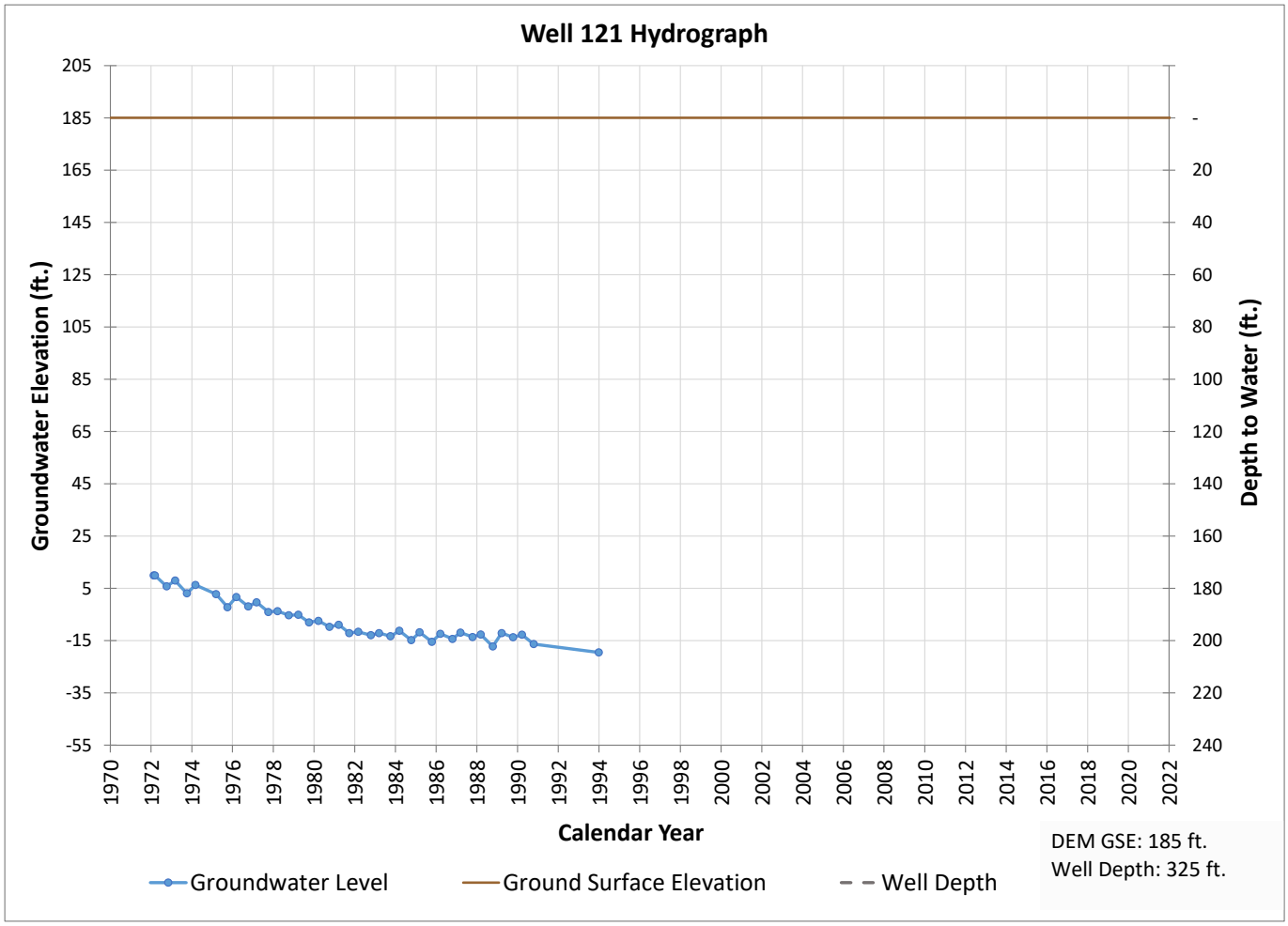

Well 115 Hydrograph
Groundwater Elevation (ft.)
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 38 ft.
Well Depth: 226 ft.

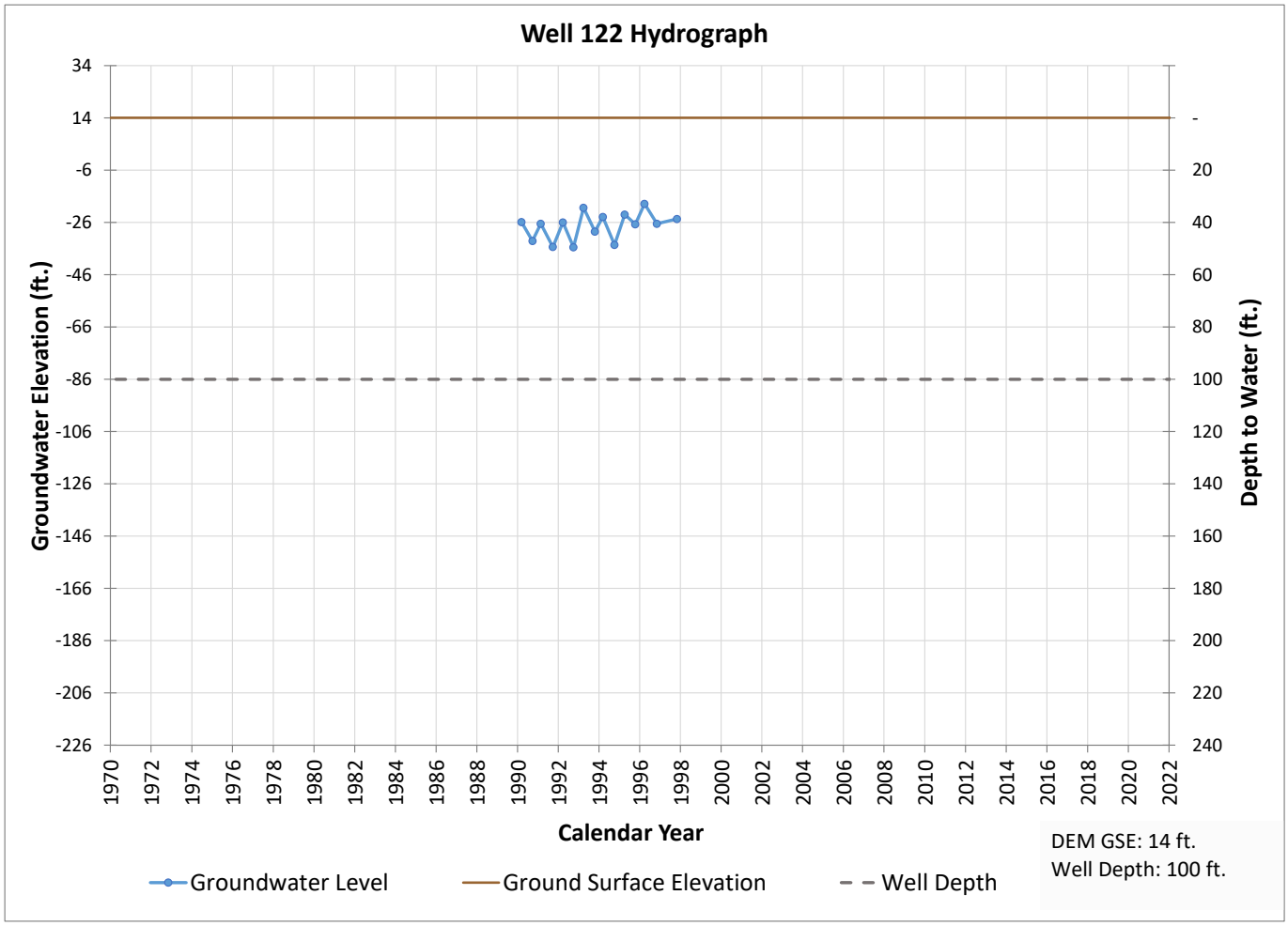

Well 116 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 38 ft.
Well Depth: ft.

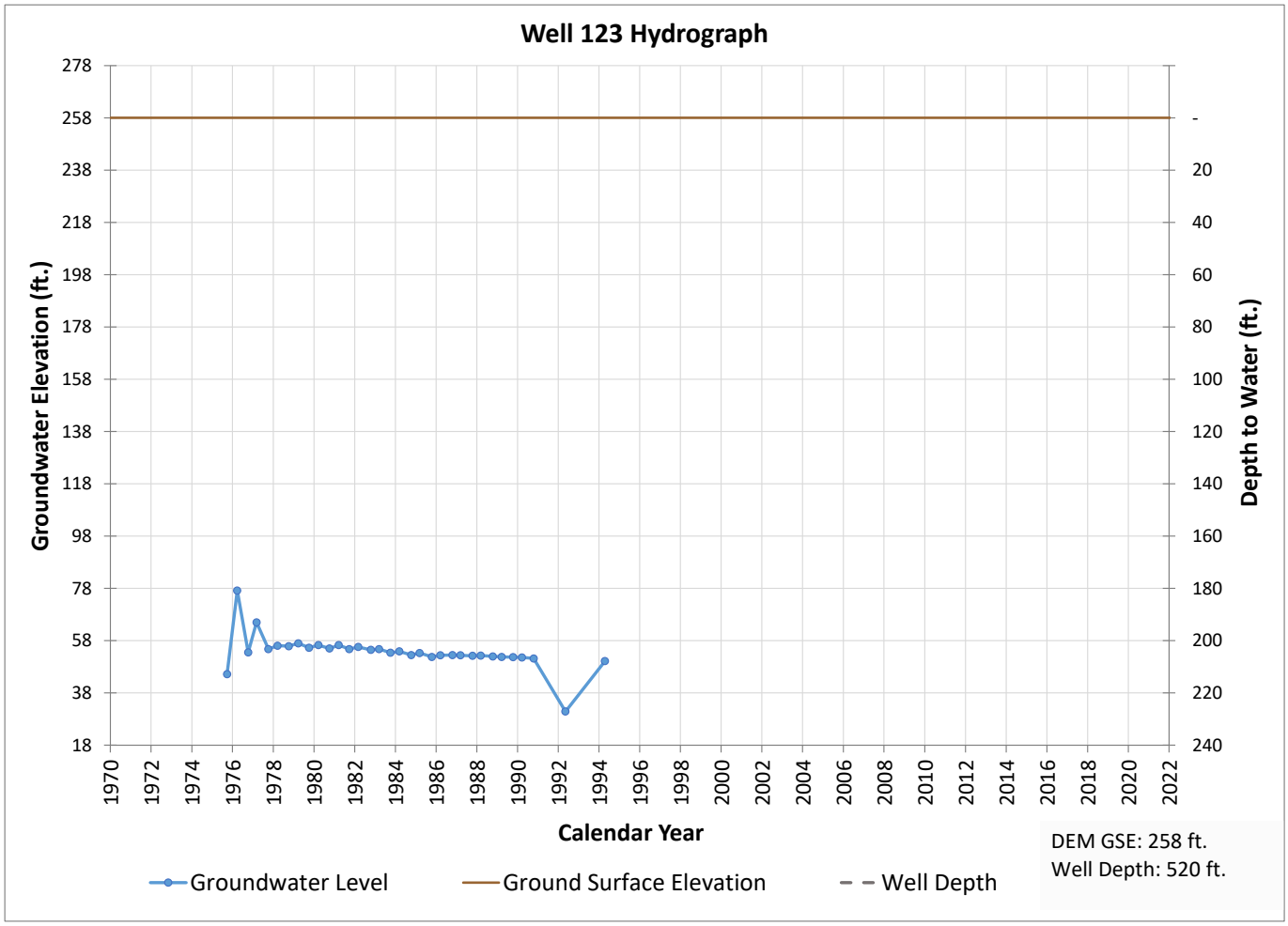

Well 117 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 48 ft.
Well Depth: 167 ft.

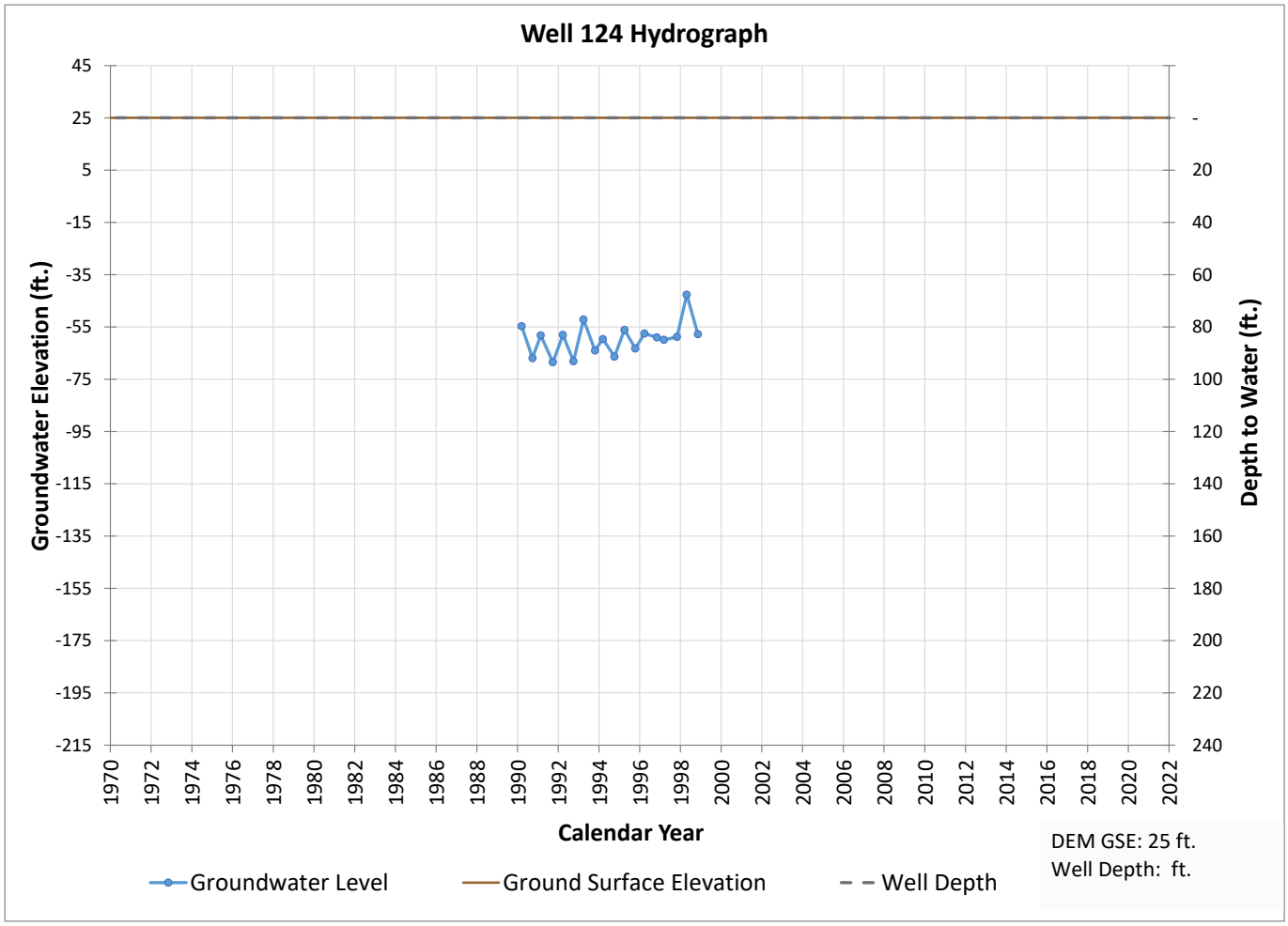

Well 119 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-228
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 12 ft.
Well Depth: 125 ft.

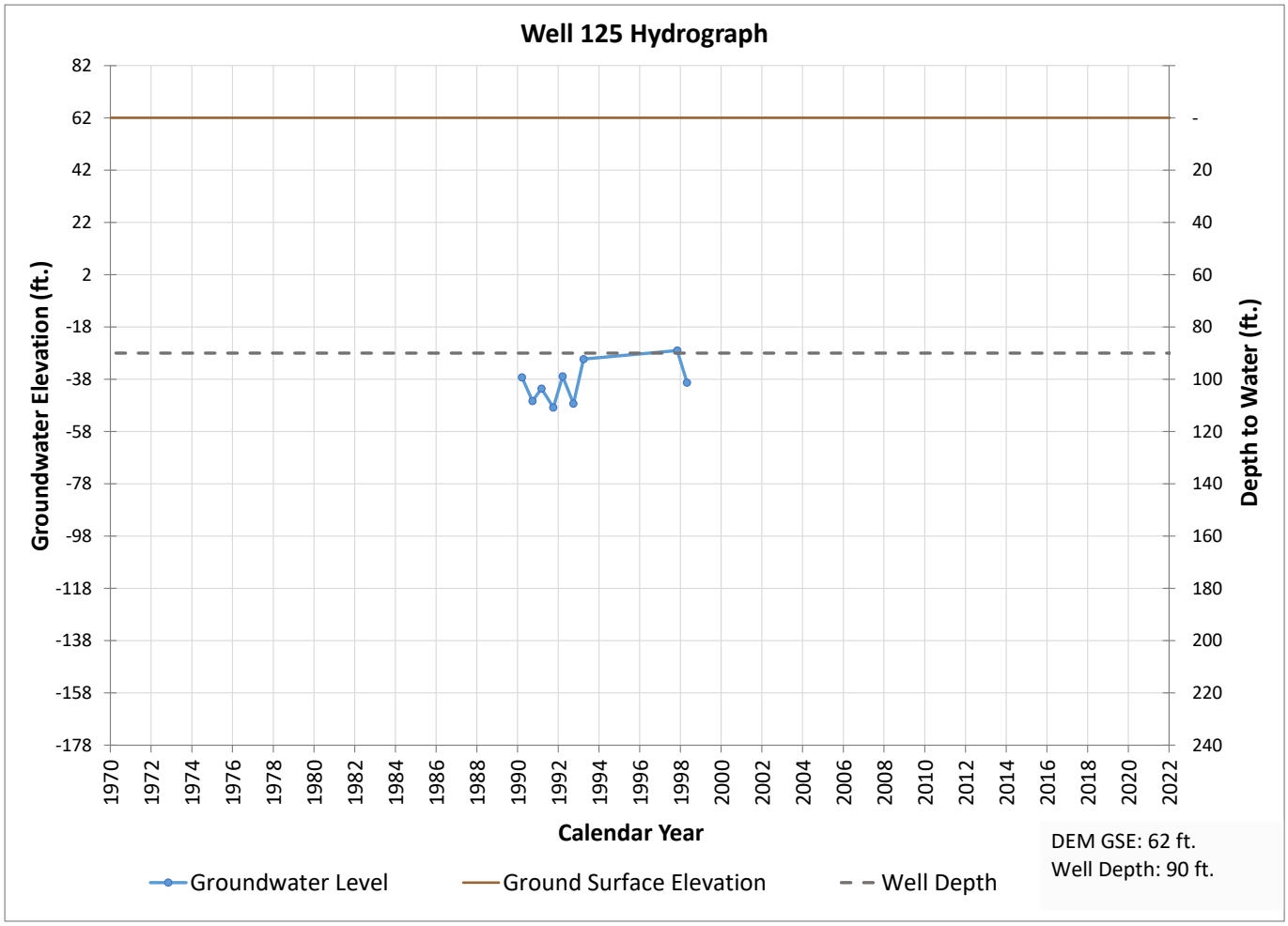

Well 120 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 88 ft.
Well Depth: 210 ft.

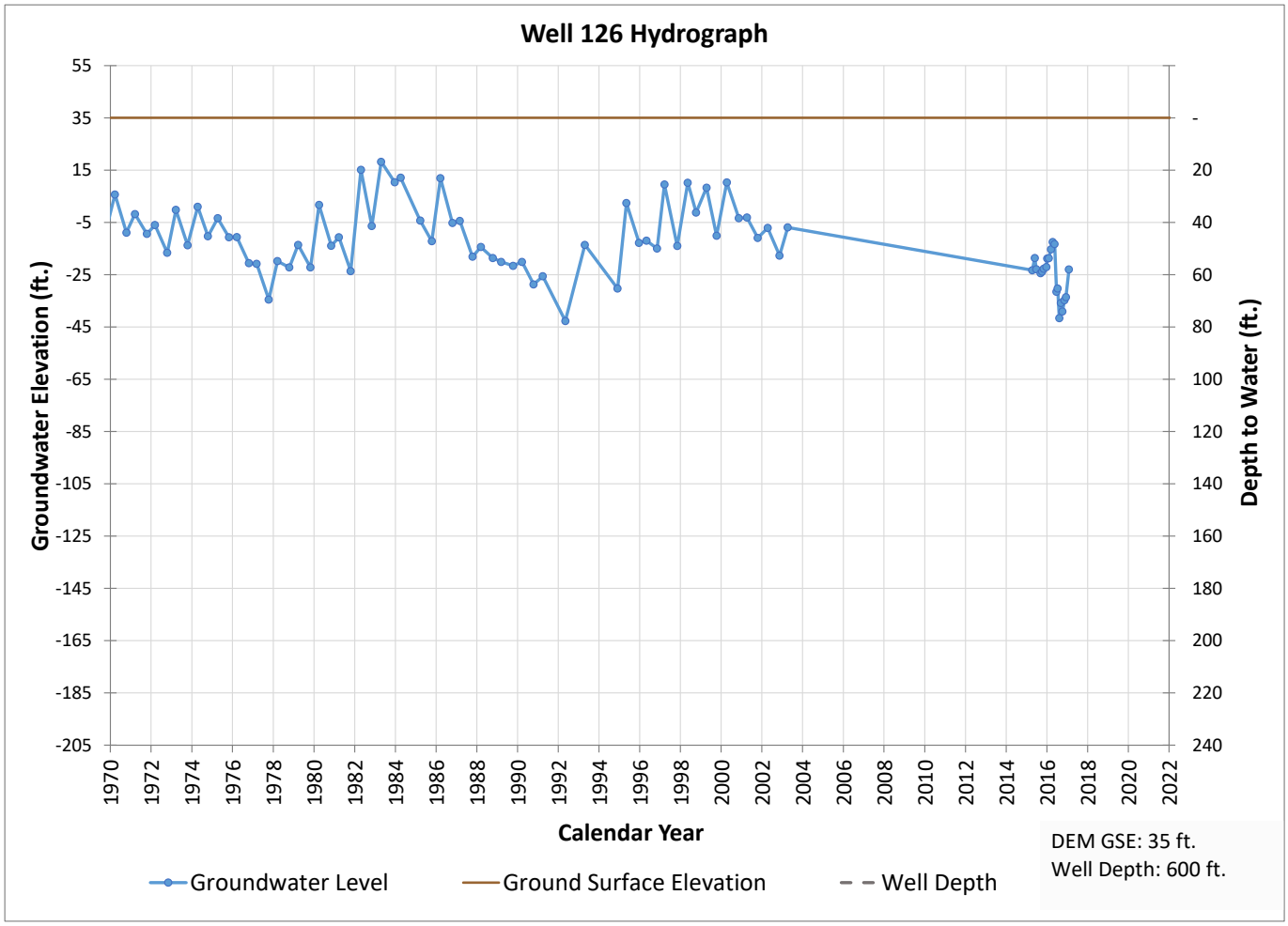

Well 121 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
205
185
165
145
125
105
85
65
45
25
5
-15
-35
-55
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 185 ft.
Well Depth: 325 ft.

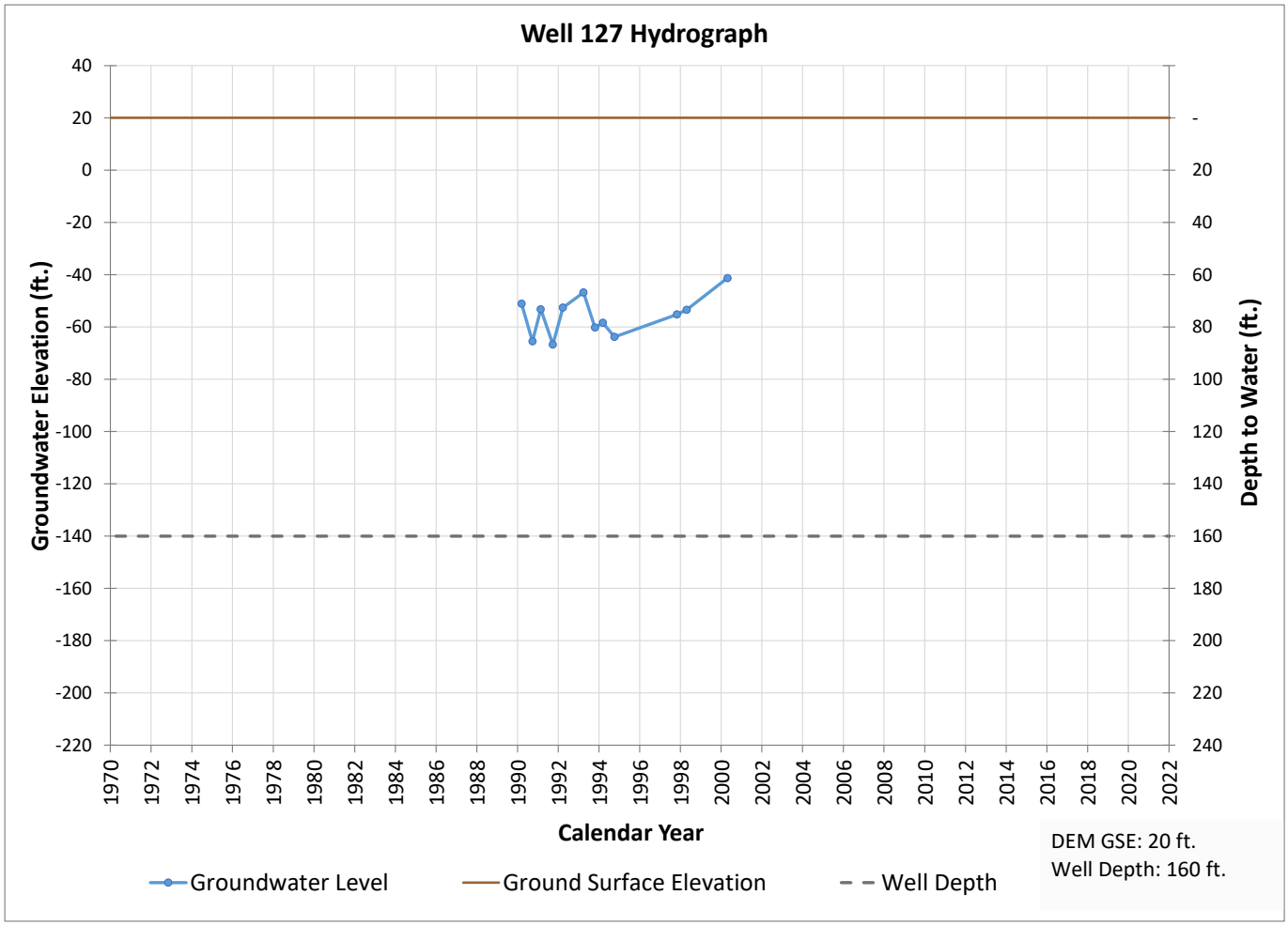

Well 122 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
-226
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 14 ft.
Well Depth: 100 ft.

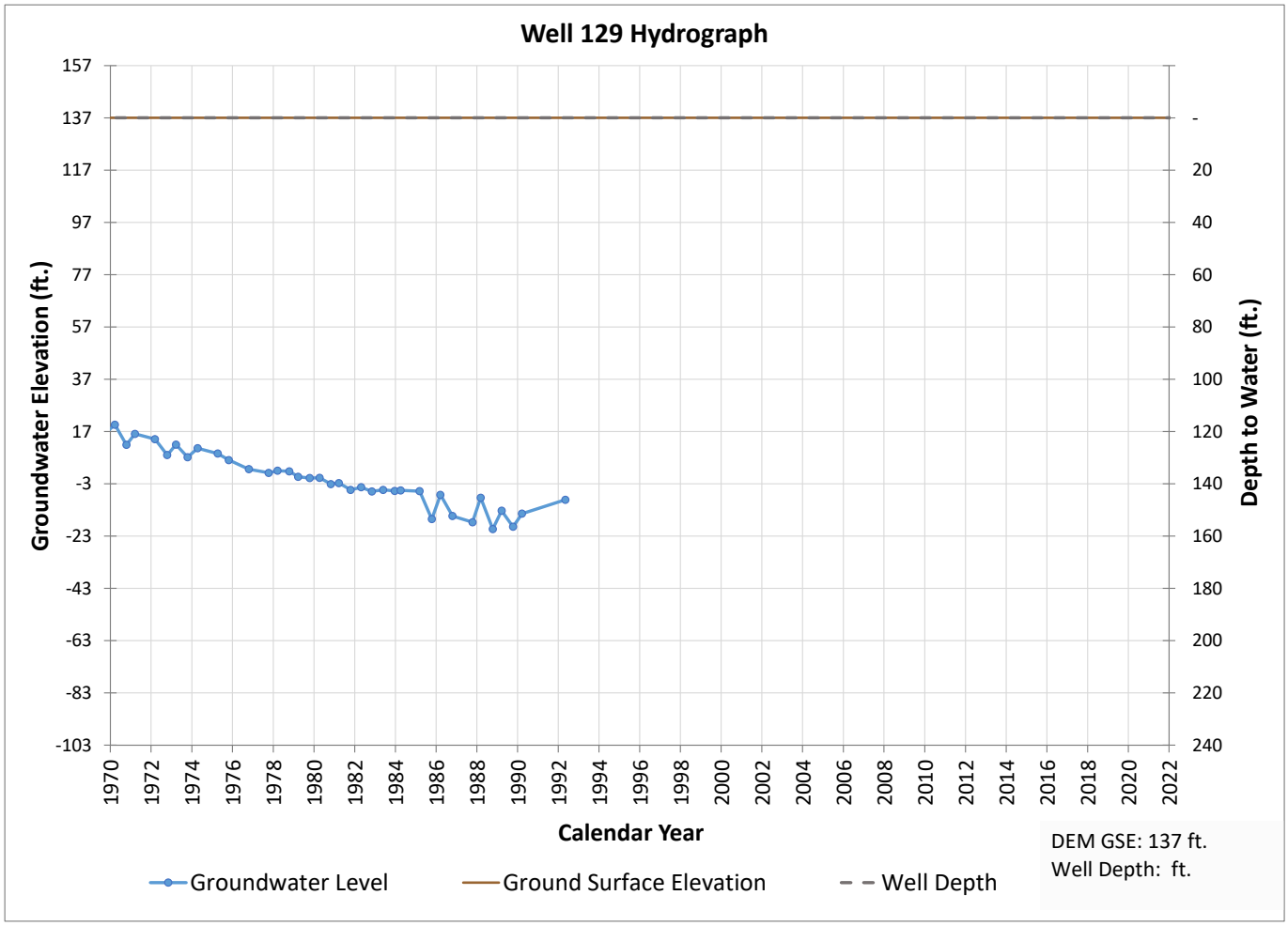

Well 123 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
278
258
238
218
198
178
158
138
118
98
78
58
38
18
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 258 ft.
Well Depth: 520 ft.

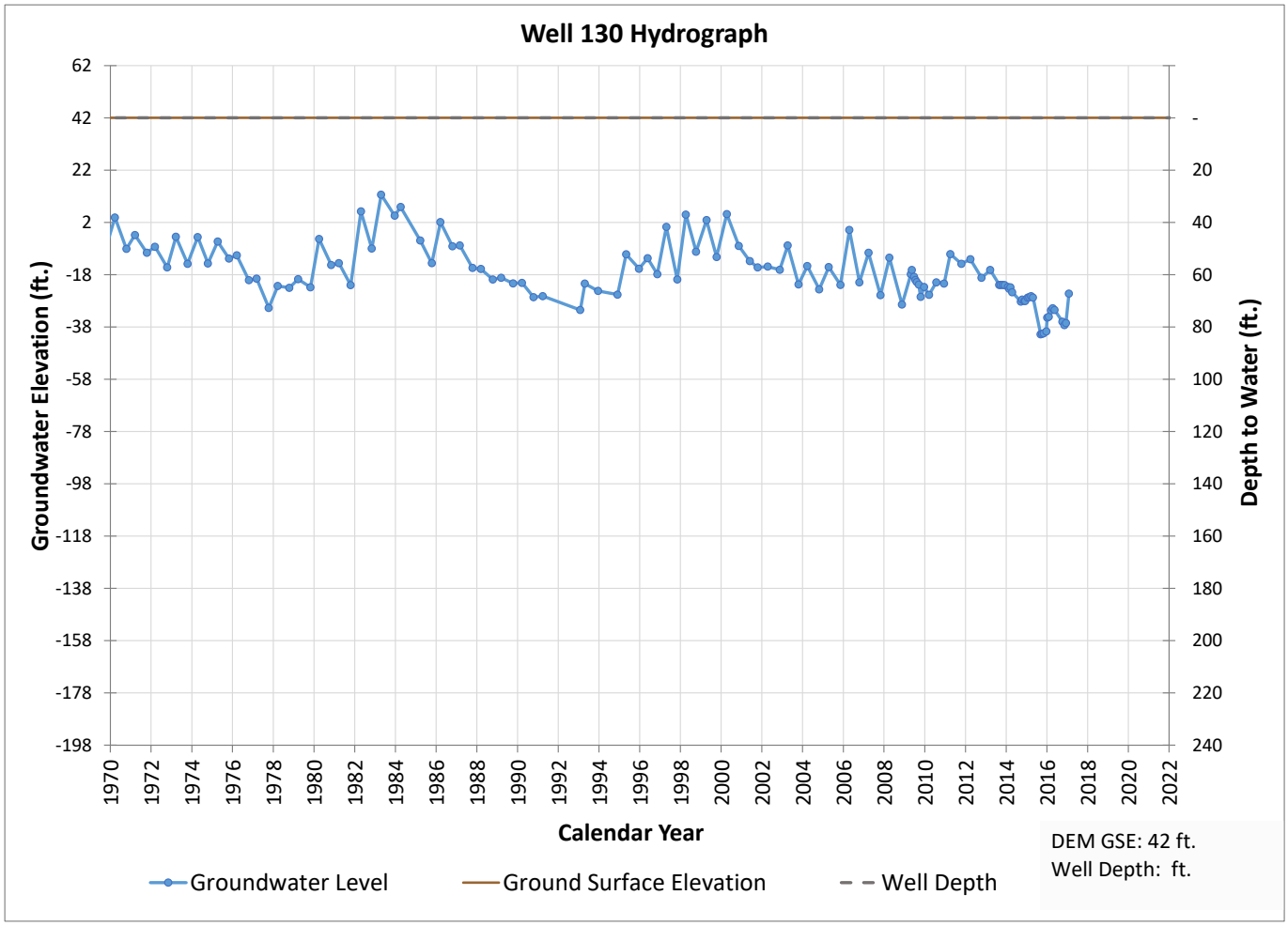

Well 124 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-195
-215
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 25 ft.
Well Depth: ft.

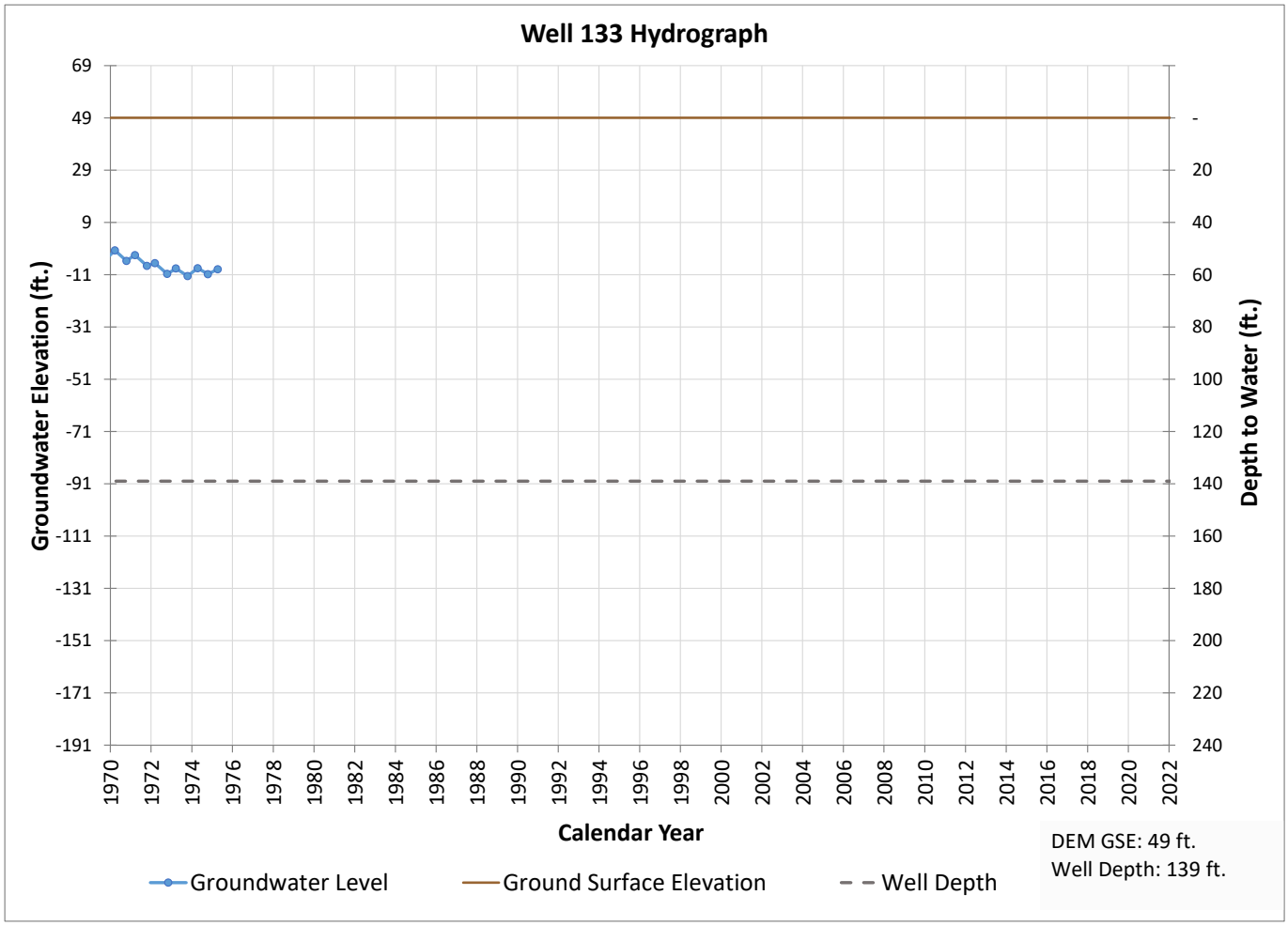

Well 125 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 62 ft.
Well Depth: 90 ft.

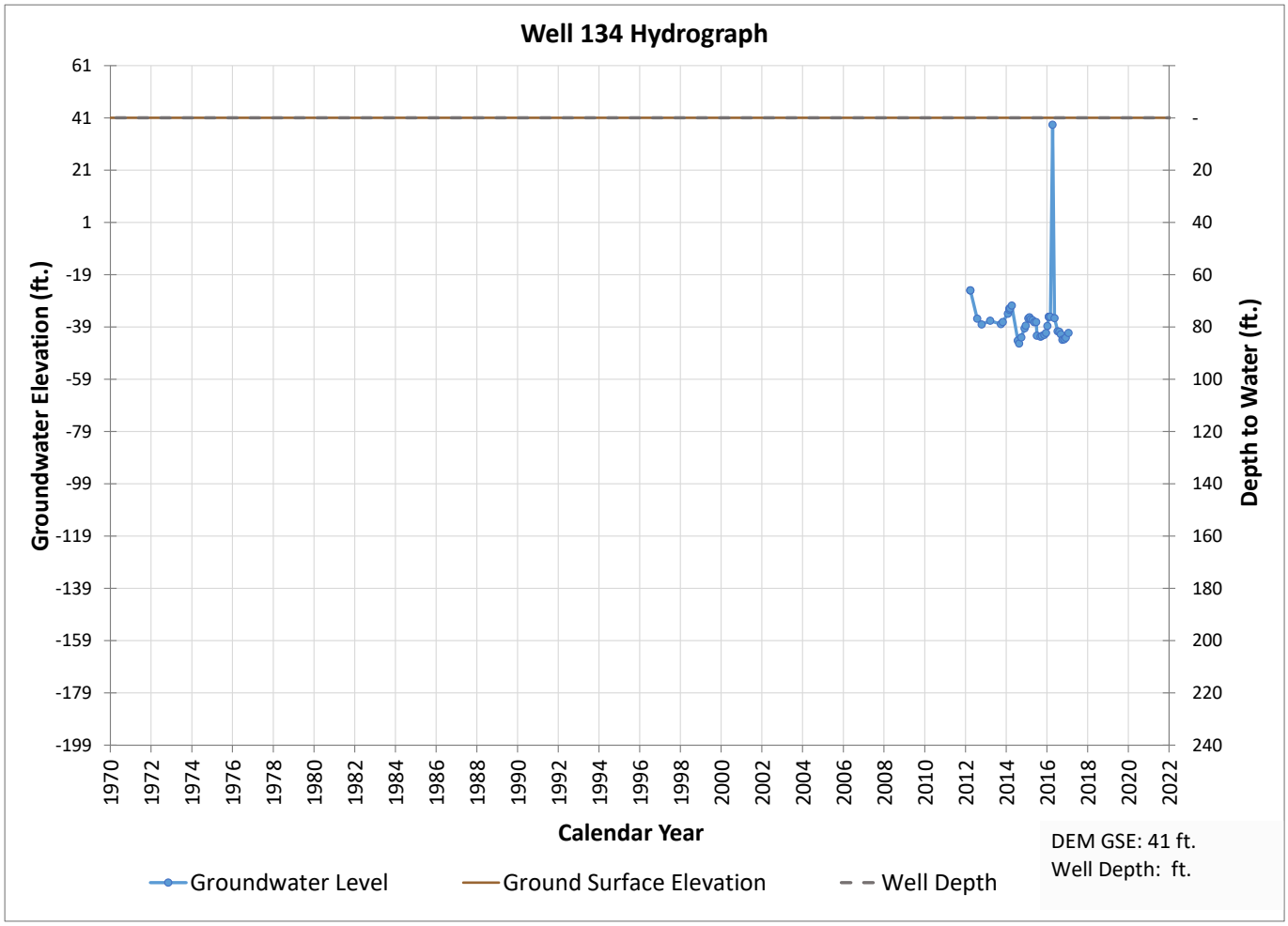

Well 126 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 35 ft.
Well Depth: 600 ft.

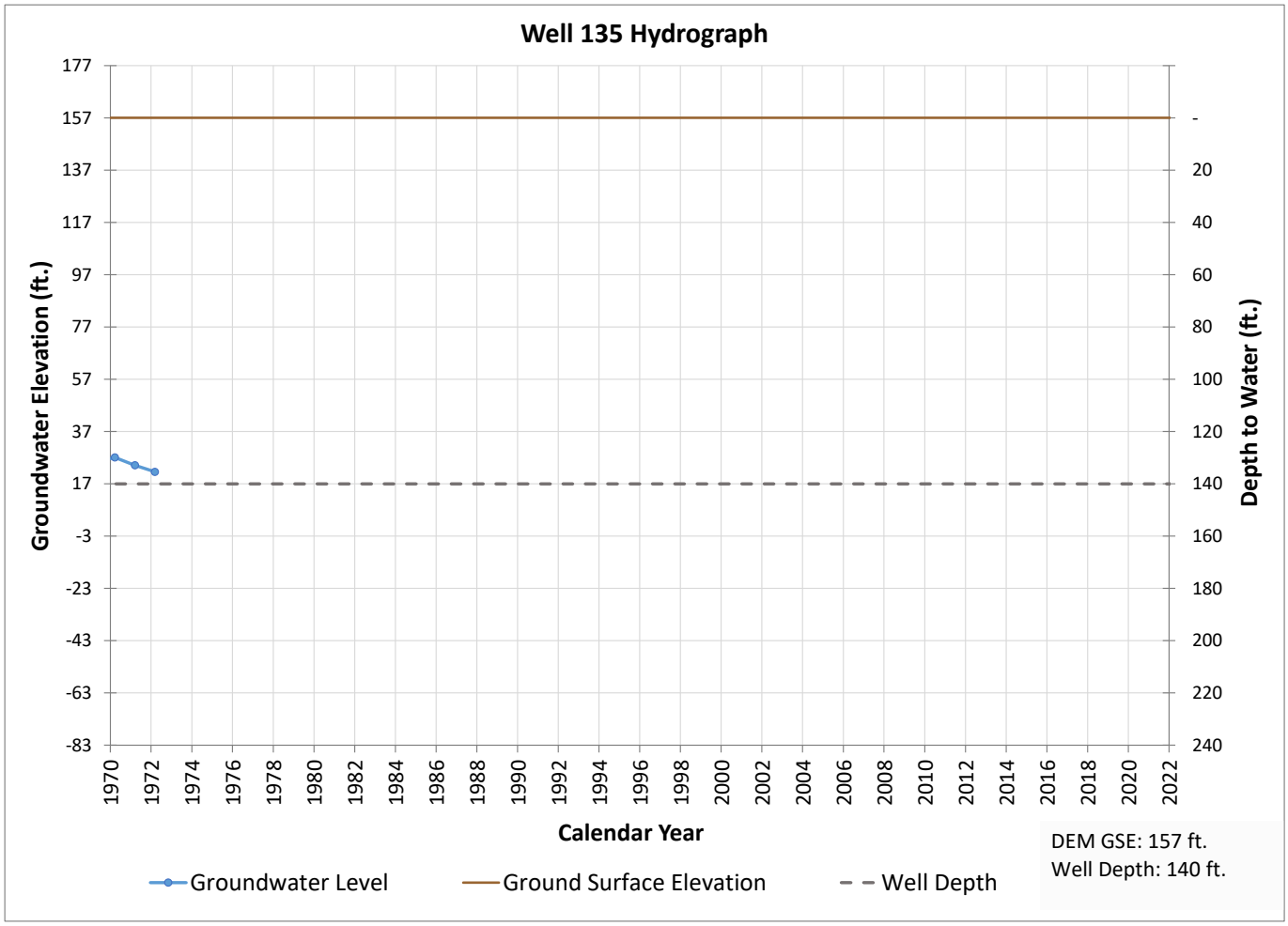

Well 127 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: 160 ft.

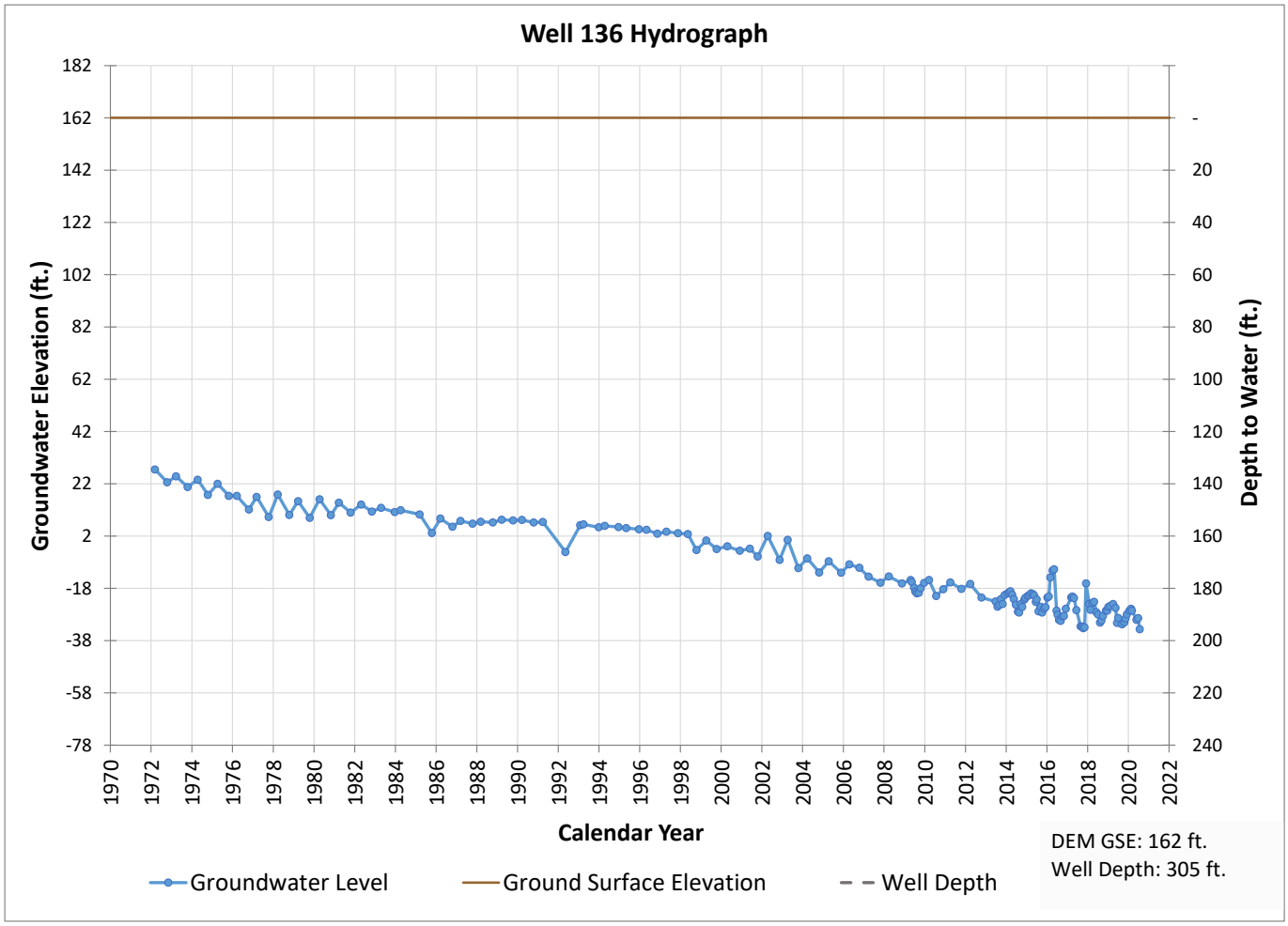

Well 129 Hydrograph
Groundwater Elevation (ft.)
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
-103
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 137 ft.
Well Depth: ft.

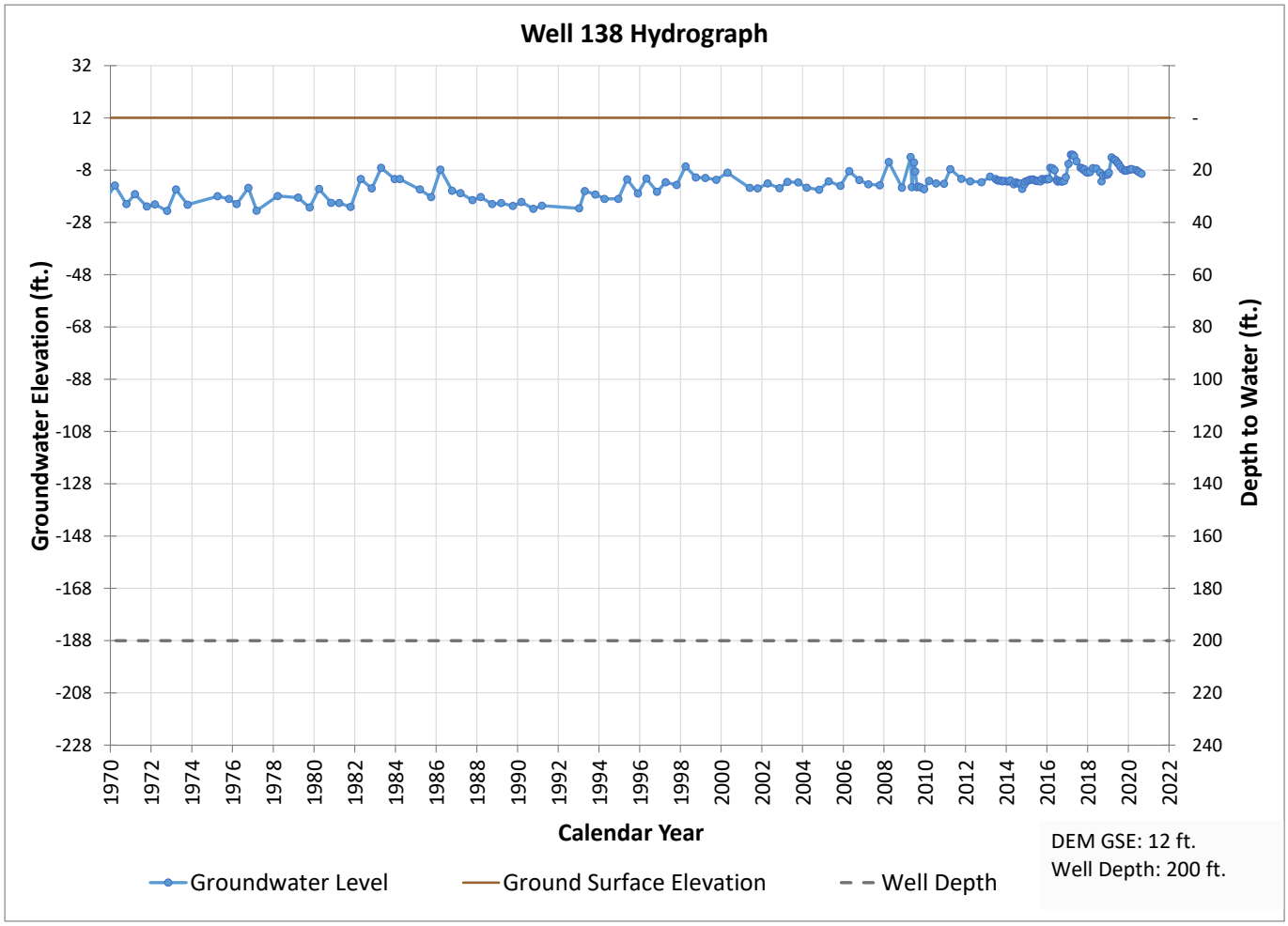

Well 130 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: ft.

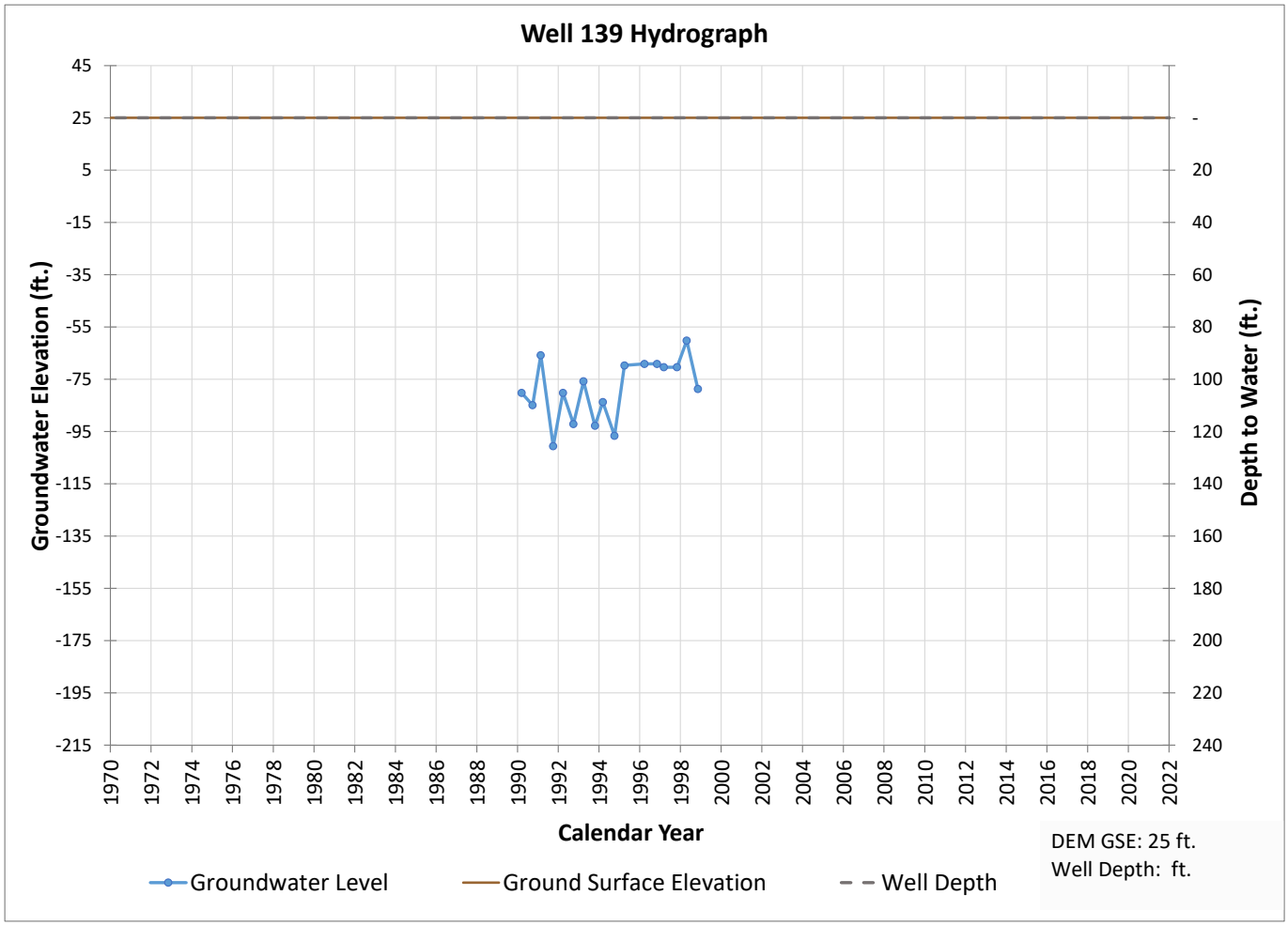

Well 133 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: 139 ft.

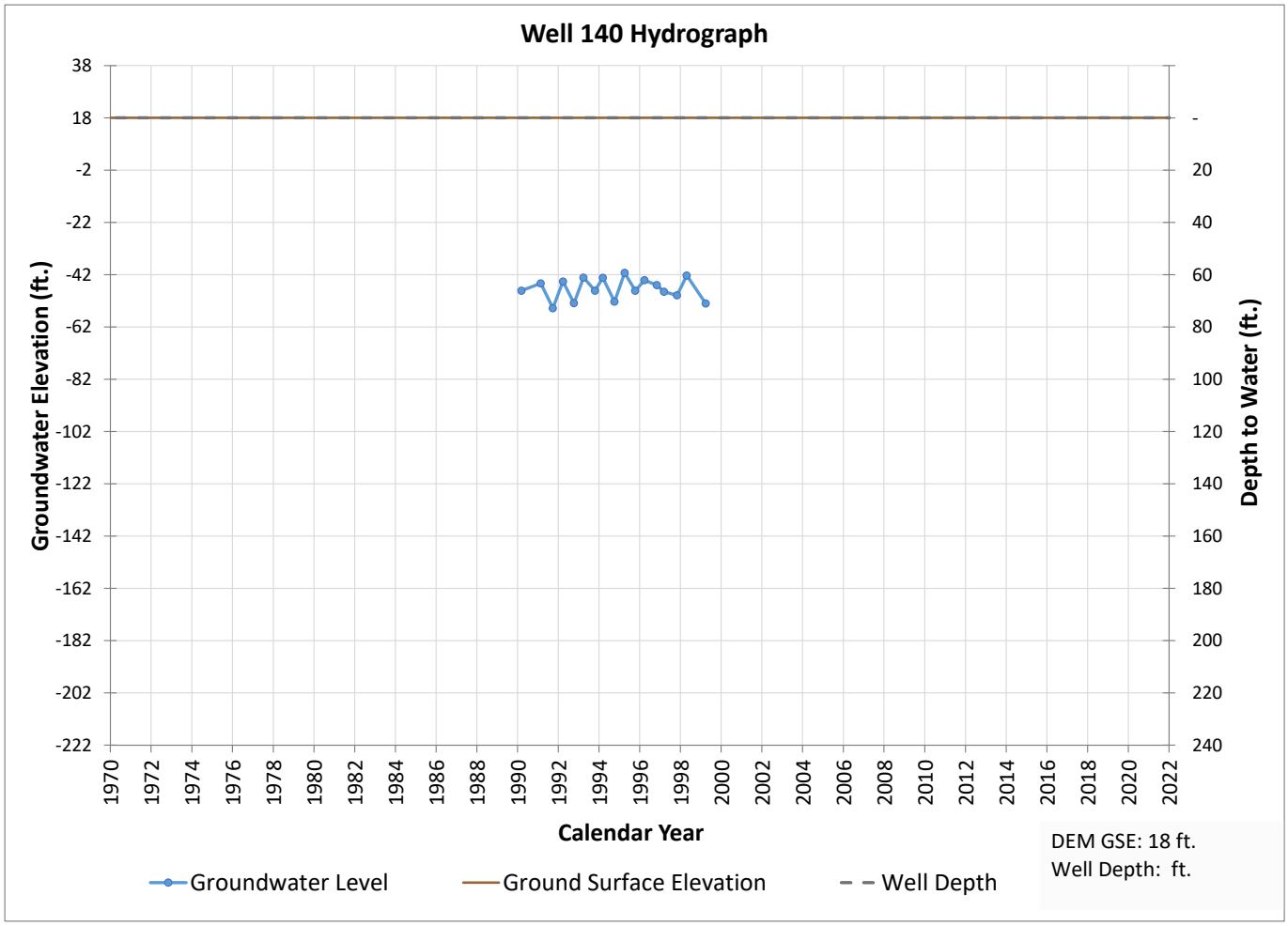

Well 134 Hydrograph
Groundwater Elevation (ft.)
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 41 ft.
Well Depth: ft.

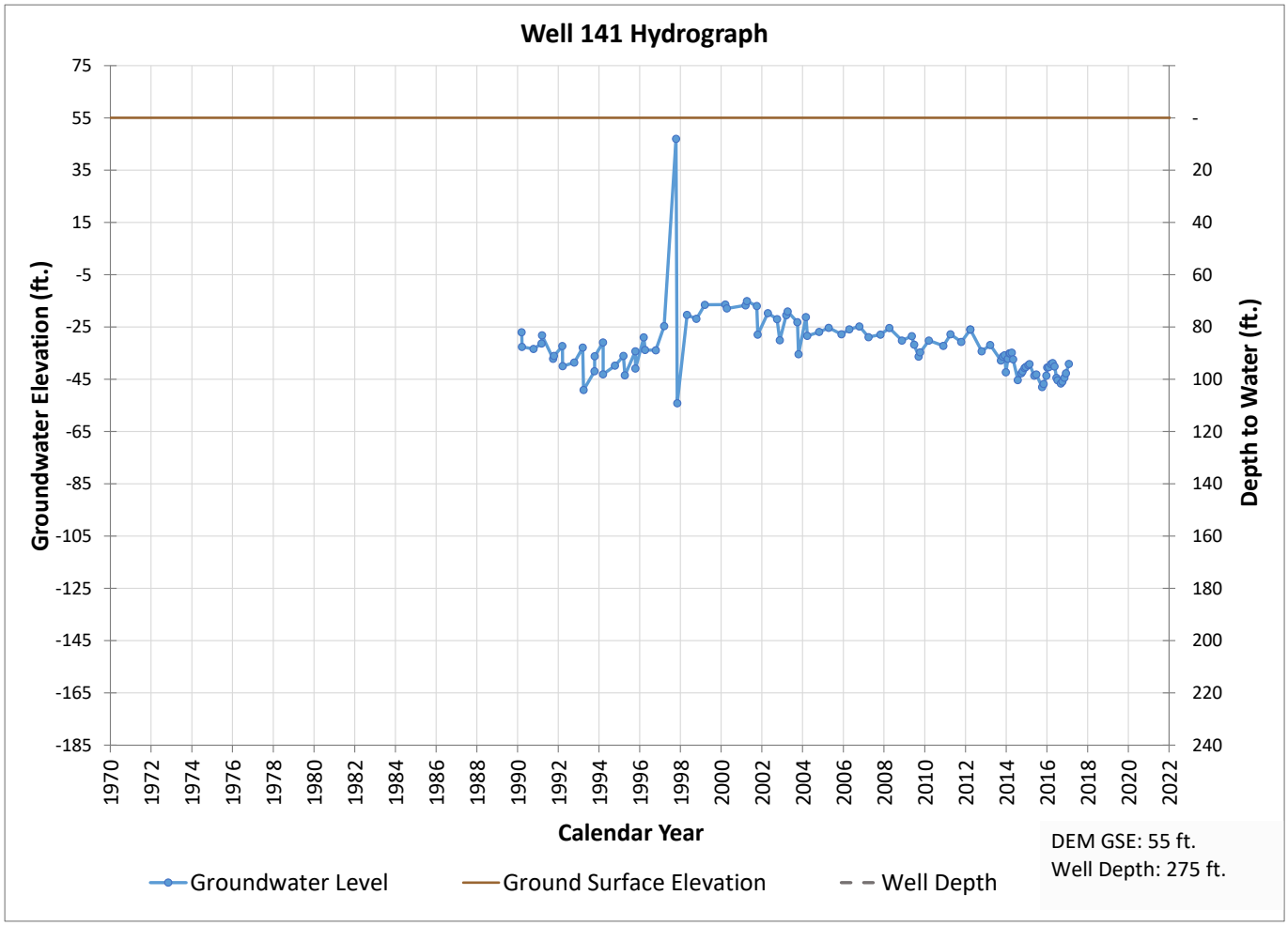

Well 135 Hydrograph
Groundwater Elevation (ft.)
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 157 ft.
Well Depth: 140 ft.

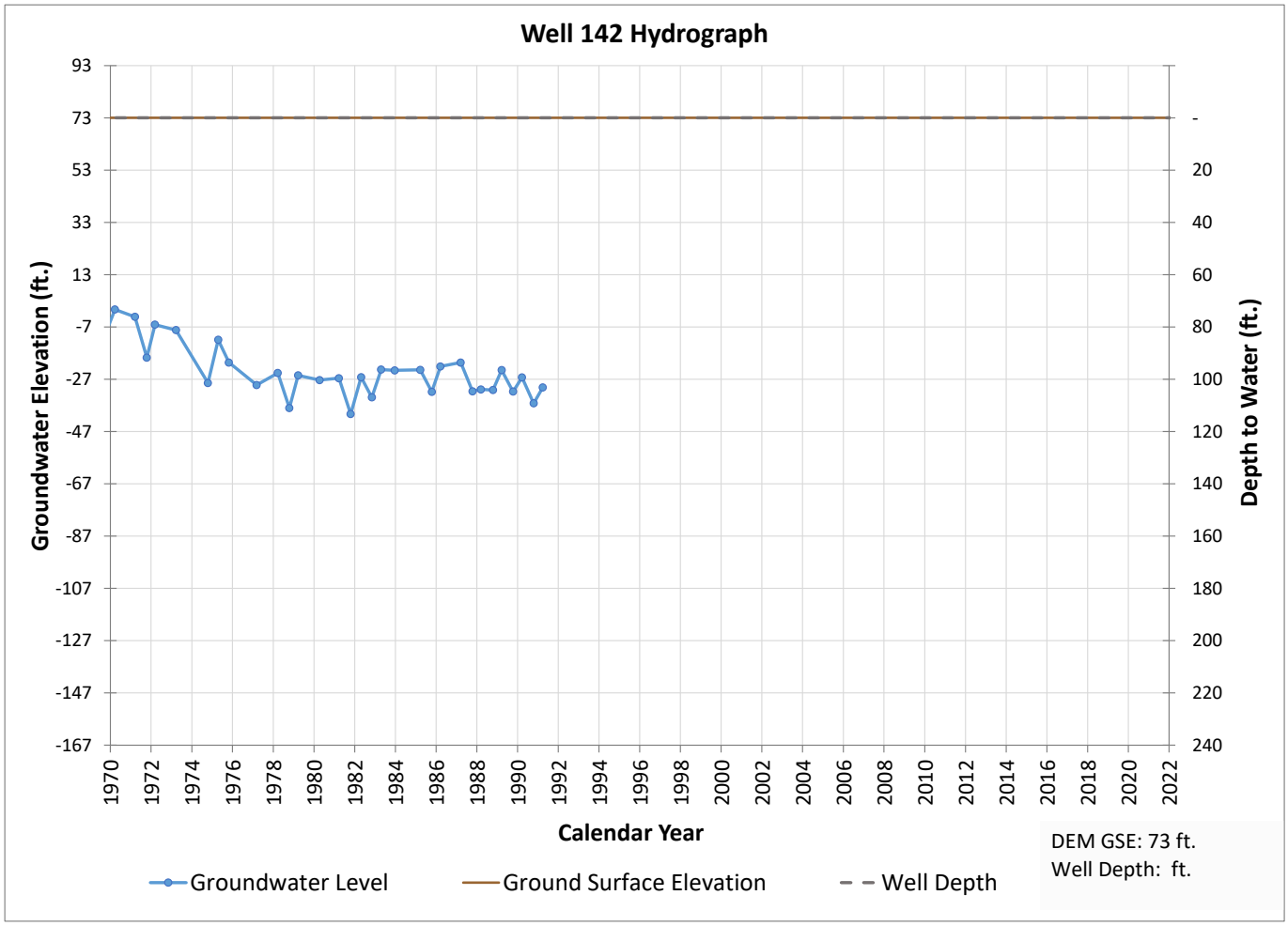

Well 136 Hydrograph
Groundwater Elevation (ft.)
182
162
142
122
102
82
62
42
22
2
-18
-38
-58
-78
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 162 ft.
Well Depth: 305 ft.

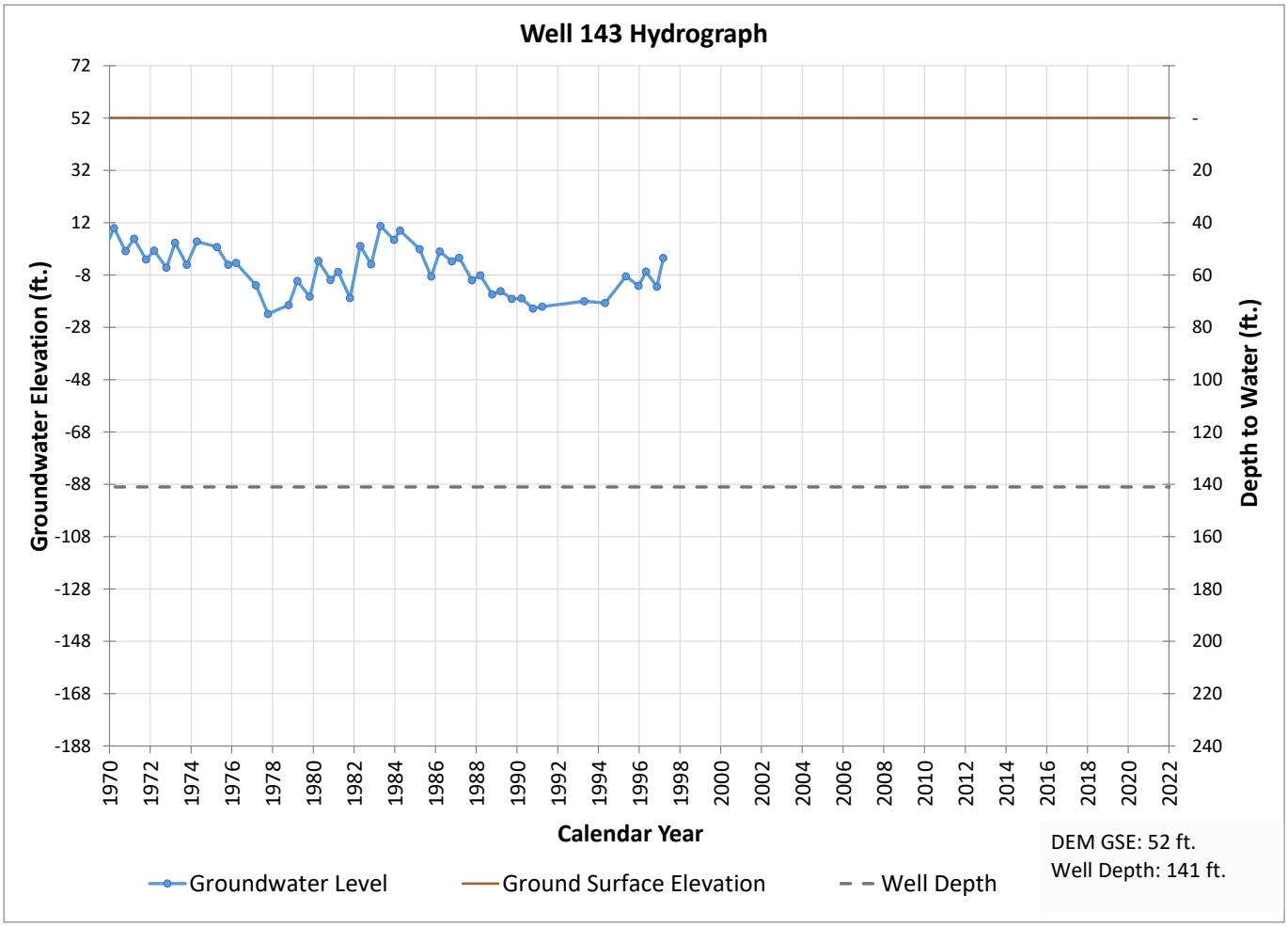

Well 138 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-228
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 12 ft.
Well Depth: 200 ft.

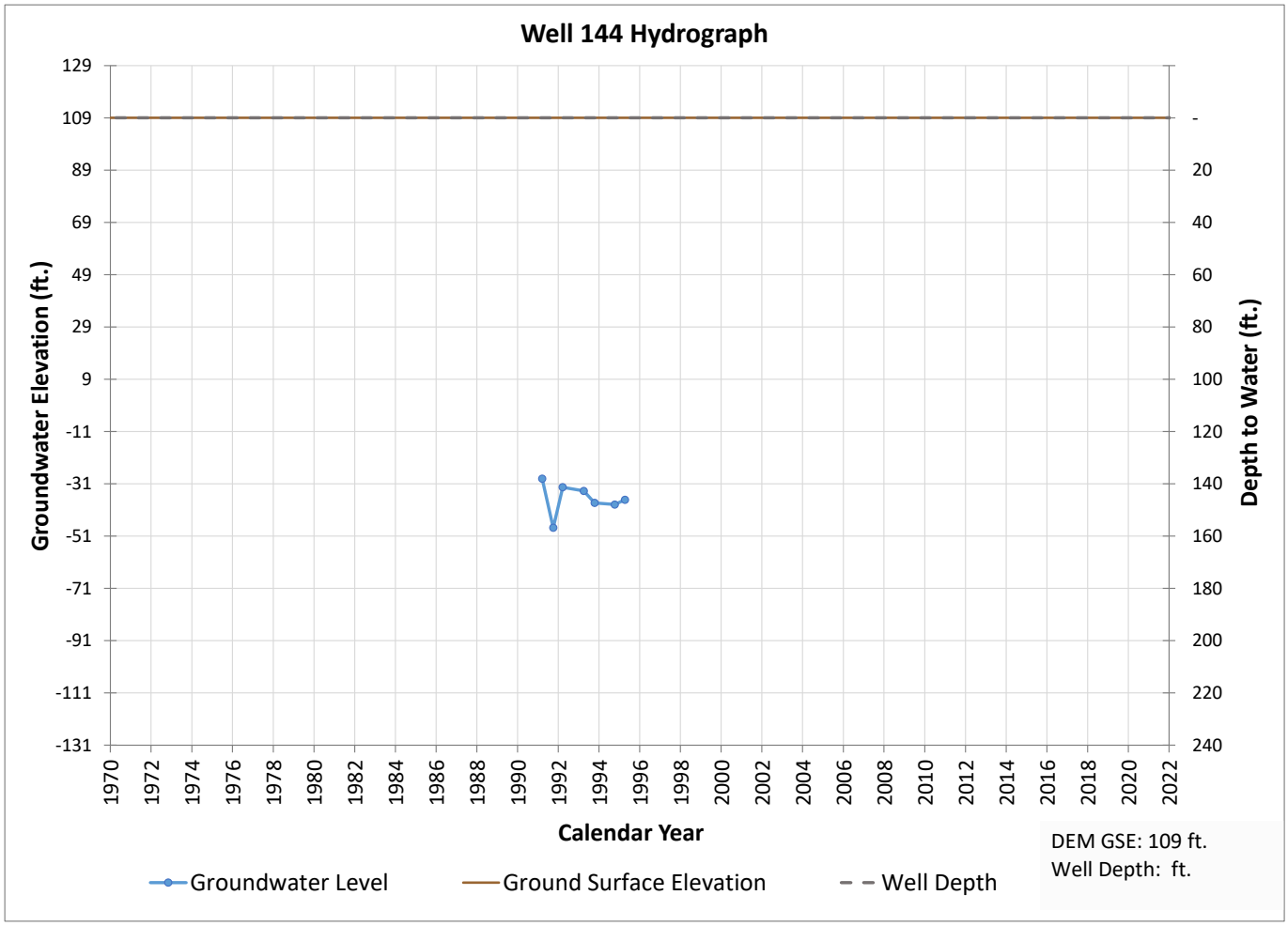

Well 139 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-195
-215
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 25 ft.
Well Depth: ft.

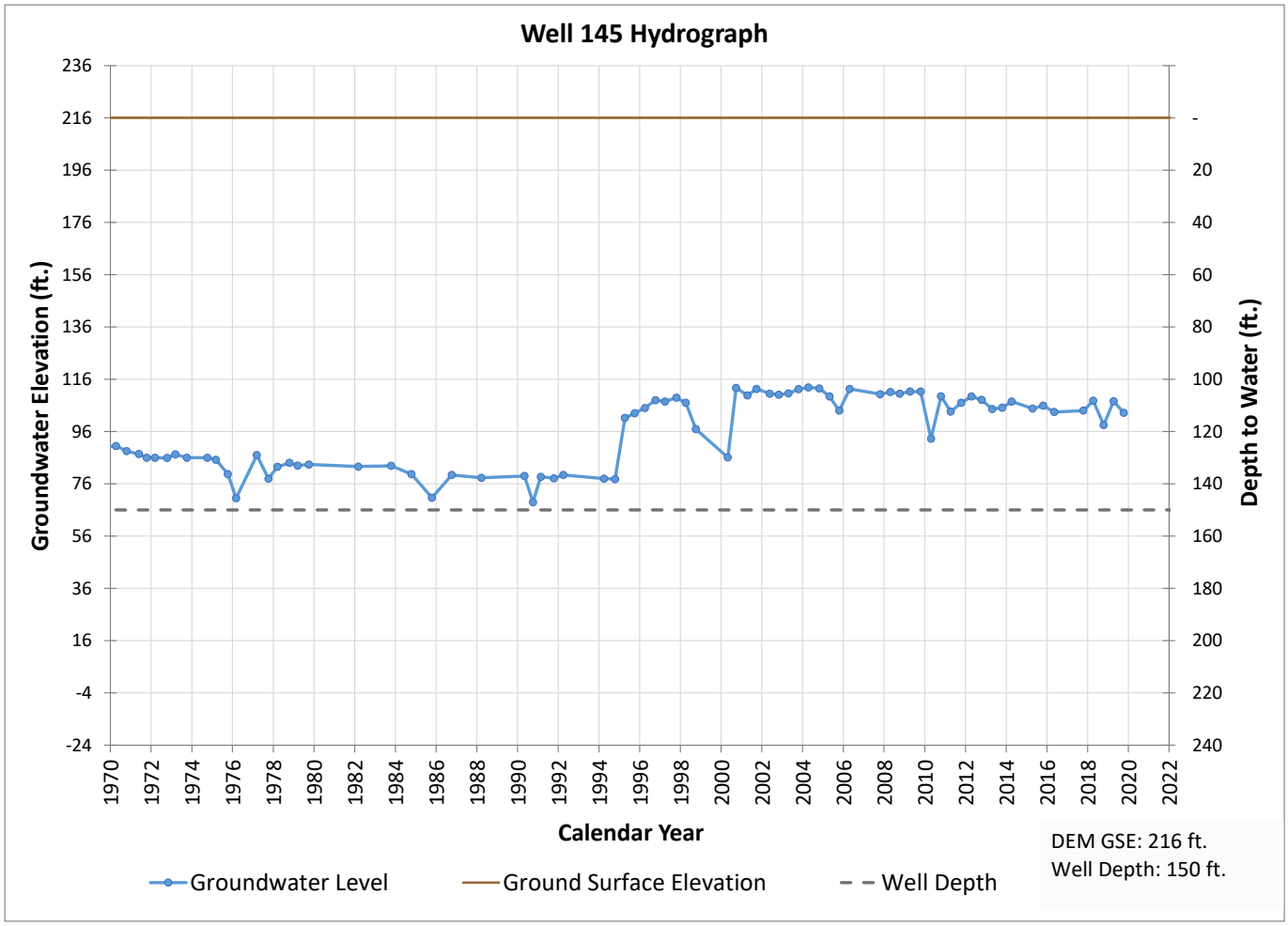

Well 140 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-222
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 18 ft.
Well Depth: ft.

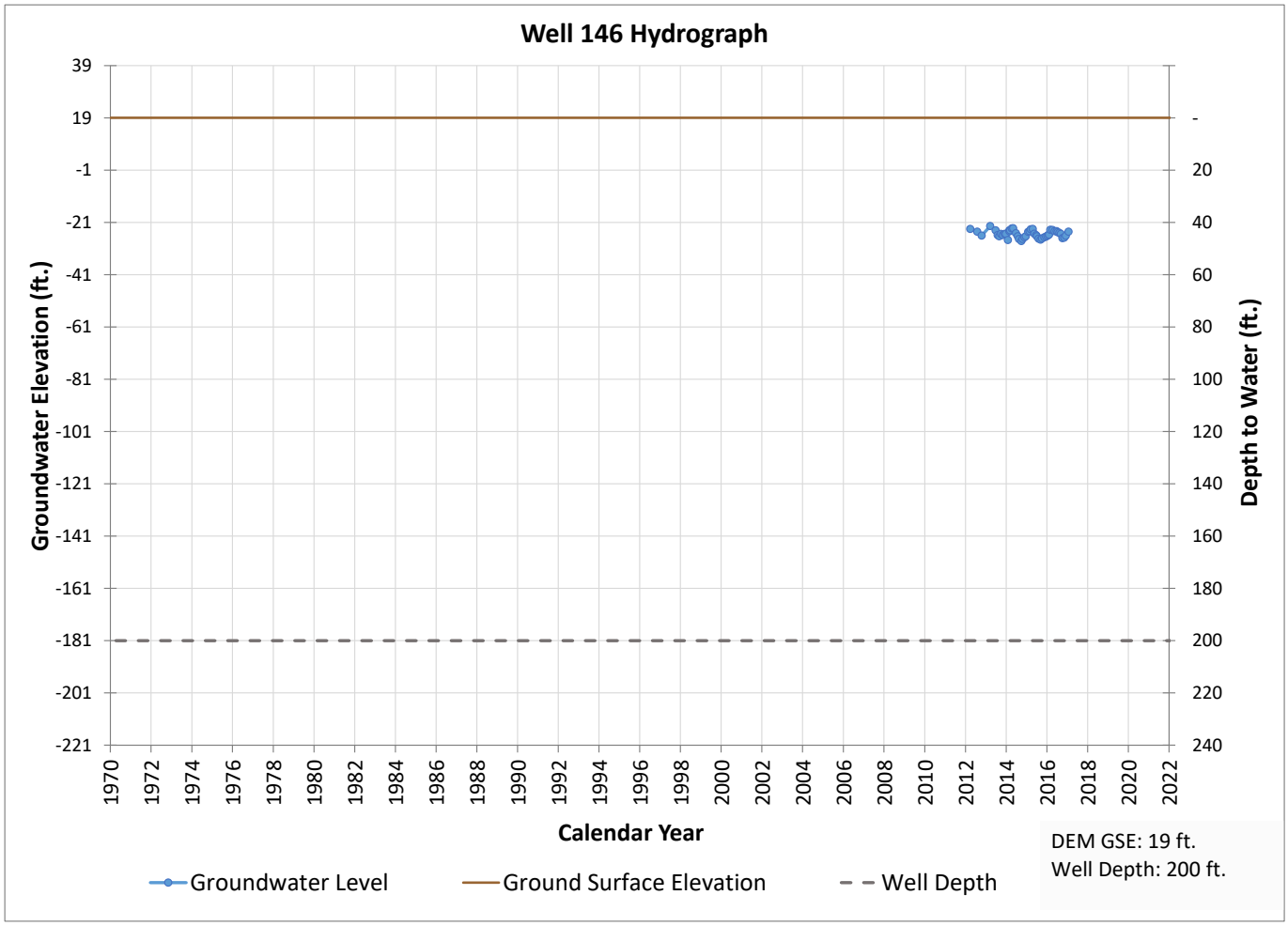

Well 141 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 55 ft.
Well Depth: 275 ft.

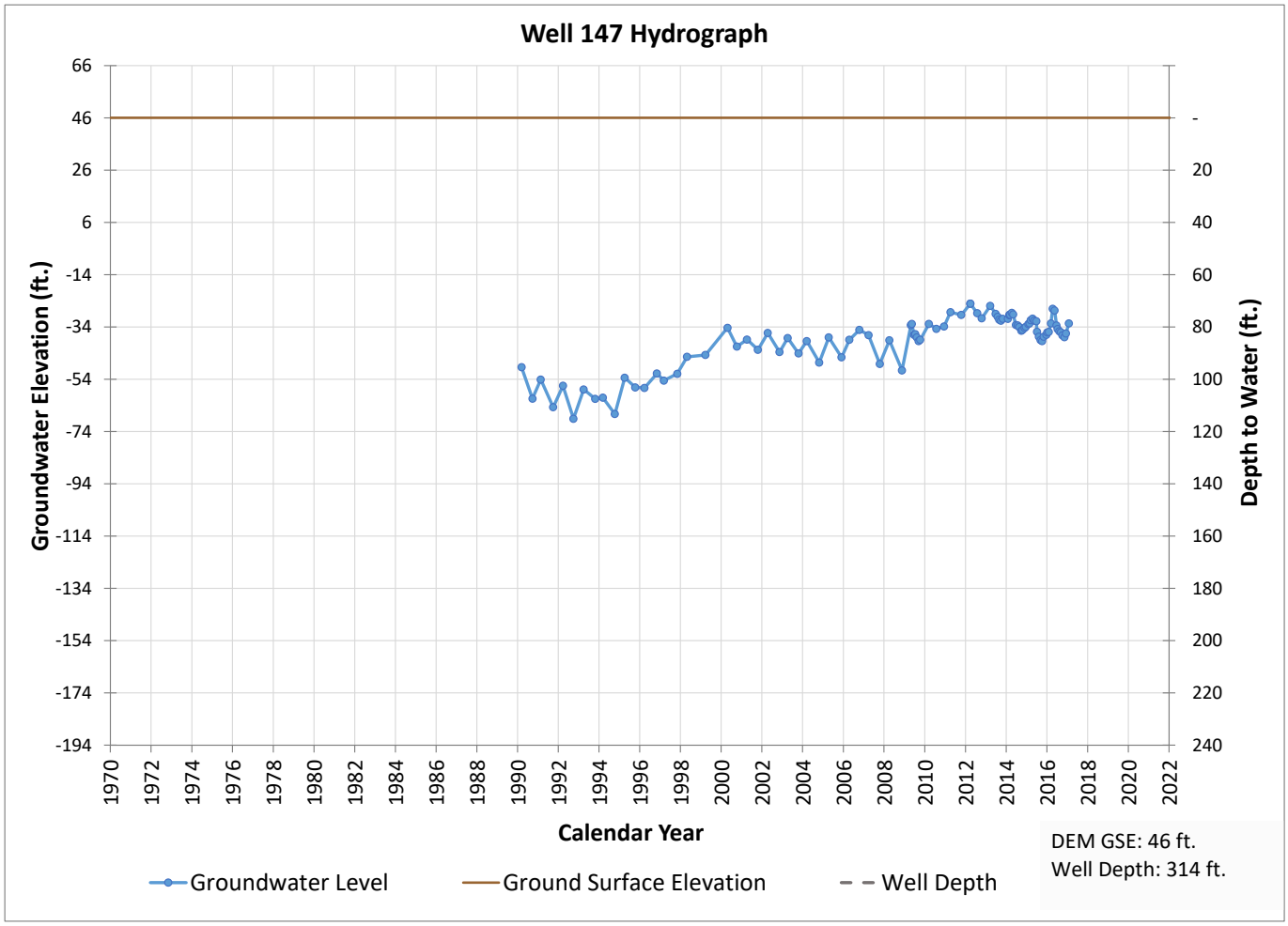

Well 142 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 73 ft.
Well Depth: ft.

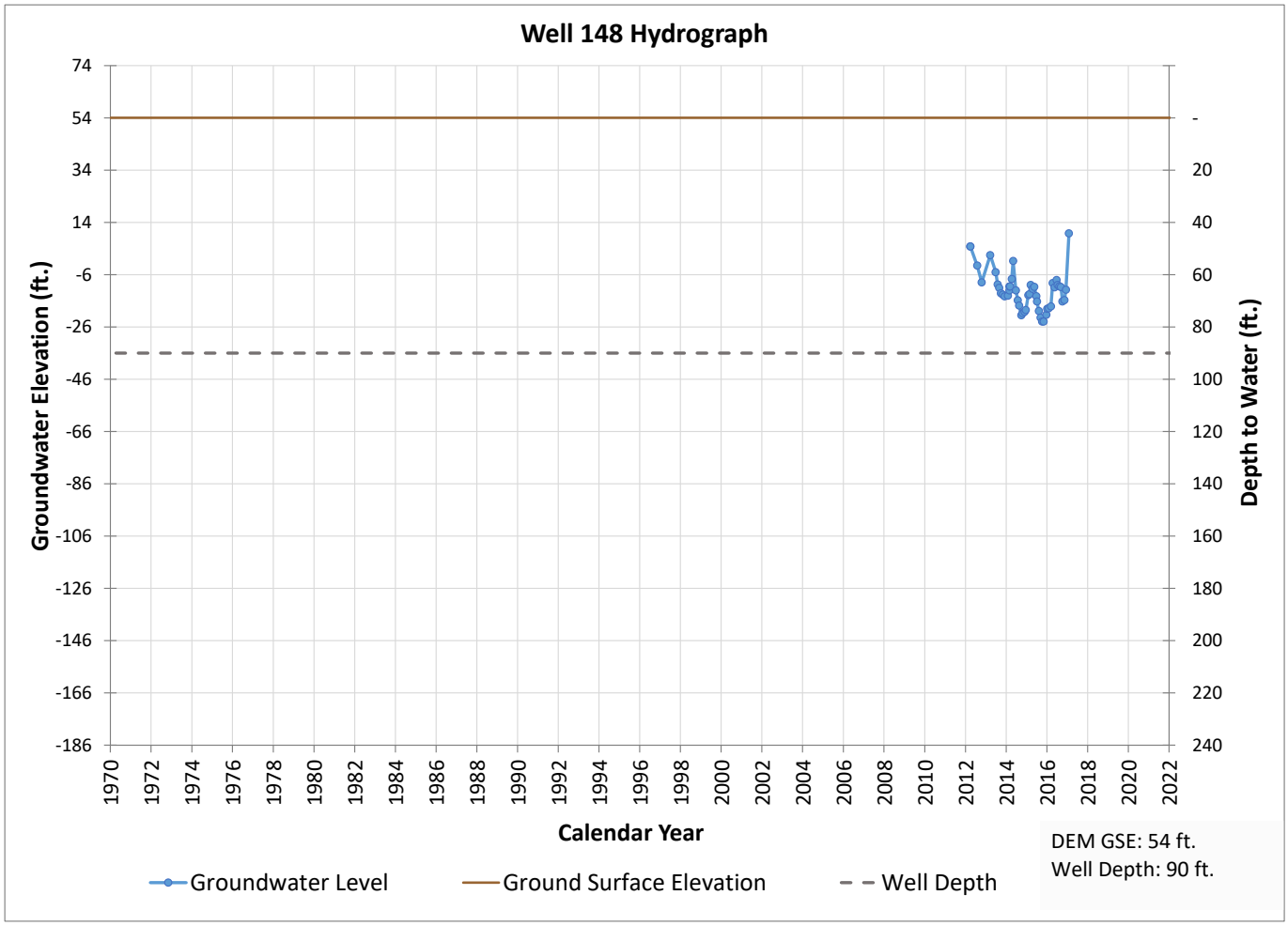

Well 143 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: 141 ft.

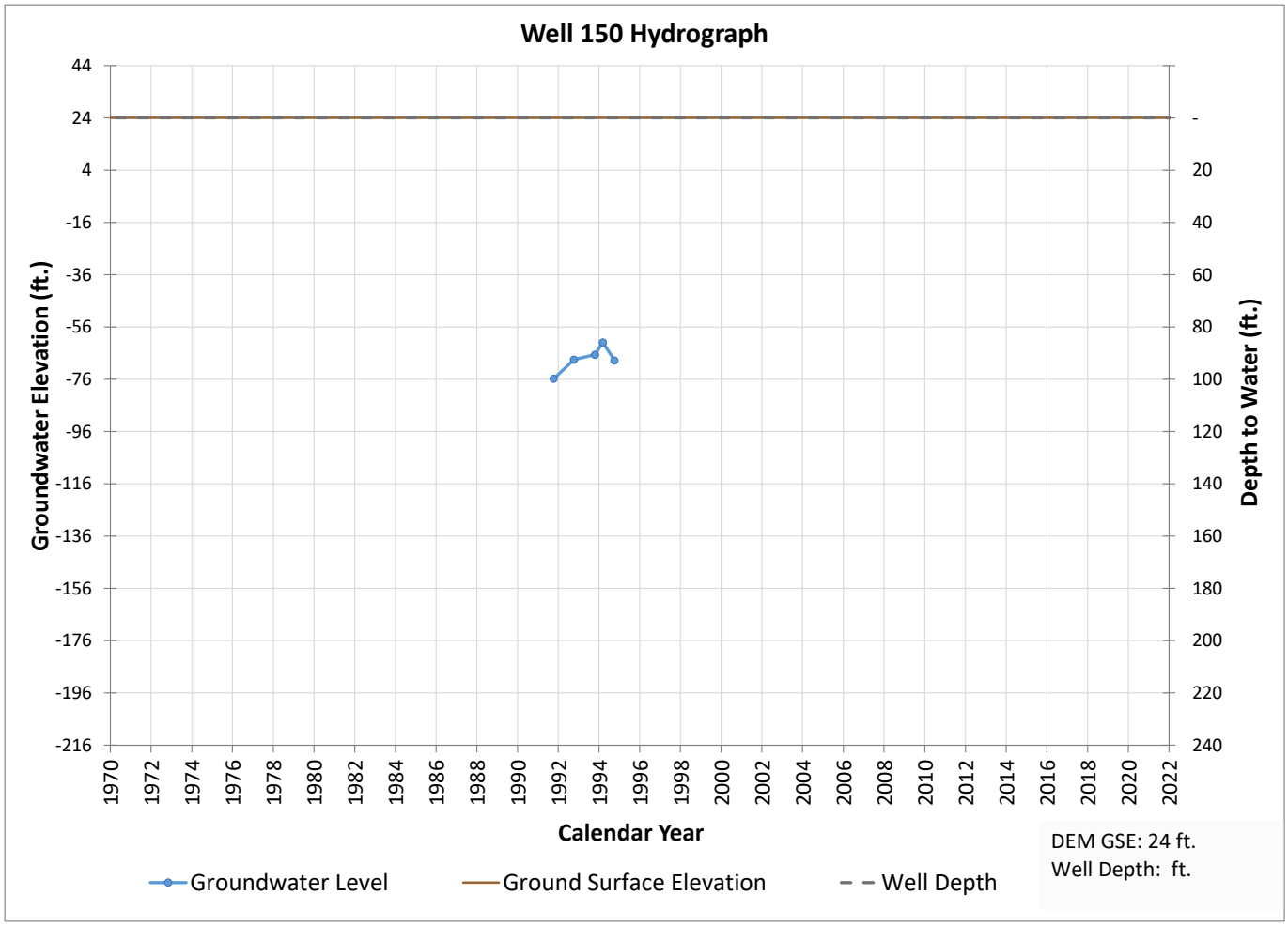

Well 144 Hydrograph
Groundwater Elevation (ft.)
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 109 ft.
Well Depth: ft.

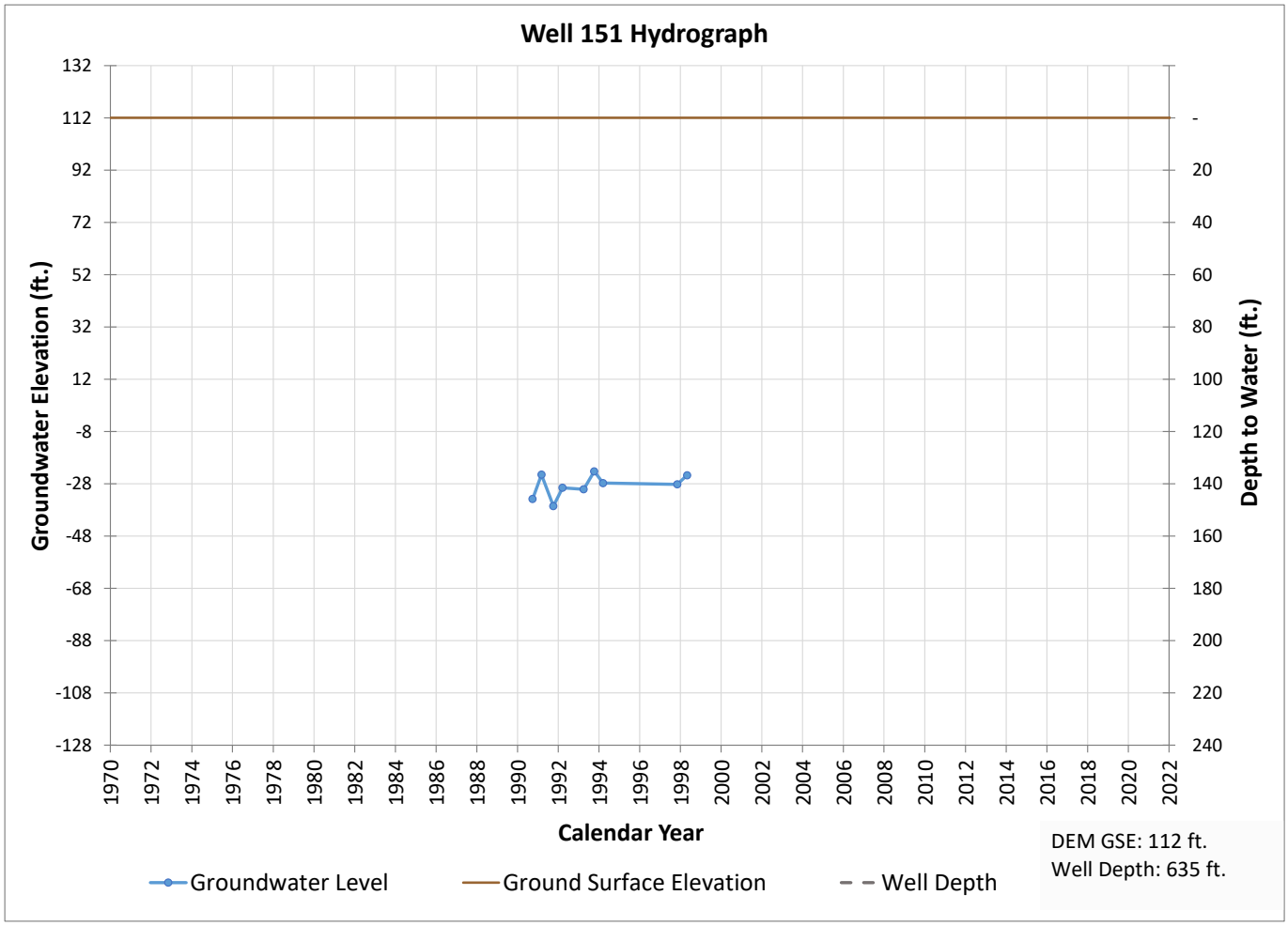

Well 145 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
236
216
196
176
156
136
116
96
76
56
36
16
-4
-24
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 216 ft.
Well Depth: 150 ft.

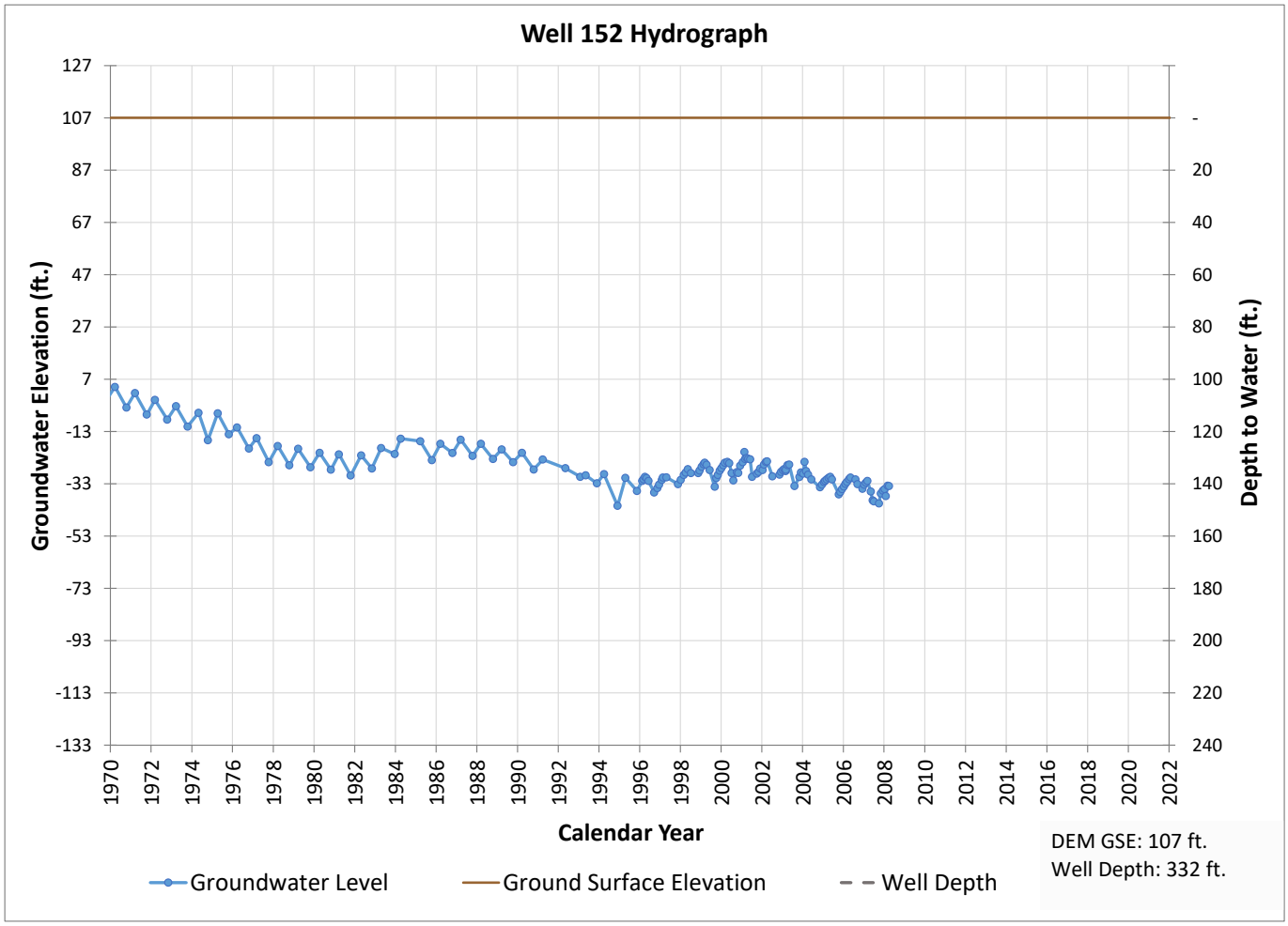

Well 146 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-201
-221
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 19 ft.
Well Depth: 200 ft.

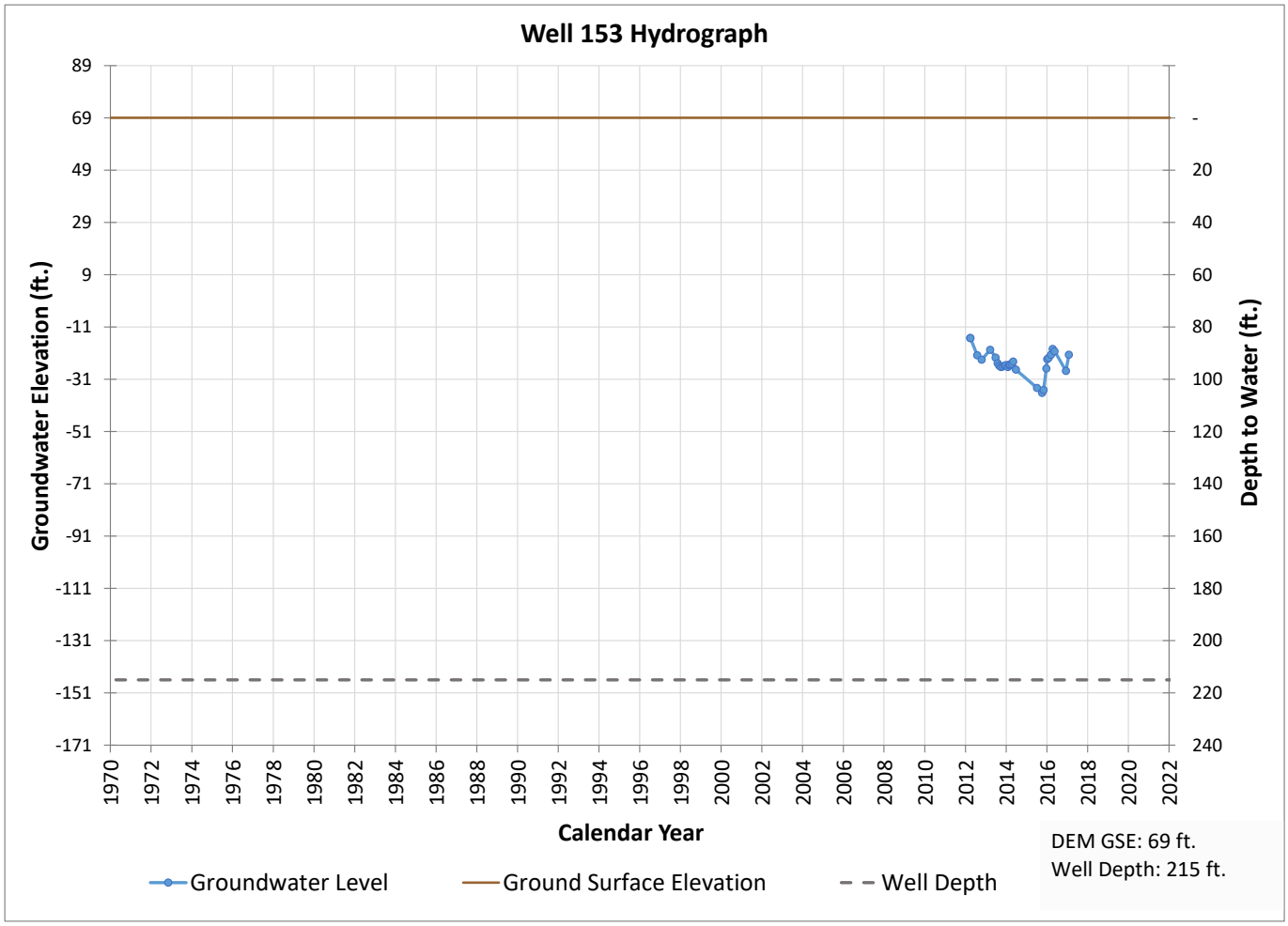

Well 147 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: 314 ft.

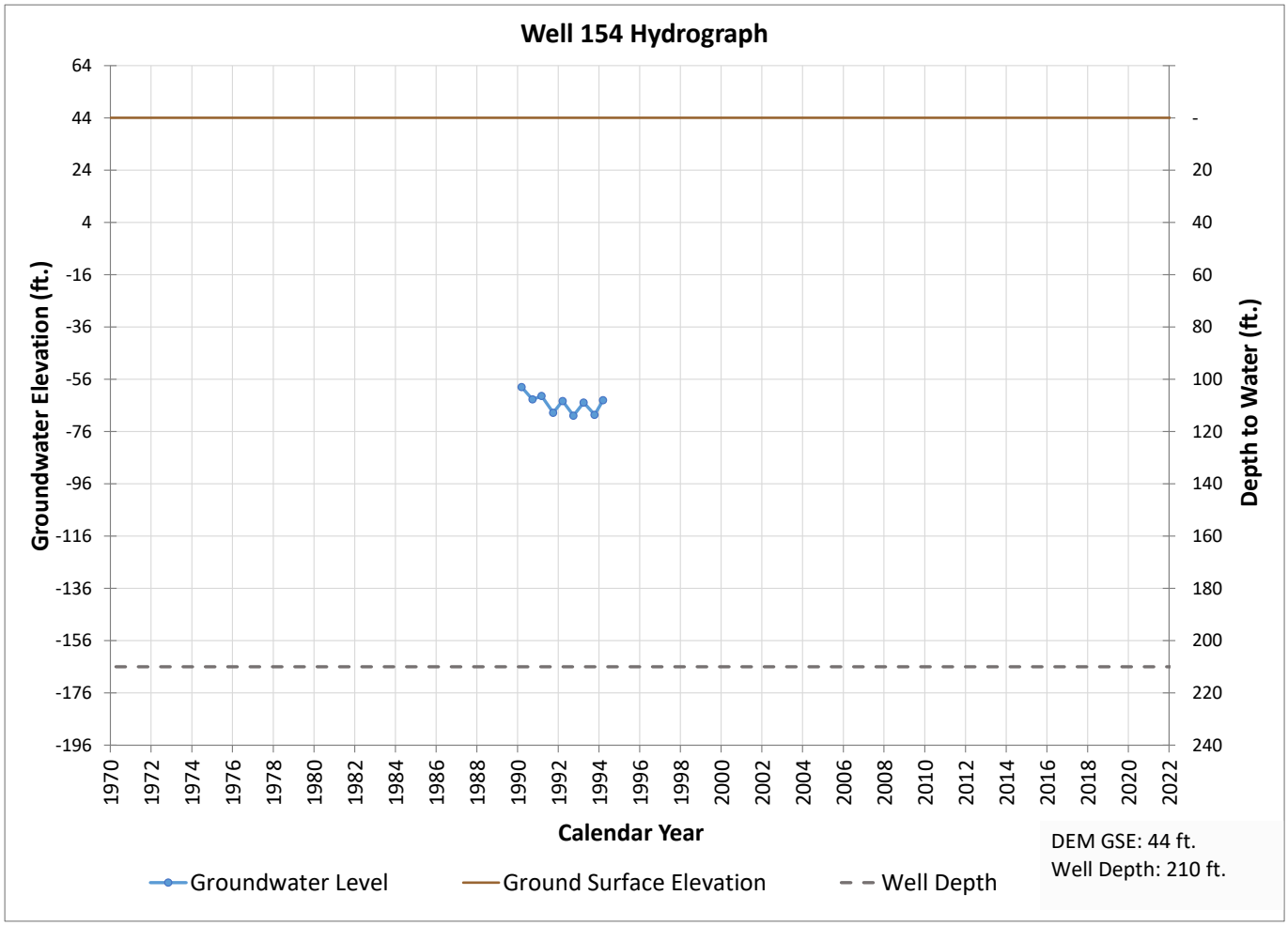

Well 148 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 90 ft.

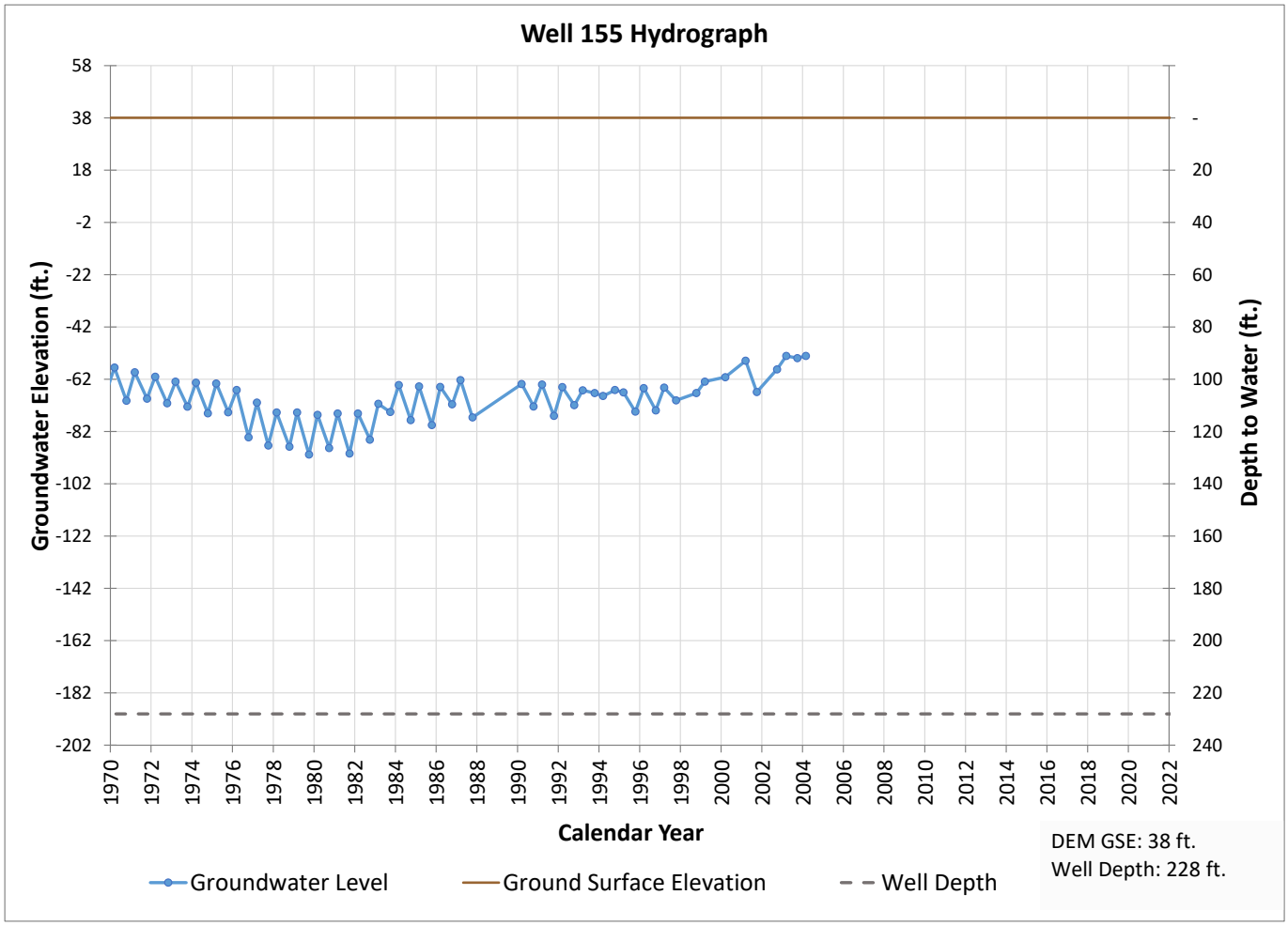

Well 150 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
-216
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 24 ft.
Well Depth: ft.

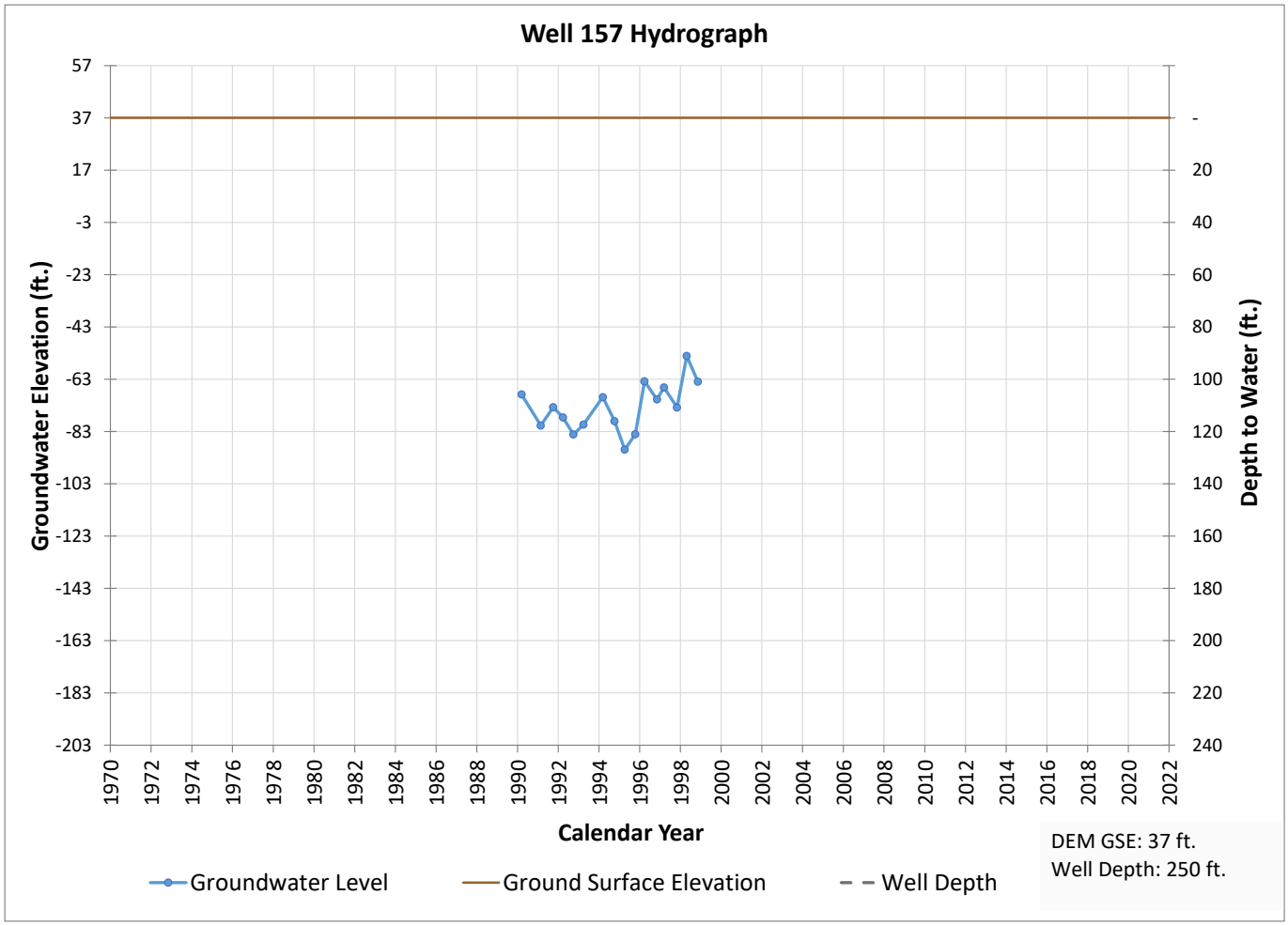

Well 151 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
132
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 112 ft.
Well Depth: 635 ft.

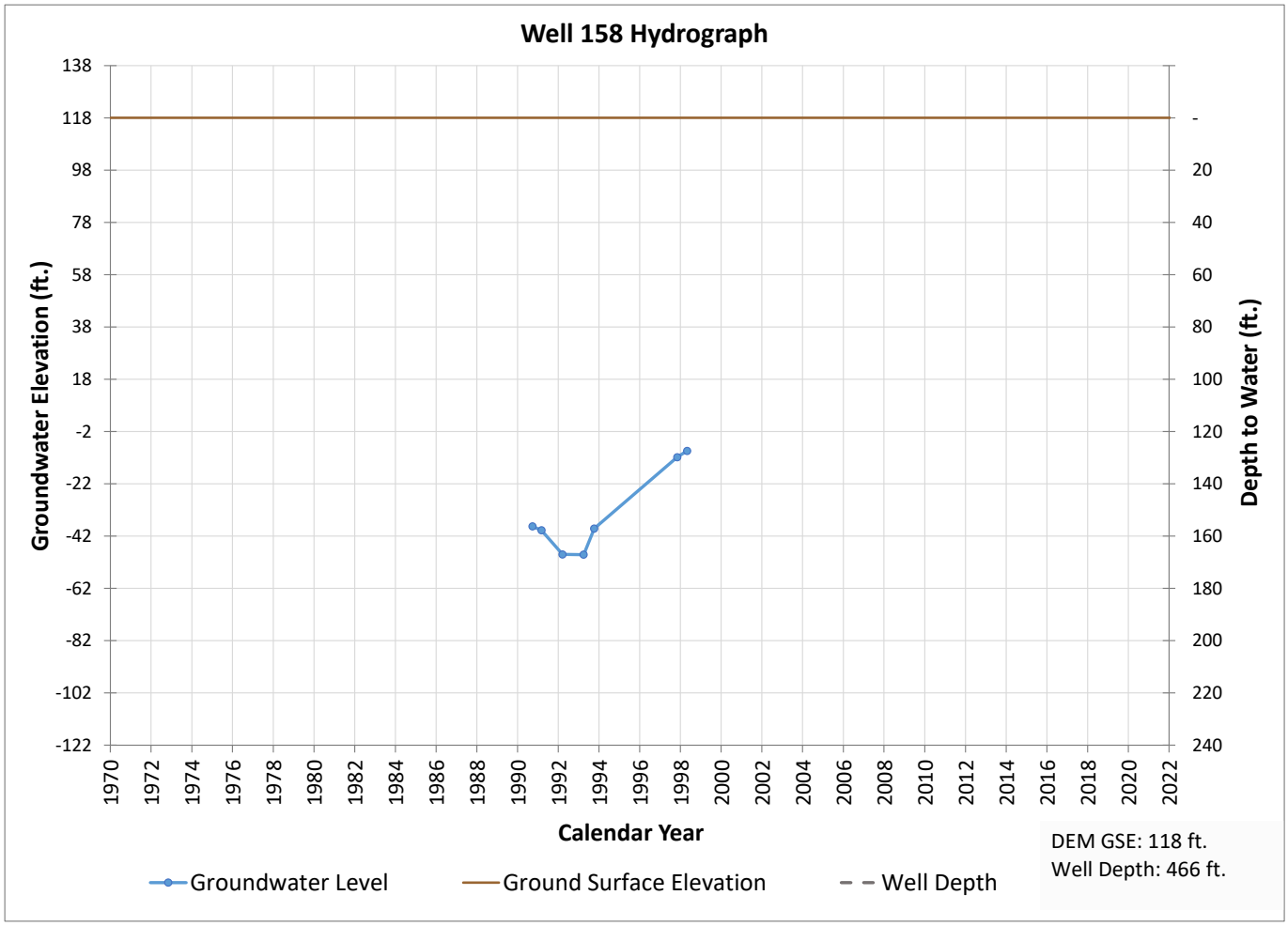

Well 152 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 107 ft.
Well Depth: 332 ft.

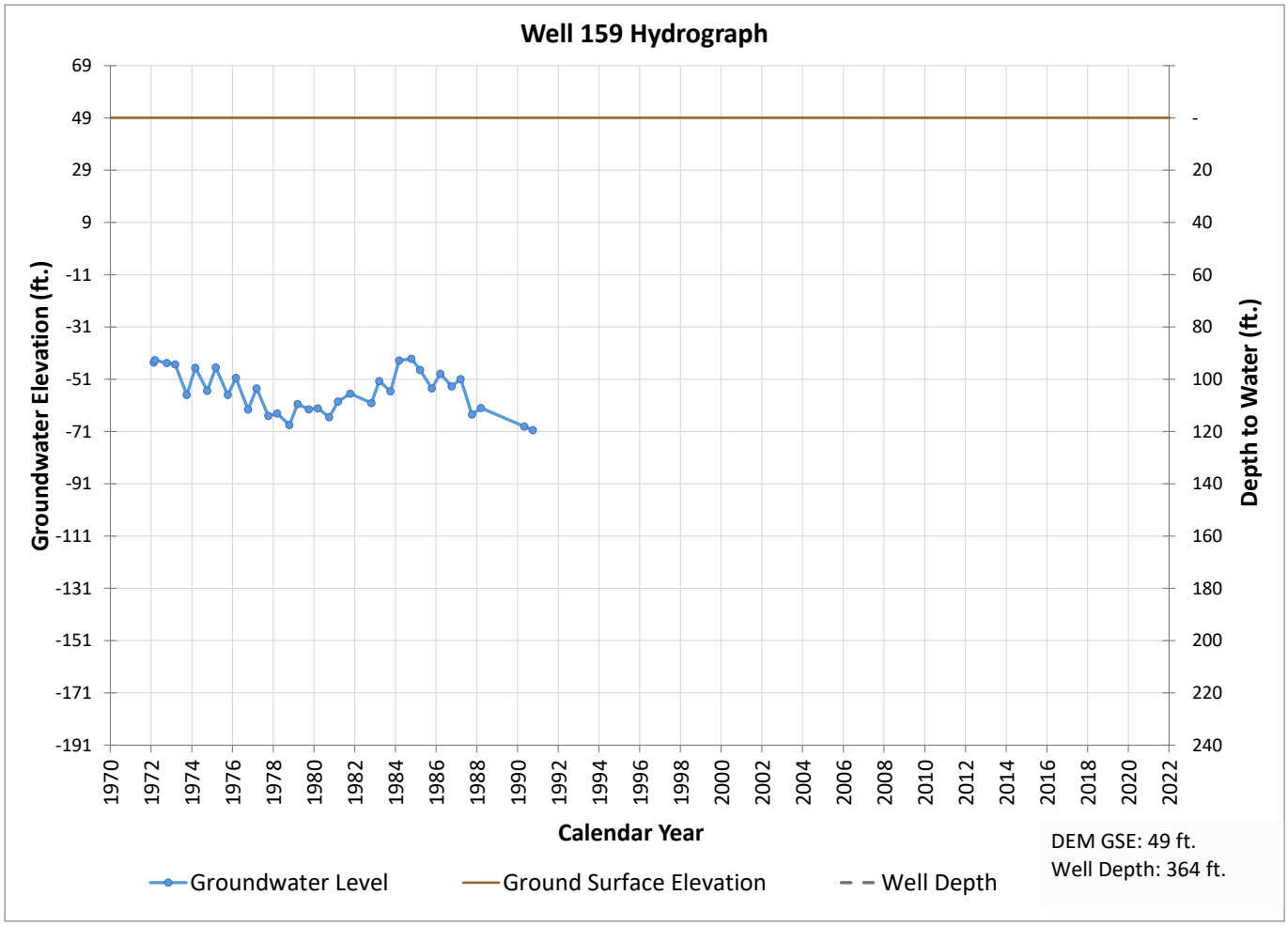

Well 153 Hydrograph
Groundwater Elevation (ft.)
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 69 ft.
Well Depth: 215 ft.

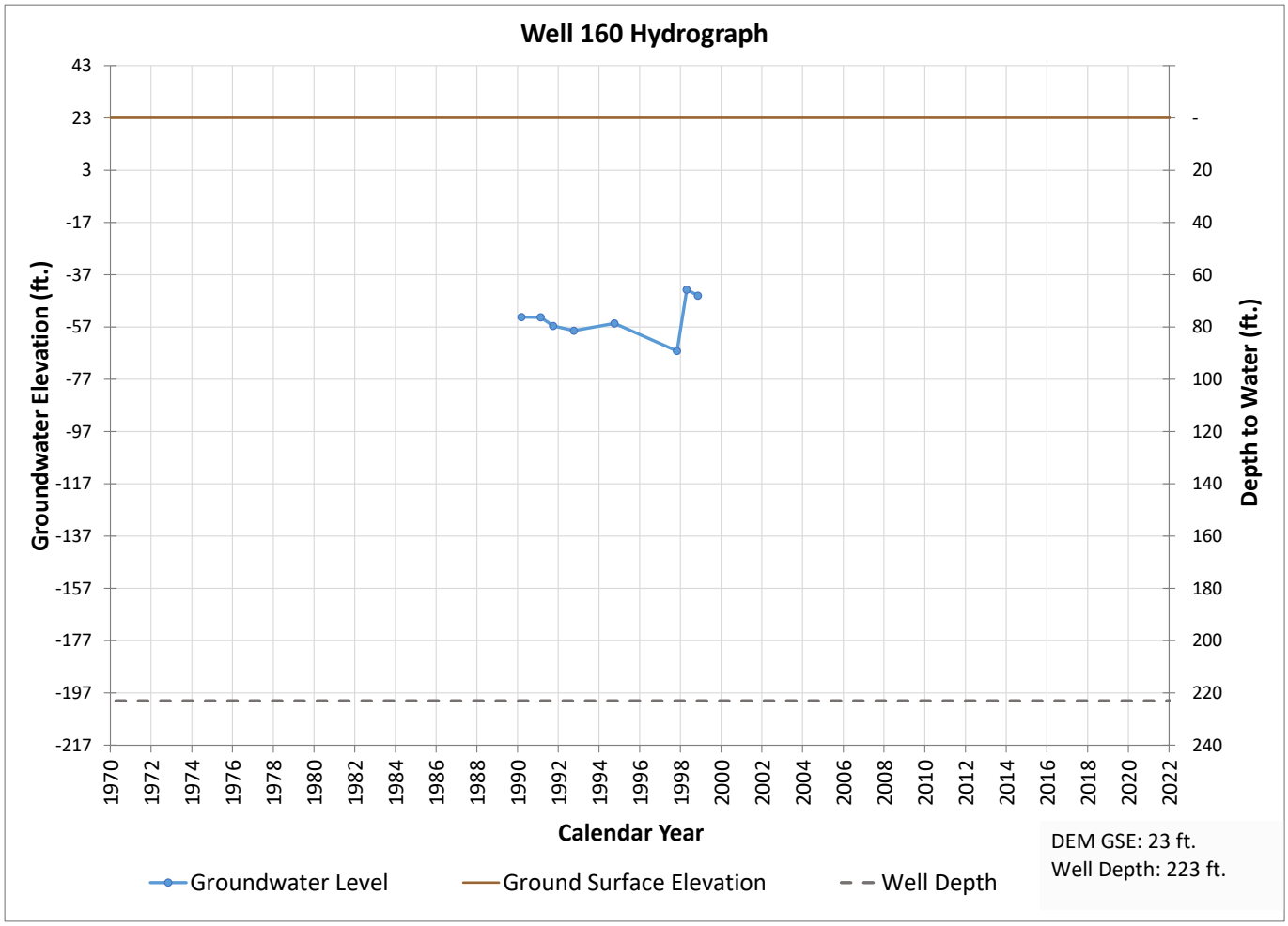

Well 154 Hydrograph
Groundwater Elevation (ft.)
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 44 ft.
Well Depth: 210 ft.

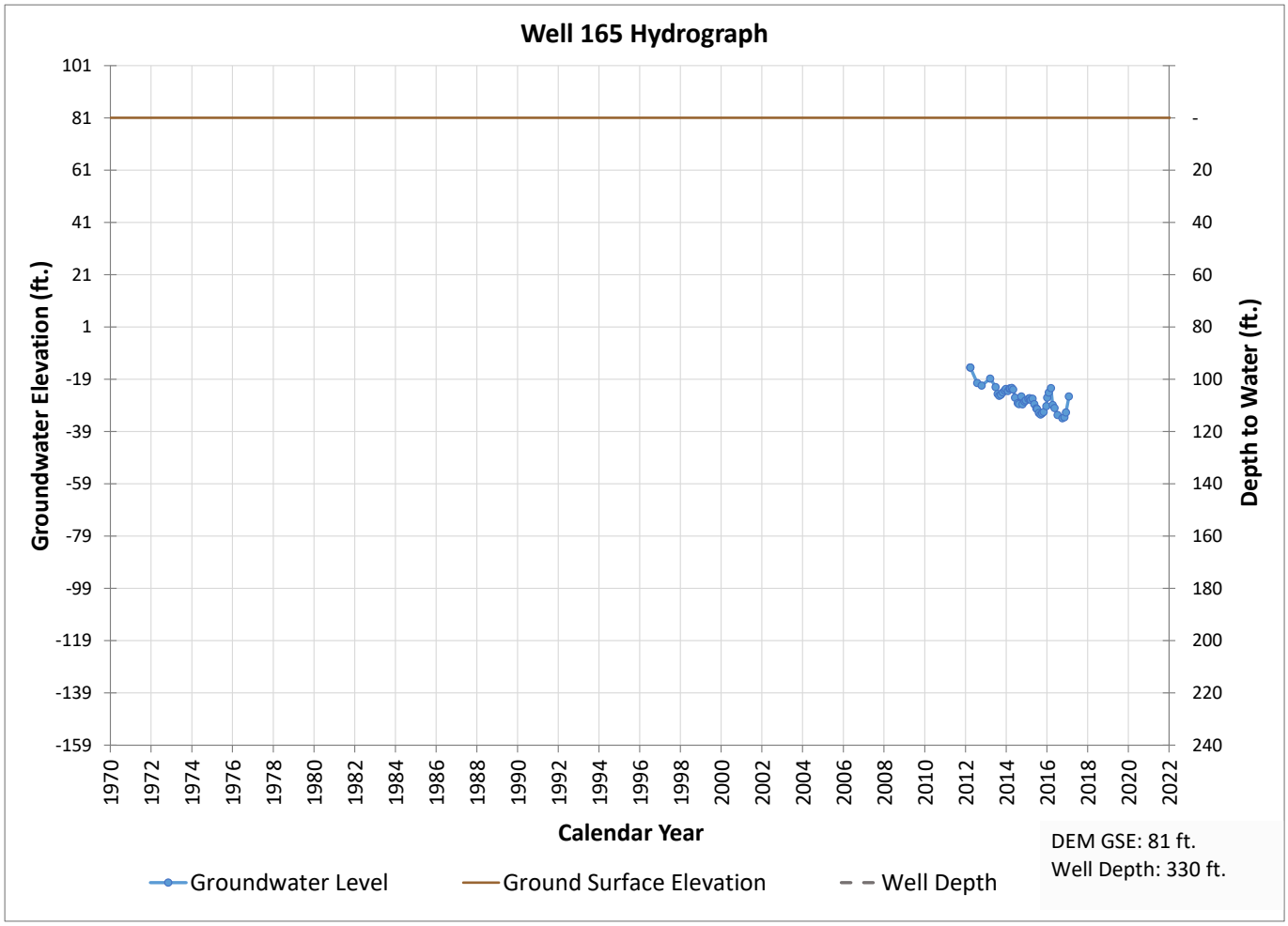

Well 155 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 38 ft.
Well Depth: 228 ft.

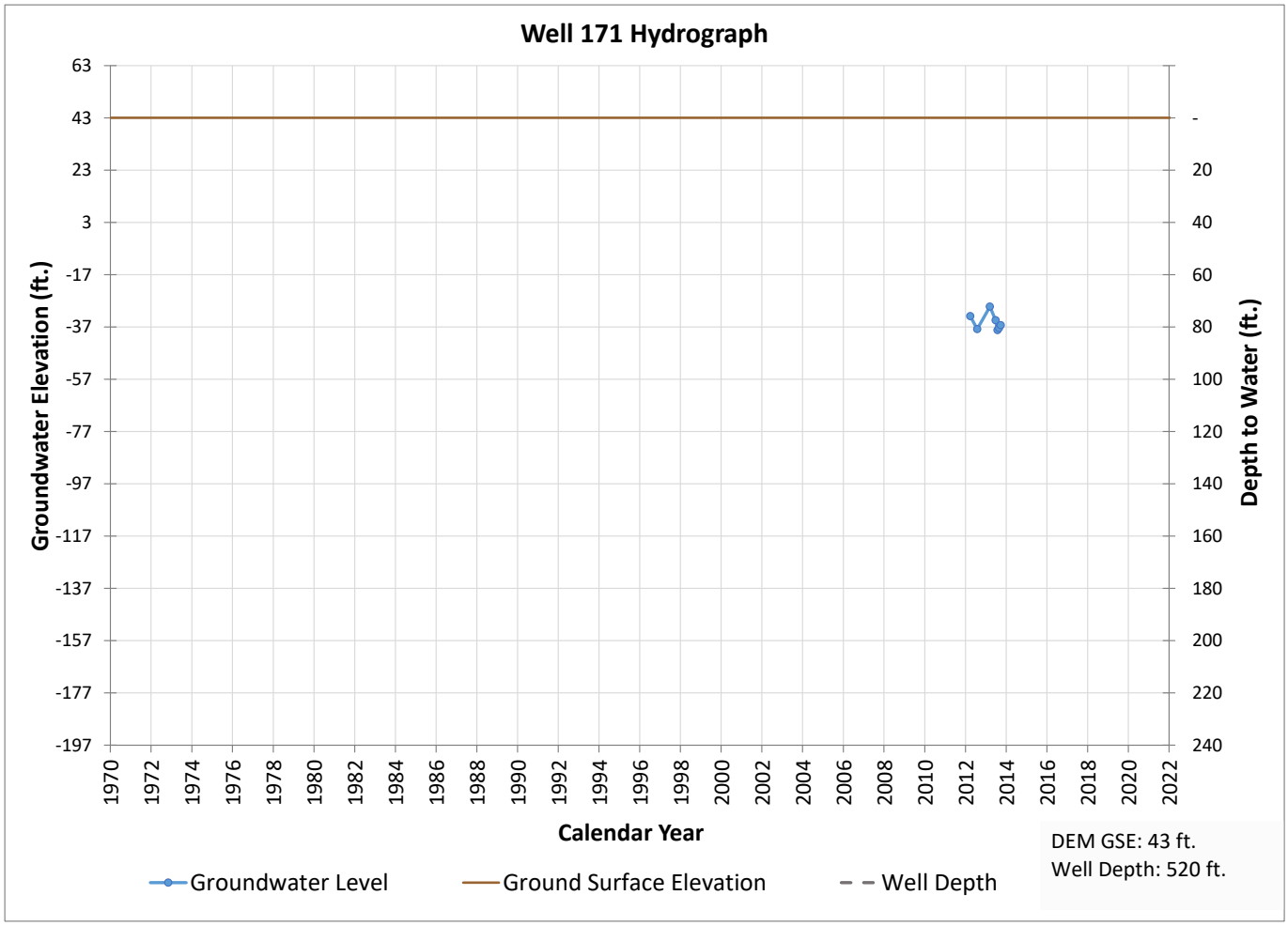

Well 157 Hydrograph
Groundwater Elevation (ft.)
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 37 ft.
Well Depth: 250 ft.

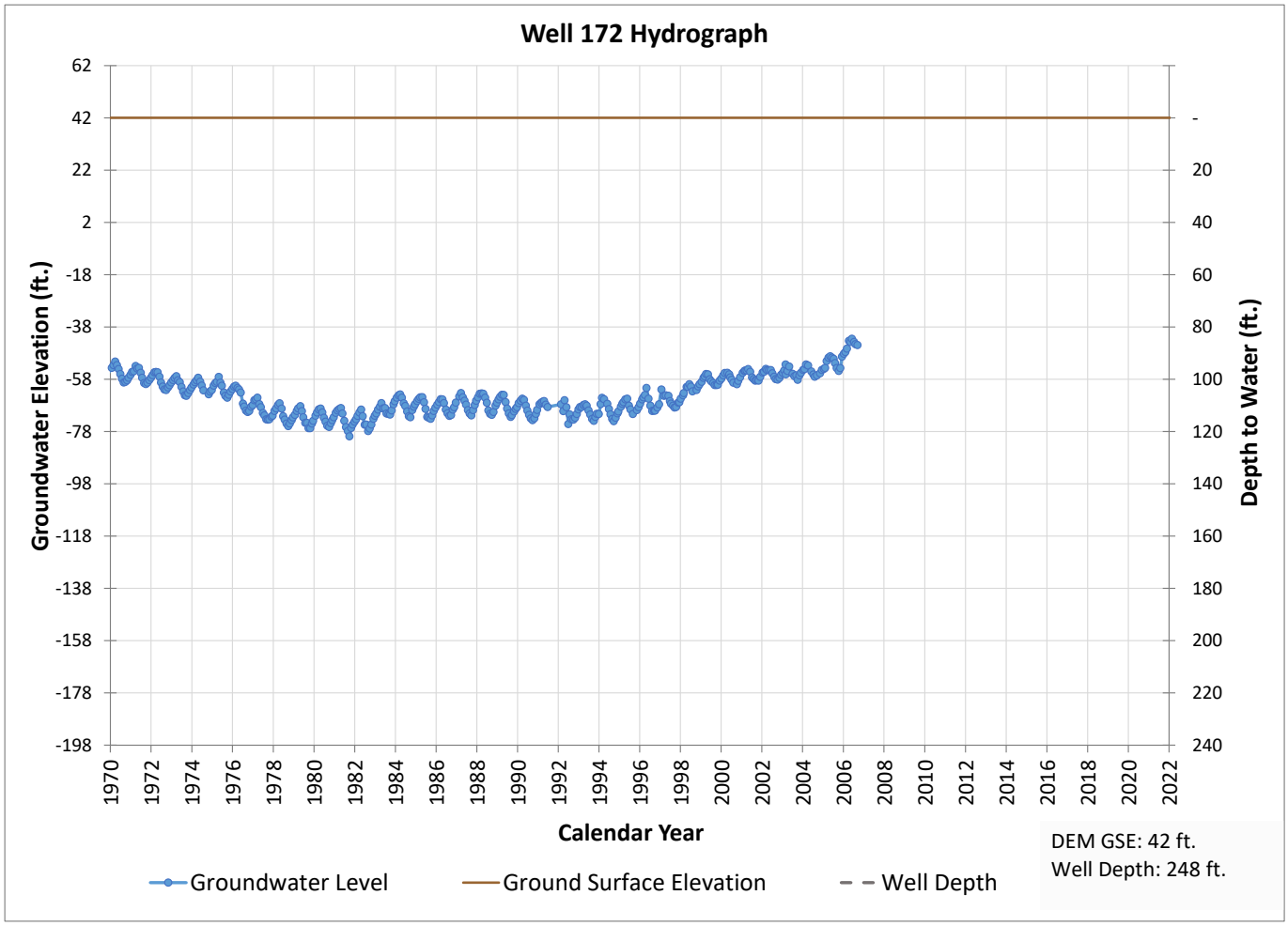

Well 158 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
138
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 118 ft.
Well Depth: 466 ft.

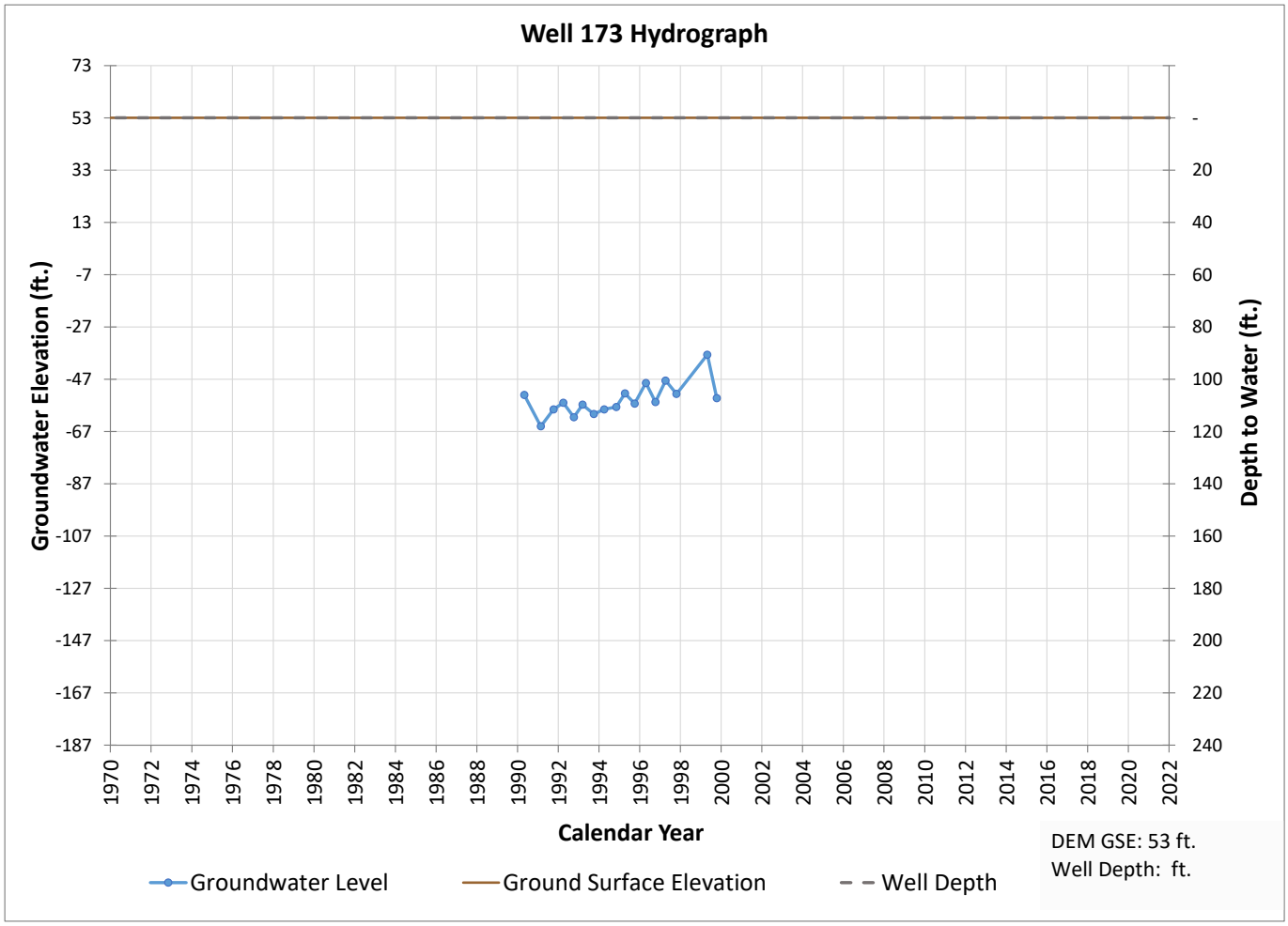

Well 159 Hydrograph
Groundwater Elevation (ft.)
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: 364 ft.

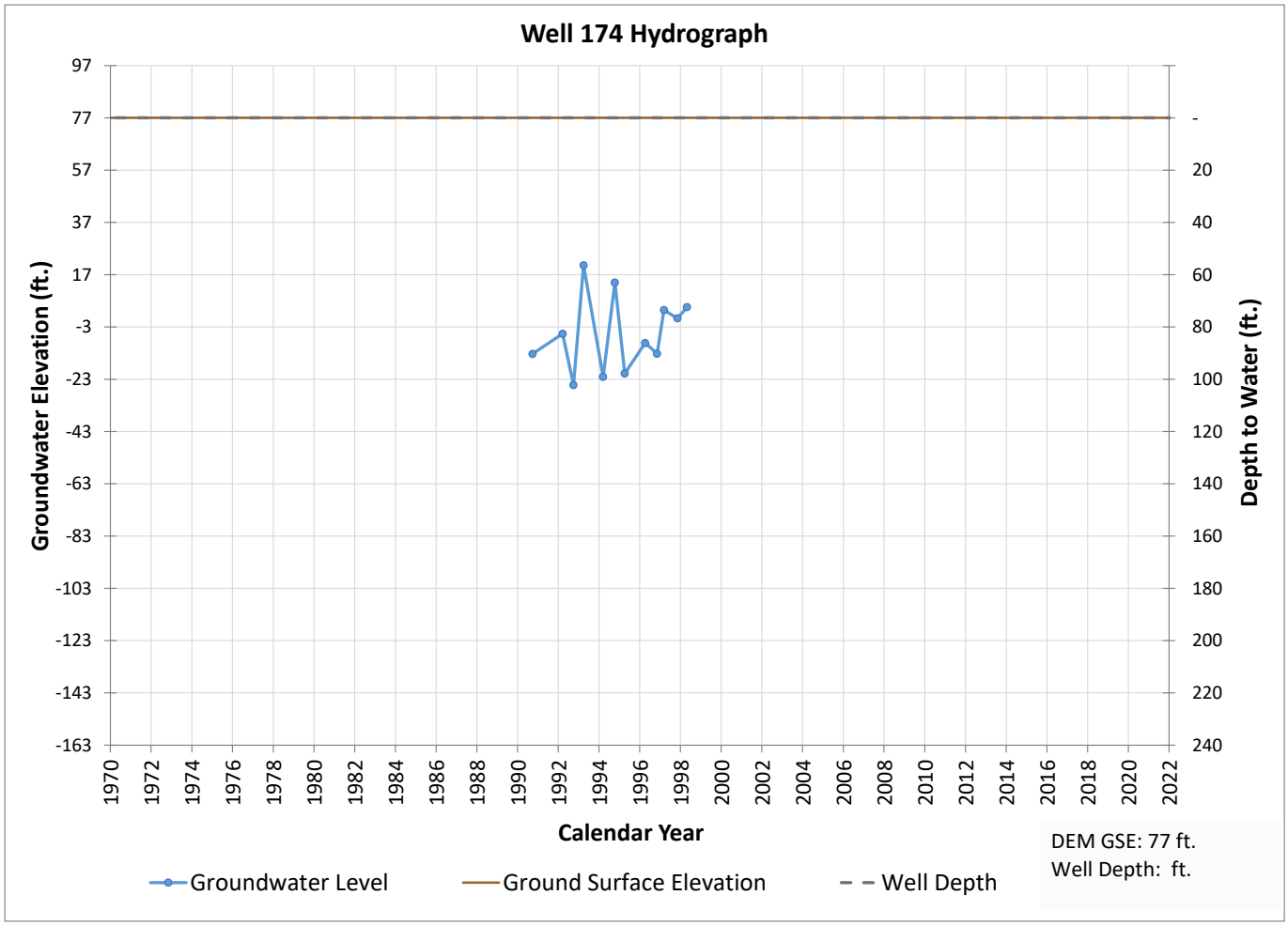

Well 160 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: 223 ft.

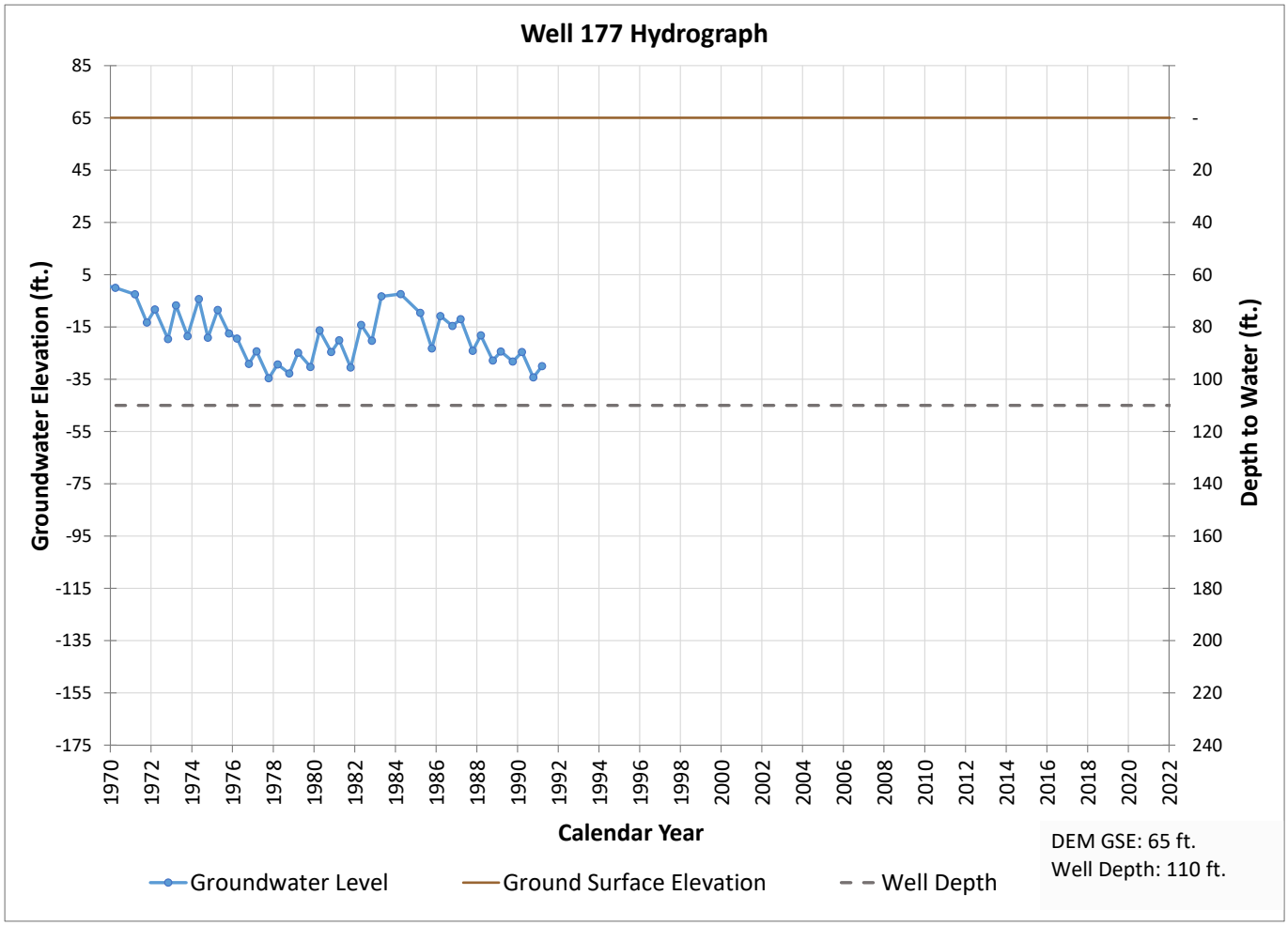

Well 165 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
101
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 81 ft.
Well Depth: 330 ft.

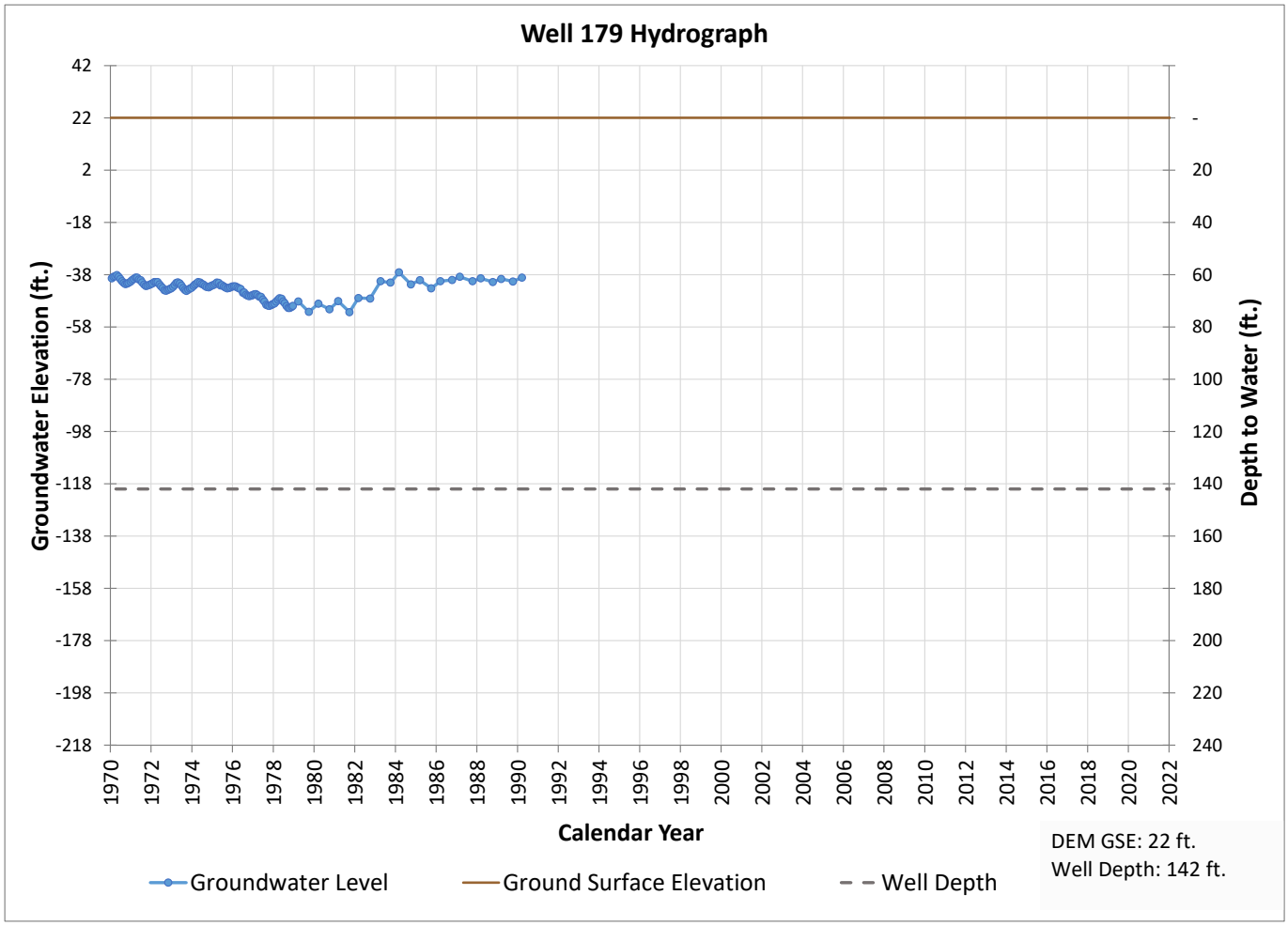

Well 171 Hydrograph
Groundwater Elevation (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: 520 ft.

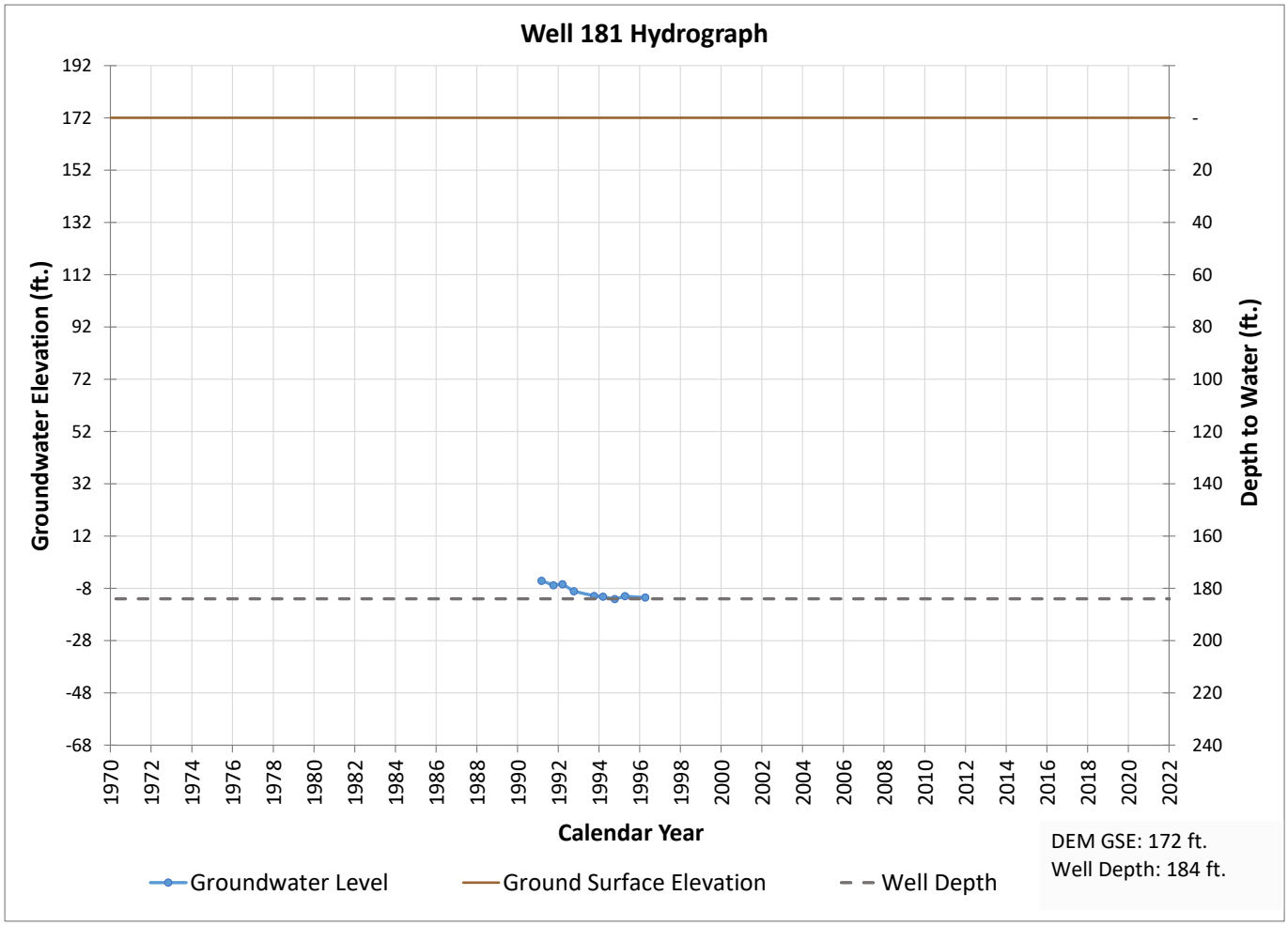

Well 172 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: 248 ft.

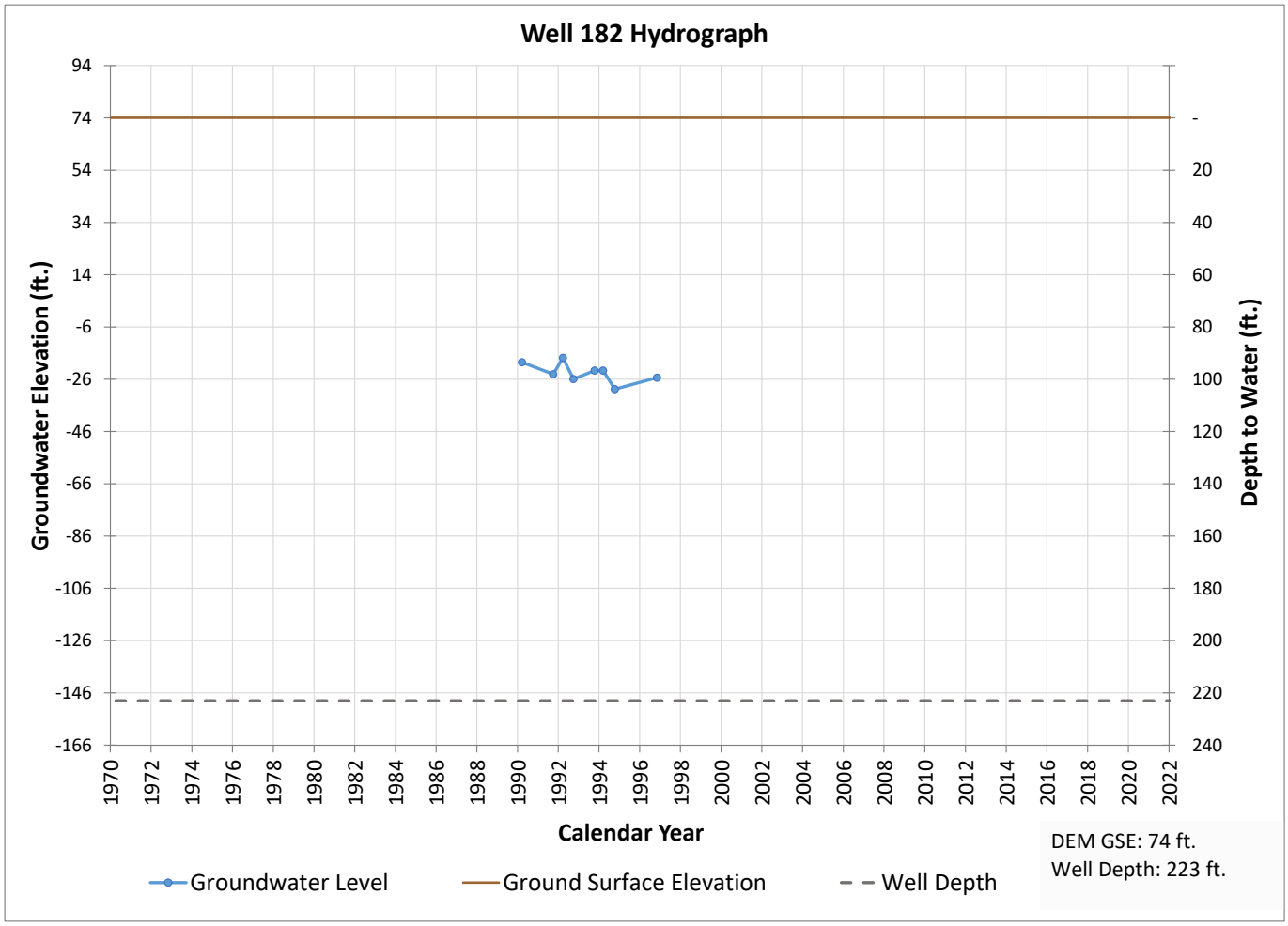

Well 173 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 53 ft.
Well Depth: ft.

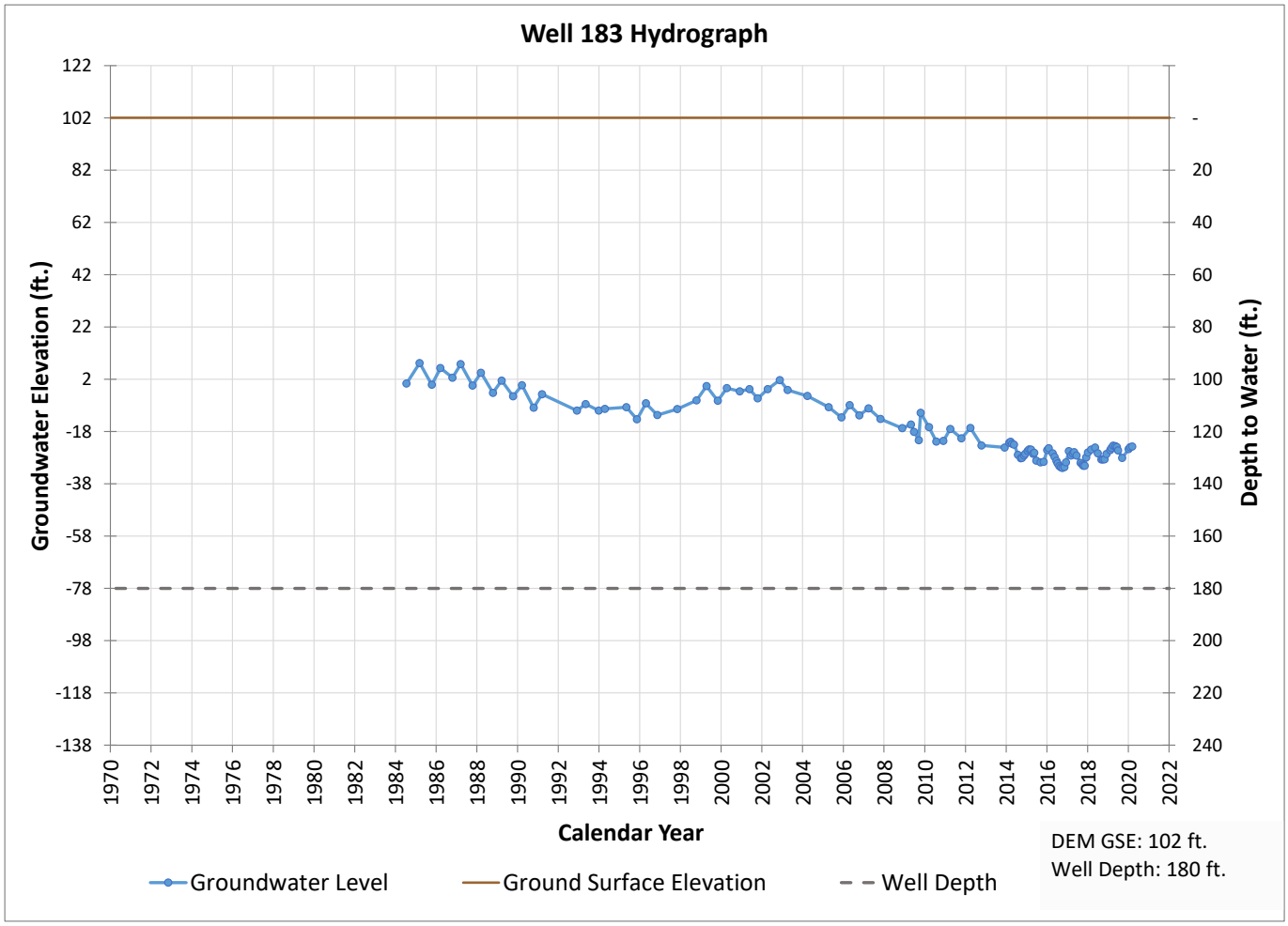

Well 174 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: ft.

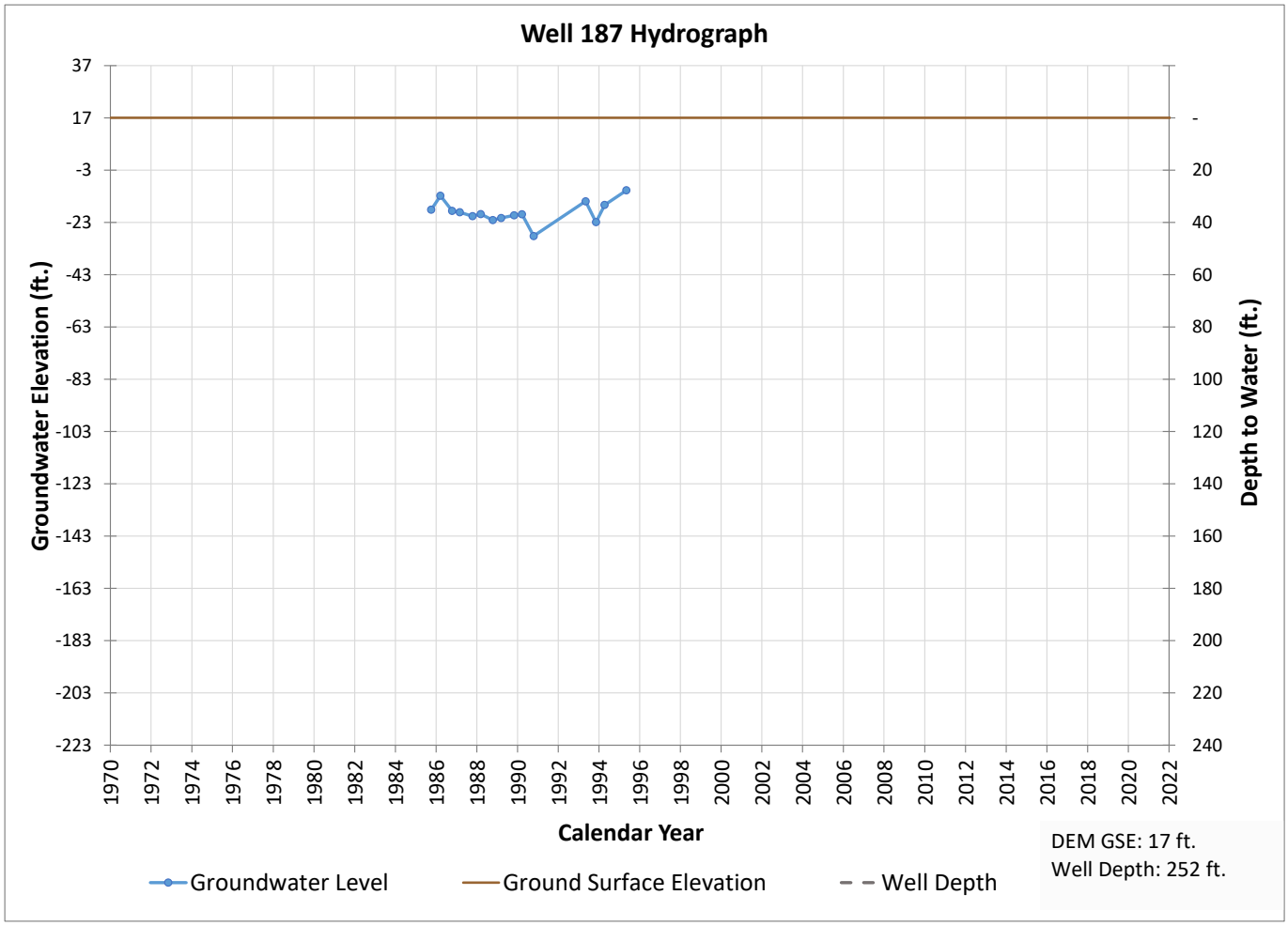

Well 177 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 65 ft.
Well Depth: 110 ft.

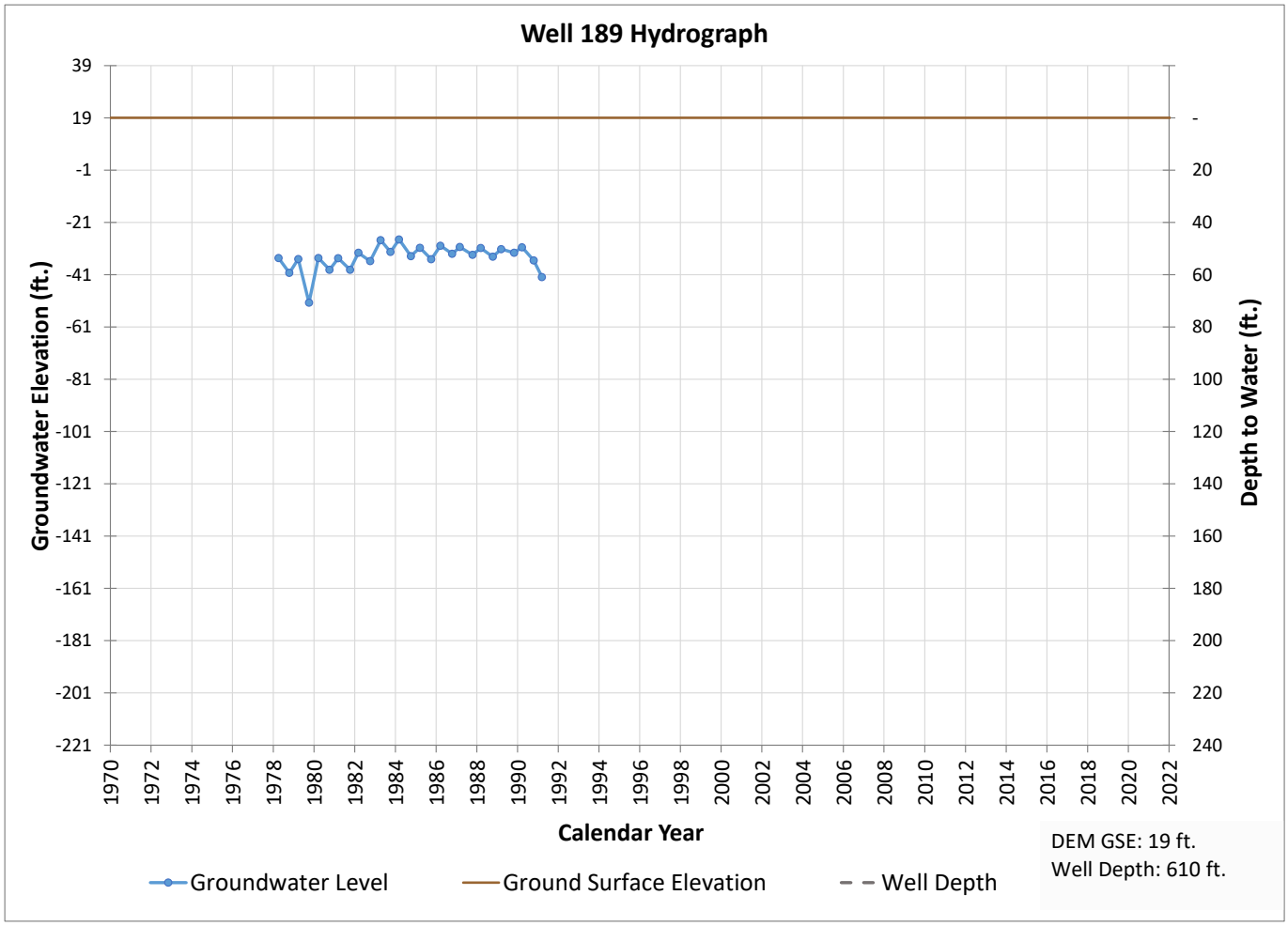

Well 179 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: 142 ft.

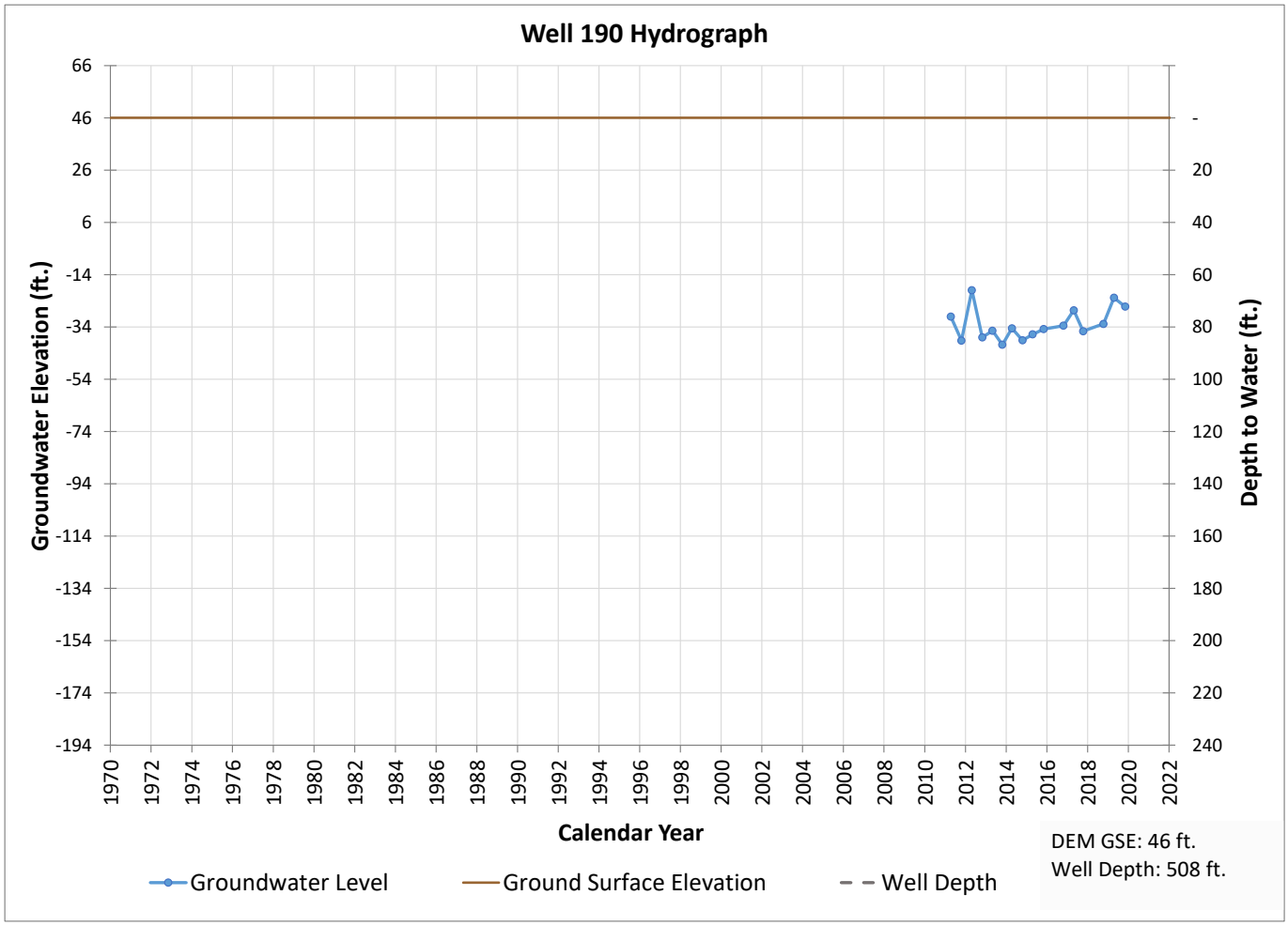

Well 181 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
192
172
152
132
112
92
72
52
32
12
-8
-28
-48
-68
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 172 ft.
Well Depth: 184 ft.

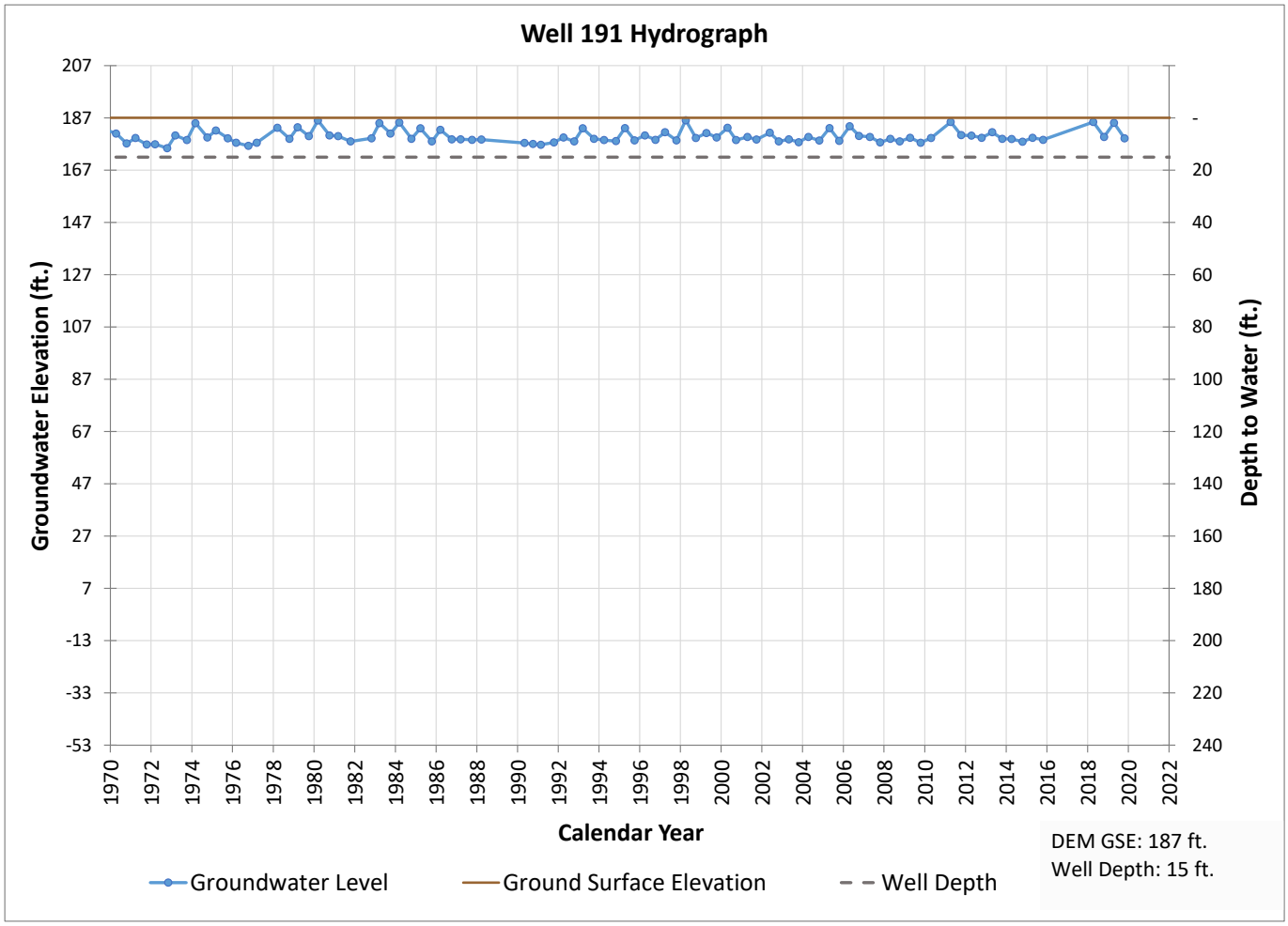

Well 182 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 74 ft.
Well Depth: 223 ft.

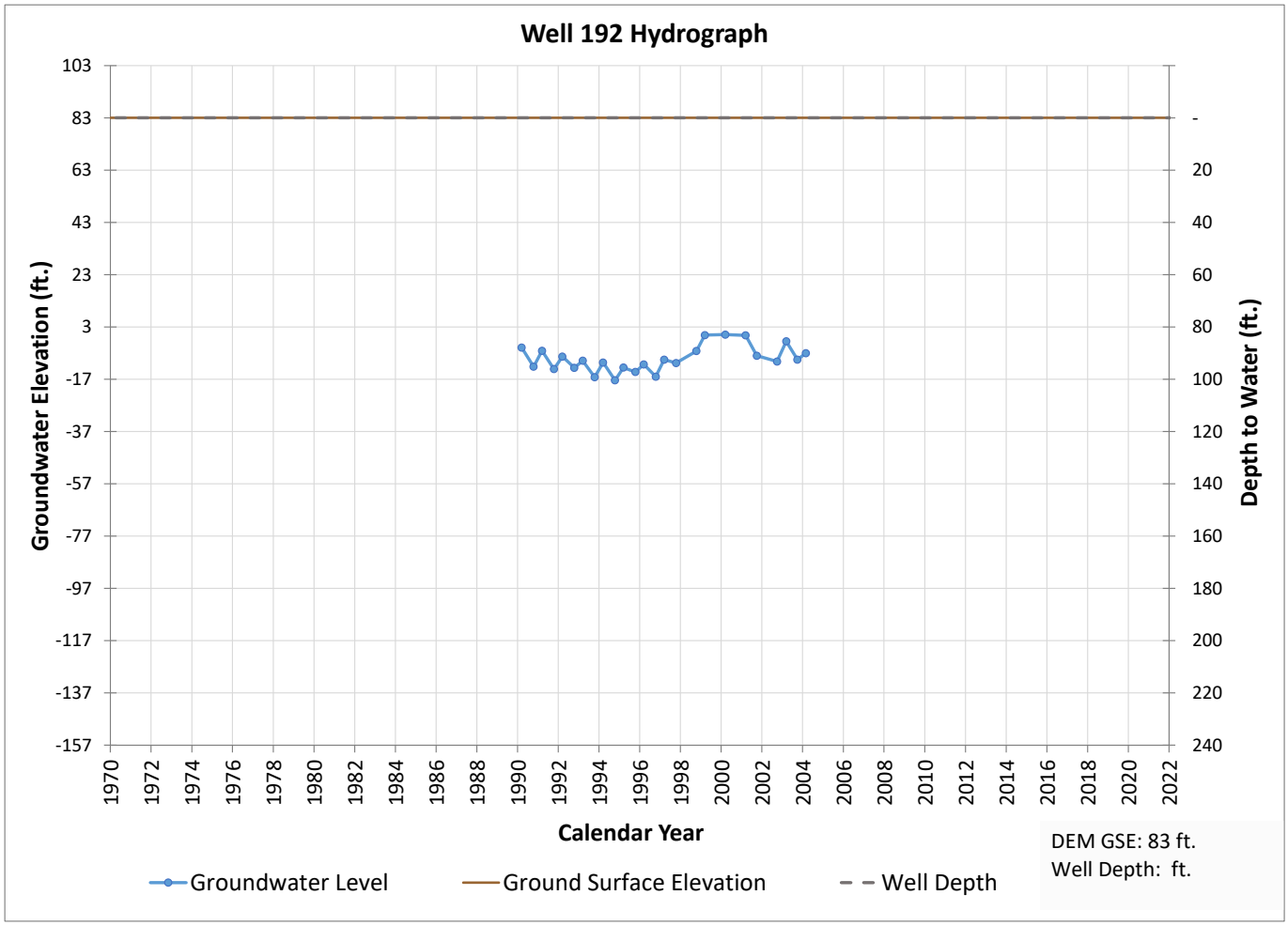

Well 183 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: 180 ft.

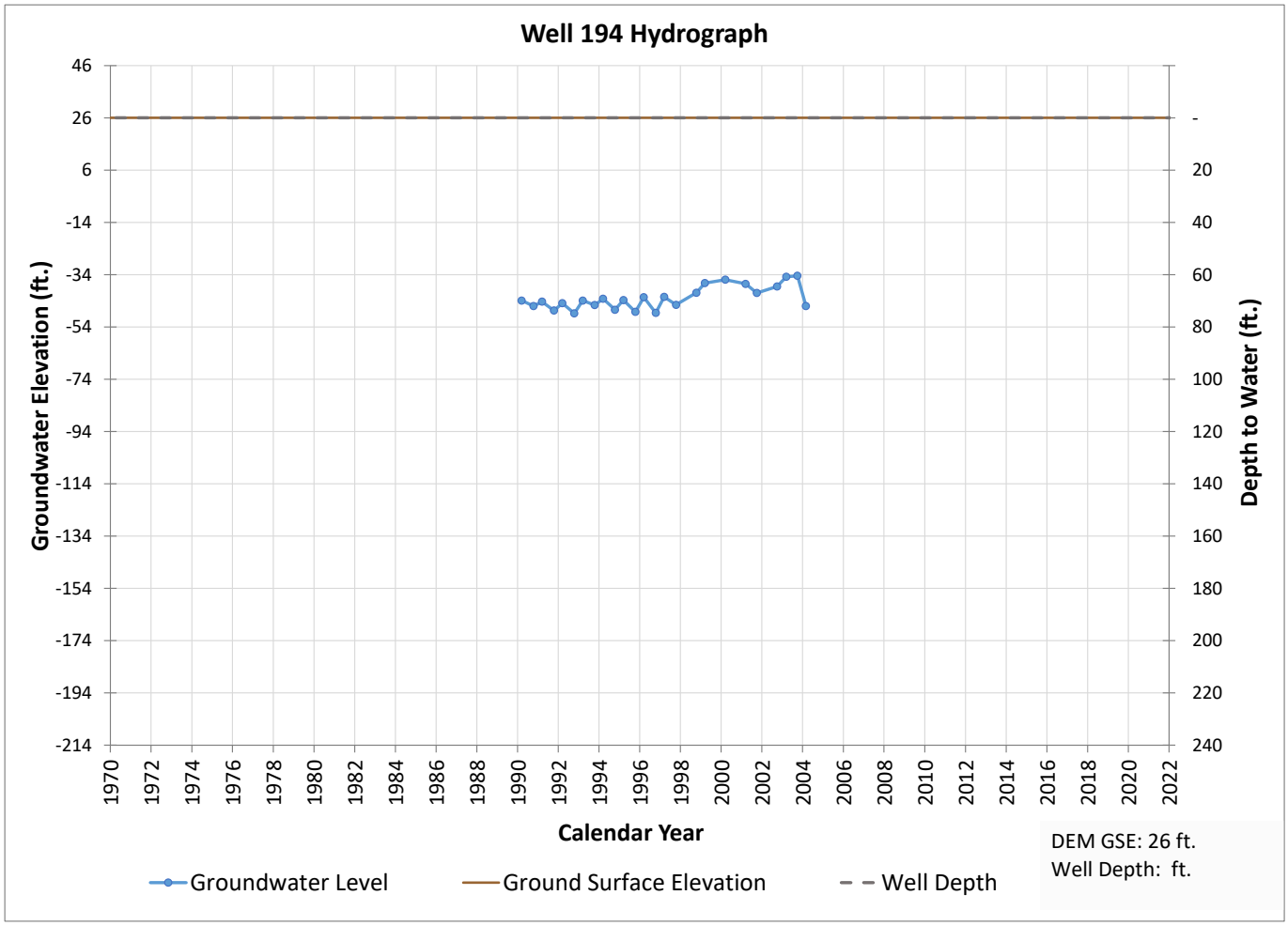

Well 187 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
-223
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 17 ft.
Well Depth: 252 ft.

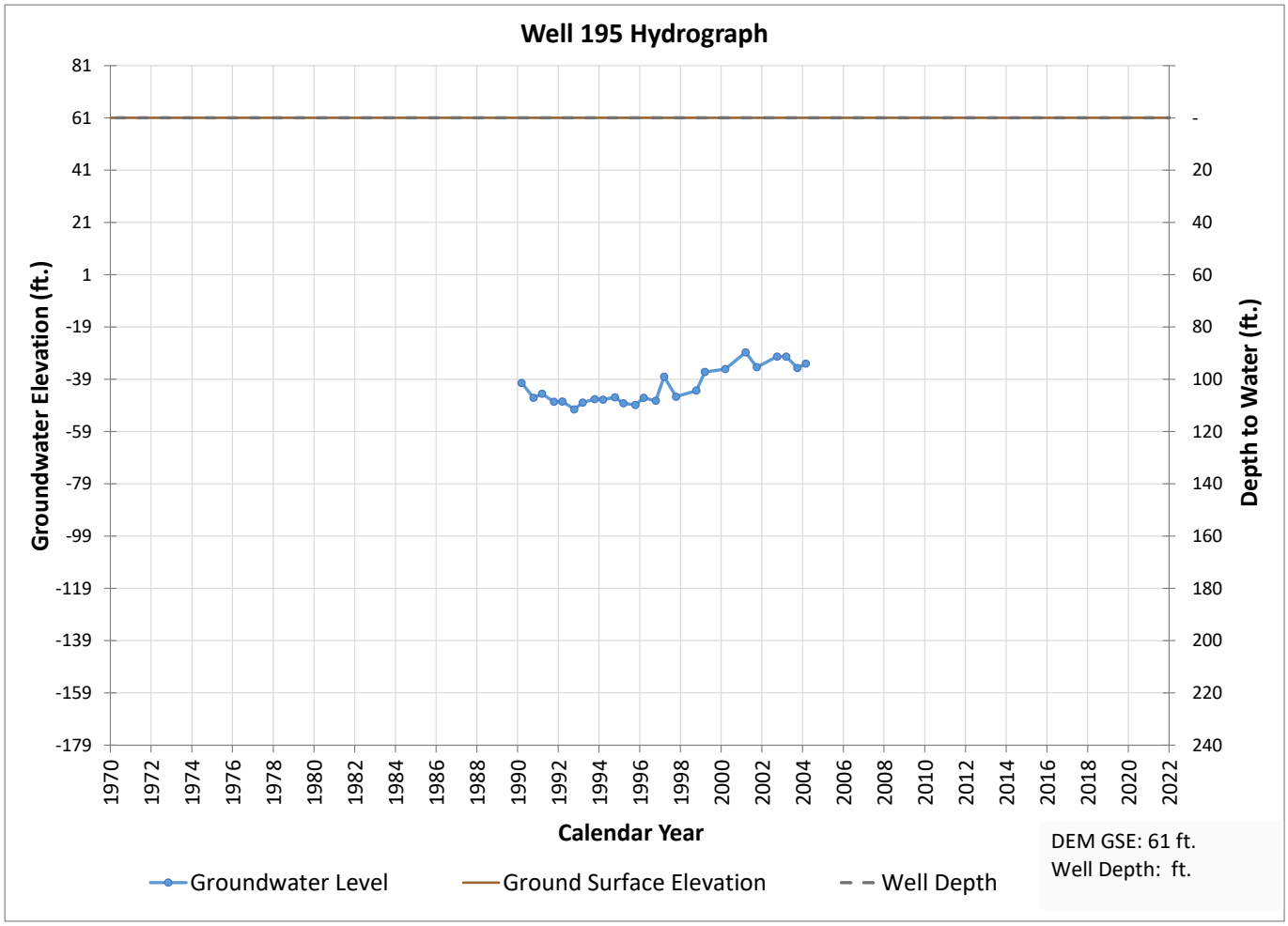

Well 189 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-201
-221
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 19 ft.
Well Depth: 610 ft.

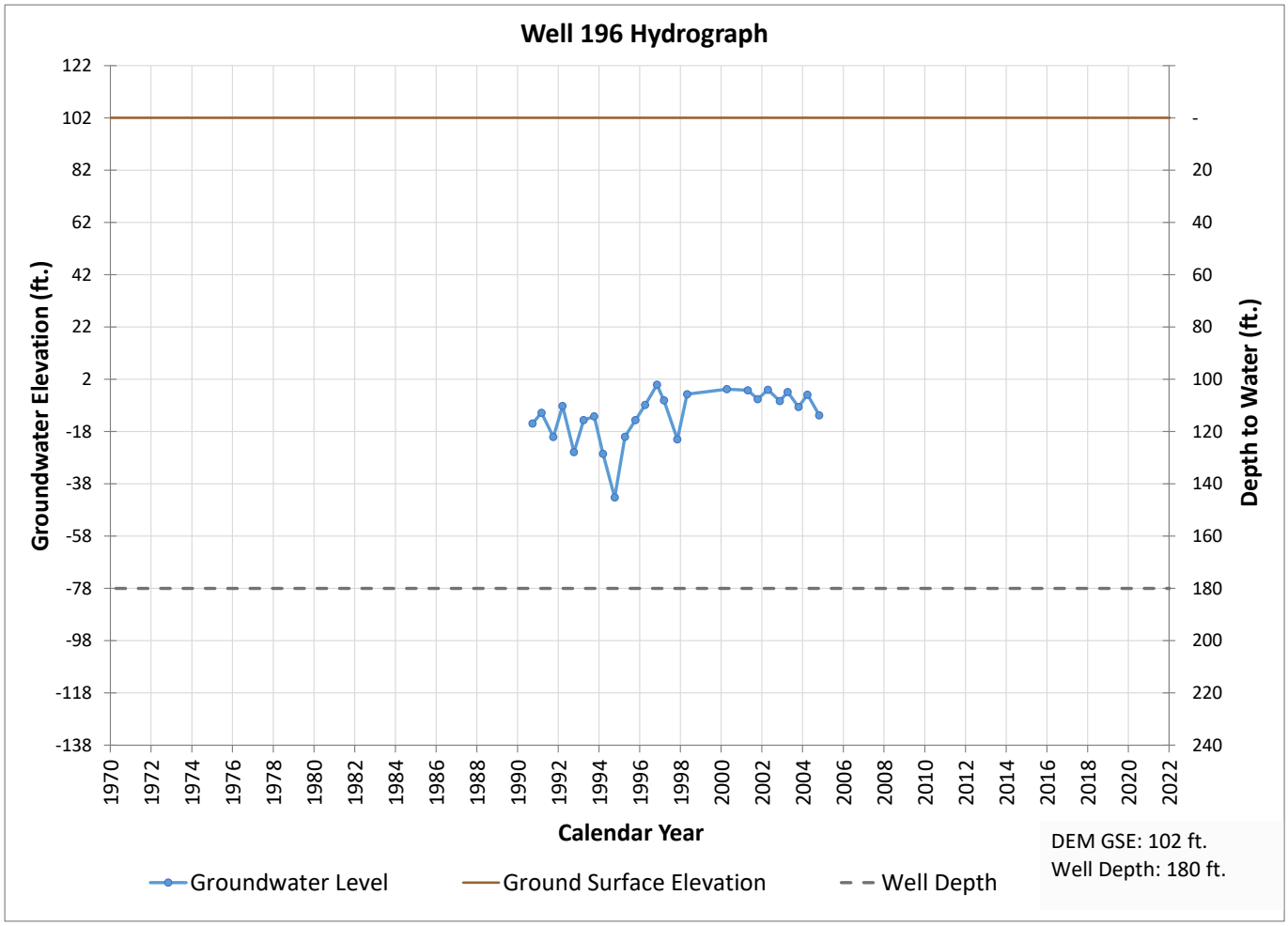

Well 190 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: 508 ft.

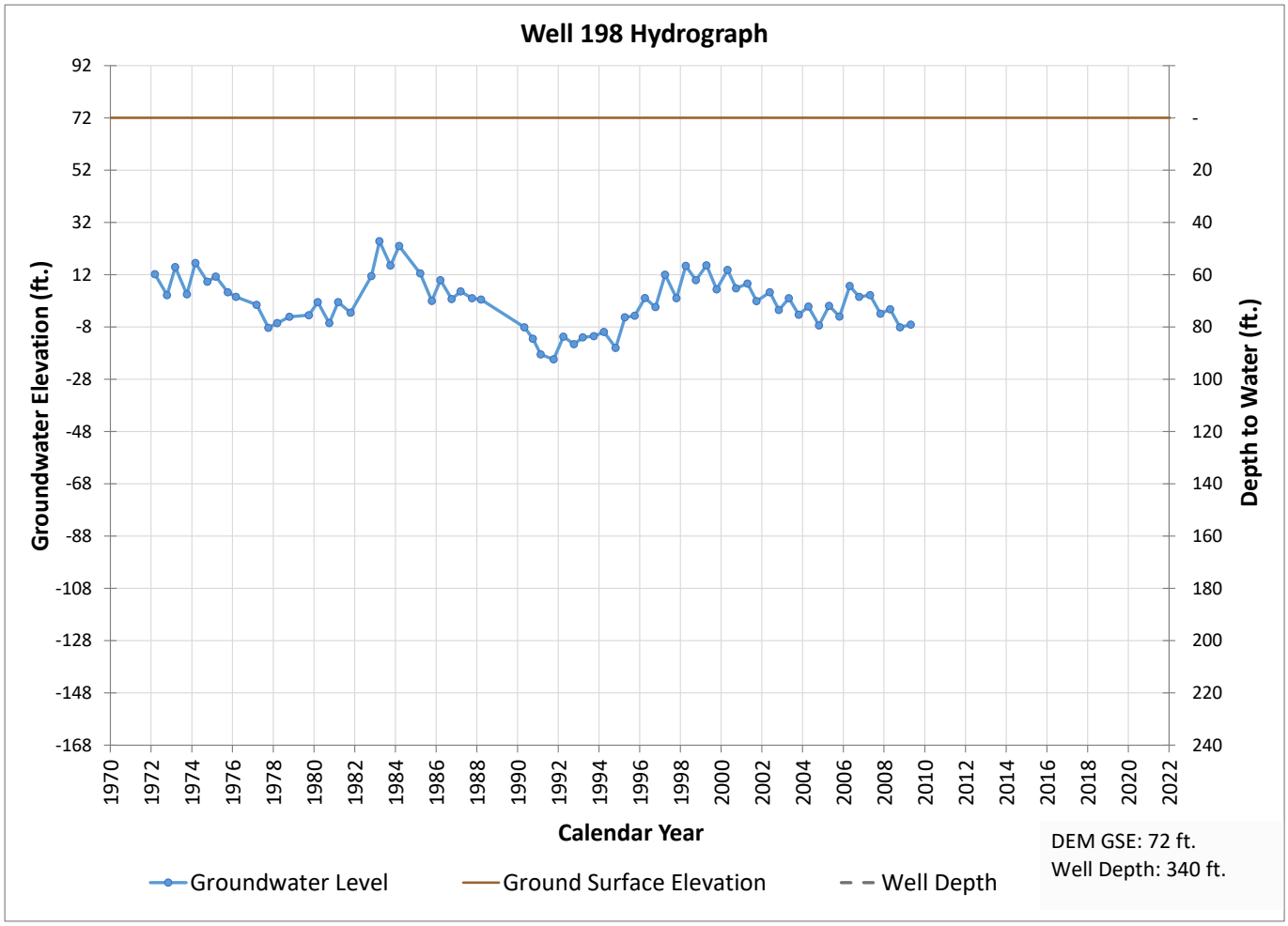

Well 191 Hydrograph
Groundwater Elevation (ft.)
207
187
167
147
127
107
87
67
47
27
7
-13
-33
-53
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 187 ft.
Well Depth: 15 ft.

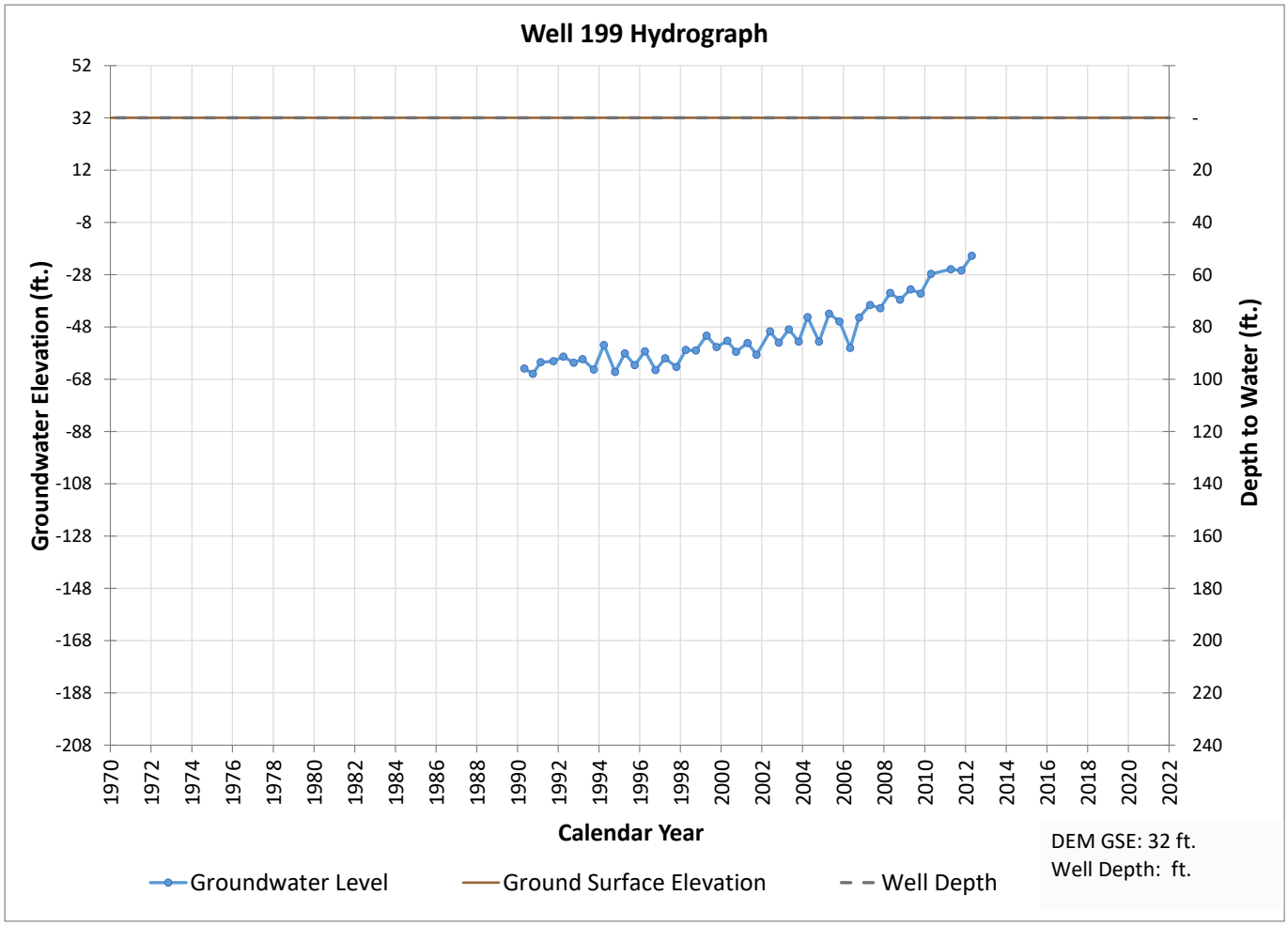

Well 192 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
103
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 83 ft.
Well Depth: ft.

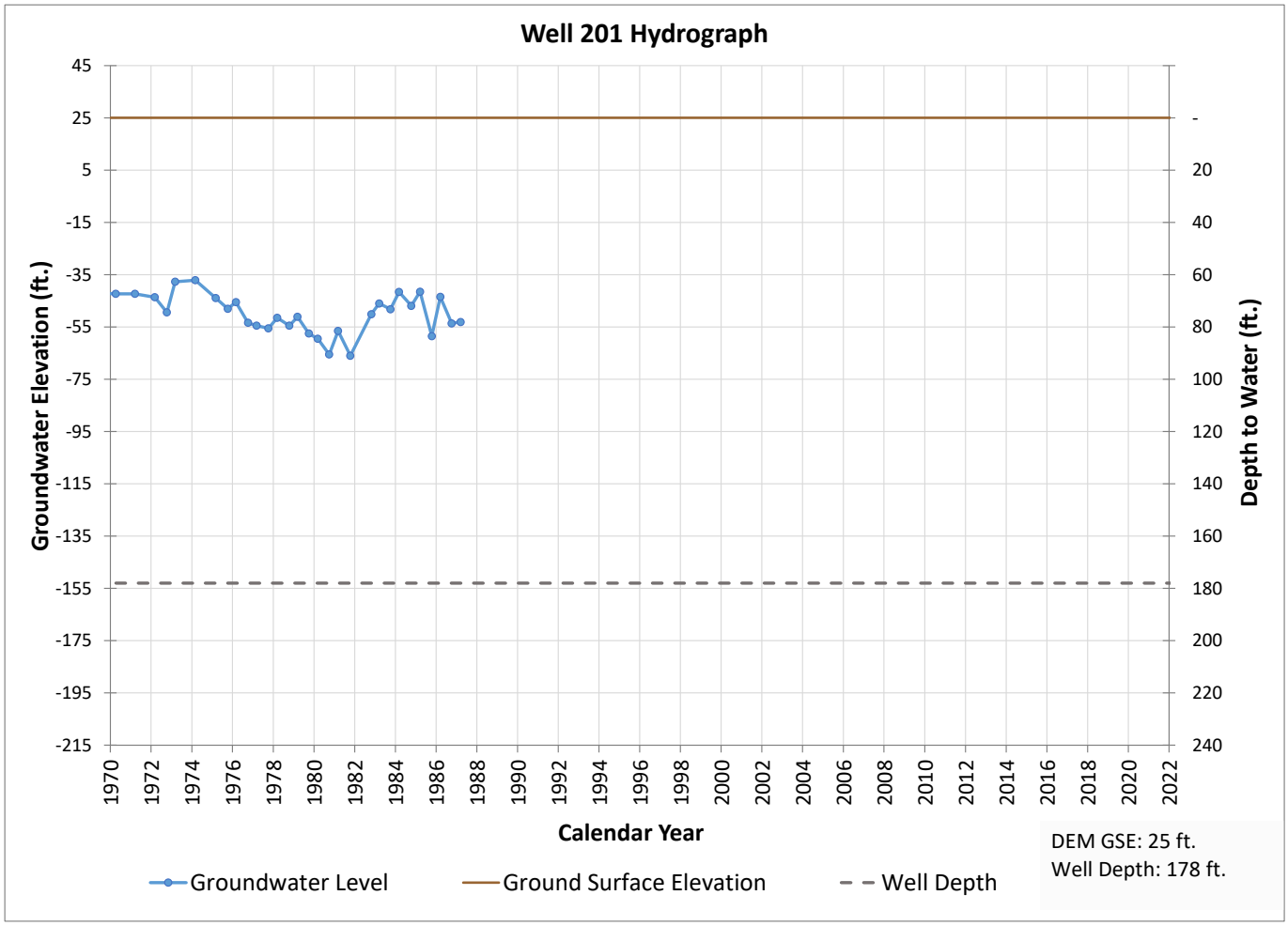

Well 194 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
-214
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 26 ft.
Well Depth: ft.

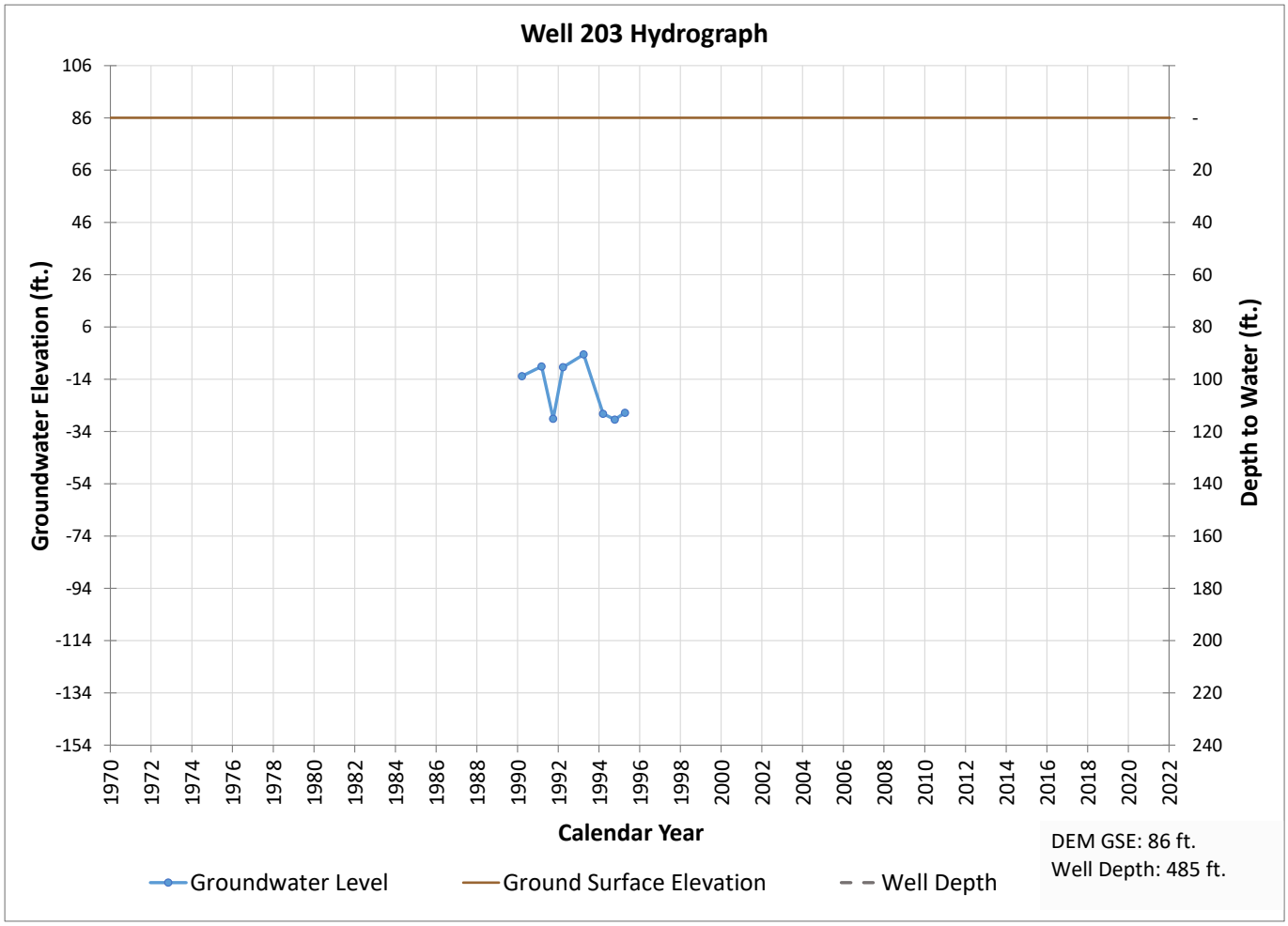

Well 195 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 61 ft.
Well Depth: ft.

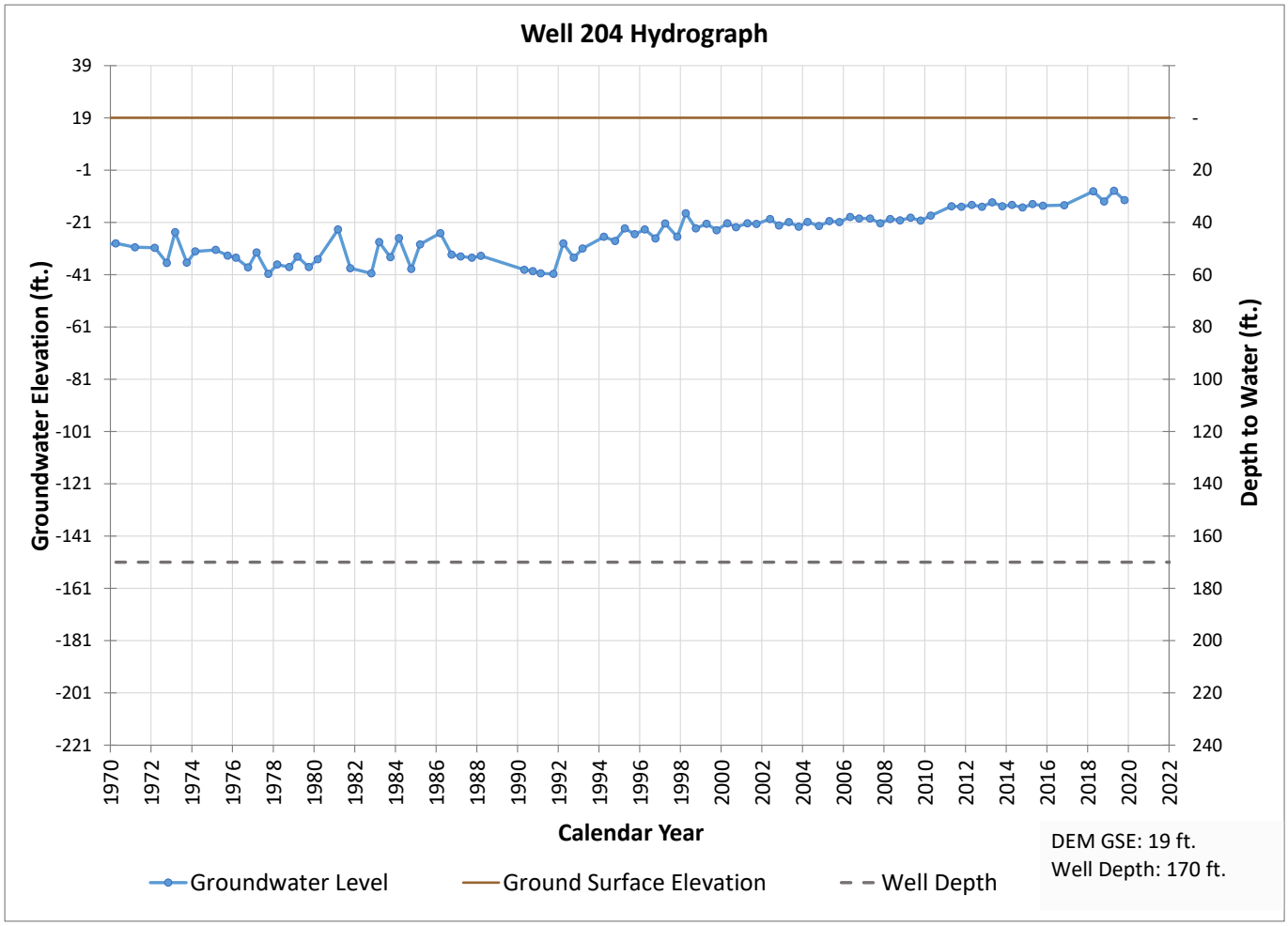

Well 196 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: 180 ft.

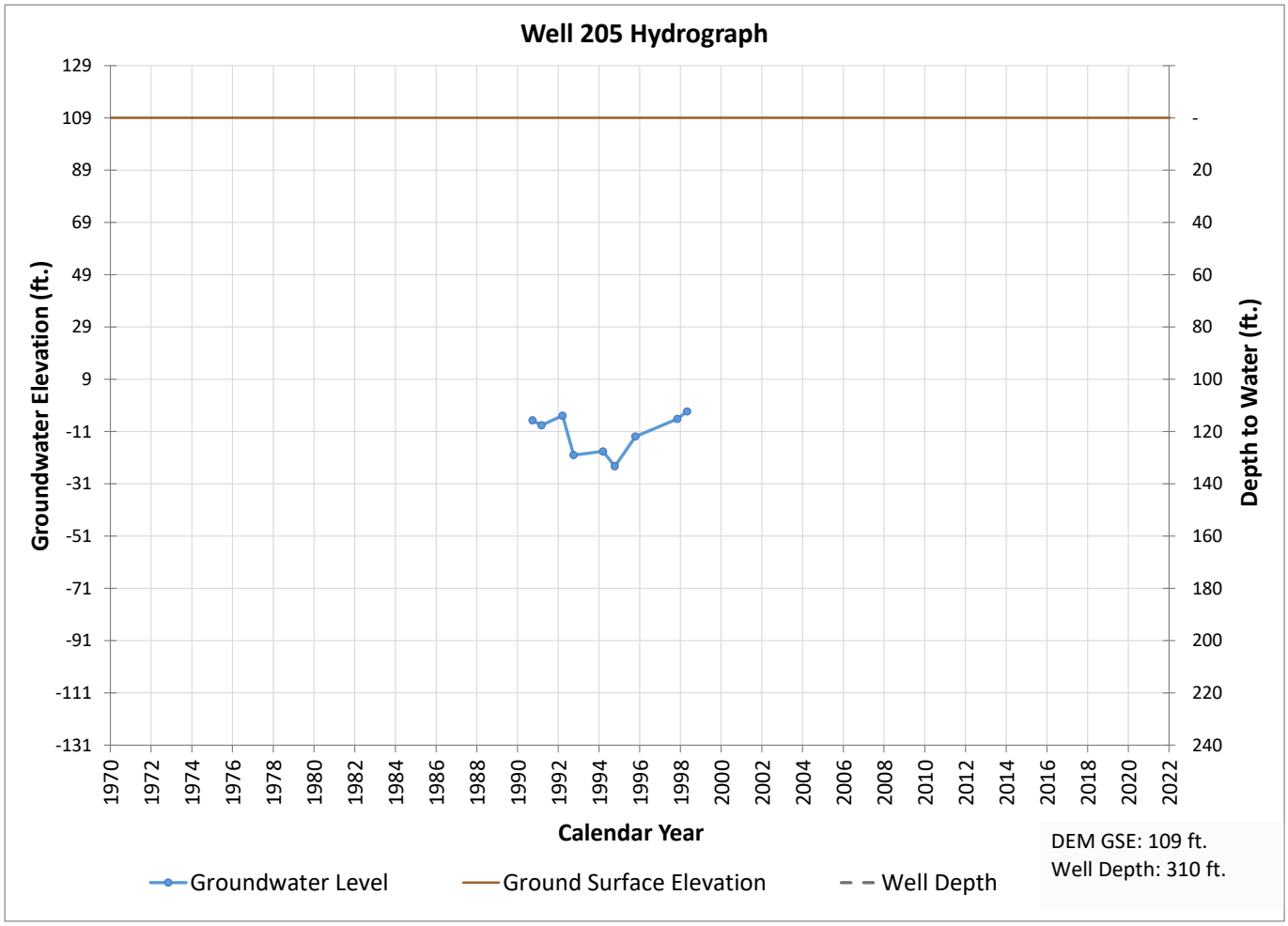

Well 198 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: 340 ft.

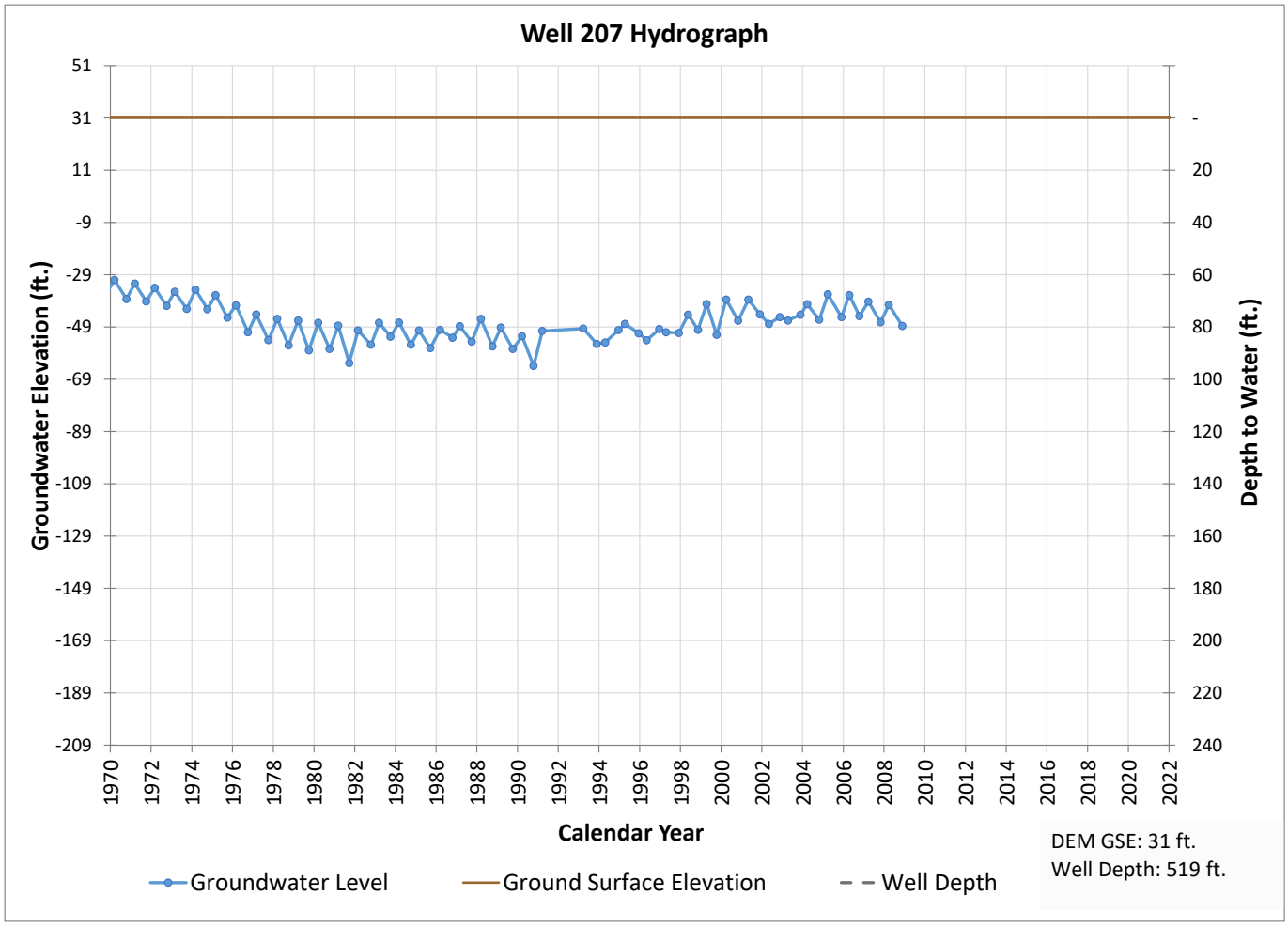

Well 199 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: ft.

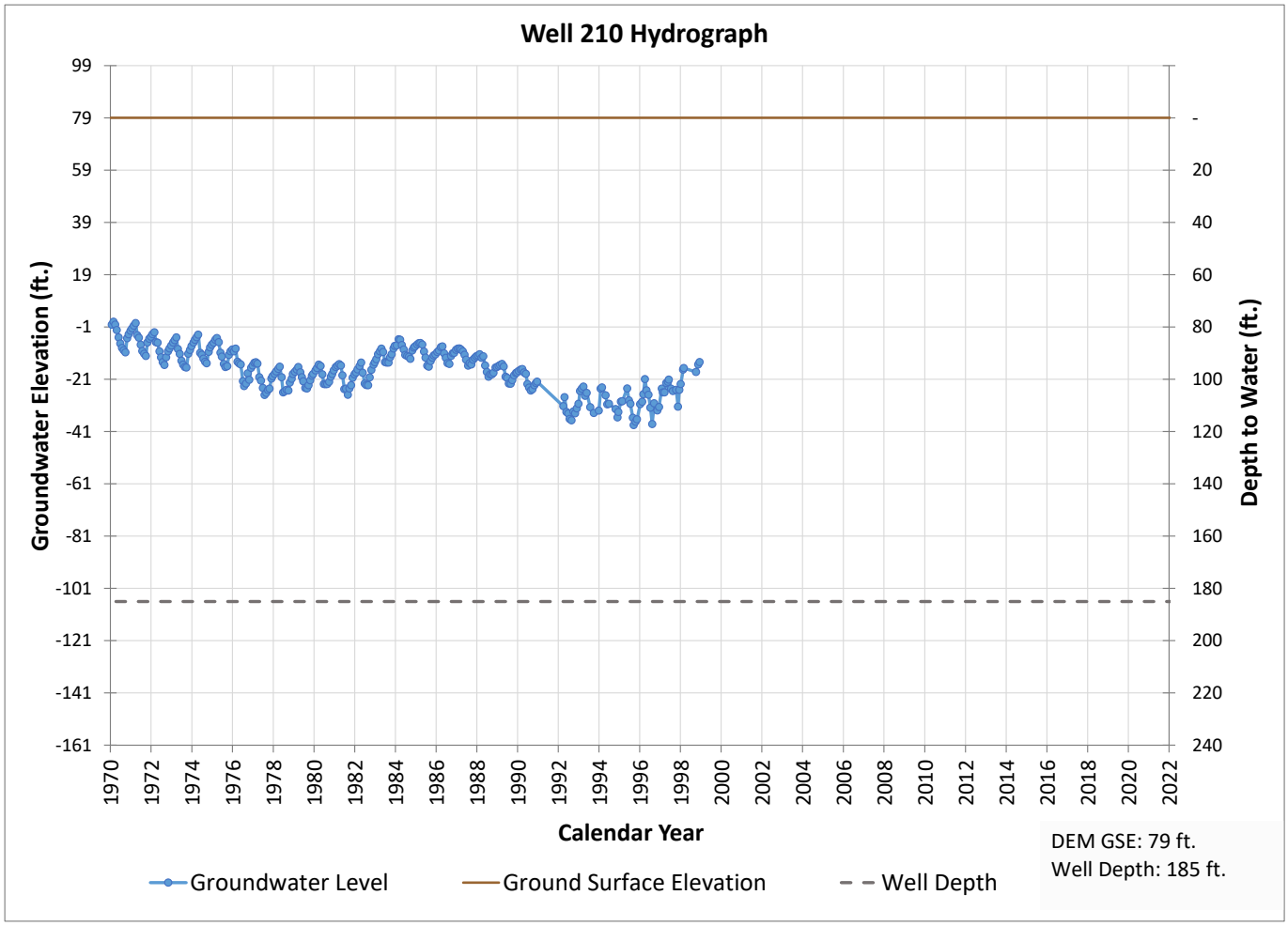

Well 201 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-195
-215
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 25 ft.
Well Depth: 178 ft.

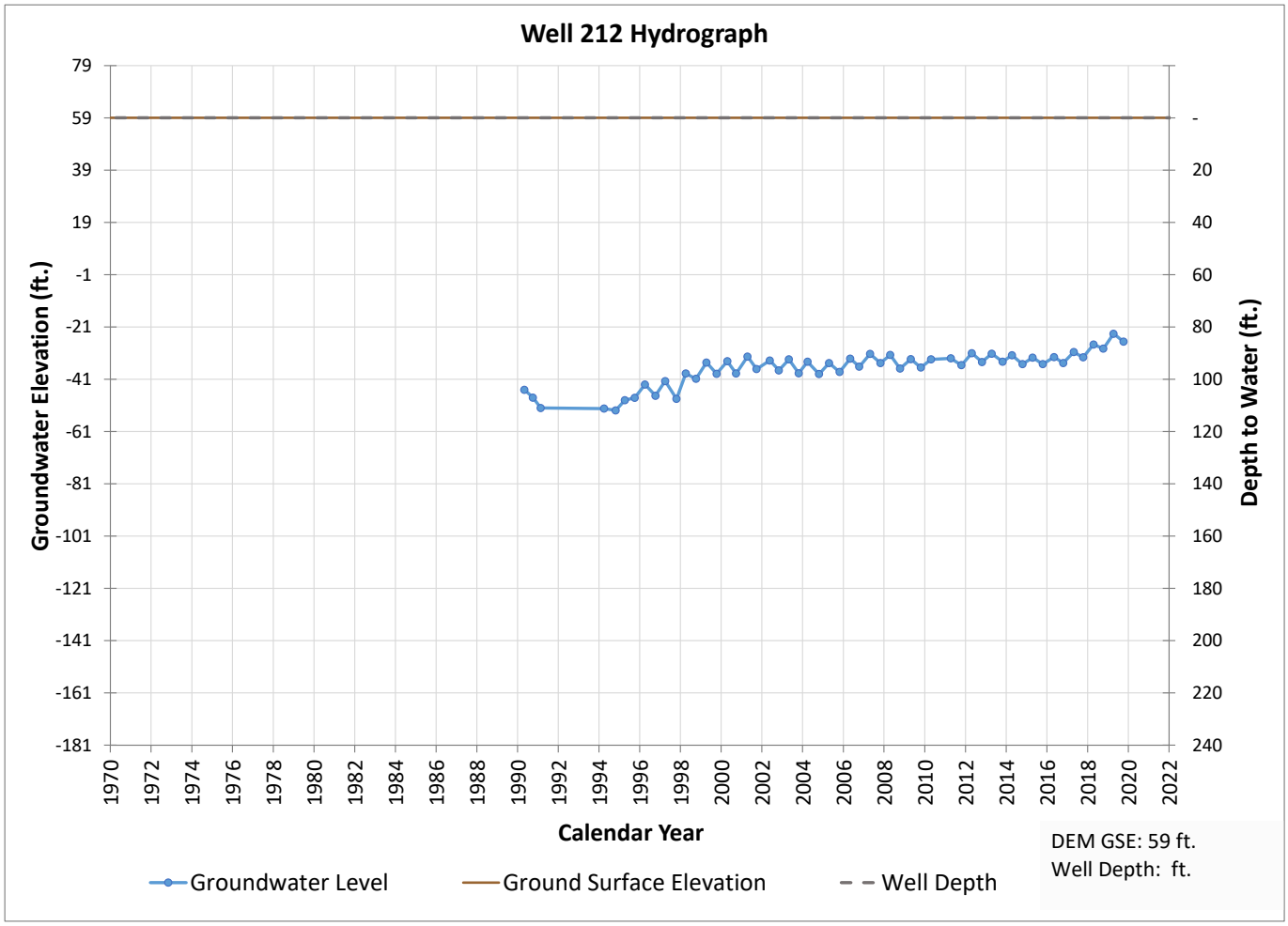

Well 203 Hydrograph
Groundwater Elevation (ft.)
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 86 ft.
Well Depth: 485 ft.

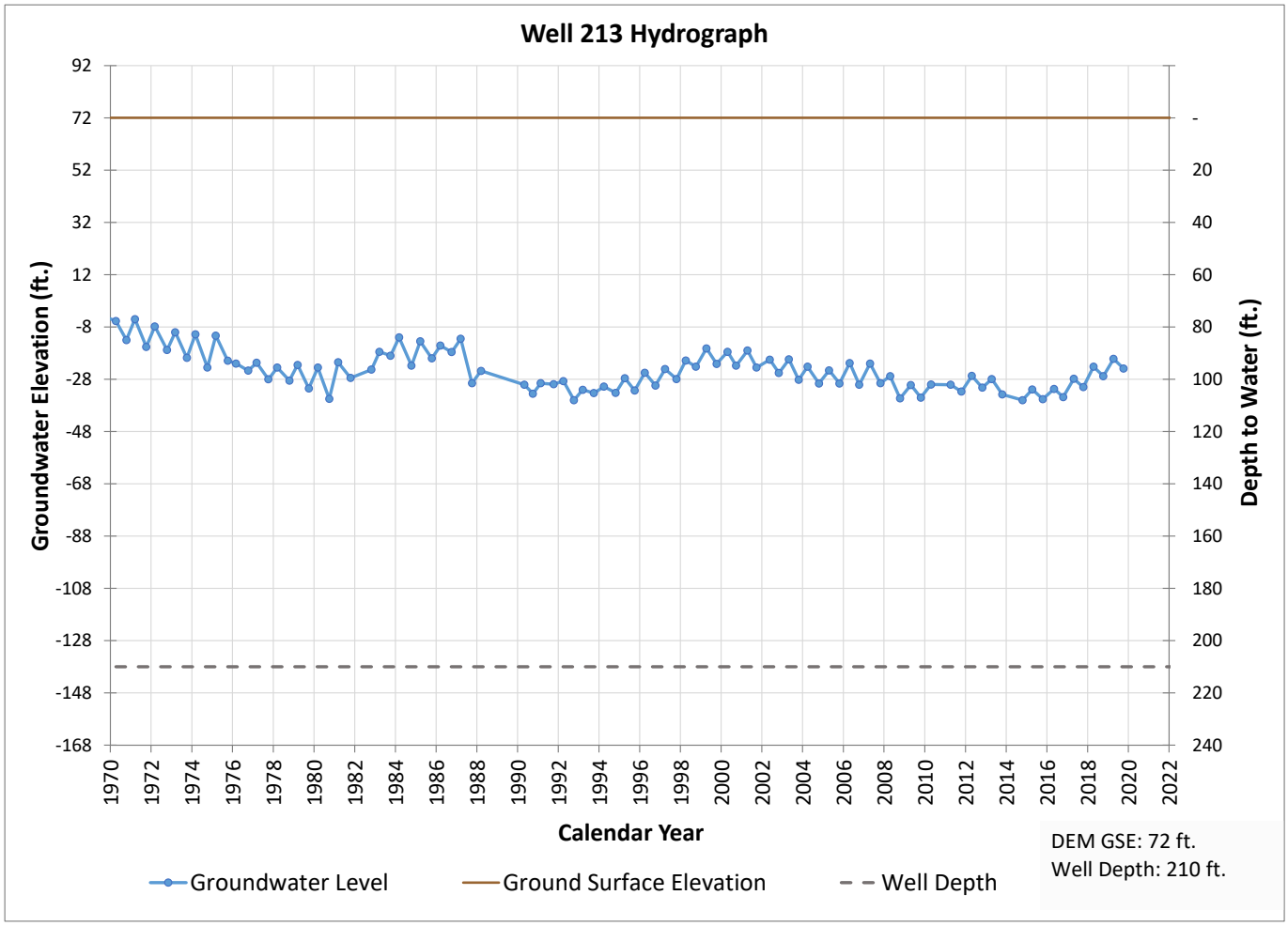

Well 204 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-201
-221
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 19 ft.
Well Depth: 170 ft.

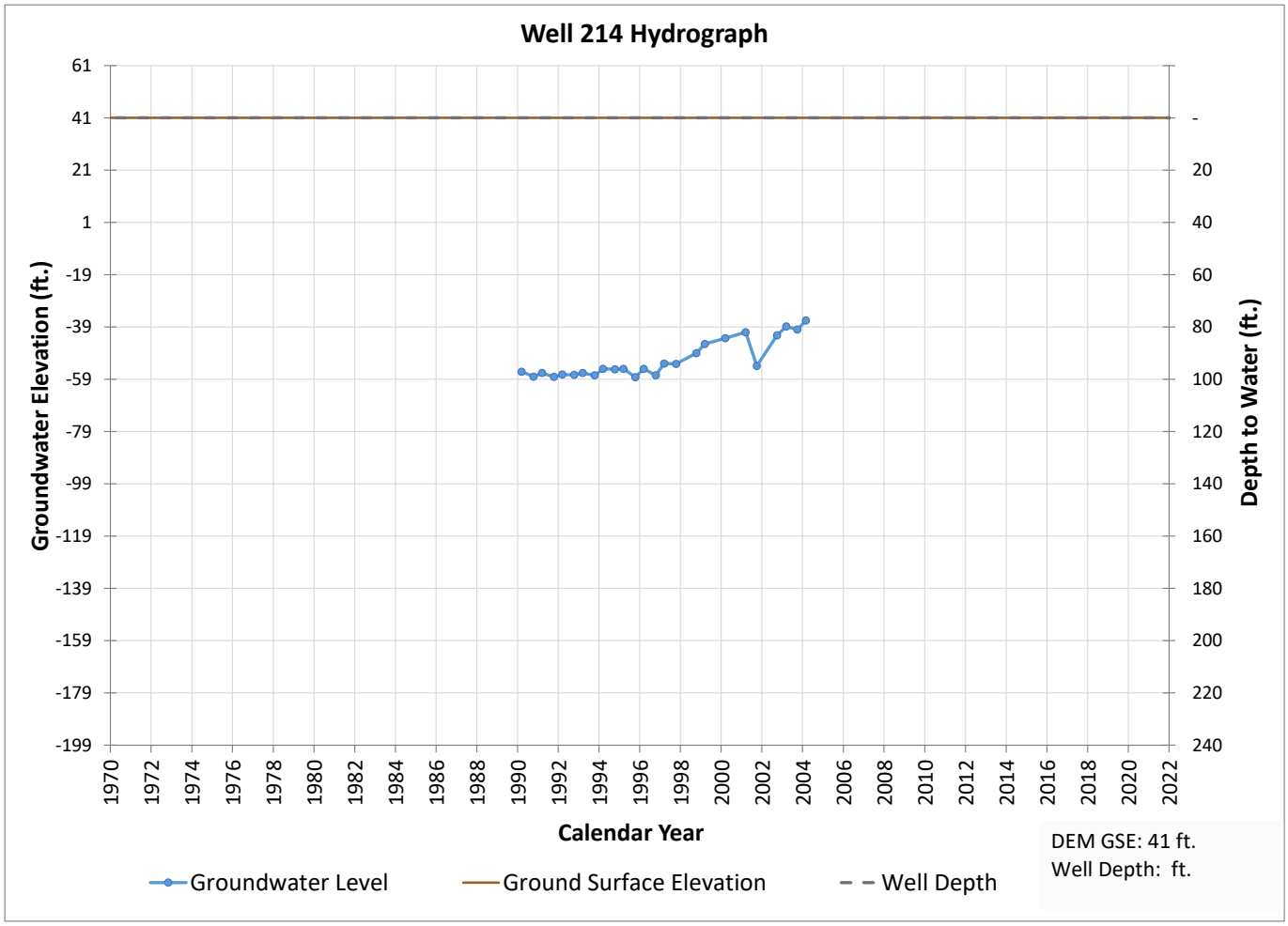

Well 205 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 109 ft.
Well Depth: 310 ft.

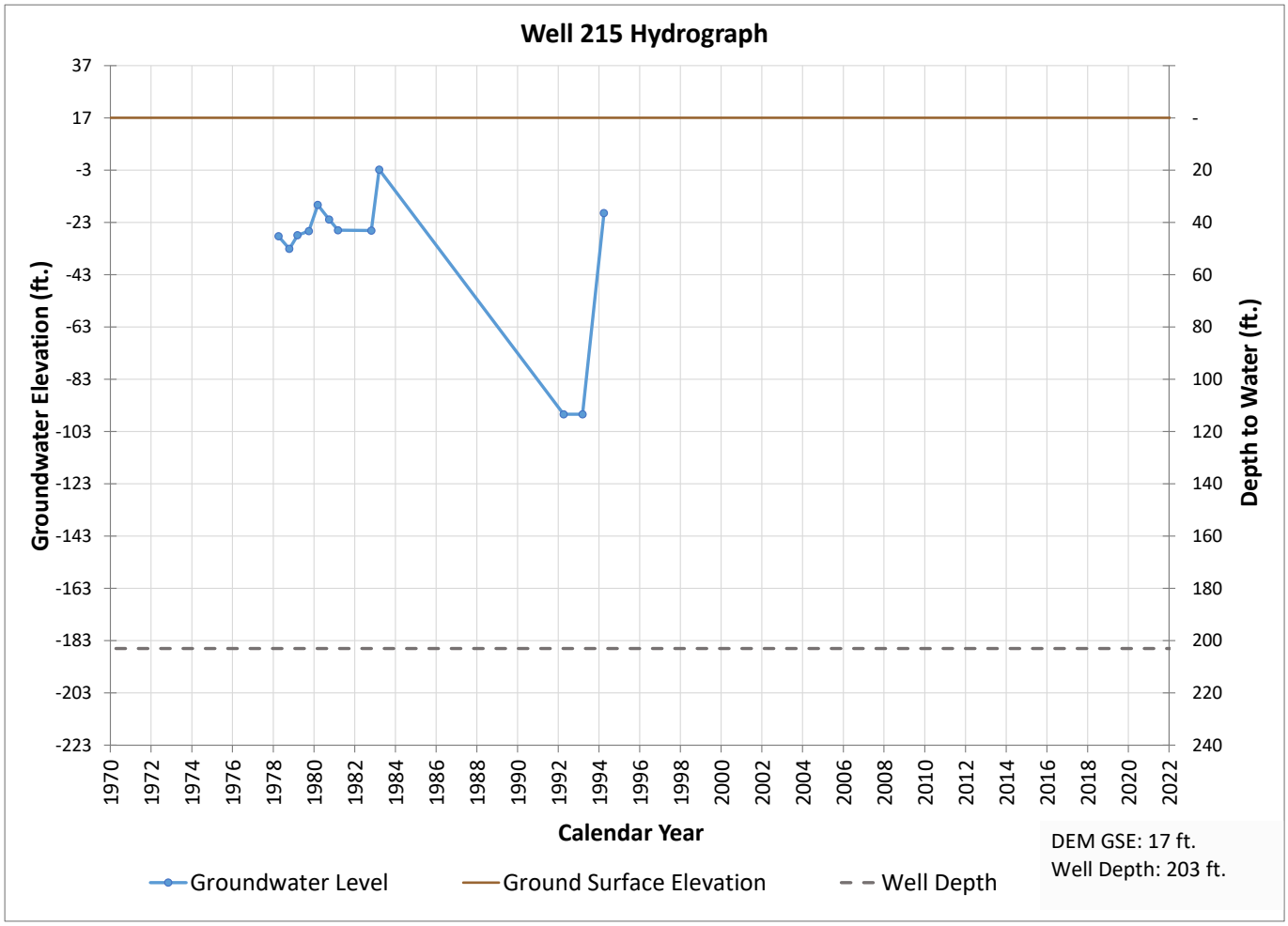

Well 207 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-189
-209
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 31 ft.
Well Depth: 519 ft.

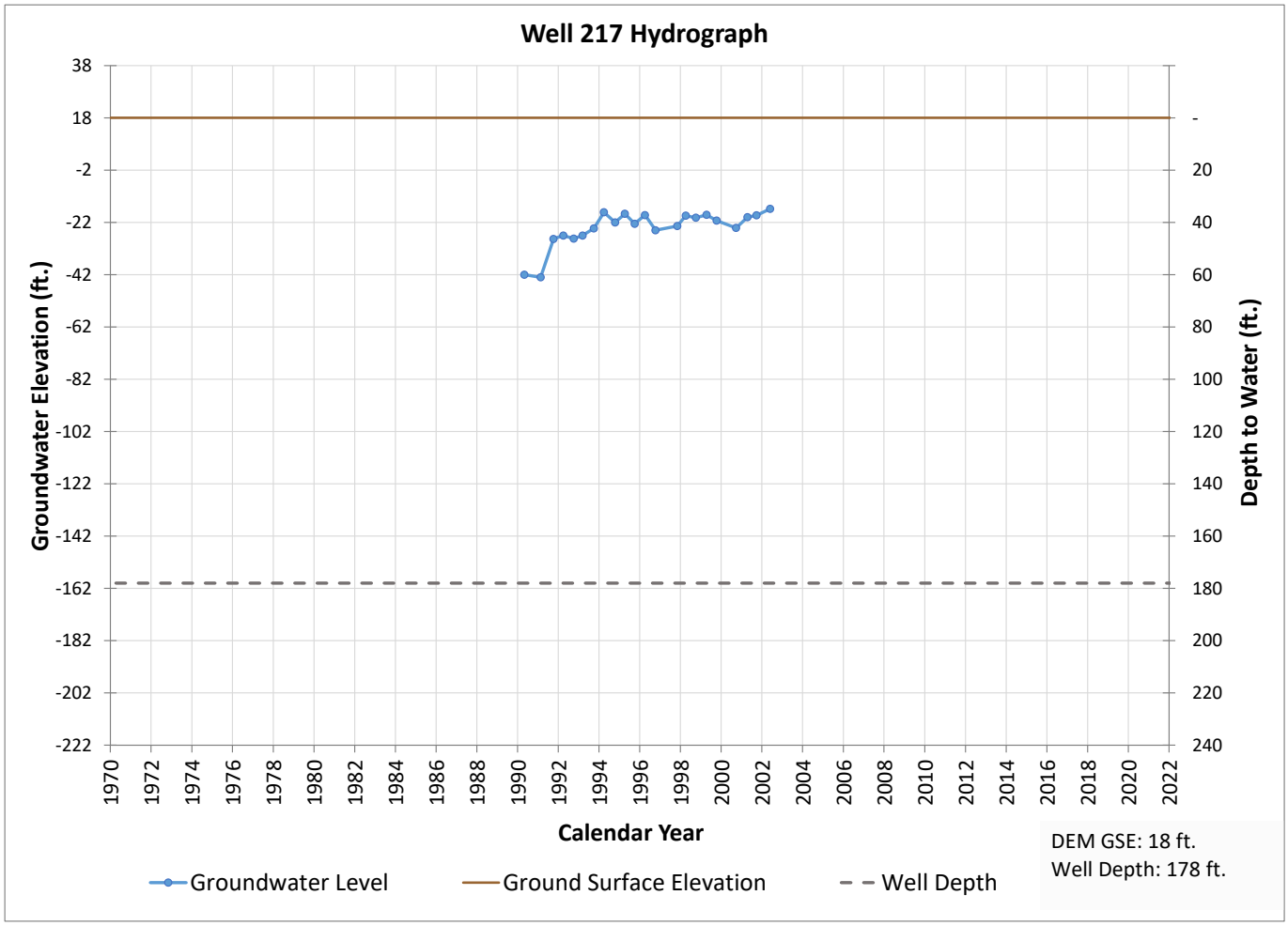

Well 210 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 79 ft.
Well Depth: 185 ft.

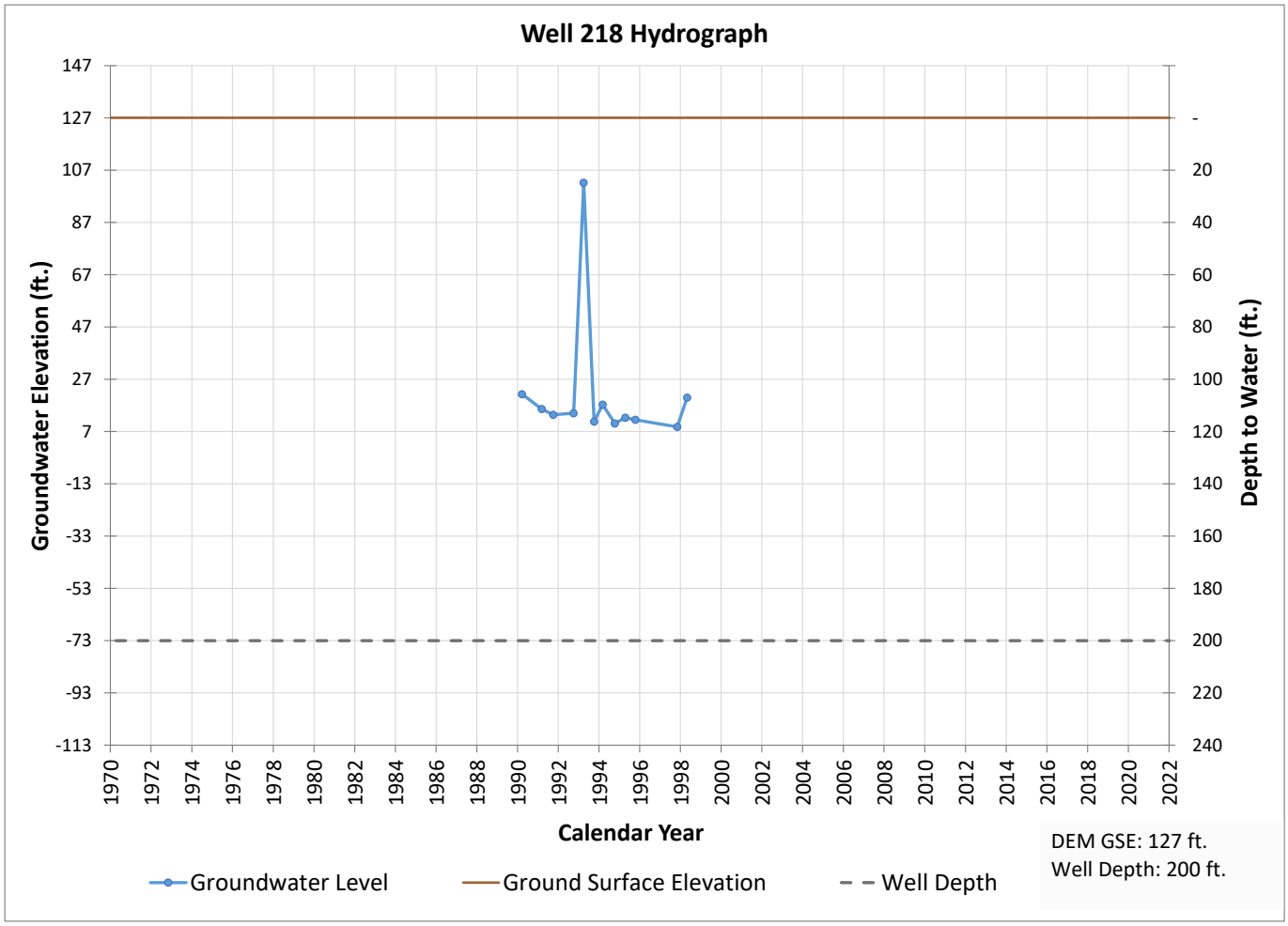

Well 212 Hydrograph
Groundwater Elevation (ft.)
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 59 ft.
Well Depth: ft.

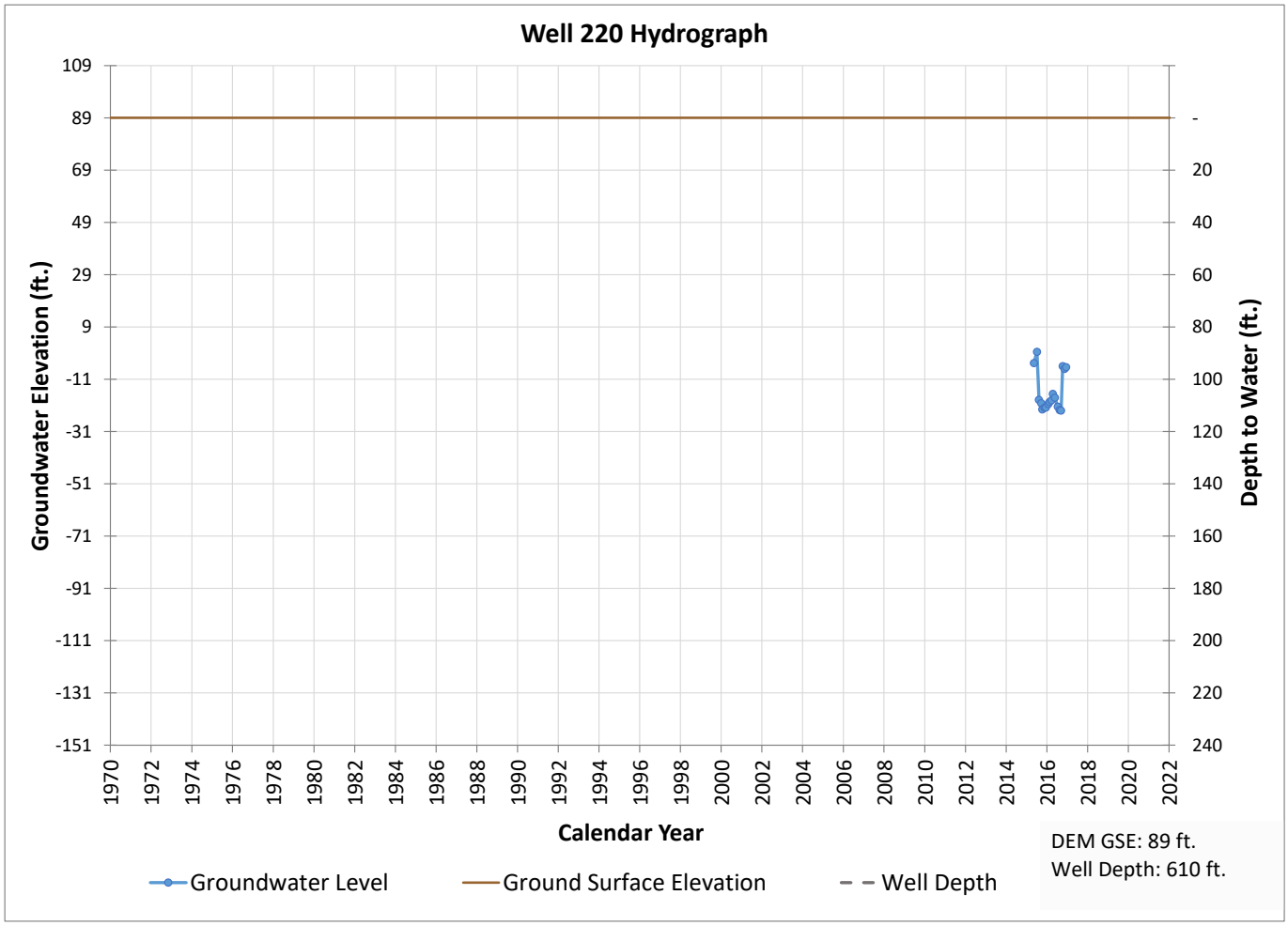

Well 213 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: 210 ft.

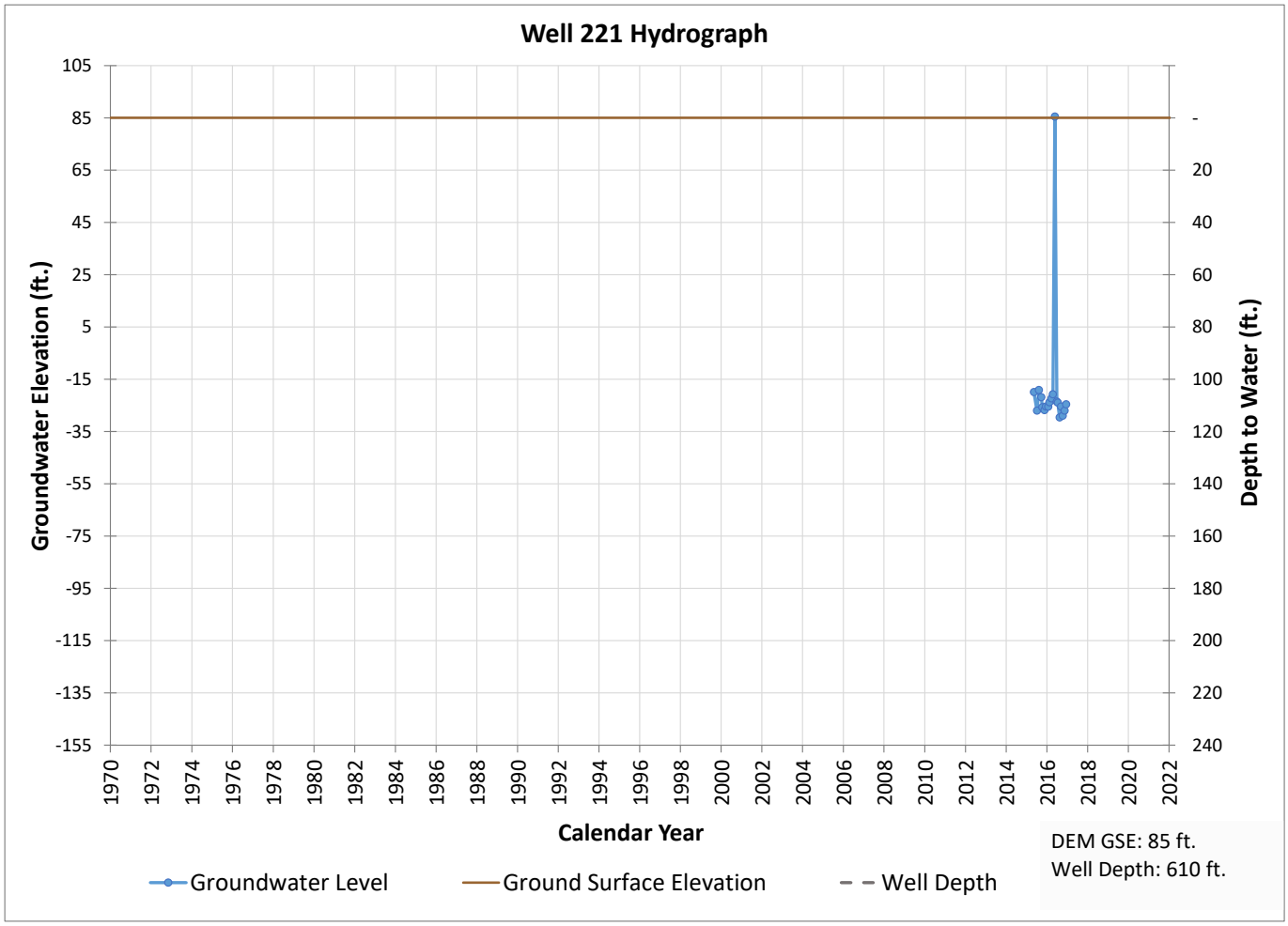

Well 214 Hydrograph
Groundwater Elevation (ft.)
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 41 ft.
Well Depth: ft.

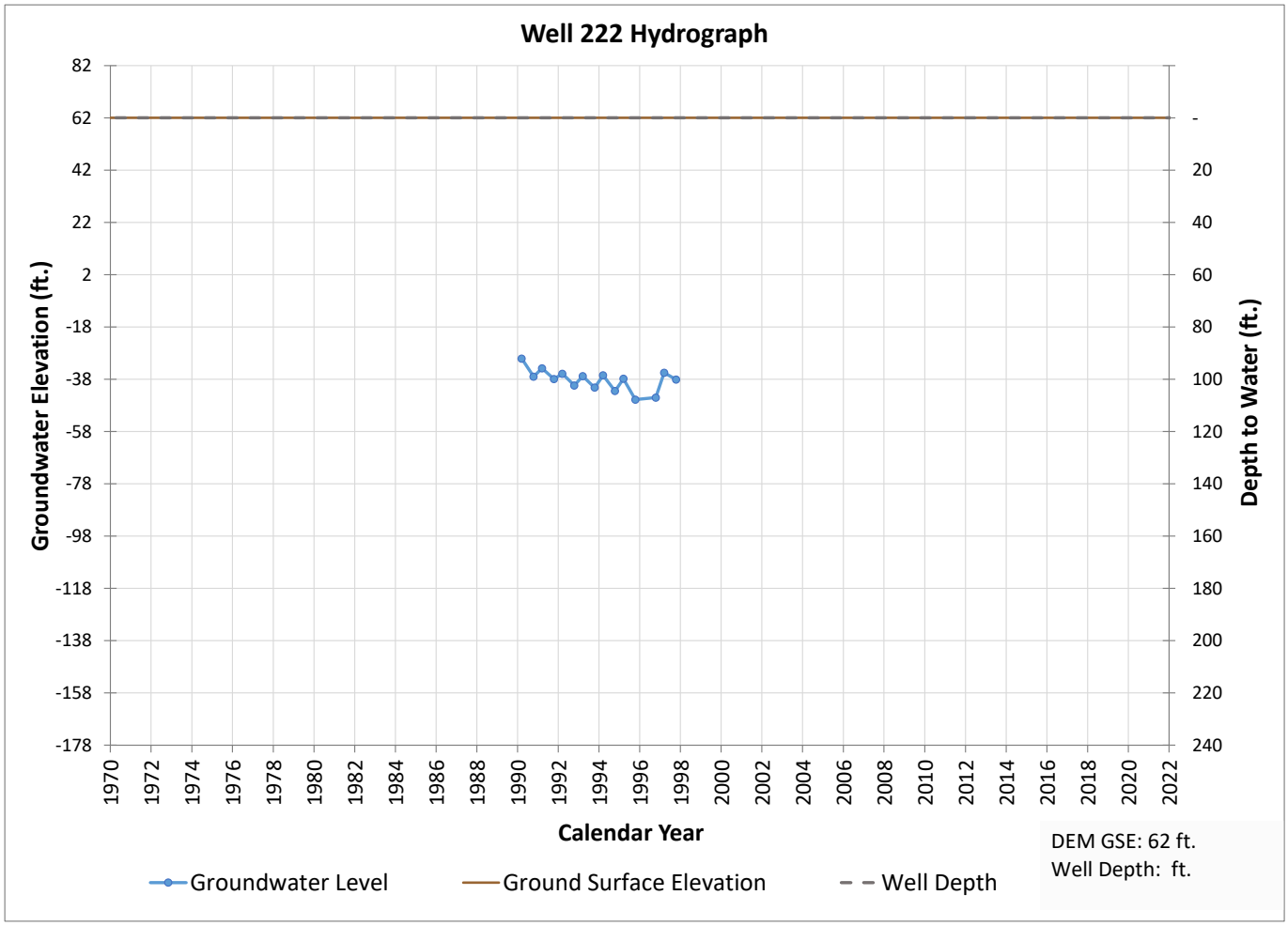

Well 215 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
-223
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 17 ft.
Well Depth: 203 ft.

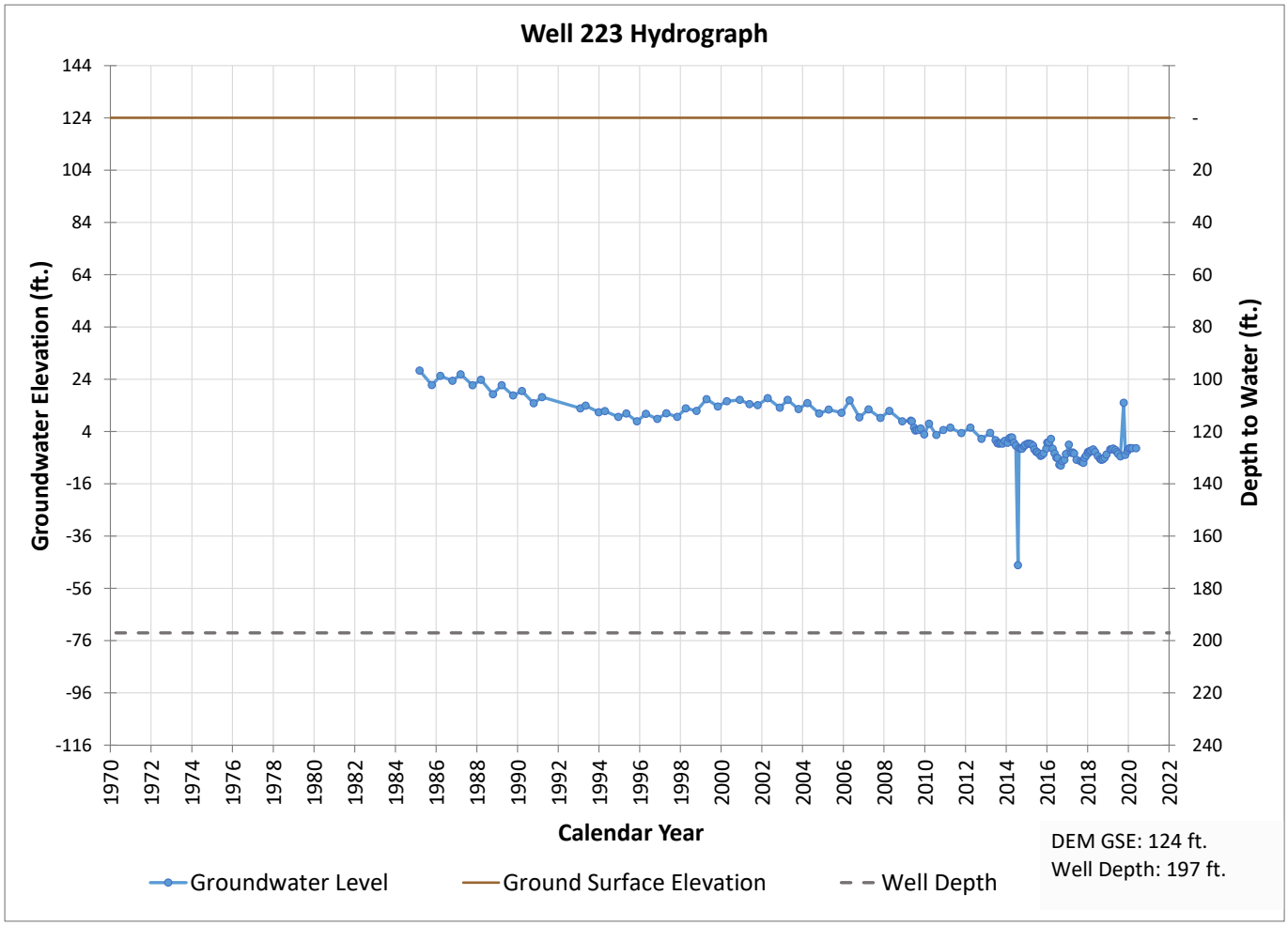

Well 217 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-222
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 18 ft.
Well Depth: 178 ft.

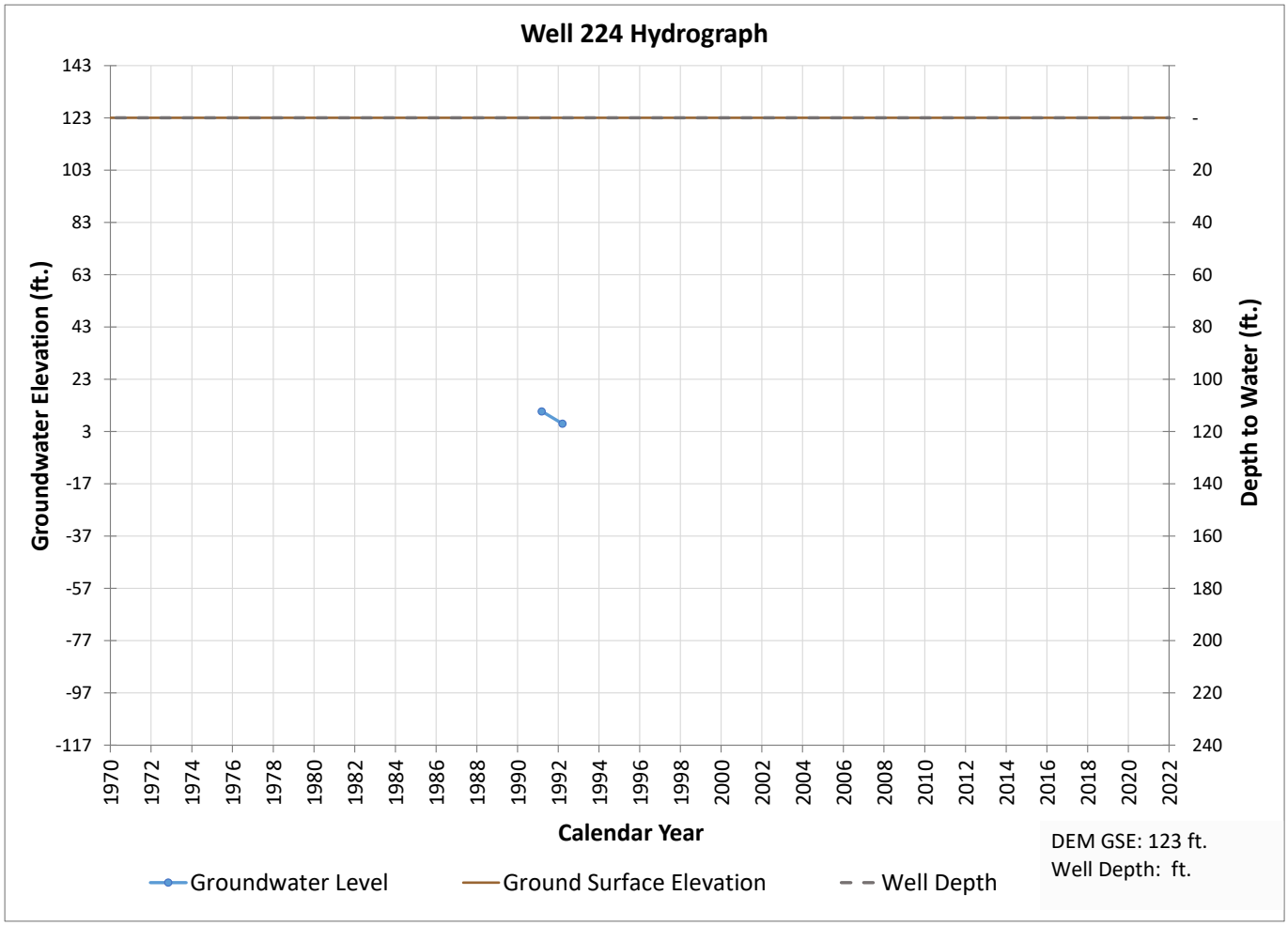

Well 218 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
147
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 127 ft.
Well Depth: 200 ft.

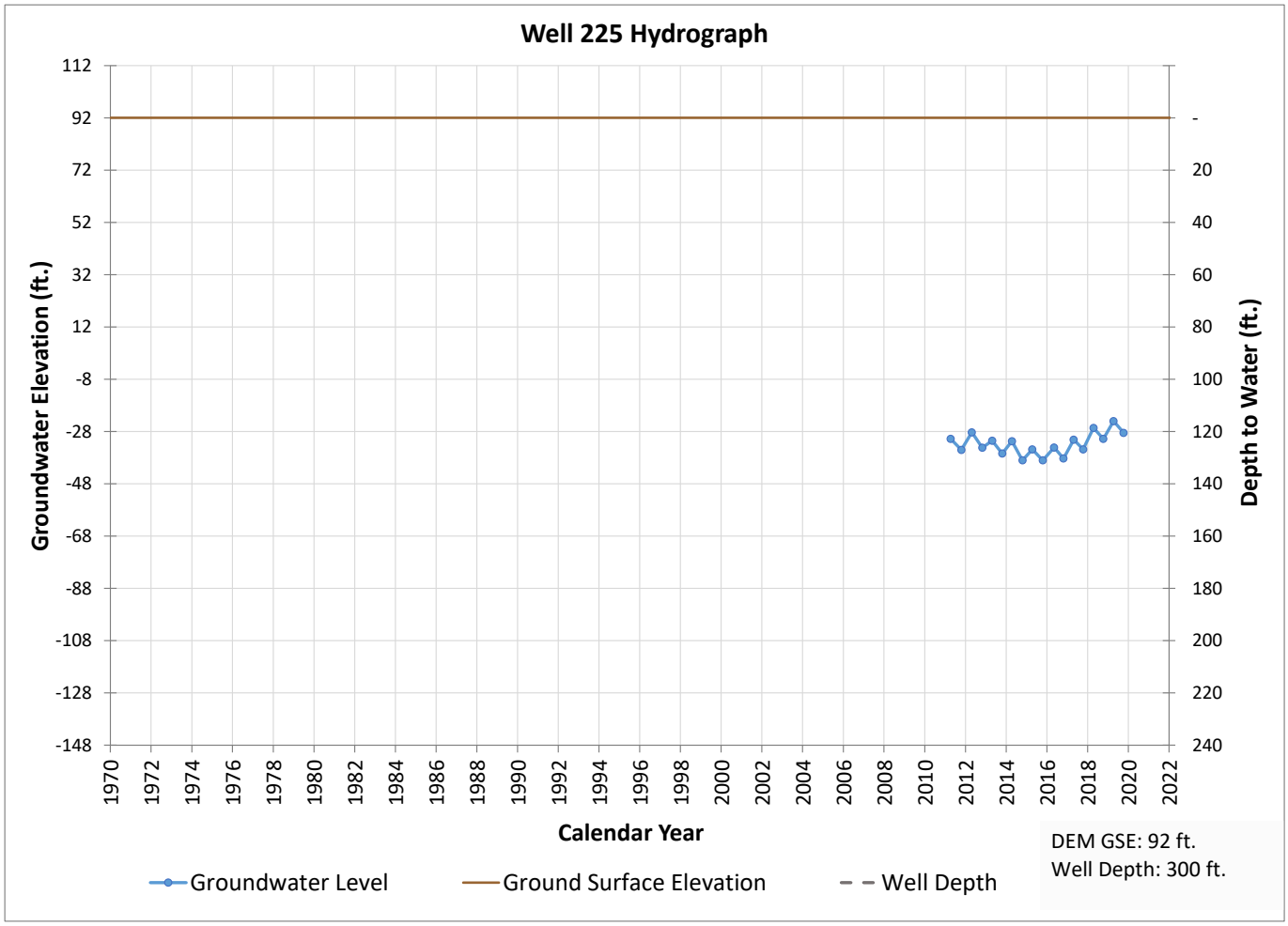

Well 220 Hydrograph
Groundwater Elevation (ft.)
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 89 ft.
Well Depth: 610 ft.

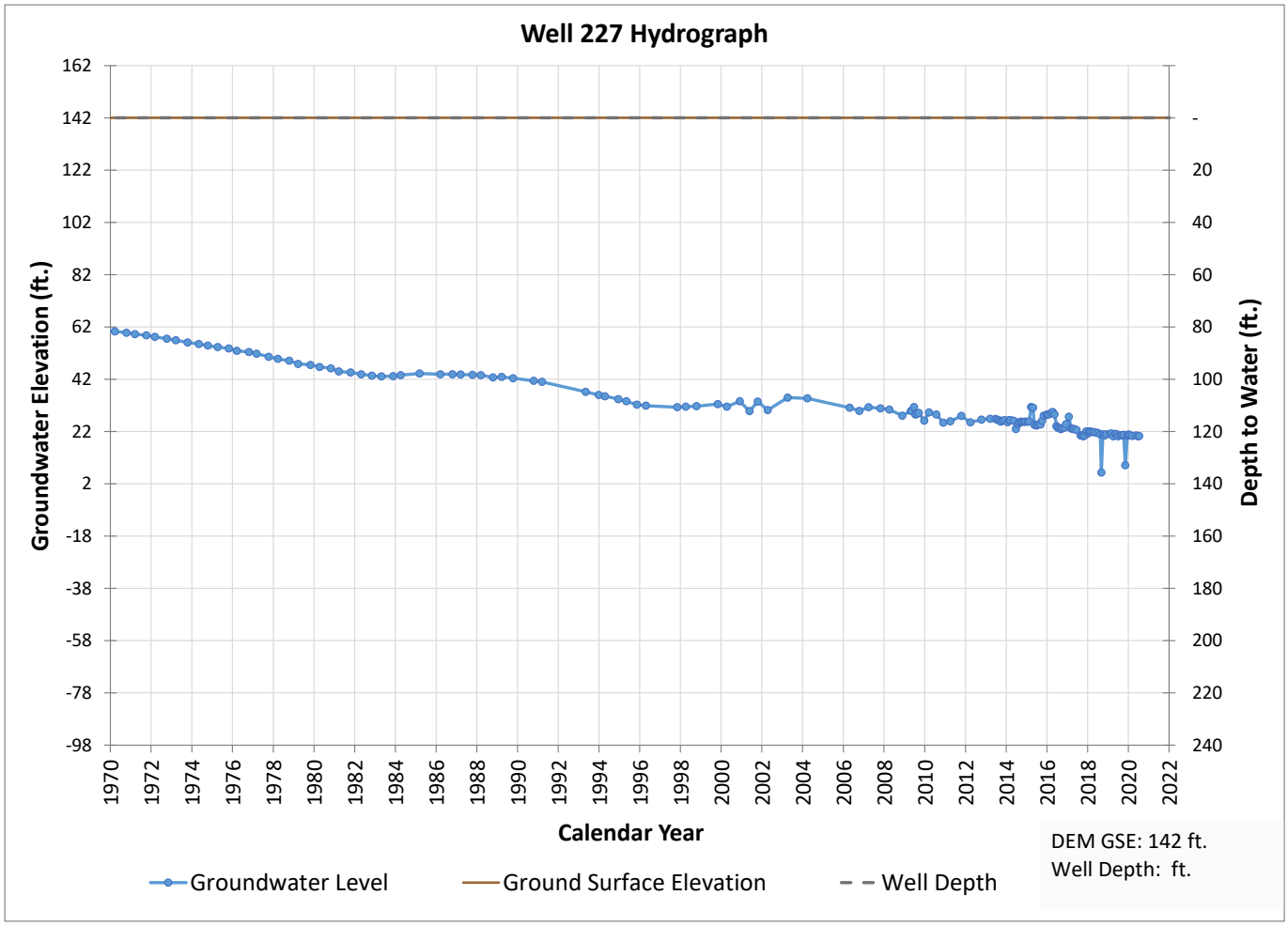

Well 221 Hydrograph
Groundwater Elevation (ft.)
105
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 85 ft.
Well Depth: 610 ft.

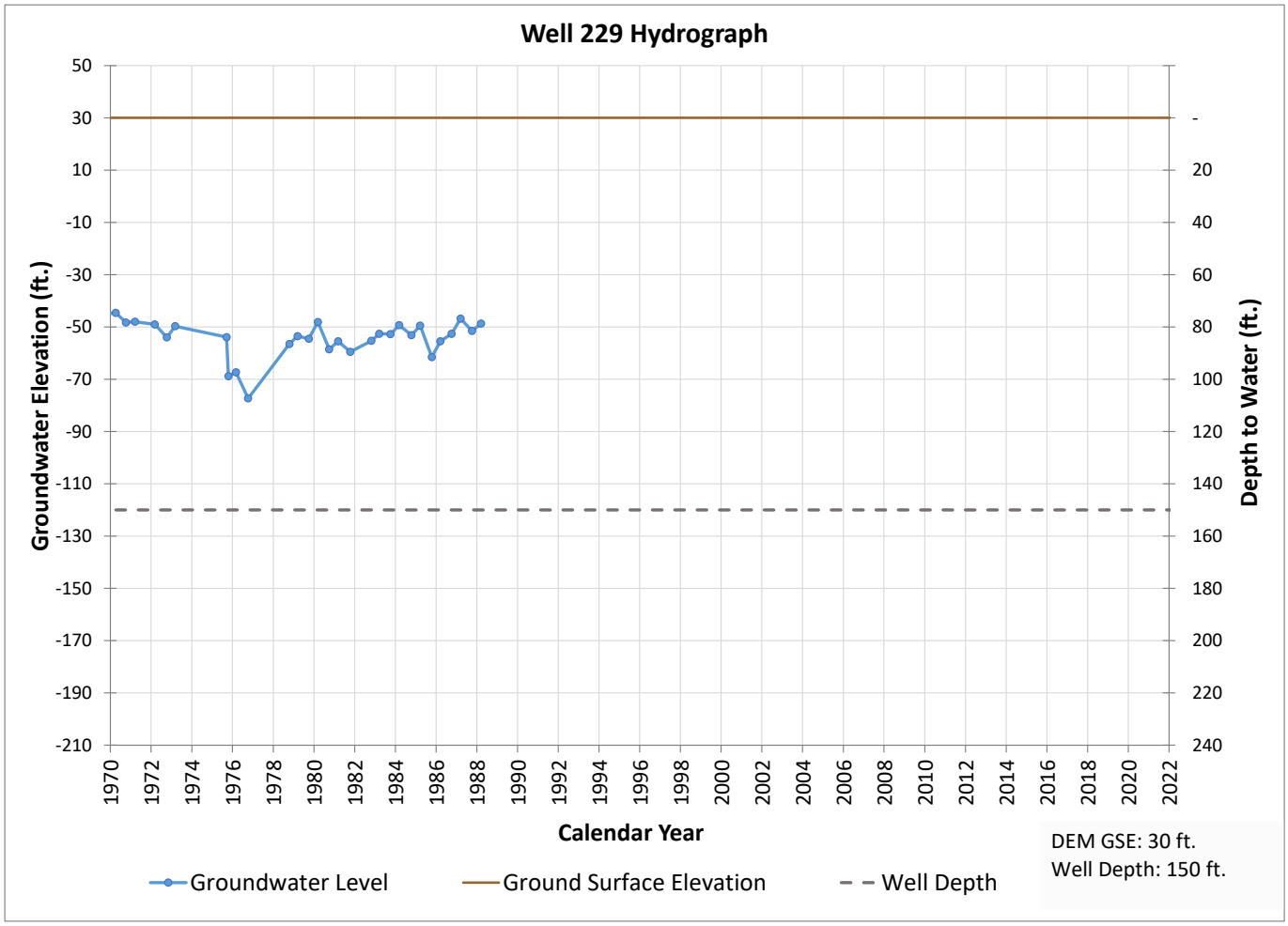

Well 222 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 62 ft.
Well Depth: ft.

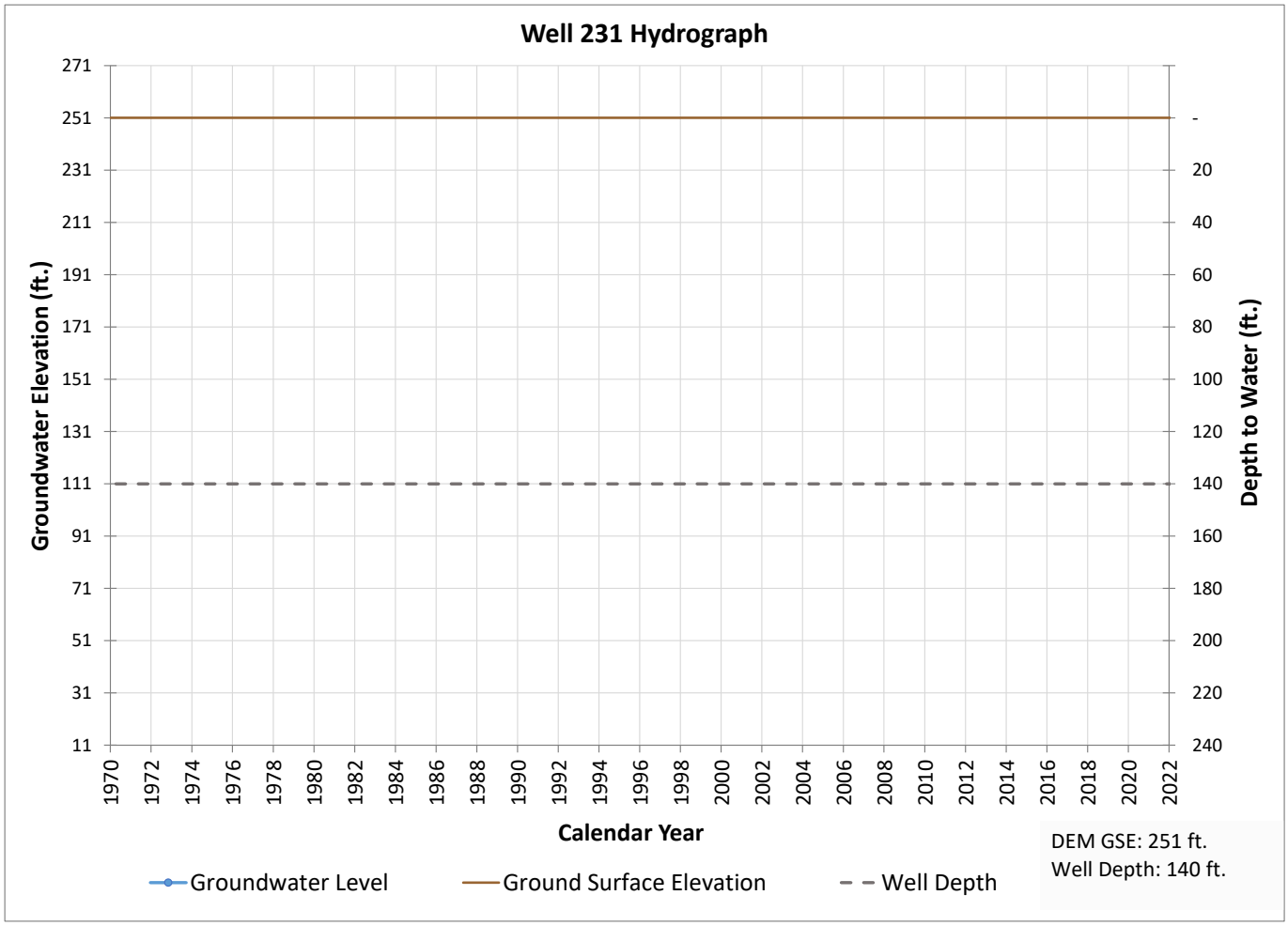

Well 223 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
144
124
104
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 124 ft.
Well Depth: 197 ft.

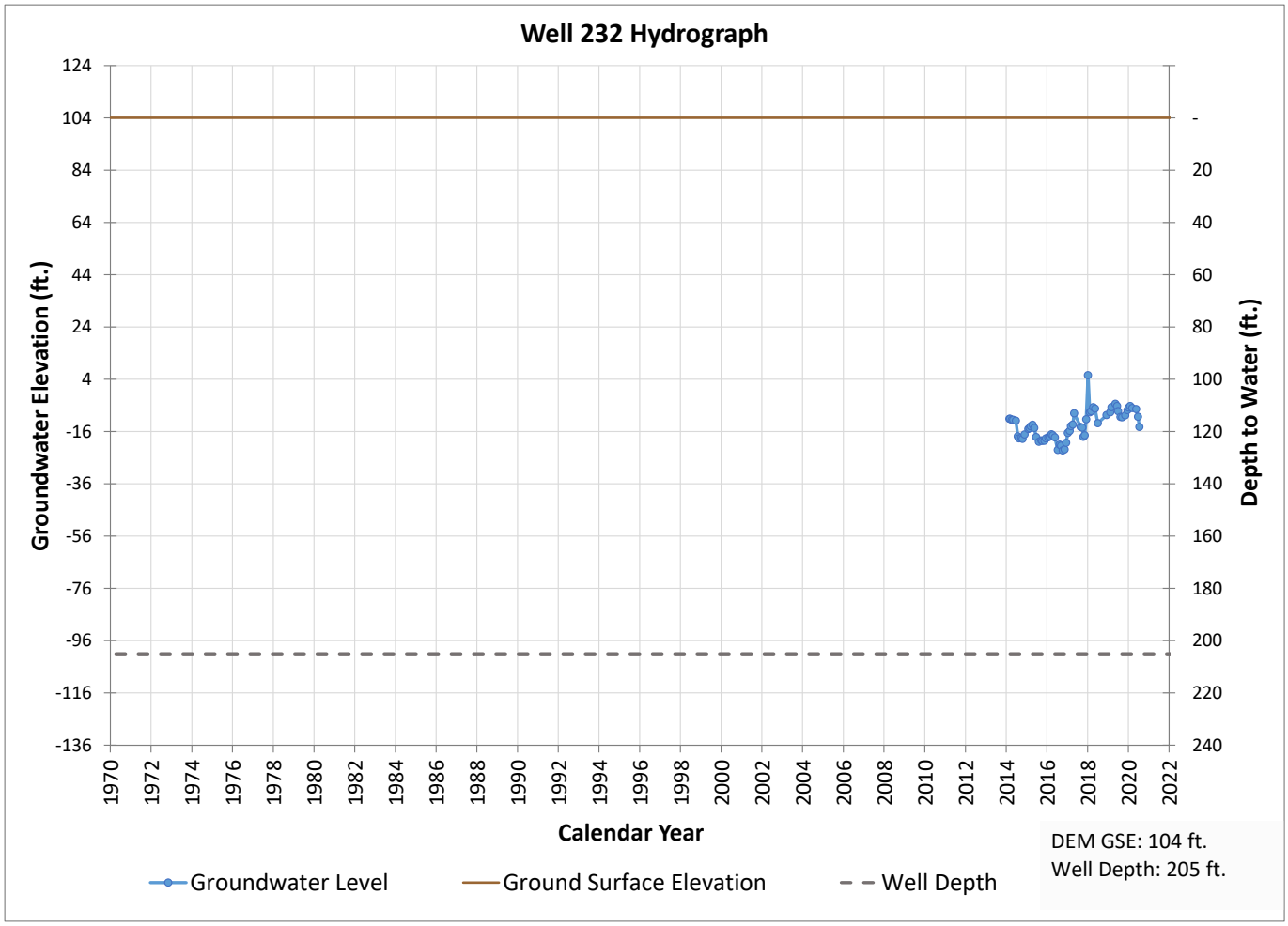

Well 224 Hydrograph
Groundwater Elevation (ft.)
143
123
103
83
63
43
23
3
-17
-37
-57
-77
-97
-117
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 123 ft.
Well Depth: ft.

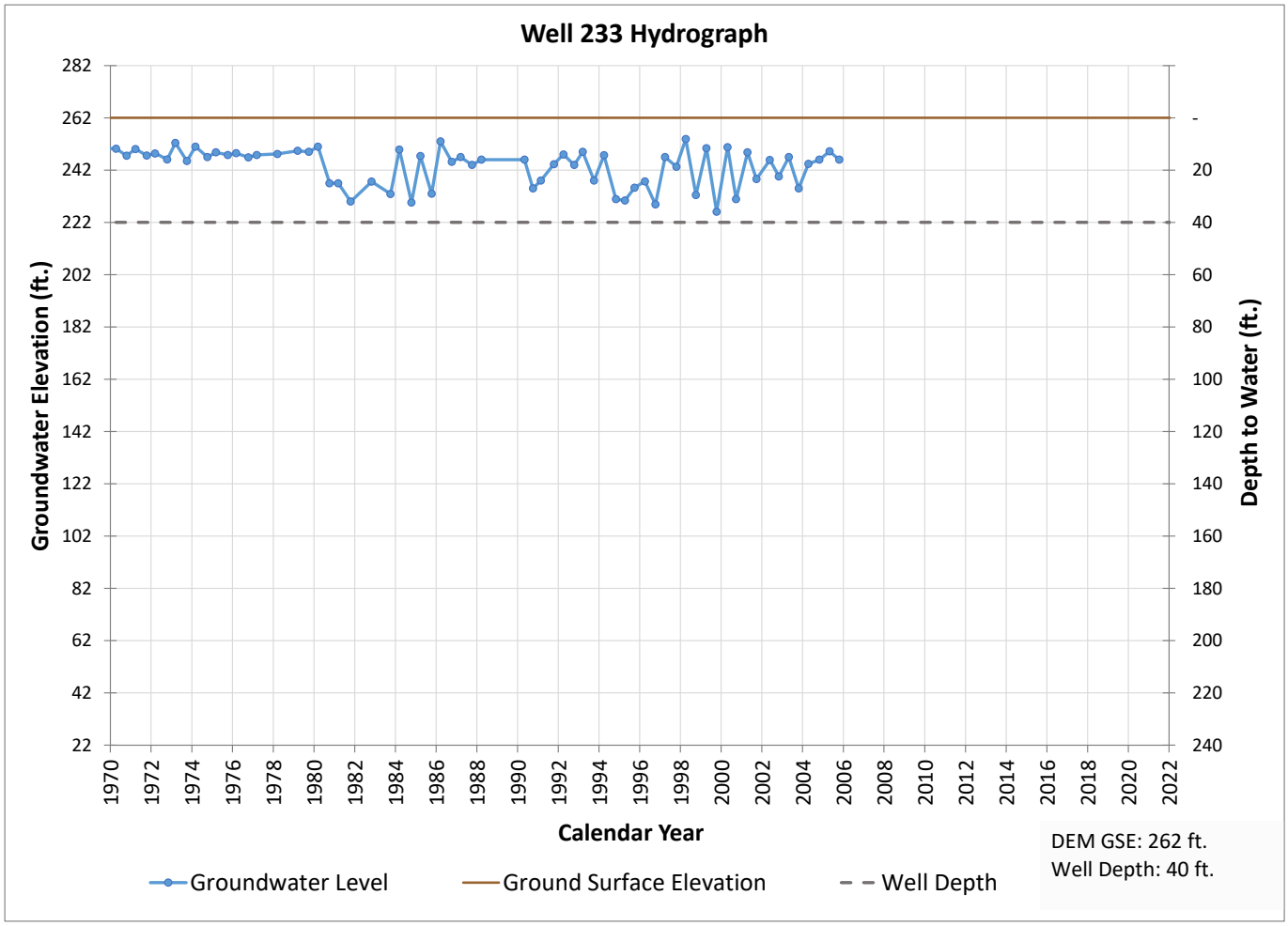

Well 225 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 92 ft.
Well Depth: 300 ft.

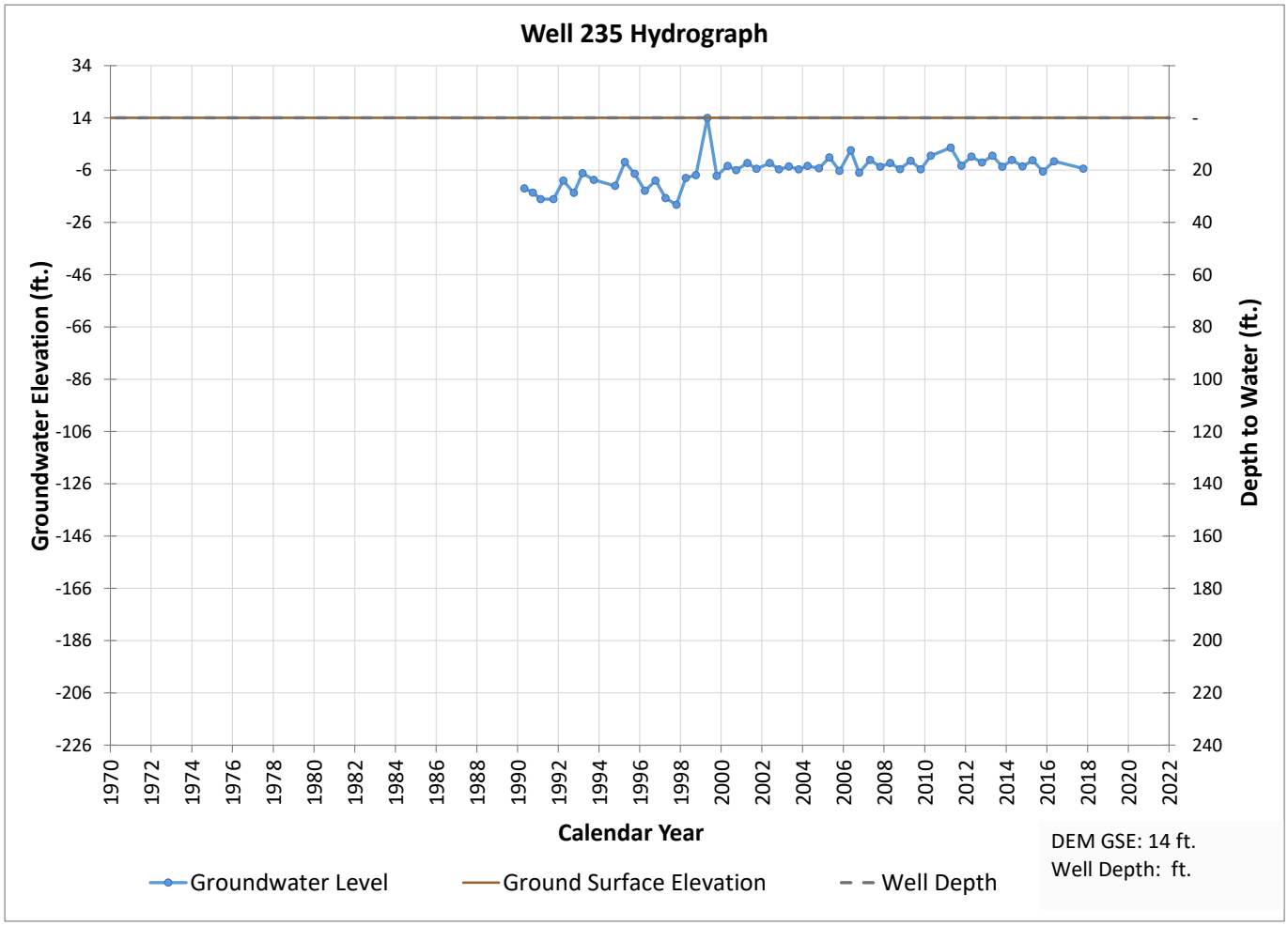

Well 227 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
162
142
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 142 ft.
Well Depth: ft.

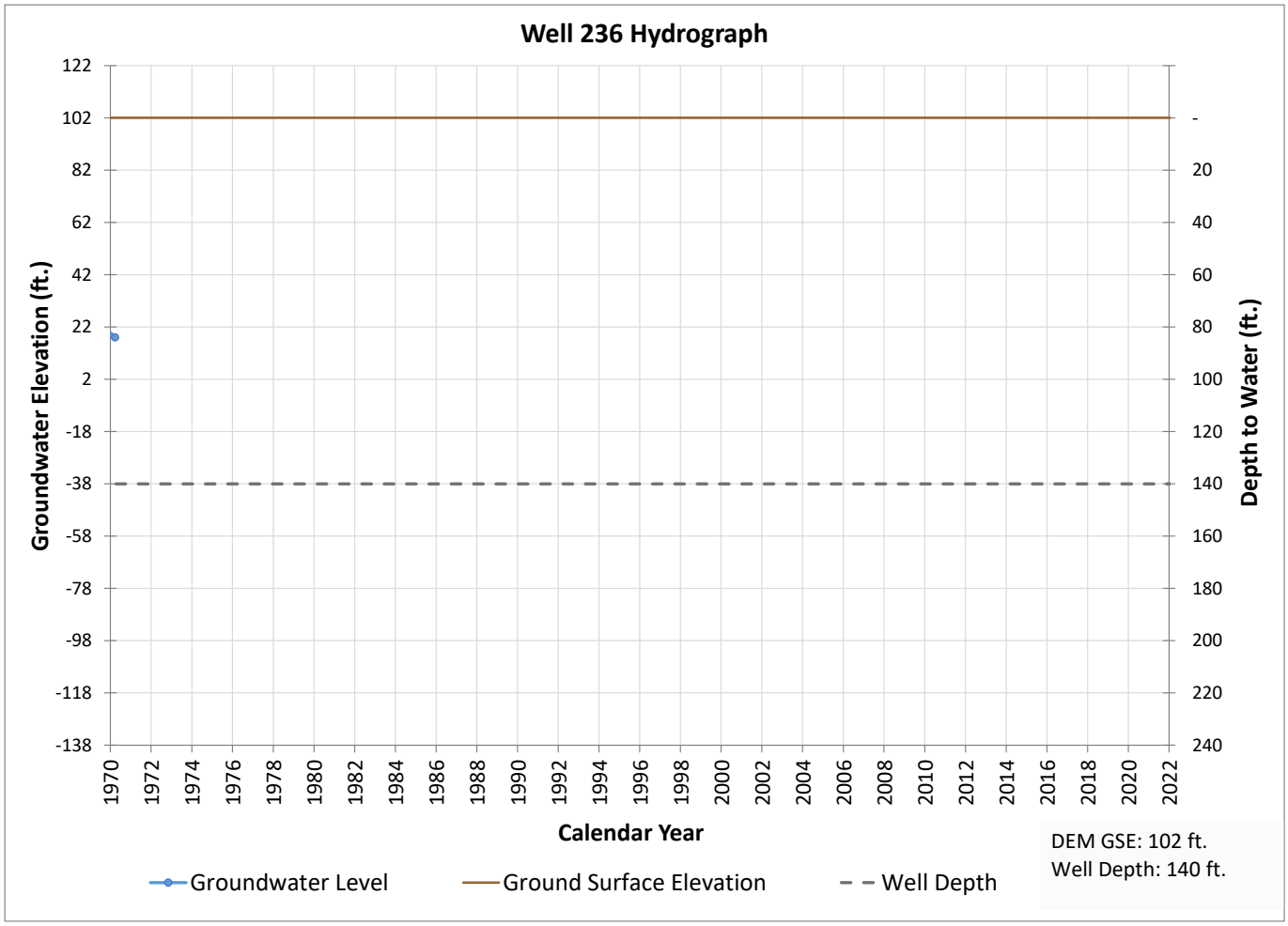

Well 229 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 30 ft.
Well Depth: 150 ft.

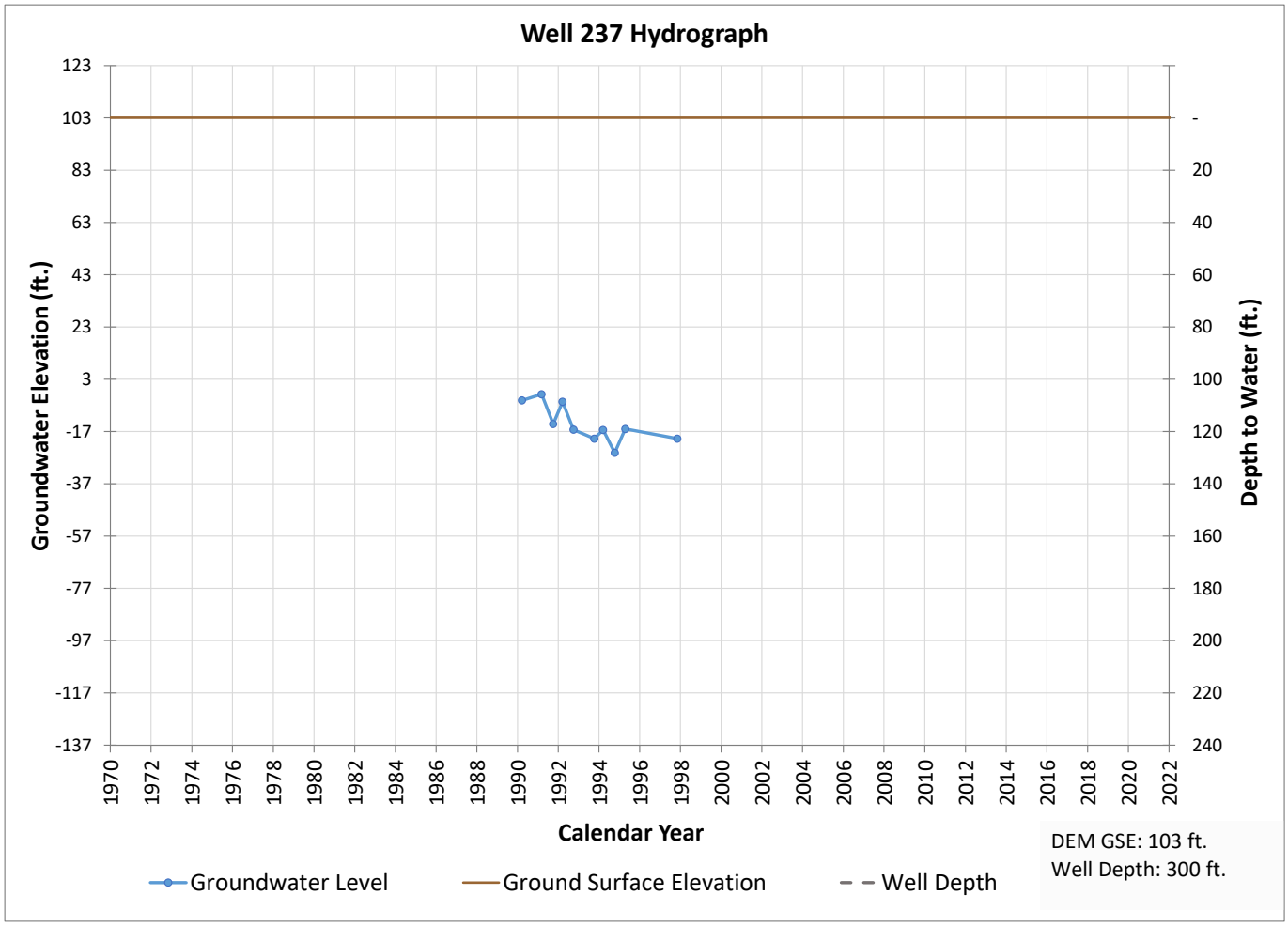

Well 231 Hydrograph
Groundwater Elevation (ft.)
271
251
231
211
191
171
151
131
111
91
71
51
31
11
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 251 ft.
Well Depth: 140 ft.

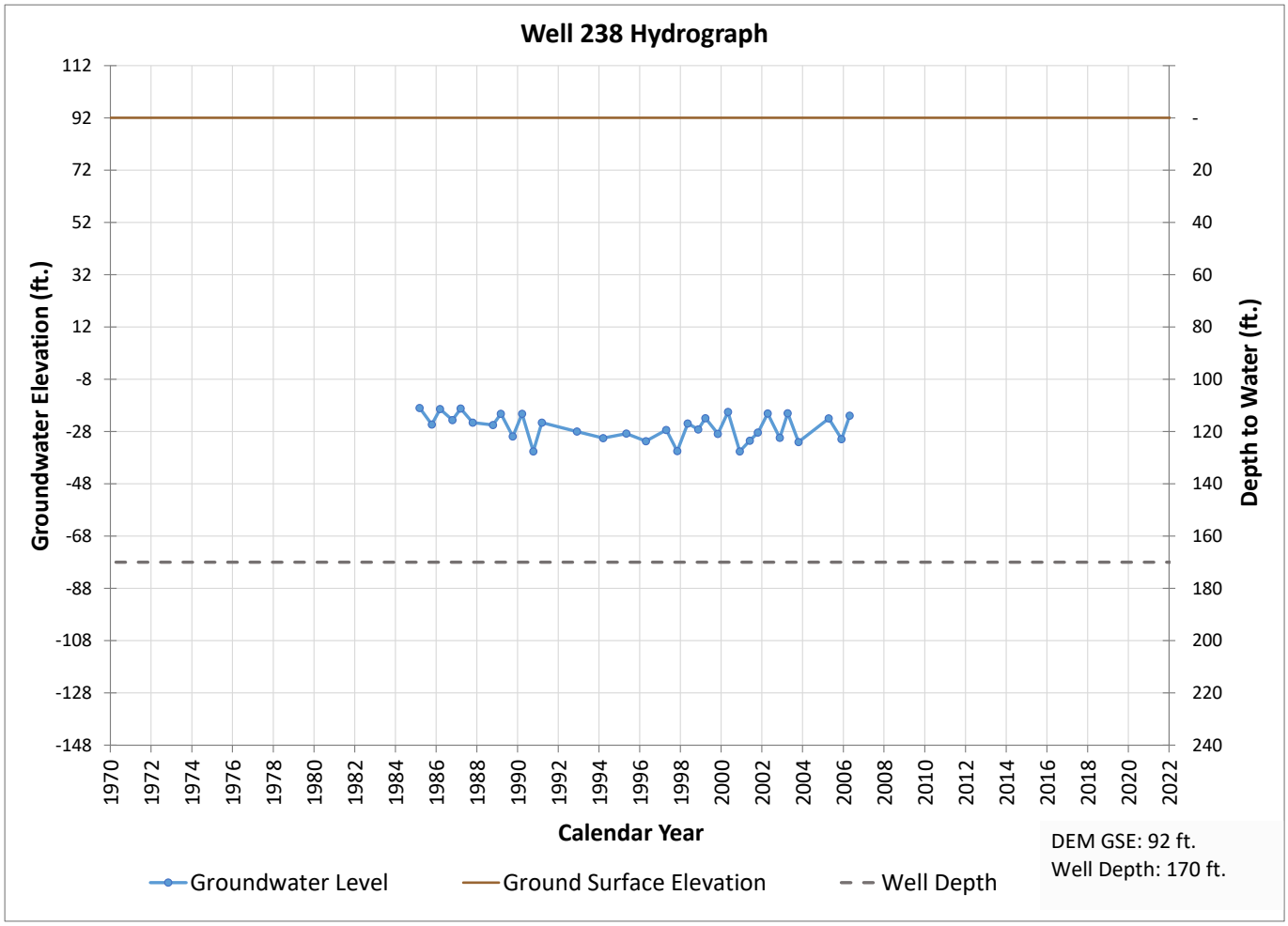

Well 232 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
124
104
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 104 ft.
Well Depth: 205 ft.

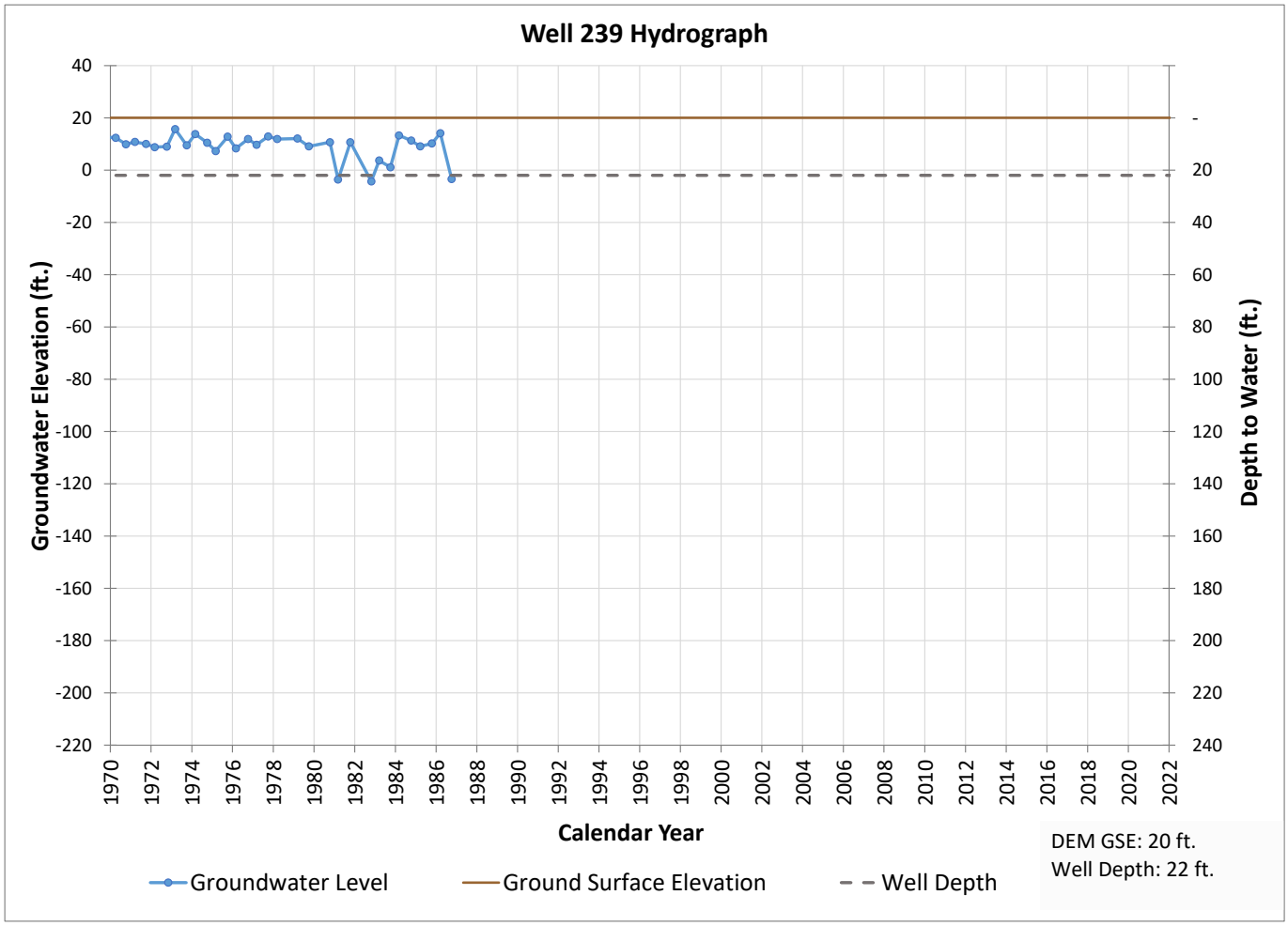

Well 233 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
282
262
242
222
202
182
162
142
122
102
82
62
42
22
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 262 ft.
Well Depth: 40 ft.

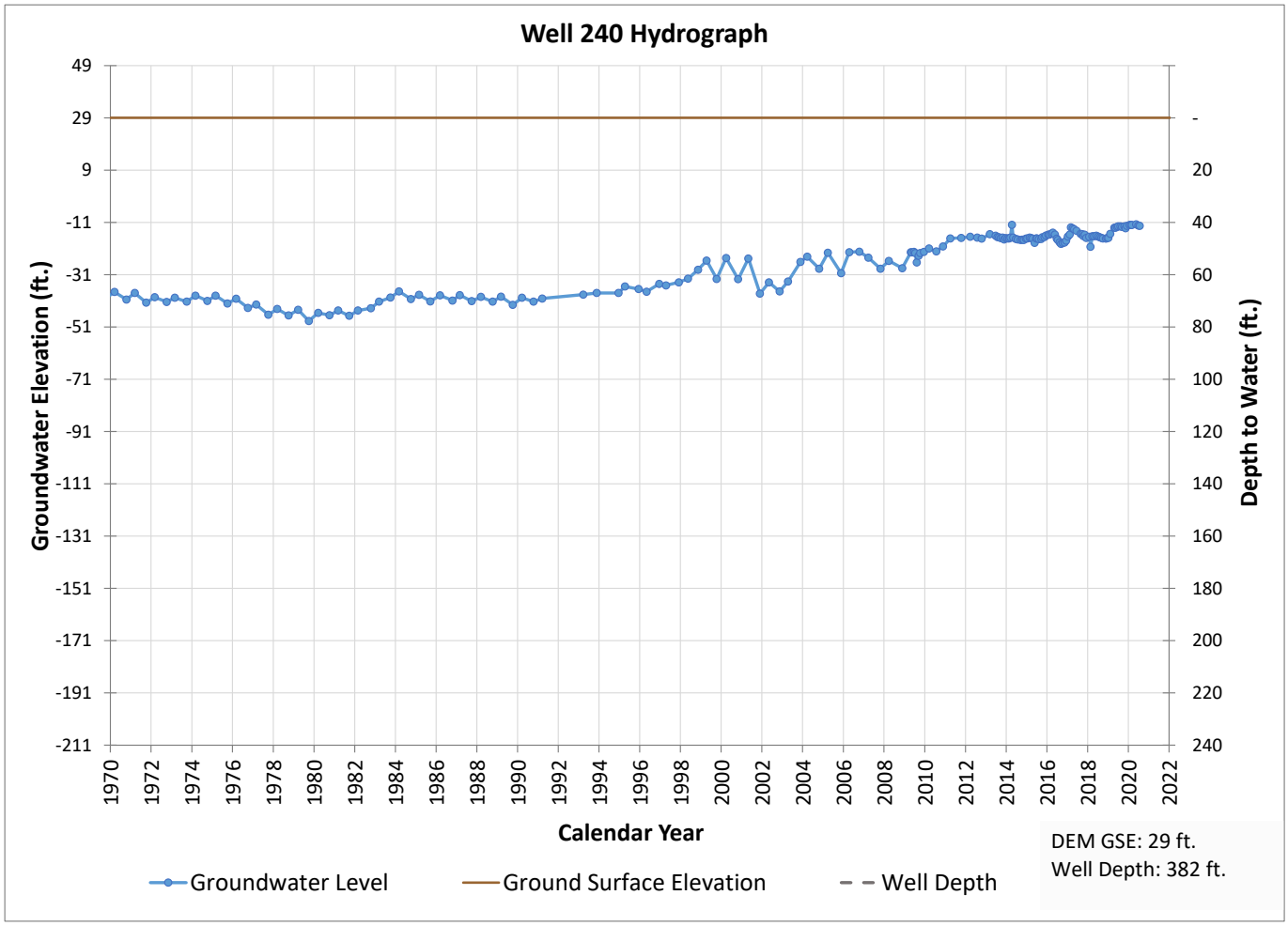

Well 235 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
-226
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 14 ft.
Well Depth: ft.

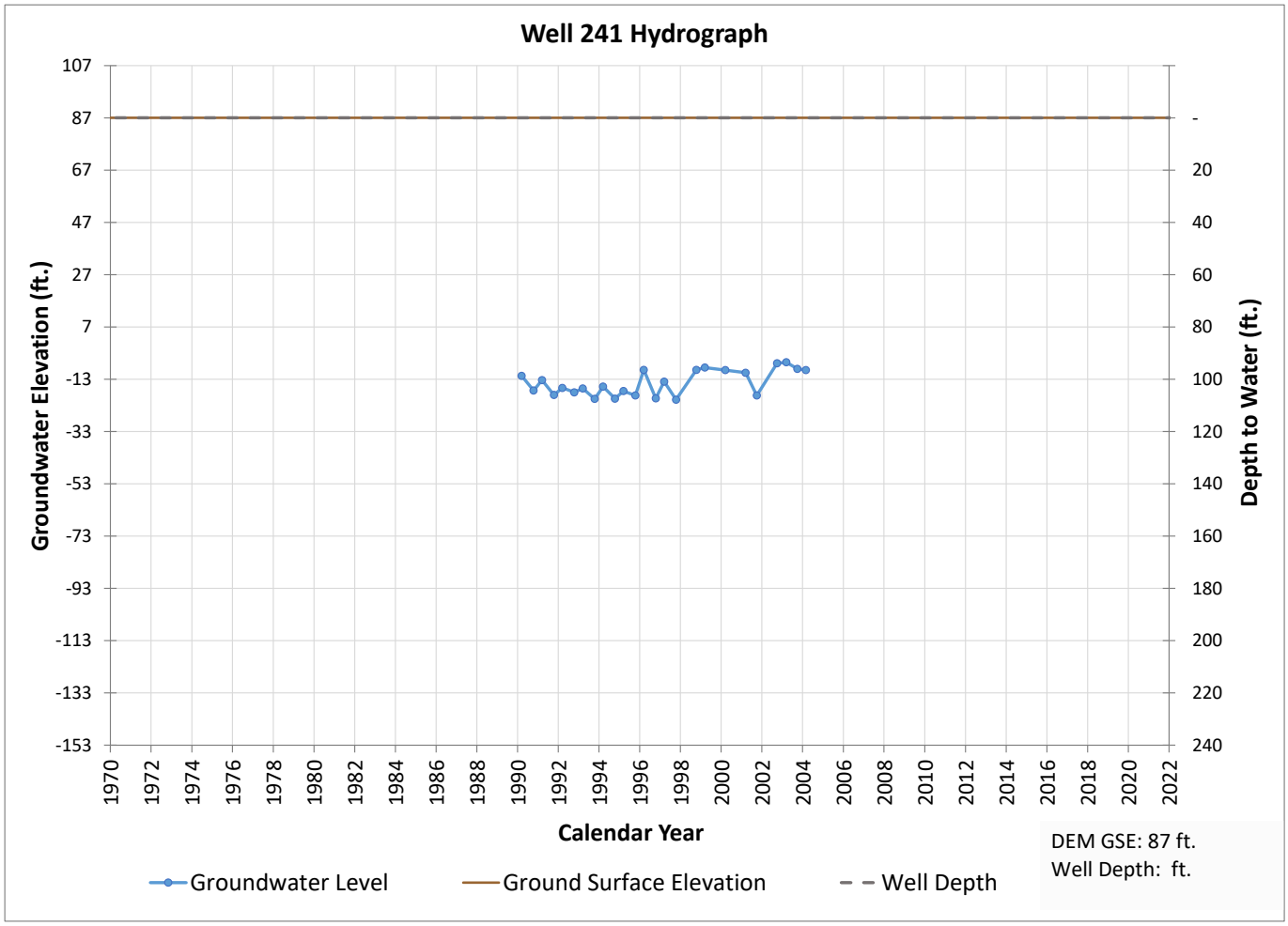

Well 236 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: 140 ft.

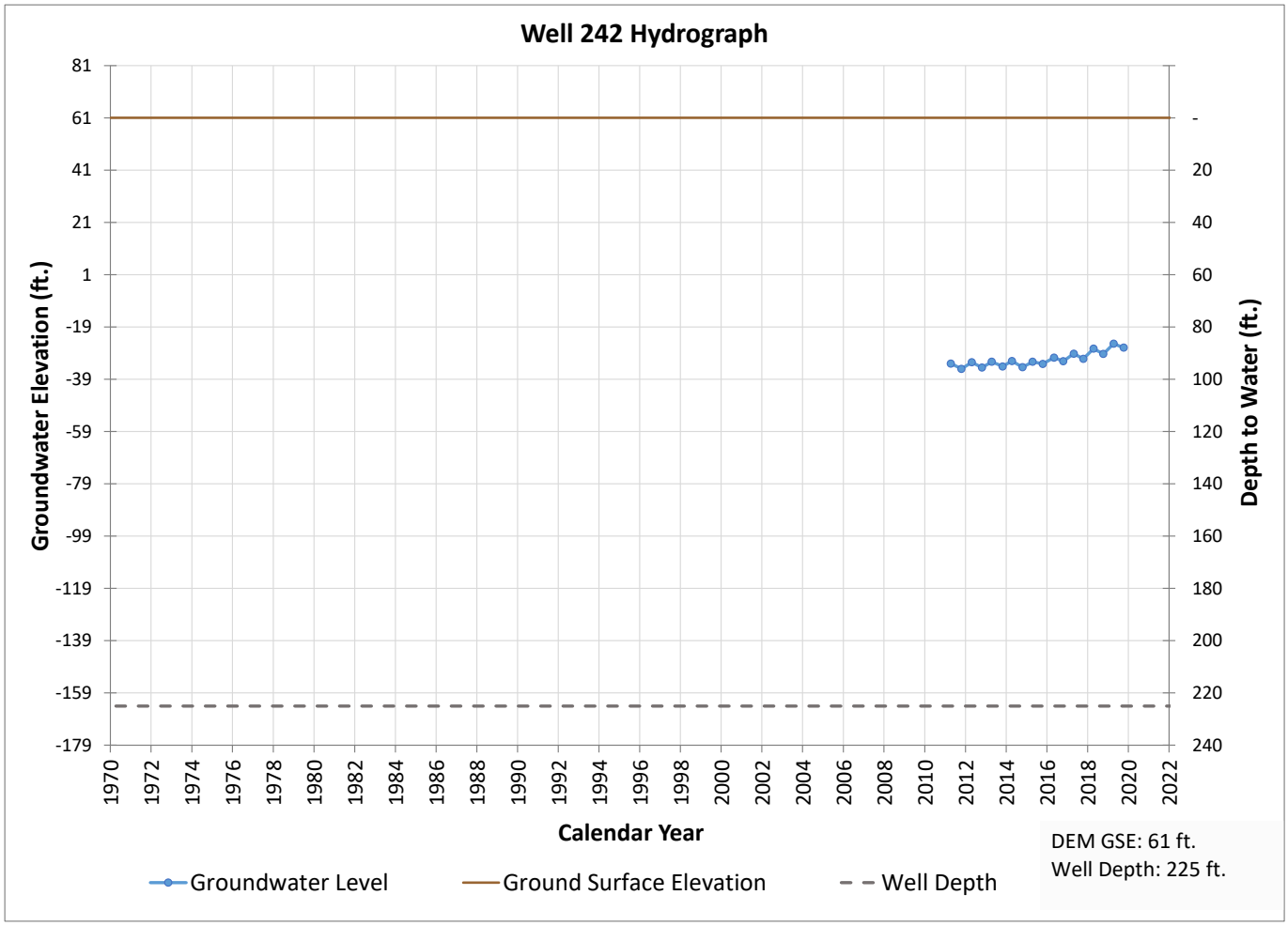

Well 237 Hydrograph
Groundwater Elevation (ft.)
123
103
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 103 ft.
Well Depth: 300 ft.

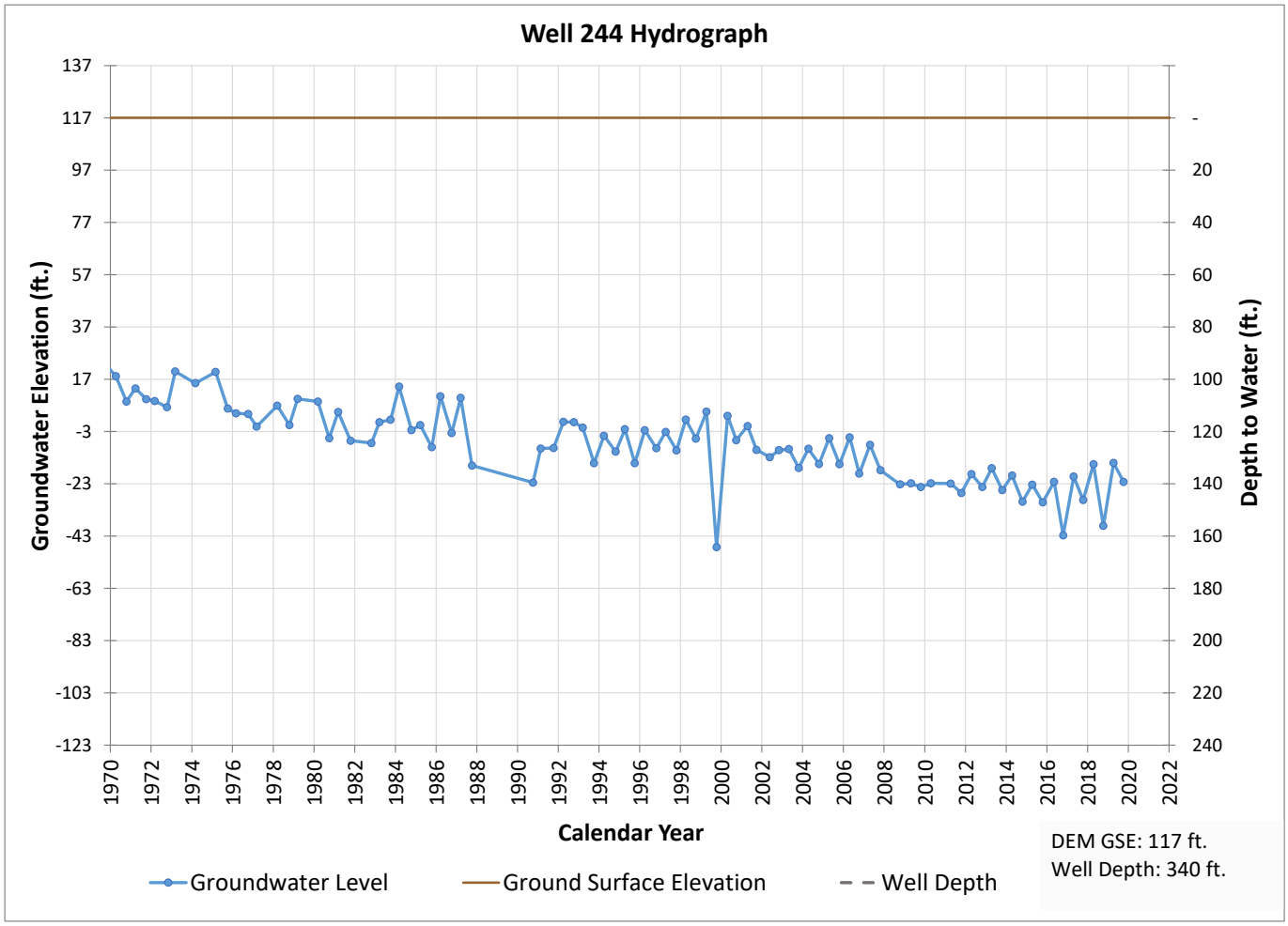

Well 238 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 92 ft.
Well Depth: 170 ft.

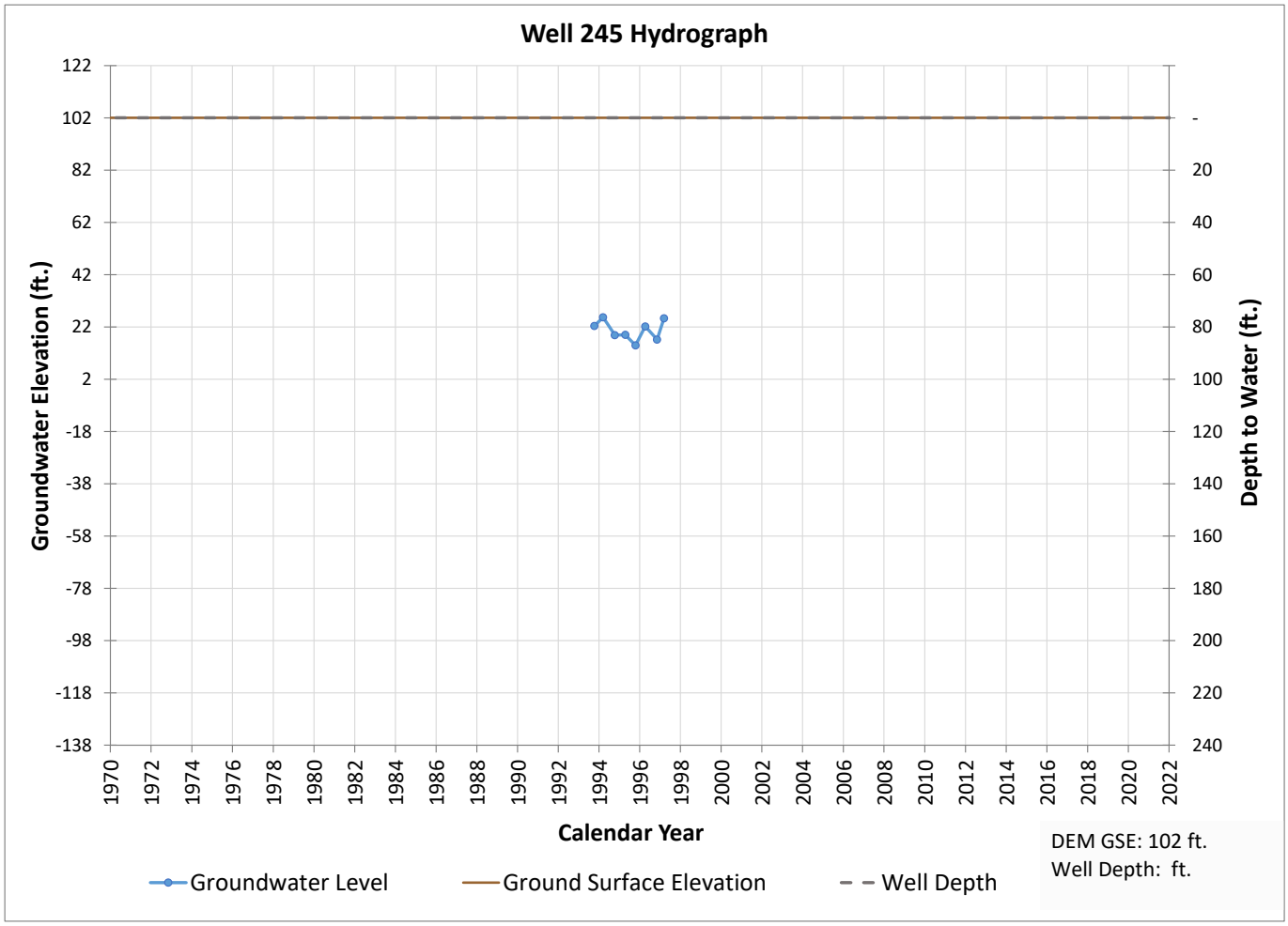

Well 239 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: 22 ft.

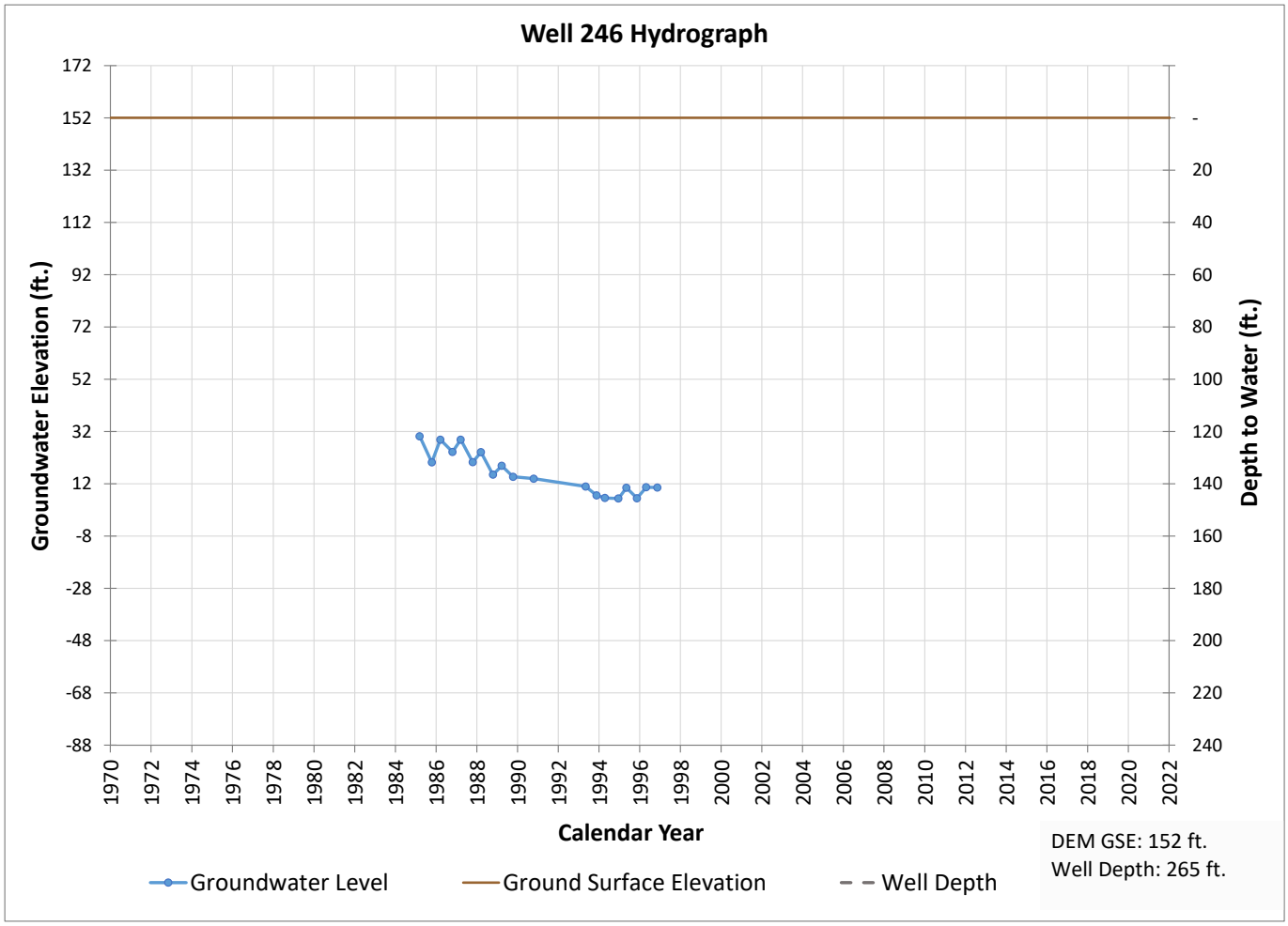

Well 240 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 382 ft.

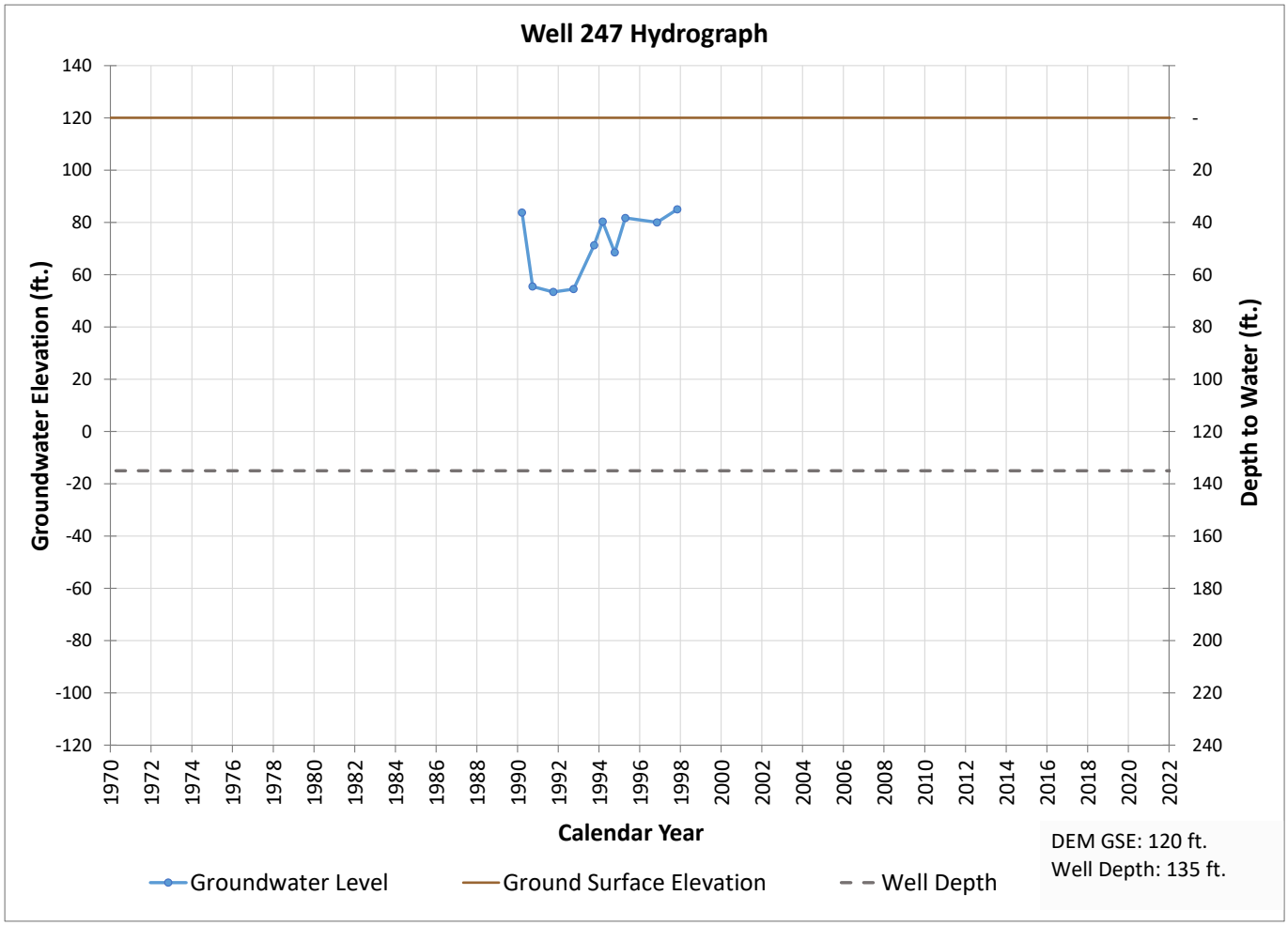

Well 241 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 87 ft.
Well Depth: ft.

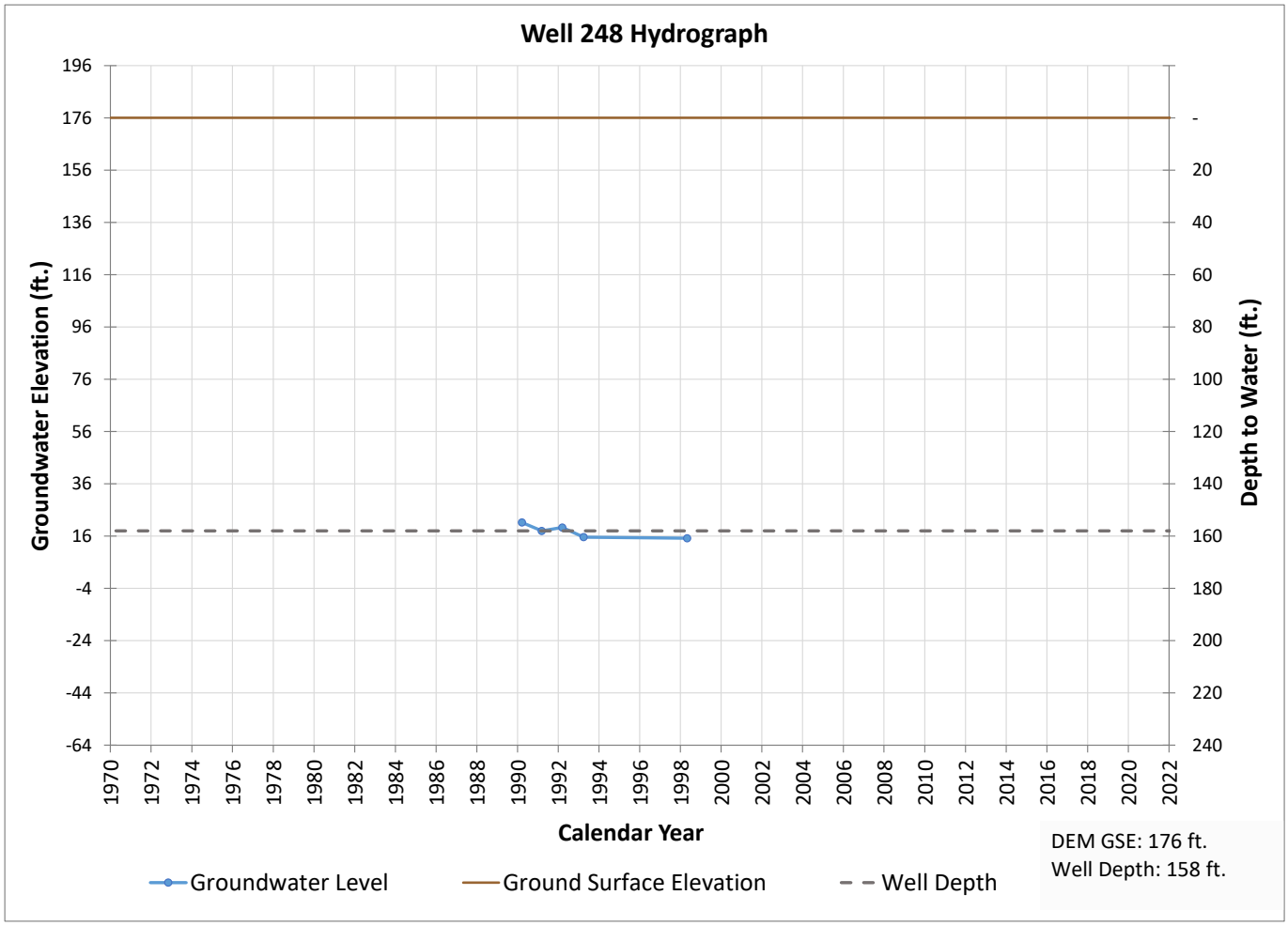

Well 242 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 61 ft.
Well Depth: 225 ft.

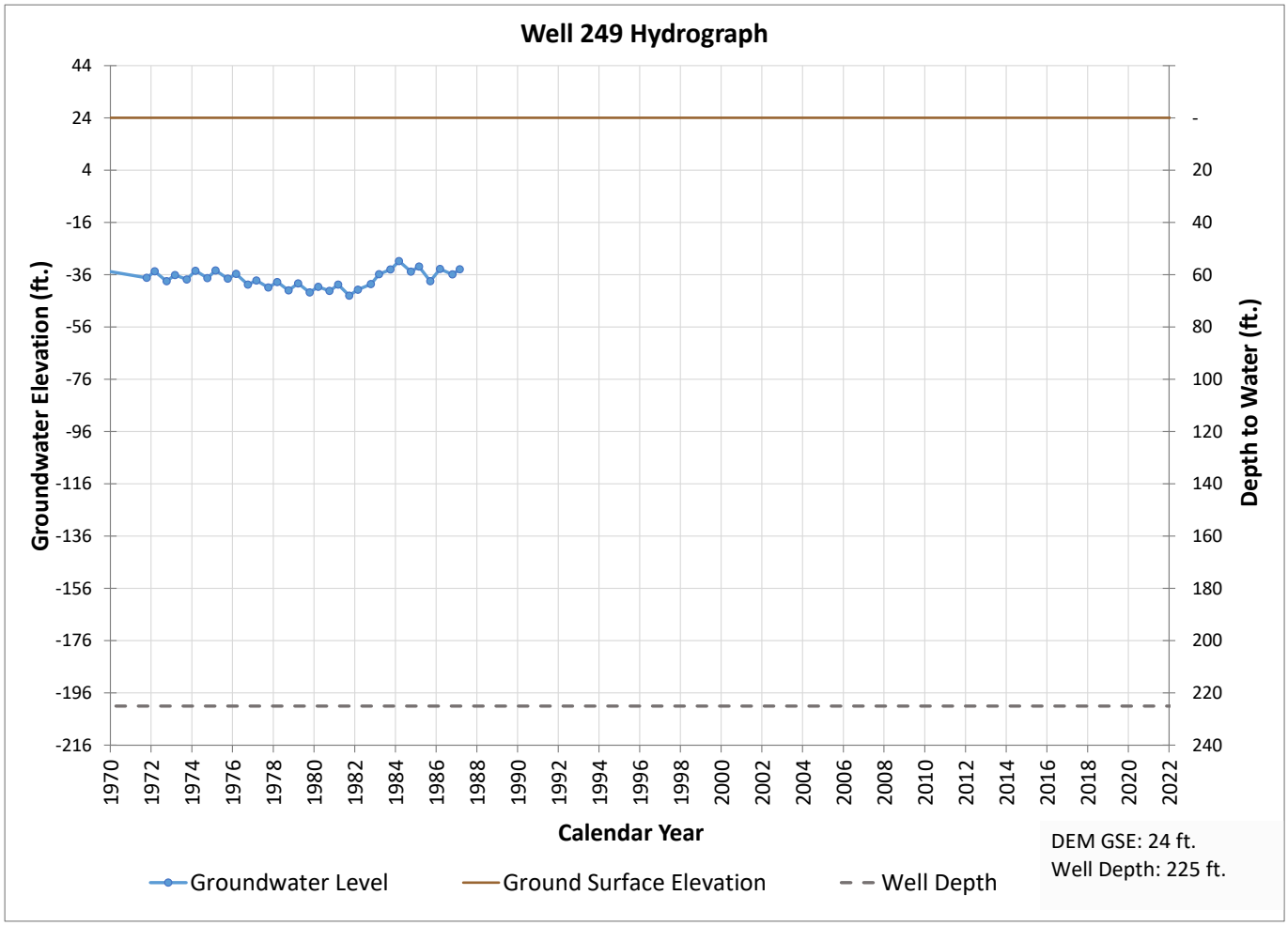

Well 244 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 117 ft.
Well Depth: 340 ft.

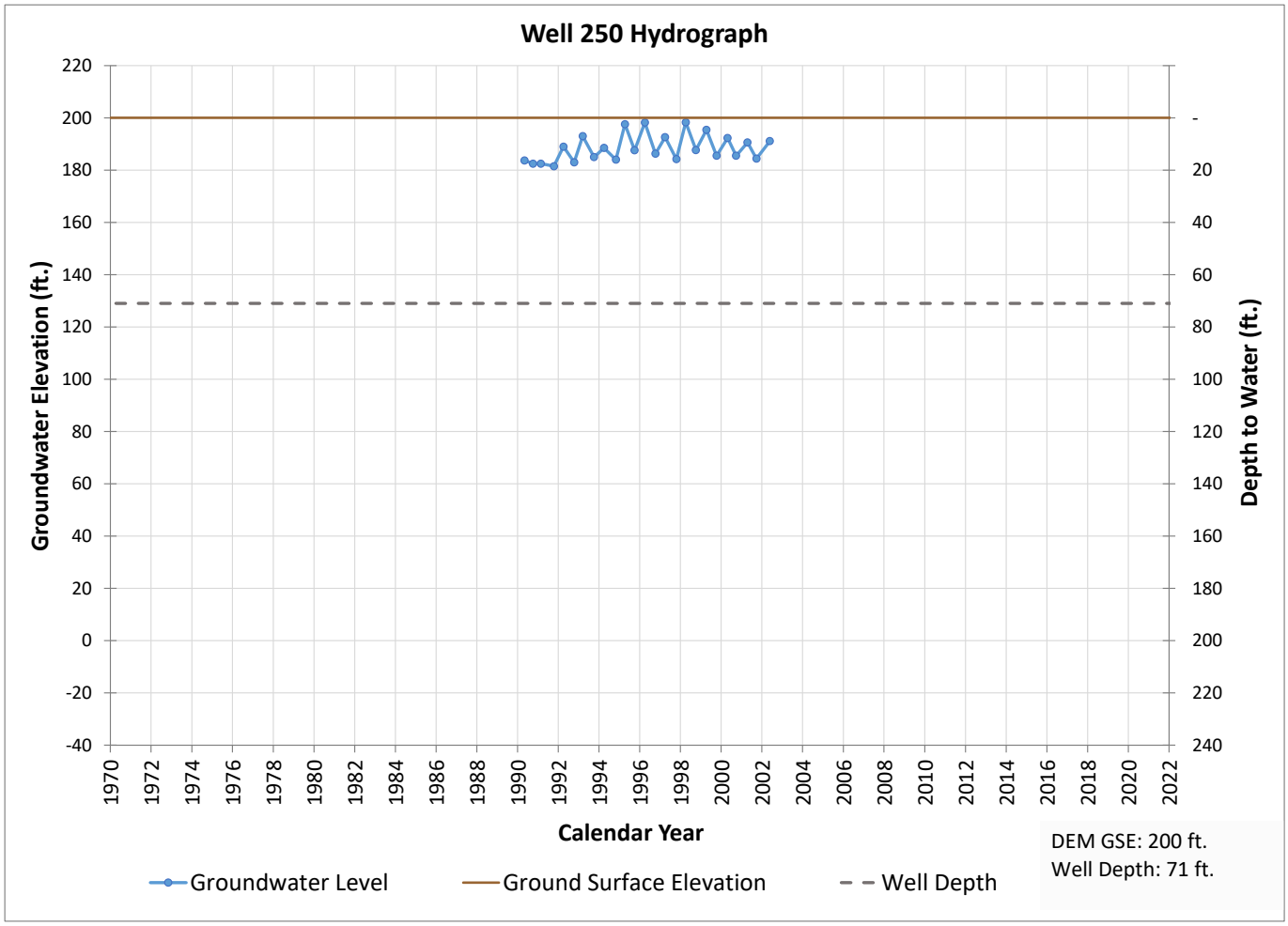

Well 245 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: ft.

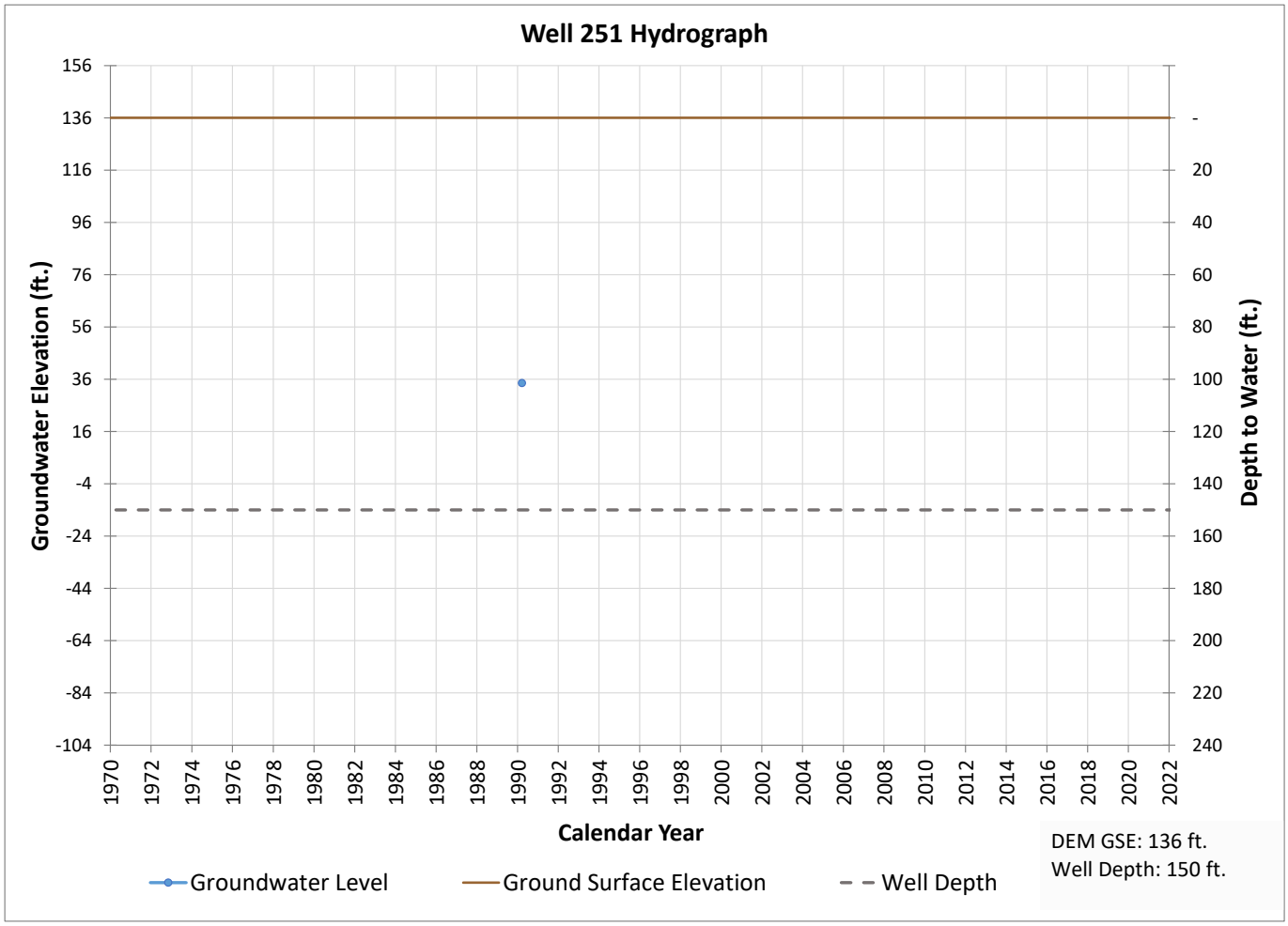

Well 246 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
172
152
132
112
92
72
52
32
12
-8
-28
-48
-68
-88
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 152 ft.
Well Depth: 265 ft.

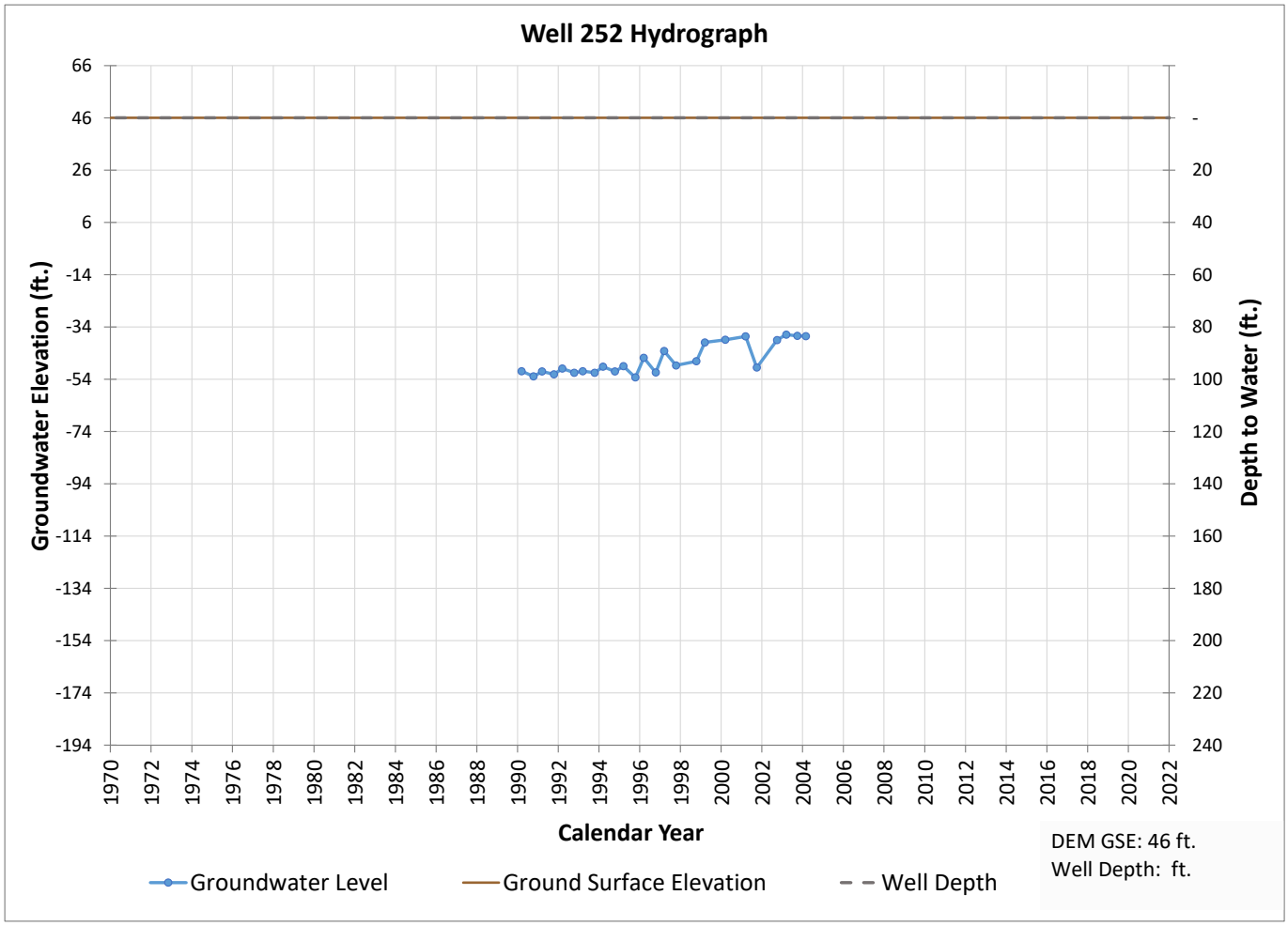

Well 247 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 120 ft.
Well Depth: 135 ft.

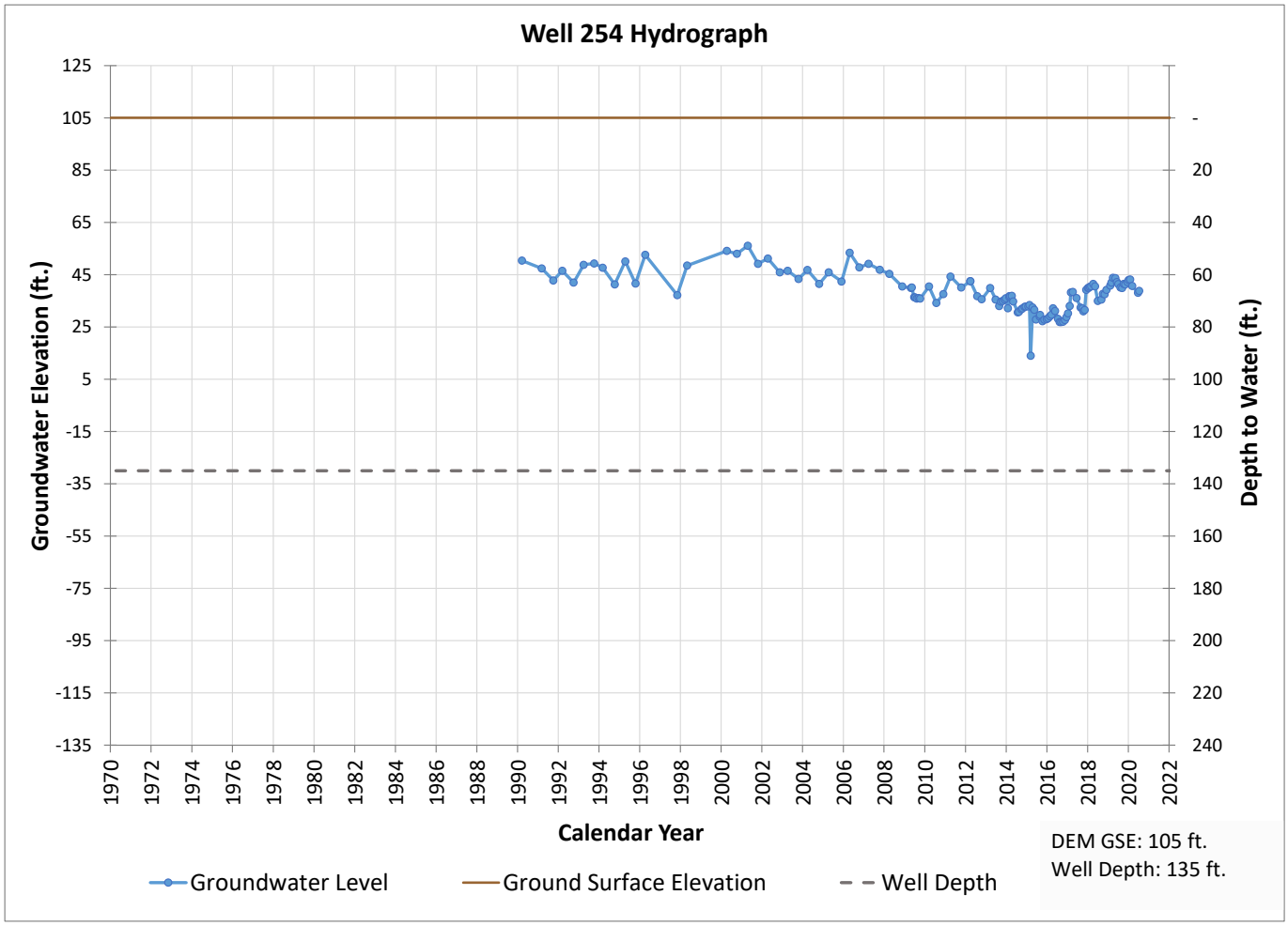

Well 248 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
196
176
156
136
116
96
76
56
36
16
-4
-24
-44
-64
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 176 ft.
Well Depth: 158 ft.

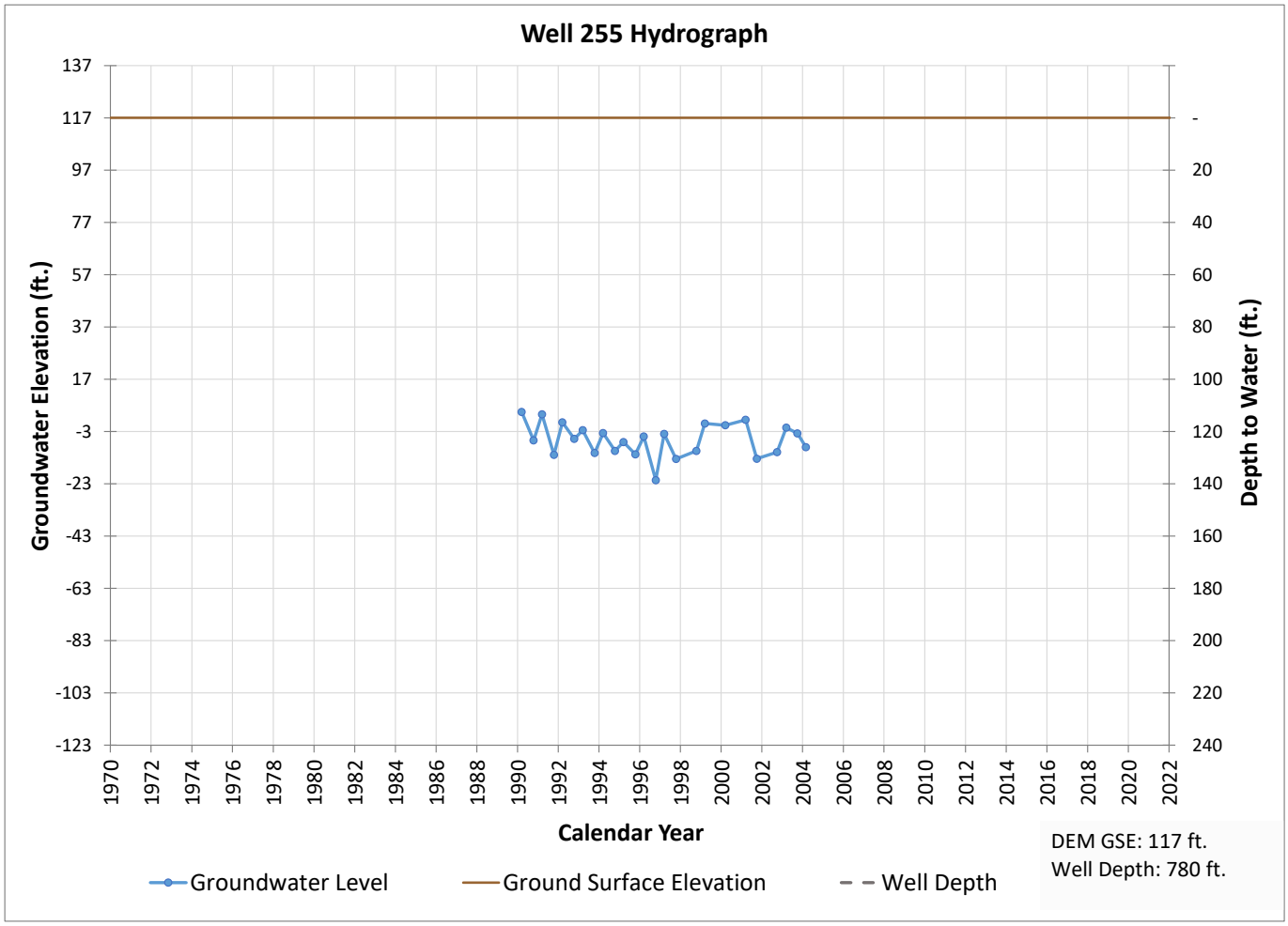

Well 249 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
-216
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 24 ft.
Well Depth: 225 ft.

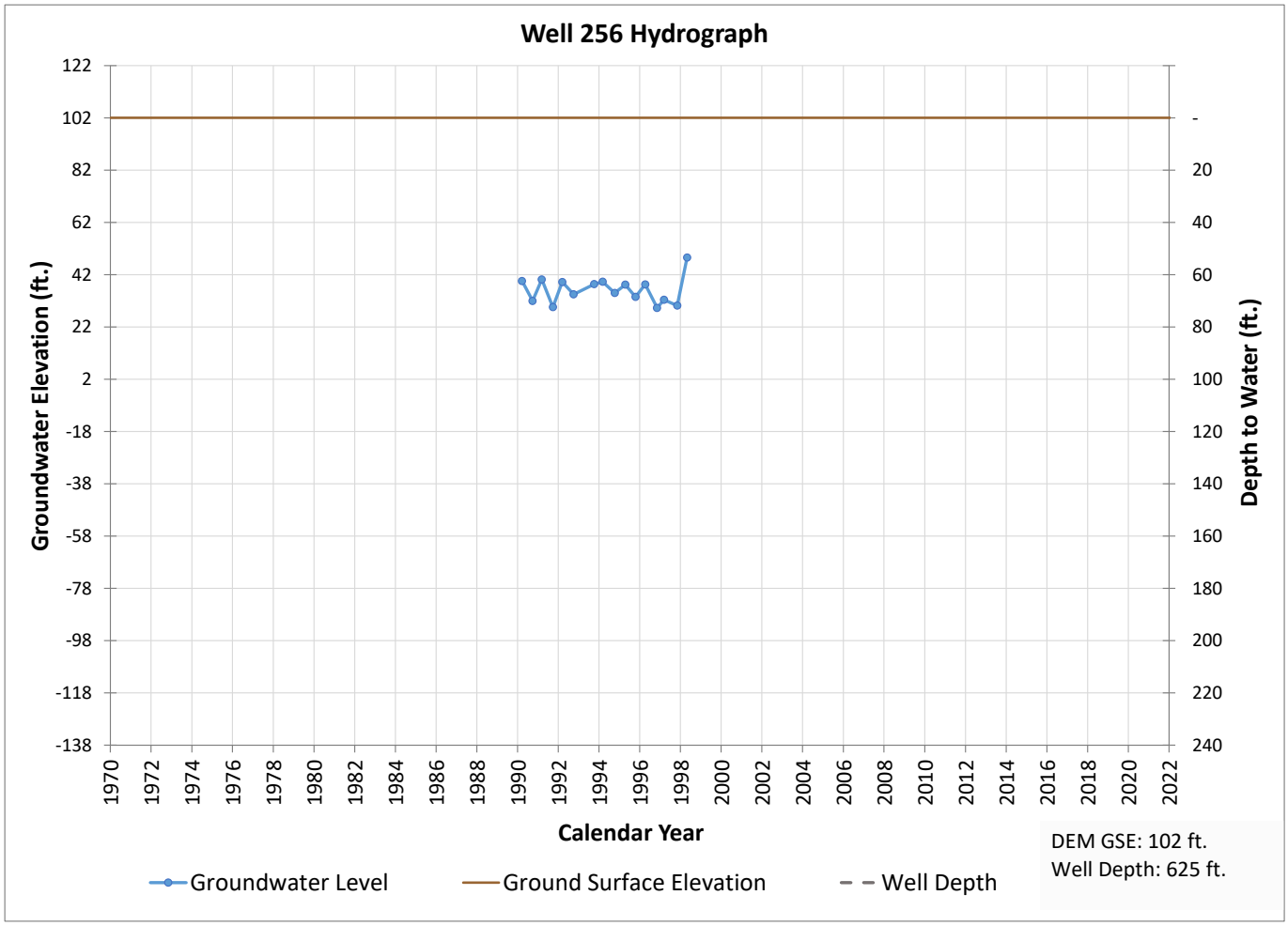

Well 250 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 200 ft.
Well Depth: 71 ft.

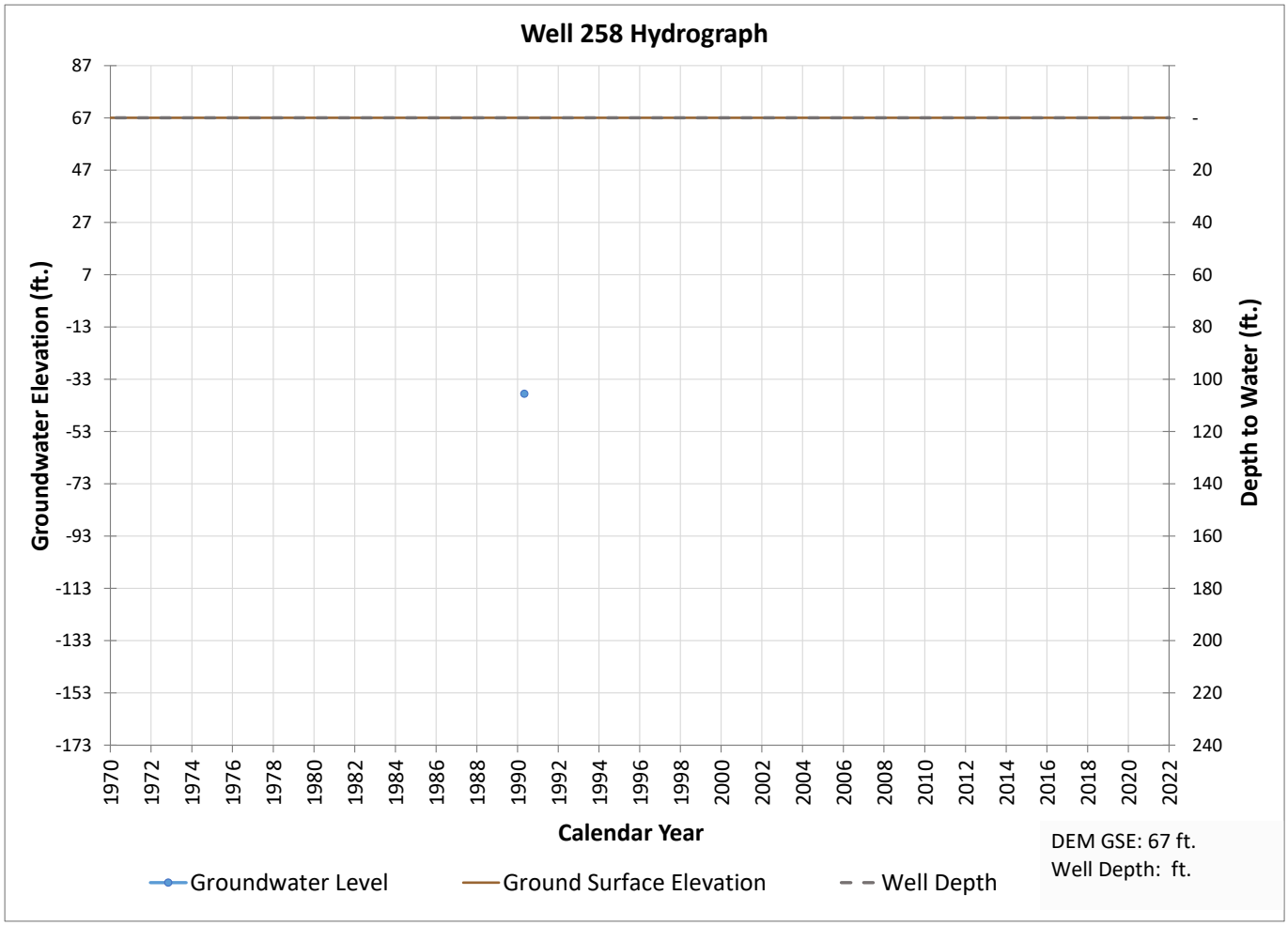

Well 251 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
156
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 136 ft.
Well Depth: 150 ft.

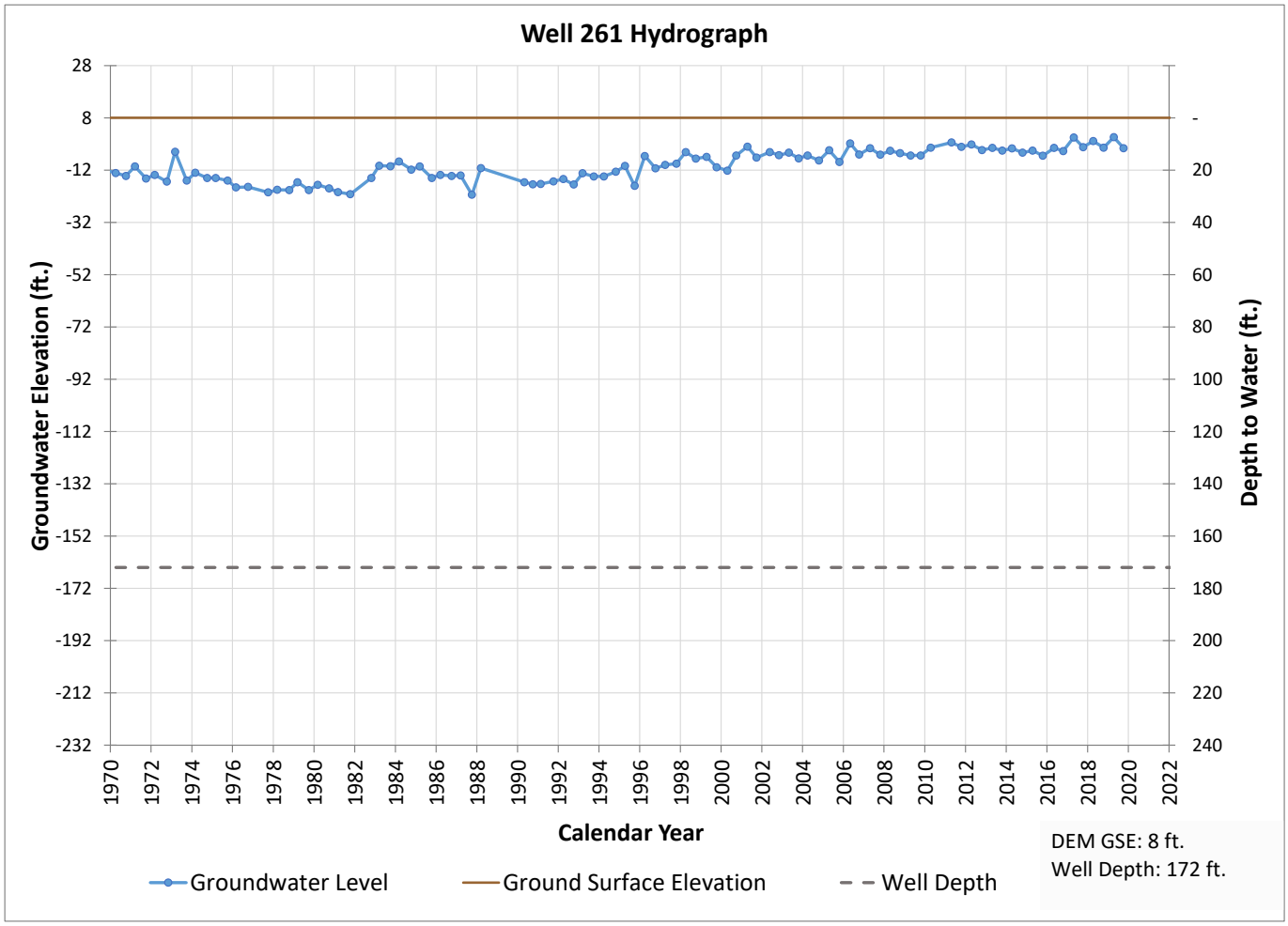

Well 252 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: ft.

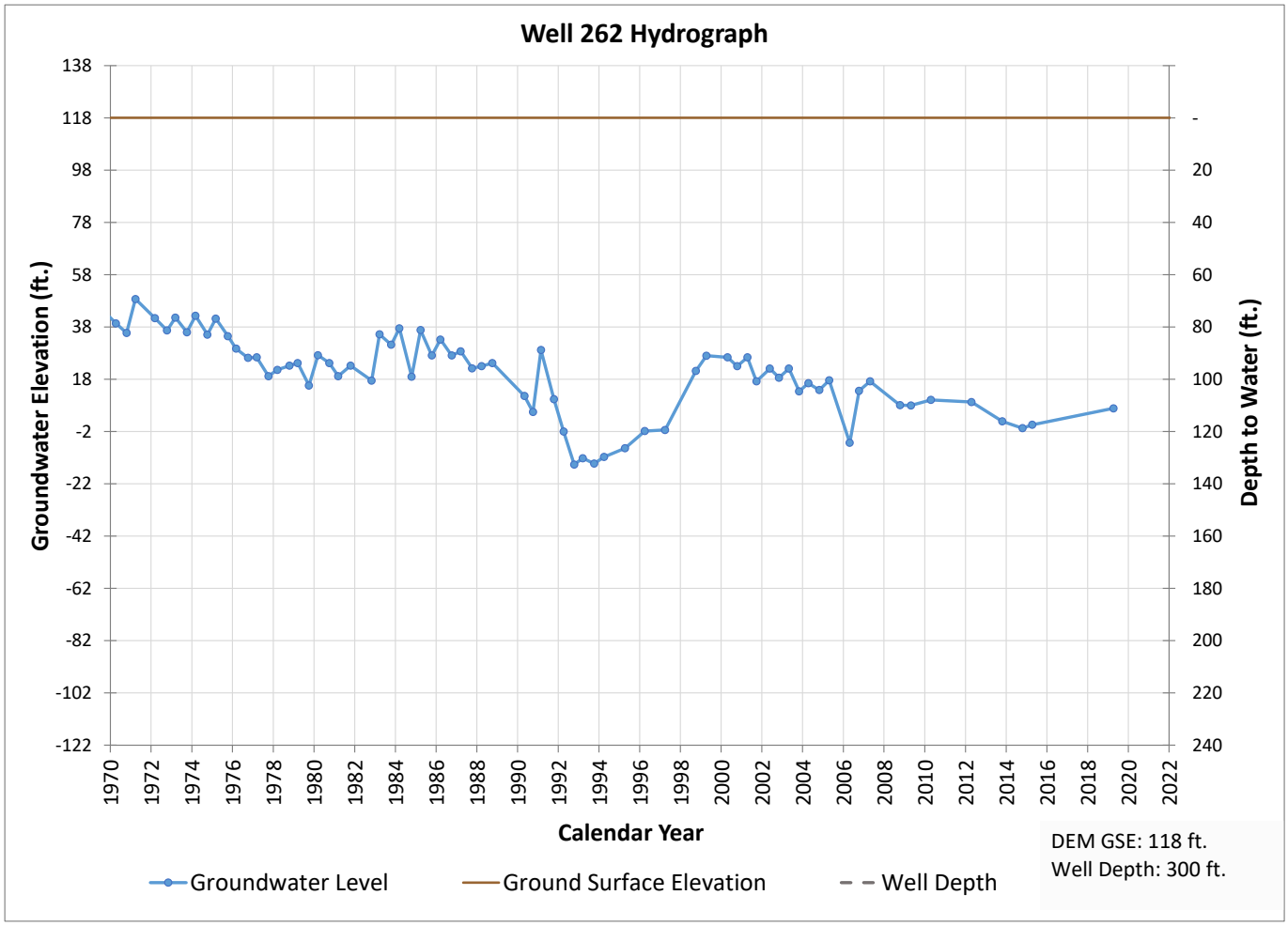

Well 254 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
125
105
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 105 ft.
Well Depth: 135 ft.

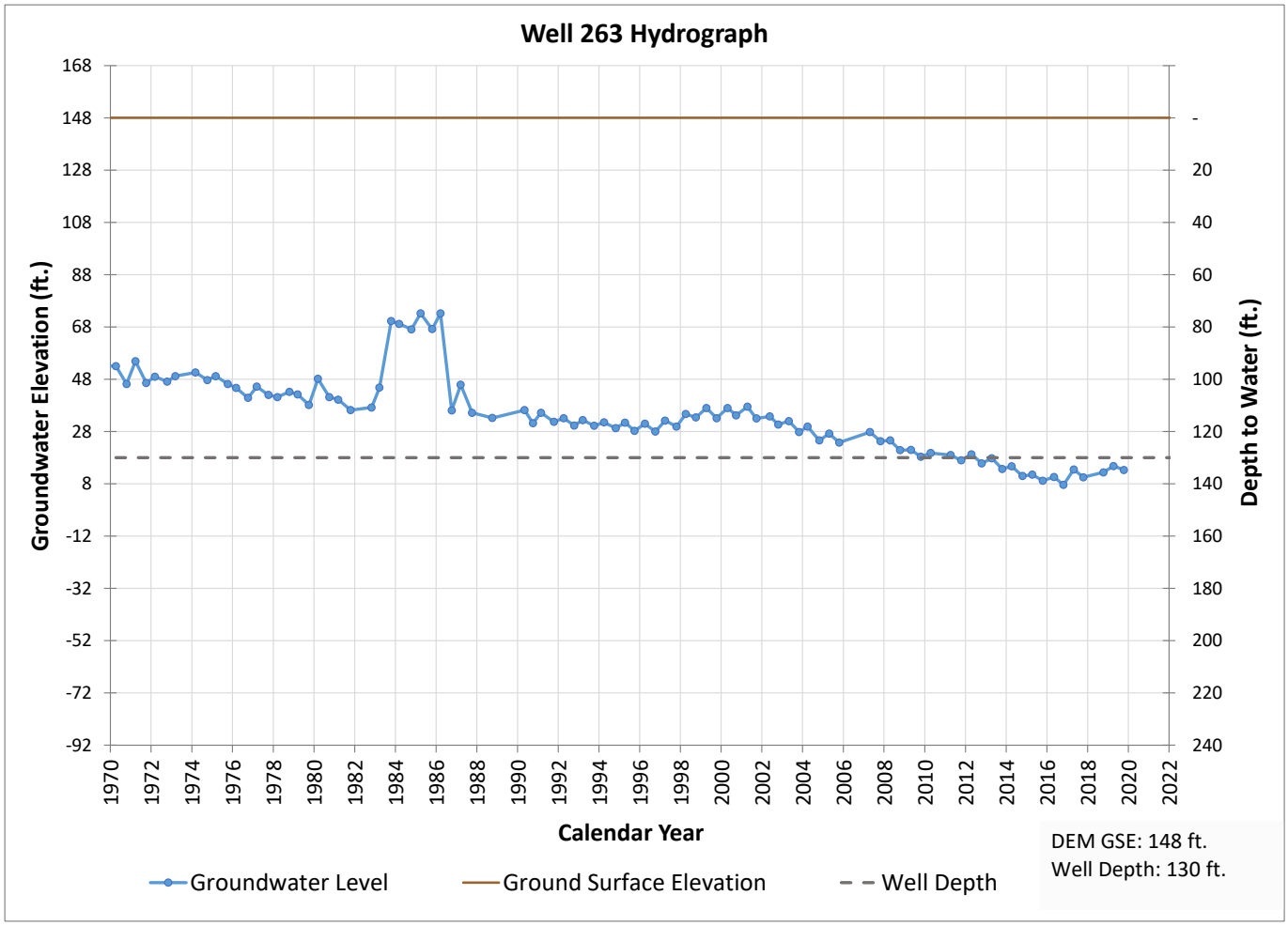

Well 255 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 117 ft.
Well Depth: 780 ft.

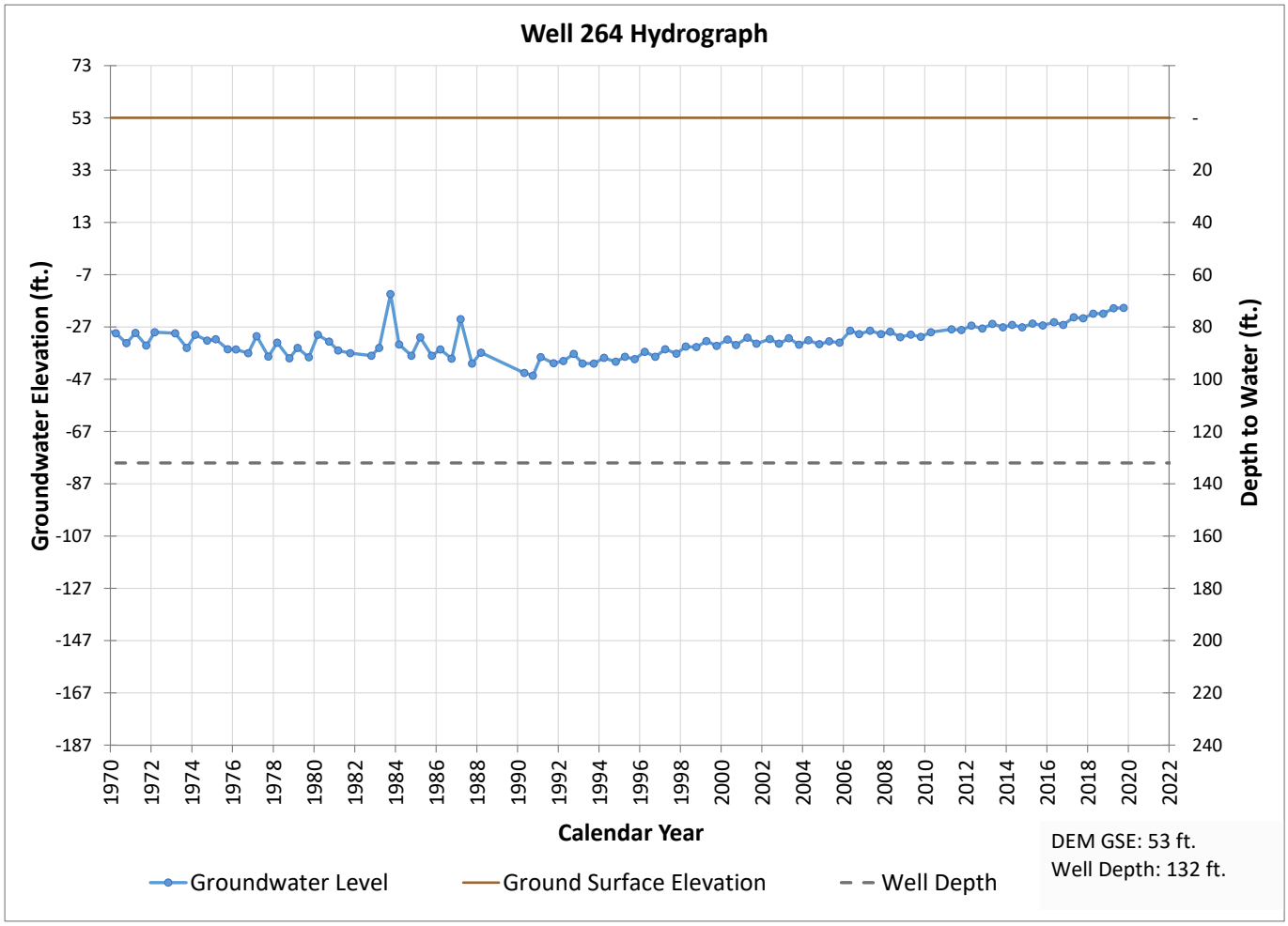

Well 256 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 102 ft.
Well Depth: 625 ft.

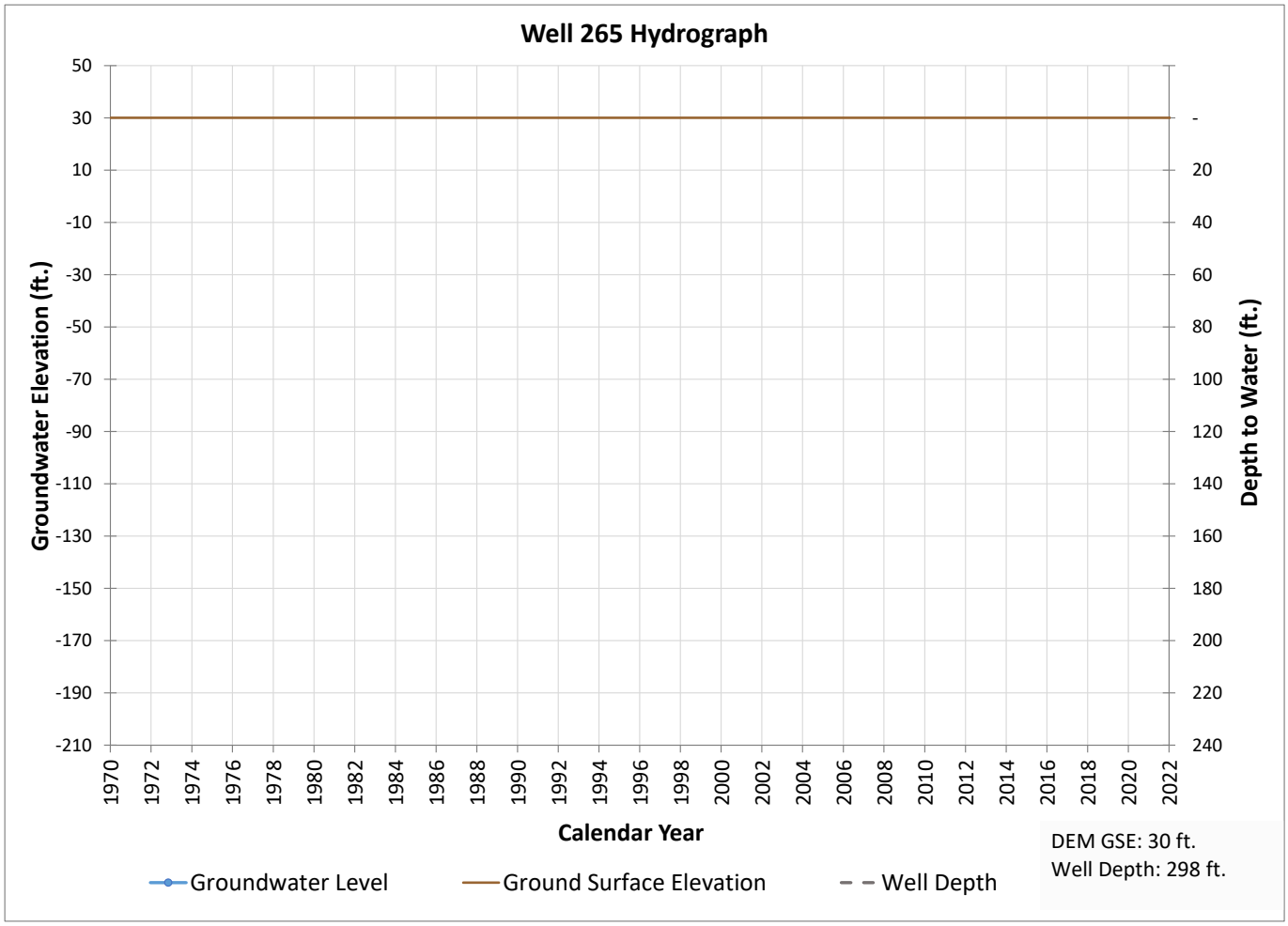

Well 258 Hydrograph
Groundwater Elevation (ft.)
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: ft.

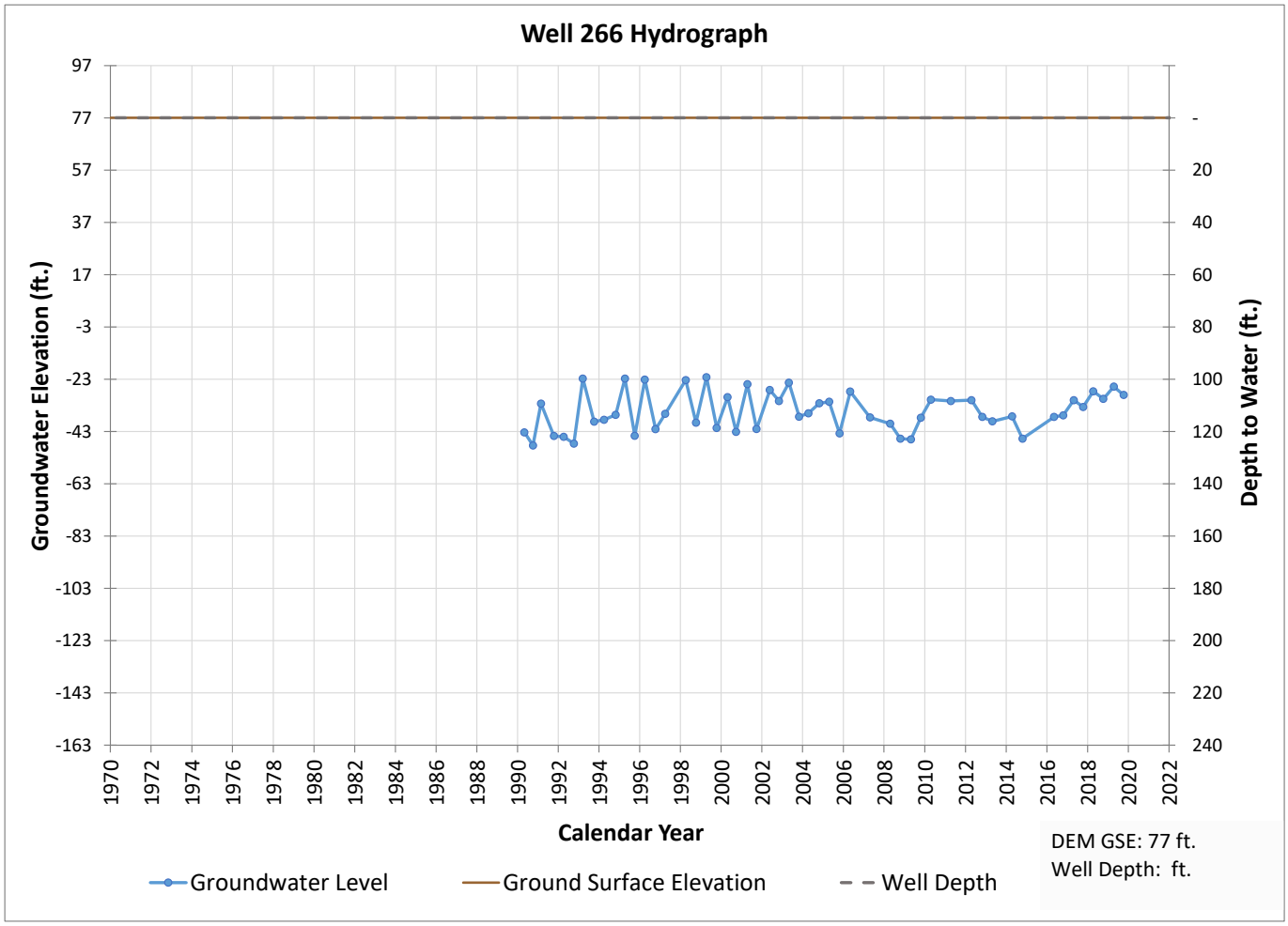

Well 261 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
-232
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 8 ft.
Well Depth: 172 ft.

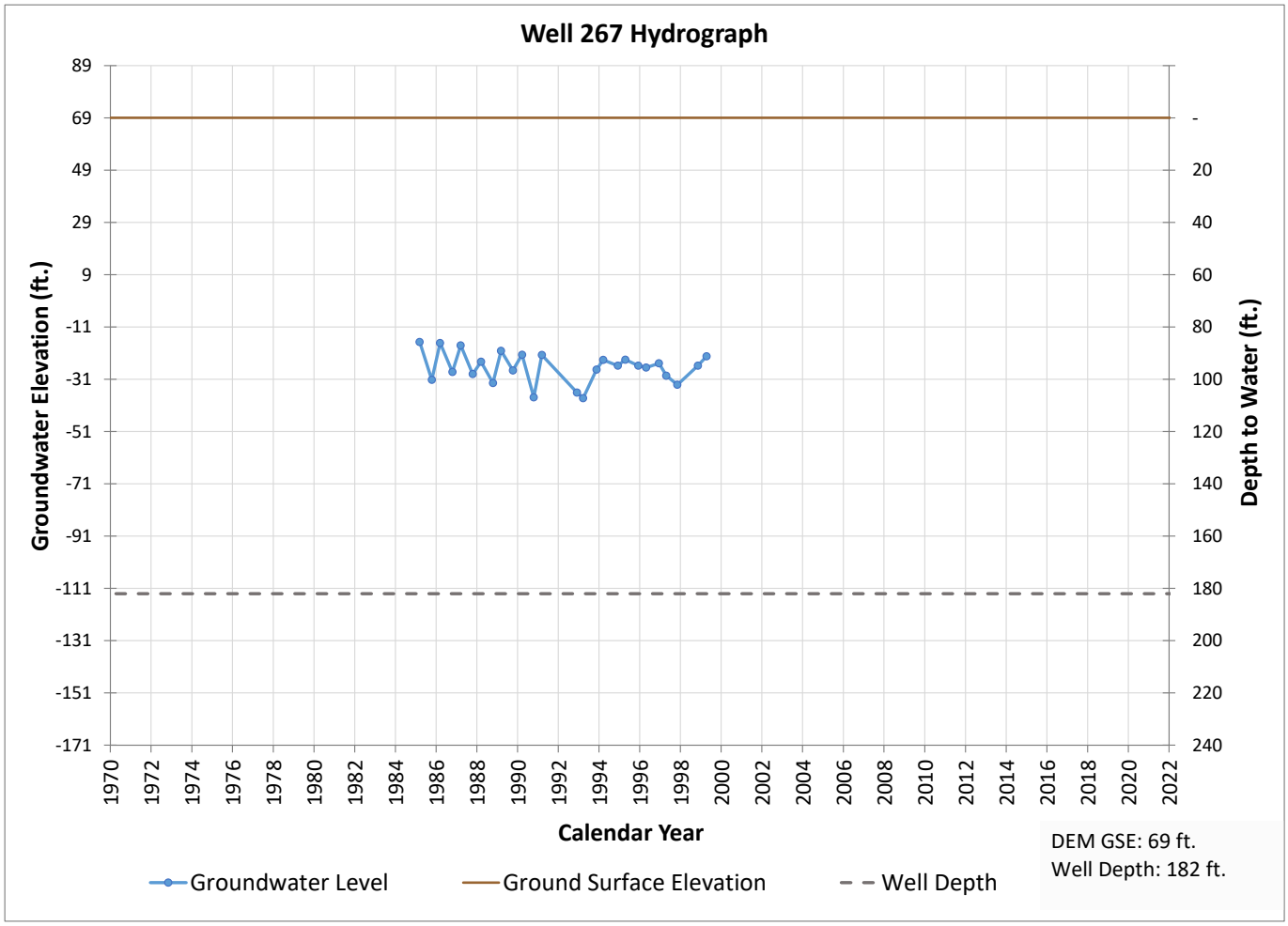

Well 262 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
138
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 118 ft.
Well Depth: 300 ft.

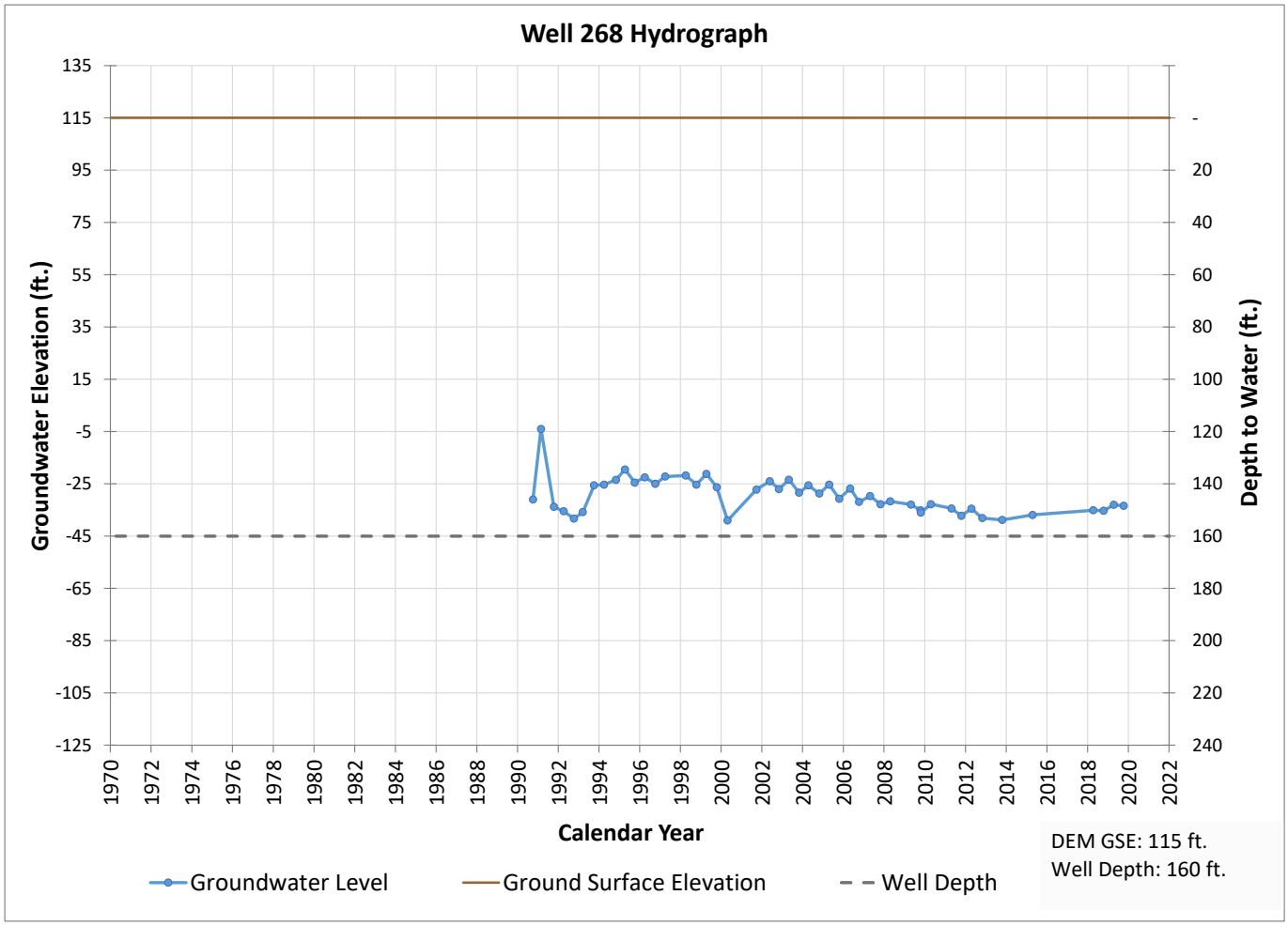

Well 263 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
168
148
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 148 ft.
Well Depth: 130 ft.

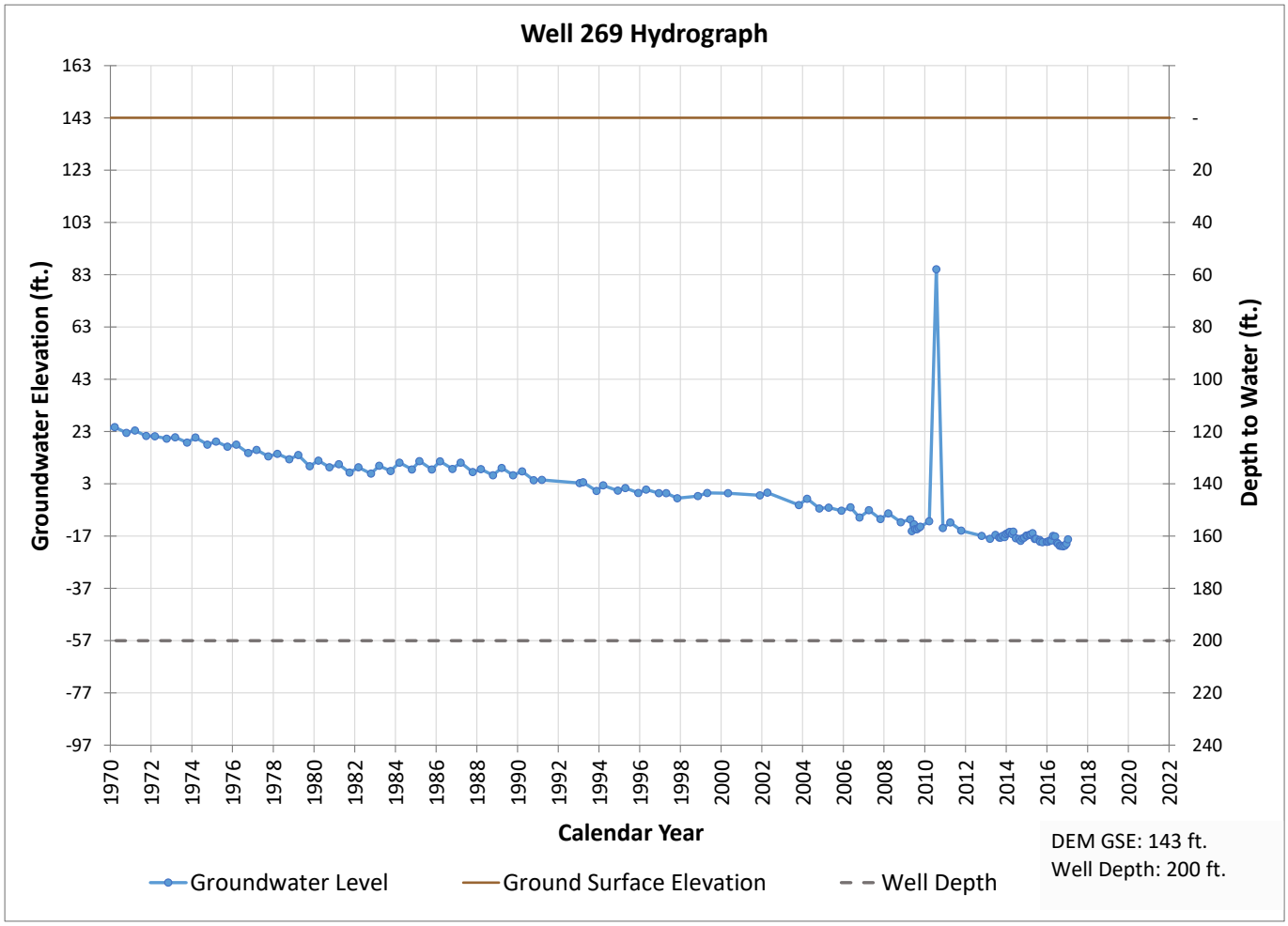

Well 264 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 53 ft.
Well Depth: 132 ft.

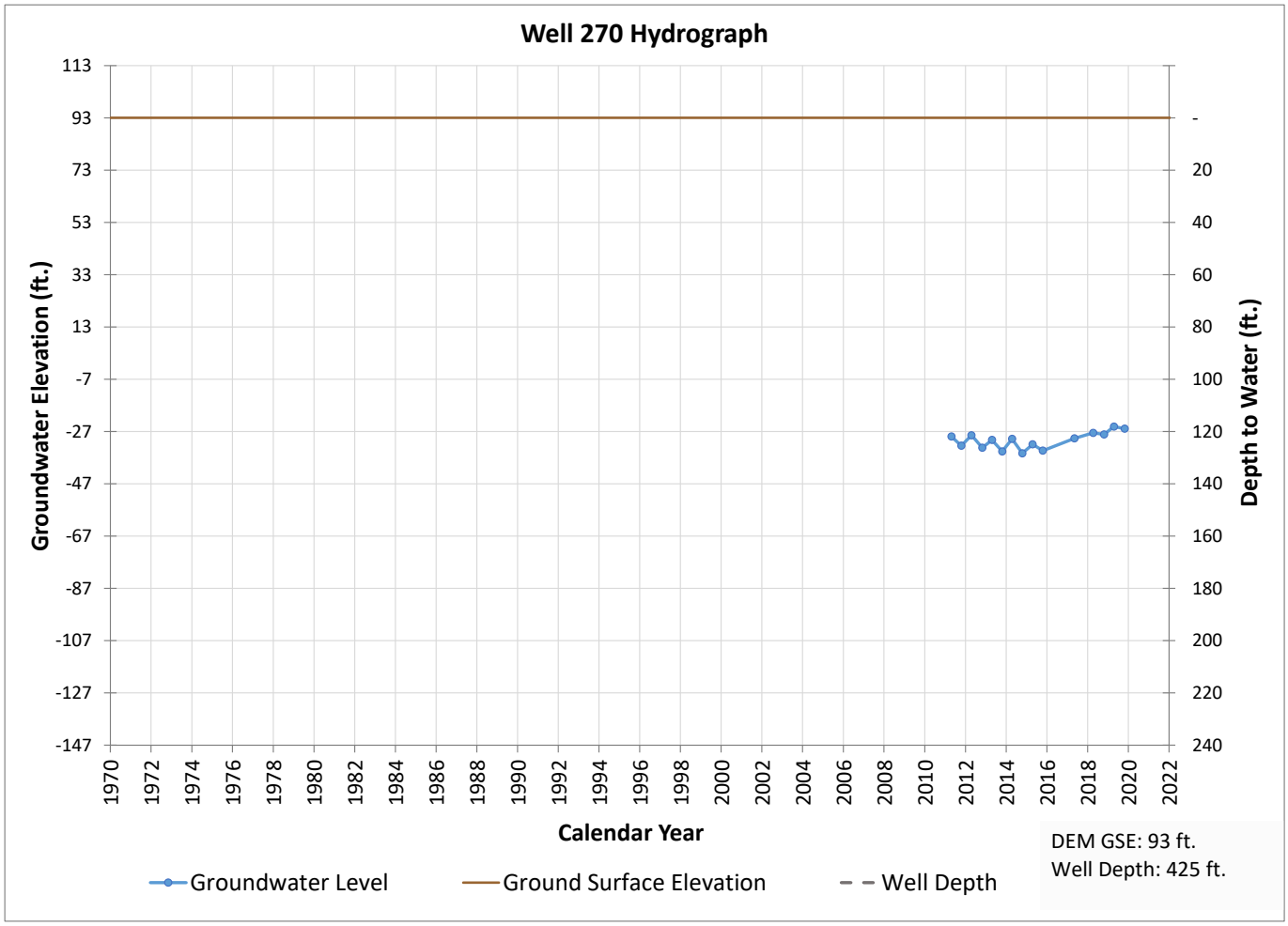

Well 265 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 30 ft.
Well Depth: 298 ft.

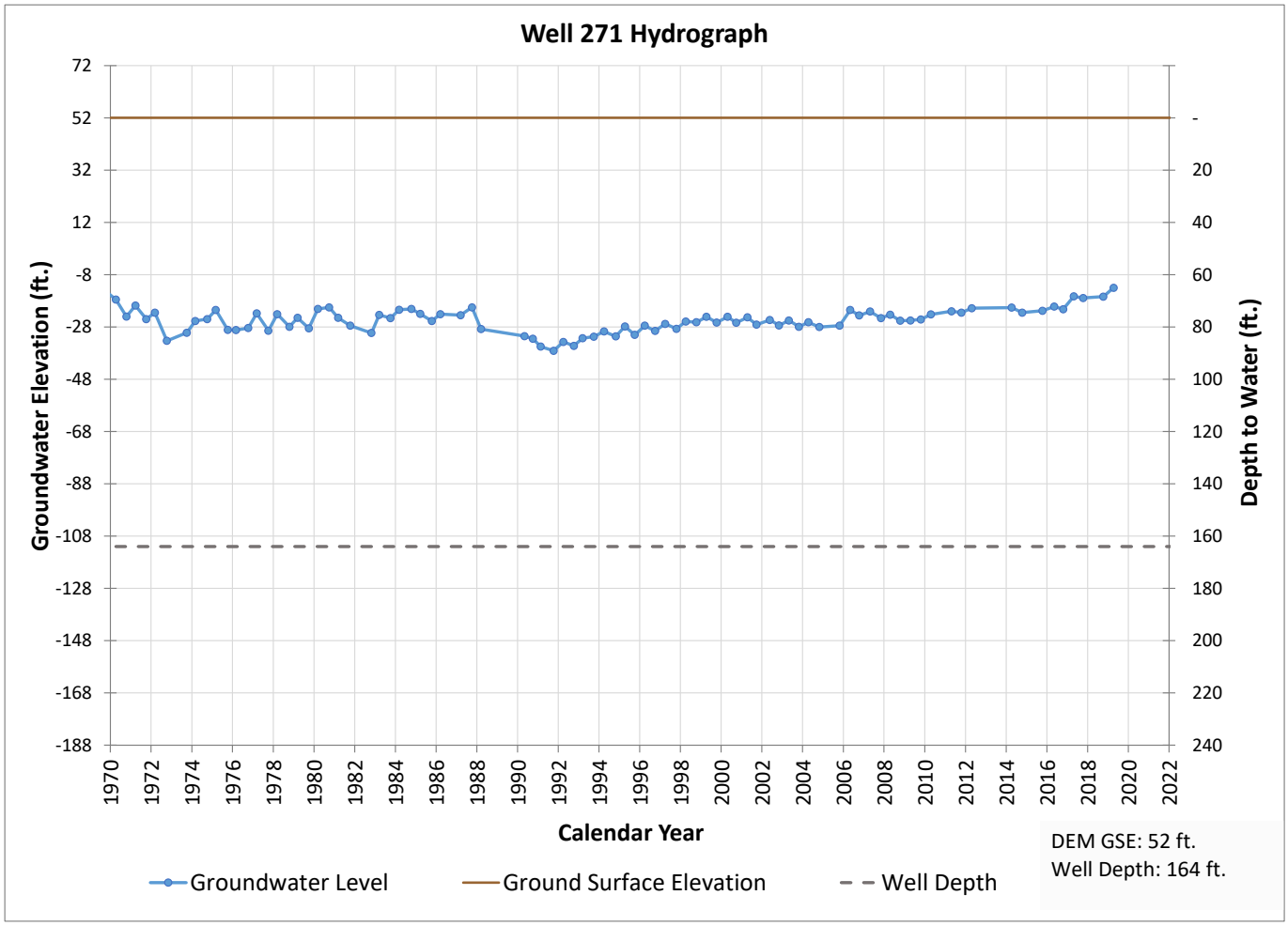

Well 266 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: ft.

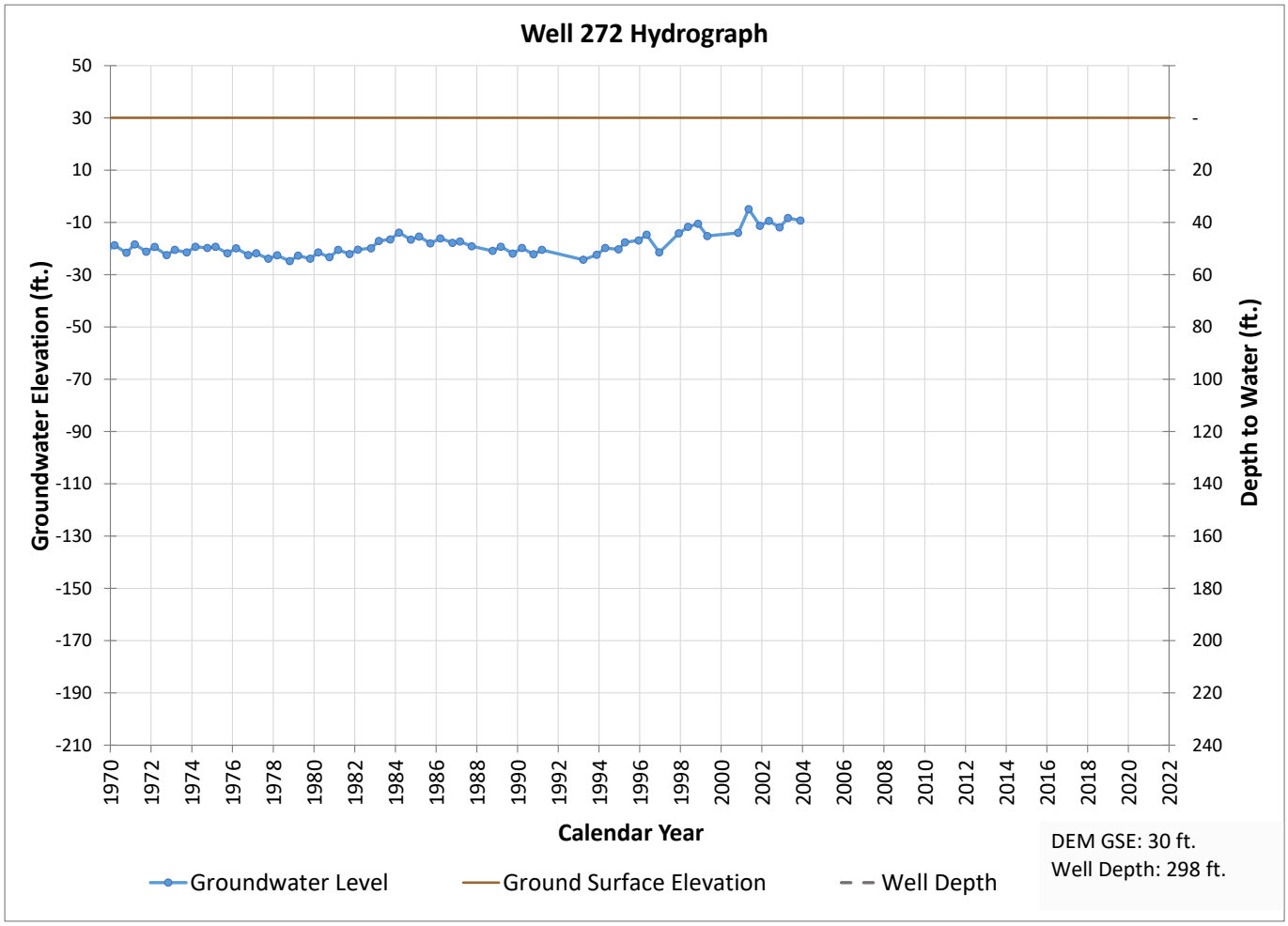

Well 267 Hydrograph
Groundwater Elevation (ft.)
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 69 ft.
Well Depth: 182 ft.

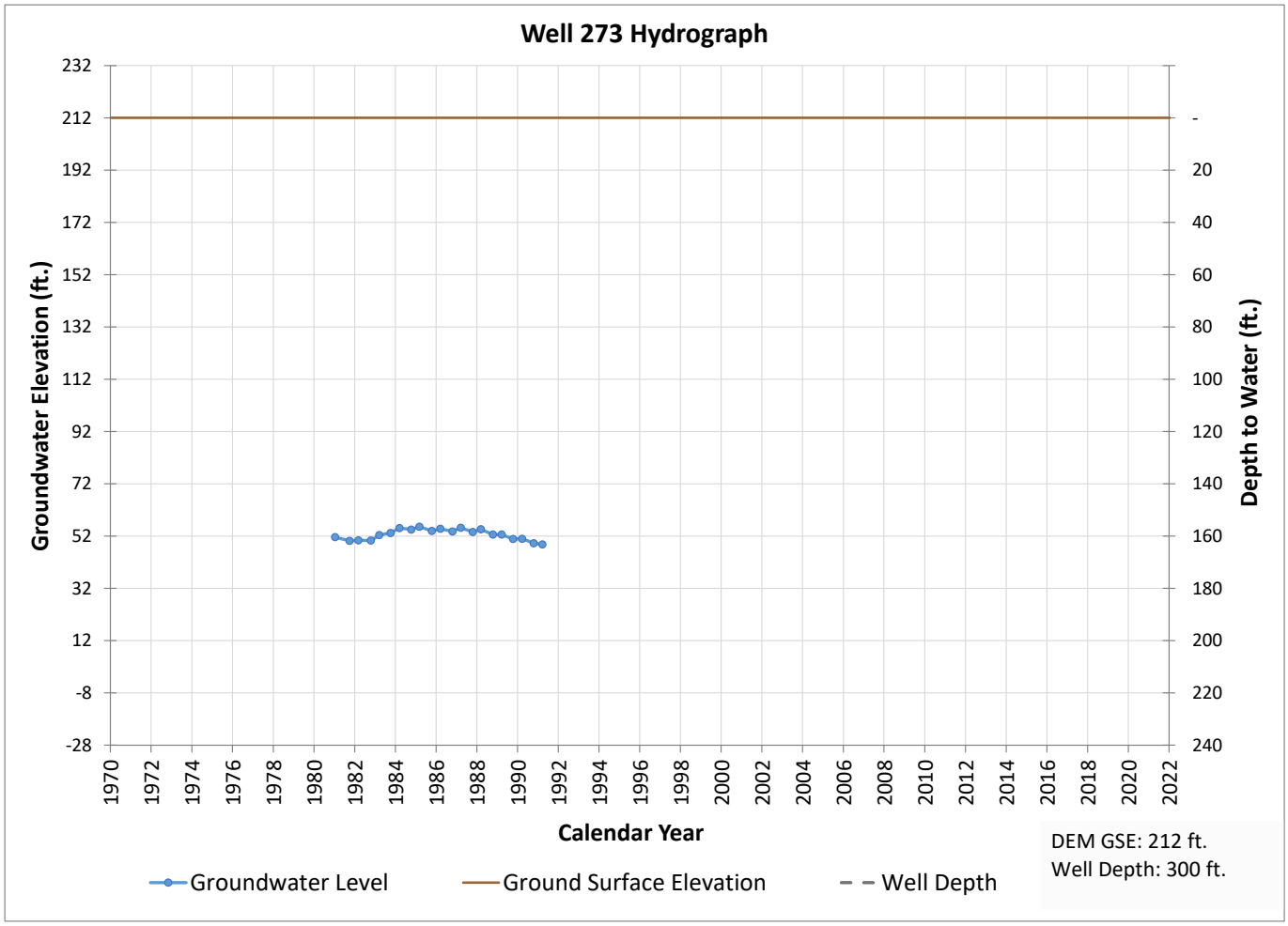

Well 268 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 115 ft.
Well Depth: 160 ft.

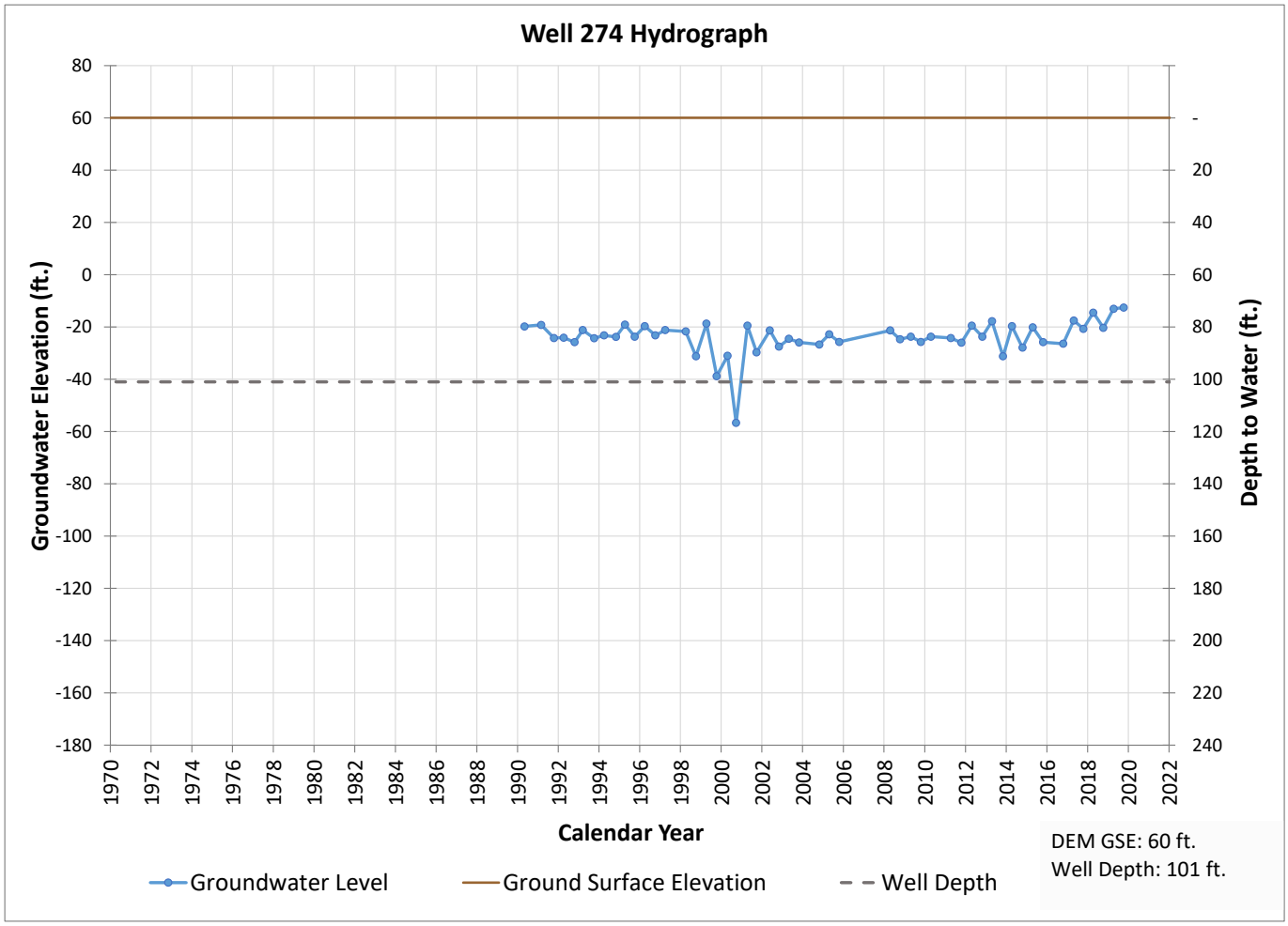

Well 269 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
163
143
123
103
83
63
43
23
3
-17
-37
-57
-77
-97
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 143 ft.
Well Depth: 200 ft.

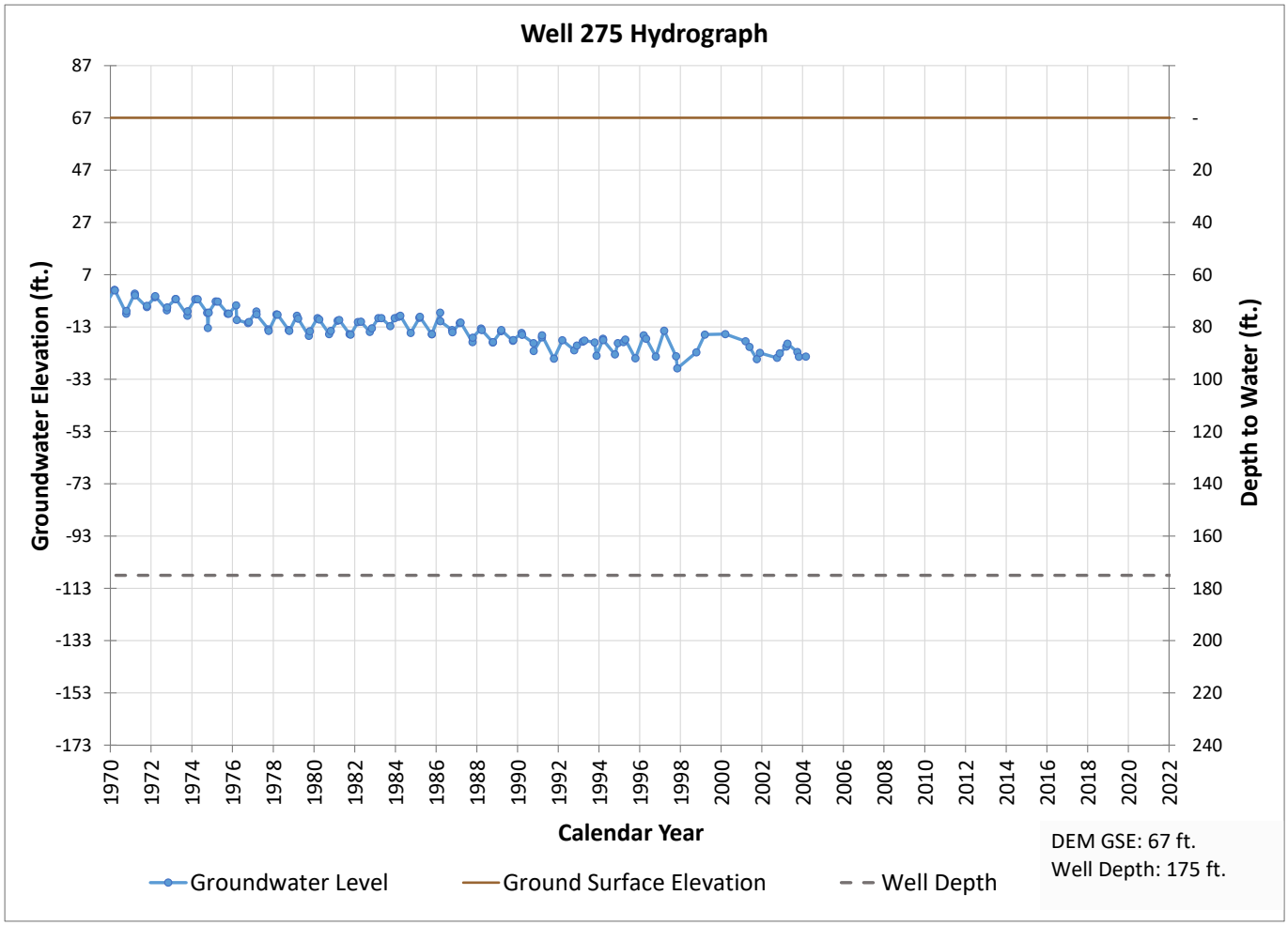

Well 270 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
113
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 93 ft.
Well Depth: 425 ft.

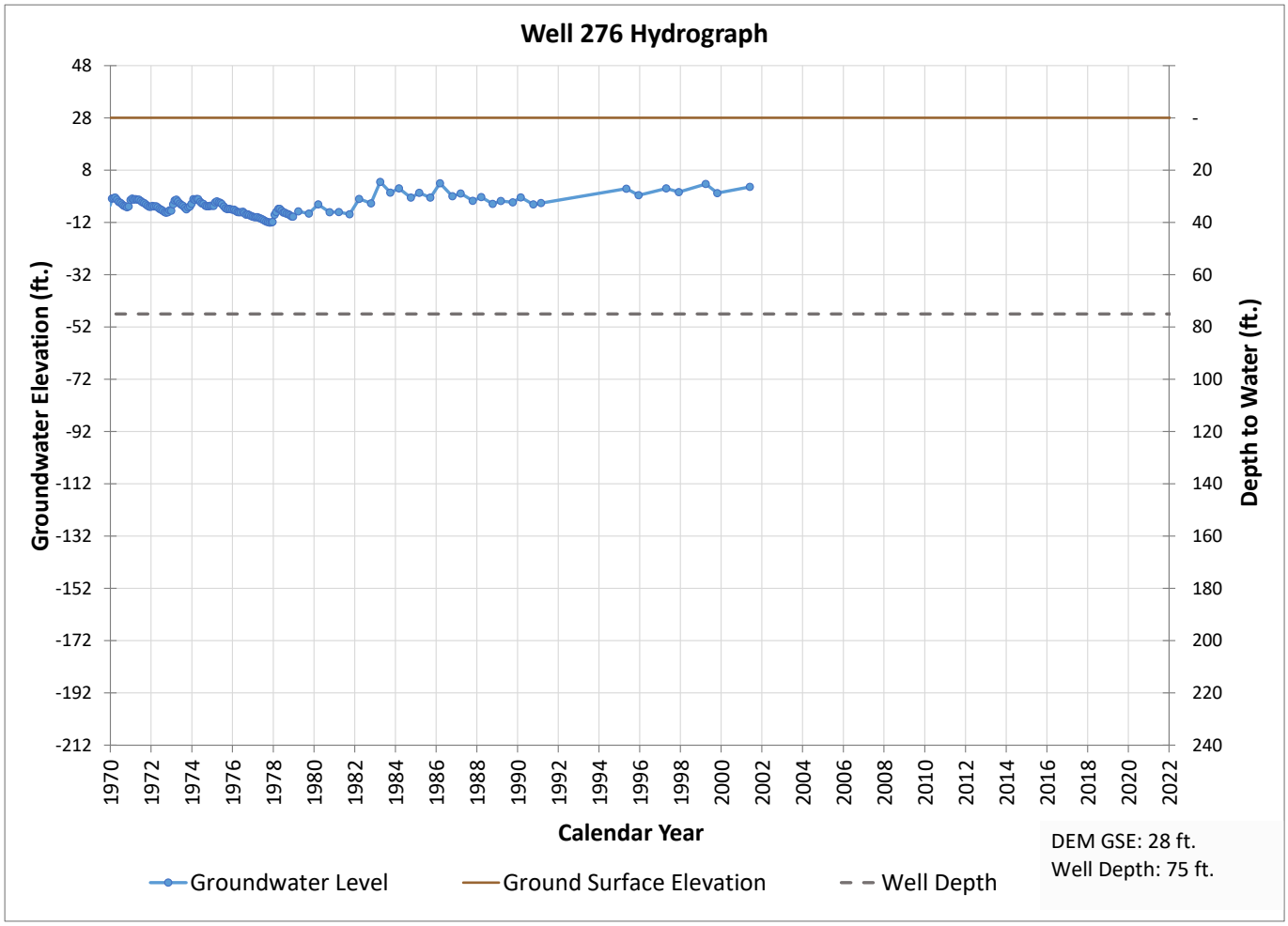

Well 271 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: 164 ft.

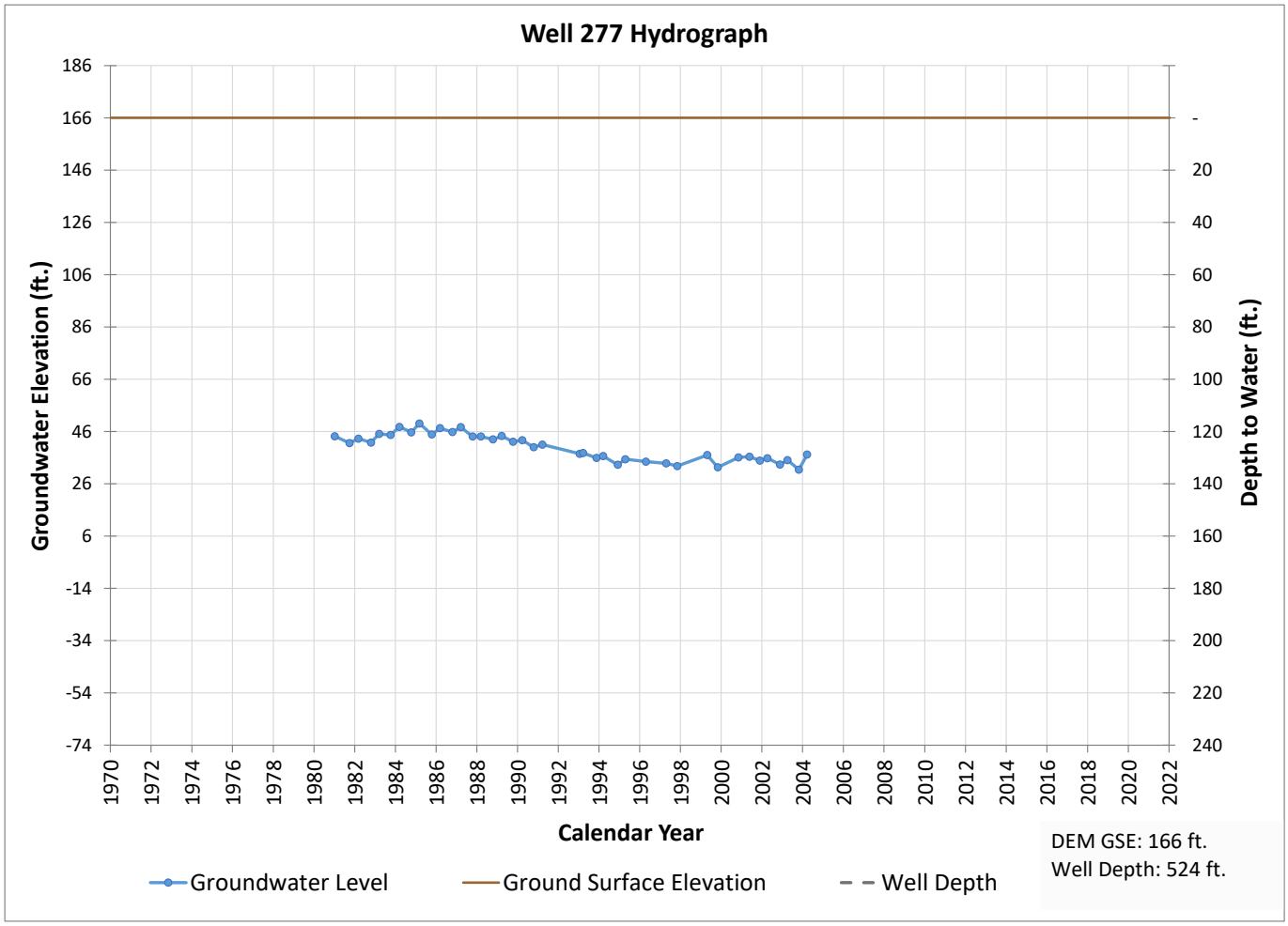

Well 272 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 30 ft.
Well Depth: 298 ft.

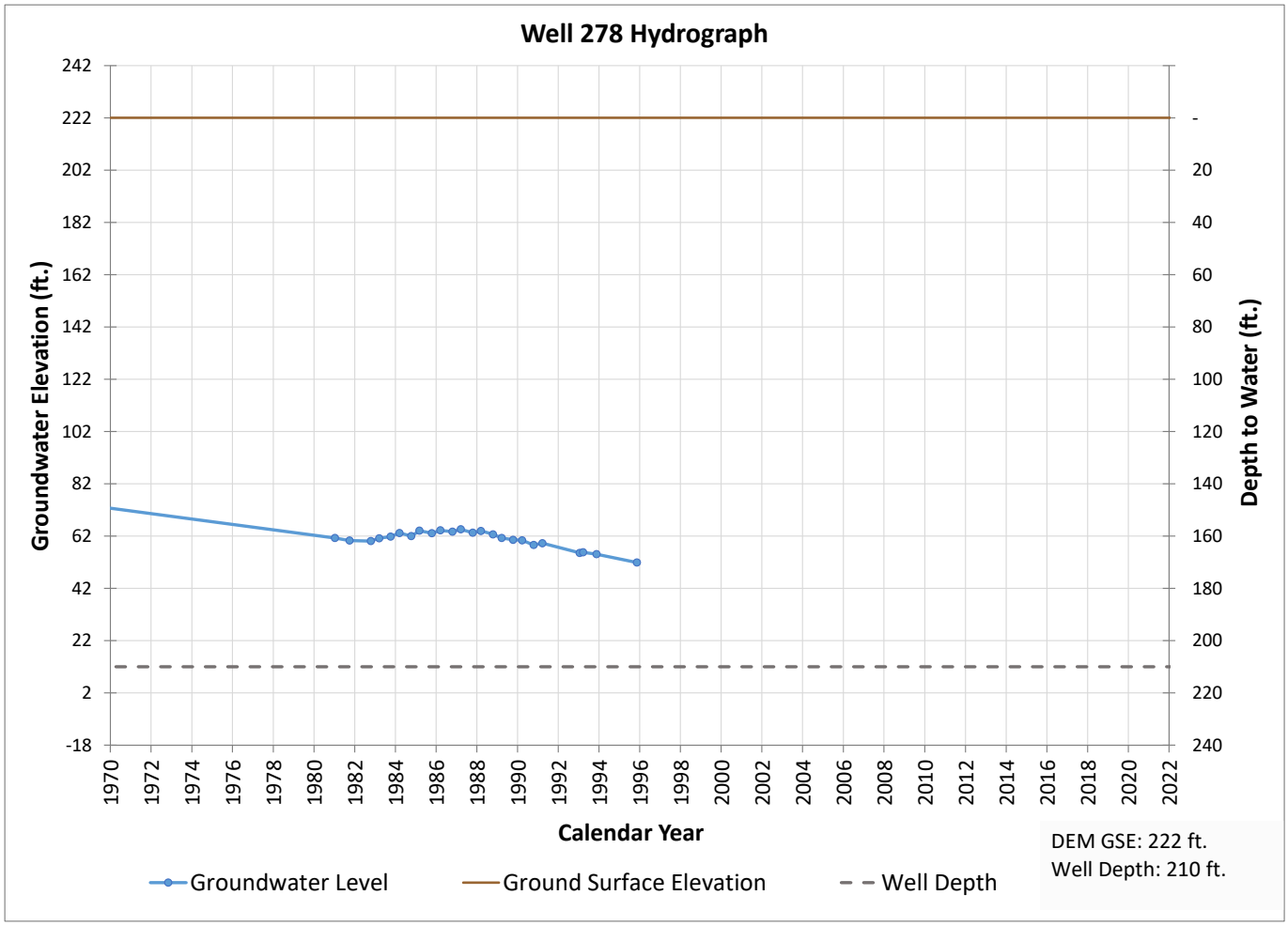

Well 273 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
232
212
192
172
152
132
112
92
72
52
32
12
-8
-28
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 212 ft.
Well Depth: 300 ft.

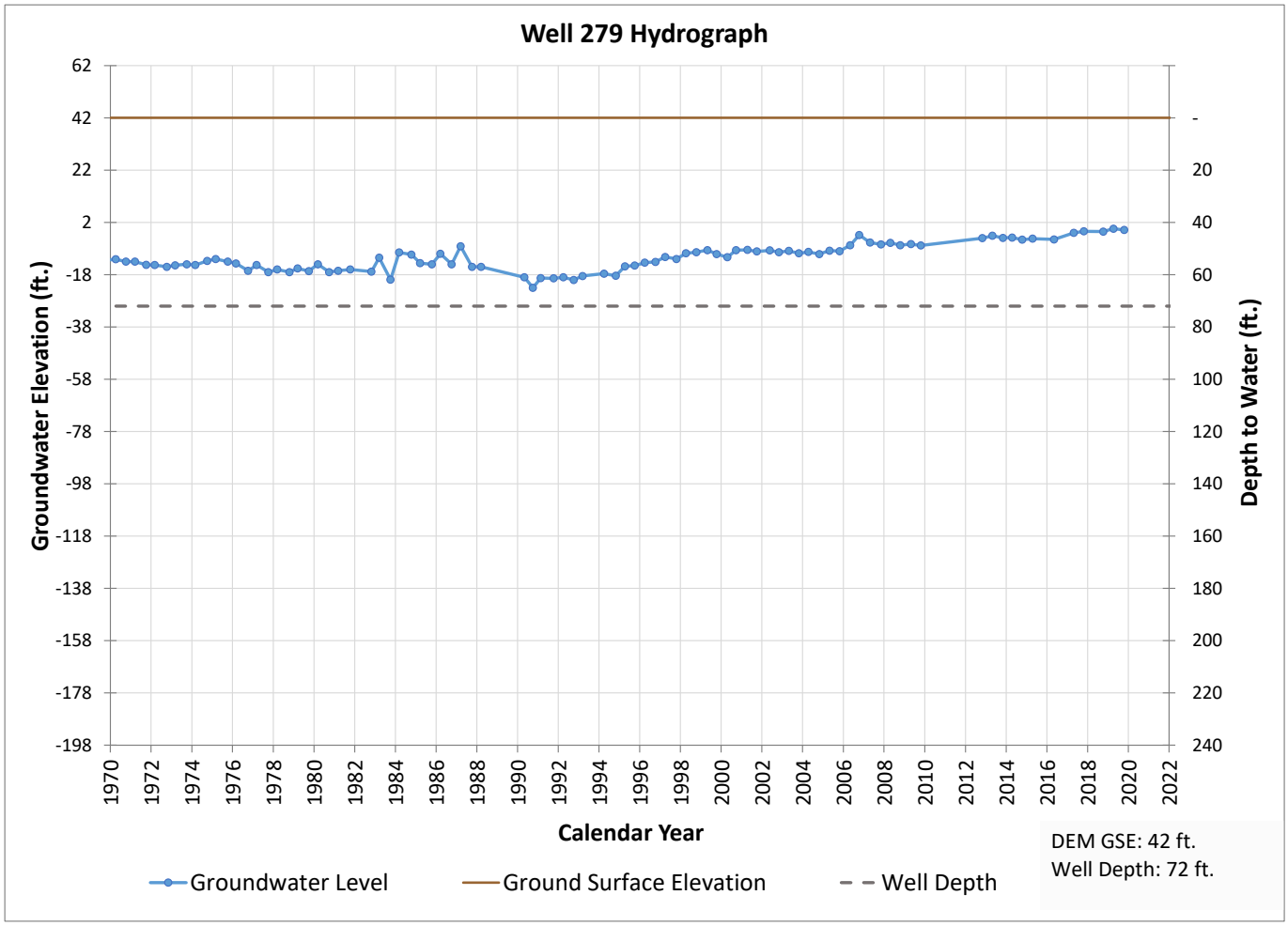

Well 274 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 60 ft.
Well Depth: 101 ft.

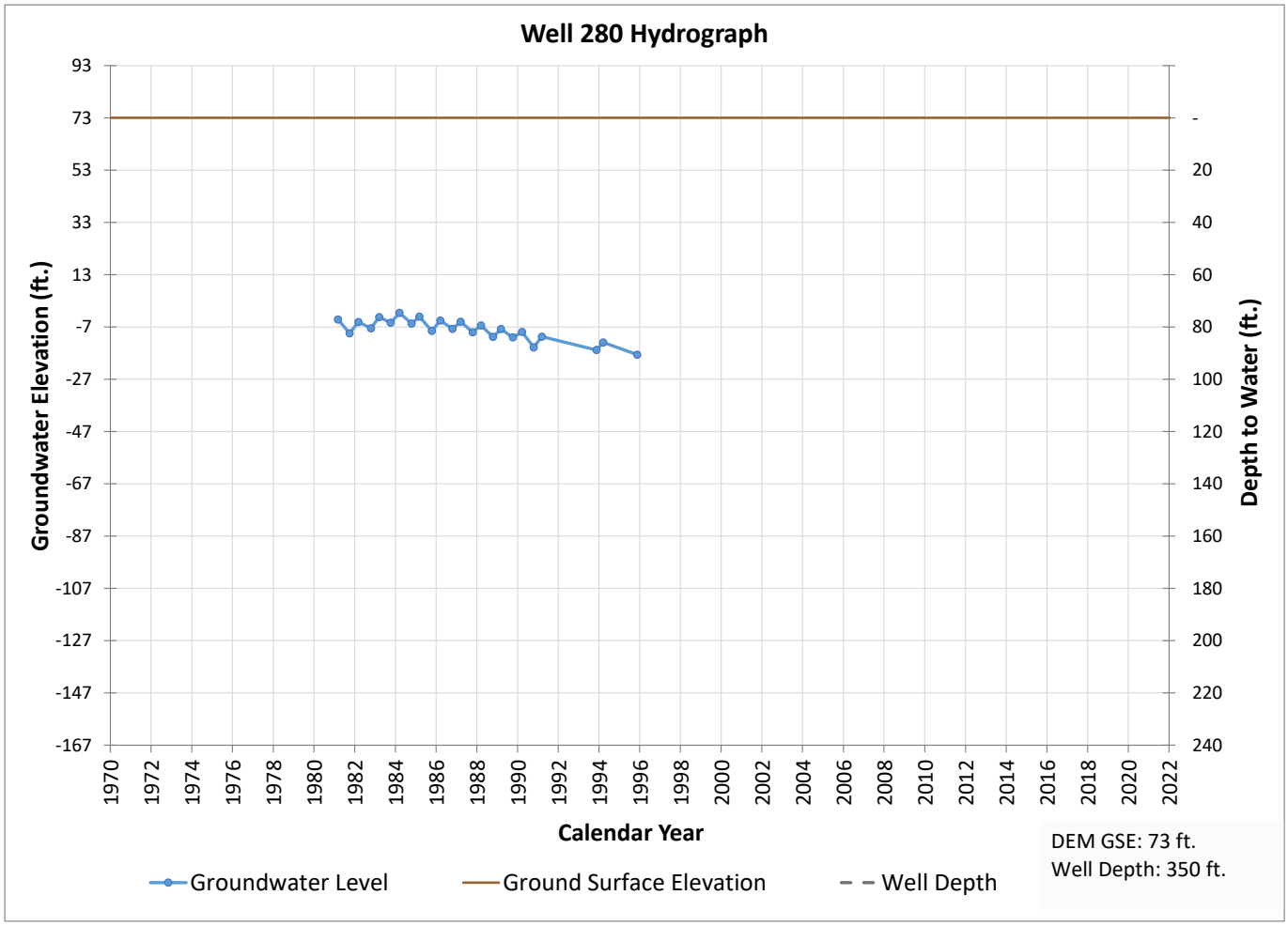

Well 275 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: 175 ft.

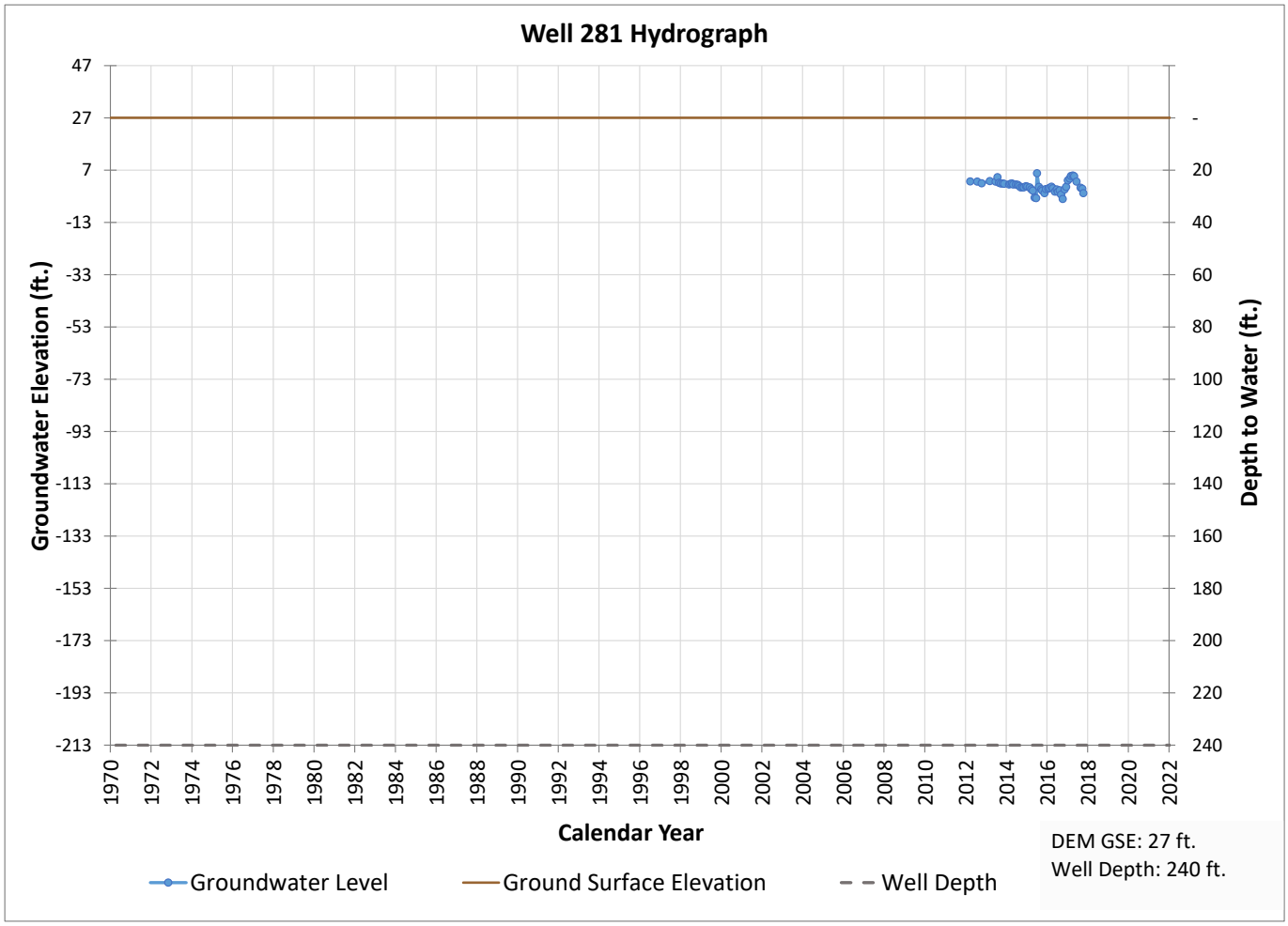

Well 276 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 28 ft.
Well Depth: 75 ft.

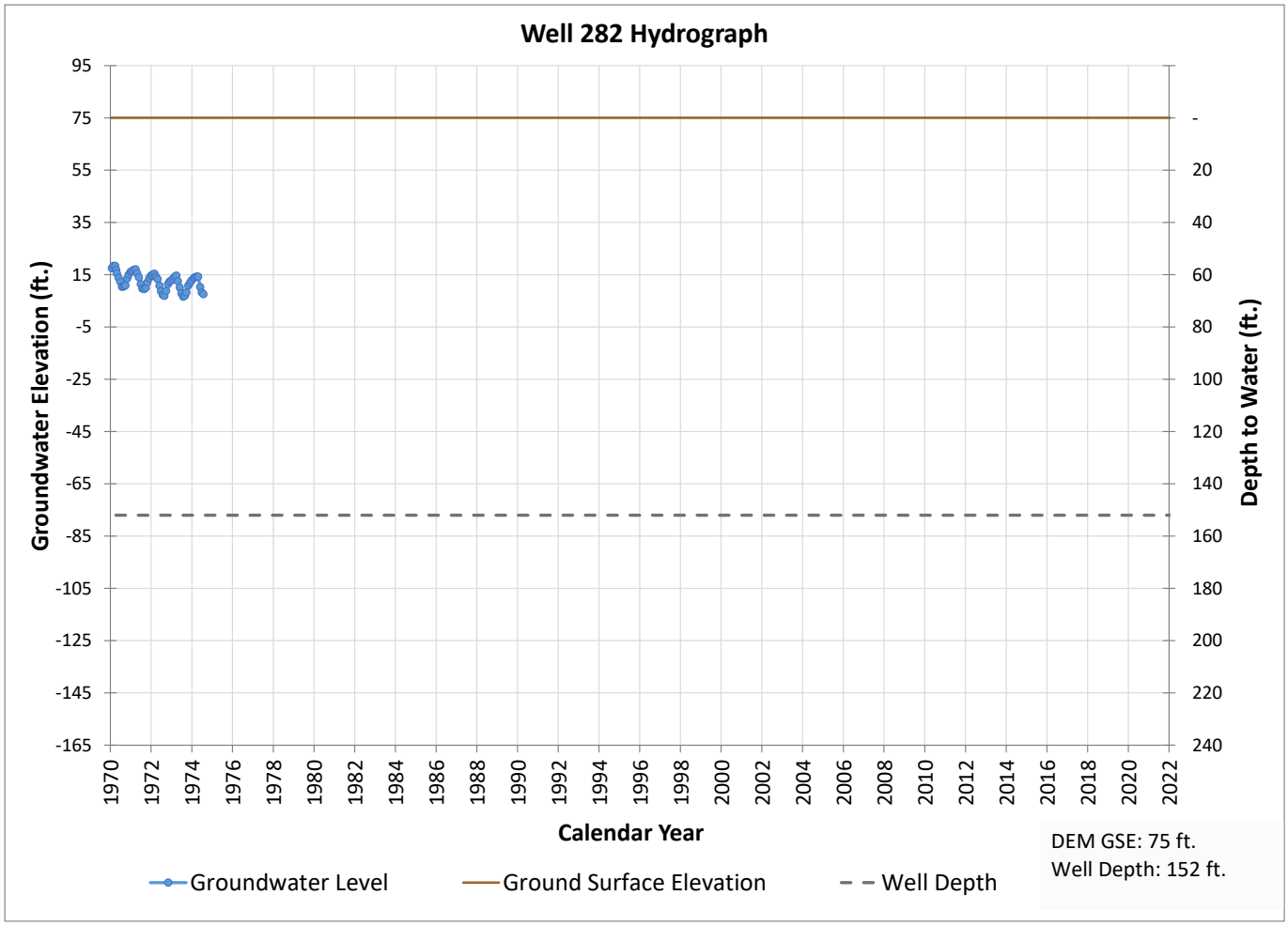

Well 277 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
186
166
146
126
106
86
66
46
26
6
-14
-34
-54
-74
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 166 ft.
Well Depth: 524 ft.

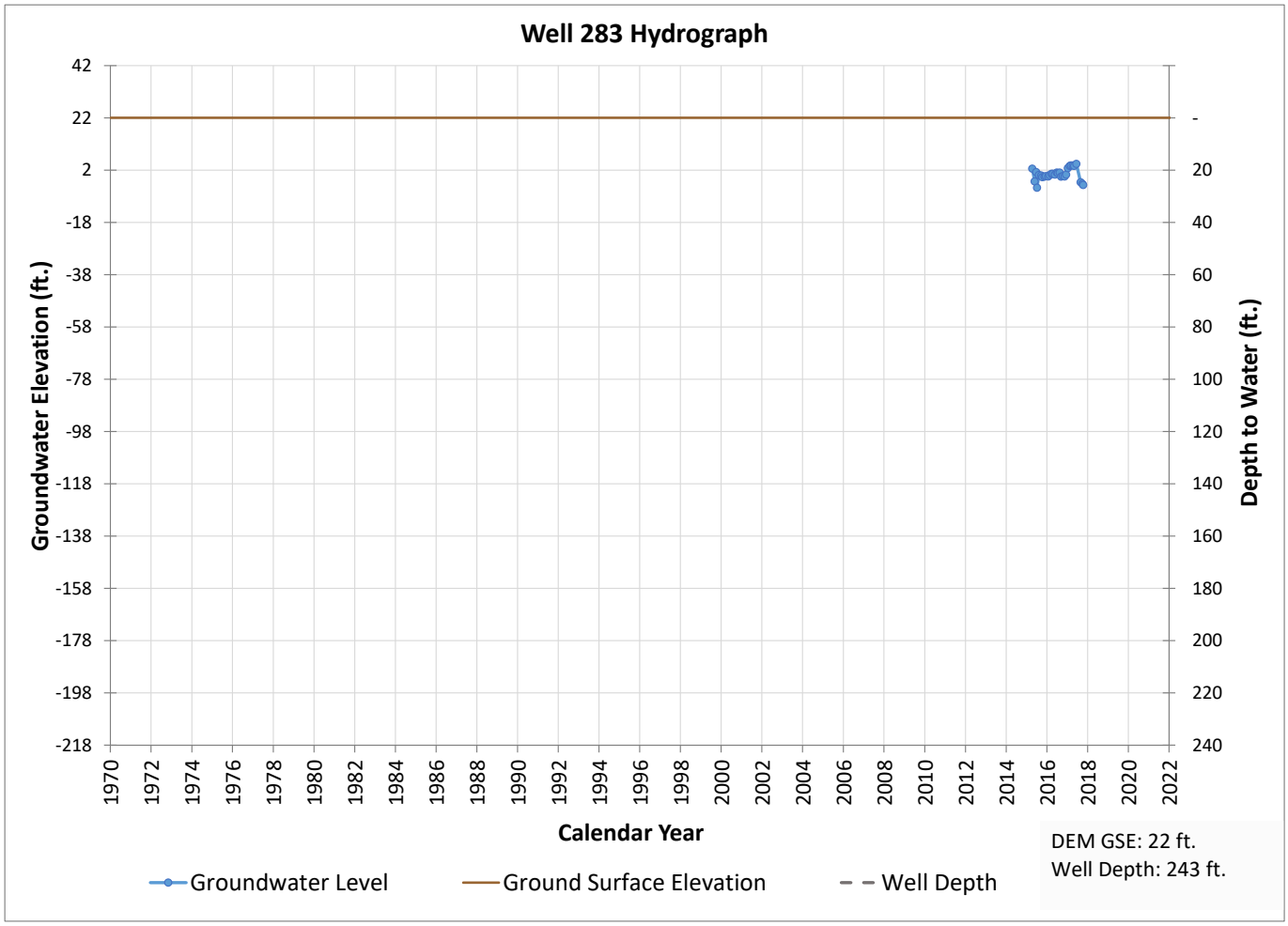

Well 278 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
242
222
202
182
162
142
122
102
82
62
42
22
2
-18
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 222 ft.
Well Depth: 210 ft.

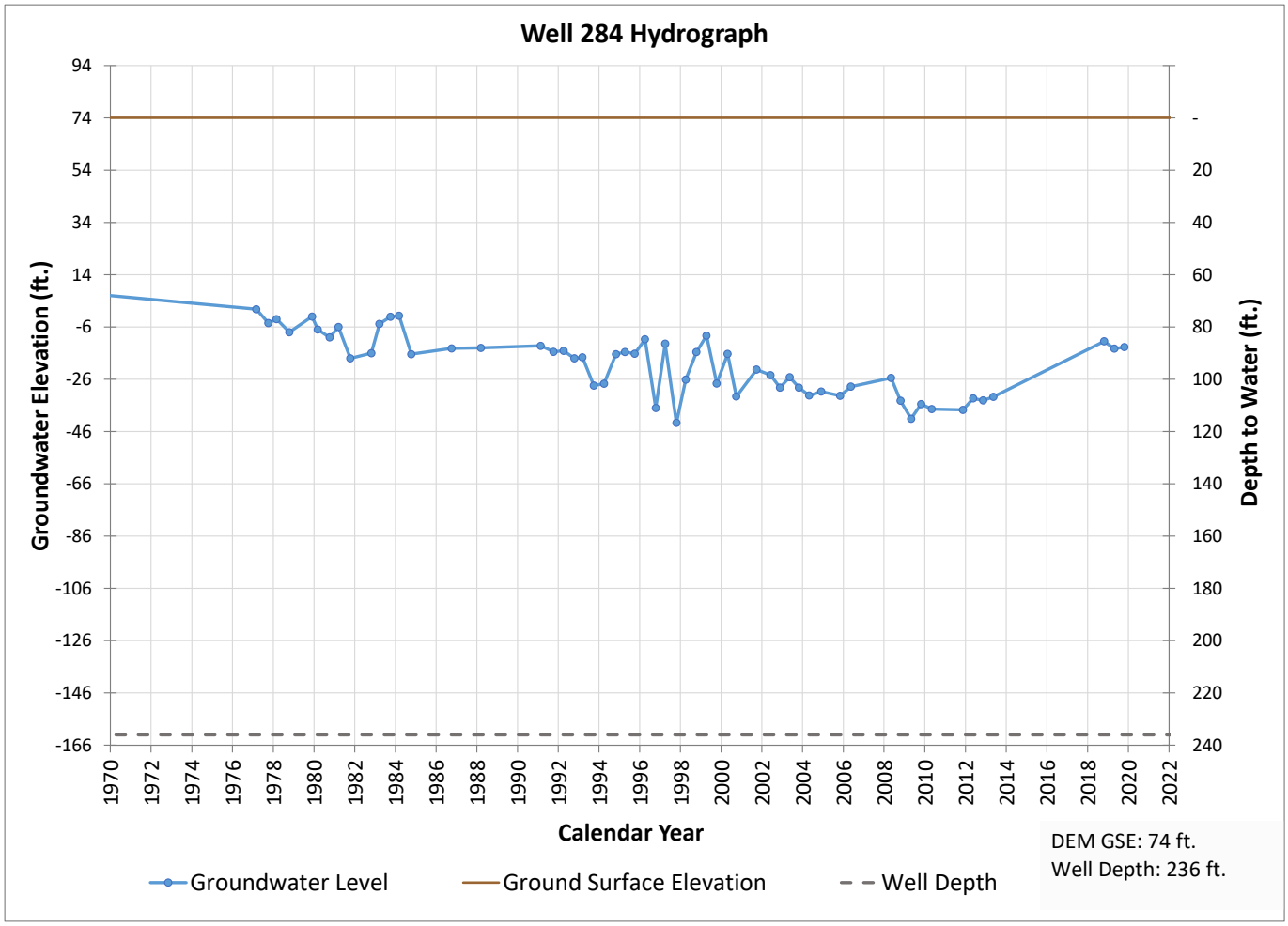

Well 279 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: 72 ft.

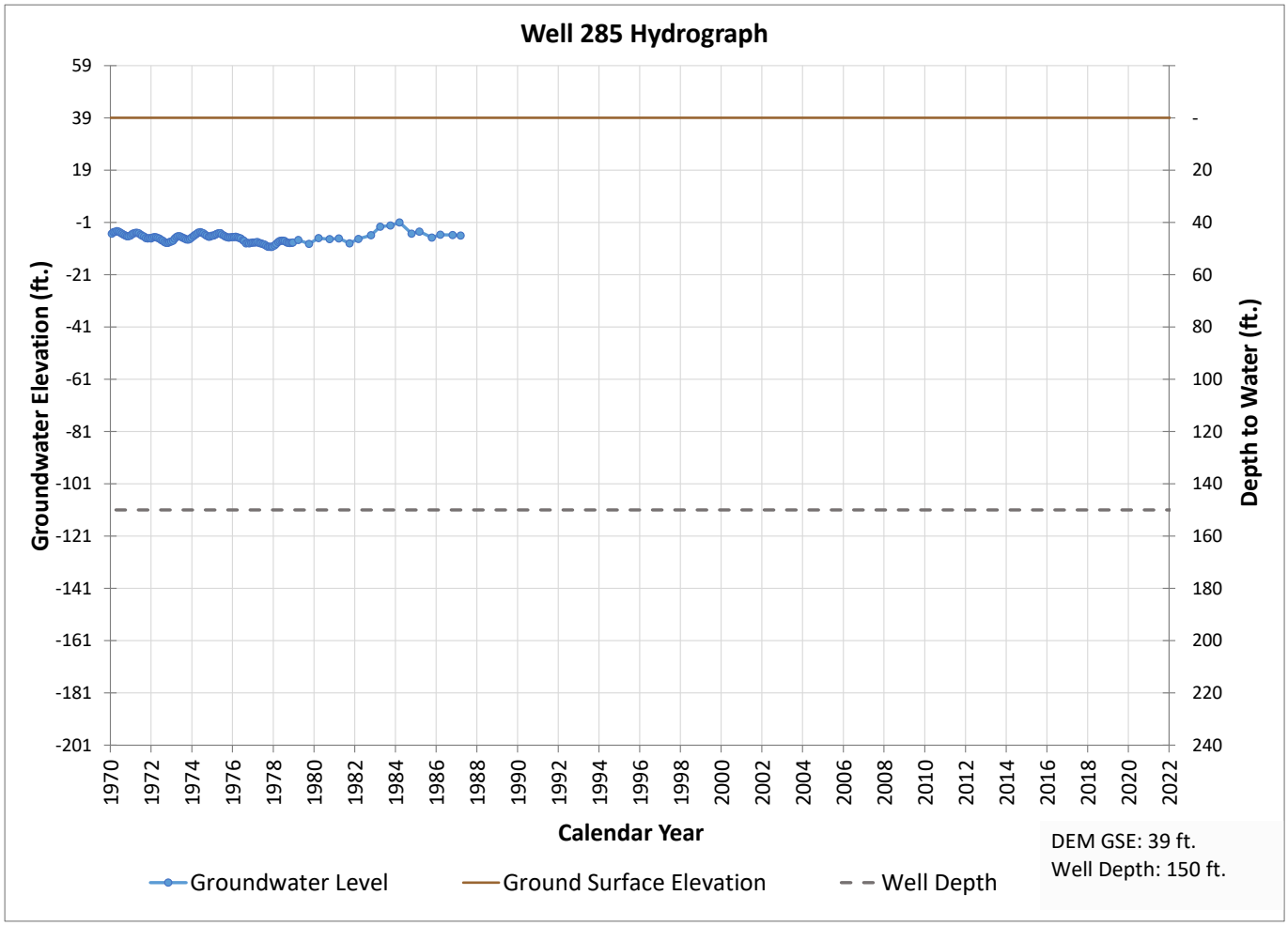

Well 280 Hydrograph
Groundwater Elevation (ft.)
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 73 ft.
Well Depth: 350 ft.

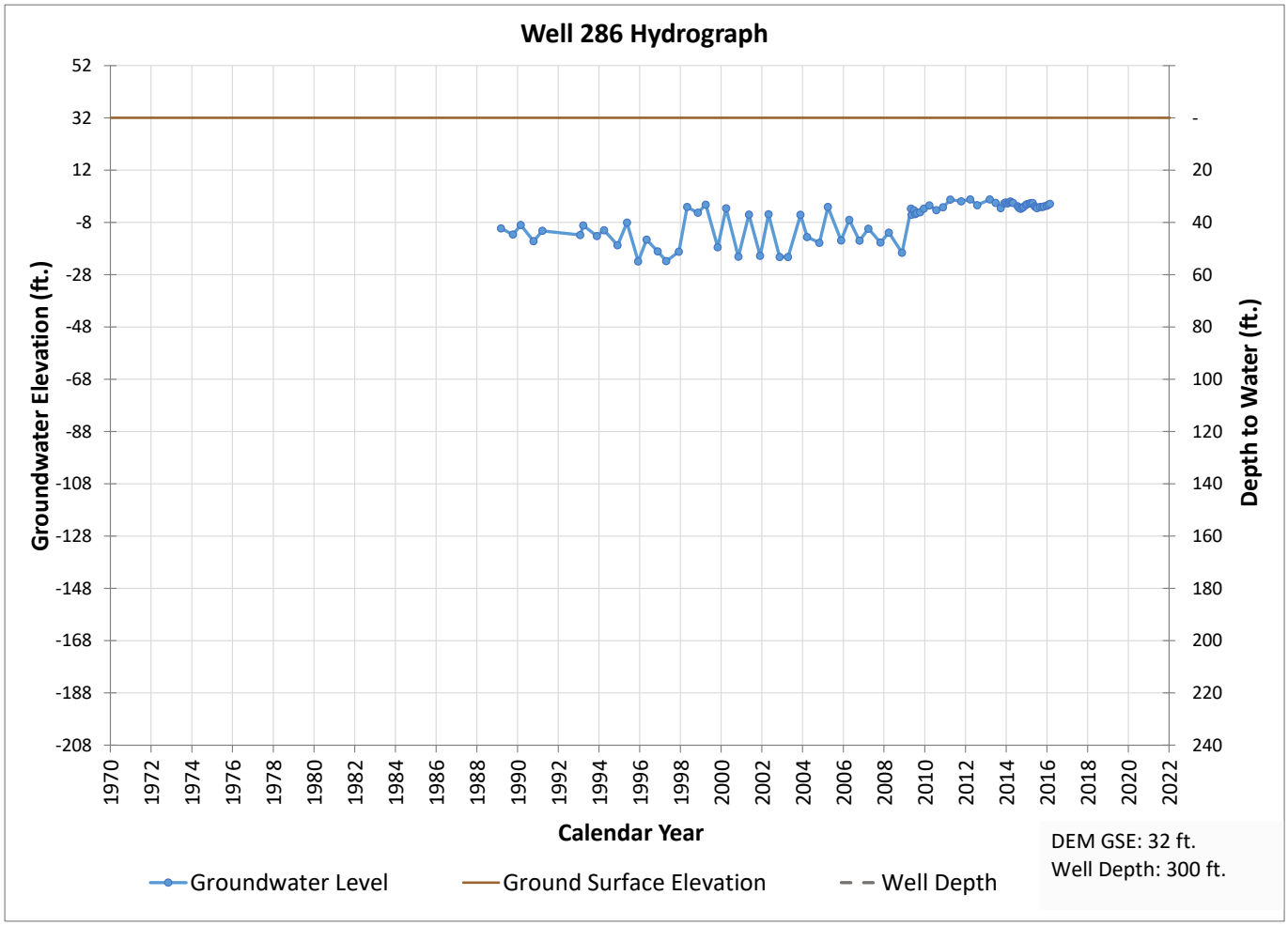

Well 281 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 240 ft.

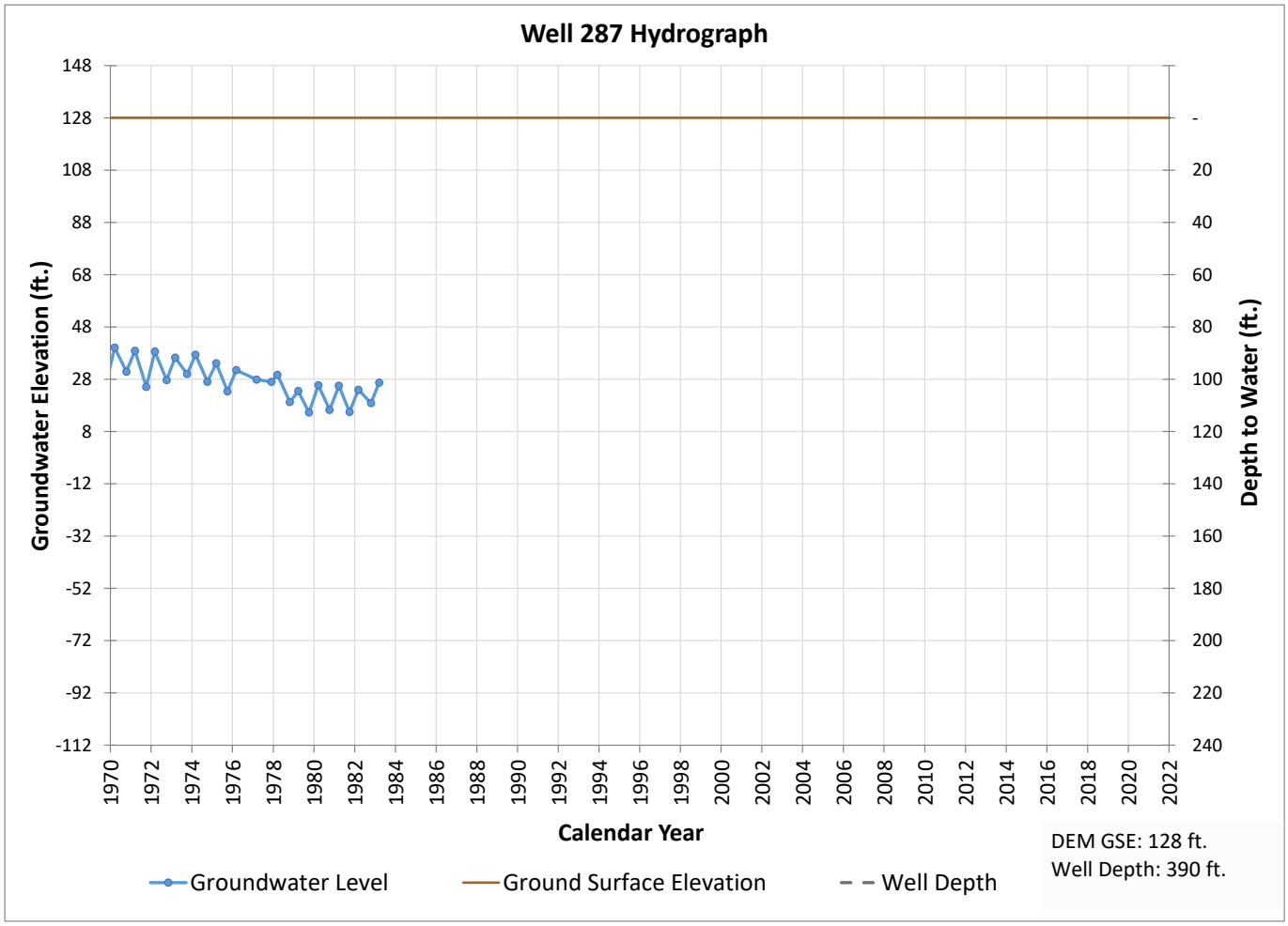

Well 282 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 75 ft.
Well Depth: 152 ft.

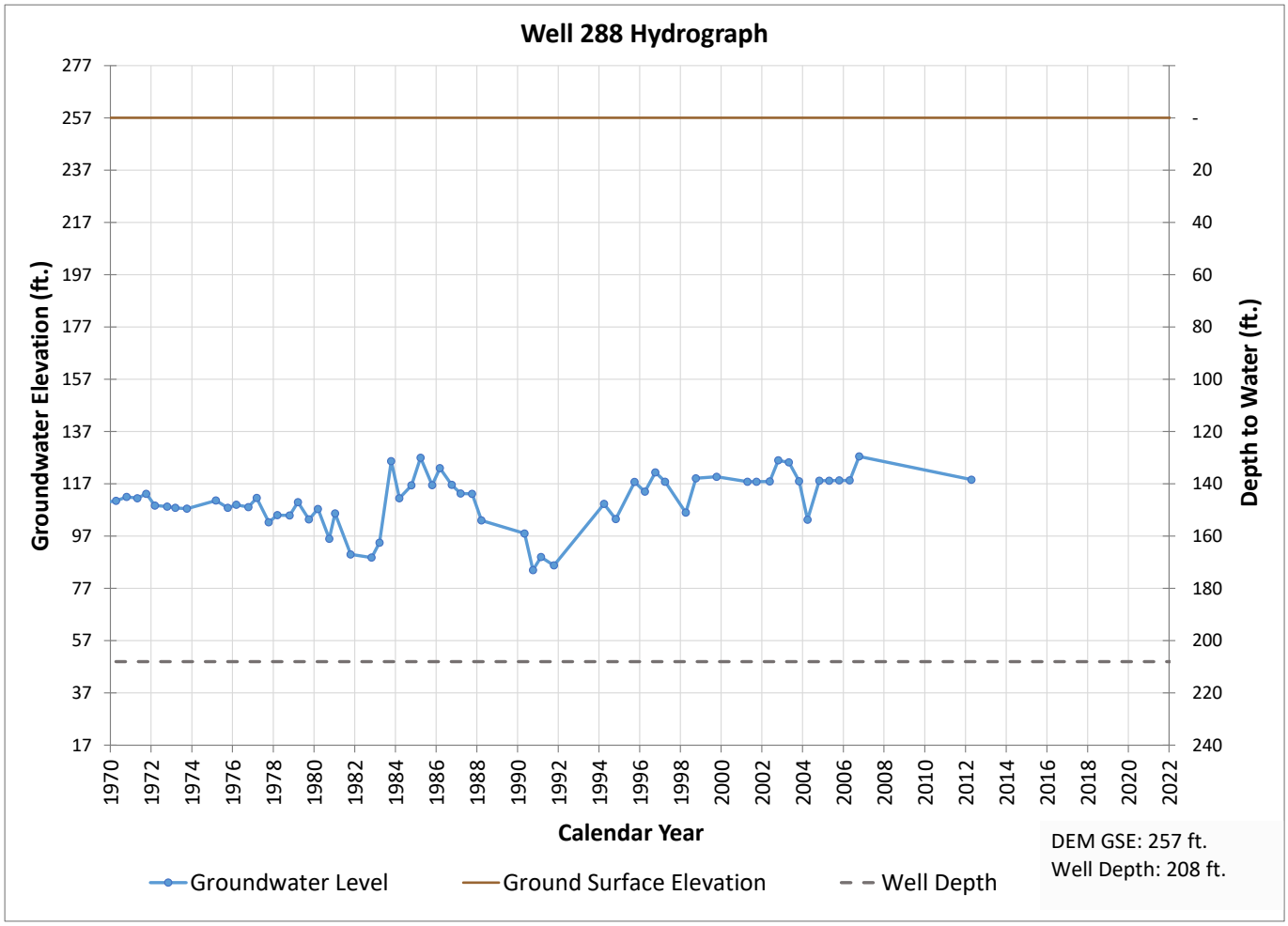

Well 283 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: 243 ft.

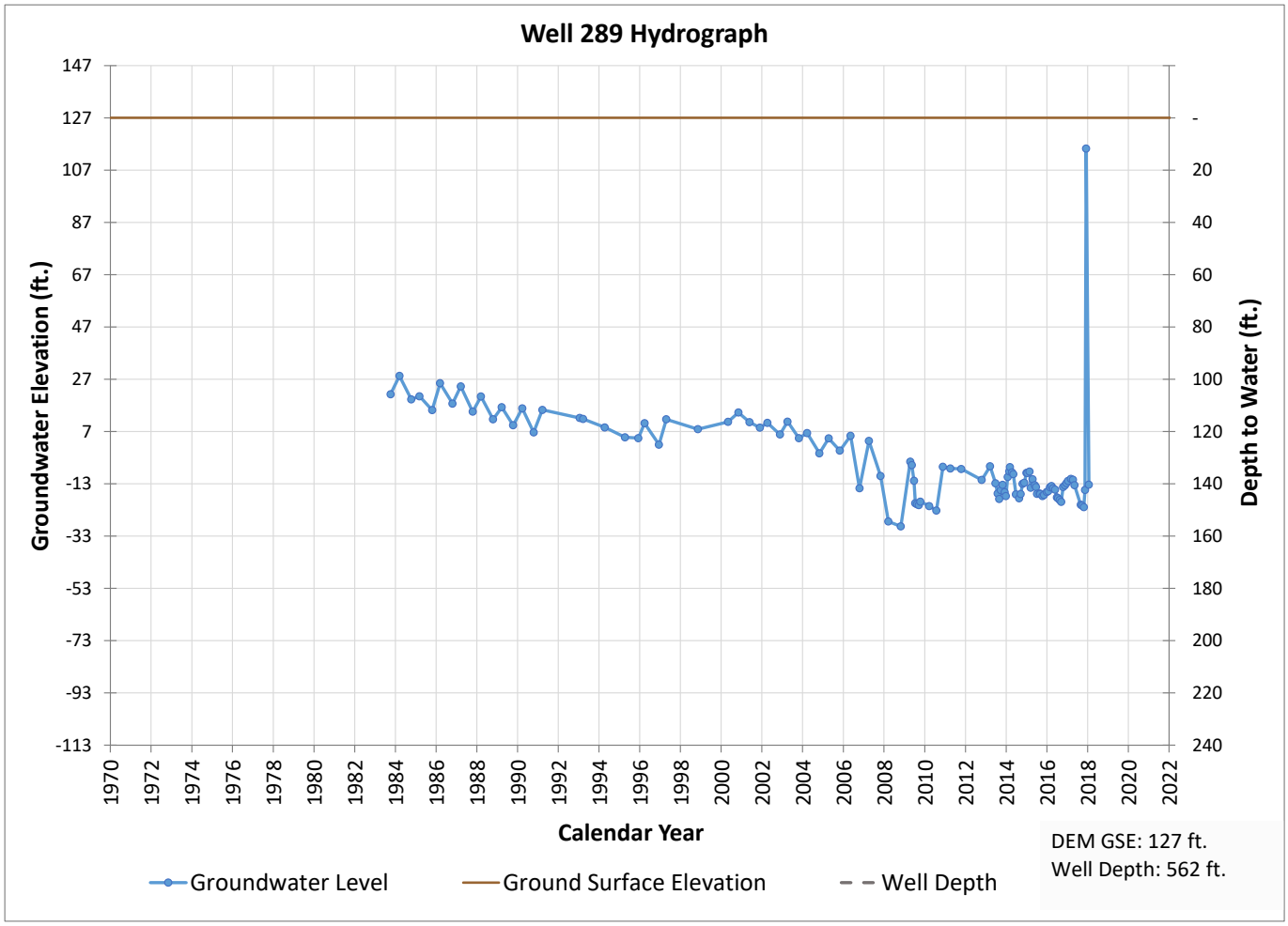

Well 284 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 74 ft.
Well Depth: 236 ft.

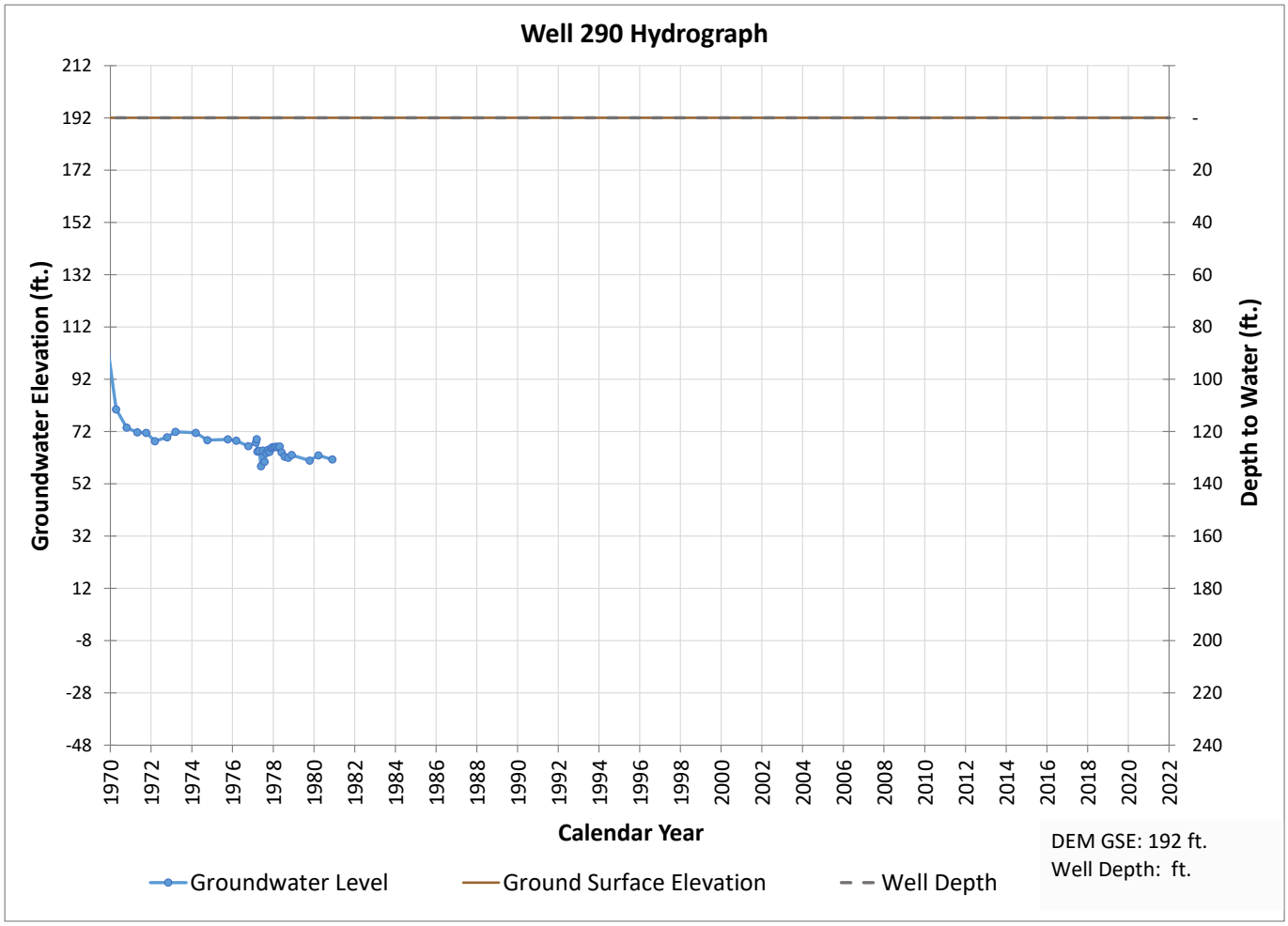

Well 285 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-201
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 39 ft.
Well Depth: 150 ft.

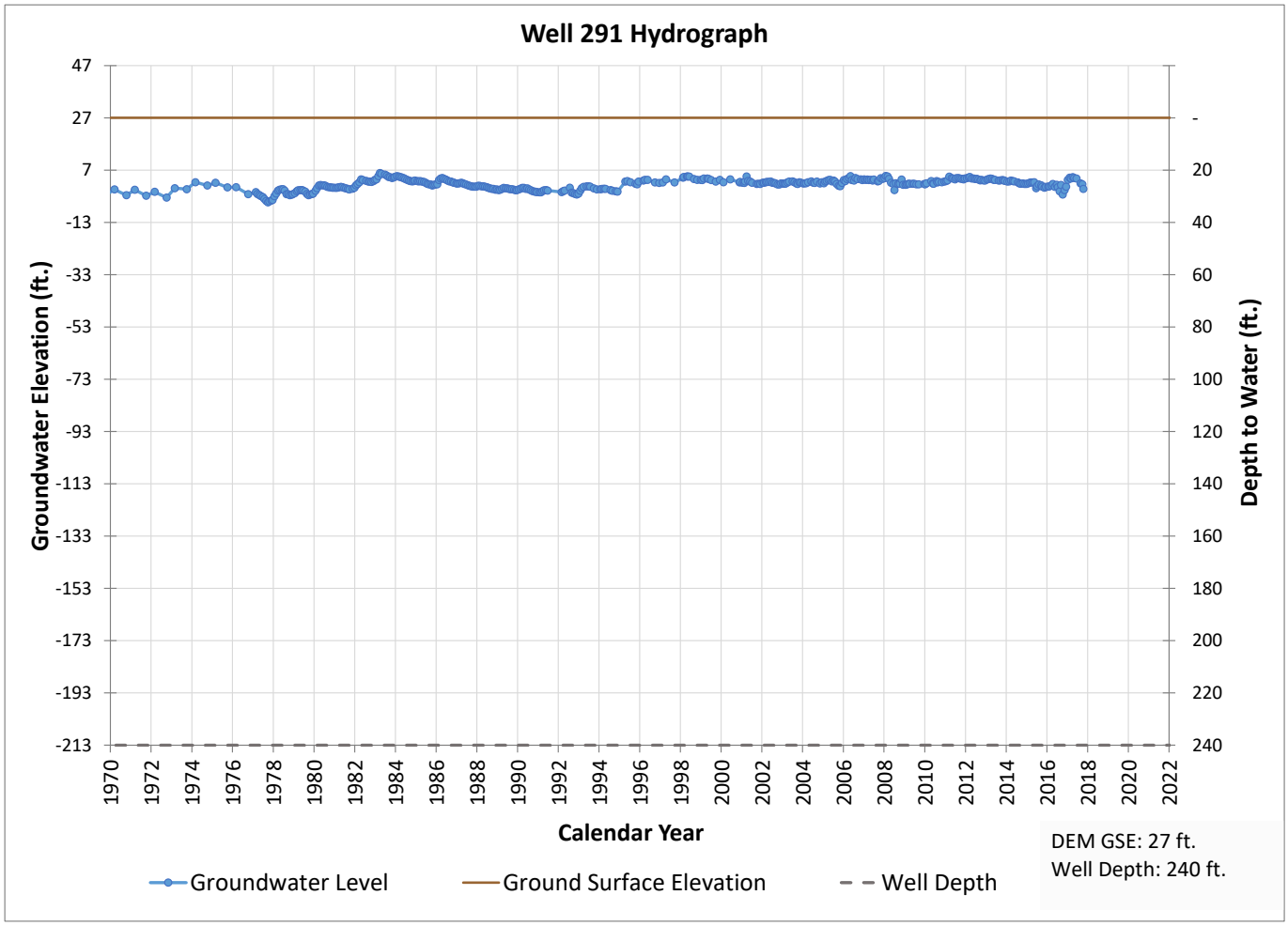

Well 286 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: 300 ft.

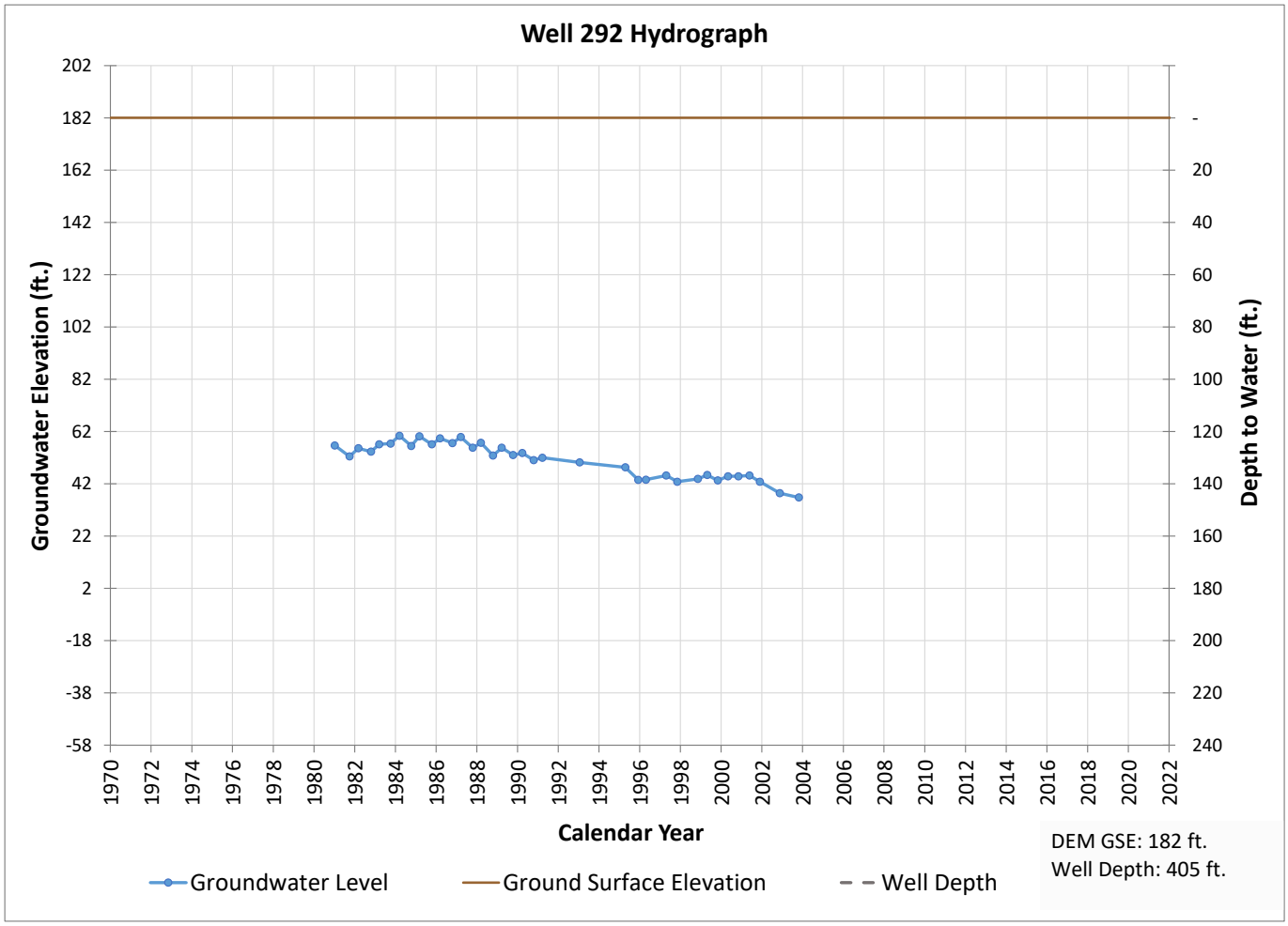

Well 287 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
148
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 128 ft.
Well Depth: 390 ft.

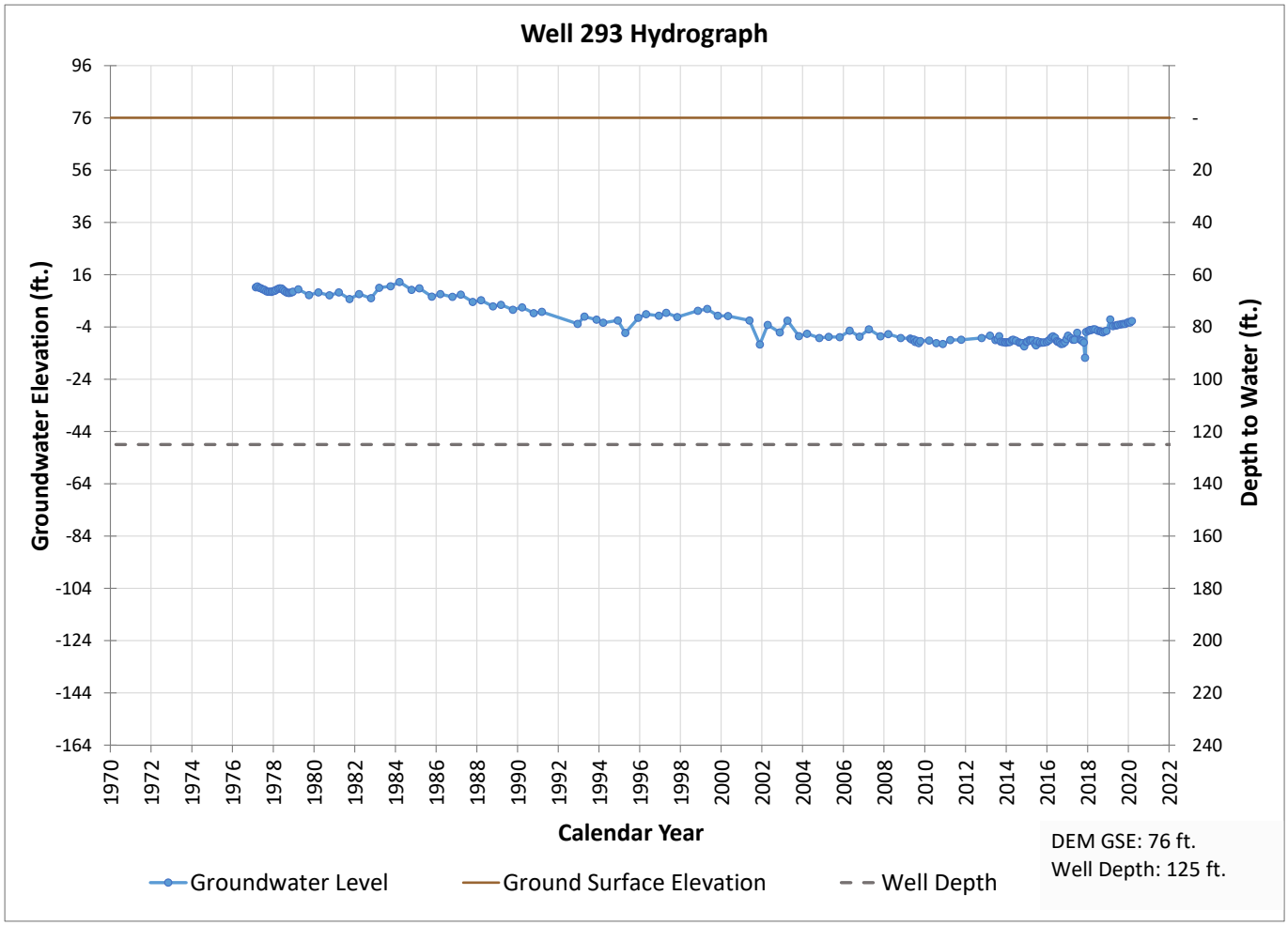

Well 288 Hydrograph
Groundwater Elevation (ft.)
277
257
237
217
197
177
157
137
117
97
77
57
37
17
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 257 ft.
Well Depth: 208 ft.

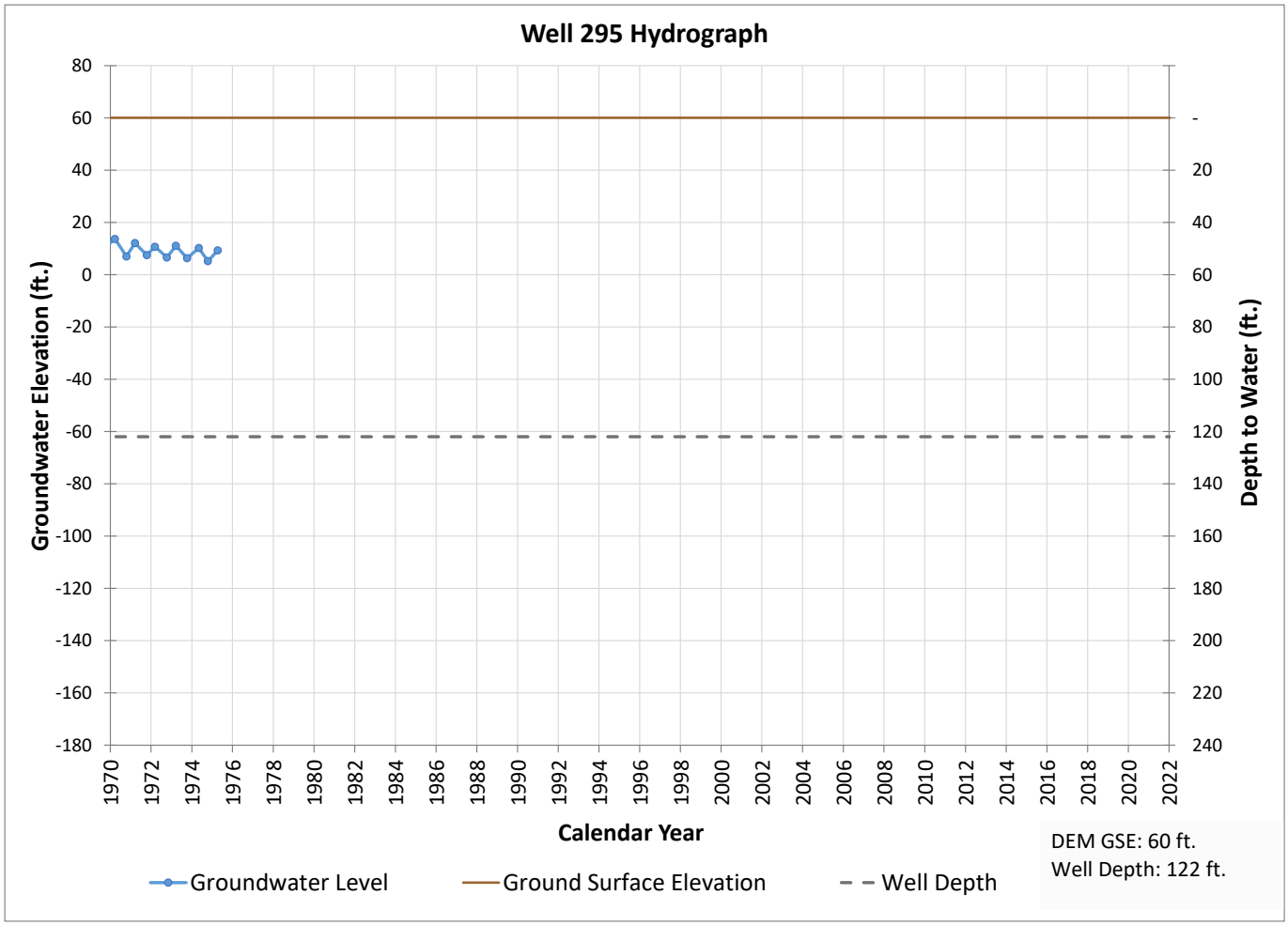

Well 289 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
147
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 127 ft.
Well Depth: 562 ft.

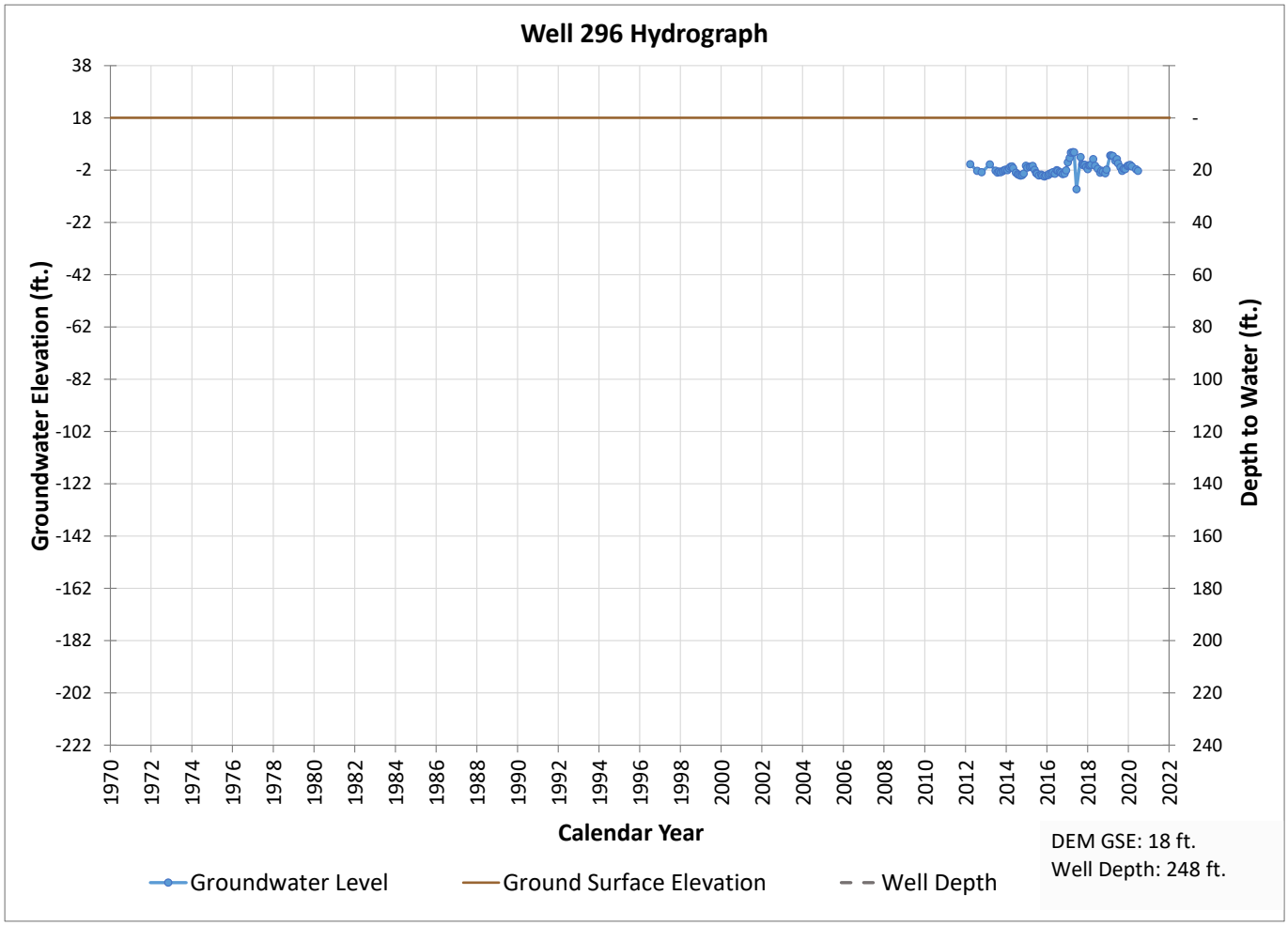

Well 290 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
212
192
172
152
132
112
92
72
52
32
12
-8
-28
-48
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 192 ft.
Well Depth: ft.

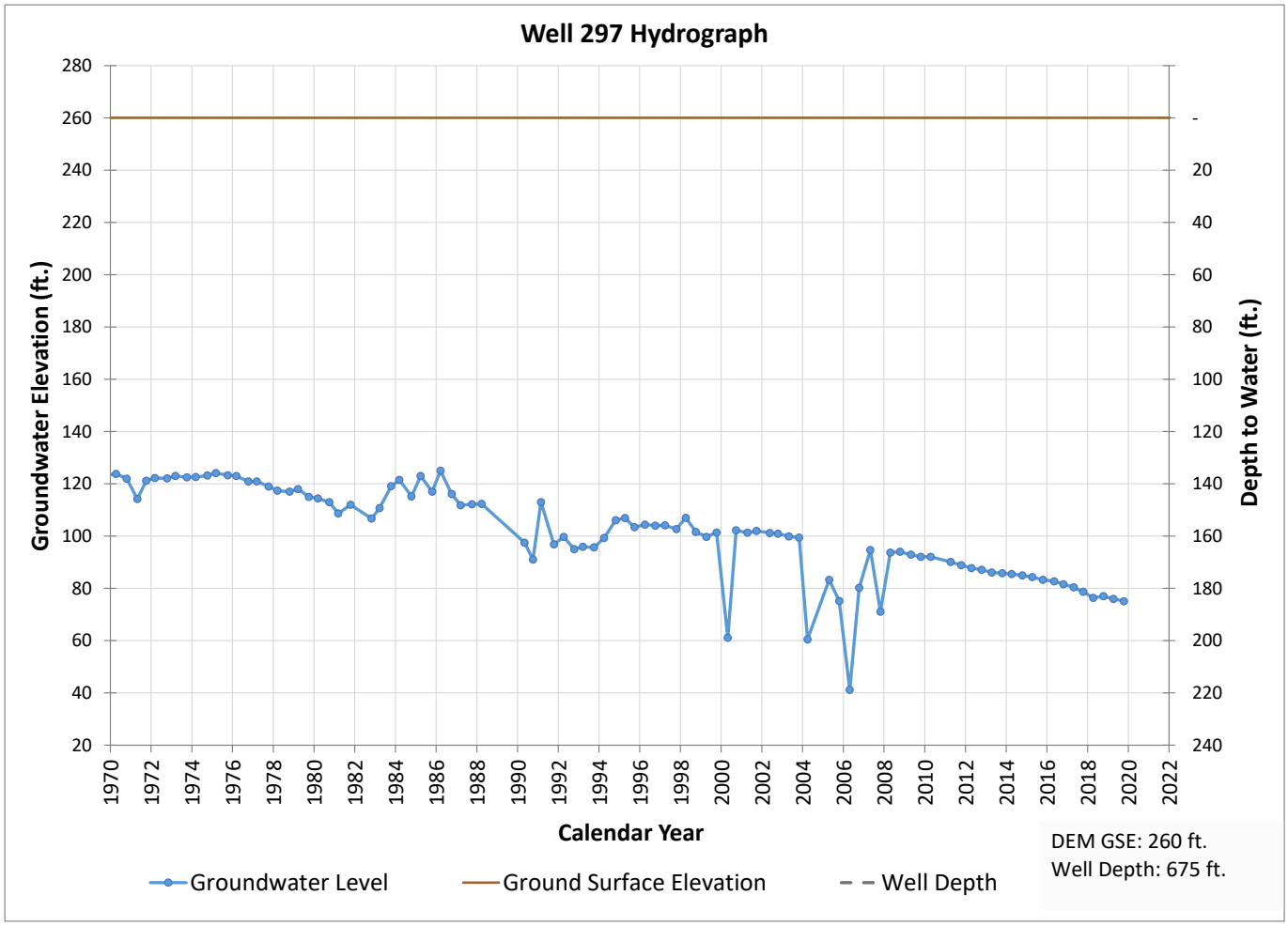

Well 291 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 240 ft.

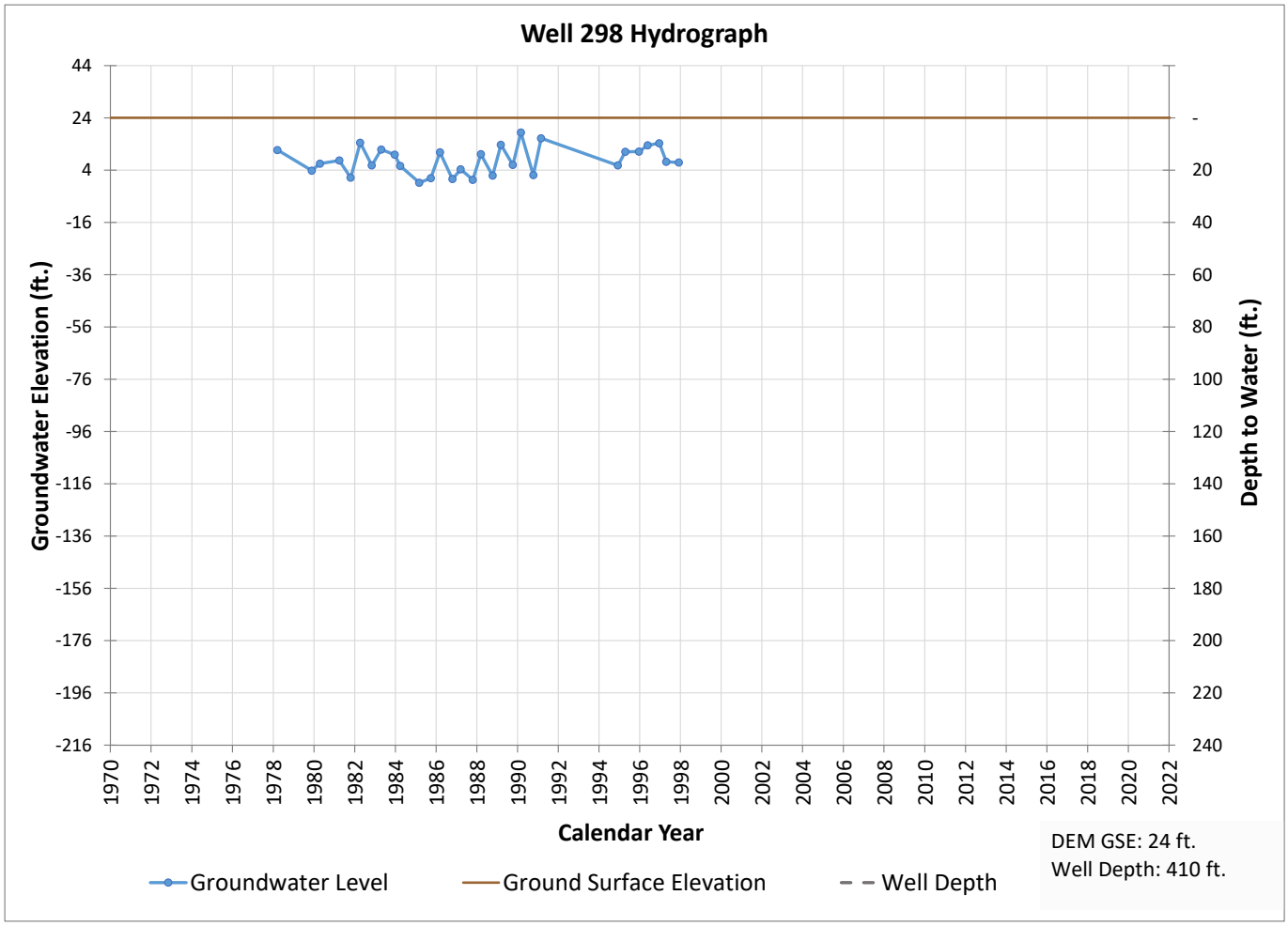

Well 292 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
202
182
162
142
122
102
82
62
42
22
2
-18
-38
-58
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 182 ft.
Well Depth: 405 ft.

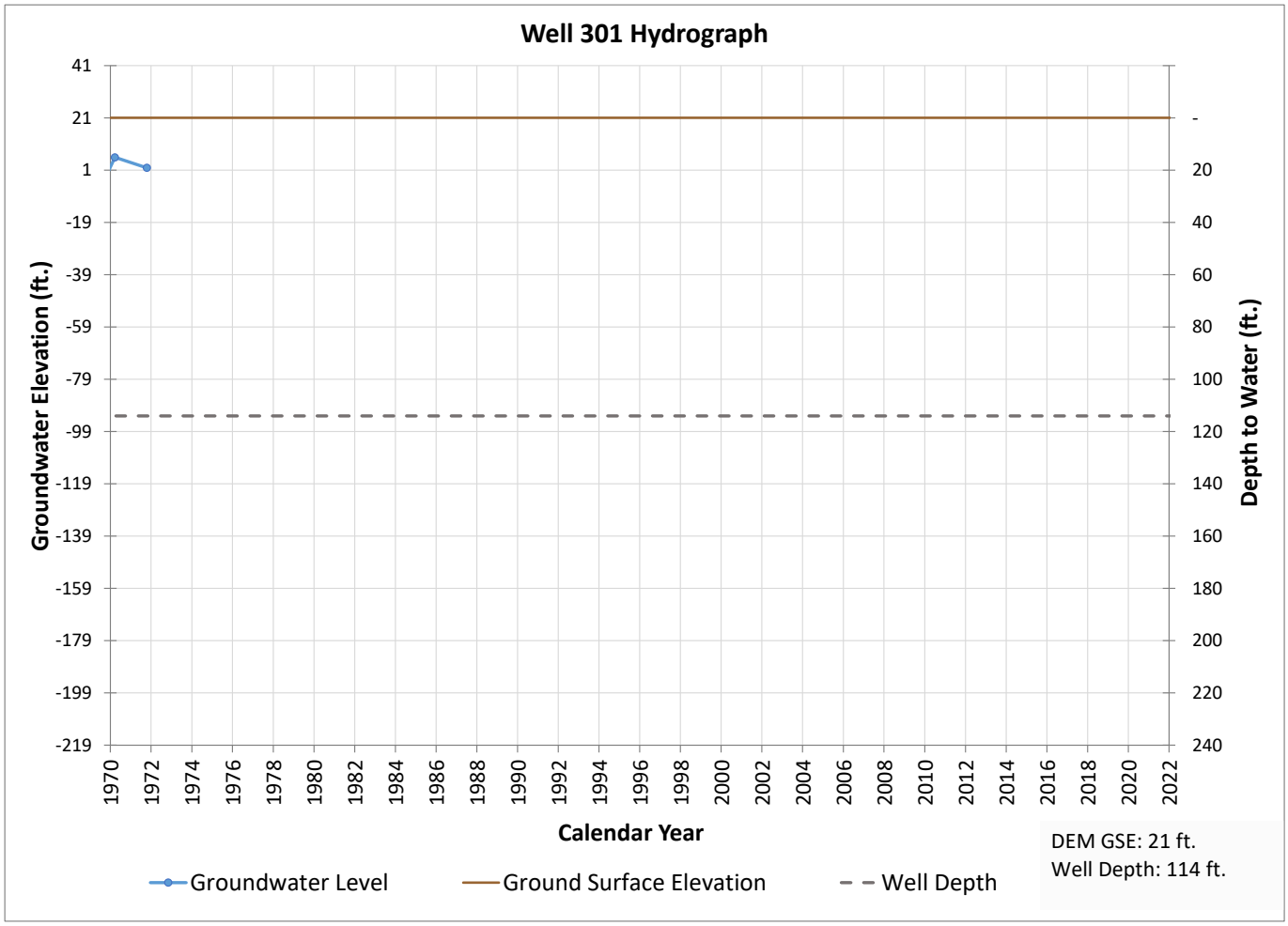

Well 293 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 76 ft.
Well Depth: 125 ft.

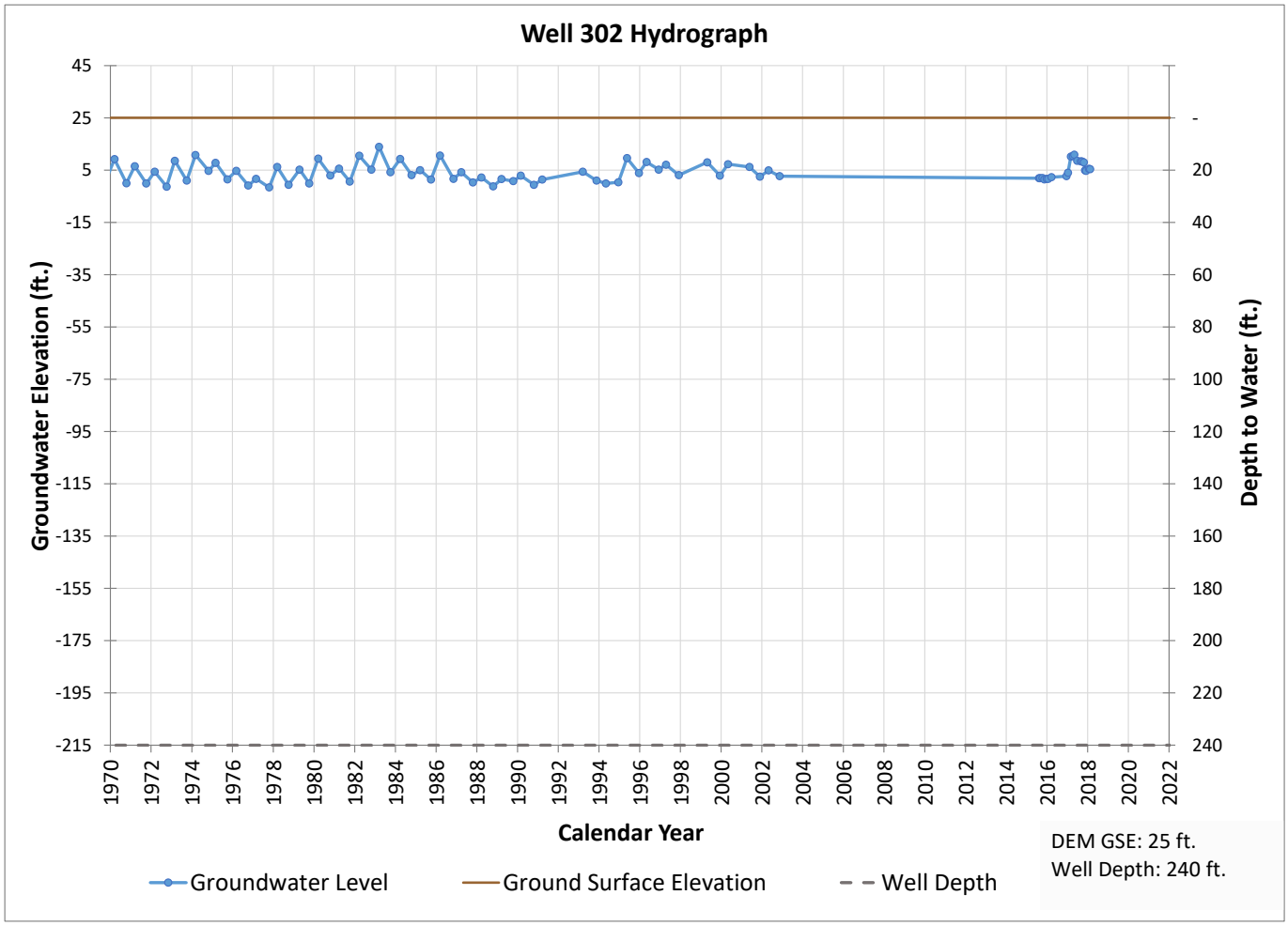

Well 295 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 60 ft.
Well Depth: 122 ft.

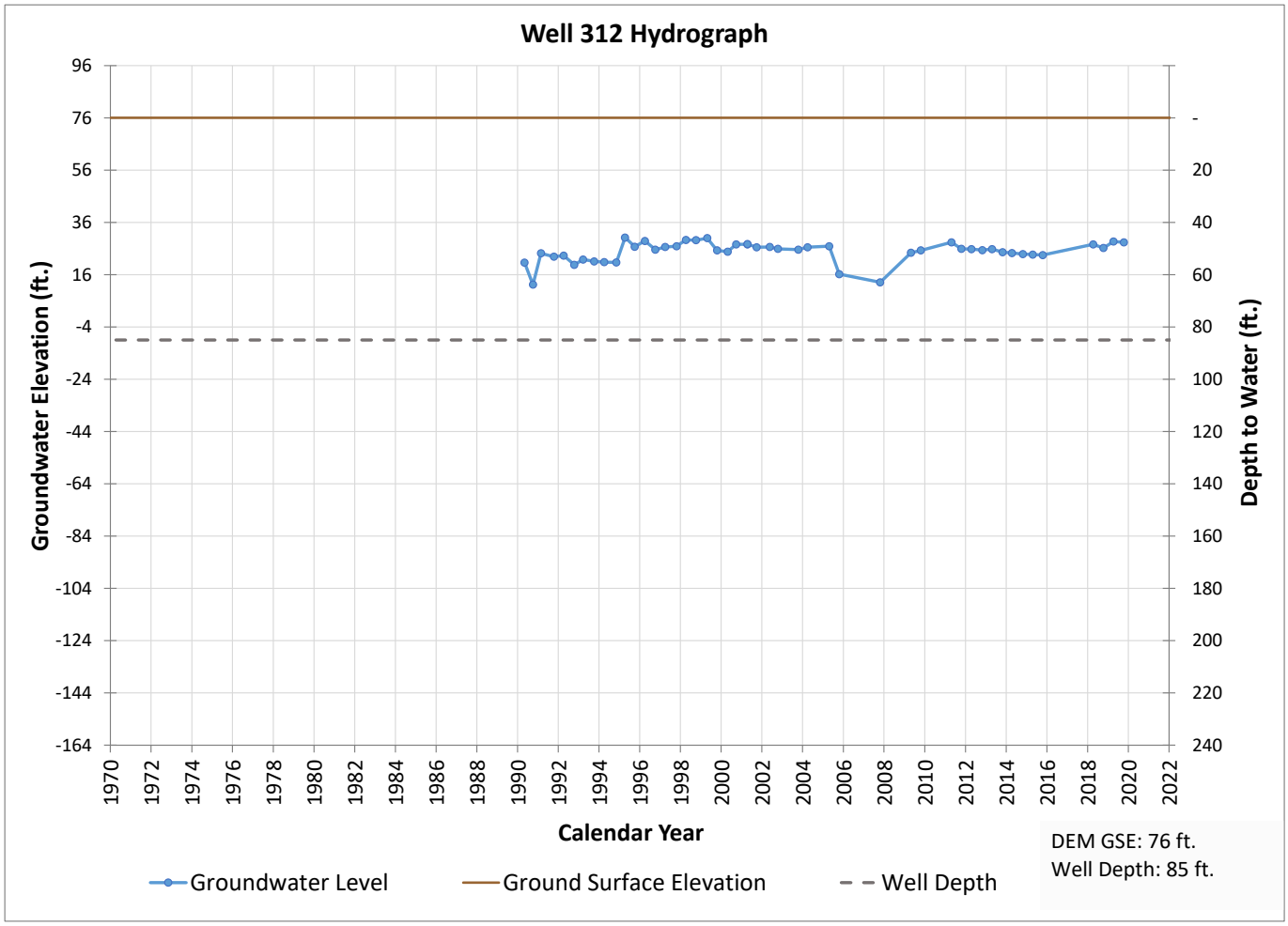

Well 296 Hydrograph
Groundwater Elevation (ft.)
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-222
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 18 ft.
Well Depth: 248 ft.

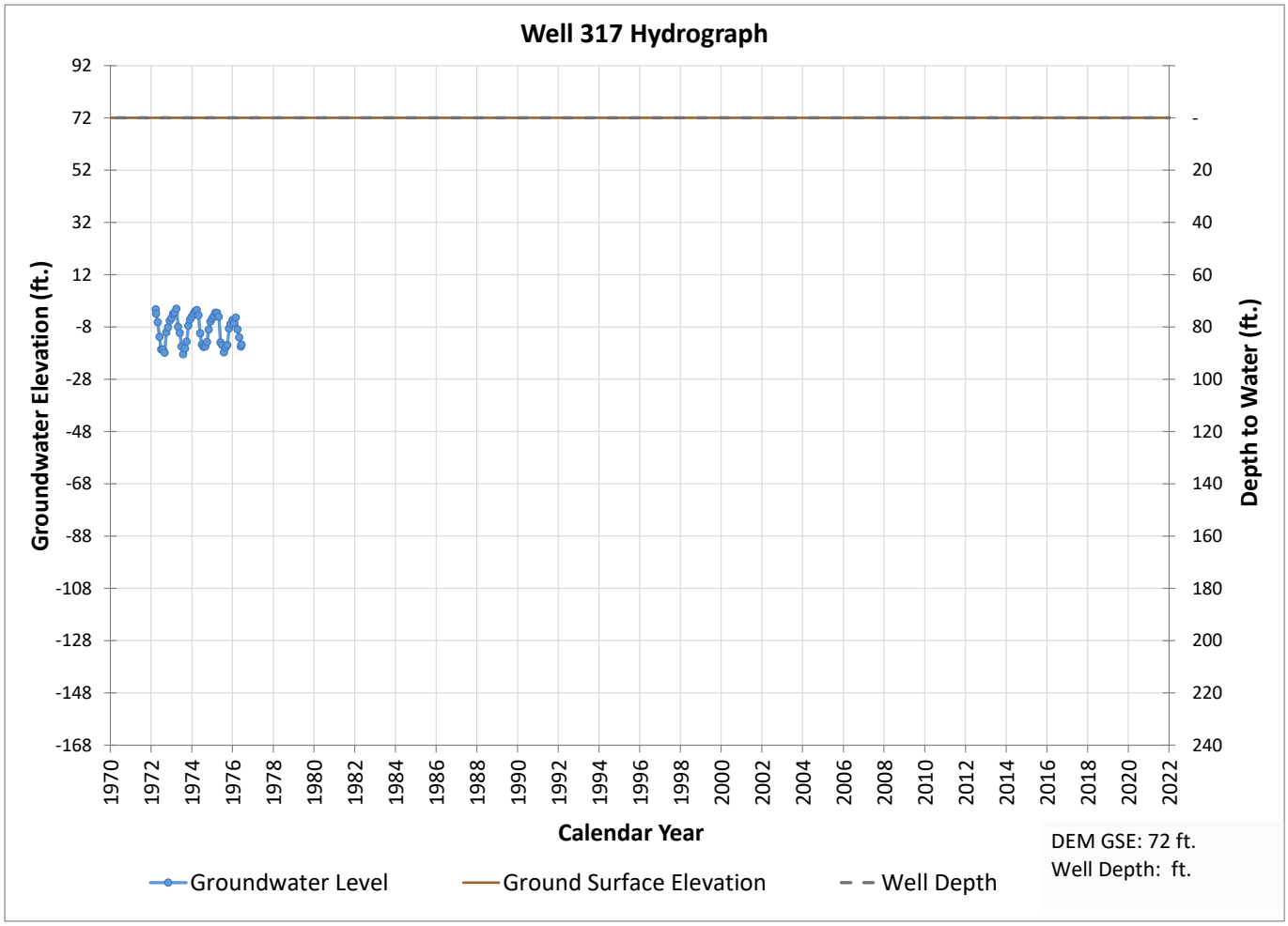

Well 297 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
280
260
240
220
200
180
160
140
120
100
80
60
40
20
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 260 ft.
Well Depth: 675 ft.

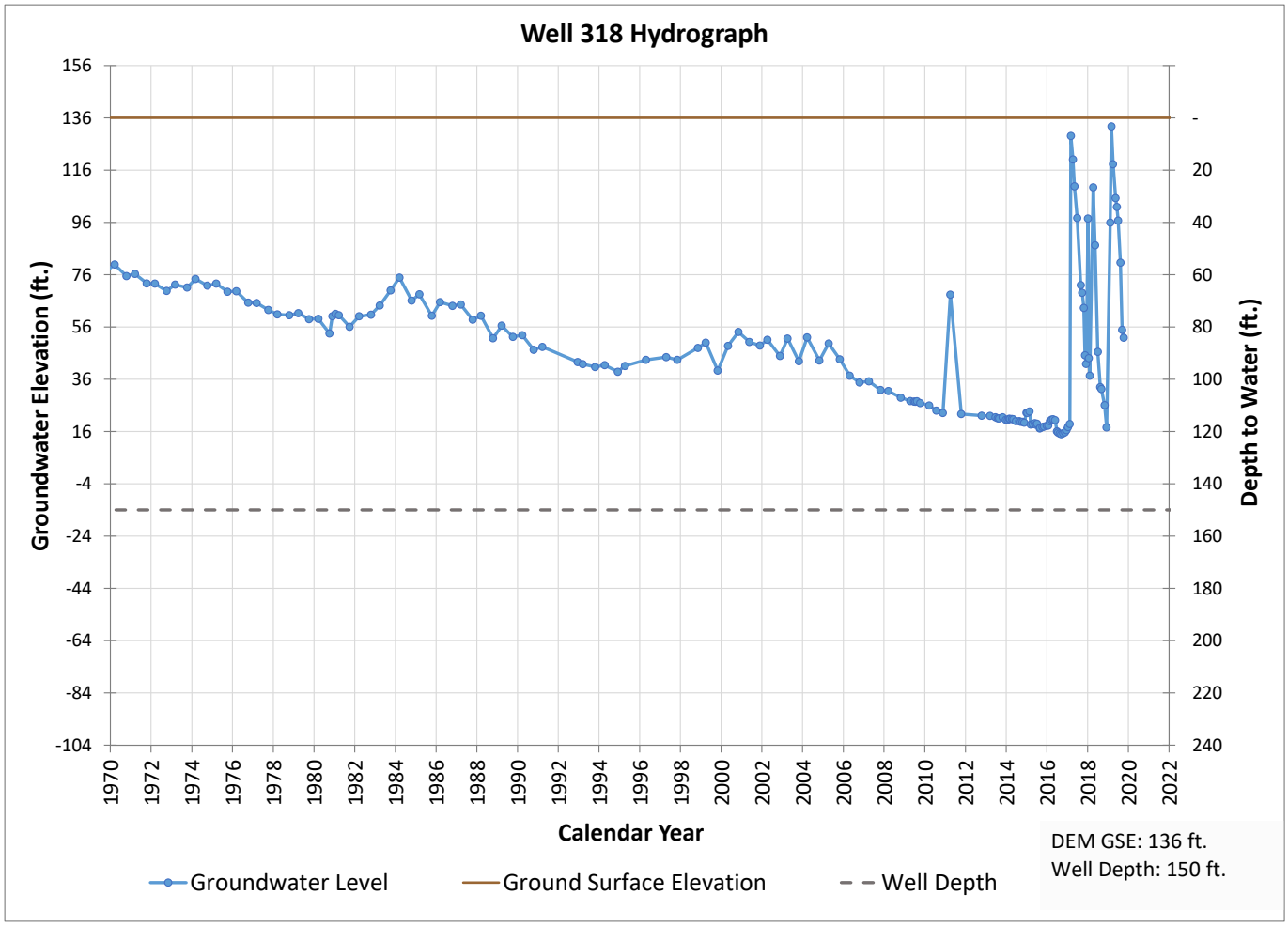

Well 298 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
-216
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 24 ft.
Well Depth: 410 ft.

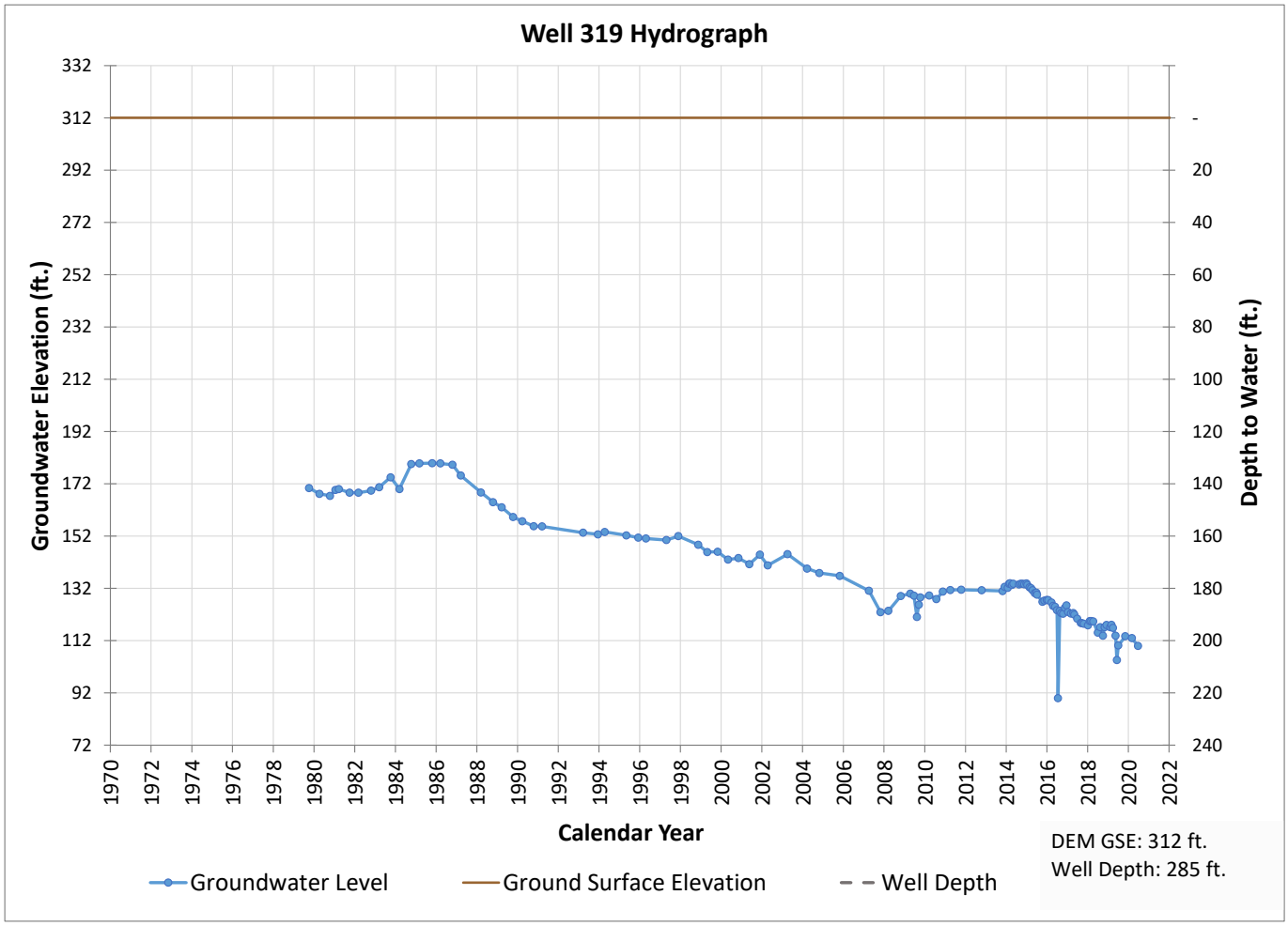

Well 301 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
-219
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 21 ft.
Well Depth: 114 ft.

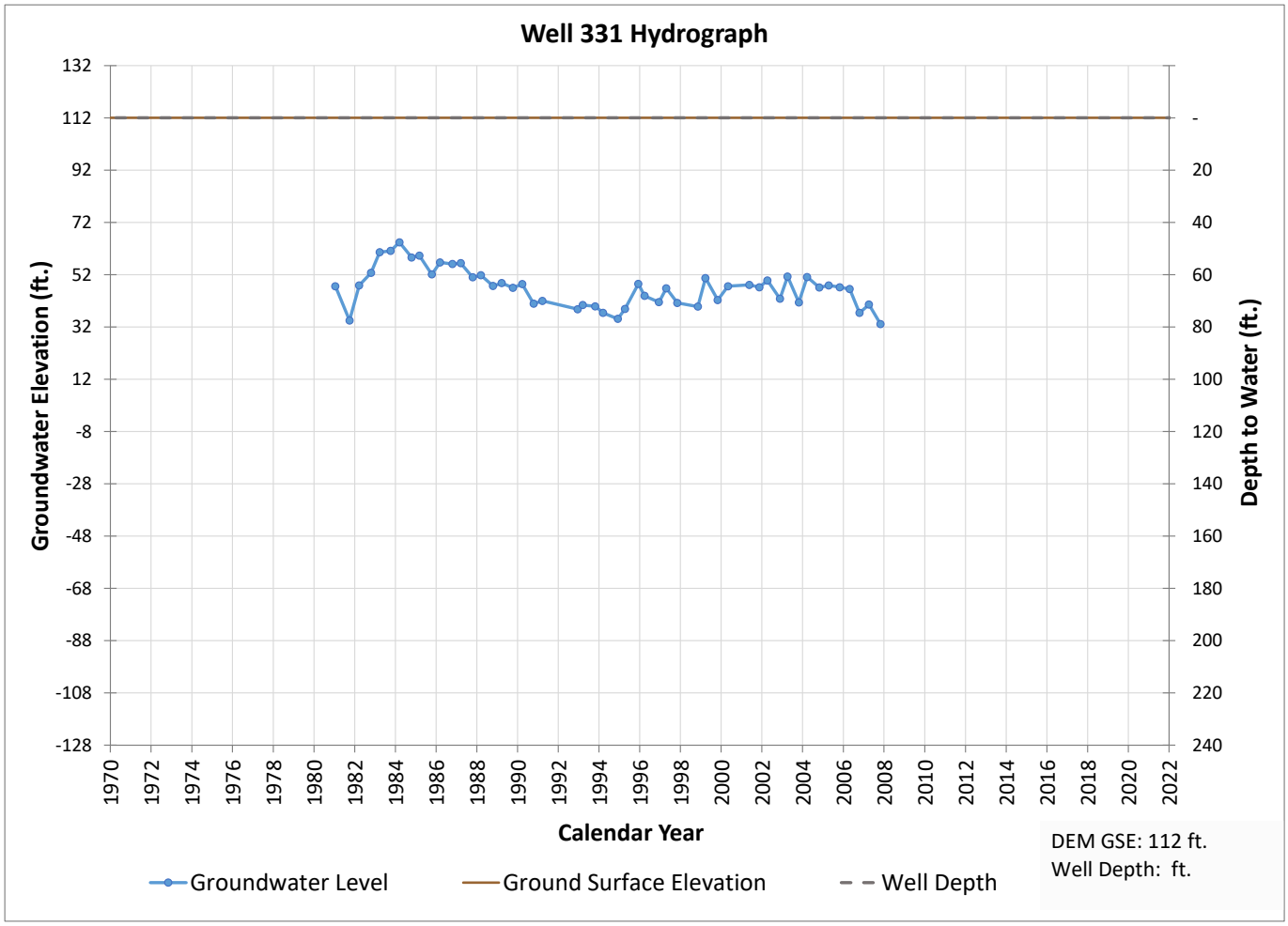

Well 302 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-195
-215
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 25 ft.
Well Depth: 240 ft.

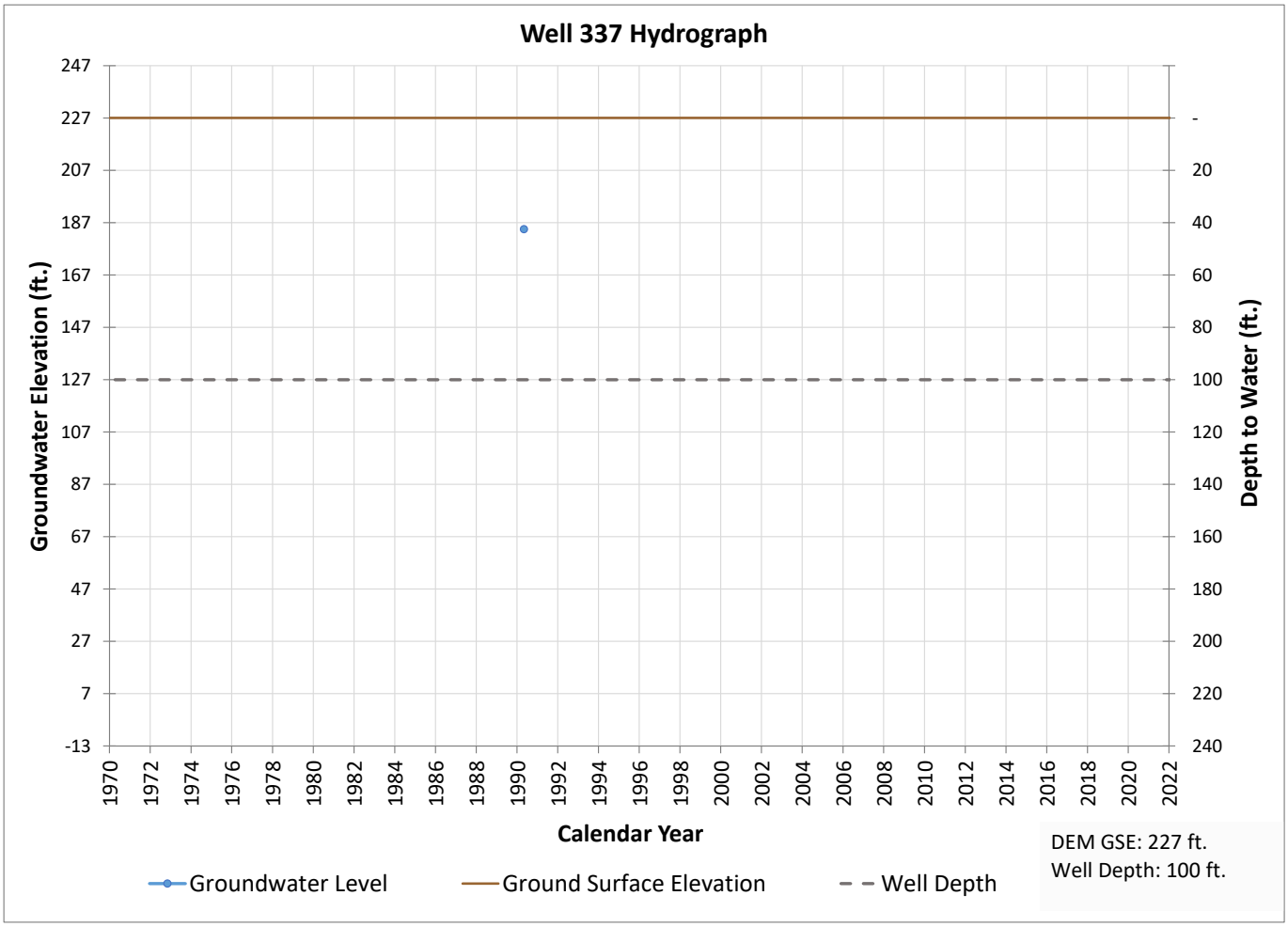

Well 312 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 76 ft.
Well Depth: 85 ft.

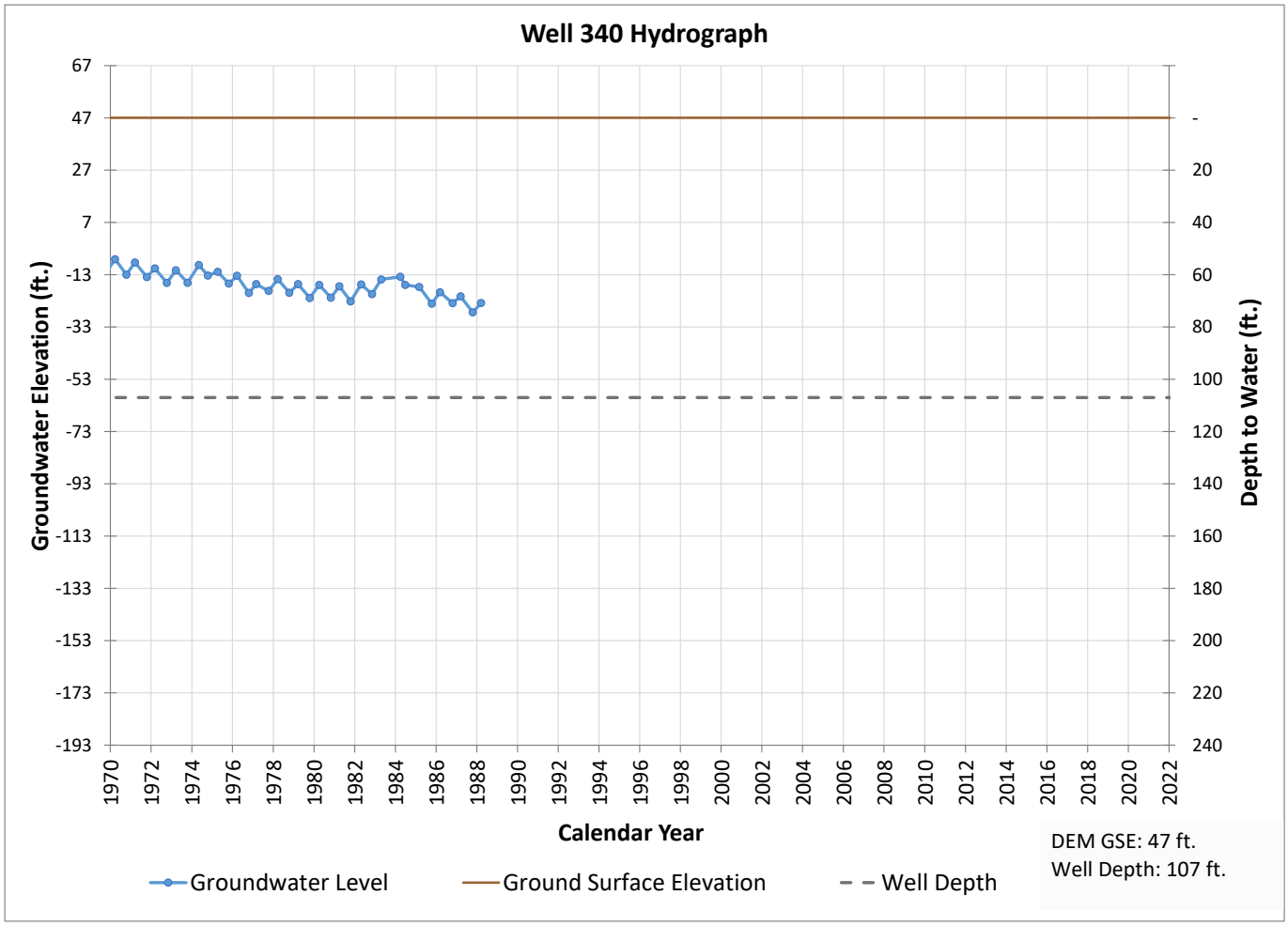

Well 317 Hydrograph
Groundwater Elevation (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: ft.

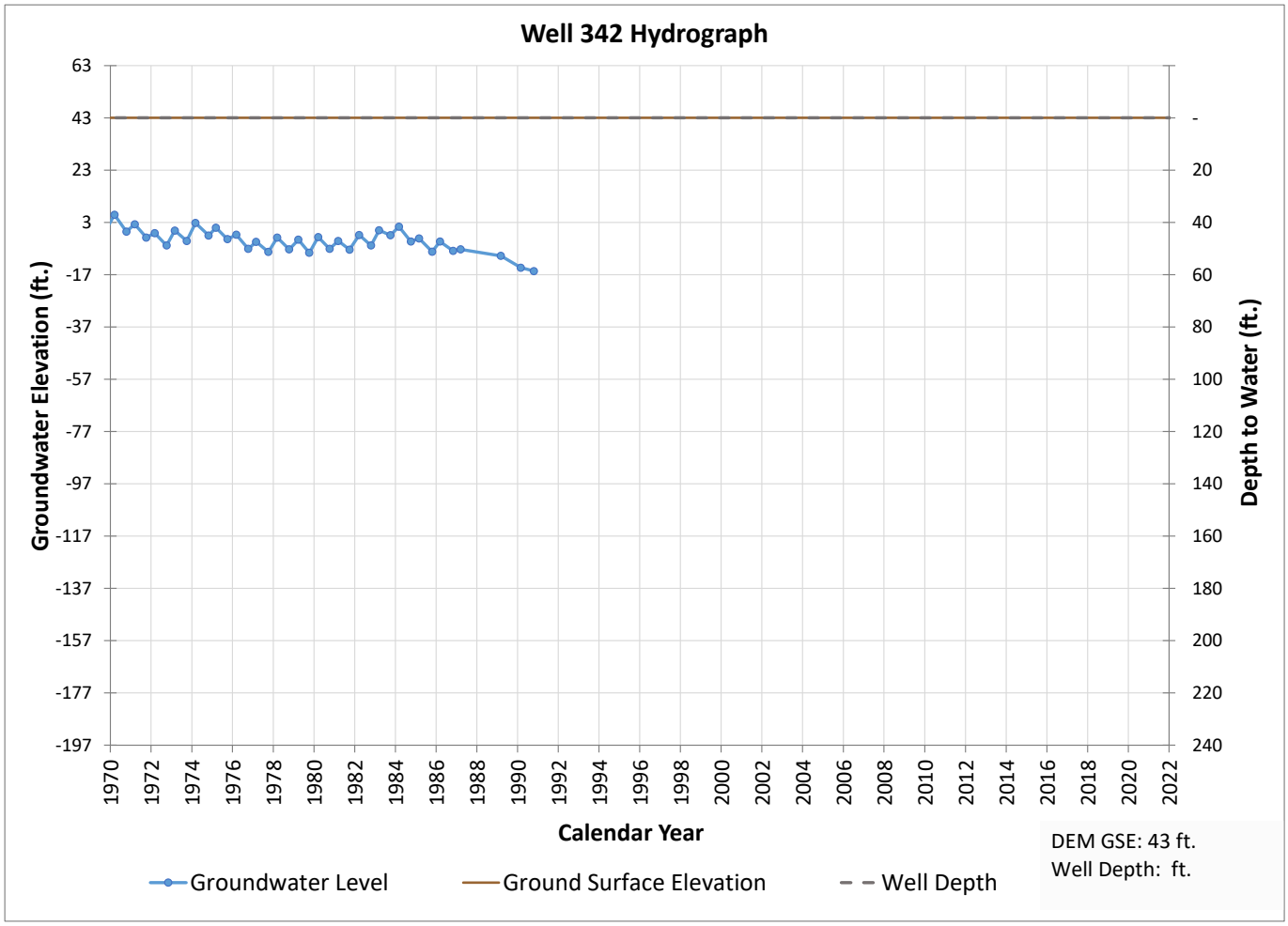

Well 318 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
156
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 136 ft.
Well Depth: 150 ft.

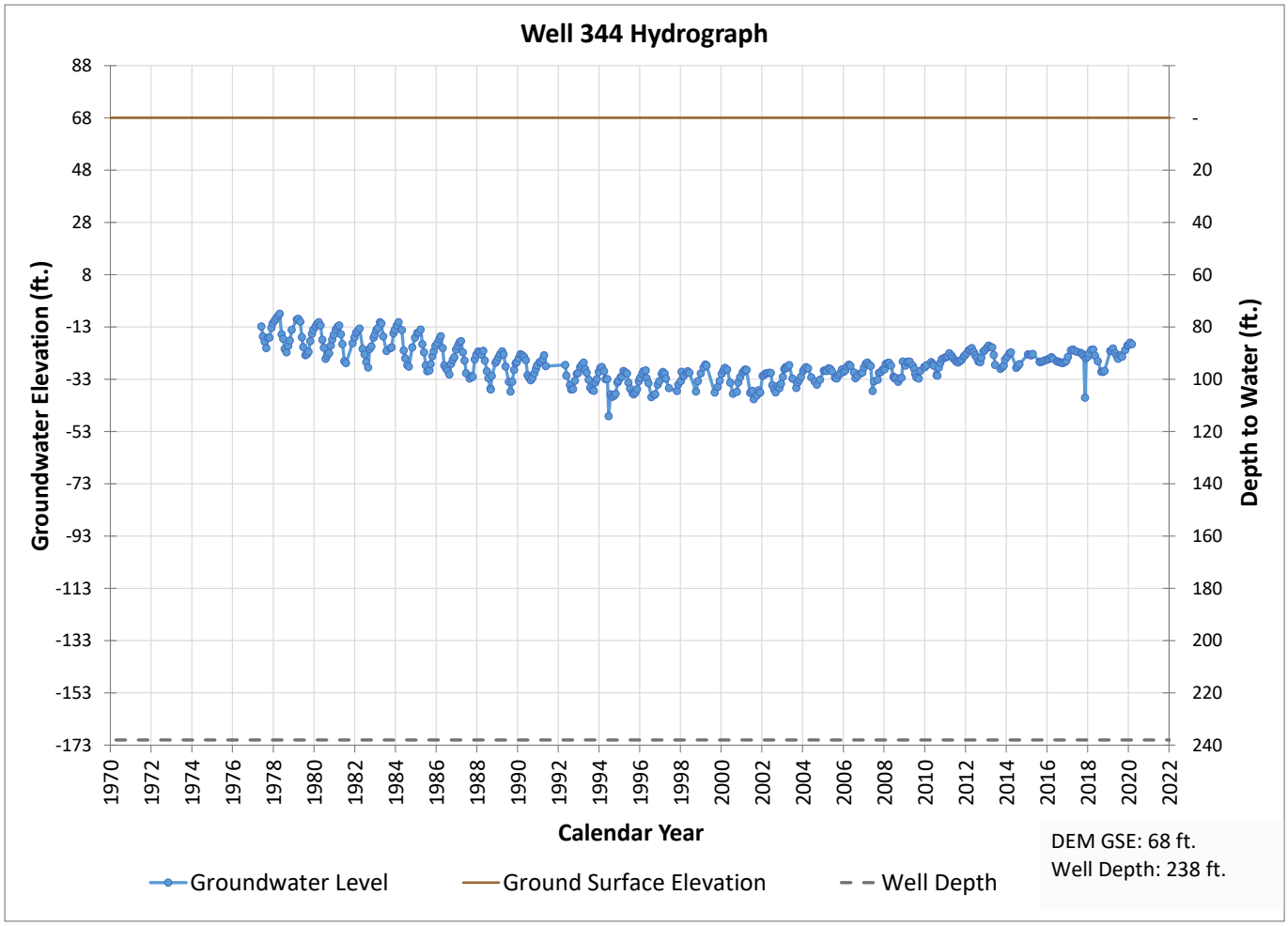

Well 319 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
332
312
292
272
252
232
212
192
172
152
132
112
92
72
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 312 ft.
Well Depth: 285 ft.

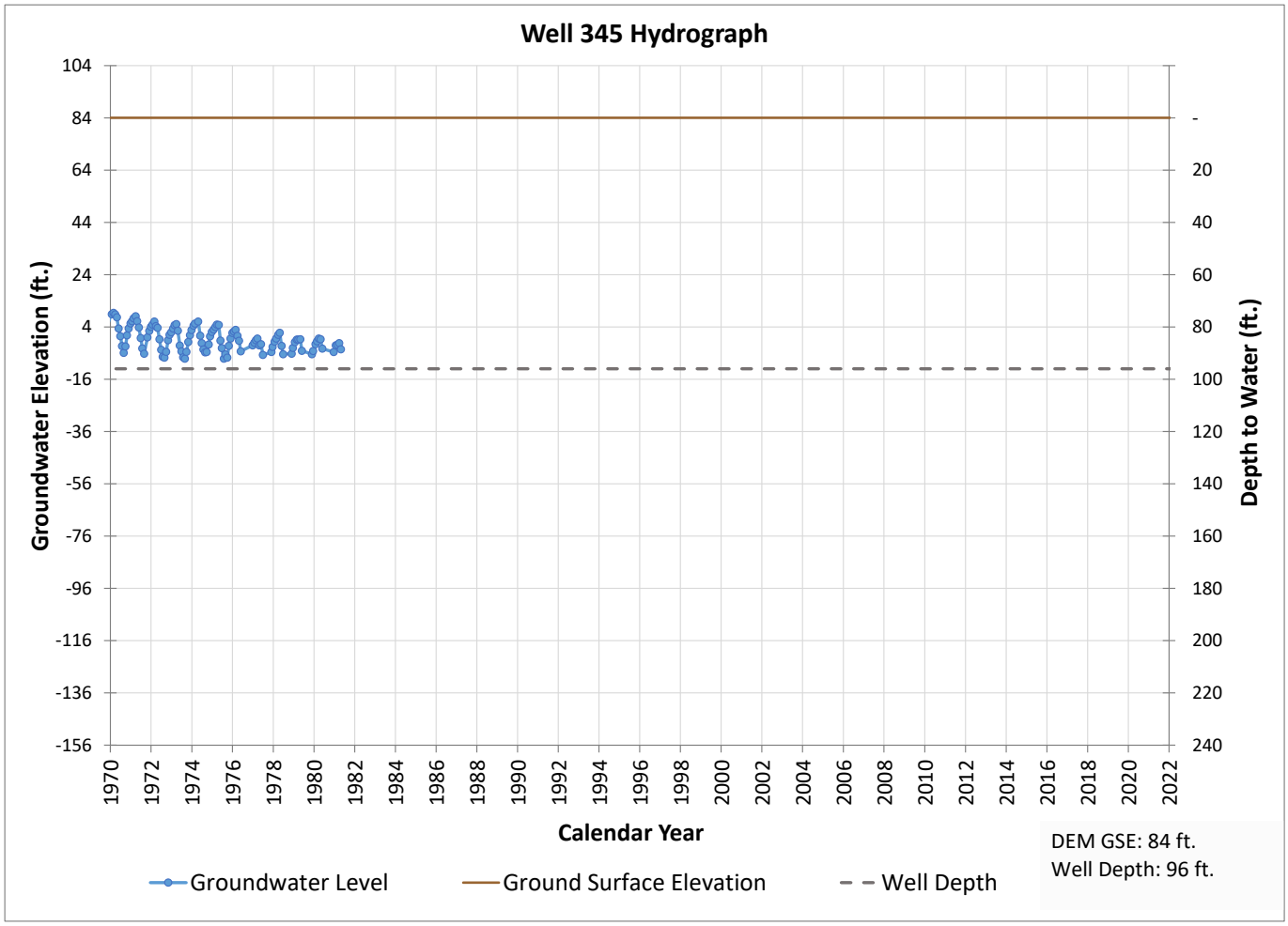

Well 331 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
132
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 112 ft.
Well Depth: ft.

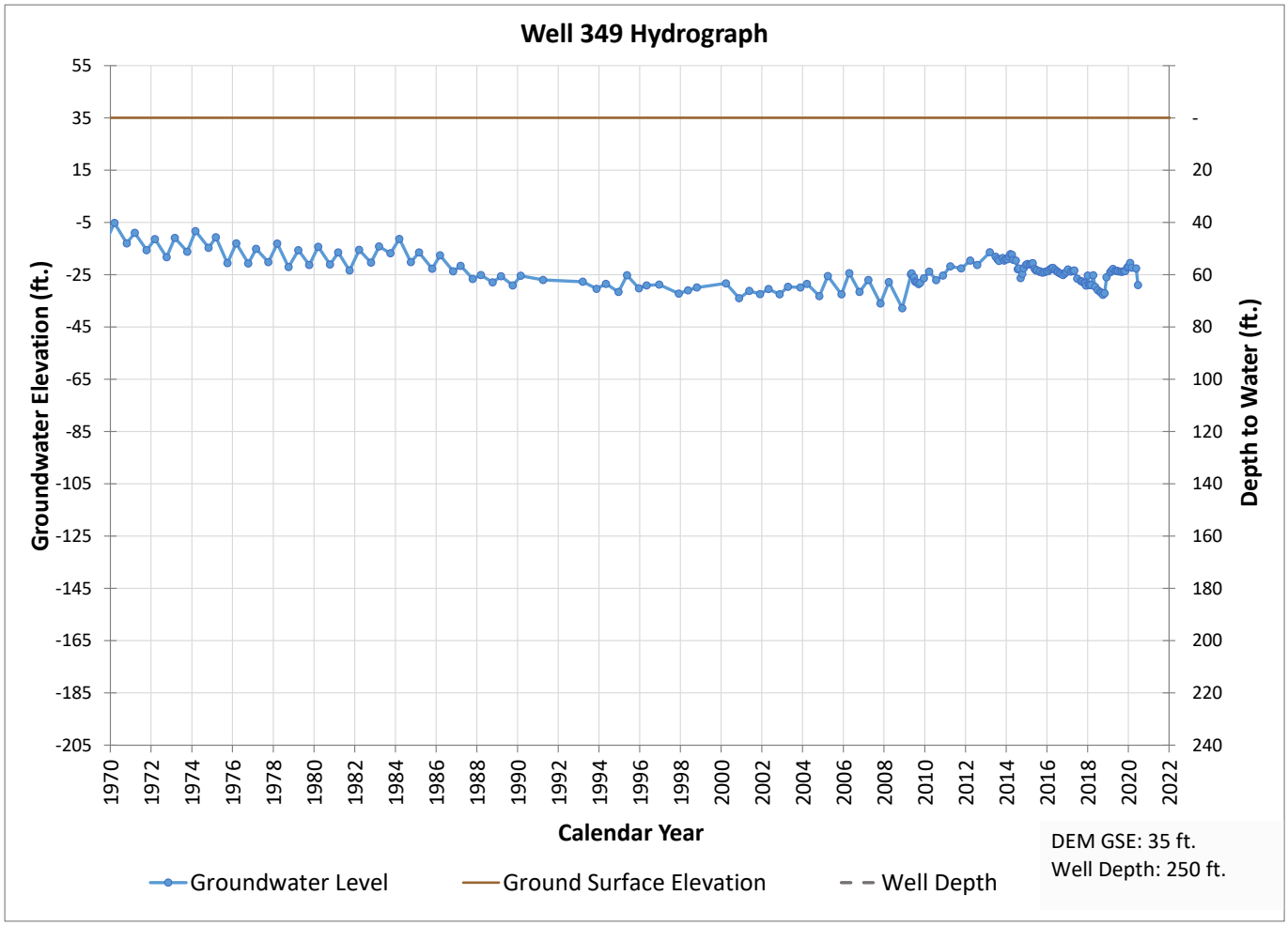

Well 337 Hydrograph
Groundwater Elevation (ft.)
247
227
207
187
167
147
127
107
87
67
47
27
7
-13
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 227 ft.
Well Depth: 100 ft.

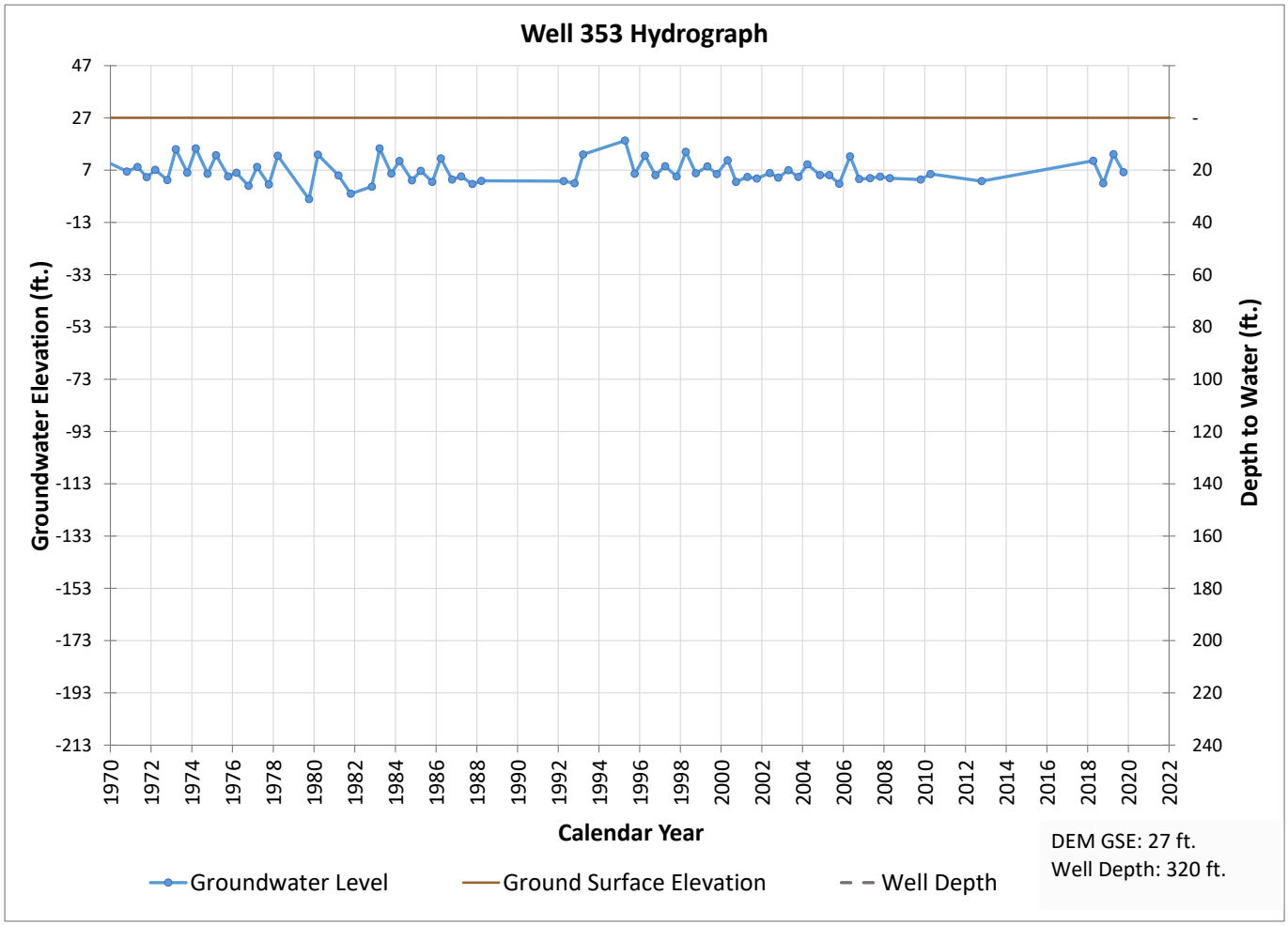

Well 340 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 47 ft.
Well Depth: 107 ft.

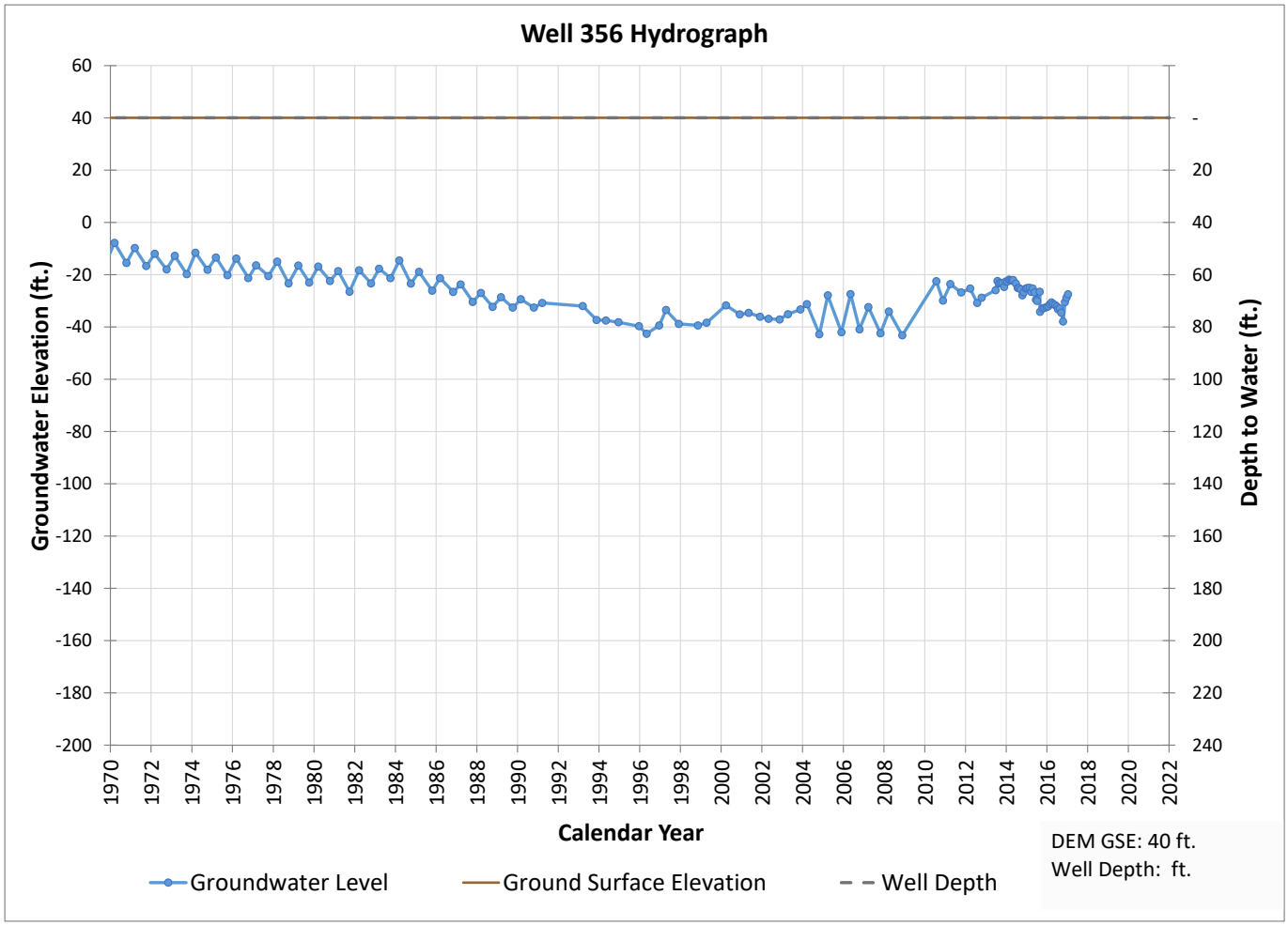

Well 342 Hydrograph
Groundwater Elevation (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: ft.

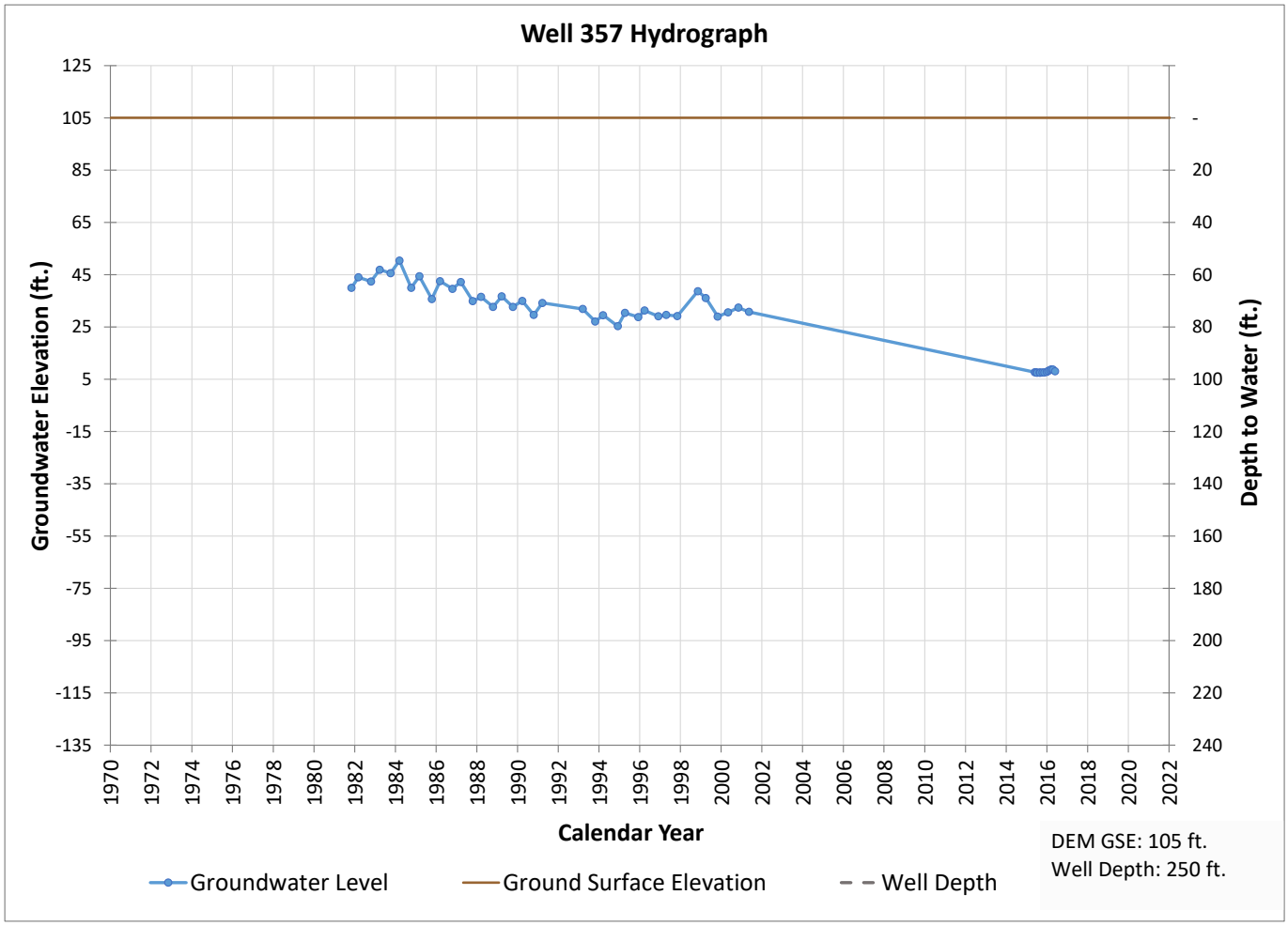

Well 344 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
88
68
48
28
8
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 68 ft.
Well Depth: 238 ft.

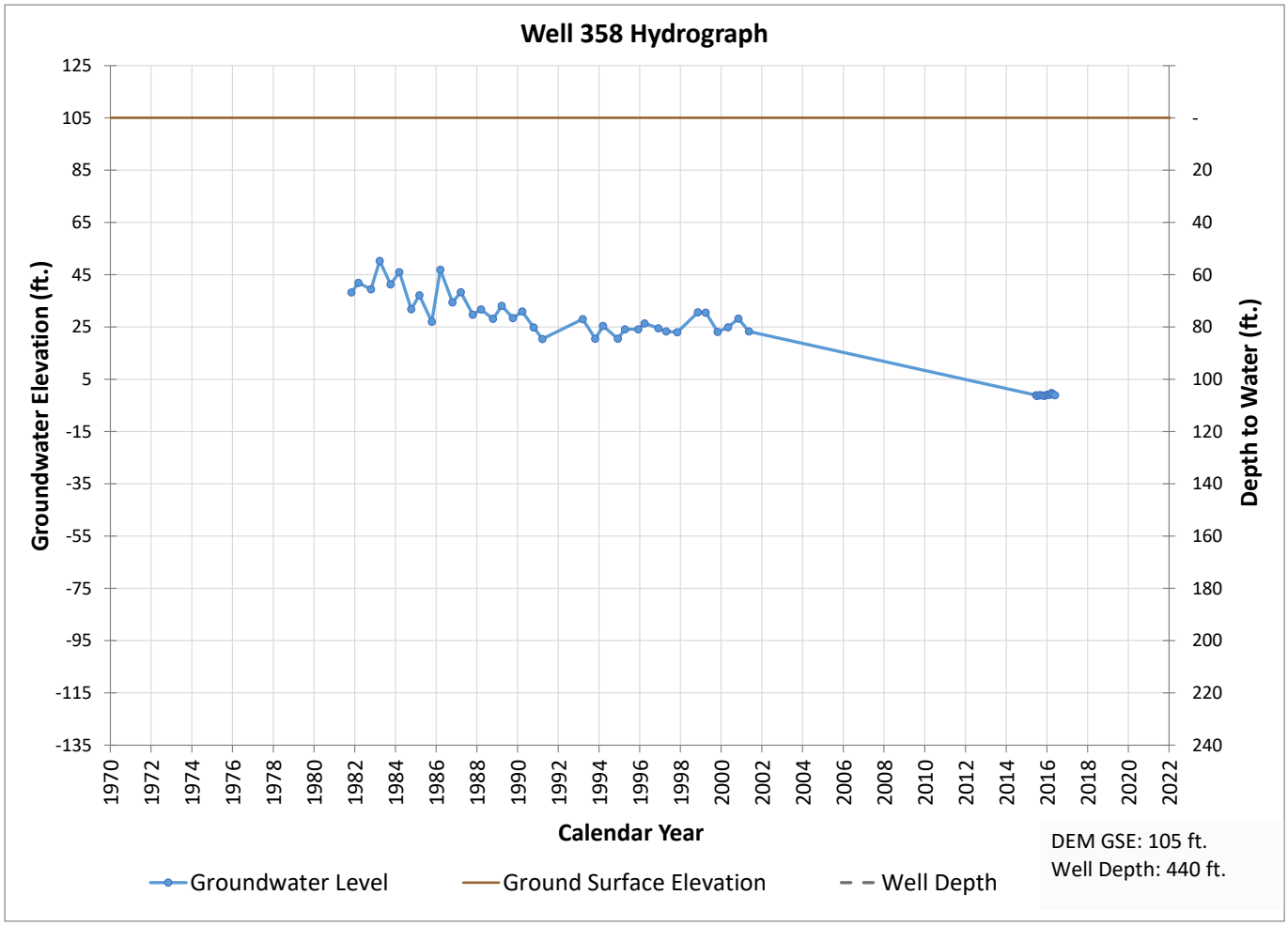

Well 345 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
104
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 84 ft.
Well Depth: 96 ft.

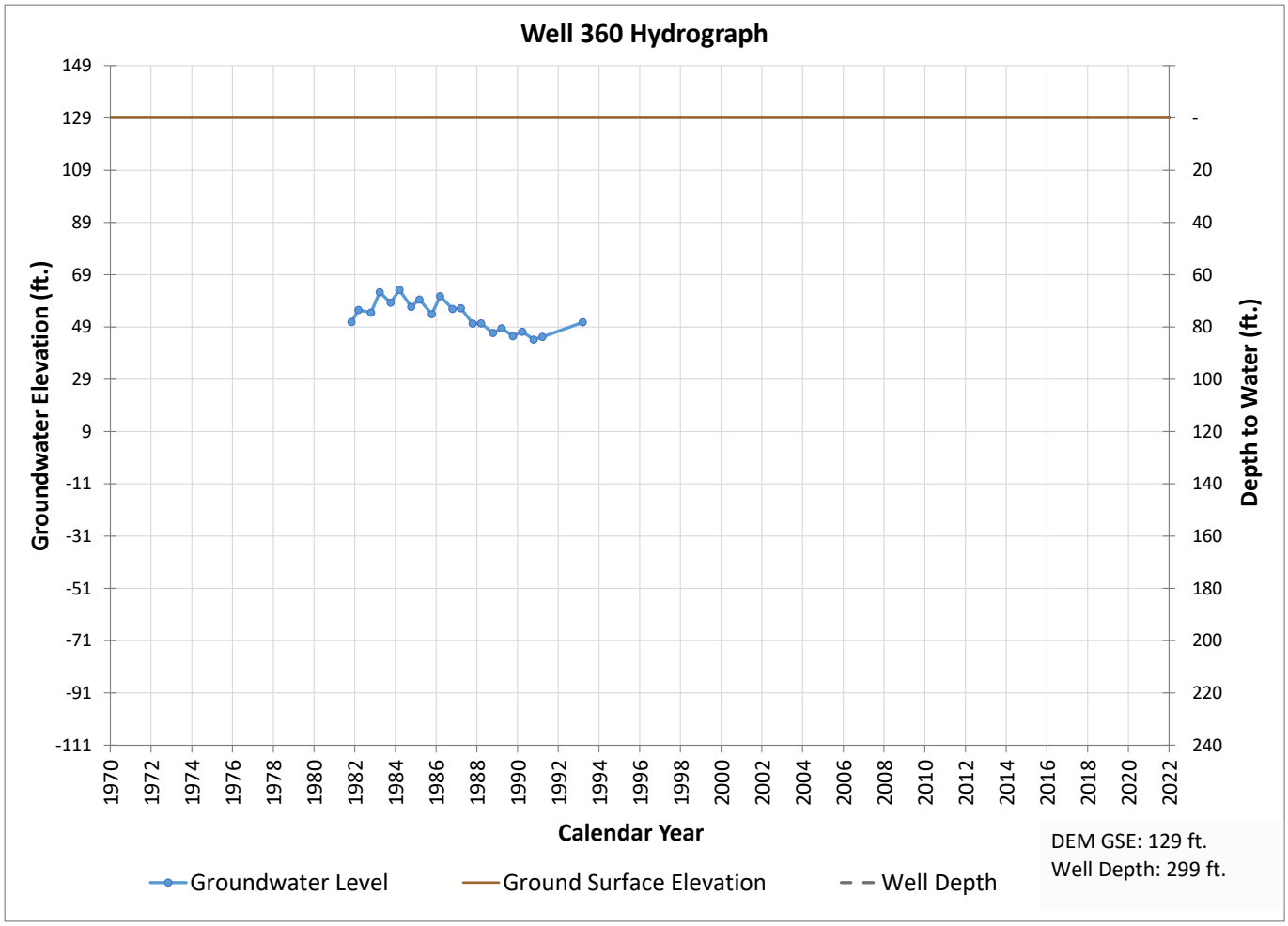

Well 349 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 35 ft.
Well Depth: 250 ft.

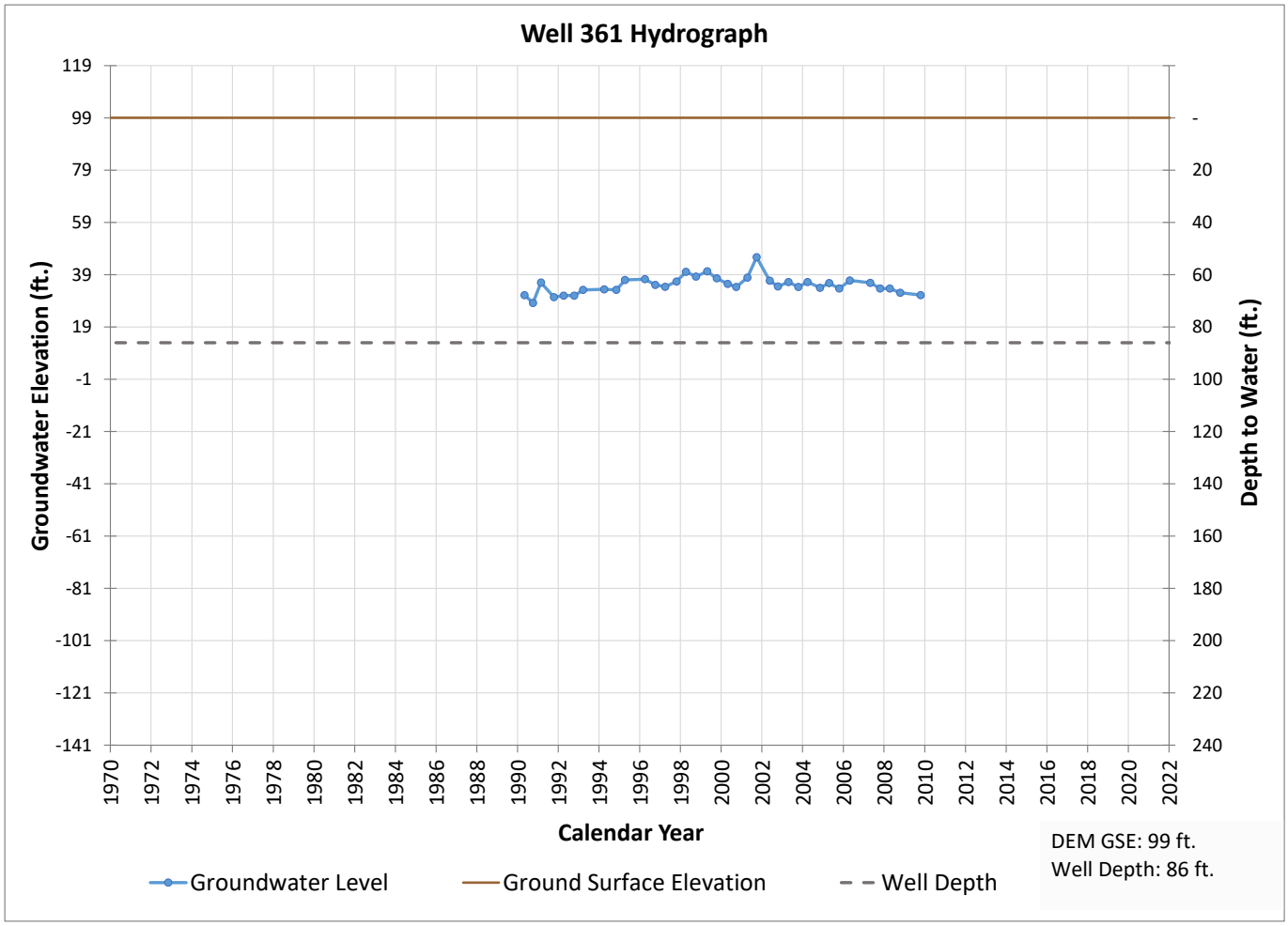

Well 353 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 320 ft.

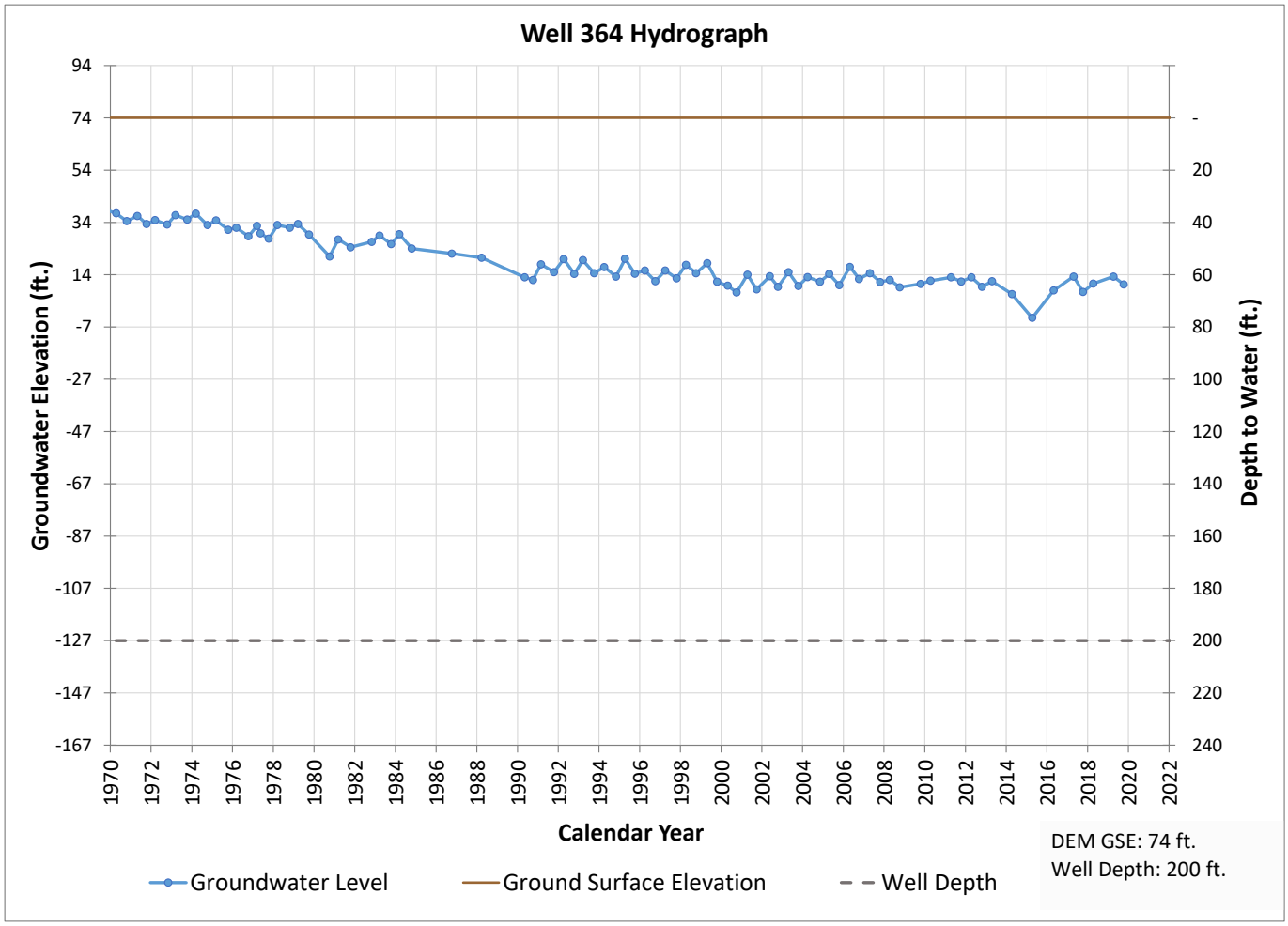

Well 356 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 40 ft.
Well Depth: ft.

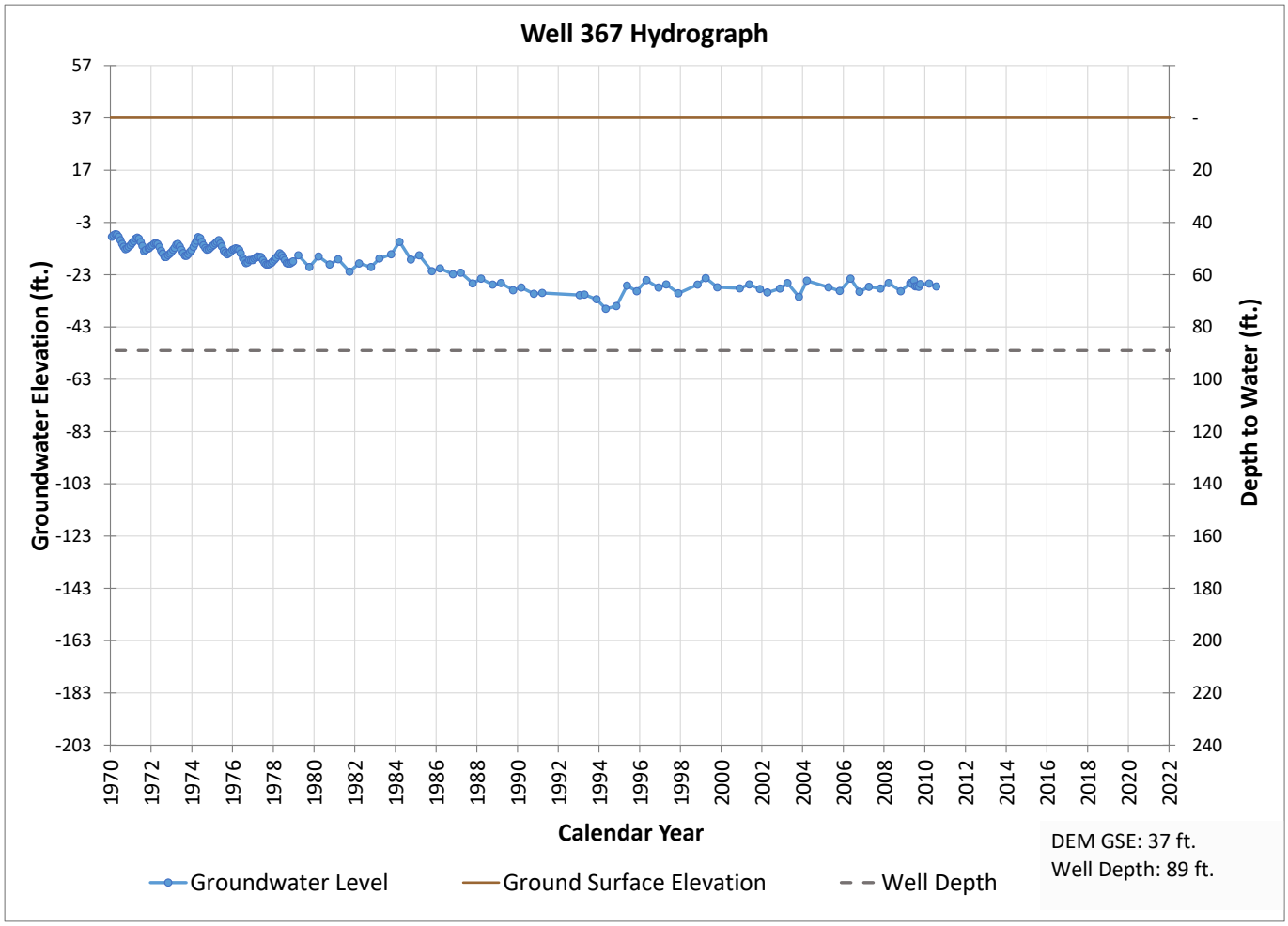

Well 357 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
125
105
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 105 ft.
Well Depth: 250 ft.

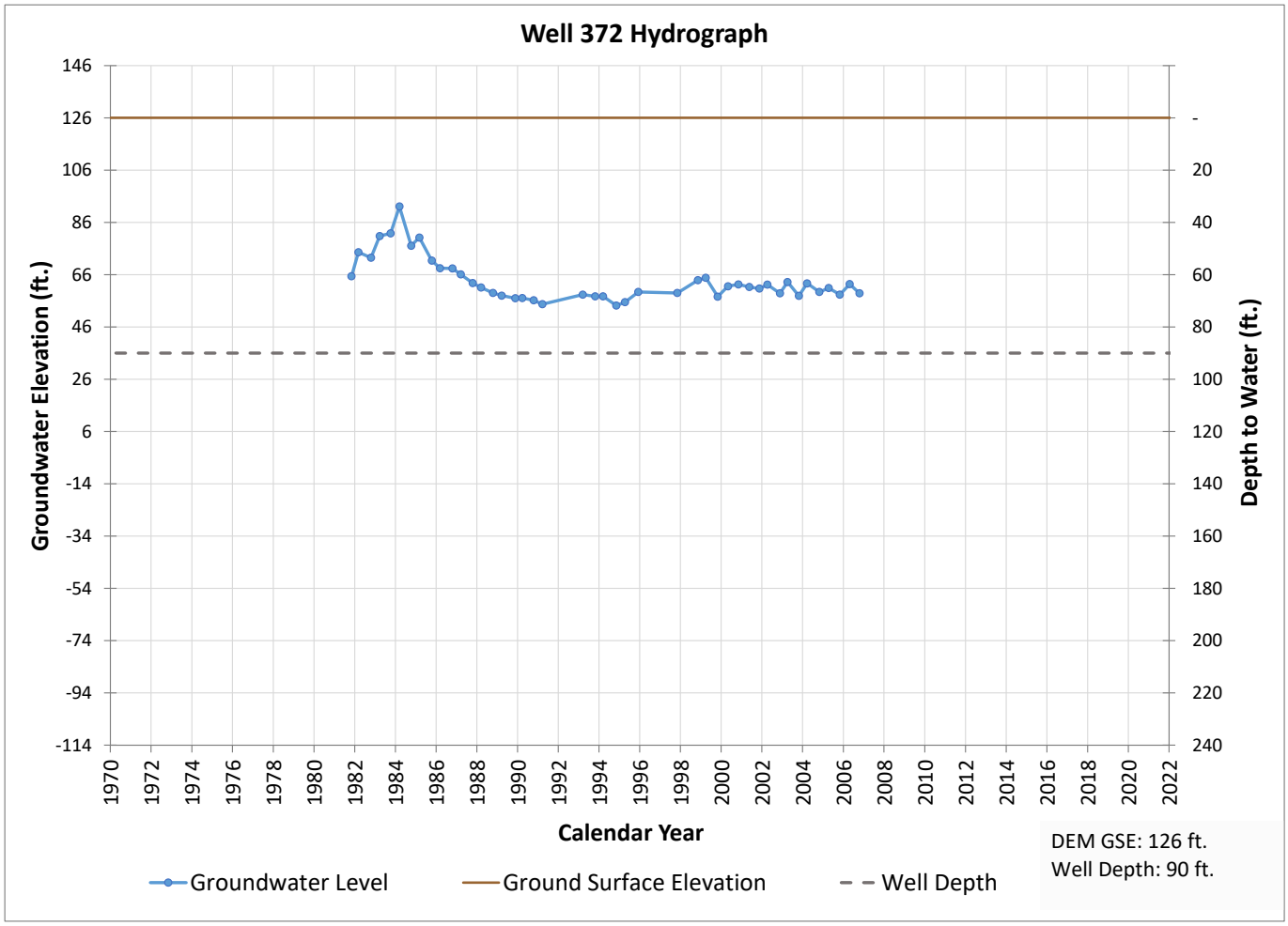

Well 358 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
125
105
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 105 ft.
Well Depth: 440 ft.

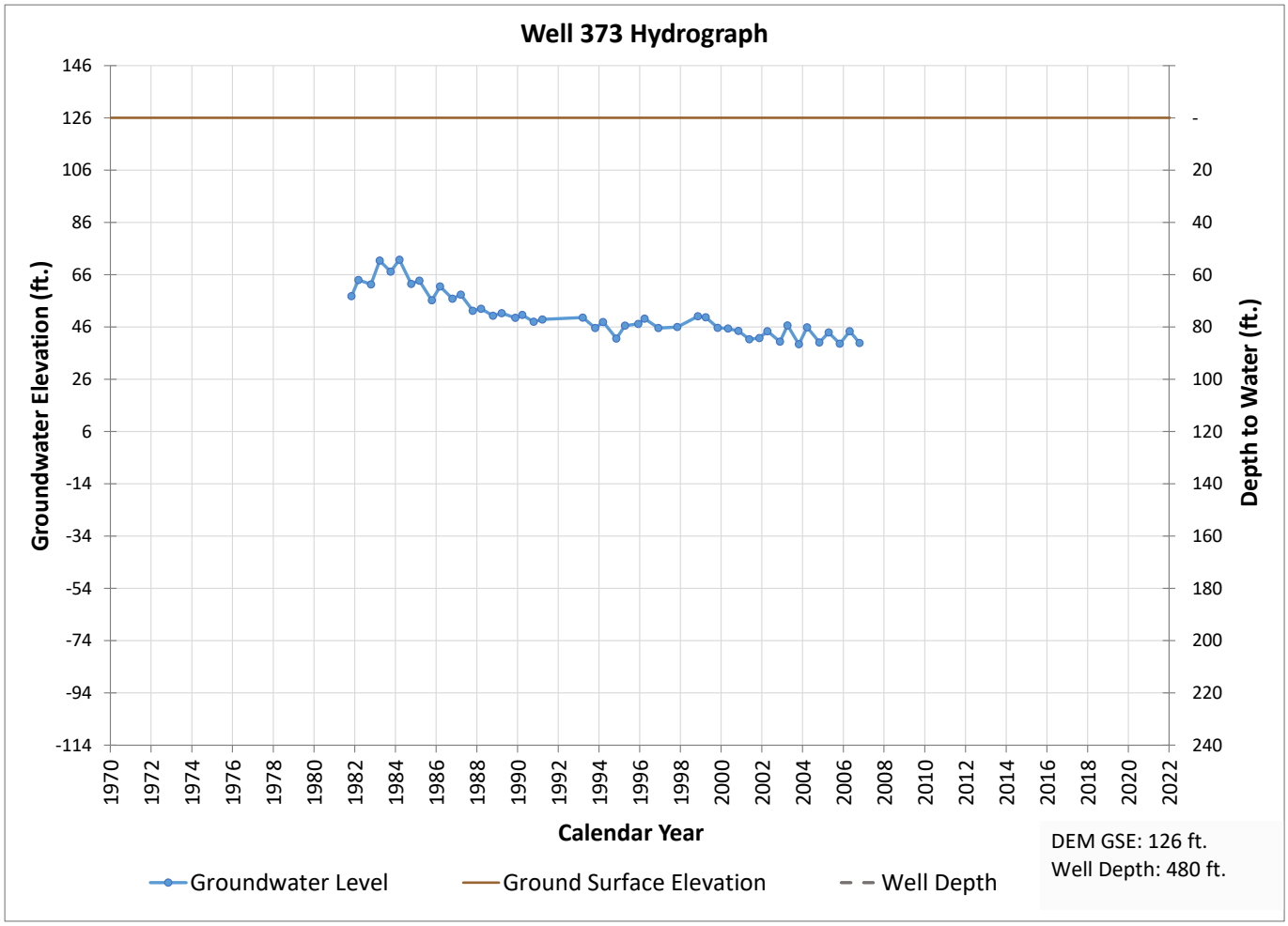

Well 360 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
149
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 129 ft.
Well Depth: 299 ft.

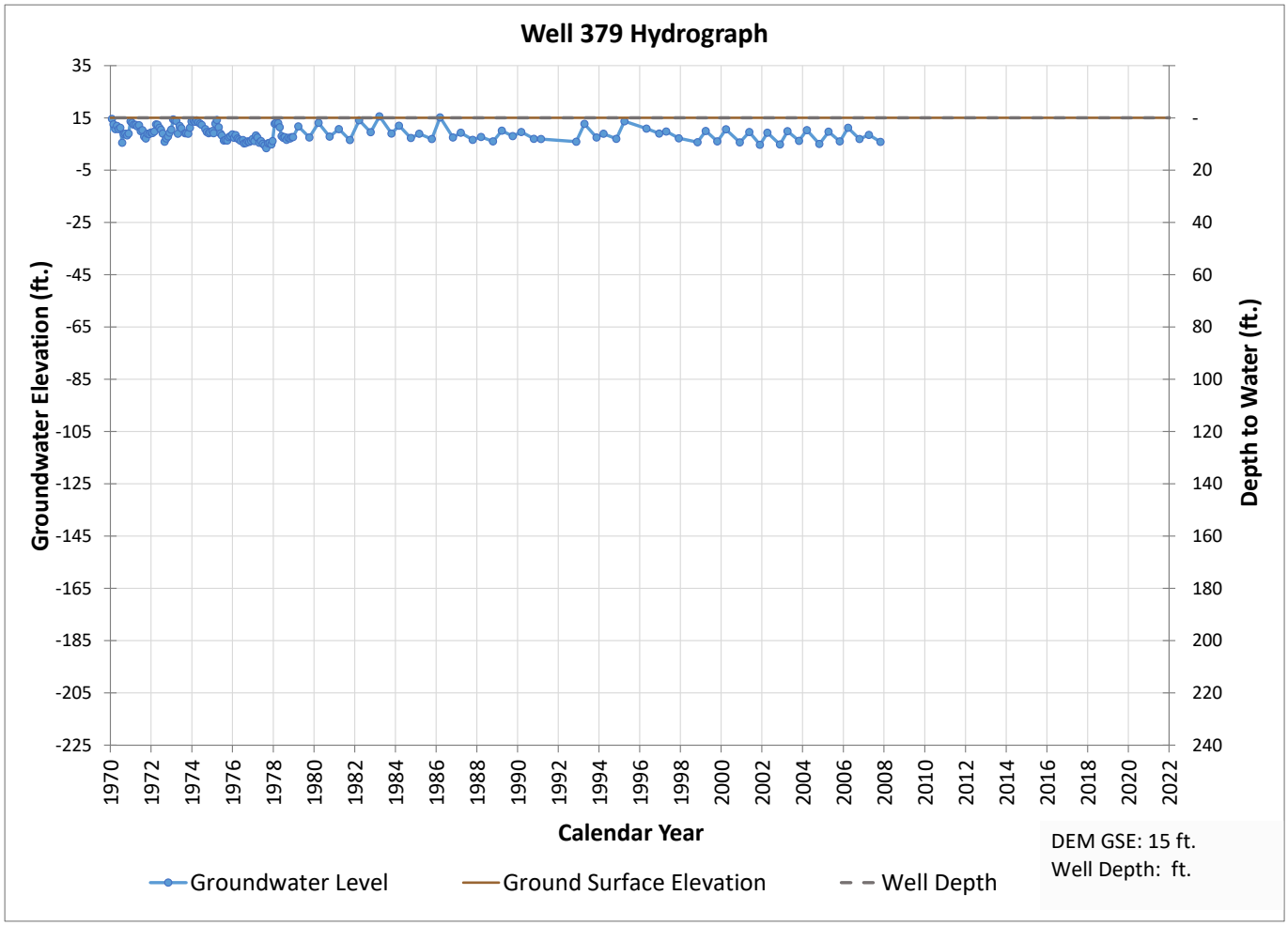

Well 361 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
119
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 99 ft.
Well Depth: 86 ft.

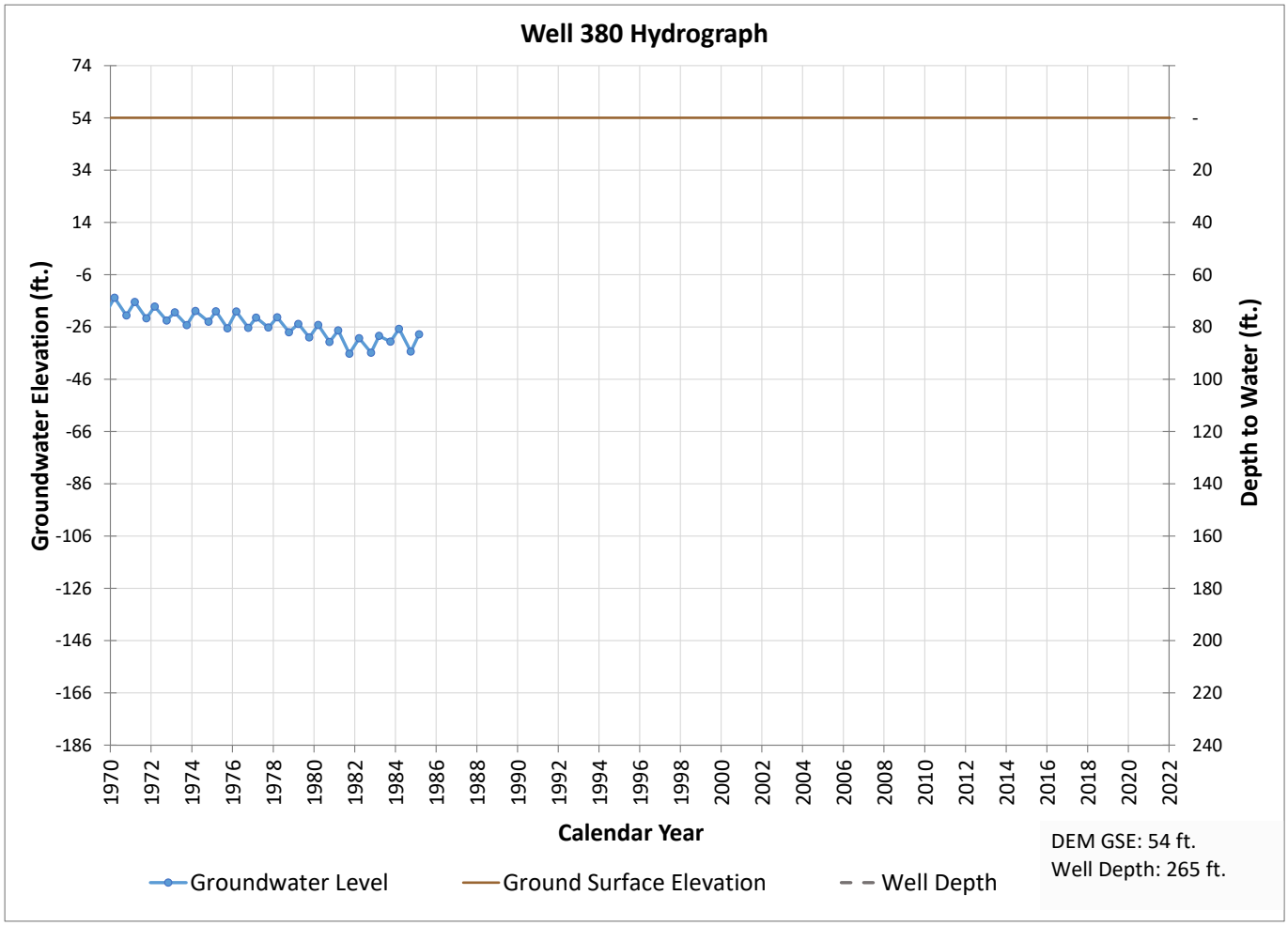

Well 364 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
94
74
54
34
14
-7
-27
-47
-67
-87
-107
-127
-147
-167
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 74 ft.
Well Depth: 200 ft.

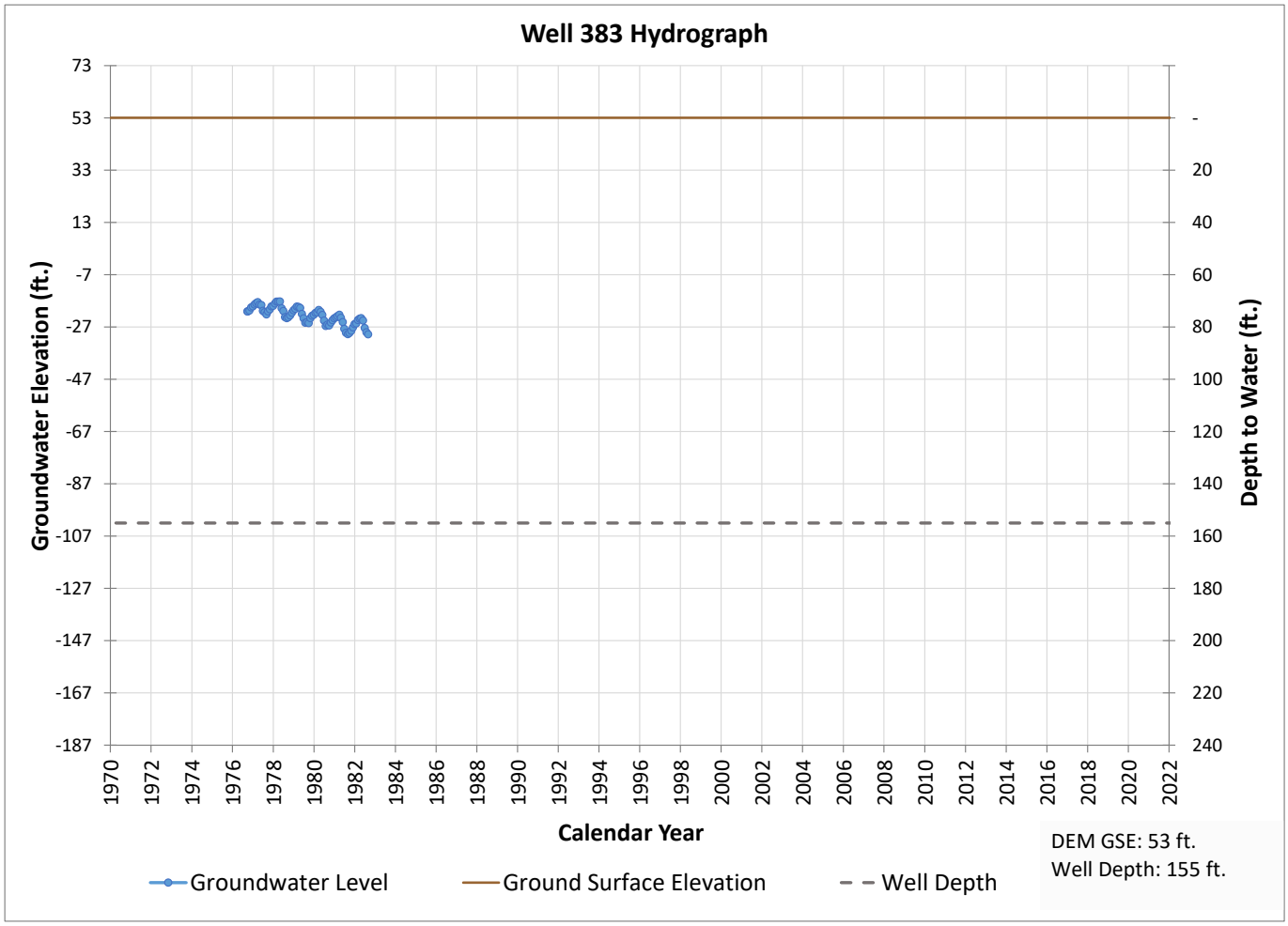

Well 367 Hydrograph
Groundwater Elevation (ft.)
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 37 ft.
Well Depth: 89 ft.

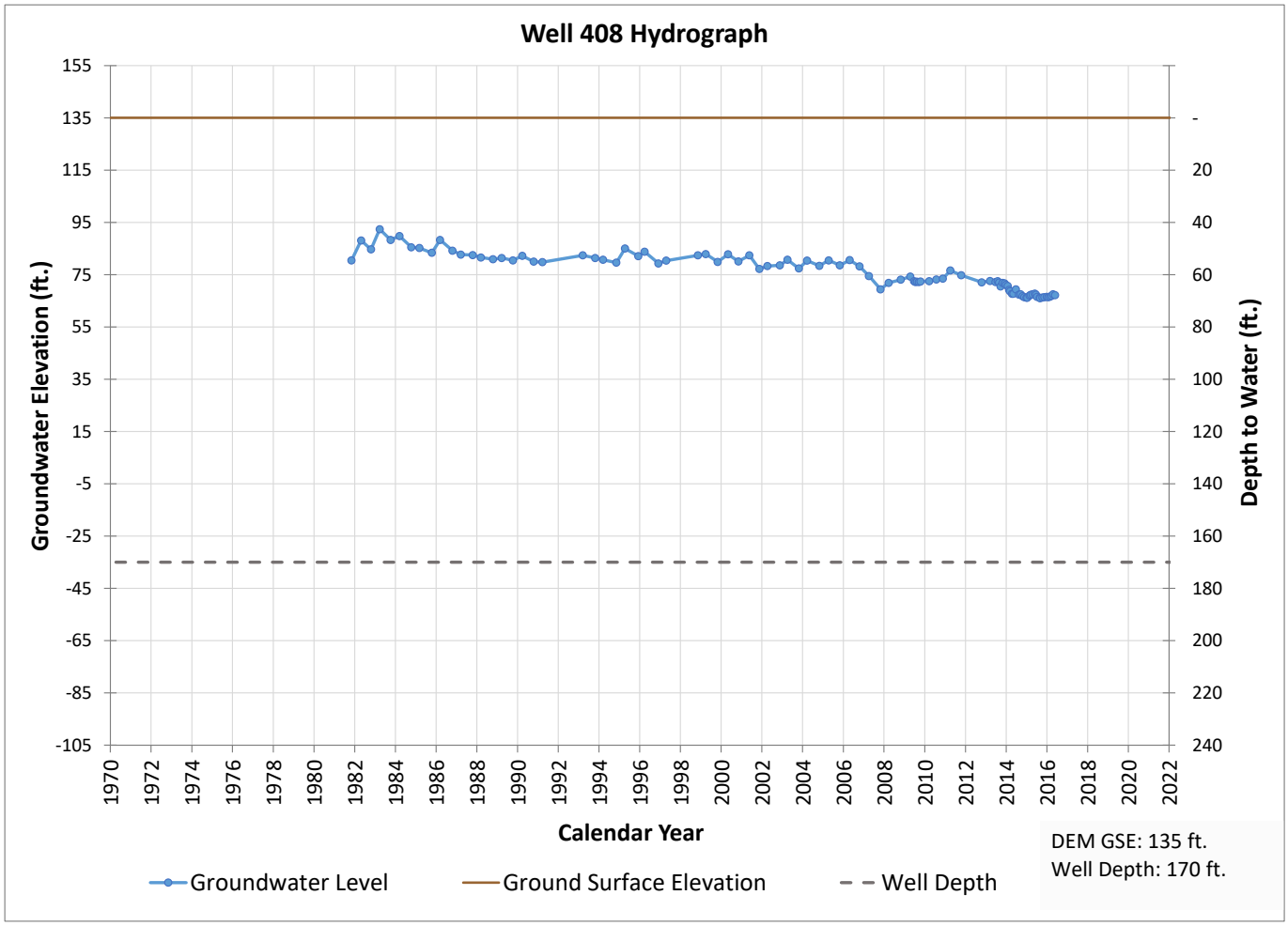

Well 372 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
146
126
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 126 ft.
Well Depth: 90 ft.

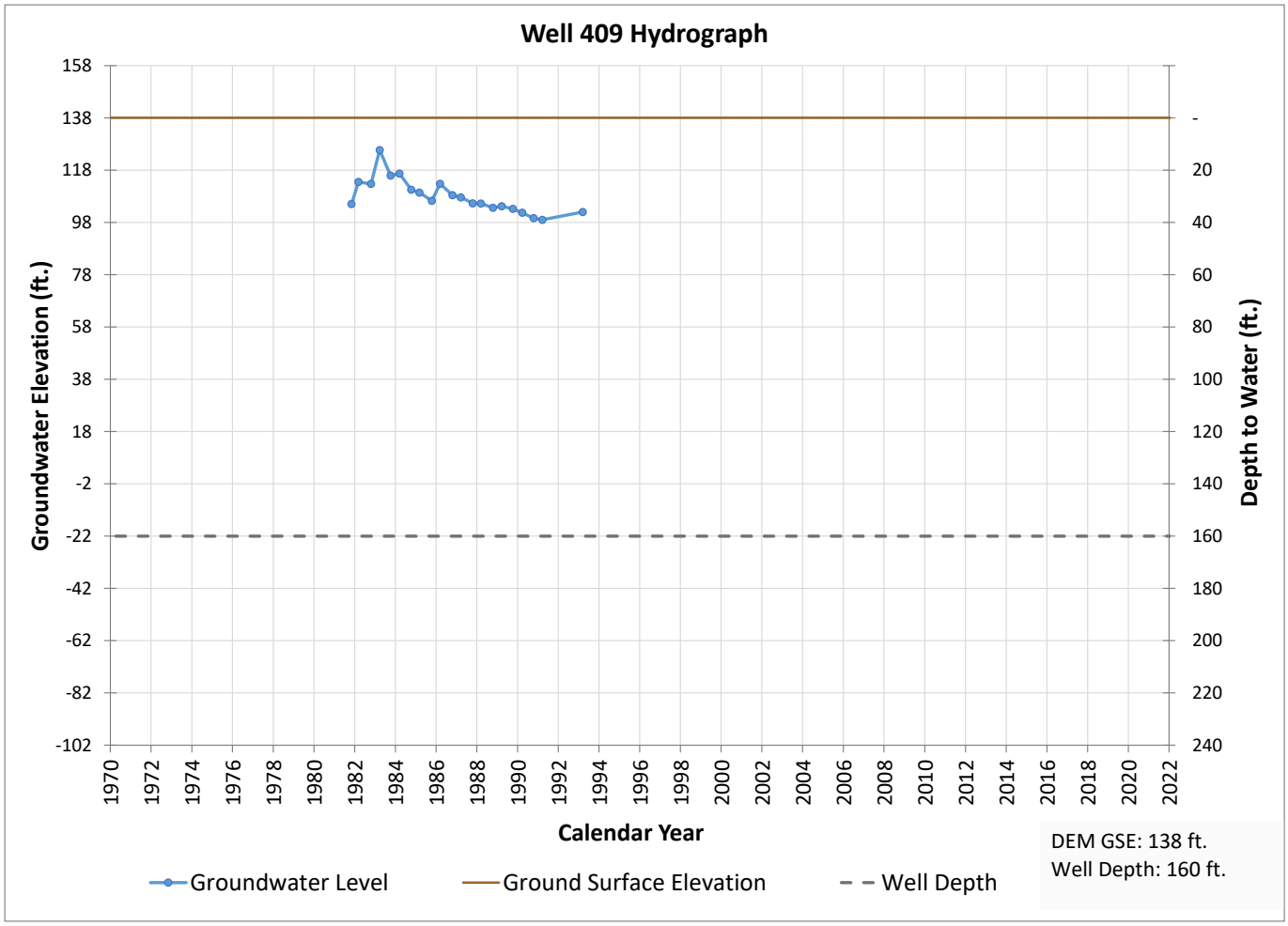

Well 373 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
146
126
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 126 ft.
Well Depth: 480 ft.

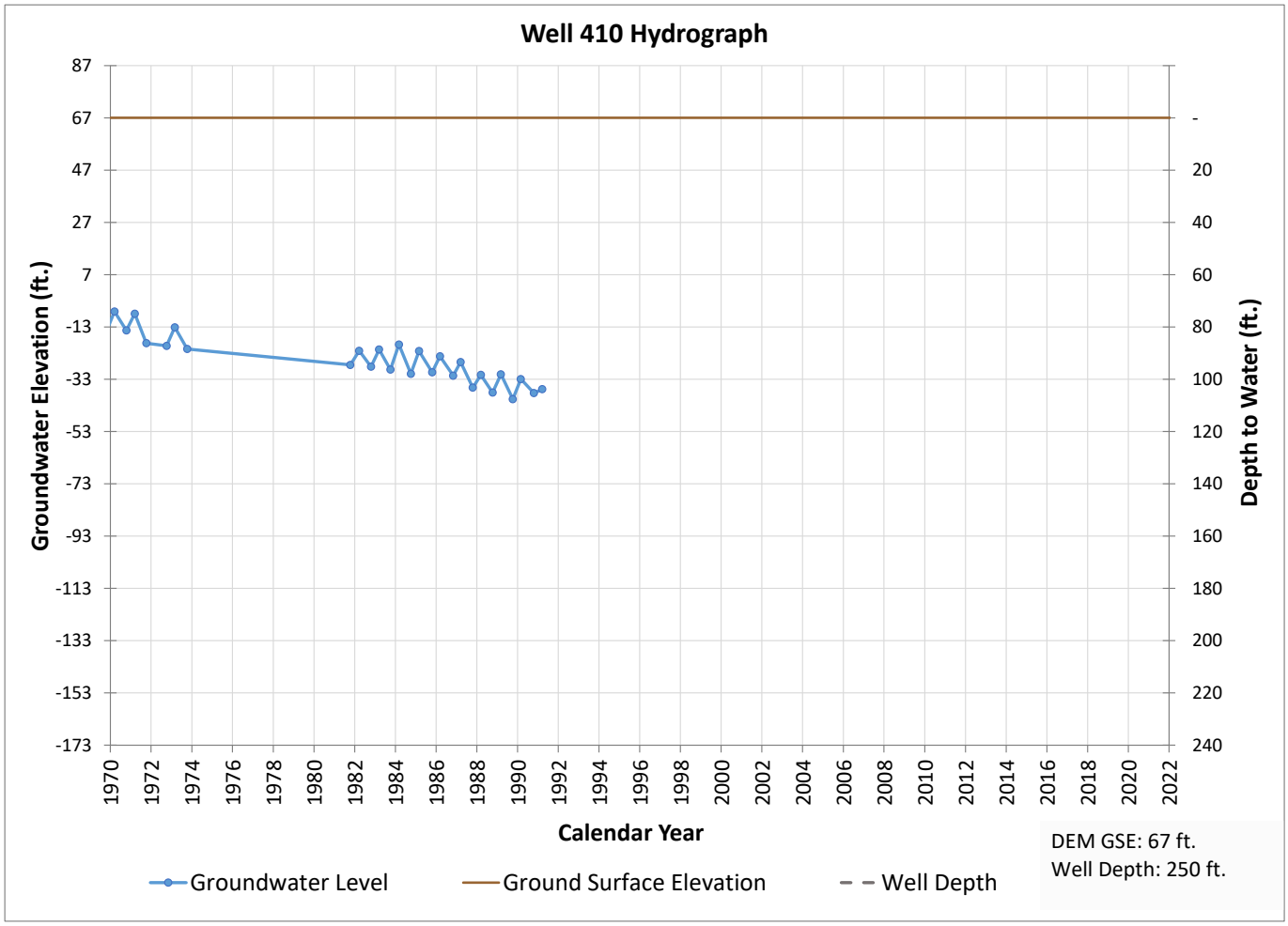

Well 379 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-225
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 15 ft.
Well Depth: ft.

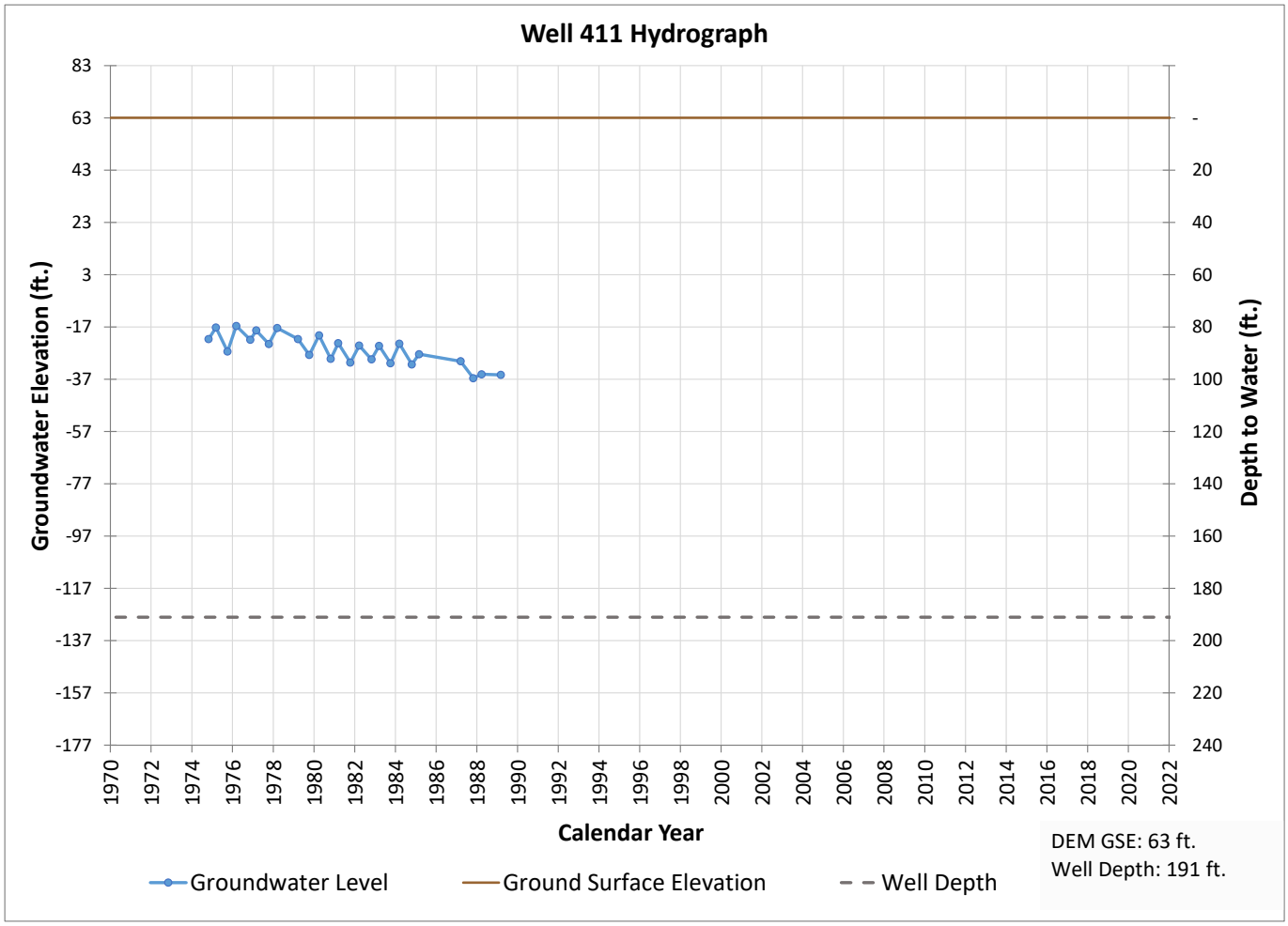

Well 380 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 265 ft.

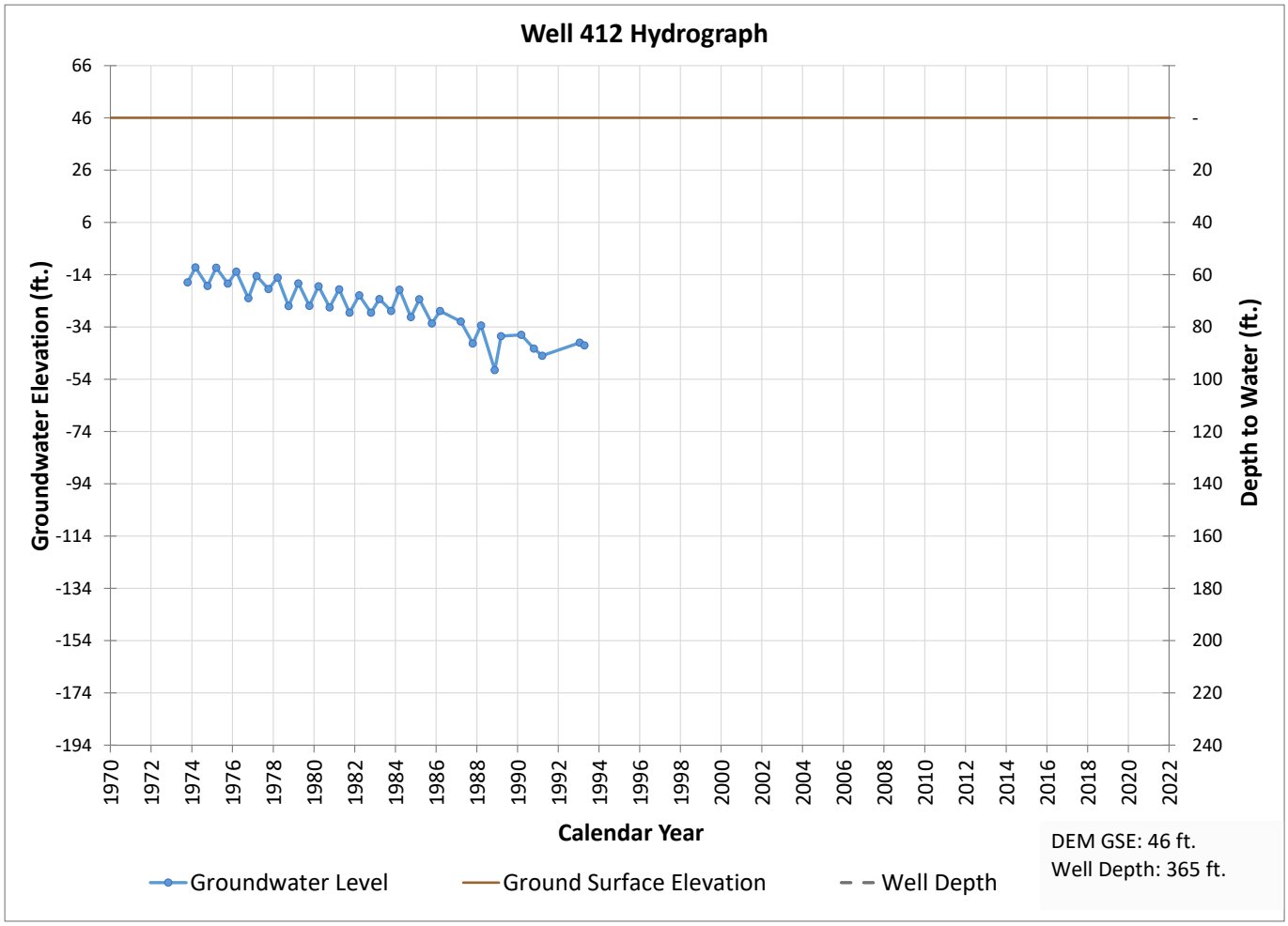

Well 383 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 53 ft.
Well Depth: 155 ft.

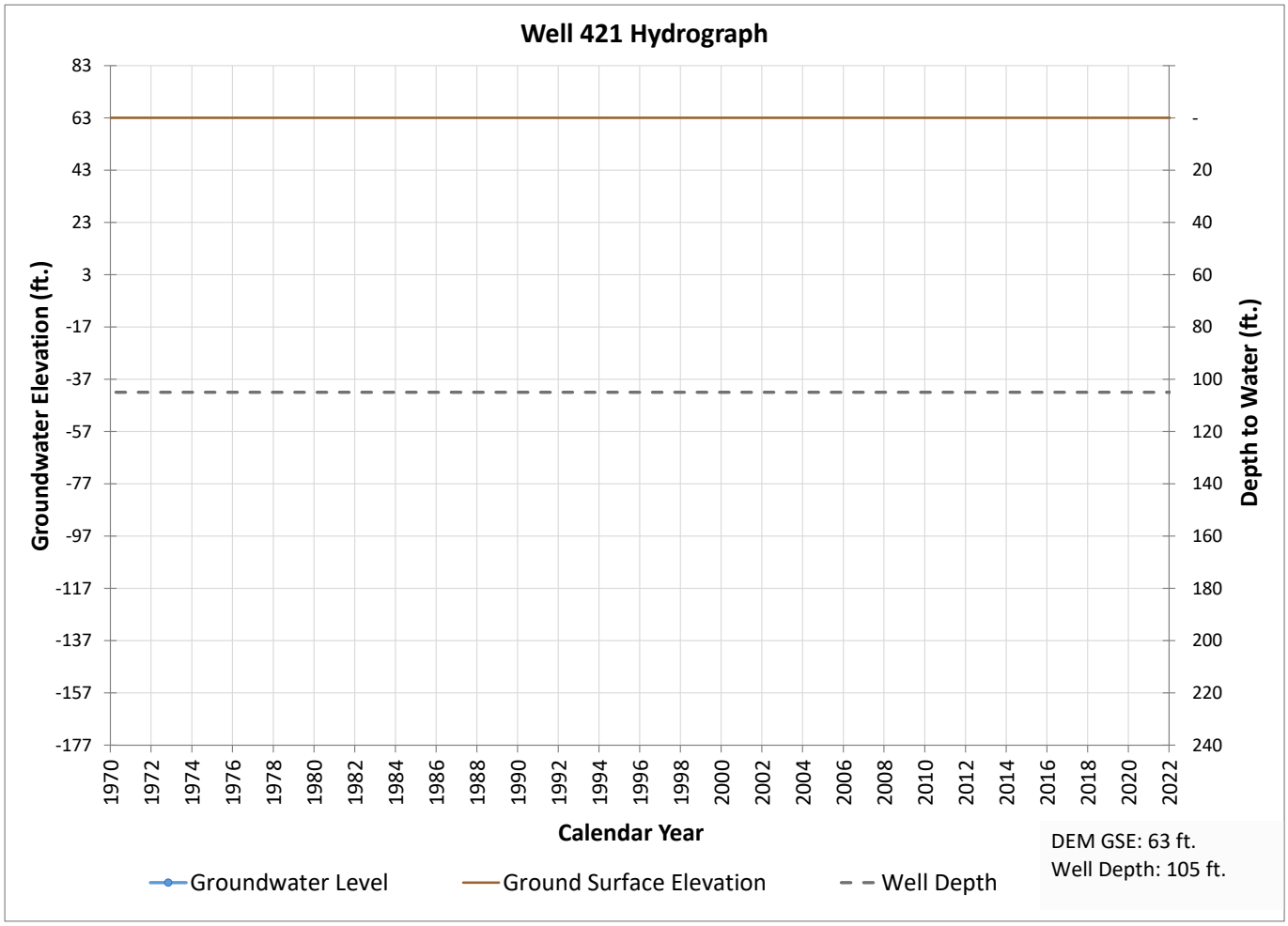

Well 408 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
155
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 135 ft.
Well Depth: 170 ft.

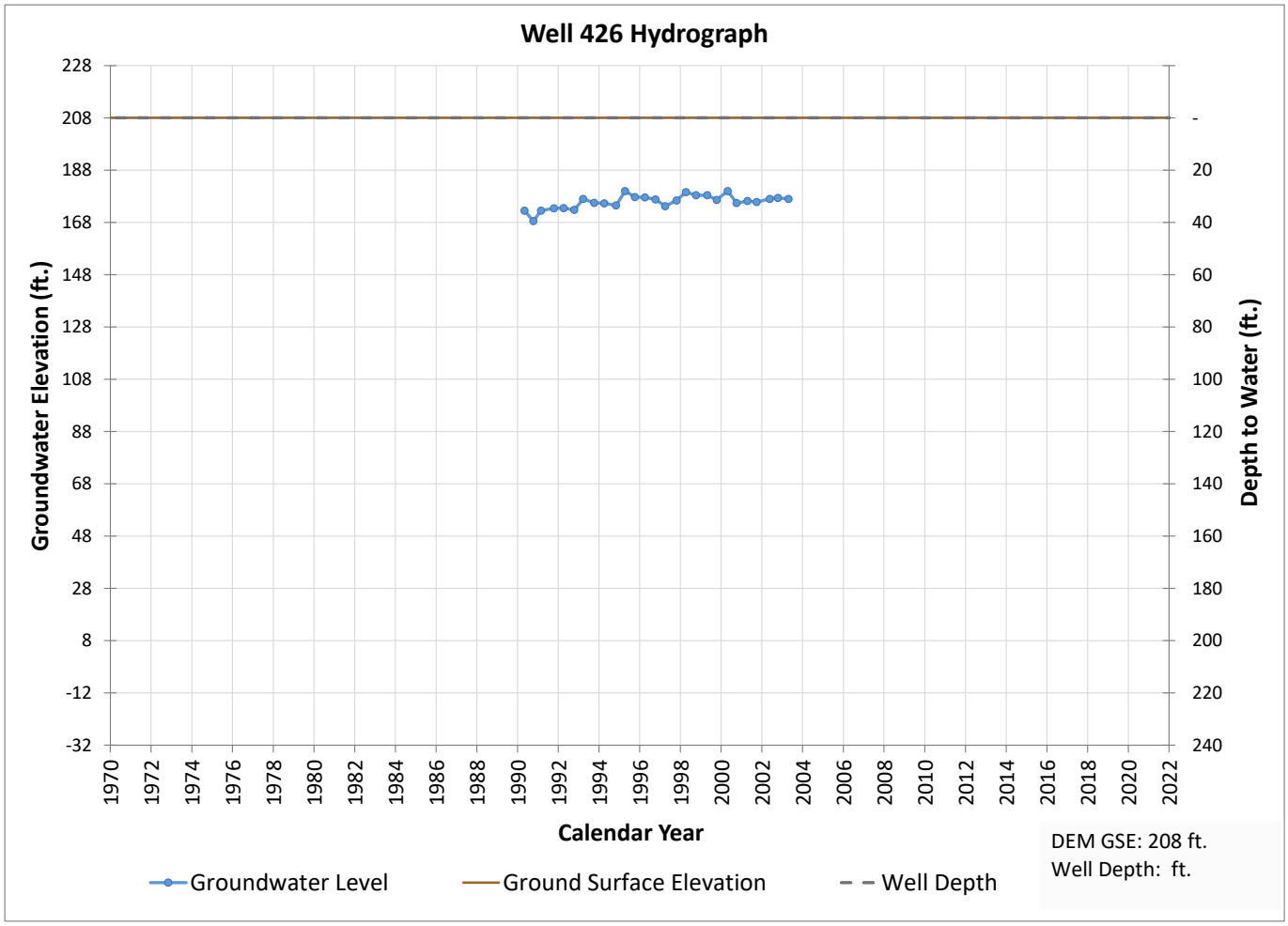

Well 409 Hydrograph
Groundwater Elevation (ft.)
158
138
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 138 ft.
Well Depth: 160 ft.

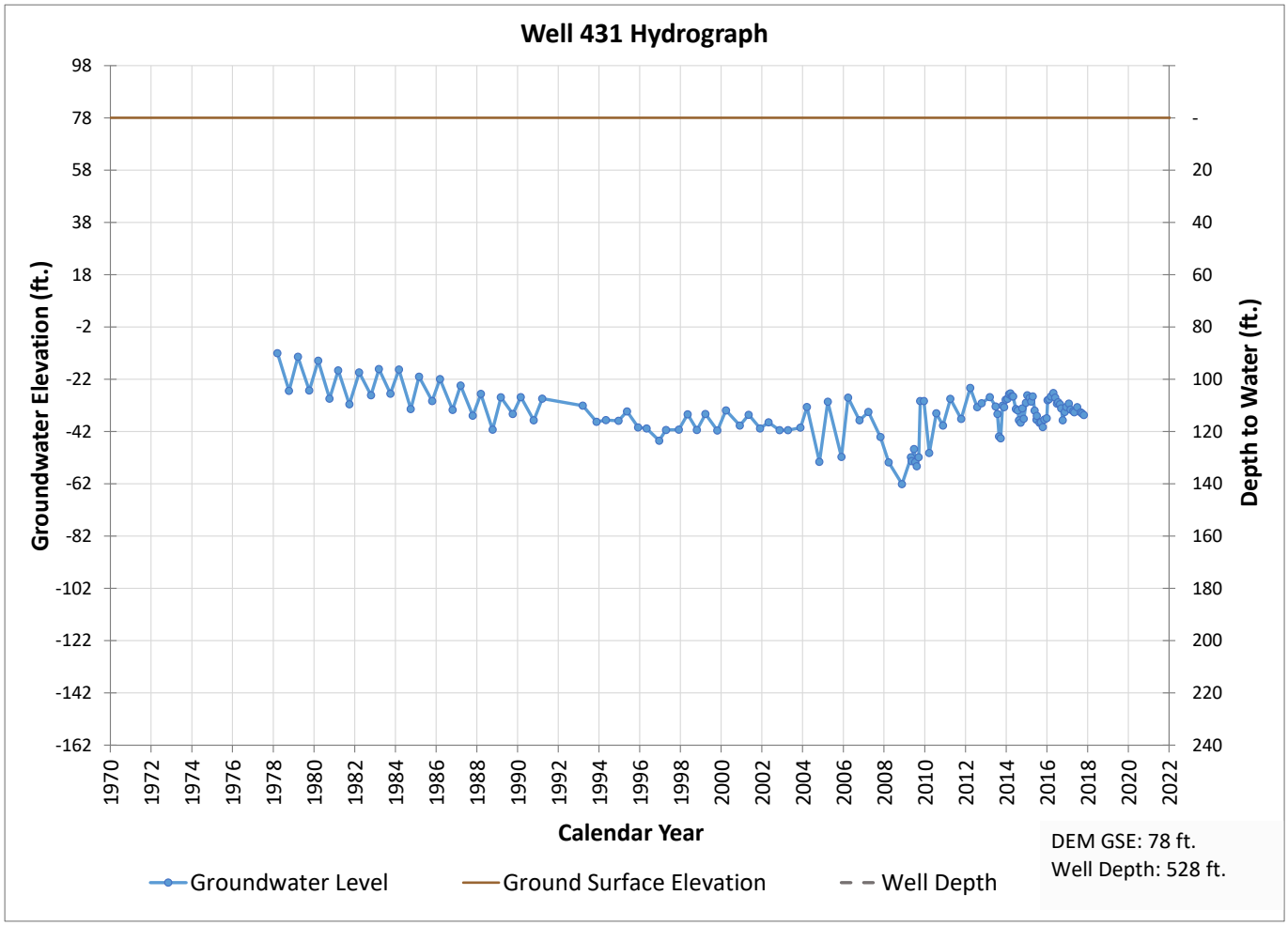

Well 410 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 67 ft.
Well Depth: 250 ft.

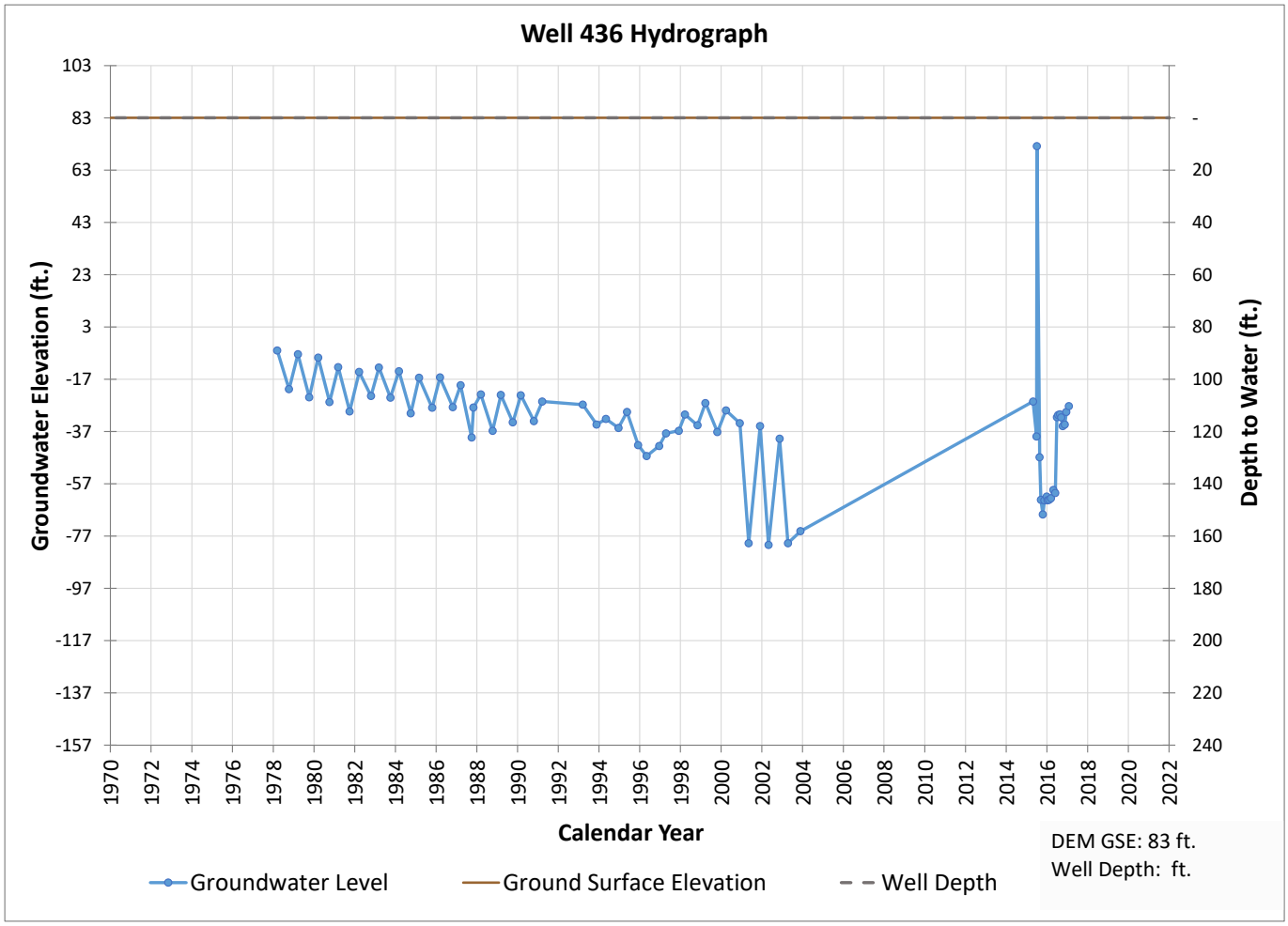

Well 411 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 63 ft.
Well Depth: 191 ft.

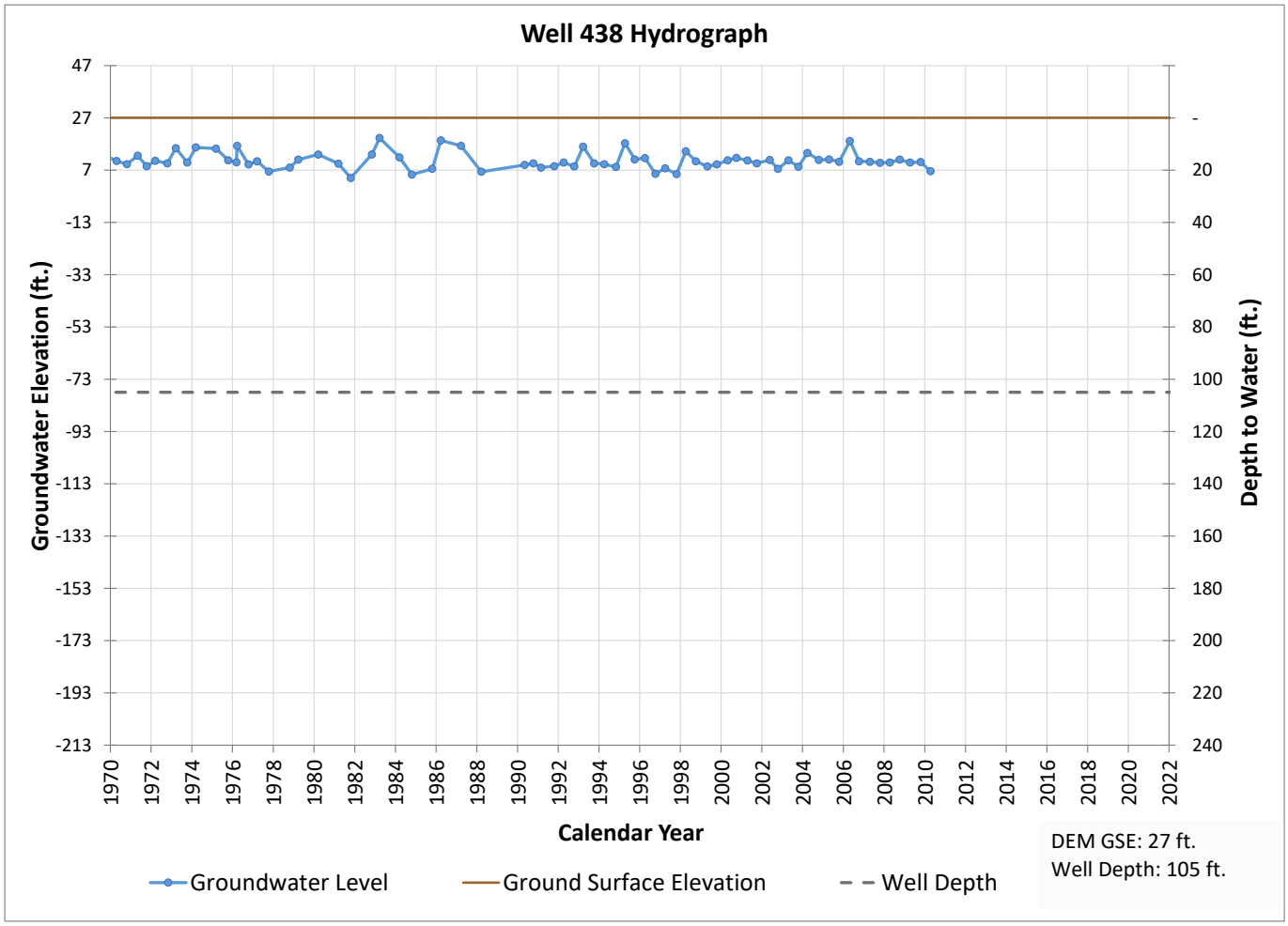

Well 412 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: 365 ft.

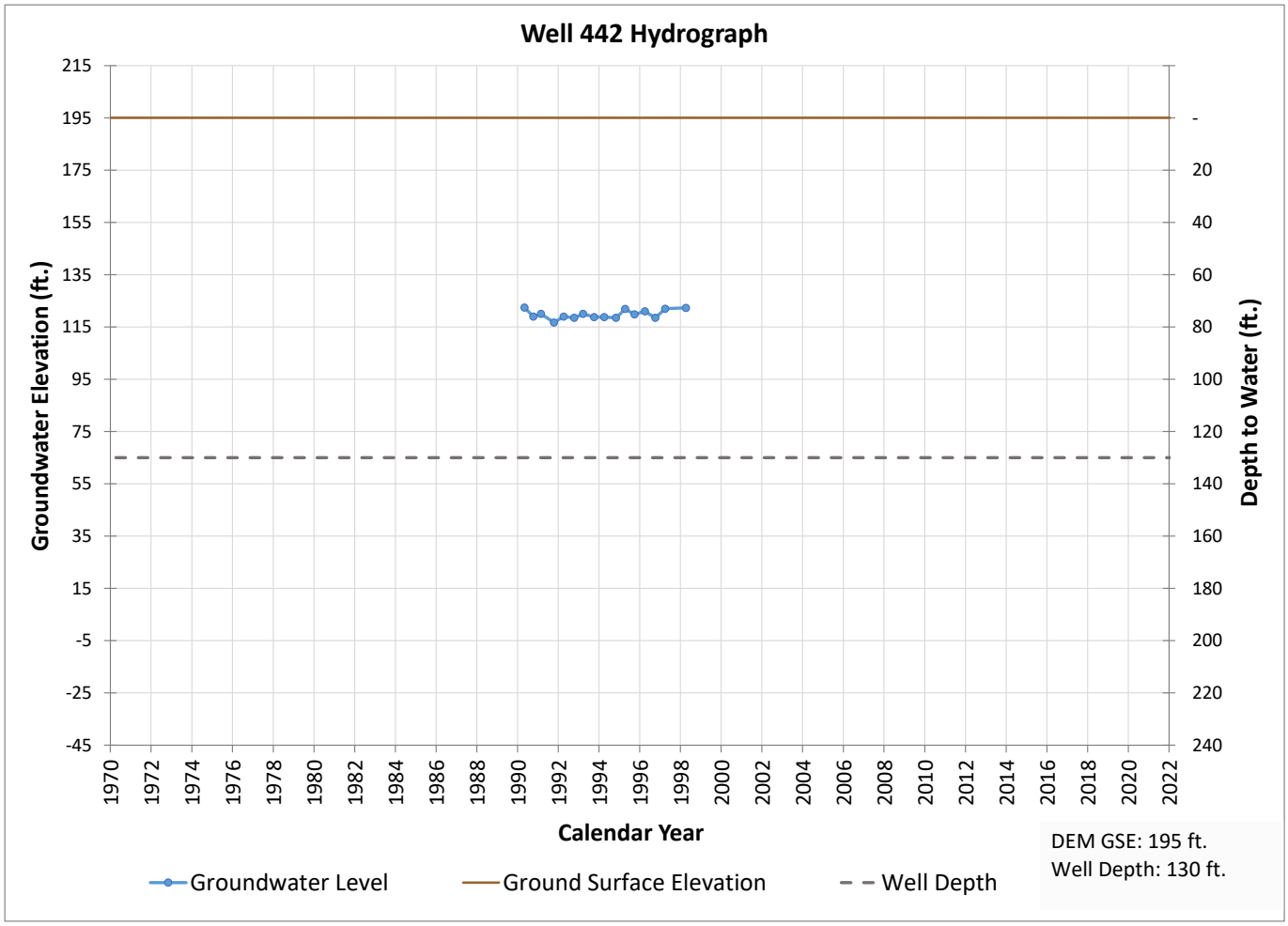

Well 421 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 63 ft.
Well Depth: 105 ft.

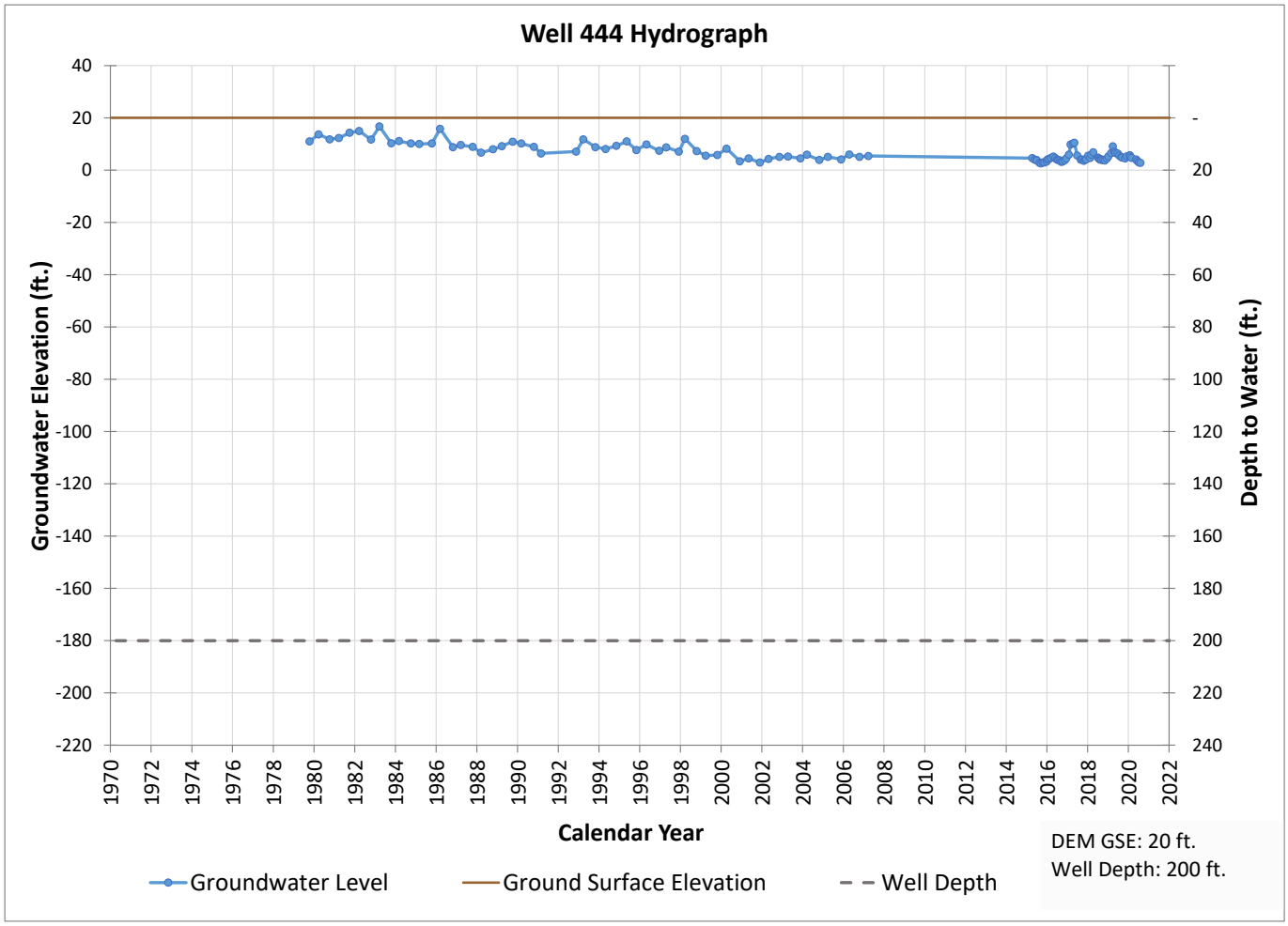

Well 426 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
228
208
188
168
148
128
108
88
68
48
28
8
-12
-32
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 208 ft.
Well Depth: ft.

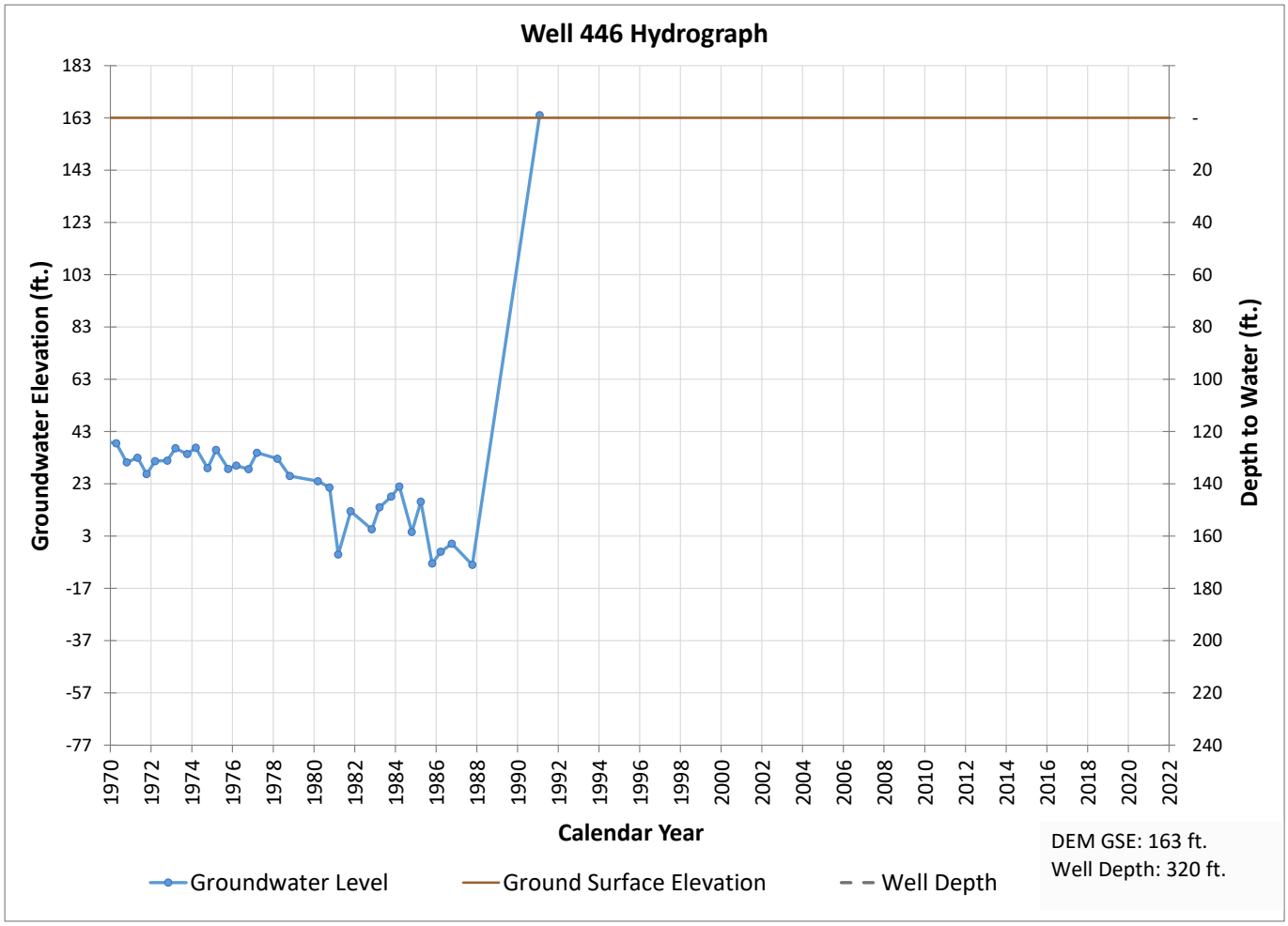

Well 431 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 78 ft.
Well Depth: 528 ft.

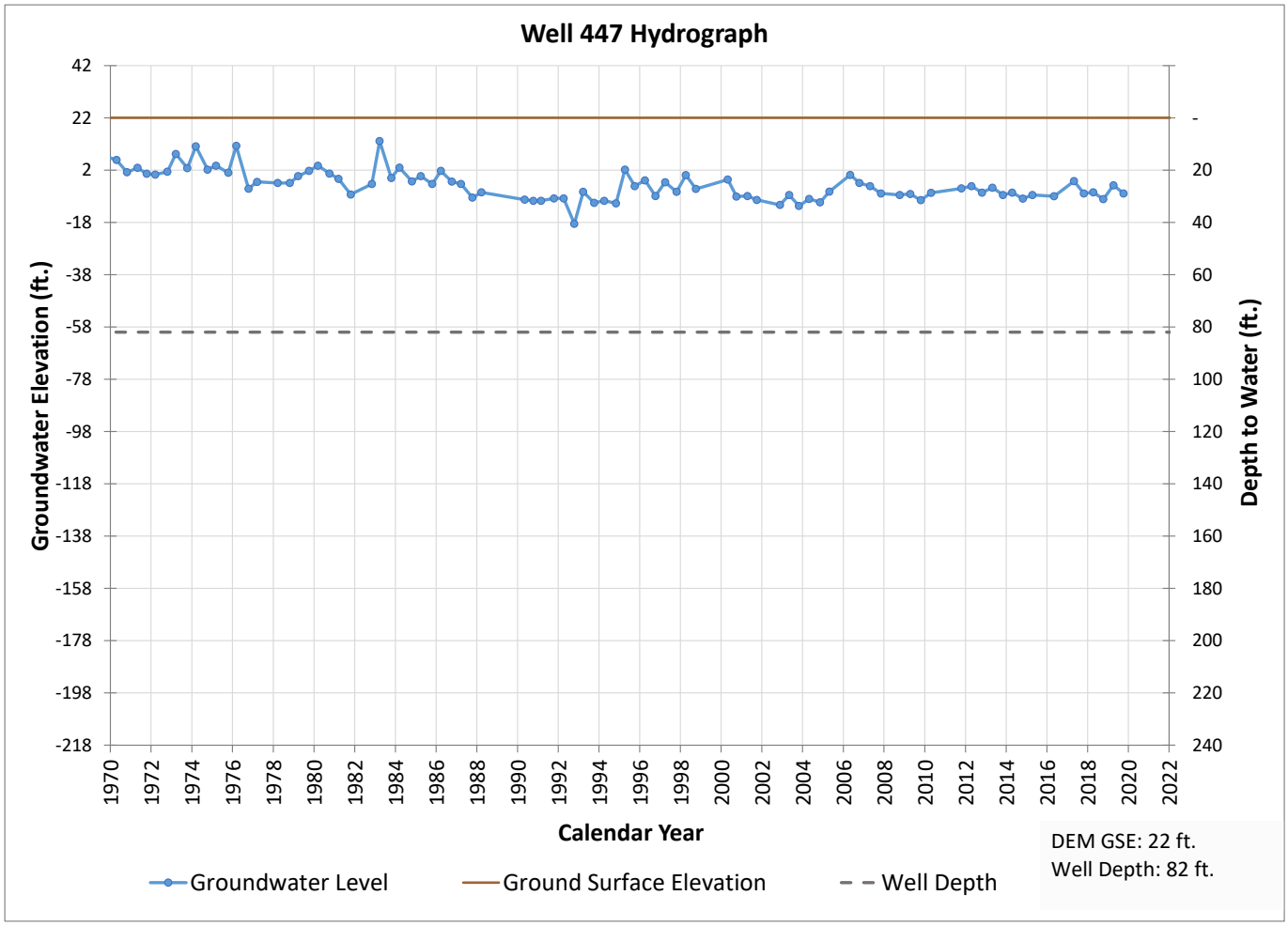

Well 436 Hydrograph
Groundwater Elevation (ft.)
103
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 83 ft.
Well Depth: ft.

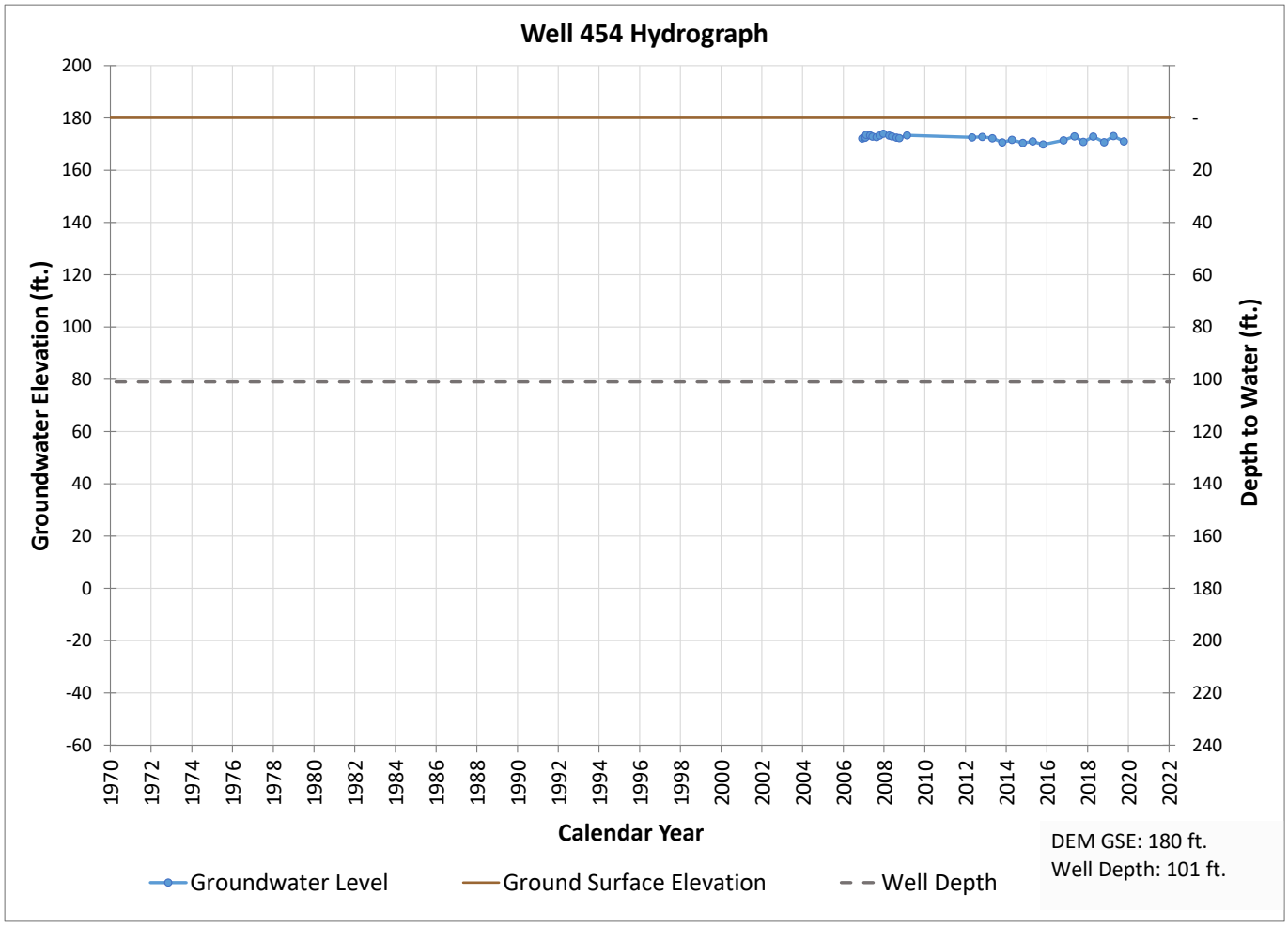

Well 438 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 105 ft.

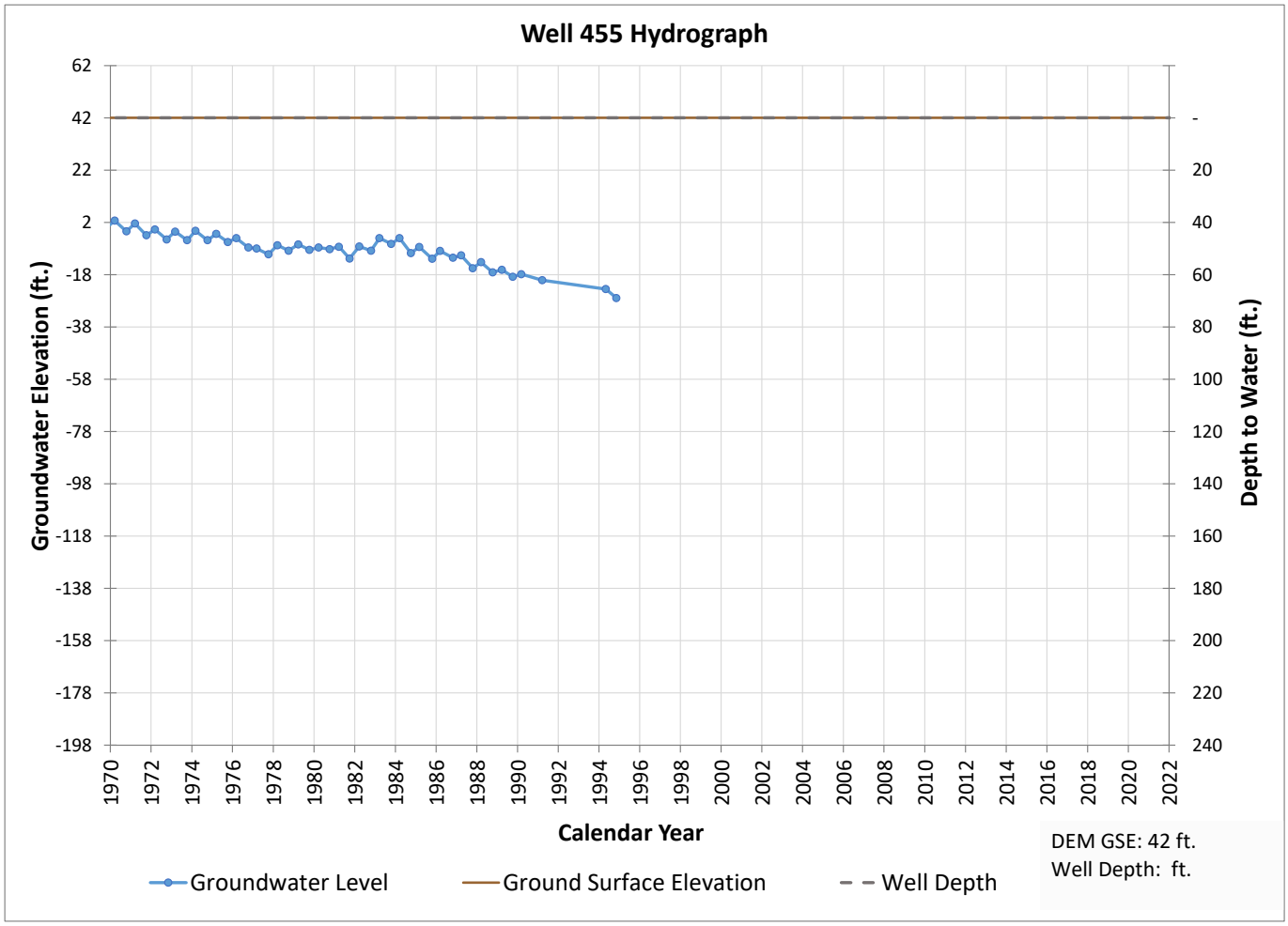

Well 442 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
215
195
175
155
135
115
95
75
55
35
15
-5
-25
-45
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 195 ft.
Well Depth: 130 ft.

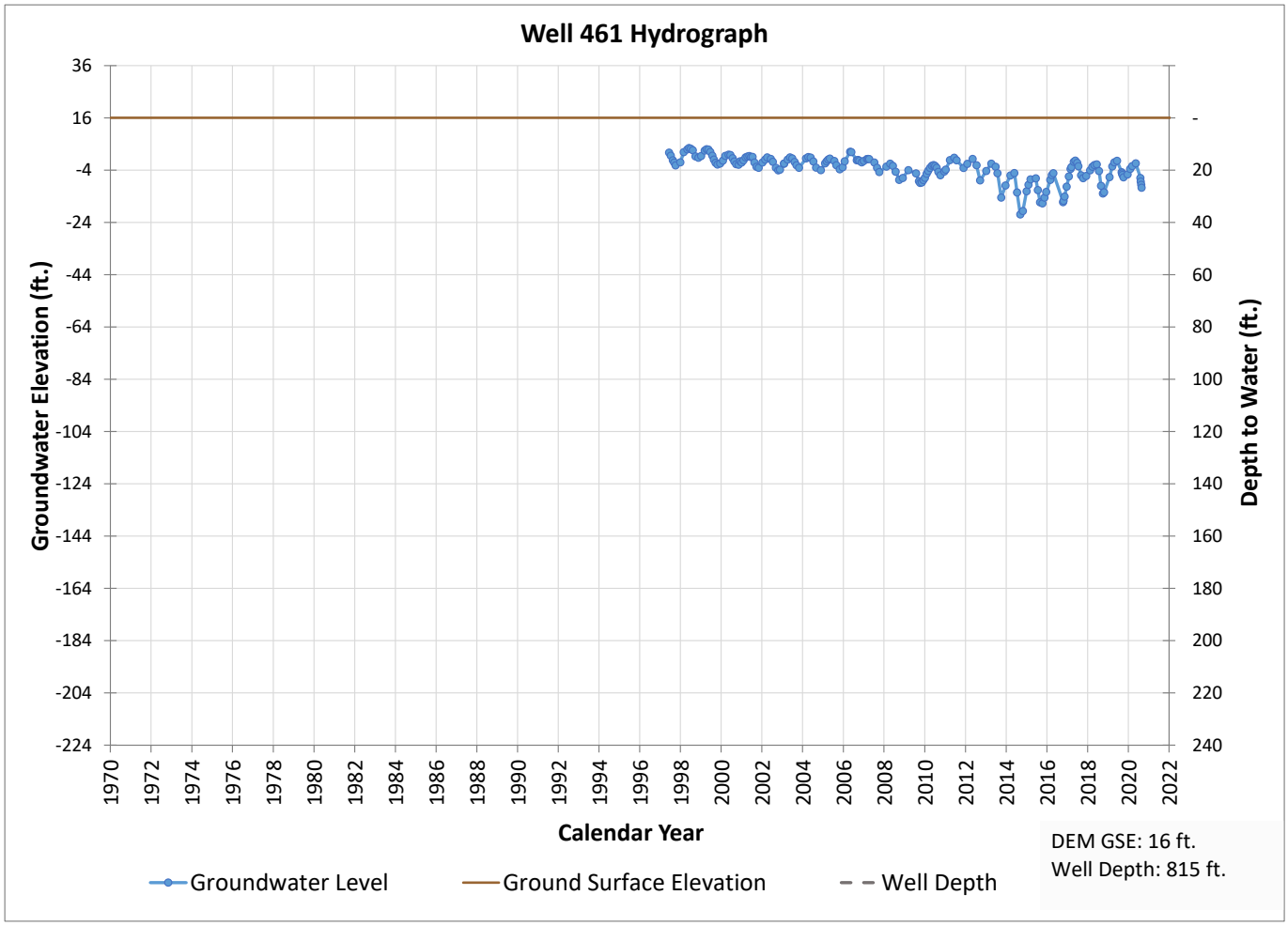

Well 444 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: 200 ft.

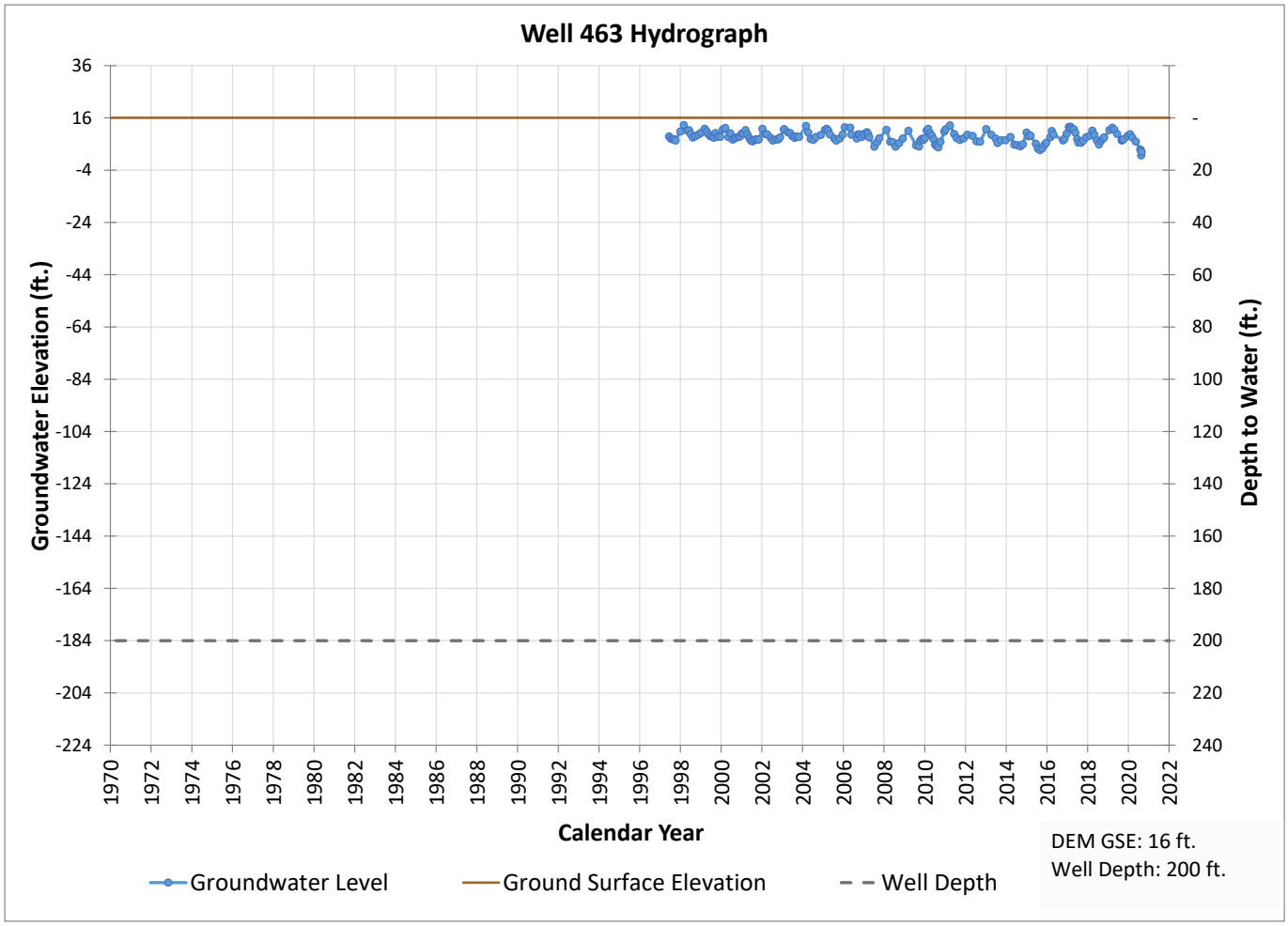

Well 446 Hydrograph
Groundwater Elevation (ft.)
183
163
143
123
103
83
63
43
23
3
-17
-37
-57
-77
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 163 ft.
Well Depth: 320 ft.

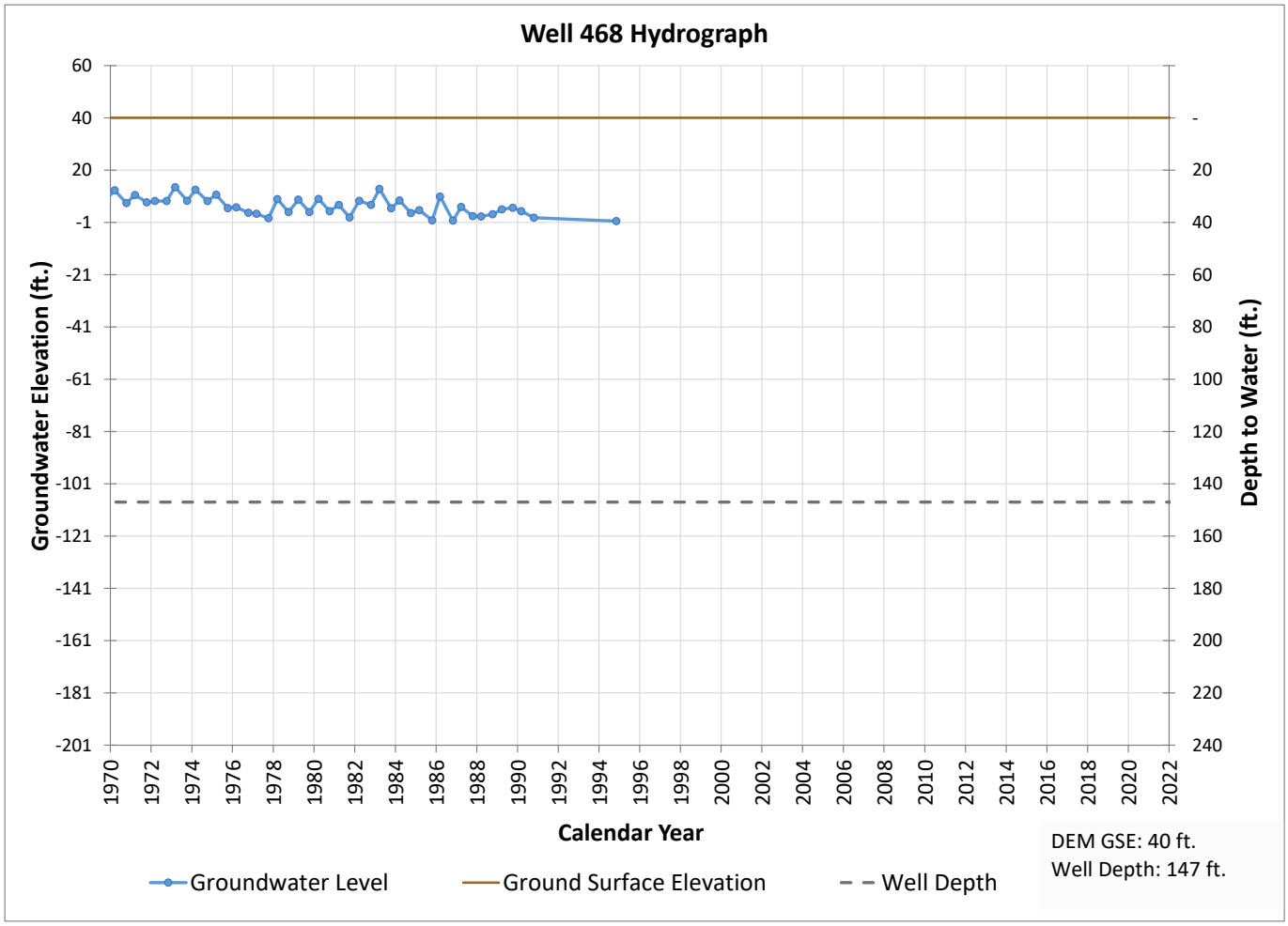

Well 447 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: 82 ft.

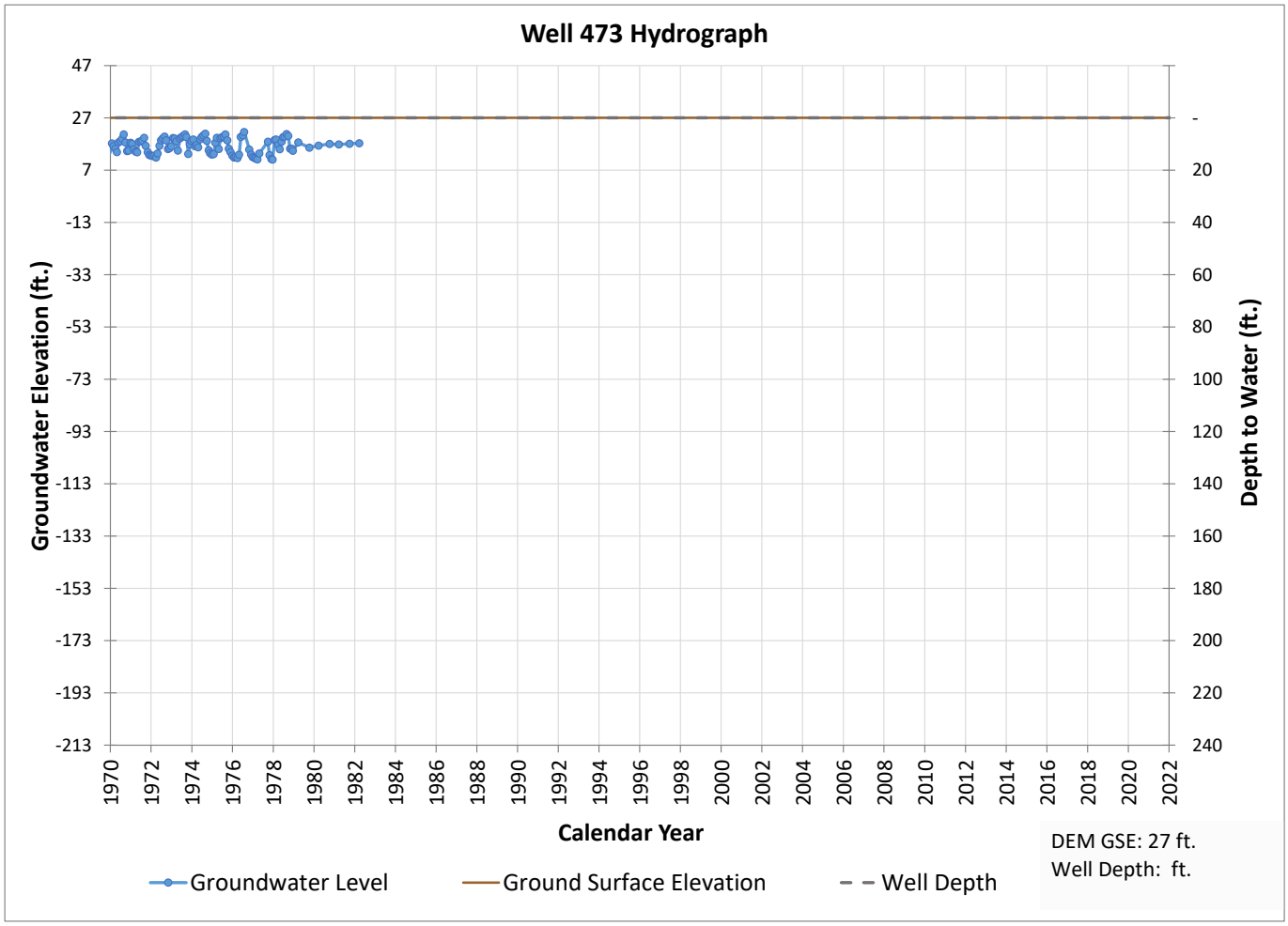

Well 454 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 180 ft.
Well Depth: 101 ft.

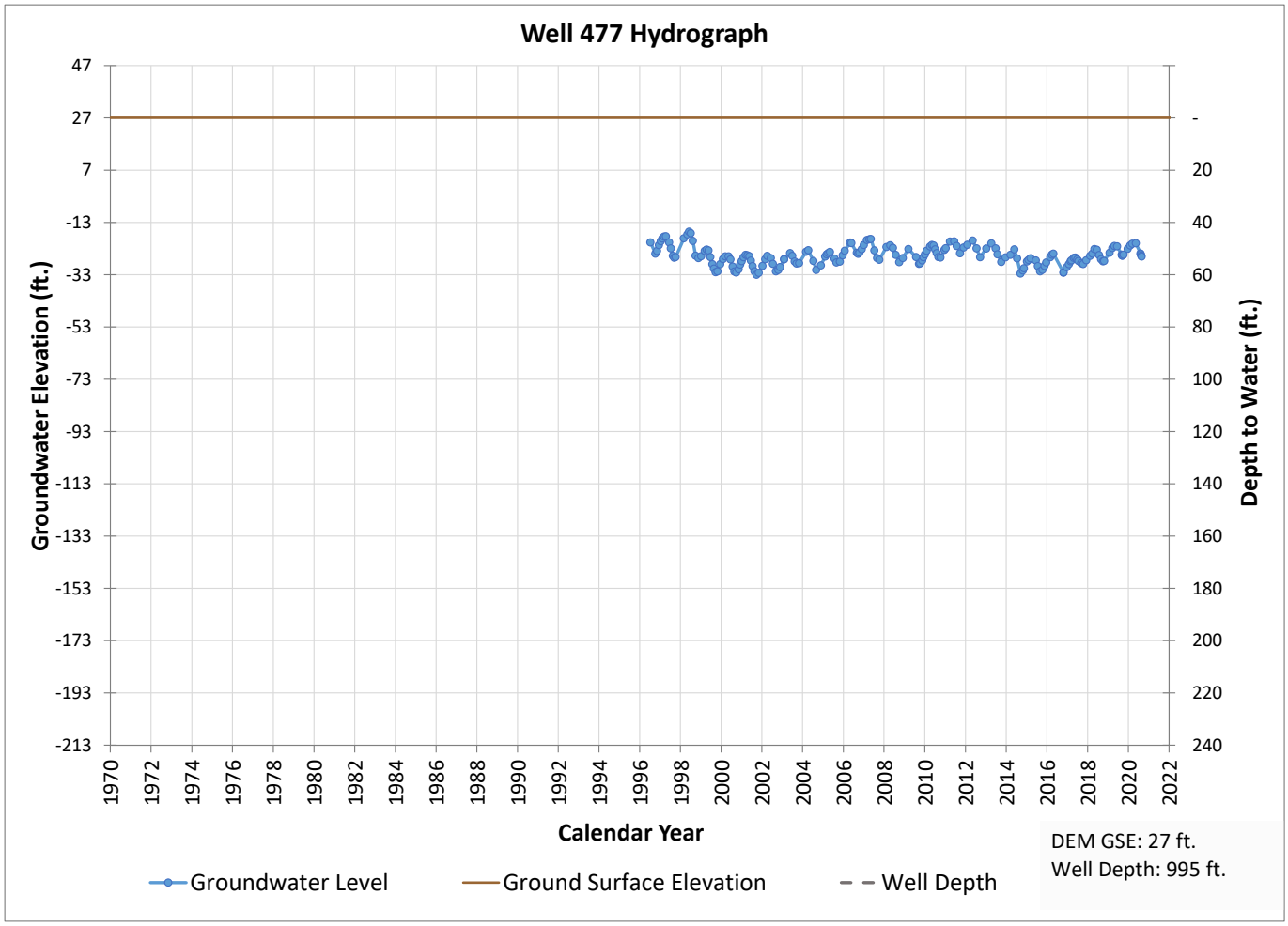

Well 455 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: ft.

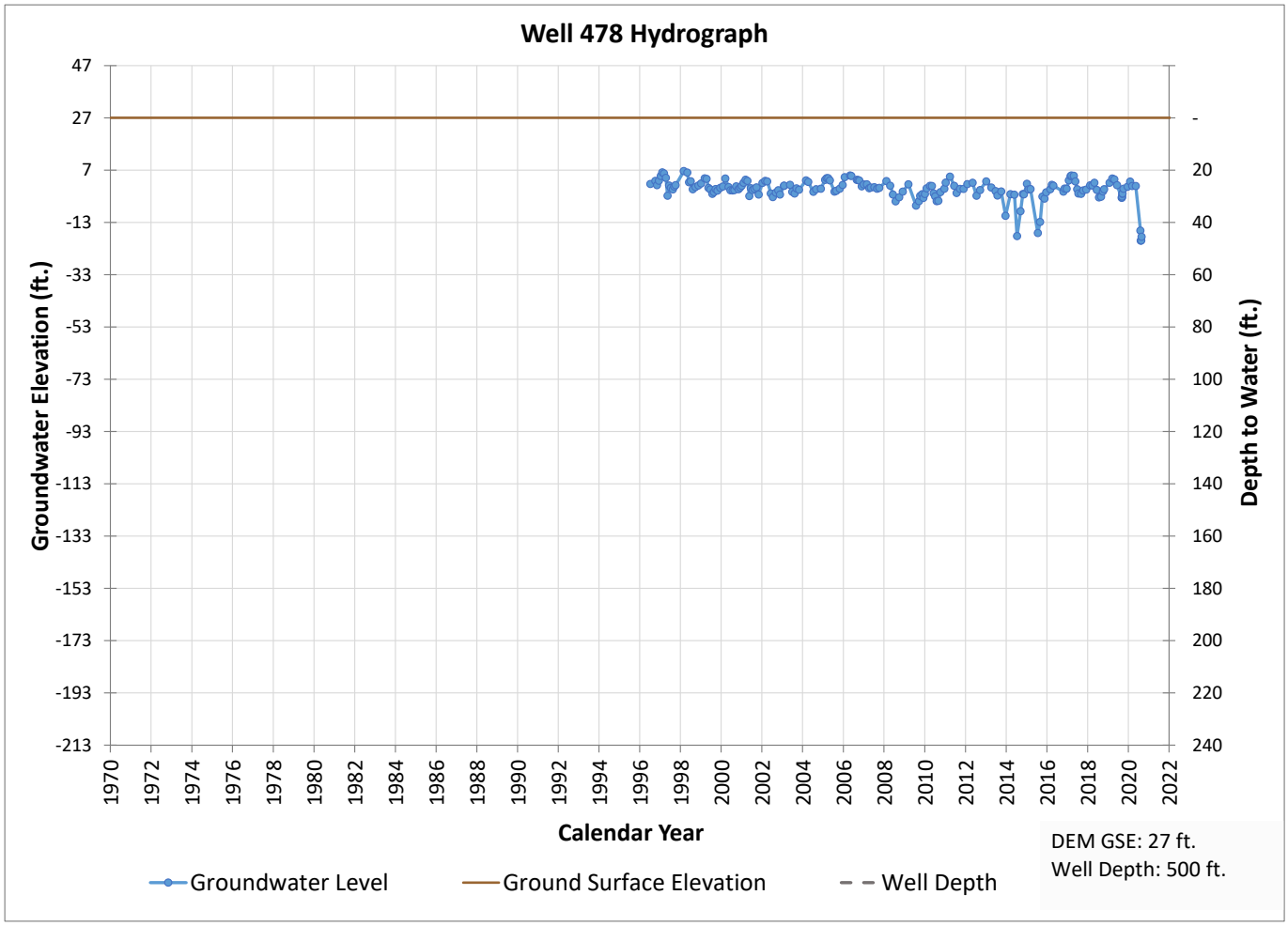

Well 461 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: 815 ft.

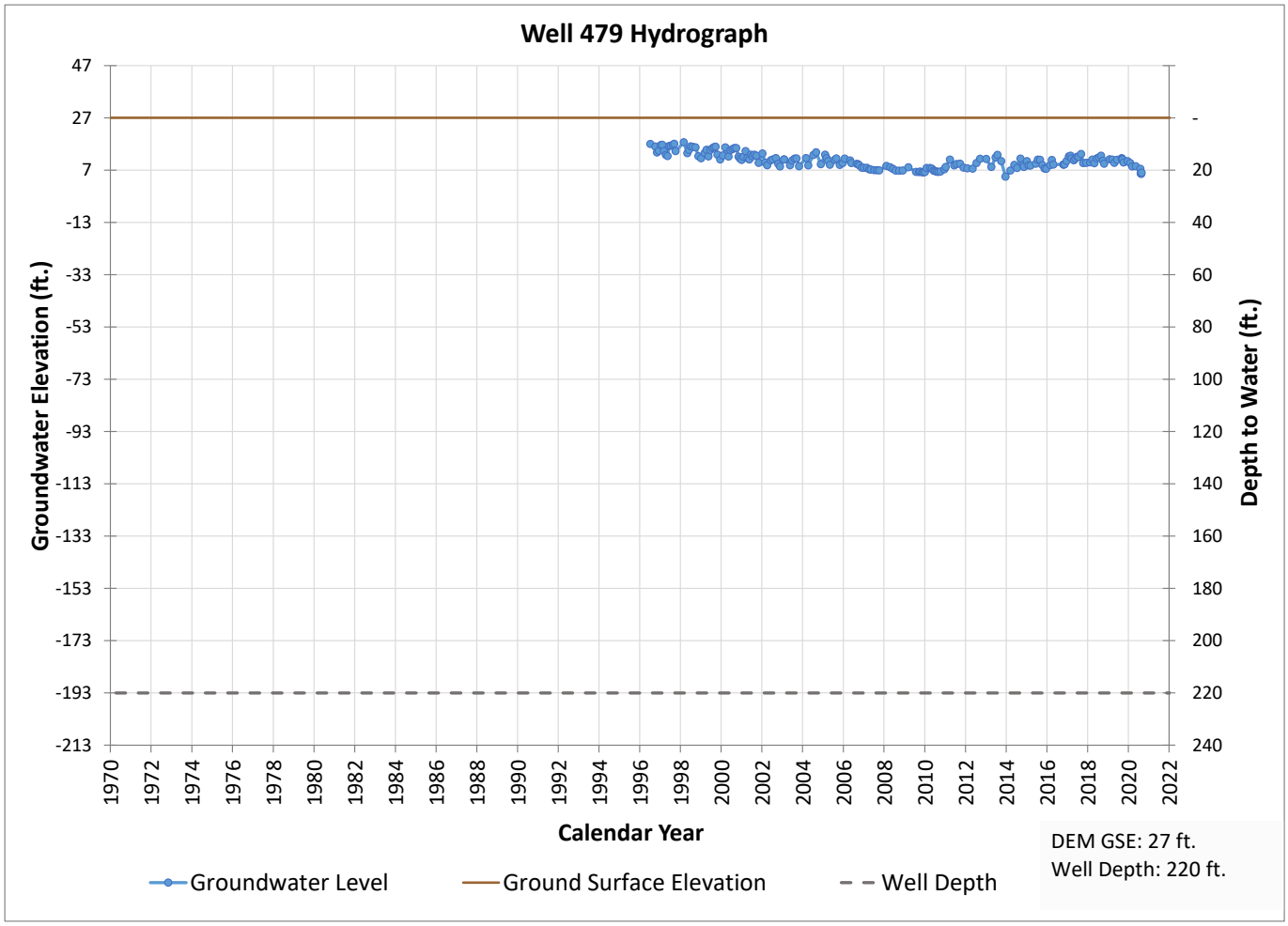

Well 463 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: 200 ft.

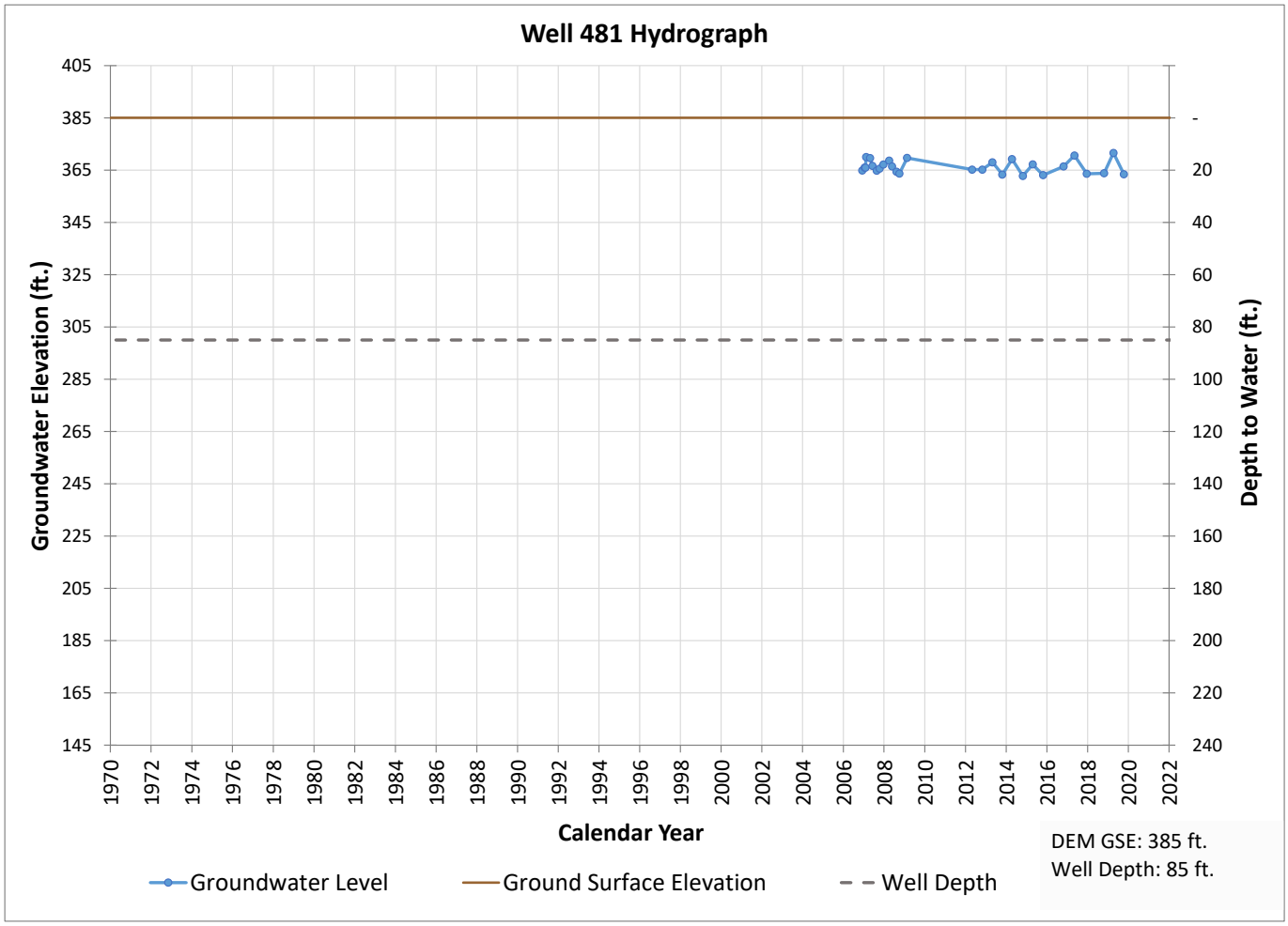

Well 468 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
60
40
20
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-201
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 40 ft.
Well Depth: 147 ft.

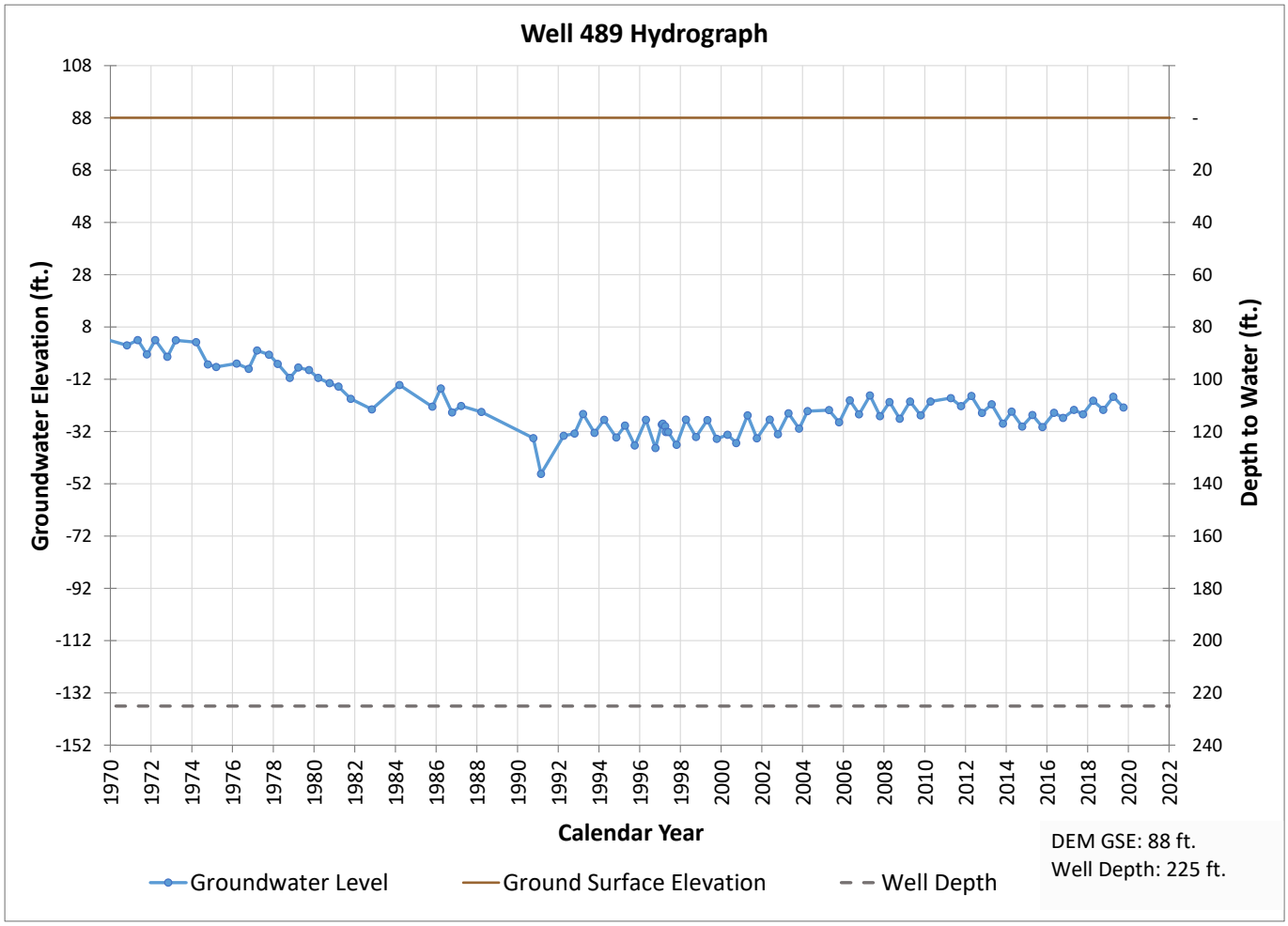

Well 473 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: ft.

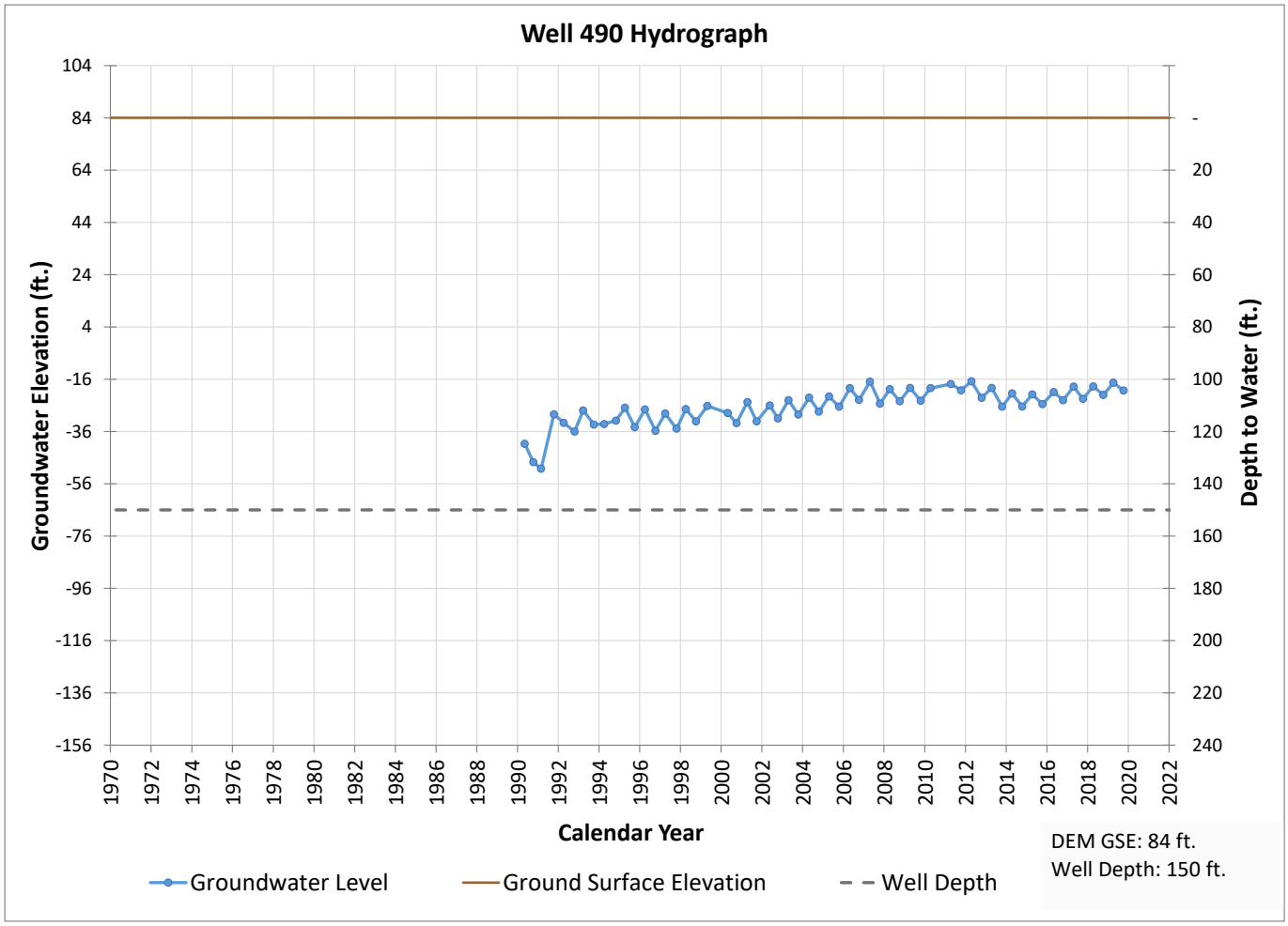

Well 477 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 995 ft.

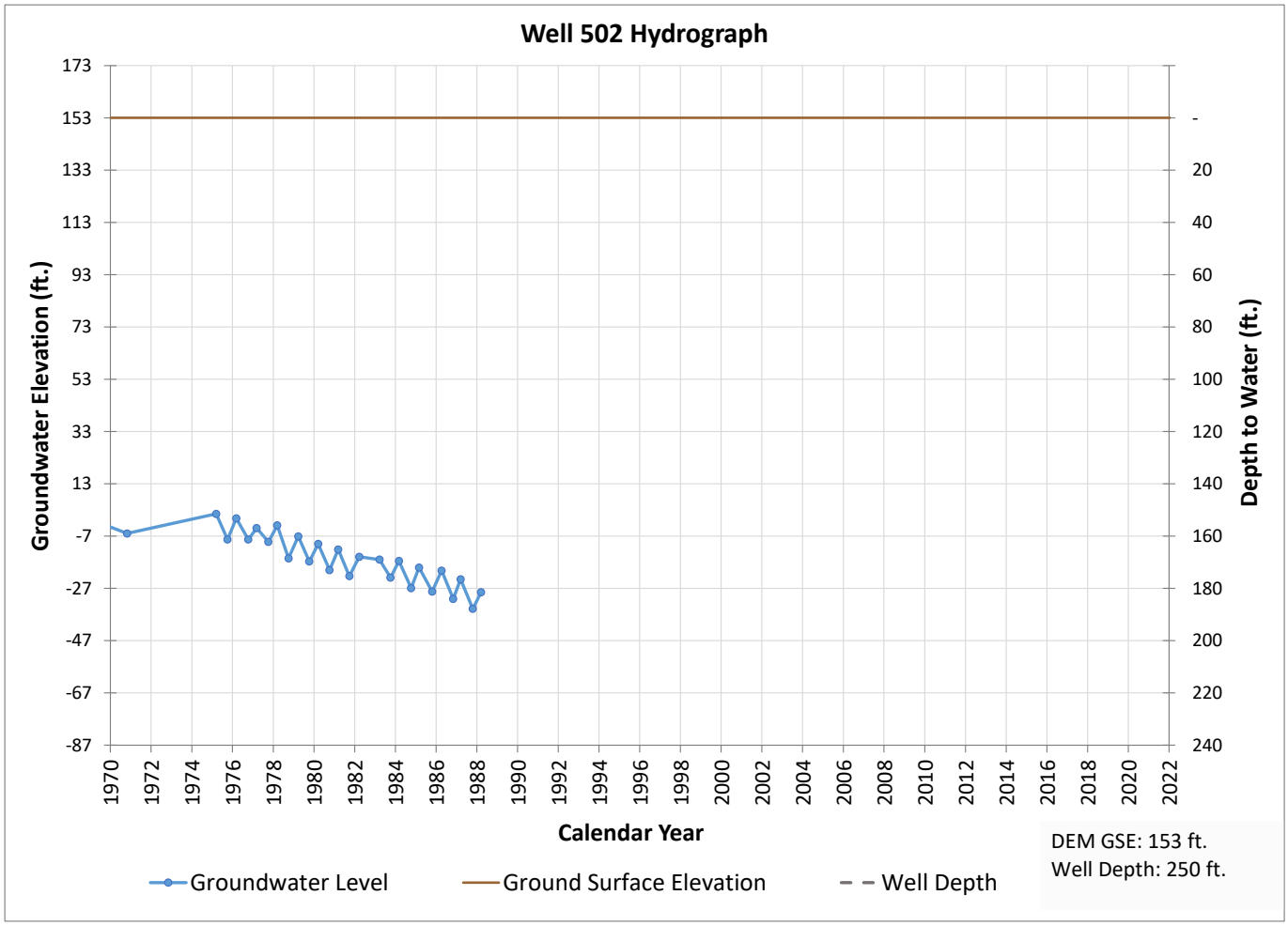

Well 478 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 500 ft.

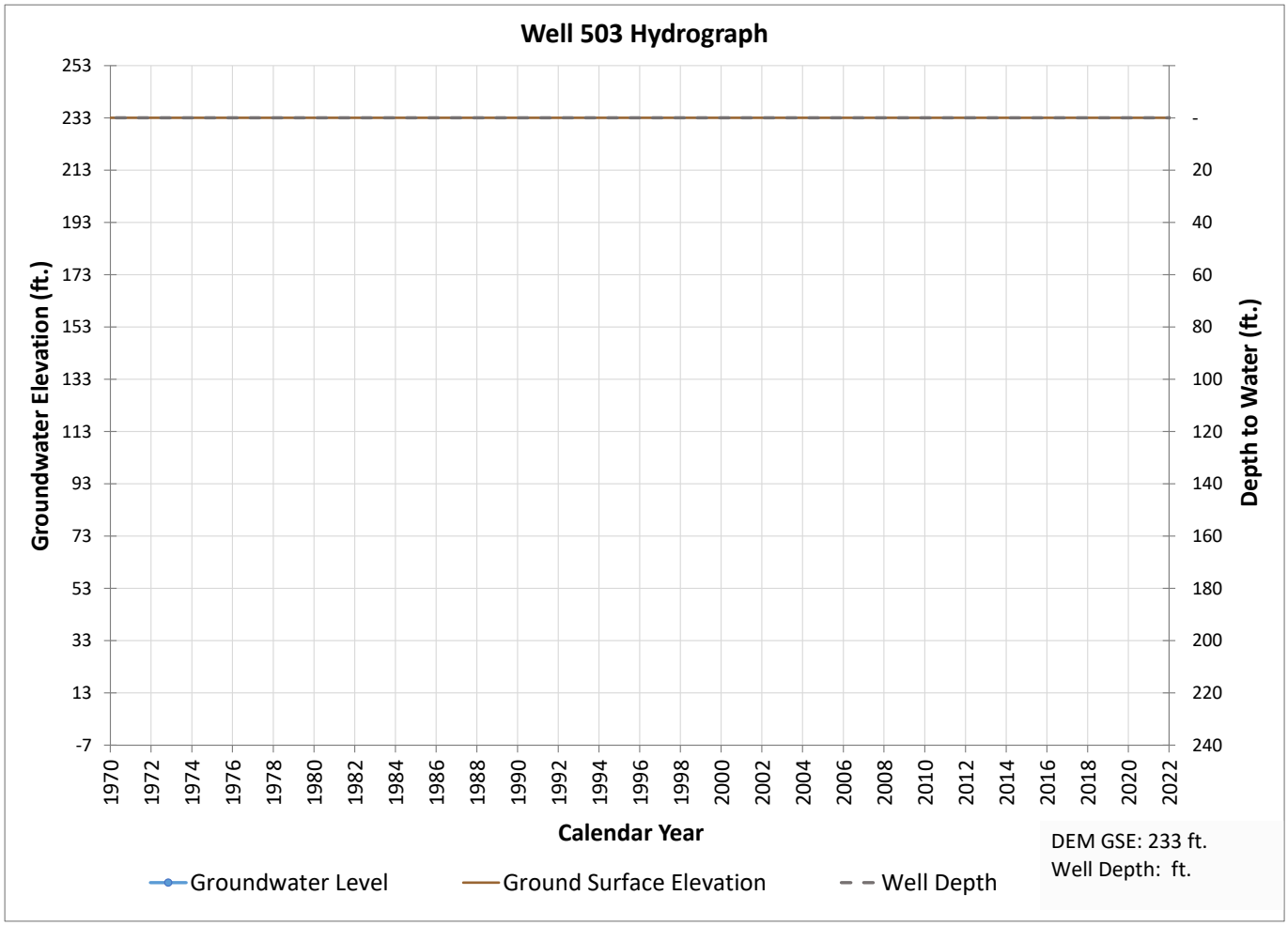

Well 479 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 220 ft.

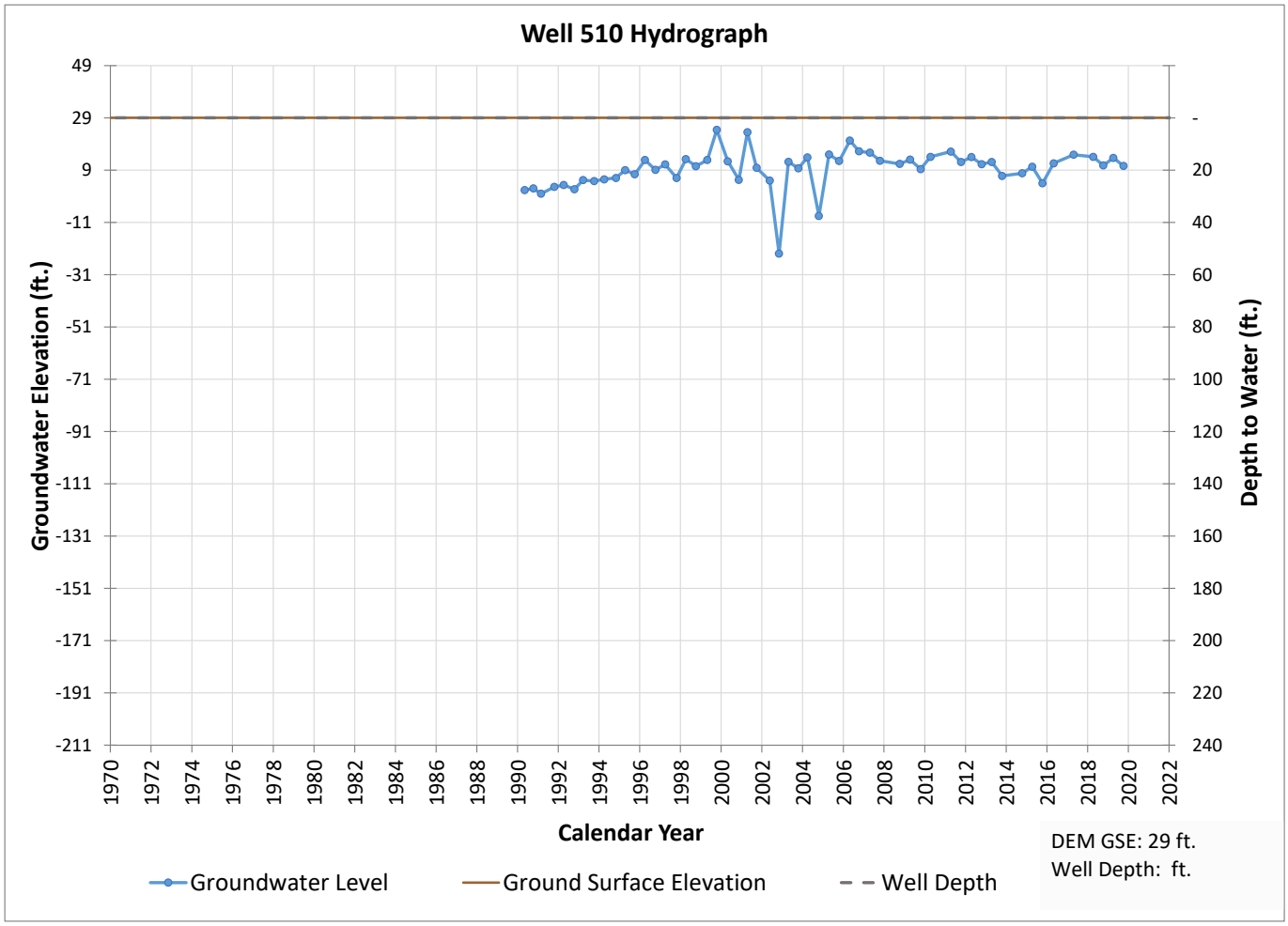

Well 481 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
405
385
365
345
325
305
285
265
245
225
205
185
165
145
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 385 ft.
Well Depth: 85 ft.

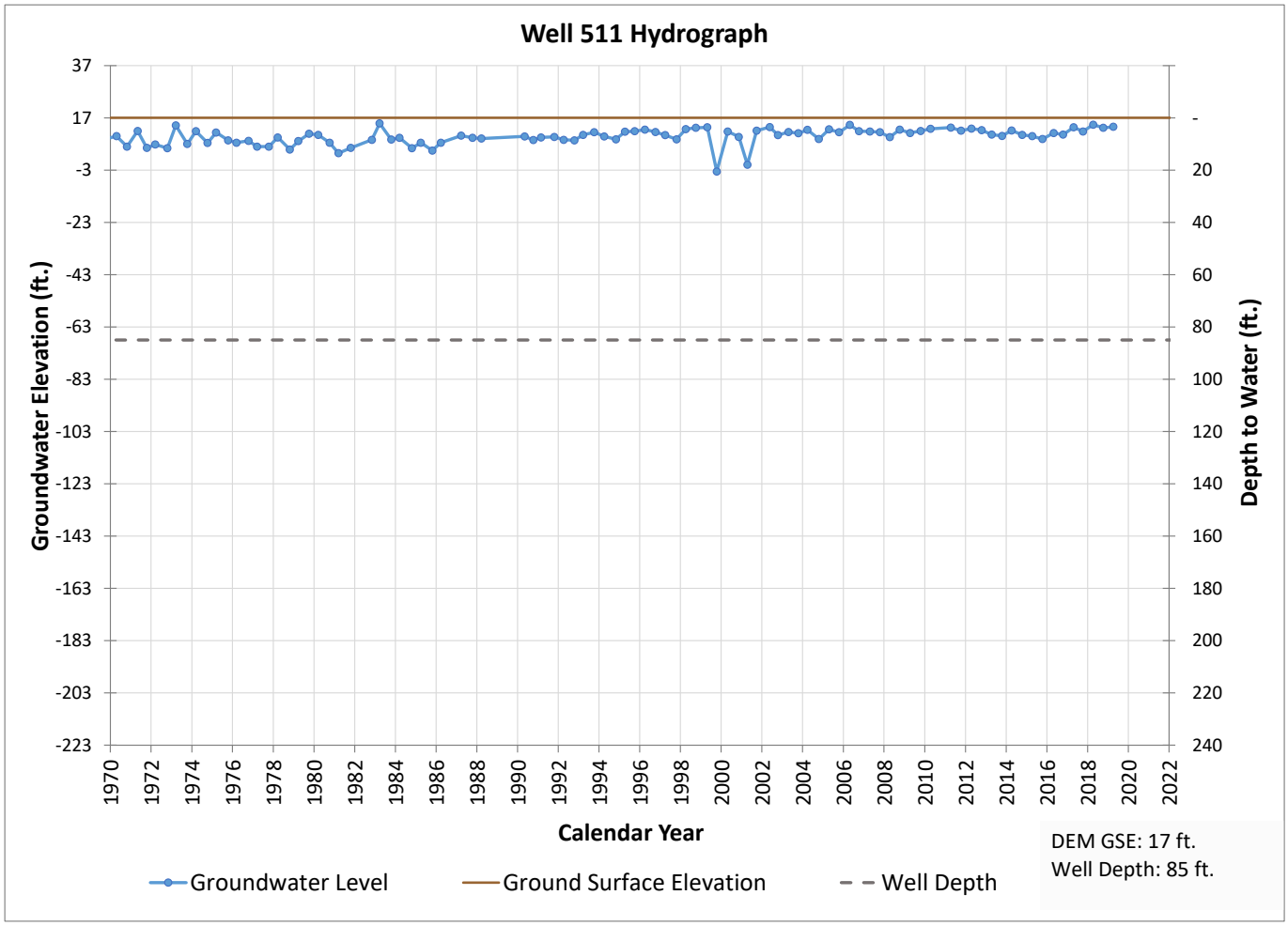

Well 489 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 88 ft.
Well Depth: 225 ft.

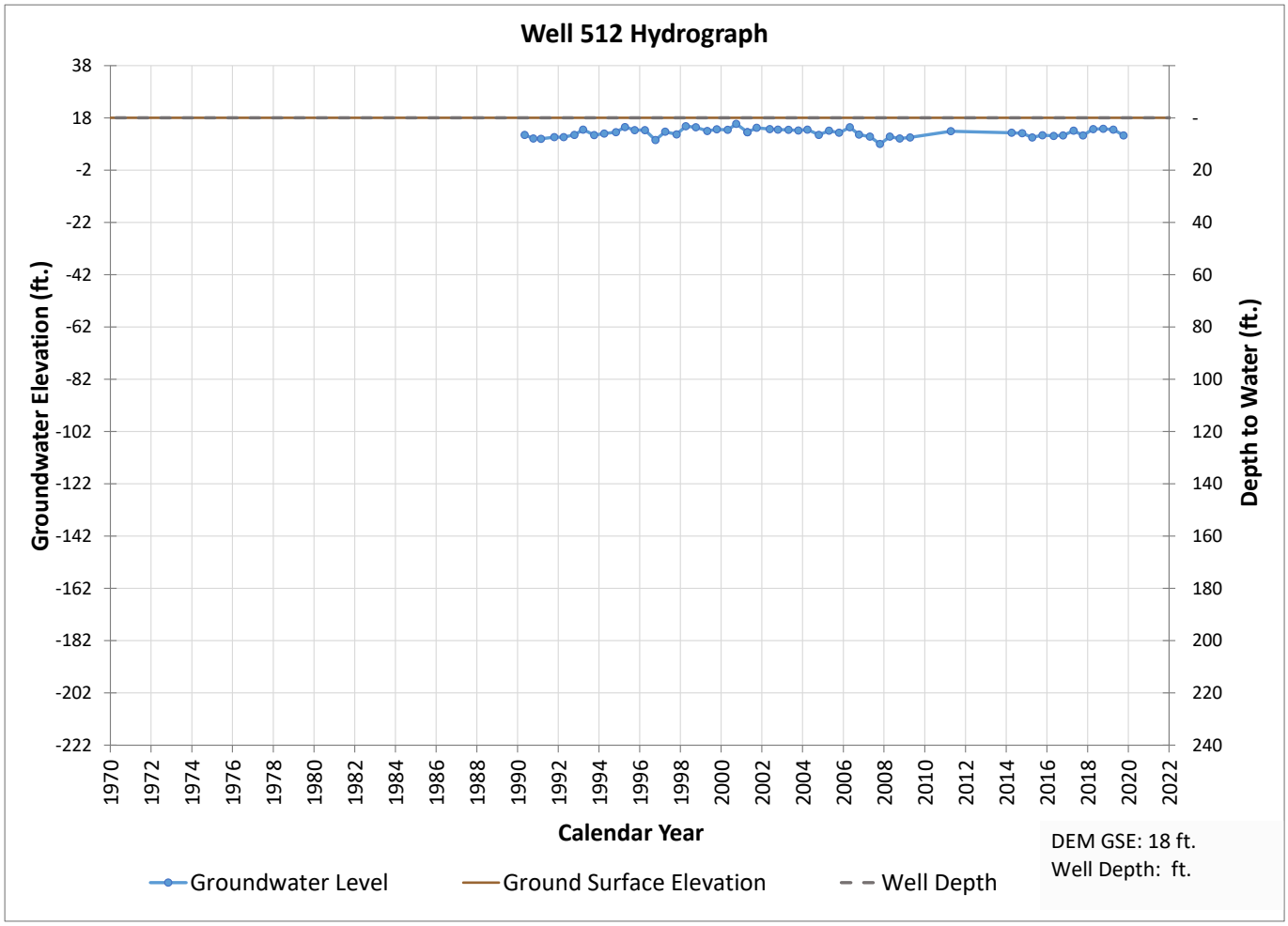

Well 490 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
104
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 84 ft.
Well Depth: 150 ft.

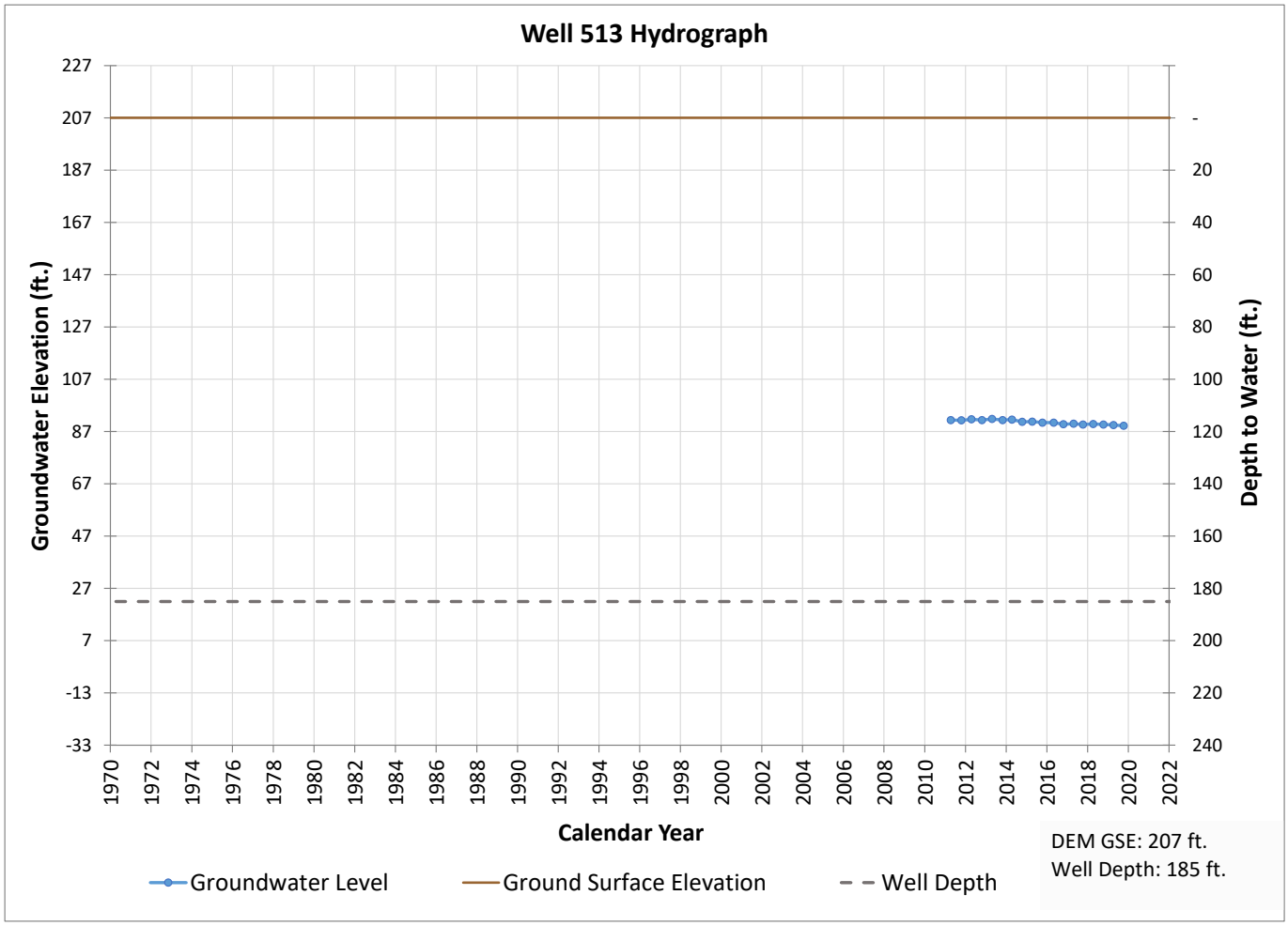

Well 502 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
173
153
133
113
93
73
53
33
13
-7
-27
-47
-67
-87
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 153 ft.
Well Depth: 250 ft.

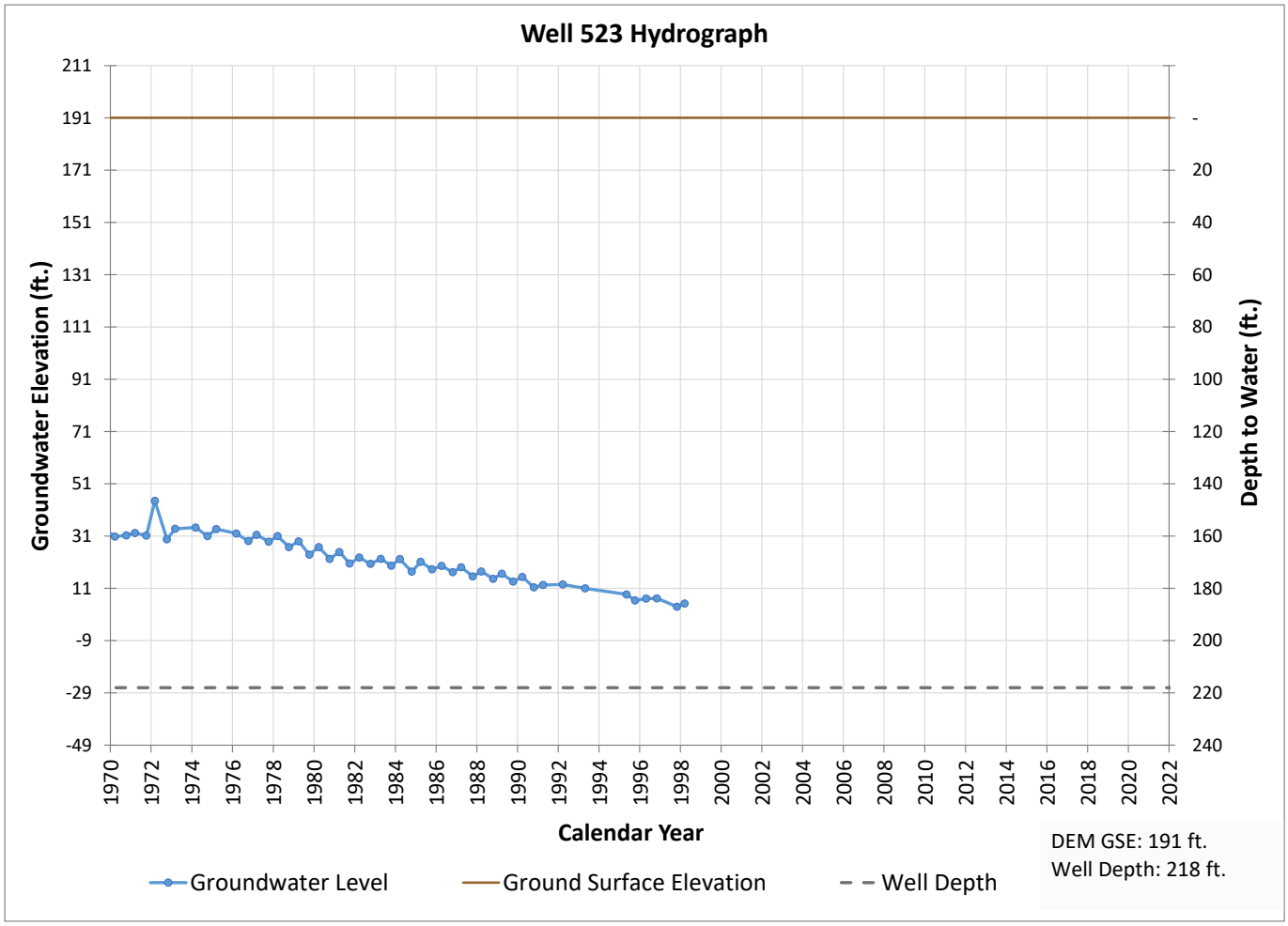

Well 503 Hydrograph
Groundwater Elevation (ft.)
253
233
213
193
173
153
133
113
93
73
53
33
13
-7
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 233 ft.
Well Depth: ft.

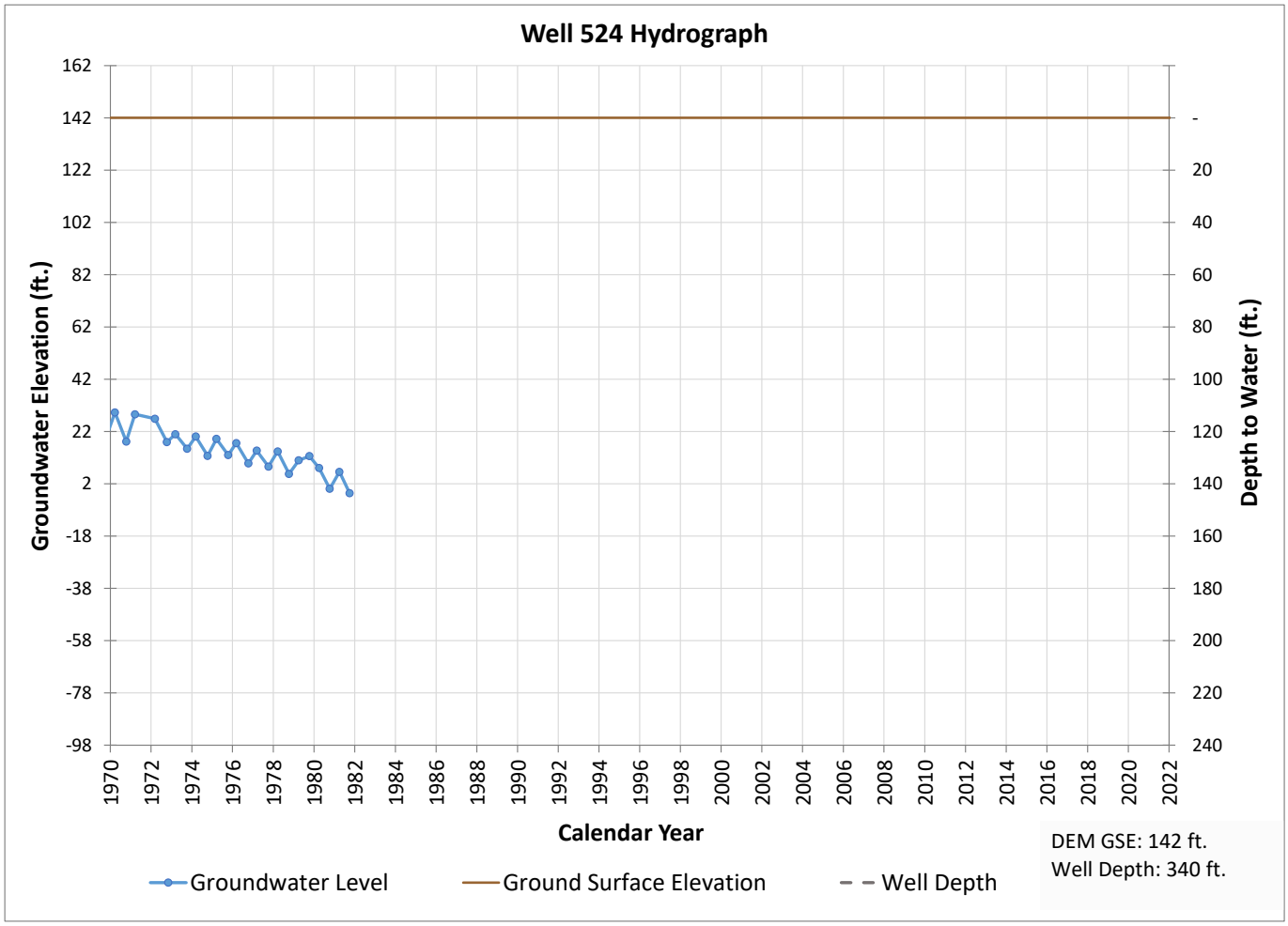

Well 510 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: ft.

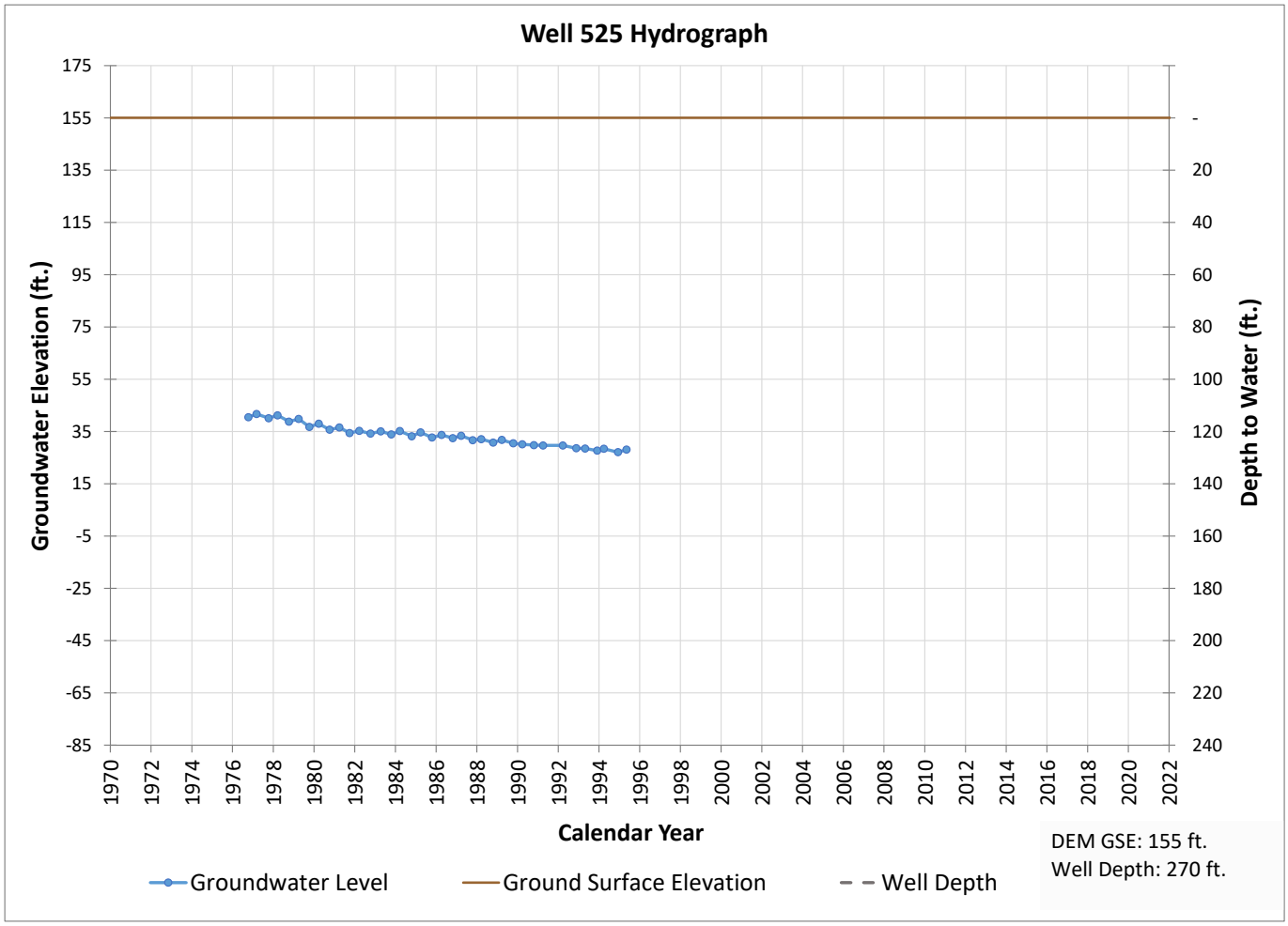

Well 511 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
-223
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 17 ft.
Well Depth: 85 ft.

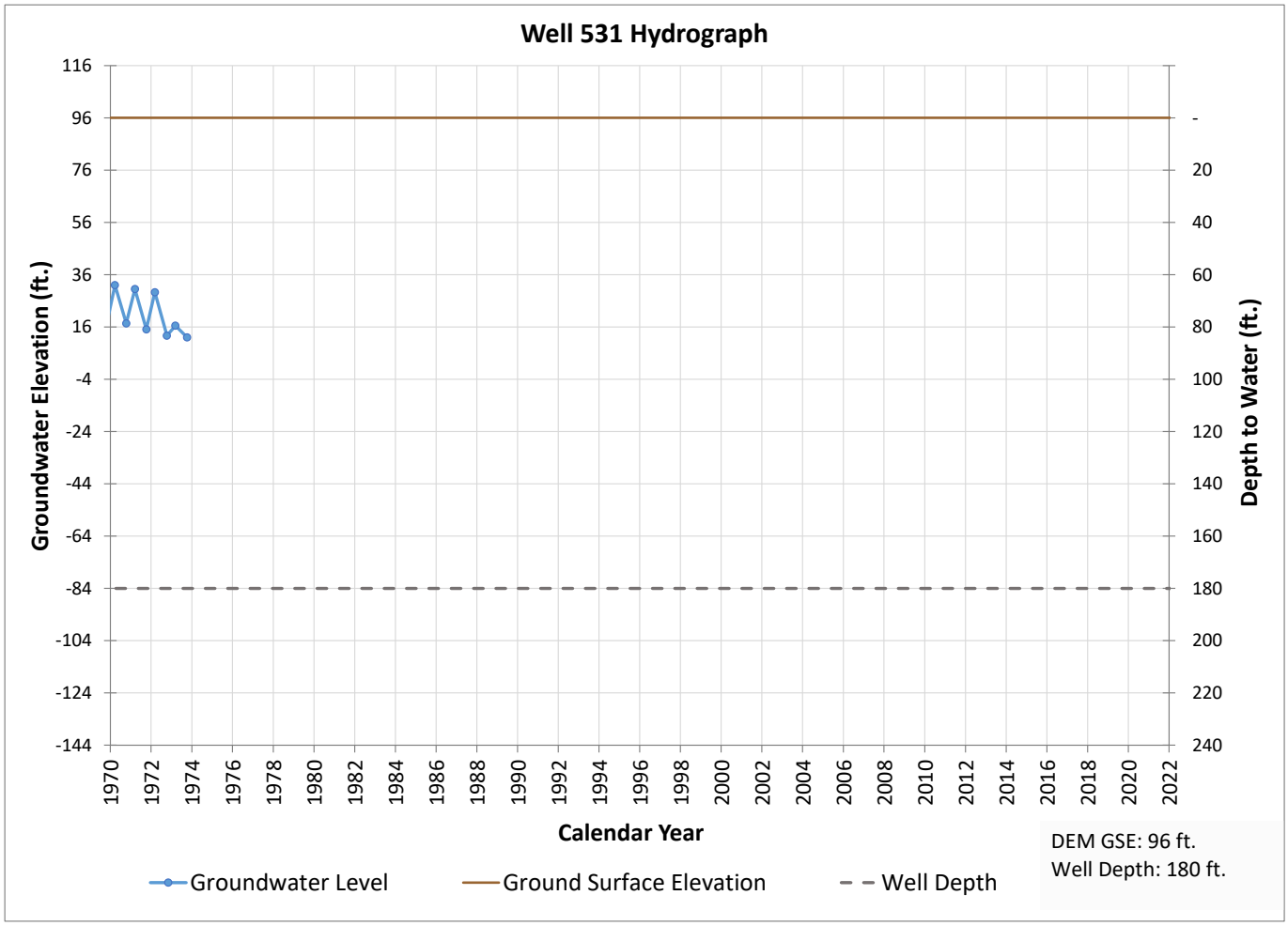

Well 512 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
-202
-222
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 18 ft.
Well Depth: ft.

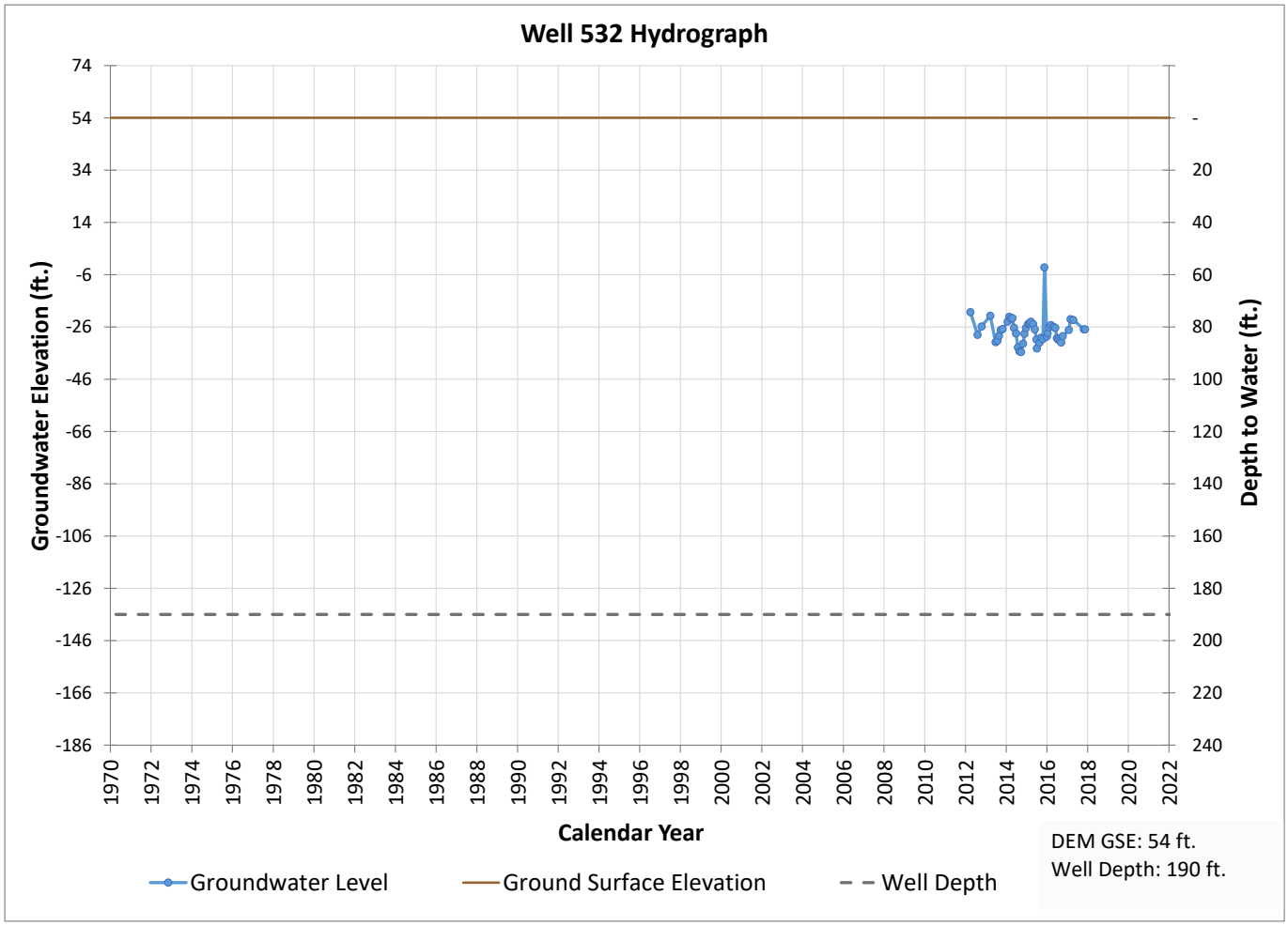

Well 513 Hydrograph
Groundwater Elevation (ft.)
227
207
187
167
147
127
107
87
67
47
27
7
-13
-33
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 207 ft.
Well Depth: 185 ft.

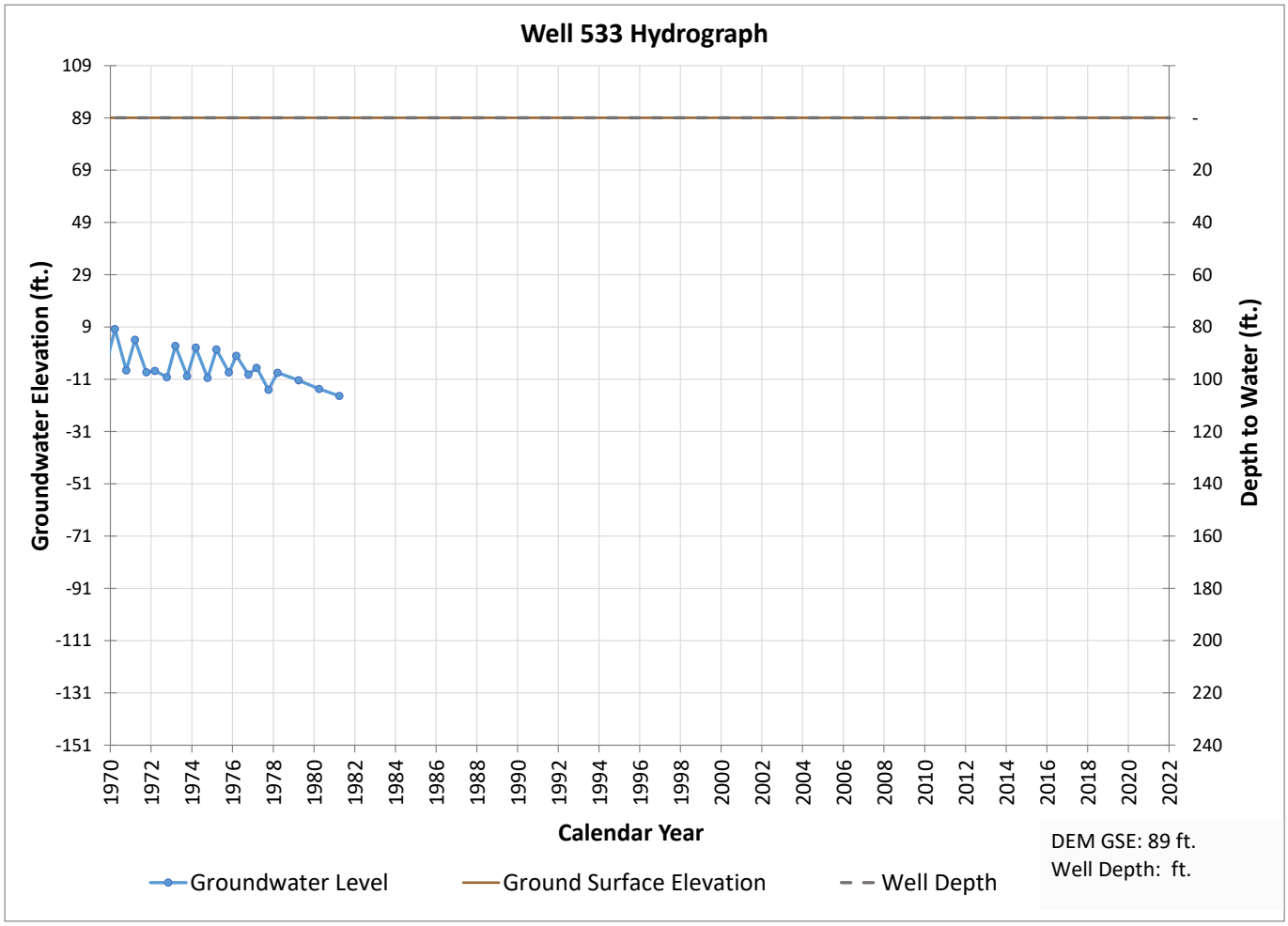

Well 523 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
211
191
171
151
131
111
91
71
51
31
11
-9
-29
-49
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 191 ft.
Well Depth: 218 ft.

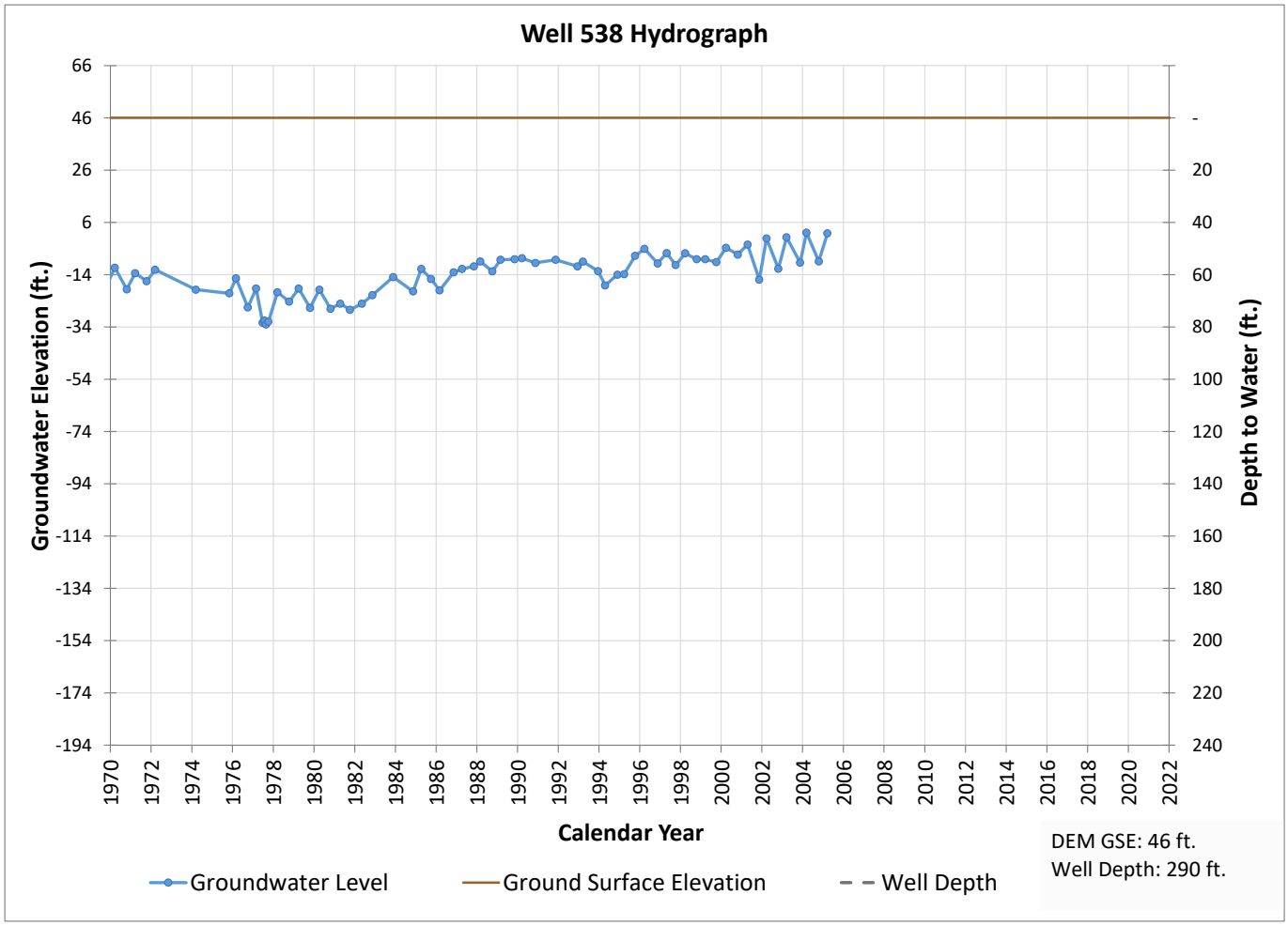

Well 524 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
162
142
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 142 ft.
Well Depth: 340 ft.

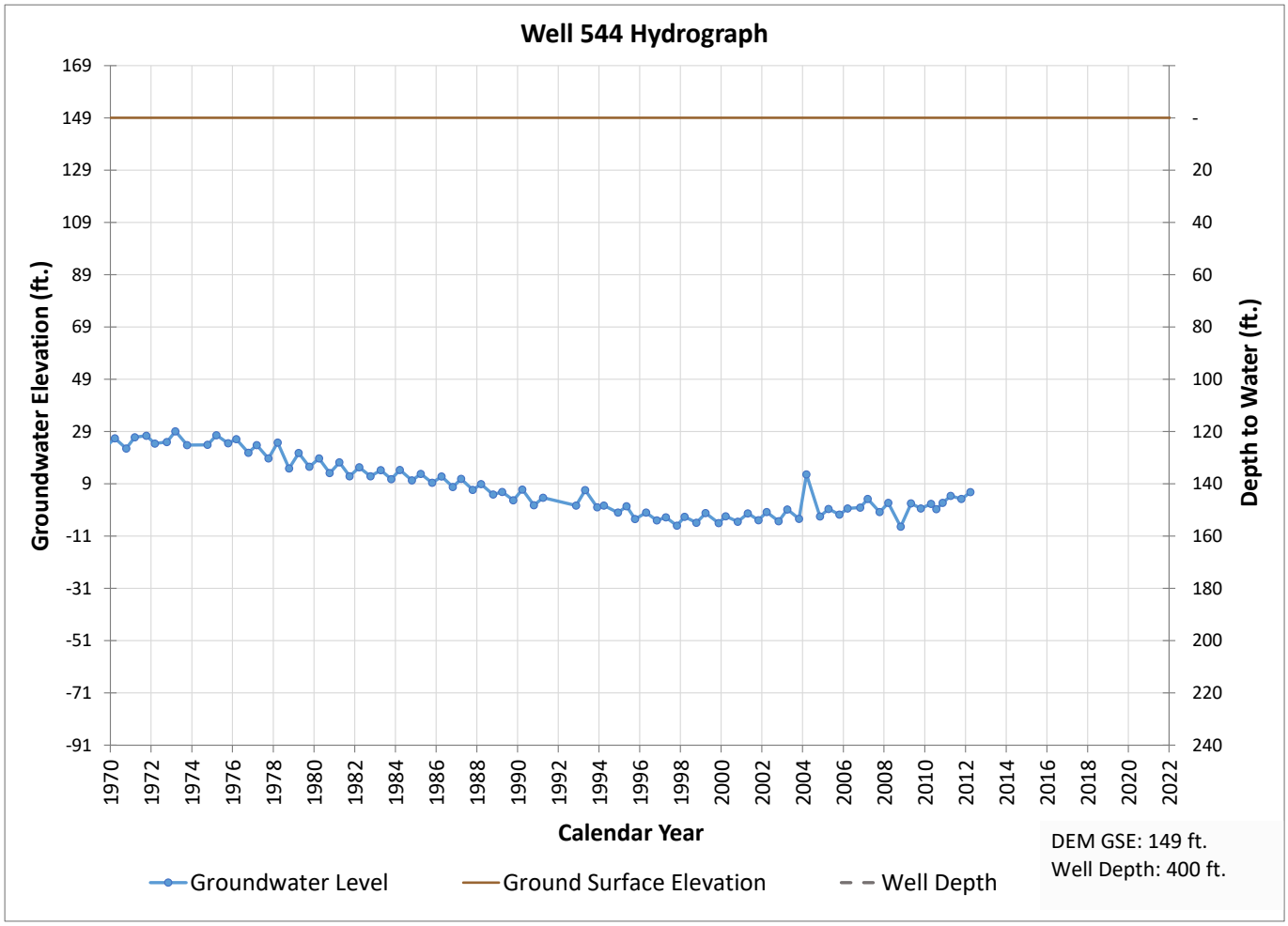

Well 525 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
175
155
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 155 ft.
Well Depth: 270 ft.

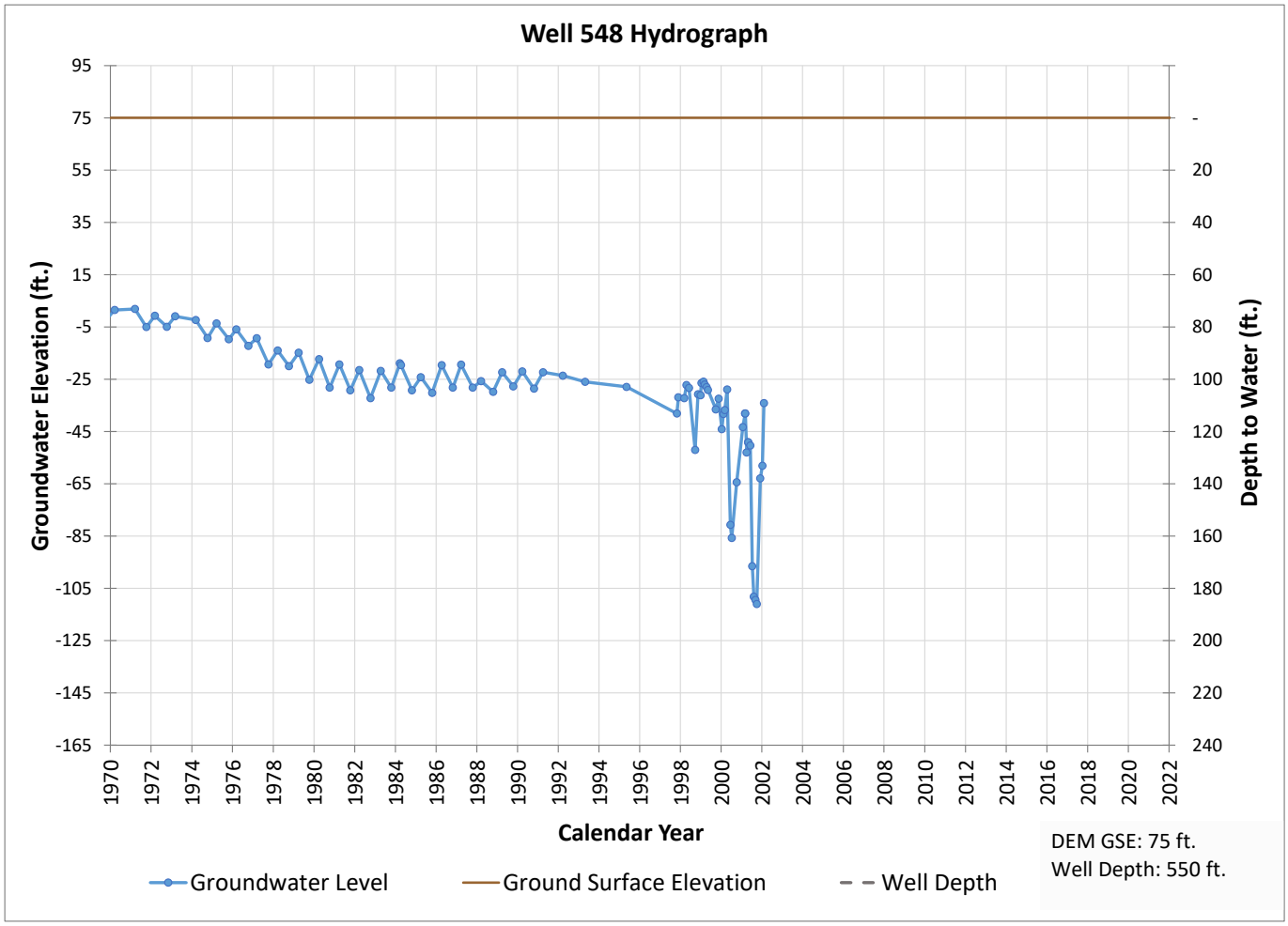

Well 531 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 96 ft.
Well Depth: 180 ft.

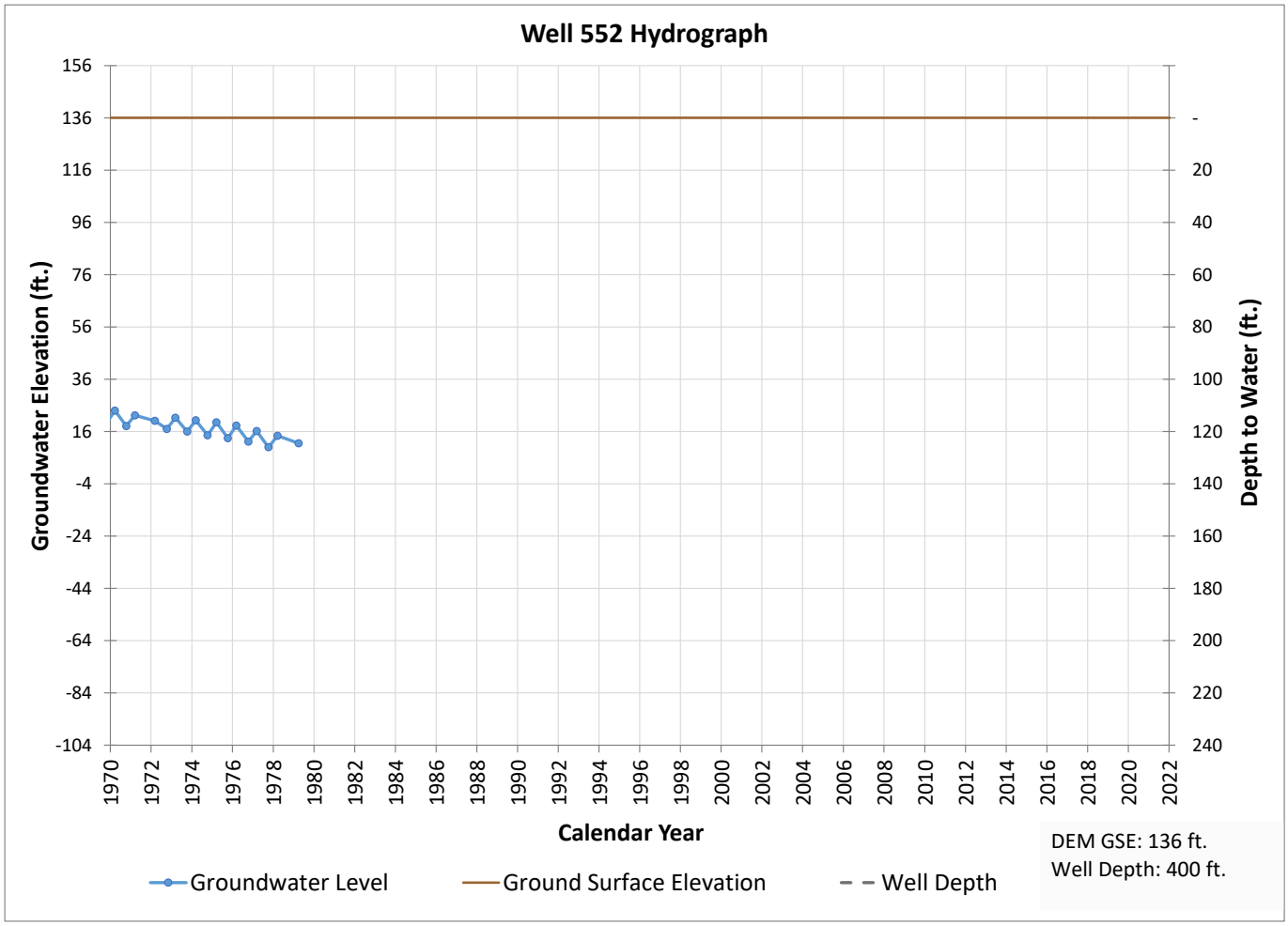

Well 532 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 190 ft.

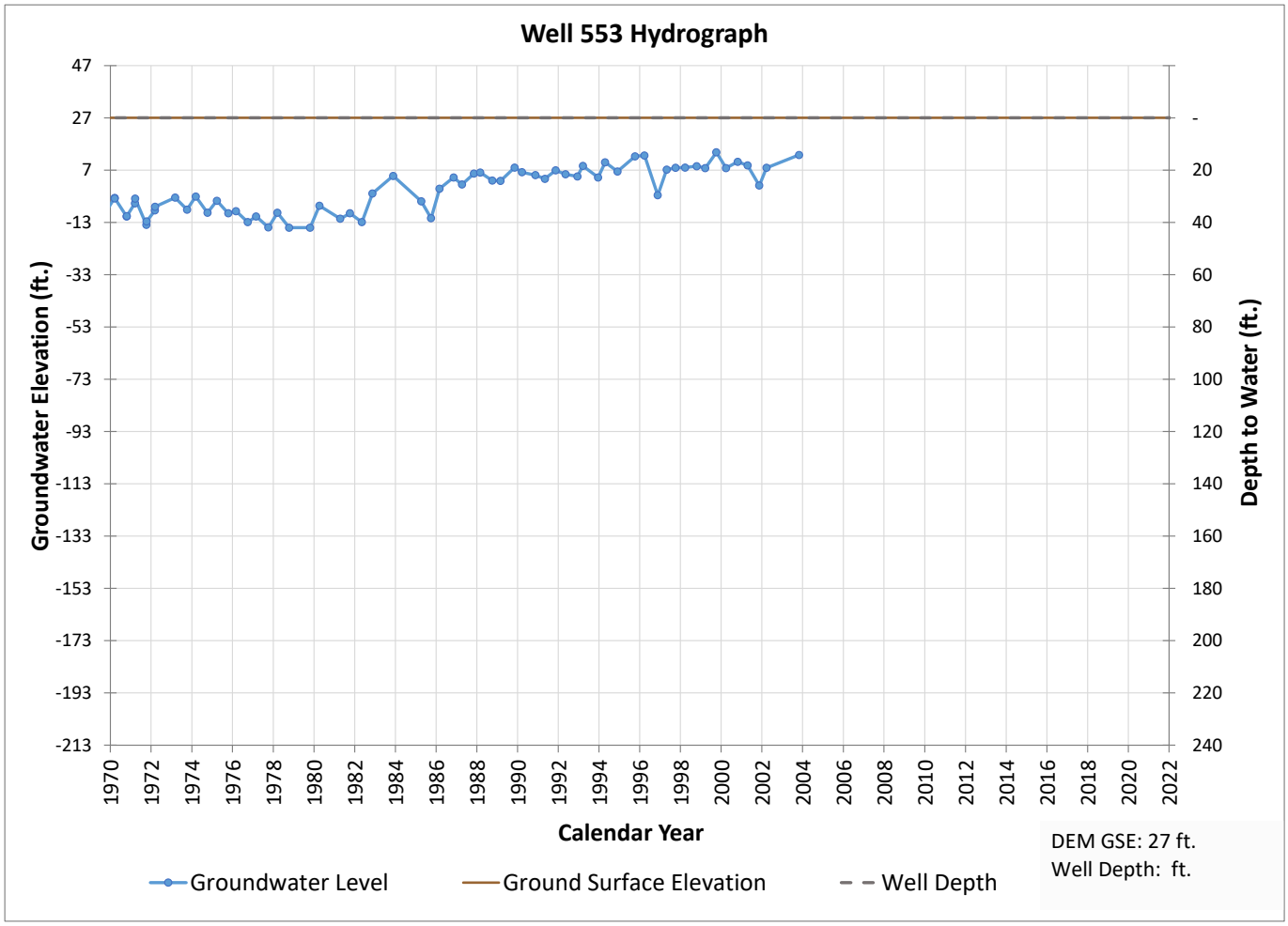

Well 533 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 89 ft.
Well Depth: ft.

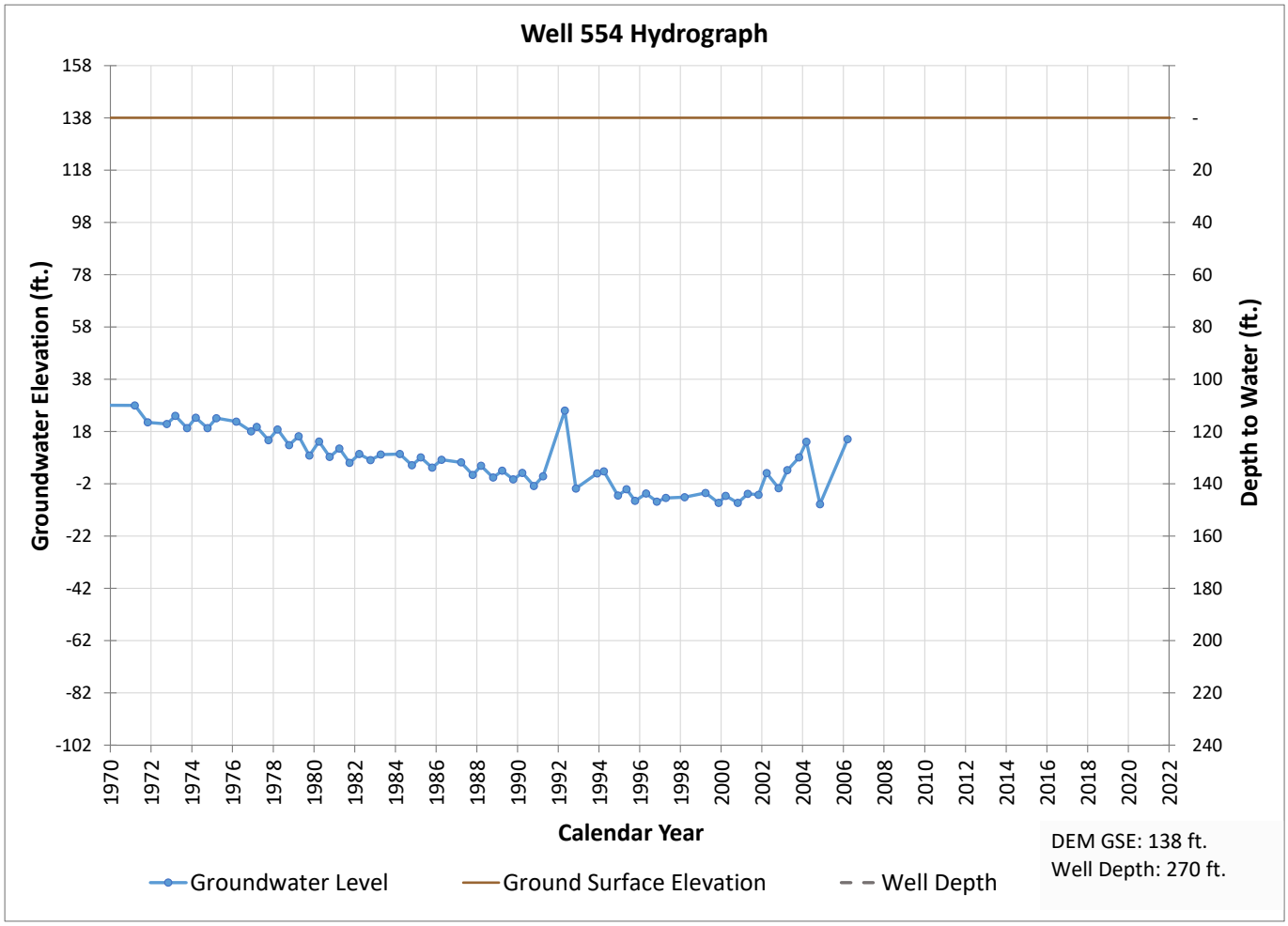

Well 538 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: 290 ft.

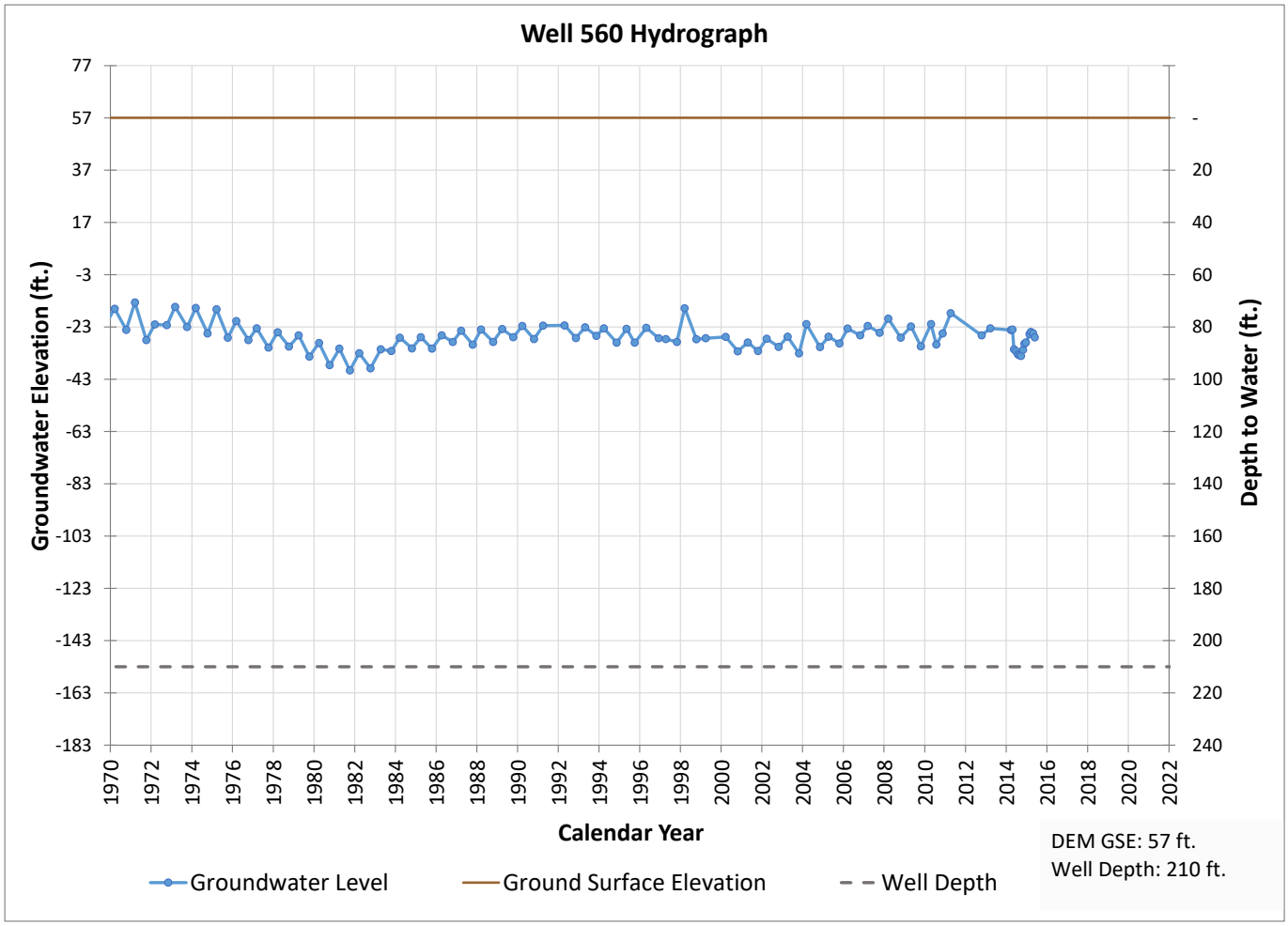

Well 544 Hydrograph
Groundwater Elevation (ft.)
169
149
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 149 ft.
Well Depth: 400 ft.

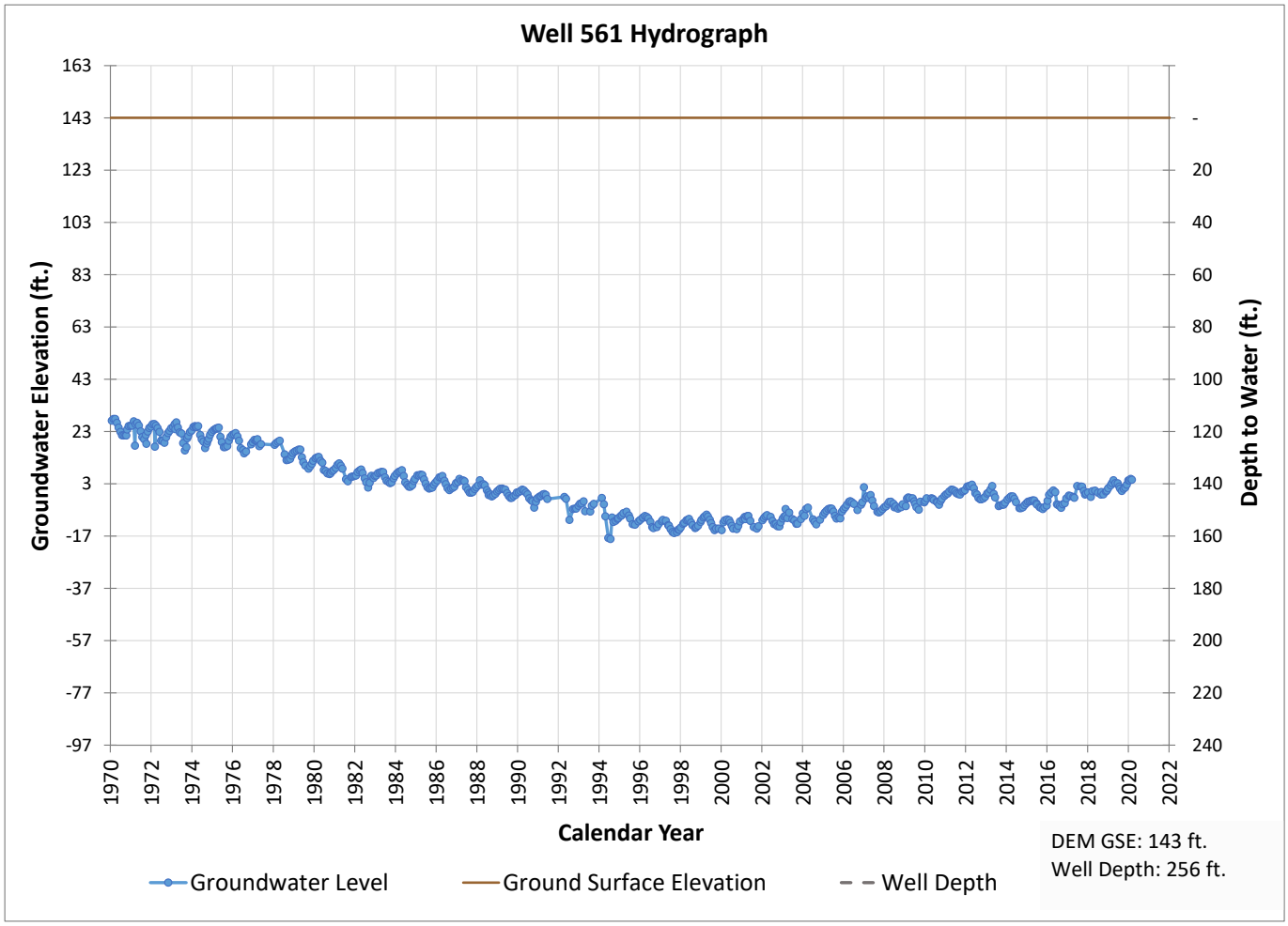

Well 548 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 75 ft.
Well Depth: 550 ft.

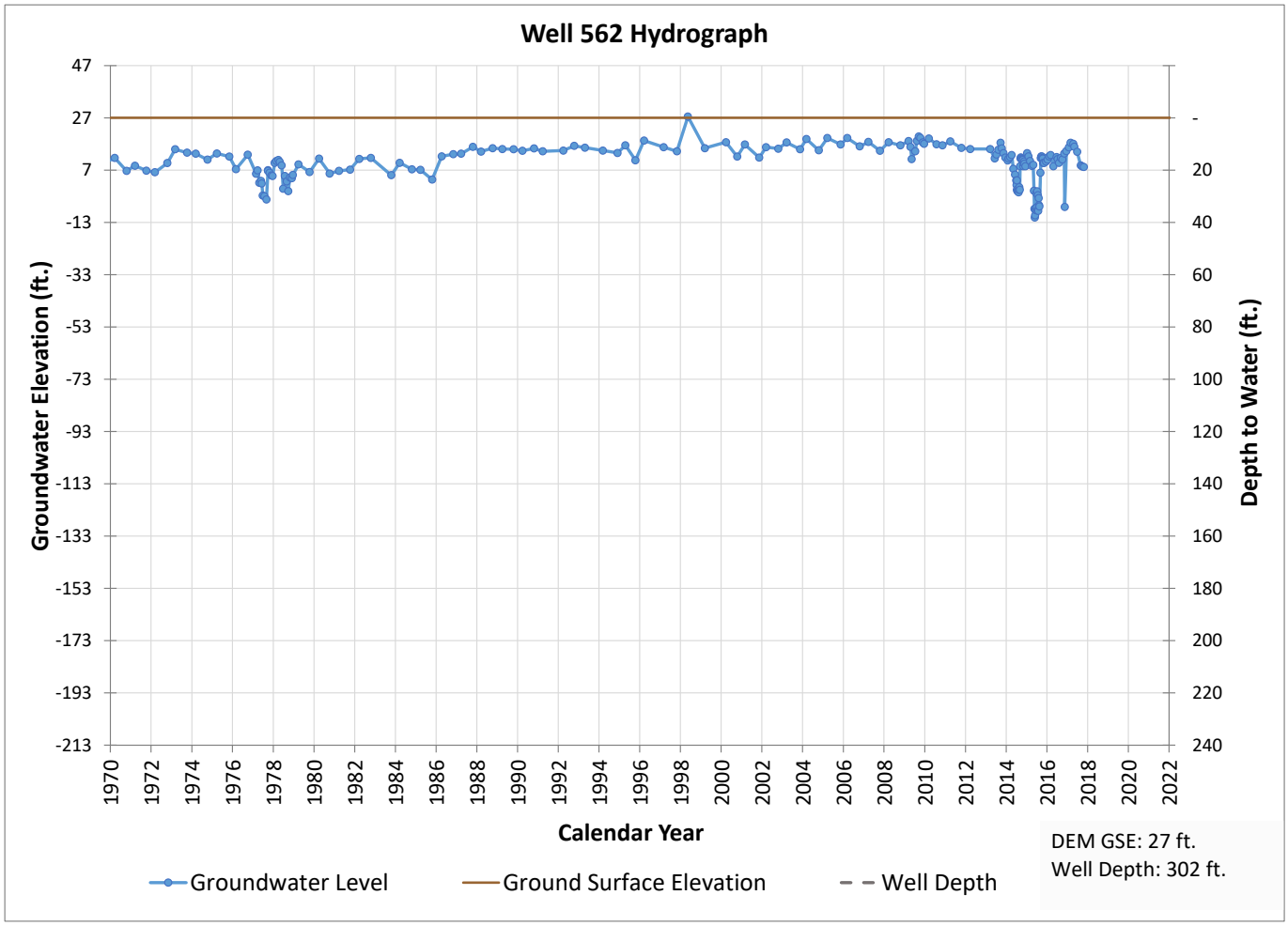

Well 552 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
156
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 136 ft.
Well Depth: 400 ft.

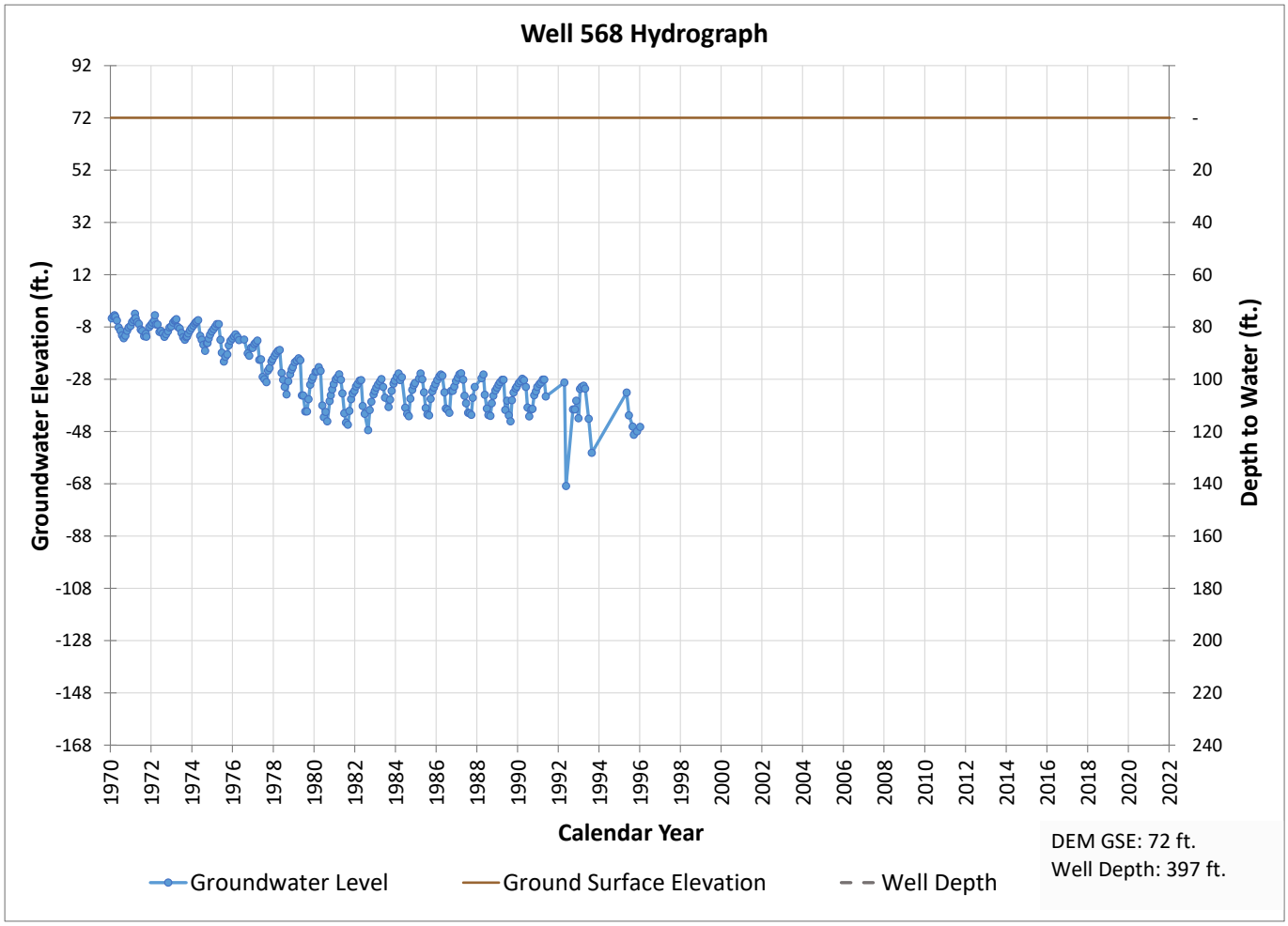

Well 553 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: ft.

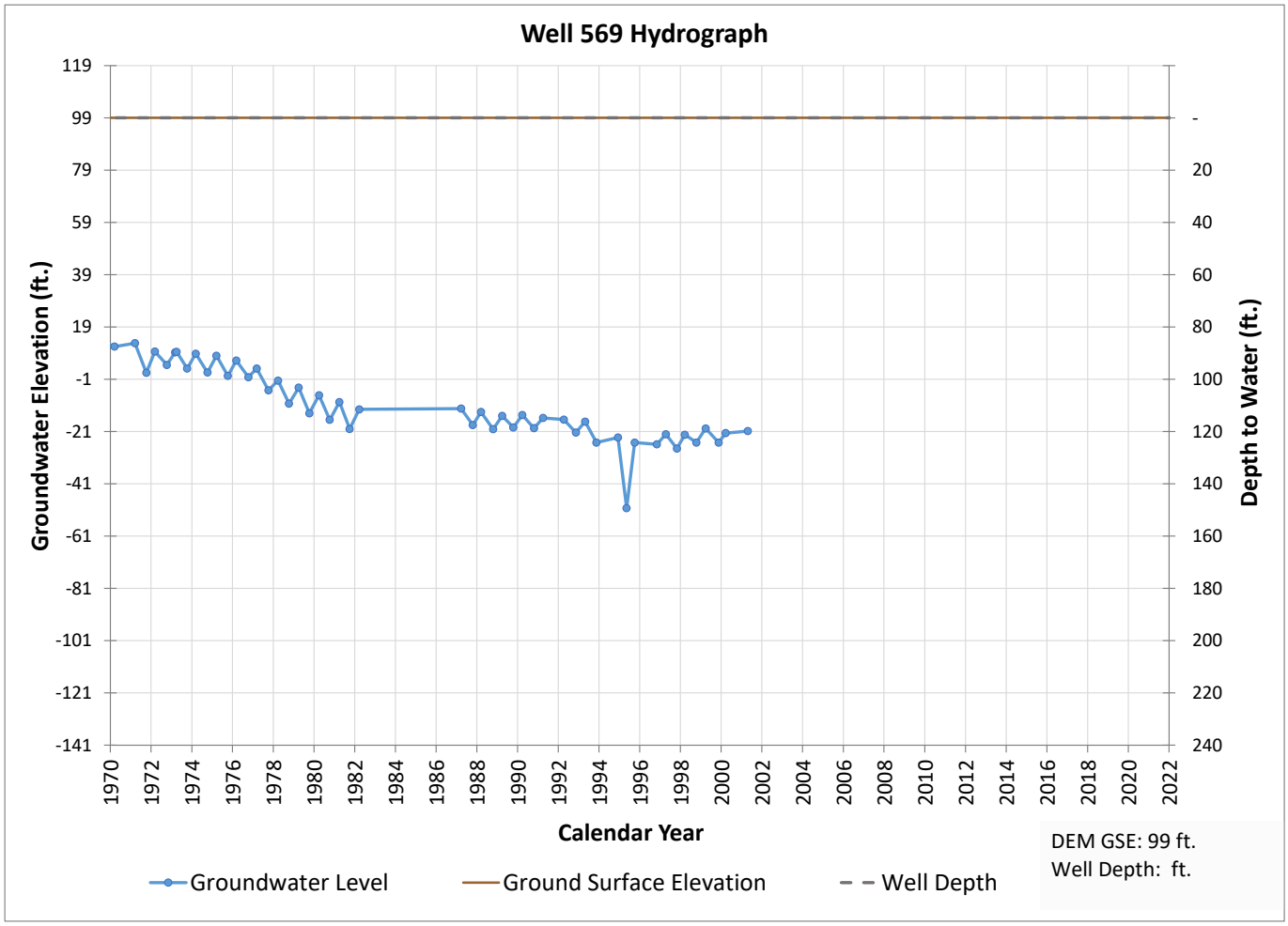

Well 554 Hydrograph
Groundwater Elevation (ft.)
158
138
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 138 ft.
Well Depth: 270 ft.

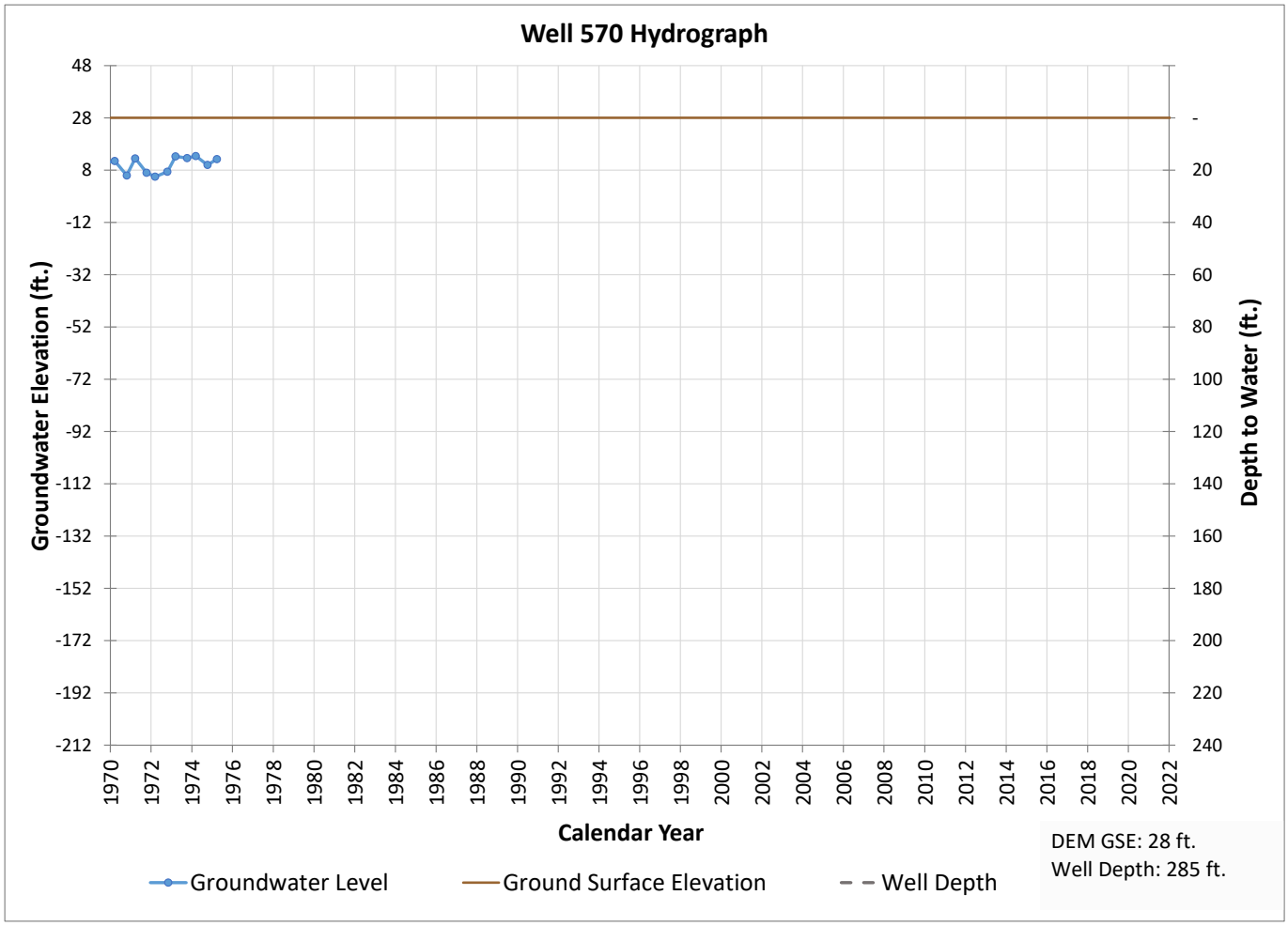

Well 560 Hydrograph
Groundwater Elevation (ft.)
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 57 ft.
Well Depth: 210 ft.

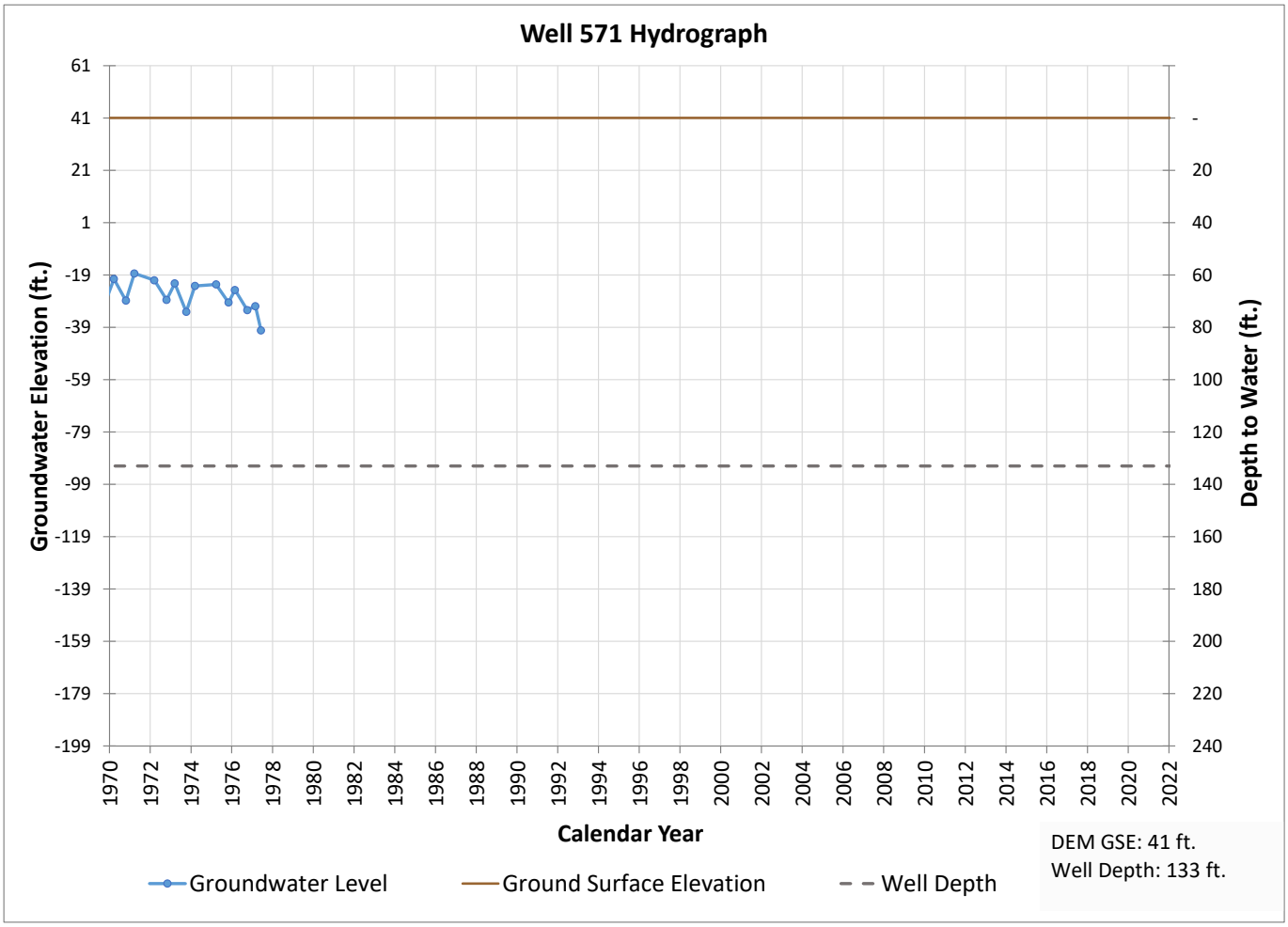

Well 561 Hydrograph
Groundwater Elevation (ft.)
163
143
123
103
83
63
43
23
3
-17
-37
-57
-77
-97
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 143 ft.
Well Depth: 256 ft.

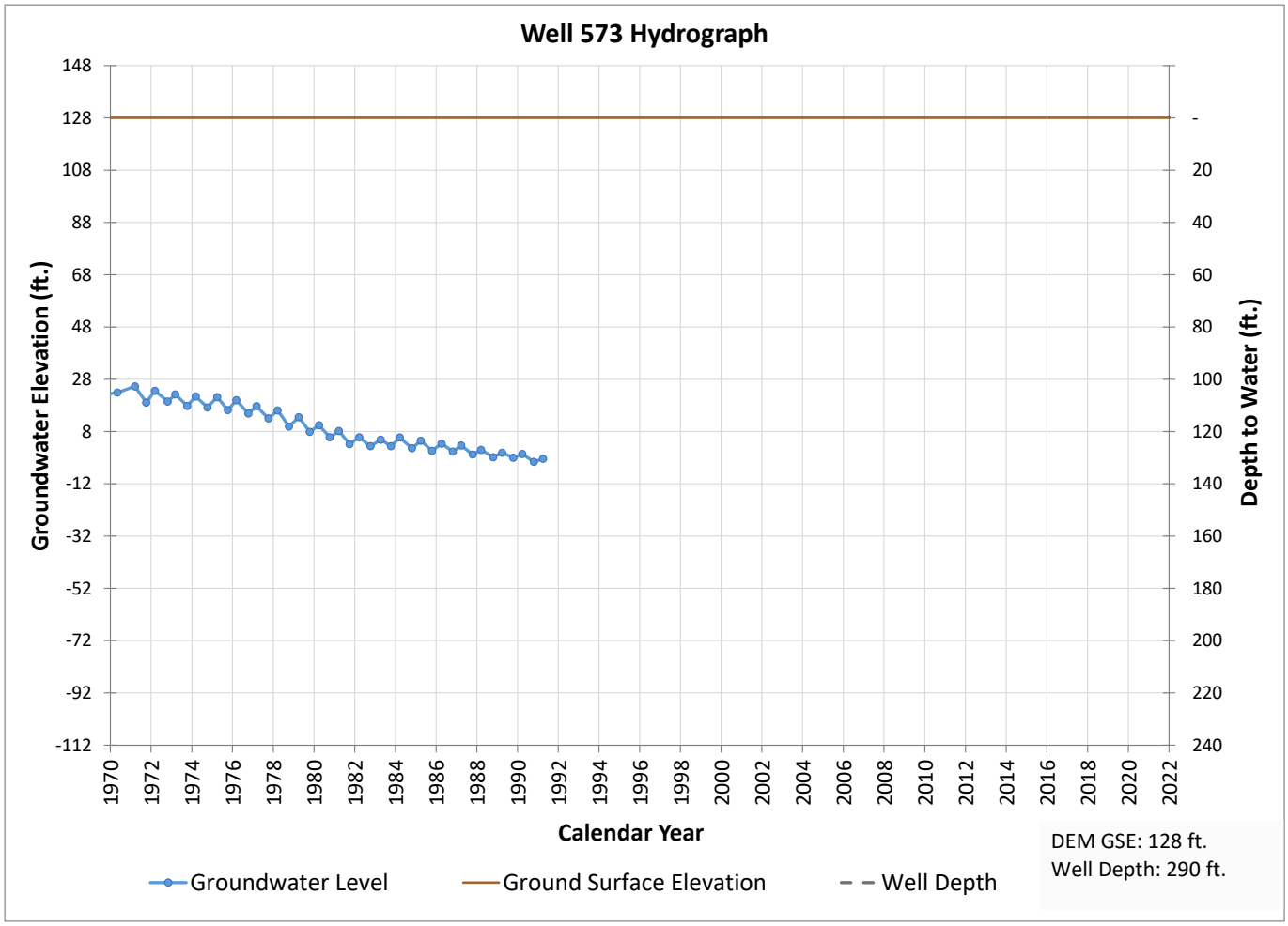

Well 562 Hydrograph
Groundwater Elevation (ft.)
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-173
-193
-213
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 27 ft.
Well Depth: 302 ft.

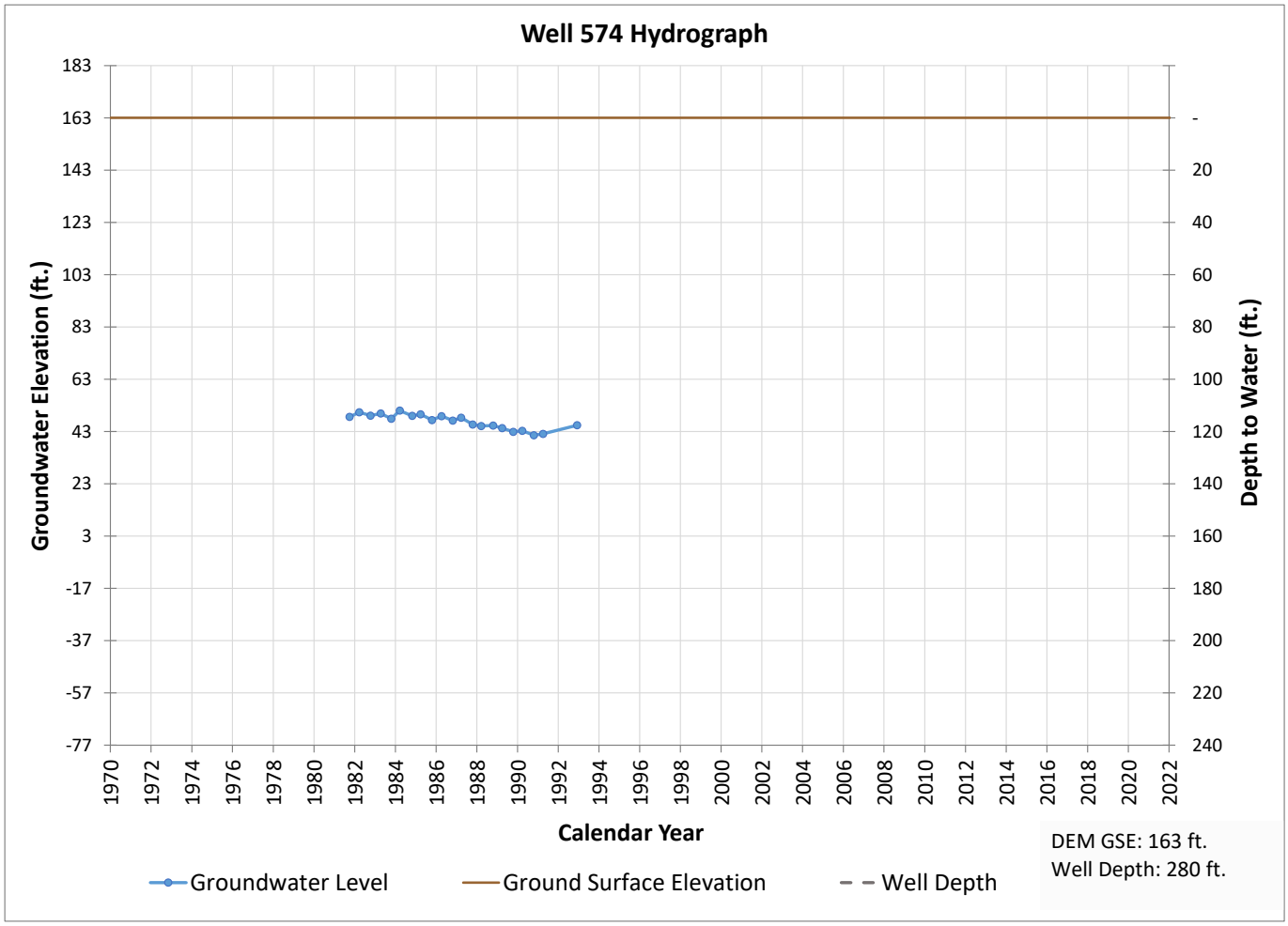

Well 568 Hydrograph
Groundwater Elevation (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: 397 ft.

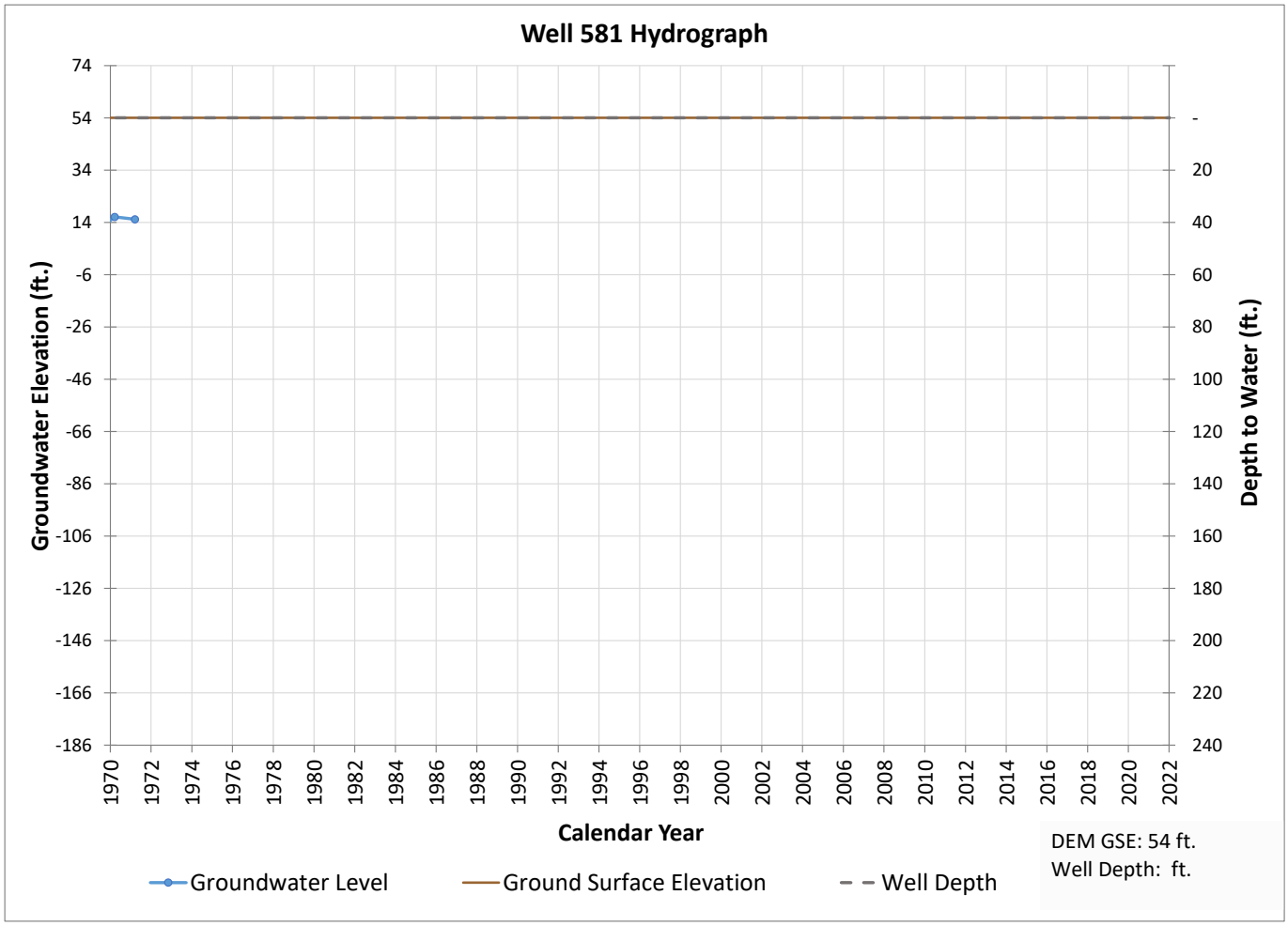

Well 569 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
119
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 99 ft.
Well Depth: ft.

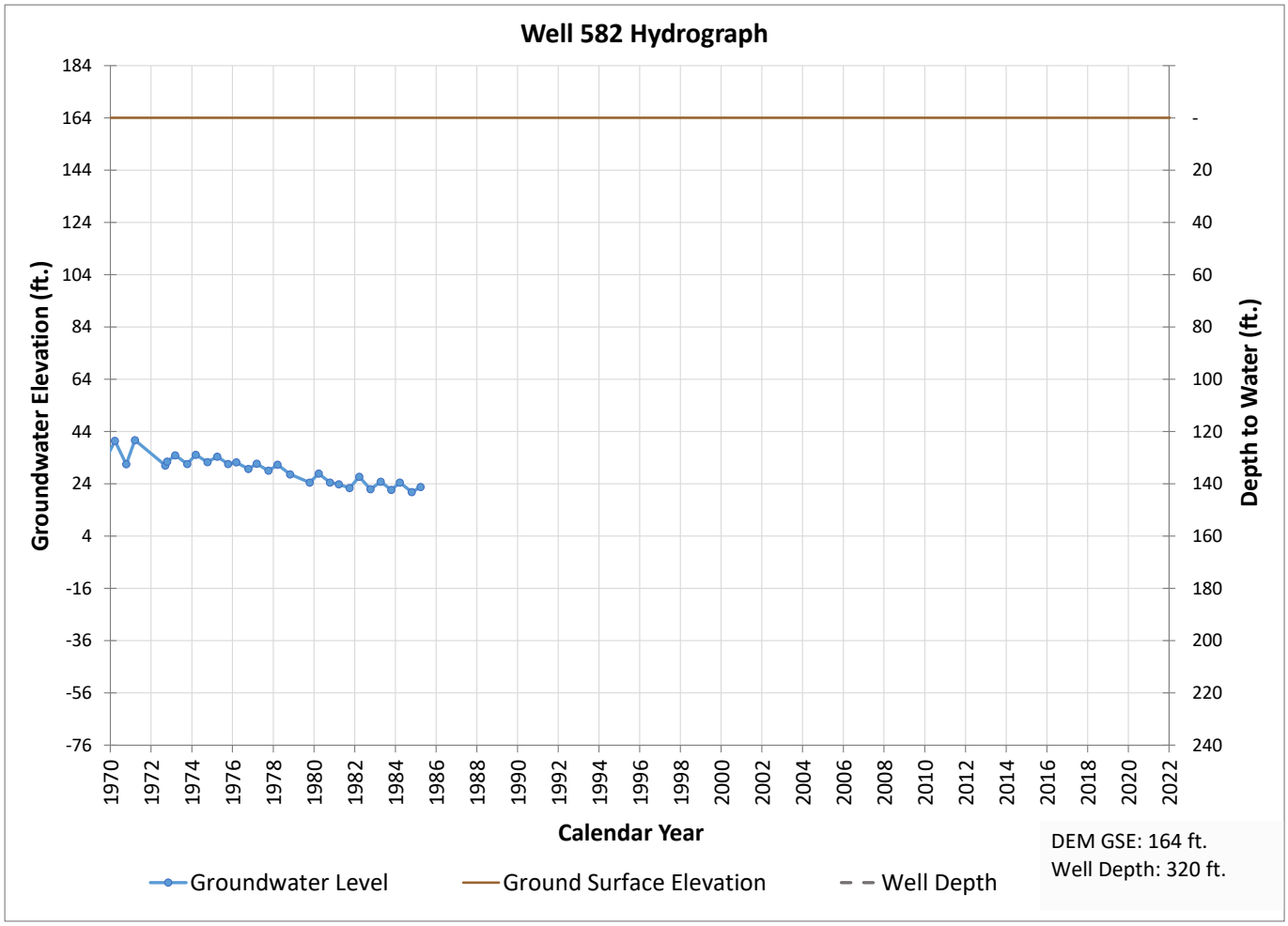

Well 570 Hydrograph
Groundwater Elevation (ft.)
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 28 ft.
Well Depth: 285 ft.

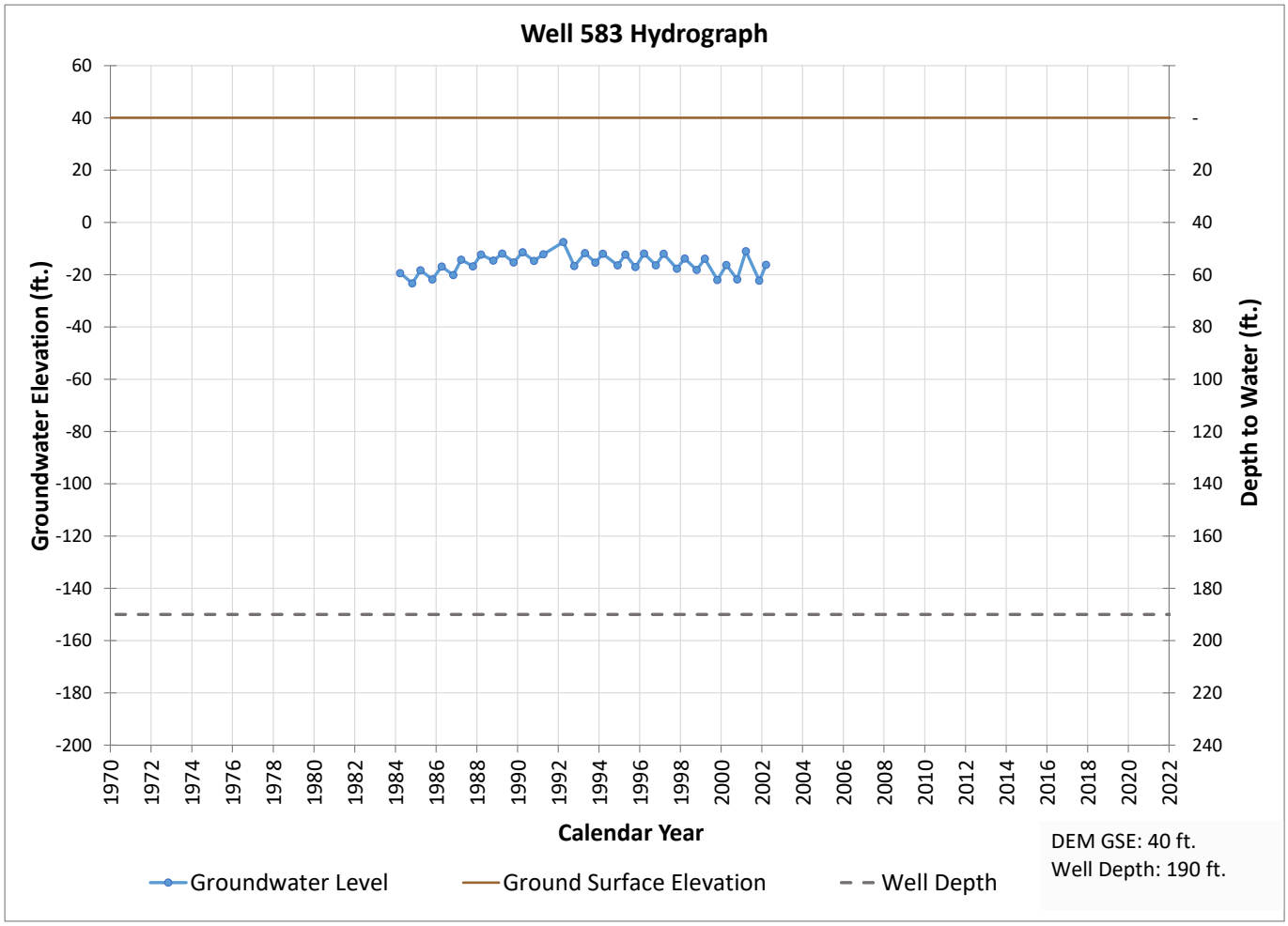

Well 571 Hydrograph
Groundwater Elevation (ft.)
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-199
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 41 ft.
Well Depth: 133 ft.

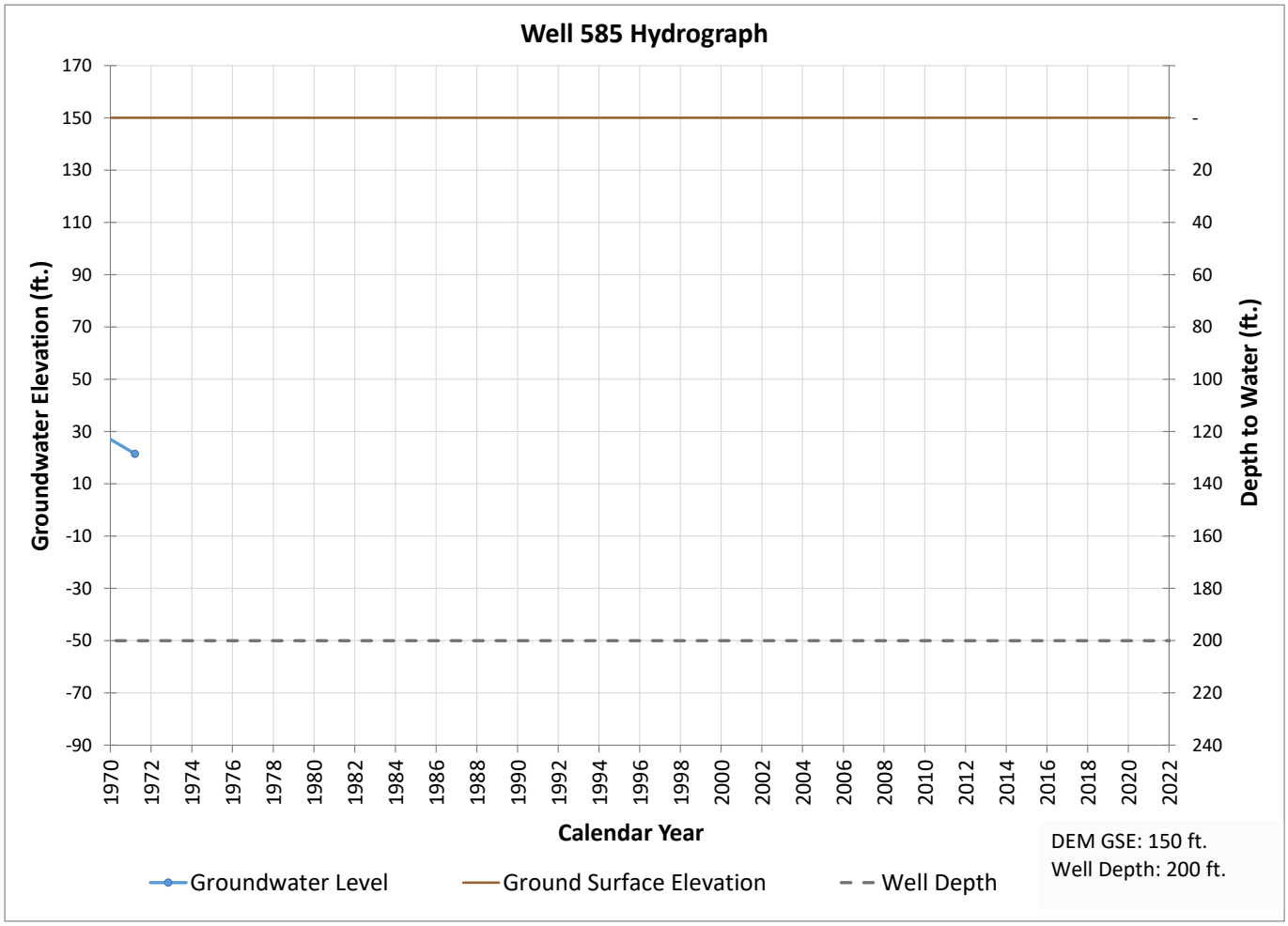

Well 573 Hydrograph
Groundwater Elevation (ft.)
148
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 128 ft.
Well Depth: 290 ft.

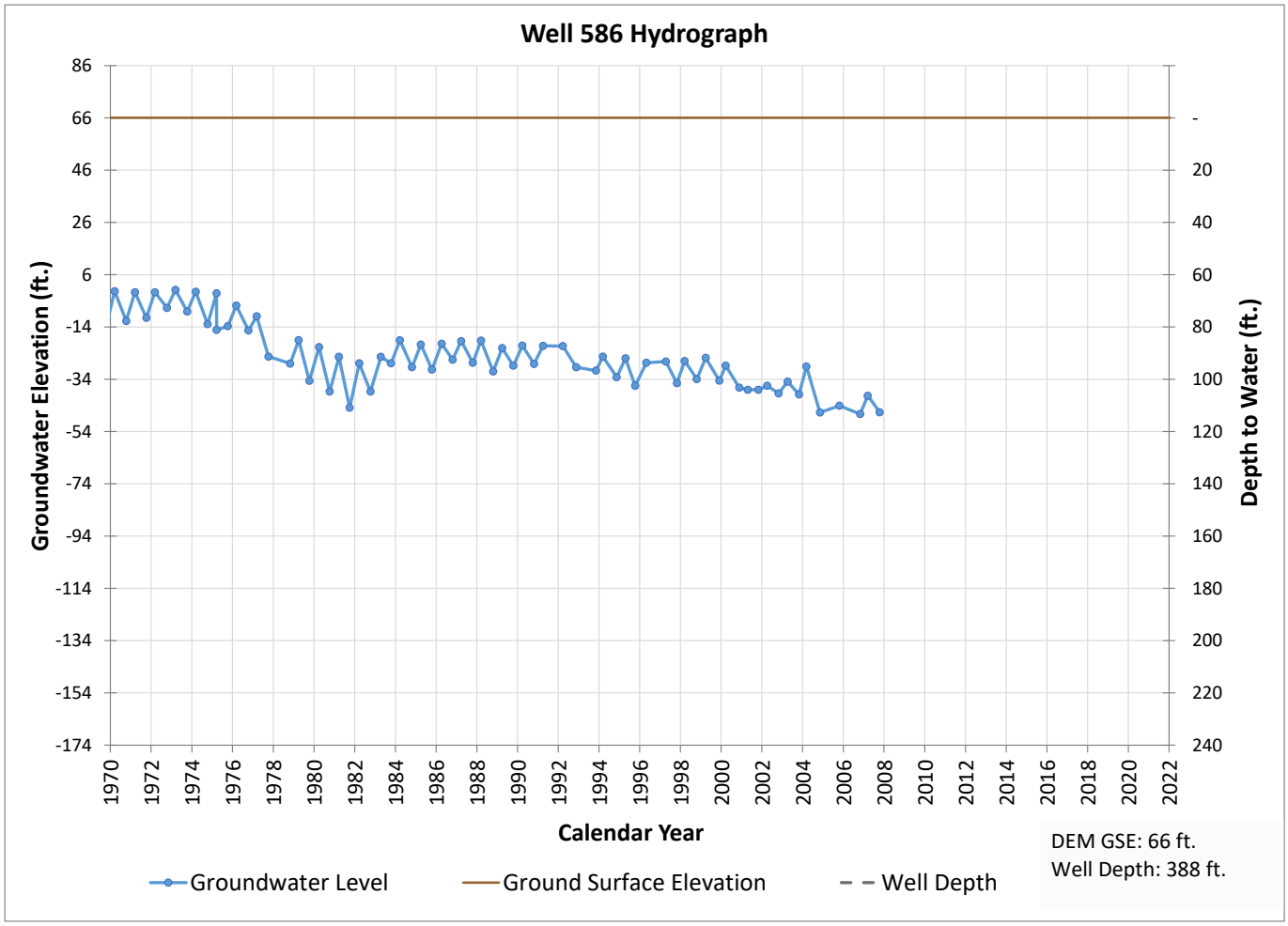

Well 574 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
183
163
143
123
103
83
63
43
23
3
-17
-37
-57
-77
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 163 ft.
Well Depth: 280 ft.

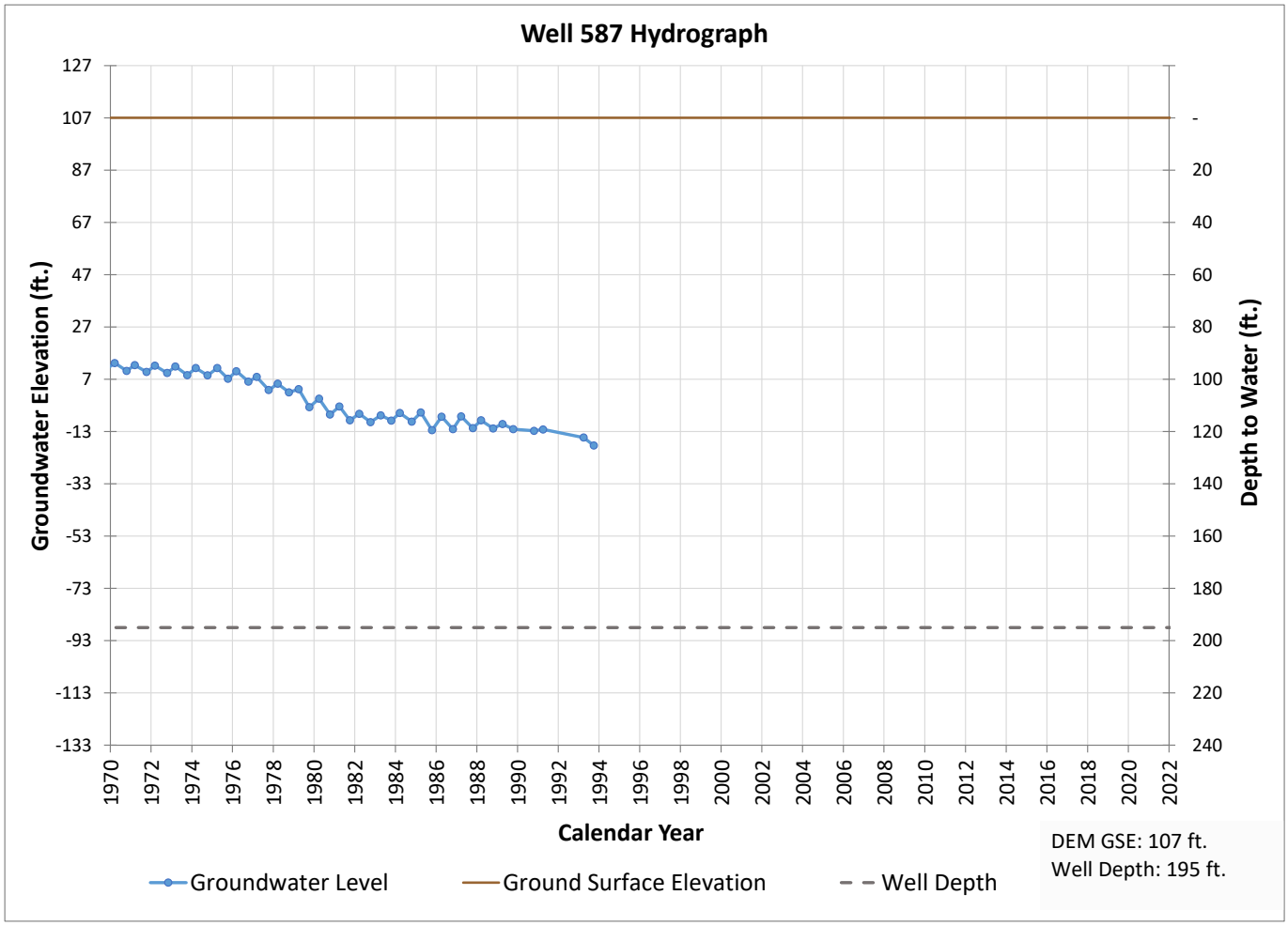

Well 581 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: ft.

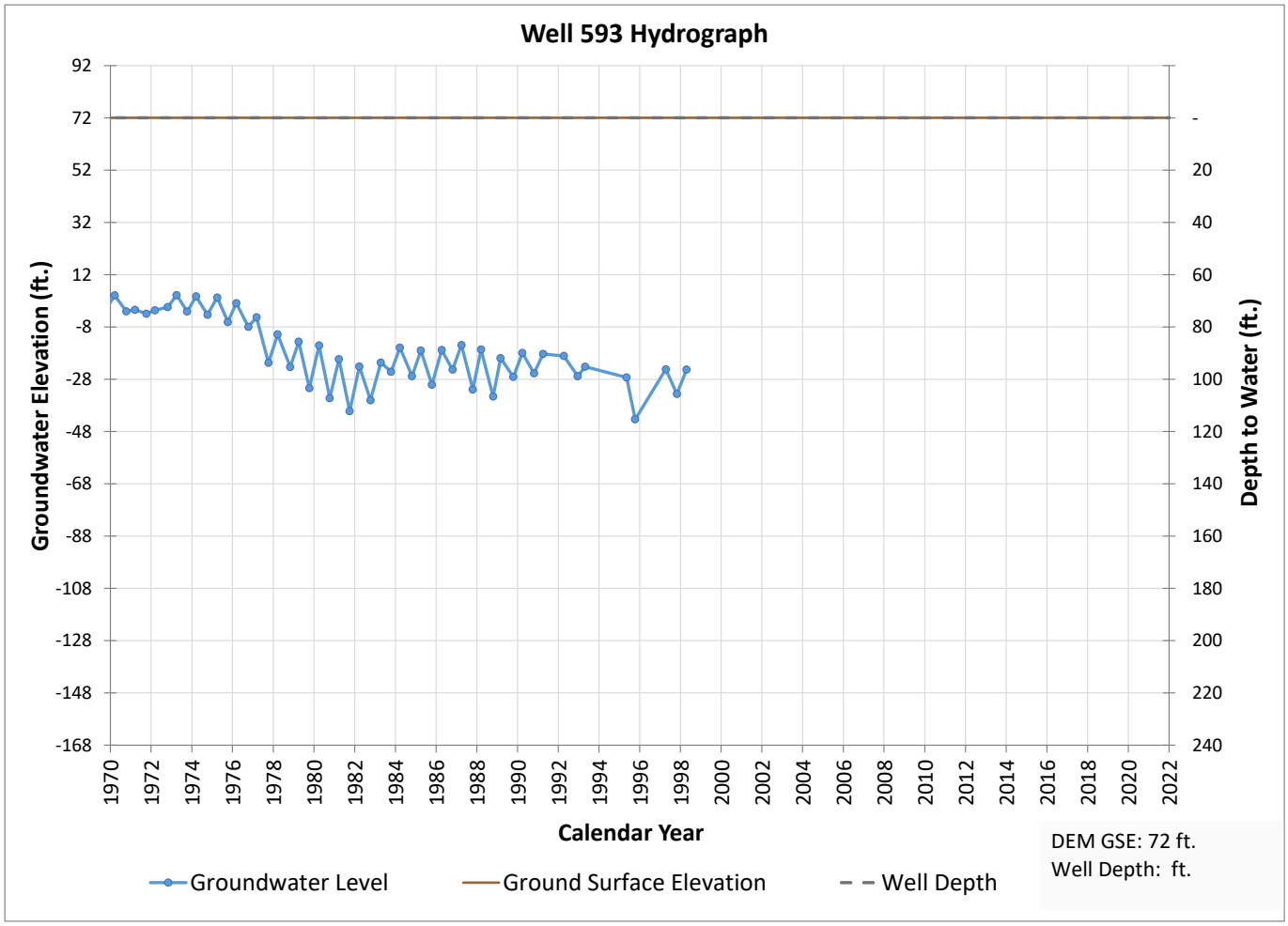

Well 582 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
184
164
144
124
104
84
64
44
24
4
-16
-36
-56
-76
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 164 ft.
Well Depth: 320 ft.

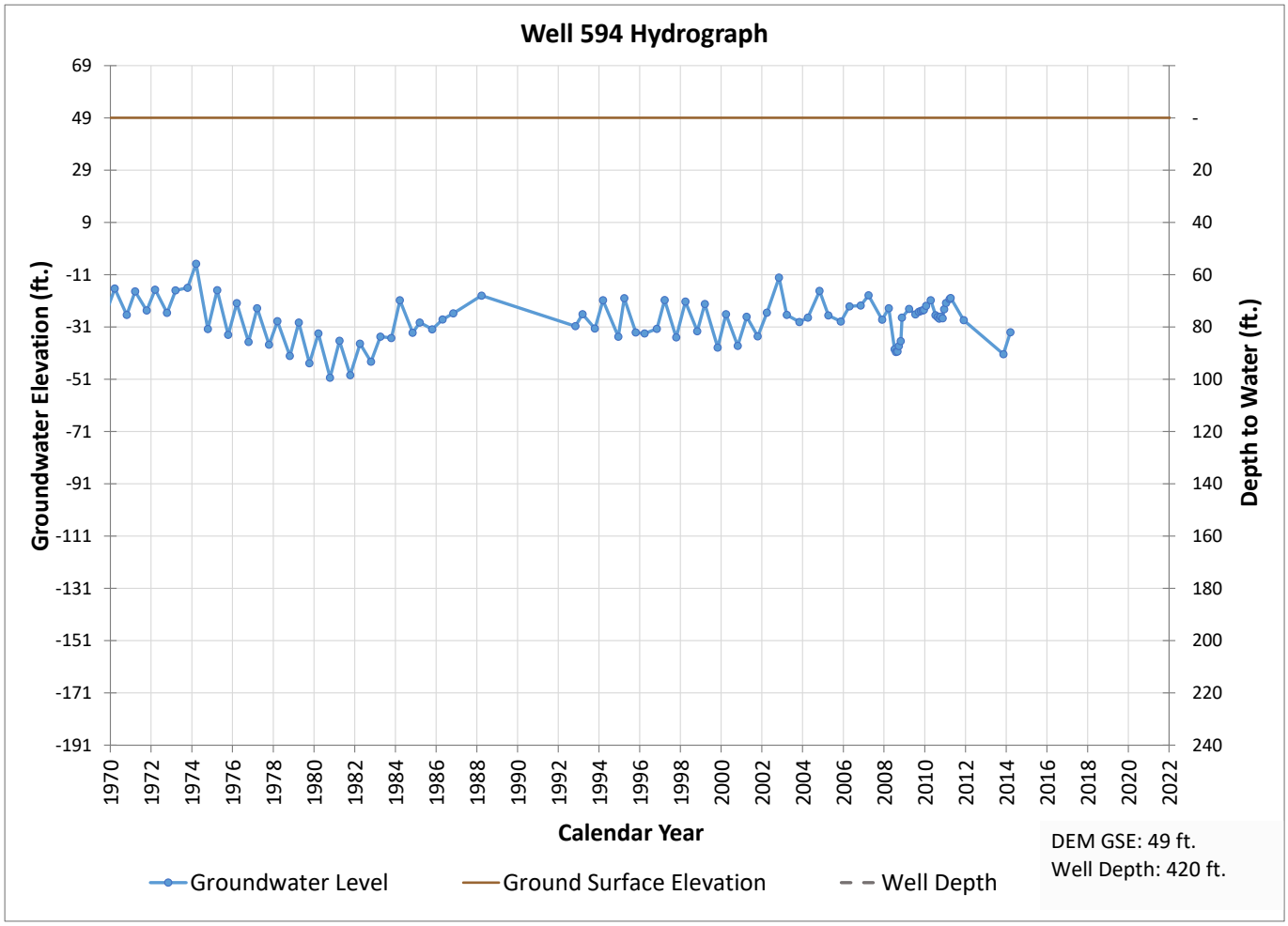

Well 583 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 40 ft.
Well Depth: 190 ft.

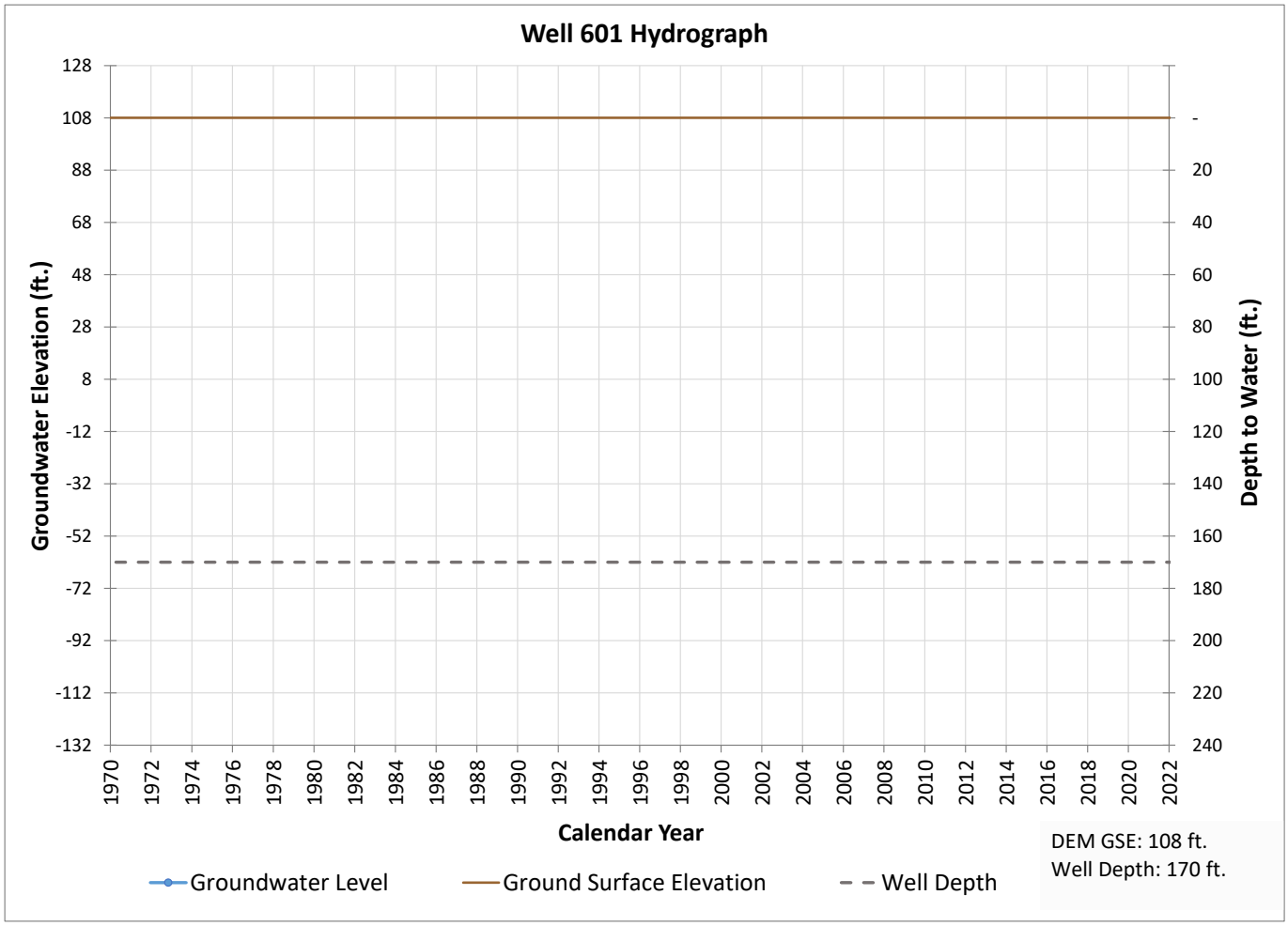

Well 585 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
170
150
130
110
90
70
50
30
10
-10
-30
-50
-70
-90
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 150 ft.
Well Depth: 200 ft.

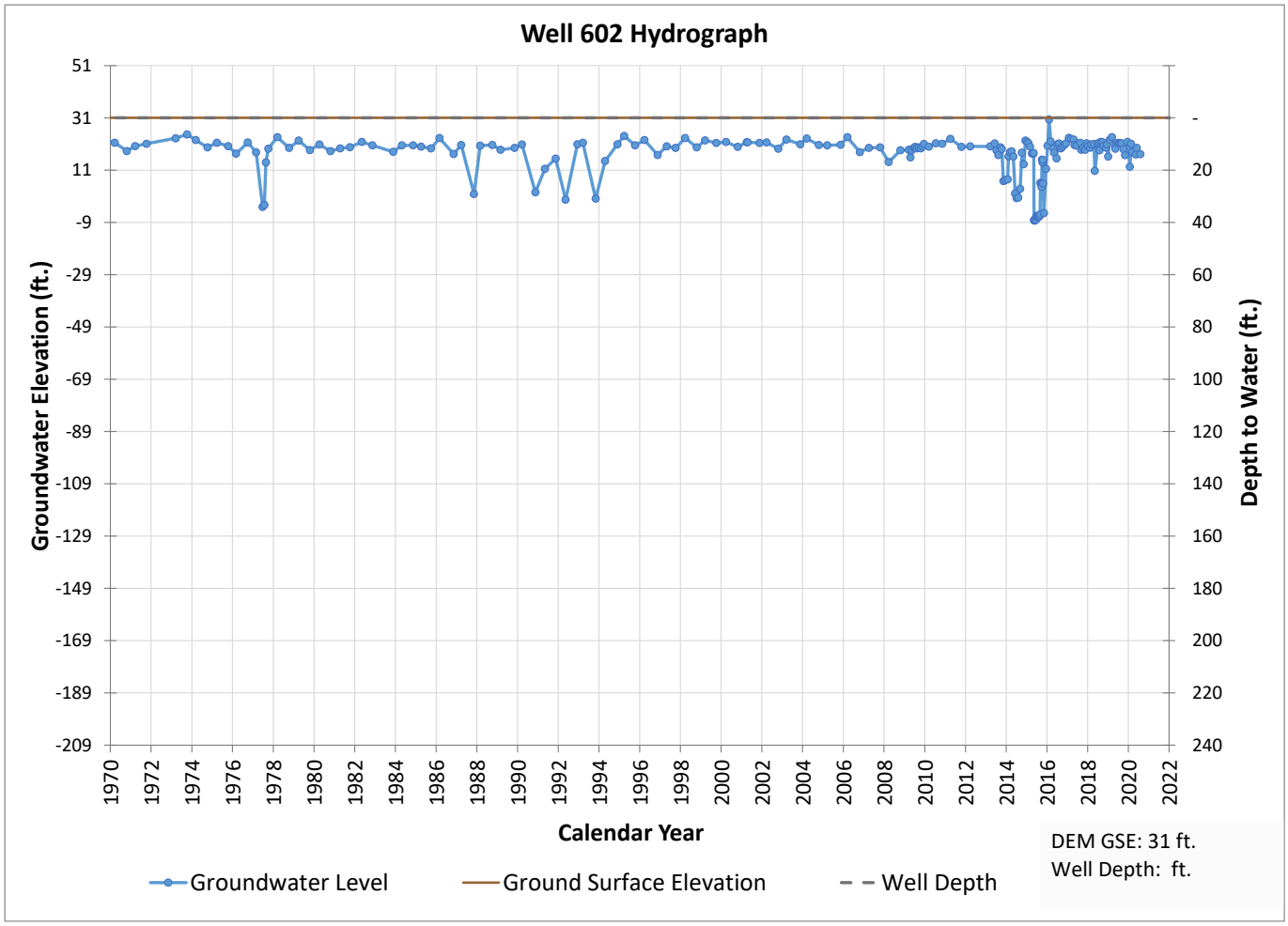

Well 586 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 66 ft.
Well Depth: 388 ft.

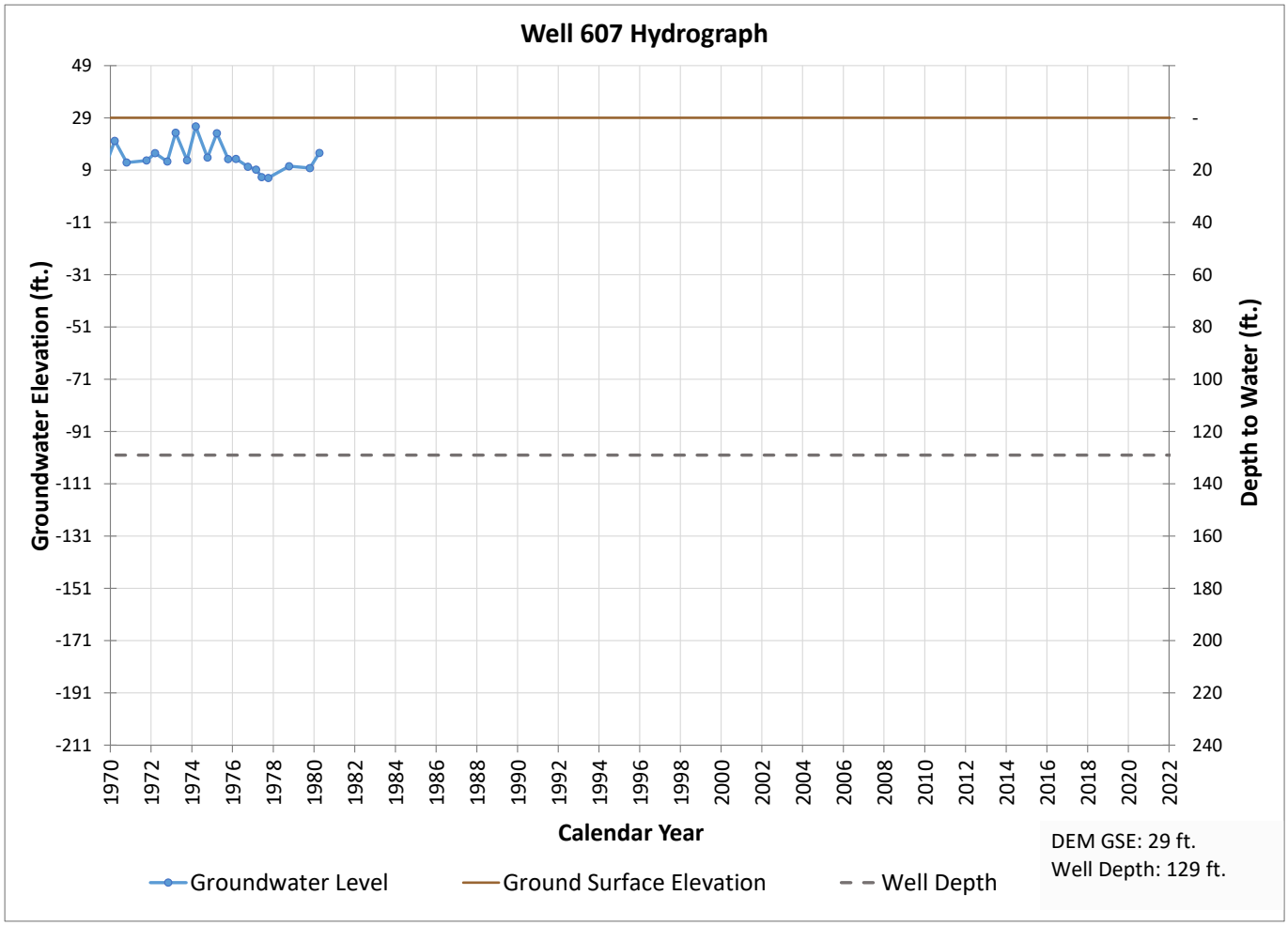

Well 587 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 107 ft.
Well Depth: 195 ft.

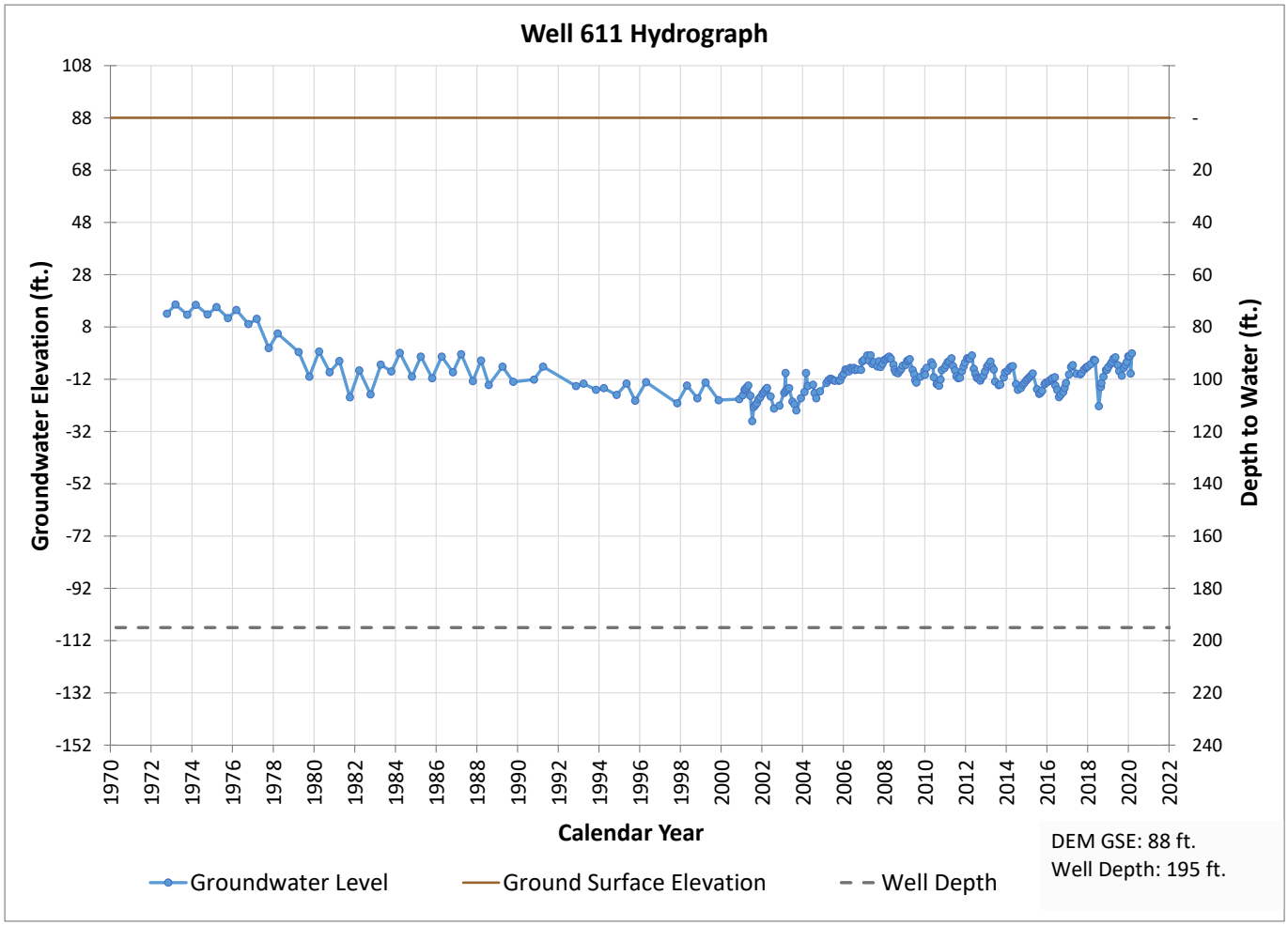

Well 593 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: ft.

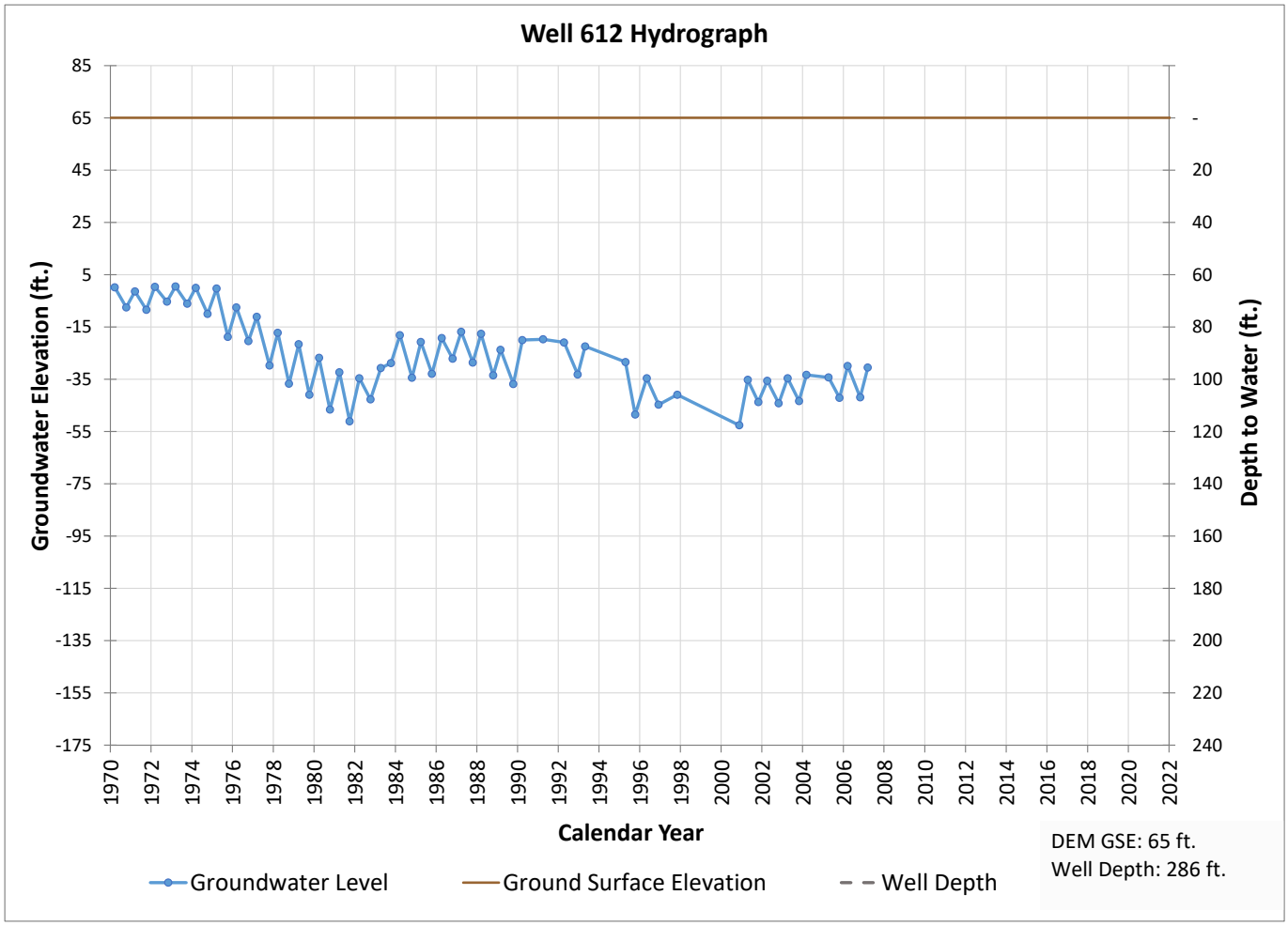

Well 594 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: 420 ft.

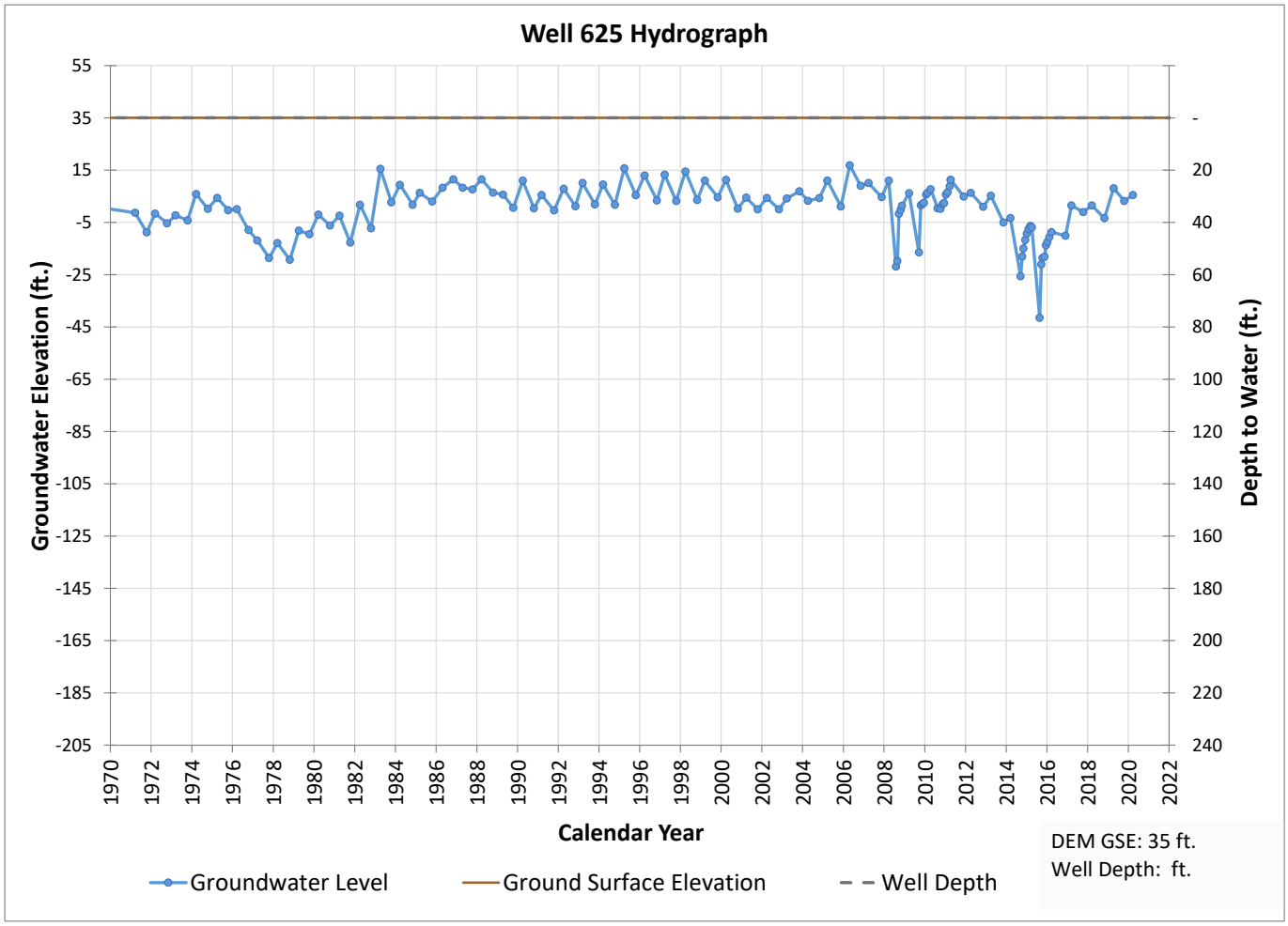

Well 601 Hydrograph
Groundwater Elevation (ft.)
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 108 ft.
Well Depth: 170 ft.

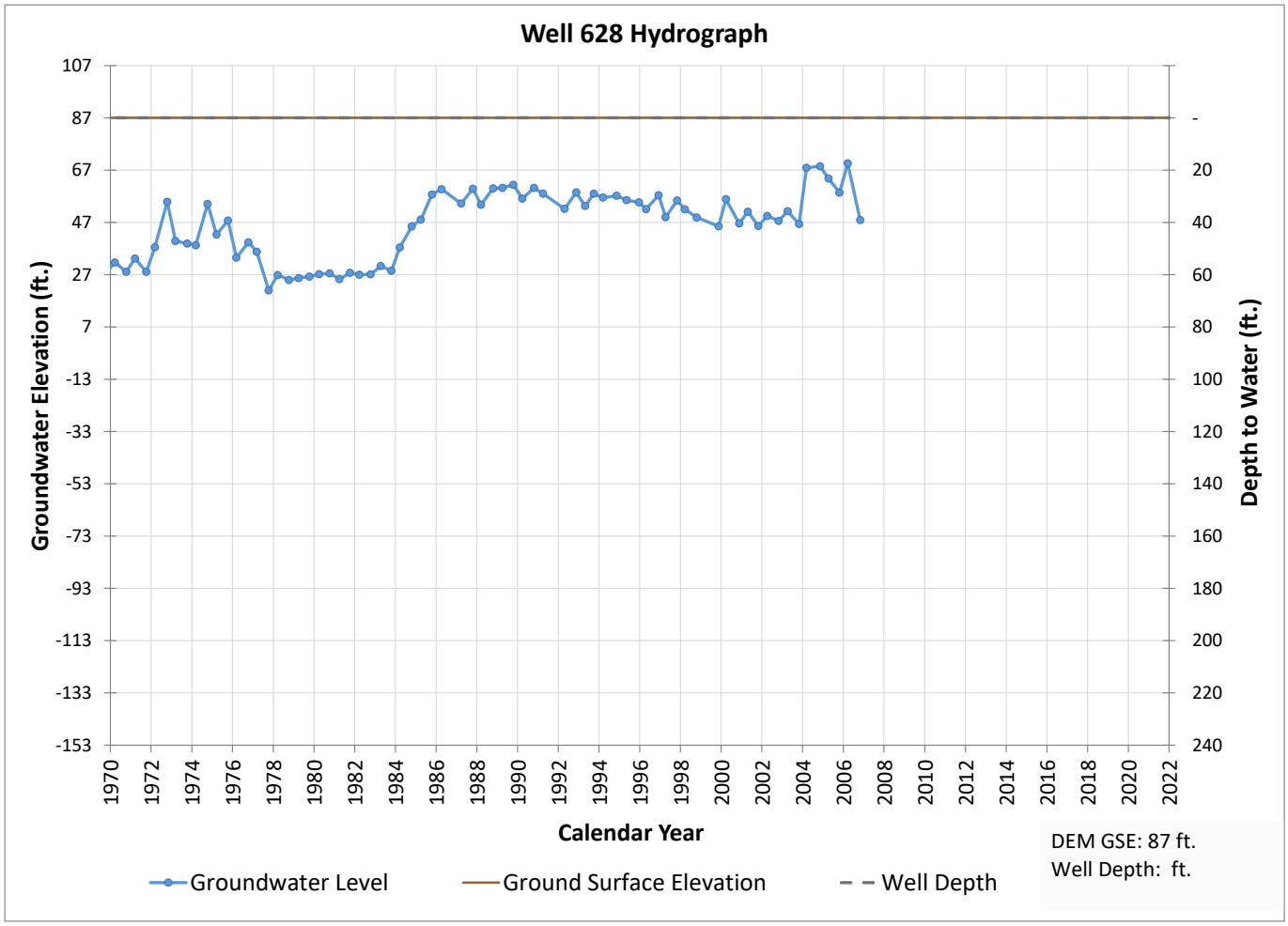

Well 602 Hydrograph
Groundwater Elevation (ft.)
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-189
-209
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 31 ft.
Well Depth: ft.

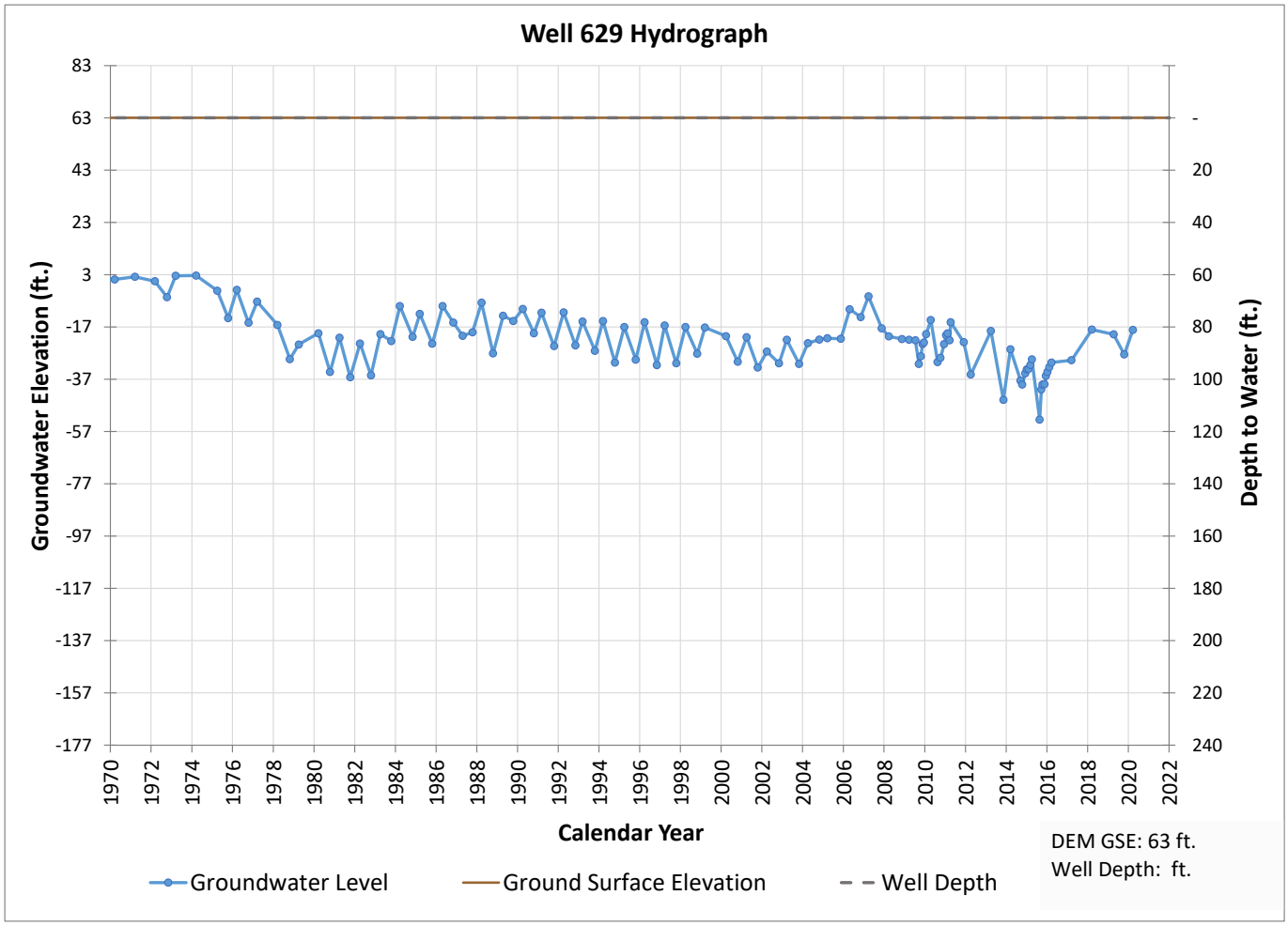

Well 607 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 129 ft.

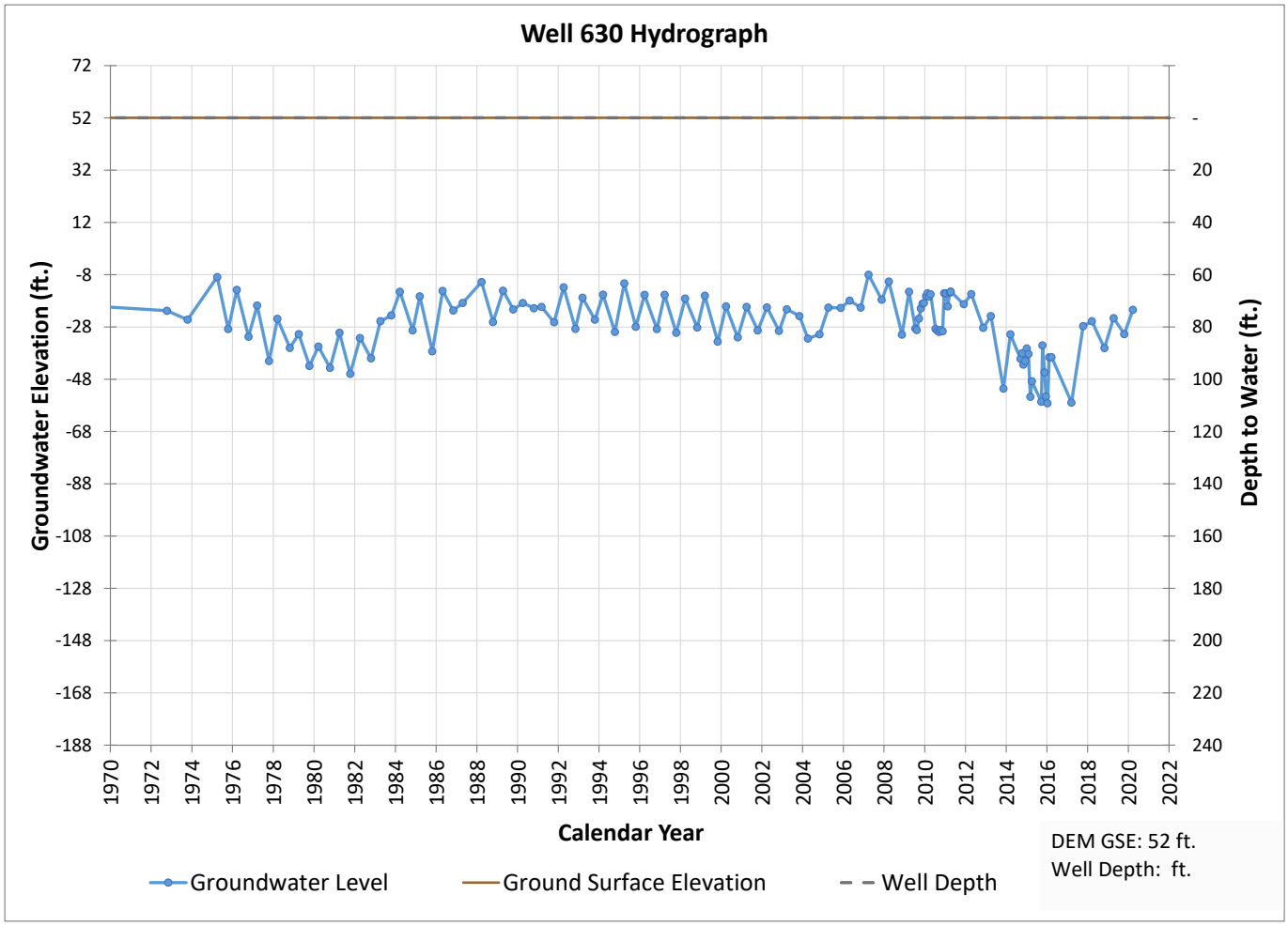

Well 611 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 88 ft.
Well Depth: 195 ft.

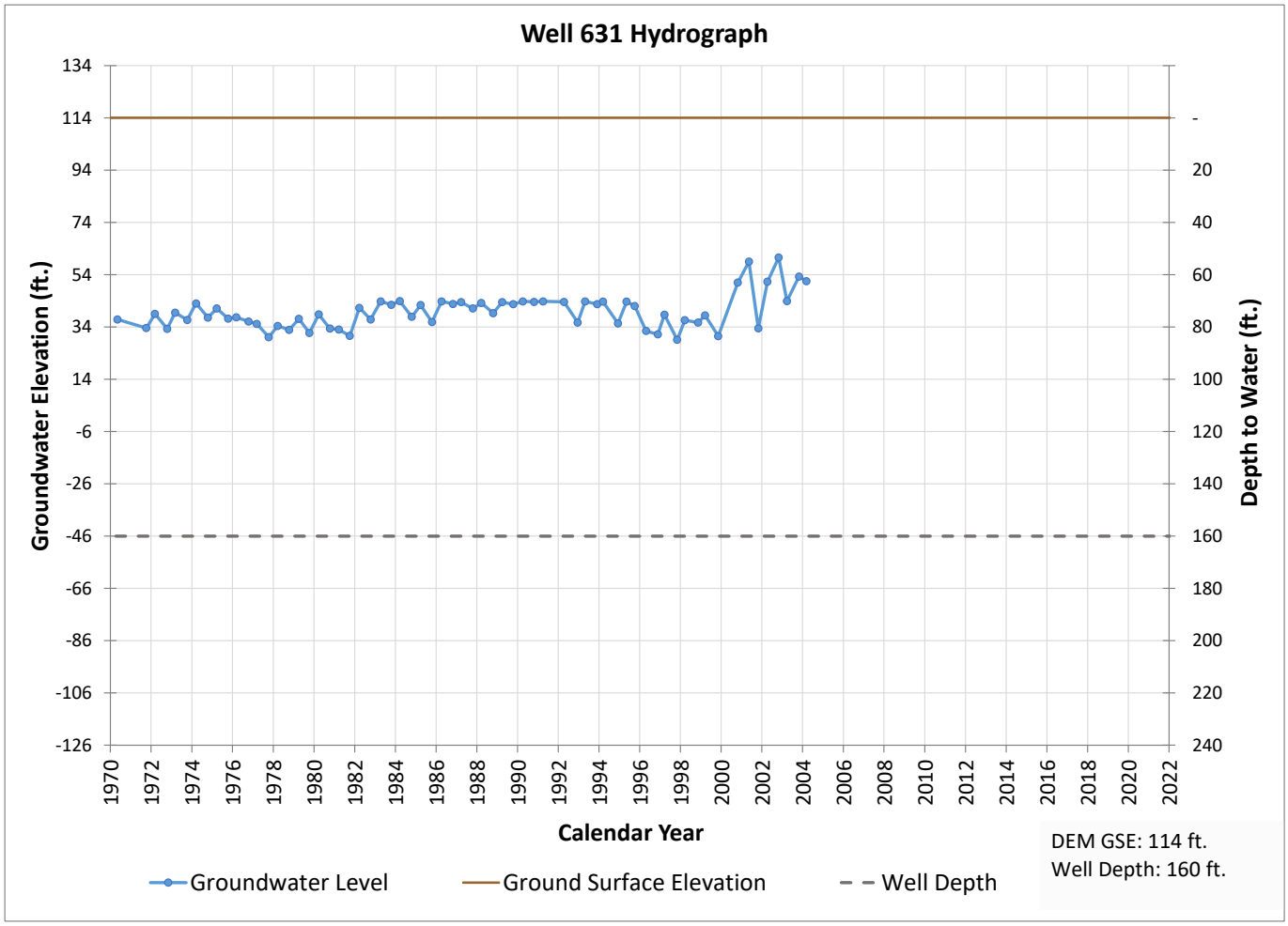

Well 612 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 65 ft.
Well Depth: 286 ft.

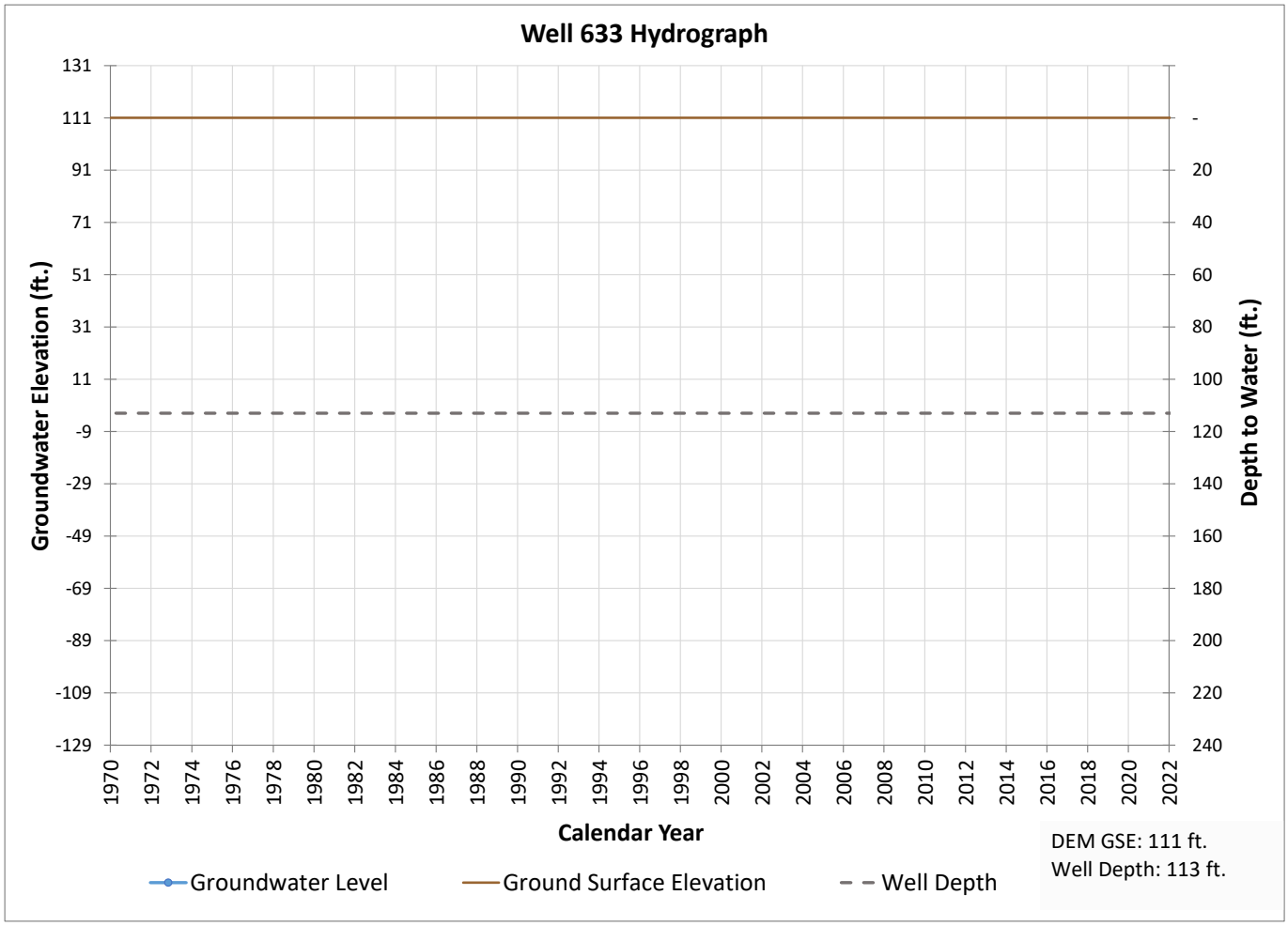

Well 625 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
55
35
15
-5
-25
-45
-65
-85
-105
-125
-145
-165
-185
-205
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 35 ft.
Well Depth: ft.

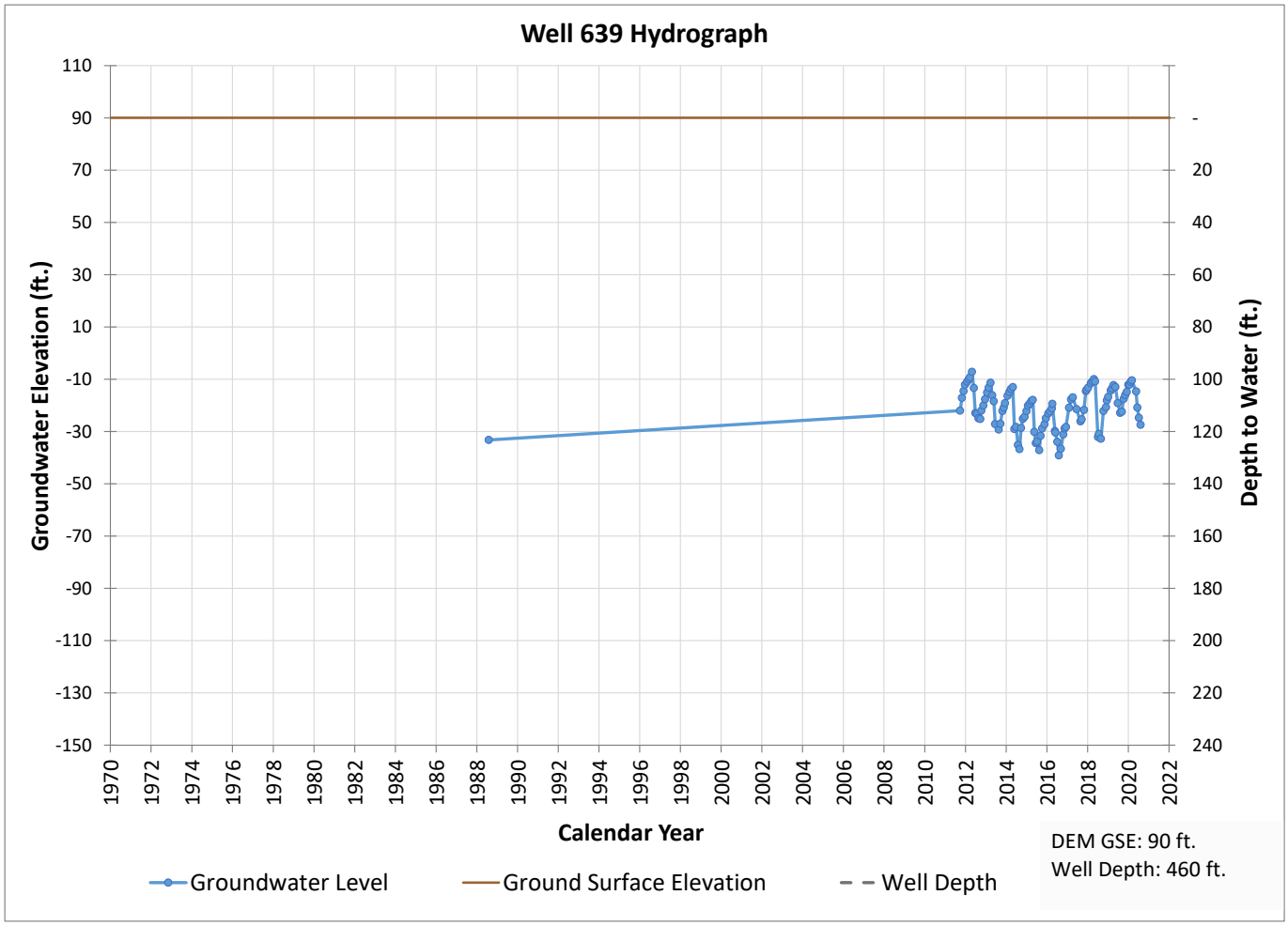

Well 628 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-133
-153
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 87 ft.
Well Depth: ft.

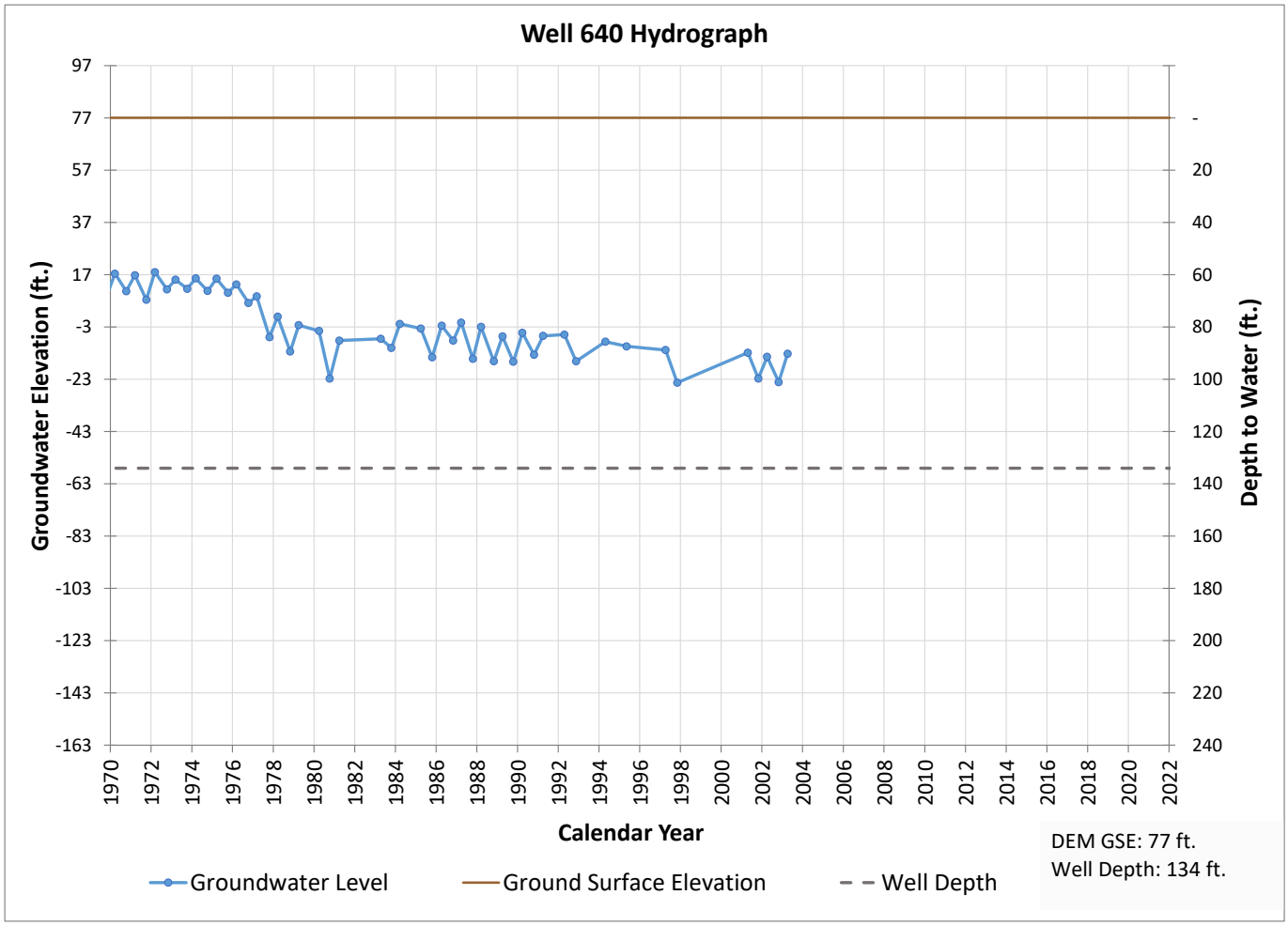

Well 629 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 63 ft.
Well Depth: ft.

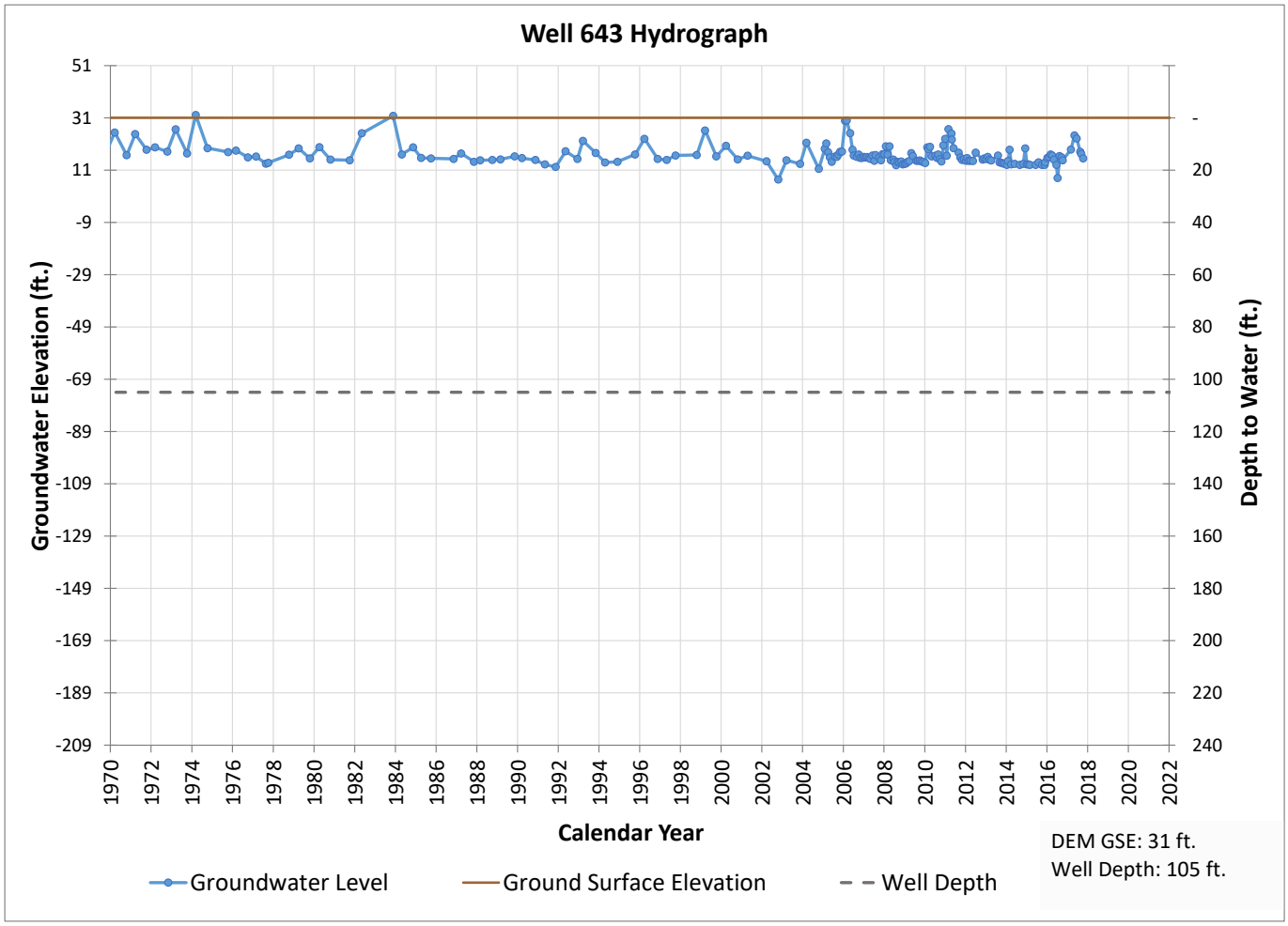

Well 630 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: ft.

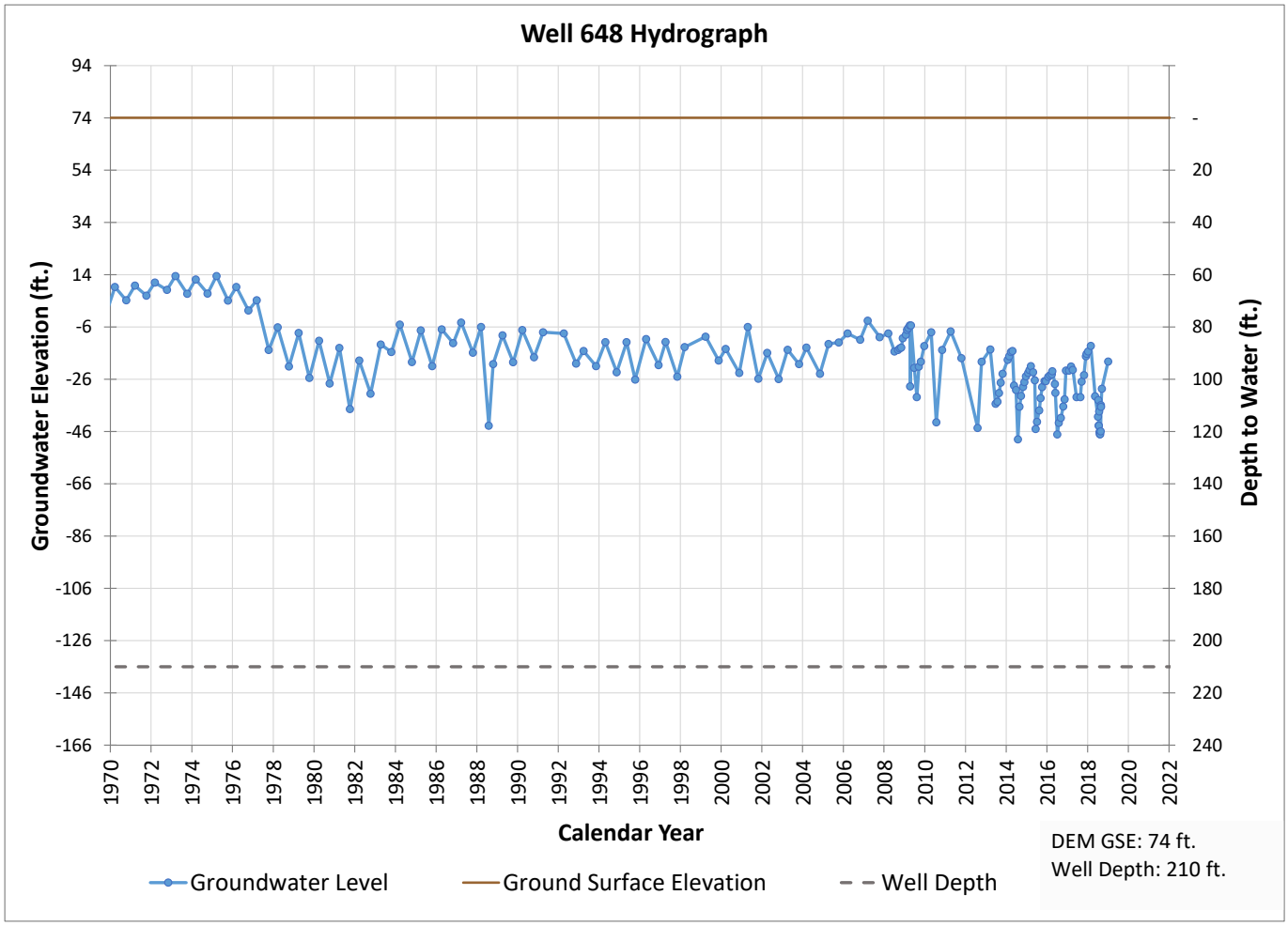

Well 631 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
134
114
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 114 ft.
Well Depth: 160 ft.

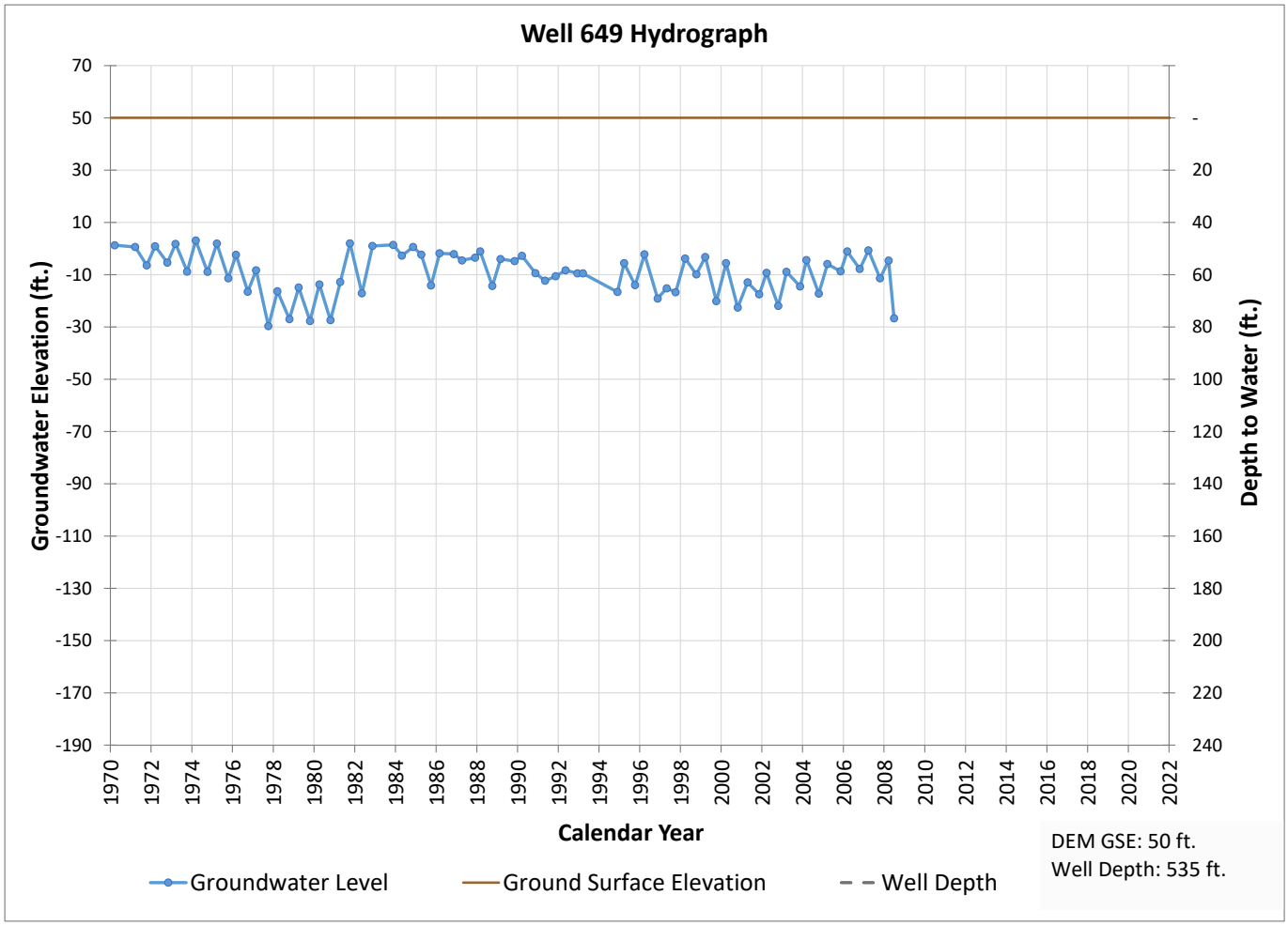

Well 633 Hydrograph
Groundwater Elevation (ft.)
131
111
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-129
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 111 ft.
Well Depth: 113 ft.

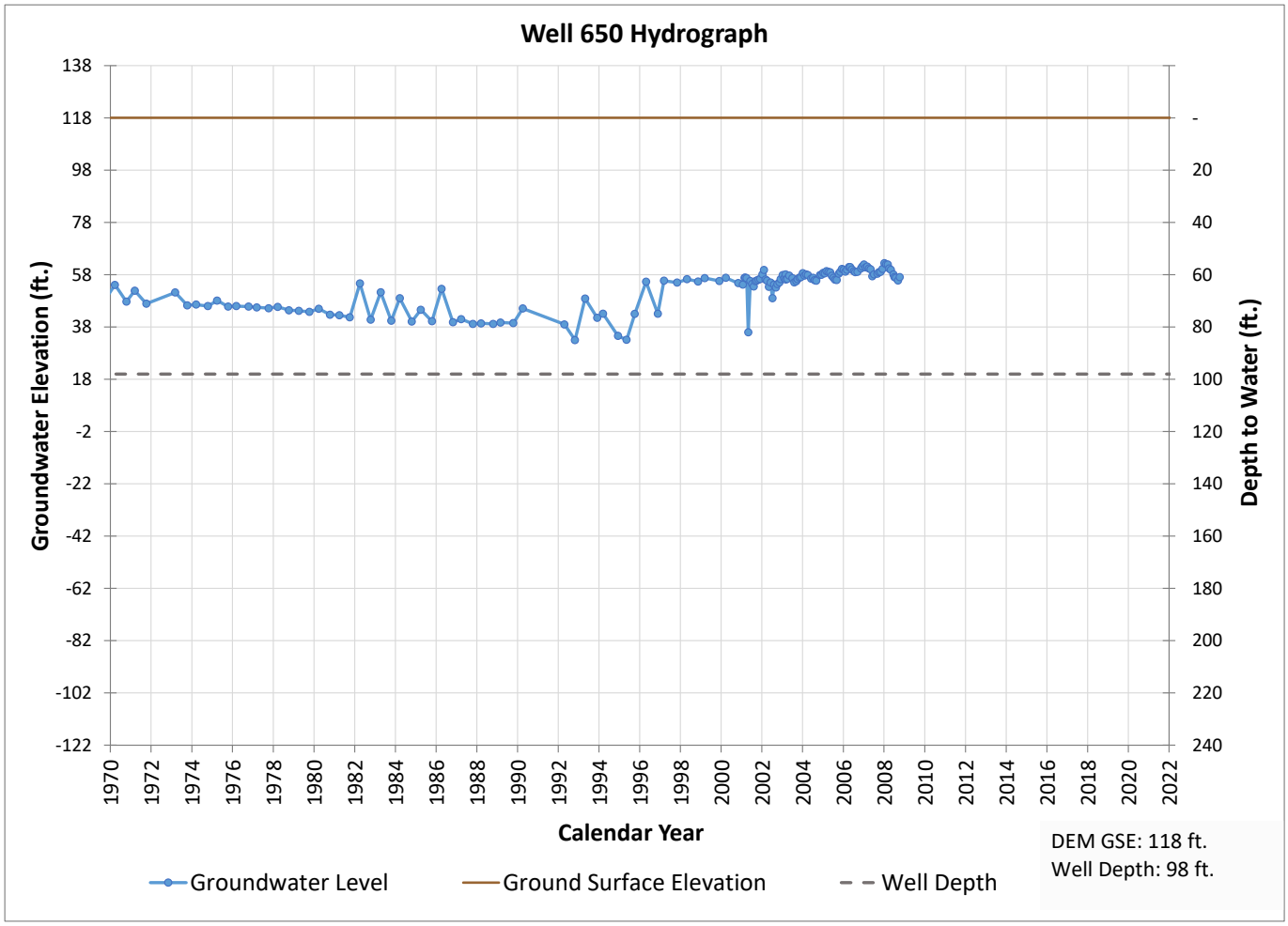

Well 639 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
110
90
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 90 ft.
Well Depth: 460 ft.

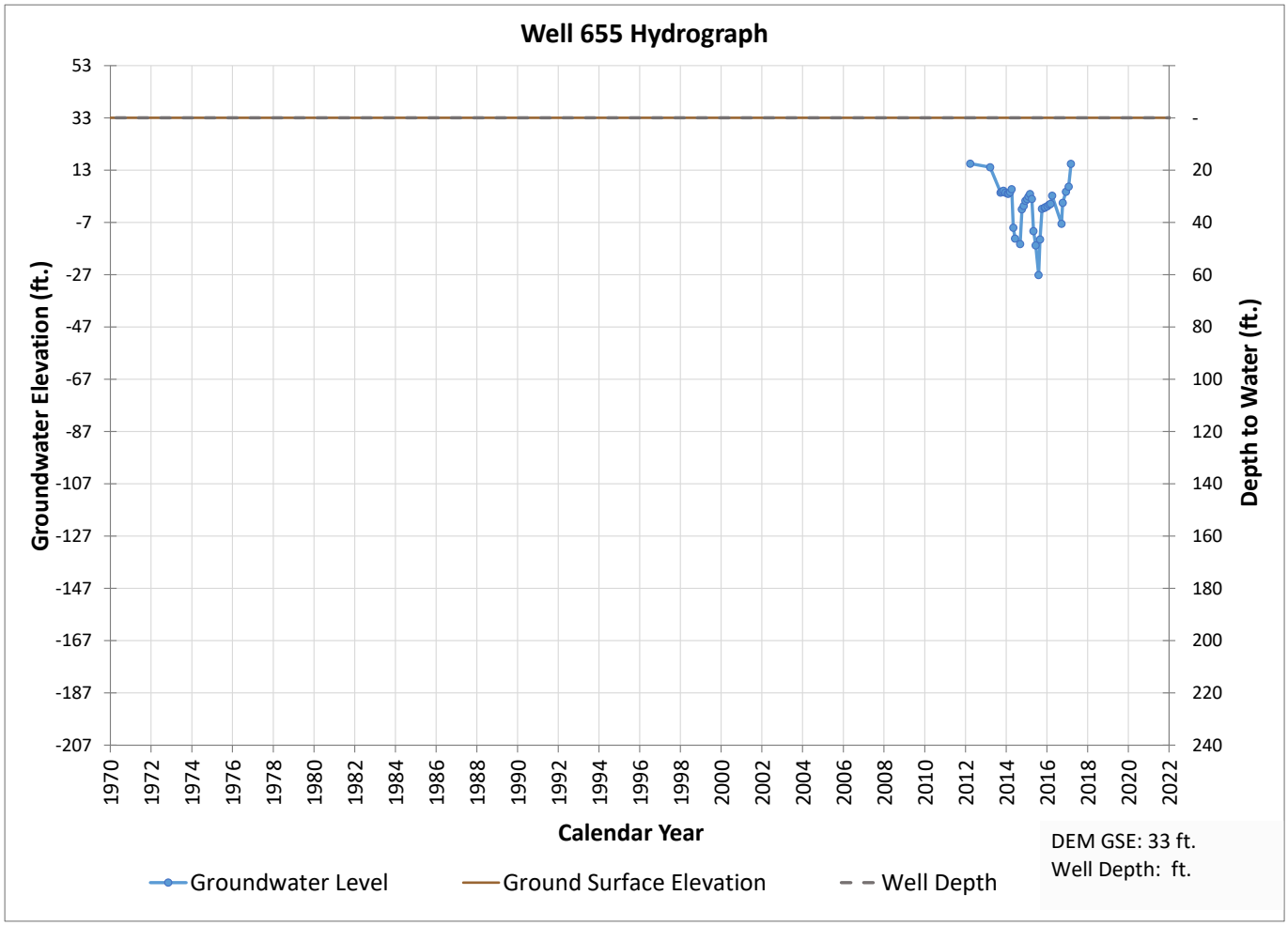

Well 640 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
97
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 77 ft.
Well Depth: 134 ft.

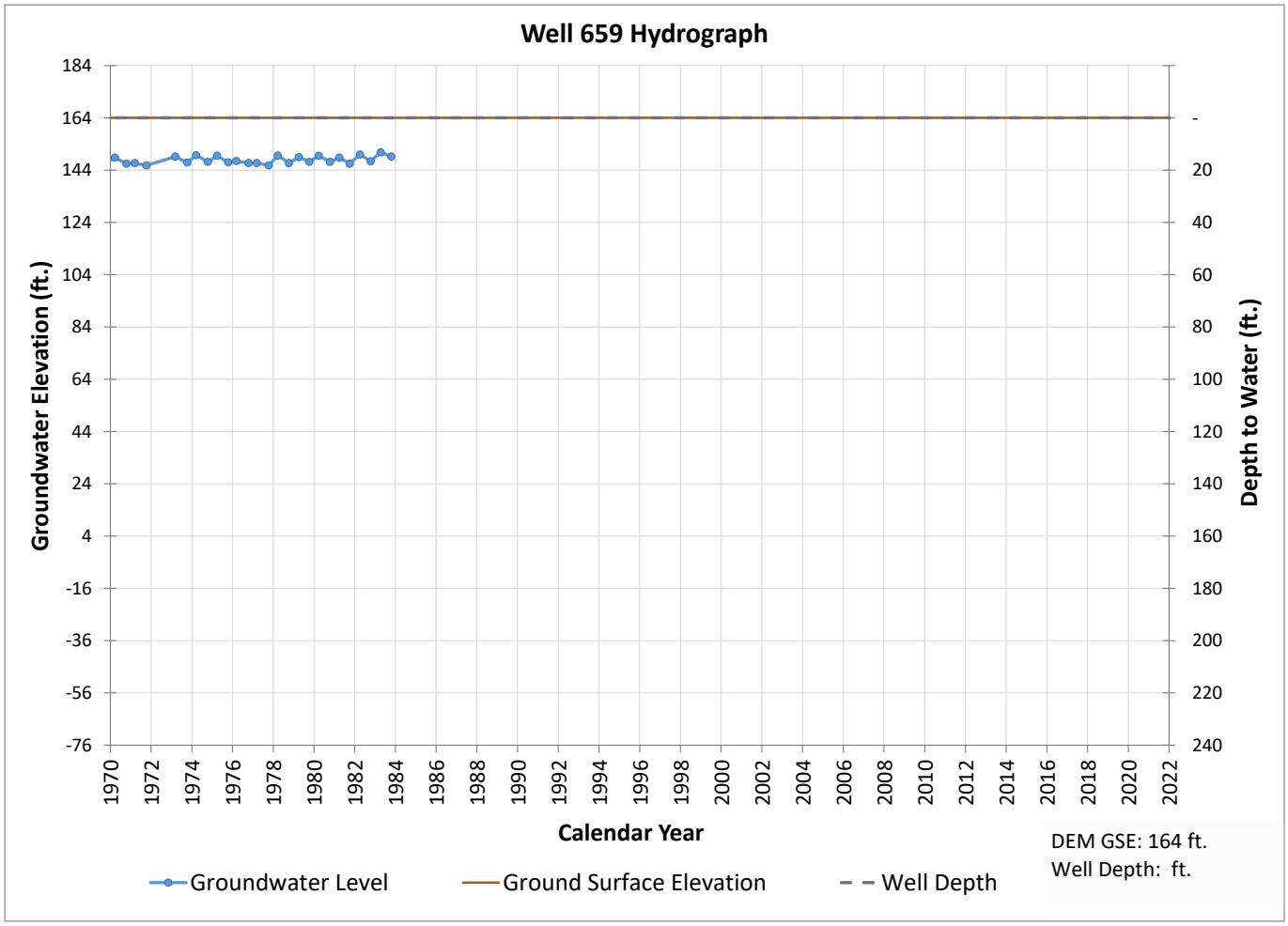

Well 643 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-189
-209
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 31 ft.
Well Depth: 105 ft.

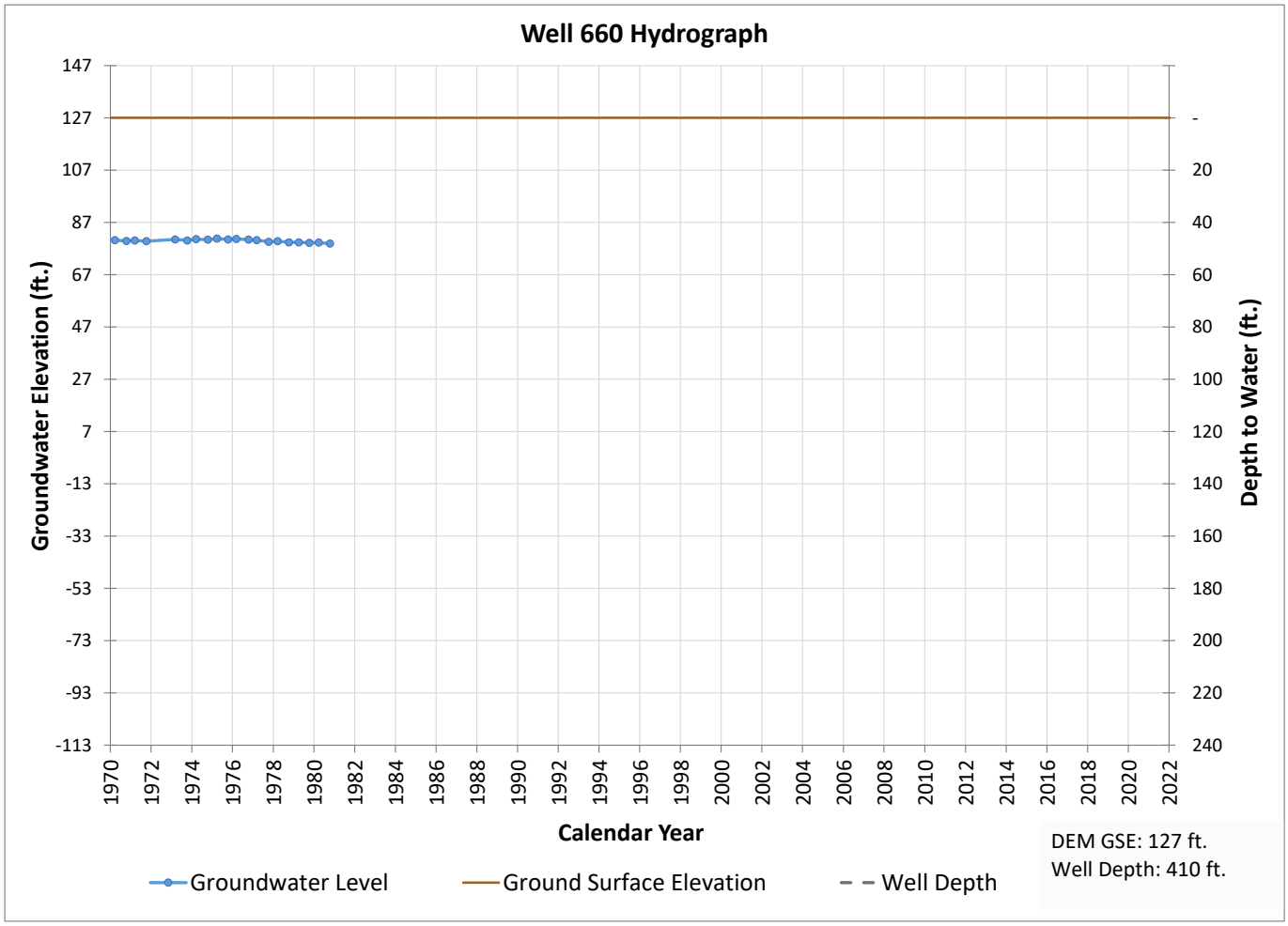

Well 648 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
94
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 74 ft.
Well Depth: 210 ft.

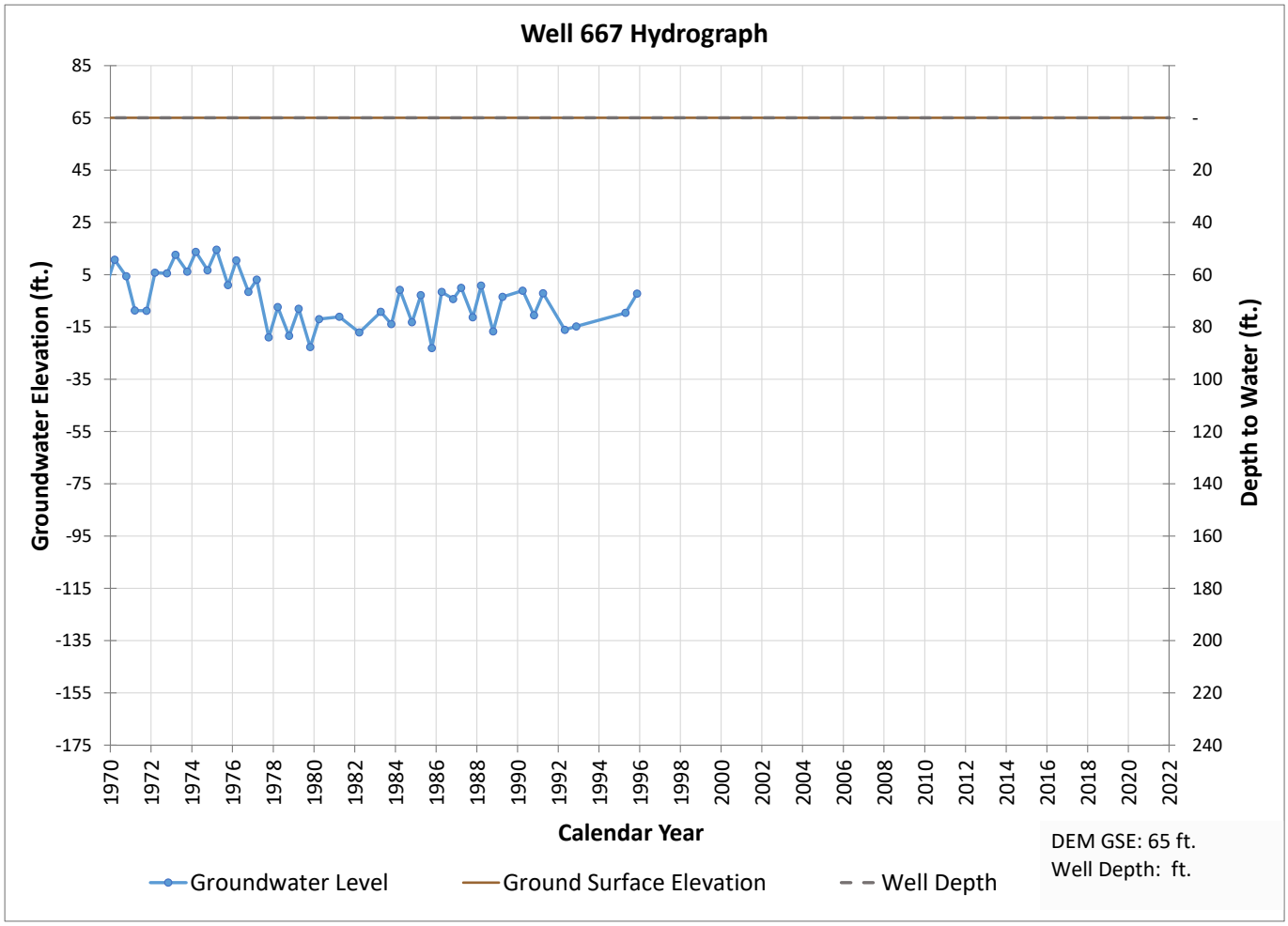

Well 649 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: 535 ft.

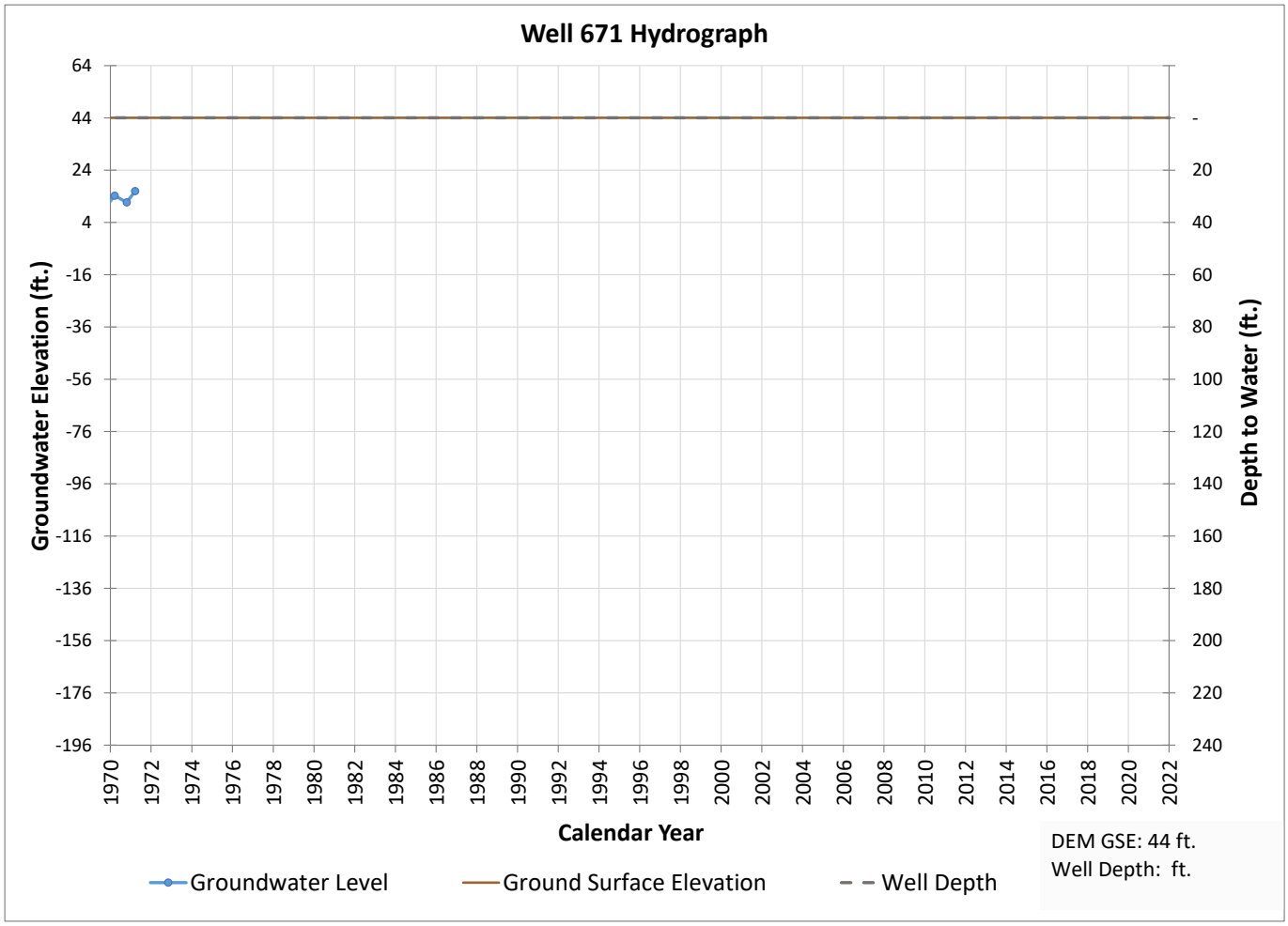

Well 650 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
138
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 118 ft.
Well Depth: 98 ft.

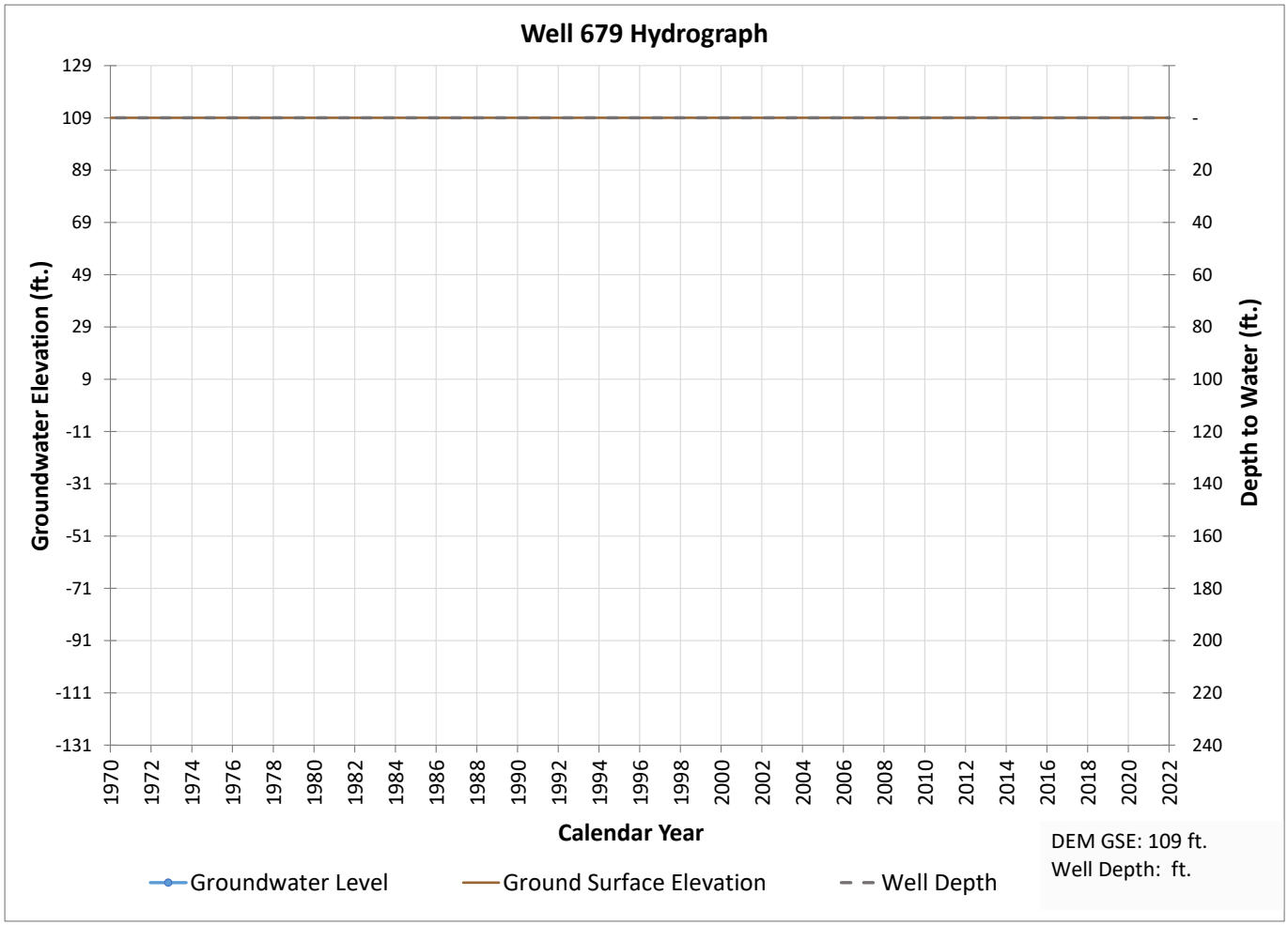

Well 655 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
-207
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 33 ft.
Well Depth: ft.

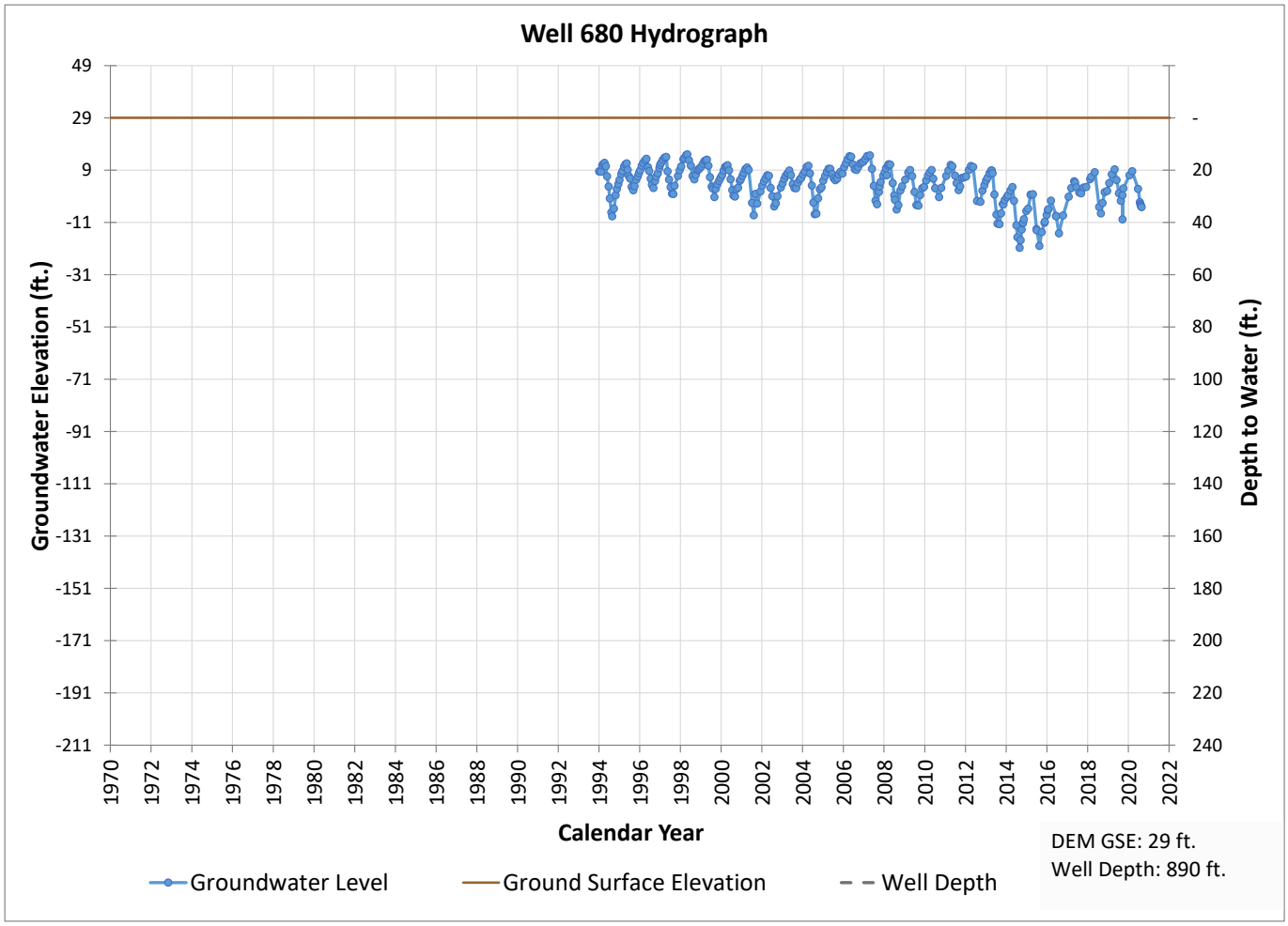

Well 659 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
184
164
144
124
104
84
64
44
24
4
-16
-36
-56
-76
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 164 ft.
Well Depth: ft.

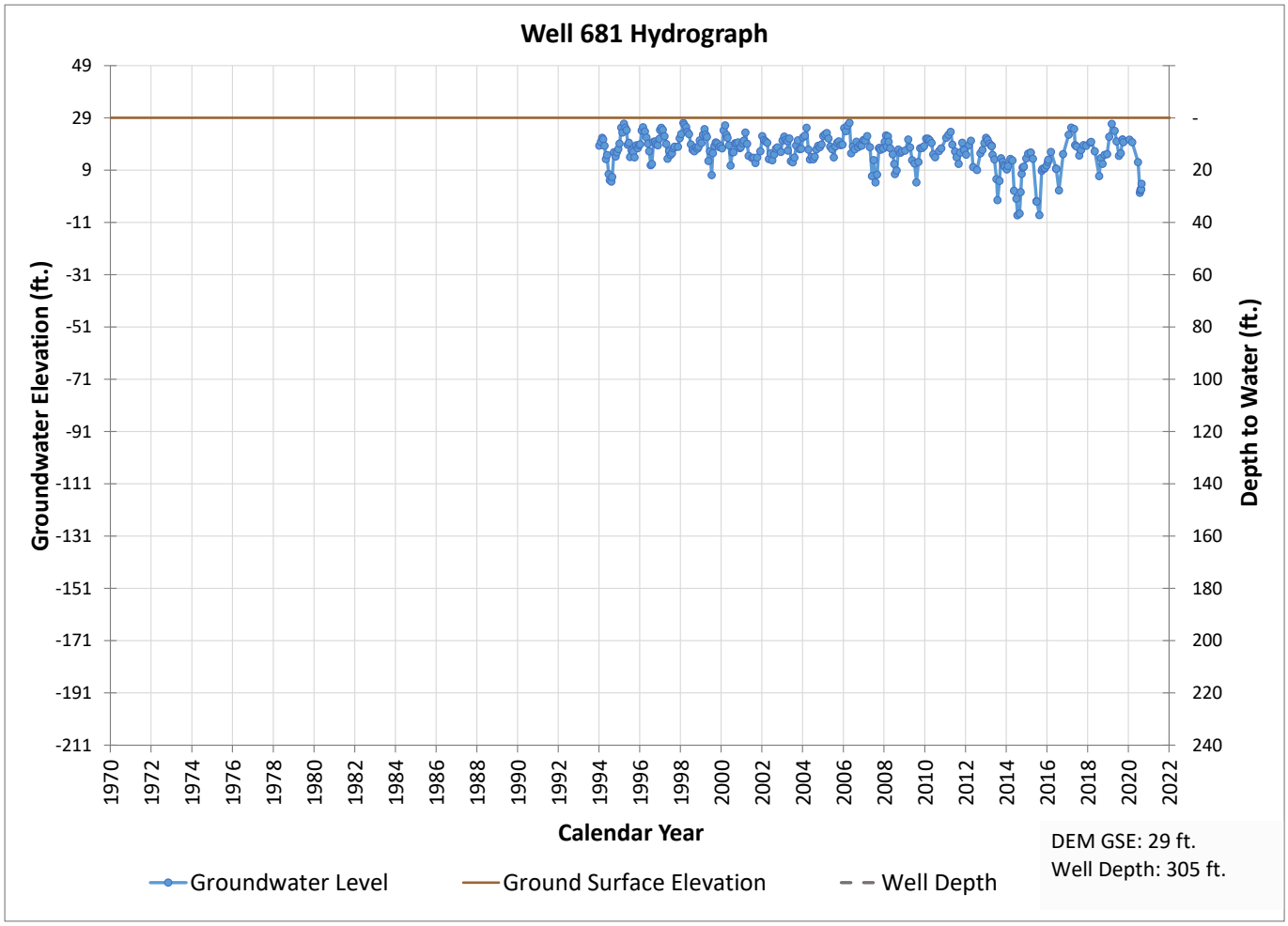

Well 660 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
147
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 127 ft.
Well Depth: 410 ft.

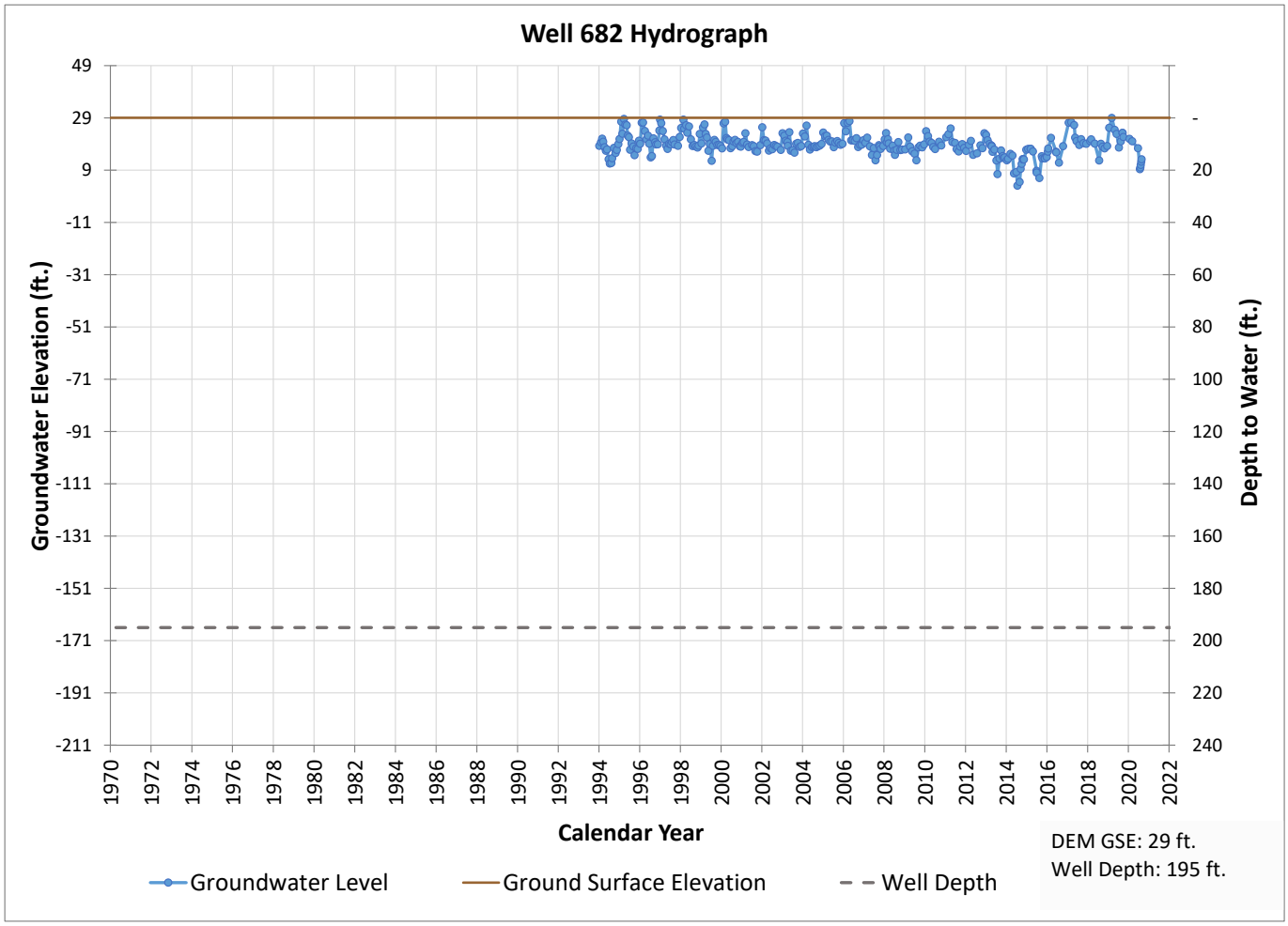

Well 667 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
85
65
45
25
5
-15
-35
-55
-75
-95
-115
-135
-155
-175
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 65 ft.
Well Depth: ft.

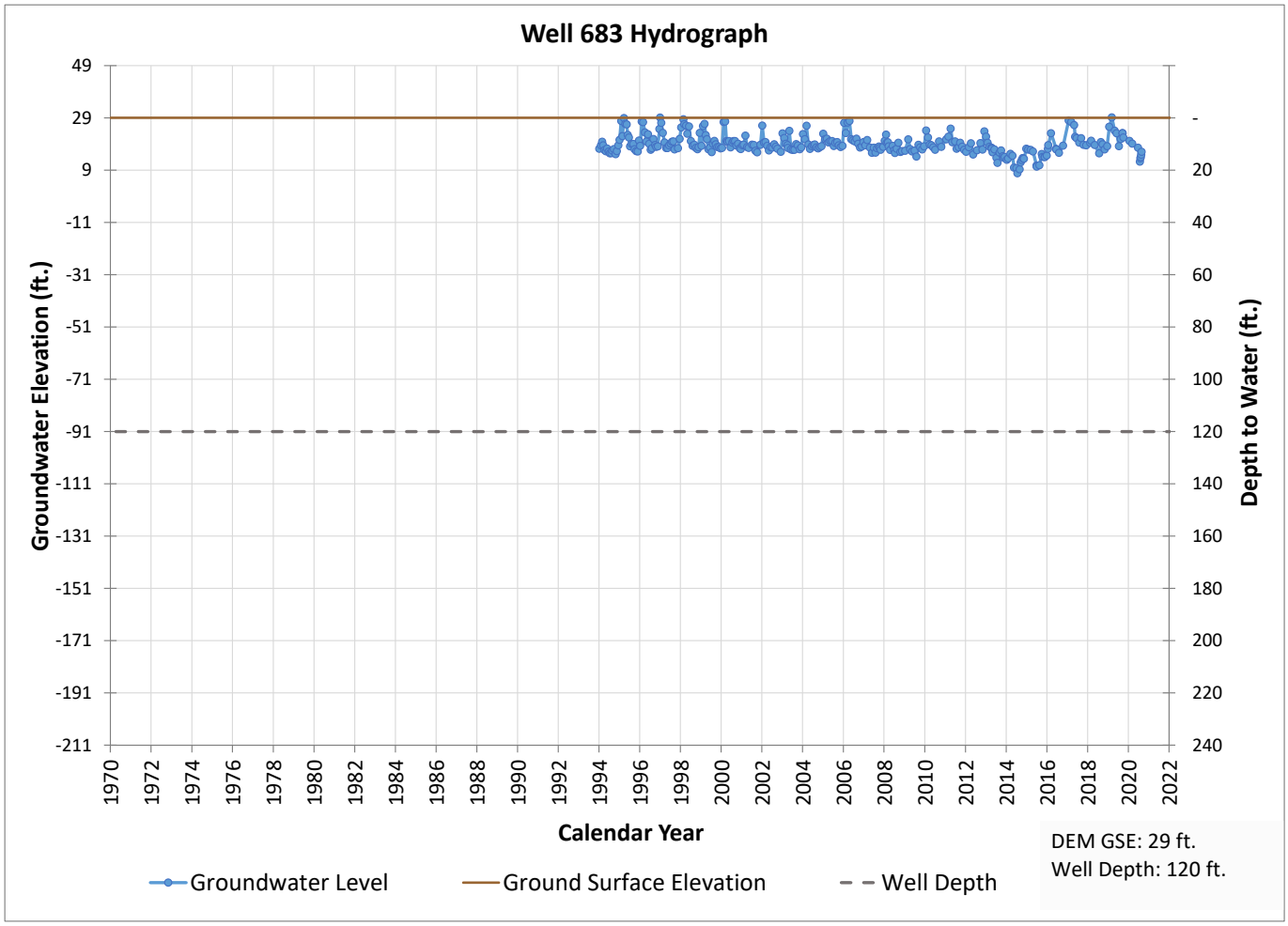

Well 671 Hydrograph
Groundwater Elevation (ft.)
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 44 ft.
Well Depth: ft.

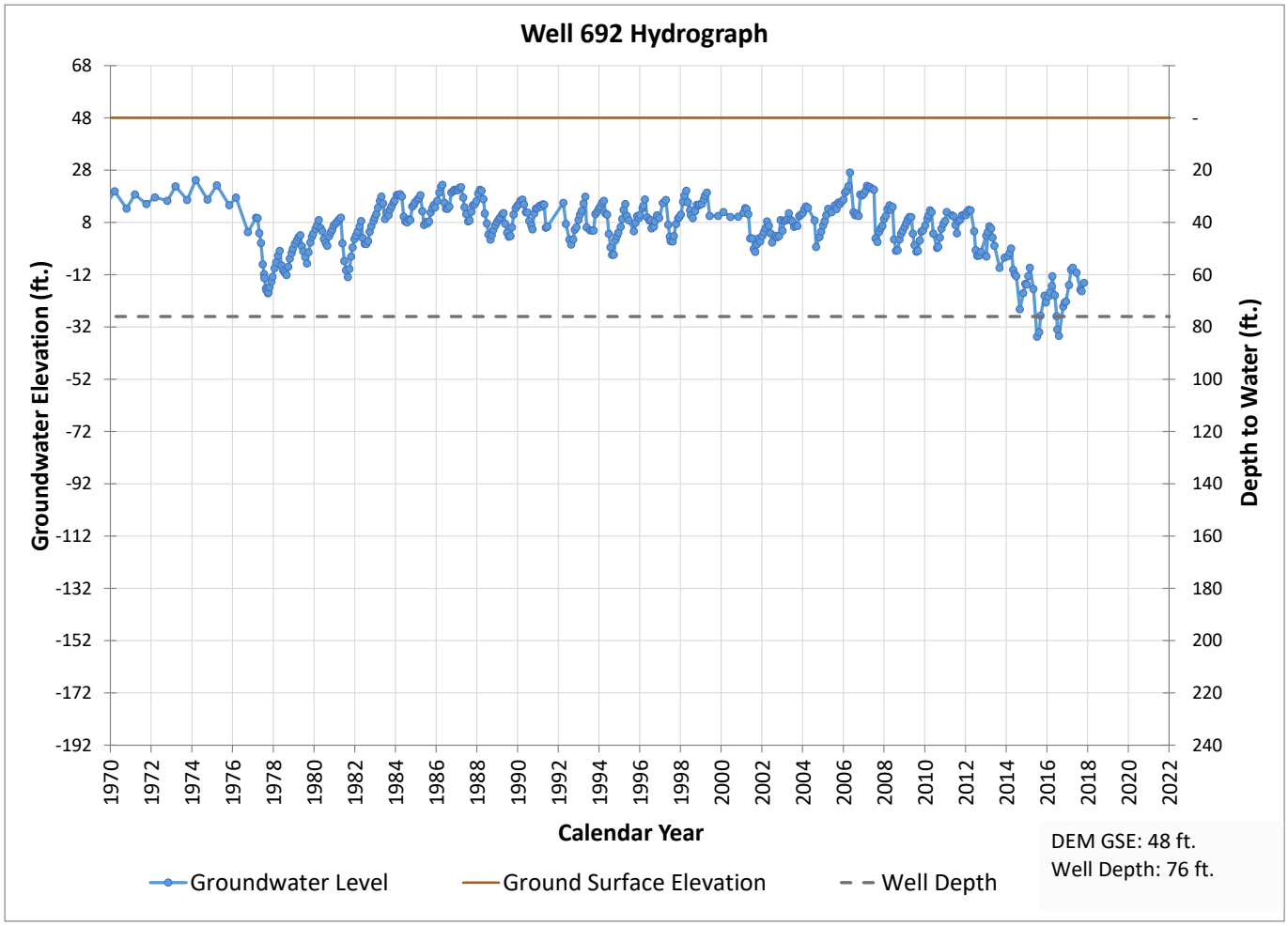

Well 679 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
129
109
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 109 ft.
Well Depth: ft.

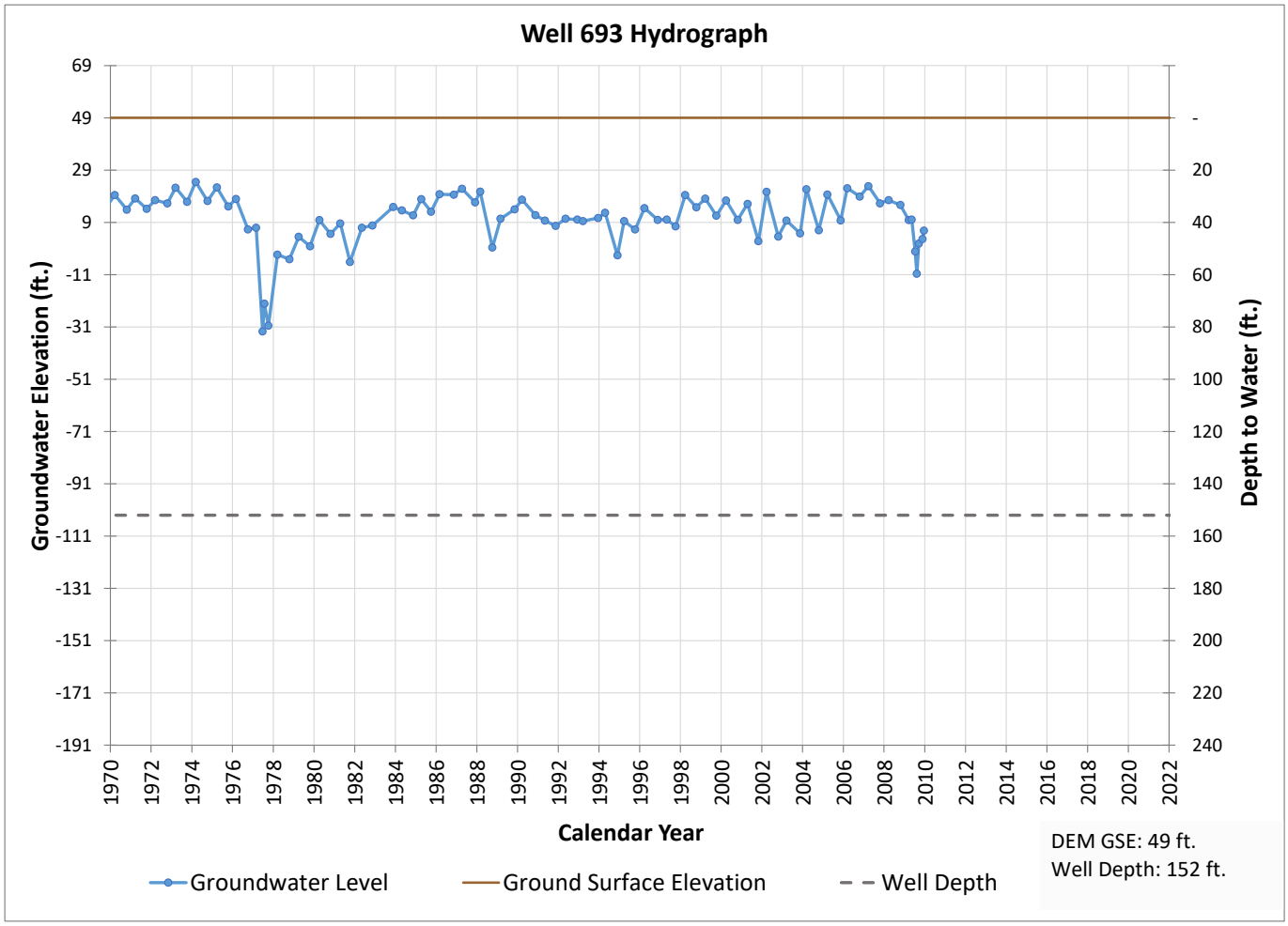

Well 680 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 890 ft.

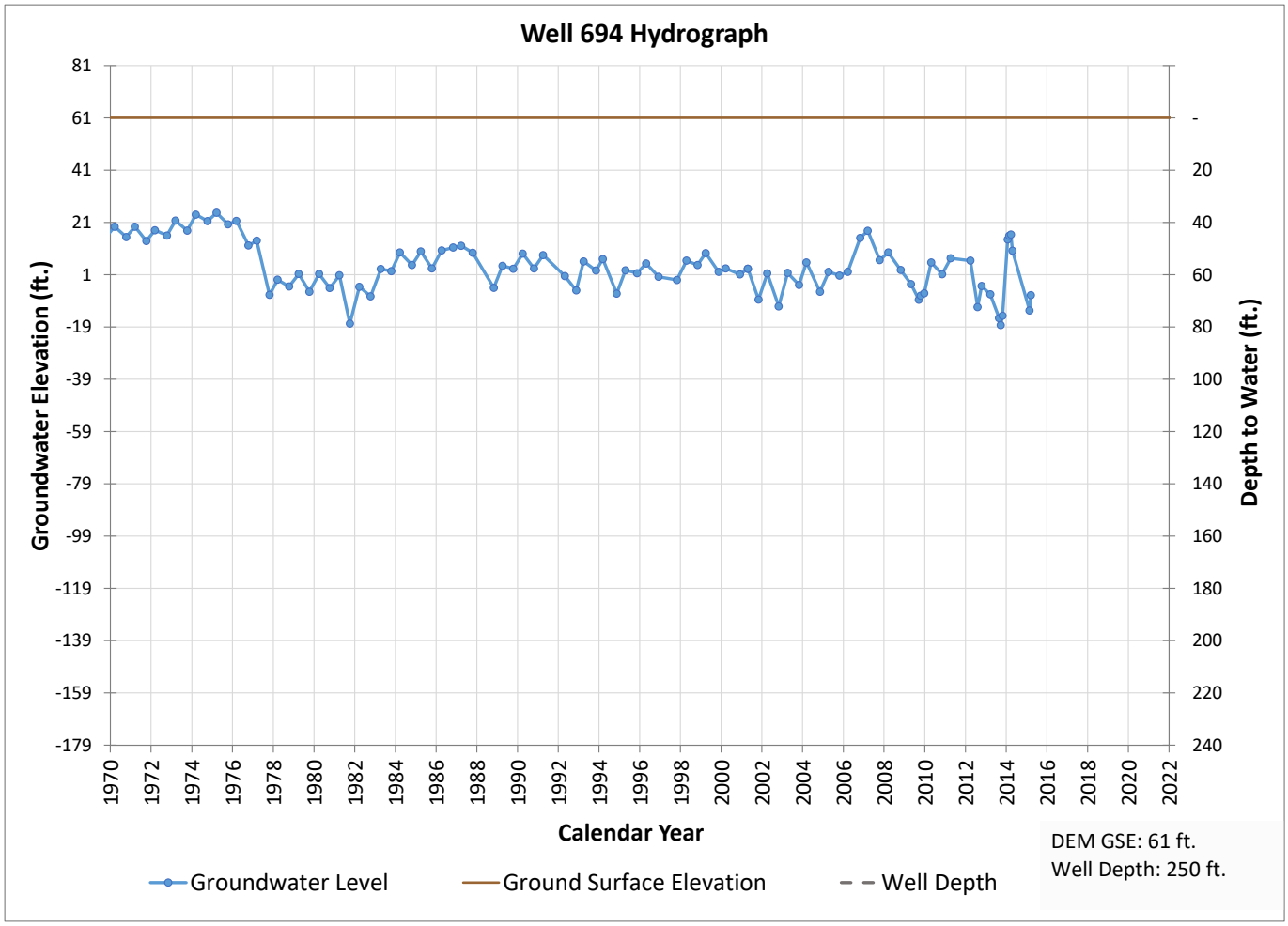

Well 681 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 305 ft.

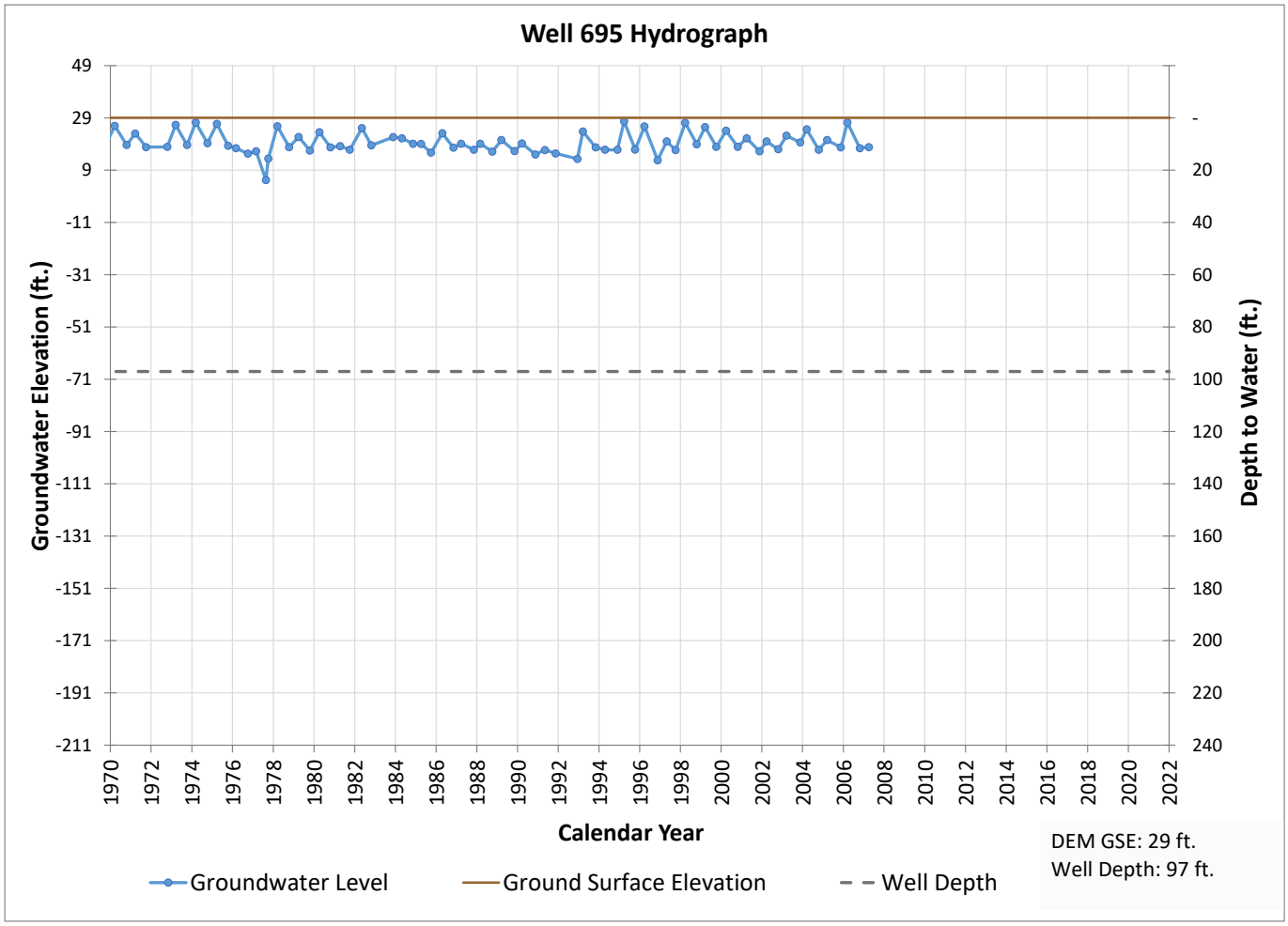

Well 682 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 195 ft.

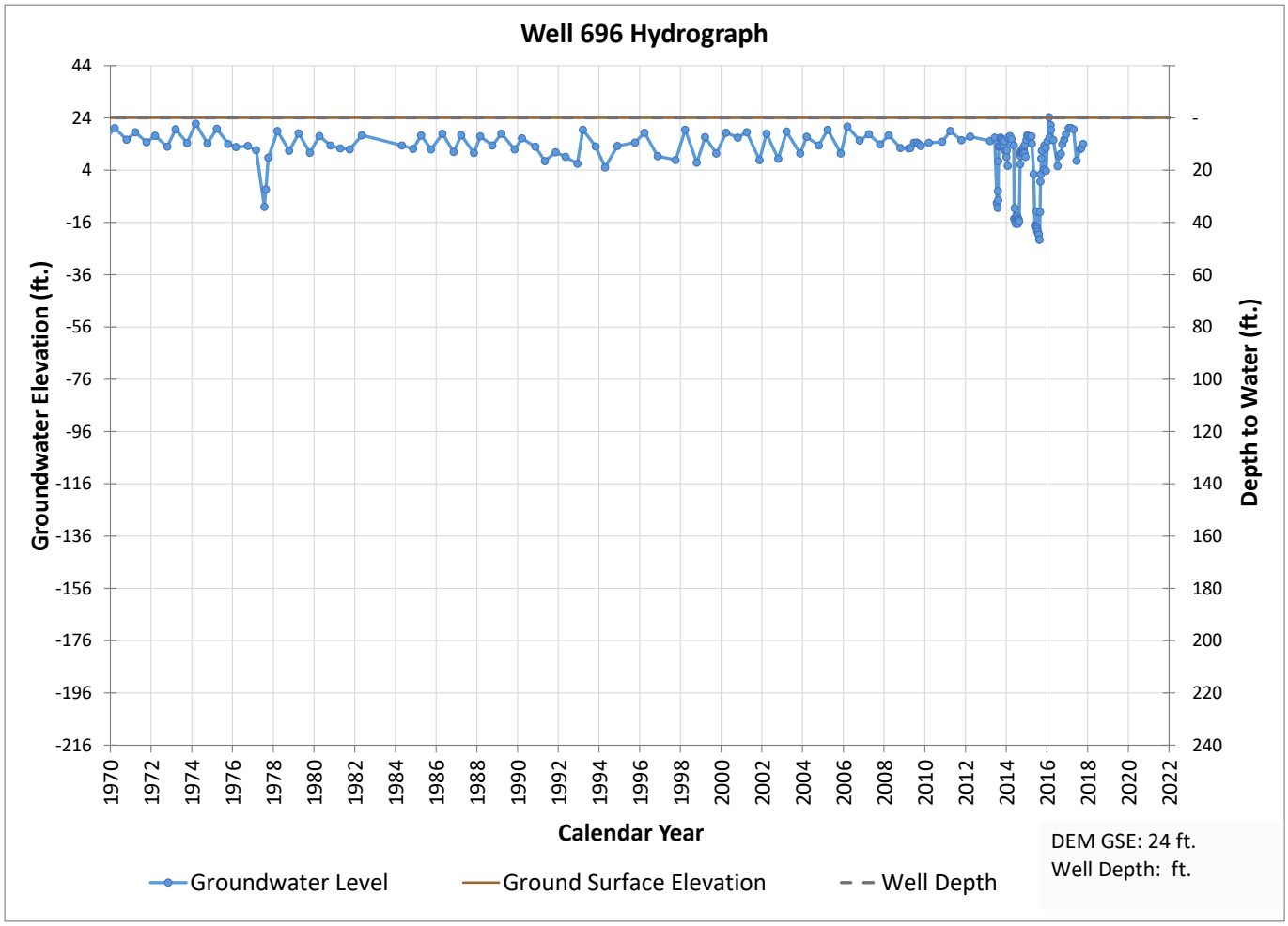

Well 683 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 120 ft.

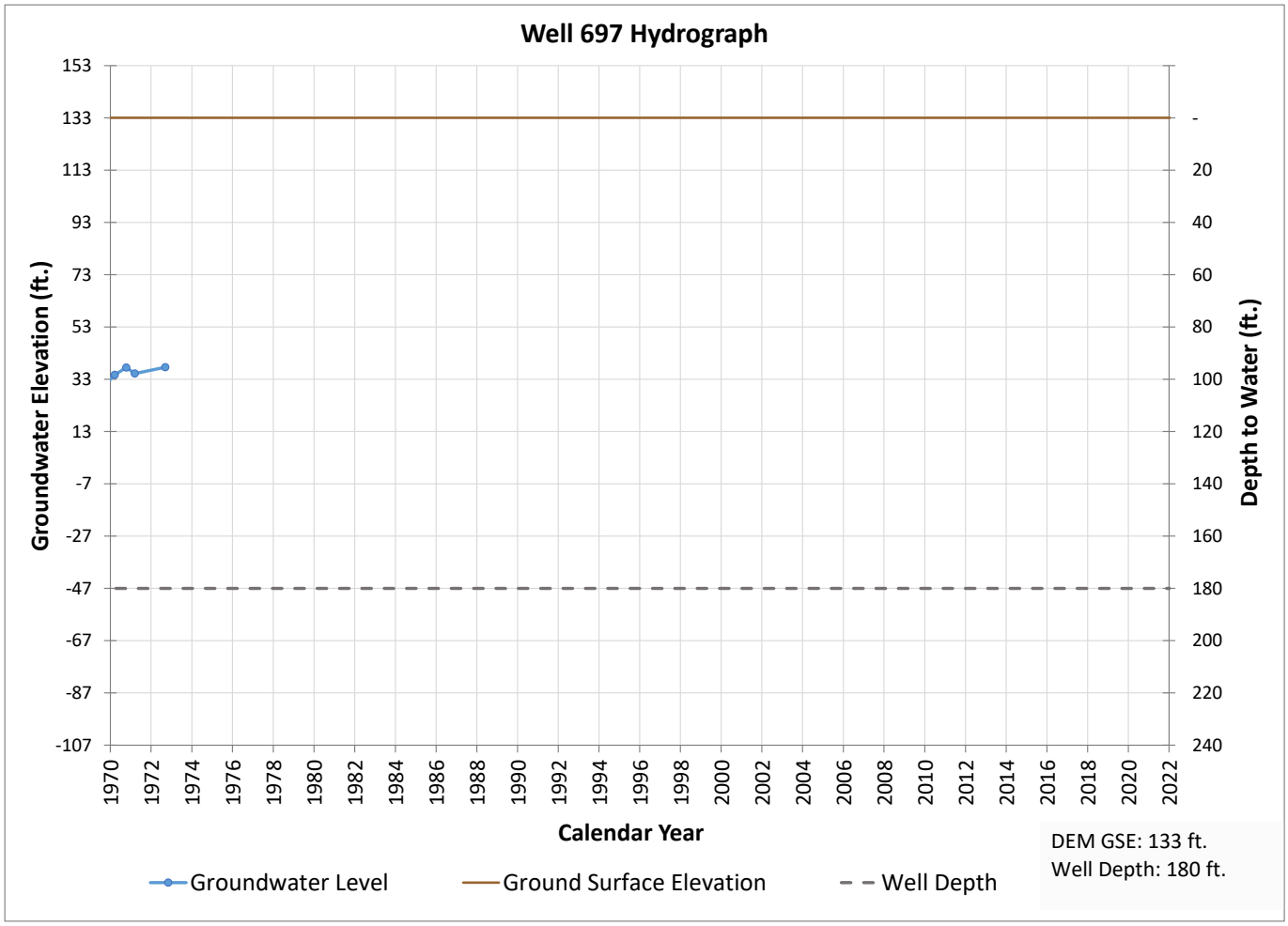

Well 692 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 48 ft.
Well Depth: 76 ft.

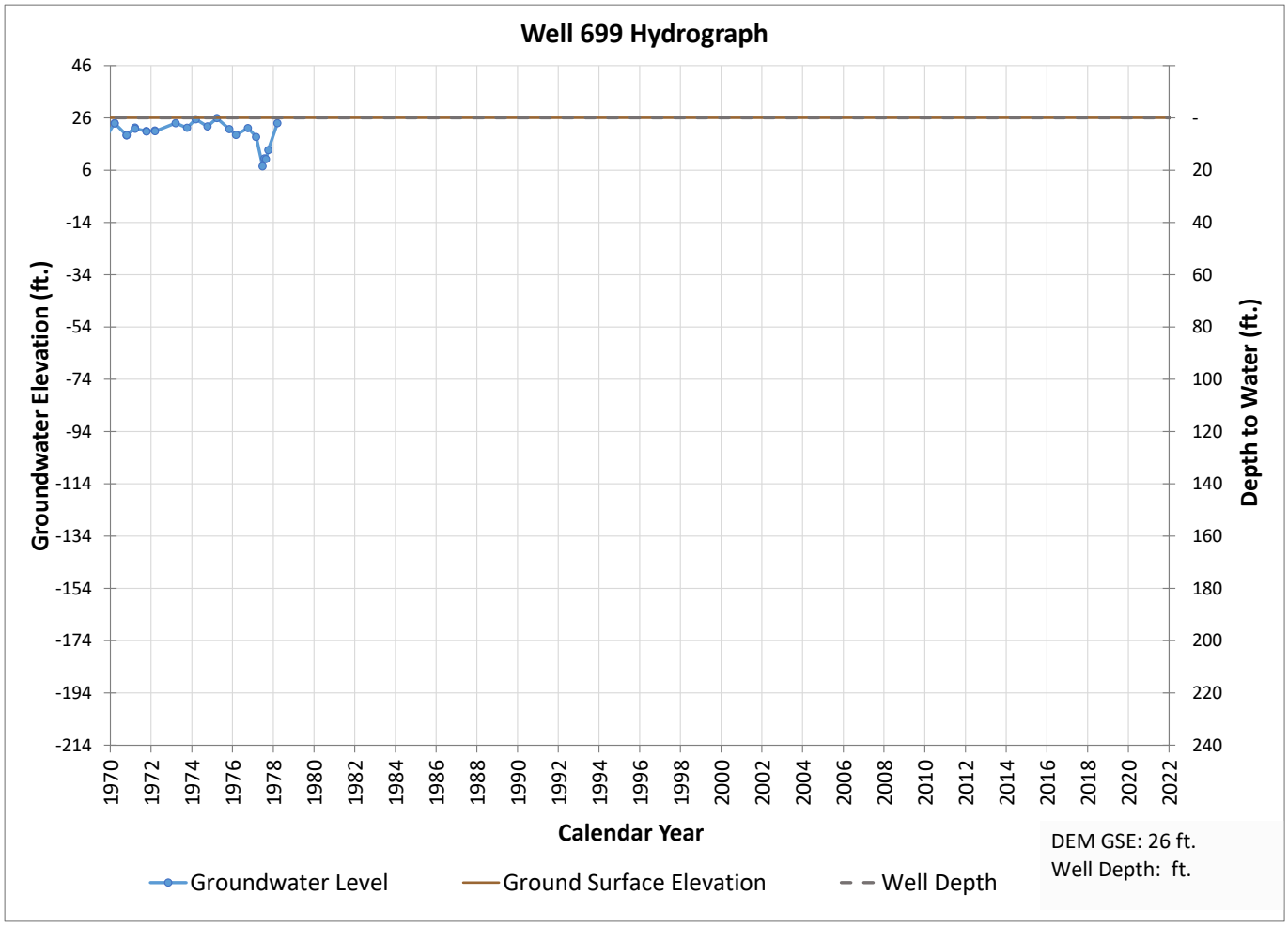

Well 693 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: 152 ft.

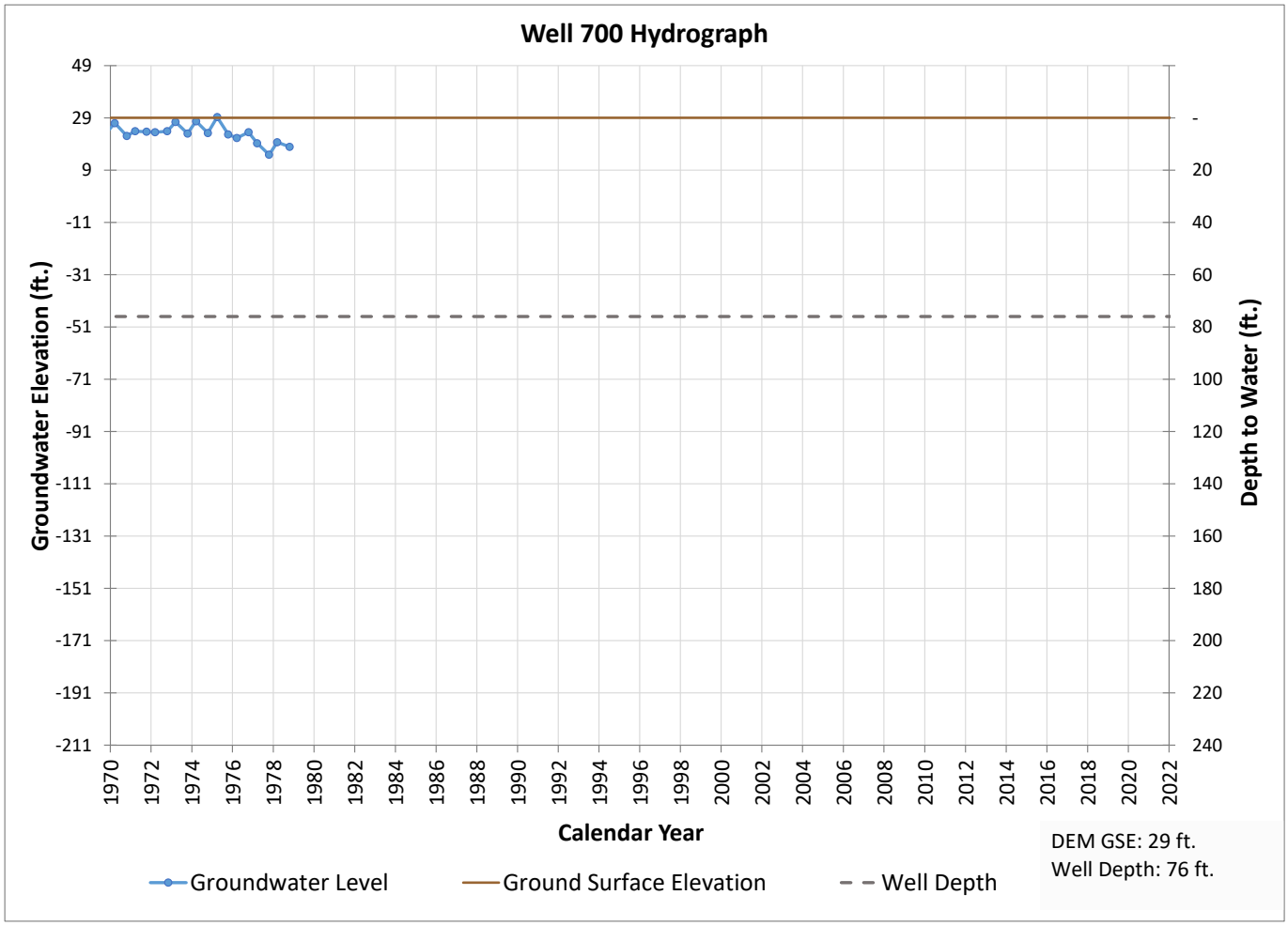

Well 694 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 61 ft.
Well Depth: 250 ft.

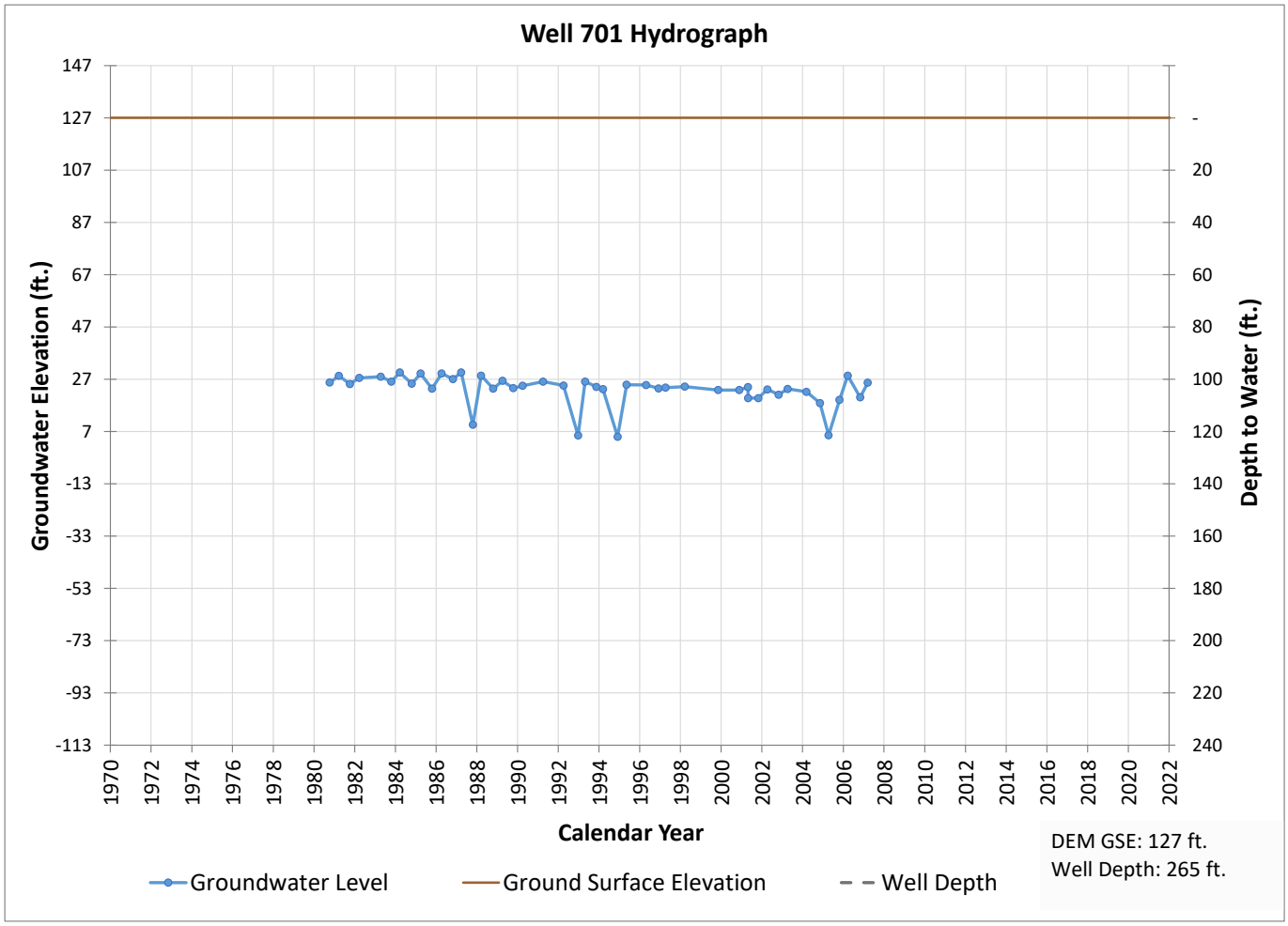

Well 695 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 97 ft.

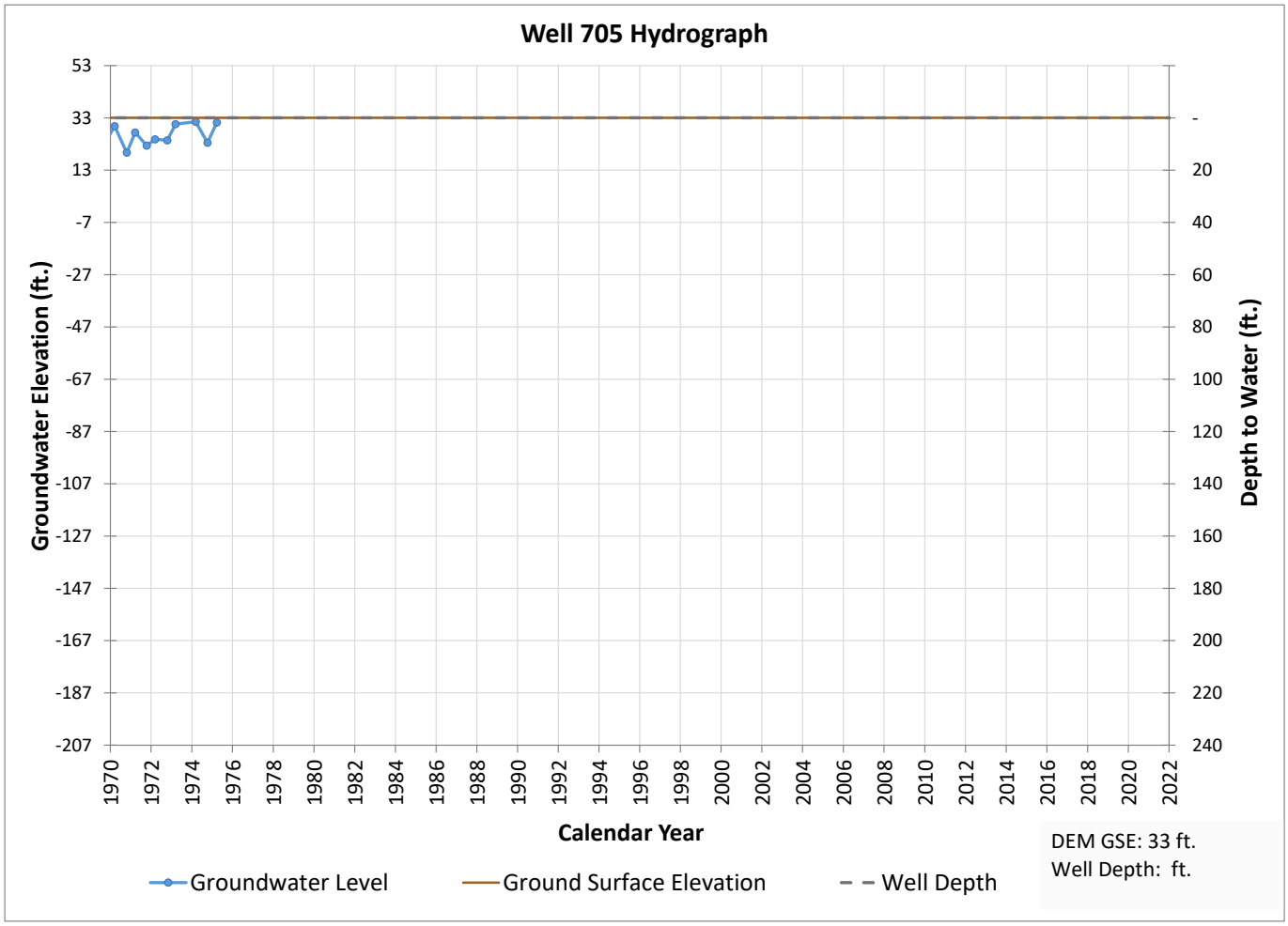

Well 696 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-196
-216
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 24 ft.
Well Depth: ft.

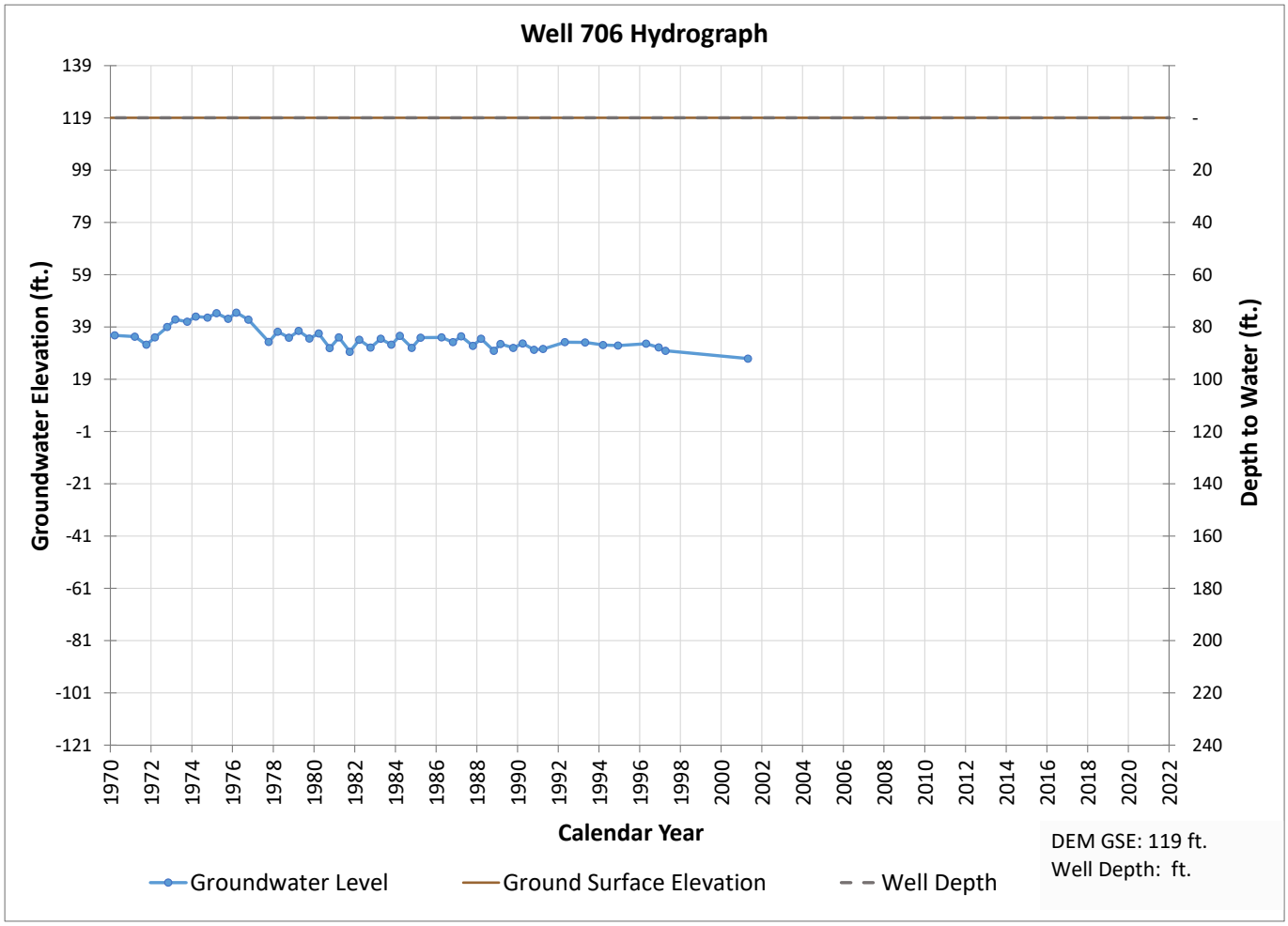

Well 697 Hydrograph
Groundwater Elevation (ft.)
153
133
113
93
73
53
33
13
-7
-27
-47
-67
-87
-107
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 133 ft.
Well Depth: 180 ft.

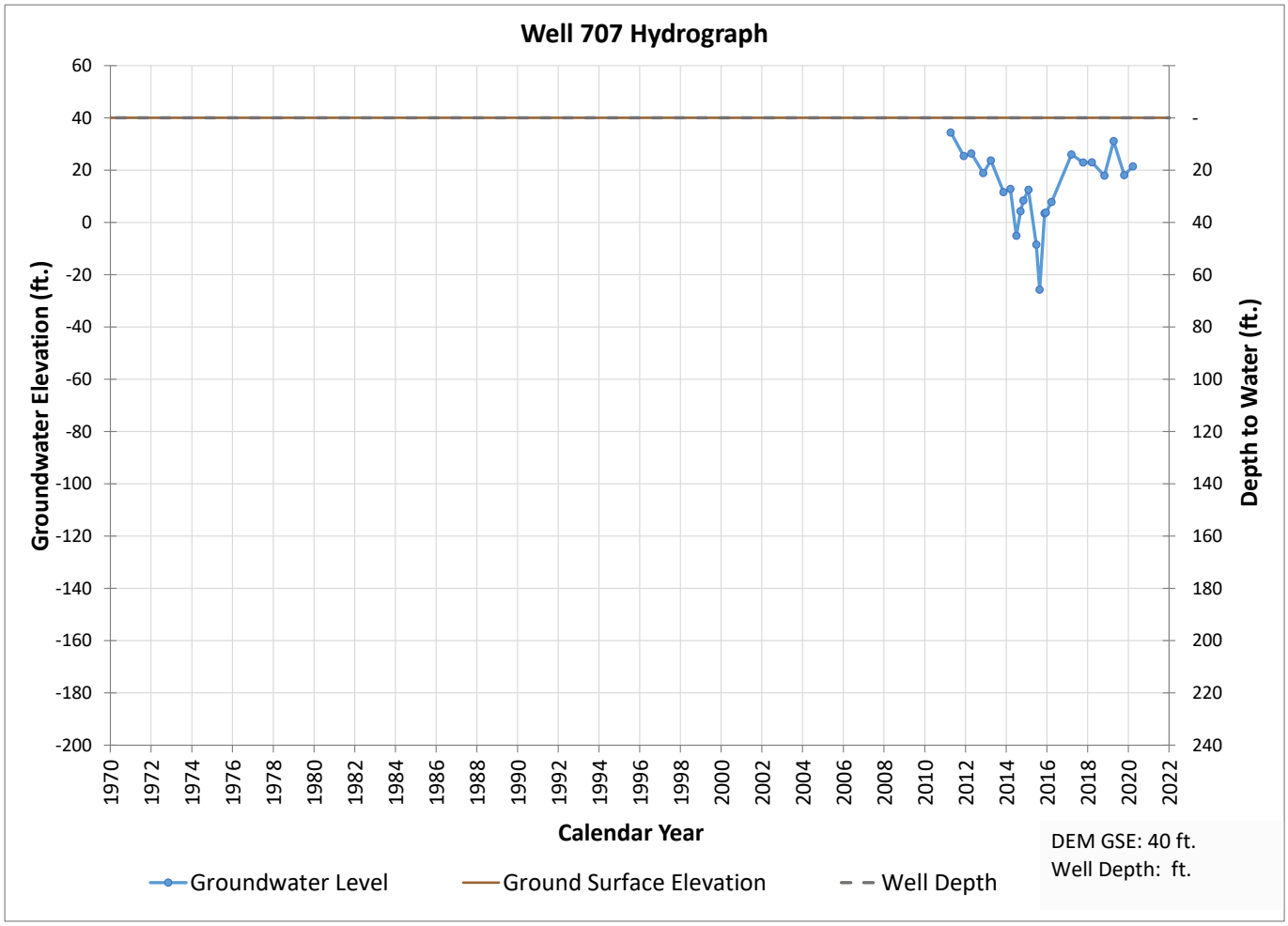

Well 699 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
-214
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 26 ft.
Well Depth: ft.

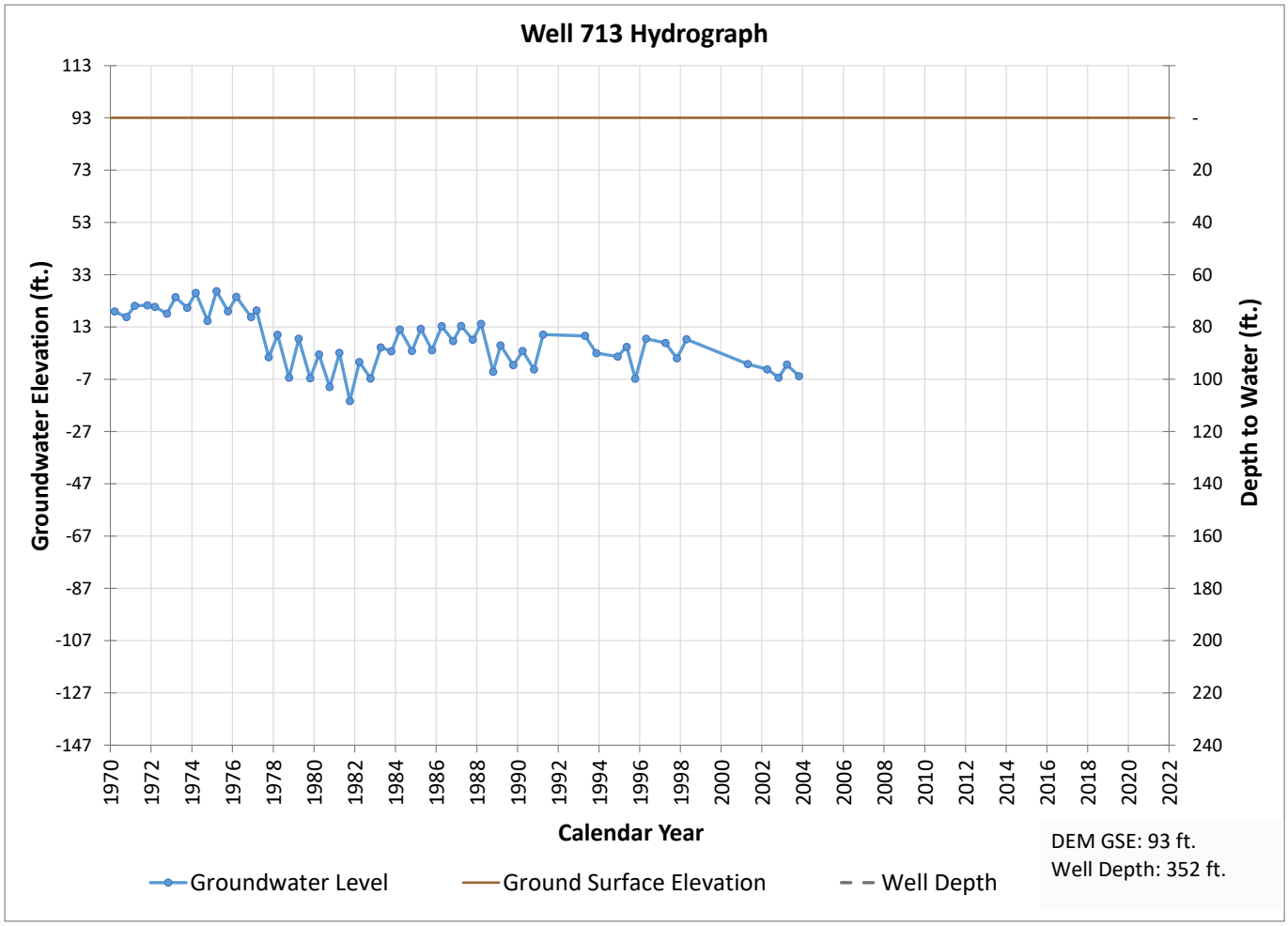

Well 700 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
-211
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 29 ft.
Well Depth: 76 ft.

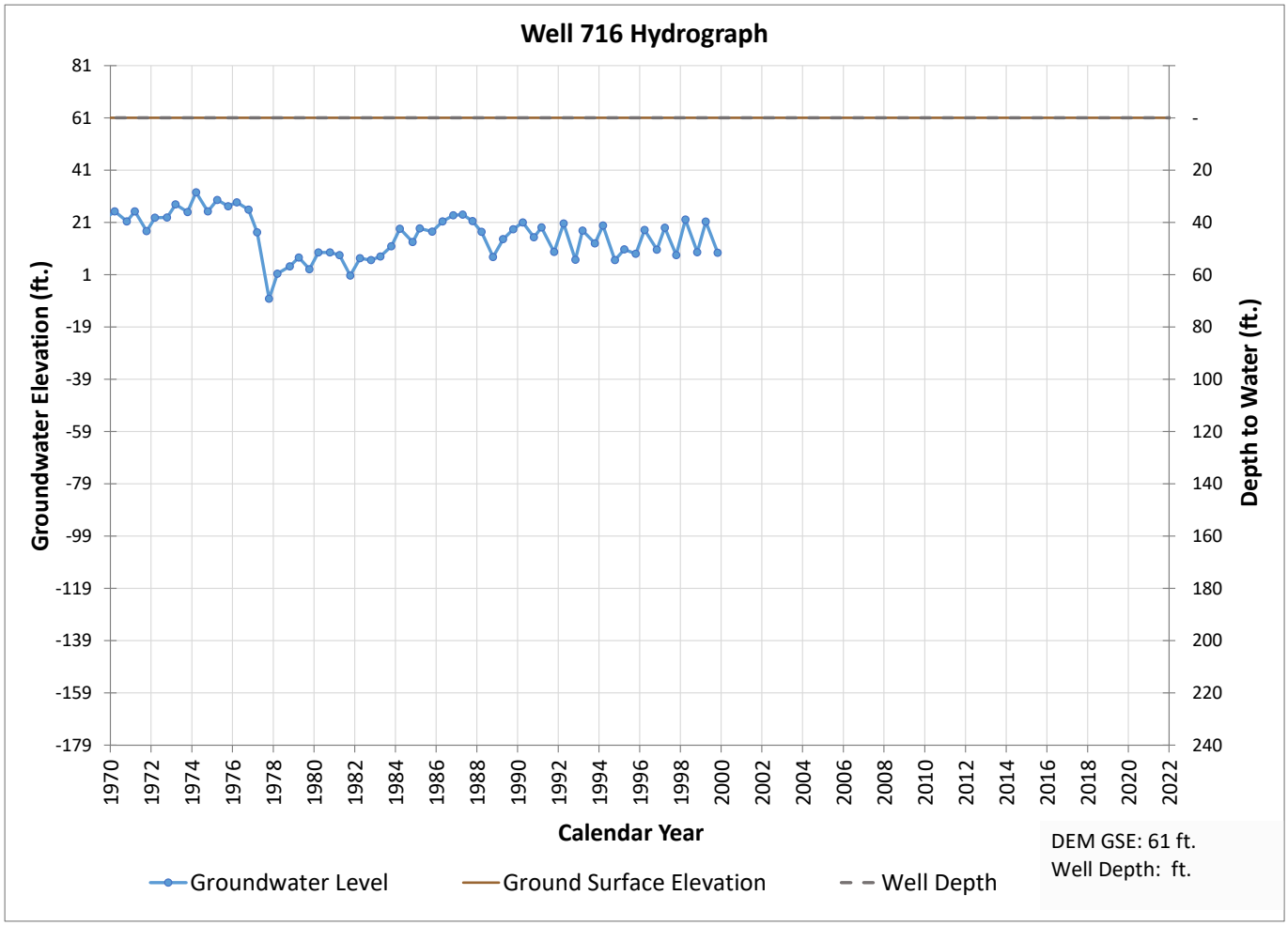

Well 701 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
147
127
107
87
67
47
27
7
-13
-33
-53
-73
-93
-113
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 127 ft.
Well Depth: 265 ft.

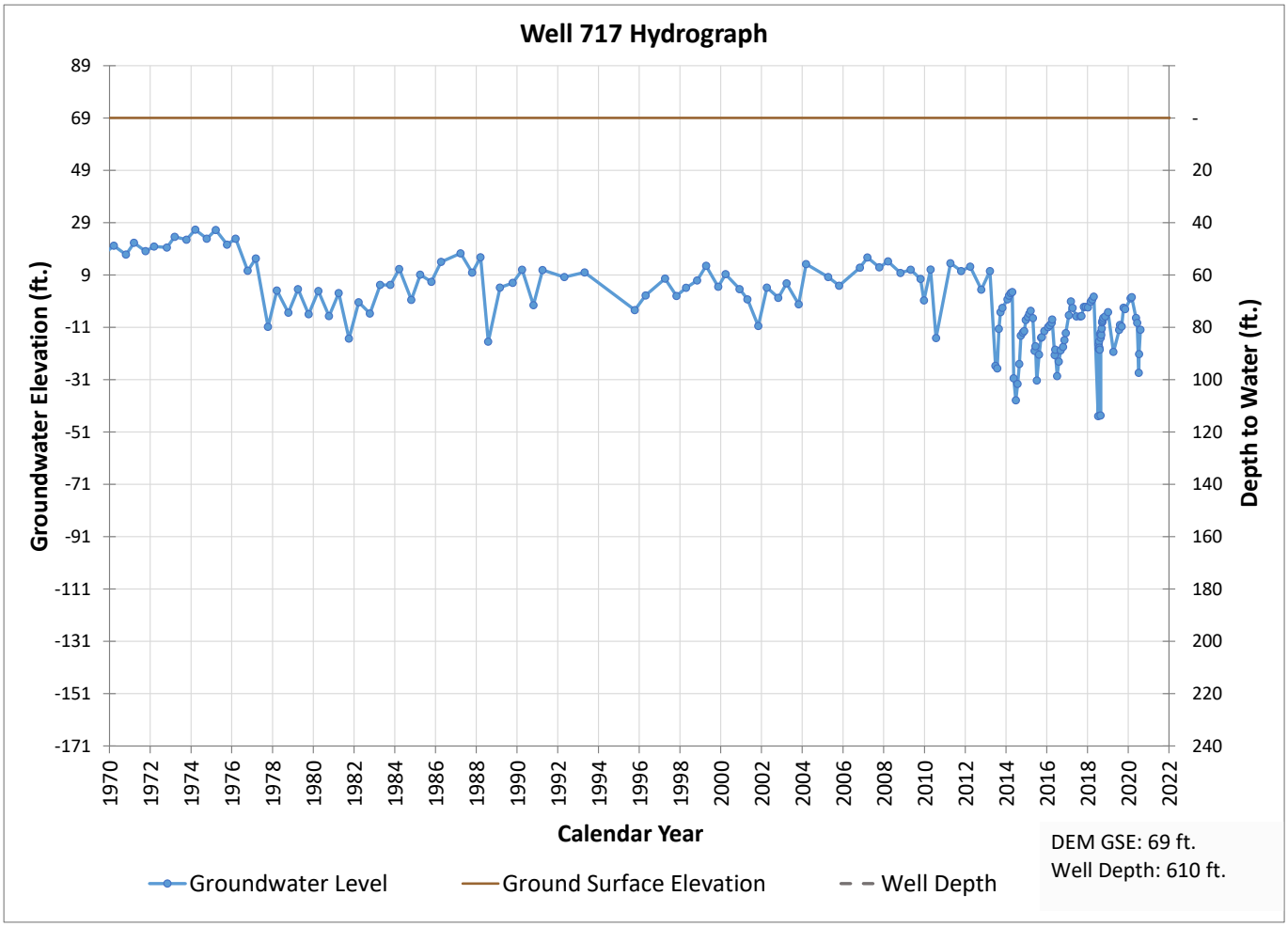

Well 705 Hydrograph
Groundwater Elevation (ft.)
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
-207
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 33 ft.
Well Depth: ft.

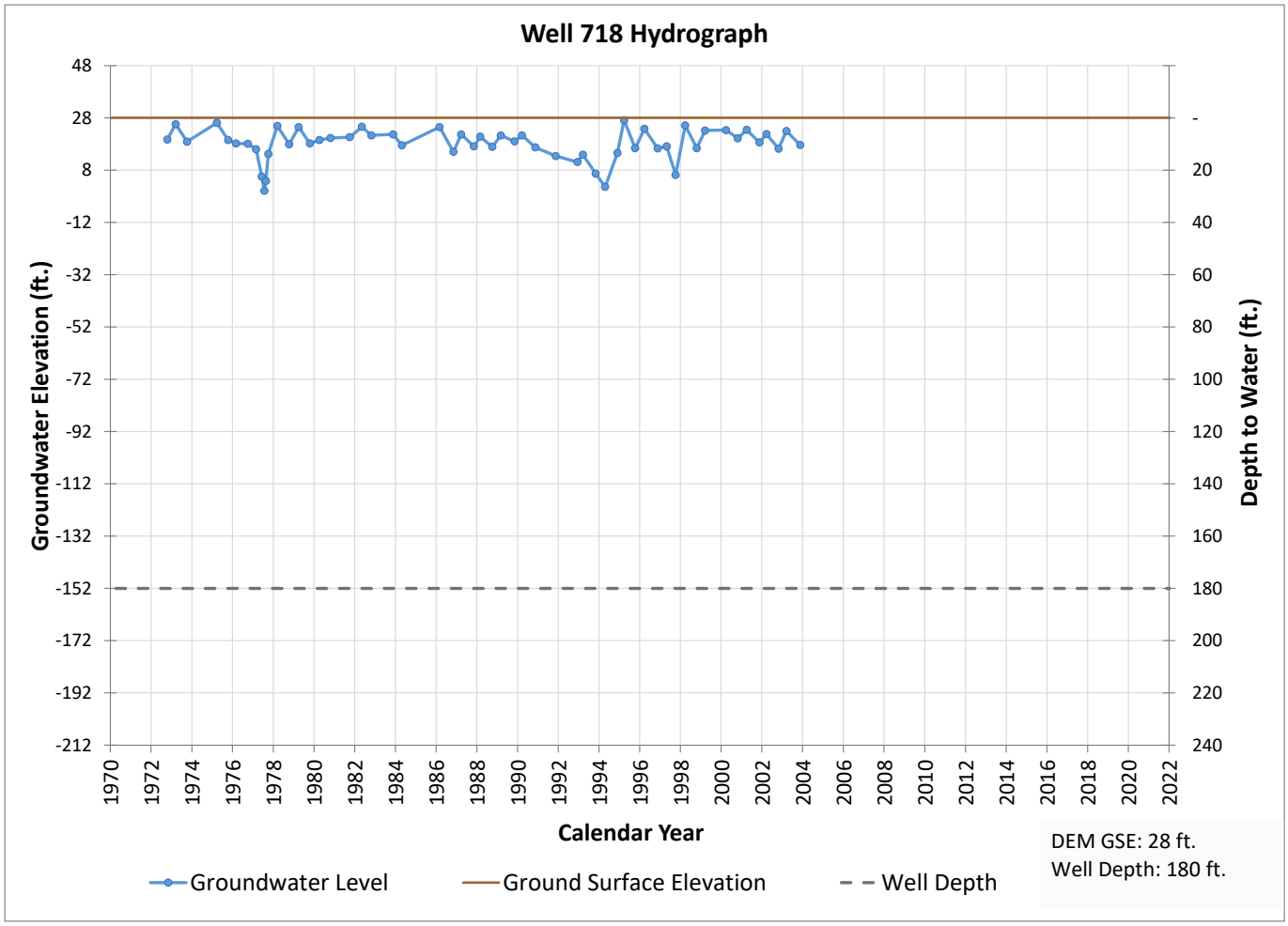

Well 706 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
139
119
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 119 ft.
Well Depth: ft.

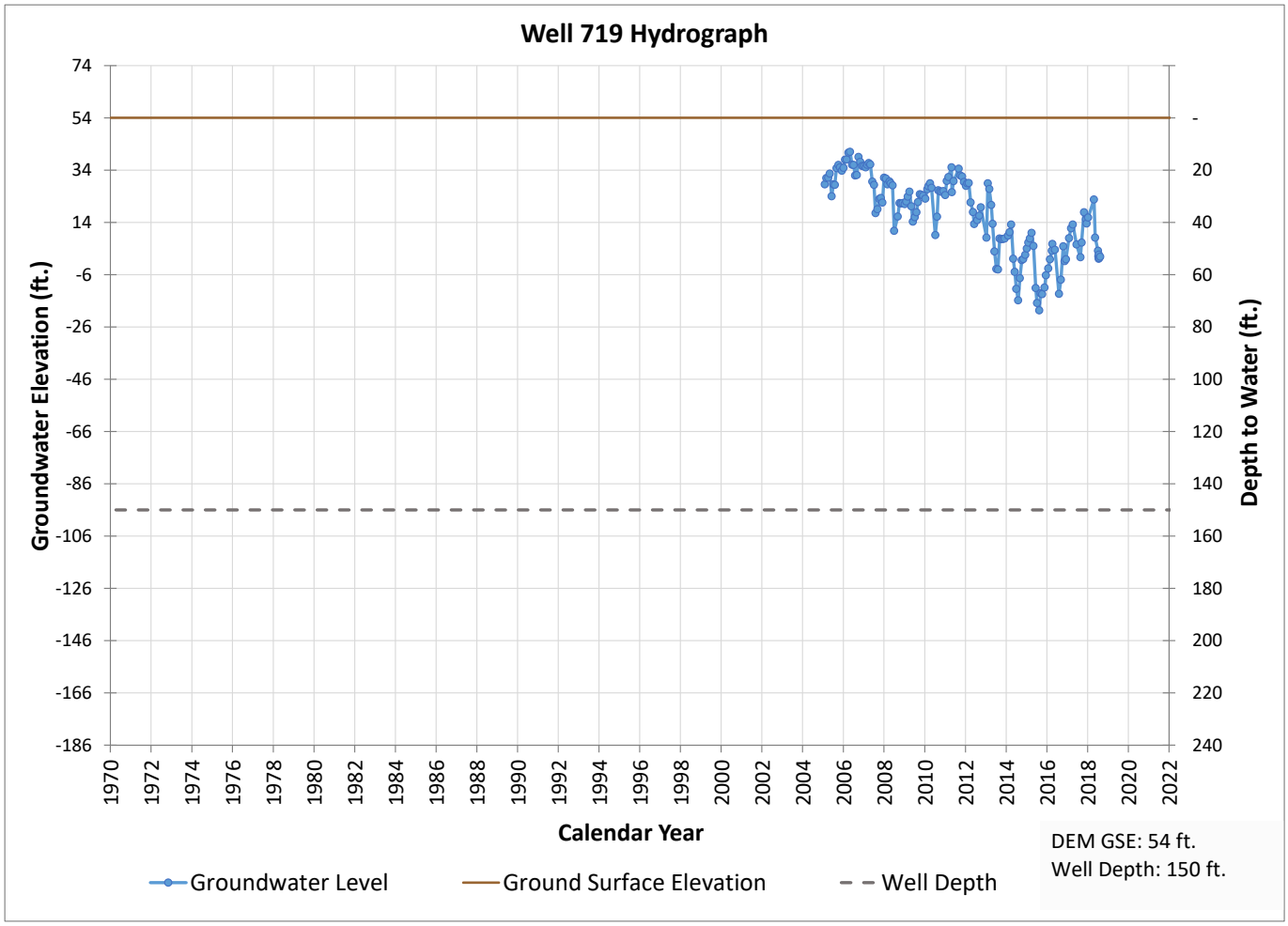

Well 707 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 40 ft.
Well Depth: ft.

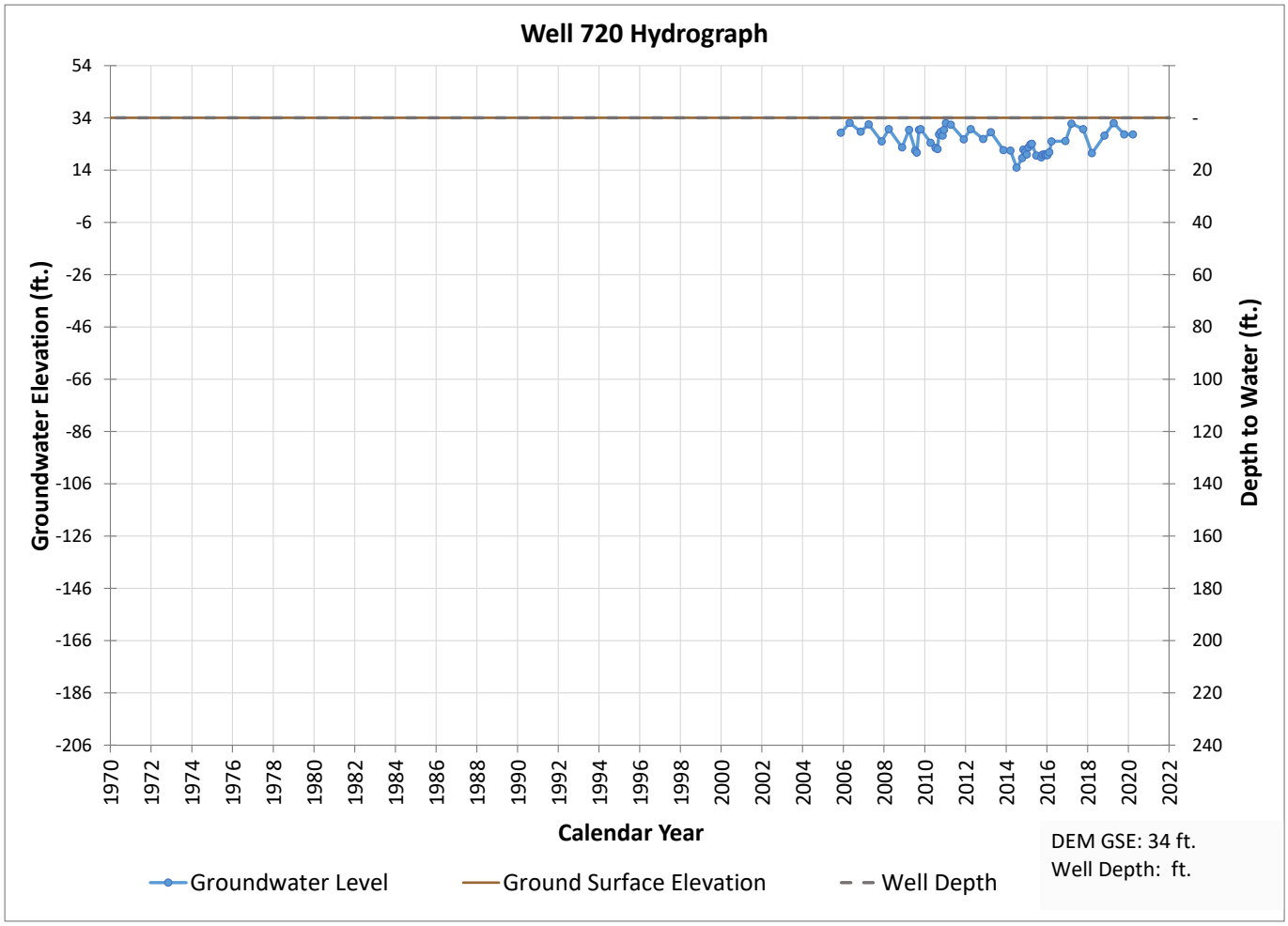

Well 713 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
113
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 93 ft.
Well Depth: 352 ft.

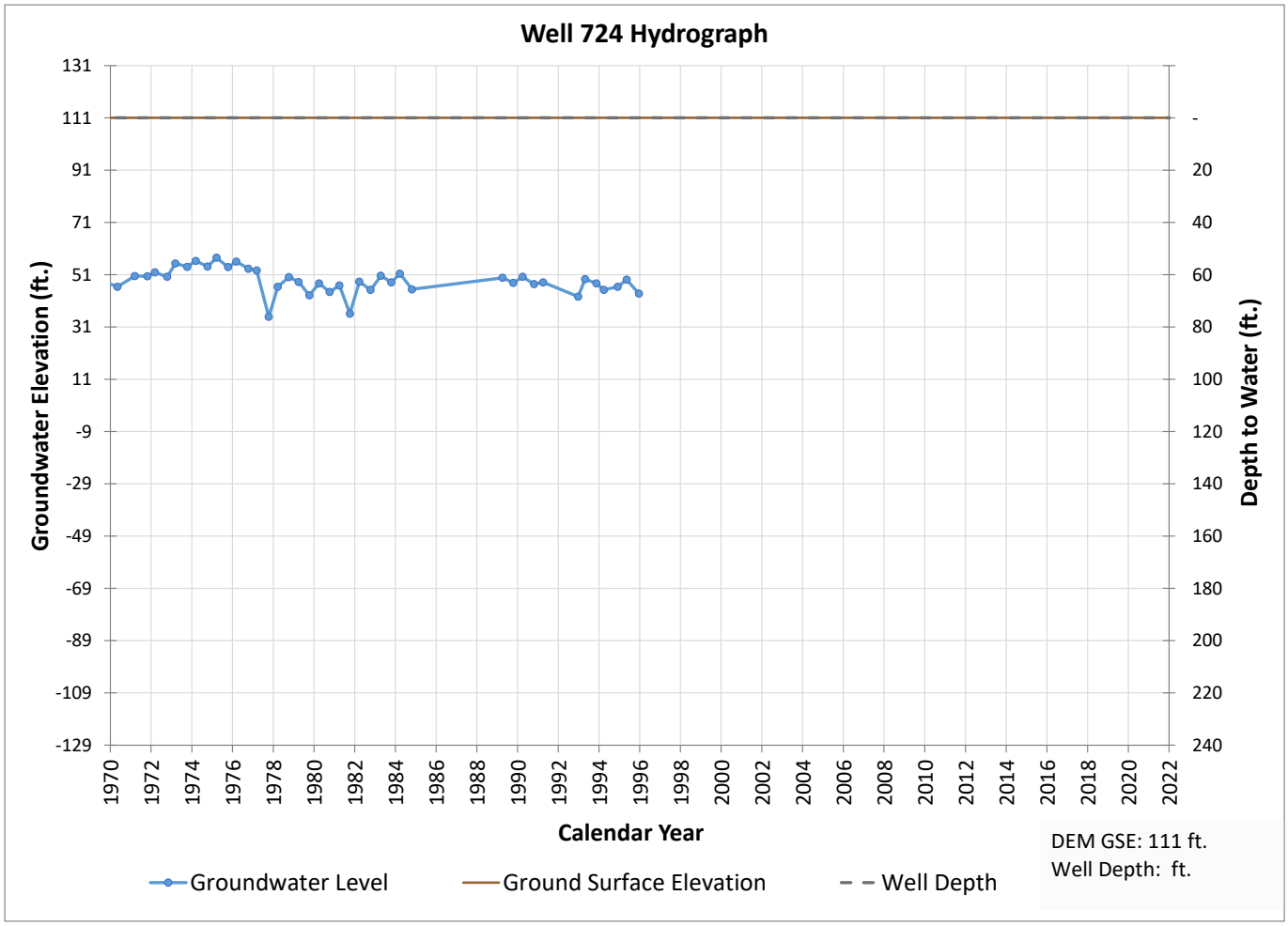

Well 716 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 61 ft.
Well Depth: ft.

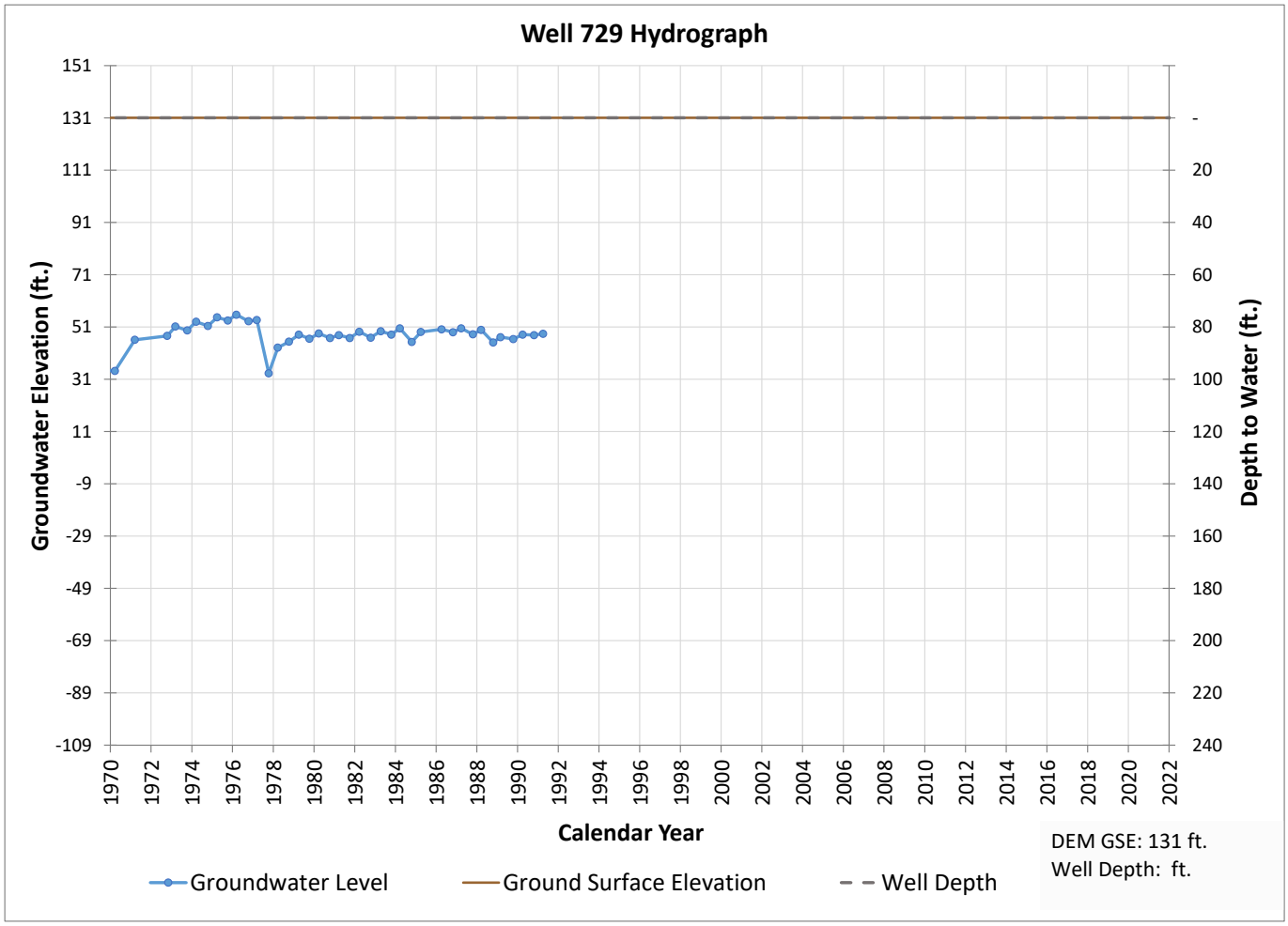

Well 717 Hydrograph
Groundwater Elevation (ft.)
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 69 ft.
Well Depth: 610 ft.

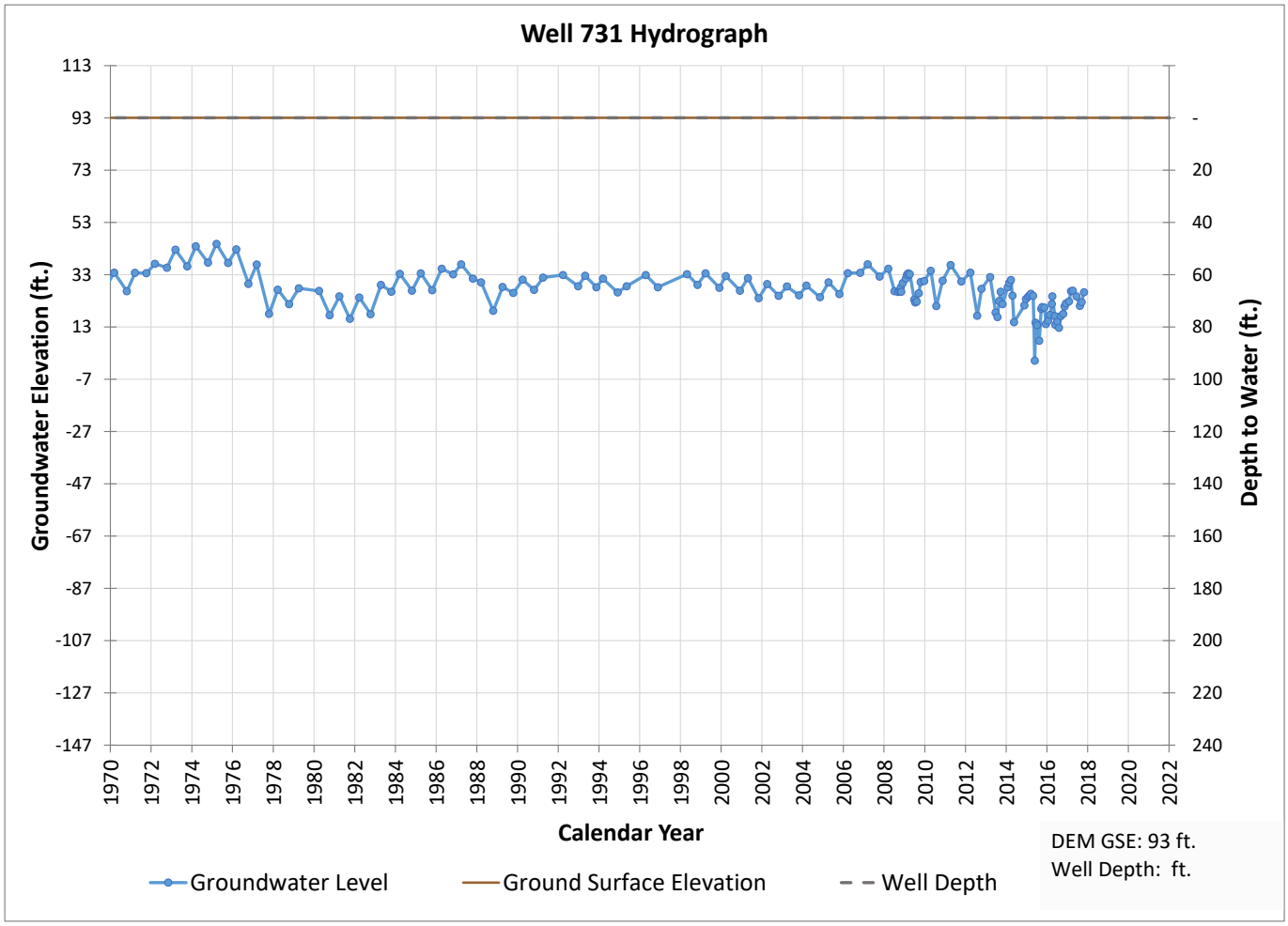

Well 718 Hydrograph
Groundwater Elevation (ft.)
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 28 ft.
Well Depth: 180 ft.

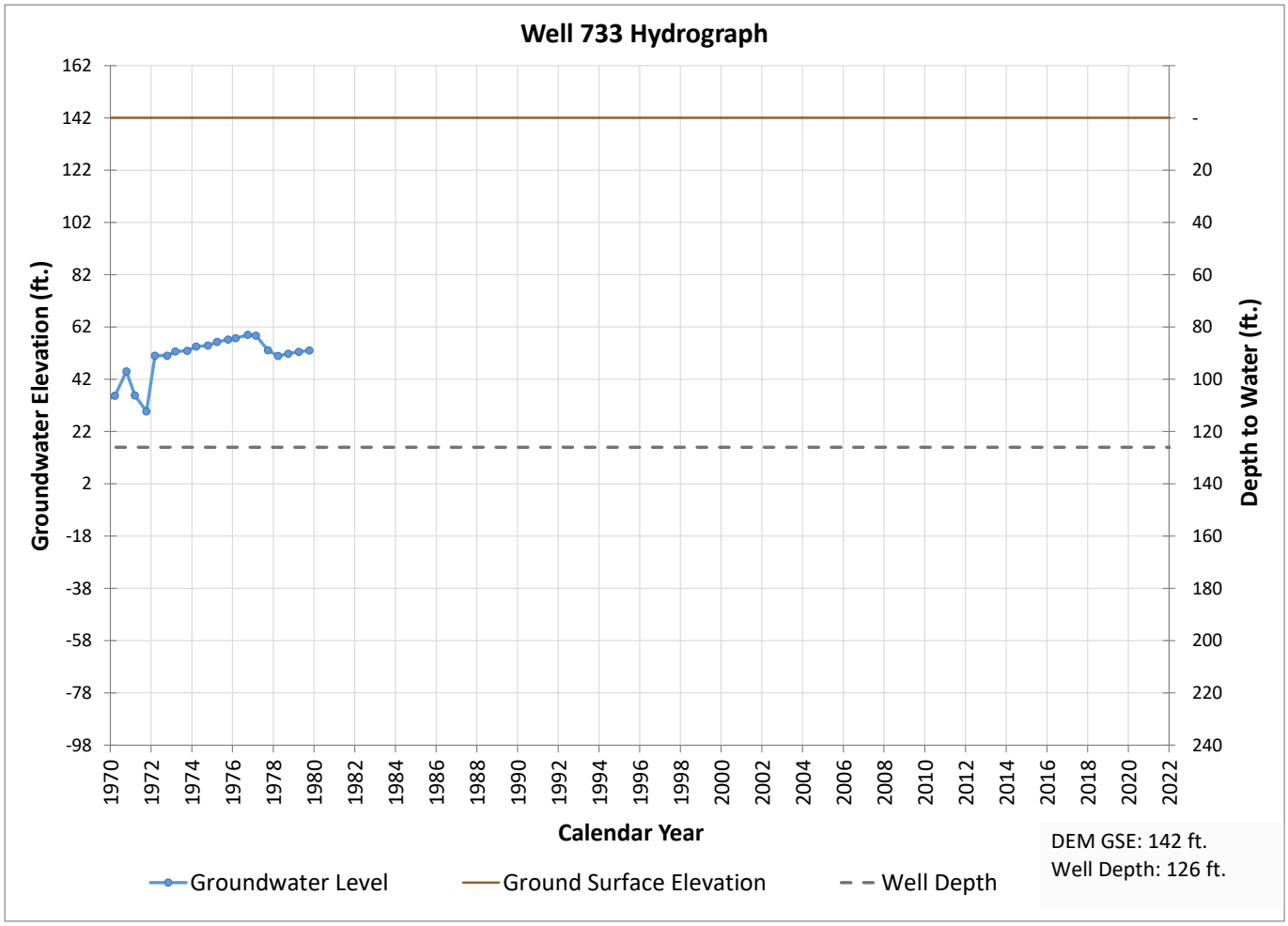

Well 719 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 150 ft.

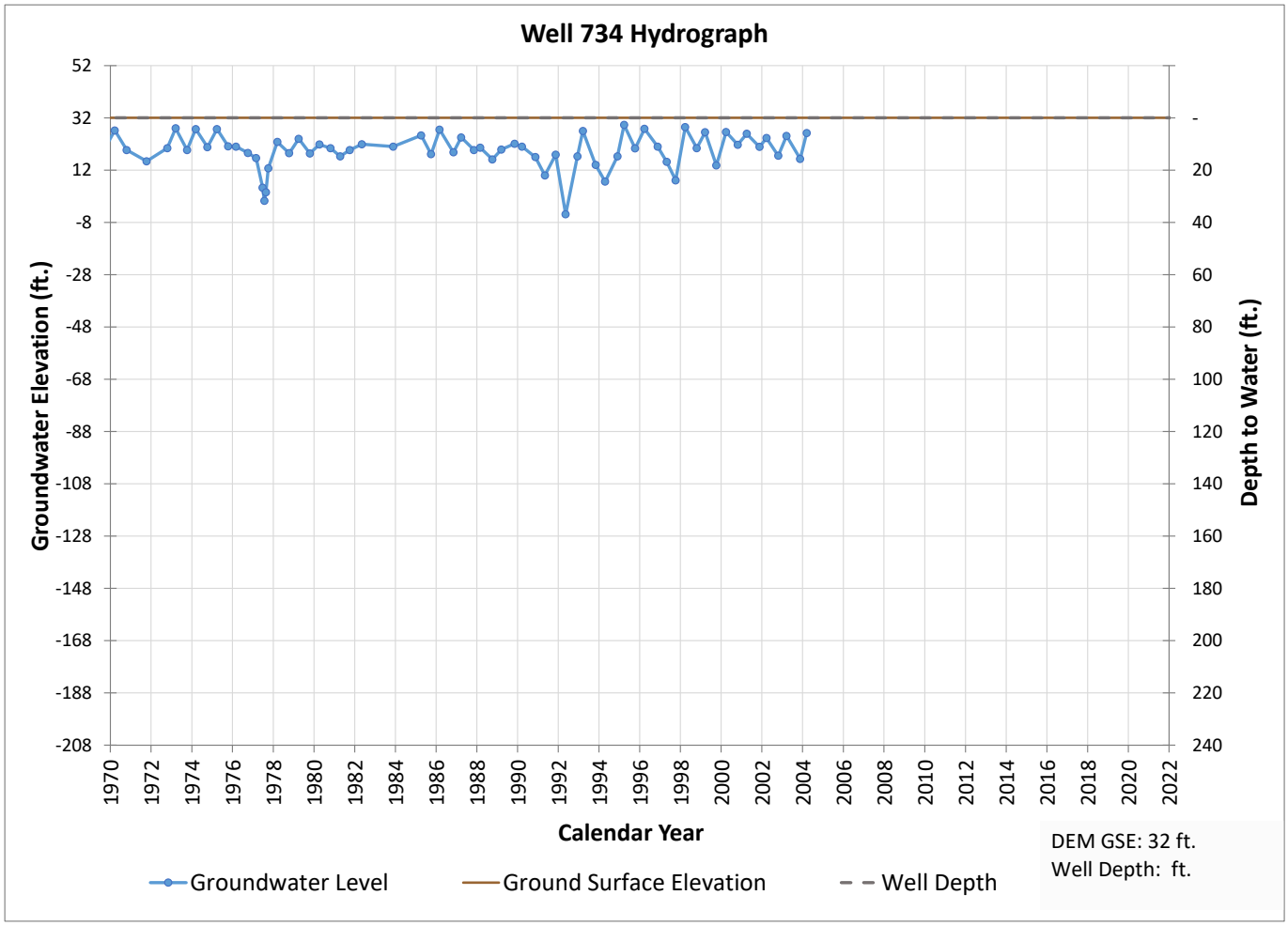

Well 720 Hydrograph
Groundwater Elevation (ft.)
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 34 ft.
Well Depth: ft.

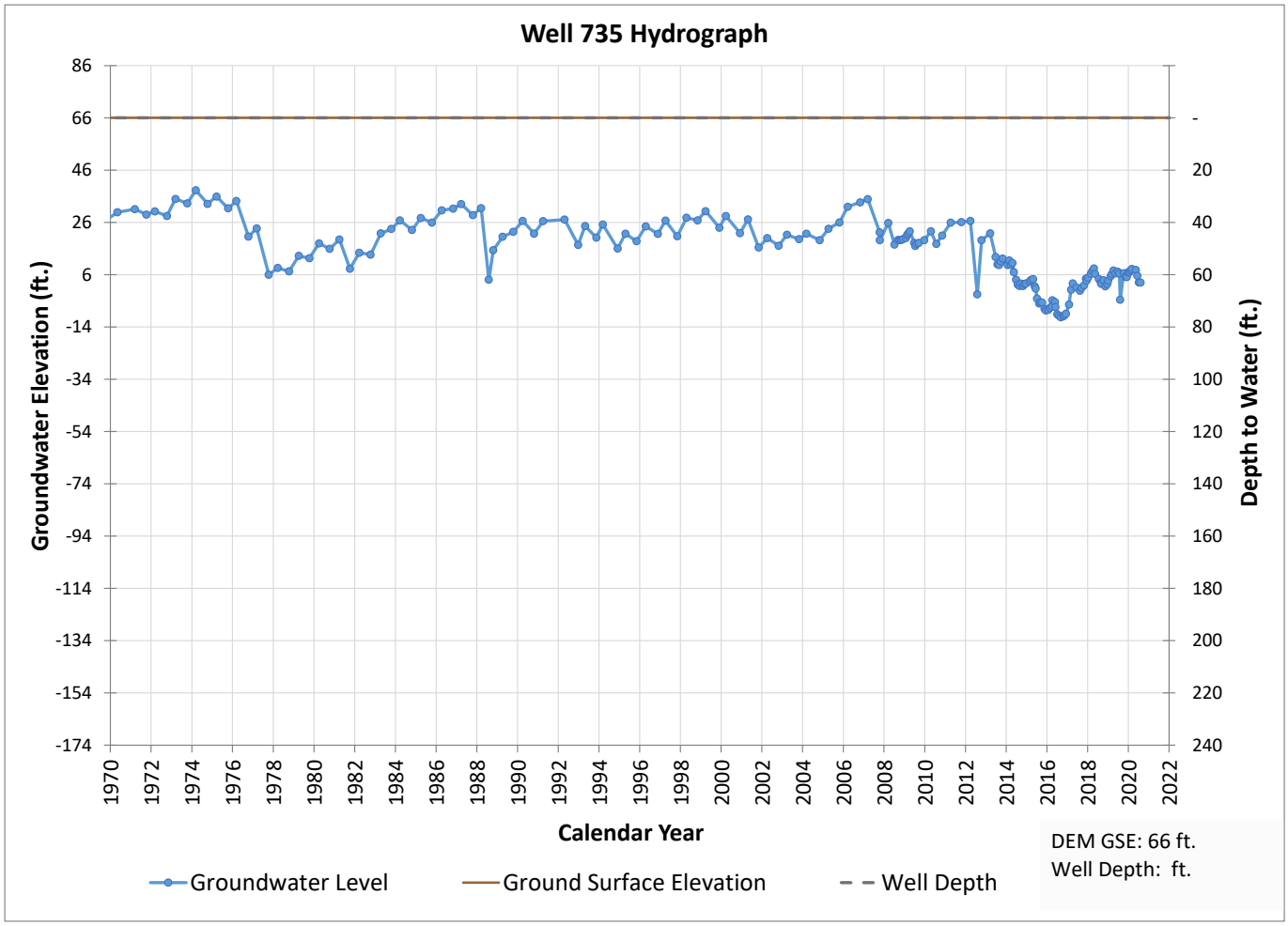

Well 724 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
131
111
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-129
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 111 ft.
Well Depth: ft.

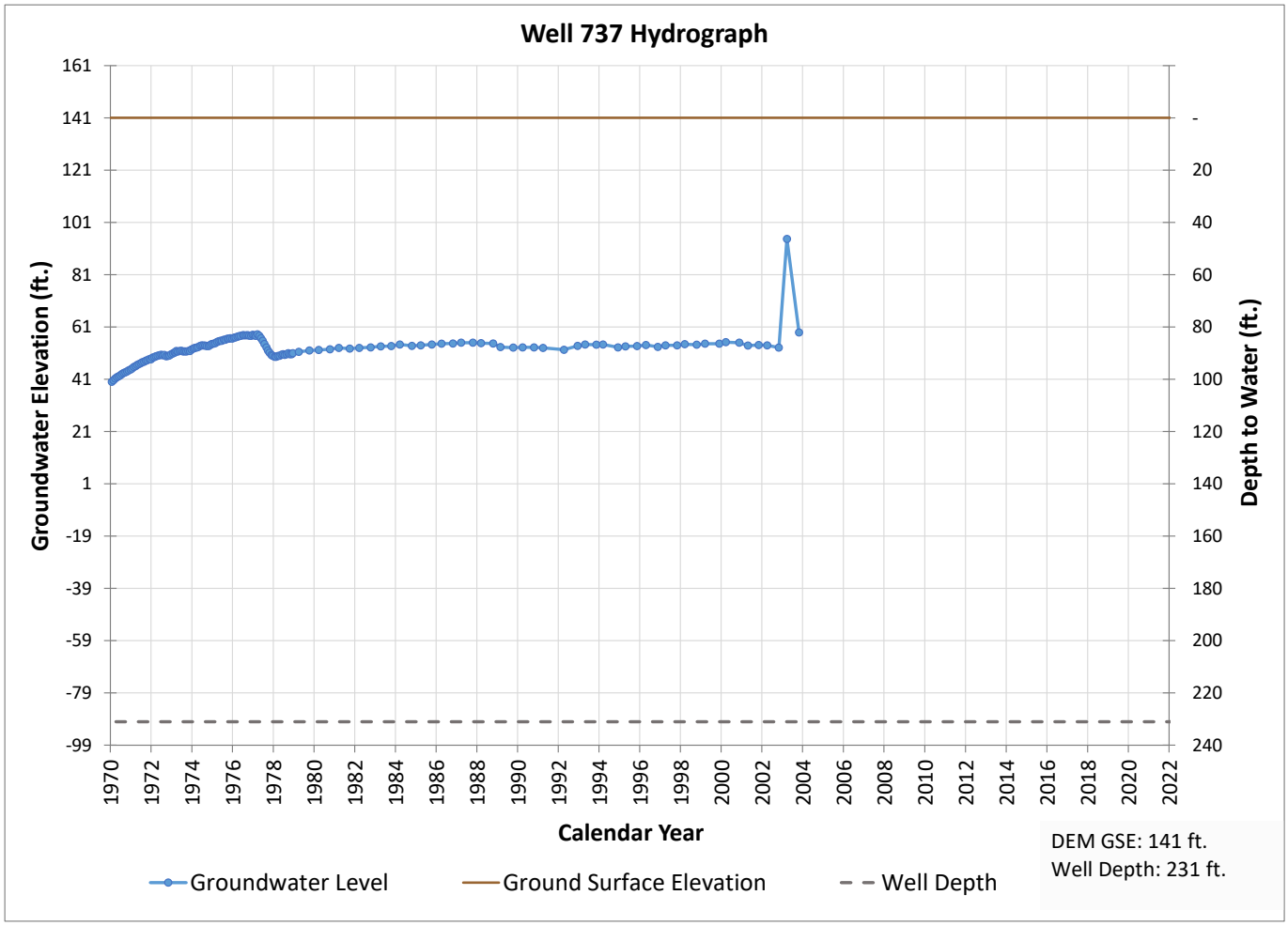

Well 729 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
151
131
111
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 131 ft.
Well Depth: ft.

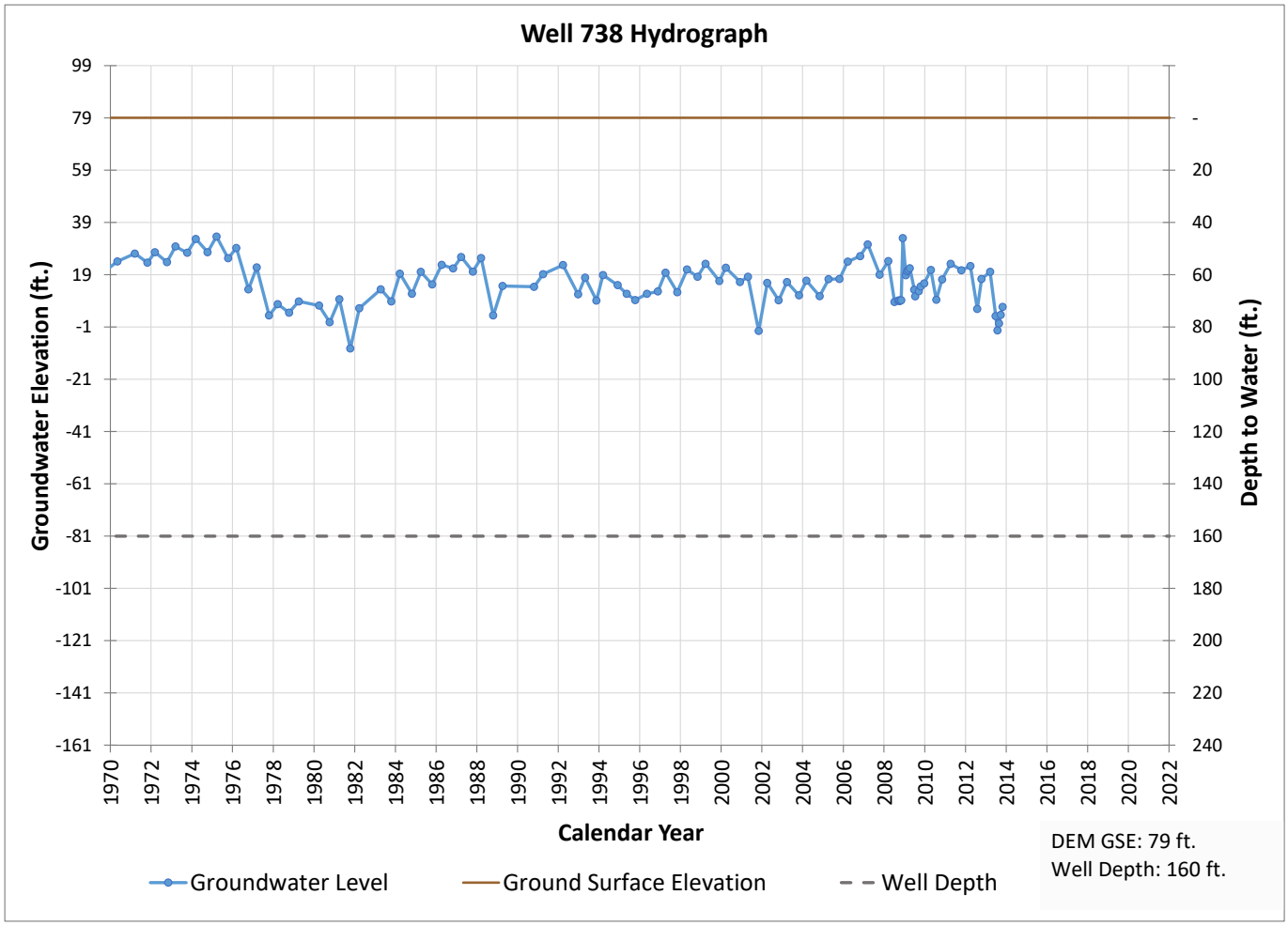

Well 731 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
113
93
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 93 ft.
Well Depth: ft.

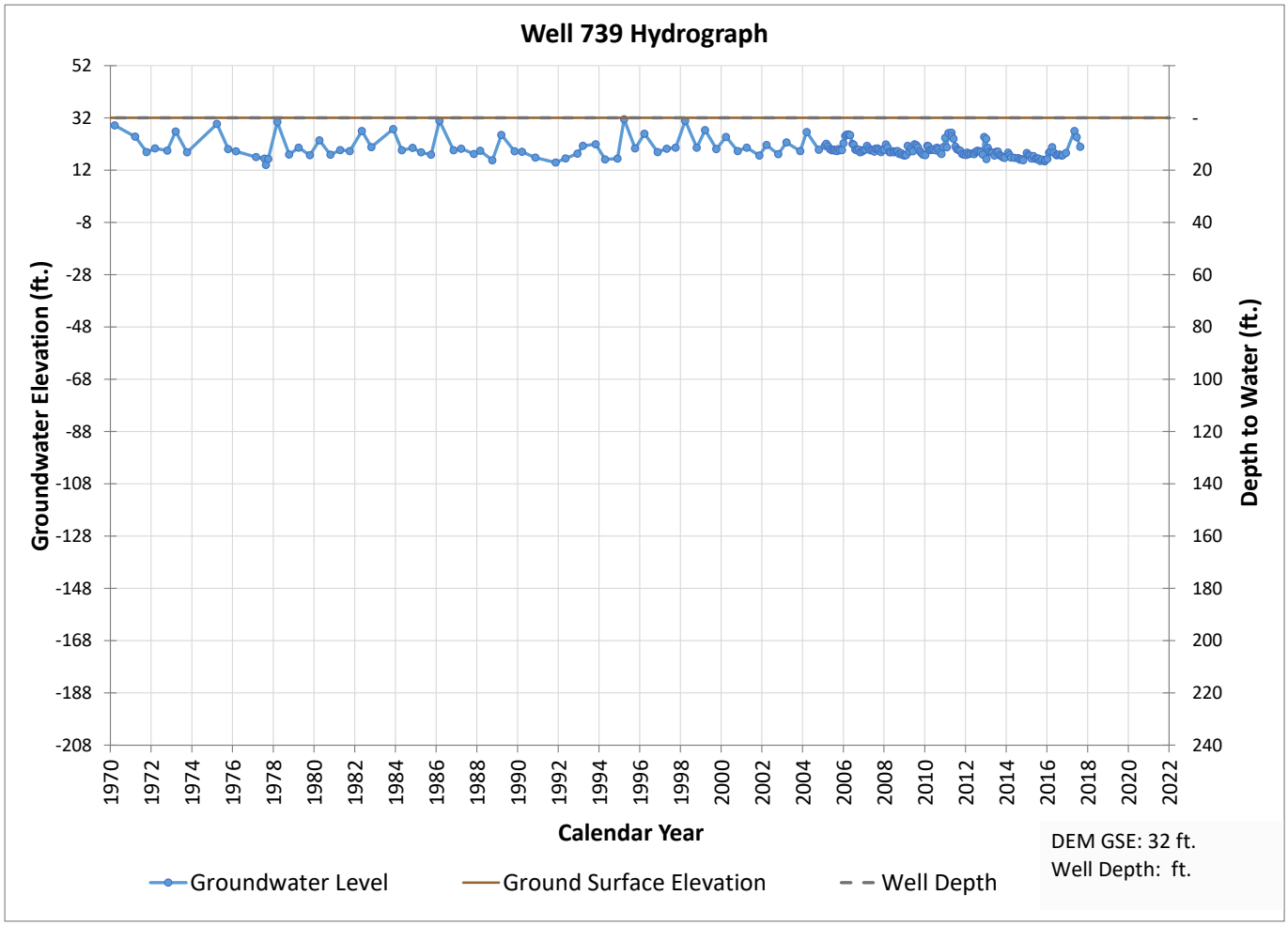

Well 733 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
162
142
122
102
82
62
42
22
2
-18
-38
-58
-78
-98
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 142 ft.
Well Depth: 126 ft.

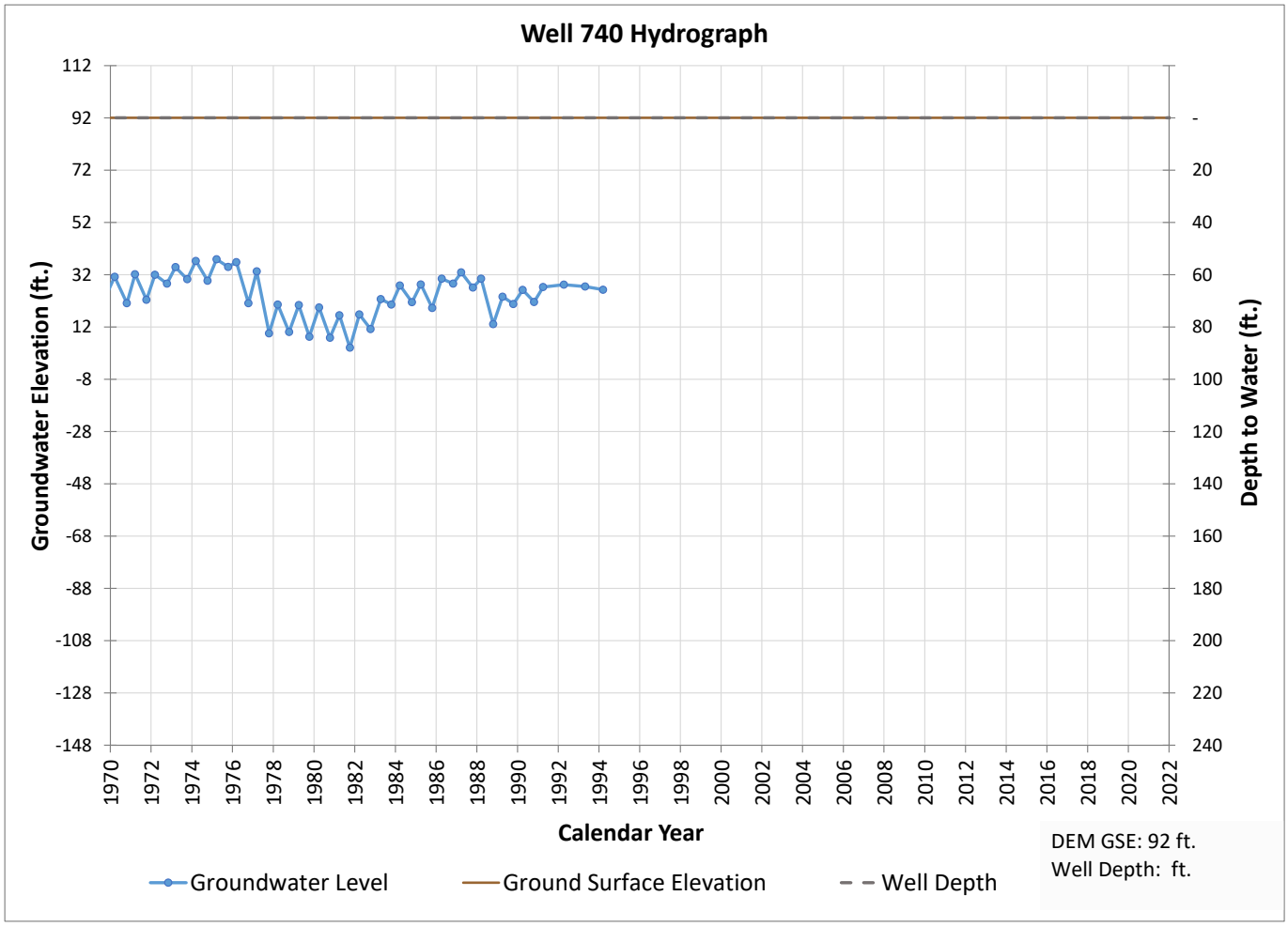

Well 734 Hydrograph
Groundwater Elevation (ft.)
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: ft.

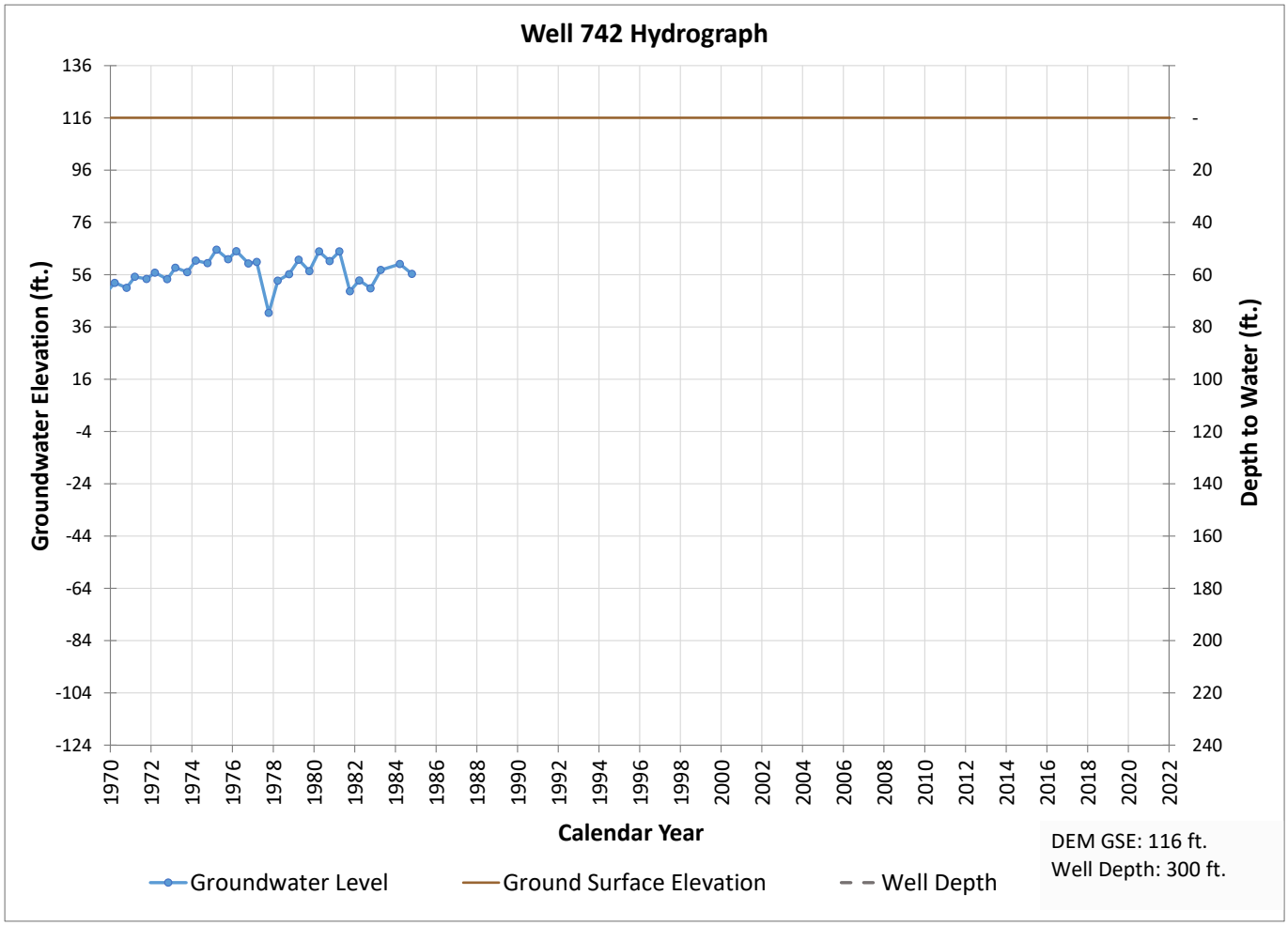

Well 735 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 66 ft.
Well Depth: ft.

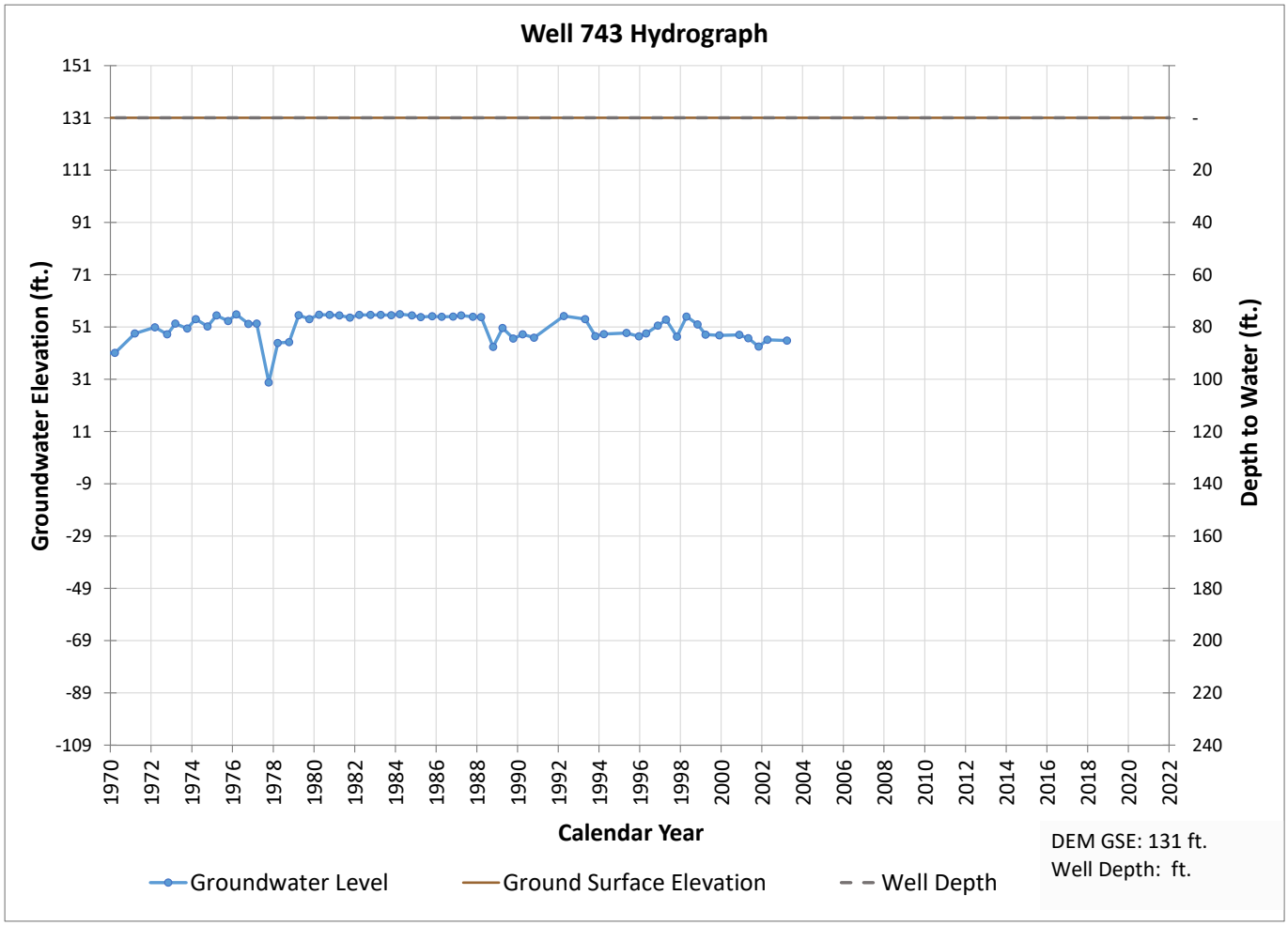

Well 737 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
161
141
121
101
81
61
41
21
1
-19
-39
-59
-79
-99
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 141 ft.
Well Depth: 231 ft.

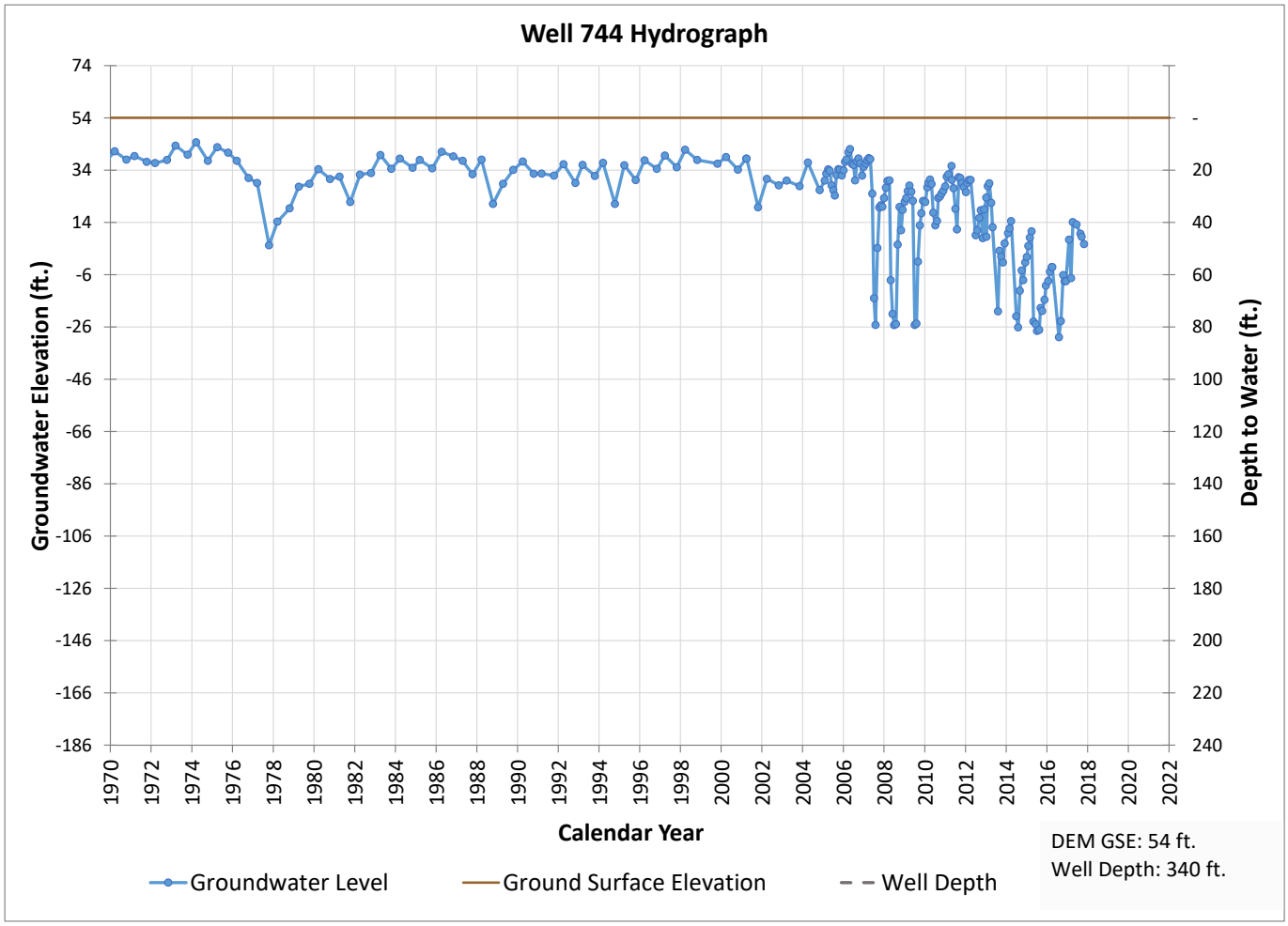

Well 738 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
99
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 79 ft.
Well Depth: 160 ft.

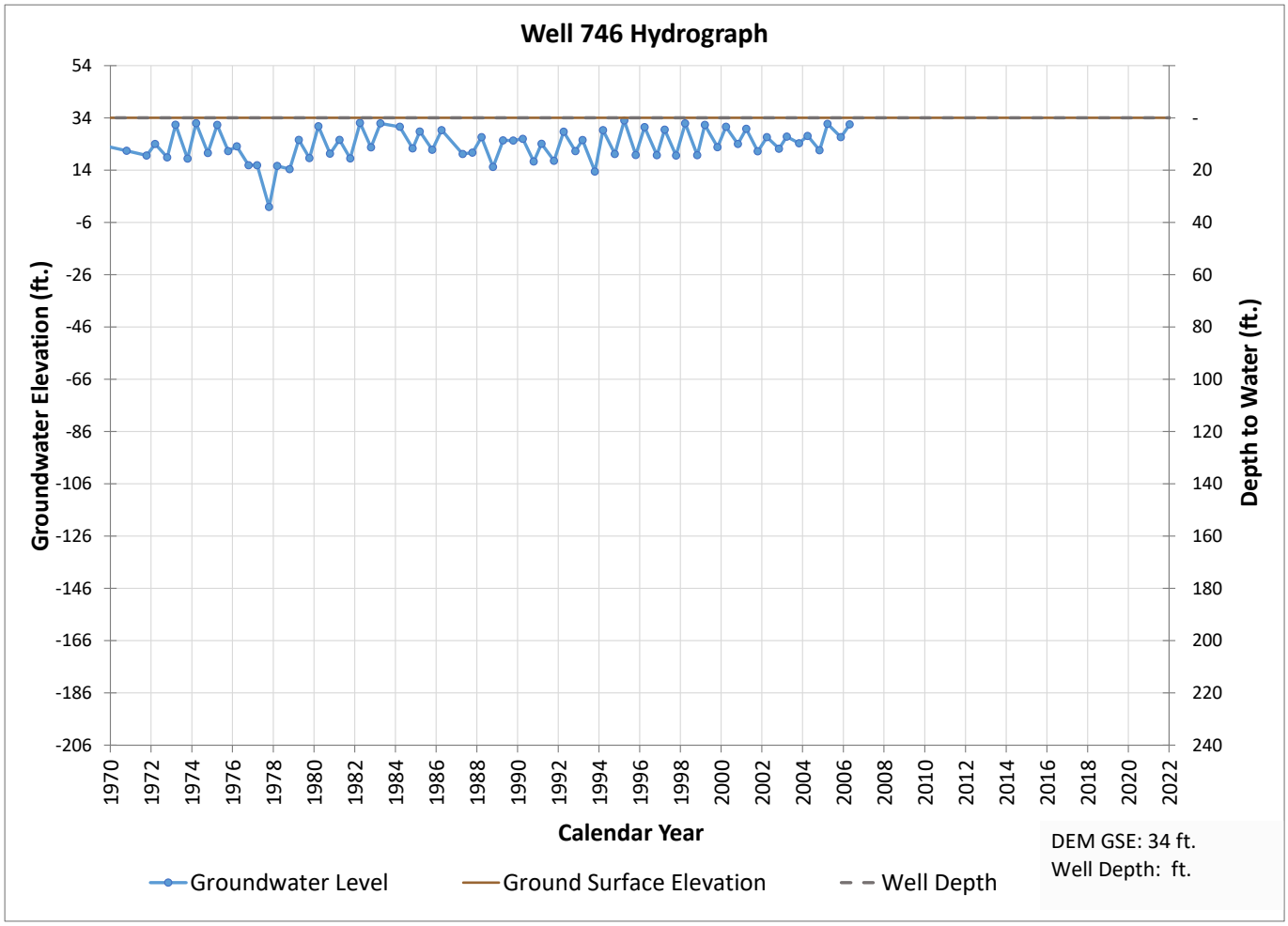

Well 739 Hydrograph
Groundwater Elevation (ft.)
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: ft.

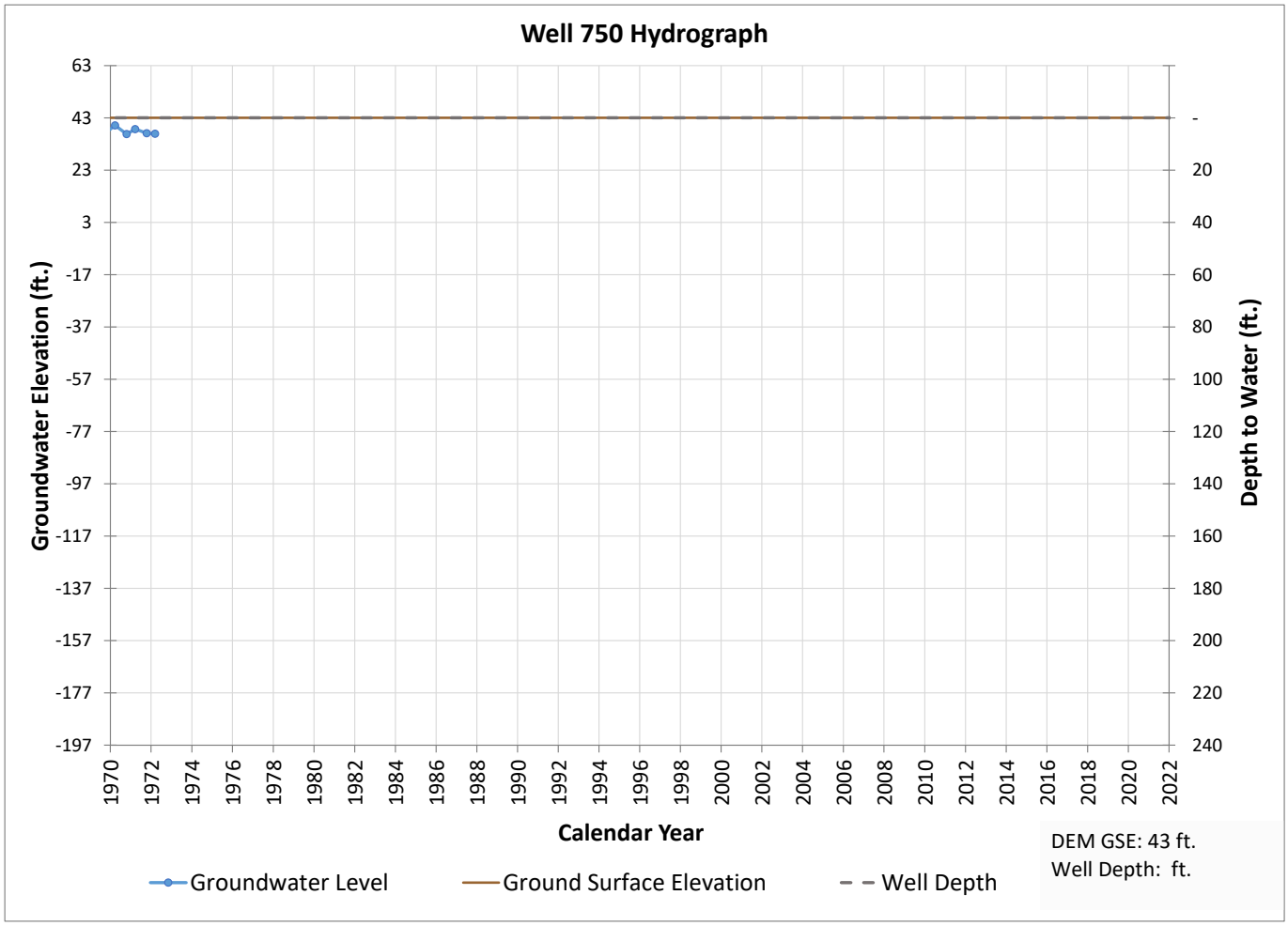

Well 740 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 92 ft.
Well Depth: ft.

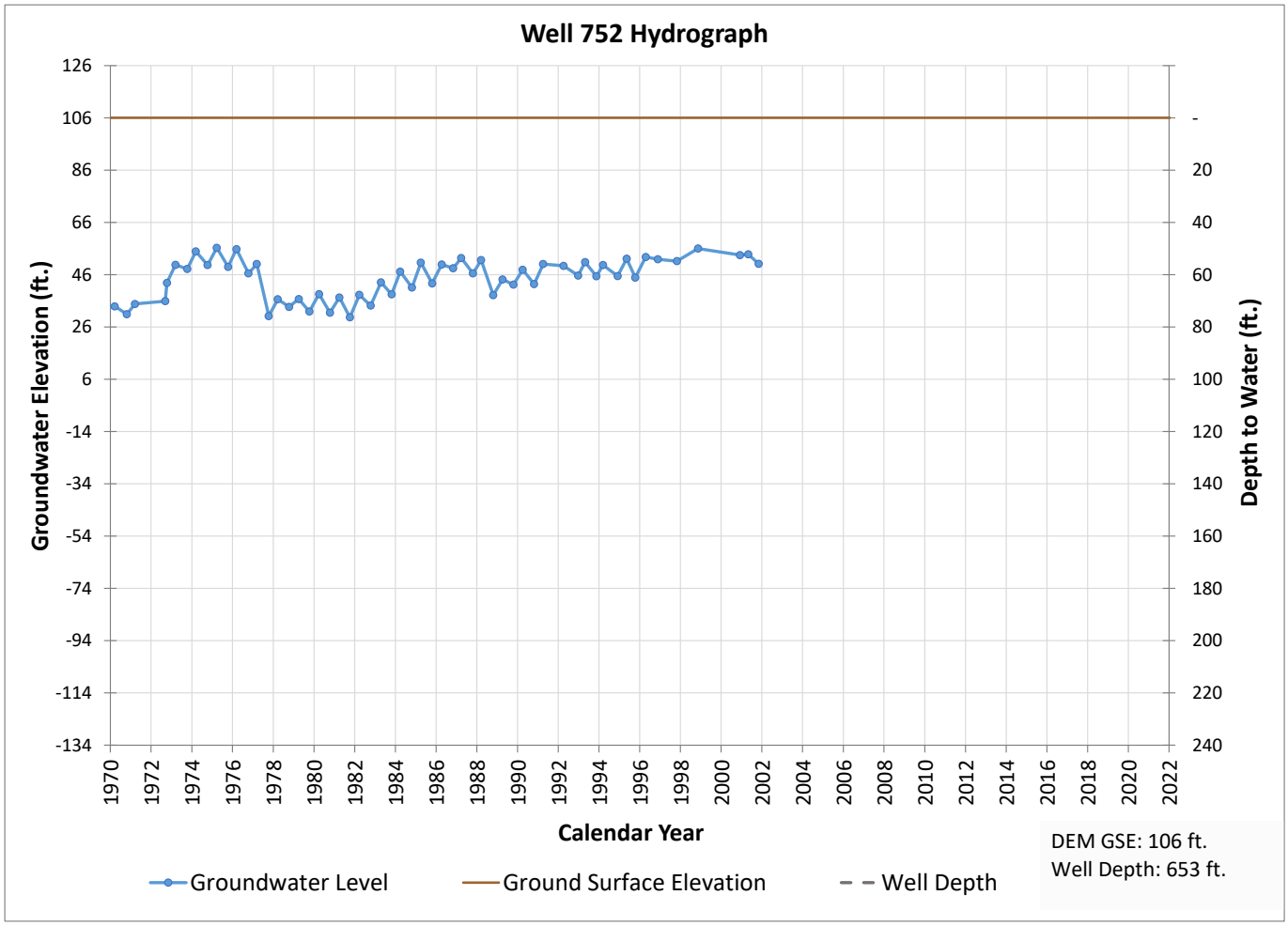

Well 742 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
136
116
96
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 116 ft.
Well Depth: 300 ft.

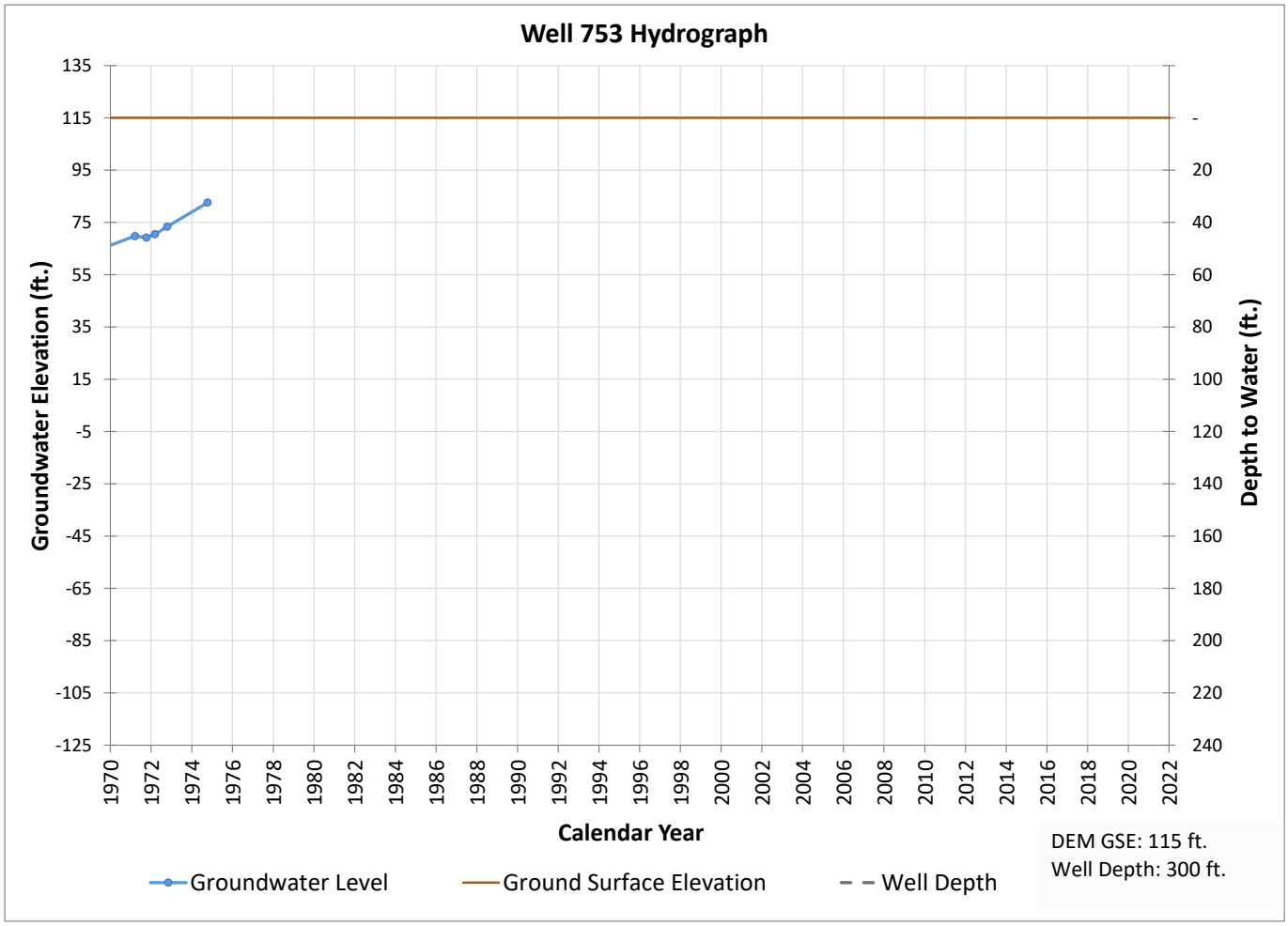

Well 743 Hydrograph
Groundwater Elevation (ft.)
151
131
111
91
71
51
31
11
-9
-29
-49
-69
-89
-109
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 131 ft.
Well Depth: ft.

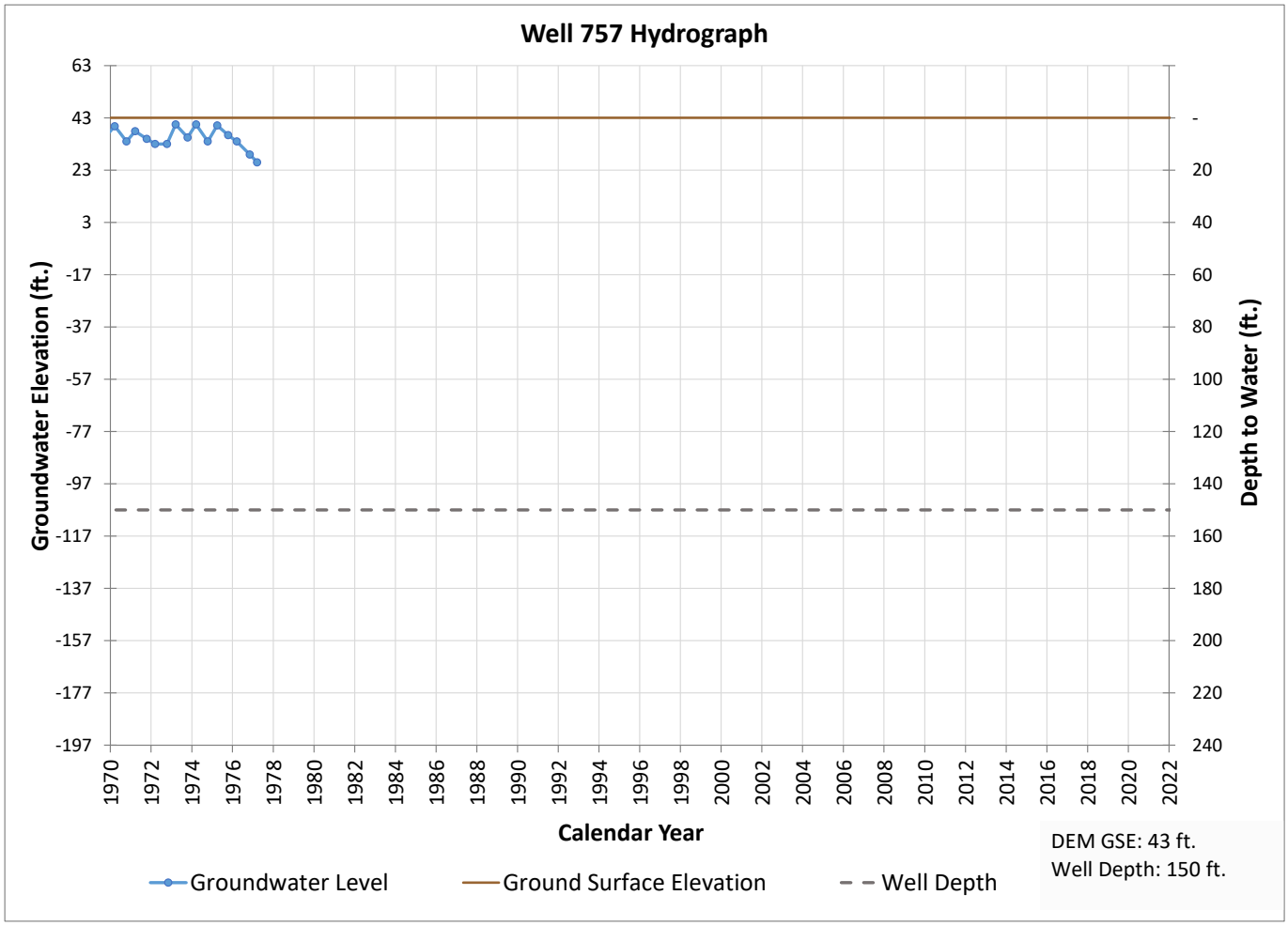

Well 744 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: 340 ft.

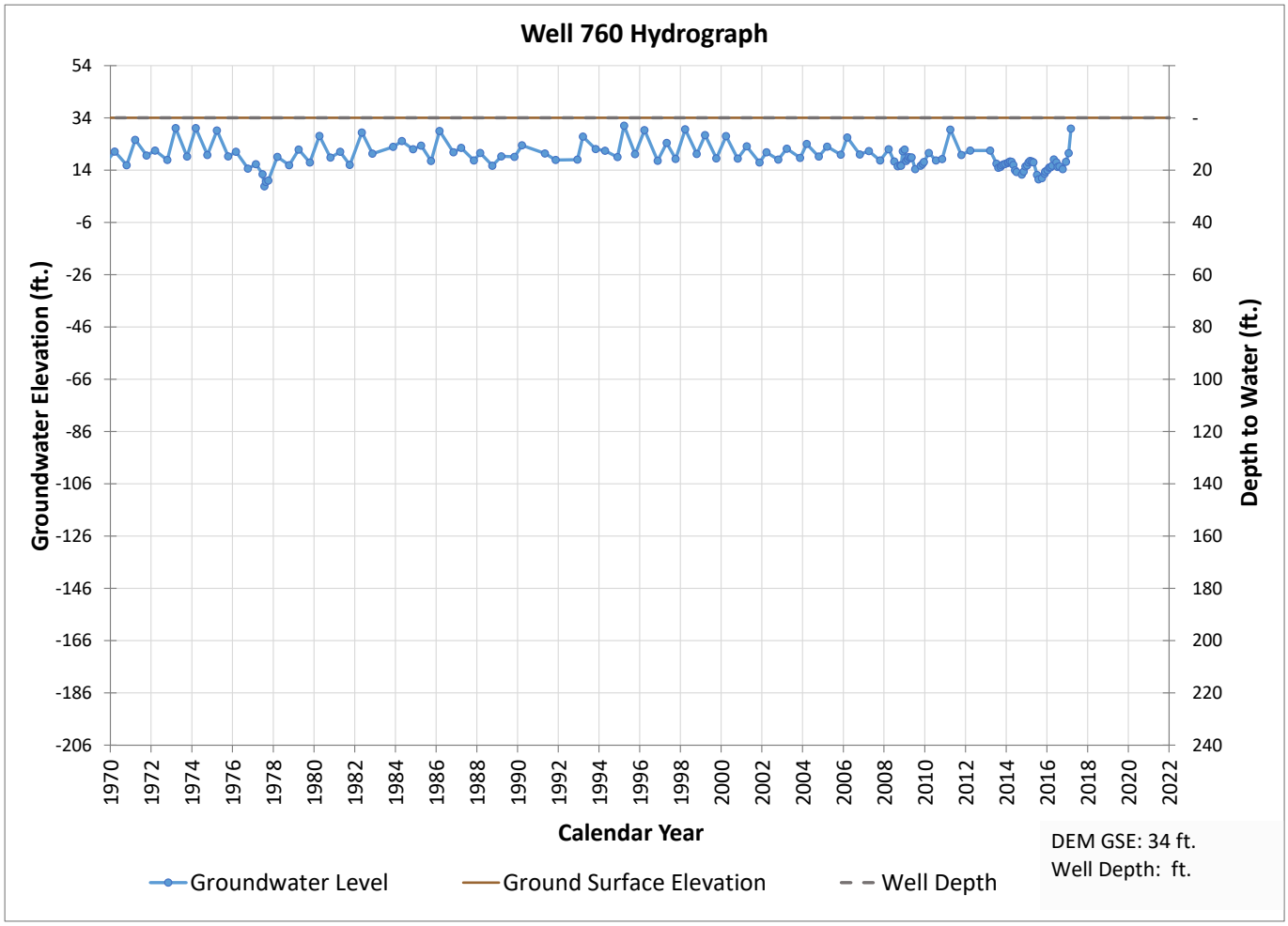

Well 746 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 34 ft.
Well Depth: ft.

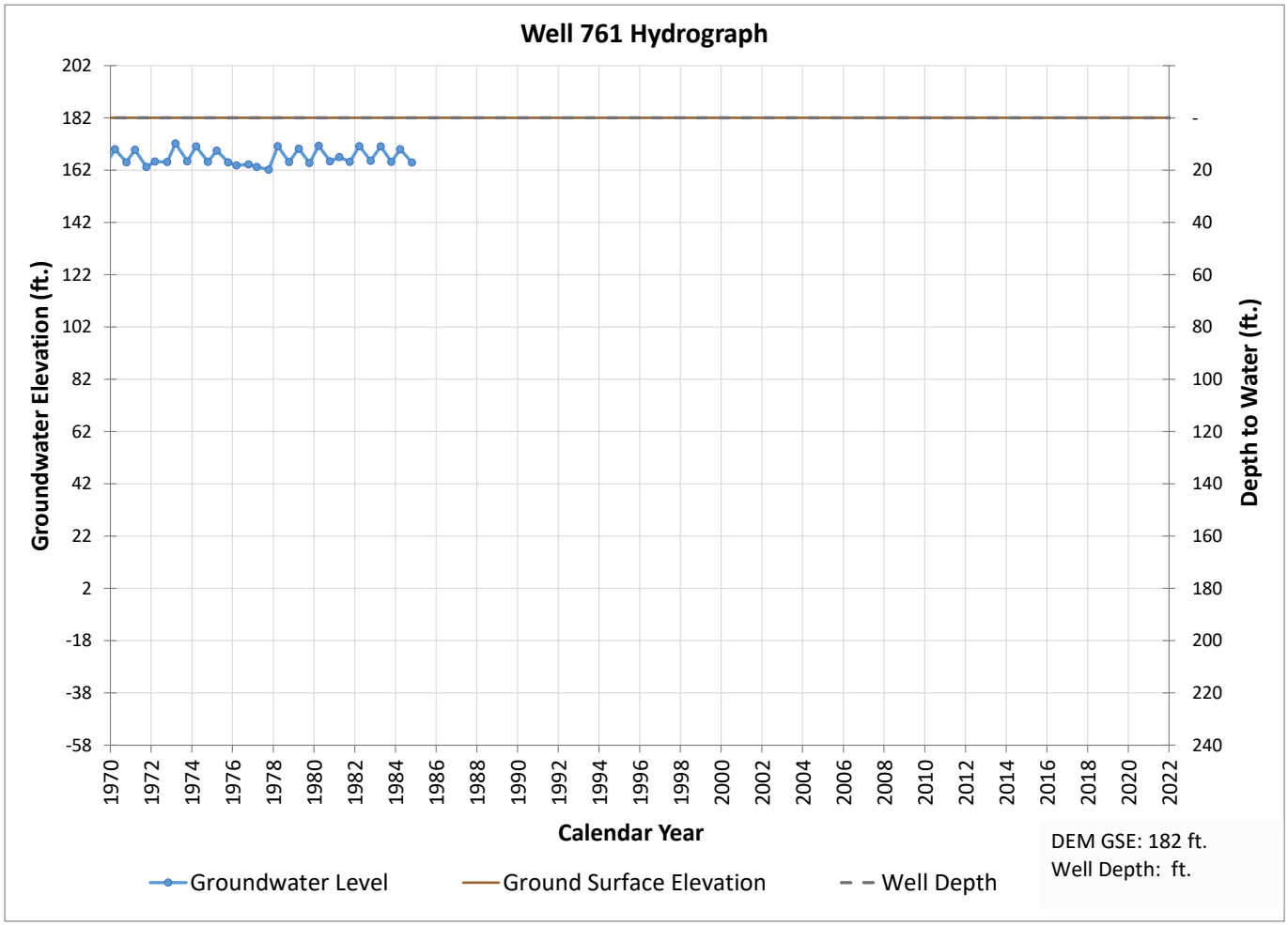

Well 750 Hydrograph
Groundwater Elevation (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: ft.

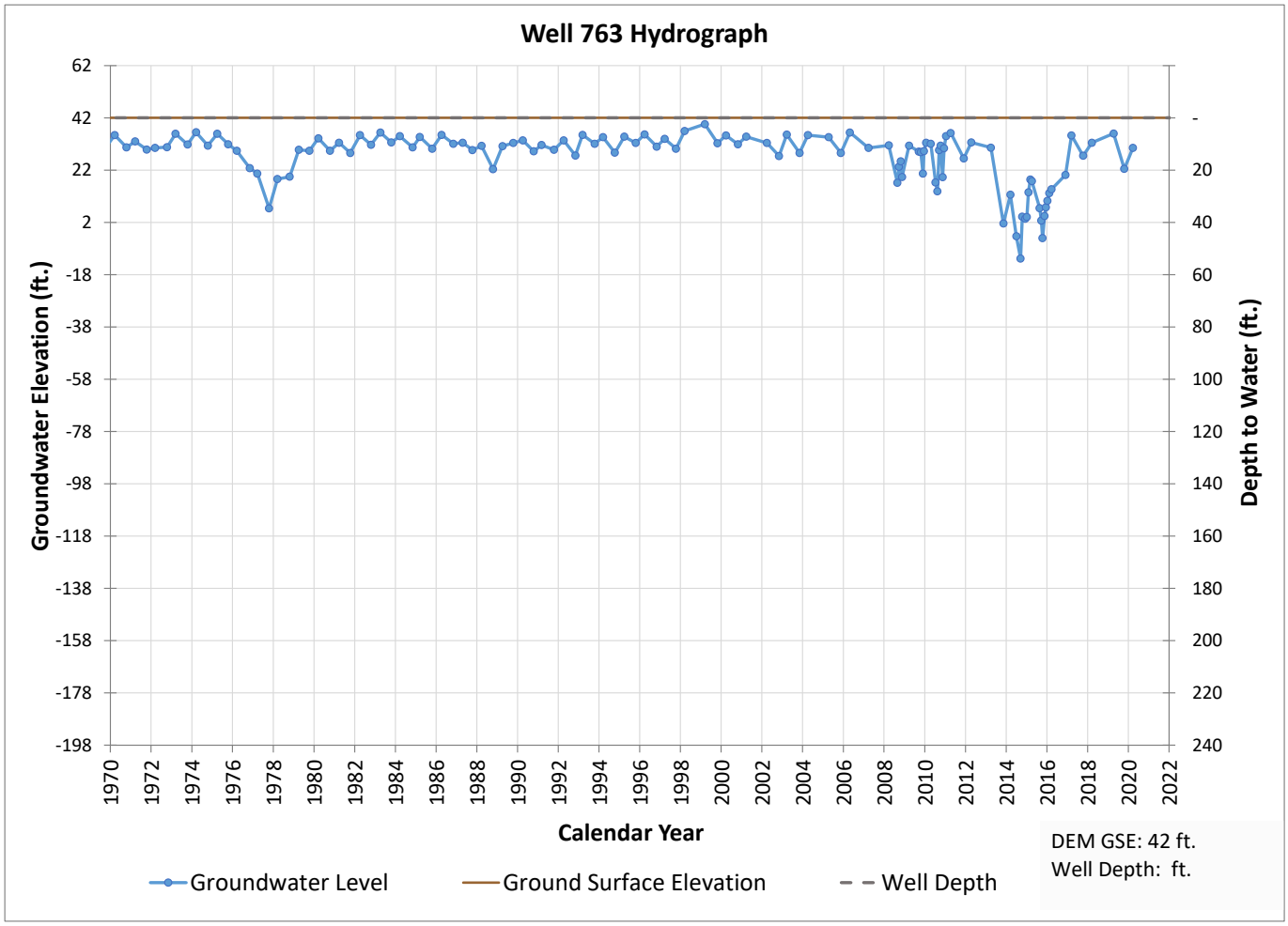

Well 752 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
126
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 106 ft.
Well Depth: 653 ft.

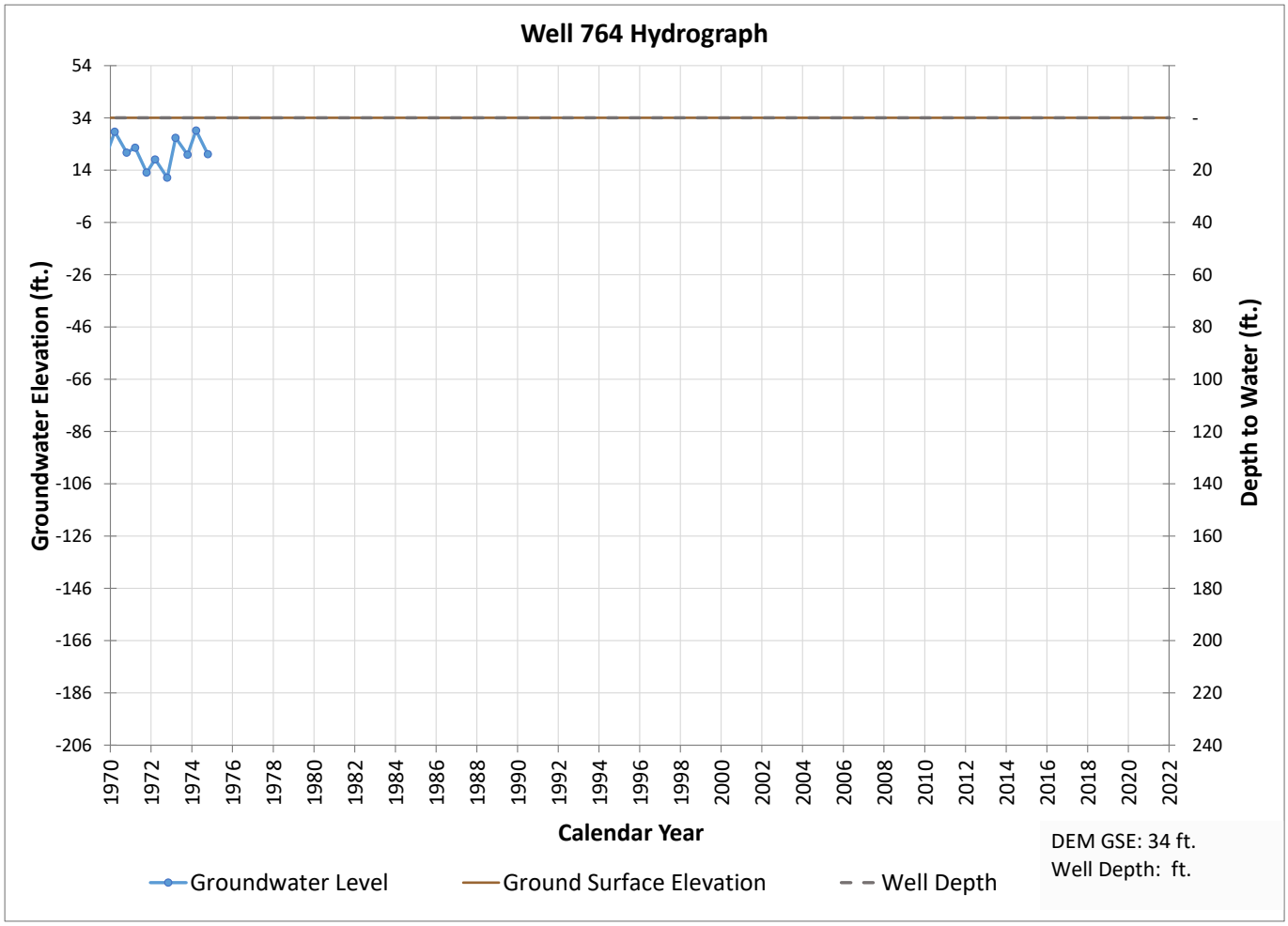

Well 753 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 115 ft.
Well Depth: 300 ft.

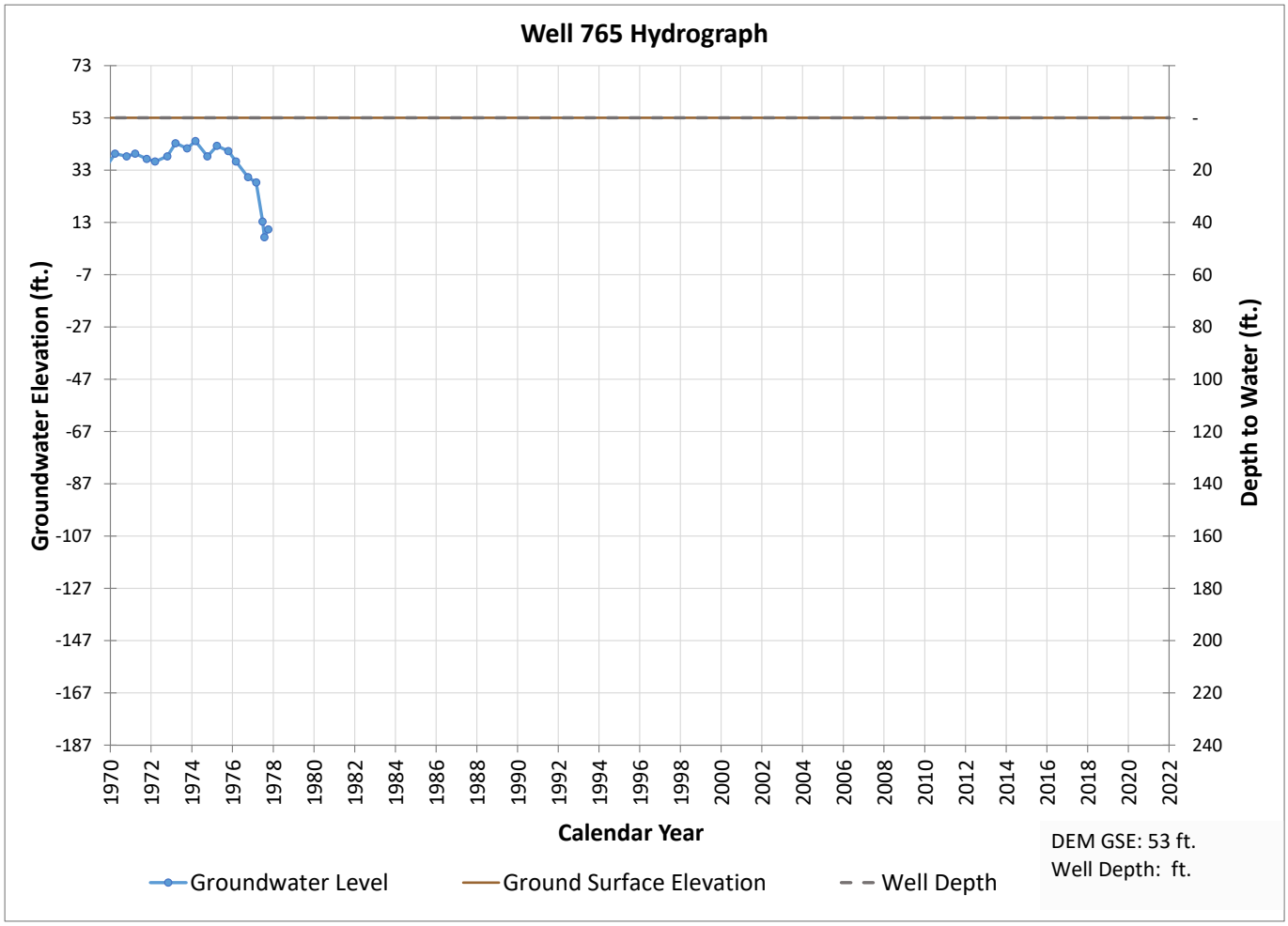

Well 757 Hydrograph
Groundwater Elevation (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: 150 ft.

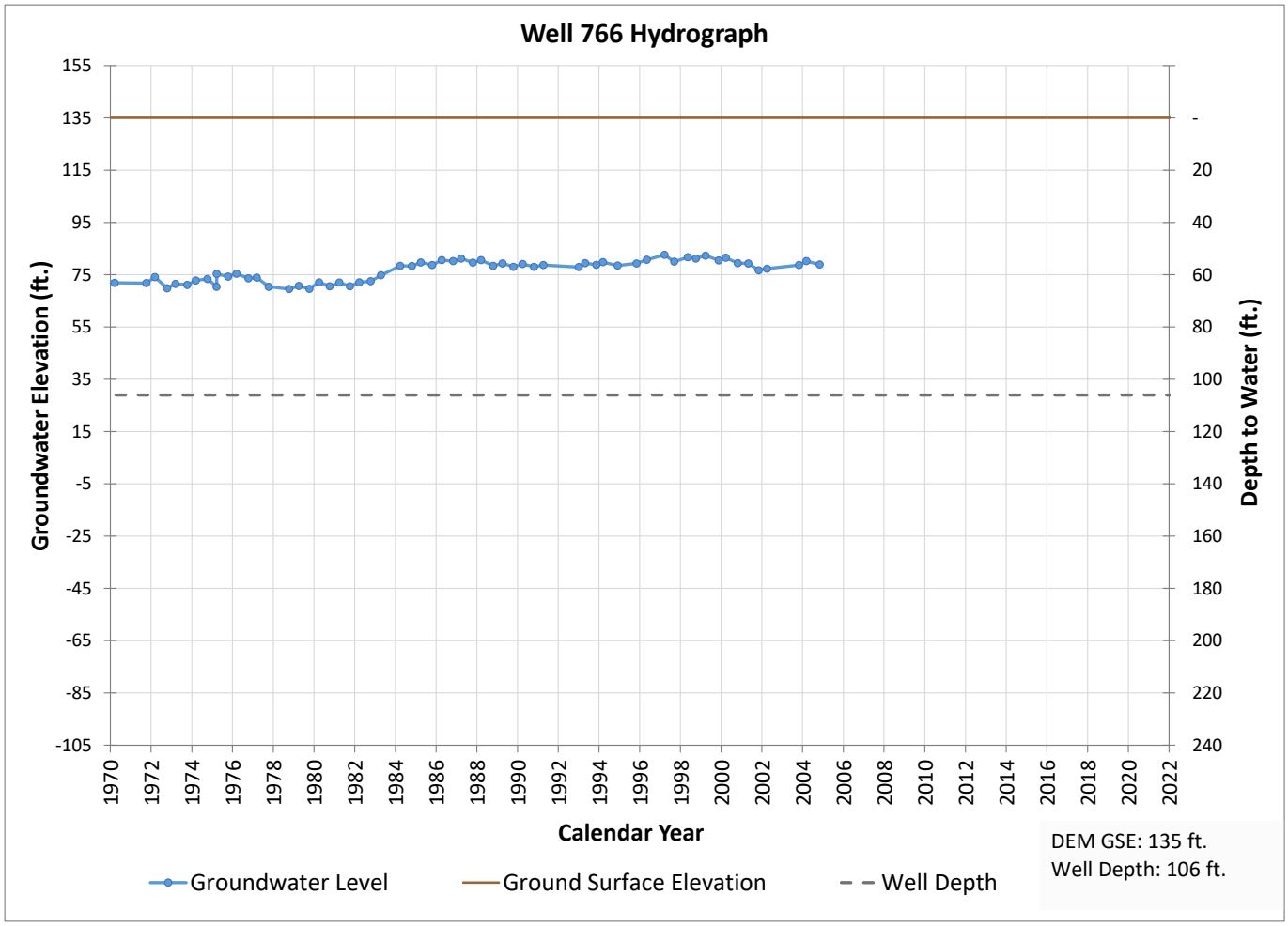

Well 760 Hydrograph
Groundwater Elevation (ft.)
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 34 ft.
Well Depth: ft.

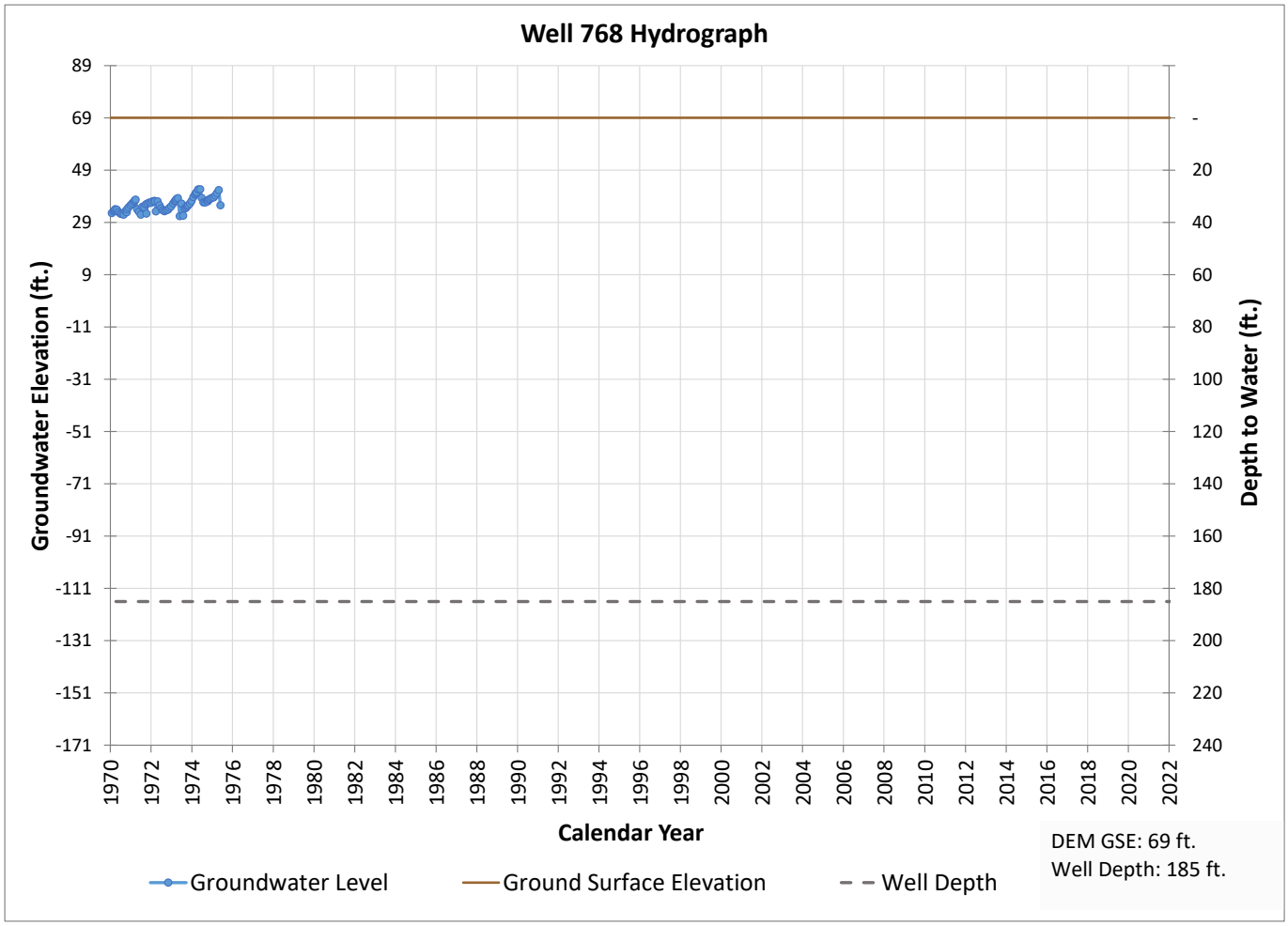

Well 761 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
202
182
162
142
122
102
82
62
42
22
2
-18
-38
-58
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 182 ft.
Well Depth: ft.

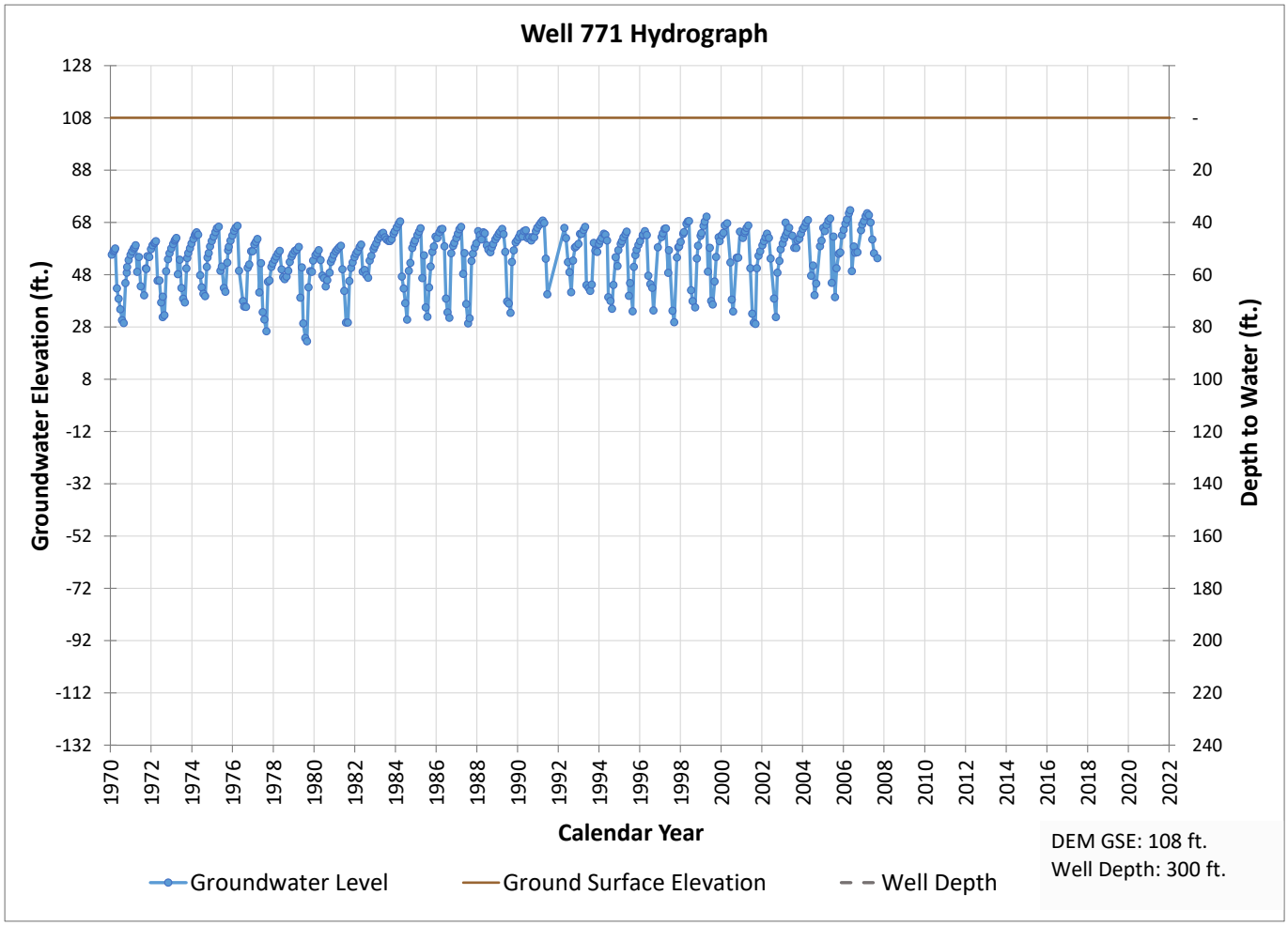

Well 763 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: ft.

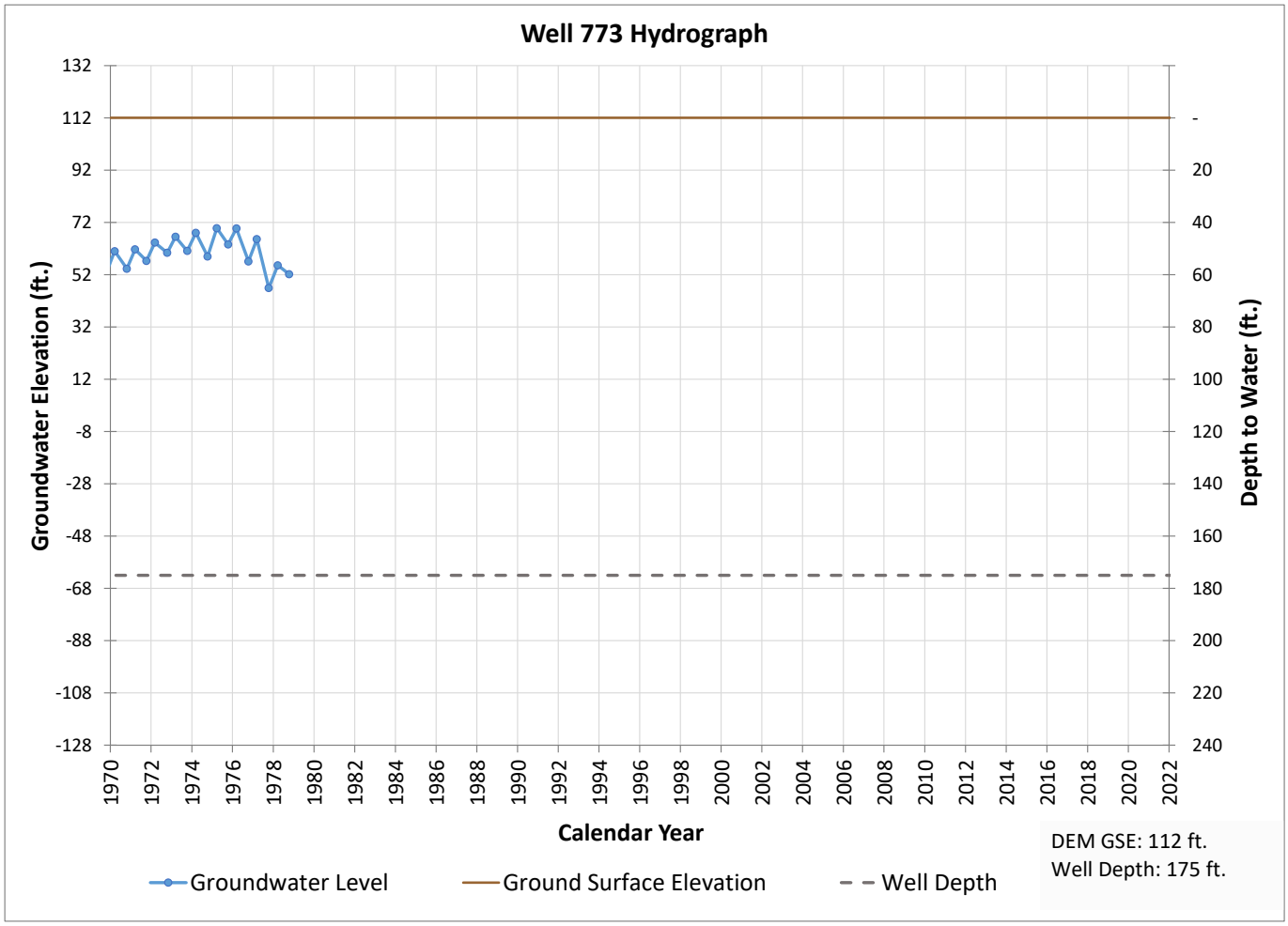

Well 764 Hydrograph
Groundwater Elevation (ft.)
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
-206
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 34 ft.
Well Depth: ft.

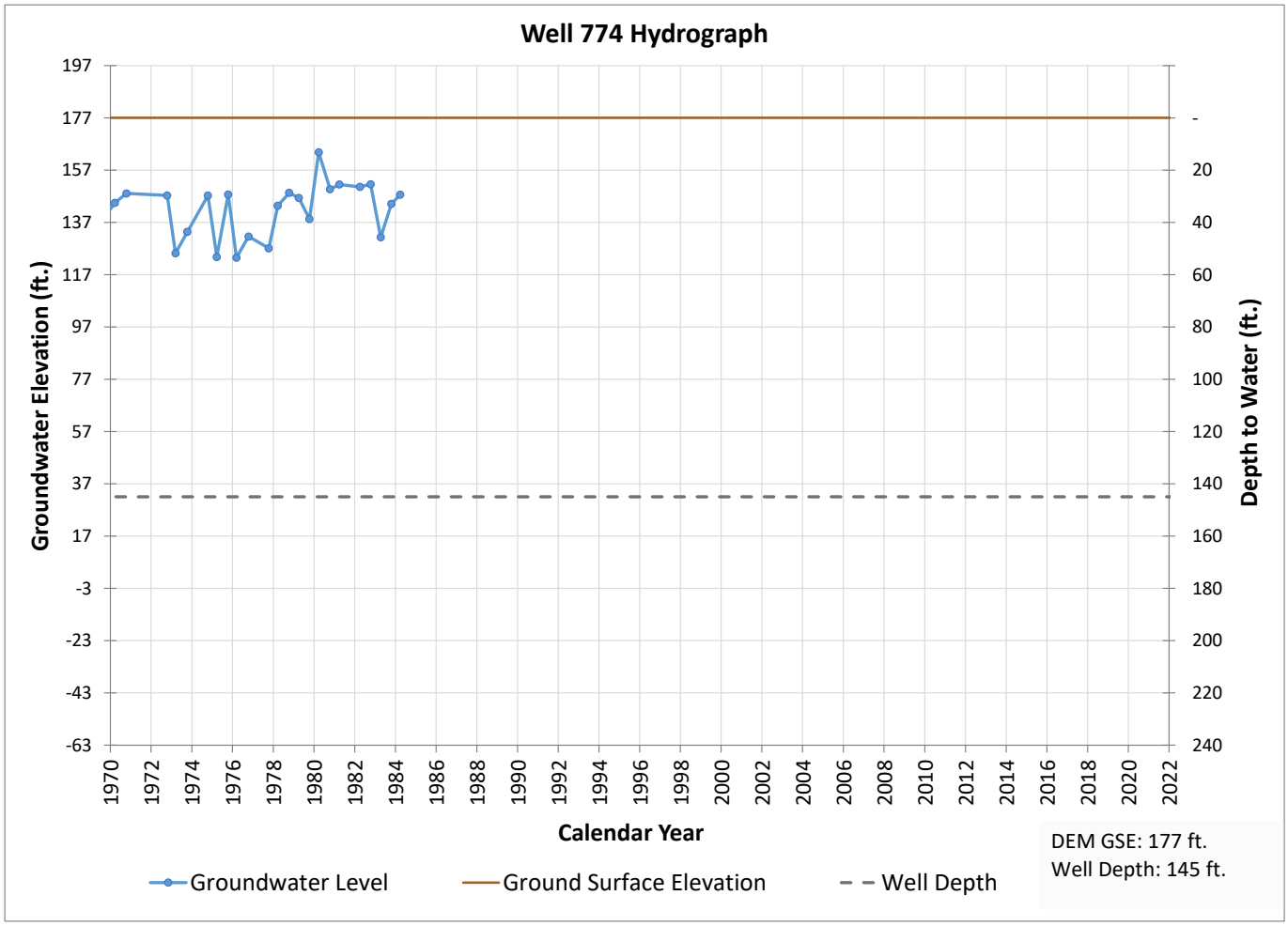

Well 765 Hydrograph
Groundwater Elevation (ft.)
73
53
33
13
-7
-27
-47
-67
-87
-107
-127
-147
-167
-187
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 53 ft.
Well Depth: ft.

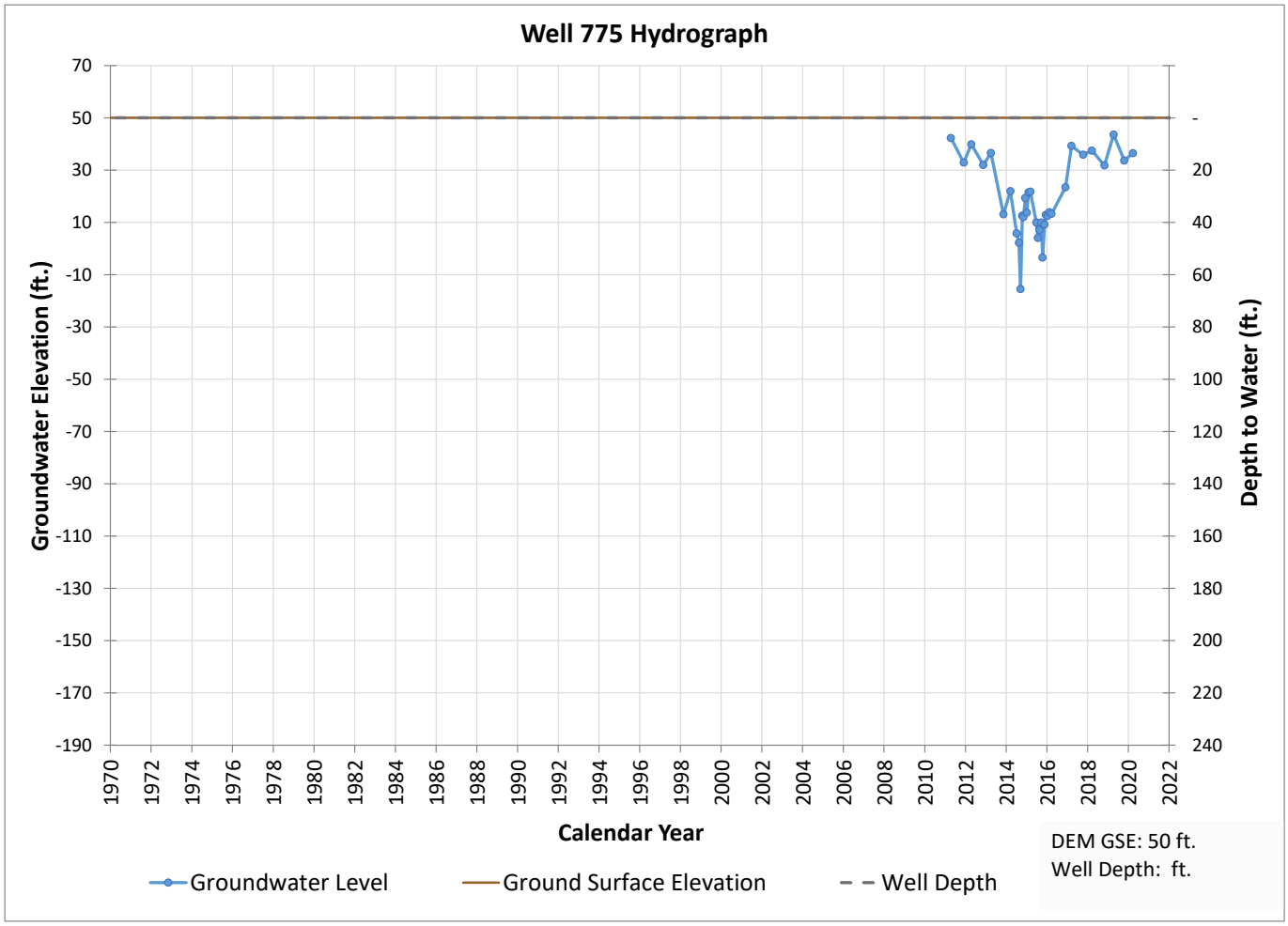

Well 766 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
155
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 135 ft.
Well Depth: 106 ft.

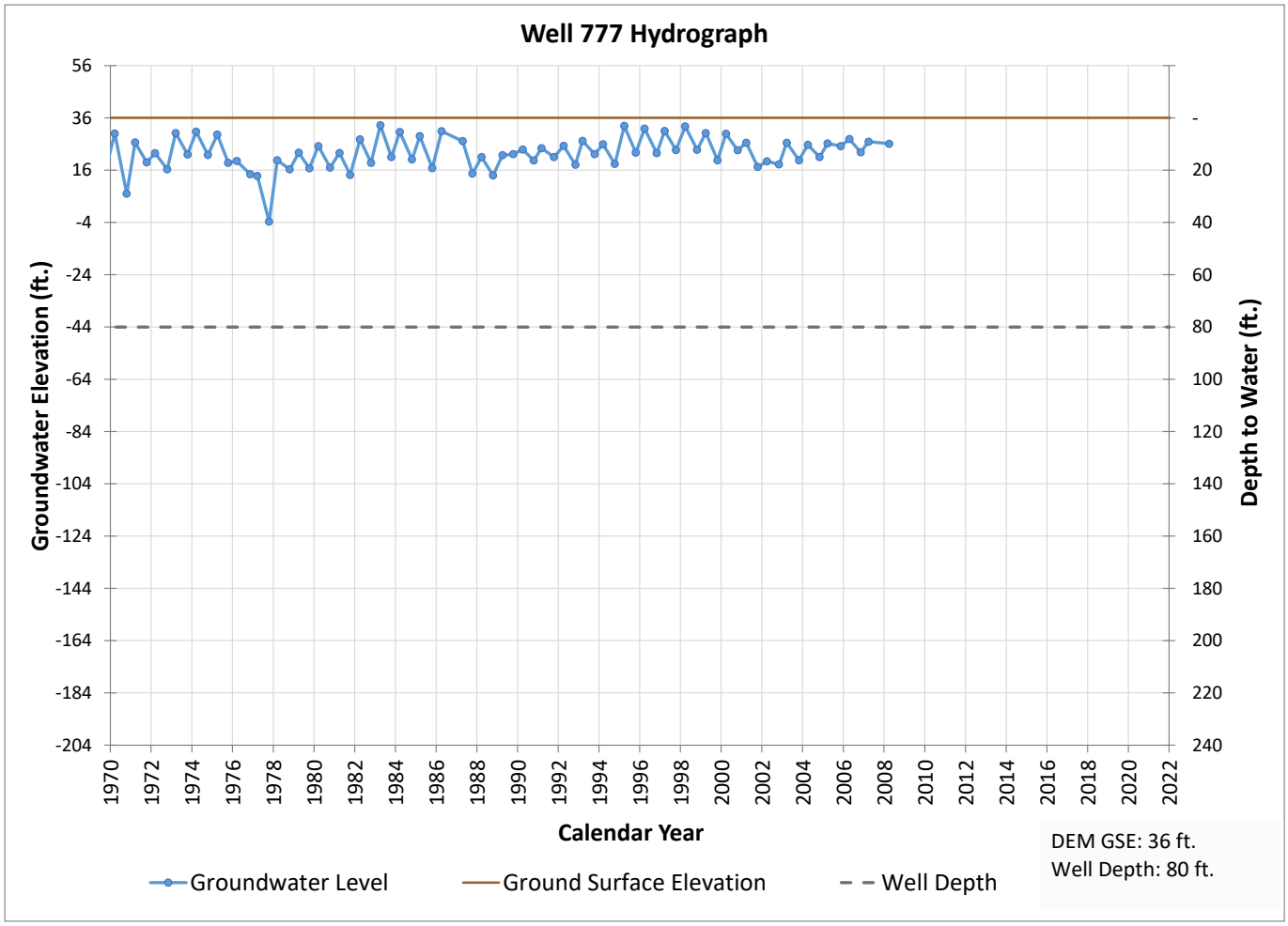

Well 768 Hydrograph
Groundwater Elevation (ft.)
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 69 ft.
Well Depth: 185 ft.

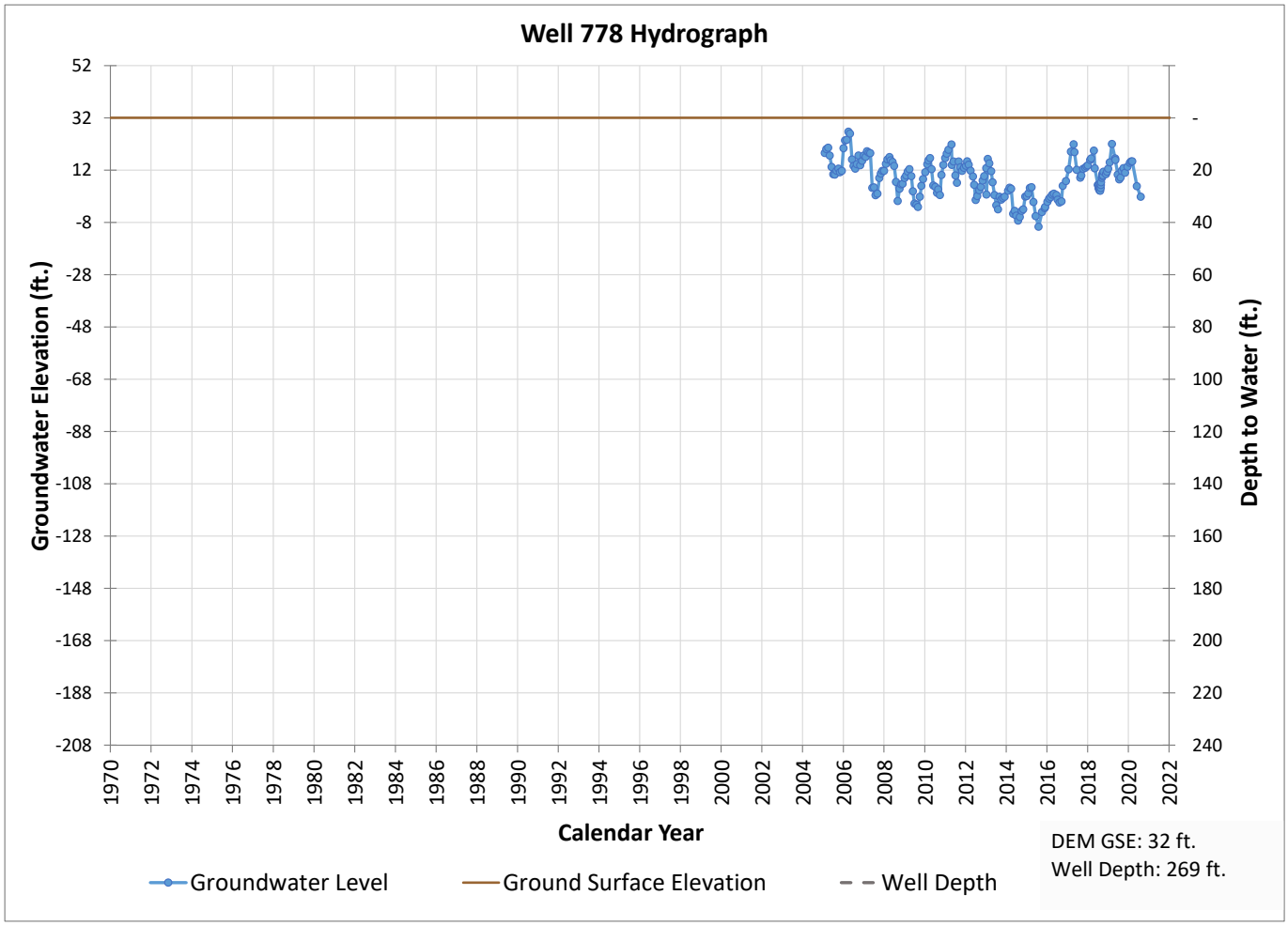

Well 771 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 108 ft.
Well Depth: 300 ft.

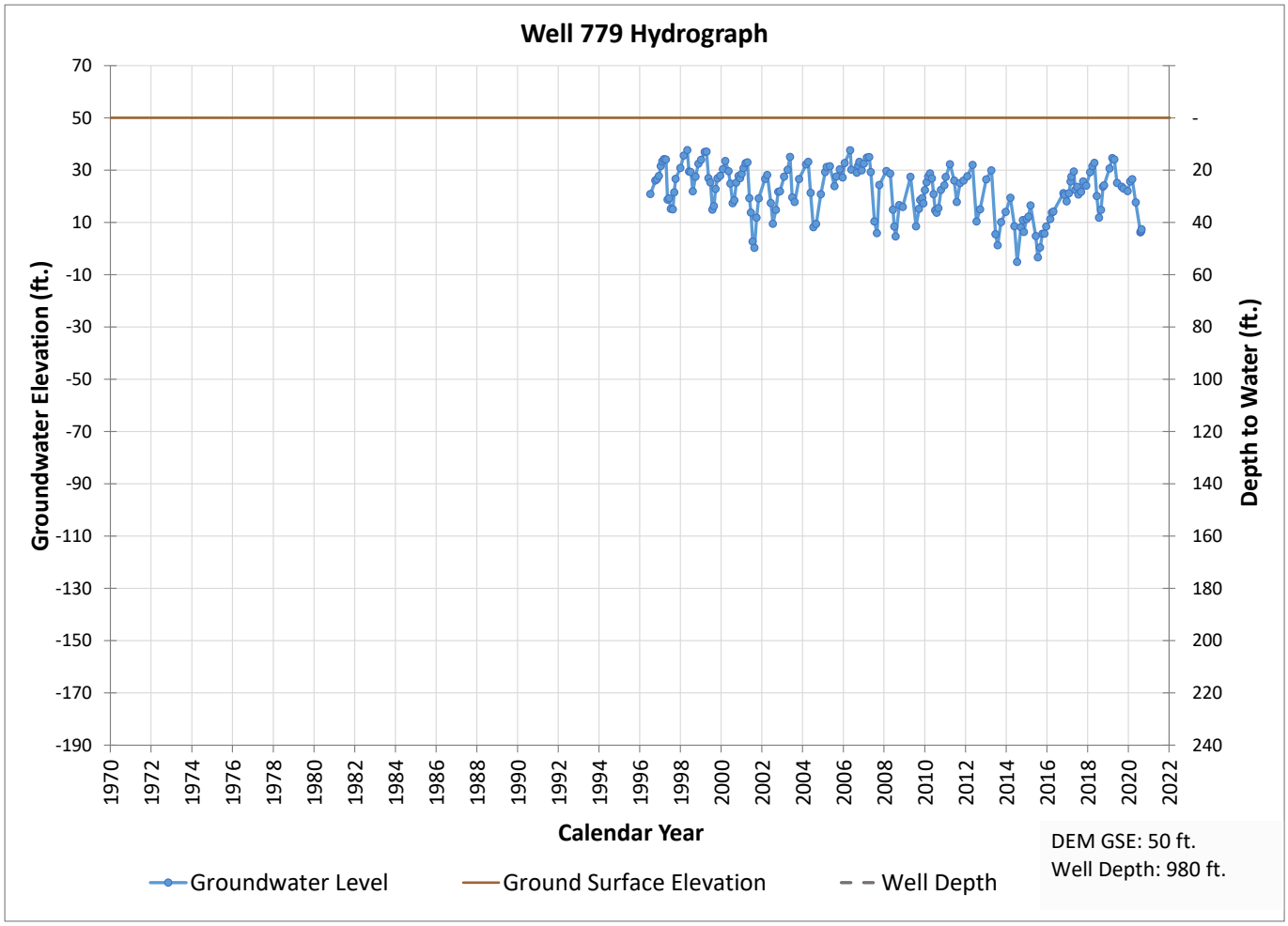

Well 773 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
132
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 112 ft.
Well Depth: 175 ft.

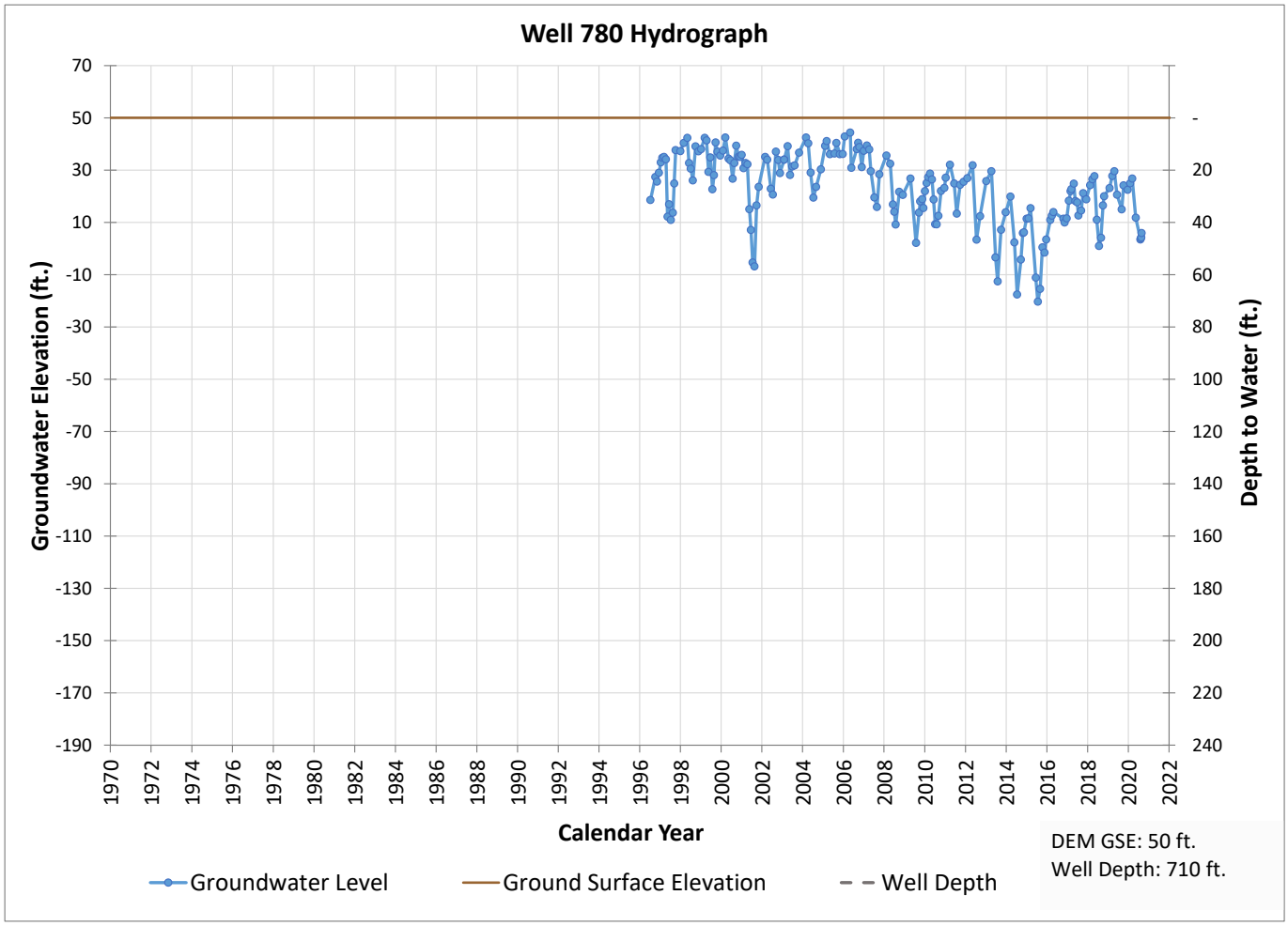

Well 774 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
197
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 177 ft.
Well Depth: 145 ft.

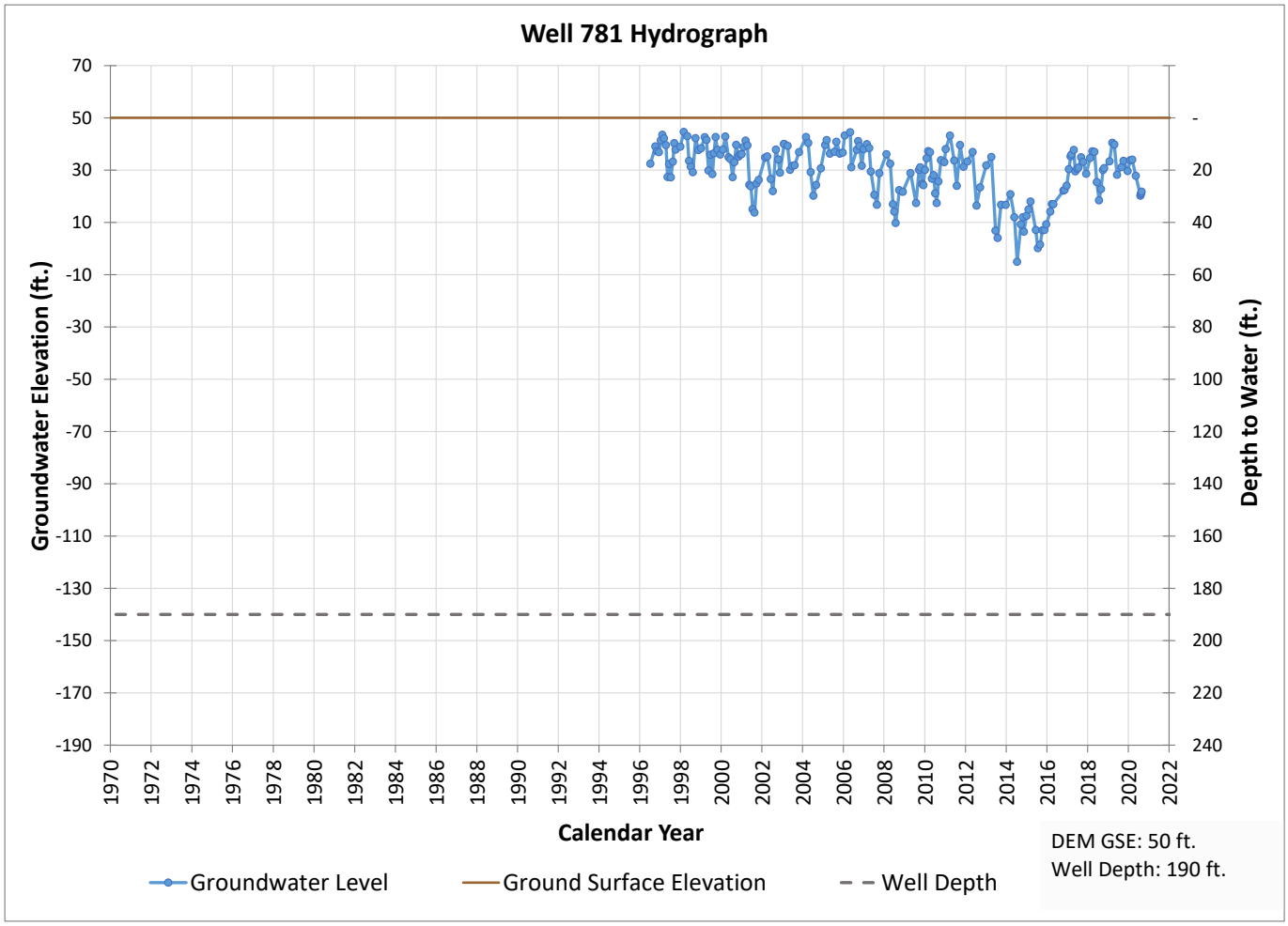

Well 775 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: ft.

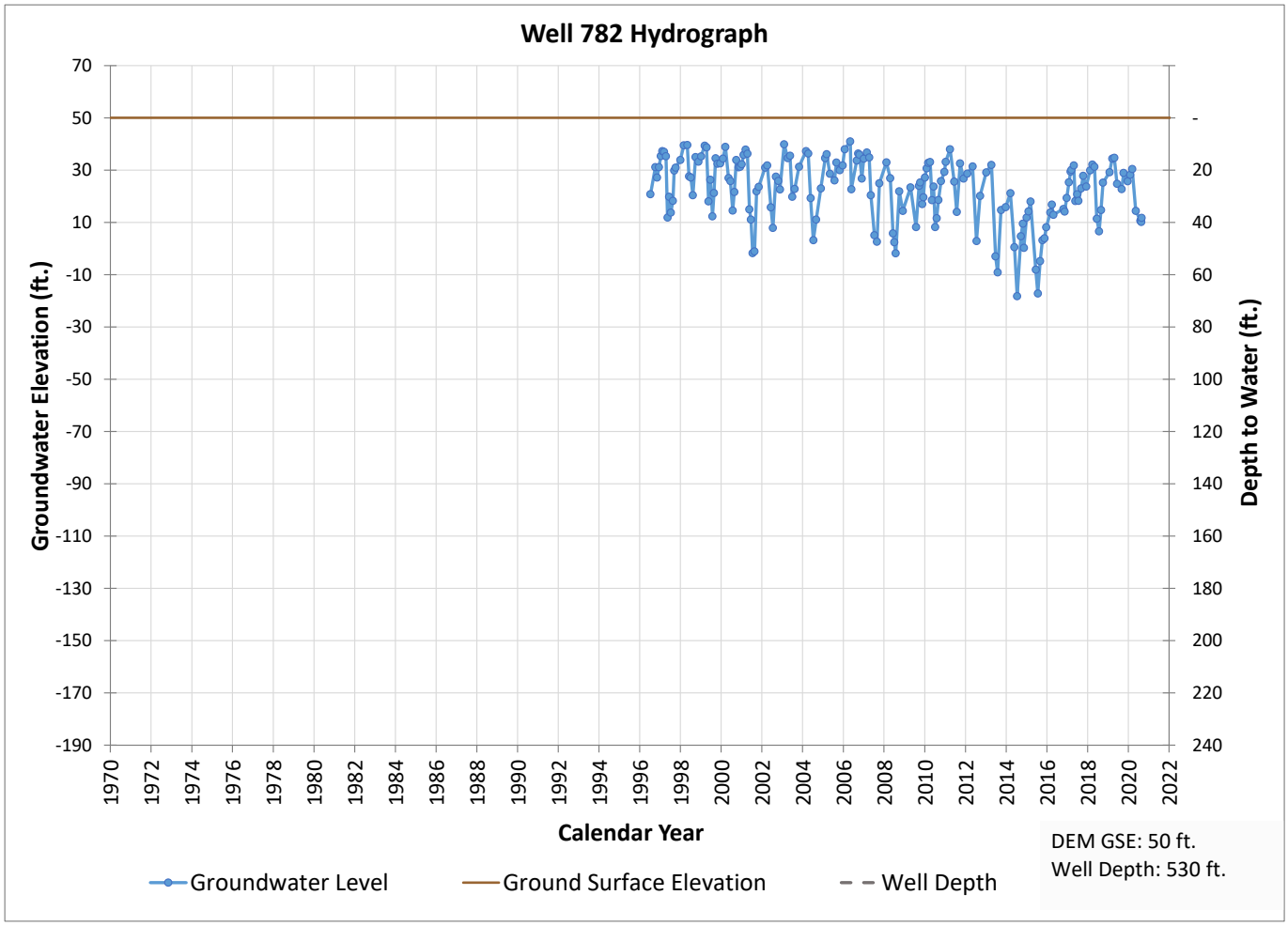

Well 777 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 36 ft.
Well Depth: 80 ft.

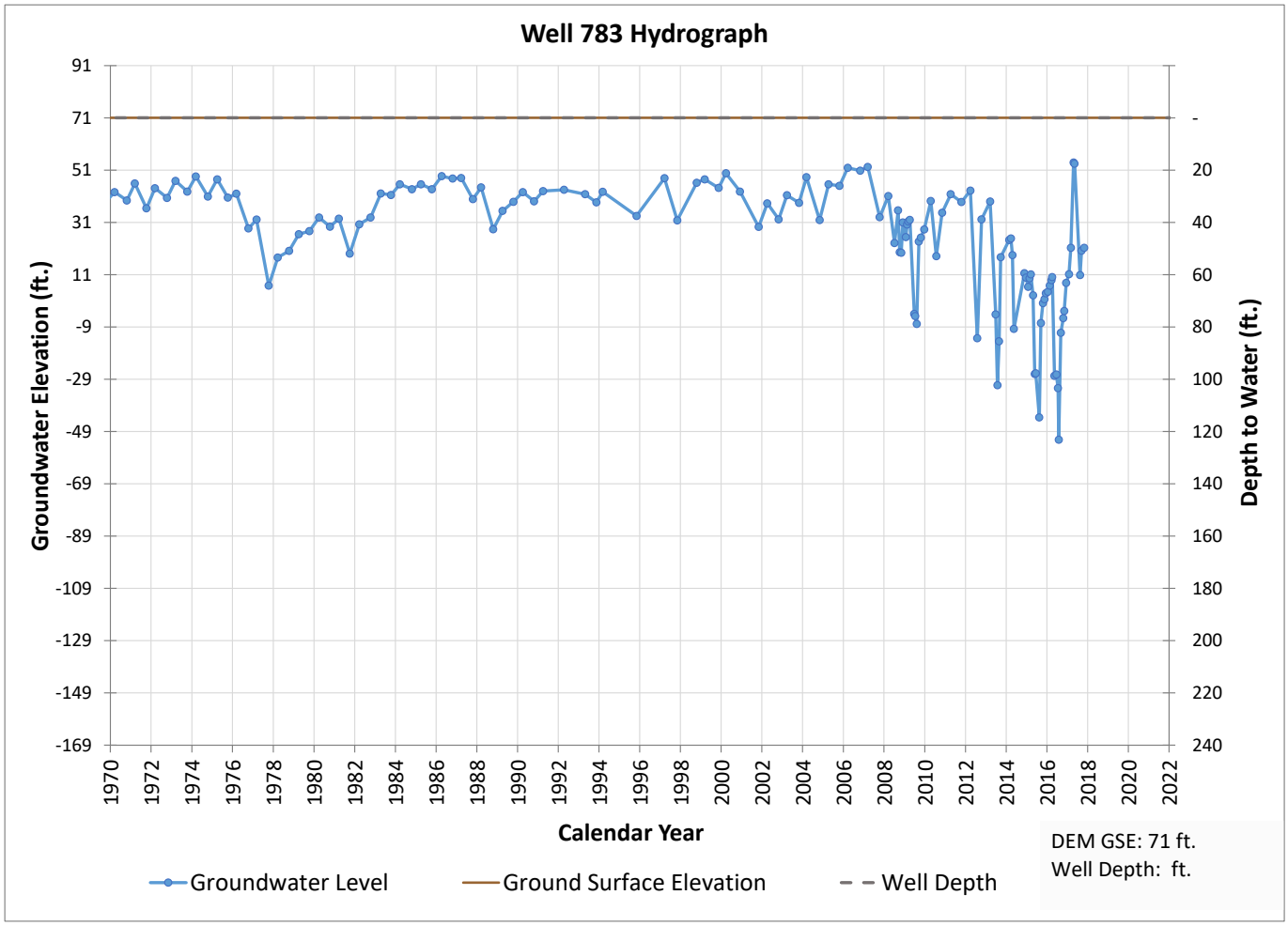

Well 778 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
-208
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 32 ft.
Well Depth: 269 ft.

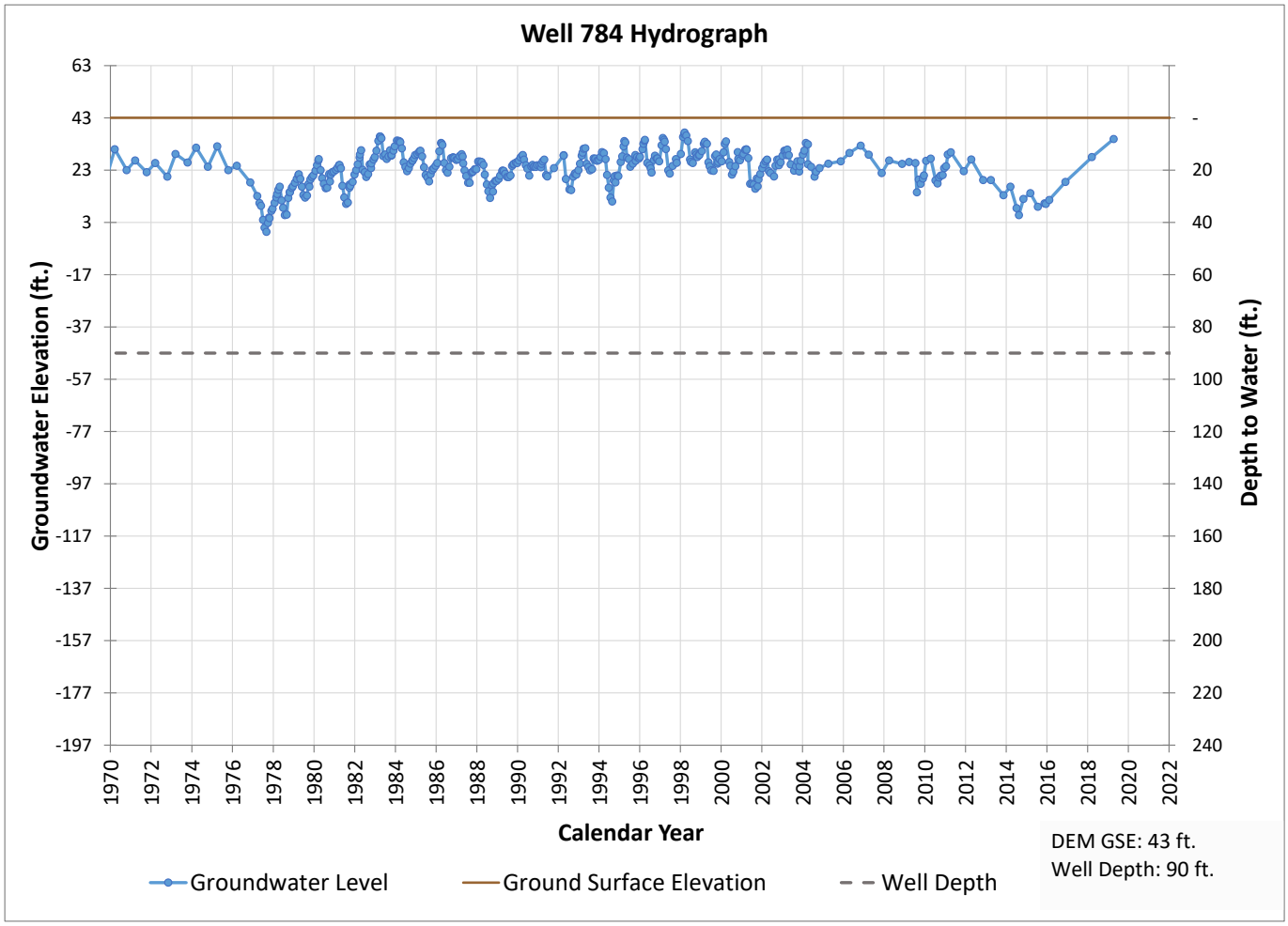

Well 779 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: 980 ft.

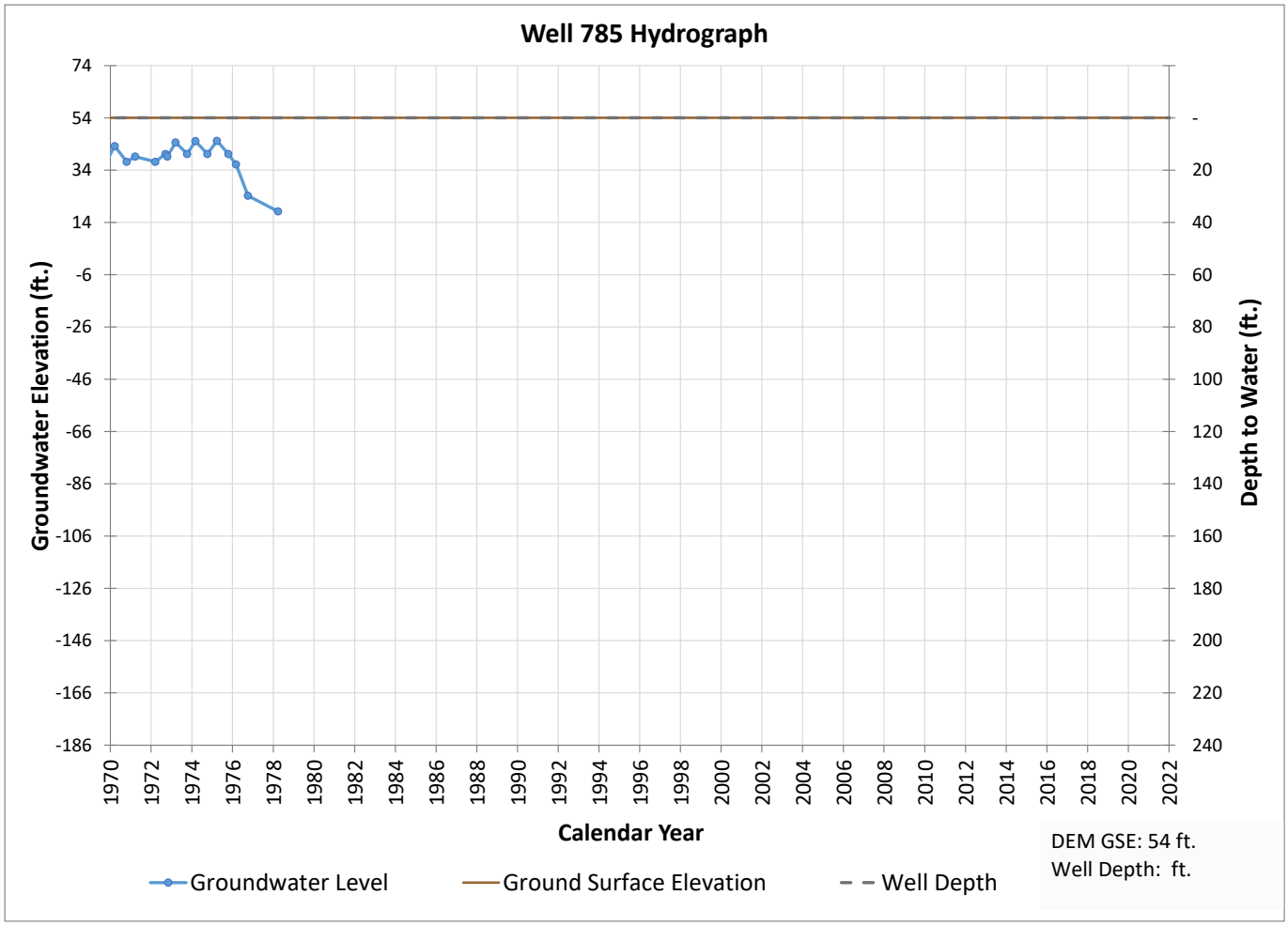

Well 780 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: 710 ft.

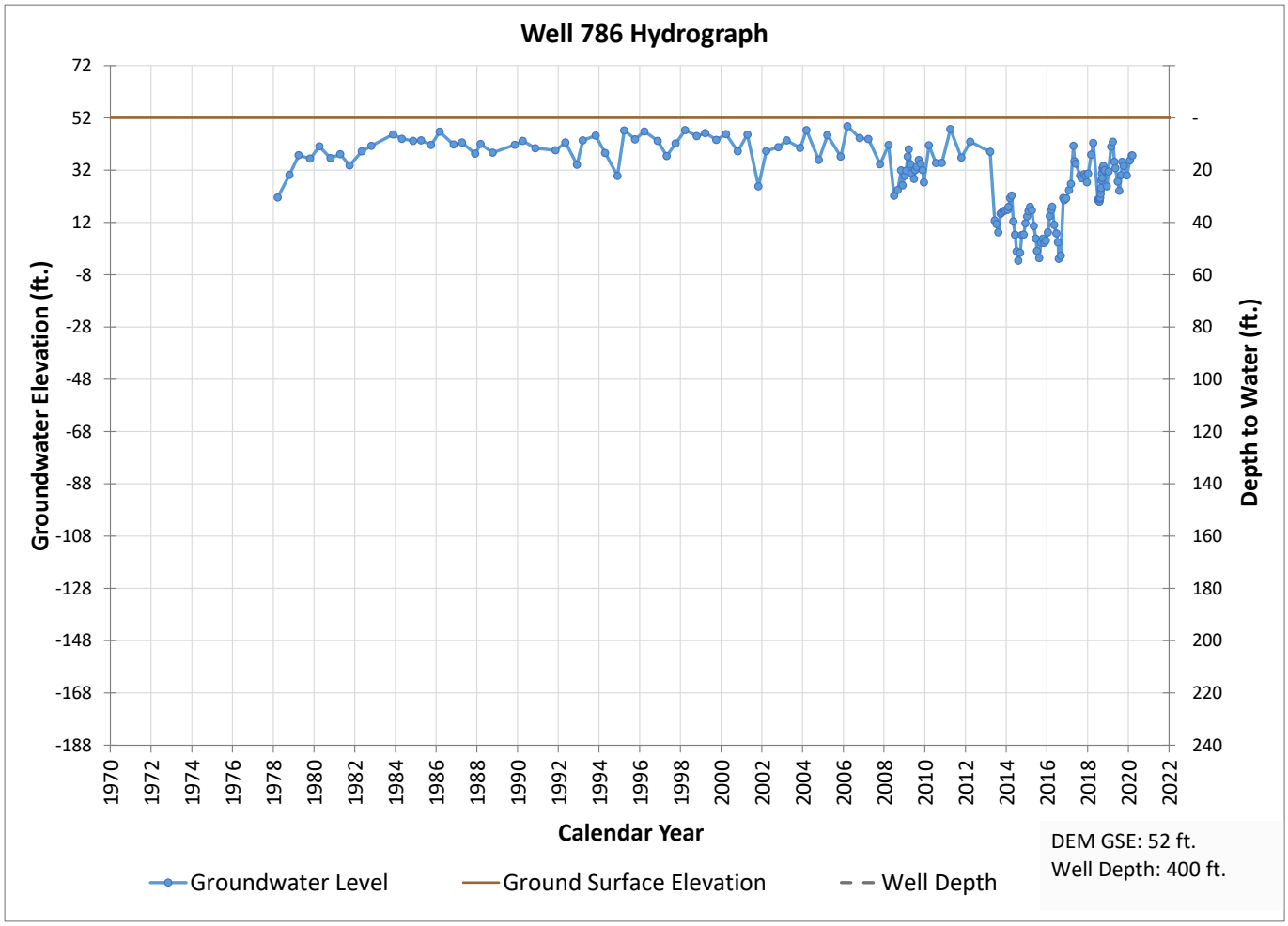

Well 781 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: 190 ft.

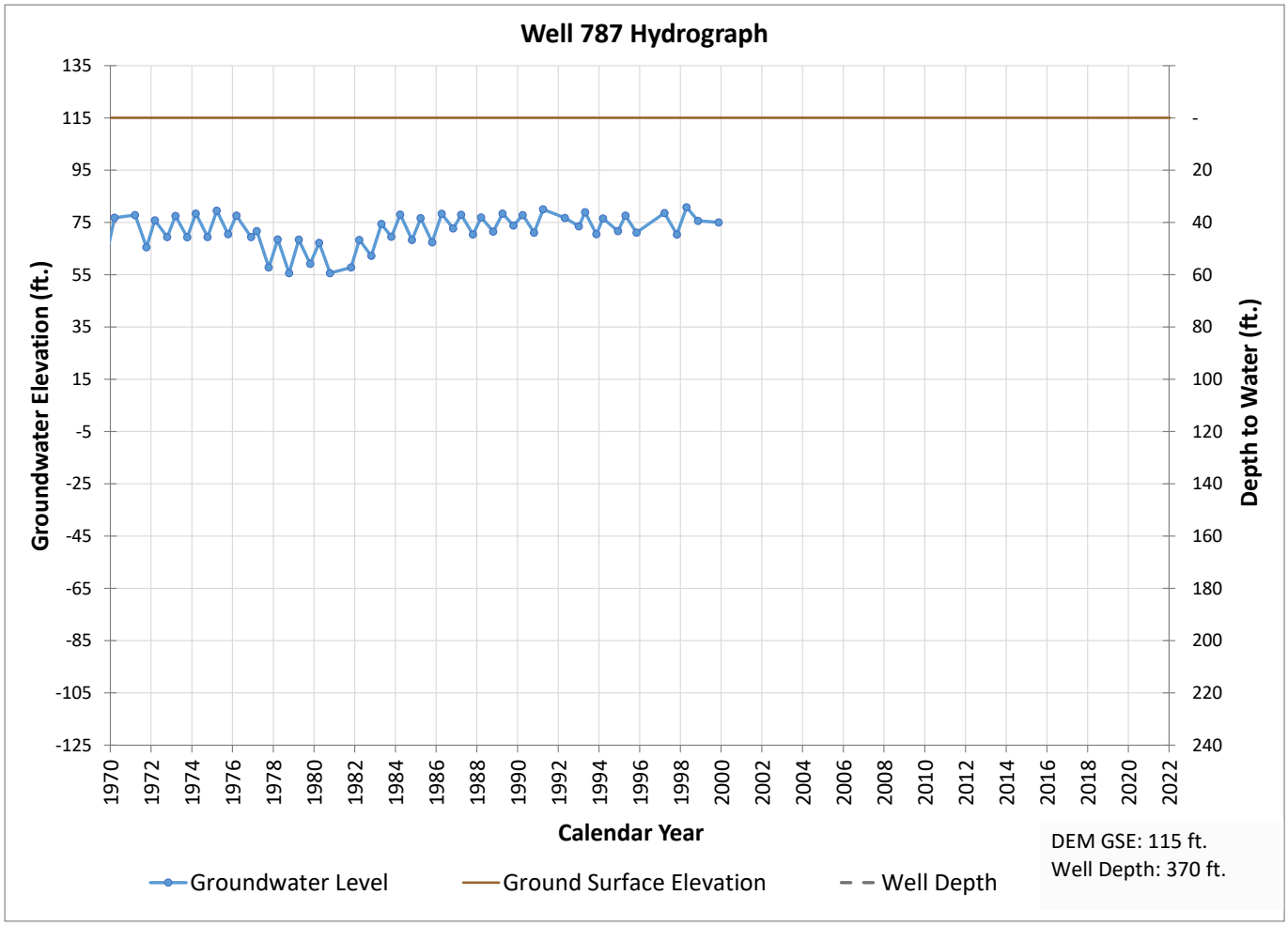

Well 782 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: 530 ft.

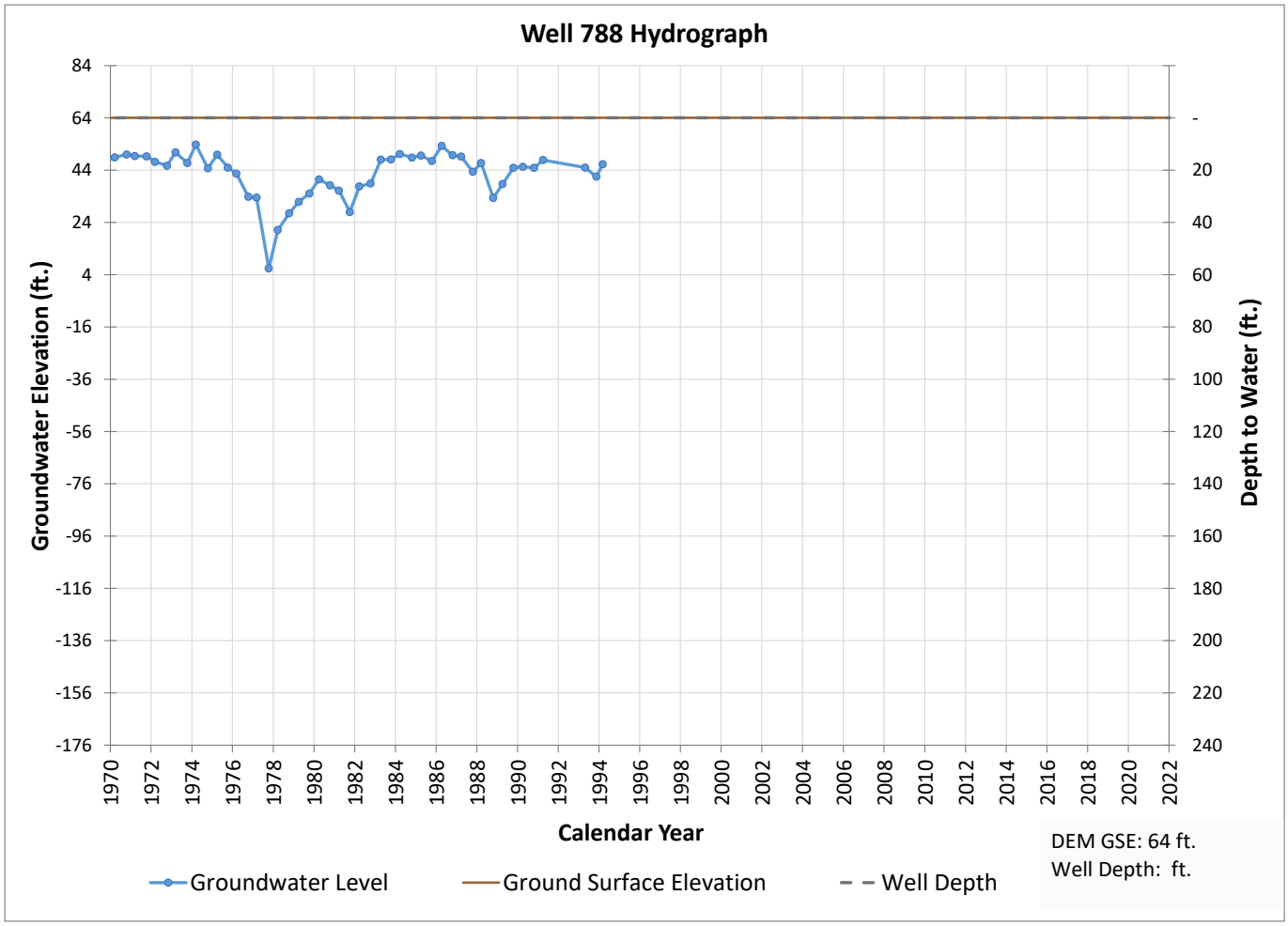

Well 783 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 71 ft.
Well Depth: ft.

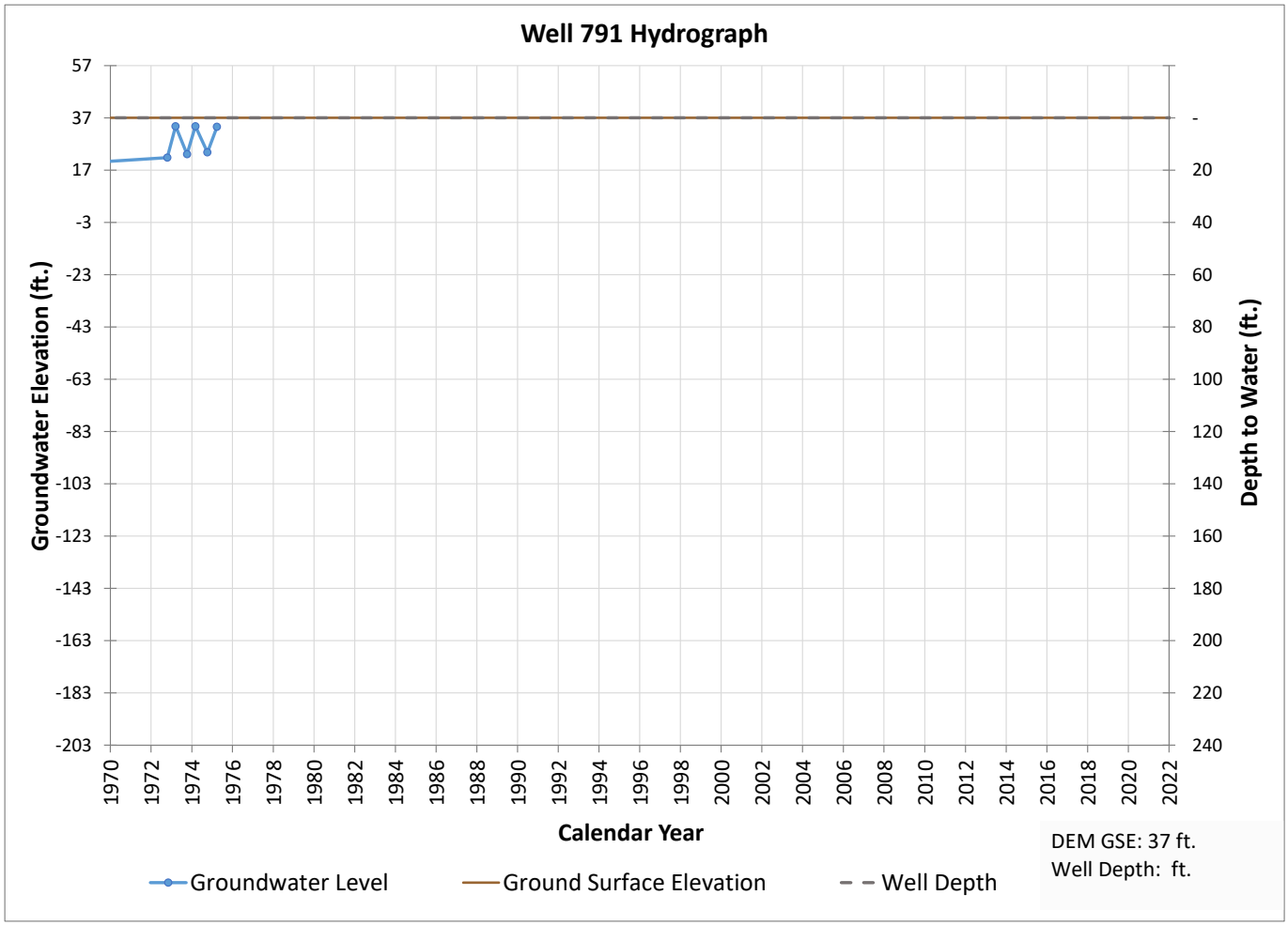

Well 784 Hydrograph
Groundwater Elevation (ft.)
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 43 ft.
Well Depth: 90 ft.

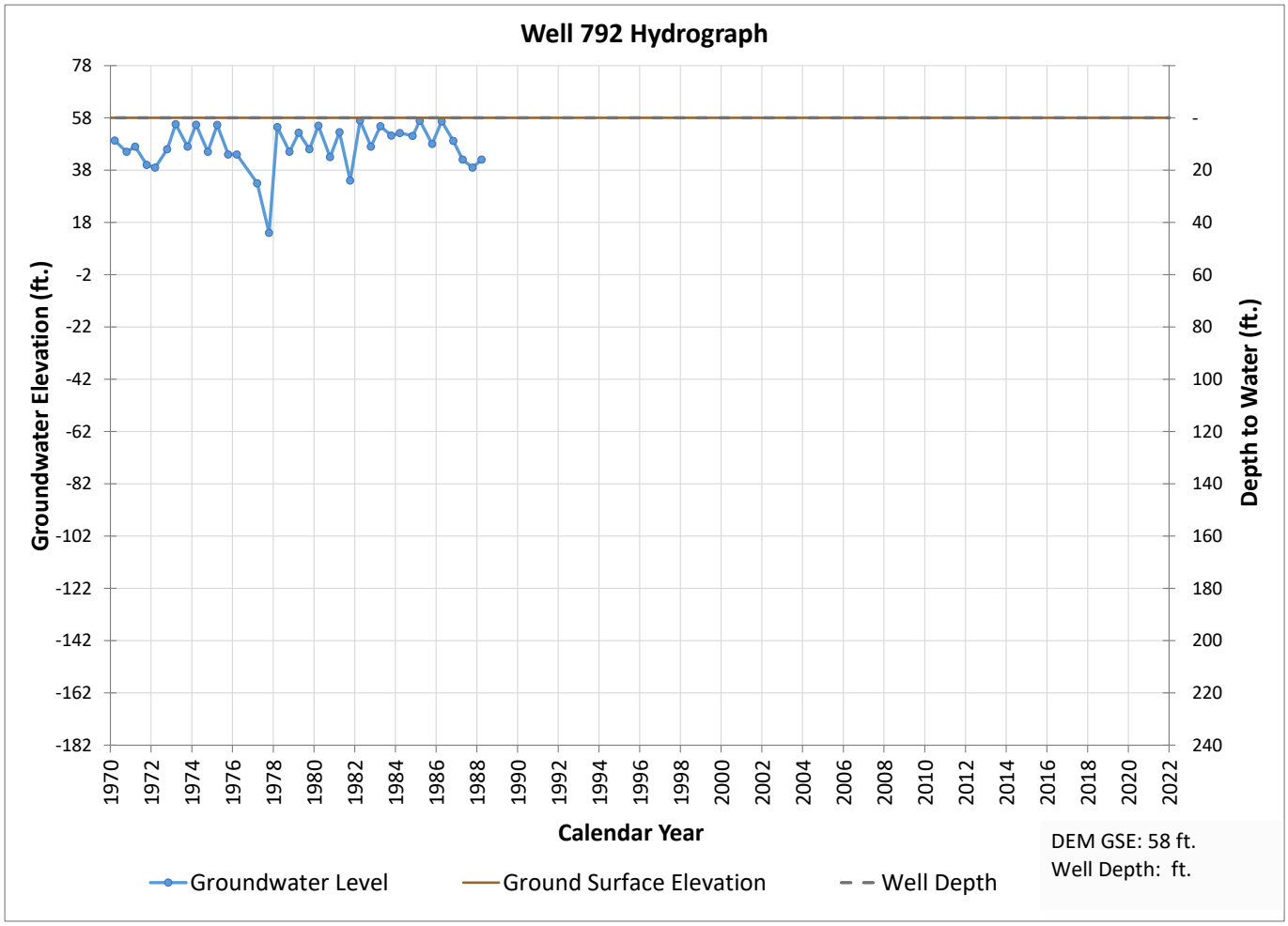

Well 785 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: ft.

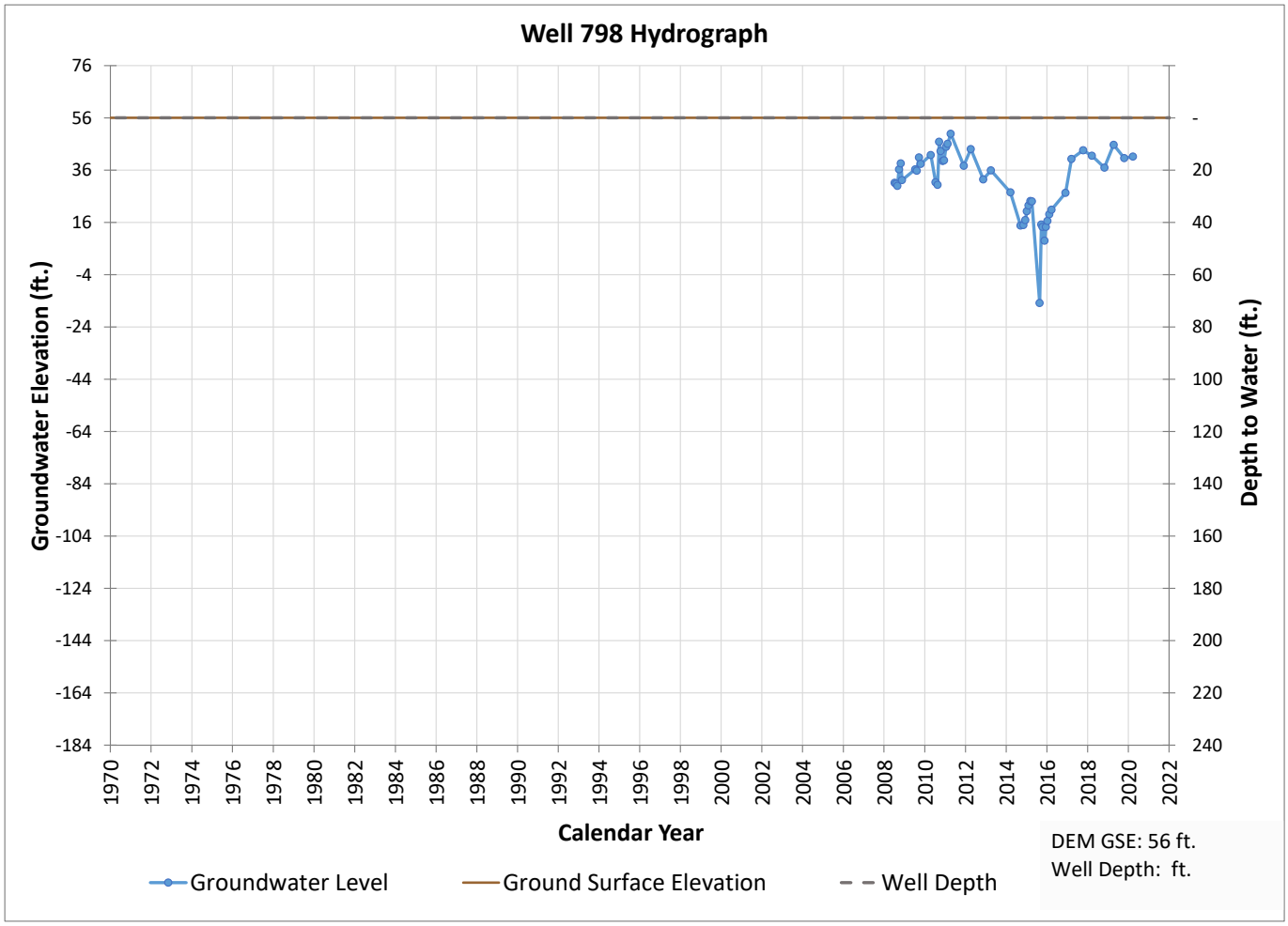

Well 786 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: 400 ft.

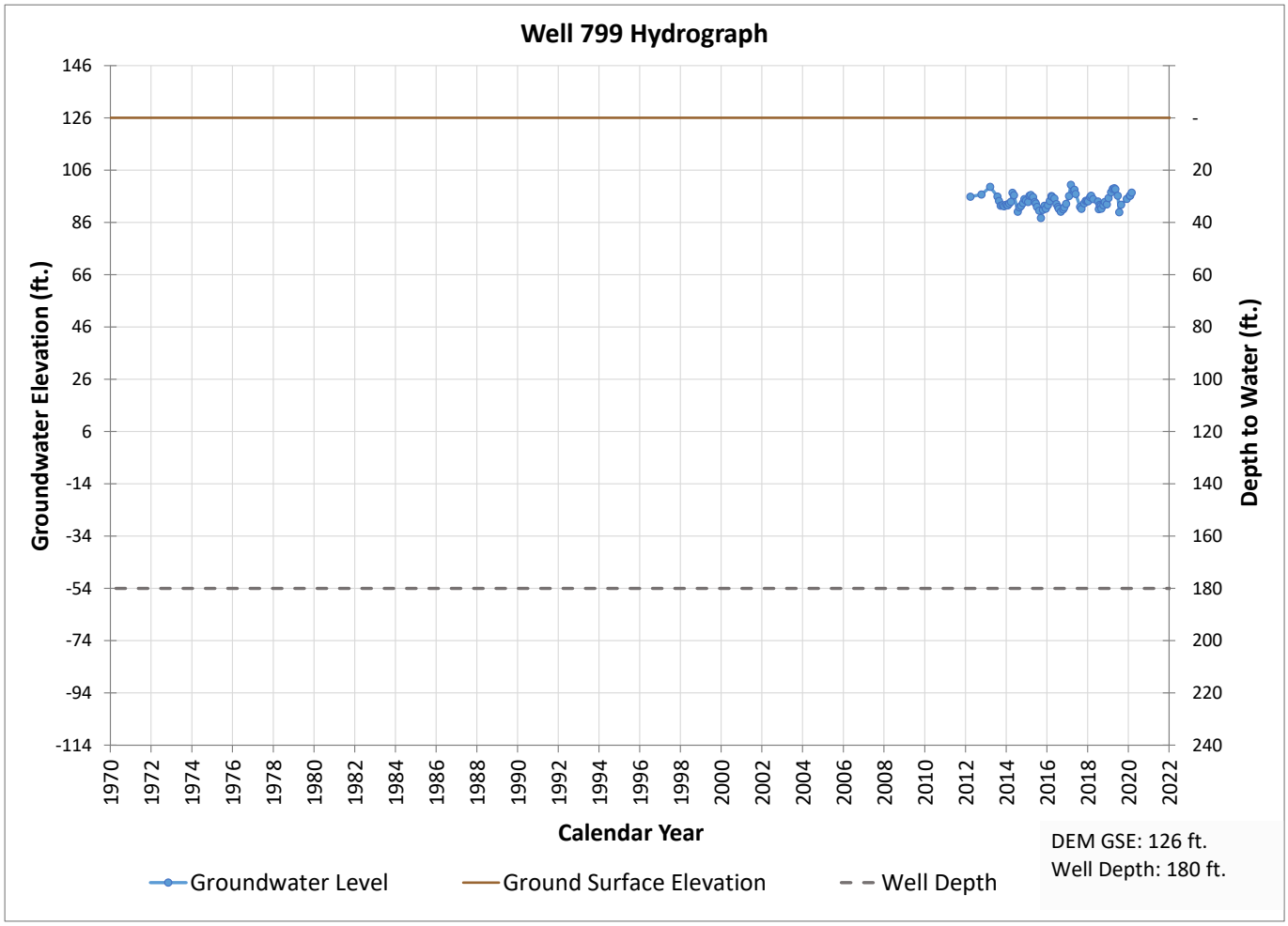

Well 787 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
135
115
95
75
55
35
15
-5
-25
-45
-65
-85
-105
-125
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 115 ft.
Well Depth: 370 ft.

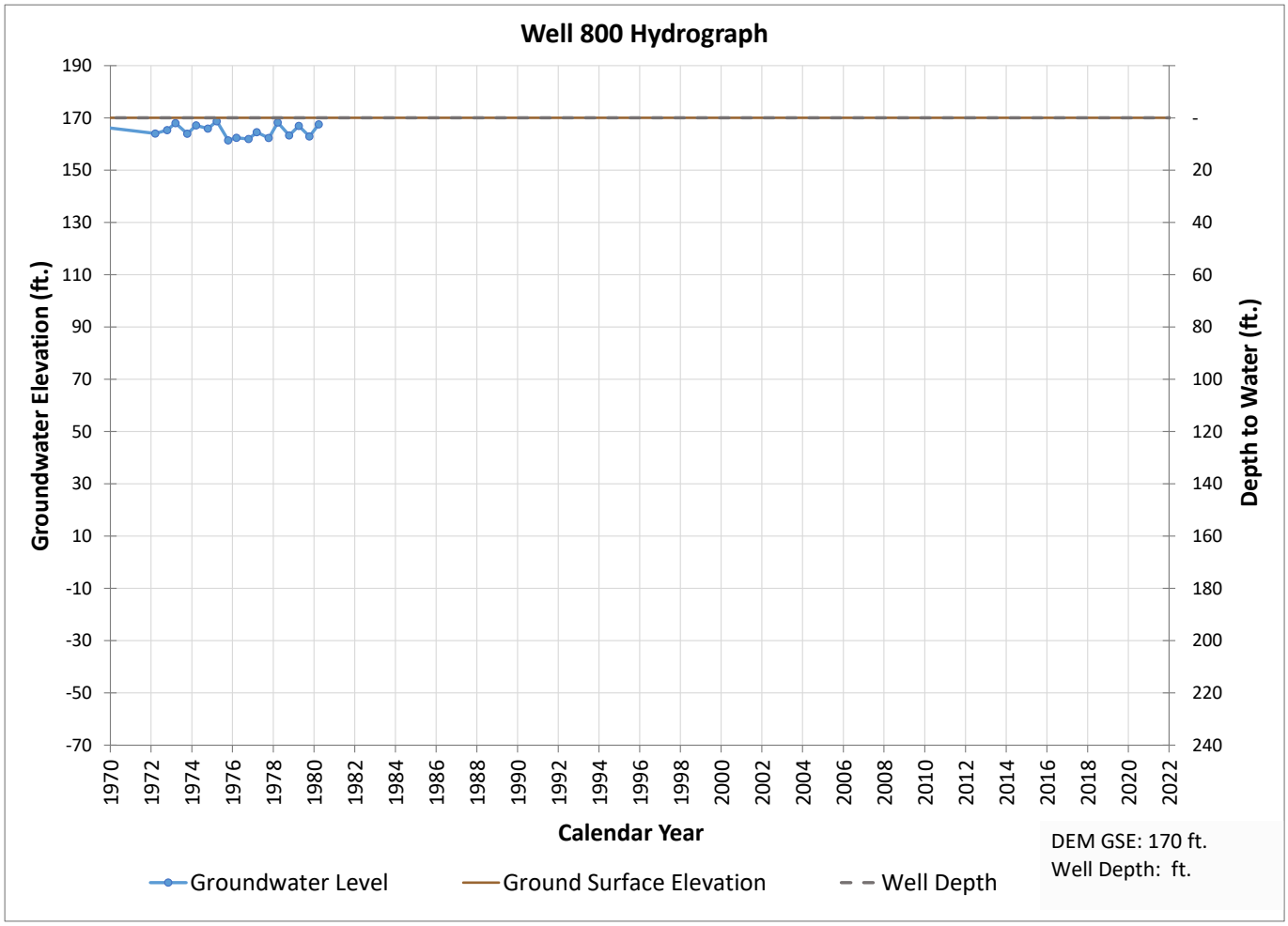

Well 788 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 64 ft.
Well Depth: ft.

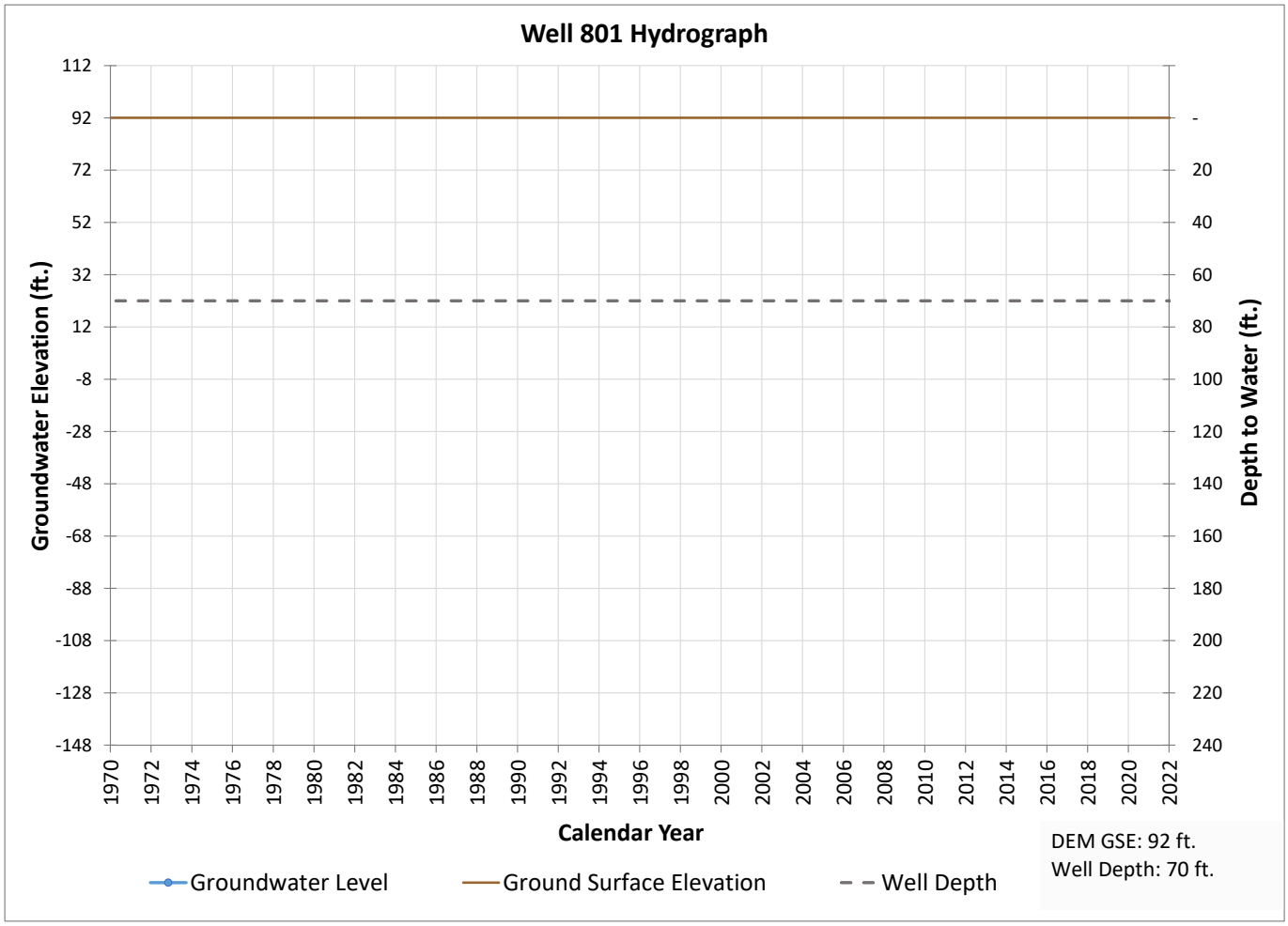

Well 791 Hydrograph
Groundwater Elevation (ft.)
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
-203
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 37 ft.
Well Depth: ft.

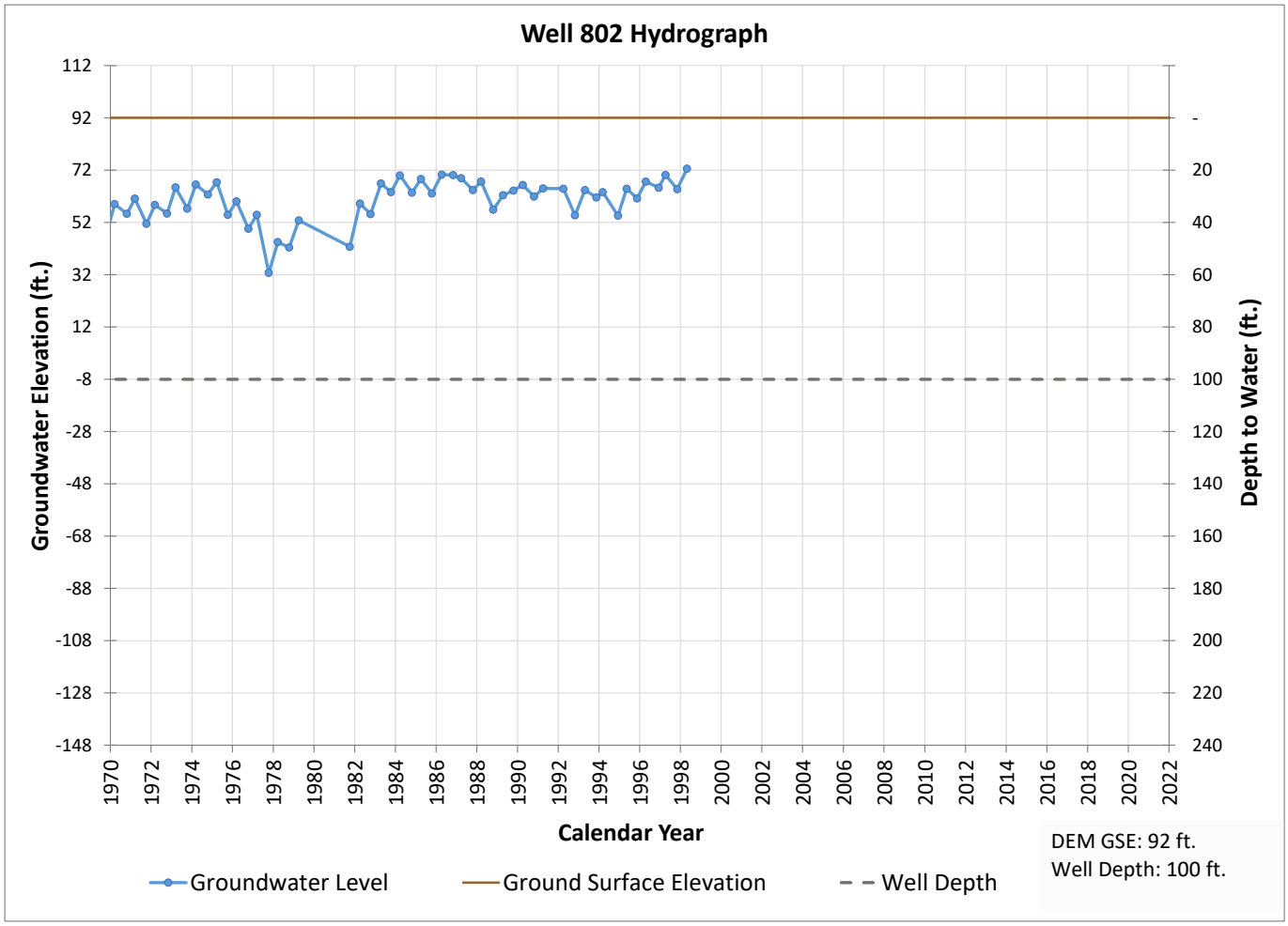

Well 792 Hydrograph
Groundwater Elevation (ft.)
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-162
-182
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 58 ft.
Well Depth: ft.

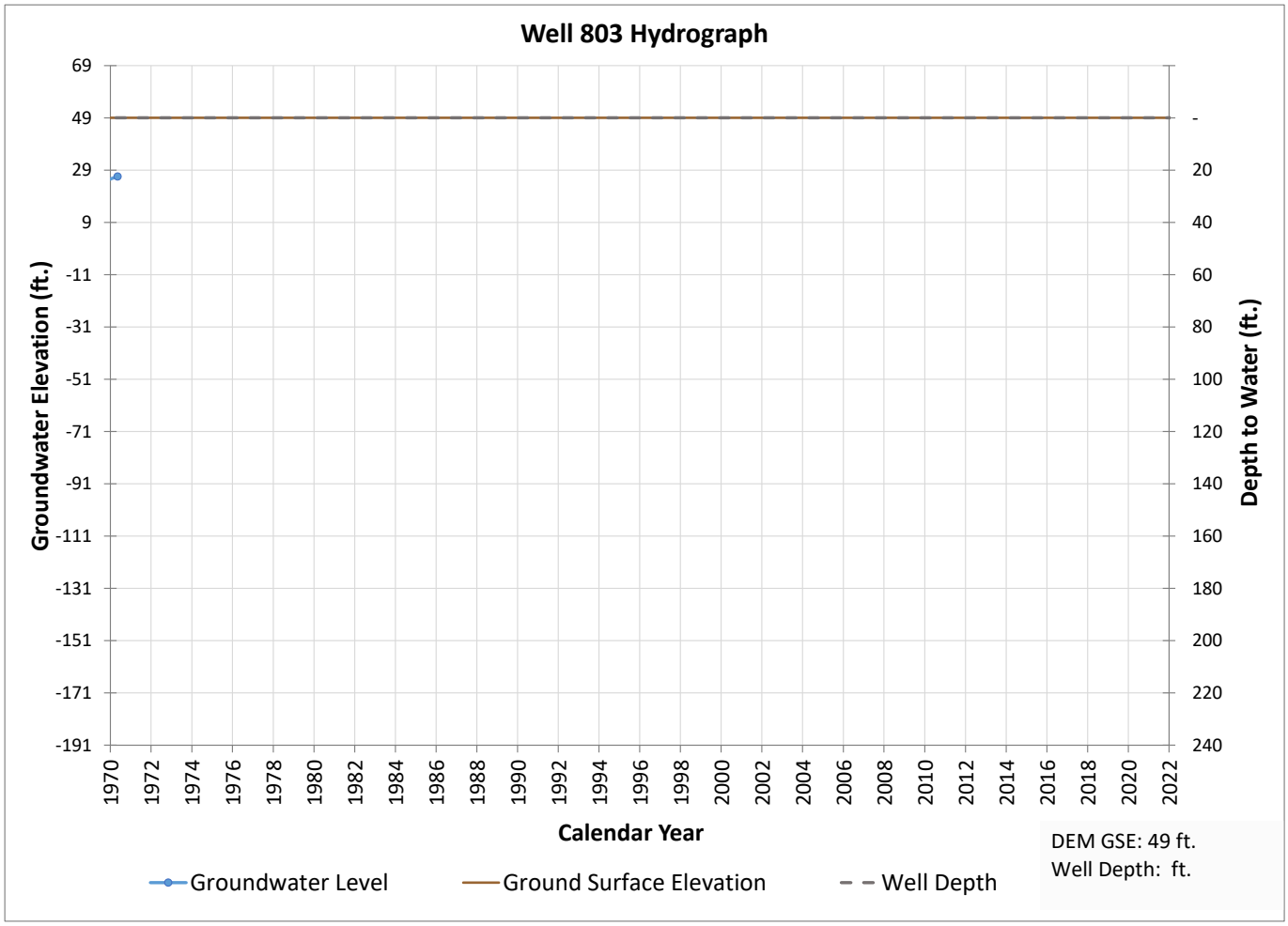

Well 798 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
76
56
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 56 ft.
Well Depth: ft.

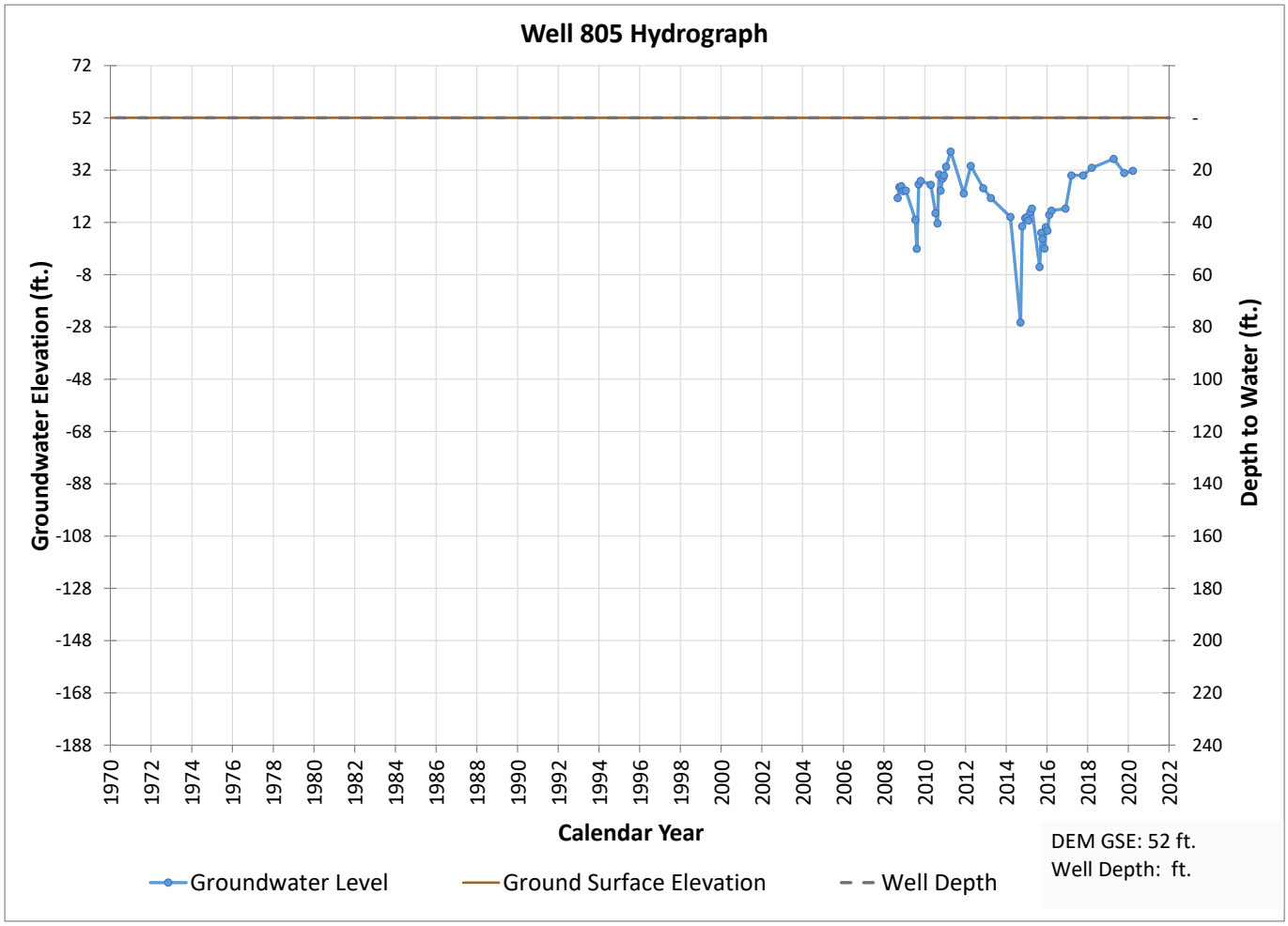

Well 799 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
146
126
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 126 ft.
Well Depth: 180 ft.

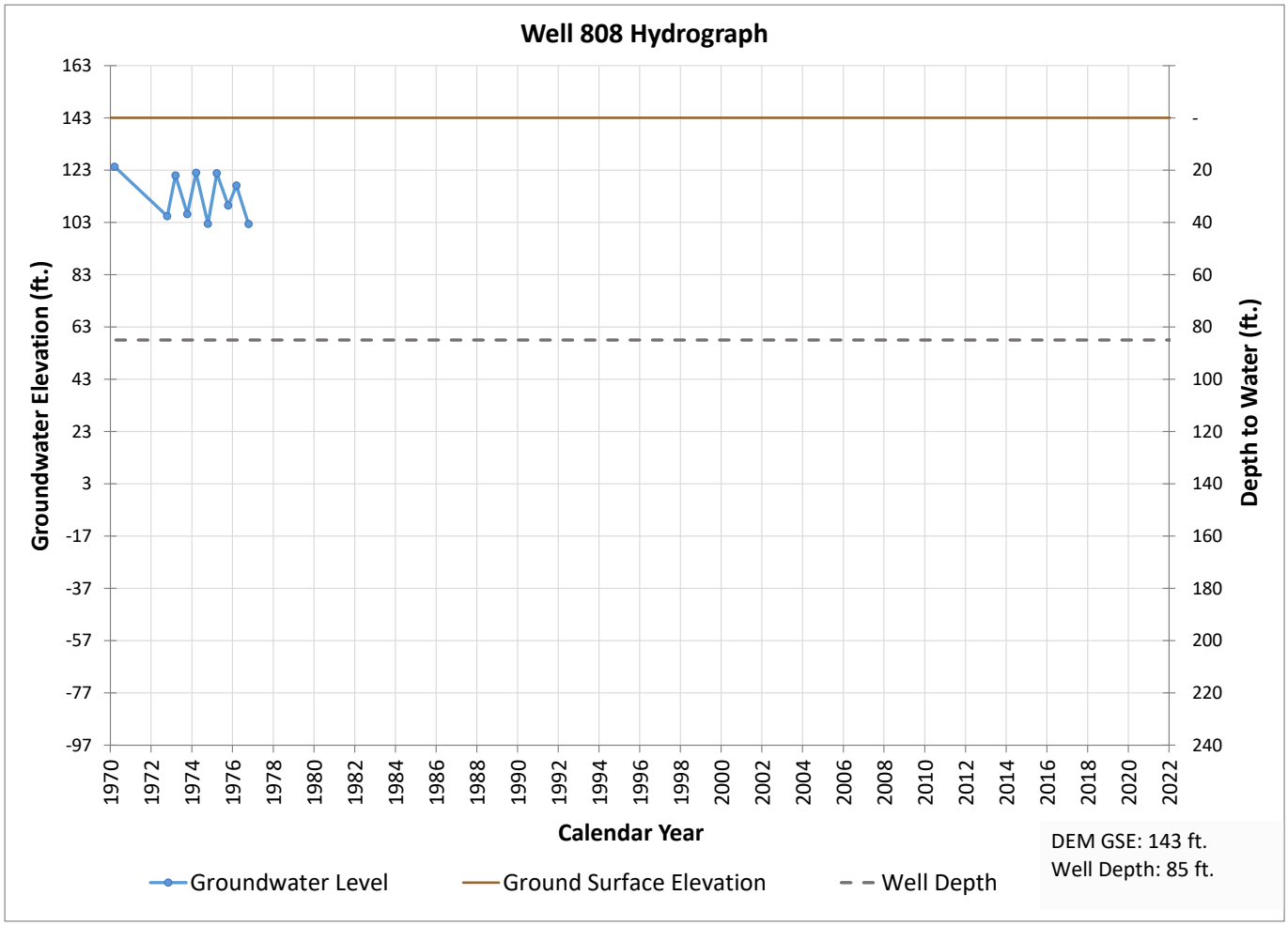

Well 800 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
190
170
150
130
110
90
70
50
30
10
-10
-30
-50
-70
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 170 ft.
Well Depth: ft.

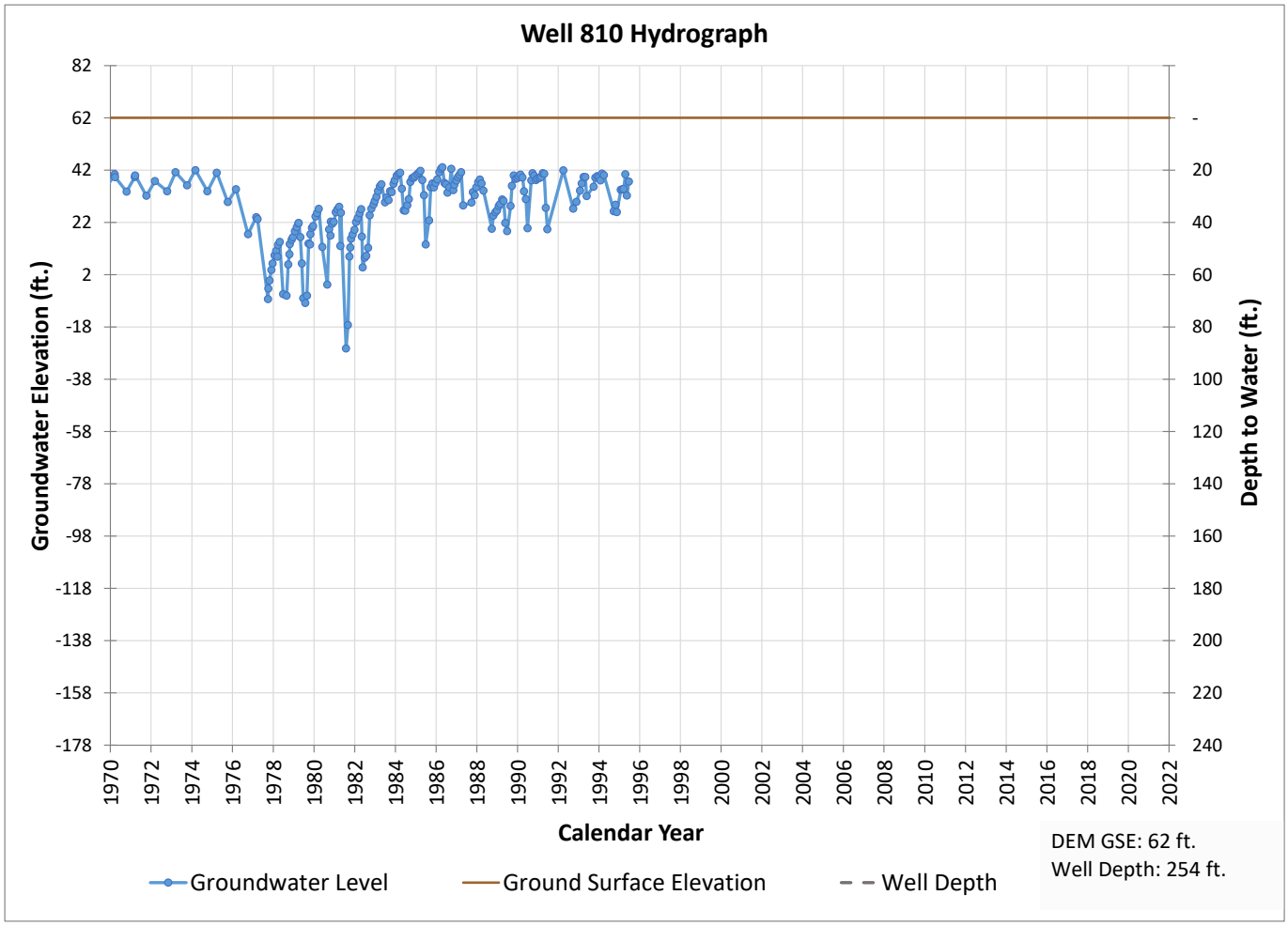

Well 801 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 92 ft.
Well Depth: 70 ft.

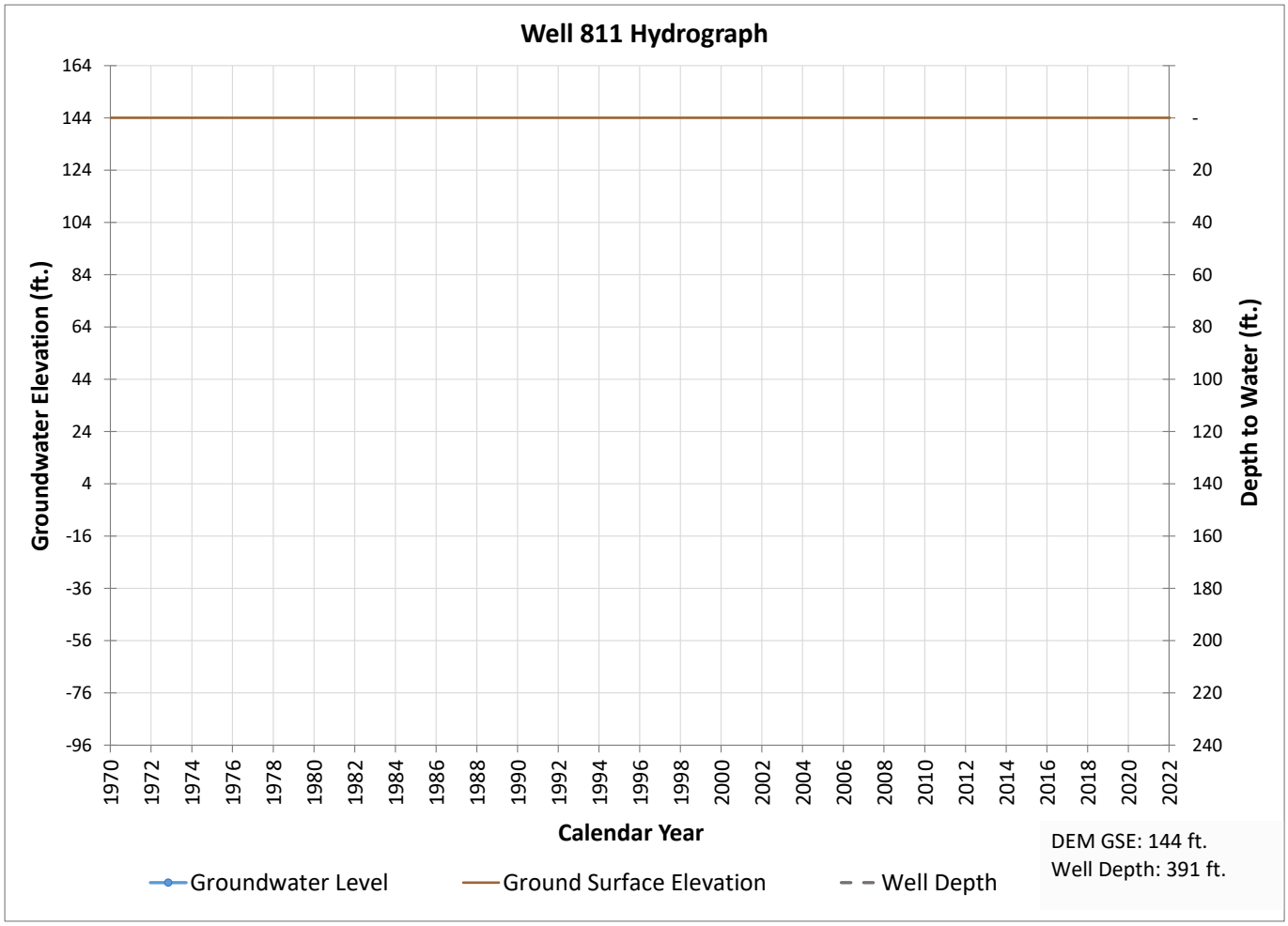

Well 802 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
112
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 92 ft.
Well Depth: 100 ft.

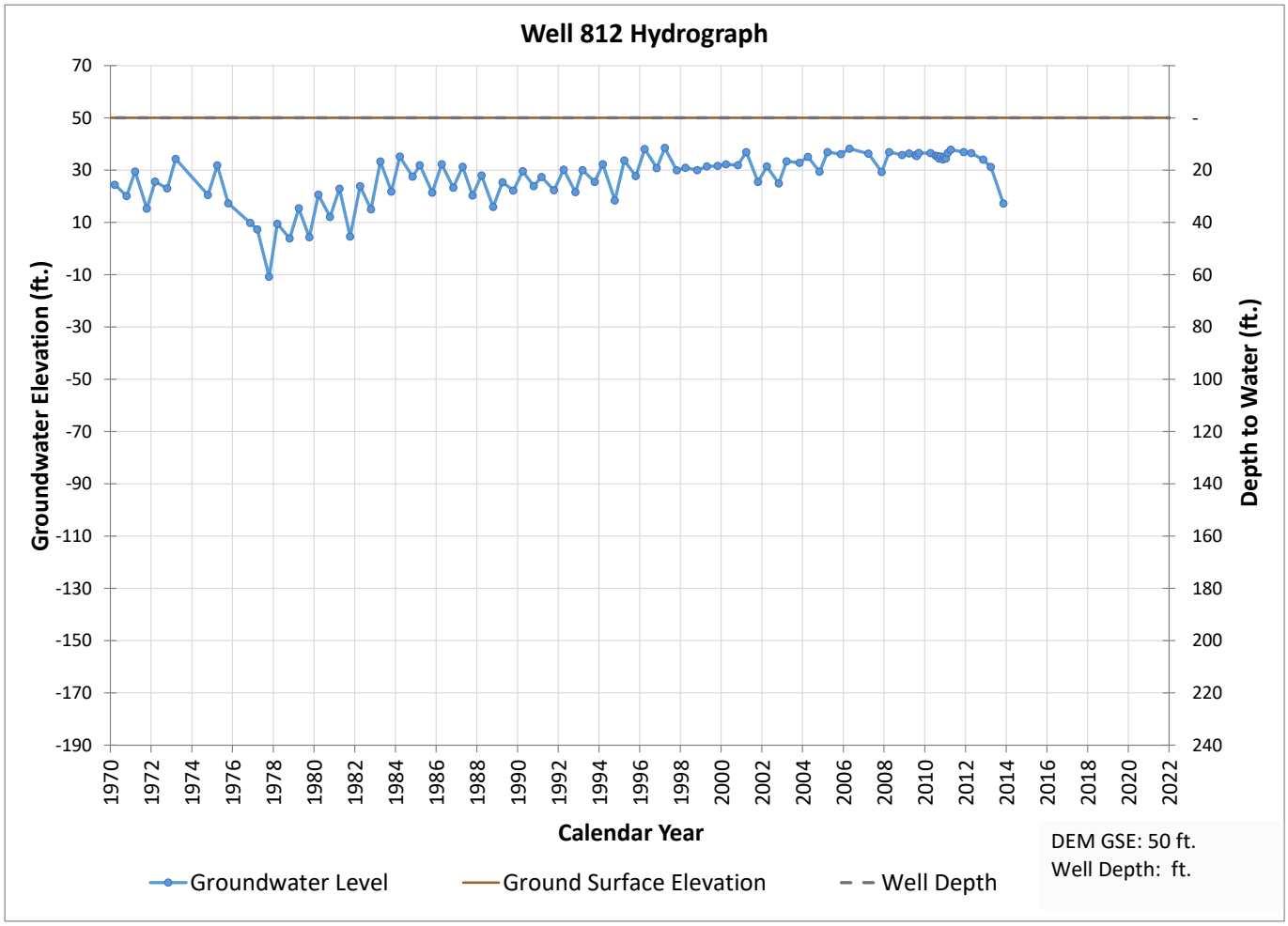

Well 803 Hydrograph
Groundwater Elevation (ft.)
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
-191
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 49 ft.
Well Depth: ft.

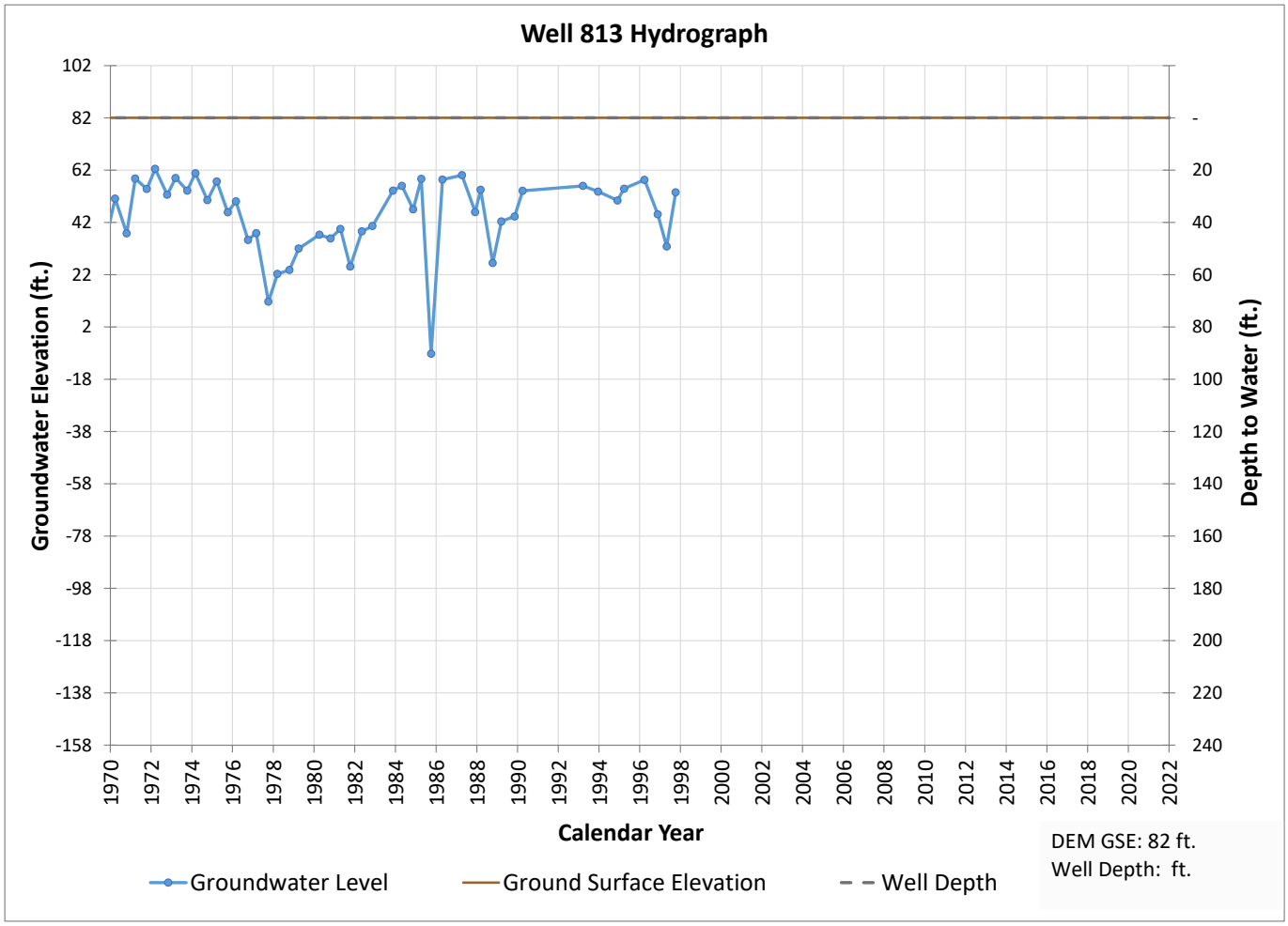

Well 805 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: ft.

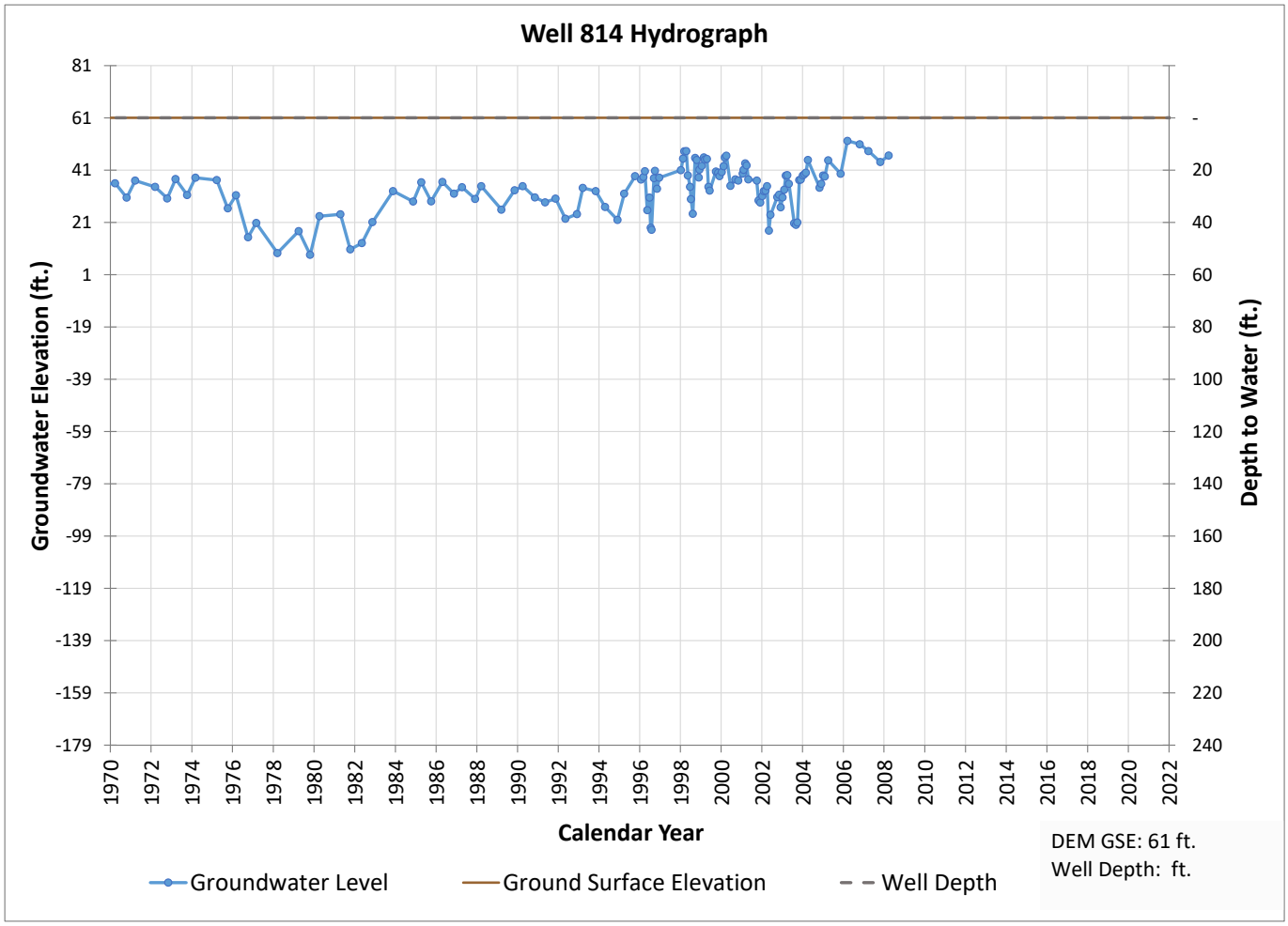

Well 808 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
163
143
123
103
83
63
43
23
3
-17
-37
-57
-77
-97
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 143 ft.
Well Depth: 85 ft.

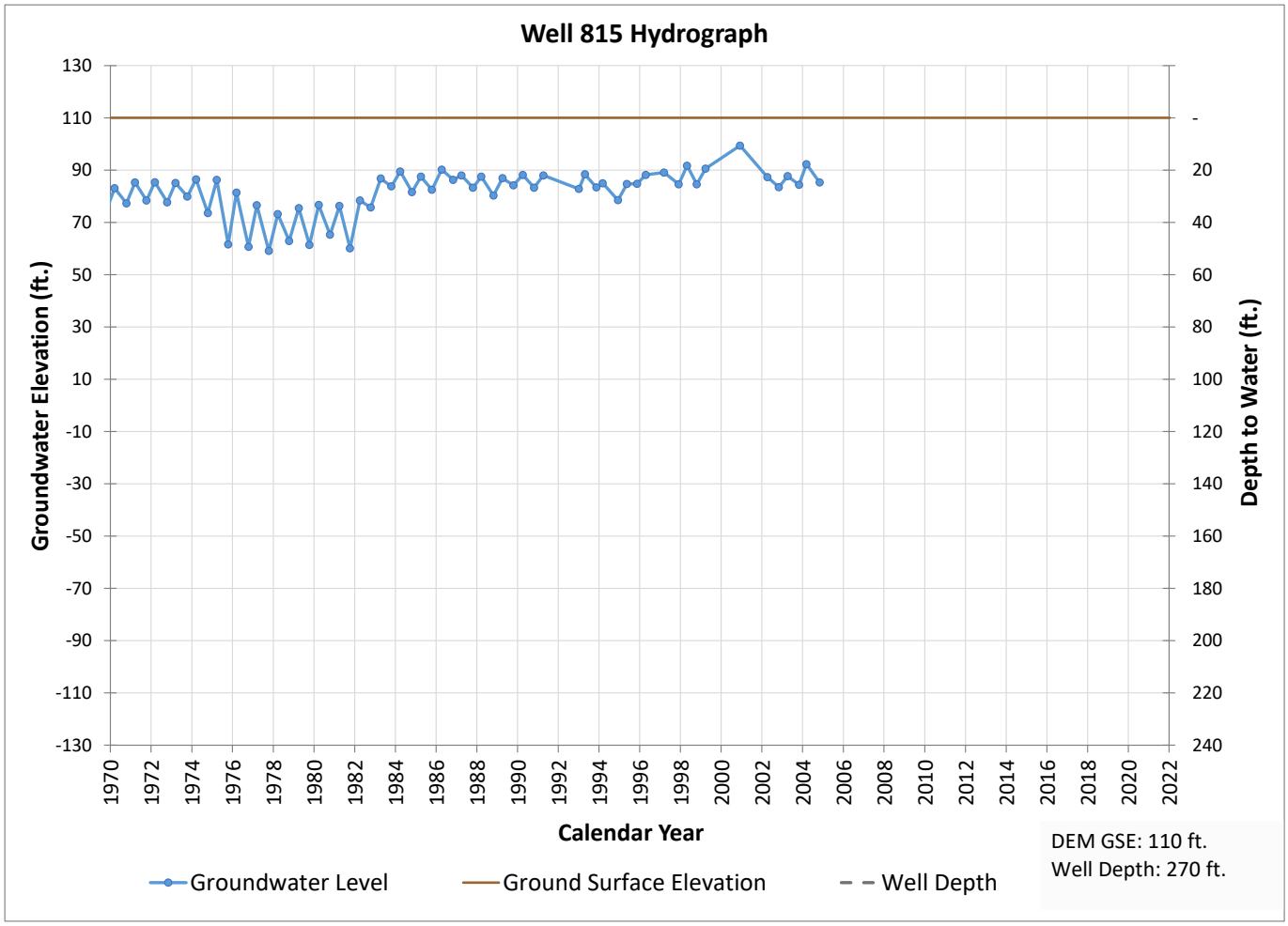

Well 810 Hydrograph
Groundwater Elevation (ft.)
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 62 ft.
Well Depth: 254 ft.

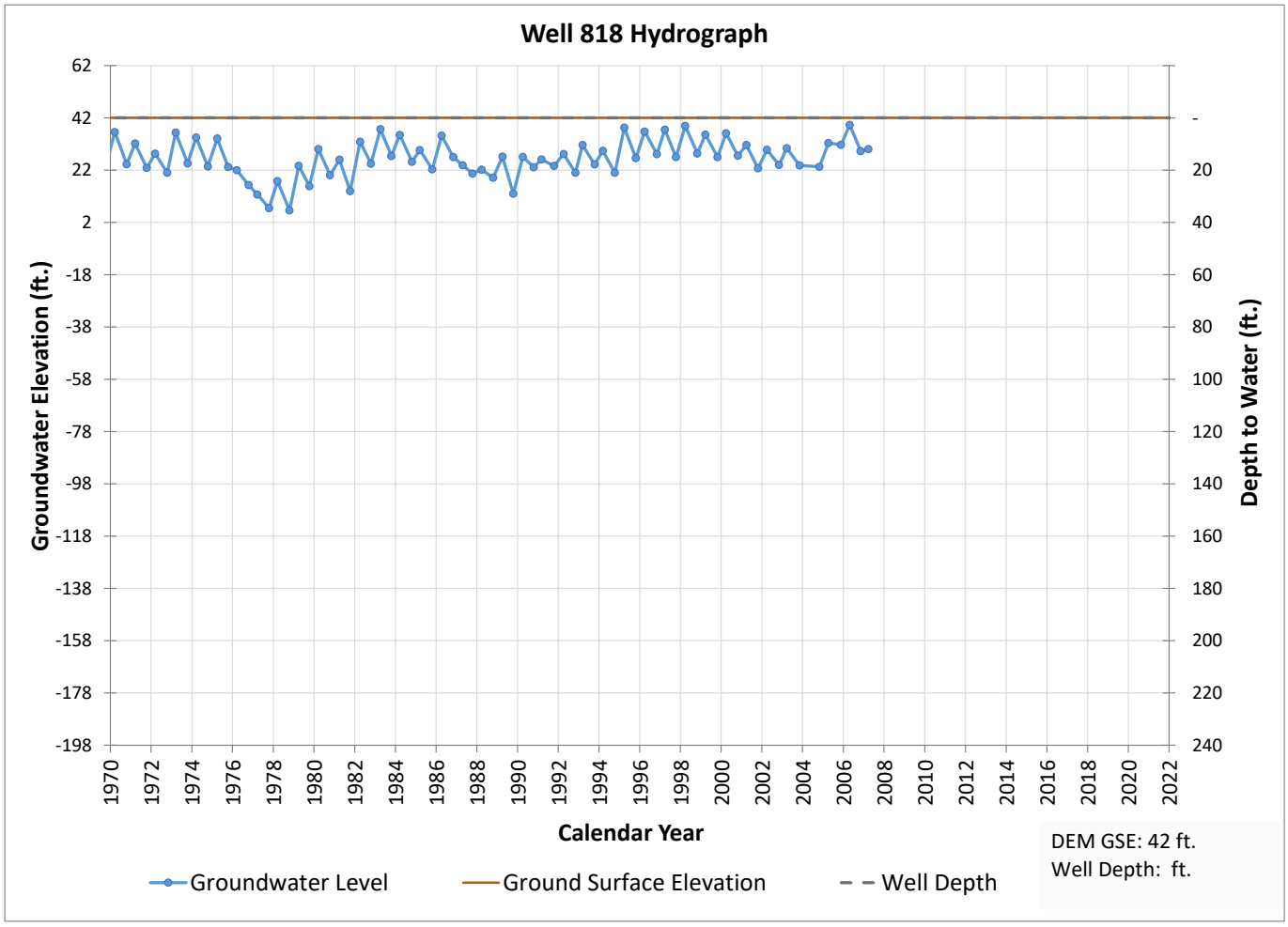

Well 811 Hydrograph
Groundwater Elevation (ft.)
164
144
124
104
84
64
44
24
4
-16
-36
-56
-76
-96
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 144 ft.
Well Depth: 391 ft.

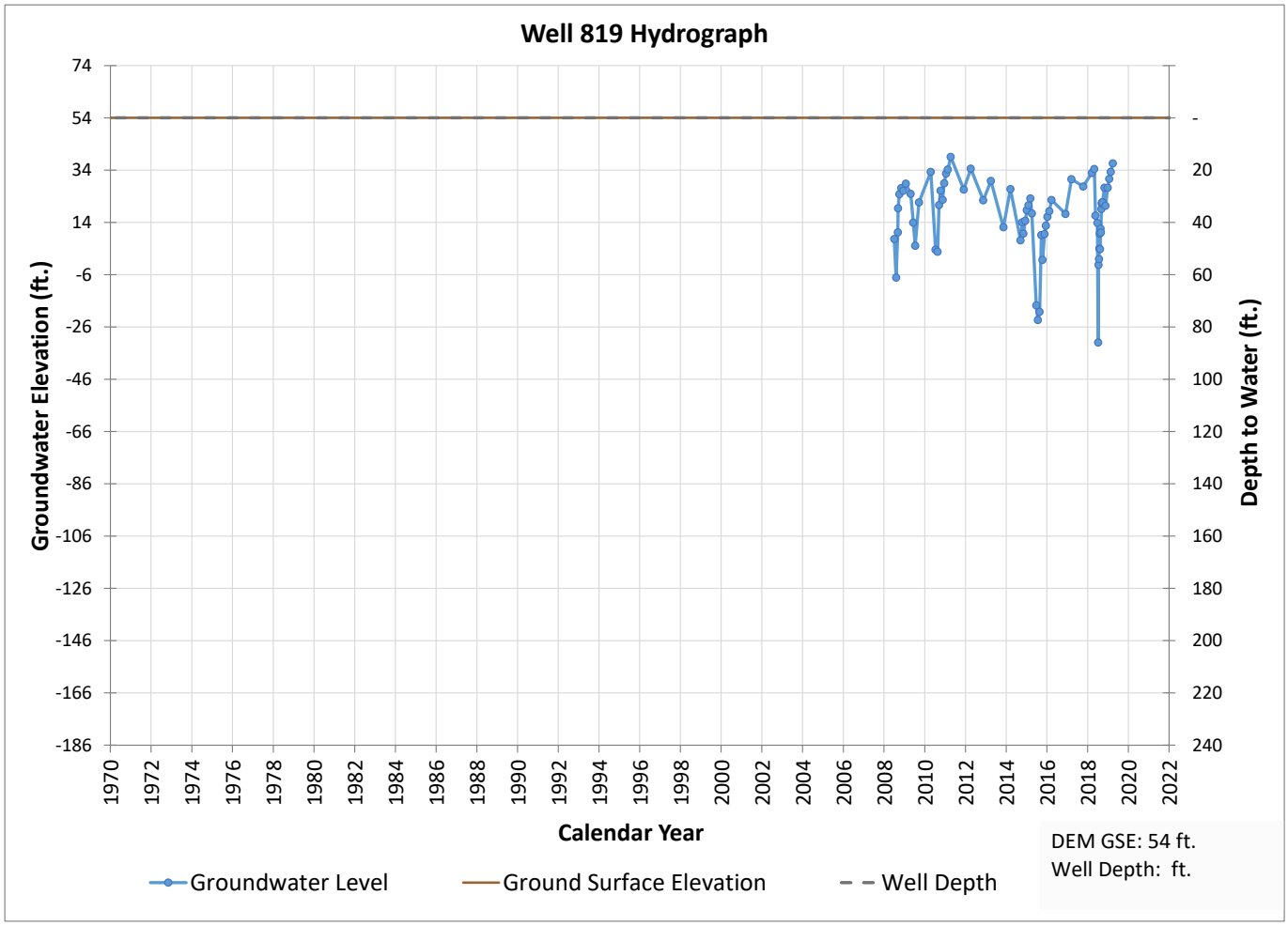

Well 812 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 50 ft.
Well Depth: ft.

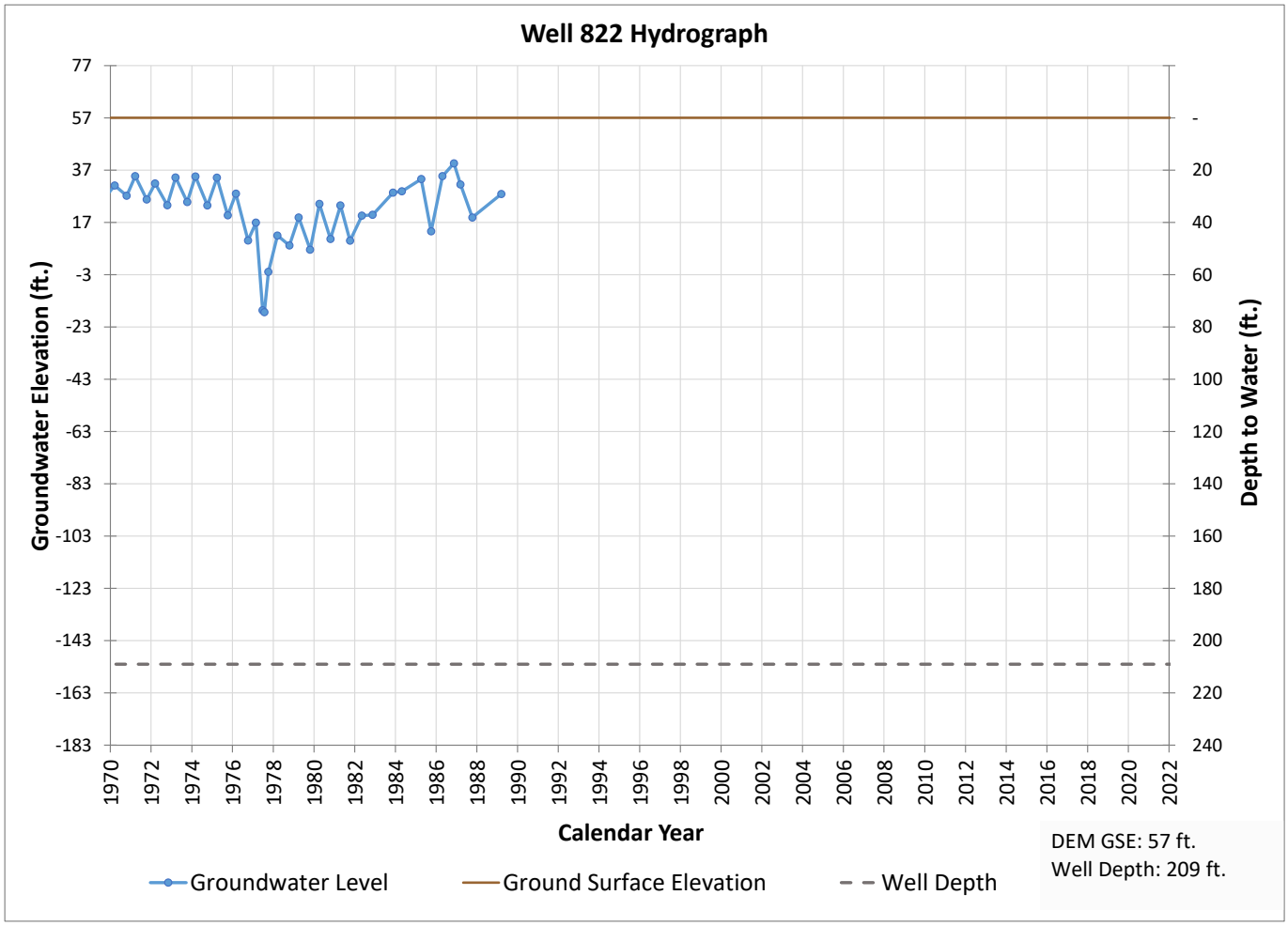

Well 813 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 82 ft.
Well Depth: ft.

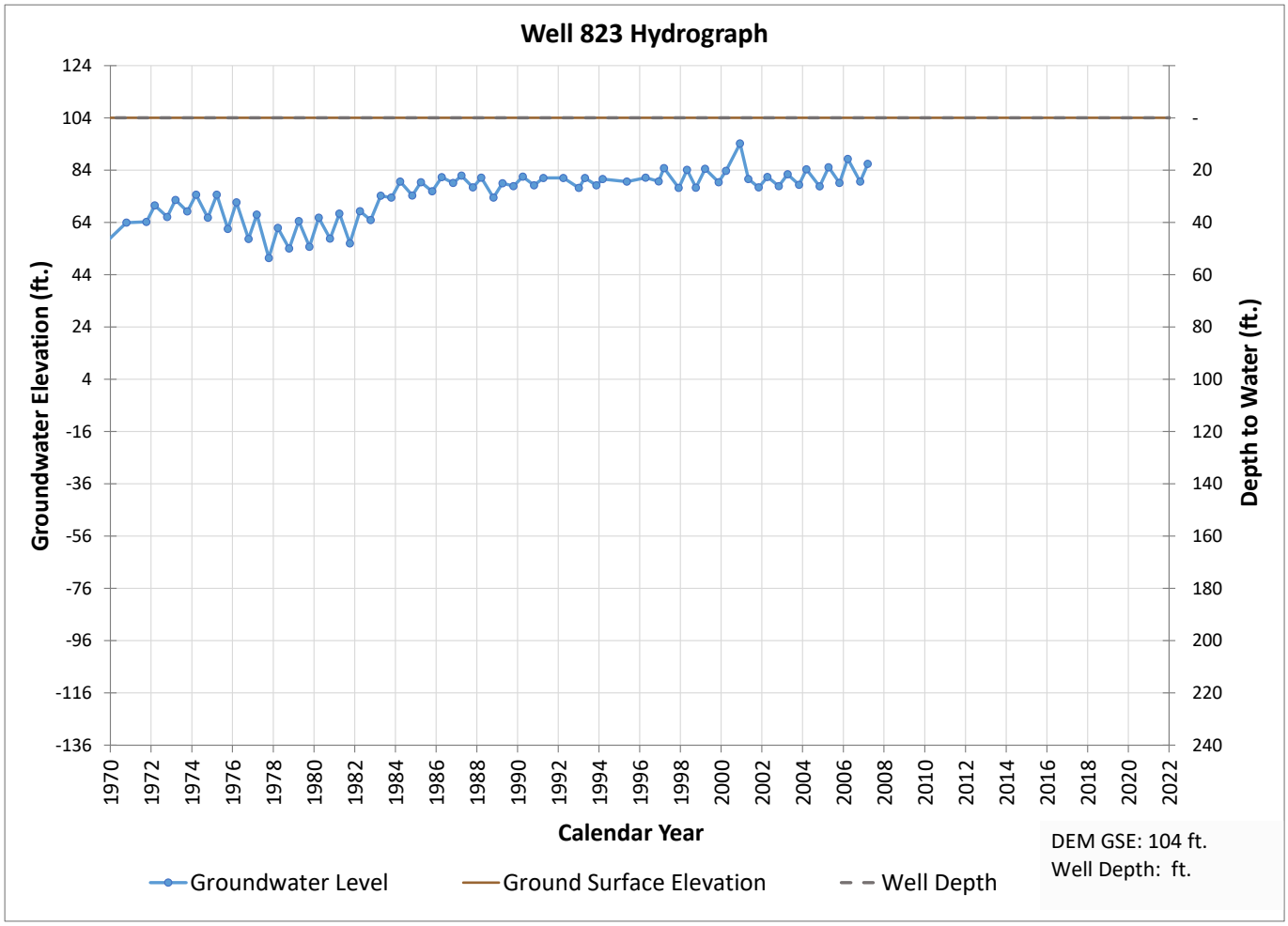

Well 814 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
81
61
41
21
1
-19
-39
-59
-79
-99
-119
-139
-159
-179
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 61 ft.
Well Depth: ft.

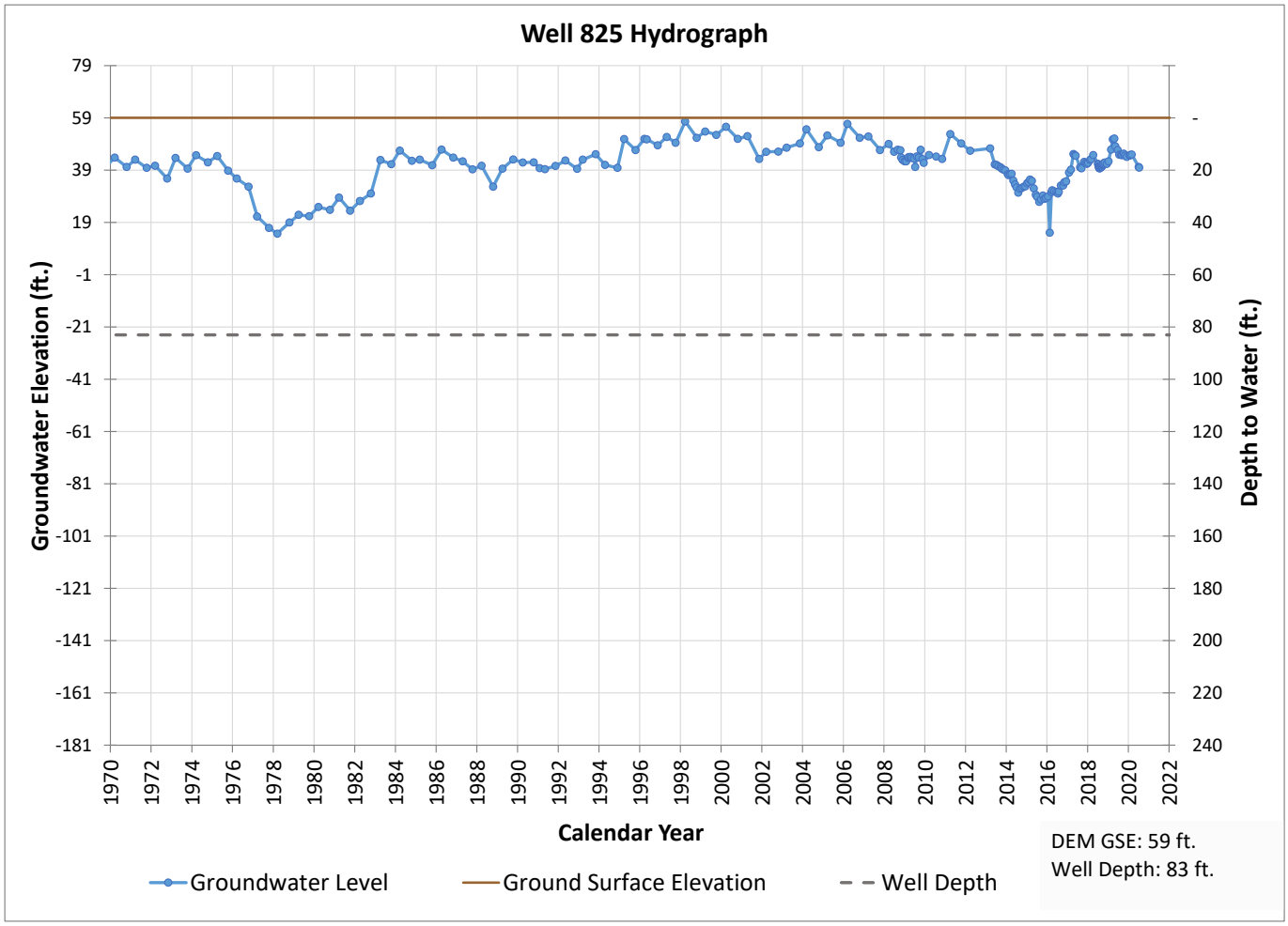

Well 815 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
130
110
90
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 110 ft.
Well Depth: 270 ft.

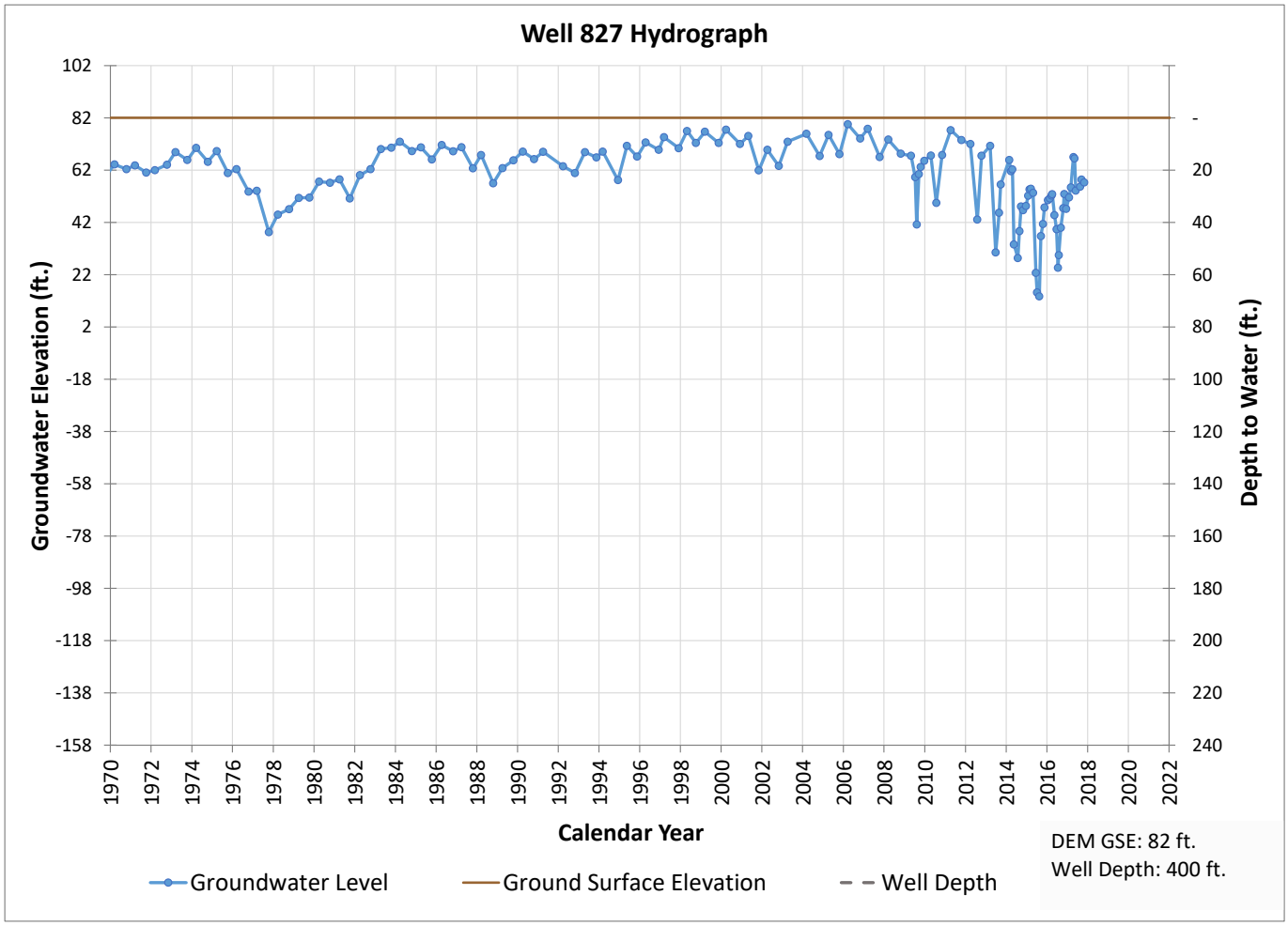

Well 818 Hydrograph
Groundwater Elevation (ft.)
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 42 ft.
Well Depth: ft.

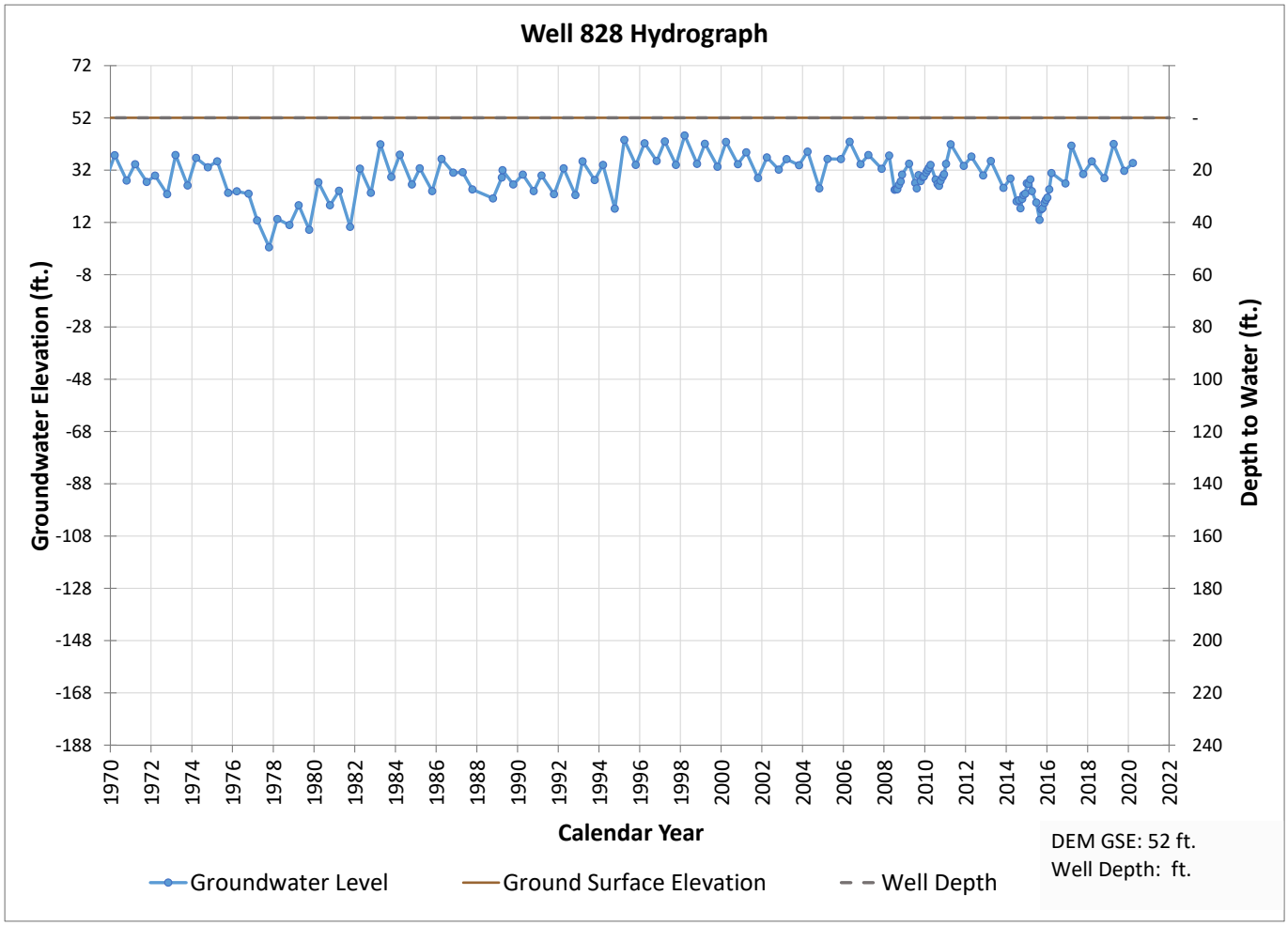

Well 819 Hydrograph
Groundwater Elevation (ft.)
74
54
34
14
-6
-26
-46
-66
-86
-106
-126
-146
-166
-186
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 54 ft.
Well Depth: ft.

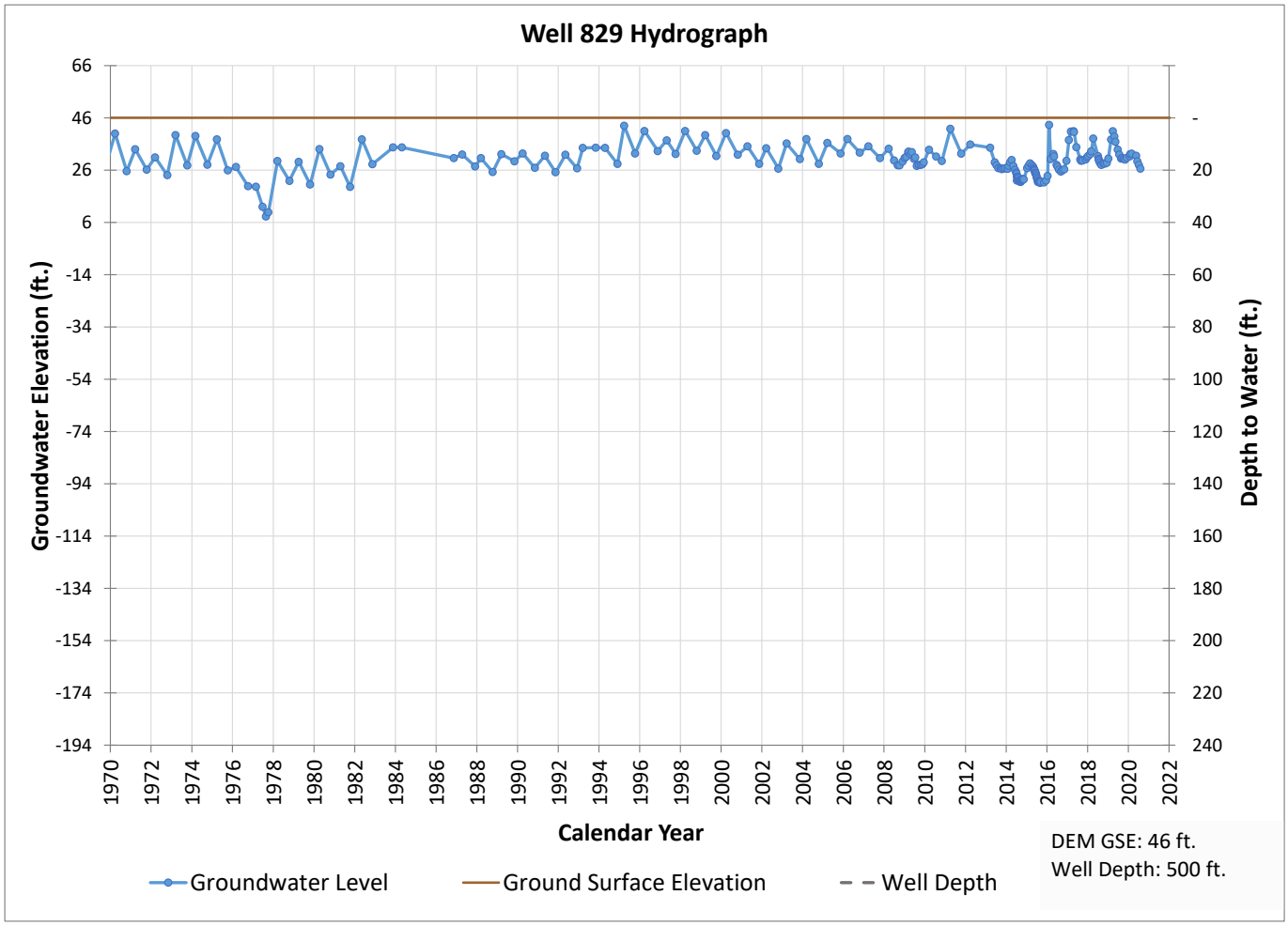

Well 822 Hydrograph
Groundwater Elevation (ft.)
77
57
37
17
-3
-23
-43
-63
-83
-103
-123
-143
-163
-183
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 57 ft.
Well Depth: 209 ft.

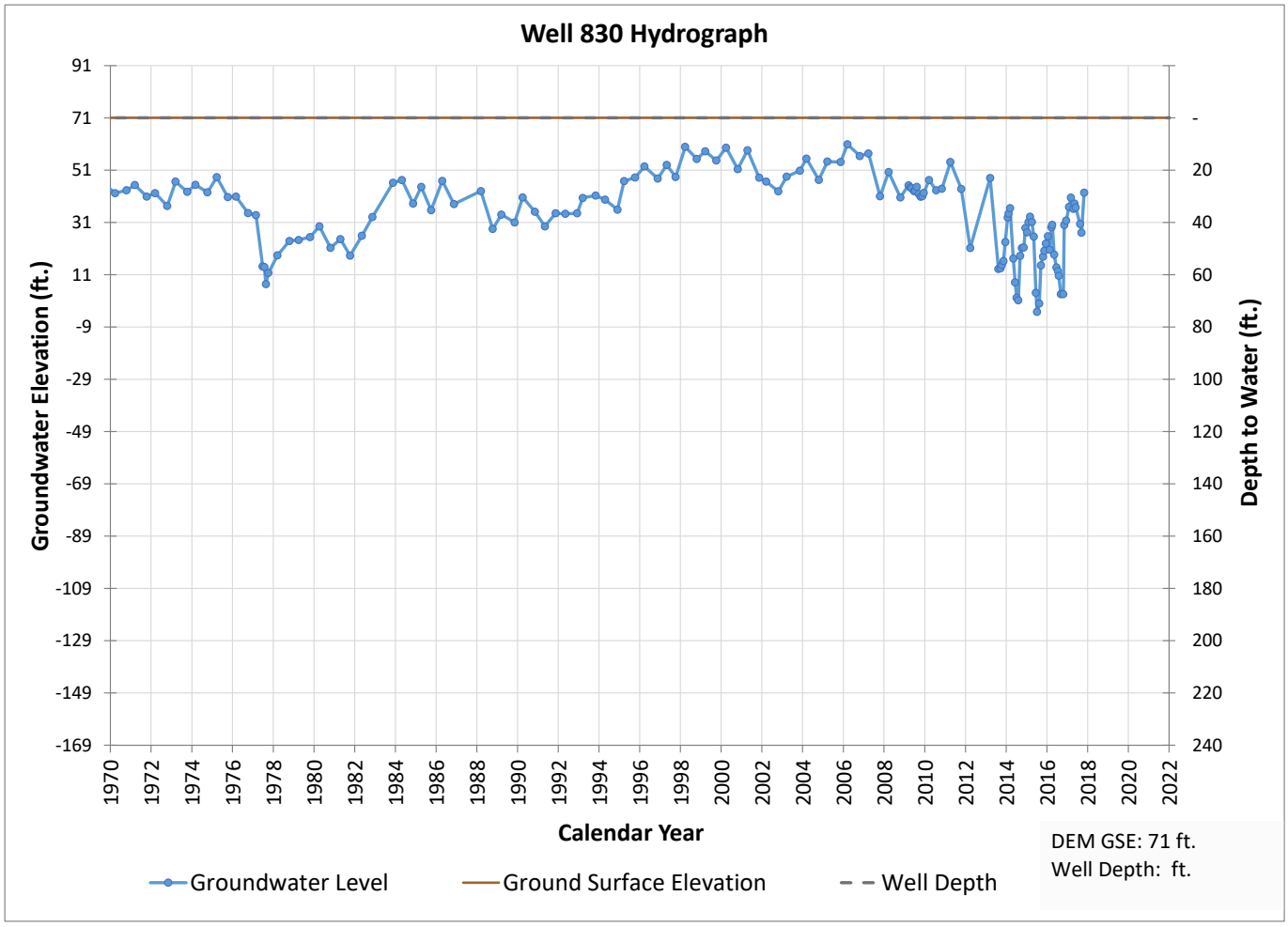

Well 823 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
124
104
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 104 ft.
Well Depth: ft.

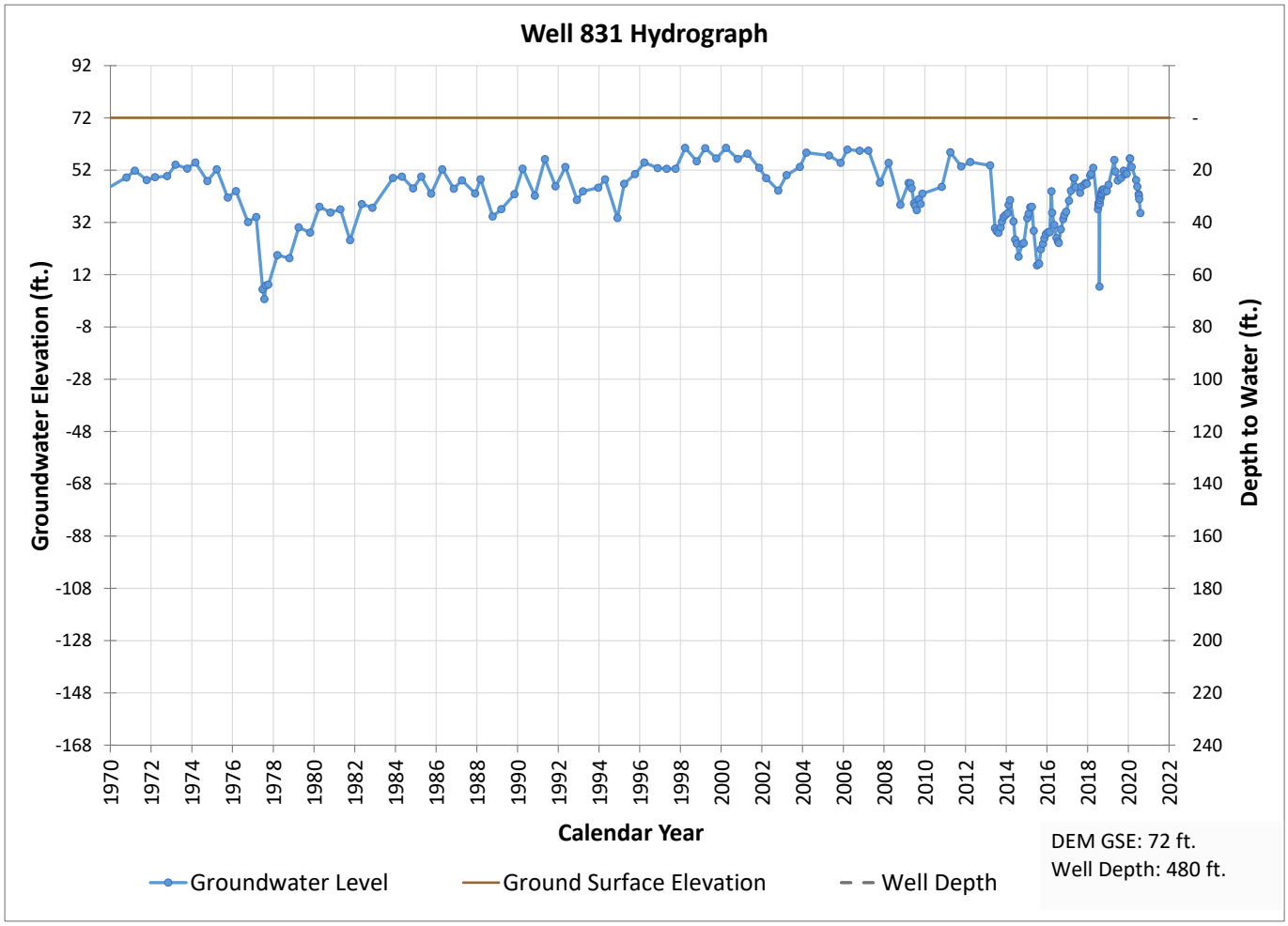

Well 825 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
79
59
39
19
-1
-21
-41
-61
-81
-101
-121
-141
-161
-181
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 59 ft.
Well Depth: 83 ft.

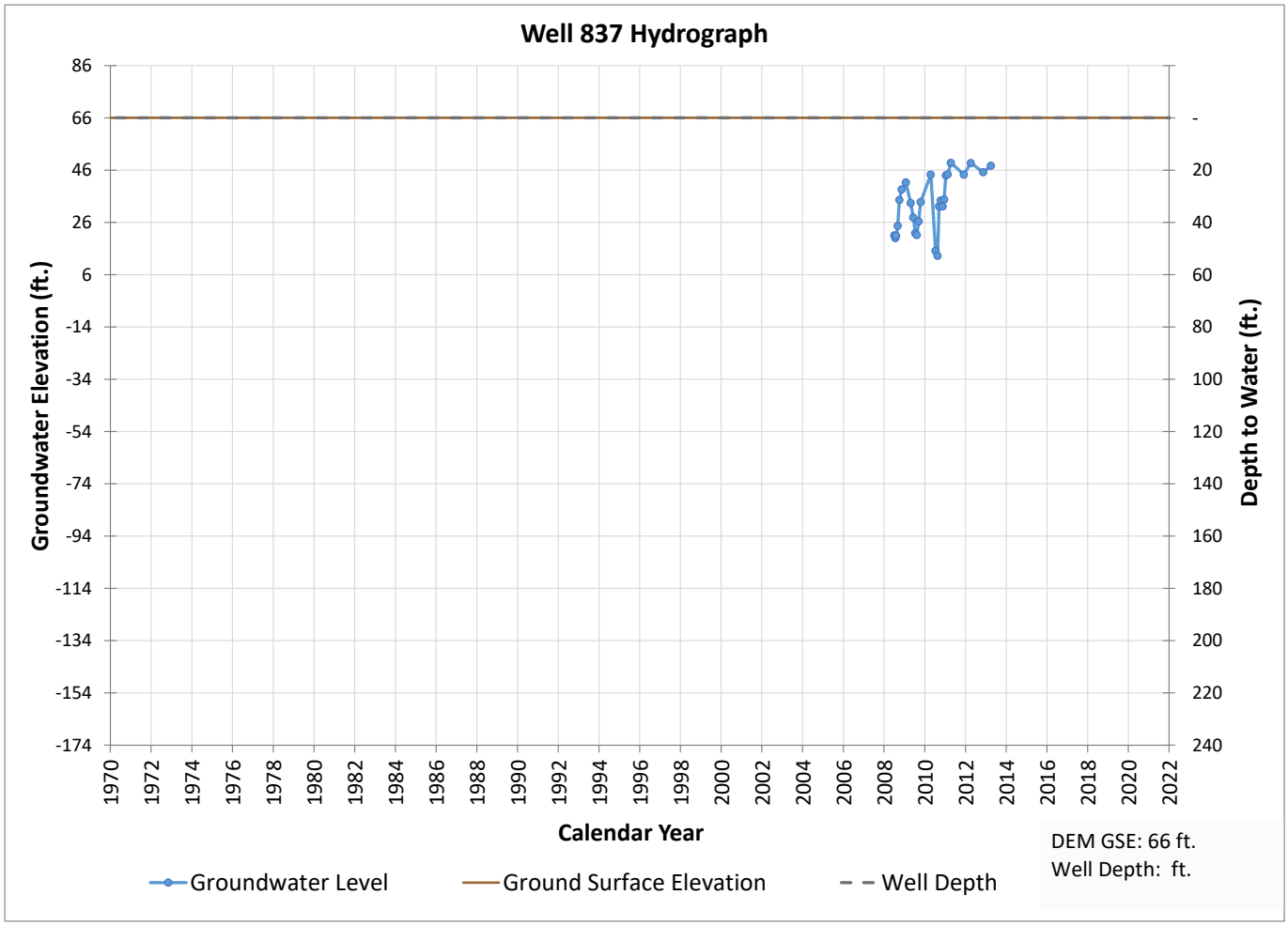

Well 827 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 82 ft.
Well Depth: 400 ft.

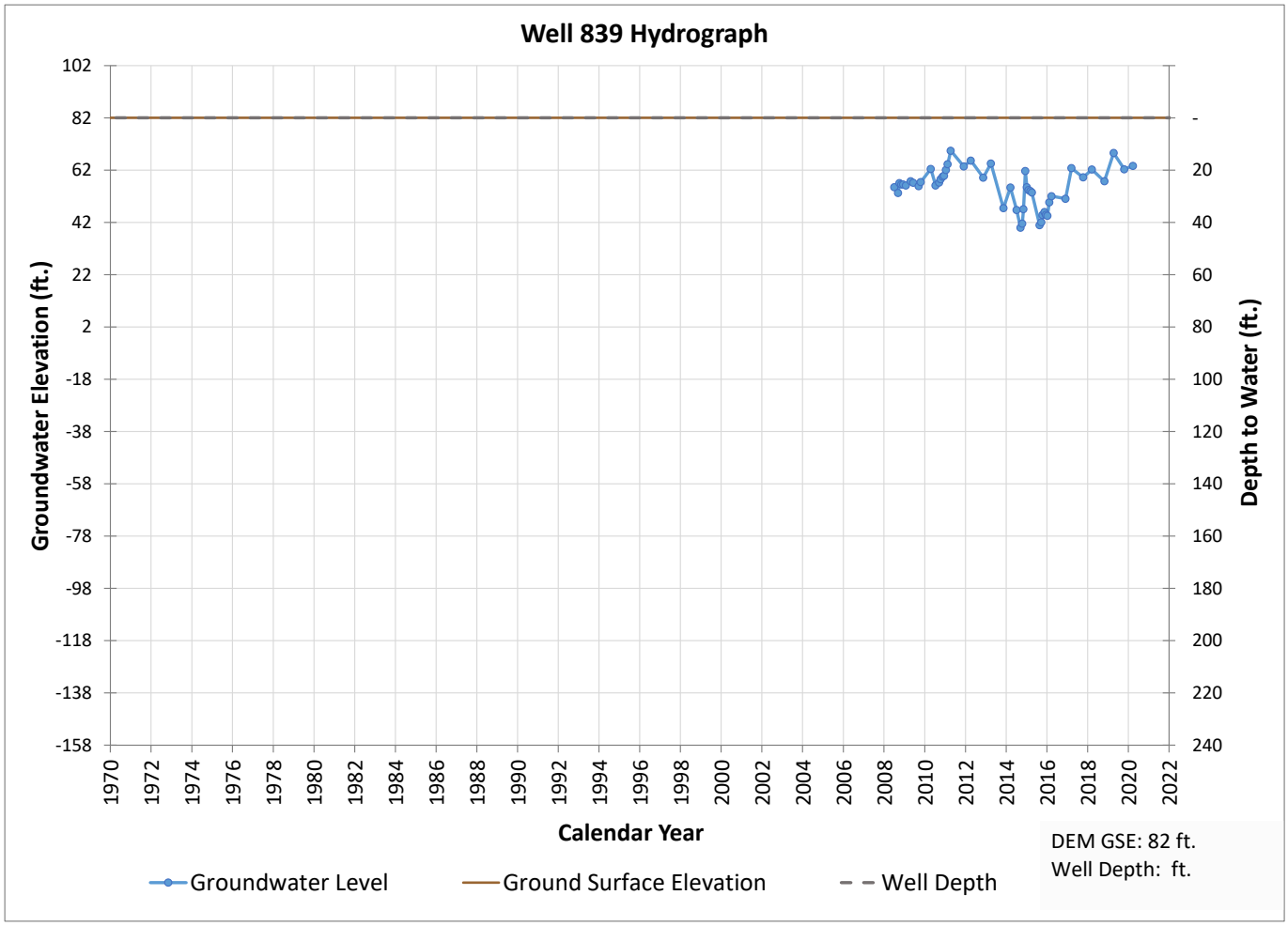

Well 828 Hydrograph
Groundwater Elevation (ft.)
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
-188
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 52 ft.
Well Depth: ft.

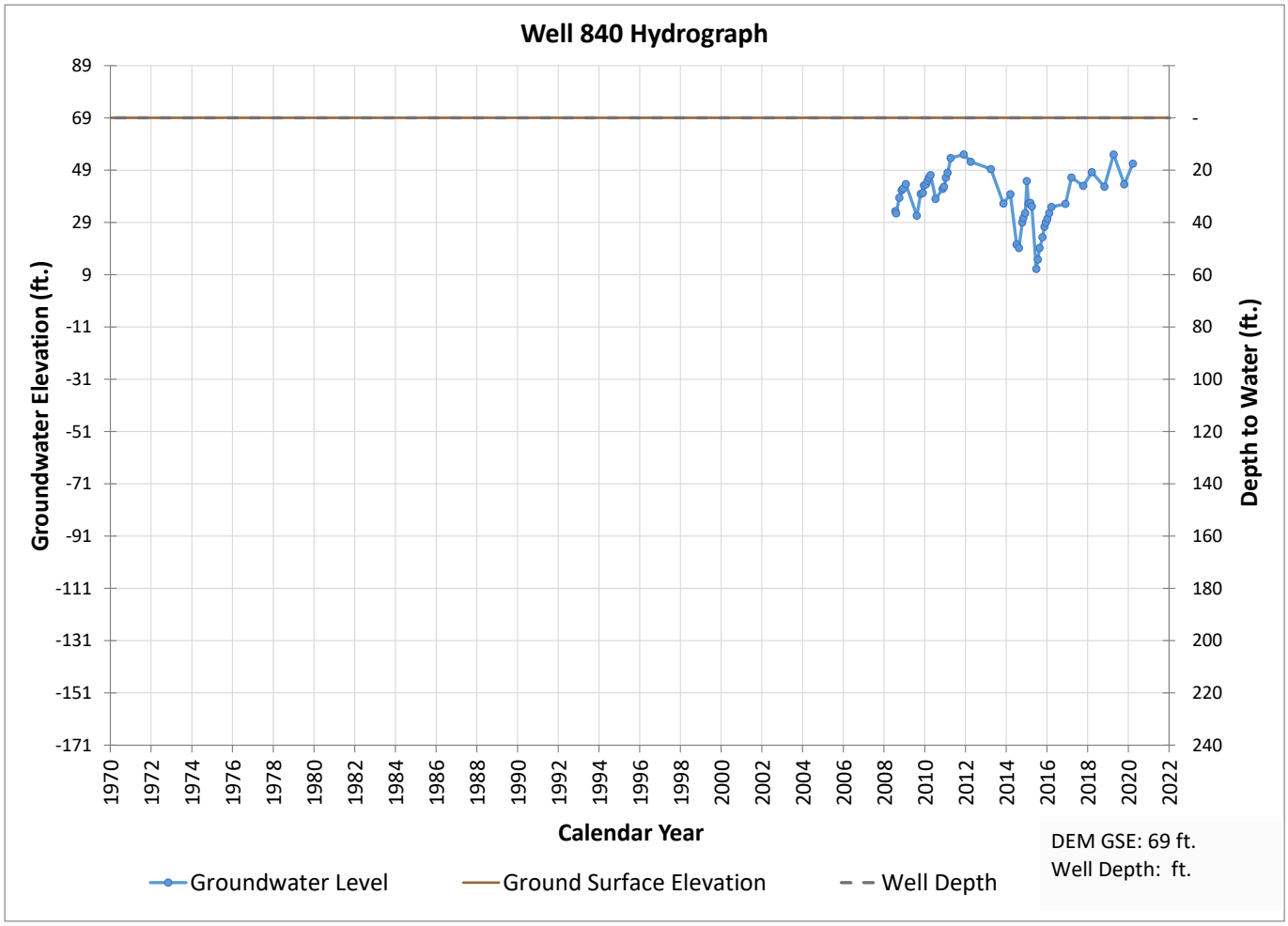

Well 829 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: 500 ft.

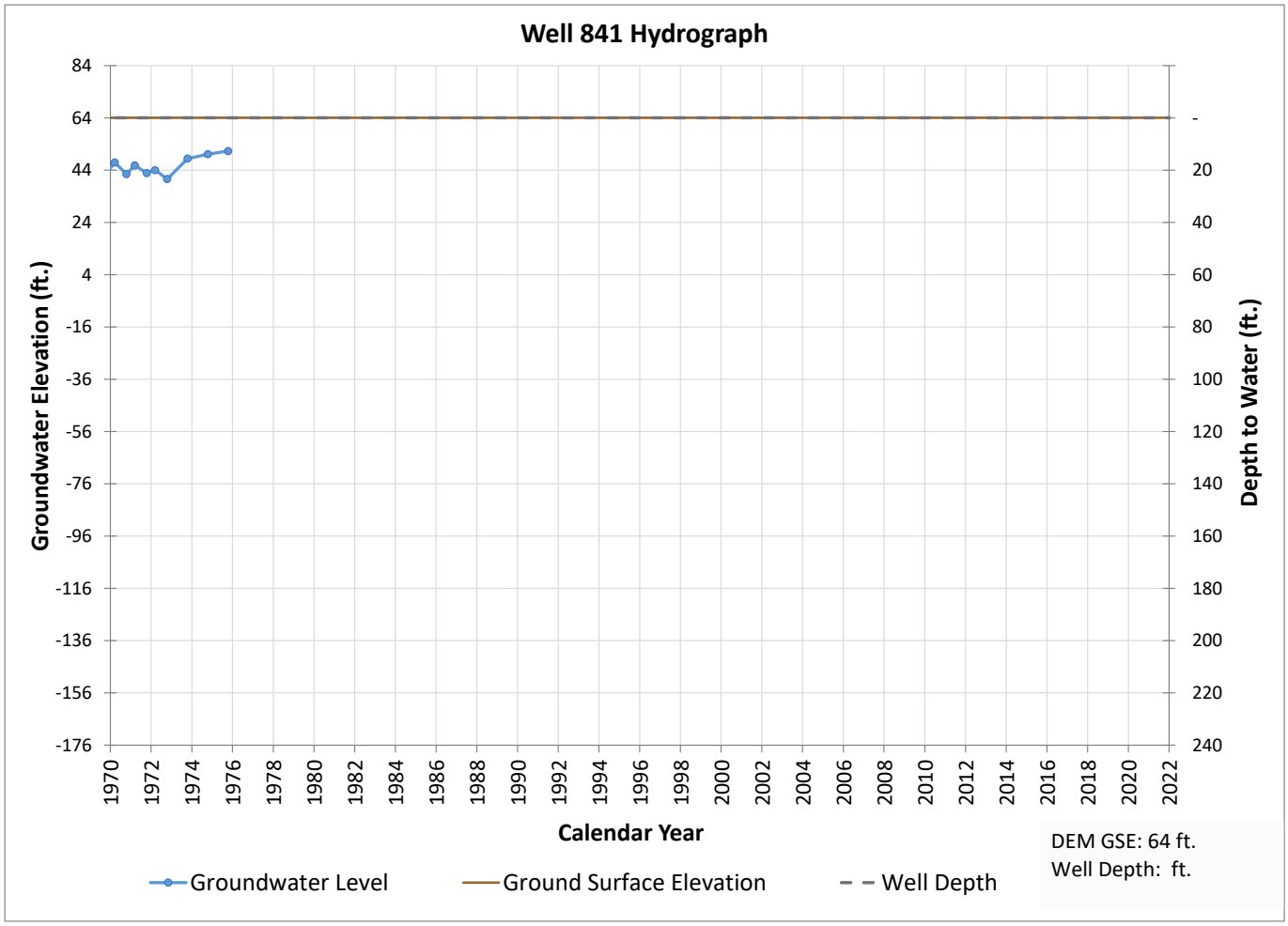

Well 830 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
91
71
51
31
11
-9
-29
-49
-69
-89
-109
-129
-149
-169
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 71 ft.
Well Depth: ft.

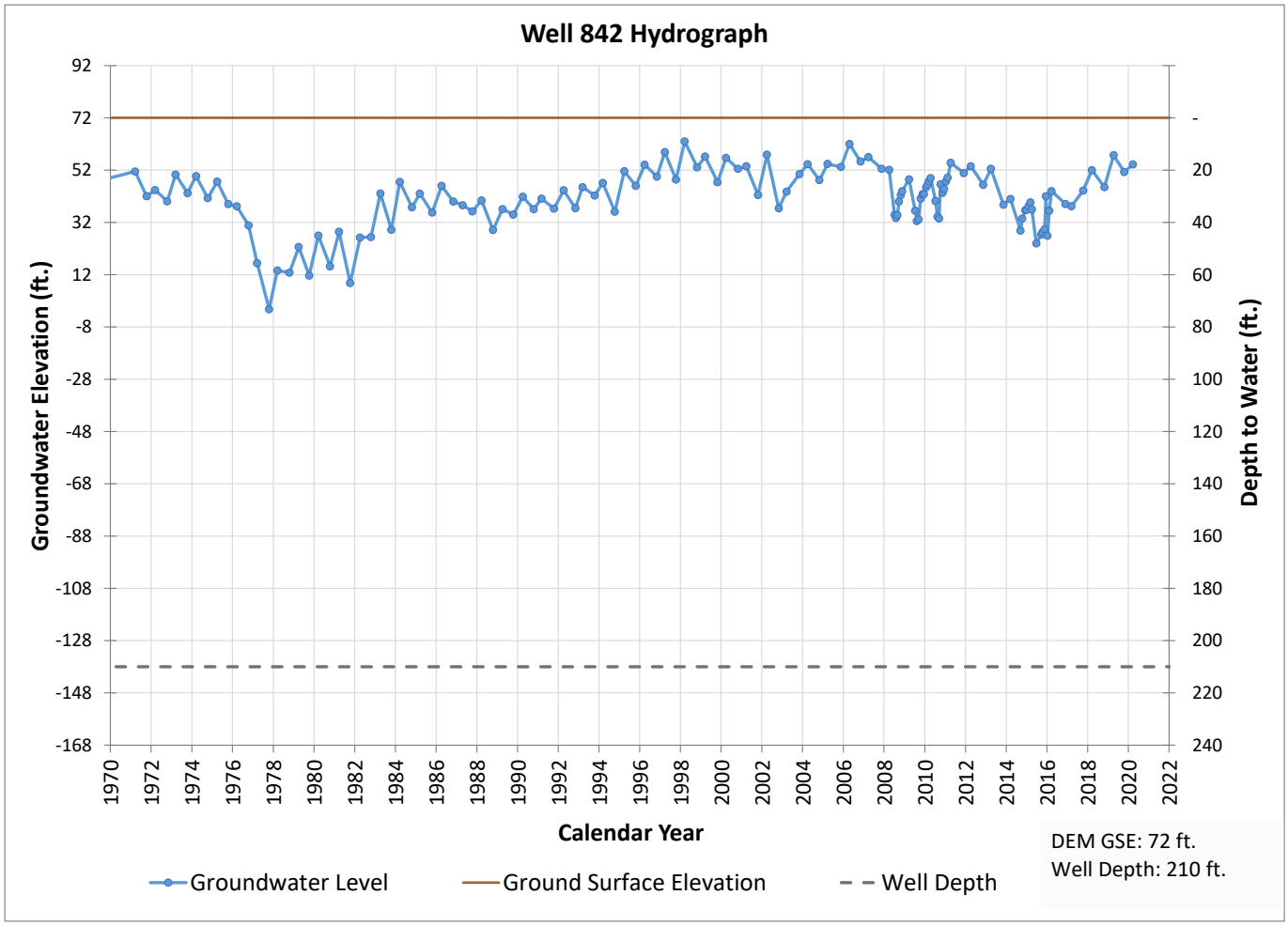

Well 831 Hydrograph
Groundwater Elevation (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: 480 ft.

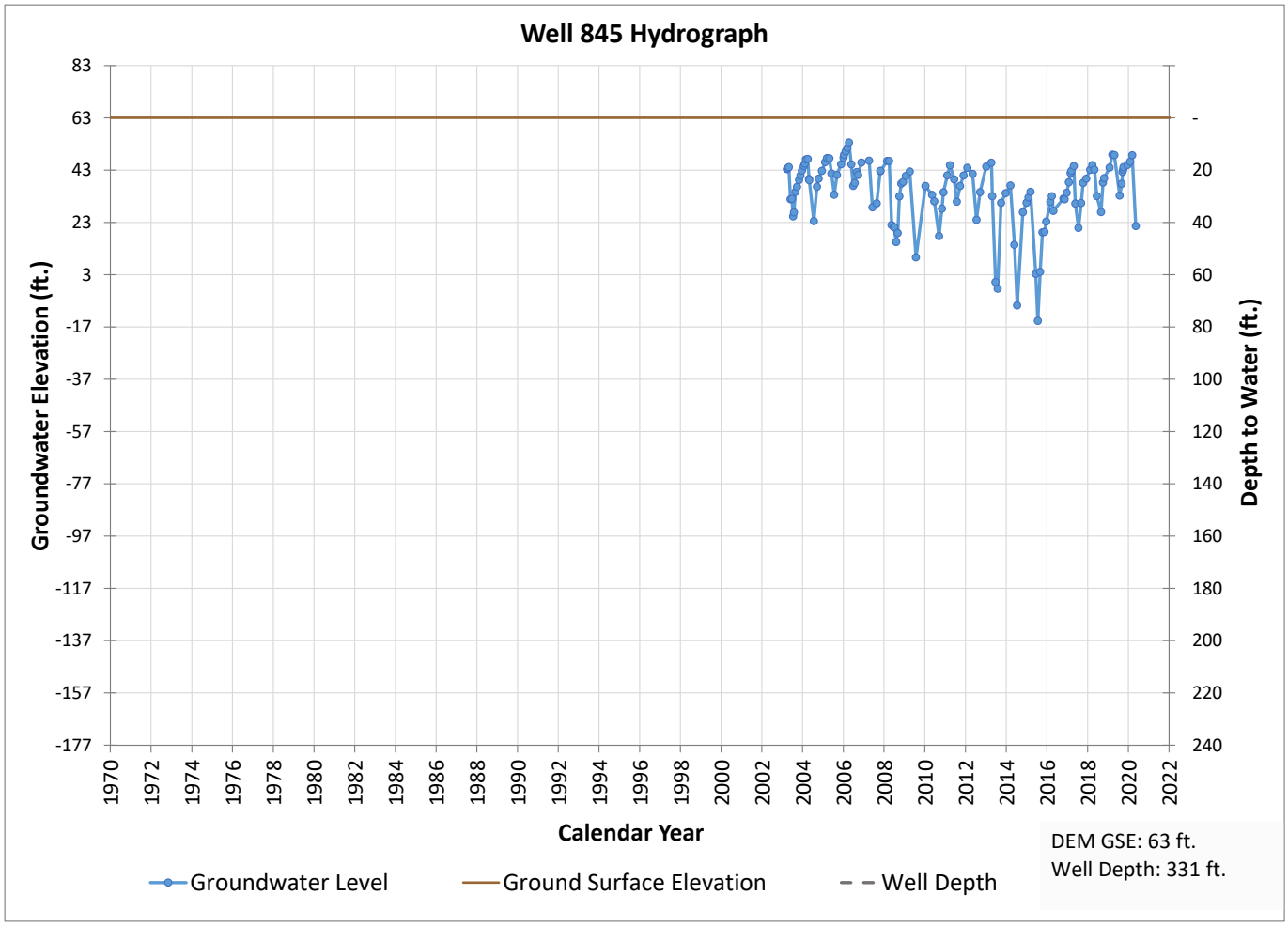

Well 837 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 66 ft.
Well Depth: ft.

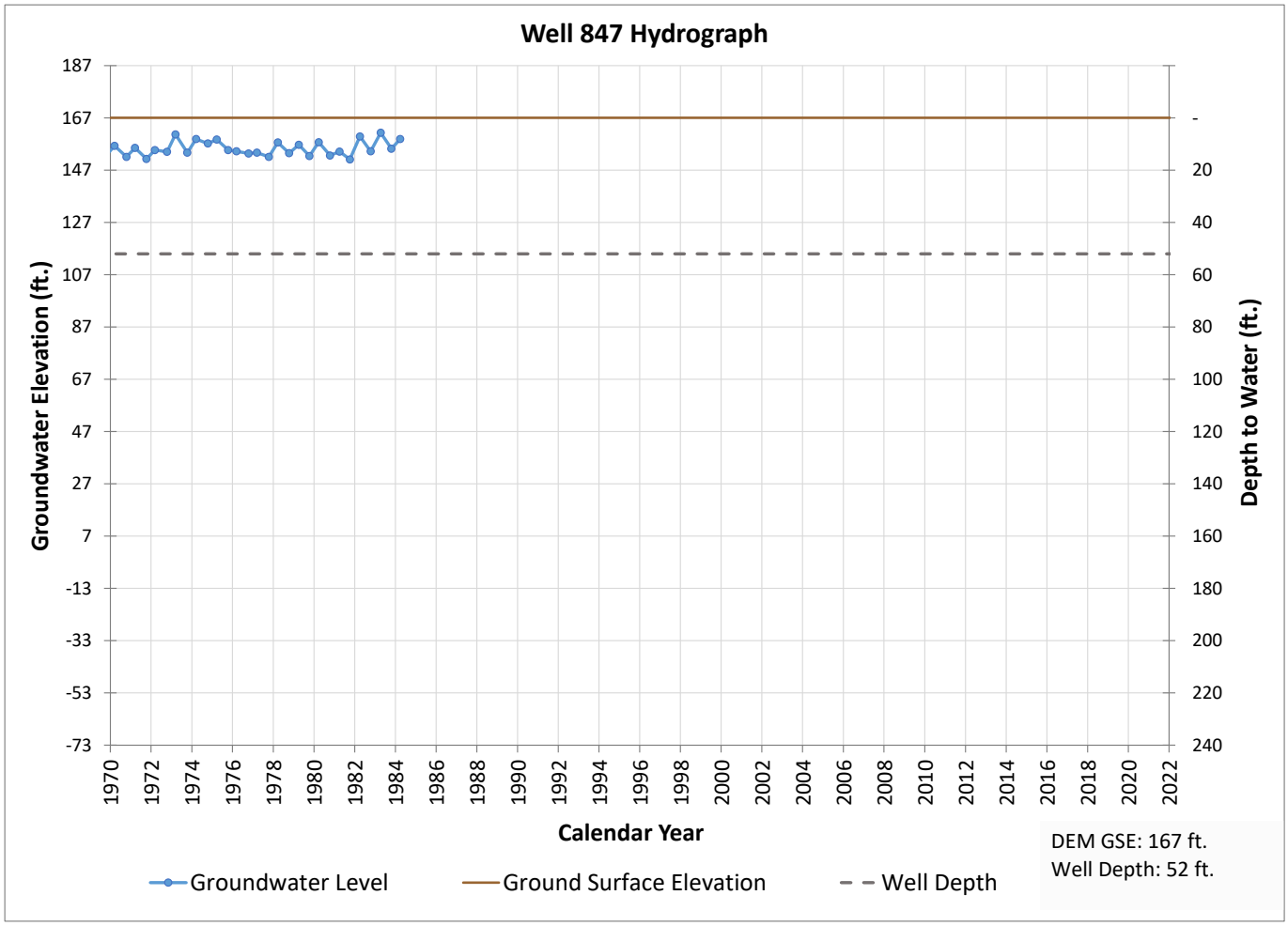

Well 839 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
102
82
62
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 82 ft.
Well Depth: ft.

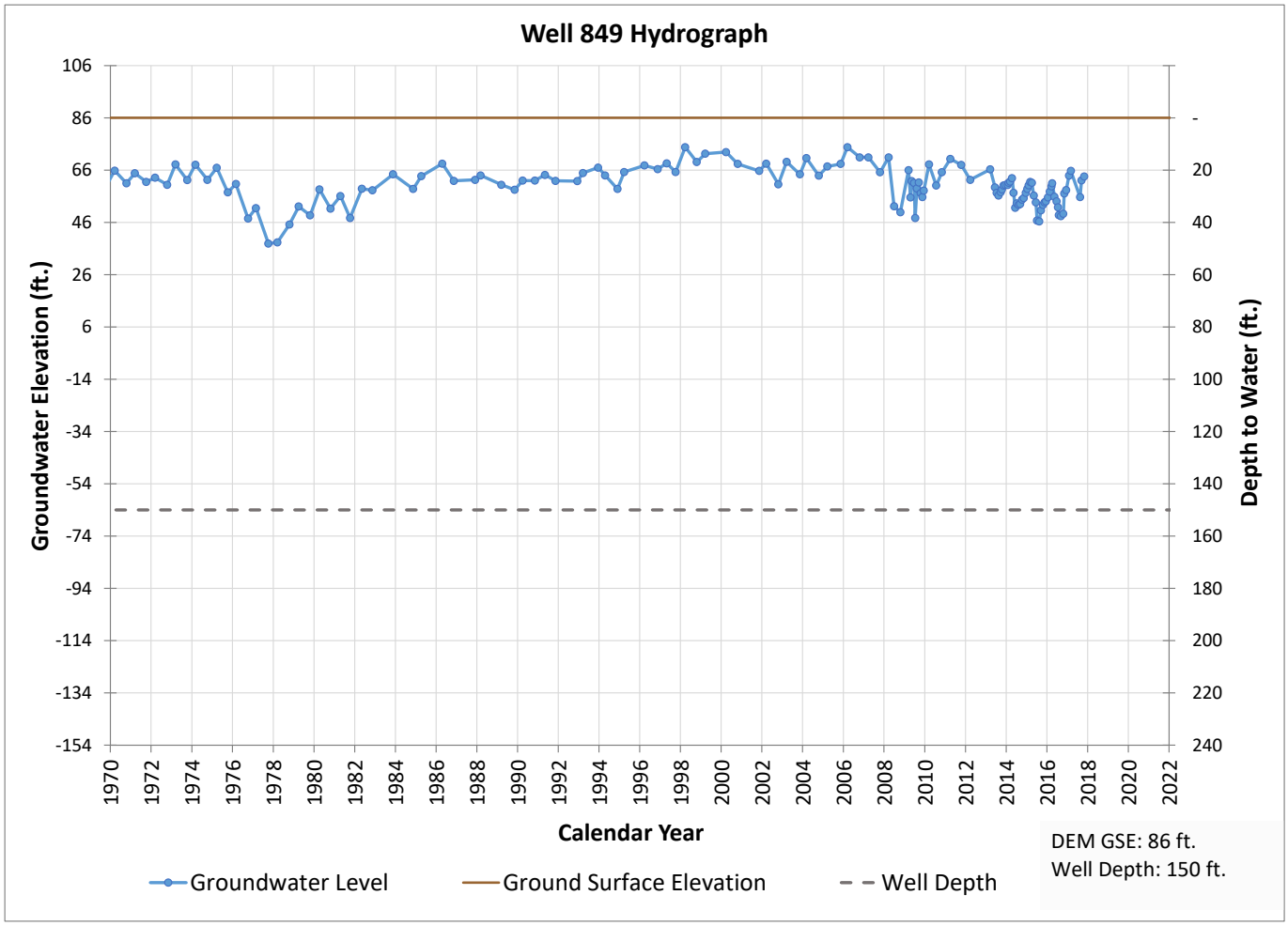

Well 840 Hydrograph
Groundwater Elevation (ft.)
89
69
49
29
9
-11
-31
-51
-71
-91
-111
-131
-151
-171
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 69 ft.
Well Depth: ft.

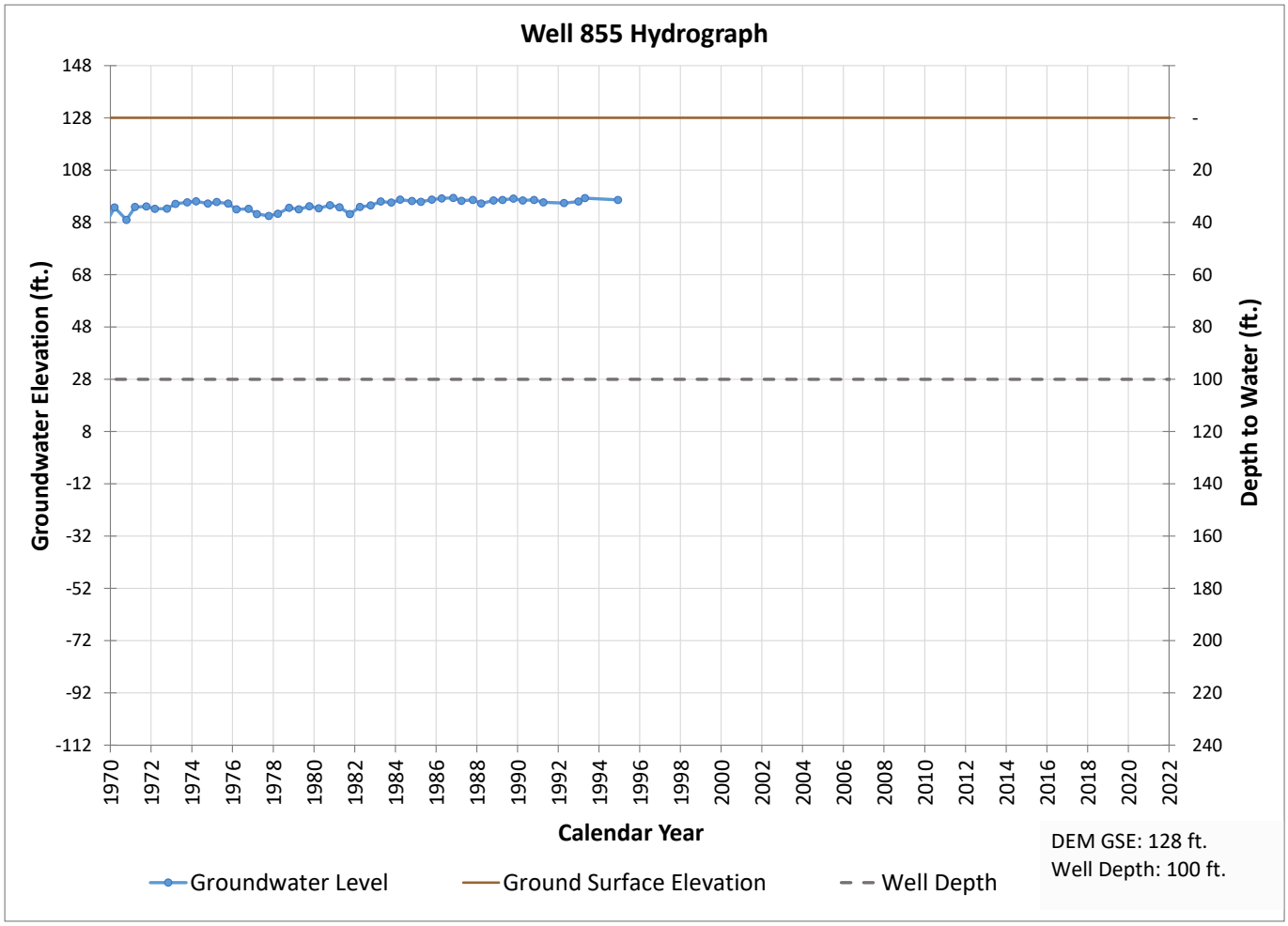

Well 841 Hydrograph
Groundwater Elevation (ft.)
84
64
44
24
4
-16
-36
-56
-76
-96
-116
-136
-156
-176
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 64 ft.
Well Depth: ft.

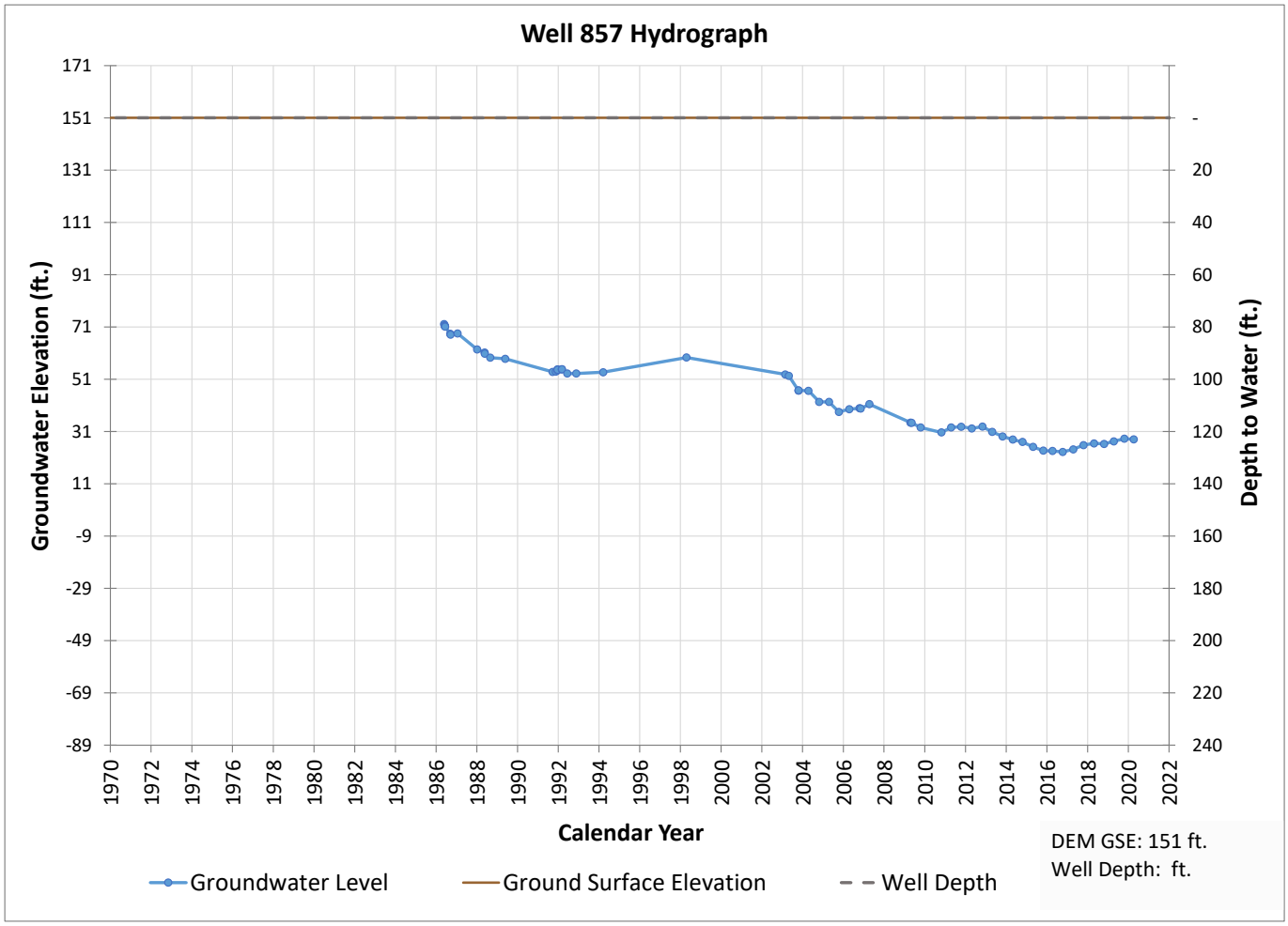

Well 842 Hydrograph
Groundwater Elevation (ft.)
92
72
52
32
12
-8
-28
-48
-68
-88
-108
-128
-148
-168
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 72 ft.
Well Depth: 210 ft.

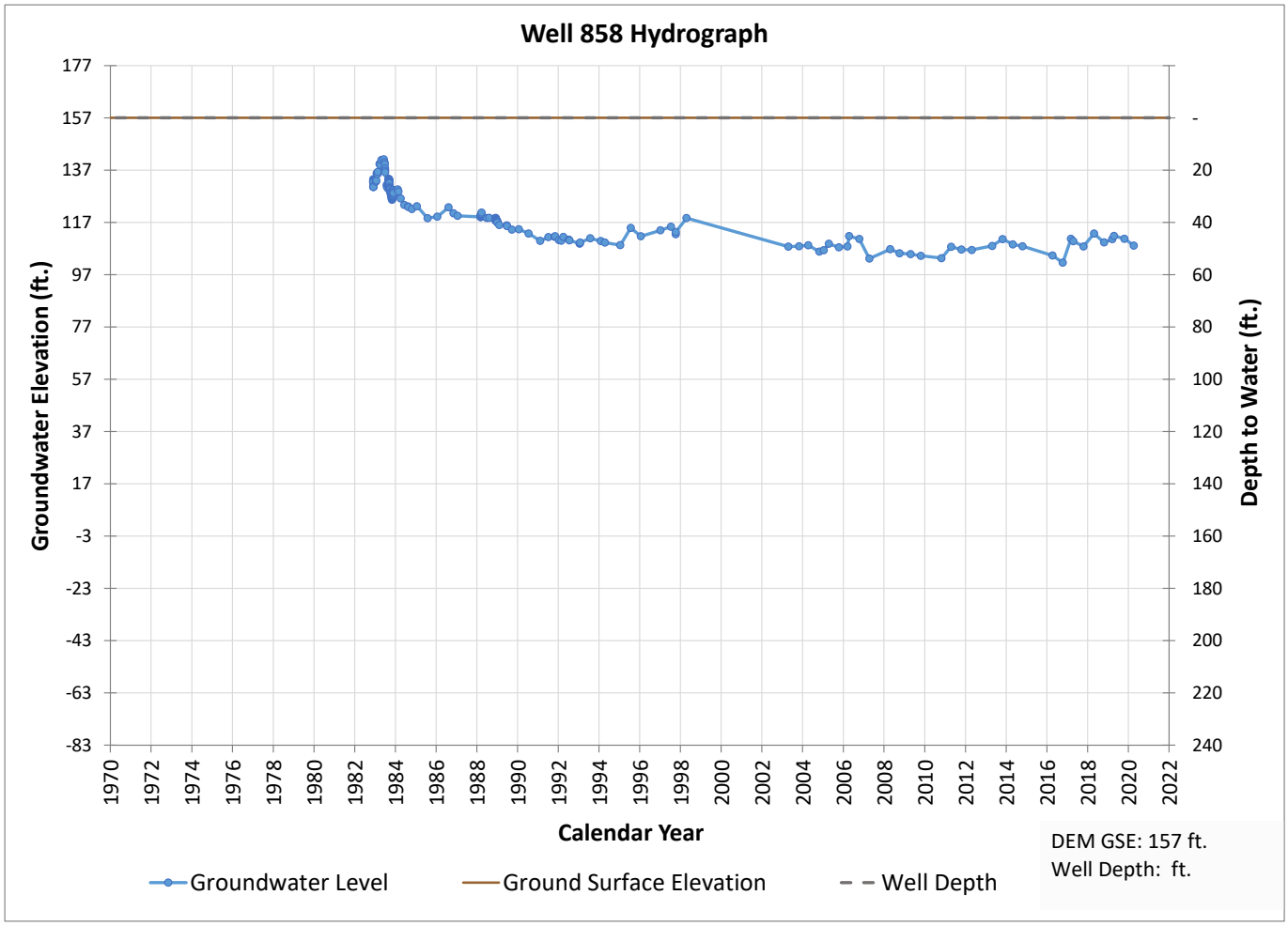

Well 845 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
83
63
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 63 ft.
Well Depth: 331 ft.

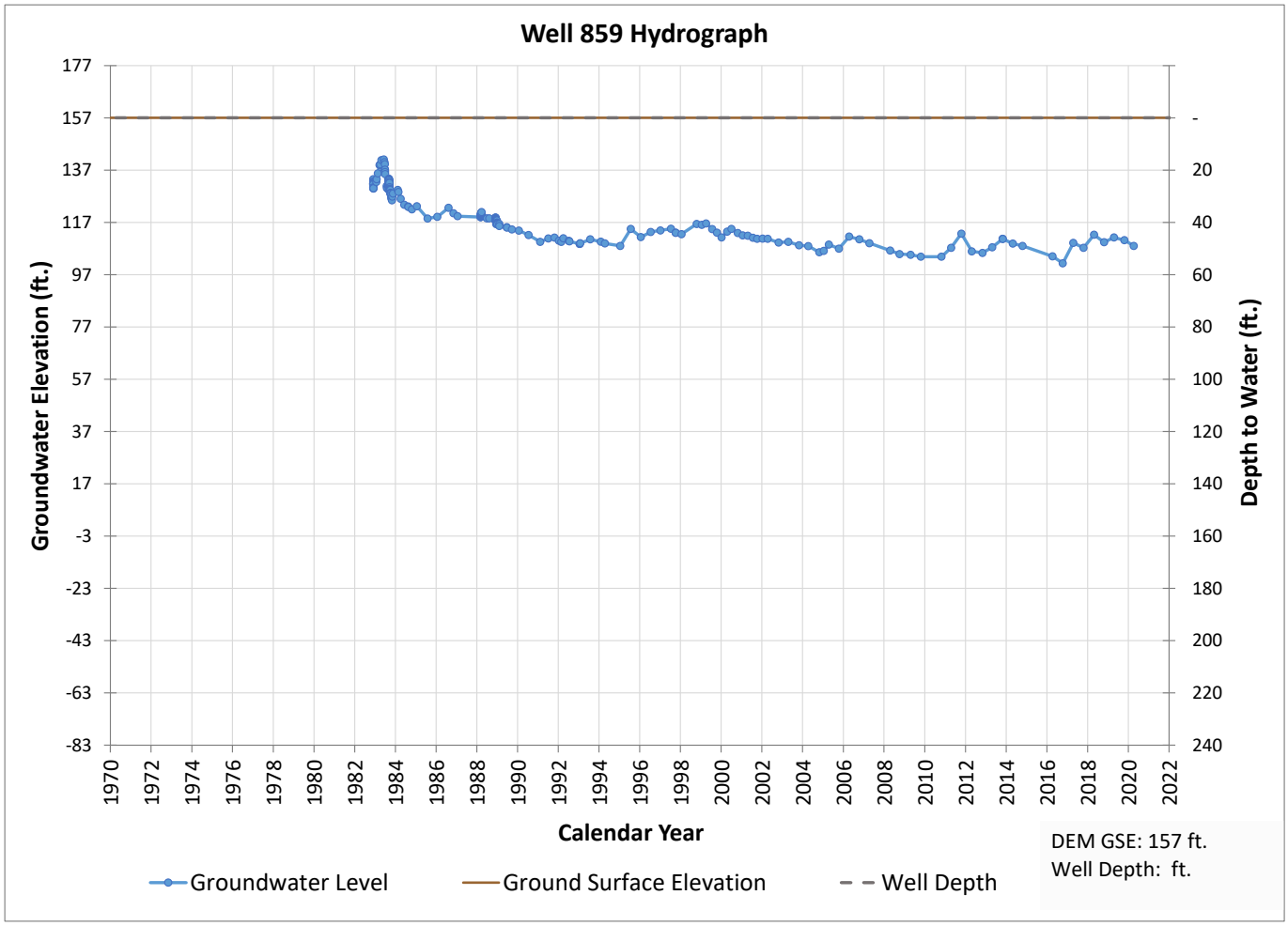

Well 847 Hydrograph
Groundwater Elevation (ft.)
187
167
147
127
107
87
67
47
27
7
-13
-33
-53
-73
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 167 ft.
Well Depth: 52 ft.

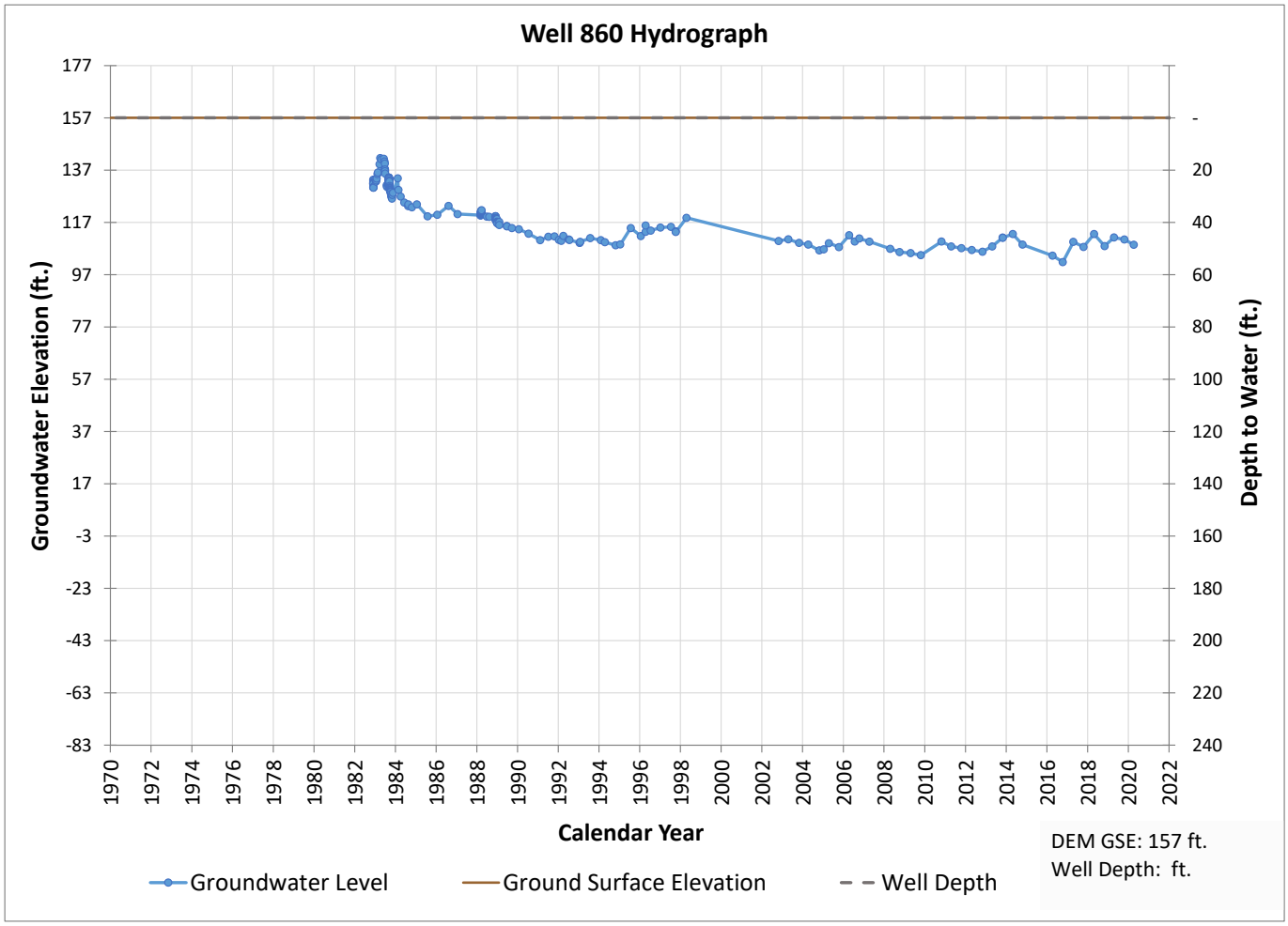

Well 849 Hydrograph
Groundwater Elevation (ft.)
106
86
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 86 ft.
Well Depth: 150 ft.

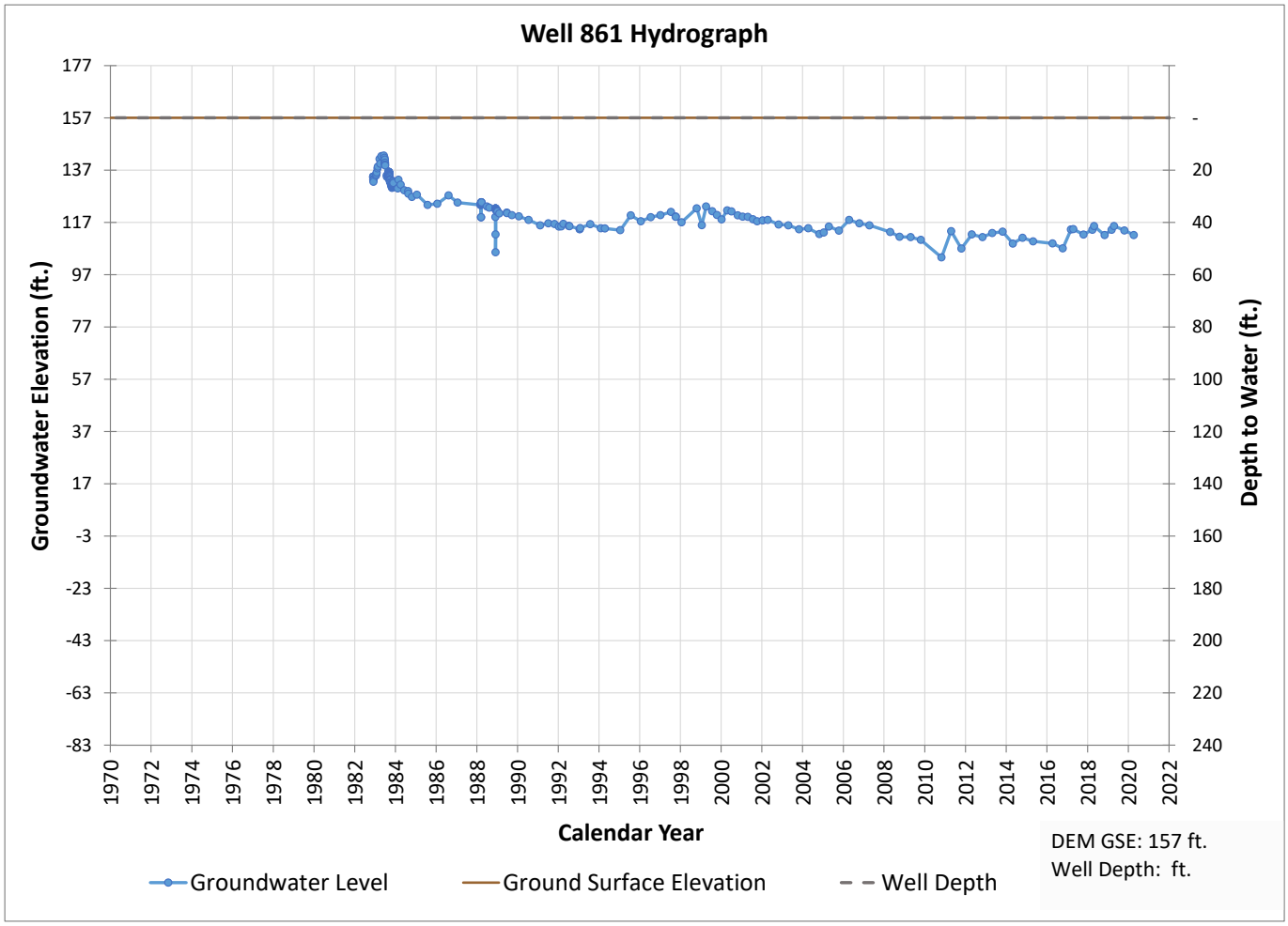

Well 855 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
148
128
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 128 ft.
Well Depth: 100 ft.

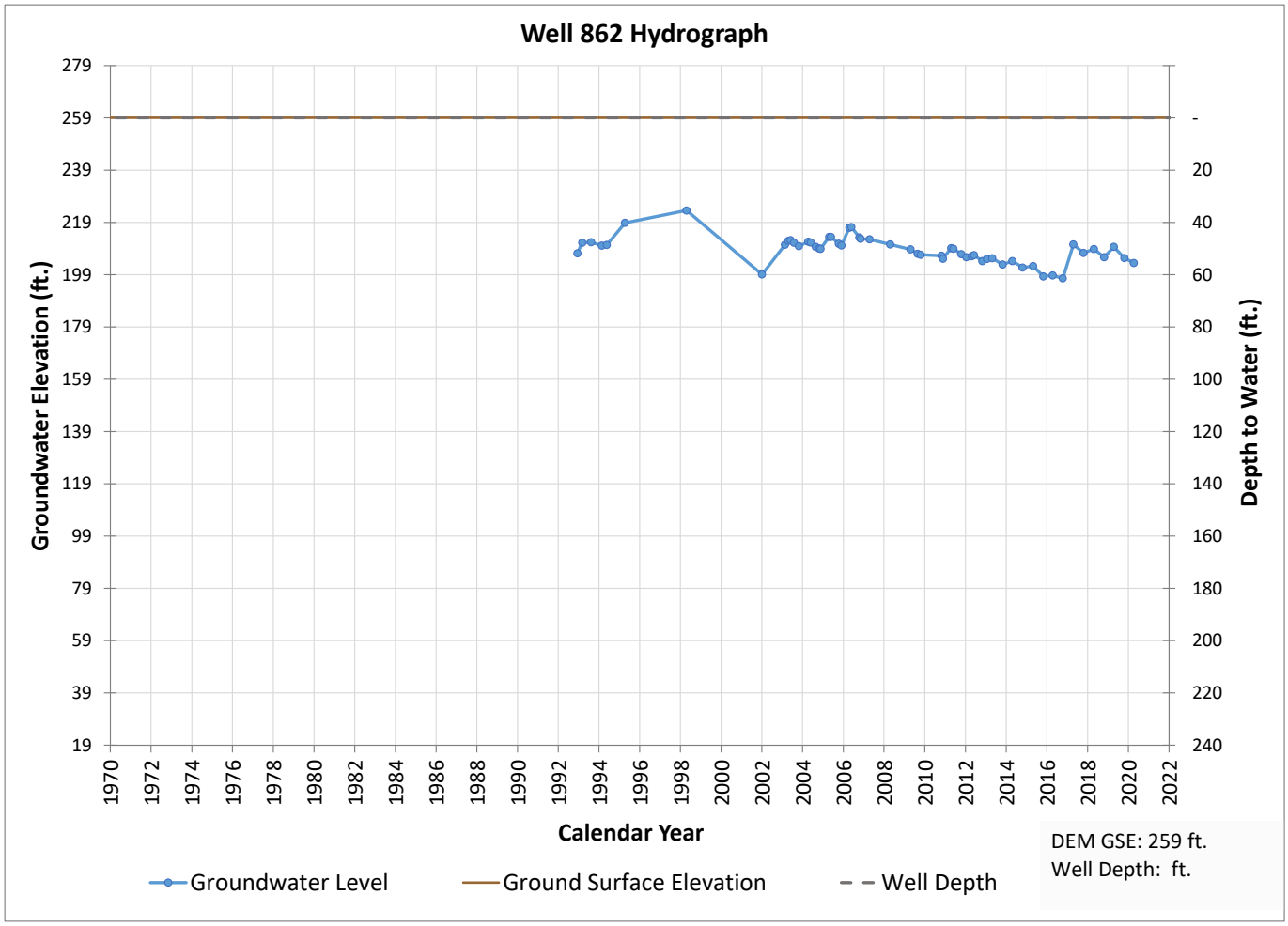

Well 857 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
171
151
131
111
91
71
51
31
11
-9
-29
-49
-69
-89
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 151 ft.
Well Depth: ft.

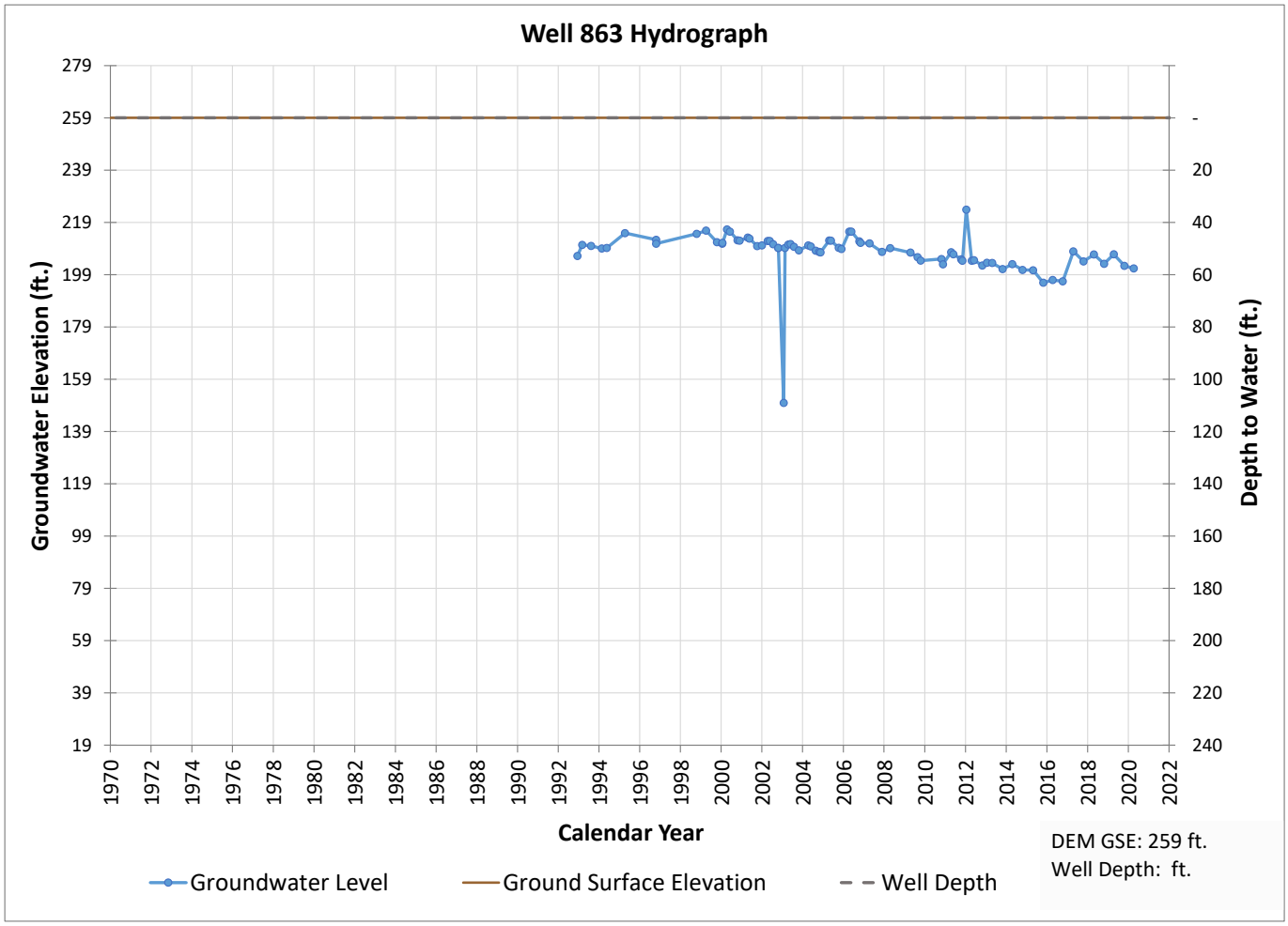

Well 858 Hydrograph
Groundwater Elevation (ft.)
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 157 ft.
Well Depth: ft.

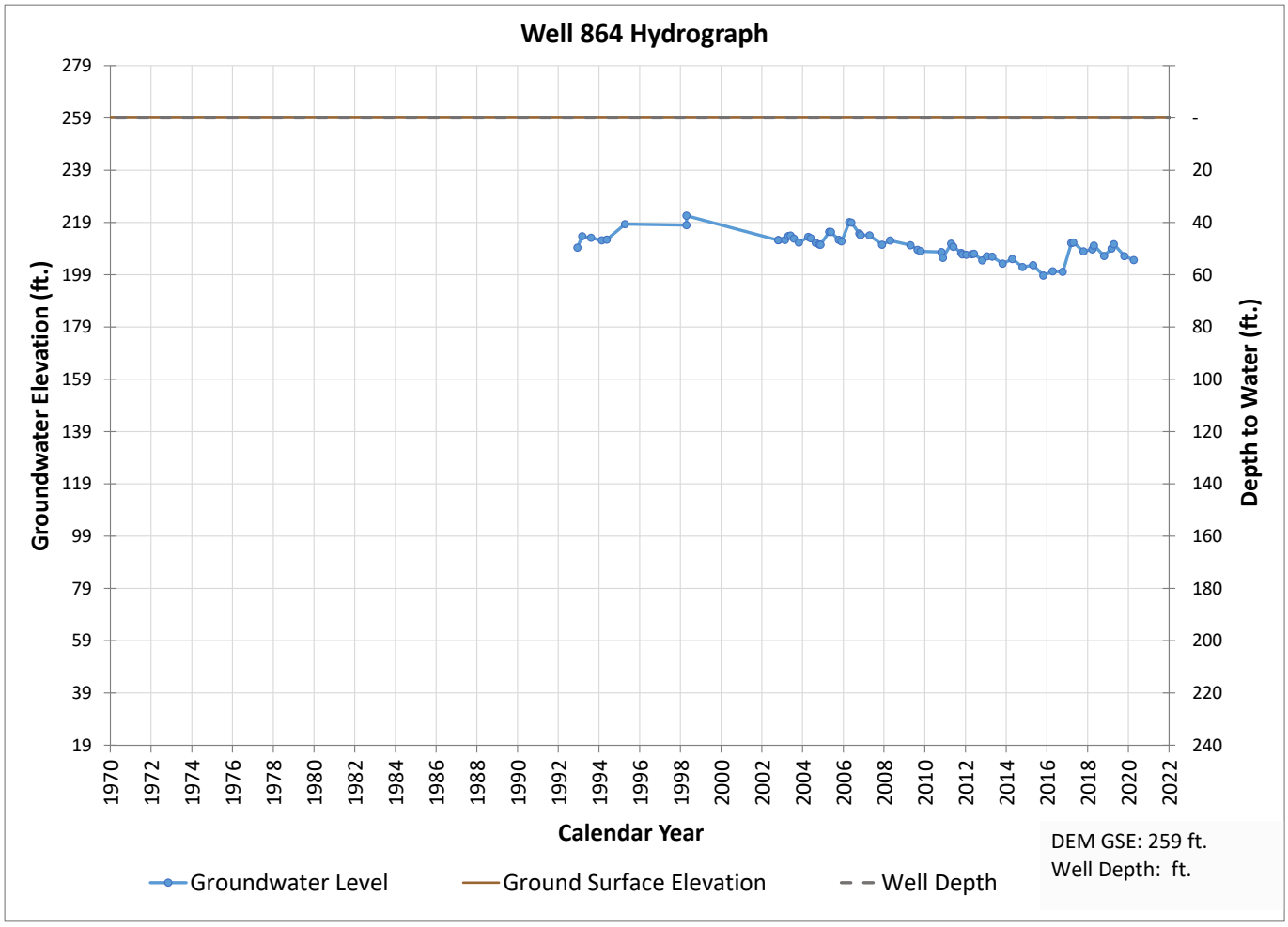

Well 859 Hydrograph
Groundwater Elevation (ft.)
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 157 ft.
Well Depth: ft.

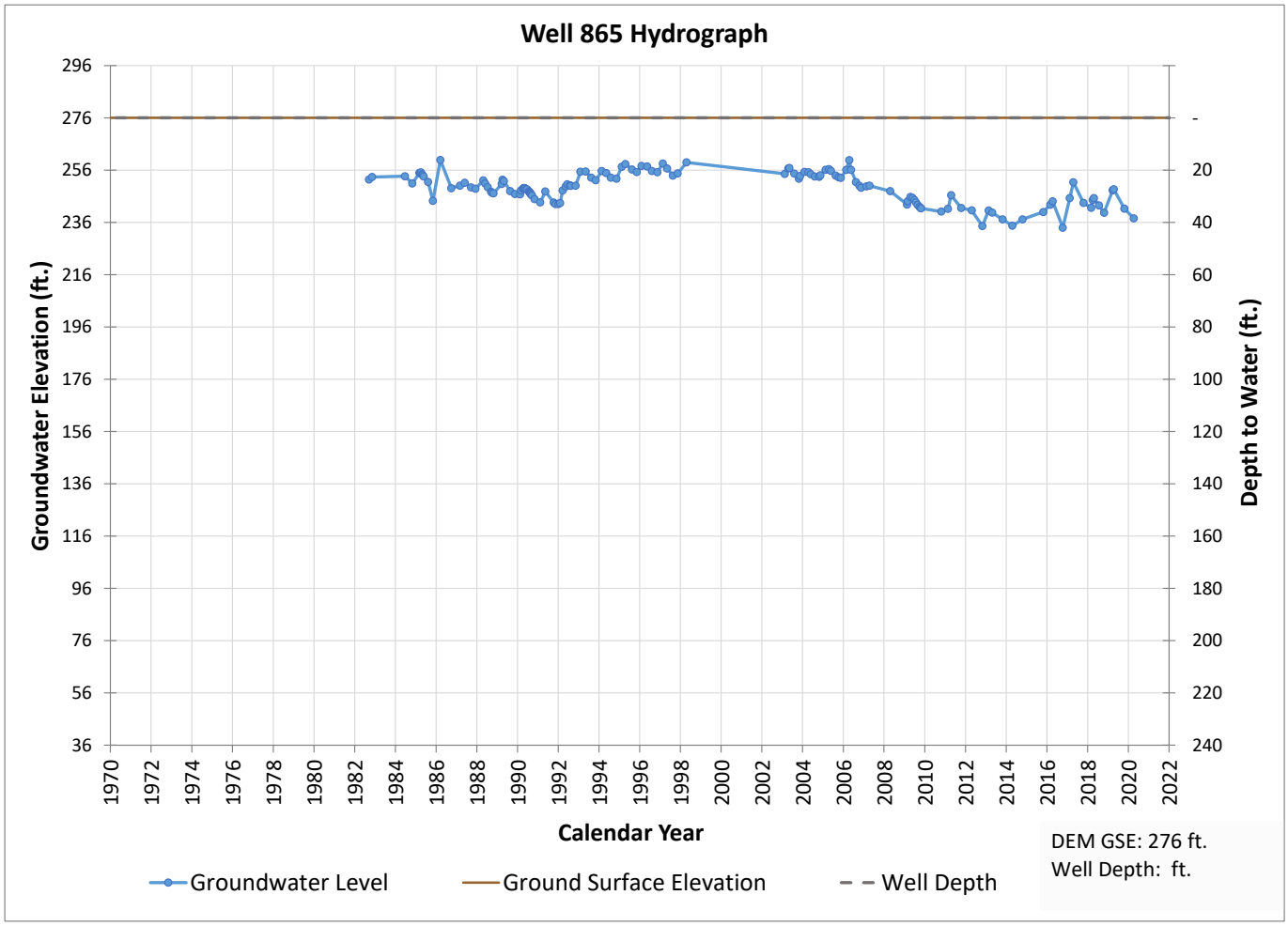

Well 860 Hydrograph
Groundwater Elevation (ft.)
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 157 ft.
Well Depth: ft.

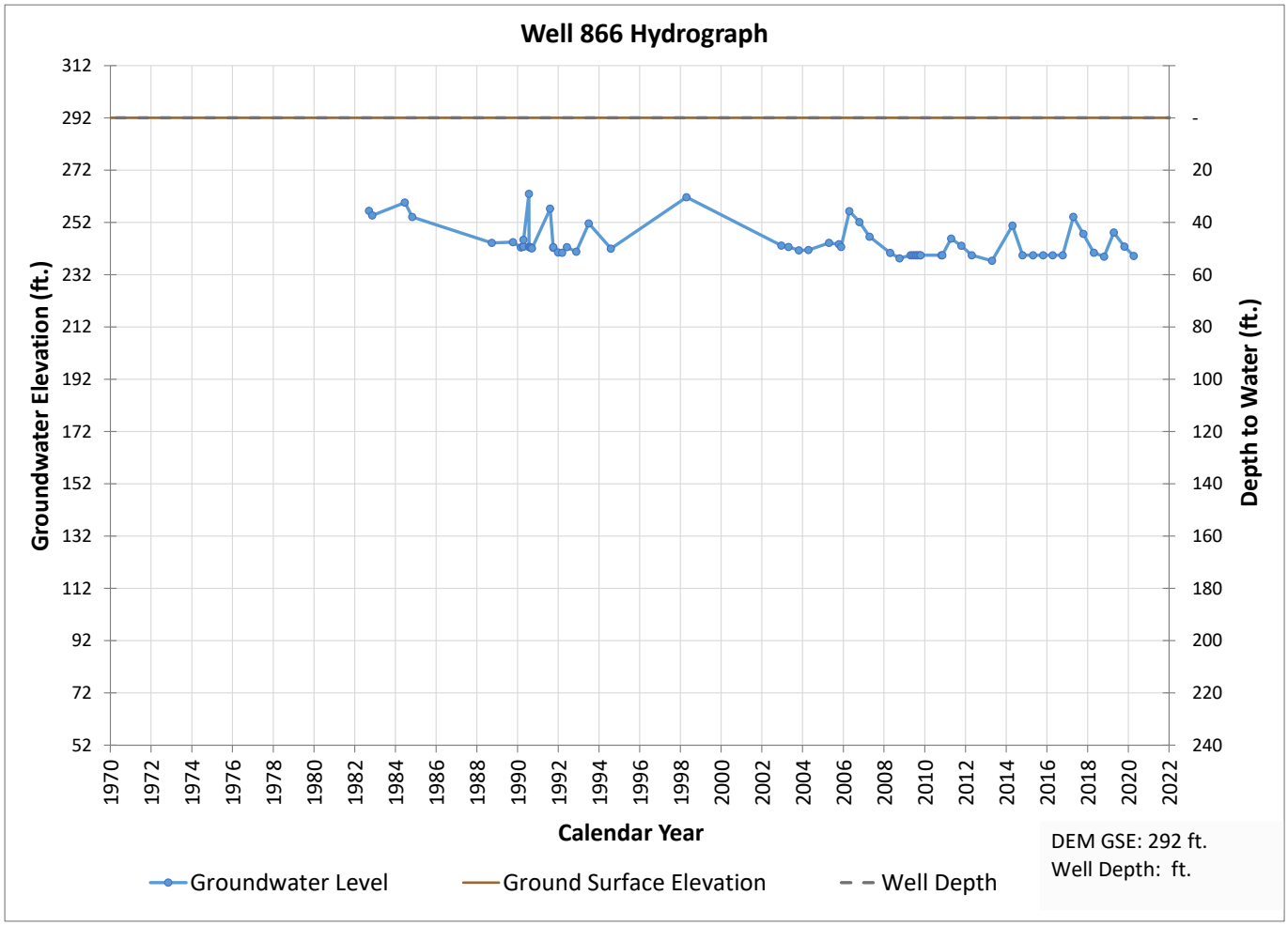

Well 861 Hydrograph
Groundwater Elevation (ft.)
177
157
137
117
97
77
57
37
17
-3
-23
-43
-63
-83
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 157 ft.
Well Depth: ft.

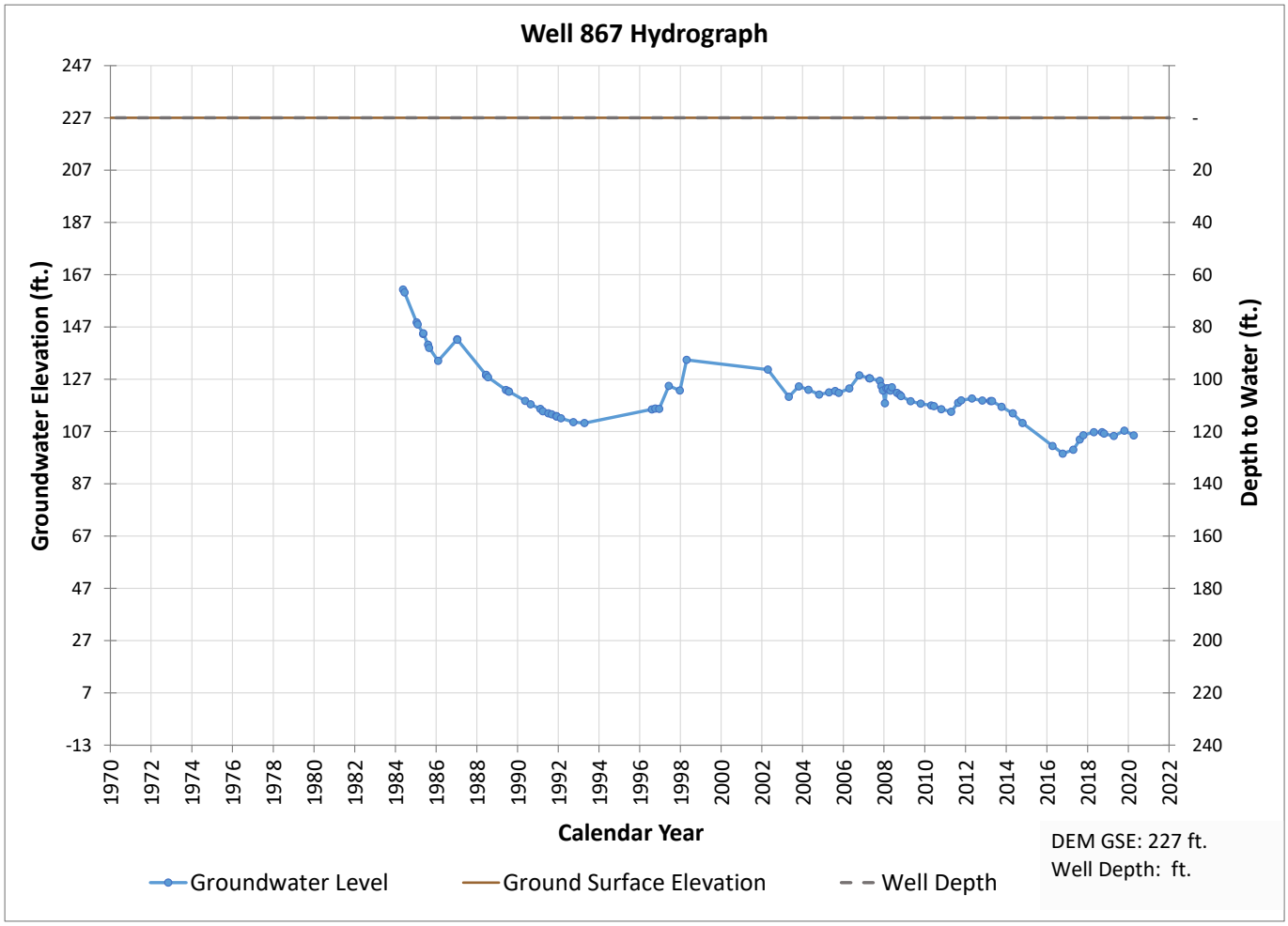

Well 862 Hydrograph
Groundwater Elevation (ft.)
279
259
239
219
199
179
159
139
119
99
79
59
39
19
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 259 ft.
Well Depth: ft.

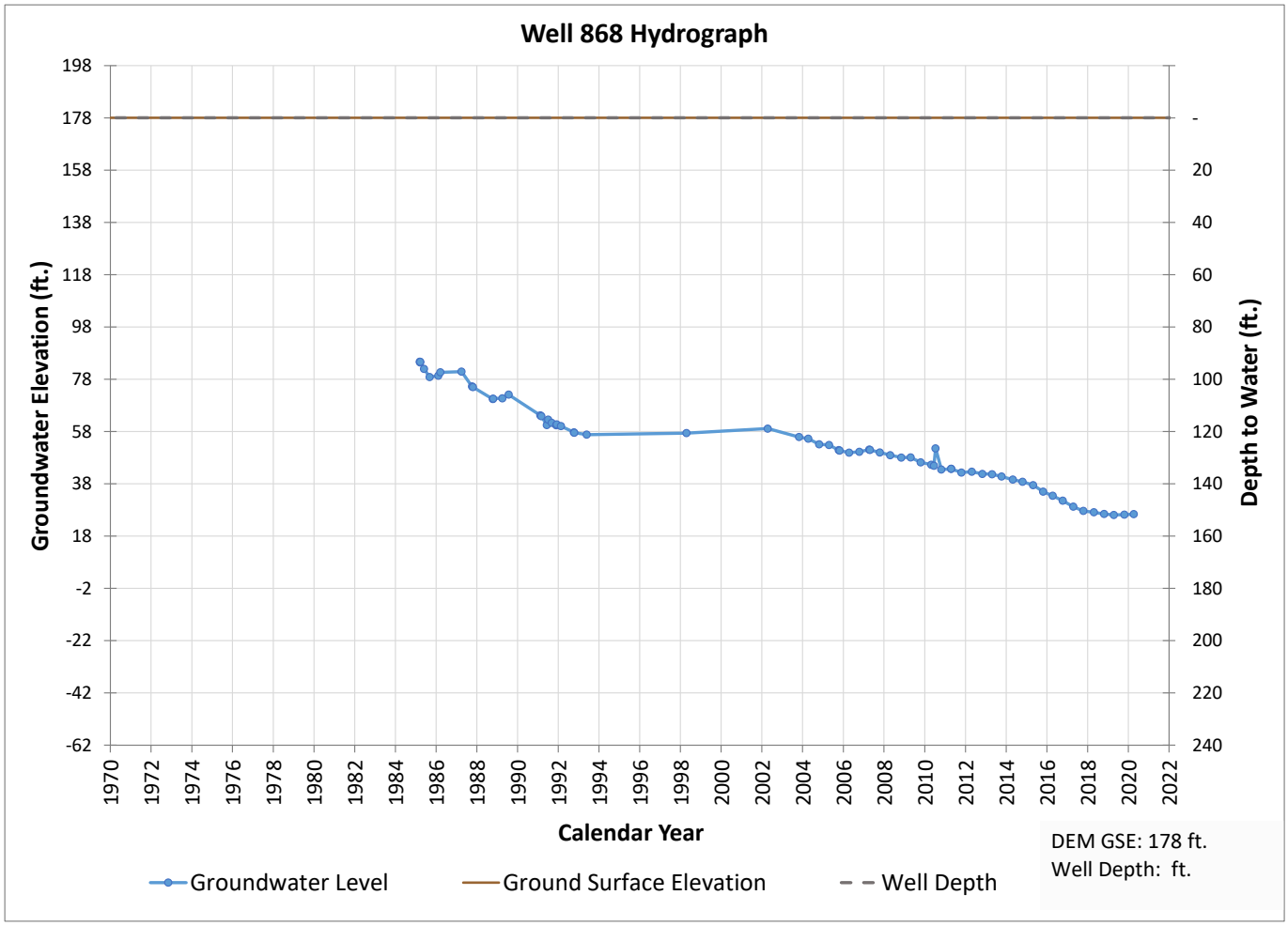

Well 863 Hydrograph
Groundwater Elevation (ft.)
279
259
239
219
199
179
159
139
119
99
79
59
39
19
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 259 ft.
Well Depth: ft.

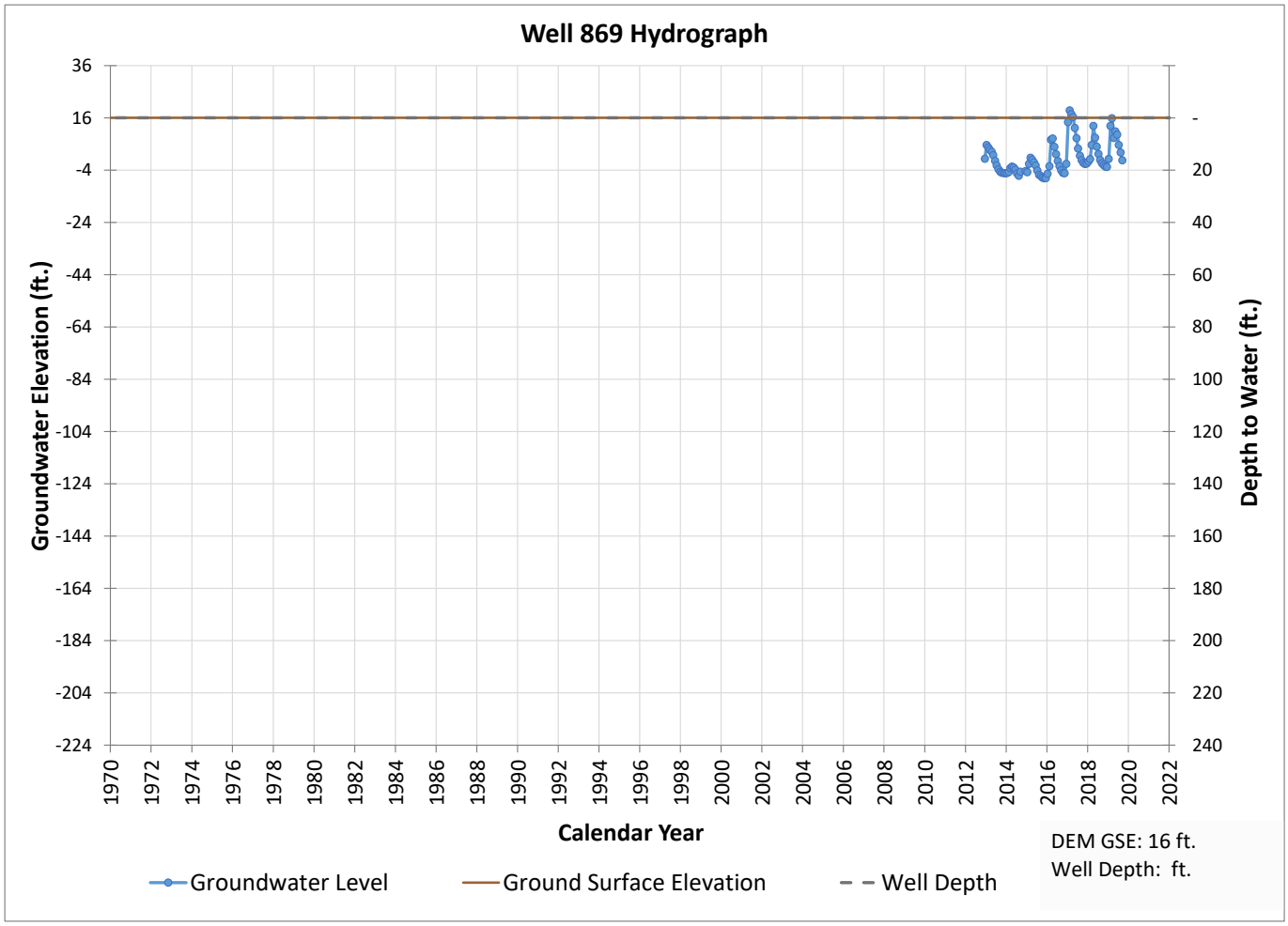

Well 864 Hydrograph
Groundwater Elevation (ft.)
279
259
239
219
199
179
159
139
119
99
79
59
39
19
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 259 ft.
Well Depth: ft.

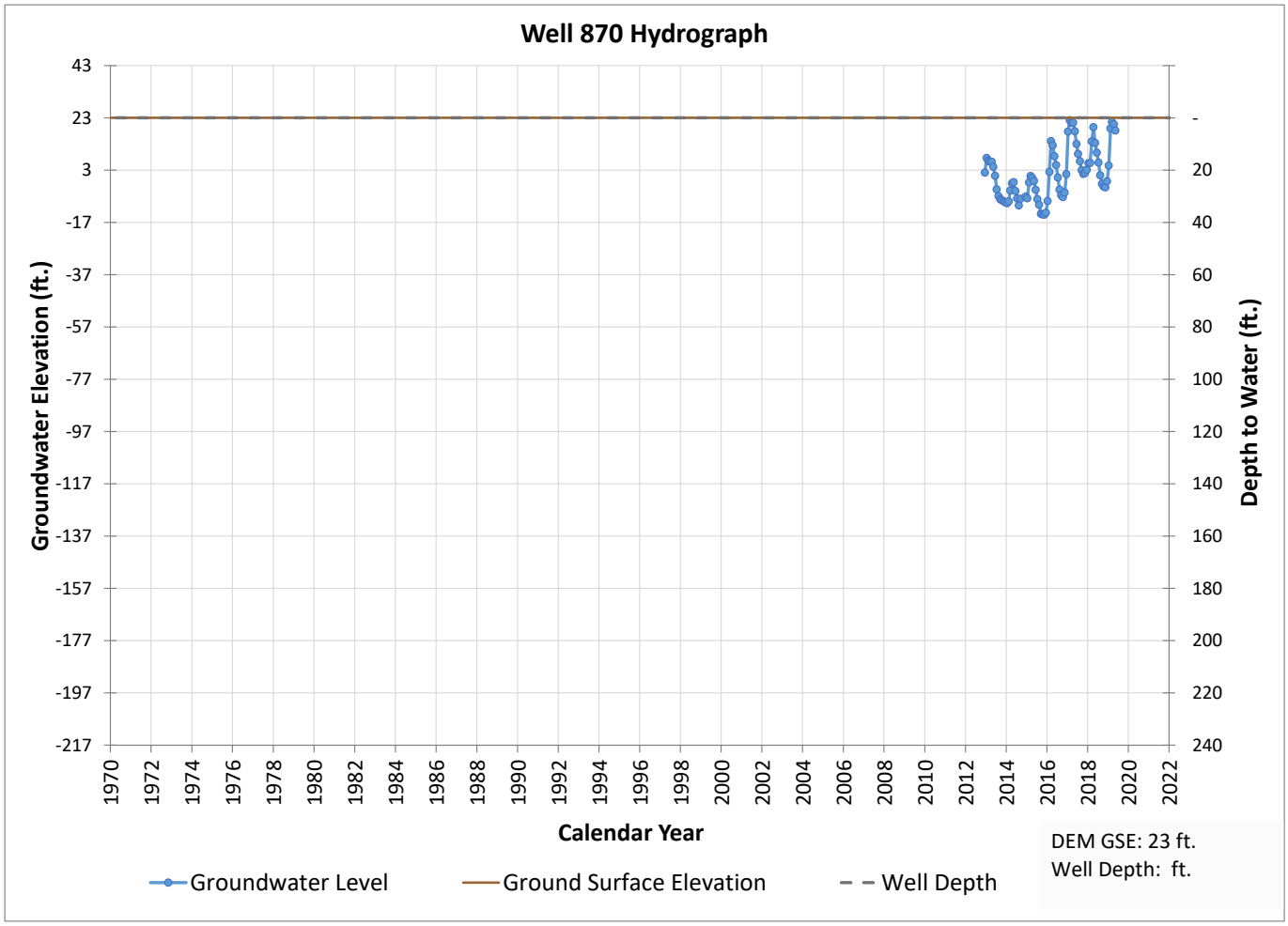

Well 865 Hydrograph
Groundwater Elevation (ft.)
296
276
256
236
216
196
176
156
136
116
96
76
56
36
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 276 ft.
Well Depth: ft.

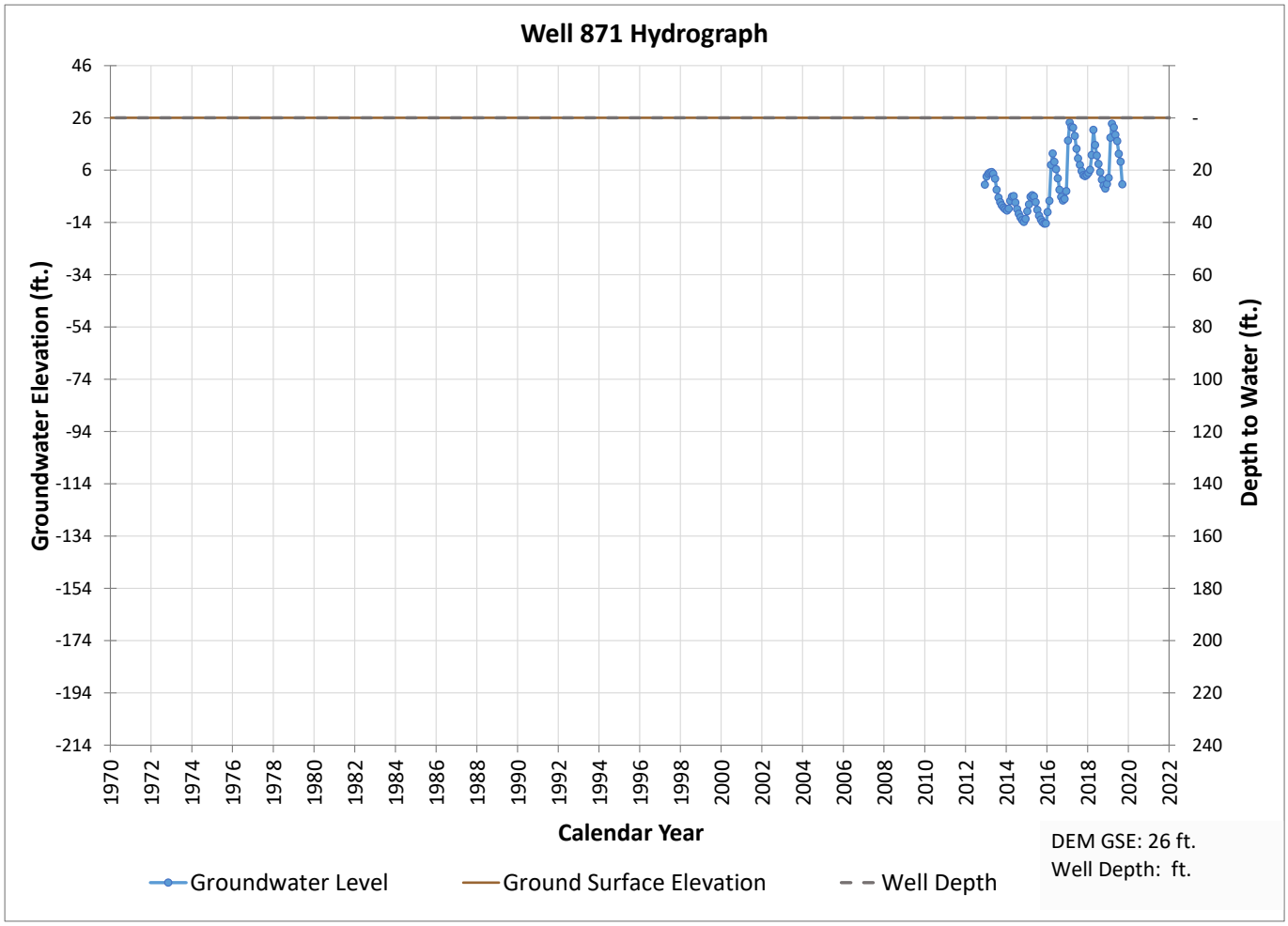

Well 866 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
312
292
272
252
232
212
192
172
152
132
112
92
72
52
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 292 ft.
Well Depth: ft.

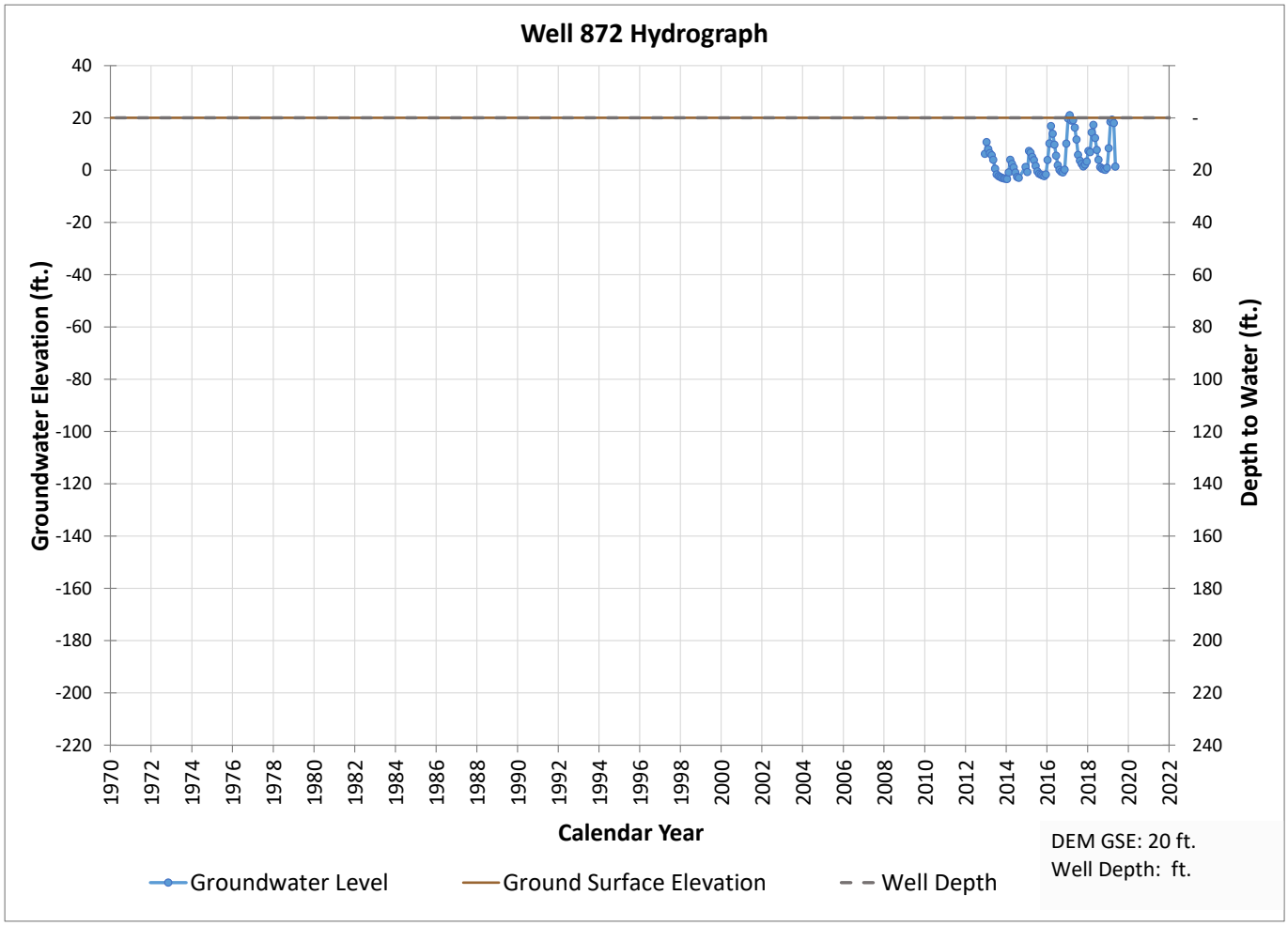

Well 867 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
247
227
207
187
167
147
127
107
87
67
47
27
7
-13
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 227 ft.
Well Depth: ft.

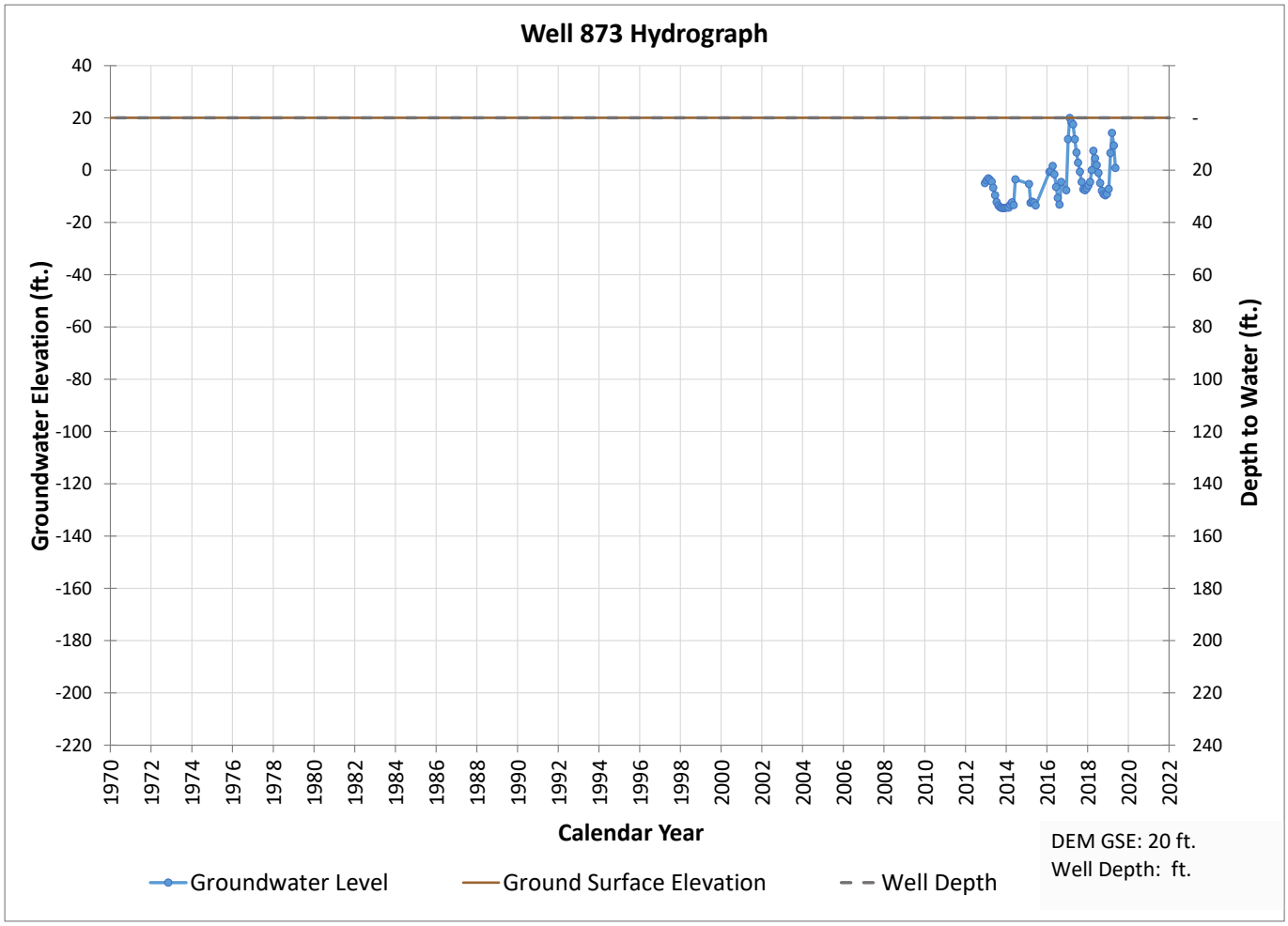

Well 868 Hydrograph
Groundwater Elevation (ft.)
198
178
158
138
118
98
78
58
38
18
-2
-22
-42
-62
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 178 ft.
Well Depth: ft.

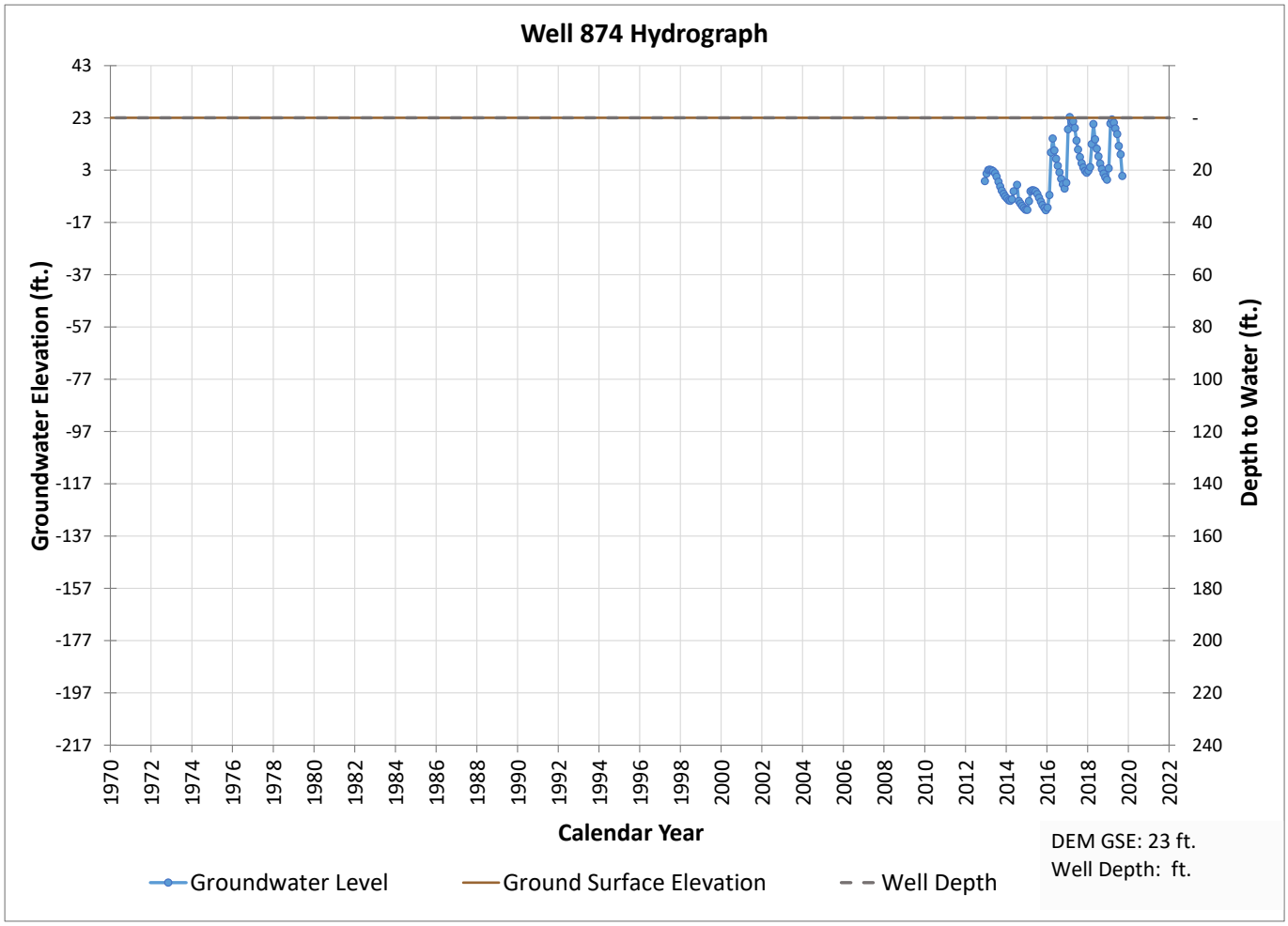

Well 869 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: ft.

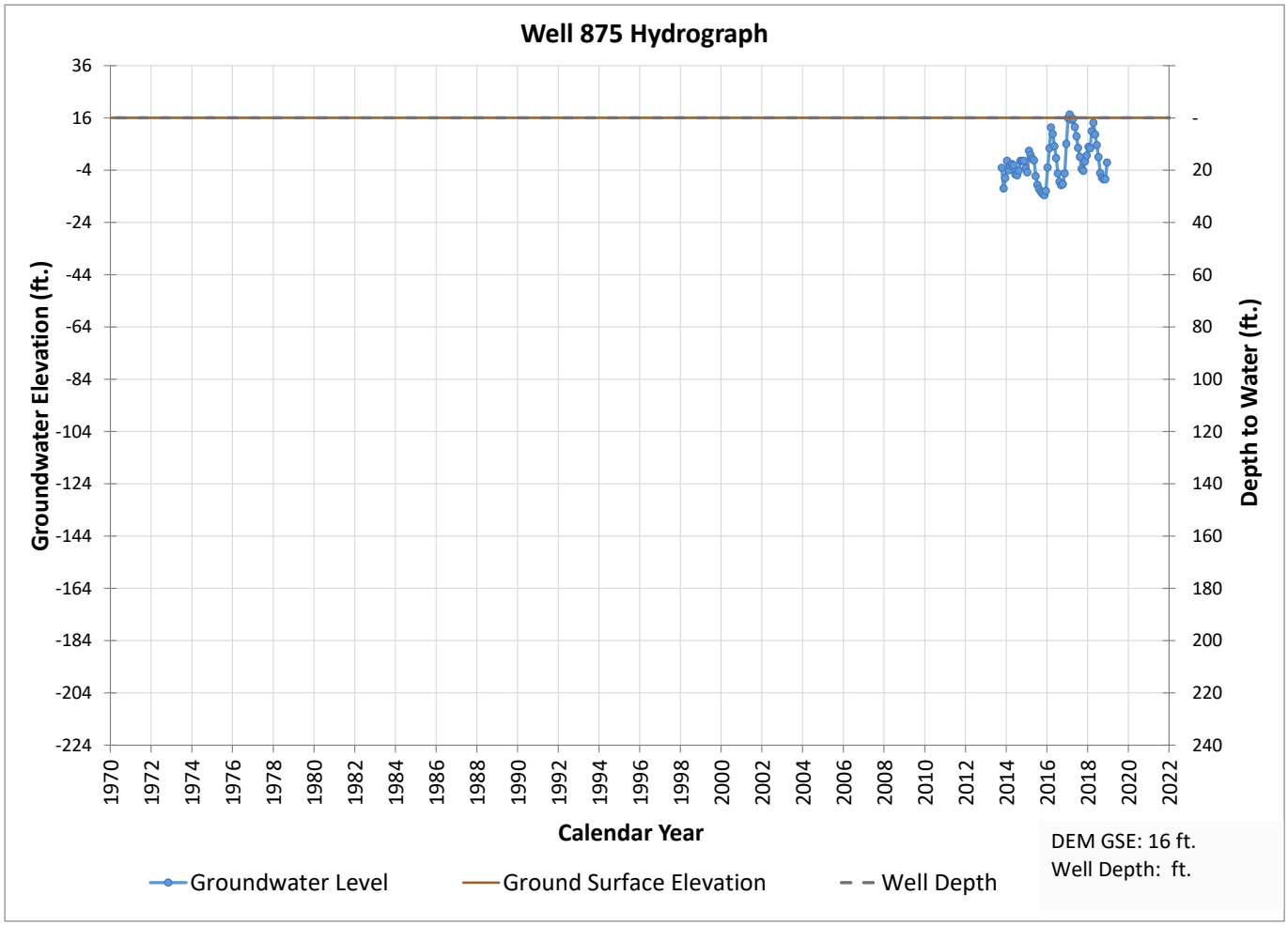

Well 870 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.

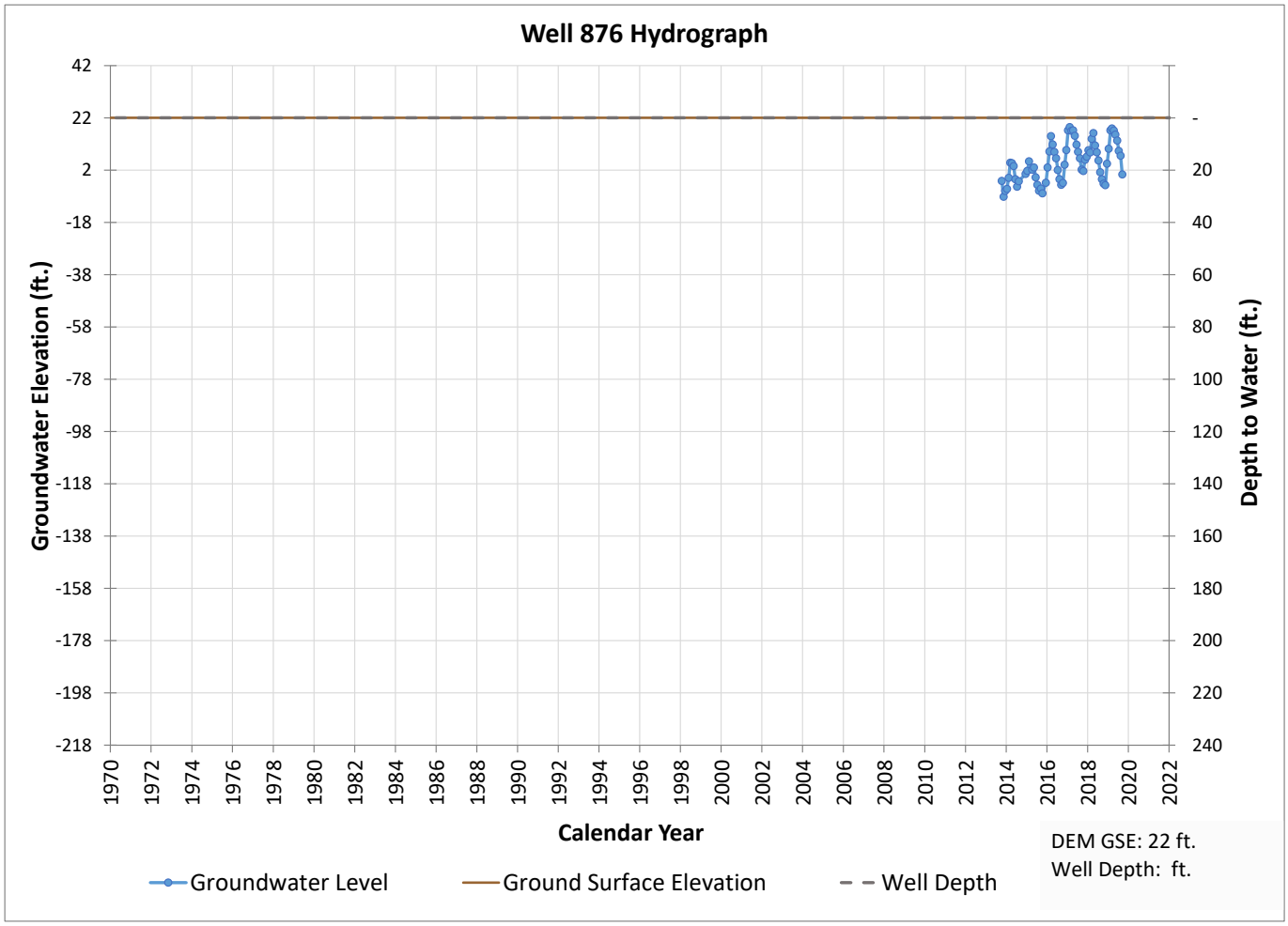

Well 871 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
-214
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 26 ft.
Well Depth: ft.

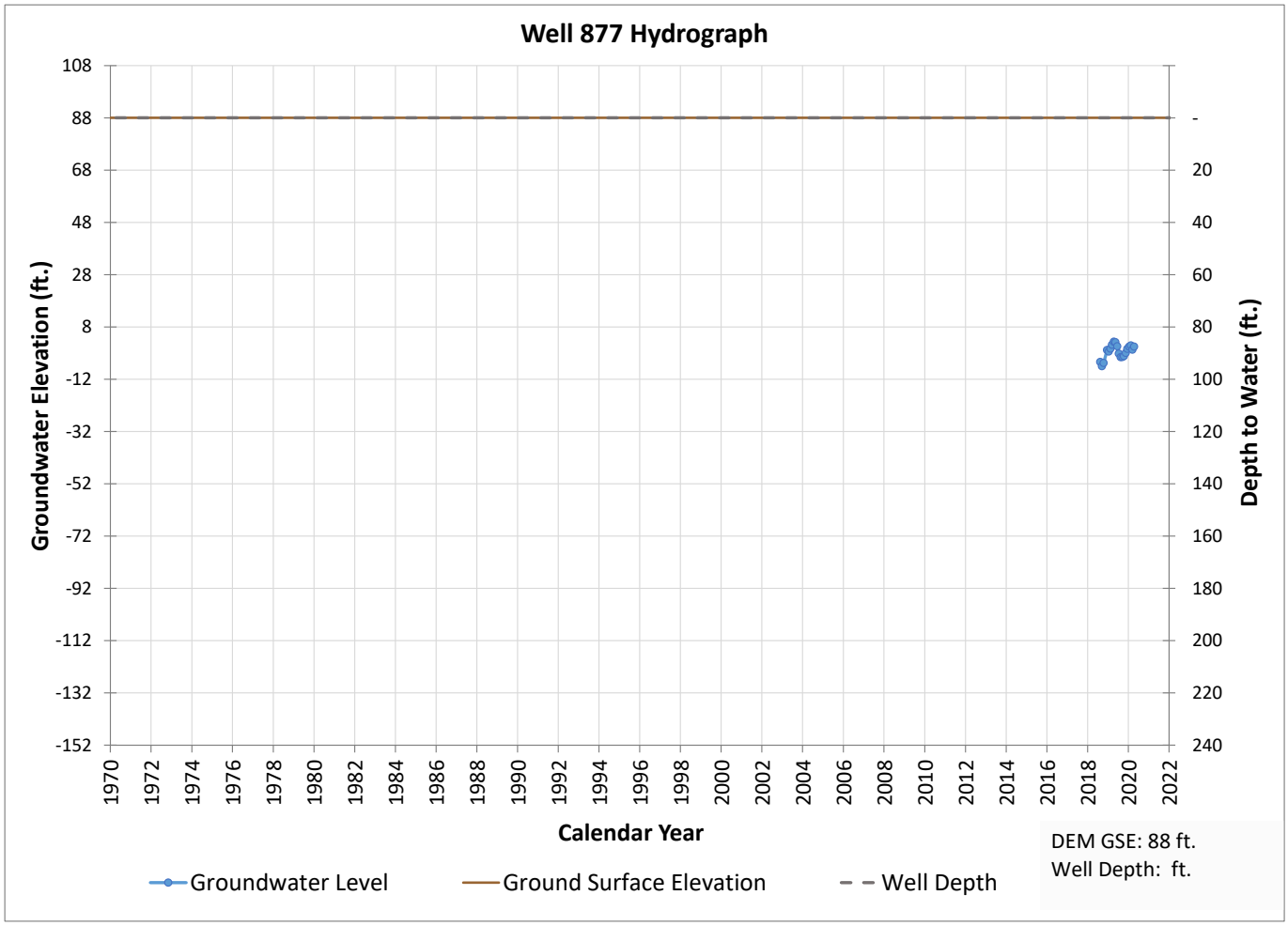

Well 872 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: ft.

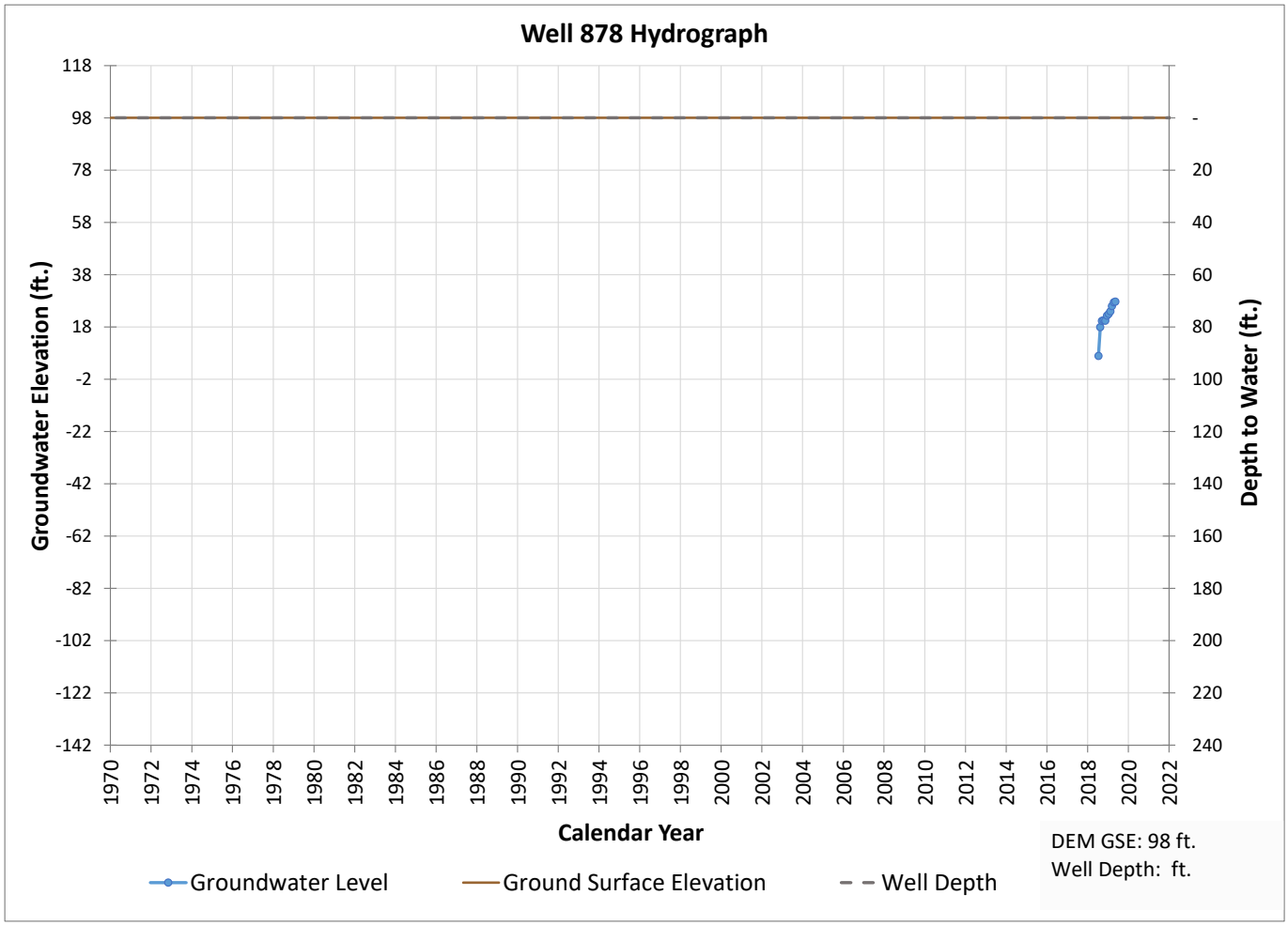

Well 873 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: ft.

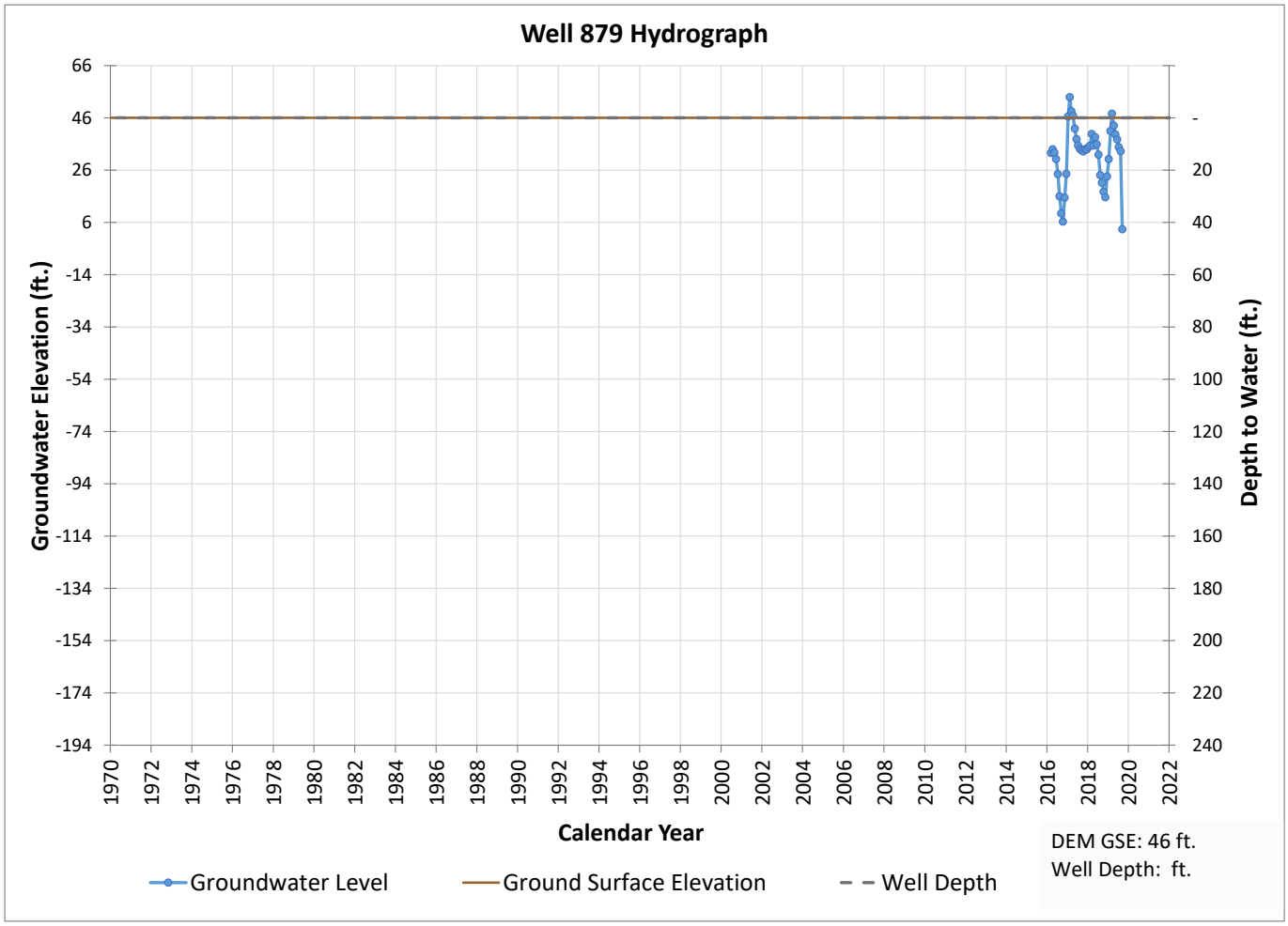

Well 874 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.

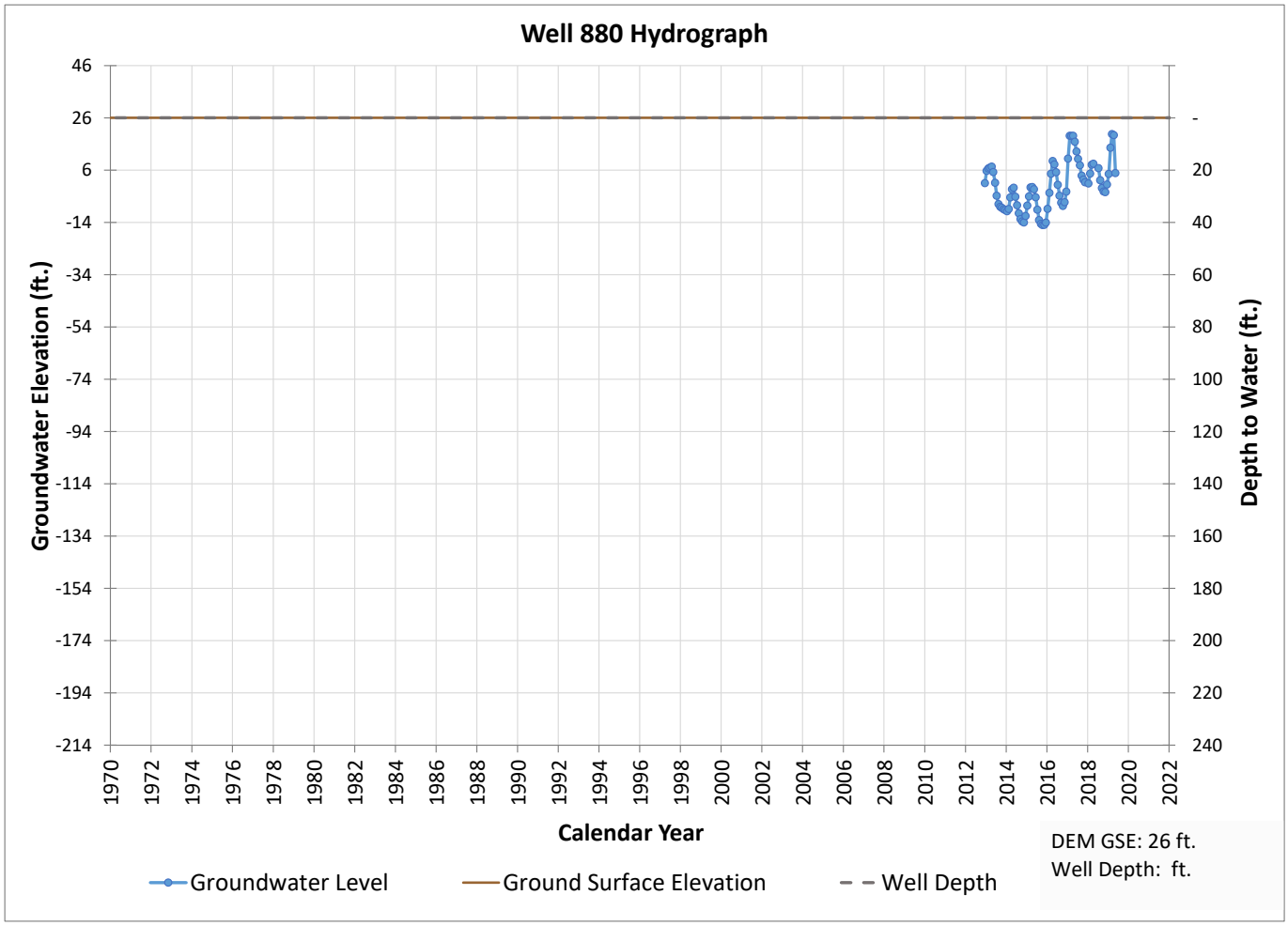

Well 875 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: ft.

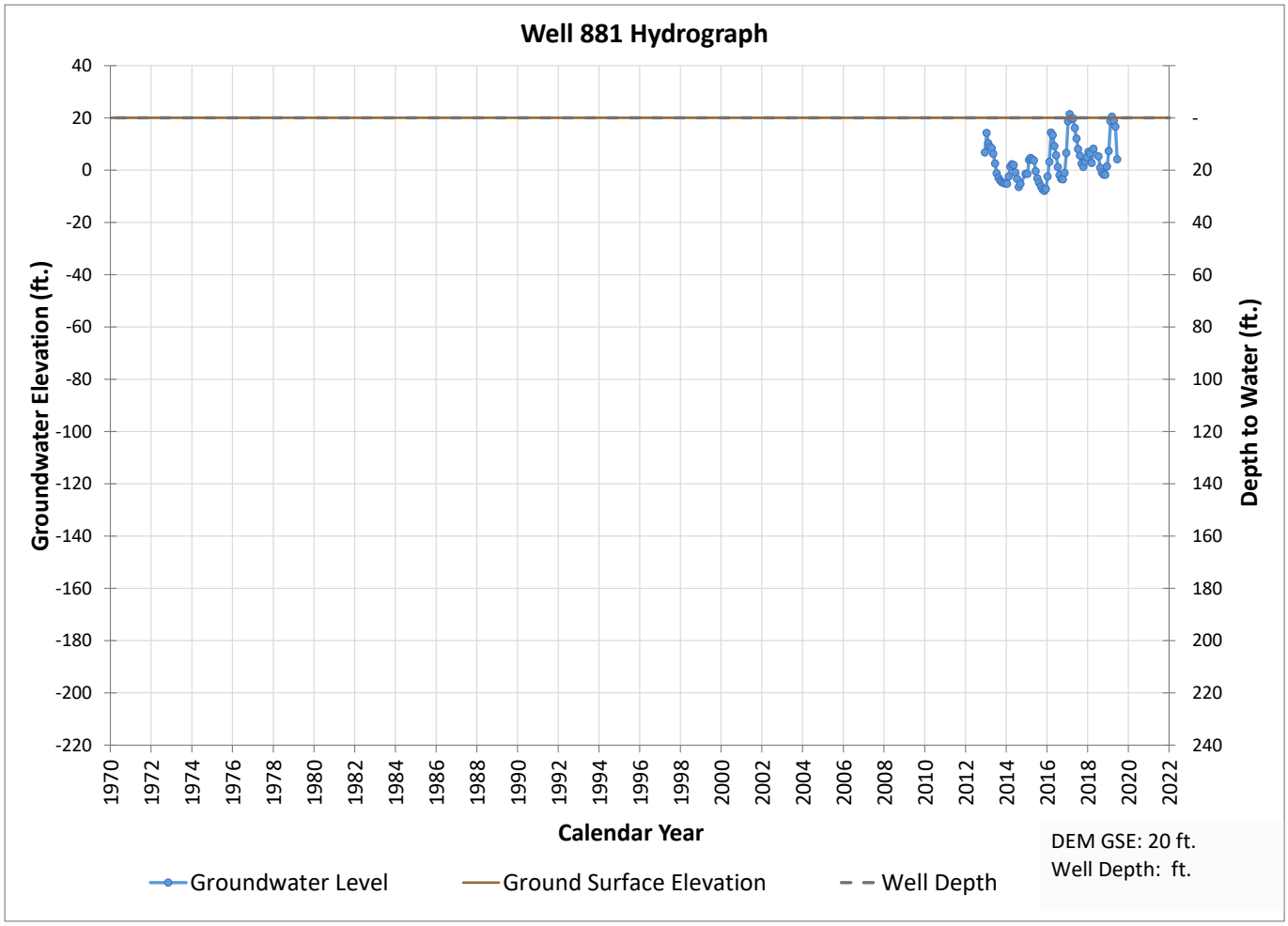

Well 876 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
42
22
2
-18
-38
-58
-78
-98
-118
-138
-158
-178
-198
-218
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 22 ft.
Well Depth: ft.

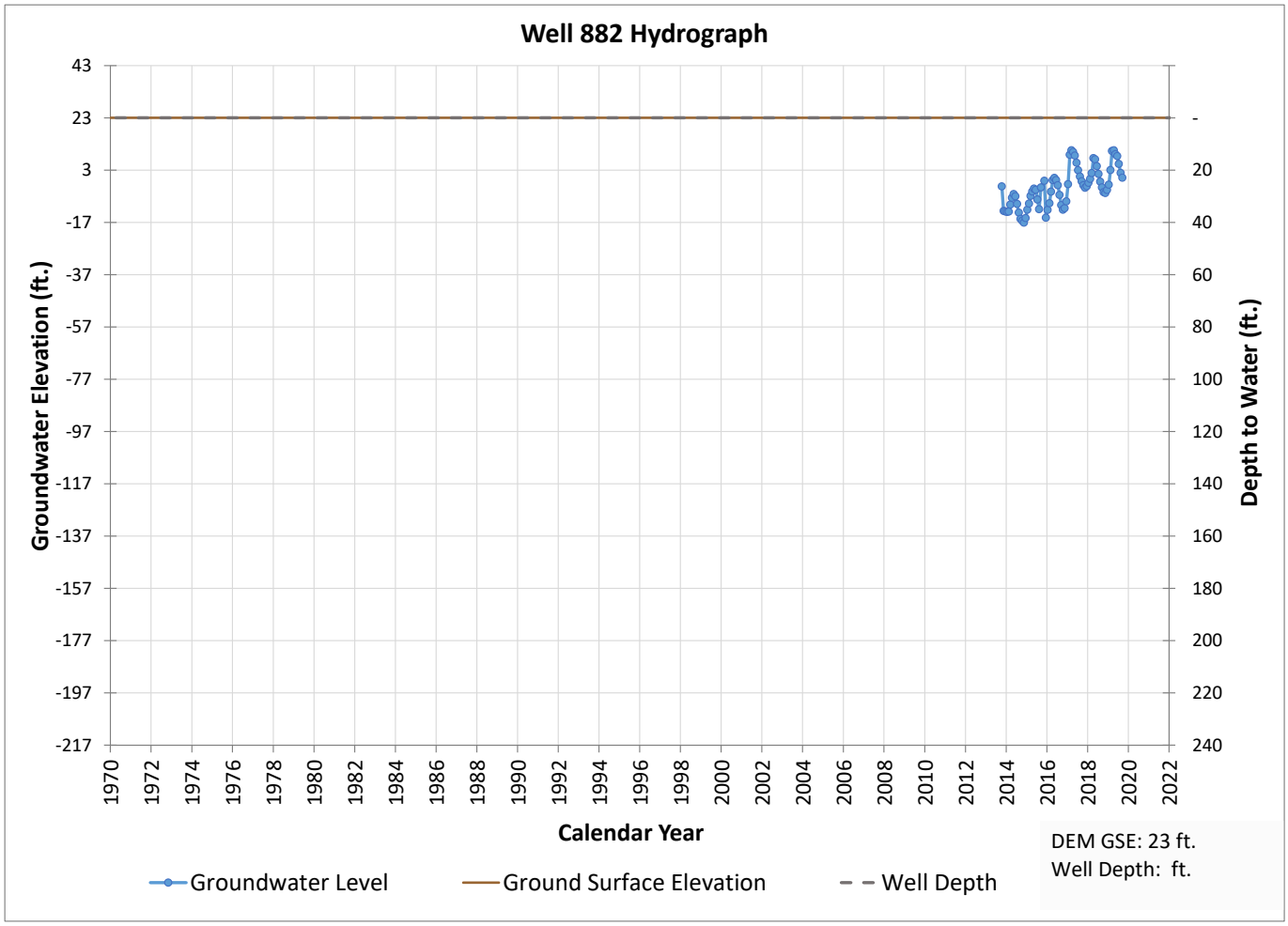

Well 877 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
108
88
68
48
28
8
-12
-32
-52
-72
-92
-112
-132
-152
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 88 ft.
Well Depth: ft.

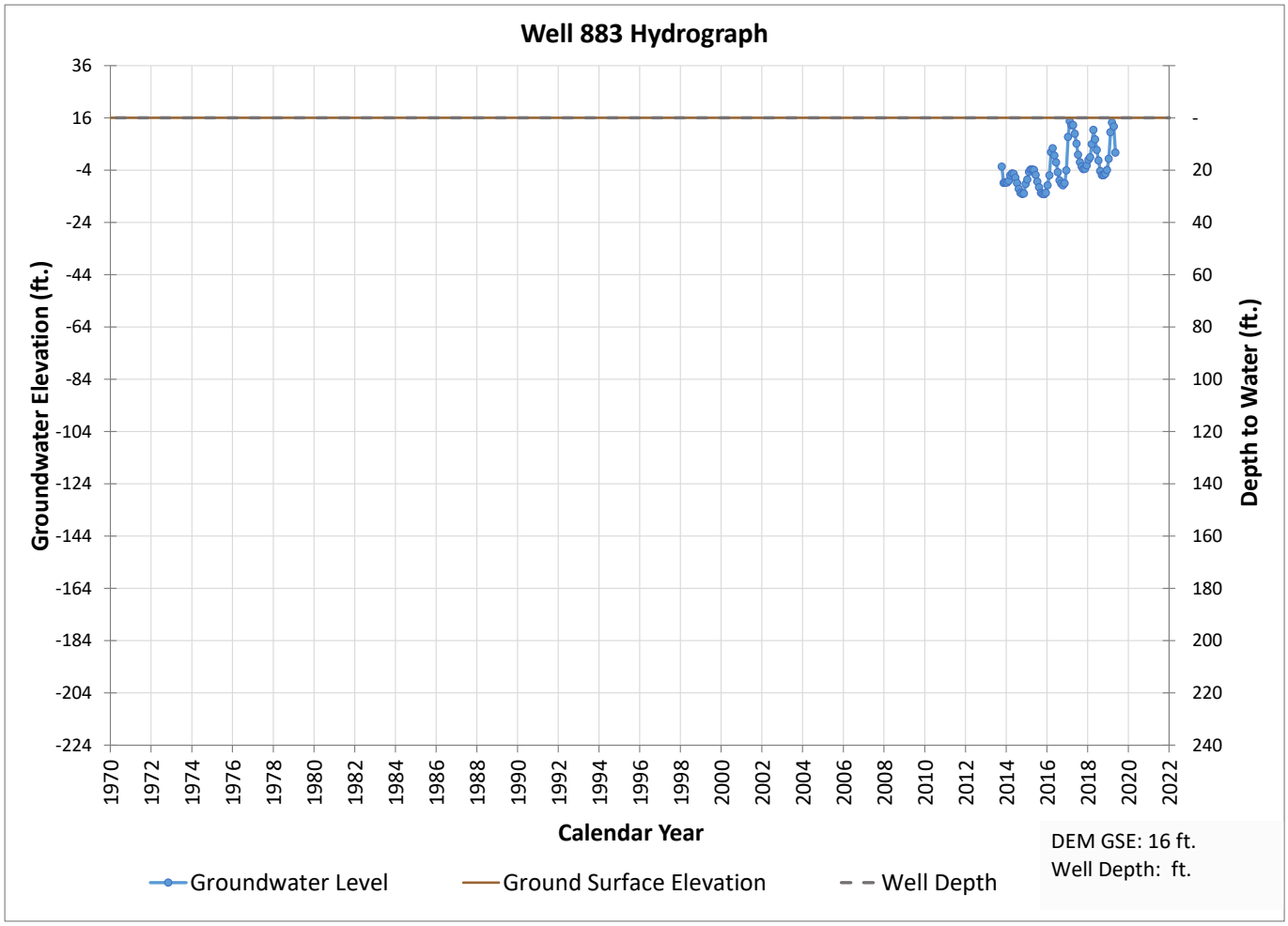

Well 878 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
118
98
78
58
38
18
-2
-22
-42
-62
-82
-102
-122
-142
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 98 ft.
Well Depth: ft.

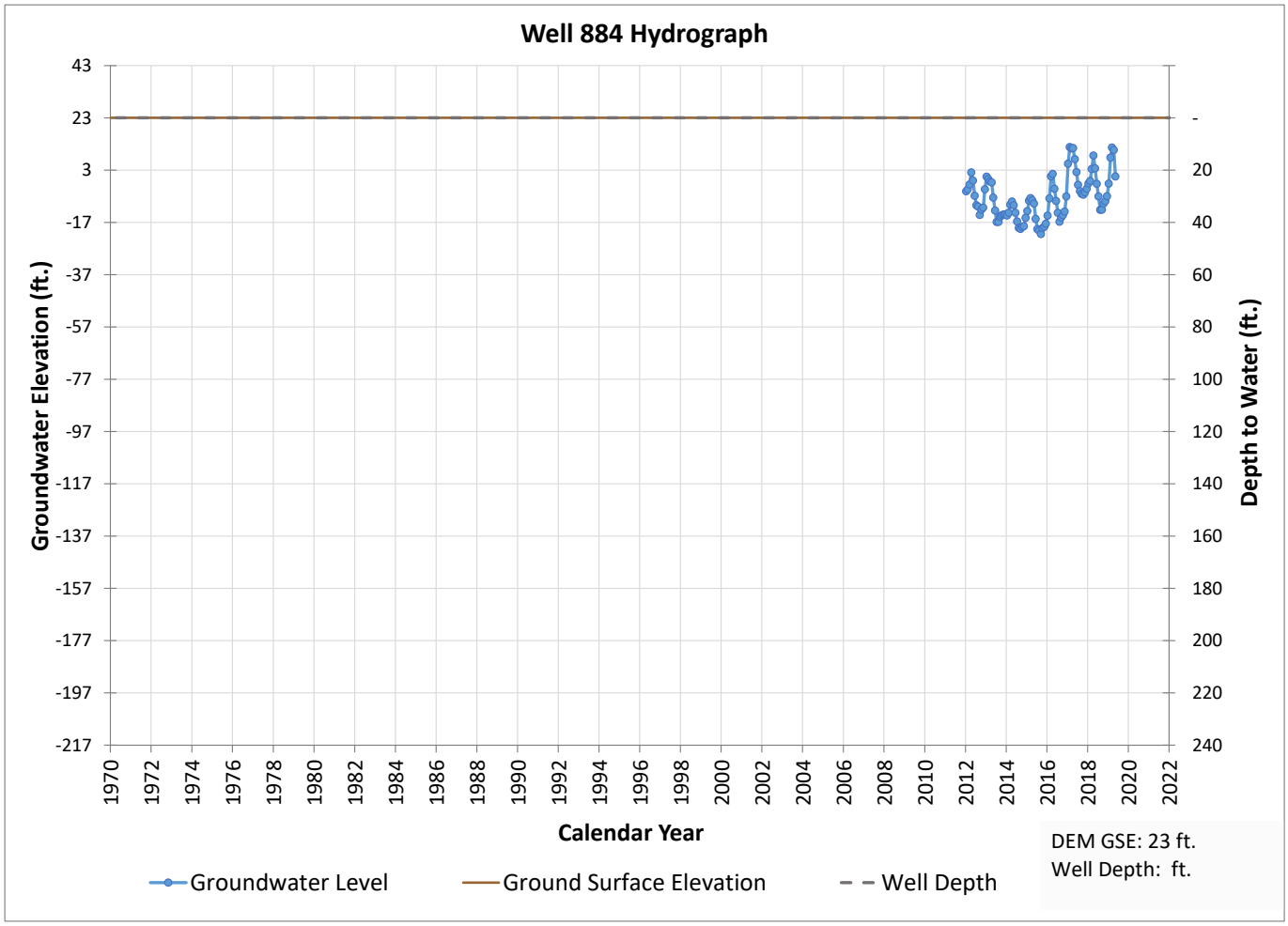

Well 879 Hydrograph
Groundwater Elevation (ft.)
66
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
Depth to Water (ft.)
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Calendar Year
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 46 ft.
Well Depth: ft.

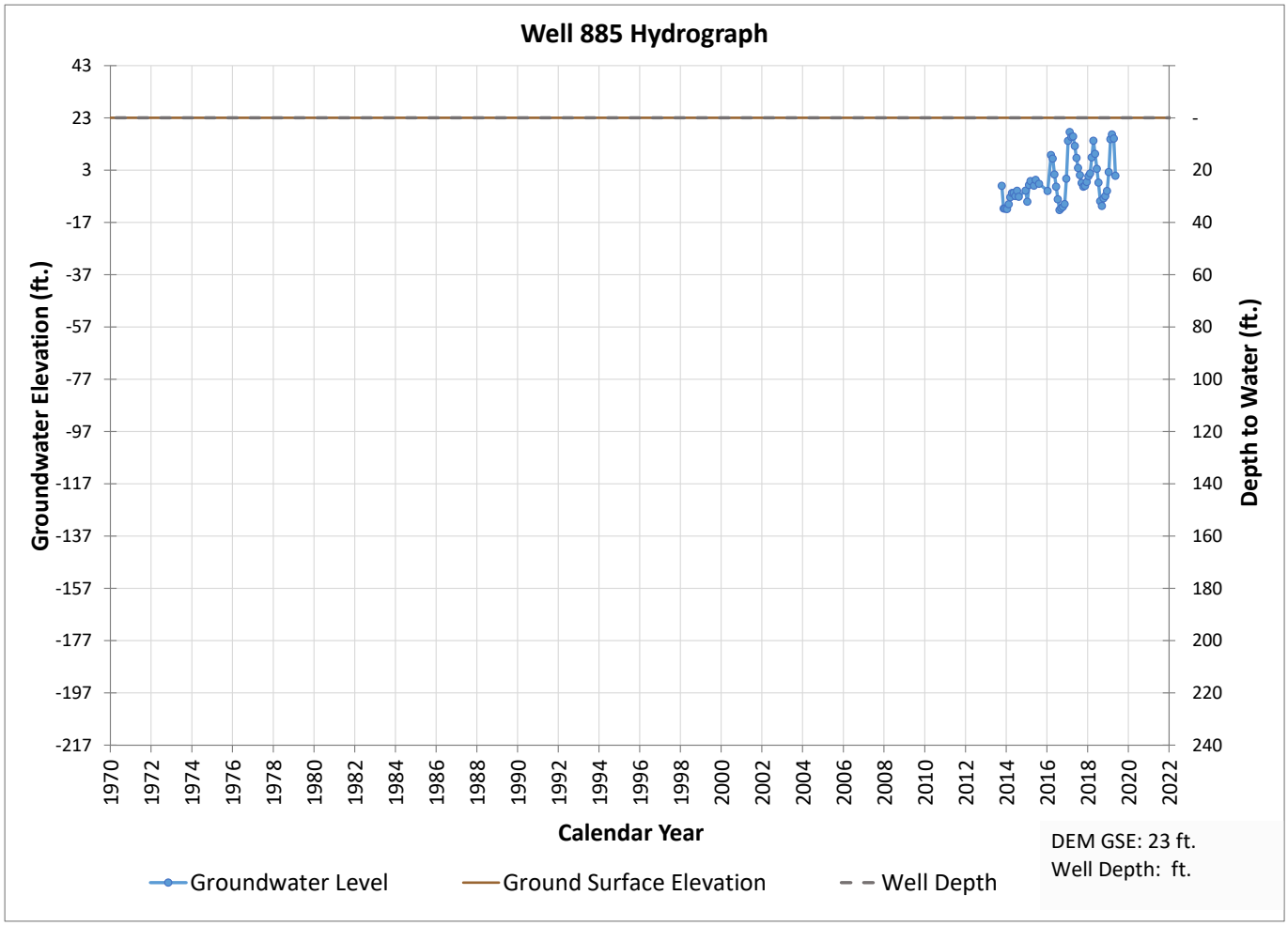

Well 880 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
46
26
6
-14
-34
-54
-74
-94
-114
-134
-154
-174
-194
-214
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 26 ft.
Well Depth: ft.

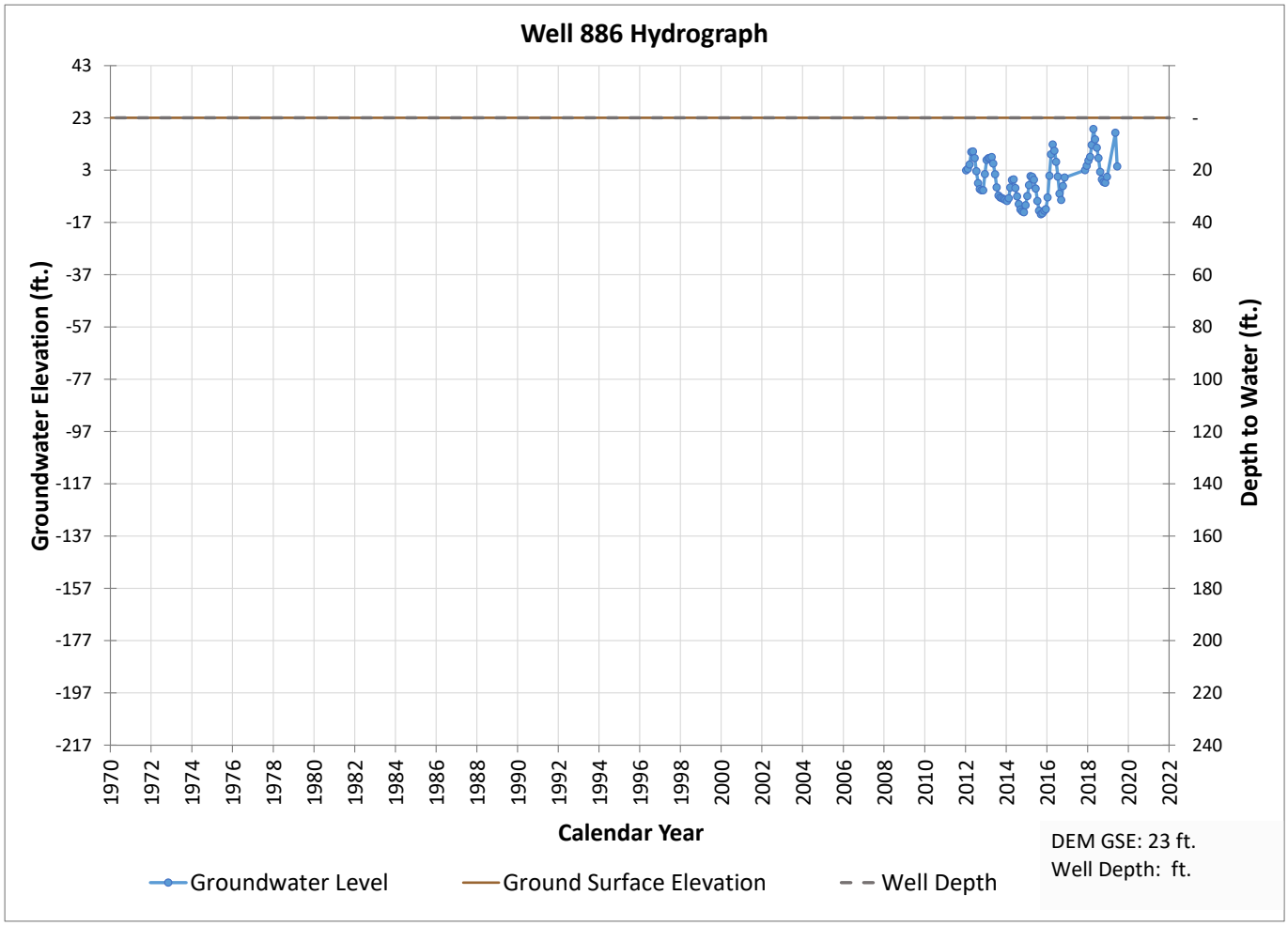

Well 881 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 20 ft.
Well Depth: ft.


Well 882 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.


Well 883 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
36
16
-4
-24
-44
-64
-84
-104
-124
-144
-164
-184
-204
-224
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 16 ft.
Well Depth: ft.


Well 884 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.


Well 885 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.


Well 886 Hydrograph
Groundwater Elevation (ft.)
Depth to Water (ft.)
Calendar Year
43
23
3
-17
-37
-57
-77
-97
-117
-137
-157
-177
-197
-217
-
20
40
60
80
100
120
140
160
180
200
220
240
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Groundwater Level
Ground Surface Elevation
Well Depth
DEM GSE: 23 ft.
Well Depth: ft.

South American
SUBBASIN

Appendix 2-D

Groundwater Quality and Land Subsidence (October 2021)

Contents

Appendix 2-D: Groundwater Quality and Land Subsidence *3*

Groundwater Quality **3**

Review of Previous Studies 3
Assessment of Current and Historical Conditions 5
Sustainable Management Criteria 13

Land Subsidence **40**

References 44

List of Tables

Table 2-D-1: Groundwater Quality Median Concentrations at Specific Wells 3
Table 2-D-2: Period of Record, Groundwater Quality Monitoring Wells in the Upper Aquifer Zone 39
Table 2-D-3: Period of Record, Groundwater Quality Monitoring Wells in the Lower Aquifer Zone 39

List of Figures

Figure 2-D-1: Historical Range of Nitrate Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 14
Figure 2-D-2: Historical Range of TDS Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 15
Figure 2-D-3: Historical Range of Arsenic Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 16
Figure 2-D-4: Historical Range of Hexavalent Chromium Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 17
Figure 2-D-5: Range of PFAS Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 18
Figure 2-D-6: Historical Range of Chloride Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 19
Figure 2-D-7: Range of Iron Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 20
Figure 2-D-8: Range of Manganese Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom) 21
Figure 2-D-9: Nitrate Concentrations in the Shallow Zone, Monitoring Wells Omitted 22
Figure 2-D-10: Nitrate Concentrations in the Shallow Zone, Monitoring Wells Included 22
Figure 2-D-11: Nitrate Concentrations in the Deep Zone, Monitoring Wells Omitted 23
Figure 2-D-12: TDS Concentrations in the Shallow Zone, Monitoring Wells Omitted 24

Figure 2-D-13: TDS Concentrations in the Shallow Zone, Monitoring Wells Included 26
Figure 2-D-14: TDS Concentrations in the Deep Zone, Monitoring Wells Omitted 26
Figure 2-D-15: Arsenic Concentrations in the Shallow Zone, Monitoring Wells Omitted 28
Figure 2-D-16: Arsenic Concentrations in the Deep Zone, Monitoring Wells Omitted 29
Figure 2-D-17: Hexavalent Chromium Concentrations in the Shallow Zone, Monitoring Wells Omitted 30
Figure 2-D-18: Hexavalent Chromium Concentrations in the Deep Zone, Monitoring Wells Omitted 31
Figure 2-D-19: PFAS Concentrations in Groundwater, Monitoring Wells Included 32
Figure 2-D-20: Chloride Concentrations in the Shallow Zone, Monitoring Wells Omitted 33
Figure 2-D-21: Chloride Concentrations in the Deep Zone, Monitoring Wells Omitted 34
Figure 2-D-22: Iron Concentrations in the Shallow Zone, Monitoring Wells Omitted 35
Figure 2-D-23: Iron Concentrations in the Deep Zone, Monitoring Wells Omitted 36
Figure 2-D-24: Manganese Concentrations in the Shallow Zone, Monitoring Wells Omitted 37
Figure 2-D-25: Manganese Concentrations in the Deep Zone, Monitoring Wells Omitted 38
Figure 2-D-1: South American Subbasin InSAR Subsidence, June 2015 – September 2019 42
Figure 2-D-2: South American Subbasin CGPS Station (UNAVCO #P274) Subsidence, October 2005 – December 2020. Note: Trend line added solely for the purpose of added assistance with the interpretation of subsidence time series data. Trend line equation included for reference. 43

Appendix 2-D: Groundwater Quality and Land Subsidence

Groundwater Quality

Review of Previous Studies

The investigation of the Folsom-East Sacramento area (DWR, 1964) is one of the earliest documents available that has assessed groundwater quality within the South American Subbasin (SASb). Following this report, DWR evaluated groundwater resources in Sacramento County in 1974 (Bulletin No. 118). More recent studies include an investigation of the groundwater quality in the southern Sacramento Valley conducted by the U.S. Geological Survey (USGS) in 2008, which was revised in 2018, and an assessment of the Sacramento-Amador Subwatershed performed by CH2M in 2016. Additionally, SCGA has produced three basin management reports with illustrations for the geographic occurrence of various water quality constituents, including total dissolved solids (TDS), iron, manganese, nitrate, and arsenic.

According to the 1964 and 1974 DWR studies, recharge water enters the groundwater system on the east side of the Subbasin. This carbon dioxide-rich water (derived from the atmosphere and the root zone) develops a mixed cation-bicarbonate composition as it dissolves calcium, magnesium, and sodium from the sediments. As groundwater migrates downgradient and deeper into the aquifer system, the concentrations of these constituents increase. Very deep in the aquifer, the water is unusable and is dominated by a sodium-chloride composition from the original marine deposits.

The Alternative Plan submitted in 2016 evaluated temporal variations in concentrations of TDS, nitrate, iron, manganese, arsenic, and chloride at various locations. The water quality data for this evaluation were obtained from the Geotracker Ground-Water Ambient Monitoring and Assessment program (GAMA) website and subdivided by sampling date into six 3-year intervals. Beginning with 1998, two data periods are presented in **Table 2-D-1**; this table provides a summary of this evaluation. The database included numerous non-detects (ND) for nitrate, iron, manganese, and arsenic which were excluded from the evaluation.

Table 2-D-1: Groundwater Quality Median Concentrations at Specific Wells

Period	TDS (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)[1]	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)
1998-2000 Median	170	8	2.5	170	11	6.8
2013-2015 Median	210	12	3.2	270	14	9.8
Non-Detects			18-25%	41-79%	20-57%	10-36%

[1] Nitrate as NO_3 converted to Nitrate as N

The slightly increasing trends in the concentration of some of these naturally occurring constituents increased as the groundwater system became more dynamic during the last century of production, and due to wells drilled deeper to increase production capacity. While iron and manganese are known to be present in the deeper groundwater, some traces of arsenic

have been occurring in shallow groundwater wells. Prior to the lowering of the public drinking water standard (primary MCL) from 50 ppb to 10 ppb, the occurrence of arsenic was not a significant regulatory issue. After the water standard was lowered, older public supply wells in Sacramento County Water Agency's (SCWA) Laguna service area were replaced with deeper wells designed for centralized treatment of iron and manganese. Additionally, private domestic well owners have been notified and encouraged through outreach to have their water tested once a year for nitrates and arsenic.

The GAMA has addressed conditions throughout much of California via a spatially-unbiased selection protocol for wells and a comprehensive suite of laboratory analyses. During a March to June 2005 study, 16 wells were sampled within the boundaries of the Subbasin and results were compared with selected Federal and State drinking-water standards (USGS, 2008). A summary of the USGS 2018 study, which updated the 2008 study results, is provided below:

- Thirteen out of the 16 wells within the SASb had one or more detections of a volatile organic compound; however, none of these concentrations were greater than an MCL or other threshold values. Their analysis of Tentatively Identified Organic Compounds (TIOCs) found cyclopentane in one well and sulfur dioxide in another well within the SASb area.
- Of the total of 129 pesticide compounds that USGS analyzed, eight were detected at least once within the SASb area, with the most frequently detected pesticide compounds being 2-chloro-4-isopropylamino-6-amino-s-triazine (deethylatrazine, a degradation of atrazine) and atrazine (general application herbicide). All of the detections were below regulatory threshold values for the corresponding pesticide.
- Among nutrients, orthophosphate and nitrate were detected at five and four wells within the SASb, respectively; nitrite was not detected in any well. Nitrate concentrations (as N) were all lower than the California Department of Health Services (CADHS) primary MCL of 10 mg/L.
- While there are no applicable health-based thresholds for the major ions, chloride and sulfate have secondary MCLs (SMCLs) set for aesthetic qualities. Concentrations of these naturally-occurring constituents were lower than the SMCL in all five wells where these constituents were detected within the Subbasin.
- USGS also analyzed 26 trace elements, including 18 trace elements with an MCL or other health-based thresholds in its study area. Three trace elements were detected at concentrations greater than the threshold: arsenic, barium, and boron. However, none of these detections were at wells within the SASb. While two naturally-occurring trace elements, iron and manganese, were detected at concentrations greater than an SMCL in the study unit, only manganese resulted in an exceedance of the SMCL (in one well) within the SASb.
- In the isotopes, radioactivity, and noble gases categories, USGS analyzed Tritium, deuterium, and oxygen-18, helium-3 to helium-4 ratio, helium-4, argon, neon, krypton, and xenon in the SASb area.

Assessment of Current and Historical Conditions

This section presents SASb groundwater quality information, including a discussion of numeric thresholds set by federal and state agencies, the processing of available water quality data, and results of water quality data analysis performed for the GSP.

This assessment focuses on the following water quality parameters that have been identified to be of interest in the Central Valley, generally, and in the SASb, specifically:

- Nitrate
- Total Dissolved Solids (TDS)
- Arsenic
- Hexavalent chromium
- PFAS compounds
- Chloride
- Iron
- Manganese

Additional wells and constituents that are not included in the Main Report's assessment are included in this Technical Appendix.

Regulatory Background

The overarching federal law regulating water quality in surface waters and wetlands is the Clean Water Act (CWA), passed in 1972. When the CWA was written, Congress explicitly left the regulation of discharges to groundwater to the states and to the United States Environmental Protection Agency (USEPA) under other statutory authorities. One of these federal statutory authorities is the federal Safe Drinking Water Act (SDWA), which applies to both surface and groundwater and provides protection to drinking water supplies. Under the SDWA, federal standards were established through USEPA in the form of primary maximum contaminant levels (1° MCLs or primary MCLs) to protect human health. Secondary maximum contaminant levels (2° MCLs or SMCLs) also were established at the federal level to address aesthetics of drinking water sources (i.e., taste, odor, or appearance) and are not federally enforceable. The State of California has its own SDWA that includes 1° MCLs and 2° MCLs which are, in some cases, more strict than those set at the federal level for select constituents. The California 1° and 2° MCLs are codified in Title 22 of the California Code of Regulations (CCR). Water quality standards to protect drinking water as established under the federal and state SDWAs are enforced through the State Water Resource Control Board's (SWRCB or State Water Board) Division of Drinking Water (DDW).

The California Porter-Cologne Water Quality Act, contained in California Water Code Division 7, applies to both groundwater and surface waters, designating responsibility for water quality and safe drinking water protection to the SWRCB and the nine Regional Water Quality Control Boards (RWQCB) in California. The Act requires RWQCBs to develop water quality control plans for the region over which it presides. These water quality control plans (Basin Plans) must include a list of the specific waterbodies and broad categories of waters (e.g., bays, estuaries, ocean waters, wetlands, and groundwaters) the RWQCB is charged with protecting, the beneficial uses designated for those waterbodies, and the water quality objectives used to

protect those beneficial uses. These water quality objectives, defined for specific hydrologic regions and waterbodies, protect the quality of surface waters, groundwaters, and their designated beneficial uses.

In the SASb, the Sacramento-San Joaquin Water Quality Control Plan (Basin Plan) issued by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) contains water quality objectives based on primary and secondary MCLs. Where available, these MCLs are used in the assessment of groundwater quality conditions in the SASb.

Groundwater Quality Data Processing

Groundwater quality data were downloaded from the Groundwater Ambient Monitoring and Assessment Program (GAMA) Groundwater Information System Data Download[1]. Data was downloaded for Sacramento County on May 22, 2020, and includes groundwater quality data from the following sources:

- Department of Pesticide Regulation (DPR)
- Department of Water Resources (DWR)
- Lawrence Livermore National Laboratory
- State and Regional Water Board Regulatory Programs (Electronic Deliverable Format (EDF) and Irrigated Agricultural Land Waiver (AGLAND))
- State Water Board, GAMA Program water quality data (GAMA, USGS)
- State Water Board, Division of Drinking Water public supply well water quality (DDW)
- U.S. Geological Survey (USGS)

Additional water quality data in the SASb were obtained directly from GEI Consultants Inc., which developed the Subbasin's 2016 Alternative Plan. All data were then compiled into a database for analysis. Data for nitrate, TDS, chloride, arsenic, iron, and manganese are from both the GAMA and GEI Consultants Inc., databases, while data for hexavalent chromium, and the larger family of per- and polyfluoroalkyl substances (PFAS) are solely from the GAMA database. Constituents were included in this analysis because they were cited in previous studies of the SASb, or they were discussed during public meetings as being of concern to stakeholders in the SASb. Analysis of chloride, iron, and manganese is included in this Technical Appendix and not the Main Report because these constituents are naturally occurring and will not likely be monitored or managed under the GSP.

Groundwater quality samples collected from less than 300 feet bgs were determined to be from the shallow zone, while samples collected from greater than 300 feet were determined to be from the deep zone. With the exception of PFAS, only measurements from wells located entirely in either the shallow zone or the deep zone are included in this analysis. Wells of all depths are analyzed for PFAS as monitoring data is sparse and less temporally extensive than the other constituents. The analysis presented in the Main Report omits State and Regional Water Board Regulatory Program (EDF) data that is included in the GAMA database because this monitoring data represents site specific conditions and is not indicative of regional groundwater conditions. Assessment of this data is included in this Technical Appendix for inclusiveness, and to present a more complete picture of all available data in the Subbasin.

[1] http://geotracker.waterboards.ca.gov/gama/datadownload

All data, except the TDS dataset, include non-detect (ND) values, as well as estimated values (where the value was detected at a concentration below the reporting limit, but above the method detection limit). Estimated values are included in the box and whisker plots at their reporting limit, and the ND values are not included. Omission of the ND values increases the median, average, and overall statistics, and therefore results in an overestimation of these values.

Groundwater Quality Trends According to Available Historical Data

The following subsections present the temporal and spatial analysis of nitrate, TDS, arsenic, hexavalent chromium, PFAS, chloride, iron, and manganese. Variations of these constituents over time were plotted as "box and whisker" plots, where the box represents the concentration range for the middle 50 percent of the data (first quartile to third quartile, or interquartile range), the mean is represented as an 'x', and the median is shown as the line in the center of the box. The top whisker extends to the highest concentration that is less than or equal to the sum of the third quartile and 1.5 times the interquartile range; and the bottom whisker extends to the lowest concentration that is greater than or equal to the difference of the first quartile and 1.5 times the interquartile range. Regulatory limits are displayed as a dashed red line, and the concentration scale is displayed on the left side of each plot.

Figures of spatial groundwater quality data plot the location of wells where groundwater quality samples were collected, and indicate the maximum sampled concentration at each well for the entirety of the dataset. This representation was used in an initial screening to see where threshold values were exceeded, but should not be interpreted as a depiction of problem areas with regular concentrations above thresholds. With the exception of PFAS, individual maps are provided for samples collected from the shallow zone and the deep zone. Due to the scarcity of PFAS data, wells of all depths are included in one map.

Groundwater in the SASb is generally of good quality and meets local needs for municipal, domestic, and agricultural uses. Exceedances of constituent thresholds may be caused by localized conditions and may not be reflective of regional groundwater quality. In the analysis described below, groundwater data that includes monitoring well data from the GAMA data has been assessed. Also, an analysis that omits monitoring well data is presented. This distinction is important, because monitoring well data tends to be focused intensively at specific sites (e.g. remediation areas), and can bias statistical analysis of regional conditions.

Nitrate

Nitrate is an ion with the chemical formula NO_3. Salts containing this ion are called nitrates (e.g. ammonium nitrate, sodium nitrate, potassium nitrate, calcium nitrate, magnesium nitrate). Some forms of nitrates are naturally occurring. Nitrates are commonly found in groundwater as a result of the application of nitrate-containing fertilizers. Other nitrate sources include feedlot discharges, treated and untreated sewage, and emissions from food processing or industrial processes. At elevated levels, nitrates can affect human health. A primary MCL of 10 mg/L (milligrams per liter, or parts per million) exists for nitrate as nitrogen, applicable to drinking water supplies, to provide human health protection.

Nitrate data in wells in the SASb were extensive and spanned from 1951 to present. **Figure 2-D-1** illustrates variation in nitrate with time for seven intervals, the top plot omits data from

monitoring wells, and the bottom plot includes data from monitoring wells; the primary MCL is displayed as a dashed red line (10 mg/L for Nitrate as N). As shown, nitrate concentrations in both the shallow and deep zone were relatively consistent throughout the period of record. Concentrations in the shallow zone increased slightly between the period 1991-95 and 1996-00; however, this increase was minor and not representative of an increasing trend. Nitrate concentrations in the deep zone have remained relatively stable throughout the period of record. It is noted that the elevated average and statistical distribution shown for the deep zone during the period 1986-90 is the result of one high estimated value (10 mg/L).

Nitrate data is plotted spatially for the shallow zone in **Figure 2-D-9** and the deep zone in **Figure 2-D-11**. **Figure 2-D-10** plots nitrate data for the shallow zone with data from monitoring wells included. The maps divide the wells into three categories: wells where all samples were below 50 percent of the MCL (indicated as a green point), wells where at least one sample was above 50 percent of the MCL (indicated as a yellow point), and wells where at least one sample was above the MCL (indicated as a red point). It is noted that not all wells analyzed are drinking water supply wells; also, a single exceedance of the MCL as indicated on the figures is not a violation of the limits as the SWRCB has set nitrate MCL compliance to be determined by a running annual average.

Figure 2-D-9 shows that the majority of shallow wells sampled for nitrate do not result in a concentration greater than 50 percent of the MCL. Analysis of wells where the maximum sampled concentration was greater than 50 percent of the MCL, or greater than the MCL, indicated that these wells are located in areas where municipal community water systems deliver domestic water supply, and that domestic well density is low. **Figure 2-D-11** shows that one deep well resulted in a concentration greater than the MCL, while no deep wells resulted in a concentration between 5 and 10 mg/L. **Figure 2-D-10** shows that when shallow monitoring wells are included in the analysis, more exceedances of the nitrate MCL occur. Also included in this figure is an inset map that focuses on the region of the Sacramento Regional Wastewater Treatment Plant (Regional San). This inset map and associated shallow water quality data (all shallow monitoring wells) highlight the fact that monitoring well data tends to be focused intensively at specific sites.

Total Dissolved Solids (TDS)

The salinity of freshwater is commonly measured either directly as the total concentration of all dissolved solids (organic and inorganic; TDS), or indirectly, as a water's ability to pass electrical flow (electrical conductivity, or EC). Conductance measured at – or normalized to – 25º Celsius is called specific conductance. Salts are both naturally occurring and man-made, and are persistent in nature. TDS levels in groundwater are often associated with agricultural irrigation, in combination with natural sources, where applied water is used by plants and water is lost in the process of evapotranspiration. Salts in the applied water remain in the root zone until they are leached out into the groundwater basin. Other sources of salts to groundwater may include municipal and industrial discharges.

TDS data in SASb wells were extensive and spanned from 1955 to present. TDS concentrations below the Recommended SMCL of 500 mg/L are desirable for a higher degree of consumer acceptance, while concentrations below the Upper SMCL of 1,000 mg/L are also deemed to be acceptable. **Figure 2-D-2** illustrates variation in TDS with time for seven intervals, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells; the

Recommended SMCL and Upper SMCL are displayed as dashed red lines. As illustrated, TDS concentrations measured in the deep zone were consistently below the SMCL value of 500 mg/L and remained relatively stable throughout the period of record. Concentrations in the shallow zone remained relatively stable from 1986 to 2005 and exhibit higher concentrations during the years 2006 to 2020; however, these elevated concentrations are still deemed acceptable.

TDS data is plotted spatially for the shallow zone in **Figure 2-D-12** and the deep zone in **Figure 2-D-14**. The maps divide the wells into four categories: wells where all samples were below 250 mg/L (indicated as a green point), wells where at least one sample was greater than 250 mg/L (indicated as a yellow point), wells where at least one sample was greater than 500 mg/L (indicated as an orange point), and wells where at least one sample was greater than 1,000 mg/L (indicated as a red point). **Figure 2-D-12** appears to show an increasing trend in shallow TDS values from the west of the subbasin to the east; however, the majority of shallow wells produced a maximum TDS concentration below the Recommended SMCL of 500 mg/L. **Figure 2-D-14** shows that no deep wells sampled for TDS resulted in a concentration greater than the Upper SMCL value of 1000 mg/L. **Figure 2-D-13** shows that when shallow monitoring wells are included in the analysis, higher concentrations of TDS are recorded. Also included in this figure is an inset map that focuses on monitoring near the Regional San wastewater treatment plant site. This inset map and associated shallow water quality data (all shallow monitoring wells) highlight the fact that monitoring well data tends to be focused intensively at specific sites.

Arsenic

Arsenic is a chemical element, naturally occurring in the earth's crust. It occurs naturally in many minerals and is naturally occurring in some groundwaters. Historically, it has been used in the production of semiconductors, pesticides and wood preservatives, and can be released during mining operations, smelting, and coal combustion. It is highly toxic in its inorganic form; a primary MCL for arsenic in drinking water is 10 µg/l (micrograms per liter, or parts per billion).

Arsenic data in SASb wells were extensive and spanned from 1982 to present. **Figure 2-D-3** illustrates variation in arsenic with time for seven intervals, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells; the MCL of 10 µg/L is displayed as a dashed red line. As shown, arsenic concentrations in the shallow zone have fluctuated over the period of analysis, with concentrations exhibiting slight increases during the 2006-10 and 2016-20 periods. Concentrations of arsenic in the deep zone appear elevated during the periods 1986-90 and 1991-95, and then decline below the MCL for the duration of analysis.

Arsenic data for the period 2005 – 2020 is plotted spatially for the shallow zone in **Figure 2-D-15** and the deep zone in **Figure 2-D-16**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the MCL of 10 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the MCL (indicated as a yellow point), and wells where at least one sample was above the MCL (indicated as a red point).

Figure 2-D-15 shows that exceedances of arsenic occur in the shallow zone of the aquifer, with 25 of the 131 sampled wells experiencing one or more exceedances. Evaluation of wells where the maximum arsenic sampled concentration was greater than 50 percent of the MCL, or greater than the MCL, indicates that municipal community water systems deliver domestic water

supply to these areas, and that domestic well density is low. Within water system boundaries, monitoring and treatment should be available to protect beneficial users of groundwater. The boundary of municipal community water systems is shown in the figure. **Figure 2-D-16** shows that high arsenic values are less prevalent in the deep zone, with no wells exceeding the MCL.

It is noted that arsenic is a naturally occurring element in soils and rocks and has also been used in wood preservatives, animal feed, and pesticides. It can also be released into groundwater from mining. Because it is known to occur naturally in the aquifer sediments, some trace is expected to occur in shallow wells. Whether the arsenic is released from a geologic source into groundwater depends on the chemical form of the arsenic, the geochemical conditions in the aquifer, and the biogeochemical processes that occur. It is noted that recent groundwater pumping, observed through land subsidence, may result in increased arsenic aquifer concentrations (Smith et al., 2018). It is unclear if this is the cause of elevated arsenic in the Basin; regardless, increased land subsidence is not predicted, and therefore is not expected to result in increased arsenic concentrations in the shallow zone.

Hexavalent Chromium

Hexavalent chromium is one of the valence states of the element chromium. It is used in many industrial applications, including electroplating, welding and chromate painting. Hexavalent chromium is found in some groundwaters. A human health-based primary MCL of 50 µg/L exists in California; a proposed MCL of 10 µg/L is being considered by the State Water Board.

Hexavalent chromium data span from 2001 to present. **Figure 2-D-4** illustrates variation in hexavalent chromium with time for three intervals; the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells. The current MCL of 50 µg/L is displayed as a dashed red line, as well as the proposed MCL of 10 µg/L. As shown, hexavalent chromium concentrations in the subbasin are consistently below 10 µg/L in the deep zone for the duration of analyses. Concentrations in the shallow zone are consistently below the MCL of 50 µg/L, but are slightly elevated over the proposed MCL of 10 µg/L in some locations. As shown in the bottom plot concentrations in the shallow zone increase when data from monitoring wells is included in the analysis.

Hexavalent chromium data is plotted spatially for the shallow zone in **Figure 2-D-17**, and the deep zone in **Figure 2-D-18**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the proposed MCL of 10 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the proposed MCL (indicated as a yellow point), and wells where at least one sample was above the proposed MCL (indicated as a red point). As shown, wells in the shallow zone produced a result above the proposed MCL of 10 µg/L, and no wells in the deep zone exhibited concentrations above 5 µg/L.

Polyfluoroalkyl substances (PFAS)

Per- and polyfluoroalkyl (PFAS) are a group of man-made chemicals, which numbers close to 5000, that have been manufactured since the 1940's. They are used in a variety of products, are commonly found in food, household products, in water supplies and in aquatic organisms, and characteristically are very persistent in the environment and in the human body. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which are no longer in production in the U.S., were the most extensively produced and have been the most extensively studied of the PFAS substances. At elevated levels, there is evidence of adverse human health

effects associated with PFOA, PFOS and other PFAS substances. The State Water Board has established notification levels and response levels for PFOA (5.1 and 10 parts per trillion or ng/L) and PFOS (6.5 and 40 parts per trillion), respectively. The California Office of Environmental Health Hazard Assessment (OEHHA) is working to develop Public Health Goals (PHG) for PFOA and PFOS, a step in the development of MCLs by the State Water Board. OEHHA has recently released proposed PHGs of 0.007 ng/l for PFOA and 1 ng/l for PFOS, which will be considered in a public process prior to adoption.

Monitoring of PFAS has begun more recently, with data available beginning in 2017. **Figure 2-D-5** presents box and whisker plots for nine PFAS substances, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells. No MCL currently exists for PFAS substances, and the notification level for PFOA and PFAS is displayed as a dashed line. As shown, the notification levels of 5.1 and 6.5 ng/L have been regularly exceeded at wells for PFOA and PFOS, respectively. Additionally, it is noted that when data from monitoring wells are included in the plots, more substances are detected.

PFOA and PFAS data are plotted spatially in **Figure 2-D-19**, and indicate that 31 of 55 samples have PFOS concentrations greater than 6.5 ng/L, and 22 of 43 samples have PFOA concentrations greater than 5.1 ng/L. Data used to generate the maps includes EDF data, as the data was sparse.

Chloride

Chloride is an ion of the element chlorine. It is commonly associated with sodium as the salt sodium chloride. A SMCL of 250 mg/L exists for chloride to address taste issues in drinking water, while concentrations below the Upper limit of 500 mg/L are also deemed to be acceptable. Chloride data in the SASb were extensive and spanned from 1952 to present. **Figure 2-D-6** illustrates variation in chloride with time for seven intervals, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells; the SMCL is displayed as a dashed red line. As illustrated, chloride concentrations in the shallow and deep zone were consistently below the SMCL value of 250 mg/L. It is noted that the elevated average and statistical distribution shown for the deep a zone quifer during the period 1986-90 is the result of one high estimated value (250 mg/L).

Chloride data is plotted spatially for the shallow zone in **Figure 2-D-20** and the deep zone in **Figure 2-D-21**. The maps divide the wells into four categories: wells where all samples were below 50 percent of the Recommended MCL of 250 mg/L (indicated as a green point), wells where at least one sample was greater than 50 percent of the Recommended MCL (indicated as a yellow point), wells where at least one sample was greater than the Recommended MCL (indicated as an orange point), and wells where at least one sample was greater than the Upper limit of 500 mg/L (indicated as a red point). As shown, wells in the shallow zone are more likely to exceed the SMCL or Upper Limit in the western portion of the SASb; however, the vast majority of shallow wells have not resulted in a concentration above 125 mg/L. **Figure 2-D-21** shows that no wells in the deep zone exceeded the SMCL.

Iron

Iron is a chemical element, a metal, which is the most common element on Earth, by mass. Iron occurs naturally as a mineral in sediments and rocks and is commonly found in groundwater in its dissolved form. A SMCL of 300 µg/L exists for iron to address aesthetics (discoloration). Iron

data in the SASb were extensive and spanned from 1958 to present. **Figure 2-D-6** illustrates variation in iron with time for seven intervals, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells; the SMCL is displayed as a dashed red line. As shown, when monitoring wells are omitted the average concentrations are consistently below the SMCL in both the shallow and deep zone. When monitoring wells are included in the analysis, concentrations increase for wells in the shallow zone during the period 2001 to present.

Iron data for the period 2005 – 2020 is plotted spatially for the shallow zone in **Figure 2-D-22** and the deep zone in **Figure 2-D-23**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the SMCL of 300 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the SMCL (indicated as a yellow point), and wells where at least one sample was above the SMCL (indicated as a red point). **Figure 2-D-22** shows that exceedances of iron occur in the shallow zone of the aquifer. Evaluation of wells where the maximum iron sampled concentration was greater than 50 percent of the SMCL, or greater than the SMCL, indicates that municipal community water systems deliver domestic water supply to these areas, and that domestic well density is low. Within water system boundaries, monitoring and treatment should be available to protect beneficial users of groundwater. The boundary of municipal community water systems is shown in the figure. Data from the deep zone is more sparse than the shallow zone, and **Figure 2-D-23** shows that maximum sampled concentrations greater than the SMCL occur throughout the region of the deep zone sampled.

Manganese

Manganese is a chemical element often found in minerals associated with iron. Manganese is a metal which occurs naturally and is typically found in its dissolved form in groundwater. A SMCL of 50 µg/L exists for manganese to address aesthetics in drinking water supplies associated with discoloration. Manganese data in the SASb were extensive and spanned from 1958 to present. **Figure 2-D-8** illustrates variation in manganese with time for seven intervals, the top plot omits data from monitoring wells, and the bottom plot includes data from monitoring wells; the SMCL is displayed as a dashed red line. As shown in the top and bottom plot, average concentrations in the shallow and deep zone are often elevated above the SMCL. When monitoring wells are included in the analysis, the average and statistical distribution of wells in the shallow zone increase greatly from the period 2001 to present.

Manganese data for the period 2005 – 2020 is plotted spatially for the shallow zone in **Figure 2-D-24** and the deep zone in **Figure 2-D-25**. The maps divide the wells into three categories: wells where all samples were below 50 percent of the SMCL of 50 µg/L (indicated as a green point), wells where at least one sample was above 50 percent of the SMCL (indicated as a yellow point), and wells where at least one sample was above the SMCL (indicated as a red point). **Figure 2-D-24** shows that exceedances of manganese occur in the shallow zone of the aquifer. Evaluation of wells where the maximum manganese sampled concentration was greater than 50 percent of the SMCL, or greater than the SMCL, indicates that municipal community water systems deliver domestic water supply to these areas, and that domestic well density is low. Within water system boundaries, monitoring and treatment should be available to protect beneficial users of groundwater. The boundary of municipal community water systems is shown in the figure. Data from the deep zone is more sparse than the shallow zone, and **Figure 2-D-23**

shows that maximum sampled concentrations greater than the SMCL occur throughout the region of the deep zone sampled.

Sustainable Management Criteria

As noted in Section 3, Sustainable Management Criteria (SMC) were developed for two of the constituents of concern in the Subbasin: nitrate and specific conductance. Although the evaluation of water quality in the Subbasin also identified elevated concentrations of arsenic, iron, and manganese, these constituents were not assigned SMCs because their presence is impacted significantly by natural processes and local geologic conditions that are not controllable by the GSAs through groundwater management processes. The GSP will monitor these constituents to track any potential mobilization of elevated concentration or exceedances of the MCLs or SMCLs. Monitoring for these constituents will be carried out as part of the GSP monitoring network that is discussed in **Section 3.5.2**, as well as the Volunteer Monitoring Program that is described in **Section 4.7.1**. The period of historical monitoring data for arsenic, iron, and manganese is presented for the upper aquifer zone in **Table 2-D-2**, and the lower aquifer zone in **Table 2-D-3**. New constituents of concern may be added with changing conditions and as new information becomes available.

Figure 2-D-1: Historical Range of Nitrate Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

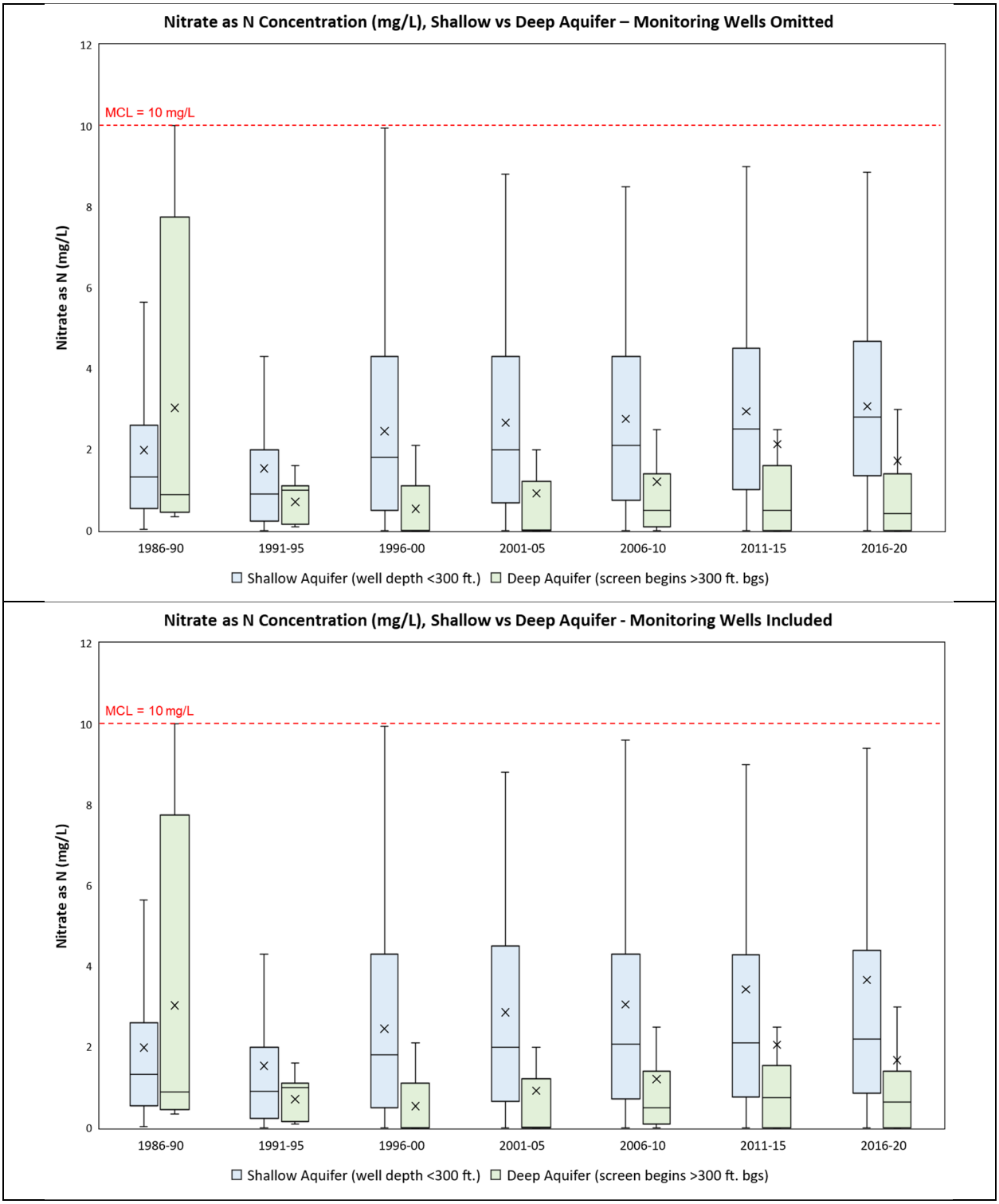
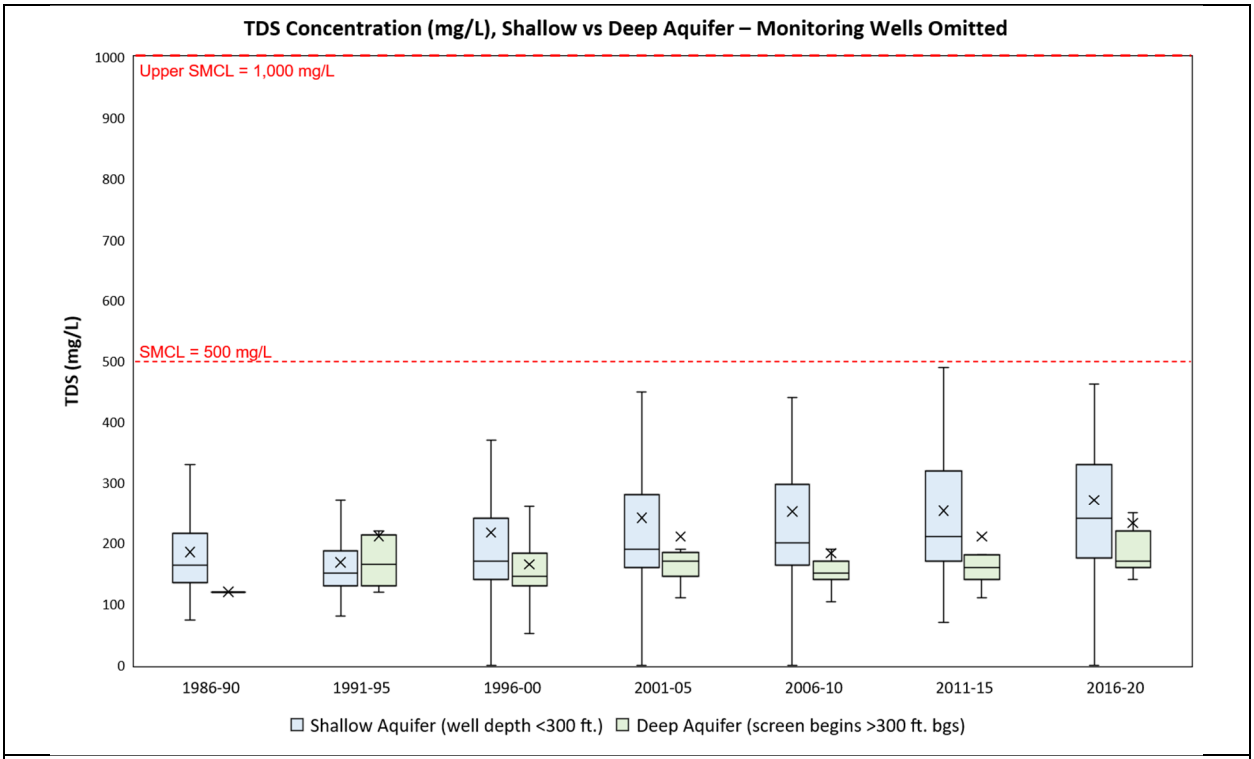


Figure 2-D-2: Historical Range of TDS Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)



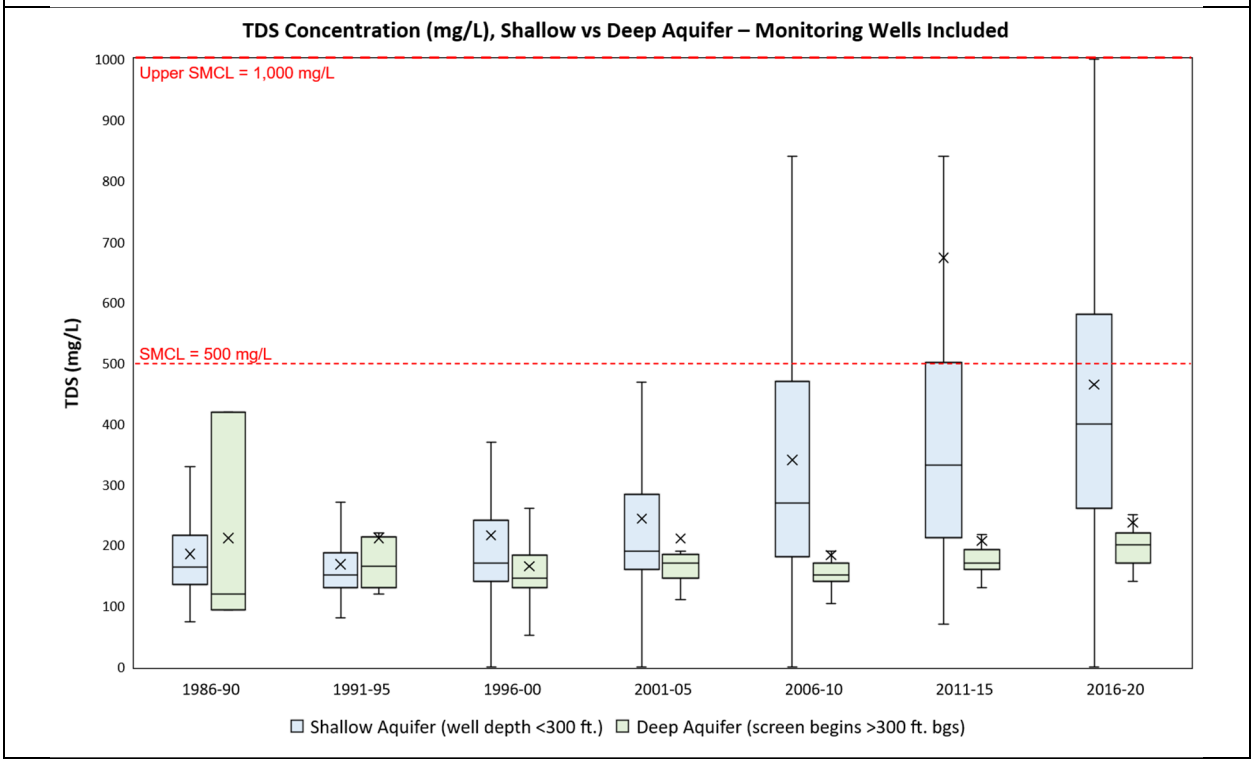


Figure 2-D-3: Historical Range of Arsenic Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

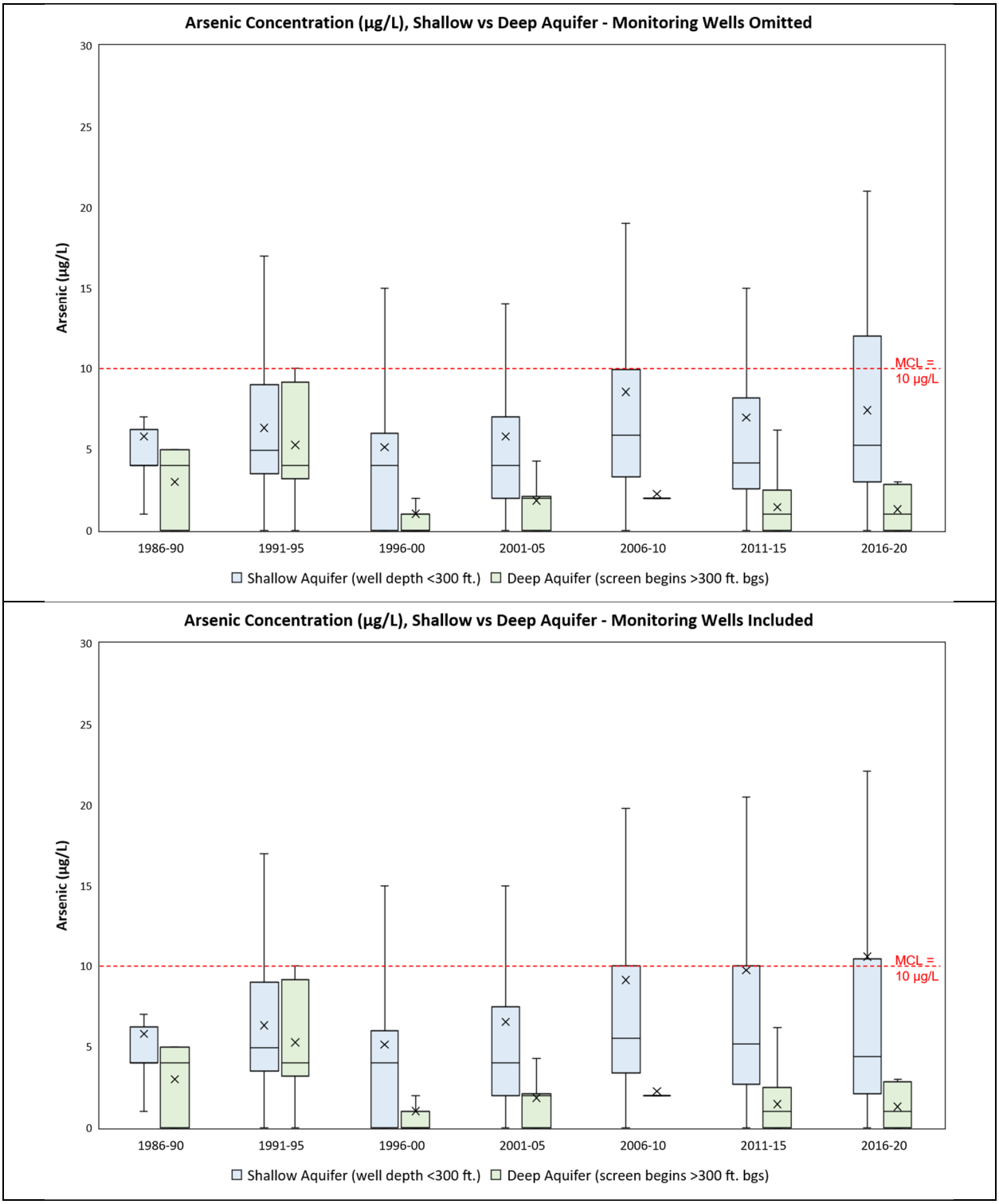


Figure 2-D-4: Historical Range of Hexavalent Chromium Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

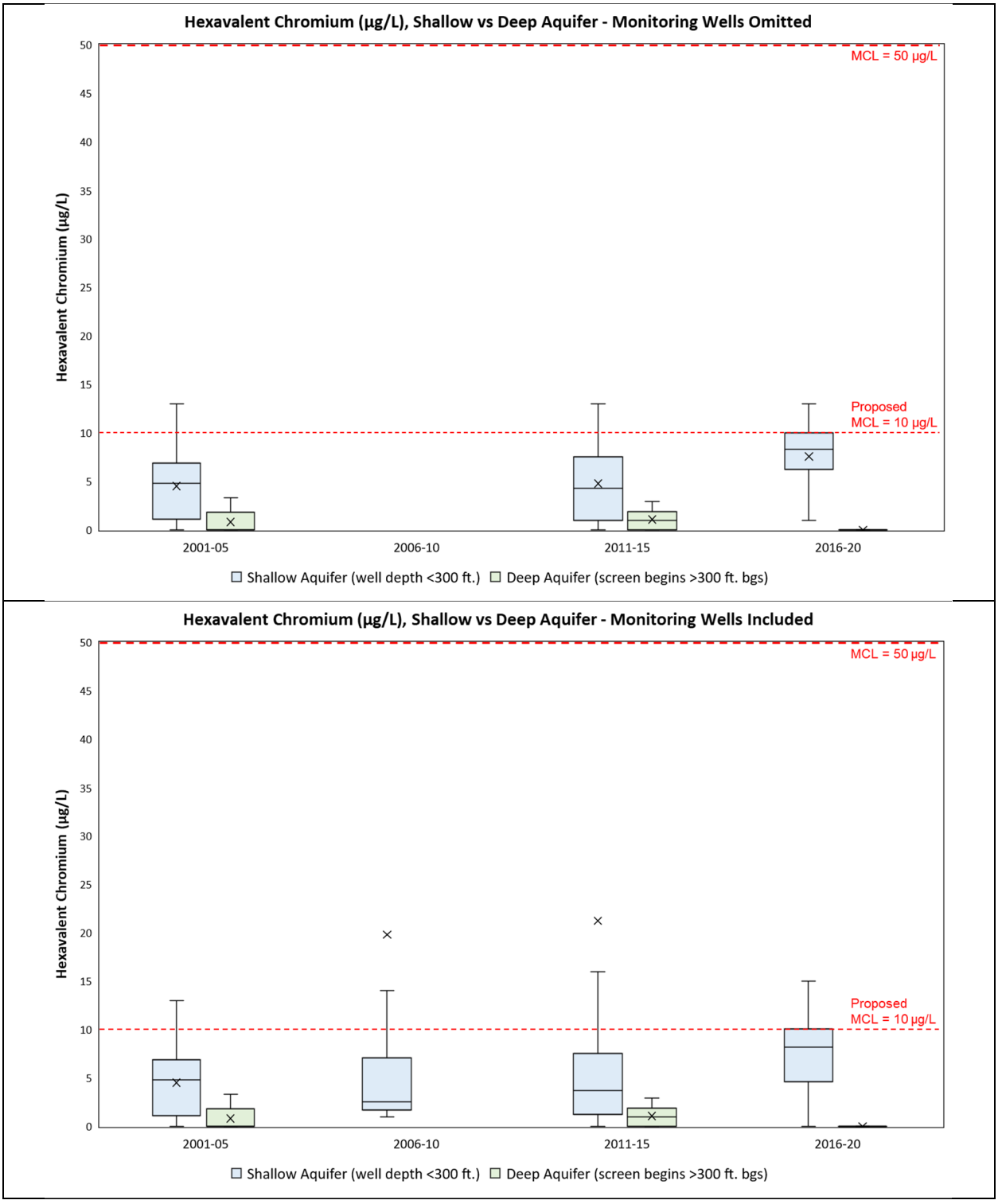


Figure 2-D-5: Range of PFAS Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

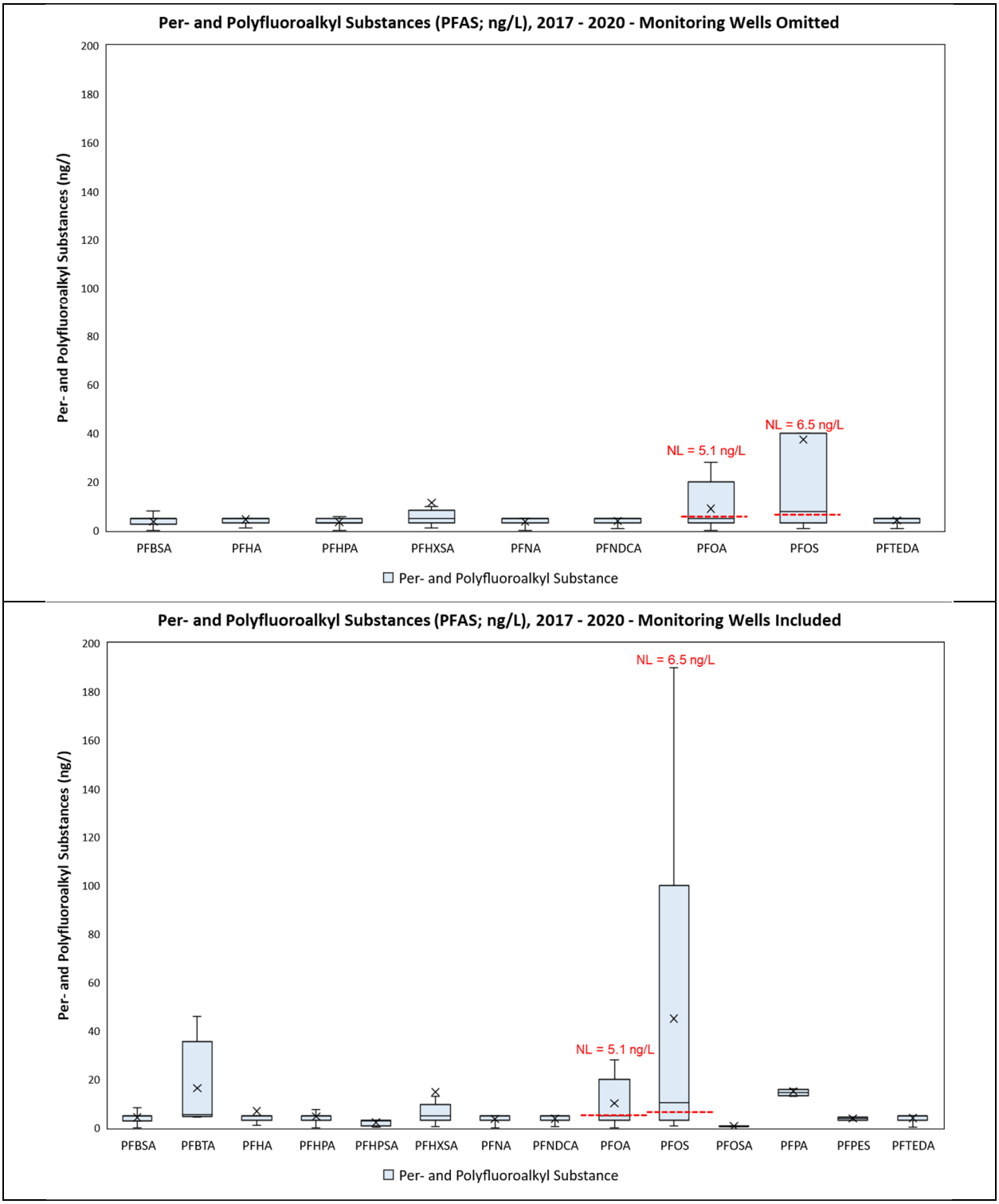


Figure 2-D-6: Historical Range of Chloride Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

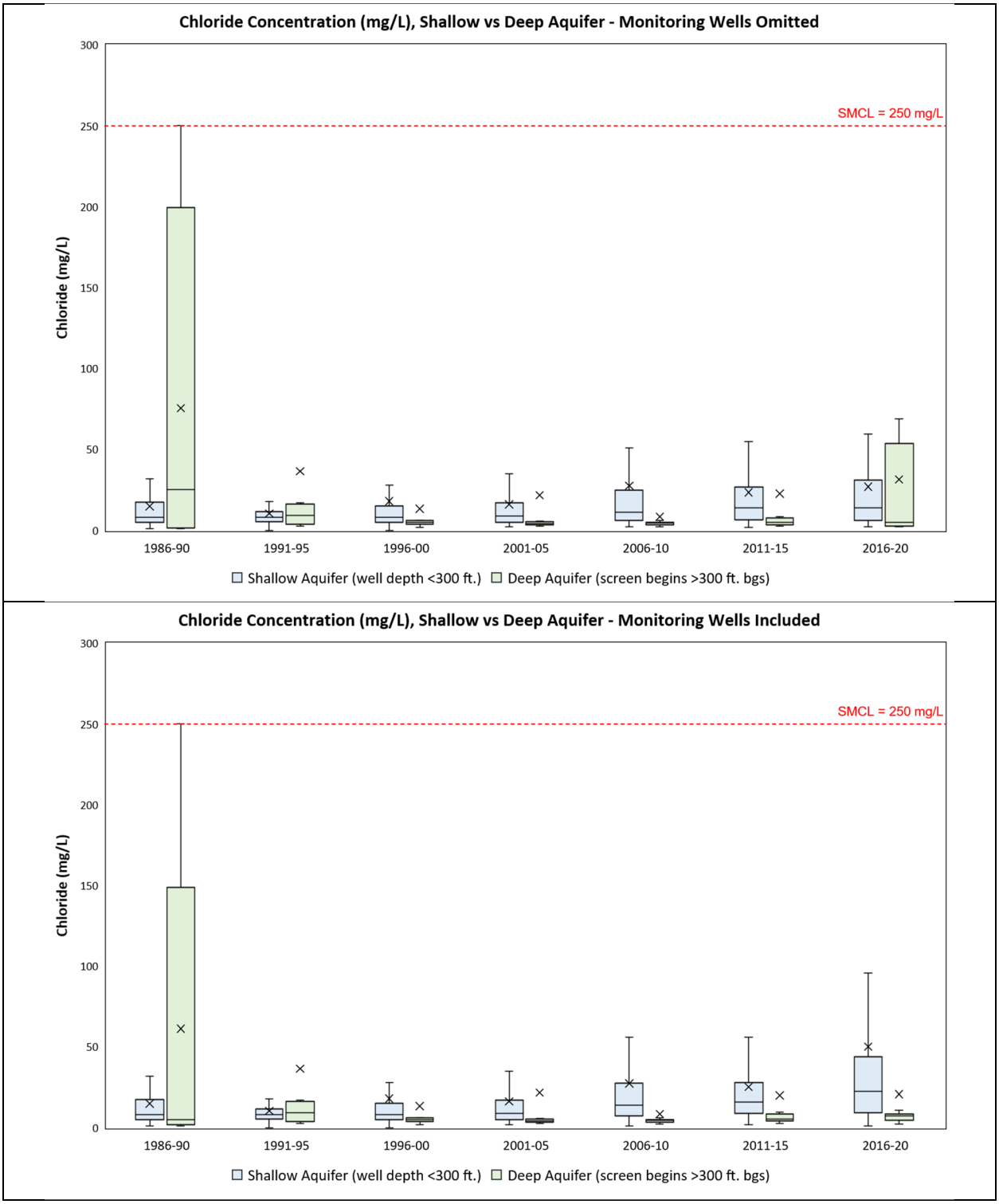


Figure 2-D-7: Range of Iron Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

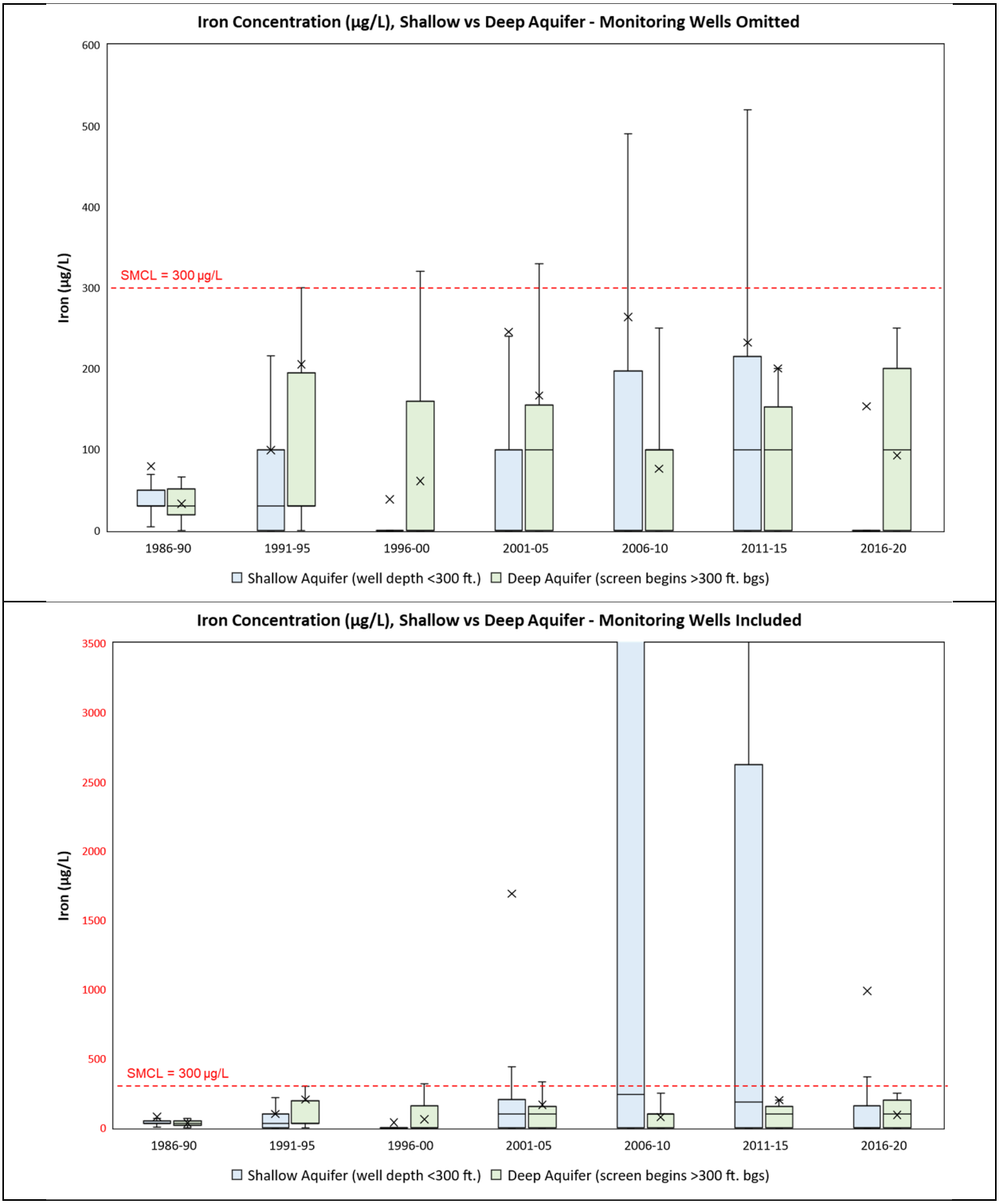


Figure 2-D-8: Range of Manganese Concentrations, without Monitoring Wells (top), with Monitoring Wells (bottom)

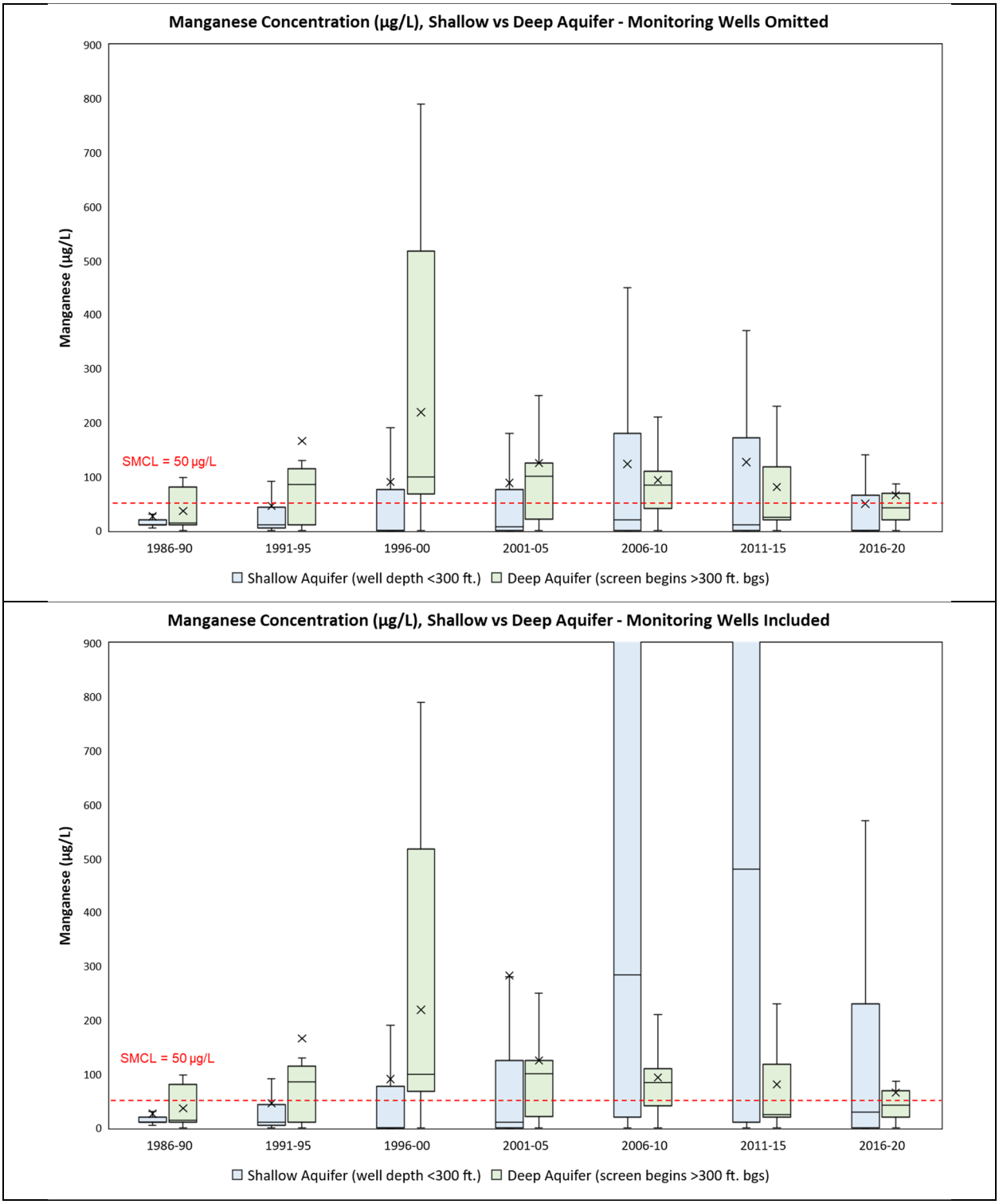


Figure 2-D-9: Nitrate Concentrations in the Shallow Zone, Monitoring Wells Omitted

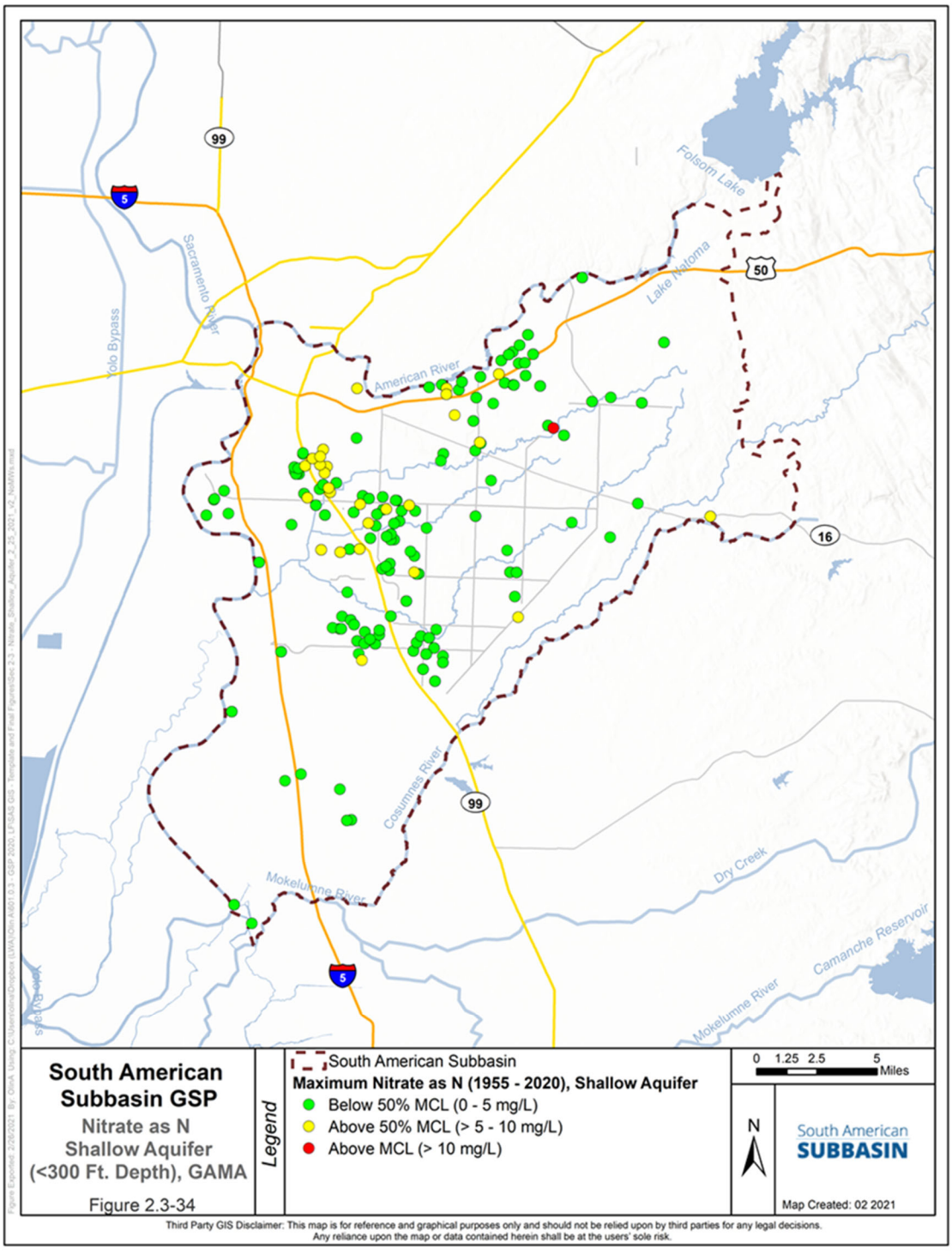


Figure 2-D-10: Nitrate Concentrations in the Shallow Zone, Monitoring Wells Included

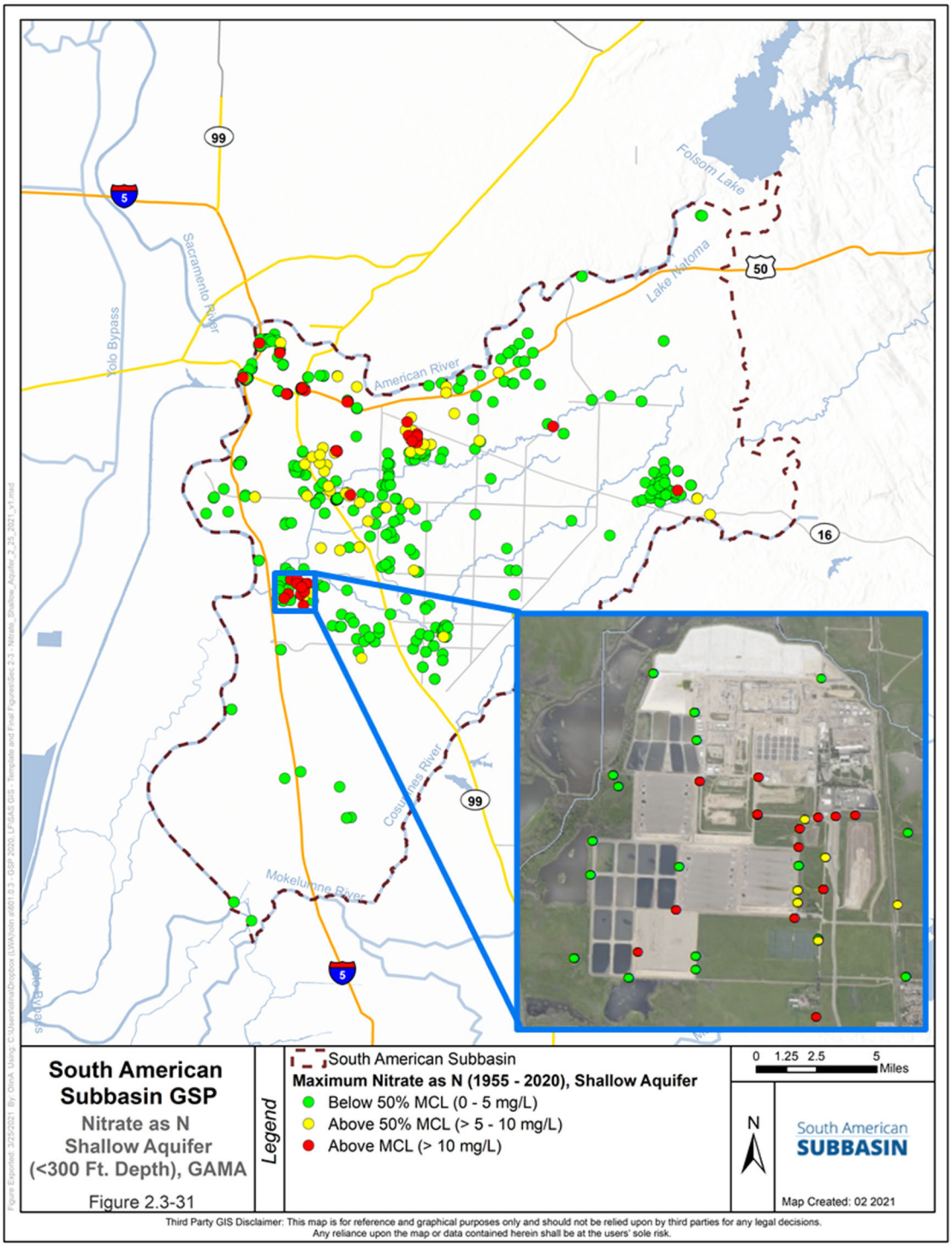


Figure 2-D-11: Nitrate Concentrations in the Deep Zone, Monitoring Wells Omitted

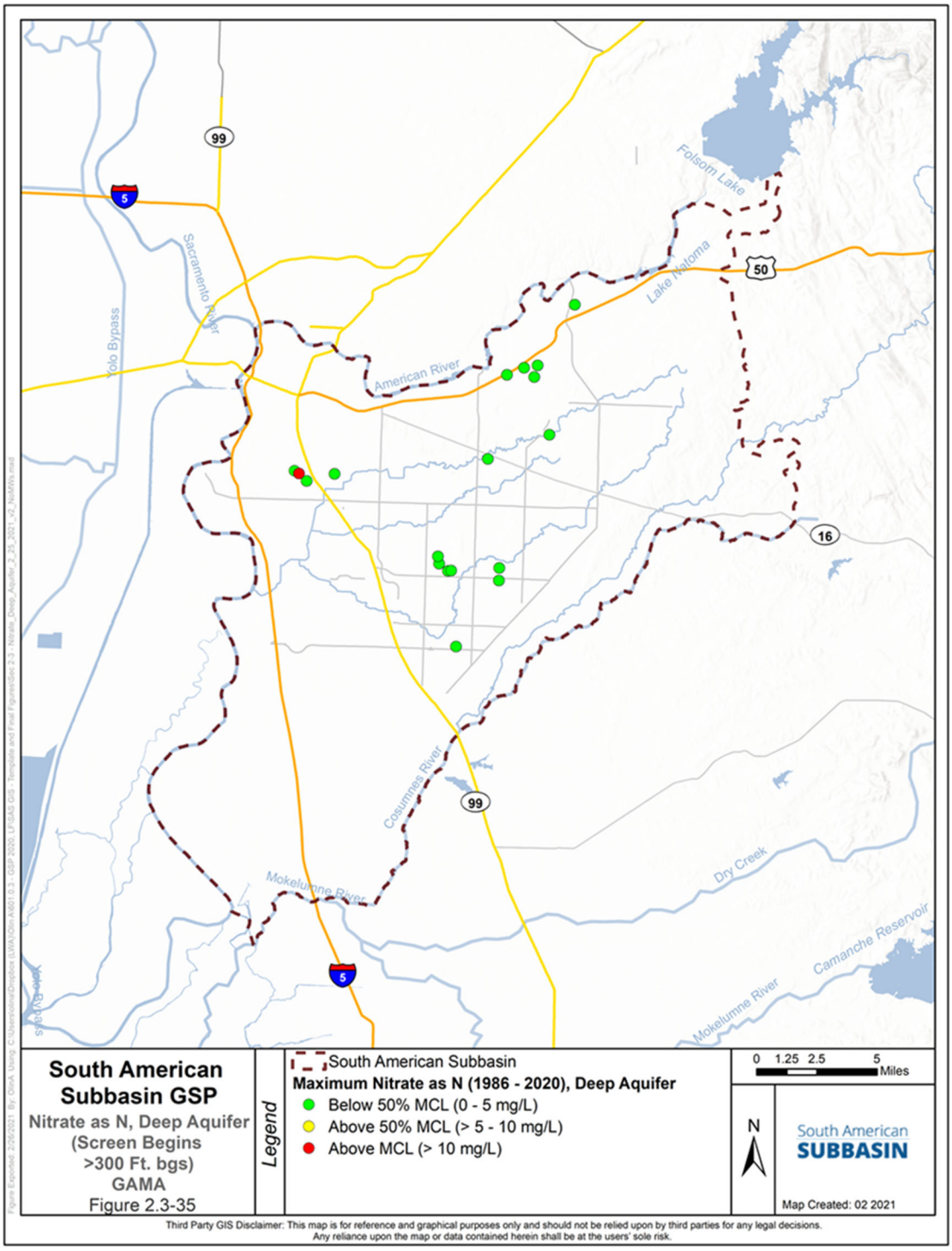


Figure 2-D-12: TDS Concentrations in the Shallow Zone, Monitoring Wells Omitted

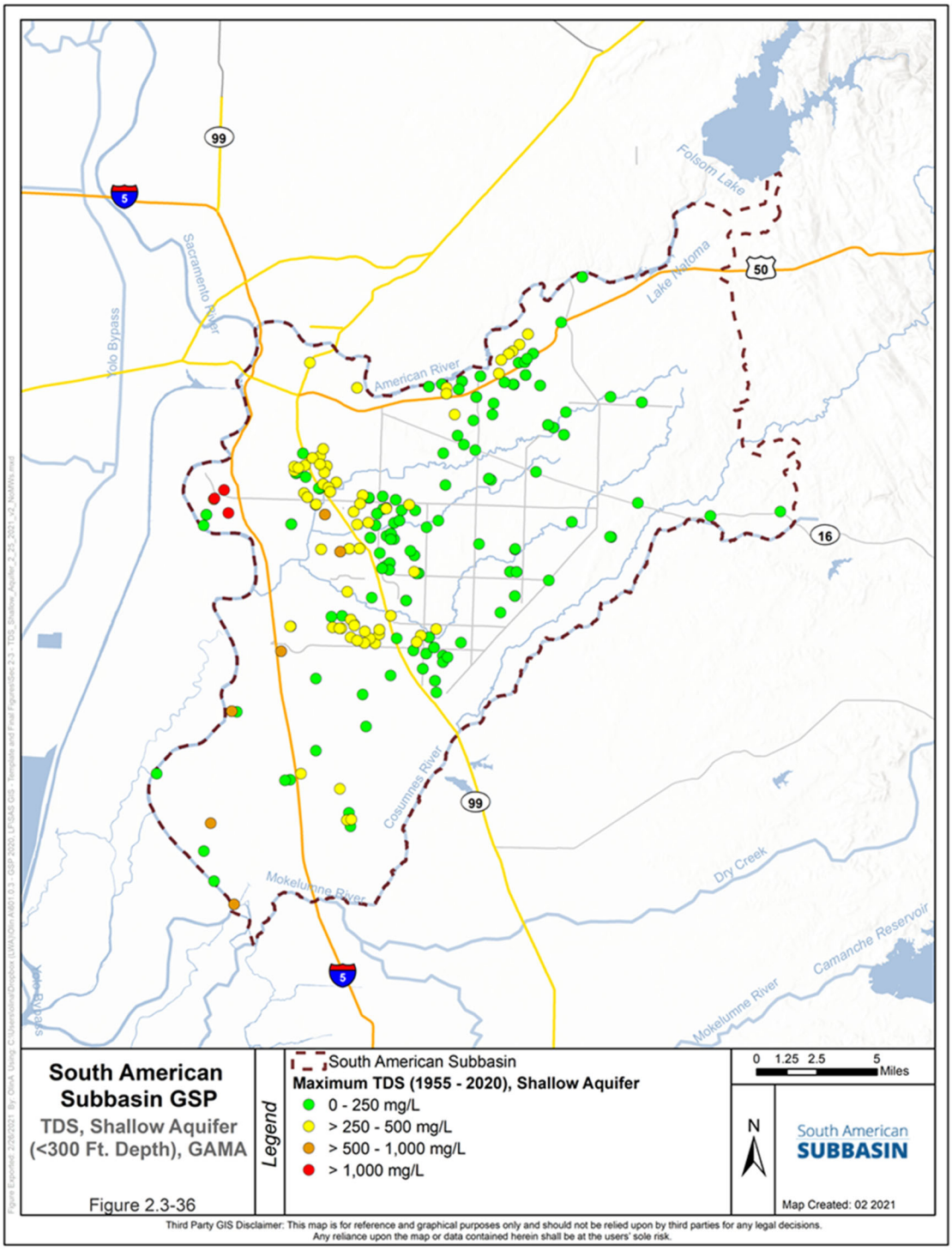

99
5
50
16
Folsom Lake
Lake Natoma
Sacramento River
Yolo Bypass
American River
Cosumnes River
Mokelumne River
Dry Creek
Camanche Reservoir
South American Subbasin GSP
TDS, Shallow Aquifer (<300 Ft. Depth), GAMA
Figure 2.3-36
Legend
South American Subbasin
Maximum TDS (1955 - 2020), Shallow Aquifer
0 - 250 mg/L
> 250 - 500 mg/L
> 500 - 1,000 mg/L
> 1,000 mg/L
0 1.25 2.5 5 Miles
N
South American SUBBASIN
Map Created: 02 2021
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions.
Any reliance upon the map or data contained herein shall be at the users' sole risk.

Figure 2-D-13: TDS Concentrations in the Shallow Zone, Monitoring Wells Included

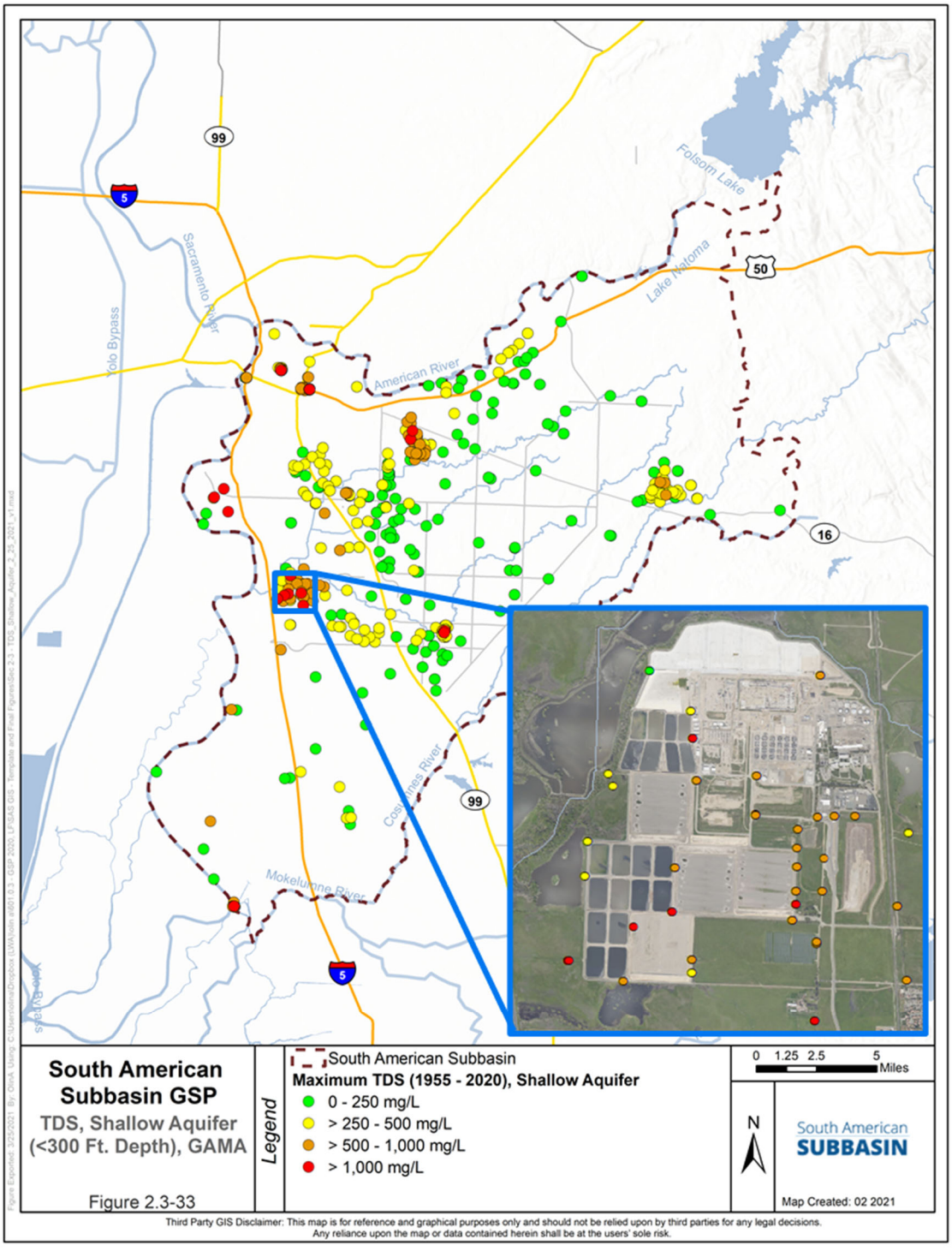


Figure 2-D-14: TDS Concentrations in the Deep Zone, Monitoring Wells Omitted

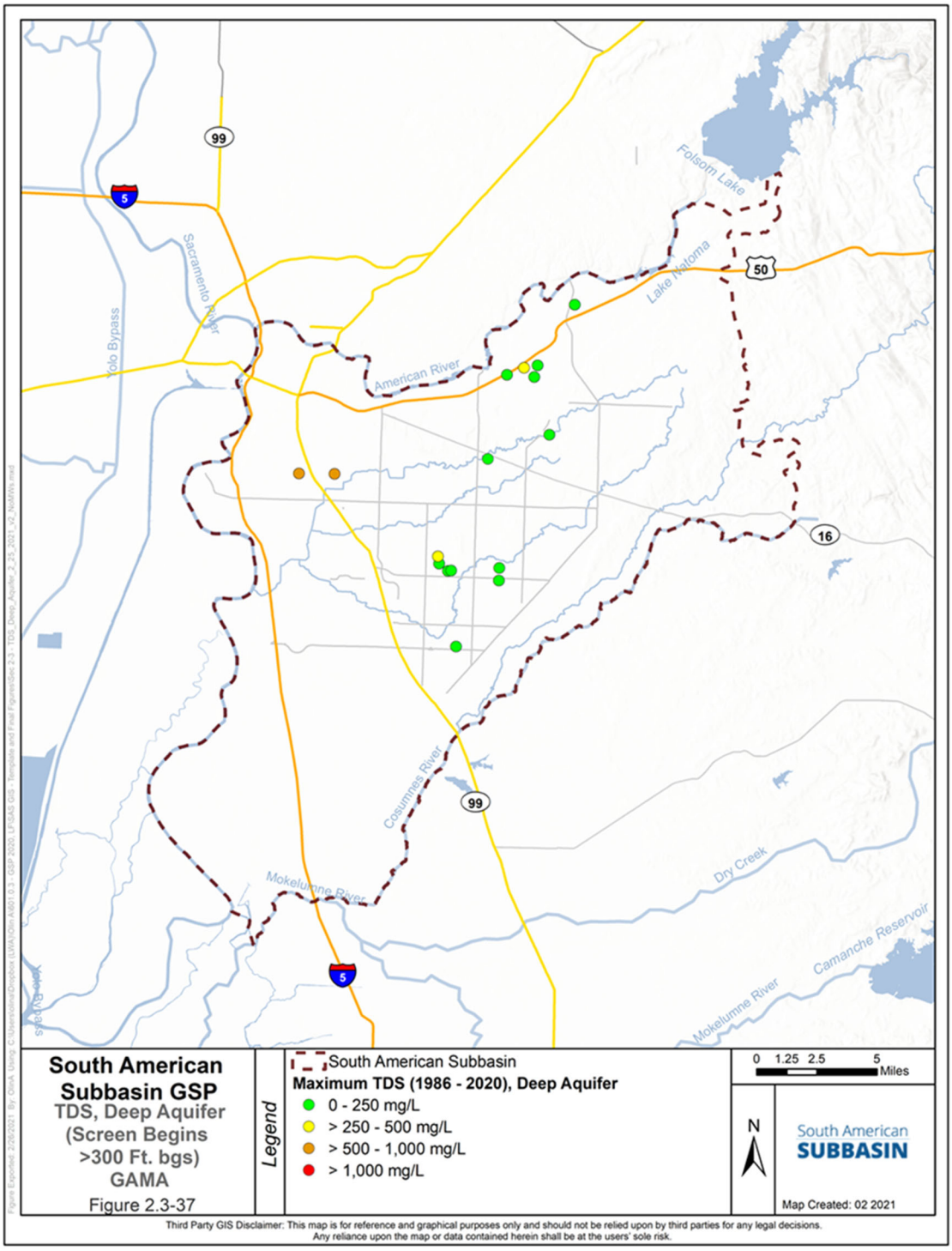

99
5
Folsom Lake
Lake Natoma
50
Sacramento River
Yolo Bypass
American River
16
Cosumnes River
99
Mokelumne River
Dry Creek
Camanche Reservoir
5
Mokelumne River
South American Subbasin GSP
TDS, Deep Aquifer
(Screen Begins
>300 Ft. bgs)
GAMA
Figure 2.3-37
Legend
South American Subbasin
Maximum TDS (1986 - 2020), Deep Aquifer
0 - 250 mg/L
> 250 - 500 mg/L
> 500 - 1,000 mg/L
> 1,000 mg/L
0 1.25 2.5 5
Miles
N
South American
SUBBASIN
Map Created: 02 2021
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions.
Any reliance upon the map or data contained herein shall be at the users' sole risk.

Figure 2-D-15: Arsenic Concentrations in the Shallow Zone, Monitoring Wells Omitted

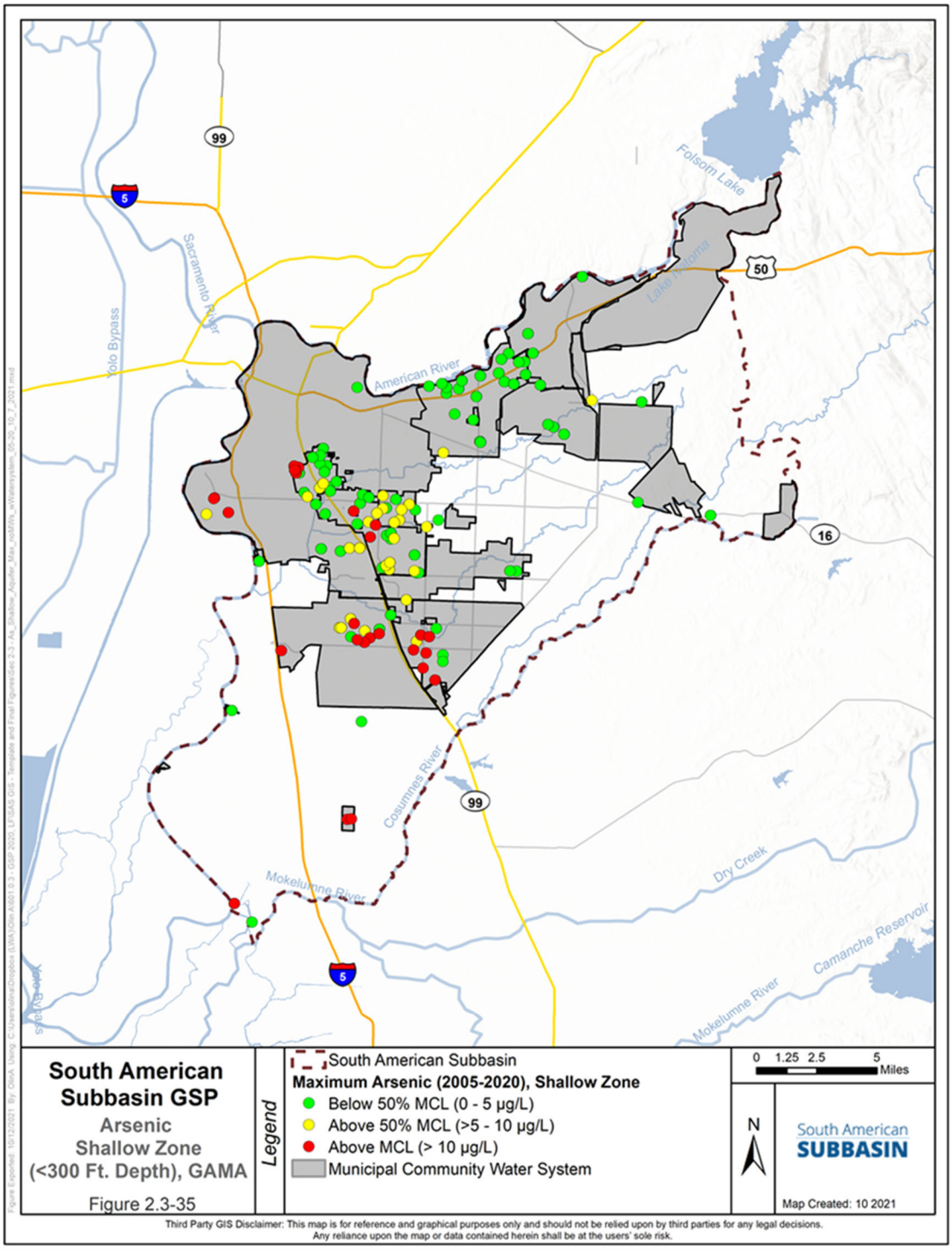


Figure 2-D-16: Arsenic Concentrations in the Deep Zone, Monitoring Wells Omitted

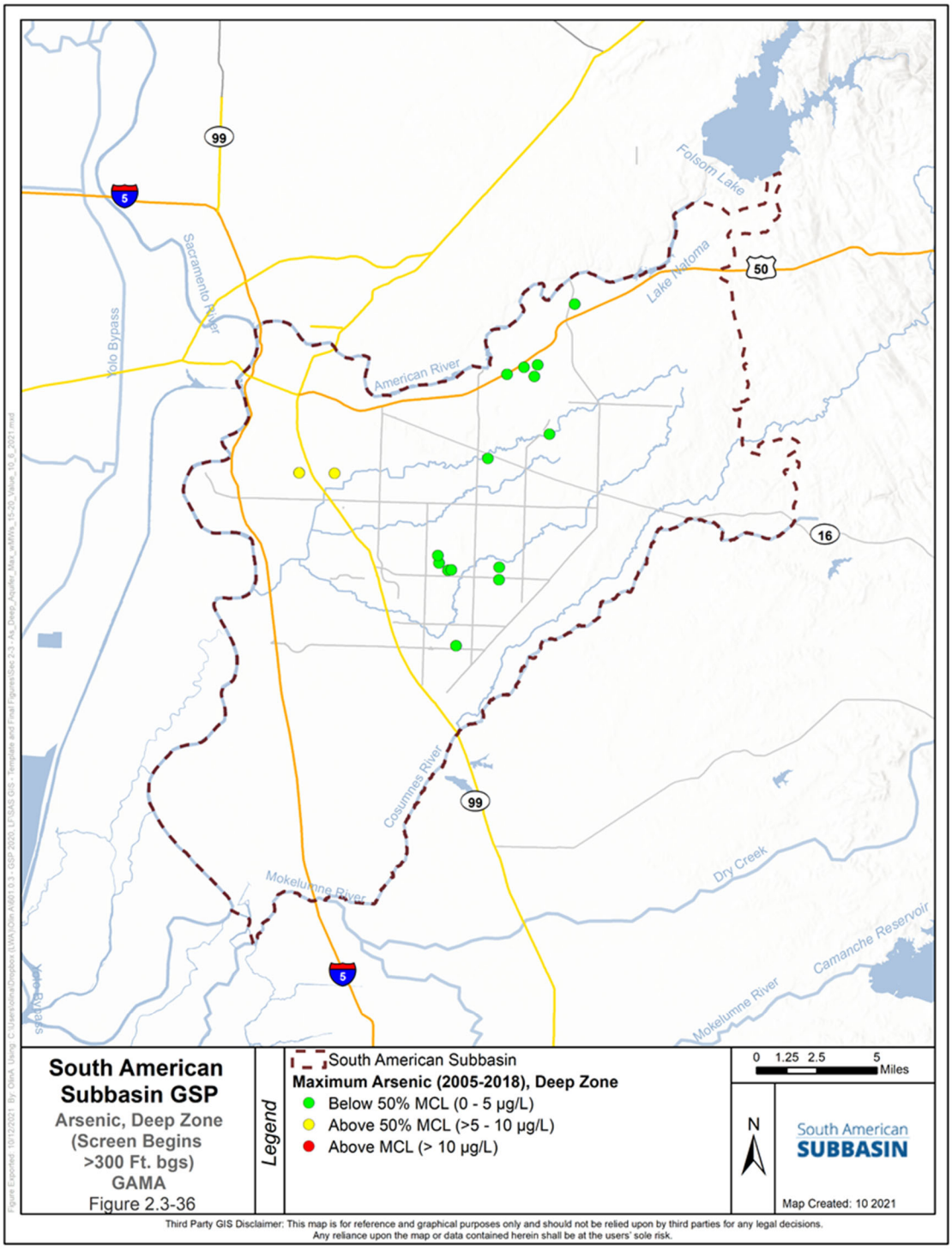


Figure 2-D-17: Hexavalent Chromium Concentrations in the Shallow Zone, Monitoring Wells Omitted

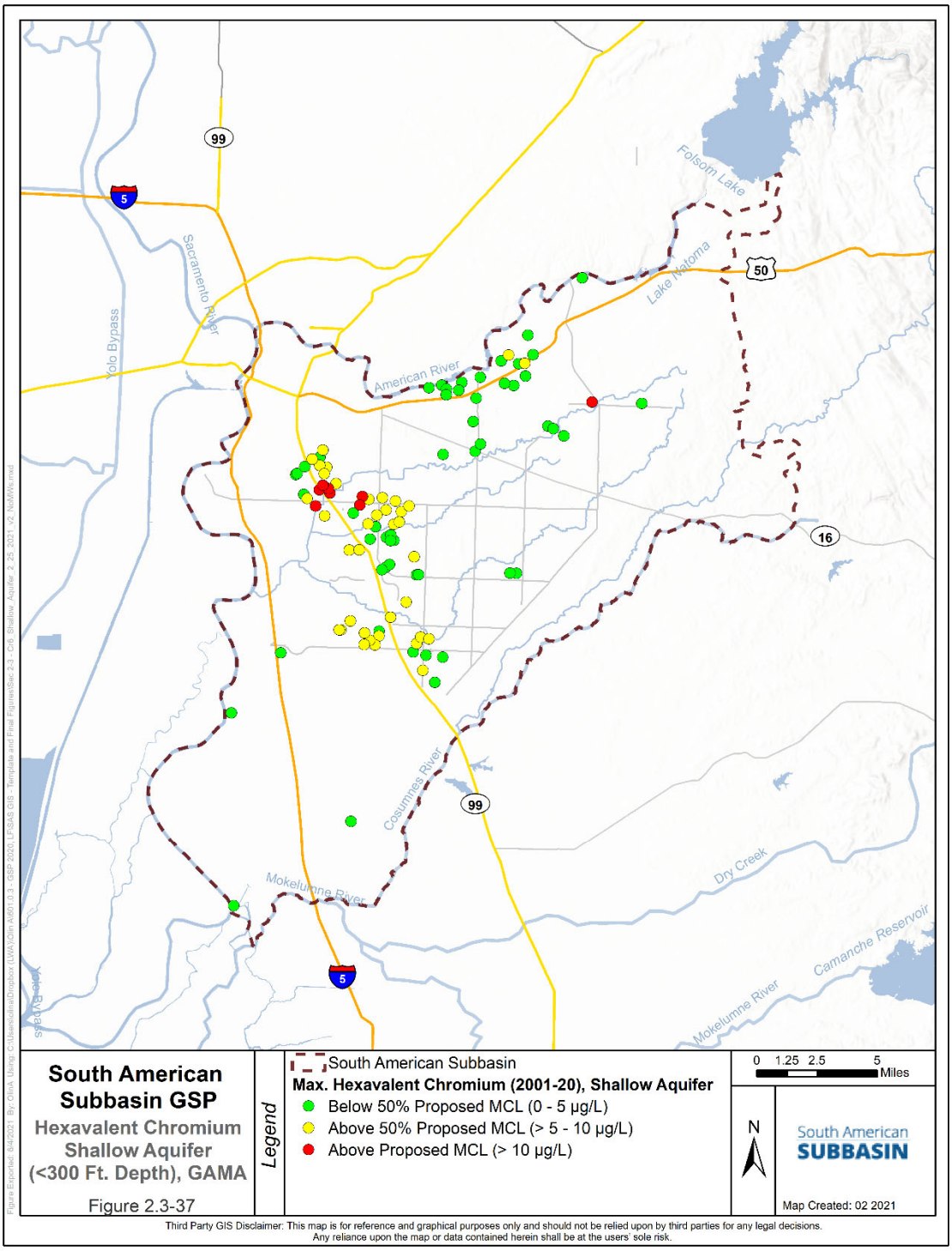


Figure 2-D-18: Hexavalent Chromium Concentrations in the Deep Zone, Monitoring Wells Omitted

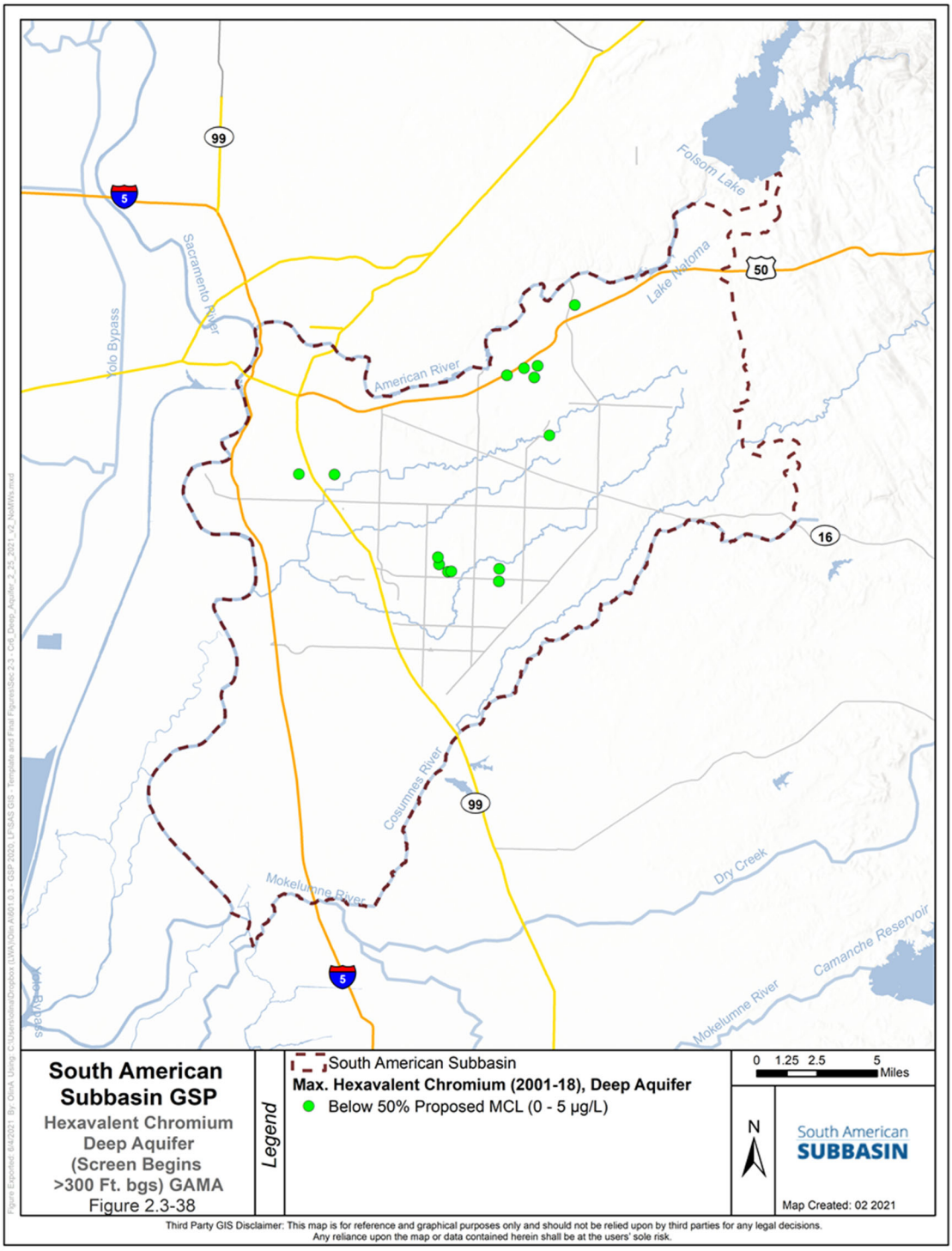


Figure 2-D-19: PFAS Concentrations in Groundwater, Monitoring Wells Included

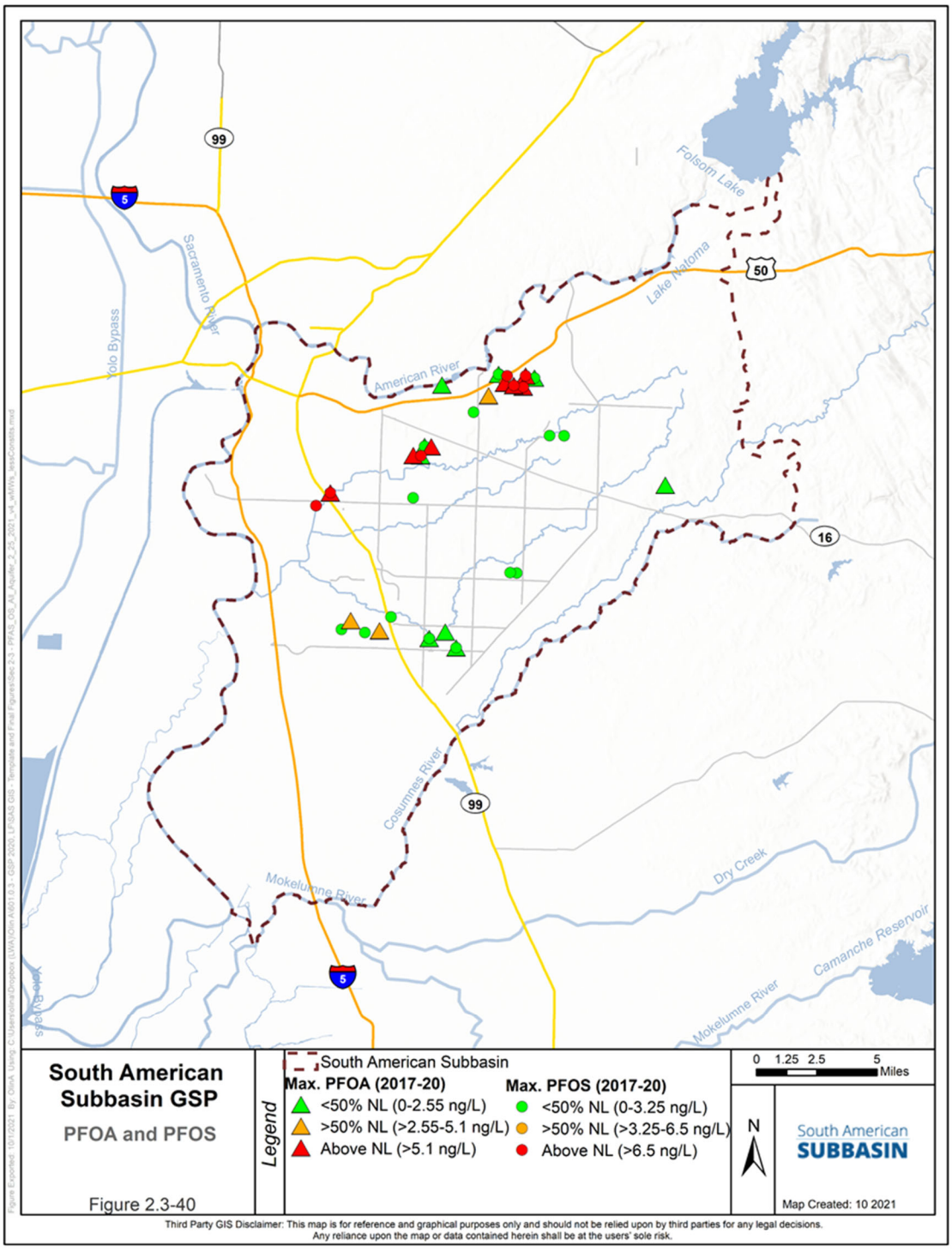


Figure 2-D-20: Chloride Concentrations in the Shallow Zone, Monitoring Wells Omitted

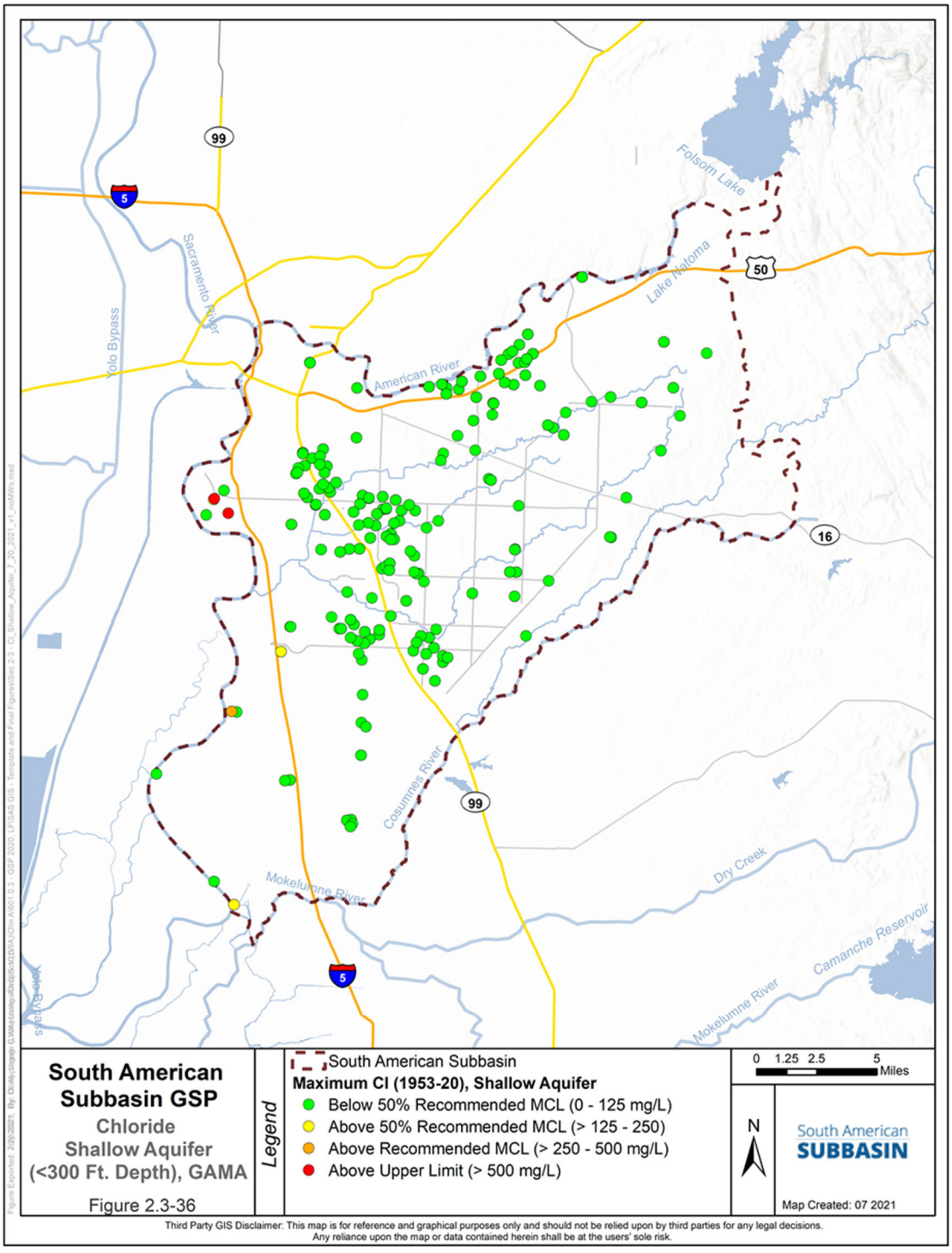


Figure 2-D-21: Chloride Concentrations in the Deep Zone, Monitoring Wells Omitted

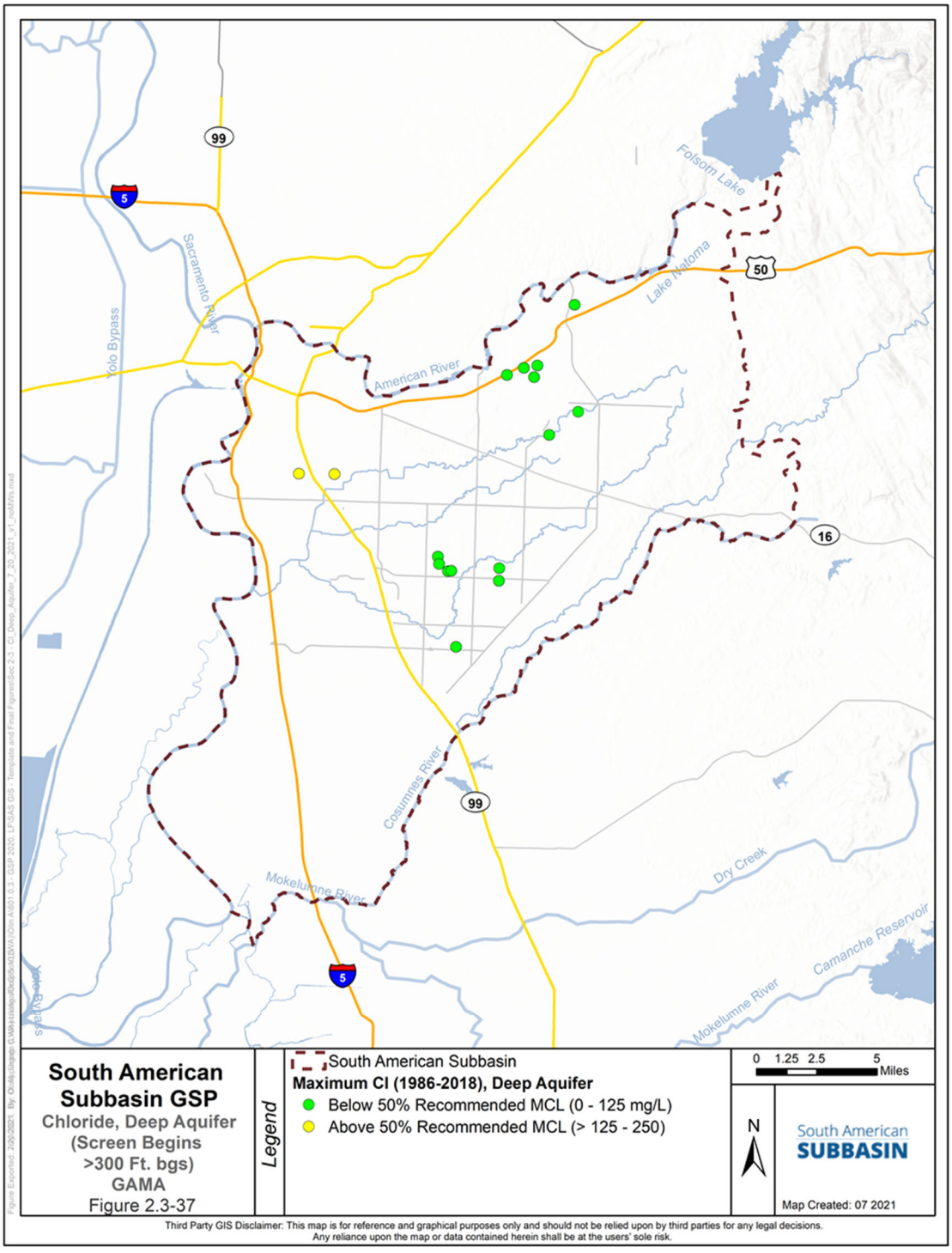


Figure 2-D-22: Iron Concentrations in the Shallow Zone, Monitoring Wells Omitted

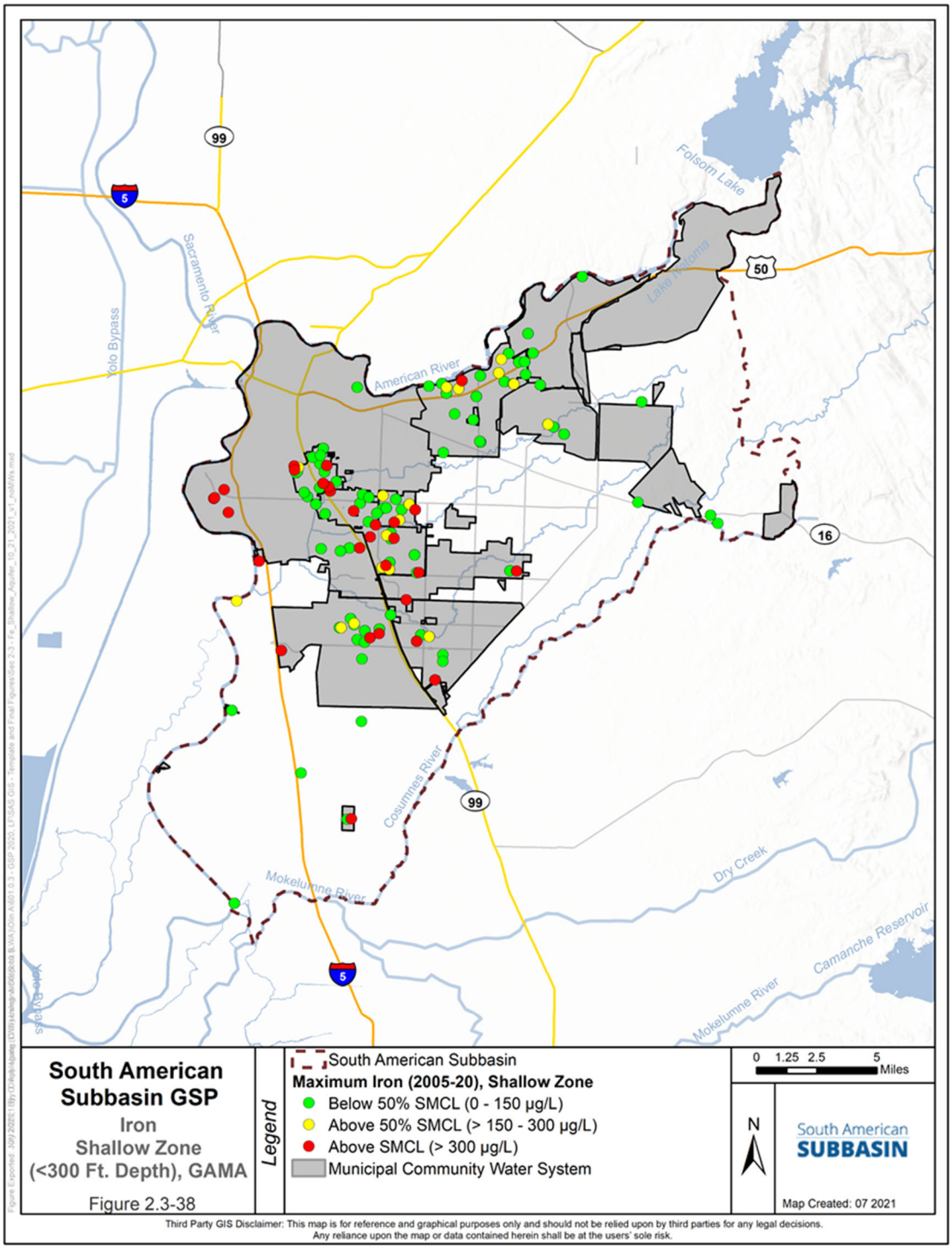


Figure 2-D-23: Iron Concentrations in the Deep Zone, Monitoring Wells Omitted

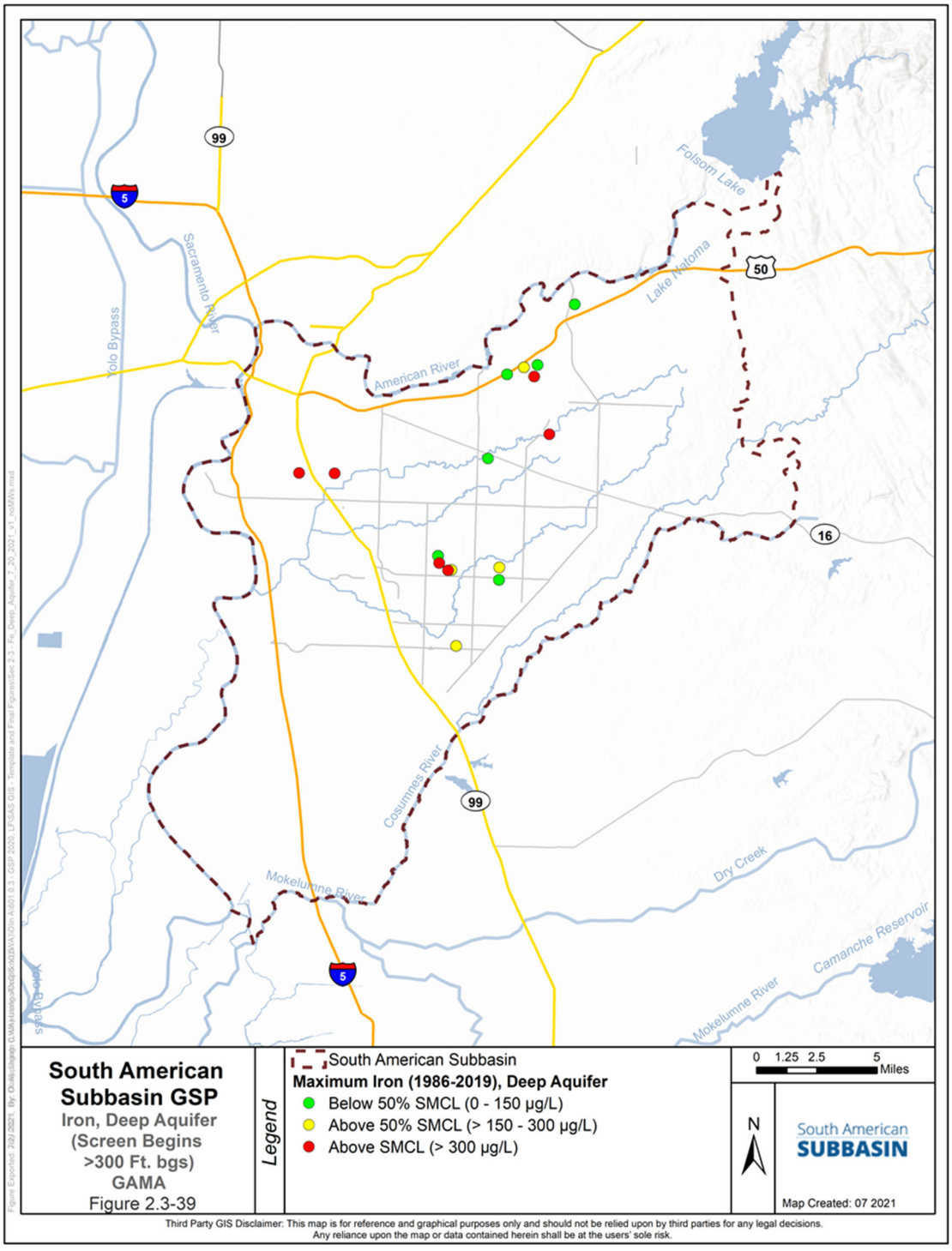


Figure 2-D-24: Manganese Concentrations in the Shallow Zone, Monitoring Wells Omitted

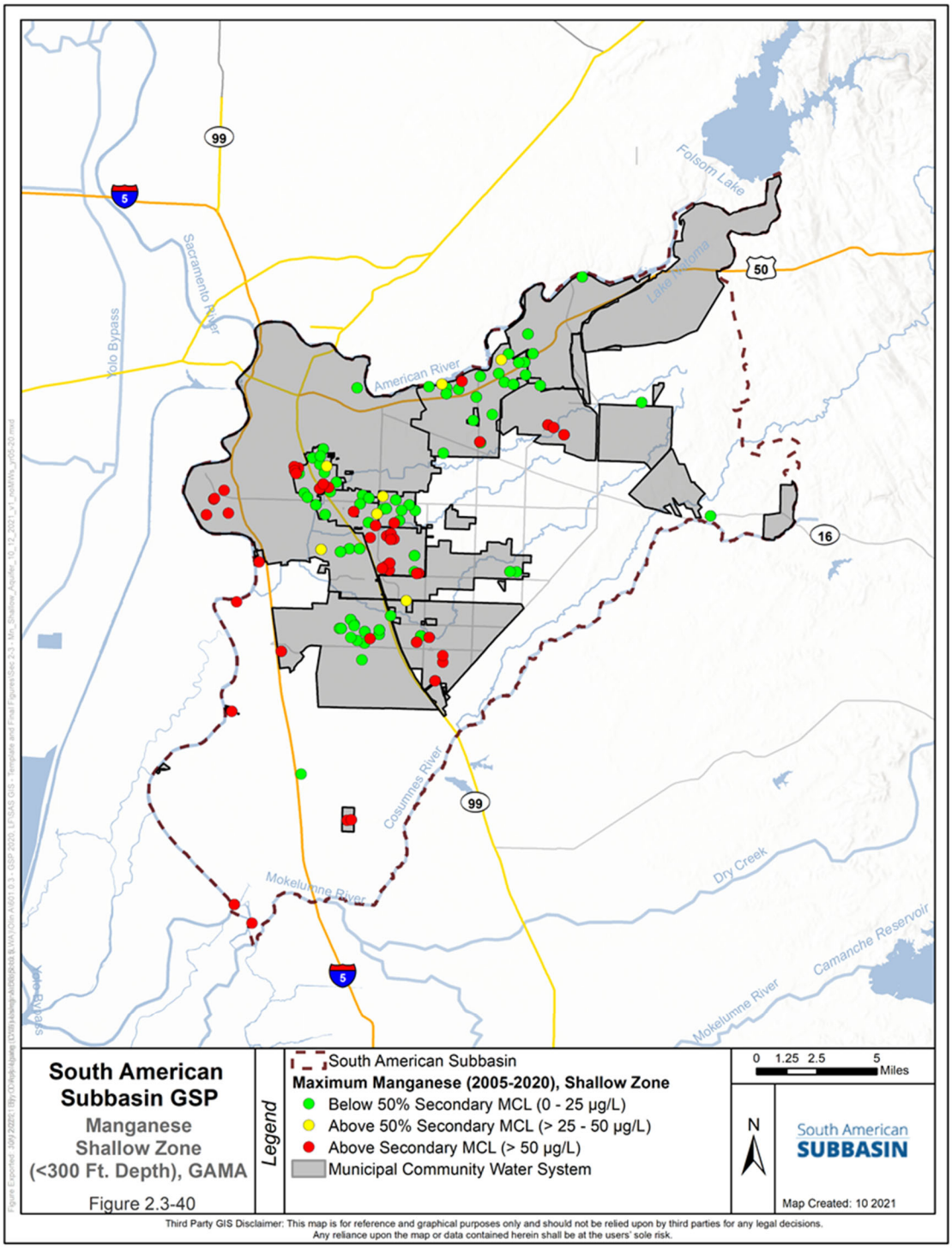


Figure 2-D-25: Manganese Concentrations in the Deep Zone, Monitoring Wells Omitted

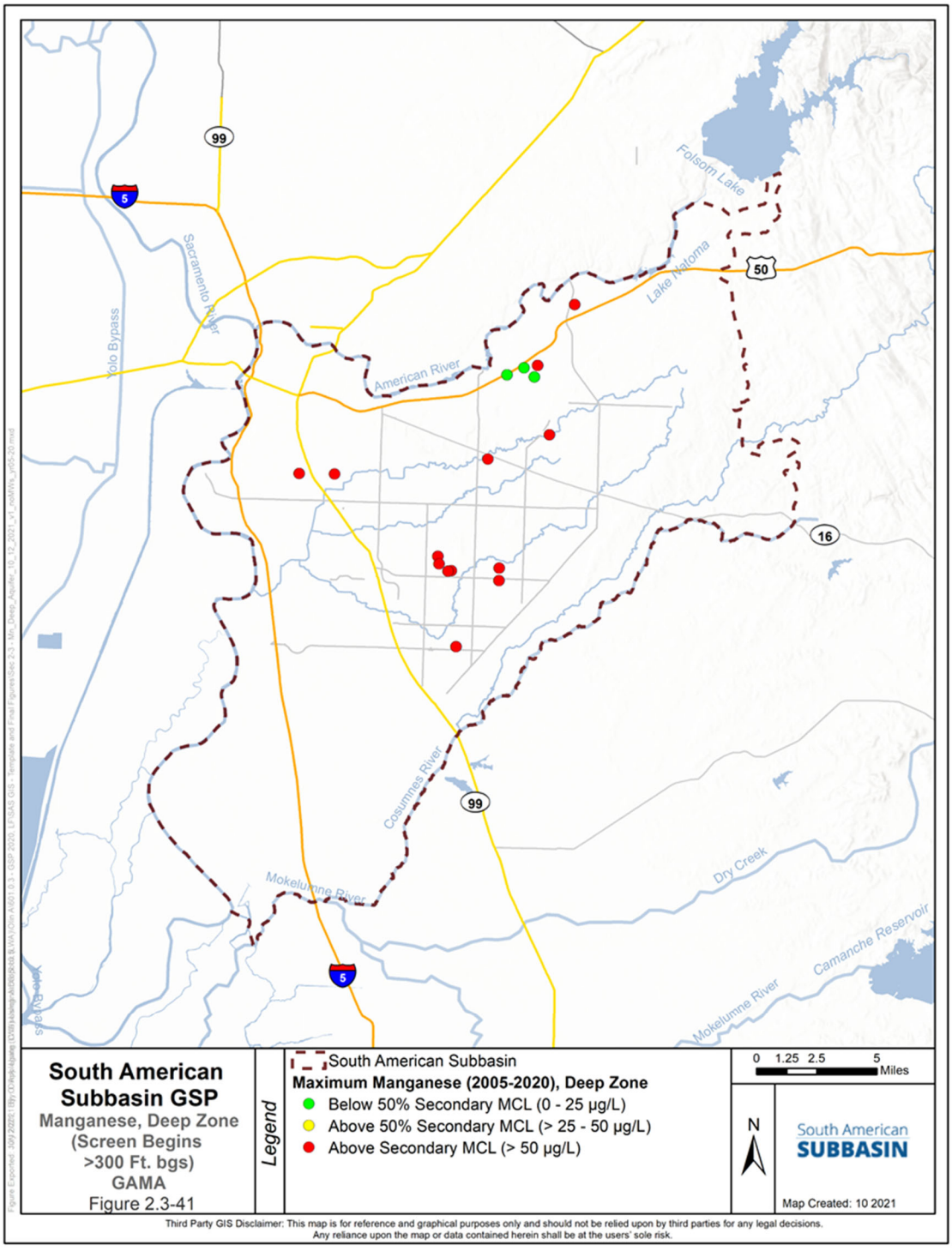


Table 2-D-2: Period of Record, Groundwater Quality Monitoring Wells in the Upper Aquifer Zone

	Arsenic Measurements			Iron Measurements			Manganese Measurements		
Well ID	From	To	# of records	From	To	# of records	From	To	# of records
3410020-009	11/16/88	5/9/17	13	11/16/88	2/4/20	13	11/16/88	2/4/20	13
3410029-002	2/21/91	2/6/17	11	7/27/89	2/13/20	15	7/27/89	2/13/20	16
3410029-016	7/1/88	2/10/20	10	7/1/88	2/10/20	13	7/1/88	2/18/14	12
3410029-029	10/25/01	2/18/14	7	10/25/01	2/18/14	6	10/25/01	2/13/20	7
3410033-006	7/13/90	12/12/13	8	5/8/87	6/13/19	12	5/8/87	6/13/19	12
L10005519750-MW-G(S)	N/A	N/A	0	10/23/17	10/23/17	1	5/20/15	5/20/15	1
L10008601447-MW-13	N/A	N/A	0	6/4/15	2/22/18	5	2/26/15	10/17/18	8
3400101-001	2/19/08	11/20/14	2	2/24/05	2/6/17	4	8/15/05	2/19/08	2
3410029-024	8/26/02	5/1/17	71	8/26/02	5/1/17	73	8/26/02	7/29/14	72
3410029-025	3/21/01	12/3/19	172	3/21/01	9/22/14	158	3/21/01	9/22/14	164
3901216-001	5/21/02	7/25/17	5	5/22/02	2/4/20	6	5/22/02	2/4/20	2

Table 2-D-3: Period of Record, Groundwater Quality Monitoring Wells in the Lower Aquifer Zone

	Arsenic Measurements			Iron Measurements			Manganese Measurements		
Well ID	From	To	# of records	From	To	# of records	From	To	# of records
3400375-001	5/5/05	6/8/12	2	5/5/05	6/8/12	2	5/5/05	6/8/12	2
3410015-020	5/27/86	1/14/14	11	5/27/86	2/28/17	14	5/27/86	2/28/17	14
3410015-022	5/19/93	5/25/17	8	5/19/93	1/14/14	10	5/19/93	10/8/19	83
3410023-015	2/15/91	1/8/15	6	7/18/89	1/8/15	23	7/18/89	1/8/15	23
3410029-015	7/1/88	5/23/18	10	7/1/88	5/23/18	16	7/1/88	5/13/15	19
3410029-026	10/25/01	5/11/17	9	10/25/01	2/18/14	10	10/25/01	5/11/17	16
3410029-027	11/19/03	8/18/11	5	11/19/03	2/5/19	8	11/19/03	2/5/19	11
3410704-001	4/30/92	5/20/14	6	4/30/92	5/11/17	8	4/30/92	5/20/14	11
L10007396297-MW-40B	N/A	N/A	0	N/A	N/A	0	N/A	N/A	0
S7-SAC-SA10	N/A	N/A	0	N/A	N/A	0	N/A	N/A	0

Land Subsidence

Land subsidence is the lowering of the ground surface elevation. This is often caused by pumping below thick clay layers. Land subsidence can be elastic or inelastic. Inelastic subsidence is generally irreversible. Elastic subsidence is small, reversible lowering and rising of the ground surface and can be cyclical with seasonal changes year to year. Land subsidence is not known to be historically or currently significant in South American Groundwater Subbasin.

Previous Land Subsidence Studies and Current Data Sources

Previous efforts to quantify land subsidence in the South American Subbasin have yielded results showing small-to-zero amounts of subsidence having occurred. Such efforts have mainly been through leveling profiles studied between 1947 and 1966, the 2006 GMP, a 2008 DWR and the US Bureau of Reclamation subsidence project throughout the Sacramento Valley using GPS technology (Frame Surveying & Mapping, 2008), and DWR's Sacramento Valley 2017 GPS Survey program (specific results are summarized in SCGA [2018]), all of which demonstrated that subsidence has been very minimal, not significant or unreasonable, across the Subbasin during the time period 2008-2017.

DWR published Interferometric Synthetic Aperture Radar (InSAR) satellite data on their SGMA Data Viewer web map in 2019 (with an additional update in 2020), providing an estimate of land subsidence covering the time period from June 2015 to September 2019 (see **Figure 2-D-1**). These data are processed by TRE Altamira and are made available by DWR as downloadable raster and point datasets for monthly time steps, updated annually.

The only current CGPS (Continuous GPS) data available within the Subbasin are from the UNAVCO CGPS station (# P274). The CGPS station data are available for the period from October 2005 to present (). The data from this station are used in estimating current land subsidence conditions in the area surrounding the CGPS station. The CGPS data are also planned for use by the GSA in estimating future land subsidence conditions in the Subbasin.

The DWR/TRE Altamira InSAR data are the only currently available subsidence-related dataset covering the whole Subbasin and provide high-resolution estimates of total vertical displacement, complementary to the CGPS station data. The CGPS and InSAR data are described in further detail below.

CGPS Data Analysis

The vertical displacement data available from the UNAVCO CGPS network station #P274 start in October 2005 and continue to the present. The record of this subsidence data product from October 2005 to December 2020 are shown in **Figure 2-D-2**Figure 2-D-2. The data suggest minimal land subsidence has occurred since measurement began in October 2005, equating to about -0.14 ft in total, or roughly -0.01 ft/year. The InSAR record of subsidence for the same area the CGPS station lies within compares similarly for the equivalent period of June 2015 to September 2019 (both recording about -0.03 ft of subsidence). This demonstrates the accuracy of InSAR to be approximate to the CGPS stations for purposes of tracking land subsidence according to SGMA needs.

InSAR Data Analysis

Using the TRE Altamira InSAR Dataset provided by DWR, it is observed that the majority of the vertical displacement values in South American Subbasin are very low to essentially zero, with minimal outliers and within the range of 0.0 to -0.14 ft (see **Figure 2-D-1**). These values are about the same to about one order of magnitude smaller than the combined data and raster conversion error. While there are areas of slight subsidence near and to the southwest of Elk Grove, these are noted by previous studies as being due to a persistent cone of depression from groundwater extraction due to pumping near Elk Grove (2006 GMP) and Delta area sediment-oxidation subsidence (DWR, 1995), respectively. The Subbasin overall reflects subsidence signals that are very low or are essentially noise in the data. Any actual signals at this level could be due to a number of possible activities, including land use change and/or agricultural or urban operational activities at the field scale, as well as sediment-oxidation induced subsidence. For perspective, during this same period (2015-2019), sections of the San Joaquin Valley in California's Central Valley experienced -3.5 ft of total vertical subsidence.

InSAR Data Quality

DWR has stated that the total vertical displacement measurement error for InSAR data are as follows:

1. The error between InSAR data and continuous GPS data is 0.052 ft (16 mm) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 ft (15 mm) with 95% confidence level.

By simply adding the errors 1 and 2, the combined error is 0.1 ft (~30.5 mm) (B. Brezing, personal communication, February 27, 2020). While this is not a robust statistical analysis, it does provide an estimate of the potential error in the InSAR maps provided by DWR. A land surface change of less than 0.1 ft is therefore within the noise of the data and may not be indicative of subsidence in the basin. Additionally, the InSAR data provided by DWR reflects both elastic and inelastic subsidence. While it is difficult to compensate for elastic subsidence, visual inspection of monthly changes in ground elevations suggest that elastic subsidence is largely seasonal.

Figure 2-D-1: South American Subbasin InSAR Subsidence, June 2015 – September 2019

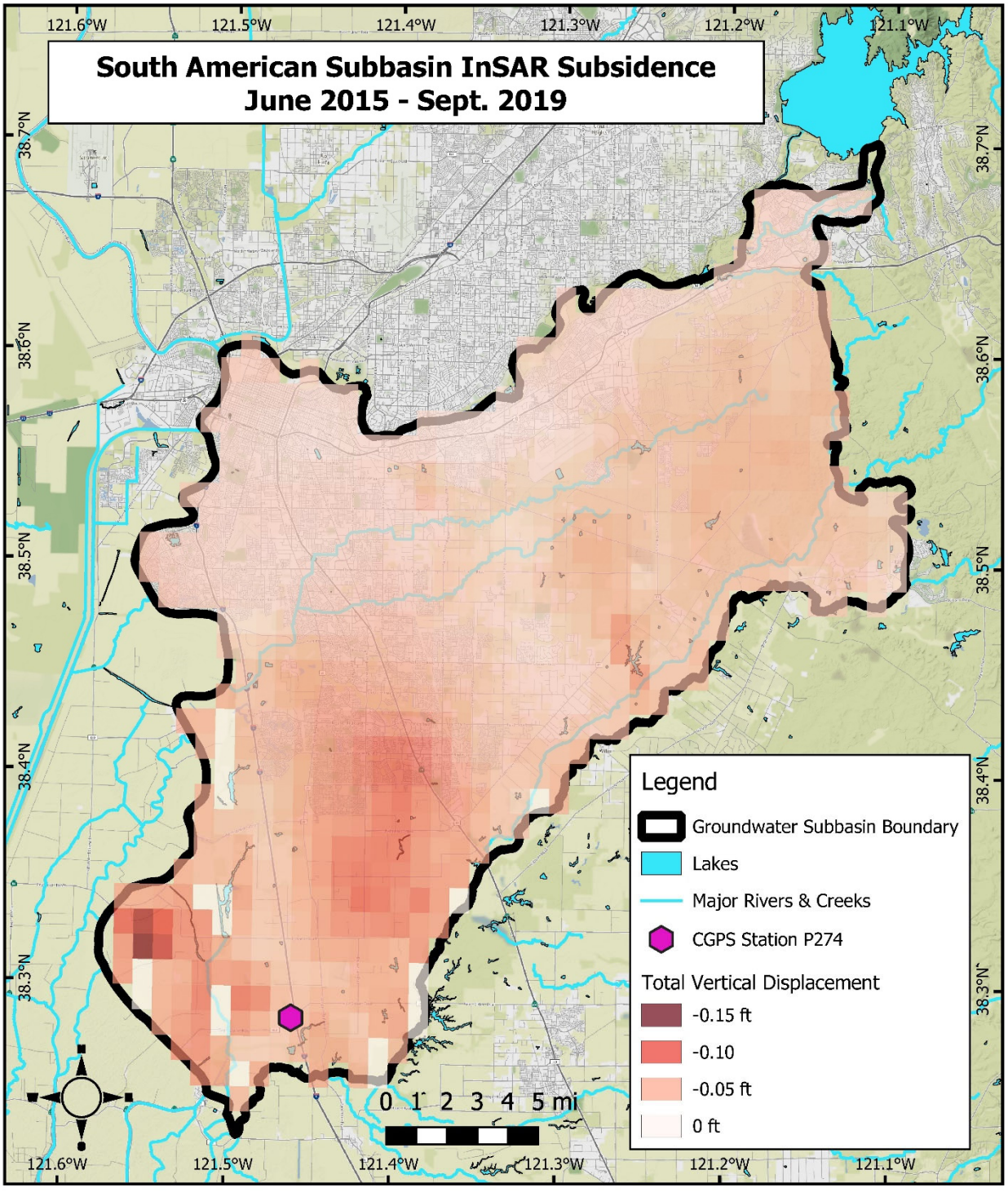
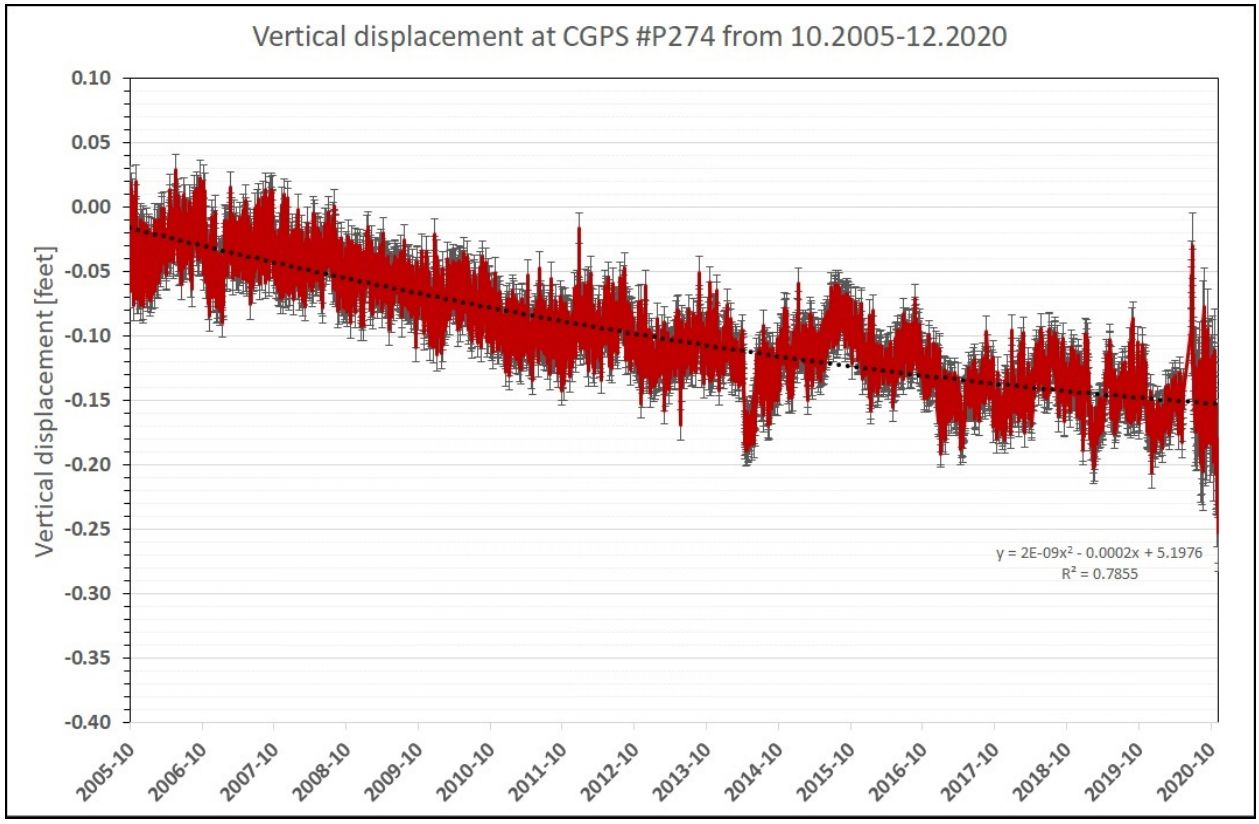


Figure 2-D-2: South American Subbasin CGPS Station (UNAVCO #P274) Subsidence, October 2005 – December 2020. Note: Trend line added solely for the purpose of added assistance with the interpretation of subsidence time series data. Trend line equation included for reference.



References

California Department of Water Resources (DWR). 1974. *Bulletin 118-3, Evaluation of Groundwater Resources: Sacramento County*. Sacramento, California. July.

California Department of Water Resources (DWR), 1974. Evaluation of Ground Water Resources: Sacramento County. Bulletin 118-3. July.

California Department of Water Resources (DWR), 1964. Folsom-East Sacramento Ground Water Quality Investigation. Bulletin 133. March.

Central Sacramento County Groundwater Forum. 2006. *Central Sacramento County Groundwater Management Plan.* Accessed December 16, 2020. https://scgah2o.saccounty.net/documents/CSCGMP_final.pdf

Central Sacramento County Groundwater Forum. 2006. *Central Sacramento County Groundwater Management Plan - Appendices.* Accessed December 16, 2020. https://scgah2o.saccounty.net/documents/CSCGMP_Appendices_all.pdf

CH2M, 2016. Final Groundwater Quality Assessment Report. Prepared for the Central Valley Regional Water Quality Control Board on behalf of the Northern California Water Association, Sacramento Valley Water Quality Coalition. January.

Dawson, B.J., Bennett, G.L., V, and Belitz, Kenneth, 2008. Ground-Water Quality Data in the Southern Sacramento Valley, California, 2005—Results from the California GAMA Program. U.S. Geological Survey Data Series 285. 93 p. https://pubs.usgs.gov/ds/285/ds285v1.1.pdf

RMC, 2014. SCGA Basin Management Report, 2011-2012. In association with Davids Engineering. August.

RMC, Draft SCGA Basin Management Report, 2013-2014. Unpublished.

Sacramento Central Groundwater Authority (SCGA). 2012. *Sacramento Central Groundwater Authority Groundwater Elevation Monitoring Plan*. February.

Sacramento Central Groundwater Authority (SCGA). 2016. *South American Subbasin Alternative Submittal.* Accessed December 16, 2020. Available online at: https://scgah2o.saccounty.net/Documents/Alt_Sub_FinalDraft_SCGA_S_American_20161214_Stamped_NoAppendices.pdf

Sacramento Central Groundwater Authority. 2018. *SGMA Annual Report South American Subbasin (5-021.65)*. Accessed December 16, 2020. Available online at: https://scgah2o.saccounty.net/Documents/2018%20SCGA%20Annual%20Report%20South%20American%20Subbasin%205-021.65_20180329.pdf

Sacramento Central Groundwater Authority. Basin Management Report 2007-2008.

Sacramento Central Groundwater Authority. Basin Management Report 2009-2010.

Sacramento Groundwater Authority GSA. 2020. Draft North American Subbasin Groundwater Sustainability Plan, Section 5, Groundwater Conditions. Accessed December 16, 2020. Available online at: https://nasbgroundwater.org/chapters-comment/

Smith, R., Knight, R. & Fendorf, S. 2018. Overpumping leads to California groundwater arsenic threat. Nature Communications 9, 2089. June 2018. https://doi.org/10.1038/s41467-018-04475-3

US Census Bureau. 1950. *1950 Census of Population, Preliminary Counts*. Accessed online on February 3, 2021 at https://www2.census.gov/library/publications/decennial/1950/pc-03/pc-3-03.pdf.

US Census Bureau. 2020. *Annual Estimates of Resident Population: April 1, 2010 to July 1, 2019: Metropolitan Statistical Area; and for Puerto Rico*. Accessed online on February 3, 2021 at https://www2.census.gov/programs-surveys/popest/tables/2010-2019/metro/totals/cbsa-met-est2019-annres.xlsx

South American
SUBBASIN

Appendix 3-A

Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management (June 18, 2021)

Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management

Larry Walker Associates

2021-06-18

Table of Contents

1. Introduction 4

2. Study Area and Setting 6

2.1 Review of Major surface waters 7

2.1.1 Lower Sacramento River 9

2.1.2 Lower American River 11

2.1.3 Lower Cosumnes River 12

2.1.4 Mokelumne River and Delta 14

2.2 Special-status species 15

2.3 Instream flow requirements 19

2.3.1 Lower Sacramento River 19

2.3.2 Lower American River 20

2.3.3 Lower Cosumnes River 20

2.4 Surface water and Groundwater Interactions 21

2.4.1 Lower Sacramento River 23

2.4.2 Lower American River 23

2.4.3 Lower Cosumnes River 24

3. Methods 28

3.1 Data sources 28

3.1.1 Groundwater 28

3.1.2 Surface Water 29

3.2 Groundwater Level Interpolation 30

3.3 Forward simulations of Projects and Management Actions and Climate Change 31

3.4 Classification of ISW and Disconnected Surface Waters 32

3.5 Estimation of Depletion Volume at ISW Reaches 33

3.6 Location and Timing of Gaining and Losing Reaches 34

3.7 Changes in ISW streamflow 34

3.8 Satellite Analysis of Wetting and Drying 34

4. Results 35

4.1 Historic and Present-day Groundwater Conditions 35

4.1.1 Monitoring well hydrographs 35

4.1.2 Groundwater elevation trends and flow direction 35

4.1.3 Shallow groundwater locations 39

4.1.4 Projected groundwater levels 40

4.2 Location and Timing of Interconnected Surface Waters 43

4.2.1 Historical data analysis 43

4.2.2 Impact of projected groundwater management on ISW reach length 45

4.3 Depletions of Interconnected Surface Waters 46
4.3.1 Comparison of current and projected seepage..... 46
Active ISW depletion is occurring in the SASb due to historical groundwater development and evidenced by the prevalence of disconnected surface water bodies and mostly losing stream reaches across the basin (discussed in Section **4.3.2 Dependence of seepage on water year type**..... 46
4.3.2 Dependence of seepage on water year type..... 49
4.4 Location and Timing of Gaining and Losing Reaches 49
4.5 Impacts to Streamflow 52
4.6 Satellite Analysis of Wetting and Drying 54
5. Limitations..... 57
6. Conclusion and Management Recommendations..... 57
6.1 Sustainable Management Criteria (SMC) and Monitoring Approach..... 58
References..... 60

1. Introduction

The South American Subbasin (SASb) is a medium priority groundwater basin in California's Central Valley. Groundwater pumping in the SASb provides water for municipal, agricultural, and domestic beneficial users, but has lowered groundwater elevations over time and lead to depletions of interconnected surface water (ISW), defined as:

> 23 CCR § 351(o): "Interconnected surface water" refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.

The Sustainable Groundwater Management Act (SGMA) identifies "Depletions of Interconnected Surface Water" as an Undesirable Result (CWC § 10721(x)). Thus, ISW depletion requires the development of Sustainable Management Criteria (SMC) to quantify existing ISW depletion and plan for sustainable groundwater management that mitigates significant and unreasonable ISW depletion. Specifically, 23 CCR § 354.28. Minimum Thresholds states that the Minimum Threshold (MT) 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*" and that developed MTs will be supported by:

A. The location, quantity, and timing of depletions of interconnected surface water.
B. A description of the groundwater and surface water model used to quantify surface water depletion.

Although numerous surface water bodies that support environmental flows and aquatic ecosystems are present in the SASb (i.e., Sacramento, American, and Cosumnes rivers, and minor creeks and streams in the basin's interior), seasonal and historical trends in the location and timing of ISW, as well as ISW volumetric depletion rates (quantity) remain poorly characterized. Herein, we report on long-term, recent groundwater level conditions (2005-2018) in the SASb, characterize the spatial location, timing, and quantity of ISW using output from the Cosana integrated hydrologic model, and recommend management actions that align ISW depletion with the mandates of SGMA.

Fundamentally, this memorandum shows that stream depletion is occurring in the SASb, and identifies ISW locations, timing, and quantity. Next, a management approach and sustainable management criteria (SMC) for groundwater level are recommended that arrest groundwater levels, which arrest hydraulic gradients, and finally, arrest streamflow depletion (Figure 1).

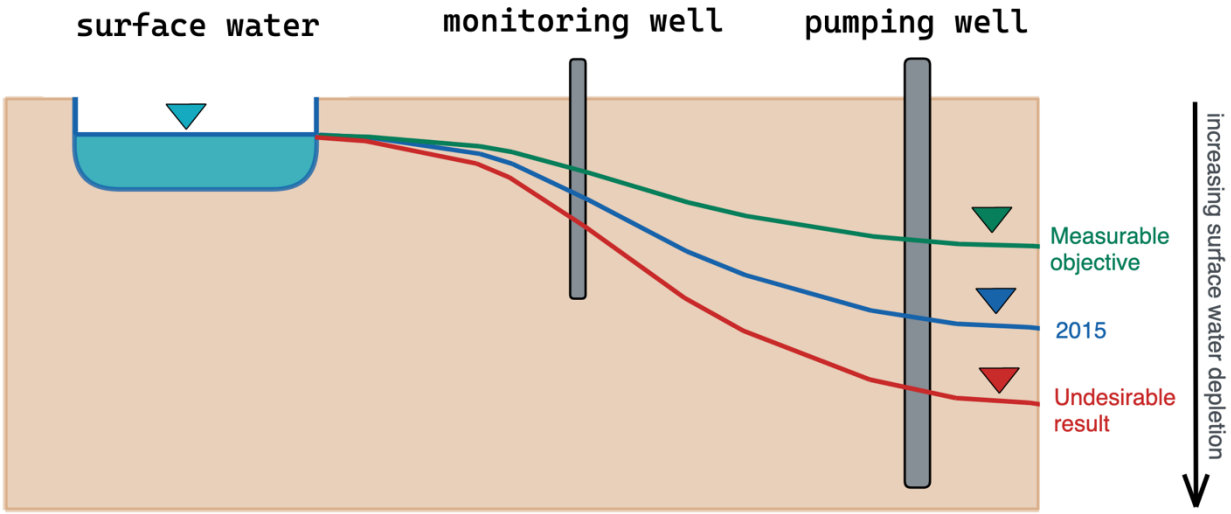


Figure 1: Surface water depletion can occur when adjacent groundwater elevation (green, blue, and red lines) falls below the stream stage elevation. As groundwater elevation declines, for example, due to groundwater pumping, the regional groundwater level falls, which steepens the gradient between surface and groundwater and increases the quantity of surface water depletion (black downwards-pointing arrow). In the figure above, the 2015 groundwater level is shown as a historic low groundwater elevation (blue line). Examples of an undesirable result (red line) and measurable objective (green line) are groundwater levels below and above this historic low, respectively.

This memorandum is outlined as follows. First, in Section 2, we briefly review study area and basin setting insofar as it is necessary to understand the subsequent material[1], then follow with an extensive review of major surface water features, special-status species, instream flow requirements, and surface and groundwater interactions in the SASb. Next, in Sections 3-4, we present the methods and results of analysis of historical and present-day groundwater level conditions. Groundwater level data and the numerical integrated surface and groundwater flow model Cosana are used to inform a characterization of ISW location, timing, and quantity in the SASb. We find persistently disconnected reaches, persistently connected reaches, and reaches that oscillate between connection and disconnection across seasons and water years. Gaining and losing reaches are identified and seepage values are quantified and discussed. Finally, in Sections 5-6 we discuss limitations of the study and propose management and monitoring actions.

Results inform a monitoring and management approach for ISW within the context of SGMA that arrests groundwater levels in ISW-adjacent representative groundwater monitoring wells. This ensures that hydraulic gradients are not increased beyond roughly present-day values plus reasonable hydrologic variability, which guarantees that ISW depletion remains within historic quantities, and that Undesirable Results to beneficial users and uses of ISW are avoided.

[1] An extensive review of study area and basin setting beyond the scope of the memo, and this information is readily accessible in existing documents. The key focus of this memorandum is to address the knowledge gap surrounding characteristics of surface waters and interconnected surface water in the SASb, and to develop a management plan for ISW consistent with requirements defined by SGMA.

2. Study Area and Setting

The SASb Groundwater Sustainability Plan (GSP) area (Figure 2) consists of five Groundwater Sustainability Agencies (GSAs), and is bordered on nearly all sides by major surface waters, including the Sacramento, American, Cosumnes and Mokelumne Rivers, which drain into the Bay Delta region – a complex aquatic ecosystem with species of concern, and a major surface water transfer point for beneficial users with appropriative surface water rights. The SASb is contained within Sacramento County and bordered by two medium priority basins: the North American subbasin to the north and the Cosumnes subbasin to the south. Interbasin coordination between adjacent basins is critical to address potential ISW depletion of the shared surface water resources that delineate basin boundaries.

Surface water in the SASb maintains aquatic ecosystems, provides recreation, and is distributed as urban water supply. At the time of writing, significant projects and management actions are in various stages of development to conjunctively manage surface and groundwater, which will bolster drought resilience and promote stable and sustainable groundwater storage and levels.

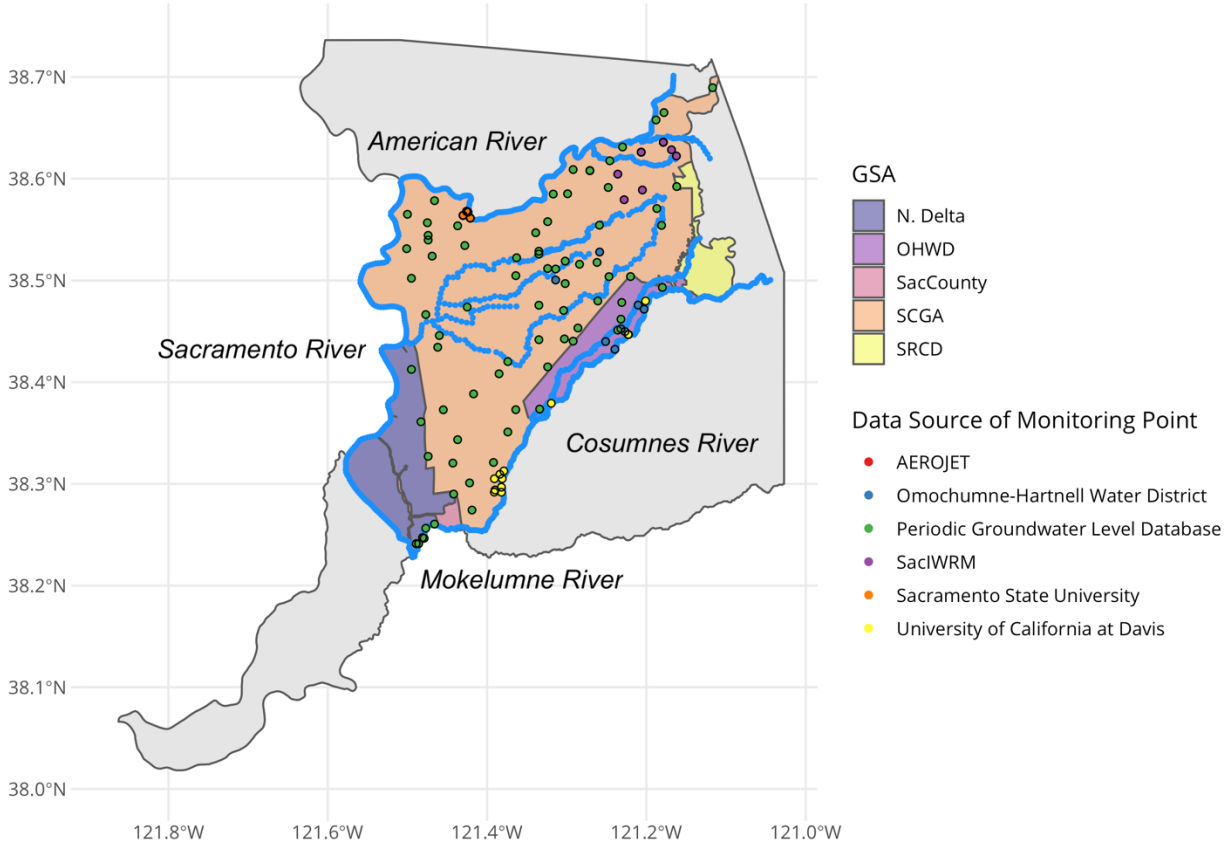


Figure 2. The South American Subbasin is an alluvial aquifer-aquitard system in California's Sacramento County (grey) housing 5 GSAs, and bordered by the American, Cosumnes, Mokelumne, and Sacramento Rivers on the north, east, south, and west boundaries respectively. Representation of these major surface water bodies in the Cosana integrated hydrologic model (including interior creeks) are shown in blue. Groundwater level monitoring

points are colored by the data source of the monitoring point. Monitoring points outside of the SASb which were used in the groundwater level interpolation are not shown.

The SASb subsurface geology is characterized by fluvial-alluvial clastic sedimentary deposits made of fines (silts and clays) and coarser, interconnecting aquifer material (sands and gavels). Long term water budgets in the SASb suggest generally stable groundwater storage conditions. The principal aquifer system primarily produces water for domestic, urban, and agricultural water supply, and interacts with major surface water bodies via baseflow and seepage[2].

Land use is characterized by the greater Sacramento urban area extending along the American and northern Sacramento Rivers. The Elk Grove urban area southeast of Sacramento is positioned at an urban-rural interface and reflects trends of urban expansion in the basin. Mixed agricultural-residential land is found along the Cosumnes River and extends north into the center of the basin. Northeastern foothills in the basin are contrasted by low-elevation wetlands in the southwest, which ultimately drain into the Sacramento-San Joaquin Delta.

It is in this diverse assemblage of GSAs in a basin bounded by surface waters and dependent on groundwater use that the sustainable management of ISW is to play out under SMGA. In the following subsections, we review characteristics of major surface waters, special-status species in these major surface waters, and instream flow requirements, and surface-groundwater interactions in the SASb.

2.1 Review of Major surface waters

Geographically, the SASb overlaps portions of the Sacramento river, American river, Cosumnes river, Mokelumne river, and San Joaquin Delta watersheds and supports a diverse assemblage of surface water bodies (Figure 3). The principal surface waters, the Sacramento, American, and Cosumnes rivers, define the basin's western, northern, and southern boundaries, respectively. The Cosumnes river flows into the Mokelumne river which serves as the southwestern boundary of the basin. The major surface water bodies in the SASb can be further subdivided into 21 reaches (Figure 4). In the subsections that follow, the lower Sacramento, lower American, Cosumnes, and Mokelumne rivers and relevant tributaries are described.

[2] For more information on the hydrogeologic conceptual model and a detailed history of groundwater conditions, please refer to the SASb GSP, section 2, "Plan Area and Basin Setting".

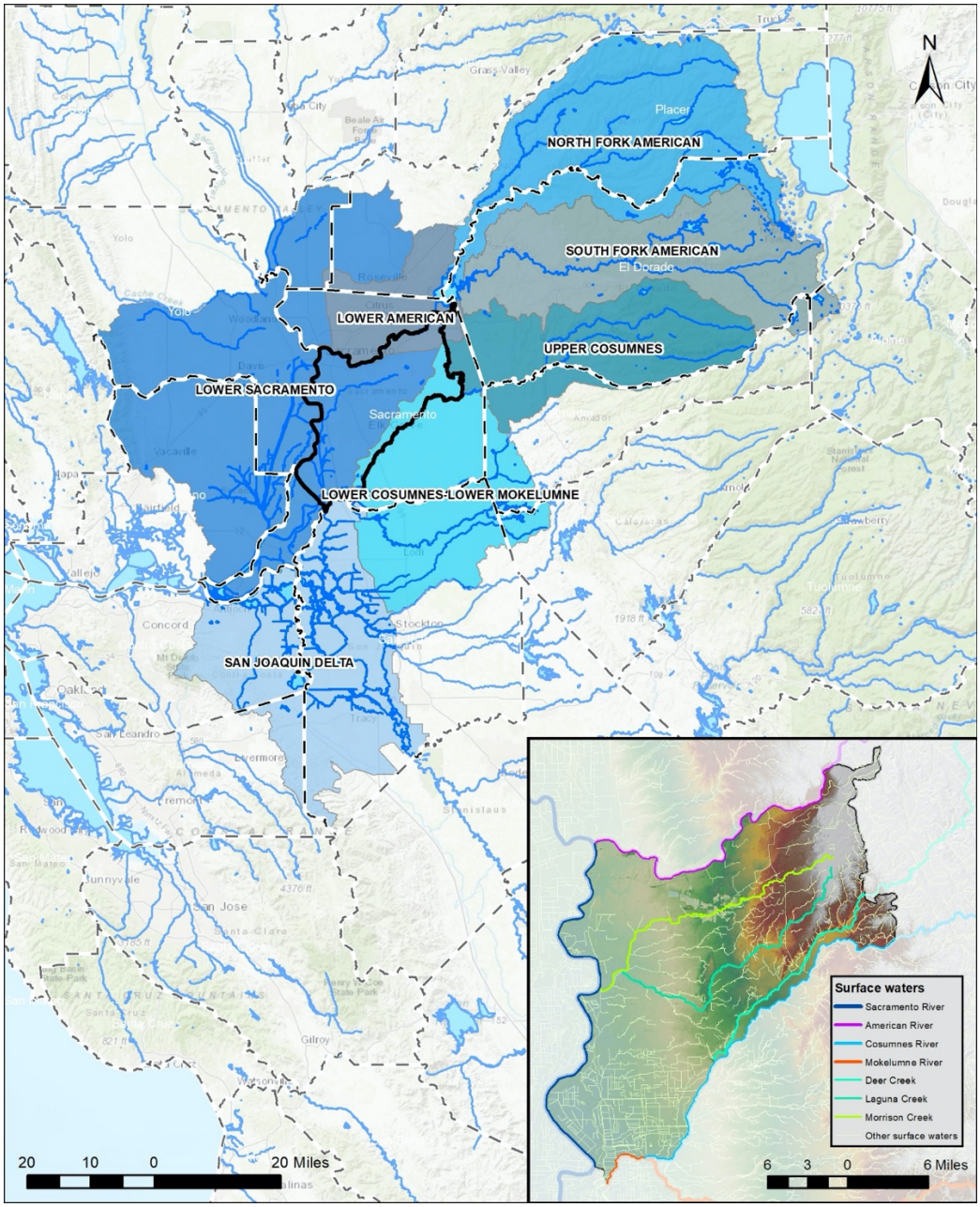


Figure 3. SASb watersheds and major surface water bodies.

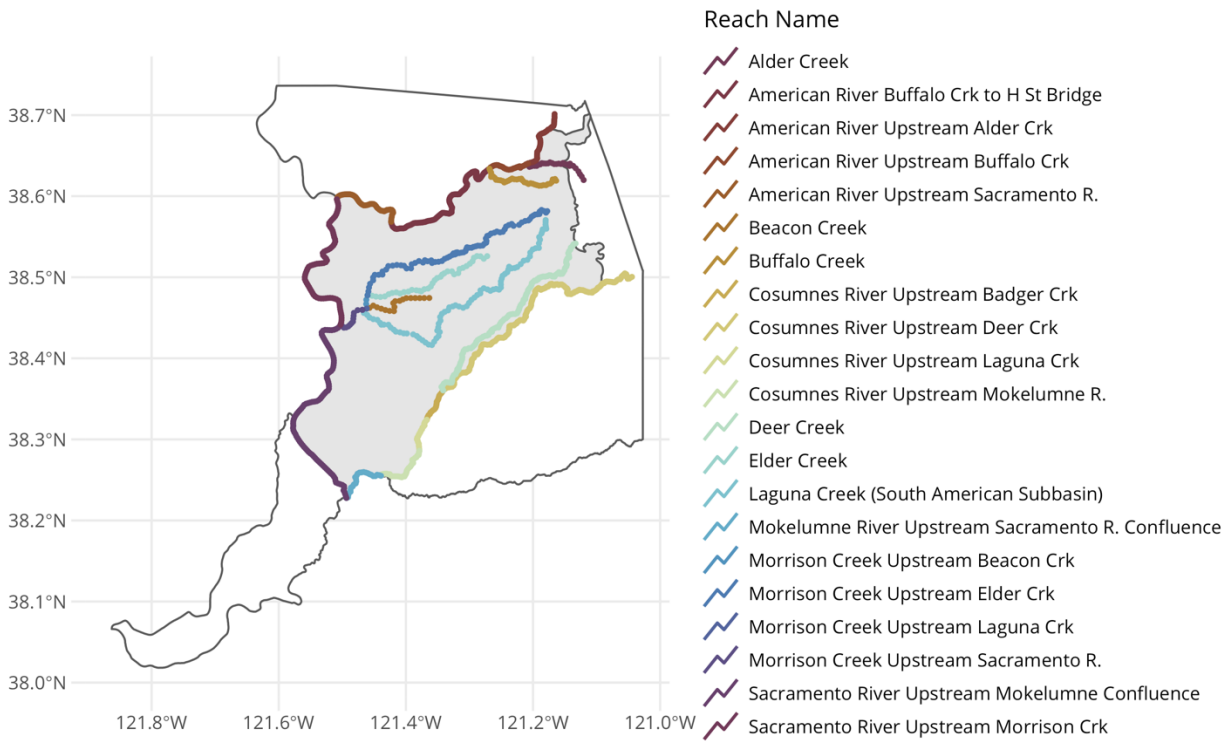


Figure 4. Major surface waters in the South American Subbasin are divided into 21 reaches, based on the surface water node representation in Cosana.

2.1.1 Lower Sacramento River

The Sacramento river watershed is the largest in the state, and drains a significant portion of Northern California. In the SASb the Sacramento river flows north-to-south along the basin's western margin from an elevation of approximately 10 feet above sea level at the northern inlet to nearly sea level at its southern outlet where it discharges out to the Sacramento-San Joaquin Delta. This portion of river is heavily modified with a system of levees present along both banks. River flows here are substantially altered compared to their natural flow regime due to a system of complex water management operations that provide societal benefits in addition to meeting environmental flow requirements.

Based on classification by Lane et al., (2018) the Sacramento river in the SASb is characterized as a 'High-Volume snowmelt and rain' (HSR) hydrologic regime. Key components of this bi-modal snow-rain driven hydrograph include a spring snowmelt pulse, high seasonality with large winter storm contributions, and high summer baseflows. Comparing dimensionless hydrographs for the HRS regime and flows recorded at the USGS gaging station at Freeport (Gage ID 11447650) illustrates the homogenizing influence of water management on river flows. While measured flows retain elements of the HRS regime there is a clear decrease in seasonality and depression of the snowmelt pulse (Figure 5).

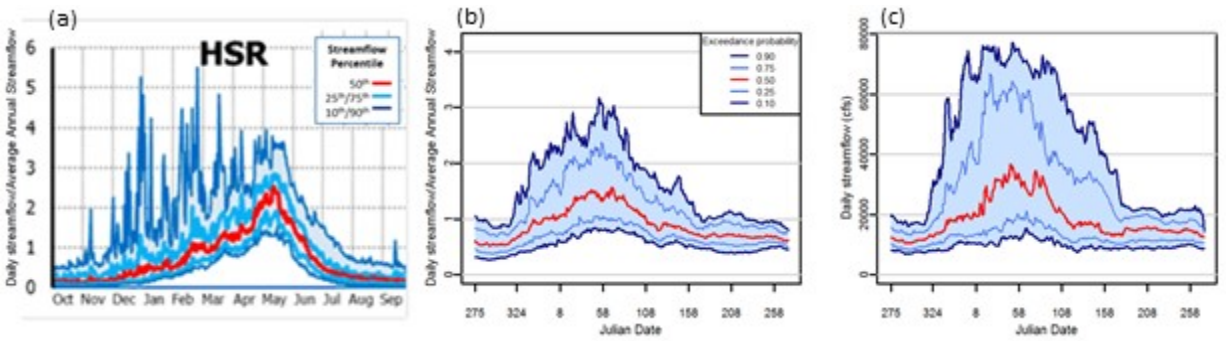


Figure 5. HSR non-dimensional hydrograph (a – modified from Figure 6 Lane et al., [2018]) and non-dimensional (b) and dimensional (c) hydrographs for Sacramento River at Freeport.

Average daily flow at the Freeport gage for the period of record between October 1, 1948 and September 30, 2015 was 22,923 cubic feet per second (cfs). Annual peak flows at Freeport over this same period ranged from 13,700 cfs in water year (WY) 1977 to 115,000 cfs in WY 1986. During high flow periods, a significant portion of flow from the Sacramento River Basin is diverted through the Yolo Bypass west of the Sacramento River and SASb. Notably, the entire SASb section of the Sacramento river is tidally influenced.

The Morrison creek watershed is the main system of tributaries that drain into the Sacramento river within the SASb. In addition to Morrison creek this system comprises a number of smaller creeks (e.g., Elder, Florin, and Stawberry creeks) which drain an approximately 192 square mile area of the central portion of the SASb. These drainages have been heavily modified, especially in the highly urbanized western portions of the basin near the City of Elk grove, and range in condition from semi-natural channels to concrete drainage canals. Morrison creek typically drains to the Sacramento River.

However, during high flow events, water may be directed to the Beach-Stone lakes basin including the Stone Lake National Wildlife Refuge and eventually to the Mokelumne River and Sacramento-San Joaquin Delta via Snodgrass Slough (Sacramento DWR, 2009). Hydrologically, flows in Morrison creek and its tributaries are driven by winter precipitation and stormwater runoff, but also receive discharge of treated groundwater. Daily average flows in Morrison creek were recorded from August 1, 1959 through November 27, 2017 at USGS gaging station ID # 11336580. These data show the flashy nature of the creek's response to storm events as well as prolonged periods of low flow (<5 cfs) during later spring and summer (e.g. May – October) (Figure 6). The average daily flow over this period was 21 cfs. Although measured flows at this location were rarely zero (< 0.1% of time) upstream portions of Morrison creek and associated tributaries have been described as intermittent or ephemeral and thus regularly do not flow in summer months (RWQCB, 2017; USFWS, 2007). While the flow records show the existence of interdecadal variability in average monthly flows, the lack of consistent monotypic trends between decades suggests flows have not experienced substantial statistical changes in bulk trends over the period of record. The peak discharge reported by the USGS gage over the period of record was 1,940 cfs during the winter of 1982.

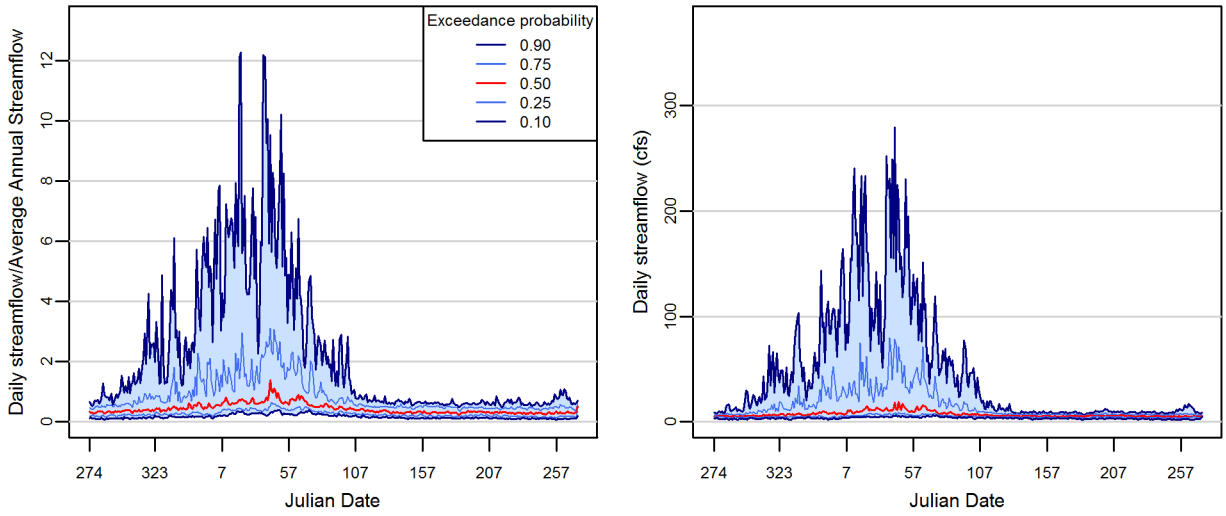


Figure 6. Non-dimensional and dimensional hydrographs for Morrison creek (USGS gage 11336580).

2.1.2 Lower American River

The American river watershed drains an area of approximately 2,155 mi^2 (5,581 km^2) ranging in elevation from over 10,000 feet in the headwaters in the Northern Sierra Nevada range to approximately 10 feet at the confluence with the Sacramento River. The lower American river defines the entirety of the northern boundary of the SASb. Like other basin surface waters the American river has been both physically modified (e.g., construction of levees, dams or other impoundments, and other in-channel infrastructure) and its flows are highly managed for water supply, flood control, and other societal and environmental benefits. Folsom reservoir, located just upstream outside of the SASb, is a critical component of the Central Valley Project (CVP) surface water storage and delivery system. The reservoir was established following completion of Folsom dam in 1955 and has a storage capacity of 976,000 acre-feet. Lake Natoma, located immediately downstream of Folsom reservoir on the northeast side of the SASb, serves as an afterbay that regulates Folsom flow releases to the American River.

Based on classification by Lane et al., (2018) the lower American river – like the lower Sacramento river – is characterized as a HSR hydrologic regime. Comparing lower American river flows recorded at the Fair Oaks USGS gaging station (Gage ID 11446500) with the HSR regime clearly reflects the influence of water management on river flows (Figure 7). This is exemplified by splitting the lower American river flow record to flows occurring prior to 1955 and those after (i.e., record split at October 1, 1954. For example, the pre-1995 hydrographs closely resemble the HSR regime, whereas post-1955 flows are much more homogenous. Average daily flows at the Fair Oaks gage for the periods between October 1, 1904 and September 30, 1954 and October 1, 1955 to March, 10 2021 were 3,752 and 3,686 cfs, respectively. Annual peak flows for the complete period of record ranged from 1,820 cfs in water year (WY) 1977 to 132,000 cfs in WY 1951, however flows as high as 318,000 cfs have been historically documented.

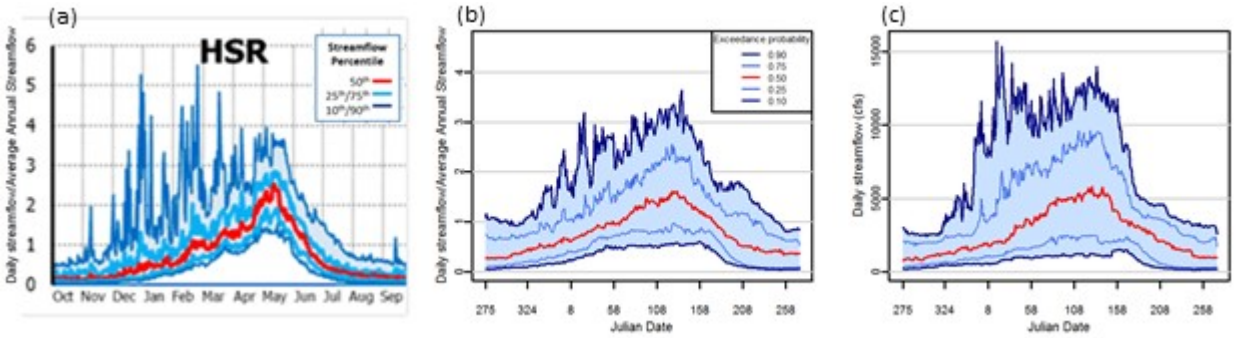


Figure 7. HSR non-dimensional hydrograph (a – modified from Figure 6 Lane et al., [2018]) and non-dimensional (b) and dimensional (c) hydrographs for American river at Fair Oaks.

2.1.3 Lower Cosumnes River

The Cosumnes river watershed drains an area of approximately 949 mi^2 ranging in elevation from 7,743 feet in the headwaters to near sea level at the confluence with the Mokelumne river. Annual rainfall in the watershed typically ranges from 22 inches in the lower portions of the watershed along the valley floor to upwards of 60 inches in the headwater portion of the watershed. Nearly all precipitation occurs between October and April, typical of the region's Mediterranean climate. The vast majority of the watershed (~84%) lies below the Sierran snow-level elevation of approximately 5,000 feet, meaning intense winter rainfall events primarily drive system flooding (Florsheim & Mount, 2002; Robertson-Bryan Inc., 2006a; Booth et al., 2006). Although snowmelt is not a large contributor to the annual streamflow volume, snowmelt and particularly rain-on-snow events influence flooding, the latter of which has been associated with peak flow events (Kleinschmidt Associates, 2008).

The Cosumnes river watershed is unique among the large-scale river systems draining the west side of California's Northern Sierra Nevada range. Unlike other major Sierran systems, the river remains relatively unregulated as it is free of high-head dams and significant surface water impoundments. This freedom allows river flows to retain a signature similar to their natural unimpaired flow regime. Detailed analysis of stream flows has been completed by several studies using data from the USGS Michigan Bar gage (ID 11335000), located approximately two miles upstream of the Highway 16 crossing, and the USGS McConnell gage (MCC) (ID 11336000), located approximately 20 miles downstream of the Michigan Bar gage (MHB) where the Cosumnes River crosses Highway 99) (e.g. Anderson et al., 2004; Fleckenstein et al., 2004; Mount et al., 2001; Robertson-Bryan Inc., 2006abc).

Of the river's natural flow regime, dry-season (May-October) baseflows at MCC appear to be the most likely altered (S. Yarnell, personal communication, January 2021). This is consistent with reports that flows at MHB are typically below 30 cfs between August and October. At this discharge, portions of the river from Highway 16 downstream to the tidal zone (RM 5-32.5) are generally dry due to seepage and evapotranspiration (Figure 8). This drying is more pronounced downstream of Wilton road (RM 17.3), where the river runs dry nearly every year (Robertson-Bryan Inc., 2006c). At the MCC gage (RM 11), the river is dry nearly 60 percent of the time in fall months (Ascent, 2014). Historical

analysis suggests discharge in the lower reaches of the river decreased steadily from 1942 to 1982, as indicated by a linear increase in the number of days per year with flows below 10 cfs at MCC (Mount et al., 2001). These decreases coincide with periods of increased groundwater extraction and have been attributed to changes in surface water-groundwater (SW-GW) interactions. Dry-season baseflows are critical to upstream migration of fall-run Chinook salmon (Oncorhynchus tshawytscha) to their spawning grounds, and declines of Cosumnes salmon populations have been linked to changes in SW-GW interactions.

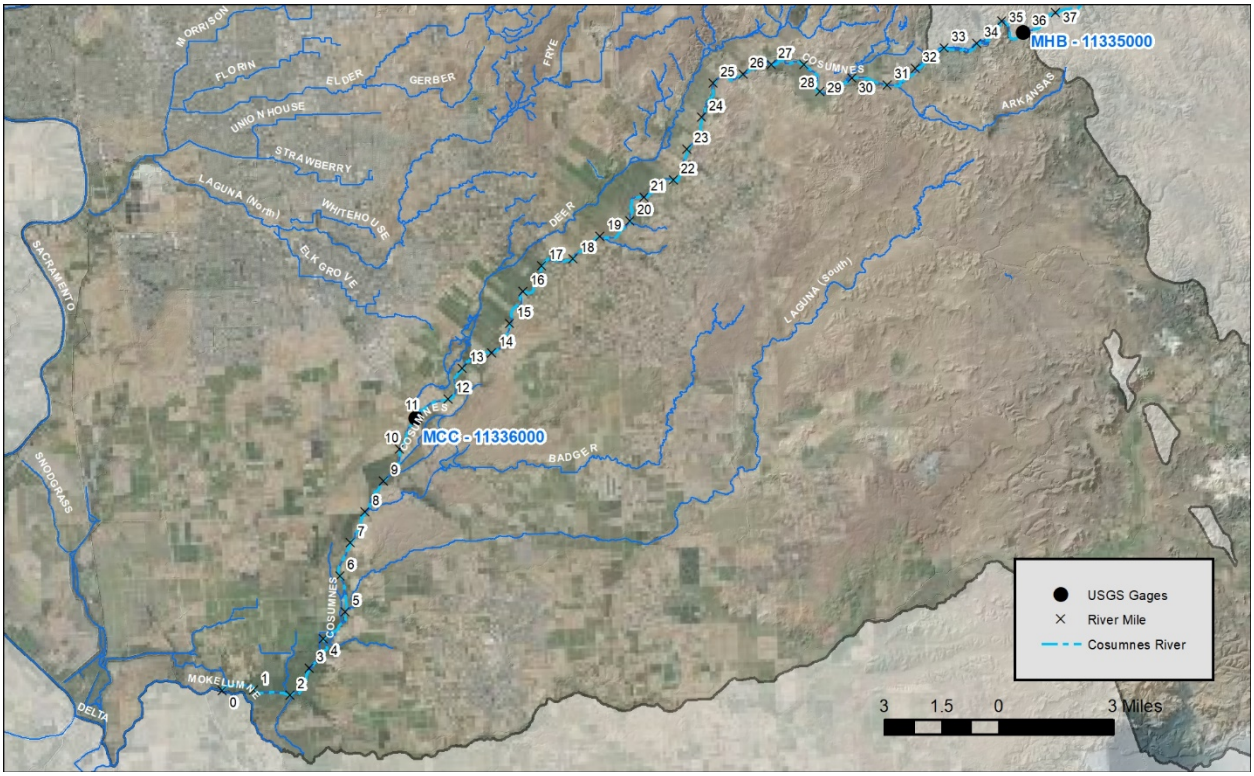


Figure 8. Lower Cosumnes river and river miles.

Based on classification by Lane et al., (2018) the Cosumnes river is mapped as having a 'Rain and seasonal groundwater' (RGW) hydrologic regime. This regime is characterized by winter storms and a low magnitude spring baseflow pulse. Waning snowmelt or groundwater contributions may result in ephemeral streamflow conditions. In general, flows at MHB and MCC coincide with the RGW regime (e.g., Figure 9). Average daily flow at the MHB for the period between October 1, 1907 and October 3, 2019 was 498 cfs, while average daily flow at MCC between October 1, 1941 and October 15, 1982 was 543 cfs. Annual peak flows at MHB for the complete period of record ranged from 134 cfs in water year (WY) 1977 to 61,600 cfs in WY 1997.

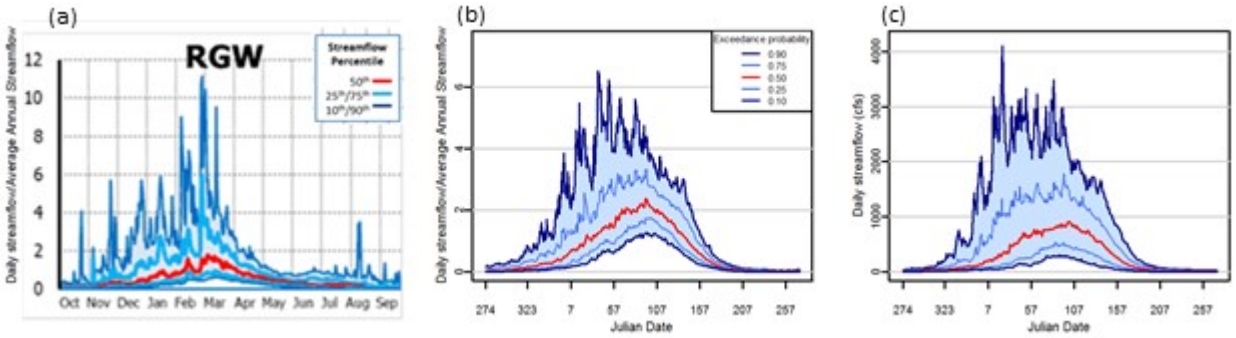


Figure 9. RGW non-dimensional hydrograph (a – modified from Figure 6 Lane et al., [2018]) and non-dimensional (b) and dimensional (c) hydrographs for Cosumnes River at Michigan bar.

The approximately 123 square mile Deer creek watershed is the main system of tributaries draining to the Cosumnes river in the SASb. Hydrologically, flows in Deer creek and its tributaries are driven by winter precipitation, stormwater runoff, irrigation runoff or return flows, and discharge of treated wastewater. Daily average flows in Deer creek were recorded from October 1, 1960 through September 29, 1977 at USGS gaging station ID # 11335700. These data show the flashy nature of the creeks response to storm events as well as prolonged periods of no or low flow (<5 cfs) during later spring and summer (e.g. May – October) (Figure 10). Overall, 45% of all days had zero flow, of which 100% of August and September measurement were zero. The average daily flow over this period was 25 cfs and the peak flow was 2,160 cfs.

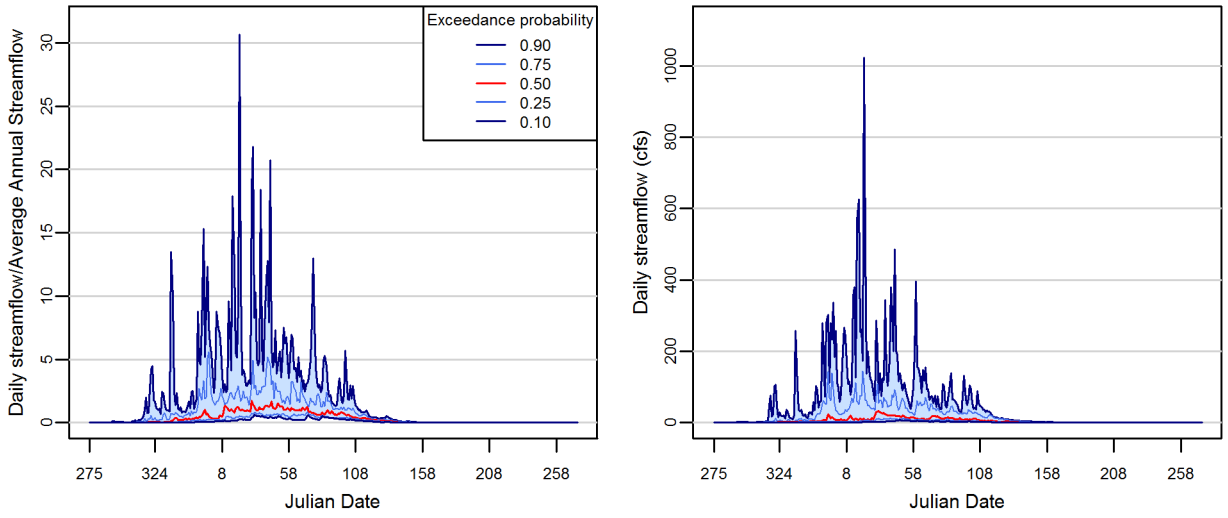


Figure 10. Non-dimensional and dimensional hydrographs for Deer creek (USGS gage 11335700).

2.1.4 Mokelumne River and Delta

The southwestern boundary of the SASb is defined by portions of the Delta cross-channel, Snodgrass slough, and the Mokelumne river. At the confluence with the Cosumnes the Mokelumne river watershed drains an area to the east of approximately 1085 mi^2 that overlaps with the Cosumnes subbasin. In addition to these areas the Mokelumne river also drains areas to the north that include Snodgrass slough, Stone Lakes National Wildlife refuge and Laguna Creek, which drains to the refuge system

and Snodgrass slough via the lower portion of Morrison creek that does not discharge to the Sacramento River. Flows in Laguna creek and its tributaries are ephemeral.

Based on flow records at USGS gage 11336585 Laguna creek was dry 12% of the time from October 1, 1995 through October 21, 2018 and regularly experienced periods of zero or low flow throughout the year (USFWS, 2007). Downstream of Laguna creek water surface elevations in the Stone lakes system and Snodgrass slough depend on both flows from upstream and tidal influence from the delta but can be influenced by backwater from the Mokelumne River. These regions as well as the Sacramento river and the American river up to the I Street Bridge are all within the extent of the legal Delta established under the Delta Protection Act (Section 12220 of the Water Code) passed in 1959. The Delta consists of a mix of water from San Francisco Bay and tidally influenced fresh water from the Sacramento and San Joaquin River watersheds, with a land surface lower than the high river stage.

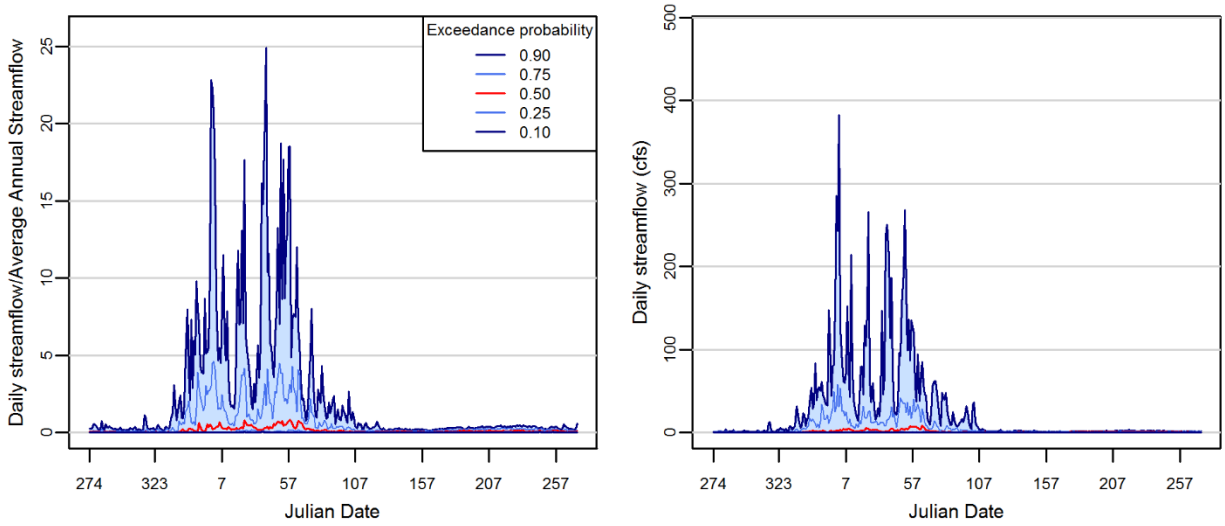


Figure 11. Non-dimensional and dimensional hydrographs for Laguna creek (USGS gage 11336585).

2.2 Special-status species

LWA conducted a review to identify potential sensitive biological features including target plant and wildlife species that have the potential to occur in the SASb. The review was initiated with a query of the most recent version of the CDFW California Natural Diversity Database (CNDDB) to identify reported occurrences of sensitive species within 1 mile of the SASb. In addition to the CNDDB query, USFWS species lists and critical habitat maps were reviewed. Existing environmental documents and reports were also reviewed to supplement these data sources (County of Sacramento et al., 2018; Moyle et al., 2015; Santos et al., 2014; SWRI, 2001; UC Davis, 1999). For the purposes of this report, special-status species are defined as follows:

- Plants and animals listed, proposed, or candidates for listing as threatened or endangered (including delisted species) under FESA.
- Plants and animals listed or proposed for listing by the State of California as threatened or endangered under CESA.
- Plants listed as rare under the California Native Plant Protection Act.
- Plants included in CNPS Ranks 1 and 2.
- California designated status:
    - Animal species that are fully protected in California; or,
    - Species of special concern (CSC) to the CDFW.

The list of special-status species was compiled and subset to only those species that occupy surface waters for at least part of their life-history. The final list includes 14 fish species and 2 reptile species (Table 1). Consideration of habitat requirements (e.g., physical and chemical conditions such as hydraulics [depth and velocity], substrate, and temperature) for these species often plays a large role in water management operations influencing SASb surface waters (Section 3).

Table 1. Special-status species occupying surface waters in the SASb

Scientific name	Common name	ESA status	CESA status	CDFW status	Principal Rivers[1]	Tributaries[2]
Acipenser medirostris	southern green sturgeon	Threatened	None	SSC	Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	low to no potential
Acipenser transmontanus	white sturgeon	None	None	SSC	Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	low to no potential
Archoplites interruptus	Sacramento perch	None	None	SSC	Transplanted populations in American and Sacramento and their tributaries	moderate potential
Cottus gulosus	riffle sculpin	None	None	SSC	Mokelumne, Sacramento, and Delta	low potential
Entosphenus tridentatus	pacific lamprey	None	None	SSC	All	low potential
Hypomesus transpacificus	delta smelt	Threatened	Endangered	SSC	Mokelumne, Sacramento, and Delta	no potential
Mylopharodon conocephalus	hardhead	None	None	SSC	Sacramento and American	moderate to high potential
Oncorhynchus mykiss irideus	steelhead - Central Valley DPS	Threatened	None		All life stages in American and Cosumnes; Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	low potential
Oncorhynchus tshawytscha	chinook salmon - Sacramento River winter-run ESU	Endangered	Threatened		Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	no potential

Scientific name	Common name	ESA status	CESA status	CDFW status	Principal Rivers[1]	Tributaries[2]
Oncorhynchus tshawytscha	chinook salmon - Central Valley spring-run ESU	Threatened	Threatened		Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	no potential
Oncorhynchus tshawytscha	chinook salmon - Central Valley fall & late fall-run ESU	None	None	SSC	All life stages in American and Cosumnes; Sacramento is a migration corridor for adults and juveniles to and from upstream spawning grounds	low to moderate potential
Pogonichthys macrolepidotus	Sacramento splittail	None	None	SSC	Delta	low potential
Spirinchus thaleichthys	longfin smelt	Candidate	Threatened	SSC	Sacramento and Delta	no potential
Emys marmorata	western pond turtle	None	None	SSC	moderate potential	moderate to high potential
Thamnophis gigas	giant garter snake	Threatened	Threatened		low potential	moderate to high potential

[1] Either brief description of occupancy within the SASb principal surface waters or potential for species to be present

[2] Potential for species to be present

2.3 Instream flow requirements

2.3.1 Lower Sacramento River

Many project-level and system-wide agreements or regulatory obligations dictate water management operations in the Sacramento river basin. Of the multitude of water management operation in the basin integrated operations of the CVP and State Water Project (SWP) aggregate to have the strongest influence on conditions downstream. A summary of several key CVP and SWP regulatory requirements are provided in Table 2 (see also reviews by NCWA, 2019; SWRI, 2001).

Table 2. Key CVP and SWP regulatory requirement

Regulatory agreement/obligation	Date(s)	Description
SWRCB Water Rights Order 90-05 & 91-01	1990 & 1991	Establishes water right requirements on the U.S. Bureau of Reclamation's (Reclamation) operations of Keswick Dam, Shasta Dam, the Spring Creek Power Plant and the Trinity River Division related to temperature control in the Upper Sacramento River for the protection of fishery resources and requires monitoring and reporting to evaluate compliance with those requirements.
SWRCB Revised Water Right Decision 1641 (Water Rights Order 2000-02)	2000	Amended the water right license and permits for the CVP and SWP requiring them to meet certain flow objectives in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay-Delta Plan). Specifically, places responsibility on the Department of Water Resources and the U.S. Bureau of Reclamation for measures to ensure that specified water quality objectives are met.
NMFS Biological Opinion for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and State Water Project	2019	Contain numerous terms and conditions for CVP and SWP operations including minimum flow requirements, temperature requirements, water quality standards, and entrainment controls.

2.3.2 Lower American River

Flow and temperature conditions in the lower American river results from complex interactions between hydrologic conditions, water management operations, and other decision-making regarding protection of environmental resources (SWRI, 2001). Folsom and Nimbus dams are part of the CVP and thus subject to some of the same requirements listed above for the lower Sacramento river. In addition to these requirements the U.S. Bureau of Reclamation who owns and operates the CVP has adopted instream flow requirements proposed by the Water Forum as outlined in the "Modified Flow Management Standard Proposed Water-Right Terms and Conditions, November 2017" (ARWA, 2017). The Water Forum is comprised of local business and agricultural leaders, citizen groups, environmentalists, water managers and local governments in the Sacramento region. The stated goals for the modified standards include "protecting anadromous salmonids, preserving recreational and aesthetic values, avoiding catastrophic water shortages in the basin and contributing to the Delta's ecological health downstream".

2.3.3 Lower Cosumnes River

To the best of our knowledge, at the time of writing, no overarching agreement or regulatory obligation exists for defining minimum instream flow requirements for the lower Cosumnes river. However, requirements for individual projects, diversions, and/or water rights exist on an ad hoc basis (see SWRCB, 2020 for example). Generally, such agreements are based on meeting flow requirements necessary to satisfy existing water rights (i.e., the State Water Resources Control Board [SWRCB] designation of the Cosumnes river as a 'fully appropriated stream' [FAS] from July 1st to October 31st, the South Fork Cosumnes river as a FAS from April 15th to October 31st, and Deer creek as a FAS from May 1st to October 31st [see SWRCB Order WR 98-08]). However, some instream flow agreements are based on environmental factors such as habitat and/or passage requirements for chinook salmon.

Cosumnes fall-run chinook salmon typically complete their spawning migration between October and December. During this period, they require flows that create conditions suitable for passage and spawning[3]. The majority of spawning in the river occurs in the 16 mile reach between Latrobe Falls (RM 41.5) downstream to Meiss Road (RM 25.5) with additional spawning occurring from Meiss to Wilton Roads (RM 25.5—17.3) (Robertson-Bryan Inc., 2006c). Historically, the Cosumnes supported large fall runs of Chinook salmon upwards of 17,000 fish. Over the past forty years, the fall run has declined to 0-5000 fish and is consistently less than 600 fish, with occasional higher returns in the last five years (USFWS, 1995; CDFW, 2020[4]).

Several studies provide estimates of what flow conditions are necessary for upstream fish passage. Most recently, hydraulic modeling by US Fish and Wildlife Service (USFWS) as part of an initial passage analysis identified 180 cfs as the minimum bypass flow condition for both the MCC and MHB locations. This estimate does not

[3] Water depth and speed are common hydraulic factors considered though spawning success is influenced by many physical, chemical, and biological factors.
[4] See CDFW Grand Tab: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381&inline.

account for river seepage, which under current conditions would necessitate a larger flow requirement at MBH. Seepage estimates vary along the river but are generally in the range of 1 to 3.5 cfs/mile, suggesting flows upward of 266 cfs at MBH would be required. The effect of stream diversions between MHB and MCC at the time of passage must also be considered and added to recommended bypass flow requirements at MHB (see SWRCB, 2020 for example).

The USFWS passage estimates are larger than previous passage estimates for flows at MHB by Anderson et al. (2004), Fleckenstein et al., (2004), and Mount et al. (2001) which estimate flows of 32.8, 54.7, and between 40-45 cfs, respectively. These earlier predictions were each based on achieving a minimum flow depth of 0.6 feet at MCC using 1-D hydraulic modeling and accounting for seepage losses[5]. Observations by the Fisheries Foundation of California (FFC), note that fall (October-November) pulse flows on the order of 100 cfs may be required for a period of at least 10 days to provide and maintain passage conditions throughout the lower Cosumnes reach. FFC also report that stranding or delays can occur for higher pulse events of 200-400 cfs when flows last for less than a week and are followed by extended dry periods (FFC, 2004).

Several factors may explain the wide range of reported flows needed for fish passage. For one, river conditions (e.g., hydraulic geometry, slope, and substrate) are constantly changing. Second, passage criteria also evolve over time as understanding of species biological requirement improves. Although the passage criteria and date of physical conditions (e.g., river topography/bathymetry) used by USFWS in their evaluation are unknown, it is presumed their analysis reflects both updated river conditions and species requirements compared to those employed by Mount et al. (2001) and Anderson et al. (2004). In this manner, the more recent USFWS passage recommendation of 180 cfs is considered to more likely account for current river conditions and species biological requirements.

In addition to flow constraints, Cosumnes salmon must also navigate several in-stream structures during migration to their spawning grounds. These include a box culvert near RM 6.75, four low-head dams (RM 12.4, 16.25, 22.5, and 25), and two fish ladders at Granlees Dam (RM 34.5). All structures have been improved for fish passage in the last three decades, and current estimates by FFC suggest a minimum flow of 100 ft^3/s (2.83 m^3/s) is needed for fish navigability.

2.4 Surface water and Groundwater Interactions

In the most basic sense, the rate and direction of water movement from the channel bed to underlying porous media is controlled by the vertical hydraulic conductivity (K_v) of the riverbed, the geometry and thickness of the riverbed, and the hydraulic gradient (hydraulic head) between the river and the aquifer (Levy et al., 2018). In the case of a losing environment and all factors being equal, increases in K_v, a thinner channel bottom, and a stronger downward hydraulic gradient will intensify infiltration (seepage)

[5] Slight variation in listed model parameters may explain differences in estimates.

into the aquifer. Alternately, when the head gradient is toward the stream, gaining conditions prevail and groundwater will discharge into the stream. Where the stream and groundwater are hydraulically disconnected (i.e., separated by an unsaturated zone), seepage is widely taken to not be influenced by the aquifer and becomes a function of streambed K_v, properties of the underlying aquifer materials, and water depth in the stream. The simplifying assumption that the underlying media is unsaturated is taken to be true in most cases due to more complicated flow dynamics under conditions of variably saturated flow (e.g., porous media is partially saturated and flow properties are highly non-linear) and that result from the presence of perched aquifers.

Complexities in even the simplest SW-GW flow systems begin to arise due to several factors. For one, it is difficult to quantify streambed K_v as well as aquifer hydraulic conductivities, which can range in value over more than 12-13 orders of magnitude. Hydraulic conductivities are also highly spatially heterogeneous, and K_v values vary temporally as bed sediment composition evolves (e.g., low flow clogging, bio-clogging, siltation, and high flow scour) (Barlow & Leake, 2002; Levy et al., 2008). Aquifer properties will also evolve under conditions of variably saturated flow. Where layers or lenses of low-permeability sediments exist, the presence of perched saturated zones can form. Such perched zones can reduce seepage and even reverse gradients to promote water discharge to the river (Niswonger & Fogg, 2008). Alternately, preferential flow via connected pathways of highly permeable materials can rapidly transmit immense seepage losses over small portions of the riverbed (Fleckenstein et al., 2006). In addition to these factors, consideration and inclusion of evapotranspiration may be equally important when quantifying SW-GW fluxes (Min et al., 2020; Niswonger, 2005). Cumulatively, these dynamical and heterogeneous conditions at the river-aquifer interface contribute to high spatial and temporal variability in SW-GW fluxes (Fleckenstein et al., 2006; Frei et al., 2009).

As noted above, near-river SW-GW interactions are strongly influenced by various scales of localized subsurface heterogeneity. Such heterogeneity is often described and stochastically represented by the arrangement of hydrofacies, which can be assigned variable conductivities amongst other physical properties. Spatial variability in hydrologic processes due to the organization of hydrofacies can result in localized mounding of GW or formation of perched water tables near the active channel bed and within the extent of paleochannels and associated floodplain surfaces (Niswonger & Fogg, 2008). These localized effects can serve to reduce or even reverse flow gradients between surface water and groundwater, and they have been documented to facilitate SW-GW interconnection in several Californian rivers thought to be disconnected from their regional GW tables (Fleckenstein et al., 2006; Niswonger 2005; Niswonger & Fogg, 2008).

A review of existing studies on SW-GW interactions in the SASb principal surface water bodies are described in the sections below.

2.4.1 Lower Sacramento River

Explicit study of SW-GW interactions along the Lower Sacramento River in the SASb has not been extensively evaluated. Limited analysis of spatial and temporal SW-GW interactions were investigated by TNC (2014) using results from C2VSim-FG model[6] historical simulation (1922-2009). Based on simulated annual groundwater flows, the researchers found the portion of the Lower Sacramento River in the SASb (e.g., defined as Reach E in their analysis) to be net losing at the beginning of the simulation period in the 1920's and found the losing trend to increase through time. Variable, but generally gaining conditions were simulated in Sacramento river reaches outside of the SASb upstream of Fremont. This finding corroborates other reports stating that while the Sacramento river may be hydraulically connected with the regional groundwater system it is a losing stream (MHW, 2006). The spatial extent of this possible hydraulic connection is not well constrained but studies support that it does not extend far from the river (RMC, 2015). For example, groundwater in the nearby Beach/Stone Lakes basin has been reported to have little exchange with the river and thus be considered hydrologically independent (Carollo Engineers, 2000).

2.4.2 Lower American River

Surface water and groundwater hydrology of the lower American river have been the subject of extensive documentation but studies explicitly focused on SW-GW interactions remain limited with the exception of focused studies centered on the Aerojet Superfund Site. Additional focus on this topic emerged as part of SWRCB review of a petition by Southern California Water Company to revise the Declaration of Fully Appropriated Streams adopted by SWRCB Order WR 98-05 in order to appropriate treated groundwater that was being discharges to the lower American river (SWRCB, 2003). Expert testimony and extensive evidentiary materials presented as part of the petition supported that circa 1980s to 2000s groundwater levels were typically at or above the bottom of the riverbed from Lake Natoma to approximately 3,000 feet downstream of Nimbus Dam and were close to riverbed for an additional 3,000 feet downstream (e.g., 3,000 to 6,000 feet downstream of the dam). Beyond the 6,000 foot mark, westward declining groundwater levels resulted in an increasingly large unsaturated zone between the river and groundwater table. Review of historic groundwater contours presented from the 1950s onward corroborated these findings consistent with the view that downstream portions of the lower American River are a losing stream. Further review indicated that prior to 1958 stream losses appeared to be at relatively steady state (e.g., groundwater withdrawals were in balance with river recharge). However, subsequent changes in head due to lowered groundwater levels resulted in increased river losses as it recharged groundwater. Although the potential exists it is unclear if higher groundwater levels in the region below lake Natoma result in groundwater discharge to the river and if so, what the magnitude of such discharges are.

In addition to materials associated with the SWRCB petition, investigation by TNC (2014) (see above) found, on average, the lower American river was annually gaining

[6] See TNC (2014) for details of the C2VSim-FG integrated hydrologic model.

during the period from 1922 to 1930 but subsequently transitioned to a losing reach after the 1960s.

2.4.3 Lower Cosumnes River

Previous study of SW-GW interactions along the Lower Cosumnes River has primarily been addressed in two ways: (1) through data-driven approaches that include field measurement of streamflow, groundwater levels, seepage rates, sediment temperatures, soil moisture, and sedimentology; and (2) through numerical simulation. Combining review of historical field measurements with a numerical groundwater-surface water model (IGSM), Mount et al. (2001) concluded that it was likely that the entire study area was connected to the primary aquifer (i.e., shallow unconfined aquifer) before the early 1940s. Under this condition, groundwater would discharge to the system at least during certain portions of the year (see also Fleckenstein et al., 2004). This finding was based on back extrapolation of historic well data and model simulation of baseline conditions with groundwater pumping set to zero (see No Pumping [S0] scenario Figure 12), thus representing a "quasi-pristine or natural pre-development groundwater condition". Both methods have uncertainty but provide a reasonable basis for the conclusion, especially in the absence of other historic records. Following the 1940s, increased groundwater production and declines of regional groundwater levels decoupled the river from saturated groundwater along much of the river. Increased groundwater pumping in subsequent decades has exacerbated this issue, resulting in continued lowering of regional water tables and increasing the saturated groundwater disconnection from the river. These groundwater declines are suggested by Mount et al. (2001) and others to be responsible for declines in fall streamflows and observed increases in low-flow and no-flow periods.

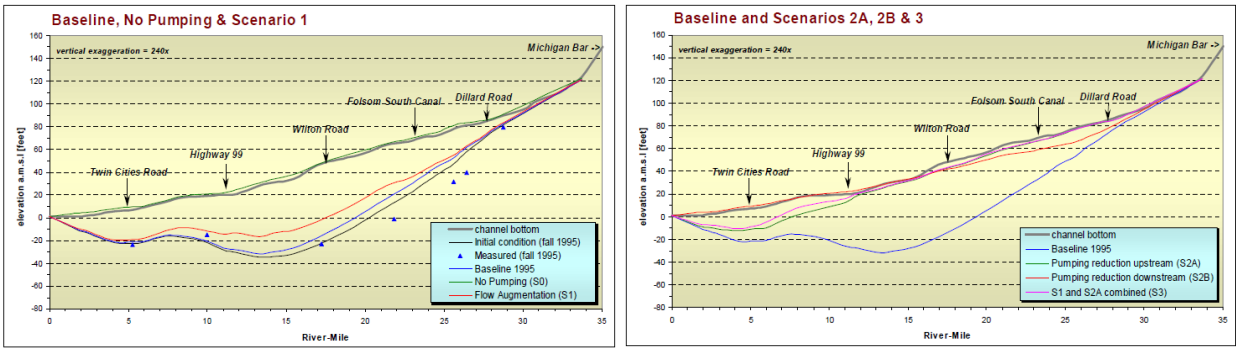


Figure 12. Measured, modeled, and simulated groundwater levels below river channel by Mount et al. (2001) (Figures 8 and 9). River miles may differ slightly from those used in this review.

Interestingly, in Mount's no-pumping simulation, 12-years were required for the MBH-MCC reach to transition to a net gaining reach, and even at the end of the simulation, the reach was net losing during the fall. This determination simply reflects the period required to raise water levels from the fall 1995 groundwater elevations that were used for the model's initial boundary condition. Over the 15-yr simulation period, the annualized water volumes necessary to overcome this deficit were estimated to be 166,000 acre-feet per year to partly reconnect the upper reaches of the river and ~250,000 acre-feet per year to reconnect the entire river. Gaining conditions were achieved more rapidly (6-years) between MCC (RM 0) and Twin Cities Bridge (RM 5.5).

Although the no-pumping scenario reduced seepage and thus improved fall conditions, that the river remained losing during this period highlights the seasonal nature of potential groundwater discharge and the importance of accurate representation of seepage processes.

Comparisons of measured and modeled groundwater levels with streambed elevations have been another effective method for spatial characterization of SW-GW interactions and have shown varying levels of disconnection between the Cosumnes riverbed and underlying principal aquifer. Using well data from April 2000 to 2001, Mount et al. (2001) recorded groundwater to be 7-20 feet below the channel near Dillard (RM 27.5), between 30-50 feet below the channel from Meiss to Highway 99 (RM 11-25.5), and between 3-15 feet below the channel from near Twin Cities Bridge (RM 5.5). Upstream of Dillard (RM 27.5-36), groundwater levels were within a few feet of the channel during the wet season, and levels were within 3-15 feet of the channel downstream of Twin Cities Bridge (RM 5.5) (Figure 12). In contrast to the well comparison, shallow piezometers installed downstream of Twin Cities Bridge documented groundwater levels at or above the ground surface, thus reflecting the spatial heterogeneity of water levels and potential limitations of this kind of comparative analysis.

Ultimately, Mount et al. (2001) concluded that reaches upstream of Dillard (RM 27.5) and downstream of Twin Cities Bridge (RM 5.5) were hydraulically connected to the primary aquifer and likely received seasonal groundwater discharge. These locations were demarcated as “sensitive transition areas” where further lowering of groundwater levels could result in increased stream flow depletions. The mechanisms driving these connections were not explicitly addressed in the study. The relatively intact connection of the river with its floodplains could be a primary driver for these observations. Further, depth to the bottom of the basin is higher (~400 feet below ground surface [bgs]) along the upstream portions of the river, and this area may receive higher relative quantities of mountain block recharge, which combined with connections to the floodplain could facilitate filling of the aquifer and thus more stable groundwater levels.

As discussed above, geologic complexity of the Cosumnes fluvial-riparian environment can induce high localized variability of groundwater conditions that may not be accurately represented with certain numerical models or groundwater measurements (such as those employed by Mount et al., 2001 and others [e.g., MHW, 2006; GEI Consultants, 2016]). Such uncertainty is exemplified when comparing the findings from these references with simulations that include higher resolution representations of aquifer heterogeneity (e.g., Fleckenstein et al. 2006; Niswonger, 2005[7]). For instance, conducting simulations with six different but equally likely geostatistical simulations of aquifer heterogeneity, Fleckenstein et al. (2006) identified spatially and temporally varying locations of local reconnection between the river bed and groundwater levels (Figure 13). Whether these connections were with the primary aquifer or due to formation of shallow perched aquifers is unclear. Although their simulated groundwater levels had large local variability between geologic realizations, most connections

[7] Note information presented by Niswonger (2005) is similar in nature to what is contained in Niswonger and Fogg (2008).

occurred during the wet season, whereas dry-season connections generally occurred in similar locations to those identified by Mount et al., (2001). In addition to the up- and-downstream ends of the study area, wet season connections were clustered between Twin Cities Bridge and Wilton (RM 5.5-17.3) and were conjectured to even promote gaining conditions. These findings have been corroborated by physical observations of shallow local saturated zones below the river channel (Niswonger, 2005). Given the time period of SW-GW connections identified by Fleckenstein et al. (2006), as well as those discussed by Mount et al. (2001), it is unclear if groundwater discharge could contribute to dry-season flows, which is generally not supported by observed low-flow conditions. However, identification and better understanding of these connected zones is relevant due to their potential to reduce seepage losses, contribute to wet-season and possibly dry-season baseflow, and provide benefits for riparian vegetation and groundwater dependent ecosystems.

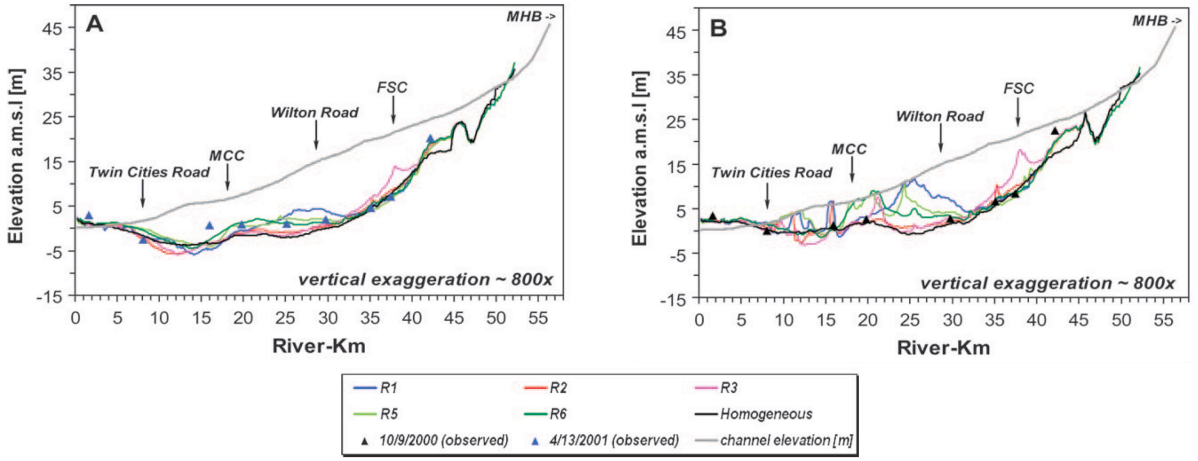


Figure 13. Simulated dry season (a) and wet season (b) groundwater levels of Fleckenstein et al., (2001) from different geologic realizations (Figure 11). River miles may differ slightly from those used in this review.

Lastly, no discussion of Cosumnes SW-GW interactions is complete without considering the influence of perched aquifers, which are covered in depth by the collective works of Niswonger (Niswonger, 2005; Niswonger & Fogg, 2008). Perched aquifer conditions occur where low conductivity sediments underlie higher conductivity sediments, and as discussed in the primer section, perched aquifers can diminish seepage losses and support gaining stream conditions. Where perched layers extend laterally from the stream corridor, perched water may also be vital to maintaining saturation of the riparian root zone. Even in the absence of providing groundwater discharge to the stream, hyporheic flows from perched aquifers can provide aeration of spawning habitats and drive biogeochemical cycling.

Under idealized circumstances, values reported by Niswonger show discharge from perched aquifers to streams could be as large as 1.5 ft^3/s per mile (0.04 m^3/s per mile), which are roughly proportional to estimates of Cosumnes seepage rates. However, the magnitude and duration of perched groundwater contributions is sensitive to properties of the streambed and underlying unsaturated porous media as well as geologic structure. Niswonger's studies show that a threshold condition for the ratio between the

hydraulic conductivity of coarse streambed sediments to that of fine underlying sediments of 200 is required to create perching conditions capable of producing baseflows. Simulations in an idealized 2,000 m long stream segment based on the Cosumnes River near Highway 99 show that regardless of model parameters, dry-season perched groundwater discharges rapidly dissipate, often reducing to zero over a period of a few days to a few weeks. Larger baseflow contributions were found to be sustained for periods up to about 2-3 months after the cessation of bankfull-flows (e.g., mid-June) where, everything else being equal, coarse sediment hydraulic conductivity was higher. Even under these best-case scenarios, simulations show that discharges only on the order of 0.6 ft^3/s (<0.02 m^3/s) would be expected during the first month after high flows, with even smaller contributions thereafter.

As shown by Niswonger and others, geologic heterogeneity strongly controls SW-GW interactions, such that perched aquifers and associated discharge in one region may seep into the subsurface downstream where perched layers are absent. Given the magnitude and spatially heterogeneous nature of these discharges, the total role of perched aquifer discharges in contributing to or potentially managing dry-season baseflows remains unclear. That said, perched aquifers undoubtedly provided benefits to the study areas through sustaining ephemeral pools, decreasing seepage losses, and contributing to wet-season baseflows.

3. Methods

In this section, we provide an overview of the data and models used in this study, the rationale behind groundwater flow simulation scenarios, and the classification system applied to ISW.

3.1 Data sources

3.1.1 Groundwater

Historic and present-day groundwater conditions were analyzed using all available data from six sources (Figure *2*):

(1) California Department of Water Resources (DWR) Periodic Groundwater Level Database
(2) University of California at Davis (UCD) monitoring network
(3) Omochumne-Hartnell Water District (OHWD) monitoring network
(4) Sacramento State monitoring wells
(5) Aerojet
(6) Sac IWRM

Most groundwater level data is collected biannually in spring and fall and intended to capture seasonal variation – notably due to winter recharge and pumping and recharge during the dry growing season. In the South American Subbasin, periodic groundwater level data measurements peak in April and October (Figure 14) and suggest that future data collection should occur in these months to maximize data comparability across space and time.

Biannual seasonal groundwater level within the Sacramento Central Groundwater Authority (SCGA) jurisdictional boundary has been measured for decades; these measurements account for most of the spatial spread of groundwater level observations in the SASb and can be found in the DWR Periodic Groundwater Level Database [source (1) above]. Three additional networks, either established or maintained by UCD, OHWD, and Sacramento State all collect high-frequency, 15-minute interval groundwater elevation data. The UC Davis network (2) is situated on land owned by the Nature Conservancy and has collected data fall of 2012, the OHWD network (3) has collected data since fall of 2018, and the Sacramento State network (4) has collected data since spring of 2016. Aerojet monitoring wells (5) used in this study have been collecting data since 1982 and are actively monitored as part of on-site monitoring and remediation actions. Sac IWRM (6) is hydrologic model that includes the SASb and incorporates historic groundwater monitoring data; most of these data are included in (1). Duplicate measurements between data sources were reconciled by comparing monitoring site identification codes and position (latitude and longitude).

Modeled groundwater hydraulic head reflecting the transmissivity-weighted layer 2 and 3 (Laguna and Mehrten) heads from Cosana which represent average groundwater

level in the production zone of the principal aquifer were compared against field-based monitoring groundwater level data[8].

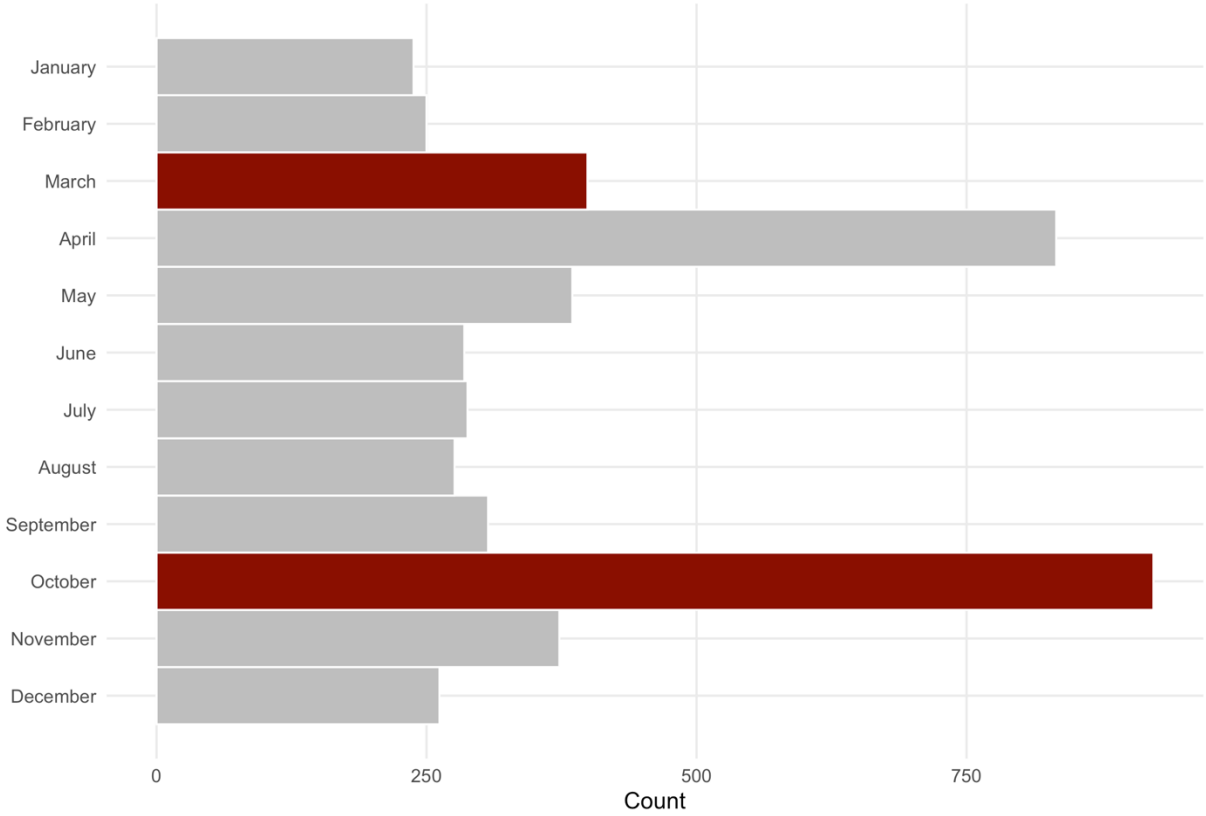


Figure 14: Periodic groundwater level measurements (2000-2021) reported by DWR in the South American Subbasin indicate peaks of seasonal data collection in April and October although DWR Best Management Practices indicate that monitoring wells should collect at least biannual measurements in spring (mid-March) and fall (mid-October) (CA-DWR, 2017). March and October are highlighted in the graph above, and roughly agree with historical data collection trends. It is especially important in dry years to monitor in mid-March, because pumping may begin as early as April; thus, a March measurement in a such a dry year provides a more accurate representation of ambient spring groundwater level. Consistent data collection in March and October ensures data comparability across years.

3.1.2 Surface Water

Surface water data considered in this analysis were designed to be consistent with the Cosana numerical groundwater flow model, and thus, the Cosana stream node representation (Figure *2 - Figure 3*) was used. In particular, the vertical thalweg elevation, which represents the bottom of the streambed was used to ascertain the approximate vertical elevation at which various parts of streams may be reasonably connected to groundwater. This study uses 1,107 stream nodes. Soil thickness from the SSURGO soil database (Soil Survey Staff, NRCS, 2021) was taken to be a reasonable proxy for the clogging layer, a thin layer beneath streams, which is typically of lower conductivity than the surrounding sediment. Thus, at each stream node location, soil

[8] As demonstrated in 3.2 Groundwater Level Interpolation, 99.4% of observations at wells occur within the Alluvium, Laguna, and Mehrten layers.

thickness[9] was extracted and subtracted from the thalweg elevation to define the elevation at which surface waters may be connected to groundwater.

Modeled nodal seepage at each of the Cosana stream nodes considered in this study were aggregated into reach-level (Figure 3) seasonal spring and fall seepages to assess historic variability in ISW depletion rates.

3.2 Groundwater Level Interpolation

Groundwater levels were assessed at biannual seasonal intervals during the period from spring 2005 to fall 2018 and encompass what can be considered "historic"[10] to approximately "present-day" seasonal conditions. This temporal range was selected because poor data density prior to spring 2005 and after fall 2018 prohibits meaningful analysis. "Spring" was defined as the months of March, April, and May and "fall" was defined as the months of August, September, and October.

At each monitoring location, the average groundwater level measured during spring and fall was computed by taking the grouped mean of observations in each spring and fall respectively. Next, to improve spatial data density and ascertain long-term regional trends, data were arranged in 4-year running seasonal means. For example, the 2005-2008 spring level is defined as the average spring groundwater elevation in 2005, 2006, 2007, and 2008. A four-year sliding window was applied to data from 2005 to 2018, resulting in 22 seasonally averaged groundwater elevation conditions (e.g., spring 2005-2009, fall 2005-2009, …, spring 2015-2018, fall 2015-2018). Windows of differing length (e.g., 1, 2, and 3-year long running means) were explored but resulted in larger groundwater level variance due to a lack of adequate spatial density, and hence, not used. By contrast, 4 year running means gave adequate regional spatial data density and were not so long in duration as to mute the impact of significant dry periods such as the 2012-2016 drought.

After data were grouped into seasonal 4-year windows, ordinary kriging[11] (Journel A.G. and Huijbregts, 1978) was applied to groundwater elevation measurements to generate groundwater level surfaces across the SASb at a 500 meter (0.31 mile) resolution. In order to minimize boundary effects, monitoring well data within a 20 kilometer (12.4 mile) buffer of the SASb were included, which effectively incorporates groundwater level data from the Cosumnes and North American subbasins, and Yolo county to the west of the Sacramento river (Figure *17*). Groundwater level measurements were screened to include data from wells shallower than 300 feet in total completed depth to reflect

[9] According to SSURGO, soil thickness in the SASb ranges from 0 to about 170 centimeters.
[10] Importantly, this period contains the recent 2012-2016 drought.
[11] An exponential variogram model was used, and results did not appreciably differ from linear or spherical models. Stationarity across the unconfined to semiconfined aquifer is a reasonable assumption in the unconsolidated, alluvial aquifer-aquitard system that spans the South American subbasin and adjacent subbasins, which exhibit relatively continuous geology across borders. Data outliers were controlled by removing tails of the distribution above and below the 97.5th and 2.5th percentiles respectively. Groundwater elevations were approximately normal in distribution, thus log-transformation and exponentiation after kriging was not required.

conditions in the unconfined to semiconfined production aquifer, which are comparable to heads in layers 2-3 of Cosana. All monitoring points were further intersected with the Cosana model grid, and 99.4% of observations at wells occur within the Alluvium, Laguna, and Mehrten layers. 0.6% of observations occur in the Ione and Valley Springs.

3.3 Forward simulations of Projects and Management Actions and Climate Change

ISW depletions are characterized in terms of historical data and models of past hydrology (i.e., via Cosana), but also in terms of future, anticipated hydrology. Forward-simulated hydrologic conditions using the Cosana groundwater flow model were used to estimate the impact to ISW from:

- the combined effects of projected water use in the Basin;
- projects and management actions (PMA) already underway (Harvest Water, OHWD[12] recharge, and regional conjunctive use); and
- climate change.

Model outputs including future groundwater basin storage, groundwater level, seepage from streams, and streamflow were collectively used to analyze impacts to ISW.

In the presentation of results (Section 4), groundwater level conditions in the current conditions (baseline) are compared to groundwater level conditions in the scenarios evaluated. Five scenarios are compared:

- ***Baseline***: current conditions
- ***Projected***: projected groundwater use (i.e., business as usual with increased demand)
- ***Projected CC***: projected groundwater use with a median climate change warming scenario[13]
- ***Projected PMA***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use)
- ***Projected PMA CC***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use) and with a median climate change warming scenario

Differences in groundwater level, seepage, and streamflow between each of the scenarios and the "baseline" inform how ISW in the basin may respond to projected groundwater management. These differences are applied to observed data to translate model estimates of change to observed data. For example, to estimate the change in ISW location (and hence,

[12] OHWD = Omochumne - Hartnell Water District

[13] Climate change (CC) scenarios are driven by changes in temperature and streamflow provided by the American River Basin Study (USBR, 2020) "central tendency" scenario, which reflect median temperature and precipitation outcomes.

change in ISW reach length) under each scenario, the groundwater level differences implied by each scenario at a Fall 2015 reference point were evaluated by the model, then this difference was applied to the measured and interpolated Fall 2015 level. Fall 2015 was chosen as a reference point because it represents a recent historical minimum in groundwater level across the basin.

3.4 Classification of ISW and Disconnected Surface Waters

The overarching goal of this analysis was to characterize the location, timing, and quantity of ISW in the SASb to inform the development of sustainable management criteria that avoid significant and unreasonable ISW depletion as defined by SGMA. Thus, it was important to classify all surface waters into "ISW" and "Disconnected" and explore how these classifications change over time. Groundwater and surface water data and modeled results were used to inform this classification.

As described in Section 2.4 Surface water and Groundwater Interactions, groundwater and surface water interact based on the relationship between the groundwater level and adjacent stream stage. Generally, if the groundwater level (also called the groundwater hydraulic head) exceeds the stream stage, a stream is interconnected and gaining. By contrast, if the stream stage exceeds the groundwater level, the stream is losing (Figure 15). However, a losing stream may still be ISW if the groundwater level intersects the clogging layer elevation; otherwise, if groundwater does not intersect the clogging layer, the stream can be considered disconnected. Importantly, a stream may be assessed along its entire reach to determine reaches characterized by connection and disconnection.

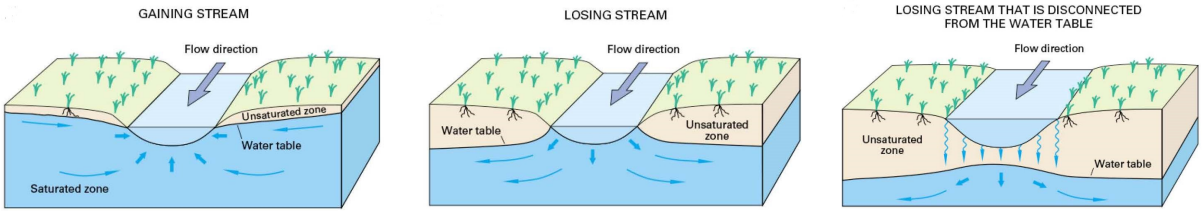


Figure 15: Surface water may be characterized as interconnected and gaining (left), interconnected and losing (center), or disconnected and losing (right). Figure modified from USGS.

This study uses a two-step system[14] to distinguish ***ISW*** and ***Disconnected*** surface water reaches described below and depicted in Figure 16. First, we determine interconnected and disconnected *stream nodes*:

[14] Previous research has advanced similar classification schemes as the one put forward in this study. For instance, Brunner et al. (2009) devised a three-class surface water classification system (interconnected, transition, and disconnected), and defined the "transition" class based on a zone of capillary action between saturated groundwater and the streambed clogging layer which was determined via a 1D analytical model informed by geologic properties. In this study, we neglect the impacts of capillary action because the local-scale geologic information required to drive 1D modeling of capillary action are poorly constrained in the study site and difficult to obtain, but may represent a potential path for future scientific investigation.

- *Interconnected stream nodes*: groundwater elevation at the stream node in question is greater than or equal to the clogging layer elevation under the thalweg
- *Disconnected stream nodes*: groundwater elevation at the stream node in question is less than the clogging layer elevation under the thalweg

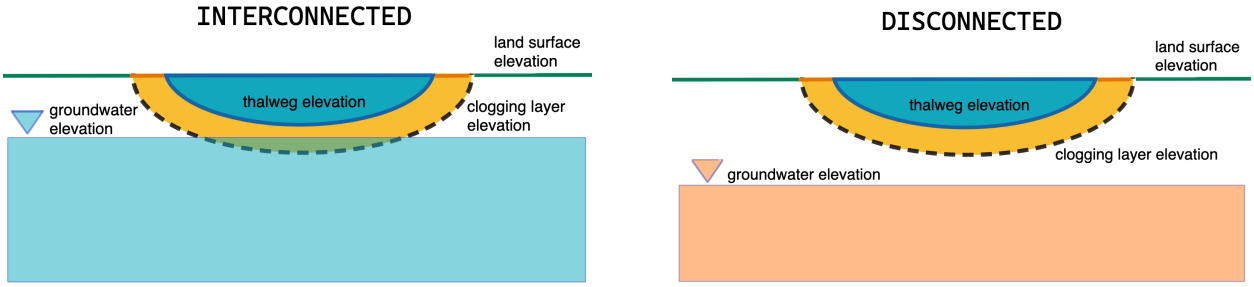


Figure 16: Classification of *Interconnected* Surface Water (ISW) and *Disconnected* stream nodes depends fundamentally on a comparison of the clogging layer elevation beneath the streambed and the groundwater elevation. If the groundwater elevation intersects the clogging layer, a stream node is considered ISW (right), otherwise, it is considered disconnected (left).

This classification is applied at each of the 1,107 stream nodes, and across the 22 seasonal groundwater level conditions from 2005-2018 (3.2 Groundwater Level Interpolation).

Second, looking across all reaches (Figure 4), we distinguish between *ISW and Disconnected* reaches (Figure 24).

- *ISW:* a majority of stream nodes are *Interconnected* for > 0% of all seasons evaluated in the historical period from 2005-2018.
- *Disconnected*: a majority of stream nodes are persistently *Disconnected* during all seasons from 2005-2018.

ISW and ***Disconnected*** categories thus represent reach- and seasonal-level summary statistics of *Probable ISW* and *Probable Disconnected* Cosana stream nodes, and are the final classifications used to inform GSP planning and SMC development. SMC and monitoring networks are developed for ***ISW*** reaches. Due to their persistent disconnection, ***Disconnected*** reaches are not considered within the requirements established by SGMA.

This classification is applied to historical groundwater level interpolations, and then across projected groundwater management in order to assess how expected groundwater use and climate change could affect ISW location.

3.5 Estimation of Depletion Volume at ISW Reaches

ISW depletion is extremely difficult to measure in the field, especially at the scale of an entire reach, and hence, numerical and analytical models are relied upon to estimate the magnitude and direction of stream-aquifer exchange. In accordance with SGMA, the Cosana groundwater flow model is used to estimate stream seepage along surface

water reaches. The time period analyzed was 2005-2018 to maintain consistency with the previous groundwater level analysis. Cosana only runs through 2018.

Depletion volume is driven by the relative difference between aquifer and stream hydraulic head. Generally, if additional groundwater drawdown occurs adjacent to a connected, losing stream, increased surface water depletion is expected because the hydraulic gradient between the stream and aquifer also increases.

3.6 Location and Timing of Gaining and Losing Reaches

Gaining and losing reaches are defined by the direction of flow between surface and groundwater, which is itself controlled by the hydraulic gradient between these two systems. Gaining surface water reaches have a stage elevation lower than adjacent groundwater elevation; losing surface water reaches have a stage elevation higher than adjacent groundwater elevation (Figure 15). Gaining and losing conditions are examined by analysis of Cosana model results of stream-aquifer interaction captured by the seepage term. Positive seepage indicates gaining stream conditions, and negative seepage indicates losing stream conditions. Seepage was aggregated at the seasonal (spring and fall) and reach level for major surface water bodies (American, Sacramento, Mokelumne, and Cosumnes Rivers) in the SASb. Location and timing of gaining and losing reaches is examined by mapping and hydrogeologic interpretation of seepage timeseries.

3.7 Changes in ISW streamflow

A primary concern of projected groundwater management is the avoidance of groundwater pumping that causes significant decreases in groundwater baseflow to streams that reduces streamflow and causes damage to beneficial users of that streamflow. Thus, changes in streamflow along the American, Sacramento, and Cosumnes rivers resulting from projects and management actions and climate change were evaluated with Cosana and compared to best available estimates of streamflow requirements for fish migration (Section 2.3.3 Lower Cosumnes River). Flows are summarized by exceedance probability during October to December flows because this time frame aligns with salmonid spawning migration. Due to modeling constraints, flows are estimated at the downstream outlets of the Cosumnes and Sacramento Rivers in the model domain. American River flows are estimated at H Street Bridge.

3.8 Satellite Analysis of Wetting and Drying

Portions of the American Sacramento, and Mokelumne Rivers that border the SASb are perennial, but certain reaches along the Cosumnes River are ephemeral. High resolution remote sensing was assessed as a potential means to qualitatively describe important reaches along the Cosumnes River. “Drying” events along the Cosumnes River were assessed with 30-centimeter pan-sharpened resolution imagery provided by

Google Earth Pro in order to scope the feasibility of on-demand, reach-scale documentation of the timing location of “drying” events.

4. Results

4.1 Historic and Present-day Groundwater Conditions

4.1.1 Monitoring well hydrographs

Historic groundwater conditions were assessed via hydrographs at monitoring points in the SASb, and groundwater surfaces derived from these measurements (grouped by season over 4-year sliding windows as described in Section 3.2 Groundwater Level Interpolation). Monitoring well hydrographs[15] – depending on the temporal resolution available – can provide sub-seasonal insights into ambient groundwater level trends at specific monitoring locations and at particular screened interval depths. Taken together, the individual hydrographs in the SASb do not show one consistent trend, but rather, show decreasing, increasing, and stable groundwater elevations trends over time. This implies that groundwater pumping is localized and depth-dependent, a trend that is visible in the 120 hydrographs in *Appendix A: Hydrographs*, and the groundwater elevation surfaces discussed in the following section.

4.1.2 Groundwater elevation trends and flow direction

Groundwater elevation surfaces are statistical representations across the entire study area computed from monitoring well hydrographs. In this study, groundwater elevation surfaces were used to compare groundwater and surface water features over time to determine the location and timing of ISW.

Interpolation occurs at a larger spatial scale than the SASb to minimize boundary effects and allow for some interpretation of groundwater flow direction, thus interpolation results show Sacramento County-wide groundwater level estimates (Figure 17). Groundwater levels in the SASb (Figure 18) show oscillating seasonal trends, which are more easily visible when comparing the median and interquartile range of groundwater level across years and seasons (Figure 19). The difference between median fall and spring groundwater level in the SASb suggests a typical interannual fluctuation of around 3 to 10 feet. Moreover, median spring and fall groundwater levels show a consistent downwards trend from 2005 to the period ending in 2016, and an increasing trend thereafter. These regional groundwater level changes were caused by the historic 2012-2016 drought and demonstrate that prolonged drought conditions have an impact not only on fall lows, but also on the height of spring groundwater level recovery. Furthermore, trends in median groundwater levels also demonstrate that following drought, groundwater levels generally rebound to pre-drought levels. For instance, the

[15] The 120 hydrographs considered in this study are presented in *Appendix A: Hydrographs*, although not all data shown in these hydrographs were used in the groundwater level interpolation due to the time period assessed in this study (2005-2018).

2015-2018 spring and fall median groundwater levels are roughly equivalent to the pre-drought 2005-2008 spring and fall levels.

Groundwater flow direction can be interpreted from groundwater elevation maps (Figure *17*, Figure *18*) which define the approximate subsurface “topography” of saturated groundwater in the principal aquifer given our best available data. Groundwater flows laterally from high to low groundwater elevation, along the lateral hydraulic gradient. Groundwater elevation mapping in the SASb indicates groundwater flow inwards towards the central and eastern SASb, coincident agricultural and rural areas which may pump more groundwater than urban areas. Urban areas near Sacramento, Rancho Cordova, and Folsom generally exhibit higher and more stable groundwater elevation trends, apart from notable groundwater drawdown near the Elk Grove urban-rural fringe. Higher groundwater elevations along the Sacramento and American river channels result from substantial seepage into groundwater causes groundwater to flow inwards to lower groundwater elevation sites in the SASb. Notably, the Cosumnes River channel does not show consistently higher groundwater elevation than interior groundwater elevation, perhaps due to seasonal wetting and drying of the river, and its closer proximity to groundwater pumping compared to the Sacramento and American rivers. Hence, groundwater in some seasons flows away from the Cosumnes towards the interior of the SASb, and in other seasons appears not to flow. North to south flow from the interior of the SASb towards the Cosumnes does not appear common in the period of record analyzed, consistent with a characterization of the Cosumnes as a stream experiencing active depletion.

A rigorous assessment of interbasin flow was outside of the scope of this study but should be conducted with the CoSANA model, or groundwater level measurements in all available datasets across the Cosumnes, South American, and North American basins. Nevertheless, Periodic Groundwater Level Measurements from the Department of Water Resources (see Section 3.1 Data sources) in the North American and Cosumnes basins provide some insight into general patterns of interbasin flow directions. Across years and seasons, lower groundwater elevations in the interior of each of these basins compared to groundwater elevations near major surface water channels suggests the presence of losing streams and active surface water depletion. This depletion moves along a hydraulic gradient from high groundwater elevation (near stream) to low groundwater elevation (basin interior). Therefore, interbasin coordination measures that arrest groundwater level decline (or increase groundwater levels) within zones of pumping inside the SASb, North American, and Cosumnes basins are critical to maintain surface water flows and preventing loss of ISW locations in the basin.

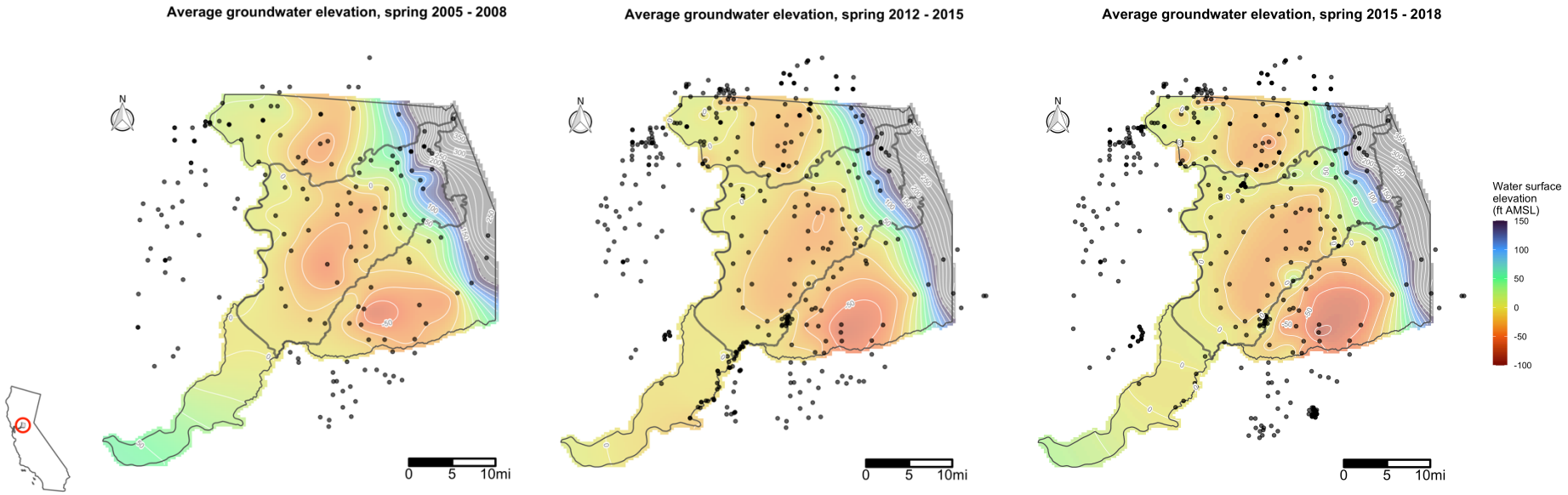


Figure 17: Spring groundwater elevation computed by ordinary kriging at three representative time steps (2005-2008, 2012-2015, and 2015-2018) demonstrate the presence of regional hydraulic gradients that contribute to inter-basin groundwater flow. Red indicates lower elevation and blue indicates higher elevation. Kriging is informed by groundwater level measurements taken at monitoring points (black dots), which are not constant across time steps. To best represent groundwater level in the SASb, monitoring points beyond the SASb boundary are incorporated into the analysis.

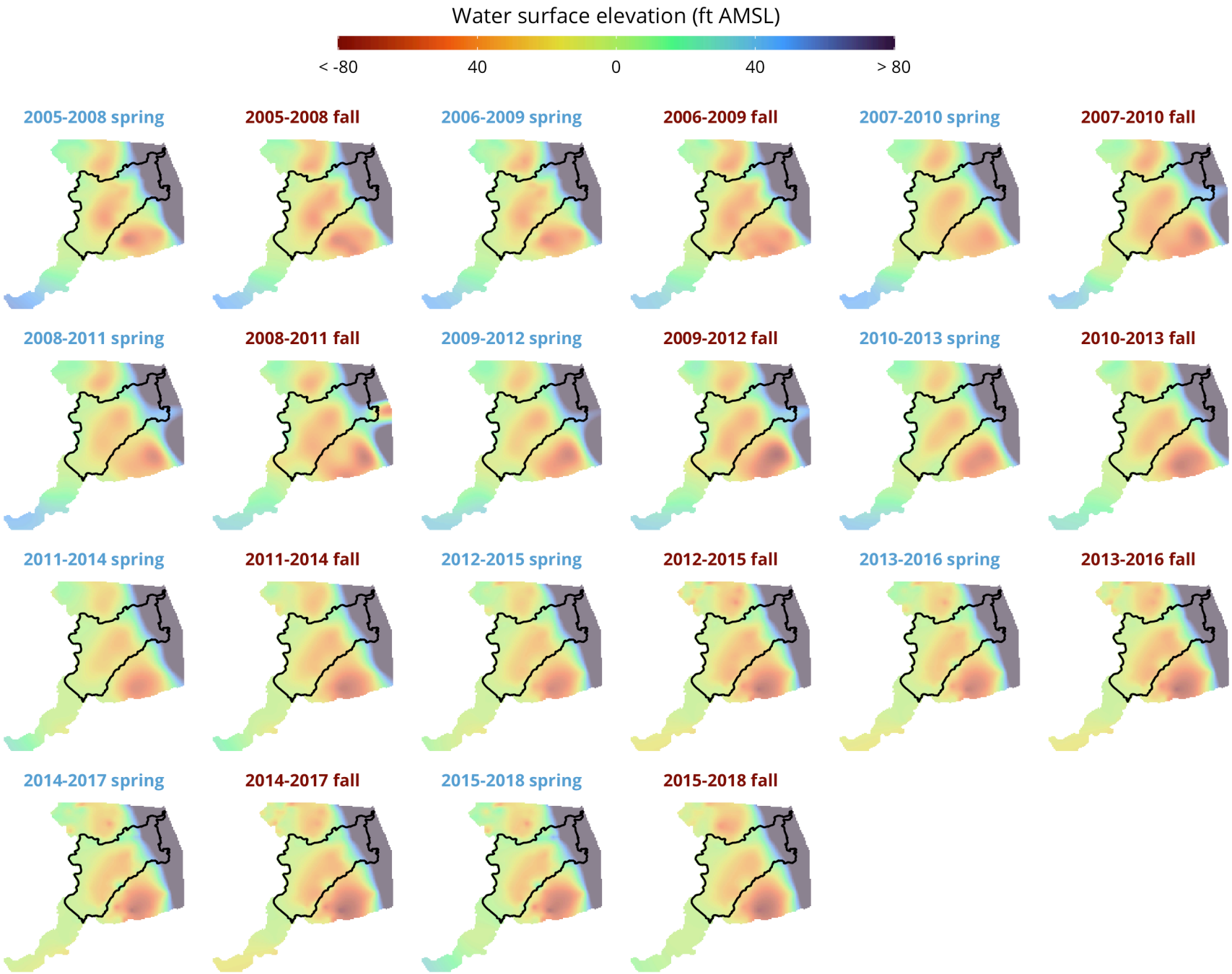


Figure 18: Seasonal, 4 year running mean interpolated groundwater elevations in the South American Subbasin from spring 2005 to fall 2018 show seasonal oscillation, with generally higher (blue) groundwater elevation in spring, and generally lower (red) groundwater elevation in the fall. Groundwater flows from areas of high (blue) to low (red) elevation groundwater elevation. Groundwater elevation mapping indicates groundwater flow inwards towards the center of the basin, coincident with areas of groundwater pumping.

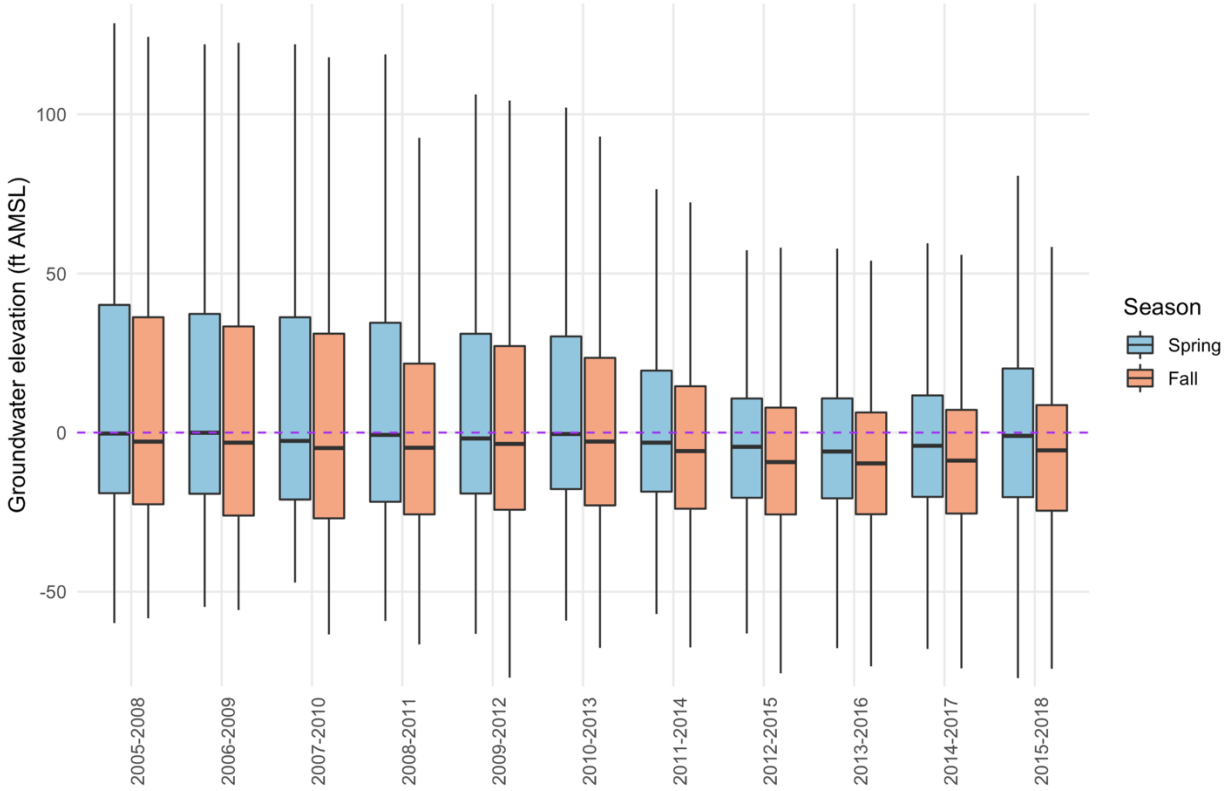


Figure 19: Seasonal summary of interpolated groundwater elevations in the SASb (Figure *18*) show oscillating seasonal medians, with consistently higher groundwater elevation in spring, and lower groundwater elevation in fall. Median fall groundwater elevation decreases over the period of record and reaches its lowest value during the average period of 2013-2016 due to the combined impact of 4 years of drought. After this minimum, spring and fall median groundwater levels trend upward. A purple, horizontal dashed line is shown at mean sea level elevation (0 feet) for reference.

4.1.3 Shallow groundwater locations

The depth to groundwater is calculated from seasonal groundwater elevations by subtracting the groundwater elevation from a digital elevation model. Estimated depth to groundwater (Figure 20) suggests that shallower groundwater is encountered moving from northeast to southwest in the SASb, from the foothills towards the Delta. Depths to groundwater are estimated at around 20-180 feet below land surface in the interior of the SASb[16], depending on the location considered. Areas of shallow groundwater occur along the southern Cosumnes River, along the American River above the Sacramento River confluence, along the Sacramento River, and within wetlands approaching the Delta. Moreover, relatively shallow depths to groundwater parallel the upper Cosumnes and American River channels, likely due to seepage from these major surface water bodies. Moving further away from these surface water channels, the depth to groundwater generally increases, which reflects the impact of groundwater pumping. Together, results suggest that ISW is more likely in regions with a shallower depth to

[16] Poorly constrained data in the foothills (dark red eastern areas in Figure 20) prohibits meaningful estimates of groundwater elevation and hence, depth to groundwater. Thus, results in these areas should be interpreted with caution. Actual depths to groundwater are likely higher in the foothills. Incidentally, most groundwater pumping does not occur in these areas.

groundwater and are consistent with subsequent findings on the estimated location of ISW.

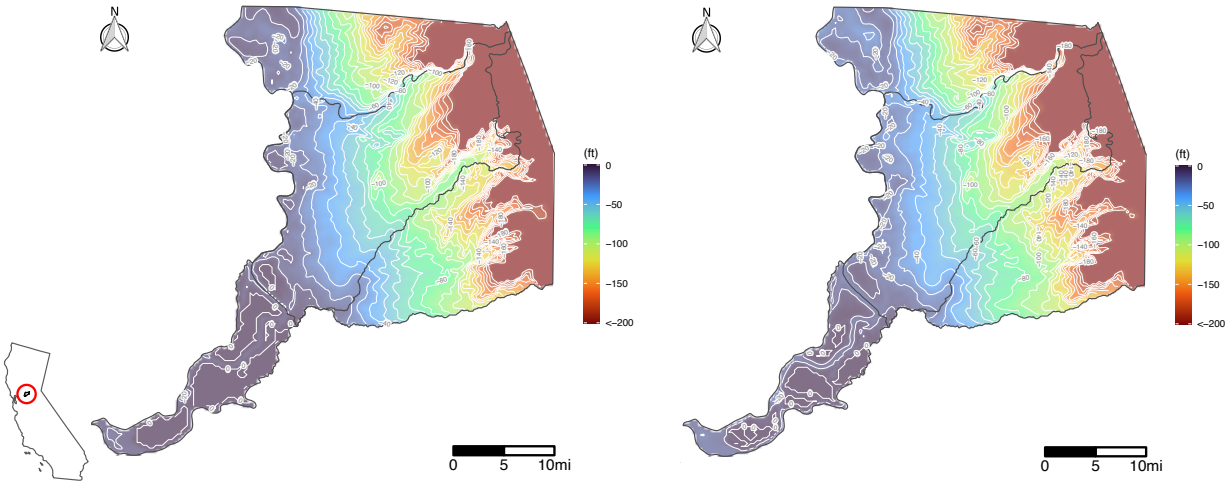


Figure 20: Depth to groundwater in the SASb for average spring (left) and fall (right) conditions across the entire period of record evaluated (2005-2018).

4.1.4 Projected groundwater levels

The impact of projected groundwater conditions including projects and management actions and climate change were evaluated with Cosana (see Section 3.3 Forward simulations of Projects and Management Actions and Climate Change).

Projected groundwater use assumes anticipated groundwater pumping on the part of water systems and GSAs across the SASb, the North American subbasin, and the Cosumnes subbasin. Results demonstrate that groundwater level declines around 15 to 20 feet or less are anticipated near Elk Grove and the Sacramento urban area respectively. Projects and management actions – including regional conjunctive use and recharge projects in Harvest Water and OHWD – lead to the mitigation of groundwater level declines near Elk Grove, and declines in the Sacramento region on the order of 15 feet or less. Groundwater level declines are estimated because of plans to exercise the basin, and declines are calculated between modeled scenarios and the current conditions baseline at the same time step (Fall 2015)[17].

Importantly, groundwater level decline in and of itself is not inherently harmful to beneficial users. Rather, declines must be evaluated with respect to beneficial users to anticipate potential significant and unreasonable impacts. The following subsections will detail the results of such analyses. In particular, we evaluate projected groundwater management and climate change impacts to ISW reach length, seepage at ISW reaches, and ISW streamflow.

[17] In practice, another time step may be chosen as a benchmark (e.g., Spring 2018), however, groundwater level decline will be similar no matter what benchmark is chosen because groundwater levels in each scenario follow repeated hydrology as in the current conditions baseline scenario (see Figure 23).

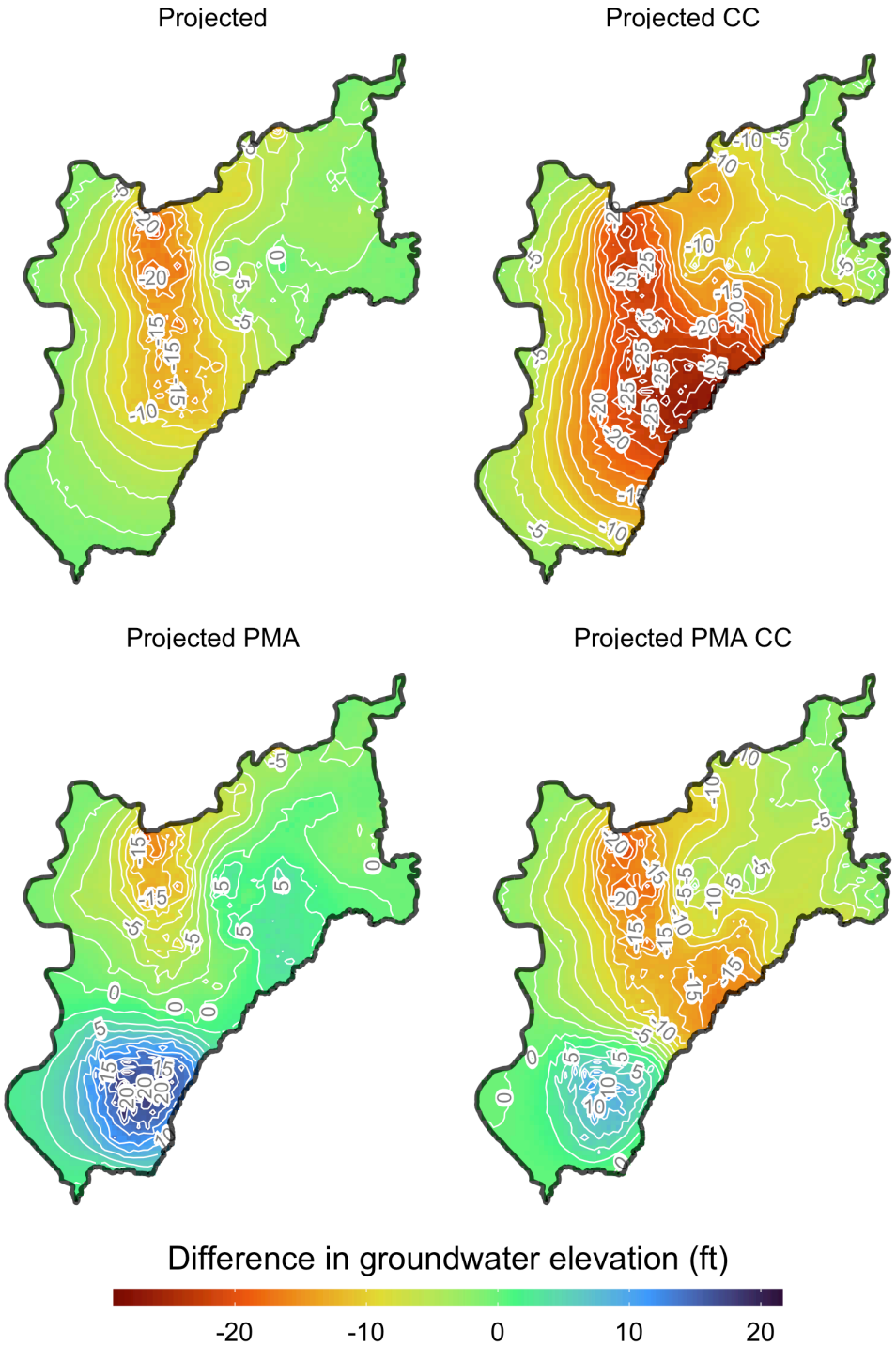


Figure 21: Modeled difference in groundwater level between each of the scenarios and the current conditions baseline at a Fall 2015 benchmark. PMA lead to substantial increases in groundwater level that reduce seepage (e.g., improve baseflow) and increase streamflow at ISW reaches. Climate change projections lead to groundwater level declines, but assume no corrective action or land use change. In reality, climate change would require specialized adaptive management to avoid significant and unreasonable impacts to beneficial users of groundwater and ISW.

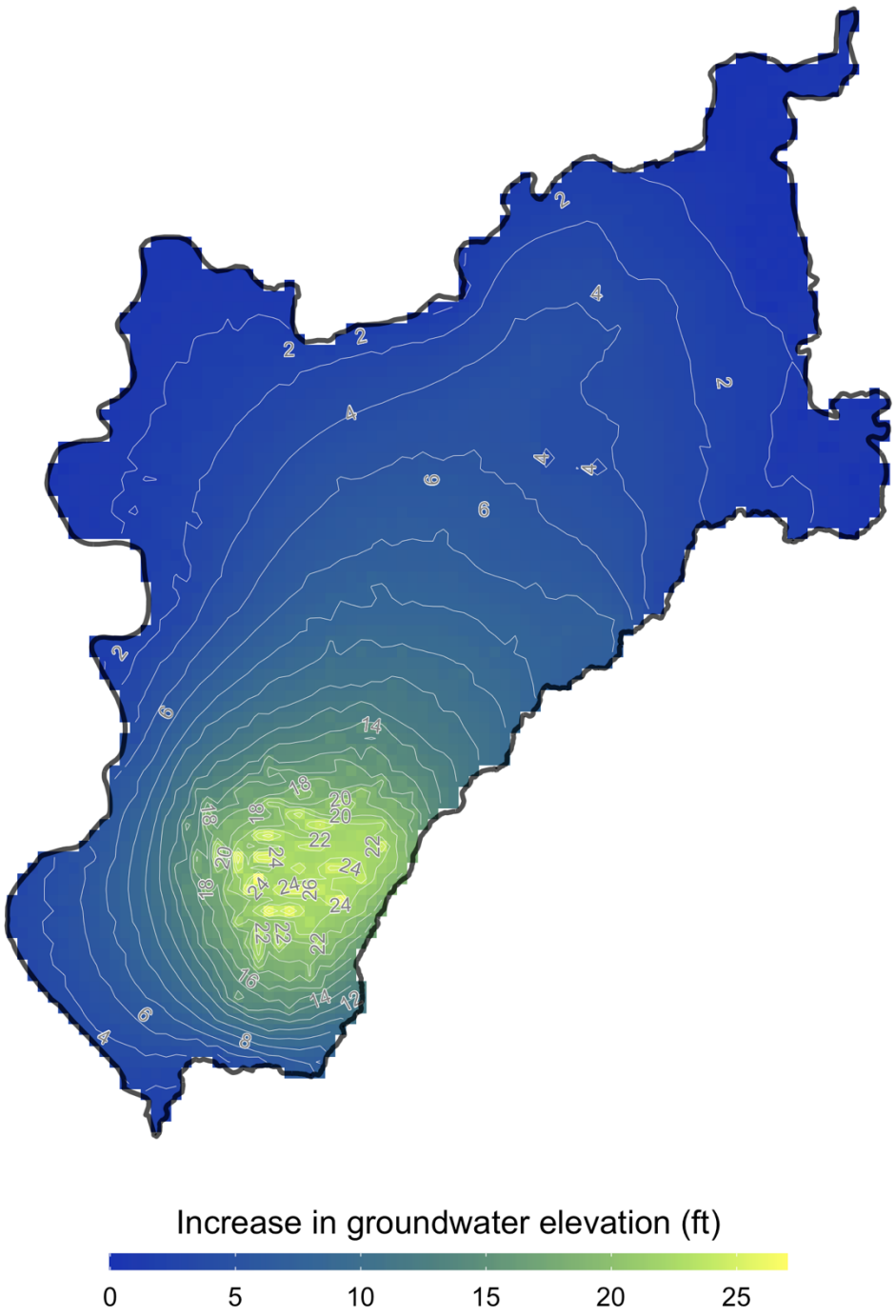


Figure 22: The difference in groundwater elevation between the "Projected PMA" and "Projected" scenarios shows the spatial distribution of groundwater level increases estimated to result from implementing PMA. Increases in groundwater level are observed across the basin, and concentrated near the Harvest Water recharge site.

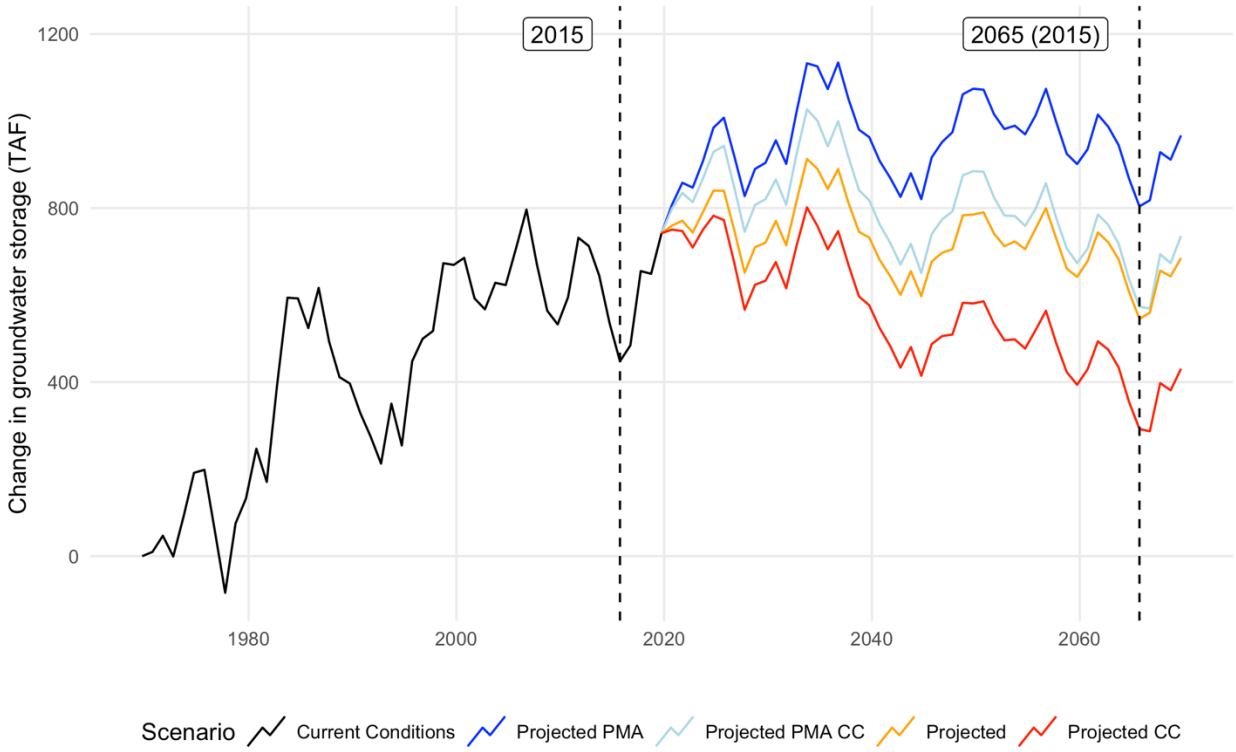


Figure 23: Cumulative change in groundwater storage under the current conditions baseline (black line), and the four scenarios (dark blue, light blue, orange, and red line). Importantly, projects and management actions (PMA) increase storage, and climate change (CC) reduces storage. A black dashed line shows where groundwater level differences are calculated between the projected scenarios and the current conditions baseline (Fall 2015) to maintain consistency.

4.2 Location and Timing of Interconnected Surface Waters

4.2.1 Historical data analysis

The location and timing of ISW was assessed by comparing each of the average seasonal groundwater level conditions presented above to the depth of the clogging layer of major surface water bodies (as described in 3.4 Classification of ISW and Disconnected Surface Waters). The proportion of seasons (across the 22 seasons evaluated in this study) that a stream node was classified as “Interconnected” to groundwater (3.4 Classification of ISW and Disconnected Surface Waters) was calculated at each stream node (Figure 24A), and used to inform a classification of “Interconnected” (ISW) and “Disconnected” stream nodes (Figure 24A) and reaches (Figure 24B).

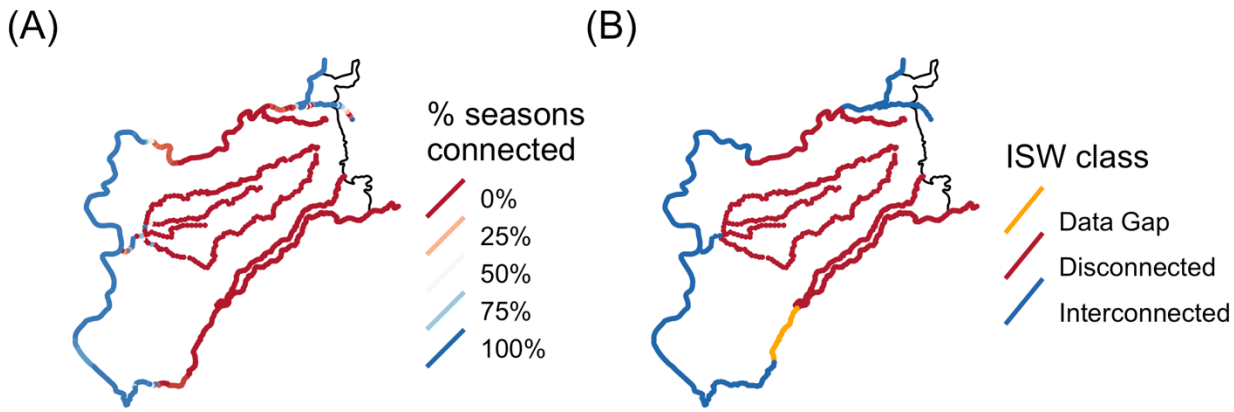


Figure 24: Interconnected and Disconnected stream nodes and reaches are defined by computing (A) the percentage of seasons evaluated from 2005 – 2018 where average groundwater elevation intersects the clogging layer of the streambed. (B) Disconnected stream reaches have a majority of stream nodes that are persistently disconnected from groundwater at all seasons evaluated, whereas Interconnected reaches are conservatively defined as having a majority of nodes connected for > 0% of all seasons evaluated. The Cosumnes River approximately between Deer Creek and Twin Cities Road is disconnected on a seasonal level, but some evidence of sub-seasonal connection exists, thus it is considered a data gap for planning purposes and more research is needed to understand stream-aquifer interactions in this region.

Final ISW classification results in a larger proportion of the Cosumnes River upstream of the Mokelumne River being classified as ISW. Due to relatively low groundwater levels in the basin's interior, most interior creeks are "Disconnected". ISW characterization is consistent with ISW characterization in The Nature Conservancy's ICONS web tool (TNC, 2021) and those in adjacent basins (North American and Cosumnes basins) that share boundaries with the South American Subbasin.

Results suggest that ISW locations over the period of record analyzed from 2005-2018 include:

- the entire Sacramento River;
- the American River upstream of the Sacramento River and downstream of the H Street Bridge;
- the American River upstream of Alder Creek and Buffalo Creek;
- Alder Creek and Morrison Creek upstream of the Sacramento River;
- the Mokelumne River; and
- the Cosumnes River upstream of the Mokelumne Confluence and downstream of the Laguna Creek confluence.

The actual location along the Cosumnes River where interconnection between surface and groundwater occurs should continue to be monitored and studied. Results suggest that seasonal average groundwater levels are not sufficiently high as to interconnect with streams, but some evidence of sub-seasonal connection exists, and this sub-seasonal connection may play a role in the maintenance of aquatic ecosystems. To better understand shorter-term interactions in this location, this region could be investigated with continuous groundwater and stream monitoring, which may improve understanding of sub-seasonal interconnection events and hydraulic gradients between surface and groundwater.

Figure 25: Probable ISW reaches by name, Disconnected reaches, and GSAs in the Basin. Monitoring points are assigned to nearby ISW reaches and are discussed in (SMC) *and Monitoring Approach*.

4.2.2 Impact of projected groundwater management on ISW reach length

The impact of projected groundwater conditions (including projects and management actions and climate change) on reach length were evaluated with Cosana (see Section 3.3 Forward simulations of Projects and Management Actions and Climate Change). Declines in the groundwater level may lead to disconnection events where previously interconnected stream nodes become disconnected, and conversely, increases in groundwater elevation may raise groundwater levels such that previously disconnected nodes become interconnected. Finally, the change in groundwater elevation may be such that connection or disconnection (relative to some historical benchmark) remains the same.

Results suggest that compared to a Fall 2015 baseline, projected conditions lead to a -4.94% decline in ISW reach length, and a 0% change if projects and management actions are implemented. The Harvest Water recharge project in the southern SASb substantially improves groundwater levels in and around the project area (Figure 22), resulting in a maintenance of ISW reach length. Decreases in reach length associated with climate change scenarios is attributable to increased temperatures and groundwater demand, but may be addressed with adaptative management.

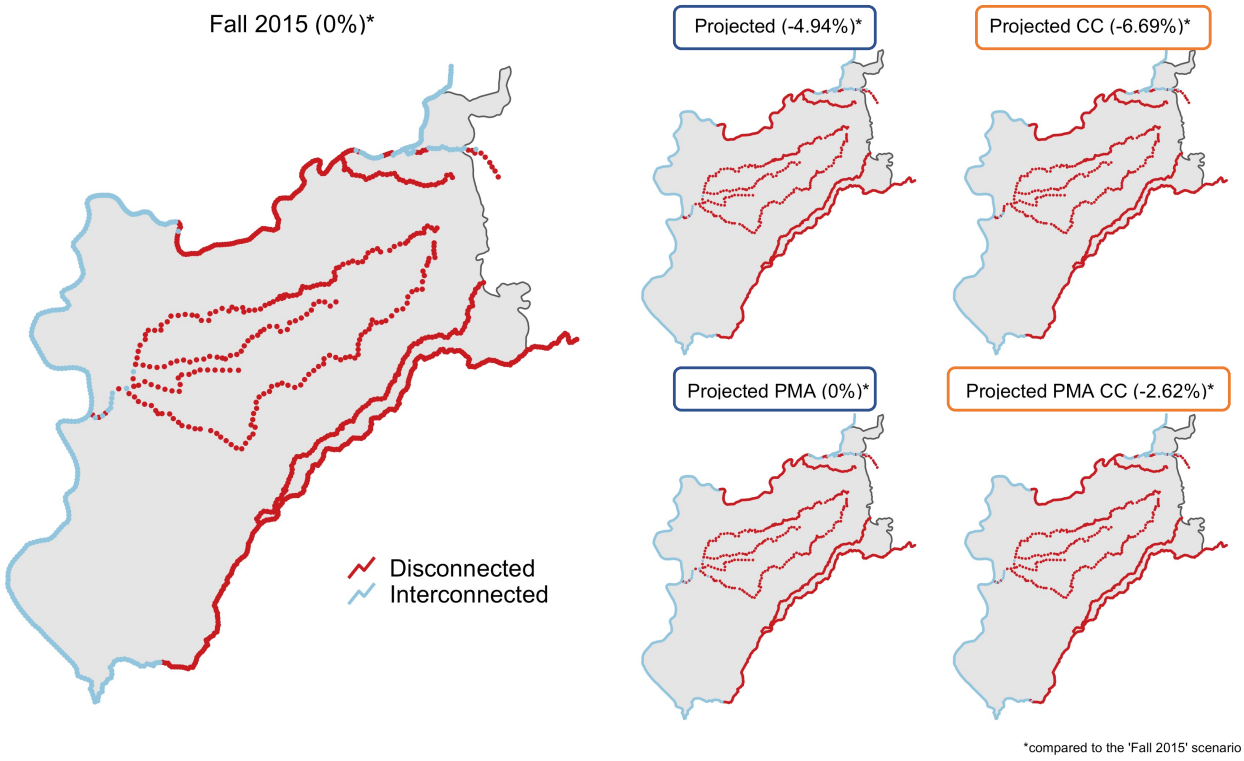


Figure 26: Impact analysis of projected groundwater level scenarios (described in Section 3.3 Forward simulations of Projects and Management Actions and Climate Change) shows minimal impacts to ISW reach length across scenarios suggesting the avoidance of significant and unreasonable disconnection events. The "Projected" and "Projected PMA" scenarios (blue border) should be compared, and the "Projected CC" and "Projected PMA CC" scenarios (orange border) should be compared. In each pair of comparable scenarios, scenarios with PMA lead to a less than 5% reduction of ISW reach length compared to a 2015 baseline, and are generally more protective of ISW than scenarios without PMA.

4.3 Depletions of Interconnected Surface Waters

4.3.1 Comparison of current and projected seepage

Active ISW depletion is occurring in the SASb due to historical groundwater development and evidenced by the prevalence of disconnected surface water bodies and mostly losing stream reaches across the basin.

In practice, streamflow depletion is difficult to measure in the field, and varies considerably along a stream reach, thus it is almost always a modeled quantity. The

Cosana model simulates stream-aquifer exchange at stream nodes. The term that describes the flux of water between surface and groundwater bodies is called “Seepage”. A negative seepage along a reach indicates losing stream conditions, and a positive seepage indicates gaining conditions (Figure 15). Cosana was used to simulate seepage under current conditions, as well as seepage under projected groundwater management and climate change (Figure 27) at ISW reaches identified above (Section 4.2 Location and Timing of Interconnected Surface Waters).

The primary driver of the direction and magnitude seepage is the relationship between groundwater elevation and the stream stage elevation. Generally speaking, water flows from areas of higher elevation to lower elevation as a result of potential energy and gravity, and thus changes in groundwater elevation (e.g., from pumping or recharge) and stream stage (e.g., from diversions or floods) change the relationship between groundwater and surface water elevations (Figure 1), and hence, the seepage. Overall, surface waters in the SASb exhibit seasonally and interannually variable stream depletion that results from the relationship between groundwater elevation and stream stage.

The magnitude of ISW depletion at interconnected stream reaches (Figure 27) is greatest along the Sacramento River due to its relatively larger stream geometry and larger volumetric flow compared to the American, Cosumnes, and Mokelumne Rivers. The American River is heavily managed and thus flows that are held back in Folsom reservoir generally decrease the magnitude of seepage along this river compared to what they may be in unmanaged conditions.

Projects and management actions generally reduce loss from losing streams and increase baseflow to gaining streams. Across all ISW reaches, all gaining and losing reaches remaining predominately gaining or losing reaches under all scenarios. A notable exception is Morrison Creek upstream of the Sacramento River, which is predominately losing assuming climate change and no PMA. Overall, projected management and PMA tend to either improve or maintain current conditions (Figure 27).

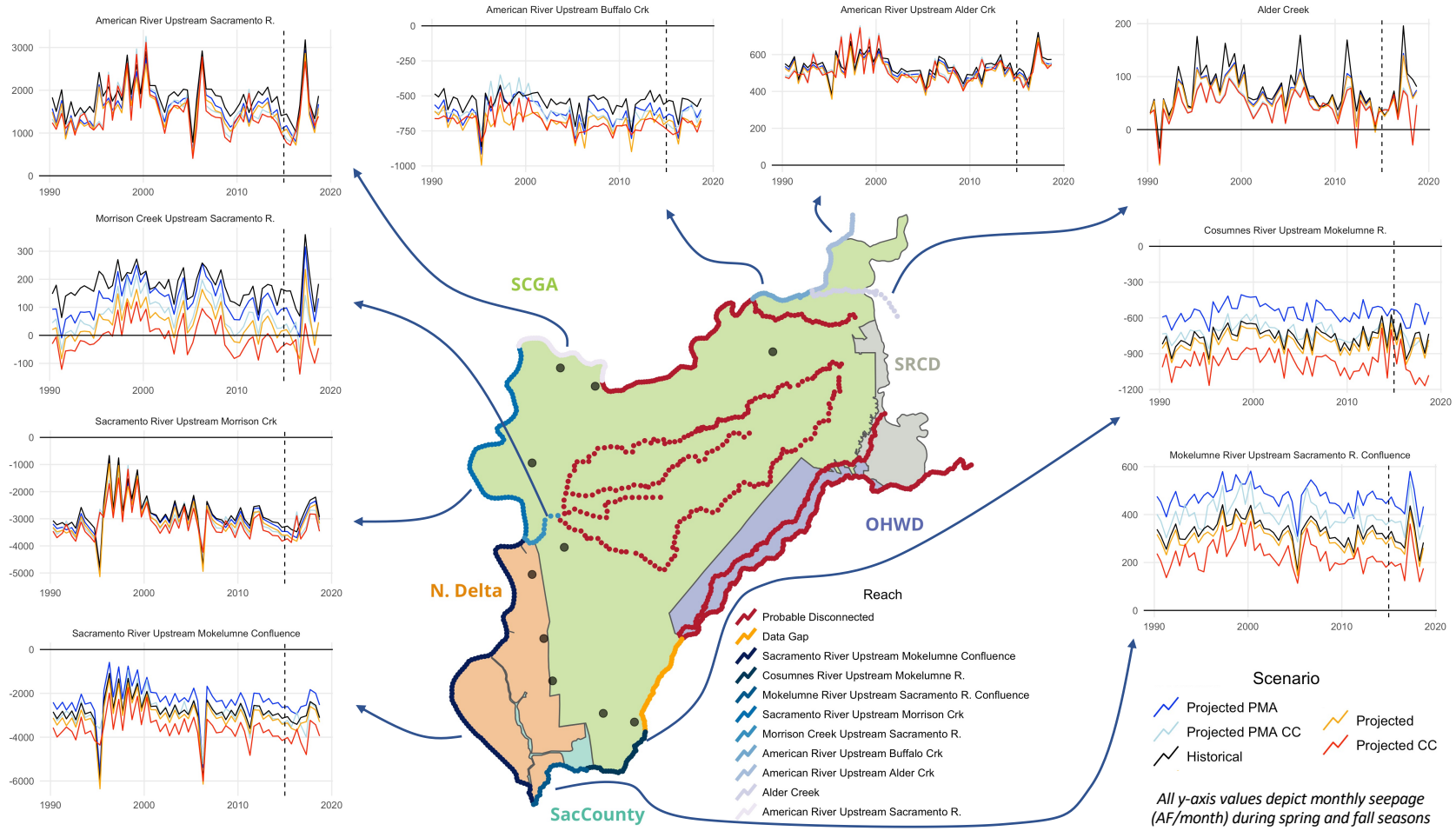


Figure 27: Seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches over the current conditions baseline model simulation is relatively constant. Negative numbers indicate losing stream conditions (stream loss to groundwater) and positive number indicate gaining stream conditions (stream gain from groundwater). Spring (February - April) and fall (August - October) depletion rates are averaged per month in each 3-month seasonal window. A black vertical dashed line at 2015-01-01 is drawn for reference, and a black solid horizontal line at y = 0 indicates the transition from gaining to losing conditions. Most scenarios have little impact on seepage. The Cosumnes and Mokelumne gain more under projected conditions, even with climate change. Morrison Creek loses more in all scenarios.

4.3.2 Dependence of seepage on water year type

Dry years tend to encourage groundwater pumping – this lowers groundwater level adjacent to streams, and hence, steepens the gradient between surface and groundwater bodies. A steeper hydraulic gradient between surface and groundwater[18], particularly in the losing streams found in the SASb, intensifies and increases depletion volumes.

Wet years sometimes lead to increased seepage from losing streams to groundwater due to excess water in stream channels that increases the hydraulic gradient. Increased seepage to groundwater during these wet years should not be interpreted as damaging aquatic habitats or ecosystem functions, but rather, as the result of floods and increased hydraulic head in rivers[19]. If the elevation of adjacent groundwater is relatively high and wet years have the effect of increasing groundwater level, the opposite effect can occur, and increased groundwater levels contribute to streamflow, observed in positive spikes in the seepage timeseries of the Mokelumne River upstream of the Sacramento River confluence.

Many factors influence seepage. Within the context of SGMA, it is important for management plans to evaluate how groundwater management may alter stream-aquifer interactions that lead to undesirable results for ISW or beneficial users of ISW. Measurable quantities that may be used in management plans include alterations to the reach length of identified ISW, changes in ISW seepage, and changes in critical flows for fish passage.

4.4 Location and Timing of Gaining and Losing Reaches

Although not directly managed by SGMA, an understanding of location and timing of gaining and losing streams is critical to anticipate how depletions of ISW may change under different water management scenarios. Importantly, a conceptual understanding of gaining and losing stream conditions may help identify *losing connected* and *gaining* reaches that should be maintained, to prevent the transition of ISW to losing disconnected reaches (Figure 15). Gaining and losing reaches according to Cosana are presented.

Seepage calculated by Cosana can be positive (stream gains from groundwater) or negative (stream loses to groundwater). The seasonal gaining and losing conditions for each reach (Figure 29) demonstrate consistent and mostly losing conditions (red) over

[18] Hence, arresting the steepness of the hydraulic gradient between surface and groundwater is the management approach proposed in this memo, consistent with recommendations by Hall, Babbit, Saracino, and Leake (2018).

[19] Increased depletion during wet years along losing reaches that result from higher hydraulic head in streams (i.e., flood conditions) motivates sustainable management criteria based on groundwater levels rather than estimated depletion volume, because groundwater levels adjacent to streams represent the impact of groundwater management decisions that ultimately impact streams. Thus, SMC based on groundwater elevation more accurately target groundwater management.

time, apart from gaining reaches (blue) along the upper and lower American river, and the Mokelumne river. The average reach-level seepage across the period of record from 2005-2018 (Figure 28) does not appreciably differ between spring and fall.

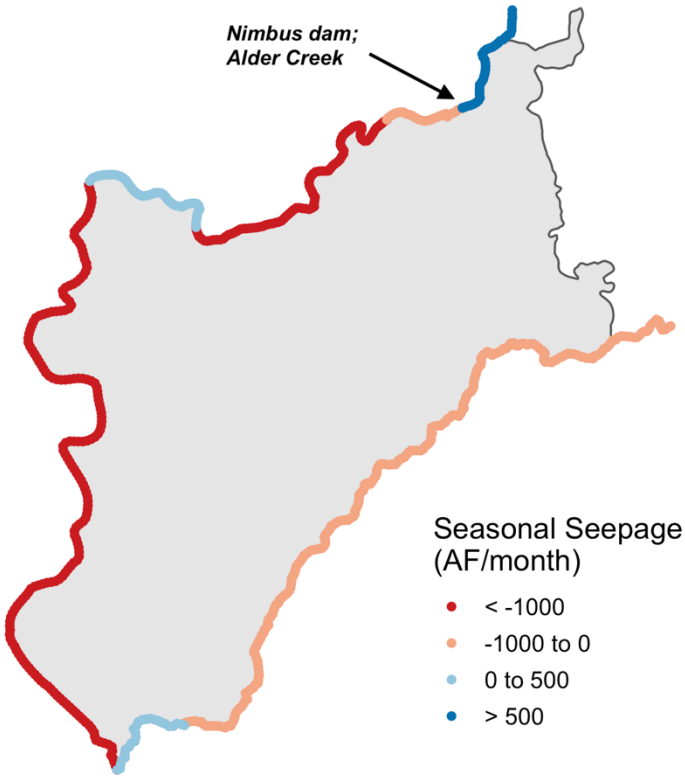


Figure 28: Average reach-level seasonal seepage from 2005-2018 computed by Cosana show gaining sections along the Mokelumne River, the lower American River downstream of the H Street bridge, and the American River upstream of Alder Creek (Nimbus dam), otherwise known as Lake Natoma. In this figure, spring and fall seasons are averaged because they do not appreciably differ.

Gaining and losing reach characterization is important insofar as it informs the hydrogeologic conceptual model of stream-aquifer interactions in the basin and provides a benchmark against which projected changes can be compared to. Future groundwater management planning should consider how projected groundwater use may impact gaining and losing systems. In particular, gaining and losing ISW that depend on minimum flows for fish migration may be sensitive to changes in seepage that deplete surface waters.

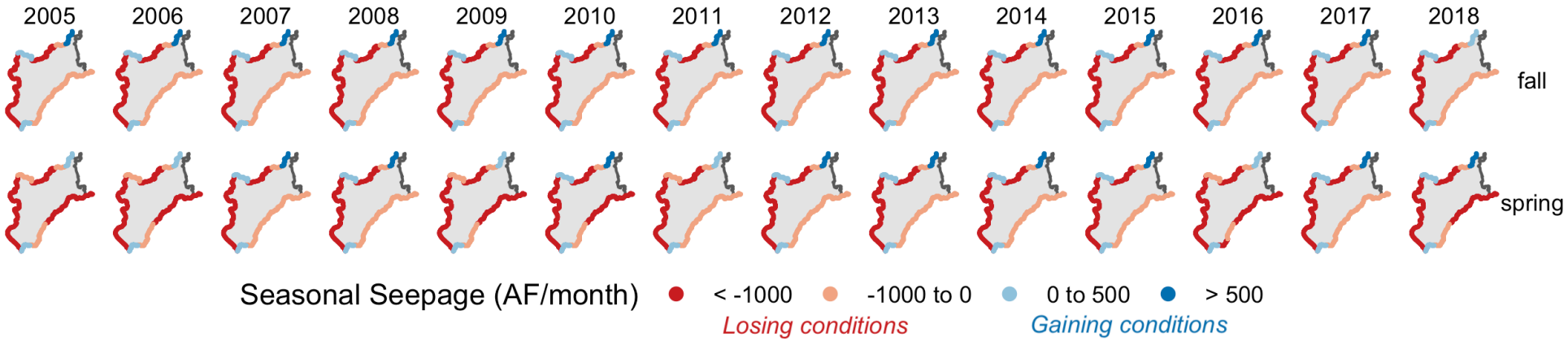


Figure 29: Major gaining and losing stream reaches from 2005-2018 in fall and spring according to the current conditions baseline. Average seasonal seepages show mostly losing (red) reaches.

4.5 Impacts to Streamflow

As in previous subsections, Cosana was used to compare the current conditions baseline scenario to projected management and climate change scenarios (3.3 Forward simulations of Projects and Management Actions and Climate Change). Streamflow exceedance probability at the outlets of the American, Cosumnes, and Sacramento rivers was compared across all scenarios. Exceedance probability represents the probability that a certain flow will be met or exceeded based on the hydrology observed during a period of record. The periods of record considered in this study are equivalent in length and based on monthly average streamflow values calculated by Cosana from 1990-2018 (and based on that hydrology). “Projected” and “Projected PMA” scenarios show increases in streamflow in the Sacramento and Cosumnes Rivers between 1-16%, and a negligible -1% decrease in the American River. Increases in flow, particularly in the Cosumnes River are attributable to increased groundwater elevations from the Harvest Water project and other regional conjunctive use projects (Figure 22), which increase local groundwater conditions upwards of 25 feet, thus reducing seepage from streams to groundwater along the losing Cosumnes River, and increasing baseflow to the gaining Mokelumne River (Figure *27*).

Climate change scenarios cause outsized direct reduction in streamflow unrelated to groundwater management. Comparison of “Projected CC” and “Projected PMA CC” shows that across all ISW in the SASb, PMA dampen the impact of climate change on streamflow.

Table 3: October-December simulated streamflow for the American, Cosumnes, and Sacramento rivers under current conditions (Baseline), and projected scenarios (also see Figure 30)

River	Scenario	10th percentile (cfs)	25th percentile (cfs)	50th percentile (cfs)	75th percentile (cfs)	90th percentile (cfs)	% Difference in 50th percentile exceedance compared to Baseline
American	Baseline	4037	2714	2025.29	1283	914	0%
American	Projected PMA	4019	2699	2004.91	1266	892	-1%
American	Projected PMA CC	2346	2181	701.37	584	507	-65%
American	Projected	4020	2692	2000.04	1261	888	-1%
American	Projected CC	2337	2177	693.52	579	503	-66%
Cosumnes	Baseline	1662	523	153.77	47	35	0%
Cosumnes	Projected PMA	1695	564	177.93	59	45	16%
Cosumnes	Projected PMA CC	1752	462	142.91	52	37	-7%
Cosumnes	Projected	1679	537	163.59	52	40	6%
Cosumnes	Projected CC	1742	443	134.42	48	34	-13%
Sacramento	Baseline	36150	19323	13857.07	11294	8554	0%
Sacramento	Projected PMA	36441	19537	13969.06	11424	8672	1%
Sacramento	Projected PMA CC	24794	14612	11300.27	8206	6822	-18%
Sacramento	Projected	36421	19514	13943.24	11401	8648	1%
Sacramento	Projected CC	24763	14585	11270.08	8181	6797	-19%

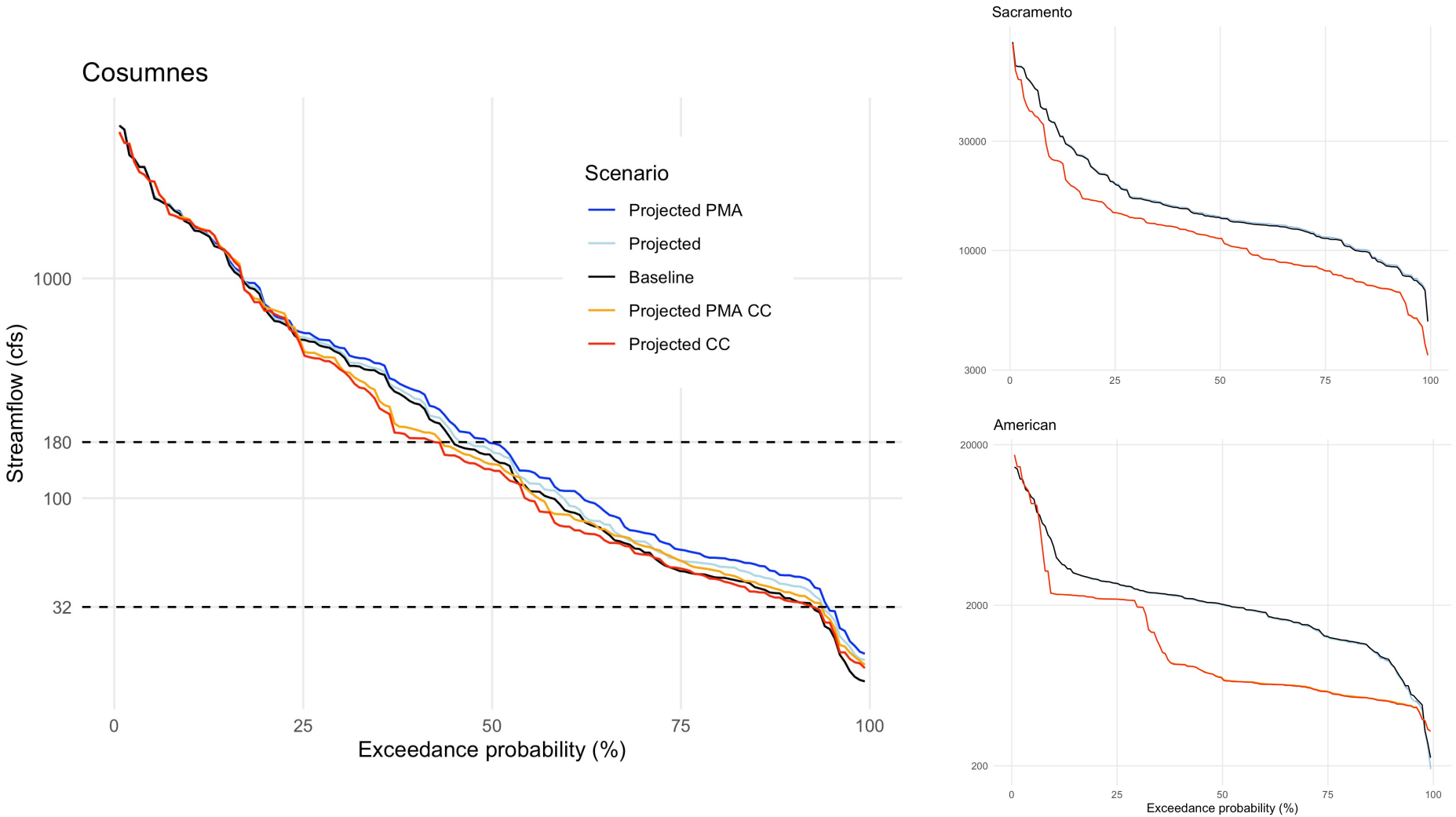


Figure 30: All projected scenarios show minimal impacts to October-December streamflow exceedance (Table 3) at ISW locations along the Cosumnes, Sacramento, and American rivers when compared to current conditions baseline flows (black solid line). American and Sacramento flows are only impacted by climate change and the absence of PMA (overlapping red and orange lines). In the Cosumnes, PMA introduction improves flow conditions, and projected management does not differ from current conditions. Black dashed horizonal lines on the leftmost plot indicate the envelope of flow target values reported by literature to support fish passage during low-flow October-December spawning months. The lower bound of this envelope (32 cfs) has a 90% exceedance probability across all scenarios which implies fish passage during spawning months. Due to modeling constraints, flows are estimated at the downstream outlets of the Cosumnes and Sacramento Rivers in the model domain. American River flows are estimated at H Street Bridge. Note the log-scale y-axis.

4.6 Satellite Analysis of Wetting and Drying

High spatial resolution, pan-sharpened, 30-centimeter satellite imagery from Google Earth Pro was used to qualitatively assess “drying” events along the ephemeral Cosumnes River. Results demonstrate the feasibility of commercial, on-demand imagery (e.g., Planet 50-centimeter satellite imagery) to assess drying events (Figure 31). True color composite images taken in the visible spectrum of light (380-750 nanometers) work best in cloud-free environments. Dry summer months when the Cosumnes is most likely to experience “drying” events co-occur with relatively cloud-free days with low atmospheric moisture, and thus the feasibility of using high resolution remote sensing to broadly assess ISW monitoring is promising.

Figure 31: Selected dates of 30-centimeter pan-sharpened true color images of a selected location along the Cosumnes River qualitatively demonstrate the effectiveness high-resolution satellite imagery in determining drying events.

Aerial images can only indicate if reaches have dried out or stranded some sections of river which may serve as critical fish passage and habitat. These images cannot, however, indicate if surface and groundwater become disconnected, and are thus not practical approaches for measurable strategies for sustainable groundwater management. Sustainable management criteria for groundwater based on the observation of dry streams in satellite imagery is thus misguided: ephemeral stream reaches are likely to dry out from upstream conditions (i.e., dry and critical years with little rainfall), which are completely unrelated to the impact of groundwater management (e.g., pumping). Thus, developed SMC in this memorandum rely on in-situ groundwater level observations to identify changes in groundwater level that would lead to increased ISW depletion. Nevertheless, remote sensing of the Cosumnes River presented in this study demonstrate the utility of remote sensing analysis towards improving regional understanding of drying events on surface water bodies.

Finally, coarser resolution, publicly accessible imagery from the Sentinel II satellite (10-meter spatial resolution) were assessed as a potential low-cost alternative to high resolution imagery, but it was determined that the features of interest are too coarse at

10-meter scale (Figure 32, Figure 33). This was unsurprising as some stream channels along the Cosumnes River can fit within less than one grid cell to a few grid cells.

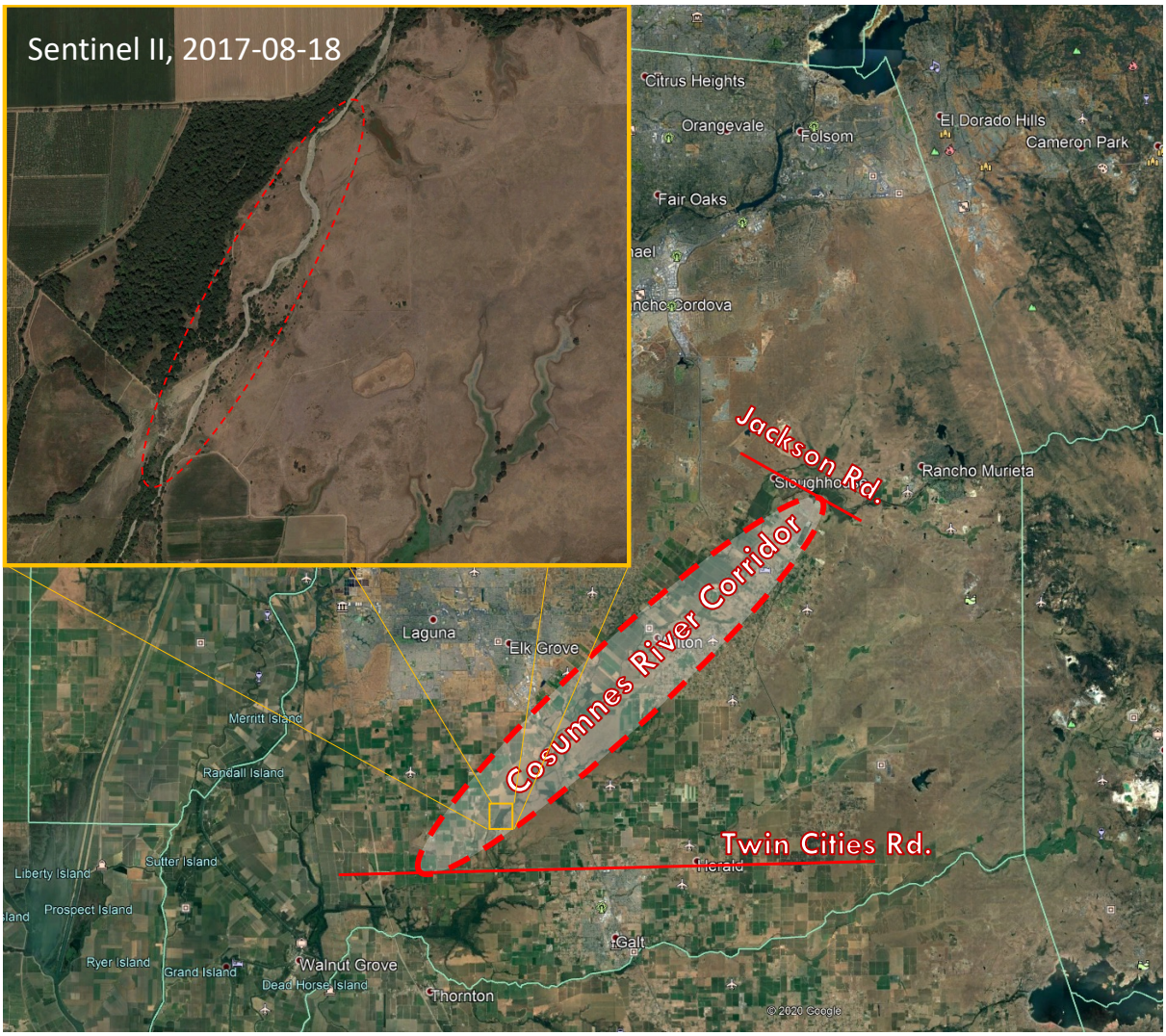


Figure 32: Sentinel II, which offers 10-meter resolution in the visible spectrum and regular flyovers of the SASb was investigated but did not offer appropriate spatial resolution for the task of qualitatively determining drying events.

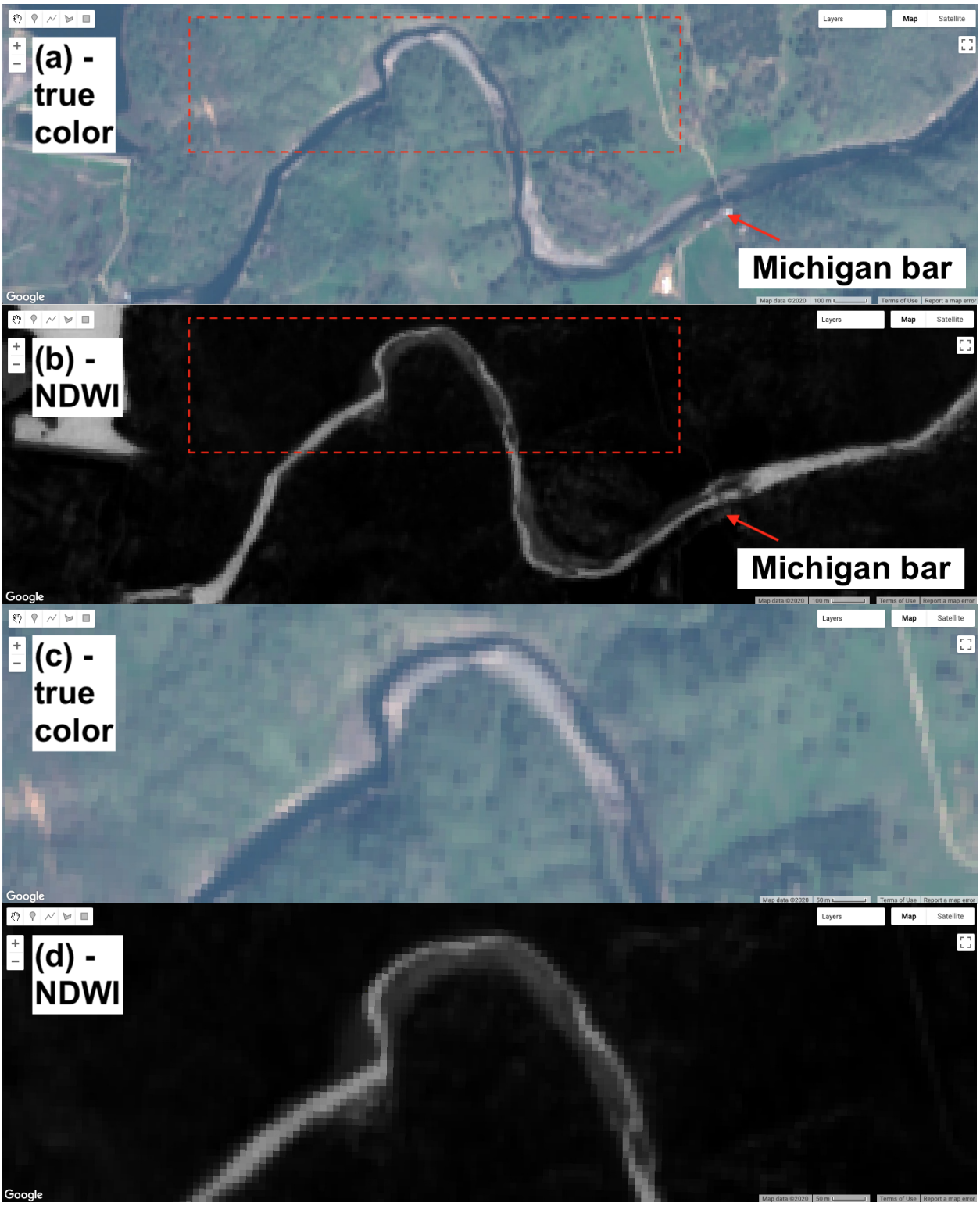


*Figure 33: Sentinel-2 true color and NDWI near Michigan Bar on the Cosumnes River for the period from 2018-02-01 to 2018-03-3. Lower right scale bar is 100m in **(a-b)**, and 50m in **(c-d)**. Dotted region in **(a-b)** is zoomed into in **(c-d)**.*

5. Limitations

Average regional, seasonal groundwater level cannot capture shorter-term connections between groundwater and surface water, or the impact of perched zones. Some studies suggest that on sub-monthly timescales, groundwater adjacent to streams may demonstrate higher hydraulic head than in the stream, consistent with gaining stream conditions. However, these trends often dissipate when looking at average conditions across the season. Therefore, the ISW mapping resulting from this study should be interpreted as regional and seasonal average conditions.

We ignore capillary action due to poorly constrained local-scale geologic data for the sediment underlying the streambed, but incorporation of these processes may allow in some cases for surface water to interconnect over a few more feet. To compensate for this effect, we conservatively consider an entire reach as connected if the majority of stream nodes within a reach are interconnected. This causes ISW classification to trend further upstream than what best available data suggest.

ISW connection estimates depend strongly on groundwater elevation data and thalweg elevation data, both of which always have room for improvement. Groundwater elevation data near streams is particularly important to refine ISW location estimates. Higher resolution thalweg elevation data may be obtained from local surveys and remote sensing (e.g., drones using LiDAR to acquire stream bathymetry data). The cost of these expeditions should be weighed against their ability to improve upon existing data, and the period of which the acquired data may become invalid (e.g., in the case of a large flood which scours channel geometry and changes the thalweg elevation).

6. Conclusion and Management Recommendations

In this section we summarize the main findings of the study and then advance management recommendations that pertain to SMC as defined by SGMA for the avoidance of Undesirable Results to beneficial users and users of ISW.
Data-driven analyses and modeling presented in this study show the location of ISW along the American, Sacramento, Mokelumne, and Cosumnes Rivers where ISW are located based on a historical (2005-2018)[20] analysis of seasonal groundwater elevation, thalweg elevation, and reach-level seepage. Modeled projected management and projects and management actions (PMA) generally improve ISW conditions compared to equivalent scenarios without PMA. Climate change has negative impacts of ISW streamflow, but these impacts are isolated from groundwater management actions.

[20] Groundwater level analyses with data run from 2005-2018, and analyses of Cosana-calculated seepage runs from 2005-2018 because 2018 is the final year in which output is available at the time of writing.

Management actions should emphasize maintenance of ISW within reasonable margins, such that undesirable results to ISW are strictly defined. The strong dependence of threatened and endangered species on streamflow also suggests that SMC should emphasize similar quantitative criteria at which undesirable results are experienced. For example, the identification of undesirable results due to ISW depletion may include significant and unreasonable:

- percent decline in an ISW reach length
- percent decline in median exceedance probability at ISW reaches

Importantly, these metrics should be easy to measure over time to inform GSP implementation. Furthermore, the GSP should clearly link groundwater level declines to the above measurable outcomes so that groundwater level may be used as a proxy for ISW depletion.

6.1 Sustainable Management Criteria (SMC) and Monitoring Approach

SMC are monitored at representative monitoring points (RMPs), and it is critical that these RMPs are strategically sited to best represent changes in hydraulic gradient that indicate ISW depletion (Figure 34).

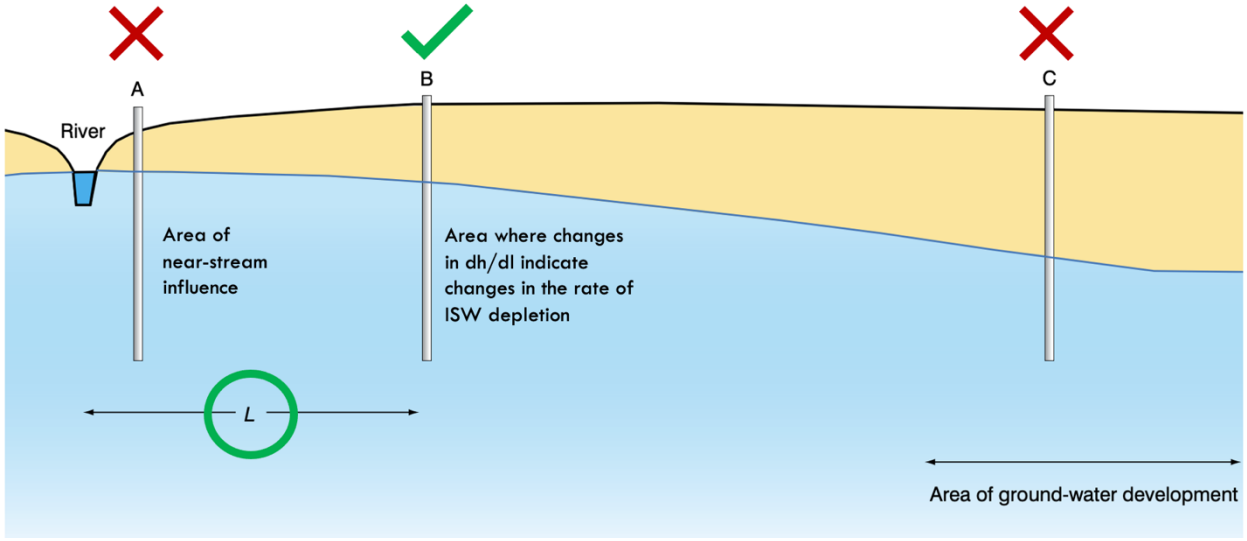


Figure 34: Monitoring wells for ISW depletion should be selected at a distance away from ISW such that areas of near-stream influence (A) and groundwater pumping (C) are avoided. Rather, groundwater levels should reflect the zone in which a propagating cone of depression has yet to reach the stream (B). In this way, monitoring reflects ambient groundwater conditions that may be impacted by overextraction, and anticipates ISW depletion. Modified from (EDF, 2018).

Analysis of hydraulic gradients along transects perpendicular to ISW demonstrated a buffer between 3000 and 9000 feet from ISW with relatively flat hydraulic gradients that appear to be unimpacted by near-stream influences or groundwater pumping. It is in this buffer that shallow monitoring wells were selected (Figure 27). Whenever possible and

appropriate, selected monitoring wells were drawn from the existing groundwater level network to minimize monitoring.

UC Davis and Sacramento State monitoring wells are situated in key locations and harbor valuable historical data, but the likelihood of these institutions supporting measurements over the GSP implementation timescale should not be taken for granted. It is recommended that the GSP monitoring effort coordinate with these entities to secure long-term monitoring, at least on a biannual basis.

References

1. American River Water Agencies (ARWA). 2017. Modified Flow Management Standard Proposed Water-Right Terms and Conditions. Available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/PCWA/part2/ARWA-502.pdf

2. Anderson, M. L., Chen, Z. Q., and Kavvas, M. L. (2004). ‘‘Modeling low flows on the Cosumnes River.’’ J. Hydrol. Eng., 9(2), 126–134. https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%291084-0699%282004%299%3A2%28126%29

3. Barlow, P.M., and Leake, S.A., 2012, Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376, 84 p. Available online at: https://pubs.usgs.gov/circ/1376/

4. Booth, Eric, Jeffrey Mount, and Joshua Viers. Hydrologic Variability of the Cosumnes River Floodplain. San Francisco Estuary and Watershed Science. Vol. 4, Issue 2 [September 2006]. Article 2. http://repositories.cdlib.org/jmie/sfews/vol4/iss2/art2

5. Brunner, P., Cook, P. G., & Simmons, C. T. (2009). Hydrogeologic controls on disconnection between surface water and groundwater. *Water Resources Research*, *45*(1).

6. California Department of Water Resources (DWR), 2017, Sustainable Management Criteria Best Management Practice, dated November 2017, 38 pp.

7. Carollo Engineering. 2000. Bufferlands Master Plan. Chapter 2. Resource and Land Use Inventory. Prepared for Sacramento Regional County Sanitation District. Available online at: https://www.regionalsan.com/bufferlands-master-plan

8. County of Sacramento, City of Rancho Cordova, City of Galt, Sacramento County Water Agency, Sacramento Regional County Sanitation District, and the Southeast Connector Joint Powers Authority. 2018. Final South Sacramento Habitat Conservation Plan. January 2018. Sacramento, CA.

9. Fishery Foundation of California. 2004. Cosumnes River Passage Improvement Monitoring Program. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=5232

10. Fleckenstein J, Anderson M, Fogg G, Mount J, (2004). Managing Surface Water-Groundwater to Restore Fall Flows in the Cosumnes River. Journal of Water Resources

Planning and Management 130(4): 301-310. doi: 10.1061/(ASCE)0733-9496(2004)130:4(301)

11. Fleckenstein JH, Niswonger RG, Fogg GE, (2006). River-Aquifer Interactions, Geologic Heterogeneity, and Low Flow Management. Ground Water 44(6): 837-853. https://doi.org/10.1111/j.1745-6584.2006.00190.x

12. Florsheim, J.L., Mount, J.F., 2002. Restoration of floodplain topography by sand splay complex formation in response to intentional levee breaches, lower Cosumnes River, California. Geomorphology 44 (1–2), 67–94. https://doi.org/10.1016/S0169-555X(01)00146-5

13. Frei, S., Fleckenstein J.H., Kollet, S.J., Maxwell, R.M. 2009. Patterns and dynamics of river–aquifer exchange with variably-saturated flow using a fully-coupled model. Journal of Hydrology: Volume 375(3-4): 383-393. https://doi.org/10.1016/j.jhydrol.2009.06.038

14. GEI Consultants, Inc. 2016. South American Subbasin Alternative Submittal, 2014 Sustainable Groundwater Management Act, dated December 2016. Available online at: https://scgah2o.saccounty.net/Pages/South-American-Subbasin-Alternative-Submittal.aspx

15. Hall, M., Babbitt, C., Saracino A., and Leake S. (2018) Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act. *Environmental Defense Fund.*

16. Journel A G and Huijbregts C J 1978 Mining Geostatistics vol 43 (London: Academic) pp 563–4.

17. Kleinschmidt Associates. 2008. Cosumnes River Preserve Management Plan. Available online at: https://cosumnes.org/documents/managementplan.pdf

18. Levy, J., Wojnar, A., Mutiti, S. 2008. Investigating Riverbed Hydraulic Conductivity at Several Well Fields along the Great Miami River, Southwest Ohio. Prepared for Hamilton to New Baltimore Groundwater Consortium, the Miami Conservancy District, and the Ohio Water Development Authority. Available upon request.

19. Min, Leilei; Vasilevskiy, Peter Y..; Wang, Ping; Pozdniakov, Sergey P.; Yu, Jingjie. 2020. "Numerical Approaches for Estimating Daily River Leakage from Arid Ephemeral Streams" Water 12, no. 2: 499. https://doi.org/10.3390/w12020499

20. Mount, JF., Fogg G., Kavvas L., Fleckenstein J., Anderson M., Chen Z Q., & Suzuki E. 2001. Linked Surface Water-Groundwater Model for the Cosumnes River Watershed:

Hydrologic Evaluation of Management Options to Restore Fall Flows. U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. http://watershed.ucdavis.edu/pdf/Mount-et-al-USFWS-2007.pdf

21. Moyle, P.B., R. M. Quiñones, J. V. Katz and J. Weaver. 2015. Fish Species of Special Concern in California. Sacramento: California Department of Fish and Wildlife. www.wildlife.ca.gov

22. MWH. 2006. Central Sacramento County, Groundwater Management Plan, Prepared for Water Forum, and Sacramento County Water Agency, dated February 2006. Available online at: https://scgah2o.saccounty.net/pages/reports.aspx

23. Niswonger, R. G. (2006), Simulation Modeling and Ecological Significance of Perched System Hydrology, Ph.D. dissertation, 171 pp., Hydrol. Sci. Grad. Group, Univ. of Calif., Davis. https://search.proquest.com/dissertations-theses/simulation-modeling-ecological-significance/docview/305364827/se-2?accountid=14505

24. Niswonger, R. G., and G. E. Fogg (2008), Influence of perched groundwater on base flow, Water Resour. Res., 44, W03405, doi:10.1029/2007WR006160.

25. Niswonger, R. G., D. E. Prudic, G. E. Fogg, D. A. Stonestrom, and E. M. Buckland (2008), Method for estimating spatially variable seepage loss and hydraulic conductivity in intermittent and ephemeral streams, Water Resour. Res., 44, W05418, doi:10.1029/2007WR006626.

26. Regional Water Quality Control Board (RWQCB) Central Valley. 2017. ORDER NO. R5-2017-0096. NPDES NO. CA0084891. *Waste Discharge Requirements for The Boeing Company groundwater extraction and treatment systems GET HB, southern groundwater study area, and ADMIN GET Sacramento County*. Available online at: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2017-0096.pdf

27. RMC. 2015. Sacramento Central Groundwater Authority. Recharge Mapping and Field Study. Available online at: https://scgah2o.saccounty.net/pages/reports.aspx

28. Robertson-Bryan, Inc. 2006a. Cosumnes River Flow Augmentation Project. Available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/swrcb/swrcb_robertsonbryan2006.pdf

29. Robertson-Bryan, Inc. 2006b. Lower Cosumnes River Watershed Assessment. Available online at: https://www.cosumnes.org/wp-content/uploads/2015/05/LowerCosumnesWatershedAssessment.pdf

30. Robertson-Bryan, Inc. 2006c. Cosumnes & Mokelumne Rivers Floodplain Integrated Resources Management Plan. Floodplain Resources Characterization Report. Prepared for Southeast Sacramento County Agricultural Water Authority. Available online at: http://cmirmp.org/cmirmp/projectDocs/CMIRMP_Floodplain_Resources_Characterization_Report.pdf

31. Sacramento County, Department of Water Resources. 2009. Stormwater Quality Improvement Plan for County of Sacramento, and Cities of Citrus Heights, Elk Grove, Folsom, Galt and Rancho Cordova. Sacramento, CA. Available online at: https://www.beriverfriendly.net/documents/

32. Santos, N. R., Katz J. V. E., Moyle P. B., & Viers J. H. 2014. A programmable information system for management and analysis of aquatic species range data in California. *Environmental Modelling & Software*. 53: 13-26. Available online at: https://pisces.ucdavis.edu/

33. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for California. Available online. Accessed 2021/02/01.

34. State Water Resources Control Board (SWRCB). 2003. Draft Order WRO 2003-XXXX: Petition of Southern California Water Company - Order Denying Petition to Revise the Declaration of Fully Appropriated Streams to Allow Processing of Applications to Appropriate Treated Groundwater Discharged into the Lower American River (Sacramento County). Available online at: www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/american_river_fas

35. SWRCB. 2020. Application to appropriate water. http://www.ohwd.org/ESW/Files/OHWD_App_to_Appropriate_Water.pdf

36. Surface Water Resources, Inc. 2001. Aquatic Resources of the lower American River: Baseline Report. Draft Report. Prepared for the Lower American River Fisheries And Instream Habitat (FISH) Working Group. Funded by CALFED, Water Forum, SAFCA, and the City of Sacramento.

37. The Nature Conservancy (TNC). 2014. *Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management.*

38. The Nature Conservancy, California. ICONS: Interconnected Surface Water in California's Central Valley, Version 1.0.1. https://icons.codefornature.org/. March 2021.

39. University of California Davis (UC Davis). 1999. *Fish Species of the Cosumnes River Watershed*. Available online at: https://watershed.ucdavis.edu/doc/cosumnes-research-group/crg2-reports-and-publications

40. United States Bureau of Reclamation, 2000. American River Basin Study. US Department of the Interior.

41. U.S. Fish and Wildlife Service (USFWS). 1995. Draft anadromous fish restoration plan: A plan to increase natural production of anadromous fish in the Central Valley of California, Sacramento, Calif. www.fws.gov/lodi/anadromous_fish_restoration/documents/AFRP_RevDraftRestPlan.PDF

42. USFWS. 2007. Stone Lakes National Wildlife Refuges. *Comprehensive Conservation Plan.*

Appendix A: Hydrographs

Appendix 3-B

Table 1: RMP ID to SITE CODE key for groundwater level, storage, and ISW RMPs in the SASb

Appendix 3-B

Table 1: RMP ID to SITE CODE key for groundwater level, storage, and ISW RMPs in the SASb. This key is used to translate new RMP site IDs to older data tracking systems which may use DWR SITE CODEs identification numbers.

RMP ID	SITE CODE
RMP_01	382604N1214665W001
RMP_02	382939N1213904W001
RMP_03	MW_17
RMP_04	383009N1214224W001
RMP_05	MW_2
RMP_06	383270N1214736W001
RMP_07	383610N1214825W001
RMP_08	383728N1214548W001
RMP_09	MW_DR1
RMP_10	384125N1214946W001
RMP_11	384150N1213239W001
RMP_12	384202N1213738W001
RMP_13	ACR_13
RMP_14	384343N1214615W001
RMP_15	ACR_14
RMP_16	384425N1213031W001
RMP_17	384532N1212856W001
RMP_18	ACR_16
RMP_19	384738N1214249W001
RMP_20	384783N1212311W001
RMP_21	384798N1212614W001
RMP_22	384931N1211797W001
RMP_23	ACR_76
RMP_24	385021N1214948W001
RMP_25	385038N1212203W001
RMP_26	385190N1213015W001
RMP_27	385223N1213630W001
RMP_28	ACR_77
RMP_29	385343N1214280W001
RMP_30	385469N1213389W001
RMP_31	385543N1212592W001
RMP_32	385578N1213240W001

RMP_33	SS_MW1
RMP_34	SS_DWR2D
RMP_35	SS_DWR3D
RMP_36	385707N1211868W001
RMP_37	385784N1214655W001
RMP_38	385849N1213173W001
RMP_39	ARJ1256
RMP_40	385914N1212475W001
RMP_41	385923N1211621W001
RMP_42	ARJ188
RMP_43	ARJ3390
RMP_44	386578N1211879W001
RMP_45	386895N1211169W001

Appendix 3-C

Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria (October 1, 2021)

Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria

Larry Walker Associates

2021-10-01

Table of Contents

1. Executive Summary 3

2. Introduction 5

3. Methods 6

3.1 Groundwater level 7

3.2 Well Completion Reports (WCRs) 9

3.4 Projected groundwater management and climate change 9

3.3 Classification of failing wells and cost estimate 11

4. Results 12

4.1 Groundwater levels 12

4.2 Well inventory and characteristics 19

4.3 Well impacts: location, count, and cost 24

4.4 Estimated cost 25

5. Discussion 26

6. Conclusion 27

7. References 28

1. Executive Summary

Groundwater planning under the Sustainable Groundwater Management Act (SGMA) aims to curb the chronic lowering of groundwater levels, which may impacts shallow, vulnerable wells and cause dewatering or failure. Relatively shallow residential, agricultural, and public wells (henceforth "vulnerable wells") in the South American Subbasin (SASb) are beneficial uses of groundwater identified by stakeholders in the SASb groundwater sustainability plan (GSP) working group. Residents and water users in the SASb that rely on drinking water obtained from private domestic wells are considered beneficial users of groundwater. The GSP aims to avoid chronic groundwater level decline that leads to significant and unreasonable impacts to vulnerable wells that hamper access to water for drinking, irrigation, and municipal use.

Although shallow wells in the SASb provide beneficial uses of groundwater, the SASb lacks a comprehensive well census (i.e., inventory) and understanding of how sustainable management criteria (SMC) may impact vulnerable wells in the SASb. These knowledge gaps motivate this memorandum, which aims to provide a well inventory based on best available data, and well protection analysis to inform critical decision-making in support of unstainable groundwater management in the SASb.

No wells in the SASb were reported dry during the past 2012-2016 drought. Herein, we assess potential impacts to vulnerable wells that may result during the SGMA planning and implementation period (2022-2042). First, we take inventory of wells in the SASb using publicly available, digitized well completion reports to describe the location and depths of different types of wells (e.g., domestic, public, agricultural). Next, we analyze historical groundwater elevation trends in the SASb from 2005-2018. Then, we combine well construction data and modeled groundwater levels to assess the count and location of impacted wells assuming different groundwater level scenarios (i.e., a return to the fall 2015 low, and 4 projected groundwater management and climate change scenarios). Finally, we estimate costs to rehabilitate impacted wells and advance recommended sustainable management criteria that mitigate impacts to vulnerable wells.

Results suggest that the most common well types with direct beneficial uses are domestic (n = 2,600), agricultural (n = 532), and public (n = 237) wells[1], although the actual number of "active" wells today is likely less due to ageing and well retirement. Assuming 31 to 40 year retirement ages (based on Pauloo et al, 2020), and that wells with pumps above initial groundwater level conditions are inactive, the number of

[1] At the time of writing (2021-06-18), these are the well counts provided by the online well completion report database. Note that public wells are "municipal" wells, and domestic wells are private residential wells.

assumed active wells in the SASb is much lower: domestic (n = 372 - 709), agricultural (n = 72 - 99), and public (n = 62 - 101). An ongoing well "census" would be supersede these data, but in its absence, this approach provides a reasonable approximation of the count and location of active wells.

During fall of 2015, groundwater levels reach a [modern] historical low in the SASb after four consecutive years of drought and excess pumping to augment lost surface water supply. Data from the DWR and Cal OPR suggests that during this time, no wells in the SASb were reported dry, in contrast to more than two thousand wells reported dry across California (Pauloo et al, 2020)[2]. Thus, a return to Fall 2015 groundwater level lows is unlikely to result in catastrophic and widespread well impacts, which we confirm via modeling described in this memorandum.

Working group input indicated significant and undesirable results to include 5% or more of impacted wells of any type (domestic, agricultural, public). Thus, well impact analysis under projected groundwater level conditions was evaluated to assess impacts assuming a return to historic Fall 2015 lows, and projected groundwater management and climate change scenarios. Results suggest that even assuming a worst-case climate change scenario with no projects and management actions (PMA) – which is unlikely as PMA are already underway – all well types are unlikely to impacted at the 5% undesirable result threshold.

Well protection analysis thus informed the creation of minimum thresholds (MTs) which avoid significant and unreasonable impacts to wells in the basin. Well rehabilitation costs for impacted wells over the implementation horizon, assuming all MTs are reached at all representative monitoring points (RMPs), were estimated at around $300,000 - $700,000 following the cost structure of Pauloo et al. (2021), EKI (2020), and Gailey (2019), but would likely be less, as significant and unreasonable impacts occur when 25% of RMPs exceed MTs.

Possible well protection measures may include a combination of regional groundwater supply and demand management (e.g., managed aquifer recharge and pumping curtailments that increase or maintain groundwater levels); well protection funds to internalize well refurbishment and replacement costs; domestic supply management, (e.g., connecting rural households to more reliable municipal water systems); and proactive community-based monitoring that acts as an early warning systems to anticipate impacts at the level of individual wells.

[2] Outage data analyzed by Pauloo et al (2020) was provided via an agreement between Cal OPR and the authors, but has since been released by the DWR at MyDryWaterSupply: https://mydrywatersupply.water.ca.gov/report/publicpage.

2. Introduction

Around 1.5 million Californians depend on private domestic wells for drinking water, about one third of which live in the Central Valley (Johnson and Belitz 2016). Even fewer reside in the South American Subbasin (SASb), and these wells tend to be in mixed agricultural-residential land. Private domestic wells are more numerous than other types of wells (e.g., public or agricultural), and tend to be shallower and have smaller pumping capacities, which makes them more vulnerable to groundwater level decline (Theis 1935; Theis 1940; Sophocleous 2020; Greene 2020; Perrone and Jasechko 2019). During previous droughts in California, increased demand for water has led to well drilling and groundwater pumping to replace lost surface water supplies (Hanak et al 2011; Medellín-Azuara et al 2016). Increased pumping lowers groundwater levels and may partially dewater wells or cause them to go dry (fail) altogether. During the 2012–2016 drought, 2,027 private domestic drinking water wells in California's Central Valley were reported dry (Cal OPR 2018). Notably, zero dry wells were reported in the SASb, which suggests a combination of relatively stable groundwater levels and more favorable well construction properties (e.g., deeper wells and pump locations). Moreover, this observation implies that a return to 2015 low groundwater levels is unlikely to cause widespread and catastrophic well failure in the SASb.

Until recently, few solutions and data products existed that addressed the vulnerability of shallow wells to drought and unsustainable groundwater management (Mitchell et al. 2017; Feinstein et al. 2017). A lack of well failure research and modeling approaches can largely be attributed to the fact that well location and construction data (well completion reports, or WCRs) were only made public only in 2017. Released digitized WCRs span over one hundred years in California drilling history and informed the first estimates of domestic well spatial distribution and count in the state (Johnson and Belitz 2015; Johnson and Belitz 2017). Since then, these WCRs, provided in the California Online State Well Completion Report Database (CA-DWR 2018), have been used to estimate failing well locations and counts (Perrone and Jasechko 2017), and domestic well water supply interruptions during the 2012–2016 drought due to overpumping and the costs to replenish lost domestic water well supplies (Gailey et al 2019). A regional aquifer scale domestic well failure model for the Central Valley was developed by Pauloo et al (2020) that simulated the impact of drought and various groundwater management regimes on domestic well failure. More recently, Bostic and Pauloo et al (2020), EKI (2020), and Pauloo et al (2021), estimated the impact of reported groundwater level minimum thresholds in critical priority basins on domestic wells across California's Central Valley and found that thousands of domestic wells were potentially vulnerable.

California's snowpack is forecasted to decline by as much as 79.3% by the year 2100 (Rhoades et al 2018). Drought frequency in parts of California's Central Valley may increase by more than 100% (Swain et al 2018). A drier and warmer climate (Diffenbaugh 2015; Cook 2015) with more frequent heat waves and extended droughts (Tebaldi et al 2006; Lobell et al 2011) will coincide with urban development and population growth, land use change, conjunctive use projects, and implementation of the Sustainable Groundwater Management Act (SGMA 2014), in which groundwater

sustainability plans (GSPs) will specify groundwater level minimum thresholds (MTs) that among other outcomes, protect vulnerable wells.

In this technical memorandum, we analyze how projected hydrologic conditions, projects and management actions (PMA), and climate change may impact vulnerable wells in the SASb. In Section 3, the methodology is explained, followed by the results in Section 4, and a discussion of the results in terms of how they impact sustainable groundwater management in Section 5. This memorandum closes with a discussion of future actions and SGMA management recommendations.

3. Methods

Key data that inform this analysis include seasonal groundwater level measurements taken by various state-level and local sources, and well completion reports (WCRs) from the California Department of Water Resources (CA-DWR 2018).

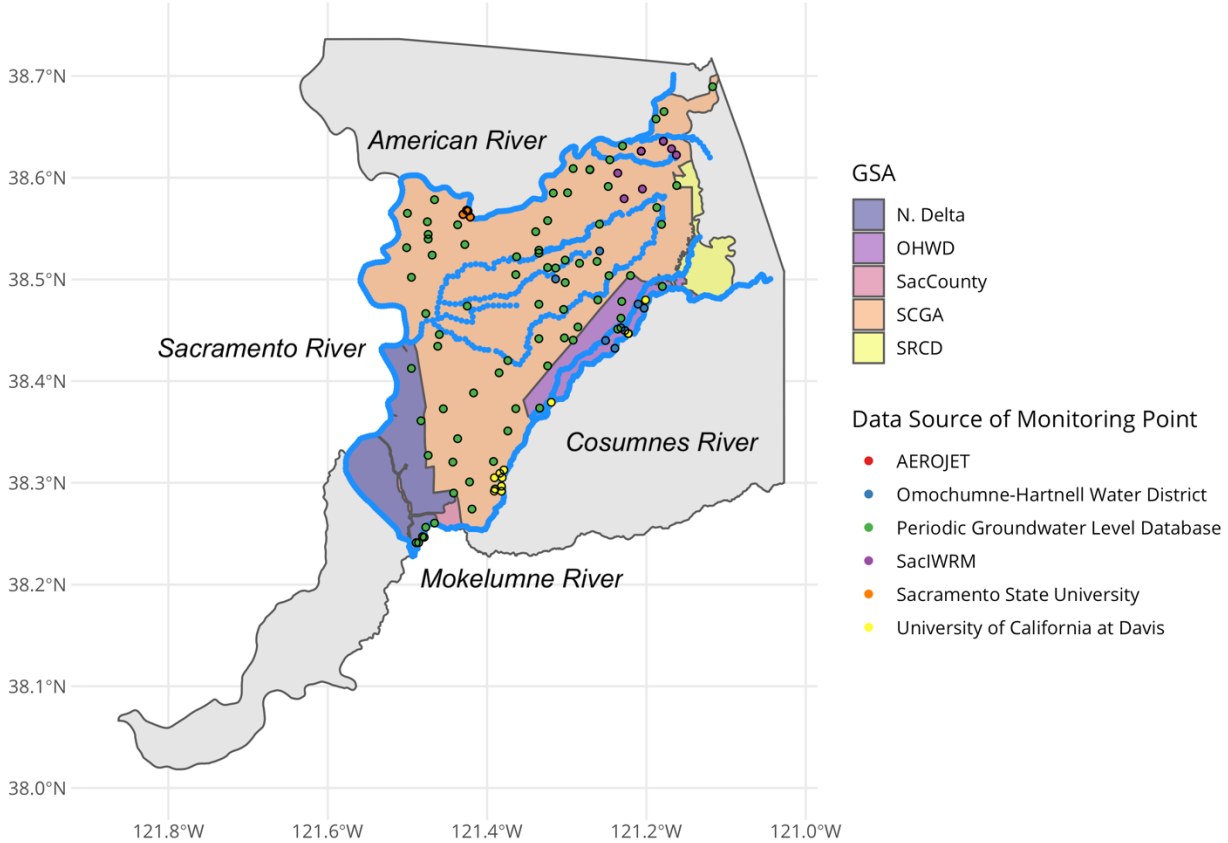


Figure 1. The South American Subbasin is an alluvial aquifer-aquitard system in California's Sacramento County (grey) housing 5 GSAs, and bordered by the American, Cosumnes, Mokelumne, and Sacramento Rivers on the north, east, south, and west boundaries respectively. Representation of these major surface water bodies in the Cosana integrated hydrologic model (including interior creeks) are shown in blue. Groundwater level monitoring points are colored by the data source of the monitoring point. Monitoring points outside of the SASb which were used in the groundwater level interpolation are not shown.

3.1 Groundwater level

Historic and present-day groundwater conditions were analyzed using all available data from six sources (Figure *1*):

(1) California Department of Water Resources (DWR) Periodic Groundwater Level Database
(2) University of California at Davis (UCD) monitoring network
(3) Omochumne-Hartnell Water District (OHWD) monitoring network
(4) Sacramento State monitoring wells
(5) Aerojet
(6) Sac IWRM

Most groundwater level data is collected biannually in spring and fall and intended to capture seasonal variation – notably due to winter recharge and pumping and recharge during the dry growing season. In the SASb, periodic groundwater level data measurements peak in April and October (Figure 2).

Biannual seasonal groundwater level within the Sacramento Central Groundwater Authority (SCGA) jurisdictional boundary has been measured for decades; these measurements account for most of the spatial spread of groundwater level observations in the SASb and can be found in the DWR Periodic Groundwater Level Database [source (1) above]. Three additional networks, either established or maintained by UCD, OHWD, and Sacramento State all collect high-frequency, 15-minute interval groundwater elevation data. The UC Davis network (2) is situated on land owned by the Nature Conservancy and has collected data fall of 2012, the OHWD network (3) has collected data since fall of 2018, and the Sacramento State network (4) has collected data since spring of 2016. Aerojet monitoring wells (5) used in this study have been collecting data since 1982 and are actively monitored as part of on-site monitoring and remediation actions. Sac IWRM (6) is hydrologic model that includes the SASb and incorporates historic groundwater monitoring data; most of these data are included in (1). Duplicate measurements between data sources were reconciled by comparing monitoring site identification codes and position (latitude and longitude).

Groundwater levels were assessed at biannual seasonal intervals during the period from spring 2005 to fall 2018 and encompass what can be considered "historic"[3] to approximately "present-day" seasonal conditions. This temporal range was selected because poor data density prior to spring 2005 and after fall 2018 prohibits meaningful analysis. "Spring" was defined as the months of March, April, and May and "fall" was defined as the months of August, September, and October.

[3] Importantly, this period contains the recent 2012-2016 drought.

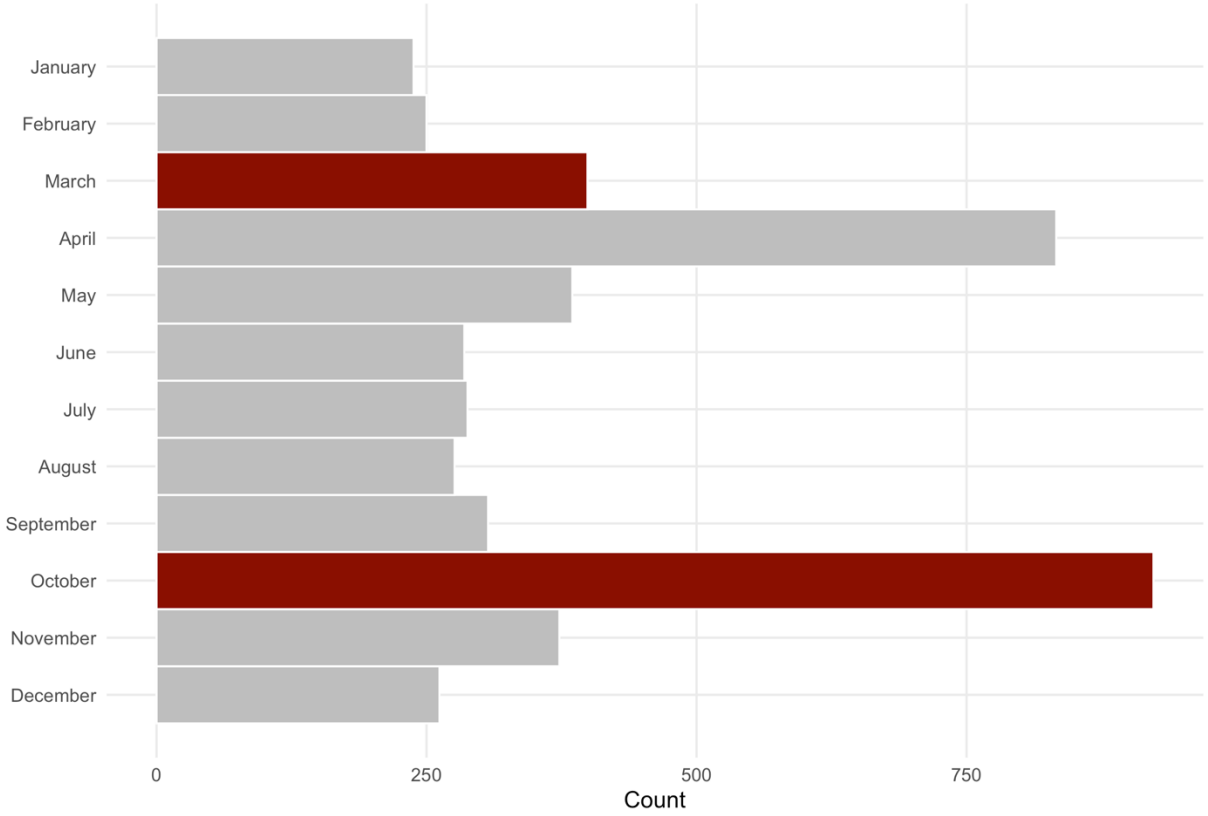


Figure 2: Periodic groundwater level measurements (2000-2021) reported by DWR in the South American Subbasin indicate peaks of seasonal data collection in April and October although DWR Best Management Practices indicate that monitoring wells should collect at least biannual measurements in spring (mid-March) and fall (mid-October) (CA-DWR, 2017). March and October are highlighted in the graph above, and roughly agree with historical data collection trends. It is especially important in dry years to monitor in mid-March, because pumping may begin as early as April; thus, a March measurement in a such a dry year provides a more accurate representation of ambient spring groundwater level. Consistent data collection in March and October ensures data comparability across years.

At each monitoring location, the average groundwater level measured during spring and fall was computed by taking the grouped mean of observations in each spring and fall respectively. Next, to improve spatial data density and ascertain long-term regional trends, data were arranged in 4-year running seasonal means. For example, the 2005-2008 spring level is defined as the average spring groundwater elevation in 2005, 2006, 2007, and 2008. A four-year sliding window was applied to data from 2005 to 2018, resulting in 22 seasonally averaged groundwater elevation conditions (e.g., spring 2005-2009, fall 2005-2009, …, spring 2015-2018, fall 2015-2018). Windows of differing length (e.g., 1, 2, and 3-year long running means) were explored but resulted in larger groundwater level variance due to a lack of adequate spatial density, and hence, not used. By contrast, 4 year running means gave adequate regional spatial data density and were not so long in duration as to dampen the impact of significant dry periods such as the 2012-2016 drought.

After data were grouped into seasonal 4-year windows, ordinary kriging[4] (Journel A.G. and Huijbregts, 1978) was applied to groundwater elevation measurements to generate groundwater level surfaces across the SASb at a 500 meter (0.31 mile) resolution. In order to minimize boundary effects, monitoring well data within a 20 kilometer (12.4 mile) buffer of the SASb were included, which effectively incorporates groundwater level data from the Cosumnes and North American subbasins, and Yolo county to the west of the Sacramento river. Groundwater level measurements were screened to include data from wells shallower than 300 feet in total completed depth to reflect conditions in the unconfined to semiconfined production aquifer, which are comparable to heads in layers 2-3 of Cosana. All monitoring points were further intersected with the Cosana model grid, and 99.4% of observations at wells occur within the Alluvium, Laguna, and Mehrten layers. 0.6% of observations occur in the Ione and Valley Springs.

3.2 Well Completion Reports (WCRs)

The well completion report database (CA-DWR, 2020) was used to filter and clean WCRs within the SASb. Similar well types were grouped into categories (e.g., "domestic", "private residential", and "residential" were all grouped together) to enable analysis of wells by type. The majority of wells are accurate to the centroid of the nearest section in the PLSS Survey system (1 square mile grid cells). All wells reviewed in the SASb had a total completed depth.

3.4 Projected groundwater management and climate change

Well impacts are characterized in terms of historical data but also in terms of future, anticipated hydrology. Forward-simulated hydrologic conditions using the Cosana groundwater flow model were used to estimate the impact to vulnerable wells from:

- the combined effects of projected water use in the Basin;
- projects and management actions (PMA) already underway (Harvest Water, OHWD[5] recharge, and regional conjunctive use); and
- climate change.

[4] An exponential variogram model was used, and results did not appreciably differ from linear or spherical models. Stationarity across the unconfined to semiconfined aquifer is a reasonable assumption in the unconsolidated, alluvial aquifer-aquitard system that spans the South American subbasin and adjacent subbasins, which exhibit relatively continuous geology across borders. Data outliers were controlled by removing tails of the distribution above and below the 97.5th and 2.5th percentiles respectively. Groundwater elevations were approximately normal in distribution, thus log-transformation and exponentiation after kriging was not required.

[5] OHWD = Omochumne - Hartnell Water District

Key model outputs include future groundwater basin storage and groundwater level. Storage provides a big picture overview of the change in available groundwater in the basin, and groundwater level shows the spatially distributed result of management actions, which are then used to evaluate well impacts.

In the presentation of results (Section **Error! Reference source not found.**), groundwater level conditions in the current conditions (baseline) are compared to groundwater level conditions in the scenarios evaluated. Five scenarios are compared:

- ***Baseline***: current conditions
- ***Projected***: projected groundwater use (i.e., business as usual with increased demand)
- ***Projected CC***: projected groundwater use with a median climate change warming scenario[6]
- ***Projected PMA***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use)
- ***Projected PMA CC***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use) and with a median climate change warming scenario

Differences in groundwater level between each of the scenarios and the "baseline" inform how wells in the basin may respond to projected groundwater management and climate change. These differences are applied to observed data to translate model estimates of change to observed data. For example, to estimate the change in vulnerable well impacts under each scenario, the groundwater level differences implied by each scenario at a Fall 2015 reference point were evaluated by the model, then this difference was applied to the measured and interpolated Fall 2015 level. Fall 2015 was chosen as a reference point because it represents a recent historical minimum in groundwater level across the basin.

[6] Climate change (CC) scenarios are driven by changes in temperature and streamflow provided by the American River Basin Study (USBR, 2020) "central tendency" scenario, which reflect median temperature and precipitation outcomes.

3.3 Classification of failing wells and cost estimate

The initial set of wells to consider are a subset of all domestic wells in the WCR database. Wells are removed based on the year in which they were constructed[7], and their estimated pump location relative to the initial groundwater level condition prior to impact analysis. In other words, wells that are likely to be inactive, or already dry at the initial condition are not considered, and do not count towards the well impact count.

Next, we assign a "critical datum"[8] to each well, equal to 30 feet above the total completed depth, roughly 3 times the height of water column required to prevent decreased well function and cavitation as calculated by Pauloo et al 2020 using standard assumptions of pumping rate, net positive suction head, barometric pressure head, vapor pressure, and frictional losses (see Pauloo et al 2020, SI Appendix Section S2.3). If groundwater level scenarios imply a groundwater elevation below this critical datum, the well is considered "impacted" and may require pump lowering or well deepening to rehabilitate it (Figure 3).

In reality, wells dewater and experience reduced yield when the groundwater level approaches the level of the pump. However, for the purposes of this study, we assumed wells maintain the net positive suction head (Tullis 1989) required to provide uninterrupted flow until groundwater falls below the critical datum. At this point, we assume the well needs replacement (i.e., a well deepening event). Therefore, the well impact estimates provided in this study should be interpreted as a worse-case scenario wherein wells can no longer access reliable groundwater and are deepened. In most cases, pumps will be able to be lowered into the 30 foot operating margin prior to a deepening event – this is more affordable than a well deepening, so the cost estimate is conservative in this sense.

[7] Two previous studies estimate well retirement ages at 28 years in the Central Valley (Pauloo et al 2020), and 33 years in Tulare county (Gailey et al 2019), thus, we use the average of these two studies and remove wells older than a retirement age of 31 years. To account for uncertainty in the well retirement age, we also consider another well retirement age of 40 years. Importantly, these numbers reflect mean retirement ages in the retirement age distribution. Although some wells in the population may be active for longer than 31 or 40 years, some will also retire before 31 or 40 years. Thus, results should be interpreted as an average estimate of well impacts.

[8] A standard approach for the choice of a critical datum is not well established. Other studies (e.g., Gailey et al, 2019; Pauloo et al, 2020; Bostic and Pauloo et al, 2020; Pauloo et al, 2021) estimate pump locations in different ways. Since considerable uncertainty exists in estimating pumps at a local scale, but WCR data for total completed depth is present and reliable for nearly all wells in the dataset, it is favored. An operating margin of 30 feet added to the bottom of each well's total completed depth is a reasonable column of water necessary for the well to properly function, although wells with greater pumping capacities may require a longer water column.

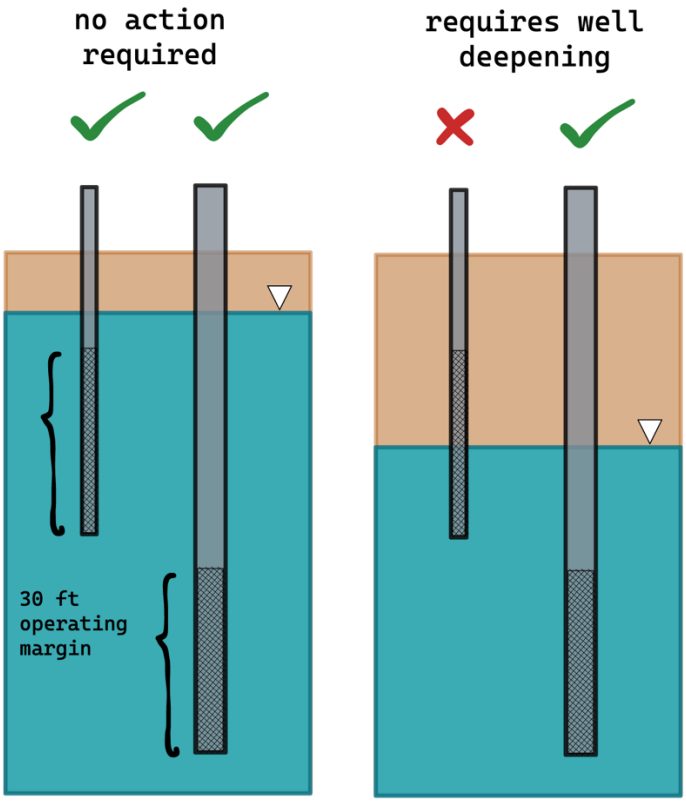


Figure 3: Wells are assigned a 30 foot operating margin above the total competed depth. When groundwater levels are above this "critical datum" at a well, the well is active (left), and the well is impacted when the groundwater falls below the critical datum, which triggers a well deepening event. Note that in reality, cones of depression form around active pumping wells, but are not shown in the figure above for simplicity.

To compute rehabilitation costs, it is assumed that if the groundwater level falls below the total completed depth of the well plus an operating margin of 30 ft, a well deepening rehabilitation event is assumed to take place. Well deepening is estaimted at $21,500 per domestic well, and $100,000 per agricultural and public well. We neglect costs associated with increased lift, as these constitute around 1% of total costs estimated by EKI, 2020. We also neglect costs associated with screen cleaning, as this action is unlikely to yield significant additional water when groundwater levels have fallen below the critical datum.

4. Results

4.1 Groundwater levels

Groundwater level analysis in this memorandum is consistent with that conducted in another technical memorandum attached to Section 3 of the SASb GSP. A detailed treatment of groundwater level results is provided in Appendix C: Interconnected Surface Water (ISW) Section 4.1, and a summary is provided here.

Groundwater elevations show seasonal oscillation (Figure 4, Figure 5) and increasing depth to groundwater in the northeast direction away from the Bay Delta (Figure 6).

Key groundwater levels include the initial condition (spring 2018), and 5 boundary conditions at which well impacts are evaluated. The first boundary condition is the Fall 2015 low, and the remaining four boundary conditions are defined by differences in groundwater elevation projected by the Cosana groundwater level scenarios (see Section 3.4 Projected groundwater management and climate change and Figure 7). The impact of projects and management actions (PMA) on groundwater levels is substantial: Harvest Water accounts for upwards of 25 feet of projected increase in groundwater level in the center of the project area (Figure 8). Importantly, to scope the severity of well impacts at potential MTs, for each scenario and at each location in the SASb, the lower of the Fall 2015 groundwater level and the projected scenario was used as a boundary condition.

Change in basin groundwater storage (Figure 9) indicates that projected management and projected management with PMA increase basin storage over the SGMA implementation horizon, whereas climate change reduces groundwater levels (assuming constant land use and ET commensurate with increased temperature).

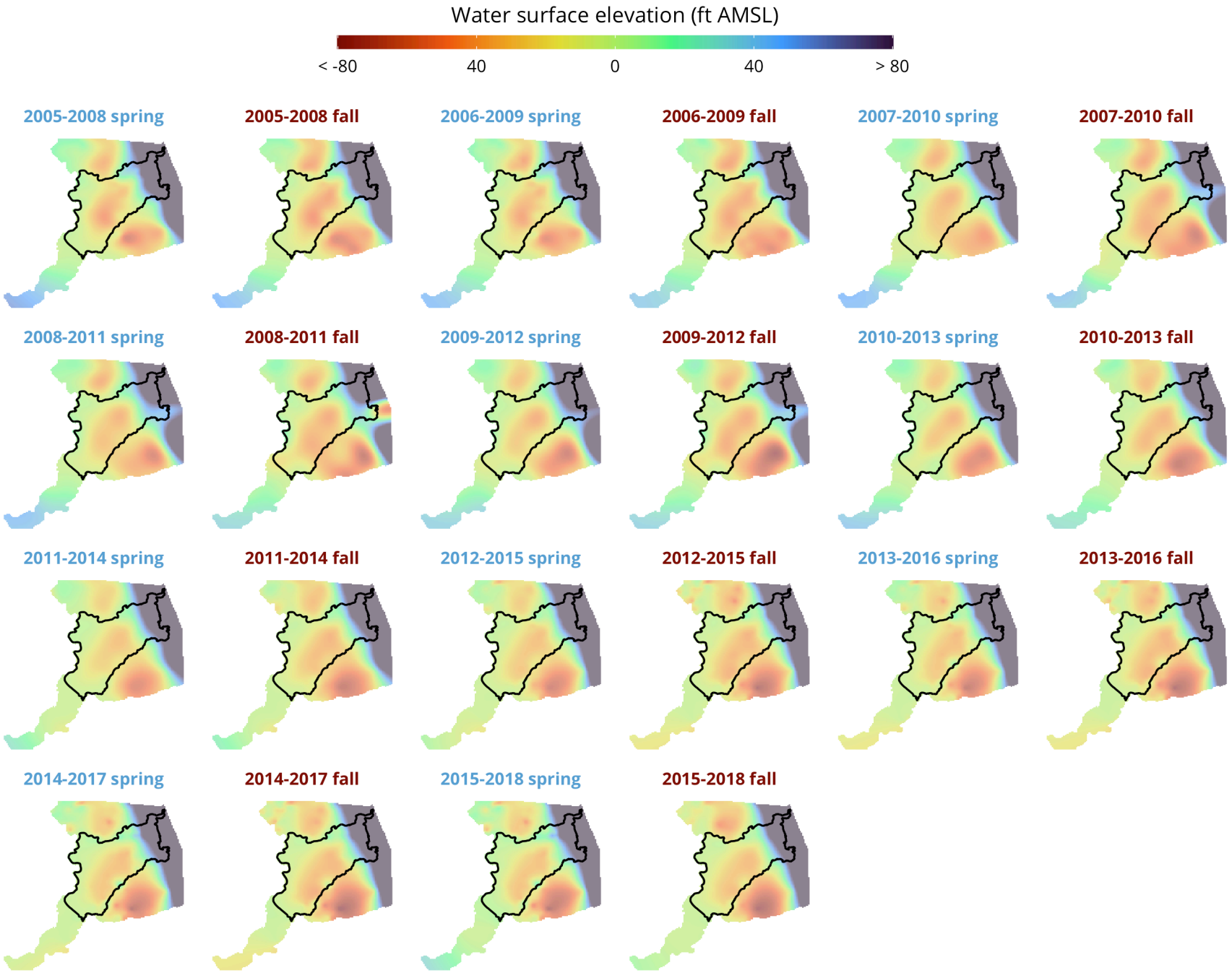

Water surface elevation (ft AMSL)
< -80
40
0
40
> 80
2005-2008 spring
2005-2008 fall
2006-2009 spring
2006-2009 fall
2007-2010 spring
2007-2010 fall
2008-2011 spring
2008-2011 fall
2009-2012 spring
2009-2012 fall
2010-2013 spring
2010-2013 fall
2011-2014 spring
2011-2014 fall
2012-2015 spring
2012-2015 fall
2013-2016 spring
2013-2016 fall
2014-2017 spring
2014-2017 fall
2015-2018 spring
2015-2018 fall

Figure 4: Seasonal, 4 year running mean interpolated groundwater elevations in the South American Subbasin from spring 2005 to fall 2018 show seasonal oscillation, with generally higher (blue) groundwater elevation in spring, and generally lower (red) groundwater elevation in the fall. Groundwater flows from areas of high (blue) to low (red) elevation groundwater elevation. Groundwater elevation mapping indicates groundwater flow inwards towards the center of the basin, coincident with areas of groundwater pumping.

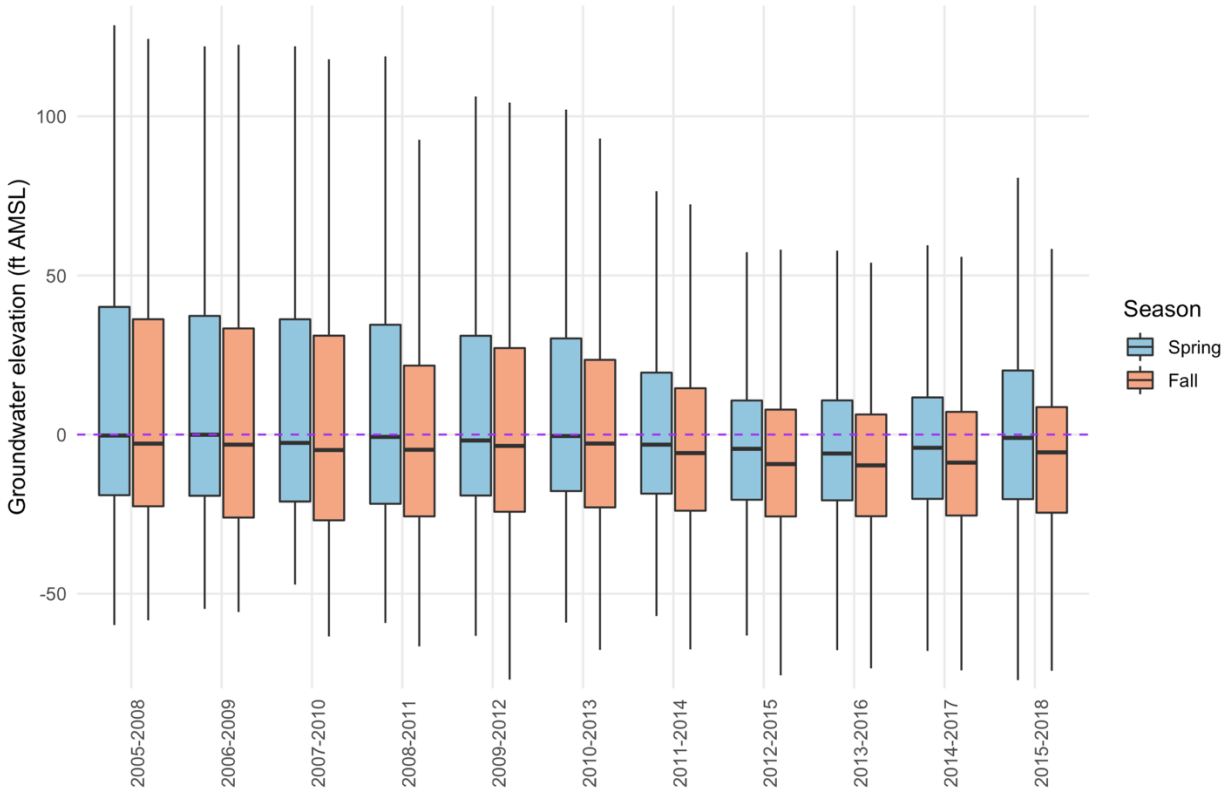


Figure 5: Seasonal summary of interpolated groundwater elevations in the SASb (Figure 4) show oscillating seasonal medians, with consistently higher groundwater elevation in spring, and lower groundwater elevation in fall. Median fall groundwater elevation decreases over the period of record and reaches its lowest value during the average period of 2013-2016 due to the combined impact of 4 years of drought. After this minimum, spring and fall median groundwater levels trend upward. A purple, horizontal dashed line is shown at mean sea level elevation (0 feet) for reference.

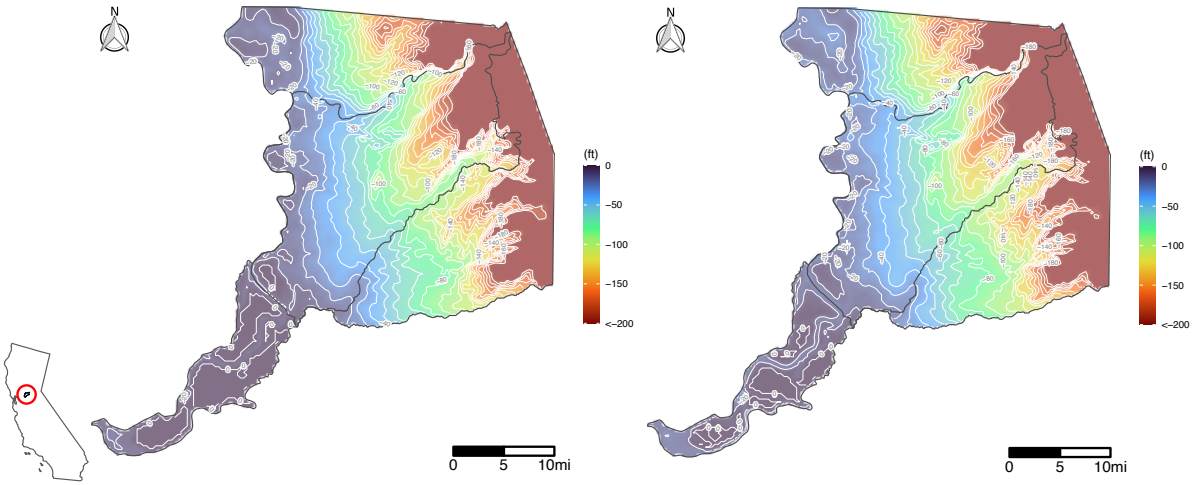


Figure 6: Depth to groundwater in the SASb for average spring (left) and fall (right) conditions across the entire period of record evaluated (2005-2018).

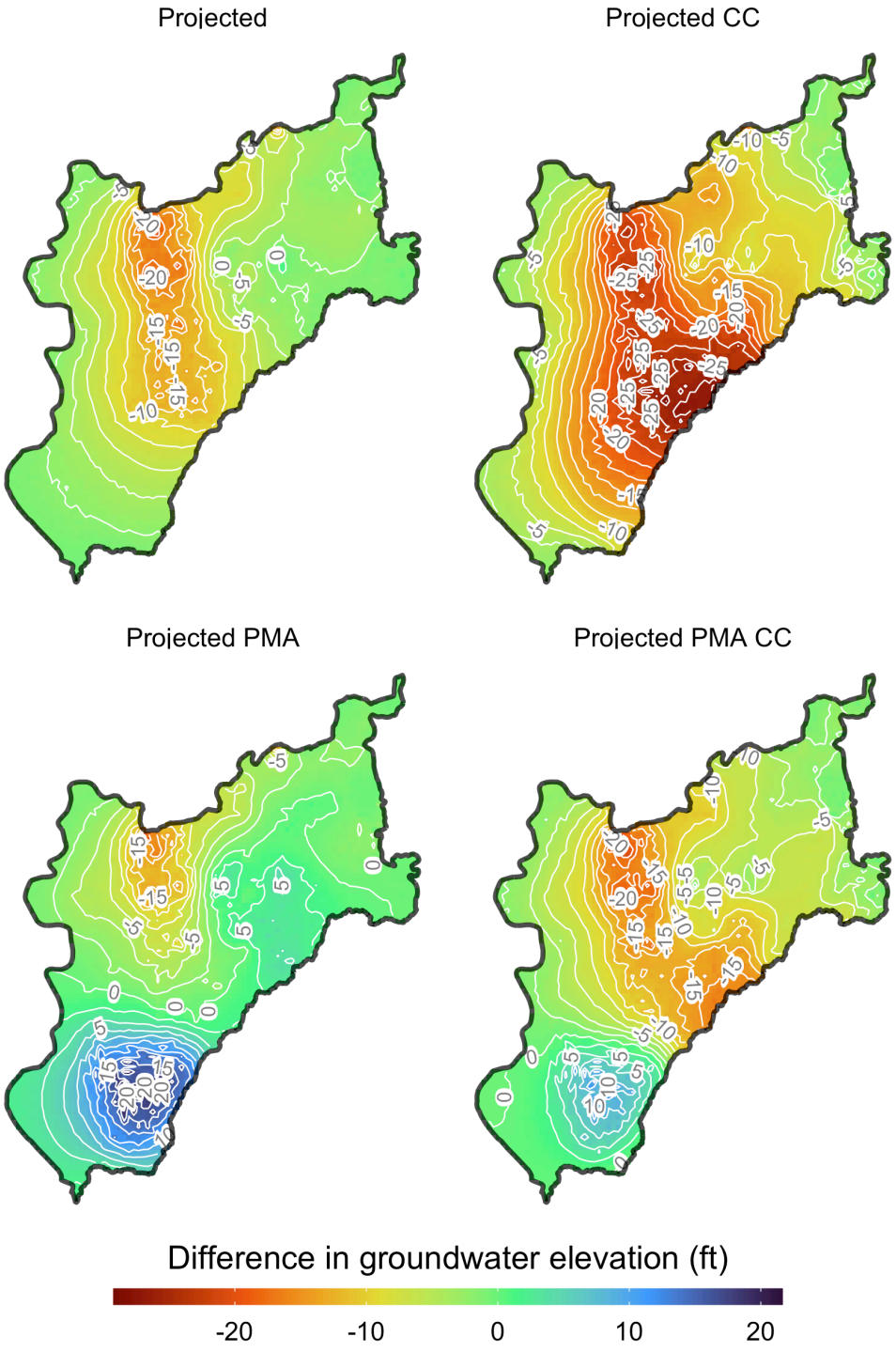


Figure 7: Modeled difference in groundwater level between each of the scenarios and the current conditions baseline at a Fall 2015 benchmark. PMA lead to substantial increases in groundwater level. Climate change projections lead to groundwater level declines, but assume no corrective action or land use change. In reality, climate change would require specialized adaptive management to avoid significant and unreasonable impacts to beneficial users, particularly ISW.

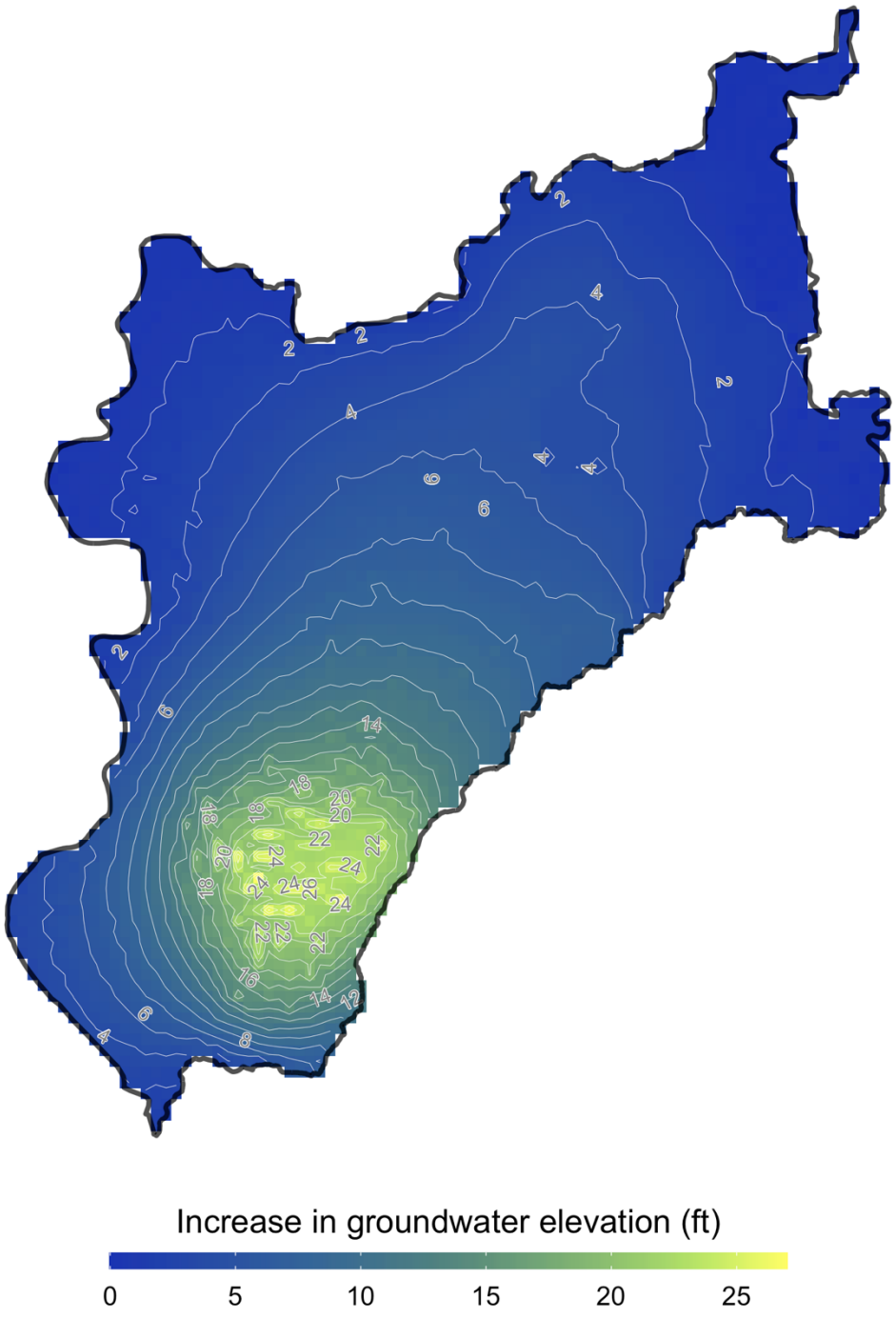


Figure 8: The difference in groundwater elevation between the "Projected PMA" and "Projected" scenarios shows the spatial distribution of groundwater level increases estimated to result from implementing PMA. Increases in groundwater level are observed across the basin and concentrated near the Harvest Water recharge site.

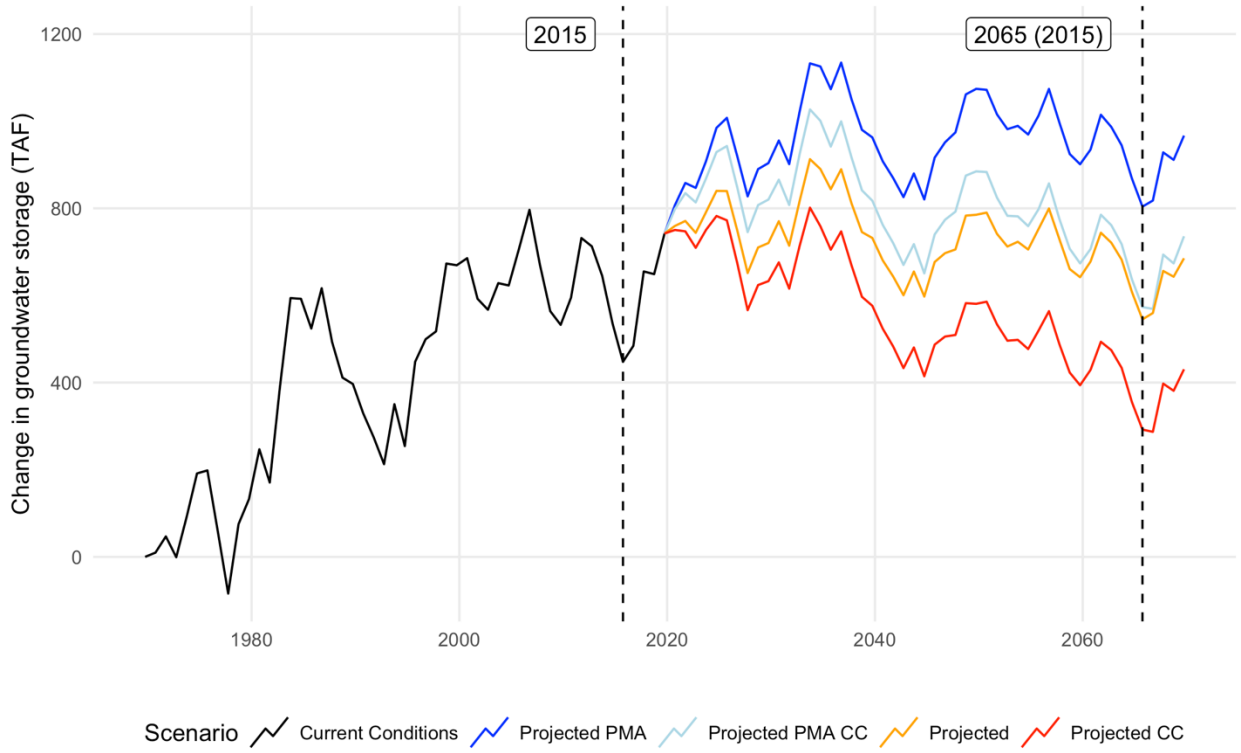


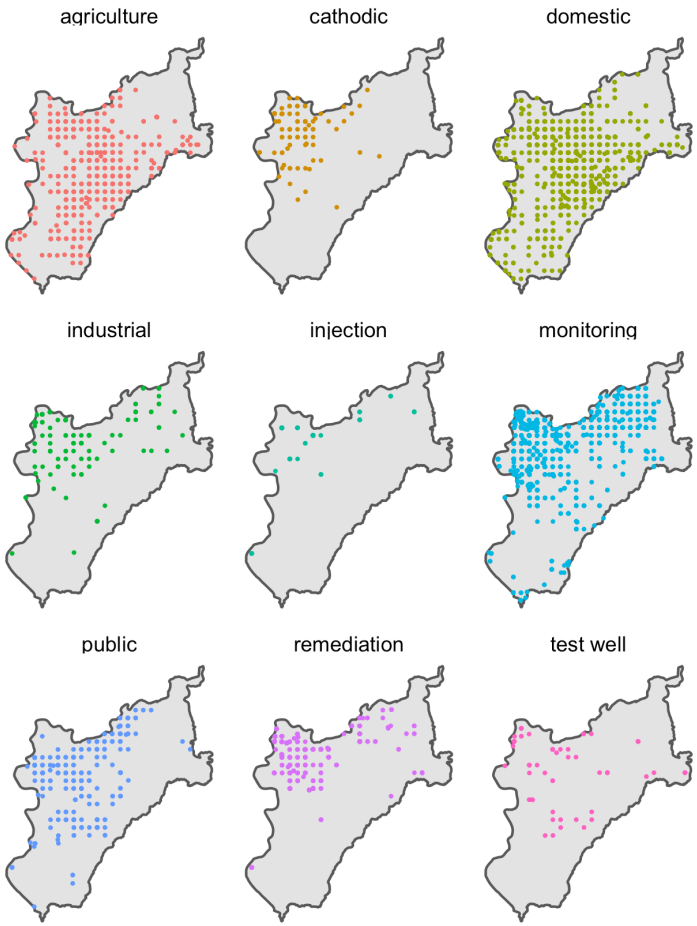
Figure 9: Cumulative change in groundwater storage under the current conditions baseline (black line), and the four scenarios (dark blue, light blue, orange, and red line). Importantly, projects and management actions (PMA) increase storage, and climate change (CC) reduces storage. A black dashed line shows where groundwater level differences are calculated between the projected scenarios and the current conditions baseline (Fall 2015) to maintain consistency.

4.2 Well inventory and characteristics

Results suggest that the most common well types (

Figure 10) with direct beneficial uses are domestic (n = 2,600), agricultural (n = 532), and public (n = 237) wells[9], although the actual number of "active" wells today is likely less due to ageing and well retirement. Assuming 31 to 40 year retirement ages (Figure 11), and that wells with pumps above initial groundwater level conditions are inactive, the number of assumed active wells in the SASb is much lower: domestic (n = 372 - 709), agricultural (n = 72 - 99), and public (n = 62 - 101). Most wells that provide beneficial uses (public, agricultural, domestic) bottom out in the Laguna and Mehrten formations (Figure 12), which constitute a principal aquifer from which transmissivity-weighted heads are extracted from the Cosana model and used to evaluate changes in groundwater level.

[9] At the time of writing (2021-06-18), these are the well counts provided by the online well completion report database. Note that public wells are "municipal" wells, and domestic wells are private residential wells.



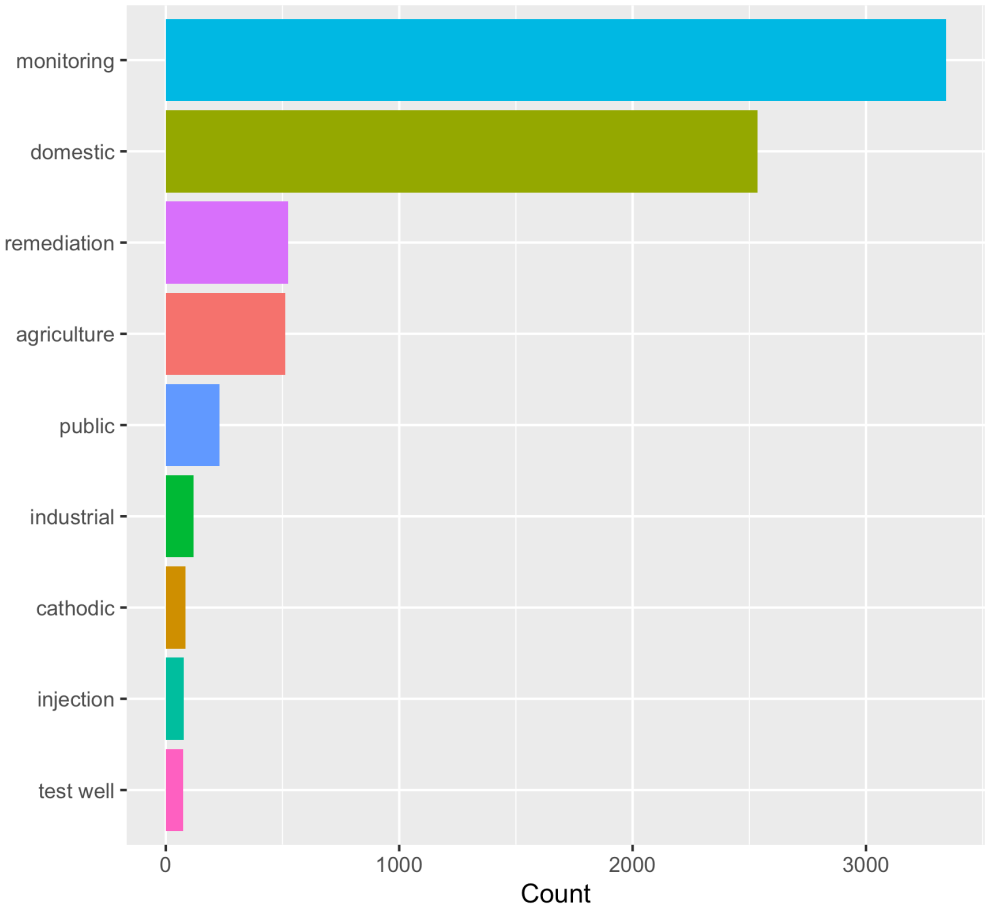


Figure 10: Well inventory of the SASb. Locations and counts do not consider retirement age, thus these wells do not reflect the location and count of active wells, but rather, all wells ever drilled for which records exist. Notice that agricultural, public, and domestic wells are collocated, and that domestic wells outnumber agricultural and public wells. Well locations appear in a grid like pattern because the accuracy of most wells is to the nearest PLSS section (1 square mile grid).

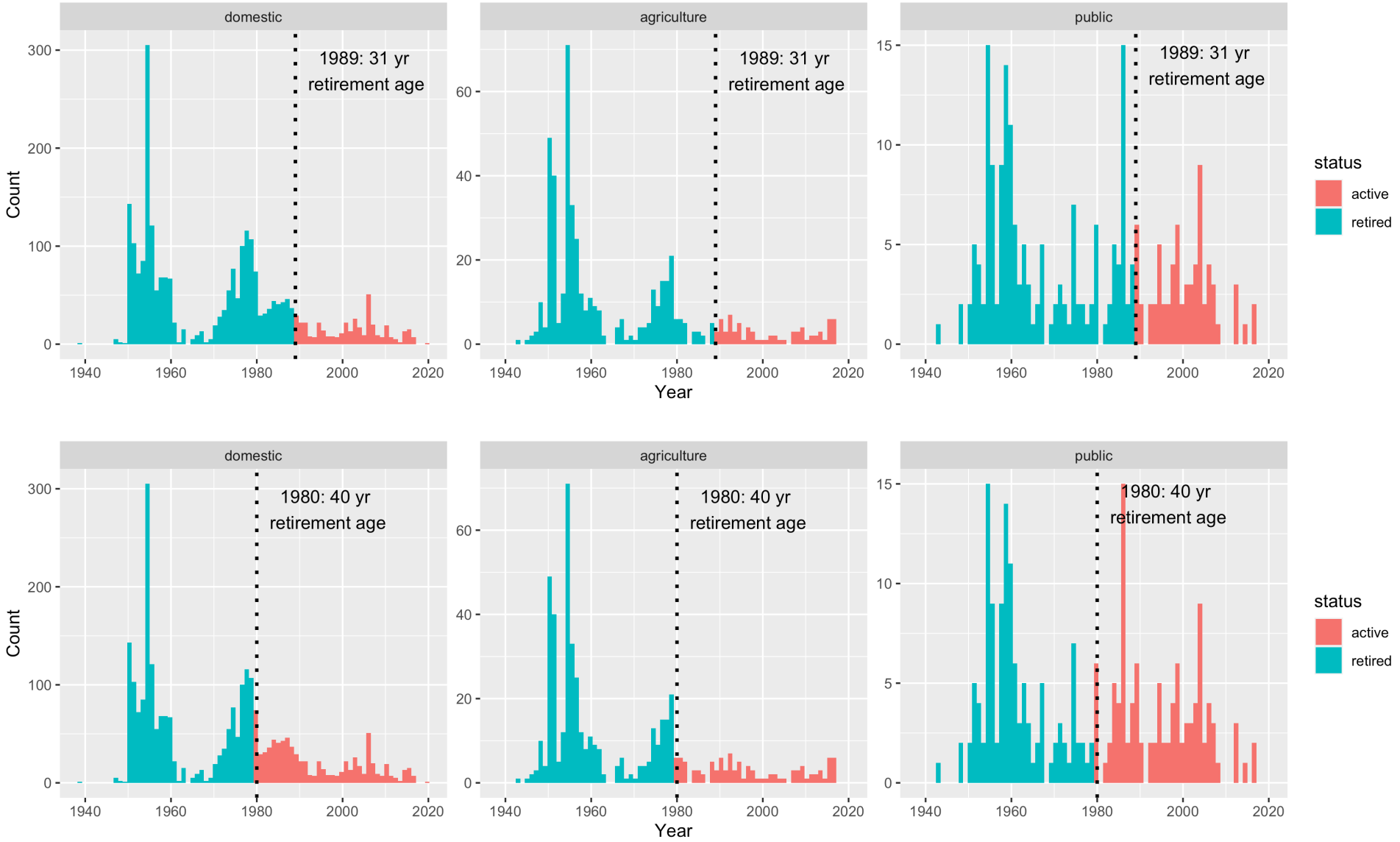


Figure 11: Not all wells drilled are active. Assuming a 31 year (top) and 40 year (bottom) retirement age, different numbers of wells are active.

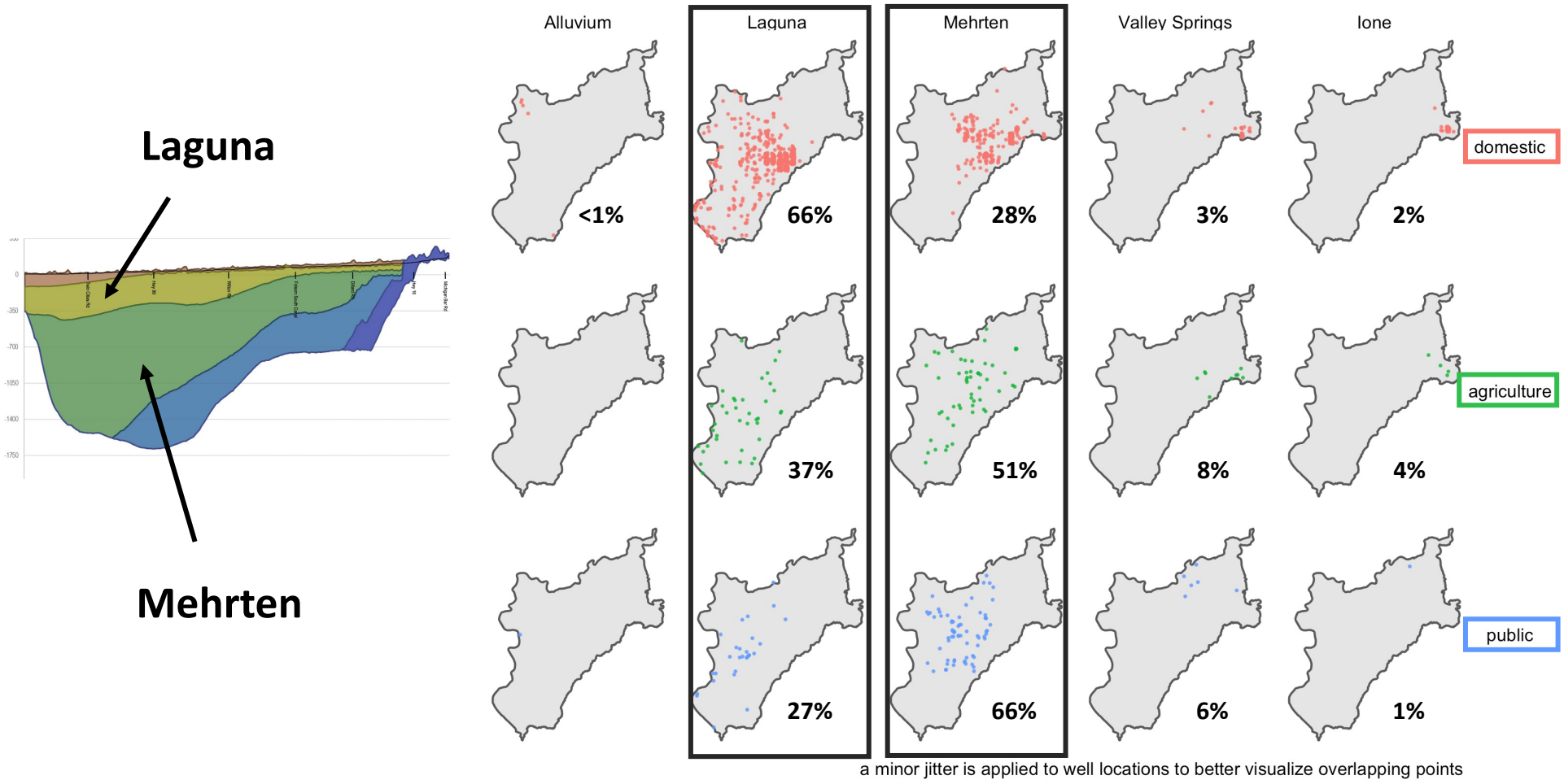


Figure 12: Most wells that provide beneficial uses bottom out in the Laguna or Mehrten, thus transmissivity-weighted heads from these layers (the principal aquifer) are used to evaluate differences in groundwater elevation implied by the projected scenarios.

Most wells are deeper than long-term average depths to groundwater in the SASb, which suggests a buffer against potential well impacts from declining groundwater levels (Figure 13). Finally, wells tend to be drilled deeper over time (Figure 14), driven by improvements in drilling technology and the need for deeper groundwater unimpacted by surface contaminants and with sufficient transmissivity to support well yield targets.

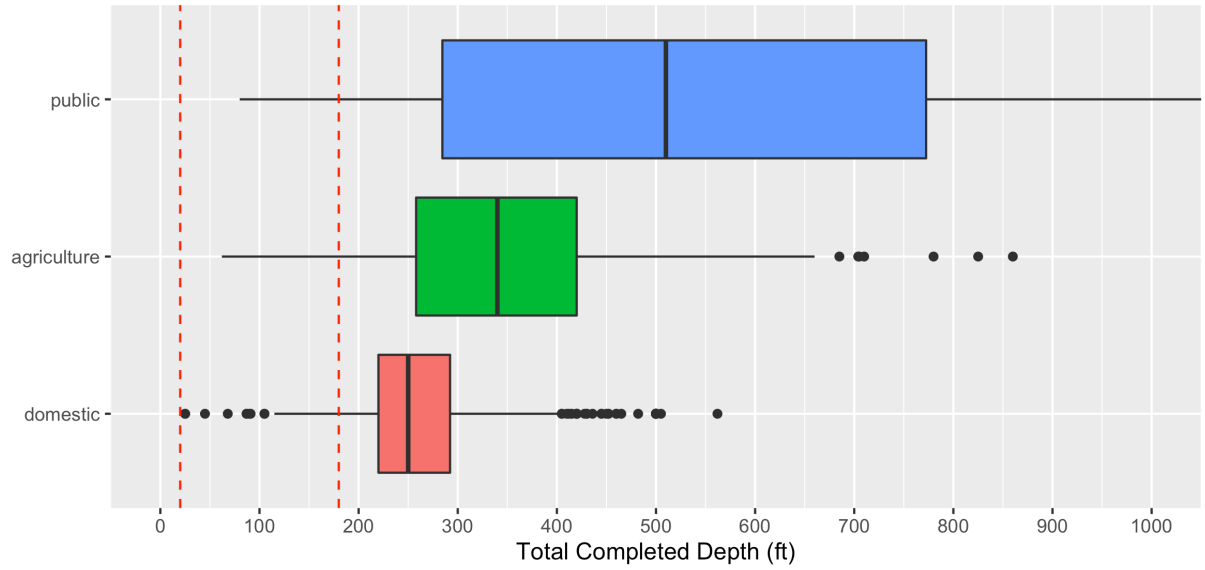


Figure 13: Relative depth distributions of domestic, agricultural, and public wells indicates increasing depth. Red dashed vertical lines are shown at 20 and 180 feet below land surface, which are the approximate modern, long-term depths to groundwater in the SASb (Figure 6)). The 25th percentile of all well depths falls outside of the 20-180 foot envelope, suggesting that many wells are deeper than present day depths to groundwater.

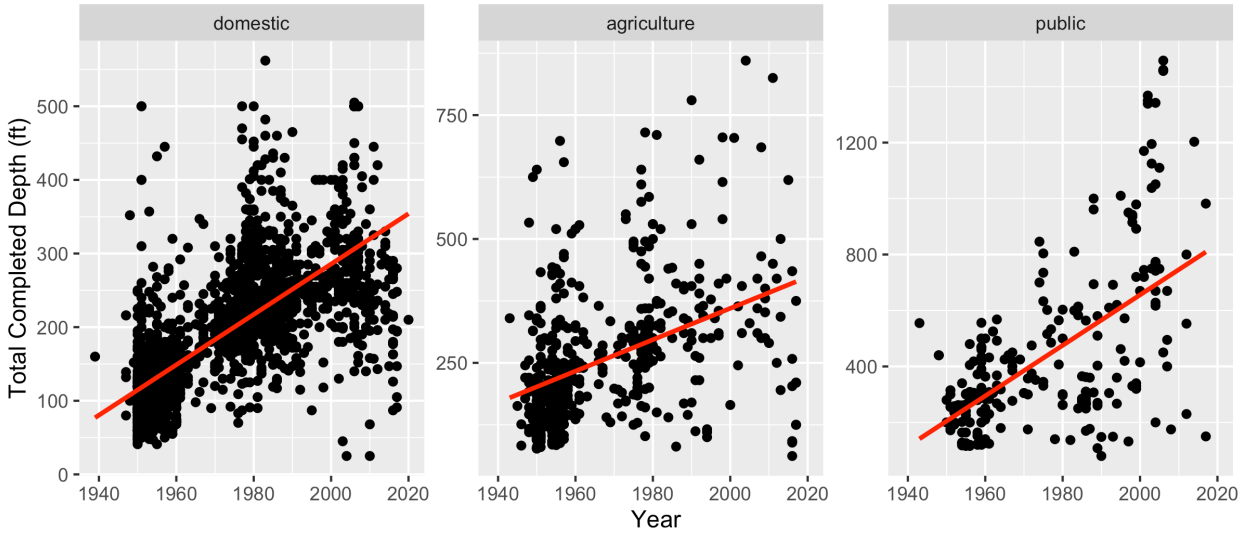


Figure 14: Since 1950, average domestic well depths increased by around 3x; agricultural and public well depths increased by around 2x and 4x respectively.

4.3 Well impacts: location, count, and cost

Fall 2015 groundwater level lows are around 12 feet lower on average compared to near present day groundwater levels. A return to these levels, as well as those implied by projected management, PMA, and climate change show little appreciable difference on well impacts (Figure 15).

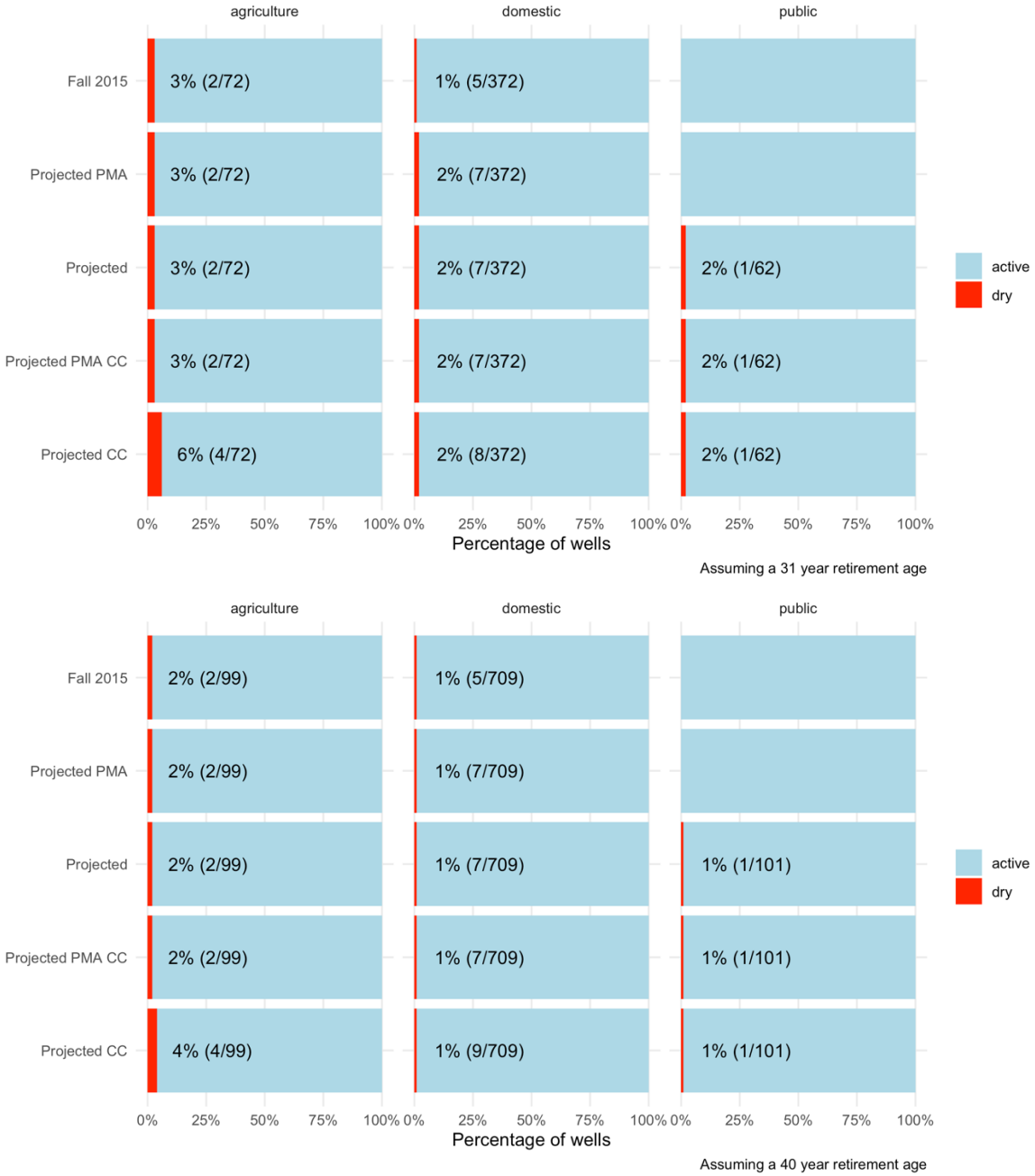


Figure 15: Vulnerable well impact analysis of a Fall 2015 baseline and 4 projected management conditions show little appreciable difference, even when accounting for a 31-year (left) and 40-year (right) well retirement age. Projected = Projected water use in the Basin. PMA = projects and management actions including Harvest Water, OHWD recharge, and regional conjunctive use. CC = climate change. Bar plots show well impact summary statistics for all scenarios and well types. Maps show results for the "Projected PMA CC" scenario on which groundwater level MTs are based.

Consequently, the point patterns of estimated active and dry wells do not appreciably differ among the five scenarios, thus only the most severe case scenario is shown (Figure 16).

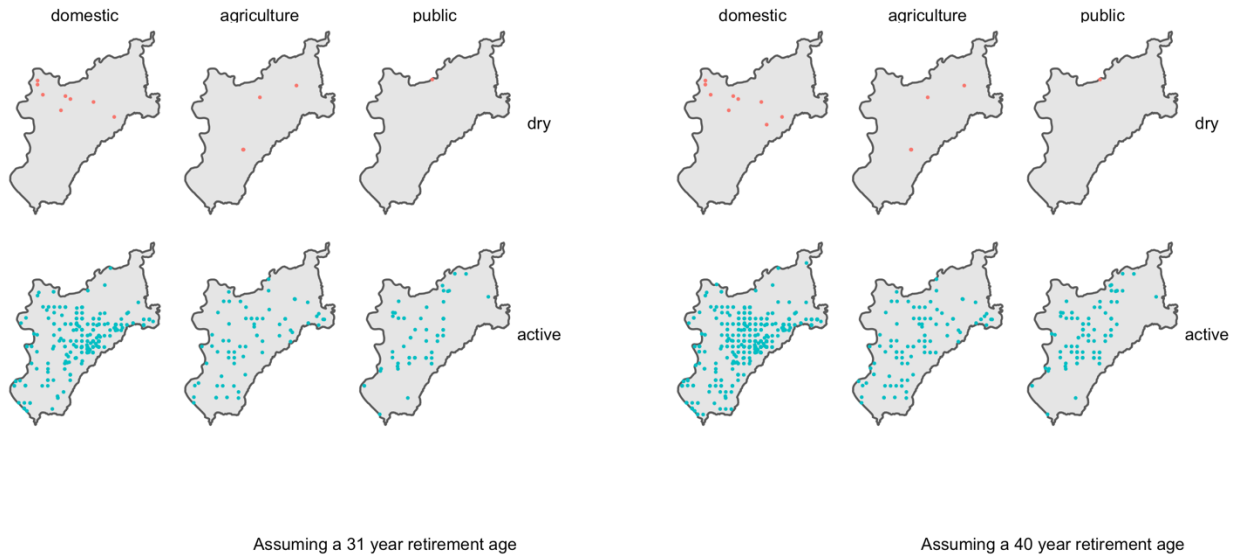


Figure 16: Of the five scenarios evaluated in this study, the Projected Conditions with climate change (and no PMA) result in the most severe well impacts (Figure 15), which are still minimal and close to a 5% impact range in agricultural wells, when accounting for uncertainty in well retirement age.

These results are unsurprising, as well depths are relatively deep compared to groundwater elevations, and the lower of Fall 2015 lows and projected groundwater head conditions do not begin to approach depths that intersect the critical datum of most wells.

4.4 Estimated cost

Costs are estimated informed by the costs put forward by Gailey et al (2019), EKI (2020), and Pauloo et al (2021), which assume well deepening events occur in intervals of 100 feet. For simplicity, domestic wells were assumed to cost $21,500 USD per well replacement, and agricultural and public wells were assumed to cost $100,000 USD per well replacement.

Results across all scenarios evaluated suggest a range of 7-15 wells would be impacted under 31-year and 40-year retirement ages, and accounting for uncertainty in projected management and climate change (Figure 15). For a conservative estimate of PMA with climate change, impacted well count is around 2-3% of domestic wells and 1-2% of public wells, and 1-2% of agricultural wells, primarily near the greater Sacramento urban area. This is explained by groundwater level simulations that indicate drawdown in these areas – areas which are also far away from the agriculture-rural interface where

most vulnerable domestic wells are located. These well impact percentages align with GSA-driven definitions of unreasonable results to vulnerable wells.

Further, unacceptable well impacts are defined as dewatering or lost access to groundwater at a well that requires well deepening. Well rehabilitation costs for impacted wells, assuming a return to the MT at all RMPs, were estimated at around $300,000 - $700,000 following the cost structure of Pauloo et al. (2021), EKI (2020), and Gailey (2019), but would likely be less, as significant and unreasonable impacts occur when 25% of RMPs exceed MTs, and less expensive rehabilitation costs such as pump lowering may be more appropriate in some situations (e.g., when operating margin exists).

5. Discussion

Vulnerable wells in the SASb tend to be privately owned and adjacent to or within areas of concentrated groundwater extraction for agricultural and municipal use. Due to their relatively shallow depth, these wells are vulnerable when water levels decline due to drought or unsustainable management. With the passage of the Sustainable Groundwater Management Act, local groundwater sustainability agencies will develop sustainable management criteria including minimum thresholds and objectives, measured at monitoring networks that will chart progress towards, or deviance from, sustainability goals. Sustainable management criteria should identify vulnerable wells as beneficial users of groundwater, and hence, identify the quantitative thresholds at which they will be impacted by declining groundwater levels, and the percentages (or count) of impacts above which, local agencies deem significant and unreasonable. The GSP should then set groundwater level MTs according to these thresholds and manage groundwater levels above them to ensure that at MTs, significant and unreasonable impacts occur, and that at MOs, significant and unreasonable impacts are avoided.

Data from the DWR and Cal OPR suggests that during Fall 2015, no wells in the SASb were reported dry, even though this period represents a [modern] historic groundwater level low. Results are consistent with this observation and suggest that a return to Fall 2015 groundwater level lows is unlikely to result in catastrophic and widespread impacts to wells. Moreover, additional declines anticipated under projected management result in negligible impacts to wells, largely owing to the relatively deep total completed depth of wells compared to present day groundwater levels, and minimal to no groundwater level decline in most parts of the basin. The percentage of wells impacted in the worst-case scenario assuming climate change and no PMA results in only one of the well types (agricultural) impacted at 4-6% (accounting for uncertainty in well retirement age). In all other scenarios (many of which are more likely), well impacts for all well types remain below 5%.

Well protection analysis thus informs the creation of minimum thresholds (MTs) which avoid significant and unreasonable impacts to wells in the basin and allow the basin to achieve projected growth targets within a framework of regional conjunctive use and PMA. Well rehabilitation costs for impacted wells, assuming all MTs are reached at all representative monitoring points (RMPs), were estimated at around $300,000 -

$700,000, but would likely be less, as significant and unreasonable impacts occur when 25% of RMPs exceed MTs, and if operational space remains in the well, a less costly pump lowering may take place.

6. Conclusion

Well completion reports, and historical and forecasted groundwater levels (using Cosana) were analyzed to estimate groundwater thresholds at which different well types in the SASb reach levels of impact deemed significant and unreasonable. Results suggest that projected groundwater management with PMAs and climate change will not lead to widespread catastrophic well failure in the SASb, and thus groundwater level MTs should be designed according to these levels.

It is advisable therefore, that MTs are based on the lower of the observed fall 2015 groundwater level and any additional decline anticipated under the projected PMA with CC scenario since this represents a likely, but conservative groundwater level scenario with an estimated 1-3% well impact across well types that also fits within the significant and unreasonable 5% impact threshold.

Well impact analyses depend on reliable data to determine the set of active wells to consider, and their critical datum (the vertical elevation at which a well is estimated to be impacted by declining groundwater levels). Reasonable assumptions are made for modeling purposes, but are not accurate to every well across the basin. Results are sensitive to well retirement age. A “well census” may improve understanding of well retirement and well vulnerability more generally. Such a census, if performed, should take place at the county level; results of the census may be attached to the parcel database used to better inform well protection and rates and fee schedules.

Top-down approaches like the analysis provided herein should be combined with bottom-up approaches. Localized, volunteer-based vulnerable well monitoring may empower point-of-use crowdsourced data and facilitate an early warning system to prioritize well rehabilitation measures before wells go dry. Truly, the best indication of well vulnerability will come from measurements at point-of-use wells. SGMA does not require this level of monitoring or provide guidance on how to achieve it, but GSAs may consider local monitoring programs outside of GSP RMP network to improve communication with well owners and take corrective actions as needed.

7. References

[1] Bostic, D., Dobbin, K., Pauloo, R., Mendoza, J., Kuo, M., and London, J. (2020). Sustainable for Whom? The Impact of Groundwater Sustainability Plans on Domestic Wells. UC Davis Center for Regional Change.

[2] CA-DWR. (2018). California Online State Well Completion Report Database. Available at: https://data.cnra.ca.gov/dataset/well-completion-reports. Accessed January 1, 2018

[3] CA-DWR. (2020) Periodic Groundwater Level Measurement database. Available at: https://data.cnra.ca.gov/dataset/periodic-groundwater-level-measurements. Accessed March 1, 2020

[4] CA-OPR (2018). Observed domestic well failures during 2012-2016 drought dataset obtained via an agreement with the California Governor's Office of Planning and Research. Sacramento, CA. Accessed May 6, 2018

[5] Deutsch, C. V., & Journel, A. G. (1992). *Geostatistical software library and user's guide*. New York, 119(147).

[6] Diffenbaugh, N. S., Swain, D. L., & Touma, D. (2015). Anthropogenic warming has increased drought risk in California. *Proceedings of the National Academy of Sciences*, 112(13), 3931-3936.

[7] EKI Environment and Water Inc. (2020). Groundwater Management and Safe Drinking Water in the San Joaquin Valley: Analysis of Critically Over-drafted Basins' Groundwater Sustainability Plans.

[8] Feinstein, L., Phurisamban, R., Ford A., Tyler, C., and Crawford, A. (2017). Drought and Equity in California Drought and Equity in California. Pacific Institute. Oakland, CA.

[9] Gailey, R.M., Lund, J., and Medellín-Azuara., J. (2019). Domestic well reliability: evaluating supply interruptions from groundwater overdraft, estimating costs and managing economic externalities. *Hydrogeology Journal*, 27.4 1159-1182.

[10] Greene C., Climate vulnerability, Drought, Farmworkers, Maladaptation, Rural communities. (2018). *Environmental Science and Policy* 89283–291. ISSN 18736416.

[11] Hanak, E., Lund, J., Dinar, A., Gray, B., and Howitt, R. (2011). Managing California's Water: From Conflict to Reconciliation. Public Policy Institute of California. ISBN9781582131412.

[12] Islas, A., Monaco, A., Ores, D. (2020) Framework for a Drinking Water Well Impact Mitigation Program. Self Help Enterprises.

[13] Johnson, T. D., & Belitz, K. (2015). Identifying the location and population served by domestic wells in California. *Journal of Hydrology: Regional Studies*, 3, 31-86.

[14] Johnson, T. D., & Belitz, K. (2017). Domestic well locations and populations served in the contiguous US: 1990. *Science of The Total Environment*, 607, 658-668.

[15] Journel, A. G., & Huijbregts, C. J. (1978). *Mining geostatistics* (Vol. 600). London: Academic press.

[16] Laurent, A. G. (1963). The lognormal distribution and the translation method: description and estimation problems. *Journal of the American Statistical Association*, 58(301), 231-235.

[17] Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, 333(6042), 616-620.

[18] Lopez, A., Tebaldi, C., New, M., Stainforth, D., Allen, M., & Kettleborough, J. (2006). Two approaches to quantifying uncertainty in global temperature changes. *Journal of Climate*, 19(19), 4785-4796.

[19] Medellín-Azuara, J., MacEwan, D., Howitt, R., Sumner, D.A., Lund, J., Scheer, J., Gailey, R., Hart, Q., Alexander, N.D., and Arnold B. (2016). Economic Analysis of the California Drought on Agriculture: A report for the California Department of Food and Agriculture. Center for Watershed Sciences, University of California Davis. Davis, CA.

[20] Mitchell, D., Hanak, E., Baerenklau, K., Escriva-Bou, A., Mccann, H., Pérez-Urdiales, M., and Schwabe, K. (2017). Building Drought Resilience in California's Cities and Suburbs. Public Policy Institute of California. SAn Francisco, CA.

[21] Pauloo, R., Fogg, G., Dahlke, H., Escriva-Bou, A., Fencl, A., and Guillon, H. (2020). Domestic well vulnerability to drought duration and unsustainable groundwater management in California's Central Valley. *Environmental Research Letters*, 15.4 044010

[22] Perrone, D., & Jasechko, S. (2017). Dry groundwater wells in the western United States. *Environmental Research Letters*, 12(10), 104002.

[23] Perrone, D. and Jasechko, S., Deeper well drilling an unsustainable stopgap to groundwater depletion. (2019). *Nature Sustainability*, 2773–782

[24] Rhoades, A. M., Jones, A. D., & Ullrich, P. A. (2018). The changing character of the California Sierra Nevada as a natural reservoir. *Geophysical Research Letters*, 45(23), 13-008.

[25] Sophocleous M., From safe yield to sustainable development of water resources—the Kansas experience., (2000). *Journal of Hydrology*, 23527–43.

[26] Sustainable Groundwater Management Act. (2014). California Water Code sec. 10720-10737.8

[27] Swain, D. L., Langenbrunner, B., Neelin, J. D., & Hall, A. (2018). Increasing precipitation volatility in twenty-first-century California. *Nature Climate Change*, 8(5), 427-433.

[28] Theis, C.V., (1935). The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage., Eos, *Transactions American Geophysical Union*, 16519–52.

[29] Theis, C.V., (1940). The source of water derived from wells., *Civil Engineering*, 10277–280.

[30] Tullis, J. Paul. (1989). Hydraulics of pipelines: Pumps, valves, cavitation, transients. John Wiley & Sons.

[31] Williams, A. P., Seager, R., Abatzoglou, J. T., Cook, B. I., Smerdon, J. E., & Cook, E. R. (2015). Contribution of anthropogenic warming to California drought during 2012–2014. *Geophysical Research Letters*, 42(16), 6819-6828.

[32] Varouchakis, E. A., Hristopulos, D. T., & Karatzas, G. P. (2012). Improving kriging of groundwater level data using nonlinear normalizing transformations—a field application. *Hydrological Sciences Journal*, 57(7), 1404-1419.

Appendix 3-D

Groundwater Dependent Ecosystems in the South American Subbasin
(April 21, 2021)

THE FRESHWATER TRUST™

700 SW Taylor Street, Suite 200
Portland, OR 97205
www.thefreshwatertrust.org

Groundwater Dependent Ecosystems in the South American Subbasin

April 21, 2021

SUMMARY

The Sustainable Groundwater Management Act (SGMA) requires Groundwater Sustainability Plans (GSPs) to identify and consider impacts to Groundwater Dependent Ecosystems (GDEs). GDEs are complex ecosystems that rely on a connection to groundwater to sustain their health and function. GDEs provide various ecosystem services (e.g., supporting habitat for life stages of State and federal special status species, providing habitat for migratory fish), and recreational amenities (e.g., parks and waterways). Groundwater Sustainability Agencies (GSAs) are required to manage GDEs and their associated beneficial uses and users consistent with the strategies outlined in the GSP to avoid "undesirable effects" resulting from unsustainable groundwater management. Despite the significant presence of GDEs in the South American Subbasin (SASb)[1] and the ecological value they provide to beneficial users of groundwater, they remain poorly understood. To support these valuable ecosystems, they must be considered in terms of scale and spatial distribution, the plant and animal communities that rely on them, best practices to monitor their condition, and how their functions may be supported through groundwater management.

The SASb's extensive vegetation communities and natural features associated with both surface and groundwater expressions were identified and classified as to their potential GDE status using a multi-faceted approach. First, potential GDEs were identified using available datasets in a geographic information system (GIS). Next, an analysis was carried out to determine if the most deeply rooted local species could reasonably reach groundwater throughout the historical period from 2005 to 2019 which contains wet, above normal, below normal, dry, and critical water year types. Then, surface vegetation health was evaluated with satellite imagery to assess the possibility of broad, rapid, and cost-effective characterization of GDE health. Finally, results were synthesized into quantitative metrics that may be monitored within the SGMA framework, and which provide reasonable assurance that undesirable results to GDEs in the SASb are avoided.

In following sections present: a brief background on GDEs in SGMA; methods used to classify and map GDEs via groundwater level and satellite imagery; management approaches (including definition and identification of Undesirable Results, and Measurable Objectives); a discussion of GDE-associated beneficial users; a discussion of study limitations; and a discussion of potential projects and management actions that may interact with GDEs in the SASb.

[1] The South American Subbasin is defined by Bulletin 118.

SGMA requires consideration of the interests of all beneficial uses and users of groundwater in the development and implementation of GSPs (CAL. WATER CODE § 10723.2). These interests explicitly include environmental users. As a result, ecosystems dependent on groundwater must be evaluated in GSPs. The identification and subsequent management of GDEs is closely related to two SGMA sustainability indicators: lowering of groundwater levels and depletion of interconnected surface waters (CAL. WATER CODE § 10721(x)).[2] Thus, SGMA requires that GSPs consider GDEs, which are a beneficial user of both groundwater and interconnected surface water.

SGMA defines GDEs as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (CAL. CODE REGS. tit. 23 § 351(m)). Hence, GDEs are habitats and populations of species whose health relies on access to groundwater. SGMA details the specific conditions and considerations that every GSP must address. These include identifying GDEs within the basin as well as evaluating the potential for adverse impacts to interconnected surface waters (ISW) (CAL. CODE REGS. tit. 23 §§ 354.8(5), .16(g), .28(6)). The ISW analysis for the SASb is presented separately in an accompanying technical memo: "Interconnected Surface Water in the South American Subbasin: Historical and Present-day Characterization, and Approaches for Monitoring and Management." SGMA requires the GSP to define an approach to monitor and manage significant and unreasonable impacts to GDEs. The identification of GDEs is based on the "best available science" and requires "the use of sufficient and credible information and data, specific to the decision being made and the time frame available for making that decision, that is consistent with scientific and engineering professional standards of practice" (CAL. CODE REGS. tit. 23 § 351(h)). The following effort has been designed and undertaken in accordance with these requirements and standards in order to provide a thorough and reliable analysis of GDEs in the SASb.

METHODS

Classes of GDEs

Applying legal standards defined by statutes, this analysis considers GDEs as ecosystems that meet the scientific framework for classification based on data available at the subbasin scale, including depth to groundwater or the presence or absence of an associated mapped vegetation community. Scientific literature identifies three GDE classes (Eamus 2006; Eamus & Froend 2006; Eamus et al. 2006, 2015):

- Class 1: Underground aquifer and cave systems hosting stygofauna (species adapted to living in underground water)
- Class 2: Ecosystems that rely on surface expressions of groundwater, including springs, perennial wetlands, and rivers whose flow is augmented by groundwater
- Class 3: Ecosystems that rely on sub-surface groundwater, including phreatophytes (Greek for "well plant", or plants with roots that reach into saturated groundwater)

[2] GDEs may or may not be reliant on the "primary aquifer" but this does not change the definition for GSP purposes.

In the SASb, only class 2 and 3 ecosystems are present (see Section 2 of the GSP, Plan Area), and hence, in this memo, references to "GDEs" indicate both class 2 and 3 GDEs.

Within GDEs, microbial and invertebrate communities that could interact with surface water systems can reside at groundwater depths to 230 ft (White 1993; Kawanishi 2013; Sorensen 2013; Korbel 2017). According to California's Bulletin 118, this hyporheic zone consists of the fully saturated sediments beneath and beside the active channel, which contains a proportion of surface water that was part of the flow in the surface channel that went back underground where it mixed with groundwater (California DWR 2003). The hyporheic zone links surface and groundwater to integrate and modulate stream ecological processes, and thereby serves as a refuge and habitat for a diverse range of aquatic organisms, from bacteria to invertebrates to aquatic worms. It also can influence river water quality due to substantial surface area contact with microbial communities and the gradient from oxygenated to unoxygenated waters that can transform and trap nutrients and organic compounds. A conceptual diagram of a hyporheic zone in a gaining stream reach where groundwater is contributing to surface water flows is presented in Figure 1. Note that although a gaining stream is shown in the conceptual diagram, a hyporheic zone also exists in losing (but still interconnected) streams where stream-aquifer interaction is present.

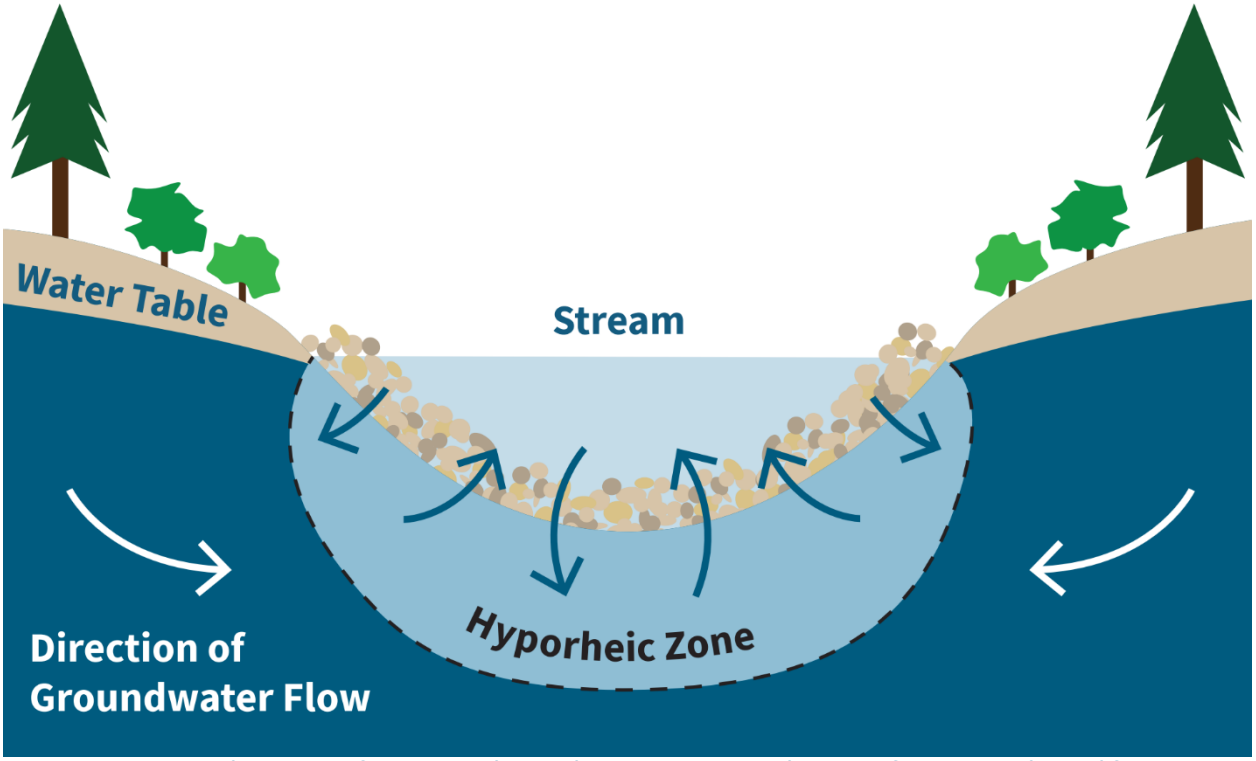


Figure 1: Conceptual Diagram of a Saturated Hyporheic Zone Surrounding a Surface Water Channel for a Graining Reach

The hyporheic zone may connect surface and groundwater when groundwater elevations are sufficiently high enough to intersect the subsurface streambed, and thus constitute ISWs. SGMA regulations define

an ISW as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted." (CAL. CODE REGS. tit. 23 § 351(o)). Accordingly, the presence of an ISW implies high water levels which may support fish passage by adding water to the stream via baseflow. Moreover, an ISW allows for the transfer of nutrients dissolved in groundwater to the stream. Both GDEs and ISWs are connected to groundwater over some vertical extent: for ISW, the streambed clogging layer must reach into saturated groundwater in order to be interconnected, and for GDEs, the rooting depth must reach into saturated groundwater to be "groundwater-dependent" (CAL. CODE REGS. tit. 23 § 354.16).

Identifying Mapped Potential GDEs

A series of geospatial datasets were used to identify potential GDEs in this analysis. These datasets and the geospatial processing steps used to translate them into an integrated representation of mapped potential GDEs within the SASb are presented in this section.

Class 1 - Aquifer Cave Systems

Aquifer cave systems are typically found in karstic limestone formations, where mineral dissolution creates caves that fill with groundwater. These systems are included here for completeness, but do not exist in the fluvial-alluvial clastic sedimentary deposits of California's Central Valley, as defined in the SASb's Hydrogeologic Conceptual Model (Chapter 2 of the GSP, Plan Area), and therefore are not identified or mapped in this study.

Class 2 - Wetlands

The second class of GDEs, referred to here as wetlands, are those ecosystems that rely on a surface expression of groundwater, such as natural springs, perennial wetlands, and rivers supplemented by groundwater. Three datasets were combined to create a representation of assumed mapped potential wetland GDE polygons including the:

- National Wetlands Inventory (NWI) developed and distributed by US Fish & Wildlife;[3]
- California Aquatic Resource Inventory (CARI) developed and distributed by the San Francisco Estuary Institute;[4] and
- Natural Communities Commonly Associated with Groundwater Wetlands (NCCAG-W) dataset developed by a working group comprised of California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) distributed by California DWR.[5]

The NCCAG-W and CARI datasets incorporated the NWI during their development, yielding a number of mapped potential wetland GDEs identified by more than one dataset. The NWI dataset was included in this analysis for completeness. The CARI dataset incorporates the U.S. Geological Survey (USGS) National Hydrography Dataset as well as Sacramento County wetland and stream mapping from the U.S. Army

[3] *Available at* https://www.fws.gov/wetlands/Data/Data-Download.html.
[4] *Available at* https://www.sfei.org/cari.
[5] *Available at* https://data.cnra.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater.

Corps of Engineers.[6] A summary of the areas of mapped potential wetland GDEs identified by each dataset and combination of datasets is presented in Table 1 with spatial distribution of each class presented in Figure 2. A series of four figures presenting the spatial distribution of mapped potential wetland GDEs at a zoomed in extent are presented in Appendix A. Geospatial processing ensured that overlapping areas were not double or triple counted in summaries.

Table 1. Mapped Potential Wetland GDEs Identified by Data Source and Combination of Data Sources in the South American Subbasin

Data Source[7]	Area (acres)	% of Mapped Potential Wetland GDE Area (Total)
NWI* + CARI** (overlap)	6,005	28.8%
CARI ** (no overlap)	5,959	28.6%
NCCAG-W* + CARI** + NWI*** (overlap)	4,693	22.5%
NWI* (no overlap)	3,153	15.1%
NCCAG-W* + NWI*** (overlap)	1,051	5.0%
NCCAG-W*** (no overlap)	0	0.0%
NCCAG-W* + CARI**** (overlap)	0	0.0%
Total	20,861	100%

*National Wetland Inventory (NWI) (total acres; 14,902)
** California Aquatic Resource Inventory (CARI) (total acres; 16,657)
*** Natural Communities Commonly Associated with Groundwater– Wetlands (NCCAG-W) (total acres; 5,744)

[6] *Available at* https://www.sfei.org/projects/six-county-aquatic-resource-inventory.
[7] "Overlap" indicates the intersection of two datasets for purposes of analysis that are not additive in acreage; "no overlap" indicates there is no intersection between datasets.

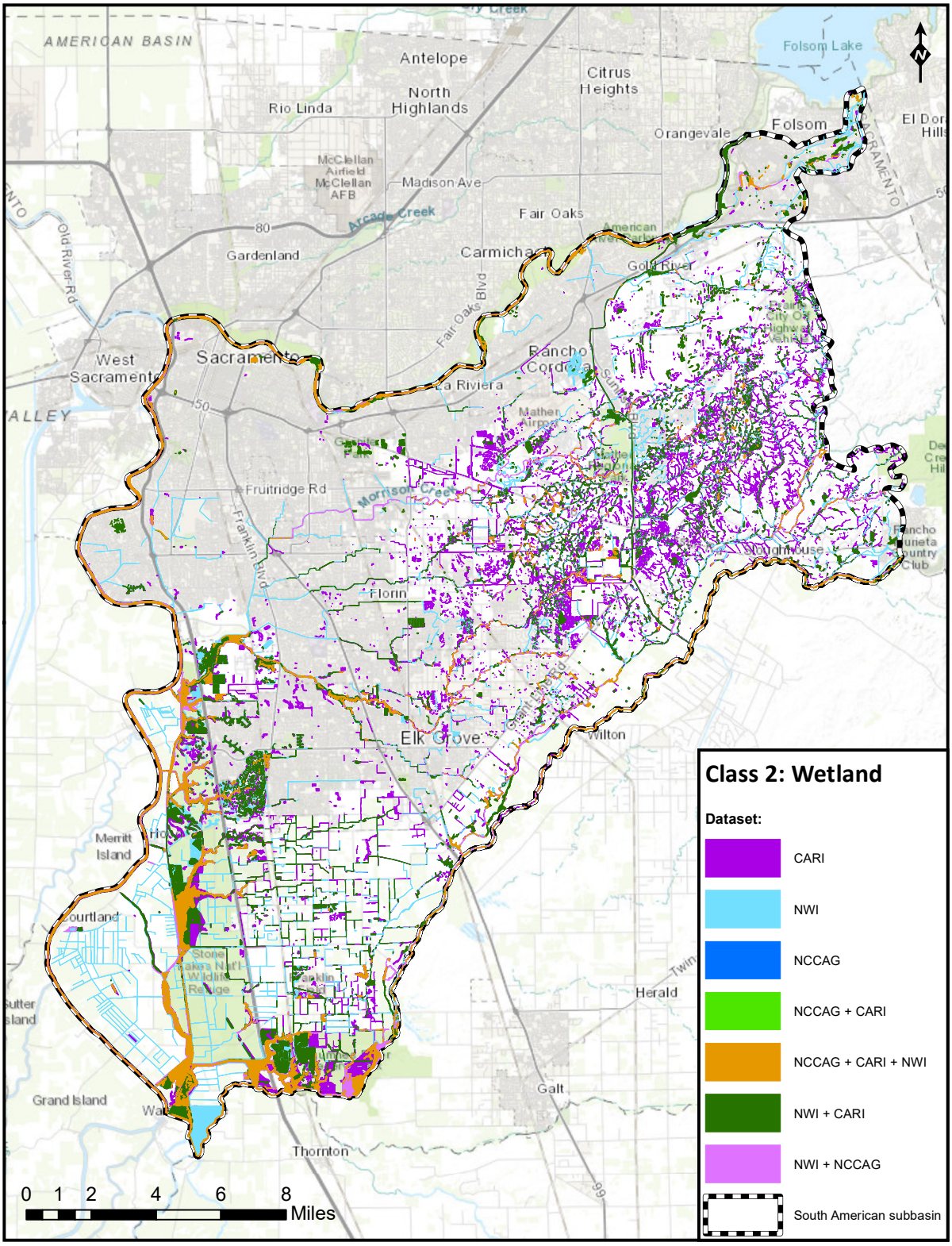


Figure 2: Mapped Potential Wetland GDEs Identified by Data Source and Combination of Data Sources in the South American Subbasin

Class 3 – Non-Wetland Vegetation

The third class of GDEs are non-wetland vegetation that rely on at least temporary connection to groundwater. Three datasets were combined to create a representation of assumed mapped potential non-wetland GDEs polygons including the:

- Natural Communities Commonly Associated with Groundwater Vegetation (NCCAG-V) developed by a working group comprised of California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) distributed by California DWR;[8]
- South Sacramento Habitat Conservation Plan (SSHCP) landcover,[9] and
- CDFW Vegetation augmented with project-based mapping for a landscape management scenario analysis.[10]

A summary of the areas of mapped potential wetland GDEs identified by each dataset and combination of datasets is presented in Table 2 with spatial distribution of each class presented in Figure 3. A series of four figures presenting the spatial distribution of mapped potential non-wetland GDEs at a zoomed in extent are presented in Appendix B. There is notable overlap between these datasets and distinct polygons from each source. Notably, the SSHCP/Underwood dataset incorporates many more stands of isolated trees.[11] The relative acreage of those mapped GDE features demonstrates that riparian species occupy double the area of underwood species. For the purpose of this analysis, the presence of a non-wetland potential mapped GDE polygon was considered to be an initial indicator of the presence of this class of GDE. The absence of vegetation in otherwise appropriate locations in near contact with shallow groundwater does not preclude classification as a GDE if additional evidence indicates the existence of a GDE.

Table 2. Mapped Potential Non-Wetland GDEs Identified by Data Source in the South American Subbasin

Data Source[12]	Area (acres)	% of Mapped Potential Non-Wetland GDE Area (Total)
NCCAG-V* (no overlap)	4,166	40.2%
SSHCP/Underwood** (overlap)	2,033	19.6%
NCCAG-V & SSHCP (overlap)	4,168	40.2%
Total	10,367	100%

*Natural Communities Commonly Associated with Groundwater – Vegetation (total acres; 8,334)
**South Sacramento Habitat Conservation Plan (total acres; 6,201)

[8] *Available at* https://data.cnra.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater.
[9] This dataset is referred to as SSHCP/Underwood as the data was provided by E. Underwood and R. Hutchinson. *Available at* https://escholarship.org/uc/item/8700x95f.
[10] *Available at* https://wildlife.ca.gov/Data/VegCAMP.
[11] This is perhaps due to the focus of the landscape management planning on carbon storage and 16 local bird species.
[12] "Overlap" indicates the intersection of two datasets for purposes of analysis that are not additive in acreage; "no overlap" indicates there is no intersection between datasets.

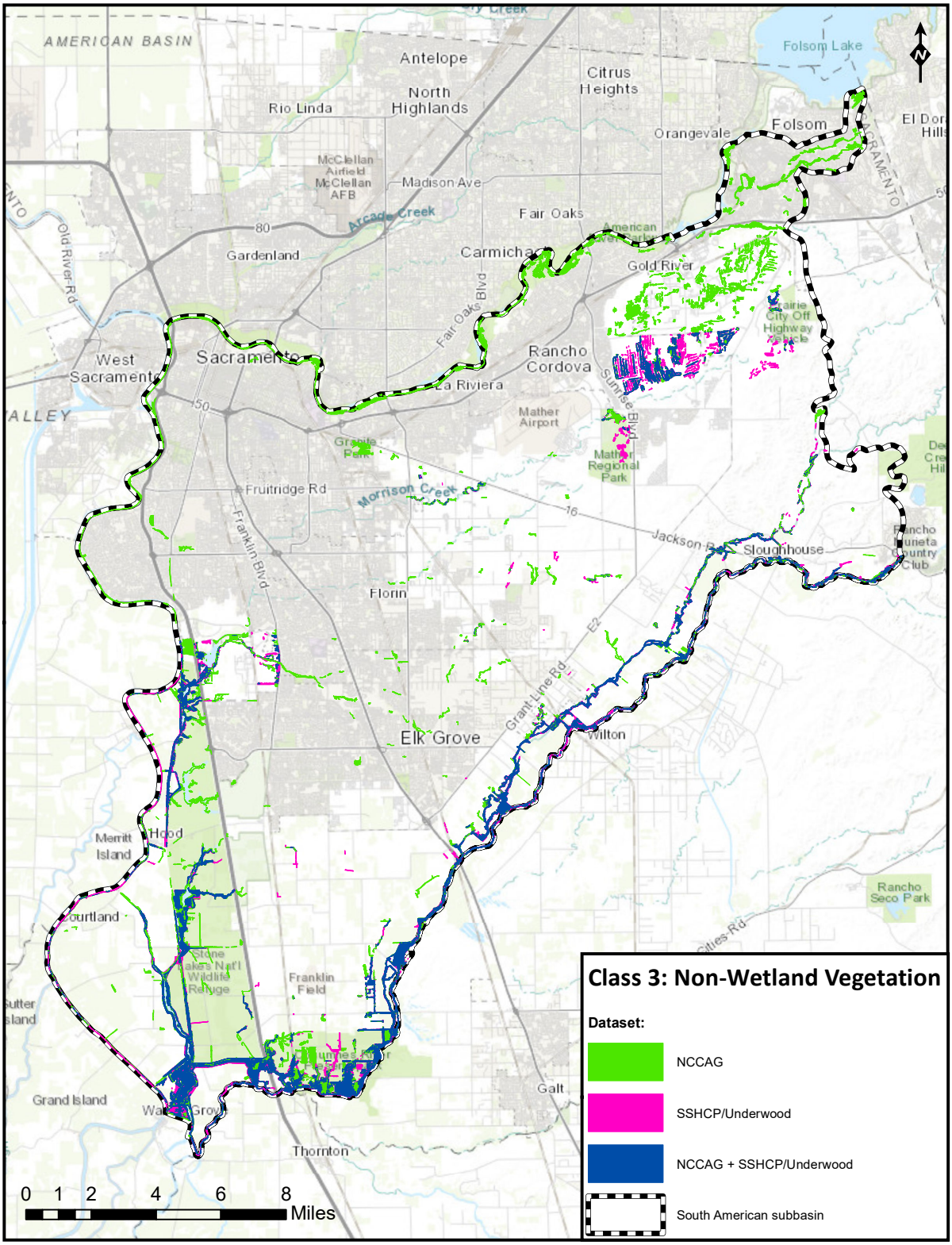


Figure 3: Mapped Potential Non-Wetland GDEs Identified by Data Source in the South American Subbasin

Rooting Zone Depth Threshold

Roots and rooting depths help plants maintain access to water. Although the rooting depths of mature vegetation may be relatively static, groundwater level fluctuations caused by pumping may temporarily or permanently disconnect roots from saturated groundwater, which may impact plant health. The California Department of Fish and Wildlife (CDFW), in collaboration with other entities, has collected data from a variety of sources to create a comprehensive list of phreatophytes, or plants that require significant contact with the groundwater table, and assigned maximum rooting zone depths by species based on available literature. This State-wide CDFW dataset was revised to more effectively reflect the vegetative communities within the SASb and is presented in Appendix C. Deeply rooted species not typically found in the region (e.g., desert species) and species that lacked rooting depth data were excluded. Plants were included if found locally, if they were native, and if their plant family or *Genus* had a reported rooting depth.

The maximum reported rooting depths of the plant species found in the SASb range from near-surface for grasses like creeping wildrye (3.84 feet) to deep-rooted trees like the Valley Oak (24.31 feet). Rooting depths of species within the SASb were evaluated, and the Valley Oak (*Quercus lobata*) was found to exhibit the largest rooting depth[13]. Because plants can extract moisture from pore spaces away from the roots themselves, a threshold depth of 30 feet was used as a cutoff for the maximum depth of groundwater that could reasonably be accessed by a GDE within the SASb. Areas within the SASb where depth to groundwater is consistently greater than 30 feet are therefore assumed incapable of supporting non-wetland GDE communities and by extension, any GDEs. In the context of identifying GDEs, this 30-foot depth threshold is very conservative and overly inclusive as shallower groundwater is likely required to support a broader array of healthy GDEs in most circumstances.

Depth to Groundwater

Available groundwater monitoring datasets were used to develop statistical representations of groundwater elevation for 12 four-year running periods for both spring and fall between 2005 and 2008 (e.g., spring 2005, 2006, 2007, and 2008 representing spring 2005 – 2008). These groundwater elevations[14] were developed by interpolating mean observed groundwater for each season with ordinary kriging. Seasonal, four-year running mean interpolated groundwater elevations in the SASb from spring 2005 to fall 2019 (Figure 4) show seasonal oscillation, with generally higher (blue) groundwater elevation in spring, and generally lower (red) groundwater elevation in the fall. Groundwater flows from areas of high (blue) to low (red) groundwater elevation. Groundwater elevation mapping indicates groundwater flow inwards towards the center of the basin, coincident with areas of groundwater pumping.

[13] Coast Live Oak (*Querus agrifolia*) is also present in the SASb and has an average maximum rooting depth of 35.1 feet, however, it occupies 2.3 acres, and is thus neglected. By comparison, Valley Oak (*Quercus lobata*) has an area of 2937.0 acres, thus we use the Valley Oak to set the upper bound of maximum rooting depth expected in the SASb.

[14] The full methodology for groundwater level interpolation is discussed in the accompanying technical memo, "Interconnected Surface Water in the South American Subbasin: Historical and Present-day Characterization, and Approaches for Monitoring and Management" and a brief summary is presented here.

The seasonal summary of interpolated groundwater elevations (Figure 5) shows oscillating seasonal medians, with consistently higher groundwater elevations in spring, and lower groundwater elevation in fall. Median fall groundwater elevation decreases over the period of record and reaches its lowest value during the average period of 2013-2016 due to the combined impact of four years of drought. After this minimum, spring and fall median groundwater levels trend upward.

Groundwater elevations were translated into depth to water by subtracting kriged groundwater elevations from the elevation of the land surface represented by Sacramento County's one-foot resolution digital elevation model (DEM).

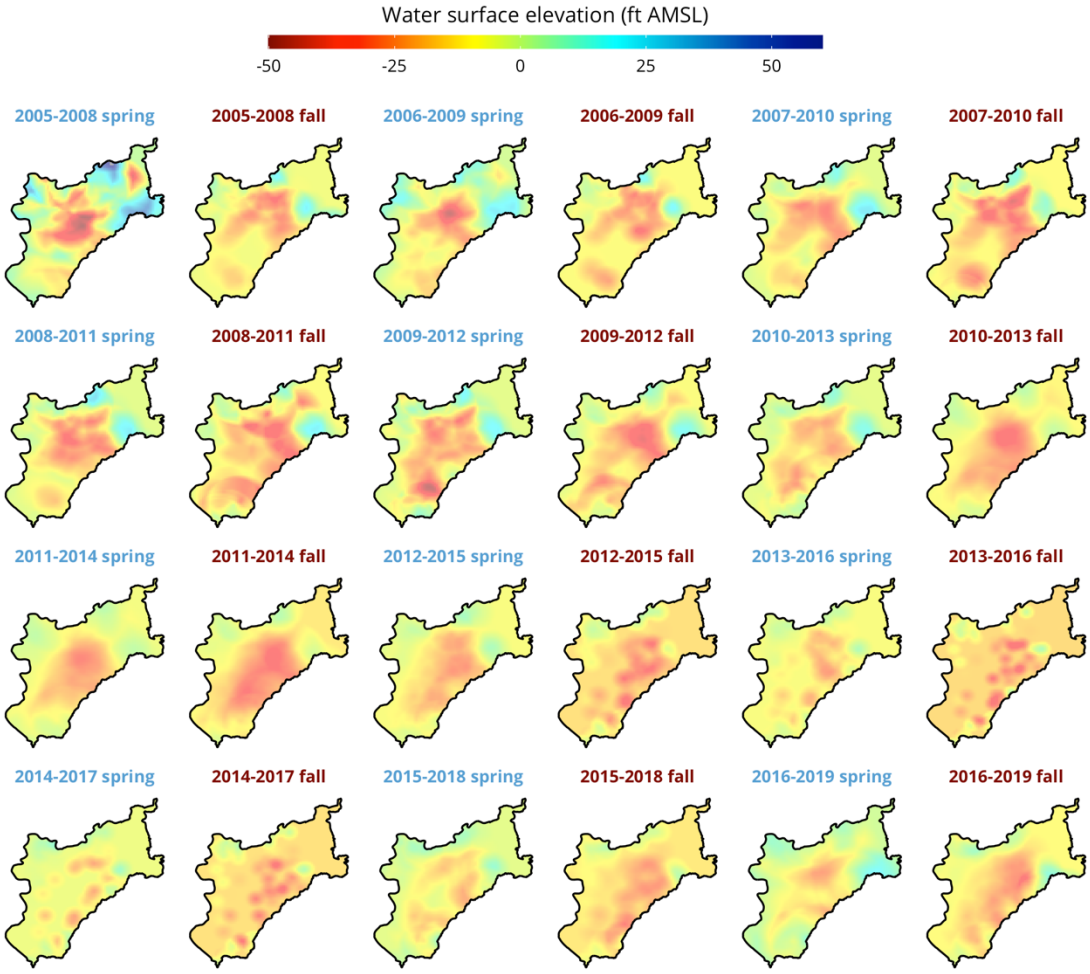


Figure 4. Groundwater Elevation (feet above mean sea level) for Four-Year Running Seasonal Groundwater Level Mean in the South American Subbasin

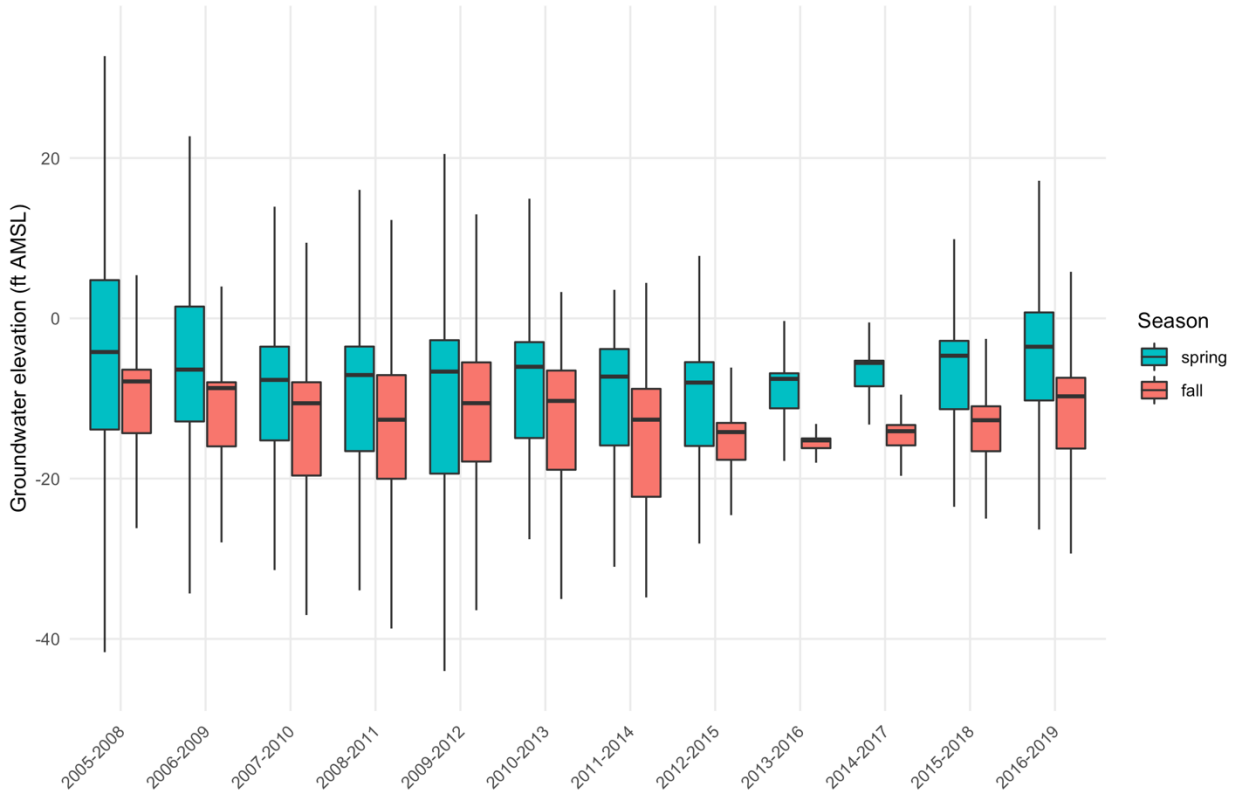


Figure 5. Box Plot Summary of Groundwater Elevations for Four-Year Running Mean Values by Season for the South American Subbasin

Mapped Potential GDE Classification

The maximum assumed extent of all mapped potential GDEs was established by combining class 2 mapped potential wetland GDEs (Figure 2) and class 3 mapped potential non-wetland GDEs (Figure 3). A two-tier classification approach (Figure 6) was developed and applied to classify GDE based on assumed access to groundwater.

The first-tier classification involved computing an area-weighted statistical representation of depth to groundwater for each mapped potential vegetative GDE area using the zonal statistics function available in many GIS programs. This zonal statistics function identifies what cells of the depth to groundwater grid or raster dataset fall within the bounds of each mapped potential GDE and then computes an area-weighted average for that area. The 30-foot depth to groundwater threshold discussed in the Rooting Zone section above was applied to each of the 24 four-year running depth to groundwater rasters for fall and spring independently to separate mapped potential GDEs into two classes: “Assumed GDE” and “Assumed Not GDE.” Areas where the area-weighted depth to groundwater was less than or equal to 30 feet were classified as “Assumed GDE” for that single four-year running representation of groundwater conditions. Conversely, areas where the area-weighted depth to groundwater was greater than 30 feet were classified as “Assumed Not GDE” for that single representation of groundwater conditions. A box plot summarizing the proportion of mapped potential GDEs split into “Assumed GDE” and “Assumed Not GDE” classes for each seasonal four-year running depth to groundwater raster or grid is presented in

Figure 7. Figures showing the spatial distribution of the classification of mapped potential GDEs into "Assumed GDE" and "Assumed Not GDE" classes for each of the four-year running depth to groundwater rasters or grids are presented in Appendix D. The difference in spring (blue) and fall (red) GDE proportion ranges from 0.4 – 7.3% (hovering text boxes) and represents natural historic seasonal and interannual variance across the period of record evaluated. The largest differences in the seasonal range occur during running means that contain years within the 2012 – 2016 drought and suggest that dry conditions may cause desiccation of mapped potential GDEs. Over the period of record evaluated, the area classified as "Assumed GDE" ranges, at a maximum, from around 44% to 54%.

The second tier of the assessment further classifies "Assumed GDE" and "Assumed Not GDE" polygons into GDE likelihood classes based on how often groundwater was within 30 feet of the polygon during the 2005-2019 record examined (**Error! Reference source not found.**). A tabular summary of GDE likelihood classes is presented in Table 4 and the spatial distribution of each category presented in Figure 8. The key difference between the Tier 1 and Tier 2 classification is that multiple representations of depth to groundwater are incorporated into the second tier of the analysis to evaluate longer term trends or persistent conditions.

Table 3. GDE Likelihood Class Descriptions

Class	Definition
GDE	Areas classified as "Assumed GDE" for 100% of groundwater conditions from 2005-2019
Potential GDE - Likely	Areas classified as "Assumed GDE" for more than 50% of groundwater conditions from 2005-2019
Potential GDE - Unlikely	Areas classified as "Assumed GDE" for less than or equal to 50% of groundwater conditions from 2005-2019
Not GDE	Areas classified as "Assumed Not GDE" for 100 % of groundwater conditions from 2005-2019

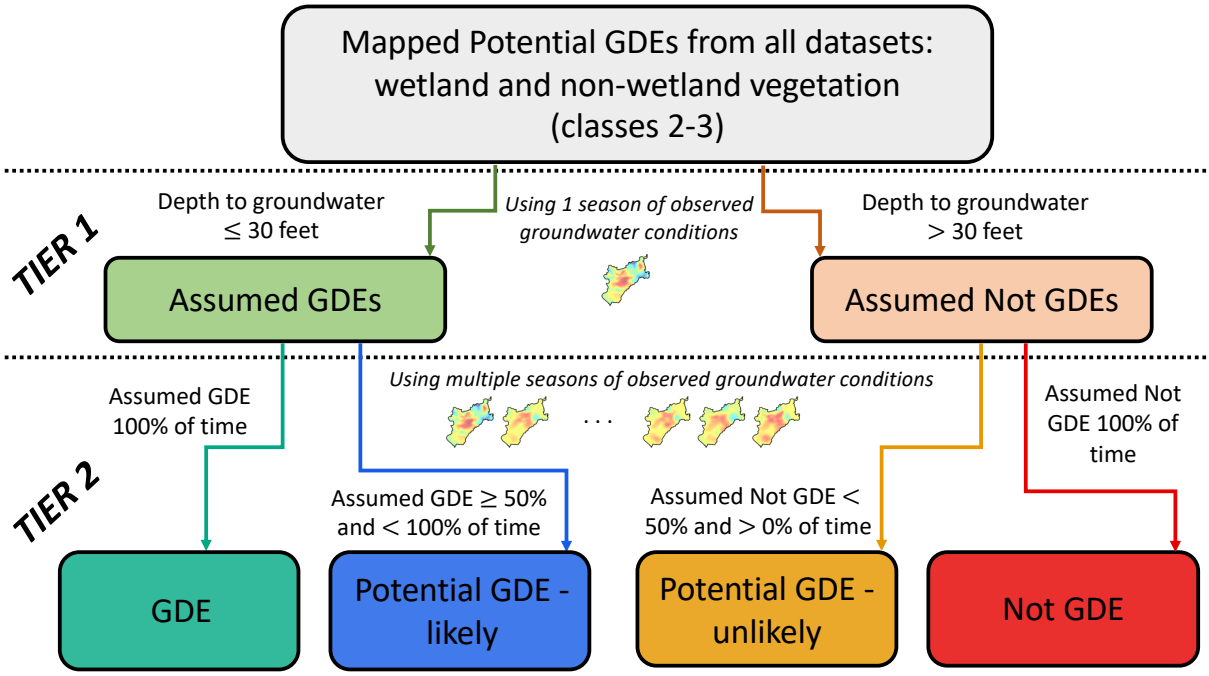


Figure 6. Conceptual Diagram Showing the Two-Tier GDE Classification Process

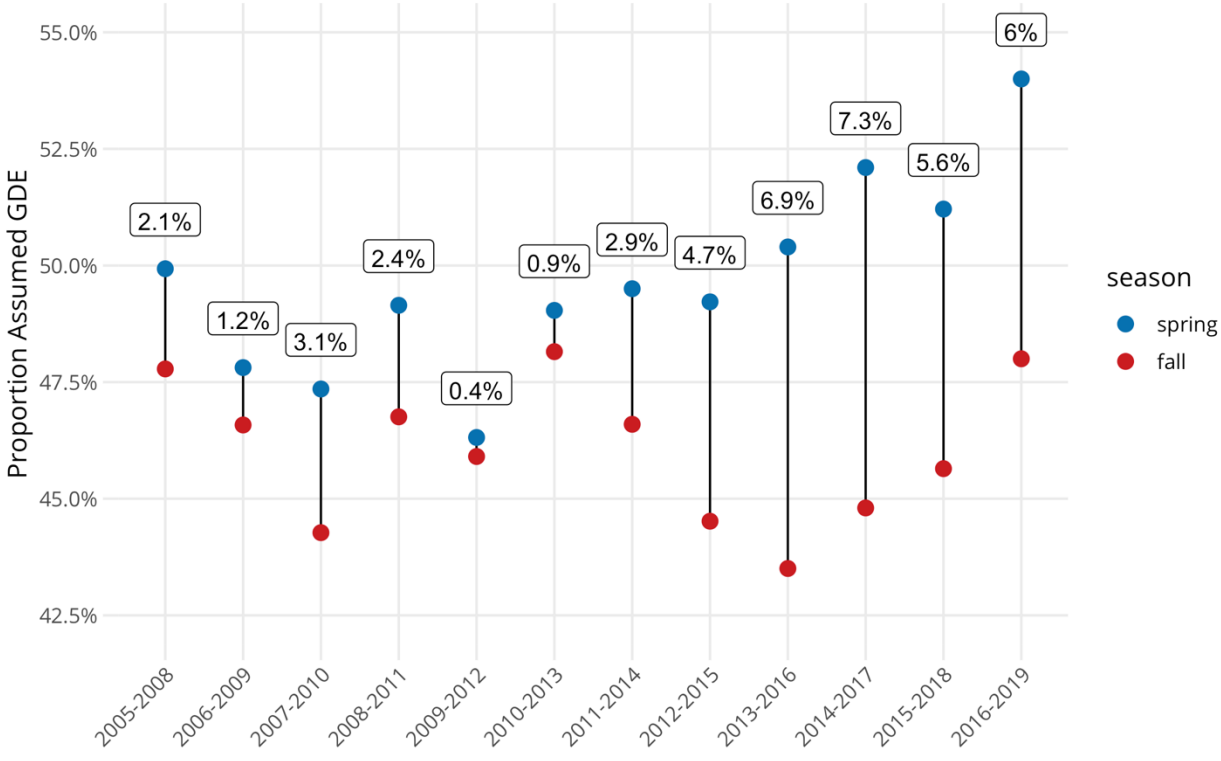


Figure 7. GDE Classification Based on the Application of a 30 ft. Depth to Groundwater Threshold on Mapped Potential GDEs

Table 4. GDE Likelihood Categorization Based All 4-year Groundwater Elevations from 2005-2019

Category	Area (acres)	% of Mapped Potential GDE Area
GDE	11,340	43.2%
Potential GDE - Likely	1,695	6.5%
Potential GDE - Unlikely	914	3.5%
Not GDE	12,296	46.9%
Total	26,245	100%

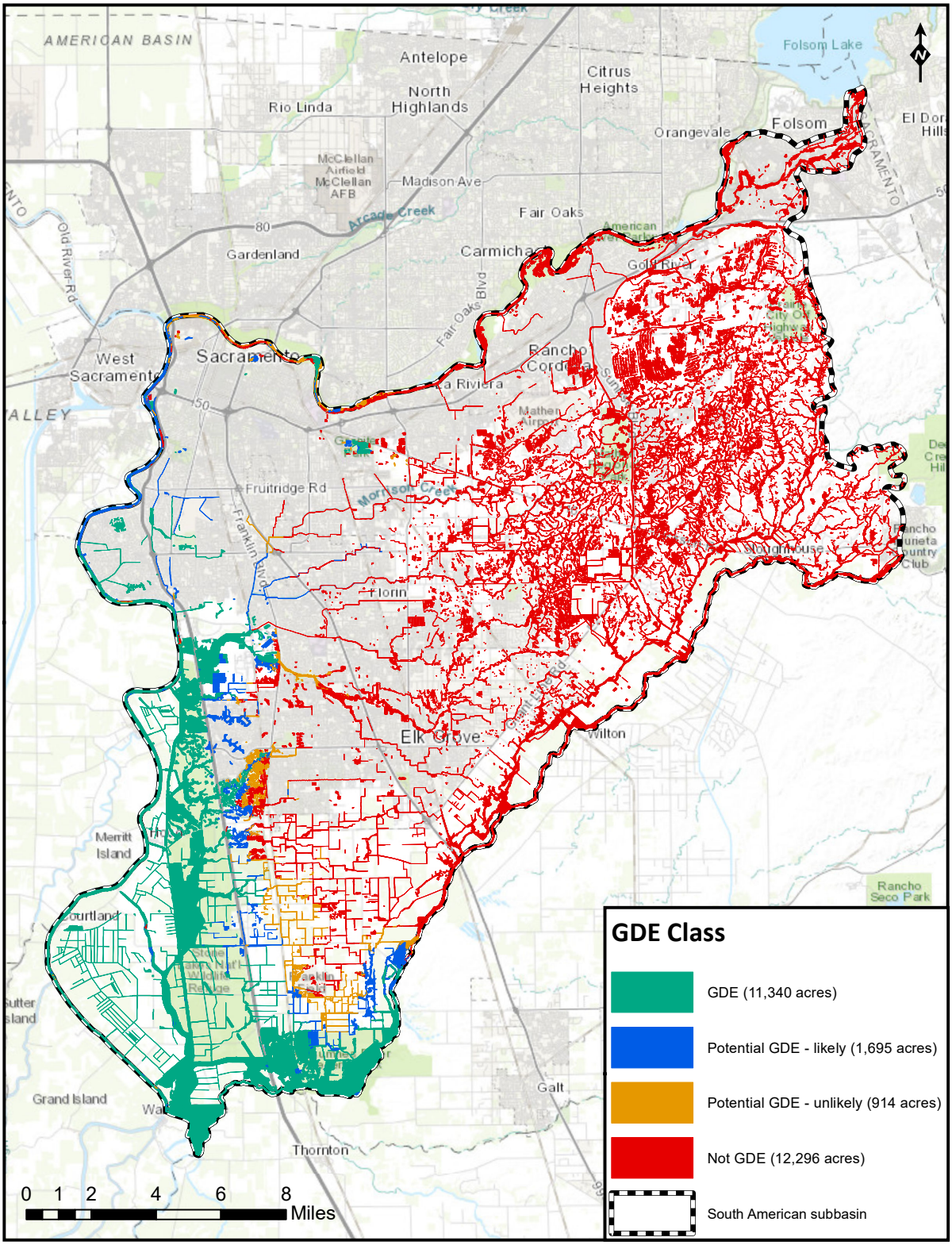


Figure 8. GDE Likelihood Classification of all Mapped Potential GDEs Over the Entire Period of Record (2005-2019)

GDE Categorization Through Aerial Imagery

An additional evaluation using aerial imagery and remote sensing techniques was carried out to validate, to the extent feasible, the Tier 2 GDE likelihood classification driven by the relationship of mapped potential GDE polygons to groundwater conditions. As previously discussed, the 30-foot depth to groundwater threshold is conservatively inclusive of GDE areas. In the SASb, only the Valley Oak would reasonably access groundwater close to 30 feet below ground surface. Thus the 30-foot threshold is most effective in identifying "Assumed Not GDE" areas based on SASb-scale representation of groundwater levels. A secondary evaluation of the classification of mapped potential GDEs into "GDE", "Potential GDE - Likely", "Potential GDE - Unlikely", and "Not GDE" classes was therefore required to account for the complex relationship between vegetation rooting depth and dynamic groundwater conditions.

Rooting depths for species vary over time as plants grow. Cottonwoods are a salient local example of the complex relationship between dynamic rooting zones and groundwater conditions because they are a relatively long-lived, deep-rooted and well-studied species commonly found in the SASb. Cottonwood seedlings require contact with moisture to sprout and elongate their roots rapidly to meet the groundwater or to follow it as water tables decline following floods. Mahoney and Rood (1992) identified that the maximum rate of root elongation was 0.47 inches per day (12 mm/day) for cottonwoods, with a 3.94 inch per day (10 cm/day) decline in experimental conditions, which matched field analysis on the cottonwood species (*P. fremontii*) found in this part of California. In other words, as groundwater levels fall, roots respond by elongating. Moreover, roots can access water through capillary action in soils with more fines (e.g., sand and smaller) and can be cut off more quickly in well-drained cobbles and boulder soils, highlighting the dependence of subsurface geology on root access to groundwater. The complexity of the root-water interface challenges measurable and scalable management criteria, thus we assume that above-ground differences in plant health (measured by plant "greenness" discussed below) are a reasonable proxy for unseen, below-ground processes. With all else being equal, greener plants presumably have greater access to groundwater, and drier plants have less access to groundwater.

An aerial imagery analysis was performed to evaluate the difference in Normalized Difference Vegetation Index (NDVI)[15] values between GDE likelihood classes. NDVI is a dimensionless measure of how surface vegetation reflects light in the visible and near-infrared parts of the electromagnetic spectrum and is a popular approach to estimate plant and community health at scale. The chlorophyll present in healthy plants absorbs visible light while the cellular structure of vibrant vegetation cover such as leaves strongly reflects near-infrared light. Healthy vegetation reflects more near infrared light and dry, unhealthy vegetation reflects more visible red light. NDVI exploits this material property of plants and is used to measure the relative health of vegetation in the SASb. Importantly, NDVI may be zero or negative for soil and water land cover classes, and NDVI can only be calculated at the scale of the pixel. Mixed pixels which contain vegetation, soil, and water have lower NDVI because soil and water do

[15] NDVI is calculated as (NIR-Red) / (NIR + Red), where NIR is reflectance measured in the near infrared portion of the electromagnetic spectrum (750 - 1400 nanometers), and Red is red visible light (625-740 nanometers).

not reflect as strongly in the near infrared; these pixels were included in this analysis, and a spectral unmixing analysis was not performed.

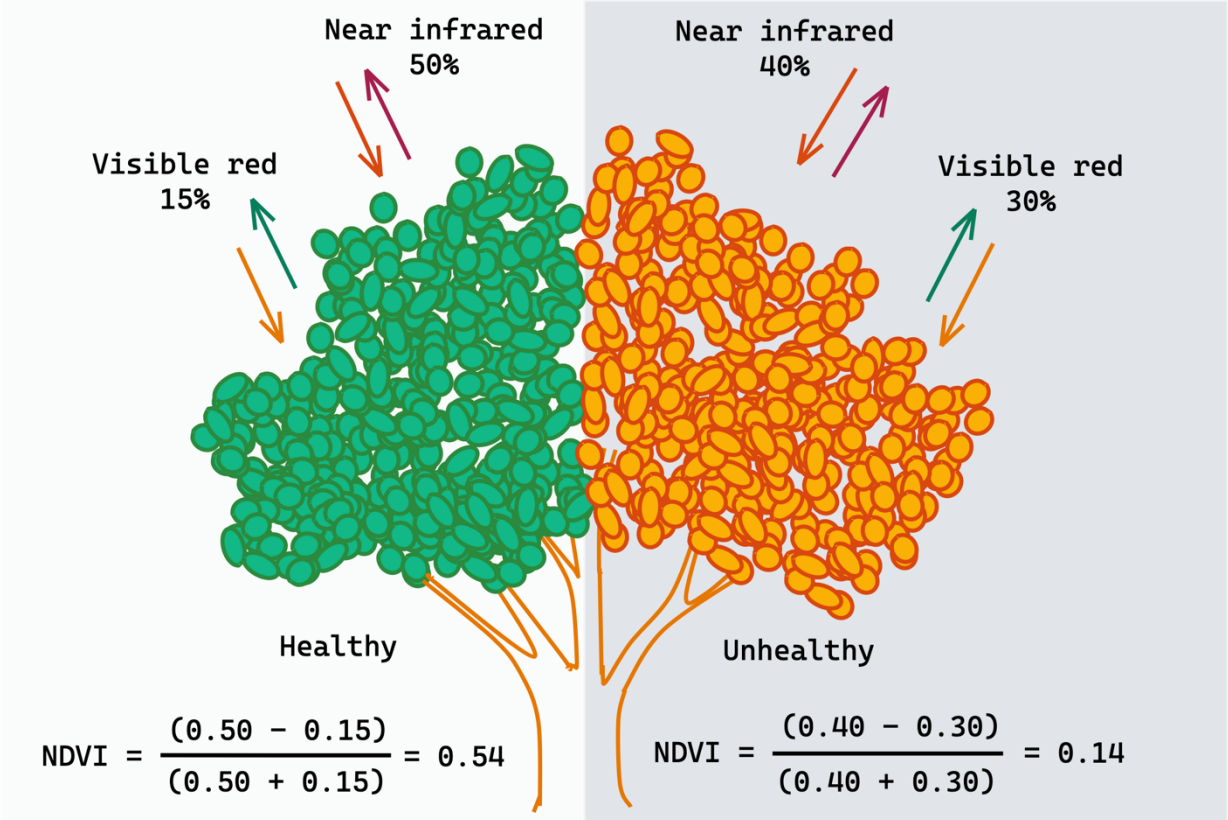


Figure 9: Normalized Difference Vegetation Index (NDVI) is higher for healthy vegetation and can be zero or less than zero for soil and water, and occurs when reflected red light exceeds reflected near infrared light.

Imagery from U.S. Department of Agriculture's (USDA) National Agriculture Imagery Program (NAIP) was obtained for summer dates from 2009-2020 when available (Table 5). NAIP imagery is generally available for a given area for one day a year during the growing season and was typically collected between late June and mid-July in the SASb. The previously discussed zonal statistics function within a GIS was used to compute grid-level NDVI values for each mapped potential GDE. NDVI values were summarized by GDE likelihood class for each NAIP imagery date (Figure 10). The NDVI distribution for areas classified as "GDE" consistently exhibit higher median NDVI compared to all other classes. Moreover, the "Potential GDE - likely" class tends to have the widest interquartile range across the years evaluated, which is unsurprising as this class is assumed to reflect vegetation where depth to groundwater is less than 30 feet in more than 50% of representations of groundwater conditions. The NDVI classification generally shows that areas assumed to have access to groundwater based on the Tier two GDE likelihood classification ("GDE" areas) have higher median and 75th percentile NDVI values (i.e., healthier vegetation) than other categories. This demonstrates that GDE can be used to separate Tier two "GDE" areas from other Tier two categories. Conversely, areas assumed to have limited or no access to groundwater based on the Tier two GDE likelihood classification such as "Not GDE", "Potential GDE -

Unlikely", "Potential GDE - Likely" classes are associated with lower median NDVI values and therefore are reasonably assumed to have less coverage, or less healthy vegetation. Moreover, class are relatively inseparable based solely on NDVI within these three non "GDE" Tier two classes.

Table 5. National Agriculture Imagery Program (NAIP) Image Dates used in this study

Calendar Year	Date
2009	June 21
2012	June 28
2014	June 5
2016	June 21
2018	July 14
2020	July 7

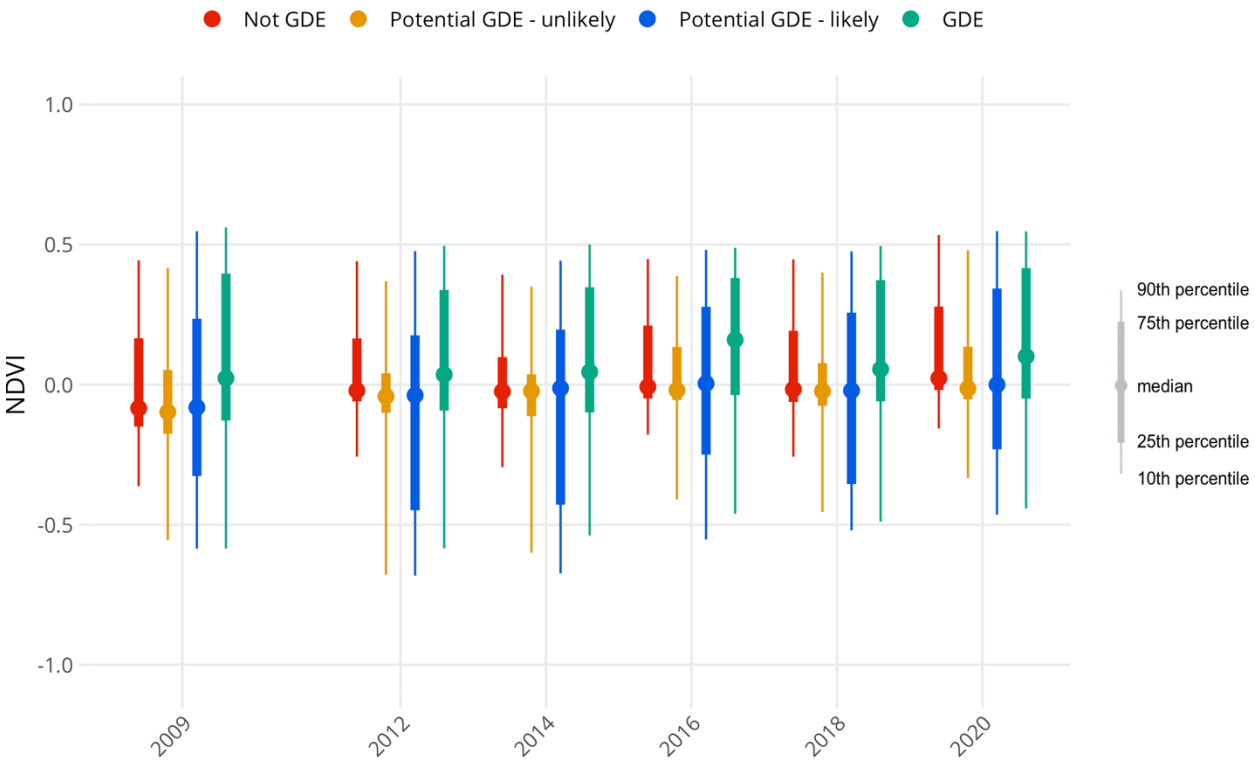


Figure 10. Distribution of Normalized Difference Vegetation Index (NDVI) Values by Tier two GDE Likelihood Class for Each National Agriculture Imagery Program (NAIP) Imagery Date

MANAGING GDEs

Wetland and non-wetland GDEs within the SASb are assumed to depend on shallow groundwater to support mature vegetation and seedling establishment (Rood et al., 2003). Shallow groundwater level decline may result in reduced plant growth and, in more severe cases, lead to plant mortality (Shafroth et al., 2000). Moreover, groundwater extraction can impact the shallow groundwater levels that support hydrophilic vegetation (Rood et al., 2003; Scott et al., 1999; Shafroth et al., 2000). For instance, Stromberg and colleagues (1996) found that mature cottonwood and willow trees required mean depths to groundwater in the range of nearly five feet and moderate, persistent reductions in

groundwater level jeopardized the species' fitness. Moreover, seasonal fluctuations in groundwater levels are normal and once established, riparian species can survive periodic declines (Stromberg & Patten, 1992). Management of GDEs will therefore focus on defining Undesirable Results and setting measurable objectives (MOs) that account for the natural variability in depth to groundwater and surface vegetation composition represented by NDVI across the SASb. The governing philosophy of the proposed management criteria is to avoid previously un-observed conditions (defined by historical variability in groundwater and GDEs) – these criteria are measured in terms of groundwater level and NDVI.

Definition of Undesirable Results

Establishing a clear definition of Undesirable Results and the quantitative criteria by which these results are identified is a key outcome of the GDE management plan within the context of SGMA.

Undesirable Results for GDEs in the SASb are experienced when GDE area or plant health falls below 2015 minima, which indicate impacts to GDEs in excess of natural variability.

Bear in mind, the "natural variability" included in this contemporary historical range includes the impacts of the 2012-2016 drought, and pre-SGMA groundwater management.

Identification of Undesirable Results

The identification of Undesirable Results is based on how depth to groundwater and NDVI relate to historical Tier 1 and Tier 2 GDE classifications (Figure 6): if Tier 1 "Assumed GDE" area or Tier 2 "GDE" health declines below historically observed (2005-2019) natural variability, Undesirable Results occur. If either of the following criteria occur for three consecutive years during the implementation horizon, Undesirable Results are identified:

- **Criteria A (based on Tier 1 classification):** The proportion of Tier 1 "Assumed GDE" class falls below 44% (the lowest historically observed proportion of "Assumed GDE" occurring in fall 2013-2016)
- **Criteria B (based on Tier 2 classification):** Median June NDVI across the Tier 2 "GDE" class falls below 0.023 (the lowest historical median NDVI value, observed in June 2009). The Tier 2 "GDE" class is computed using observed groundwater conditions from the previous five fall seasons.

Criteria A was defined by reviewing the GDE likelihood categorization based on the relationship between area-weighted depth to groundwater value and the 30-foot threshold. The fall seasonal depth to groundwater from 2013-2016 represented the lowest proportion of historically observed Tier 1 "Assumed GDE" and "Assumed Not GDE" classes, with 44% of mapped potential GDEs falling into the "Assumed GDE" category. Thus, this criterion stipulates that Undesirable Results are identified if the proportion of the area in the "Assumed GDE" class falls to levels roughly observed during the 2012-2016 drought and remains there for three consecutive years.

Criteria B was defined by identifying the lowest historical median NDVI value (0.023) for the Tier 2 "GDE" class observed in the June 2009 NAIP imagery (Figure 10). Notably, this date precedes the 2012-2016 drought and represents an NDVI minimum based on natural variability in GDE vegetation. If the median "GDE" NDVI falls below the historically observed median "GDE" NDVI (0.023) this equates to a reduction

in median plant health previously unobserved in the SASb. The Tier 2 "GDE" class is computed using the previous five fall groundwater level conditions, to represent a running five-year window of relatively recent groundwater conditions. Using the entire historical record (2005 - present) was considered, but it was determined that a running five-year window would be more representative of present-day conditions during the implementation horizon.

Collectively, Criteria A and B are based on Tier one and two GDE classification, and measure changes to GDE area and health, respectively. Thus, during an implementation year, even if GDE area may appear constant according to Criteria A, Criteria B will provide a lens into GDE conditions. Similarly, if GDE conditions are constant according to Criteria B, Criteria A will provide a lens into how GDE area has changed.

Median NDVI close to zero may be misinterpreted as indicating unhealthy vegetation. In fact, NDVI values form a distribution. In the year with the lowest median NDVI (2009), half of NDVI values in areas identified as "GDE" exceed 0.023, and half fall below this value. These Tier two GDE areas (groundwater within 30 feet of land surface in 100% of times evaluated) include vegetated areas (NDVI > 0), non-vegetated areas like water and soil (NDVI $\leq$ 0), and mixed pixels that contain vegetation, soil, water, and other materials (NDVI $\leq$ 0, and sometimes > 0). Median NDVI in Tier two GDE areas that falls below 0.023 during the implementation time period indicates the areas which are consistently within 30 feet of groundwater have become less photosynthetic as a whole, which indicates loss of healthy vegetation in excess of historically observed natural variability in NDVI. If this criteria is observed, it should be considered alongside Criteria A, and change in NDVI maps should inform strategic field-based monitoring.

Table 6. Quantitative Definition of Undesirable Results

Identification of Undesirable Result	Historical minimum observed	Quantitative Metric
Criteria A: Proportion of Mapped Potential GDE Classified as "Assumed GDE" in Tier 1 GDE Likelihood Analysis	2013-2016 Fall	44%
Criteria B: Lowest Median NDVI for "GDE" in Tier 2 GDE Likelihood Analysis	June 2009	0.023

Both criteria to identify Undesirable Results use metrics based on evolving representations of mapped potential GDE areas and hence allow for the future addition or removal of mapped potential GDE areas as the composition of surface vegetation within the SASb is more comprehensively understood. Furthermore, future iterations of this GDE analysis can be carried out and compared to the period or dates associated with the quantitative definitions of Criteria A and B. In subsequent implementation years, a dataset representing the current understanding of the spatial distribution of class 2 wetland and class 3 non-wetland mapped potential GDEs will be developed and set the extent of the GDE analysis.

Mapped potential GDEs will be undergo Tier 1 classification into "Assumed GDE" and "Assumed Not GDE" classes by applying the 30-foot threshold based on the current representation of depth to groundwater (Figure 6). If the proportion of mapped potential GDEs classified as "Assumed GDE" in Tier 1 is less than 44% for 3 consecutive years, an Undesirable Result is observed. A comparison of "Assumed

GDE" Tier 1 class for the current year and the 2013-2016 Fall period will reveal areas where changes in groundwater conditions have moved areas into the "Assumed Not GDE" Tier 1 class.

Areas will then be further classified consistent with the Tier 2 criteria into GDE likelihood classes (**Error! Reference source not found.**). NDVI summary statistics will be computed for each Tier 2 GDE likelihood class based on groundwater conditions for five fall seasons (the year of the evaluation and the previous four years). If the median NDVI for areas that fall into the Tier 2 "GDE" class is less than 0.023, an Undesirable Result is observed. A map showing pixel NDVI change between the NDVI for the year in question with the June 2009 date used to establish the Undesired Result metric will show what areas have experienced vegetative condition change.

Measurable Objectives

Measurable objectives (MOs) are sustainable management targets to reach within the implementation horizon. The clear relationship between Tier 2 GDE likelihood classes based on depth to groundwater and NDVI (Figure 10) suggest that sustainable management criteria for groundwater which maintain groundwater levels within 30 feet of land surface in existing GDE areas will support GDE health.

Like the identification of Undesirable Results, MOs for GDE health are based on maintaining or exceeding the average historically observed GDE area proportion and NDVI. GDE MOs for the implementation horizon are summarized as follows:

- Tier 1 "Assumed GDE" class remains at 48% or higher (mean of GDE area proportion from 2005-2019)
- Median five-year running June NDVI for the Tier 2 "GDE" class remains at or above 0.07 (average median June NDVI over NAIP period of record evaluated in this study)

Stabilization at these levels implies GDE area and plant health consistent with average historical conditions.

GDE-ASSOCIATED BENEFICIAL USES & USERS

There are a variety of aquatic, amphibious and riparian species that may be associated with GDEs in the SASb. In order to better understand these users and their uses of aquatic and riparian habitat, the analysis includes a report from CDFW's Biogeographic Information and Observation System (BIOS), a database that provides a comprehensive list of special status species and some of their habitat in Sacramento County.[16] The database does not allow querying by Bulletin 118 subbasins. As such, it contains more species than are found in the SASb, as well as some species that are found in the general watershed but have not been identified as occupying this region. The complete list and an annotated list of those species and habitats that have known or likely relationships to GDEs are included in Appendix E. These environmental beneficial users have the potential to be impacted through chronic or acute lowering of water tables.

LIMITATIONS

[16] *Available at* https://wildlife.ca.gov/Data/BIOS.

The approach developed and carried out to identify and evaluate GDEs within the SASb represents a conservative application of best available science through the application of reasonable assumptions. Representations of mapped potential GDEs were developed based on available geospatial datasets, though these resources cannot be assumed to be definitive. The vegetation classes present in the datasets outlined in the Mapped Potential GDEs section above are broad and could reasonably represent a broad array of vegetation types precluding the reasonable and defensible assignment of assumed rooting zone depths. Groundwater conditions were represented by the interpolation of observed conditions in the Subbasin's well network. These interpolated groundwater elevations may not reflect smaller scale variations in conditions both in space (less than 500 meters) and time (sub-seasonal). Because the groundwater elevations used herein represent regional, seasonal trends, they cannot capture the impact of perched aquifers on GDE health. Moreover, regional groundwater models such as CoSANA were not incorporated into the analysis.

Notably, GDEs are not necessarily static and can vary in time and space depending on water year type and other environmental conditions. As such, this analysis is not intended to be a definitive cataloging of each class of GDE, but rather a survey of the maximum possible extent of above-ground, vegetated GDEs in the SASb. A physical determination of GDEs must show that roots are connected to groundwater, which would require an infeasible subsurface geophysical survey across the SASb.

NDVI analysis included data from 2009, 2012, 2014, 2016, 2018, and 2020. These 6 years are a sample of water year types and GDE conditions and may not reflect the entire range of natural variation in NDVI across the SASb. SGMA implementation will require the re-calculation of this metric, and over time, a better understanding of the variance in NDVI in Tier two GDE areas will be reached.

BIBLIOGRAPHY

California Department of Water Resources (DWR). (2003). *Bulletin 118 – Update 2003*. California's Groundwater (Bulletin 118). California Wetlands Monitoring Workgroup. (2013). *California Rapid Assessment Method for Wetlands, Version 6.1*. *California Rapid Assessment Method (CRAM) for Wetlands*. Version 6.1, 67.

California Wetlands Monitoring Workgroup (CWMW) (2017). EcoAtlas. Retrieved January 1, 2017, from http://www.ecoatlas.org.

Klausmeyer, K. (2019). Identifying GDEs Under SGMA: Best Practices for Using the NC Dataset https://groundwaterresourcehub.org/sgma-tools/mapping-indicators-of-gdes/.

Kleinschmidt Associates. (2008). Cosumnes River Preserve Management Plan. Grass Valley, CA.

Kawanishi, R., Inoue, M., Dohi, R. *et al.* (2013). The role of the hyporheic zone for a benthic fish in an intermittent river: a refuge, not a graveyard. *Aquatic Science* **75,** 425–431. Retrieved from https://doi.org/10.1007/s00027-013-0289-4.

Mahoney J.M. *&* Rood S.B. (1992) Response of a hybrid poplar to water table decline in different substrates. Forest Ecology and Management 54*,* 141–156*.*

Rood, S. B., Braatne, J. H., & Hughes, F. M. R. (2003). Ecophysiology of riparian cottonwoods: stream flow dependency, water relations and restoration. *Tree Physiology*, *23*(16), 1113–1124.

Scott, M. L., Shafroth, P. B., & Auble, G. T. (1999). Responses of riparian cottonwoods to alluvial water table declines. *Environmental Management*, *23*(3), 347–358.

Shafroth, P. B., Stromberg, J. C., & Patten, D. T. (2000). Woody riparian vegetation response to different alluvial water table regimes. *Western North American Naturalist*, *60*(1), 66–76.

Sorensen JPR, Maurice L, Edwards FK, Lapworth DJ, Read DS, et al. (2013) Using Boreholes as Windows into Groundwater Ecosystems. PLoS ONE 8(7):e70264. doi:10.1371/journal.pone.0070264

Stromberg, J. C., & Patten, D. T. (1992). Mortality and age of black cottonwood stands along diverted and undiverted streams in the eastern Sierra Nevada, California. *Madroño*, *39*(3), 205–223.

Stromberg, J. C., Tiller, R., & Richter, B. (1996). Effects of Groundwater Decline on Riparian Vegetation of Semiarid Regions: The San Pedro, Arizona. *Ecological Applications*, *6*(1), 113–131.

White, D. (1993). Perspectives on Defining and Delineating Hyporheic Zones. *Journal of the North American Benthological Society, 12*(1), 61-69. doi:10.2307/1467686.

Appendix 3-E

Table A-1: Groundwater Quality Monitoring Wells Within the South American Subbasin that Measure Both Nitrogen and TDS

Appendix 3-E

Table A-1: Groundwater quality monitoring wells within the South American Subbasin that measure both nitrate and TDS.

WELL ID	Facility or Water System Name	GSA	Well Depth	Formation	Nitrate Measurements			TDS Measurements		
					From	To	# of records	From	To	# of records
3400101-001	Hood Water Maintenance Dist	ND	60	Alluvium	3/21/2001	11/13/2018	9	2/19/2008	2/11/2020	3
3400173-001	Northgate 880 (SWS)	ND	284	Laguna	7/26/2001	2/3/2020	15	5/24/2001	2/27/2007	3
3410020-009	City of Sacramento Main	SCGA	91	Laguna	11/16/1988	2/4/2020	23	11/16/1988	2/4/2020	13
3410029-002	SCWA - Laguna/Vineyard	SCGA	176	Laguna	2/21/1991	2/13/2020	26	2/21/1991	2/13/2020	9
3410029-016	SCWA - Laguna/Vineyard	SCGA	150	Laguna	7/1/1988	2/10/2020	24	7/1/1988	2/10/2020	9
3410029-024	SCWA - Laguna/Vineyard	SCGA	232	Laguna	8/26/2002	5/10/2018	16	8/26/2002	5/22/2014	5
3410029-025	SCWA - Laguna/Vineyard	SCGA	252	Laguna	3/21/2001	5/14/2019	17	3/21/2001	5/22/2014	6
3410029-029	SCWA - Laguna/Vineyard	SCGA	153	Laguna	10/25/2001	2/13/2020	17	10/25/2001	2/13/2020	7
3410033-006	Florin County Water District	SCGA	127	Laguna	7/13/1990	3/19/2019	48	7/13/1990	6/13/2019	10
3901216-001	Unknown	ND	292	Laguna	5/22/2002	2/12/2018	9	5/22/2002	2/16/2017	4
L10004137499-MW-11	L &D Landfill	SCGA	136	Laguna	11/11/2009	8/20/2019	14	5/13/2009	8/20/2019	16
L10004137499-MW-19	L &D Landfill	SCGA	100	Laguna	12/14/2010	11/6/2019	8	5/12/2009	11/6/2019	17
L10004137499-MW-21	L &D Landfill	SCGA	100	Laguna	5/12/2009	8/19/2019	18	5/9/2011	8/19/2019	11
L10004137499-MW-23	L &D Landfill	SCGA	100	Laguna	5/12/2009	5/21/2019	15	5/5/2010	8/19/2019	17
L10004137499-MW-24	L &D Landfill	SCGA	100	Laguna	5/13/2009	5/21/2019	14	5/14/2012	11/7/2019	10
L10004137499-MW-29	L &D Landfill	SCGA	90	Laguna	5/6/2010	11/6/2019	7	5/15/2012	5/22/2019	5

WELL ID	Facility or Water System Name	GSA	Well Depth	Formation	Nitrate Measurements			TDS Measurements		
					From	To	# of records	From	To	# of records
L10004137499-MW-5	L &D Landfill	SCGA	91	Laguna	5/7/2010	5/24/2019	12	5/15/2009	11/8/2019	17
L10004137499-MW-8	L &D Landfill	SCGA	120	Laguna	5/7/2010	11/6/2019	7	5/7/2010	5/22/2019	9
L10005519750-MW-D	Unknown	SCGA	48	Laguna	5/5/2014	12/10/2019	8	5/5/2014	12/10/2019	7
L10005519750-MW-E	Unknown	SCGA	60	Laguna	5/5/2014	12/10/2019	5	5/5/2014	12/10/2019	5
L10005519750-MW-G(S)	Unknown	SCGA	59	Laguna	5/6/2014	12/10/2019	7	5/6/2014	12/10/2019	9
L10008601447-EW-1	Elk Grove Class III Landfill	SCGA	75	Laguna	8/6/2013	6/7/2019	9	10/28/2014	6/7/2019	6
L10008601447-EW-4	Elk Grove Class III Landfill	SCGA	120	Laguna	8/28/2013	9/17/2019	11	6/11/2014	6/6/2019	5
L10008601447-MW-12	Elk Grove Class III Landfill	SCGA	122	Laguna	5/2/2013	9/17/2019	8	6/11/2014	9/17/2019	7
L10008601447-MW-13	Elk Grove Class III Landfill	SCGA	130	Laguna	9/25/2014	9/19/2019	13	9/25/2014	9/19/2019	12
L10008601447-MW-2	Elk Grove Class III Landfill	SCGA	134	Laguna	5/6/2013	6/5/2019	7	9/5/2013	9/19/2019	12
L10008601447-MW-3	Elk Grove Class III Landfill	SCGA	125	Laguna	2/22/2013	9/18/2019	9	2/22/2013	9/18/2019	9
L10008601447-MW-6	Elk Grove Class III Landfill	SCGA	121	Laguna	5/2/2013	6/10/2019	7	5/2/2013	9/17/2019	10
L10008601447-MW-8	Elk Grove Class III Landfill	SCGA	125	Laguna	5/2/2013	9/16/2019	9	5/2/2013	9/16/2019	6
L10008601447-MW-9	Elk Grove Class III Landfill	SCGA	176	Laguna	5/2/2013	7/10/2019	6	9/17/2013	6/5/2019	5
3400125-001	Freeport Marina	SCGA	0	-	3/13/2001	3/14/2019	19	7/14/2005	3/14/2019	5
3400375-001	Slavic Missionary Church Inc	SCGA	300	Mehrten	7/9/2003	3/8/2019	14	6/8/2012	6/8/2012	1
3410010-002	Cal Am - Suburban Rosemont	SCGA	350	Mehrten	2/13/1991	9/12/2013	23	2/13/1991	8/17/2006	6
3410010-021	Cal Am - Suburban Rosemont	SCGA	366	Mehrten	1/21/1997	8/13/2018	22	1/21/1997	8/13/2018	8

WELL ID	Facility or Water System Name	GSA	Well Depth	Formation	Nitrate Measurements			TDS Measurements		
					From	To	# of records	From	To	# of records
3410015-020	Golden State Water Co. - Cordova	SCGA	363	Mehrten	5/27/1986	1/8/2019	32	5/27/1986	1/14/2014	11
3410015-022	Golden State Water Co. - Cordova	SCGA	430	Mehrten	5/19/1993	1/15/2019	24	5/19/1993	5/25/2017	11
3410015-029	Golden State Water Co. - Cordova	SCGA	510	Mehrten	5/18/1998	1/8/2019	20	5/18/1998	1/14/2014	7
3410023-015	Cal Am Fruitridge Vista	SCGA	340	Mehrten	2/15/1991	1/19/2017	29	2/15/1991	1/11/2018	7
3410029-015	SCWA - Laguna/Vineyard	SCGA	744	Mehrten	7/1/1988	5/7/2019	22	7/1/1988	5/23/2018	9
3410029-017	SCWA - Laguna/Vineyard	SCGA	0	-	2/1/1995	2/10/2020	24	8/20/1989	2/10/2020	10
3410029-018	SCWA - Laguna/Vineyard	SCGA	780	Mehrten	2/1/1995	5/7/2019	19	2/10/1998	5/22/2014	9
3410029-020	SCWA - Laguna/Vineyard	SCGA	950	Mehrten	2/23/2000	8/21/2018	16	2/23/2000	8/16/2017	7
3410029-021	SCWA - Laguna/Vineyard	SCGA	303	Mehrten	10/19/1999	8/23/2017	17	10/19/1999	8/20/2014	7
3410029-022	SCWA - Laguna/Vineyard	SCGA	366	Mehrten	10/26/2000	8/16/2018	20	10/26/2000	8/16/2017	9
3410029-026	SCWA - Laguna/Vineyard	SCGA	979	Mehrten	10/25/2001	8/15/2019	17	10/25/2001	5/11/2017	8
3410029-027	SCWA - Laguna/Vineyard	SCGA	720	Mehrten	11/19/2003	5/22/2018	15	11/19/2003	2/5/2019	5
3410704-001	SCWA Mather-Sunrise	SCGA	300	Mehrten	10/25/1999	5/6/2019	18	8/27/2002	6/4/2014	5
L10007396297-MW-12A	Kiefer Landfill	SCGA	60	Mehrten	9/15/2015	10/8/2019	5	9/15/2015	4/10/2019	5
L10007396297-MW-12B	Kiefer Landfill	SCGA	120	Mehrten	9/12/2016	10/2/2019	5	5/20/2014	10/2/2019	8
L10007396297-MW-16A	Kiefer Landfill	SCGA	114	Mehrten	9/29/2015	10/3/2019	5	11/5/2013	10/3/2019	8
L10007396297-MW-17A	Kiefer Landfill	SCGA	65	Mehrten	9/4/2014	10/7/2019	11	9/22/2015	4/10/2019	5
L10007396297-MW-20C	Kiefer Landfill	SCGA	336	Mehrten	5/12/2015	4/18/2019	4	6/2/2014	4/18/2019	6

WELL ID	Facility or Water System Name	GSA	Well Depth	Formation	Nitrate Measurements			TDS Measurements		
					From	To	# of records	From	To	# of records
L10007396297-MW-22B	Kiefer Landfill	SCGA	196	Mehrten	5/27/2014	4/17/2019	7	5/27/2014	9/30/2019	5
L10007396297-MW-27A	Kiefer Landfill	SCGA	126	Mehrten	9/21/2015	9/27/2019	7	6/2/2014	9/27/2019	5
L10007396297-MW-2C	Kiefer Landfill	SCGA	314	Mehrten	5/29/2014	4/16/2019	5	10/17/2013	4/16/2019	2
L10007396297-MW-37C	Kiefer Landfill	SCGA	350	Mehrten	10/13/2015	4/16/2019	2	6/4/2014	4/16/2019	6
L10007396297-MW-38B	Kiefer Landfill	SCGA	170	Mehrten	6/30/2014	10/3/2019	8	9/26/2014	4/18/2019	9
L10007396297-MW-40B	Kiefer Landfill	SCGA	300	Mehrten	5/7/2014	4/24/2019	5	9/2/2014	4/24/2019	8
L10007396297-MW-43A	Kiefer Landfill	SCGA	150	Mehrten	5/20/2015	10/8/2019	6	5/20/2015	10/8/2019	6
L10007396297-MW-5A	Kiefer Landfill	SCGA	114	Mehrten	5/5/2014	9/30/2019	8	5/5/2014	9/30/2019	6
L10007396297-MW-5B	Kiefer Landfill	SCGA	176	Mehrten	5/27/2014	10/4/2019	5	11/3/2015	10/4/2019	5
L10007396297-MW-6A1	Kiefer Landfill	SCGA	117	Mehrten	9/3/2014	10/8/2019	8	5/29/2014	10/8/2019	10
L10007396297-MW-7AR	Kiefer Landfill	SCGA	190	Mehrten	5/22/2014	10/4/2019	7	5/22/2014	4/26/2019	6
S7-SAC-SA10	Unknown	SCGA	480	Mehrten	11/2/2017	11/2/2017	1	11/2/2017	11/2/2017	1

Appendix 4-A

Projects and Management Actions

Appendix 4-A: Projects and Management Actions

No.	Project and Management Action Type	Project Name	Organization	Status
Structural				
1	Recharge Enhancement	Laguna Creek and Whitehouse Creek Multi-Functional Corridor Enhancement Project	City of Elk Grove	In Progress
2	Recharge Enhancement	Alder Creek Watershed Open Space/Conservation Easement Catalog	City of Folsom	In Progress
3	Recharge Enhancement	Alder Creek Watershed Tree Planting Program	City of Folsom	In Progress
4	Recharge Enhancement	American River Parkway Cordova Creek Naturalization	County of Sacramento	In Progress
5	Recharge Enhancement	Lower American River Berm Restoration	Sacramento Area Flood Control Agency	In Progress
6	Recharge Enhancement	Lower American River Gravel Augmentation and Side Channel Enhancement	Water Forum	In Progress
7	Recharge Enhancement	Carmichael Creek Restoration Project	Water Forum	
8	Recharge Enhancement	Alder Creek Channel and Floodplain Restoration	City of Folsom	Not Started
9	Recharge Enhancement	Alder Creek Watershed Coordinator Position	City of Folsom	Not Started
10	Recharge Enhancement	Alder Creek Watershed Invasive Weed Removal Strategy	City of Folsom	Not Started
11	Recharge Enhancement	Cosumnes River Preserve Wetland Units	Ducks Unlimited	Not Started
12	Recharge Enhancement	Bushy Lake Enhancement	Sacramento Area Flood Control Agency	Not Started
13	Recharge Enhancement	Cordova Creek Phase II	Water Forum	Not Started
14	Recharge Enhancement	Revolving Power Bypass Fund	Water Forum	Not Started
15	Recharge Enhancement	Gardenland Flood Management, Habitat Restoration, and Recreation Project	Sacramento Area Flood Control Agency	
16	Flood/Stormwater Management	Strawberry Creek Detention Basin Retrofit	City of Elk Grove	Not Started
17	Flood/Stormwater Management	Natomas Company Dam/Alder Reservoir Management	City of Folsom	Not Started
18	Water Quality	Abandoned Wells Program (AWP)	County of Sacramento	In Progress
19	Water Quality	Franklin Septic Conversion Project	Sacramento Area Sewer District	In Progress
20	Water Quality	Hood Community Septic Conversion Project	Sacramento Area Sewer District	In Progress

No.	Project and Management Action Type	Project Name	Organization	Status
21	Water Quality	SRCSD Biological Nutrient Removal Project	Sacramento Regional County Sanitation District	In Progress
22	Water Quality	SRCSD Disinfection System Project	Sacramento Regional County Sanitation District	In Progress
23	Water Quality	SRCSD Granular Media Filtration System Project	Sacramento Regional County Sanitation District	In Progress
24	Water Quality	Alder Pond Restoration and Management	City of Folsom	Not Started
25	Water Quality	Broadway Green Infrastructure Project	City of Sacramento	Not Started
26	Water Quality	Department of Utilities River Friendly Landscape and Water Efficient Irrigation System Demonstration Project	City of Sacramento	Not Started
27	Water Quality	Stormwater Pollution Reduction at Riverfront Parks: Sand Cove Park, Miller Park, Garcia Bend Park, Chicory Bend Park	City of Sacramento	Not Started
28	Water Quality	SW Pollution Reduction at Riverfront Parks: Del Paso Regional Park	City of Sacramento	Not Started
29	Water Quality	SW Pollution Reduction at Riverfront Parks: Glen Hall Park	City of Sacramento	Not Started
30	Water Quality	SW Pollution Reduction at Riverfront Parks: Tiscornia Park	City of Sacramento	Not Started
31	Flood/Stormwater Management	Alder Creek Watershed Stormwater Detention Basin Management	City of Folsom	In Progress
32	Flood/Stormwater Management	Basin 26 Drainage Project	City of Sacramento	In Progress
33	Flood/Stormwater Management	The Upper Laguna Creek Open Space Preserve	County of Sacramento	In Progress
34	Flood/Stormwater Management	Florin Creek Multi-Use Basin	Sacramento Area Flood Control Agency	In Progress
35	Flood/Stormwater Management	Lower Sacramento River Regional Project	Sacramento Area Flood Control Agency	In Progress
36	Flood/Stormwater Management	Pocket Area Levee Underseepage Repair	Sacramento Area Flood Control Agency	In Progress
37	Flood/Stormwater Management	Regional Integration with Central Valley Flood Protection Plan	Sacramento Area Flood Control Agency	In Progress
38	Flood/Stormwater Management	Multi-Functional Drainage Corridor for Shed C	City of Elk Grove	
39	Flood/Stormwater Management	Combined Sewer Green Infrastructure Pilot Projects	City of Sacramento	Not Started
40	Flood/Stormwater Management	Folsom Dam Raise	Sacramento Area Flood Control Agency	Not Started

No.	Project and Management Action Type	Project Name	Organization	Status
41	Flood/Stormwater Management	South Sacramento Streams Group Flood Management	Sacramento Area Flood Control Agency	
42	Water Quality	Elk Grove Green Street Project: Repurposing Urban Runoff with Green Instructure Technologies	City of Elk Grove	Not Started
43	Water Quality	City of Sacramento 16th Street Greenscape	City of Sacramento	In Progress
44	Water Quality	Elk Grove Creek Watershed Storm Water Detention Groundwater Recharge, Habitat Restoration and LID Project	City of Elk Grove	Not Started
45	Supply Augmentation	Sacramento Railyards Stormwater Stewardship and Groundwater Protection Project	City of Sacramento	In Progress
46	Supply Augmentation	Harvest Water Dilutant Stormwater Project	Sacramento Regional County Sanitation District	Not Started
47	Flood/Stormwater Management	Mather Field Road Rehabilitation	City of Rancho Cordova	Not Started
48	Flood/Stormwater Management	Monier Circle Detention and Water Quality Retrofit Project	City of Rancho Cordova	Not Started
49	Flood/Stormwater Management	Rockingham Drive Rehabilitation	City of Rancho Cordova	Not Started
50	Flood/Stormwater Management	Sunrise Blvd Rehabilitation - Phase II	City of Rancho Cordova	Not Started
51	Flood/Stormwater Management	Sunrise Blvd. Rehabilitation - Phase III	City of Rancho Cordova	Not Started
52	Flood/Stormwater Management	Sunrise Blvd. Rehabilitation Phase I	City of Rancho Cordova	Not Started
53	Flood/Stormwater Management	White Rock Road Rehabilitation	City of Rancho Cordova	Not Started
54	Recharge Enhancement	Groundwater Recharge/Swainson's Hawk Habitat Project	American River Conservancy	In Progress
55	Recharge Enhancement	Franklin Groundwater Treatment Plant - Recycled Water Storage Tank & Booster Pump Station	Sacramento County Water Agency	In Progress
56	Recharge Enhancement	Cosumnes River Area Conjunctive Use	The Nature Conservancy	Not Started
57	Recharge Enhancement	Phase II Recycled Water Project	Sacramento County Water Agency	
58	Water Quality	Iron/Manganese Removal Treatment Plant for Town of Hood	Sacramento County Water Agency	In Progress
59	Water Quality	Water Treatment Plants Rehabilitation Project	City of Sacramento	
60	Supply Augmentation	City of Folsom Turf Removal and Landscape Irrigation Upgrades	City of Folsom	In Progress
61	Supply Augmentation	E. A. Fairbairn Groundwater Well	City of Sacramento	In Progress
62	Supply Augmentation	Groundwater Well Recharge Improvements	City of Sacramento	In Progress

No.	Project and Management Action Type	Project Name	Organization	Status
63	Supply Augmentation	River Friendly Retrofit Program	City of Sacramento	In Progress
64	Supply Augmentation	FWTP Improvements and Pumpback Pipeline	City of Sacramento	In Progress
65	Supply Augmentation	City of Sacramento Conjunctive Use - Well 167	City of Sacramento	In Progress
66	Supply Augmentation	Sacramento Regional Weather Based Controller Irrigation Efficiency Incentives Project	City of Sacramento	In Progress
67	Supply Augmentation	Folsom Lake Raw Water Pump Station Replacement	El Dorado Irrigation District	In Progress
68	Supply Augmentation	Regional Leak Detection and Repair	Regional Water Authority	In Progress
69	Supply Augmentation	Water Loss Control Program	Regional Water Authority	In Progress
70	Supply Augmentation	Cordova Hills Storage Tanks & Booster Pump Station	Sacramento County Water Agency	In Progress
71	Supply Augmentation	Franklin Intertie Project	Sacramento County Water Agency	In Progress
72	Supply Augmentation	Hood Distribution Upgrades	Sacramento County Water Agency	In Progress
73	Supply Augmentation	Meter Retrofit Project for Tower Reads	Sacramento County Water Agency	In Progress
74	Supply Augmentation	North Service Area Pipeline - Phase 2	Sacramento County Water Agency	In Progress
75	Supply Augmentation	North Service Area Terminal Tanks & Booster Pump Station - Phase 1	Sacramento County Water Agency	In Progress
76	Supply Augmentation	Harvest Water Project	Sacramento Regional County Sanitation District	In Progress
77	Supply Augmentation	SRCSD/City of Sacramento Recycled Water Phase 2 Project	Sacramento Regional County Sanitation District	In Progress
78	Supply Augmentation	SRCSD/City of Sacramento Recycled Water Phase 3 Project	Sacramento Regional County Sanitation District	In Progress
79	Supply Augmentation	SRCSD/SPA Recycled Water Project	Sacramento Regional County Sanitation District	In Progress
80	Supply Augmentation	City of Sacramento/Commercial, Industrial and Institutional Expanded Water Conservation Program	City of Sacramento	N/A

No.	Project and Management Action Type	Project Name	Organization	Status
81	Supply Augmentation	GSWC/Cal-Am Interconnection Upgrade	Golden State Water Company	N/A
82	Supply Augmentation	City of Sacramento Conjunctive Use - Well 168	City of Sacramento	Not Started
83	Supply Augmentation	City of Sacramento Conjunctive Use - Well 169	City of Sacramento	Not Started
84	Supply Augmentation	City of Sacramento Conjunctive Use and Pressure Augmentation - New Pressure Zone	City of Sacramento	Not Started
85	Supply Augmentation	River Bend Park Water Supply Enhancement Project	County of Sacramento	Not Started
86	Supply Augmentation	Automatic Meter Infrastructure (AMI)	Elk Grove Water District	Not Started
87	Supply Augmentation	Railroad Corridor Water Line	Elk Grove Water District	Not Started
88	Supply Augmentation	American River South Interconnection Pipeline	Fair Oaks Water District	Not Started
89	Supply Augmentation	FOWD/CWD Interconnection Pipeline & Booster Facility	Fair Oaks Water District	Not Started
90	Supply Augmentation	Omochumne Hartnell Water District Off Season Irrigation Project Expansion	Omochumne Hartnell Water District	Not Started
91	Supply Augmentation	Franklin Groundwater Treatment Plant	Sacramento County Water Agency	Not Started
92	Supply Augmentation	Laguna Ridge (Whitelock) Groundwater Treatment and Storage Facility Plant	Sacramento County Water Agency	Not Started
93	Supply Augmentation	North Vineyard Storage and Booster Pump Facility	Sacramento County Water Agency	Not Started
94	Supply Augmentation	Poppy Ridge Groundwater Treatment and Storage Facility Plant - Phase 2	Sacramento County Water Agency	Not Started
95	Supply Augmentation	Power Inn Road Transmission Main - Calvine Road to Geneva Pointe Drive	Sacramento County Water Agency	Not Started
96	Supply Augmentation	Sunrise Douglas (Suncreek) Groundwater Treatment Plant	Sacramento County Water Agency	Not Started
97	Supply Augmentation	Walnut Grove Distribution Upgrades	Sacramento County Water Agency	Not Started
98	Supply Augmentation	SSWD-City of Sacramento Enterprise Intertie	Sacramento Suburban Water District	Not Started
99	Supply Augmentation	Booster pump for Northgate service area	City of Sacramento	
100	Supply Augmentation	River Arc completion	Placer County Water Agency	
101	Supply Augmentation	California-American Water Company Parkway well system (6 wells)	California-American Water Company	

No.	Project and Management Action Type	Project Name	Organization	Status
102	Supply Augmentation	California-American Water Company Rosemont well system (3 wells)	California-American Water Company	
103	Supply Augmentation	City of Sacramento groundwater well drilling (up to 24 wells)	City of Sacramento	
104	Supply Augmentation	Groundwater well construction (1)	Rancho Murieta Community Services District	
105	Supply Augmentation	City of Sacramento groundwater well flexible pump install (12 wells)	City of Sacramento	
106	Supply Augmentation	California-American Water Company and SCWA Intertie (Mather Air Force Base)	California-American Water Company	
107	Supply Augmentation	Golden State Water Company - City of Folsom Intertie	City of Folsom	
108	Supply Augmentation	Folsom South Canal pipeline	City of Folsom	
109	Supply Augmentation	Folsom-EID intertie	City of Folsom	
110	Supply Augmentation	Folsom-FOWD intertie	City of Folsom	
111	Supply Augmentation	City of Sacramento - SSWD intertie	City of Sacramento	
112	Supply Augmentation	City of West Sacramento-City of Sacramento intertie	City of Sacramento	
113	Supply Augmentation	Valve replacement at Franklin Road	City of Sacramento	
114	Supply Augmentation	American River South Interconnection Pipeline	Fair Oaks Water District	
115	Supply Augmentation	Golden State Water Company - Cordova booster pump station	Golden State Water Company	
116	Supply Augmentation	SCWA Zone 40 Pipeline improvement (P-17)	Sacramento County Water Agency	
117	Supply Augmentation	SCWA Zone 40 Pipeline improvement (P-19)	Sacramento County Water Agency	
118	Supply Augmentation	Folsom scalping plant	City of Folsom	
119	Supply Augmentation	Recycled water use expansion	Rancho Murieta Community Services District	
120	Supply Augmentation	Clementia and Bass Lake watershed stormwater capture and reuse	Rancho Murieta Community Services District	
121	Supply Augmentation	CoGen project and conveyance expansion	Sacramento Regional County Sanitation District	

No.	Project and Management Action Type	Project Name	Organization	Status
122	Supply Augmentation	Explore GSWC, OVWC, and CWD recycled water opportunities	Sacramento Regional County Sanitation District	
123	Supply Augmentation	Harvest Water groundwater pumping offset	Sacramento Regional County Sanitation District	Not Started
124	Supply Augmentation	Alder Creek Reservoir and diversion points	El Dorado County Water Agency	
125	Supply Augmentation	Calero Dam raising	Rancho Murieta Community Services District	
Non-Structural				
126	Demand Management	City of Sacramento Demand Management Projects	City of Sacramento	
127	Demand Management	Golden State Water Company Demand Management Projects	Golden State Water Company	
128	Demand Management	California American Water Company Demand Management Projects	California American Water Company	
129	Community Stewardship	Cordova Creek & River Viewing Chamber	City of Rancho Cordova	In Progress
130	Community Stewardship	American River Basin Creek Week	Sacramento Area Creeks Council	In Progress
131	Community Stewardship	Nimbus Hatchery Visitors Center	Water Forum / California Department of Fish and Wildlife	In Progress
132	Community Stewardship	Effie Yeaw Nature Center -- Education Program	Water Forum / Effie Yeaw Nature Center	In Progress
133	Community Stewardship	Alder Creek Watershed Stewardship program	City of Folsom	In Progress
134	Community Stewardship	Alder Creek Watershed Water Use Efficiency Outreach and Education	City of Folsom	In Progress
135	Community Stewardship	Promote River Friendly Landscaping in the Alder Creek Watershed	City of Folsom	In Progress
136	Demand Management	Regional Joint Water Energy Rebate Program	Regional Water Authority	In Progress
137	Demand Management	Advancing Water Efficiency in the Sacramento Region	Regional Water Authority	Not Started
138	Demand Management	Water Efficiency on Large Landscapes (WELL) project	Sacramento Central Groundwater Authority	
139	Community Stewardship	Citizen Science Program	Water Forum / Effie Yeaw Nature Center	Not Started
140	Recharge Enhancement	Alder Creek Watershed Monitoring Program	City of Folsom	In Progress

No.	Project and Management Action Type	Project Name	Organization	Status
141	Recharge Enhancement	Cordova Creek Maintenance	Water Forum	In Progress
142	Recharge Enhancement	Cosumnes River Water Quality Monitoring Program	American River Conservancy	Not Started
143	Water Quality	Sacramento-San Joaquin Delta Watershed Models for Water Supply /Water Quality	Sacramento Regional County Sanitation District	In Progress
144	Conjunctive Use	Examine and expand groundwater monitoring	Sacramento Central Groundwater Authority	
145	Conjunctive Use	Groundwater Accounting Program	Sacramento Central Groundwater Authority	
146	Conjunctive Use	PUC Groundwater Sales Improvement	California-American Water Company	
147	Conjunctive Use	Regional groundwater bank	various	
148	Conjunctive Use	Long-Term Water Supply Contracts with Reclamation	various	
149	Conjunctive Use	Reclamation Modified Flow Management Standard	various	
150	Conjunctive Use	CVP American River Division accelerated water transfer program	various	
151	Conjunctive Use	Clarification of Reclamation drought documents and policies	various	
152	Conjunctive Use	City of Sacramento surface water economic study	City of Sacramento	
153	Conjunctive Use	Fluoridation practice consistency	various	
154	Conjunctive Use	City of Sacramento POU expansion	City of Sacramento	
155	Conjunctive Use	City of Sacramento POU expansion	City of Sacramento	
156	Conjunctive Use	City of Sacramento Hodge Flow study	City of Sacramento	
157	Conjunctive Use	Folsom - Golden State Water Company emergency water agreement	City of Folsom	
158	Conjunctive Use	Folsom - Fair Oaks Water District emergency water agreement	City of Folsom	
159	Conjunctive Use	Golden State Water Company - SCWA agreement	Golden State Water Company	
160	Conjunctive Use	Long-term partnership agreements with SCWA, City of Sacramento, and/or others	Sacramento Suburban Water District	
161	Conjunctive Use	City of Sacramento - SCWA Southwest track agreement	Sacramento County Water Agency	
162	Community Stewardship	Morrison Creek Revitalization Plan	Environmental Justice Coalition for Water	In Progress

No.	Project and Management Action Type	Project Name	Organization	Status
163	Community Stewardship	Alder Creek Watershed Connected Creek Trails, Open Space and Interpretive Signage	City of Folsom	In Progress
164	Community Stewardship	American River Basin Collaborative for Watersheds	Valley Foothill Watersheds Collaborative	In Progress
165	Recharge Enhancement	Lower American River Ecosystem Enhancement Decision Support Tool	Water Forum	In Progress
166	Recharge Enhancement	Lake Natoma Warming Study	Water Forum	Not Started
167	Recharge Enhancement	Stormwater Quality and Groundwater Recharge Study Using Flood Detention Basins and Local Creeks/Streams	Sacramento County Water Agency	
168	Conjunctive Use	Maintain and Update HydroDMS	Sacramento Central Groundwater Authority	
169	Conjunctive Use	Sacramento Area Integrated Water Resource Model Hydrologic Model	Sacramento Central Groundwater Authority	

Sources:

1. American River Basin Integrated Water Management Plan, 2018. Regional Water Authority.
2. SCGA Basin Management Report 2013-2014, 2017. Sacramento Central Groundwater Authority.
3. City of Sacramento - 2015 Urban Water Management Plan, 2016. City of Sacramento.
4. 2015 Urban Water Management Plan, Northern Division - Sacramento District, 2016. California American Water.
5. Regional Water Reliability Plan, 2019. Regional Water Authority
6. 2015 Urban Water Management Plan, Cordova, 2016. Golden State Water Company.
7. Personal communication, Dave Ocenosak, Regional San.
8. Personal communication, Terrie Mitchell, Regional San.

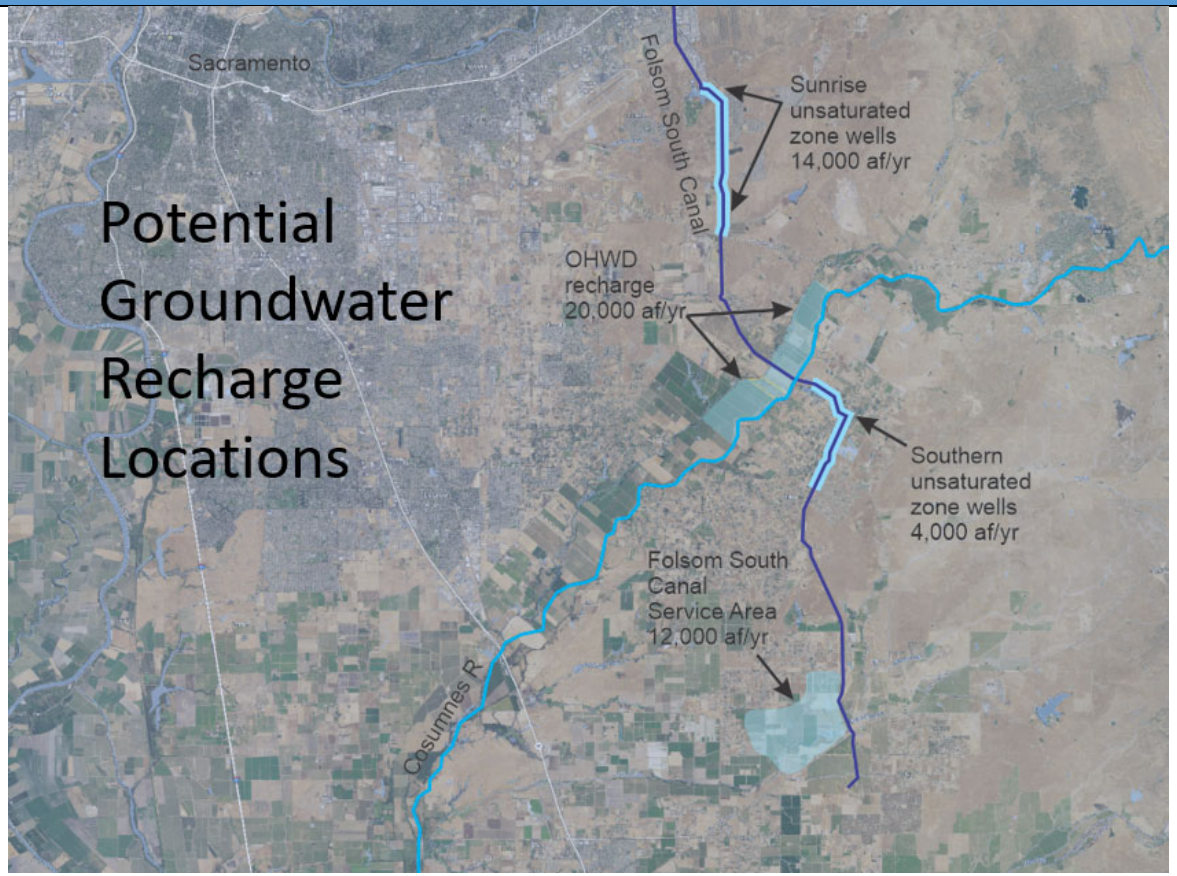
Appendix 4-B

Project Descriptions

Appendix 4-B: Project Descriptions

SAFCA FLOOD-MAR

PROJECTS & MANAGEMENT ACTIONS	
Date	**4/14/21**
Project Title	**SAFCA Flood-MAR Project**
PROJECT PROPONENT	
Agency Name	Sacramento Area Flood Control Agency
Key Contact	Timothy Washburn
Email	washburnt@SacCounty.NET
Phone	

PROJECT LOCATION	
Map	
PROJECT DESCRIPTION	
Description of Project Elements	This project will consist of modifications to Hell Hole, French Meadows, and Union Valley Reservoirs to enable forecast informed operations, changes in operations in Folsom Lake, the use of the Folsom South Canal, and the creation of recharge zones along the FSC alignment using unsaturated zone wells and spreading basins.

Actions	This project will utilize storage in the Middle and South Forks of the American River Basin as well as Folsom Reservoir to capture flood flows that would otherwise flow down the American River. These flows will then be diverted into the Folsom South Canal for recharge at 4 locations (see Figure) located in the South American and Cosumnes Subbasins.
Project Goals	Recharge up to 125,000 AF/year in four of ten years into aquifers in South American and Cosumnes Subbasins.
Project Benefits	• Increased groundwater recharge. • Improve flows and temperature conditions along the American and Cosumnes Rivers • Sustain agricultural productivity in South Sacramento County • Meet urban water needs in drought conditions
Project Impacts	Enhanced capture and use of flood flows.
Project Costs/Financing	The cost of the infrastructure necessary to support the program (recharge pipes, pumps, infiltration wells, recovery wells, etc.) will be provided largely by state and federal grant funds. Annual operation and maintenance costs will be provided principally through the banking and sale of fallowed water by the GSAs to an urban water purveyor for dry year augmentation.

PROJECT STATUS				
Concept ☒	**Planned** ☐	**In-Design** ☐	**Under Construction** ☐	**Completed** ☐
Project Schedule				

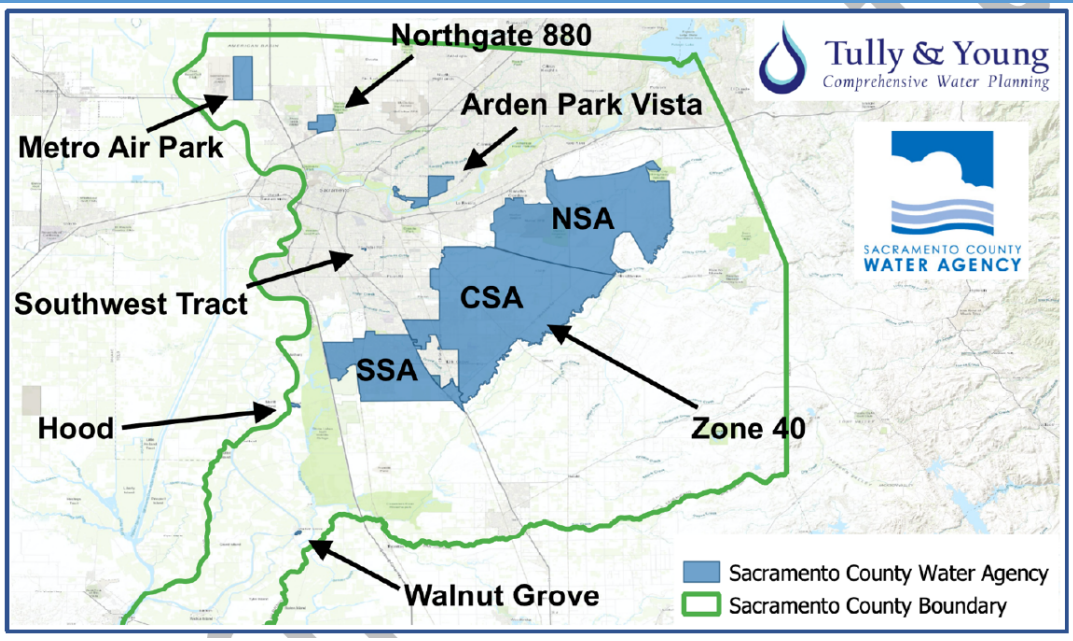
Fruitridge Vista Main Replacement and Meter Retrofit

PROJECTS & MANAGEMENT ACTIONS	
Date	**March 15, 2021**
Project Title	**Fruitridge Vista Main Replacement and Meter Retrofit**
PROJECT PROPONENT	
Agency Name	California American Water
Key Contact	Evan Jacobs
Email	Evan.jacobs@amwater.com
Phone	916 568-4252
PROJECT LOCATION	
Map	

PROJECT DESCRIPTION				
Description of Project Elements	CAW acquired the Fruitridge Vista Water Company in south Sacramento in February 2020. There are several projects needed to comply with state law requiring meter installation and address aging steel mains that were installed in the 1950s and 60s.			
Actions	California American Water plans to install approximately 81,382 linear feet of aging water mains in the Fruitridge Vista service area - $26 million project and install 2396 meters - $11 million project			
Project Goals	The combination of metering and tiered rate design, conservation services, and replacing mains that are known to frequently leak/break is expected to reduce current demand (usually all groundwater pumped from the basin) by 241,159 thousand gallons			
Project Benefits	Comply with state law, reduce leaks and main breaks, improve service for the Fruitridge Vista Community			
Project Impacts				
Project Costs/Financing	$26 million in main replacement and $11 million for meter retrofit			
PROJECT STATUS				
Concept ☐	**Planned ☐**	**In-Design ☐**	**Under Construction ☒**	**Completed ☐**
Project Schedule	All work done by 2025			

Sacramento County Water Agency New Surface Water Supply

PROJECTS & MANAGEMENT ACTIONS	
Date	**4/12/2021**
Project Title	**New Surface Water Supply**
PROJECT PROPONENT	
Agency Name	Sacramento County Water Agency
Key Contact	Mike Huot
Email	huotm@saccounty.net
Phone	916-875-6947

PROJECT LOCATION	
Map	
PROJECT DESCRIPTION	
Description of Project Elements	Procurement of new surface water supplies to bolster surface water portfolio in dry year types.
Actions	Increase the use of surface water by procuring new surface water supplies to bolster availability of surface water in dry year types.
Project Goals	Maximize the ability to use surface water, improve SCWA's conjunctive use water portfolio, and enhance the reliability SCWA's water supplies.

Project Benefits	Additional groundwater could be left in the basin, which could provide both environmental benefits as well as provide long-term water reliability for the water agencies. • Increases regional and state water supply reliability through groundwater storage and conjunctive use • Improves water quality by restoring groundwater levels and increasing in-stream flows in the Cosumnes River • Provides reliable water supplies, enhanced groundwater storage opportunities, and drought resiliency			
Project Impacts	Significant Financial Investment			
Project Costs/Financing	• Currently unknown			
PROJECT STATUS				
Concept ☒	**Planned ☐**	**In-Design ☐**	**Under Construction ☐**	**Completed ☐**
Project Schedule	Anticipated Completion Years: Currently unknown, concept only.			

Contact Information

www.scgah2o.com

admin@scgah2o.com