





Colusa Groundwater Authority &
Glenn Groundwater Authority

Colusa Subbasin Groundwater Sustainability Plan

ANNUAL REPORT

APRIL 2024

COLUSA SUBBASIN

Colusa Subbasin Groundwater Sustainability Plan

Annual Report

For Water Year 2023 (October 2022 – September 2023)

April 2024

Prepared For

Colusa Groundwater Authority
Glenn Groundwater Authority

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

af	acre-feet
af/yr	acre-feet per year
AMSL	above mean sea level
ASCE	American Society of Civil Engineers
bgs	below ground surface
C2VSimFG	fine-grid version of the California Central Valley Groundwater-Surface Water Simulation Model
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
CCWD	Colusa County Water District
CDEC	California Data Exchange Center
CDMWC	Colusa Drain Mutual Water Company
cfs	cubic feet per second
CGA	Colusa Groundwater Authority
CVO	Central Valley Operations
CVP	Central Valley Project
DWR	California Department of Water Resources
EC	electrical conductivity
ET	evapotranspiration
ET_{aw}	ET of applied water
ft	feet
GCID	Glenn-Colusa Irrigation District
GGA	Glenn Groundwater Authority
GIS	geographic information system
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
InSAR	Interferometric Synthetic Aperture Radar
IRWM	Integrated Regional Water Management
ISW	Interconnected Surface Water
LAFCO	Local Agency Formation Commission
MO	measurable objective
MT	minimum threshold
OAWD	Orland-Artois Water District
OUWUA	Orland Unit Water Users' Association
P&G	Proctor and Gamble
PMAs	projects and management actions
RD108	Reclamation District 108
RMS	Representative monitoring sites
SGMA	Sustainable Groundwater Management Act
SMC	Sustainable Management Criteria
SVHMP	Sacramento Valley Height Modernization Project
SWN	state well number
SWRCB	State Water Resources Control Board
taf	thousands of acre-feet
TCC	Tehama-Colusa Canal
TCCA	Tehama-Colusa Canal Authority
TNC	The Nature Conservancy
uS/cm	microSiemens per centimeter
USDA	U.S. Department of Agriculture
WMPP	Well Monitoring Pilot Program
yr	year

Executive Summary (§356.2.a)

INTRODUCTION

The California Code of Regulations Title 23 (23 CCR) Section (§) 356.2 requires that Annual Reports be submitted to the California Department of Water Resources (DWR) by April 1 of each year following the adoption of the Groundwater Sustainability Plan (GSP). This Annual Report for water year 2023[1] is the third Annual Report for the Colusa Subbasin GSP, which is required to be submitted to DWR by April 1, 2024.

The Colusa Subbasin GSP was adopted in December 2021 and was submitted to DWR in January 2022 in fulfillment of the requirements established under the Sustainable Groundwater Management Act (SGMA). The full extent of the Colusa Subbasin (Subbasin) is managed by the two Groundwater Sustainability Agencies (GSAs) that jointly developed and adopted the Colusa Subbasin GSP: the Colusa Groundwater Authority (CGA) GSA, which manages the Colusa and Yolo County portions of the Subbasin, and the Glenn Groundwater Authority (GGA) GSA, which manages the Glenn County portions of the Subbasin (**Figure ES-1**). Coordinated implementation of the Colusa Subbasin GSP is now underway, in alignment with the GSP sustainability goal:

> *"…to maintain, through a cooperative and partnered approach, locally managed sustainable groundwater resources to preserve and enhance the economic viability, social well-being and culture of all Beneficial Uses and Users, without experiencing undesirable results."* (Colusa Subbasin GSP, Section 5.2)

This Annual Report describes conditions across the Subbasin in water year 2023 and GSP implementation efforts by the GSAs and others in the Subbasin since the previous Annual Report. The Annual Report sections follow the requirements outlined in 23 CCR §356.2. The following appendices are also included at the end of this Annual Report:

- **Appendix A**. Groundwater Elevation Contour Maps – Spring/Fall 2020 through 2023.
- **Appendix B**. Groundwater Elevation Hydrographs for Groundwater Level RMS Wells.
- **Appendix C**. Maps of Annual Change in Groundwater Storage – 2015 through 2023.
- **Appendix D**. Approach for Estimating Groundwater Extraction in the Colusa Subbasin GSP Annual Report.

Key data sources and findings from each section of the Annual Report are summarized below, and are described in fuller detail in the associated Annual Report section.

GSP REVISIONS PROCESS

In October 2023, DWR completed their initial evaluation of the Colusa Subbasin GSP and determined the GSP to be "incomplete" pursuant to 23 CCR §355.2(e)(2), initiating a 180-day period for the GSAs to revise the GSP to address the identified deficiencies by April 23, 2024. In this determination, DWR identified three deficiencies:

- DWR found that the GSP did not include a reasonable assessment of overdraft conditions and a reasonable means to mitigate overdraft,
- DWR found that the chronic lowering of groundwater levels SMC were not compliant with the GSP regulations, and
- DWR found that the subsidence SMC were not compliant with the GSP regulations.

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[1] Water Year 2023 spans the period from October 1, 2022, through September 30, 2023. Some information provided in this Annual Report is also reported after the end of water year 2023, including groundwater level measurements collected in Fall 2023 (some after September 30, 2023) and implementation of projects, management actions, and other activities that occurred before April 1, 2024.

Since the previous Annual Report, the GSAs have completed technical analyses and GSP revisions to address the three deficiencies, have met with DWR on multiple occasions to discuss the revisions, and have drafted formal agreements to develop and implement a domestic well mitigation program and a demand management program for the Subbasin. Implementation of these programs is expected to provide the GSAs with additional means of mitigating overdraft, subsidence, and groundwater level decline in the Subbasin and of mitigating undesirable results that may occur to domestic well users during GSP implementation while other projects and management actions are being developed, prior to achieving sustainable groundwater conditions (no later than 2042). Details about the two programs are included in the Colusa Subbasin Revised GSP. The Colusa Subbasin Revised GSP is expected to be adopted and submitted to DWR for evaluation ahead of the April 23, 2024 deadline.

GROUNDWATER ELEVATION (§356.2.B.1)

Groundwater level monitoring and groundwater elevation are described in **Section 1** of this Annual Report. Groundwater elevation data were assembled from publicly available databases for the entire available period of record. During spring of calendar year 2023 (Spring 2023), groundwater elevations at available representative monitoring site (RMS) wells in the Subbasin ranged from 1.0 feet (ft) above mean sea level (AMSL) to 189.7 ft AMSL. During fall of calendar year 2023 (Fall 2023), groundwater elevations at available RMS wells in the Subbasin ranged from -18.1 ft AMSL to 178.5 ft AMSL.

Spring 2023 and Fall 2023 groundwater elevation contour maps are shown in **Figures 1-2 and 1-3**. Spring contours typically represent seasonal high groundwater levels, while fall contours typically represent seasonal low groundwater levels. Groundwater hydrographs for all RMS wells are shown in **Appendix B** of this Annual Report. Seasonal groundwater trends in the Subbasin in 2023 were generally consistent with those seen in 2021-2022 and earlier. Higher groundwater elevations are commonly seen along Stony Creek and the Sacramento River and along the southeastern boundary of the Subbasin, with typically lower groundwater elevations in the south and along the northwestern boundary. Due to wet hydrologic conditions in 2023, groundwater elevations are generally higher than in 2021-2022.

GROUNDWATER EXTRACTION (§356.2.B.2)

Groundwater extraction is summarized in **Section 2** of this Annual Report. Groundwater extraction in the Subbasin was measured directly from flowmeters when available, or was estimated through a water demand analysis approach using the best available information (**Appendix D**). The relative amounts of groundwater extraction that were quantified from flowmeter records or were estimated are summarized in **Tables 2-1 through 2-2**.

In total, an estimated 577,000 acre-feet (af) of groundwater was extracted for use within the Subbasin area during water year 2023 (**Table 2-3**). Of this total, the majority was extracted for agricultural use (approximately 553,000 af), while the remainder was extracted for urban and domestic use (approximately 24,000 af). The wet conditions in 2023 compared to the 2020-2022 drought period and the substantial increase in surface water supplies compared to 2022 facilitated a substantial reduction in groundwater extraction compared to recent years.

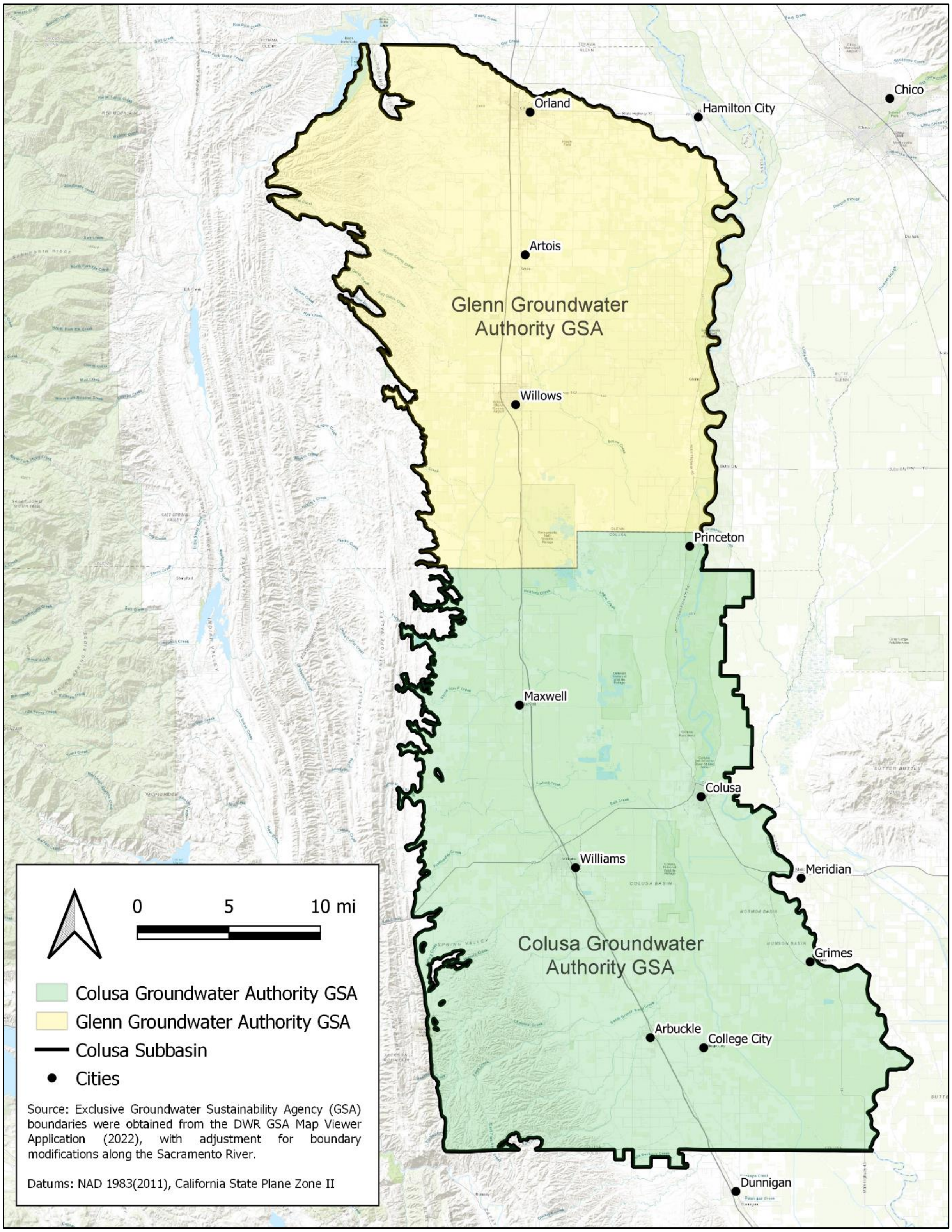

Figure ES-1. Map of Colusa Subbasin GSP Area and GSAs.

SURFACE WATER SUPPLY (§356.2.B.3)

Surface water supplies used or available for use are summarized in **Section 3** of this Annual Report. Surface water supplies available to certain entities within the Colusa Subbasin include surface water deliveries (Central Valley Project [CVP] supplies from the Tehama-Colusa Canal and the Sacramento River), water rights diversions, and riparian or other diversions of natural flows crossing the Subbasin. In this Annual Report, surface water supplies used or available for use are assumed to be the volume of surface water diverted by agencies and water rights users in the Subbasin (**Table 3-1**). Estimated surface water deliveries to water users are also reported (**Table 3-2**). During water year 2023, approximately 1,343,000 af of surface water supplies were diverted by water users in the Subbasin, including approximately 1,299,000 af of CVP supplies and approximately 44,000 af of local supplies. Surface water supplies were substantially greater in 2023 due to full allocations, compared to the severe curtailments seen in 2022. Sustained access to contract surface water supplies is inextricably tied to groundwater sustainability, and is necessary for the ongoing vitality of the Subbasin and its communities.

TOTAL WATER USE (§356.2.B.4)

Total water use is summarized in **Section 4** of this Annual Report. In this Annual Report, total water use is assumed to equal the total combined groundwater extractions (described in **Section 2**) and surface water diversions (described in **Section 3**) in the Subbasin. During water year 2023, total water use in the Subbasin area was estimated to be approximately 1,921,000 af. Of this total, approximately 70% came from surface water while the remaining use came from groundwater. Wet conditions and full surface water allocations in 2023 led to greater use of surface water compared to groundwater, similar to historical conditions in the Subbasin prior to the 2020-2022 drought period.

CHANGE IN GROUNDWATER STORAGE (§356.2.B.5)

Change in groundwater storage is described in **Section 5** and maps are provided in **Appendix C** of this Annual Report. Consistent with 23 CCR §354.18.b, annual changes in groundwater elevation were calculated for the principal aquifer between Spring 2015 and Spring 2023 based on the difference in annual spring groundwater elevations (representing seasonal high groundwater conditions).

Table ES-1 lists the spring-to-spring changes in groundwater storage for water years 2015 through 2023, as well as the cumulative change in groundwater storage over the 2015-2023 period. A positive change in groundwater storage means that the volume of groundwater in storage increased, whereas a negative change in groundwater storage means that the volume of groundwater in storage decreased. The change in groundwater storage from Spring 2022 to Spring 2023 was approximately +34 thousand acre-feet (taf), and the cumulative change in groundwater storage from Spring 2015 to Spring 2023 was approximately -553 taf.

Table ES-1. Estimated Change in Groundwater Storage in the Primary Aquifer – Spring 2015 through Spring 2023.

Analysis Time Period	Annual Change in Groundwater Storage[1] (taf)	Cumulative Change in Groundwater Storage since Spring 2015-2016 (taf)
Spring 2015-2016	-106	-106
Spring 2016-2017	+261	155
Spring 2017-2018	-150	5
Spring 2018-2019	+125	130
Spring 2019-2020	-219	-89
Spring 2020-2021	-284	-373
Spring 2021-2022	-214	-587
Spring 2022-2023	+34	-553

[1] Annual change in groundwater storage was recalculated for all years in February 2024 using updated groundwater elevation data available from DWR and a refined aquifer storage coefficient. Values through spring 2022 may have changed slightly following analysis of updated information.

CURRENT CONDITIONS FOR SUSTAINABILITY INDICATORS (§356.2.C)

A review of current conditions in the Colusa Subbasin for all applicable sustainability indicators is provided in **Section 6.1**. To track groundwater conditions in relation to the Sustainable Management Criteria (SMC) in the Colusa Subbasin GSP, conditions at monitoring network sites are presented in relation to the interim milestones (IMs), Measurable Objectives (MOs), and Minimum Thresholds (MTs) defined in the GSP. Overall, groundwater levels in the Subbasin remain above their MTs and the majority of RMS wells remain at or above their MOs (and 2027 IMs). Subsidence persists in two focus areas of the Subbasin (south of Orland and near Arbuckle), although subsidence rates have slowed compared to recent years. Conditions with respect to groundwater quality and interconnected surface water (ISW) also remain above the MTs at all but one well (a water quality RMS well last measured in 2018). As part of the GSP revisions process, the GSAs are considering revisions to the SMC for chronic lowering of groundwater levels and subsidence, as well as efforts to address data gaps. Any revisions made to the SMC and data gaps efforts in the Revised GSP will be accounted in future Annual Reports.

IMPLEMENTATION OF PROJECTS AND MANAGEMENT ACTIONS (§356.2.C)

Projects and management actions (PMAs) are described in **Section 6.2**. As of early 2024, progress has been made in developing or implementing approximately 15 PMAs, including 14 direct or in-lieu recharge projects and one ongoing management action for urban water conservation. In total, approximately 22,000 af of benefits to the Subbasin were achieved in 2023, in addition to substantial recharge benefits of surface water supplies accounted in the Subbasin water use estimates. The GSAs have also moved forward with several efforts in support of GSP implementation, including groundwater recharge and water rights-related efforts and efforts to secure funding for GSP implementation.

Development of some projects that began prior to adoption and submittal of the Colusa Subbasin GSP are still underway, but may have not yet reached the point where benefits have been realized. Additional PMAs planned to start in 2023 are still in the early stages of implementation and have not progressed to the point where average annual benefits, average annual operating costs, or actual capital costs can be accurately quantified. The initial benefits and costs of implementation for these projects will be reported in future Annual Reports.

As part of the GSP revision process, the GSAs have also drafted formal agreements to develop and implement a domestic well mitigation program and a demand management program for the Subbasin. Implementation of these programs is expected to provide the GSAs with additional means of mitigating overdraft, subsidence, and groundwater level decline in the Subbasin and of mitigating undesirable results that may occur to domestic well users during GSP implementation while other PMAs are being developed, prior to achieving sustainable groundwater conditions (no later than 2042). Details about the two programs are included in the Colusa Subbasin Revised GSP. The GSAs plan to move forward with program development and implementation, consistent with the agreements, following submittal of the Colusa Subbasin Revised GSP in April 2024.

1 Groundwater Elevation (§356.2.b.1)

This Annual Report provides an update on groundwater elevation conditions in the Colusa Subbasin in water year 2023 and since the end of the GSP[2]. The representative monitoring sites (RMS) currently include 48 well completions within the Subbasin. RMS wells are shown in **Figure 1-1**. The RMS wells are a mix of active supply and dedicated observation wells. For nested multiple completion observation wells, the completion that best represents the pumping depth of nearby water supply wells was selected as the RMS well.

Groundwater elevation data were assembled from DWR's periodic groundwater levels dataset, a compilation of publicly available databases containing historical data collected by various entities, including DWR, California Statewide Groundwater Elevation Monitoring (CASGEM) Program monitoring entities, and other cooperating agencies. Groundwater elevation data were evaluated and summarized for the entire available period of record (including the period from January 1, 2015, through the current water year).

RMS wells are monitored two to three times per year (or more frequently), typically in spring, fall, and/or summer. Spring groundwater measurements (typically measured between February-April) provide an indication of groundwater conditions after winter precipitation and groundwater recharge. Fall groundwater measurements (typically measured between September-November) provide an indication of groundwater conditions after the primary irrigation season and (depending on timing) before winter flood-up for rice decomposition and wetlands habitat. In rice growing areas, summer groundwater levels may be relatively high compared to spring and fall levels due to field flooding using surface water supplies.

Wet hydrologic conditions and full allocations of surface water supplies in 2023 generally resulted in higher groundwater elevations across much of the Subbasin as compared to recent drought years, particularly 2022. These conditions are seen throughout the groundwater level measurements, groundwater elevation contour maps, and hydrographs shown later in this section.

The GSAs have noted that several RMS wells selected in the GSP have limited data availability in recent years, including three RMS wells that have not been measured since between 2015-2017. During the next five-year GSP evaluation and update (anticipated in 2027), the GSAs are planning to re-evaluate the RMS network and potentially select new RMS wells to replace sites with limited data to ensure there is sufficient information to help monitor and manage groundwater conditions in the Subbasin and achieve sustainability.

The GSAs have also noted that one RMS site at a multi-completion well is currently referencing the deepest completion (14N02W22A002M). The GSAs propose changing this RMS site to the shallowest completion (14N02W22A005M), as it is more representative of nearby water supply wells. This change to the RMS network is expected to be completed when the Revised GSP is submitted in April 2024 (**Table 1-1**).

[2] The Colusa Subbasin GSP documented existing and historical groundwater elevation conditions through the end of calendar year 2020.

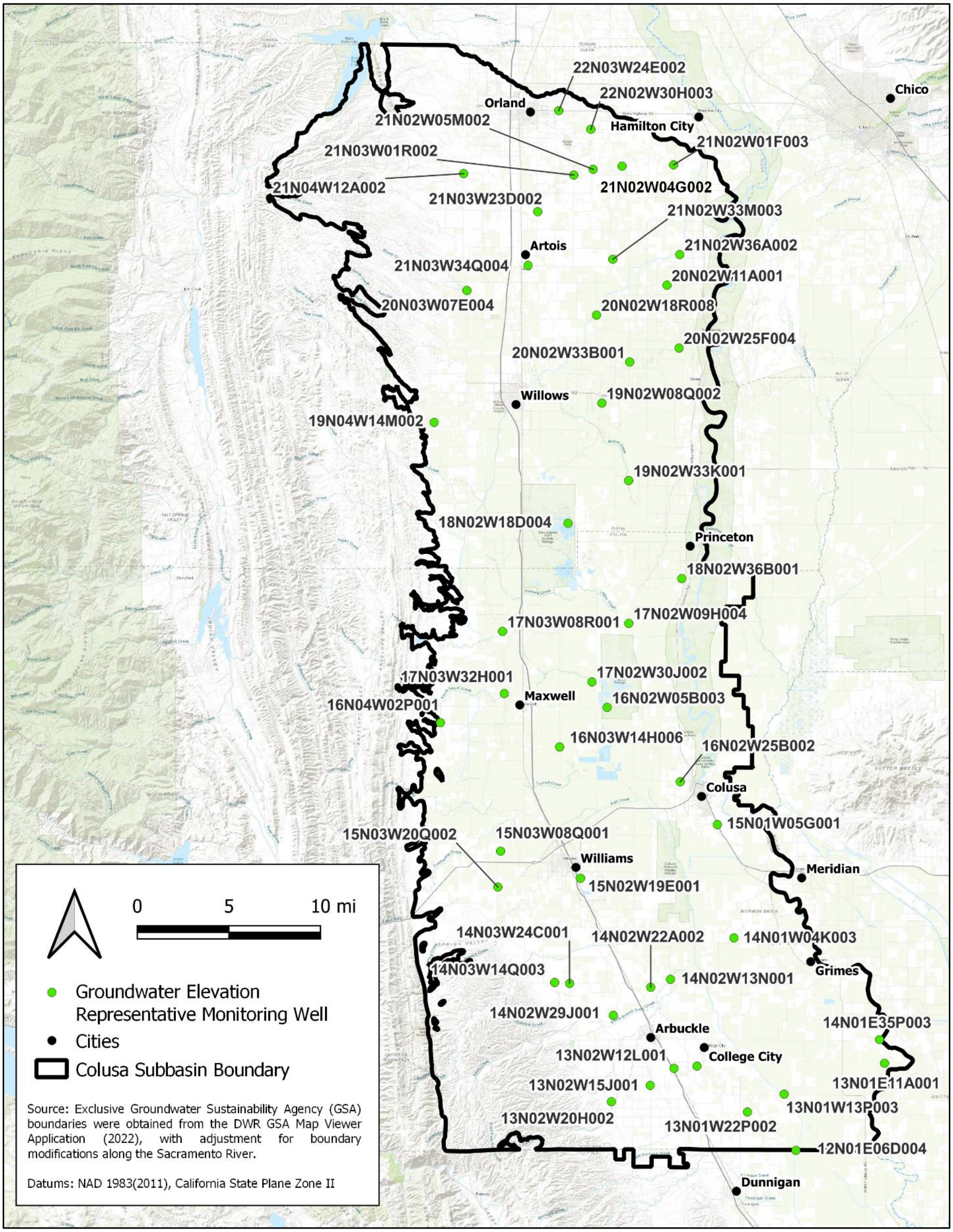

Figure 1-1. Groundwater Level RMS Wells.

Table 1-1. Changes to the Groundwater Level Representative Monitoring Network (If Applicable).

State Well Number	GSA	New Information	Changes
14N02W22A002M	CGA	This RMS site is part of a multi-completion observation well monitored since 2019. The RMS site currently references the deepest completion (14N02W22A002M); however, the shallowest completion (14N02W22A005M) is recommended as it is more representative of nearby water supply wells.	Recommend changing to 14N02W22A005M when the Revised GSP is submitted (with appropriate sustainable management criteria).

1.1 GROUNDWATER LEVEL CONDITIONS

Groundwater elevations measured in Spring and Fall 2023 are listed in **Table 1-2**. During spring of calendar year 2023 (Spring 2023), groundwater elevations at available RMS wells in the Subbasin ranged from 1.0 feet (ft) above mean sea level (AMSL) to 189.7 ft AMSL. During fall of calendar year 2023 (Fall 2023), groundwater elevations at available RMS wells in the Subbasin ranged from -18.1 ft AMSL to 178.5 ft AMSL. Of the 48 RMS wells, groundwater elevation data were not available for 10 wells in Spring 2023 and for seven wells in Fall 2023. The primary reasons for unavailable groundwater level measurements were site accessibility issues and well pumping. Notes and issues regarding the RMS wells are documented in **Section 6.1.1.**

1.2 GROUNDWATER ELEVATION CONTOUR MAPS (§356.2.B.1.A)

Spring and Fall 2023 groundwater elevation contour maps are provided for the Primary Aquifer in **Figures 1-2 and 1-3**, respectively. Groundwater elevation contour maps for Spring and Fall 2020-2023 are included in **Appendix A** for reference. Those earlier contour maps come from the Colusa Subbasin GSP and the previous Annual Reports. Spring contours typically represent seasonal high groundwater levels, while fall contours typically represent seasonal low groundwater levels. Groundwater elevation contours were developed by creating a continuous groundwater elevation surface based on available well data using the kriging interpolation method. Measurements indicated as questionable in the DWR database were excluded, and minor refinements were made to the contours based on professional judgement.

Seasonal groundwater trends in the Subbasin in 2023 were generally consistent with those seen in 2021-2022 and earlier. Higher groundwater elevations are generally seen along Stony Creek and the Sacramento River and along the southeastern boundary of the Subbasin, with lower groundwater elevations generally in the south and along the northwestern boundary. Regionally, groundwater generally flows from the north and west towards the south and east, although localized areas of lower groundwater elevation and depressions caused by groundwater pumping and/or a reduction in recharge has resulted in locally varying flow regimes. These can be seen in the area southwest of Orland and in areas around and west of Arbuckle in both the Spring and Fall 2023 groundwater elevation contour maps (**Figures 1-2 and 1-3**, respectively). These depressions in groundwater elevations are also evident in the 2020-2022 contours to varying extents (**Appendix A**).

Table 1-2. Summary of Groundwater Level RMS Well Information and Measurements During Annual Report Year (2023).

State Well Number	Ground Surface Elevation (feet AMSL)[1]	Completed Well Depth (feet bgs)[2]	Screen Interval(s) (Top-Bottom) (feet bgs)	Spring 2023 GWE (feet AMSL)	Date of Spring 2023 GWE (feet AMSL)	Fall 2023 GWE (feet AMSL)	Date of Fall 2023 GWE (feet AMSL)	GSA
12N01E06D004M	27.94	298	275-285	13.3	4/3/2023	-4.8	9/12/2023	CGA
13N01E11A001M	31.8	145	136-158	28.1	4/3/2023	24.8	10/16/2023	CGA
13N01W07G001M	90.47	180	108-180	1.0	4/3/2023	3.4	12/12/2023	CGA
13N01W13P003M	32.23	355	271-278	17.0	4/3/2023	1.6	9/1/2023	CGA
13N01W22P002M[4]	60.46	236	196-236	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	CGA
13N02W12L001M	135.49	Not Available	Not Available	Not Available[3]	Not Available[3]	-18.1	10/11/2023	CGA
13N02W15J001M[4]	212.52	362	270-362	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	CGA
13N02W20H002M	342.58	320	200-260, 300-320	167.8	2/13/2023	178.5	10/16/2023	CGA
14N01E35P003M	46.88	275	135-145, 215-225	32.5	4/3/2023	28.1	9/12/2023	CGA
14N01W04K003M	37.43	73	46-70	32.7	4/3/2023	23.4	10/9/2023	CGA
14N02W13N001M	62.45	392	104-392	Not Available[3]	Not Available[3]	14.0	10/11/2023	CGA
14N02W22A002M	84	1050	1020-1030	2.5	4/30/2023	-12.0	9/12/2023	CGA
14N02W29J001M[4]	162.5	412	119-143, 152-158, 176-182, 198-208, 215-239, 264-276, 307.5-319.5, 334.5-349.5	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	Not Available[3,4]	CGA
14N03W14Q003M	172.52	685	390-480, 500-590, 614-685	Not Available[3]	Not Available[3]	-18.1	10/10/2023	CGA
14N03W24C001M	172.51	312	292-312	Not Available[3]	Not Available[3]	Not Available[3]	Not Available[3]	CGA
15N01W05G001M	47.42	140	75-140	41.9	4/3/2023	35.3	10/9/2023	CGA
15N02W19E001M	87.46	334	162-182, 198-206, 262-274,	73.7	4/5/2023	65.4	10/10/2023	CGA

State Well Number	Ground Surface Elevation (feet AMSL)[1]	Completed Well Depth (feet bgs)[2]	Screen Interval(s) (Top-Bottom) (feet bgs)	Spring 2023 GWE (feet AMSL)	Date of Spring 2023 GWE (feet AMSL)	Fall 2023 GWE (feet AMSL)	Date of Fall 2023 GWE (feet AMSL)	GSA
			290-294, 310-334					
15N03W08Q001M	116.26	350	30-130, 250-350	Not Available[3]	Not Available[3]	Not Available[3]	Not Available[3]	CGA
15N03W20Q002M	128.56	170	130-160	114.9	4/5/2023	111.5	10/10/2023	CGA
16N02W05B003M	65	301	174-184, 246-256	54.6	4/5/2023	43.8	9/1/2023	CGA
16N02W25B002M	55.42	274	254-274	46.1	4/4/2023	38.6	10/9/2023	CGA
16N03W14H006M	65.7	378	295-305	54.0	4/30/2023	44.9	9/12/2023	CGA
16N04W02P001M	162.53	203	112-203	141.3	4/4/2023	140.4	10/10/2023	CGA
17N02W09H004M	67	302	250-260	62.4	4/4/2023	Not Available[3]	Not Available[3]	CGA
17N02W30J002M	63.43	159	157-159	56.4	4/4/2023	48.6	10/10/2023	CGA
17N03W08R001M	107.46	130	125-130	92.7	4/5/2023	90.4	10/16/2023	CGA
17N03W32H001M	100.47	112	68-72, 104-112	95.3	4/4/2023	93.1	10/10/2023	CGA
18N02W18D004M	85.43	266	246-256	75.8	4/6/2023	33.2	10/18/2023	GGA
18N02W36B001M	75.4	410	88-128, 195-225, 240-340	67.9	4/4/2023	59.1	10/16/2023	CGA
19N02W08Q002M	108.36	228	208-218	101.6	4/5/2023	98.7	10/10/2023	GGA
19N02W33K001M	87.41	260	160-260	Not Available[3]	Not Available[3]	73.3	10/18/2023	GGA
19N04W14M002M	185.83	65	45-55	Not Available[3]	Not Available[3]	Not Available[3]	Not Available[3]	GGA
20N02W11A001M	125.4	90	70-90	123.5	4/30/2023	115.8	10/13/2023	GGA
20N02W18R008M	131.38	201	140-150, 70-180	114.7	4/30/2023	116.4	10/13/2023	GGA
20N02W25F004M	102.2	85	55-65	99.2	3/23/2023	96.8	10/13/2023	GGA
20N02W33B001M	105.41	320	100-120, 200-320	100.6	4/11/2023	99.3	10/13/2023	GGA
20N03W07E004M	179.17	138	118-128	61.8	4/27/2023	56.4	9/3/2023	GGA
21N02W01F003M	161.84	124	109-119	127.9	4/5/2023	125.3	10/12/2023	GGA
21N02W04G004M	178.41	289	165-175,	125.5	4/5/2023	113.8	10/12/2023	GGA

State Well Number	Ground Surface Elevation (feet AMSL)[1]	Completed Well Depth (feet bgs)[2]	Screen Interval(s) (Top-Bottom) (feet bgs)	Spring 2023 GWE (feet AMSL)	Date of Spring 2023 GWE (feet AMSL)	Fall 2023 GWE (feet AMSL)	Date of Fall 2023 GWE (feet AMSL)	GSA
			269-279					
21N02W05M002M	188.93	153	122-132	144.6	4/22/2023	127.3	9/18/2023	GGA
21N02W33M003M	149	171.1	140-150	107.2	4/3/2023	112.8	10/11/2023	GGA
21N02W36A002M	135.39	145	120-140	107.1	4/6/2023	102.6	9/1/2023	GGA
21N03W01R002M	203.32	255	235-245	143.0	4/5/2023	132.0	10/11/2023	GGA
21N03W23D002M	204.76	191.5	142-152, 160-170	131.3	4/24/2023	127.6	9/3/2023	GGA
21N03W34Q004M	166.65	80	60-70	97.6	4/6/2023	97.5	10/12/2023	GGA
21N04W12A002M	247.88	278	247-257	40.8	4/6/2023	25.0	9/6/2023	GGA
22N02W30H003M	204.43	275	130-140, 150-160, 250-260	170.1	4/5/2023	132.9	9/13/2023	GGA
22N03W24E002M	230.51	195	130-150, 170-180	189.7	4/15/2023	175.6	10/13/2023	GGA

[1] Elevations are in reference to feet above mean sea level (AMSL).

[2] Depths are below ground surface (bgs).

[3] Notes and issues regarding the RMS wells are documented in Section 6.1.1. The primary reasons for unavailable groundwater level measurements were site accessibility issues and well pumping.

[4] RMS well has not been measured in five or more years. The adequacy of all RMS wells will be evaluated during the 2027 GSP evaluation and updates. It is anticipated that RMS wells with severe data gaps will be prioritized for replacement at that time with alternate sites that have more recent data.

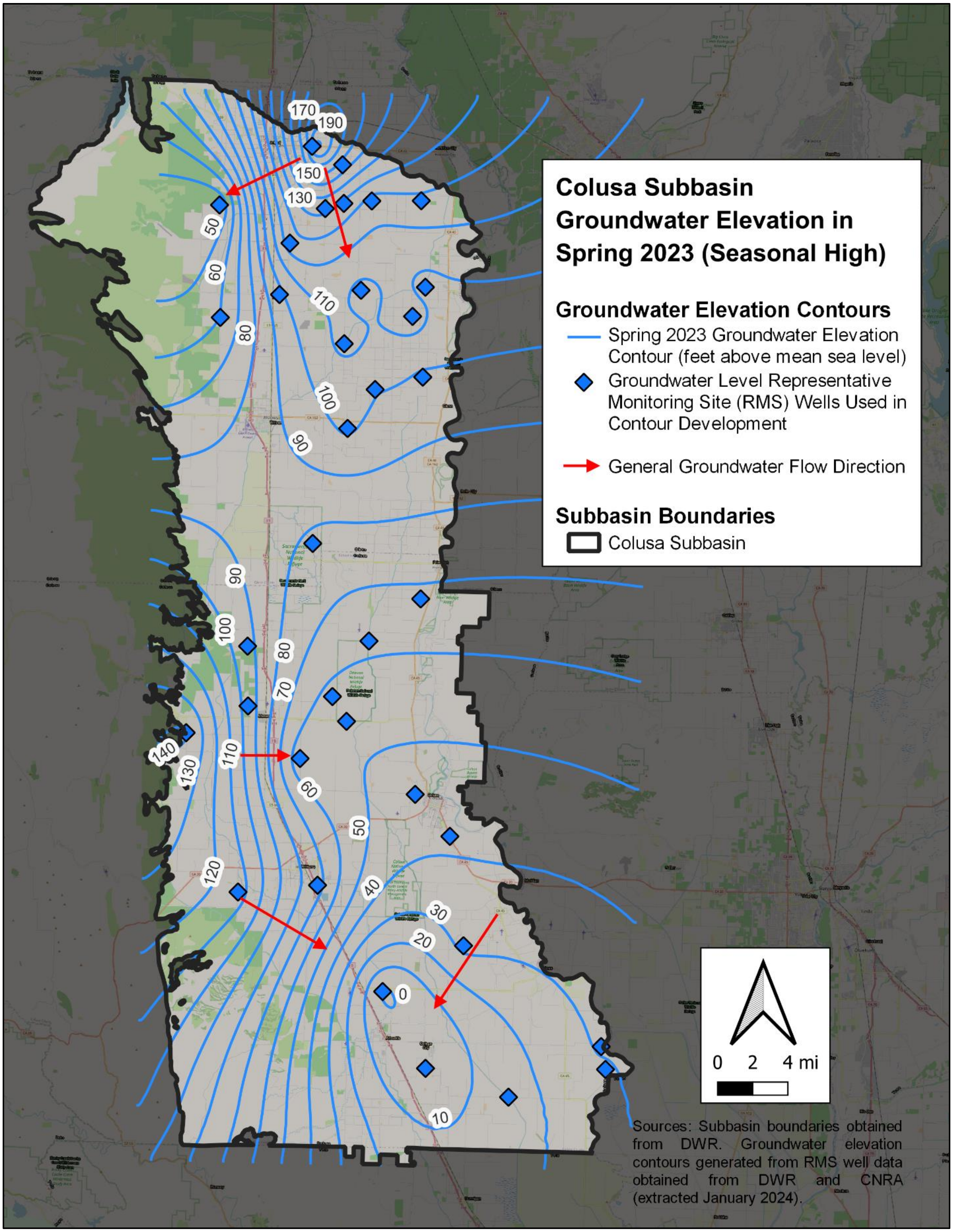

Figure 1-2. Groundwater Elevation Contours for the Principal Aquifer – Spring 2023.

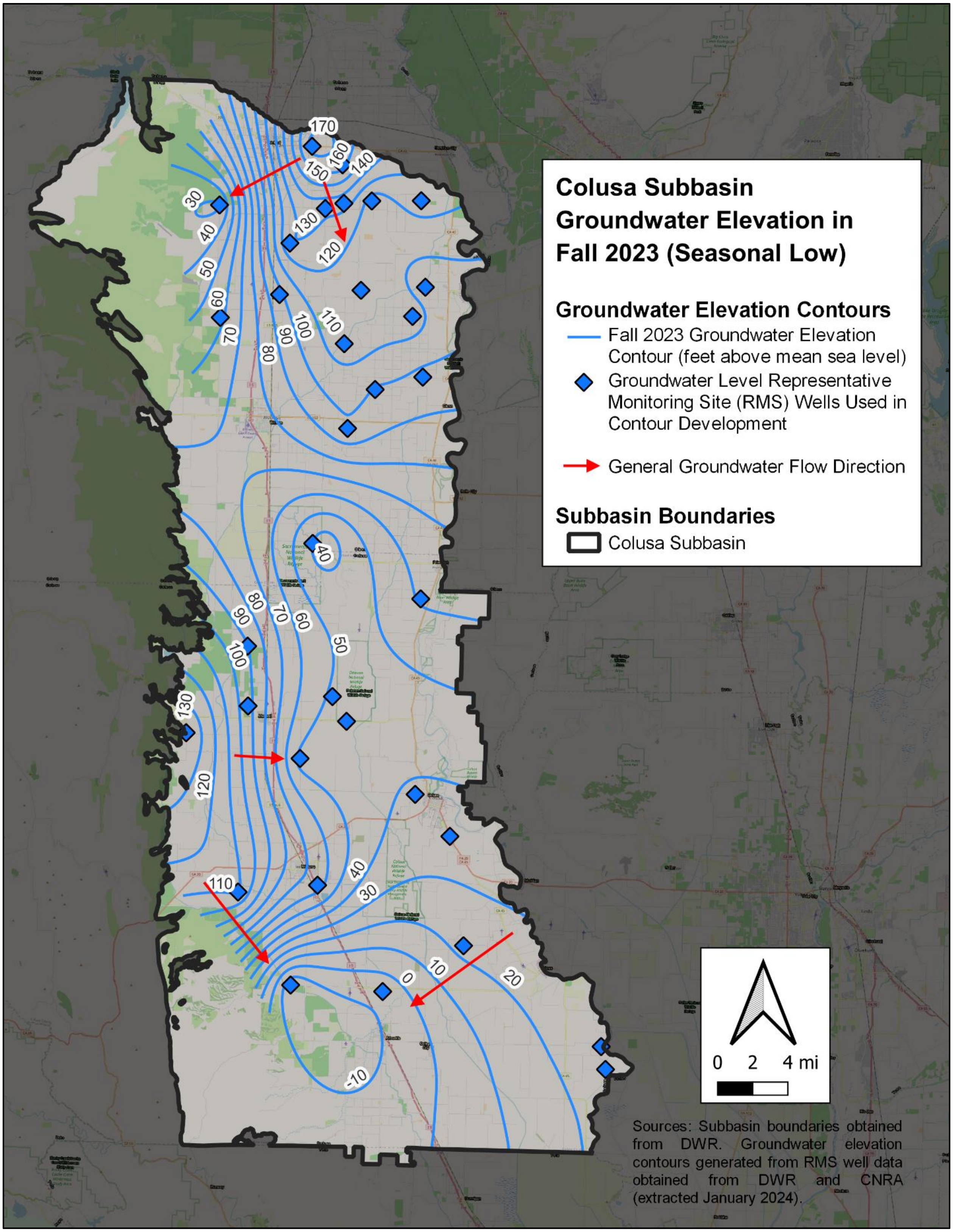

Figure 1-3. Groundwater Elevation Contours for the Principal Aquifer – Fall 2023.

1.3 GROUNDWATER HYDROGRAPHS (§356.2.B.1.B)

Groundwater elevation hydrographs for each RMS well identified in the Colusa Subbasin GSP are presented in **Appendix B**. The hydrographs include the RMS well Sustainable Management Criteria (SMC), groundwater elevation summary statistics, and water year index and type. The average Spring and Fall 2023 groundwater levels measured at each RMS well are presented in **Table 1-2**.

Groundwater levels typically fluctuate seasonally within and between water years. Seasonal groundwater fluctuations occur primarily in response to groundwater pumping and recovery but can also be affected by land and water use activities (such as rice flood-up), recharge, and natural discharge. Precipitation, applied irrigation water, managed aquifer recharge projects, and seepage from local streams, rivers, and canals are all likely sources of groundwater recharge in the Subbasin. Groundwater pumping, which typically occurs from April to September, is the predominant contributor to groundwater discharge in the Subbasin. Consequently, groundwater levels are usually highest in the spring and lowest during the irrigation season in the summer months. However, the timing and spatial distribution of the above-mentioned events and activities may result in localized impacts to the typical seasonal trend. Groundwater fluctuations are particularly noticeable in groundwater dependent areas or where/when groundwater is relied upon during drought years to compensate for reductions in surface water supplies.

In water year 2023, wet hydrologic conditions and full allocations of surface water supplies contributed to a recovery in groundwater elevations across much of the Subbasin as compared to recent drought years, particularly 2022. RMS wells near Stony Creek, the Sacramento River, and Colusa Basin Drain generally exhibited the most significant groundwater elevation recoveries in 2023, or saw continued stability in groundwater levels. However, a smaller portion of wells, particularly those along the western edge of the Subbasin, saw groundwater elevation decline from Spring 2022 to Spring 2023. This may be due to reduced recharge in those areas, greater extraction, or a combination of factors.

2 Groundwater Extraction (§356.2.b.2)

This section summarizes the measurement methods, accuracy, and volumes of groundwater extraction in the Colusa Subbasin for the current reporting year (water year 2023).

2.1 QUANTIFICATION AND ACCURACY

Groundwater extraction in the Colusa Subbasin was either measured directly from flowmeters or was estimated as the volume of water needed to satisfy water demand (i.e., evapotranspiration of applied water (ET_{aw}) or per capita water use requirements) after accounting for available surface water supplies and typical water use efficiencies. Flowmeter records were used when available. Otherwise, groundwater extraction was estimated using the best available information to characterize water use requirements in the Colusa Subbasin. Specific data sources and methods are described in **Section 2.2**, below, and in **Appendix D**.

Table 2-1 summarizes groundwater extraction in water year 2023 and the associated measurement methods, by water use sector. Additional detail about the groundwater extraction measurement methods and accuracy is provided in **Table 2-2**.

Table 2-3 summarizes the total groundwater extraction by water use sector in the Colusa Subbasin between water year 2016 (following the historical water budget period in the Colusa Subbasin GSP) and water year 2023 (the current reporting year). In total, an estimated 577,000 acre-feet (af) of groundwater was extracted for use within the Subbasin area during water year 2023. Of this total, the majority was extracted for agricultural use (approximately 553,000 af), while the remainder was extracted for urban and domestic use (approximately 24,000 af). The wet conditions in 2023 compared to the 2020-2022 drought period and the substantial increase in surface water supplies compared to 2022 facilitated a substantial reduction in groundwater extraction compared to recent years.

Figure 2-1 provides a map of the estimated groundwater extraction and applied surface water in each water budget subregion of the Colusa Subbasin in water year 2023. These results come from the water use analysis described in **Appendix D**, and are based on the methods and data sources described in **Sections 2 and 3**. The subregions are generally consistent with the C2VSimFG-Colusa subregions described in the GSP, representing the major water supplier service areas in the Subbasin. Subregions are also presented delineating urban areas and the three national wildlife refuges in the Subbasin. The remainder of the Subbasin is represented by two subregions that encompass all areas within each county that are outside the service areas of the water suppliers and are primarily dependent on groundwater supplies for irrigation and other water uses. Those “groundwater dependent areas” (GDAs) represent all noncontiguous "white areas” in each county outside the boundaries of all other subregions.

Notably, **Figure 2-1** illustrates the average depths of groundwater extraction and applied surface water over the entire gross area of each subregion based on available information. Groundwater extraction and applied surface water are reported in aggregate by subregion, so the precise location of use is neither verified nor indicated. However, it is expected that groundwater pumping would generally be higher in irrigated areas of the Colusa Subbasin without access to surface water, and generally lower in irrigated areas of the Colusa Subbasin with access to surface water in water year 2023.

Table 2-1. Groundwater Extraction Volumes and Measurement Methods by Water Use Sector, and Uncertainty (2023).

Water Use Sector	Groundwater Extraction, 2023 (acre-feet, rounded[1])	Measurement Method	Measurement Method Description
Agricultural	545,400	Estimate	Estimated from water budget (based on land use, ET, consumptive use fraction, and surface water supplies)
	7,470	Direct	Flowmeter records from the Colusa Subbasin WMPP
Urban[2]	3,500	Estimate	Estimated from water budget (based on population, per capita water use requirements, and outdoor use)
	5,230	Direct	Flowmeter records from cities
Managed Wetlands	15,800	Estimate	Estimated from water budget (based on land use, ET, consumptive use fraction, surface water supplies, and ponding water use requirements from GSP analyses)
Managed Recharge	0	Estimate	No groundwater extraction for groundwater recharge.
Native Vegetation	-	Estimate	No noted groundwater extraction for native vegetation, per GSP analyses
Colusa Subbasin	**Groundwater Extraction, 2023 (acre-feet, rounded)**	**Estimated Uncertainty**	**Uncertainty Source**
Total	**577,400**	20%	Volume-weighted combined uncertainty of water budget estimates (approximately 20%) and flowmeter records (approximately 5%)

[1] Estimates rounded to 100 af, direct measurements rounded to 10 af.
[2] The Urban water use sector includes urban, industrial, rural residential, and semi-agricultural areas in the Colusa Subbasin.

Table 2-2. Groundwater Extraction Volumes, Measurement Methods, and Accuracy Summary (2023).

Groundwater Extraction, 2023 (acre-feet, rounded)	Measure-ment Type	Measurement Method Description	Accuracy	Accuracy Description
12,700	Meters	Flowmeter records of groundwater extraction for urban use from cities and for agricultural use from the Colusa WMPP.	5-10%	Estimated based on the typical field accuracy of meters, and the typical combined accuracy of volumes in urban distribution systems (accounting for metered groundwater, metered deliveries, unmetered deliveries, and apparent losses)
561,200	Estimate based on Land Use, ET	Estimated from a water use analysis based on land use, ET, available surface water supplies, and ponding water use requirements (where applicable).	20-30%	Typical uncertainty of a water use analysis approach, considering the combined uncertainty of other flow paths and the data sources used to quantify those (Clemmens and Burt, 1997)
3,500	Estimate based on Population, Urban/Rural Water Use	Estimated in urban and rural areas where flowmeter records were unavailable based on annual population data, monthly per capita water use requirements, and outdoor use assumptions.	20-30%	Typical uncertainty when calculated from population, per capita water use, and outdoor use assumptions, considering the combined uncertainty of those data sources.

Table 2-3. Groundwater Extraction Volumes, by Water Use Sector (acre-feet, rounded).

Water Year (Type)	Agricultural	Urban[1]	Managed Wetlands	Native Vegetation	Total
2016 (BN)	598,000	9,500	24,000	-	631,500
2017 (W)	542,000	9,700	21,000	-	572,700
2018 (BN)	566,000	9,800	26,000	-	601,800
2019 (W)	611,000	9,600	22,000	-	642,600
2020 (D)	723,000	10,200	27,000	-	760,200
2021 (C)	933,000	10,200	34,000	-	977,200
2022 (C)	860,000	10,900	28,000	-	898,900
2023 (W)	552,900	8,700	15,800	-	577,400
Average (2016-2023)	**673,000**	**10,000**	**25,000**	**-**	**708,000**

[1] The Urban water use sector includes urban, industrial, rural residential, and semi-agricultural areas in the Colusa Subbasin.

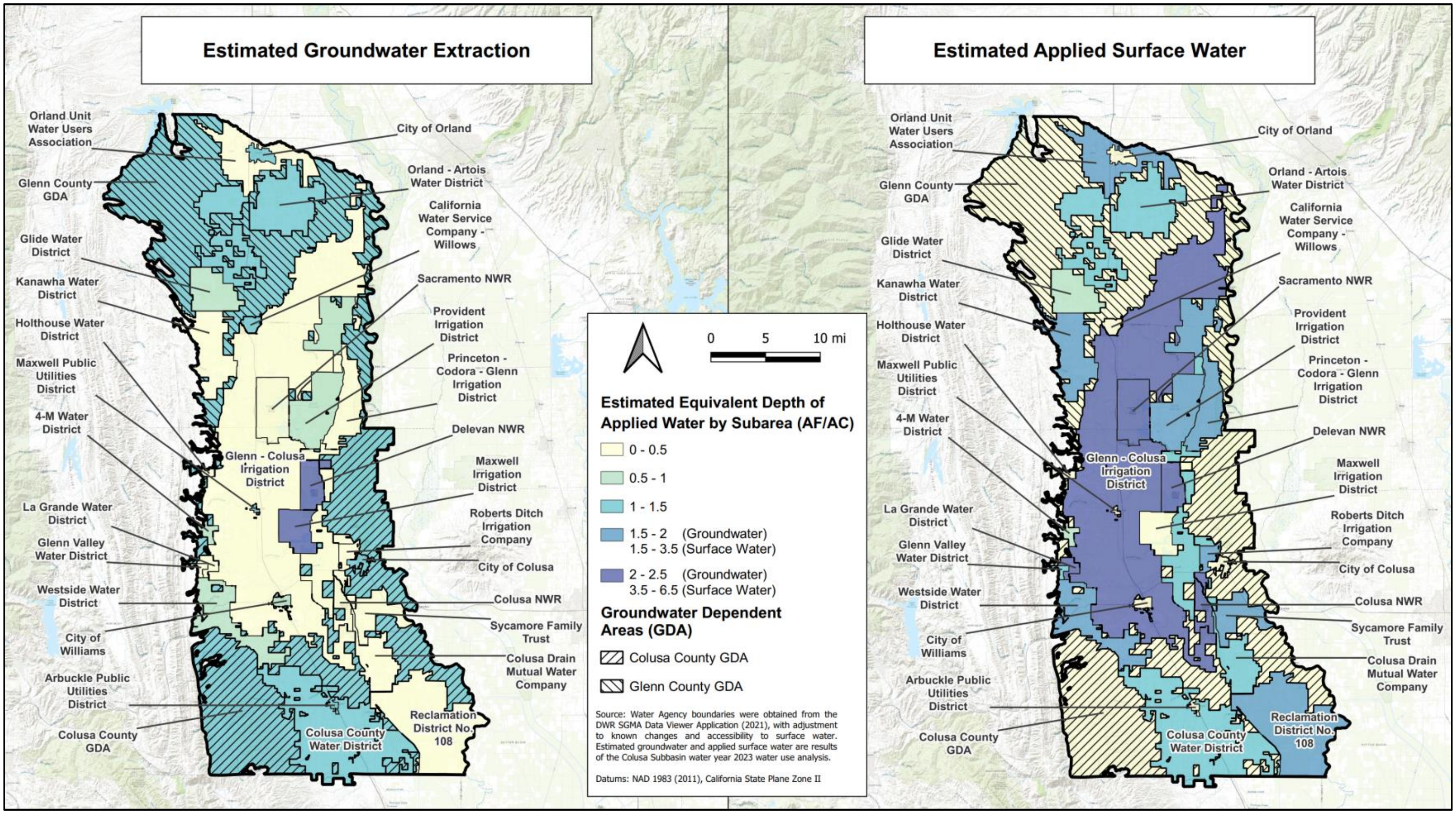

Figure 2-1. Estimated Groundwater Extraction and Applied Surface Water by Subregion.*

**Subregions are generally consistent with the C2VSimFG-Colusa subregions described in the GSP, representing major water supplier service areas, urban areas, and national wildlife refuges. (Left) The groundwater extraction volumes per acre represent measured and/or estimated groundwater extraction in 2023. (Right) The surface water use volumes per acre represent measured and/or estimated applied surface water use in 2023.*

2.2 DATA SOURCES

Direct measurements of groundwater extraction in urban areas were summarized from flowmeter records available from the Cities of Colusa, Orland, Williams, and Willows in 2023. These data are assumed to represent urban groundwater extraction for delivery and use within the boundaries of each respective service area. Direct measurements of groundwater extraction in agricultural areas were summarized from flowmeter records available from the Colusa Subbasin Well Monitoring Pilot Program (WMPP). While some water districts operate groundwater wells in certain years, no districts reported groundwater pumping for district supplies in the Subbasin in 2023.

Estimates of groundwater extraction in agricultural and managed wetland areas of the Colusa Subbasin were quantified through the Groundwater Extraction Estimates from Earth Observations (GEEEO) approach (described in **Appendix D**) as the amount of water needed to meet remaining ET_{aw} demand after applying available surface water supplies. Groundwater extraction estimates were calculated with consideration of land use, evapotranspiration (ET), consumptive use fractions, and other parameters impacting water demand and irrigation. Available surface water supplies were quantified as described in **Section 3**, below.

Estimates of groundwater extraction in urban and rural areas where flowmeter records were unavailable were estimated based on annual population data, monthly per capita water use requirements, and consideration of outdoor water use in urban areas based on the GEEEO approach. Annual population data were obtained from the California Department of Finance or from the United States Census Bureau American Community Survey for cities and census designated places in Colusa and Glenn Counties. Average monthly per capita water use rates in 2023 were quantified from population data and available historical pumping data in Arbuckle and Maxwell following similar methods identified during GSP development (see Colusa Subbasin GSP Appendix 3D).

In the Colusa Subbasin, precipitation is understood to be the primary originating source of water available to native vegetation. Groundwater uptake through the root zone of native vegetation was evaluated during GSP analyses, but was ultimately not included in the final GSP water budgets due to confounding factors regarding the origins of water that is used. During GSP implementation, the GSAs will seek to work with resource agencies, stakeholders, beneficial users and the public to fill data gaps and refine the understanding of groundwater use by native vegetation, including groundwater dependent ecosystems that may be identified in the Subbasin. The best methodology for quantifying water use by native vegetation will be assessed in subsequent analyses moving forward and documented to the extent applicable in subsequent annual reports and/or periodic GSP evaluations and updates.

3 Surface Water Supply (§356.2.b.3)

This section summarizes the annual volumes and data sources for surface water supplies used, or available for use, within the Colusa Subbasin through the current reporting year (2023).

3.1 QUANTIFICATION BY WATER SOURCE TYPE

Surface water supplies available to certain entities within the Colusa Subbasin include surface water contract deliveries, water rights diversions, and riparian or other diversions of natural flows crossing the Colusa Subbasin.

In this Annual Report, surface water supplies used or available for use are assumed to be the volume of surface water diverted by agencies and water rights users in the Subbasin.[3] Estimated surface water deliveries to water users are also reported.

Per the GSP Regulations, surface water supplies must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Table 3-1 summarizes the total surface water supplies diverted and **Table 3-2** summarizes the total estimated surface water supplies delivered (used or available for use) in the Colusa Subbasin, by water source type. Water year 2023 was marked by full allocations and thus substantially greater surface water supplies compared to the severe curtailments seen in 2022. Sustained access to contract surface water supplies is inextricably tied to groundwater sustainability, and is necessary for the ongoing vitality of the Subbasin and its communities.

3.1.1 CVP Supplies

Agencies that have contracts with the USBR for CVP supplies can receive CVP supplies in the Colusa Subbasin. CVP supplies used for agriculture are received via the Tehama-Colusa Canal and via the Sacramento River. CVP supplies are also delivered to the Sacramento, Delevan, and Colusa National Wildlife Refuges through the Refuge Water Supply Program according to their respective contract quantities established through the Central Valley Project Improvement Act.

Diversions and deliveries of CVP supplies reported in this Annual Report include only those supplies delivered to contractors whose service areas are located within the Colusa Subbasin. This water is used or available for various beneficial uses within and downstream of the service area of the entities that receive this water.

3.1.2 Local Supplies

Local supplies available to certain entities within the Subbasin primarily include Orland Project supplies delivered along the South Canal to areas within the Colusa Subbasin, and relatively smaller diversions of natural flows, when available, from along the Sacramento River and the Colusa Basin Drain (Colusa Drain). Diversions of natural flows, especially along the Colusa Drain, are generally limited in dry years. Most of the water in the Colusa Drain is generally passed

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[3] In the first Annual Report, surface water supplies used or available for use are assumed to be the volume of surface water diverted *and delivered* by agencies and water rights users in the Colusa Subbasin. The reporting approach in the water year 2022-2023 Annual Reports has changed following consideration that (1) all diversions are "available for use," and that (2) diversions data is directly measured, and thus provides a clearer understanding of "surface water supplies available for use" from year to year.

through by upstream diverters from the Sacramento River, and is therefore not accounted as local supplies to avoid double-counting surface water supplies.

3.1.3 Reuse

Some reuse does occur within the Colusa Subbasin, primarily along the Colusa Drain. The Colusa Drain captures rainfall runoff, agricultural runoff, return flows, and spillage and conveys flows from the agricultural lands in the Colusa Subbasin to the Sacramento River and the Tule Canal near Knights Landing in Yolo County. Some of the water within the Colusa Drain is captured and reused prior to being discharged into the Sacramento River. Some local reuse also occurs, particularly for irrigation of rice crops. However, these supplies originate as part of the CVP supplies and local supplies accounted in **Table 3-1** and are generally not distinguished from those supplies. Reuse is not quantified in this Annual Report to avoid double-counting water supplies, though reuse may be quantified in future Annual Reports.

3.2 DATA SOURCES

Table 3-3 summarizes the data sources and estimation procedures for quantifying diversions and deliveries in the Colusa Subbasin, by water source type. Diversions are generally directly measured and reported in the Colusa Subbasin. Deliveries were estimated based on diversions data with adjustments for seepage, evaporation, and downstream spillage outflows following methods similar to those used in GSP development.

Table 3-1. Surface Water Diversions (Supplies Used or Available for Use), by Water Source Type (acre-feet, rounded).

Water Year (Type)	CVP Supplies	Local Supplies	Total
2016 (BN)	1,258,000	42,000	1,300,000
2017 (W)	1,232,000	44,000	1,276,000
2018 (BN)	1,298,000	50,000	1,348,000
2019 (W)	1,191,000	45,000	1,236,000
2020 (D)	1,200,000	54,000	1,254,000
2021 (C)	986,000	28,000	1,014,000
2022 (C)	327,000	45,000	372,000
2023 (W)	1,298,600	44,500	1,343,100
Average (2016-2023)	**1,099,000**	**44,000**	**1,143,000**

Table 3-2. Surface Water Deliveries, by Water Source Type (acre-feet, rounded).

Water Year (Type)	CVP Supplies	Local Supplies	Total
2016 (BN)	1,146,000	35,000	1,181,000
2017 (W)	1,120,000	37,000	1,157,000
2018 (BN)	1,185,000	42,000	1,227,000
2019 (W)	1,082,000	37,000	1,119,000
2020 (D)	1,093,000	45,000	1,138,000
2021 (C)	895,000	23,000	918,000
2022 (C)	306,000	38,000	344,000
2023 (W)	1,181,300	37,300	1,218,600
Average (2016-2023)	**1,001,000**	**37,000**	**1,038,000**

Table 3-3. Data Sources for Surface Water Supplies.

Associated Agency	Water Source Type	Water Source Detail	Diversions Data Sources[1]
4-M Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR Central Valley Operations (CVO) delivery reports (2016-2023), Tehama-Colusa Canal Authority (TCCA) Report
Colusa County Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Colusa Drain Mutual Water Company	CVP Supplies	Colusa Basin Drain Diversions	District-reported diversions
Colusa National Wildlife Refuge	CVP Supplies	Refuge Water Supply Program Contract Deliveries	Contract Quantities and USBR Annual CVP Allocation Quantities
Cortina Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Davis Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Delevan National Wildlife Refuge	CVP Supplies	Refuge Water Supply Program Contract Deliveries	Contract Quantities and USBR Annual CVP Allocation Quantities
Glenn-Colusa Irrigation District	CVP Supplies	Tehama-Colusa Canal Deliveries, Main Canal Diversions from Sacramento River	USBR CVO delivery reports (2016-2023), district records, water rights deliveries during winter months
Glenn Valley Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Glide Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Holthouse Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Kanawha Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
La Grande Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Maxwell Irrigation District	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023)
Misc. Sac River Diversions	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023), aggregated for various water users in the Colusa Subbasin outside other district areas
Myers-Marsh Mutual Water Company	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Orland-Artois Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report
Orland Unit Water Users' Association	Local Supplies	Orland Project (South Canal only)	USBR CVO delivery reports (2016-2023)
Princeton-Codora-Glenn Irrigation District	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023)
Provident Irrigation District	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023)
Reclamation District #108	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023), limited to estimated use in Colusa Subbasin
Robert's Ditch Irrigation Company	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023)
Sacramento National Wildlife Refuge	CVP Supplies	Refuge Water Supply Program Contract Deliveries	Contract Quantities and USBR Annual CVP Allocation Quantities
Sycamore Mutual Water Company	CVP Supplies	Sacramento River Deliveries (Long-term contracts)	USBR CVO delivery reports (2016-2023)
Westside Water District	CVP Supplies	Tehama-Colusa Canal Deliveries	USBR CVO delivery reports (2016-2023), TCCA Report

4 Total Water Use (§356.2.b.4)

Total water use in water year 2023 is reported in **Table 4-1** by water source type. Total water use in water year 2023 is also reported in **Table 4-2** by water use sector, distinguishing between agricultural, urban, managed wetlands, native vegetation, and managed recharge (the total volume of water used for groundwater recharge in the Colusa Subbasin in water year 2023). **Figure 4-1** graphically depicts the annual total water use in the Colusa Subbasin from 2016-2023, distinguishing between groundwater and surface water supplies. The volume of total water use is summarized from the results presented in **Section 2** and **Section 3** of this Annual Report. The methods used to determine the total water use volumes are the same as those indicated in **Section 2** and **Section 3.**

Wet conditions and full surface water allocations in 2023 led to greater use of surface water compared to groundwater, similar to historical conditions in the Subbasin seen prior to the 2020-2022 drought period. Conditions in 2023 have marked a positive change from the tumultuous conditions of 2020-2022, following three years of drought, difficult hydrologic and weather conditions, and severe constraints on water supplies.

Several pilot recharge projects conducted in 2023 led to use of approximately 22,000 af of surface water for managed recharge. All of this water, plus a large portion of other water supplies used for irrigation, has provided recharge benefits to the aquifer, as indicated by the increased groundwater levels (or continuance of stable groundwater levels) observed across much of the Subbasin in 2023.

Table 4-1. Total Water Use in Water Year 2023, by Water Source Type (acre-feet, rounded).

Water Source Type	Water Use (acre-feet)	Methods Used to Determine
Groundwater	577,400	Combined measured and estimated groundwater extraction (see Section 2).
Surface Water	1,343,100	Measured surface water diversions (see Section 3).
Recycled Water	0	No quantified recycled water use in the Colusa Subbasin.
Reused Water	0	No quantified reused water use in the Colusa Subbasin.
Other	0	No quantified other water use in the Colusa Subbasin.
Total	**1,920,500**	

Table 4-2. Total Water Use in Water Year 2023, by Water Use Sector (acre-feet, rounded).

Water Use Sector	Water Use (acre-feet)	Methods Used to Determine
Agricultural	1,781,700	Combined groundwater extraction and surface water diversions for agricultural use (see Sections 2-3).
Urban[1]	8,700	Groundwater for urban use (see Section 2).
Managed Wetlands	108,200	Surface water for managed wetlands use (see Section 3).
Managed Recharge	21,900	Benefits of projects and management actions (Section 6.2)
Native Vegetation	-	No noted groundwater extraction or surface water diversions for native vegetation, per GSP analyses.
Other	-	No quantified other water use in the Colusa Subbasin.
Total	**1,920,500**	

[1] The Urban water use sector includes urban, industrial, rural residential, and semi-agricultural areas in the Colusa Subbasin.

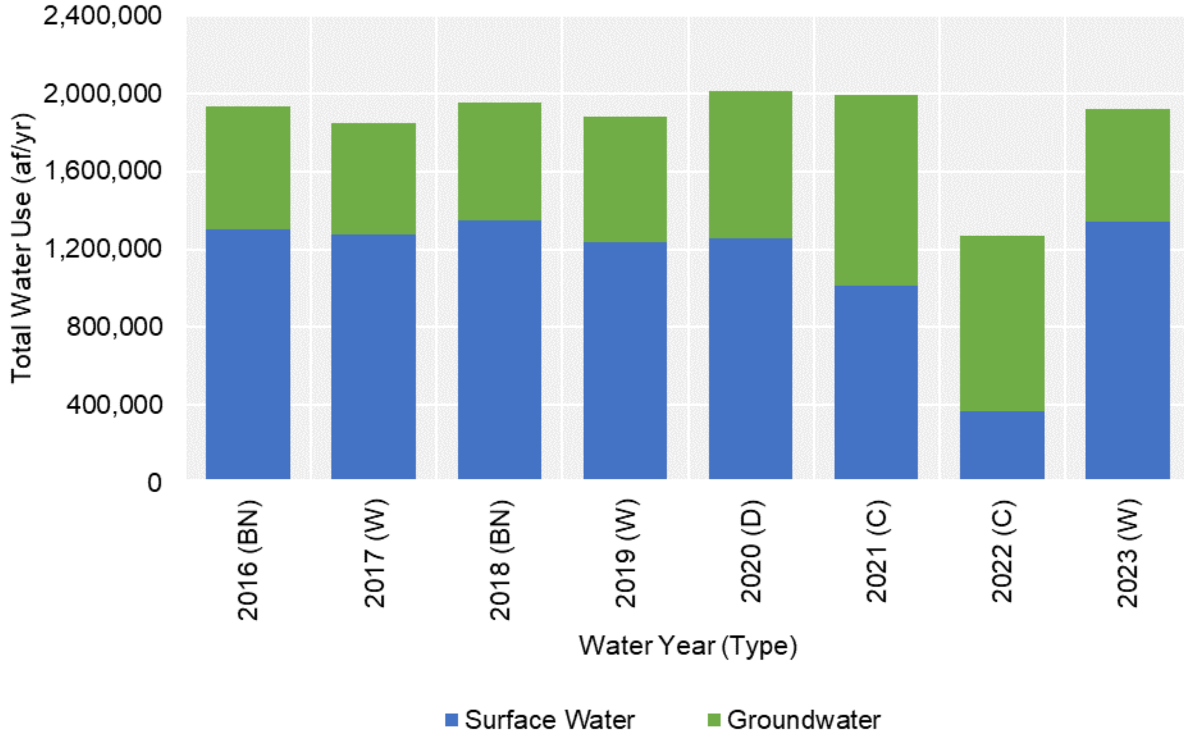

Figure 4-1. Annual Total Water Use – 2016 through 2023.

5 Change in Groundwater Storage (§356.2.b.5)

5.1 CHANGE IN GROUNDWATER STORAGE MAPS

Consistent with 23 CCR §354.18.b, changes in groundwater elevation were calculated for individual years between Spring 2015 and Spring 2023, based on a comparison of the annual spring groundwater elevations representing seasonal high groundwater conditions.

Change in groundwater storage reported in the Colusa Subbasin GSP was estimated using the C2VSimFG-Colusa groundwater model, an integrated hydrologic flow model application created and used during GSP development. Due to uncertainty in the model and limitations in the ability to update the complete groundwater model for this Annual Report, an alternate method for determining change in groundwater storage has been utilized for the Annual Reports. This method has been calibrated to provide comparable results in the pre-2015 period relative to the simulated change in storage outputs from the C2VSimFG-Colusa groundwater model.

Change in groundwater storage was estimated from changes in groundwater levels at RMS wells using a Thiessen polygon method. Thiessen polygons, also known as Voronoi polygons, were constructed for each groundwater level RMS well with consecutive year-to-year spring groundwater elevation measurements. Annual change in groundwater storage was then calculated based on the change in measured spring-to-spring groundwater elevation at each RMS well multiplied by the area of the surrounding Thiessen polygon associated with that RMS well and a storage coefficient of 0.063.[4] Spring groundwater elevations were calculated each year as the average of all measurements flagged by DWR as "good" data between February-April. A storage coefficient of 0.063 is reasonable given the depositional history, sediment types, and aquifer characteristics of the Primary Aquifer within the Colusa Subbasin, and the range of coefficients proposed for the Subbasin in prior technical work. A constant storage coefficient was applied to the entire Colusa Subbasin.

Figure 5-1 shows the annual spring-to-spring change in groundwater storage for Spring 2022-2023. **Appendix C** contains the annual spring-to-spring change in groundwater storage maps for 2015 to 2023. A positive change in groundwater storage means that the volume of groundwater in storage increased, and is shown in blue, whereas a negative change in groundwater storage means that the volume of groundwater in storage decreased, and is shown in red.

Table 5-1 lists the annual change in storage and cumulative change in storage in the Primary Aquifer since Spring 2015. Fluctuations in groundwater storage in the Colusa Subbasin follow a pattern typically seen in the majority of the Sacramento Valley. Groundwater extraction typically peaks in the summer when demand is high. During this time the primary pathways for groundwater recharge are deep percolation from irrigation applications and canal seepage. During wetter years, net reductions in groundwater storage during the summer are replenished over the winter from precipitation and surface water, allowing storage to potentially rebound by the following spring. This pattern is often disrupted during drier years and drought periods when demands for groundwater may equal or exceed those of normal and wet years, and reduced precipitation, lower stream levels, and the possibility of curtailed surface water deliveries reduces opportunities to replenish depleted storage. The seasonal and annual change in groundwater storage trends

[4] Annual change in groundwater storage was recalculated for all years in February 2024 using updated groundwater elevation data available from DWR and a refined aquifer storage coefficient of 0.063. The refined storage coefficient was updated from the storage coefficient used in previous years (0.10) during the GSP revisions process to more closely align the average groundwater storage estimates from this methodology with the average groundwater storage estimates from the GSP groundwater model over the 1990-2015 period. Earlier values have changed following the inclusion of this updated information.

can be seen in groundwater level RMS hydrographs (**Appendix B**) and the Thiessen polygon change in storage estimates (**Appendix C**).

As described throughout this report, wet hydrologic conditions and full allocations of surface water supplies in 2023 generally resulted in higher groundwater elevations across much of the Subbasin and resulted in a net increase in groundwater storage in 2023. The change in groundwater storage from Spring 2022 to Spring 2023 was approximately +34 thousand acre-feet (taf), and the cumulative change in groundwater storage from Spring 2015 to Spring 2023 was approximately -553 taf.

During the GSP revisions process, the GSAs have re-evaluated overdraft conditions in the Subbasin according to this same methodology used to calculate change in groundwater storage, and have proposed recurring evaluation of overdraft conditions in the Subbasin each year in the Annual Report. It is anticipated that this section of the Annual Report will include an evaluation of overdraft conditions in future years, following adoption and submittal of the Colusa Subbasin Revised GSP.

5.2 GROUNDWATER USE AND CHANGE IN GROUNDWATER STORAGE

Annual groundwater extractions and change in groundwater storage in the Colusa Subbasin are shown in **Figure 5-2** for water years 2015 through 2023. Groundwater extractions in water years 2016 through 2023 were estimated or directly measured following the procedures described in **Section 2**. Change in groundwater storage was estimated based on an annual comparison of spring groundwater elevations, described in **Section 5.1**. Historical groundwater extraction in water years 1990 through 2015 – including the period from January 1, 2015, to September 30, 2015 (the end of water year 2015) – are provided in the Colusa Subbasin GSP historical water budgets (see Section 3.3.4 and Appendix 3E of the Colusa Subbasin GSP). Historical groundwater extractions shown in water year 2015 were calculated in the C2VSimFG-Colusa groundwater flow model (described in the Colusa Subbasin GSP).

Total annual groundwater extraction increased during the 2020-2022 drought period, but wet conditions and full surface water allocations in 2023 led to greater use of surface water compared to groundwater, similar to historical conditions in the Subbasin prior to the 2020-2022 drought period. The annual change in groundwater storage has fluctuated between -284,000 af and +261,000 af since water year 2016 (**Figure 5-2**).

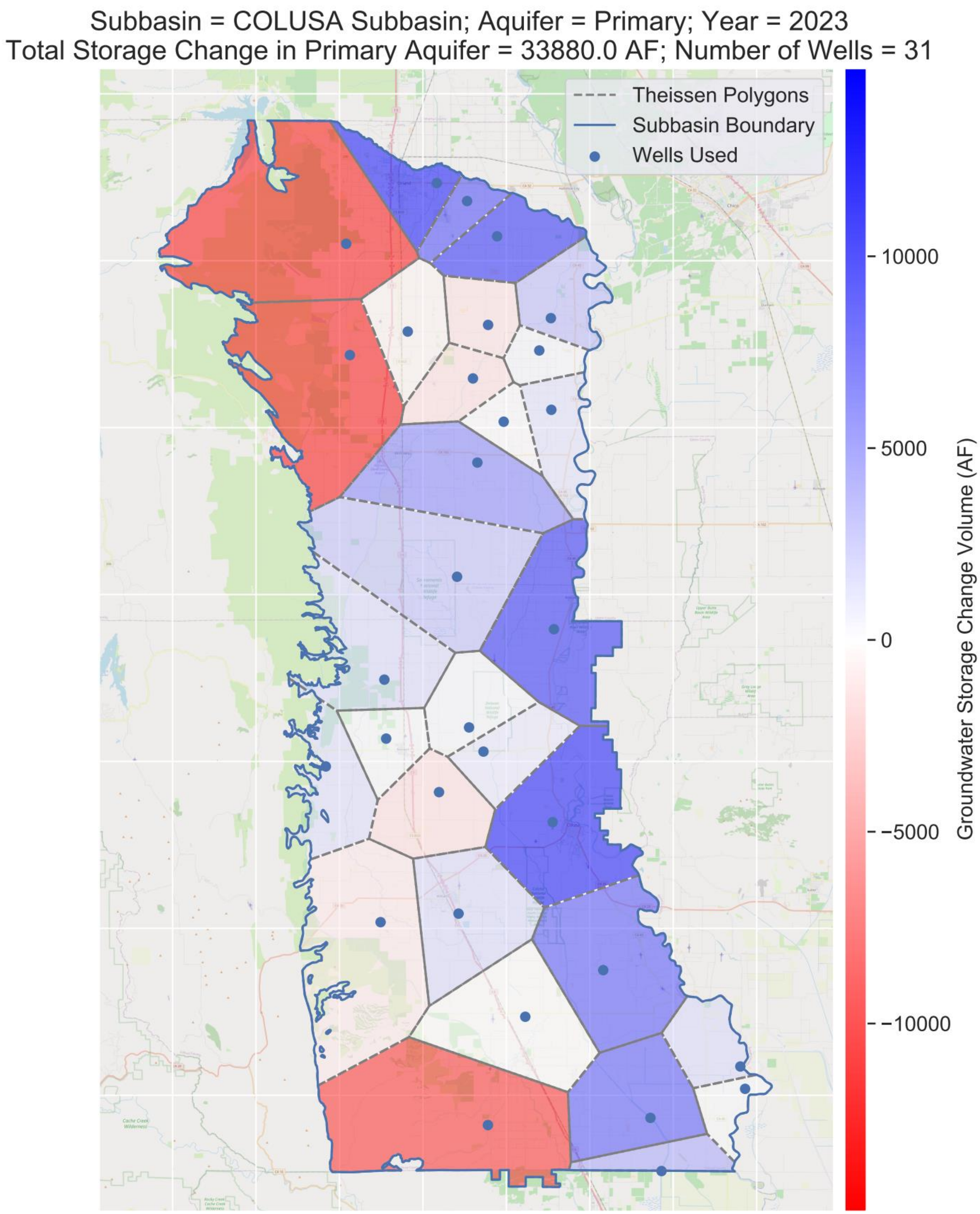

Figure 5-1. Change in Groundwater Storage in the Primary Aquifer – Spring 2022 through Spring 2023.

Table 5-1. Estimated Change in Groundwater Storage in the Primary Aquifer – Spring 2015 through Spring 2023.

Analysis Time Period	Annual Change in Groundwater Storage[1] (taf)	Cumulative Change in Groundwater Storage since Spring 2015-2016 (taf)	Calculation Method
Spring 2015-2016	-106	-106	Estimated based on spring-to-spring changes in groundwater levels at RMS wells and a representative aquifer storage coefficient.
Spring 2016-2017	+261	155	
Spring 2017-2018	-150	5	
Spring 2018-2019	+125	130	
Spring 2019-2020	-219	-89	
Spring 2020-2021	-284	-373	
Spring 2021-2022	-214	-587	
Spring 2022-2023	+34	-553	

[1] Annual change in groundwater storage was recalculated for all years in February 2024 using updated groundwater elevation data available from DWR and a refined aquifer storage coefficient. Values through spring 2022 may have changed slightly following analysis of updated information.

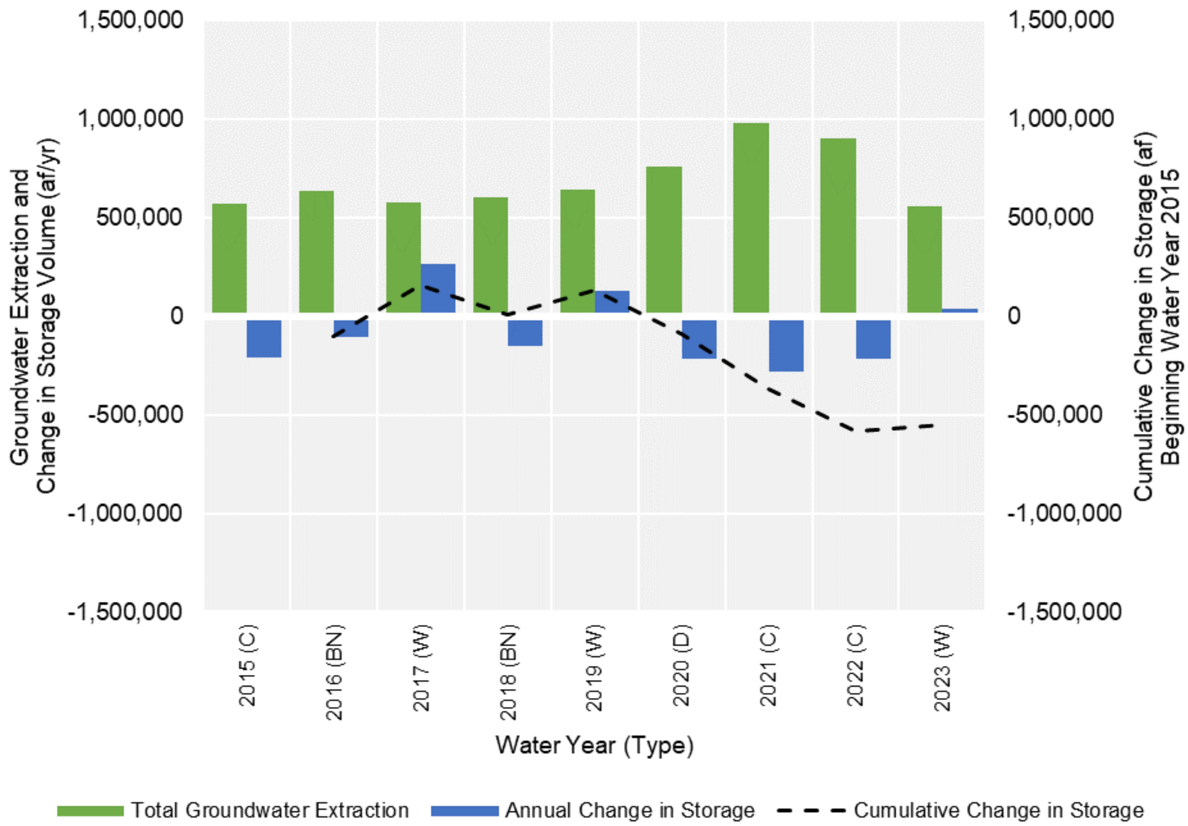

Figure 5-2. Annual Groundwater Extraction and Change in Groundwater Storage – 2015 through 2023.

6 Progress Toward Implementation (§356.2.c)

This section describes the progress that has been made toward GSP implementation in the Colusa Subbasin since the previous Annual Report, including current conditions in the Subbasin relative to each sustainability indicator, as well as efforts made toward implementation of PMAs by the project proponents and GSAs.

6.1 CURRENT CONDITIONS FOR SUSTAINABILITY INDICATORS

The GSAs have been diligently tracking current groundwater conditions in relation to the Sustainable Management Criteria (SMC) established in the Colusa Subbasin GSP. This section presents the status of RMS measurements in relation to the Interim Milestones (IMs), Measurable Objectives (MOs), and Minimum Thresholds (MTs) defined in the GSP. In the Colusa Subbasin GSP, IMs were established to maintain groundwater conditions in the Colusa Subbasin's margin of operational flexibility, as established by the MTs and MOs. The IMs for chronic lowering of groundwater levels are consistent with the MOs shown in **Table 6-1**.

Undesirable results occur when significant and unreasonable effects to any of the five applicable sustainability indicators defined by SGMA are caused by groundwater conditions occurring in the Colusa Subbasin. The GSAs are working to avoid undesirable results and achieve the GSP sustainability goal by 2042 through proactive monitoring and management, including implementation of projects and management actions.

As part of the GSP revisions process, the GSAs are considering revisions to the SMC for chronic lowering of groundwater levels and subsidence. Any revisions made to the SMC in the Revised GSP will be accounted in future Annual Reports.

Table 6-1. Summary of Minimum Thresholds, Measurable Objectives, and Undesirable Results (from Table 5-1 of the Colusa Subbasin GSP).

Sustainability Indicator	Monitoring Network	Undesirable Result	Minimum Threshold (MT)	Measurable Objective (MO)[1]
Chronic Lowering of Groundwater Levels	48 RMS wells monitored at least 2 to 3 times annually by DWR	25% (12 of 48) RMS wells fall continuously below their MT for 24 consecutive months	The lower of 50% of measured historical groundwater elevation range below the historical measured low elevation and the elevation corresponding to the 20th percentile of domestic well depths in the RMS well's Thiessen polygon, subject to interbasin coordination and consistency to ensure operational compatibility	Mean of the most recent 5 years of available groundwater elevation measurements up to 2020, subject to interbasin coordination and consistency to ensure operational compatibility; A fixed value, not a rolling average
Reduction in Groundwater Storage	Same as Groundwater Level monitoring network	Use groundwater levels as proxy	Use groundwater levels as proxy	Use groundwater levels as proxy

Sustainability Indicator	Monitoring Network	Undesirable Result	Minimum Threshold (MT)	Measurable Objective (MO)[1]
Degraded Groundwater Quality	25 RMS wells monitored by others at variable intervals under existing State of California regulatory programs	Electrical conductivity (EC) in 25% (6 of 23) of the RMS wells exceeds the MT for two (2) consecutive years	The higher of the recommended California Secondary Maximum Contaminant Level for EC (900 microSiemens per centimeter [µS/cm]) OR the pre-2015 historical maximum measured EC	EC of 700 µS/cm (corresponding to an agricultural water quality objective providing for no yield reduction for crops commonly grown in the Subbasin)
Land Subsidence	Existing Sacramento Valley Height Modernization Project (SVHMP) benchmarks (63 sites)	20% or more (13 of 63) monitoring sites (benchmarks) experience subsidence rates above the MT	0.5 feet per five years	0.25 feet per five years
Depletions of Interconnected Surface Water	12 RMS wells less than 200 feet deep and between 2,000 feet and five miles of interconnected streams (Sacramento River, Colusa Drain, Stony Creek)	25% (3 of 12) RMS wells fall below their MT for 24 consecutive months	Ten (10) feet below the observed fall 2015 groundwater level (Fall 2015 level is the measured elevation recorded on the date closest to Oct 15)	Mean of last 5 years available groundwater elevation measurements subject to interbasin coordination and consistency to ensure operational compatibility; A fixed value, not a rolling average

[1] Since groundwater conditions were at or near the MO in the Colusa Subbasin at the time of GSP development, the Colusa Subbasin GSP established IMs equal to the MOs.

6.1.1 Chronic Lowering of Groundwater Levels

In the development of the GSP, it was deemed that a significant and unreasonable reduction in the long-term viability of beneficial uses and users would constituent an undesirable result for chronic lowering of groundwater levels. Potential impacts of chronic lowering of groundwater levels were identified and include:

- A significant and unreasonable number of wells going dry;
- A significant and unreasonable reduction in the pumping capacity of existing wells;
- A significant and unreasonable increase in the need for deeper wells or lower pump settings; and
- Adverse impacts to environmental uses and users, including reductions in the flows of ISW and reductions in groundwater available to the root zones of groundwater-dependent ecosystems.

The identification of an undesirable result for chronic lowering of groundwater levels was set to the conditions when 25% or more of the RMS wells in the Subbasin fall below their minimum threshold (MT) groundwater elevation levels for 24 consecutive months. The method used to define the MTs and MOs for chronic lowering of groundwater levels is provided in **Table 6-1**.

Table 6-2 provides a comparison of Spring and Fall 2023 groundwater levels to the established MT, MO, and IM groundwater elevations. The statuses of known monitoring site issues are also provided in **Table 6-2**. Note that groundwater elevation measurements are not available for some RMS wells during calendar year 2023, and so have no measurements to compare with MTs, MOs, and IMs. Hydrographs comparing the measured groundwater elevations with the MTs, MOs, and IMs are in **Appendix B**.

Of the 48 RMS wells for chronic lowering of groundwater levels, ten were unable to be measured in the spring and 7 were unable to be measured in the fall. For Spring and Fall 2023 measurements, all groundwater levels were above the MT, while 9 and 25 measurements were below in the MO in spring and fall, respectively. The majority of RMS wells were at or above the MO in Spring 2023.

As part of the GSP revisions process, the GSAs are considering revisions to the SMC for chronic lowering of groundwater levels. Any revisions made to the SMC in the Revised GSP will be accounted in future Annual Reports.

Table 6-2. Summary of Groundwater Levels Relative to Sustainable Management Criteria at Groundwater Level RMS Wells.

State Well Number	Minimum Threshold (MT)[1] (feet AMSL)	Interim Milestone and Measurable Objective (IM, MO) (feet AMSL)	Spring 2023 Conditions			Fall 2023 Conditions			GSA	Status
			Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)[2]	Difference relative to IM, MO (feet AMSL)	Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)	Difference relative to IM, MO (feet AMSL)		
12N01E06D004M	-108	-1	13.3	121.3	14.3	-4.8	103.2	-3.8	CGA	
13N01E11A001M	-75	22	28.1	103.1	6.1	24.8	99.8	2.8	CGA	
13N01W07G001M	-106*	-9	1.0	107.0	10.0	3.4	109.4	12.4	CGA	
13N01W13P003M	-88	8	17.0	105.0	9.0	1.6	89.6	-6.4	CGA	
13N01W22P002M	-124	26	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	CGA	Could not access due to thick oil. Last meas. 2016.
13N02W12L001M	-72*	9	Not Available	Not Available	Not Available	-18.1	53.9	-27.1	CGA	No Spring measurement
13N02W15J001M	-62*	61	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	CGA	New pump installed. Last meas. 2015.
13N02W20H002M	95	174	167.8	72.8	-6.2	178.5	83.5	4.5	CGA	
14N01E35P003M	-118	28	32.5	150.5	4.5	28.1	146.1	0.1	CGA	
14N01W04K003M	-86	12	32.7	118.7	20.7	23.4	109.4	11.4	CGA	
14N02W13N001M	-80	24	Not Available	Not Available	Not Available	14.0	94.0	-10.1	CGA	No Spring measurement
14N02W22A002M	-126	84	2.5	128.5	-81.5	-12.0	114.0	-96.0	CGA	
14N02W29J001M	-86*	22	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	CGA	Could not access due to well pumping. Last meas. 2017.
14N03W14Q003M	-89*	-13	Not Available	Not Available	Not Available	-18.1	70.9	-5.1	CGA	Inaccessible in Spring
14N03W24C001M	-5*	38	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	CGA	Could not access due to

State Well Number	Minimum Threshold (MT)[1] (feet AMSL)	Interim Milestone and Measurable Objective (IM, MO) (feet AMSL)	Spring 2023 Conditions			Fall 2023 Conditions			GSA	Status
			Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)[2]	Difference relative to IM, MO (feet AMSL)	Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)	Difference relative to IM, MO (feet AMSL)		
										tape sticking downhole. Last meas. 2020.
15N01W05G001M	-54	28	41.9	95.9	13.9	35.3	89.3	7.3	CGA	
15N02W19E001M	-13	73	73.7	86.7	0.7	65.4	78.4	-7.6	CGA	
15N03W08Q001M	43	107	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	CGA	No measurement in 2023
15N03W20Q002M	60	113	114.9	54.9	1.9	111.5	51.5	-1.5	CGA	
16N02W05B003M	-71	47	54.6	125.6	7.6	43.8	114.8	-3.2	CGA	
16N02W25B002M	-25	30	46.1	71.1	16.1	38.6	63.6	8.6	CGA	
16N03W14H006M	-94	51	54.0	148.0	3.0	44.9	138.9	-6.1	CGA	
16N04W02P001M	63	139	141.3	78.3	2.3	140.4	77.4	1.4	CGA	
17N02W09H004M	-52	56	62.4	114.4	6.4	Not Available	Not Available	Not Available	CGA	No Fall measurement
17N02W30J002M	-119	44	56.4	175.4	12.4	48.6	167.6	4.6	CGA	
17N03W08R001M	-13	88	92.7	105.7	4.7	90.4	103.4	2.4	CGA	
17N03W32H001M	-38	92	95.3	133.3	3.3	93.1	131.1	1.1	CGA	
18N02W18D004M	-80	62	75.8	155.8	13.8	33.2	113.2	-28.8	GGA	
18N02W36B001M	-3	53	67.9	70.9	14.9	59.1	62.1	6.1	CGA	
19N02W08Q002M	12	98	101.6	89.6	3.6	98.7	86.7	0.7	GGA	
19N02W33K001M	21	71	Not Available	Not Available	Not Available	73.3	52.3	2.3	GGA	Possible oil in casing
19N04W14M002M	46	151	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	GGA	Dry sediment at 50 feet
20N02W11A001M	49	119	123.5	74.5	4.5	115.8	66.8	-3.2	GGA	
20N02W18R008M	47	120	114.7	67.7	-5.3	116.4	69.4	-3.6	GGA	

State Well Number	Minimum Threshold (MT)[1] (feet AMSL)	Interim Milestone and Measurable Objective (IM, MO) (feet AMSL)	Spring 2023 Conditions			Fall 2023 Conditions			GSA	Status
			Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)[2]	Difference relative to IM, MO (feet AMSL)	Groundwater Elevation (feet AMSL)	Difference relative to MT (feet AMSL)	Difference relative to IM, MO (feet AMSL)		
20N02W25F004M	37	97	99.2	62.2	2.2	96.8	59.8	-0.2	GGA	
20N02W33B001M	31	100	100.6	69.6	0.6	99.3	68.3	-0.7	GGA	
20N03W07E004M	31	100	61.8	30.8	-38.2	56.4	25.4	-43.6	GGA	
21N02W01F003M	71	124	127.9	56.9	3.9	125.3	54.3	1.3	GGA	
21N02W04G004M	51*	121	125.5	74.5	4.5	113.8	62.8	-7.2	GGA	
21N02W05M002M	55	140	144.6	89.6	4.6	127.3	72.3	-12.7	GGA	
21N02W33M003M	67	119	107.2	40.2	-11.8	112.8	45.8	-6.2	GGA	
21N02W36A002M	24*	91	107.1	83.1	16.1	102.6	78.6	11.6	GGA	
21N03W01R002M	48*	151	143.0	95.0	-8.0	132.0	84.0	-19.0	GGA	
21N03W23D002M	84*	140	131.3	47.3	-8.7	127.6	43.6	-12.4	GGA	
21N03W34Q004M	42	112	97.6	55.6	-14.4	97.5	55.5	-14.5	GGA	
21N04W12A002M	18*	73	40.8	22.8	-32.2	25.0	7.0	-48.0	GGA	
22N02W30H003M	82*	150	170.1	88.1	20.1	132.9	50.9	-17.1	GGA	
22N03W24E002M	122*	176	189.7	67.7	13.7	175.6	53.6	-0.4	GGA	

[1] Minimum thresholds with an asterisk (*) were calculated as 50% of the measured groundwater level range below the historical low within the monitoring well. All other MTs were calculated as the 20th percentile of domestic well depth near the RMS well.

[2] Negative differences relative to the MT or MO indicate that the measured groundwater elevation is deeper than the MT or MO.

6.1.2 Reduction in Groundwater Storage

The Colusa Subbasin GSP uses groundwater levels as a proxy for the groundwater storage sustainability indicator. Thus, current conditions related to the reduction in groundwater storage SMC are also captured in **Section 6.1.1**.

6.1.3 Degraded Groundwater Quality

Groundwater quality across the Subbasin is generally good. The sole groundwater quality concern not addressed by the existing groundwater quality regulatory programs is mobilization of saline water from deeper parts of the aquifer. Undesirable results caused by degraded water quality could affect the Human Right to Water by limiting the ability of drinking water beneficial users, including disadvantaged communities (DACs), severely disadvantaged communities (SDACs) and Tribes, to access safe, clean, and affordable water for human consumption, cooking, and sanitary purposes.

Monitoring locations for degraded groundwater quality include 25 RMS wells. The identification of an undesirable result for degraded water quality was defined as the conditions when electrical conductivity (EC) in 25% of the RMS wells exceeds the MT for two (2) consecutive years. Available measurements relative to the MT and MO for degraded water quality is provided in **Table 6-3**.

Of the 25 RMS wells for degraded water quality, data was not available for eleven RMS wells. Of the remaining wells, only one well exceeded the MT (in Fall 2018), and three wells exceeded the MO. For the remaining RMS wells, all available EC measurements were below the MT and the MO.

Table 6-3. Summary of Groundwater Quality Relative to Sustainable Management Criteria at Groundwater Quality RMS Wells.

Well ID	Well Name	Minimum Threshold (MT, us/cm)[2]	Measurable Objective (MO, us/cm)[2]	Latest Measurement (us/cm)	Date of Latest Measurement	Previous Measurement (us/cm)	Date of Previous Measurement
1100404-001	Del Oro Water Company - Black Butte District Representative Well	900	700	564	11/14/2017	387	7/20/2009
1110001-001	City of Orland Representative Well	900	700	479	12/13/2016	479	12/4/2007
1100203-002	Artois Community Service District Representative Well	900	700	374	3/8/2018	405	3/11/2015
1110003-007	Cal-Water Service Company - Willows Representative Well	900	700	480	6/8/2023	500	6/9/2020
0600013-002	Colusa County WWD #2 - Princeton Representative Well	900	700	420	12/12/2021	539	1/13/2013
0610003-003	Maxwell Public Utility District Representative Well	1200	700	1140	4/14/2021	1000	5/16/2012
0610002-002	City of Colusa Representative Well	900	700	518	4/7/2020	600	11/8/2011
0610004-004	City of Williams Representative Well	1180	700	1200	10/3/2018	740	10/28/2015
0600008-001	Colusa County WWD #1 - Grimes Representative Well	900	700	317	10/16/2019	315	9/18/2019
0610001-004	Arbuckle Public Utility District Representative Well	900	700	742	8/3/2017	698	7/31/2008
0606011-001	Del Oro Water Company - Arbuckle District Representative Well	900	700	--[1]	--[1]	--[1]	--[1]
25A1M	Electrical Conductivity: CRC Well 25A1M (Screened Depth: 25-30 ft)	900	700	--[1]	--[1]	--[1]	--[1]
32J1M	Electrical Conductivity: CRC Well 32J1M (Screened Depth: 25-30 ft)	967	700	--[1]	--[1]	--[1]	--[1]
23E1M	Electrical Conductivity: CRC Well 23E1M	900	700	--[1]	--[1]	--[1]	--[1]
25E1M	Electrical Conductivity: CRC Well 25E1M (Screened Depth: 25-30 ft)	950	700	--[1]	--[1]	--[1]	--[1]
25R1M	Electrical Conductivity: CRC Well 25R1M (Screened Depth: 28.5-33.5 ft)	900	700	--[1]	--[1]	--[1]	--[1]
12G2M	Electrical Conductivity: CRC Well 12G2M (Screened Depth: 25-30 ft)	900	700	--[1]	--[1]	--[1]	--[1]
14G1M	Electrical Conductivity: CRC Well 14G1M (Screened Depth: 25-30 ft)	2120	700	--[1]	--[1]	--[1]	--[1]
35M1M	Electrical Conductivity: CRC Well 35M1M (Screened Depth: 25-30 ft)	1680	700	--[1]	--[1]	--[1]	--[1]
03E1M	Electrical Conductivity: CRC Well 03E1M (Screened Depth: 25-30 ft)	4060	700	--[1]	--[1]	--[1]	--[1]
16R1M	Electrical Conductivity: CRC Well 16R1M (Screened Depth: 25-30 ft)	5530	700	--[1]	--[1]	--[1]	--[1]

Well ID	Well Name	Minimum Threshold (MT, us/cm)[2]	Measurable Objective (MO, us/cm)[2]	Latest Measurement (us/cm)	Date of Latest Measurement	Previous Measurement (us/cm)	Date of Previous Measurement
SVWQC00005	Electrical Conductivity: SVWQC Well SVWQC00005 (Screened Depth: 145-225 ft)	900	700	534	8/15/2023	533	8/19/2022
SVWQC00021	Electrical Conductivity: SVWQC Well SVWQC00021 (Screened Depth: 90-120 ft)	900	700	474	8/15/2023	493	8/17/2022
SVWQC00019	Electrical Conductivity: SVWQC Well SVWQC00019 (Screened Depth: <126 ft)	900	700	613	8/16/2022	621	8/16/2022
SVWQC00006	Electrical Conductivity: SVWQC Well SVWQC00006 (Screened Depth: 180-260 ft)	900	700	483	8/16/2023	505	8/17/2022

[1] Indicates Missing or Questionable Measurement

[2] MTs, MOs, and measurements are in units microSiemens per centimeter (us/cm)

6.1.4 Land Subsidence

An undesirable result for land subsidence is defined as the conditions when 20% or more (13 of 63) monitoring sites (benchmarks) experience subsidence rates above the MT. The MT for subsidence is a rate of 0.5 feet per five years, while the MO is 0.25 feet per five years. The official monitoring network, as documented in the GSP, is the Sacramento Valley Height Modernization Project (SVHMP) benchmark locations. A resurvey of these benchmark locations has not occurred in water year 2023. A narrative description of subsidence is provided here based on measurements provided by DWR based on Interferometric Synthetic Aperture Radar (InSAR) data.

There are two areas of subsidence within the Subbasin. The first area is located in the southern portion of the Subbasin near Arbuckle and the second is located north of Willows and south of Orland. **Figure 6-1** presents the annual vertical ground displacement measured by InSAR for water year 2023. **Figure 6-2** presents the net vertical ground displacement measured by InSAR from June 2015 to October 2023, an approximately eight-year period. Negative vertical displacement values depict a decrease in land surface elevation, and positive values depict an uplift in land surface. Subsidence is opposite, where positive subsidence depicts a decrease in land surface elevation and negative subsidence depicts an increase in land elevation.

The southern area of interest shows a maximum displacement value of -0.35 feet during water year 2023. During the June 2015 to October 2023 period, the maximum amount of vertical land displacement was approximately -2.6 feet, or approximately -0.33 feet per year of vertical land displacement, on average.

The northern area of interest shows a maximum displacement value of approximately -0.27 feet during water year 2023. During the June 2015 to October 2023 period, the maximum amount of vertical land displacement was approximately -1.9 feet, or approximately -0.23 feet per year of vertical land displacement, on average.

As part of the GSP revisions process, the GSAs are considering revisions to the SMC and monitoring approach for subsidence, as well as efforts to address subsidence-related data gaps. Any revisions made to the SMC and monitoring network in the Revised GSP will be accounted in future Annual Reports.

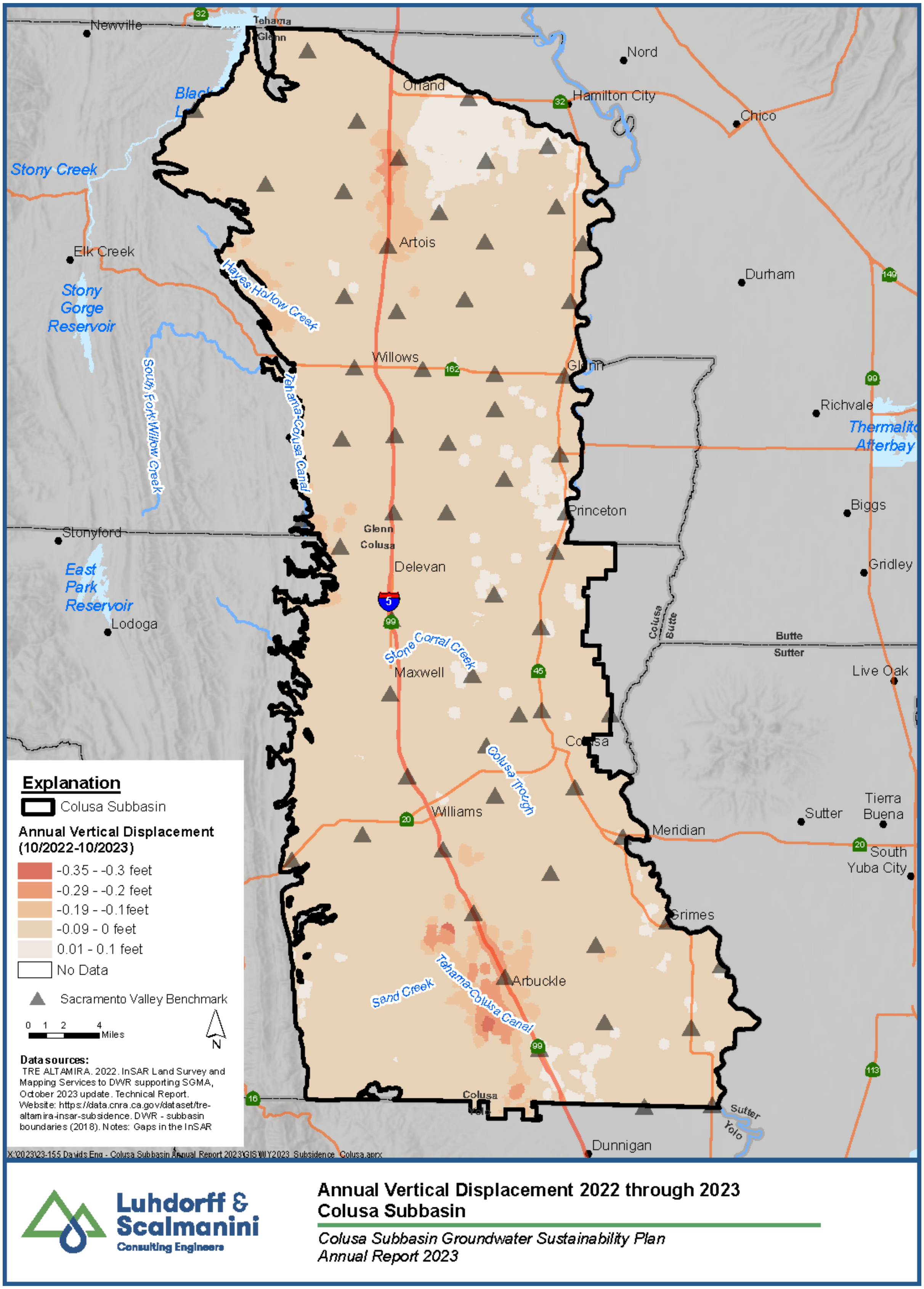

Figure 6-1. Annual Vertical Displacement – Water Year 2023.

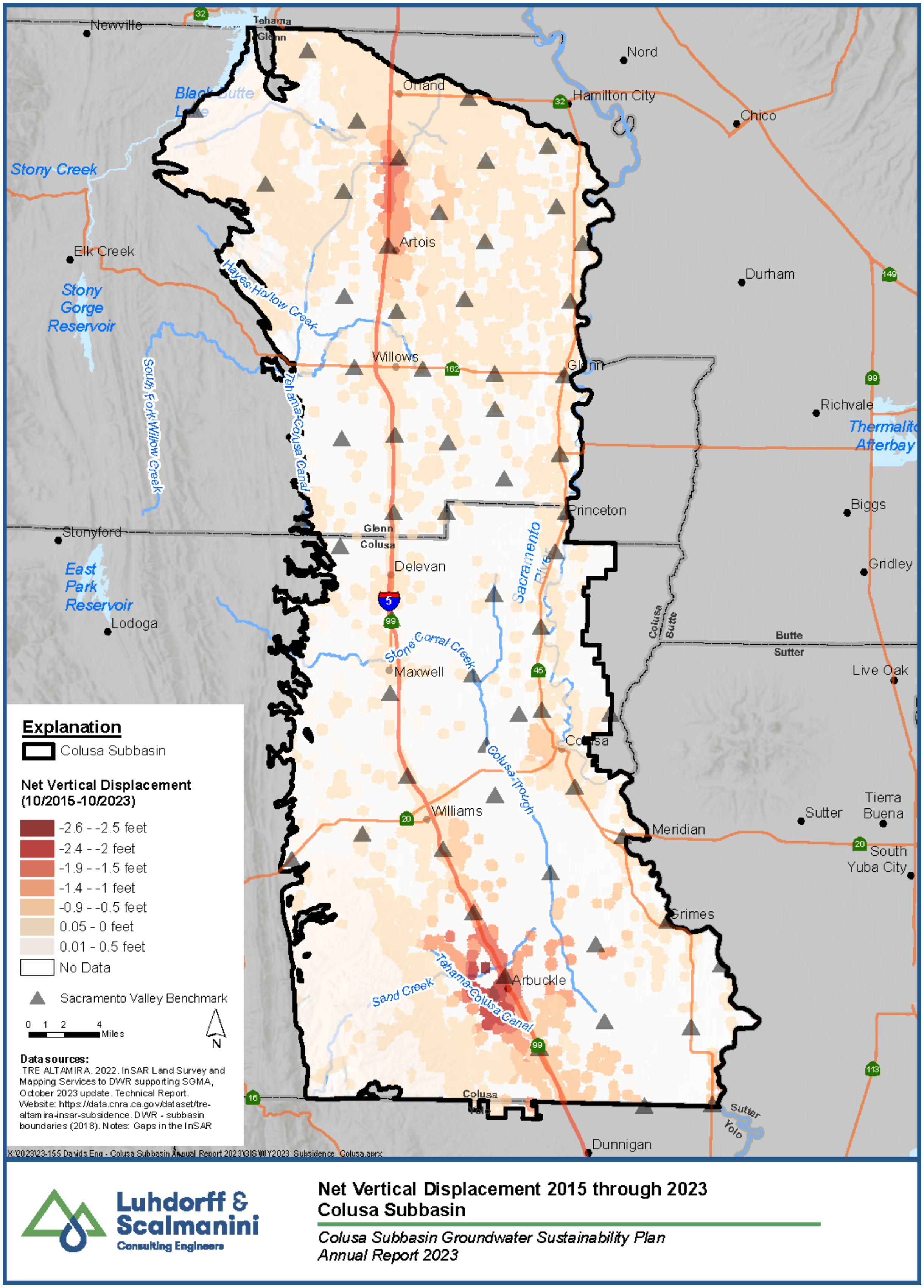

Figure 6-2. Net Vertical Displacement – June 2015 through October 2023.

6.1.5 Depletions of Interconnected Surface Water

The undesirable result for depletions of interconnected surface water (ISW) is a result that causes significant and unreasonable adverse effects on beneficial uses and users of ISW within the Subbasin over the planning and implementation horizon of this GSP. During development of the GSP, potential undesirable results identified by stakeholders included:

- Significant and unreasonable impacts to stream flows
- Significant and unreasonable impact to riparian and riverine habitat
- Significant and unreasonable impacts to GDEs
- Significant and unreasonable impacts to springs

The undesirable result for depletions of ISW is considered to occur during GSP implementation when 25% of RMS wells fall below their MT for 24 consecutive months. The three wells must be the same subset of wells, not any combination of three wells. The subset of wells is not predetermined; rather, it is delineated only as wells that collectively fall below their minimum threshold levels. **Table 6-4** provides a comparison of Spring and Fall 2023 groundwater levels to the established MT, MO, and IM groundwater elevations for ISW. In Spring 2023, the groundwater elevation at RMS wells ranged between 28.10 ft AMSL and 212.11 ft AMSL. In Fall 2023, water levels range between 3.37 ft AMSL and 207.41 ft AMSL. The statuses of known monitoring site issues are also provided in **Table 6-4**. Note that groundwater elevation measurements are not available for some RMS wells during calendar year 2023, and so have no measurements to compare with MTs, MOs, and IMs.

Of the 12 RMS wells for ISW, one was unable to be measured in spring. For Spring and Fall 2023 measurements, groundwater elevations at the majority of RMS wells were above the MO and the IM. No RMS wells exceeded their MT in 2023.

Table 6-4. Summary of Groundwater Levels Relative to Sustainable Management Criteria at Interconnected Surface Water Representative Monitoring Sites.

Representative Monitoring Site, State Well Number (SWN)	Measurable Objective and Interim Milestone (MO, IM) (feet AMSL)	Minimum Threshold (MT) (feet AMSL)	Seasonal High (Spring)			Seasonal Low (Fall)		
			2023 (feet AMSL)	Difference (feet) MO, IM	Difference (feet) MT	2023 (feet AMSL)	Difference (feet) MO, IM	Difference (feet) MT
13N01E11A001M	22	13	28.10	6.10	15.10	24.80	2.80	11.80
13N01W07G001M	-10	-19	--[1]	--	--	3.37	13.37	22.37
14N01W04K003M	12	3	32.73	20.73	29.73	23.43	11.43	20.43
15N01W05G001M	27	19	41.92	14.92	22.92	35.32	8.32	16.32
17N02W30J002M	44	26	56.43	12.43	30.43	48.63	4.63	22.63
20N02W11A001M	119	106	114.7	-4.30	8.70	115.8	-3.20	9.80
20N02W25F004M	97	87	98	1.00	11.00	96.8	-0.20	9.80
21N02W01F004M	126	105	128.92	2.92	23.92	126.42	0.42	21.42
21N02W05M003M	148	125	145.53	-2.47	20.53	138.73	-9.27	13.73
21N02W36A002M	91	59	107.09	16.09	48.09	104.29	13.29	45.29
22N02W30H004M	179	161	175.73	-3.27	14.73	178.63	-0.37	17.63
22N03W24E003M	208	194	212.11	4.11	18.11	207.41	-0.59	13.41

[1] Indicates data is marked as "Missing" or "Questionable Measurement"

6.2 IMPLEMENTATION OF PROJECTS AND MANAGEMENT ACTIONS (§356.2.C)

Implementation of projects and management actions (PMAs) is critical to achieving groundwater sustainability and avoiding undesirable results. As described in the Colusa Subbasin GSP, PMAs proposed in the GSP were conceptualized and categorized in three groups: planned PMAs, ongoing PMAs, and potential PMAs. The estimated costs, timing, and benefits (i.e., increased groundwater recharge or reduced groundwater use) of the PMAs at full implementation are described in the GSP.

As described in Section 6.1 of the Colusa Subbasin GSP, ongoing management of the Colusa Subbasin under the GSP will follow an “adaptive management” strategy that involves active monitoring of groundwater conditions and addressing any challenges related to maintaining groundwater sustainability by scaling and implementing PMAs in a targeted and proportional manner in accordance with the needs of the Colusa Subbasin. The CGA and GGA GSAs are committed to adaptive management of groundwater resources in the Colusa Subbasin through the suite of PMAs identified in the Colusa Subbasin GSP. As PMAs are implemented and monitored, the project timelines and consequential effects on the Colusa Subbasin will be reviewed. If adjustments are needed to meet the sustainability objectives identified in the Colusa Subbasin GSP, project timelines will be evaluated and adjusted. In addition to continuous monitoring and review of PMA implementation, each Annual Report represents an opportunity to review the status of GSP implementation efforts.

This section describes progress that has been made toward implementation of the GSP and specific PMAs since the previous Annual Report. First, a brief overview is given regarding the GSAs’ efforts in 2023-2024 to revise the GSP to address deficiencies identified by DWR and a commitment to develop a domestic well mitigation program and a demand management program. The remainder of this section describes in greater detail the progress made in PMA implementation.

6.2.1 GSP Revisions and Development of Management Actions

In October 2023, DWR completed their initial evaluation of the Colusa Subbasin GSP and determined the GSP to be “incomplete” pursuant to 23 CCR §355.2(e)(2), initiating a 180-day period for the GSAs to revise the GSP to address the identified deficiencies by April 23, 2024. In this determination, DWR identified three deficiencies:

- DWR found that the GSP did not include a reasonable assessment of overdraft conditions and a reasonable means to mitigate overdraft,
- DWR found that the SMC for chronic lowering of groundwater levels were not substantially compliant with the GSP regulations, and
- DWR found that the SMC for subsidence were not substantially compliant with the GSP regulations.

Since the previous Annual Report, the GSAs have completed technical analyses and GSP revisions to address the three deficiencies. In total, the GSAs have held five consultation meetings with DWR to discuss their plans for addressing the deficiencies and to ensure that those plans are sufficient to create a revised GSP that is acceptable to DWR. The Colusa Subbasin Revised GSP is expected to be adopted and submitted to DWR for evaluation ahead of the April 23, 2024 deadline.

As part of the GSP revision process, the GSAs have drafted formal agreements to develop and implement a domestic well mitigation program and a demand management program for the Subbasin. Implementation of these programs is expected to provide the GSAs with additional means of mitigating overdraft, subsidence, and groundwater level decline in the Subbasin and of mitigating undesirable results that may occur to domestic well users during GSP implementation while other PMAs are being developed, prior to achieving sustainable groundwater conditions (no later than 2042). Details about the two programs are included in the Colusa Subbasin Revised GSP. The GSAs plan to move forward with program development and implementation, consistent with the agreements, following submittal of the Colusa Subbasin Revised GSP in April 2024.

6.2.2 Overview of Projects and Management Actions

Table 6-5 summarizes the implementation status of PMAs from the GSP as well as major updates to PMAs since the previous Annual Report. The status of PMAs is generally defined as follows:

- **Implemented/Implementation Ongoing**: Active efforts to operate the project or management action have begun, though benefits may or may not have been achieved.
- **In Progress**: Active efforts needed to initiate the project or management action have begun (e.g., permitting), though development has not reached the point of operability.
- **Planned**: Early conceptual development is still in progress, though active efforts to initiate or operate the project or management action have not begun.

Table 6-6 provides further updates on the benefits of PMAs since GSP development, in comparison with the anticipated benefits presented in the Colusa Subbasin GSP.

This Annual Report covers the second full year of PMA implementation under the GSP. Wet conditions in 2023 allowed the GSAs to achieve substantial recharge benefits in the Subbasin through irrigation with surface water in lieu of groundwater, following on the heels of a multi-year drought and surface water curtailments. The GSAs have also continued to make progress in implementing existing PMAs, as well as developing and implementing new PMAs. As of early 2024, progress has been made in developing or implementing approximately 15 PMAs, including 14 direct or in-lieu recharge projects and one ongoing management action for urban water conservation. As noted in **Section 6.2.1**, the GSAs are also in the process of developing a domestic well mitigation program and demand management program to provide a backstop for other PMAs and to address undesirable results in the Subbasin. Updates on these programs will be provided in future Annual Reports, along with an assessment of the response of PMA activities on achieving the sustainability goal for the Subbasin.

In total, approximately 22,000 af of benefits to the Subbasin were achieved in 2023, in addition to substantial recharge benefits of surface water supplies accounted in the Subbasin water use estimates (see **Sections 2 through 4**). This represents approximately 27% of the estimated 83,000 af in total anticipated benefits of all planned PMAs at full implementation (GSP Table 6-4), although it is noted that many of the planned PMAs are currently being actively developed and have not achieved their full anticipated benefits as of early 2023. Wet hydrologic conditions experienced in 2023, together with implementation of PMAs, has facilitated substantial recovery of groundwater levels at RMS wells across the Subbasin (**Section 1**) and has helped to lower the rate of subsidence observed in both the Orland-Artois and Arbuckle-College City areas (**Section 6.1.4**). There are no known adverse impacts to the various sustainability indicators, adjacent groundwater basins, or beneficial uses and users resulting from PMA implementation in the Colusa Subbasin, although the GSAs will continue to monitor conditions in the Subbasin.

The CGA and GGA GSAs are committed to adaptive management to respond to changing hydrologic, climate, and groundwater conditions in the Subbasin through this suite of identified PMAs and the demand management program currently in development. As PMAs are implemented and monitored, the timelines of other PMAs and volume of demand management necessary to achieve sustainable groundwater conditions in the Subbasin will be reviewed. If adjustments are needed to meet the sustainability goal for the Subbasin, timelines for implementation of these efforts will be evaluated and adjusted. In addition to continuous monitoring and review of PMA implementation, each Annual Report represents an important milestone and opportunity to review the status of GSP implementation efforts.

Table 6-5. Updates to Projects and Management Actions Since GSP Development.

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
Planned	Colusa County Water District (CCWD) In-Lieu Groundwater Recharge	CCWD	2021	In Progress	CCWD will utilize 30,000 af of additional surface water for irrigation in all years but Shasta Critical years for in-lieu recharge. The additional surface water will be made available through full use of the district's existing CVP contract and annual and multi-year water purchase and transfer agreements. Additional surface water deliveries are estimated to be 27,000 acre-feet per year (af/yr), enabling reduction of groundwater pumping by a like amount.	CCWD has available surface water, although efforts are needed to disincentivize groundwater pumping and make surface water a more economical option for irrigators.
Planned	Colusa Drain MWC (CDMWC) In-Lieu Groundwater Recharge	CDMWC	2021	Planned	CDMWC diverters use both ground and surface water because Colusa Drain supplies are insufficient to satisfy all irrigation requirements. This project would provide additional surface supplies averaging approximately 28,000 af/yr in the Drain allowing CDMWC diverters to increase their diversions of surface water to provide in lieu groundwater recharge of a like amount.	*No change in implementation noted since GSP development.* *Project planning is still underway.*
Planned	Colusa Subbasin Multi-Benefit Groundwater Recharge	CGA, GGA and TNC	2021	Implemented	The Nature Conservancy (TNC) is partnering with entities for an on-farm, multi benefit groundwater recharge incentive program. The pilot program was initiated in Colusa County in 2018 and concluded in the spring of 2021, with plans to expand and continue into the future. DWR is a partner in the Colusa Subbasin Multi-Benefit Groundwater Recharge project as it moves into the expanded program.	The pilot program was completed in 2021, and the grant-funded project concluded in January 2022. Ongoing multi-benefit recharge work is occurring through separate projects, including the Spring Valley Multi-Benefit Project (described below).
Planned	Orland-Artois Water District (OAWD) Land	OAWD	2020	In Progress	OAWD is planning to annex approximately 12,000 acres of groundwater dependent	In 2023, OAWD annexed approx. 10,300 acres, completed CEQA, and

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
	Annexation and Groundwater Recharge				agricultural lands. Additional direct recharge may be considered on suitable annexed lands. The project is an area where groundwater levels have been in decline in recent years. It is estimated that a long-term average of approximately 23,000 af/yr of surface water would be available, reducing groundwater pumping by approximately 23,000 af/yr.	initiated NEPA. Approval is anticipated in mid-2024, at which point approximately 3,000 acres could begin receiving surface water immediately. Deliveries to the remaining area will occur after completion of ongoing permitting (2-4 years) and construction of delivery infrastructure. Also in 2023, OAWD collaborated with the GGA to implement a pilot groundwater recharge project, which delivered nearly 1,800 af of water for recharge. The pilot project identified areas with significant recharge potential for focusing future recharge efforts.
Planned	Sycamore Slough Groundwater Recharge Pilot Project	Landowner	2021	Implementation Ongoing	Proctor and Gamble (P&G) and Davis Ranches have entered into an agreement to implement a 10-year groundwater recharge pilot project. A 66-acre field on Davis Ranches will receive surface water for groundwater recharge and provide habitat for migrating shorebirds. Water would be diverted from the Sacramento River during fall/winter months using existing riparian rights or would be available from settlement contract supplies (should the project begin before November 1). An expansion of the project is planned for recharge and revegetation in the neighboring Sycamore and Dry Sloughs.	Davis Ranches applied surface water for recharge and habitat benefits in December 2023-January 2024, with recharge benefits of approx. 380 af.
Planned *(Proposed since GSP)*	GGA Recharge Project	GGA	2022	Implementation Ongoing	The GGA is planning, designing, implementing, and monitoring multi-benefit, direct and in-lieu groundwater recharge projects to alleviate critical drought conditions. This Project will	GGA conducted two pilot projects in collaboration with OAWD and OUWUA, completing over 15 groundwater recharge projects in Glenn County and

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
					provide habitat for migratory shorebirds and enhance groundwater dependent ecosystems supporting the region's objective to implement multi-benefit projects. Recharge will occur across GGA's service area focusing on areas to maximize urban and environmental benefits.	recharging approximately 2,100 af of water.
Ongoing	Reclamation District 108 (RD108) and CCWD Agreement for Five-Year In-Lieu Groundwater Recharge Project	RD108 and CCWD	N/A (Ongoing)	On Hold	CCWD (and Dunnigan Water District [DWD]) purchases surface water from RD108 for distribution within its service area. The agreement expires in 2022. This project supplies additional surface water to CCWD (and DWD) that provides in lieu recharge.	Agreement expired as or 2023 and has been put on hold temporarily due to wet conditions, CVP 215 water availability, and Voluntary Agreement efforts. However, CCWD plans to re-initiate discussions with RD108 shortly.
Ongoing	Glenn-Colusa Irrigation District (GCID) Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits	GCID	N/A (Ongoing)	Implementation Ongoing	GCID holds a water right for winter water. This project will increase the groundwater recharge and habitat enhancement benefits of winter water use by increasing use for rice straw decomposition, irrigation, and frost control provided that certain constraints can be alleviated.	GCID continues to deliver winter water to users, including those outside the District. In 2023, GCID had approximately 174,000 af of surface water available in the winter (November-March). Approx. 66,000 acres applied for winter water from GCID, including approx. 27,500 acres for decomposition and habitat.
Ongoing	Sycamore Marsh Farm Direct Recharge Project	Landowner	N/A (Ongoing)	Implementation Ongoing	Sycamore Marsh Farm is developing a groundwater recharge plan to store groundwater. The plan provides for 205 acres of year-round recharge basins and 163 additional acres of winter recharge areas.	*No change in implementation noted since GSP development.* *Project is still ongoing.*
Ongoing	GCID Expansion of In-Basin Program for In-lieu Groundwater Recharge	GCID	N/A (Ongoing)	Implementation Ongoing	GCID has developed arrangements to supply district surface water to neighboring non-district agricultural lands that primarily use groundwater. These temporary arrangements expired in 2020. There is interest in continuing and expanding this in	Project is ongoing. GCID is working with neighboring non-district lands to supply water for in-lieu recharge.

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
					basin surface water use for in lieu groundwater recharge. Supplies would potentially be available only in Shasta Non-Critical years.	
Ongoing	Orland Unit Water Users' Association (OUWUA) Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping	OUWUA	N/A (Ongoing)	Implementation Ongoing	Modernization of OUWUA southside system for more reliable and flexible farm deliveries that will provide incentive for growers to use more surface water and less groundwater.	OUWUA continues to promote and support efficient on-farm irrigation systems. In most cases, groundwater pumping is offset by using Orland Project water for pressurized sprinkler/drip/micro-sprinkler applications. In the past several years, efficient on-farm irrigation systems have increased, driven by drought conditions. One new modified delivery system came online in 2023.
Ongoing	Urban Water Conservation in Willows	California Water Service – Willows District	N/A (Ongoing)	Implementation Ongoing	This project includes urban water conservation measures through water waste prevention ordinances, metering, conservation pricing, public education, and outreach programs to assess and manage distribution system real loss, water conservation program coordination and staffing support, and other demand management measures.	Implementation of urban water conservation measures continued in 2023.
Potential	GCID In-Lieu Groundwater Recharge	GCID	N/A (Potential)	In Progress	GCID will investigate, develop, and implement measures to incentivize growers in the GCID service area that currently rely on groundwater to instead utilize surface water supplied by GCID, which will provide in-lieu recharge through reduced groundwater pumping.	GCID is continuing to work with landowners to incentivize utilization of all available surface water supplies, in coordination with GCID's efforts to strategically expand winter water use. As of 2023, there remain about 4,200 acres within the GCID boundary that are primarily irrigated with groundwater pumped from private wells.
Potential	Tehama-Colusa Canal Trickle Flow to Ephemeral Streams	CCWD	N/A (Potential)	Implementation Ongoing	Operate Tehama-Colusa Canal (TCC) existing gates for discharge into ephemeral streams at a rate where they	CCWD has installed three discharge sites, has coordinated with landowners to monitor the project area, and is

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
					do not flow out of the Colusa Subbasin but recharge the groundwater system.	completing mapping of monitoring sites. CCWD has received funding through an IRWM grant for project development, although funding for recharge water is still being identified. A temporary water right application has been submitted but is not yet approved.
Potential	GCID Water Transfers to TCCA CVP Contractors	GCID	N/A (Potential)	In Progress	GCID is exploring the possibility of transferring surface water to CVP contractors served by the TCC to provide in-lieu groundwater recharge and reduce groundwater pumping through increased CVP water utilization. Priority would be placed on transfers to CVP contractors in areas where groundwater level declines have been observed, particularly in the areas around the cities of Orland and Arbuckle.	Project is ongoing. GCID is continuing discussions with the TCCA, although those discussions are not concluded at the time of this Annual Report. GCID is also identifying opportunities for partnerships with other districts in the Subbasin. Updates will be provided in future years.
Potential *(Proposed since GSP)*	Spring Valley Recharge Project – Phase 1	T&M King Farms LLC	2023	In Progress	The Spring Valley Multi-Benefit Project focuses on achieving four goals of increasing groundwater recharge, restoring wetland habitat, sequestering carbon and increasing the sustainability of domestic wells, many of which serve local disadvantaged communities.	This project was included in the SGMA Implementation Round 2 grant application, although funding was not awarded. Phase 1 of this project is projected to last for two years once funding is secured.
Potential *(Proposed since GSP)*	Sycamore Slough Reconnection and Recharge	Davis Ranches	2023	Implementation Ongoing	The Sycamore Slough Reconnection and Recharge project would divert surface water from the Sacramento River and/or the Colusa Basin Drain to flood fields and the slough itself to provide groundwater recharge, create habitat for migrating shorebirds/waterfowl, and provide essential support for groundwater	In 2023, Davis Ranches completed work on the slough reconnection, began conservation and rehabilitation improvements to approx. 2,000-3,000 feet of channels, and organized with neighboring landowners and a neighboring RCD to join together in recharge and conservation efforts.

Category (from GSP)	Project/Management Action Name	Proponent	Year Planned (from GSP)	Status	Brief Description (from GSP)	Updates Since GSP
					dependent ecosystems along the path of Sycamore Slough.	
Potential *(Proposed since GSP)*	GCID Recharge Basin	GCID	2023	Planned	GCID is planning to install a turnout to a gravel pond that will supply available surface water for groundwater recharge.	GCID is currently planning this project, and anticipates moving forward with construction in 2024-2025.
Potential	*All Others Listed in GSP*	-	-		-	*No change in implementation noted since GSP development*

Table 6-6. Anticipated Benefits and Actual Benefits of Projects and Management Actions.

Category (from GSP)	Project/Management Action Name	Proponent	Anticipated or Reported Benefits from GSP		Actual Benefits		Note
			Average Annual Benefits from GSP (af/yr)	Refined Average Annual Benefits Since GSP (af/yr)	Actual Benefits in 2023 (af/yr)	Actual Average Annual Benefits Since GSP (af/yr)*	
Planned	CCWD In-Lieu Groundwater Recharge	CCWD	27,000	-	-	-	No benefits noted since GSP development.
Planned	CDMWC In-Lieu Groundwater Recharge	CDMWC	28,000	-	-	-	No update since GSP development.
Planned	Colusa Subbasin Multi-Benefit Groundwater Recharge	CGA, GGA and TNC	5,200	-	-	220	Grant-funded project concluded in January 2022. Ongoing multi-benefit recharge work is occurring through other projects.
Planned	OAWD Land Annexation and Groundwater Recharge	OAWD	23,000	14,000	*(1,793 af of benefits in coordination with the GGA, see GGA Recharge Project)*	*(1,793 af of benefits in coordination with the GGA, see GGA Recharge Project)*	Project benefits have been refined since GSP development. The project is targeting 15,000 af of deliveries in Shasta Non-Critical years, with an updated gross average annual benefit of approximately 14,000 af/yr. Recharge in 2023 occurred in coordination with the GGA (Benefits accounted under the GGA Recharge Project).
Planned	Sycamore Slough Groundwater Recharge Pilot Project	Landowner	500	-	380	350	Recharge occurred in December 2023-January 2024.
Planned *(Proposed since GSP)*	GGA Recharge Project	GGA	-	7,500	2,093	2,093	Recharge in 2023 occurred in coordination with OAWD and OUWUA.
Ongoing	RD108 and CCWD Agreement for Five-Year In-Lieu Groundwater Recharge Project	RD108 and CCWD	8,000	-	-	450	Agreement on hold in 2023. Anticipate re-initiating discussions shortly.
Ongoing	GCID Strategic Winter Water Use for	GCID	*TBD*	-	19,300	19,300	Approx. 66,000 acres applied for winter water from GCID in 2023, including approx. 27,500 acres

Category (from GSP)	Project/Management Action Name	Proponent	Anticipated or Reported Benefits from GSP: Average Annual Benefits from GSP (af/yr)	Anticipated or Reported Benefits from GSP: Refined Average Annual Benefits Since GSP (af/yr)	Actual Benefits: Actual Benefits in 2023 (af/yr)	Actual Benefits: Actual Average Annual Benefits Since GSP (af/yr)*	Note
	Groundwater Recharge and Multiple Benefits						for decomposition and habitat. Recharge benefit is estimated for typical recharge of ponding in Nov-Mar for rice decomposition.
Ongoing	Sycamore Marsh Farm Direct Recharge Project	Landowner	*TBD*	-	-	-	No update since GSP development.
Ongoing	GCID Expansion of In-Basin Program for In-lieu Groundwater Recharge	GCID	*TBD*	-	-	-	GCID is working with neighboring non-district lands to supply water for in-lieu recharge.
Ongoing	OUWUA Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping	OUWUA	*TBD*	-	-	-	No benefits noted since GSP development.
Ongoing	Urban Water Conservation in Willows	California Water Service – Willows District	2	-	80	80	Implementation of urban water conservation measures continued in 2023.
Potential	GCID In-Lieu Groundwater Recharge	GCID	-	-	-	-	GCID is continuing to work with landowners to incentivize utilization of all available surface water supplies. There remain about 4,200 acres within the GCID boundary (approx. 5%) that still rely on private wells.
Potential	Tehama-Colusa Canal Trickle Flow to Ephemeral Streams	RD108, CCWD	-	-	-	-	No recharge benefits noted in 2023.
Potential	GCID Water Transfers to TCCA CVP Contractors	GCID	-	-	-	-	GCID is continuing discussions with the TCCA and identifying

Category (from GSP)	Project/Management Action Name	Proponent	Anticipated or Reported Benefits from GSP		Actual Benefits		Note
			Average Annual Benefits from GSP (af/yr)	Refined Average Annual Benefits Since GSP (af/yr)	Actual Benefits in 2023 (af/yr)	Actual Average Annual Benefits Since GSP (af/yr)*	
							opportunities for partnerships with other districts.
Potential *(Proposed since GSP)*	Spring Valley Recharge Project – Phase 1	T&M King Farms LLC	*5,400*	-	-	-	No recharge benefits noted in 2023.
Potential *(Proposed since GSP)*	Sycamore Slough Reconnection and Recharge	Davis Ranches	-	-	-	-	No recharge benefits noted in 2023, although conservation and rehabilitation improvements are ongoing.
Potential	*All Others Listed in GSP*	-	-	-	-	-	*No update since GSP development.*

**In years with recharge benefits.*

6.2.3 Updates to Planned Projects and Management Actions

This section describes updates to planned PMAs as of early 2024. Descriptions are provided only for those PMAs with noted updates during GSP implementation.

6.2.3.1 CCWD In-Lieu Groundwater Recharge

In this project, Colusa County Water District (CCWD) will utilize additional surface water for irrigation in-lieu of groundwater, targeting a long-term average annual use of 27,000 af/yr. The additional surface water will be made available through full use of the district's existing CVP contract and annual and multi-year water purchase and transfer agreements. The additional water will be conveyed through the existing Tehama-Colusa Canal (TCC) and CCWD facilities and will be used primarily on existing district lands, resulting in in-lieu groundwater recharge through reduction of groundwater pumping. As an optional component of this project, CCWD is considering relatively small annexations of lands adjoining the district and supplying surface water to these lands in-lieu of groundwater pumping. If these annexations proceed, the additional water may also be used on the newly annexed lands that are currently dependent on groundwater and require construction of additional infrastructure for surface water delivery.

Use of additional surface water within CCWD requires a combination of incentivizing additional use of CCWD existing CVP supplies and transfer arrangements with other districts. As of 2023, CCWD has surface water available for customers, but those supplies are not economical for many users. Efforts are still needed to incentivize surface water use. CCWD is currently working with others in the CGA on a rate structure that could incorporate fees for groundwater extraction, thereby disincentivizing groundwater pumping and making surface water a more economical option. Those efforts are ongoing.

6.2.3.2 OAWD Land Annexation and Groundwater Recharge

Orland-Artois Water District (OAWD), a CVP water contractor, is working with a group of neighboring non-district landowners to annex approximately 12,000 acres into the district service area. These lands are already developed agricultural properties that currently rely solely on groundwater for irrigation water supplies. Supplemental surface water for the annexed lands would be secured through annual and multi-year purchase or transfer agreements with willing sellers, conveyed through the existing Tehama-Colusa Canal (TCC), and distributed to the annexed lands through existing OAWD facilities and new distribution facilities. New facilities include turnouts off the TCC, pipelines, pumping plants, and metered farm turnouts. This project is described in greater detail in Section 6.3.4 of the Colusa Subbasin GSP. This project is of key interest, as it would directly address groundwater conditions in an area of the Subbasin that has experienced land subsidence, providing surface water to irrigators and reducing agricultural groundwater pumping by 10,000 to 20,000 af/yr. This project is actively being developed and is planned for implementation as soon as possible.

Since GSP development, planning efforts and discussions have continued with OAWD, the Tehama-Colusa Canal Authority (TCCA), the Glenn Local Agency Formation Commission (LAFCO), and USBR. While the SGMA Implementation Round 2 grant application was unsuccessful, this will only slow project implementation, not stop it.

In 2023, the CEQA process was completed and the Glenn LAFCO approved the annexation of 10,308 acres into OAWD. Draft NEPA documentation has been submitted to USBR and OAWD is currently working with USBR to finalize the document. It is anticipated that the project will receive approval from USBR by mid-2024, at which point approximately 3,000 acres could begin receiving surface water immediately. The remaining area is expected to be added to the project pending successful completion of required permitting and eventually construction. Permitting for all construction efforts is currently ongoing, and is expected to be completed in 2 to 4 years.

In 2023, OAWD also collaborated with the GGA to implement a District-wide pilot groundwater recharge project, which delivered nearly 1,800 af of water for recharge. The focus of the pilot project was geographic areas affected by land subsidence and/or areas experiencing a high concentration of dry domestic wells. With a budget of $50,000, the District offered to cover the cost of recharge water and connections for water recharged by District landowners. In total, three permanent connections were made and 13 projects were completed. Approximately 1,800 af of recharge water was delivered through mid-June 2023 at a cost of approximately $33,500. All of the water delivered for recharge was CVP Section 215 water. District staff measured groundwater conditions at multiple wells – including domestic, agricultural, and monitoring wells – which all showed some improvement in groundwater levels. As part of this project, the GGA and OAWD also examined the potential for future recharge opportunities at multiple sites in OAWD. The Vereschagin site, a ¼-acre pond with an observed infiltration rate of 10 feet per day, demonstrated immense potential for scaling future groundwater recharge projects to address overdraft. A 10-acre site at this location could provide 12,600 af of groundwater recharge in just three months in future wet years. Other sites where recharge occurred included old recirculation sumps, landscape ponds, and pasture.

Combined, the in-lieu recharge from the OAWD annexation project and the direct groundwater recharge potential demonstrated by OAWD pilot groundwater recharge project show that it is feasible to reduce groundwater demand and increase groundwater supply to eliminate groundwater overdraft in the area.

6.2.3.3 Sycamore Slough Groundwater Recharge Pilot Project

Proctor and Gamble (P&G) and Davis Ranches entered into a cooperative agreement to implement a 10-year groundwater recharge pilot project from fall 2021 through 2030. The project plans to apply surface water diverted from the Sacramento River to a 66-acre field on Davis Ranches for 30 to 45 days each fall or winter, providing multiple benefits to the Colusa Subbasin through groundwater recharge and creation of habitat for migrating birds. This project is described in greater detail in Section 6.3.5 of the Colusa Subbasin GSP.

Since GSP development, Davis Ranches has continued with project development and planning and has begun project implementation with field flooding and monitoring. Surface water was applied to the field in three consecutive flooding events between December 2023 and January 2024. Applied water and groundwater recharge benefits are being monitored through a combination of existing and newly installed data collectors in the field. The project has provided approximately 380 af of groundwater recharge benefits as well as five weeks of habitat benefits in winter 2023/2024. The project is expected to continue in the 2024 season.

6.2.3.4 GGA Recharge Project

Since GSP implementation, the GGA began work on a recharge project with the goal of immediately addressing unprecedented drought conditions impacting communities and domestic well users in Glenn County. The project objective is to plan, design, implement, and monitor multi-benefit, direct and in-lieu groundwater recharge projects in a unified approach and demonstrate that groundwater recharge is a viable tool to immediately alleviate critical drought conditions. This Project will provide habitat for migratory shorebirds and enhance groundwater dependent ecosystems supporting the region's objective to implement multi-benefit projects. The Project will utilize (when available) CVP Section 215 water, excess CVP contract water, purchased water from senior water right holders, and high stormflows from Stony Creek and other streams, as feasible. Recharge will occur across GGA's service area focusing on areas to maximize urban and environmental benefits. The proposed recharge sites may include Van Tol Dairy, California Olive Ranch, Jasper Ranch, Martin Property, fallow farmland, or gravel pits for direct recharge, and planted farmland for in-lieu recharge.

In 2023, the GGA conducted two pilot projects in collaboration with OAWD and OUWUA, completing over 15 groundwater recharge projects in Glenn County and recharging more approximately 2,100 af of water.

The pilot project with OAWD is described in **Section 6.2.3.2**, and resulted in approximately 1,800 af of water delivered for recharge.

The pilot project with OUWUA delivered approximately 300 af of surface water for groundwater recharge at two sites. Both sites are located in Orland, which was a hotspot for dry domestic wells during the 2020-2022 drought. One of the recharge sites was at Lely Park, providing an aesthetic benefit as well as an opportunity for outreach to the community. A media event was hosted in October 2023 at Lely Park to highlight the groundwater recharge projects and the importance of groundwater in the community. Two television news stations covered the story as did multiple newspapers in print and online. The second recharge site was located in close proximity to a DWR monitoring well, which showed positive increases in groundwater levels following each delivery of water for groundwater recharge. The well level rose over the course of the groundwater recharge project, despite the project taking place during the dry summer months when groundwater pumping is at its peak. Overall, the recharge efforts in 2023 provided benefits to the aquifer while also benefitting the community and providing the GGA and OUWUA insight into recharge opportunities available through utilization of the OUWUA system.

Since the previous Annual Report, the GGA applied for grant funding to support this project through the Urban Community Drought Relief Program; however, funding was not awarded.

As of early 2024, the GGA is also completing an initial evaluation of potential projects for long term groundwater recharge, including an analysis of pros and cons such as capital and upfront costs, operating and ongoing costs, potential for grant funding, level of certainty, partnerships, permitting, other benefits such as flood control and habitat, impacts to shallow wells, impacts to deep wells, impacts to domestic wells, and ability to slow land subsidence. A report is being developed to explore six prioritized potential projects for future recharge efforts: (1) existing basins with local creek winter flows, (2) winter water, (3) Black Butte reservoir storage/releases, (4) Stony Creek Section 215 designation water, (5) on-farm system modernization, and (6) water right application.

6.2.4 Updates to Ongoing Projects and Management Actions

This section describes updates to ongoing PMAs as of early 2024. Descriptions are provided only for those ongoing PMAs with noted updates during GSP implementation.

6.2.4.1 RD108 and CCWD Agreement for Five-Year In-Lieu Groundwater Recharge Project

RD108 and CCWD (and Dunnigan Water District [DWD] located in the neighboring Yolo Subbasin) entered into a five-year agreement (ending in 2022) that provided for the purchase of water by CCWD (and DWD) from RD108. The purchased water was available to RD108 through contractual rights under Sacramento River Settlement Contract 14-06-200-876A between RD108 and the Bureau of Reclamation. Under the five-year agreement, 10,000 af was purchased by and transferred to CCWD and DWD, with 80 percent of the 10,000 af going to CCWD and 20 percent to DWD. The project has provided in-lieu recharge by supplying surface water to meet irrigation demands that otherwise would be met through groundwater pumping. At the time of GSP development, it was expected that the five-year agreement would be extended with the price schedule potentially renegotiated.

As of 2023, the agreement with RD108 has expired and has not yet been renewed. Due to the wet conditions in 2023, the extended availability of CVP 215 water, and efforts by the Settlement contractors working on Voluntary Agreements, all parties opted to put agreement on hold at this time. However, CCWD plans to re-initiate the in-lieu recharge discussions with RD108 shortly.

CCWD has also been working on implementing policies to encourage more surface water use and decrease private groundwater pumping in the District where surface supplies are available (see **Section 6.2.3.1**).

6.2.4.2 GCID Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits

In addition to the water supply available to Glenn-Colusa Irrigation District (GCID) under its settlement contract with USBR, GCID holds a 1999 water right permit to divert Sacramento River water between November 1 and March 31 each year. Water used under the permit is referred to as "winter water." Winter water use is beneficially used in GCID for rice straw decomposition, habitat enhancement for Pacific Flyway migrating waterfowl, groundwater recharge, frost control, and for irrigating crops. Under this project, working in collaboration with partners within the Subbasin and with environmental advocacy groups, GCID is investigating opportunities to increase winter water use by alleviating constraints on winter water supplies (i.e., cost, labor and management effort, conflicts with GCID system construction and maintenance, and water supply constraints during dry periods). Objectives of the project are to incentivize growers to: 1) maximize winter water use on rice land including targeting rice lands with highest recharge potential, 2) expand use of winter water for irrigation and frost control where groundwater would otherwise be used, and 3) encourage temporary flooding of permanent and annual crop lands including targeting lands with the highest recharge potential.

Since GSP development, GCID filed a new winter water right permit in 2022 and is currently awaiting an administrative hearing with the State Water Resources Control Board (SWRCB). GCID currently diverts winter water under an amended permit that limits annual diversions of winter water to 182,900 af (approximately 1,068 cubic feet per second (cfs)).

GCID continues to deliver winter water to GCID customers and users outside the District. In 2023, GCID had approximately 174,000 af of winter water available between November-March, the majority of which stayed within the GCID system and was used for beneficial purposes in the Subbasin. Only approximately 1,600 af of spillage occurred during those months. Approximately 66,000 acres applied for winter water from GCID, including approximately 27,500 acres for decomposition and habitat. The estimated benefits of winter water use for decomposition and habitat benefits was approximately 19,300 af in 2023 (approximately 0.7 af per acre over 27,500 acres, representing typical recharge of ponding for rice decomposition). Additional recharge also occurred due to application of winter water for irrigation on other lands, although those benefits are accounted in the Subbasin water use estimates (see **Sections 2 through 4**).

6.2.4.3 OUWUA Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping

The Orland Unit Water Users' Association (OUWUA) flood water conveyance project is proposed to modernize the OUWUA's southside irrigation conveyance and distribution system to provide for groundwater recharge through deliveries of flood water to customers and regulating reservoirs. Infrastructure improvements are expected to include delivery infrastructure and recharge basins as well as expanded and improved flow measurement and water level control, system interties, and expansion and upgrading of the existing supervisory control and data acquisition (SCADA) system. These improvements are expected to result in more reliable and flexible farm deliveries that will provide incentives for growers to use more surface water and pump less groundwater. In-lieu recharge is expected to increase groundwater levels within and neighboring the OUWUA service area.

OUWUA continues to promote and support efficient on-farm irrigation systems. In most cases, groundwater pumping is offset by using Orland Project water for pressurized sprinkler/drip/micro-sprinkler applications. In the past several years, efficient on-farm irrigation systems have increased, driven by drought conditions. One new modified delivery system came online in 2023.

6.2.4.4 Urban Water Conservation in Willows

The California Water Service – Willows District is implementing urban water conservation measures through water waste restrictions, conservation pricing, public education and outreach, programs to assess and manage distribution system real loss, water conservation program coordination and staffing support, and other demand management measures. These are described in greater detail in Chapter 9 of the 2020 Urban Water Management Plant (UWMP) for the California Water Service, and are described in Section 6.4.2.1 of the Colusa Subbasin GSP.

In water year 2023, the California Water Service – Willows District continued implementation of these many measures with similar benefits reported in the previous Annual Report (approximately 80 af).

6.2.5 Updates to Potential Projects and Management Actions

This section describes updates to potential PMAs as of early 2024. Descriptions are provided only for those potential PMAs with noted updates during GSP implementation.

6.2.5.1 GCID In-Lieu Groundwater Recharge

Despite GCID having highly reliable surface water supplies, a small percentage of district lands rely primarily on groundwater for irrigation supply. In this project, GCID plans to investigate, develop, and implement measures to incentivize associated growers to utilize surface water supplied by GCID, which will provide in-lieu recharge through reduced groundwater pumping.

GCID is continuing to work with landowners to incentivize utilization of all available surface water supplies, in coordination with GCID's efforts to strategically expand winter water use (**Section 6.2.4.2**). As of 2023, there remain about 4,200 acres within the GCID boundary that are primarily irrigated with groundwater pumped from private wells. Approximately 90% of these lands are in Glenn County. These represent approximately 5% of District lands in a full surface water supply allocation year, but more lands may rely on groundwater during years with curtailments. Hence, sustained access to contract surface water supplies is critical and inextricably tied to groundwater sustainability, and is necessary for the ongoing vitality of the Subbasin and its communities.

6.2.5.2 Tehama-Colusa Canal Trickle Flow to Ephemeral Streams

The Tehama-Colusa Canal (TCC) has existing gates that are used to dewater sections of the canal into ephemeral streams that intersect the canal. In the GSP, a potential recharge project concept was proposed in which water could be discharged from the TCC into these streams at a rate where they do not flow out of the Colusa Subbasin but recharge the groundwater system. Flow measurement devices would need to be added to the gates for project implementation. Surface water for recharge would be sourced from the Sacramento River under existing USBR water supply contracts held by TCC contractors, existing water rights settlement contracts, and annual Section 215 contracts. A summary of the project is provided in Section 6.5.1.8 of the Colusa Subbasin GSP.

Further conceptual development of this project has occurred since the GSP, with identification of potential streams, water sources, and operating strategies to most effectively conduct recharge. CCWD is leading the development of this project. The District has installed three discharge sites and has coordinated with several landowners willing to participate in the project monitoring network. However, the monitoring infrastructure is not yet in place. CCWD has also been working with on a mapping project that will include mapping for the project monitoring network, including DWR monitoring wells and private wells.

To assist with implementation costs of the project, CCWD applied for grant funding through the Integrated Regional Water Management (IRWM) Grant Program, as well as other DWR grant funding requests. The project has successfully received funding for infrastructure development through an IRWM grant being administered by Sutter County. Agreements are in development, with the goal of initiating the project in winter 2023/2024.

Funding for recharge water – either USBR Section 215 or 3F water – is still being identified, although CCWD anticipate working with the CGA and potentially individual landowners for financing. Once the IRWM grant agreements are in place, work will begin on landowner access agreements, installing the project monitoring network, and completing the project infiltration study. CCWD is also looking at installing stream flow gauges to monitor flows in ephemeral streams following high rain events, and in turn monitor “natural recharge” to the aquifer.

CCWD has also filed a temporary water right application for winter water that would provide the project with lower-cost water for recharge, although the application has not yet been approved.

Once the project is implemented, CCWD plans to quantify project benefits through the monitoring network and confirm prior studies of natural recharge within District. This monitoring will help to identify areas where surface water may be used for recharge with the greatest benefit to bolster groundwater levels and reduce or halt subsidence.

6.2.5.3 GCID Water Transfers to TCCA CVP Contractors

GCID is exploring the possibility of transferring surface water to CVP contractors served by the TCC to provide in-lieu groundwater recharge and reduce groundwater pumping through increased CVP water utilization. The water to be transferred would be Sacramento River water available to GCID under its water rights settlement contract that is temporarily surplus to GCID's needs under certain conditions. Transferred water would be diverted into the Tehama-Colusa Canal at the Red Bluff Pumping Plant and Fish Screen facility rather than at the GCID pumping plant and fish screen facility north of Hamilton City. Priority would be placed on transfers to CVP contractors in areas where groundwater levels have been declining over the past approximately 20 years, particularly in the areas around the cities of Orland and Arbuckle.

This project is ongoing as of early 2024. GCID is continuing discussions with the TCCA, although those discussions are not concluded at the time of this Annual Report. GCID is also identifying opportunities for partnerships with other districts in the Subbasin. Importantly, GCID and other districts in the Subbasin together recognize that sustained access to contract surface water supplies is critical and inextricably tied to groundwater sustainability in the Subbasin.

Updates on these discussions and efforts will be provided in future Annual Reports.

6.2.5.4 Spring Valley Recharge Project – Phase 1

The Spring Valley Multi-Benefit Project focuses on achieving four goals of increasing groundwater recharge, restoring wetland habitat, sequestering carbon and increasing the sustainability of domestic wells, many of which serve local disadvantaged communities. Phase 1 will focus on 646 acres along the Colusa Drain and directly north of College City.

This phase includes implementing a restored wetland, in-lieu recharge almond blocks, and a recharge basin. The project will result in both direct and in lieu recharge. An estimated 3,376 af/yr of excess area water will infiltrate and recharge the underlying aquifer. In-lieu recharge in the amount of 1,360 af/yr will occur on 340 acres of almonds, reducing groundwater pumping and area demand. Lastly, a small recharge basin will provide an additional 150 af/yr in groundwater recharge. Total direct and in lieu recharge associated with the project are calculated as approximately 5,400 af/yr during wet years.

This project was included in the SGMA Implementation Round 2 grant application, although funding was not awarded. Phase 1 of this project is projected to last for two years once funding is secured.

6.2.5.5 Sycamore Slough Reconnection and Recharge

In this project, Davis Ranches would divert surface water from the Sacramento River and/or the Colusa Basin Drain to flood fields and the slough itself to provide groundwater recharge, create habitat for migrating shorebirds/waterfowl, and provide essential support for groundwater dependent ecosystems along the path of Sycamore Slough.

It is anticipated that this project would benefit groundwater levels, groundwater storage, ISW, and groundwater dependent ecosystems. Recharge benefits would be calculated through a mass balance calculation, similar to the monitoring program already in place at Davis Ranches. Sacramento River pumps would track the total acre feet of surface water applied to recharge fields and along the Sycamore Slough channel. The existing monitoring well field would be expanded to capture the interaction between applied surface water and groundwater levels along the slough. All monitoring wells would have data loggers installed that are compatible with the Colusa Subbasin Well Monitoring Pilot Program. Benefits to the groundwater dependent ecosystems would be documented through the help of The Nature Conservancy.

In 2023, Davis Ranches completed efforts on the slough reconnection, spanning approximately 2,000-3,000 feet of channels that are now connected back to the Sacramento River. Davis Ranches is currently in the process of conservation and rehabilitation improvements to the channel, including riparian plantings in December. Davis Ranches is also organizing with neighboring landowners and a neighboring RCD to join together in recharge and conservation efforts.

6.3 OTHER INFORMATION ON IMPLEMENTATION PROGRESS

In addition to the PMAs described above, the CGA and the GGA have also continued other efforts toward GSP implementation:

- While both the CGA and GGA both have initial funding in place, each GSA is continuing their efforts to secure updated long-term funding and financing for GSP implementation, including projects and management actions. These efforts have involved development of a rate analysis and evaluation of approaches for establishing and administering fees, including public workshops. Both efforts are ongoing as of early 2024.
- Both the CGA and GGA continued coordination efforts among their respective counties, member agencies, and other interested parties in the Subbasin to strategically coordinate on efforts to support the sustainability goal of the Subbasin.
- Both the CGA and GGA continued to notice and hold public meetings throughout the year, providing stakeholders the opportunity to learn and engage with the GSA Boards on topics related to GSP implementation.
- The CGA and GGA jointly held two stakeholder outreach meetings (one virtual webinar, one in-person meeting) where they presented on groundwater conditions in the Colusa Subbasin in water year 2022.
- The CGA and GGA jointly submitted an application to DWR for SGMA Round 2 grant funding for the Colusa Subbasin, although funding was not awarded.
- The GGA continued work on the GGA Recharge Project (described in **Section 6.2.3.4**). These efforts have resulted in:
    - Successful recharge in water year 2023 (approximately 2,100 af),
    - Public outreach about the importance of recharge efforts and groundwater sustainability, and
    - Submittal of a 2022 Urban Community Drought Relief Program Grant Application (however, funding was not awarded).
- The CGA submitted an application with the SWRCB for a 180-day Temporary Water Rights Permit that would allow diversions of up to 6,000 af/yr of excess flows from the

Sacramento River through the TCC into portions of Salt Creek and Elk Creek for groundwater recharge.

- Glenn County Resource Conservation District, in partnership with the GGA, is in the process of initiating the Glenn County Recharge Plan, which will help to evaluate, prioritize, and guide development of future recharge projects in Glenn County. Efforts on the Glenn County Recharge Plan will be funded through a grant.

7 References

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United States Department of Agriculture (USDA). 2023. CropScape – 2022 Cropland Data Layer, Released January 2023. Available at: https://nassgeodata.gmu.edu/CropScape/.

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Appendix A. Groundwater Elevation Contour Maps – Spring/Fall 2020 through 2023.

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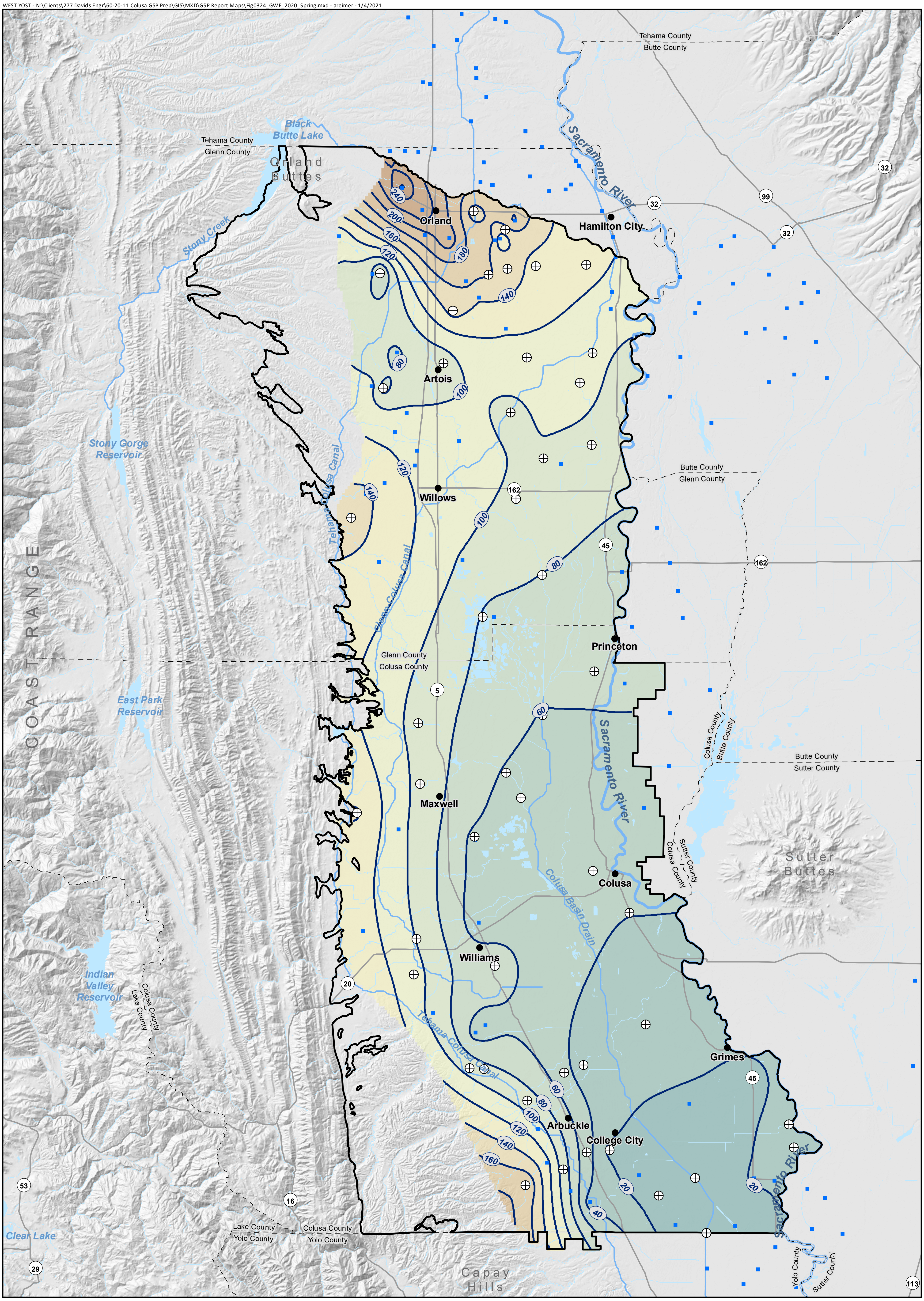


Groundwater Elevation (ft)

- 260 - 280
- 240 - 260
- 220 - 240
- 200 - 220
- 180 - 200
- 160 - 180
- 140 - 160
- 120 - 140
- 100 - 120
- 80 - 100
- 60 - 80
- 40 - 60
- 20 - 40
- 0 - 20
- -20 - 0
- -40 - -20

- Well Used for Contouring
- Monitoring Network Wells
- Groundwater Elevation Contour (20-Foot Interval)
- Colusa Subbasin

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Vertical Datum: North American Vertical Datum of 1988, feet (NAVD 88).

N

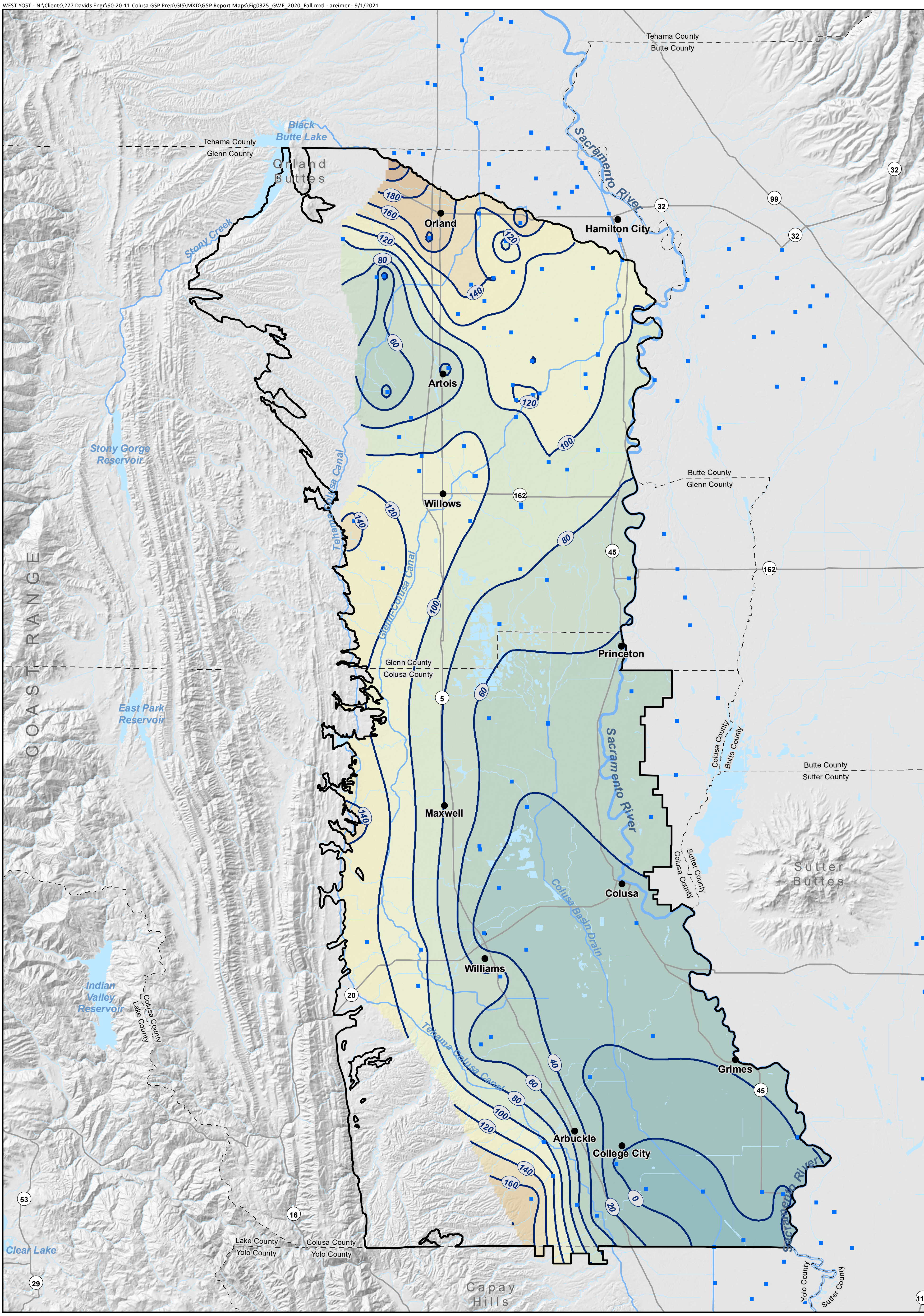
0 2.5 5
Scale in Miles

Figure A-1

Groundwater Elevation Contours Spring 2020

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin

WEST YOST - N:\Clients\277 Davids Engr\60-20-11 Colusa GSP Prep\GIS\MXD\GSP Report Maps\Fig0325_GWE_2020_Fall.mxd - areimer - 9/1/2021



Groundwater Elevation (ft)

- 260 - 280
- 240 - 260
- 220 - 240
- 200 - 220
- 180 - 200
- 160 - 180
- 140 - 160
- 120 - 140
- 100 - 120
- 80 - 100
- 60 - 80
- 40 - 60
- 20 - 40
- 0 - 20
- -20 - 0
- -40 - -20

- Well Used for Contouring
- Groundwater Elevation Contour (20-Foot Interval)
- Colusa Subbasin

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Vertical Datum: North American Vertical Datum of 1988, feet (NAVD 88).

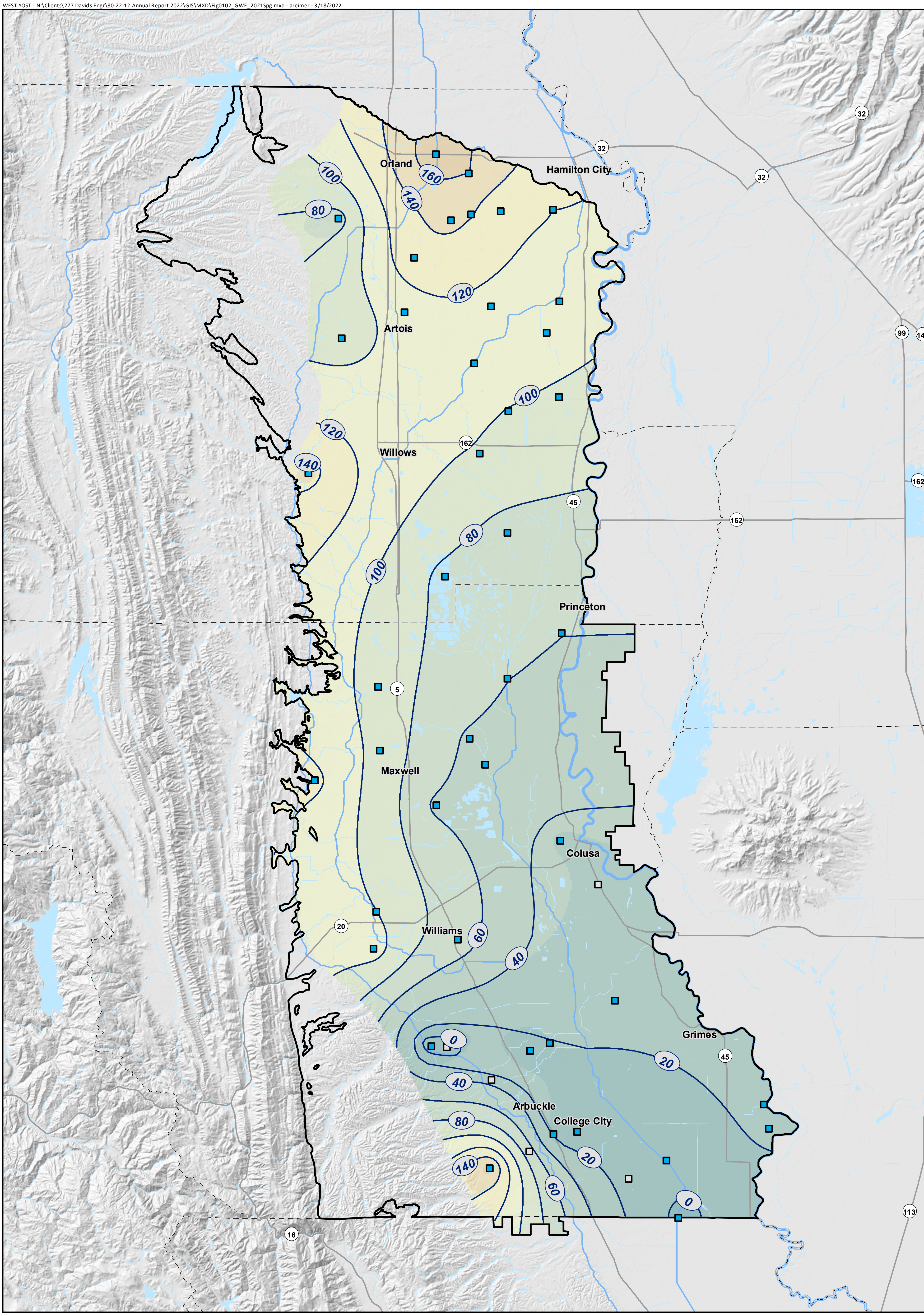
0 2.5 5
Scale in Miles

Figure A-2

Groundwater Elevation Contours Fall 2020

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin

WEST YOST - N:\Clients\277 Davids Engr\80-22-12 Annual Report 2022\GIS\MXD\Fig0102_GWE_2021Spg.mxd - areimer - 3/18/2022



Groundwater Elevation Representative Monitoring Well Used for Contouring

Groundwater Elevation Representative Monitoring Well Not Used for Contouring

Groundwater Elevation Contour (20-Foot Interval)

Colusa Subbasin

Groundwater Elevation (feet)

160 - 180
140 - 160
120 - 140
100 - 120
80 - 100
60 - 80
40 - 60
20 - 40
0 - 20
-20 - 0

N

0 2.5 5

Scale in Miles

1 inch = 5 miles

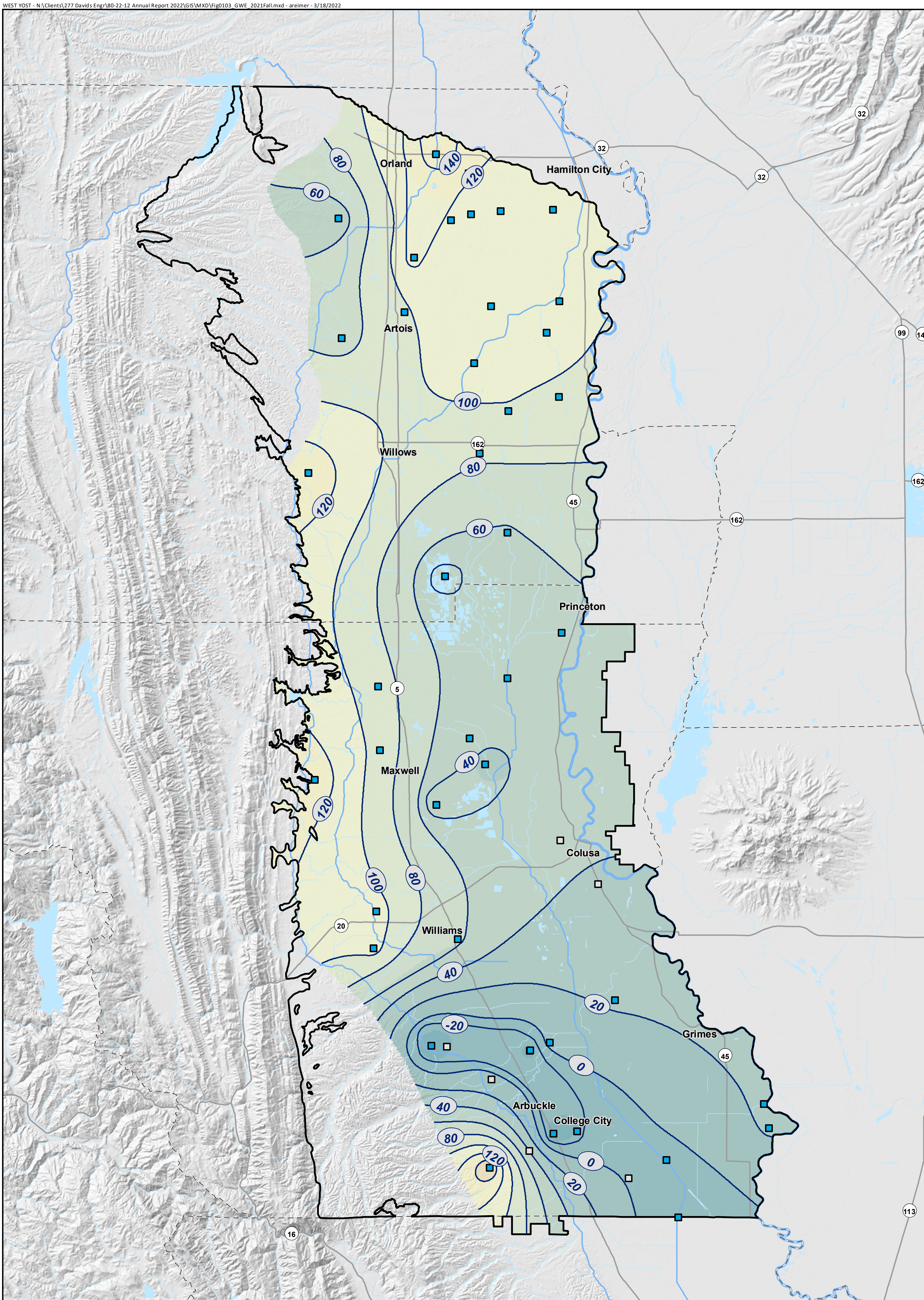
Datum: NAD1983 California State Plane Zone II, feet. North American Vertical Datum 1988, feet.

Figure A-3

Groundwater Elevation Contours
Spring 2021

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin

WEST YOST - N:\Clients\277 Davids Engr\80-22-12 Annual Report 2022\GIS\MXD\Fig0103_GWE_2021Fall.mxd - areimer - 3/18/2022



- Groundwater Elevation Representative Monitoring Well Used for Contouring
- Groundwater Elevation Representative Monitoring Well Not Used for Contouring
- Groundwater Elevation Contour (20-Foot Interval)
- Colusa Subbasin

Groundwater Elevation (feet)

- 160 - 180
- 140 - 160
- 120 - 140
- 100 - 120
- 80 - 100
- 60 - 80
- 40 - 60
- 20 - 40
- 0 - 20
- -20 - 0
- -40 - -20

N

0 2.5 5
Scale in Miles
1 inch = 5 miles

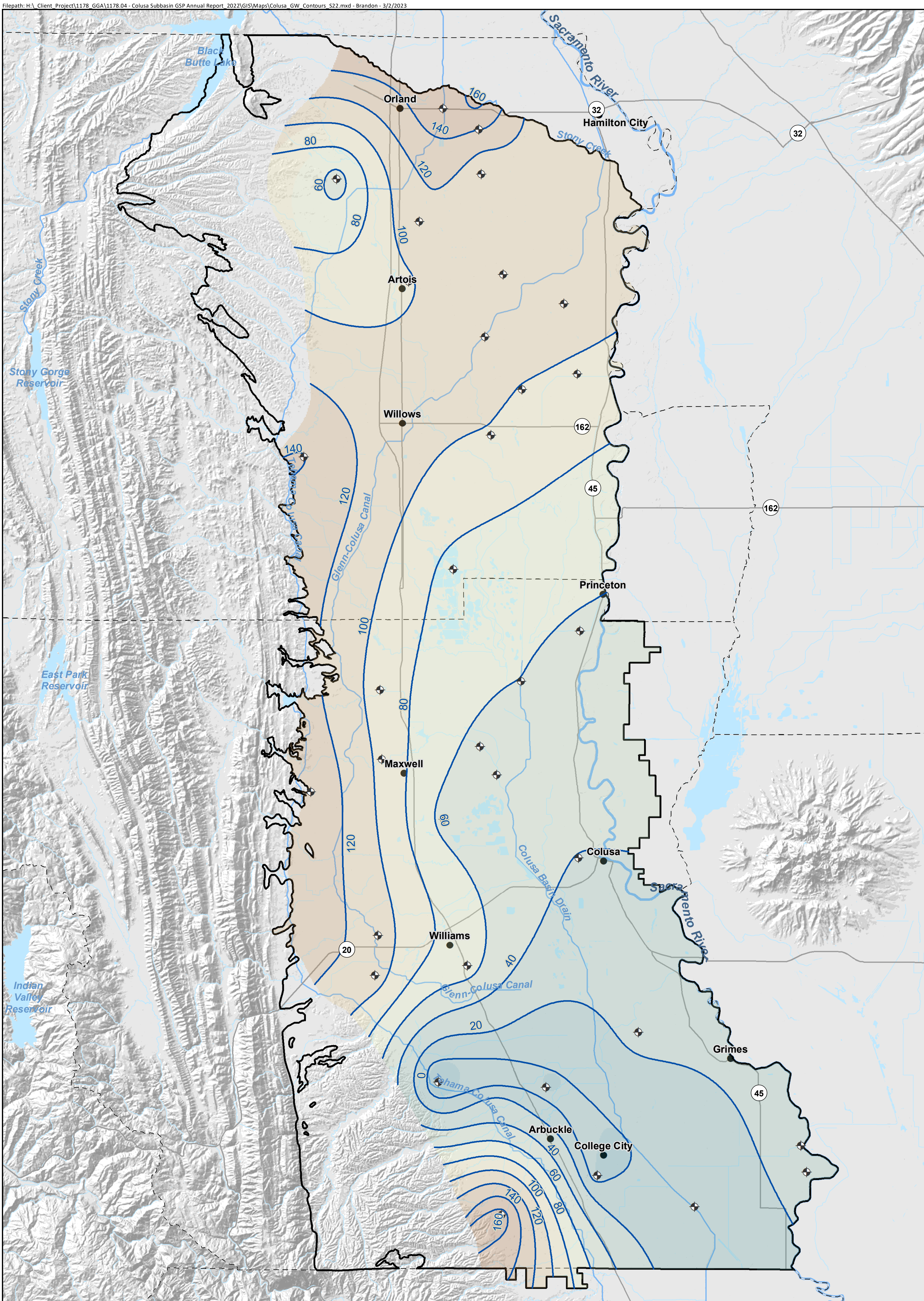
Datum: NAD1983 California State Plane Zone II, feet. North American Vertical Datum 1988, feet.

Figure A-4

Groundwater Elevation Contours
Fall 2021

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin

Filepath: H:_Client_Project\1178_GGA\1178.04 - Colusa Subbasin GSP Annual Report_2022\GIS\Maps\Colusa_GW_Contours_S22.mxd - Brandon - 3/2/2023



Groundwater Elevation Measurement (Well Used for Contouring)

Groundwater Elevation Contour (20-Foot Interval)

Colusa Subbasin Boundary

Groundwater Elevation (feet above mean sea level)

-20 - 0	80 - 100
0 - 20	100 - 120
20 - 40	120 - 140
40 - 60	140 - 160
60 - 80	160 - 180

N

0 2.5 5

Scale in Miles

Figure A-5

Groundwater Elevation Contours Spring 2022

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin Annual Report 2023

Filepath: H:_Client_Project\1178_GGA\1178.04 - Colusa Subbasin GSP Annual Report_2022\GIS\Maps\Colusa_GW_Contours_F22.mxd - Brandon - 3/2/2023

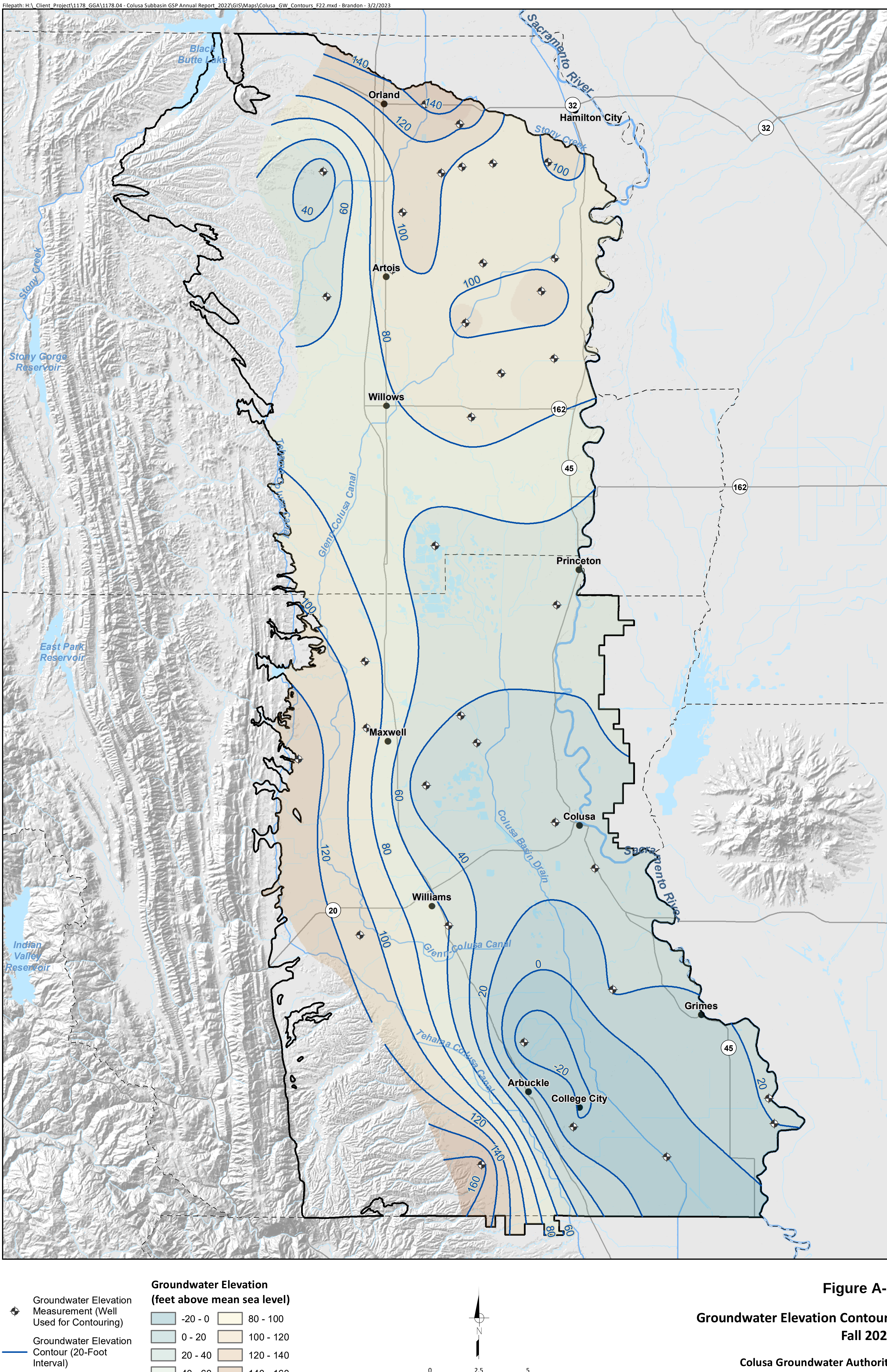
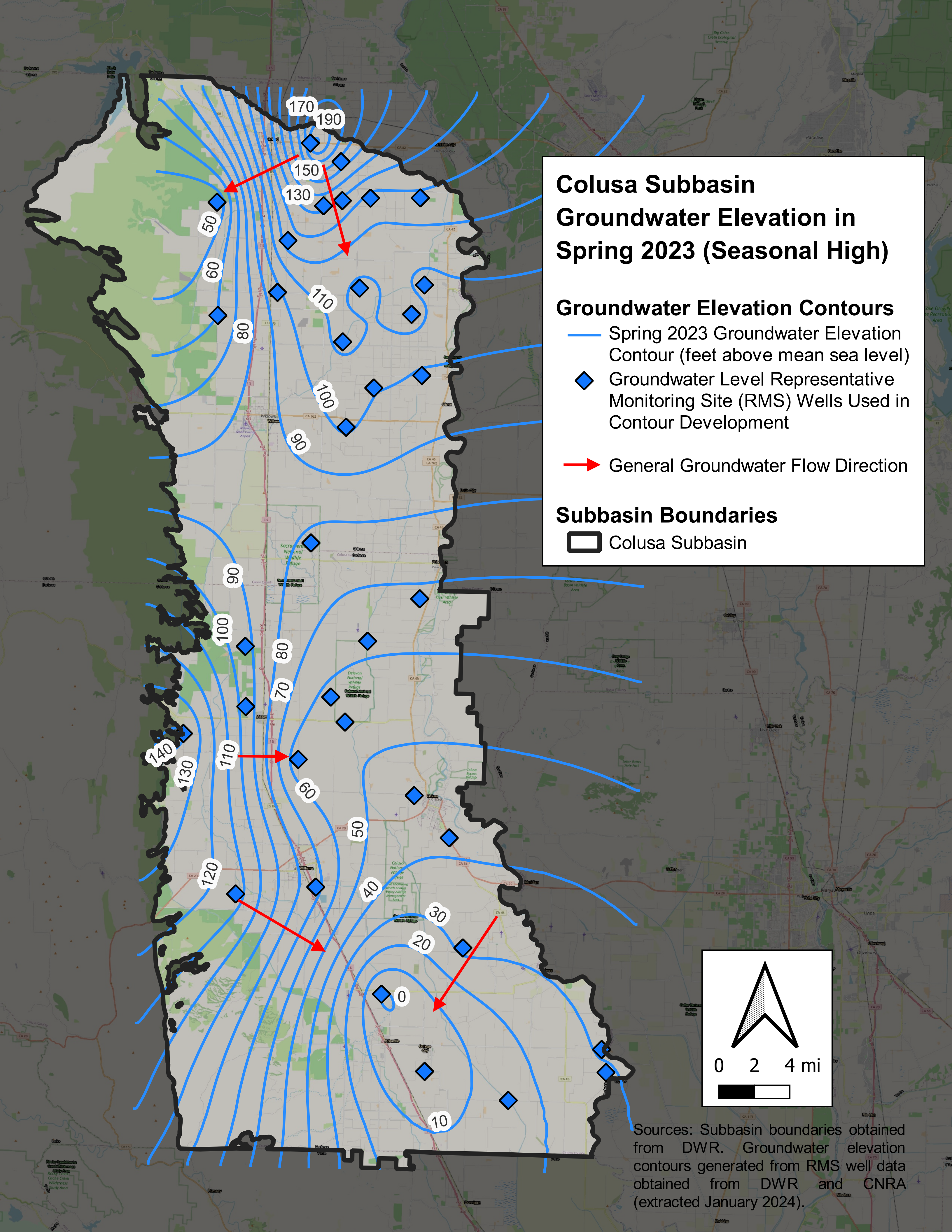
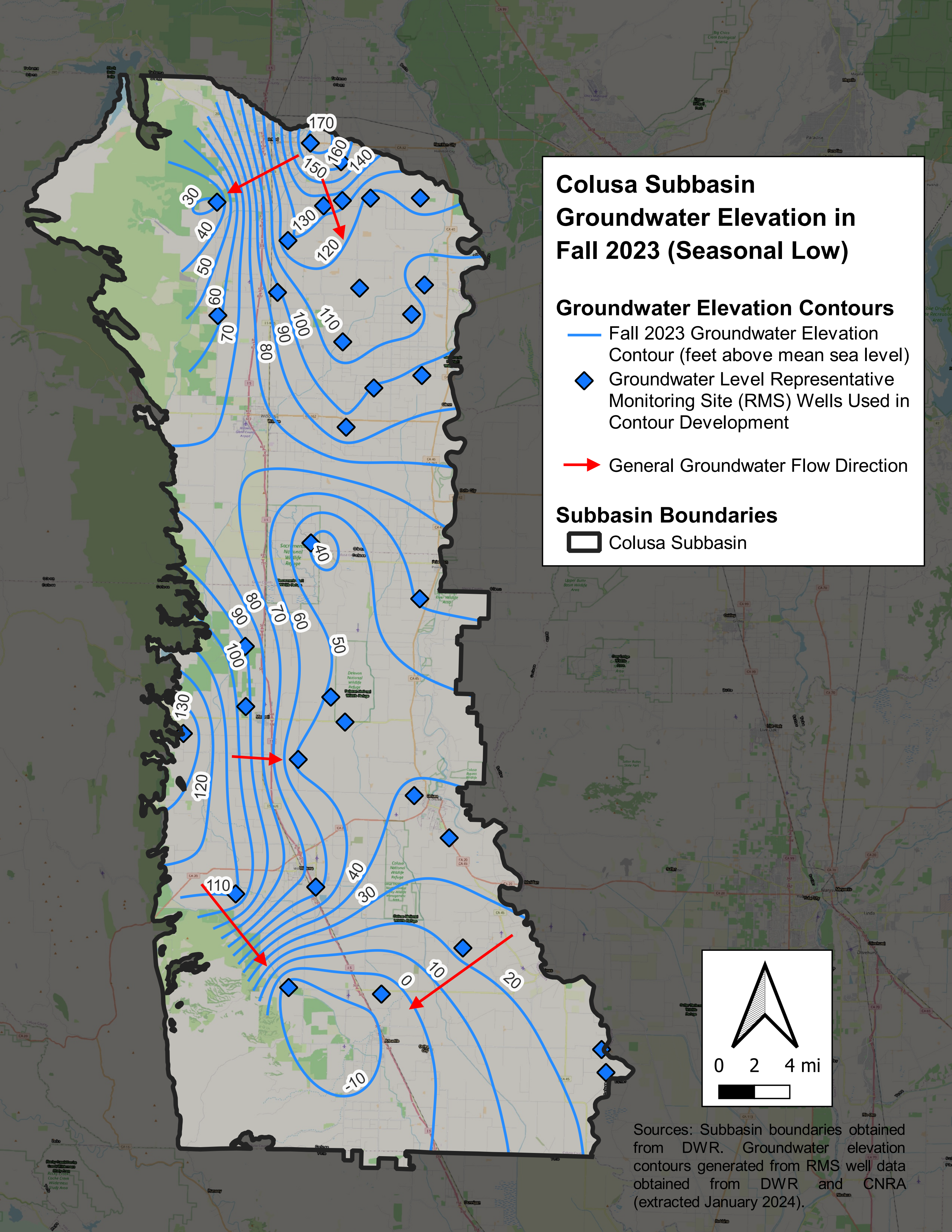


Figure A-6

Groundwater Elevation Contours Fall 2022

Colusa Groundwater Authority
Glenn Groundwater Authority
Colusa Subbasin Annual Report 2023

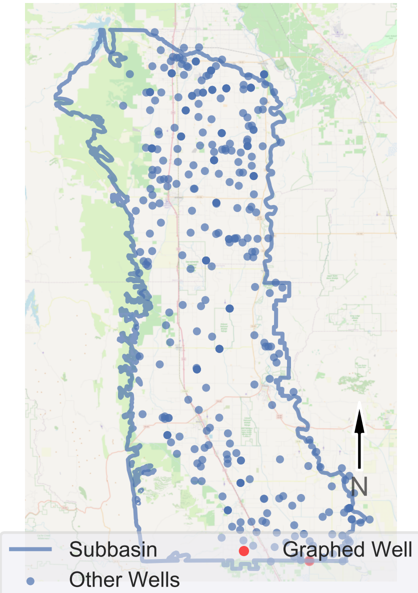

Colusa Subbasin
Groundwater Elevation in
Spring 2023 (Seasonal High)
Groundwater Elevation Contours
Spring 2023 Groundwater Elevation Contour (feet above mean sea level)
Groundwater Level Representative Monitoring Site (RMS) Wells Used in Contour Development
General Groundwater Flow Direction
Subbasin Boundaries
Colusa Subbasin
170
190
150
130
50
60
110
80
100
90
90
100
80
70
140
130
110
60
50
120
40
30
20
0
10
0 2 4 mi
Sources: Subbasin boundaries obtained from DWR. Groundwater elevation contours generated from RMS well data obtained from DWR and CNRA (extracted January 2024).


Colusa Subbasin Groundwater Elevation in Fall 2023 (Seasonal Low)
Groundwater Elevation Contours
Fall 2023 Groundwater Elevation Contour (feet above mean sea level)
Groundwater Level Representative Monitoring Site (RMS) Wells Used in Contour Development
General Groundwater Flow Direction
Subbasin Boundaries
Colusa Subbasin
0 2 4 mi
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
Sources: Subbasin boundaries obtained from DWR. Groundwater elevation contours generated from RMS well data obtained from DWR and CNRA (extracted January 2024).

Appendix B. Groundwater Elevation Hydrographs for Groundwater Level RMS Wells.

COLUSA Subbasin - State Well Number (SWN): 12N01E06D004M

Well Location Map

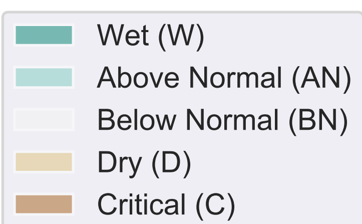


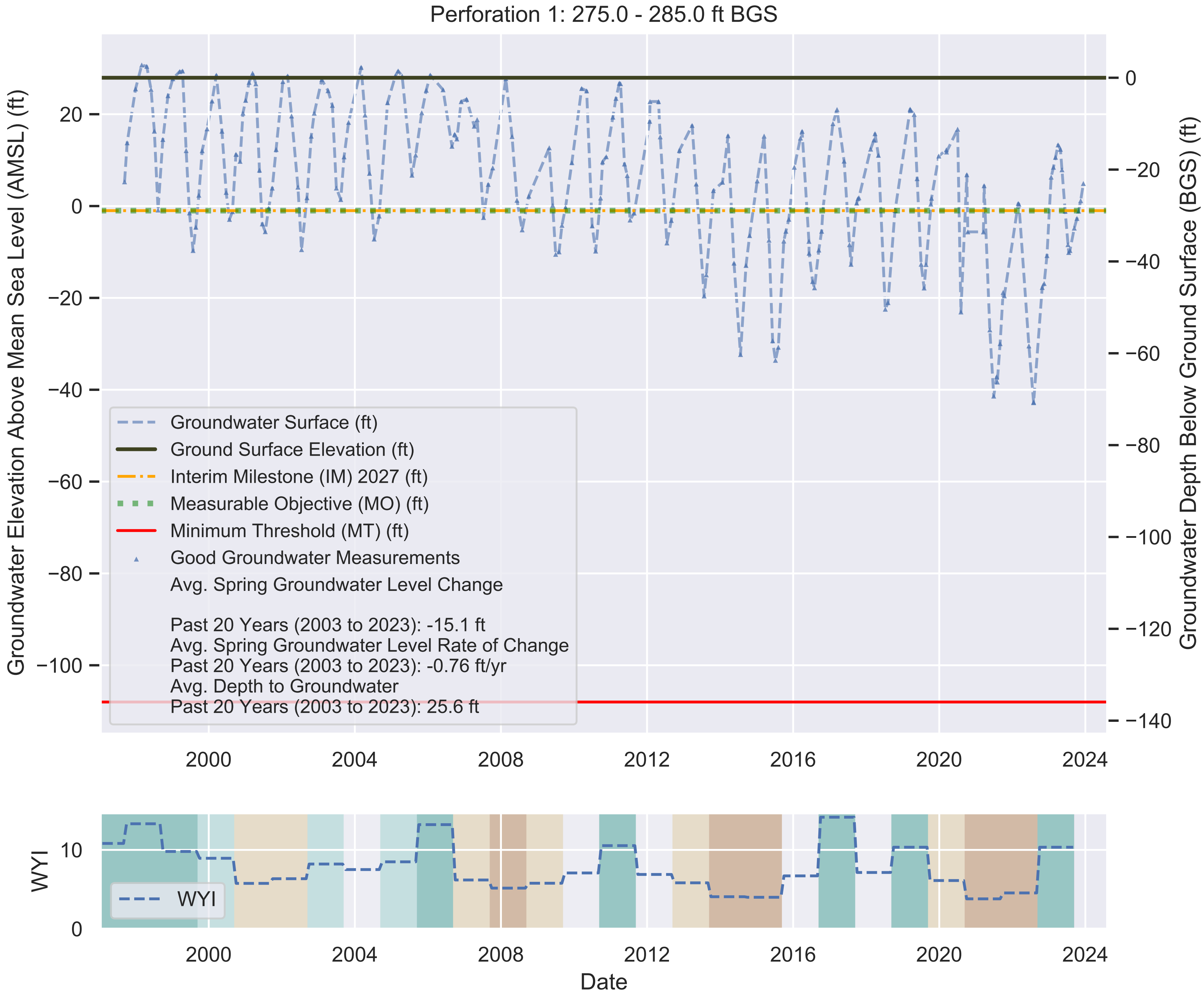
Sustainable Management Criteria:

IM (2027) = -1.0 ft AMSL
MO = -1.0 ft AMSL
MT = -108.0 ft AMSL

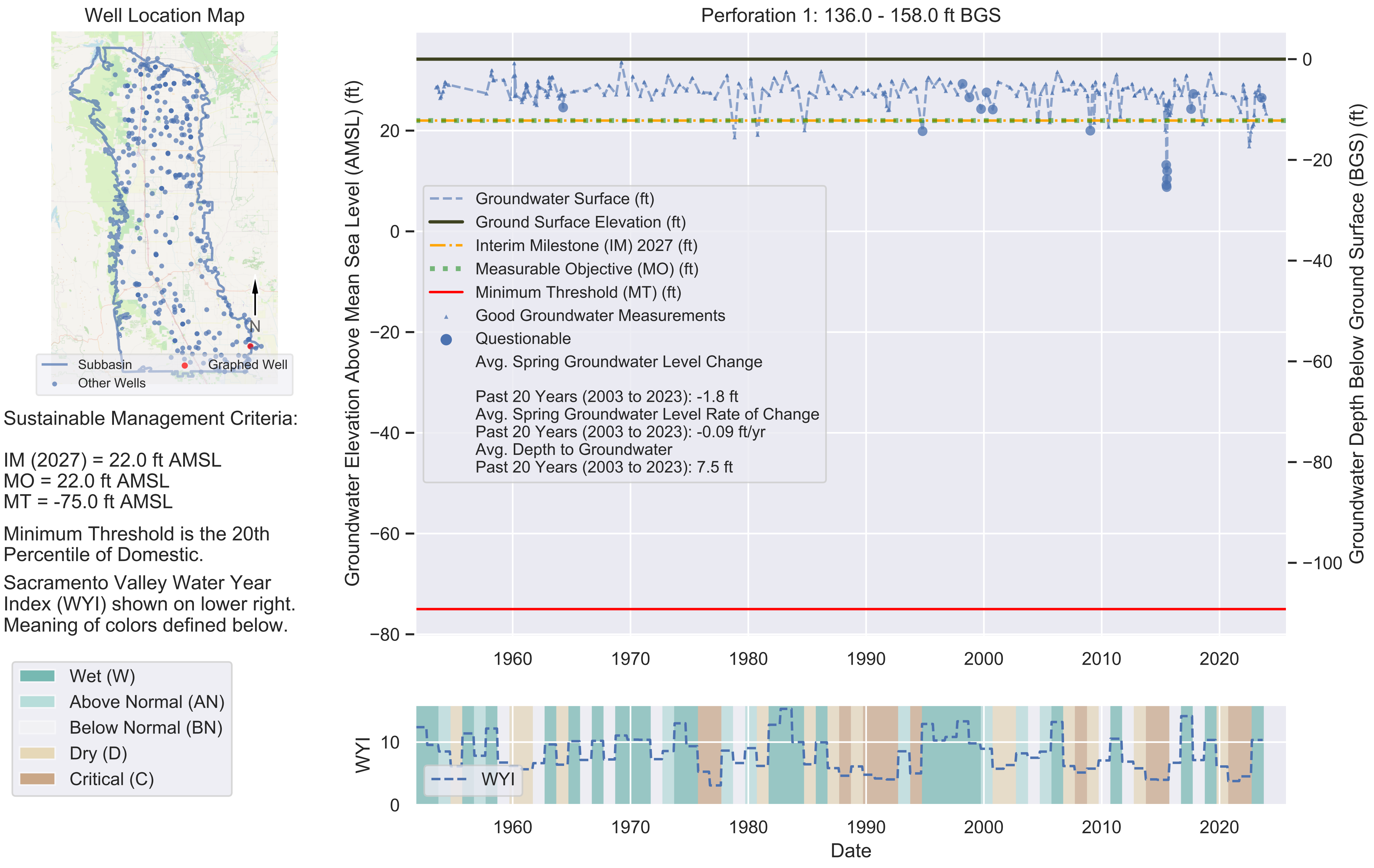
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

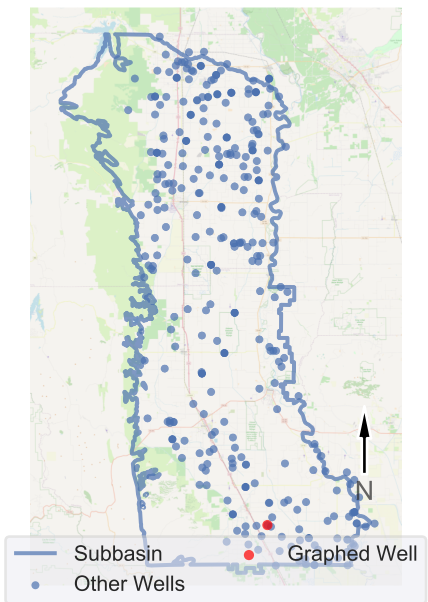




COLUSA Subbasin - State Well Number (SWN): 13N01E11A001M



COLUSA Subbasin - State Well Number (SWN): 13N01W07G001M



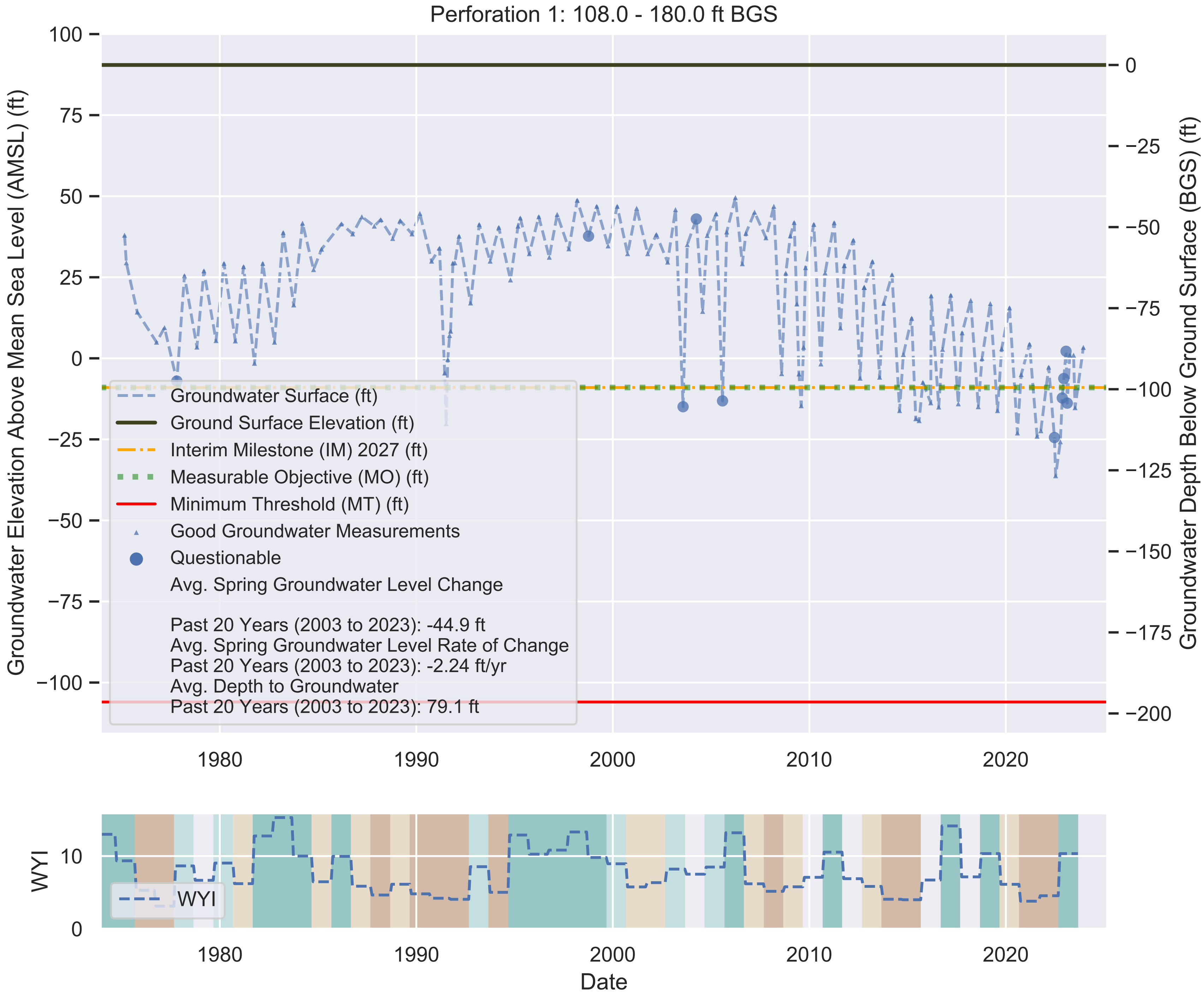
Sustainable Management Criteria:

IM (2027) = -9.0 ft AMSL
MO = -9.0 ft AMSL
MT = -106.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

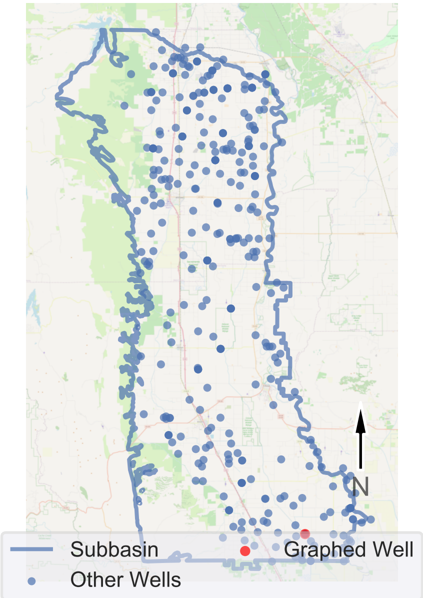
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

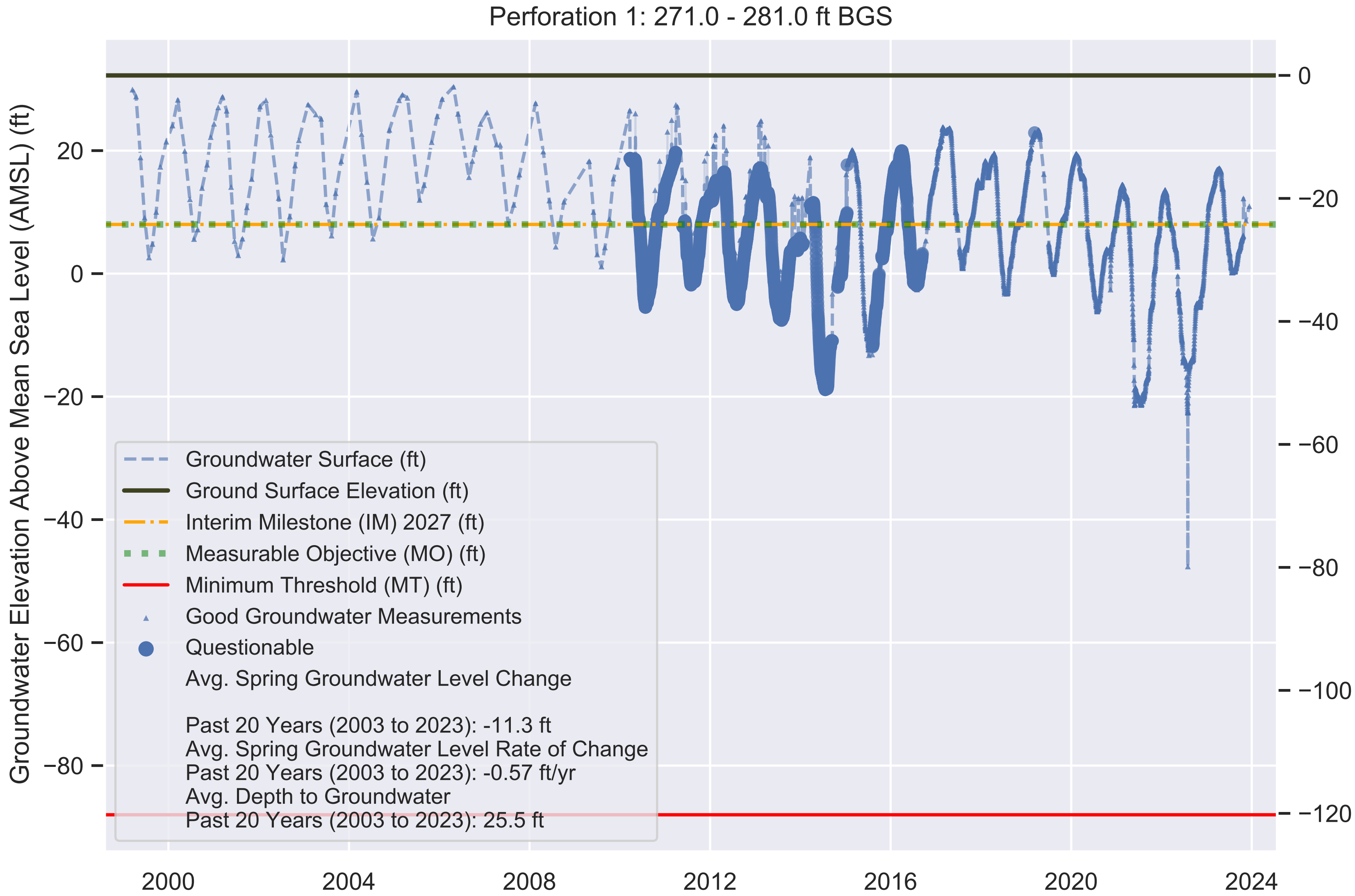
- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 13N01W13P003M

Well Location Map





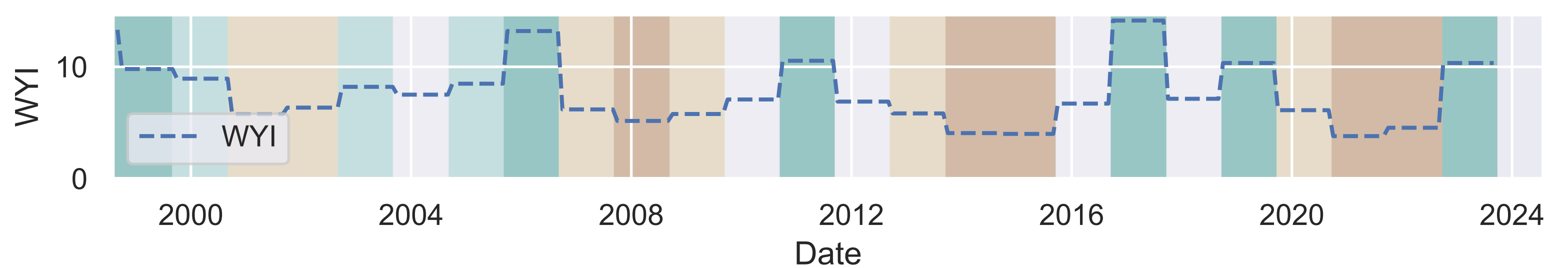
Sustainable Management Criteria:

IM (2027) = 8.0 ft AMSL
MO = 8.0 ft AMSL
MT = -88.0 ft AMSL

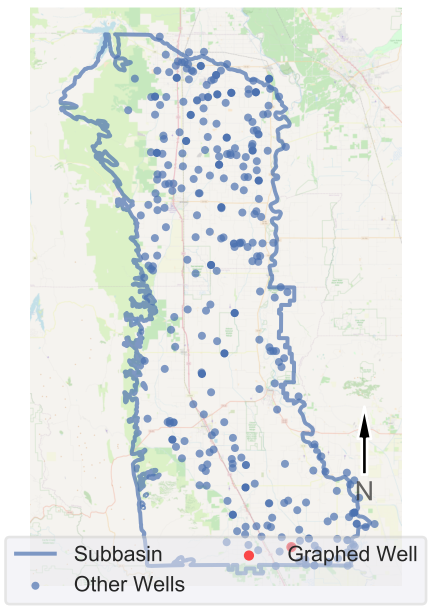
Minimum Threshold is the 20th Percentile of Domestic.

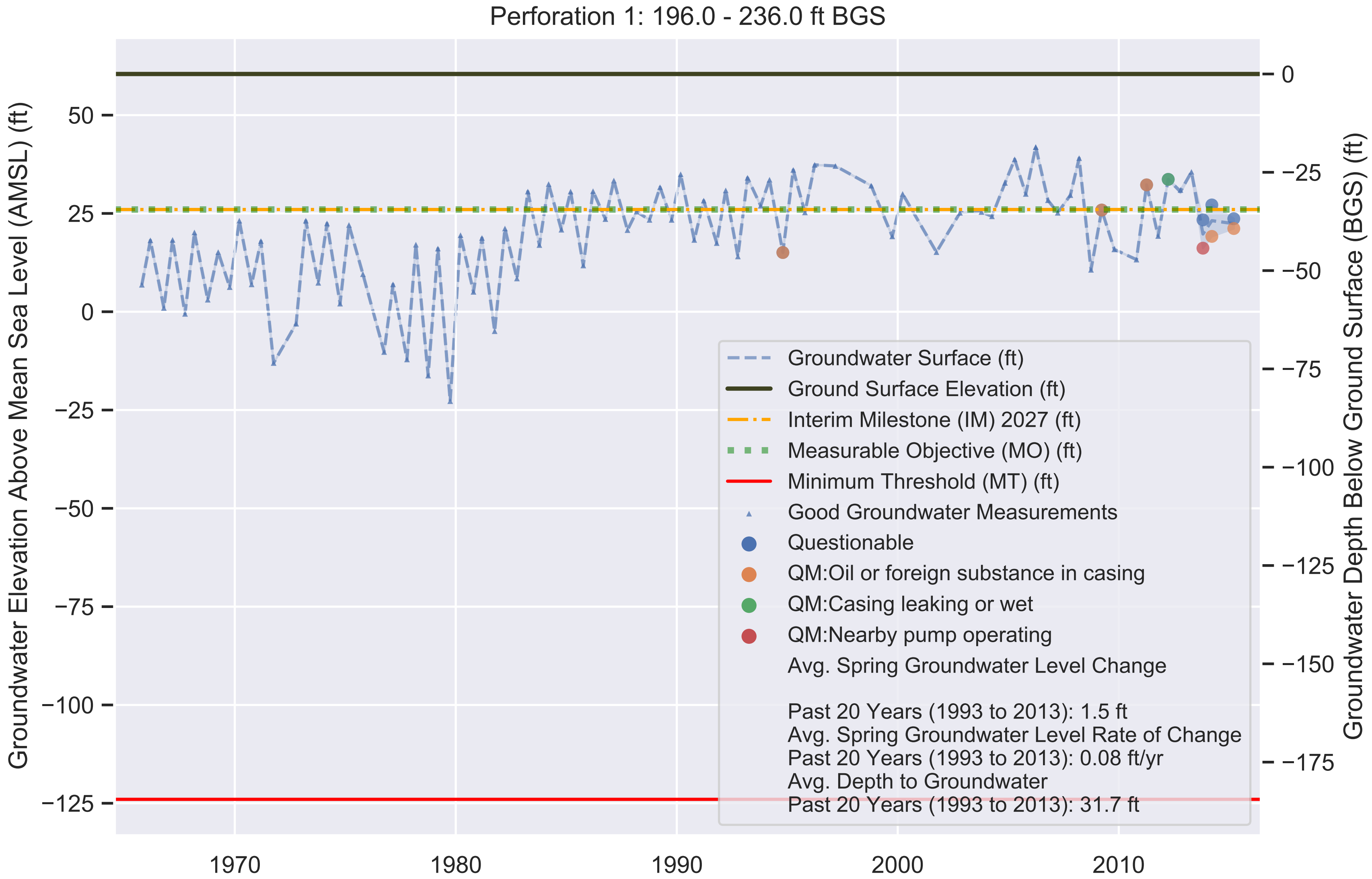
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 13N01W22P002M



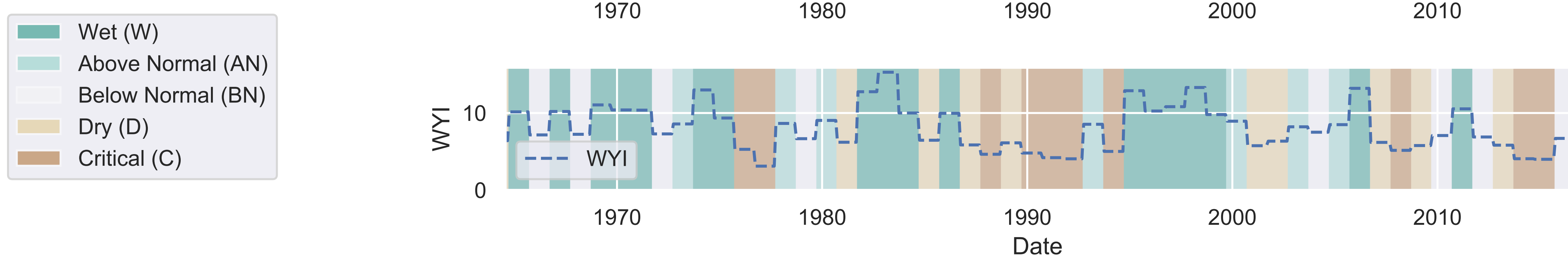


Sustainable Management Criteria:

IM (2027) = 26.0 ft AMSL
MO = 26.0 ft AMSL
MT = -124.0 ft AMSL

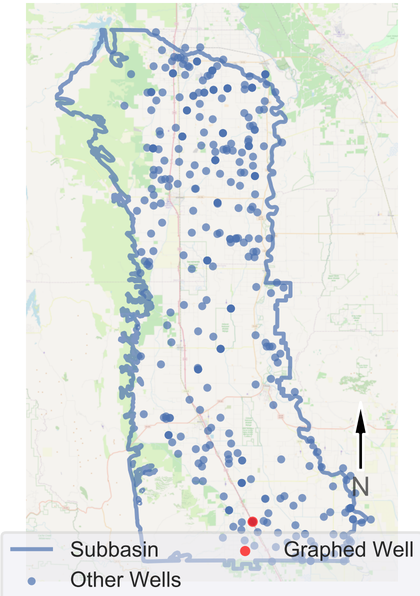
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



COLUSA Subbasin - State Well Number (SWN): 13N02W12L001M

Well Location Map



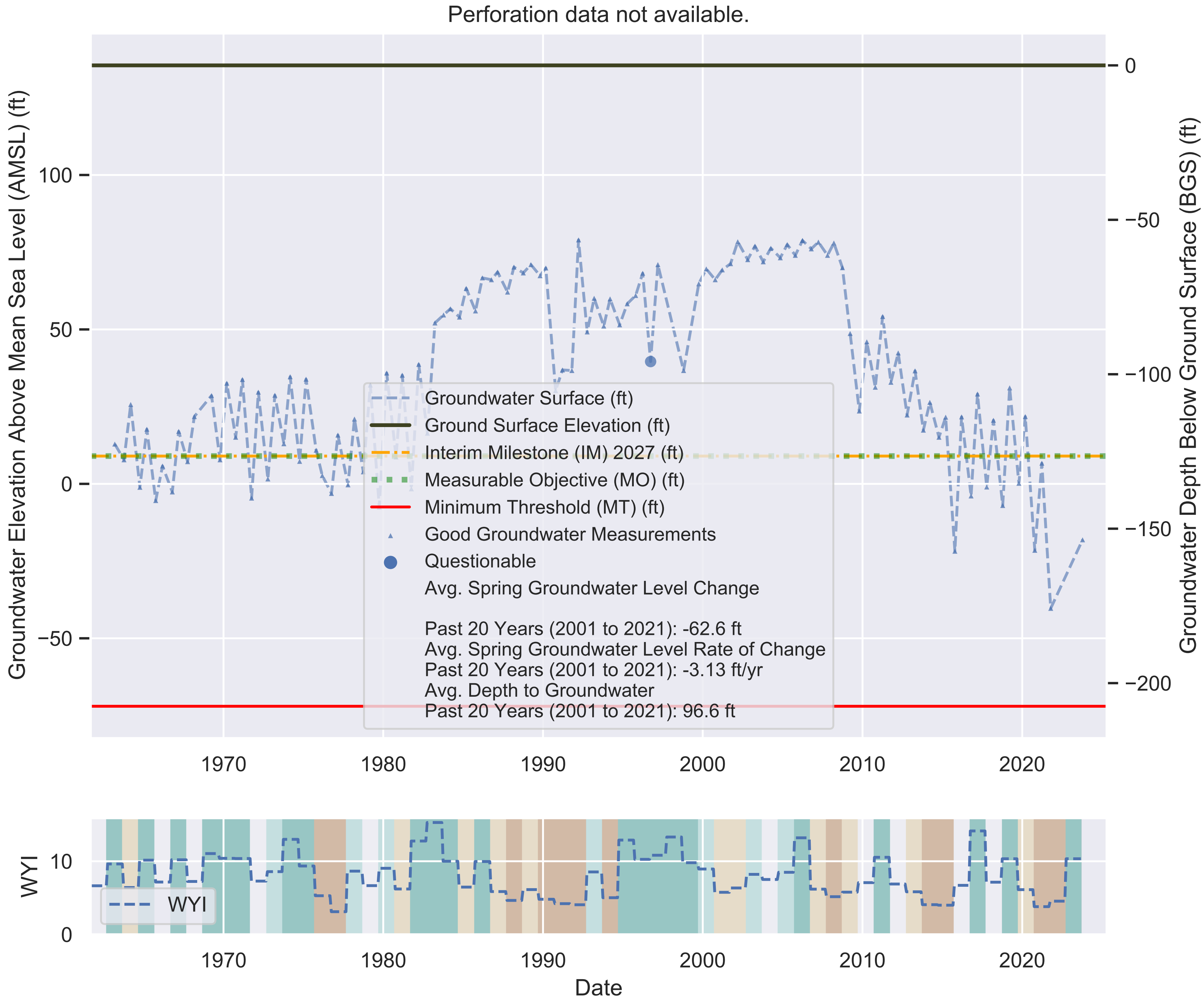
Sustainable Management Criteria:

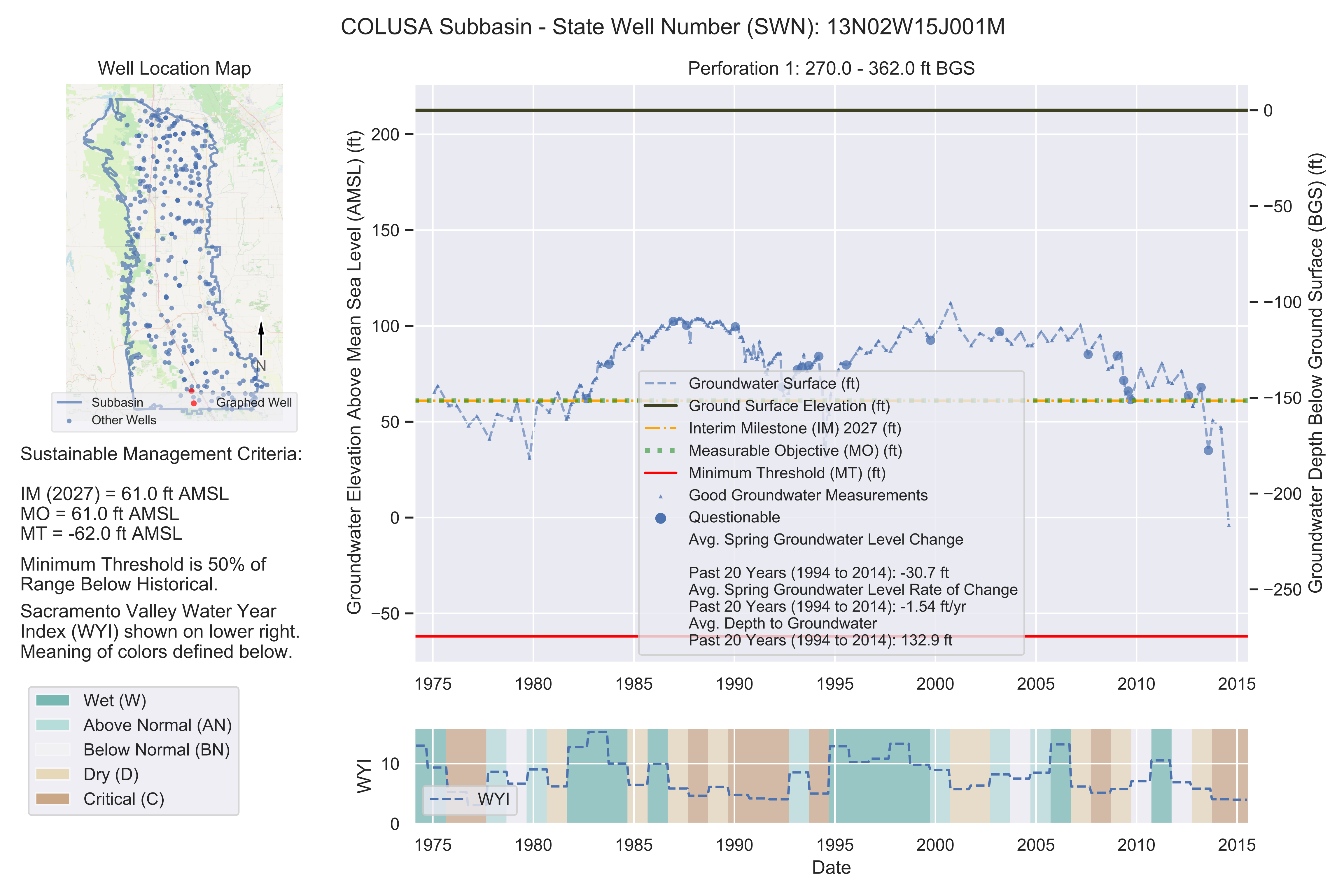
IM (2027) = 9.0 ft AMSL
MO = 9.0 ft AMSL
MT = -72.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

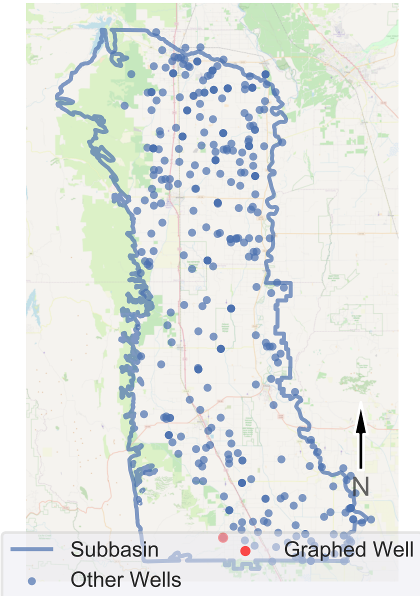
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)




COLUSA Subbasin - State Well Number (SWN): 13N02W15J001M
Well Location Map
N
Subbasin
Graphed Well
Other Wells
Sustainable Management Criteria:
IM (2027) = 61.0 ft AMSL
MO = 61.0 ft AMSL
MT = -62.0 ft AMSL
Minimum Threshold is 50% of Range Below Historical.
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.
Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)
Perforation 1: 270.0 - 362.0 ft BGS
Groundwater Elevation Above Mean Sea Level (AMSL) (ft)
Groundwater Depth Below Ground Surface (BGS) (ft)
200
150
100
50
0
−50
0
−50
−100
−150
−200
−250
Groundwater Surface (ft)
Ground Surface Elevation (ft)
Interim Milestone (IM) 2027 (ft)
Measurable Objective (MO) (ft)
Minimum Threshold (MT) (ft)
Good Groundwater Measurements
Questionable
Avg. Spring Groundwater Level Change
Past 20 Years (1994 to 2014): -30.7 ft
Avg. Spring Groundwater Level Rate of Change
Past 20 Years (1994 to 2014): -1.54 ft/yr
Avg. Depth to Groundwater
Past 20 Years (1994 to 2014): 132.9 ft
1975
1980
1985
1990
1995
2000
2005
2010
2015
WYI
10
0
WYI
1975
1980
1985
1990
1995
2000
2005
2010
2015
Date

COLUSA Subbasin - State Well Number (SWN): 13N02W20H002M

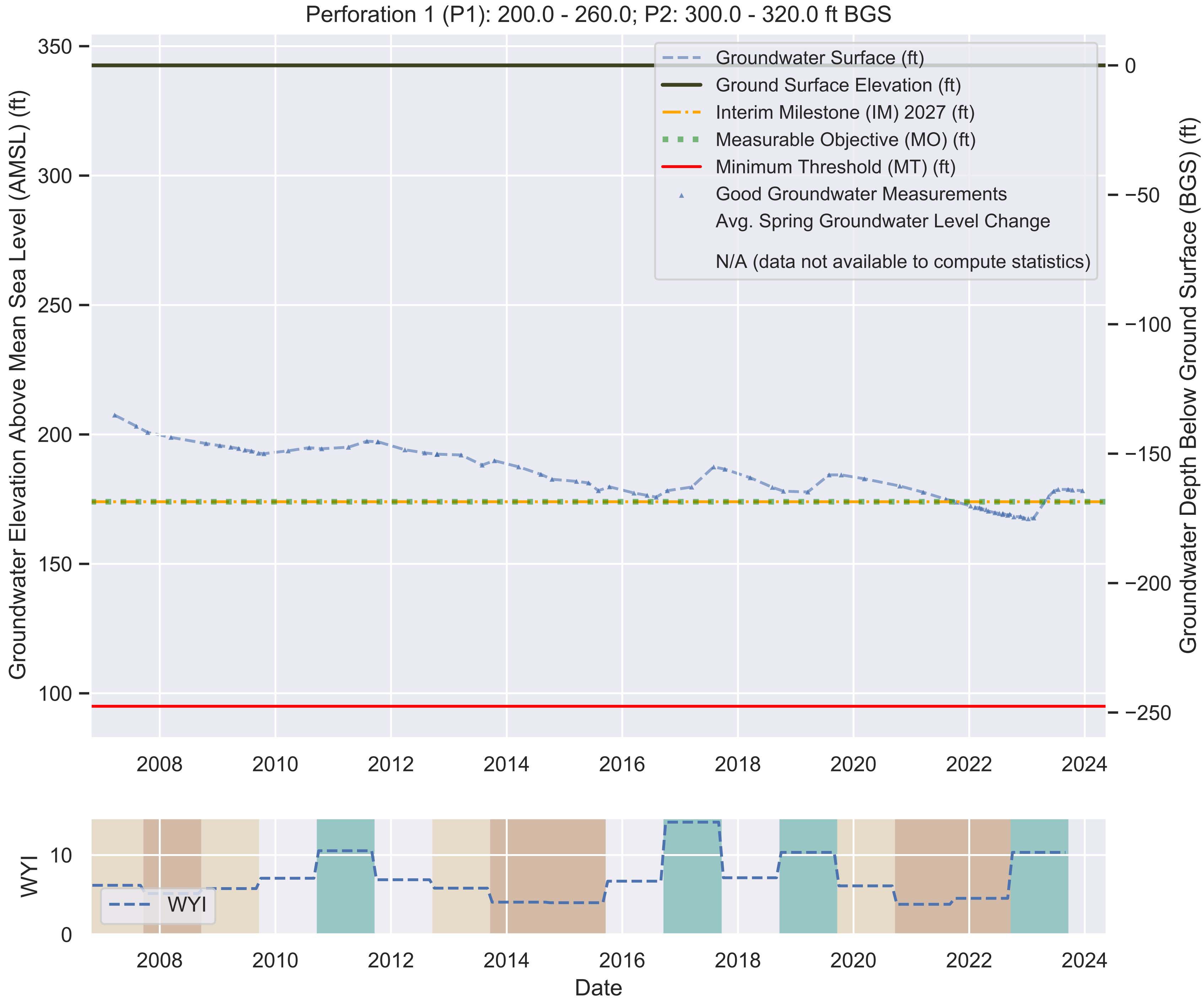


Sustainable Management Criteria:

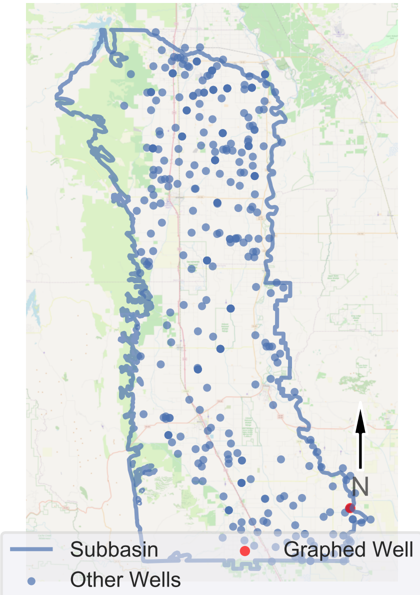
IM (2027) = 174.0 ft AMSL
MO = 174.0 ft AMSL
MT = 95.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



COLUSA Subbasin - State Well Number (SWN): 14N01E35P003M

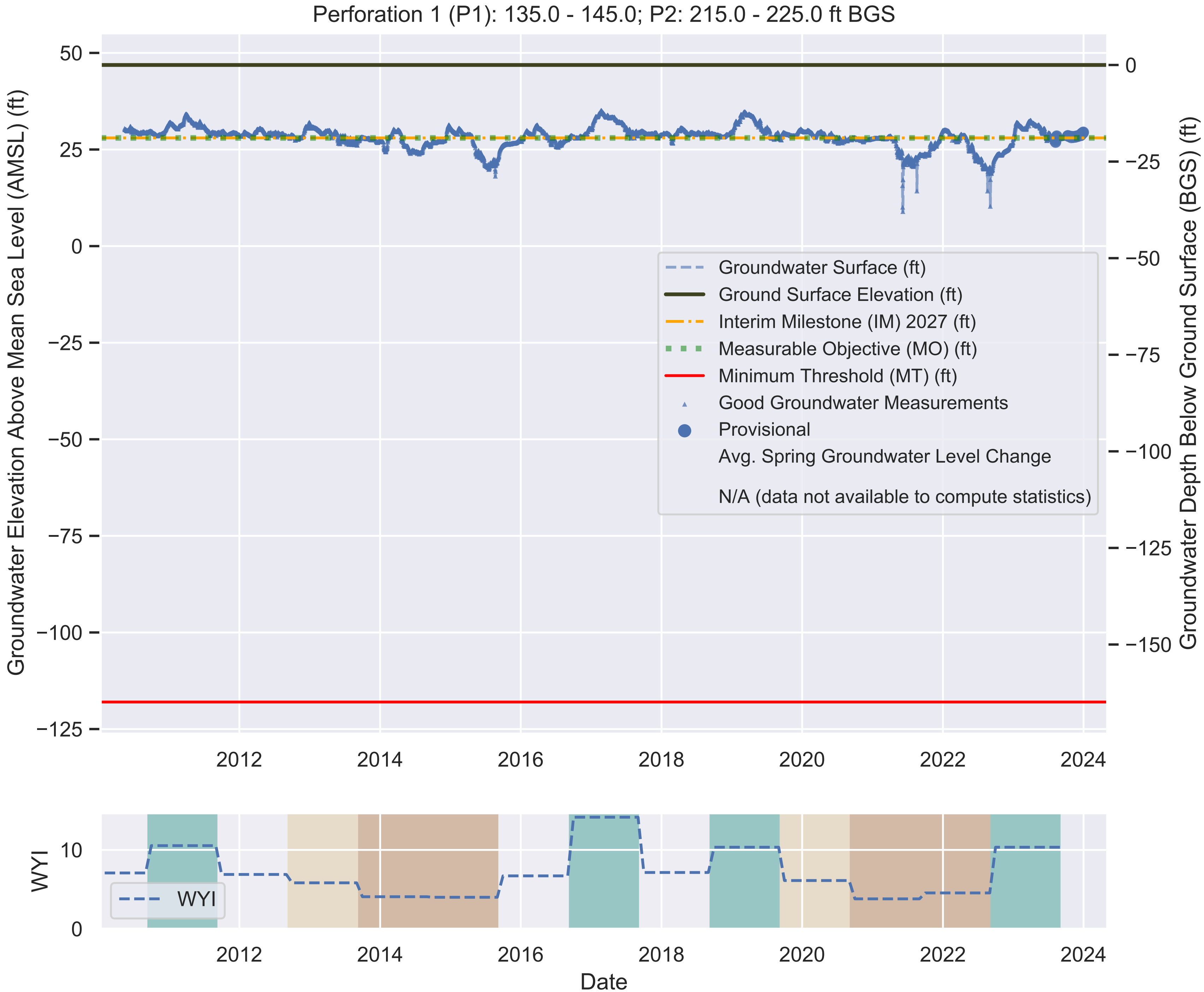


Sustainable Management Criteria:

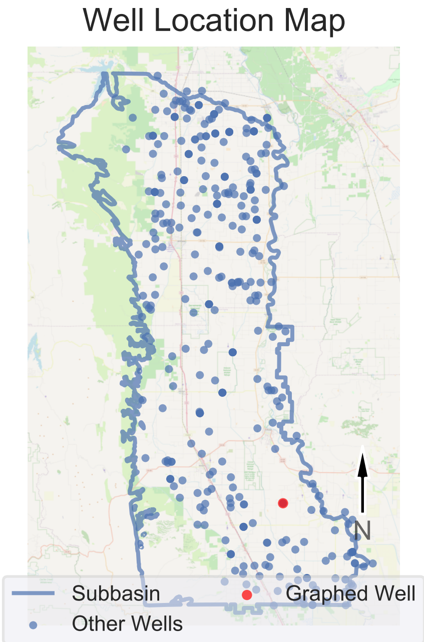
IM (2027) = 28.0 ft AMSL
MO = 28.0 ft AMSL
MT = -118.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



COLUSA Subbasin - State Well Number (SWN): 14N01W04K003M

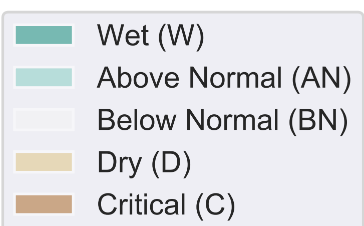


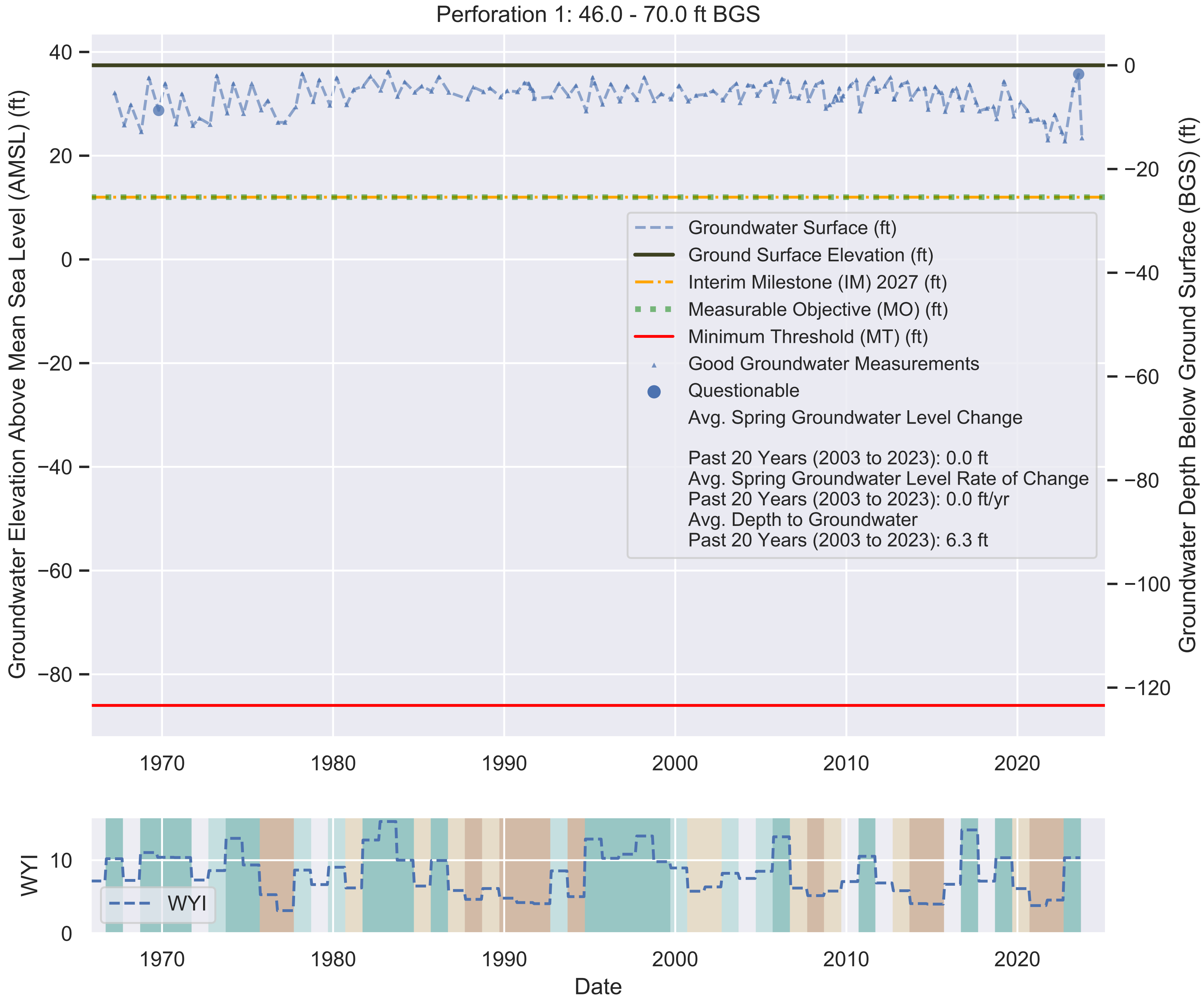
Sustainable Management Criteria:

IM (2027) = 12.0 ft AMSL
MO = 12.0 ft AMSL
MT = -86.0 ft AMSL

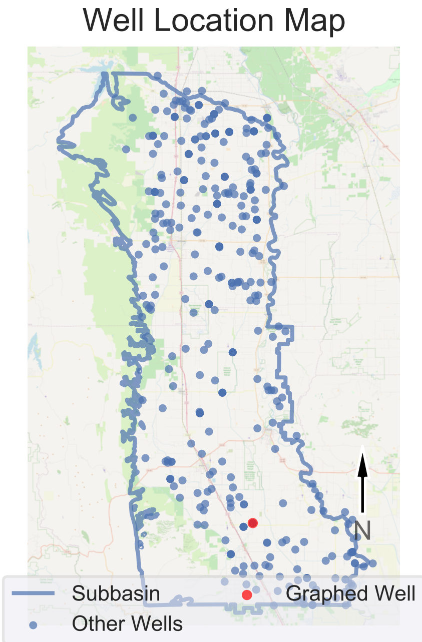
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 14N02W13N001M

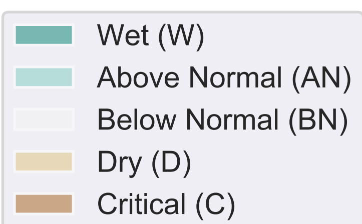


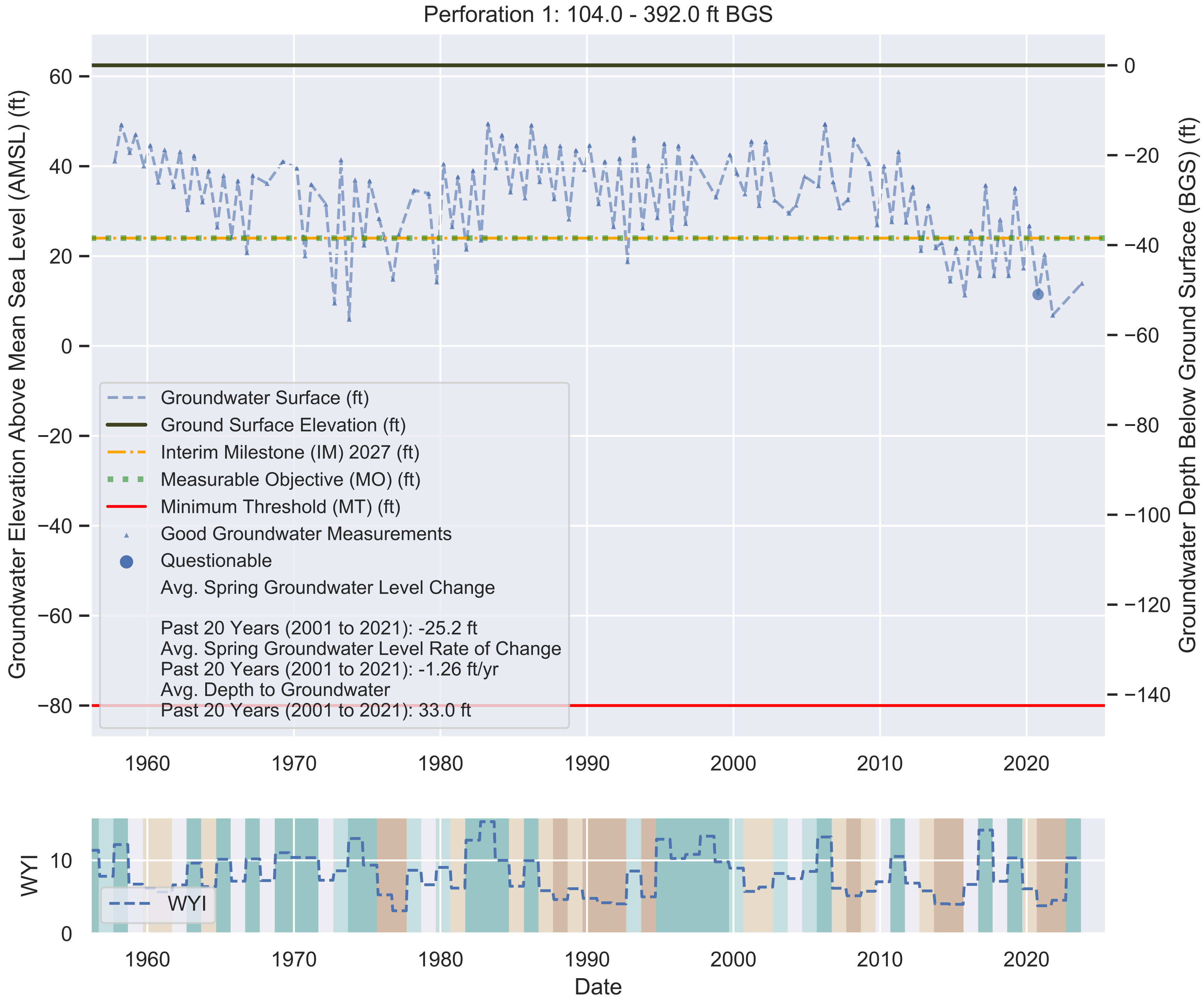
Sustainable Management Criteria:

IM (2027) = 24.0 ft AMSL
MO = 24.0 ft AMSL
MT = -80.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

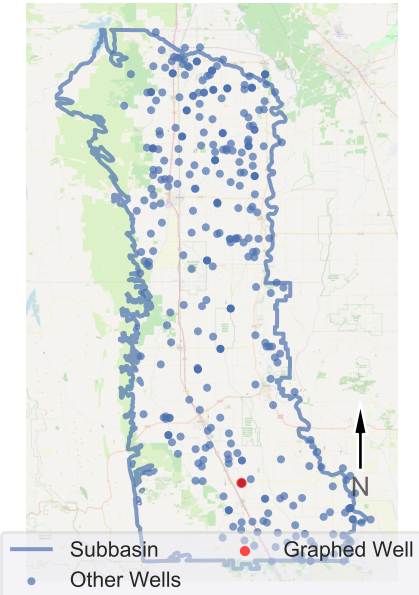
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 14N02W22A002M

Well Location Map

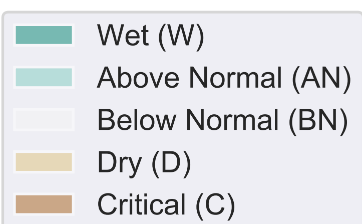


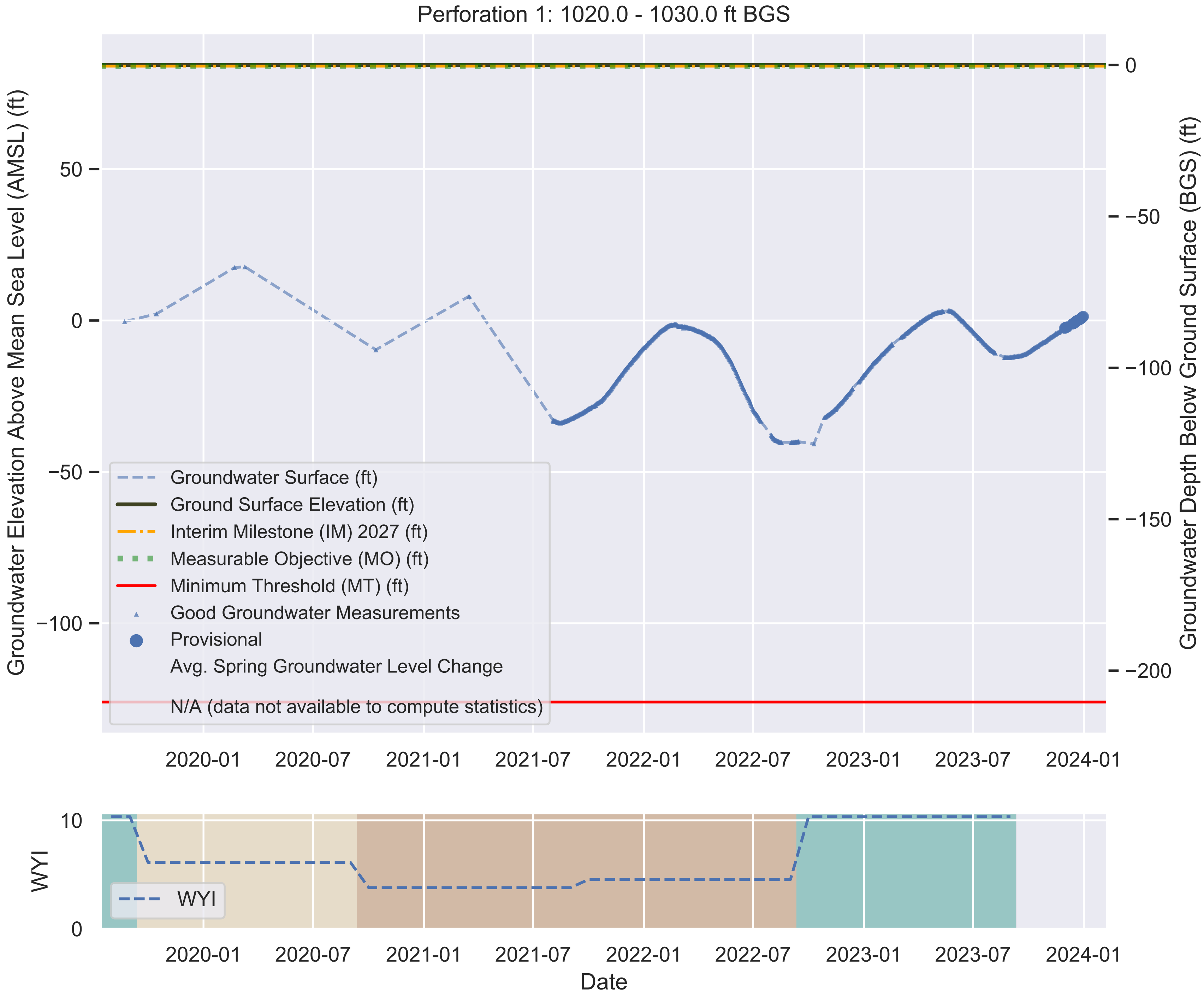
Sustainable Management Criteria:

IM (2027) = 84.0 ft AMSL
MO = 84.0 ft AMSL
MT = -126.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

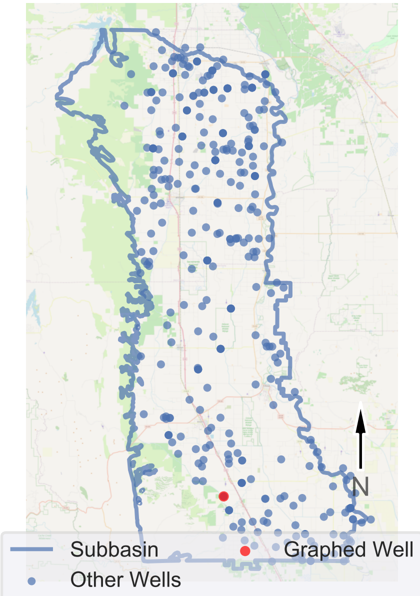


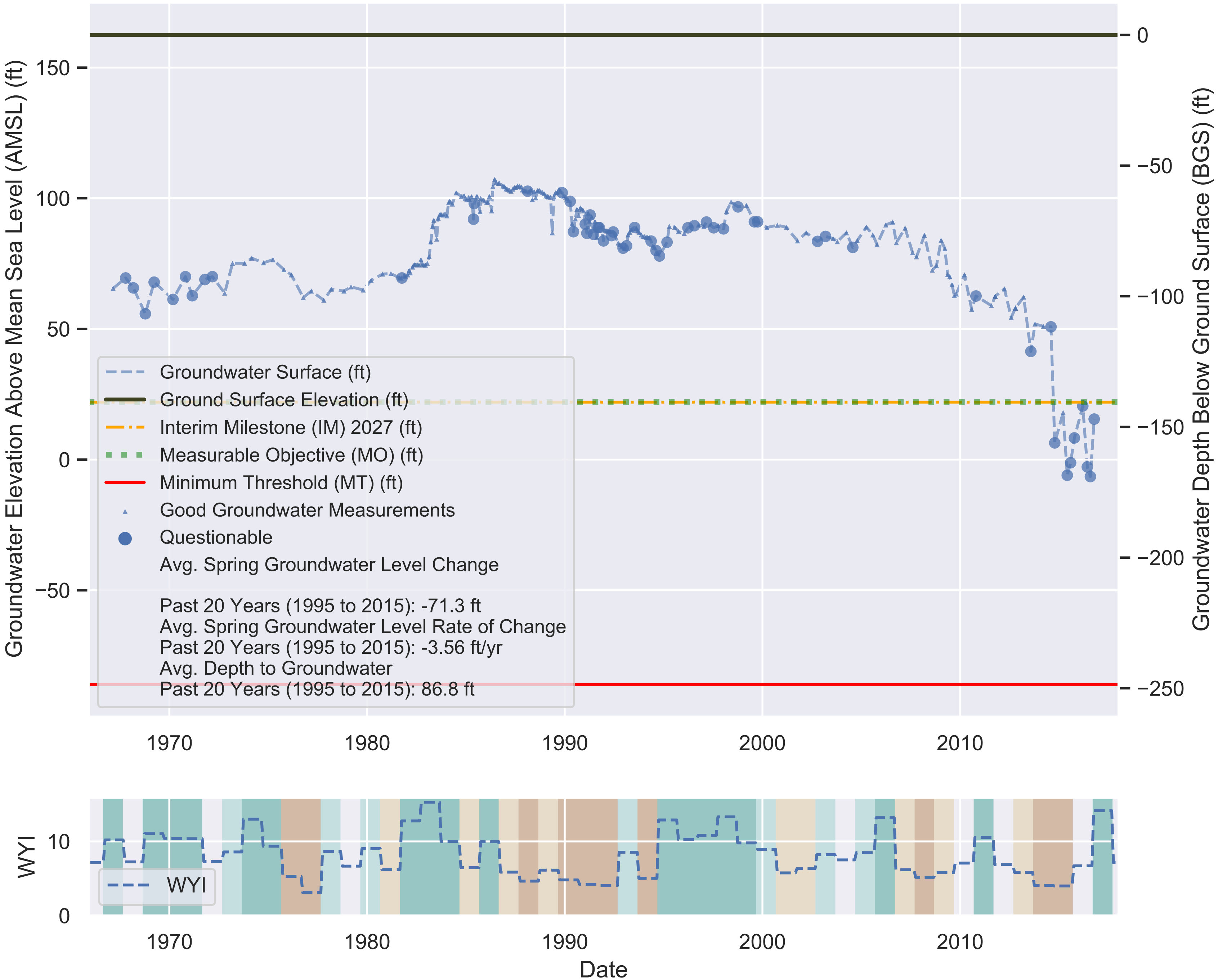


COLUSA Subbasin - State Well Number (SWN): 14N02W29J001M

Perforation 1 (P1): 119.0 - 143.0; P2: 152.0 - 158.0; P3: 176.0 - 182.0; P4: 198.0 - 208.0; P5: 215.0 - 239.0; P6: 264.0 - 276.0; P7: 307.5 - 319.5; P8: 334.5 - 349.5 ft BGS

Well Location Map





Sustainable Management Criteria:

IM (2027) = 22.0 ft AMSL
MO = 22.0 ft AMSL
MT = -86.0 ft AMSL

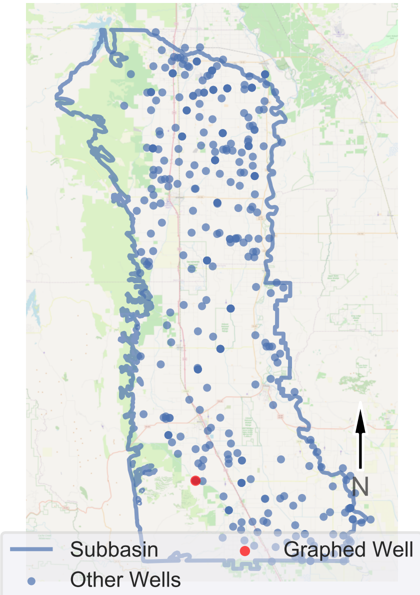
Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)

COLUSA Subbasin - State Well Number (SWN): 14N03W14Q003M

Well Location Map



Sustainable Management Criteria:

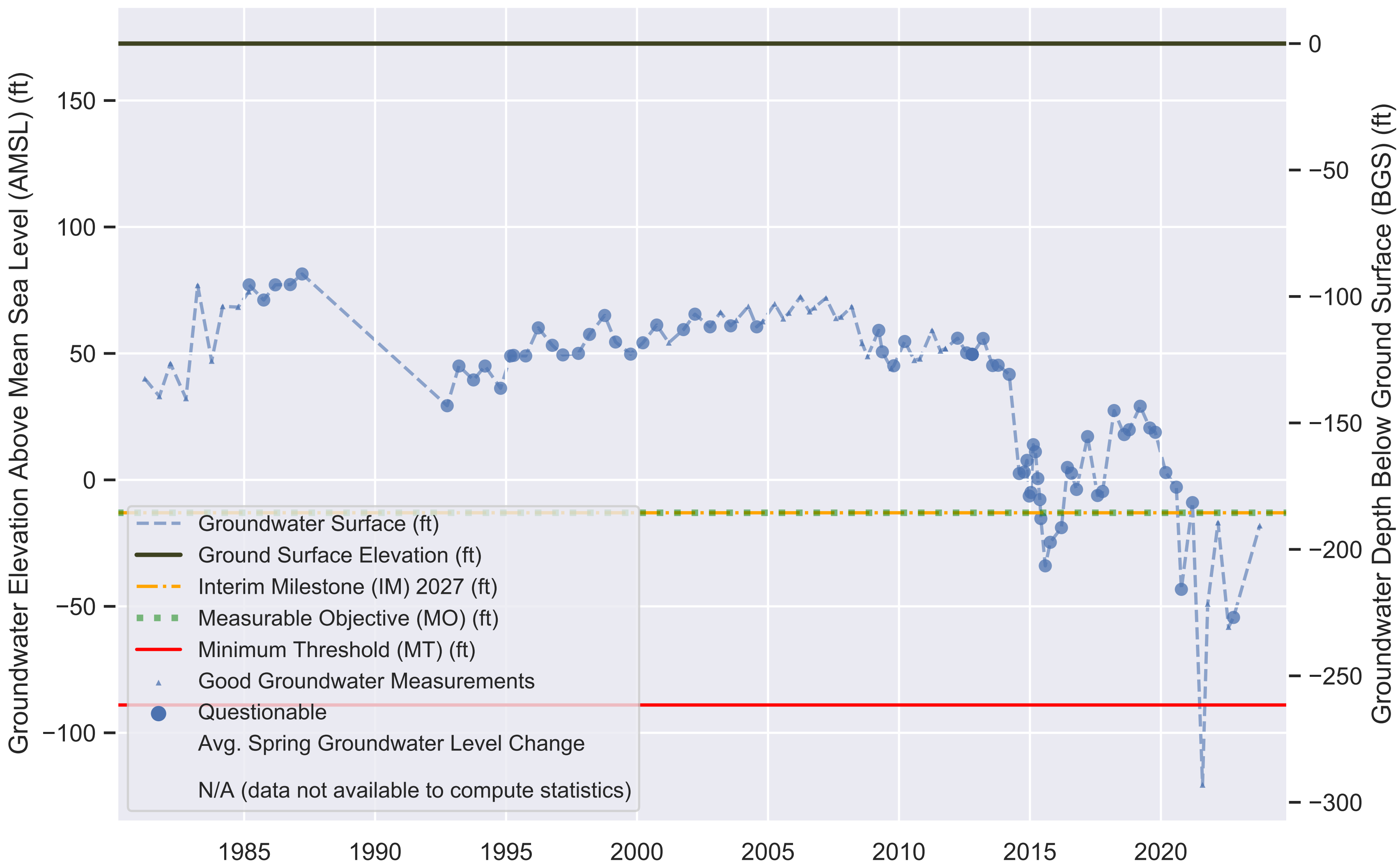
IM (2027) = -13.0 ft AMSL
MO = -13.0 ft AMSL
MT = -89.0 ft AMSL

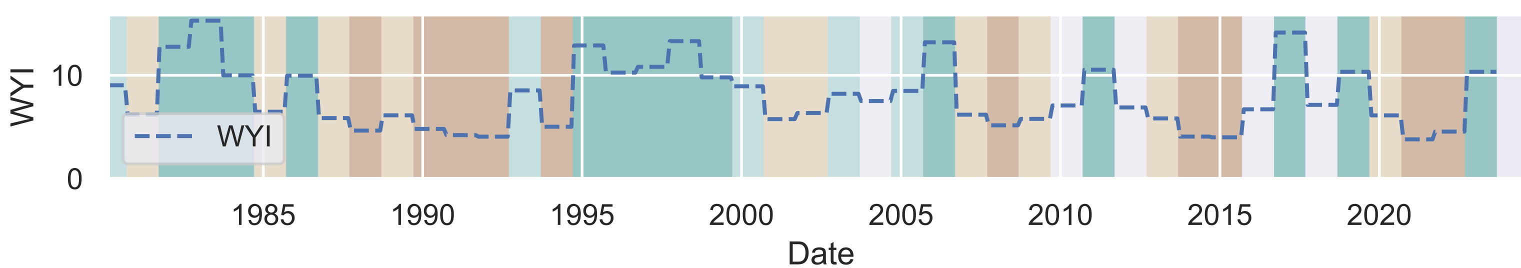
Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)

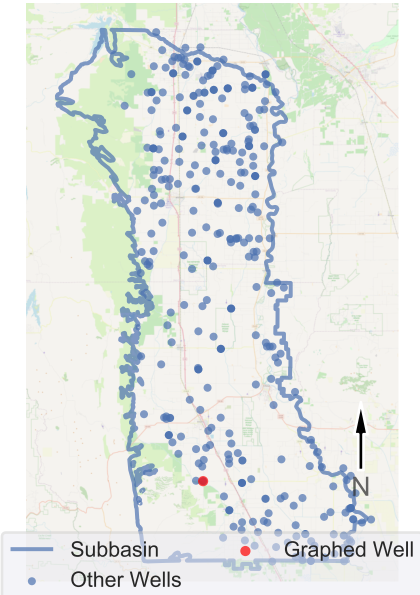
Perforation 1 (P1): 390.0 - 480.0; P2: 500.0 - 590.0; P3: 614.0 - 685.0 ft BGS





COLUSA Subbasin - State Well Number (SWN): 14N03W24C001M

Well Location Map



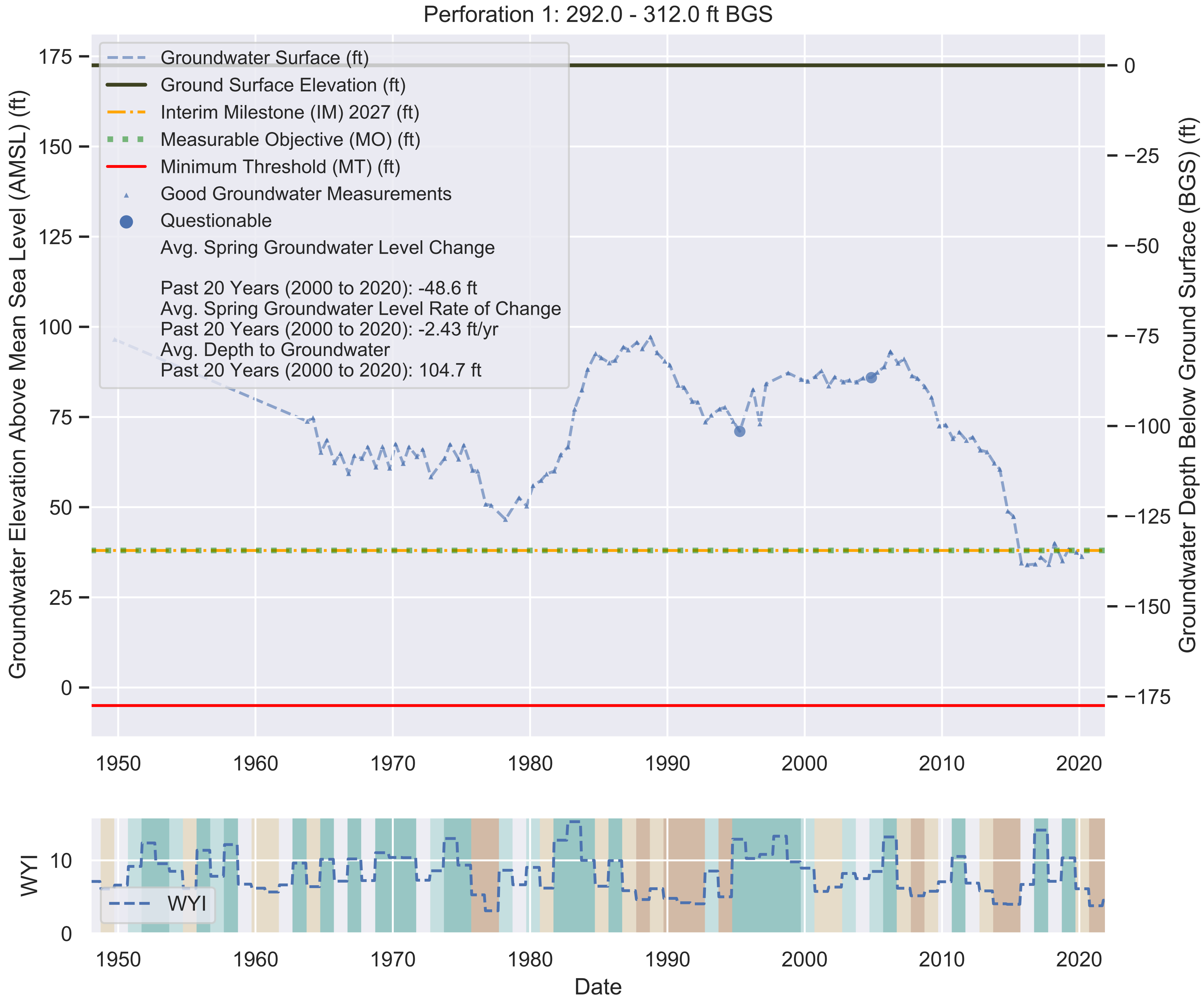
Sustainable Management Criteria:

IM (2027) = 38.0 ft AMSL
MO = 38.0 ft AMSL
MT = -5.0 ft AMSL

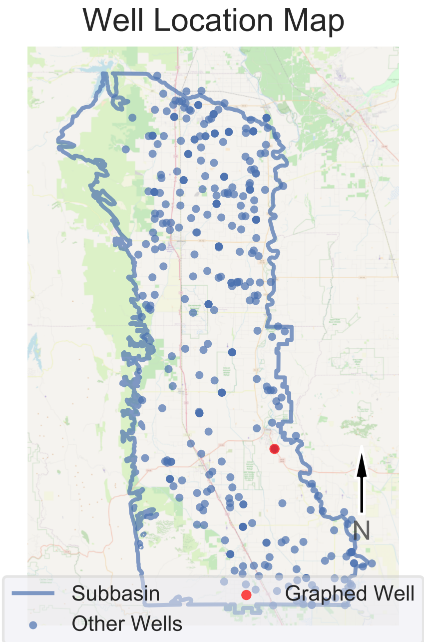
Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)



COLUSA Subbasin - State Well Number (SWN): 15N01W05G001M

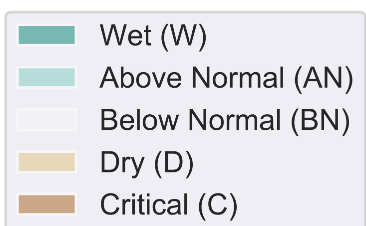


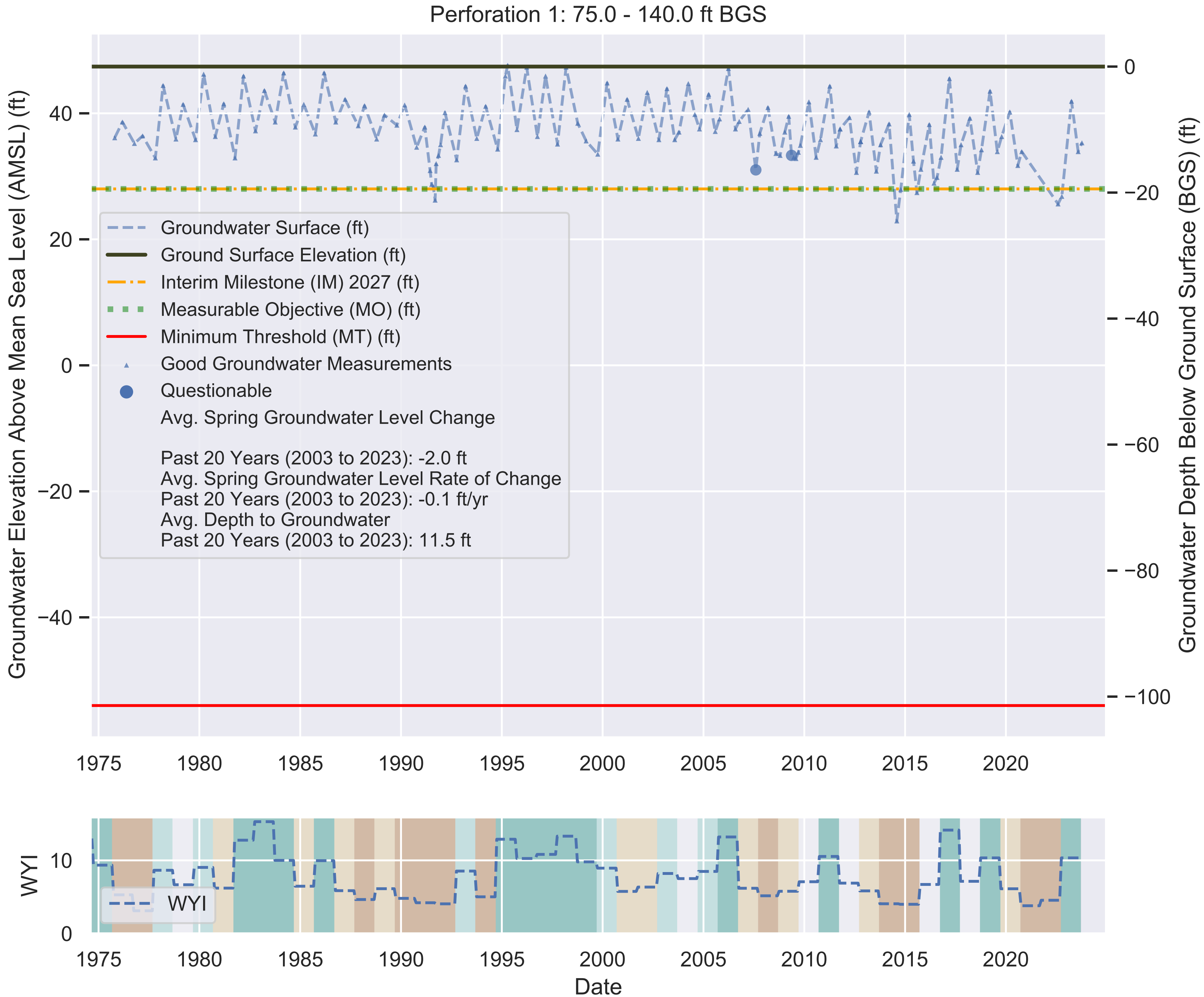
Sustainable Management Criteria:

IM (2027) = 28.0 ft AMSL
MO = 28.0 ft AMSL
MT = -54.0 ft AMSL

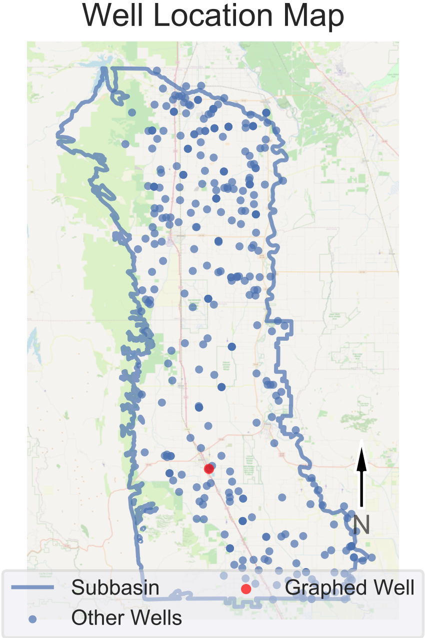
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 15N02W19E001M

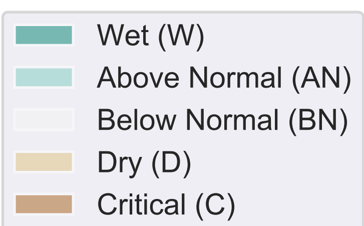


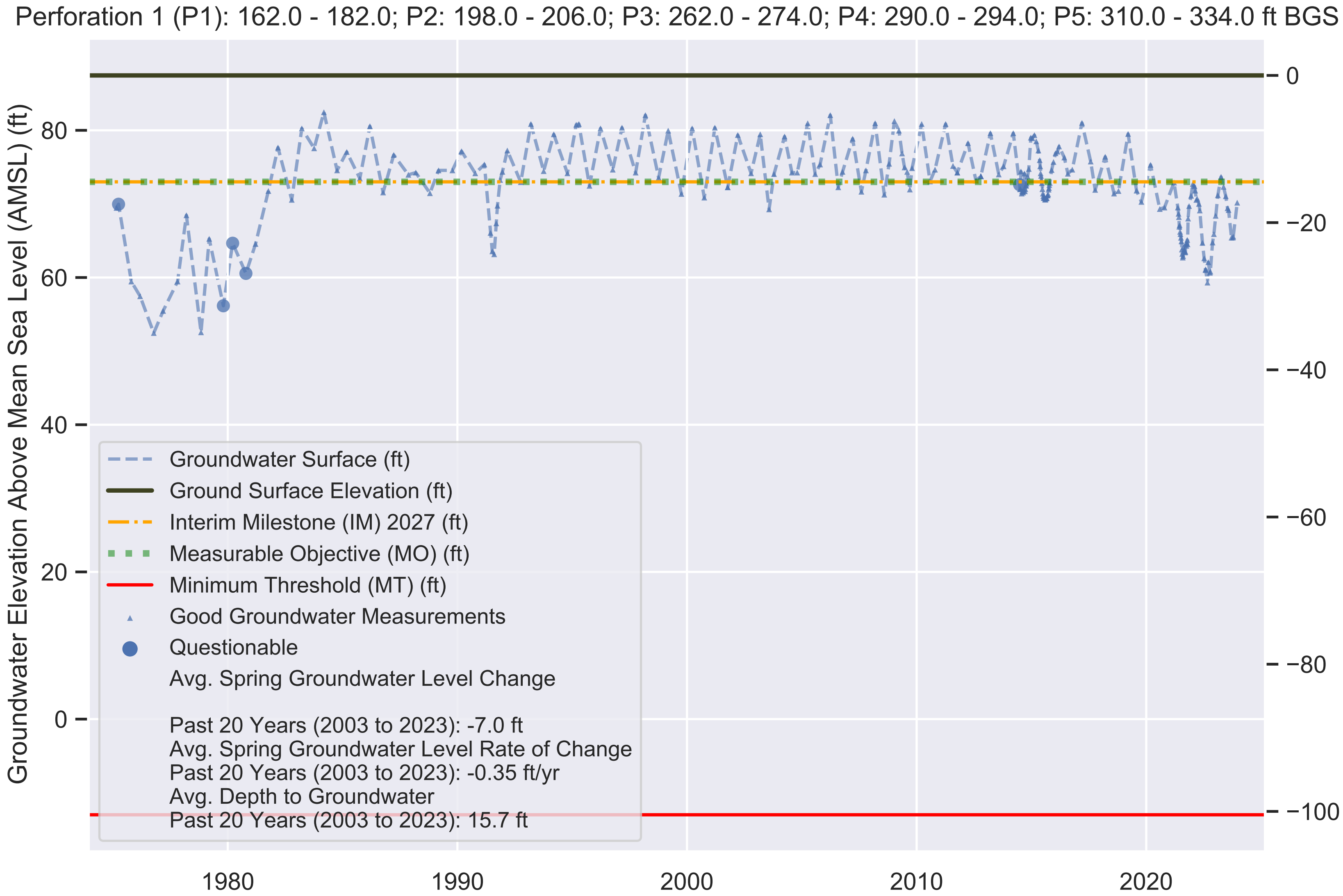
Sustainable Management Criteria:

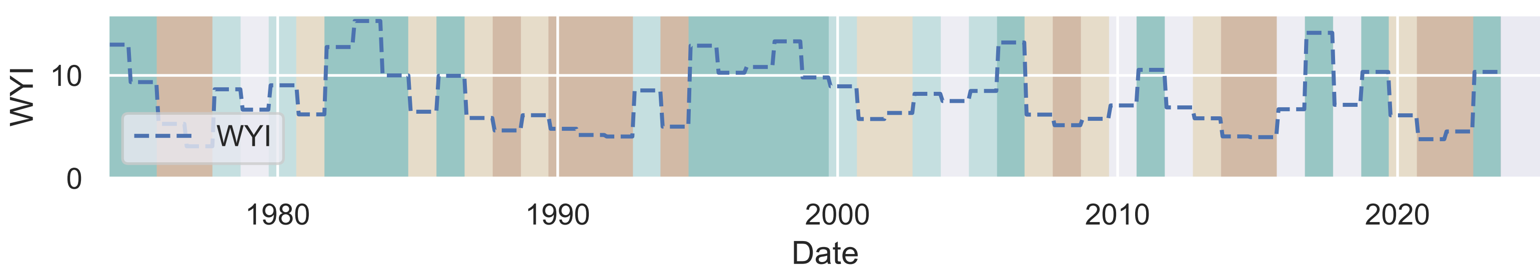
IM (2027) = 73.0 ft AMSL
MO = 73.0 ft AMSL
MT = -13.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

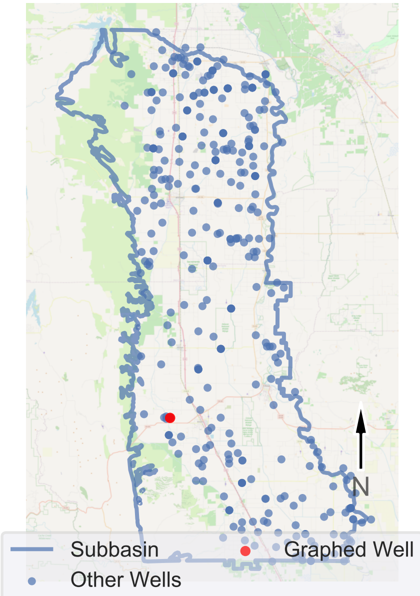
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.







COLUSA Subbasin - State Well Number (SWN): 15N03W08Q001M

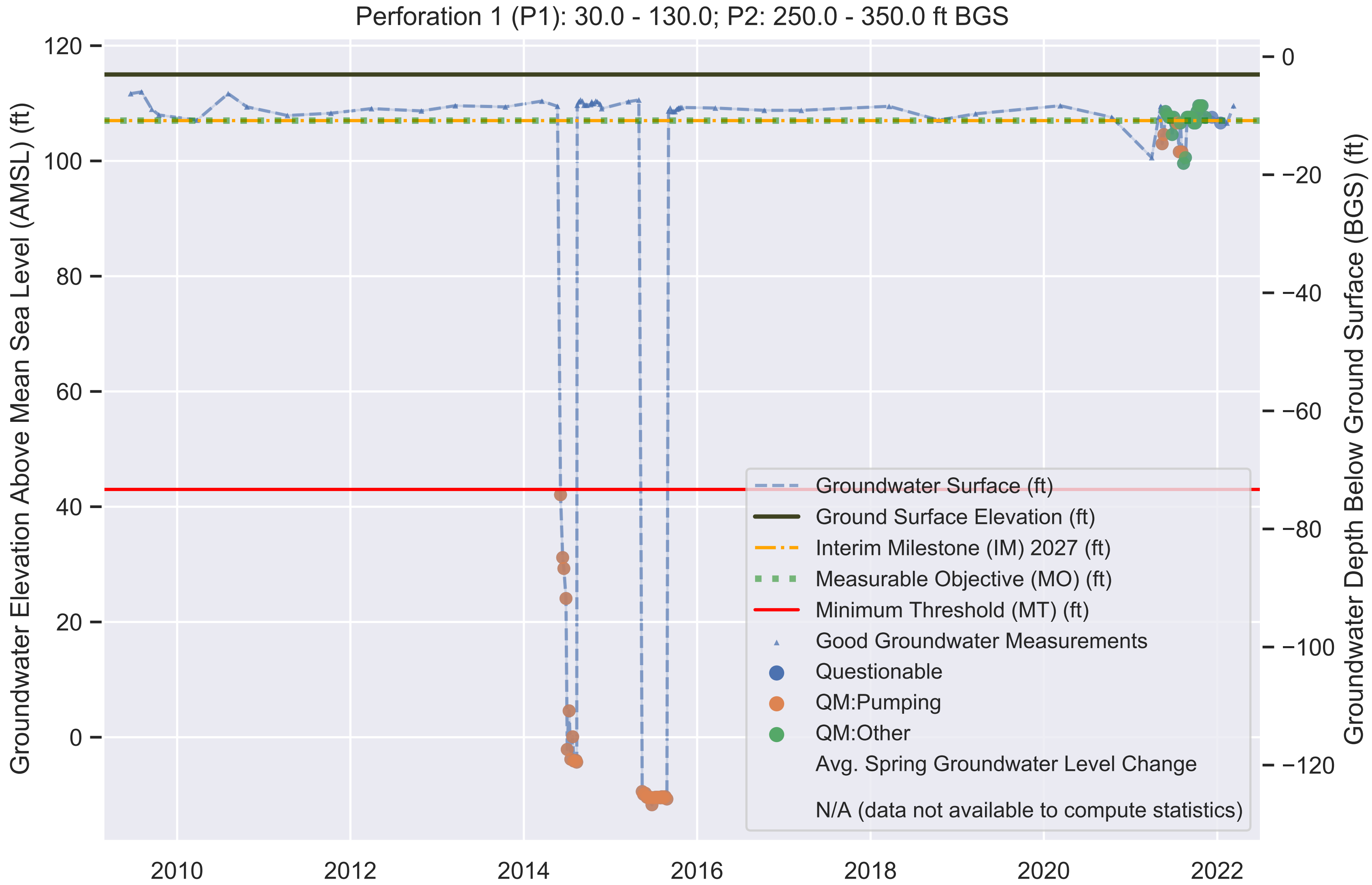


Sustainable Management Criteria:

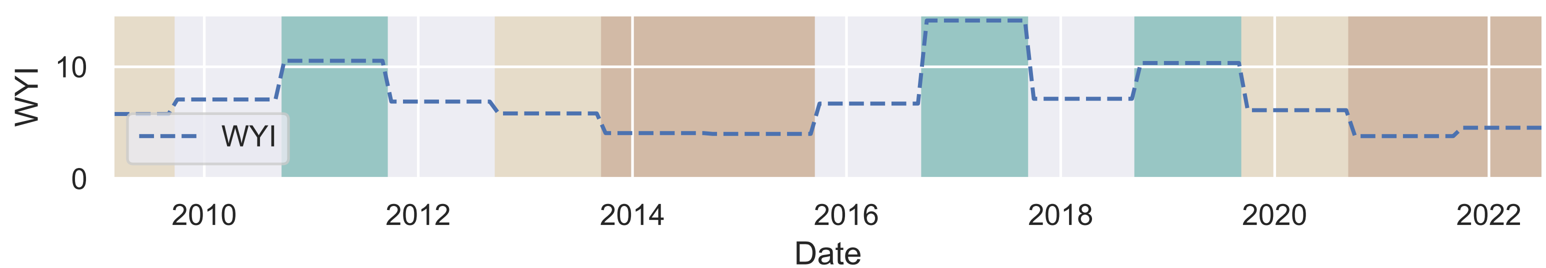
IM (2027) = 107.0 ft AMSL
MO = 107.0 ft AMSL
MT = 43.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

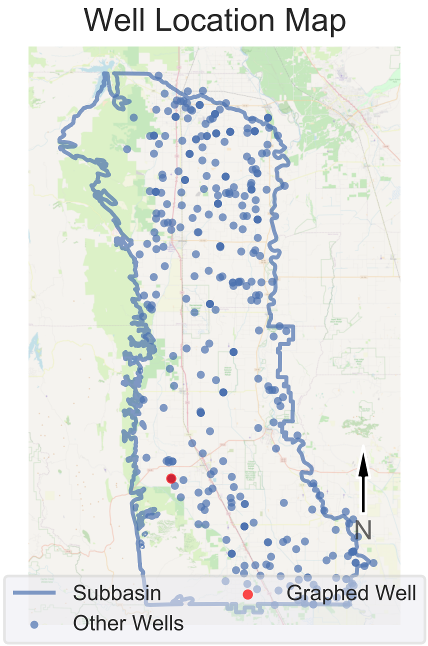
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)



COLUSA Subbasin - State Well Number (SWN): 15N03W20Q002M

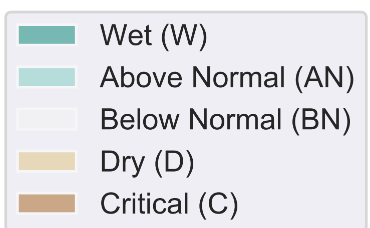


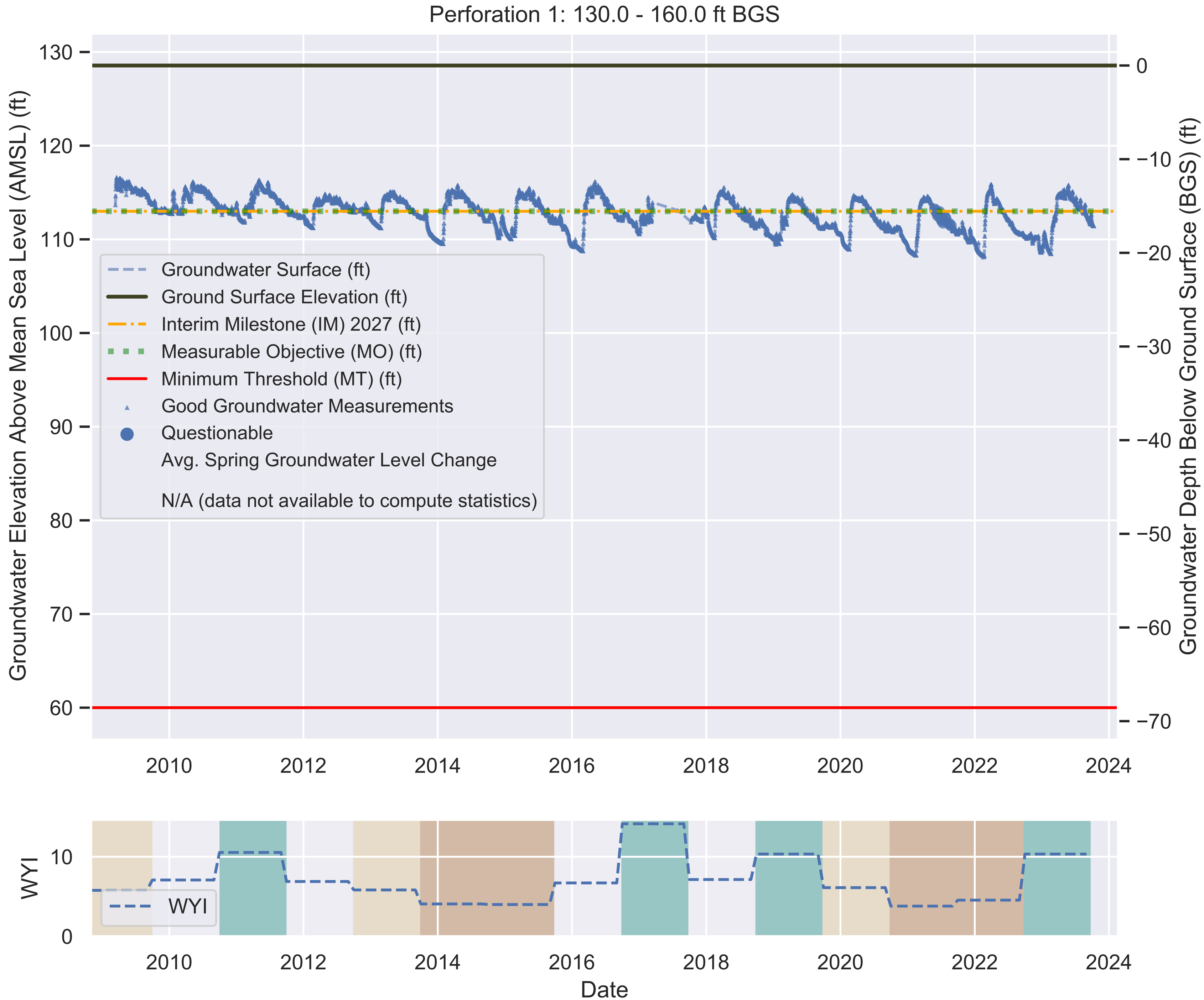
Sustainable Management Criteria:

IM (2027) = 113.0 ft AMSL
MO = 113.0 ft AMSL
MT = 60.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

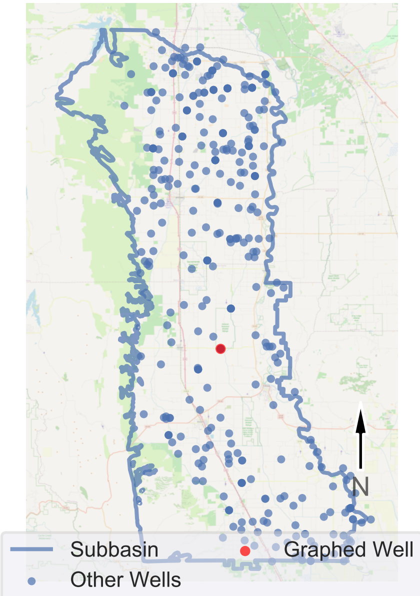
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



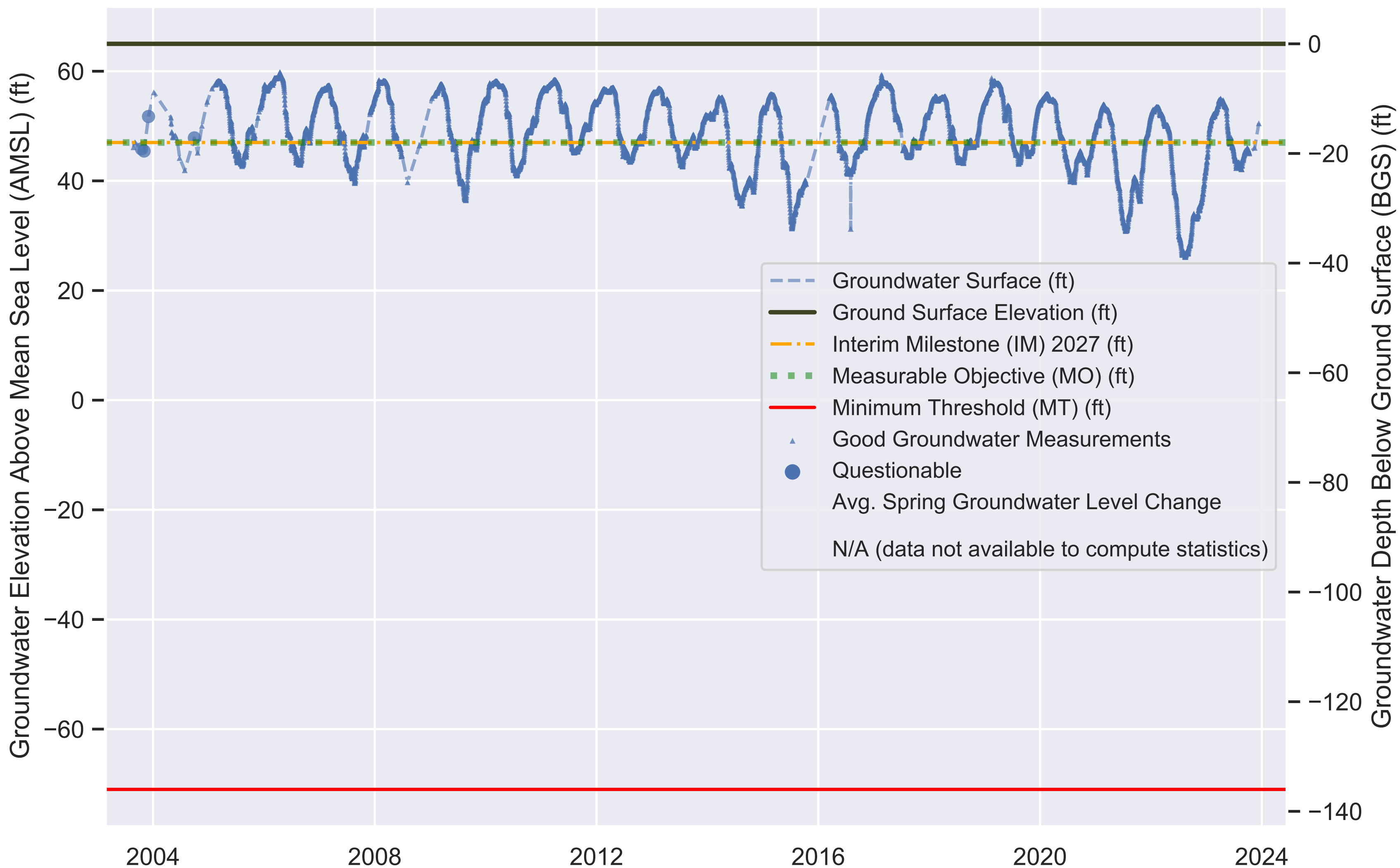


COLUSA Subbasin - State Well Number (SWN): 16N02W05B003M

Well Location Map



Perforation 1 (P1): 174.0 - 184.0; P2: 246.0 - 256.0 ft BGS

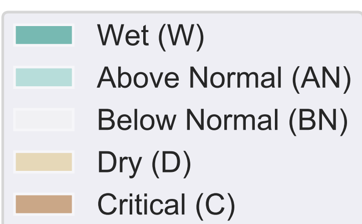


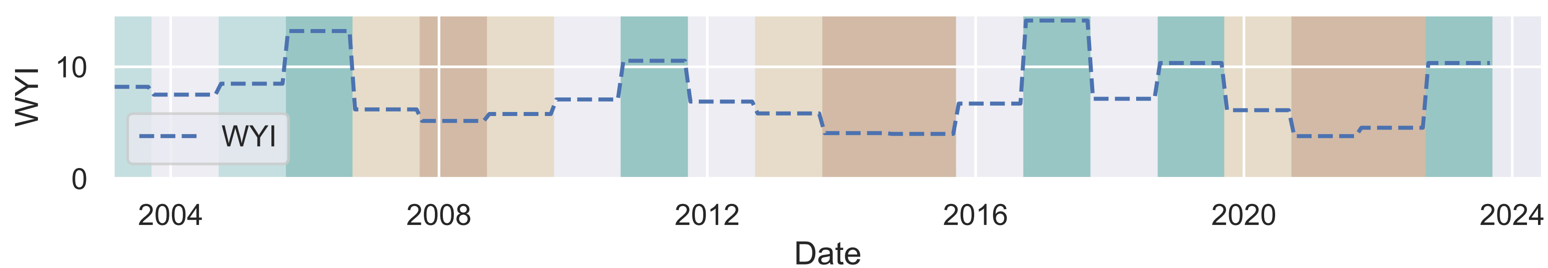
Sustainable Management Criteria:

IM (2027) = 47.0 ft AMSL
MO = 47.0 ft AMSL
MT = -71.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

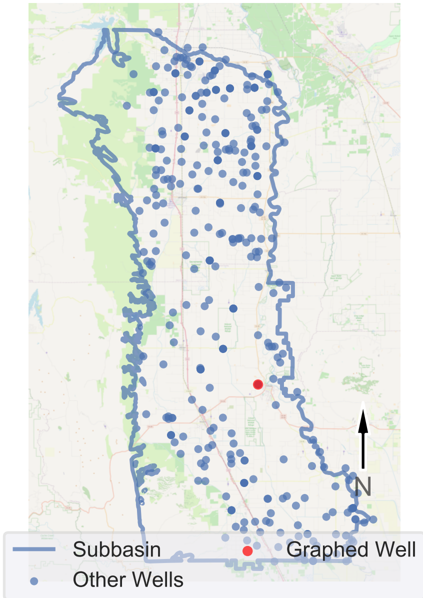
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 16N02W25B002M

Well Location Map



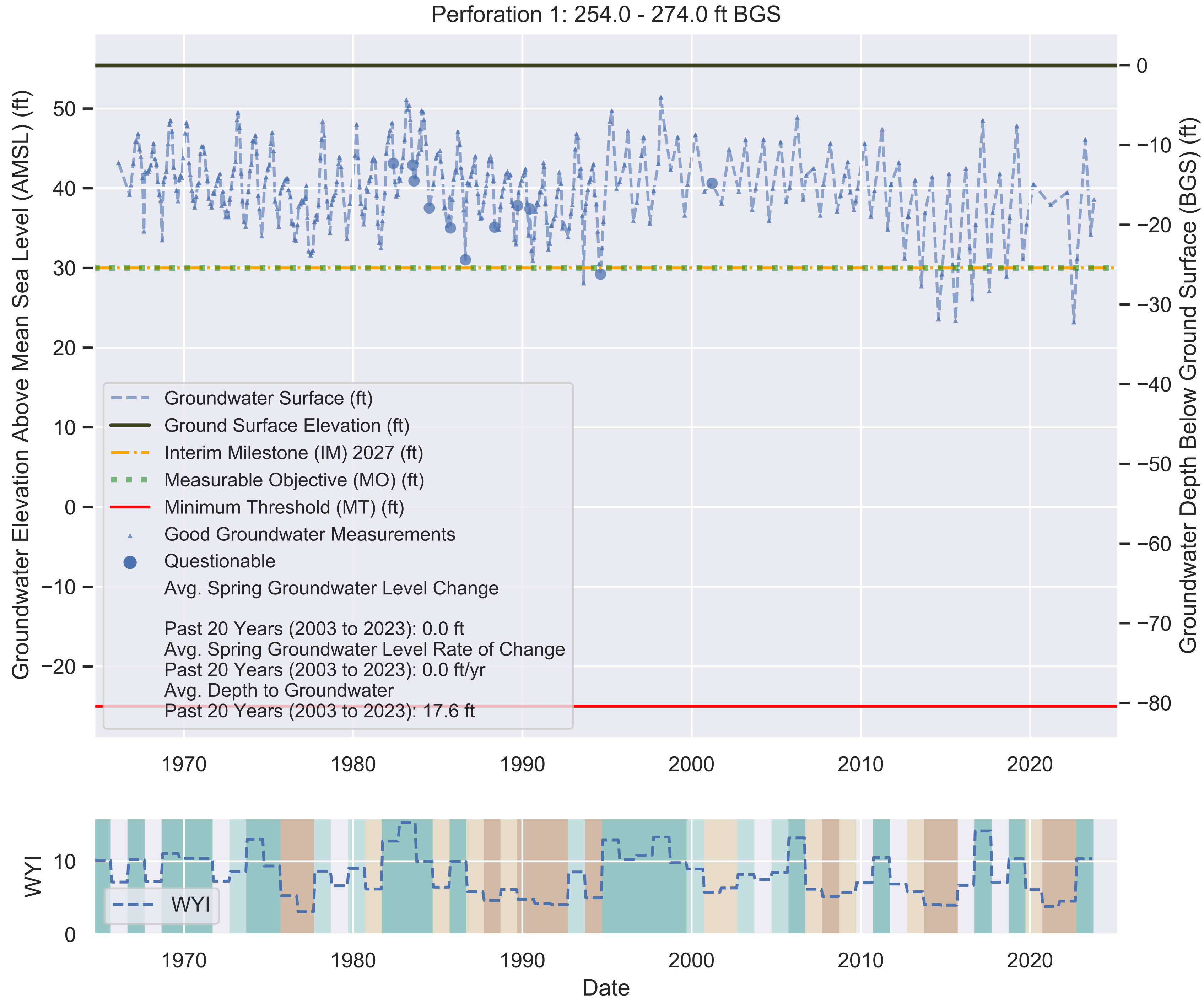
Sustainable Management Criteria:

IM (2027) = 30.0 ft AMSL
MO = 30.0 ft AMSL
MT = -25.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

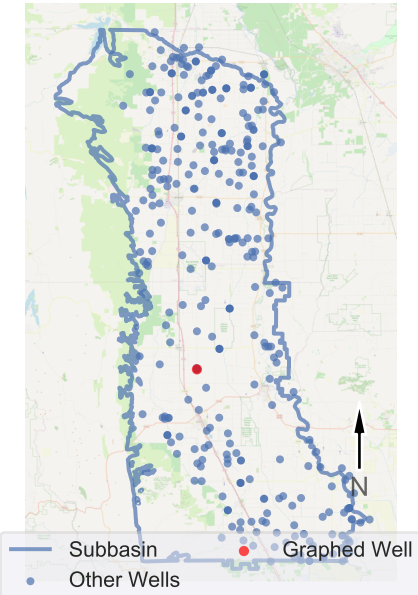
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 16N03W14H006M

Well Location Map

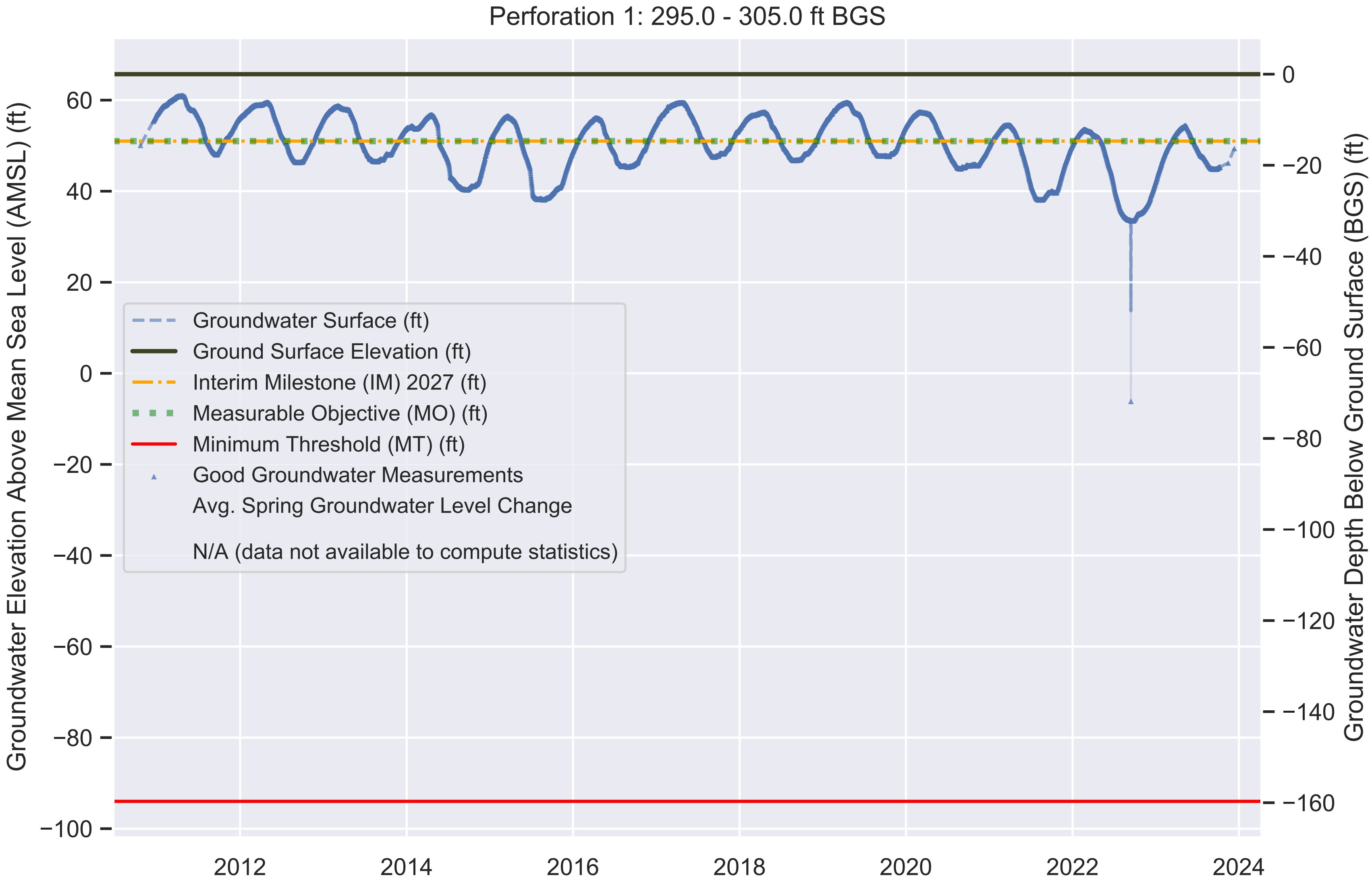


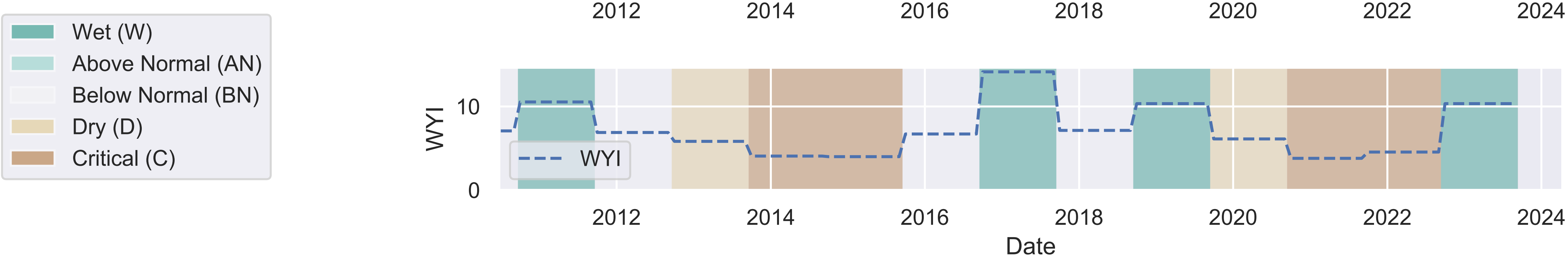
Sustainable Management Criteria:

IM (2027) = 51.0 ft AMSL
MO = 51.0 ft AMSL
MT = -94.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

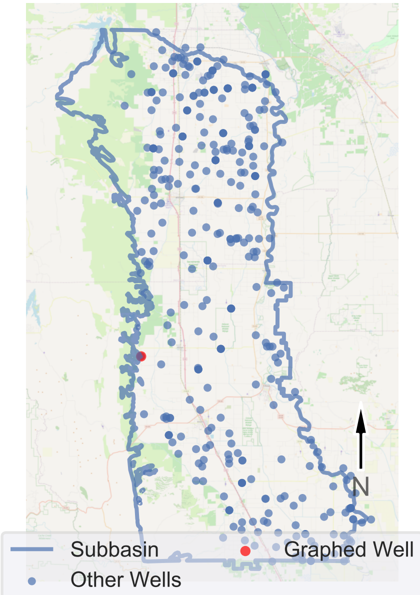
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 16N04W02P001M

Well Location Map

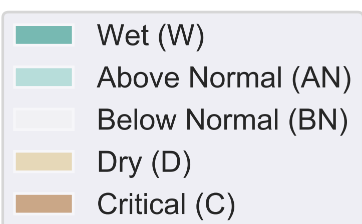


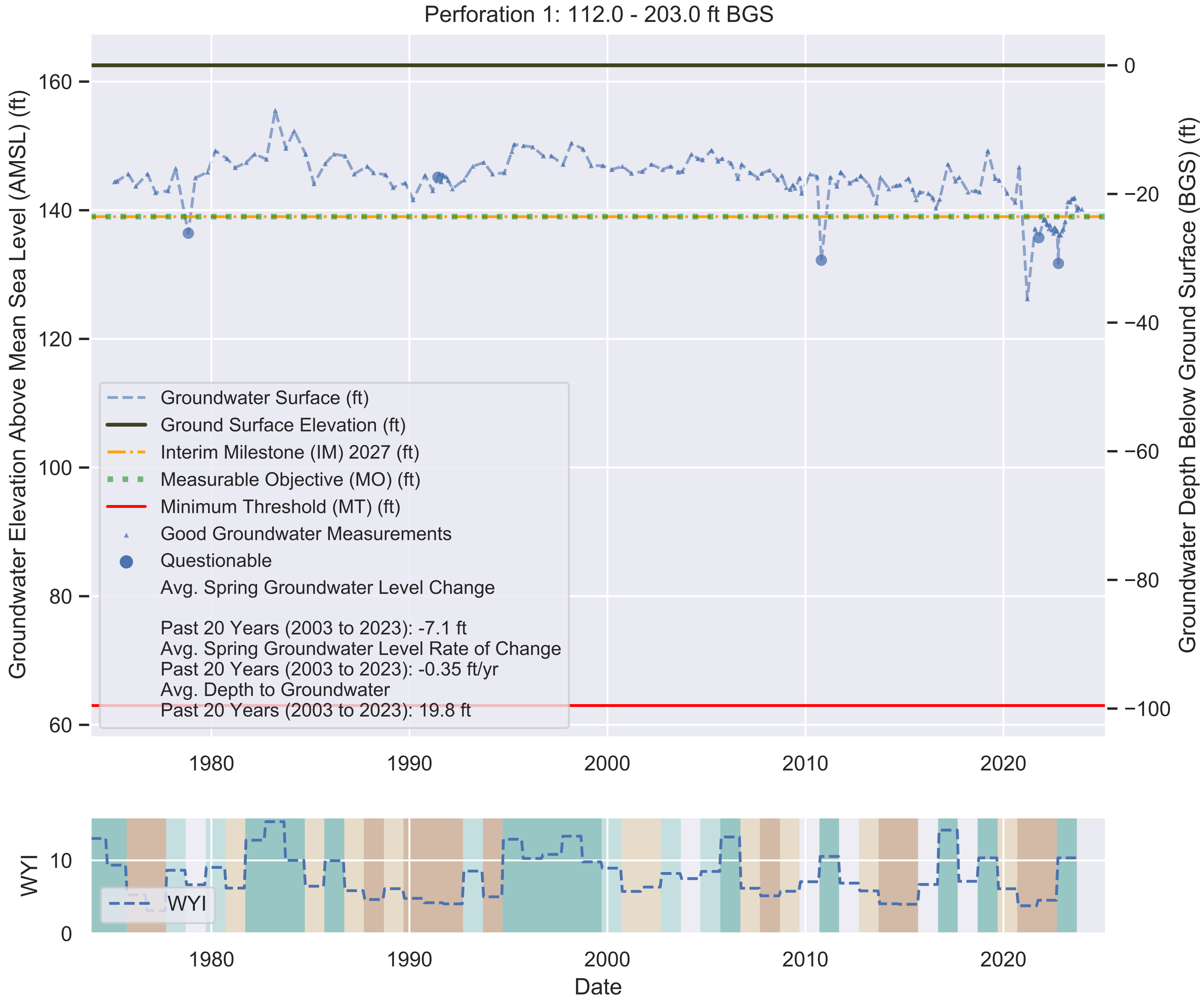
Sustainable Management Criteria:

IM (2027) = 139.0 ft AMSL
MO = 139.0 ft AMSL
MT = 63.0 ft AMSL

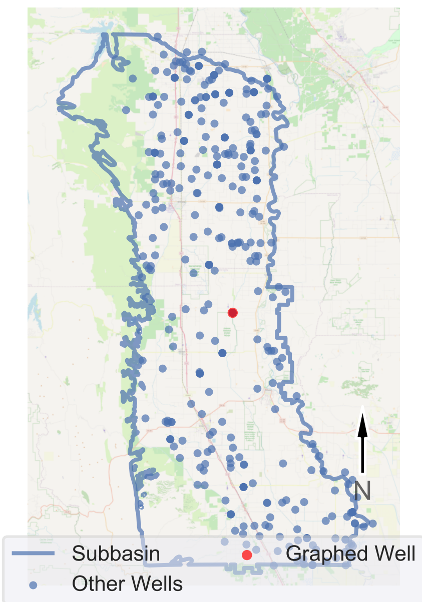
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 17N02W09H004M

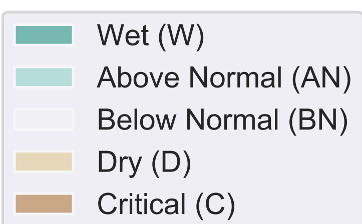


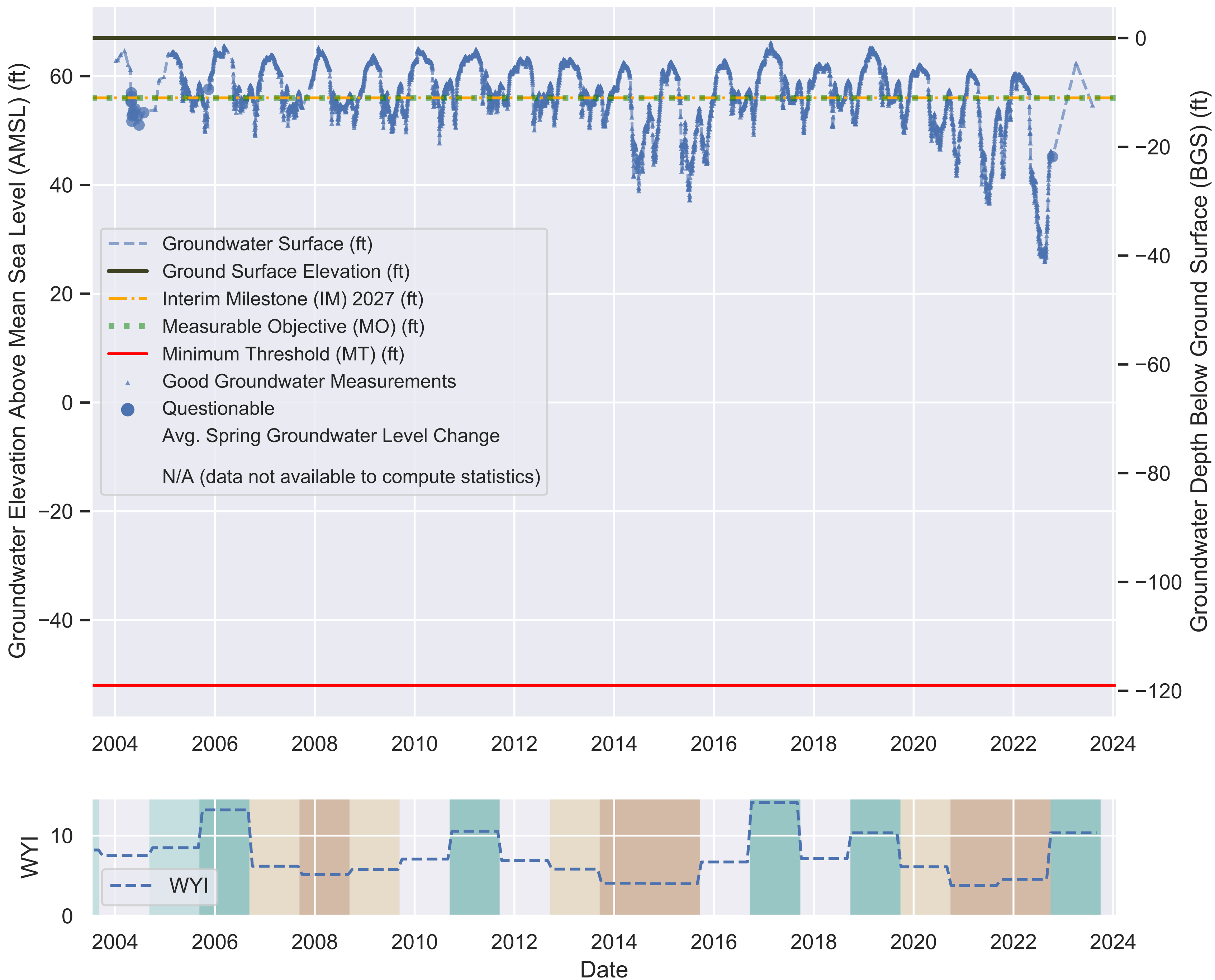
Sustainable Management Criteria:

IM (2027) = 56.0 ft AMSL
MO = 56.0 ft AMSL
MT = -52.0 ft AMSL

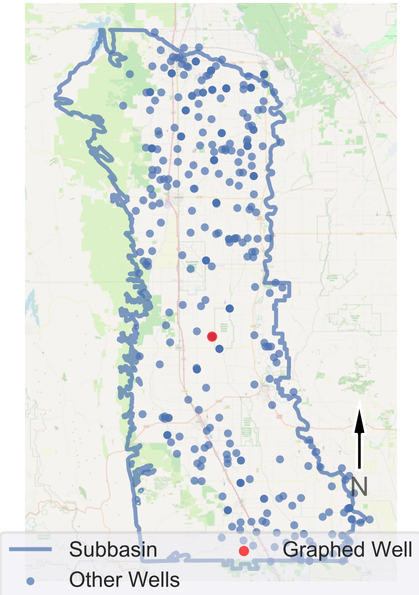
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 17N02W30J002M

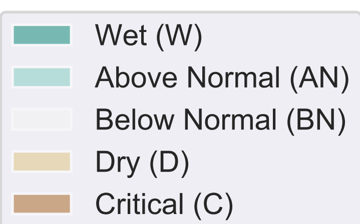


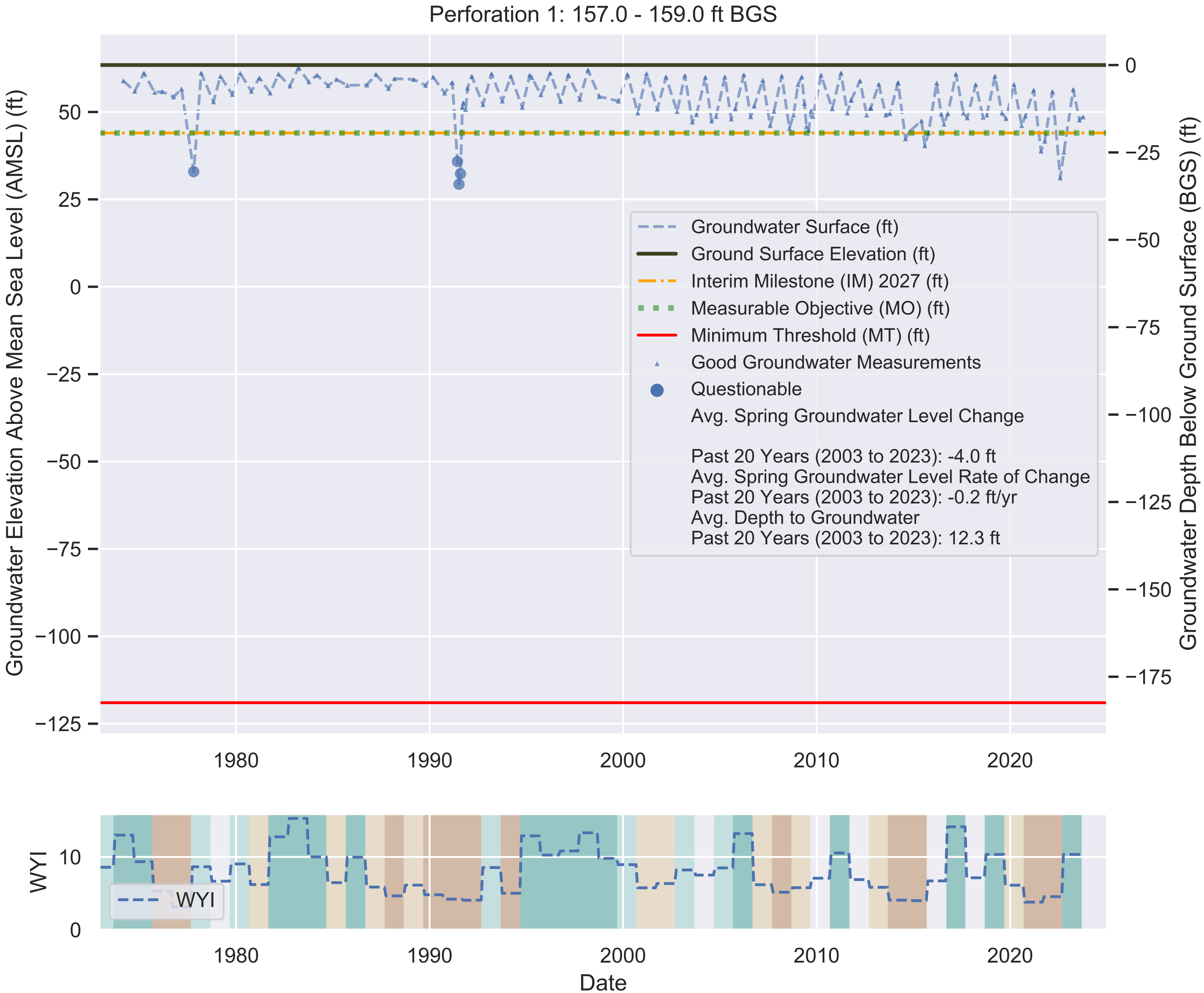
Sustainable Management Criteria:

IM (2027) = 44.0 ft AMSL
MO = 44.0 ft AMSL
MT = -119.0 ft AMSL

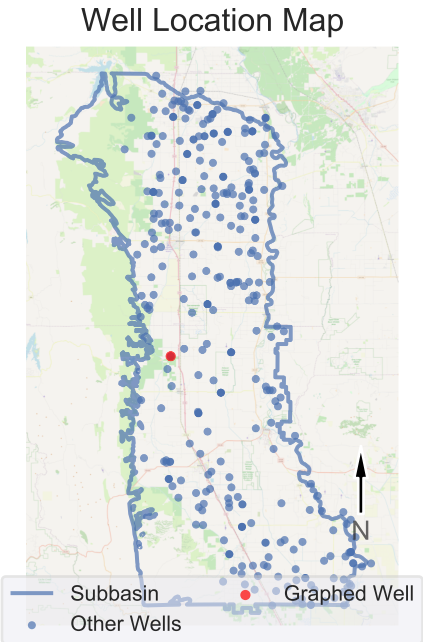
Minimum Threshold is the 20th Percentile of Domestic.

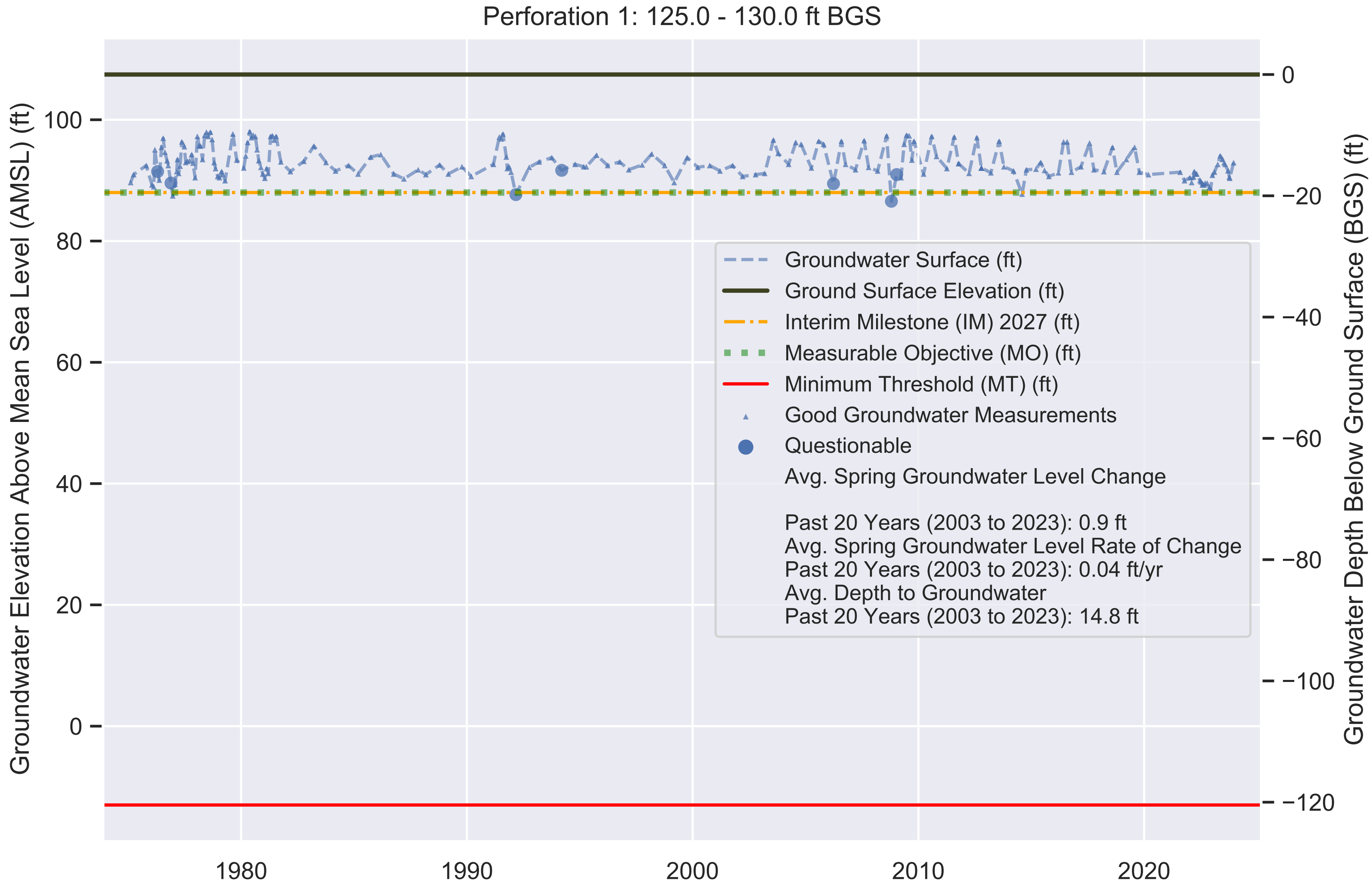
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 17N03W08R001M



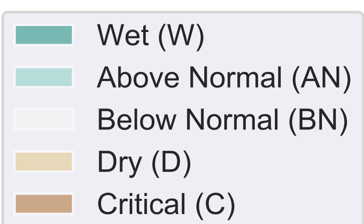


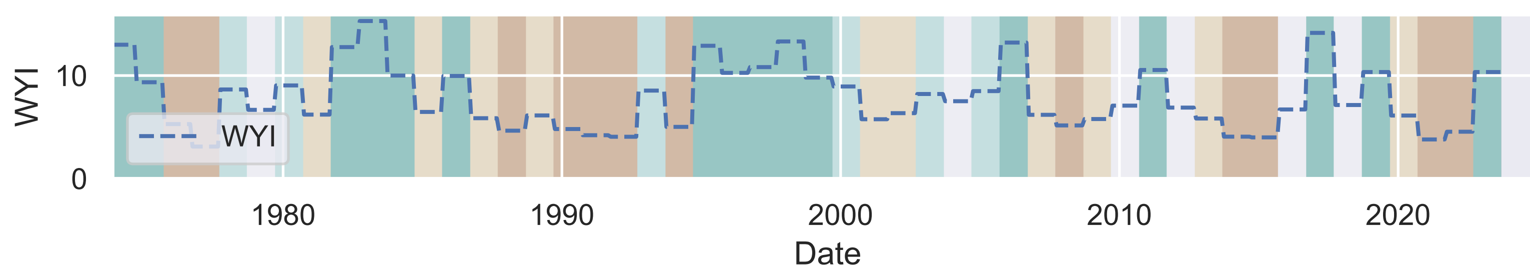
Sustainable Management Criteria:

IM (2027) = 88.0 ft AMSL
MO = 88.0 ft AMSL
MT = -13.0 ft AMSL

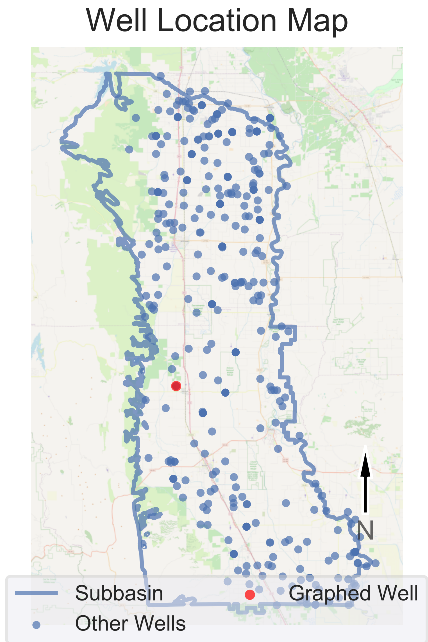
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 17N03W32H001M

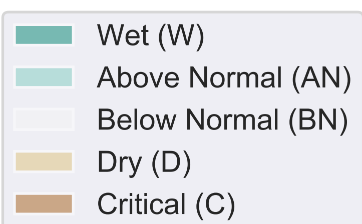


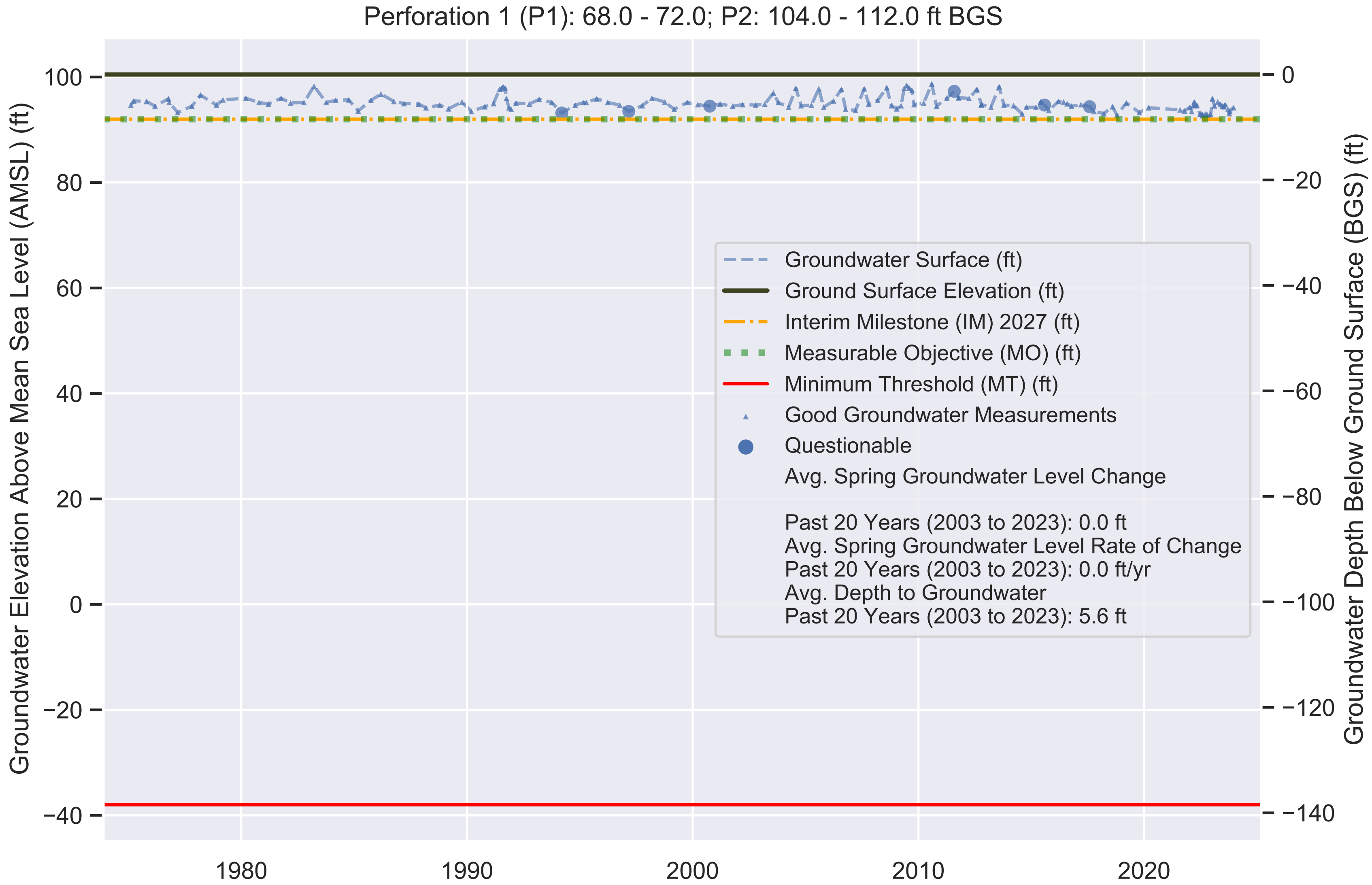
Sustainable Management Criteria:

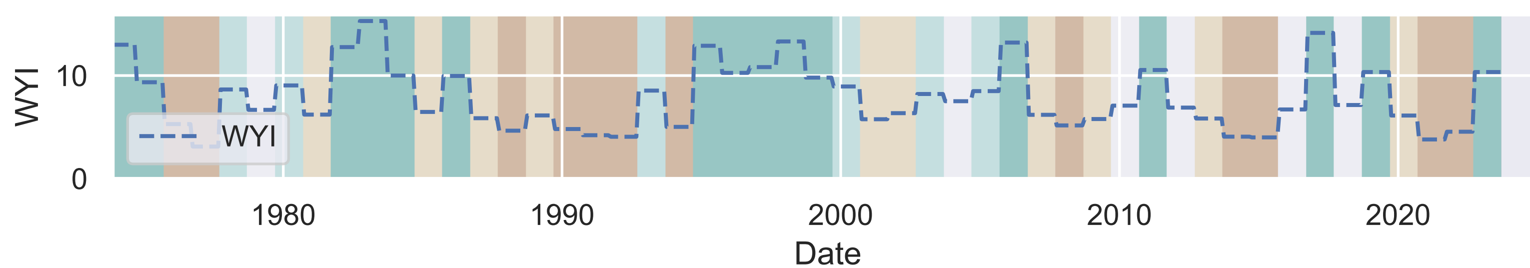
IM (2027) = 92.0 ft AMSL
MO = 92.0 ft AMSL
MT = -38.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

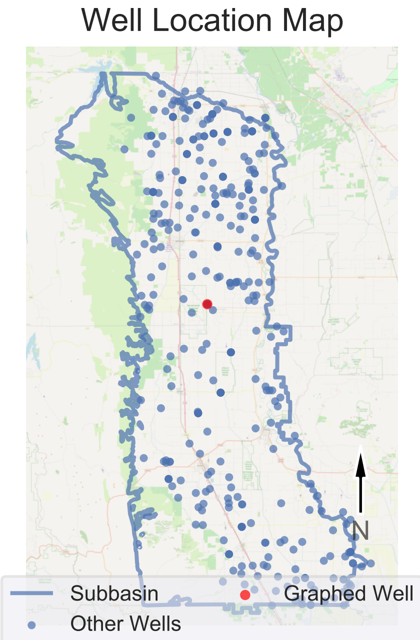
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

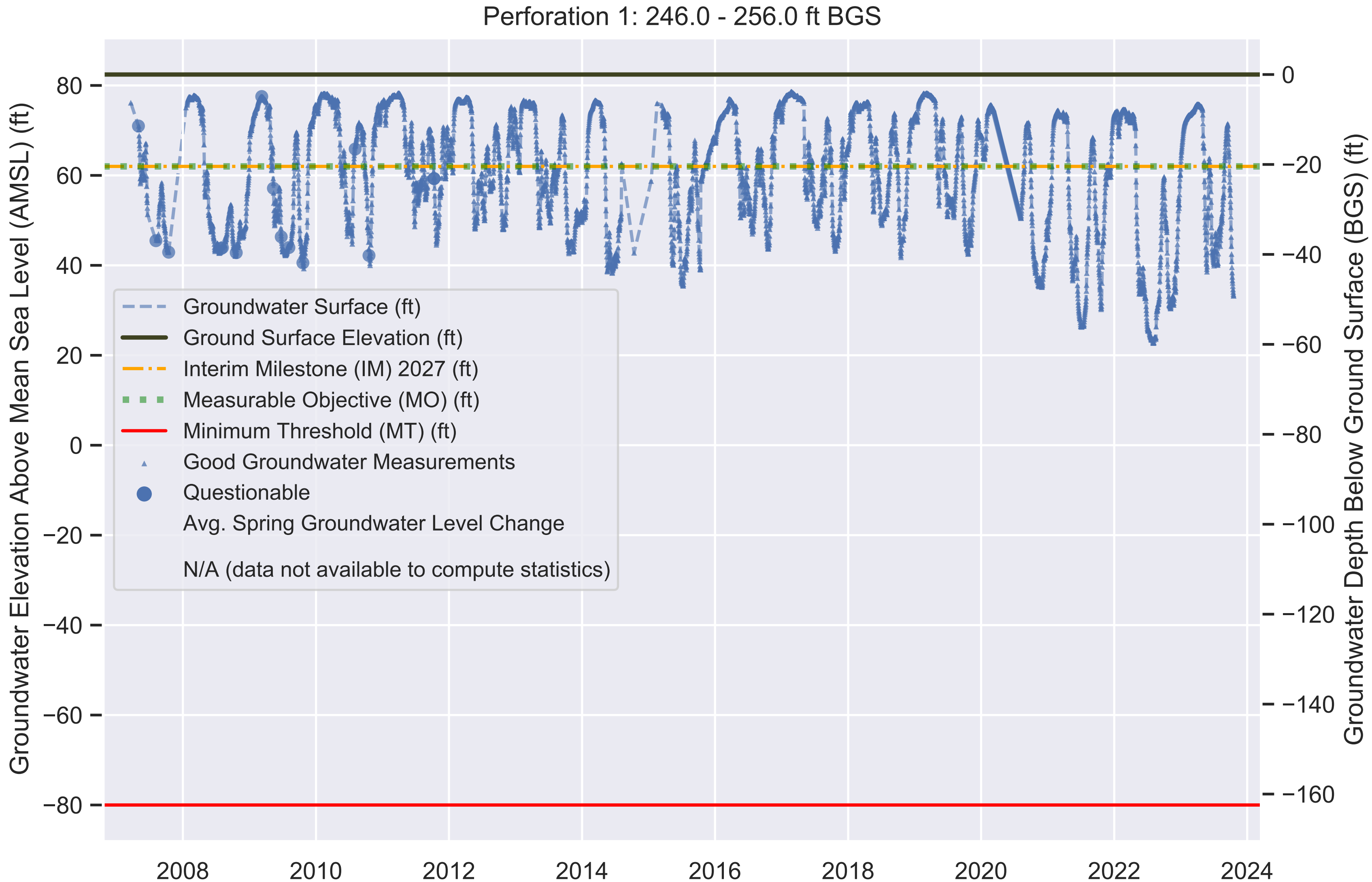






COLUSA Subbasin - State Well Number (SWN): 18N02W18D004M



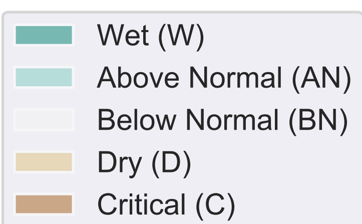


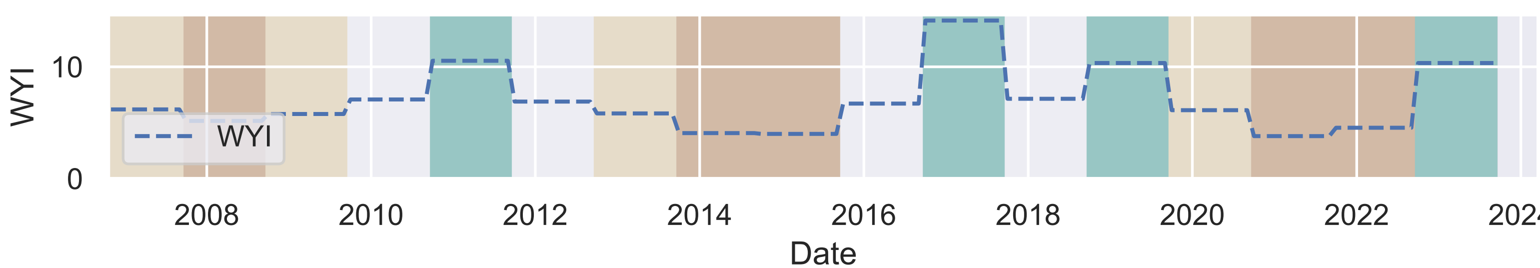
Sustainable Management Criteria:

IM (2027) = 62.0 ft AMSL
MO = 62.0 ft AMSL
MT = -80.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

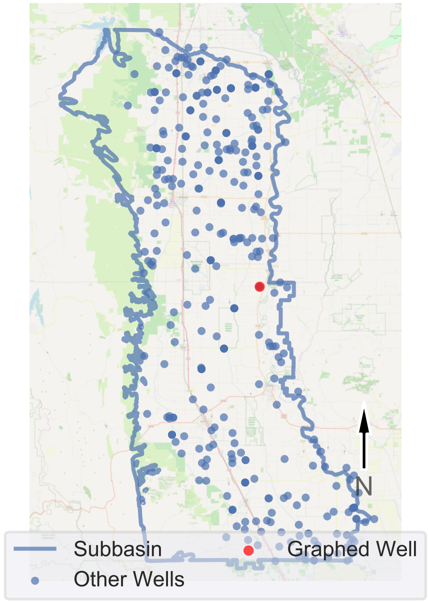
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





COLUSA Subbasin - State Well Number (SWN): 18N02W36B001M

Well Location Map

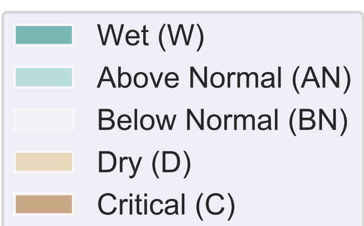


Sustainable Management Criteria:

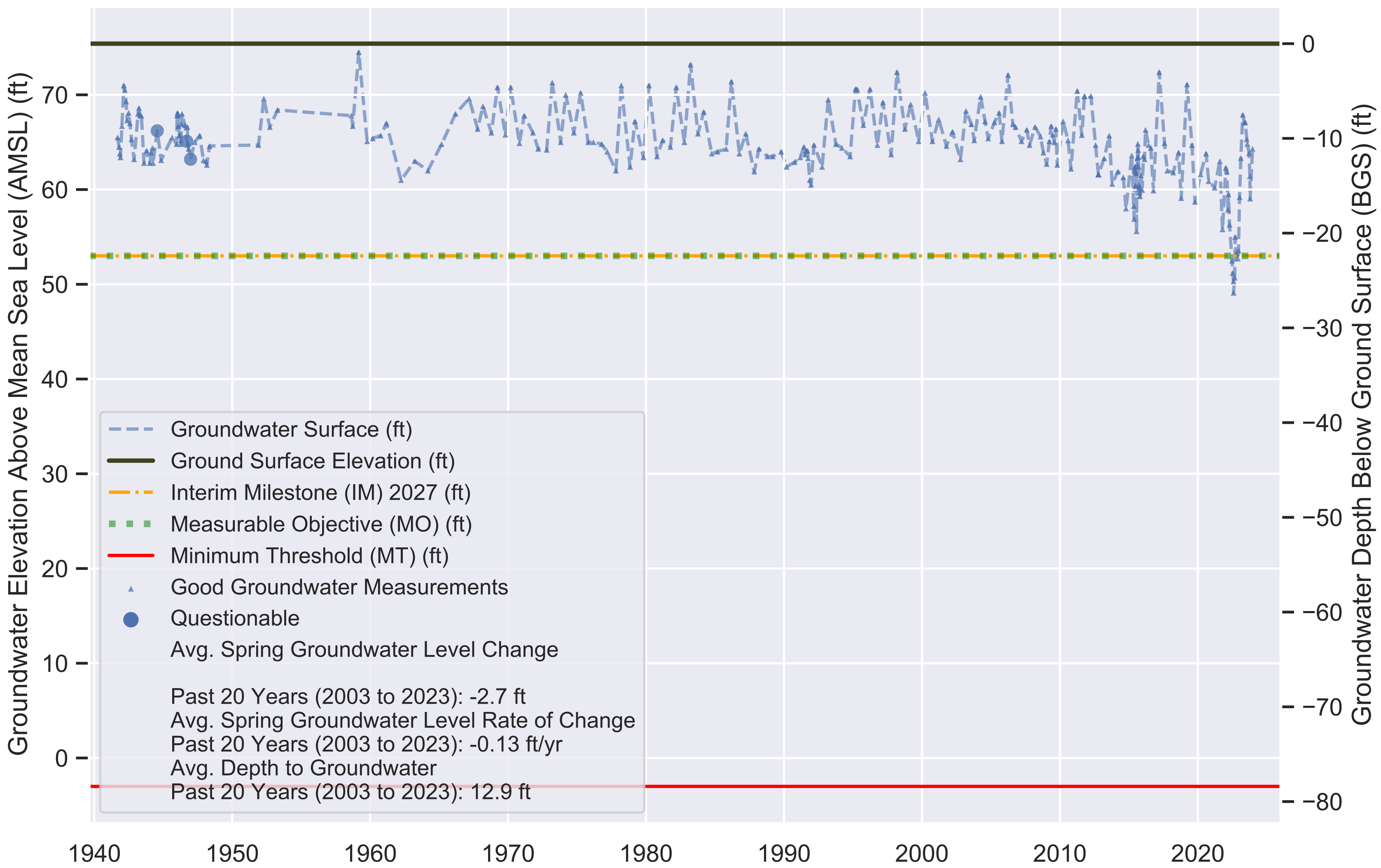
IM (2027) = 53.0 ft AMSL
MO = 53.0 ft AMSL
MT = -3.0 ft AMSL

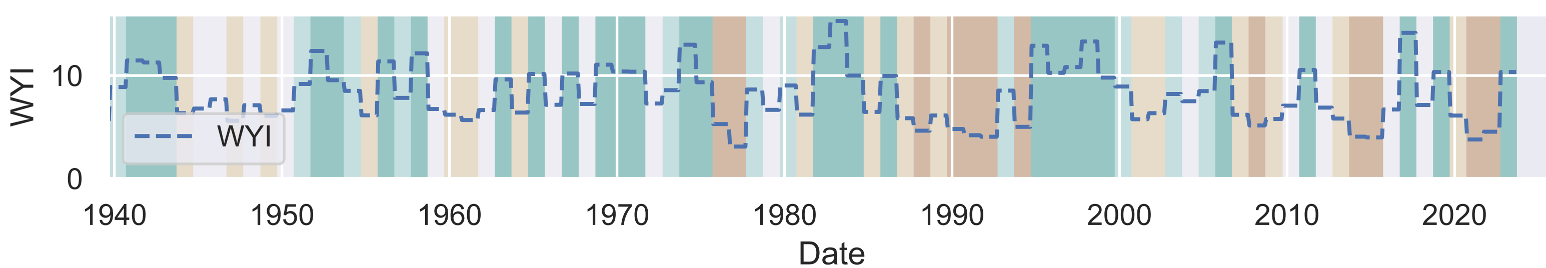
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



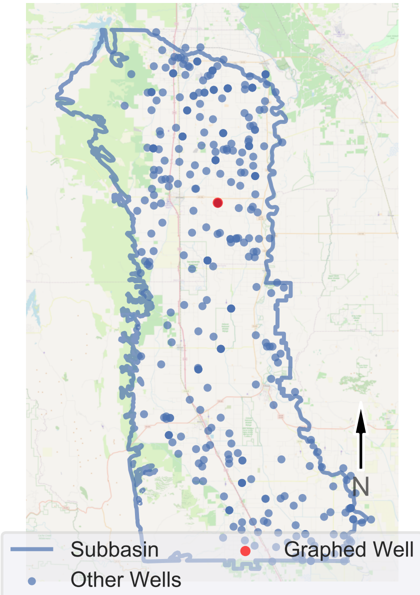
Perforation 1 (P1): 88.0 - 128.0; P2: 195.0 - 225.0; P3: 240.0 - 340.0 ft BGS





COLUSA Subbasin - State Well Number (SWN): 19N02W08Q002M

Well Location Map



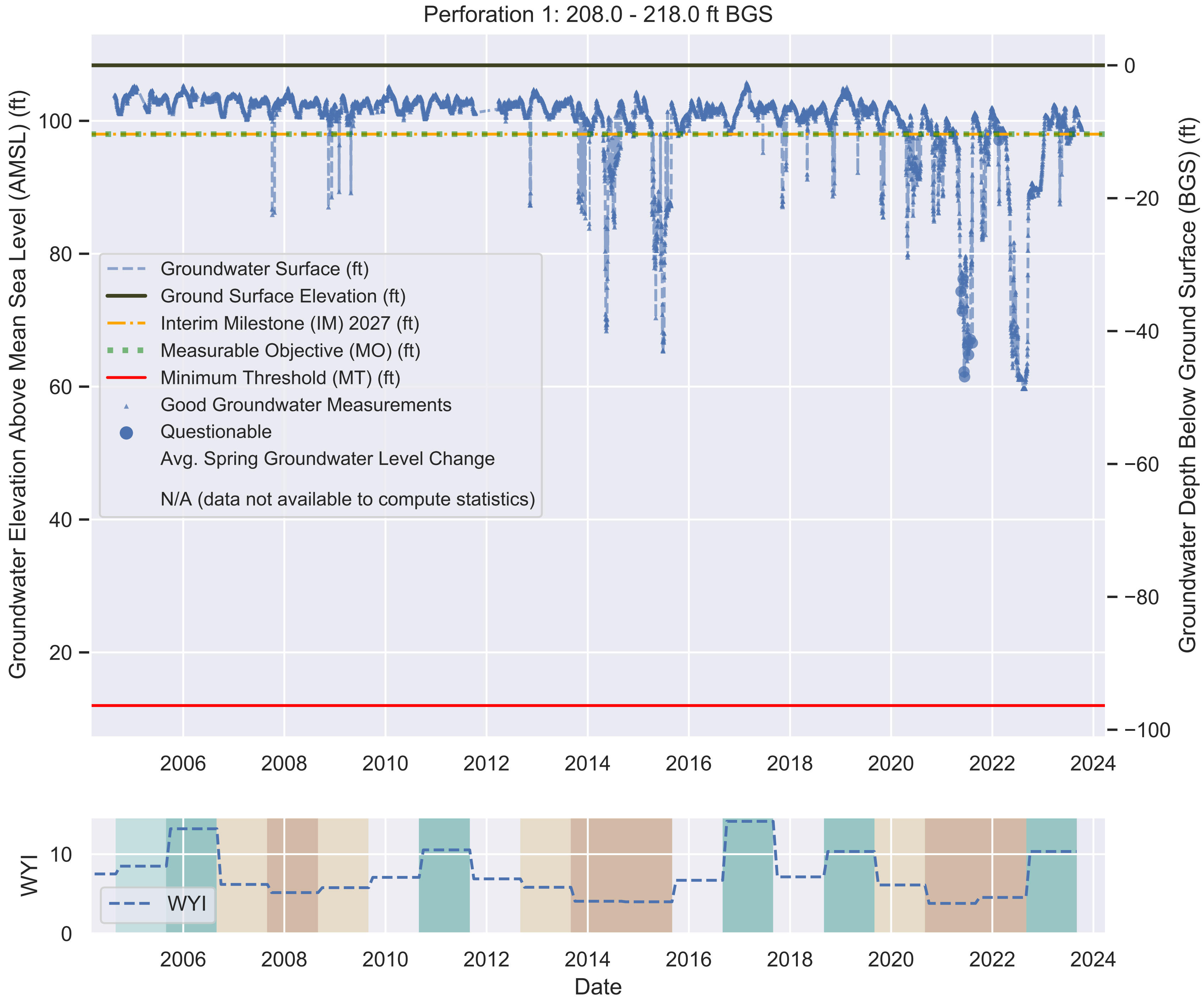
Sustainable Management Criteria:

IM (2027) = 98.0 ft AMSL
MO = 98.0 ft AMSL
MT = 12.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

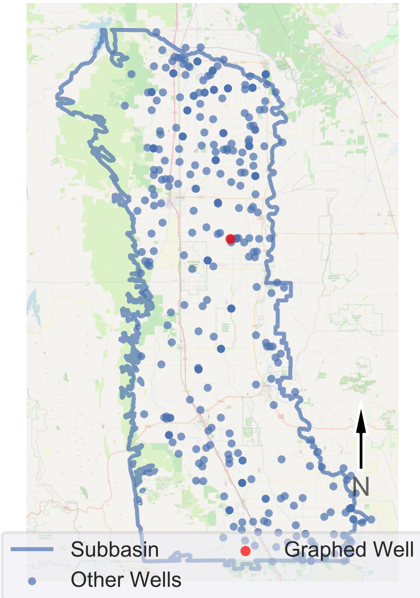
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 19N02W33K001M

Well Location Map

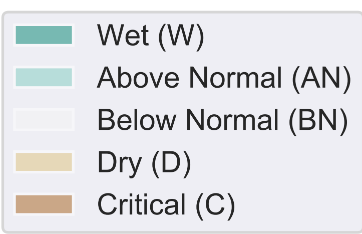


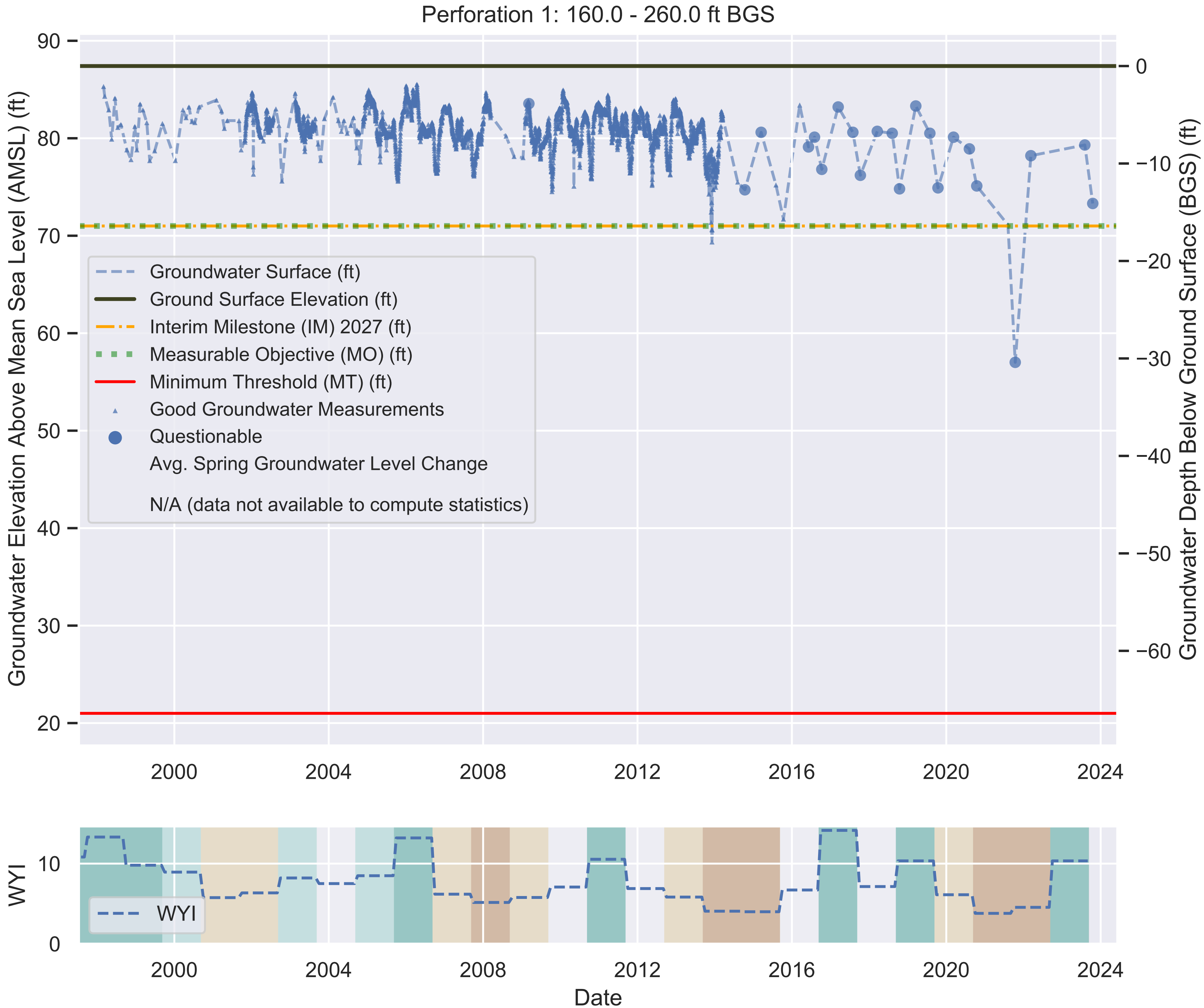
Sustainable Management Criteria:

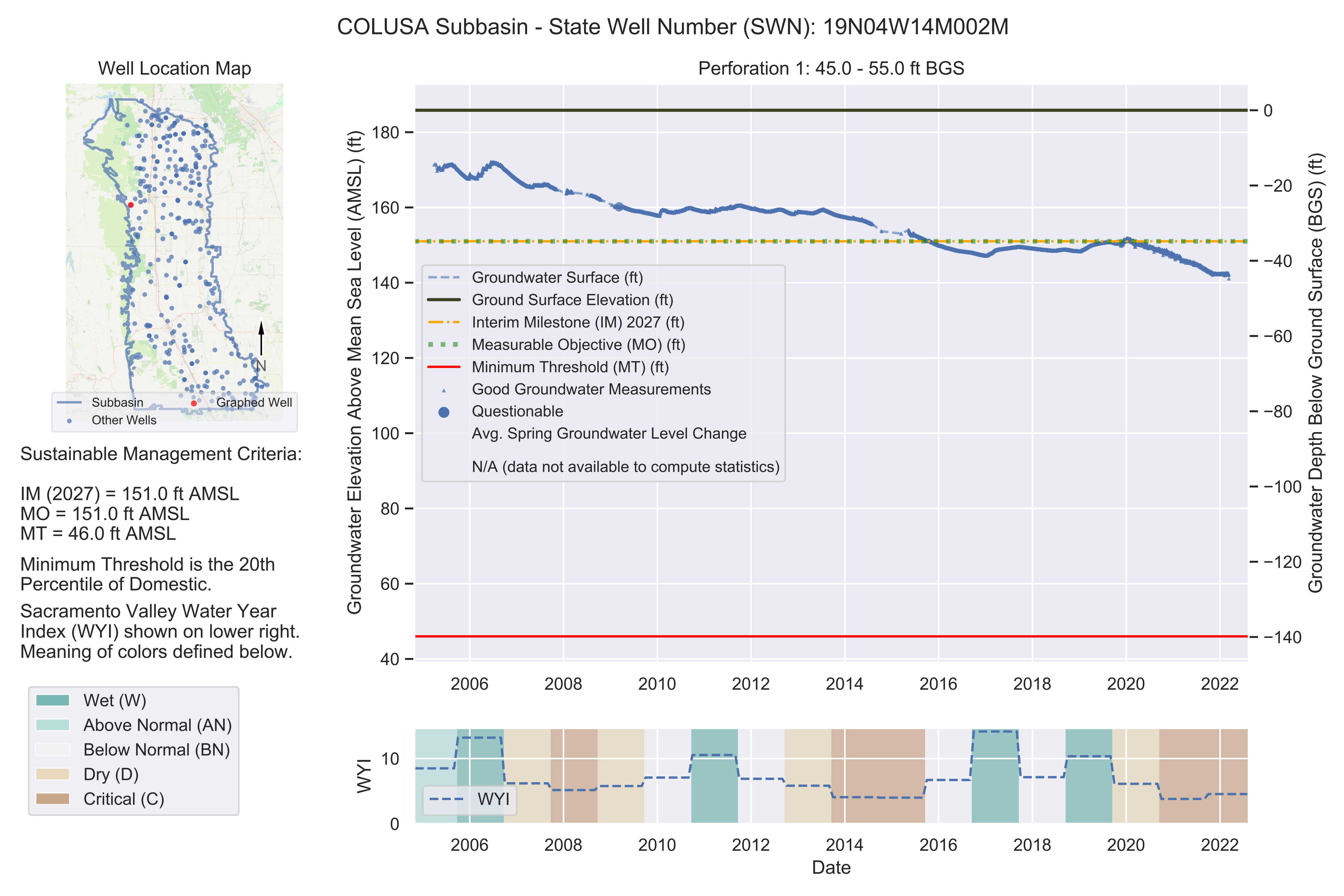
IM (2027) = 71.0 ft AMSL
MO = 71.0 ft AMSL
MT = 21.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



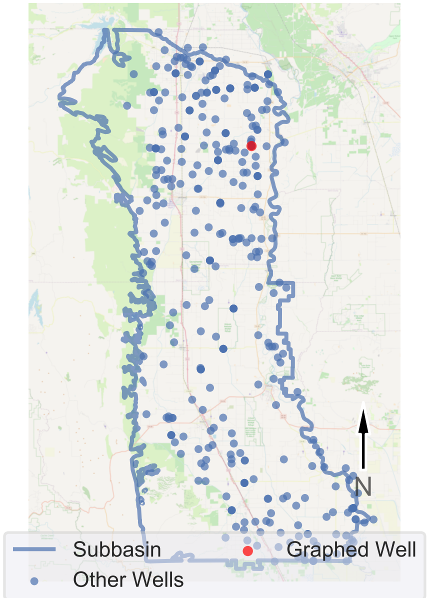




COLUSA Subbasin - State Well Number (SWN): 19N04W14M002M
Well Location Map
Subbasin
Graphed Well
Other Wells
N
Sustainable Management Criteria:
IM (2027) = 151.0 ft AMSL
MO = 151.0 ft AMSL
MT = 46.0 ft AMSL
Minimum Threshold is the 20th Percentile of Domestic.
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.
Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)
Perforation 1: 45.0 - 55.0 ft BGS
Groundwater Elevation Above Mean Sea Level (AMSL) (ft)
Groundwater Depth Below Ground Surface (BGS) (ft)
Groundwater Surface (ft)
Ground Surface Elevation (ft)
Interim Milestone (IM) 2027 (ft)
Measurable Objective (MO) (ft)
Minimum Threshold (MT) (ft)
Good Groundwater Measurements
Questionable
Avg. Spring Groundwater Level Change
N/A (data not available to compute statistics)
180
160
140
120
100
80
60
40
0
−20
−40
−60
−80
−100
−120
−140
2006
2008
2010
2012
2014
2016
2018
2020
2022
WYI
10
0
Date

COLUSA Subbasin - State Well Number (SWN): 20N02W11A001M

Well Location Map



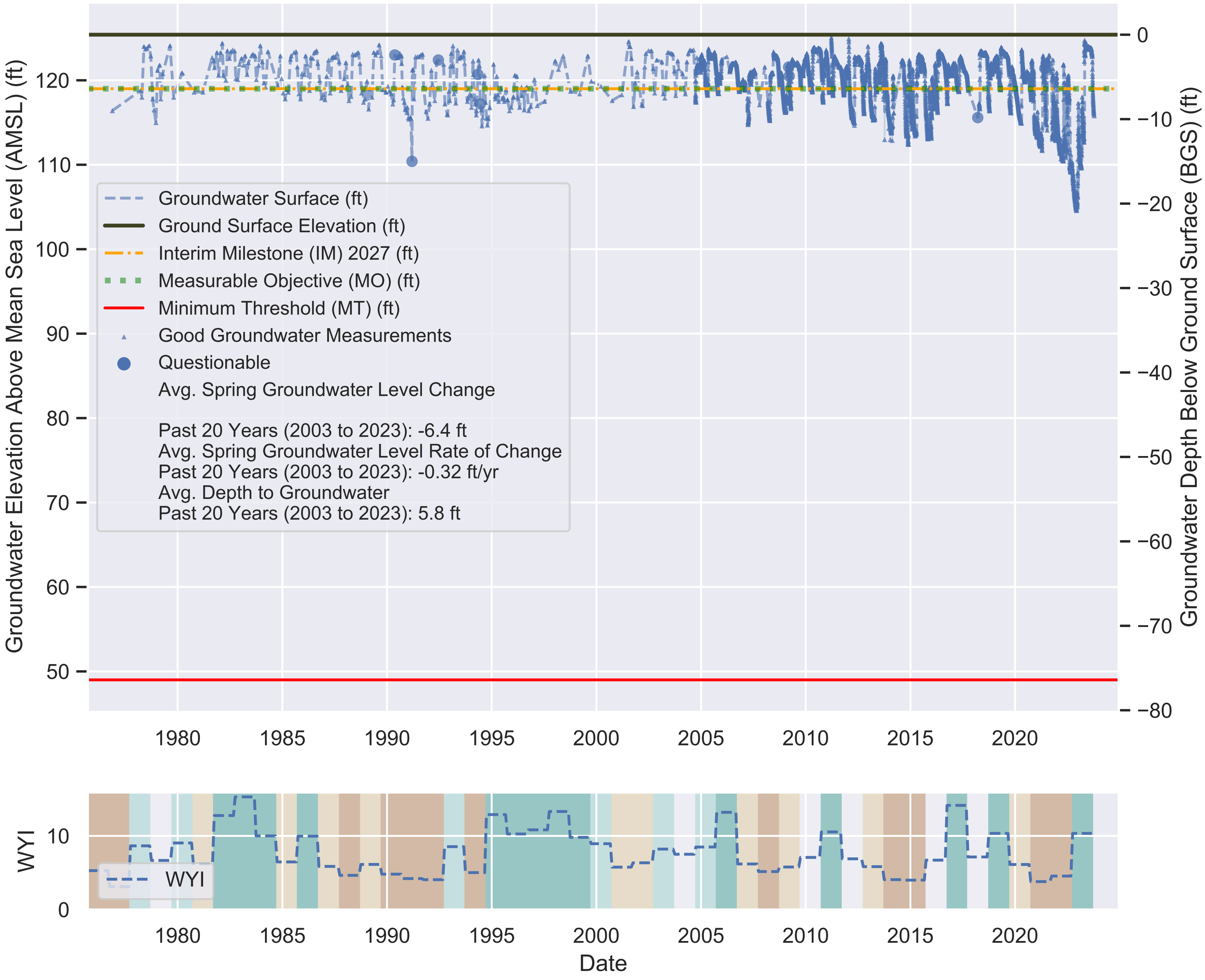
Sustainable Management Criteria:

IM (2027) = 119.0 ft AMSL
MO = 119.0 ft AMSL
MT = 49.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

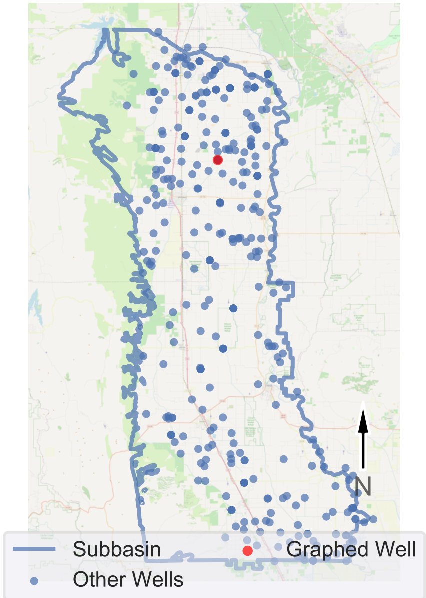
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

Perforation 1: 70.0 - 90.0 ft BGS



COLUSA Subbasin - State Well Number (SWN): 20N02W18R008M

Well Location Map

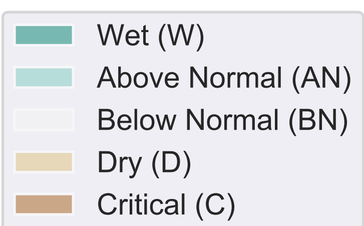


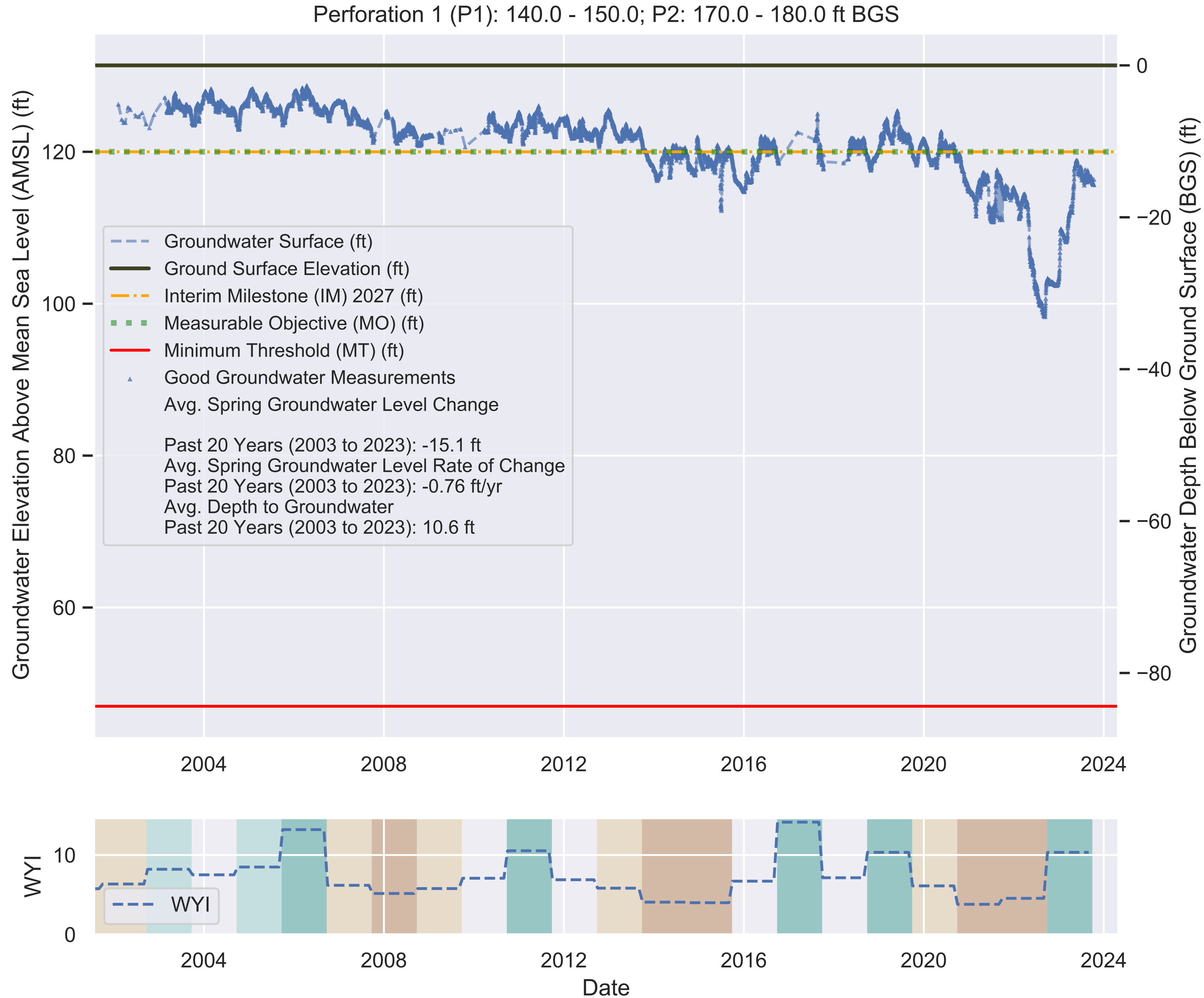
Sustainable Management Criteria:

IM (2027) = 120.0 ft AMSL
MO = 120.0 ft AMSL
MT = 47.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

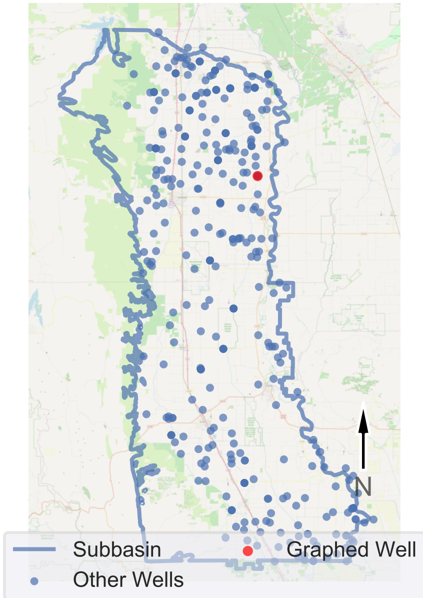
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



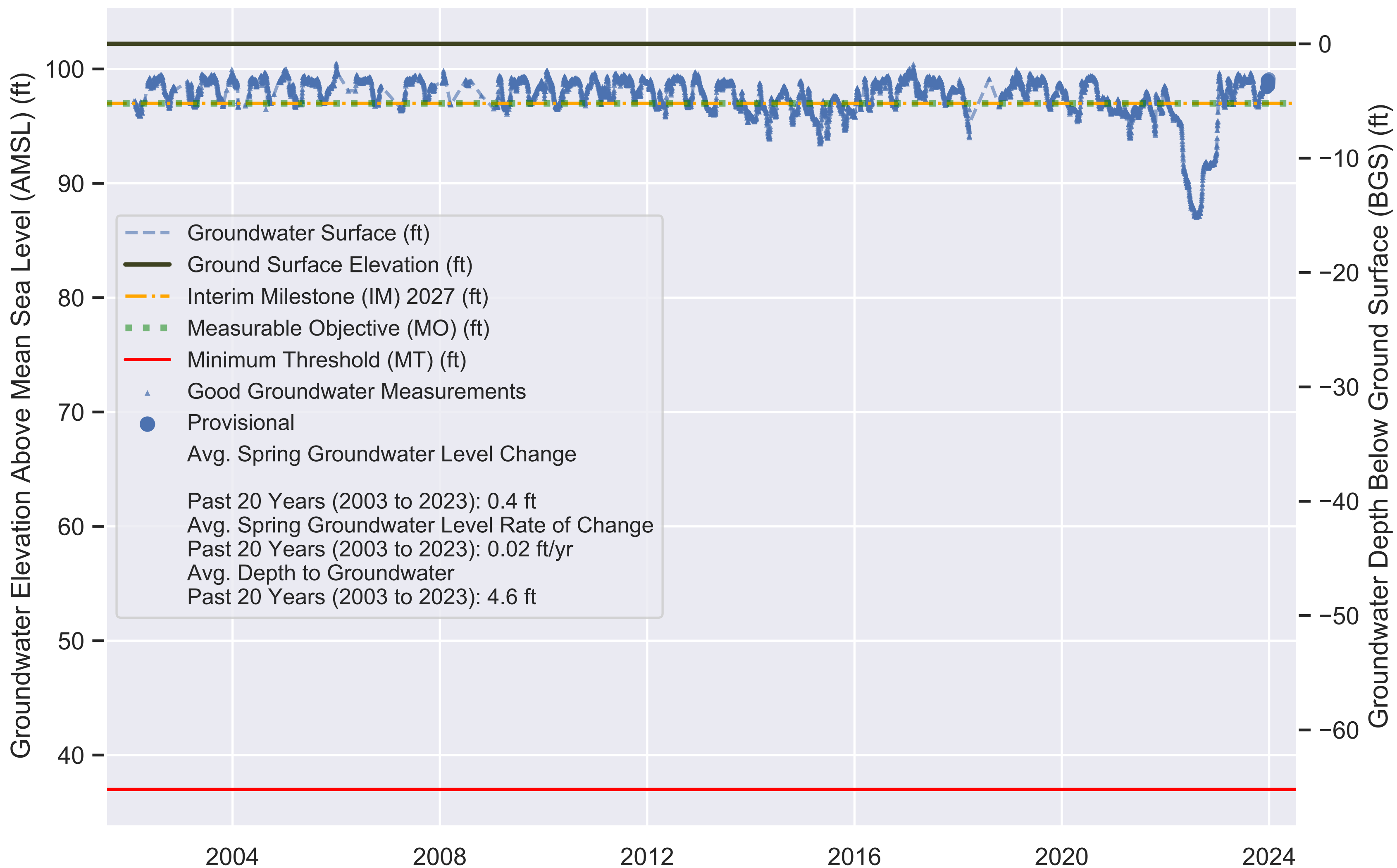


COLUSA Subbasin - State Well Number (SWN): 20N02W25F004M

Well Location Map



Perforation 1: 55.0 - 65.0 ft BGS



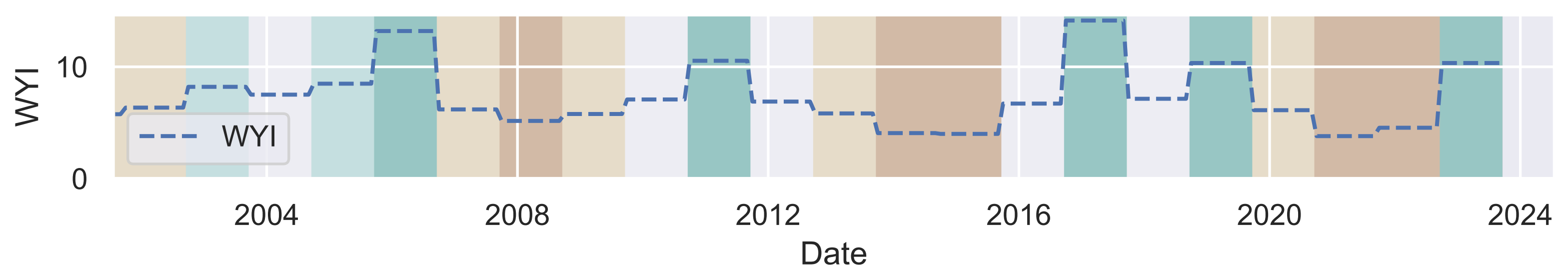
Sustainable Management Criteria:

IM (2027) = 97.0 ft AMSL
MO = 97.0 ft AMSL
MT = 37.0 ft AMSL

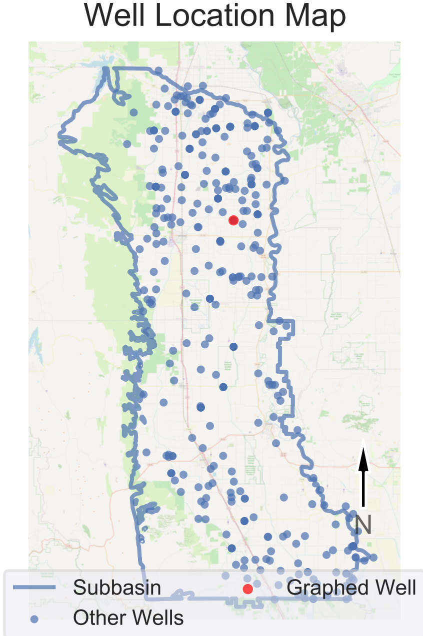
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 20N02W33B001M

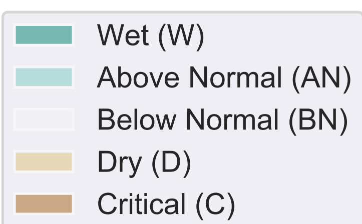


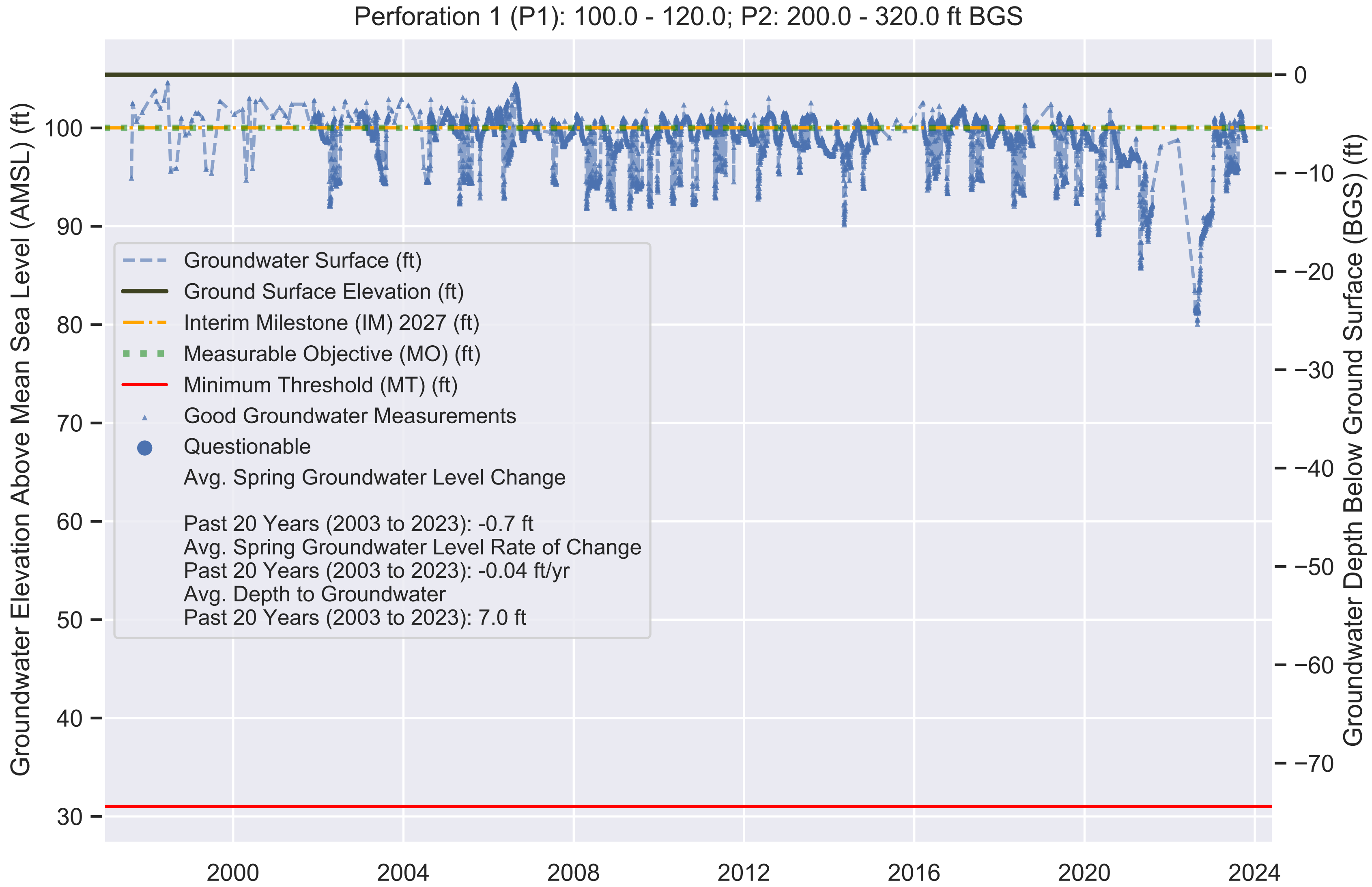
Sustainable Management Criteria:

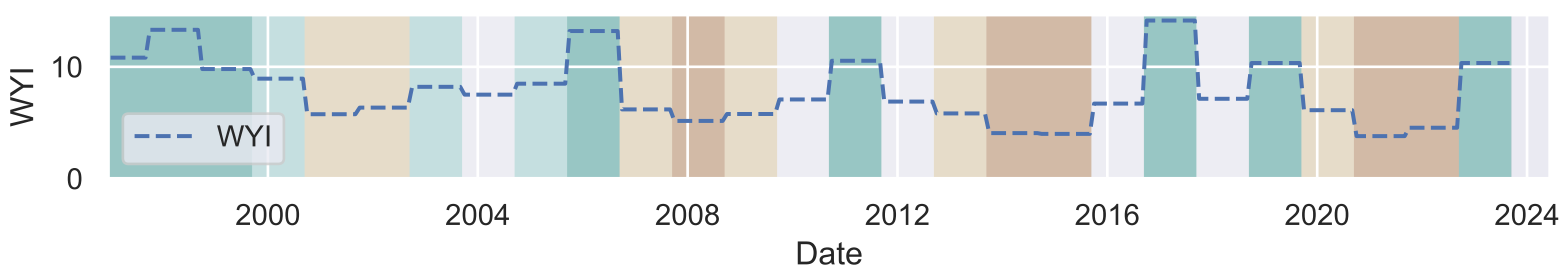
IM (2027) = 100.0 ft AMSL
MO = 100.0 ft AMSL
MT = 31.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

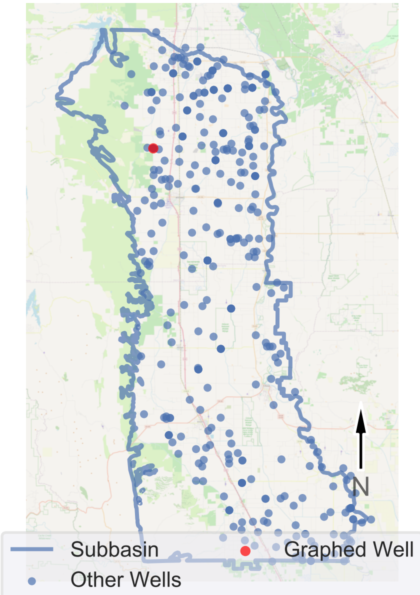






COLUSA Subbasin - State Well Number (SWN): 20N03W07E004M

Well Location Map

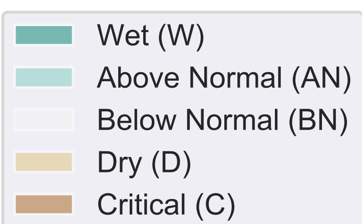


Sustainable Management Criteria:

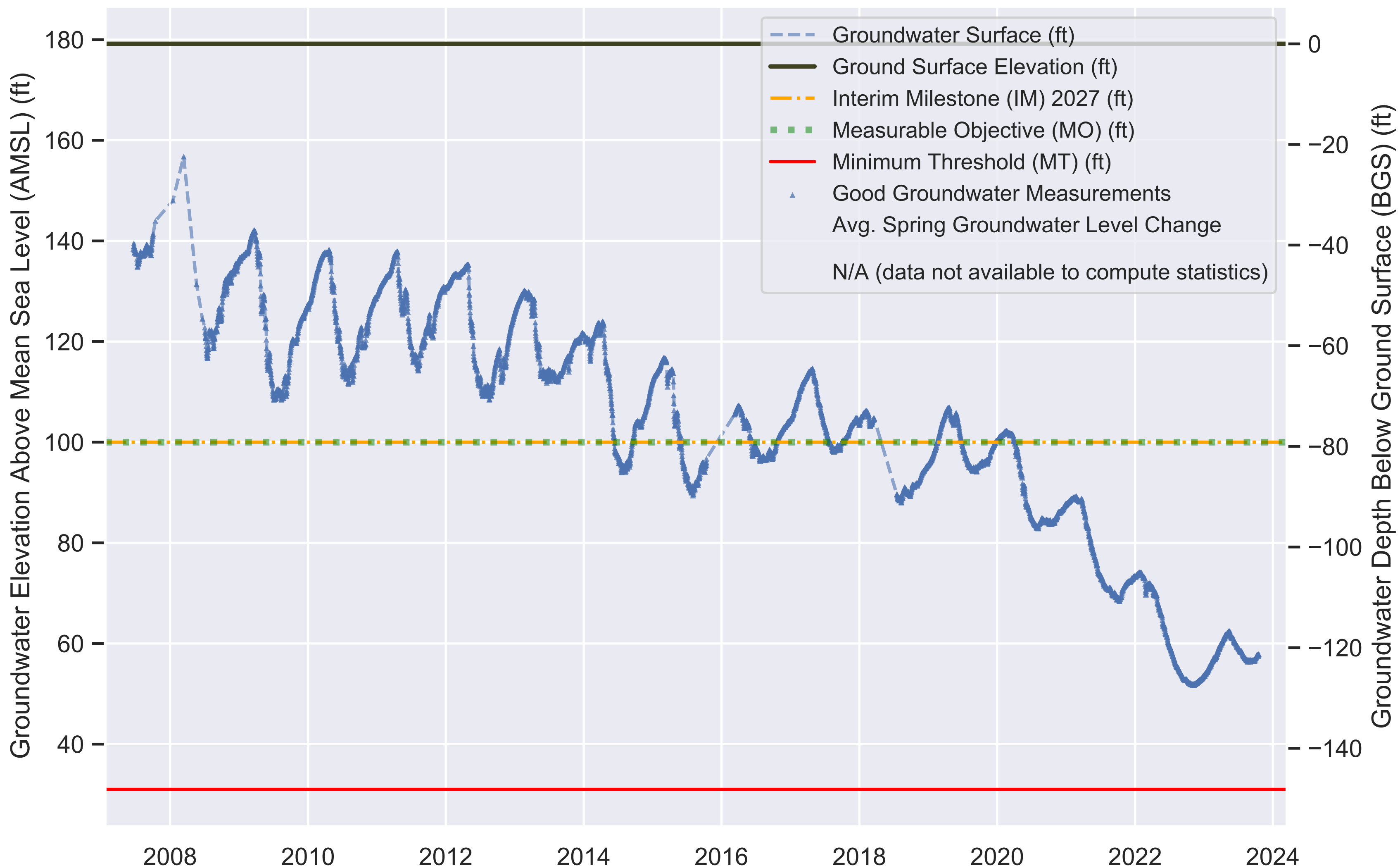
IM (2027) = 100.0 ft AMSL
MO = 100.0 ft AMSL
MT = 31.0 ft AMSL

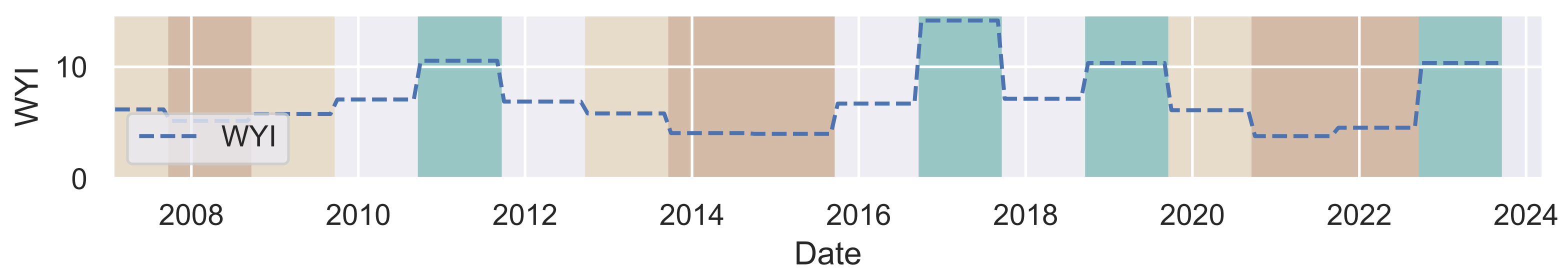
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

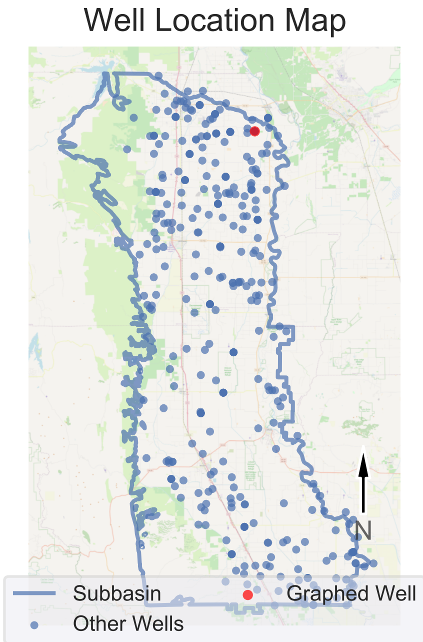


Perforation 1: 118.0 - 128.0 ft BGS





COLUSA Subbasin - State Well Number (SWN): 21N02W01F003M



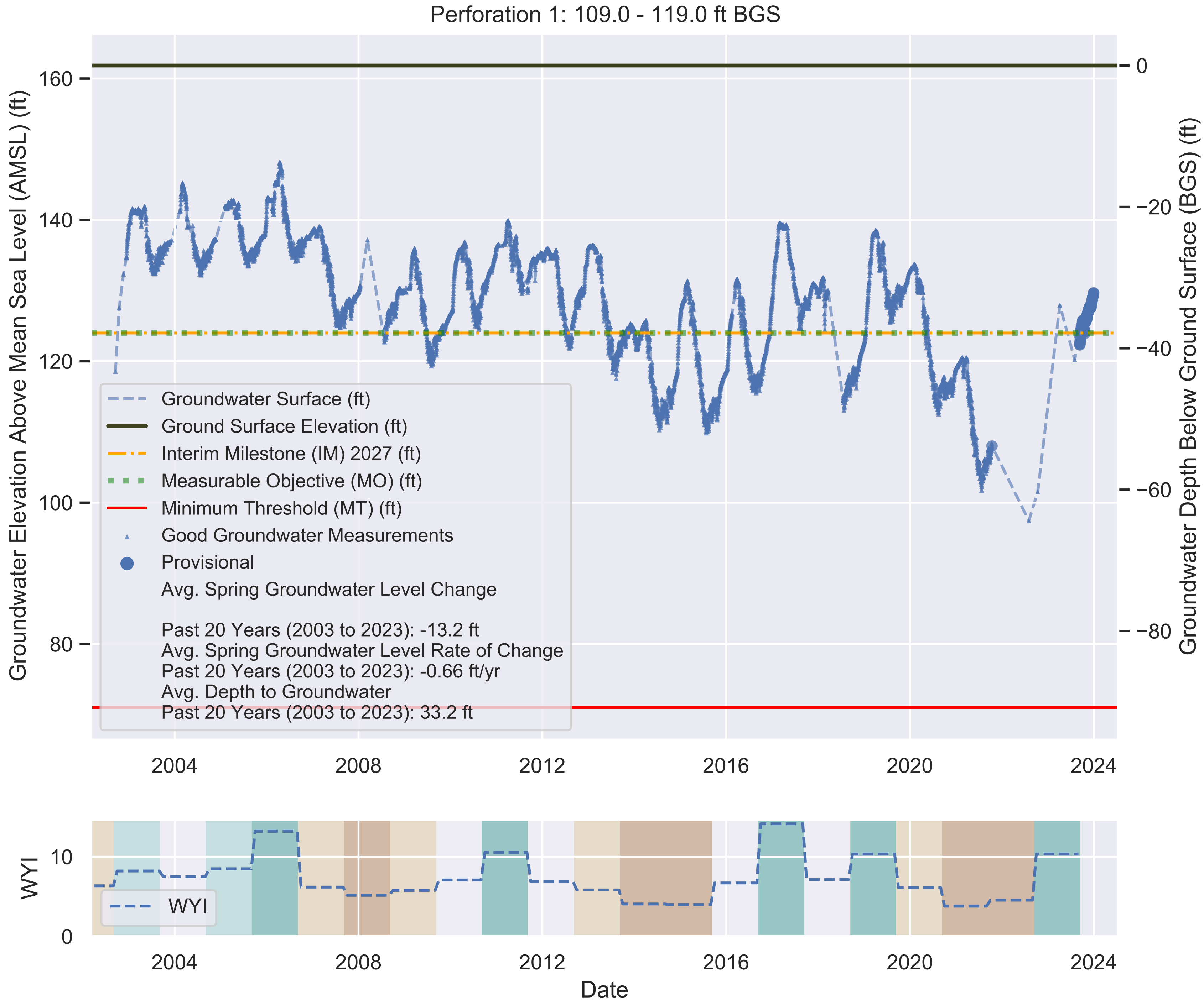
Sustainable Management Criteria:

IM (2027) = 124.0 ft AMSL
MO = 124.0 ft AMSL
MT = 71.0 ft AMSL

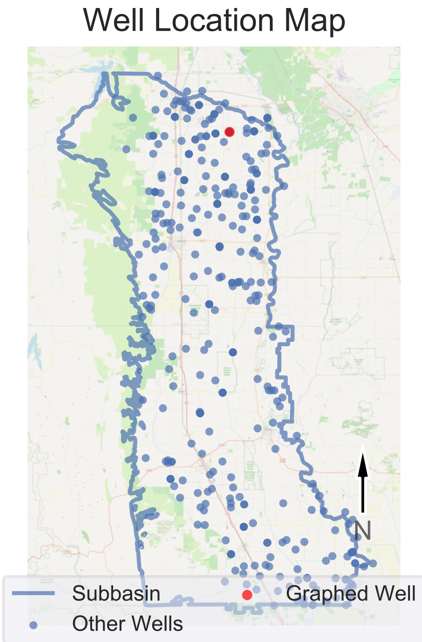
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 21N02W04G004M

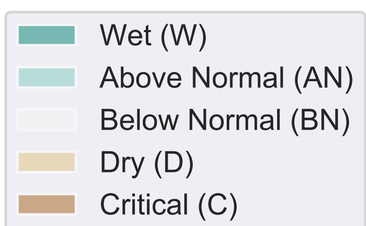


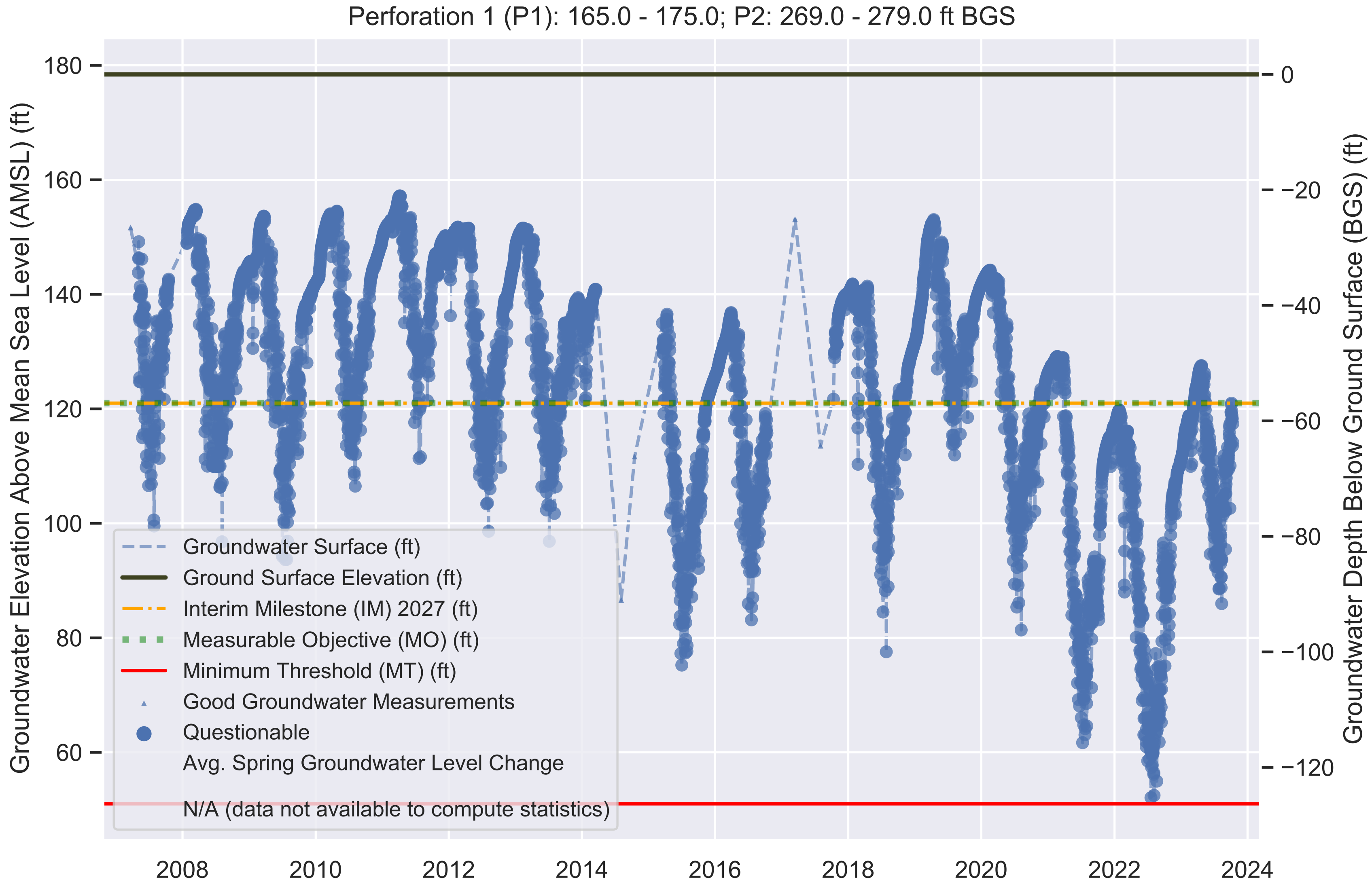
Sustainable Management Criteria:

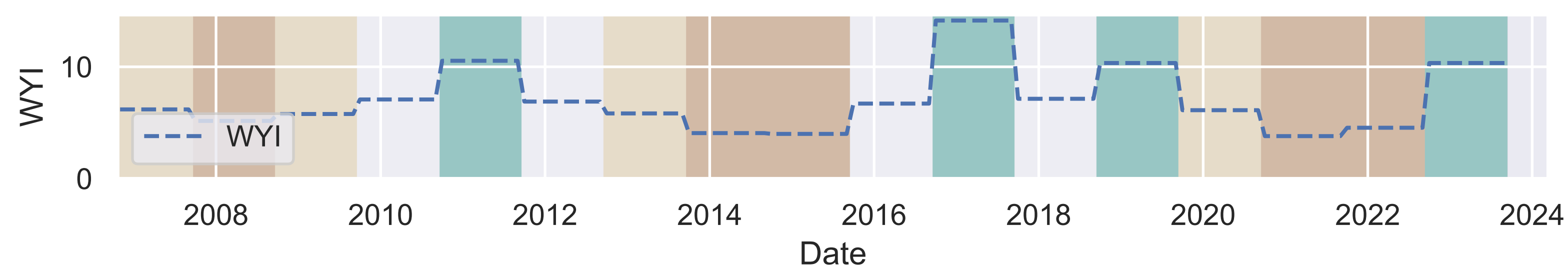
IM (2027) = 121.0 ft AMSL
MO = 121.0 ft AMSL
MT = 51.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

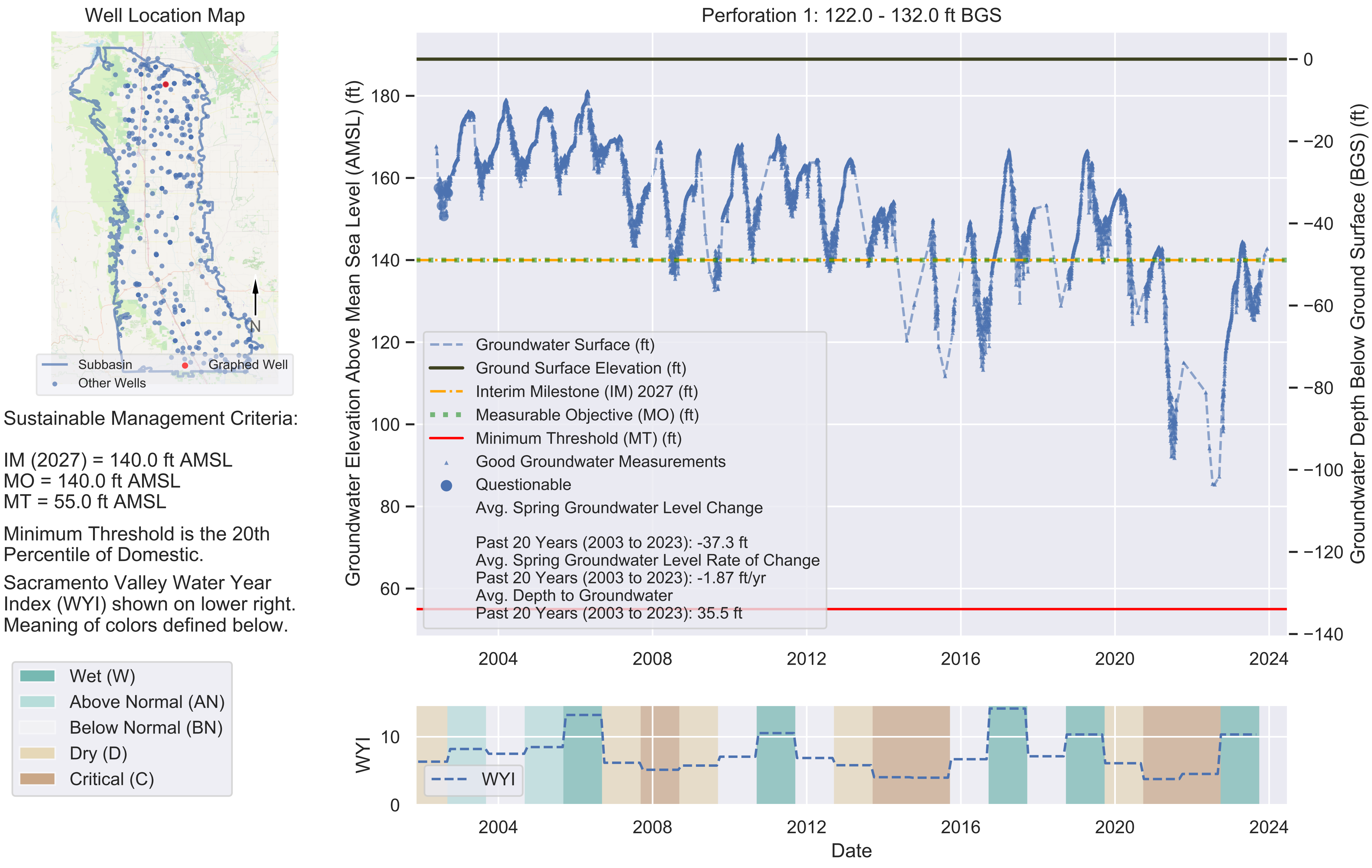
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





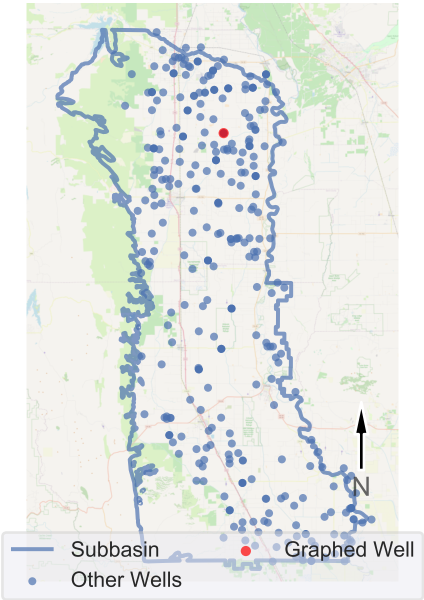


COLUSA Subbasin - State Well Number (SWN): 21N02W05M002M



COLUSA Subbasin - State Well Number (SWN): 21N02W33M003M

Well Location Map

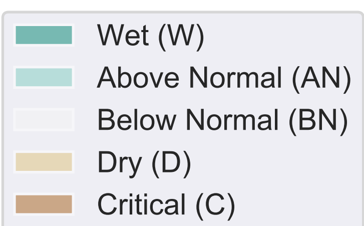


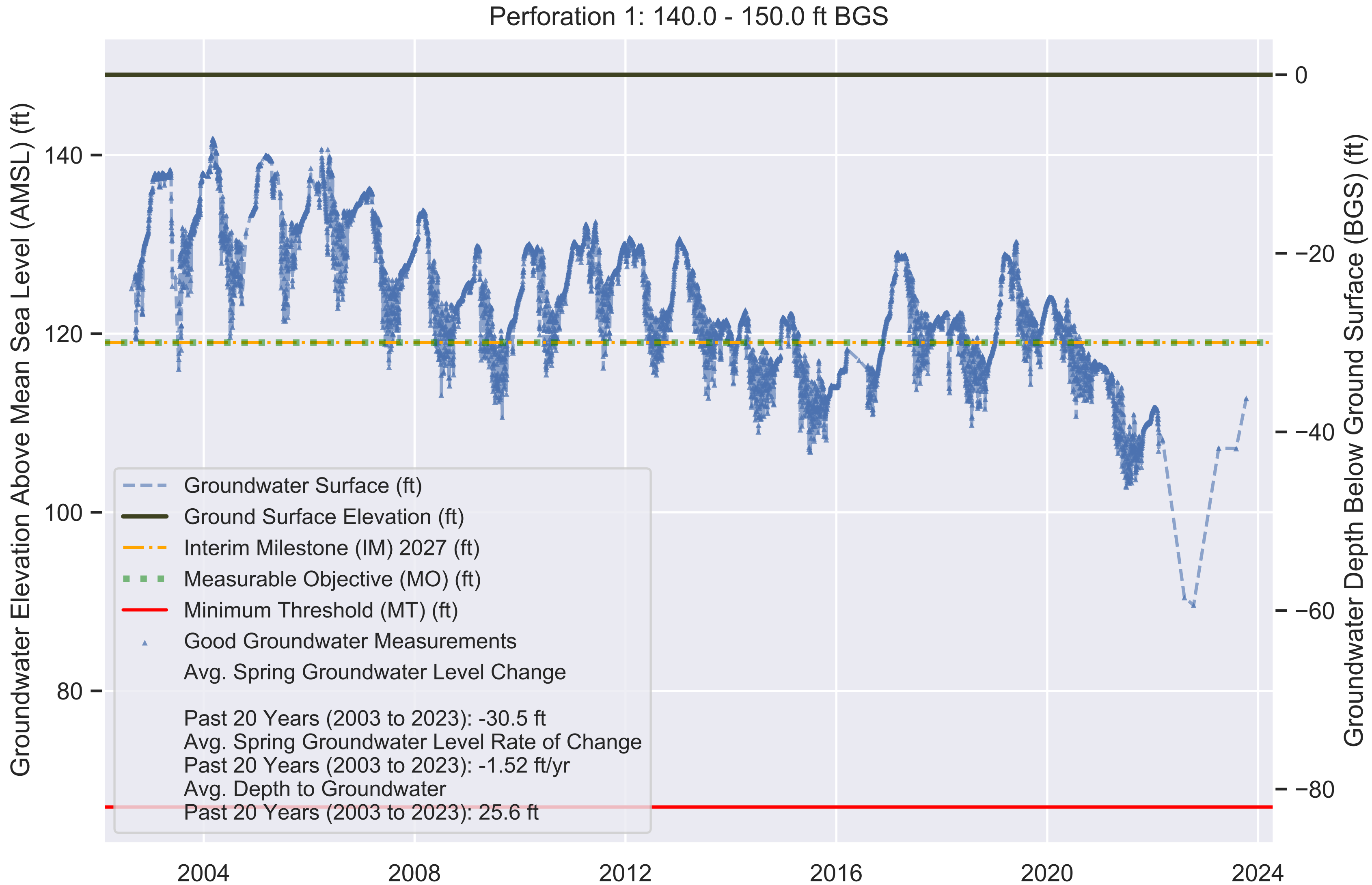
Sustainable Management Criteria:

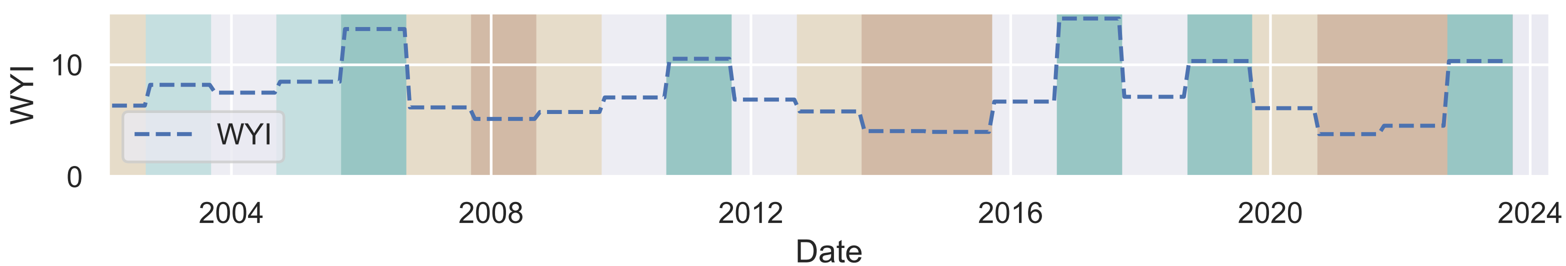
IM (2027) = 119.0 ft AMSL
MO = 119.0 ft AMSL
MT = 67.0 ft AMSL

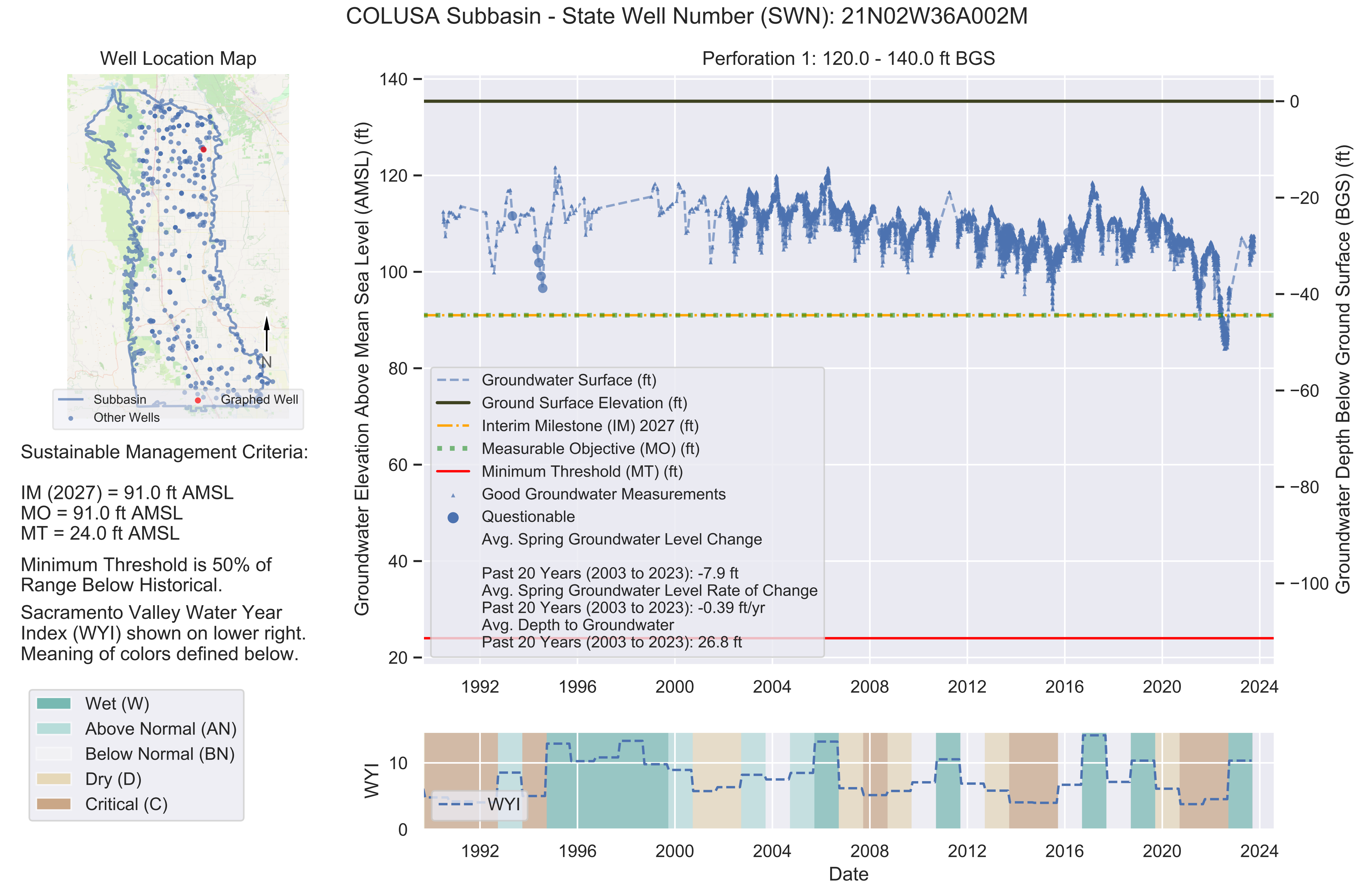
Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.





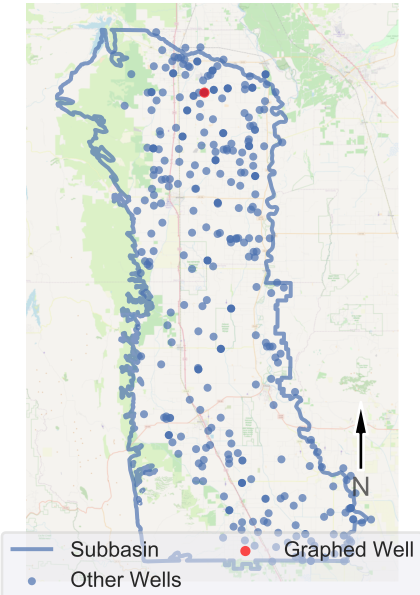




COLUSA Subbasin - State Well Number (SWN): 21N02W36A002M
Well Location Map
N
Subbasin
Graphed Well
Other Wells
Sustainable Management Criteria:
IM (2027) = 91.0 ft AMSL
MO = 91.0 ft AMSL
MT = 24.0 ft AMSL
Minimum Threshold is 50% of Range Below Historical.
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.
Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)
Perforation 1: 120.0 - 140.0 ft BGS
Groundwater Elevation Above Mean Sea Level (AMSL) (ft)
Groundwater Depth Below Ground Surface (BGS) (ft)
Groundwater Surface (ft)
Ground Surface Elevation (ft)
Interim Milestone (IM) 2027 (ft)
Measurable Objective (MO) (ft)
Minimum Threshold (MT) (ft)
Good Groundwater Measurements
Questionable
Avg. Spring Groundwater Level Change
Past 20 Years (2003 to 2023): -7.9 ft
Avg. Spring Groundwater Level Rate of Change
Past 20 Years (2003 to 2023): -0.39 ft/yr
Avg. Depth to Groundwater
Past 20 Years (2003 to 2023): 26.8 ft
140
120
100
80
60
40
20
0
−20
−40
−60
−80
−100
1992
1996
2000
2004
2008
2012
2016
2020
2024
WYI
10
0
Date

COLUSA Subbasin - State Well Number (SWN): 21N03W01R002M

Well Location Map



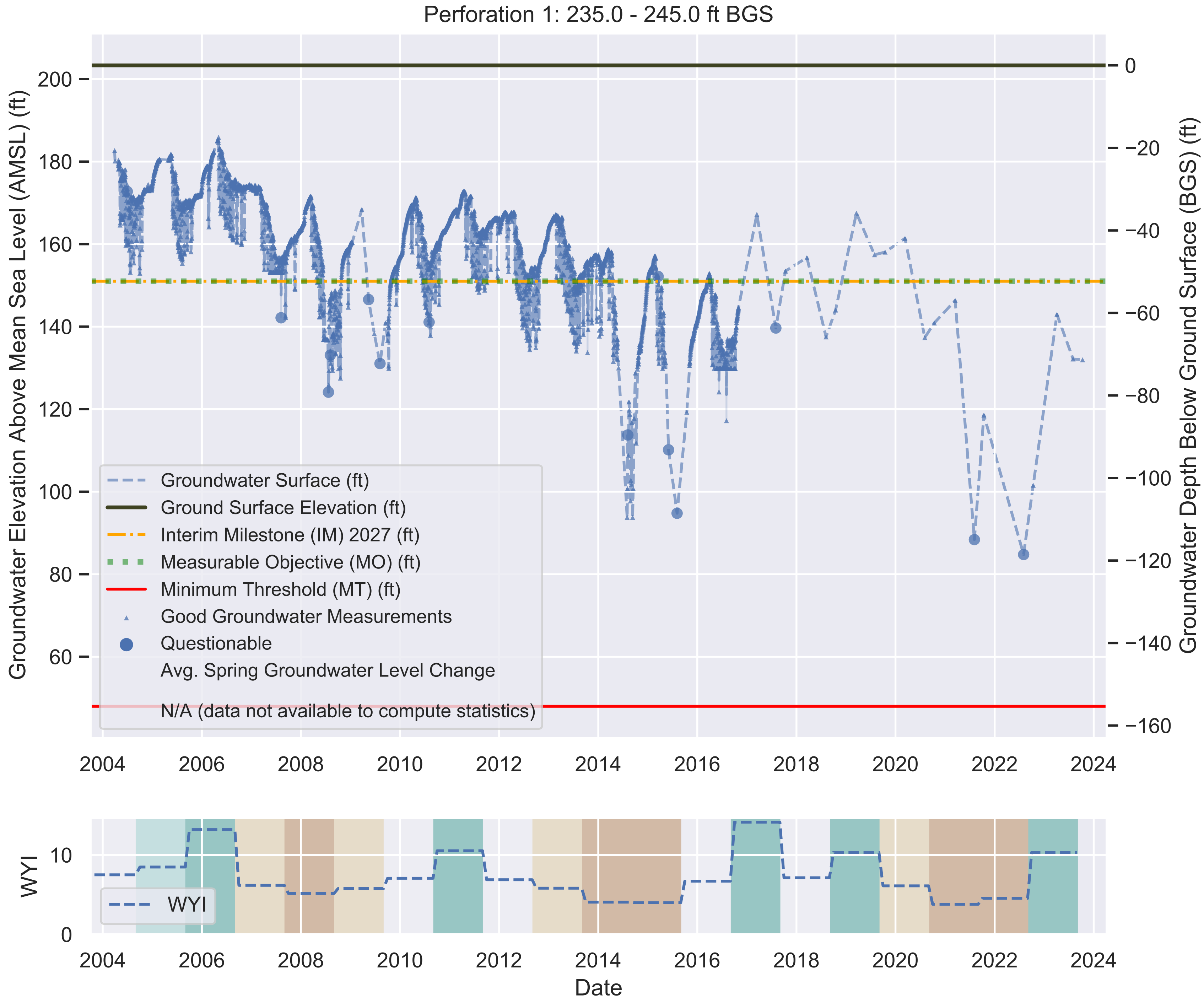
Sustainable Management Criteria:

IM (2027) = 151.0 ft AMSL
MO = 151.0 ft AMSL
MT = 48.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

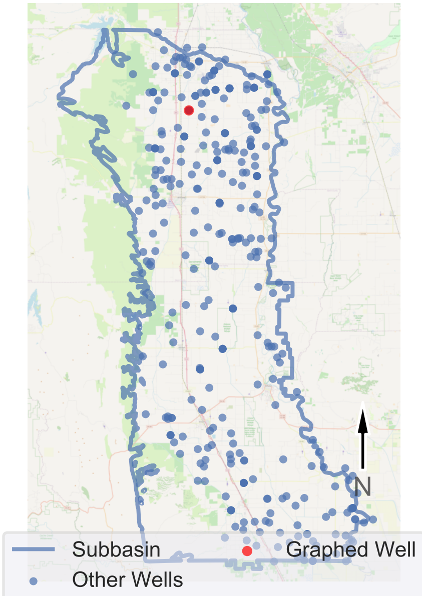
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 21N03W23D002M

Well Location Map

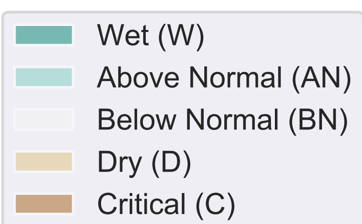


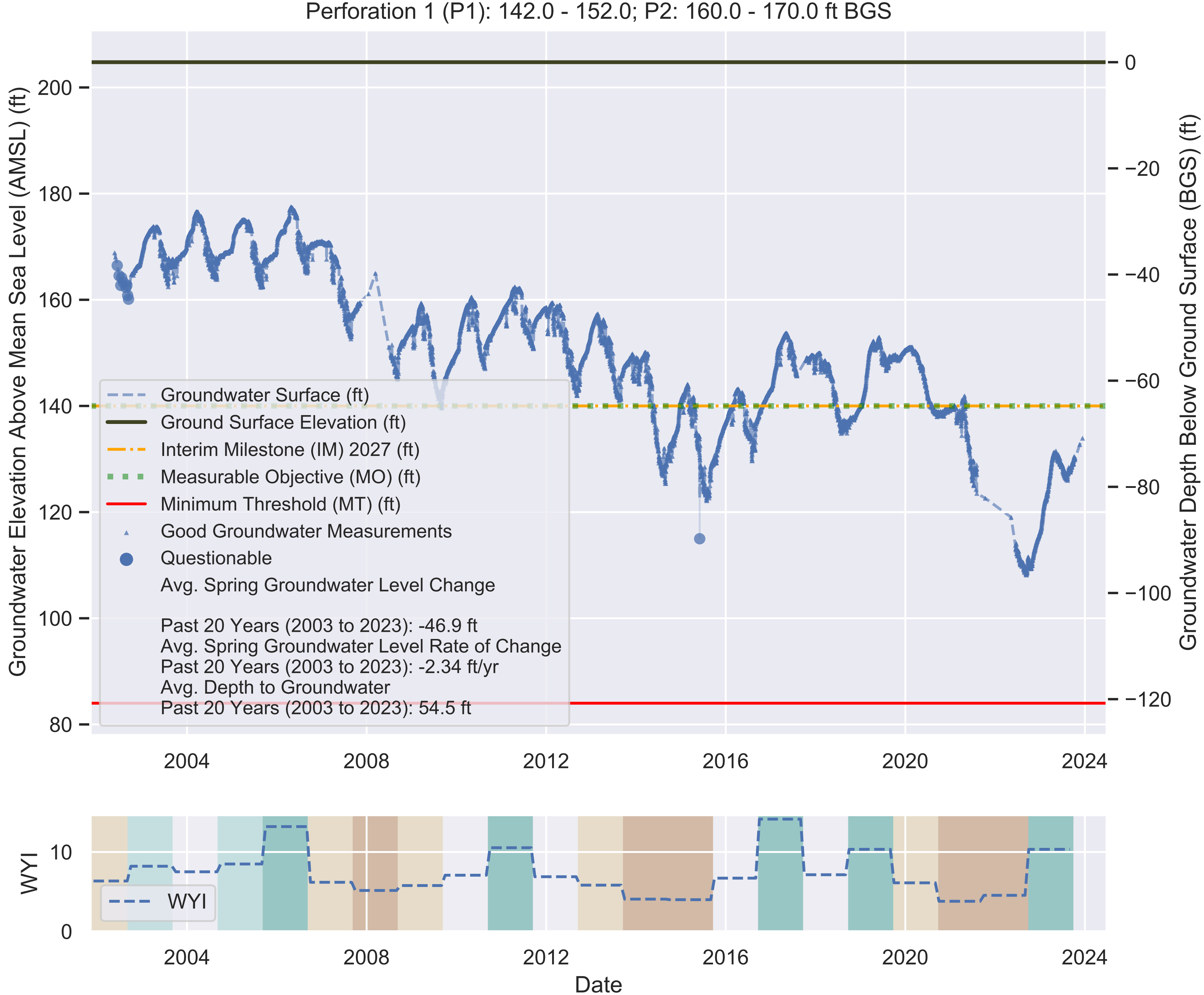
Sustainable Management Criteria:

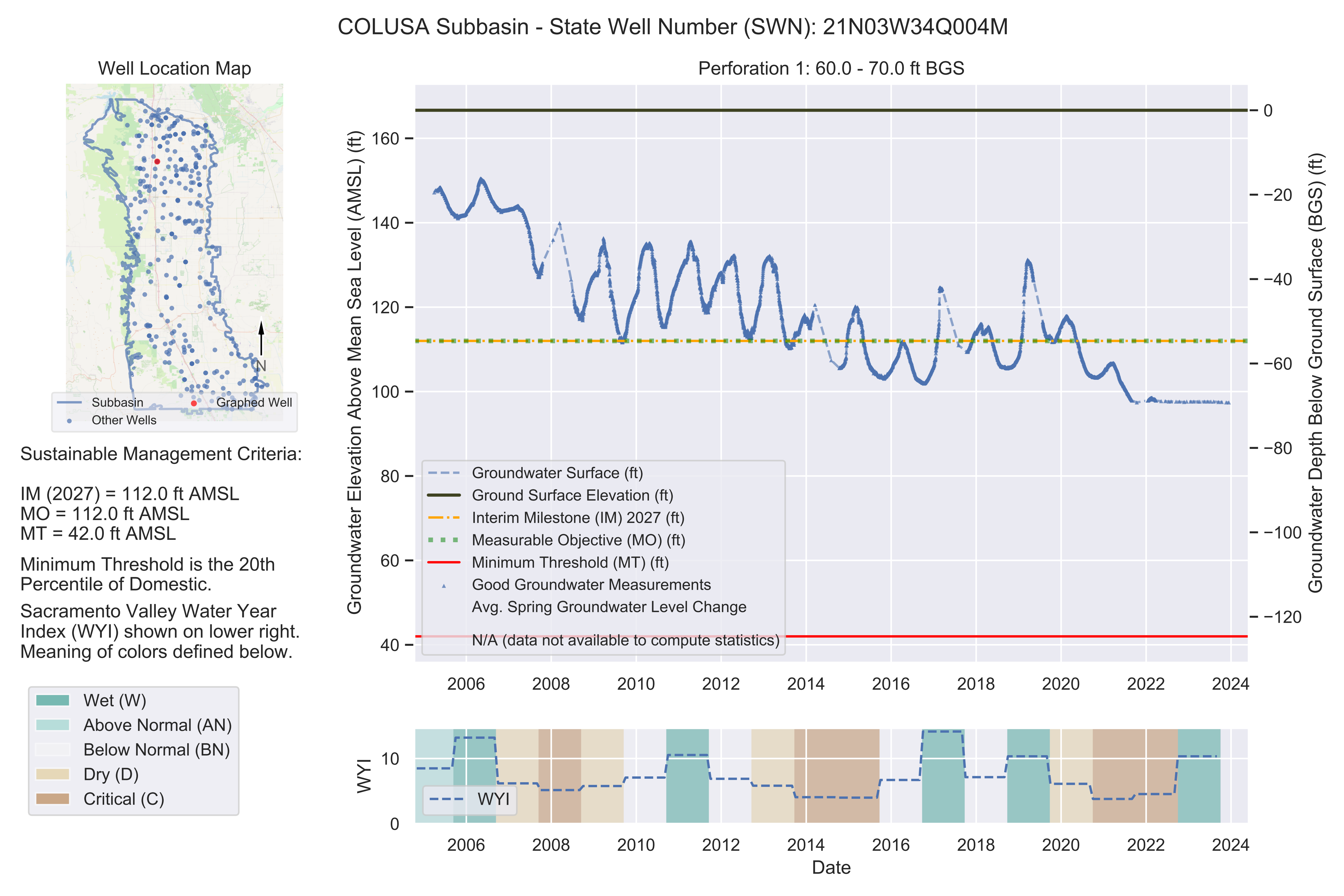
IM (2027) = 140.0 ft AMSL
MO = 140.0 ft AMSL
MT = 84.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

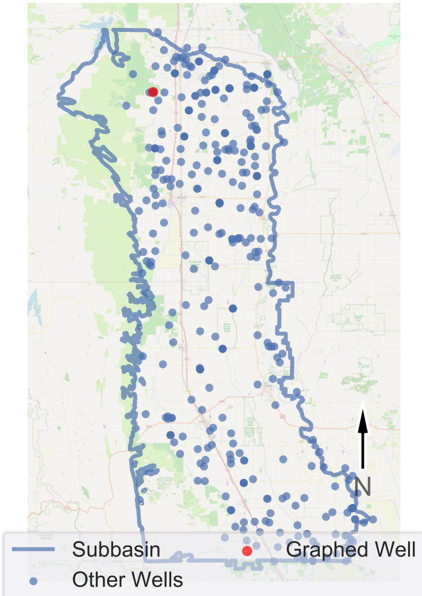


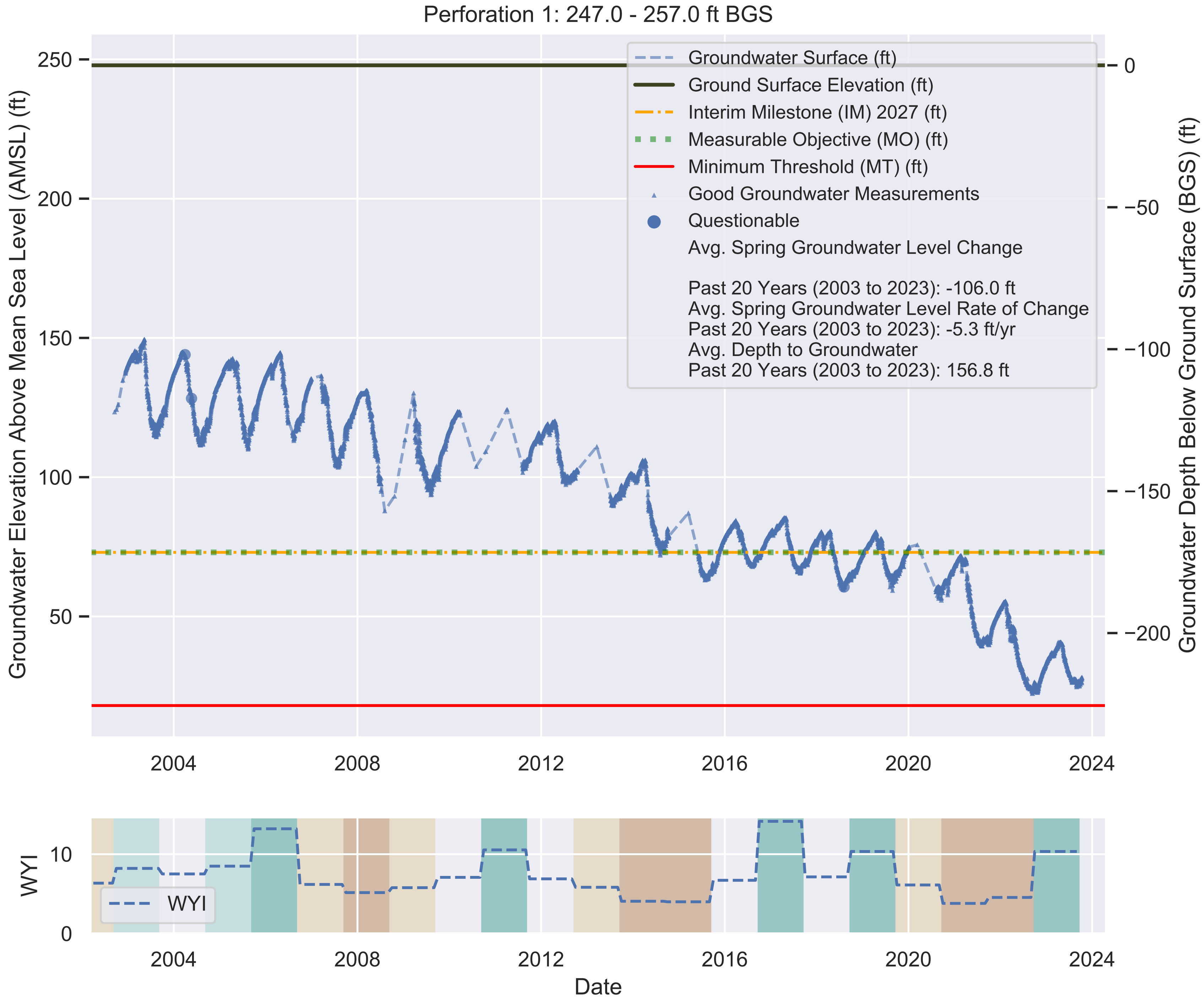



COLUSA Subbasin - State Well Number (SWN): 21N03W34Q004M
Well Location Map
N
Subbasin
Graphed Well
Other Wells
Sustainable Management Criteria:
IM (2027) = 112.0 ft AMSL
MO = 112.0 ft AMSL
MT = 42.0 ft AMSL
Minimum Threshold is the 20th Percentile of Domestic.
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.
Wet (W)
Above Normal (AN)
Below Normal (BN)
Dry (D)
Critical (C)
Perforation 1: 60.0 - 70.0 ft BGS
Groundwater Elevation Above Mean Sea Level (AMSL) (ft)
Groundwater Depth Below Ground Surface (BGS) (ft)
160
140
120
100
80
60
40
0
−20
−40
−60
−80
−100
−120
Groundwater Surface (ft)
Ground Surface Elevation (ft)
Interim Milestone (IM) 2027 (ft)
Measurable Objective (MO) (ft)
Minimum Threshold (MT) (ft)
Good Groundwater Measurements
Avg. Spring Groundwater Level Change
N/A (data not available to compute statistics)
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
WYI
10
0
Date

COLUSA Subbasin - State Well Number (SWN): 21N04W12A002M

Well Location Map





Sustainable Management Criteria:

IM (2027) = 73.0 ft AMSL
MO = 73.0 ft AMSL
MT = 18.0 ft AMSL

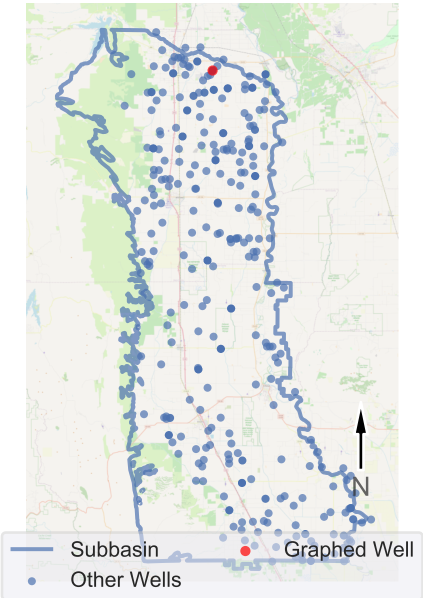
Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)

COLUSA Subbasin - State Well Number (SWN): 22N02W30H003M

Well Location Map



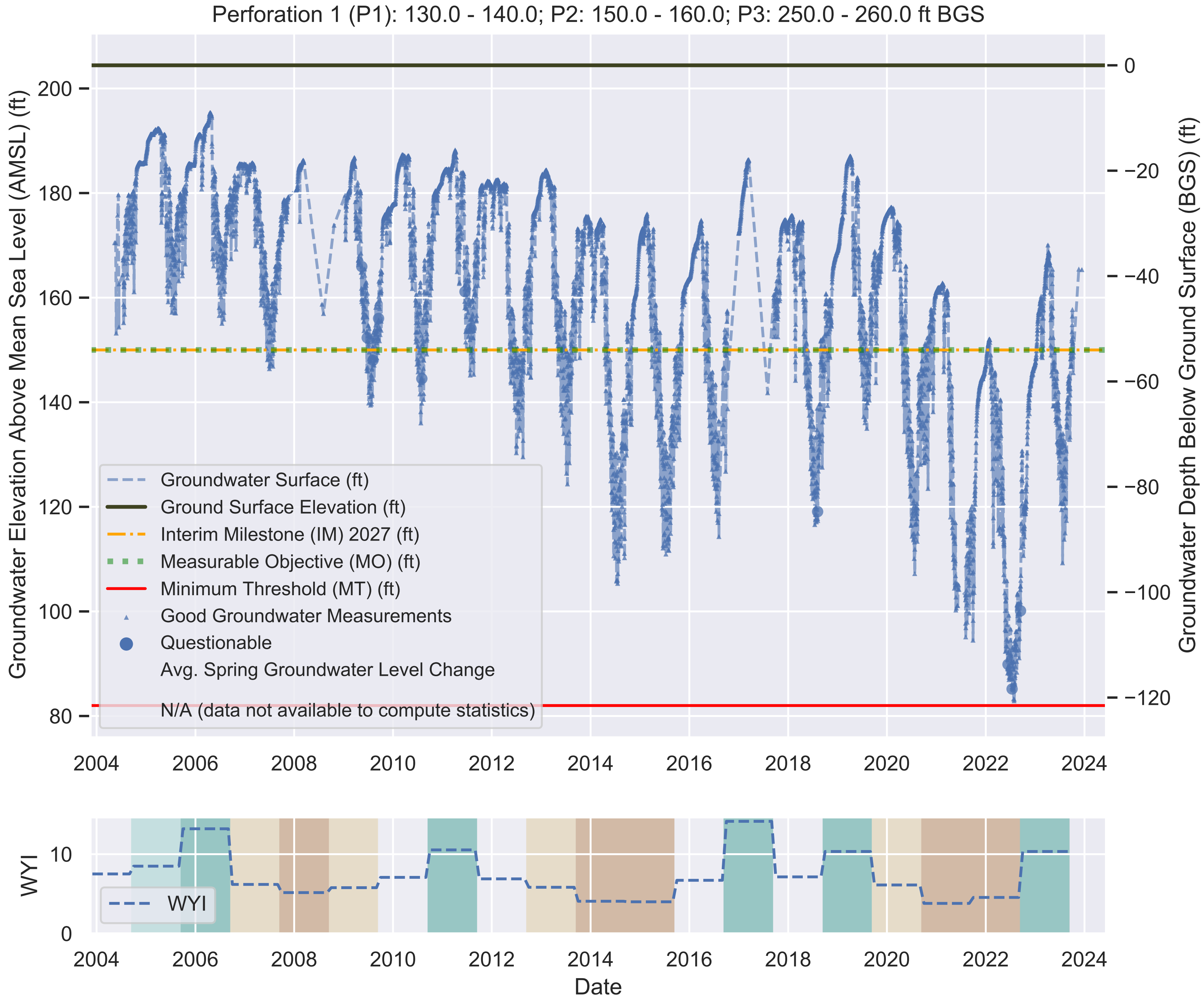
Sustainable Management Criteria:

IM (2027) = 150.0 ft AMSL
MO = 150.0 ft AMSL
MT = 82.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

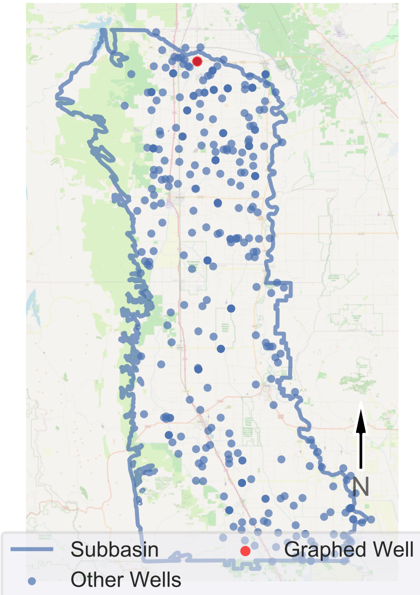
Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



COLUSA Subbasin - State Well Number (SWN): 22N03W24E002M

Well Location Map

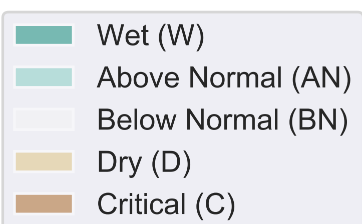


Sustainable Management Criteria:

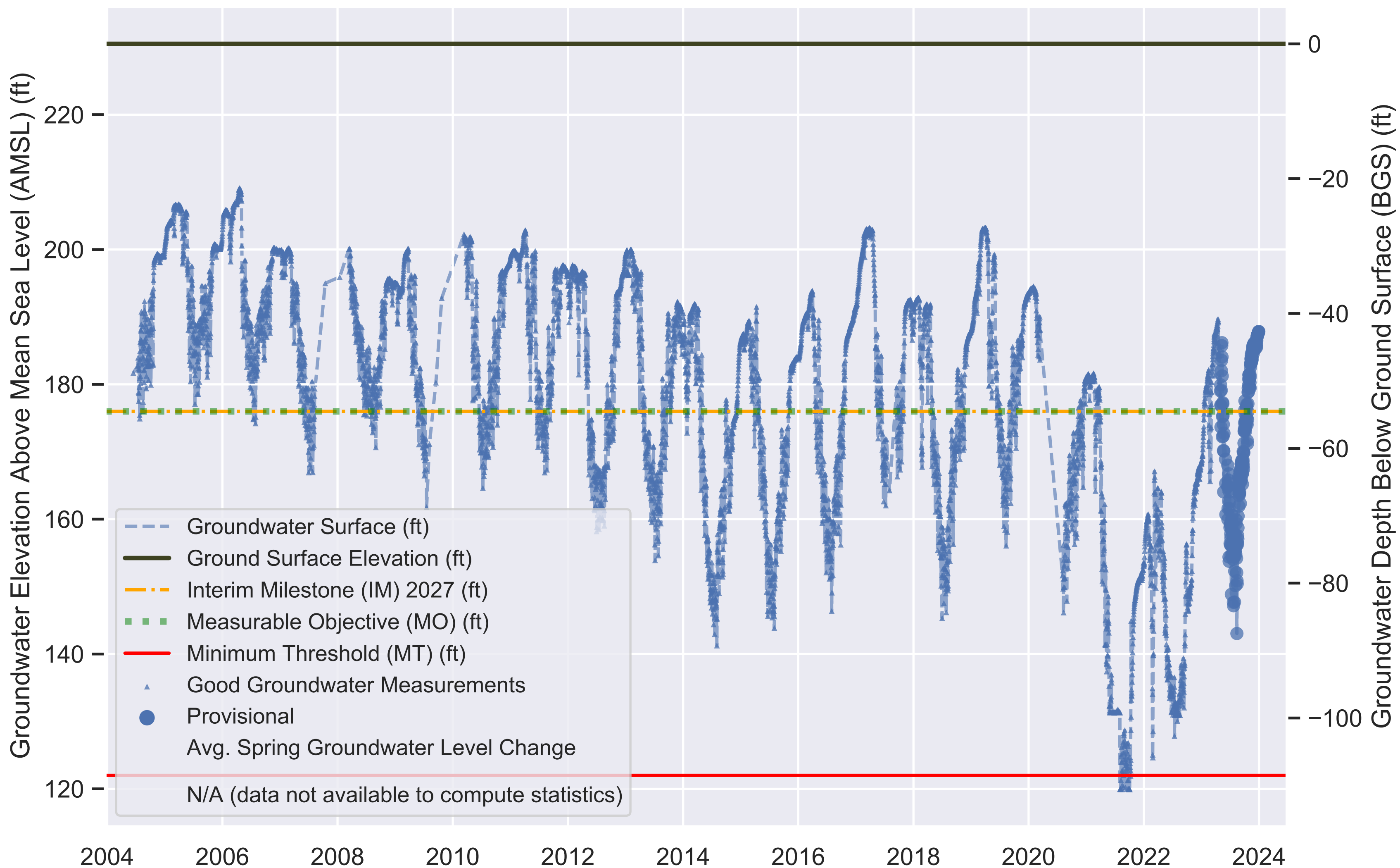
IM (2027) = 176.0 ft AMSL
MO = 176.0 ft AMSL
MT = 122.0 ft AMSL

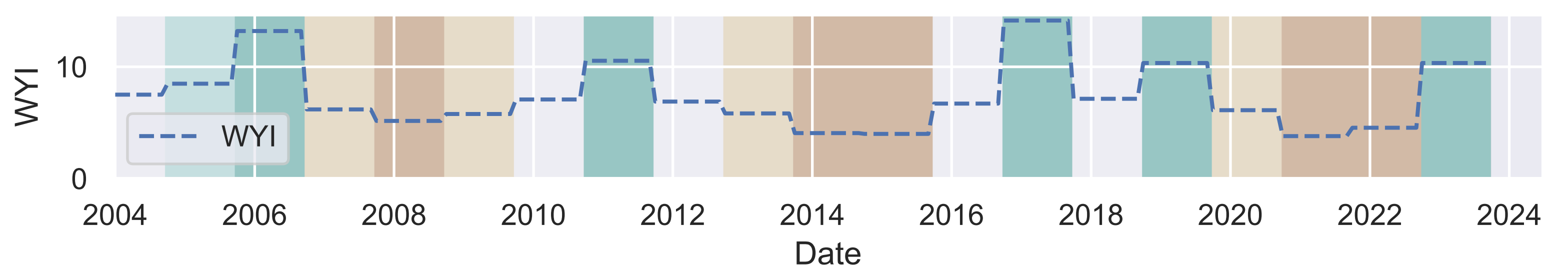
Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.



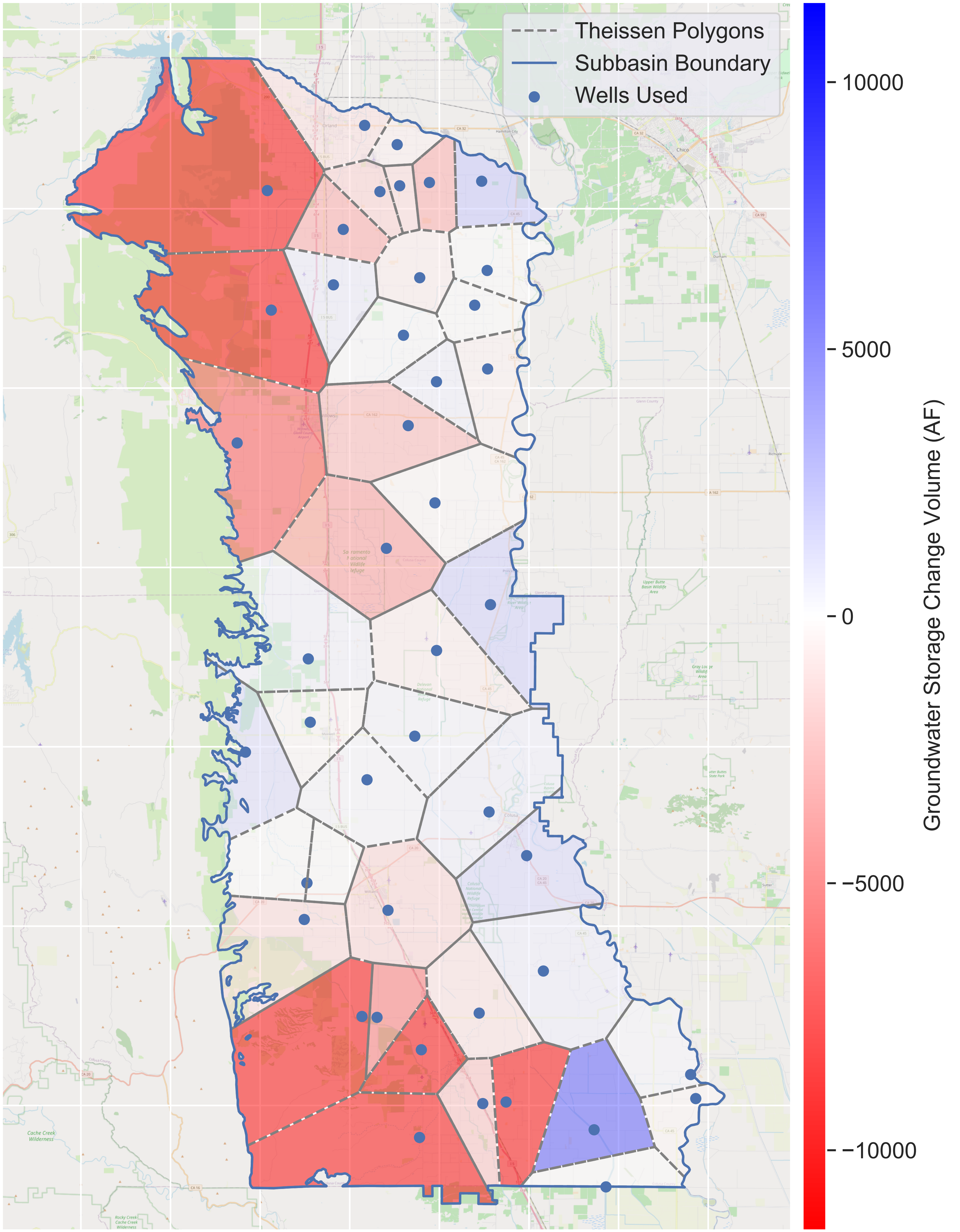
Perforation 1 (P1): 130.0 - 150.0; P2: 170.0 - 180.0 ft BGS



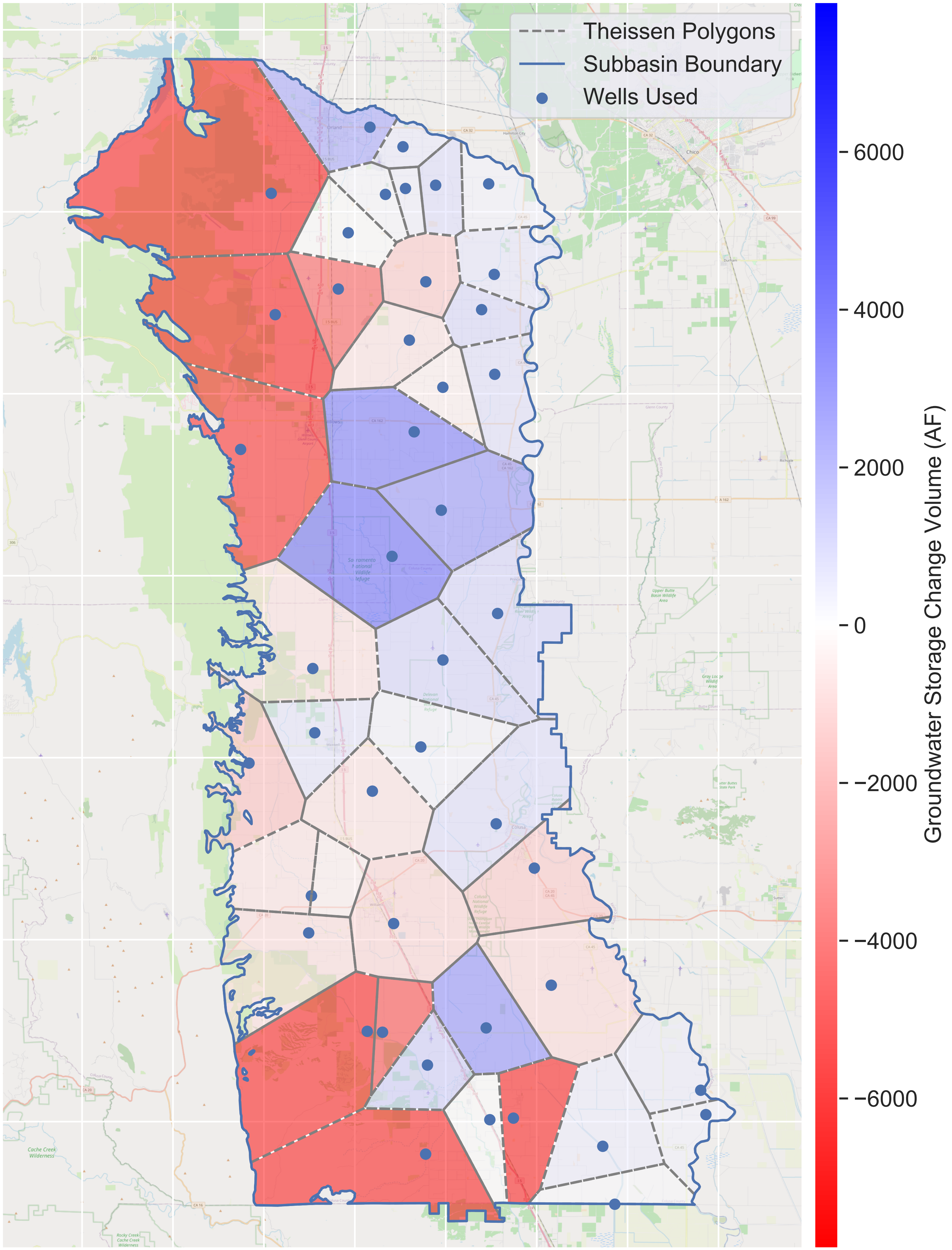


Appendix C. Maps of Annual Change in Groundwater Storage – 2015 through 2023.

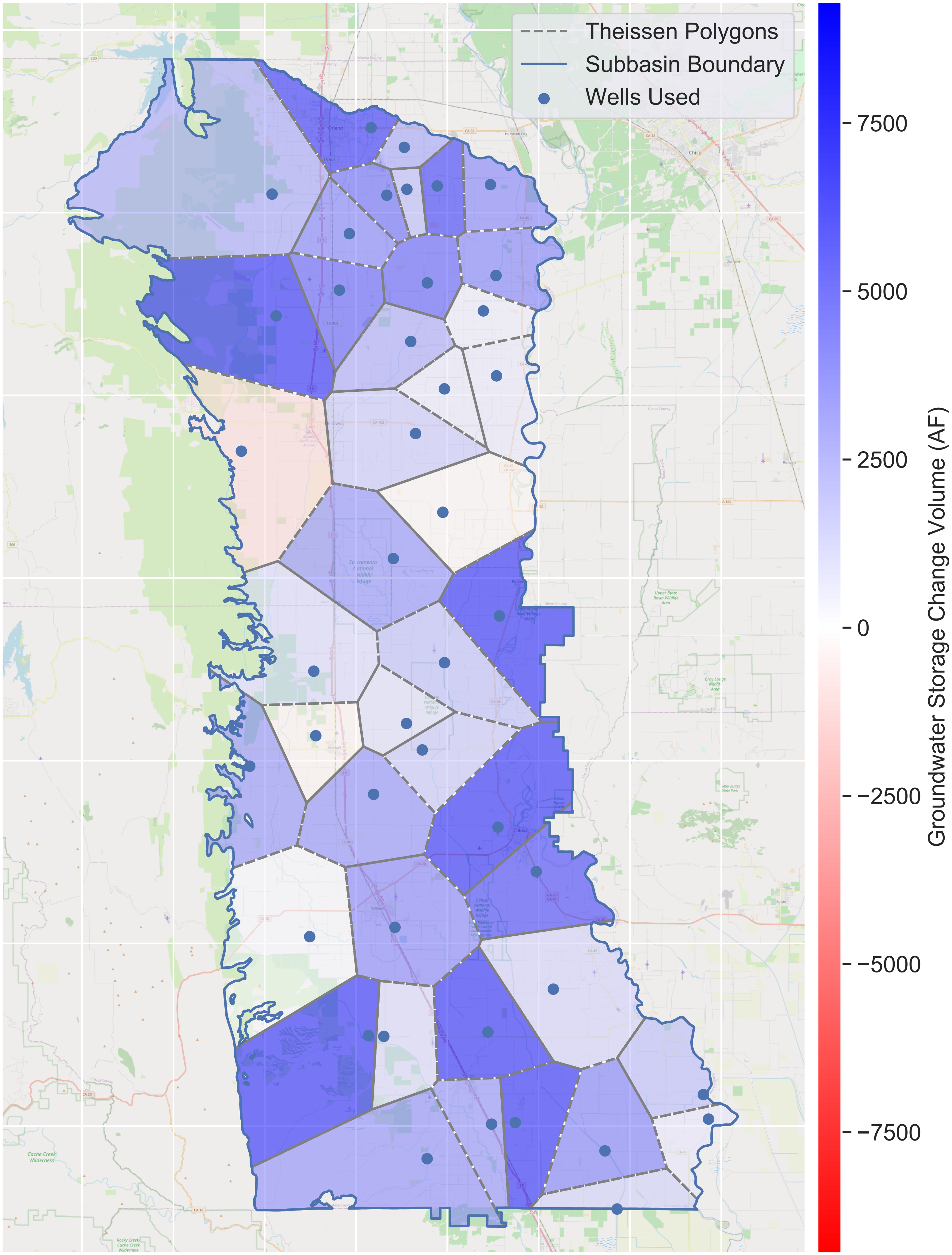
Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2015
Total Storage Change in Primary Aquifer = -210470.0 AF; Number of Wells = 44



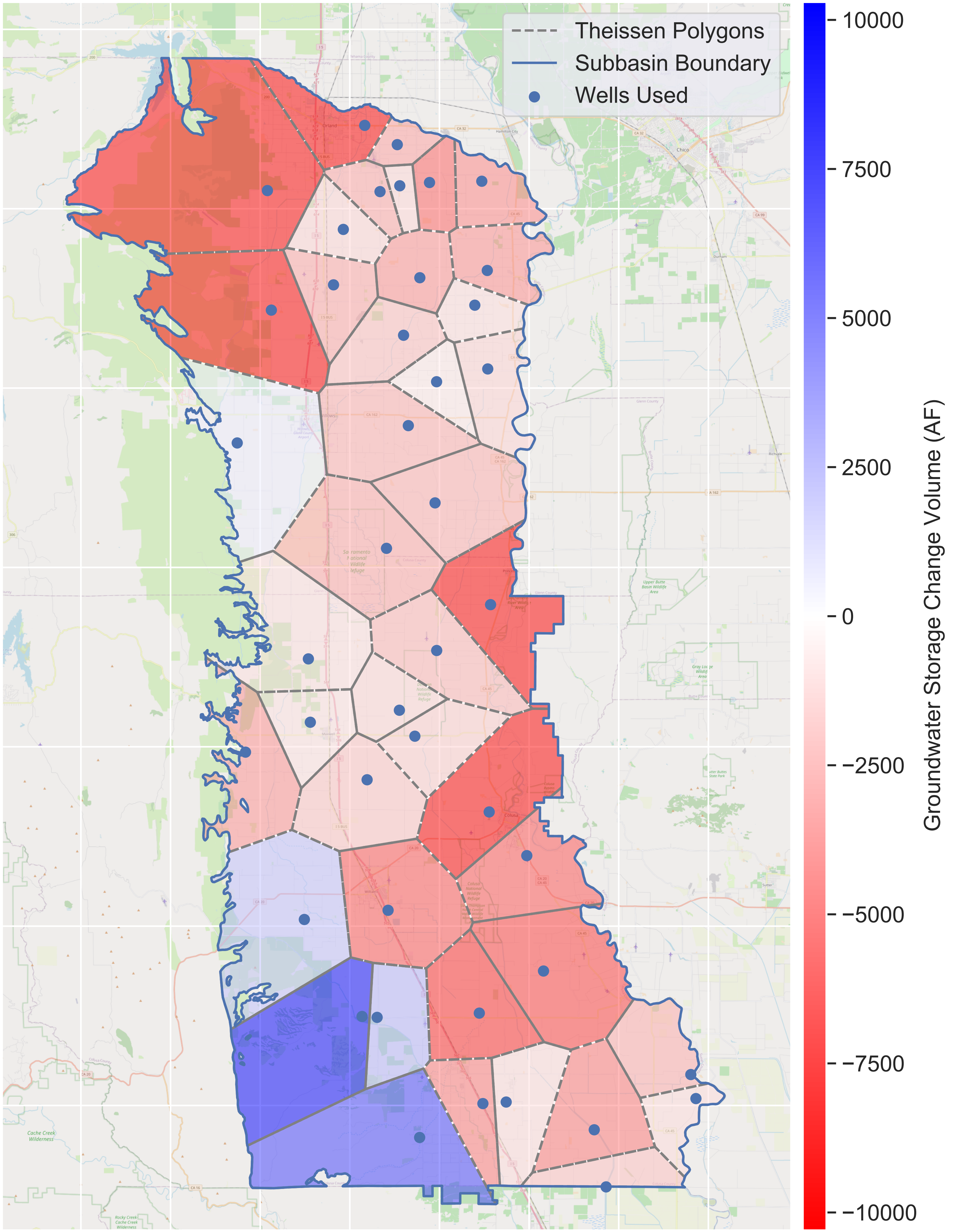
Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2016
Total Storage Change in Primary Aquifer = -105770.0 AF; Number of Wells = 44



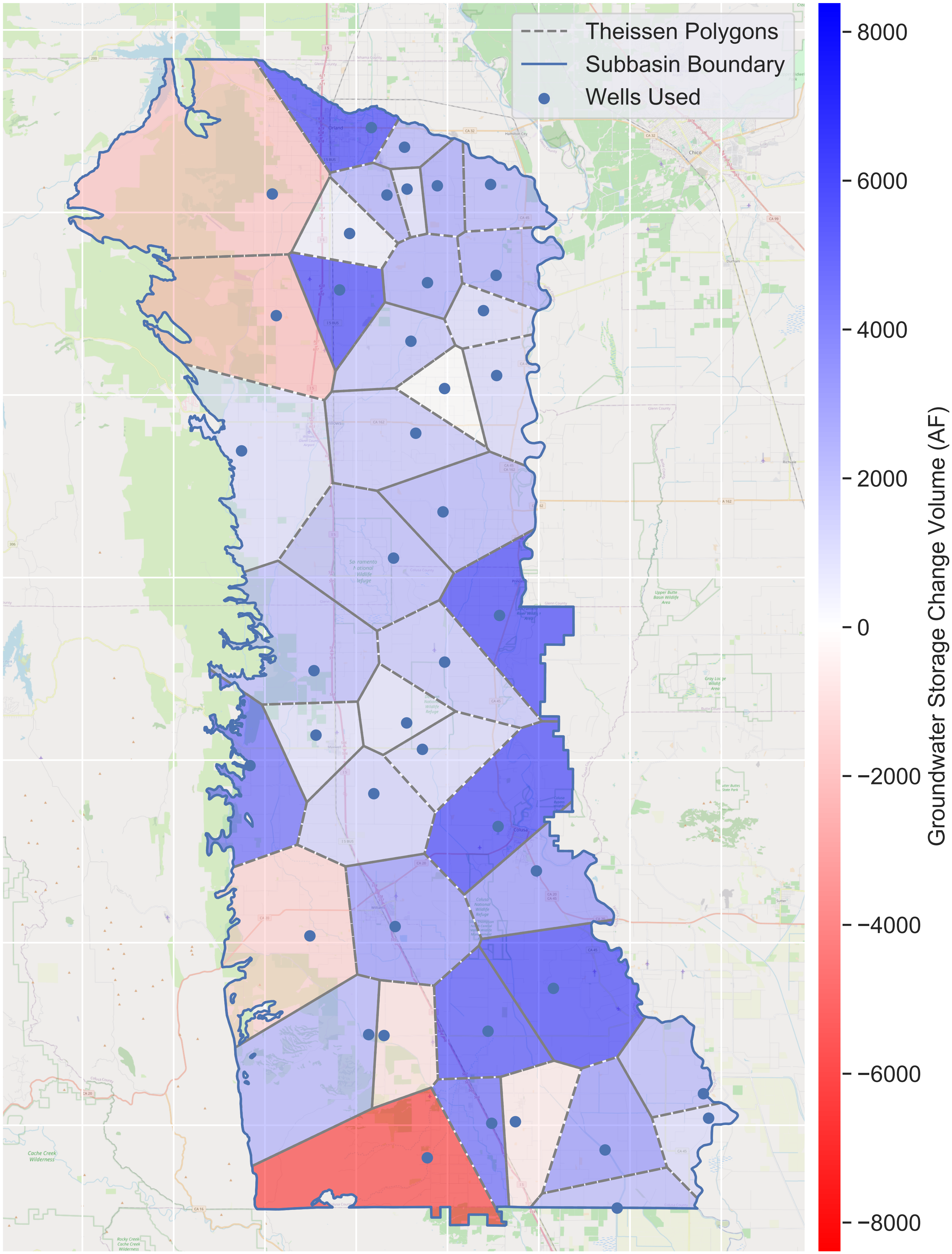
Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2017
Total Storage Change in Primary Aquifer = 260530.0 AF; Number of Wells = 43



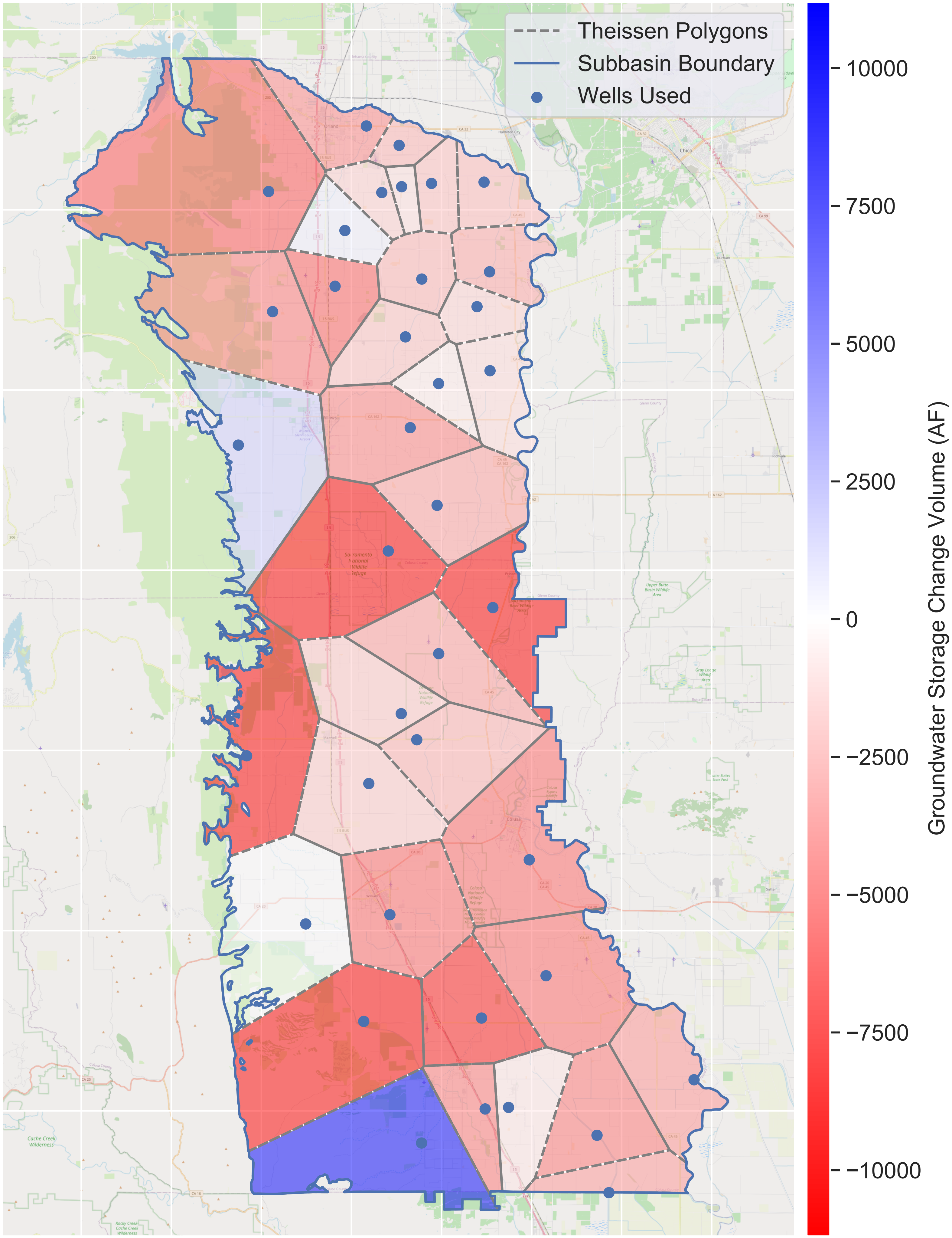
Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2018
Total Storage Change in Primary Aquifer = -149730.0 AF; Number of Wells = 43



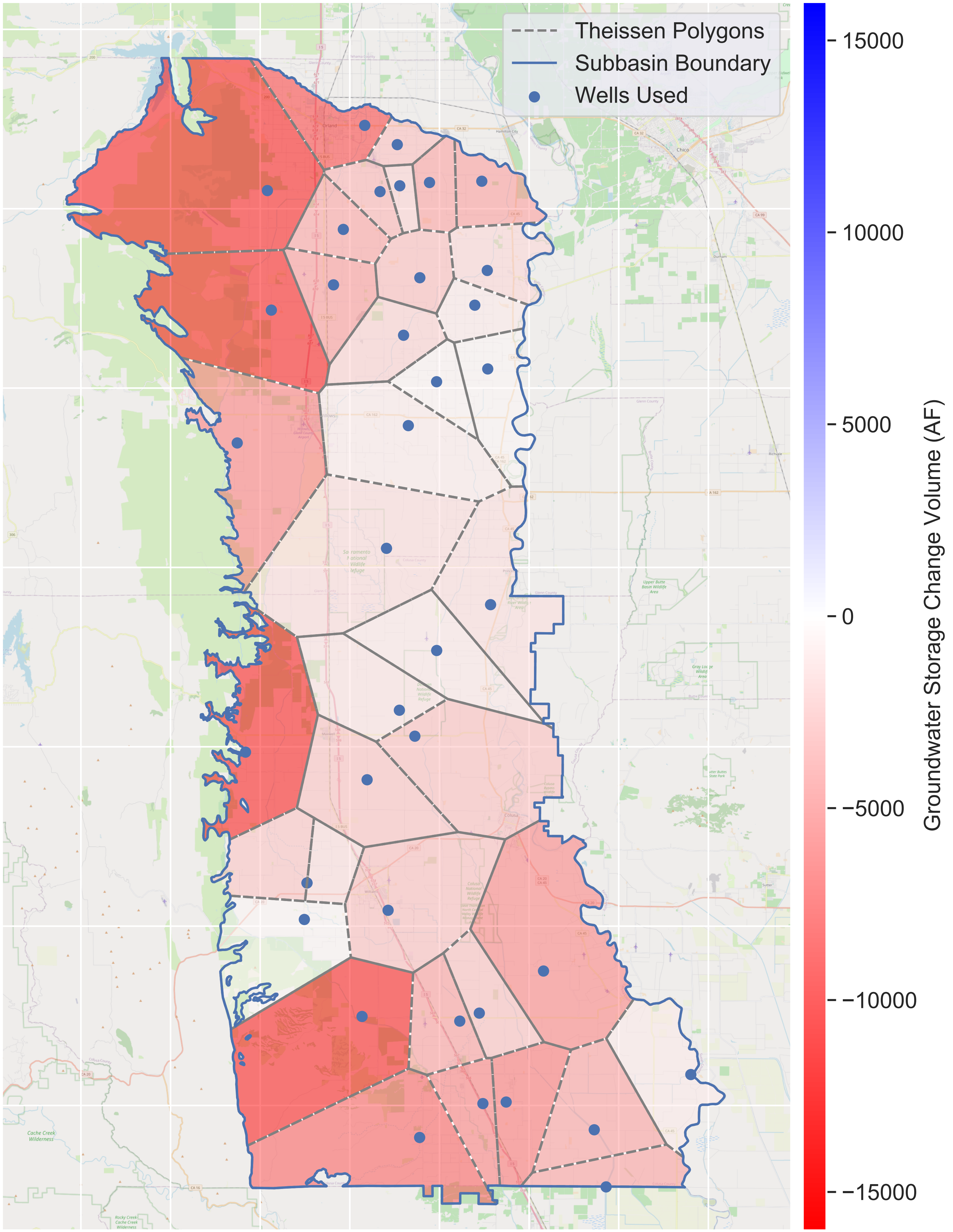
Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2019
Total Storage Change in Primary Aquifer = 124610.0 AF; Number of Wells = 43

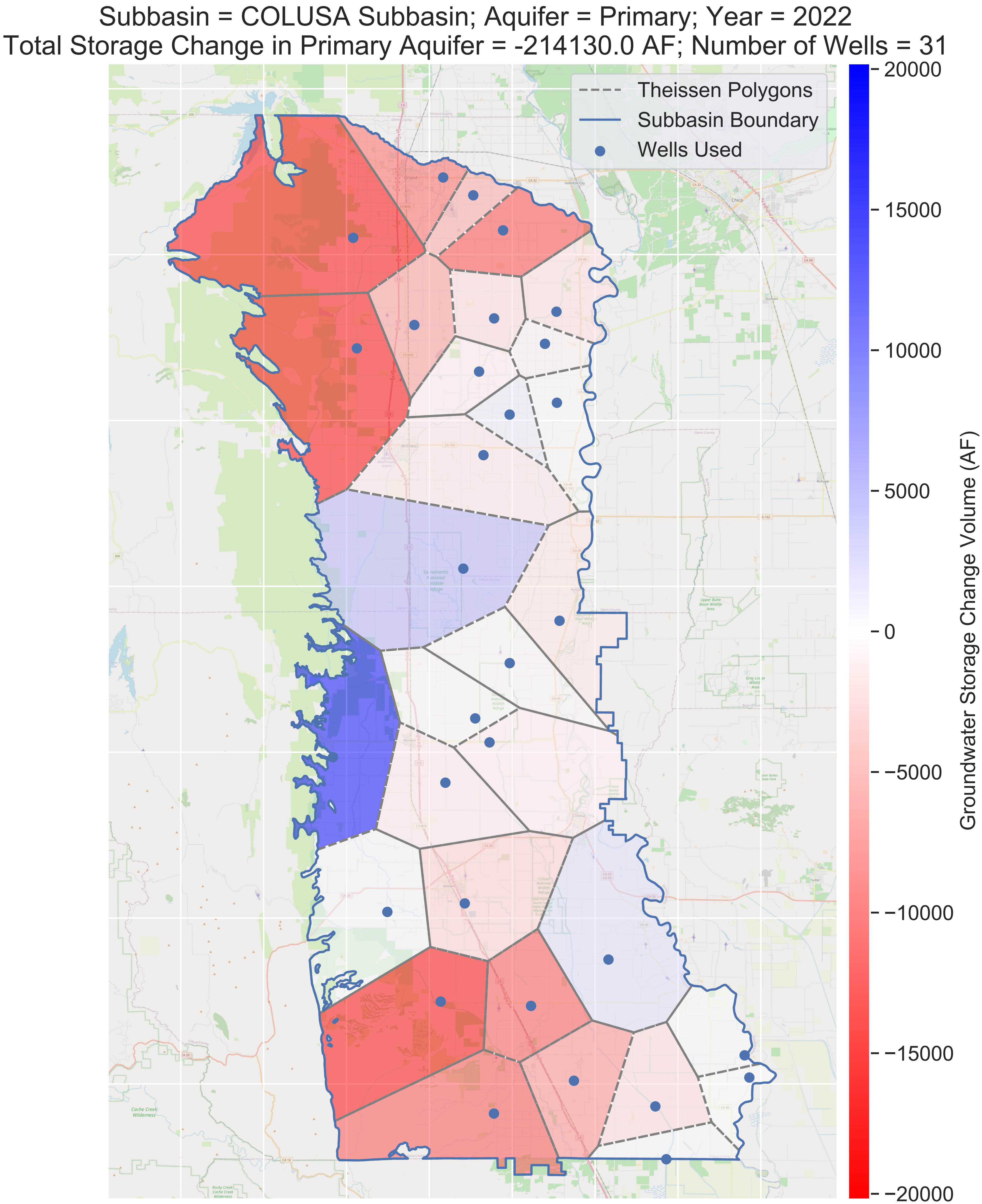


Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2020
Total Storage Change in Primary Aquifer = -218580.0 AF; Number of Wells = 38

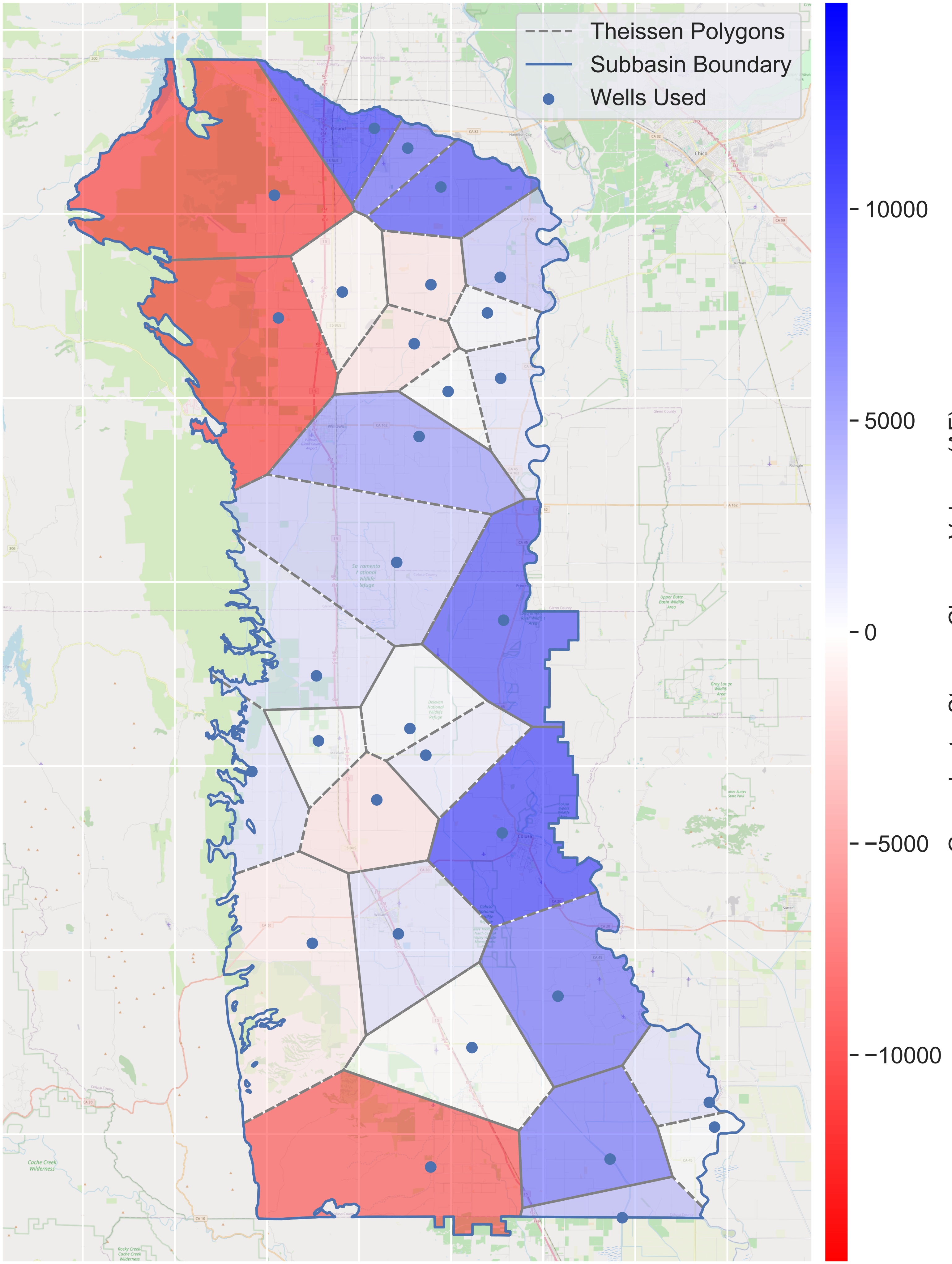


Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2021
Total Storage Change in Primary Aquifer = -283990.0 AF; Number of Wells = 38




Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2022
Total Storage Change in Primary Aquifer = -214130.0 AF; Number of Wells = 31
Theissen Polygons
Subbasin Boundary
Wells Used
Groundwater Storage Change Volume (AF)
20000
15000
10000
5000
0
−5000
−10000
−15000
−20000

Subbasin = COLUSA Subbasin; Aquifer = Primary; Year = 2023
Total Storage Change in Primary Aquifer = 33880.0 AF; Number of Wells = 31



Appendix D. Approach for Estimating Groundwater Extraction in the Colusa Subbasin GSP Annual Report.

TECHNICAL MEMORANDUM

To: Colusa Groundwater Authority and Glenn Groundwater Authority

From: Davids Engineering, Inc.

Date: February 28, 2024

Subject: **Approach for Estimating Groundwater Extraction in the Colusa Subbasin GSP Annual Report**

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1 Introduction

The California Code of Regulations Title 23 (23 CCR[1]) Section (§) 356.2 establishes certain requirements for all Groundwater Sustainability Plan (GSP) Annual Reports that are submitted to the California Department of Water Resources (DWR). Among other requirements, Annual Reports must quantify water supply and water use in a subbasin for the preceding water year, specifically:

- Groundwater extraction (23 CCR §356.2.b.2)
- Surface water supplies used, or available for use, for groundwater recharge or in-lieu use (23 CCR §356.2.b.3)
- Total water use (23 CCR §356.2.b.4)

Pursuant to these requirements, the Colusa Subbasin (Subbasin) GSP Annual Report includes quantification of water supplies and water uses in the reporting year, including groundwater extraction by water use sector[2]. Water supplies and water uses in the Subbasin have been quantified based on the best available data sources and information, either collected from measured records or estimated where necessary.

This technical memorandum (TM) provides information about the process, data sources, and methods that were used to estimate unmeasured groundwater extraction in the Colusa Subbasin in Water Year 2023. Information about the data sources and methods used to quantify measured groundwater extraction, surface water use, and total water use are described in the Annual Report (Sections 2 through 5).

While some groundwater extraction in the Subbasin is measured, the majority of groundwater extraction is currently unmeasured, including extraction from privately-owned wells. For this Annual Report, the approach used to estimate unmeasured groundwater extraction for the agricultural and managed wetlands water use sectors is referred to as the Groundwater Extraction Estimates from Earth Observations (GEEEO) process. In this approach, a spatial water use analysis is computed on a monthly basis using current land use data, climate conditions (e.g., precipitation and evapotranspiration), crop water demands, and other local information, allowing for estimation of total water use and estimated groundwater extraction, after accounting for the use of other available water supplies.

[1] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2. Groundwater Sustainability Plans.
[2] Water use sectors are identified in the GSP Regulations as "categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation" (23 CCR Section 351(al)).

This approach differs from the water budget methodology used in GSP development, where the C2VSimFG-Colusa groundwater model g was used to generate historical, current, and projected water budgets for the Subbasin. The shift toward the GEEEO process is due to the time and cost constraints associated with updating the GSP groundwater model annually. Despite this change, key inputs and results from the GEEEO process have been compared with those of the GSP groundwater model to ensure consistency in the water use analyses. This TM describes the methodology and data sources used in the GEEEO process. Results of the GEEEO process are documented in the Annual Report.

2 GEEEO Process and Computational Approach

2.1 Computational Approach

The GEEEO process utilizes available geospatial data and information to quantify water use, including groundwater extraction volumes, spatially across the Subbasin:

1. First, geospatial evapotranspiration (ET) information at a pixel-scale (see Section 2.2) is used to quantify the total consumptive water use and total applied water requirements during a given time period in a given area of the Subbasin, and geospatial land use information is used to help identify where irrigation water may have been applied (i.e., whether the area in question features irrigated agricultural land, versus idled land or undeveloped vegetation).
2. After quantifying total applied water requirements, available surface water supply and groundwater extraction data is incorporated into the GEEEO process by distributing that water out to specific regions where that water is applied (e.g., irrigated lands in surface water supplier service areas).
3. The remaining groundwater extraction needed to meet applied water demands is then calculated based as the difference between total applied water requirements and available water supply information, with consideration for effective precipitation.
4. Finally, the pixel-scale results can then be aggregated to the desired spatial or temporal domains of interest (e.g., water districts or GSAs).

The result is a spatially-distributed water use analysis calculated with a finer spatial resolution than was possible in the GSP water budgets. The pixel-scale water budget results provide greater insight into where water use occurs in the Subbasin and are configurable to create water use summaries for any region of the Subbasin. Additional detail about the GEEEO computational approach is provided in Attachment A, generally following the process described in Hessels et al. (2022).

2.2 Spatial Resolution

GEEEO quantifies water use and groundwater extraction volumes with pixel-scale resolution (30 meters (m) x 30 m), corresponding to the spatial resolution of satellite imagery used in developing many of the GEEEO inputs. For those inputs that are not available at the 30 m x 30 m resolution, available data and information is distributed as averages over the area where that information is applicable (e.g., district-reported surface water deliveries are distributed as an average acre-feet per acre (AF/ac) over irrigated lands in that district's service area[3]). Additional information about the spatial resolution of specific data sources is provided in Section 3.

The fine spatial resolution of the GEEEO inputs and computations allows for highly configurable GEEEO results summaries. For the Annual Report, results are summarized by subregions that are defined to roughly correspond with the boundaries of the water budget regions in the GSP groundwater model, with distinction between water districts, managed wetlands and refuge areas, and out-of-district lands.

2.3 Period and Timestep

For each Annual Report, the GEEEO process operates from 2016 through the current reporting year[4] on a monthly timestep. The period and timestep are set according to data availability and reporting needs. However, the GEEEO process is configurable to operate on different timescales (e.g., daily or weekly). The start year is currently limited by the availability of geospatial ET information from OpenET, although further historical ET information is expected to be available in the near future.

3 Data Sources

The GEEEO process uses data sources and information that capture the unique, local conditions within the Subbasin to the extent available. Details about the data and information used in the GEEEO process are described below.

3.1 Evapotranspiration

ET, or consumptive water use, is the major driver of water use in the Subbasin, particularly agricultural use. In this context, consumptive water use is defined as "*the part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment*" (ASCE, 2016). Unlike surface runoff, or infiltration of water into the groundwater system (whether through seepage, deep percolation, managed recharge, or other means), ET is water that cannot be recovered or directly reused in the Subbasin.

In the GEEEO process, ET is quantified from satellite-based remote sensing analyses available from OpenET. OpenET is a multi-agency web-based geospatial information system (GIS) utility that quantifies ET over time with a spatial resolution of 30 m x 30 m (approximately 0.22 acres). OpenET information is available in raster coverages of the Subbasin on both a daily and monthly timestep from 2016 through present.[5] The GEEEO process utilizes monthly rasters of the ensemble ET from OpenET to calculate total water use for the Annual Report.

While OpenET is a new utility, the underlying methodologies to quantify ET apply a variety of well-established modeling approaches that are widely used in government and research applications. The

[3] Future refinements to the GEEEO process could potentially incorporate field-scale surface water delivery records to improve spatial detail of results rather than equally distributing surface water deliveries across the irrigated lands within the district's service area.

[4] Annual Reports are required to be submitted by April 1 each year following the adoption of the GSP. The current reporting year for each Annual Report is the preceding water year (i.e., October 1 through September 30)

[5] OpenET raster information is typically available within about one month after the period has ended.

OpenET modeling approaches are also similar to the approaches used to quantify ET in the GSP groundwater model. Additional information about the OpenET team, data sources, and methodologies are available at: https://openetdata.org/.

3.2 Land Use

Areas in each water use sector in the Subbasin were identified using the most recent and reliable spatial land use data in the region, including:

1. Statewide crop mapping, available from the California Department of Water Resources (DWR) (DWR, 2024)
2. CropScape Cropland Data Layer coverage, available from the United States Department of Agriculture (USDA, 2024).

Land use data from these sources were compiled into 30 m x 30 m raster coverages of the Subbasin. To prepare the GEEEO process inputs, DWR data (which includes extensive ground-truthing review of results) is preferentially used to identify agricultural land (including irrigated and non-irrigated lands) and urban areas, and then USDA data is utilized to back-fill gaps of non-irrigated, idled, and non-developed land in the Subbasin. Local refinements are also applied, as needed, to account for local land use information.

These land use data sources and applications were similar to those used in development of the GSP water budgets. Comparisons were made to evaluate the consistency of the datasets and with earlier land uses analyses, and found generally good correspondence for the major land use classes found in the Subbasin.

DWR data is typically available in provisional form approximately two years after a given year has passed. USDA data is typically available for the prior year in early- to mid-February. When data for the current reporting year is not yet available, raster coverages of the Subbasin are generally assembled utilizing land use data from the most recent, hydrologically similar year (i.e., similar water supply conditions and similar cropping patterns, to the extent possible). Idling of annual and ponded crops in a given year may also be locally refined through comparison with USDA data for the current reporting year or through an analysis of vegetation coverage in the current reporting year. However, it is noted that land use data is only used in the GEEEO process to identify areas in each water use sector where water is applied. The total water use for lands in the agricultural and managed wetlands water use sectors are determined through an analysis of OpenET data, regardless of the precise land use classification.

3.3 Precipitation

Spatial precipitation estimates were extracted from the Parameter-elevation Regressions on Independent Slopes Model (PRISM), developed by the PRISM Climate Group at Oregon State University. PRISM quantifies spatial precipitation estimates, among other climate parameters, based on available weather station data and modeled spatial relationships with topography and other factors influencing weather and climate.

PRISM data is available in raster coverages of the Subbasin on both a daily and monthly timestep, with a spatial resolution of 4-kilometer (km) x 4 km. The GEEEO process utilizes monthly rasters for the Annual Report analysis, and the precipitation results for each 4 km pixel are applied to each of the 30 m pixels within it (i.e., downscaled) for which ET and land use data are available. Additional information about the PRISM data and methodologies are available at: https://prism.oregonstate.edu. PRISM precipitation data is consistent with the historical precipitation inputs to the GSP groundwater model.

PRISM precipitation data along with estimated mean rooting depths from the rooting depth ranges listed in Appendix B of ASCE 70 (2016) is used to create pixel-level estimates of effective precipitation (ETPR). For crops not listed in ASCE 70, rooting depths are based on rooting depths of similar crops and professional judgement. ETPR is computed using the National Engineering Handbook Part 623 method (USDA, 1993).

3.4 Local Water Supply Data

As described in Section 2, available surface water supply and groundwater extraction data is incorporated into the GEEEO process to quantify the amount of known water supply available, prior to estimating the remaining groundwater extraction needed to meet demand. Water supply data is distributed as averages over the area where that information is applicable (e.g., average AF/ac over lands where that water is available for use).

Surface water supply and groundwater extraction data is collected from both publicly available and local sources. Information gathered may include, where applicable:

1. Water supply contract delivery records, from the United States Bureau of Reclamation (USBR), State Water Project (SWP), or other publicly available sources as applicable.
2. Water rights diversions records, from the State Water Resources Control Board (SWRCB) through the Electronic Water Rights Information Management System (eWRIMS)
3. Data requests to local water agencies and water users, requesting surface water diversions, surface water deliveries, surface water outflows, groundwater pumping records, or other available water use data.

In cases where current surface water data is not available, general information on surface water inflows and outflows may be gathered from other local sources as available (e.g., Agricultural Water Management Plan water budgets). More information about surface water data sources is described in the Annual Report.

While groundwater extraction data is not available in many parts of the Subbasin, local data is requested each year so that new data can be incorporated into the GEEEO process as it becomes available. It is noted that while groundwater extraction for municipal water supply systems is generally reported for urban areas in the Annual Report based on SWRCB and locally-provided data, groundwater extraction for municipal areas is not directly included in the GEEEO process due to underlying differences in how the majority of water is used in urban areas. The data sources and approaches used to quantify municipal and rural residential groundwater extraction are described in the Annual Report.

3.5 Other Agronomic Data

Other agronomic and climate-related data that is incorporated into the GEEEO process includes:

1. Representative consumptive use fractions for crops (i.e., fraction of total applied water that is consumed through ET). Values are based on typical irrigation methods and efficiencies for crops.

2. Conveyance system fractions for subregions (i.e., fraction of diverted water that is delivered, accounting for losses).
3. Reuse fractions for subregions (i.e., fraction of delivered water that is reused).

Information gathered from local sources is used where available, otherwise representative values for agronomic practices in the region are used.

4 References

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Attachment A. GEEEO Computational Approach Details

Figures A-1 and A-2, below, present a schematic of the GEEEO computational approach as it has been developed and is being generally applied to support Annual Report Development.

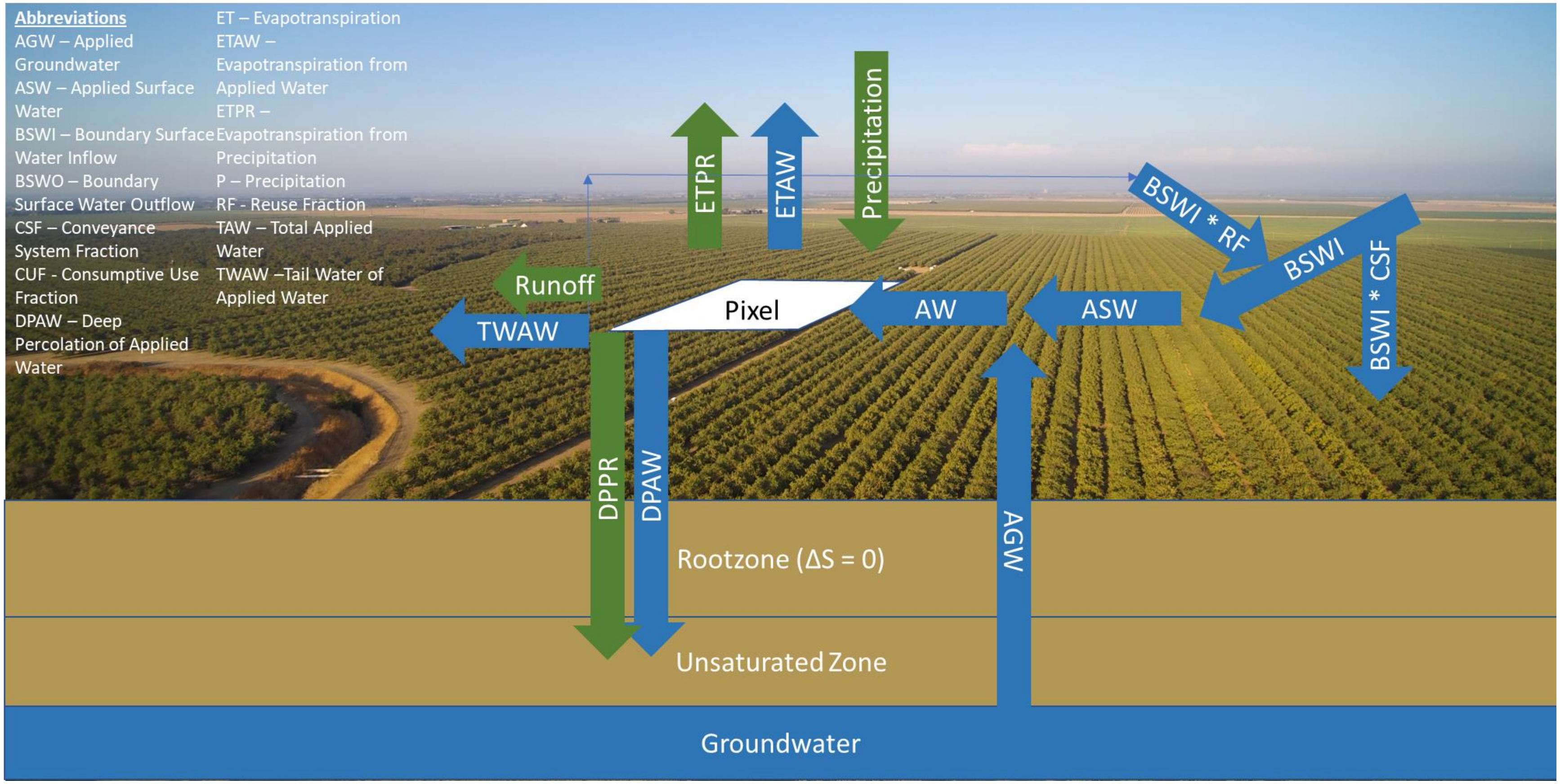

Figure A-1. Inflows and Outflows to Each 30 m x 30 m Pixel in the GEEEO Process.

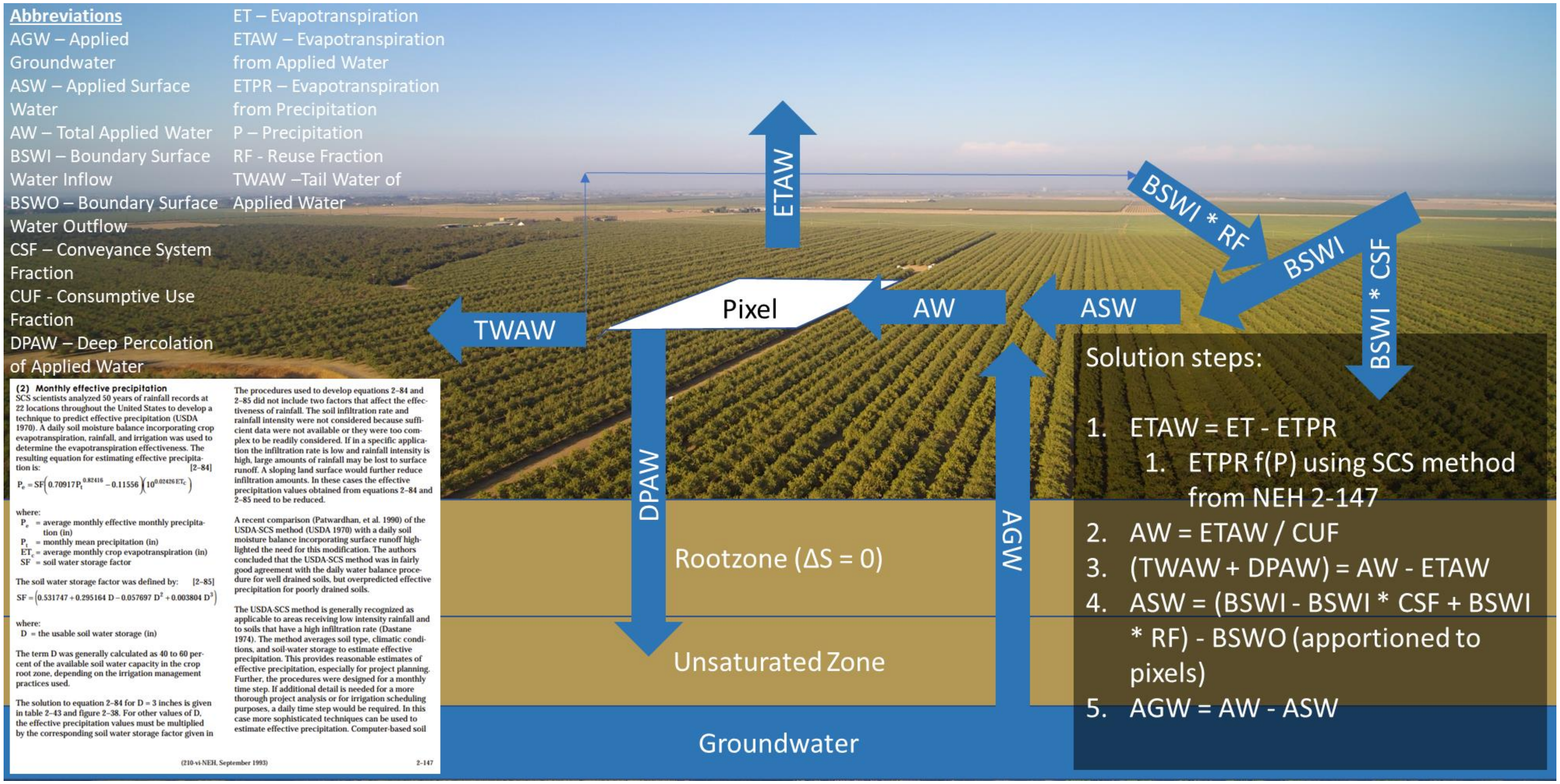

Figure A-2. Solution Steps for Calculating Applied Groundwater (AGW) in Each 30 m x 30 m Pixel in the GEEEO Process.