MADERA SUBBASIN

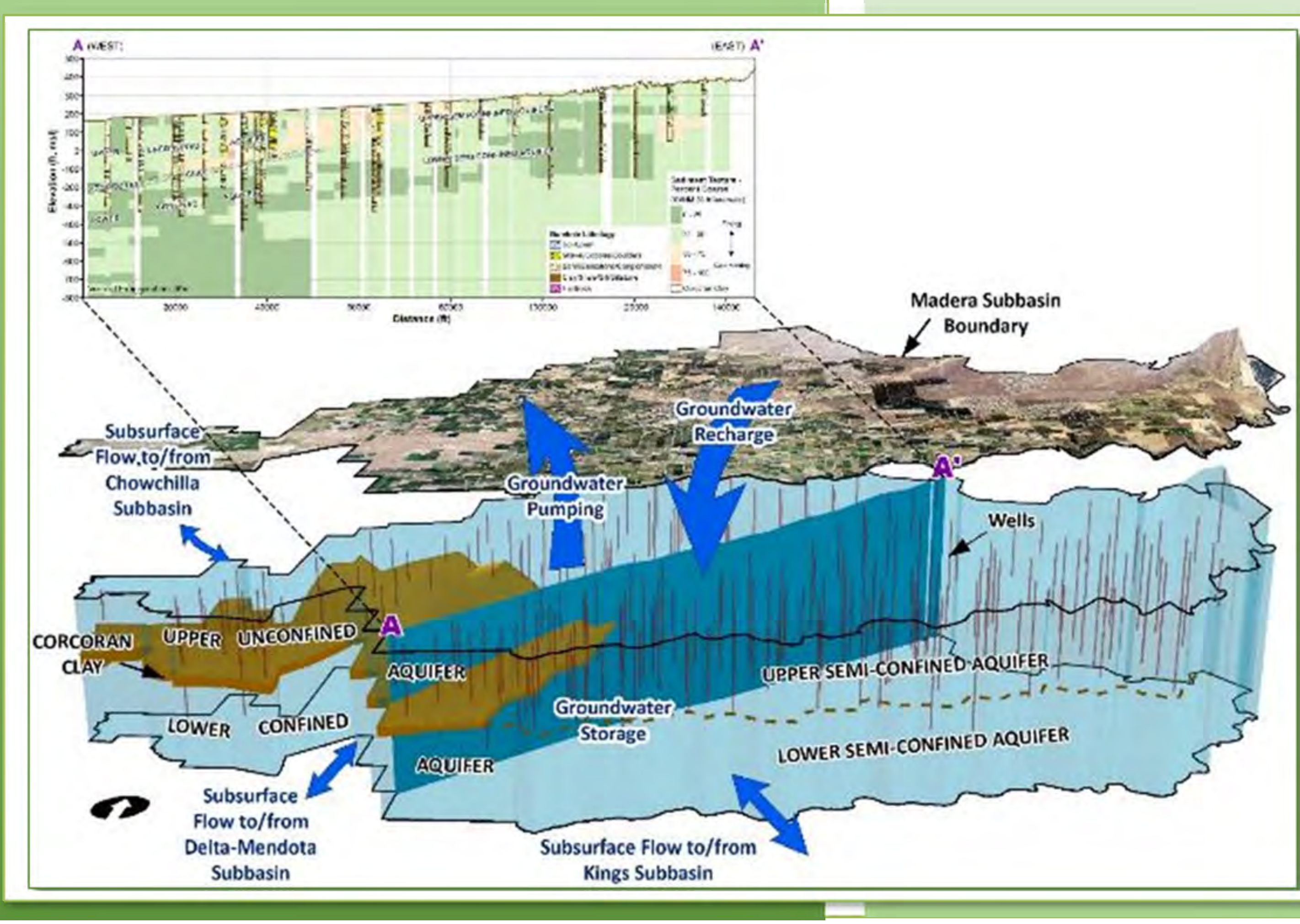
Sustainable Groundwater Management Act (SGMA)

First Annual Report

Prepared by

Davids Engineering, Inc
Luhdorff & Scalmanini
ERA Economics

April 2020



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List of Abbreviations

AF	acre-feet
AG	Agricultural Land
AGR	agricultural supply
AN	above normal
AWMPs	Agricultural Water Management Plans
AWS	Automatic Weather Stations
BMP	Best Management Practice
BN	below normal
C	critical
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
C2VSim-CG	coarse-grid version of C2VSim, Version R374
C2VSim-FG	fine-grid version of C2VSim
CCP	Consensus and Collaboration Program at California State University, Sacramento
CCR	California Code of Regulations
CDEC	California Data Exchange Center
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CM	City of Madera
CSUS	California State University, Sacramento (Consensus and Collaboration Program)
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CWC	California Water Code
CWD	Chowchilla Water District
D	dry
DDW	Division of Drinking Water
DE	Davids Engineering
DMS	Data Management System
DQO	data quality objectives
DTW	depth to water
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ERA	ERA Economics, LLC
ET	evapotranspiration
ET_a	actual ET
ET_{aw}	ET of applied water
ET_c	crop ET
ET_o	grass reference ET
ET_{pr}	ET of precipitation
ET_r	alfalfa reference ET
ET_{ref}	reference crop evapotranspiration
eWRIMS	Electronic Water Rights Information Management System
Flood-MAR	Flood Managed Aquifer Recharge
FTE	full-time-equivalent
GAMA	Groundwater Ambient Monitoring and Assessment
GDEs	groundwater dependent ecosystems
GFWD	Gravelly Ford Water District
GIS	geographic information system
GMP	Groundwater Management Plan
GRF	Gravelly Ford
GSA	Groundwater Sustainability Agencies
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWS	Groundwater system
HCM	hydrogeologic conceptual model
HGL	hydraulic grade line
IDC	Integrated Water Flow Model Demand Calculator
iGDEs	indicators of GDEs
ILRP	Irrigated Lands Regulatory Program
IND	industrial service supply
IWFM	Integrated Water Flow Model
K	hydraulic conductivity
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity

LDC	Little Dry Creek
LSCE	Luhdorff & Scalmanini Consulting Engineers
MA	management actions
maf	millions of acre-feet
MC	Madera County
MCL	maximum contaminant level
MCDEH	Merced County Department of Public Health, Division of Environmental Health
MCWPA	Madera-Chowchilla Water and Power Authority
Merced	Merced Irrigation District
mg/L	milligrams/liter
MID	Madera Irrigation District
MO	measurable objectives
MSL	mean sea level
MT	minimum thresholds
MUN	Municipal and domestic supply
MWD	Madera Water District
MWELO	Model Water Efficient Landscape Ordinance
NASA-JPL	National Aeronautics and Space Administration Jet Propulsion Laboratory
NCCAG	Natural Communities Commonly Associated with Groundwater
NOAA NCEI	National Oceanic and Atmospheric Administration National Centers for Environmental Information
NSWD	New Stone Water District
NV	Native Vegetation Land
NWIS	National Water Information System
O&M	operation and maintenance
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
PRO	industrial process supply
PV	Present Value
Q_b	Quaternary flood-plain deposits
QT_{cd}	Quaternary continental rocks and deposits
RCWD	Root Creek Water District
redox	reduction-oxidation
RFP	Request for Proposals
RH	relative humidity
RMS	Representative monitoring sites
RPE	Reference Point Elevation
R_s	solar radiation
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SCS	USDA Soil Conservation Service (renamed Natural Resources Conservation Service)
SCS-CN	SCS curve number
SEBAL	Surface Energy Balance Algorithm for Land
SGMA	Sustainable Groundwater Management Act of 2014
SJRRP	San Joaquin River Restoration Program
SJV	San Joaquin Valley
SLDMWA	San Luis Delta-Mendota Water Authority
SMC	Sustainable Management Criteria
SOPs	Standard Operating Procedures
SS	Stillwater Sciences
SWRCB	State Water Resources Control Board
SWS	surface water system
Sy	specific yield
T	transmissivity
T_a	air temperature
TAF	thousand acre-feet
TDS	total dissolved solids
TM	Technical Memorandum
TMWA	Truckee Meadows Water Authority
UR	Urban Land
USACE	U.S. Army Corps of Engineers
USBR or Reclamation	United States Bureau of Reclamation
USDA	U.S. Department of Agriculture

USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
UWMPs	Urban Water Management Plans
W	wet
WCRs	well completion reports
WDL	Water Data Library
W_s	wind speed
WYI	Water Year Index
YCWA	Yuba County Water Agency
Yield	net groundwater benefit
µg/L	micrograms per liter

Introduction

The California Code of Regulations Title 23 (23 CCR) §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). Enclosed is the first Annual Report for the Madera Subbasin Joint GSP, which is required to be submitted to DWR by April 1, 2020.[1]

The Annual Report for the Madera Subbasin Joint GSP has been developed in compliance with all of the requirements of 23 CCR §356.2. This report describes the GSP implementation efforts and subbasin conditions within the area managed pursuant to this Joint GSP. This area is covered by the four groundwater sustainability agencies (GSAs) that prepared the Joint GSP: City of Madera (CM) GSA, Madera County (MC) GSA, Madera Irrigation District (MID) GSA, and Madera Water District (MWD) GSA. These four GSAs are identified in this Annual Report as the four Joint GSAs.

This Annual Report does not summarize the subbasin conditions within the areas managed by the other GSAs in the Madera Subbasin that elected to develop and implement individual GSPs. Please refer to the Annual Reports prepared by Gravelly Ford Water District (GFWD) GSA, New Stone Water District (NSWD) GSA, and Root Creek Water District (RCWD) GSA for a description of the subbasin conditions and GSP implementation efforts within each of their jurisdictional areas.

This Annual Report provides basic information about the Joint GSP area, and presents technical information from water year 2015 (after the end of the historical water budget period) through the current reporting year (water year 2019) (23 CCR §356.2.b.5.B), including:

- Groundwater elevation data from monitoring wells
- Contour maps and hydrographs of groundwater elevations
- Total groundwater extractions
- Surface water supply used, including for groundwater recharge or other in-lieu uses
- Total water use
- Change in groundwater storage
- Progress towards implementing the Joint GSP

The structure for the Annual Report generally follows the structure of the requirements outlined in 23 CCR §356.2.

Also included with this Annual Report are appendices that contain the required groundwater maps and hydrographs that must be submitted with each Annual Report, recommendations for stakeholder communication and engagement during GSP implementation, and an economic impact analysis for demand management in the Madera Subbasin. The following appendices are located at the end of this Annual Report:

- Appendix A. Contour Maps of the Different Aquifer Units.
- Appendix B. Hydrographs of Time-Series Groundwater Level Data for Groundwater Level RMS Wells

[1] Due to the ongoing health and safety concerns associated with COVID-19, DWR announced that it would accept Annual Reports after the April 1, 2020 deadline, with no specific date set.

- Appendix C. Maps of change in groundwater levels for each of the years between Spring 2016 and 2018, separated by principal aquifer. Maps of annual change in storage for years between Spring 2016 and Spring 2018.
- Appendix D. Stakeholder Communication and Engagement During Groundwater Sustainability Plan (GSP) Implementation: Recommendations[2]
- Appendix E. Madera Subbasin GSP Demand Management Plan Economic Impact Analysis

Executive Summary (§356.2.a)

In January 2020, the four Joint GSAs in the Madera Subbasin collectively adopted and submitted the Madera Subbasin Joint GSP, fulfilling the requirements established under the Sustainable Groundwater Management Act (SGMA). Implementation of the Joint GSP is now underway, together with the individual GSPs adopted by other agencies in the Madera Subbasin. (**Table ES-1**). The full extent of the Madera Subbasin is covered by these four GSPs (**Figure ES-1**). Approximately 94% of the subbasin area is covered by the Joint GSAs, while the remaining 6% of the subbasin area is covered by the three individual GSAs. These GSPs will collectively result in sustainable operation of the Madera Subbasin by 2040.

Following adoption of the GSP, 23 CCR §356.2 requires that GSAs submit Annual Reports to DWR by April 1 of each year to document the progress made in GSP implementation. This document is the first Annual Report for the Madera Subbasin Joint GSP, which is required to be submitted to DWR by April 1, 2020. In accordance with GSP Regulations, this report summarizes groundwater conditions and water use in the Joint GSP area, as well as the progress that has been made to implement projects and management actions and achieve interim milestones established in the Joint GSP. Key data sources and findings of each section are summarized below for 2019, and described in fuller detail in the associated Annual Report section.

Table ES-1. Coordination of Madera Subbasin Groundwater Sustainability Plans and Annual Reports.

Groundwater Sustainability Agency	Coordinating Body	Groundwater Sustainability Plan and Annual Report Type
City of Madera	Madera Subbasin Coordination Workgroup	Joint GSP and Joint Annual Reports
Madera County		
Madera Irrigation District		
Madera Water District		
Gravelly Ford Water District		Individual GSP and Annual Reports
Root Creek Water District		Individual GSP and Annual Reports
New Stone Water District	N/A	Individual GSP and Annual Reports

[2] The GSAs' abilities to follow the recommendations outlined in Appendix E will be impacted in 2020 by the ongoing health and safety concerns associated with COVID-19 and its repercussions on public agencies' ability to engage with stakeholders (e.g., challenges of conducting effective outreach exclusively by online meetings and phone calls).

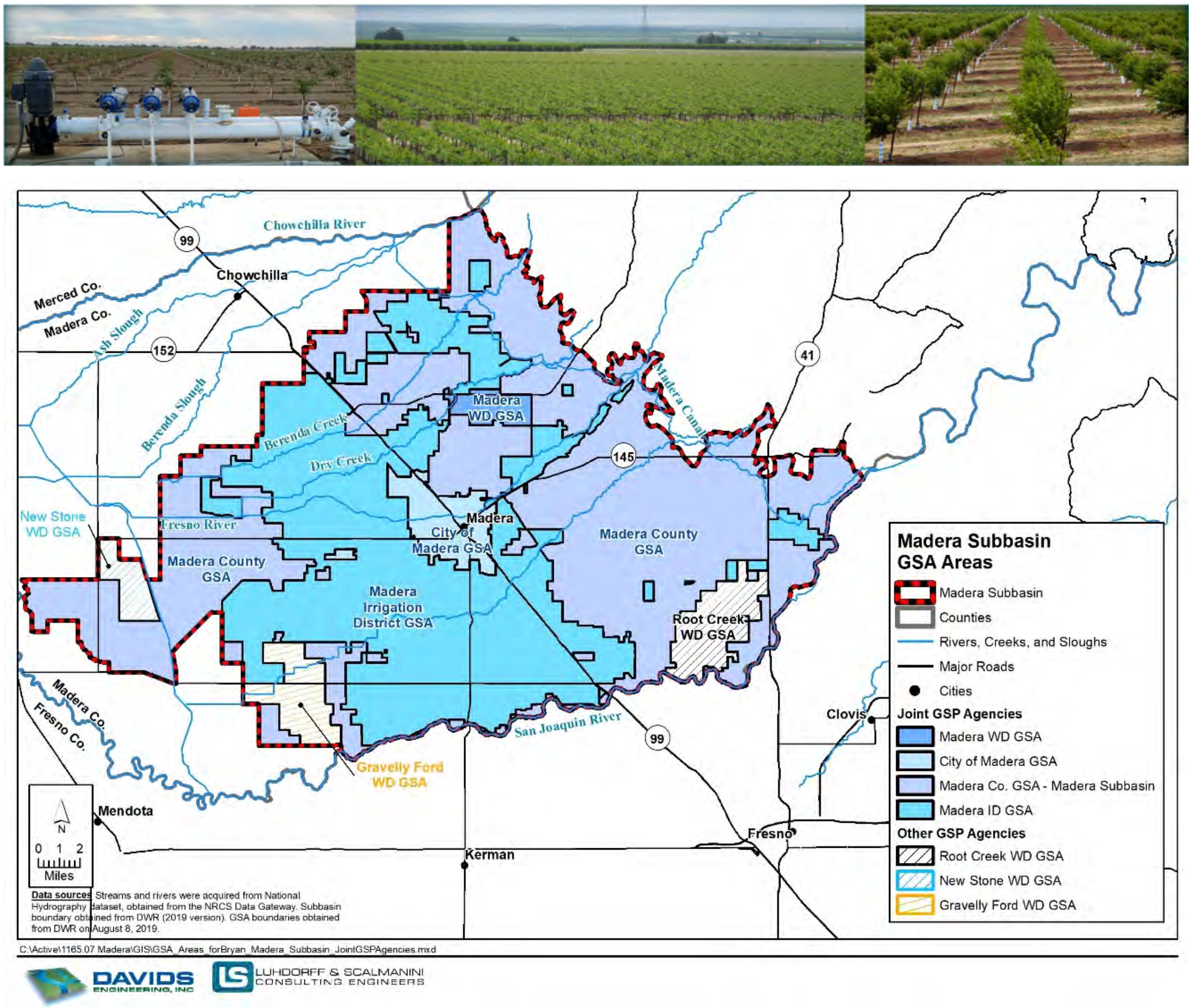

Figure ES-1. Map of Madera Subbasin Joint GSP GSAs.

Groundwater Elevations (§356.2.b.1)

Groundwater level monitoring data was assembled for the period from January 1, 2015[3] through the end of water year 2019. Data was collected from various entities, including: Madera Irrigation District, Madera County, City of Madera, Madera Water District, DWR, USBR, Geotracker GAMA, and CASGEM (the Madera-Chowchilla Groundwater Monitoring Group).

In spring 2019, groundwater elevations at available representative monitoring site (RMS) wells in the subbasin ranged from -43.9 ft AMSL to 136.5 ft AMSL (mean[4] groundwater elevation of 27.3 ft AMSL). In fall 2019, groundwater elevations at available RMS wells in the subbasin ranged from -57.6 ft AMSL to 132.5 ft AMSL (mean groundwater elevation of 4.3 ft AMSL).

Groundwater Elevation Contour Maps (§356.2.b.1.A)

Spring and fall groundwater elevation contour maps were prepared for all years during the period from January 1, 2015 through the end of water year 2019. Spring contours are intended to

[3] Insufficient data are available to map groundwater levels in Spring 2015.

[4] Mean groundwater elevation calculated across all RMS wells. This does not necessarily equal the mean groundwater elevation in the Joint GSP area.

represent seasonal high groundwater levels, while fall contours are intended to represent seasonal low groundwater levels. Data was assembled from all known and available groundwater level information in the Joint GSP area, including from public sources, local GSAs, and other local entities.

In summary, general patterns seen in the spring 2019 and fall 2019 groundwater elevation contour maps are similar to patterns observed in earlier spring and fall time periods, respectively. In the upper aquifer and undifferentiated unconfined groundwater zone, spring and fall contours generally show higher groundwater elevations near the San Joaquin River with groundwater flow to the north-northwest to a broad depression located in the north-central portion of Madera Subbasin. In the lower aquifer (within the extent of the Corcoran Clay), spring and fall contours generally show higher groundwater elevations in the southeast and lower groundwater elevations in the northwest. In both aquifers, the fall groundwater level elevations are generally lower than those observed in the spring, consistent with typical spring to fall changes seen in prior years.

Groundwater Hydrographs (§356.2.b.1.B)

All available groundwater level monitoring data were used to prepare groundwater hydrographs for all years during the period from January 1, 2015 through the end of water year 2019 (Appendix B). Between 2015 and 2019, these hydrographs show generally stable groundwater levels at most RMS wells in Madera Irrigation District, stable to slightly declining levels at RMS wells in City of Madera and Madera Water District, and variable trends at RMS wells in Madera County.

Groundwater Extractions (§356.2.b.2)

Groundwater extraction in the four Joint GSAs was either measured directly from meters or estimated using a water budget that provides a complete accounting of all inflows and outflows from the surface water system in each GSA. Meter records were used when available; otherwise, groundwater extraction was estimated using the best available information (sources and methods are summarized below).

In total, an estimated 397,300 acre-feet (AF) of groundwater was extracted for use within the Joint GSP area during water year 2019. Of this total, 93% was extracted for agricultural use (368,700 AF), and 7% was extracted for urban and domestic use (28,600 AF).

Surface Water Supplies (§356.2.b.3)

Surface water supplies available to the four Joint GSAs include surface water deliveries (CVP supplies from Millerton Reservoir and Hidden Dam), riparian and water rights diversions, and natural flows crossing the Joint GSA boundaries. In this Annual Report, surface water supplies used or available for use are assumed to be the difference between surface water inflows and surface water outflows for the four Joint GSAs. During water year 2019, approximately 40,000 AF of local supplies and over 160,000 AF of CVP supplies were used in the Joint GSP area (combined irrigation deliveries, infiltration, and evaporation).

Total Water Use (§356.2.b.4)

In this Annual Report, total water use is assumed to equal the total applied water from all sources and precipitation in the Joint GSP area, including all consumptive water use (evapotranspiration) and non-consumptive water use (other water uses, e.g. deep percolation and runoff). During water year 2019, total water use in the Joint GSP area was estimated to be 873,100 AF. Of this total, 19% is from surface water, 46% is from groundwater, and 35% is from precipitation. Consumptive water use in the Joint GSP area was estimated to be 690,200 AF in water year 2019.

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

Consistent with §354.18.b, annual changes in groundwater elevation were calculated for each of the principal aquifers between Spring 2016[5] and Spring 2019 based on the difference in annual spring groundwater elevation contours (representing seasonal high groundwater conditions).

Outside of the delineated confined area, changes in groundwater levels (in both the Upper and Lower Aquifers) were multiplied by representative specific yield values to estimate change in groundwater storage. Within the delineated confined area in the Lower Aquifer, groundwater potentiometric surface changes in the Lower Aquifer were multiplied by a much smaller storage coefficient value to calculate annual changes in groundwater storage in the Lower Aquifer. The specific yield and storage coefficient values used in the analysis are derived from values in the calibrated integrated groundwater flow model (MCSim) developed and applied during the preparation of the Joint GSP.

In summary, the combined change in groundwater storage for the entire Joint GSP area was about -75,600 AF from Spring 2018 to 2019, about -19,000 AF for Spring 2017 to 2018 and about -73,500 AF from Spring 2016 to 2017. Negative change in storage values indicate depletion of groundwater storage, whereas positive change in storage values represent accretion of groundwater in storage.

Implementation of Projects or Management Actions (§356.2.c)

Due to the short time period between the GSP submittal deadline (January 31, 2020) and the Annual Report submittal deadline, appreciable progress has only been made on those projects or management actions that were already being implemented prior to the adoption and submission of the Joint GSP. Nevertheless, recharge benefits have already been realized for 13 of the 23 total projects and management actions developed by the four Joint GSAs, with a total estimated benefit of over 37,600 AF of recharge in water year 2019.

Some projects started prior to adoption and submittal of the Joint GSP are underway but may have not yet progressed to a point where benefits are being realized. Additional projects and management actions planned to start in 2020 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. Progress on some projects and stakeholder outreach have slowed as a result of the ongoing health and safety concerns associated with COVID-19 and its repercussions on both public agencies and private parties (e.g., challenges of conducting effective outreach exclusively by online meetings and phone calls). The initial benefits and costs from the first year of implementation of these projects will be reported in the Annual Report to be submitted in 2021.

Interim Milestone Status (§356.2.c)

In the Joint GSP, Interim Milestones (IMs) for chronic lowering of groundwater levels were established at five-year intervals over the Implementation Period from 2020 to 2040, at years 2025, 2030, 2035, and 2040, based on the modeled groundwater level for the month of October in the year preceding the IM date (e.g., October 2024 for the 2025 IM).

Although this Annual Report covers a time period prior to GSP implementation, the status of groundwater level RMS wells are presented in relation to the 2025 IMs, Measurable Objectives

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[5] Insufficient data are available to map groundwater levels in Spring 2015.

(MOs), and Minimum Thresholds (MTs) defined in the Joint GSP. Review of the Fall 2019 groundwater level measurements that are available for 12 RMS wells indicates that groundwater levels remain well above MTs and the majority of groundwater levels are above the 2025 IMs.

Groundwater Elevations (§356.2.b.1)

GROUNDWATER LEVEL MONITORING

This report summarizes and presents monitoring data collected as part of early GSP monitoring and additional monitoring data available for the period from January 1, 2015 through water year 2019. Because the Madera Subbasin Joint GSP was adopted and submitted to DWR in January 2020, this first Annual Report covers the period prior to implementation of the Joint GSP. The groundwater level monitoring information included in this first Annual Report represents a combination of data from regular and historical monitoring conducted in the Subbasin by various entities. This information includes some local GSA-coordinated monitoring conducted as part of initial efforts to establish the long-term GSP monitoring program that will be continued during the GSP implementation period through 2040. Formal GSP groundwater level monitoring conducted by GSAs was initiated upon adoption and submittal of the Joint GSP in January 2020.

Historically, groundwater level monitoring in the Joint GSP area of the subbasin has been conducted by a variety of entities including Madera Irrigation District, Madera County, City of Madera, Madera Water District, DWR, USBR, and Geotracker GAMA. The California State Groundwater Elevation Monitoring Program (CASGEM) was initiated in 2011, with the Madera-Chowchilla Groundwater Monitoring Group designated as the local monitoring entity. This Group includes Madera Irrigation District, Madera County, Madera Water District, Gravelly Ford Water District, and Root Creek Water District along with other entities in the Chowchilla Subbasin. Groundwater levels have been collected and submitted each fall and spring as part of the CASGEM program. Additionally, the Madera Subbasin GSAs also conducted groundwater level monitoring in selected wells in advance of the Joint GSP adoption and submittal. Groundwater level monitoring data available from the entities listed above and all GSAs party to the Madera Subbasin Joint GSP, were assembled for the period from January 1, 2015 through the end of water year 2019 and are presented in this report. **Figure 1-1** includes a map illustrating the well locations and most recent monitoring date for historical groundwater level monitoring conducted in the Subbasin. All available groundwater level measurements acquired for groundwater level RMS wells identified in the Joint GSP are submitted through the Monitoring Network Module on the SGMA Portal. **Figure 1-2** illustrates the groundwater level RMS well network included in the Joint GSP. A summary of RMS well information and recent groundwater level measurements is presented in **Table 1-1**.

Table 1-1. Summary of Groundwater Level RMS Well Information and Measurements During Report Year (2019).

RMS Well I.D. [4]	Estimated Surface Elevation (msl, feet)[1]	Well Depth (feet)	Screen Top-Bottom (feet)	Aquifer Designation	Spring 2019 GWE[1]	Date of Spring 2019 GWE[1]	Fall 2019 GWE[1]	Date of Fall 2019 GWE[1]	GSA
MCW RMS-2	173	216	205-212	Upper	48	3/19/2019	32	10/14/2019	Madera County West
MCW RMS-3	162	Unknown	Unknown	Upper	31.3	3/13/2019			Madera County West
MID RMS-9	202	143	Unknown	Upper					MID
MID RMS-11	232	Unknown	Unknown	Upper					MID
MID RMS-12	262	176	Unknown	Upper					MID
MID RMS-14	214	Unknown	Unknown	Upper					MID
MID RMS-15	247	502	160-200	Upper	136.5	3/25/2019	132.5	10/17/2019	MID
MCE RMS-2	378	Unknown	Unknown	Composite	130.39	3/25/2019			Madera County East
MCE RMS-3	327	Unknown	Unknown	Composite					Madera County East
MID RMS-8	287	Unknown	Unknown	Composite					MID
MID RMS-13	271	600	228-552	Composite					MID
MCW RMS-1	169	800	Unknown	Lower[2]	-2.5	3/28/2019	-36.5	10/18/2019	Madera County West
MCW RMS-4	208	580	220-580	Lower[2]	86.3	3/11/2019			Madera County West
MID RMS-4	190	698	320-667	Lower[2]	-43.9	3/11/2019			MID
MID RMS-5	207	570	270-570	Lower[2]	-10.9	3/11/2019			MID
MID RMS-10	213	615	315-615	Lower[2]	65.7	3/8/2019			MID
COM RMS-1	278	520	210-510	Lower[3]			42.11	11/20/2019	City of Madera
COM RMS-2	262	590	370-590	Lower[3]			56.03	11/27/2019	City of Madera
COM RMS-3	264	620	310-600	Lower[3]					City of Madera
MCE RMS-1	332	500	420-500	Lower[3]					Madera County East
MCE RMS-4	404	Unknown	Unknown	Lower[3]					Madera County East
MCE RMS-5	340	Unknown	Unknown	Lower[3]	96.43	3/21/2019			Madera County East
MCE RMS-6	328	550	450-550	Lower[3]	28.5	3/21/2019	8.5	10/16/2019	Madera County East
MCE RMS-7	388	840	370-820	Lower[3]					Madera County East

RMS Well I.D. [4]	Estimated Surface Elevation (msl, feet)[1]	Well Depth (feet)	Screen Top-Bottom (feet)	Aquifer Designation	Spring 2019 GWE[1]	Date of Spring 2019 GWE[1]	Fall 2019 GWE[1]	Date of Fall 2019 GWE[1]	GSA
MWD RMS-1	330	500	200-500	Lower[3]	8.5	3/19/2019	-10.81	10/23/2019	Madera WD
MWD RMS-2	310	537	200-537	Lower[3]	-27.5	3/19/2019	-39.25	10/25/2019	Madera WD
MWD RMS-3	295	800	380-800	Lower[3]	-43.5	3/19/2019	-54.81	10/24/2019	Madera WD
MID RMS-1	308	950	320-942	Lower[3]	10	3/15/2019	4.75	10/17/2019	MID
MID RMS-2	218	563	298-509	Lower[3]	-37.8	3/11/2019	-57.6	10/23/2019	MID
MID RMS-3	241	516	260-507	Lower[3]	-12.8	3/11/2019			MID
MID RMS-6	237	680	320-680	Lower[3]					MID
MID RMS-7	238	656	290-635	Lower[3]	64.9	3/8/2019			MID
MID RMS-16	308	452	348-388	Lower[3]	-8.9	3/12/2019	-25.7	10/21/2019	MID

[1] Estimated surface elevation and groundwater elevations (GWE) are expressed in feet above mean sea level.
[2] Lower Aquifer wells within Corcoran Clay
[3] Lower Aquifer wells outside Corcoran Clay; considered representative of undifferentiated unconfined groundwater zone
[4] Groundwater level data were not available for all RMS sites because the GSP was not yet adopted and RMS sites not finalized at time of data collection.

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

Historical groundwater elevation contours for the period from January 1, 2015 through the end of water year 2019 were prepared for this first Annual Report. All contours are presented as feet above mean sea level (referenced to the NAVD 88 vertical datum). These contours were developed from all known and available groundwater level information in the Joint GSP area, including data from public sources and from local GSAs and other local entities. Annual spring and fall contour maps were prepared for each year and for each of the principal aquifers in the Subbasin: Upper Aquifer and Lower Aquifer. Annual spring contours are intended to represent seasonal high groundwater levels, while fall contours are intended to represent seasonal low groundwater levels. For the purpose of mapping groundwater elevations, the aquifer system in areas outside the Corcoran Clay was treated as a single undifferentiated unconfined aquifer system and interpretation of groundwater levels in these areas utilized data from wells assigned to both the Upper and Lower depth zones. In areas within the extent of the Corcoran Clay, the aquifer system was separated into an Upper Aquifer unconfined system above the Corcoran Clay and a Lower Aquifer below the Corcoran Clay. To evaluate recent groundwater level conditions in the Subbasin, separate groundwater elevation contour maps were prepared for spring and fall of each year for the combined Upper Aquifer and undifferentiated unconfined groundwater zone and also for the Lower Aquifer within the extent of the Corcoran Clay. The groundwater elevation contour maps for the Lower Aquifer represent a combination of potentiometric elevations where the aquifer is under confined conditions and water table surface elevations where the Lower Aquifer is unconfined. Contour maps of the different aquifer units are presented in **Figure 1-3 through 1-6 and in Appendix A** and are discussed below.

Upper Aquifer and Undifferentiated Unconfined Groundwater Zone

Seasonal high groundwater elevation contour maps for the Upper Aquifer and undifferentiated unconfined groundwater zone were generated for Spring 2019 (**Figure 1-3**), as well as Spring 2016, 2017, and 2018 (**Appendix A**). There were insufficient data available to generate a useful map of Spring 2015 groundwater elevation contours in the Subbasin, although maps of Spring 2014 and Spring 2016 unconfined groundwater elevations were previously included in the Joint GSP. The Spring 2019 Groundwater Elevation Contour Map (**Figure 1-3**) generally shows higher groundwater elevations near the San Joaquin River with groundwater flow to the north-northwest to a broad depression located in the north-central portion of Madera Subbasin. The general patterns in the groundwater elevation contour maps for previous spring time periods (**Appendix A**) are similar to the Spring 2019 map.

Seasonal low groundwater elevation contour maps for the Upper Aquifer and undifferentiated unconfined groundwater zone were generated for Fall 2019 (**Figure 1-4**), as well as Fall 2015, 2016, 2017, and 2018 (**Appendix A**). Similar to the spring contour maps, the Fall 2019 Groundwater Elevation Contour Map (**Figure 1-4**) generally shows higher groundwater elevations near the San Joaquin River with groundwater flow to the north-northwest towards a broad depression located in the north-central portion of Madera Subbasin. As would be expected, the Fall groundwater level elevations are generally lower than for Spring. The general patterns in the groundwater elevation contour maps for previous fall time periods (**Appendix A**) are generally similar to the Fall 2019 map. In addition, Fall 2015 groundwater elevations do appear to be notably lower overall compared to subsequent fall groundwater elevation, which corresponds to the transition from the end of a drought in 2015 to wetter overall conditions in subsequent years.

Lower Aquifer

Seasonal high groundwater elevation contour maps for the Lower Aquifer (within the extent of the Corcoran Clay) were generated for Spring 2019 (**Figure 1-5**), as well as Spring 2016, 2017, and 2018 (**Appendix A**). There were insufficient data available to generate a useful map of Spring 2015 groundwater elevation contours in the Subbasin. The Spring 2019 Groundwater Elevation Contour Map for the Lower Aquifer beneath the Corcoran Clay (**Figure 1-5**) generally shows higher groundwater elevations in the southeast and lower groundwater elevations in the northwestern portion of the Lower Aquifer. The difference in groundwater elevations from southeast to northwest is approximately 100 feet. The general patterns in the groundwater elevation contour maps for previous spring time periods (**Appendix A**) are similar to the Spring 2019 map.

Seasonal low groundwater elevation contour maps for the Lower Aquifer were generated for Fall 2019 (**Figure 1-6**), as well as Fall 2015, 2016, 2017, and 2018 (**Appendix A**). Similar to the spring contour maps, the Fall 2019 Groundwater Elevation Contour Map (**Figure 1-5**) generally shows higher groundwater elevations in the southeast and lower groundwater elevations in the northwestern portions of the Lower Aquifer. As would be expected, the fall groundwater elevations are generally lower than for spring. The general patterns in the groundwater elevation contour maps for previous fall time periods are similar to the Fall 2019 map. In addition, Fall 2015 groundwater elevations do appear to be notably lower overall compared to subsequent fall groundwater elevations (**Appendix A, Figure 1-6**), which corresponds to the transition from the end of a drought in 2015 to wetter overall conditions in the following years.

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

Hydrographs of time-series groundwater level data for groundwater level RMS wells were prepared with all available groundwater level monitoring data through water year 2019 and are contained in **Appendix B**. Madera Irrigation District RMS wells (designated MID) generally showed stable groundwater elevations between 2015 and 2019, with the exception of MID RMS-16, which showed an ongoing decline. Madera County East (designated MCE) and Madera County West (designated MCW) RMS wells show variable trends in groundwater elevations over the 2015 to 2019 time period with increasing, stable and decreasing levels for different wells. The three City of Madera RMS wells (designated COM) generally showed stable to slightly decreasing trends from 2015 to 2019. Similarly, the three Madera Water District wells (designated MWD) showed stable to slightly decreasing groundwater elevation trends from 2015 to 2019. It is notable in MWD RMS wells that the sharp declines in groundwater levels that occurred during the 2012 to 2015 drought had largely stabilized between 2015 and 2019.

Water Budget Approach for Quantifying Groundwater Extraction, Surface Water Supplies, and Total Water Use

In fulfillment of the Annual Report requirements, a water budget approach has been used to quantify groundwater extraction, surface water supply availability, and total water use in the four Joint GSAs. This section describes the structure and uncertainties of these water budgets.

WATER BUDGET STRUCTURE

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[6] over a specified period of time. During development of the Joint GSP, water budgets were prepared for each GSA in the Madera Subbasin to characterize historical, current, and projected water budget conditions. For this Annual Report, the historical water budgets of the four Joint GSAs have been extended through the current reporting year to characterize historical water use through 2019.

Water budgets were prepared for the Surface Water System (SWS) and Groundwater System (GWS). The SWS represents the land surface down to the bottom of the plant root zone, within the lateral boundaries of the Madera Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the subbasin, within the lateral boundaries of the Madera Subbasin.

These systems are referred to as accounting centers. Flows between accounting centers and storage within each accounting center are water budget components. Separate but related water budgets were prepared for each accounting center that together represent the overall water budget for the Madera Subbasin. A schematic of the general water budget accounting structure is provided in **Figure 2-1**.

During GSP development, the SWS water budget accounting center was further subdivided into detailed accounting centers, including the Land Surface System that represents water use in all irrigated and non-irrigated lands. To estimate the water budget components required by the GSP Regulations, the Land Surface System was subdivided into accounting centers representing water use sectors 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 §351(al)). Across the Madera Subbasin and within each GSA, the water use sector accounting centers include Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural), Native Vegetation Land (NV), and Managed Recharge (MR) Land. Industrial land covers only a small area of the subbasin, so industrial water uses have been combined with urban and semi-agricultural uses in the Urban land use sector.

To meet the Annual Report requirements, groundwater extraction and total water use were tracked by water use sector, and surface water supplies were calculated. Water budgets for each water use sector accounting center were developed with distinct, but similar, inflow and outflow components. Water budgets for each water use sector accounting center were developed uniquely for each Madera Subbasin GSA, as described in the Madera Subbasin Joint GSP.

For this Annual Report, flows through the SWS in each GSA were accounted for on a monthly timestep using interrelated water budgets. These water budgets resulted in complete accounting of all SWS inflows and outflows in each GSA, including all water budget components required to quantify groundwater extraction, surface water supplies, and total water use:

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[6] Where 'volume' refers to a space with length, width and depth properties, which for purposes of the GSP means the defined aquifer and associated surface water system.

- **Groundwater Extraction**: Equal to “Groundwater Extraction”
- **Surface Water Supplies (used, or available for use)**: Assumed to be equal to the difference between “Surface Water Inflows” and “Surface Water Outflows.”
- **Total Water Use**: Water use is defined by ASCE (2016) as “water that is used for a specific purpose such as domestic use, irrigation, or industrial processing.” This definition includes both consumptive and non-consumptive components. The total consumptive water use (the sum of “Evapotranspiration of Applied Water” and “Evapotranspiration of Precipitation”) is also reported as this the volume of water that is no longer available for use within the subbasin.

The data sources, calculation procedures, and results pertaining to these key water budget components are described in the sections below for each the four Joint GSAs. Details about groundwater extractions, surface water supplies, and total water use for the GFWD GSA, NSWD GSA, and RCWD GSA can be found in each of their respective Annual Reports.

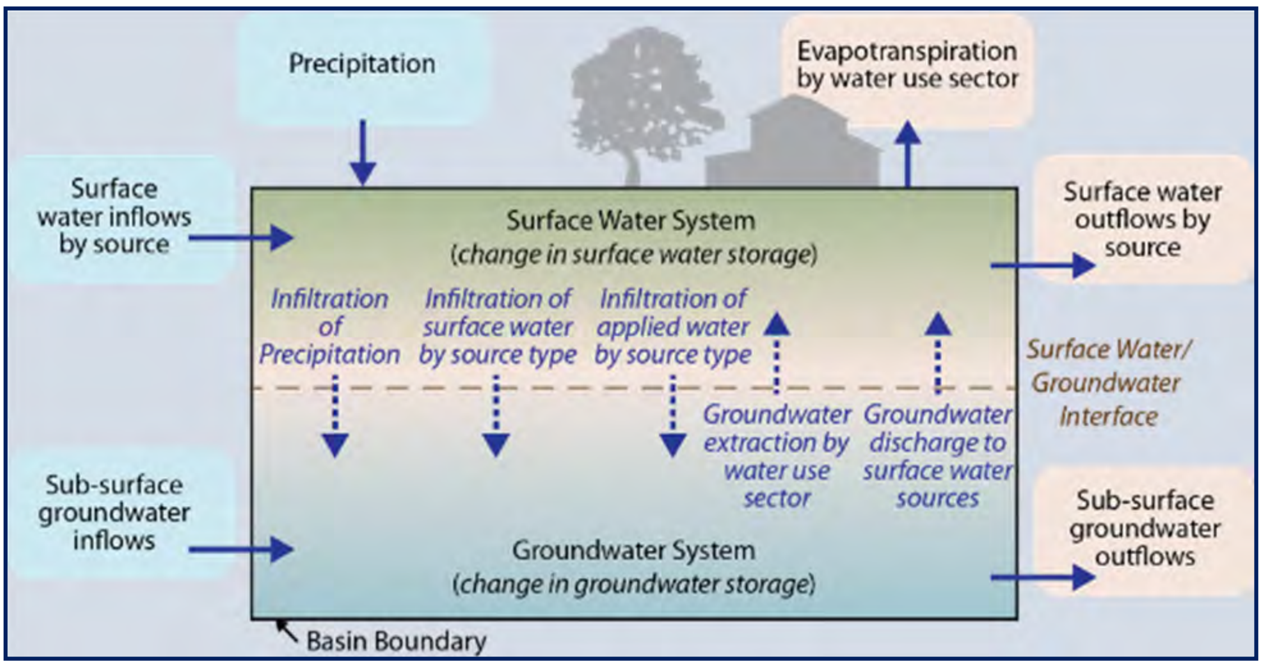


Figure 2-1. Water Budget Accounting Structure (Source: DWR, 2016).

UNCERTAINTIES IN WATER BUDGET COMPONENTS

Uncertainties associated with each water budget component have been estimated as described by Clemmens and Burt (1997), as follows:

1. The uncertainty of each independently-estimated water budget component (excluding the closure term) is calculated or estimated as a percentage that approximately represents a 95% confidence interval. Uncertainties are influenced by the accuracy of available data, the uncertainty of supporting calculations and estimation procedures, and professional judgement.
2. Assuming random, normally-distributed error, the standard deviation is calculated for each independently-estimated component as the average uncertainty on a volumetric basis (uncertainty percentage multiplied by the average component volume) divided by two.
3. The variance is calculated for each independently-estimated component as the square of the standard deviation.
4. The variance of the closure term is estimated as the sum of variances of all independently-estimated components.
5. The standard deviation of the closure term is estimated as the square root of the sum of variances.
6. The 95% confidence interval of the closure term is estimated as twice the estimated standard deviation.

Estimated uncertainties were calculated following the above procedure for all GSA water budgets.

Groundwater Extraction (§356.2.b.2)

This section summarizes the measurement methods, accuracy, and volumes of groundwater extraction by the four Joint GSAs for the current reporting year (2019).

QUANTIFICATION AND ACCURACY

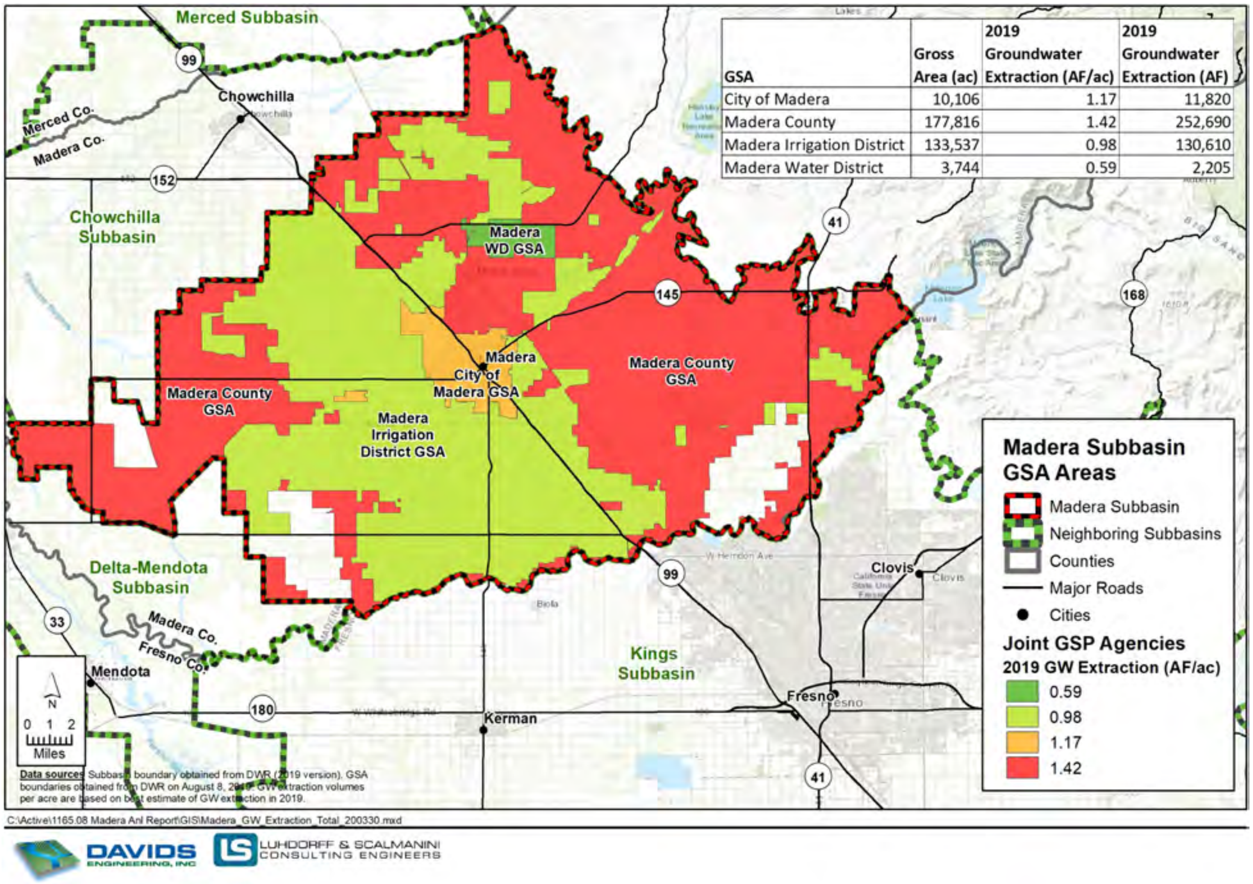
Groundwater extraction in the four Joint GSAs was either measured directly from meters or estimated based on other inflows and outflows from the surface water system. Meter records were used when available (MWD GSA agricultural water use sector, and City of Madera GSA urban water use sector); otherwise, groundwater extraction was estimated using the best available information. **Table 3-1** summarizes groundwater extraction in 2019 and the associated measurement methods, by GSA and water use sector.

Figure 3-1 provides a map of the 2019 total groundwater extraction volumes and depths in each of the four Joint GSAs in the Madera Subbasin, while **Figure 3-2** provides a map of the 2019 agricultural groundwater extraction volumes and depths in irrigated areas in the Joint GSAs.

Table 3-2 further summarizes the total groundwater extraction by water use sector in the four Joint GSAs between 1989 (the beginning of the Madera Joint GSP historical water budget period) and 2019 (the current reporting year).

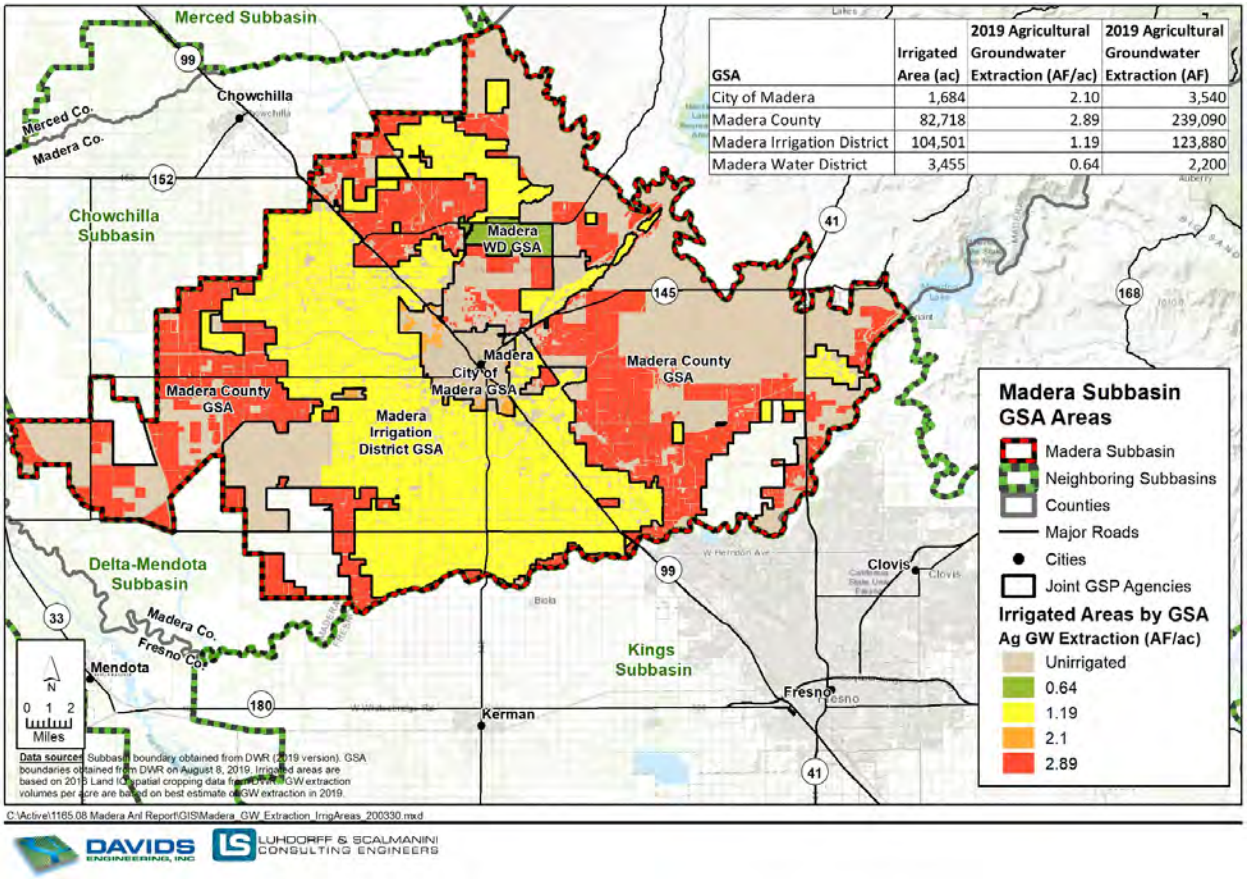
Table 3-1. Groundwater Extraction Volumes and Measurement Methods by Water Use Sector, and Uncertainty (2019).

GSA	Water Use Sector	Groundwater Extraction, 2019 (acre-feet)	Measurement Method	Description
All (except Madera Water District GSA)	Agricultural	366,499	Estimate	Water use sector closure
Madera Water District GSA	Agricultural	2,201	Direct	Meter records
All	Managed Recharge	0	Estimate	No groundwater extraction for managed recharge
All	Native Vegetation	0	Estimate	Water use sector closure
All (except City of Madera GSA)	Urban	20,333	Estimate	Water use sector closure
City of Madera GSA	Urban	8,275	Direct	Meter records
Joint GSP Area		Groundwater Extraction, 2019 (acre-feet)	Average Uncertainty	Uncertainty Source
Total		397,308	20%	Typical uncertainty when calculated for Land Surface System water balance closure, combined with uncertainty of measurement devices for MWD GSA and City of Madera urban sector



GSA	Gross Area (ac)	2019 Groundwater Extraction (AF/ac)	2019 Groundwater Extraction (AF)
City of Madera	10,106	1.17	11,820
Madera County	177,816	1.42	252,690
Madera Irrigation District	133,537	0.98	130,610
Madera Water District	3,744	0.59	2,205

Figure 3-1. Total Groundwater Extraction Volumes and Depth, by Joint GSP GSA.



GSA	Irrigated Area (ac)	2019 Agricultural Groundwater Extraction (AF/ac)	2019 Agricultural Groundwater Extraction (AF)
City of Madera	1,684	2.10	3,540
Madera County	82,718	2.89	239,090
Madera Irrigation District	104,501	1.19	123,880
Madera Water District	3,455	0.64	2,200

**Irrigated areas are based on the 2016 Land IQ spatial cropping data available from DWR (City of Madera GSA, Madera County GSA, Madera Irrigation District GSA) or from District records (Madera Water District GSA). The groundwater extraction volumes per acre are based on measured or estimated groundwater extraction in 2019.*

Figure 3-2. Agricultural Groundwater Extraction Volumes and Depths in Irrigated Areas*, by Joint GSP GSA.

Table 3-2. Joint GSP Groundwater Extractions, by Water Use Sector (acre-feet, rounded).

Water Year (Type)	Agricultural	Managed Recharge	Native Vegetation	Urban and Industrial	Total
1989 (C)	366,250	0	0	16,920	383,170
1990 (C)	412,050	0	0	17,940	429,990
1991 (C)	405,240	0	0	16,890	422,130
1992 (C)	466,510	0	0	22,400	488,910
1993 (W)	352,910	0	0	17,670	370,580
1994 (C)	387,840	0	0	20,610	408,450
1995 (W)	297,030	0	0	11,070	308,100
1996 (W)	347,820	0	0	16,810	364,630
1997 (W)	408,960	0	0	26,930	435,890
1998 (W)	314,700	0	0	14,510	329,210
1999 (AN)	361,860	0	0	21,220	383,080
2000 (AN)	394,490	0	0	20,100	414,590
2001 (D)	408,070	0	0	18,640	426,710
2002 (D)	448,330	0	0	24,330	472,660
2003 (BN)	424,440	0	0	23,830	448,270
2004 (D)	475,970	0	0	30,860	506,830
2005 (W)	353,550	0	0	19,550	373,100
2006 (W)	348,440	0	0	18,990	367,430
2007 (C)	430,360	0	0	30,260	460,620
2008 (C)	427,160	0	0	30,250	457,410
2009 (BN)	407,860	0	0	29,580	437,440
2010 (AN)	312,280	0	0	17,430	329,710
2011 (W)	326,960	0	0	19,780	346,740
2012 (D)	470,750	0	0	31,200	501,950
2013 (C)	471,430	0	0	32,910	504,340
2014 (C)	529,790	0	0	32,020	561,810
2015 (C)	602,290	0	0	36,810	639,100
2016 (D)	438,740	0	0	31,070	469,810
2017 (W)	394,000	0	0	31,380	425,380
2018 (BN)	449,890	0	0	31,810	481,700
2019 (W)	368,700	0	0	28,610	397,310
Average (1989-2014)	398,130	0	0	22,410	420,540
Average (1989-2019)	406,600	0	0	23,950	430,550
W	351,300	0	0	20,540	371,840
AN	356,210	0	0	19,580	375,790
BN	427,400	0	0	28,400	455,800
D	448,370	0	0	27,210	475,580
C	449,890	0	0	25,700	475,590

DATA SOURCES

Measured Groundwater Extraction

Measured groundwater pumping was available from meter records available from MWD (for agricultural groundwater extraction) and City of Madera (for urban groundwater extraction). MWD meter records were reported in the MWD Groundwater Management Plan or provided by the District for years 1993 through 2019. All available pumping records were used to complete the MWD GSA water budget. City of Madera SCADA records were available for years 2013 through 2019. Available pumping records from 2015 through 2019 were used to complete the City of Madera GSA water budget, while the SCADA data in 2013 and 2014 were used as a comparison for validating the groundwater extraction estimation procedures described below.

Estimated Groundwater Extraction

Estimated groundwater extraction was calculated as the Land Surface System water budget “closure” term – the difference between all other estimated or measured inflows and outflows from each water use sector. Groundwater extraction was selected as the closure term because groundwater pumping data has generally been unavailable across the subbasin (except where indicated in **Table 3-2**). Also, groundwater extraction serves as a relatively large inflow to the Land Surface System, resulting in lower relative uncertainty when calculated as a closure term compared to smaller flow paths following the procedure outlined by Clemmens and Burt (1997).

GROUNDWATER RECHARGE

As mandated under 23 CCR §354.24, GSAs within the Madera Subbasin have established a “sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline.” The expressed sustainability goal for the Joint GSP area is “to implement a package of projects and management actions that will, by 2040, balance long-term groundwater system inflows with outflows.” (pg. 3-2 of the Joint GSP). To track the GSAs’ progress toward meeting this sustainability goal, both the groundwater system inflows and outflows must be quantified.

As shown in **Figure 2-1**, GWS outflows to the SWS include groundwater extraction (quantified above) and groundwater discharge (assumed to be negligible in the Madera Subbasin, given the substantial depth to groundwater). GWS inflows from the SWS include infiltration of precipitation, infiltration of applied water, and infiltration of surface water. While these GWS inflows are not required to be reported in this Annual Report, the Madera Subbasin GSAs feel that they are necessary to understanding the total contribution of the SWS to subbasin sustainability.

Table 3-3 summarizes the total annual groundwater recharge from the SWS in the Joint GSP area. The components of recharge are useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS. The data sources and calculations used to develop each recharge component are described in Section 2.2.3.3 (pages 2-64 through 2-80 of the Joint GSP).

Table 3-3. Joint GSP Groundwater Recharge (acre-feet, rounded).

Water Year (Type)	Infiltration of Applied Water	Infiltration of Precipitation	Infiltration of Surface Water[1]	Total Groundwater Recharge
1989 (C)	132,000	88,800	107,000	327,800
1990 (C)	129,100	74,800	93,800	297,700
1991 (C)	143,400	114,000	100,400	357,800
1992 (C)	136,600	57,900	99,900	294,400
1993 (W)	147,300	150,400	249,700	547,400
1994 (C)	129,200	53,800	96,700	279,700
1995 (W)	131,600	199,100	245,800	576,500
1996 (W)	124,500	93,600	199,100	417,200
1997 (W)	173,700	160,600	218,500	552,800
1998 (W)	131,000	161,300	190,200	482,500
1999 (AN)	115,000	39,900	116,700	271,600
2000 (AN)	127,600	69,900	136,500	334,000
2001 (D)	128,200	61,800	108,200	298,200
2002 (D)	134,800	58,000	102,400	295,200
2003 (BN)	119,700	43,400	105,900	269,000
2004 (D)	126,000	33,700	97,500	257,200
2005 (W)	122,700	68,100	154,500	345,300
2006 (W)	115,300	92,800	173,700	381,800
2007 (C)	112,000	26,700	155,000	293,700
2008 (C)	114,600	42,900	113,800	271,300
2009 (BN)	102,200	31,300	93,800	227,300
2010 (AN)	102,400	82,300	120,900	305,600
2011 (W)	116,900	94,200	186,100	397,200
2012 (D)	116,400	26,100	67,000	209,500
2013 (C)	122,400	43,600	95,800	261,800
2014 (C)	105,400	16,700	81,600	203,700
2015 (C)	118,400	22,000	82,500	222,900
2016 (D)	125,900	80,500	128,200	334,600
2017 (W)	126,400	105,900	277,600	509,900
2018 (BN)	119,000	42,200	127,000	288,200
2019 (W)	116,000	61,000	139,100	316,100
Average (1989-2014)	125,400	76,400	135,000	336,800
Average (1989-2019)	124,700	74,100	137,600	336,400
W	130,500	118,700	203,400	452,600
AN	115,000	64,000	124,700	303,700
BN	113,600	39,000	108,900	261,500
D	126,300	52,000	100,700	279,000
C	124,300	54,100	102,600	281,000

[1] Infiltration of Surface Water includes infiltration of surface water in the rivers, streams, and canals within the Joint GSP area, plus boundary seepage from the San Joaquin River.

Surface Water Supplies (§356.2.b.3)

This section summarizes the annual volumes and data sources for surface water supplies used, or available for use, by the four Joint GSAs through the current reporting year (2019).

QUANTIFICATION BY WATER SOURCE TYPE

Surface water supplies available to the four Joint GSAs include surface water deliveries and surface water flowing across GSA boundaries. In this Annual Report, surface water supplies used or available for use are assumed to be the difference between surface water inflows and surface water outflows for the four Joint GSAs.

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 4-1 summarizes the total surface water supplies used or available for use in the four Joint GSAs, by water source type. The supplies included in these totals are described below.

Local Supplies

Local supplies available to the four Joint GSAs include natural surface water flows along Berenda Creek, Dry Creek, Cottonwood Creek, and Chowchilla Bypass. Much of this water passes through the subbasin or infiltrates into the GWS. Local supplies also include MID’s Pre-1914 water rights, as well as riparian deliveries from the San Joaquin River and the Fresno River to water rights users in Madera County GSA and MID GSA. This water is applied to irrigated land and is assumed to be completely used within the Madera Subbasin.

CVP Supplies

Agencies with CVP contracts can receive CVP supplies in the Madera Subbasin. CVP supplies received via Madera Canal include Millerton irrigation releases and flood releases. CVP supplies are also received from Hidden Dam releases to the Fresno River. Outflows of CVP supplies from the four Joint GSAs include MID deliveries to growers outside the Joint GSAs (Gravelly Ford Water District, Root Creek Water District, and Chowchilla Water District), MID conveyance system spillage to the San Joaquin River, MID releases to Cottonwood Creek (for delivery to Gravelly Ford Water District), and pass-through flood releases along Fresno River.

Local Imported Supplies

The Joint GSAs do not receive local imported supplies.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within Madera Subbasin. However, urban wastewater treated by the City of Madera, as well as water associated with private septic systems, general returns to the groundwater system within the subbasin and has been included in prior budgets.

SURFACE WATER SUPPLIES AVAILABLE TO EACH GSA

The surface water supplies available to each GSA are summarized below.

City of Madera GSA

The majority of irrigated agricultural lands in City of Madera GSA are located within the boundaries of MID and have the ability to receive surface water in accordance with MID's normal operating practices. Some owners have utilized surface water from MID to meet a portion of their agricultural water needs, while others have chosen to rely solely on groundwater. In water year 2019, City of Madera GSA jointly operated Berry Basin with MID GSA to provide approximately 470 AF of recharge for the City.

Madera County GSA

Surface water supplies available for agriculture in MC GSA include riparian deliveries to water rights users along the San Joaquin River, the Fresno River, and other minor streams. In water year 2019, water rights holders within MC GSA diverted approximately 2,300 AF from San Joaquin River, while reports for Fresno River and other minor stream diversions are not yet available. Madera County GSA also jointly operated Ellis Basin with MID GSA to provide approximately 150 AF of recharge for the County.

Madera Irrigation District GSA

MID GSA receives substantial surface water supplies to support agriculture. MID receives CVP supplies under contract with Reclamation from the Madera Canal and from Hidden Dam releases. MID also receives local supplies through Pre-1914 water rights. In water year 2019, MID GSA received a substantial portion of the District's surface water contracts which include MID's Friant Class 1 contract amount of 85,000 AF and Class 2 contract amount of 186,000 AF along with the MID's Hidden Dam contract supplies, Pre-1914 water rights supplies, and other types of surface water made available to the District. Water rights holders along the San Joaquin River diverted an additional 3,300 AF from San Joaquin River.

Madera Water District GSA

To support agriculture, MWD GSA receives surface water supplies from MID via Dry Creek. In water year 2019, MWD received over 5,600 AF of surface water at their turnout along Dry Creek.

All GSAs

As defined above, the volume of surface water supplies used or available for use is assumed to be the difference between surface water inflows and outflows from each GSA. This total volume encompasses all water that is diverted and applied to land within each GSA (from the water sources described above), as well as all water that is lost through seepage and evaporation along the waterways that cross each GSA's boundaries.

DATA SOURCES

Table 4-2 summarizes the data sources and estimation procedures for all water budget components that are used to quantify surface water supplies available to the four Joint GSAs. Additional detail is given below for each water budget component. The data sources for surface water inflows and outflows along the Fresno River, Chowchilla Bypass and the Berenda, Cottonwood and Dry Creeks within the Madera Subbasin are described in Section 2.2.3.3, pages 2-66 through 2-70 of the Madera Subbasin Joint GSP. For each waterway, a subbasin boundary water budget was computed first by following the procedure described for each waterway in the

GSP. Unless otherwise specified, all missing and inaccurate data were replaced by estimates equal to the average monthly value of available data, computed by water year type.

Table 4-1. Joint GSP Surface Water Supplies Used (Surface Water Inflows – Surface Water Outflows), by Water Source Type (acre-feet, rounded).

Water Year (Type)	Local Supplies	CVP Supplies	Total
1989 (C)	11,700	104,400	116,100
1990 (C)	17,500	62,500	80,000
1991 (C)	14,300	104,600	118,900
1992 (C)	11,700	91,400	103,100
1993 (W)	49,500	253,500	303,000
1994 (C)	9,200	137,400	146,600
1995 (W)	72,900	196,300	269,200
1996 (W)	46,500	238,900	285,400
1997 (W)	89,400	211,900	301,300
1998 (W)	67,300	154,000	221,300
1999 (AN)	12,000	188,000	200,000
2000 (AN)	18,000	175,800	193,800
2001 (D)	11,200	156,600	167,800
2002 (D)	9,900	134,200	144,100
2003 (BN)	12,300	132,400	144,700
2004 (D)	13,400	139,400	152,800
2005 (W)	38,900	161,600	200,500
2006 (W)	60,800	183,300	244,100
2007 (C)	18,500	186,300	204,800
2008 (C)	11,300	148,100	159,400
2009 (BN)	18,100	108,700	126,800
2010 (AN)	15,900	161,800	177,700
2011 (W)	65,300	196,700	262,000
2012 (D)	13,700	95,300	109,000
2013 (C)	10,100	89,600	99,700
2014 (C)	7,900	17,700	25,600
2015 (C)	9,200	8,400	17,600
2016 (D)	23,100	122,400	145,500
2017 (W)	93,700	209,200	302,900
2018 (BN)	9,900	163,500	173,400
2019 (W)	40,100	160,700	200,800
Average (1989-2014)	28,000	147,300	175,300
Average (1989-2019)	29,100	145,000	174,100
W	62,400	196,600	259,100
AN	15,300	175,200	190,500
BN	13,400	134,900	148,300
D	14,300	129,600	143,800
C	12,100	95,000	107,200

Table 4-2. Detailed Water Budget Components and Estimation Techniques Related to Surface Water Supplies (Rivers and Streams System and Conveyance System Water Budgets)

Detailed Component	Associated Waterway	Water Source Type	Calculation/Estimation Technique	Information Sources
Surface Inflows	Berenda Creek	Local Supplies	Calculated from MID recorder measurements adjusted upstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 13, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Cottonwood Creek	Local Supplies	Calculated from MID recorder measurements adjusted upstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 14, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Chowchilla Bypass	Local Supplies	Calculated from SLDMWA CBP station measurements adjusted downstream to the subbasin boundary for estimated seepage and evaporation	SLDMWA CBP station, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Dry Creek	Local Supplies	Estimated as equal to Berenda Creek recorder measurements adjusted upstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 13, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Fresno River	CVP Supplies	Estimated as equal to USGS measurement site along Fresno River below Hidden Dam	USGS Site 11258000 (FRESNO R BL HIDDEN DAM NR DAULTON CA)
Surface Outflows	Berenda Creek	Local Supplies	Calculated from MID recorder measurements adjusted downstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 2, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Cottonwood Creek	Local Supplies	Calculated from MID recorder measurements adjusted downstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 10, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Chowchilla Bypass	Local Supplies	Calculated from SLDMWA CBP station measurements adjusted downstream to the subbasin boundary for estimated seepage and evaporation	SLDMWA CBP station, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
	Fresno River	CVP Supplies	Calculated from MID recorder measurements (downstream of convergence with Dry Creek) adjusted downstream to the subbasin boundary for estimated seepage and evaporation	MID Recorder 4, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
Riparian Deliveries[1]	San Joaquin River	Local Supplies	Reported riparian deliveries and estimated riparian deliveries based on estimated consumptive use of riparian parcels during streamflow	eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Madera Canal Releases to Fresno River	Madera Canal	CVP Supplies	Reported in USBR CVP irrigation delivery records at Madera Canal Mile 18.8	USBR CVP delivery records
MID Diversions from Madera Canal	Madera Canal	CVP Supplies	Reported in USBR CVP irrigation delivery records at Madera Canal Miles 6.1, 13.06, 22.95, 24.1, 26.8, 27.5, 28.38, 28.39, 28.64, 30.4, 30.5, 32.2	USBR CVP delivery records

Detailed Component	Associated Waterway	Water Source Type	Calculation/Estimation Technique	Information Sources
MID Flood Diversions from Madera Canal	Madera Canal	CVP Supplies	Reported in USBR CVP flood delivery records at Madera Canal Miles 6.1, 13.06, 22.95, 24.1, 26.8, 27.5, 28.38, 28.39, 28.64, 30.4, 30.5, 32.2	USBR CVP delivery records
MID Diversions from Fresno River[2]	Fresno River	CVP Supplies	Closure of Fresno River Balance	USGS Site 11258000 (FRESNO R BL HIDDEN DAM NR DAULTON CA), USBR CVP delivery records, IDC root zone water budget, NRCS soils characteristics, CIMIS precipitation data, MID recorders
Spillage[3]	San Joaquin River	CVP Supplies	Measured by MID recorders at spillage sites	MID Recorders 9, 11
MID Conveyance System to Cottonwood Creek	Cottonwood Creek	CVP Supplies	Estimated from MID Recorder 10, GFWD reports	MID Recorder 10, GFWD reports
MID Deliveries to Other Districts	MID Conveyance System	CVP Supplies	Measured by MID, or reported from other districts' records	MID STORM[4] delivery database, GFWD reports, MWD reports, RCWD reports

[1] Riparian deliveries along Fresno River within the Madera Subbasin are included in the "MID Diversions from Fresno River."
[2] Total diversions from Fresno River includes riparian deliveries from Fresno River.
[3] Spillage to Fresno River (MID Recorders 15-20) are accounted in the Fresno River outflows.
[4] The water ordering and delivery management software used by Madera Irrigation District.

Total Water Use (§356.2.b.4)

This section summarizes the annual volumes and data sources for total water use by the four Joint GSAs through the current reporting year (2019).

QUANTIFICATION BY WATER USE SECTOR AND WATER SOURCE TYPE

Water use is defined by ASCE (2016) as "water that is used for a specific purpose such as domestic use, irrigation, or industrial processing." This definition includes both consumptive and non-consumptive components.

In the context of agriculture, 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). As most field crops dry to a very low moisture content approaching harvest, total consumptive water use is generally equivalent to the combined evaporation (E) and crop transpiration (T), together referred to as crop evapotranspiration (ET_c). ET_c encompasses evapotranspiration of all water available to crops, including primarily evapotranspiration of precipitation (ET_{pr}) and evapotranspiration of applied water (ET_{aw}). Non-consumptive water use is generally equal to the remaining volume of precipitation and applied water that is not consumptively used.

Accordingly, the total water use reported below is assumed to be equal to the total combined precipitation and applied water from all sources within the Joint GSP area.

In addition to reporting the total water use in the Joint GSAs, the total consumptive water use (the sum of ET_{aw} and ET_{pr}) is also reported below, as this represents the volume of water that is no longer available for use within the Joint GSAs (i.e., unavailable for reuse or future groundwater extraction).

Water sources available for use in the Joint GSP area include applied water (surface water and groundwater) and precipitation. **Table 5-1** summarizes the total water use by the four Joint GSAs, by water use sector and water source type from 1989 through 2019 (the current reporting year). **Table 5-2** summarizes the consumptive water use by the four Joint GSAs, by water use sector and water source type from 1989 through 2019.The methodology and data sources used to develop these tables are provided below.

Table 5-1. Joint GSP Total Water Use, by Water Use Sector and Water Source Type (acre-feet, rounded).

Water Year (Type)	Agricultural				Managed Recharge				Native Vegetation				Urban				Total			
	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation
1989 (C)	629,880	68,580	366,250	195,050	0	0	0	0	104,290	0	0	104,290	39,830	0	16,900	22,930	774,010	68,580	383,160	322,270
1990 (C)	647,360	53,310	412,060	181,990	0	0	0	0	96,810	0	-10	96,820	39,570	0	17,940	21,630	783,750	53,310	429,990	300,450
1991 (C)	682,370	86,860	405,250	190,260	0	0	0	0	100,800	0	0	100,800	39,740	0	16,880	22,860	822,920	86,860	422,130	313,930
1992 (C)	691,420	69,150	466,510	155,760	0	0	0	0	81,890	0	0	81,890	41,300	0	22,400	18,900	814,600	69,150	488,910	256,540
1993 (W)	747,760	130,690	352,900	264,170	0	0	0	0	138,140	0	0	138,140	50,030	0	17,670	32,360	935,930	130,690	370,570	434,670
1994 (C)	654,180	116,390	387,840	149,950	0	0	0	0	77,830	0	-10	77,840	39,150	0	20,610	18,540	771,150	116,390	408,440	246,320
1995 (W)	726,610	107,200	297,020	322,390	0	0	0	0	166,160	0	0	166,160	51,300	0	11,060	40,240	944,070	107,200	308,080	528,790
1996 (W)	704,080	159,100	347,820	197,160	0	0	0	0	101,150	0	0	101,150	41,670	0	16,810	24,860	846,910	159,100	364,640	323,170
1997 (W)	798,000	163,590	408,960	225,450	0	0	0	0	115,120	0	0	115,120	55,650	0	26,920	28,730	968,770	163,590	435,890	369,290
1998 (W)	691,980	106,050	314,700	271,230	0	0	0	0	137,850	0	0	137,850	49,410	0	14,500	34,910	879,230	106,050	329,200	443,980
1999 (AN)	607,290	135,340	361,860	110,090	0	0	0	0	55,690	0	0	55,690	35,540	0	21,230	14,310	698,520	135,340	383,090	180,090
2000 (AN)	696,540	122,440	394,500	179,600	0	0	0	0	90,420	0	0	90,420	43,680	0	20,100	23,580	830,640	122,440	414,600	293,600
2001 (D)	688,850	113,100	408,060	167,690	0	0	0	0	84,020	0	0	84,020	40,860	0	18,630	22,230	813,730	113,100	426,690	273,940
2002 (D)	701,760	101,800	448,320	151,640	0	0	0	0	76,220	0	0	76,220	45,010	0	24,320	20,690	822,990	101,800	472,640	248,550
2003 (BN)	661,810	104,630	424,430	132,750	0	0	0	0	66,940	0	0	66,940	42,460	0	23,830	18,630	771,210	104,630	448,260	218,320
2004 (D)	701,220	115,350	475,970	109,900	0	0	0	0	55,600	0	0	55,600	46,720	0	30,870	15,850	803,540	115,350	506,830	181,360
2005 (W)	660,010	117,560	353,540	188,910	0	0	0	0	95,890	0	0	95,890	47,550	0	19,550	28,000	803,460	117,560	373,090	312,810
2006 (W)	682,960	127,150	348,440	207,370	0	0	0	0	105,600	0	0	105,600	50,550	0	18,990	31,560	839,100	127,150	367,420	344,530
2007 (C)	626,540	112,500	430,360	83,680	0	0	0	0	42,760	0	0	42,760	43,320	0	30,250	13,070	712,620	112,500	460,610	139,510
2008 (C)	659,760	105,920	427,160	126,680	0	0	0	0	64,940	0	0	64,940	50,550	0	30,250	20,300	775,260	105,920	457,420	211,920
2009 (BN)	619,610	97,720	407,860	114,030	0	0	0	0	58,650	0	0	58,650	48,320	0	29,580	18,740	726,580	97,720	437,440	191,420
2010 (AN)	634,330	126,940	312,280	195,110	0	0	0	0	100,690	0	0	100,690	50,290	0	17,430	32,860	785,320	126,940	329,720	328,660
2011 (W)	672,870	142,440	326,950	203,480	0	0	0	0	105,350	0	0	105,350	54,890	0	19,780	35,110	833,110	142,440	346,730	343,940
2012 (D)	641,160	100,440	470,750	69,970	0	0	0	0	35,110	0	0	35,110	43,200	0	31,200	12,000	719,460	100,440	501,940	117,080
2013 (C)	667,180	76,330	471,420	119,430	0	0	0	0	58,030	0	0	58,030	53,250	0	32,900	20,350	778,470	76,330	504,330	197,810
2014 (C)	608,670	19,960	529,790	58,920	0	0	0	0	27,730	0	10	27,720	42,000	0	32,020	9,980	678,390	19,960	561,810	96,620
2015 (C)	696,780	13,150	602,280	81,350	0	0	0	0	36,830	0	0	36,830	50,500	0	36,810	13,690	784,110	13,150	639,090	131,870
2016 (D)	742,540	99,470	438,730	204,340	0	0	0	0	90,990	0	0	90,990	71,560	0	31,070	40,490	905,100	99,470	469,810	335,820
2017 (W)	728,640	133,990	394,010	200,640	0	0	0	0	85,930	0	0	85,930	70,870	0	31,380	39,490	885,440	133,990	425,390	326,060
2018 (BN)	712,090	139,700	449,890	122,500	0	0	0	0	50,010	0	0	50,010	55,760	0	31,800	23,960	817,870	139,700	481,690	196,480
2019 (W)	719,280	155,330	368,700	195,250	11,010	11,010	0	0	76,360	0	0	76,360	66,490	0	28,610	37,880	873,140	166,340	397,310	309,490
Average (1989-2014)	673,240	106,940	398,120	168,180	0	0	0	0	86,300	0	0	86,300	45,610	0	22,410	23,200	805,140	106,940	420,520	277,680
Average (1989-2019)	680,760	107,170	406,600	166,990	360	360	0	0	83,350	0	0	83,350	48,420	0	23,950	24,470	812,890	107,520	430,550	274,820
W	713,230	134,310	351,310	227,610	1,100	1,100	0	0	112,750	0	0	112,750	53,840	0	20,530	33,310	880,910	135,410	371,830	373,670
AN	646,060	128,240	356,220	161,600	0	0	0	0	82,270	0	0	82,270	43,170	0	19,590	23,580	771,490	128,240	375,800	267,450
BN	664,500	114,020	427,390	123,090	0	0	0	0	58,540	0	0	58,540	48,840	0	28,400	20,440	771,890	114,020	455,800	202,070
D	695,110	106,030	448,370	140,710	0	0	0	0	68,390	0	0	68,390	49,470	0	27,220	22,250	812,960	106,030	475,580	231,350
C	656,410	72,210	449,890	134,310	0	0	0	0	69,190	0	0	69,190	43,920	0	25,700	18,220	769,520	72,210	475,590	221,720

Table 5-2. Joint GSP Consumptive Water Use, by Water Use Sector and Water Source Type (acre-feet, rounded).

Water Year (Type)	Agricultural				Managed Recharge				Native Vegetation				Urban				Total			
	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation	Total	Surface Water	Ground-water	Precipitation
1989 (C)	432,040	44,970	266,490	120,580	0	0	0	0	78,270	0	10	78,260	26,890	0	12,340	14,550	537,210	44,970	278,840	213,400
1990 (C)	456,420	34,280	296,630	125,510	0	0	0	0	75,960	0	0	75,960	28,280	0	12,970	15,310	560,670	34,280	309,610	216,780
1991 (C)	445,400	55,960	288,830	100,610	0	0	0	0	68,210	0	0	68,210	24,890	0	12,000	12,890	538,490	55,960	300,820	181,710
1992 (C)	509,580	46,920	351,930	110,730	0	0	0	0	81,570	0	0	81,570	30,750	0	15,220	15,530	621,890	46,920	367,150	207,820
1993 (W)	488,170	87,200	255,780	145,190	0	0	0	0	80,740	0	0	80,740	29,860	0	13,010	16,850	598,760	87,200	268,780	242,780
1994 (C)	484,450	80,810	296,120	107,520	0	0	0	0	63,440	0	0	63,440	29,410	0	15,480	13,930	577,290	80,810	311,600	184,880
1995 (W)	458,010	72,010	217,220	168,780	0	0	0	0	78,300	0	0	78,300	27,450	0	9,400	18,050	563,760	72,010	226,620	265,130
1996 (W)	510,640	111,180	261,000	138,460	0	0	0	0	81,240	0	0	81,240	29,670	0	10,750	18,920	621,540	111,180	271,740	238,620
1997 (W)	515,660	108,230	293,800	113,630	0	0	0	0	70,950	0	0	70,950	31,890	0	15,430	16,460	618,500	108,230	309,230	201,040
1998 (W)	453,130	71,300	231,190	150,640	0	0	0	0	67,960	0	0	67,960	28,040	0	11,990	16,050	549,130	71,300	243,180	234,650
1999 (AN)	470,150	96,900	283,410	89,840	0	0	0	0	58,790	0	0	58,790	28,260	0	14,160	14,100	557,200	96,900	297,570	162,730
2000 (AN)	513,160	87,580	307,820	117,760	0	0	0	0	66,840	0	0	66,840	30,640	0	15,630	15,010	610,640	87,580	323,450	199,610
2001 (D)	513,980	79,790	316,570	117,620	0	0	0	0	71,910	0	0	71,910	30,280	0	13,850	16,430	616,170	79,790	330,420	205,960
2002 (D)	525,190	70,900	346,980	107,310	0	0	0	0	68,010	0	0	68,010	33,560	0	17,630	15,930	626,750	70,900	364,600	191,250
2003 (BN)	512,100	75,460	336,410	100,230	0	0	0	0	54,710	0	0	54,710	33,040	0	18,920	14,120	599,850	75,460	355,330	169,060
2004 (D)	553,000	83,810	381,790	87,400	0	0	0	0	60,290	0	0	60,290	37,780	0	22,890	14,890	651,070	83,810	404,680	162,580
2005 (W)	492,880	85,130	278,040	129,710	0	0	0	0	67,490	0	0	67,490	33,610	0	16,380	17,230	593,980	85,130	294,420	214,430
2006 (W)	499,450	91,200	272,850	135,400	0	0	0	0	72,850	0	0	72,850	34,750	0	15,570	19,180	607,050	91,200	288,410	227,440
2007 (C)	501,580	82,430	348,320	70,830	0	0	0	0	54,170	0	0	54,170	35,260	0	20,180	15,080	591,010	82,430	368,500	140,080
2008 (C)	513,180	77,480	343,900	91,800	0	0	0	0	57,330	0	0	57,330	39,100	0	23,380	15,720	609,600	77,480	367,280	164,840
2009 (BN)	496,220	72,350	335,090	88,780	0	0	0	0	47,170	0	0	47,170	38,890	0	24,460	14,430	582,270	72,350	359,540	150,380
2010 (AN)	482,710	94,570	252,260	135,880	0	0	0	0	66,560	0	0	66,560	35,460	0	15,970	19,490	584,730	94,570	268,230	221,930
2011 (W)	497,250	105,340	258,950	132,960	0	0	0	0	72,250	0	0	72,250	36,580	0	14,670	21,910	606,070	105,340	273,620	227,110
2012 (D)	508,280	72,540	376,710	59,030	0	0	0	0	41,240	0	0	41,240	33,800	0	20,300	13,500	583,330	72,540	397,020	113,770
2013 (C)	520,270	55,610	382,590	82,070	0	0	0	0	51,980	0	0	51,980	40,440	0	25,080	15,360	612,680	55,610	407,670	149,400
2014 (C)	497,980	14,380	431,090	52,510	0	0	0	0	26,860	0	0	26,860	34,150	0	24,670	9,480	558,990	14,380	455,760	88,850
2015 (C)	564,380	9,700	494,070	60,610	0	0	0	0	29,940	0	0	29,940	38,950	0	28,680	10,270	633,260	9,700	522,750	100,810
2016 (D)	562,270	72,650	353,120	136,500	0	0	0	0	67,530	0	0	67,530	48,350	0	24,370	23,980	678,150	72,650	377,490	228,010
2017 (W)	544,580	98,840	318,560	127,180	0	0	0	0	59,440	0	0	59,440	44,290	0	19,950	24,340	648,310	98,840	338,510	210,960
2018 (BN)	559,620	104,090	366,820	88,710	0	0	0	0	42,780	0	0	42,780	39,820	0	22,110	17,710	642,230	104,090	388,930	149,210
2019 (W)	577,500	120,480	309,680	147,340	4,150	4,150	0	0	60,440	0	0	60,440	48,150	0	21,920	26,230	690,230	124,630	331,600	234,000
Average (1989-2014)	494,260	75,320	308,140	110,800	0	0	0	0	64,810	0	0	64,810	32,410	0	16,630	15,780	591,480	75,320	324,770	191,390
Average (1989-2019)	505,130	76,260	317,870	111,000	130	130	0	0	62,750	0	0	62,750	34,270	0	17,720	16,550	602,280	76,390	335,590	190,300
W	503,720	95,090	269,700	138,930	420	420	0	0	71,170	0	0	71,170	34,430	0	14,910	19,520	609,730	95,510	284,610	229,610
AN	488,670	93,020	281,160	114,490	0	0	0	0	64,070	0	0	64,070	31,460	0	15,260	16,200	584,200	93,020	296,420	194,760
BN	522,640	83,960	346,110	92,570	0	0	0	0	48,220	0	0	48,220	37,250	0	21,830	15,420	608,110	83,960	367,930	156,220
D	532,540	75,940	355,030	101,570	0	0	0	0	61,790	0	0	61,790	36,760	0	19,810	16,950	631,090	75,940	374,840	180,310
C	492,530	50,250	350,000	92,280	0	0	0	0	58,770	0	0	58,770	32,810	0	19,000	13,810	584,110	50,250	369,000	164,860

DATA SOURCES

ET_{aw} and ET_{pr} volumes were calculated by water use sector and water source type using a root zone water balance model as described in Section 2.2.3.3, pages 2-62 through 2-65 of the Madera Subbasin Joint GSP.

Daily ET_o values were computed based on weather data in the study area (**Table 5-3**) and were provided as inputs to the root zone model for calculating crop consumptive use requirements. Daily precipitation inflows to each Land Surface System water use sector were calculated as the daily precipitation depth derived from weather station data (**Table 5-3**) applied over the total area of each water use sector within the subbasin (in acres). Daily precipitation depths were provided as inputs to the root zone model to compute the fraction of ET_c that is represented by ET_{pr}. The Madera II CIMIS station last day with reported data was June 23, 2018. Beginning June 24, 2018 PRISM data was used for precipitation and spatial CIMIS data was used for reference ET.

Table 5-3. Madera Subbasin Weather Data Sources.

Weather Station	Station Type	Start Date	End Date	Comment
Fresno State	CIMIS	Oct. 2, 1988	May 12, 1998	CIMIS Station #80. Used before Madera CIMIS station was installed.
Madera	CIMIS	May 13, 1998	Apr. 2, 2013	CIMIS Station #145. Moved eastward 2 miles in 2013 and renamed "Madera II."
Madera II	CIMIS	Apr. 3, 2013	Jun. 23, 2018	CIMIS Station #188.
Spatial CIMIS	Spatial CIMIS	Jun. 24, 2018	Sep. 30, 2019	Used for developing ET_o time series in 2018-2019 after CIMIS station data was available.
PRISM	PRISM	Jun. 24, 2018	Sep. 30, 2019	Used for developing precipitation time series in 2018-2019 after CIMIS station data was available.
Madera	NOAA NCEI	Jan. 1, 1928	Sep. 30, 2019	Used for developing ET_o time series for projected water budget period before CIMIS station data was available.

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

CHANGE IN GROUNDWATER STORAGE MAPS

Consistent with §354.18.b, based on a comparison of the annual spring groundwater elevation contour maps representing seasonal high groundwater conditions, changes in groundwater elevation were calculated for individual years between Spring 2016 and Spring 2019. As noted previously, insufficient data are available to map groundwater levels in Spring 2015. To calculate annual change in groundwater storage from the groundwater level contour maps, the difference in groundwater elevation between annual spring contour maps was calculated for each of the principal aquifers (Upper and Lower Aquifers). Both confined and unconfined groundwater conditions occur within the Subbasin. To accurately estimate change in groundwater storage from changes in groundwater levels, it is important to differentiate areas of confined groundwater conditions from unconfined conditions. Accordingly, the groundwater elevation data were reviewed to estimate an area over which the Lower Aquifer exhibits confined conditions and where the groundwater levels are representative of a potentiometric surface. This was done by

comparing groundwater elevations to the elevation of the bottom of the Corcoran Clay confining geologic unit. The extent of the area where groundwater elevations in the Lower Aquifer occur above the bottom of the Corcoran Clay was delineated as the area of confined groundwater conditions for the purpose of calculating change in groundwater storage. From the review of available groundwater level data for the Lower Aquifer, no substantial changes in the spatial extent of the confined conditions were apparent during the period from 2015 to 2019. Therefore, the delineated area of confined conditions in the Lower Aquifer were assumed to be the same for all years during the analysis.

Outside of the delineated confined area, changes in groundwater levels (in both the Upper and Lower Aquifers) were multiplied by representative specific yield values to estimate change in groundwater storage. Within the delineated area of confinement in the Lower Aquifer, groundwater potentiometric surface changes in the Lower Aquifer were multiplied by a much smaller storage coefficient value to calculate annual changes in groundwater storage in the Lower Aquifer. The specific yield and storage coefficient values used in the analysis are derived from values in the calibrated integrated groundwater flow model (MCSim) developed and applied during the preparation of the Joint GSP. The specific yield values in MCSim are lower than previous values estimated for the Subbasin; however, recent testhole drilling and associated subsurface geologic and geophysical logging conducted at seven monitoring well sites across the Subbasin indicate a high fraction of fine-grained sediments in many parts of the Subbasin, which is consistent with the relatively low specific yield values in MCSim.

Figures 6-1 and 6-2 show the spatial distribution of calculated annual change in groundwater level for the most recent reporting year between Spring 2018 and Spring 2019 for the Upper Aquifer/undifferentiated unconfined groundwater zone and also for the Lower Aquifer. Maps of change in groundwater levels for each of the years between Spring 2016 and 2018, separated by principal aquifer, are presented in **Appendix C**. Because there was incomplete spatial coverage of groundwater elevation data within the Joint GSP area, it was not deemed appropriate to extend groundwater elevation contours into some parts of the Joint GSP area. In these areas without contour data, the average change in groundwater elevation value calculated for the area with data was applied to areas without data to estimate change in storage amounts for the entire Joint GSP area. **Tables 6-1** through **6-3** summarize the calculated annual change in groundwater storage volumes for each year and by principal aquifer for the Joint GSP area. The discussion of estimated change in storage values presented below is based on the aquifer parameter values derived from MCSim as presented in **Tables 6-1** through **6-3**. Change in storage values in the Upper Aquifer/undifferentiated unconfined groundwater zone for different assumed specific yield values are presented in **Table 6-1**, recognizing the uncertainty in specific yield and the associated uncertainty in estimated change in unconfined groundwater storage. Maps of the spatial distribution of change in storage in the principal aquifers for the most recent period from Spring 2018 to Spring 2019 are presented in **Figures 6-3 and 6-4**. Maps of annual change in storage for years between Spring 2016 and Spring 2018 are presented in **Appendix C**. All maps of change in groundwater storage utilize specific yield and storage coefficient values derived from MCSim.

Using representative aquifer parameter values derived from the calibrated groundwater flow model MCSim, the calculated changes in groundwater levels in the combined Upper Aquifer and undifferentiated unconfined zone translate to annual changes in groundwater storage of about -84,000 AF from Spring 2018 to 2019, about -10,000 AF between Spring 2017 and 2018, and about -84,000 AF between Spring 2016 and 2017 (**Table 6-1**). Negative change in storage values indicate depletion of groundwater storage, whereas positive change in storage values represent accretion of groundwater in storage. In the Lower Aquifer, changes in groundwater levels

translated to substantially smaller changes in groundwater storage, in part because of the confined conditions in much of the Lower Aquifer and also because of the smaller spatial extent. Between Spring 2018 and Spring 2019 groundwater storage increased in the Lower Aquifer by about 8,600 AF; storage declined by about 5,500 AF from Spring 2017 to 2018 (e.g. -5,500 AF), but also increased by about 9,600 AF between Spring 2016 and 2017 (**Table 6-2**). The combined change in groundwater storage for the entire Joint GSP area was about -75,600 AF from Spring 2018 to 2019, approximately -19,000 AF for Spring 2017 to 2018 and about -73,500 AF from Spring 2016 to 2017 (**Table 6-3**).

Adding the annual changes in storage together yields a total storage change between Spring 2016 and Spring 2019 of -165,500 AF. However, it should be noted that while it was not possible to calculate the groundwater storage change from Spring 2015 to Spring 2016 due to lack of water level data for Spring 2015, there may have been a net no change to positive change in groundwater storage between Spring 2015 and Spring 2016 that is not reflected in the combined total groundwater storage change.

Table 6-1. Calculated Change in Groundwater Storage in the Combined Upper Aquifer and Undifferentiated Unconfined Zone.

Analysis Time Period	Specific Yield	Average Groundwater Elevation Change (ft)	Average Groundwater Storage Change Per Acre (AF/acre)	Area Applied for Estimating Groundwater Storage Change (acres)	Total Groundwater Storage Change in Joint GSP Area (AF)[1]	Notes on Specific Yield Basis
Spring 2015-2016	0.04	Insufficient data to calculate change in storage.				Representative value from MCSim model
	0.08					
	0.10					2020 AB3030 Madera County GMP
	0.104					DWR Bulletin 118
	0.12					
	0.13					2014 Regional GMP
Spring 2016-2017	0.04	-7.39	-0.26	325,834	-84,718	Representative value from MCSim model
	0.08	-7.39	-0.59	325,834	-192,633	
	0.10	-7.39	-0.74	325,834	-240,791	2020 AB3030 Madera County GMP
	0.104	-7.39	-0.77	325,834	-250,423	DWR Bulletin 118
	0.12	-7.39	-0.89	325,834	-288,950	
	0.13	-7.39	-0.96	325,834	-313,029	2014 Regional GMP

Analysis Time Period	Specific Yield	Average Groundwater Elevation Change (ft)	Average Groundwater Storage Change Per Acre (AF/acre)	Area Applied for Estimating Groundwater Storage Change (acres)	Total Groundwater Storage Change in Joint GSP Area (AF)[1]	Notes on Specific Yield Basis
Spring 2017-2018	0.04	-0.97	-0.03	325,834	-11,064	Representative value from MCSim model
	0.08	-0.97	-0.08	325,834	-25,285	
	0.10	-0.97	-0.10	325,834	-31,606	2020 AB3030 Madera County GMP
	0.104	-0.97	-0.10	325,834	-32,870	DWR Bulletin 118
	0.12	-0.97	-0.12	325,834	-37,927	
	0.13	-0.97	-0.13	325,834	-41,088	2014 Regional GMP
Spring 2018-2019	0.04	-7.44	-0.26	325,834	-85,255	Representative value from MCSim model
	0.08	-7.44	-0.60	325,834	-193,936	
	0.10	-7.44	-0.74	325,834	-242,420	2020 AB3030 Madera County GMP
	0.104	-7.44	-0.77	325,834	-252,117	DWR Bulletin 118
	0.12	-7.44	-0.89	325,834	-290,905	
	0.13	-7.44	-0.97	325,834	-315,147	2014 Regional GMP

Table 6-2. Calculated Change in Groundwater Storage in the Lower Aquifer Zone.

Analysis Time Period	Lower Aquifer Zone	Storage Coefficient[1]	Specific Yield[2]	Average Change in Groundwater Potentiometric Surface (ft)	Average Confined Groundwater Storage Change Per Acre (AF/acre)	Area Used for Estimating Confined Groundwater Storage Change (acres)	Total Groundwater Storage Change[3] (AF)	Notes on Storage Coefficient Basis
Spring 2015-2016	Insufficient data to calculate change in storage.							Representative value from MCSim model
Spring 2016-2017	Confined	1.24E-03		22.45	0.03	56,545	1,569	Representative value from MCSim model
	Unconfined		0.049	15.73	0.77	12,474	9,628	
	TOTAL				0.16	69,019	11,197	
Spring 2017-2018	Confined	1.24E-03		-34.07	-0.04	56,545	-2,381	Representative value from MCSim model
	Unconfined		0.049	-9.04	-0.44	12,474	-5,531	
	TOTAL				-0.11	69,019	-7,913	
Spring 2018-2019	Confined	1.24E-03		15.80	0.02	56,545	1,105	Representative value from MCSim model
	Unconfined		0.049	13.99	0.69	12,474	8,560	
	TOTAL				0.14	69,019	9,665	

[1] Storage Coefficient value applies to those areas under the Corcoran Clay considered to be confined (56,545 acres).

[2] Specific Yield value applies to those areas under the Corcoran Clay considered to be unconfined (12,474 acres).

[3] Total Lower Aquifer within the Joint GSP area is 69,019 acres and includes areas of the Madera Subbasin outside of Root Creek Water District, Gravelly Ford Water District, and New Stone Water District.

Table 6-3. Total Calculated Change in Groundwater Storage in the Joint GSP Area.

Analysis Time Period	Average Groundwater Storage Change Per Acre (AF/acre)	Total Joint GSP Area (acres)	Total Joint GSP Area Groundwater Storage Change (AF)
Spring 2015-2016	Insufficient data to calculate change in storage.		
Spring 2016-2017	-0.23	325,834	-73,520
Spring 2017-2018	-0.06	325,834	-18,976
Spring 2018-2019	-0.23	325,834	-75,590

GROUNDWATER USE AND CHANGE IN GROUNDWATER STORAGE

Annual groundwater extractions and change in groundwater storage in the Joint GSP area is shown in **Figure 6-5** for water years 2015 to 2019. Groundwater extractions are estimated or directly measured following the procedures described in the corresponding section above. Change in groundwater storage is estimated based on an annual comparison of spring groundwater elevations. Change in groundwater storage is not provided for water years 2015 and 2016, as there was insufficient historical data to accurately calculate change in storage. Historical groundwater extractions in water years 1989 through 2014 are shown in Figure 2-88 of the Joint GSP (page 2-89). Historical annual changes in groundwater storage and cumulative changes in storage are also shown in the Joint GSP (Appendix D.1.b, pages A6.D-D-15 and A6.D-D-15). Historical changes in groundwater storage between 1989 and 2014 were calculated based on a water balance of the subbasin groundwater system using the MCSim numerical groundwater flow model (described in the Joint GSP). Total groundwater extraction has generally decreased since water year 2015, while the annual change in groundwater storage has fluctuated between approximately -18,000 AF and -75,000 AF since water year 2017 (**Table 6-3**).

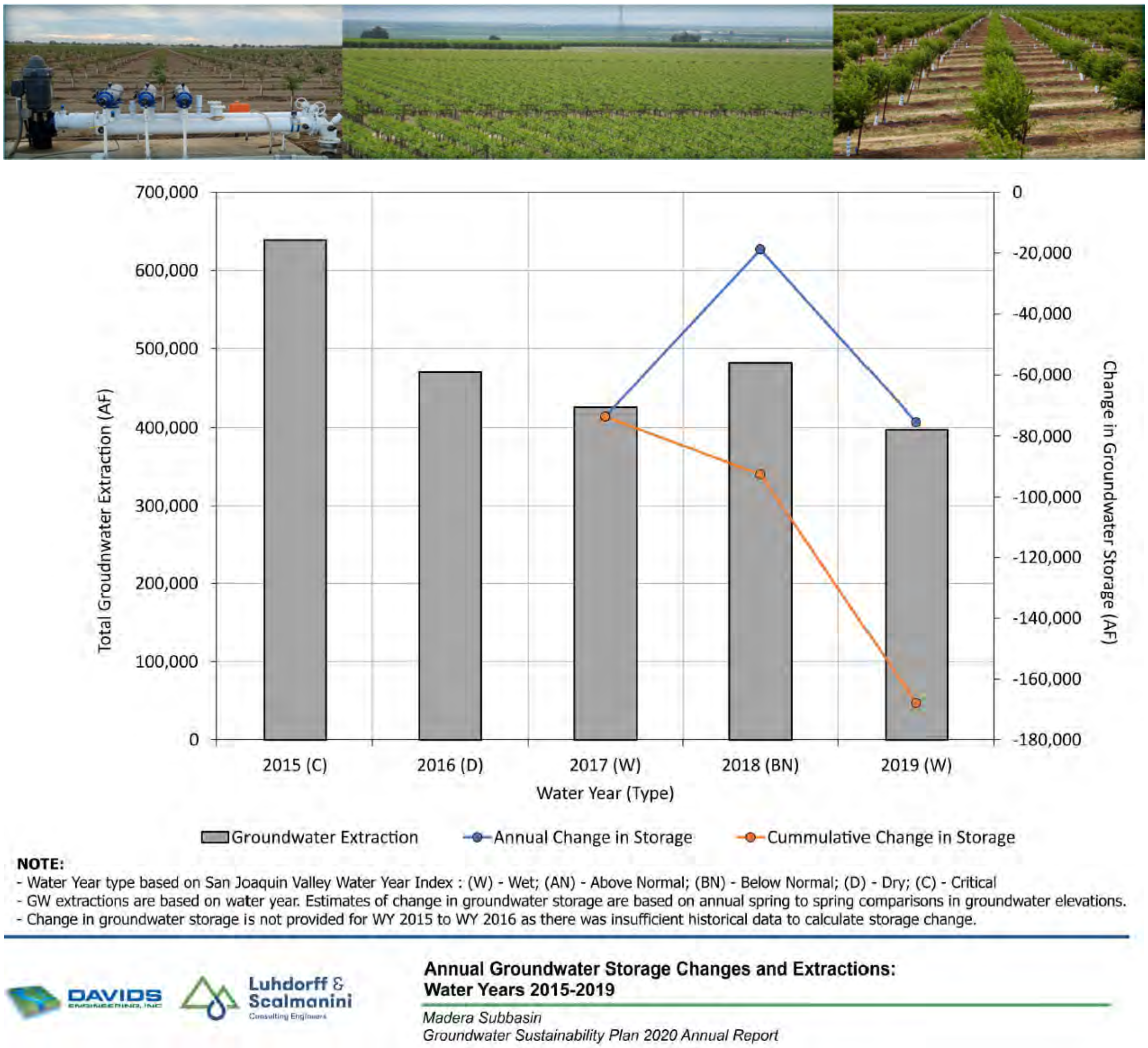


Figure 6-5. Annual Groundwater Storage Changes and Extractions.

Groundwater Sustainability Plan Implementation Progress (§356.2.c)

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

The implementation of projects and management actions is critical for achieving and/or maintaining groundwater sustainability, as described in the Madera Subbasin Joint GSP. The estimated costs, timing, and benefits (i.e. increased groundwater recharge or reduced groundwater use) vary across individual projects and management actions and across GSAs. All projects and management actions are described in the Joint GSP. Projects and management actions are scheduled for implementation throughout the 2020 through 2040 implementation period.

Projects and management actions are listed and described in **Table 7-1**. In addition to providing the estimated costs and benefits of each project and management action, as presented in the Joint GSP, this table also reports the average annual benefits and actual costs of those projects already in implementation (i.e., all projects that are in active development, or are currently being utilized). This table provides a comparison of actual versus estimated costs and benefits for

projects, as well as the progress of the implementation for projects or management actions that will take multiple years to fully implement. The GSAs in the Madera Subbasin are committed to adaptive management of groundwater resources through this suite of identified projects and management actions. As projects are implemented and monitored, the project timelines and amount of demand management necessary will be reviewed. If adjustments are needed to meet the sustainability objectives identified in the Joint GSP, project timelines will be evaluated and adjusted. In addition to continuous monitoring and review of project and management action implementation, each Annual Report represents an opportunity to review the status of Joint GSP implementation efforts.

There was only a short amount of time between the GSP submittal deadline of January 31, 2020 and the Annual Report submittal deadline of April 1, 2020. Due to this short time period, appreciable progress has only been made on those projects or management actions that were already in implementation prior to the adoption and submission of the Joint GSP. Some projects started prior to adoption and submittal of the Joint GSP are underway but may have not yet progressed to where benefits are being realized, as described below. Additional projects and management actions planned to start in 2020 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. Progress on some projects and stakeholder outreach have slowed as a result of the ongoing health and safety concerns associated with COVID-19 and its repercussions on both public agencies and private parties (e.g., challenges of conducting effective outreach exclusively by online meetings and phone calls). The initial benefits and costs from the first year of implementation of these projects will be reported in the Annual Report to be submitted in 2021.

Table 7-1 lists and describes each of the projects and management actions planned in the Joint GSP. It also lists the mechanism by which the project or management action will increase the sustainability of the basin, the first year of planned implementation and current status of the project as of the time of this Annual Report. Finally, for projects in implementation, the gross average annual benefit, actual capital cost, and actual average annual operating costs to date are shown, along with estimated annual benefits, capital costs, and annual operating costs from the Joint GSP. It should be noted that the estimated benefits and costs were developed for full project implementation, not partial implementation. Following the table, individual projects are described in greater detail.

Madera Irrigation District Projects

The majority of the projects in the subbasin are being implemented by the MID GSA, which is the second largest GSA in the subbasin (by area, behind the Madera County GSA) and contains the largest irrigated area. A number of dedicated recharge basins are already being utilized by MID, with two phases for developing additional recharge basins, if needed, planned for the future. The average annual benefits shown in **Table 7-1** are for the water year (WY) 2019, during which recharge was monitored and quantified. Ellis Basin is operated in partnership with Madera County, and Berry Basin is operated in partnership with the City of Madera. Ellis Basin recharged a total of 306 AF in 2019, divided evenly in **Table 7-1** between MID and Madera County. Berry Basin recharged a total of 929 AF in 2019, divided evenly in **Table 7-1** between MID and the City of Madera. Allende Basin is operated by MID and was used intensively to recharge 3,088 AF in 2019. An additional six dedicated recharge facilities, which have been recently rehabilitated and upgraded, were able to recharge 3,683 AF. The largest of these six facilities (Madera Lake) was unable to be used for recharge in 2019 due to operational constraints. Water year 2019 was a wet year, with larger water volumes available for recharge compared to an average year, so it is

expected that recharge volumes in 2019 would exceed estimated average annual benefits. MID also administered an on-farm recharge program, resulting in 3,000 acre-feet of recharge in 2019.

Upgrades to MID infrastructure (pipelines and SCADA systems) to reduce conveyance losses are also underway and have resulted in cumulative average annual benefits to date of 2,530 AF. Planned activities for MID include developing water supply partnerships with partners outside of the Madera Subbasin to import surface water supplies and developing an incentive program to encourage growers to use surface water.

In line with the incentive program, in 2019 MID utilized nearly 250,000 AF of surface water through grower deliveries and groundwater recharge, including making water available free of charge and at a reduced rate for specific periods during the year to encourage surface water use.

In 2018, 320 acres were detached from the MID GSA and joined the Root Creek Water District GSA. This reduced the consumptive use within the MID GSA by about 1,020 AF.

In total, at the current stage of implementation, the suite of projects and management actions by MID result in a gross average annual benefit of 33,691 AF in 2019.

Madera Water District Projects

The expanded surface water purchase project proposed by MWD is scheduled for implementation beginning in 2023. However, in 2019 MWD had an opportunity to substantially increase its purchase of surface water to preserve groundwater supplies. MWD's per acre groundwater demand was substantially reduced compared to previous years. MWD is also hoping to purchase a small supply of surface water for 2020 depending on hydrology/availability. As a result, costs (in the form of higher priced surface water) have been incurred and benefits have been realized in association with this project ahead of schedule. MWD continues to move forward on the Madera Lake Project. the Madera Lake Project, MWD has obtained an easement from MID for the proposed MWD facilities. MWD has also contracted with a consultant for environmental, permitting, and design and has initiated discussions/contact with applicable regulatory and permitting agencies.

As of 2019, approximately one acre of pistachio trees within the District has been removed to build a new small reservoir, providing for water regulation and storage.

City of Madera Projects

In addition to operating the Berry Basin in a partnership with MID, the City of Madera is implementing a project to install water meters and a volumetric billing process. The installation of water meters is roughly 98% complete. To date, the average annual benefits have been 3,350 AF.

Madera County Projects

In addition to operating the Berry Basin in a partnership with MID, Madera County is in the initial stages of implementing demand management efforts. This management action is expected to result in a large reduction in groundwater pumping (roughly 90,000 AF per year by 2040) at the cost of reduced crop production and related economic activities in Madera County. **Appendix E** contains an economic impact analysis for the planned demand management program. At this point, the actual costs and benefits of demand management efforts completed to date have not been quantified, but they will be in future years.

Table 7-1. Project and Management Action Implementation Summary.

Groundwater Sustainability Agency (GSA)	Project	Project Mechanism	First Year of Implementation	Status	Project Description	Gross Average Annual Benefit to Date (acre-feet)	Actual Capital Cost to Date ($, millions)	Actual Average Annual Operating Cost ($, millions)	Estimated Average Annual Benefit[1] (acre-feet)	Estimated Capital Cost[1] ($/year, millions)	Estimated Average Annual Operating Cost[1] ($/year, millions)
MWD	Expanded Surface Water Purchase	Purchase water from willing partners in the basin to reduce GW pumping	2023	Planned	Expand ability to purchase additional surface water supply, including upgrades to conveyance infrastructure.	-	-	-	2,810	14.9	0.9
MID	Rehab Recharge Basins	Increase Recharge	2016	In Implementation	Rehabilitate and upgrade six recharge facilities, including metering.	3,683	0.06	0.40	5,030	0.06	0.43
MID/Madera County	Ellis Basin	Increase Recharge	2016	In Implementation	Cooperatively operate Ellis Basin for recharge.	153	0.02	0.02	240	0.02	0.02
MID/City of Madera	Berry Basin	Increase Recharge	2018	In Implementation	Cooperatively operate Berry Basin for recharge.	465	0.02	0.05	20	0.02	0
MID	Allende Basin	Increase Recharge	2019	In Implementation	Operate Allende Basin for recharge.	3,088	0.2	0.34	1,050	0.2	0.07
MID	Additional Recharge Basins Phase 1	Increase Recharge	2030	Planned	Construct and operate 90 acres of additional recharge basins.	-	-	-	5,470	1	0.24
MID	Additional Recharge Basins Phase 2	Increase Recharge	2040	Planned	Construct and operate 260 acres of additional recharge basins.	-	-	-	21,890	14.2	3.75
MID	On-Farm Recharge	Increase Recharge	2015	In Implementation	Deliver available flood water to agricultural or other suitable land for recharge.	3,000	0	0.33	510	0	0.05
MID	Phase 2 On-Farm Recharge	Increase Recharge	2025	Planned	Expand delivery of available flood water to agricultural or other suitable land for recharge.	-	-	-	1,690	0	0.19
MID	MID Pipeline	Reduce evaporation and GW Pumping	2016	In Implementation	Rehabilitate aging pipelines to reduce losses.	420			420	0.56	0
MID	WaterSMART Pipeline	Reduce evaporation and GW Pumping	2019	In Implementation	Rehabilitate additional pipelines to reduce losses and allow MID to deliver water later in the irrigation season.	880			880	1.3	0
MID	WaterSMART SCADA	Reduce evaporation and GW Pumping	2019	In Implementation	Expand SCADA to improve MID water management, reduce losses, and allow MID to deliver water later in the irrigation season.	1,230			1,230	1.2	0
MID	Water Supply Partnerships	Purchase water from willing partners outside of the basin to increase recharge or reduce GW pumping	2025	Planned	Identify and purchase or exchange additional water supplies from partnering districts.	-	-	-	3,990	0	2.5
MID	Incentive Program	Encourage more use of district SW; reduce GW pumping	2019	Planned	Develop incentive structures to encourage more MID growers to utilize surface water supplies instead of groundwater.	22,900	0	2.50	5,010	0	3.08
MID	Demand Reduction[2]	Reduce demand	2019	In Implementation	Detach 320 acres from the MID GSA[2]	1,020	0.012	0.11	1,020[2]	0.012[2]	0.11[2]
City of Madera	Meters and Volumetric Pricing	Reduce evaporation and GW Pumping	2015	In Implementation	Install water meters and implement a volumetric billing process for single-family users to promote water conservation.	3,350			3,350	11	0
City of Madera/MID	Berry Basin	Increase Recharge	2018	In Implementation	Cooperatively operate Berry Basin for recharge.	465			20	0.02	0
Madera County/MID	Ellis Basin	Increase Recharge	2016	In Implementation	Cooperatively operate Ellis Basin for recharge.	153	0	0.03	240	0.02	0.02
Madera County	Water Imports Purchase	Purchase water from willing partners outside of the basin to increase recharge or reduce GW pumping	2025	Planned	Develop partnerships and import additional water into Madera County for direct or in-lieu recharge.	-	-	-	3,610	0.3	2.49

Groundwater Sustainability Agency (GSA)	Project	Project Mechanism	First Year of Implementation	Status	Project Description	Gross Average Annual Benefit to Date (acre-feet)	Actual Capital Cost to Date ($, millions)	Actual Average Annual Operating Cost ($, millions)	Estimated Average Annual Benefit[1] (acre-feet)	Estimated Capital Cost[1] ($/year, millions)	Estimated Average Annual Operating Cost[1] ($/year, millions)
Madera County	Millerton Flood Release Imports	Purchase water from willing partners outside of the basin to increase recharge or reduce GW pumping	2025	Planned	Request CVP Section 215 flood water when available for recharge.	-	-	-	7,060	31.9	0.45
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 1	Increase Recharge	2025	Planned	Construct and operate diversion and conveyance facilities and basins to recharge an average of 12,700 AF per year.	-	-	-	12,710	67	0.32
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 2	Increase Recharge	2040	Planned	Construct and operate diversion and conveyance facilities and basins to recharge an average of 25,000 AF per year.	-	-	-	26,470	118.9	1.16
Madera County	Demand Management	Reduce demand by limiting groundwater pumping	2020	In Implementation	Reduce consumptive water use through actions such as water-stressing crops, shifting to lower water-using crops, reducing evaporation losses, and reducing irrigated acreage.	-	-	-	90,000	0	53.9
GFWD	Recharge Basin and Canals	Increase Recharge	2020	In Implementation	Operate an existing basin to recharge surface water, from either purchased supplies or available as excess flow.	See GFWD Annual Report			2,620	See GFWD Annual Report	
NSWD	Water Right Utilization	Divert flood flow from Chowchilla Bypass, under existing water right	2020	In Implementation	Utilize an existing appropriative water right along the Chowchilla Bypass to divert up to 15,700 AF of surface water per year.	See NSWD Annual Report			5,540	See NSWD Annual Report	
RCWD	Purchased Water for In-Lieu Storage	Purchase water from willing partners in the basin to reduce GW pumping	2019	In Implementation	Construct and operate conveyance facilities to import purchased surface water for irrigation.	See RCWD Annual Report			4,380	See RCWD Annual Report	
RCWD	Holding Contracts	Divert flood flow from San Joaquin River, under existing water right	2020	In Implementation	Utilize holding contract right to divert an average of 9,840 AF of surface water per year from San Joaquin River.	See RCWD Annual Report			9,840	See RCWD Annual Report	
Totals						37,659	0.31	3.78	217,080	262.61	69.68

Notes:

1. Estimates developed for full project implementation. Projects have been added to this list since the Joint GSP was adopted, so these totals may not equal the totals reported in the GSP.
2. Project or action was not included in original Joint GSP; the project or management action has been developed since adoption and submission of the Joint GSP. Estimated benefit and costs are estimated to be equal to the reported actual benefit and costs in the 2020 Annual Report.

Madera County has applied for a number of grants to support water planning efforts:

- *Sustainable Agricultural Lands Conservation (SALC) Grant.* The Madera County GSA received a grant to fund a planning project to explore the feasibility of adopting an agricultural easement process within Madera County. The goal of this project is to develop two primary items:

    1. Criteria for identifying and prioritizing agricultural land for protection. These criteria will be based on the land's potential to be farmed or temporarily rested (not used as irrigated farmland), permanently retired, retired and restored, or (when appropriate) permanently protected.
    2. An incentive structure for agricultural landowners to rest, retire, restore, or permanently protect their land via various types of water-centric conservation easements.

    The Madera County GSA issued an RFP to obtain a consultant to assist with the work and is currently evaluating responses. The consultant is anticipated to be selected around the first week of April, with work beginning in early May.

- *Domestic Well Inventory Grant.* The Madera County GSA applied for a grant to inventory domestic wells to better understand how to protect and mitigate for potential undesirable effects on disadvantaged communities during GSP implementation. The Chowchilla Subbasin was awarded the grant. Unfortunately, the Madera Subbasin did not receive the grant because one GSA did not sign the coordination agreement during GSP submittal.

- *Water Markets Grant.* The Madera County GSA applied for and was awarded a grant from Reclamation to develop a comprehensive water marketing strategy. An RFP was issued and a contractor selected. The contractor is working closely with Madera County, stakeholders, and technical experts to conduct economic analysis to support development of a comprehensive water marketing strategy that is acceptable to stakeholders and maximizes economic benefits to the regional economy. This work was initiated in late 2019 and is ongoing, with the next workshop scheduled for late April 2020.

Madera County has other projects planned for implementation in coming years, including purchasing and importing additional surface water supplies and diverting Chowchilla Bypass flood flows for groundwater recharge.

Madera County has also been actively discussing options and approaches with local landowners and DWR's Flood MAR project team to initiate recharge projects in the western portion of the Subbasin along the Chowchilla Bypass and Fresno River. These efforts represent the preliminary steps for the Chowchilla Bypass Flood Flow Recharge – Phase 1 project described in the GSP. As part of additional efforts to expand opportunities for recharge, the County is working with the Bureau of Reclamation to modify its current CVP contract to enable access to additional CVP supplies (e.g. Section 215 water) and to open up opportunities for acquiring CVP supplies from outside the Subbasin and also expanding cooperative projects with MID.

And to assist with the demand reduction objectives, the County is obtaining extended satellite-based ET datasets to help design and manage demand reduction efforts.

Other GSA Projects in Madera Subbasin

GFWD, NWSD, and RCWD are implementing projects in the Madera Subbasin with aggregated gross average annual benefits estimated in their respective GSP Annual Reports. More

information about the costs and implementation status of these projects can be found in each of their Annual Reports.

Summary

Overall, the projects developed by the four Joint GSAs have provided a gross average annual net benefit of 37,659 AF for the Madera Subbasin, which is 17% of the estimated benefits from all projects and management actions proposed by the Joint GSAs at full-scale implementation. This Annual Report is the first of 20, meaning that the implementation period is roughly 5% complete. Comparing percentage of estimated benefits to the percentage of the implementation period complete shows that implementation of the Joint GSP is progressing according to schedule, although this is a simple comparison and it is worth noting that 2019 was a wet year with more recharge water available than will be available during drier years. As the implementation period progresses and gross average annual net benefits are averaged over time, the results will provide a more representative picture of actual status of Joint GSP implementation.

INTERIM MILESTONE STATUS (§356.2.C)

In the Joint GSP, interim milestones (IMs) for chronic lowering of groundwater levels were established at five-year intervals over the Implementation Period from 2020 to 2040, at years 2025, 2030, 2035, and 2040. IMs for groundwater levels were established through review and evaluation of measured groundwater level data and future projected fluctuations in groundwater levels utilizing the numerical groundwater flow model, which simulated implementation of projects and management actions. Each IM was developed based on the modeled groundwater level for the month of October in the year preceding the interim milestone date (e.g., October 2024 for the 2025 interim milestone). Where necessary, adjustments were made to account for occasional offsets between historically observed and modeled data as described in the Joint GSP.

Measurable objectives for groundwater levels were established in accordance with the sustainability goal and to provide estimates of the expected groundwater level variability due to climatic and operational variability. Measurable objectives for groundwater levels were calculated as the model-derived average groundwater levels over the Sustainability Period from 2040 to 2090, modified if necessary, to account for occasional offsets between historically observed and modeled groundwater levels.

The regulations define undesirable results as occurring when significant and unreasonable effects are caused by groundwater conditions occurring throughout the Plan area for a given sustainability indicator. Significant and unreasonable effects occur when minimum thresholds (MTs) are exceeded for one or more sustainability indicators. The GSP Regulations provide that the “minimum thresholds for chronic lowering of groundwater levels shall be the groundwater level indicating a depletion of supply at a given location that may lead to undesirable results.” (354.28.c.1) Chronic lowering of groundwater levels in the Plan area is determined in the Joint GSP to cause significant and unreasonable declines if they are sufficient in magnitude to lower the rate of production of pre-existing domestic groundwater wells below that necessary to meet the minimum required to support overlying beneficial use(s) where alternative means of obtaining sufficient groundwater resources are not technically or financially feasible.

Although this 2020 Annual Report covers a time period prior to the start of the GSP implementation period, which began after adoption and submittal of the Joint GSP in January 2020, for the purpose of tracking the status of groundwater levels in the Plan area, **Table 7-2** and **Figures 7-1 and 7-2** present the status of groundwater level RMS wells in relation to the 2025 IMs, MO, and MTs defined in the Joint GSP. Note that there are a number of RMS wells that do

not have Fall 2019 measurements to compare with IMs, MOs, and MTs. Again, this is because the Joint GSP was not finished as of Fall 2019 and RMS site selection had not been finalized. Review of the Fall 2019 groundwater level measurements that are available for 12 RMS wells indicates that groundwater levels remain well above MTs and the majority of groundwater levels are above the 2025 IMs.

Table 7-2. Summary of RMS Well Groundwater Levels Relative to Interim Milestones, Minimum Thresholds, and Measurable Objectives

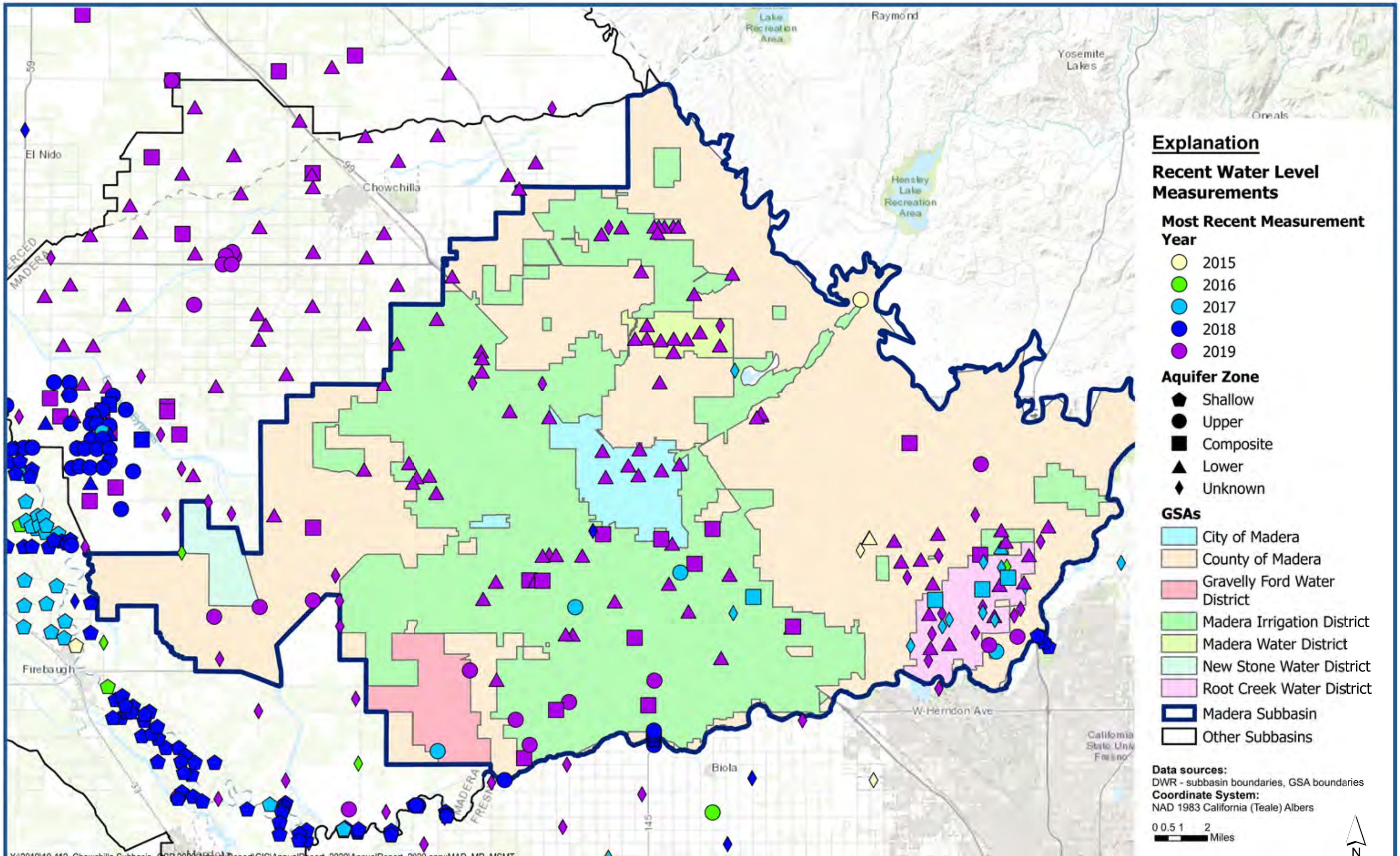
RMS Well I.D.	Estimated Surface Elevation (msl, feet)[1]	Aquifer Designation	2025 IM GWE[1]	MT GWE[1]	MO GWE[1]	Fall 2019 GWE[1]	Date of Fall Measure-ment	2025 IM Status	MT Status
MID RMS-1	308	Lower	-33	-75	6	4.75	10/17/19	+37.75	+79.75
MID RMS-2	218	Lower	-70	-150	5	-57.6	10/23/19	+12.4	+92.4
MID RMS-3	241	Lower	-66	-135	10				
MCW RMS-1	169	Lower	47	-85	88	-36.5	10/18/19	-83.5	+48.5
MID RMS-4	190	Lower	-1	-100	46				
MID RMS-5	207	Lower	14	-115	55				
MID RMS-6	237	Lower	-29	-65	29				
MID RMS-7	238	Lower	70	0	107				
MCE RMS-1	332	Lower	1	-40	66				
MID-RMS-8	287	Composite	17	0	74				
MCE RMS-2	378	Composite	98	25	83				
MCE RMS-3	327	Composite	20	-5	78				
MCE RMS-4	404	Lower	174	120	162				
MCW RMS-2	173	Upper	76	-10	75	32.00	10/14/19	-44	+42
MCW RMS-3	162	Upper	86	5	118				
MID RMS-9	202	Upper	64	10	95				
MID RMS-10	213	Lower	69	0	100				
MCW RMS-4	208	Lower	105	30	115				
MID RMS-11	232	Upper	99	65	130				
MID RMS-12	262	Upper	93	75	130				
MID RMS-13	271	Composite	98	75	123				
MCE RMS-5	340	Lower	102	35	108				
MID RMS-14	214	Upper	139	95	146				
COM RMS-1	278	Lower	13	-35	70	42.11	11/20/19	+29.11	+77.11
COM RMS-2	262	Lower	0	-55	65	56.03	11/27/19	+56.03	+111.03
COM RMS-3	264	Lower	42	-20	75				
MWD RMS-1	330	Lower	-29	-95	15	-10.81	10/23/19	+18.19	+84.19
MWD RMS-2	310	Lower	-57	-130	-5	-39.25	10/25/19	+17.75	+90.75
MWD RMS-3	295	Lower	-87	-150	-23	-54.81	10/24/19	+32.19	+95.19
MID RMS-15	247	Upper	131	115	136	132.5	10/17/19	+1.5	+17.5
MCE RMS-6	328	Lower	53	-15	77	8.5	10/16/19	-44.5	+23.5
MID RMS-16	308	Lower	-39	-100	15	-25.7	10/21/19	+13.3	+74.3
MCE RMS-7	388	Lower	150	75	127				

[1] Estimated surface elevation and groundwater elevations (GWE) are expressed in feet above mean sea level.

References

American Society of Civil Engineers (ASCE). 2016. Evaporation, Evapotranspiration and Irrigation Water Requirements. Manual 70. Second Edition. M. E. Jensen and R. G. Allen (eds). Am. Soc. Civ. Engrs.

California Department of Water Resources (DWR). 2016. Best Management Practices for Sustainable Management of Groundwater, Water Budget, BMP.



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Most Recent Groundwater Level Measurement by Well

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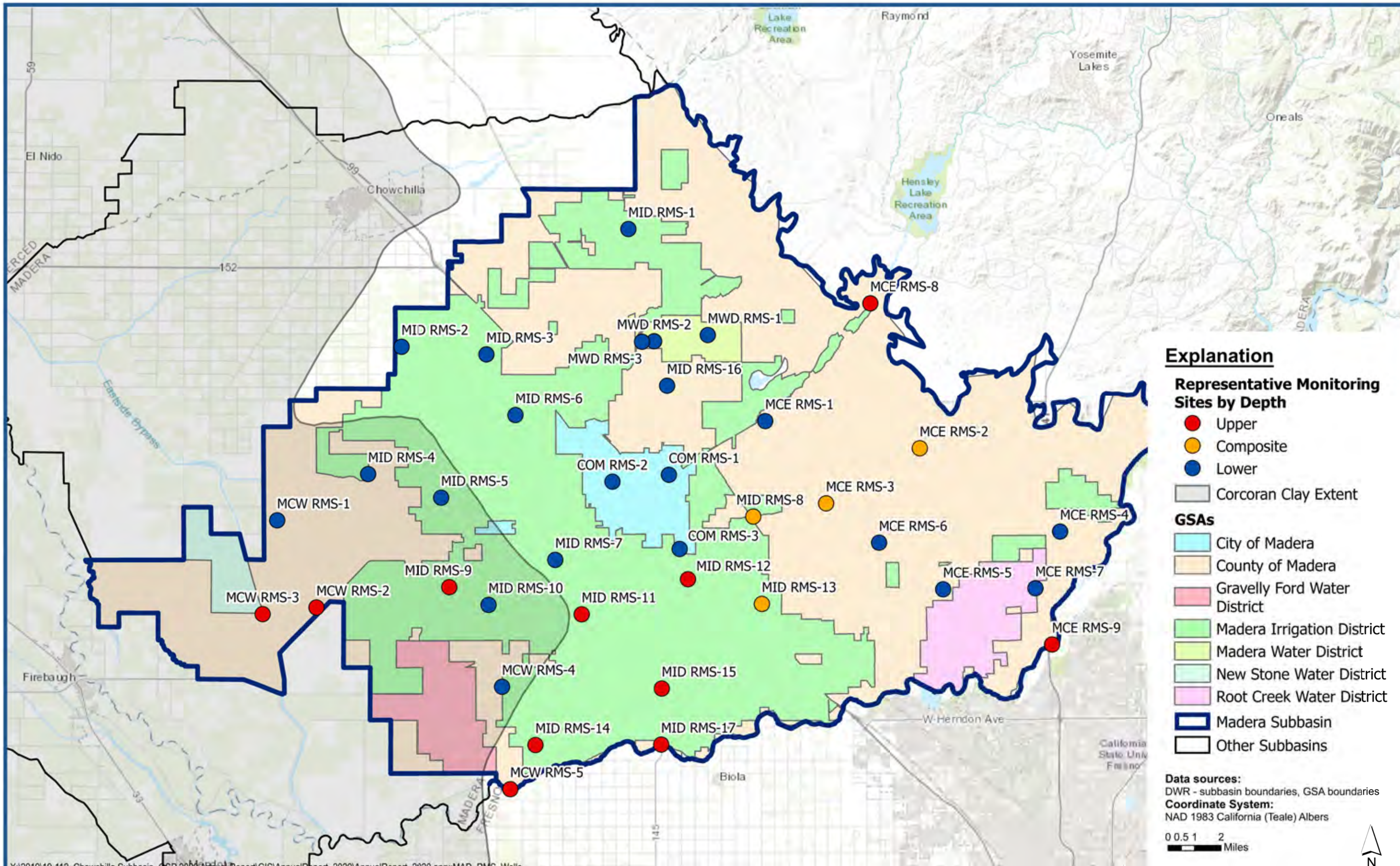
Figure 1-1



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Groundwater Levels Sustainable Indicator Wells

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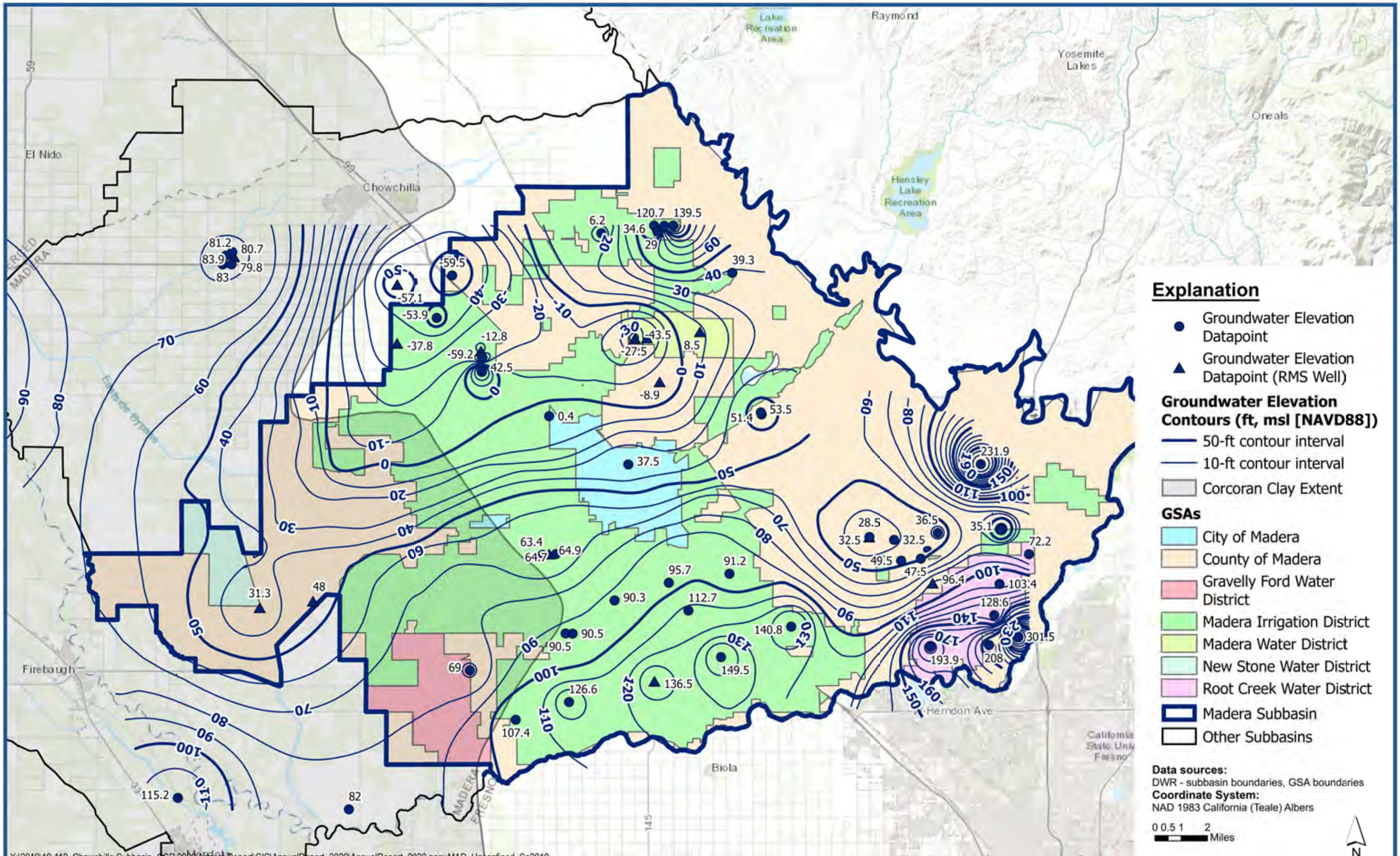
Figure 1-2



Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2019

Madera Subbasin
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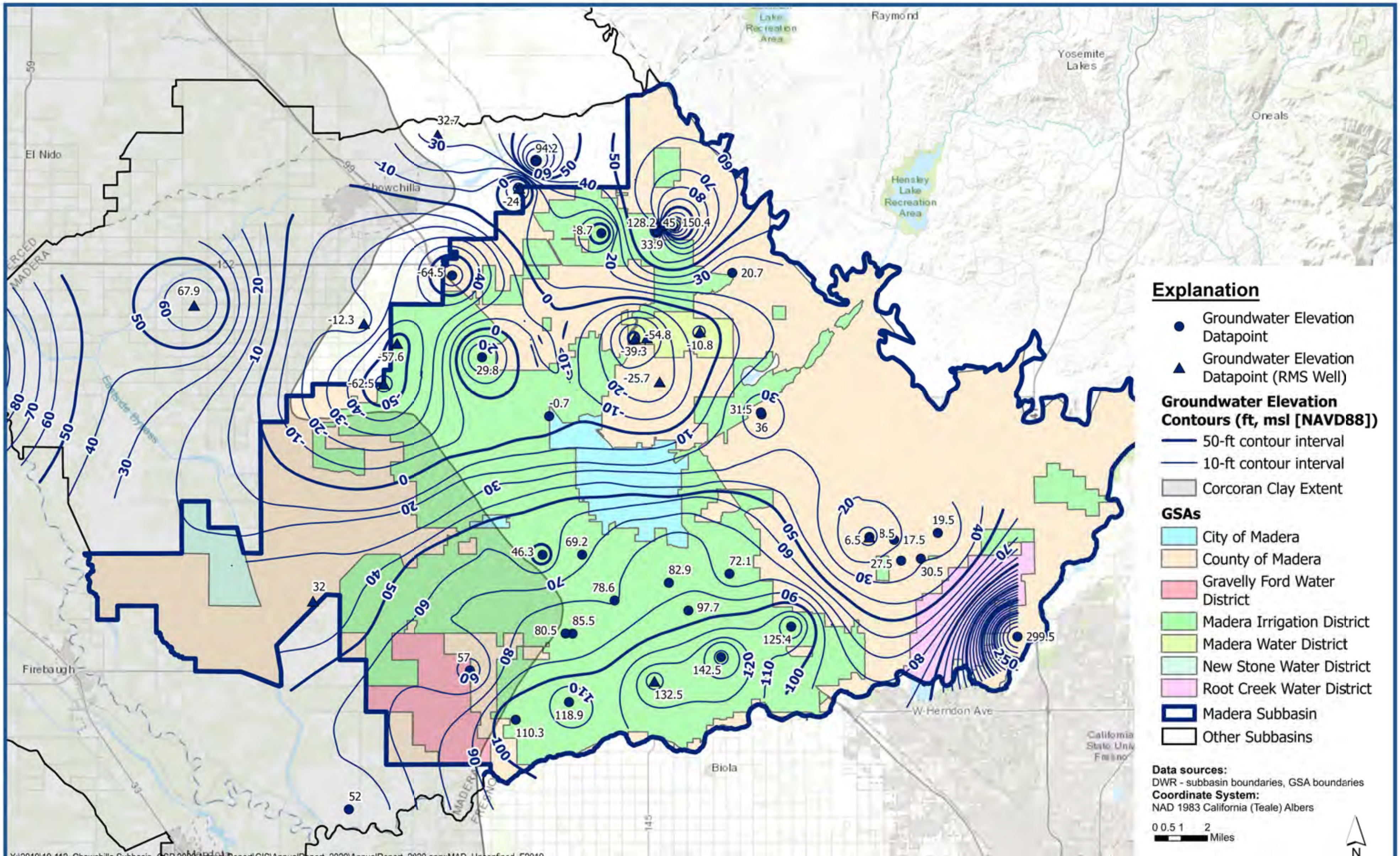
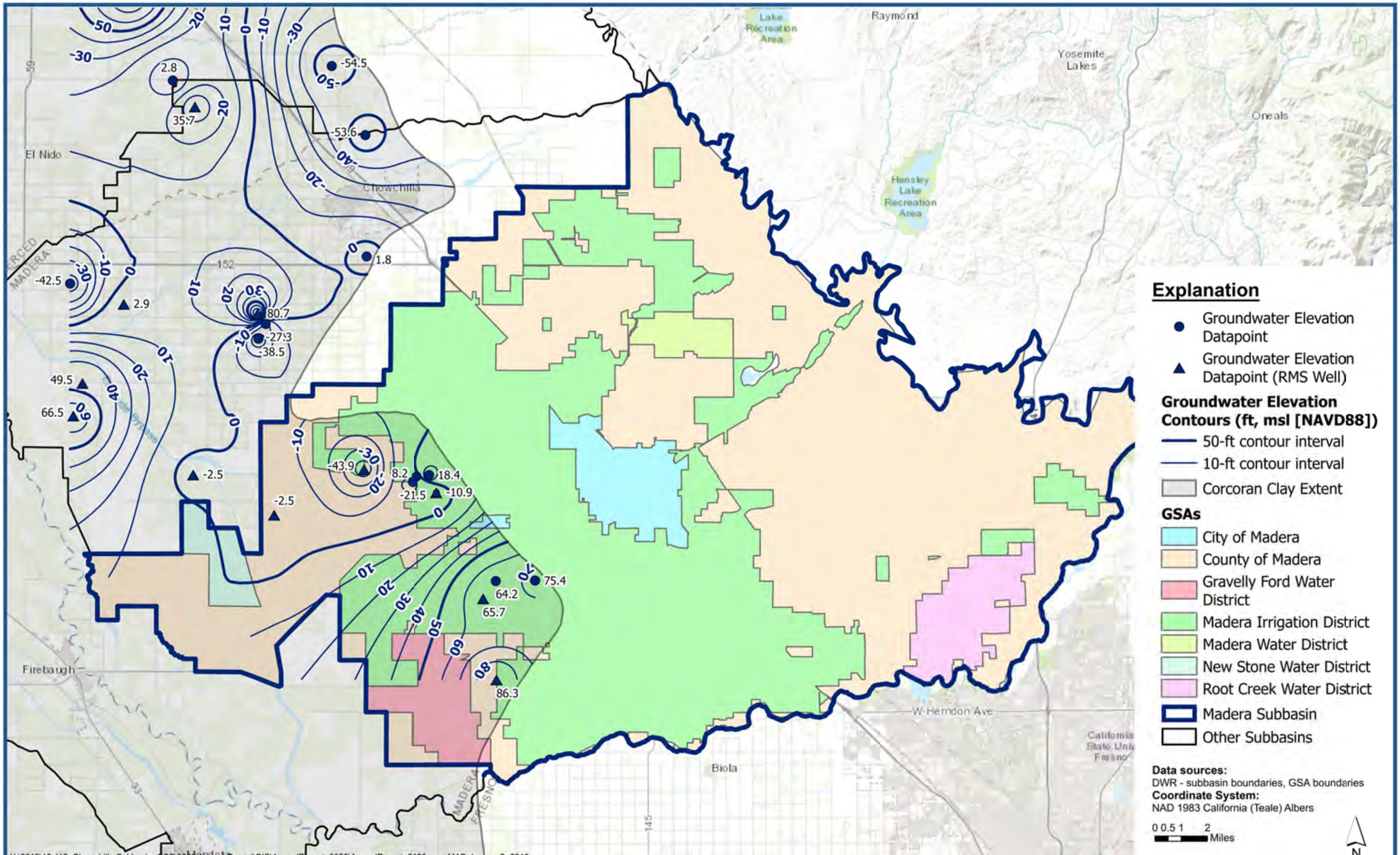
Figure 1-3



Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Fall 2019

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure 1-4



Contours of Equal Groundwater Elevation Lower Aquifer - Spring 2019

Madera Subbasin

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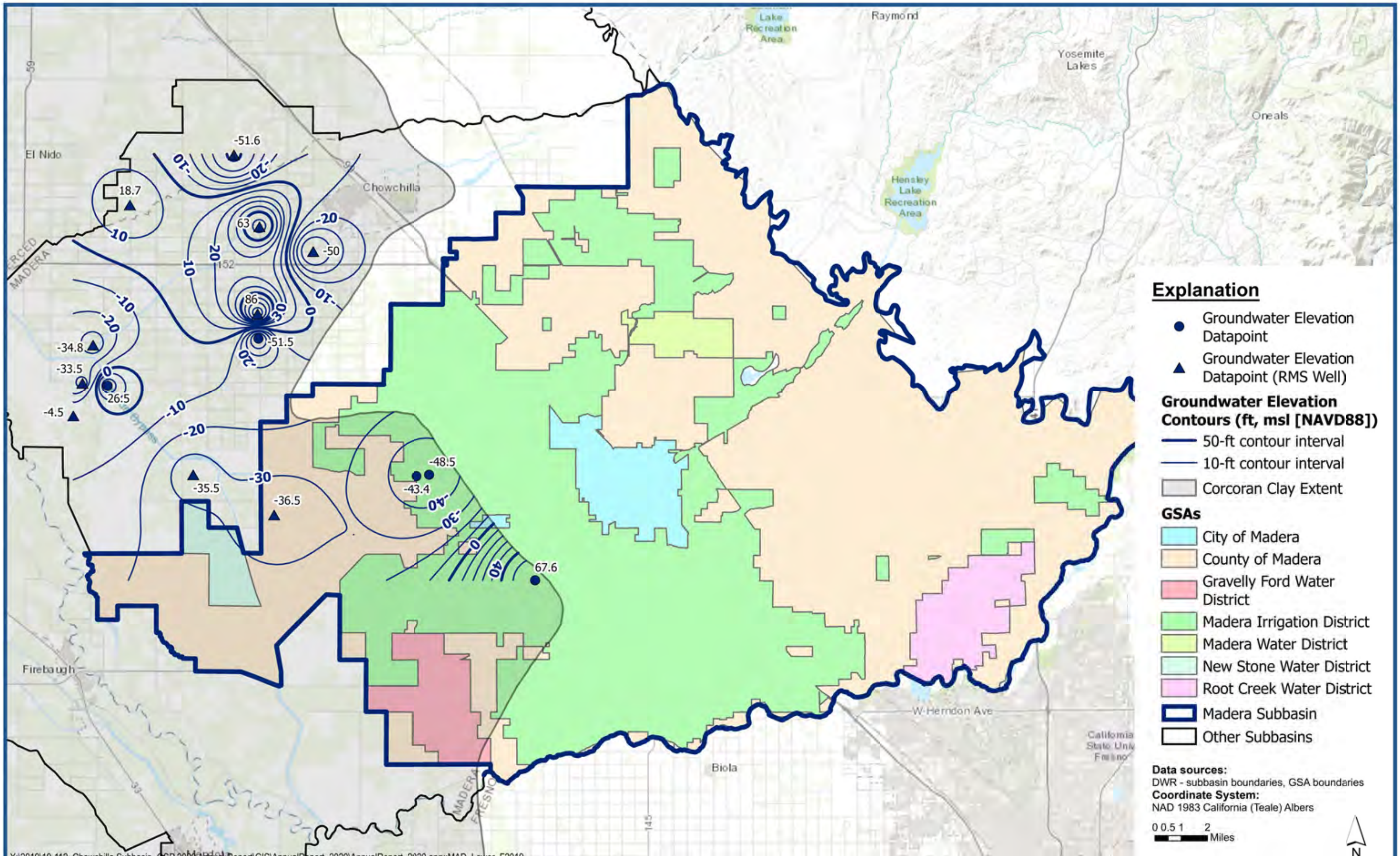
Figure 1-5



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Contours of Equal Groundwater Elevation
Lower Aquifer - Fall 2019

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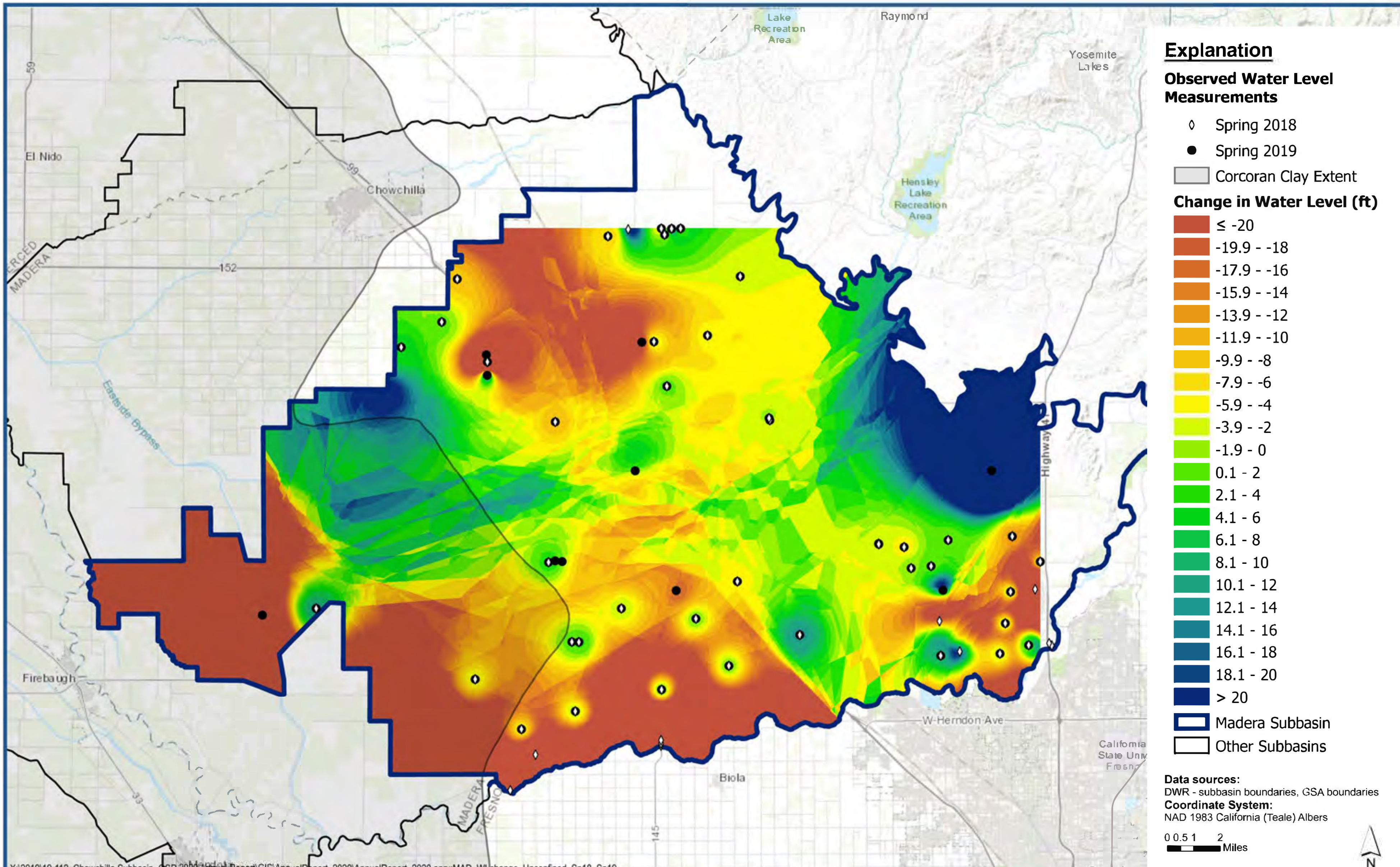
Figure 1-6



Change in Water Level in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2018 through Spring 2019

Figure 6-1

Madera Subbasin
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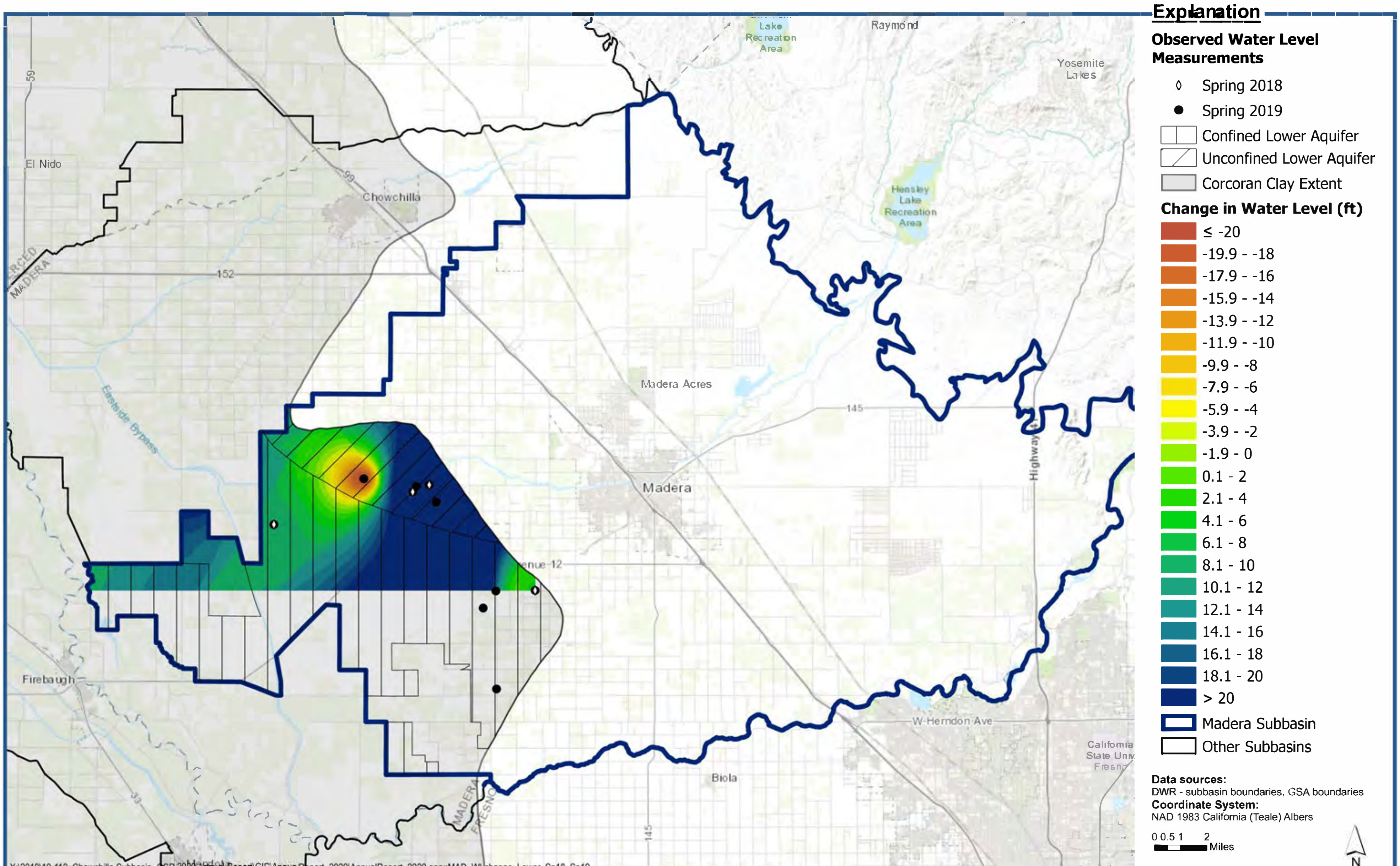

Change in Water Level in the Lower Aquifer - Spring 2018 through Spring 2019

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Figure 6-2

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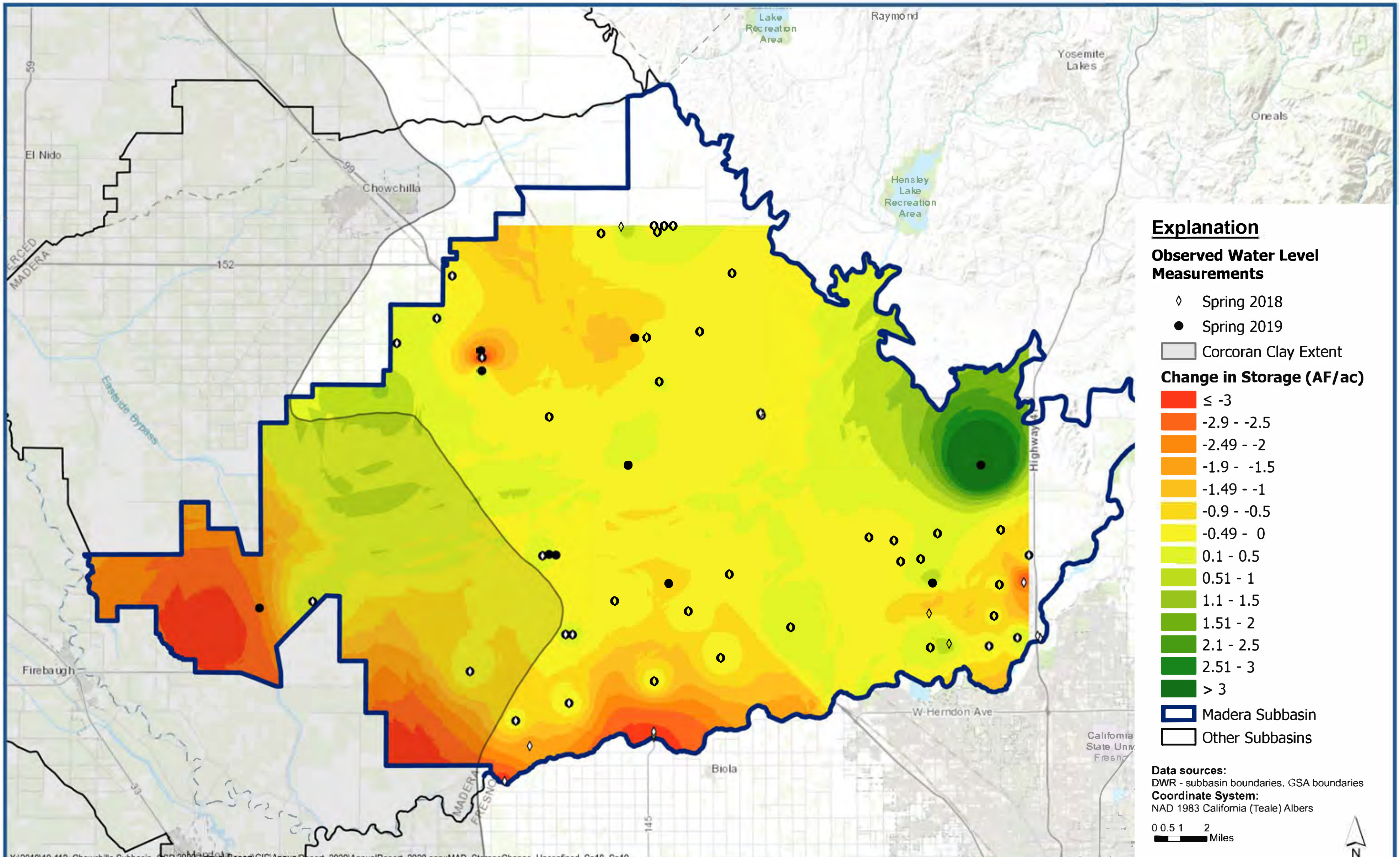

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Change in Groundwater Storage in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2018 through Spring 2019

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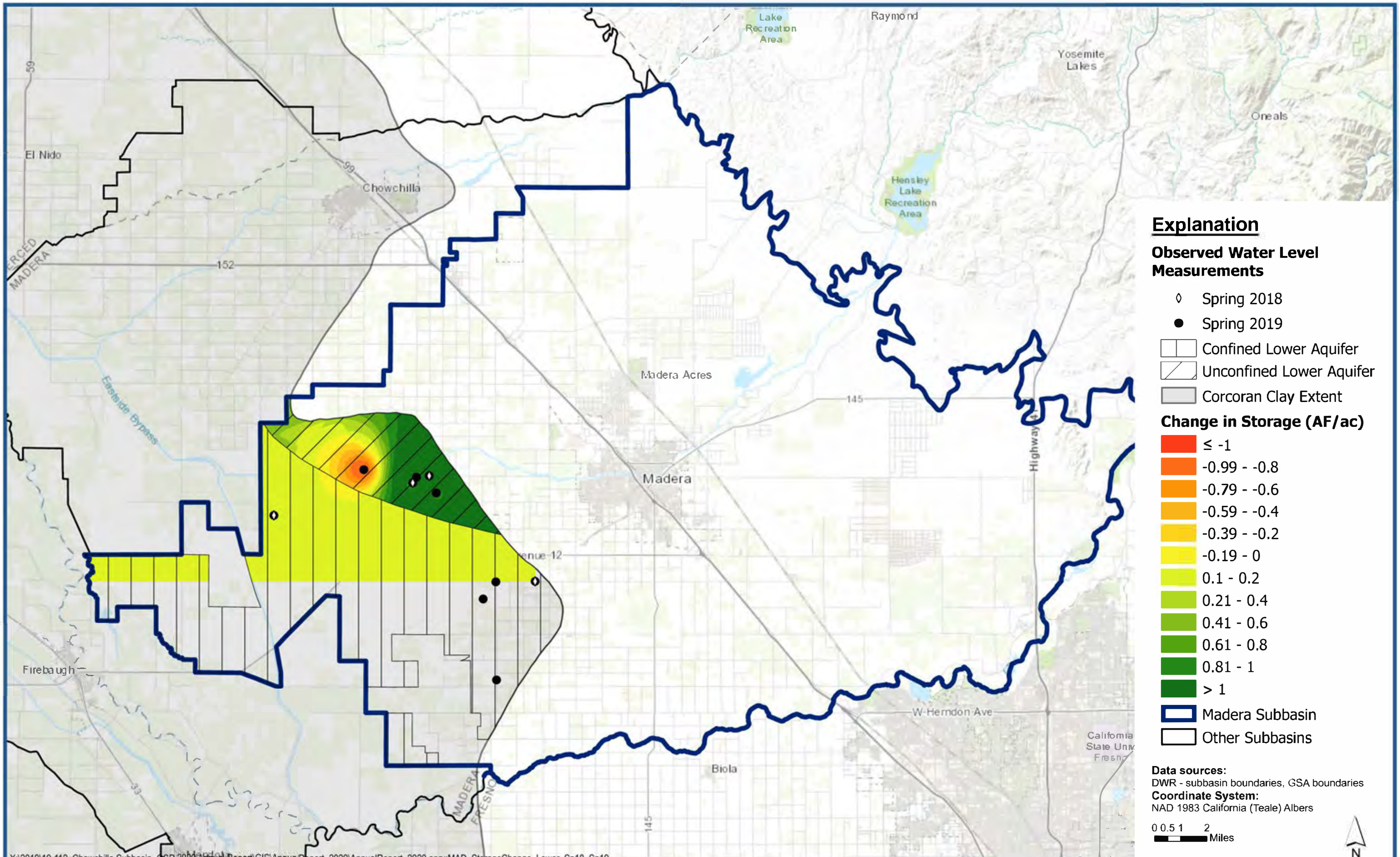
Figure 6-3



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Change in Groundwater Storage in the Lower Aquifer - Spring 2018 through Spring 2019

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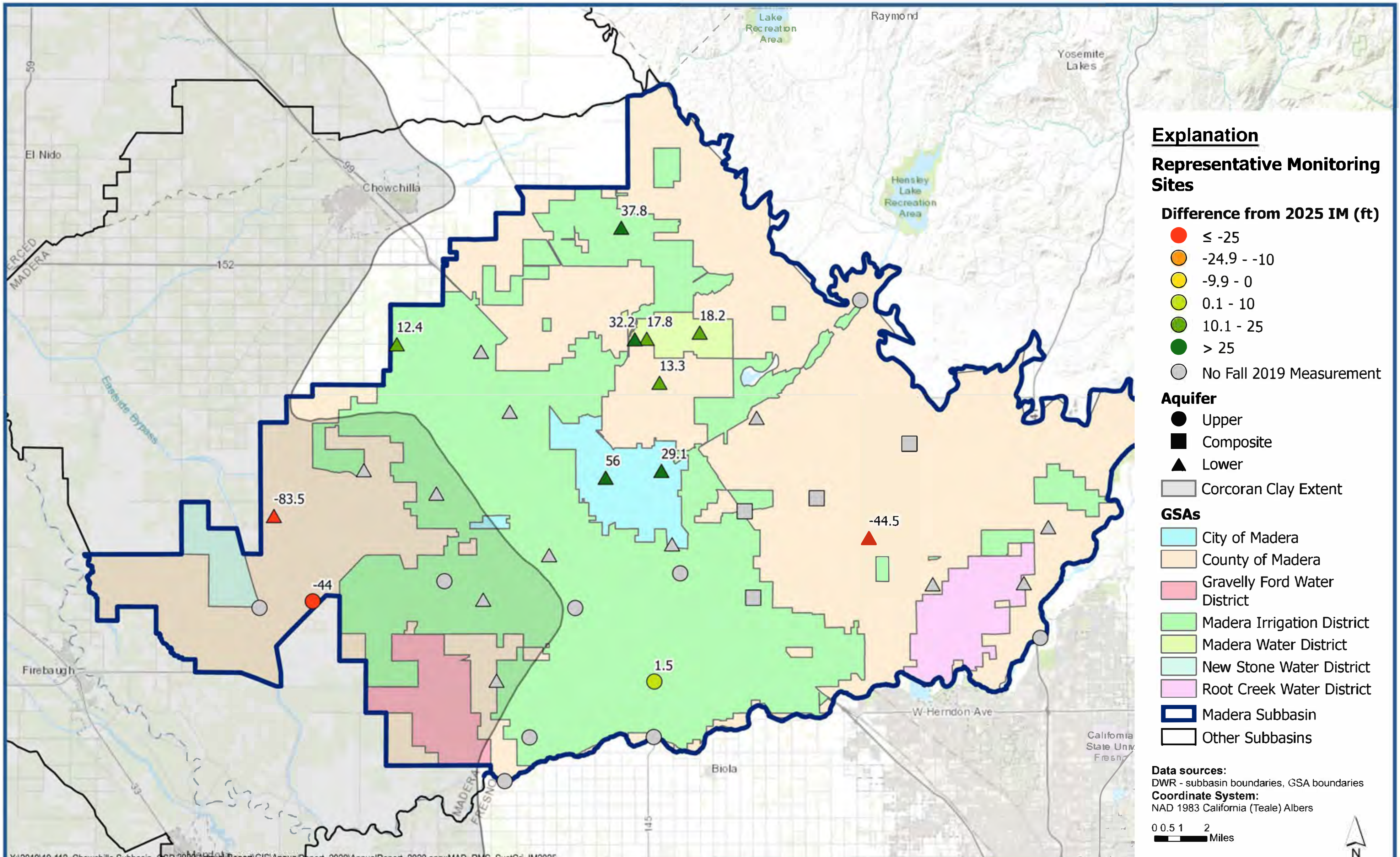
Figure 6-4



Fall 2019 Water Level Measurements at RMS Wells compared to 2025 Interim Milestone

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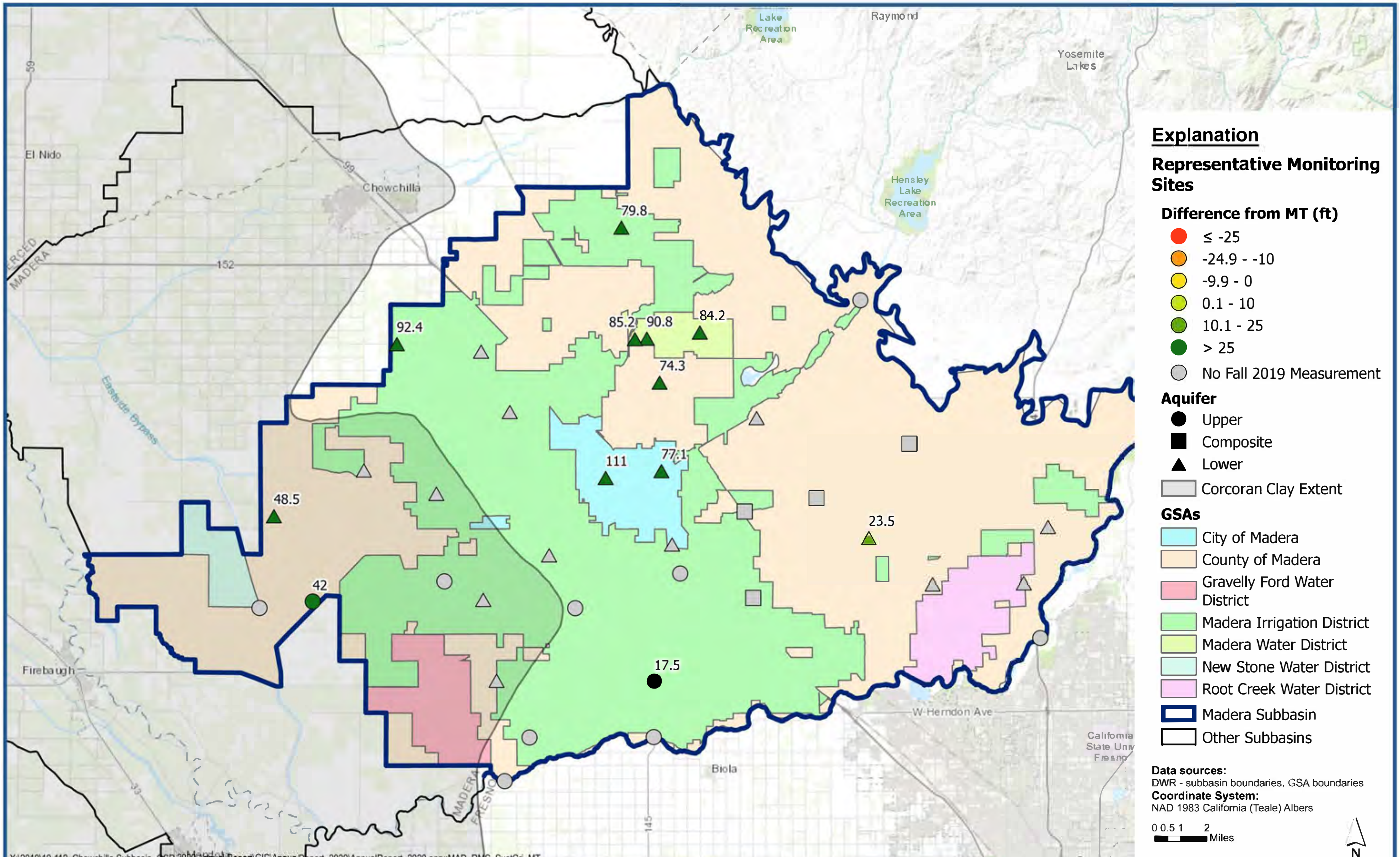
Figure 7-1



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Fall 2019 Water Level Measurements at RMS Wells compared to Minimum Threshold

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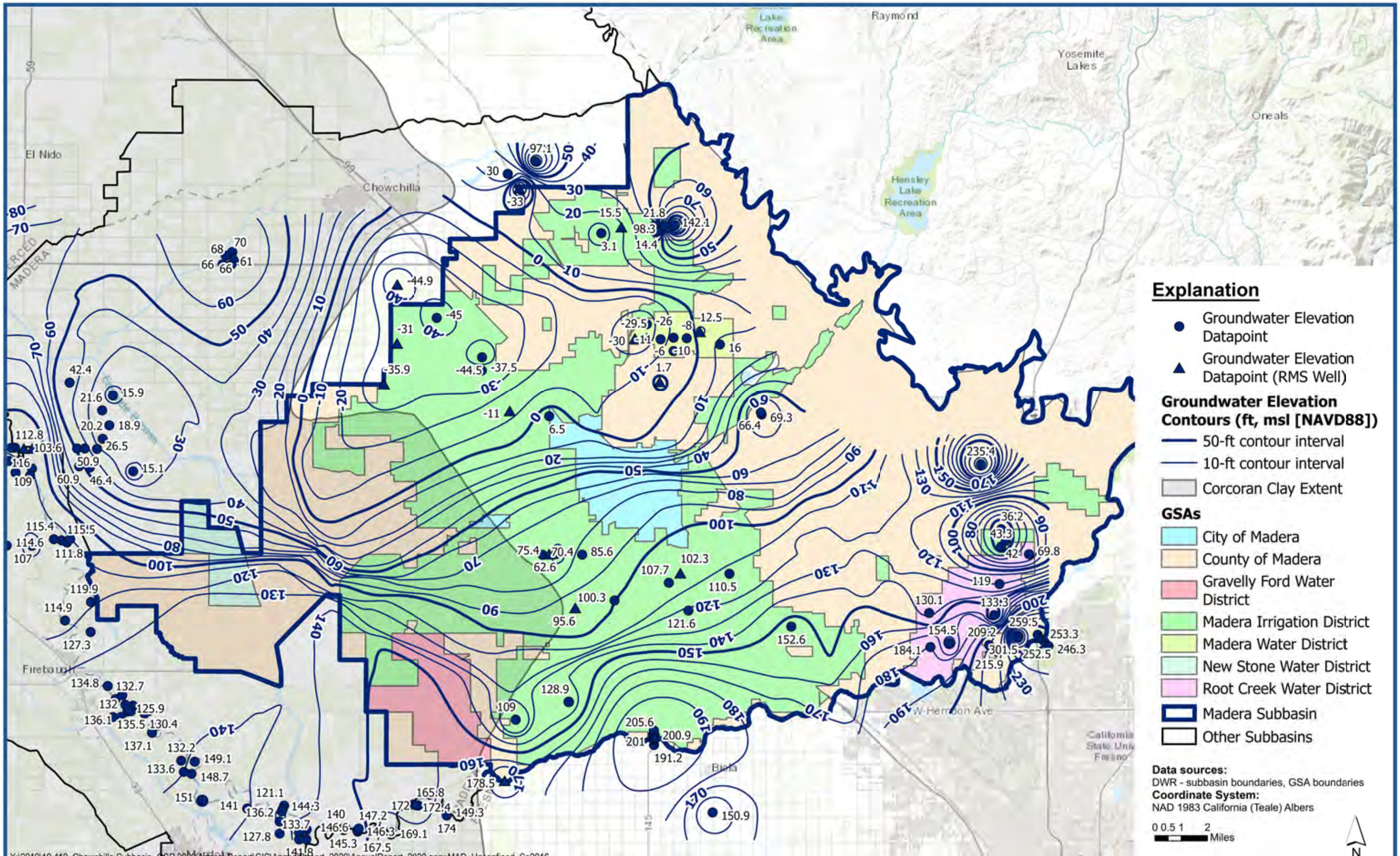
Figure 7-2

Appendix A. Contour Maps of the Different Aquifer Units



Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2016

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Figure A-1

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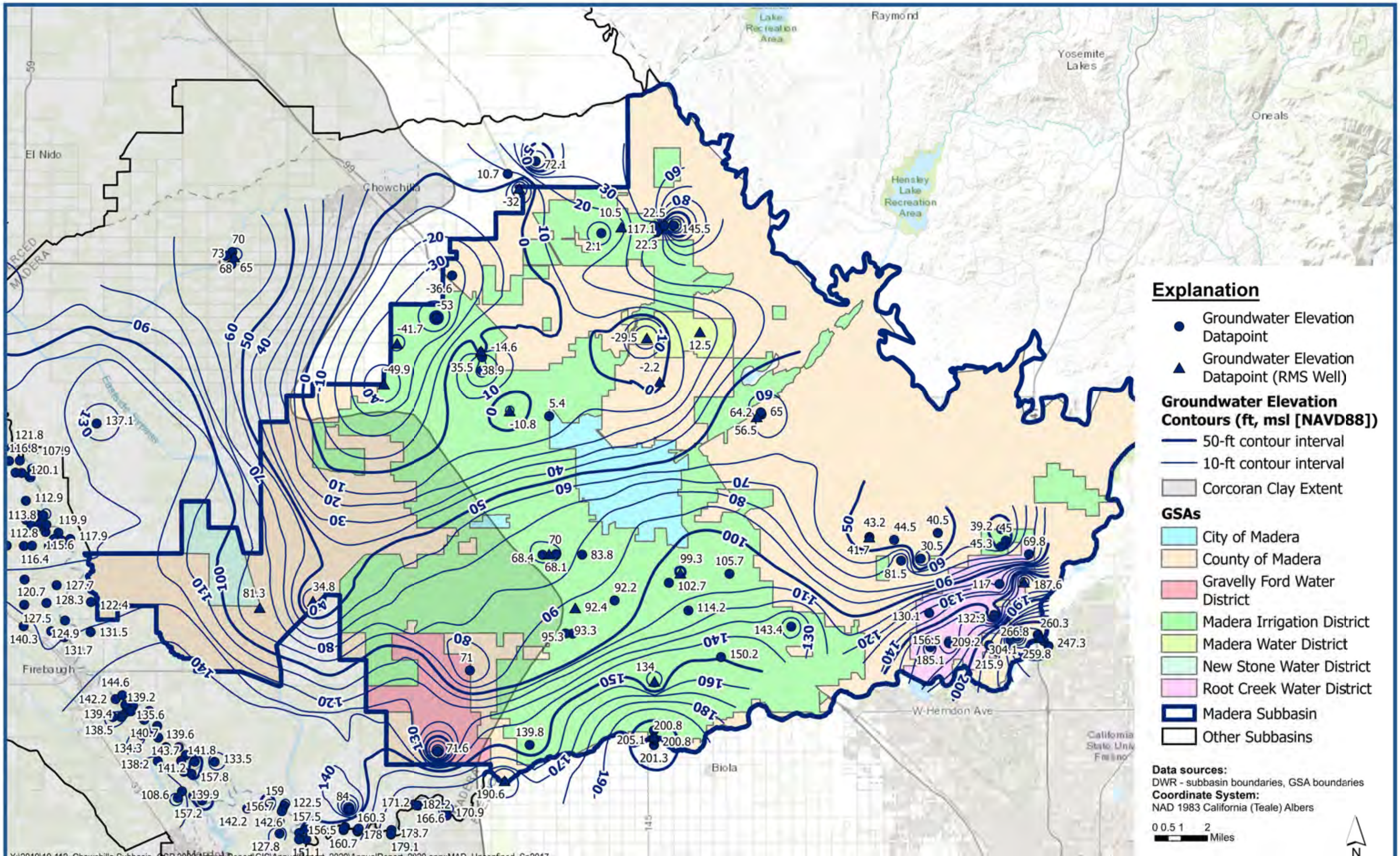

Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2017

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Figure A-2

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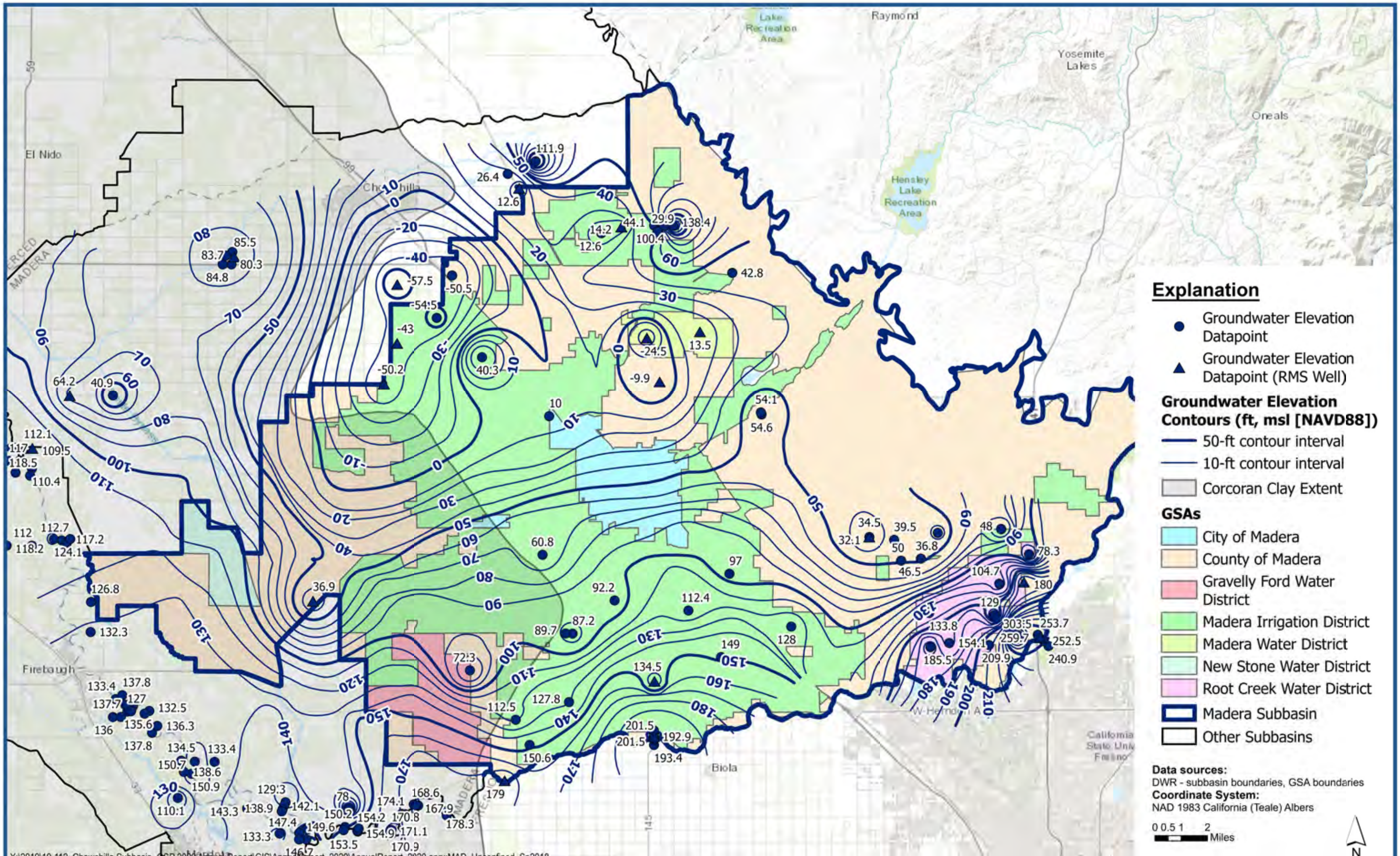

Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2018

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Figure A-3

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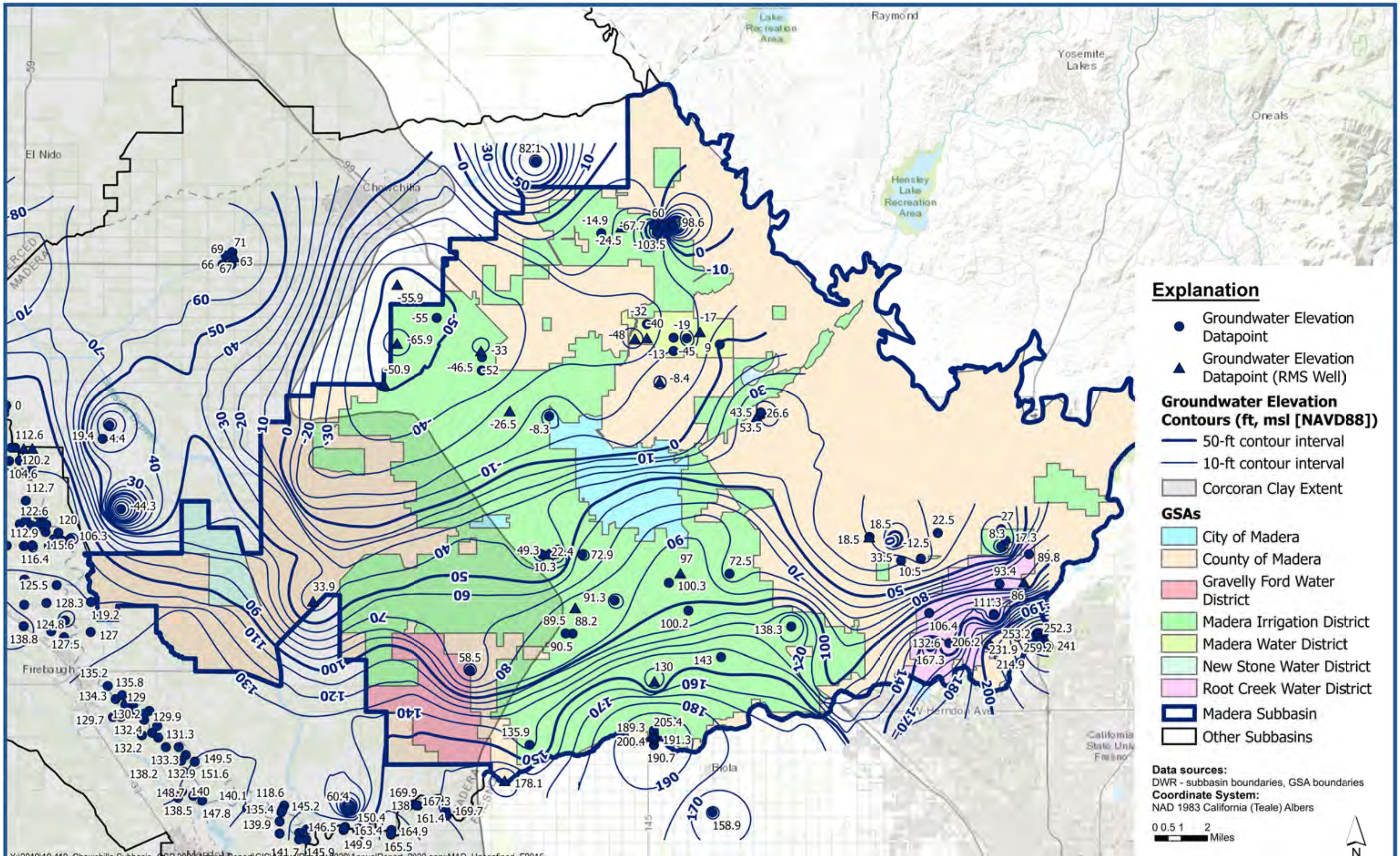

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Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Fall 2015

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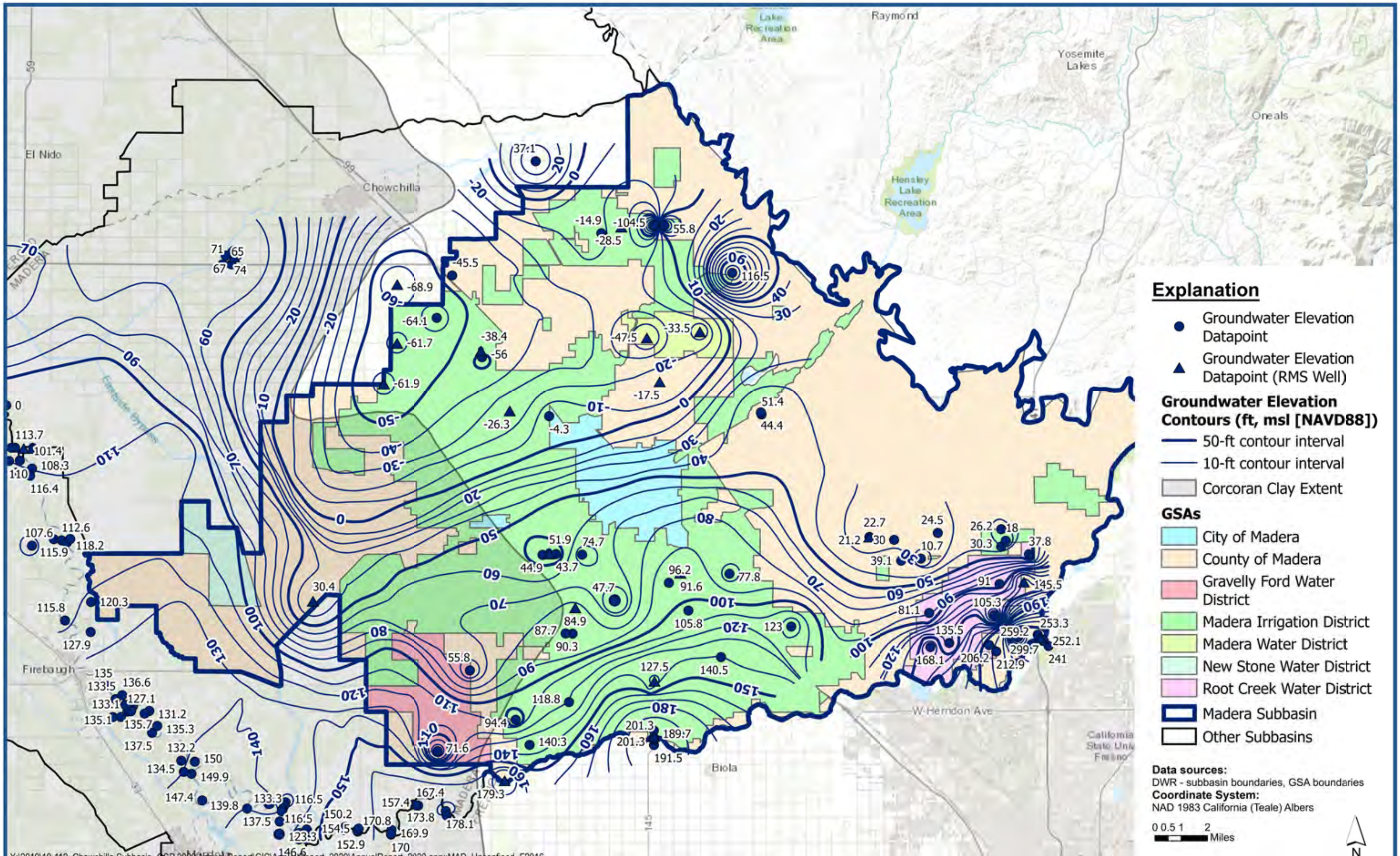
Figure A-4



Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Fall 2016

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Figure A-5

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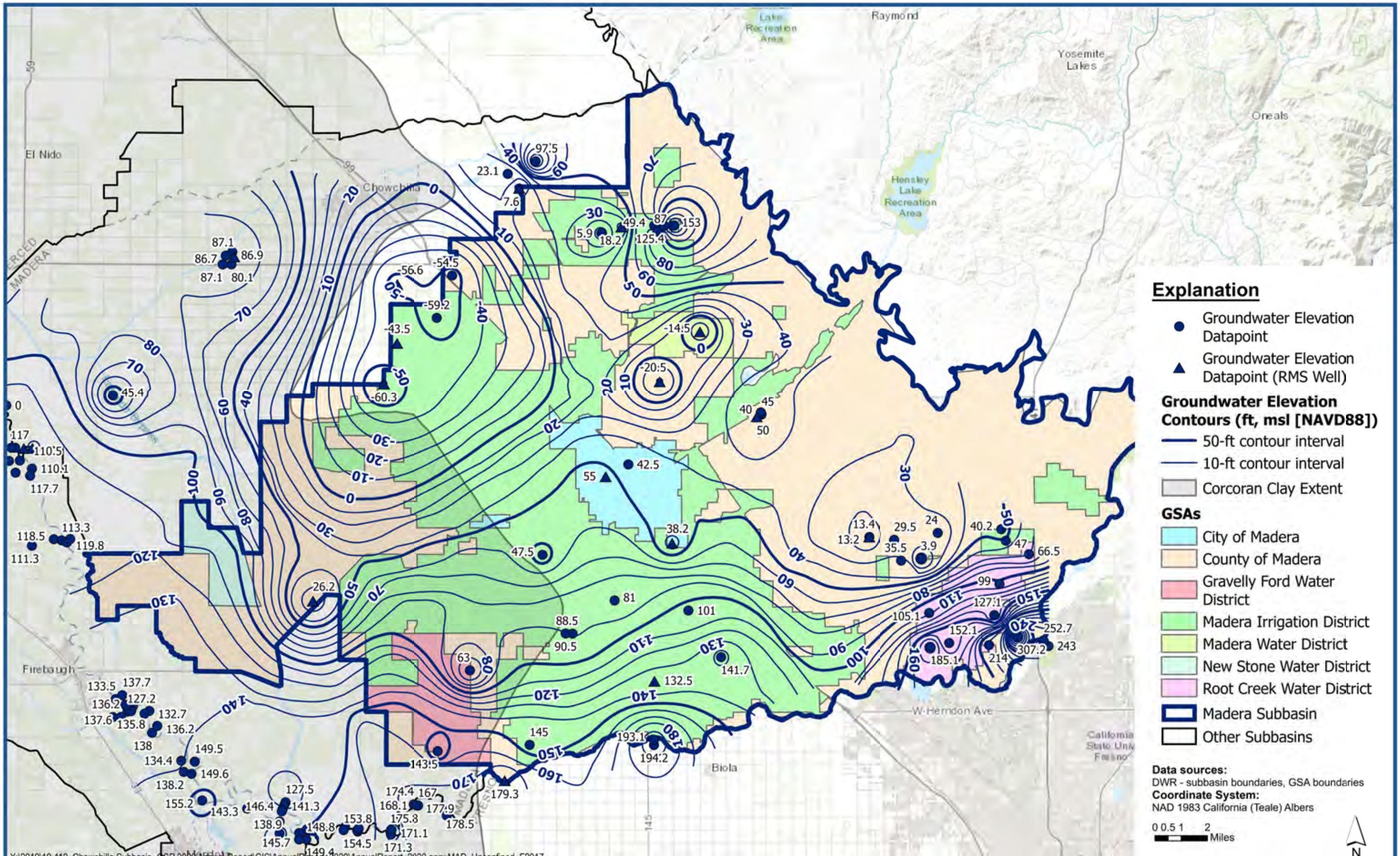

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Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Fall 2017

Madera Subbasin
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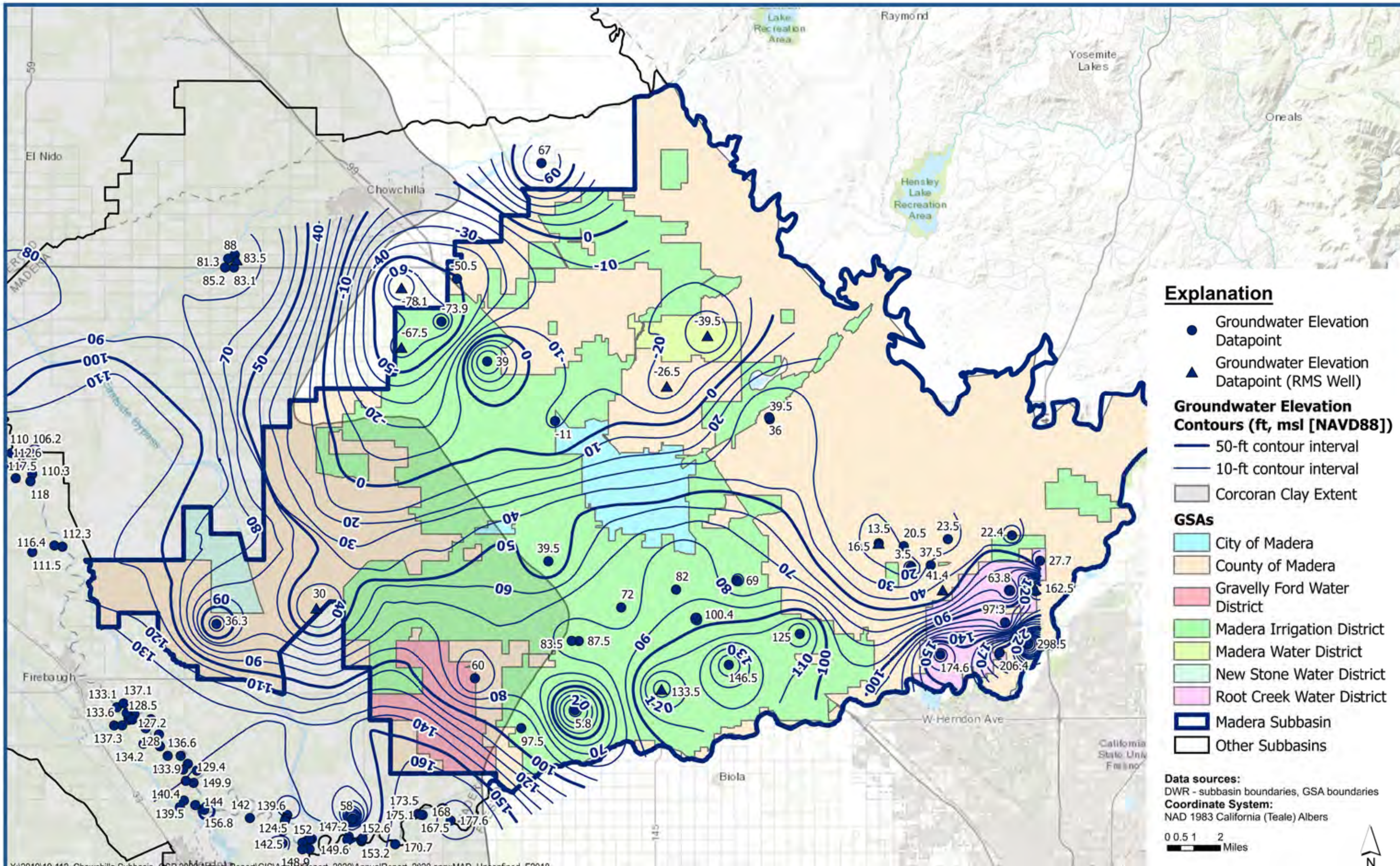
Figure A-6



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Contours of Equal Groundwater Elevation
Upper Aquifer/Undifferentiated Unconfined Zone - Fall 2018

Madera Subbasin

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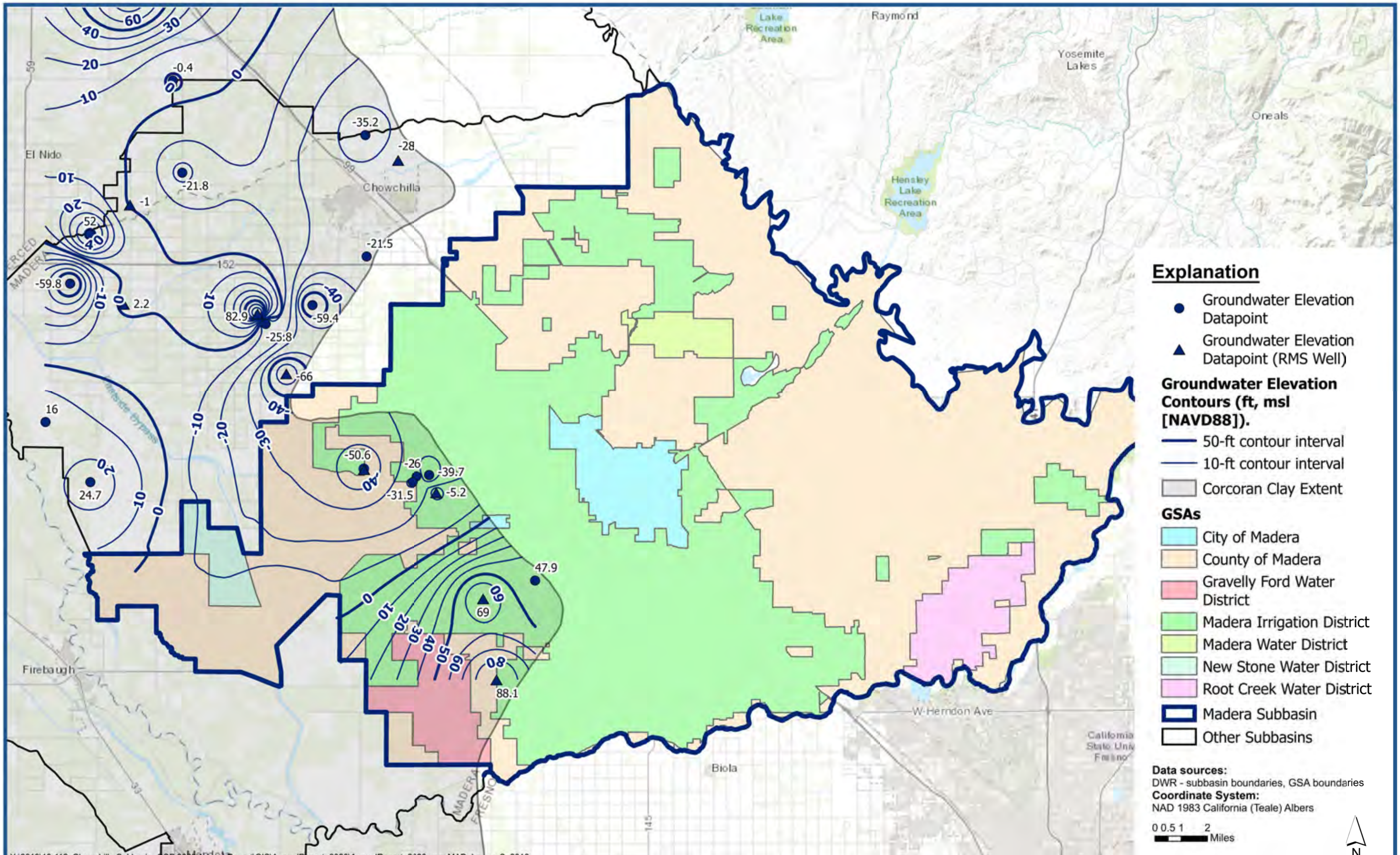
Figure A-7



Contours of Equal Groundwater Elevation
Lower Aquifer - Spring 2016

Figure A-8

Madera Subbasin
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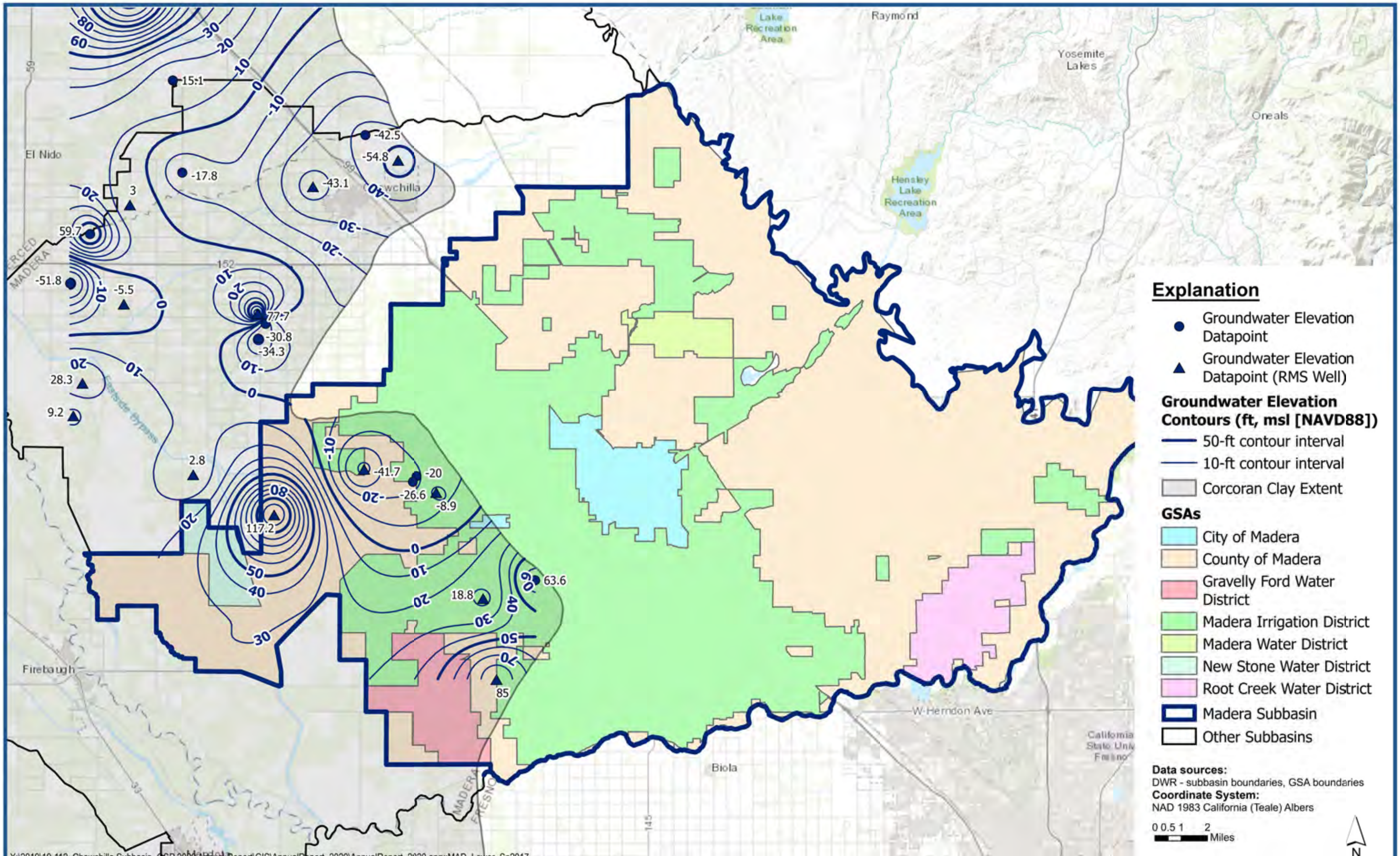

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Contours of Equal Groundwater Elevation
Lower Aquifer - Spring 2017

Madera Subbasin
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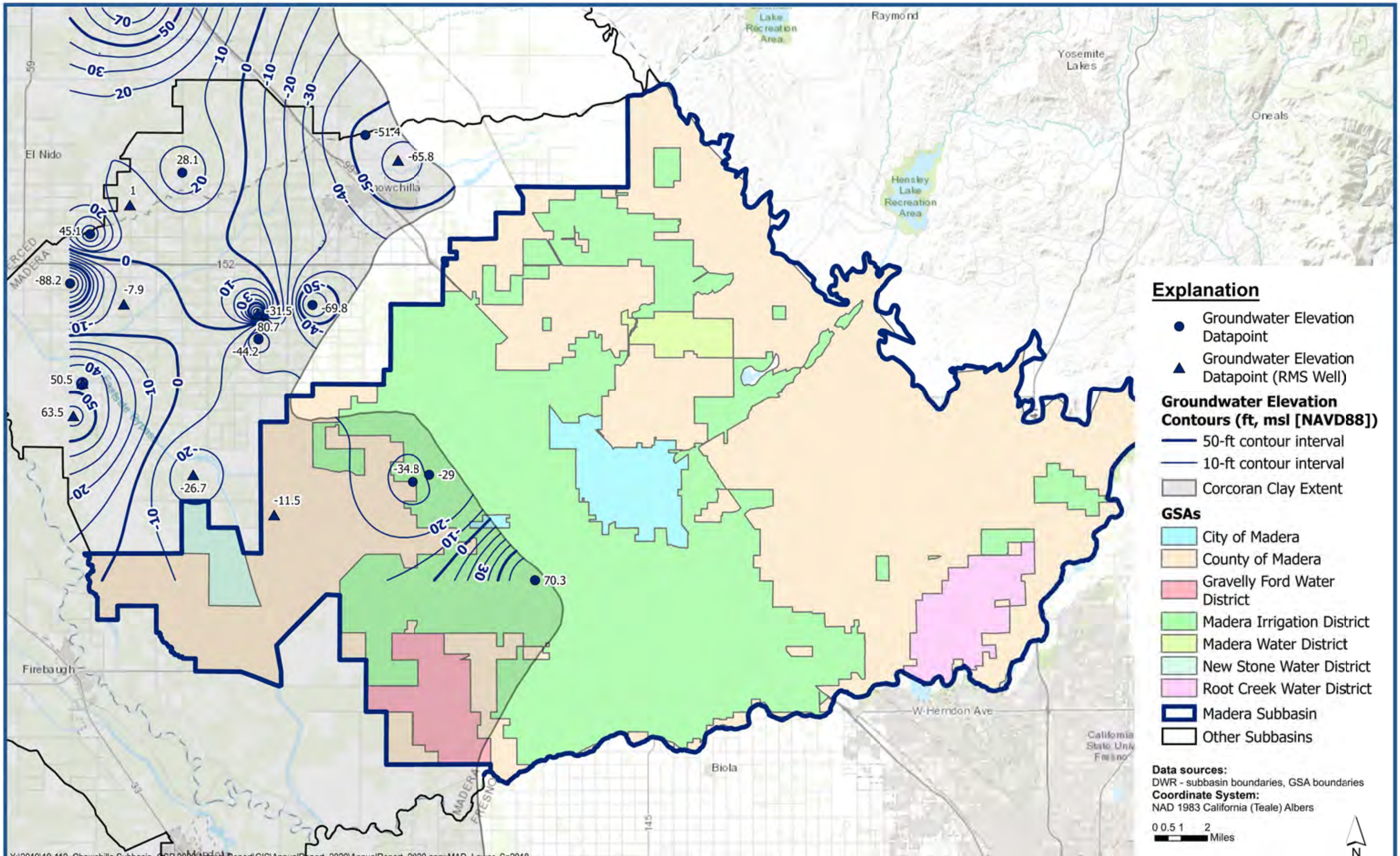
Figure A-9



X:\2019\19-112_Chowchilla Subbasin_GSP 2020 Annual Report\GIS\AnnualReport_2020\AnnualReport_2020.aprx MAD_Lower_Sp2018

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Contours of Equal Groundwater Elevation Lower Aquifer - Spring 2018

Figure A-10

Madera Subbasin

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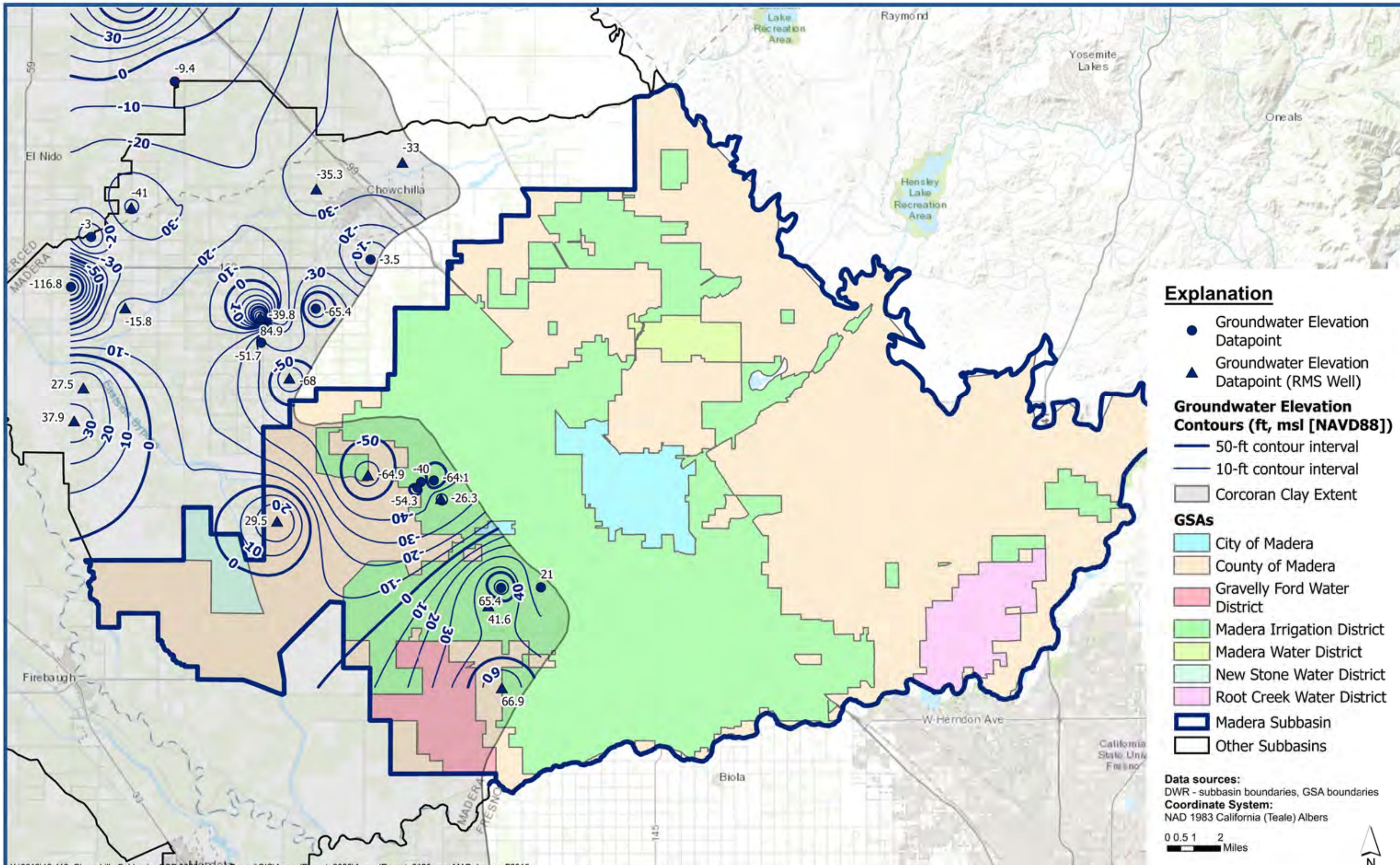

Contours of Equal Groundwater Elevation
Lower Aquifer - Fall 2015

Madera Subbasin
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Figure A-11

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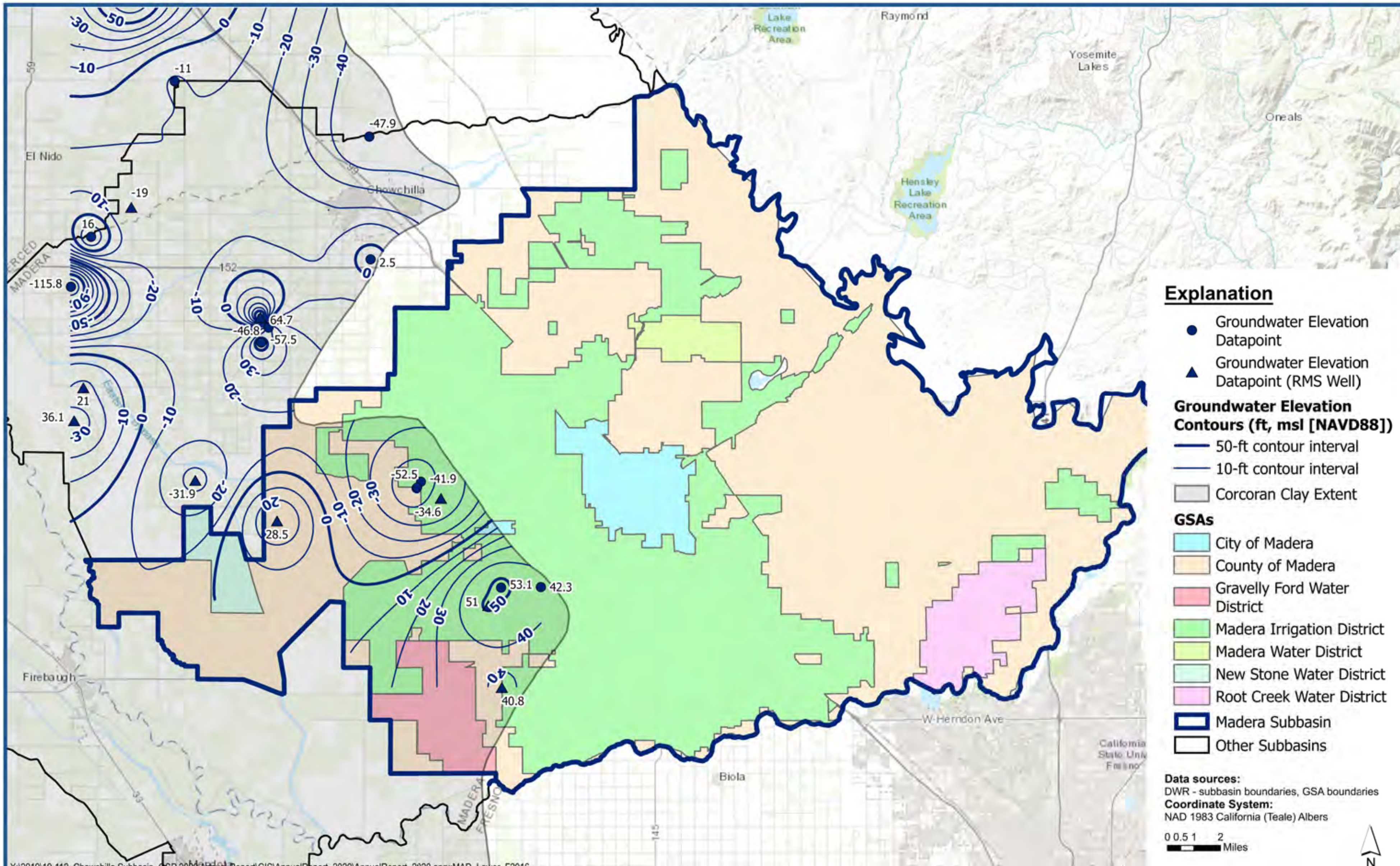

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Contours of Equal Groundwater Elevation
Lower Aquifer - Fall 2016

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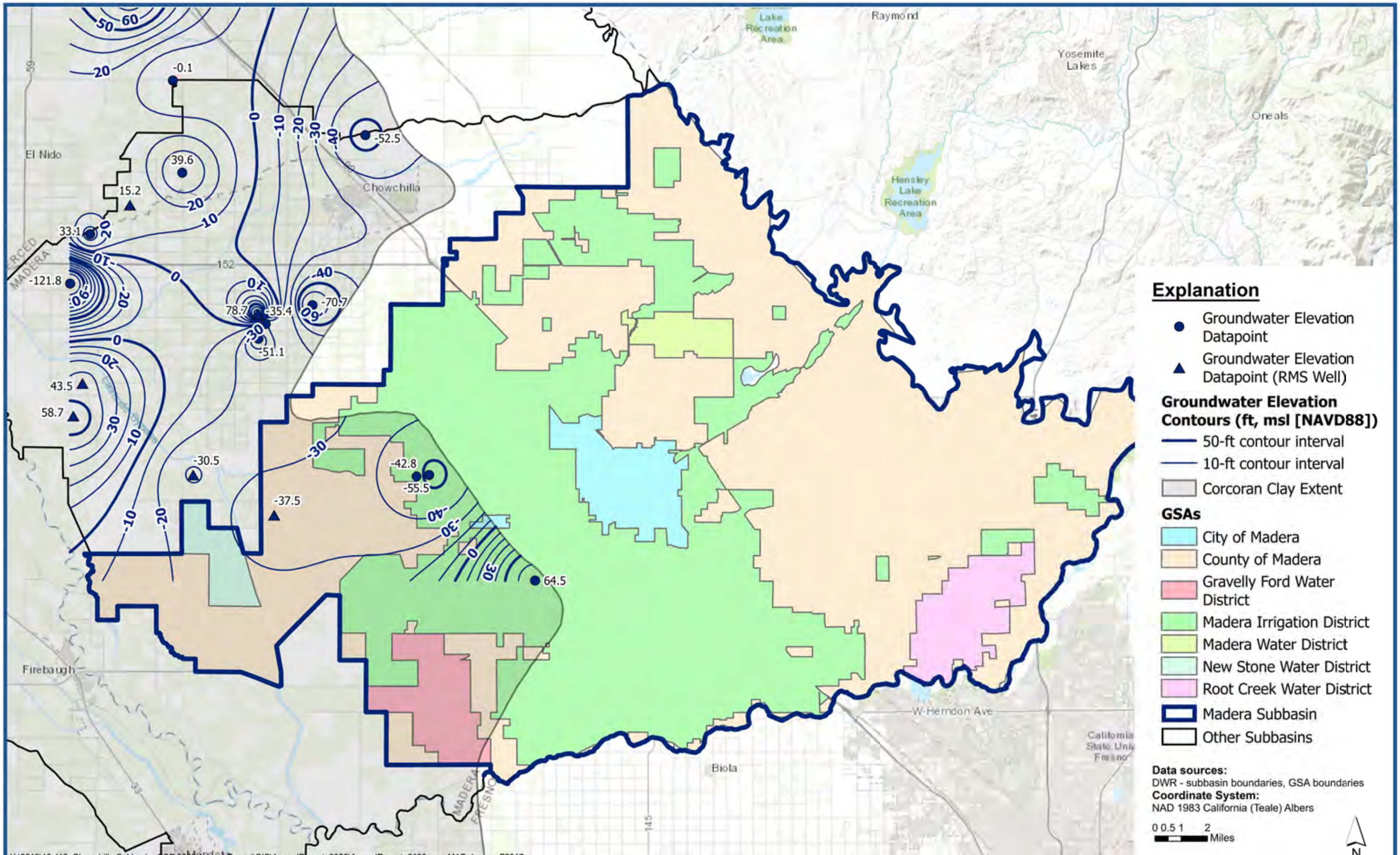
Figure A-12



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Contours of Equal Groundwater Elevation
Lower Aquifer - Fall 2017

Madera Subbasin
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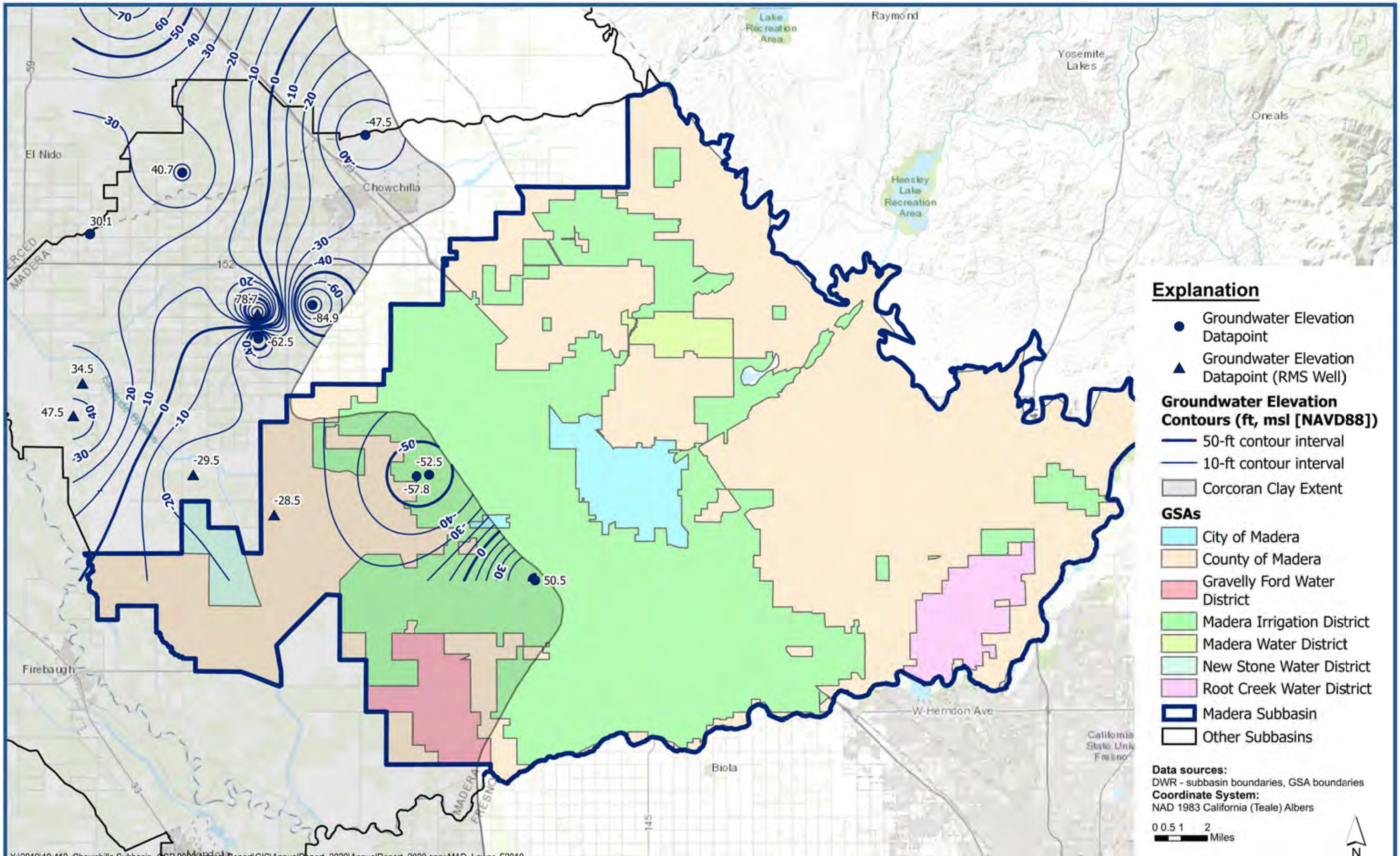
Figure A-13



Contours of Equal Groundwater Elevation Lower Aquifer - Fall 2018

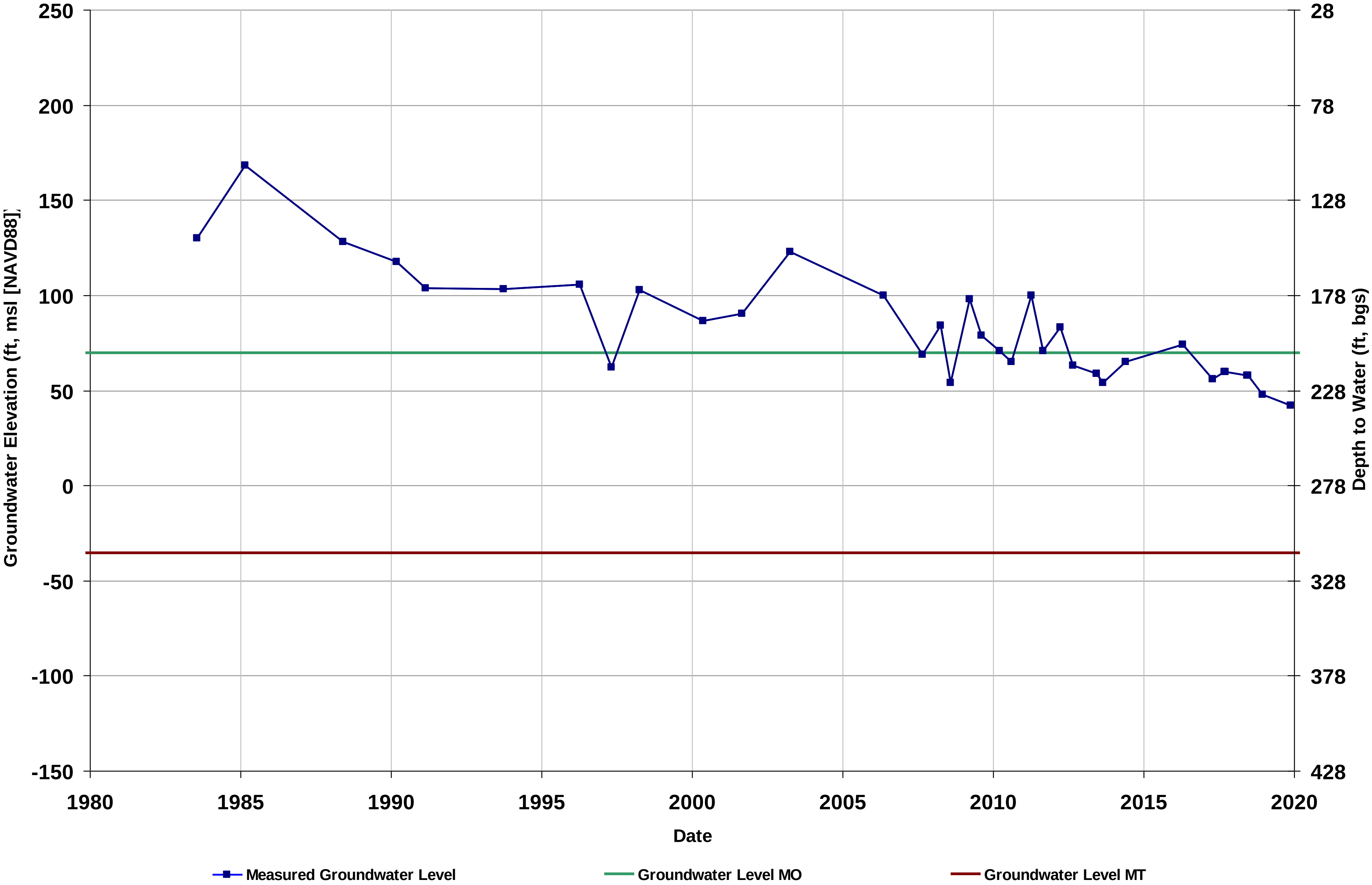
Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure A-14

Appendix B. Hydrographs of Time-Series Groundwater Level Data for Groundwater Level RMS Wells

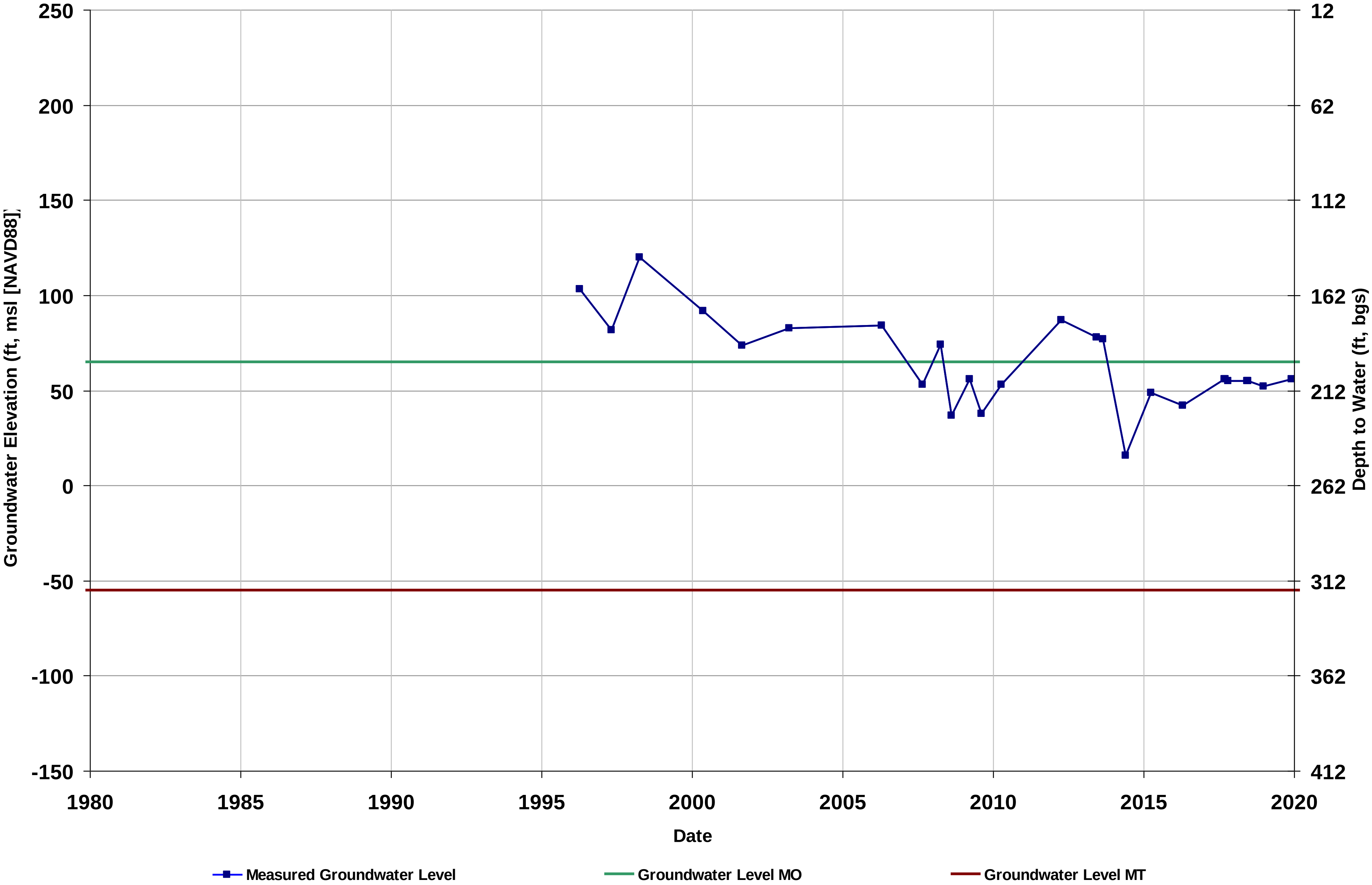
Well Name: COM RMS-1
Depth Zone: Lower
Subbasin: Madera
GSA: City of Madera

Total Depth (ft): 520
Perf Top (ft): 210
Perf Bottom (ft): 510
GSE (ft, msl): 278



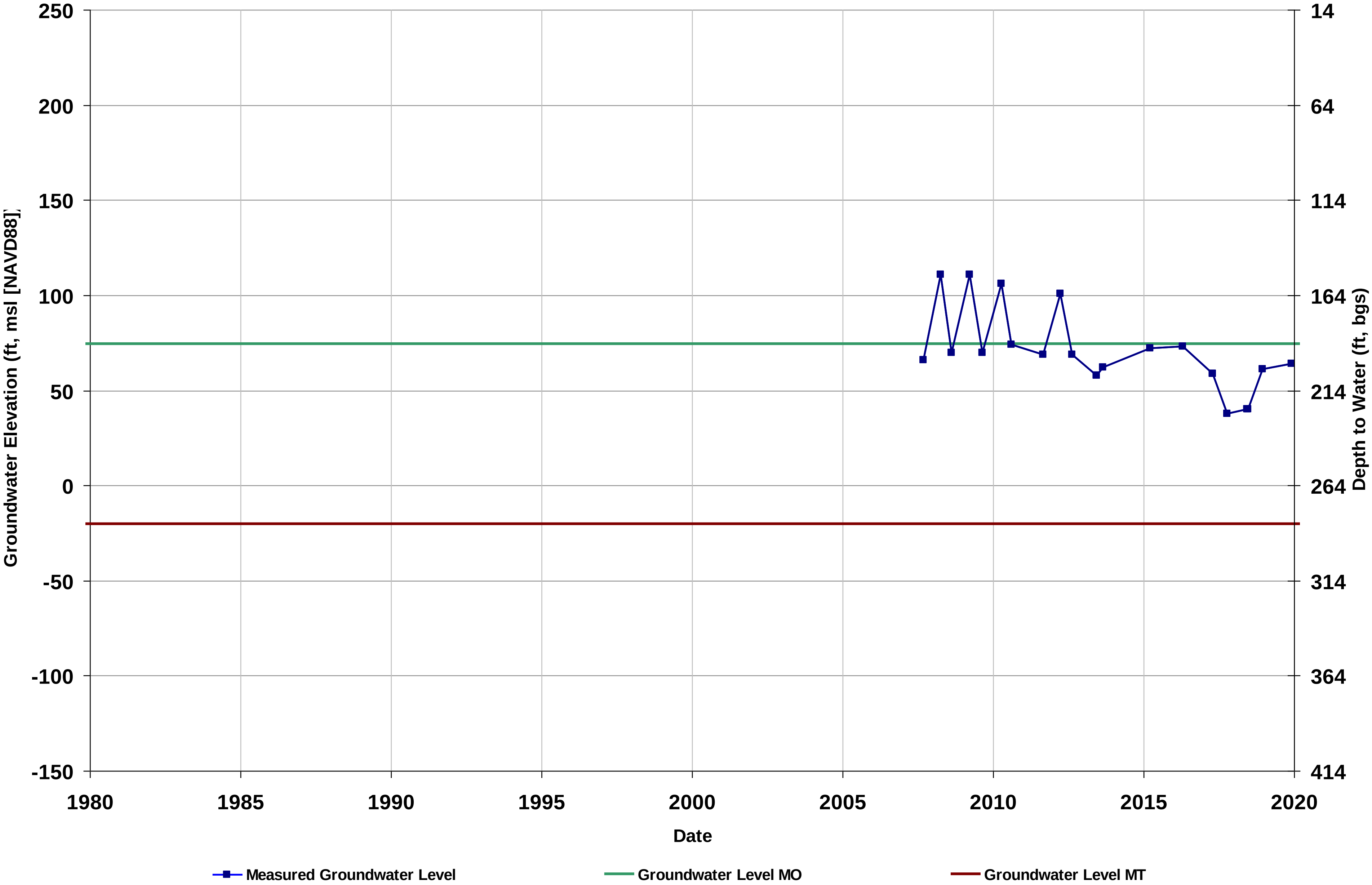
Well Name: COM RMS-2
Depth Zone: Lower
Subbasin: Madera
GSA: City of Madera

Total Depth (ft): 589
Perf Top (ft): 370
Perf Bottom (ft): 590
GSE (ft, msl): 262



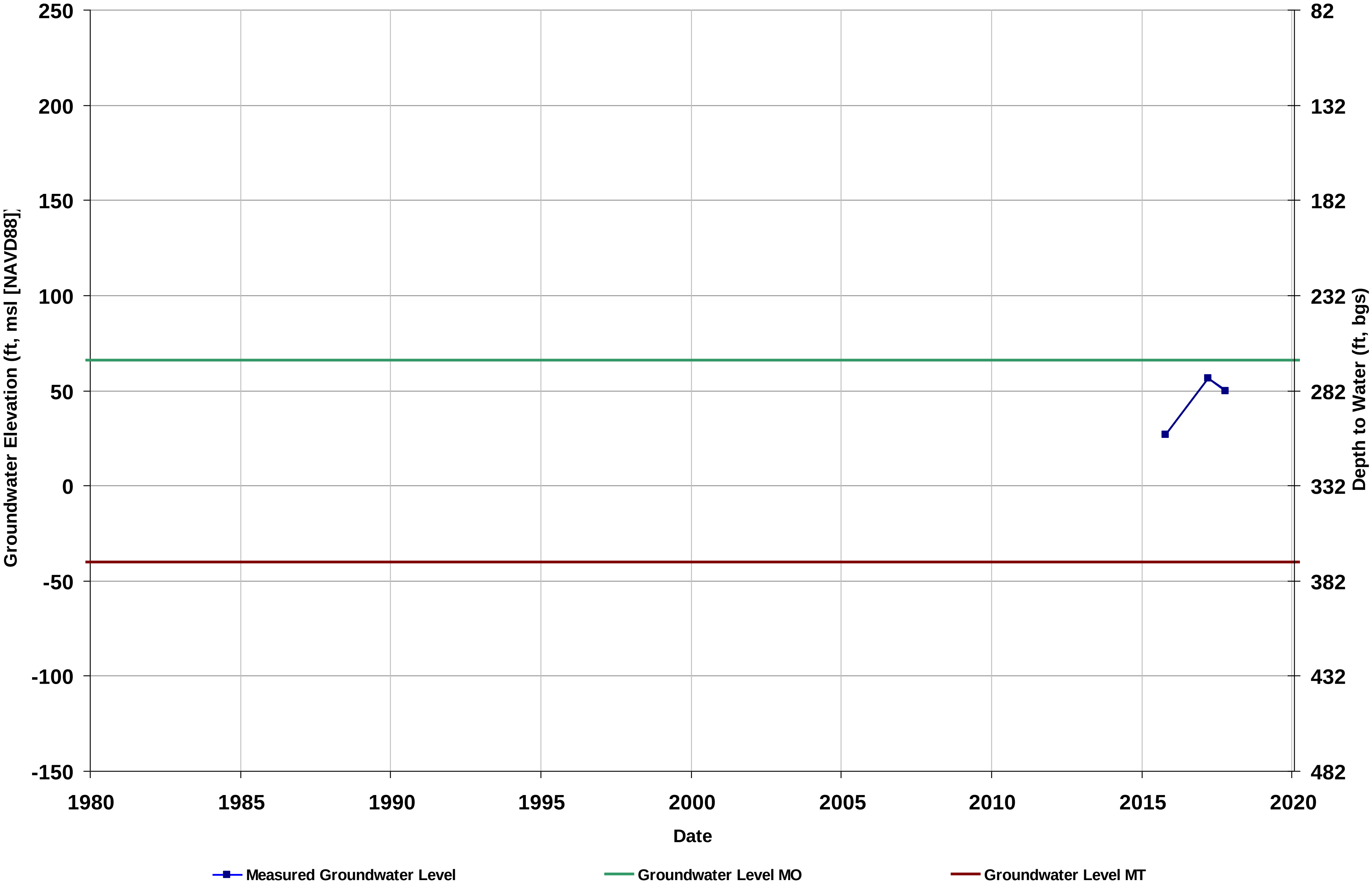
Well Name: COM RMS-3
Depth Zone: Lower
Subbasin: Madera
GSA: City of Madera

Total Depth (ft): 620
Perf Top (ft): 310
Perf Bottom (ft): 600
GSE (ft, msl): 264



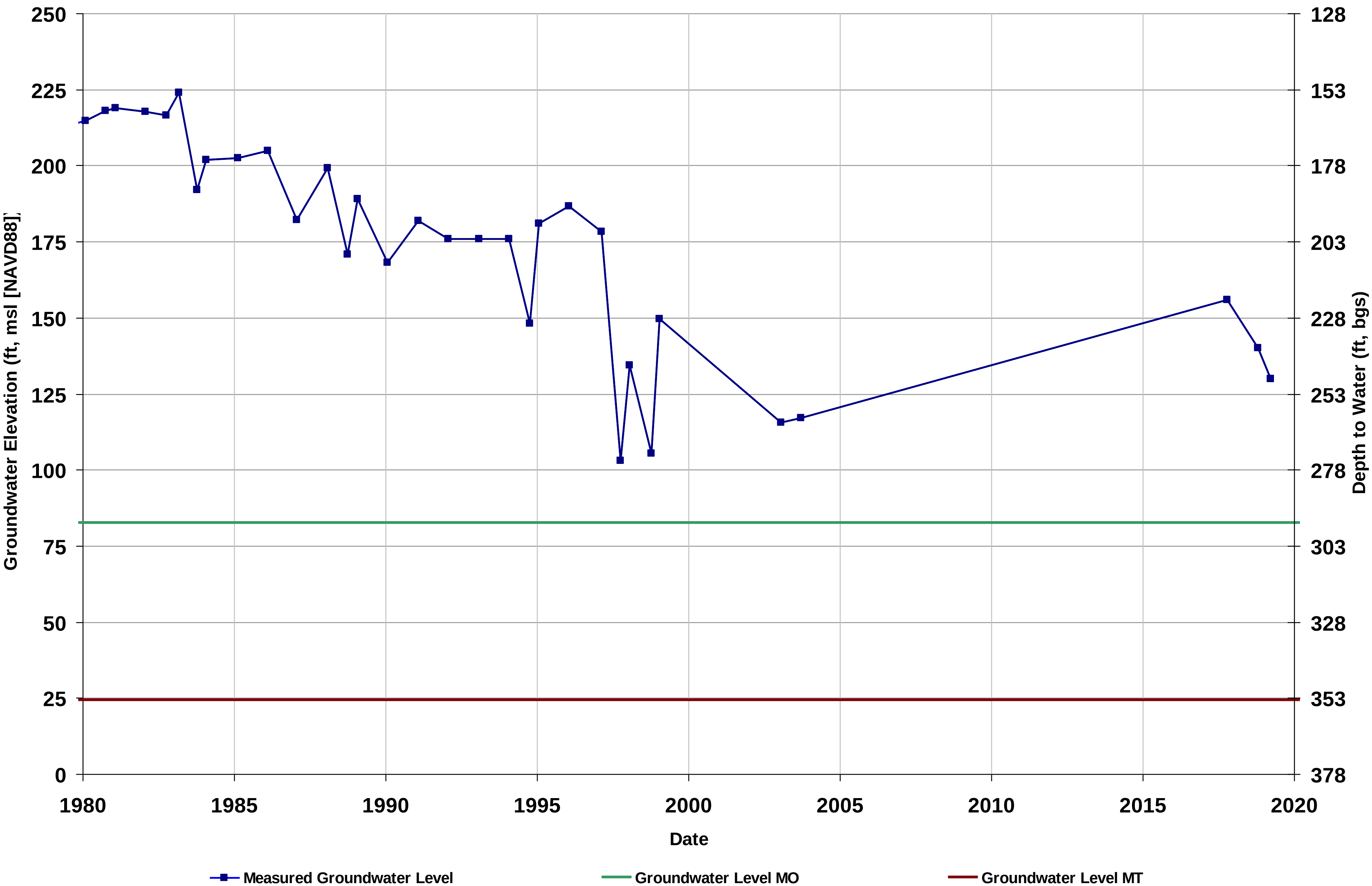
Well Name: MCE RMS-1
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft): 500
Perf Top (ft): 420
Perf Bottom (ft): 500
GSE (ft, msl): 332



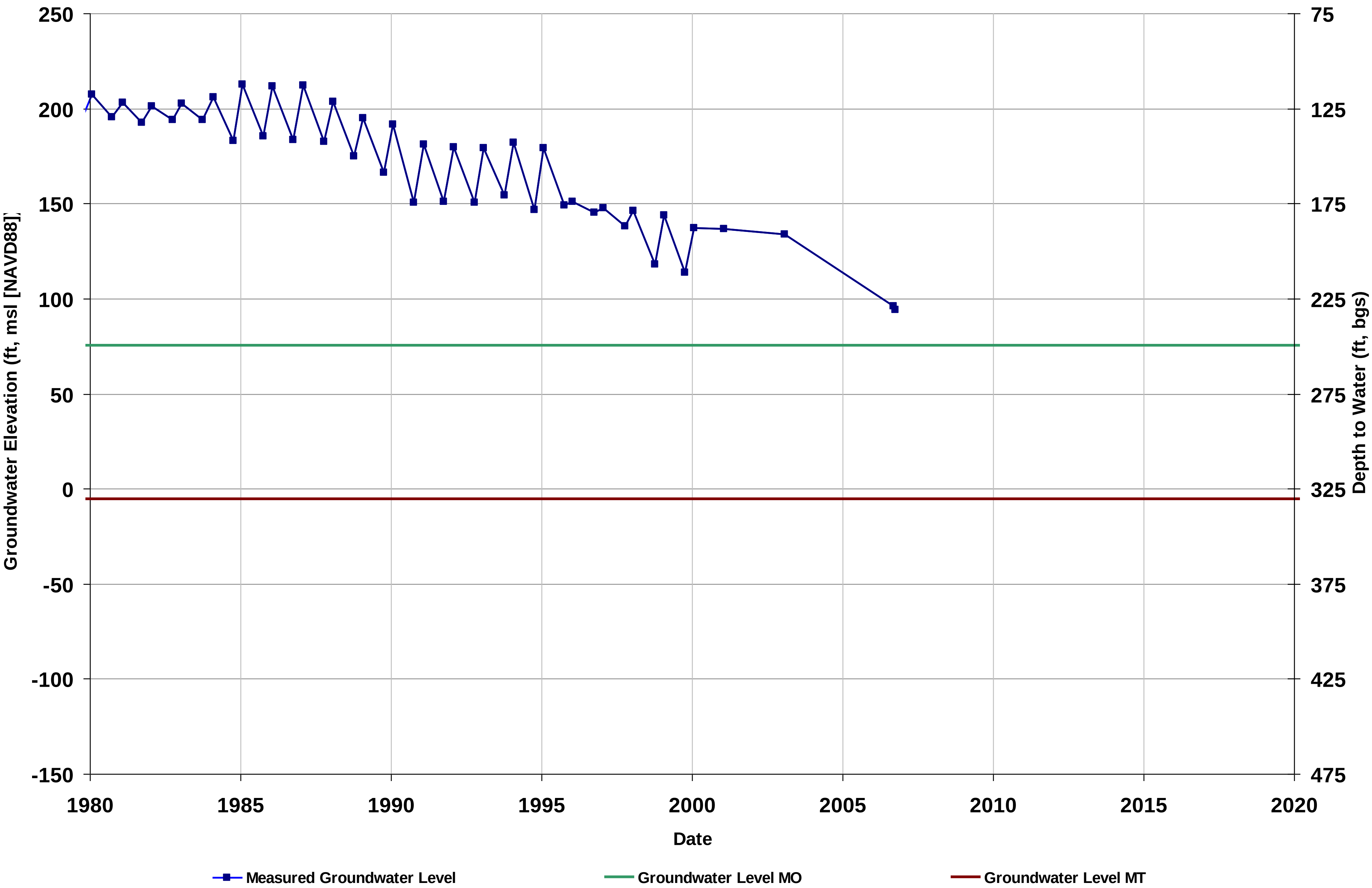
Well Name: MCE RMS-2
Depth Zone: Composite
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 378



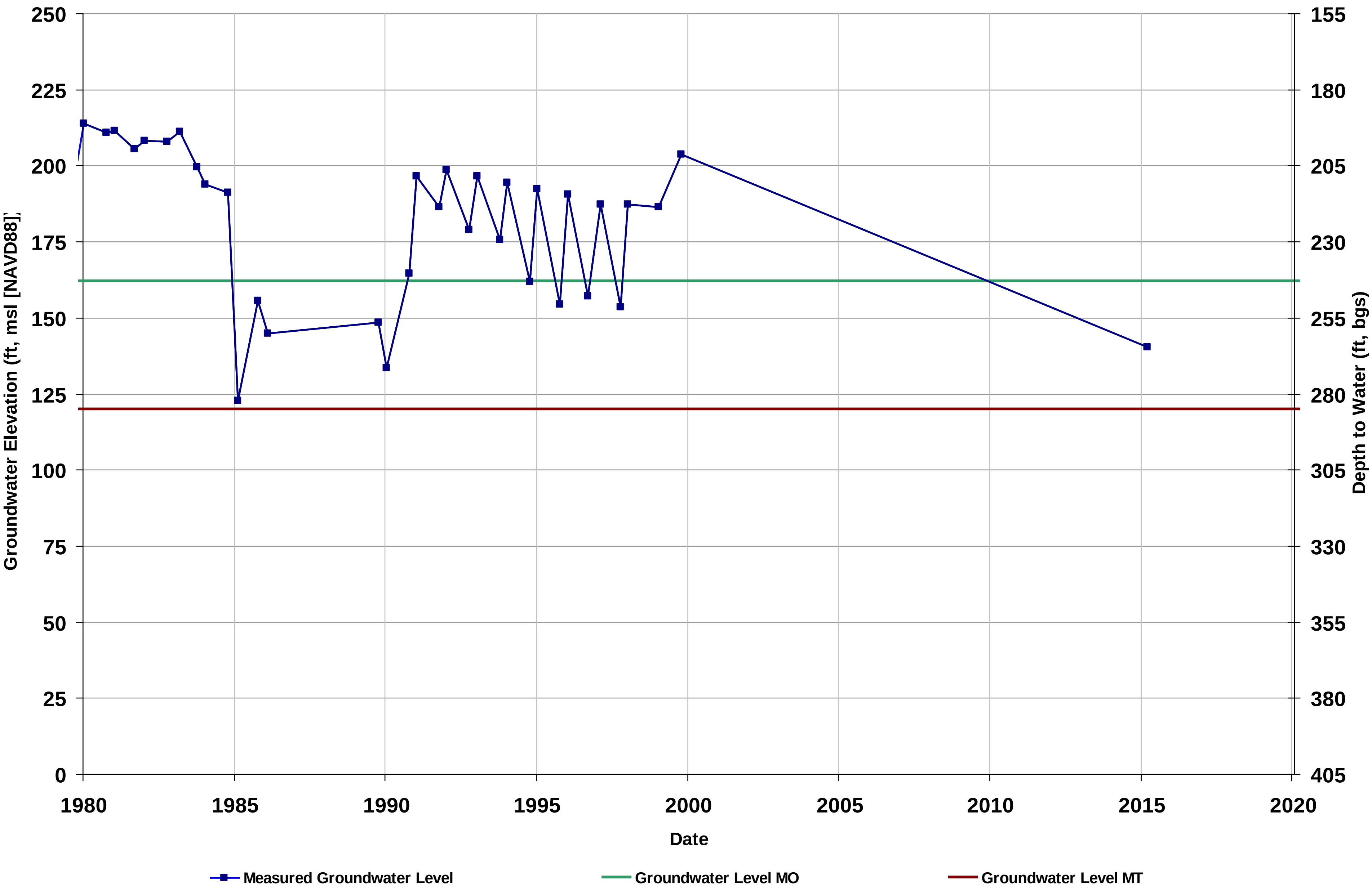
Well Name: MCE RMS-3
Depth Zone: Composite
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 325



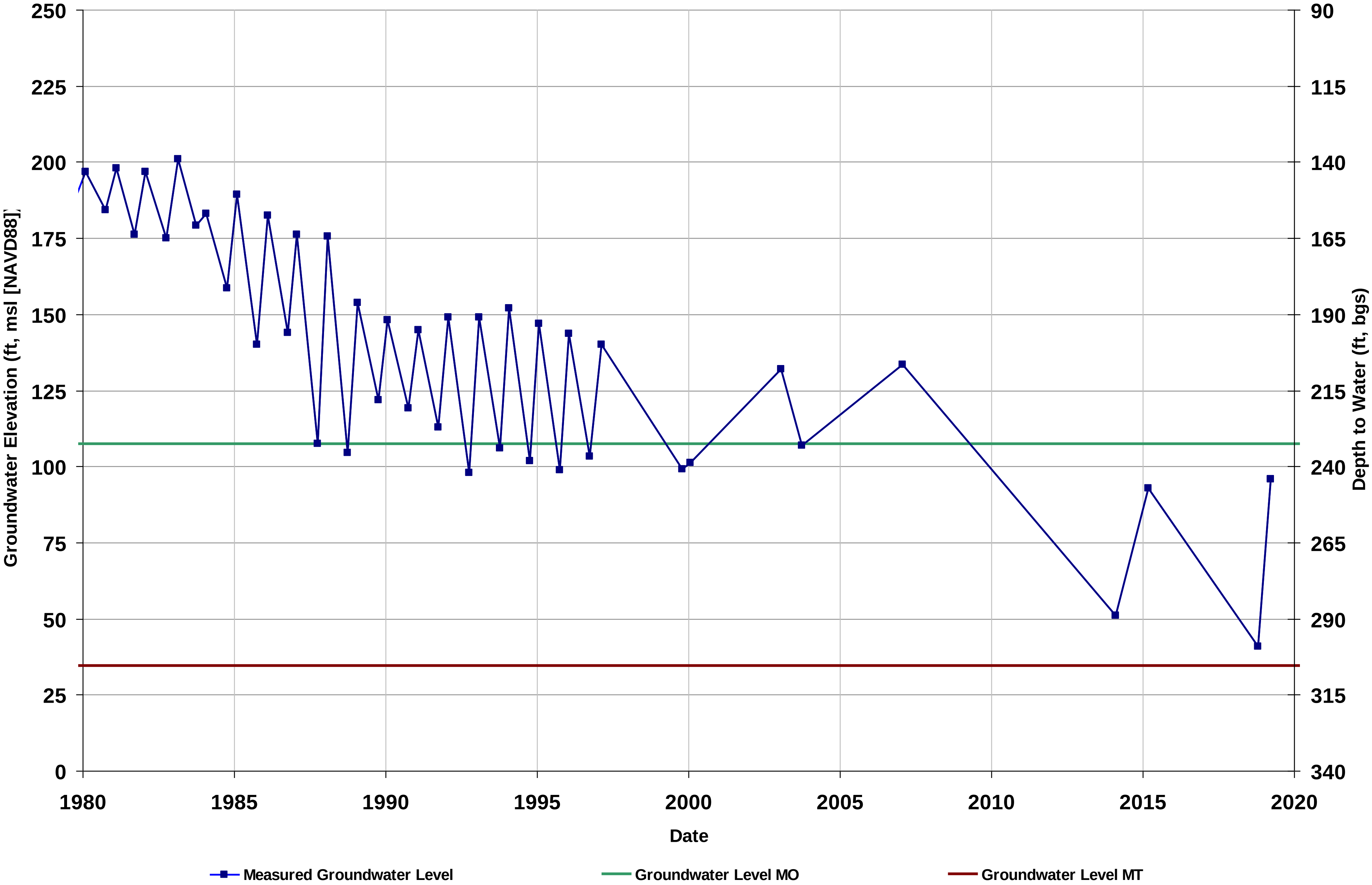
Well Name: MCE RMS-4
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 404



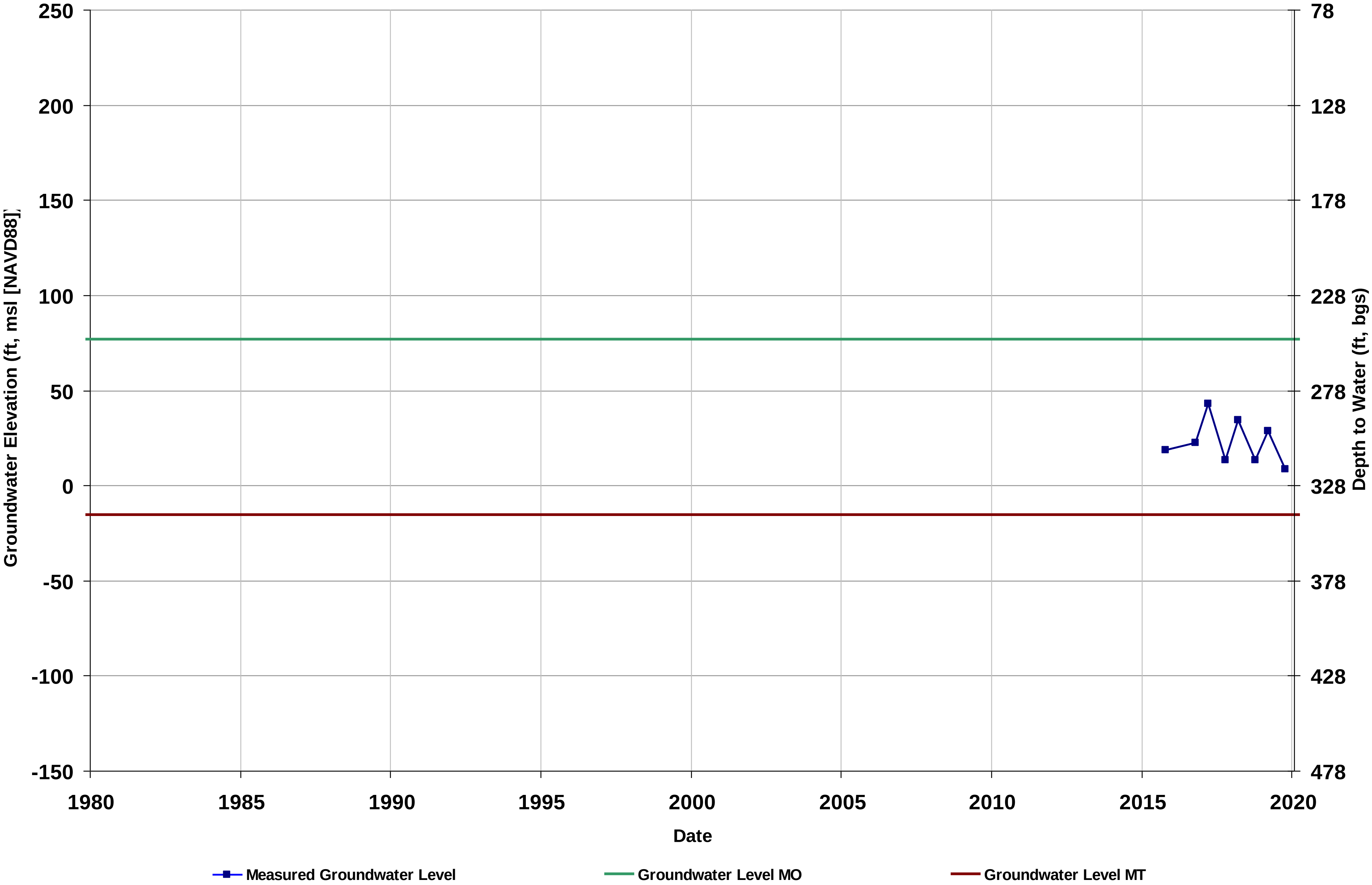
Well Name: MCE RMS-5
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 340



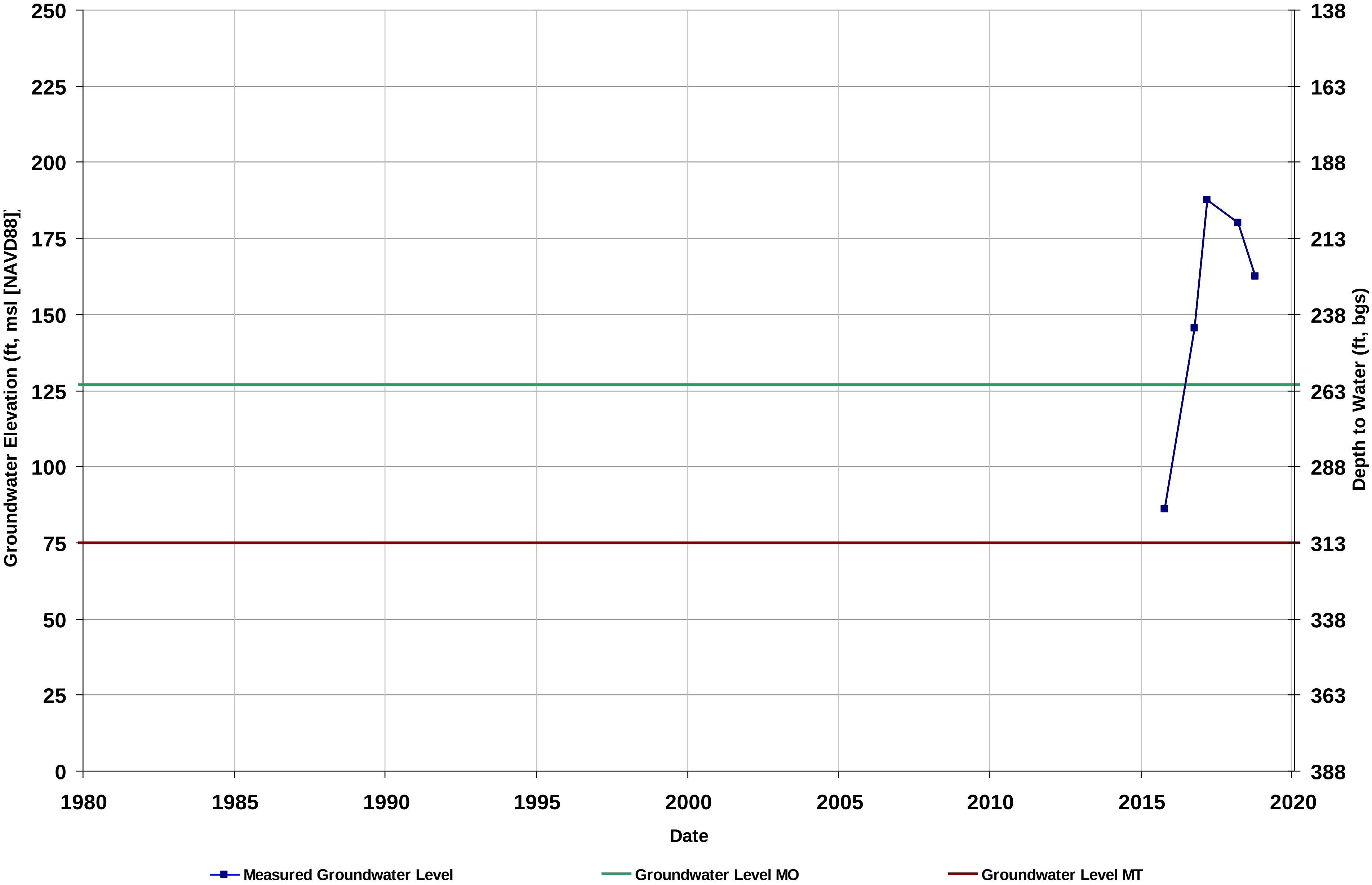
Well Name: MCE RMS-6
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft): 550
Perf Top (ft): 450
Perf Bottom (ft): 550
GSE (ft, msl): 328



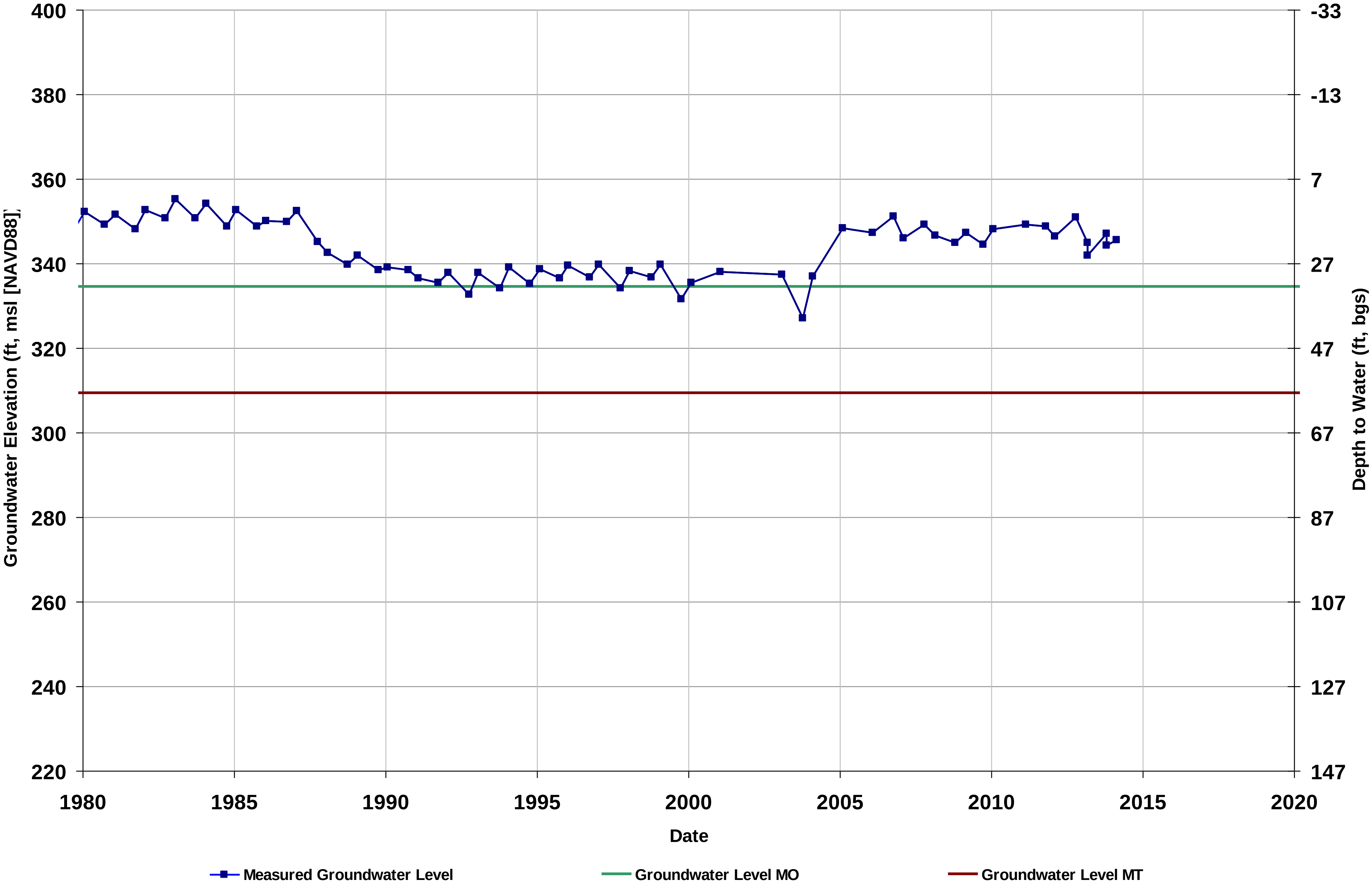
Well Name: MCE RMS-7
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft): 840
Perf Top (ft): 370
Perf Bottom (ft): 820
GSE (ft, msl): 388



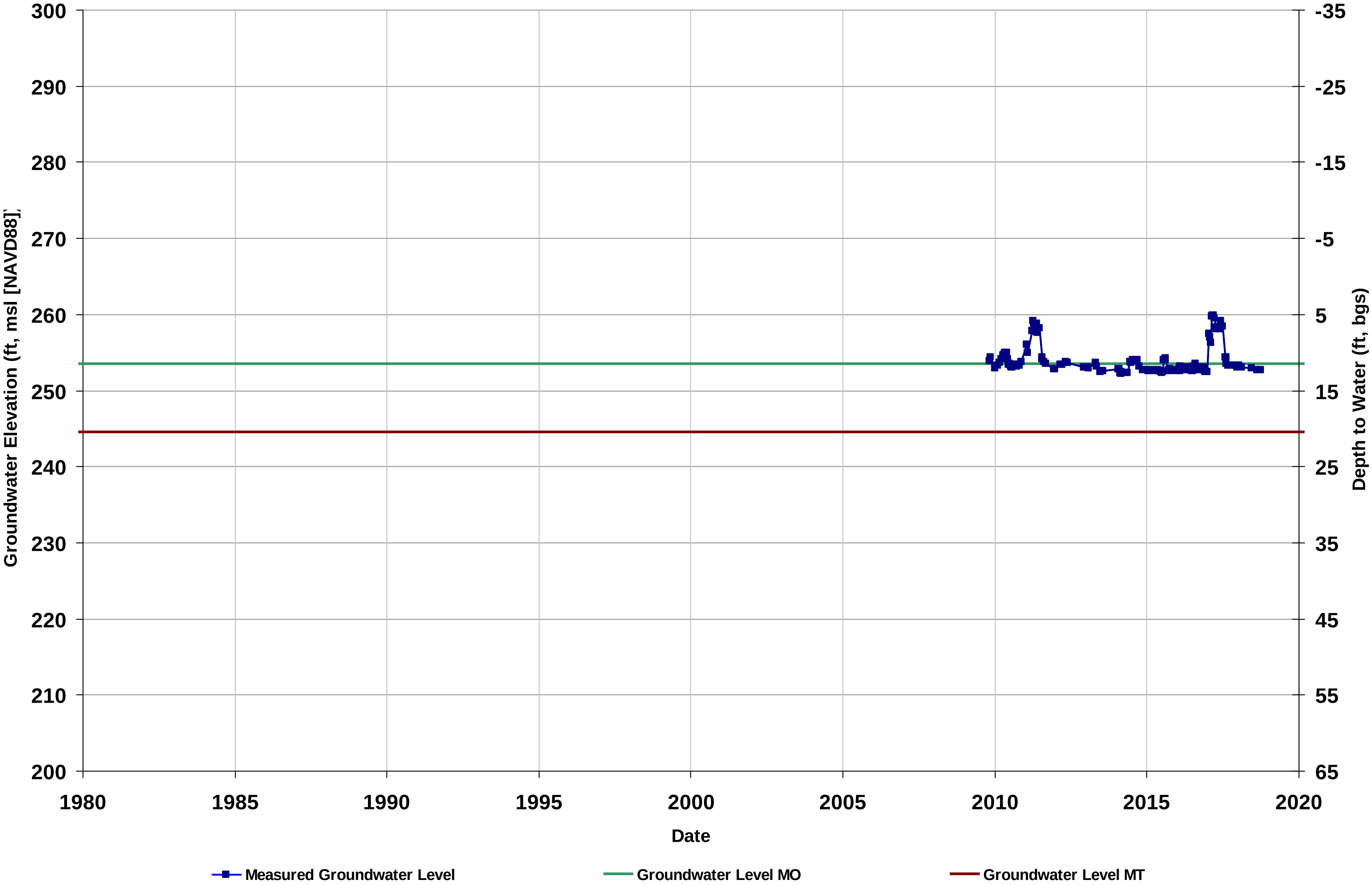
Well Name: MCE RMS-8
Depth Zone: Upper
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft): 92
Perf Top (ft): 32
Perf Bottom (ft): 92
GSE (ft, msl): 367



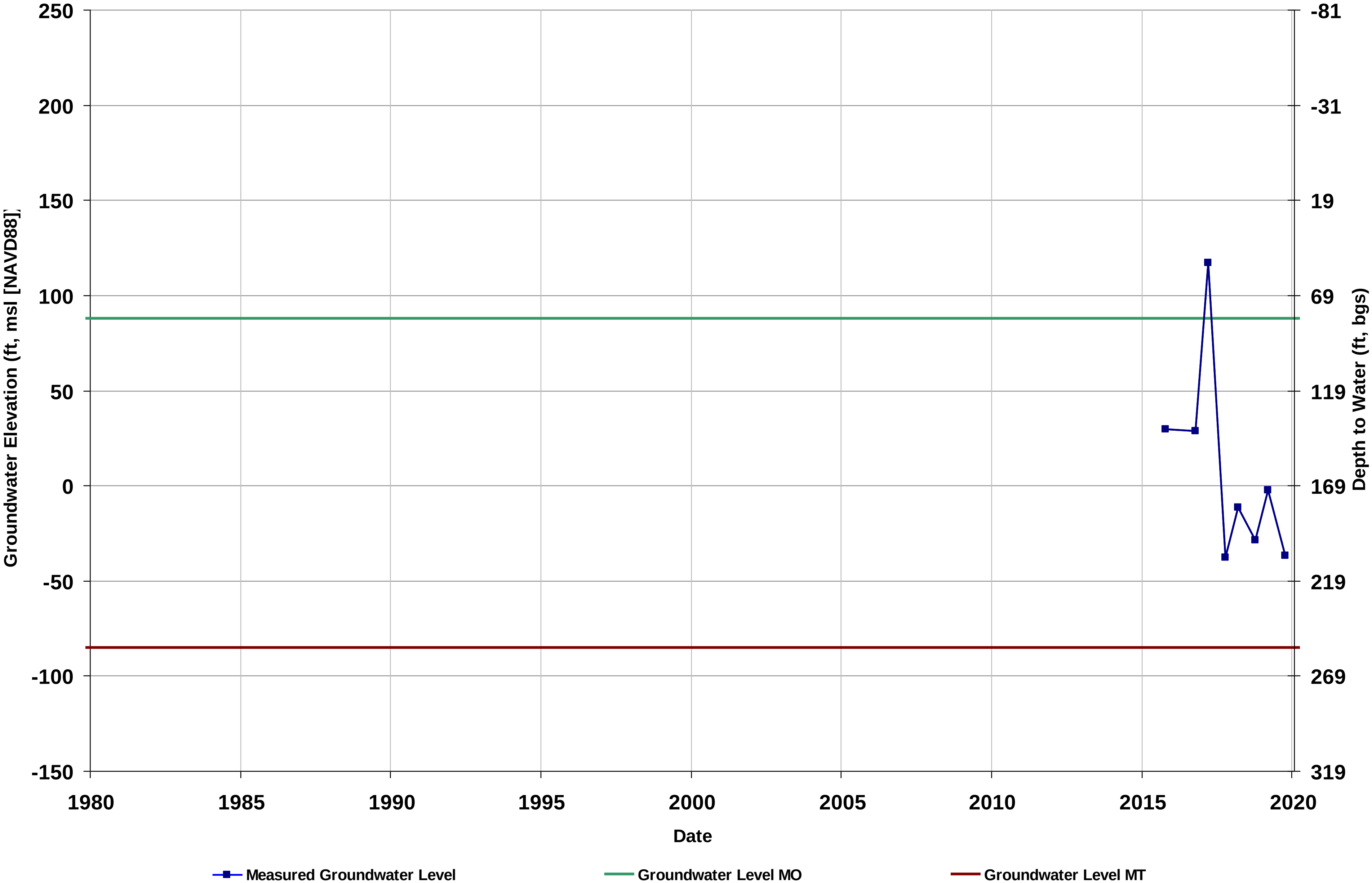
Well Name: MCE RMS-9
Depth Zone: Upper
Subbasin: Madera
GSA: Madera County - East

Total Depth (ft): 37
Perf Top (ft): 17
Perf Bottom (ft): 37
GSE (ft, msl): 265



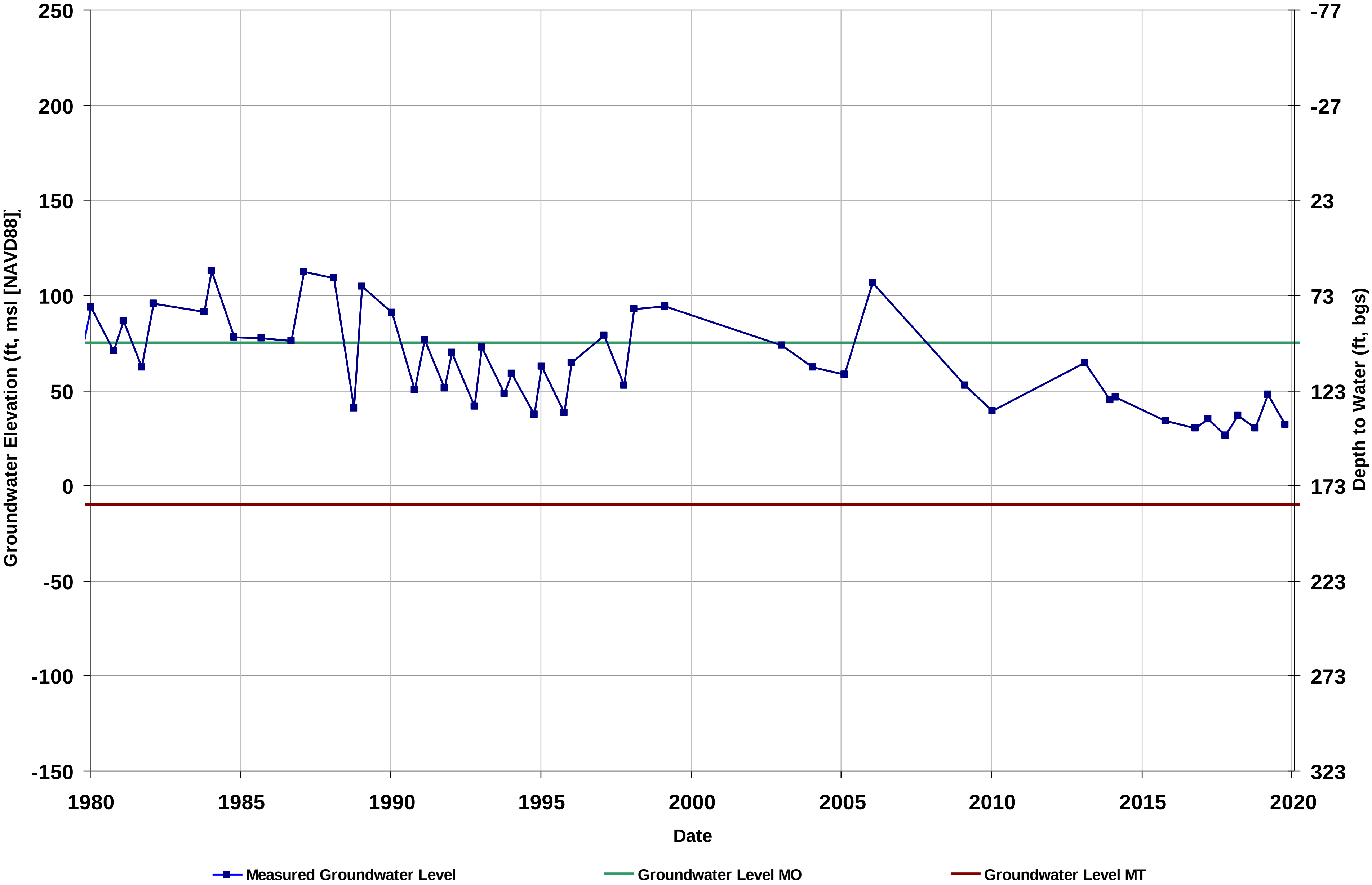
Well Name: MCW RMS-1
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - West

Total Depth (ft): 800
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 169



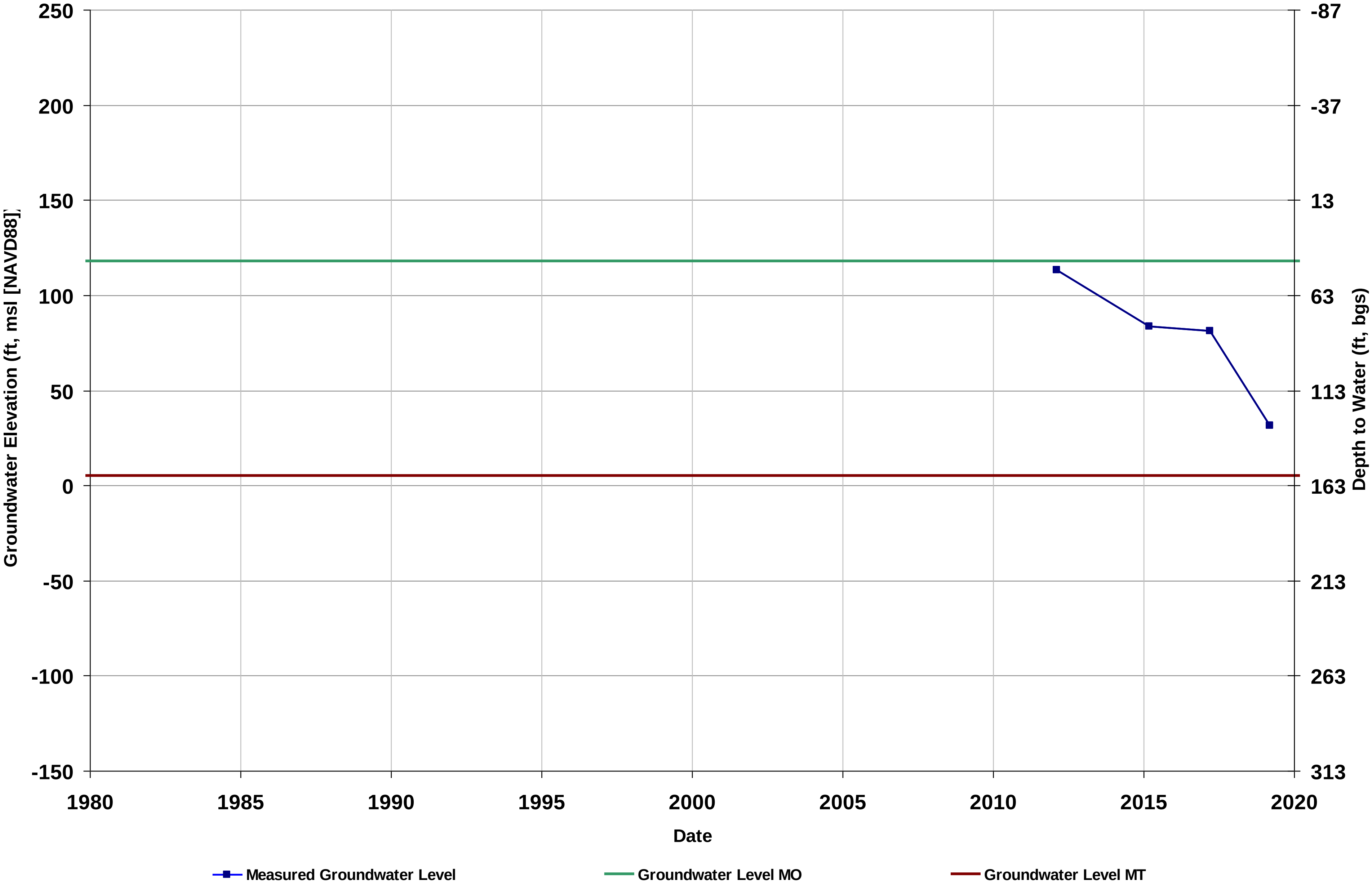
Well Name: MCW RMS-2
Depth Zone: Upper
Subbasin: Madera
GSA: Madera County - West

Total Depth (ft): 216
Perf Top (ft): 205
Perf Bottom (ft): 212
GSE (ft, msl): 173



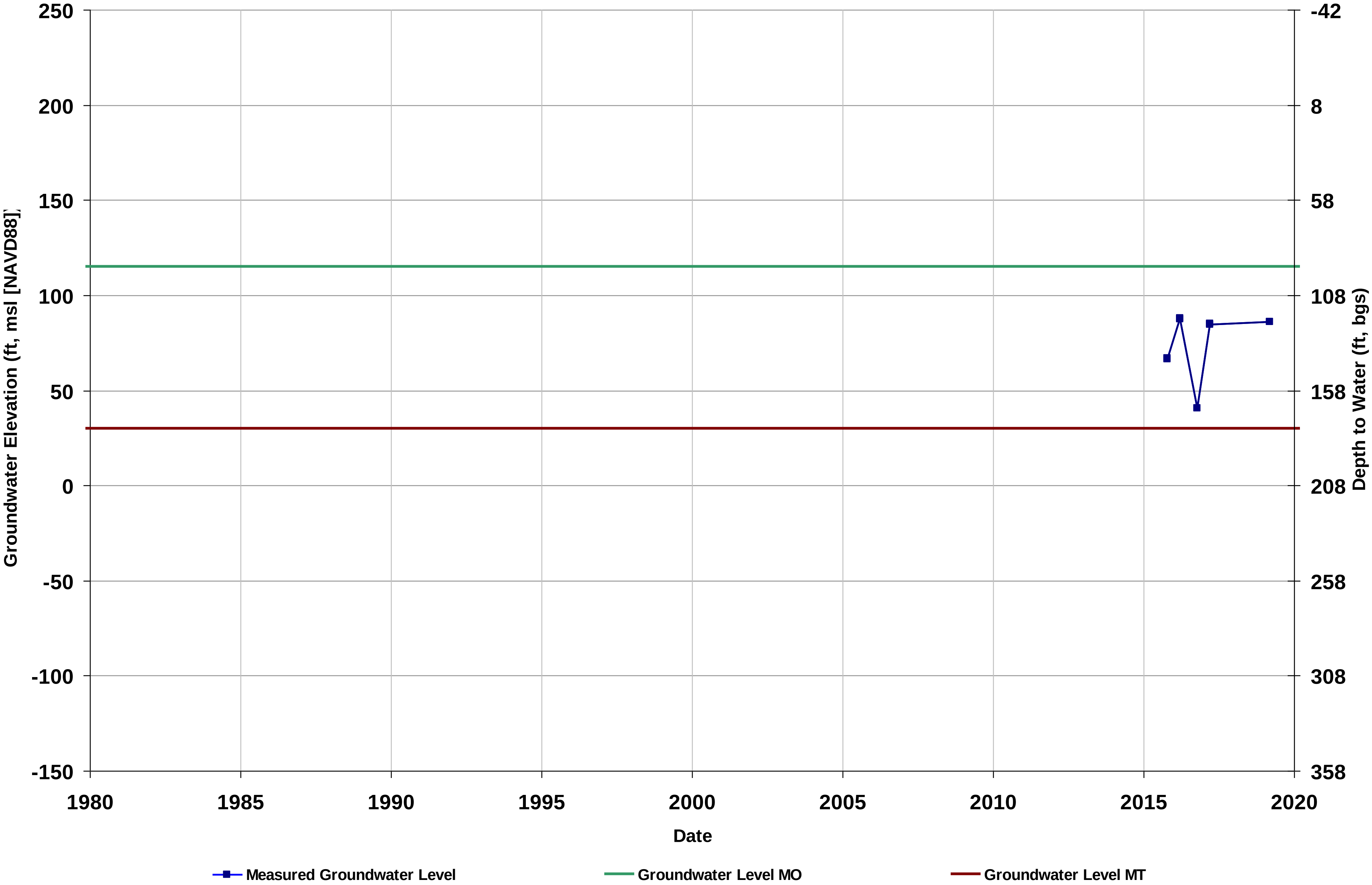
Well Name: MCW RMS-3
Depth Zone: Upper
Subbasin: Madera
GSA: Madera County - West

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 162



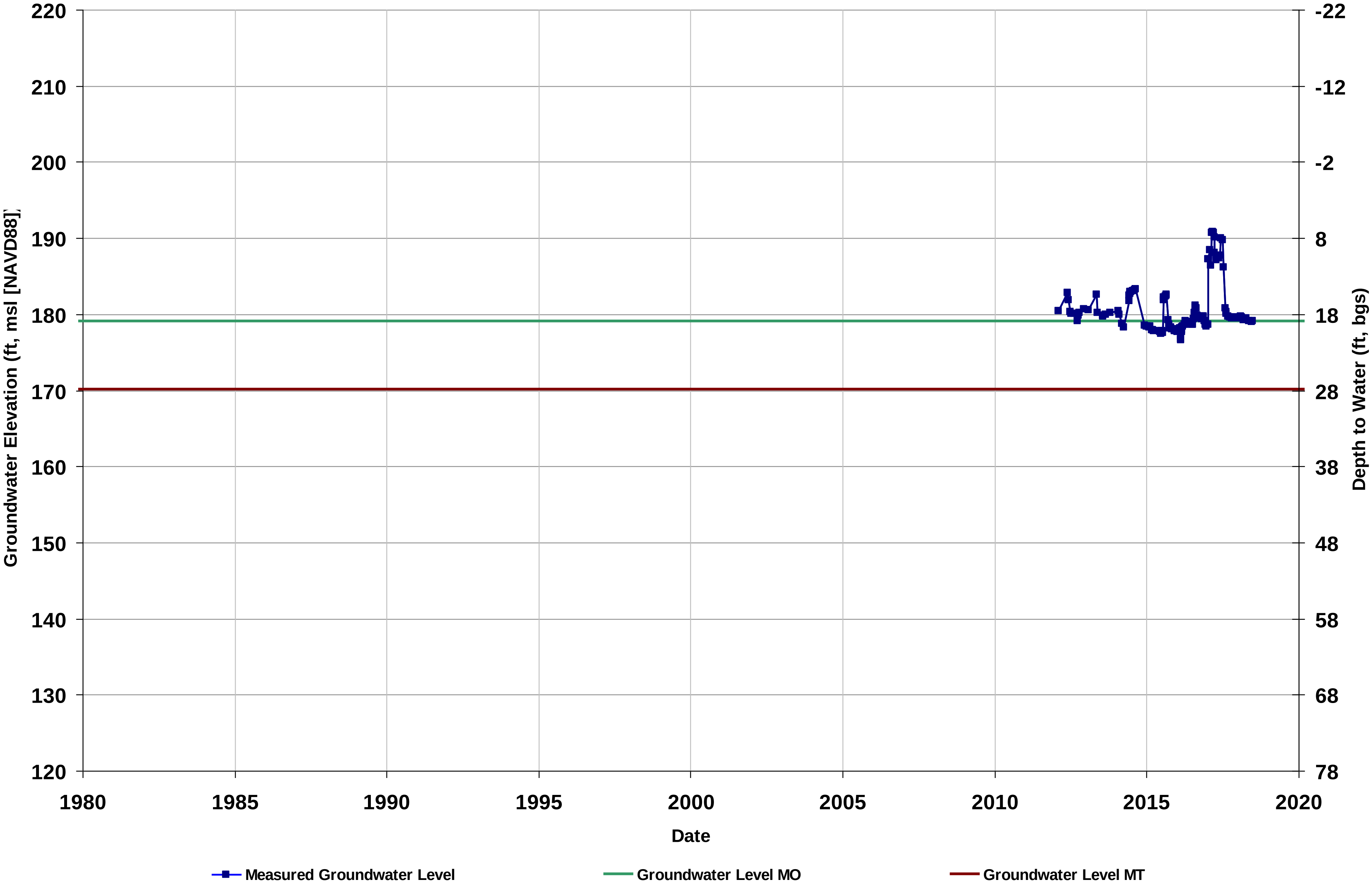
Well Name: MCW RMS-4
Depth Zone: Lower
Subbasin: Madera
GSA: Madera County - West

Total Depth (ft): 580
Perf Top (ft): 220
Perf Bottom (ft): 580
GSE (ft, msl): 208



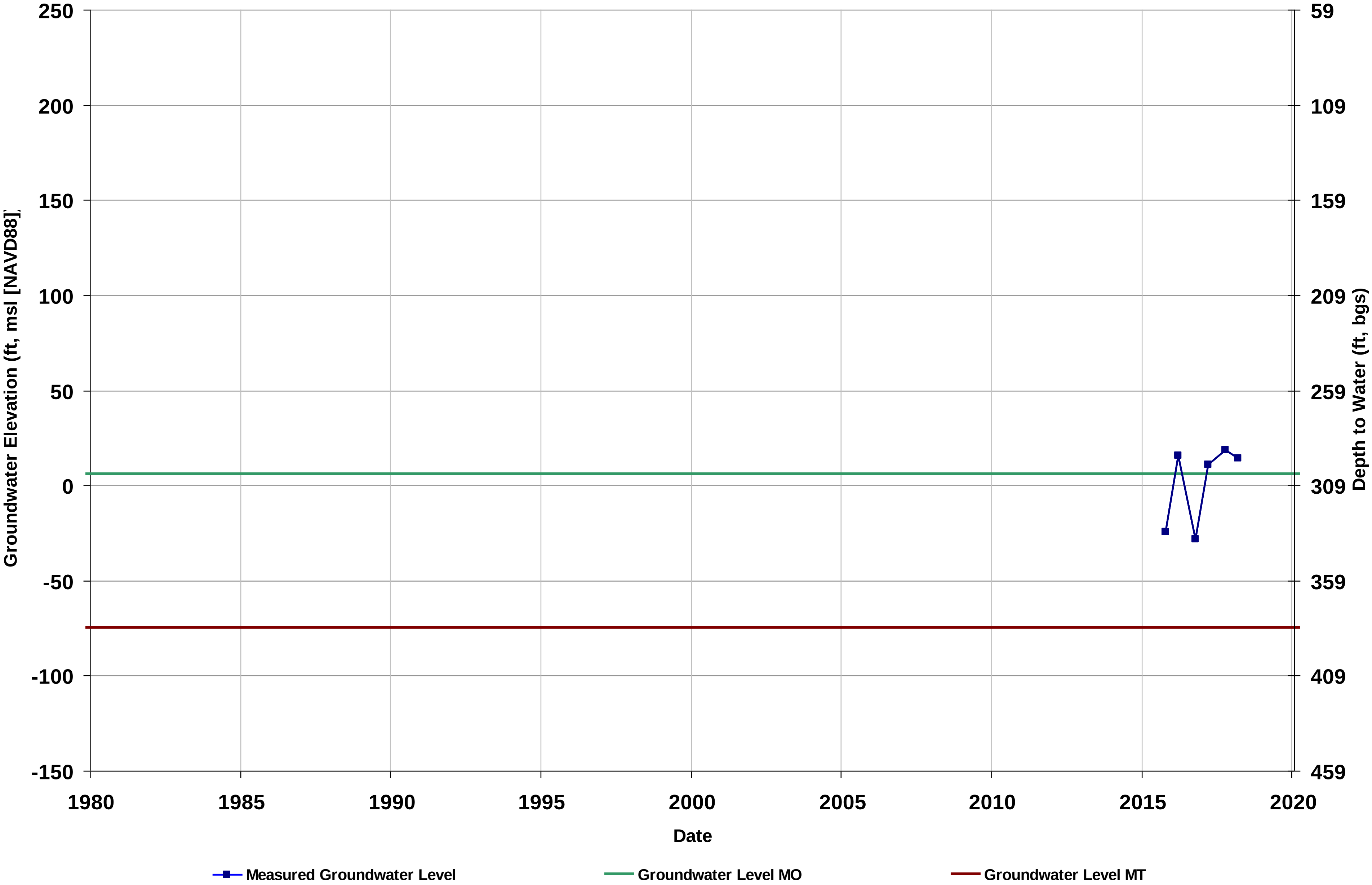
Well Name: MCW RMS-5
Depth Zone: Upper
Subbasin: Madera
GSA: Madera County - West

Total Depth (ft): 30
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 197



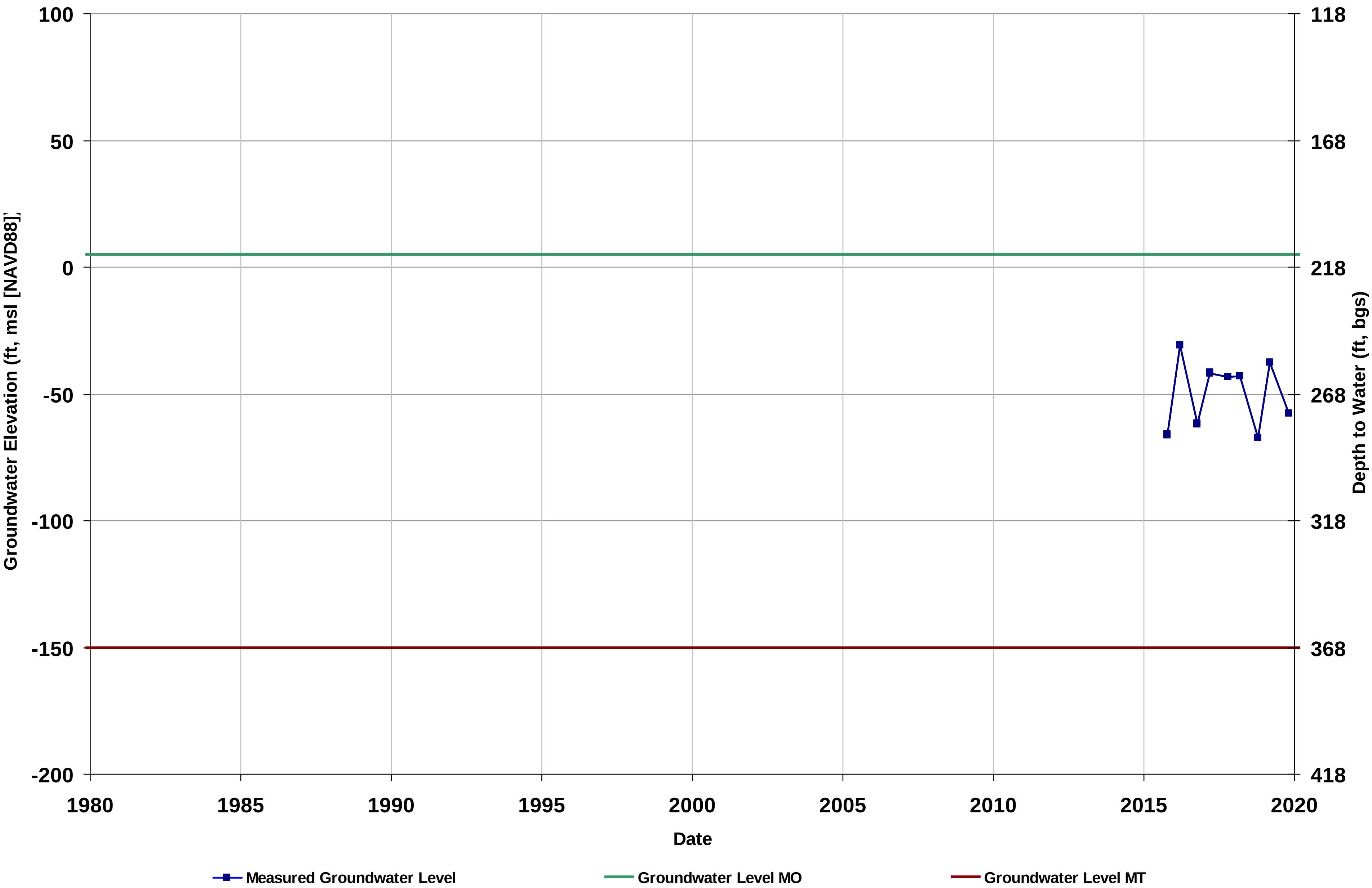
Well Name: MID RMS-1
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 950
Perf Top (ft): 320
Perf Bottom (ft): 942
GSE (ft, msl): 308



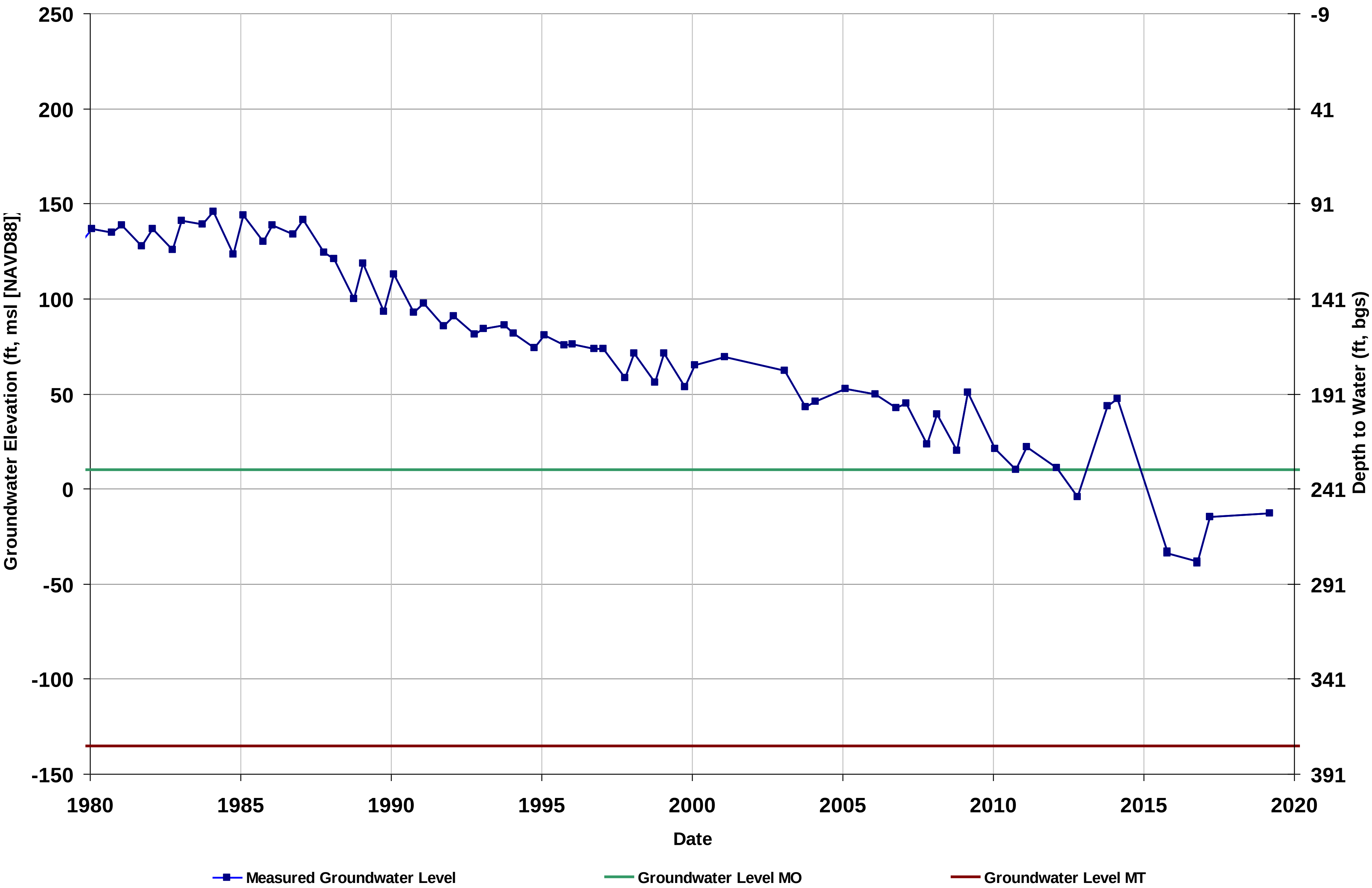
Well Name: MID RMS-2
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 563
Perf Top (ft): 298
Perf Bottom (ft): 509
GSE (ft, msl): 218



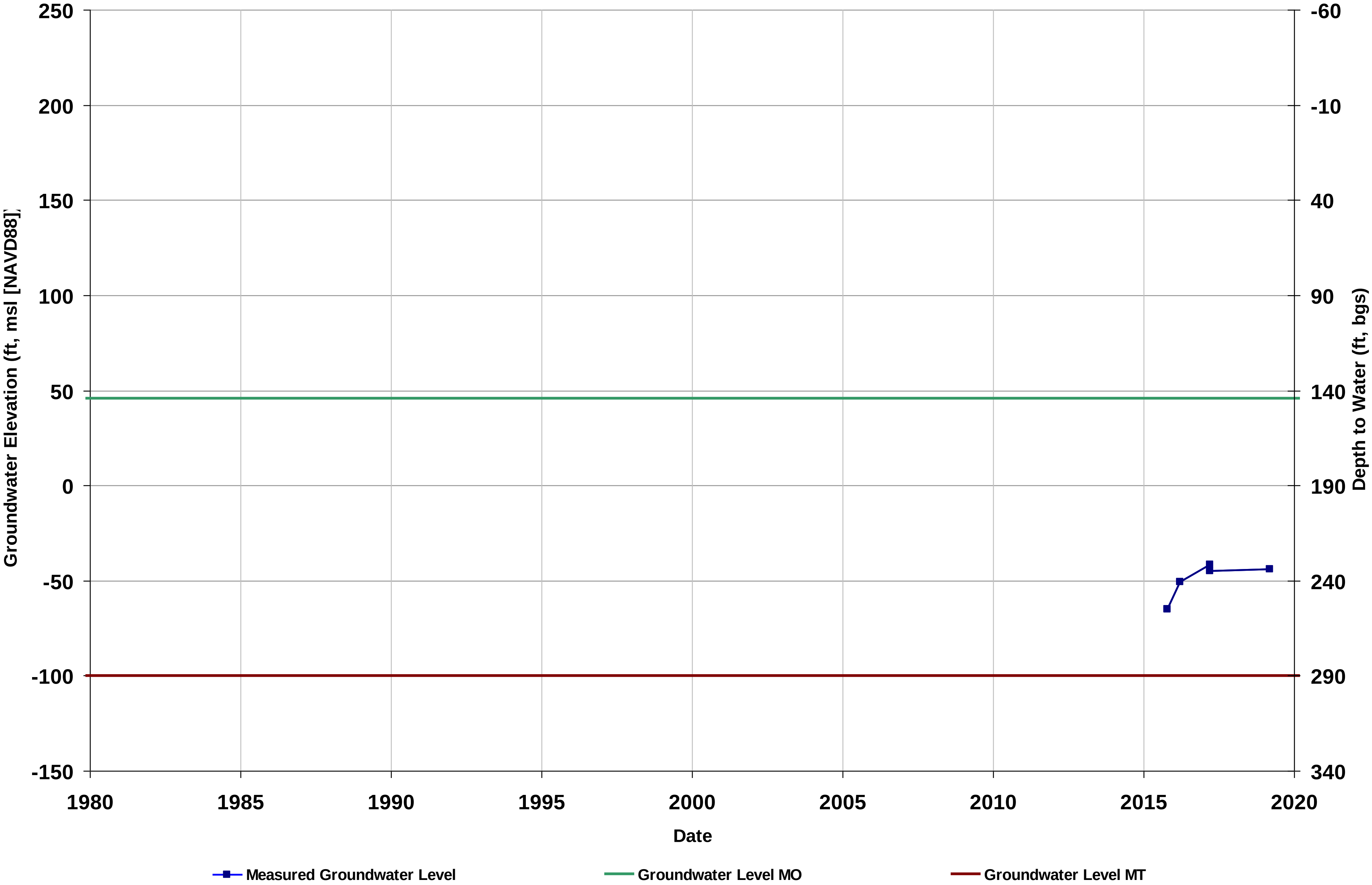
Well Name: MID RMS-3
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 516
Perf Top (ft): 260
Perf Bottom (ft): 507
GSE (ft, msl): 241



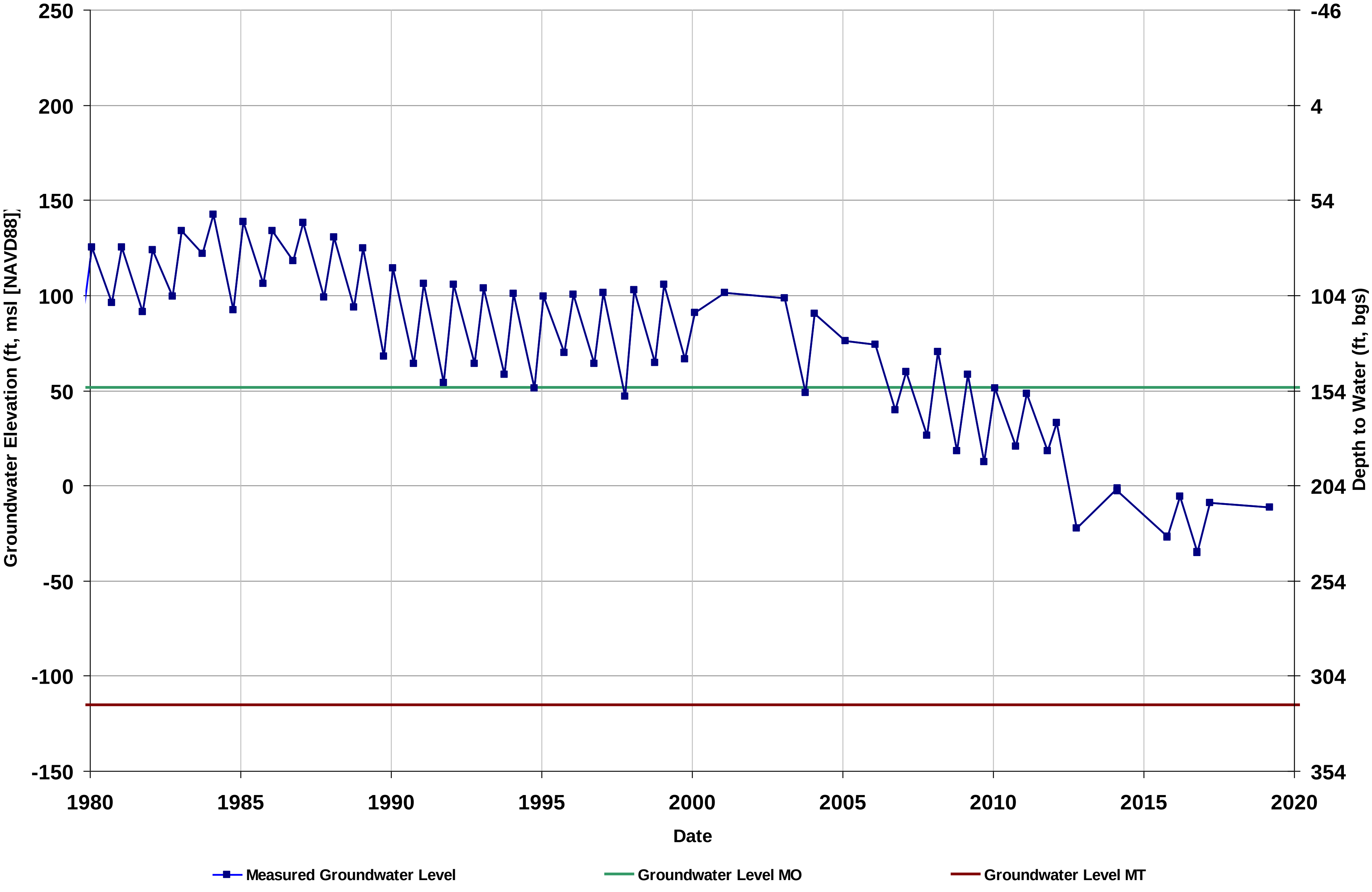
Well Name: MID RMS-4
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 698
Perf Top (ft): 320
Perf Bottom (ft): 667
GSE (ft, msl): 190



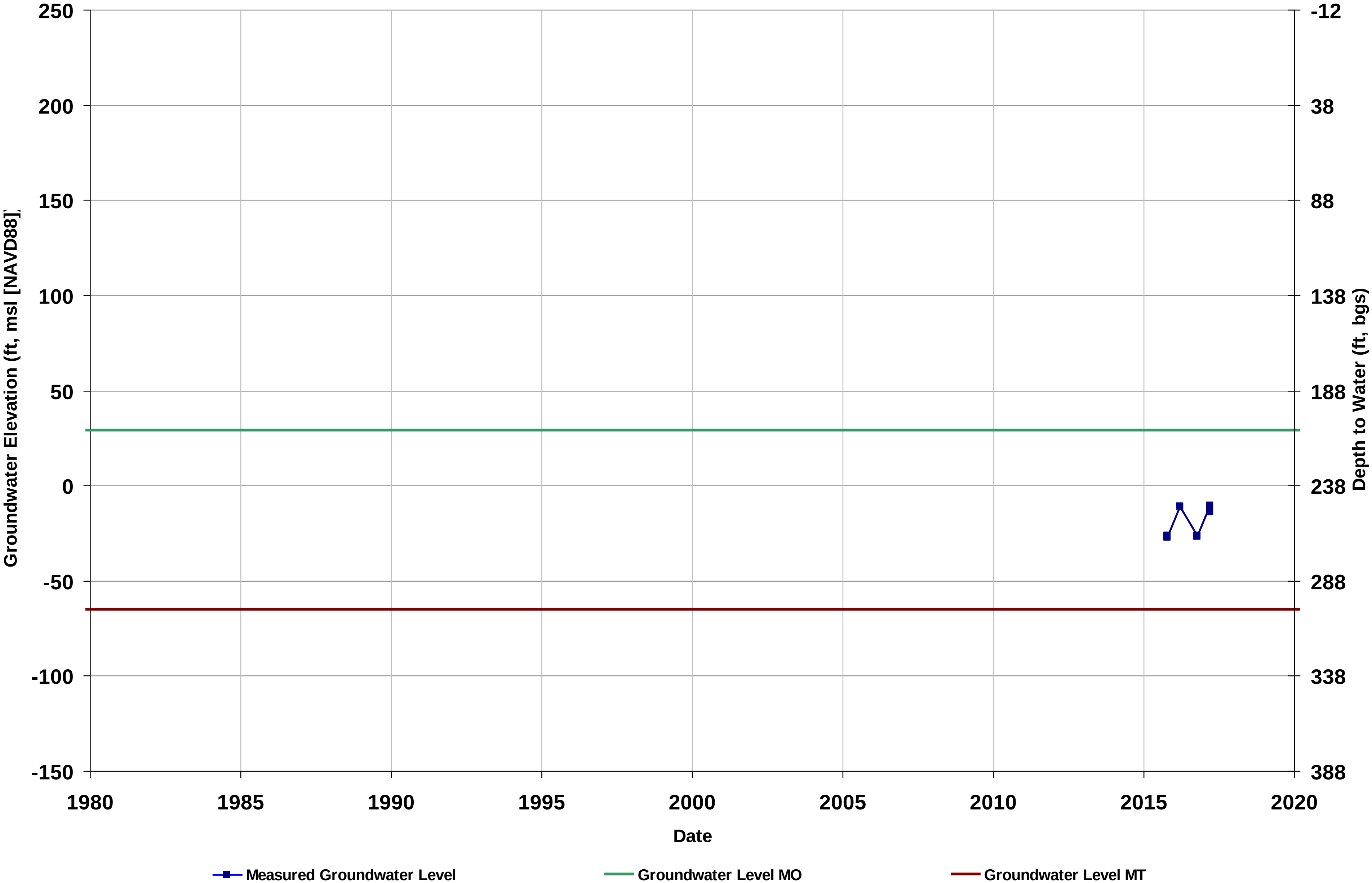
Well Name: MID RMS-5
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 570
Perf Top (ft): 270
Perf Bottom (ft): 570
GSE (ft, msl): 204



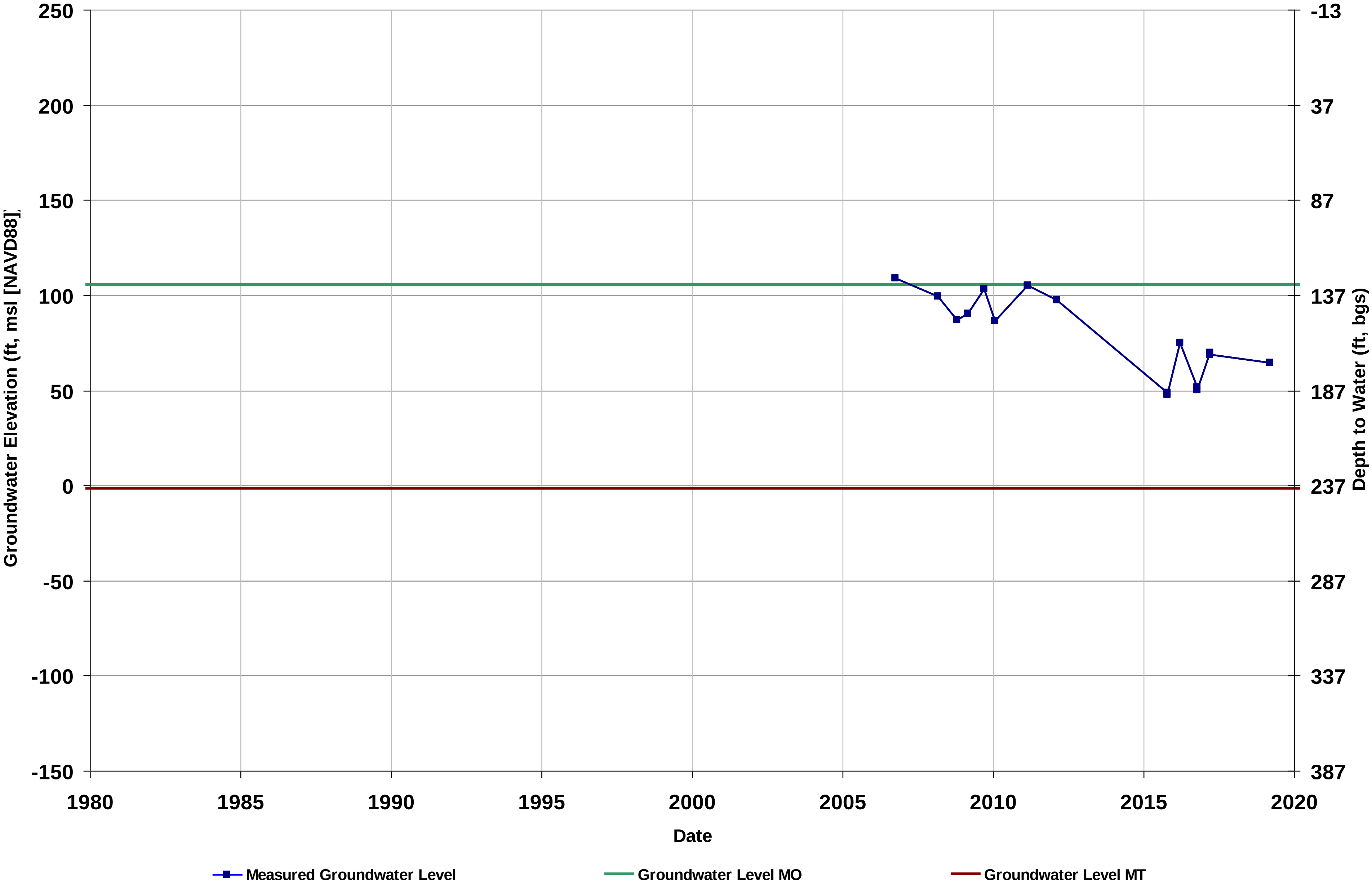
Well Name: MID RMS-6
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 680
Perf Top (ft): 320
Perf Bottom (ft): 680
GSE (ft, msl): 237



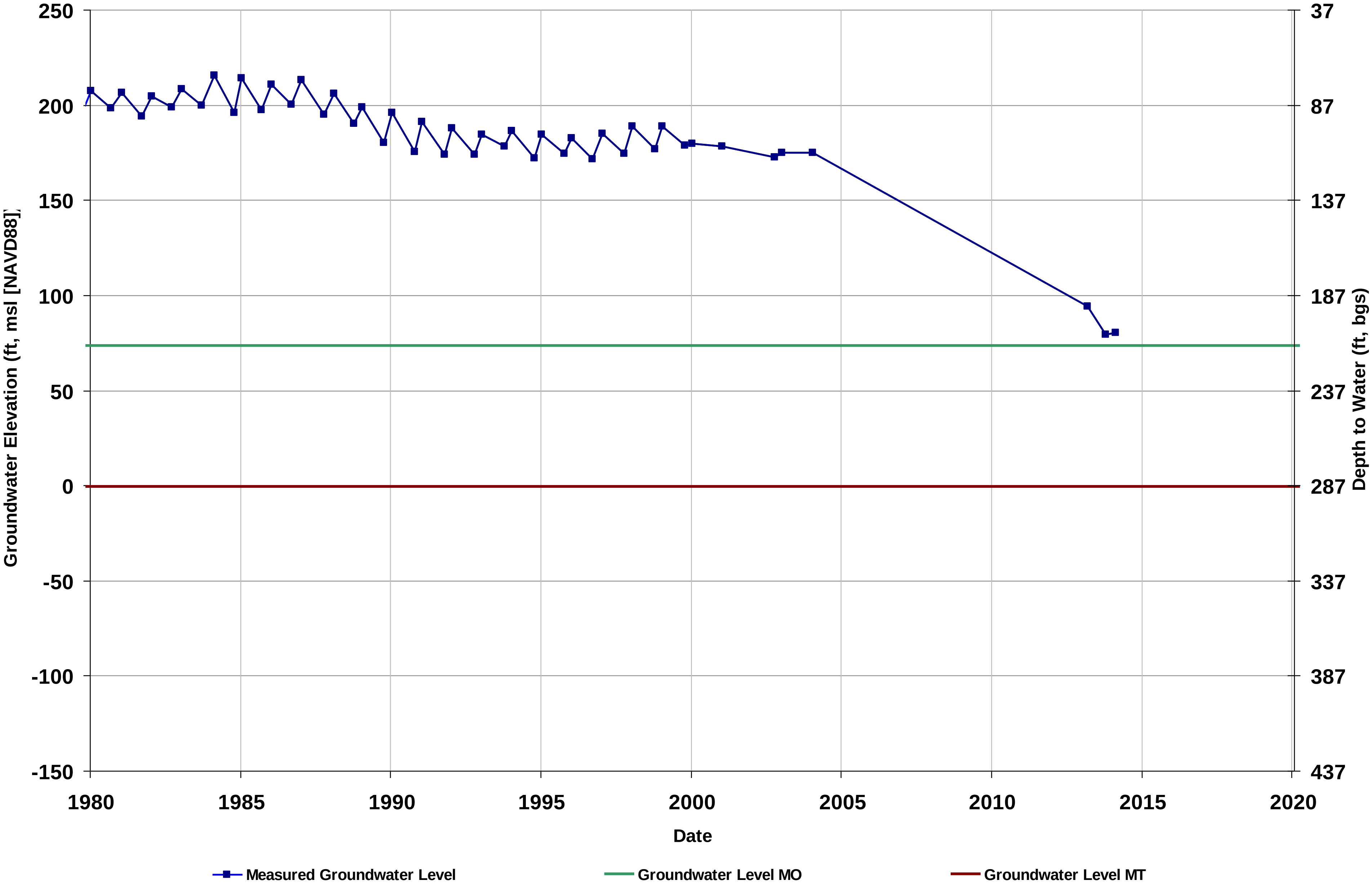
Well Name: MID RMS-7
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 656
Perf Top (ft): 290
Perf Bottom (ft): 635
GSE (ft, msl): 237



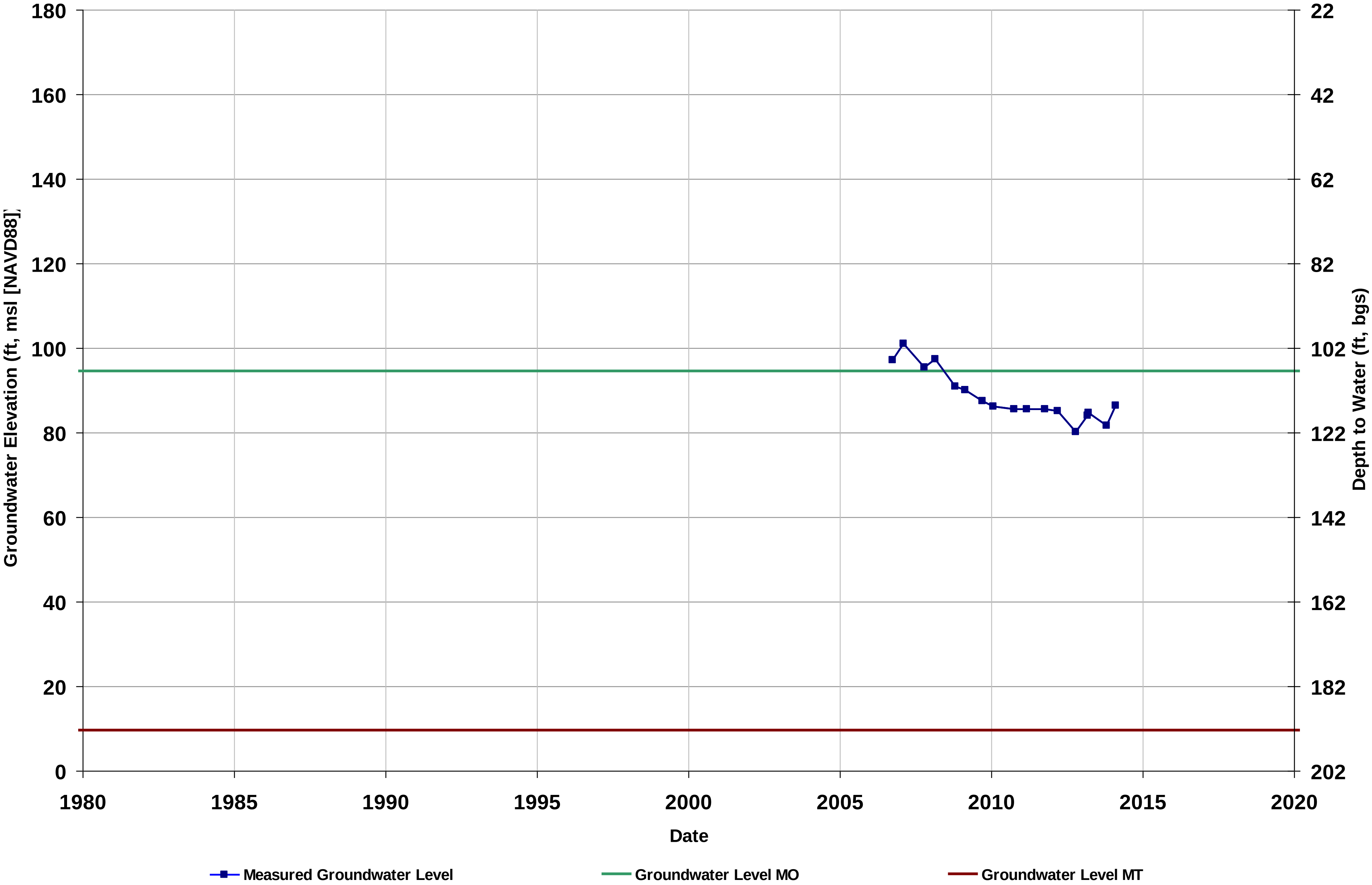
Well Name: MID RMS-8
Depth Zone: Composite
Subbasin: Madera
GSA: Madera ID

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 287



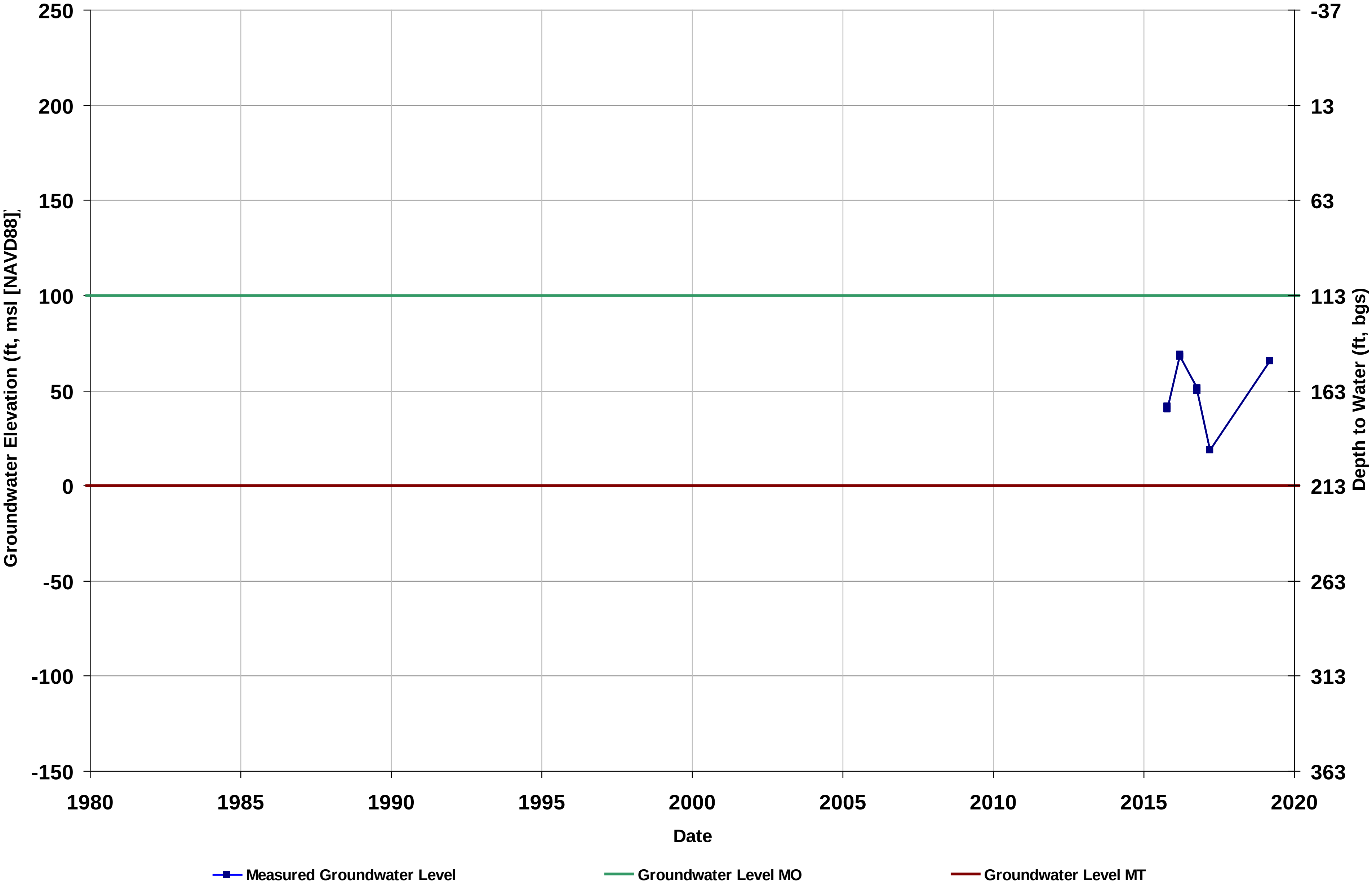
Well Name: MID RMS-9
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 144
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 202



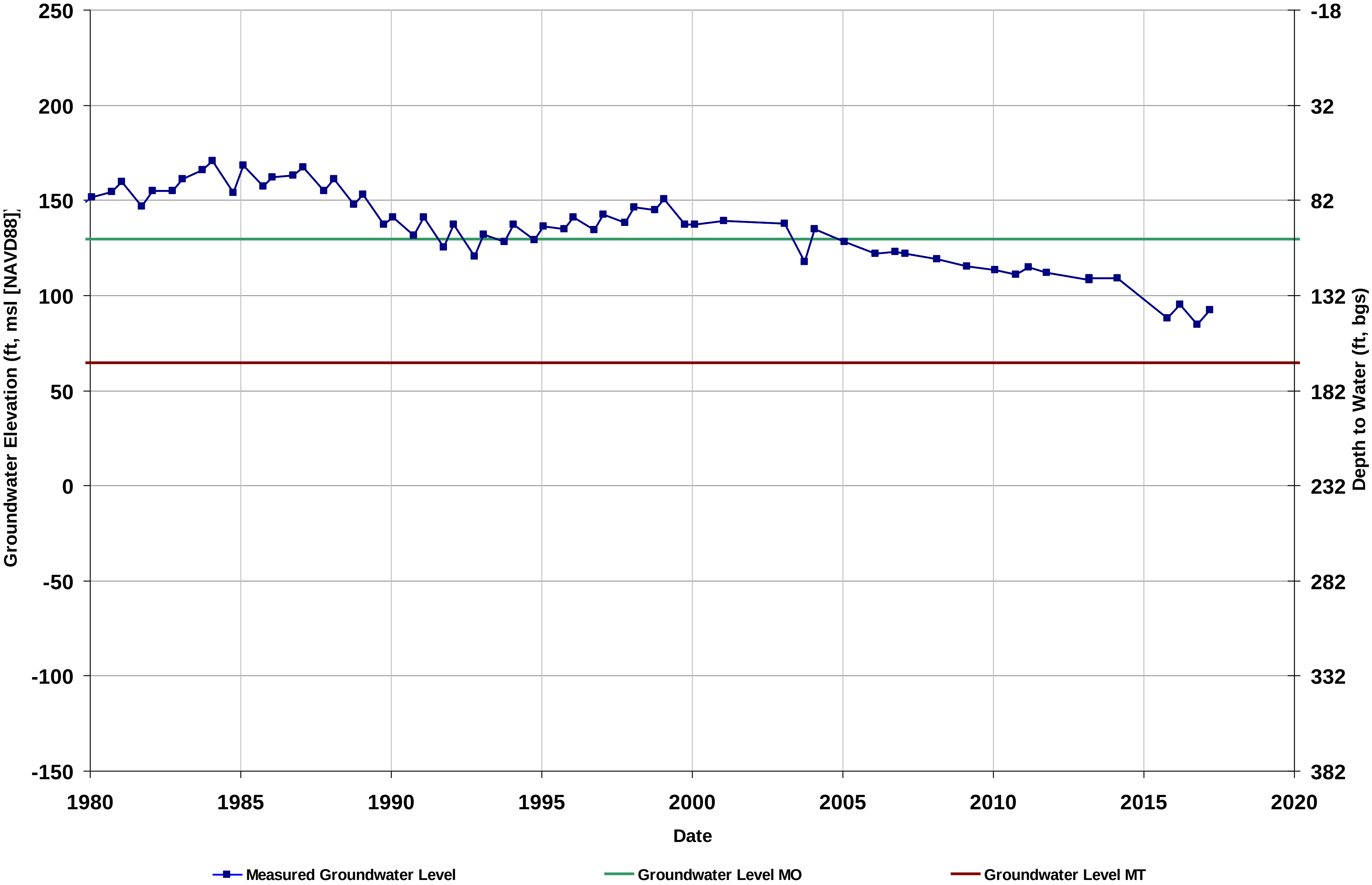
Well Name: MID RMS-10
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 615
Perf Top (ft): 315
Perf Bottom (ft): 615
GSE (ft, msl): 213



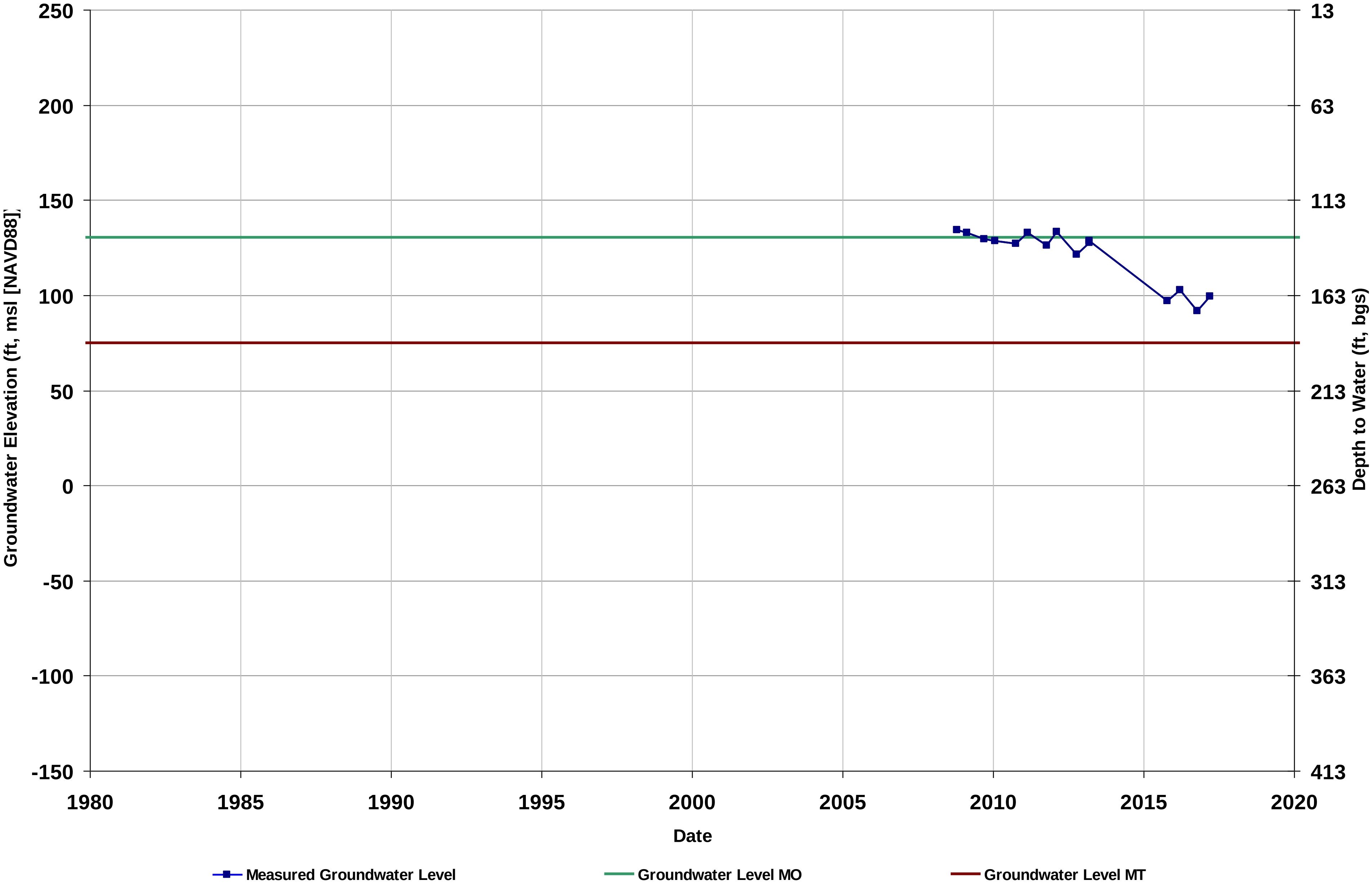
Well Name: MID RMS-11
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 232



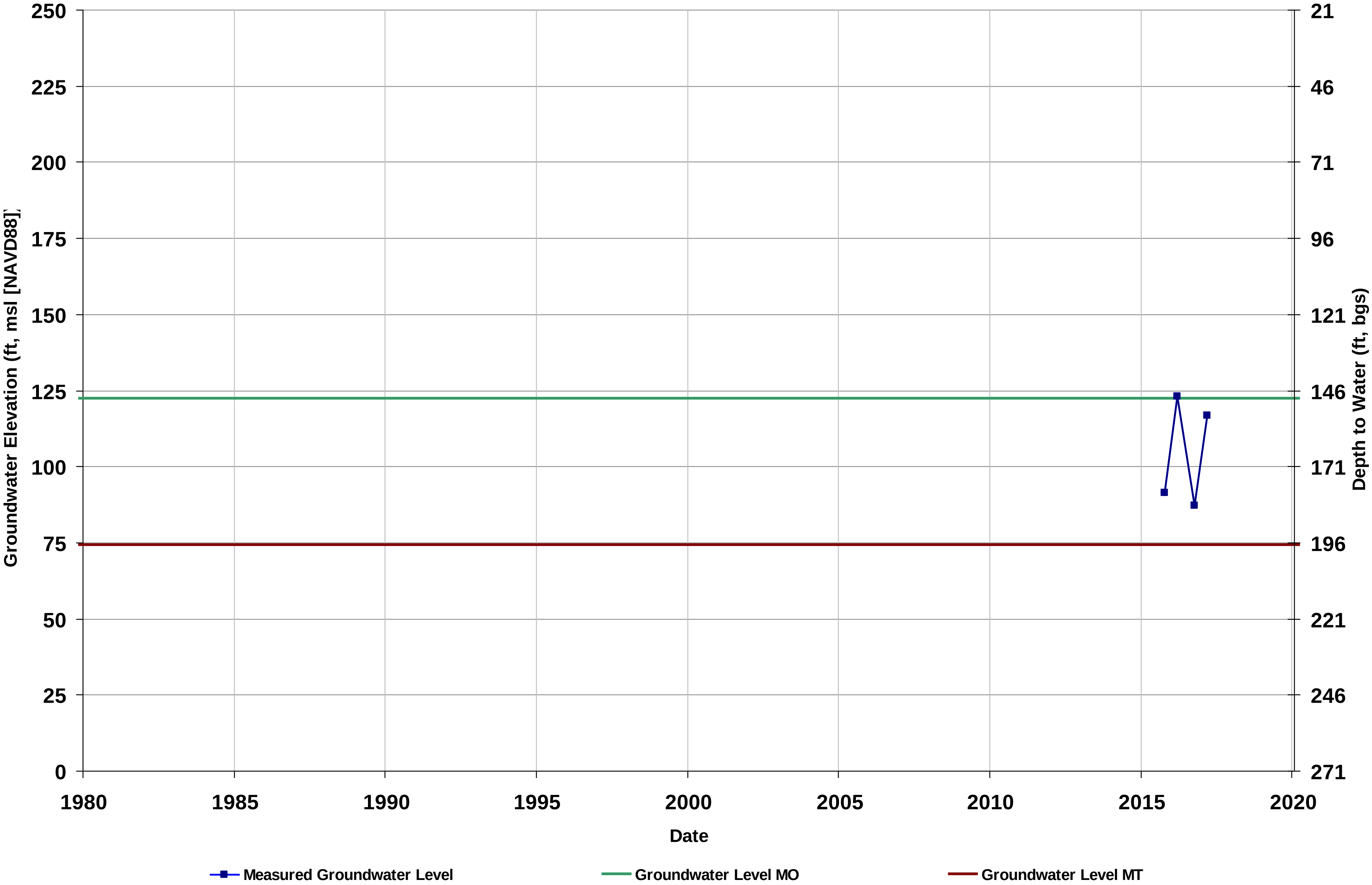
Well Name: MID RMS-12
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 176
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 262



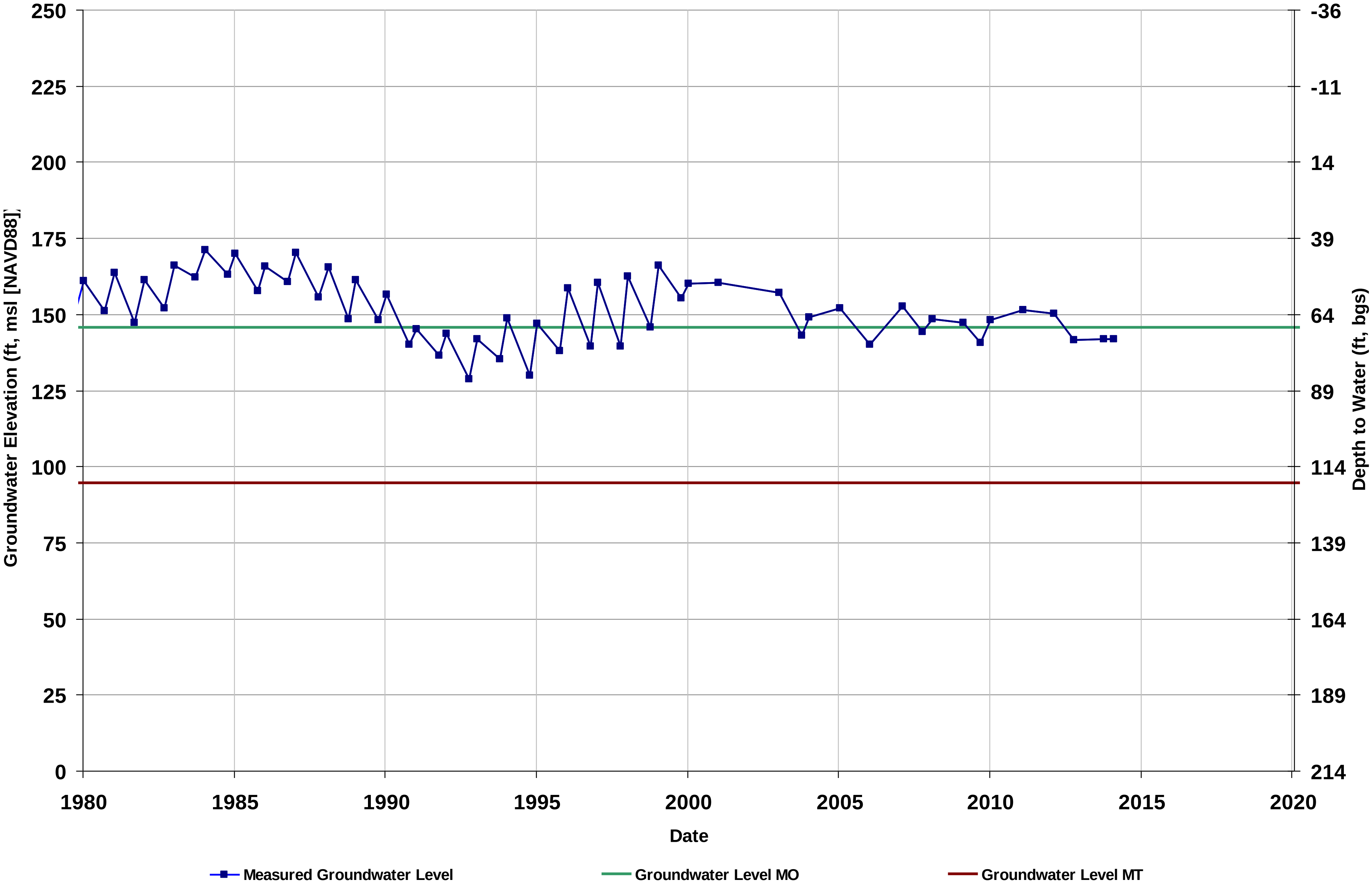
Well Name: MID RMS-13
Depth Zone: Composite
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 600
Perf Top (ft): 228
Perf Bottom (ft): 552
GSE (ft, msl): 271



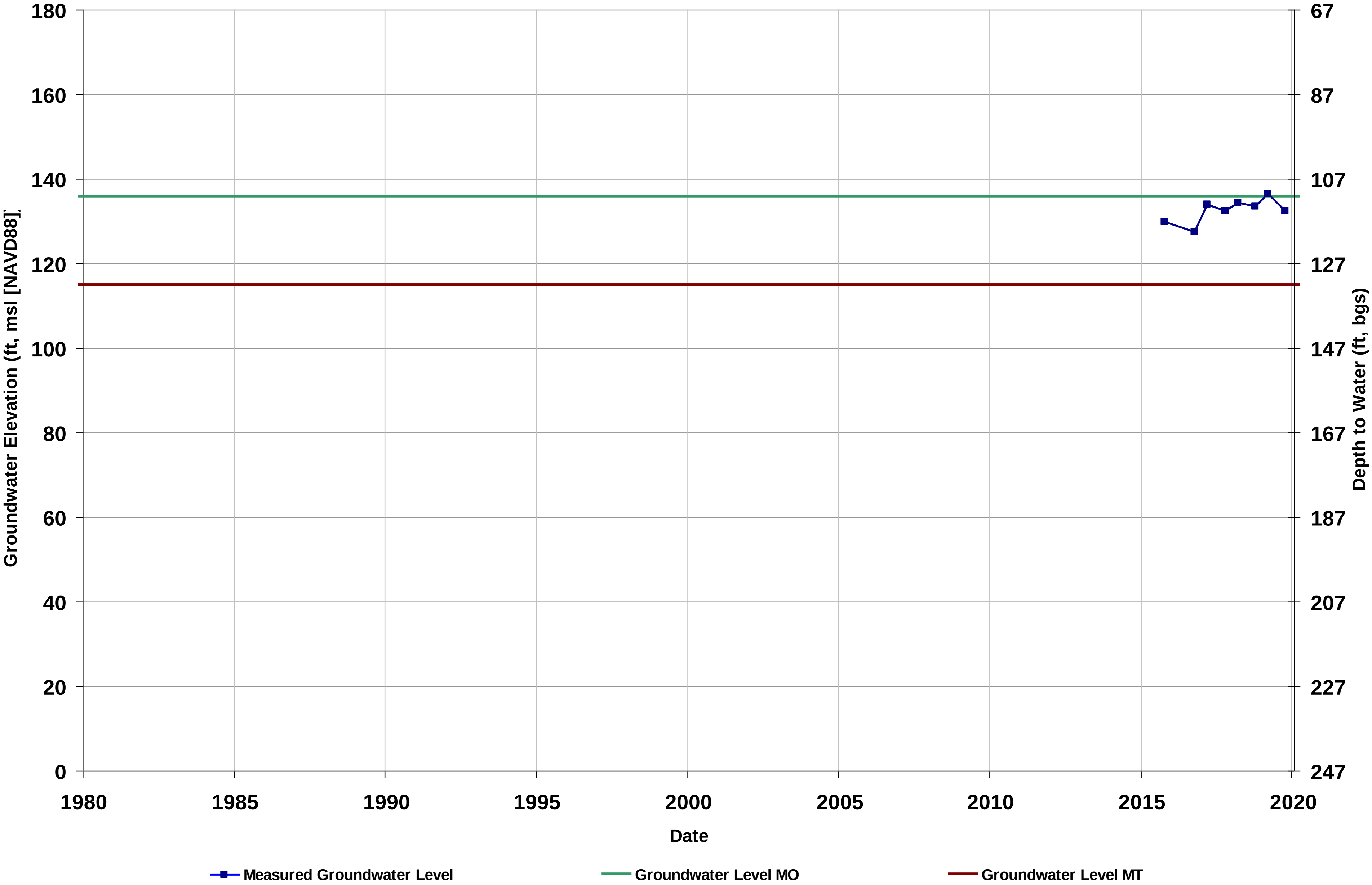
Well Name: MID RMS-14
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft):
Perf Top (ft):
Perf Bottom (ft):
GSE (ft, msl): 214



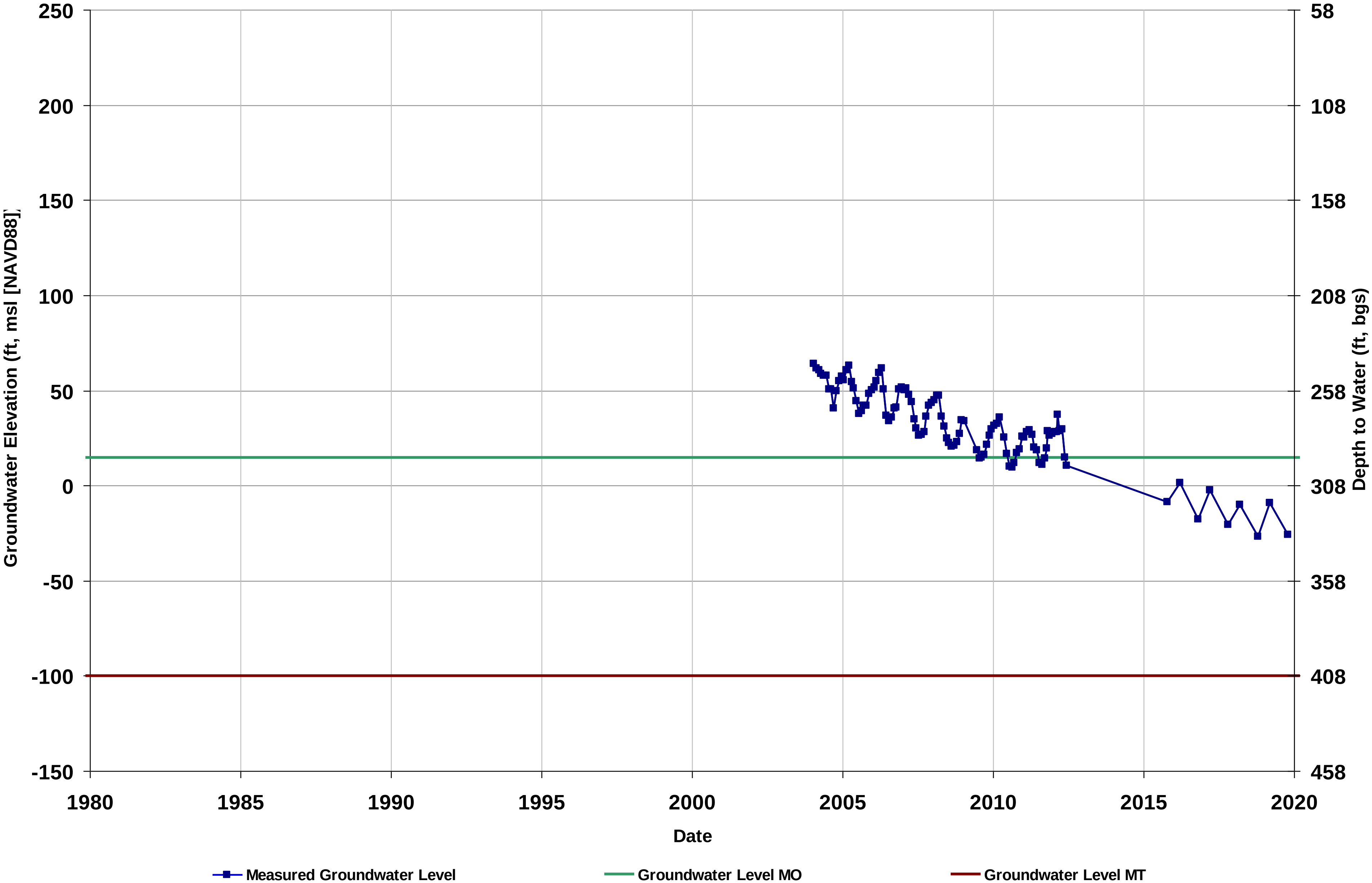
Well Name: MID RMS-15
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 502
Perf Top (ft): 160
Perf Bottom (ft): 200
GSE (ft, msl): 247



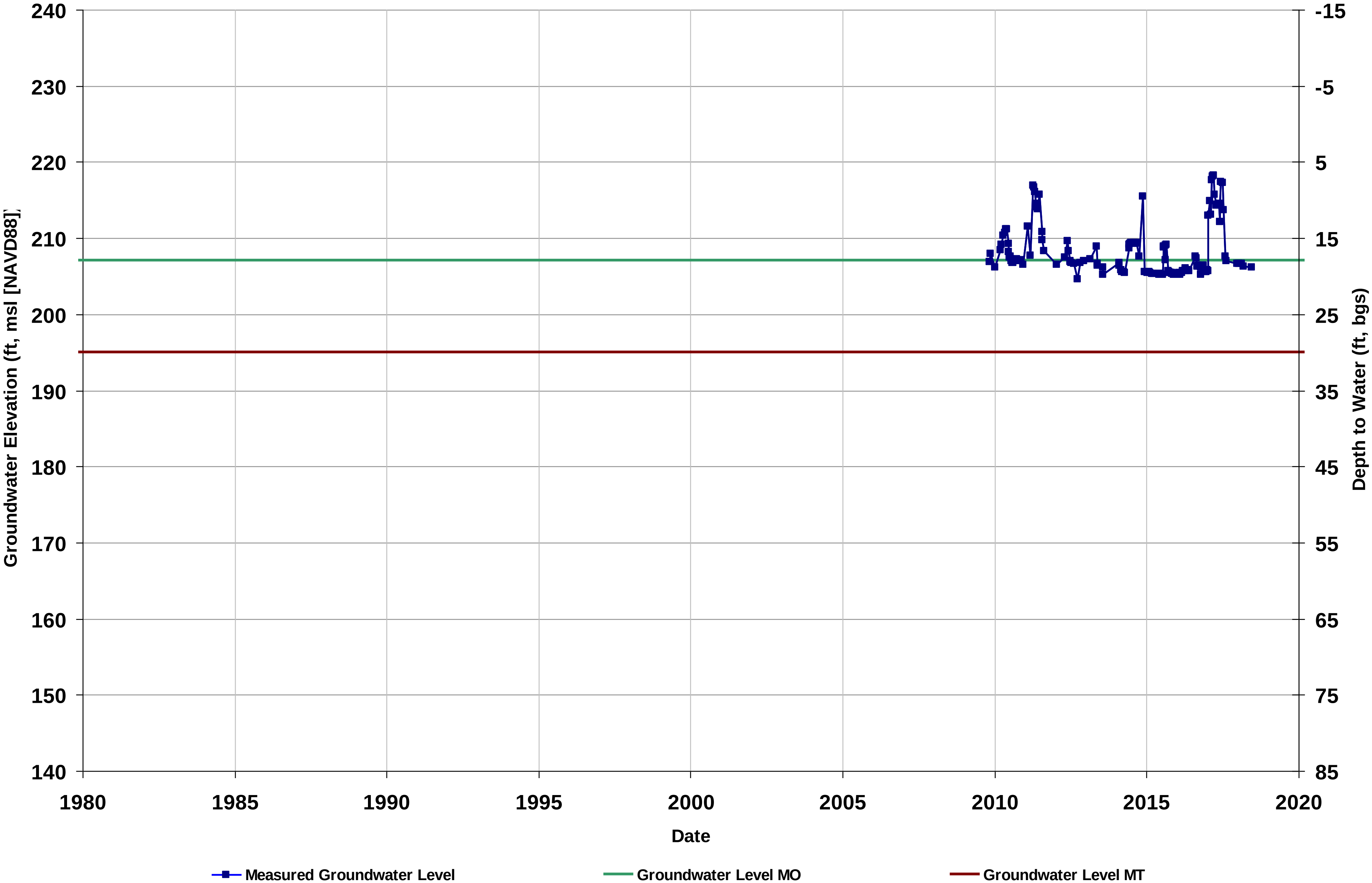
Well Name: MID RMS-16
Depth Zone: Lower
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 452
Perf Top (ft): 348
Perf Bottom (ft): 388
GSE (ft, msl): 308



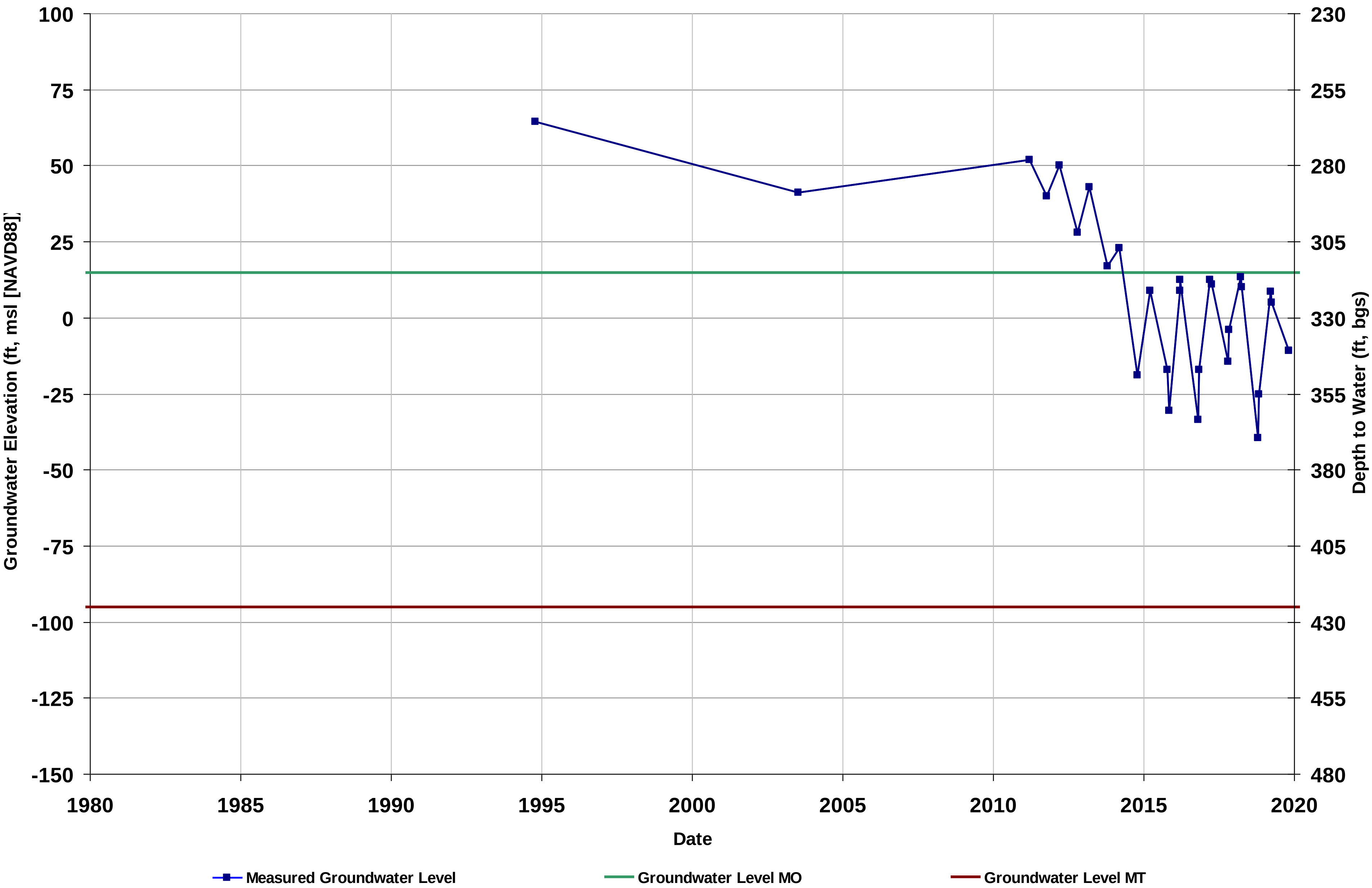
Well Name: MID RMS-17
Depth Zone: Upper
Subbasin: Madera
GSA: Madera ID

Total Depth (ft): 47
Perf Top (ft): 26.5
Perf Bottom (ft): 46.5
GSE (ft, msl): 224



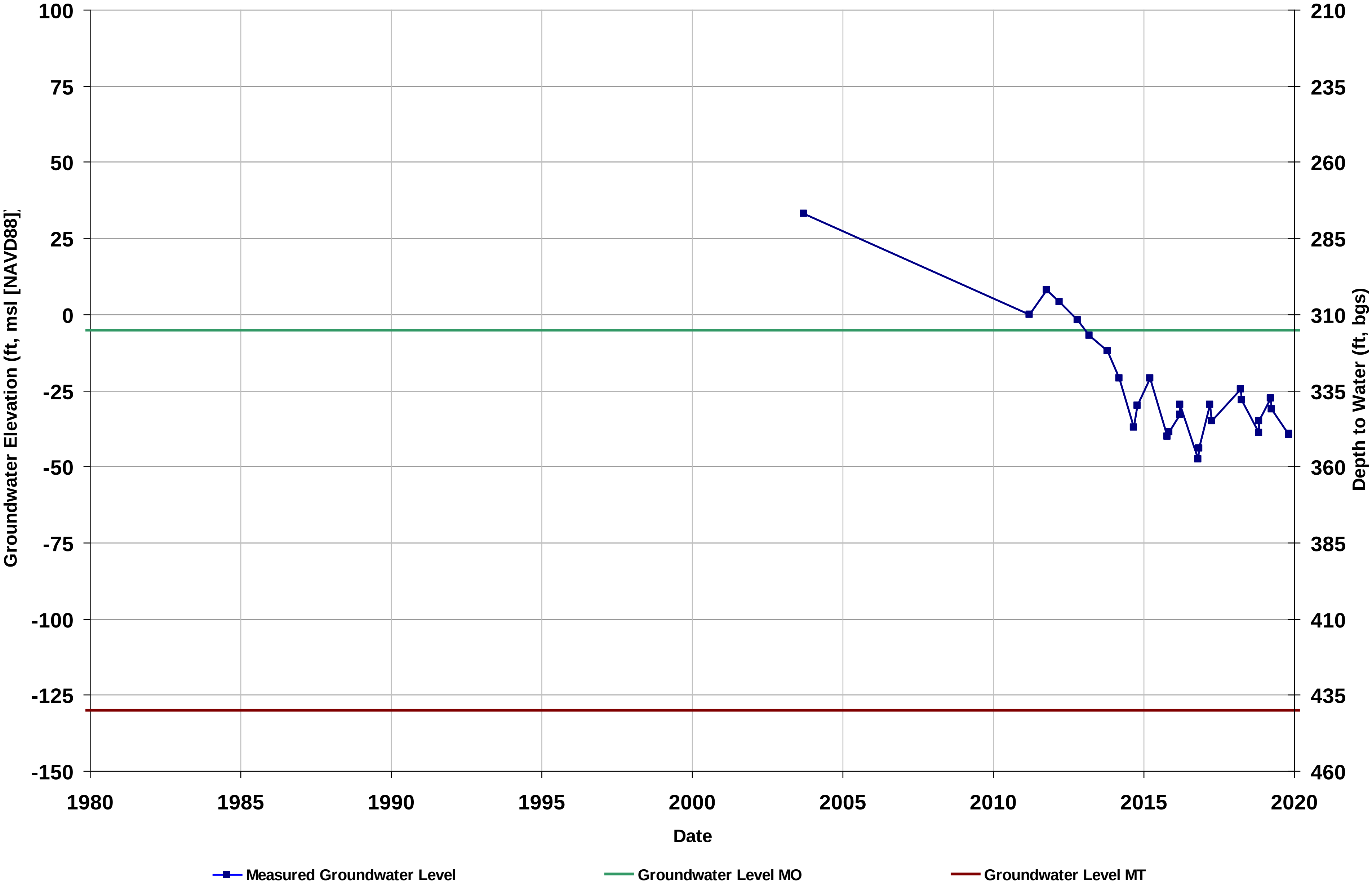
Well Name: MWD RMS-1
Depth Zone: Lower
Subbasin: Madera
GSA: Madera WD

Total Depth (ft): 500
Perf Top (ft): 200
Perf Bottom (ft): 500
GSE (ft, msl): 330



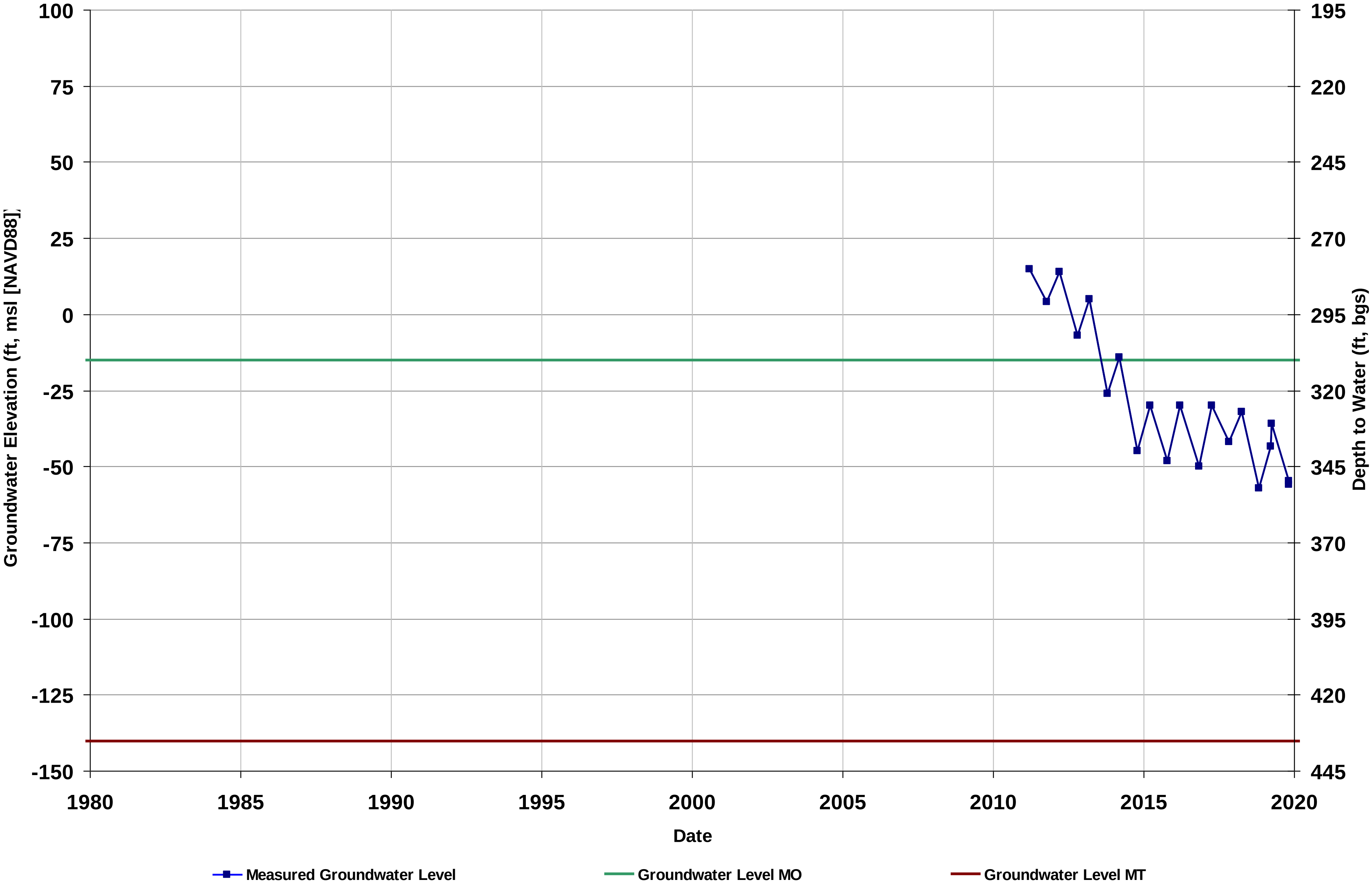
Well Name: MWD RMS-2
Depth Zone: Lower
Subbasin: Madera
GSA: Madera WD

Total Depth (ft): 537
Perf Top (ft): 200
Perf Bottom (ft): 537
GSE (ft, msl): 310

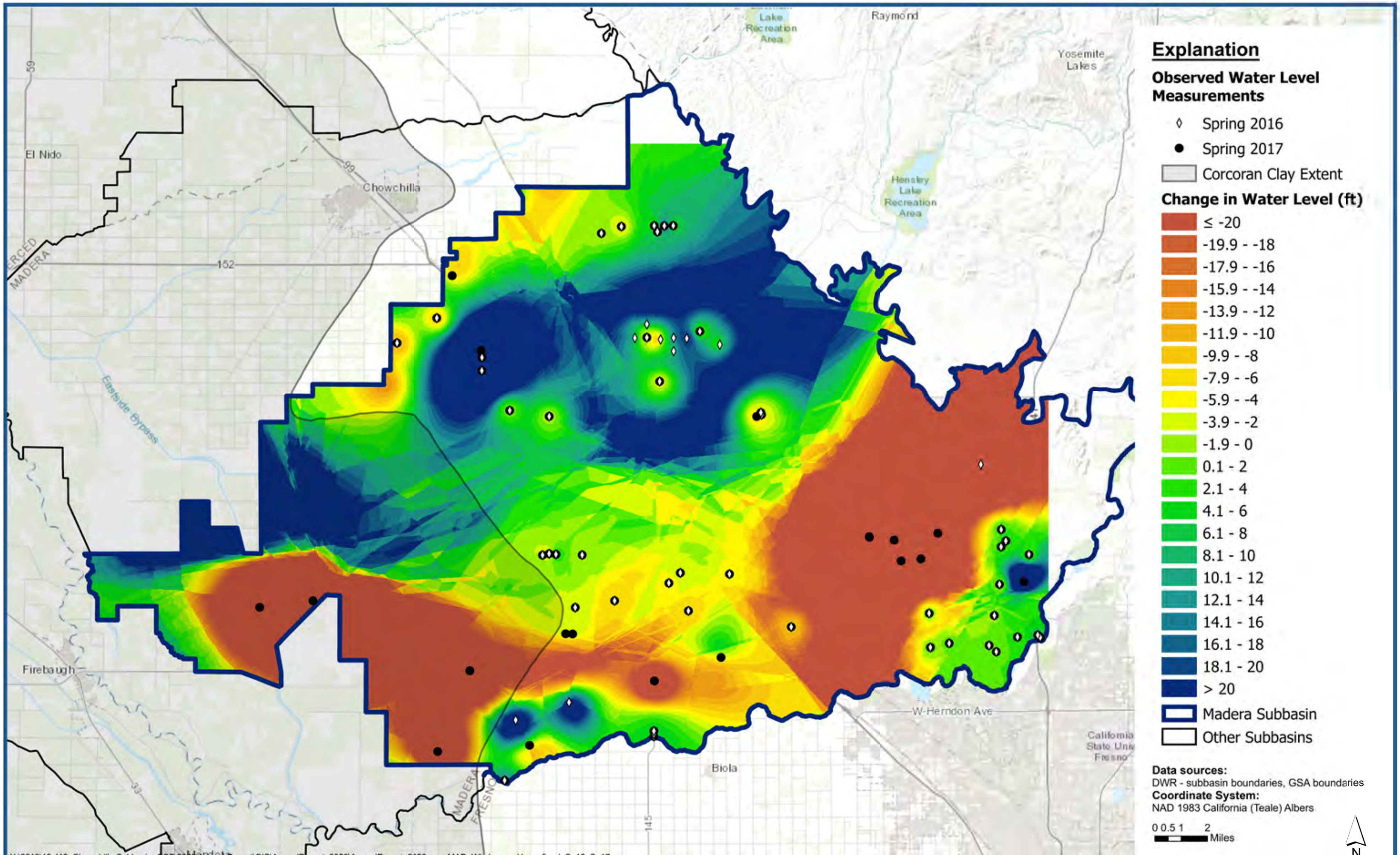


Well Name: MWD RMS-3
Depth Zone: Lower
Subbasin: Madera
GSA: Madera WD

Total Depth (ft): 800
Perf Top (ft): 380
Perf Bottom (ft): 800
GSE (ft, msl): 295



Appendix C. Maps of change in groundwater levels for each of the years between Spring 2016 and 2018, separated by principal aquifer. Maps of annual change in storage for years between Spring 2016 and Spring 2018



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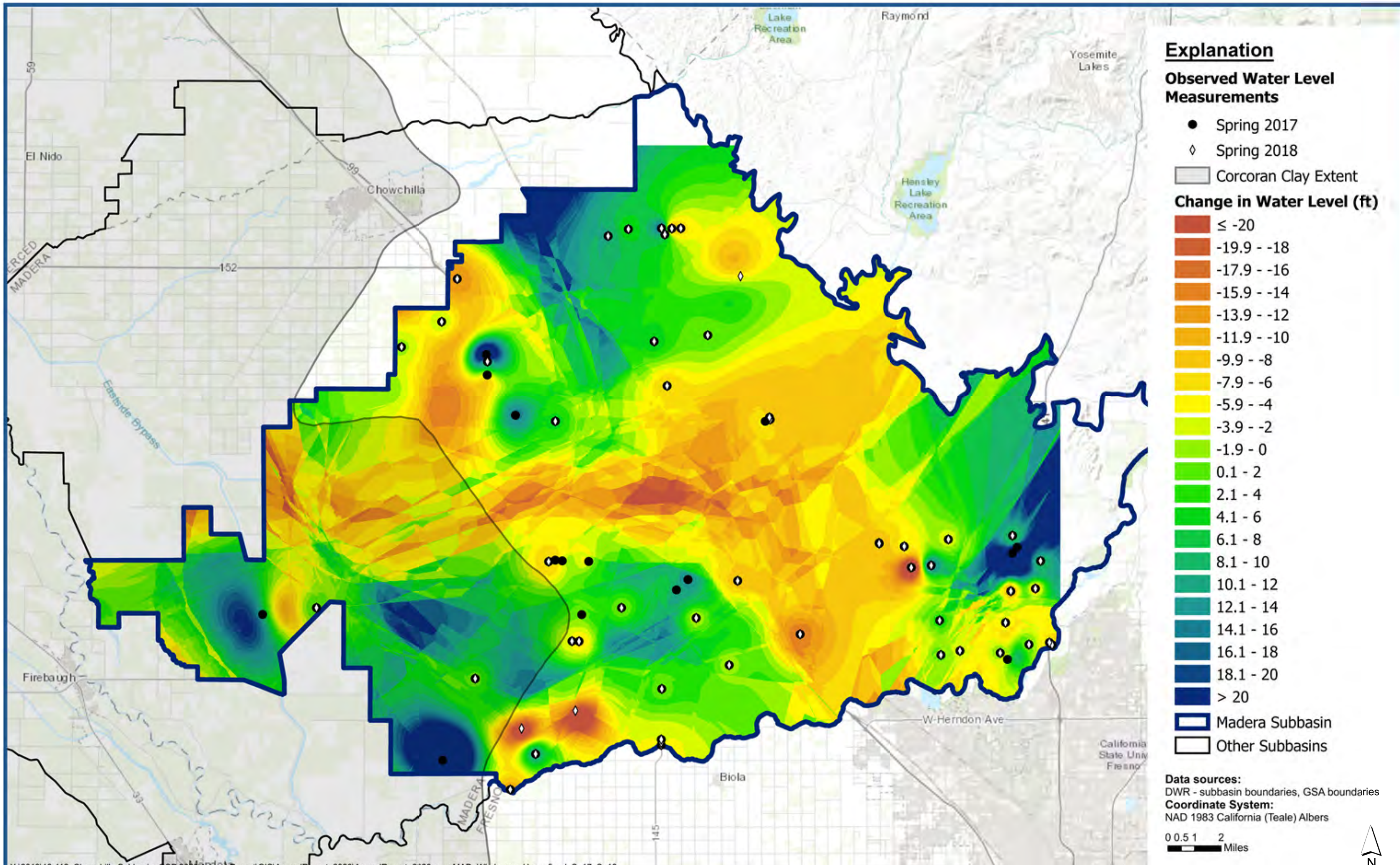
Luhdorff & Scalmanini Consulting Engineers

Change in Water Level in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2016 through Spring 2017

Figure C-1

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report



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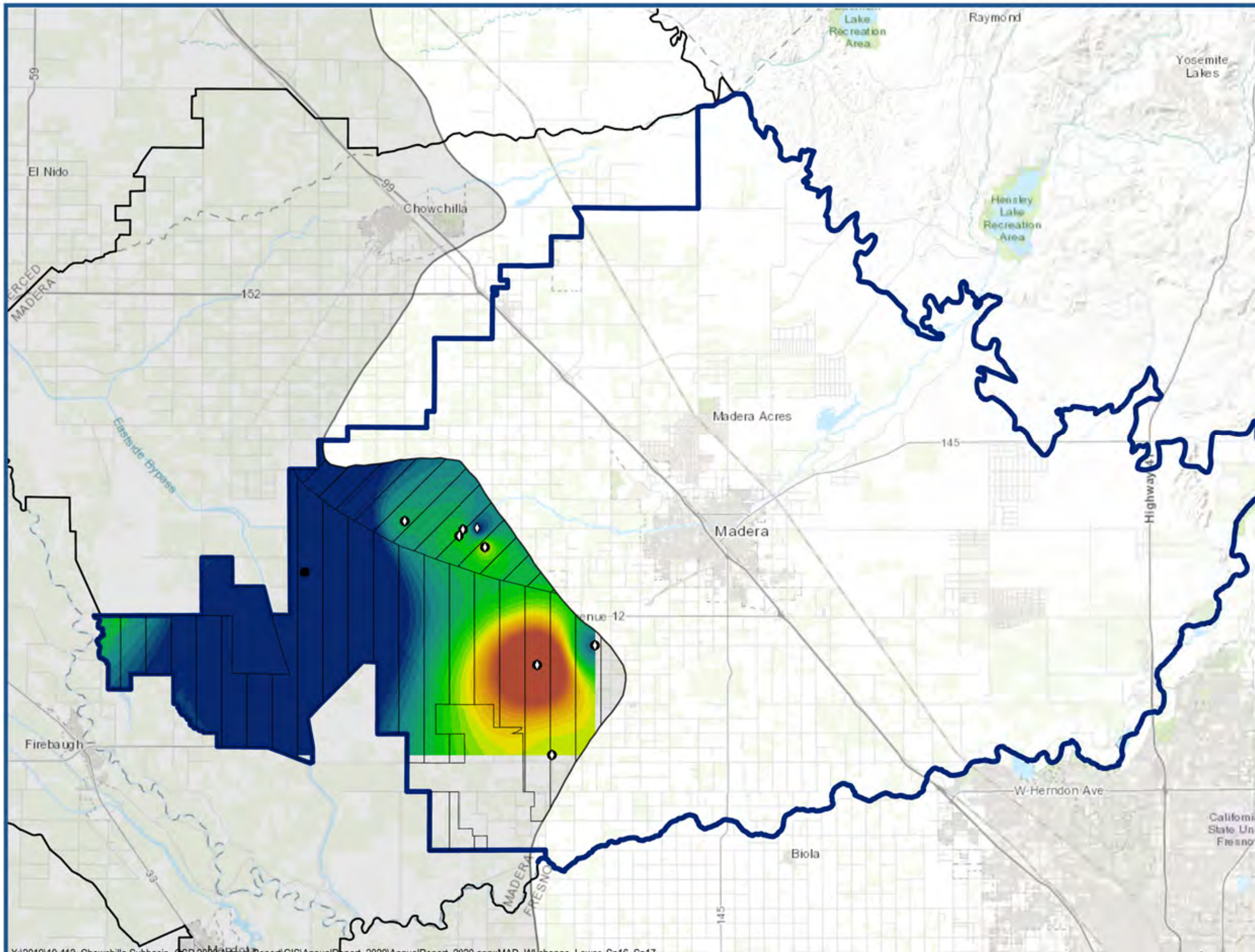
Consulting Engineers

Change in Water Level in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2017 through Spring 2018

Figure C-2

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report



Explanation

Observed Water Level Measurements

- Spring 2016
- Spring 2017

- Confined Lower Aquifer
- Unconfined Lower Aquifer
- Corcoran Clay Extent

Change in Water Level (ft)

- ≤ -20
- -19.9 - -18
- -17.9 - -16
- -15.9 - -14
- -13.9 - -12
- -11.9 - -10
- -9.9 - -8
- -7.9 - -6
- -5.9 - -4
- -3.9 - -2
- -1.9 - 0
- 0.1 - 2
- 2.1 - 4
- 4.1 - 6
- 6.1 - 8
- 8.1 - 10
- 10.1 - 12
- 12.1 - 14
- 14.1 - 16
- 16.1 - 18
- 18.1 - 20
- > 20

- Madera Subbasin
- Other Subbasins

Data sources:
DWR - subbasin boundaries, GSA boundaries
Coordinate System:
NAD 1983 California (Teale) Albers

0 0.5 1 2
Miles

N

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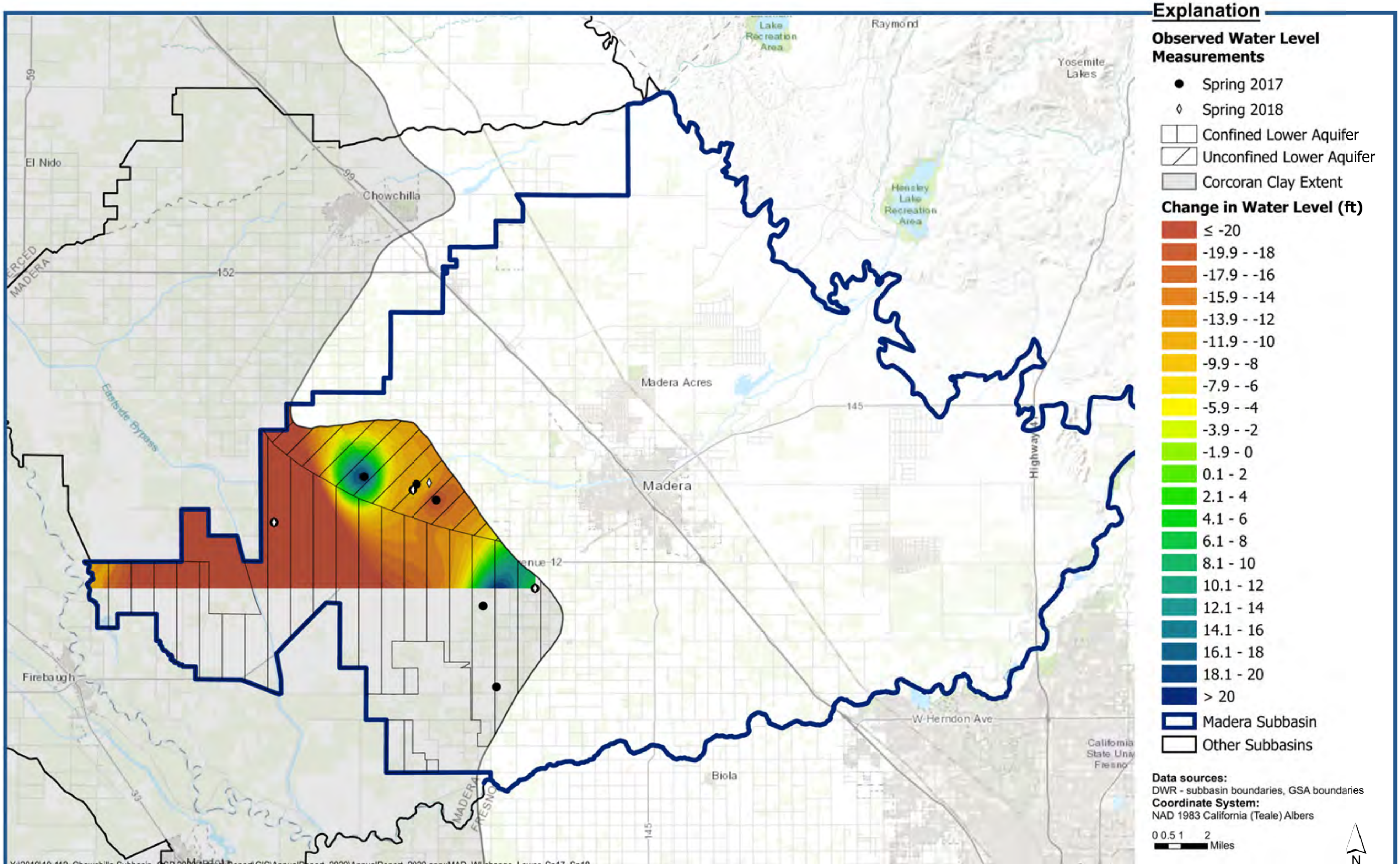
Change in Water Level in the Lower Aquifer - Spring 2016 through Spring 2017

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure C-3



Change in Water Level in the Lower Aquifer - Spring 2017 through Spring 2018

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure C-4

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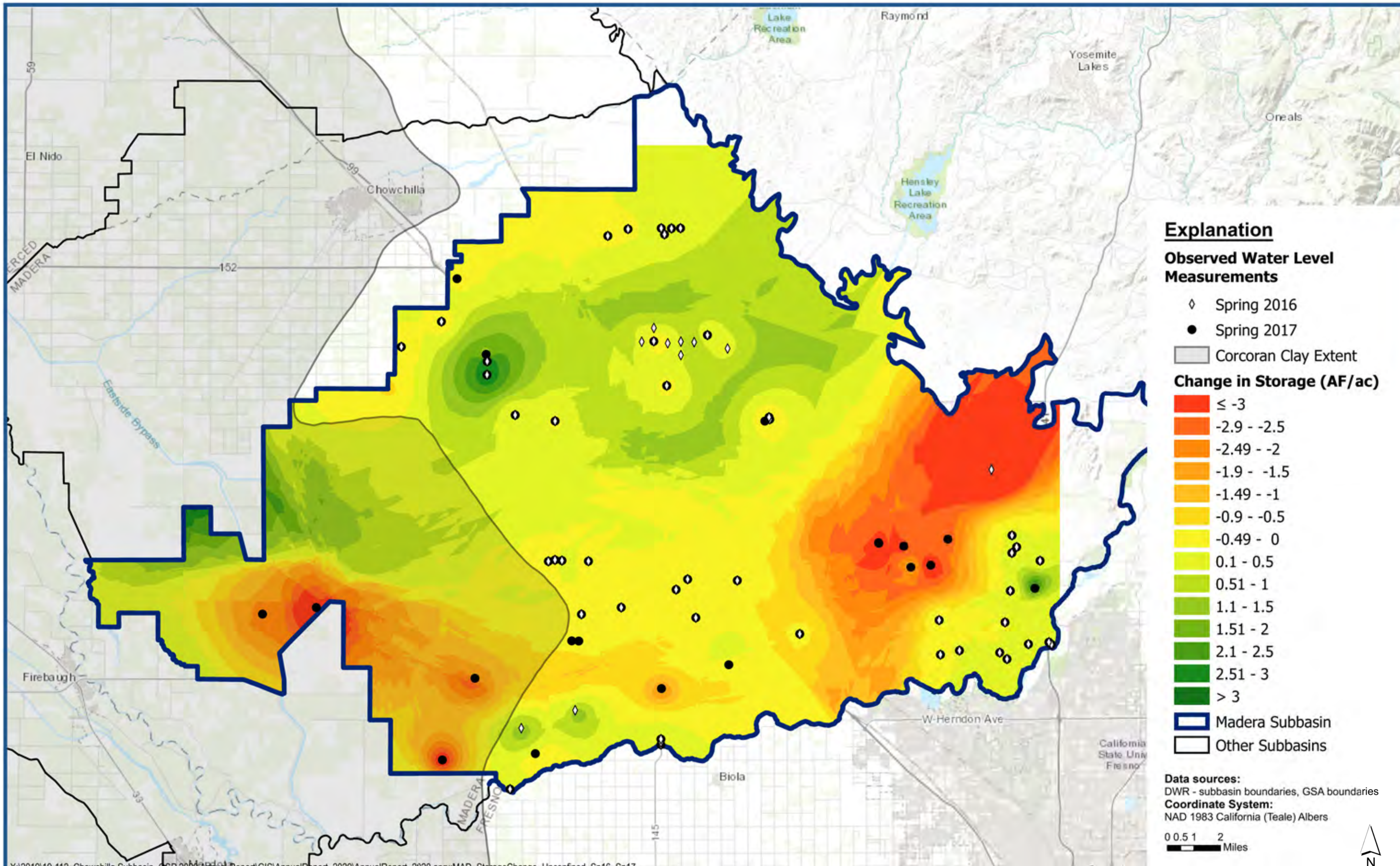

Change in Groundwater Storage in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2016 through Spring 2017

Madera Subbasin

Groundwater Sustainability Plan 2020 Annual Report

Figure C-5

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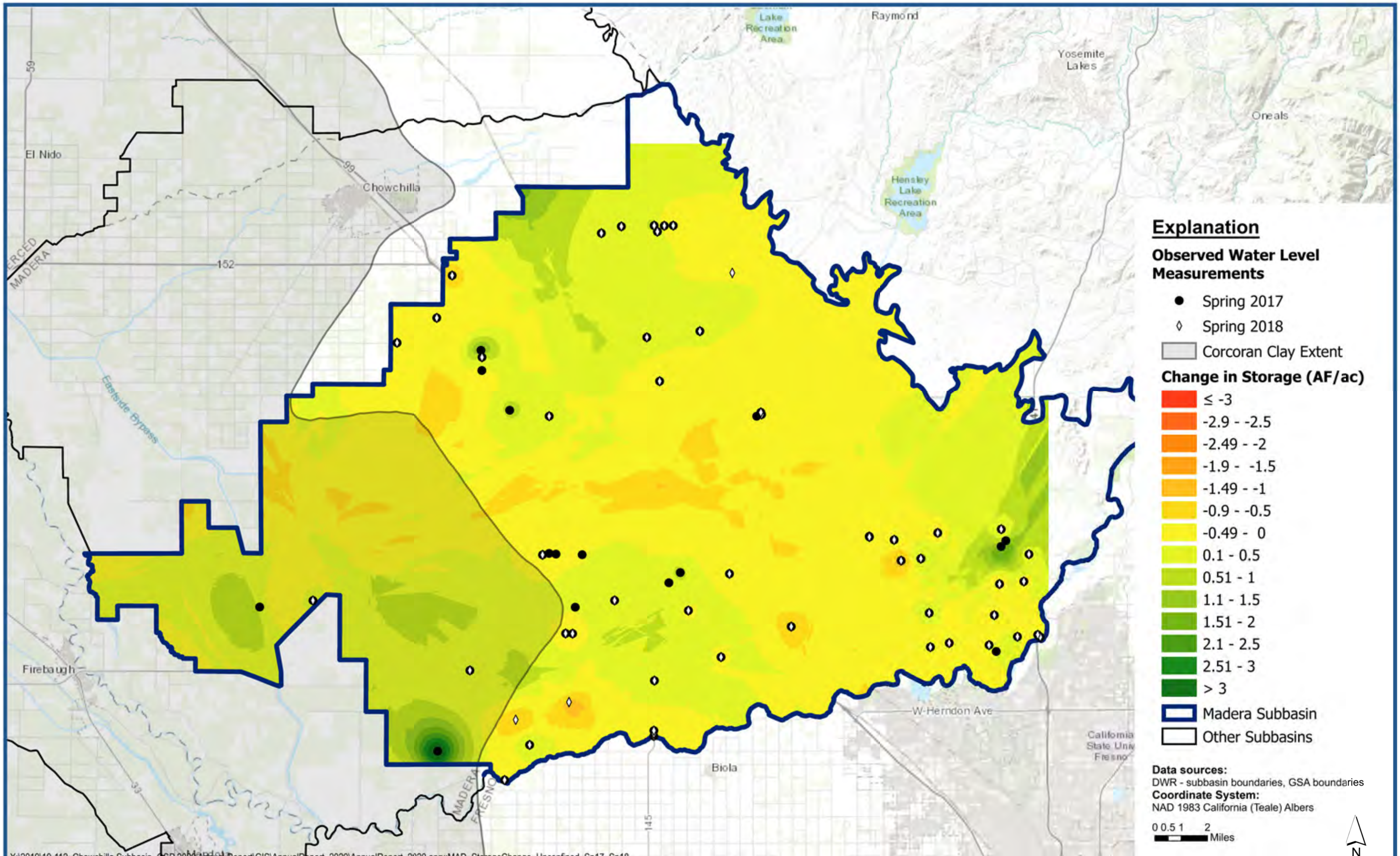

X:\2019\19-112 Chowchilla Subbasin GSP 2020 Annual Report\GIS\AnnualReport_2020\AnnualReport_2020.aprx:MAD_StorageChange_Unconfined_Sp17_Sp18

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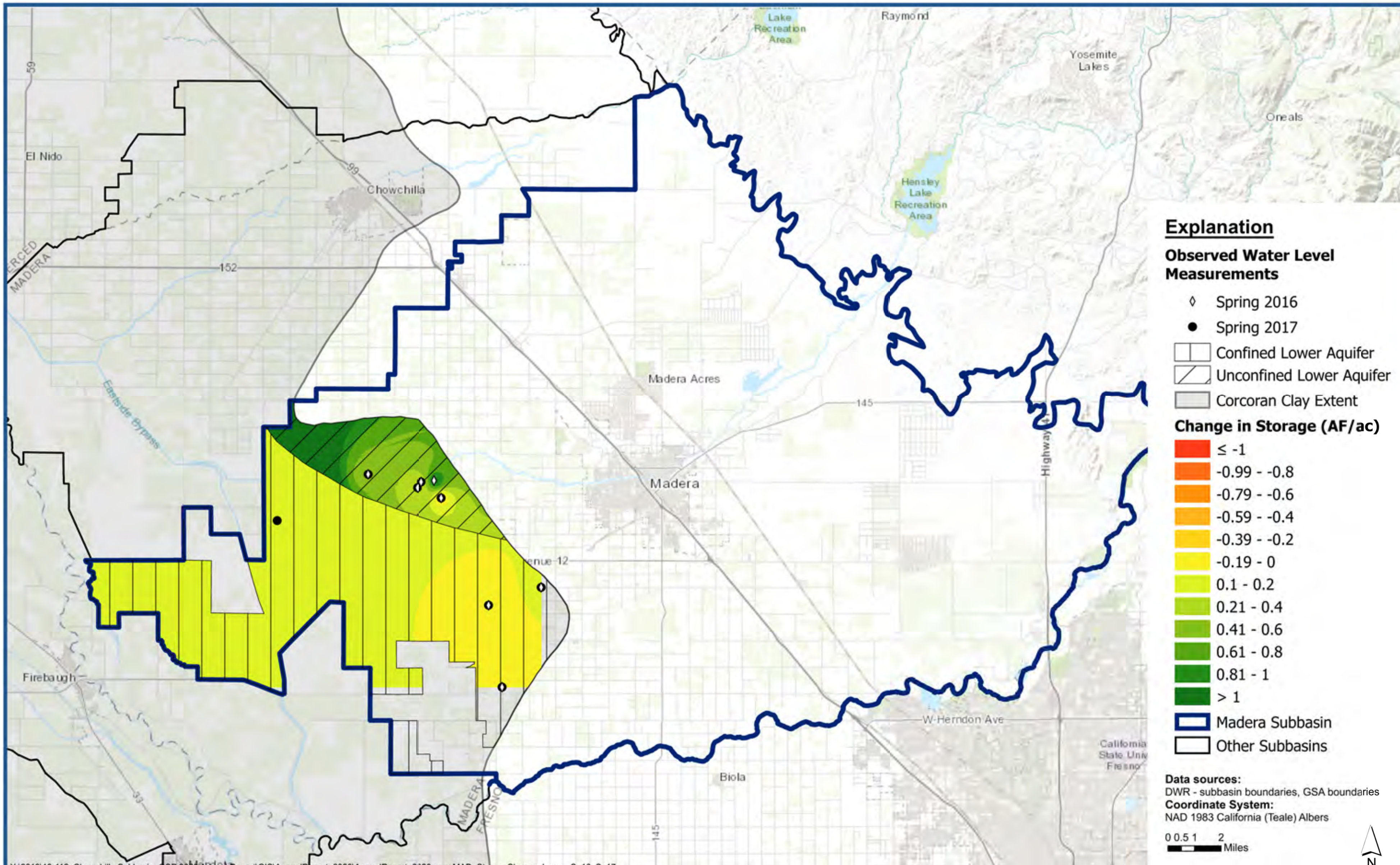
Change in Groundwater Storage in the Upper Aquifer/Undifferentiated Unconfined Zone - Spring 2017 through Spring 2018

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure C-6



Change in Groundwater Storage in the Lower Aquifer - Spring 2016 through Spring 2017

Madera Subbasin
Groundwater Sustainability Plan 2020 Annual Report

Figure C-7

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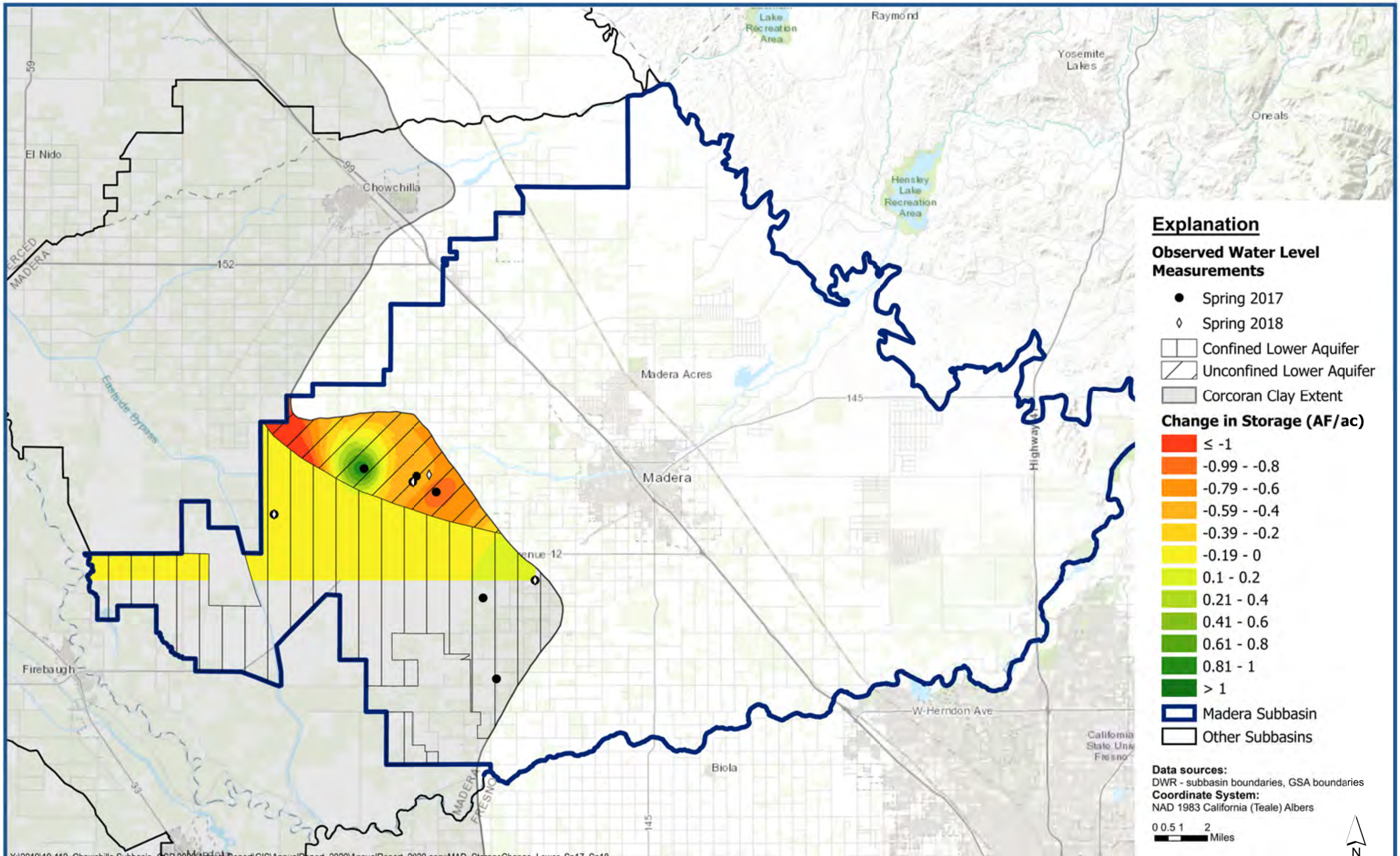

X:\2019\19-112_Chowchilla Subbasin_GSP 2020 Annual Report\GIS\AnnualReport_2020\AnnualReport_2020.aprx:MAD_StorageChange_Lower_Sp17_Sp18

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Change in Groundwater Storage in the Lower Aquifer - Spring 2017 through Spring 2018

Madera Subbasin

Groundwater Sustainability Plan 2020 Annual Report

Figure C-8

Appendix D. Stakeholder Communication and Engagement During Groundwater Sustainability Plan (GSP) Implementation: Recommendations

Madera Subbasin

Stakeholder Communication and Engagement During Groundwater Sustainability Plan (GSP) Implementation: Recommendations

January 2020

NOTE: The following recommendations are those of the Consensus and Collaboration Program at California State University, Sacramento. These recommendations incorporate many outreach processes begun during the GSP planning process, but also include some new processes. In order to ensure an adaptive, responsive approach to stakeholder outreach and engagement, similar to during the GSP development, we recommend that any outreach be planned in collaboration with the Madera Subbasin stakeholders, beginning with the GSA managers, board members, and staff.

NOTE: This document was drafted before the COVID-19 pandemic. In that environment, some of the engagement tools would need to be modified.

Prepared by the California State University of Sacramento (CSUS)

Contents

Madera Subbasin Stakeholder Communication and Engagement During GSP Implementation: Recommendations

January 2020

Purpose

The purpose of these recommendations is to assist Madera Subbasin Groundwater Sustainability Agencies (GSAs) in their strategic communication and engagement with stakeholders during implementation of groundwater management activities per their respective GSPs. This document is intended to serve as an initial guide and framework which we expect will be fleshed out and added to as GSP implementation unfolds.

Overview and Background

California's Sustainable Groundwater Management Act (SGMA) of 2014 requires broad and diverse stakeholder involvement in GSA activities and the development and implementation of Groundwater Sustainability Plans (GSPs) for 127 groundwater basins around the state, including the Madera Subbasin. The intent of SGMA is to ensure successful, sustainable management of groundwater resources at the local level. Success will require cooperation by all stakeholders, and cooperation is far more likely if stakeholders have consistent messaging of valid information and are provided with opportunities to help shape the path forward.

For detail regarding communication and engagement during development of the Madera Subbasin GSPs, please consult the *Madera Subbasin Stakeholder Communication and Engagement Plan (see Appendix 2.C.a in the Madera Subbasin Joint GSP)*.

Implementation Communication and Engagement Recommendation Goals

This document seeks to accomplish the following goals:

1. Educate stakeholders about:
    - A. SGMA and its requirements and
    - B. Opportunities to provide input related to the implementation of the Madera Subbasin GSPs.
2. Provide a roadmap to GSAs on ways to effectively and efficiently reach all elements of the population to share information.
3. Articulate strategies and channels for GSAs to use to obtain stakeholder input and feedback to inform GSP implementation.

4. Encourage stakeholder engagement, for example, by continuing to use dedicated SGMA outreach strategies and channels established during the GSP development period and highlighting all opportunities for stakeholders to provide input in GSP implementation decision-making processes.

Primary Stakeholders for Outreach and Engagement

Madera Subbasin stakeholders are "beneficial users" as described by SGMA. Under the requirements of SGMA, all beneficial uses and users of groundwater must be considered in the development and implementation of GSPs, and GSAs must encourage the active involvement of diverse social, cultural, and economic elements of the population. Beneficial users, therefore, are any stakeholders who have an interest in groundwater use and management in the Madera Subbasin community. Their interest may be related to GSA activities, GSP development and implementation, and/or water access and management in general.

To assist in determining who the specific SGMA stakeholders and beneficial users are, the Department of Water Resources (DWR) created a Stakeholder Engagement Chart for GSP development in their 2017 *GSP Stakeholder Communication and Engagement Guidance Document*. The following table (Table 1) is based on the DWR chart, modified to fit the circumstances and stakeholders of the Madera Subbasin. It can continue to be updated during the GSP implementation process.

Table 1. Stakeholder Engagement Chart for GSP Development

Category of Interest	Examples of Stakeholder Groups [1]	Engagement purpose
General Public	• Citizens groups • Community leaders	Inform to improve public awareness of sustainable groundwater management
Land Use	• Municipalities (City, County planning departments) • Regional land use agencies	Consult and involve to ensure land use policies are supporting GSPs
Private Users	• Private pumpers (domestic and agricultural) • Domestic users • Schools and colleges • Hospitals	Inform and involve in assessing impacts to users
Urban/ Agricultural	• Water agencies • Irrigation districts	Collaborate to ensure sustainable management of

[1] The groups and communities referenced are examples identified during initial assessment. GSA Interested Parties lists shall maintain current and more exhaustive lists of stakeholders fitting into these groups.

Category of Interest	Examples of Stakeholder Groups [1]	Engagement purpose
Users	• Municipal water companies • Resource conservation districts • Farmers/Farm bureaus	groundwater
Industrial Users	• Commercial and industrial self-supplier • Local trade association or group	Inform and involve in assessing impacts to users
Environmental and Ecosystem Uses	• Federal and State agencies: CA Dept. of Fish and Wildlife • The Nature Conservancy • Environmental groups	Inform and involve to consider/incorporate potential ecosystem impacts to GSP process
Economic Development	• Chambers of Commerce • Business groups/associations • Elected officials (Board of Supervisors, City Council) • State Assembly members • State Senators	Inform and involve to support a stable economy
Human Right to Water	• Disadvantaged communities: Fairmead Community and Friends, La Vina Residents, etc. • Small water systems • Environmental justice groups/community-based organizations: Leadership Council for Justice and Accountability, Self-Help Enterprises, Community Water Center, etc.	Inform and involve to provide safe and secure groundwater supplies to all communities reliant on groundwater
Tribes	Federally Recognized Tribes and non-Federally Recognized Tribes with lands or potential interests in Madera Subbasin: • Northfork Rancheria of Mono Indians of California • Picayune Rancheria of Chuckchansi Indians • Northfork Band of Mono Indians • Chaushilha Yokuts • Big Sandy Rancheria of Mono Indians of California • Cold Springs Rancheria of Mono Indians of California • Table Mountain Rancheria of	Inform, involve and consult with tribal governments

Category of Interest	Examples of Stakeholder Groups [1]	Engagement purpose
	California • Tule River Indian Tribe of the Tule River Reservation	
Federal Lands	• Bureau of Reclamation (USBR) • Bureau of Land Management	Inform, involve and collaborate to ensure basin sustainability
Integrated Water Management	• Regional water management groups (IRWM regions) • Flood agencies • Recycled water coalition	Inform, involve and collaborate to improve regional sustainability

SGMA and Engagement

SGMA strongly encourages broad stakeholder engagement in development and implementation of GSPs. According to SGMA:

- "The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the groundwater sustainability plan." [CA Water Code Sec. 10727.8(a)]
- "The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater." [CA Water Code Sec. 10723.2]

GSAs are given broad discretion in the methods and processes utilized to meet engagement requirements, but the methods are required to "successfully" engage all stakeholders, including elements of the population that are hard to reach. Additionally, SGMA sets forth some required engagement strategies as well as several GSA-specific requirements regarding public notice, public hearings, and public meetings.

SGMA-Required Engagement During Implementation

The table below, from DWR's *GSP Stakeholder Communication and Engagement Guidance Document* (page 13), presents the engagement requirements for Phase 4, implementation and reporting, and those applicable to all phases. Details about these strategies are included in the *How to Engage* section below.

Phase 4 Engagement Requirements

- **Public Notices and Meetings** §10730
  - Before amending a GSP
  - Prior to imposing or increasing a fee
- **Encourage Active Involvement** §10727.8

Engagement Requirements Applicable to ALL PHASES

- **Beneficial Uses and Users** §10723.2
  Consider interests of all beneficial uses and users of groundwater
- **Advisory Committee** §10727.8
  GSA may appoint and consult with an advisory committee
- **Public Notices and Meetings** §10730
  - Before electing to be a GSA
  - Before adopting or amending a GSP
  - Prior to imposing or increasing a fee
- **Encourage Active Involvement** §10727.8
  Encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin
- **Native American Tribes** §10720.3
  - May voluntarily agree to participate
  - See Engagement with Tribal Government Guidance Document
- **Federal Government** §10720.3
  - May voluntarily agree to participate

When to Engage

As evident from the table above, continuing to share information with and gather feedback from the public and specific stakeholder groups remains important throughout the GSP implementation period, particularly at key junctures, such as:

- when new monitoring information comes to light;
- as fees are being considered;
- during planning and development of projects; and
- whenever input from beneficial users is helpful and/or necessary to move GSP implementation forward.

When deciding how to prioritize efforts, consider when engagement is needed to support relationship building, provide timely information, and gather timely input. Is something new being developed? Is a key decision being made?

As outlined in the *How to Engage* section below, GSA and Subbasin-wide outreach can continue to utilize the communication channels developed during GSP development. Some relationships and structures that were built during GSP development can be maintained, for example monitoring the agendas of other GSAs and attending meetings as relevant. In other cases, it may be appropriate to create new engagement processes for example, during development of new projects. This project-based engagement may be discrete in terms of timing, with a clear beginning and end. And depending on the project, the audience could be broad or focused – for example, targeting particular categories, of relevant beneficial users.

How to Engage

To maximize efficiency and support consistent messaging, it is appropriate that some outreach activities be conducted on a subbasin-wide level. However, it is also important to recognize that under SGMA each GSA has its own responsibility for engagement of the beneficial users within its boundaries. Regional (subbasin-wide) and localized (GSA-specific) strategies should be considered when planning outreach and engagement activities.

Regional Communication and Engagement Strategies

The following are strategies that can be undertaken at the Subbasin-wide level to ensure successful engagement of Madera Subbasin stakeholders during the GSP implementation process. Most of these strategies were developed during the GSP development phase.

1. Develop and Maintain a List of Interested Parties

A contact list of stakeholders and beneficial users was developed during GSP planning and will continue to be updated throughout GSP implementation and enforcement processes. Each GSA is required to maintain its own list, however coordinating these lists into a single Subbasin list will improve stakeholder engagement.

2. Maintain a Centralized Madera Subbasin Website

The Madera Subbasin website (http://www.maderacountywater.com) was built during GSP development. During implementation it should continue to be kept up to date, including the following content:

- Links to external sites (DWR and State Water Resources Control Board)
- Information specific to each GSA, including service areas (if applicable), maps, GSA Board meetings, updates, and opportunities for stakeholder input
- Links to individual GSA websites, relevant blogs, etc.
- Frequently Asked Questions (FAQ) and/or white papers
- GSA documents (MOUs, by-laws, etc.)
- GSP documents (the GSP, notices and meeting calendars for subbasin-wide GSP-related workshops)

3. Newsletter and Other Notices

A Subbasin-wide newsletter was established during GSP development and should continue to be utilized to share information and opportunities for engagement with interested parties.

Newsletters and notices can be sent on a regular schedule, for example bi-monthly or monthly, or as needed. Content should be appropriate to the audience and their interests, ensuring information is articulated in a way that is easily understood. For example:

- Notices to community members with less SGMA or technical experience should be easily understood, with streamlined, relatable, and repetitive information.
- Updates and messages should be condensed to one page when possible, providing a succinct summary of the issues discussed, and including links for further or additional information.
- As applicable, specific items should have an estimated timeline and a designated point of contact, including the person’s position, email and telephone number.

- Updates and information are needed in both English and Spanish.

4. Social Media

The Madera Subbasin centralized social media account (https://www.facebook.com/MaderaCounty/) should continue to be utilized to share information and opportunities for engagement.

5. Coordination Committee

A coordination work group was formed and will continue to meet as needed and at critical junctures for coordination.

6. Regional Meetings and Workshops

As during GSP development, subbasin-wide meetings and workshops should continue to be held on an as-needed basis. For example, if a region-wide issue comes up, a meeting may be held to share information and gather input about it. Additionally, region-wide workshops targeting a specific beneficial user group may be held; see below for details.

Beneficial User-Specific Meetings

There may be occasion to hold region-wide workshops or meetings targeted toward specific beneficial user groups; for example, a subbasin-wide public workshop to encourage and support Resource Conservation Districts to assist with outreach to small farmers. Ad-hoc stakeholder committees may also be created, for example, to provide feedback specific to a project; see *Project-Specific Communication and Engagement Strategies* below.

Disadvantaged communities (DACs) are a beneficial user category that may require additional outreach and engagement efforts. During GSP development, the Madera Subbasin Joint GSP worked with three organizations – Fairmead and Friends, Self-Help Enterprises and Leadership Counsel for Justice and Accountability – to support engagement with DAC communities. These relationships can continue to be leveraged to communicate with DAC communities about opportunities to receive information and share input.

7. Public Meetings of Subbasin-Wide Bodies

In addition to regional meetings and workshops designed to share information and/or gather input from stakeholders, GSA Boards will hold public meetings. These meetings are subject to Brown Act compliance, as outlined below.

Ensure Brown Act Compliance

Meetings subject to the Brown Act, such as GSA Board Meetings, must provide public notice and post an agenda 72 hours in advance of each regularly scheduled meeting. Emergency meetings require 24-hour advance notice. For more information on Brown Act requirements, see https://oag.ca.gov/sites/all/files/agweb/pdfs/publications/2003_Intro_BrownAct.pdf.

8. Project-Specific Communication and Engagement Strategies

As specific projects are developed during GSP implementation, additional communication and engagement will be needed. This increased outreach s likely to include additional workshops and meetings, with associated communication to notice and publicize these. The extra engagement may be discrete in terms of timing, with a clear beginning and end as the project is developed, as well as audience, targeting particular beneficial users relevant to the project. For example, input from DAC beneficial users will be particularly important during development of a mitigation program for impacted drinking water wells and agricultural beneficial users will be particularly important to engage during development of an agricultural land conservation program. In some cases, it could be helpful to create a separate advisory committee to support project development.

9. Meetings of Related Bodies

As during GSP development, coordination with other related bodies, such as Regional Water Management groups, may be beneficial. Meeting agendas may be monitored and meetings attended as relevant.

Localized Communication and Engagement Strategies

As during GSP development, individual GSA representatives and staff will need to continue to engage with their own stakeholders and will be responsible for tracking the needs of their local communities. GSAs should also consider stakeholder input gathered from outreach efforts as they move through GSP implementation processes.

See requirements below:

1. Develop and Maintain a List of Interested Parties

Each GSA must maintain its list of interested parties on an ongoing basis. Anyone who wishes to be put on this list can do so upon making this request in writing. [CA Water Code Section 10730. (b) (2); 10723.2; 10723.4; and 10723.8. (a)].

2. Public Meetings

As noted above, SGMA requires that GSAs hold public meetings prior to adopting or amending a GSP and prior to imposing or increasing fees. These and all GSA meetings are subject to Brown Act requirements; see link above.

When adopting or amending a GSP, SGMA sets forth the following requirements:

- A GSA seeking to adopt or amend a GSP must provide notice to cities and counties within the area encompassed by the proposed plan or amendment, and consider comments provided by the cities and counties. Cities and counties receiving the notice may request consultation with the GSA, in which case the GSA must accommodate that request within 30 days. The GSA also must hold a public hearing prior to adopting or amending a GSP. There must be at least 90 days between the notice issued to cities and counties and the public hearing. [CA Water Code Section 10728.4]

When imposing or increasing fees, SGMA sets forth the following noticing requirements:

- If a GSA intends to impose or increase a fee, it must first hold at least one public meeting, at which attendees may make oral or written comments. See below for requirements for public notice of the meeting:
  - Information about the time and place of the meeting and a general explanation of the topic to be discussed.
  - Public notice must be posted on the GSA's website and mailed to any interested party who submits a written request for mailed notice of meetings on new or increased fees.
  - The public notice must also be consistent with Section 6066 of the Government Code.
  - In addition, the GSA must share with the public the data upon which the proposed fee is based, and this must be done at least ten days before the public meeting takes place. [CA Water Code Section 10730.(b)(1),(2), and (3). (Note: Additional processes are required under Proposition 218 and 26 related to taxes; these processes are not currently referenced in this document but should be followed as relevant.)
  - In addition to complying with the formal meeting notice requirements, in order to maximize participation we recommend informing the public as soon as the meeting is scheduled – if possible, at least 10 business days before.

3. Advisory Committees

SGMA explicitly authorizes GSAs to form Public Advisory Committees if they choose but does not require them to do so. The decision to form an advisory committee is left to the individual GSAs, based on the need and effectiveness of these processes within their communities. For example, the Madera County GSA convenes an Advisory Committee with members representing diverse stakeholders within the GSA.

GSAs that have advisory committees should consider mobilizing members to support outreach. For example, members of GSA advisory committees who are also part of an organization representing a beneficial user group should report out to each about the efforts of the other so that they can remain abreast of appropriate times to share information and input.

Conclusion

SGMA requires that diverse stakeholders be engaged in development as well as implementation of GSPs. Engagement during the implementation phase focuses on sharing information and gathering feedback from the public at key junctures, such as when monitoring information comes to light, projects are being developed, or input from beneficial users is necessary to move implementation forward. These recommendations, including strategies for outreach at the regional/subbasin-wide and the local/GSA levels, will assist the Madera Subbasin GSAs in their strategic communication and engagement during implementation of GSP activities.

Appendix E. Madera Subbasin GSP Demand Management Plan Economic Impact Analysis

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Draft Technical Memorandum

RE: Madera Subbasin GSP Demand Management Plan Economic Impact Analysis

BY: ERA Economics LLC

FOR: Madera Subbasin Joint GSP Team

DATE: January 4, 2020

Overview

The Madera Subbasin is being managed by seven Groundwater Sustainability Agencies (GSAs). Four of these GSAs have prepared the Madera Subbasin Joint Groundwater Sustainability Plan (hereafter, Joint GSP) and the other three GSAs have prepared separate groundwater sustainability plans (GSPs) . The GSPs have been developed with significant technical and stakeholder input to transition the Madera Subbasin to sustainable groundwater conditions by 2040.

This memorandum evaluates the economic impact of demand management planned in the Joint GSP. Direct economic impacts (e.g. changes in irrigated acreage) occur in the Madera Subbasin as a whole and regional multiplier effects (e.g. changes in farm labor income) occur in the broader Madera County area. The implementation plan described in Chapter 5 of the Joint GSP features a gradual transition to sustainability over the next 20 years. This allows time for GSAs to study, develop, finance, and build an estimated $250 million in capital projects in the subbasin by 2040 primarily to increase groundwater recharge using flood water available in wet years. It also allows time for GSAs to develop monitoring, metering, and enforcement programs to implement a demand management (water use reduction) program to limit groundwater pumping.

This memorandum describes the results of an economic analysis developed to evaluate the direct economic impact of the Joint GSP demand management program to the Madera Subbasin and the regional impacts to the Madera County economy. This analysis only evaluates the impact of demand management. It does not evaluate any effects of new water supply and groundwater recharge projects that are part of the GSP implementation plan. It also does not evaluate the impacts of rates and assessments (or other mechanisms) needed to cover costs of the Joint GSP, or other GSPs in the Madera Subbasin. As specified in the Joint GSP, the demand management program only applies to the portion of the Madera County GSA that falls in the Madera Subbasin. The conclusions of the economic impact analysis are as follows:

- Approximately half of the Madera County economy and one in three jobs is linked to Madera County agriculture. This does not include some warehousing, transportation, storage, and other farm-related industries.
- Once demand management is fully implemented as specified in the Madera Subbasin Joint GSP, it would cause direct farm revenue losses of $130 million per year and require idling an average

of 28,300 acres per year in the Madera Subbasin. This would result in the following regional economic impacts in Madera County:

- The Madera County economy would contract by $135 million per year by 2040, or about $2.7 billion in present value over the 2020 – 2040 implementation period.
- Madera County tax revenues would fall by approximately $1.4 million per year by 2040 (~3.3%), or about $28.6 million in present value over the 2020 – 2040 implementation period[1]. The loss in tax revenue reflects local revenue to the County and to cities and special districts in the County. Local services provided by these agencies would be impacted as revenues fall.
- Labor income (wages) would fall by $53 million per year, including wages for many seasonal jobs that support County Disadvantaged Communities (DACs). Full time equivalent jobs in Madera County would decrease by 575 (or 1,200 – 1,800 seasonal jobs[2]), and many of these jobs generate income for DACs in the County.

Appendix 3C of the Joint GSP describes an analysis of economic impacts that would result if demand management were implemented immediately (in 2021), in all GSAs, rather than phased-in over 20 years. This was used to support development of the implementation plan specified in the Joint GSP. In contrast, the analysis in this memorandum is the impact of the demand management program specified in the Joint GSP. It was developed in response to requests from stakeholders after adoption of the Joint GSP. However, as stated previously, neither this analysis nor the previous analysis has evaluated the economic impacts of all components of the Joint GSP. Additional detailed analysis of the total impact and refinement of the economic data/models applied in this analysis is recommended to support additional planning efforts.

The following section describes the general method, logic, and data underlying the economic analysis. This is followed by a summary of the contribution of agriculture to the Madera County economy to provide context for the subsequent economic impact analysis. The final section describes estimated direct economic impacts to farming in the Madera Subbasin, indirect impacts to the Madera County economy, as well as estimated fiscal (tax) impacts to Madera County.

GSP Demand Management Economic Impact Analysis Overview

An economic analysis was developed to evaluate the impact of the planned demand management (water use reduction) program described in Chapters 4 and 5 of the Joint GSP. The Joint GSP implementation plan calls for a gradual, phased implementation of demand management, starting in 2020 and continuing through 2040. This allows time to develop program administration, monitoring, and enforcement, and gives growers time to adjust farming operations in response to reductions in water availability and increasing costs. This economic impact analysis evaluates the annual and cumulative impacts of demand management in the Madera Subbasin and to the broader Madera County economy.

Currently, Madera County GSA is the only GSA in the subbasin requiring demand management as one of its planned management actions. This economic impact analysis quantifies the effect of that demand

[1] The analysis uses relatively simple assumptions to relate changes in sales and income to changes in local tax revenues. See Indirect and Induced Economic Impact of Madera Subbasin Demand Management below for further discussion.

management. In order to provide context for the magnitude of the direct impact, it is shown relative to acreage and agricultural revenue in the entire Madera Subbasin. The analysis does not address demand management that may occur in other GSAs. It also does not include the economic impact of water supply and recharge projects that will be implemented, nor the impact of additional fees or assessments needed to fund the implementation plan.

The economic impact analysis quantifies direct impacts (changes in farm revenue, acreage, and crop mix in the Madera Subbasin) and indirect and induced impacts (changes in jobs, value added, income, and taxes) to Madera County. Direct economic impacts are quantified using an economic model[3] of Madera Subbasin agriculture that represents crops, water use, and market conditions in the area. The economic model quantifies the effect of changes in water supply availability and cost on farm income (e.g. net income and gross farm revenues) and simulates how the agricultural sector would respond to changes in water availability and cost. Responses include switching to higher value and/or lower water use crops, idling land, and adjusting other farm practices. Indirect and induced (also called "multiplier" or "secondary") impacts are estimated using default, uncalibrated IMPLAN model data for Madera County that quantify the linkage between agriculture and all other industries in the area. Key assumptions for the analysis include the following:

- Implementation of the demand management program specified in the GSP begins in 2020 and only applies to the Madera County GSA[4]. Demand management is implemented as a reduction in the consumptive demand for irrigation water by crops.
- The analysis is specific to the Madera Subbasin and does not consider the impact of additional demand management in the Chowchilla or Delta Mendota Subbasin portions of Madera County that may occur.
- The yield, operations, and cost of new supply and recharge projects are not considered in this analysis. The cost of administering the GSP, including annual and periodic 5-year updates, is also not included in the analysis. These projects and GSP administration costs would increase the cost of water in the Madera Subbasin, with additional economic impacts to the local economy.
- No specific mechanism for imposing or inducing demand reduction is assumed (and the analysis does not include any additional costs for developing/implementing such a program). Mechanisms could include a mix of incentive programs, easements, and groundwater markets. An economic model of Madera Subbasin agricultural production, water use, and crop markets previously applied to the GSP is used to estimate how the agricultural sector would allocate the demand reduction among crops. The model does not assume that the reduction must be met by land idling; rather, it predicts the mix of crop switching, production changes, and land idling that would achieve the needed reduction at minimum cost to growers.
- The analysis also evaluates impacts to the Madera County economy in terms of value added, employment, labor income, and tax revenue. These effects are estimated using default,

[3] The economic model of Madera Subbasin agriculture was calibrated during development of the GSP and applies a similar economic methodology as the Statewide Agricultural Production Model (SWAP) that has been widely applied by DWR, Reclamation, and others to evaluate the effect of changes in water supply on agricultural operations. It is tailored to market conditions, costs, returns, and water supply in Madera County and Madera Subbasin GSAs.

[4] As described in the Joint GSP, all the other GSAs were able to reach sustainability by implementing projects without the need for demand reduction.

uncalibrated data in an IMPLAN model of Madera County that was previously applied to the GSP.

Direct impacts are estimated for the years 2020 - 2040. The impacts occurring in 2040 reflect full implementation of demand management and could continue over the entire planning horizon (through 2090). These impacts are quantified by comparing results of the economic analysis with and without demand management. Annual direct impacts are reported in current (2019) dollars. Annual impacts vary in this analysis because the demand management program is implemented gradually, allowing time for the agricultural sector, its workers, and related economic activities to adjust in order to minimize impacts to Madera County residents. Since impacts occur over a period of 20 years, the stream of annual costs is also reported in present value. Estimates of indirect and induced impacts to Madera County are shown for a single point-in-time, based on the difference in annual gross agricultural revenues prior to GSP implementation (current conditions) and at full GSP implementation (2040). The combined economic analysis quantifies:

- The current value of crops produced in Madera County and the contribution of farming to the regional economy
- Change in crop mix and fallowing resulting from demand reduction specified in the Joint GSP
- The direct economic impact of the demand management program to Madera County
- Changes in gross and net farm income by crop type
- Secondary impacts to value added, labor income, and employment in Madera County using uncalibrated IMPLAN model data
- Estimated local tax impact using uncalibrated IMPLAN model data

Economic Contribution of Agriculture to Madera County Economy

Farming in Madera County is characterized by high-value, specialty crops produced for a wide range of domestic and export markets. This includes a mix of nut crops, vineyards, and a strong local dairy industry. New orchards have been established in most GSAs in the subbasin over the last several years. Consistent with broader market trends in California, the value of Madera County agriculture has been increasing over the last several decades in response to strong market conditions for many of the crops produced in the county. This economic activity supports the local economy, providing jobs, income, and tax revenue for the benefit of Madera County residents.

The Madera County economy produces approximately $6.1 billion per year in economic value added[5] and supports around 63,000 full-time-equivalent (FTE[6]) jobs. As of the 2010 U.S. Census, per-capita income was approximately $20,435 (in current dollars), or about 35% below the U.S. average of $31,895. Approximately 21% of the county population of 150,000 was at or below the poverty line, compared to

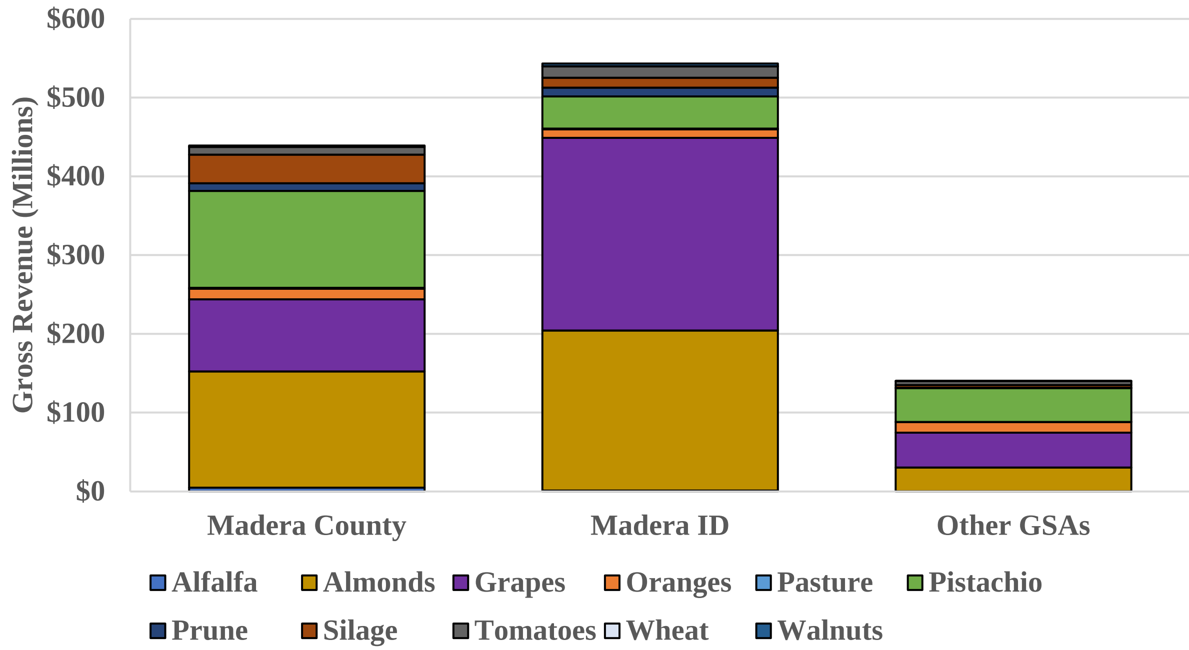
[5] Value added is a measure of the size of the Madera County economy that is analogous to the commonly cited measure of the U.S. economy, Gross Domestic Product (GDP).

[6] An FTE job is approximately equivalent to 2,080 hours of work. An FTE typically includes multiple (2-3) seasonal jobs, which is an important consideration for the farming industry where most jobs are seasonal. The total number of seasonal jobs in Madera County is significantly greater than 63,000 FTE.

the U.S. average of 12%. Over 75% of the county (by area) is classified as a Disadvantaged Community (DAC)[7].

A significant share of the Madera County economy is from farming or agriculture-related industries within the Madera Subbasin. It follows that a significant share of jobs and wage income for DACs in the county is linked to farming and related industries in the area. The gross revenue of crops (excluding dairy and livestock) produced in Madera Subbasin currently exceeds $1.2 billion dollars. Figure 1 illustrates the breakdown of revenue by crop in Madera County GSA, Madera Irrigation District GSA, and all other GSAs. The majority of crop revenue comes from the Madera County GSA and the Madera ID GSA. Permanent crops (vines and orchards) account for roughly 85% of agricultural value in the subbasin. Field crops account for roughly 7% of agricultural value, including silage which is a high-value input to the economically important dairy industry in the subbasin. Dairy and other animal products contribute the remaining 8% of agricultural value[8] in the subbasin (not shown in Figure 1) .

Figure 1. Madera Subbasin Gross Crop Revenues (excluding dairy and livestock), by GSA



Source: Calculations using USDA data, adjusted for subbasin conditions and indexed to current dollars.

The Joint GSP includes demand management in the Madera County GSA, which accounts for approximately 40% of applied water in the Madera Subbasin. Table 1 summarizes acreage and gross value of agriculture. As shown, Madera County GSA accounts for approximately 40% of irrigated acreage and 39% of gross revenue in the Madera Subbasin. Average crop revenue per acre is similar to the subbasin average of $5,000 per acre, which is slightly above the state average of $4,500 per acre.

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[7] Using the Department of Water Resources (DWR) DAC Mapping Tool.

[8] Dairy industry values are estimated using uncalibrated IMPLAN model data.

Table 1: Madera County GSA and Subbasin Acreage and Value

	Acres	Gross Crop Revenue ($M)	Revenue Per Acre
Madera County GSA	87,700	$439.1	$5,000
Madera Subbasin	218,400	$1,122.7	$5,100
Share	***40%***	***39%***	***97%***

Farming and agriculture-related industries in the Madera Subbasin generate multiplier effects in the Madera County economy. Growers purchase inputs from regional suppliers, employ workers, and rely on local trucking, storage, processing, and related businesses for post-harvest activities. Transportation, storage, processing, and other businesses purchase trucks, warehouses, machines, and hire workers required for their operations. The economic cluster of agriculture-dependent industries generates jobs in farming and other industries, and employees in all these related industries purchase housing, consumer items, and other goods and services in Madera County. Demand management in the Madera County GSA will have significant implications for farming, and ancillary jobs, taxes, and businesses in the region.

Direct Economic Impact of Madera Subbasin Demand Management

Implementation of demand management in the Madera Subbasin starts in 2021. Full implementation occurs by 2040, resulting in a net reduction in crop water use of 90,000 acre-feet per year at that time. The glide-path implementation timeline specified in the Joint GSP helps reduce and delay economic impacts to the Madera Subbasin and Madera County by allowing for continued depletion of groundwater storage over a period of twenty years. During the years 2021 – 2025 groundwater pumping will be reduced by about 1,800 acre-feet annually (i.e., by 1,800 acre-feet in 2021, by 3,600 acre-feet in 2022, etc.). From 2026-2040 groundwater will be reduced by an additional 5,400 AF each year to reach the full 90,000 acre-feet of demand reduction needed for sustainability by 2040. The net effect of the demand management program is to reduce crop evapotranspiration of applied water (ETAW) to approximately 65% of current levels. Figure 2 illustrates the phase-in of demand reduction specified in the Joint GSP and the reduction in ETAW.

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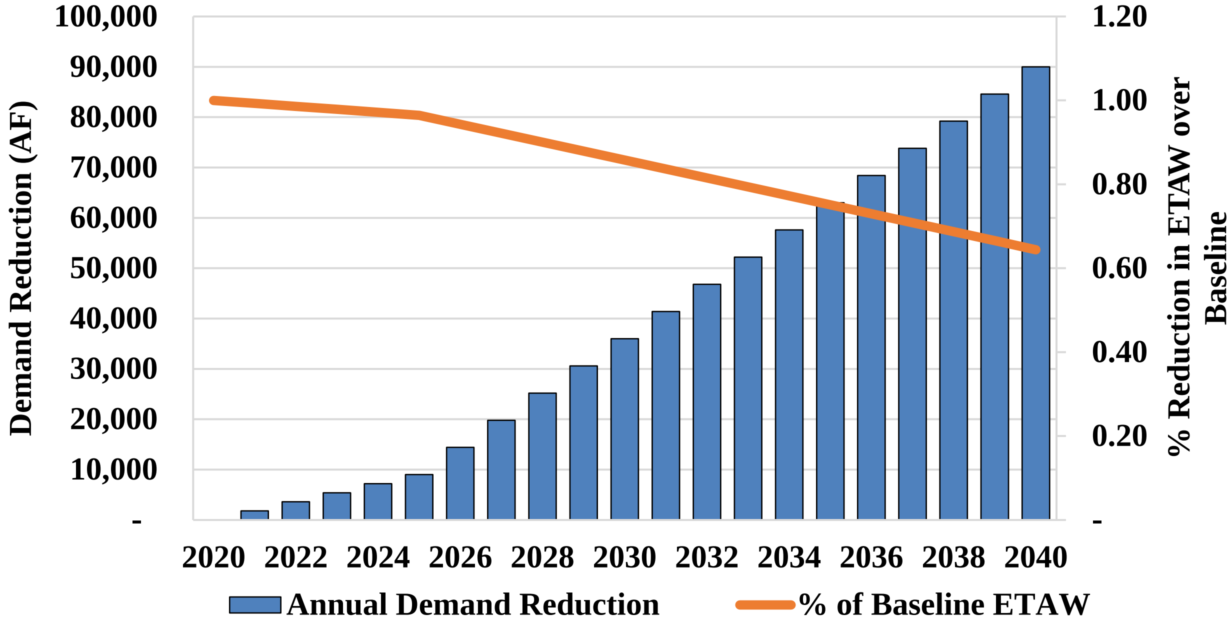
Figure 2. Madera Subbasin Demand Management Implementation Timeline



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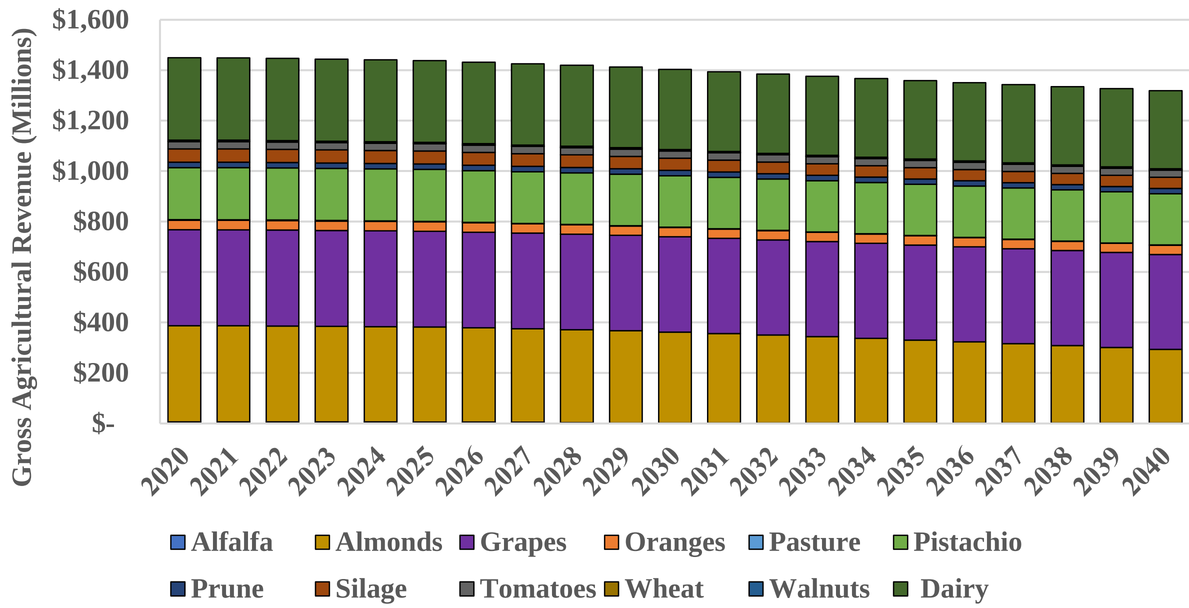
The average annual direct economic impact (loss of gross revenue) attributable to demand management in the Madera Subbasin equals $53.5 million. This is a decrease of 3.7% in the Madera Subbasin relative to current conditions. Annual losses increase gradually over the implementation period as the scale of the demand management program increases. Annual gross revenue losses equal $130.4 million in 2040, or approximately 9% of gross revenue in the entire Madera Subbasin. The present value of the stream of gross revenue losses over the 20-year implementation timeline equals $682 million dollars. The impacts are greatest to the nut industry (which has the largest share of acreage) and hay/silage production sectors. Changes in feed production also impact the local dairy industry. Table 2 summarizes the results of the analysis for major crop and dairy sectors in Madera County. The economic impact does not include the additional cost of stranded investments, such as orchards and dairies, remaining at the end of the implementation period.

Table 2. Average Annual Direct Economic Impact to Madera Subbasin

Agricultural Sector	Current	Average Annual Impact		2040 Impact	
	Gross Farm Revenue	Gross Farm Revenue Loss	% Chg.	Gross Farm Revenue Loss	% Chg.
Dairy	$326	($8.7)	-2.7%	($16.8)	-5.1%
Almonds & Pistachios	$588	($32.8)	-5.6%	($92.9)	-15.8%
Other Deciduous	$64	($1.2)	-1.8%	($2.0)	-3.1%
Grapes	$380	($2.2)	-0.6%	($3.7)	-1.0%
Misc. Row Crops	$30	($0.4)	-1.3%	($0.7)	-2.2%
Hay & Silage	$61	($8.2)	-13.6%	($14.4)	-23.7%
Total	$1,449	**($53.5)**	-3.7%	**($130.4)**	-9.0%

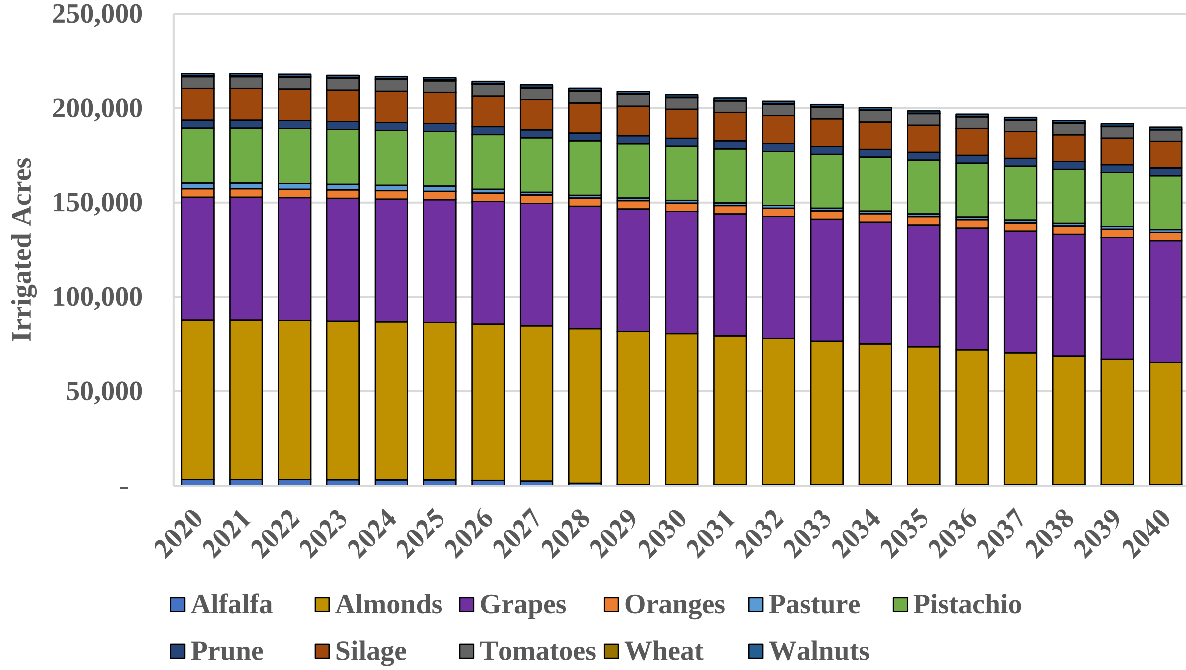
The impact of the demand management program is not distributed evenly across all crops in the Madera Subbasin. Impacts increase gradually over the implementation period. Figure 3 illustrates the change in gross crop revenue in the Madera Subbasin during the GSP implementation period.

Figure 3. Madera Subbasin Gross Agricultural Revenue Timeline, 2020 – 2040



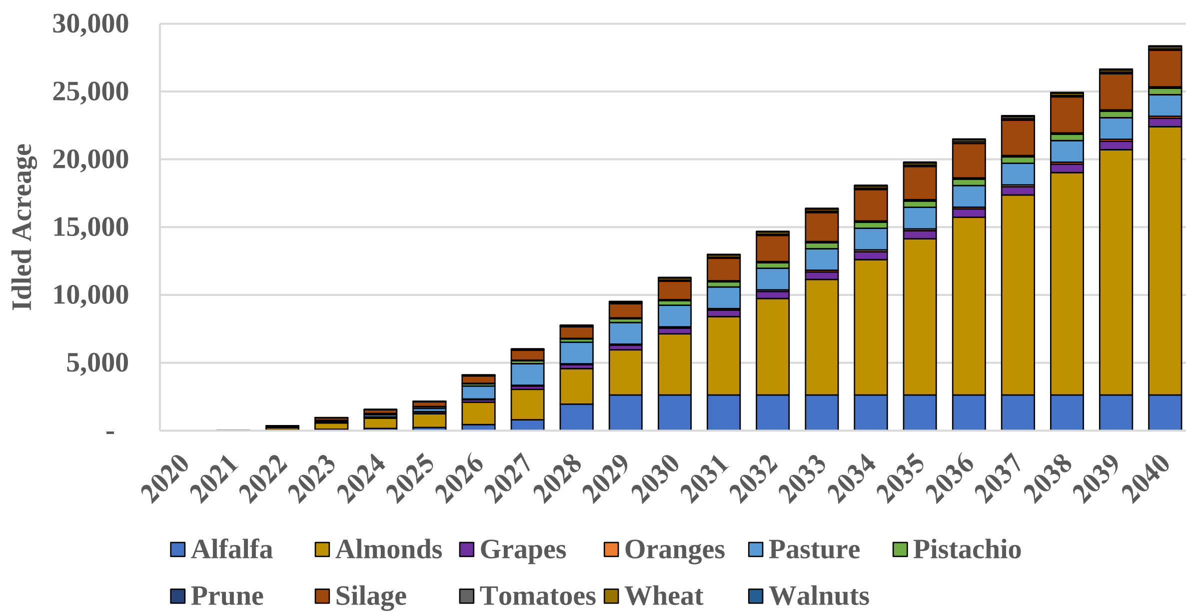
At full implementation, demand management requires a total of 28,400 acres idled in the Madera Subbasin, or approximately 13% of current irrigated acreage. This reduction takes place gradually - on average an additional 1,350 acres will be idled every year. Impacts are greatest to crops that generate lower returns per unit water. This includes a mix of alfalfa, pasture, and miscellaneous grains that require high water use but provide low returns relative to other crops in the subbasin. Given the magnitude of the demand management program (over 90,000 acre-feet per year by 2040), high-value nut crops would also be affected, with approximately 19,800 acres (23%) of Madera Subbasin almond orchards idled. Figure 4 and 5 illustrate the change in irrigated acreage in the Madera Subbasin during the GSP implementation period.

Figure 4. Madera Subbasin Irrigated Acreage by Crop, 2020 – 2040



The impact of demand management includes a mix of crop switching and land idling. Figure 5 illustrates land idling by crop type over the implementation period. At full implementation in 2040, the total of 28,400 acres idled would continue in perpetuity.

Figure 5. Madera Subbasin Idled Acreage by Crop, 2020 – 2040



In summary, the direct economic impact of the demand management program at full implementation in 2040 is to reduce applied water by approximately 15%, acreage by 13%, and gross revenue by 9%. The reductions in land and revenue are estimated to be proportionally less severe than the percent reduction in water use. As the Joint GSP is implemented, crops having higher water use per acre, or generating lower returns to water, tend to be idled first and growers switch to other crops. Implementing demand reduction in the Madera Subbasin reduces average applied water per acre from approximately 3.00 AF under current conditions to 2.92 AF by 2040. Over the implementation period, gross crop revenue rises from about $5,140 per acre in 2019 to $5,310 per acre by 2040, reflecting a shift to crops that generate a greater return to water.

Indirect and Induced Economic Impact of Madera Subbasin Demand Management

The direct impacts of demand management in the Madera Subbasin cause important secondary impacts to jobs, wages, and tax revenues in the Madera County economy. As growers reduce water use by adjusting crops grown and idling land, purchases of inputs to production, such as seed, machinery, fertilizers, fuel, and other services decrease. In turn, demand for farm labor and jobs in the industries that depend on agriculture also decrease. Therefore, spending by businesses and individuals directly and indirectly employed in these industries is affected by demand management.

A version of the Impact Analysis for Planning (IMPLAN) model data used in Joint GSP analyses is applied to quantify indirect and induced effects resulting from the primary direct impacts. IMPLAN uses county-level summaries of tax information to estimate spending flows between industries. Based on these relationships, it can be used to estimate indirect and induced effects in Madera County caused by direct changes in the Madera Subbasin as a result of the demand management program. However, the default IMPLAN model is based on transactions between industries at an aggregate level, such as fruit farming or grain farming, and may not accurately represent some of the unique aspects of specialty crop farming in Madera County. The default IMPLAN model and data are applied in this analysis to provide a general sense of the magnitude of impacts in Madera County[9]. Table 3 summarizes the total economic impacts to Madera County.

The direct economic impact (gross revenue loss) of demand management in the Madera Subbasin equals $130.4 million per year at full implementation (2040). This direct loss in crop revenue causes farming input purchases to fall by $10.4 million dollars per year as growers increase land idling. As a result, wages and jobs in farming and related industries decrease, and expenditures by workers in Madera County falls by $21.5 million per year. The total impact of demand management in the Madera Subbasin to Madera County equals $162.2 million per year in 2040. The present value of the annual reductions in economic activity due to SGMA during the implementation period (2020-2040) equals $3.3 billion.

The impact of $162 million represents a reduction in direct, indirect, and induced gross output value. The impact can also be measured as a net economic impact to Madera County. The measure of net economic impact is value-added, which is analogous to the measure of Gross Domestic Product (GDP). The direct impact of $130.4 million causes value added losses of $116 million per year[10]. Including multiplier effects, the net impact of demand management in the Madera County GSA equals $134.8 million per year in value added. This is the net reduction in the overall size of the Madera County economy as a result of

[9] A re-calibrated version of IMPLAN coupled with more refined county data would better represent Madera County agriculture and is recommended for more detailed analysis to support planning and implementation efforts.
[10] Value-added is a different way of measuring impact. It should not be added to the gross value impacts.

demand management in the Madera County GSA. The present value of this stream of losses over the implementation period equals $2.7 billion.

Demand management causes labor income (wages) for farm workers and employees in related industries to decrease by a total of $52.9 million per year. The present value of this stream of losses equals $1.1 billion. This reduction translates to an estimated loss of 575 FTE jobs in the county. The majority of these jobs are seasonal farm labor jobs. Typically, one full time equivalent job translates to 2-3 seasonal farm jobs. Therefore, the impact on total number of seasonal jobs in Madera County is between 1,200 and 1,800 jobs[11].

Table 3. Madera County Total Economic Impact Summary, 2040, ($ Millions)

Impact Type	Employment	Labor Income	Value Added	Gross Output (Revenue)
Direct	(295)	($42.2)	($116.0)	($130.3)
Indirect	(130)	($4.5)	($6.7)	($10.4)
Induced	(145)	($6.2)	($12.2)	($21.5)
Total Effect	**(575)**	**($52.9)**	**($134.8)**	**($162.2)**

Tax revenues to local governments would fall as agricultural production falls and business activity slows across the region. IMPLAN uses relatively simple assumptions to relate changes in sales and income to changes in local tax revenues. The actual impact on local taxes, especially property taxes, is complex due to California tax law and the divergence between agricultural land's market value and its assessed value. The uncalibrated IMPLAN model estimates that the average annual impact of a $134.8 million contraction in the Madera County economy will cause a decrease of approximately $1.4 million dollars in local tax revenue, or approximately $28.6 million dollars in present value. The loss in tax revenue reflects local revenue to the County and to cities and special districts in the County. These local government agencies provide important services that would be impacted as revenues fall. This would affect the ability of agencies to cover operating costs for public services and will create additional ripple effects in the County economy that are not evaluated in this initial impact analysis.

Summary

Demand management to achieve the sustainability objectives specified in the Joint GSP will limit the quantity of water available for farming in the Madera Subbasin. This will impact land use in the region, the mix of crops grown, and gross agricultural revenues. In turn, this affects purchases in other Madera County businesses.

Conclusions of the economic impact analysis:

- Demand management in the Madera Subbasin would cause direct farm revenue losses of $130 million and require idling 28,300 acres per year at full implementation.
- The total impact to the Madera County economy is a reduction in value added of $134.8 million per year at full implementation.

[11] Job estimates based on labor income can underestimate the true number of employed farm workers. "Employment and Earnings of California Farmworkers in 2015" by Martin et al. (California Agriculture, 2017) estimates that one full time equivalent job supports 2-3 seasonal farm jobs in California.

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- FTE jobs decrease by approximately 575 per year. This equates to between 1,200 and 1,800 seasonal jobs in Madera County. Total labor income (wages) income falls by $52.9 million per year. Many of these jobs and income support DACs in the county.
- The impact to the Madera County economy would cause a decrease of approximately $1.4 million dollars per year in local tax revenue. The loss in tax revenue reflects local, discretionary revenue to the County. This discretionary spending supports important services in the County that will be impacted as revenues fall.

Limitations:

- The analysis only considered the effect of demand management in the Madera County GSA. Other impacts caused by changes in groundwater levels, fees or assessments needed to cover GSP administrative costs, or projects implemented by other GSAs are not considered. This would increase economic impacts.
- Demand management is a planned management action in the Madera County GSA within the Madera Subbasin. Demand reduction may occur in other portions of Madera Subbasin or Madera County as a result of GSP implementation or due to unforeseen changes in future groundwater conditions. These additional economic impacts were not evaluated.

Potential methods to reduce economic impacts:

- Madera Subbasins sustainability criteria are related to the physical objectives of avoiding six undesirable results of groundwater overdraft. Meeting these objectives is only possible if pumping is reduced in some areas, such as the Madera County GSA, resulting in economic impacts in the Madera Subbasin and broader Madera County economy. This economic impact analysis provides preliminary estimates of the cost of demand management. The analysis can be refined to evaluate alternative implementation plans and demand management mechanisms to reduce economic costs and still achieve sustainability.
- The economic analysis developed for this memorandum indicates intra- and inter-regional variability in the value of water (although that result was not the primary focus of this memorandum). This suggests potential gains from trading between water users within and between GSAs (allowing water to move to its highest and best use).
- The pumping reductions specified in the demand management program are implemented at an almost constant rate over time (with one change after five years). That is, the same two percentage reductions are applied every year regardless of conditions in the basin. A more flexible reduction regime could allow deviations in the rate of reduction in order to, for example, take advantage of high crop prices over a year or two, so long as the reduction reverts to overall trend. Allowing flexibility for growers to increase pumping above the sustainable yield in some years, so long as it is replenished in future years, could mitigate some of the losses associated with demand management.
- The concept of groundwater allocations is implicit to this analysis. Effective and enforceable demand management requires that growers know ahead of time what their allocations will be. How allocations are developed and assigned affects the distribution of costs between groundwater pumpers as well as the overall implementation costs to the local economy. A careful economic analysis of alternative allocation approaches using the framework applied in this analysis could identify ways to reduce overall GSP implementation costs.

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