REGULAR MEETING OF THE
ROOT CREEK WATER DISTRICT
GROUNDWATER SUSTAINABILITY AGENCY

AGENDA

will be held on
Monday, October 14, 2024
11:00 a.m.
(or immediately following the Root Creek Board of Directors meeting)
at the Lodge at Riverstone
370 Lodge Road
Madera, CA 93638

1. **CALL TO ORDER**

2. **ADDITIONS TO THE AGENDA**
(The Board may add an item to the agenda if, upon a two-thirds vote, the Board finds that there is a need for immediate action on the matter and the need came to the attention of the District after the posting of this Agenda).

3. **PUBLIC COMMENT**
Members of the public may address the Board on any matter related to the District that is not included on the Agenda. Comments are limited to five (3) minutes per person.

4. **POTENTIAL CONFLICT(S) OF INTEREST**
(Any Board member who has a potential conflict of interest may now identify the item and recuse himself or herself from discussing and voting on the matter).

5. **MINUTES**
   a. Review and consider action to accept the minutes from the meeting on September 9, 2024.

6. **Staff Report**
   a. Facilitation Services – Madera Subbasin/RCWD Application
   b. Madera Joint GSP Corrective Actions Presentation

c. RCWD GSP Update and Periodic Review
d. Correspondence from Dept. of Water Resources May 31, 2024 to Madera Basin GSAs RE: Annual Reports

7. CORRESPONDENCE

(Members of the Board or Staff may provide comment on any timely matter related to the District that is not included on the agenda).

8. STAFF REPORT

a. **Facilitation Services –** Review and consider action to act as the applicant for grant funds on behalf of the Madera Subbasin for Facilitation Services funded through the Department of Water Resources.
b. Other items as needed

9. ADJOURN

▪ Items on the Agenda may be taken in any order.
▪ Action may be taken on any item listed on the Agenda.
▪ Writings relating to open session Agenda items that are distributed to members of the Board of Directors will be available for inspection at the District office, excluding writings that are not public records or are exempt from disclosure under the California Public Records Acts.
▪ ACCOMMODATIONS FOR PERSONS WITH DISABILITIES
A person with a qualifying disability under the Americans With Disabilities Act of 1990 may request the District to provide a disability-related modification or accommodation in order to participate in any public meeting of the District. Such assistance includes appropriate alternative formats for the agendas and agenda packets used for any public meetings of the District. Requests for such assistance and for agendas and agenda packets shall be made in person, by telephone, or by written correspondence to the District at (559) 970-8778 or P.O. Box 27950, Fresno, California 93729, at least 48 hours before a District meeting.

Department of Water Resources
Facilitation Support Services Application

The Department of Water Resources (DWR) is offering Facilitation Support Services (FSS) to help GSAs and local water management groups foster discussions among diverse water management interests and jurisdictions in support of Sustainable Groundwater Management Act (SGMA) implementation.

For questions or assistance with this FSS Application, contact Christina Boggs-Chavira at Christina.Boggs@water.ca.gov or (916) 384-6061.

I. Applicant Background: *(Questions 1-6 of 17)*

* **1) Select the groundwater basin/subbasin that is requesting FSS:**

SAN JOAQUIN VALLEY - MADERA (5-022.06)

* **2) Enter applicant information:**
Applicant Name: Root Creek Water District
Point of Contact: Julia Berry
Phone Number: 559-283-8011
Email Address: julia@rootcreekwd.com

* **3) Is the applicant affiliated with a GSA?**
Which GSA is the applicant affiliated with, or if not affiliated with a GSA, briefly describe how the request for professional facilitation will aid SGMA implementation for the groundwater basin/subbasin identified above, and how the applicant plans to work with the GSAs.

Yes, affiliated with a GSA

Root Creek Water District GSA

* **4) Please provide a brief narrative discussion on the applicant's current involvement, roles, and responsibilities regarding SGMA implementation activities located within the groundwaterbasin/subbasin.**

The GSA is actively engaged with other subbasin GSAs to prepare both a Periodic Evaluation and Plan Amendment, aimed at addressing the 6 corrective actions as identified in DWRs December 21, 2023 GSP approval letter. The GSA is also engaged with developing a Subbasin wide Domestic Well Mitigation Program, revision of the current Coordination Agreement, and future methods to improve multi-GSA engagement regarding SGMA implementation.

* **5) What other professional facilitation funding or services has the applicant received from the State?**

- [x] **None**
- [ ] **DWR Prop 1**
- [ ] **DWR Prop 68**
- [ ] **DWR Facilitation Support Services**
- [ ] **State Water Resources Control Board**
- [ ] **Other** *(please specify)*

6) Please explain the scope of any active professional facilitation.

Through a prior application by Madera Irrigation District, an FSS agreement was in place to support: 1) completion of a Subbasin Assessment (and associated summary document and recommendations to improve multi-GSA functions and engagement; 2) Interest-based Negotiation and Consensus Building; 3) Intra-Based Coordination Support, 4) Public Outreach.

II. Collaboration within and across Groundwater Basin/Subbasin Boundaries: *(Questions 7-10 of 17)*

* **7) List all GSAs (and/or other water management entities) within the groundwater basin/subbasin that the applicant is currently collaborating with, or intends to collaborate with, on SGMA implementation:**

City of Madera GSA, Madera County GSA, Madera Irrigation District GSA, Madera Water District GSA, Gravelly Ford Water District GSA, New Stone Water District GSA, Root Creek Water District GSA

* **8) Are there any GSAs (and/or other water management entities) *across* the groundwater basin/subbasin boundary, that the applicant currently is, or intends to collaborate with, on SGMA implementation?**

The various GSAs defined in question 7 coordinate with Delta-Mendota, Chowchilla, and Kings.

* **9) Please discuss the nature of collaboration. What are the GSAs collaborating on?**

As per recommendations from the Subbasin Assessment, the GSAs will benefit from: facilitation/mediation of focused discussions to ensure shared understanding about needs and interests, facilitation/of Guiding Principles, facilitation/mediation to review/revise the Coordination Agreement (CA) and/or Prepare a GSA Charter or some similar document that guides future shared approaches and decision-making. Use Guiding Principles / Charter (or revised CA) to guide all discussions for the Plan Amendment and Periodic Evaluation. In addition to the Assessment recommendations, the GSA are also using a facilitator to finalize a Subbasin Domestic Well Mitigation Program (DWMP). This is currently supported by a separate DWR grant (SB 552) to the County of Madera and the facilitator/mediator that prepared the Assessment and is recommended for this application, is already supporting that work.

* **10) Which beneficial uses and users of groundwater has the applicant established a venue for engagement, or plans to establish a venue for engagement?(List all applicable uses and users of groundwater – see Water Code Section 10723.2)**

Holders of overlying groundwater rights, including:
(1) Agricultural users, including farmers, ranchers, and dairy professionals.
(2) Domestic well owners.
(b) Municipal well operators.
(c) Public water systems.
(d) Local land use planning agencies.
(e) Environmental users of groundwater.
(f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.
(g) NOT APPLICABLE The federal government, including, but not limited to, the military and managers of federal lands.
(h) California Native American tribes.
(i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.

III. Facilitation Needs: *(Questions 11-14 of 17)*

* **11) Please explain the key challenges the applicant has encountered that has led to the need for professional facilitation.**

As described in the Subbasin Assessment report, long-standing interpersonal relationships; political dynamics; resource investments, availability and limitations (e.g. financial, water, land, etc.) have influenced past conditions in the Subbasin with less than collaborative results at times. These conditions pre-date SGMA but it is clear that compliance with SGMA, in concert with increased general competition for water, urban growth, and the increasingly volatile nature of the agricultural economy has exacerbated these historical conditions and inhibits the GSA's effectiveness to be collaborative. The passage of SGMA, combined with the accelerated time frame the Subbasin faced as a Critically Overdrafted Basin, resulted in the organizations that became the GSAs to "dive in" to the specifics of problem solving. Lost in that immediate reaction was an awareness that SGMA created a dynamic that required more collaboration. In this context, the need to build more effective collaborative tools was given less attention because the immediate need was to comply with initial requirements of SGMA. The GSAs have been challenged ever since and agree that they will benefit from "developmental facilitation that supports building better tools to build durable and sustainable collaborative conditions.

* **12) DWR's FSS program requires applicants to have a well-defined goal for the requested services. What is the applicant's goal for professional facilitation?**

As noted above and in the Subbasin Assessment, the GSAs moved rapidly into a state of SGMA problem solving, working to a large degree as independent entities. They wish to now build necessary tools to help create future effective discussions and collaborative problem solving. These are operational tools that were not created in the early steps of SGMA and this has hampered the GSA's effectiveness in mutual problem solving.

* **13) Which facilitation support services are you seeking?** *(select all that apply)*

- [ ] **Stakeholder assessment**
- [ ] **Tribal government outreach and engagement**
- [ ] **Meeting facilitation**
- [x] **Intra-basin and inter-basin coordination support**
- [x] **Interest-based negotiations/consensus building**
- [ ] **Stakeholder communication and engagement planning and support**

- [x] **Public and stakeholder outreach**
- [x] **Governance development**
- [ ] **Targeted outreach to underrepresented groundwater users - Severely disadvantaged communities/ disadvantaged communities**
- [ ] **Targeted outreach to underrepresented groundwater users - Private domestic well owners**
- [ ] **Targeted outreach to underrepresented groundwater users - Small growers**
- [ ] **Targeted outreach to underrepresented groundwater users - Communities on small water systems**
- [ ] **Targeted outreach to underrepresented groundwater users - Other** ***(please specify)***

14) Regarding SGMA implmentation activities, is there any additional information you would like to provide that professional facilitation will help support?

See above

IV. Applicant's Commitments: *(Questions 15-16 of 17)*

* **15) DWR requires ALL of the following commitments from applicants benefiting from DWR's FSS program. Please review and select the commitments you agree to:**

- [x] **Commit to meet regularly and work diligently toward a clear and defined goal.**
- [x] **Agree to work in an open, inclusive, and collaborative manner toward SGMA implementation.**
- [x] **Support an inclusive process that encourage and welcomes involvement of all stakeholders and interested parties.**
- [x] **Commit to providing a meeting space that is suitably located and sized.**

Is there any additional information you would like to add?

16) Are there any other considerations DWR should take into account?

The GSAs are very appreciative of the initial FSS investment to support the Subbasin Assessment and the role those outcomes have already played to inform the GSA's mutual work. The GSAs are eager to complete the recommendations from the Assessment and to enhance their work together.

V. Anticipated Tasks and Timeline: *(Questions 17 of 17)*

17) Please summarize anticipated tasks, deliverables, and completion dates to be completed with support of DWR FSS.
(Applicants can use the text box or attach files below.)

The GSAs have an immediate need to update and ratify their CA since that agreement sunsets on December 31, 2024. The GSAs (through the DWMP) will soon start work on reconciling differences regarding that Program. Likewise, the GSAs' technical staff are working on both a Plan Amendment and Periodic Evaluation and will have that completed no later than January 31, 2025. In support of that target, the GSAs seek facilitation support on Guiding Principles and some form of mutual work document such as a Charter, MOU or MOA.

Introduction

This document summarizes draft text edits for the Madera Subbasin Joint Groundwater Sustainability Plan (GSP) suggested for the Plan Amendment to address corrective and additional actions recommended by the California Department of Water Resources (DWR).

Please note that there are some references (to tables, figures, sections, or appendices) that still need to be inserted and updated.

Corrective Action 1

DWR Feedback: *Not all GSAs that are a part of the Joint GSP have adopted the Plan. Add language to the Joint GSP explaining that all GSAs have all adopted the Joint GSP and are committed to implementing it consistent with SGMA.*

New or Revised GSP Text: The Joint GSP covers the extent of the Madera Subbasin (Subbasin) which is managed by the four Joint GSP GSAs: CM GSA, MC GSA, MID GSA, and MWD GSA. The four Joint GSP GSAs collectively adopted and submitted the initial Joint GSP in January 2020, and later revised and resubmitted the Joint GSP in March of 2023 (March 2023 Revised GSP) to address deficiencies identified by DWR and incorporate new information made available since 2020. As documented in the March 2023 Revised GSP, the MID GSA took action to approve the First Amendment to the Madera Subbasin Coordination Agreement and the Memorandum of Understanding Establishing a Domestic Well Mitigation Program for the Madera Subbasin of the San Joaquin Valley Groundwater Basin, but did not take action to approve the March 2023 Revised GSP. On April 16, 2024 and as documented in MID GSA Resolution NO. 2024-GSA01, the MID GSA took action to approve and adopt the March 2023 Revised GSP. To date, all four Joint GSP GSAs have taken action to approve the March 2023 Revised GSP.

Corrective Action 2

DWR Feedback: *The GSAs must continue to coordinate to eliminate areas of disagreement.*

New or Revised GSP Text:

<u>Introduction</u>

Since original GSA formation, subsequent GSP development, completion of the March 2023 Revised GSP, and now through GSP implementation and the Plan Amendment and Periodic Evaluation process, the GSAs in the Subbasin have committed to continued coordination in an effort to eliminate areas of disagreement. Despite multiple GSPs in the Subbasin, the GSAs have worked continuously over the last several years to seek consensus, striving to bring consistency across the 4 GSPs where possible and eliminating contradictory policies, procedures, and methodologies. The following sub-sections seek to efficiently and accurately detail continued coordination activities being undertaken by the GSAs in the Subbasin since the Fall of 2023, prior to DWRs approval of the March 2023 Revised GSP on December 21, 2023.

Facilitation Support Services (FSS) Grant

Understanding the importance of continued coordination and prior to approval of the March 2023 Revised GSP by DWR on December 12, 2023, the GSAs in the Subbasin were the recipient of a Facilitation Support Services Grant (FSS Grant) from DWR. The Implementation Service Plan (ISP) included assistance in the nine categories listed below.

1. Stakeholder Assessments
2. Governance Development
3. Stakeholder Communication and Engagement Planning and Support
4. Public and Stakeholder Outreach
5. Targeted Outreach to Underrepresented Groundwater Users
6. Tribal Government Outreach and Engagement
7. Meeting Facilitation
8. Intra-Basin and Inter-Basin Coordination Support
9. Interest-Based Negotiation

The original contract for the FSS Grant was held by the MID GSA on behalf of the Subbasin (DWR Contract #4600013267). Upon FSS Grant receipt, the GSAs in the Subbasin embarked on a robust and detailed Stakeholder Assessment. The final Stakeholder Assessment is included herein as Appendix XXX. Since completion of the initial Stakeholder Assessment, the RCWD GSA has taken over the contract for the FSS Grant and continued facilitation and coordination is currently focused on 4 of the 9 categories listed above; (1) Governance Development (Coordination Agreement modification(s)), (2) Stakeholder Communication and Engagement Planning and Support, (3) Interest-Based Negotiation, and (4) Meeting Facilitation. A primary focus during Plan Amendment has modification of the Coordination Agreement. Engagement in activities stemming from the FSS Grant have been broadly supported by the GSAs and continued facilitation support services in the Subbasin will continue to be a valuable component of GSP implementation.

DWR Grant for SB 552 Compliance

The MC GSA has been awarded $125,000 grant from DWR to assist with Senate Bill 552 (SB 552) compliance. The grant has two main components; (1) installation of a new monitoring well in the Ranchos and (2) facilitation and related services, in connection with the Domestic Well Mitigation Program (Program). Related to component 2, the MC GSA has contracted with David M. Ceppos to provide neutral, stakeholder engagement and consultation support to the MC GSA regarding implementation of a Program in the Madera Subbasin with a specific focus on developing rules of said Program. Specific tasks include the following.

1. Conduct Background Review
2. Conduct Engagement Strategy Discussions
3. Conduct Stakeholder Interviews
4. Design and Conduct Program Public Meetings
5. Project Management

Following development of the Memorandum of Understanding Establishing a Domestic Well Mitigation Program for the Madera Subbasin of the San Joaquin Valley Groundwater Basin (MOU) and execution by

5 of the 7 GSAs within the Subbasin, this is a critical and necessary step in advancing a well-functioning and Subbasin-wide Program. For purposes of the 2025 Plan Amendment, it is assumed that the facilitation and related services associated with the Program as set-forth above will result in complete development of the Program such that implementation can begin in 2025 as set-forth and agreed upon in the MOU.

MCSim Groundwater Model

As detailed in Section 5.2.1 of the 2025 Plan Amendment, significant updates have been made to the MCSim Groundwater Model (MCSim Model) for the Madera and Chowchilla Subbasins. Importantly, and aside from the technical updates, the MCSim Model continues to be supported broadly by the GSAs in the Subbasin and serves as a uniform and consistent basis for development of GSA water budgets, future subsidence estimates, and establishment of SMC. Refinements to the MCSim Model as detailed herein were reviewed and discussed in great detail during development of the 2023 Revised GSPs and 2024 Plan Amendment and Periodic Evaluation Processes and have streamlined the GSAs responses to many of the corrective actions identified by DWR in their December 21, 2023 GSP approval letter. Moving forward the MCSim Model will be updated on a five-year interval and diligently used by the GSAs in the Subbasin as a predictive tool to aid in siting of planned and proposed Projects and Management Actions (PMAs) and evaluation of the benefit of implementated PMAs, in addition to broader management of the Subbasin.

GSA Technical Meetings

Since development of the 2023 Revised GSPs and serving at the direction of each GSA, the technical teams for each GSA (or group of GSAs in the case of the Joint GSP) have continued meeting on a regular basis. As part of the 2024 Plan Amendment, the technical teams for each GSA have met on a bi-weekly or weekly basis to discuss methodologies and preferred technical approaches for addressing DWRs identified deficiencies. To date, the GSA technical teams have met XX times. Meeting agendas are developed collaboratively and as reflected in each of the four Plan Amendments, these technical team meetings have served as the basis for reaching consensus and ensuring consistent policies, procedures, and methodologies and ultimately, consistent groundwater management across the Subbasin.

Corrective Action 3

DWR Feedback: *The GSAs must revise the GSP to include a discussion of the relationship between the SMC for chronic lowering of groundwater levels and the other sustainability indicators, including an explanation of how the SMC, including IMs, were established to avoid undesirable results for each of the other sustainability indicators.*

New or Revised GSP Text:

Relationships Between Groundwater Levels and Subsidence

Subsidence in the San Joaquin Valley has been attributed to groundwater level declines (and associated reduced pore pressure) within the groundwater system at depths below the Corcoran Clay in the Lower Aquifer. This association between conditions in the Lower Aquifer and subsidence has been observed nearby in the vicinity of Mendota in data from extensometer and continuous GPS monitoring coupled with groundwater level monitoring. This data suggests that most of the subsidence in the area is occurring at depths below the Corcoran Clay and correlates with declining groundwater levels in the Lower Aquifer (LSCE, 2015). This relationship has also been observed in other parts of the San Joaquin Valley (Lees et al., 2022) and has been attributed to a combination of the confined conditions in the Lower Aquifer in which small changes in storage can translate to large pressure changes along with the presence of a higher fraction of fine-grained sediments.

There is limited historical data available for the Subbasin with which to evaluate the relationship between subsidence and water levels. Spatial subsidence data are available from 2012 through present, but very limited data exist prior to 2012 in the Subbasin and the most data for the period since 2012 are not available as continuous data. Most available time-series subsidence monitoring in the Subbasin started in 2012 as part of USBR monitoring associated with the San Joaquin River Restoration Program. InSAR data has been available since 2015. Furthermore, long-term groundwater level data for comparing with subsidence monitoring are also limited in availability and often have not occurred at or near the same locations as historical subsidence monitoring. Together, the limited availability of wells with long-term historical groundwater level monitoring data and the absence of known construction information in the vicinity of locations where historical subsidence monitoring has occurred, make comparisons between historical water levels and subsidence challenging.

Using the limited available data, to evaluate the relationship between groundwater levels and subsidence, time-series point data available from SJRRP benchmarks were compared with water levels in nearby well with historical water level monitoring. **Figure 2-Xa** presents a map with callout graphs illustrating time-series subsidence and water level data at paired SJRRP subsidence benchmark locations and nearby wells. Many wells have limited construction information for confirming their depth and screened interval, and there are a range of relationships between groundwater levels and subsidence are apparent in the graphs on **Figure 2-Xa**, which vary by location and well depth. Some of the graphs on **Figure 2-Xa** indicate groundwater levels declining in the Lower Aquifer and continued subsidence over the same period, suggesting that declining Lower Aquifer water levels may be related to ongoing subsidence. However, many other graphs indicate that subsidence has continued even during periods when water levels in the Lower Aquifer have remained stable or recovered, potentially indicating that ongoing subsidence is not a result of current declines in groundwater levels in the Lower Aquifer.

Additional comparison of water levels and subsidence were conducted by extracting time-series subsidence data from DWR's TRE ALTAMIRA InSAR dataset at points where existing historical water level monitoring has occurred, although the length of the historical monitoring record (only since 2016) and temporal resolution of the DWR InSAR subsidence data are limited. Raster data from the DWR InSAR data were extracted at points for selected wells chosen based on period of record, availability of construction data, and location within areas of interest for subsidence. **Figure 2-Xb** presents a map of the locations where these comparisons were made with graphs comparing groundwater level and subsidence trends. Because of the limited period of record for these comparisons, it is difficult to identify any strong associations between water levels and subsidence. While some locations exhibit apparent relationships between declining water levels and the rate of subsidence, many other locations suggest there is no clear relationship between water levels and subsidence. Notably, subsidence continues even when water levels are stable or recovering at many locations. Such continued subsidence during periods when Lower Aquifer water levels remains stable may be a result of the delayed effects of residual subsidence caused by historically low groundwater levels that are not mitigated by the more recent stabilization or raising of groundwater levels. Residual subsidence resulting from historical conditions has been observed in many areas of the San Joaquin Valley and is discussed below.

Chronic Lowering of Groundwater Levels

MOs and interim milestones for chronic lowering of groundwater levels are described below.

Measurable Objectives

MOs for groundwater levels were established in accordance with the sustainability goal through review and evaluation of measured groundwater level data, to the extent available, and simulated historical groundwater levels derived from the Madera-Chowchilla Groundwater-Surface Water Simulation Model (MCSim) (**Appendix 6.D**). MOs for groundwater levels were set at Fall 2010 groundwater elevations, which represent Subbasin conditions prior to the drought period from 2012 to 2015, and are a target average condition for long-term sustainable groundwater management in the Subbasin. The MOs define an average sustainable groundwater level condition with the understanding that levels will fluctuate somewhat around the MO during the Sustainability Period (starting in 2040). The MO values at all groundwater level representative monitoring site (RMS) wells were set based on observed Fall 2010 groundwater elevation data, when available. In cases where observed Fall 2010 groundwater elevation data were not available, simulated Fall 2010 groundwater elevation values were used to determine the MO, with consideration for offsets between historically observed and simulated groundwater elevations at each RMS.

MOs for groundwater levels for each sustainability indicator well or RMS are summarized in **Table 3-2**, and locations of groundwater level sustainability indicator wells are shown in **Figure 3-1**[1]. These MOs are set specific to aquifer zones designated as Upper Aquifer (above the Corcoran Clay where present, and equivalent depth to the east where Corcoran Clay is not present) and Lower Aquifer. Groundwater level hydrographs showing MOs for each groundwater level sustainable indicator well are provided in **Appendix 3.A.**

Interim Milestones

Interim milestones (IMs) for chronic lowering of groundwater levels were established at five-year intervals over the GSP implementation period from 2020 to 2035, at years 2025, 2030, and 2035. IMs for groundwater levels were established through review and evaluation of measured groundwater level data and future projected fluctuations in groundwater levels during the GSP implementation period utilizing the numerical groundwater flow model, which simulated implementation of projects and management actions. IMs were set at the Fall 2024, 2029, and 2034 simulated water levels for 2025, 2030, and 2035, respectively. Offsets between historically observed and modeled data were accounted for, as needed, based on Fall observed and modeled groundwater levels. IMs for groundwater levels for each RMS are summarized in **Table 3-3**, and locations of groundwater level RMS are shown in **Figure 3-1**.

[1] Figure titles that are bolded can be found at the end of each chapter.

Impact of Groundwater Level IM on Groundwater Quality

Background and Previous Studies

The relationship between changes in groundwater levels and groundwater quality is difficult to quantify due to the many additional variables that may be involved and may affect historical trends between levels and quality (e.g., variability in recharge quantities, land surface management activities). However, some studies have been conducted that document investigations into how TDS, nitrate, and arsenic may be affected by fluctuations in groundwater levels, and are summarized in the following paragraphs.

TDS: A study of a project area in Poland (Blaszyk and Gorski, 1981) suggests that TDS increases can occur via introduction of oxygen to the hydrogeochemical environment during pumping, which oxidizes sulfur compounds to produce acid the increases solubility of various chemical compounds, thereby leading to potential for increases in TDS. A USGS (2018) study concluded that TDS concentrations in San Joaquin Valley have increased by an average of about 100 mg/L in the last 100 years. This increase in TDS was attributed primarily to irrigated agricultural activities at the land surface and associated recharge of irrigation water. While the primary cause of overall increases in TDS was attributed to land surface activities (and not changes in groundwater levels), the study concluded that declining groundwater levels from municipal and agricultural pumping served to cause shallow groundwater with higher TDS to migrate vertically downward. The study further concluded that continued municipal and agricultural pumping will likely lead to higher TDS concentrations in deeper groundwater in the future.

Nitrate: A USGS study (Levy et.al., 2021) indicated the detection frequency of high nitrate (defined as greater than 5 mg/L as N in the study) in the San Joaquin Valley that was episodically higher during droughts and superimposed on a long-term upwards trend. Wells with long-term nitrate records indicate a tendency for lower concentrations during wet periods such as 1993-1999, 2010-2011, and 2016-2017. The study goes on to suggest that drought/overdraft conditions with declining groundwater levels may cause higher concentrations of nitrate in the shallower zone to migrate vertically downward to enter well screens in deeper zones, thereby resulting in overall contribution of a higher proportion of modern high nitrate groundwater to wells as groundwater levels decline.

Arsenic: A Stanford study (Smith et.al., 2018) suggests higher arsenic concentrations residing in clay layers within aquifers (interbeds) may be released in association with groundwater pumping that causes compaction of clay layers. Another USGS study (Haugen, et.al., 2021) found both increasing and decreasing trends in arsenic: decreasing arsenic trends associated with groundwater pumping contributing younger more toxic groundwater, and increasing arsenic trends associated with higher pH and more reduced groundwater. More reduced groundwater tended to be associated with deeper wells along the San Joaquin Valley trough where aquifer materials are more fine-grained (favoring reducing conditions). A study by USGS and CDC (Lombard et.al., 2021) for domestic wells across the U.S. found an inverse relationship between precipitation and arsenic concentrations (decreasing precipitation tends to correlate with increasing arsenic concentrations) but a positive relationship between groundwater recharge and arsenic concentrations (i.e., increasing recharge correlates to increasing arsenic concentrations). The inverse relationship between precipitation and arsenic concentrations was interpreted to be related to climate regimes and pattern of higher arsenic concentrations in arid regions. They suggested the positive relationship of recharge and arsenic concentrations may be a function of reductive desorption and/or dissolution of arsenic from iron oxides, and/or a flushing of arsenic into groundwater with increased recharge. Regardless of the physical mechanism, the association of increased rainfall with increased recharge would tend to mean these two variables act in opposition to each other.

GSP Actions Related to GWL Decline and Potential GW Quality Impacts

Project and management activities being conducted by the GSAs, as described in **Sections 4** and **5** of this GSP, are expected to help slow and potentially reverse groundwater level declines and minimize potential impacts of groundwater level IMs on groundwater quality as summarized below:

1) The GSAs are working diligently to implement PMA to minimize future groundwater level declines and subsidence, which should serve to reduce the possibility for impacts to groundwater quality.
2) More specifically, minimizing future water levels declines is expected to:
   a) Minimize the opportunity for greater contribution of water to deep screened wells from deeper reduced sediments that may have higher arsenic concentrations. Reduced sediments (typically blue to gray in color) tend to be more prevalent at deeper depths compared to shallower depths where more oxidized sediments (typically brown, yellow, tan, red colors) tend to be present. In general, maintaining a greater proportion of water flowing into a well from shallower sediments would tend to result in lower arsenic concentrations;
   b) Minimize the opportunity for a greater contribution of shallow groundwater with higher nitrate concentrations to deeper screened production wells due to vertical downward migration of this water;
   c) Minimize the potential for increasing TDS concentrations that some studies suggest may occur with declining groundwater levels; and
   d) Reduce the possibility for impacts to groundwater quality from general groundwater level declines while also reducing the amount of water with potentially higher arsenic concentrations that is being derived from compaction of interbed clay layers.
3) Available data indicate groundwater quality is generally relatively good with respect to TDS concentrations, provided wells are not screened below the base of fresh water previously defined by USGS (Page, 1973; **Figure 2-18**). There are no studies indicating significant changes in TDS concentrations with modest groundwater level fluctuations. However, to the extent that some wells in the subbasin may tap into areas or vertical depth zones with somewhat elevated existing TDS concentrations, the SMC used in the GSP for groundwater quality will serve to minimize future increases in concentrations.

Impact of Groundwater Level IM on Subsidence

Background

The total subsidence that may occur in the future is a combination of active subsidence caused by groundwater level declines to new lows and residual subsidence that may occur due to previous groundwater level declines from undeveloped (no pumping) conditions. The portion of total subsidence that occurs with any further groundwater level declines during the GSP implementation period prior to groundwater level stabilization and potential recovery with attainment of sustainable conditions would generally be associated with the active subsidence component.

GSP Actions Related to GWL Decline and Potential Subsidence Impacts

Project and management activities being conducted by the GSAs, as described in Sections 4 and 5 of this GSP, are expected to help slow and potentially reverse groundwater level declines and minimize potential impacts of groundwater level IMs on subsidence. The potential impact of establishment of the groundwater level IM for this GSP that result in new lows can be estimated from use of the IWFM subsidence package that was recently incorporated into the MCSim Model update (**Appendix 6D**). The relatively good calibration of the updated MCSim Model to recent active subsidence since 2012 allows for model estimation of the active subsidence component that may occur at the established groundwater level IM. These estimates of future active subsidence, which generally occurs around 2030 based on assumed hydrology and PMA, are estimated to range up to one foot as shown in **Figure 3-X**. Additional subsidence at the groundwater level IM range from negligible along the San Joaquin River along the southern subbasin boundary to 0.5 feet over the middle portion of the subbasin and a maximum of about one foot in the northwest portion of the subbasin. The amount of subsidence described above is within the estimated tolerance of approximately two feet discussed in **Section X**.

While the above description provides our best estimate of groundwater level IM impact on subsidence, it should be noted that residual subsidence (which is more difficult to predict) may be a significant component of total subsidence that would occur without any further groundwater level decline. Thus, even if the groundwater level IM were not set any lower than lows that have already occurred (generally 2022), residual subsidence would still be expected to occur during the GSP implementation period. More discussion of residual subsidence is provided in **Chapter 2** and **Appendix 6E**.

<u>Impact of Selected Measurable Objectives on Adjacent Basins</u>

The MOs established for Plan Area provide a good basis for evaluation of anticipated impacts on adjacent subbasins from implementation of the GSP. This is because MOs are set to reflect the expected average groundwater levels to be maintained during the sustainability period. Ultimately, the potential for impacts on adjacent subbasins will be primarily a function of average water levels in Plan Area during the sustainability period, average water levels in adjacent subbasins during the sustainability period, and natural groundwater flow conditions that would be expected to occur at Plan Area boundaries (e.g., pre-development groundwater flow conditions). The average groundwater levels expected for the Plan Area are reflected in the MOs. As indicated in the individual RMS hydrographs in **Appendix 3.A**, the MOs are higher than the MTs. MOs set for Madera Subbasin are based on Fall 2010 groundwater elevations, which is consistent with proposed Chowchilla Subbasin MOs and generally higher than MOs proposed in Delta Mendota Subbasin and higher than DWR approved MOs in Kings Subbasin. In addition, groundwater model results indicate that the anticipated groundwater levels after 2040 will result in greatly reduced net subsurface inflow to the Plan Area from surrounding subbasins compared to historical net subsurface inflow. Therefore, the projects and management actions implemented for this GSP are expected to benefit adjacent subbasins (compared to historical conditions) and not hinder the ability of adjacent subbasins to be sustainable.

Table 3-2. Summary of Groundwater Level Measurable Objectives for Representative Monitoring Sites.

Well I.D.	Estimated Surface Elevation (msl, feet)	Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation[1]	MO Depth[2] (feet)	MO Elev (msl, feet)	GSA[3]	CASGEM Well?
COM RMS-1	278	520	210 - 510	4	Lower			City of Madera	No
COM RMS-2	262	590	370 - 590	5	Lower			City of Madera	No
COM RMS-4	268	588	433 - 568	4	Lower			City of Madera	No
MCE RMS-2	378	Unknown	Unknown	3	Upper			Madera County East	Voluntary
MCE RMS-3	325	Unknown	Unknown	6	Lower			Madera County East	Voluntary
MCE RMS-5	340	Unknown	Unknown	4	Lower			Madera County East	Voluntary
MCE RMS-6	328	550	450 - 550	5	Lower			Madera County East	CASGEM
MCE RMS-9	265	37	17 - 37	1	Upper			Madera County East	No
MCW RMS-3	162	Unknown	Unknown	6	Lower			Madera County West	Voluntary
MCW RMS-5	197	30	Unknown	1	Upper			Madera County West	No
MID RMS-2	218	563	298 - 509	5	Lower			Madera Irrigation District	CASGEM
MID RMS-3	241	516	260 - 507	4	Lower			Madera Irrigation District	CASGEM
MID RMS-4	190	698	320 - 667	5	Lower			Madera Irrigation District	CASGEM
MID RMS-5	204	570	270 - 570	5	Lower			Madera Irrigation District	CASGEM
MID RMS-6	237	680	320 - 680	5	Lower			Madera Irrigation District	CASGEM
MID RMS-7	237	656	290 - 635	5	Lower			Madera Irrigation District	CASGEM
MID RMS-10	213	615	315 - 615	5	Lower			Madera Irrigation District	CASGEM
MID RMS-11	232	315	Unknown	3	Upper			Madera Irrigation District	CASGEM
MID RMS-12	262	176	Unknown	3	Upper			Madera Irrigation District	CASGEM
MID RMS-13	271	600	228 - 552	3	Composite			Madera Irrigation District	CASGEM
MID RMS-15	247	502	160 - 200	2	Upper			Madera Irrigation District	CASGEM
MID RMS-16	308	452	348 - 388	4	Lower			Madera Irrigation District	CASGEM
MID RMS-17	224	47	26 - 46	1	Upper			Madera Irrigation District	No
MSB03B	148	295	215 - 285	3	Upper			Madera County	No
MSB03C	148	430	355 - 420	4	Lower			Madera County	No

Well I.D.	Estimated Surface Elevation (msl, feet)	Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation[1]	MO Depth[2] (feet)	MO Elev (msl, feet)	GSA[3]	CASGEM Well?
MSB04B	271	695	530 - 685	4	Lower			Madera County	No
MSB05A	177	210	140 - 200	3	Upper			Madera County	No
MSB05B	177	375	240 - 365	4	Lower			Madera County	No
MSB06A	192	350	135 - 340	3	Upper			Madera County	No
MSB06C	192	715	630 - 705	5	Lower			Madera County	No
MSB09C	233	955	880 - 945	5	Lower			Madera County	No
MSB10C	251	880	790 - 870	5	Lower			Madera County	No
MSB11C	306	880	775 - 870	5	Lower			Madera County	No
MSB12	350	465	355 - 465	4	Lower			Madera County	No
MWD RMS-1	330	504	200 - 500	4	Lower			Madera Water District	CASGEM
MWD RMS-2	310	537	200 - 537	4	Lower			Madera Water District	CASGEM
MWD RMS-3	295	800	380 - 800	5	Lower			Madera Water District	CASGEM

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

[2] The actual MO is based on the groundwater elevation, but the depth to water corresponding to the surface elevation in the project database is also provided.

[3] Each GSA is responsible for collecting groundwater levels for the sustainability indicator wells within their GSA area.

Table 3-3. Summary of Groundwater Level Interim Milestones for Representative Monitoring Sites.

Well I.D.	Aquifer Designation	2025 Depth (feet)	2030 Depth (feet)	2035 Depth (feet)	2025 Elev (msl, feet)	2030 Elev (msl, feet)	2035 Elev (msl, feet)	CASGEM Well?
COM RMS-1	Lower							No
COM RMS-2	Lower							No
COM RMS-4	Lower							No
MCE RMS-2	Upper							Voluntary
MCE RMS-3	Lower							Voluntary
MCE RMS-5	Lower							Voluntary
MCE RMS-6	Lower							CASGEM
MCE RMS-9	Upper							No
MCW RMS-3	Lower							Voluntary
MCW RMS-5	Upper							No
MID RMS-2	Lower							CASGEM
MID RMS-3	Lower							CASGEM
MID RMS-4	Lower							CASGEM
MID RMS-5	Lower							CASGEM
MID RMS-6	Lower							CASGEM
MID RMS-7	Lower							CASGEM
MID RMS-10	Lower							CASGEM
MID RMS-11	Upper							CASGEM
MID RMS-12	Upper							CASGEM
MID RMS-13	Composite							CASGEM
MID RMS-15	Upper							CASGEM
MID RMS-16	Lower							CASGEM
MID RMS-17	Upper							No
MSB03B	Upper							No
MSB03C	Lower							No
MSB04B	Lower							No
MSB05A	Upper							No
MSB05B	Lower							No
MSB06A	Upper							No
MSB06C	Lower							No
MSB09C	Lower							No
MSB10C	Lower							No
MSB11C	Lower							No
MSB12	Lower							No
MWD RMS-1	Lower							CASGEM
MWD RMS-2	Lower							CASGEM
MWD RMS-3	Lower							CASGEM

Relationship to Other Sustainability Indicators

Groundwater elevation MTs can influence other sustainability indicators. The groundwater elevation MTs were set to avoid undesirable results for other sustainability indicators as described below.

1. Reduction in groundwater storage. A significant and unreasonable condition for change in groundwater storage is pumping groundwater in excess of the sustainable yield for an extended period of years during the Sustainability Period. Pumping at or less than the sustainable yield will maintain or raise average groundwater elevations in the Plan area. The groundwater elevation MTs are set at Fall 2015 groundwater elevations, consistent with avoiding long-term declines in groundwater storage. Therefore, management of the Subbasin according to the groundwater elevation MTs established for this GSP will not result in significant or unreasonable long-term change in groundwater storage.
2. Subsidence. A significant and unreasonable condition for land subsidence is measurable permanent (inelastic) subsidence that significantly damages existing infrastructure. Inelastic subsidence is caused by reduction in pore pressure and compaction of clay-rich sediments in response to declining groundwater levels. There have been small amounts of land surface elevation fluctuation/subsidence that have been recorded across the Plan area; however, these levels of recent historical fluctuation/subsidence have not yet resulted in any known significant impacts to infrastructure. Nonetheless, a rate of 0 feet/year MT for subsidence has been set for the Subbasin to avoid potential future subsidence impacts as well. The groundwater level MT set equal to Fall 2015 groundwater levels is consistent with the subsidence MT established for the Subbasin.
3. Degraded water quality. Protecting groundwater quality is critically important to all who depend upon the groundwater resource, particularly drinking water and agricultural uses. A significant and unreasonable condition of degraded water quality is exceeding regulatory limits for constituents of concern in wells due to actions proposed in the GSP. Water quality could be affected through three processes:
    a. Low groundwater elevations in an area could cause deeper, poor-quality groundwater to flow upward into existing wells. Groundwater elevation MTs are generally set well above depths to reduced sediments that may provide poorer quality water with respect to naturally occurring constituents (e.g., arsenic), thereby minimizing opportunities for poor quality groundwater flowing into wells. To the extent that temporary declines during the GSP implementation period may result in domestic wells previously below the arsenic MCL to be above the MCL as a direct result of declining groundwater levels after 2020, a proposed Domestic Well Mitigation Program would help to address this issue (**Appendices 3.D and 3.E**). Therefore, the combination of the groundwater elevation MTs and Domestic Well Mitigation Program will avoid poor-quality water (resulting directly from GSP actions) from impacting existing wells.
    b. Changes in groundwater elevation as a result of PMAs implemented to achieve sustainability could change groundwater gradients, which could cause poor quality groundwater (i.e., contaminant plumes) from documented contaminant sites to flow towards wells that would not have otherwise been impacted. These groundwater gradients, however, are dependent on differences between groundwater elevations, not in the groundwater elevations themselves. Therefore, the MT for groundwater elevations do not directly lead to significant and unreasonable degradation of groundwater quality in wells. Although distributed areas of degraded groundwater quality from non-point

source contamination exist in the Plan area (most notably elevated nitrate concentrations), there are no current documented large-scale contaminant plumes of concern in the regional groundwater aquifers. Smaller localized and shallow contaminant site plumes have been documented in parts of the Plan area, although these contaminants are generally restricted to very shallow depths above the regional aquifer system. RWQCB files for existing and potential new documented contaminant site plumes will be reviewed every five years for potential changes in contaminant movement that may be related to GSP PMAs, and adaptive management implemented as necessary.

c. GSP PMAs include a number of recharge basins and Flood MAR programs that will recharge surface water available in wet years through the vadose zone (unsaturated zone about the regional water table) to the water table. Such PMAs have the potential to flush existing constituents of concern (i.e., TDS, nitrates) from the vadose zone to the water table. While such flushing has been occurring and will continue to occur naturally (e.g., via rainfall recharge, excess irrigation recharge) without such GSP PMAs, it may be the case that GSP PMAs temporarily increase the rate of vadose zone flushing and result in temporarily higher constituent concentrations in groundwater prior to eventual dilution (due to recharge of higher quality water) and a reduction in these constituent concentrations. Overall, it is anticipated that there will likely be an overall net benefit to groundwater quality from GSP PMAs; however, the overall groundwater monitoring program developed for this GSP plus additional site-specific monitoring if determined to be needed (e.g., additional groundwater or potentially soil sampling), will be utilized to evaluate need for adaptive management related to GSP recharge projects.

4. Depletion of interconnected surface waters. The assessment of surface water flows and groundwater levels indicate that there are likely time periods with interconnected surface waters in the Plan area. Interim sustainable management criteria for ISW have been established for the San Joaquin River based on the percent of time historical groundwater elevations at key Upper Aquifer RMS wells near the San Joaquin River reflect direct connection between groundwater and the San Joaquin River. The interim MT for interconnected surface water requires that the future percent of time with connected between surface water and shallow groundwater be maintained. Therefore, the MT for interconnected surface water is consistent with the groundwater elevation MTs being equal to historical Fall 2015 groundwater elevations.

Impact of Selected Minimum Thresholds to Adjacent Basins

The potential for impacts on adjacent subbasins will primarily be a function of average water levels in the Plan area during the sustainability period, average water level in adjacent subbasins during the sustainability period, and natural groundwater flow conditions that would be expected to occur along subbasin boundaries (e.g., pre-development groundwater flow conditions). The average groundwater levels expected for the Plan Area are reflected in the MOs. Therefore, the impact to adjacent subbasins is primarily described under the section on MOs. With regard to MTs, the Madera Subbasin set MTs at Fall 2015 groundwater levels, which is consistent with proposed groundwater level MTs in Chowchilla and Delta Mendota Subbasins. Kings Subbasin was approved by DWR with groundwater level MTs lower than Fall 2015 groundwater levels. Thus, Madera Subbasin MTs are consistent with or beneficial to adjacent subbasins and will not hinder their ability to achieve their own MTs.

Description of Monitoring Network *(23 CCR § 354.34)*

This subsection on the monitoring network is intended to:

- Describe how the monitoring network is capable of collecting sufficient data about groundwater conditions to evaluate GSP implementation
- Describe monitoring network objectives
- Describe how monitoring network demonstrates progress towards achieving MOs, monitors impacts to beneficial uses/users, monitors changes in groundwater conditions, and quantifies annual changes in water budget components
- Describe how monitoring network allows documentation of groundwater occurrence, flow, and hydraulic gradients, calculation of annual groundwater storage change, rate and extent of subsidence, and groundwater quality trends
- Describe how monitoring network provides adequate coverage of sustainability indicators
- Describe monitoring network density and measurement frequency
- Describe monitoring network site selection rationale
- Describe data and reporting standards
- Provide map(s) with location and types of monitoring sites

The GSP groundwater level monitoring network was initially developed using existing wells in the Plan Area. The database for existing wells was reviewed with the following criteria in mind:

- CASGEM wells preferred;
- Known construction (screen intervals, depth) preferred;
- Long histories of water level data (including recent data) preferred;
- Relatively good match between observed and modeled water levels preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Plan Area) and Lower Aquifers preferred.

As part of the First Plan Amendment, a comprehensive review of the RMS network was conducted, and the network was updated as necessary. Notable in this update of the monitoring network is the inclusion of dedicated monitoring wells that have been drilled as part of the Joint GSP implementation. A detailed discussion of wells removed and added to the network as part of this evaluation is presented in **Appendix XXX**.

To the extent possible, the network was composed of wells known to represent either the Upper or Lower Aquifer, but not screened in both. However, this was not always possible due to need to consider all the criteria above. Matching of modeled to observed data was used to some extent to initially assign wells with unknown construction details to a given aquifer. The network will enable the collection of data to assess sustainability indicators, the effectiveness of management actions and projects to achieve sustainability, and evaluate the MOs and MTs of each applicable sustainability indicator (i.e., chronic lowering of groundwater levels, reduction in groundwater storage, and degraded water quality). The Subbasin is isolated from the Pacific Ocean and is not threatened by seawater intrusion; therefore, this Joint GSP does not provide monitoring for the seawater intrusion sustainability indicator. For depletion of interconnected surface waters, available data indicate that streams in the Plan Area do not have direct connections to the regional groundwater system; therefore, this Joint GSP does not provide monitoring for the surface water depletion sustainability indicator.

As described above, for the purposes of the GSP monitoring program, a subset of wells was identified that best meet certain criteria. Not all the criteria were satisfied for each well, but this effort resulted in 37 wells to represent the Plan Area, with 10 wells in the Upper Aquifer and 26 wells in the Lower Aquifer, and 1 composite well – referred to as the representative monitoring sites. Due to incomplete well construction information for some of these wells, the portion of the aquifer being monitored could not be determined with certainty for all wells, but was initially classified based on match to model results where construction data is unknown.

These wells are distributed throughout the Plan Area to provide coverage of the entire area to the extent possible. This coverage generally allows for the collection of data to evaluate groundwater gradients and flow directions over time and the annual change in storage over most of the Plan Area for the Lower Aquifer. The spatial coverage for the Upper Aquifer is currently limited to the southwestern portion of the Plan Area due to availability of existing wells and the general lack of Upper Aquifer saturation in the eastern portion of the Plan Area (installation of nested monitoring wells by 2020 is expected to expand the area of coverage for the Upper Aquifer). Furthermore, the monitoring frequency of the representative monitoring sites will allow for the monitoring of seasonal highs and lows. For wells that have relatively long historical data records, future groundwater data will be able to be compared to historical data. The monitoring network is expected to evolve over time as new wells are drilled and water level data histories are developed (included DWR grant funded nested monitoring wells to be installed by 2020). The monitoring network will be periodically reviewed and improvements made where possible.

<u>Groundwater Level Monitoring Program</u>

The MTs and MOs for the chronic lowering of groundwater levels sustainability indicator are evaluated by monitoring groundwater levels. The SGMA regulations require a network of monitoring wells sufficient to demonstrate groundwater occurrence, flow direction and hydraulic gradients between principal aquifers and surface water features. The overall proposed monitoring network for groundwater levels, comprised of wells monitored for CASGEM, by GSAs, and by USBR is provided in **Appendices 3.A and 3.J**.

The objectives of the groundwater level monitoring program include the following:

- Improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, especially in areas where short- and long-term development of groundwater resources are planned;
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation), irrigation, and surface water seepage to groundwater or recharge PMAs (recharge basins, Flood MAR) that affect groundwater levels and trends;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater Subbasin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

The overall groundwater level monitoring network is summarized in **Appendix 3.J**. **Figures 3-7** and **3-8** illustrate the locations of the wells selected as representative monitoring sites for monitoring of groundwater levels in the Upper and Lower Aquifers, respectively (composite wells are included in **Figure 3-9**). **Tables 3-15** and **3-16** list the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the Upper and Lower Aquifer, respectively. Similar information for composite wells is provided in **Table 3-17**.

In order to assist GSAs with the preparation of their GSP's, DWR released a series of best management practices. The best management practices document for monitoring networks provides guidance on determining an appropriate number of monitoring wells for a given area. The method developed by Hopkins (1984) was applied to the Plan Area. This methodology states that for districts pumping more than 10,000 acre-feet/year per 100 square miles, they should have four monitoring wells for every 100 square miles. The Madera Subbasin area occupies an area of approximately 543 square miles, yielding 22 monitoring wells. Subtracting the areas of the three GSAs not included in this Joint GSP yields an area of approximately 509 square miles and minimum of 20 monitoring wells. This number was taken to be the minimum number of monitoring wells for the Plan Area and additional wells were added based on informational needs resulting from management actions and historical trends in groundwater levels. This Joint GSP includes a total of 37 RMS. The selection rationale for all water level monitoring wells is summarized in **Tables 3-15** through **3-17**.

Corrective Action 4

DWR Feedback: *Land subsidence-related updates:*

- *Refine the description of URs:*
    - *Clearly describe the significant and unreasonable conditions the GSAs are managing the Subbasin to avoid.*
    - *Reevaluate the quantitative metrics that define a UR, considering:*
        - *Localized subsidence conditions and the irreversibility of continued inelastic subsidence, especially in an area deemed of "greater subsidence concern."*
        - *The current quantitative metrics (i.e., 75 percent of RMS) would not minimize or avoid inelastic subsidence in the most susceptible areas of the Subbasin – predominantly in the north-northwestern portion of the Subbasin.*
- *Identify the cumulative amount of subsidence that, if exceeded, would substantially interfere with groundwater and land surface beneficial uses and users in the Subbasin.*
    - *Explain how the rate and extent of any future subsidence permitted in the Subbasin may interfere with surface land uses.*
    - *Describe the current and potentially lasting impacts of subsidence on land uses and groundwater beneficial uses and users.*
- *Revise the GSPs to include a discussion of the relationship between the SMC for land subsidence and the other sustainability indicators, including an explanation of how the SMC, including IMs, were established to avoid undesirable results for each of the other sustainability indicators.*
- *Reevaluate or eliminate the application of the level of uncertainty as it relates to subsidence measurements (i.e., clarify SMC so that subsidence can't continue into perpetuity).*

- *Describe PMAs that will be implemented to minimize or eliminate subsidence (with details/schedule).*

New or Revised GSP Text:

Sustainable Management Criteria

This chapter of the Joint GSP provides a discussion of the sustainable management criteria (SMC), including the sustainability goals, measurable objectives (MOs), interim milestones, minimum thresholds (MTs), undesirable results, and the monitoring network for each sustainability indicator within the Joint GSP Plan Area. The SMC described in this chapter were developed and updated during GSP Revisions in 2022-2023 and again during a Plan Amendment in 2024 through an extensive and collaborative coordination process between the four Joint GSP GSAs (Madera County, Madera Irrigation District, Madera Water District, and the City of Madera) and the three other GSAs in the Subbasin (Root Creek Water District, Gravelly Ford Water District, and New Stone Water District). Coordination efforts have resulted in SMC that are consistent across all four GSPs in the Subbasin.

This is the fundamental chapter that defines sustainability in the Subbasin; it addresses significant regulatory requirements and updates to the chapter since the original GSP addressing DWR's identified deficiencies and corrective actions from their GSP review. The MOs, MTs, and undesirable results presented in this chapter define the future sustainable conditions in the Subbasin, and commit the Joint GSP GSAs to actions that will achieve the Subbasin sustainability goal and avoid undesirable results.

The Sustainable Groundwater Management Act (SGMA) defines "sustainable groundwater management" as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" [CWC §10721(v)]. The "planning and implementation horizon" is defined as "a 50-year time period over which a groundwater sustainability agency determines that plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield" [CWC §10721(r)]. The 50-year planning and implementation horizon in the Madera Subbasin begins after the GSP implementation period ends in 2040. Prior to 2040, the GSAs are implementing PMAs, monitoring, and other efforts described in the GSP to achieve and maintain sustainable groundwater management. However, it is possible that groundwater conditions may temporarily exceed MTs during the GSP implementation period while these actions are occurring. By 2040, GSP implementation is expected to achieve the Subbasin sustainability goal through implementation of PMAs, demonstration that the SMC have been met, and demonstration that no undesirable results are occurring. The sustainability goal will be maintained through proactive monitoring and management by the GSAs.

Defining SMC requires considerable analysis and evaluation of many factors. This chapter presents the data and methods used to develop the SMC and demonstrates how they relate to beneficial uses and users within the Plan Area. The SMC presented in this chapter are based on the best available data and applications of the best available science.

As noted in this Joint GSP, data gaps and uncertainty exist in the characterization of the hydrogeologic conceptual model and groundwater conditions. The uncertainty was considered when developing the SMC and because of these uncertainties, the SMC presented herein are considered "working" criteria and subject to revision as part of adaptive management in the Subbasin. The GSAs will periodically evaluate this Joint GSP, assess changing conditions in the Plan Area that may warrant modifications of the GSP or management objectives, and may adjust components accordingly. An evaluation is anticipated to typically be completed as part of the Periodic Evaluation and/or Plan Amendment occurring every five years during GSP implementation, but the GSAs may initiate them at other times as well in response to hydrologic conditions or other factors. The GSAs will focus their evaluation on determining whether the actions under the GSP are meeting the GSP management objectives and whether those objectives are meeting the sustainability goal of the Subbasin.

This chapter is organized to address all the SGMA regulations regarding SMC and is organized in accordance with DWR's GSP annotated outline. This chapter includes a description of:

- How locally defined significant and unreasonable conditions were developed
- How MTs were developed, including:
  - The information and methodology used to develop MTs
  - The relationship between MTs and relationship of these MTs to other sustainability indicators
  - The effect of MTs on neighboring basins
  - The effect of MTs on beneficial uses and users
  - How MTs are related to relevant Federal, State or local standards
  - The method for quantifying measurable MTs
- How MOs were developed, including:
  - The methodology for setting MOs
  - Interim milestones
- How undesirable results were developed, including:
  - The criteria defining when and where the effect of the groundwater conditions cause undesirable results based on a quantitative description of the combination of MT exceedances
  - The potential causes of undesirable results
  - The effect of these undesirable results on the beneficial use and users.

The SMC presented in this chapter were developed using information from stakeholder and public input and correspondence with the GSAs, public meetings, hydrogeologic analysis, groundwater dependent ecosystem analysis, meetings with GSA technical representatives, meetings with the technical teams from other GSAs within the Subbasin, meetings with DWR's technical experts during the coordination meetings held with DWR during the 180-day revision period, and the corrective actions outlined in DWR's Revised GSP approval letter. SMC may be revised in the future as more data is collected and more information is made available during GSP implementation and adaptive management. The general process for establishing revised SMC included:

- GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC

- Conducting GSP public meetings to present proposed methodologies to establish MTs and MOs and receive additional public input. Two public meetings on SMC were held in the Plan Area
- Reviewing public input on preliminary SMC methodologies with GSA staff/technical representatives
- Providing a Draft GSP for public review and comment
- Conducting technical coordination meetings between the Joint GSP technical team and the technical teams for the three other GSPs in the Subbasin.
- Establishing and modifying MTs, MOs, and definition of undesirable results based on feedback from public meetings, public/stakeholder review of the Draft GSP, input from GSA staff/technical representatives, and input from DWR technical experts.

To ensure the Plan Area meets its sustainable goal by 2040, the GSAs have proposed the PMAs described in Section 4 to address undesirable results and to achieve and maintain sustainable groundwater conditions by the end of the implementation period. The PMAs expected to be implemented will include projects (e.g., recharge basins, Flood MAR, in-lieu recharge) and management actions including demand reduction. The overarching sustainability goal and the absence of undesirable results are expected to be achieved by 2040 through implementation of the PMAs. The sustainability goal will be maintained through proactive monitoring and management by the GSAs as described in this and the following chapters. Table 3-1 summarizes whether each of the six undesirable results has occurred, is occurring, or is expected to occur in the future in the Plan Area without and with GSP implementation.

Measurable Objectives

An MO for subsidence of 0 feet/year was established with the goal of long-term avoidance of land subsidence. Achieving this MO will take into consideration the level of uncertainty associated with survey measurements. SJRRP has reported that survey measurements have a vertical accuracy of +/-2.5 centimeters (Reclamation, 2011). With two measurements necessary to calculate a rate (before and after), the total uncertainty in the subsidence rate value is 5 centimeters, or approximately -0.16 feet/year. Therefore, a rate of subsidence of less than -0.16 feet/year (values that are less negative) are considered to be within the uncertainty of the measurement and would be considered compliant with the MO of 0 feet/year. This is not meant to allow for a continued rate of 0.16 feet/year of subsidence in the Subbasin. Rather, this is an acknowledgement that there may be instances where measurement error will indicate a rate of subsidence greater than the MO. The definition of undesirable results (as described in **Section 3.4.3**) will govern and exceedances of the undesirable result will trigger further management actions within the Subbasin.

Land subsidence has historically not resulted in significant and unreasonable impacts to infrastructure in the Plan Area. Information on historical subsidence in the Subbasin is presented in the hydrogeologic conceptual model (HCM) (Chapter 2). The MO for land subsidence is set recognizing that land subsidence within Subbasin is tied to actions in neighboring subbasins, and the ability to meet this MO is dependent on the successful implementation of PMAs in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are not specifically tied to subsidence thresholds, they are consistent with the objective to limit the potential for future subsidence.

3.2.3.2 Interim Milestones

Interim milestones for land subsidence were established at five-year intervals over the GSP implementation period from 2020 to 2040, at years 2025, 2030, and 2035. Interim milestones were informed by a detailed infrastructure sensitivity assessment and recent interviews with agency personnel and stakeholders (**Appendix 3.G**). The established IM also have capacity to accommodate some residual subsidence that may continue to occur due to historical cycles of lower groundwater levels and subsidence, while providing time for GSAs to implement PMAs. A combination of eight survey benchmarks monitored by the US Bureau of Reclamation (USBR) on a semi-annual basis as part of the San Joaquin River Restoration Program (SJRRP) and one continuous GPS station monitored daily as part of the UNAVCO Plate Boundary Observatory (PBO) project have been selected as part of the land subsidence RMS network. Locations of subsidence RMS are shown in **Figure 3-2** and described in **Table 3-4**.

Table 3-4. Summary of Land Subsidence Representative Monitoring Sites.

RMS ID	Data Source	Period of Record for Available Data
29	SJRRP	2013 to 2023
127	SJRRP	2012 to 2023
1007R	SJRRP	2013 to 2023
141	SJRRP	2012 to 2023
142	SJRRP	2012 to 2023
160R	SJRRP	2012 to 2023
165	SJRRP	2018 to 2023
201R	SJRRP	2018 to 2023
P307	PBO	2005 to 2023

A detailed Infrastructure Assessment has been conducted and describes critical infrastructure in the Subbasin (e.g., highways, bridges, waterways, wells, etc.) and the historical and potential future impacts from subsidence (**Appendix 3.G**). The infrastructure assessment was based on a combination of review/assessment of discussions with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, through individual stakeholder input to various GSA representatives, review of historical subsidence, and in meetings with all technical representatives from all GSAs in the Subbasin regarding existing and potential impacts of subsidence across the subbasin on critical infrastructure (e.g., waterways, wells). In addition, GSP consultants recently (2024) conducted interviews with local, state, and federal agencies to better understand subsidence concerns and how the potential for future subsidence may be accounted for in agency maintenance of critical infrastructure within the Subbasin. The results of this infrastructure assessment indicated a certain amount of tolerance for some impacts (e.g., growers willing to accept costs for some replacement wells to account for agricultural well collapse), a neutral to beneficial impact from subsidence on some impacts (e.g., southwest flowing waterways where channel gradients steepened, thereby increasing flow capacity), and/or a degree of planning/design to accommodate future subsidence (e.g., 2.5 to 5 feet by SJRRP). While the GSAs recognize the importance of reducing the rates of active subsidence across the Subbasin as quickly as possible, it should be recognized that residual subsidence will occur regardless of future actions due to the lag time associated with historical low groundwater elevations (see **Section 2.2.2.4.3** for more detailed discussion of residual subsidence).

Based on the updated Infrastructure Assessment, it has been determined that the maximum allowable additional cumulative subsidence within the subbasin should be set at two feet between now (December 2023) and January 2040 in order to be further protective of critical infrastructure. This amount of tolerable cumulative subsidence is less than the 2.5 to 5 feet of additional subsidence in the planning criteria for the SJRRP and two feet is consistent with the tolerable additional subsidence proposed in the recent Public Draft GSP for adjacent Delta Mendota Subbasin. IMs were established for additional cumulative subsidence between now (December 2023) and January 2025, and at five-year intervals for 2025 to 2030, 2030 to 2035, and 2035 to 2040 to ensure a ramp down to the zero subsidence MT by 2040 (**Table 3-5**). An IM for average annual rate of subsidence has also been set for each five-year interval in order to evaluate annual progress toward meeting the cumulative subsidence IMs.

Review of critical infrastructure and historical subsidence impacts indicates there is likely greater tolerance for additional subsidence in the southern portion of the subbasin compared to the central/northern portions of the Subbasin based on the generally lower amounts of historical subsidence along the San Joaquin River. However, it has been determined that the maximum allowable additional cumulative subsidence in all the areas of the subbasin should be set at two feet between now (December 2023) and January 2040. IMs were established for five-year intervals through 2040 to ensure a ramp down to the zero subsidence MT by 2040 (**Table 3-5**). An IM for average annual rate of subsidence has also been set for each five-year interval in order to evaluate annual progress toward meeting the cumulative subsidence IMs.

Table 3-5. Summary of Land Subsidence Interim Milestones.

5-Year Interval Ending at Year	Maximum Average Annual Rate of Subsidence (feet)	Maximum 5-Year Cumulative Subsidence (feet)
2025		1.5[2]
2030	0.2	1.0
2035	0.1	0.5
2040	0.05	0.25

The nine RMS stations identified in **Table 3-4** will be reviewed on an annual basis to track progress towards IMs. Achievement of these IMs will take into consideration the level of uncertainty associated with survey measurements (+/- 0.16 feet/year as described in **Section 3.2.3.1**, assuming two measurements per year). However, this uncertainty is not intended to allow for 0.16 feet of subsidence

[2] A cumulative total of up to 1.0 feet of subsidence has already occurred in some portions of the subbasin between December 2019 and December 2023 (see **Appendix 3.X**). Therefore, the maximum allowable cumulative subsidence of 1.5 feet as of December 2024 requires annual subsidence in 2024 to be less than 0.5 feet. Subsequent years after 2024 have significantly lower allowable annual rates of subsidence.

per year on an ongoing basis, but rather that an amount of subsidence within this range for a given year should be considered as potentially within the uncertainty of that year's measurements.

The IMs for land subsidence are set recognizing that land subsidence within the Subbasin is tied to actions in neighboring subbasins, and the ability to meet these IMs is dependent on the successful implementation of projects and management actions in neighboring subbasins.

The GSAs will continue to prioritize implementation of projects and management actions, to the extent feasible, in those areas of the Subbasin where subsidence rates have historically been greatest to ensure that sustainable groundwater conditions are reached by 2040. Ultimately, progress toward achieving IMs for the most constraining sustainability indicator will govern the determination of whether the Subbasin is on track toward achieving sustainability. Progress toward implementation of projects and management actions will be reported in Annual Reports.

3.2.3.3. Achieving and Maintaining Sustainability

The combination of IMs and MO reflect how the basin will achieve and maintain sustainability. The land subsidence IMs and MOs are set at values reflecting gradual reductions in the rate of subsidence over the Implementation Period with the intent of limiting future subsidence and achieving a long-term rate of zero subsidence by 2040.The interim milestones and MO for land subsidence are set recognizing that land subsidence within Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is dependent on the successful implementation of PMAs in neighboring subbasins.

3.3.3.1 Methodology

The MT for land subsidence was selected to prevent undesirable results. While an increased rate of subsidence has been observed in recent years in some areas of the Subbasin, no significant impacts to infrastructure have been noted to date in the Plan Area. As discussed in **Section 2.2.2.4.3** of this GSP, some amount of subsidence is assumed to be occurring and will likely occur for some time into the future. Given the lack of historical undesirable results experienced in Subbasin and the results of the Infrastructure Assessment (which included coordination with agencies responsible for management of critical infrastructure that may be impacted by subsidence, see **Section 3.2.3.2**, combined with the expectation of some future subsidence that is already occurring due to past cycles of lower groundwater levels and land subsidence, interim milestones were set to manage cumulative subsidence during GSP implementation. Interim milestones for subsidence are described in **Section 3.2.3.2** of this GSP.

The land subsidence MT is set at a rate of 0 feet/year. However, compliance with this threshold will take into consideration the level of uncertainty associated with survey measurements. SJRRP has reported that survey measurements have a vertical accuracy of +/-2.5 centimeters (Reclamation, 2011). With two measurements necessary to calculate a rate (before and after), the total uncertainty in the subsidence rate value is 5 centimeters, or approximately -0.16 feet/year. Therefore, a rate of subsidence of less than -0.16 feet/year (values that are less negative) are considered to be within the uncertainty of the measurement and would be considered compliant with the MT of 0 feet/year. This is not meant to allow for a continued rate of 0.16 feet/year of subsidence in the Subbasin. Rather, this is an acknowledgement that there may be instances where measurement error will indicate a rate of subsidence greater than the MT. The definition of undesirable results (as described in **Section 3.4.3**) will govern and exceedances of the undesirable result will trigger further management actions within the Subbasin.

The MT for land subsidence is set recognizing that land subsidence within the Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is influenced by the successful implementation of projects and management actions in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are a separate sustainability indicator and are not specifically tied to subsidence thresholds, they are consistent with the objective to limit the potential for future subsidence. The MT may require modification in the future if subsidence continues to be seen approaching the end of the 20-year GSP implementation period.

3.3.3.6 Other Considerations for Setting Minimum Thresholds

Infrastructure Sensitivity Assessment

As part of the original GSP development, the GSAs completed an infrastructure assessment to evaluate the characteristics of critical infrastructure in the Subbasin, including its proximity, orientation, and relative vulnerability to adverse effects of land subsidence and areas where it has occurred or is occurring. The assessment is documented in **Appendix 3.G.** and the results of this assessment were considered during development of SMC in the Subbasin with the goal of protecting this critical infrastructure from experiencing significant detrimental impacts.

In 2024, critical infrastructure, the potential impacts of land subsidence, and the extent to which they are considered significant and unreasonable were re-evaluated by the GSAs with input from interested stakeholders and members of the public. Agencies with critical infrastructure in the Subbasin were interviewed in Spring 2024 to confirm identification of their critical infrastructure, further document observed and possible impacts attributable to land subsidence, and assess the potential future impacts of land subsidence. See **Section 3.4.3** for more information.

3.4.3 Land Subsidence

The cause of Subbasin groundwater conditions that would result in significant and unreasonable land subsidence is excessive overall average annual groundwater pumping and other outflows from the Plan Area that exceed average annual inflows and results in groundwater levels that decline to a level that, combined with clay layers having certain properties conducive to compaction, result in significant land subsidence. Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040.

Prior to the 2024 GSP Revisions, locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, through individual stakeholder input to various GSA representatives, review of historical land subsidence, and in meetings with technical representatives from all GSAs in Subbasin. Through these discussions, it was determined that significant and unreasonable land subsidence may result in significant impacts to critical infrastructure. A survey of critical infrastructure in Subbasin was conducted and is provided in **Appendix 3.G**. The information presented below uses the initial assessment as a foundation upon which subsequent detailed analysis was completed.

In 2024, critical infrastructure, the potential impacts of land subsidence, and the extent to which they are considered significant and unreasonable were re-evaluated by the GSAs with input from interested stakeholders and members of the public. Agencies with critical infrastructure in the Subbasin were interviewed in Summer 2024 to confirm identification of their critical infrastructure, further document observed and possible impacts attributable to land subsidence, and assess the potential future impacts of land subsidence. **Table 3-15** lists the agencies contacted, the identified critical infrastructure, and references to GSP figures showing the locations of critical infrastructure.

Table 3-15. Agencies, Critical Infrastructure, Reported and Possible Subsidence Impacts, GSP Figure Reference, and Interview Date.

Agency	Identified Critical Infrastructure in Madera Subbasin	Reported Impacts in the Madera Subbasin	Possible Impacts	GSP Figure Reference	Interview Date
Madera Irrigation District	Supply canals, pipelines, diversion infrastructure.	None.	None.	Figure 1-8	6/19/2024
Madera Water District	Pipelines, diversion infrastructure.	None.	None.	Figure 1-10	6/19/2024
City of Madera (Public Works)	Potable water system, groundwater wells, wastewater system, roads, stormwater/floodwater control infrastructure, Madera Municipal Airport.	None.	None.	Figure 1-2	6/25/2024
County of Madera (Public Works)	Roads, bridges, stormwater/floodwater control infrastructure, potable water system, sewer water system, wells.	Protrusion of urban wells out of the ground.	Collapsed urban well casings.	Figure 1-6	7/8/2024
Central Valley Flood Protection Board	Control structures, Drop structures, and Levees within the Chowchilla Bypass, San Joaquin River, Fresno River, Ash Slough, and Berenda Slough	Washouts and scouring, loss of freeboard, impacts to control structures and drop structures.	Loss of freeboard, loss of capacity to move flood flows.	Figure 2-1	6/26/2024
San Joaquin River Restoration Program	Wells, fish bypasses/ladders	None.	Change in water stage and velocities.	Figure 2-1	7/2/2024
Lower San Joaquin Levee District	Control structures, Drop structures, and Levees within the San Joaquin River, and Chowchilla Bypass,	Impacts to drop structures, washouts and scouring.	Impacts to drop structures on Fresno River and Ash Slough, worsening scouring on the Chowchilla Bypass.	Figure 2-1	6/24/2024
New Stone Water District	Chowchilla Bypass, Eastside Bypass, distribution systems, wells, pumps.	None.	Damage to wells and pipelines, loss of conveyance in Chowchilla Bypass	Figure 1-12	8/20/2024

Agency	Identified Critical Infrastructure in Madera Subbasin	Reported Impacts in the Madera Subbasin	Possible Impacts	GSP Figure Reference	Interview Date
			and Eastside Bypass.		
Root Creek Water District	San Joaquin River	None.	None.	Figure 1-14	6/10/2024
Gravelly Ford Water District	Agricultural wells, San Joaquin River lift pump station, Gravelly Ford Canal, road crossings, San Joaquin River.	None.	Damage to wells, damage to pump stations, reduction in canal capacity, pipeline failure.	Figure 1-4	7/24/2024

Key findings from these interviews are summarized in the table above and list below:

- The County of Madera noted that some urban wells were reported to be protruding out of the ground a distance of up to approximately 18 inches.
- The San Joaquin River Restoration Program expressed concern for changing water level and velocities falling outside the design criteria for fish passage. This would make them noncompliant with biological opinions and require them to re-open consultation with fishery agencies to continue operations.
- San Joaquin River Restoration Program noted two planned future projects in which future subsidence was being incorporated into the design. Mendota Dam is being designed to withstand up to 2.5 feet of subsidence and Sack Dam is being designed to withstand up to 5 feet of subsidence.
- The Central Valley Flood Protection Board noted that the Fresno River has lost roughly 3 to 4 feet of freeboard since 2015.
- Both the Central Valley Flood Protection Board and the Lower San Joaquin Levee District noted impacts to drop structures on the Fresno River and Ash Slough as well as scouring on Berenda Slough and the Chowchilla Bypass.

To keep up to date on impacts to critical infrastructure within the Subbasin, the GSAs, with support from the agencies interviewed, are proposing to establish a Subbasin Critical Infrastructure Operator Group. Although discussions are ongoing, the Critical Infrastructure Operator Group is planning to meet annually to provide updates on any potential critical infrastructure impacts related to subsidence, coordinate ongoing PMA implementation, and to discuss any potential critical infrastructure mitigation concerns.

All agencies interviewed expressed a strong interest in participating in the Subbasin Critical Infrastructure Operator Group.

An undesirable result is defined as occurring when the average subsidence across greater than 25 percent of RMS in the Subbasin (including RMS in all four GSP plan areas) exceeds the minimum threshold for two consecutive years. Conditions that may lead to an undesirable result for a significant and unreasonable amount for land subsidence have historically occurred during periods with groundwater pumping in excess of sustainable yield in areas where critical infrastructure exists, because of the confined nature of the groundwater conditions in these areas coupled with the presence of sediments that are more susceptible to compaction when the piezometric head in the aquifer is reduced. This is of particular concern in the Lower Aquifer where the Corcoran Clay exists. Conditions that may lead to an undesirable result include the following:

- Localized pumping. Even if regional pumping is maintained within the sustainable yield, clusters (or pumping centers) of high-capacity wells pumping below the Corcoran Clay may cause excessive localized drawdowns that lead to undesirable results in specific areas. These effects could also be caused by pumping in neighboring subbasins.
- Extensive, unanticipated drought. Extensive, unanticipated droughts may lead to excessively low groundwater elevations and subsidence.

Groundwater System Conceptualization

The primary water-bearing sediments are comprised of unconsolidated Older Alluvium, which is generally equivalent to the Turlock Lake (oldest), Riverbank, and Modesto (youngest) Formations. The maximum thicknesses of these geologic formations are 800, 200, and 100 feet, respectively (California Division of Mines and Geology, Bulletin 182, year). The Madera Subbasin is underlain by the Corcoran Clay over approximately the western one-third of the Subbasin area. The depth to top of Corcoran Clay varies from 100 to 150 feet at its northeastern extent to in excess of 300 feet in the southwestern portion of the Subbasin (**Figure 2-15**).

Where the Corcoran Clay aquitard exists, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure 2-35**). The upper unconfined and lower confined aquifers in the area where Corcoran Clay is present are defined as principal aquifers in Madera Subbasin for this GSP. The lateral boundaries of the unconfined upper aquifer and the confined lower aquifer include the extent of the Corcoran Clay on the east, the boundary with Chowchilla Subbasin on the north, the boundary with Delta-Mendota Subbasin on the west and south. The upper boundary of unconfined Upper Aquifer is the land surface, although the saturated aquifer upper boundary is at the water table. The confined Lower Aquifer upper boundary is at the base of the Corcoran Clay. The lower boundary of the unconfined Upper Aquifer is the top of the Corcoran Clay (**Figure 2-15**). The lower boundary of the confined Lower Aquifer is the base of fresh water (**Figure 2-18**).

In the central and eastern portions of the Subbasin where the Corcoran Clay does not exist, the aquifer system consists of undifferentiated sediments (meaning no continuous aquitard layer is present) and is generally considered to be unconfined. However, it may gradually transition to a semi-confined aquifer at depth with discontinuous more permeable coarse-grained units interbedded in predominantly fine-grained sediments (**Figure 2-35**). In the eastern part of the Subbasin, the undifferentiated unconfined aquifer is defined as a principal aquifer, and for discussion purposes can be subdivided into an upper unconfined aquifer and a lower unconfined to semi-confined aquifer at a somewhat arbitrary depth that ranges from 200 to 400 feet bgs (generally corresponding to the depth of Corcoran Clay at its eastern extent). The lateral boundaries of the unconfined undifferentiated aquifer include the Madera Subbasin boundaries on the north (Chowchilla Subbasin), east (Sierra Nevada Mountains), and south (Kings Subbasin), and the extent of Corcoran Clay on the west. The upper boundary of the unconfined Undifferentiated Aquifer is the land surface, although the saturated aquifer upper boundary is at the water table. The lower boundary of the unconfined undifferentiated aquifer is the base of fresh water (**Figure 2-18**).

In addition to the generally higher percentages of coarse-grained material in the Upper Aquifer, the available cross-sections described above and provided in **Appendix 2.D** generally indicate that approximately the upper 500 feet of the Lower Aquifer are comprised of a greater percentage of coarse-grained sediments as compared to deeper zones within the Lower Aquifer. Thus, it can be anticipated that most wells will obtain close to their maximum yield within approximately the upper 800 feet of sediments. The vast majority of water wells are constructed within the upper 1,000 feet because sediments generally become finer with depth and towards the center of the valley (Provost and Pritchard, 2014).

The general occurrence of higher percentages of coarse-grained sediments at shallower depths is further illustrated by the sediment texture model developed by the United States Geological Survey (USGS) for the Central Valley Hydrologic Model (CVHM). **Figures 2-36 and 2-37** illustrate the spatial distribution of coarse-grained sediments at 50-foot depth intervals from the ground surface to a total depth of 1,400 feet. These maps indicate percentages of coarse-grained sediments are noticeably greater in the upper 400 feet compared to deeper depths.

2.2.2.4.3 Residual Subsidence Resulting from Historical Conditions

The theory of subsidence suggests that when regional groundwater levels reach a historical low point and subsidence occurs, future subsidence will not occur unless those historical lows are exceeded. However, it takes time for all the subsidence to occur in association with a low point in groundwater levels (often referred to as preconsolidation head), which is known as the subsidence lag time. The lag time may be several years to decades in some cases; therefore, it has often been observed that additional subsidence occurs even prior to the historical low point being exceeded. This is referred to as residual subsidence.

DWR defines active subsidence as being caused by, "…direct pumping and groundwater overdraft" and residual subsidence as, "…additional subsidence that occurs after the time of groundwater overdraft, as water pressures slowly reach equalization or drain in the clays that are being overdraft." (DWR, 2017). LSCE, et.al. (2014) note that, "Residual compaction may continue long after water levels have stabilized in the aquifers." It was noted in Antelope Valley that residual compaction in thick low permeability clay layers was still occurring in the 1990s from large regional groundwater level declines that occurred between 1950 and 1975.

The DWR study notes that with construction of the California Aqueduct and delivery of surface water to replace groundwater pumping in the late 1960s, groundwater levels recovered as much as 200 feet (from up to 400 feet of decline) in the deep aquifer system. However, land subsidence continued to occur at a lesser rate than before the aqueduct went into service even though groundwater levels were recovering. This phenomenon was attributed to time delay in compaction of aquitards, which take more time to equilibrate their pore-fluid pressures with pressure changes occurring in aquifers. The lag time for equilibration of aquitard pore pressures depends on aquitard thickness and permeability (thicker and less permeable aquitards take longer to equilibrate). DWR notes it may take decades to centuries for some aquitards to equilibrate.

In terms of the relationship between groundwater level declines and subsidence (during the active subsidence phase), DWR notes the ratio varies from 8 to 25 feet of groundwater level decline being equal to one foot of subsidence throughout San Joaquin Valley. The center of subsidence area west of Fresno had a ratio of one foot of subsidence per every 16 feet of groundwater level decline. A study cited by DWR (USBR, 1963) estimated residual subsidence rates to be 10 percent of active subsidence rates.

Subsidence data in the Subbasin indicated that rates of subsidence during the 2012 to 2015 drought ranged from 0.2 to 0.4 feet/year northwest portion of the Subbasin. The central and southwest portions of the Subbasin had subsidence rates of approximately 0.1 feet/year from 2012 to 2015. In the years from 2017 to 2021, subsidence rates were approximately 0.2 to 0.3 feet/year in the northwest area, while subsidence rates in the central and southwest Subbasin were approximately 0.2 to 0.3 feet/year.

Based on review and comparison of available groundwater level and subsidence data in the Subbasin, establishing definitive relationships between groundwater levels and subsidence is challenging with the limitations of currently available data. However, making use of the best available data results in a range of from X to Y feet in groundwater level decline (with an average of X feet) per each foot of subsidence during active subsidence time periods. In addition, the rate of residual subsidence in the immediate 3 to 6 years after groundwater levels stabilized or rose was from X to Y% of the active subsidence rate in the northwest area.

A study conducted by Lees et.al. (2022) provides some insights regarding overall subsidence and especially residual subsidence (referred to as deferred subsidence in this study) in the San Joaquin Valley over the past 65 years. The study uses a one-dimensional aquitard drainage model to evaluate the relationship between groundwater level fluctuations and subsidence over time near Hanford, California, including rates of subsidence during past time periods with declines in groundwater levels (i.e., periods of active subsidence) as well as rates of subsidence during times of stable to increasing groundwater levels (i.e., periods of residual subsidence). The study notes that significant subsidence occurred in San Joaquin Valley between the 1920s and 1970 with modeled subsidence rates of between 0.3 and 1.0 feet/year in the 1950s and 1960s. After 1970 the increased availability of surface water reduced rates of subsidence to near zero (0.03 feet/year) by 1987. However, another cycle of groundwater level declines occurred during the drought of 1987 to 1992 with subsidence rates increasing back up to 0.5 feet/year, followed by groundwater level recovery after 1992 with subsidence rates falling to 0.1 feet/year by 1999.

Additional cycles of declining groundwater levels and increasing subsidence occurred after 2000 as follows: 2001-2004 (subsidence rates up to 0.5 feet/year in 2004); 2007-2009 (subsidence rates up to 0.55 feet/year in 2009), and 2012-2015 (subsidence rates up to 1.2 feet/year in 2015). Intervening cycles of stable to increasing groundwater levels during 2005-2006 and 2010-2011 resulted in lower rates of subsidence, with a final cycle of groundwater level recovery in 2016-2017 that reduced subsidence rates to 0.45 feet/year in 2017. The study notes that the residual (deferred) subsidence rate of 0.45 feet/year in 2017 was as large as peak (active) subsidence rates during the 1987-92 and 2001-2004 periods of declining groundwater levels. The study suggests that the relatively high rate of residual subsidence observed in 2017 is due to the cumulative effect of repeated cycles of groundwater level declines (active subsidence) since the 1940s that resulted in incremental amounts/rates of residual subsidence being carried forward into the future from each cycle of groundwater level decline. Thus, the residual subsidence rate observed in 2017 encompasses a certain amount/rate of residual subsidence still remaining in the aquitard system from previous cycles of groundwater level decline that occurred in the 1950s/1960s, 1987-1992, 2001-2004, 2007-2009, and 2012-2015. Overall, the modeled residual subsidence rates increased from 0.03 feet/year after 1970 to 0.16 feet/year after 2009 and then to 0.46 feet/year after 2015.

Modeling conducted for this study by Lees, et.al. (2022) also concluded that the proportional compaction of clay layers causing subsidence prior to 1980 was distributed approximately as follows: 70% in the Lower Aquifer, 20% in the Upper Aquifer, and 10% in the Corcoran Clay. The proportional distribution of compaction in clay layers changed after 1980 to approximately 90% in the Lower Aquifer and 5% each in the Upper Aquifer and Corcoran Clay. These study results indicate the great majority of subsidence is due to compaction of clay layers in the Lower Aquifer system and only small amounts of subsidence are due to compaction of the Corcoran Clay, which is consistent with previous extensometer and numerical modeling studies by others.

Another significant conclusion of Lees, et.al. (2022) was that the effective time constant that characterizes the time scale for head propagation through an aquitard (and hence aquitard compaction) ranges from 60 to 1,300 years. The authors concluded that given the thick aquitards and clay interbeds prevalent throughout the San Joaquin Valley, time scales on the order of decades to centuries are needed to characterize compaction and subsidence in this area. It was noted that while the modeling results reported in this study are specific an area near Hanford, their modeling approach could be generalized to evaluate subsidence at other locations in San Joaquin Valley.

It is useful to compare estimates of residual subsidence from the two studies by DWR (2017) and Lees et.al. (2022) with subsidence data in the Subbasin since 2012. The residual subsidence rate of 10% of the active subsidence rate cited in the DWR study is consistent with the residual subsidence rate cited in the study by Lees et.al. after the first cycle of active subsidence ended in 1970. However, the Lees et.al. study includes more detailed evaluation of groundwater level and subsidence data since 2000 relative to characterizing residual subsidence rates than is included in the DWR study, and indicates that rates of residual subsidence (relative to active subsidence) have increased significantly since 2000. Comparison of the subsidence rates cited by Lees et.al. in 2017 (0.46 feet/year) compared to 2012 to 2015 (1.2 feet/year) yield a residual subsidence rate of 38% of the active subsidence rate. Review of recent subsidence data for the Madera Subbasin suggest a residual subsidence rate of approximately X% of the active subsidence rate during the 2012 to 2015 drought period.

<u>Land Subsidence Monitoring Program</u>

The sustainability management criteria for the land subsidence sustainability indicator will be evaluated by monitoring land subsidence. The objectives of the monitoring program to calculate changes in land subsidence include the following:

- Monitor vertical displacement of the land surface to improve the understanding of the potential occurrence of land subsidence.

The proposed monitoring network, shown in **Figure 3-10**, is comprised of all benchmark survey points monitored by the United States Bureau of Reclamation (USBR) as part of the SJRRP and local continuous GPS stations monitored by UNAVCO as part of the Plate Boundary Observatory (PBO) Project. Locations of subsidence RMS are shown in **Figure 3-2**. Additional monitoring stations located outside of the

Subbasin are included in the network to provide regional context. In addition to the point locations included in the monitoring network, Interferometric Synthetic Aperture Radar (InSAR) data provided by DWR will be evaluated on an annual basis as part of the Annual Report to monitor subsidence within the Subbasin. The control points selected for inclusion in the monitoring network are currently monitored for other purposes. As a result, control points may be added or removed from the monitoring network as they are added or removed from the various programs currently maintaining these networks. An expansion of the subsidence monitoring network is planned in the Subbasin and described in more detail in the subsidence workplan provided in **Appendix 3.H**.

Throughout the PMA section:

Make a note of plans to implement projects in areas where subsidence is occurring.

Corrective Action 5

DWR Feedback: *The GSAs must discuss the uncertainty concerning the hydrogeologic conceptual model and a description of hydrogeologic conceptual model data gaps. Discuss the uncertainty concerning the hydrogeologic conceptual model and a description of hydrogeologic conceptual model data gaps.*

New or Revised GSP Text:

Uncertainty and Data Gaps in Hydrogeologic Conceptualization and Groundwater Conditions

Certain data gaps and associated uncertainty are described below. Additional information about data gaps is provided in **Section 3.5.4**.

Hydrogeologic Conceptual Model

Uncertainty in the HCM is related to limitations on the amount of available data (e.g., lithologic logs, borehole geophysical logs), reliability of those available data, and the reliability of correlations made from the available data. The amount of available data has been increasing over time and, in particular, several dedicated multi-completion (nested) monitoring wells have been drilled and installed since 2019 with plans to install additional wells in the future. These GSA efforts result in very reliable data being collected in that lithologic logs are compiled by geologists using both drill cuttings samples and downhole geophysical logs. Additional data being collected over time includes lithologic logs included in water well reports prepared by drillers, although these logs are somewhat less reliable in that they generally do not benefit from incorporation of downhole geophysical logs and detailed logging by a geologist. The uncertainty in the HCM is expected to decrease in the future as such data are collected and incorporated into HCM updates. For example, drilling of dedicated monitoring wells since 2019 has already resulted in some refinement of the extent of the Corcoran Clay (**Figure 2-15**), which has also been incorporated into the recent MCSim Model update (**Appendix 6D**).

Groundwater Levels and Storage

Uncertainty in our understanding of groundwater levels and storage is primarily a function of locations and frequency of groundwater level data. Groundwater storage has some additional uncertainty related to availability of data for specific yield and storage coefficient values. There is some uncertainty in both groundwater elevation contours and storage changes related to lack of data in some portions of the groundwater basin (e.g., the far eastern portion of Madera Subbasin), which requires estimates to be prepared for those areas in annual reports. These data gaps and uncertainty are being addressed with the installation of dedicated monitoring wells, which has been ongoing since 2019. Relatively deep (up to 1,000 feet) exploration drilling has already been conducted at nine locations, with installation of up to three monitoring wells at each location screened in different depth zones. Each of these new dedicated monitoring wells provides continuous (monitored by transducers) water level data, which helps to fill data gaps and expands our coverage and understanding of both groundwater levels and storage both spatially and vertically (different aquifers). This ongoing installation of dedicated monitoring wells will reduce uncertainty and data gaps in the future.

Groundwater Quality

Uncertainty in our understanding of groundwater quality is primarily a function of available well locations and ability to obtain access to wells for groundwater quality sample collection. Existing wells owned by others present challenges in obtaining well owner corporation and in coordination of site visits for sample collection when the pump is operating. These types of existing wells (typically agricultural production wells and, to a lesser extent, drinking water production wells) are being utilized to the extent possible. In addition, these data gaps and uncertainty are being addressed with the installation of dedicated monitoring wells, which has been ongoing since 2019. Relatively deep (up to 1,000 feet) exploration drilling has already been conducted at nine locations, with installation of up to three monitoring wells at each location screened in different depth zones. Each of these new dedicated monitoring wells provides groundwater quality sampling locations under the control of the GSAs, which helps to fill data gaps and expands our coverage and understanding of groundwater quality both spatially and vertically (different aquifers). This ongoing installation of dedicated monitoring wells will reduce uncertainty and data gaps in the future.

Land Subsidence

There is considerable uncertainty associated with the characterization of historical and future subsidence in the Subbasin. This uncertainty is related to a limited number of subsidence monitoring locations, limited data for correlations between groundwater levels and rate of subsidence, and limitations on the understanding of how total subsidence that occurs may be broken down into active (associated with groundwater levels going to new lows) and residual (subsidence that continues to occur in the absence of ongoing declines groundwater levels to new lows) subsidence.

To address the need and interest in improving the understanding of subsidence in the Subbasin, the GSAs have developed a workplan outlining future activities related to monitoring and understanding conditions relating to subsidence in the Subbasin. One of the key objectives of the workplan is to expand the subsidence RMS network to allow for better characterization of the spatial distribution of subsidence in the subbasin, and to improve our understanding of the mechanisms and conditions causing land subsidence including development of better correlations between groundwater elevation fluctuations and rates of subsidence. In addition, a key objective is to better characterize residual land subsidence versus new/active subsidence. A subsidence workplan is included in **Appendix 3.H**. Key topics considered in the workplan include the following:

- Summary of existing subsidence monitoring
- Improvements to subsurface hydrogeologic characterization related to occurrence of fine-grained layers most subject to compaction, including review of results from recently completed aerial electromagnetic surveys of the area
- Refinement of our understanding of the extent and thickness of the Corcoran Clay
- Identification and instrumentation of additional existing wells to expand the monitoring network

- Drilling and installation of new monitoring wells to expand the monitoring network
- Develop an inventory of active production wells
- Technical analyses to improve understanding of the relationship between groundwater level fluctuations and subsidence, groundwater production and subsidence, and the occurrence of residual subsidence
- Groundwater and subsidence modeling

Develop technical support for a strategy to manage groundwater pumping and recharge in the Subbasin to minimize future subsidence

Corrective Action 6

DWR Feedback: *Water quality-related updates:*

- *Revise the definition of URs so that exceedances of minimum thresholds caused by groundwater extraction are considered in the assessment of undesirable results in the Subbasin.*
- *Clearly define what the Plan considers a UR for degraded water quality by describing conditions that it would consider to be significant or unreasonable.*
  - *Quantify the specific potential effects to beneficial users and uses from undesirable results using best available data and science.*
  - *Definition should be supported by information described in the basin setting, and other data or models as appropriate*
- *Identify which minimum threshold values—either the MCL or existing concentration plus 20 percent—will be used at which representative monitoring sites.*
- *Justify how establishing minimum thresholds at the higher of either MCLs or existing concentrations plus 20 percent does not constitute significant and unreasonable effects as defined by the GSP.*

New or Revised GSP Text:

2.2.2.3 Groundwater Quality

Maps of available groundwater quality data for a variety of constituents were prepared to characterize groundwater quality in the Subbasin. Key groundwater quality constituents discussed below include nitrate, total dissolved solids (TDS), and arsenic. These constituents have greater potential for presenting broader regional groundwater quality concerns extending beyond localized or site-specific contamination cases and are likely to reflect a range of potential contamination sources. A variety of maps of other groundwater quality constituents are included in **Appendix 2.E** and highlight local areas of groundwater quality contamination that are important for consideration when evaluating GSP-related PMAs and their potential to have adverse groundwater quality impacts.

Nitrate is one of the most common groundwater contaminants and is generally the water quality constituent of greatest concern in agricultural areas where application of fertilizers containing nitrogen can lead to elevated nitrate levels in groundwater. Additionally, nitrate is a constituent of concern in groundwater near dairy or other large-scale livestock operations. Natural concentrations of nitrate in groundwater are generally low, and elevated levels usually indicate impacts from land use activities. Nitrate presents health concerns at high concentrations and is regulated in public drinking water systems. The U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) for nitrate (as nitrogen) of 10 mg/L under its National Primary Drinking Water Regulations; this MCL standard is established for public health reasons and is a requirement of all public drinking water systems. Total Dissolved Solids (TDS) is a general measure of salinity and overall water quality. Elevated salinity in groundwater can be a result of land use activities, but can also be naturally-occurring, especially in western parts of the San Joaquin Valley where subsurface geologic materials are derived from marine sediments. Arsenic is a naturally occurring chemical found in groundwater and has a primary MCL of 10 micrograms/liter (µg/L).

Additional maps of other groundwater quality constituents are presented in **Appendix 2.E** including maps of select chemicals typically found associated with point-source contamination including hydrocarbon products and pesticides. Several studies and maps of regional groundwater quality have also been prepared in recent years, and some of these maps are included in **Appendix 2.E**. Work for CV-SALTS (LSCE and LWA, 2016) evaluated ambient TDS and nitrate concentrations for the period 2000 to 2016 in the upper and lower zones within the Upper Aquifer. LSCE (2014) conducted groundwater quality mapping for the San Joaquin Valley for various constituents including TDS, nitrate, arsenic, vanadium, uranium, DBCP/fumigants, herbicides, solvents, and perchlorate. Maps of TDS and nitrate from the Groundwater Quality Assessment Report prepared for the East San Joaquin Water Quality Coalition (LSCE, 2014) presents groundwater quality data delineated by shallow and deep wells. Although the maps were not necessarily aquifer specific (shallow wells were distinguished from deeper wells for this study primarily based upon well use type), they do illustrate general concentrations in wells across the Subbasin. Other mapping of regional groundwater quality was included in the Regional Groundwater Management Plan (Provost & Pritchard, 2014). Typically, the major considerations for municipal/domestic and agricultural use with respect to groundwater quality include salinity (specific conductance, TDS), nutrients (nitrate), and metals (arsenic, manganese). For the purposes of their groundwater quality evaluation, Provost & Prichard (2014) defined shallow wells (0 to 400 feet), intermediate wells (400 to 600 feet), and deep wells (greater than 600 feet deep). This depth classification differs slightly from how groundwater conditions are represented in the HCM as defined in this Joint GSP, and is utilized only for the discussion of groundwater quality in this section. Groundwater quality maps from previous reports are provided in **Appendix 2.E.**

Groundwater quality data for other constituents as presented in published reports, particularly data from the USGS Groundwater Ambient Monitoring and Assessment (GAMA) Program investigations conducted for the area, are also presented in **Appendix 2.E.**

Total Dissolved Solids

Maps of maximum historical TDS concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) in the Madera Subbasin (**Figures 2-58 to 2-60**) indicate relatively low salinity groundwater quality across most of the Subbasin with maximum historical TDS concentrations less than 500 milligrams/liter (mg/L) in most places. Wells with maximum historical TDS concentrations greater than 750 mg/L exist scattered across the Subbasin and a relatively small number of wells with maximum TDS concentrations above 1,000 mg/L located mainly in the far western parts of the

Subbasin. Higher TDS concentrations in the western part of the Subbasin may be caused by natural salinity present in groundwater occurring within Coast Range derived sediments of marine source material. Otherwise, there are no widely apparent and consistent spatial patterns in concentrations, although the wells exhibiting higher TDS concentrations above 1,000 mg/L are screened in the Upper Aquifer (**Figure 2-59**).

Regional groundwater quality mapping of TDS concentrations was conducted for the CV-SALTS project (LSCE and LWA, 2016). These analyses for the upper zone (of the Upper Aquifer) showed generally increasing TDS from east to west across Madera Subbasin. TDS concentrations ranged from less than 250 mg/L in the east to greater than 1,000 mg/L in the southwestern corner of the Subbasin. Analyses of the lower zone (of the Upper Aquifer) showed a similar pattern of increasing TDS from east to west, but with a smaller area of high TDS groundwater (**Appendix 2.E**).

Nitrate

Maps of maximum historical nitrate concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) are presented in **Figures 2-61 to 2-63**. These maps highlight patterns in historical maximum nitrate concentrations across the Subbasin. A large percentage of the wells with nitrate data have maximum historical concentrations below 7.5 mg/L and many have concentrations below 5 mg/L. However, a number of areas of locally high maximum nitrate concentrations above 7.5 mg/L or above 10 mg/L are apparent across the Subbasin. The higher concentrations appear to be more common in the more western parts of the Subbasin. One particular area with a high density of wells with maximum nitrate concentrations above the MCL of 10 mg/L (as N) is located in the western part of the Subbasin along Highway 145, directly south of where Dry Creek joins the Fresno River (**Figure 2-61**). Some of the clusters of wells with high nitrate concentrations are known to be associated with regulated facilities and contamination remediation sites. Most of the higher concentrations are from wells with unknown construction information, although maps of nitrate concentrations by depth zone indicate more wells known to be screened in the Upper Aquifer with higher concentrations than in the Lower Aquifer.

Regional mapping of nitrate concentrations in groundwater were also performed as part of the CV-SALTS project (LSCE and LWA, 2016). Maps of nitrate concentrations in the upper zone (of the Upper Aquifer) showed a small area exceeding the MCL of 10 mg/L (as N) in the northwestern part of the Subbasin, while nitrate in the lower zone (of the Upper Aquifer) was indicated to exceed 10 mg/L in a similar but somewhat larger area in (compared to upper zone of Upper Aquifer) the northwest portion of the Subbasin (**Appendix 2.E**).

Arsenic

Maps of maximum historical arsenic concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) are presented in **Figures 2-64 to 2-66**. Although there are wells with high arsenic concentrations scattered throughout the Subbasin, they are more common in the eastern part of the Subbasin. Most of the wells with maximum arsenic concentrations above the MCL of 10 µg/L are located northeast of Highway 99. Although a number of wells exhibit maximum concentrations above the MCL, the dominant fraction of wells with maximum arsenic concentrations are below 5 µg/L with many or most of these wells having concentrations below 2.5 µg/L. Few wells known to be screened in the Upper Aquifer (**Figure 2-65**) have elevated concentrations and a higher number of wells known to be constructed in the Lower Aquifer (**Figure 2-66**) have maximum concentrations above the MCL, although most wells of the identified Lower Aquifer wells have maximum concentrations below 5.

Other Groundwater Quality Constituents

Maps of a variety of other groundwater quality constituents are presented in **Appendix 2.E**. Many of these maps highlight distinct areas of local groundwater contamination or groundwater constituents that should be considered when evaluating potential groundwater quality impacts from implementation of PMAs to achieve sustainability. Wells with exceedances for a variety of constituents, including anthropogenic contaminants like pesticides, solvents, and petroleum-related chemicals, are displayed in maps in **Appendix 2.E**. Most notably, maps of DBCP, EDB, 1,2,3-TCP, perchlorate, PCE, and BTEX concentrations all indicate areas with wells exceeding the respective drinking water MCLs. Naturally occurring constituents such as uranium and manganese are also elevated in some wells with high uranium concentrations more apparent in the western part of the Subbasin and high manganese concentrations more common in the eastern parts of the Subbasin.

Degraded Water Quality

The cause of subbasin groundwater conditions that would result in significant and unreasonable degraded water quality is implementation of a GSP project or management action that causes concentrations of key groundwater quality constituents to increase to concentrations exceeding the MTs, which are set at the MCLs for drinking water for identified key constituents (10 mg/L for nitrate as nitrogen; 500 mg/L for TDS; 10 µg/L for arsenic) or when existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent. Although distributed areas of degraded groundwater quality from non-point source contamination exist in the Plan Area (most notably elevated nitrate concentrations), there are no current documented large-scale contaminant plumes in the regional groundwater aquifers. Smaller more localized and shallow contaminant site plumes have been documented in parts of the Plan Area, most notably in the vicinity of the City of Madera, although these contaminants are generally restricted to depths above the regional aquifer system. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Plan Area; therefore, groundwater quality degradation resulting from a GSP project or management action or overall groundwater extraction is considered significant and unreasonable based on adverse impacts to this beneficial use. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, and input received from interested stakeholders and the public through public meetings and through individual stakeholder input to various GSA representatives. Significant and unreasonable degradation of water quality occurs when beneficial uses for groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs for one of the key constituents (nitrate, arsenic, TDS) previously identified in Chapter 2 (Plan Area and Basin Setting) of the GSP at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action or overall groundwater extraction. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent.

Adverse impacts related to groundwater quality could include additional costs being imposed on municipal or domestic well owners for water treatment, a decrease in water available for certain beneficial uses (e.g., irrigation water supply), or need for remediation systems for control of contaminant plumes. A potential scenario of adverse groundwater quality impacts related to municipal and domestic wells could include increases in nitrate concentrations from ongoing agricultural and wastewater treatment and disposal activities in the subbasin from below to above the MCL, thereby requiring treatment, blending, and/or deeper well drilling to provide for drinking water supply. In addition, ongoing land surface activities combined with additional long-term groundwater level declines may result in TDS increases that create aesthetic (e.g., taste) concerns for drinking water supplies that require municipal and/or domestic well owners to purchase bottled water. Excessive increases in TDS may also impact the suitability of irrigation water supplies for certain crops. Similarly, unmitigated and ongoing groundwater level declines could lead to increasing arsenic concentrations that require use of bottled water. Another adverse scenario could involve excessive groundwater pumping in an area near a contaminant plume that requires major modifications to a remediation system to maintain control of the plume. The development of groundwater quality SMC in this GSP are intended to avoid or minimize the types of scenarios described above. The MTs for degraded water quality apply to RMS selected from among existing and proposed future wells located throughout the Plan Area and screened in both in the Upper and Lower Aquifers. The RMS for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Plan Area GSAs together with wells that are sampled by others as part of other groundwater quality monitoring programs. The selected RMS for groundwater quality are listed in **Table 3-12** and shown on **Figure 3-3**.

Methodology

The methodology to develop MTs for groundwater quality is based on the objective of protecting all designated beneficial uses from significant and unreasonable adverse impacts from implementation of GSP PMAs or overall groundwater extraction. In accordance with the Water Quality Control Plan (Basin Plan) for the Sacramento and San Joaquin River Basins (RWQCB, 2018), groundwater in the Plan Area is considered suitable or potentially suitable for municipal and domestic water supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO) beneficial uses. From a groundwater quality standpoint, the municipal and domestic supply beneficial use is the most restrictive with Basin Plan water quality objectives linked to drinking water MCLs. As a result, the MTs for groundwater quality set for each of the three identified key water quality constituents (nitrate, arsenic, TDS) are the respective MCL values, except for cases where existing or historical concentrations for these constituents already exceed the MCL. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent. The summary of currently available groundwater quality data for RMS wells provided in **Appendix 3.X** provides an indication of the baseline for each key constituent for the RMS wells relative to MCLs. The vast majority of RMS wells have baseline concentrations below MCLs and are expected to have MT set at MCLs (MT will be finalized as part of upcoming 2025 Periodic Evaluation). When current or historical water quality for the key constituents has not been measured, the MT will be set as the MCL and will be adjusted if needed after the GSP groundwater quality monitoring program commences (see Section 3.5.1.4). The applicable MTs for groundwater quality in the GSP apply to degraded groundwater quality as a direct result of impacts from projects/MAs or overall groundwater extraction under the GSP that cause an exceedance to occur. Future exceedances of the MT may occur due to activities or conditions unrelated to the GSP, in which case they would not constitute an MT exceedance that contributes to an undesirable result.

A review of literature reveals several studies related to the uncertainty in hydrologic measurements, including water quality. Montgomery and Sanders (1986) noted that data acquisition involves three main activities: network design, sample collection, and lab analysis. Focusing on the latter two activities, sample collection comprises sampling technique, field measurements, sample preservation, and sample transport; and lab analysis involves analysis techniques, operational procedures, quality control, and data recording. Each component listed above has the potential to slightly alter the final results reported for a given constituent, thereby creating a degree of uncertainty. One study (McMillan, et.al., 2018) suggested that hydrologic data uncertainties, including for water quality, are typically in the range of 10 to 40%. Another study (Harmel, et.al., 2006) found uncertainties in the range of 4 to 48% for sample collection, 2 to 16% for sample preservation and storage, and 5 to 21% for laboratory analysis.

The East Bay Plain Subbasin GSP noted the following:

The technical justification for using a 20% increase from baseline concentrations to set the interim MT for RMS wells that already exceed the MCL for a key constituent is based on evaluation of three potential sources of fluctuations in key constituent concentrations from a series of sampling events at a given well:

1) *Variability/uncertainty related to analytical lab methods/analysis;*
2) *Variability/uncertainty caused by slight differences in sampling methods or purge rates (this will be addressed to some extent with GSP sampling protocols, but some variability can still occur between different sampling personnel or from one sampling event to another plus existing data that may have been collected using slightly different protocols), and*
3) *Fluctuations/variability in constituent concentrations in the groundwater system due to the rise/fall of groundwater levels, changes in local groundwater flow directions, fluctuations in recharge rates, water year type, and other natural conditions affecting the groundwater system.*

Consultation with the EBMUD analytical laboratory indicated that the margin of error associated with analytical lab measurements within a method may be set as:

a. *The method reference used in the analysis.*
b. *Statistically calculated based on historical data of laboratory fortified blank samples or fortified matrix spikes.*
c. *Estimating the uncertainty of measurement by taking into consideration all sources contributing to the uncertainty, including, but not limited to standard references, reference materials, equipment used, environmental conditions, properties and conditions of the samples being tested or calibrated, and the operator.*
d. *Based on The National Environmental Laboratory Accreditation Program Institute (TNI) acceptable criteria of performance testing (PT) study; these may be set by EPA or statistically calculated for the study.*

Table X. Analytical Laboratory Error of Measurement for Key Constituents				
Analyte	*Method Reference*	*Method Reference or Laboratory Statistically Calculated Precision (% RPD[1])*	*Method Acceptance Criteria for Accuracy (% Recovery)*	*TNI Acceptance Criteria of Performance Testing Study (% Recovery)*
TDS	*SM2540C*	*10%*	*±15%*	*±20%*
Nitrate	*EPA 300.1*	*At ≥ 10xMRL[2]xMRL[2]: ±10% RPD At < 10xMRL: ±20% RPD*	*±15%*	*±10%*
Chloride	*EPA 300.1*	*At ≥ 10xMRL: ±10% RPD At < 10xMRL: ±20% RPD*	*±15%*	*±15%*
Arsenic	*EPA 200.8*	*20%*	*±15%*	*±30%*

1 Relative percent difference (RPD).

2 Minimum reporting limit (MRL) typically set by a lab as 3 x Method Detection Limit ≈ 3 x Standard Deviation.

Based on the laboratory input summarized above, the error based on the "Method Acceptance Criteria for Accuracy" may be the best reference to use since it is 15% for all the constituents and takes into consideration sources that contribute to the uncertainty.

Work being conducted for other programs, such as the Central Valley Irrigated Lands Regulatory Program (ILRP), requires extensive review of QA/QC procedures for field sampling and analytical lab analyses for various constituents of concern (including nitrate and TDS), along with quantification of the expected Relative Percent Difference (RPD) that may occur with key constituent concentrations from groundwater quality sampling events. An RPD of up to 25% constitutes the acceptance criteria for field duplicate samples, which accounts for analytical laboratory plus field sampling methods/procedures but not natural factors influencing the groundwater system. The groundwater system fluctuations/variability factor would add greater uncertainty beyond the 25% from laboratory and field sampling methods/procedures factors. Based on prior experience, the potential constituent fluctuations from various natural factors influencing the groundwater system likely exceed 5% and result in a total expected range of fluctuations from all three factors of greater than 30%. Therefore, use of a 20% increase over baseline conditions is likely a conservative (i.e., low) value relative to the reasonably expected range of fluctuations in constituent concentrations that could be expected to occur during a series of sampling events.

Based on the review of the studies and reports described above, it is reasonable and justified to set MT by adding 20% to groundwater quality RMS with existing concentrations near or above the MCL. This methodology provides a relatively conservative and narrow range to account for the uncertainties in several variables that may affect lab reported concentrations for a key constituent. Using this methodology will help avoid the occurrence of false positives in which expected variability in sample collection and/or lab analyses results in developing a conclusion that undesirable results have occurred when there is actually no (or a very minimal) increase in concentrations. In addition, a 20% increase when baseline concentrations exceed the MCL (e.g., baseline of 15 mg/L increases to between 15 and 18 mg/L for nitrate) represents a relatively small net increase that would not be expected to have significant and unreasonable effects. Finally, the selection of the greater of the MCL or 20% increase is intended to avoid more false positives that could easily result when a baseline concentration is very close to but less than the MCL (e.g., a baseline arsenic concentration at 9.8 ug/L only needs to have sample results that increase by 3% to exceed the MCL).

Groundwater Quality Monitoring Program

The sustainability indicator for degraded water quality is evaluated by monitoring groundwater quality at a network of wells.

The objectives of the groundwater quality monitoring program for the Plan Area include the following as they relate to the implementation of GSP PMAs:

- Evaluate groundwater quality conditions in the various areas of the Subbasin, and identify differences in water quality spatially between areas and vertically in the aquifer system;
- Detect the occurrence of and factors attributable to key constituents of interest as represented by nitrate, arsenic, and TDS;
- Assess the changes and trends in groundwater quality; and
- Identify the natural and human factors that affect changes in water quality.

For the purpose of monitoring groundwater quality conditions and potential impacts from GSP PMAs and overall groundwater extraction, a network of representative monitoring sites selected from among existing and proposed future wells located throughout the Joint GSP GSAs and screened in both in the Upper and Lower Aquifers. The representative monitoring sites for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Joint GSP GSAs together with wells that are sampled by others as part of other groundwater quality monitoring programs. The selected RMS for groundwater quality are listed in **Table 3-12** and shown on **Figure 3-3**. Information on well construction and historical groundwater quality monitoring for each of the indicator wells is included in **Appendix 3.B**.

As part of the First Plan Amendment, a comprehensive review of the RMS network was conducted, and the network was updated as necessary. A detailed discussion of wells removed and added to the network as part of this evaluation is presented in **Appendix XXX.** The network of groundwater quality representative monitoring sites includes 7 existing wells that are also part of the water level monitoring indicator well network and will also be sampled for groundwater quality by the Joint GSP GSAs. Additionally, 23 dedicated monitoring wells at nine nested monitoring well sites that were constructed in the Joint GSP GSAs as part of GSP implementation, and will be sampled for groundwater quality by the Joint GSP GSAs. Ongoing groundwater quality monitoring being conducted by other entities for the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) program of 12 selected public supply wells will also be incorporated into the representative groundwater quality monitoring in the Plan Area. Available results from groundwater quality sampling conducted by the monitoring entities for these public supply wells will be acquired and incorporated into the ongoing evaluation of groundwater quality monitoring as part of implementing the GSP. Monitoring and assessment of groundwater quality is also being conducted for the Irrigated Lands Regulatory Program (ILRP), currently including sampling of two domestic wells and future incorporation of the new monitoring wells described above as part of the Groundwater Quality Trend Monitoring program for the East San Joaquin Water Quality Coalition. The two current domestic wells will also be included in the representative groundwater quality monitoring network. As details of GSP PMAs are refined, the groundwater quality monitoring network will be reviewed and modified if needed to ensure that the network is sufficient to achieve the objective of monitoring for groundwater quality impacts caused by GSP PMAs.

In addition to the regular monitoring of groundwater quality using the selected sustainability indicator wells, ongoing assessment of groundwater quality conditions for the ILRP is also occurring and involves annual sampling of a regional network of relatively shallow wells, evaluation of trends in groundwater quality related to irrigated agricultural practices, and also includes additional compilation and analysis of groundwater quality trends and conditions at five-year intervals based on readily available public data. Under the ILRP Waste Discharge Requirements for the East San Joaquin Water Quality Coalition (Coalition), growers in the Plan Area also must sample and report groundwater quality domestic wells on parcels enrolled in the Coalition. Data and reports on groundwater quality conditions developed through the ILRP will be considered and evaluated as part of assessing the groundwater quality sustainability indicator and relationships with GSP PMAs. Additionally, many more public water supply wells exist with recent groundwater quality monitoring for the three key constituents of interest. Some of these wells are incorporated as part of the representative groundwater quality monitoring network; however, data for other wells will also be considered in evaluating any potential groundwater quality impacts from GSP PMAs.

Groundwater quality impacts from activities unrelated to specific GSP PMAs are under the purview of separate regulatory programs including the ILRP or other regulatory programs overseeing waste discharges to groundwater and groundwater contamination sites.

2.2.1.2 Lateral and Vertical Subbasin Boundaries

The Madera Subbasin is bordered by the Sierra Nevada Mountains to the east, Kings Subbasin to south, Chowchilla Subbasin to the north, and Delta-Mendota Subbasin to the west (**Figure 2-17**). Bedrock to the east represents a hydrogeologic boundary, whereas the other three boundaries are political/agency boundaries across which groundwater flow can and does occur. There is a small amount of fractured bedrock groundwater inflow to Madera Subbasin on the east.

The base of fresh water was evaluated by Page (1973), and was defined in this study as including water with conductivity up to 3,000 micromhos/centimeter (umhos/cm). Overall, the base of freshwater was mapped as ranging approximately from elevation -400 to -1,200 feet msl within Madera Subbasin. In general, the shallowest depths to base of fresh water were along the western boundary of the Subbasin, and the greatest depths were areas located just north of the City of Madera in the eastern portion of the Subbasin (**Figure 2-18).** This base of fresh water mapped by Page should be considered approximate and might be expected to be slightly shallower, because fresh water is generally considered to have total dissolved solids of less the 1,000 milligrams/liter (mg/L) or conductivity of less than 1,600 umhos/cm. The base of fresh water will be refined over time as more data are collected, including lithologic, geophysical, water level, and water quality data currently being collected as part of the 2019-2020 nested monitoring well program.

Maps of the depth to basement rock (**Figure 2-19**) and elevation of basement rock (**Figure 2-20**) show increasing depths (and decreasing elevations) to basement rock from northeast to southwest across the Subbasin. The depths to bedrock range from less than 500 feet (essentially zero at the eastern Subbasin boundary) to greater than 4,000 feet at the southwestern boundary of the Subbasin. In general, the aquifer base is controlled mostly by the base of fresh water provided in **Figure 2-18** except in the far eastern portions of the Subbasin. It should also be recognized that wells drilled and screened below the currently defined base of fresh water likely will still have a hydraulic connection with the overlying fresh water zone and are considered part of the Madera Subbasin. While the extent of any extraction from well screens below the base of fresh water is unknown, such extraction is likely negligible given that the defined base of freshwater by Page (1973) is relatively high (TDS of approximately 2,000 mg/L) and groundwater exceeding a TDS of 2,000 mg/ exceeds the standards needed for the primary beneficial uses in the basin (e.g., drinking water, irrigation water).

Additional Action 1: ISW

<u>Interconnected Surface Water Coordination with Kings, United States Bureau of Reclamation, Friant Water Authority, and the San Joaquin River Restoration Program</u>

Since late 2023 and as a result of individual comments received following submission of the 2020 Joint GSP, representatives from the Madera Subbasin and Kings Subbasin have been meeting monthly with representatives from the United States Bureau of Reclamation (USBR) and Friant Water Authority (FWA) to better understand their issues and concerns related to Interconnected Surface Water (ISW) along the San Joaquin River (SJR) from Reach 1A to the Mendota Pool. Concurrent with meetings with USBR and FWA, representatives from both the Madera and Kings subbasins have had extensive communication with representatives of the San Joaquin River Restoration Program (SJRRP). As of the date of this Plan Amendment, USBR and FWA are continuing to work to quantify total diversions, uses, and estimates of losses along the SJ River. USBR is also working on a detailed analysis of the Holding Contracts and the groundwater pumping allowances and limitations that will need to be factored into any allowable groundwater pumping within proximity to the SJR. As a sign of their commitment to collaboratively working together to better understand ISW along the SJ River, the Kings and Madera subbasins have developed a Memorandum of Understanding (MOU) with USBR and FWA that includes a cooperative scope of work for further investigation of possible ISW from along the SJR from Reach 1a to Mendota Pool. A copy of the MOU between Kings, Madera, USBR, and FWA has been included in Appendix X.

In addition to development of the above noted ISW MOU and the resulting cooperatively developed work products, the GSAs plan to review the additional ISW guidance by DWR that was released in September 2024. In February 2024, DWR release the 1st of 3 papers on ISW. Papers 2 and 3 were were released in late September of 2024. In addition to the aforementioned papers, the GSAs understand that DWR plans to release an ISW guidance document in December 2024. During subsequent Plan Amendments, the GSAs may consider revisions to the current ISW SMC based on information gleaned from the collaborative work with USBR and FWA, in addition to the additional papers and guidance document issues by DWR. Any potential revisions to SMC for ISW will be reported in Annual Reports, Periodic Evaluations, and/or Plan Amendments.

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MEMORANDUM

To:	Julia Stornetta Root Creek Water District
From:	Provost & Pritchard
Subject:	Notable Updates to RCWD GSP
Date:	October 8, 2024

This memo summarizes notable updates to the Root Creek GSP in coordination with the Madera Subbasin GSAs suggested for the Plan Amendment to address corrective and additional actions recommended by the California Department of Water Resources.

- Revised definitions of MTs, MOs, and Undesirable Results (**Table 1**)
- Revised Interim Milestones established at five-year intervals (2025, 2030, and 2035) for groundwater levels and subsidence
- Water Levels
  - In the event of an IM exceedance or potential Undesirable Results after 2040, a domestic well mitigation program will be agreed and implemented within the RCWDGSA. RCWDGSA is cooperating in the development of the subbasin-wide domestic well mitigation program and plans to implement the provisions within the RCWDGSA boundary.
- Subsidence
  - Plans to install subsidence monument to monitor subsidence within RCWD
  - Revised IMs:
    - 2020-2025 = 1.5 feet of maximum cumulative subsidence
    - 2025-2030 = 1.0 feet of maximum cumulative subsidence
    - 2030-2035 = 0.5 feet of maximum cumulative subsidence
    - 2035-2040 = 0.25 feet of maximum cumulative subsidence
  - A proposed 'Subbasin Critical Infrastructure Operator Group' will be utilized if a subsidence IM is exceeded during implementation or the MT of 0 feet/year (+/- 0.16 feet) is exceeded after 2040
- Interconnected Surface Water
  - Madera Subbasin GSAs, along with neighboring Kings Subbasin GSAs along the San Joaquin River, have established the framework of an Interconnected Surface Water Working Group outlined in a Memorandum of Understanding. This collaborative effort will assist in establishing the framework to determine the timing and magnitude of potential surface water depletions from occurring in the future.
  - Any potential revisions to SMC for ISW will be reported in Annual Reports, Periodic Evaluations, and/or Plan Amendments.

Table 1 Summary of MTs, MOs, and Undesirable Results after 2040

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result (After 2040)
Chronic Lowering of Groundwater Levels	Set equal to the Fall 2015 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2015 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Set equal to the Fall 2010 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2010 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Same 30 percent of wells in the subbasin below minimum threshold for two consecutive fall measurements.
Reduction of Groundwater Storage	Same as MTs for chronic lowering of groundwater levels. (Groundwater levels used as proxy.)	Same as MOs for chronic lowering of groundwater levels. (Groundwater levels used as proxy.)	Same 30 percent of wells in the subbasin below minimum threshold for two consecutive fall measurements (Groundwater levels used as proxy)
Degraded Water Quality	Nitrate as N = 10 mg/L or existing level plus 20% (whichever is greater) Arsenic = 10 µg/L or existing level plus 20% (whichever is greater) TDS = 500 mg/L or existing level plus 20% (whichever is greater)	Baseline constituent concentrations	10 percent of wells in the subbasin above the minimum threshold for the same constituent due to projects and/or management actions, based on average of most recent three year period
Land Subsidence	0 feet/year, subject to uncertainty of +/- 0.16 feet/year	0 feet/year, subject to uncertainty of +/- 0.16 feet/year	Average subsidence across greater than 25 percent of RMS exceeding the minimum threshold for two consecutive years.
Depletion of Interconnected Surface Water	Madera Subbasin GSAs, Kings Subbasin GSAs adjacent to the San Joaquin River, the USBR, and the FWA established an Interconnected Surface Water Working Group outlined in the Memorandum of Understanding included as Appendix 6. This collaborative effort will assist in establishing the framework to determine MTs, MOs, and Undesirable Results associated with the timing and magnitude of potential surface water depletions from occurring in the future		
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable

CALIFORNIA DEPARTMENT OF WATER RESOURCES

SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE

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May 31, 2024

John Davids
Madera Subbasin – Plan Manager
1772 Picasso Avenue, Suite A
Davis, CA 95618
john@davidsengineering.com

RE: Annual Reports for the Madera Subbasin, Water Year 2023

Dear John Davids,

As the basin point of contact for the groundwater sustainability plans (GSPs or Plans) in the Madera Subbasin (Subbasin), this letter is to inform you that the Department of Water Resources (Department) has reviewed the annual reports submitted for the Subbasin for Water Year 2023. The Sustainable Groundwater Management Act (SGMA) requires, on April 1 following the adoption of a GSP and annually thereafter, an annual report to be submitted to the Department. The required contents of annual reports are included in the GSP Regulations (23 CCR § 356.2), as is the Department's role in reviewing annual reports (23 CCR § 355.8).

Once an annual report has been submitted, the Department is required to notify the submitting agency of receipt within 20 days, review the information to determine whether the basin's GSPs are being implemented in a manner likely to achieve its established sustainability goal, and notify the submitting agency in writing if additional information is required (23 CCR § 355.8).

Based on the review of the annual reports, Department staff have determined additional information is required from the submitting agency to either fulfill data and reporting standards or meet the requirements of the GSP Regulations (23 CCR § 356.2). Without this information, it is unclear whether the Plans are being implemented in a manner that will likely achieve the sustainability goal for the basin. Staff note three items that warrant requesting additional information pursuant to 23 CCR § 355.8.(b), as explained below.

1. Additional Information Related to Monitoring

While the annual reports provide estimates of groundwater elevation and storage change in Subbasin, the groundwater sustainability agencies (GSAs) have not collected monitoring data for a large portion of the monitoring network. For example, groundwater level data has not been collected at nearly 50% of representative monitoring sites. The annual reports indicate that the GSAs are facing ongoing issues with loss of access and propose potential new monitoring sites. However, staff have noted that ten sites from the current monitoring network have not had a successful measurement in several years due to repeated inaccessibility or destruction, as documented in the reports. Despite not having measurements for several years, these monitoring sites have not been replaced. Department staff request:

- The GSAs either provide the missing information, if available, or provide an analysis of the level of uncertainty created in developing a detailed understanding of groundwater conditions given that measurements for most of the monitoring networks were not collected. Further, the GSAs should explain how future monitoring efforts will either collect data from each of the representative monitoring sites or identify replacement locations where data will be collected.

2. Additional Information Related to Progress Toward Implementing the Plans

Based on the measurements that have been collected, minimum thresholds are being exceeded at over 85% of measured wells (6 of 7) in the Upper Aquifer and over 90% of measured wells (15 of 16) in the Lower Aquifer. Staff note that measurements provided for the spring in 2023—which represents a seasonal high for groundwater elevations—are also below established minimum thresholds for three monitoring sites.

While the planned exceedance of minimum thresholds via interim milestones for a temporary period to allow necessary projects and management actions to be developed and implemented has been evaluated and approved by the Department, it is critical the GSAs show actual progress towards implementing those activities and mitigating overdraft. The GSAs have not provided details demonstrating actual progress toward implementing the Plans to address these exceedances. A key management action planned by the GSAs—titled Demand Management—is anticipated to provide over 40% of the demand reduction required (90,000 acre-feet per) in the Subbasin by 2040. The annual reports document that management action has provided no benefit to date despite the expectation that the quantifiable benefit would start in 2020 and increase by 2% (of the total demand reduction amount) annually, for a total cumulative reduction of 10% by 2025. Given the lack of progress to date, it is unclear how the GSAs will reduce groundwater pumping by the proposed 6% per year rate starting in 2026 as anticipated in the Plans to mitigate the ongoing overdraft and raise water levels to minimum threshold levels. Department staff request:

- The GSAs provide a clear and concise explanation of current groundwater conditions, which include how many minimum threshold and interim milestone exceedances are present in the Subbasin and whether they constitute undesirable results.
- The GSAs provide an update to the suite of feasible projects and management actions to mitigate current levels of overdraft in the Subbasin and are likely to

achieve the sustainability goal for the Subbasin and allow water levels to stabilize and recover to minimum thresholds levels by 2040.

3. Additional Information Related to Effects to Beneficial Uses and Users of Groundwater

The Department's Dry Well Reporting System received 37 reports of wells going dry during water year 2023 in the Madera Subbasin. However, the annual reports do not mention this and completely lack a discussion of reported effects to beneficial uses and users, property interests, or well infrastructure as groundwater levels continue to decline. Staff believe documenting the effects occurring in the basin, especially wells going dry, is required to effectively implement the planned well mitigation program and demonstrate progress towards implementing the Plans, including achieving interim milestones.

- The GSAs provide a description of the effects to beneficial uses and users, property interests, and well infrastructure that occurred during water year 2023 due to groundwater conditions. This should include a comparison of the observed dry wells to the anticipated level of impact on domestic and municipal wells used to develop estimates in the GSPs and the mitigation plan. The GSAs should also describe how the GSAs are coordinating with these users to manage the Subbasin to avoid significant and unreasonable conditions.

The GSAs should provide additional information to the Department in the upcoming periodic evaluation (required to be submitted before January 31, 2025) and future annual reports. Failure to provide additional information requested may prevent the Department from concluding that the Plans are being implemented in a manner that will likely achieve the sustainability goal for the basin, which may result in the Plans being found inadequate and referred to the State Water Resources Control Board.

A few other minor issues were noted during the review that should be addressed in future annual report submittals including:

- The data submitted to the SGMA Portal needs to be aggregated for the entire basin, rather than separate data submittals for each GSA.

- The basin point of contact should submit one annual report for the entire Subbasin each year with the additional GSA specific information included as appendices, as necessary. The one coordinated annual report should document the aggregated data for the entire Subbasin that was submitted to the SGMA Portal while also presenting the GSA-specific data and information in tabular form.

Please contact the assigned DWR basin point-of-contact or sgmps@water.ca.gov if you have questions about this notice or the annual reporting process. The Department looks forward to receiving your Water Year 2024 Annual Report by April 1, 2025.

Thank You,

Paul Gosselin

Paul Gosselin
Deputy Director
Sustainable Groundwater Management