CHOWCHILLA SUBBASIN

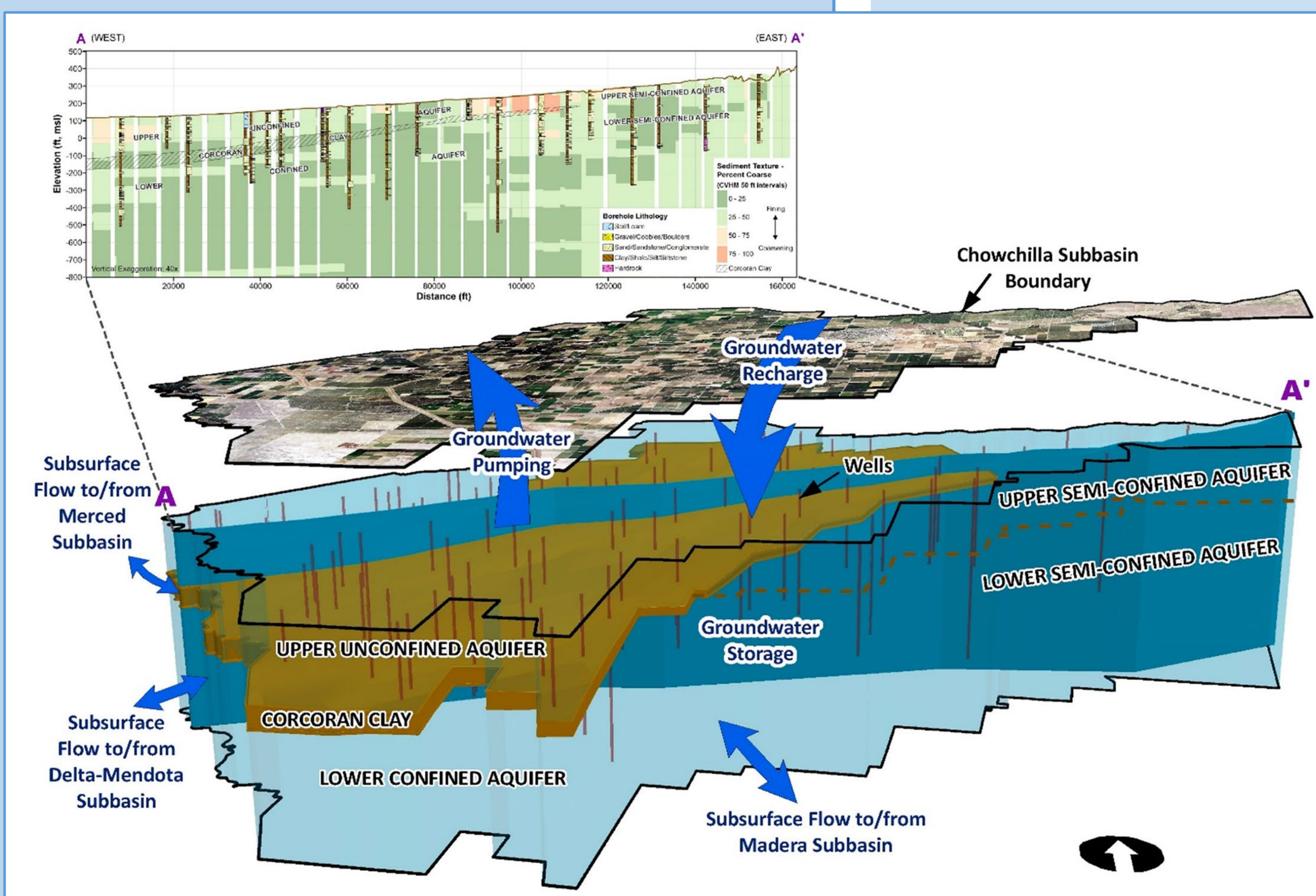
Sustainable Groundwater Management Act (SGMA)

Groundwater Sustainability Plan

January 2020
Revised July 2022

Prepared by

Davids Engineering, Inc. (Revised GSP)
Luhdorff & Scalmanini (Revised GSP)
ERA Economics
Stillwater Sciences and
California State University, Sacramento



Final

Chowchilla Subbasin

Sustainable Groundwater Management Act

Groundwater Sustainability Plan

January 2020

Revised July 2022

Prepared For

Chowchilla Subbasin GSP Advisory Committee

Prepared By

Davids Engineering, Inc. (Revised GSP)
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ERA Economics
Stillwater Sciences and
California State University, Sacramento

TRIANGLE T WATER DISTRICT | CHOWCHILLA WATER DISTRICT | MERCED COUNTY | MADERA COUNTY

July 27, 2022

Paul Gosselin
Deputy Director for Sustainable Groundwater Management
California Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

Sent Electronically

RE: Revisions to the 2020 Chowchilla Subbasin Groundwater Sustainability Plan

Dear Mr. Gosselin:

The Chowchilla Subbasin (Subbasin) and the four Groundwater Sustainability Agencies (GSAs) representing the Subbasin (Chowchilla Water District, County of Madera – Chowchilla, County of Merced – Chowchilla, and Triangle T Water District) submitted a Groundwater Sustainability Plan (GSP) to the California Department of Water Resources (DWR) in January 2020, which outlined a plan for achieving groundwater sustainability in the Subbasin by 2040, in accordance with the Sustainable Groundwater Management Act (SGMA). The GSP developed for the Subbasin and submitted in January 2020 was the result of extensive technical work and stakeholder engagement spanning over two years leading up to the submittal. During the GSP revision process in 2022, the GSAs conducted further public outreach through three public GSP Advisory Committee meetings, public GSA governing body meetings, and through public notices regarding the GSP revision process. The GSP submitted in January 2020 and the Revised GSP is the product of this process and reflects a balance of local interests across a very broad and diverse cross-section of stakeholders and beneficial users.

A key element included and described in the GSP is a Domestic Well Mitigation Program to mitigate undesirable results for domestic well users that are significantly and adversely impacted by groundwater level declines that may occur during the GSP implementation period while the GSAs implement other projects and management actions to achieve and maintain sustainability.

On November 18, 2021, the four GSAs received DWR's letter initiating consultation for the Chowchilla Subbasin GSP. The letter described the potential deficiencies identified by DWR that may preclude approval of the submitted GSP at this time and indicated the GSAs would have the opportunity to perform corrective actions to address the noted deficiencies within a 180-day period after the final DWR determination was released in January 2022. On January 24, 2022, the GSAs provided a written response to DWR's November 18, 2021 letter (please see attached). In the GSAs' January 24, 2022 correspondence, the GSAs outlined the potential deficiencies, summarized the progressive implementation actions taken by the GSAs since submission of the GSP in January 2020, reaffirmed their commitment to implementing the GSP, and further their commitment to working cooperatively with DWR and to revising the GSP during the 180-day consultation period. As an update to the comprehensive summary of progressive implementation actions provided in the GSAs' January 24, 2022 correspondence, it is important to note that a Proposition 218 approval effort that would have financed projects for the County of Madera – Chowchilla GSA to finance projects had a successful majority protest. At this time, funding for the County of Madera – Chowchilla GSA projects could be acquired through penalties, grants, and/or privately through grower efforts, but it is noted that a groundwater allocation is currently in effect that decreases water use over time.

On January 28, 2022, the four GSAs received DWR's final incomplete determination (please see attached). As noted in DWR's January 28, 2022 letter, the GSAs had 180 days, the maximum allowed by GSP Regulations, to address the identified deficiencies. A summary of the three GSP deficiencies identified in DWR's January 28, 2022 letter is as follows:

1. The GSP lacks justification for, and effects associated with, the sustainable management criteria for groundwater levels (GWL), particularly the minimum thresholds and undesirable results, and the effects of those criteria on the interest of beneficial uses and users of groundwater.

2. The GSP lacks justification for, and effects associated with, the sustainable management criteria for land subsidence, particularly the minimum thresholds and undesirable results and the effects of those criteria on the interests of land surface beneficial uses and users in the Subbasin.

3. The GSAs do not sufficiently demonstrate that interconnected surface water (ISW) or undesirable results related to depletions of interconnected surface water are not present and are not likely to occur in the Subbasin.

Consistent with the GSAs' commitment to work cooperatively with DWR regarding revisions to the GSP, the GSAs have met with DWR five (5) times from December 2021 through May 2022. Specific meeting dates and subjects for each of the meetings is as follows:

Chowchilla Subbasin - DWR Meeting Summary	
Meeting Date	Topic(s)
December 3, 2021	General considerations, progress update, deficiency review, and next steps
January 11, 2022	Representative monitoring sites and groundwater levels
February 10, 2022	Subsidence
March 16, 2022	Subsidence
May 13, 2022	Interconnected surface water

From the GSAs' perspective, the meetings with DWR Staff were helpful in facilitating an open and transparent discussion about the deficiencies identified and the subsequent corrective actions necessary to allow DWR to approve the revised GSP for the Subbasin. The GSAs want to thank DWR for their cooperation and associated direction on each of the deficiencies. In all cases, the GSAs provided DWR with a detailed agenda and/or questions ahead of time in an effort to solicit a meaningful and productive discussion (please see attached). A summary of the guidance provided is as shown below:

Overarching Comments:

1. Subbasin conditions can temporarily exceed Minimum Thresholds (MTs) on the way to achieving sustainable conditions, and will not immediately be considered a failure of the GSP as long as Projects and Management Actions are being implemented according to schedule and Interim Milestones (IMs) are being met.

2. IMs are intended to chart a path towards sustainability. IMs should be set to reflect conditions that are anticipated to occur during the GSP implementation period while the GSAs are implementing projects and management actions to achieve sustainable conditions. IMs may exceed MTs provided that the GSP demonstrates a plan for achieving sustainable conditions and avoiding Undesirable Results (URs) by 2040.

3. Annual reports are an important opportunity to explain and demonstrate progress towards implementation of the GSP, especially as it pertains to conditions relative to IMs and MTs.

4. The GSAs have opportunities to review the GSP and adjust Sustainable Management Criteria (SMC) through the GSP updates required to occur at least every five years.

Domestic Well Mitigation Program:

1. The Domestic Well Mitigation Program (Program) must be implemented.

    a. Because the SMC were established with the understanding that URs are occurring/will occur for domestic well users, the acceptability of the GSP hinges on implementation of this Program to mitigate for the most vulnerable users.

    b. By the end of the 180-day period, the GSAs must set clear intentions and have a specific plan and timeline for implementing this Program, e.g. having a fully executed Memorandum of Understanding (MOU) in place by the time the revised GSP is submitted.

2. It is ok for the GSAs to coordinate with the Safe and Affordable Funding for Equity and Resilience (SAFER) and/or other short-term programs, but the GSAs need to make sure that they have a plan to manage around those programs without relying on them for long-term mitigation.

    a. Domestic well mitigation over the GSP implementation horizon should be more comprehensive and include lasting solutions to address domestic water needs beyond short-term mitigation programs.

Groundwater Levels:

1. Subbasin conditions can temporarily exceed MTs on the way to achieving sustainable conditions.

2. If GWL decline is occurring, the GSP must have an implementable plan to address those impacts.

    a. Because the SMC were established with the understanding that URs are occurring/will occur for domestic well users, acceptability of the GSP hinges on implementation of the Domestic Well Mitigation Program (see above).

3. Provide more explanation of the Domestic Well Mitigation Program (Program) and rationale for setting SMC in coordination with that Program.

4. Need to clearly address/assess URs for municipal service wells, public supply wells, and agricultural wells.

Subsidence:

1. GSP should clarify the nexus between the MTs and URs in the Western Management Area (MA).

    a. The more degrees of freedom you allow in defining URs (e.g., allowing 50% of your wells to drop below the MTs), the more burden there is on the GSAs to justify those definitions and explain how the GSP will sufficiently identify URs, if they occur.

    b. Recommend using Statewide subsidence data to assess how different rates of subsidence are causing URs.

2. GSP should set formal SMC in the Eastern MA (even if they are considered "interim," acknowledging data gaps and that these SMC will be revisited).

3. Modeling (during the 180-day consultation period) is not necessary to establish or support SMC.

4. The GSP should clearly define the type/location of critical infrastructure and analyze/explain the potential effects of subsidence on critical infrastructure.

5. The GSP should clearly analyze/explain the relationship between subsidence and the Corcoran clay layer, as relevant to the processes that were used to set the subsidence SMC.

6. The GSP should include additional descriptions of actions toward subsidence mitigation since GSP adoption (e.g., updates to the subsidence mitigation agreement executed by certain landowners in the Western MA).

7. DWR understands that data gaps exist. Creating the framework for subsequent detailed work plans that will collect more data to improve understanding of subsidence conditions would be helpful.

8. The GSP should provide some estimate of anticipated/expected residual and/or additional subsidence that may occur during the GSP implementation period.

9. Zero subsidence is not a realistic expectation; however, the GSP needs an assessment and narrative discussion of anticipated additional subsidence (whether that be considered "residual" or "renewed" and what that means for critical infrastructure).

10. SMC can be changed in the five-year GSP updates with justification from additional data collection and improved basin understanding.

11. The GSP can set different MTs for different portions of management areas depending on proximity to critical infrastructure, but it is important that those differences are described.

12. IMs are a way to account for subsidence expectations during the GSP implementation period (e.g., IMs reflect a declining rate of subsidence).

13. GSP regulations make no distinction between elastic and inelastic subsidence so both should be considered in setting SMC.

14. GWLs may be acceptable for use as proxy for subsidence with sufficient demonstration of the relationship between GWLs and subsidence.

Interconnected Surface Water:

1. Create the framework for a detailed work plan for filling ISW data gaps, including:

    a. Additional locations for shallow monitoring wells.

    b. River stage recorders paired with monitoring wells.

    c. Incorporating Airborne Electromagnetic (AEM) data when available.

    d. Thalweg surveys.

2. In terms of the temporal aspect of ISW, the historical percent of time a GW/SW connection exists (e.g., primarily during winter/spring of wet years) should not decrease in the future.

3. The GSP should analyze whether future groundwater management will deplete any possible connection, and whether Groundwater Dependent Ecosystems (GDEs) are affected.

4. If data gaps exist, note those and a preliminary timeline/schedule for filling those.

5. DWR recognizes the high uncertainty related to the ISW Sustainability Indicator (SI) as implied by regulations that indicate SWRCB will not intervene until 2025 for this SI.

Considering DWR's direction as summarized above, the GSAs have worked diligently during the 180-Day revision period to make the necessary revisions to the GSP. In an effort to streamline DWR's review of the Revised GSP as included herein, the GSAs have prepared a matrix (please see attached) that outlines each of the defined deficiencies, a general description of the deficiency, the corrective action taken in the Revised GSP, where the deficiency was addressed in the Revised GSP, how the deficiency was addressed in the Revised GSP, and the corresponding direction from DWR that was relied upon for the revision.

As you will see, and consistent with your recommendations, one of the most prominent revisions to the GSP is the inclusion of a fully executed Domestic Well Mitigation Program MOU that very clearly articulates the foundational components of the Program in the Subbasin and further that the Program will be **funded and operational by January 1, 2023**. Another prominent revision to the GSP is development of a Subsidence Workplan. Protection of critical infrastructure, such as the Eastside Bypass and Sack Dam continue to be a priority. The GSAs will continue to enhance their subsidence monitoring and management that will be informed by additional information collected through completion of the activities set-forth in Subsidence Workplan. The Subsidence Workplan will include, but not be limited to recommendations and implementation plans for future subsidence monitoring, as well a review of existing groundwater pumping relative to the upper and lower aquifers. As is evidenced by the initial GSP, progressive action to implement the GSP since submission of the GSP in January 2020, and the subsequent revisions included in the Revised GSP, the GSAs in the Subbasin remain steadfast in their commitment to manage groundwater resources in a sustainable manner.

The GSAs in the Subbasin look forward to your timely review of the Revised GSP and should you have any questions or concerns, please feel free to contact me at (559) 479-6050.

Sincerely,

Douglas Welch

Douglas Welch
Chowchilla Subbasin Plan Manager

Enclosures: Copy of January 24, 2022 Letter to DWR
Copy of January 28, 2022 Letter from DWR
December 3, 2021 Meeting Agenda
January 11, 2022 Meeting Agenda
February 10, 2022 Meeting Agenda
March 16, 2022 Meeting Questions
May 13, 2022 Meeting Questions
Revised GSP Matrix
Revised GSP

cc: Administration Files
Madera County Board of Supervisors
Chowchilla Water District Board of Directors
Triangle T Water District Board of Directors
Merced County Board of Supervisors

Copy of January 24, 2022 Letter to DWR

January 24, 2022

Paul Gosselin
Deputy Director for Sustainable Groundwater Management
California Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

Sent Electronically

RE: DWR's November 18, 2021 Correspondence Initiating Consultation Regarding the Chowchilla Subbasin GSP

Dear Mr. Gosselin,

The Chowchilla Subbasin (Subbasin) and the four Groundwater Sustainability Agencies (GSAs) representing the Subbasin (Chowchilla Water District, County of Madera – Chowchilla, County of Merced – Chowchilla, and Triangle T Water District) submitted a Groundwater Sustainability Plan (GSP) to the California Department of Water Resources (DWR) in January 2020, which outlined a plan for achieving groundwater sustainability in the Subbasin by 2040, in accordance with the Sustainable Groundwater Management Act (SGMA). The GSP developed for the Subbasin and submitted in January 2020 was the result of extensive technical work and stakeholder engagement spanning over two years leading up to the submittal. The GSP is the product of this process and reflects a balance of local interests across a very broad and diverse cross-section of stakeholders and beneficial users. A key element included and described in the GSP is a Domestic Well Mitigation Program to mitigate undesirable results for domestic well users that are significantly and adversely impacted by groundwater level declines that may occur during the GSP implementation period while the GSAs implement other projects and management actions to achieve and maintain sustainability. The four GSAs are committed to implementing the GSP, implementing the Domestic Well Mitigation Program, and achieving groundwater sustainability, as described in the GSP.

The four GSAs received DWR's letter initiating consultation for the Chowchilla Subbasin GSP dated November 18, 2021. The letter describes the potential deficiencies identified by DWR that may preclude approval of the submitted GSP at this time and indicates the GSAs will have the opportunity to perform corrective actions to address the noted deficiencies within a 180-day period after the final DWR determination is released in January 2022.

The potential GSP deficiencies identified in the letter initiating consultation relate to the following topics:

- Chronic lowering of groundwater levels sustainable management criteria and details related to the Domestic Well Mitigation Program;
- Land subsidence sustainable management criteria; and

- Applicability of sustainable management criteria related to interconnected surface water in the Subbasin.

Following release of the letter initiating consultation, technical representatives of the four GSAs in the Chowchilla Subbasin held meetings with DWR in December and January to discuss the potential GSP deficiencies identified by DWR and the potential corrective actions described in the letter initiating consultation. The GSAs look forward to continuing this dialogue with DWR during the 180-day consultation period to clarify and refine our understanding of what revisions to the GSP may be necessary to address the noted deficiencies and obtain DWR approval of the GSP. Based on the two meetings conducted to date, the GSAs believe there is a path forward for meeting DWR's expectations of the GSP and achieving approval of a revised GSP within the 180-day consultation period.

We understand that the letter initiating consultation is based strictly on the content of the GSP and actions taken by the GSAs leading up to submission of the final GSP in January 2020. It is important to note that since submitting the GSP in January 2020, the Chowchilla Subbasin GSAs have proceeded with GSP implementation and have taken numerous actions during the past two years to implement projects, management actions, and additional studies to enhance our understanding of groundwater conditions and the many beneficial users of groundwater in the Subbasin. A brief list of some of these actions is included below:

- Initiation of steps toward developing a Domestic Well Mitigation Program, including conducting a domestic well inventory and planning for installation of nine dedicated monitoring wells at three well sites for additional groundwater monitoring near domestic wells;
- Installation of dedicated groundwater monitoring wells across the Subbasin, including 34 separate wells screened in the Upper or Lower Aquifers at 14 unique sites, including 12 new monitoring wells at six sites in the Triangle T Water District (TTWD);
- County of Madera GSA's efforts in developing a groundwater allocation framework (including tracking water use through remote sensing) and demand management program for areas within the GSA, conducting two studies (water market study and sustainable agricultural land conservation study) as part of the demand management program, and conducting a rate study to fund the County of Madera GSA's portion of implementation costs for projects and management actions in the GSP, including support of the Domestic Well Mitigation Program;
- Chowchilla Water District (CWD) GSA's expanded groundwater recharge efforts through greater use of two existing recharge basins, construction of two new recharge basins, implementation of Flood Managed Aquifer Recharge (Flood-MAR), and utilization of its canal system and other conveyance features (Chowchilla River, Ash Slough, and Berenda Slough) to recharge surplus water supply when available;
- TTWD GSA's efforts in construction of two pipeline projects to import additional surface water to the Subbasin, construction of 508 acres of dedicated recharge basins plus planning related to an additional 310 acres of dedicated recharge basins to be constructed by landowners, and updating and amending the Subsidence Agreement with parties in the Delta-Mendota Subbasin (which is anticipated to include installation of a subsidence monitoring station at Sack Dam);

- Sierra Vista Mutual Water Company's efforts in planning for development of up to 300 acres of dedicated recharge ponds (located within the County of Merced and County of Madera GSAs) with anticipated operations to begin in 2023;
- Additional recharge project planning and design efforts, including work being conducted by the County of Madera and TTWD GSAs under a $4.6M Prop 68 grant.
- Development of an Emergency Recharge Program by County of Madera in an effort to have water rights and conveyance infrastructure in place to take flood waters off the Chowchilla Bypass for implementation of Flood-MAR as an interim stop-gap measure until all permanent recharge infrastructure is completed and operational.
- Submission and approval of temporary and appropriative water right applications by TTWD for diverting water off the Chowchilla Bypass.

DWR's letter initiating consultation indicates the revised GSP should provide a greater level of detail in describing the rationale for establishing sustainable management criteria related to groundwater levels, subsidence, and interconnected surface water. Additionally, because the Domestic Well Mitigation Program is a key element in the GSP, the letter initiating consultation notes that more details on plans related to the development and implementation of the Domestic Well Mitigation Program should be included in the revised GSP.

The criteria for setting sustainable management criteria, including minimum thresholds, in the GSP incorporated an assumption that a Domestic Well Mitigation Program will be established by the GSAs. This was recognized early in GSP development, thoroughly vetted, and discussed in numerous public forums during GSP development. Analyses presented in the GSP (Appendix 3C) demonstrate that establishing a Domestic Well Mitigation Program is a far superior economic alternative for the Subbasin when compared to immediate reductions in pumping leading to cascading regional economic losses. This approach to mitigate impacts to domestic wells balances the imperative water supply concerns of many different stakeholder groups with the economic wellbeing of the entire region. SGMA provides 20 years to reach sustainability, and the Domestic Well Mitigation Program is intended to provide assistance to domestic well owners impacted by declining groundwater levels during the GSP implementation period while the Subbasin works towards achieving sustainability through the implementation of projects and management actions.

To support the development of the Domestic Well Mitigation Program, the GSAs have been working on a number of projects and actions, described above, including an inventory of domestic wells, evaluation of the number of domestic wells that may go dry during the GSP Implementation Period, and estimates of associated domestic well mitigation costs. This work is nearing completion and draft results have been reported in public meetings and during a meeting with DWR in November 2021. The results from the domestic well inventory are being used to develop plans for funding the Domestic Well Mitigation Program, including through a rate study and initiation of a Prop 218 process for the County of Madera GSA in an effort to fund their portion of implementation.

The GSAs in the Chowchilla Subbasin have been working hard to implement the GSP submitted in 2020 and have made substantial progress towards reaching sustainable groundwater management in the initial two years, with much work ahead before 2040. The GSAs in the Subbasin look forward to continuing to work cooperatively with DWR and to revising the GSP during the 180-day consultation period to address deficiencies identified by DWR and achieve approval of the revised GSP. Should you have any questions or concerns, please feel free to reach out to one or all of the representatives noted below.

Sincerely,

Douglas Welch

Doug Welch
Chowchilla Water District GSA

Stephanie Anagnoson
County of Madera GSA – Chowchilla

Lacey McBride
County of Merced GSA – Chowchilla

chase hurley

Chase Hurley
Triangle T Water District GSA

Copy of January 28, 2022 Letter from DWR

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE
715 P Street, | Sacramento, CA 95814 | P.O. Box 942836 | Sacramento, CA 94236-0001

January 28, 2022

Doug Welch
Chowchilla Subbasin Plan Manager
327 S. Chowchilla Blvd.
Chowchilla, CA 93610
dwelch@cwdwater.com

RE: Incomplete Determination of the 2020 Chowchilla Subbasin Groundwater Sustainability Plan

Dear Doug Welch,

The Department of Water Resources (Department) has evaluated the groundwater sustainability plan (GSP) submitted for the Chowchilla Subbasin (Subbasin) and has determined that the GSP is incomplete. The Department based its determination on recommendations from the Staff Report, included as an enclosure to the attached Statement of Findings, which describes that the Chowchilla Subbasin GSP does not satisfy the objectives of the Sustainable Groundwater Management Act (SGMA) nor substantially comply with the GSP Regulations. The Staff Report also provides corrective actions which the Department recommends to address the identified deficiencies.

The Subbasin's Groundwater Sustainability Agencies (GSAs) have 180 days, the maximum allowed by GSP Regulations, to address the identified deficiencies. Where addressing the deficiencies requires modification of the GSP, the GSAs must adopt those modifications into the Subbasin's GSP or otherwise demonstrate that those modifications are part of the GSP before resubmitting it to the Department for evaluation no later than July 27, 2022. The Department understands that much work has occurred to advance sustainable groundwater management since the GSAs submitted the GSP in January 2020. To the extent to which those efforts are related or responsive to the Department's identified deficiencies, we encourage you to document that as part of your resubmittal. The Department prepared a Frequently Asked Questions document to provide general information and guidance on the process of addressing deficiencies in an incomplete determination.

Department staff will work expeditiously to review the revised components of your GSP resubmittal. If the revisions address the identified deficiencies, the Department will determine that the GSP is approved. In that scenario, Department staff will identify additional recommended corrective actions that the GSAs should address early in implementing their GSP (i.e., no later than the first required periodic evaluation). Among other items, those recommendations will include for the GSAs to provide more detail on their plans and schedules to address data gaps. Those recommendations will also call for significantly expanded documentation of the plans and schedules to implement specific projects and management actions. Regardless of those recommended corrective actions, the Department expects the first periodic evaluations, required no later than January 2025 – one-quarter of the way through the 20-year implementation period – to document significant progress toward achieving sustainable groundwater management.

If the GSAs cannot address the deficiencies identified in this letter by July 27, 2022, then the Department, after consultation with the State Water Resources Control Board, will determine the GSP to be inadequate. In that scenario, the State Water Resources Control Board may identify additional deficiencies that the GSAs would need to address in the state intervention processes outlined in SGMA.

Please contact Sustainable Groundwater Management staff by emailing sgmps@water.ca.gov if you have any questions about the Department's assessment, implementation of your GSP, or to arrange a meeting with the Department.

Thank You,

Paul Gosselin

Paul Gosselin
Deputy Director of Sustainable Groundwater Management

Attachment:

1. Statement of Findings Regarding the Determination of Incomplete Status of the San Joaquin Valley - Chowchilla Subbasin Groundwater Sustainability Plan

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

STATEMENT OF FINDINGS REGARDING THE DETERMINATION OF INCOMPLETE STATUS OF THE CHOWCHILLA SUBBASIN GROUNDWATER SUSTAINABILITY PLAN

The Department of Water Resources (Department) is required to evaluate whether a submitted groundwater sustainability plan (GSP or Plan) conforms to specific requirements of the Sustainable Groundwater Management Act (SGMA or Act), is likely to achieve the sustainability goal for the basin covered by the Plan, and whether the Plan adversely affects the ability of an adjacent basin to implement its GSP or impedes achievement of sustainability goals in an adjacent basin. (Water Code § 10733.) The Department is directed to issue an assessment of the Plan within two years of its submission. (Water Code § 10733.4.) This Statement of Findings explains the Department's decision regarding the Plan submitted jointly by the Chowchilla Water District Groundwater Sustainability Agency (GSA), Madera County GSA, County of Merced Chowchilla GSA, and Triangle T Water District GSA (collectively, the GSAs or Agencies) for the Chowchilla Subbasin (No. 5-022.05).

Department management has reviewed the enclosed Staff Report, which recommends that the identified deficiencies should preclude approval of the GSP. Based on its review of the Staff Report, Department management is satisfied that staff have conducted a thorough evaluation and assessment of the Plan and concurs with, and hereby adopts, staff's recommendation and all the corrective actions provided. The Department thus deems the Plan incomplete based on the Staff Report and the findings contained herein.

A. The GSP has not defined sustainable management criteria in the manner required by SGMA and the GSP Regulations.

    1. The GSP lacks justification for, and effects associated with, the sustainable management criteria for groundwater levels, particularly the minimum thresholds and undesirable results, and the effects of those criteria on the interests of beneficial uses and users of groundwater.

        i. The GSP does not describe when the Potential Domestic Well Mitigation Program will be implemented and financed by the GSAs in the Subbasin, or how rapidly the GSAs will be able to respond to developing domestic well impacts. Absent this information, Department staff cannot evaluate whether the sustainable management criteria for groundwater levels are reasonable and will avoid undesirable results.

ii. The GSP does not provide supporting information for how it determined that the selected minimum thresholds will not interfere with other sustainability indicators. The GSP fails to examine the relationship between allowable groundwater level declines and land subsidence in the Subbasin. Absent that supporting information and specific details regarding how that information was considered by the GSAs, Department staff cannot evaluate whether the criteria are reasonable or whether operating the Subbasin to avoid those thresholds is consistent with avoiding interference with other sustainability indicators.

2. The GSP lacks justification for, and effects associated with, the sustainable management criteria for land subsidence, particularly the minimum thresholds and undesirable results and the effects of those criteria on the interests of land surface beneficial uses and users in the Subbasin.

   i. The GSP does not describe in specific terms what land surface beneficial uses and users in the Subbasin (e.g., infrastructure such as canals or levees) may be susceptible to substantial interference as a result of continued subsidence, or what amount of continued subsidence is tolerable for the identified land surface beneficial uses and users. Absent this information, Department staff cannot evaluate whether the criteria will avoid undesirable results.

   ii. The GSP does not include analysis demonstrating a significant correlation between groundwater levels, which are allowed to decline below the historical low at up to 50 percent of monitoring sites, and land subsidence in the Western Management Area. Absent this information, Department staff cannot evaluate whether the criteria will avoid undesirable results.

   iii. The GSP allows for continued land subsidence in the Eastern Management Area, which does not reflect the intent of SGMA that subsidence be avoided or minimized once sustainability is achieved. The GSP does not explain how implementation of the projects and management actions is consistent both with achieving the long-term avoidance or minimization of subsidence and with not exceeding the tolerable amount of cumulative subsidence.

B. The GSAs do not sufficiently demonstrate that interconnected surface water or undesirable results related to depletions of interconnected surface water are not present and are not likely to occur in the Subbasin.

   1. The GSP does not provide a clear and comprehensive analysis of the potential for interconnected surface water to be present along the San Joaquin River in the Subbasin.

Based on the above, the GSP submitted by the Agencies for the Chowchilla Subbasin is determined to be incomplete because the GSP does not satisfy the requirements of SGMA, nor does it substantially comply with the GSP Regulations. The corrective actions provided in the Staff Report are intended to address the deficiencies that, at this time, preclude approval. The Agencies have up to 180 days to address the deficiencies outlined above and detailed in the Staff Report. Once the Agencies resubmit their Plan, the Department will review the revised GSP to evaluate whether the deficiencies were adequately addressed. Should the Agencies fail to take sufficient actions to correct the deficiencies identified by the Department in this assessment, the Department shall disapprove the Plan if, after consultation with the State Water Resources Control Board, the Department determines the Plan inadequate pursuant to 23 CCR § 355.2(e)(3)(C).

Signed:

Karla Nemeth, Director
Date: January 28, 2022

Enclosure: Groundwater Sustainability Plan Assessment Staff Report – San Joaquin Valley – Chowchilla Subbasin

State of California
Department of Water Resources
Sustainable Groundwater Management Program
Groundwater Sustainability Plan Assessment Staff Report

Groundwater Basin Name:	Chowchilla Subbasin (No. 5-022.05)
Submitting Agencies:	Chowchilla Water District Groundwater Sustainability Agency, Madera County Groundwater Sustainability Agency, County of Merced Chowchilla Groundwater Sustainability Agency, Triangle T Water District Groundwater Sustainability Agency
Recommendation:	Incomplete
Date:	January 28, 2022

The Sustainable Groundwater Management Act (SGMA)[1] allows for any of the three following planning scenarios: a single groundwater sustainability plan (GSP) developed and implemented by a single groundwater sustainability agency (GSA); a single GSP developed and implemented by multiple GSAs; and multiple GSPs implemented by multiple GSAs and coordinated pursuant to a single coordination agreement.[2] Here, as presented in this staff report, a single GSP covering the entire basin was adopted and submitted to the Department of Water Resources (Department) for review.[3]

The Chowchilla Water District GSA, Madera County GSA, County of Merced Chowchilla GSA, and Triangle T Water District GSA (collectively, the GSAs) jointly submitted the Chowchilla Subbasin Groundwater Sustainability Plan (GSP or Plan) to the Department for evaluation and assessment as required by SGMA and the GSP Regulations.[4] The GSP covers the entire Chowchilla Subbasin (Subbasin) for the implementation of SGMA.

Evaluation and assessment by the Department is based on whether the adopted and submitted GSP, either individually or in coordination with other adopted and submitted GSPs, complies with SGMA and substantially complies with GSP Regulations. Department staff base their assessment on information submitted as part of an adopted GSP, public comments submitted to the Department, and other materials, data, and reports that are relevant to conducting a thorough assessment. Department staff have evaluated the GSP and have identified deficiencies that staff recommend should preclude its approval.[5] In addition, consistent with the GSP Regulations, Department staff have

[1] Water Code § 10720 *et seq*.
[2] Water Code § 10727.
[3] Water Code §§ 10727(b)(1), 10733.4; 23 CCR § 355.2.
[4] 23 CCR § 350 *et seq*.
[5] 23 CCR §355.2(e)(2).

provided corrective actions[6] that the GSAs should review while determining how and whether to address the deficiencies. The deficiencies and corrective actions are explained in greater detail in Section 3 of this staff report and are generally related to the need to define sustainable management criteria in the manner required by SGMA and the GSP Regulations and the development of sustainable management criteria for depletions of interconnected surface water.

This assessment includes four sections:

- **Section 1 – Evaluation Criteria:** Describes the legislative requirements and the Department's evaluation criteria.
- **Section 2 – Required Conditions:** Describes the submission requirements, GSP completeness, and basin coverage required for a GSP to be evaluated by the Department.
- **Section 3 – Plan Evaluation:** Provides a detailed assessment of deficiencies identified in the GSP which may be capable of being corrected by the GSAs. Consistent with the GSP Regulations, Department staff have provided corrective actions for the GSAs to address the deficiencies.
- **Section 4 – Staff Recommendation:** Provides the recommendation of Department staff regarding the Department's determination.

[6] 23 CCR §355.2(e)(2)(B).

1 EVALUATION CRITERIA

The Department evaluates whether a GSP conforms to the statutory requirements of SGMA[7] and is likely to achieve the basin's sustainability goal.[8] To achieve the sustainability goal, the GSP must demonstrate that implementation of its groundwater sustainability program will lead to sustainable groundwater management, which means the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.[9] Undesirable results are required to be defined quantitatively by the GSAs overlying a basin and occur when significant and unreasonable effects for any of the applicable sustainability indicators are caused by groundwater conditions occurring throughout the basin.[10] The Department is also required to evaluate whether the GSP will adversely affect the ability of an adjacent basin to implement its groundwater sustainability program or achieve its sustainability goal.[11]

To evaluate a GSP, the Department must first determine a GSP was submitted by the statutory deadline,[12] is complete,[13] and covers the entire basin.[14] For those GSAs choosing to develop multiple GSPs, the GSPs must be coordinated pursuant to a single coordination agreement that covers the entire basin.[15] If these conditions are satisfied, the Department evaluates the GSP to determine whether it complies with SGMA and substantially complies with the GSP Regulations.[16] As stated in the GSP Regulations, "[s]ubstantial compliance means that the supporting information is sufficiently detailed and the analyses sufficiently thorough and reasonable, in the judgment of the Department, to evaluate the Plan, and the Department determines that any discrepancy would not materially affect the ability of the Agency to achieve the sustainability goal for the basin, or the ability of the Department to evaluate the likelihood of the Plan to attain that goal."[17]

When evaluating whether implementation of the GSP is likely to achieve the sustainability goal for the basin, Department staff review the information provided and relied upon in the GSP for sufficiency, credibility, and consistency with scientific and engineering professional standards of practice.[18] The Department's review considers whether there is a reasonable relationship between the information provided by the GSA and the

[7] Water Code §§ 10727.2, 10727.4.
[8] Water Code §§ 10733(a).
[9] Water Code § 10721(v).
[10] 23 CCR § 354.26 *et seq*.
[11] Water Code § 10733(c).
[12] Water Code § 10720.7; 23 CCR § 355.4(a)(1).
[13] 23 CCR §§ 355.4(a)(2).
[14] 23 CCR § 355.4(a)(3).
[15] Water Code §§ 10727(b)(3), 10727.6; 23 CCR § 357.4.
[16] 23 CCR § 350 *et seq*.
[17] 23 CCR § 355.4(b).
[18] 23 CCR § 351(h).

assumptions and conclusions presented in the GSP, including whether the interests of the beneficial uses and users of groundwater in the basin have been considered; whether sustainable management criteria and projects and management actions described in the GSP are commensurate with the level of understanding of the basin setting; and whether those projects and management actions are feasible and likely to prevent undesirable results.[19] The Department also considers whether the GSA has the legal authority and financial resources necessary to implement the GSP.[20]

To the extent that overdraft is present in a basin, the Department evaluates whether the GSP provides a reasonable assessment of the overdraft and includes reasonable means to mitigate it.[21] When applicable, the Department will assess whether coordination agreements have been adopted by all relevant parties and satisfy the requirements of SGMA and the GSP Regulations.[22] The Department also considers whether the GSP provides reasonable measures and schedules to eliminate identified data gaps.[23] Lastly, the Department's review considers the comments submitted on the GSP and evaluates whether the GSA adequately responded to the comments that raise credible technical or policy issues with the GSP.[24]

The Department is required to evaluate the GSP within two years of its submittal date and issue a written assessment.[25] The assessment is required to include a determination of the GSP's status.[26] The GSP Regulations provide three options for determining the status of a GSP: approved,[27] incomplete,[28] or inadequate.[29]

After review of the GSP, Department staff may find that the information provided is not sufficiently detailed, or the analyses not sufficiently thorough and reasonable, to evaluate whether the GSP is likely to achieve the sustainability goal for the basin. If the Department determines the deficiencies precluding approval may be capable of being corrected by the GSA in a timely manner,[30] the Department will determine the status of the GSP to be incomplete. A formerly deemed incomplete GSP may be resubmitted to the Department for reevaluation after all deficiencies have been addressed by the GSA within 180 days after the Department makes its incomplete determination. The Department will review the revised GSP to evaluate whether the identified deficiencies were sufficiently addressed. Depending on the outcome of that evaluation, the Department may determine the resubmitted GSP is approved. Alternatively, the Department may find a formerly deemed

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[19] 23 CCR §§ 355.4(b)(1), (3), (4) and (5).
[20] 23 CCR § 355.4(b)(9).
[21] 23 CCR § 355.4(b)(6).
[22] 23 CCR § 355.4(b)(8).
[23] 23 CCR § 355.4(b)(2).
[24] 23 CCR § 355.4(b)(10).
[25] Water Code § 10733.4(d); 23 CCR § 355.2(e).
[26] *Ibid*.
[27] 23 CCR § 355.2(e)(1).
[28] 23 CCR § 355.2(e)(2).
[29] 23 CCR § 355.2(e)(3).
[30] 23 CCR § 355.2 (e)(2)(B)(i).

incomplete GSP is inadequate if, after consultation with the State Water Resources Control Board, it determines that the GSA has not taken sufficient actions to correct any identified deficiencies.[31]

Even when the Department determines a GSP is approved, indicating that it satisfies the requirements of SGMA and is in substantial compliance with the GSP Regulations, the Department may still recommend corrective actions.[32] Recommended corrective actions are intended to facilitate progress in achieving the sustainability goal within the basin and the Department's future evaluations, and to allow the Department to better evaluate whether implementation of the GSP adversely affects adjacent basins. While the issues addressed by the recommended corrective actions in an approved GSP do not, at the time the determination was made, preclude its approval, the Department recommends that the issues be addressed to ensure the GSP's implementation continues to be consistent with SGMA and the Department is able to assess progress in achieving the basin's sustainability goal.[33] Unless otherwise noted, the Department proposes that recommended corrective actions be addressed by the submission date for the first five-year assessment.[34]

The staff assessment of the GSP involves the review of information presented by the GSA, including models and assumptions, and an evaluation of that information based on scientific reasonableness. In conducting its assessment, the Department does not recalculate or reevaluate technical information provided in the GSP or perform its own geologic or engineering analysis of that information. The recommendation to approve a GSP does not signify that Department staff, were they to exercise the professional judgment required to develop a GSP for the basin, would make the same assumptions and interpretations as those contained in the GSP, but simply that Department staff have determined that the assumptions and interpretations relied upon by the submitting GSA are supported by adequate, credible evidence, and are scientifically reasonable.

Lastly, the Department's review of an approved GSP is a continual process. Both SGMA and the GSP Regulations provide the Department with the ongoing authority and duty to review the implementation of the GSP.[35] Also, GSAs have an ongoing duty to reassess their GSPs, provide annual reports to the Department and, when necessary, update or amend their GSPs.[36] The passage of time or new information may make what is reasonable and feasible at the time of this review to not be so in the future. The emphasis of the Department's periodic reviews will be to assess the progress toward achieving the sustainability goal for the basin and whether GSP implementation adversely affects the ability of adjacent basins to achieve its sustainability goals.

[31] 23 CCR § 355.2 (e)(3)(C).
[32] Water Code § 10733.4(d).
[33] Water Code § 10733.8.
[34] 23 CCR § 356.4.
[35] Water Code § 10733.8; 23 CCR § 355.6 *et seq*.
[36] Water Code §§ 10728 *et seq.*, 10728.2.

2 REQUIRED CONDITIONS

A GSP, to be evaluated by the Department, must be submitted within the applicable statutory deadline.[37] The GSP must also be complete and must, either on its own or in coordination with other GSPs, cover the entire basin. If a GSP is determined to be incomplete, Department staff may require corrective actions that address minor or potentially significant deficiencies identified in the GSP. The GSAs in a basin, whether developing a single GSP covering the basin or multiple GSPs, must sufficiently address those required corrective actions within the time provided, not to exceed 180 days, for the GSP to be reevaluated by the Department and potentially approved.

2.1 SUBMISSION DEADLINE

SGMA required basins categorized as high- or medium-priority as of January 1, 2017 and that were subject to critical conditions of overdraft to submit a GSP no later than January 31, 2020.[38]

The GSAs submitted the Plan for the Chowchilla Subbasin on January 29, 2020, in compliance with the statutory deadline.

2.2 COMPLETENESS

GSP Regulations specify that the Department shall evaluate a GSP if that GSP is complete and includes the information required by SGMA and the GSP Regulations.[39]

The GSAs submitted an adopted GSP for the entire Chowchilla Subbasin. Department staff found the GSP to be complete and include the required information, sufficient to warrant an evaluation by the Department. The Department posted the GSP to its website on January 31, 2020.

2.3 BASIN COVERAGE

A GSP, either on its own or in coordination with other GSPs, must cover the entire basin.[40] A GSP that intends to cover the entire basin may be presumed to do so if the basin is fully contained within the jurisdictional boundaries of the submitting GSAs.

The GSP intends to manage the entire Chowchilla Subbasin and the jurisdictional boundaries of the submitting GSAs cover the entire Subbasin.

[37] Water Code § 10720.7.
[38] Water Code § 10720.7(a)(1).
[39] 23 CCR § 355.4(a)(2).
[40] Water Code § 10727(b); 23 CCR § 355.4(a)(3).

3 Plan Evaluation

As stated in Section 355.4 of the GSP Regulations, a basin "shall be sustainably managed within 20 years of the applicable statutory deadline consistent with the objectives of the Act." The Department's assessment is based on a number of related factors including whether the elements of a GSP were developed in the manner required by the GSP Regulations, whether the GSP was developed using appropriate data and methodologies and whether its conclusions are scientifically reasonable, and whether the GSP, through the implementation of clearly defined and technically feasible projects and management actions, is likely to achieve a tenable sustainability goal for the basin.

Department staff have identified deficiencies in the GSP, the most serious of which preclude staff from recommending approval of the GSP at this time. Department staff believe the GSAs may be able to correct the identified deficiencies within 180 days. Consistent with the GSP Regulations, Department staff are providing corrective actions related to the deficiencies, detailed below, including the general regulatory background, the specific deficiency identified in the GSP, and the specific actions to address the deficiency.

3.1 Deficiency 1. The GSP does not provide sufficient information to support the selection of the chronic lowering of groundwater levels sustainable management criteria.

3.1.1 Background

The GSP Regulations state that the description of minimum thresholds shall include the relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the GSA has determined that basin conditions at each minimum threshold would avoid undesirable results for each of the sustainability indicators.[41]

The GSP Regulations state that minimum thresholds for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. These quantitative values should be supported by:

- The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin;
- Potential effects on other sustainability indicators.[42]

[41] 23 CCR § 354.28(b)(2).
[42] 23 CCR § 354.28(c)(1)(B).

3.1.2 Deficiency Details

Department staff find that the Chowchilla Subbasin GSP's explanation of the chronic lowering of groundwater levels sustainable management criteria, particularly for undesirable results and minimum thresholds, does not include sufficient detail and analysis as required by the GSP Regulations.

The GSP provides quantitative values for the minimum thresholds and includes a combination of those minimum threshold exceedances that the GSAs consider to be an undesirable result.[43] However, the GSP does not appear to base its minimum thresholds on groundwater levels that indicate "a depletion of supply at a given location that may lead to undesirable results," as required by the GSP Regulations.[44] Nor does the GSP explain the GSAs' understanding of the effects those corresponding groundwater conditions would have on beneficial uses and users of groundwater. In the absence of documented analysis and explanation for selecting the minimum thresholds and undesirable results, the GSP does not satisfy the requirements of the GSP Regulations.[45] Due to this deficiency, Department staff cannot determine whether the sustainable management criteria for chronic lowering of groundwater levels are reasonable.[46]

The GSP defines significant and unreasonable lowering of groundwater levels as "conditions that:

1) cause significant financial burden to local agricultural interests or others who rely on subbasin groundwater resources,
2) cause groundwater level conditions at private domestic wells that cannot be mitigated, and
3) interfere with other sustainability indicators."[47]

The GSP describes undesirable results due to chronic lowering of groundwater levels as having been present during the historical period and during existing conditions,[48] but does not describe what those undesirable results specifically were, who or what they affected, or where in the Subbasin they occurred.

Department staff review of the minimum thresholds presented in the GSP indicates that the GSAs consider that further groundwater level declines below historical groundwater level lows in the Upper Aquifer of the Western Management Area and the Lower Aquifer in the Eastern Management Area are tolerable and acceptable. A review of the minimum thresholds for each representative monitoring site (and the site's respective historic low reading) indicates that proposed management under the GSP could allow groundwater

[43] Chowchilla Subbasin GSP, Table 3-6, p. 253-254, p. 271.
[44] 23 CCR § 354.28(c)(1).
[45] 23 CCR §§ 354.26, 354.28.
[46] 23 CCR § 355.4(b)(1).
[47] Chowchilla Subbasin GSP, p. 271.
[48] Chowchilla Subbasin GSP, Table 3-1, p. 232.

level declines of up to 85 feet in the Upper Aquifer of the Western Management Area and 190 feet in the Lower Aquifer of the Eastern Management Area.[49]

In its discussion of these groundwater level minimum thresholds and the relation to the three defined significant and unreasonable conditions, the GSP states that the predominant financial burden on agricultural interests in the Subbasin would be costs associated with executing direct and in-lieu recharge projects and lost crop yield associated with converting farmland to recharge areas. The GSP anticipates that impacts to private domestic wells would be mitigated via the Potential Domestic Well Mitigation Program detailed in Appendix 3.C. of the GSP.[50] Lastly, in its discussion of groundwater level minimum thresholds and their relation to subsidence, the GSP fails to examine the relationship between allowable groundwater level declines and land subsidence in the Subbasin.[51]

Although the referenced Potential Domestic Well Mitigation Program provides a first step in addressing impacts to domestic wells in the Subbasin, it is still in the development phase, with a more accurate survey of domestic wells in the Subbasin underway.[52] It is unclear to Department staff when the program will be implemented and financed by the GSAs in the Subbasin, or how rapidly the GSAs will be able to respond to developing domestic well impacts. Also, the GSP does not provide explanation of how established groundwater level minimum thresholds will affect land subsidence in the Eastern Management Area of the Subbasin. Without commitment to the Potential Domestic Well Mitigation Program or an analysis of how groundwater level minimum thresholds may affect land subsidence included in the GSP, Department staff cannot determine whether the sustainable management criteria for chronic lowering of groundwater levels will avoid conditions that cause groundwater level conditions at private domestic wells that cannot be mitigated or interfere with other sustainability indicators.[53]

3.1.3 Corrective Action 1

The GSP must explain how the chronic lowering of groundwater level minimum thresholds, defined at representative monitoring sites, represent groundwater levels that indicate a depletion of supply at that location that may lead to undesirable results. Additionally, the GSP should support the explanation by describing the specific significant and unreasonable effects on groundwater supply uses and users that the GSA intends to avoid. The GSP should include specific details about those effects, supported by the best available information and science. If the GSAs intended that the minimum threshold values in the GSP do not explicitly represent a depletion of supply that may lead to undesirable results, but that those users impacted by planned depletion of supply (via lowering of groundwater levels and reduction of storage) would be mitigated, then the

[49] Chowchilla Subbasin GSP, Appendix A2.E, p. 735-836.
[50] Chowchilla Subbasin GSP, Appendix 3.C., p. 1137-1147.
[51] Chowchilla Subbasin GSP, p. 256.
[52] Chowchilla Subbasin WY2020 Annual Report, p. 50.
[53] Chowchilla Subbasin GSP, p. 271.

GSAs should more clearly describe, with specific detail, the Subbasin-wide mitigation program. Department staff note that, while the GSP states significant adverse impacts to domestic wells are expected to be addressed through a temporary domestic well mitigation program that the GSAs in the Subbasin are currently developing with the assistance of Proposition 68 grant funding,[54] it is unclear when the program will be implemented and financed by the GSAs, or how rapidly the GSAs will be able to respond to developing domestic well impacts. Department staff recommend the GSAs include additional information regarding the implementation of the mitigation program in responding to this deficiency. In addition to domestic wells, the GSAs should explain whether and how the mitigation program extends to other drinking water users that rely on shallow wells, such as public water systems and state small water systems.

The GSP should also clearly explain the relationship between the chronic lowering of groundwater levels minimum thresholds and those developed for subsidence and explain how allowing continued lowering of groundwater levels would avoid undesirable results for subsidence.

3.2 Deficiency 2. The GSP does not provide sufficient information to support the selection of land subsidence sustainable management criteria.

3.2.1 Background

The GSP Regulations state that minimum thresholds for land subsidence should identify the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. These quantitative values should be supported by:

- The identification of land uses or property interests potentially affected by land subsidence;
- An explanation of how impacts to those land uses or property interests were considered when establishing minimum thresholds; and
- Maps or graphs showing the rates and extents of land subsidence defined by the minimum thresholds.[55]

The GSP Regulations allow the use of groundwater elevations as a proxy for land subsidence. However, GSAs must demonstrate a significant correlation between groundwater levels and land subsidence and must demonstrate that the groundwater level minimum threshold values represent a reasonable proxy for avoiding land subsidence undesirable results.[56]

[54] Chowchilla Subbasin WY2020 Annual Report, p. 50.
[55] 23 CCR § 354.28(c)(5).
[56] 23 CCR § 354.28(d).

3.2.2 Deficiency Details

The GSP states that significant and unreasonable conditions due to land subsidence are significant impacts to infrastructure and, specifically for the Western Management Area, significant continued subsidence that impacts infrastructure.[57] However, the GSP does not define or identify what infrastructure is susceptible to impacts from land subsidence. (See Corrective Action 1.)

The GSP creates two management areas, the Western and Eastern management areas, in the Subbasin to address undesirable results due to land subsidence observed in the western side of the Subbasin. In describing the rationale for creating two management areas in the Subbasin, the GSP states that a distinguishing hydrogeologic feature is that the Western Management Area is comprised of two distinct aquifers, the Upper Aquifer and the Lower Aquifer, which are situated above and below the Corcoran Clay, respectively, and the Eastern Management Area is largely unsaturated or contains a thin perched aquifer, or the Corcoran Clay layer is not present.[58]

In the Western Management Area, where the GSP explains historical subsidence has been significant, Lower Aquifer groundwater levels are used as a proxy to establish subsidence minimum thresholds.[59] Minimum thresholds for the Lower Aquifer in the Western Management Area are set at "the higher of:

- projected lowest future groundwater level at the end of an estimated 10-year drought; or
- recent historic groundwater level lows observed in the well, which in most cases occurred during 2014-2016."[60]

As defined in the GSP, 50 percent of the representative monitoring site wells (four out of seven) for the Lower Aquifer in the Western Management Area would need to exceed the established minimum thresholds for two consecutive fall readings to trigger an undesirable result for land subsidence.[61] In justifying the monitoring of groundwater levels as proxy for land subsidence in the Western Management Area, the GSP states, "the recent drought from 2012 to 2015 resulted in historic low groundwater elevations in many Lower Aquifer wells in the 2014 to 2016 time frame, which correlates recent rates of subsidence."[62] While Department staff agree that there will always be some correlation between groundwater levels and subsidence, the GSP fails to provide adequate evidence to further evaluate this correlation, specifically with regard to potential subsidence caused by groundwater levels falling below historical lows, as would occur if groundwater levels are allowed to decline below historical lows at up to 50 percent of representative monitoring wells. The GSP does not provide an analysis of how much subsidence may

[57] Chowchilla Subbasin GSP, p. 272.
[58] Chowchilla Subbasin GSP, p. 158.
[59] Chowchilla Subbasin GSP, p. 261-262.
[60] Chowchilla Subbasin GSP, p. 262.
[61] Chowchilla Subbasin GSP, p. 272-273.
[62] Chowchilla Subbasin GSP, p. 290.

be expected if up to 50 percent of representative monitoring site wells exceed their established minimum thresholds. Additionally, the GSP does not provide an analysis of how much land subsidence may be expected if groundwater levels exceed their historical lows in the Lower Aquifer of the Western Management Area, as MCSim groundwater model simulation results show that, even after implementing all the projects proposed in the GSP, groundwater levels may still decline below historical lows.[63] Without these analyses, and a discussion of how continued subsidence relates to sensitive infrastructure, Department staff are unable assess whether representative groundwater level values are a reasonable proxy for monitoring for subsidence in the Western Management Area.[64] (See Corrective Action 2.)

The GSP defines an adaptive management strategy for land subsidence in the Eastern Management Area which establishes a minimum threshold of 0.25 feet per year of land subsidence over a three-year period but, should the threshold be exceeded or should significant and unreasonable impacts be observed, groundwater level minimum thresholds as a proxy will be developed and implemented.[65] The GSAs provided no discussion or evidence for why they selected 0.25 feet per year as the minimum threshold in the Eastern Management Area. The GSAs should document their understanding, through efforts such as coordination and technical studies, of the amount of subsidence that would be significant and unreasonable, because it would substantially interfere with groundwater and land surface beneficial uses and users. Department staff note that public comments were received which expressed concern about impacts to infrastructure due to allowable continued land subsidence under the GSP. Without a discussion of what would constitute a significant and unreasonable impact or how 0.25 feet per year of continued land subsidence relates to sensitive infrastructure in the Eastern Management Area, Department staff are unable to assess whether this minimum threshold and the adaptive management strategy are reasonable.

Also, because the GSP, in its current form, allows for continuation of subsidence in perpetuity in the Eastern Management Area, Department staff note that it was the intent of the legislature that implementation of SGMA would avoid or minimize subsidence[66] once basins achieve their sustainability goals. To be consistent with that intent, and in the absence of compelling information as to why additional long-term subsidence is acceptable for the Subbasin, Department staff suggest that the Eastern Management Area minimum threshold be revised and set commensurate with expected residual subsidence. It may be that those rates are exceeded during the implementation period (i.e., between 2020 and 2040), as projects and management actions are implemented and sustainability is achieved, but that result can be acceptable if the GSAs are making adequate progress in implementing their GSP. The rates at which projects and management actions are implemented should be consistent with the cumulative

[63] Chowchilla Subbasin GSP, pp. 1947 and 1951.
[64] 23 CCR § 354.28(d).
[65] Chowchilla Subbasin GSP, p. 262.
[66] Water Code § 10720.1(e).

subsidence that the GSAs determine need to be avoided, as informed by the understanding of potential impacts or interference to beneficial uses and users of groundwater and surface land uses. (Corrective Action 3.)

Department staff do not believe that the GSP, in a Subbasin with significant historical subsidence that has been identified as an undesirable result, should be recommended for approval without identifying minimum thresholds and undesirable results that reflect the level of additional subsidence that would interfere with surface land uses. Department staff recognize that the total allowable cumulative subsidence may be modified as the GSP is implemented, data gaps are filled, and additional analyses are conducted; therefore, Department staff encourage the GSAs to actively evaluate and adjust management criteria as new information and data are acquired.

3.2.3 Corrective Action 2

a) The GSP should be revised to include discussion of land surface beneficial uses and users in the Subbasin (e.g., infrastructure such as canals or levees) that may be susceptible to substantial interference as a result of continued subsidence. This information should be used to inform other revisions to the GSP necessitated by this corrective action.

b) The GSAs should provide supporting information for using groundwater levels as a proxy for subsidence in the Western Management Area. The GSP should be revised to include analysis that demonstrates a significant correlation between groundwater levels, which are allowed to decline below the historical low at up to 50 percent of monitoring sites, and land subsidence. The GSAs should evaluate the potential for subsidence impacts (i.e., substantial interference for surface land uses) related to any allowable further groundwater level decline. The GSAs should also consider incorporation of remotely-sensed subsidence data made available by the Department on an ongoing basis to verify the appropriateness of the groundwater level proxy.

c) The GSAs should revise their minimum thresholds and measurable objectives for land subsidence in the Eastern Management Area to reflect the intent of SGMA that subsidence be avoided or minimized once sustainability is achieved. The GSAs should explain how implementation of the projects and management actions is consistent both with achieving the long-term avoidance or minimization of subsidence and with not exceeding the tolerable amount of cumulative subsidence.

3.3 Deficiency 3. The GSP does not provide sufficient information to support the determination that interconnected surface water or undesirable results related to depletions of interconnected surface water are not present and are not likely to occur in the Subbasin.

3.3.1 Background

The GSP Regulations require a GSP to identify interconnected surface water systems in the basin and evaluate the quantity and timing of depletions of those systems using the best available information.[67]

The GSP Regulations state that a GSA that is able to demonstrate one or more sustainability indicators are not present and are not likely to occur in the basin is not required to develop sustainable management criteria for those indicators.[68] Absent an explanation of why a sustainability indicator is inapplicable, the Department assumes all sustainability indicators apply.[69] Demonstration of applicability (or non-applicability) of sustainability indicators must be supported by best available information and science and should be provided in descriptions throughout the GSP (e.g., information describing basin setting, discussion of the interests of beneficial users and uses of groundwater).

The Department's assessment of a GSP's likelihood to achieve its sustainability goal for its basin is based, in part, on whether a GSP provides sufficiently detailed and reasonable supporting information and analysis for all applicable indicators. The GSP Regulations require the Department to evaluate whether establishment of sustainable management criteria is commensurate with the level of understanding of the basin setting.[70]

3.3.2 Deficiency Details

The GSP explains that the primary surface water features in the Subbasin are the Chowchilla River, Ash Slough, Berenda Slough, and the San Joaquin River and that, while each of these are a source of natural groundwater recharge, none are interconnected with groundwater. For the development of the GSP, a comparison of the historical regional groundwater levels to stream thalweg elevations was performed and regional groundwater levels were determined to be "relatively far below"[71] the thalweg elevations. The GSP states that the analysis indicated the San Joaquin River, along the western boundary of the Subbasin, was connected through 2008 but that from 2009 to 2016 the groundwater levels were "generally below (and apparently disconnected from)" the river.[72] The GSP lacks adequate documentation of the analysis used for the

[67] 23 CCR §§ 354.28(c)(6)(A), 354.28(c)(6)(B).
[68] 23 CCR §§ 354.22, 354.26(d), 354.28(e).
[69] DWR Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria (DRAFT), November 2017.
[70] 23 CCR § 355.4(b)(3).
[71] Chowchilla Subbasin GSP, p. 99.
[72] Chowchilla Subbasin GSP, p. 99-100.

development of this conclusion. The GSP provides and references maps showing the depth to shallow groundwater for 2014 and 2016 but does not provide details regarding the wells selected for these maps.[73] It is unclear if these wells are screened in only the Upper Aquifer or if composite wells or wells with unknown construction details were also included. The GSP does not provide the stream thalweg depths that were used for comparison to the groundwater levels, nor does it quantify what "relatively far below" the thalweg is.

A brief analysis of groundwater levels in Upper Aquifer well SJRRP_MW-10-89 (located approximately 100 feet from the San Joaquin River) is provided in the discussion of hydrologic conditions associated with the groundwater dependent ecosystems assessment. Recorded measurements at SJRRP_MW-10-89 show groundwater levels approximately 2 feet below ground surface in early 2017.[74] Also in this analysis, the following statement is made: "The shallowest well depths indicate that the surface water may be temporarily connected with the perched/mounded groundwater beneath the well."[75] Further, in its own discussion of groundwater and surface water interaction near the San Joaquin River, the GSP states, "given the apparent fully saturated water column at these locations [areas adjacent to the San Joaquin River], there is at least potential for regional groundwater pumping to impact groundwater dependent ecosystems (GDEs) with roots extending down 20 to 30 feet along the San Joaquin River."[76] Department staff note that is generally understood that perched groundwater is separated from an underlying body of groundwater by an unsaturated zone.[77] Due to the presence of the fully saturated water column in areas adjacent to the San Joaquin River, it appears the GSP has identified areas of interconnected surface water, instead of identifying areas of perched/mounded groundwater that support riparian habitat. The possible presence of interconnected surface water along the San Joaquin River is further reinforced by information found in an adjacent subbasin's GSP.

The Subbasin shares a boundary with the Delta-Mendota Subbasin, and that boundary is aligned with the San Joaquin River. The San Joaquin River Exchange Contractors (SJREC) GSP in the Delta-Mendota Subbasin, which is adjacent to the Chowchilla Subbasin, states, "The SJRRP [San Joaquin River Restoration Program] and the SJREC have established a series of shallow monitoring wells near the San Joaquin River as part of the Seepage Management Plan for the Program. Data from these wells were used to determine the location of potentially connected surface water and groundwater. Figure 52 in Appendix I has a map that shows the potential locations of the interconnected portions of the San Joaquin River."[78] Appendix I is the hydrogeologic conceptual model for the SJREC GSP. In the hydrogeologic conceptual model section titled "Interconnected

[73] Chowchilla Subbasin GSP, Figures 2-70 and 2-71, p. 226-227.
[74] Chowchilla Subbasin GSP, Figure A2.B-4, p. 468.
[75] Chowchilla Subbasin GSP, Appendix 2.B., p. 469.
[76] Chowchilla Subbasin GSP, p. 100.
[77] Water Basics Glossary. U.S. Geological Survey (USGS), https://water.usgs.gov/water-basics_glossary.html.
[78] SJREC GSP, p. 130; Appendix I, Figure 52, p. 956.

Surface Water and Groundwater Systems in the SJREC GSA" there are "several areas where the shallow groundwater is indicated to be in direct hydraulic continuity with streamflow."[79] Department staff note that Figure 52 in Appendix I indicates potentially connected surface water and groundwater along the San Joaquin River at the southern portion of the boundary between the Delta-Mendota and Chowchilla subbasins.

Department staff do not believe the GSAs sufficiently demonstrate that interconnected surface water or undesirable results related to depletions of interconnected surface water are not present and are not likely to occur in the Subbasin.

3.3.3 Corrective Action 3

a) The GSP must be revised to include a clear and comprehensive analysis of the potential for interconnected surface water to be present along the San Joaquin River in the Subbasin. The revision should provide data and complete analysis to support any conclusion regarding the presence or absence of interconnected surface water. Department staff suggest the GSAs review information from adjacent GSPs, as described above. If the GSAs find that there is insufficient data to justify the conclusion that interconnected surface water is, or is not, present in the Subbasin, a plan and schedule should be developed and submitted to the Department to address this data gap.

b) Should data indicate the presence of interconnected surface water, the GSAs should develop sustainable management criteria, as required in the GSP Regulations,[80] based on best available information and science. The GSAs should evaluate and disclose, sufficiently and thoroughly, the potential effects of the GSP's sustainable management criteria for depletion of interconnected surface water on beneficial uses of the interconnected surface water and on groundwater uses and users.

[79] SJREC GSP, Appendix I, p. 951-956.
[80] 23 CCR §§ 354.26, 354.28, 354.30.

4 STAFF RECOMMENDATION

Department staff believe that the deficiencies identified in this assessment should preclude approval of the GSP for the Chowchilla Subbasin. Department staff recommend that the GSP be determined incomplete.

December 3, 2021 Meeting Agenda

From: John Davids
To: Craig.Altare@water.ca.gov
Cc: Stephanie Anagnoson; Lacey McBride; Doug Welch; Brandon Tomlinson; Nick Watterson; Chase Hurley; Katherine Klug; Brad Samuelson; Pete Leffler; Sarah Woolf
Subject: 12/3 Chowchilla Subbasin Meeting - DRAFT Agenda
Date: Wednesday, December 1, 2021 5:16:00 PM

Good Evening Craig –

The parties in the Chowchilla Subbasin would propose the following draft agenda for our discussion on Friday afternoon.

Agenda

1. Introductions (All)
2. Review agenda (John)
3. Opportunity for DWR to discuss general considerations for GSP evaluations (DWR)
4. Progress update from Chowchilla Team about activities in the Chowchilla Subbasin since GSP adoption:
    a. Madera County Activities (Stephanie)
    b. Updates to Triangle T Water District subsidence mitigation agreement (Sarah/Brad/Chase)
    c. New monitoring well sites to replace inaccessible RMS wells (Nick/Pete/Brad)
5. Chowchilla Team to lead discussion of deficiency topics and ideas for resolution (Pete/All):
    a. Subsidence
    b. Interconnected Surface Water (ISW)
    c. Groundwater Levels
5. Next steps (All)

Thanks ahead of time for meeting with us and we look forward to the discussion.

Regards,

John B. Davids, P.E. | Principal Engineer **|** Davids Engineering, Inc.
1772 Picasso Avenue, Suite A, Davis, CA 95618-0550 **|** office 530.757.6107 x106 **|** mobile 209.404.8896

January 11, 2022 Meeting Agenda

John Davids

Subject: Chowchilla GSP Deficiencies / DWR & GSAs
Location: Microsoft Teams Meeting

Start: Tue 1/11/2022 1:00 PM
End: Tue 1/11/2022 3:00 PM

Recurrence: (none)

Meeting Status: Accepted

Organizer: Peisch, Amanda@DWR

DRAFT agenda:

1. Intro
2. RMS
   a. Issues with existing sites
   b. Newly constructed nested monitoring wells
   c. DWR guidance and path forward
3. GW levels
   a. Review of approach used during GSP prep
   b. Domestic well mitigation program
   c. Approach to addressing deficiency
4. Next meeting

____

Microsoft Teams meeting

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Welcome to the California Natural Resources Agency and affiliated organizations online meeting system. Enjoy your meeting.

February 10, 2022 Meeting Agenda

From:	John Davids
To:	Peisch, Amanda@DWR
Cc:	Katherine Klug; pleffler@lsce.com; Nick Watterson; Brad Samuelson; "Brandon Tomlinson"; Chase Hurley; Doug Welch (dwelch@cwdwater.com); McBride, Lacey; "sarahwoolf@me.com"; Stephanie Anagnoson
Subject:	Chowchilla Subbasin - Agenda for 2/10 Meeting
Date:	Tuesday, February 8, 2022 6:44:00 AM
Attachments:	image001.png image003.png image004.png image005.png image006.png

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Good Morning Amanda –

Below is a draft agenda for our discussion later this week related to subsidence.

1. Intro
2. Recap of GSP SMC and DWR Concerns
3. Potential Revisions to GSP
    a. Additional text/discussion
    b. Quantify Residual Subsidence
    c. Quantify Subsidence beyond Residual
    d. Use of Cumulative vs. Rate of Subsidence (and/or GWL as proxy) for SMC Metric
    e. Potential use of different SMC for Implementation Period vs. Sustainability Period
    f. Potential refinements to UR/SMC
4. Next Meeting

Please distribute to your team as you see fit and should you have any questions, please feel free to reach out.

Have a good day.

Regards,

John B. Davids, P.E. | Principal Engineer | Davids Engineering
1772 Picasso Avenue, Suite A, Davis, CA 95618-0550 **|** O: 530.757.6107 x106 **|** M: 209.404.8896

Water **Infrastructure** **Technology**

March 16, 2022 Meeting Questions

Chowchilla Subbasin - Subsidence-Related Follow Up Questions/Topics for DWR March 16,2022 Meeting

1) **Can we establish different SMC for the Implementation Period vs. the Sustainability Period?** Want to set acceptable MTs for long-term, but likely to be exceeded over short-term before sustainability is achieved.
2) **If we use cumulative subsidence as a metric, can we combine that with using groundwater levels (i.e., exceeding MTs and producing UR is tied to subsidence caused by ongoing chronic groundwater level declines)?** This would better track impact of groundwater withdrawals in terms of its impact on subsidence. Some very small amount of residual subsidence may extend into the Sustainability Period even if groundwater levels have stabilized.
3) **Based on DWR Consultation Letter language and subsequent discussions, is some level of quantification of anticipated future residual subsidence needed?** "The GSP does not provide an analysis of how much subsidence may be expected if up to 50 percent of representative monitoring site wells exceed their established minimum thresholds. Additionally, the GSP does not provide an analysis of how much land subsidence may be expected in groundwater levels exceed their historical lows in the Lower Aquifer of the Western Management Area, as MCSim groundwater model simulation results show that, even after implementing all projects proposed in the GSP, groundwater levels may still decline below historical lows. Without these analyses…Department staff are unable assess whether representative groundwater level values are a reasonable proxy…" (pp. 11-12). "…Department staff suggest that the Eastern Management Area minimum threshold be revised and set commensurate with expected residual subsidence." (p. 12)
4) **Can we use different minimum thresholds for different portions of a MA, depending on proximity to critical infrastructure (i.e., higher level of concern near Sack Dam and Bypass in WMA vs. along boundary with EMA)? Or can we use another way of differentiating how MT exceedances are defined (e.g., one measurement near critical infrastructure exceeding MT = UR vs. two or more consecutive measurements away from critical infrastructure = UR)? Or can we use a combination of the two?**
5) **Can we establish SMC for each sustainability indicator independent of other indicators so that we can specifically identify cause(s) of any UR?** An example would be if GW levels are used as proxy for subsidence (for surface infrastructure impacts), can we set different GW level MTs for chronic GW level decline to reflect UR for groundwater beneficial users.
6) **In terms of meeting IM and potential occurrence of UR during the Implementation Period, is DWR factoring in the assumed vs. actual hydrology in their evaluation of GSP implementation progress?** A better metric might be progress on PMA instead just comparing to IMs that are hydrology dependent.

May 13, 2022 Meeting Questions

ISW-Related Questions/Topics for DWR April Meeting

Date: April 15, 2022

1) **How is Interconnected Surface Water (ISW) defined in terms of temporal connection?** For example, if groundwater is only directly connected to surface water for 5 or 10% of the time (i.e., for short-duration periods in winter or spring of wet years), does this constitute interconnected surface water?
2) **Is the GSP responsible for addressing increases in river seepage if the cause of the increased seepage is from more water being released into a river with losing conditions?** Certain comment letters have suggested observed increases in river seepage may be due to groundwater pumping; however, increases in streamflow in the San Joaquin River from implementation of the San Joaquin River Restoration Project (SJRRP) also result in increased seepage. Groundwater pumping should have little or no impact on river seepage if the river is disconnected from the groundwater system.
3) **In the situation where the connection between groundwater and surface water was broken in the past (prior to 2015) such that groundwater pumping no longer impacted surface water: if a direct hydraulic connection between groundwater and surface water is restored in the future as a result of GSP projects/management actions and/or another program (e.g., SJRRP), is the GSP then responsible for managing potential for surface water depletion?** SGMA regulations seem to indicate GSAs are not responsible for restoration of prior (before 2015) groundwater conditions. However, some comment letters suggest GSAs become responsible for ISW under some future condition that didn't exist prior to 2015.
4) **In the situation where very shallow groundwater level conditions are problematic for an adjacent subbasin across a river: if one subbasin raises its groundwater levels and contributes to exacerbation of problems related shallow groundwater levels on the other side of the river, is the subbasin that raised its groundwater levels responsible in part for the problematic shallow groundwater levels on the other side of the river?** Geologic and hydrologic conditions near the boundary between the Chowchilla and Delta-Mendota (DM) Subbasins create very different groundwater conditions on either side of the San Joaquin River. A major concern of landowners along the San Joaquin River related to the SJRRP has been about potential exacerbation of problematic shallow groundwater conditions in the DM Subbasin resulting from increasing river flows. If future Chowchilla GSP actions were to contribute to higher shallow groundwater elevations across the river in DM Subbasin, would Chowchilla GSAs somehow be considered partially responsible for these problematic future shallow groundwater conditions.
5) **Given the uncertainty and limited information related to characterizing stream depletion and interconnected surface water conditions, does DWR expect that GSPs will establish SMC for interconnected surface water now or do the Chowchilla Subbasin GSAs have until 2025 to further evaluate the relationship between surface water and groundwater before determining the need for SMC?** There is currently limited information for characterizing the relationship between surface water and groundwater along the San Joaquin River in Chowchilla Subbasin. Some GSPs for adjacent basins have speculated on possible existence of ISW conditions along the San Joaquin River, but provide little or no evidence supporting such a conclusion that a surface water – groundwater connection exists. In the Chowchilla Subbasin, although the available data suggest there was likely no direct hydraulic connection between and groundwater

and surface water along the length of the San Joaquin River adjacent to the Subbasin prior to 2015 and groundwater pumping was therefore unlikely to cause significant stream depletion, available data to evaluate these conditions are currently limited.

Revised GSP Matrix

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
1	**The GSP does not provide sufficient information to support the selection of the chronic lowering of groundwater levels Sustainable Management Criteria (SMC).**	**The GSP must provide sufficient information to support the selection of the chronic lowering of groundwater levels SMC.**	• 3.3.1 (groundwater level Minimum Thresholds (MTs)) • 3.4.1 (groundwater level Undesirable Results (URs)) • ES-3 (summary) • Appendix 3.A (hydrographs) • Appendix 3.C (Domestic Well Mitigation Program (Mitigation Program) economic analysis) • Appendix 3.D (Mitigation Program Memorandum of Understanding (MOU))	The revised GSP includes additional discussion of the considerations and analyses that went into selection of the chronic lowering of groundwater levels SMC, **including updates regarding the GSAs' specific plans for implementing the Domestic Well Mitigation Program (Mitigation Program)**. The GSAs in the Chowchilla Subbasin have expressed and formalized their **clear commitment to fund and implement the Mitigation Program beginning no later than January 1, 2023**. GSA staff and representatives have already made substantial and material progress toward program development and implementation by creating and executing an MOU (Appendix 3.D).	• The GSAs must provide more explanation of the Mitigation Program and rationale for setting SMC in coordination with the Mitigation Program. • If groundwater level decline is occurring, the GSP must have an implementable plan to address those impacts.
1.a	Chowchilla Subbasin GSP's explanation of the chronic lowering of groundwater levels SMC, particularly for Undesirable Results (URs) and Minimum Thresholds (MTs), does not include sufficient detail and analysis as required by the GSP Regulations.	The GSP should support the explanation by describing the specific significant and unreasonable effects on groundwater supply uses and users that the GSA intends to avoid. The GSP should include specific details about those effects, supported by the best available information and science.	• 3.3.1 (groundwater level MTs) • 3.4.1 (groundwater level URs) • 2.2.2.7 (workplan) • Appendix 3.A (hydrographs) • Appendix 3.C (Mitigation Program economic analysis) • Appendix 3.D (Mitigation Program MOU)	The revised GSP addresses this deficiency by: • Providing additional explanation of the considerations and decisions to set MTs for chronic lowering of groundwater levels, including: o Stakeholder input and discussions of what constitutes existing and future URs (stakeholders expressed a clear desire to protect domestic well users, but also saw a need to protect local agricultural economy – the economic lifeblood of the region – while GSP implementation ramps up) o Economic analyses and considerations of the tradeoffs of setting MTs at different levels relative to the cost of implementing a Mitigation Program (Appendix 3.C) o Updates regarding the GSAs' **clear commitment to fund and implement the Mitigation Program beginning no later than January 1, 2023** (Appendix 3.D). o Anticipated completion of a groundwater levels workplan by October 1, 2022. • Revising and providing more explanation of the MTs to be more conservative and protective of groundwater levels (described in Table 3-14 and shown in Appendix 3.A; now based on groundwater levels during a modeled 6-year drought)	• Because the SMC were established with the understanding that undesirable results are occurring/will occur for domestic well users, acceptability of the GSP hinges on implementation of the Mitigation Program. • The GSAs need to clearly address and assess URs for municipal service wells, public supply wells, and agricultural wells.
1.b	The GSP does not appear to base its MTs on groundwater levels that indicate "a depletion of supply at a given location that may lead to URs," as required by the GSP Regulations.	The GSP must explain how the chronic lowering of groundwater level MTs, defined at representative monitoring sites, represent groundwater levels that indicate a depletion of supply at that location that may lead to URs.	• 3.3.1 (groundwater level MTs) • 3.4.1 (groundwater level URs) • Appendix 3.A (hydrographs) • Appendix 3.C (Mitigation Program economic analysis) • Appendix 3.D (Mitigation Program MOU)	The revised GSP addresses this deficiency by: • Revising and providing more explanation of the MTs to be more conservative and protective of groundwater levels (described in Table 3-14 and shown in Appendix 3.A; now based on groundwater levels during a modeled 6-year drought). • Providing additional explanation of the considerations and decisions to set MTs and define URs for chronic lowering of groundwater levels (described above). Recognizing that groundwater levels are anticipated to decline during the GSP Implementation Period while projects are implemented and demand reduction programs expand, the GSAs	• The GSAs need to clearly address and assess undesirable results for municipal service wells, public supply wells, and agricultural wells. • Subbasin conditions can temporarily exceed MTs on the way to achieving sustainable conditions. • Because the SMC were established with the understanding that

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
				are **committed to funding and implementing a Mitigation Program beginning no later than January 1, 2023** (Appendix 3.D) and continuing until groundwater sustainability is achieved.	undesirable results are occurring/will occur for domestic well users, acceptability of the GSP hinges on implementation of the Mitigation Program.
1.c	The GSP fails to examine the relationship between allowable groundwater level declines and land subsidence in the Subbasin.	The GSP should clearly explain the relationship between the chronic lowering of groundwater levels MTs and those developed for subsidence and explain how allowing continued lowering of groundwater levels would avoid URs for subsidence.	• 3.3.1 (groundwater level MTs) • 3.3.3 (subsidence MTs) • 2.2.2.4 (Relationship between groundwater levels and historical subsidence) • 2.2.2.7 (workplan)	The revised GSP addresses the relationship between SMC for groundwater levels and subsidence through text revisions in Section 3.3.1 and in Section 3.3.3. Additional text has also been added to Section 2.2.2.4 to describe how historical subsidence in the Chowchilla Subbasin (and more regionally in the San Joaquin Valley) is related to declining groundwater levels in the Lower Aquifer. The revised GSP also includes an overview of a groundwater levels workplan and a subsidence workplan that is anticipated to be completed by October 1, 2022.	• Groundwater levels may be acceptable for use as proxy for subsidence with sufficient demonstration of the relationship between groundwater levels and subsidence. • DWR understands that data gaps exist. Creating the framework for subsequent detailed work plans that will collect more data to improve understanding of subsidence conditions would be helpful.
1.d	Without commitment to the Potential Domestic Well Mitigation Program or an analysis of how groundwater level MTs may affect land subsidence included in the GSP, Department staff cannot determine whether the SMC for chronic lowering of groundwater levels will avoid conditions that cause groundwater level conditions at private domestic wells that cannot be mitigated or interfere with other sustainability indicators	Department staff recommend the GSAs include additional information regarding the implementation of the mitigation program in responding to this deficiency. In addition to domestic wells, the GSAs should explain whether and how the mitigation program extends to other drinking water users that rely on shallow wells, such as public water systems and state small water systems.	• 3.3.1 (groundwater level MTs introductory discussion) • Appendix 3.D (Mitigation Program MOU)	The revised GSP includes additional discussion of the GSAs' specific plans for implementing the Mitigation Program. The GSAs in the Chowchilla Subbasin have expressed and formalized their **clear commitment to fund and implement the Mitigation Program beginning no later than January 1, 2023** and continuing until groundwater sustainability is achieved. GSA staff and representatives have already made substantial and material progress toward Program development and implementation by creating and executing an MOU (Appendix 3.D).	• The Mitigation Program must be implemented. • The GSAs must provide more explanation of the Mitigation Program and rationale for setting SMC in coordination with the Mitigation Program. • Because the SMC were established with the understanding that undesirable results are occurring/will occur for domestic well users, the acceptability of the GSP hinges on implementation of this Program to mitigate for the most vulnerable users. • By the end of the 180-day period, the GSAs must set clear intentions and have a specific plan and timeline for implementing the Mitigation Program, e.g., having a fully executed MOU in place by the time the revised GSP is submitted.
2	**The GSP does not provide sufficient information to support the selection of land subsidence SMC.**	**The GSP must provide sufficient information to support the selection of the subsidence SMC.**	• 3.2.3 (subsidence Measurable Objectives (MOs)) • 3.3.3 (subsidence MTs) • 3.4.3 (subsidence URs) • ES-3 (summary)	The revised GSP contains revised SMC for land subsidence, including new SMC for land subsidence in the Eastern Management Area (MA) and provides more explanation of the SMC (described in Table 3-14 and throughout Chapter 3).	• The GSP should clarify the nexus between the MTs and URs in the Western Management Area (MA). • The GSP should set formal SMC in the Eastern MA, even if they are considered "interim," acknowledging

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
			• 2.2.2.4 (Relationship between groundwater levels and historical subsidence) • 2.2.2.7 (workplan) • Appendix 3.E (Chowchilla Subbasin Infrastructure Assessment) • Appendix 3.F (Subsidence Control Measures Agreement)	The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the subsidence SMC, including: • Analyses of critical infrastructure, their location/ orientation, their impacts from historical subsidence, and their potential sensitivity to future subsidence (Appendix 3.E). • Ongoing subsidence mitigation measures successfully implemented by landowners in the Western MA (since 2017) and recharge projects targeted toward areas where historical subsidence has been greatest (Section 3.3.3 and Appendix 3.F). • Additional information about how historical subsidence in the Chowchilla Subbasin (and more regionally in the San Joaquin Valley) is related to declining groundwater levels in the Lower Aquifer. • Anticipated completion of a subsidence workplan by October 1, 2022	data gaps and that these SMC will be revisited. • Modeling (during the 180-day consultation period) is not necessary to establish or support SMC. • SMC can be changed in the five-year GSP updates with justification from additional data collection and improved basin understanding.
2.a	The GSP does not define or identify what infrastructure is susceptible to impacts from land subsidence.	The GSP should be revised to include discussion of land surface beneficial uses and users in the Subbasin (e.g., infrastructure such as canals or levees) that may be susceptible to substantial interference as a result of continued subsidence.	• 3.3.3 (subsidence MTs) • 3.4.3 (subsidence URs) • 2.2.2.7 (workplan) • Appendix 3.E (Chowchilla Subbasin Infrastructure Assessment)	The revised GSP includes additional discussion of land surface beneficial uses and users, including analyses of critical infrastructure, their location/orientation, their impacts from historical subsidence, and their potential sensitivity to future subsidence (Appendix 3.E). The revised GSP also includes an overview of a subsidence workplan that is anticipated to be completed by October 1, 2022.	• The GSP should clearly define the type/location of critical infrastructure and analyze/explain the potential effects of subsidence on critical infrastructure. • DWR understands that data gaps exist. Creating the framework for subsequent detailed work plans that will collect more data to improve understanding of subsidence conditions would be helpful.
2.b	The GSP fails to provide adequate evidence to evaluate the correlation between groundwater levels and subsidence, specifically with regard to potential subsidence caused by groundwater levels falling below historical lows,	The GSAs should provide supporting information for using groundwater levels as a proxy for subsidence in the Western MA.	• 3.3.3 (subsidence MTs) • 3.4.3 (subsidence URs) • 2.2.2.4 (Relationship between groundwater levels and historical subsidence)	The revised GSP contains revised SMC for land subsidence and provides more explanation of the SMC (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional information about how historical subsidence in the Chowchilla Subbasin (and more regionally in the San Joaquin Valley) is related to declining groundwater levels in the Lower Aquifer.	• Groundwater levels may be acceptable for use as proxy for subsidence with sufficient demonstration of the relationship between groundwater levels and subsidence. • The GSP should clearly analyze/explain the relationship between subsidence and the Corcoran clay layer, as relevant to the processes that were used to set the subsidence SMC.

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
2.c	The GSP does not provide an analysis of how much subsidence may be expected if up to 50 percent of representative monitoring site wells exceed their established MTs.	The GSP should be revised to include analysis that demonstrates a significant correlation between groundwater levels, which are allowed to decline below the historical low at up to 50 percent of monitoring sites, and land subsidence.	• 3.3.3 (subsidence MTs) • 3.4.3 (subsidence URs) • 2.2.2.4 (Relationship between groundwater levels and historical subsidence) • 2.2.2.7 (workplan)	The revised GSP contains revised SMC for land subsidence (described in Table 3-14 and throughout Chapter 3) and includes additional information about how historical subsidence in the Chowchilla Subbasin (and more regionally in the San Joaquin Valley) is correlated to declining groundwater levels in the Lower Aquifer. The revised GSP also includes an overview of a subsidence workplan that is anticipated to be completed by October 1, 2022.	• The GSP should clarify the nexus between the MTs and URs in the Western Management Area (MA). • The GSP should provide some estimate of anticipated/expected residual and/or additional subsidence that may occur during the GSP implementation period. • DWR understands that data gaps exist. Creating the framework for subsequent detailed work plans that will collect more data to improve understanding of subsidence conditions would be helpful.
2.d	The GSP does not provide an analysis of how much land subsidence may be expected if groundwater levels exceed their historical lows in the Lower Aquifer of the Western MA.	The GSAs should evaluate the potential for subsidence impacts (i.e., substantial interference for surface land uses) related to any allowable further groundwater level decline.	• 2.2.2.4 (Relationship between groundwater levels and historical subsidence) • 2.2.2.7 (workplan) • Appendix 3.E (Chowchilla Subbasin Infrastructure Assessment) • Appendix 3.F (Subsidence Control Measures Agreement)	The revised GSP contains revised SMC for land subsidence (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the subsidence SMC and their potential impacts on land use beneficial uses and users, including: • Analyses of critical infrastructure, their location/ orientation, their impacts from historical subsidence, and their potential sensitivity to future subsidence (Appendix 3.E). • Ongoing subsidence mitigation measures successfully implemented by landowners in the Western MA (since 2017) and recharge projects targeted toward areas where historical subsidence has been greatest (Section 3.3.3 and Appendix 3.F). • Additional information about how historical subsidence in the Chowchilla Subbasin (and more regionally in the San Joaquin Valley) is related to declining groundwater levels in the Lower Aquifer. • Anticipated completion of a subsidence workplan by October 1, 2022	• The GSP should clarify the nexus between the MTs and URs in the Western Management Area (MA). • The GSP should provide some estimate of anticipated/expected residual and/or additional subsidence that may occur during the GSP implementation period. • Zero subsidence is not a realistic expectation; however, the GSP needs an assessment and narrative discussion of anticipated additional subsidence (whether that be considered "residual" or "renewed" and what that means for critical infrastructure). • Interim milestones are a way to account for subsidence expectations during the GSP implementation period (e.g., interim milestones reflect a declining rate of subsidence).
2.e	The GSAs provided no discussion or evidence for why they selected 0.25 feet per year as the MT in the Eastern MA. The GSAs should document their understanding, through efforts such as coordination and technical studies, of the	The GSAs should revise their MTs and MOs for land subsidence in the Eastern MA to reflect the intent of SGMA that subsidence be avoided or minimized once sustainability is achieved. Department staff suggest that the Eastern MA MT be revised and set	• 3.2.3 (subsidence Measurable Objectives (MOs)) • 3.3.3 (subsidence MTs) • 3.4.3 (subsidence URs)	The revised GSP contains revised SMC for land subsidence, including revised MTs and MOs for land subsidence in the Eastern MA (described in Table 3-14 and throughout Chapter 3).	• Zero subsidence is not a realistic expectation; however, the GSP needs an assessment and narrative discussion of anticipated additional subsidence (whether that be considered "residual" or "renewed" and what that means for critical infrastructure).

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
	amount of subsidence that would be significant and unreasonable, because it would substantially interfere with groundwater and land surface beneficial uses and users.	commensurate with expected residual subsidence.			• DWR understands that data gaps exist. Creating the framework for subsequent detailed work plans that will collect more data to improve understanding of subsidence conditions would be helpful.
2.f	The rates at which projects and management actions are implemented should be consistent with the cumulative subsidence that the GSAs determine need to be avoided, as informed by the understanding of potential impacts or interference to beneficial uses and users of groundwater and surface land uses.	The GSAs should explain how implementation of the projects and management actions is consistent both with achieving the long-term avoidance or minimization of subsidence	• Appendix 3.E (Chowchilla Subbasin Infrastructure Assessment) • Appendix 3.F (Subsidence Control Measures Agreement)	The revised GSP contains revised SMC for land subsidence (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the subsidence SMC and their potential impacts on land use beneficial uses and users, including: • Analyses of critical infrastructure, their location/ orientation, their impacts from historical subsidence, and their potential sensitivity to future subsidence (Appendix 3.E). • Ongoing subsidence mitigation measures successfully implemented by landowners in the Western MA (since 2017) and recharge projects targeted toward areas where historical subsidence has been greatest (Section 3.3.3 and Appendix 3.F).	• The GSP should include additional descriptions of actions toward subsidence mitigation since GSP adoption (e.g., updates to the subsidence mitigation agreement executed by certain landowners in the Western MA).
3	**The GSP does not provide sufficient information to support the determination that interconnected surface water or URs related to depletions of interconnected surface water are not present and are not likely to occur in the subbasin.**	**The GSP must provide sufficient information to support the determination that interconnected surface water or URs related to depletions of interconnected surface water are not present and are not likely to occur in the subbasin, or the GSP must include SMC for interconnected surface water.**	• 3.2.5 (interconnected surface water MOs) • 3.3.5 (interconnected surface water MTs) • 3.4.5 (interconnected surface water URs) • ES-3 (summary) • 2.2.2.5 (groundwater - surface water interactions) • 2.2.2.7 (workplan)	The revised GSP contains new SMC for depletion of interconnected surface water (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the interconnected surface water SMC, including: • Updated analyses of groundwater - surface water interactions, including the percent of time with surface water – groundwater connection (the basis for the depletion of interconnected surface water SMC) • Anticipated completion of an interconnected surface water workplan by October 1, 2022	• If data gaps exist, the GSAs should note those and a preliminary timeline/ schedule for filling those. • DWR recognizes the high uncertainty related to the interconnected surface water sustainability indicator as implied by regulations that indicate SWRCB will not intervene until 2025 for this sustainability indicator.
3.a	The GSP states that the analysis indicated the San Joaquin River, along the western boundary of the Subbasin, was connected through 2008 but that from 2009 to 2016 the groundwater levels were "generally below (and apparently disconnected from)" the river. 72 The GSP lacks adequate	The GSP must be revised to include a clear and comprehensive analysis of the potential for interconnected surface water to be present along the San Joaquin River in the Subbasin. The revision should provide data and complete analysis to support any conclusion regarding the	• 3.2.5 (interconnected surface water MOs) • 3.3.5 (interconnected surface water MTs) • 3.4.5 (interconnected surface water URs) • 2.2.2.5 (groundwater - surface water interactions) • 2.2.2.7 (workplan)	The revised GSP contains new SMC for depletion of interconnected surface water on the San Joaquin River (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the interconnected surface water SMC, including: • Updated discussion of groundwater - surface water interactions along the San Joaquin River • Anticipated completion of an interconnected surface water workplan by October 1, 2022.	• In terms of the temporal aspect of interconnected surface water, the historical percent of time a groundwater/surface water connection exists (e.g., primarily during winter/spring of wet years) should not decrease in the future • The GSP should analyze whether future groundwater management will deplete any possible connection, and

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
	documentation of the analysis used for the development of this conclusion.	presence or absence of interconnected surface water.			whether Groundwater Dependent Ecosystems (GDEs) are affected.
3.b.	The GSP provides and references maps showing the depth to shallow groundwater for 2014 and 2016 but does not provide details regarding the wells selected for these maps.	GSAs review information from adjacent GSPs, as described above. If the GSAs find that there is insufficient data to justify the conclusion that interconnected surface water is, or is not, present in the Subbasin, a plan and schedule should be developed and submitted to the Department to address this data gap.	• 3.2.5 (interconnected surface water MOs) • 3.3.5 (interconnected surface water MTs) • 3.4.5 (interconnected surface water URs) • 2.2.2.5 (groundwater - surface water interactions) • 2.2.2.7 (workplan)	The revised GSP contains new SMC for depletion of interconnected surface water on the San Joaquin River (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the interconnected surface water SMC, including: • Updated discussion of groundwater - surface water interactions along the San Joaquin River • Anticipated completion of an interconnected surface water workplan by October 1, 2022.	• If data gaps exist, the GSAs should note those and a preliminary timeline/ schedule for filling those. • The GSAs should create the framework for a detailed work plan for filling interconnected surface water data gaps, including: additional locations for shallow monitoring wells, river stage recorders paired with monitoring wells, incorporating Airborne Electromagnetic (AEM) data when available, and thalweg surveys.
3.c	GSP does not provide the stream thalweg depths that were used for comparison to the groundwater levels, nor does it quantify what “relatively far below” the thalweg is.	Should data indicate the presence of interconnected surface water, the GSAs should develop SMC, as required in the GSP Regulations, based on best available information and science.	• 3.2.5 (interconnected surface water MOs) • 3.3.5 (interconnected surface water MTs) • 3.4.5 (interconnected surface water URs) • 2.2.2.5 (groundwater - surface water interactions) • 2.2.2.7 (workplan)	The revised GSP contains new SMC for depletion of interconnected surface water on the San Joaquin River (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the interconnected surface water SMC, including: • Updated discussion of groundwater - surface water interactions along the San Joaquin River • Anticipated completion of an interconnected surface water workplan by October 1, 2022.	• If data gaps exist, the GSAs should note those and a preliminary timeline/ schedule for filling those. • The GSAs should create the framework for a detailed work plan for filling interconnected surface water data gaps, including: additional locations for shallow monitoring wells, river stage recorders paired with monitoring wells, incorporating Airborne Electromagnetic (AEM) data when available, and thalweg surveys.
3.d	Department staff do not believe the GSAs sufficiently demonstrate that interconnected surface water or URs related to depletions of interconnected surface water are not present and are not likely to occur in the Subbasin	The GSAs should evaluate and disclose, sufficiently and thoroughly, the potential effects of the GSP’s SMC for depletion of interconnected surface water on beneficial uses of the interconnected surface water and on groundwater uses and users.	• 3.2.5 (interconnected surface water MOs) • 3.3.5 (interconnected surface water MTs) • 3.4.5 (interconnected surface water URs) • 2.2.2.5 (groundwater - surface water interactions) • 2.2.2.7 (workplan)	The revised GSP contains new SMC for depletion of interconnected surface water on the San Joaquin River (described in Table 3-14 and throughout Chapter 3). The revised GSP also includes additional discussion of the considerations and analyses that went into selection of the interconnected surface water SMC, including: • Updated discussion of groundwater - surface water interactions along the San Joaquin River • Anticipated completion of an interconnected surface water workplan by October 1, 2022.	• In terms of the temporal aspect of interconnected surface water, the historical percent of time a groundwater/surface water connection exists (e.g., primarily during winter/spring of wet years) should not decrease in the future. • The GSP should analyze whether future groundwater management will deplete any possible connection, and

Deficiency Number	Deficiency Identified by DWR	Corrective Action Recommended by DWR	Sections Where Deficiency was Primarily Addressed in the Revised GSP	How Deficiency was Addressed in the Revised GSP	Information Learned from DWR During Consultation
					whether Groundwater Dependent Ecosystems (GDEs) are affected. • If data gaps exist, the GSAs should note those and a preliminary timeline/schedule for filling those.

Revised GSP

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APPENDIX 5. PLAN IMPLEMENTATION

There are no appendices associated with Chapter 5. Plan Implementation.

APPENDIX 6. REFERENCES AND TECHNICAL STUDIES

LIST OF ABBREVIATIONS

AF	acre-feet
AFY	acre-feet per year
AG	Agricultural Land
AN	above normal
AWMPs	agricultural water management plans
AWS	Automatic Weather Stations
Bgs	below ground surface
BMP	Best Management Practice
BN	below normal
C	critical
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
C2VSim-CG	published coarse-grid version of C2VSim, Version R374
C2VSim-FG	published fine-grid version of C2VSim
CCC	Columbia Canal Company
CCID	Central California Irrigation District
CCP	Consensus and Collaboration Program at California State University, Sacramento
CCR	California Code of Regulations
CDEC	California Data Exchange Center
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CSUS	California State University, Sacramento (Consensus and Collaboration Program)
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CWC	California Water Code
CWD	Chowchilla Water District
D	dry
DAC	Disadvantaged Community
DDW	Division of Drinking Water
DE	Davids Engineering
DMS	Data Management System
DQO	data quality objectives
DTW	depth to water
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
EMA	Eastern Management Area
ERA	ERA Economics, LLC
ET	evapotranspiration
Et_a	actual ET
ET_{aw}	ET of applied water
ET_c	crop ET
ET_o	grass reference ET
ET_{pr}	ET of precipitation
ET_r	alfalfa reference ET
ET_{ref}	reference crop evapotranspiration
eWRIMS	Electronic Water Rights Information Management System
Flood-MAR	Flood Managed Aquifer Recharge
FTE	full-time-equivalent
GAMA	Groundwater Ambient Monitoring and Assessment
GDEs	groundwater dependent ecosystems
GFWD	Gravelly Ford Water District
GIS	geographic information system

GMP	Groundwater Management Plan
GRF	Gravelly Ford
GSA	Groundwater Sustainability Agencies
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWS	groundwater system
HCM	hydrogeologic conceptual model
HGL	hydraulic grade line
IDC	Integrated Water Flow Model Demand Calculator
iGDEs	indicators of GDEs
ILRP	Irrigated Lands Regulatory Program
ISW	interconnected surface water
IWFM	Integrated Water Flow Model
K	hydraulic conductivity
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LDC	Little Dry Creek
LSCE	Luhdorff & Scalmanini Consulting Engineers
Madera Co	Madera County
Maf	millions of acre-feet
MAR	Managed aquifer recharge
MC	Madera County
MCDEH	Merced County Department of Public Health, Division of Environmental Health
MCL	maximum contaminant level
MCWPA	Madera-Chowchilla Water and Power Authority
Merced Co	Merced County
Merced ID	Merced Irrigation District
mg/L	milligrams/liter
MID	Madera Irrigation District's
MIGR	Warm and cold migration habitat
MOs	measurable objectives
MSL	mean sea level
MTs	minimum thresholds
MUN	Municipal and domestic supply
MWELO	Model Water Efficient Landscape Ordinance
NASA-JPL	National Aeronautics and Space Administration Jet Propulsion Laboratory
NCCAG	Natural Communities Commonly Associated with Groundwater
NOAA NCEI	National Oceanic and Atmospheric Administration National Centers for Environmental Information
NV	Native Vegetation Land
NWIS	National Water Information System
O&M	operation and maintenance
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
PMAs	projects and management actions
pTb	Pre-Tertiary basement complex
PV	Present Value
Qb	Quaternary flood-plain deposits
Qoa	Older Quaternary alluvium
QTc	Tertiary and Quaternary continental deposits
QTcd	Quaternary continental rocks and deposits

Qya	younger Quaternary alluvium
Reclamation	United States Bureau of Reclamation
redox	reduction-oxidation
RFP	Request for Proposals
RH	relative humidity
RMS	Representative monitoring sites
RPE	Reference Point Elevation
Rs	solar radiation
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCS	USDA Soil Conservation Service (renamed Natural Resources Conservation Service)
SCS-CN	SCS curve number
SEBAL	Surface Energy Balance Algorithm for Land
SGMA	Sustainable Groundwater Management Act of 2014
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program
SJV	San Joaquin Valley
SLDMWA	San Luis Delta-Mendota Water Authority
SMC	Sustainable Management Criteria
SPWN	Warmwater spawning habitat
SS	Stillwater Sciences
SVMWC	Sierra Vista Mutual Water Company
SWRCB	State Water Resources Control Board
SWS	surface water system
Sy	specific yield
T	transmissivity
Ta	air temperature
TAF	thousand acre-feet
TDS	total dissolved solids
TM	Technical Memorandum
TMWA	Truckee Meadows Water Authority
TpTu	Pre-Tertiary and Tertiary marine and continental sedimentary rocks
TTWD	Triangle T Water District
UR	Urban Land
USACE	United States Army Corps of Engineers
USBR	U.S. Bureau of Reclamation, or Reclamation
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
UWMPs	urban water management plans
W	wet
WARM	Warm freshwater habitat
WCRs	well completion reports
WDL	Water Data Library
WILD	Wildlife habitat
WMA	Western Management Area
Ws	wind speed
WYI	Water Year Index
YCWA	Yuba County Water Agency
yield	groundwater benefit
µg/L	micrograms per liter

EXECUTIVE SUMMARY

In September 2014, the California legislature passed the Sustainable Groundwater Management Act (SGMA), establishing new measures for groundwater management and regulation statewide. SGMA provides for local control of groundwater resources while requiring sustainable management of the state's groundwater basins. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP, or Plan) for the subbasin. Under the GSP, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

The Chowchilla Subbasin (Subbasin) is identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Therefore, the Chowchilla Subbasin GSP must be developed, adopted, and submitted to DWR by January 31, 2020. This document, the Chowchilla Subbasin GSP, satisfies these requirements and outlines the strategy by which the Chowchilla Subbasin GSAs will achieve sustainable groundwater management by 2040.

GSP Revisions

In 2022, the GSAs in the Chowchilla Subbasin revised the Chowchilla Subbasin GSP to resolve deficiencies identified by DWR in their January 2022 consultation letter, and during consultation meetings in January-May 2022.

In November 2021, the GSAs in the Chowchilla Subbasin received a letter from DWR initiating consultation for the Chowchilla Subbasin GSP. The letter described potential deficiencies identified by DWR that may preclude approval of the submitted GSP at this time and indicated the GSAs would have the opportunity to perform corrective actions to address the noted deficiencies within a 180-day period after the final DWR determination was released. On January 28, 2022, the GSAs in the Chowchilla Subbasin received DWR's final incomplete determination.

In 2022, the GSAs revised the Chowchilla Subbasin GSP to:

- Resolve the potential deficiencies identified by DWR in their January 2022 consultation letter, and discussed during five DWR consultation meetings between December 2021 and May 2022;
- Summarize the progressive implementation actions taken by the GSAs since submission of the GSP in January 2020;
- Recognize the Chowchilla Subbasin GSAs' clear and formal commitment to fund and implement a Domestic Well Mitigation Program beginning no later than January 1, 2023, including the execution of a memorandum of understanding (MOU); and
- Reaffirm their commitment to implementing the GSP and achieving sustainable groundwater conditions by 2040.

As of July 2022, revisions have been made in various sections of the GSP to address these points. However, some text, estimated costs and benefits, and other analyses related to GSP implementation remain unchanged from the initial GSP submitted in January 2020. Updates to GSP implementation costs, benefits, and related analyses will be reassessed and reported in future GSP updates and Annual Reports as more is known.

Approach to Achieving Sustainability

A pragmatic approach to achieving sustainable groundwater management requires firm understanding of: (1) historical trends and current groundwater conditions in the Subbasin (including, but not limited to, groundwater levels, groundwater extraction, and groundwater quality), and (2) what must change in the future to ensure sustainability without causing undesirable results[1] or negatively affecting potential groundwater dependent ecosystems (GDEs).

In developing this GSP, a Hydrogeologic Conceptual Model (HCM) and water budgets were created to first characterize historical and current groundwater conditions in the Chowchilla Subbasin, with specific focus on vertical interactions between surface water and groundwater. The historical water budget identified historical trends in surface water availability and groundwater extraction and recharge, while the current water budget identified how current land use and cropping has changed groundwater demand while surface water availability did not change. These water budgets were used to calculate the average annual "net recharge from the surface water system" (net recharge), defined as the average annual sum of all groundwater extraction (negative) and groundwater recharge (positive) to and from the surface and root zone overlying the Chowchilla Subbasin. "Shortage" was also calculated from these water budgets as the inverse of net recharge (sum of all groundwater extraction (positive) and groundwater recharge (negative) to and from the surface and root zone overlying the Chowchilla Subbasin). Lateral subsurface inflows/outflows from/to adjacent subbasins were not considered in these water budget calculations of net recharge or shortage.

Projects and management actions (PMAs) were then developed with the goal of bringing the current net recharge into balance. A total of 12 PMAs are proposed in this GSP. In wet years, projects will provide direct recharge of surplus surface water and in-lieu recharge from strategic and expanded use of surface water through conveyance and storage efforts. Management actions will reduce groundwater pumping through demand management. These PMAs may change over the GSP implementation period (2020-2040) as GSAs practice adaptive management while they monitor and learn more about groundwater conditions in the Chowchilla Subbasin. In particular, the volume of groundwater pumping required through demand management may increase or decrease depending on the volume of direct recharge or in-lieu recharge provided by projects. Any changes in the PMAs will be reported in subsequent GSP Annual Reports and/or in future GSP updates.

Importantly, this approach to developing PMAs identifies the average annual "shortage" (groundwater extraction in excess of groundwater recharge from the surface water system) of water required to recharge the Subbasin and balance the average annual pumping. The PMAs were developed to fill this shortage with a preference for projects to the extent that additional surface water is available. This strategy will achieve sustainable groundwater management without relying on subsurface inflows to bring the Subbasin into balance. It is expected that subsurface inflows and outflows will decline as the Chowchilla Subbasin and adjacent subbasins all achieve sustainability by 2040.

[1] California Water Code (CWC) Section 10721(x) defines undesirable results as one of more of the following effects (summarized): chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater storage, significant and unreasonable seawater intrusion, significant and unreasonable degraded water quality, significant and unreasonable land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses and users of surface water.

GSP Development and Outreach

This GSP has been developed by the Chowchilla Subbasin GSAs through extensive outreach and engagement and considers feedback received from local agencies, agricultural water users, municipal water users, Disadvantaged Community (DAC) members, and other stakeholders in the Subbasin. Public meetings and workshops were hosted throughout GSP development, including monthly GSA meetings, Chowchilla Subbasin GSP Advisory Committee meetings, joint subbasin meetings, County Advisory Committee meetings, Madera County Farm Bureau Water Forum meetings, and Madera County Regional Water Management Group meetings (see Section 2.1.5). During the GSP revision process in 2022, the GSAs conducted further public outreach through three public GSP Advisory Committee meetings, public GSA governing body meetings, and through public notices regarding the GSP revision process. The Chowchilla Subbasin GSAs have also met multiple times with GSAs in adjacent subbasins, sharing data and information on GSP projects to ensure that this Plan will not interfere with the ability of adjacent subbasins to also achieve sustainable groundwater management.

The following sections in this Executive Summary provide a concise overview of the complete Chowchilla Subbasin GSP and changes made as part of revising the GSP in response to DWR's final incomplete determination.

ES-1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, industrial, and environmental beneficial uses and users throughout the Chowchilla Subbasin[2], which underlies approximately 146,000 acres within Madera and Merced Counties. Agriculture in the Chowchilla Subbasin has historically relied on approximately 300,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the agricultural economies of both Madera County and Merced County, which have a total combined value of over $5 billion dollars.[3] Groundwater also supports a large portion of domestic, municipal, and industrial water use in and around the City of Chowchilla. Thus, the sustainable management of groundwater in the Chowchilla Subbasin is important for long-term prosperity within Madera and Merced Counties.

The Sustainable Groundwater Management Act of 2014 (SGMA) provides for local control of groundwater resources while requiring sustainable management of these resources. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP, or Plan) for the subbasin. Under this Plan, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

Sustainable management of groundwater is defined under SGMA as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" (California Water Code (CWC) Section 10721(v)). These undesirable

[2] Groundwater basin number 5-022.05, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.

[3] According to the Madera County Department of Agricultural Weights and Measures, the gross value of all agricultural production in the County was $1,973,449,000 (2017 Crop and Livestock Report). According to the Merced County Department of Agriculture, the gross value of all agricultural commodities in the County was $3,408,866,000 (Merced County 2017 Report on Agriculture).

results include significant and unreasonable lowering of groundwater levels, loss of groundwater storage and supply, degradation of water quality, land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses and users of surface water. Sea water intrusion, while a SGMA-defined undesirable result, is not applicable to the Chowchilla Subbasin.

The Chowchilla Subbasin has been identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Under SGMA, GSAs in critically overdrafted subbasins are required to prepare and adopt a GSP (or GSPs) by January 31, 2020 (CWC Section 10720.7(a)(1)).

This GSP is the coordinated Plan for four GSAs that represent the entirety of the Chowchilla Subbasin area: Chowchilla Water District (CWD) GSA, County of Madera GSA - Chowchilla Subbasin (also referred to herein as Madera County GSA), County of Merced GSA - Chowchilla Subbasin (also referred to herein as Merced County GSA), and Triangle T Water District (TTWD) GSA (**Figure ES-1**). The Chowchilla Subbasin will satisfy SGMA requirements with this single GSP that covers the entire Subbasin.

The purpose of this GSP is to characterize groundwater conditions in the Chowchilla Subbasin, to evaluate and report on conditions of overdraft, to establish sustainability goals, and to describe PMAs the GSAs will implement to achieve sustainable groundwater management by 2040.

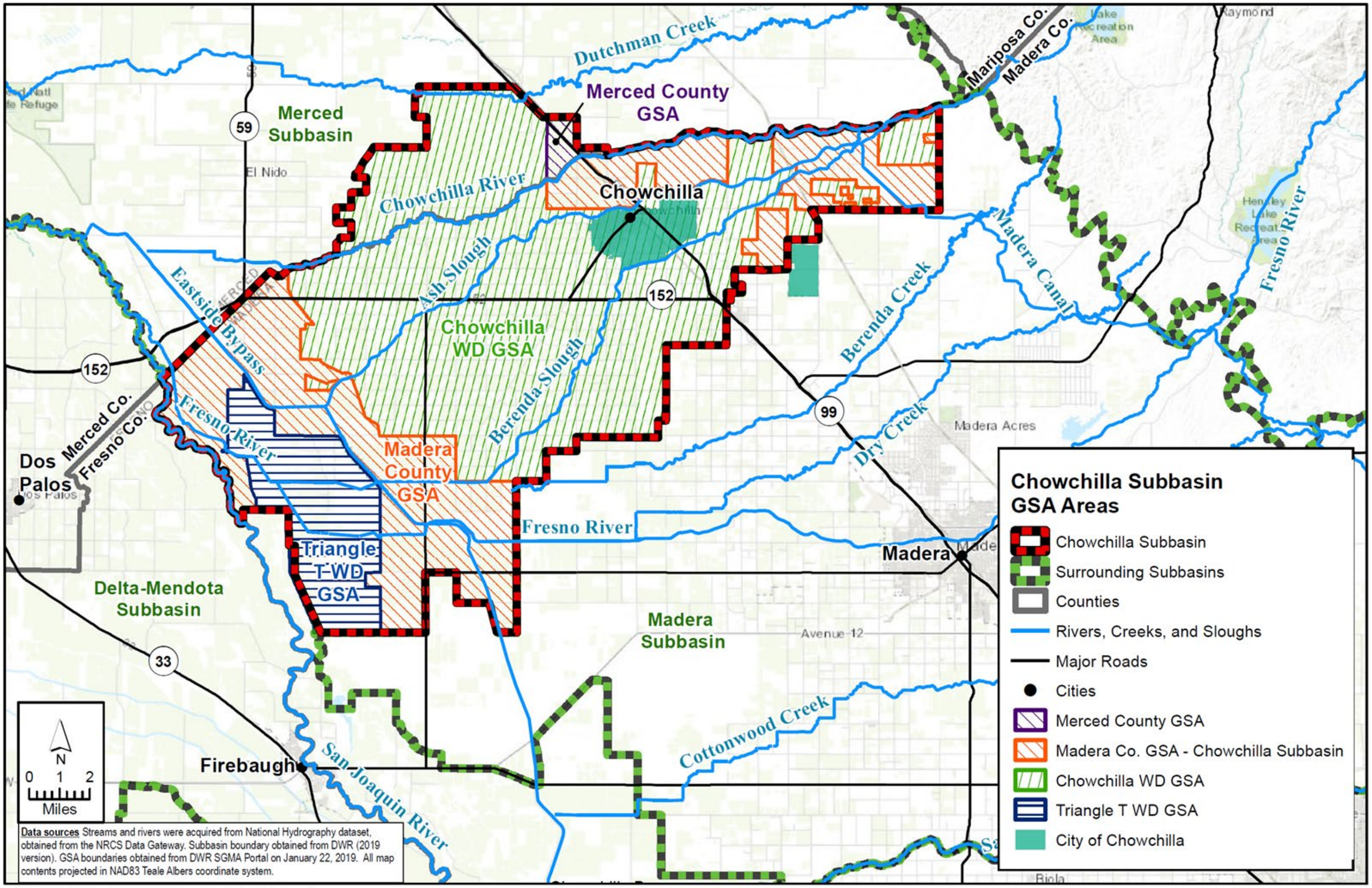

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Figure ES-1. Chowchilla Subbasin GSAs Map.

This GSP also serves to comply with DWR's requirements that the Chowchilla Subbasin GSAs prepare, adopt, and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon" as defined in the California Code of Regulations Title 23 (23 CCR), Section 350.4 (f).

As mandated under 23 CCR Section (§) 354.24, GSAs within the Chowchilla Subbasin have established a "sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline." Specifically, this sustainability goal establishes that the Chowchilla Subbasin will be operated within its sustainable yield by 2040, or 20 years following GSP submittal in January 2020. Sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC Section 10721(w)).

ES-2 PLAN AREA AND BASIN SETTING

The Plan Area is defined as the Chowchilla Subbasin (5-022.05), part of the San Joaquin Valley Groundwater Basin, as described in Bulletin 118 (DWR, 2003) updated in 2016, with boundary updates approved in early 2019. The Subbasin is bounded in the south and east by the Madera Subbasin, in the west by the San Joaquin River and the Delta-Mendota Subbasin, and in the north by the Merced Subbasin (**Figure ES-1**). The vertical boundaries of the Subbasin are the land surface (upper boundary) and the definable bottom of the basin (lower boundary). The vertical extent of the Subbasin is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone,[4] within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

Hydrogeologic Conceptual Model

The Chowchilla Subbasin is underlain by the Corcoran Clay over approximately the western and central two-thirds of the Subbasin area. The depth to the top of the Corcoran Clay varies from 50 to 100 feet at its northeastern extent to in excess of 250 feet in the southwestern portion of the Subbasin. In the western portion of the Subbasin, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure ES-2**). In the central and eastern portions of the Subbasin where the Corcoran Clay is shallow or does not exist, the aquifer system is generally considered to be semi-confined with discontinuous clay layers interspersed with more permeable coarse-grained units.

The upper 800 feet of sediments are comprised of multiple layers of coarse-grained sediments. 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).

[4] The depth to the bottom of the root zone varies by crop, but typically ranges from 2-7 feet (ASCE, 2016).

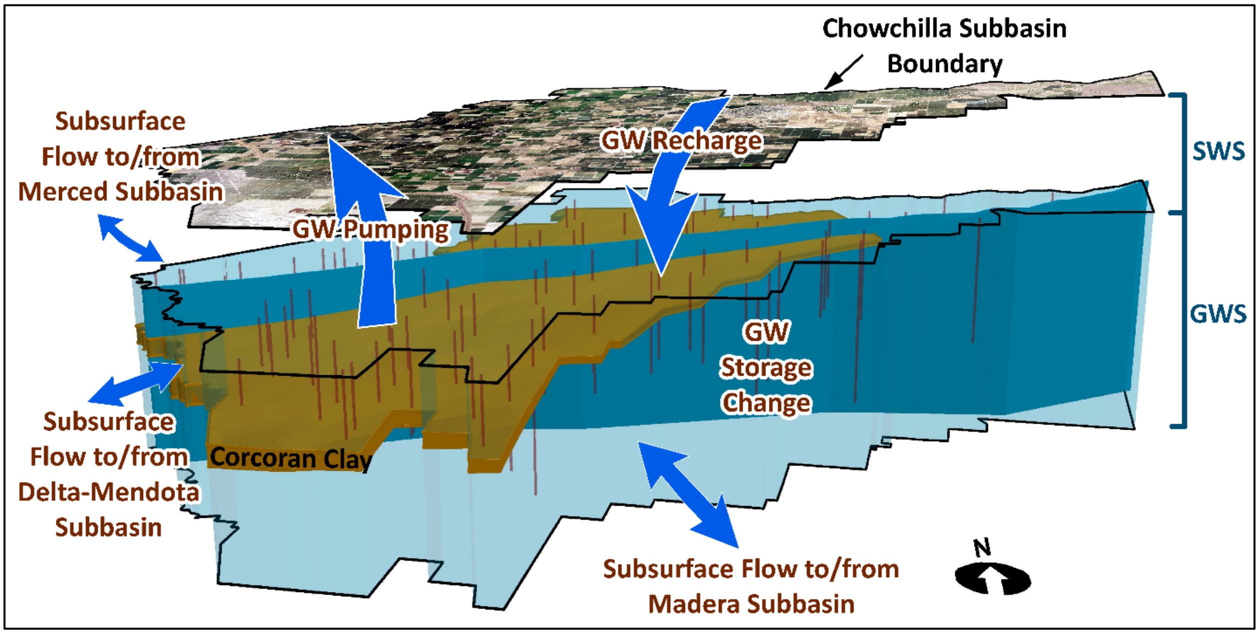


Figure ES-2. Chowchilla Subbasin Hydrogeologic Conceptual Model.

Groundwater recharge can occur throughout the Chowchilla Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources. Net subsurface inflows to the Chowchilla Subbasin from adjacent subbasins also contribute to groundwater recharge (but are not included in the water budget “net recharge” or “shortage” calculations described below); however, subsurface inflows and outflows are expected to decline as the Chowchilla Subbasin and adjacent subbasins achieve sustainability by 2040. A relatively large area of hydrologic group A and B soils with higher infiltration capacity is located in the central portion of the Subbasin from north of Chowchilla River to south of Berenda Slough, and from the City of Chowchilla on the east to Eastside Bypass on the west. This large area of hydrologic group A and B soils has soil saturated vertical hydraulic conductivity (K) from 1.1 to greater than 5 feet/day, whereas most other areas have soil saturated vertical K of less than 1 foot/day.

Under current and recent historical groundwater conditions, the primary groundwater discharge from the Subbasin is groundwater pumping for agricultural, municipal, domestic, and industrial uses. The majority of domestic wells are located in the central to eastern portions of the Subbasin, agricultural wells are relatively evenly distributed throughout the entire Subbasin, and public supply wells are concentrated in the central to eastern portions of the Subbasin. Domestic well depths vary across the Subbasin, with the most common domestic well depth between 300 and 400 feet. Agricultural and public supply wells also vary in depth across the Subbasin, but they tend to be somewhat deeper than domestic wells with the most typical well depths in the range of 500 to 750 feet.

Groundwater Conditions

The general prevailing groundwater flow direction in the unconfined Upper Aquifer is northeast to southwest, though a few notable, localized areas of low water levels (i.e., groundwater levels) exist in the Subbasin. These local depressions cause more local variability in the groundwater flow directions, including most prominently to the south of the City of Chowchilla along the Subbasin boundary with the Madera Subbasin, and in the northwestern and southwestern portions of the Subbasin. Recent groundwater level data indicates a small area of slightly higher groundwater elevations occurs within the City of Chowchilla (180 ft msl).

Local areas of very shallow perched groundwater also exist above low-permeability (e.g., clay) layers where an unsaturated zone is present between the perching layer and the regional water table. Perched groundwater has been documented in Chowchilla Subbasin at several sites through review and comparison of local groundwater level data from regulated facility sites obtained from Geotracker and regional groundwater level data from CASGEM and other sources.

The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer indicates Lower Aquifer groundwater elevations of between -30 and -40 feet msl in the area of the Chowchilla Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 shows relatively lower groundwater elevations with some areas from -40 and -60 feet msl in the Lower Aquifer in the City of Chowchilla and in the southwestern portion of the Subbasin east of the Eastside Bypass. However, there is also an area of higher groundwater elevations than in 2014 in the middle portion of the Subbasin along Highway 152. Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in Chowchilla Subbasin is challenging.

Varying levels of groundwater level decline have been observed over the historical period across the Subbasin. Prior to the mid-1980s, trends of more stable water levels, although slightly declining, are apparent in most wells. Over the period from the mid-1980s to 2015, rates of groundwater level decline greatly increased. The calculated changes in groundwater levels from groundwater elevation contour maps translate to decreases in groundwater storage estimated to range between 27,000 and 57,500 acre-feet per year (AFY) between 1988 and 2016, assuming a range of specific yield values from 7 to 13 percent.

Key groundwater quality constituents of interest in the Subbasin 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.

Historical TDS concentrations in groundwater in the Chowchilla Subbasin indicate variable salinity across the Subbasin with more elevated TDS concentrations in the western portion 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.

A large percentage of the wells with nitrate data have maximum historical concentrations below 7.5 milligrams per liter (mg/L) and many have concentrations below 5 mg/L. However, a number of areas of locally high 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 central parts of the Subbasin. Several notable areas with a high density of wells with nitrate concentrations above the maximum contaminant level (MCL) of 10 mg/L (as nitrogen) are located in the more central parts of the Subbasin to the west and southwest of the City of Chowchilla and between Ash Slough and Highway 152.

Although there are a few wells with higher arsenic concentrations above 7.5 micrograms per liter (µg/L), most of the wells with data have concentrations below 5 µg/L with a considerable number having concentrations of less than 2.5 µg/L. The available groundwater quality data do not indicate any wells with arsenic concentrations above the MCL of 10 µg/L.

Recent land subsidence has been a major concern in the western portion of the Chowchilla Subbasin. Approximately 1 to 2 feet of subsidence occurred between 1926 and 1970 in the western portion of Chowchilla Subbasin. Subsidence mapping using a combination of InSAR remote sensing data and data from surveys conducted by the United States Bureau of Reclamation (USBR) for the San Joaquin River Restoration Project indicate a maximum subsidence of almost seven feet occurred from 2007 to 2021 in the northwest part of the Chowchilla Subbasin between Eastside Bypass and the western basin boundary, which reflects a recent period of subsidence re-activation in the Subbasin. Maps for the two-year period between 2015 and 2017 show one to two feet of subsidence in a large portion of the western Subbasin. Since 2017, subsidence has continued in the western part of the Subbasin, although the greatest areas of subsidence since 2017 are focused in areas farther east and south than prior to 2017. Overall, the available historical subsidence maps for the three time periods indicate up to approximately nine feet of subsidence in some areas of western Chowchilla Subbasin since 1920. The subsidence has generally been concentrated in areas of the Subbasin within the extent of the Corcoran Clay. Recent subsidence mapping indicates smaller amounts of subsidence in the central to eastern portions of the Subbasin.

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. These data suggest 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.

Review of available data for interconnected surface water indicates regional groundwater and surface water are disconnected across most of the Subbasin, with depths to regional groundwater commonly in excess of 100 feet below ground surface. Depths to regional groundwater generally increase from west to east. However, high groundwater elevations (at or above the adjacent thalweg) are periodically observed in the shallow subsurface along the San Joaquin River at the western boundary of the Subbasin. These high groundwater elevations in the shallow zone may be related to shallow clay layers causing perching/mounding conditions, and the relationship to underlying regional groundwater is not well documented. The source of water causing these high groundwater elevations in the shallow zone appears to be infiltration of San Joaquin River streamflow derived from reservoir releases or other upstream surface water contributions. Extensive review and assessment of potential GDEs identified by TNC compared to depths to groundwater resulted in identification of a GDE unit along the San Joaquin River in the western portion of Chowchilla Subbasin. This GDE unit is composed of a mix of riparian forest, shrub, and herbaceous habitat totaling approximately 70 acres.

Water Budget

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[5] over a specified period of time. When the water budget volume is an entire subbasin, the water budget facilitates assessment of the total volume of groundwater and surface water entering and leaving the subbasin over time, along with the change in the volume of water stored within the subbasin. Water budgets were developed for the Subbasin to characterize historical, current, and projected water budget conditions. A numerical integrated groundwater flow model (MCSim) was developed based on the fine-

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

grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSim-FG), and was utilized to support development of water budgets.

The objective of the historical water budget is to evaluate availability or reliability of past surface water supplies and aquifer response to water supply and demand trends relative to water year type. The historical water budget was calculated for the 1989 through 2014 period, which was found to be representative of long-term average conditions in the Subbasin based on analysis of precipitation, unimpaired flows, and CVP supplies.

The objective of the current water budget is to understand the impact of current land use on water demand in the context of the Subbasin's hydrology and water supply. This requires a water budget that considers current land use conditions and average historical hydrologic and climatic conditions. The current water budget was calculated using land use data from 2015 to compute consumptive use and other root zone components in the Surface Water System water budget, and surface water supply and precipitation data for the 1989 through 2014 period. This approach accounts for changes in land use and water demand occurring over the historical period, most notably in the significant shift from pasture and alfalfa to almonds. With current land use conditions and average 1989 through 2014 hydrology, the current shortage in the Chowchilla Subbasin is estimated to be 100,600 AF (**Figure ES-3**). In this context, shortage represents groundwater extraction in excess of groundwater recharge from the surface water system. Unlike overdraft, calculations of shortage do not consider lateral, subsurface groundwater flows between neighboring subbasins. The current water budget shortage is effectively the current rate of shortage if 2015 land use/water demand conditions continued in the future under historical hydrologic conditions. PMAs described below were designed to address the current water budget shortage.

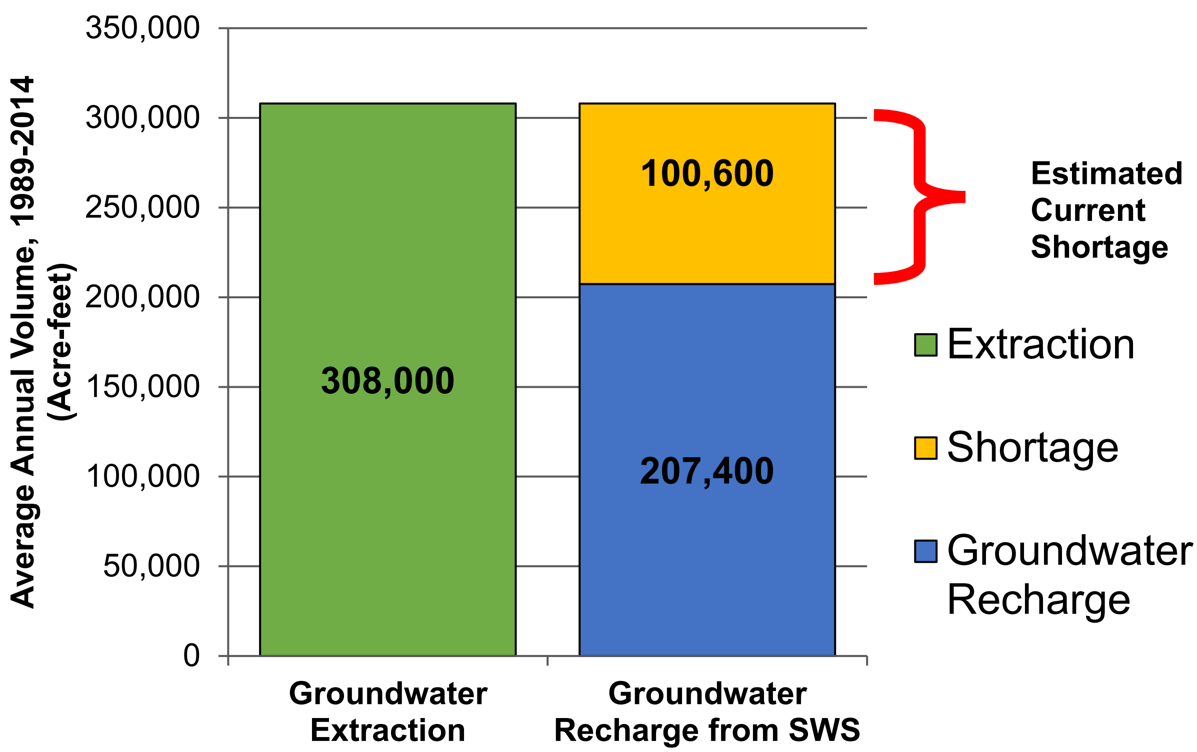


Figure ES-3. Summary Groundwater Budget for Current Subbasin Conditions (2015 Land Use).

The groundwater model was used to estimate projected water budgets over 70 years of future hydrology under different future climate scenarios, and to evaluate the effects of PMAs[6] on Subbasin conditions. Two primary projected water budget scenarios were considered: one without projects (no action), and another with projects. Both of these projected scenarios were evaluated in the context of potential effects of climate change on future surface water supply and weather parameters. The climate change scenarios used climate change parameters specified by DWR and served as a sensitivity analysis for the projected water budgets. While the climate change scenarios shows the effects on groundwater resulting from reasonably foreseeable climate change impacts on precipitation, evapotranspiration, and surface water supply, the precise future impacts of climate change are unknown. Ultimately, the GSAs will need to continue adaptive management of the Chowchilla Subbasin to address the climate change scenario that actually occurs.

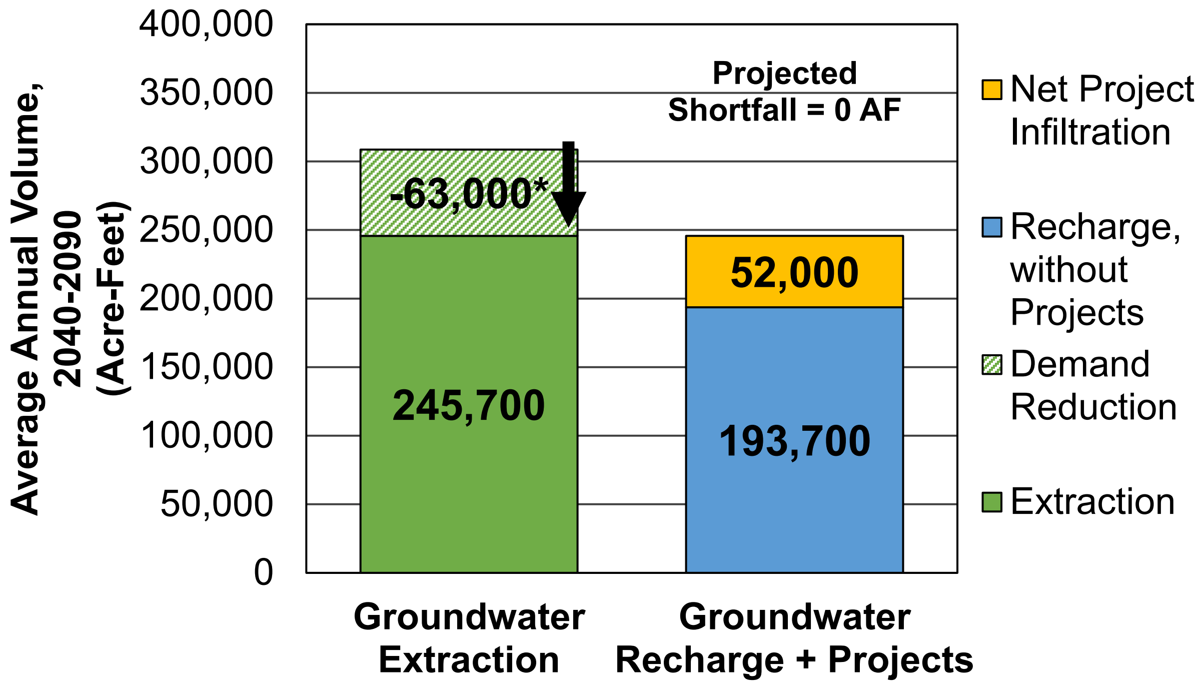
Two major time periods exist in the future projected model: the implementation period (2020-2039), during which PMAs are implemented to bring the Subbasin into sustainability, and the sustainability period (2040-2090), after which PMAs have been fully implemented. The projected with projects scenario results showed no shortage or overdraft in the Chowchilla Subbasin during the sustainability period (**Figure ES-4**).

The GSP regulations require the water budget to quantify the sustainable yield for the Subbasin. Sustainable yield is dependent upon conditions in existence at the time, and would therefore change during the implementation period while PMAs are being completed. Thus, sustainable yield was only calculated for the sustainability period, after all PMAs identified in the GSP are fully implemented.

The model results for the projected with projects scenario demonstrate that sustainability indicator minimum thresholds (MTs) and associated undesirable results are avoided during the sustainability period (2040-2090). Thus, the sustainable yield for the 2040-2090 projected period is the quantity of groundwater "…that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC Section 10721(w)). In alignment with the GSP regulations and DWR's Sustainable Management Criteria BMP (DWR, 2017), the sustainable yield has been calculated for the 2040-2090 projected period (**Table ES-1**) with a single value of sustainable yield for the Subbasin as a whole (DWR, 2017).

The sustainable yield is estimated as the average annual groundwater extraction during the 2040-2090 period. This projected groundwater extraction equals the sum of the average annual recharge without projects and the average annual net project infiltration during the projected period. Since average vertical groundwater inflows approximately equal average vertical groundwater outflows after sustainability is reached during the 2040-2090 period, the average annual change in the groundwater storage was assumed to be zero over this 50-year period. Accounting for all uncertainties in groundwater system inflows and outflows, the sustainable yield is estimated to range between 184,300 AF and 307,100 AFY. While a range of sustainable yield is stated above to provide some context for the uncertainty involved in such an analysis, the actual value of sustainable yield is much more likely to occur in the middle of this range. By this method, sustainable yield is estimated to be 245,700 AFY.

[6] Projects and management actions identified to achieve sustainable operation of the Chowchilla Subbasin are discussed in section ES-4.



*Crop Water Use Reduction Program: County of Madera GSA-Chowchilla Subbasin 27,550 AF and TTWD GSA 1,700 AF. The balance of crop water use reduction is due to permanent recharge basins replacing irrigated area and increased use of surface water in lieu of groundwater.

Figure ES-4. Summary Groundwater Budget With Projects during Sustainability Period (2040-2090).

Table ES-1. Summary of Sustainable Yield Estimates from Projected with Projects Water Budget (23 CCR §354.18(b)(7)).

Quantification Method	Average Volume, 2040-2090 (AF)	Estimated Confidence Interval[1] (percent)	Average minus CI (AF)	Average plus CI (AF)
Groundwater Extraction	245,700	25%	184,300	307,100

[1] Confidence interval source: Professional judgment based on historical calculations.

ES-3 SUSTAINABLE MANAGEMENT CRITERIA

Sustainability Indicators

Undesirable results occur when significant and unreasonable effects for any of the six sustainability indicators defined by SGMA are caused by groundwater conditions occurring in the Subbasin. The overarching sustainability goal and the absence of undesirable results are expected to be achieved by 2040 through implementation of the PMAs. The sustainability goals will be maintained through proactive monitoring and management by the GSAs. **Table ES-2** summarizes whether, for each of the six sustainability indicators, undesirable results have occurred, are occurring, or are expected to occur in the future in the Subbasin without and with GSP implementation.

Table ES-2. Summary of Undesirable Results Applicable to the Plan Area.

Sustainability Indicator	Historical Period (before 2015)	Existing Conditions	Future Conditions without GSP Implementation	Future Conditions with GSP Implementation (after 2040)
Chronic Lowering of Groundwater Levels	Yes	Yes	Yes	No
Reduction of Groundwater Storage	Yes	Yes	Yes	No
Land Subsidence (Western Management Area)	Yes	Yes	Yes	No
Land Subsidence (Eastern Management Area)	No	No	Possibly	No
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Yes	Yes	Yes	No[1]
Depletion of Interconnected Surface Water	Yes	Possibly[2]	Possibly	No

[1] There may be future continued degradation of groundwater quality that is not related to GSP Projects and Management Actions.
[2] Surface water and groundwater are disconnected under existing conditions in most of the Subbasin; insufficient data exists to fully evaluate interconnected surface water along the San Joaquin River.

The regulations define undesirable results as occurring when significant and unreasonable effects are caused by groundwater conditions occurring for a given sustainability indicator. Significant and unreasonable effects occur when MTs are exceeded for one or more sustainability indicators. A summary of the sustainable management MTs, measurable objectives (MOs) and undesirable results is provided in **Table ES-3**. Locally defined undesirable results were based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives.

Table ES-3. Summary of MTs, MOs and Undesirable Results.

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result
Chronic Lowering of Groundwater Levels (Eastern Management Area)	The projected lowest future groundwater level after January 2040 plus a 10-foot operational buffer with an adjustment for offset between observed and modeled groundwater elevations (if necessary)	Projected average future groundwater level from projected with projects model simulation (2040-2090)	Greater than 30 percent of wells below MT for two consecutive fall measurements
Chronic Lowering of Groundwater Levels (Western Management Area)	The projected lowest future groundwater level after January 2040 plus a 10-foot operational buffer with an adjustment for offset between observed and modeled groundwater elevations (if necessary)	Projected average future groundwater level from projected with projects model simulation (2040-2090)	Greater than 30 percent of wells below MT for two consecutive fall measurements
Reduction of Groundwater Storage	No long-term reduction in groundwater storage based on measured groundwater levels, consistent with chronic lowering of groundwater level MTs	Projected average future groundwater level from projected with projects model simulation (2040-2090)	Greater than 30 percent of wells below MT for two consecutive fall measurements
Land Subsidence (Western Management Area)	The historical low groundwater elevation based on model results for Fall 2014 or lowest observed measurement (whichever is lower)	Projected average future groundwater level from projected with projects model simulation (2040-2090)	Greater than 25 percent of wells near key infrastructure below MT, or greater than 33 percent of wells not considered to be near key infrastructure below MT for two consecutive fall measurements
Land Subsidence (Eastern Management Area)	The additional subsidence tolerance amount based on difference between subsidence at RMS well and at boundary with WMA,in combination with groundwater level subsidence value based on historical low groundwater elevation based on model results or lowest observed measurement (whichever is lower)	Projected average future groundwater level from projected with projects model simulation (2040-2090)	Exceedance of subsidence tolerance amount MT and subsidence water level MT at greater than 25 percent of RMS associated with any individual critical conveyance feature for two consecutive years
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result
Degraded Water Quality	Nitrate = 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)	Current constituent concentrations	10 percent of wells above the MT for the same constituent due to GSP projects and/or management actions, based on average of most recent three year period
Depletion of Interconnected Surface Water	A percent of time surface water is connected to shallow groundwater equal to historical conditions for a similar climatic/hydrologic period.	A percent of time surface water is connected to shallow groundwater equal to historical conditions for a similar climatic/hydrologic period.	Greater than 30 percent of RMS wells below MT for two consecutive annual five-year rolling average annual evaluations

Chronic Lowering of Groundwater Levels

The GSP regulations provide that the “minimum thresholds for chronic lowering of groundwater levels shall be the groundwater level indicating a depletion of supply at a given location that may lead to undesirable results.” Chronic lowering of groundwater levels in the Subbasin cause significant and unreasonable declines if they are sufficient in magnitude to lower the rate of production of pre-existing groundwater wells below that necessary to meet the minimum required to support overlying beneficial uses and users where alternative means of obtaining sufficient groundwater resources are not technically or financially feasible. At the same time, the GSAs recognize that groundwater levels are anticipated to fall below 2015 levels during the GSP implementation period. Thus, the interim milestones have been developed with these considerations in mind.

With groundwater levels anticipated to decline further during the Implementation Period as PMAs are implemented and demand reduction programs expand, **the Chowchilla Subbasin GSAs have expressed and formalized their clear commitment to fund and implement a Domestic Well Mitigation Program** to provide assistance to domestic well owners adversely impacted by future groundwater level declines. The GSAs have executed an MOU, and have committed funding and other resources to implementing the Program beginning no later than January 1, 2023, and continuing until groundwater sustainability is achieved. As of July 2022, the GSAs are in the process of developing the Program eligibility and terms and conditions. In accordance with the MOU, the Program and its development are on track to be active starting 2023. Additional information about the Domestic Well Mitigation Program and the MOU is provided in Section 3.3.1. The alternative of specifying higher MTs that avoid any additional groundwater level declines (to avoid need for a Domestic Well Mitigation Program) would require immediate and substantial cutbacks in groundwater pumping (i.e., immediate demand reduction) that would result in major impacts to the local economy and all Subbasin stakeholders, including domestic well owners. The

GSAs evaluated the economic tradeoffs of these alternatives (**Appendix 3.C**), and determined that the avoided costs (fewer domestic wells requiring replacement) resulting from immediate demand reduction would be small ($4.6 million) relative to the additional lost agricultural net return ($122.9 million) in the Chowchilla Subbasin, even after accounting for pumping cost savings ($82.5 million). These analyses considered the impacts of immediate demand reduction only on agricultural net return, but in reality the economic impacts would spread to other county businesses and industries, significantly increasing the net effect on all beneficial uses and users of groundwater in the Chowchilla Subbasin, including domestic well owners. With these considerations in mind, the GSAs will mitigate for potential impacts to domestic wells caused by temporary further declines in groundwater levels during the implementation period. The selection of RMS wells for chronic groundwater level decline and definition of undesirable results included consideration of GDEs.

Reduction of Groundwater Storage

The groundwater storage reduction metric will be evaluated using groundwater levels as a proxy in conjunction with annual evaluations of the previous year's groundwater storage change and periodic evaluations of long-term groundwater level and storage changes over average climatic periods during the Sustainability Period. Based on considerations applied in developing the groundwater level MTs, reduction in groundwater storage MTs do not exceed any identified significant and unreasonable level of depleted groundwater storage volume.

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 Subbasin that exceed average annual inflows. Significant and unreasonable land subsidence results in significant impacts to infrastructure.

Subsidence-based MTs established in the Western and Eastern Management Areas are intended to mitigate future adverse impacts from subsidence on critical surface infrastructure. Historical subsidence that has occurred in the Subbasin, and also more regionally in the San Joaquin Valley, has been related to declining groundwater levels in the Lower Aquifer. Therefore, groundwater levels in the Lower Aquifer are being used as a proxy for subsidence, in conjunction with the use of subsidence MTs (from contemporaneous and ongoing review of subsidence surveys in the region) established at representative monitoring sites in the Eastern Management Area.

Degraded Water Quality

The cause of Subbasin groundwater conditions that would result in significant and unreasonable degraded water quality is implementation of a GSP PMA that causes concentrations of key groundwater quality constituents to increase to concentrations exceeding 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). There are no known significant large-scale groundwater quality contamination plumes in regional groundwater aquifers within the Subbasin. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Subbasin; therefore, groundwater quality degradation is considered significant and unreasonable based on adverse impacts to this beneficial use. Significant and unreasonable degradation of water quality occurs when beneficial uses and users of groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs for one of the key constituents (nitrate, arsenic, TDS) at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent.

Depletion of Interconnected Surface Water

Regional groundwater levels have been below the stream channel bottoms in Chowchilla Subbasin for at least the last several years, and for many decades in most of the Subbasin. It has been determined that a direct hydraulic connection between regional groundwater and streams does not exist for streams in most of the Subbasin; therefore, surface water depletion sustainability criteria are not applicable over most of the Subbasin. However, water levels in the shallowest groundwater zone below and along parts of the San Joaquin River at the western boundary of Chowchilla Subbasin periodically rise to elevations equal to or above the stream thalweg. Although it appears this shallow groundwater is associated with infiltration of streamflow from the nearby river resulting from upstream reservoir releases or other surface water conditions, interim SMC have been established for interconnected surface water (ISW) along the San Joaquin River until additional field investigations, studies, evaluations, and monitoring can be completed to update and refine the hydrogeologic understanding of subsurface conditions and interactions between groundwater and surface water in this area. The interim minimum thresholds are the same as the interim measurable objectives: to maintain the percent of time of surface water – groundwater connectivity consistent with conditions during the baseline historical time period, as measured over a rolling five-year period. The connection between regional groundwater and surface water will be reevaluated after further studies are completed and, if necessary, the interim SMC will be updated.

Seawater Intrusion

The seawater intrusion sustainability criterion is not applicable to this Subbasin.

Monitoring Networks

The GSP groundwater monitoring network was developed using existing wells in the Subbasin and will be supplemented (and/or some initial wells replaced) by new nested monitoring wells. 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 data (including recent data) preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Subbasin) and Lower Aquifers preferred;
- Relatively good match between observed and modeled water levels preferred for water levels monitoring wells.

The selected groundwater level indicator wells (Representative Monitoring Sites) are distributed throughout the Subbasin to provide broad spatial coverage of the Subbasin, to the extent possible (**Figure ES-5**). The groundwater quality indicator wells represent a subset of the water level indicator wells with additional wells included from other groundwater quality monitoring programs. The monitoring network will be periodically reviewed and modified as needed.

ES-4 SUBBASIN PROJECTS AND MANAGEMENT ACTIONS

To achieve the Subbasin sustainability goal by 2040 and avoid undesirable results through 2090 as required by SGMA regulations, various PMAs have been developed and will be implemented by the GSAs between 2020 and 2040. Projects generally refer to structural features whereas management actions are typically non-structural programs or policies designed to incentivize reductions in groundwater pumping.

The GSAs have prioritized implementing projects that provide additional surface water supply, thereby reducing groundwater pumping. However, recognizing that access to surface water supplies is variable, the GSAs are also planning demand management to directly reduce groundwater pumping to achieve sustainability. The GSAs are also committed to an adaptive management approach to implementing PMAs that is informed by continued monitoring of groundwater conditions using the monitoring networks. As PMAs are implemented and Subbasin conditions are monitored, the GSAs will review PMA timelines, benefits, and the volume of demand management that may be necessary to achieve sustainability. If the GSAs find that adjustments are needed to meet the sustainability goal, the GSAs will evaluate and adjust plans for project implementation and, to the extent necessary, demand management. Any adjustments will be reported in subsequent annual reports and/or the 5-year updates.

Three types of projects are included in the Chowchilla Subbasin GSP: recharge, conveyance, and storage. Recharge projects are designed to support sustainability by increasing recharge. Conveyance projects facilitate the delivery of additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping (in-lieu recharge). Storage projects store additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping. Some projects have a specific water source, but many of the recharge projects can draw from the same general sources. In addition to projects, the GSP includes one management action planned by the County of Madera GSA: a demand management program that will reduce demand by placing restrictions on groundwater pumping, among other actions. Together, the PMAs have been developed and planned to achieve the Chowchilla Subbasin sustainability goal by 2040.

The cost, timing, and gross groundwater benefit (yield) of the PMAs included in the GSP vary by GSA. Table ES-4 lists all of the PMAs, by GSA or implementing entity, and the estimated implementation timeline, capital cost, operating cost, and gross benefit of the projects. **Table ES-5** further summarizes the total gross benefits and costs of all PMAs developed for each GSA or implementing entity.

The gross yield across all PMAs at full implementation (2040) equals approximately 134,400 AFY. This includes the demand management program (management action) to be implemented by the Madera County GSA that will reduce net groundwater pumping by about 28,000 AFY.

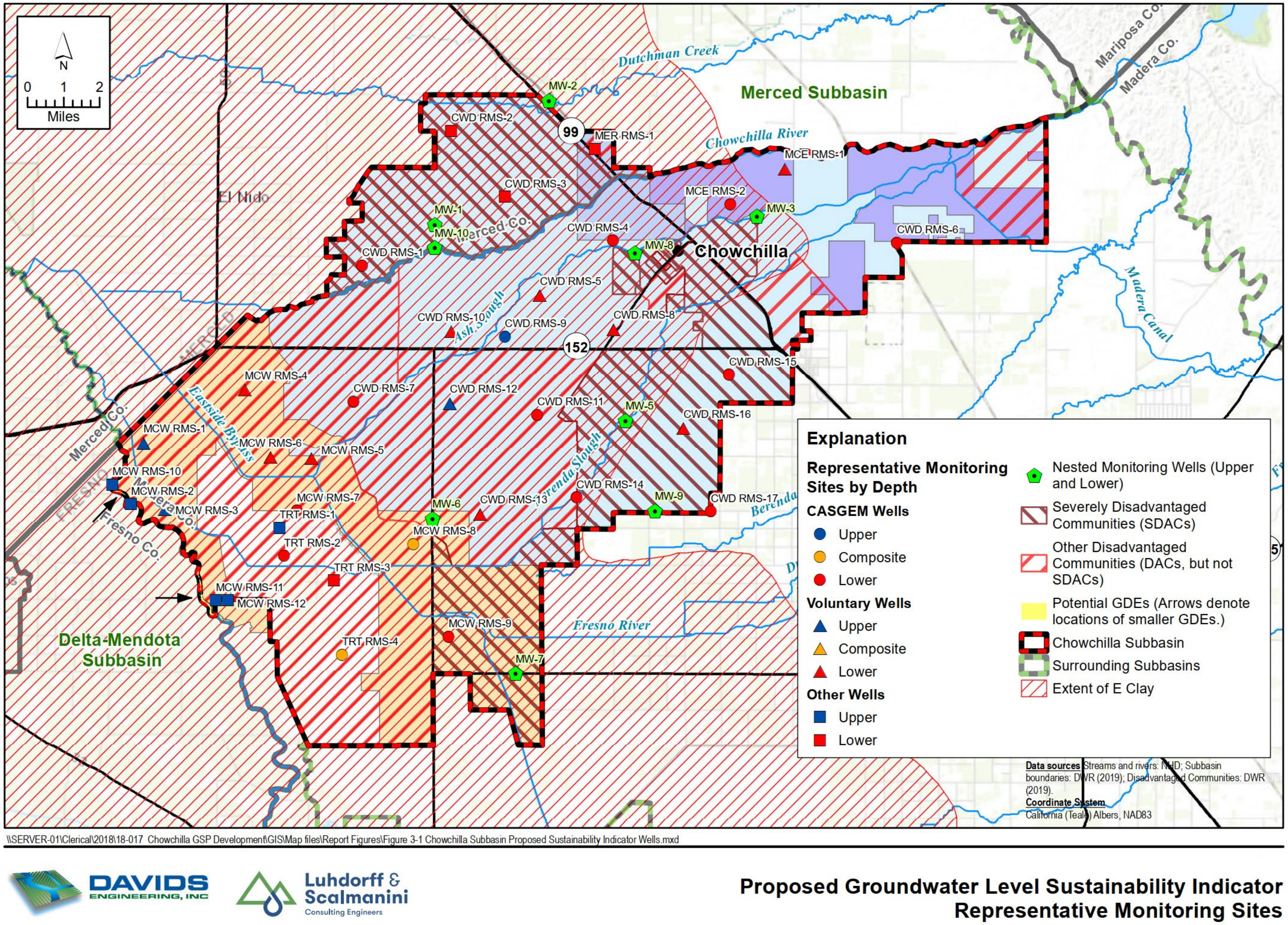


Figure ES-5. Groundwater Level Monitoring Network: CASGEM, Voluntary and Other Wells.

Table ES-4. Chowchilla Subbasin Projects and Management Actions.

GSA[1]	Project	First Year of Implementation	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	Recharge Basin	2018	1,359	3.1	0.01
CWD	Flood-MAR	2020	5,836	N/A	0.2
CWD	Additional Recharge Basins (1,000 acres)	2021	10,803	38.6	0.5
CWD	Madera Canal Capacity Increase	2035	5,147	61.2	0.3
CWD	Merced-Chowchilla Intertie	2035	7,350	6.7	1.5
CWD	Eastman Lake (Buchannan Dam) Enlargement	2040	8,753	49.2	0.2
Madera County (East)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	3,015	1.0	1.1
Madera County (West)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	27,953	118.0	0.7
Madera County (All)	Demand Management	2020	27,550	N/A	19.6[3]
Sierra Vista Mutual Water Company (SVMWC)[2]	SVMWC Recharge Basin	2020	4,344	7.5	0.2
TTWD	Poso Canal Pipeline / Settlement Agreement	2020	7,647	5.2	4.6
TTWD	Eastside Bypass Flood Water / Redtop Joint Banking	2021	24,657	24.5	0.7
Total			**134,414**	**315.0**	**29.6**

[1] PMAs summarized by each GSA, GSA subregion, or local agency responsible for implementation.
[2] SVMWC includes portions of both County of Madera GSA and County of Merced GSA.
[3] Costs of demand management include reduced economic activities in the County of Madera, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

Table ES-5. Summary of Chowchilla Subbasin Projects and Management Actions by GSA.

GSA[1]	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	39,248	158.8	2.7
Madera County	58,518	119.0[3]	21.4[3]
SVMWC[2]	4,344	7.5	0.2
TTWD	32,304	29.7	5.3
Total	**134,414**	**315.0**	**29.6**

[1] PMAs summarized by each GSA or local agency responsible for implementation.
[2] SVMWC includes portions of both County of Madera GSA and County of Merced GSA.
[3] Costs of demand management include reduced economic activities in the County of Madera, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

ES-5 PLAN IMPLEMENTATION

As of January 2020, administering the GSP and monitoring and reporting progress was projected to cost approximately $1.2 million per year across all GSAs in the Chowchilla Subbasin. These total costs did not include:

- The costs of implementing the Domestic Well Mitigation Program, although the GSAs have expressed their clear and firm commitment to funding the Program. As of July 2022, the total annual cost of implementing the Domestic Well Mitigation Program is anticipated to range between approximately $1.18 million and $10,000 per year between 2023-2032, with higher costs expected in the first several years. Additional information is provided in **Appendix 3.D.**
- The costs of implementing data gaps workplans that the GSAs identified and are developing in 2022. The GSAs plan to complete development of the subsidence workplan by October 1, 2022. Upon completion of the workplan, the GSAs will submit the workplan to DWR.
- The capital and annual operating cost of PMAs.

The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports. The total costs are expected to be higher during years in which five-year periodic evaluations are required, and slightly lower during years in which annual reports are required.

Development of this GSP was funded through a Proposition 1 Grant and contributions from individual GSAs (e.g., through in-kind staff time, or separately contracted consulting services). Individual GSAs are also funding additional, ancillary studies and implementation efforts. To fund GSA operations and GSP implementation, GSAs are developing a financing plan that will include one or more of the following financing approaches:

- **Grants and low-interest loans**: GSAs will continue to pursue grants and low interest loans to help fund planning studies and other GSA activities. However, grants and low-interest loans are not expected to cover most GSA operating costs for GSP implementation.
- **Groundwater extraction charge**: A charge per AF of groundwater pumped could be used to fund GSP implementation activities.
- **Other Fees and charges**: Other fees may include permitting fees for new wells or development, transaction fees associated with contemplated groundwater markets, or commodity-based fees, all directed at aiding with sustainability objectives. Depending on the justification and basis for a

fee, it may be considered a property-related fee subject to voting requirements of Article XIII D of the California Constitution (passed by voters in 1996 as Proposition 218) or a regulatory fee exempt from such requirements.

- **Assessments:** Special benefit assessments under Proposition 218 could include a per-acre (or per-parcel) charge to cover GSA costs.
- **Taxes:** This could include general property related taxes that are not directly related to the benefits or costs of a service (ad valorem and parcel taxes), or special taxes imposed for specific purposes related to GSA activities.

GSAs are pursuing a combined approach, targeting available grants and low interest loans, and considering a combination of fees and assessment to cover operating and program-specific costs. As required by statute and the Constitution, GSAs would complete an engineer's report, rate study, and other analysis to document and justify any rate, fee, or assessment. For example, Madera County initiated two separate rate studies in Fall 2019. At the time of initial GSP adoption in January 2020, the initial rate study was producing an engineering report to adequately fund an existing flood control and water conservation agency, which would allow for the agency to adequately control flood flows with existing infrastructure. In the next rate study, an engineering report was being produced for the ongoing costs associated with running the three County GSAs, which would include administration as well as sufficient planning funds for eventual project implementation.

The GSP implementation schedule allows time for GSAs to develop and implement PMAs and meets all sustainability objectives by 2040. While some projects began immediately after SGMA became law and are already contributing to Subbasin goals (**Figure ES-6**), the GSAs will begin implementing all other GSP activities in 2020, with full implementation of PMAs to achieve sustainability by 2040. **Figure ES-7** illustrates the GSP implementation schedule for PMAs implemented by each GSA (Madera County East and West correspond to the portion of the County of Madera GSA within each Management Area). The GSP implementation schedule also shows mandatory reporting and updating for all GSAs, including annual reports and five-year periodic updates (evaluations) prepared and submitted to DWR.

The GSP Implementation Plan uses the best available information and the best available science to provide a road map for the Chowchilla Subbasin to meet its sustainability goal by 2040 and comply with the SGMA regulations. During each five-year update, progress will be assessed, and the implementation plan revised as necessary, to achieve the sustainability goal by 2040 and comply with the SGMA regulations.

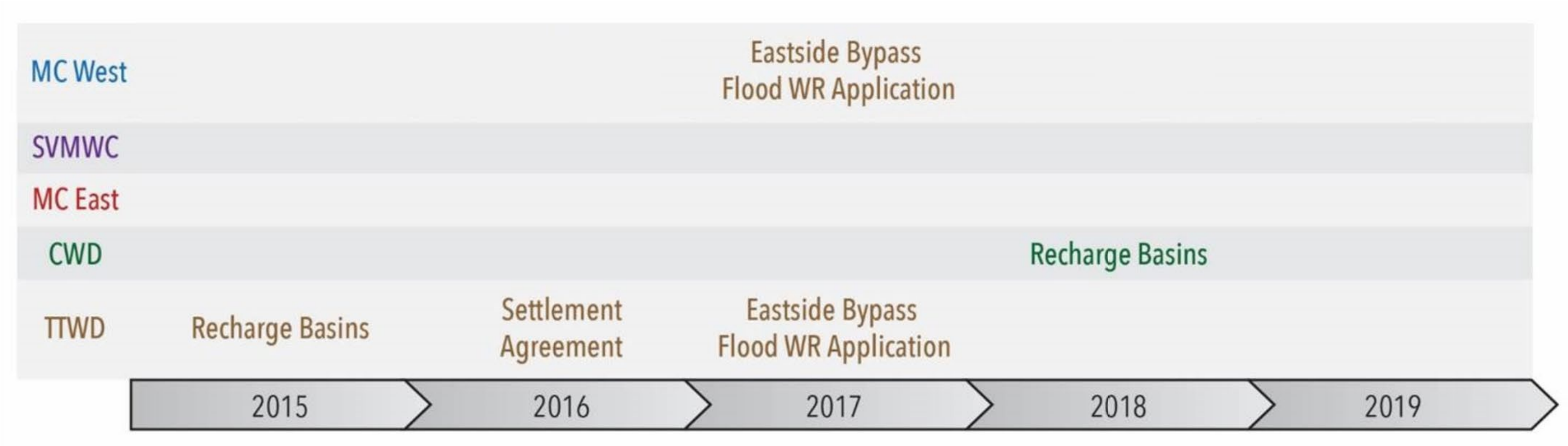


Figure ES-6. Chowchilla Subbasin Projects in Response to SGMA (2015-2019).

	2020 – 2024	2025	2026 – 2029	2030	2031 – 2034	2035	2036 – 2039	2040
MC West	Red Top Joint Banking Project; Demand Management	Demand Management; Flood-MAR; Recharge Basins	Demand Management	Demand Management	Demand Management	Demand Management	Demand Management	Demand Management
Sierra Vista MWC	Recharge Basins	Recharge Basins						
MC East	Flood Water Recharge; Imported Water Purchase;Demand Management	Flood-MAR; Demand Management	Demand Management	Demand Management	Demand Management	Demand Management	Demand Management	Demand Management
CWD	Flood-MAR	Recharge Basins; Flood-MAR	Recharge Basins; Flood-MAR	Merced-Chowchilla Intertie; Madera Canal Capacity Increase	Recharge Basins; Flood-MAR	Recharge Basins; Flood-MAR	Recharge Basins; Flood-MAR	Eastman Lake Enlargement
TTWD	Red Top Joint Banking Project							
All GSAs	Annual Reports	Periodic Evaluation	Annual Reports	Periodic Evaluation	Annual Reports	Periodic Evaluation	Annual Reports	Periodic Evaluation

Figure ES-7. Chowchilla Subbasin Implementation Schedule (2020-2040).

1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, and industrial beneficial uses and users throughout the Chowchilla Subbasin[7], which underlies approximately 146,000 acres within Madera and Merced Counties. Agriculture in the Chowchilla Subbasin has historically relied on approximately 300,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the agricultural economies of both Madera County and Merced County, which have a total combined value of over $5 billion dollars.[8] Groundwater also supports a large portion of domestic, municipal, and industrial water use in and around the City of Chowchilla. Thus, the sustainable management of groundwater in the Chowchilla Subbasin is important for long-term prosperity within Madera and Merced Counties.

The Sustainable Groundwater Management Act of 2014 (SGMA) provides for local control of groundwater resources while requiring sustainable management of these resources. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming local Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP, or Plan) for the subbasin. Under this Plan, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

Sustainable management of groundwater is defined under SGMA as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" (California Water Code (CWC) Section 10721(v)). These undesirable results are defined in CWC Section 10721(x)[9] and include significant and unreasonable lowering of groundwater levels, loss of groundwater storage and supply, degradation of water quality, land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. Sea water intrusion, while a SGMA-defined undesirable result, is not applicable to the Chowchilla Subbasin.

The Chowchilla Subbasin (Subbasin) has been identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Under SGMA, GSAs in critically overdrafted subbasins are required to prepare and adopt a GSP (or GSPs) by January 31, 2020 (CWC Section 10720.7(a)(1)).

This GSP is the coordinated Plan for four GSAs that represent the entirety of the Chowchilla Subbasin area: Chowchilla Water District (CWD) GSA, County of Madera GSA – Chowchilla Subbasin (also referred to herein as Madera County GSA), County of Merced GSA – Chowchilla Subbasin (also referred to herein as Merced County GSA), and Triangle T Water District (TTWD) GSA. The Chowchilla Subbasin will satisfy

[7] Groundwater basin number 5-022.05, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.

[8] According to the Madera County Department of Agricultural Weights and Measures, the gross value of all agricultural production in the County was $1,973,449,000 (2017 Crop and Livestock Report). According to the Merced County Department of Agriculture, the gross value of all agricultural commodities in the County was $3,408,866,000 (Merced County 2017 Report on Agriculture).

[9] CWC Section 10721(x) defines undesirable results as one of more of the following effects (summarized): chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater storage, significant and unreasonable seawater intrusion, significant and unreasonable degraded water quality, significant and unreasonable land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

SGMA requirements with this single GSP that covers the entire Subbasin. The Chowchilla Subbasin is coordinating GSP development with the Madera Subbasin. An interbasin agreement was developed by all GSAs in the Chowchilla Subbasin detailing required GSP cooperation and coordination with neighboring GSAs in the Merced Subbasin.

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this GSP is to characterize groundwater conditions in the Chowchilla Subbasin, to evaluate and report on conditions of overdraft, to establish sustainability goals, and to describe projects and management actions (PMAs) the GSAs will implement to achieve sustainable groundwater management by 2040.

This GSP also serves to comply with DWR's requirements that the Chowchilla Subbasin GSAs prepare, adopt, and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon" as defined in the California Code of Regulations Title 23 (23 CCR), Section 350.4 (f).

1.2 Sustainability Goal

As mandated under 23 CCR Section (§) 354.24, GSAs within the Chowchilla Subbasin have established a "sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline." Specifically, this sustainability goal establishes that the Chowchilla Subbasin will be operated within its sustainable yield by 2040, or 20 years following GSP implementation in January 2020.

SGMA regulations define sustainable yield as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC Section 10721(w)). Subbasin sustainable yield must therefore be determined in the context of the complete basin setting, which includes historical, current, and projected conditions regarding groundwater, surface water, and land use.

To achieve the sustainability goal, this GSP details accounting of the Chowchilla Subbasin used to identify sustainable yield and establishes the criteria for GSAs to operate sustainably. Finally, planned monitoring networks, projects, and management actions are proposed to achieve and verify sustainable groundwater use. To facilitate review, **Table 1-1** aligns the regulations with this GSP's corresponding section.

1.3 Agency Information

Four local agencies have formed GSAs covering the full extent of the Chowchilla Subbasin: Chowchilla Water District (CWD) GSA, Madera County (Madera Co) GSA, County of Merced Chowchilla GSA (Merced Co), and Triangle T Water District (TTWD) GSA. **Figure 1-1** delineates the areas managed exclusively by each GSA.

Information on each GSA's organization and management structure, jurisdictional area, land use, and water supplies are described below and summarized in **Table 1-2**. Information provided by each GSA to DWR pursuant to CWC Section 10723.8 is included in **Appendix 1**. Contact information for each GSA is provided in **Table 1-3**.

Table 1-1. Sustainability Goal Development and Associated GSP Sections.

Sustainability Goal Development	23 CCR Section	Requirement	GSP Section
Context, basis for goal	§ 354.12	Basin Setting	2.2
	§ 354.14	Hydrogeologic Conceptual Model	2.2.1
	§ 354.16	Groundwater Conditions	2.2.2
	§ 354.18	Water Budget	2.2.3
	§ 354.20	Management Areas	2.2.4
Establishment of goal	§ 354.24	Sustainability Goal	3.1
	§ 354.26	Undesirable Results	3.4
	§ 354.28	Minimum Thresholds	3.3
	§ 354.30	Measurable Objectives	3.2
Measures of ensuring goal achievement	§ 354.32	Introduction to Monitoring Networks	3.5
	§ 354.34	Monitoring Network	3.5.1, 3.5.2
	§ 354.36	Representative Monitoring	3.5.3
	§ 354.38	Assessment and Improvement of Monitoring Network	3.5.4
	§ 354.44	Projects and Management Actions	4

Table 1-2. Summary of Chowchilla Subbasin Groundwater Sustainability Agencies.

GSA	GSA Abbreviation	GSA Area, Acres	Average Irrigated Area (2015), Acres
Chowchilla Water District GSA	CWD GSA	85,200	71,400
County of Madera GSA - Chowchilla	Madera Co GSA	45,100	37,100
County of Merced GSA - Chowchilla	Merced Co GSA	1,300	1,200
Triangle T Water District GSA	TTWD GSA	14,700	13,700
	Total	**146,300**	**123,400**

Table 1-3. Chowchilla Subbasin Groundwater Sustainability Agencies' Contact Information.

Groundwater Sustainability Agency	Contact Person	Contact Title	Mailing Address	Phone Number	Email Address
Chowchilla Water District	Doug Welch[1]	General Resources Manager, Chowchilla Water District	327 S. Chowchilla Blvd., Chowchilla, CA 93610	(559) 665-3747	dwelch@cwdwater.com
County of Madera GSA - Chowchilla	Stephanie Anagnoson	Director of Water and Natural Resources, County of Madera	200 W. Fourth Street, Madera, CA 93637	(559) 598-0362	stephanie.anagnoson@maderacounty.com
County of Merced GSA - Chowchilla	Lacey McBride	Water Resources Coordinator, County of Merced	2222 M Street, Merced, CA 95340	(209) 385-7654	lacey.mcbride@countyofmerced.com
Triangle T Water District	Brad Samuelson	Water & Land Solutions, LLC GSA Manager	2941 Hwy 59 Merced, CA 95341	(559) 658-8487	bsamuelson@waterandlandsolutions.com

[1] Doug Welch is the Plan Manager (23 CCR § 354.6(c)).

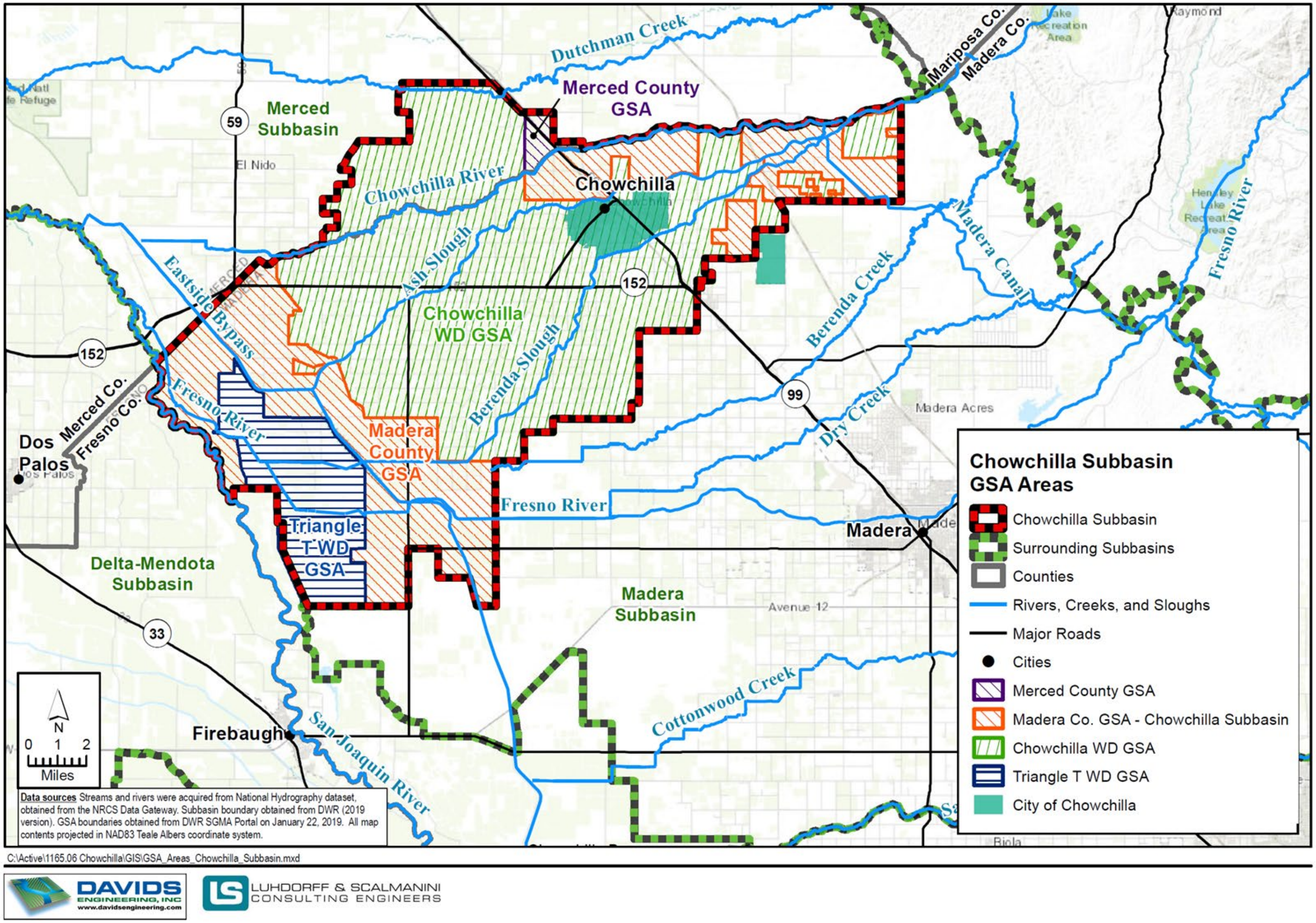


Figure 1-1. Chowchilla Subbasin GSAs Map.

1.3.1 Organization and Management Structure of the Groundwater Sustainability Agencies

A summary is provided below for each GSA detailing its formation date, management structure, and background regarding typical land use and water supply availability. This GSP has been developed through joint coordination between the GSAs within the Chowchilla Subbasin GSP Advisory Committee, also described below.

1.3.1.1 Chowchilla Water District GSA

Chowchilla Water District (CWD) GSA was formed on December 14, 2016 and manages approximately 85,200 acres of the Chowchilla Subbasin, representing the largest jurisdictional area in the Subbasin (**Figure 1-2**). CWD GSA includes the portion of the City of Chowchilla that falls within the District service area. As of 2015, much of the GSA area is agricultural land (85%) and developed land (11%), including urban, semi-agricultural, and industrial land. The remaining area is primarily native vegetation (3%) with some water surface (1%).

In 2015, irrigated agricultural land represented over 71,000 acres in the CWD GSA. Much of this area is used for cultivating almonds, though mixed pasture, alfalfa, corn, and grapes are also grown across substantial portions of the GSA. CWD GSA receives substantial surface water supplies to support agriculture. These include CVP supplies received under contract with Reclamation from Buchanan Dam and the Madera Canal (**Figure 1-3**). CWD also diverts water from the Chowchilla River under its appropriative water rights on the Chowchilla River System and purchases water from Merced Irrigation District. Remaining agricultural water demand in CWD GSA is met by privately owned groundwater wells.

The Board of Directors for CWD GSA is the Chowchilla Water District Board of Directors. CWD GSA Board of Directors meetings are held concurrently with the regular CWD Board of Directors meetings, which are typically scheduled on the second Wednesday of each month at 1:30 p.m. These meetings are open to the public and are held at the Chowchilla Water District offices (327 South Chowchilla Boulevard, Chowchilla, CA, 93610).

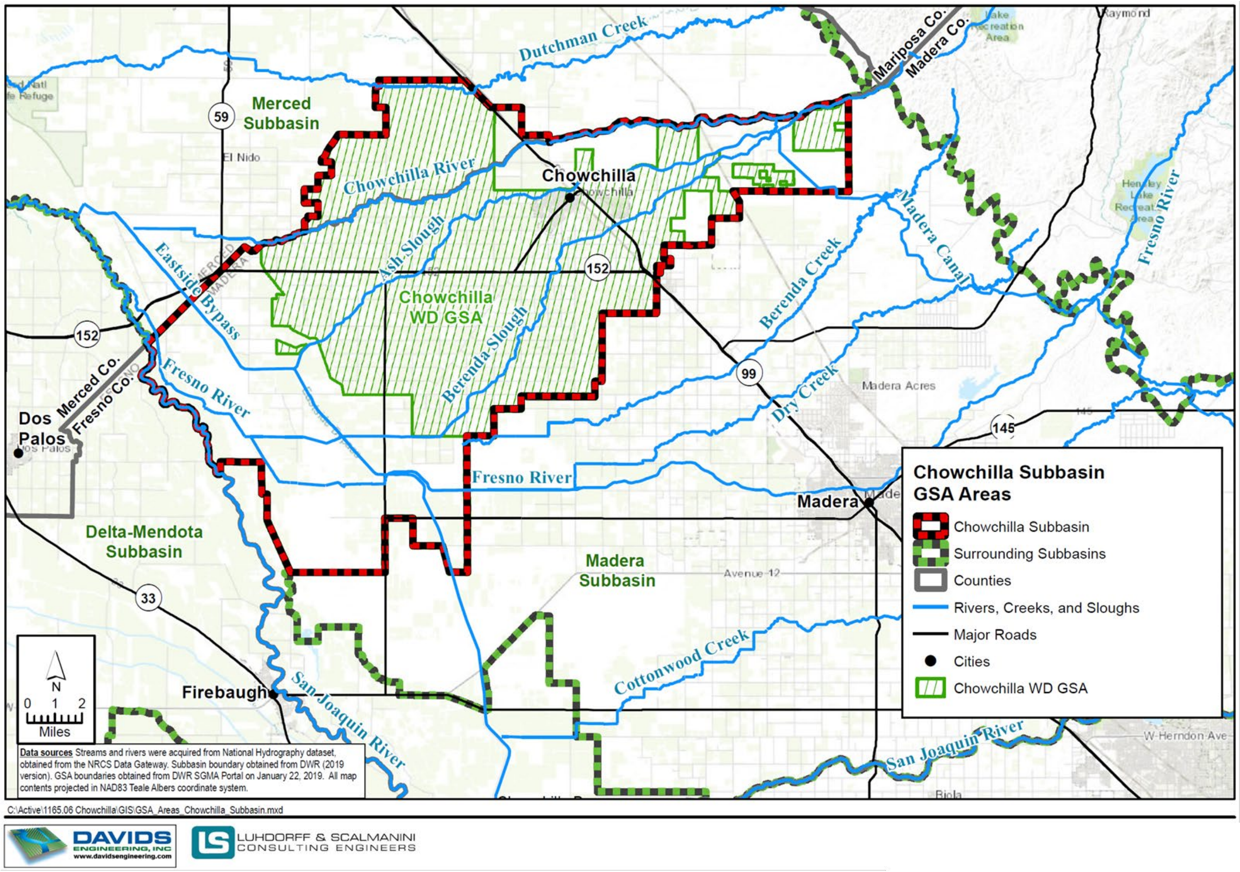


Figure 1-2. Chowchilla Water District GSA Map.

Figure 1-3. Madera Canal Mile 33.6 Deliveries to Chowchilla Water District GSA.

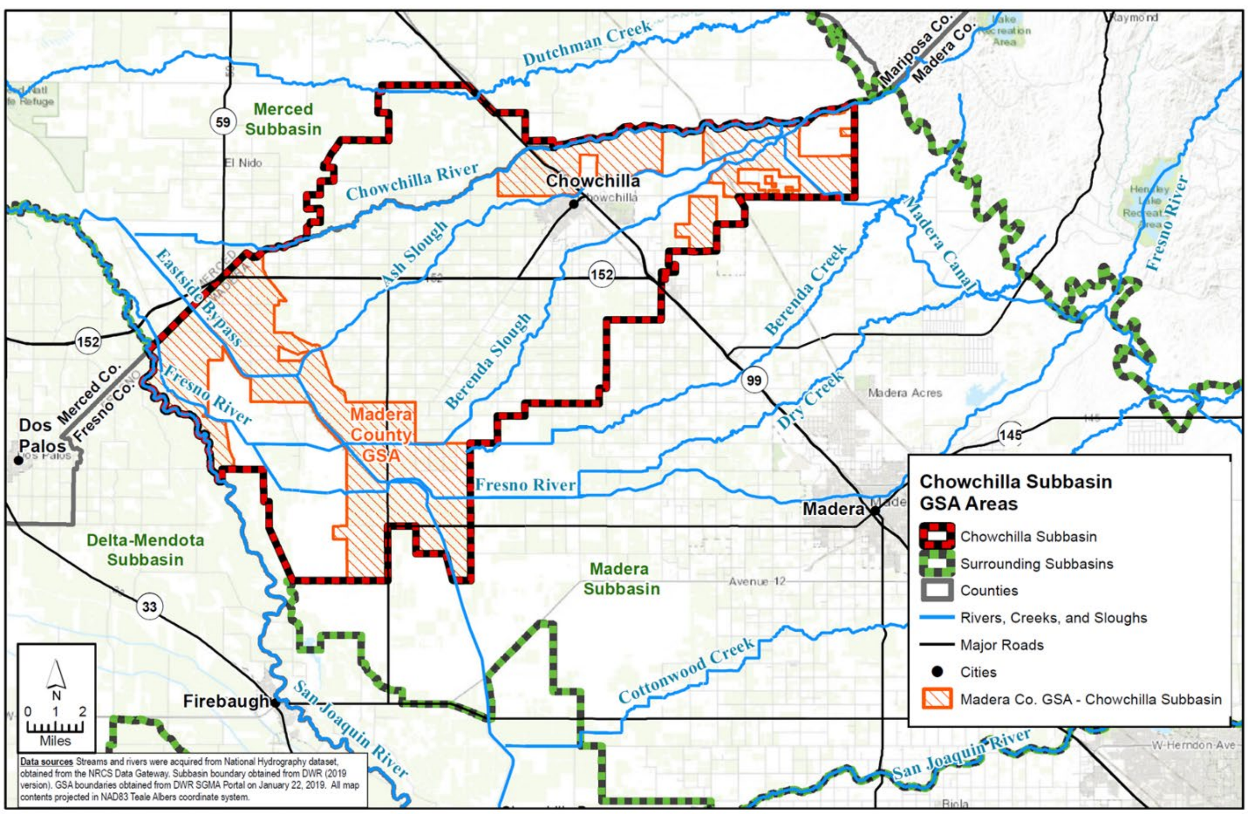
1.3.1.2 Madera County GSA

Madera County (Madera Co) GSA was formed on January 24, 2017 and manages approximately 45,100 acres of the Chowchilla Subbasin (**Figure 1-4**). As of 2015, the majority of this area is comprised of agricultural land (82%) or native vegetation (12%). The remaining area consists of developed land (includes urban, semi-agricultural, and industrial land) and some water surface (6%).

In 2015, irrigated agricultural land represented approximately 37,100 acres in Madera Co GSA. Much of this area is used for cultivating orchard crops (primarily almonds and pistachios), corn, mixed pasture, alfalfa, and grapes (**Figure 1-5**). Surface water supplies available for agriculture in Madera Co GSA are limited to riparian and appropriative deliveries to individual water rights users along waterways within the GSA. Thus, agricultural water demand in Madera Co GSA is primarily fulfilled by groundwater.

North of the City of Chowchilla, a portion of Madera Co GSA overlaps with Sierra Vista Mutual Water Company (SVMWC). Within this GSP, the water budgets, projects, and management actions developed for SVMWC are applicable to this portion of Madera Co GSA.

The Board of Directors for Madera Co GSA is the Madera County Board of Supervisors. As the Board of Directors, the Board of Supervisors meets on the first Tuesday of each month at the end of the 10 a.m. Board of Supervisors Meeting. These meetings are open to the public (200 West Fourth Street, Madera, CA, 93637) and are recorded and available for public viewing on the Madera County website (maderacounty.com). Madera County GSA also has an Advisory Committee that meets bimonthly and provides feedback to the Board of Supervisors on SGMA-related matters. Members of the committee also serve as ambassadors in their communities regarding water issues.



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DAVIDS ENGINEERING, INC   LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Figure 1-4. Madera County GSA Map.

Figure 1-5. Viticulture in Madera County GSA.

1.3.1.3 Merced County GSA

County of Merced Chowchilla (Merced Co) GSA was formed on February 21, 2017 and manages approximately 1,300 acres of the Chowchilla Subbasin (**Figure 1-6**). As of 2015, the majority of this area is comprised of agricultural land (89%) or developed land (10%) (urban, semi-agricultural, or industrial land). The remaining area consists of native vegetation or water surfaces (1%).

In 2015, irrigated agricultural land represented approximately 1,200 acres in Merced Co GSA. This area is used primarily for cultivating mixed pasture, alfalfa, corn, and orchard crops (**Figure 1-7**). Surface water supplies available to agriculture in Merced Co GSA include deliveries from CWD and individual water rights usage along the Chowchilla River. Remaining agricultural water demand in Merced Co GSA is fulfilled by privately owned groundwater wells.

In the Chowchilla Subbasin, Merced Co GSA lies almost entirely within the jurisdictional bounds of SVMWC. SVMWC also overlaps with a portion of Madera Co GSA. Within this GSP, the water budgets, projects, and management actions developed for SVMWC are applicable to the entirety of Merced Co GSA and the portion of Madera Co GSA overlapping SVMWC.

The Board of Directors for Merced Co GSA is the Merced County Board of Supervisors. The Merced Co GSA Board of Directors meetings are held as needed following the regular Merced County Board of Supervisors meetings. The regularly scheduled Board of Supervisors meetings are typically held on the first and third Tuesday of each month at 10:00 a.m. and are open to the public at the Merced County Administration Building (2222 M Street, 3rd Floor, Merced, CA 95340).

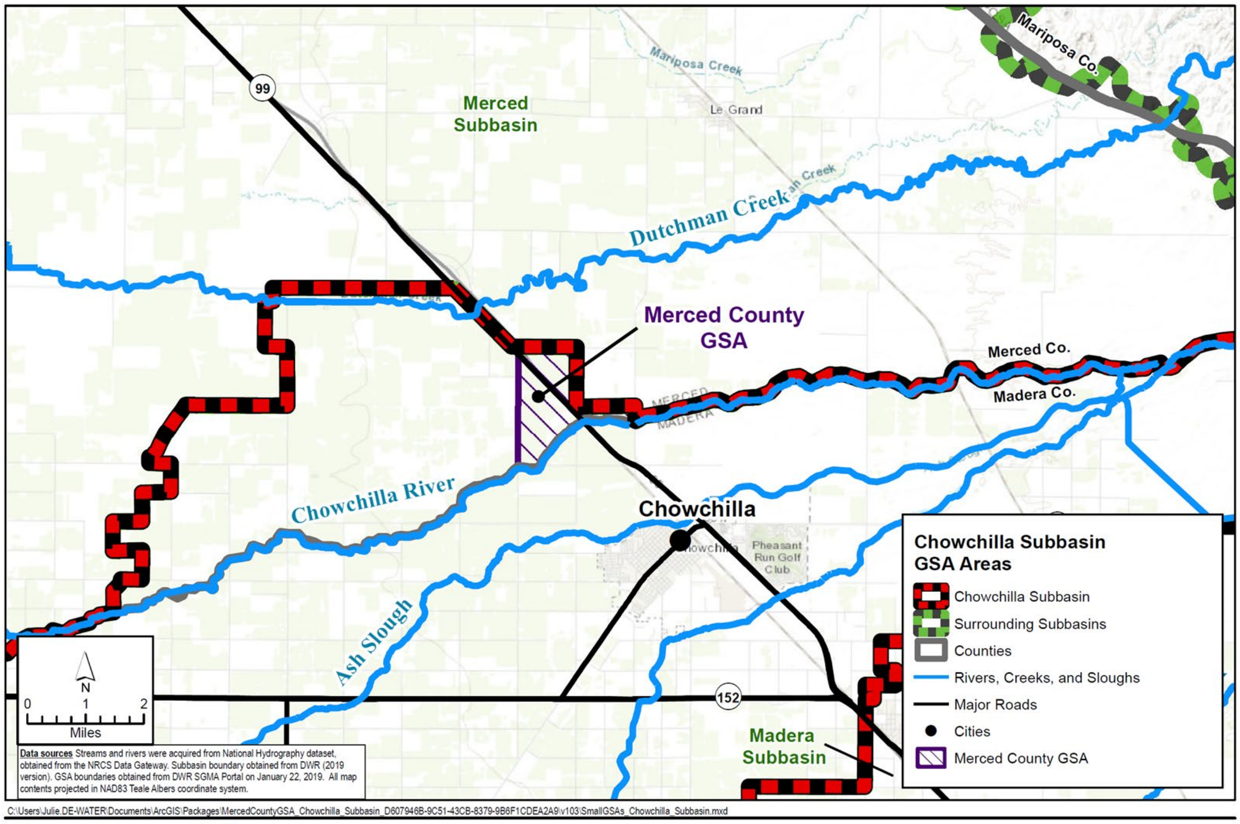

Figure 1-6. Merced County GSA Map.

Figure 1-7. Orchard in Merced County GSA.

1.3.1.4 Triangle T Water District GSA

Triangle T Water District (TTWD) GSA was formed on October 26, 2017 and manages approximately 14,700 acres of the Chowchilla Subbasin (**Figure 1-8**). As of 2015, most of this area is comprised of agricultural land (94%). Small portions (6%) of the GSA are also covered by native vegetation, developed land (urban, semi-agricultural, or industrial land), and water surfaces.

In 2015, irrigated agricultural land represented approximately 13,700 acres in TTWD GSA. At present, this area is used primarily for cultivating almonds and pistachios (**Figure 1-9**). Prior to SGMA, surface water supplies available to agriculture in TTWD GSA were limited to water rights users along waterways in the district. Remaining agricultural water demand in TTWD GSA has historically been fulfilled by groundwater.

The Board of Directors for TTWD GSA is the Triangle T Water District Board of Directors. TTWD GSA Board of Directors meetings are held concurrently with the regular Triangle T Water District Board of Directors meetings on the second Thursday of each month at 1:00 pm. These meetings are open to the public and are held at Triangle T Ranch.

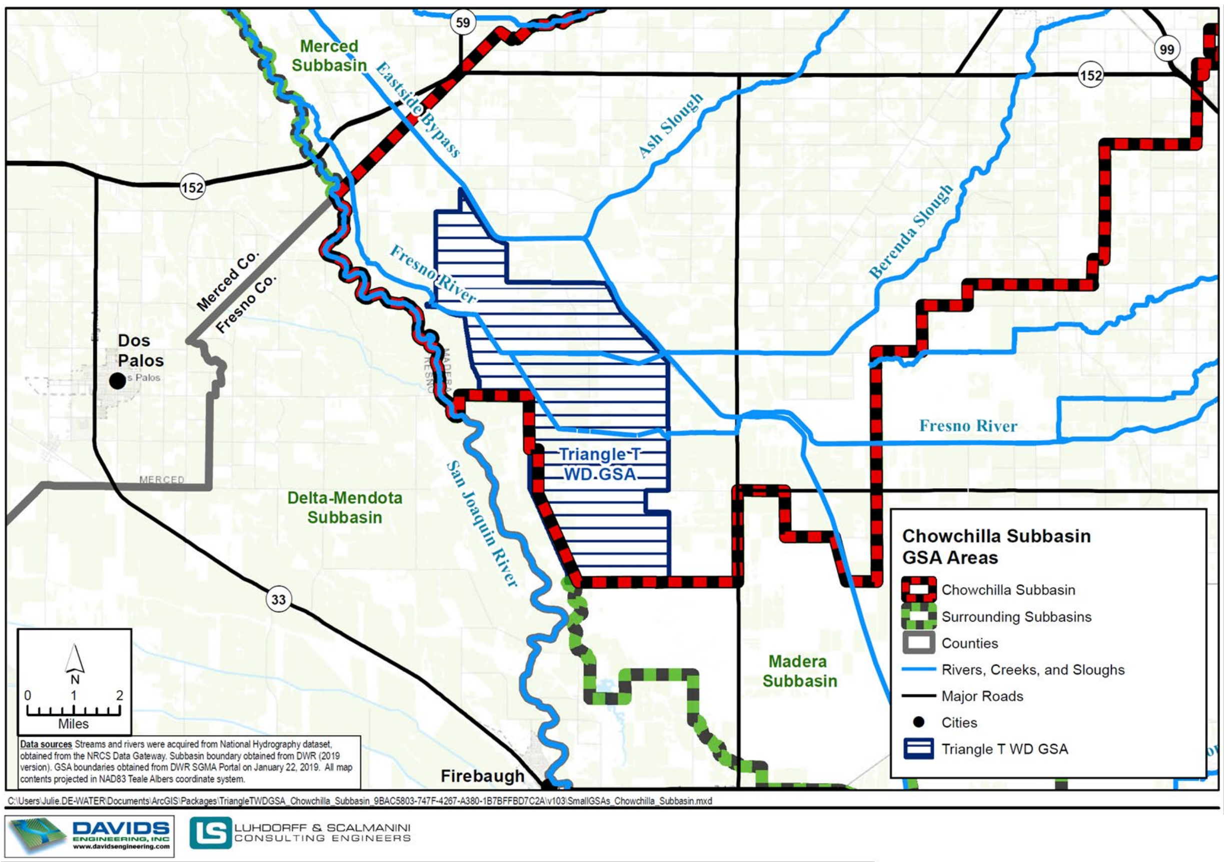

Figure 1-8. Triangle T Water District GSA Map.

Figure 1-9. Orchard Crops and Flood-MAR field in Triangle T Water District.

1.3.1.5 Chowchilla Subbasin GSP Advisory Committee

The Chowchilla Subbasin GSAs have jointly formed the Chowchilla Subbasin GSP Advisory Committee (the "Committee"). The Committee was formed in September 2017 by a memorandum of understanding (MOU) and serves as the coordinating body for guiding the Chowchilla Subbasin GSAs through development of the Chowchilla Subbasin GSP. In this role, the Committee advises the GSAs' governing bodies on GSP development, implementation, and public engagement consistent with each GSA's policies.

The aim of the Committee is to facilitate cooperation between GSAs to obtain and share costs related to consulting, administrative, and management services needed to efficiently develop a GSP, to conduct outreach to other basin agencies and private parties, and to identify mechanisms for the management and funding commitments reasonably anticipated to be necessary for the purposes of the MOU.

The Committee members and staff include at least one representative of each GSA. Committee meetings are typically held monthly and are open to the public.

1.3.2 Legal Authority of the GSA

The GSAs involved in development of this GSP have the legal authority and are pursuing the financial resources necessary to implement the GSP.

Chowchilla Water District, Madera County, Merced County, and Triangle T Water District are local agencies[10] overlying the Chowchilla Subbasin as defined under SGMA and are therefore eligible to serve as separate GSAs within the Chowchilla Subbasin (CWC Section 10723(a)). Pursuant to CWC Section 10724(a), Madera County and Merced County each serve as the GSA for all areas within their respective counties in the Chowchilla Subbasin that are outside the management area of other GSAs.

Each agency held public hearings regarding the establishment of a GSA in accordance with CWC Section 10723(b). Public notice for these hearings was provided in accordance with Government Code Section 6066. After holding these hearings, the governing bodies of each agency adopted resolutions to establish the associated GSAs.

Pursuant to CWC Section 10723.2, the aforementioned GSAs "shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans."

1.3.3 Estimated Cost of GSP Implementation

The estimated annual costs of GSP implementation for the four GSAs included under this GSP are shown in **Figure 1-10** (in current dollars). Additional detail is provided in Chapter 5 of this GSP. Also illustrated are the estimated annual operations and maintenance (O&M) costs (in current dollars) for all GSP PMAs described in Chapter 4. This figure does not include the cost that the Madera County GSA demand management program would impose on growers and the County economy. Average annual operating costs for projects increase from $6.5 million per year in 2020 to over $12 million per year by 2040. Project costs will be refined by GSAs as the GSP is implemented. GSA implementation costs total about $1.05 million per year.

Individually, the GSAs manage their own financing, staffing, contracting, and daily operations related to GSP implementation. The approach to meeting the GSP implementation costs varies between GSAs.

Table 1-4 provides a summary of the estimated capital costs (in current dollars) and the average annual gross recharge benefit anticipated at full implementation of each GSA's PMAs. In total, GSP PMAs are estimated to provide a gross average annual benefit of about 134,000 AF to Subbasin recharge with an estimated average annual operating cost of $29,600,000. Annual operating costs include the direct cost of demand management (crop revenue loss from fallowing) but do not include additional indirect, or "multiplier," effects on the Madera County economy. The total capital cost of all PMAs implemented by the Chowchilla Subbasin GSAs is around $315 million dollars. All costs are preliminary estimates that will be refined by the GSAs. Additional information is provided in Chapter 4 of this GSP.

[10] California Water Code Section 10721(n): "Local agency" means a local public agency that has water supply, water management, or land use responsibilities within a groundwater basin.

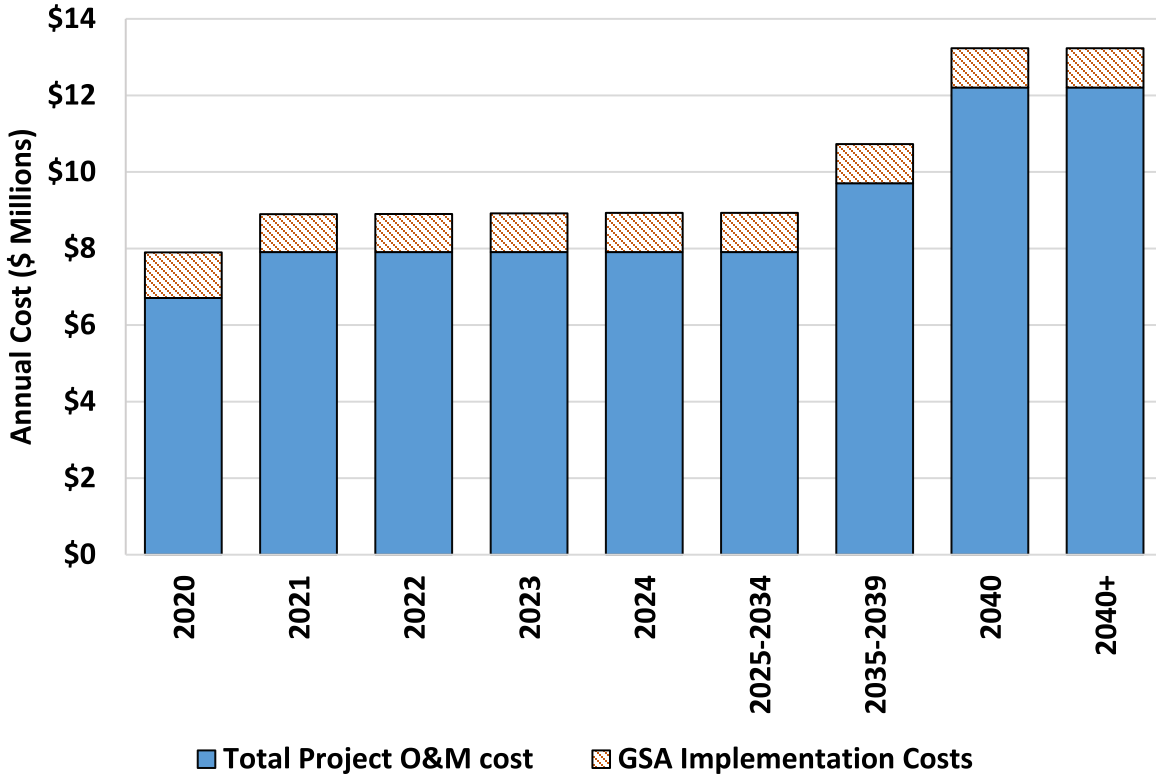

Figure 1-10. Chowchilla Subbasin Estimated Annual Costs (in current dollars) for Project O&M and GSA Implementation.

Table 1-4. Summary of Chowchilla Subbasin Groundwater Sustainability Plan Projects and Management Actions by GSA.

GSA[1]	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	39,248	158.8	2.7
Madera County	58,518	119.0[3]	21.4[3]
SVMWC[2]	4,344	7.5	0.2
TTWD	32,304	29.7	5.3
Total	**134,414**	**315.0**	**29.6**

[1]Projects and management actions summarized by each GSA or local agency responsible for implementation.
[2] SVMWC includes portions of both Madera County GSA and Merced County GSA.
[3] The cost of the County's demand management program includes approximately $19.1 million per year in direct economic impacts (crop revenue losses), excluding any multiplier effects.

1.4 GSP Organization

This GSP has been developed by the consulting team on behalf of CWD GSA, Madera Co GSA, Merced Co GSA, and TTWD GSA. The consulting team is comprised of Davids Engineering (DE), Luhdorff & Scalmanini

Consulting Engineers (LSCE), ERA Economics, LLC (ERA), Stillwater Sciences (SS), and the Consensus and Collaboration Program at California State University Sacramento (CSUS or CCP).

The GSP is organized in accordance with 23 CCR § 354 as follows:

- Chapter 1 of this Plan provides an introduction to the Chowchilla Subbasin GSAs and the development of this GSP.
- Chapter 2 provides a detailed summary of the Plan area and development of the basin setting, including the hydrogeologic conceptual model, current and historical groundwater conditions, water budgets, and Management Areas (as applicable).
- Chapter 3 establishes the Subbasin sustainability goal to be achieved through coordination among all GSAs in the Subbasin. This section also establishes MOs, MTs, and undesirable results for each sustainability indicator, followed by a description of the proposed monitoring network to track and verify progress toward the Subbasin sustainability goal.
- Chapter 4 proposes PMAs for achieving the Subbasin sustainability goal.
- Chapter 5 proposes the Plan implementation strategy, costs, and schedule.

To facilitate DWR review and assure compliance with all applicable GSP regulations, **Table 1-5** was prepared to cross-reference between sections of this GSP to applicable sections and the GSP regulations. Terminology in this GSP has also been used in alignment with the SGMA definitions provided in CWC Section 10721 and in 23 CCR § 351. These definitions are provided as **Appendix 1.F.** of this GSP.

Table 1-5. Cross Reference of GSP Regulations[11] and Associated GSP Sections.

Subarticle	Section	Paragraph	Requirement	GSP Section
1. Administrative Information	4. General Information	(a)	Executive summary	Executive Summary
		(b)	List of references and technical studies	6
	6. Agency Information	-	Agency information pursuant to CWC Section 10723.8, along with:	App. 1
		(a)	Agency name and mailing address	1.3
		(b)	Agency organization and management structure, persons with management authority for Plan implementation	1.3.1
		(c)	Plan manager name and contact information	1.3
		(d)	Legal authority of agency	1.3.2
		(e)	Estimate of Plan implementation costs and description of how Agency plans to meet costs	1.3.3, 5.1
	8. Description of Plan Area	(a)	Maps of Plan area	2.1.1
		(b)	Written description of Plan area	2.1.1
		(c)-(d)	Identification of existing water resource monitoring and management programs, and description of any such planned programs	2.1.2
		(e)	Description of conjunctive use programs	2.1.2
		(f)	Description of the land use elements or topic categories	2.1.3
		(g)	Description of additional Plan elements (CWC Section 10727.4)	2.1.4
	10. Notice and Communication	(a)	Description of the beneficial uses and users of groundwater in the Subbasin	2.1.5
		(b)	List of public meetings	2.1.5
		(c)	Comments and responses regarding the Plan	2.1.5
		(d)	Description of communication procedures	2.1.5
2. Basin Setting	12. Introduction to Basin Setting	-	Information about the basin setting (physical setting, characteristics, current conditions, data gaps, uncertainty)	2.2
	14. Hydrogeologic Conceptual Model	(a)	Description of the Subbasin hydrogeologic conceptual model	2.2.1
		(b)	Summary of regional geologic and structural setting, Subbasin boundaries, geologic features, principal aquifers and aquitards	2.2.1
		(c)	Cross-sections depicting major stratigraphic and structural features	2.2.1
		(d)	Maps of Subbasin physical characteristics	2.2.1
	16. Groundwater Conditions	(a)-(g)	Description of current and historical groundwater conditions including: 1. Groundwater elevation 2. Change in storage 3. Seawater intrusion	2.2.2

[11] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents

Subarticle	Section	Paragraph	Requirement	GSP Section
2. Basin Setting			4. Groundwater quality issues 5. Land subsidence 6. Interconnected surface water systems 7. Groundwater dependent ecosystems	
	17. Water Budget	(a)	Water budget providing total annual volume of groundwater and surface water entering and leaving the Subbasin, including historical, current and projected water budget conditions, and change in storage.	2.2.3
		(b)-(f)	Development of a numerical groundwater and surface water model to quantify current, historical, and projected: 1. Total surface water entering and leaving by water source type 2. Inflow to the groundwater system by water source type 3. Outflows from the groundwater system by water use sector 4. Change in groundwater storage 5. Overdraft over base period 6. Annual supply, demand, and change in storage by water year type. 7. Estimated sustainable yield	2.2.3
	20. Management Areas	(a)	Description of Management Areas	2.2.4
		(b)	Describe purpose, MTs, MOs, monitoring, analysis	2.2.4
		(c)	Maps and supplemental information	2.2.4
3. Sustainable Management Criteria	22. Introduction to Sustainable Management Criteria	-	Criteria by which an Agency defines conditions that constitute sustainable groundwater management for the Subbasin	3
	24. Sustainability Goal	-	Description of Subbasin sustainability goal, including basin setting information used to establish the goal, sustainability indicators, discussion of measures to ensure the Subbasin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved and maintained.	3.1
	26. Undesirable Results	(a)	Processes and criteria used to define undesirable results applicable to the Subbasin.	3.4
		(b)-(c)	Description of undesirable results, including cause of groundwater conditions and potential effects on beneficial uses and users of groundwater.	3.4
	28. Minimum Thresholds	(a)	Establish MTs to quantify groundwater conditions for each applicable sustainability indicator.	3.3
		(b)-(d)	Describe information and criteria to select, establish, justify, and quantitatively measure MTs.	3.3
	30. Measurable Objectives	(a)-(g)	Establish MOs, including interim milestones in increments of five years, to achieve and maintain the Subbasin sustainability goal.	3.2

Subarticle	Section	Paragraph	Requirement	GSP Section
4. Monitoring Networks	32. Introduction to Monitoring Networks	-	Description of monitoring network, monitoring objectives, monitoring protocols, and data reporting.	3.5
	34. Monitoring Network	(a), (e)-(g)	Development of monitoring network to yield representative information about groundwater conditions.	3.5.1
		(b)-(d)	Monitoring network objectives.	3.5.1
		(h)	Maps and tables of monitoring sites.	3.5.1
		(i)	Monitoring protocols.	3.5.2
	36. Representative Monitoring	(a)-(c)	Designation of representative monitoring sites.	3.5.3
	38. Assessment and Improvement of Monitoring Network	(a)-(d)	Evaluation of monitoring network, including uncertainty, data gaps, and efforts to fill data gaps	3.5.4
		(e)	Adjustment of monitoring frequency and density to assess management action effectiveness	3.5.4
	40. Reporting Monitoring Data to the Department	(f)	Copy of monitoring data from data management system	-
5. Projects and Management Actions	44. Projects and Management Actions	(a)-(c)	Description of projects and management actions to achieve and maintain the Subbasin sustainability goal.	4

2 PLAN AREA AND BASIN SETTING

2.1 Description of the Plan Area (23 CCR § 354.8)

The Plan Area is defined as the Chowchilla Subbasin (5-022.05), part of the San Joaquin Valley Groundwater Basin, as described in Bulletin 118 (DWR, 2003) updated in 2016, with boundary updates approved in early 2019.

The lateral extent of the Subbasin is defined by the Subbasin boundaries provided in Bulletin 118 (DWR, 2016), with boundary updates approved in late 2018. The Subbasin is bounded in the south and east by the Madera Subbasin, in the west by the San Joaquin River and the Delta-Mendota Subbasin, and in the north by the Merced Subbasin (**Figure 1-1**).

The vertical boundaries of the Subbasin are the land surface (upper boundary) and the definable bottom of the basin (lower boundary). The definable bottom was established as part of development of the preliminary hydrogeologic conceptual model (HCM) during previous data collection and analysis efforts conducted by DE and LSCE (2017). The vertical extent of the Subbasin is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone,[12] within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

2.1.1 Summary of Jurisdictional Areas and Other Features (23 CCR § 354.8(b))

As identified in **Section 1.3**, four GSAs cover the Chowchilla Subbasin: CWD GSA, Madera Co GSA, Merced Co GSA, and TTWD GSA. These four GSAs have agreed to cooperate and develop a single GSP for the Chowchilla Subbasin.

Table 1-2 and **Figure 1-1** delineate the areas managed exclusively by each GSA in this GSP and portions of the subbasins adjacent to the Plan Area. No area in the Subbasin is covered by an alternative. The Subbasin is within the jurisdictional boundaries of Madera County and Merced County and is covered by the respective general plans of the counties. The area covered by the City of Chowchilla General Plan is contained within the CWD GSA boundaries. The Chowchilla Subbasin is not adjudicated and contains no considerable state land or federal land.[13]

2.1.1.1 Land Uses

Land in the Chowchilla Subbasin is broadly classified across three land use sectors: agricultural, urban, and native vegetation. Agricultural land use (and water use) encompasses all agricultural crops reported in the Chowchilla Subbasin, including idle agricultural land and dairies. Urban land use includes urban, industrial, and semi-agricultural land. Native vegetation land use includes all land covered by native vegetation and water surfaces.

[12] The depth to the bottom of the root zone varies by crop, but typically ranges from 2-7 feet (ASCE, 2016).

[13] Federal land includes primarily rights of way along canals conveying USBR Central Valley Project water.

Figure 2-1 depicts land use in the Chowchilla Subbasin as reported in the 2011 DWR Madera County Land Use Survey and 2012 DWR Merced County Land Use Survey spatial coverages[14]. Annual land use areas within Chowchilla Subbasin were derived from the aforementioned DWR spatial land use surveys of Madera and Merced Counties, Land IQ remotely sensed land use data obtained through DWR, and Madera County and Merced County Agricultural Commissioner annual crop production area reports. Additional detail for the process used to develop an annual land use database for Madera County is provided in **Appendix 2.A**.

Annual land use within each of the three sectors are summarized in **Figure 2-2** and **Table 2-1** for the entire Chowchilla Subbasin between 1989-2015. Agricultural land use categories are further detailed in **Figure 2-3** and **Table 2-2**. Average land use across each sector and category is provided for the 1989-2014 historical water budget period described below in Section 2.2.3. Land use summaries are provided for each GSA in **Appendix 2.F**.

[14] The 2011 DWR Madera County Land Use Survey and 2012 DWR Merced County Land Use Survey are the most recent parcel-based land use data available at the time of GSP development. Field-based data is also available in 2014 from Land IQ, LLC. The DWR Land Use interpolation tool was used to estimate spatial land use data in years without parcel-based or field-based data, including 2015.

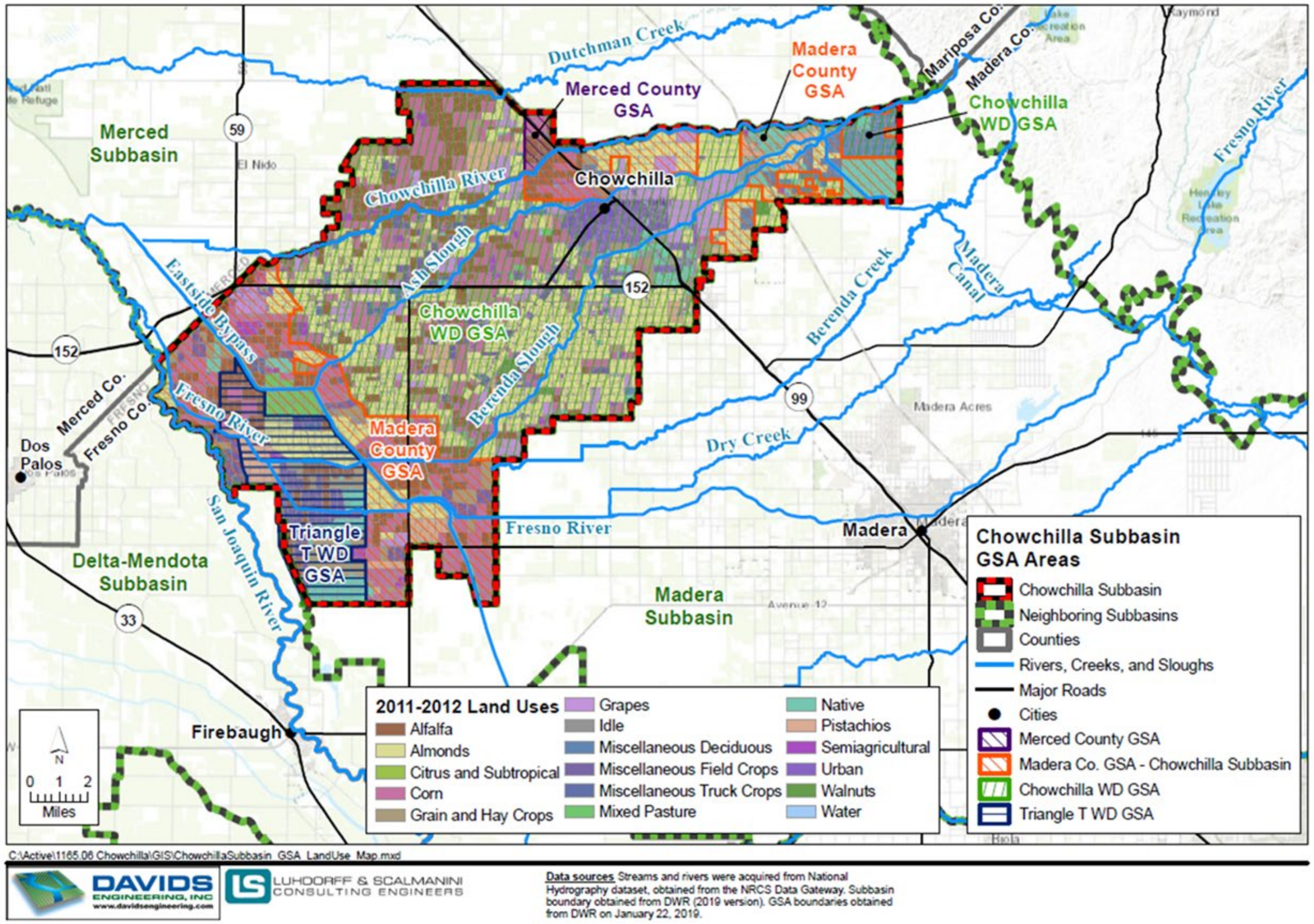

Figure 2-1. Chowchilla Subbasin Land Use Map.[15]

[15] Land uses extracted from the 2011 DWR Madera County and 2012 DWR Merced County spatial land use survey results.
Water User Sectors: Native Vegetation (Native and Water land uses), Urban (Semiagricultural and Urban land uses), and Agricultural (all other land uses).
Water Source Type: The Urban water use sector uses groundwater. The Agricultural water use sector uses a mixture of groundwater and surface water sources (CVP and local supplies are used for agriculture in Chowchilla WD GSA; local supplies are used in all other GSAs). The mixture of groundwater and surface water sources depends on the GSA (see **Appendices 2.F.a.** through **2.F.e**).

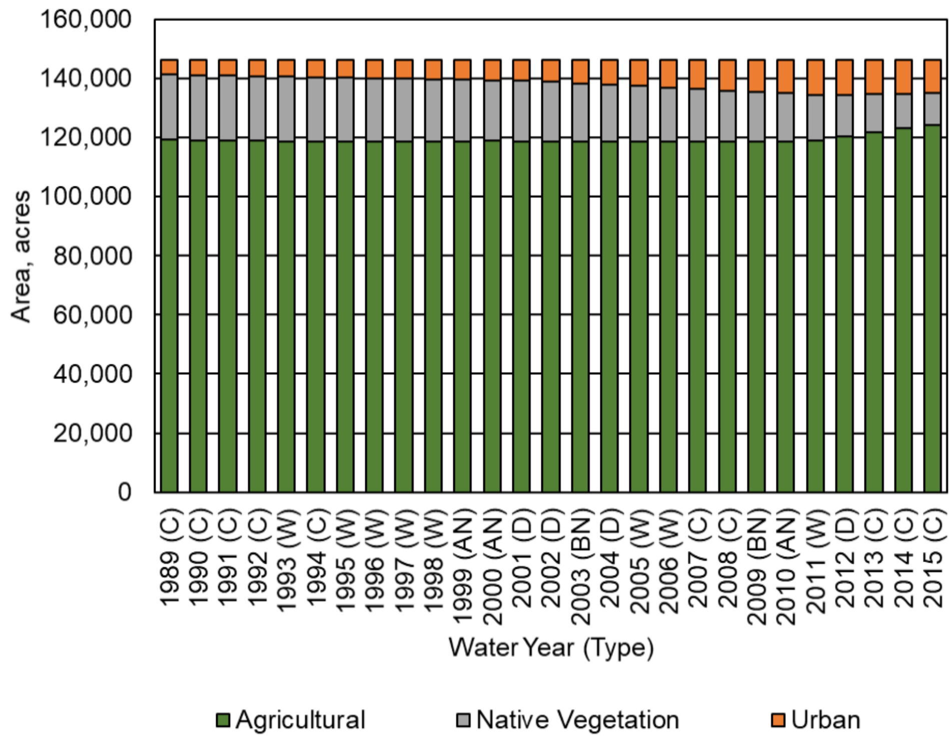

Figure 2-2. Chowchilla Subbasin Land Use Areas.

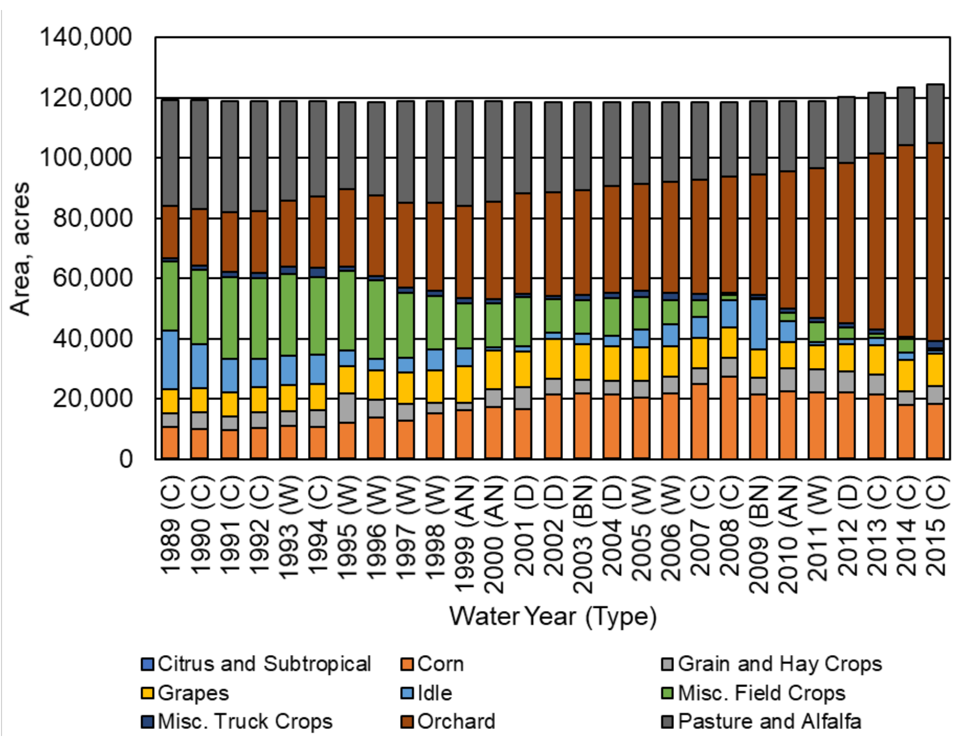

Figure 2-3. Chowchilla Subbasin Agricultural Land Use Areas.

Table 2-1. Chowchilla Subbasin Land Use Areas (Acres).

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	119,134	22,046	5,145	146,325
1990(C)	119,000	22,040	5,285	146,325
1991 (C)	118,929	21,960	5,436	146,325
1992 (C)	118,784	21,942	5,599	146,325
1993 (W)	118,737	21,824	5,764	146,325
1994 (C)	118,658	21,730	5,936	146,325
1995 (W)	118,601	21,612	6,112	146,325
1996 (W)	118,634	21,411	6,280	146,325
1997 (W)	118,667	21,210	6,448	146,325
1998 (W)	118,700	21,010	6,615	146,325
1999 (AN)	118,733	20,809	6,783	146,325
2000 (AN)	118,766	20,608	6,950	146,325
2001 (D)	118,577	20,613	7,135	146,325
2002 (D)	118,605	20,156	7,564	146,325
2003 (BN)	118,611	19,666	8,048	146,325
2004 (D)	118,616	19,177	8,531	146,325
2005 (W)	118,623	18,686	9,015	146,325
2006 (W)	118,629	18,197	9,499	146,325
2007 (C)	118,635	17,707	9,982	146,325
2008 (C)	118,641	17,219	10,465	146,325
2009 (BN)	118,648	16,727	10,949	146,325
2010 (AN)	118,653	16,238	11,433	146,325
2011 (W)	118,861	15,570	11,894	146,325
2012 (D)	120,293	14,184	11,848	146,325
2013 (C)	121,760	12,822	11,743	146,325
2014 (C)	123,247	11,425	11,653	146,325
2015 (C)	124,350	10,645	11,330	146,325
Average (1989-2014)	119,067			

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

Table 2-2. Chowchilla Subbasin Agricultural Land Use Areas (Acres).

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard[1]	Pasture and Alfalfa	Total
1989 (C)	59	10,439	4,590	8,023	19,511	22,850	1,201	17,449	35,012	119,134
1990 (C)	64	9,875	5,545	8,033	14,688	24,528	1,521	18,680	36,065	119,000
1991 (C)	67	9,519	4,369	8,119	11,065	27,411	1,566	19,889	36,925	118,929
1992 (C)	67	10,302	5,097	8,387	9,450	26,605	1,815	20,739	36,322	118,784
1993 (W)	67	10,845	4,993	8,529	9,912	27,249	2,162	22,078	32,902	118,737
1994 (C)	64	10,691	5,287	8,823	9,761	25,913	2,834	23,832	31,454	118,658
1995 (W)	112	11,782	9,891	8,981	5,264	26,486	1,178	25,975	28,932	118,601
1996 (W)	146	13,597	5,919	9,759	3,729	26,040	1,543	26,709	31,193	118,634
1997 (W)	135	12,628	5,686	10,325	4,768	21,525	1,785	28,138	33,677	118,667
1998 (W)	34	15,211	3,462	10,753	6,930	17,799	1,530	29,306	33,674	118,700
1999 (AN)	78	16,084	2,457	12,262	5,926	14,983	1,591	30,817	34,535	118,733
2000 (AN)	83	17,212	5,730	12,941	966	14,844	1,199	32,292	33,500	118,766
2001 (D)	72	16,574	7,383	11,604	1,683	16,445	1,197	33,159	30,462	118,577
2002 (D)	85	21,273	5,408	13,044	1,983	11,156	1,240	34,368	30,049	118,605
2003 (BN)	39	21,785	4,537	11,820	3,432	11,190	1,533	35,020	29,255	118,611
2004 (D)	37	21,217	4,860	11,199	3,520	12,484	1,876	35,279	28,144	118,616
2005 (W)	33	20,227	5,845	10,846	5,927	10,907	1,980	35,569	27,288	118,623
2006 (W)	30	21,811	5,595	10,139	7,070	8,117	2,269	36,905	26,693	118,629
2007 (C)	26	25,012	5,039	10,115	6,829	5,710	2,174	37,866	25,865	118,635
2008 (C)	21	27,377	6,092	10,023	9,086	1,724	677	38,640	25,002	118,641
2009 (BN)	18	21,245	5,664	9,386	16,696	398	1,153	39,895	24,193	118,648
2010 (AN)	22	22,514	7,498	8,822	6,866	2,918	1,201	45,530	23,281	118,653
2011 (W)	17	21,979	7,679	8,133	890	6,889	1,228	49,602	22,445	118,861
2012 (D)	46	22,131	6,950	8,940	1,723	3,875	1,301	53,289	22,037	120,293
2013 (C)	87	21,465	6,605	9,755	2,307	1,254	1,426	58,411	20,449	121,760
2014 (C)	190	17,660	4,510	10,624	2,236	4,497	785	63,752	18,992	123,247
2015 (C)	130	18,117	5,805	10,934	1,085	666	2,479	65,699	19,435	124,350
Average (1989-2014)	65	17,325	5,642	9,976	6,624	14,377	1,537	34,353	29,167	119,067

[1] Orchard crops include primarily almonds and pistachios, as well as walnuts and miscellaneous deciduous crops.

2.1.1.2 Groundwater Wells

The spatial distribution of domestic wells and irrigation wells within the Chowchilla Subbasin, by well type and section, are shown in **Figures**[16] **2-4a and 2-4b.** Summaries of domestic wells in the Chowchilla Subbasin were compiled based on the best available data in DWR's Well Completion Report (WCR) dataset (DWR, 2022). Characteristics of domestic wells were summarized for WCRs of new wells constructed since 1970 and are presented in **Table 2-3**. Records for a total of 500 domestic wells exist in the WCR dataset. Total well depths for domestic wells in the WCR dataset range from 140 to 960 feet deep, with an average well depth of 377 feet. The GSAs recently completed an inventory of domestic wells in the Subbasin. As part of the Chowchilla Subbasin Domestic Well Inventory project, well permits were compared to the WCR dataset to evaluate the completeness of the WCR dataset. Comparisons were made in each year since 1990, beginning the first year that well permit data was available. A total of 439 domestic well permits were issued in the Subbasin since 1990 compared to 375 domestic well WCRs available for the same period. This suggests that the DWR WCR dataset may underrepresent the number of domestic wells in the Subbasin (ratio of 1.17 well permits to WCRs). No information on well construction characteristics (e.g., depth, screened interval) are currently available for well permits. Additional detail on domestic wells in the Chowchilla Subbasin is presented in the Domestic Well Inventory in **Appendix 2.G**.

Characteristics of agricultural wells were also summarized based on WCRs since 1970, as presented in **Figure 2-4b** and **Table 2-3**. A total of 749 agricultural well WCRs since 1970 exist in the DWR WCR dataset. Total well depths range from 130 to 1,960 feet deep with an average depth of 597 feet (**Table 2-3**). Similar to the analyses of domestic wells, well permits since 1990 for agricultural wells were compared to the WCR dataset to evaluate the completeness of the WCR dataset. A total of 557 new agricultural well permits were issued since 1990 compared to 443 agricultural well WCRs in DWR's dataset over the same period. This suggests the WCR data may underrepresent the number of agricultural wells in the Subbasin (ratio of 1.26 well permits to WCRs); however, as noted above, no information on well construction characteristics (e.g., depth, screened interval) are currently available for well permits.

A list of identified public supply wells in the Chowchilla Subbasin was compiled based on the best available data in the DWR WCR (**Figure 2-5a**) and data available through the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) (SWRCB, 2022a) and Groundwater Ambient Monitoring and Assessment Program (GAMA) (SWRCB, 2022b). **Figure 2-5b** presents the locations of public supply wells in the Subbasin, identified by activity status. **Table 2-4** presents information on public water supply wells identified in the Subbasin. A total of 45 public supply wells were initially identified in the Subbasin, with 20 wells reported as active, 19 inactive, and 6 with unknown status according to records from SWRCB DDW. Total depths of public water supply wells ranged from 280 feet to 900 feet, with an average depth of 656 feet. According to SWRCB DDW data, public water system wells were categorized into five main categories: businesses, churches, schools, community residential supply, and municipal supply. Community residential and municipal supply wells are considered community wells, meaning they have at least 15 connections serving at least 25 residents.[17] Businesses, churches, and schools are considered non-community wells, serving smaller populations.

Notably, the information on wells in the Subbasin is derived primarily from WCR data provided by DWR, supplemented by information from the SWRCB DDW and GAMA or local data sources for public water supply wells. The well information reported for the Subbasin are based mainly on new WCRs submitted

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

[17] Definitions of different types of public water systems are given in Part 12, Chapter 4 of the California Health and Safety Code § 116275 (part of the California Safe Drinking Water Act).

to DWR for the period 1970 through 2021 and may not reflect the total number of existing or active wells in the Subbasin. The highest concentrations of domestic wells are centered primarily along the southern side of the City of Chowchilla. Irrigation wells are generally less concentrated and more evenly distributed across the entirety of the Subbasin, though slightly higher concentrations are found in sectors within the western portions of Madera Co GSA and CWD GSA. **Figure 2-6a** presents comparisons of the number of wells constructed by decade within the Subbasin and **Figure 2-6b** presents typical well depths by well type.

Table 2-3. Summary of DWR Well Completion Report (WCR) Dataset (1970-2021)

	Well Type		
	Agriculture/ Irrigation	**Domestic**	**Municipal/ Public Supply**
Count of Wells	749	507	14
Minimum Total Well Depth (feet)	130	140	280
Maximum Total Well Depth (feet)	1,960	960	900
Average Total Well Depth (feet)	597	377	591
Minimum Top of Perforations (feet)	20	100	150
Maximum Top of Perforations (feet)	1,180	604	775
Average Top of Perforations (feet)	313	250	387
Minimum Bottom of Perforations (feet)	20	40	280
Maximum Bottom of Perforations (feet)	1,960	940	900
Average Bottom of Perforations (feet)	548	371	560

NOTE:
bgs = below ground surface
WCR dataset includes new constructions since 1970

Table 2-4. Summary of Public Supply Wells in Chowchilla Subbasin

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
City of Chowchilla	WELL 01 – INACTIVE	2010001-001	Inactive	Municipal Supply Well		556	825		DDW
City of Chowchilla	WELL NO. 1A	2010001-023	Active	Municipal Supply Well	800		800	WCR2018-004564	DDW
City of Chowchilla	WELL 02 – DESTROYED	2010001-002	Inactive	Municipal Supply Well	754		754	WCR2019-006868	DDW
City of Chowchilla	WELL 03 – RAW	2010001-003	Active	Municipal Supply Well	900	506	832	WCR0081513	DDW
City of Chowchilla	WELL 04 – RAW	2010001-004	Inactive	Municipal Supply Well	610	500	628	WCR0183879?	DDW
City of Chowchilla	WELL 05 – DESTROYED	2010001-005	Inactive	Municipal Supply Well					DDW
City of Chowchilla	WELL 05A – RAW	2010001-019	Active	Municipal Supply Well	795	775	795	WCR0120517	DDW
City of Chowchilla	WELL 06 – INACTIVE – RAW	2010001-006	Inactive	Municipal Supply Well	790	218	548		DDW
City of Chowchilla	WELL 07 – DESTROYED – 2004	2010001-007	Inactive	Municipal Supply Well		506	618	WCR0303277	DDW
City of Chowchilla	WELL 08 – RAW	2010001-008	Active	Municipal Supply Well	396	242	297	WCR0288824	DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
City of Chowchilla	WELL 09 – INACTIVE	2010001-009	Inactive	Municipal Supply Well	640				DDW
City of Chowchilla	WELL 10 – RAW	2010001-010	Active	Municipal Supply Well	470	358	474		DDW
City of Chowchilla	WELL 11 – RAW	2010001-011	Active	Municipal Supply Well	608.1	310	393		DDW
City of Chowchilla	WELL 14 – RAW	2010001-020	Active	Municipal Supply Well					DDW
MD #85 Valeta	SOURCE WELL 1 – DEEPEN 2009	2000511-001	Active	Community Residential Supply Well					DDW
Wagon Wheel Super Market	SOURCE WELL 1	2000514-001	Active	Business				WCR2017-000511	DDW
Dairyland School	SOURCE WELL 1	2000597-001	Active	School					DDW
Alview School	SOURCE WELL 1	2000598-001	Inactive	School					DDW
Alview School	SOURCE WELL 5 2015	2000598-002	Active	School				WCR2015-008230	DDW
Alview School	NEW WELL 3 (DRILLED 2011) INACTIVE	2000598-004	Inactive	School					DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
Alview School	NEW WELL 3 (DRILLED 2011)	2000598-006	Active	School					DDW
Howard Elementary School	WELL 1 – ABANDONED	2000600-001	Inactive	School					DDW
Alview School	WELL 01 – INACTIVE	2000604-001	Inactive	School					DDW
Red Top Market	SOURCE MARKET WELL – INACTIVE	2000609-001	Inactive	Business					DDW
Red Top Market	COTTON GIN WELL – INACTIVE	2000609-002	Inactive	Business					DDW
Red Top Market	NEW WELL 2014	2000609-005	Active	Business					DDW
North Fork Union School	SOURCE RADIAL WELL	2000612-002	Inactive	School					DDW
Bowles Farming Co. – Forced To Picme	WELL 01 – INACTIVE	2000676-001	Inactive	Business					DDW
Bowles Farming Co. – Forced To Picme	WELL 02 – INACTIVE	2000677-001	Inactive	Business					DDW
CertainTeed	SOURCE WELL 1 – EMERGENCY	2000681-001	Active	Business					DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
CertainTeed	SOURCE WELL 6 FRONT WELL	2000681-002	Active	Business					DDW
CertainTeed	WELL 100	2000681-003	Active	Business					DDW
United Park Inc	SOURCE WELL 1	2000790-001	Inactive	Business		300	360	WCR0195493	DDW
United Park Inc	SOURCE WELL #2	2000790-002	Active	Business				WCR2019-006638	DDW
Pioneer Market	SOURCE WELL 1 – DESTROYED 2011	2000823-001	Inactive	Business					DDW
Pioneer Market	WELL 2 – DRILLED 2011	2000823-005	Active	Business					DDW
Solis Water System	SOURCE WELL 1	2000833-001	Unknown	Business					DDW
Chowchilla Cong. Of JWS	SOURCE WELL #2	2000942-002	Active	Church				WCR2017-005311	DDW
Merced RV and Truck Stop-Closed	WELL #1 – SE CORNER OF PRPRTY – DESTROYED	2400100-001	Inactive	Business					DDW
CalTrans CHP Chowchilla River Facility	WELL 1 – S END OF FACILITY	2400216-001	Active	Business		400	460		DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
Unknown	WCR0220448	00151057	Unknown	Unknown	280	150	280	WCR0220448	WCR
Unknown	WCR2016-011638	E0322799	Unknown	Unknown	660	330	610	WCR2016-011638	WCR
Unknown	WCR2017-000468		Unknown	Unknown	600		600	WCR2017-000468	WCR
Unknown	WCR0168864	00550225	Unknown	Unknown	670		495	WCR0168864	WCR
Unknown	WCR2017-008608	E0338392	Unknown	Unknown				WCR2017-008608	WCR

2.1.2 *Water Resources Monitoring and Management Programs (23 CCR § 354.8(c), (d), (e))*

Existing surface water and groundwater monitoring and management programs within the Chowchilla Subbasin are identified below following a summary of water planning documents applicable to the Subbasin GSAs.

Continued monitoring is required to track the progress of the GSP implementation plan by providing data on groundwater and surface water availability in the Subbasin. One overarching project in the implementation plan adds additional monitoring to fill data gaps (see Section 4 for more details).

2.1.2.1 Water Planning Documents

As stewards of the water resources within their jurisdictions, the local agencies that have formed each of Chowchilla Subbasin's GSAs have prepared and adopted several water planning documents. These include:

- Regional Water Plans
    - Madera Integrated Regional Water Management Plan (approved in 2008, updated in 2015)
        - This plan is a collaborative effort to improve regional coordination in management of water resources among the 17 groups and agencies forming the Madera Regional Water Management Group as well as other interested parties. These agencies include two currently organized as GSAs in the Chowchilla Subbasin (CWD and Madera Co). The plan establishes regional water management goals and serves as a basis for pursuing funding to accomplish these goals.
    - Madera Regional Groundwater Management Plan (adopted in 2014)
        - This plan provides a framework for regional groundwater management among six participating groups and agencies, including two currently organized as GSAs in the Chowchilla Subbasin (CWD and Madera Co). The objectives of the plan are to establish collaborative governance, stabilize and recover groundwater levels, mitigate subsidence, improve public awareness, and maintain and improve the economic viability of the Madera region.
- Water Management Plans
    - Chowchilla Water District Water Management Plan (2017)
- Groundwater Management Plans
    - Chowchilla-Red Top Resource Conservation District Joint Powers Authority Groundwater Management Plan (1997)
    - Madera County Groundwater Management Plan (2002)
- Other Plans
    - General Plans:
        - City of Chowchilla General Plan (updated 2017)
        - Madera County General Plan (updated 2015)
        - Merced County General Plan (updated 2016)
    - Municipal Service Reviews:
        - City of Chowchilla Sphere of Influence Expansion and Municipal Service Review (2011)
        - Clayton Water District Municipal Service Review (2017)
        - Triangle T Water District Municipal Service Review (2017)

- Other:
  - City of Chowchilla Urban Water Management Plan (2017)
  - Madera County Storm Water Resource Plan (2017)
  - PG&E San Joaquin Valley Operations & Maintenance Habitat Conservation Plan (HCP) (2006, permit issues 2007)[18]

Information developed for these plans regarding GSA surface water and groundwater supplies, distribution infrastructure, and monitoring programs have contributed to the development of this GSP.

GSP implementation will support all HCP goals to minimize and avoid adverse effects to threatened and endangered species in the Chowchilla Subbasin. No Natural Community Conservation Plans overlap with the Chowchilla Subbasin.

Development and implementation of this GSP has and will continue to consider the interests of all beneficial uses and users of groundwater, including agricultural water users, municipal water users, disadvantaged communities (DACs), groundwater dependent ecosystems (GDEs), and other stakeholders.

Implementation of this GSP will support all goals for the protection of natural resources and DACs, including those established in the plans above, consistent with SGMA and GSP regulations. This includes recognition and support of:

- Madera County General Plan, SB 244 Disadvantaged Unincorporated Communities (DUC) Amendments[19]: Identification of the water service needs of DUCs in Madera County.
- Merced County General Plan, SB 244 Analysis[20]: Identification of water service needs of DUCs in Merced County.
- PG&E San Joaquin Valley Operations and Maintenance HCP: Establishes goals to minimize and avoid adverse effects to threatened and endangered species in the Chowchilla Subbasin.

2.1.2.2 Surface Water Monitoring and Management Programs

Surface water flows into and within the Chowchilla Subbasin are extensively monitored through existing federal, state, regional, and local programs. Data and spatial information from these monitoring programs have been incorporated directly into this GSP to support water budget development, per 23 CCR § 354.18.

These sources and the data they provide are summarized below.

2.1.2.2.1 Federal, State, and Regional Programs

In support of GSP development, surface water data were collected from the following agencies and programs:

- California Data Exchange Center (CDEC)
- California State Water Resources Control Board (SWRCB)

[18] The goal of this HCP is to "minimize, avoid, and compensate for possible direct, indirect, and cumulative adverse effects on threatened and endangered species" that could result from PG&E operations and maintenance efforts. The HCP covers all land owned by PG&E and/or associated with PG&E gas and electrical facilities, access routes, and mitigation areas, and therefore may overlap with any adjacent GDEs or potential ISW habitats.

[19] This GSP considers the water service and supply needs of other DACs in the subbasin not discussed in the Madera County General Plan, SB 244 DUC Amendments.

[20] This GSP considers the water service and supply needs of other DACs in the subbasin not discussed in the Merced County General Plan, SB 244 Analysis.

  - SWRCB GeoTracker
- Department of Water Resources Water Data Library (WDL)
- Madera-Chowchilla Water and Power Authority (MCWPA)
- San Joaquin River Restoration Program (SJRRP)[21]
- San Luis Delta-Mendota Water Authority (SLDMWA)
- United States Army Corps of Engineers (USACE)
- United States Bureau of Reclamation (Reclamation)
- United States Geological Survey (USGS)
  - National Water Information System (NWIS)

Key federal and state surface water monitoring stations and the agency collecting the data are identified in **Table 2-5**. In the Chowchilla Subbasin, Chowchilla Bypass and San Joaquin River inflows are compiled from CDEC and WDL data, Chowchilla River inflows are measured and reported by USACE, Fresno River inflows are measured by the MID recorder network (this is also the Fresno River outflow from the Madera Subbasin), and Madera Canal inflows are recorded and reported by Reclamation. These monitoring stations are important for monitoring surface water available to potential interconnected surface water (ISW) habitats and groundwater dependent ecosystems (GDEs).

Deliveries of Central Valley Project (CVP) water along Madera Canal to lands within Chowchilla Subbasin are managed by MCWPA. Reclamation monitors and reports these deliveries as part of the CVP Friant Division.

2.1.2.2.2 Local Programs

Water data were also collected from the following local monitoring programs:

- The City of Chowchilla's SCADA system and records of monthly volumes pumped from groundwater supply wells (available since 2003).
- CWD's SCADA system and records of canal flows and conveyance system spillage (available since 1995).
- CWD's records of monthly water supply from Madera Canal (Class 1, Class 2, 215, URF, RWA, Free Water, Flood Releases), Buchanan Dam (Irrigation Releases, Flood Releases), Legrand, and transfers.
- CWD's records of grower deliveries in their STORM[22] database (available since 2000).
- CWD's records of riparian deliveries to white areas (available since 1996)
- CWD's records of riparian deliveries to Roduner Ranch (available since 1994)
- CWD's records of prescriptive water rights deliveries to growers along Chowchilla River (available since 1981)

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[21] SJRRP requires the release of flows from Friant Dam to the confluence with the Merced River to support the life-stages of salmon and other fish species. The amount of water available for the SJRRP – the Restoration Allocation – depends upon the amount of runoff in the San Joaquin River watershed above Friant Dam. The SJRRP develops Allocations and Default Flow Schedules to identify the annual volume of Restoration Flows available. Each year, the Restoration Allocation is adjusted, often many times, between the date of the initial allocation and the final allocation, based on the hydrologic conditions. In May 2019, a Restoration Allocation of over 556,5000 thousand acre-feet (TAF), as measured at Gravelly Ford (GRF), was calculated by Reclamation using the 50% exceedance forecast. For more information, see http://www.restoresjr.net/restoration-flows/flow-schedule/.

[22] The water ordering and delivery management software used by Chowchilla Water District and Madera Irrigation District.

- Madera County's requirement to include a flow measurement device on new wells and the resulting groundwater pumping records.
- Madera Irrigation District's (MID) recorders network with records of Fresno inflows to the Chowchilla Subbasin (available since the 1950s).
- Triangle T Ranch well reports (available since 2011) and water level reports (available since 2016).

Table 2-5. Surface Water Monitoring Stations.

Waterway	Source	Site ID	Site Name	Available Data Period	Details
Chowchilla Bypass	CDEC	CBP	Chowchilla Bypass	1997-2018	Station operated by SLDMWA
Chowchilla Bypass	WDL	B07802	Chowchilla Bypass at Head Below Control Structure	1978-1991	
Chowchilla River	USACE	Buchanan Reservoir	Buchanan Reservoir, Chowchilla River, California	1981-2017	
Fresno River	MID	Recorder 24	Rd. 9 at Fresno River	2005-2013	
Madera Canal	Reclamation	Indicated by Mile	Miles 33.6, 35.6	1978-2018	CVP water deliveries to CWD reported by Mile
San Joaquin River	WDL	B07610	San Joaquin River near Dos Palos	1980-2018	

Streamflow monitoring stations and MID recorders along waterways were used to prepare time series datasets for Subbasin surface water inflows and outflows, as applicable. CWD SCADA records at spillage sites were used to prepare time series datasets for CWD conveyance system outflows. Records of groundwater pumping, and deliveries were used to prepare time series datasets for agricultural land inflows. These data and methodologies are described in **Section 2.2.3**.

2.1.2.2.3 Program Limitations on Operation Flexibility in Basin

Continued operation of these water monitoring programs will support tracking the progress of the GSP implementation plan by providing data on water availability as well as inflows and outflows from the Subbasin.

Limitations on surface water deliveries will limit operational flexibility by reducing surface water supplies available for conjunctive use programs.

2.1.2.3 Groundwater Monitoring and Management Programs

There are a variety of local, state, and federal monitoring programs currently and historically conducted in Chowchilla Subbasin related to groundwater levels, groundwater quality, and land subsidence. Each monitoring category is described in more detail in the sections below.

2.1.2.3.1 Groundwater Level Monitoring

Groundwater level monitoring has been conducted historically by variety of entities in the Subbasin including Chowchilla Water District, Madera County, Triangle T Water District, DWR, United States Bureau of Reclamation (USBR), and Geotracker GAMA. The California State Groundwater Elevation Monitoring Program (CASGEM) was initiated in 2011, with the Madera-Chowchilla Groundwater Monitoring Group as the local monitoring entity. This Group includes Chowchilla Water District and the County, along with other entities in Madera Subbasin. Groundwater levels are collected and submitted each Fall and Spring as part of the CASGEM program. **Appendix 2.E** includes a map presenting the well locations and most recent monitoring date for historical groundwater level monitoring conducted in the Subbasin.

2.1.2.3.2 Groundwater Quality Monitoring

Groundwater quality monitoring has historically been conducted by a variety of entities in the Subbasin including the City of Chowchilla and other public drinking water suppliers, regulated facility operators and other contaminant site monitoring for the RWQCB, the East San Joaquin Water Quality Coalition (the third-party entity representing growers in the area) as part of the Irrigated Lands Regulatory Program (ILRP), USGS for the Groundwater Ambient Monitoring and Assessment Program (GAMA), and other programs under the direction of agencies such as the RWQCB, DPR, EPA, DTSC, USGS. Some historical groundwater quality monitoring has also been conducted by well owners in the Subbasin for other purposes.

All public drinking water supply systems must conduct groundwater quality monitoring as part of requirements for the Division of Drinking Water (DDW). The required frequency and constituents for DDW monitoring vary by water system and monitoring point. Groundwater quality monitoring is also conducted at regulated facilities and contaminant sites for the RWQCB in association with tracking and reporting on the status of groundwater contamination near these sites. More recently, groundwater quality monitoring required by the Irrigated Lands Regulatory Program has been initiated. Groundwater quality assessment and monitoring for the ILRP included preparation of a Groundwater Quality Assessment Report with five-year updates, including delineation of High Vulnerability Areas relative to groundwater quality impacts from irrigated agricultural practices and also includes development and maintenance of a network of wells for groundwater quality sampling as part of a Groundwater Quality Trend Monitoring (GQTM) program. The GQTM program includes annual monitoring results reporting and five-year evaluations of groundwater quality trends and conditions relative to irrigated agriculture. Additionally, as part of the ILRP, all domestic wells on parcels enrolled in the agricultural coalition must also be tested for nitrate. The ILRP domestic well monitoring efforts are newly underway and neither results nor well locations related to this monitoring are available at the time of preparation of this report. **Appendix 2.E** includes a map presenting the well locations, monitoring programs, and most recent monitoring date for historical groundwater quality monitoring conducted in the Subbasin.

The Chowchilla Subbasin is identified as a Priority 1 Area for nitrate control efforts to be required under the Nitrate Control Program included in the Basin Plan Amendment approved by the RWQCB in May 2018 and in the process of undergoing approval by the SWRCB (anticipated Summer or Fall 2019). After adoption of the Basin Plan Amendment, the RWQCB is expected to issue notices to comply within a short time period, which will start the clock on requirements of the Nitrate Control Program. As a Priority 1 Subbasin identified by CV-SALTS, dischargers in the Chowchilla Subbasin will be among the first required to comply with the program and develop an approach to ensure shallow groundwater is protected. The Nitrate Control Program requires development of Early Action Plans in areas where nitrate discharges to groundwater may be impacting public drinking water supplies. Once in effect, it is expected that the Nitrate Control Program will include considerable analysis and/or monitoring of groundwater quality conditions and development of actions to address groundwater quality impacts from nitrate discharges.

2.1.2.3.3 Land Subsidence Monitoring

Land subsidence monitoring has been conducted by various agencies including USGS, DWR, USBR, USACE, San Luis & Delta-Mendota Water Authority (SLDMWA), Central California Irrigation District (CCID), California Department of Transportation (Caltrans), National Geodetic Survey (NGS), UNAVCO, and others

(MRGMP, 2014). A key ongoing subsidence program is conducted by USBR in conjunction with DWR, USGS, and USACE, which collects and publishes subsidence data twice per year as part of the SJRRP. **Appendix 2.E** includes a map presenting the monitoring sites and most recent monitoring date for historical land subsidence monitoring conducted in the Subbasin and vicinity. Additionally, through remote sensing and similar data acquisition methods such as InSAR, maps of periodic snapshots of spatial distribution of land subsidence have been historically generated including by DWR, USGS, and The Jet Propulsion Laboratory (JPL). The frequency of such land subsidence mapping efforts has been variable but has increased in frequency and regularity since 2010 and are anticipated to continue in the future.

2.1.2.4 Conjunctive Use Programs

To support overall water management objectives, water distributors in the Chowchilla Subbasin strategically manage their conjunctive use of surface and groundwater supplies.

CWD receives surface water supplies from Millerton Reservoir (along Madera Canal) and Eastman Lake (along Chowchilla River) that is delivered to customers in CWD, Madera Co, and Sierra Vista Mutual Water Company (SVMWC). The districts practice conjunctive use of these surface water supplies through policies to encourage grower use of surface water when available. These practices reduce groundwater pumping and increase groundwater recharge in wet years, providing increased groundwater supplies available for use by private groundwater wells in dry years. For growers, the historical advantages of groundwater are many and include greater flexibility in providing water for frost protection, chemigation, and fertigation and to better align irrigations with crop water demands, field activities, and harvest. Because of these many perceived advantages, policies encouraging surface water use when the water is available are important. Irrigation by surface water supplies provides the advantage of in-lieu recharge of groundwater, and brings an additional resource into the Basin to help meet crop water demands.

Domestic water users in the City of Chowchilla rely solely on groundwater, while some agricultural water users within the City limits use groundwater to supplement surface water supplies from CWD. The domestic water system infrastructure includes seven active groundwater wells and with two additional off-line wells, that together supply up to 6,000 gpm of water to 37 miles of main distribution pipelines and over 3,700 connections.[23] The Central California Women's Facility and the Valley State Prison for Women in Chowchilla each operate their own separate water systems.

Conjunctive use programs in the Subbasin include indirect reuse and recharge of surface water supplies, treated wastewater, and/or stormwater in CWD, City of Chowchilla, and Madera County.

In addition to encouraging growers to use surface water when available, CWD provides or facilitates groundwater recharge through infiltration of surface water along 150 miles of unlined canals, local sloughs, and nearby stream channels (Chowchilla River, Dutchman Creek, Ash Slough and Berenda Slough). [24] Recharge is also provided through two surface water retention reservoirs, eight recharge basins, and the City of Chowchilla stormwater basins.[25] CWD also utilizes various water management techniques to enhance water delivery efficiency, including measurement weirs, water meters, rated canal gates, regulating reservoirs and ponds, long-crested weirs, flap gates, and a SCADA system.[26]

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[23] Madera Regional Groundwater Management Plan, December 2014. Pg. 130-131.
[24] Madera Regional Groundwater Management Plan, December 2014. Pg. 119, 132.
[25] Madera Regional Groundwater Management Plan, December 2014. Pg. 119, 133.
[26] Madera Regional Groundwater Management Plan, December 2014. Pg. 132.

The City of Chowchilla provides groundwater recharge through incidental infiltration of secondary treated wastewater released from the city's wastewater treatment plant.[27] The wastewater treatment plant collects approximately 1.8 MGD of wastewater from Chowchilla's population of over 19,000 people along 26 miles of sanitary sewers, and discharges approximately 1.0 MGD to percolation ponds.[28]

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans (23 CCR § 354.8 (f))

The Chowchilla Subbasin lies primarily within Madera County, though a small portion lies within Merced County. Thus, both the Madera County General Plan and Merced County General Plan are applicable to the Subbasin. Additionally, the City of Chowchilla General Plan is applicable to land in CWD GSA defined by the boundaries of City of Chowchilla.

Implementation of this GSP will support all goals and policies established in these plans, consistent with SGMA and GSP regulations. Development and implementation of this GSP has and will continue to consider the interests of all beneficial uses and users of groundwater, including agricultural water users, municipal water users, disadvantaged communities (DACs), groundwater dependent ecosystems (GDEs), and other stakeholders.

2.1.3.1 Madera County General Plan

In the Madera County General Plan updated in 2015[29], Madera County affirms its general land use policies to designate sufficient land for projected population growth in Madera County (Policy 1.A.2), but plans for this growth through higher-density, or infill, development in existing communities and "designated new growth areas" to minimize urban encroachment into agricultural lands and other open spaces and to consolidate infrastructure expansion (Policies 1.A.3-4, 1.B.2, 1.C.2). Furthermore, Madera County restricts development in "areas with sensitive environmental resources" (Policy 1.A.5).

With regard to agricultural land, Madera County maintains policies to encourage water conservation, re-use of reclaimed water, soil conservation practices, land improvement programs, and enrollment of agricultural land in the Williamson Act program (Policies 3.C.11-12; 5.A.6-8,12).

County policies regarding domestic water supply are summarized in Section 3.C (Policies 3.C.1-10). Madera County has policies that limit new development unless an adequate water supply is demonstrated, require supplies serving new development to meet state water quality standards, and limit development in areas with severe water table depression to uses without high water usage or to uses served by surface water supplies.

County policies regarding water resources are summarized in Section 5.C (Policies 5.C.1-9). Madera County's policies are to "protect and preserve areas with groundwater recharge capabilities" (Policy 5.C.1), minimize groundwater overdraft by utilizing surface water for urban and agricultural use where available, and support the policies of the San Joaquin River Parkway Plan (Policy 5.E.11).

County policies regarding wetland and riparian areas are summarized in Section 5.D (Policies 5.D.1-8), and policies regarding fish and wildlife habitat are summarized in Section 5.E (Policies 5.E.1-11). Madera County supports the protection of "critical nesting and foraging areas, important spawning grounds, migratory routes, waterfowl resting areas, oak woodlands, wildlife movement corridors, and other unique wildlife habitats critical to protecting and sustaining wildlife populations" (Policy 5.E.1), and complies with

[27] Madera Regional Groundwater Management Plan, December 2014. Pg. 119.
[28] Madera Regional Groundwater Management Plan, December 2014. Pg. 131.
[29] Madera County General, Plan Policy Document Adopted October 1995, housing element updated November 2015.

the wetlands policies of the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife to ensure that appropriate mitigation measures and the concerns of these agencies are adequately addressed (Policy 5.D.1).

County policies regarding natural vegetation and open spaces are summarized in Section 5.F (Policies 5.F.1-8) and Section 5.H (Policies 5.H.1-5). Madera County supports the preservation of natural vegetation, land forms, and resources as open space, with permanent protection where feasible (Policy 5.H.1). Madera County also supports the preservation and protection of outstanding areas of natural vegetation (including, but not limited to, riparian areas) as well as rare, threatened, and endangered plant species (Policies 5.F.3,5).

2.1.3.1.1 Implementation Effects on Water Demands and Sustainability

Implementation of proposed land use developments under this general plan is not expected to shift water demands, in part due to the County's ordinance for large developments to not exceed available sustainable yield (e.g. equivalent to a 'net zero' impact policy). Furthermore, the 2009 remote sensing ET results developed as part of this GSP indicate that medium and high-density housing consume less water on a per-acre basis than the agricultural uses replaced. Thus, even though domestic water demand is met entirely by groundwater, urban growth is estimated to slightly reduce overall water consumption.

Implementation of the general plan's policies to restrict development in "areas with sensitive environmental resources" and to support preservation of natural resources provides for the protection of wetlands, aquatic resources, and other potential ISW habitats and GDEs. This GSP supports these policies by identifying and considering the effects of GSP implementation on groundwater-surface water interactions **(Section 2.2.2.5**) and GDEs (Section **2.2.2.6**, **Appendix 2.B**) in the Chowchilla Subbasin. Consistent with GSP regulations, the minimum thresholds (MTs) established by this GSP and the measurable objectives (MOs) monitored throughout GSP implementation will confirm the protection of wetlands, aquatic resources, and other GDEs identified in the Subbasin.

2.1.3.1.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla Subbasin to be operated within its sustainable yield by 2040, which will include restrictions on groundwater pumping and implementation of projects to increase groundwater recharge (see Chapter 4). However, urban water use has historically represented a small fraction of all water consumption in the Subbasin and is unlikely to be as significantly affected as agricultural water use. Furthermore, some of this urban development is expected on currently irrigated agricultural land and, because new urban developments consume less water per acre, will lower water use compared to the agricultural consumption. New development and retrofitted landscape water efficiency standards are governed by numerous state statutory requirements, such as the Model Water Efficient Landscape Ordinance (MWELO) and the Urban Water Management Planning Act. The MWELO increases water efficiency standards for new and retrofitted landscapes by encouraging more efficient irrigation systems, graywater usage, and onsite storm water capture, and by limiting the portion of landscapes that can be covered in turf. Studies and reviews by Olmos and Loge (2013), Engelhardt et al. (2016), and Loux et al. (2012) support the feasibility of achieving these standards through adoption of such water conservation measures in California and elsewhere, particularly when considered in early planning stages of developments.

Generally, implementation of policies related to agricultural land, water supply, water resources, wetlands, riparian areas, native vegetation, and open spaces are in alignment with GSP planning efforts and are expected to support achievement of Subbasin sustainability.

2.1.3.2 Merced County General Plan

In the Merced County General Plan adopted in December 2013 and amended in July 2016[30], Merced County affirms its countywide growth and development goal to shape land use patterns that "enhance the integrity of both urban and rural areas" by limiting urban sprawl and protecting agricultural and wetland habitat areas (Goal LU-1). To achieve this, Merced County has established policies to promote compact development of existing or well-planned new urban communities established apart from productive agricultural land, to limit growth in rural centers, and to forbid development adjacent to wetland habitat (Policies LU-1.1-5,7,9-10,13).

With regard to agricultural land, Merced County maintains policies that would "preserve, promote, and expand the agricultural industry" (Goal LU-2) by limiting land use activities in designated agricultural and foothill pasture land use areas to agricultural crop production, grazing, and related ancillary uses that directly support farm operations or produce renewable energy without interfering with agriculture or natural resources (Policies LU-2.1-7). These policies stipulate that ancillary agricultural land uses "shall not have a detrimental effect on surface or groundwater resources" (Policy LU-2.5(h)).

With regard to water resources, Merced County's goals are to ensure the reliability and quality of surface and groundwater resources to meet the existing and future needs of users (Goals W-1-2). Toward these goals, policies have been established to support water management planning (Policies W-1.1,3), to require demonstration of sufficient water supply for new development (Policies W-1.2,7), to support surface water storage and groundwater recharge projects (Policies W-1.4,6), to develop guidelines for new well construction (Policy W-1.5), to encourage conjunctive use of groundwater and surface water supplies (Policy W-1.10), and to develop regulations and/or promote practices that reduce point source and non-point source water pollution (Policies W-2.2-8)

Merced County also promotes maximizing water use efficiency through policies that support conservation, reuse and recycling, and public education programs (Policies W-3.1-15)

2.1.3.2.1 Implementation Effects on Water Demands and Sustainability

Implementation of proposed land use developments under this general plan is not expected to increase water demands in the Subbasin because the County's policies require that new developments demonstrate sufficient water supply and because, as described above, medium and high density housing consumes less water than the agricultural uses replaced. Implementation of policies to promote surface water storage, groundwater recharge, conjunctive use, water conservation, and recycling will all benefit Subbasin sustainability by enhancing surface water supplies and groundwater recharge.

The general plan's policies forbidding urban development adjacent to wetland habitat and forbidding agricultural land uses from detrimentally affecting surface water or groundwater resources provides for the protection of wetlands, aquatic resources, and other potential ISW habitats and GDEs. This GSP supports these policies by identifying and considering the effects of GSP implementation on groundwater-surface water interactions (Section 2.2.2.5) and GDEs (Section 2.2.2.6, **Appendix 2.B**) in the Chowchilla Subbasin. Consistent with GSP regulations, the MTs established by this GSP and the MOs monitored throughout GSP implementation will confirm the protection of wetlands, aquatic resources, and other GDEs identified in the Subbasin.

[30] 2030 Merced County General Plan, Adopted December 10, 2013 and Amended July 12, 2016.

2.1.3.2.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla Subbasin to be operated within its sustainable yield by 2040, which will include restrictions on groundwater pumping and implementation of projects to increase groundwater recharge. However, urban water use has historically represented a small fraction of all water consumption in the Subbasin and is unlikely to be as significantly affected as agricultural water use. Furthermore, some of this urban development is expected on agricultural land and will lower water use requirements. As described above, new development is governed by the MWELO, which increases water efficiency standards and encourages more efficient irrigation systems, graywater usage, and onsite storm water capture, while limiting the portion of landscapes that can be covered in turf. Such measures will result in lower water use.

Generally, implementation of policies related to agricultural land, water resources, and open spaces are in alignment with GSP planning efforts and are expected to support achievement of Subbasin sustainability.

2.1.3.3 City of Chowchilla General Plan

In the City of Chowchilla General Plan[31], City of Chowchilla establishes a vision for future development that would, among other goals, support contiguous urban development, even into agricultural land when necessary, within and around the existing city bounds.

In the plan, City of Chowchilla identifies critical growth challenges, including managing urban expansion efficiently, resisting premature conversion of agricultural land, and discouraging urban encroachment on prime agricultural land. For future growth into 2040, City of Chowchilla’s projected planning area would absorb approximately 8,000 acres for residential, commercial, and industrial uses between 2020 and 2040, including land within and outside the existing city limits.[32] Much of this would go into expanding high and medium density housing and mixed use land[33], reflecting City policies to develop a mixture of residential types and densities (Policies LU 2.1-4, 3.1-2, 4.1).

While the plan allows conversion of agricultural lands to urban uses, it establishes growth management policies to resist premature conversion, to require contiguous urban expansion within the City, and to seek an agreement with Madera County to regulate eastward growth and maintain agricultural buffer zones (Policies LU 17.1-2, 4-6).

Finally, the City of Chowchilla General Plan maintains a policy to support Madera County’s General Plan goals, objectives, and policies for land outside the City limits (Policies LU 19.1).

2.1.3.3.1 Implementation Effects on Water Demands and Sustainability

Similar to the Madera County and Merced County General Plans, implementation of proposed land use developments under the City of Chowchilla General Plan is expected to reduce water demands because new developments are required to follow the MWELO and because, as described above, medium and high density housing consumes less water than the agricultural uses replaced.

[31] City of Chowchilla 2040 General Plan.

[32] City of Chowchilla 2040 General Plan, Land Use Element Table LU-1, pg. LU-5.

[33] City of Chowchilla 2040 General Plan, Land Use Element Figures LU-2 and LU-3, pg. LU-7.

2.1.3.3.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla Subbasin to be operated within its sustainable yield by 2040, which will include restrictions on groundwater pumping and implementation of projects to increase groundwater recharge. Because the City of Chowchilla does not have surface water rights and does not currently import surface water from other sources, larger urban communities will require additional groundwater extraction. However, urban development would extend partly into agricultural lands, which also consume significant groundwater resources. Thus, water use requirements are projected to decrease slightly due to urban expansion, benefitting Subbasin sustainability.

Implementation of the GSP will also provide for recharge projects to achieve Subbasin sustainability. Within the bounds of CWD GSA, City of Chowchilla has opportunities to recharge stormwater and flood flows, which will benefit sustainability and help to offset potential increases in water use associated with urban development.

2.1.3.4 Permitting Process for Wells in Chowchilla Subbasin

The well permitting processes in Madera and Merced Counties are described below. GSAs in the Chowchilla Subbasin will work with the counties to ensure that future well permitting aligns with the Subbasin sustainability goal established under this GSP. In alignment with the findings of California's Third Appellate District, future well permitting will also align with the requirement that counties consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses. Furthermore, future well permitting processes will consider and address permitting steps required by local or state law or other order.

2.1.3.4.1 Permitting Process for Wells in Madera County

Within Madera County, including much of the Chowchilla Subbasin, the Madera County Environmental Health Division is entrusted with all permitting and enforcement for the construction, reconstruction, and destruction of wells. Wells under their oversight include, but are not limited to, agricultural wells, observation/monitoring wells, community water supply wells, and individual domestic water supply wells.

The application process for Water Well Permits is handled online through the Madera County Permits Online website: https://www.maderacounty.com/services/county-permits-online. This site allows parties to apply for a permit, submit plans, remit payment, and monitor the status of their permit. Annular seal appointments are scheduled by contacting the Madera County Water Wells Permitting Program by phone.

Madera County Environmental Health Division restricts work on all water wells to be performed only by those possessing an active C-57 Water Well Contractors License.

2.1.3.4.2 Permitting Process for Wells in Merced County

Within Merced County, including a portion of CWD GSA and the entirety of Merced Co GSA, the permitting process for all well construction and destruction is managed by the Merced County Department of Public Health, Division of Environmental Health (MCDEH). Wells under their oversight include, but are not limited to, agricultural/irrigation wells, domestic private wells, industrial wells, municipal wells, test wells, and monitoring wells.

The process for well permits is detailed on the MCDEH Well Systems website: https://www.co.merced.ca.us/2247/Well-Systems. MCDEH restricts work on all water wells to be performed only by those possessing an active C-57 Water Well Contractors License.

2.1.3.5 Effects of Land Use Plans Outside Subbasin

Outside the Chowchilla Subbasin, other land use plans have been developed as part of the general plans for the City of Merced to the north and the City of Madera and Fresno County to the south. These general plans are similar in scope to the Madera County, Merced County, and City of Chowchilla General Plans described above.

The subbasins underlying City of Merced, City of Madera, and Fresno County have also been identified by DWR as critically overdrafted and are also required to prepare and be managed under a GSP by January 31, 2020 (CWC Section 10720.7(a)(1)). As such, future land use changes in these jurisdictions will also need to be managed to achieve sustainability in the subbasins adjacent to Chowchilla Subbasin. Provided that these subbasins are managed to achieve sustainability, these land use plans are not expected to affect the ability of the Chowchilla Subbasin GSAs to achieve sustainable groundwater management.

2.1.4 Additional GSP Elements (23 CCR § 354.8 (g))

There are various GSP elements to be addressed in this subsection of the GSP as described below. In some cases, the related information is provided elsewhere in the GSP and the section where the information is provided is noted. In other cases, additional information is provided below.

2.1.4.1 Control of Saline Water Intrusion

Seawater intrusion is not applicable to the Chowchilla Subbasin as explained in Section 3.2.6. It should also be noted that the Lower Aquifer in the Subbasin is underlain by brackish water below the base of fresh water as described in Section 2.2.1.2. Upward movement of brackish water from greater depths has not been a reported problem historically or currently, but excessive pumping from the lowermost coarse-grained layers (should it occur in the future) may have the potential to cause such upward migration of brackish water in the future. The Madera Regional Groundwater Management Plan (MRGMP) (Provost & Pritchard, Wood Rodgers, KDSA, 2014), which includes most of the Chowchilla Subbasin, lists no existing activities, but did include the following planning activities: 1) amend County well standards for new well designs to ensure proper sealing of test holes that penetrate below the known base of fresh water; 2) amend County well standards to require exploratory test holes to be sealed with approved materials from total depth to ground surface; and 3) use well permitting process to require use of borehole geophysical surveys in all new boreholes that have potential to penetrate the base of fresh water, which would enhance groundwater protection by aiding in the current and future design of well seals to help prevent upward migration of brackish water.

2.1.4.2 Wellhead Protection

Wellhead protection refers to both the immediate location of the well in terms of well and pump station design features (e.g., well pad, annual seal) and the broader area surrounding the well. As noted in the MRGMP, a wellhead protection area is the area surrounding a public water supply well through which contaminants are reasonably able to move towards the well (i.e., the recharge area that provides water to the well).

The Madera County and City of Chowchilla well ordinances do not specifically address wellhead protection but do include requirements related to placement of annual seals. The MRGMP lists existing activities as: design new wells with appropriate wellhead protection features. The MRGMP lists planned actions as: 1) manage potential sources of contamination to minimize threat to drinking water sources; 2) develop contingency plan to prepare for emergency well closing and to plan for future water supply needs; 3) encourage establishment of wellhead project areas for non-municipal wells; and 4) develop more detailed wellhead protection standards for Madera County and City of Chowchilla.

2.1.4.3 Migration of Contaminated Groundwater

Migration of contaminated groundwater can occur through improperly constructed wells, which can become conduits for vertical flow of poor-quality water between aquifers. Inadequate surface sanitary seals can allow downward migration of contaminants from ground surface into the well structure and ultimately the aquifers screened by the well. Abandoned and improperly destroyed wells are also potential conduits for migration of contaminants in the subsurface. There are also numerous types of facilities and land uses that can be potential sources of chemical constituents that migrate down through the vadose zone and into aquifers with subsequent migration to pumping wells.

The MRGMP describes the main sources of information related to groundwater contamination including: the California Water Resources Control Board (SWRCB), the Department of Toxic Substance Control (DTSC), and the Groundwater Ambient Monitoring and Assessment Program (GAMA). The MRGMP describes related existing activities as including: 1) current County regulation for new well construction permitting that requires sanitary/annular seal depths sufficient to avoid creating conduit for contamination of shallow groundwater or co-mingling of aquifers with different water quality; and 2) current County regulation to properly abandon existing wells when connecting to a municipal water system. Planned actions listed in the MRGMP included: 1) review online databases for existing plumes and ensure that existing and new well operations do not induce downward migration of contaminants; 2) during new well construction permitting – require sanitary/annular seal depths sufficient to avoid creating conduit for downward migration of shallow groundwater contamination or co-mingling of aquifers with different water quality; 3) design a well abandonment program to identify abandoned wells and develop plans to properly destroy wells.

2.1.4.4 Well Abandonment and Well Destruction Program

An existing Madera County ordinance and state law require proper abandonment of wells. Madera County is responsible for administration and enforcement of the well ordinance, and oversees well abandonment in the Subbasin, including within cities, irrigation districts, water districts, and private wells. Wells are required to be abandoned in accordance with State standards as delineated in Water Well Standards (DWR, 1981). The County requires that a property owner properly destroy any abandoned or unused wells prior to permitting construction of a new well (unless it is determined the well is appropriate for use as a monitoring well). The MRGMP lists existing related activities as encouraging property owners to abandon wells in accordance with County and State standards. Planned actions listed in the MRGMP included: 1) outreach and education for property owners about well abandonment standards and proper conversion of abandoned wells to monitoring wells; 2) conduct inventory of unused/abandoned wells to identify wells for abandonment or conversion to monitoring wells; and 3) emphasize and promote to the extent possible the conversion of production wells to monitoring wells when appropriate. Merced County Department of Public Health manages well destruction for Merced County portions of Chowchilla Subbasin as described under Section 2.1.3.4.

2.1.4.5 Replenishment of Groundwater Extractions

The replenishment of groundwater extractions occurs through various forms of recharge. The types and amounts of historical and current recharge are described in detail in Section 2.2.3 (Water Budget Information), and future estimates of recharge are detailed in **Appendix 6.D** (Groundwater Model Documentation). Future replenishment for groundwater extractions that will occur with implementation of projects and management actions (PMAs) for this GSP are described in detail in Chapter 4.

2.1.4.6 Conjunctive Use and Underground Storage

Historical and current conjunctive use operations in the Subbasin have primarily been conducted by Chowchilla Water District. CWD and other Subbasin conjunctive use activities are described in more detail in Section 2.1.2.4 (Conjunctive Use Programs). There have also been recent efforts by Triangle T Water District and Chowchilla Water District, along with some private landowners, to conduct recharge for underground storage during wet years in 2016-17 and 2018-19. Planned future conjunctive use and underground storage operations are described in detail in Chapter 4 and simulated by the groundwater model as described in **Appendix 6.D**.

2.1.4.7 Well Construction Policies

Well construction policies are described in Section 2.1.3.4 (Well Permitting Process for Wells in Chowchilla Subbasin).

2.1.4.8 Groundwater Contamination Cleanup, Recharge, Diversions to Storage, Conservation, Water Recycling, and Extraction Projects

Monitoring and remediation of pre-existing and historical groundwater contamination areas are primarily being addressed by various regulatory programs under the RWQCB and DTSC. Various types of projects (e.g., recharge, extraction, diversions) are described in Section 2.2.3 Water Budget Information) and in the Chapter 4 discussion of PMAs. There are no significant water recycling projects in the Plan area, because such projects are generally not feasible in sparsely populated areas that dominate in Chowchilla Subbasin. Water conservation projects are covered under Section 2.1.4.9 (Efficient Water Management Practices) below.

2.1.4.9 Efficient Water Management Practices

Water conservation and efficient water management practices are described in Section 2.1.3 (Land Use Elements or Topic Categories in Applicable General Plans). In addition, agricultural irrigation practices have been evolving towards use of more efficient irrigation methods such as drip irrigation and decreased use of less efficient methods such as spray and flood irrigation.

2.1.4.10 Relationships with State and Federal Agencies

The GSAs in Chowchilla Subbasin have relationships with a number of State and Federal agencies related to surface water supply, water quality, and water management. Chowchilla Water District obtains a portion of its surface water supply from Millerton Lake/Friant Dam via Madera Canal; Friant Dam is owned and operated by the United States Bureau of Reclamation (USBR). The USBR is also the lead agency for the San Joaquin River Restoration Project (SJRRP), which establishes instream flow requirements along the San Joaquin River between Friant Dam and the Merced River to support the life-stages of salmon and other fish species, and consequently requires current and future reductions in surface water diversions for irrigation.[34] The GSAs also apply for and occasionally receive grants from various State/Federal agencies for water-related projects; a current grant being implemented is drilling of several new monitoring wells in the Subbasin to provide better definition of Subbasin geology, water levels, and water

[34] The SJRRP develops Allocations and Default Flow Schedules to identify the annual volume of Restoration Flows available. Each year, the amount of water available for the SJRRP – the Restoration Allocation – is adjusted, often many times, between the date of the initial allocation and the final allocation, based on the hydrologic conditions. In May 2019, a Restoration Allocation of over 556,5000 thousand acre-feet (TAF), as measured at Gravelly Ford (GRF), was calculated by Reclamation using the 50% exceedance forecast. For more information, see: http://www.restoresjr.net/restoration-flows/flow-schedule/.

quality; and for ultimate incorporation in the GSP monitoring network. The State Regional Water Quality Control Board (RWQCB) provides oversight of contaminant sites within the Subbasin, the Irrigated Lands Regulatory Program, and is considering potential adoption of a Basin Plan amendment related to salt and nutrient management issues. There are many other important GSA relationships with Federal/State agencies, some of which are described throughout this GSP, including in Chapter 5 (Plan Implementation).

2.1.4.10.1 Land Use Plans and Efforts to Address Potential Risks to Groundwater Quality and Quantify

Land use plans are described in Section 2.1.3 (Land Use Elements or Topic Categories in Applicable General Plans).

2.1.4.10.2 Impacts on Groundwater Dependent Ecosystems

Potential impacts to groundwater dependent ecosystems (GDEs) are described in detail in various sections in Chapters 2 and 3, and in **Appendix 2.B**.

2.1.5 Notice and Communication (23 CCR § 354.10)

2.1.5.1 Overview

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

To facilitate stakeholder involvement in the GSA process, a Communication and Engagement Plan (**Appendix 2.C**) was created for the GSAs in the Chowchilla Subbasin to:

- Provide GSAs, community leaders, and other beneficial users a roadmap to follow to ensure consistent messaging of SGMA requirements and related Chowchilla Subbasin information and data.
- Provide a roadmap to GSAs, community leaders, and other beneficial users to ensure everyone has meaningful input into GSA decision-making, including GSP development.
- Ensure the roadmap demonstrates a process that is widely seen by beneficial users as fair and respectful to the range of interested parties.
- Make transparent to beneficial users, their opportunities to contribute to the development of a GSP that can effectively address groundwater management within the Chowchilla Subbasin.
- Ensure that information reaches all beneficial users who have an interest in the Basin.

2.1.5.2 Description of Beneficial Uses and Users in the Basin

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

To assist in identifying categories of beneficial uses and users in the Chowchilla Subbasin, the Communications and Engagement Plan included a Stakeholder Engagement chart (**Table 2-6**).

Table 2-6. Stakeholder Engagement Chart for GSP Development.

Category of Interest	Examples of Stakeholder Groups [35]	Engagement purpose
General Public	• Citizens groups • Community leaders	Inform to improve public awareness of sustainable groundwater management
Land Use	• Municipalities (City, County planning departments): City of Chowchilla • Regional land use agencies	Consult and involve to ensure land use policies are supporting GSPs
Private users	• Private pumpers • Domestic users • School systems: Chowchilla Elementary School District • Hospitals: Chowchilla Memorial Health Care District	Inform and involve to minimize negative impact to these users
Urban/ Agriculture users	• Water agencies • Irrigation districts • Mutual water companies • Resource conservation districts: Madera/Chowchilla RCD (formerly the Chowchilla Red Top RCD) • Farm Bureau: Merced Farm Bureau, Madera County Farm Bureau	Collaborate to ensure sustainable management of groundwater
Industrial users	• Commercial and industrial self-supplier • Local trade association or group	Inform and involve to avoid negative impact to these users
Environmental and Ecosystem	• Federal and State agencies: CDFW • Environmental groups: The Nature Conservancy, Audubon California, American Rivers, Clean Water Action/Clean Water Fund	Inform and involve to sustain a vital ecosystem
Economic Development	• Chambers of commerce: Chowchilla District Chamber of Commerce • Business groups/associations • Elected officials (Board of Supervisors, City Council) • State Assembly members • State Senators	Inform and involve to support a stable economy
Human right to water	• Disadvantaged Communities • Small community systems • Environmental Justice Groups: Leadership Council for Justice and Accountability, Self-Help Enterprises, Community Water Center	Inform and involve to provide a safe and secure groundwater supplies to all communities reliant on groundwater

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

Category of Interest	Examples of Stakeholder Groups [35]	Engagement purpose
Tribes	• Federally Recognized Tribes and non-federally recognized Tribes with Lands or potential interests in Chowchilla Subbasin	Inform, involve and consult with tribal government
Federal lands	• Bureau of Reclamation (USBR) • Bureau of Land Management	Inform, involve and collaborate to ensure basin sustainability
Integrated Water Management	• Regional water management groups (IRWM regions) • Flood agencies	Inform, involve and collaborate to improve regional sustainability

2.1.5.3 Communications

2.1.5.3.1 Decision-making Processes

As noted above, the Chowchilla Subbasin is divided among four GSAs for GSP development. The four GSAs have jointly developed this coordinated GSP.

GSA Boards are the final decision-makers for the Chowchilla Subbasin. To assist in GSP development, the GSAs convened a Chowchilla Subbasin GSP Advisory Committee (Advisory Committee) in 2018 to bring together local agencies and related parties vested with the authority and/or ability to support implementation of SGMA in the Chowchilla Subbasin. Representatives from Merced County, Merced Irrigation District, Madera County, CWD, Madera Farm Bureau, Triangle T Water District, Sierra Vista Mutual Water Company, Clayton Water District and City of Chowchilla regularly attend the Advisory Committee meetings. The Advisory Committee has been meeting approximately monthly since its formation.

Generally, the representatives attending the Advisory Committee are technical experts associated with the various Subbasin GSAs and water districts. In addition to coordinating between the GSAs, the Advisory Committee developed recommendations for GSP development which were presented to the GSA boards in public meetings as well as at Subbasin-wide public meetings.

2.1.5.3.2 Public Engagement Opportunities

There were a number of different meetings at which the public had the opportunity to engage during the GSP development process:

- **GSA meetings**: Each of the GSAs in the Chowchilla Subbasin held regular public meetings, generally on a monthly schedule and in many cases in conjunction with standing board meetings.
- **Joint Subbasin meetings:** The intent of the Joint Subbasin meetings was to provide a forum for representatives from the Chowchilla Subbasin and the adjacent Madera Subbasin to share perspectives and information about GSP development and SGMA implementation.
- **Subbasin-wide Technical meetings:** Subbasin-wide technical meetings were held throughout the GSP development process to provide opportunities for the public to learn about the SGMA process and GSP components, receive updates about GSP planning activities, and provide input on GSP development. These meetings often included presentations by the GSP preparation consultants about technical aspects of GSP preparation, on topics such as basin setting, water budgets, and undesirable results. Subbasin-wide public workshops were held in varied locations and at varied hours in order to encourage participation by a wide range of stakeholders. Spanish translation was available at Subbasin-wide workshops. Numerous Subbasin-wide meetings were

live-streamed, and summaries of the meetings were posted online so that anyone unable to attend the meeting in person could remain informed about the Plan.

- **County Advisory Committee**: The Madera County GSA was supported by an advisory committee which consisted of members from different demographic groups and communities, including DAC representatives. The County Advisory Committee provided feedback on GSP development to the board of the Madera County GSA as well as relaying information back to the communities to which the committee members belong. The County Advisory Committee met quarterly in 2018 and bi-monthly in 2019.
- **Madera County Farm Bureau Water Forum**: The Chowchilla and Madera Subbasins made a joint presentation on SGMA efforts by the Subbasin GSAs.
- **City of Chowchilla**: The Chowchilla GSA gave a SGMA presentation in the City of Chowchilla City Council Chambers.
- **Madera County Regional Water Management Group:** Updates on Chowchilla Subbasin GSP activities were given at the monthly meetings of the Madera County Regional Water Management Group.

Figure 2-7 describes the GSP process steps, including topic development, technical review, and public meetings both at the Subbasin and individual level.

2.1.5.3.3 Encouraging Active Involvement

There were also activities related to encouraging involvement and building capacity for engagement. Madera County worked with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability, organizations that represent DAC communities, to inform DAC members about the plan and encourage their involvement. The following activities were organized in coordination with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability:

- **Capacity-building workshops**: Workshops encouraged and prepared community members to participate in GSP development by providing technical information as well as information about opportunities for engagement.
- **Educational tours**: Tours provided members of the public with additional opportunities to hear about the concerns of people with differing perspectives. Tours included stops in the community of Fairmead, La Vina, a farm, and at a groundwater recharge basin.
- **Presentations in communities**: Self-Help Enterprises and the Leadership Counsel for Justice and Accountability both encouraged participation in GSP preparation through presentations held in communities around the Subbasin, including a visit by a Madera County representative.

In addition to the activities organized in coordination with Madera County, these two organizations also conducted further outreach and workshops in the communities they work in.

2.1.5.3.4 Soliciting Written Comments

In addition to soliciting feedback at GSA meetings, an opportunity was provided to offer written comments on the plan via an online comment form or letter. An informal comment period began when the draft of the first chapter of the GSP was released in April 2019, and an official 90-day comment period began on the date the full draft of the GSP was released, on August 5, 2019, and continued through November 5, 2019. In addition, a special GSP Advisory Committee meeting was held on October 23, 2019 to solicit written comments. All comments received via the comment form or a letter were circulated to the GSAs.

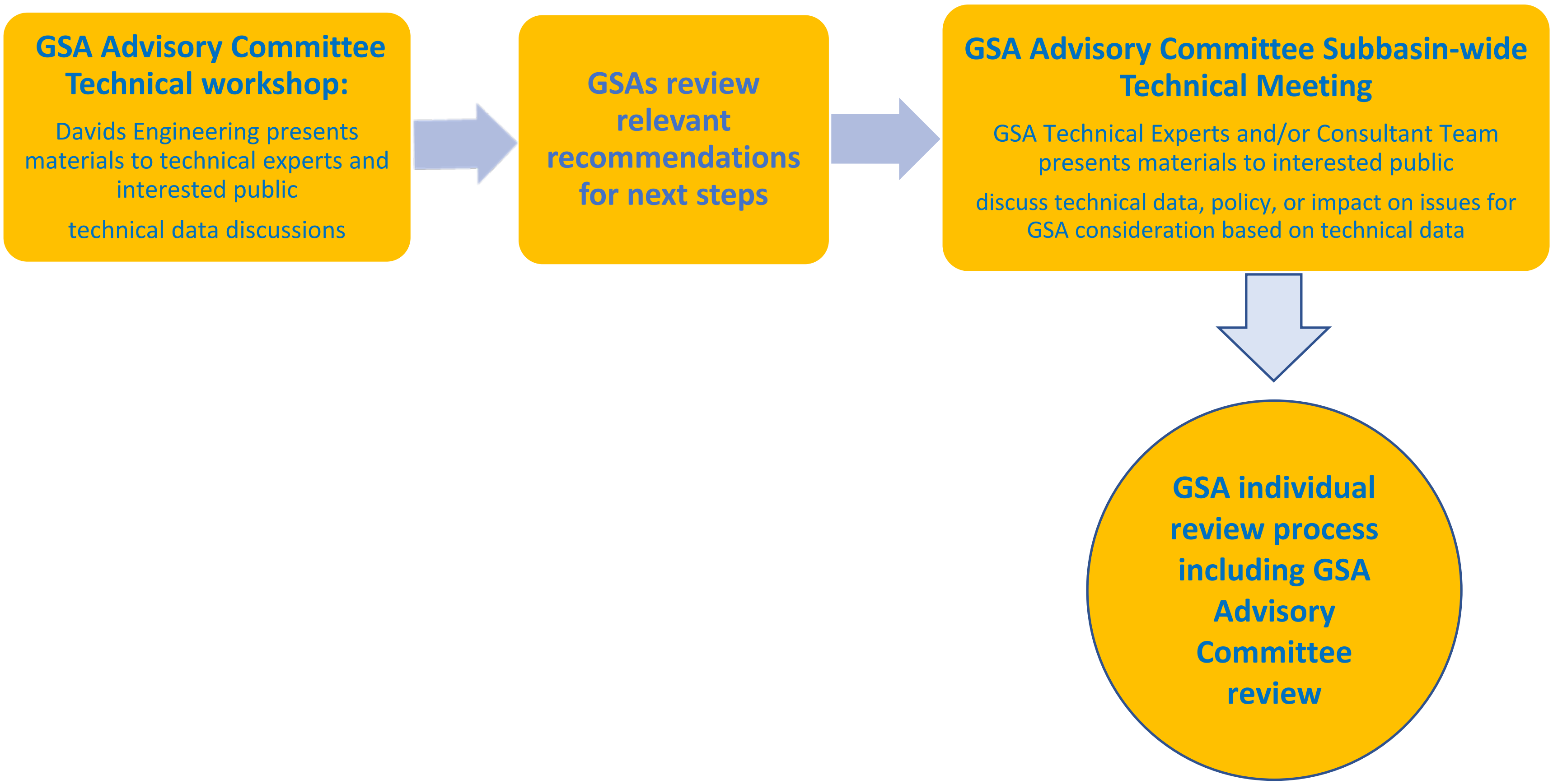

Figure 2-7. Plan Development Sequence (public meetings in yellow).

The written comments and responses can be found in **Appendix 2.C.e**.

2.1.5.4 Informing the Public about GSP Development Progress

2.1.5.4.1 Interested Parties List

An email distribution list of Subbasin-wide stakeholders and beneficial users was developed for outreach throughout the GSP planning process. The list was maintained and updated by the CWD and is included in **Appendix 2.C**. In many cases, information was distributed in both English and Spanish. Any interested member of the public could be added to the list by signing up via this link: https://www.maderacountywater.com/join-list/.

2.1.5.4.2 Distribution of Flyers

Typically, before a public meeting in the Chowchilla Subbasin, a flyer was created with key information provided. The flyer was emailed out to the Interested Party list as well as to the GSAs and the Madera County Farm Bureau for electronic distribution. The flyer was also handed out at GSA meetings and other public meetings. (**Figure 2-8**).

2.1.5.4.3 Press Outreach

Press releases were issued at key junctures and decision-making points for the Chowchilla Subbasin.

2.1.5.4.4 A Centralized Chowchilla Subbasin Website

Throughout the planning process (and beyond) the County has maintained a Subbasin website (http://www.maderacountywater.com) with information about Chowchilla Subbasin-wide planning efforts related to SGMA.

The Chowchilla Subbasin website contains:

- Calendar of public meetings and other events
- Information about past public meetings, including relevant meeting materials
- Links to external sites (e.g., Department of Water Resources SGMA portal) and other resources such as white papers
- A link to the website of the Triangle T Water District GSA
- Information about the County GSAs, adjacent Madera GSAs, Chowchilla Subbasin technical meetings and the Advisory Committee
- GSP background documents
- Fact sheets and Subbasin maps

2.1.5.4.5 Engagement Matrix

The Engagement Matrix, in **Appendix 2.C**, provides details about the implementation of each of the communication methods outlined above. The matrix presents each communication strategy, as required by statute or laid out in the Chowchilla Subbasin Communication and Engagement Plan, along with details about specific instances of that strategy. For example, each public GSP-related meeting is listed with information about the date, topic, and location of the meeting as well as how it was publicized, to whom it was targeted, what opportunities for feedback were provided, and who participated.

2.1.5.4.6 Stakeholder Input and Responses

The engagement opportunities described above provided various avenues for stakeholders to provide input on GSP development. The matrix in **Appendix 2.C** summarizes the public comments received, organized by type of water user, and outlines how this input influenced decision-making in GSP development.

2.1.5.4.7 Public Outreach During GSP Revision Process

During the GSP revision process in 2022, the GSAs conducted further public outreach through three public GSP Advisory Committee meetings, public GSA governing body meetings, and through public notices regarding the GSP revision process.

Figure 2-8. GSA Public Event.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model (23 CCR § 354.14)

A preliminary hydrogeologic conceptual model (HCM) was developed for the Chowchilla Subbasin (DWR Subbasin No. 5-22.05) based on existing reports/data and published in a previous report (DE/LSCE, July 2017). Various aspects of the preliminary HCM were subsequently updated for GSP efforts and are documented in this GSP report. Overall, this chapter of the GSP provides the updated HCM based on a combination of previous reports/data and recent updated analyses performed as part of GSP preparation efforts.

2.2.1.1 Regional Geologic and Structural Setting

The Chowchilla Subbasin is generally comprised of relatively flat topography that slopes gently downward to the west. Topographic elevations vary from about 340 feet above mean sea level (MSL) in the east to about 120 feet above MSL in the west over a distance of about 25 miles (**Figure 2-9**). The major geomorphic features of the Subbasin are the alluvial fan and floodplain associated with sediment deposition from the Chowchilla River (Mitten et al., 1970). A map of hydrologic soil groups in Chowchilla Subbasin is provided in **Figure 2-10**, and a map of soil saturated hydraulic conductivity (K_{sat}) is provided in **Figure 2-11.** These maps indicate that soils with higher permeability and infiltration rates are present along and between the Chowchilla River, Ash Slough, and Berenda Slough channels in the central portion of the Subbasin. It should be noted that these soil maps are relatively general in nature, and localized areas of higher permeability/infiltration capacity may exist in areas otherwise indicated to be low permeability/infiltration capacity in these figures and vice versa. In addition, it is recognized that hard pan, which tends to greatly limit infiltration capacity, exists in many areas at depths typically in the range of 5 to 10 feet below ground surface. However, many areas with irrigated agricultural (particularly orchards) have constructed holes through the hard pan to facilitate proper drainage.

Surface geology maps are provided in **Figures 2-12 and 2-13**. The surficial geology of the Chowchilla Subbasin is dominated by Younger and Older Alluvium (generally equivalent to Modesto, Riverbank, and Turlock Lake Formations), which are described in more detail below. Younger Alluvium is most prevalent between the Chowchilla River and Berenda Slough in the middle portion of the Subbasin.

The Preliminary HCM Report provided some existing geologic cross-sections distributed throughout the Subbasin, which varied considerably in quality and level of detail. In addition, new cross-sections were developed as part of GSP tasks performed subsequent to publication of the Preliminary HCM Report. The existing and new geologic cross-sections are further described in the section below (and in **Appendix 2.D**) on Major Aquifers/Aquitards.

The stratigraphy of the chowchilla Subbasin from the surface down is comprised primarily of Continental Deposits of Quaternary Age (Younger and Older Alluvium), Continental Deposits of Tertiary and Quaternary age, Marine and Continental sedimentary rocks, and crystalline basement rock. The Continental Deposits are unconsolidated, and underlying sedimentary and basement rocks are consolidated. It is uncertain if Mehrten and Ione Formation are present in the Chowchilla Subbasin. Younger Alluvium is generally limited to 50 feet thickness and typically unsaturated. The Older Alluvium consists of up to 1,000 feet of interbedded clay, silt, sand, and gravel. Older Alluvium becomes finer-grained with depth and is underlain by the generally finer-grained Continental deposits of Tertiary and Quaternary age (Mitten et.al., 1970). The primary water bearing unit is Older Alluvium, although recent deeper drilling of agricultural wells is tapping into the underlying Continental Deposits of Tertiary/Quaternary age (Provost & Pritchard, 2014).

The Corcoran Clay occurs in the middle and western portions of Chowchilla Subbasin (**Figure 2-14**) within the upper portion of Older Alluvium (Mitten et al., 1970). The Corcoran Clay is also considered to be a member of the Turlock Lake Formation (Page, 1986). The depth to top of the Corcoran Clay generally ranges from about 50 to 275 feet where present within Chowchilla Subbasin (Provost & Pritchard, 2014). The Corcoran Clay is comprised of clay and silt ranging in thickness from 10 feet at its eastern extent to 80 feet on the western edge of Chowchilla Subbasin (**Figure 2-15**). As explained further in the section on major aquifers/aquitards, the depth to Corcoran Clay in the central to eastern portions of the Subbasin becomes shallow enough such that the regional aquifer occurs entirely below the Corcoran Clay.

2.2.1.2 Lateral and Vertical Subbasin Boundaries

The Chowchilla Subbasin is bordered by the Madera Subbasin to the east and south, Merced Subbasin to the north, and Delta-Mendota Subbasin to the west (**Figure 2-16**). All Subbasin boundaries are political/agency boundaries across which groundwater flow can and does occur. A basin boundary modification request was approved by DWR in 2016, and the revised boundary is incorporated in this study.

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 umhos/cm. Overall, the base of freshwater was mapped as ranging approximately from elevation -600 to -1,200 feet msl within Chowchilla Subbasin. In general, the shallowest depths to base of fresh water were along the southern boundary of the Subbasin, and the greatest depths were areas located just south of the City of Chowchilla and beneath the Chowchilla River in the central portion of the Subbasin (**Figure 2-17).** 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 than 1,000 milligrams/liter (mg/L) and 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 2-18**) and elevation of basement rock (**Figure 2-19**) show increasing depths (and decreasing elevations) to basement rock from northeast to southwest across the Subbasin. The depths to bedrock range from about 500 feet to greater than 3,500 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 2-17** 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 Chowchilla Subbasin.

2.2.1.3 Major Aquifers/Aquitards

Geologic cross-sections are a key element of the HCM required in a GSP under SGMA. Related work completed for this GSP included review of existing literature to extract the available geologic cross-sections and construction of additional new geologic cross-sections based on data compiled for GSP efforts. This section of the GSP (and **Appendix 2.D**) provides a general description of the existing and new cross-sections, and documents the source of available existing geologic cross-sections along with details of how the new cross-sections were developed.

2.2.1.3.1 Existing Geologic Cross-Sections

The geologic cross-sections derived from previous reports are presented in **Appendix 2.D**, and were described in a previous report (DE/LSCE, 2017). Two of these existing cross-sections are described below to provide overall regional context for the stratigraphy of the Subbasin (Mitten, et al.,1970; Page, 1986). The locations of these two existing geologic cross-sections are provided in **Figure 2-20**, and the individual cross-sections are provided in **Figures 2-21 and 2-22**. A summary of the two regional geologic cross-sections is provided below.

Mitten's (1970) cross-section A-A' (**Figure 2-21**) runs west to east across the northern portion of the Chowchilla Subbasin, and extends down to an elevation of -1,400 feet msl. The top of the E-Clay (Corcoran Clay) is present at a depth of approximately 200 feet below ground surface (bgs) on the western edge of the section (with a thickness of about 50 feet) and thins and tapers out near Ash Slough at a depth of about 80 feet bgs. A small deposit of Quaternary floodplain deposits (Qb) is present at the surface on the western edge of the section, and thin layers of younger Quaternary alluvium (Qya) are present at the surface across the rest of the section. Older Quaternary alluvium (Qoa) underlies the surface deposits, and overlies Tertiary and Quaternary continental deposits (QTc). Undifferentiated Pre-Tertiary and Tertiary marine and continental sedimentary rocks (TpTu) underlie QTc in the eastern portion of the section. Pre-Tertiary basement complex (pTb) is present at the surface along the eastern edge of the section.

Page (1986) cross-section B-B′ (**Figure 2-22**) runs north to south through the western portion of the Chowchilla Subbasin, and extends to a depth of about 9,000 feet bgs. Within the Chowchilla Subbasin, the Corcoran Clay is present throughout, at an approximate elevation of -100 feet msl. Thin deposits of Quaternary floodplain deposits (Qb) are present at the surface, underlain by Quaternary continental rocks and deposits (QTcd). A layer of Tertiary marine rocks and deposits interfinger the QTcd layer. A layer of Pre-Tertiary and Tertiary continental and marine rocks and deposits (i.e., bedrock) underlies these units at elevations ranging from about -2,500 to -3,500 feet msl.

2.2.1.3.2 New Geologic Cross-Sections

New geologic cross-sections were developed during GSP preparation efforts utilizing data collected for the GSP. A location map for new geologic cross-sections is provided in **Figure 2-20**. The new geologic cross-sections include some that do not cross Chowchilla Subbasin, but are included here because they occur within the Model Domain for the Madera-Chowchilla Groundwater-Surface Water Simulation (MCSim) Model developed for Chowchilla Subbasin. The CVHM well log dataset and DWR well log database developed for this project were reviewed to select logs for relatively deep wells that had fairly detailed descriptions of geologic units encountered. Locations for screened well logs were plotted to selected representative well logs at a reasonable spacing along each geologic cross-section line.

New geologic cross-sections A-A′, B-B′, and C-C′ (**Figures 2-23, 2-24, and 2-25**) extend from southwest to northeast across Chowchilla Subbasin towards (perpendicular to) the Sierra Nevada Mountains, with A-A′ being furthest north and C-C′ being furthest south. Each cross-section generally shows the ground surface, the lithology associated with each well log, the Spring 2014 unconfined groundwater level, the Corcoran Clay (from C2VSim), and the base of fresh water (from Page 1986). The well logs generally range from very close to section lines to one mile of offset from the section line. The cross-sections illustrate the interbedded and variable nature of fine- and coarse-grained sediments both laterally and vertically. There are significant coarse-grained layers to depths of at least 800 feet. However, fine-grained sediments comprise a larger percentage of the subsurface than do coarse-grained sediments overall. Thus, it can be expected that vertical hydraulic conductivity (Kv) values will likely be orders of magnitude lower than horizontal hydraulic conductivity (Kh) values for a given aquifer. Geologic cross-sections A-A′, B-B′, and C-C′ also illustrate the Corcoran Clay extends beneath the western and central portions of the Subbasin, and other clay layers are prominent throughout the Subbasin. New geologic cross-sections D-D′, E-E′, and F-F′ (**Figures 2-26, 2-27, and 2-28**) are included here but not described further as they do not cross Chowchilla Subbasin.

New geologic cross-sections G-G′ through K-K′ (**Figures 2-29, 2-30, 2-31, 2-32, 2-33**) were constructed parallel to the Sierra Nevada Mountain front starting from the southwestern end of Chowchilla Subbasin and progressing towards the northeast (i.e., cross-section G-G′ is furthest from and parallel to the Sierra Nevada Mountain front and K-K′ is closest to the mountain front). These geologic cross-sections further demonstrate and confirm the features/characteristics described above for the cross-sections perpendicular the Sierra Nevada Mountains. While it is challenging to reliably correlate coarse-grained units in these cross-sections, they do illustrate well the general distribution of coarse- and fine-grained sediments both laterally and vertically. The textural analysis described in the Groundwater Model

Documentation (**Appendix 6.D**) used to develop inputs to the groundwater model attempts to capture the somewhat disconnected distribution of coarse-grained sediments reflected in the cross-sections.

2.2.1.3.3 Geologic Cross-Section Summary

The existing geologic cross-sections provided in Mitten et al. (1970) and Page (1986) illustrate the vertical distribution of major geologic formations, but do not provide any detail on distribution of fine and coarse-grained sediments of the major aquifer units. The new geologic cross-sections illustrate in a fairly detailed manner the lateral and vertical distribution of fine- and coarse-grained sediments throughout the Subbasin. It is apparent from these cross sections that significant coarse-grained intervals are present to the full depths of most borings shown on the cross sections, although overall the percentage of fine-grained sediments exceeds that of coarse-grained sediments. These cross sections further demonstrate that Kv values are likely to be orders of magnitude less than Kh values.

Groundwater System Conceptualization

The Chowchilla Subbasin is underlain by the Corcoran Clay over approximately the western and central two-thirds of the Subbasin area. The depth to the top of the Corcoran Clay varies from 50 to 100 feet at its northeastern extent to in excess of 250 feet in the southwestern portion of the Subbasin (**Figure 2-14**). In the western portion of the Subbasin, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure 2-34**). In the central and eastern portions of the Subbasin where the Corcoran Clay is shallow or does not exist, the aquifer system is generally considered to be semi-confined with discontinuous clay layers interspersed with more permeable coarse-grained units (**Figure 2-34**).

As illustrated in the geologic cross-sections described above and provided in **Appendix 2.D,** the upper 800 feet of sediments are comprised of multiple layers of coarse-grained sediments. 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 distribution of percentages of coarse-grained sediments at various 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 2-35 and 2-36** 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 overall percentages of coarse-grained sediments are less than 50 percent of total sediment thicknesses.

2.2.1.4 Aquifer Parameters

A detailed summary of aquifer parameter data derived from existing reports was presented in the Preliminary HCM and is included in **Appendix 2.D**. For Madera County as a whole, the Madera Regional Groundwater Management Plan indicates the Older Alluvium generally has transmissivity values ranging from about 20,000 to 250,000 gpd/ft. Well test data indicate that wells tapping a significant thickness of coarse-grained materials in the upper 500 feet tend to have the highest specific capacities. The underlying Continental Deposits are reported to have transmissivities ranging from 10,000 to 30,000 gpd/ft (Provost and Pritchard, 2014).

Specific yield (Sy) values for Madera County were evaluated in previous studies for use in groundwater storage change calculations (Provost and Pritchard, 2014; Todd, 2002). These county-wide studies used Sy values ranging from 0.10 to 0.13. A study specific to Chowchilla Subbasin (DWR, 2004) cited a specific yield value of 0.086 for use in calculating total groundwater in storage. Given that sediments generally become finer grained with depth, it is possible that the lower Sy value from DWR (2004) is due to evaluation of specific yield to a deeper depth than in the other studies.

As part of recent GSP efforts related to the HCM, DWR well completion reports (WCRs) were reviewed to obtain additional specific capacity data from various wells throughout Chowchilla Subbasin and the greater model domain. The details of the specific wells, well construction data, and specific capacity data are summarized in **Appendix 2.D**. The specific capacity data were converted to transmissivity values based on methodology developed by Driscoll (1986). Maps of transmissivity (T) values were prepared for the Upper Aquifer (**Figure 2-37**), Lower Aquifer (**Figure 2-38**), and for composite wells screened in both aquifers (**Figure 2-39**).

There are six transmissivity values displayed on the map for the Upper Aquifer, all of which are located in the western portion of the Subbasin (**Figure 2-37**). Transmissivity values were quite variable ranging from less than 25,000 to 100,000 gpd/ft. The transmissivity map for the Lower Aquifer (**Figure 2-38**) includes data for 15 wells with 5 wells in the eastern portion of the basin, 6 wells in the central Subbasin and 4 wells in the western Subbasin area. Wells in the eastern Subbasin area show significant variability in estimated transmissivity values from less than 25,000 to 100,000 gpd/ft. The central Subbasin wells have transmissivity values from less than 25,000 to 75,000 gpd/ft, and the western region has wells with estimated transmissivity values ranging from less than 25,000 to 50,000 gpd/ft. Although data for the Upper Aquifer is limited, there were no wells with estimated transmissivity values greater than 100,000 gpd/ft in the Lower Aquifer while 3 of 6 available wells with estimated transmissivity values exceeded 100,000 gpd/ft in the Upper Aquifer. The map of transmissivity values for composite/unknown wells shows three wells in the western portion of the Subbasin (**Figure 2-39**). The transmissivity values range from 50,000 to 100,000 gpd/ft.

2.2.1.5 Recharge and Discharge Areas

Groundwater recharge can occur throughout the Chowchilla Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources.[36] However, some areas may provide greater potential for existing recharge and future managed recharge that may occur during GSP implementation. Areas with increased recharge potential were evaluated using soil mapping data and the SAGBI index. Soils data are evaluated for infiltration potential and categorized into one of four hydrologic groups with hydrologic group A having highest infiltration potential and hydrologic group D having lowest infiltration potential (**Figure 2-10**). The map of hydrologic soil groups shows the main areas with hydrologic group A soils located along Chowchilla River, Ash Slough, and Berenda Slough. A relatively large area of hydrologic group A and B soils is located in the central portion of the Subbasin from north of Chowchilla River to south of Berenda Slough, and from the City of Chowchilla on the east to Eastside Bypass on the west. Mapping of saturated soil vertical hydraulic conductivity (K) shows a similar distribution of areas with higher infiltration potential as the soil hydrologic group map (**Figure 2-11**). The large area of hydrologic group A and B soils described above has soil saturated vertical K from 1.1 to greater than 5 feet/day, whereas most other areas have soil saturated vertical K of less than 1 foot/day.

The Soil Agricultural Groundwater Banking Index (SAGBI) provides a characterization of potential for groundwater recharge on agricultural land. The SAGBI index is based on five main factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface conditions. The

[36] Net subsurface inflows to the Chowchilla Subbasin from adjacent subbasins also contribute to groundwater recharge; however, subsurface inflows and outflows are expected to decline as the Chowchilla Subbasin and adjacent subbasins achieve sustainability.

unmodified (by tilling) SAGBI index map (**Figure 2-40**) shows the main areas of high deep percolation potential mirror the relatively large area of higher infiltration potential on the soil hydrologic group map between Highway 99 and Eastside Bypass from north of Chowchilla River to south of Berenda Slough. The modified SAGBI map (**Figure 2-41**) shows similar results as the unmodified SAGBI map with an additional area in the western portion of Chowchilla Subbasin west of Eastside Bypass with moderate to high deep percolation potential.

Another mechanism of groundwater recharge is subsurface inflow from adjacent subbasins, including Merced, Madera, Delta Mendota Subbasins. Subsurface groundwater inflows (and outflows) were evaluated with the Subbasin groundwater model and are summarized in **Appendix 6.D.**, Groundwater Model Documentation.

Overall, the primary areas with the highest recharge potential occur along and between rivers/sloughs in the central portion of the Subbasin, and secondary areas with greater recharge potential occur in the western portions of the Subbasin to the west of Eastside Bypass. **Figure 2-42** shows areas of higher recharge potential if defined by mapped soils with relatively high vertical hydraulic conductivities (greater than 2 feet/day). It is worth noting that areas of high infiltration/deep percolation potential shown in **Figures 2-40 to 2-42** occur in the region underlain by the Corcoran Clay, which may constrain the ability to recharge the maximum volumes of water that may be available for recharge basins and on-farm recharge during wet years.

Under current and recent historical groundwater conditions, the primary groundwater discharge from the Subbasin is groundwater pumping for agricultural, municipal, domestic, and industrial uses. Maps of general locations of domestic, agricultural, and public supply wells are provided in **Figures 2-4 and 2-5**. Maps of the average depths of domestic, agricultural, and public supply wells by section are provided in **Figures 2-43, 2-44, and 2-45**. These maps generally indicated the majority of domestic wells are located in the central to eastern portions of the Subbasin, agricultural wells are relatively evenly distributed throughout the entire Subbasin, and public supply wells are concentrated in the central to eastern portions of the Subbasin. Domestic well depths are variable across the Subbasin, with the most common well depths in the 300 to 400-foot range. Similarly, agricultural well depths are variable across the Subbasin, with the most common well depths in the 500 to 750-foot range. Public supply wells are most commonly in the 500 to 750-foot depth range.

A secondary mechanism of groundwater discharge may be subsurface outflow to portions of some adjacent Subbasins. Subsurface groundwater outflows (and inflows) were evaluated with the Subbasin groundwater model and are summarized in **Appendix 6.D.**, Groundwater Model Documentation.

2.2.1.6 Surface Water Bodies and Source/Delivery Points for Local and Imported Water Supplies

The primary surface water bodies within the boundaries of Chowchilla Subbasin include Chowchilla River, Ash Slough, Berenda Slough, Eastside Bypass, and San Joaquin River (along a portion of the western Subbasin boundary). The major reservoirs within the watersheds upstream of Chowchilla Subbasin include Eastman Lake along the Chowchilla River and Millerton Lake along the San Joaquin River (via the Madera Canal). These surface water features are shown on several maps describing the HCM (e.g., **Figures 2-9, 2-12, and 2-20**), and are described in more detail in the subsequent water budget section of Chapter 2. In addition, the sources and delivery points for local and imported water are described in detail in the water budget section.

2.2.2 Current and Historical Groundwater Conditions (23 CCR § 354.16)

2.2.2.1 Groundwater Levels

Considerable historical groundwater level data are available in the Chowchilla Subbasin. These data include water level (i.e., groundwater level) observations in wells and groundwater elevation contour maps prepared by others. Additional groundwater elevation maps and hydrographs were generated to evaluate historical and current groundwater level conditions in the Subbasin. The existing data and maps are described below, along with updated groundwater elevation contour maps and hydrographs prepared as part of this GSP. The discussion of groundwater elevation contour maps focuses on Spring season water levels (as opposed to Fall) to limit influences actively pumping wells may have on interpretations of groundwater conditions. However, available historical Fall groundwater elevation contour maps were compiled and are included in **Appendix 2.E**.

2.2.2.1.1 Groundwater Elevation Contours

Maps of groundwater elevation from the early 1900s indicate groundwater flow from northeast to southwest prior to significant development of groundwater in the Chowchilla Subbasin. The western portion of the Subbasin was considered part of an "artesian zone" running through the center of the San Joaquin Valley (Mendenhall, 2016). More recently, groundwater elevation contour maps developed by DWR are available for selected years between 1958 and 1989, and annual maps were published from 1989 to 2011 (**Appendix 2.E**). Groundwater elevation data and GIS data files of groundwater contours are also available from DWR for 2012 to 2016 (**Appendix 2.E**). Although the DWR maps are developed with water level measurements that include wells with unknown construction details, DWR has categorized these groundwater contour maps as being representative of unconfined and semi-confined aquifer groundwater levels across the Chowchilla Subbasin. To evaluate recent groundwater level conditions in the Subbasin, separate groundwater elevation contour maps were prepared for Winter/Spring 1988, Winter/Spring 2014, and Winter/Spring 2016 for unconfined groundwater and for the Lower Aquifer within the extent of the Corcoran Clay. For the purpose of mapping groundwater elevations, the aquifer system in areas outside the Corcoran Clay was treated as a single unconfined groundwater system. In areas within the Corcoran Clay, the aquifer system was separated into an unconfined system above the Corcoran Clay and a Lower Aquifer below the Corcoran Clay. Contour maps of the different depth zones are presented and discussed below. Historical groundwater contour maps of unconfined groundwater prepared by others are referenced in the discussion below and are provided in **Appendix 2.E**.

Unconfined Groundwater

Groundwater elevation contour maps of the unconfined/semi-confined aquifer zone developed by DWR are available for selected years between 1958 and 1989, and annual maps were published from 1989 to 2011 (**Appendix 2.E**). Groundwater elevation data and GIS files of groundwater contours are also available from DWR for 2012 to 2016 (**Appendix 2.E**). Although the DWR maps are developed with water level measurements that include wells with unknown construction details, DWR has categorized these groundwater contour maps as being representative of unconfined and semi-confined aquifer groundwater levels across the Chowchilla Subbasin. The groundwater contour maps referenced in the discussion below for 1958 through 1984 are provided in **Appendix 2.E**.

The Spring 1958 DWR groundwater contours generally run northwest to southeast with elevations decreasing from northeast to southwest. A significant groundwater depression was developing in the northwest portion of the groundwater basin, initially centered just north of the Chowchilla River in Merced County in the 1950's. Groundwater elevations range from highs exceeding 220 feet msl northeast of the City of Chowchilla to lows of 70 feet msl in the groundwater depression in the northwest portion of Chowchilla Subbasin (as originally defined). Within the City of Chowchilla, groundwater elevations ranged from 200 to 210 feet msl.

The Spring 1962 DWR groundwater elevations showed declines of approximately 20 to 30 feet in the late 1950s/early 1960s, with highs exceeding 190 feet msl northeast of the City of Chowchilla to lows of 50 feet msl in the groundwater depression in the northwest portion of the Subbasin. Within the City of Chowchilla, groundwater elevations were approximately 180 feet msl. The Spring 1969 groundwater elevations showed continued declines in the northeastern portion of the Subbasin, with an overall range from 150 feet msl within the City of Chowchilla to lows of 50 feet msl in the northwestern portion of the Subbasin.

Spring 1976 DWR groundwater elevations indicated declines of approximately 10 feet in the western portion and approximately 10 to 30 feet in the eastern portion of the basin during the 1970s. The depression in the northwest expanded in size throughout the decade, while a separate depression formed in the northeast near the City of Chowchilla along the Chowchilla River. Within the City of Chowchilla, groundwater elevations ranged from 110 to 130 feet msl.

The Spring 1984 DWR groundwater elevations generally showed increases of approximately 10 to 20 feet in the early to mid-1980s. Two groundwater depressions were still present in the northwest and northeast, but a mound had formed in the center of the basin between the two pumping depressions. Within the City of Chowchilla, groundwater elevations ranged from 130 to 140 feet msl.

Contours of groundwater elevations in Winter and Spring 1988 (**Figure 2-46**) show similar patterns as historical groundwater elevations with groundwater flow generally from northeast to southwest. Areas of locally lower groundwater levels are apparent in **Figure 2-46** north of the City of Chowchilla and Chowchilla River (in the adjacent Merced Subbasin), southeast of City of Chowchilla (along the boundary with Madera Subbasin), and in the northwestern portion of the Subbasin. Locally slightly higher groundwater elevations are apparent in 1988 along Chowchilla River, Ash Slough, and Berenda Slough in the central to eastern portions of the Subbasin. In Winter/Spring 1988 groundwater elevations near the City of Chowchilla are between about 150 and 160 feet msl.

In Winter/Spring 2014, unconfined groundwater elevations in the Subbasin are generally lower than in 1988 with several groundwater depressions apparent in **Figure 2-47**. Although the general prevailing groundwater flow direction remains northeast to southwest, a few notable, localized areas of low water levels (i.e., groundwater levels) exist in the Subbasin. These local depressions cause more local variability in the groundwater flow directions including most prominently to the south of the City of Chowchilla along the Subbasin boundary with the Madera Subbasin, and in the northwestern and southwestern portions of the Subbasin. A small area of slightly higher groundwater elevations occurs within the City of Chowchilla (180 ft msl). Although more limited water level data are available in Winter/Spring 2016, a contour map of groundwater elevation in 2016 is presented in **Figure 2-48** for comparison and illustrates similar patterns in groundwater flow and relative elevations. Groundwater elevation contours in the western part of the Subbasin indicate groundwater flowing into the Subbasin from the west near the San Joaquin River in 2014 and 2016.

Considerably more groundwater level data are available along the San Joaquin River in 2014 and 2016, in part because of recent monitoring being conducted in association with the San Joaquin River Restoration Program. However, it is worth noting that many of the San Joaquin River Restoration Program monitoring wells are very shallow (less than 50 feet) and exhibit water levels that may be shallower than the regional groundwater system. In evaluating and comparing groundwater level contour maps, it can be difficult to distinguish between influences of the unique water level datapoints used for each contour snapshot from what may be actual differences in water level conditions. Some of the differences in the contour maps for 2014 and 2016 are a result of differences in the spatial distribution of water level datapoints.

Perched Groundwater Conditions

The definition of perched groundwater is shallow groundwater present above a low-permeability (e.g., clay) layer with an unsaturated zone present between the perching layer and the regional water table. Perched groundwater has been documented in Chowchilla Subbasin at several sites through review and comparison of local groundwater level data from regulated facility sites obtained from Geotracker and regional groundwater level data from CASGEM and other sources. These regulated facilities have shallow monitoring wells that reflect shallow groundwater conditions that can differ from regional groundwater levels in the deeper zones in which groundwater extraction wells are typically screened. It is likely that other occurrences of perched groundwater exist in the Subbasin, although their existence may not be apparent due to lack of available information on water levels at different depths. A primary area of perched groundwater is expected to be present in the central to eastern portion of Chowchilla Subbasin above the Corcoran Clay, and it has been specifically documented in the City of Chowchilla area. There are three documented sites with groundwater level data in the City of Chowchilla area. These sites show perched groundwater levels ranging from 36 to 58 feet below ground surface (corresponding to groundwater elevations of 179 to 203 feet msl) over the time period from May 1995 to February 2018. Review of regional groundwater level data from CASGEM and other wells for this same time frame showed groundwater elevations ranging from less than -30 to about 70 feet msl. The perching layer in this area is likely the Corcoran Clay, which is estimated to be present at depths of approximately 70 to 80 feet beneath the City of Chowchilla.

Lower Aquifer

Contouring groundwater elevations in the Lower Aquifer is challenging because of combined limitations in availability of groundwater level data with well construction information and wells screened exclusively in the Lower Aquifer. In contouring groundwater levels in the Lower Aquifer, water levels from wells known to be constructed in the Lower Aquifer and any water levels below the Corcoran Clay (even if well construction is not known) were used for mapping groundwater elevations.

A combined dataset of Winter/Spring 1988 and Winter/Spring 1989 water level measurements was used to map Winter/Spring 1988 and 1989 groundwater elevation contours. The limited spatial representation of Lower Aquifer water level data is apparent in **Figure 2-49** with only one water level datapoint available in the central to western portion of Chowchilla Subbasin during the 1988 and 1989 time period. With this datapoint, groundwater elevation in the Lower Aquifer was estimated to be around 130 feet msl in Winter/Spring of 1988/1989. The pattern in Lower Aquifer groundwater elevations, including direction of groundwater flow, is difficult to interpret from the few datapoints and limited spatial representation.

More recent groundwater elevation contours for Winter/Spring 2014 and 2016 have greater spatial coverage than the 1988/1989 map, but still have relatively limited point control in the Lower Aquifer within the Chowchilla Subbasin. The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer is presented as **Figure 2-50** and indicates Lower Aquifer groundwater elevations of between -30 and -40 feet msl in the area of the Chowchilla Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 (**Figure 2-51**) shows relatively lower groundwater elevations with some areas from -40 and -60 feet msl in the Lower Aquifer in the City of Chowchilla and in the southwestern portion of the Subbasin east of the Eastside Bypass. However, there is also an area of higher groundwater elevations than in 2014 in the middle portion of the Subbasin along Highway 152.

Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in Chowchilla Subbasin is challenging.

2.2.2.1.2 Groundwater Hydrographs

Hydrographs of time-series groundwater level data were reviewed to evaluate long-term trends in groundwater levels. Selected groundwater level hydrographs for unconfined groundwater, Lower Aquifer, and composite wells or wells with unknown construction are presented in **Figures 2-52 to 2-54** to illustrate temporal trends in groundwater levels across the Subbasin. Overall, long-term declines were prevalent throughout the Subbasin.

Select hydrographs of water levels in the unconfined groundwater (outside the Corcoran Clay or above the Corcoran Clay) are displayed in **Figure 2-52**. All of the hydrographs displayed on **Figure 2-52** with extended water level histories exhibit long-term water level declines. Two wells (TTR-1 and TTR-35) in the western portion of the Subbasin with short-term water level histories show steep declines between 2013 and 2016 but subsequent recovery of groundwater levels in 2017. The wells in **Figure 2-52** with longer-term records in the eastern to central part of the Subbasin (9S/16E-15Q1, 9S/17E-19L1, 10S/16E-17C1, 10S/15E-35A2) show groundwater level declines of between 4 and 6 feet per year over the period from the mid-1980s through about 2015.

Select hydrographs of water levels in the Lower Aquifer (within the extent of the Corcoran Clay) are displayed in **Figure 2-53**. As discussed above, the availability of groundwater level data known to be specific to the Lower Aquifer is limited. Only two of the wells (9S/15E-23J2 and 9S/16E-16N1) shown in **Figure 2-53** have a period of record sufficiently long to interpret trends in water levels. Over the period of time from the mid-1980s through 2015 there was an annual groundwater level decline of about 5 to 6 feet per year.

Because of limitations related to available well construction information, there are many wells with long periods of record for water levels but lacking well construction information. Select hydrographs of water levels in wells of unknown construction are presented in **Figure 2-54**. The hydrographs on **Figure 2-54** show groundwater level trends generally consistent with those seen in the Upper and Lower Aquifers with declines of 4 to 6 feet/year over the time period between the mid-1980s and 2015. However, two wells (10S/13E-22R1 and 10S/14E-26C2) located in the western portion of the Subbasin show lower rates of decline between 1 and 3 feet/year. Prior to the mid-1980s, trends of more stable water levels, although slightly declining, are apparent in most wells. Over the period from the mid-1980s to 2015, rates of groundwater level decline greatly increased.

Additional groundwater level hydrographs are presented in **Appendix 2.E**.

2.2.2.2 Groundwater Storage

2.2.2.2.1 Total Groundwater Storage

The total groundwater storage volume within the Chowchilla Subbasin above the basement and base of freshwater is estimated to be between about 6.5 million AF and 13 million AF based on an analysis using contouring of 2014 groundwater levels and an assumed average specific yield range of 5 to 10 percent. **Table 2-7** summarizes the calculations of total groundwater storage in the Subbasin using a range of specific yield values, although recent groundwater modeling conducted to support development of the GSP suggest average specific yield values for the full saturated thickness in the Subbasin (i.e., from the regional water table to the base of fresh water) may be lower than previously estimated and closer to the lower end of the values listed in **Table 2-7**. In Bulletin 118, DWR previously estimated the total groundwater storage In the Chowchilla Subbasin above the base of freshwater to be about 13.9 million

AF using 1995 groundwater levels and a specific yield value of 8.6 percent. However, DWR's Bulletin 118 estimate was for a larger area of about 159,000 acres compared to the current Chowchilla Subbasin area of a little under 146,000 acres.

Table 2-7. Estimates of Total Groundwater Storage Above Base of Freshwater (as of 2014)

Chowchilla Subbasin Area (acres)	Specific Yield (percent)	Total Groundwater Storage (AF)	Notes on Specific Yield Basis
145,574	5%	6,453,000	
	7%	9,034,000	
	8.6%	11,099,000	DWR Bulletin 118
	10%	12,906,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	15,487,000	
	13%	16,777,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)

2.2.2.2.2 Change in Groundwater Storage

Based on a comparison of the contour maps of unconfined groundwater elevation for Winter/Spring 1988 and the two more recent contour maps for Winter/Spring 2014 and 2016, changes in groundwater elevation were calculated between 1988 and both 2014 and 2016. **Figure 2-55** shows the calculated change in unconfined groundwater levels for 1988 to 2014 and **Figure 2-56** presents the calculated change over the period 1988 to 2016. Unconfined groundwater levels declined substantially across much of the Chowchilla Subbasin between 1988 and both 2014 and 2016. Groundwater level declines of 50 to 150 feet occurred throughout most of the Subbasin in 2014, except for an area around the City of Chowchilla and to the west/northwest of the City of Chowchilla and in the far western portion of the Subbasin along the San Joaquin River. The greatest areas of groundwater level decline occurred in the far eastern portion of the Subbasin and in the south-central portion of the Subbasin adjacent to the Madera Subbasin boundary. The patterns of groundwater level declines between 1988 and 2016 were similar to 1988 to 2014, with slightly greater overall declines in the 1988 to 2016 period. The areas indicated in **Figures 2-55 and 2-56** to have increasing groundwater levels are primarily a result of differences in water level data availability between the different time periods and are unlikely to be an indication of actual rising groundwater levels.

The calculated changes in groundwater levels translate to changes In groundwater storage estimated to range between -700,000 to -1.3 million AF between 1988 and 2014 and between -800,000 and -1.5million AF between 1988 and 2016, assuming a range of specific yield values from 7 to 13 percent. This calculation, which represents the upper portion of the total saturated sediment thickness in the Subbasin, utilizes a more representative higher range of specific yield values compared to the total basin groundwater storage calculation presented above. These storage decreases translate to annual decreases of about -27,000 to -50,000 acre-feet per year (AFY) for 1988 to 2014 and -31,000 to -57,500 AFY for 1988 to 2016. **Table 2-8** summarizes the calculations of changes in groundwater storage from 1988 to 2014 and 1988 to 2016 under different specific yield values.

Table 2-8. Calculated Change in Groundwater Storage

Analysis Time Period	Specific Yield (percent)	Total Groundwater Storage Change (AF)	Average Annual Groundwater Storage Change (AFY)	Notes on Specific Yield Basis
Change 1988 to 2014	7%	-701,000	-27,000	
	8.6%	-861,000	-33,000	DWR Bulletin 118
	10%	-1,002,000	-38,500	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	-1,202,000	-46,000	
	13%	-1,302,000	-50,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)
Change 1988 to 2016	7%	-805,000	-31,000	
	8.6%	-989,000	-38,000	DWR Bulletin 118
	10%	-1,150,000	-44,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	-1,380,000	-53,000	
	13%	-1,495,000	-57,500	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)

Previous estimates of groundwater storage change for Madera County include DWR (1992), Todd (2002), and Provost & Pritchard (2014). DWR (1992) estimated groundwater storage decline from 1970 to 1990 to be 74,115 AFY. Todd (2002) calculated a groundwater storage decline of 68,338 AFY for the period from 1990 to 1998. The most recent of these evaluations of groundwater level and storage change is included in the 2014 Groundwater Management Plan (Provost & Pritchard, 2014), and covers the time period from 1980 to 2011. In general, groundwater levels declined between 30 and 150 feet throughout Madera County, or an average of 1 to 5 feet per year. Groundwater storage change was not quantified by subbasin. For the Madera County area included in the plan (not including areas of Root Creek Water District, Madera Water District, Aliso Water District, or Columbia Canal Company) studied in 2014 (plus the area of Merced County included in Chowchilla Water District), groundwater storage between 1980 and 2011 was estimated to have declined at an average rate of 143,000 AFY, which equates to a total decline of 4.4 million AF over the 31-year period.

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 mg/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 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**.

2.2.2.3.1 Total Dissolved Solids

Maps of maximum historical TDS concentrations in groundwater in the Chowchilla Subbasin (**Figures 2-57 to 2-59**) indicate variable salinity across the Subbasin with more elevated TDS concentrations in the western portion of the Subbasin. However, wells having high (greater than 1,000 mg/L) TDS concentrations are also intermingled with wells with relatively low (less than 500 mg/L) TDS concentrations. 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. Given the number of wells with groundwater quality data but without well construction details, it is difficult to make interpretations of relationships between water quality and screen depths across the Subbasin from these data.

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 Chowchilla Subbasin. TDS concentrations ranged from less than 250 mg/L in the east to greater than 1,000 mg/L in the northwestern portion 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 considerably larger area of high TDS groundwater (**Appendix 2.E**).

2.2.2.3.2 Nitrate

Maps of maximum historical nitrate concentrations in groundwater are presented for all wells and also individually for Upper Aquifer wells and Lower Aquifer wells in **Figures 2-60 to 2-62**. Due to the limited number of datapoints with known well construction information, many results cannot be attributed to a specific aquifer zone. These maps highlight patterns in historical 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 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 central parts of the Subbasin. Several notable areas with a high density of wells with nitrate concentrations above the MCL of 10 mg/L (as N) are located in the more central parts of the Subbasin to the west and southwest of the City of Chowchilla and between Ash Slough and Highway 152. Most of the higher concentrations are from wells with unknown construction information.

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 relatively large area exceeding the MCL of 10 mg/L (as N) in the central part of the Subbasin, while nitrate in the lower zone (of the Upper Aquifer) was indicated to exceed 10 mg/L in a smaller area in southwest portion of the Subbasin (**Appendix 2.E**).

2.2.2.3.3 Arsenic

Maps of maximum historical arsenic concentrations in groundwater are presented in **Figures 2-63 to 2-65**. Although there are a few wells with higher arsenic concentrations above 7.5 micrograms per liter (µg/L), most of the wells with data have concentrations below 5 µg/L with a considerable number having concentrations of less than 2.5 µg/L. The available groundwater quality data do not indicate any wells with arsenic concentrations above the MCL of 10 µg/L. The map of arsenic concentrations in the Lower Aquifer (**Figure 2-65**) suggest that concentrations of arsenic may be somewhat higher in the Lower Aquifer, although still generally below the MCL.

2.2.2.3.4 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 of groundwater constituents that should be considered when evaluating potential groundwater quality impacts from implementation of PMAs to achieve sustainability.

2.2.2.4 Land Subsidence

Recent land subsidence has been a major concern in the western portion of the Chowchilla Subbasin.

2.2.2.4.1 Subsidence Mapping Data

A map of subsidence that occurred between 1926 and 1970 shows one to two feet of subsidence in the western portion of Chowchilla Subbasin (**Figure 2-66**). Subsidence mapping using a combination of InSAR remote sensing data and data from surveys conducted by the USBR for the San Joaquin River Restoration Project for the 2007 to 2021 time period is shown in **Figure 2-67**. A maximum subsidence of almost seven feet occurred in the northwest part of the Chowchilla Subbasin between the Eastside Bypass and the western basin boundary during this period, which reflects a recent period of subsidence re-activation in the Subbasin. Maps of the most recent remote sensing subsidence data available from DWR for the period 2015 through 2021 are presented in **Figures 2-68a and 2-68b**. These maps show one to two feet of subsidence in a large portion of the western Subbasin between the two-year period 2015 to 2017. Since 2017 subsidence has continued in the western part of the Subbasin, although the greatest areas of subsidence since 2017 are focused in areas farther east and south than prior to 2017. The reduction in subsidence rates seen in TTWD since 2017 is attributed, in part, to successful implementation of the Subsidence Control Measures Agreement (**Appendix 3.F**). Additional information about the Agreement is provided in Section 3.3.3. Overall, the available historical subsidence data for the Subbasin indicate up to approximately nine feet of subsidence in some areas of western Chowchilla Subbasin since 1920. The subsidence has generally been concentrated in areas of the Subbasin within the extent of the Corcoran Clay. Specific subsidence monitoring locations are shown in **Figure 2-69**, which shows a relatively continuous monitoring record of subsidence at eight locations in the Subbasin between 2011 and 2021. Review of the subsidence monitoring location records indicate about seven feet of subsidence in the western portion of the Subbasin and about two to three feet of subsidence near the intersection of Highway 152 and Highway 99 in the eastern portion of Chowchilla Subbasin.

Other mapping of recent subsidence is included in **Appendix 2.D**. In northwest Chowchilla Subbasin, subsidence from 2008 to 2010 was 1.5 to two feet. Mapping by USBR between July 2012 and December 2016 showed total subsidence ranging up to three feet in western portion of Chowchilla Subbasin during this period of dry conditions. Various ongoing subsidence monitoring programs are being funded and/or conducted by DWR, USGS, USBR, and National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA-JPL).

2.2.2.4.2 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. This concept is also the foundation on which approaches to mitigating subsidence in the western management area of the Subbasin by reducing pumping in the Lower Aquifer are based.

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 2007 through present, but very limited data exist prior to 2007 in the Subbasin and the data for the period since 2007 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. Furthermore, long-term groundwater level data for comparing with subsidence monitoring are also limited in availability and often have not occurred at 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 2-70a** 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 a range of relationships between groundwater levels and subsidence are apparent in the graphs on **Figure 2-70a**, which vary by location and well depth. Some of the graphs on **Figure 2-70a** 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 2-70b** 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.

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 through 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 Chowchilla Subbasin indicated that rates of subsidence during the 2012 to 2015 drought ranged from 0.4 to 0.65 feet/year over the Western Management Area with the higher rates generally occurring along the Chowchilla Bypass. The central portion of Chowchilla Subbasin had subsidence rates of 0.3 to 0.4 feet/year from 2012 to 2015. In the years from 2017 to 2021, subsidence rates were approximately 0.2 to 0.4 feet/year in the Western Management Area, while subsidence rates in the central Chowchilla Subbasin and along the border with Madera Subbasin did not appear to decrease significantly from rates prior to 2017.

Based on review and comparison of available groundwater level and subsidence data in Chowchilla 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 17 to 35 feet in groundwater level decline (with an average of 23 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 44 to 58% of the active subsidence rate in the Western Management 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 Chowchilla 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 Western Management Area of Chowchilla Subbasin suggest a residual subsidence rate of approximately 50% of the active subsidence rate during the 2012 to 2015 drought period.

2.2.2.5 Groundwater – Surface Water Interaction

The primary surface water features in Chowchilla Subbasin are the Chowchilla River, Ash Slough, Berenda Slough, and San Joaquin River (**Figure 2-10**). Each of these streams is considered to be a natural source of recharge to the Subbasin. A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin. However, comparison of historical groundwater levels to the stream thalweg (i.e., deepest portion of stream channel) indicate that the San Joaquin River along the western Subbasin boundary was connected with groundwater from 1958 (and likely before) through 2008. Groundwater levels were generally below (and apparently disconnected from) the San Joaquin River from 2009 through 2016 based on this analysis, which involved use of groundwater elevation contour maps for the "Unconfined Aquifer" prepared by DWR for the following years; Spring 1958, Spring 1962, Spring 1969, Spring 1970, Spring 1976, Spring 1984, and Spring 1989 through Spring 2011 (**Appendix 2.E**), and groundwater elevation contour maps for Spring 2014 and 2016 (**Figures 2-47 and 2-48**).

Maps of depths to shallow groundwater for 2014 and 2016 are displayed on **Figures 2-71** and **2-72**. These maps incorporate very shallow monitoring wells (i.e., less than 50 feet deep), including San Joaquin River Restoration Project (SJRRP) wells (many of which have well screens in the upper 30 feet). Depth to shallow groundwater maps were generated by contouring groundwater surface elevation and subtracting the contoured water surface from the ground surface elevation as represented by the USGS National Elevation Dataset Digital Elevation Model. Some of the areas in western Chowchilla Subbasin along/adjacent to the San Joaquin River are underlain by the "C" clay and other shallow clay layers that are above the more regional Corcoran Clay. Shallow groundwater in these areas can be considered perched/mounded aquifers in that shallow clay layers help to maintain shallow groundwater levels but there is no unsaturated zone beneath them as in a truly perched aquifer condition described below in the section on groundwater dependent ecosystems. It is likely that seepage from the San Joaquin River is the source of water that, combined with the presence of shallow clay layers, serves to maintain shallow groundwater levels at these locations. The depth to the Corcoran Clay becomes relatively shallow in the Eastern Management Area, where it serves as the base of a shallow perched aquifer. While groundwater levels in this perched aquifer may be approximately 50 to 90 feet below ground surface, the underlying regional water table is typically at depths exceeding 200 feet.

Review of **Figures 2-71 and 2-72** indicates that the San Joaquin River was disconnected from the shallow perched/mounded aquifer during these time periods. However, review of groundwater elevation hydrographs for wells screened in the Upper Aquifer (see Sections 3.2.5 and 3.3.5) indicate that there may be some connection between shallow groundwater levels and the San Joaquin River during certain time periods (e.g., wet season of wet years). The relationship between stream depletion in the San Joaquin River along the western boundary of Chowchilla Subbasin and groundwater pumping along this portion of the San Joaquin River within the Chowchilla Subbasin (i.e., within approximately 0.75 miles of the San Joaquin River) is shown in **Figure 2-73**. The relationship between groundwater pumping from the Upper Aquifer throughout the entire Western Management Area and stream seepage is shown in **Figure 2-74**. These figures indicate no distinct and consistent relationships between the amount of groundwater pumping and stream seepage. Similarly, the relationship between streamflow coming in at the upstream boundary of this river reach and stream depletion is provided in **Figure 2-75**. In this case, a very distinct and strong relationship is demonstrated where increasing streamflow correlates with increasing stream depletion. This relationship streamflow and stream depletion is expected because this segment of the San Joaquin River is known to be a losing reach. These relationships among various factors are discussed further in Sections 3.2.5 and 3.3.5.

Regardless of whether or not the San Joaquin River is considered to have interconnected surface water, there is at least some potential for regional groundwater pumping to impact groundwater dependent ecosystems (GDEs) with roots extending down 20 to 30 feet along the San Joaquin River. Thus, shallow groundwater areas adjacent to the San Joaquin River were further evaluated in regard to GDEs in the following section and in Chapter 3.

Based on review of available data, characterization of hydrogeologic conditions related to the potential for interconnected surface water (and potential impacts on GDEs) is currently based on very limited data. Thus, additional data collection and analyses are needed to update and refine the understanding of how surface water and GDEs may (or may not) be connected to the regional aquifers where groundwater pumping occurs. Key elements of a workplan are described in Section 2.2.2.7.4. It is anticipated that some additional data to better characterize shallow stratigraphy, groundwater levels, interconnected surface water, and GDEs will be available and incorporated into the 2025 GSP Update.

2.2.2.6 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined in California's Sustainable Groundwater Management Act (SGMA) as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (23 CCR § 351(m)). As described in The Nature Conservancy's guidance for GDE analysis (Rohde et al. 2018), a GDE's dependence on groundwater refers to reliance of GDE species and/or communities on groundwater for all or a portion of their water needs. Review of available groundwater level data from Winter/Spring 2014 and Winter/Spring 2016 indicates that shallow groundwater levels (i.e., within 30 feet of ground surface) exist in some portions of the Subbasin (Section 2.2.2.1). The depth to water (DTW) evaluation described in the above section for Groundwater – Surface Water Interaction also provides input for evaluation of GDEs.

A DTW of 30 feet was used as one of the primary criteria in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to screen potential GDEs is based on reported maximum rooting depths of California phreatophytes[37] and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying GDEs. Potential GDEs were retained for further analysis if the underlying DTW in either winter/spring 2014 or winter/spring 2016 was equal to or shallower than 30 feet. The 2014 and 2016 DTW data were the most accurate and recent DTW data available for the Chowchilla Subbasin. While the 2016 data represent conditions after the 2015 SGMA baseline, the use of shallow groundwater data from both years was deemed appropriate because it provided a more conservative (i.e., more inclusive) indicator of potential GDEs than the use of a data from a single year.

Where DTW was greater than 30 feet, other criteria were used to determine whether potential GDEs should be subject to further analysis. For example, surface flow characteristics of rivers in the Chowchilla Subbasin were also used to screen potential GDEs. Because the vast majority of rivers in the Subbasin are not perennial and all are in a net-losing hydrological condition (i.e., losing water to the groundwater system), this criterion excluded most of the smaller river channels and associated terrestrial vegetation from consideration as GDEs.

One GDE unit, the San Joaquin River Riparian GDE Unit, was identified in the Chowchilla Subbasin (**Appendix 2.B**). The GDE unit was identified using the California Department of Water Resources' (DWR) indicators of GDEs (iGDE) dataset, published online and referred to as the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (Klausmeyer et al. 2018), augmented with other relevant vegetation mapping data, aerial imagery, and hydrologic data. Field reconnaissance was conducted in portions of the unit in May 2019 to help characterize the vegetation composition and structure, document

[37] A phreatophyte is a deep-rooted plant that obtains its water from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone (Rohde et al. 2018).

dominant plant species, and assess habitat characteristics to determine the potential for presence of special-status species.

Groundwater beneath the San Joaquin River Riparian GDE Unit was approximately 20–30 feet deep in winter/spring 2014 and 2016 (i.e., the upper 20–30 feet of the subsurface was unsaturated during this time). This is too deep for the San Joaquin River's surface flow to be connected to groundwater, but within the 30-foot maximum rooting depth of the dominant riparian plants in the unit. Below the San Joaquin River, the groundwater is perched or mounded atop the shallow clay layer, but there is no unsaturated zone below the perched/mounded aquifer (Section 2.2.2.5). It is therefore at least possible that changes to the regional aquifer could affect the shallower perched/mounded aquifer that maintains the GDE, although any such connection would be limited by presence of multiple clay layers between the shallow perched/mounded aquifer and the deeper regional aquifer where pumping occurs. The riverine aquatic habitat of the San Joaquin River is not contained within the GDE unit because available hydrologic data indicates no groundwater contribution to the surface flow in this reach of the river (i.e., this reach of the San Joaquin River does not gain but rather is generally disconnected and loses water to the groundwater system). The net-losing condition of the San Joaquin River in this area likely began in 2009 or earlier (Section 2.2.2.5; TNC 2014).

2.2.2.6.1 San Joaquin River Riparian GDE Unit

The San Joaquin River Riparian GDE Unit is located along the San Joaquin River on the western margin of the Chowchilla Subbasin (**Figure 2-76**) and is composed of a mix of riparian forest, shrub, and herbaceous habitat types totaling approximately 70 acres. The May 2019 reconnaissance assessment of representative portions of the San Joaquin River Riparian GDE Unit identified areas of mature riparian forest with a stratified canopy and moderately open understory, overhanging vegetation along the riverbank, and downed wood (**Figure 2-77**). Vegetation at the representative sites provided over 90% native cover in the shrub and tree layer and 15–25% native cover in the herbaceous ground cover, with the balance occupied by non-native species.

Figure 2-77. Stratified canopy along the banks of the San Joaquin River in the San Joaquin River Riparian GDE.

The GDE unit is located in the current and former floodplain of the San Joaquin River, which has been subject to major land use and water use modifications over the last century, primarily resulting from agricultural development and the near-complete curtailment of flow in the San Joaquin River subsequent to completion of Friant Dam in 1944 (McBain & Trush 2002). Despite these changes, the San Joaquin River Riparian GDE Unit provides habitat or ecosystem support for several special-status species and natural communities, including aquatic species that use the adjacent San Joaquin River for all or part of their life cycle including:

- bald eagle (*Haliaeetus leucocephalus),*
- Swainson's hawk (*Antrozous pallidas),*
- pallid bat (*Antrozous pallidas),*
- western red bat *(Lasiurus blossevillii),*
- western pond turtle (*Emys marmorata),*
- Sanford's arrowhead (*Sagittaria sanfordii),*
- California satintail (*Imperata brevifolia),*
- brittlescale (*Atriplex depressa),*
- heartscale (*Atriplex cordulata* var. *Cordulata),*
- palmate-bracted bird's-beak (*Chloropyron palmatum),*

- spiny-sepaled button-celery (*Eryngium spinosepalum),*
- California alkali grass (*Puccinellia simplex),*
- Valley Sacaton Grassland, and
- Sycamore Alluvial Woodland.

These species include special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE Unit, or (3) directly observed during the May 2019 reconnaissance survey conducted by Stillwater Sciences (see **Appendix 2.B** for the status of each species listed above). This unit does not contain or overlap any known protected lands or critical habitat for federally listed species (USFWS 2019, NMFS 2019) but the adjacent San Joaquin River contains Essential Fish Habitat (EFH) for Chinook salmon which is partially dependent on riparian inputs to provide important salmon habitat elements including shade, overhead cover, nutrients, and woody material for instream cover and habitat complexity (PFMC 2014).

Designated fish and wildlife beneficial uses of other surface water bodies in the Chowchilla Subbasin, including the Fresno River and Chowchilla River, are limited to warm freshwater habitat (WARM) and wildlife habitat (WILD). The Basin Plan also lists coldwater spawning habitat (SPWN) for salmon and trout as a potential beneficial use for this portion of the San Joaquin River.

The San Joaquin River Riparian GDE Unit was determined to have high ecological value because of: (1) the known occurrence and presence of suitable habitat for several special-status species in the unit; (2) the vulnerability of these species and their habitat to changes in groundwater levels; and (3) contributions of the unit to the ecological function of adjacent riverine habitat that supports special-status salmonids and other species.

2.2.2.7 Data Gaps in Hydrogeologic Conceptualization and Groundwater Conditions

Although considerable evaluation and synthesis of data on hydrogeology and groundwater conditions in the Subbasin have occurred historically and as part of the development of the GSP, improved information in several notable areas would enhance the understanding of the hydrogeology and groundwater conditions in the Subbasin. Keys areas where improved characterization of the hydrogeologic conceptualization and groundwater conditions would benefit the sustainable management of groundwater in the Subbasin are listed below.

2.2.2.7.1 Wells

This GSP presents the best available data to characterize existing wells in the Subbasin based on DWR WCR data, well permits, and other available sources. The Subbasin completed a Domestic Well Inventory project in 2022, which sought to improve the mapping of existing domestic wells and evaluate their potential to be impacted by future groundwater level conditions. The Domestic Well Inventory project also identified three locations where additional dedicated monitoring wells are to be installed in 2022 for monitoring conditions in areas of higher densities of domestic wells. Although currently available data on WCRs and well permits provide useful information on where wells have historically been constructed and some of their construction characteristics (e.g., total depth, perforated interval, seal depth), no data indicating currently active domestic and agricultural wells is currently available across the Subbasin. Refining the available well information to identify the active wells in the Subbasin and their characteristics would improve the ability to sustainably manage groundwater in the Subbasin, including determining what impacts on beneficial uses and users may occur in the Subbasin and improving the assessment of what conditions represent an undesirable result. There may be opportunities to coordinate these data refinement activities with well permitting activities and data recordkeeping occurring in the Subbasin.

2.2.2.7.2 Water Levels

A key data gap related to water levels in the Subbasin is the availability of well construction information for wells currently monitored and wells with historical water level monitoring records. This is important for understanding groundwater levels conditions and trends at different depths within the groundwater system across the Subbasin. The lack of known construction information for some wells, in combination with the destruction of some wells with long-term water level monitoring history and challenges accessing water level observations in wells present difficulties in assessing current and historical groundwater conditions and tracking future conditions. The GSAs recognized these challenges, and since 2019 the GSAs have installed 25 dedicated monitoring wells at nine unique sites in the Subbasin that targeted filling water level monitoring data gaps, as part of a Proposition 1 Sustainable Groundwater Management Planning grant from DWR. Ten additional dedicated monitoring wells are planned for installation in the Subbasin as part of completion of Proposition 1 and Proposition 68 grant projects. Additional dedicated monitoring facilities are also planned as part of the construction of recharge projects in the Subbasin. These dedicated groundwater monitoring facilities, and the continuous groundwater level monitoring that is occurring at these sites, will greatly improve the characterization of groundwater conditions in the Subbasin; however, it will take some time before the monitoring record at these sites is sufficiently long to integrate into the understanding of the Subbasin hydrogeologic conceptualization and trends in groundwater conditions. The need and opportunity for supplementing or replacing historical water level monitoring facilities that may not provide optimal monitoring information with dedicated monitoring facilities should continue to be evaluated on an ongoing basis.

2.2.2.7.3 Subsidence

There are many subsidence benchmarks in the Subbasin that are monitored twice a year by the USBR as part of the SJRRP. The continued monitoring of these sites, and the extension of the monitoring record at each site, will be greatly beneficial to tracking and understanding subsidence trends and patterns in the Subbasin. To improve understanding of the relationship between groundwater levels and subsidence, coupling groundwater level monitoring in the vicinity of these benchmark sites would provide value information. The locations of these benchmark sites should be considered as part of the groundwater monitoring planning in the Subbasin, including when considering locations for potential additional dedicated groundwater monitoring facilities. Continuation of monitoring at the SJRRP benchmarks will also be important for evaluating any elasticity to the historical subsidence, or any recovery of historical subsidence that may occur.

In addition to the existing SJRRP benchmark subsidence monitoring that occurs within the Subbasin, there is likely also benefit to installing some continuous GPS monitoring or other station for continuous monitoring of vertical displacement or compaction at a finer temporal resolution. The benefit of such monitoring would likely be greatest in the western management area where the greatest historical subsidence has occurred and near key water conveyance features. Coupling any new continuous subsidence monitoring stations with dedicated groundwater monitoring facilities would provide the greatest benefit to relating groundwater conditions to land subsidence.

One of the key aspects of subsidence in the Subbasin that is not well understood or quantified relates to residual subsidence and differentiating residual subsidence caused by historical conditions from new subsidence. Robust subsidence monitoring coupled with well-defined groundwater level monitoring will be important for tracking the different mechanisms related to subsidence. Because of the limited ability to identify strong relationships between groundwater levels, groundwater pumping, and land subsidence in the Subbasin based on currently available data, the GSAs intend to develop a workplan outlining future activities related to monitoring and understanding the different causes and circumstances related to subsidence in the Subbasin. One of the key objectives of the workplan is to differentiate residual subsidence from new subsidence. Residual subsidence is largely believed to be unavoidable because it is a result of historical conditions. While it may not be possible to mitigate the amount of residual subsidence in the Subbasin, the Subbasin intends to manage groundwater to avoid adverse impacts related to any new subsidence that may be activated by future groundwater conditions in the Subbasin. The GSAs plan to complete development of the subsidence workplan by October 1, 2022. Upon completion of the workplan, the GSAs will submit the workplan to DWR. Key considerations and topics to potentially be addressed in the workplan include the following:

- Summary of existing subsidence monitoring
- Overview of existing groundwater level monitoring in relation to subsidence monitoring
- Review of groundwater pumping and monitoring
- Subsurface hydrogeologic characterization related to subsidence
- Assessment of potential impacts on critical infrastructure
- Review of potential modeling approaches to evaluate residual subsidence
- Recommendations on future subsidence and groundwater monitoring needs
- Recommendations on future analytical activities
- Relationship and coordination with Subsidence Control Measures Agreement

2.2.2.7.4 Interconnected Surface Water

There is considerable uncertainty associated with the characterization of interconnectivity between groundwater and surface water along the San Joaquin River in the Subbasin. The considerable depth to groundwater in most other areas of the Subbasin indicate no interconnectivity exists along other waterways. However, available data suggest that historically there likely has been some very limited time periods and reaches where groundwater and surface water are directly connected along the San Joaquin River within the Subbasin. Because of the limited available data to directly relate stream stage and flow with groundwater levels along the San Joaquin River in the Subbasin, additional coordinated characterization of groundwater and surface water conditions in and along the San Joaquin River would improve the understanding of the nature of any connectivity between groundwater and surface water and inform evaluations of the extent to which groundwater pumping may influence seepage from the River.

One of the key considerations in understanding the groundwater and surface water connectivity along the San Joaquin River in the Subbasin relates to the subsurface sediments along the San Joaquin River. The presence of shallow prominent clay layers beneath the San Joaquin River, including the A Clay and C Clay units of the Tulare Formation, along with other shallow clays, likely play a major role in how stream seepage interacts with the groundwater system and the extent to which these clay layers caused perched groundwater conditions occurring at shallow depths hydraulically separated from the deeper zones where groundwater pumping is occurring. Improving the characterization of these shallow subsurface sediments and identification and mapping of any perched groundwater conditions will inform the understanding of surface water and groundwater interactions along the San Joaquin River.

To address the need and interest in improving the understanding of the relationships between groundwater and surface water along the San Joaquin River in the Subbasin, the GSAs intend to develop a workplan outlining future activities related to monitoring and understanding conditions relating to groundwater and surface water connectivity along the San Joaquin River. One of the key objectives of the workplan is to develop an understanding of how groundwater pumping may influence streamflow in the San Joaquin River. The GSAs plan to complete development of the interconnected surface water workplan by October 1, 2022. Upon completion of the workplan, the GSAs will submit the workplan to DWR. Key considerations and topics to potentially be addressed in the workplan include the following:

- Summary of existing surface water monitoring
- Overview of existing groundwater level monitoring in relation to surface water and surface water monitoring
- Review of groundwater pumping and monitoring
- Improvements to subsurface hydrogeologic characterization related to shallow clays and perched groundwater conditions including review of results from recently completed aerial electromagnetic surveys of the area
- Construction of shallow hydrogeologic cross-sections in the vicinity of the San Joaquin River
- Evaluation of groundwater levels at different depths and understanding of vertical hydraulic connections
- Identification of sites for additional characterization through lithologic borings, monitoring well construction, and pumping testing activities
- Review of numerical modeling results and simulation approaches to evaluate stream seepage responses to groundwater management activities
- Recommendations and implementation plans for future surface water and groundwater monitoring
- Recommendations on future analytical activities and numerical model improvements and any associated field studies that may be needed, including thalweg surveys, rating curve development, or other activities
- Considerations related to coordination of monitoring for any new recharge projects in western areas of the Subbasin

2.2.3 Water Budget Information (23 CCR § 354.18)

The Chowchilla Subbasin is managed by four GSAs (CWD GSA, Madera Co GSA, Merced Co GSA, TTWD GSA) whose jurisdictional areas have been organized into five Subbasin subregions for GSP planning efforts (**Figure 2-78)**. These subregions include: CWD GSA, Madera Co GSA – East, Madera Co GSA – West, Sierra Vista Mutual Water Company (SVMWC), and TTWD GSA.

This section presents the historical and current water budgets for the entire Chowchilla Subbasin refined with information and knowledge gained during the assembly of individual water budgets for each of the five subregions within the Subbasin.

DWR has published guidance and Best Management Practice (BMP) documents related to the development of GSPs (DWR, 2016), including Water Budget BMPs. Consistent with these BMPs, this section presents the water budget development methodology and results to describe the hydrologic systems within the Study Area, and includes estimates of uncertainty for various water budget components. An estimate of the sustainable yield of the Chowchilla Subbasin is provided at the end of this section for (1) the reference historical period (1989-2014 hydrologic conditions and land use), (2) the current period (2015 land use with 1989-2014 average hydrologic conditions), and (3) the projected future period (2041-2090) following the GSP implementation period (2020-2039) using projected future land use and historical 1965-2015 hydrologic data.

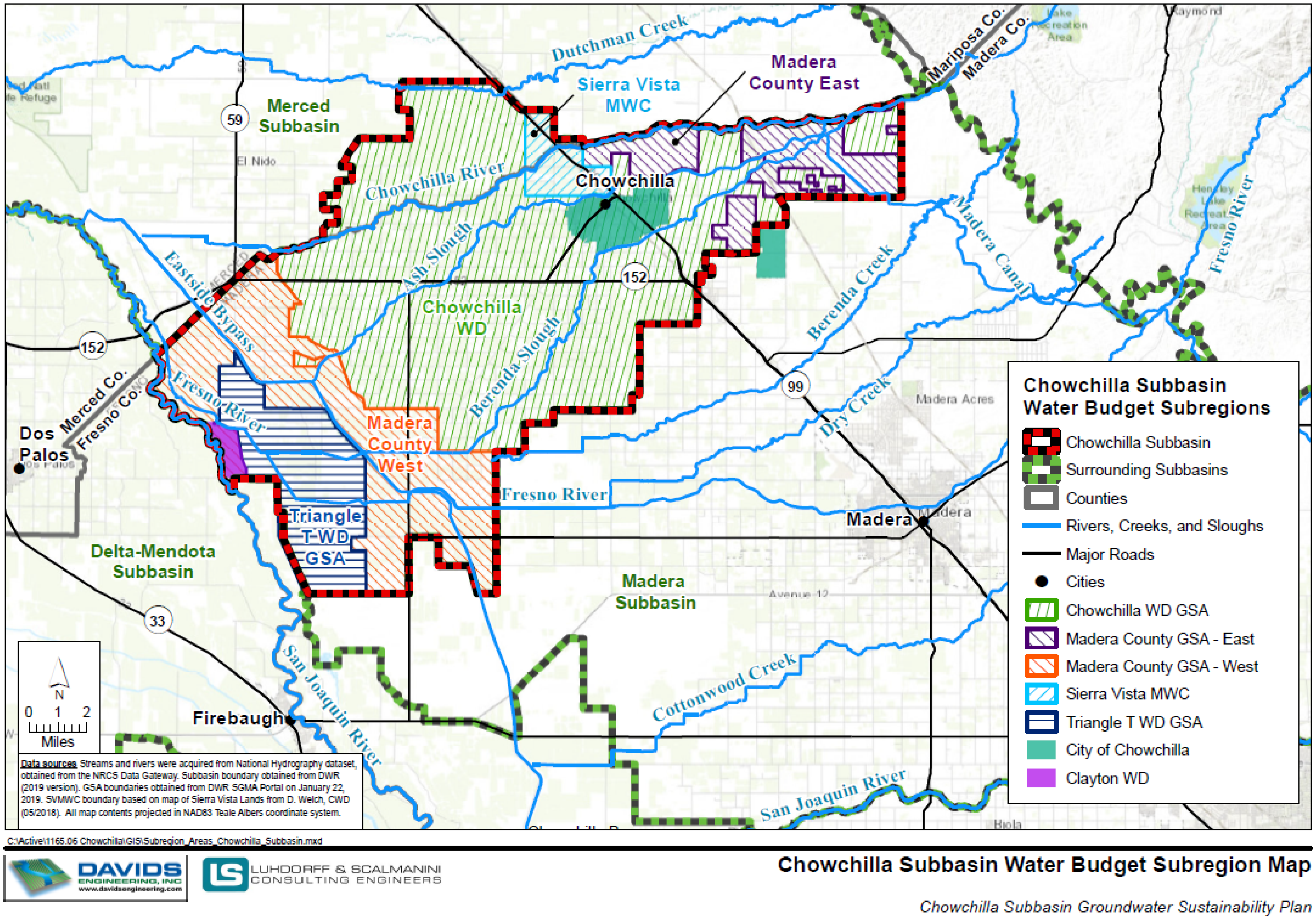

Figure 2-78. Chowchilla Subbasin Water Budget Subregions.

2.2.3.1 Water Budget Conceptual Model

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[38] over a specified period of time. When the water budget volume is an entire subbasin, the water budget facilitates assessment of the total volume of groundwater and surface water entering and leaving the subbasin over time, along with the change in the volume of water stored within the subbasin. When applied to a GSA or subregion, this method also facilitates assessment of the total volume of surface water entering and leaving a defined GSA or subregion boundary.

The conceptual model for the Chowchilla Subbasin and subregion water budgets was developed during previous data collection and analysis efforts conducted by DE and LSCE (2017). This conceptual model is consistent with the GSP regulations, adhering to sound water budget principles and practices described in the Water Budget BMPs, including the use of defined water budget accounting centers covering the three-dimensional Subbasin area and defined water budget components quantified according to best available information and science (DWR, 2016).

Water budgets were developed for the Subbasin to characterize historical, current, and projected water budget conditions. These water budgets were developed for the Subbasin and individual subregions utilizing the data sources and procedures outlined in Section 2.2.3.3 below.

2.2.3.1.1 Study Area

The water budget study area is defined as the Chowchilla Subbasin Plan Area, described above in Section 2.1 (23 CCR § 354.8). The lateral and vertical extents of the study area are the same as those defined for the Plan Area.

Similar to the Plan Area, the vertical extent of the water budget study area is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone, within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

During water budget development, the study area was also subdivided into five subregions: CWD GSA, Madera Co GSA – East, Madera Co GSA – West, SVMWC, and TTWD GSA. The relationships between the Chowchilla Subbasin GSAs and subregions is outlined in **Table 2-9**. Each subregion represents either one entire GSA (CWD GSA, TTWD GSA), a portion of one GSA (Madera Co GSA – East, Madera Co GSA – West), or combined areas across more than one GSA (SVMWC).

For each subregion, the SWS water budget was developed based on subregion-specific information describing land use, available surface water supplies, and other flow paths to facilitate estimation of groundwater extraction.

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

Table 2-9. Chowchilla Subbasin GSAs and Water Budget Subregions.

<table>
<tr><th>GSA</th><th>Subregion</th><th>Subregion Abbreviation</th><th>Subregion Area, Acres</th></tr>
<tr><td>Chowchilla Water District GSA</td><td>Chowchilla Water District GSA</td><td>CWD GSA</td><td>85,200</td></tr>
<tr><td rowspan="3">Madera County GSA</td><td>Madera County GSA – East</td><td>Madera Co GSA – East</td><td>11,400</td></tr>
<tr><td>Madera County GSA – West</td><td>Madera Co GSA – West</td><td>31,200</td></tr>
<tr><td rowspan="2">Sierra Vista Mutual Water Company</td><td rowspan="2">SVMWC</td><td rowspan="2">3,800</td></tr>
<tr><td>Merced County GSA</td></tr>
<tr><td>Triangle T WD GSA</td><td>Triangle T Water District GSA</td><td>TTWD GSA</td><td>14,700</td></tr>
<tr><td colspan="3">Total</td><td>146,300</td></tr>
</table>

2.2.3.1.2 General Water Budget Accounting Structure and Components

For accounting purposes, the water budget is divided into the Surface Water System (SWS) and Groundwater System (GWS), described above. These systems are referred to as *accounting centers*. Flows between accounting centers and storage within each accounting center represent water budget *components*. Separate but related water budgets were prepared for each accounting center that together represent the overall Subbasin water budget. A schematic of the general water budget accounting structure is provided in **Figure 2-79**.

For accounting for water in the SWS, interrelated water budgets were prepared individually for each subregion and for the entire Subbasin. For accounting for water in the GWS, a Subbasin water budget was prepared integrating components in a numerical model of both the SWS and GWS, referred to as the MCSim model. The MCSim model was developed based on the fine-grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSim-FG)

A conceptual representation of the MCSim model water budget accounting centers and components is provided in **Figure 2-80**. Required components for each accounting center are listed in **Table 2-10**, along with the corresponding section of the GSP regulations. Note that precipitation is not explicitly listed as a required water budget component, though it is needed to provide complete accounting of Subbasin inflows and outflows.

Subbasin boundary inflows and outflows must be quantified according to GSP regulations, as stated in 23 CCR § 354.18(b). Inflows and outflows may cross the Subbasin boundary or may represent exchanges of water between the SWS and the underlying GWS within the Subbasin.

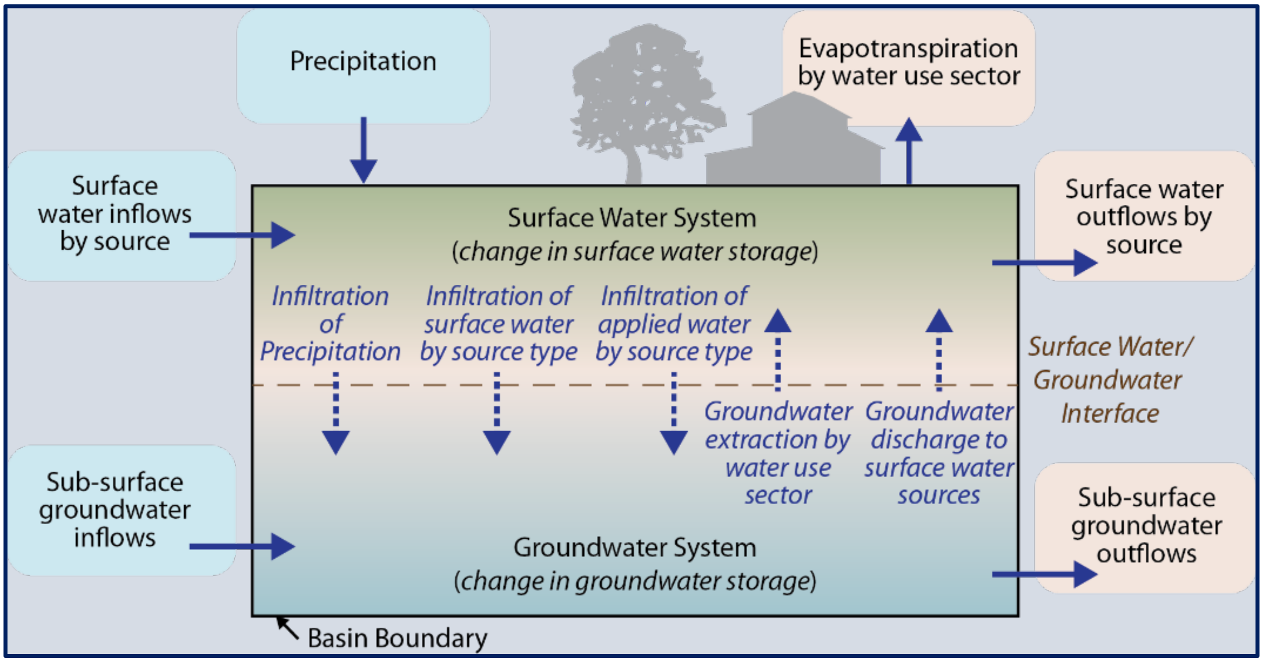

Figure 2-79. Water Budget Accounting Structure (Source: DWR, 2016).

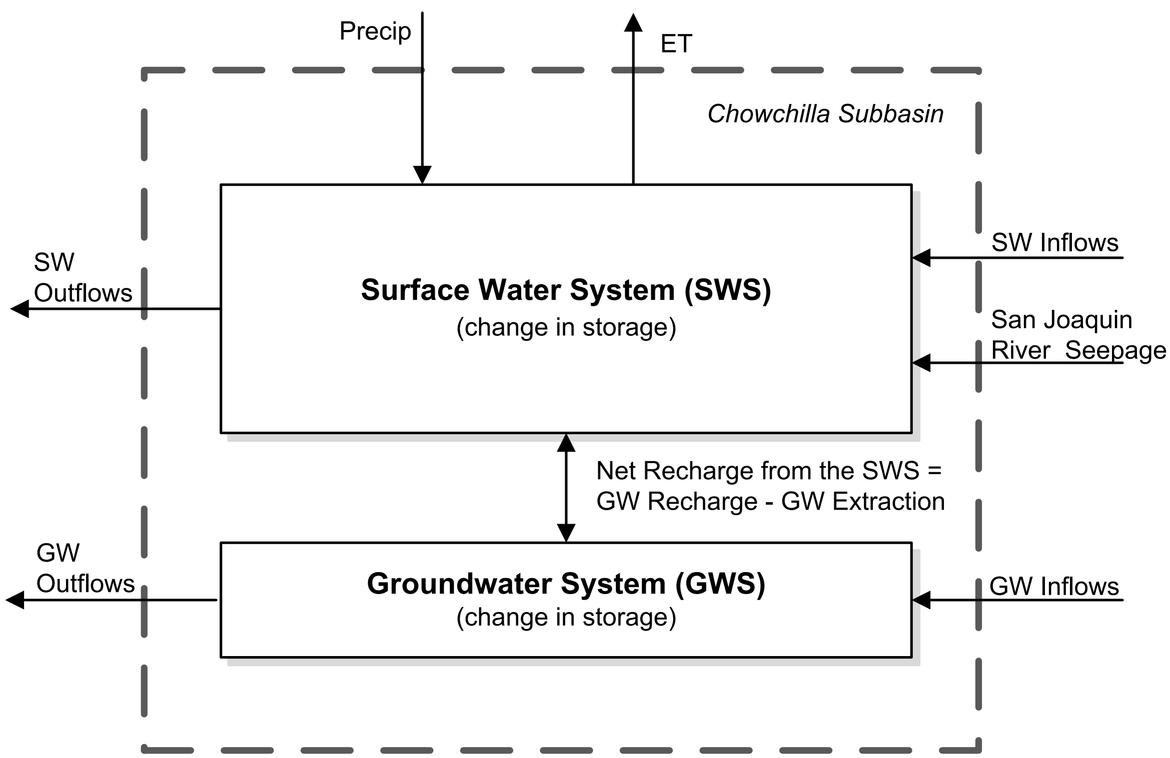

Figure 2-80. Chowchilla Subbasin Boundary Water Budget Diagram.

Table 2-10. Water Budget Components by Accounting Center and Associated GSP Regulations.

Accounting Center	Water Budget Component (flow direction)	23 CCR Section[39]
Basin	Surface Water Inflow[1] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Evapotranspiration[2] (-)	§354.18(b)(3)
	Surface Water Outflow[1] (-)	§354.18(b)(1)
	Subsurface Groundwater Outflow (-)	§354.18(b)(3)
	Change in Storage	§354.18(b)(4)
Surface Water System	Surface Water Inflow[1] (+)	§354.18(b)(1)
	Precipitation (+)	Implied
	Groundwater Extraction (+)	§354.18(b)(3)
	Groundwater Discharge (+)	§354.18(b)(3)
	Evapotranspiration[2] (-)	§354.18(b)(3)
	Surface Water Outflow[1] (-)	§354.18(b)(1)
	Infiltration of Applied Water[3,4] (-)	§354.18(b)(2)
	Infiltration of Surface Water[5] (-)	§354.18(b)(2)
	Infiltration of Precipitation[3] (-)	§354.18(b)(2)
	Change in SWS Storage[6]	§354.18(a)
Groundwater System	Subsurface Groundwater Inflow (+)	§354.18(b)(2)
	Infiltration of Applied Water[3,4] (-)	§354.18(b)(2)
	Infiltration of Surface Water[5] (-)	§354.18(b)(2)
	Infiltration of Precipitation[3] (-)	§354.18(b)(2)
	Subsurface Groundwater Outflow (-)	§354.18(b)(3)
	Groundwater Extraction (-)	§354.18(b)(3)
	Groundwater Discharge (-)	§354.18(b)(3)
	Change in Storage	§354.18(b)(4)

1. By water source type.
2. By water use sector.
3. Synonymous with deep percolation.
4. Includes infiltration of applied surface water, groundwater, recycled water, and reused water
5. Includes infiltration of lakes, streams, canals, drains, and springs. Synonymous with seepage.
6. Includes surface water streams and root zone (not groundwater system).

Boundary inflows include precipitation, surface water inflows (in various canals and streams), boundary watercourse seepage and groundwater inflows from adjoining subbasins. Outflows include evapotranspiration (ET), surface water outflows (in various canals and streams), and groundwater outflows. ET includes: ET of applied water (ET from soil and crop surfaces, of water that is derived from

[39] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents

applied surface water, groundwater, recycled water, and reused water); ET of precipitation (ET from soil and crop surfaces, of water that is derived from precipitation); and evaporation from rivers, streams, canals, reservoirs, and other water bodies. ET of applied water (also identified as ET_{aw}) differs from applied water in that applied water is the volume of water that is directly applied to the land surface by irrigators (from all water sources), whereas ET_{aw} is the volume of that applied water that is consumptively used by crops, vegetation, and soil surfaces.

Also represented in Figure 2-80 are groundwater recharge and extraction, which are "internal" flows between the SWS and GWS. Net recharge from the SWS is defined as groundwater recharge minus groundwater extraction, and is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS. Subbasin boundary inflows and outflows are quantified on a monthly basis, including accounting for any changes in storage, such as changes is water stored in the root zone (Equation 2-1).

Inflows – Outflows = Change in Storage (monthly time step) [2-1]

Selection of the water budget analysis period is discussed in Section 2.2.3.2 below. The specific components of SWS inflows and outflows and the available data and calculation methodology for each component are summarized briefly in Section 2.2.3.3 below. Additional detail regarding inflows to and outflows from each subregion is provided in **Appendix 2.F.** Inflows and outflows were calculated independently using measurements and other data or were calculated as the water budget closure term.

The Subbasin water budget was completed on a monthly time step and water year annual results are reported in Section 2.2.3.4 according to GSP regulations. Detailed SWS water budgets are reported for each individual subregion in **Appendix 2.F.a.** through **Appendix 2.F.e.**

Quantification of GWS inflows and outflows is described below and in **Appendix 6.D.**, Groundwater Model Documentation. The GWS water budget was completed for the entire Subbasin on a monthly time step. Some subregions are small or are composed of noncontiguous small areas, making it difficult to accurately calculate the change in volume of groundwater stored. As a result, GWS water budgets were not calculated for individual subregions.

2.2.3.1.3 Detailed Water Budget Accounting Centers and Components

To estimate the water budget components required by the GSP regulations, the SWS water budget accounting center is further subdivided into detailed accounting centers representing the Land Surface System (irrigated and non-irrigated lands), the Rivers and Streams System (natural waterways), and the Canal System.

Finally, the Land Surface System is subdivided into accounting centers representing water use sectors identified in the GSP regulations as "categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation" (23 CCR § 351(al)). Across the Chowchilla Subbasin and within each subregion, the water use sector accounting centers include Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural), and Native Vegetation Land (NV). Industrial land covers only a small area of the Subbasin, so industrial water uses have been combined with urban and semi-agricultural uses in the Urban land use.

Detailed water budget components are defined for each detailed accounting center. Within the Land Use Sector accounting center, detailed water budget components are also defined for each water use sector accounting center. The addition of these detailed water budget accounting centers and components facilitates the development of water budgets based on the best available data and science by facilitating the incorporation of information from agricultural water management plans (AWMPs), urban water management plans (UWMPs) and other sources.

Water budget components for each detailed accounting center within the Chowchilla Subbasin SWS are described in **Tables 2-11** through **Table 2-13**. These water budget components were independently considered for each subregion to account for unique inflows and outflows to each subregion water budget presented in **Appendix 2.F.**

Table 2-11. Land Surface System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Land Surface System *Water Use Sectors: Agricultural Land, Native Vegetation Land, Urban Land*	Deliveries	Inflow	Deliveries from canal system to customers.
	Riparian Deliveries	Inflow	Deliveries from rivers and streams system to water rights users on lands adjacent to a river or stream.
	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands.
	Precipitation	Inflow	Direct precipitation on the land surface.
	Reuse	Inflow	Reuse of percolated water from the unsaturated zone[40] (considered negligible in the Chowchilla Subbasin).
	ET of Applied Water	Outflow	Consumptive use of applied irrigation water. In wetlands and riparian areas, may represent shallow groundwater uptake.
	ET of Precipitation	Outflow	Consumptive use of infiltrated precipitation.
	Runoff of Applied Water	Outflow	Direct runoff of applied irrigation water, includes tailwater and pond drainage for ponded crops (no ponded crops are grown in the Chowchilla Subbasin).
	Runoff of Precipitation	Outflow	Direct runoff of precipitation.
	Infiltration of Applied Water	Outflow	Percolation of applied water below the root zone.
	Infiltration of Precipitation	Outflow	Percolation of precipitation below the root zone.
	Change in SWS Storage	Storage	Change in SWS storage of applied water within the root zone.

[40] "The unsaturated zone is below the land surface system and represents the portion of the basin that receives percolated water from the root zone and either transmits it as deep percolation to the groundwater system or to reuse within the land surface system, or both." In *Water Budget BMP* (DWR, 2016).

Table 2-12. Rivers and Streams System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Rivers and Streams System	Surface Inflows	Inflow	Surface inflows at upper boundary of water budget area.
	Evaporation	Outflow	Direct evaporation from river and stream water surfaces.[41]
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from rivers and streams to the groundwater system during times of natural flow (during the times that rivers and streams serve as conveyance for irrigation releases, seepage is considered as part of the Canal System accounting center).
	Riparian Deliveries	Outflow	Deliveries from the rivers and streams system to water rights users on lands adjacent to a river or stream.
	Surface Outflows	Outflow	Surface outflows at lower boundary of water budget area.

Table 2-13. Canal System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Canal System	Diversions	Inflow	Diversions from Rivers and Streams System, including lakes and reservoirs in some cases.
	Evaporation	Outflow	Direct evaporation from canal water surfaces (unlined canals are generally maintained to be weed-free, so ET from bankside vegetation is not included).
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from canals to the groundwater system and seepage from rivers and streams during the times that they serve as conveyance for irrigation releases.
	Spillage	Outflow	Spillage resulting from canal operations to the Rivers and Streams System.
	Deliveries	Outflow	Deliveries from the canal system to customers.

2.2.3.1.4 Characterization of Water Budget Components by Hydrologic Year Type

Surface water hydrology of the San Joaquin Valley is characterized by large variability in inter-annual precipitation and runoff resulting in both drought and flooding, sometimes in the same year. In contrast, relative differences in seasonal runoff are more predictable, with rainfall runoff occurring during the winter or snowfall forming snowpack in higher elevations that runs off as it melts in the spring and early summer.

[41] Does not include evapotranspiration of riparian vegetation (accounted in Land Surface System evapotranspiration).

A key Indicator of seasonal variability in inter-annual hydrology is the San Joaquin Valley Water Year Index[42] (WYI), which is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the San Joaquin River Basin. These classifications are termed "water year types." A water year is defined as the period from October 1 of the preceding calendar year to September 30 of the current calendar year. For example, the 2000 water year represents the period from October 1, 1999 to September 30, 2000.

Rivers contributing to runoff from the San Joaquin Basin include, amongst others, the San Joaquin River itself, the Tuolumne River, the Stanislaus River, and the Merced River. The WYI for each year is weighted 80 percent based on unimpaired runoff from the San Joaquin Basin for the current year and 20 percent based on unimpaired runoff from the prior year (expressed in millions of acre-feet (maf)).[43] Unimpaired runoff represents the amount of runoff that would occur in the basin absent any diversions, storage, or inter-basin imports and exports.

The San Joaquin Valley WYI for the 51-year period from 1965 to 2015 is shown in **Figure 2-81**, along with corresponding water year type classifications. During this period, the WYI ranged from 0.81 maf in 2015 to 7.22 maf in 1983, representing a nine-fold difference. The average WYI over this period is 3.2 maf. Historical and recent drought periods are evident in the figure. Notably, only two above normal or wet years occurred between 2007 and 2015, and only four above normal or wet years have occurred between 2001 and 2015.

The distribution of water year types was considered in selecting water budget analysis periods that appropriately represent average historical hydrologic conditions. To support evaluation of differences in water budget components related to variable hydrology, the water year type associated with each year is also shown along with the SWS water budget results reported in section 2.2.3.4 of this report.

2.2.3.2 Water Budget Analysis Period

2.2.3.2.1 Criteria for Base Period Selection

In accordance with GSP regulations, a base period must be selected so that the analysis of sustainable yield is performed for a representative period with minimal bias that might result from the selection of an overly wet or dry period, while recognizing changes in other conditions including land use and water demands.

Per GSP regulations, the historical base period must include a minimum of 10 years of surface water supply information, with 30 years recommended; the current base period must include a representative recent one-year period; and the projected base period must include a minimum of 50 years of historical precipitation, evapotranspiration, and stream flow data.

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[42] California Department of Water Resources, California Cooperative Snow Surveys, *Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices* (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). Last accessed on 2/22/2019.

[43] California Environmental Protection Agency State Water Resources Control Board (SWRCB). 1995. *Water Quality Control Plan for the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary*, pg. 24.

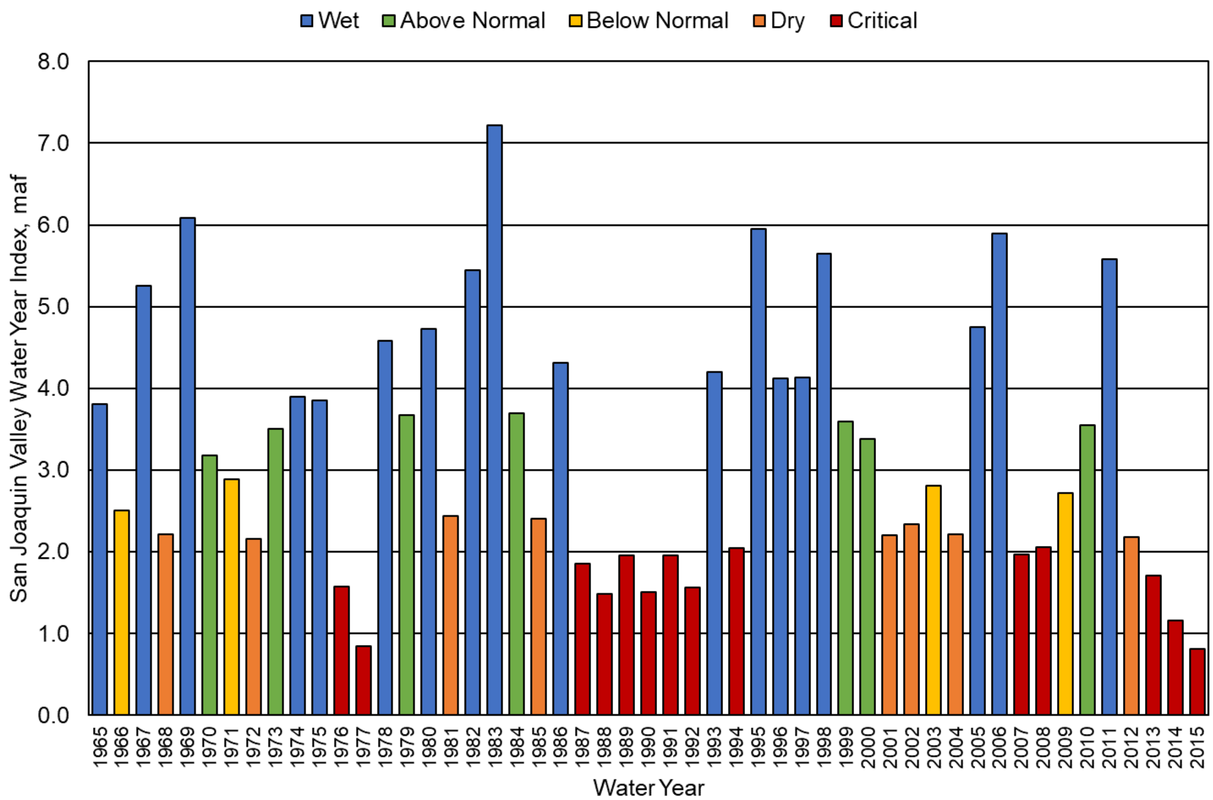

Figure 2-81. San Joaquin Valley Water Year Index, 1965-2015.

The historical, current, and projected water budget base periods were selected on a water year basis considering the following criteria: San Joaquin Valley water year type; long-term mean annual water supply; inclusion of both wet and dry periods, antecedent dry conditions, adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the Subbasin. Historical records of precipitation, unimpaired flows along the Chowchilla River, and USBR Central Valley Project (CVP) supplies served as an indicator of long-term mean water supply and potential for natural groundwater recharge during evaluation of proposed periods.

2.2.3.2.2 Historical Period

For the Chowchilla Subbasin GSP, a 26-year historical water budget base period of water years 1989 through 2014 was selected.

As described in the Data Collection and Analysis Technical Memorandum for Madera County (DE and LSCE, 2017), available data was sufficient to develop a historical water budget for water years 1989 through 2015. However, the 1989 through 2014 period was found to be more representative of long-term average as compared to the 1989 through 2015 following analysis of precipitation, unimpaired flows, and CVP supplies. Due to the comparative dryness of 2015 and corresponding low water supplies that year, including 2015 in the historical period would result in drier average hydrologic conditions than the long-term average.

Precipitation records from a nearby weather station in Madera, including annual precipitation, mean annual precipitation, and cumulative departure[44] from mean annual precipitation, are provided in **Figure 2-82**. As shown, alternating wet and dry periods between the late 1920s and late 1950s were followed by a 20-year average period between the late 1950s and the late 1970s. This was followed by alternating wet and dry periods, an average period between the late 1990s and 2011, and a dry period between 2012 and 2015.

In this context, 1989 to 2014 is a relatively balanced climatic period compared to the 1929 through 2015 period with a similar number of wet and dry years and some prolonged periods of wet, dry, and average conditions, representing a reasonable base period for conducting sustainability analyses.

Historical patterns of CVP supplies along Madera Canal and unimpaired flows[45] along the Chowchilla River are shown in **Figures 2-83** and **2-84**. Given the extremely low CVP supplies and unimpaired flows in 2015, a historical base period of water years 1989 through 2014 was selected.

This period begins in 1989, a critical year preceded by two critical years, and ends in 2014, a critical year with several prior critical or dry years, so that any water unaccounted for in the unsaturated zone is minimized[46]. Lastly, the proposed historical base period ends near the present time so that this period can also be used to assess groundwater conditions as they currently exist.

Thus, the historical base period of 1989 to 2014 provides an appropriate base period for assessing historical groundwater conditions with minimal bias from long-term land use changes or imbalances due to wet or dry conditions.

2.2.3.2.3 Current Period

For the current water budget, land use data from 2015 was used to calculate consumptive use and other root zone components in the Land Surface System water budget. This year was selected as most representative of current land use among years with available data at the initiation of SGMA data collection and analysis work in early 2017. The objective of completing a current water budget is to understand the impact of current land use on the water budget. This requires applying average historical climatic demands and water supplies to the current water budget. This was accomplished by assuming the 2015 land use occurred in each year during the 1989 through 2014 historical base period.

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[44] Cumulative departure curves are useful to illustrate long-term hydrologic characteristics and trends during drier or wetter periods relative to the mean annual precipitation or streamflow. Downward slopes of the cumulative departure curve represent drier periods relative to the mean, while upward slopes represent wetter periods relative to the mean. A steep slope indicates a drastic change in dryness or wetness during that period, whereas a flat slope indicates average conditions during that period, regardless of whether the total cumulative departure falls above or below zero.

[45] Unimpaired flow is defined as flow “that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted.” (DWR, 2007).

[46] Antecedent (i.e., prior or left-over year) dry conditions minimize differences in groundwater in the unsaturated zone at the beginning and at the end of a study period. Given that the volume of water in the unsaturated zone is difficult to determine, particularly at the scale of a groundwater subbasin, selection of a base period with relatively dry conditions antecedent to the beginning and end of the period of record is preferable.

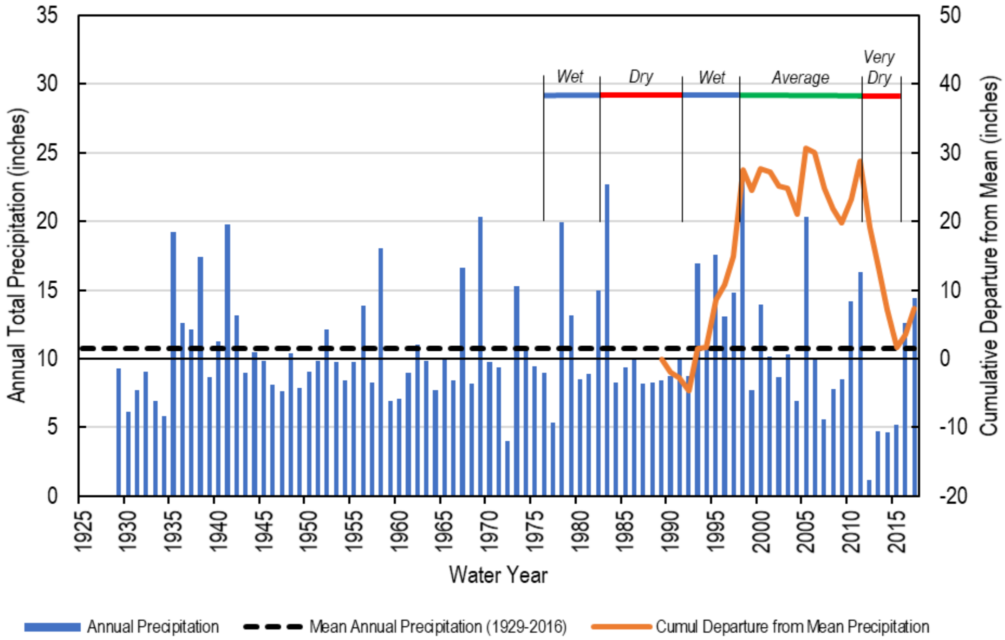

Figure 2-82. Annual Precipitation and Cumulative Departure from Mean Precipitation in Madera, CA.[47]

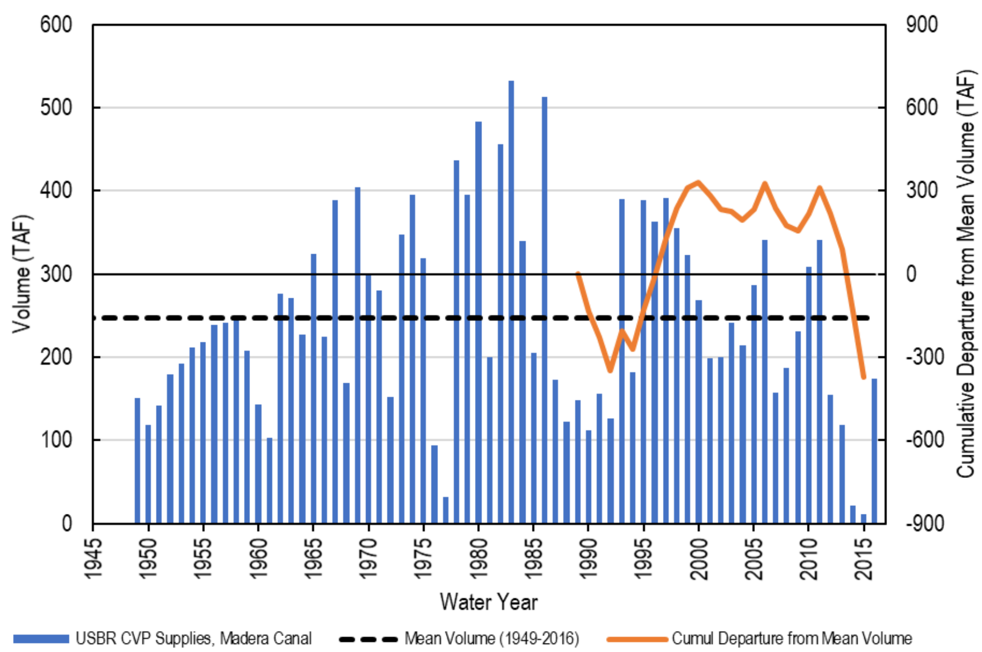

Figure 2-83. Annual CVP Supplies and Cumulative Departure from Mean CVP Supplies along Madera Canal.[48]

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[47] Precipitation data from National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI) Station 045233.

[48] Madera Canal inflows from U.S. Geologic Survey (USGS) Site 11249500 (MADERA CN A FRIANT CA).

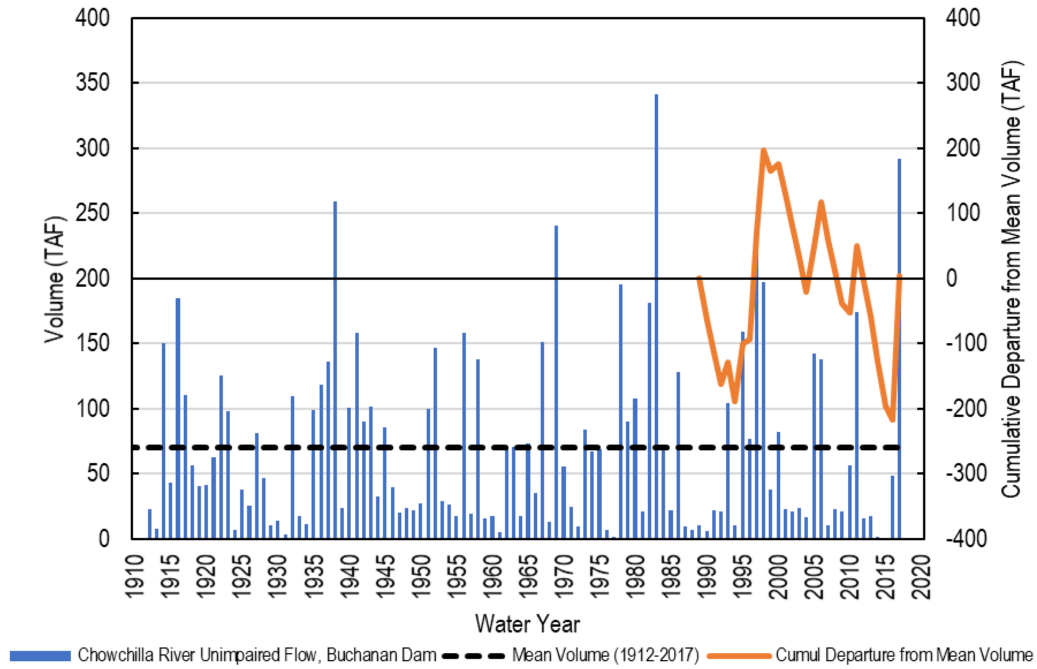

Figure 2-84. Annual Natural Flow and Cumulative Departure from Mean Natural Flow along Chowchilla River at Buchanan Dam.[49]

2.2.3.2.4 Projected Period

For the projected water budgets used to evaluate projects, a 72-year projected period was chosen to provide a 22-year project implementation period from 2019-2040 and a 50-year period to evaluate sustainability from 2041-2090. Time series data for water years 2019-2090 were developed using:

1. Historical hydrologic data from water years 1965-2015
2. Historical water supply data from 1989-2015, with adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program[50]
3. 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090)[51]

[49] Chowchilla River natural flows compiled from: U.S. Army Corps of Engineers (USACE) computed natural flows at Buchanan Lake (1912-1970); U.S. Geological Survey (USGS) Station 11259000 (CHOWCHILLA R BL BUCHANAN DAM NR RAYMOND CA) (1971-1975); USACE computed inflows to Eastman Lake (1976-2017).

[50] Estimated by the Friant Water Authority Report (or Friant Report): "Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California" (2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Madera Canal deliveries under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Steiner Report Kondolf Hydrograph (Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

[51] Land use adjustment for urban area projected growth also accounts for changes in agricultural and municipal water use. See Section 2.2.3.3, "Crop Water Use" and "Urban Water Use."

The first eleven years of the projected period were simulated with hydrologic and water supply data from 2000-2010. Other years were simulated with hydrologic and water supply data matched to each year based on expected similarities in water year indices.

To evaluate sensitivity to climate change, projected water budgets were also developed using:

1. Historical hydrologic data from water years 1965-2015 adjusted by DWR-provided 2030 mean climate change factors[52]
2. Historical water supply data from 1989-2015 adjusted similarly by climate change factors, with additional adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program
3. 2017 land use adjusted for urban area projected growth from 2017 through 2070 (areas were held constant from 2071 through 2090)

2.2.3.2.5 Water Budget Time Step

GSP regulations specify that sustainability analyses be conducted on at least an annual time step. However, a monthly time step is recommended to support evaluation of sustainability indicators and potential PMAs. These sustainability evaluations, which may include analyses involving hydrologic modeling, require data and analyses at a time step sufficient to assess seasonal conditions and trends within an annual interval in addition to long-term trends spanning years.

Water budget calculations were performed on a monthly time step, although certain water budget components identified in Section 2.2.3.3 (e.g. runoff of precipitation) were calculated on a daily basis before being summed to monthly values. For reporting purposes, water budget results are summarized by water year.

2.2.3.2.6 Water Budget Reporting by Analysis Period

The historical and current water budgets were completed for the SWS outside of the MCSim model. The historical budget was used to develop model inputs and to confirm and calibrate model outputs. The current budget was used to estimate the net recharge from the SWS (net recharge), defined as the average annual sum of all groundwater extraction (negative) and groundwater recharge (positive) to and from the surface and root zone overlying the Chowchilla Subbasin. “Shortage” was also calculated from the water budget as the inverse of net recharge (sum of all groundwater extraction (positive) and groundwater recharge (negative) to and from the surface and root zone overlying the Chowchilla Subbasin). This “shortage” was used to inform stakeholders regarding the Subbasin status and to determine the extent of projects and/or demand management required for the Subbasin to reach sustainability.

The projected water budget was completed only in the MCSim model. The projected water budget in the MCSim model was first developed without projects. Then, the projects and/or demand reduction actions developed to bring the Subbasin to sustainability were added to the projected water budget to confirm that these projects and/or demand reduction actions were sufficient to reach sustainability by 2040.

2.2.3.3 Water Budget Components and Uncertainties

This section provides a summary of the data sources and calculations used to develop time series datasets for each component in the Subbasin SWS water budget. The datasets include surface water inflows and outflows, meteorological data used to compute reference crop evapotranspiration (ET_{ref}), land use and

[52] Climate change factors are from the DWR CalSim II simulated volume projections from State Water Project (SWP) and CVP operations under the 2030 mean climate change scenario.

cropping patterns, crop water use (evapotranspiration, or ET), surface water diversions, applied surface water volumes, and groundwater pumping volumes. Each of these datasets is summarized below by accounting center.

2.2.3.3.1 Land Surface System

In the Chowchilla Subbasin, the Land Surface System encompasses all land surface area apart from rivers, streams, and canal systems. As required by the GSP regulations, the total Land Surface System is subdivided into four water budget accounting centers representing Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural land), Native Vegetation Land (NV), and Managed Recharge Land (MR) water use sectors. In the Chowchilla Subbasin, land is not exclusively demarcated for managed recharge, so the MR water use sector represents a small portion of agricultural land receiving flood deliveries for managed recharge during non-irrigation season months.

Water budgets for each water use sector accounting center are developed with distinct, but similar, inflow and outflow components. Water budgets for each water use sector accounting center were developed uniquely for each Chowchilla Subbasin subregion, as described in **Appendix 2.F.**

Detailed Land Surface System water budget components are summarized in **Table 2-14**, including general components included in every water use sector water budget and specific components unique to individual water use sectors. This table also includes a brief description of the estimation methods and information sources for each component.

Meteorological Data

In the Land Surface System water budgets, meteorological data is used directly in calculating precipitation inflows and indirectly in estimating crop consumptive use, or evapotranspiration, and in simulating root zone characteristics over time.

The California Irrigation Management Information System (CIMIS) and National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI) weather stations provide all weather data required for developing time series of many of the Land Surface System water budget components. CIMIS and NOAA NCEI data were obtained and quality controlled following the procedure described in **Appendix 2.F.f.** to develop daily reference crop evapotranspiration (ET_{ref}) and precipitation records for the Chowchilla Subbasin during the water budget analysis periods described in the previous section. **Table 2-15** lists the stations and periods of record used for each station.

Precipitation

Precipitation inflows to each Land Surface System water use sector were calculated as the daily precipitation depth derived from weather station data applied over the total area of that water use sector within the Subbasin. Daily precipitation volumes were summarized to monthly and annual volumes for water budget development. Daily precipitation depths were also provided as inputs to the root zone model to simulate precipitation availability for consumptive use, infiltration, and runoff.

Table 2-14. Land Surface System Water Budget General Detailed Components and Estimation Techniques.

Detailed Component	Category	Water Use Sector	Subregion	Data Type	Calculation/Estimation Technique	Information Sources
Precipitation	Inflow	AG, UR, NV	All	Meteorological Data	Calculated as the precipitation depth over the total land area by Water Use Sector	Madera NCEI, Fresno/Madera/Madera II CIMIS, land use data
Groundwater Extraction/Upflux	Inflow	AG, UR, NV	All	Closure Term	Calculated as the difference of total inflows and total outflows from the Water Use Sector water balance	Closure Term
Surface Water Deliveries	Inflow	AG	CWD GSA	Surface Water Data	Measured by CWD	CWD STORM delivery database, CWD monthly water supply reports
Water Rights Deliveries[1]	Inflow	AG	CWD GSA, Madera Co GSA – East, Madera Co GSA – West, SVMWC, TTWD GSA	Surface Water Data	Reported riparian/appropriative/prescriptive water rights deliveries during flood releases and/or natural flood flows; estimated from streamflow and crop ET when records not available	CWD delivery records, eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Flood Deliveries	Inflow	MR	CWD GSA	Surface Water Data	Measured by water supplier during flood releases outside the irrigation season	CWD STORM delivery database
Evapotranspiration (ET) of Applied Water	Outflow	AG, UR	All	Meteorological Data, Crop Water Use (Root Zone Model)	Estimated by IDC root zone water budget using CIMIS reference ET, precipitation, estimated crop coefficients from energy balance (SEBAL) analysis, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data
Evapotranspiration (ET) of Precipitation	Outflow	AG, UR, NV	All	Meteorological Data, Crop Water Use (Root Zone Model)	Estimated by IDC root zone water budget using CIMIS reference ET, CIMIS precipitation, estimated crop coefficients from energy balance (SEBAL) analysis, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data
Infiltration of Applied Water	Outflow	AG, UR	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Infiltration of Precipitation	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Runoff of Applied Water	Outflow	AG, UR	All	Root Zone Model	Estimated as negligible in the Chowchilla Subbasin	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Runoff of Precipitation	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Change in SWS Storage	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget as net change in root zone water due to consumption or infiltration.	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey

[1] Includes riparian, appropriative, and prescriptive water rights deliveries during flood releases and/or natural flood flows along Subbasin waterways.

Table 2-15. Chowchilla Subbasin Weather Data Time Series Summary.

Weather Station	Station Type	Start Date	End Date	Comment
Fresno State	CIMIS	Oct. 2, 1988	May 12, 1998	Used before Madera CIMIS station was installed.
Madera	CIMIS	May 13, 1998	Apr. 2, 2013	Moved eastward 2 miles in 2013 and renamed "Madera II."
Madera II	CIMIS	Apr. 3, 2013	Dec. 31, 2015	
Madera	NOAA NCEI	Jan. 1, 1928	Dec. 31, 2017	Used for developing ET_{ref} time series for projected water budget period before CIMIS station data was available.

Reference Evapotranspiration

Daily reference crop evapotranspiration (ET_{ref}) was determined by following the scientifically sound and widely accepted standardized Penman-Monteith (PM) method, as described by the ASCE Task Committee Report on the Standardized Reference Evapotranspiration Equation (ASCE-EWRI, 2005). The Task Committee Report standardizes the ASCE PM method for application to a full-cover alfalfa reference (ET_r) and to a clipped cool season grass reference (ET_o). The clipped cool season grass reference is widely used throughout California and was selected for this application. Daily ET_o values were provided as inputs to the root zone model for simulating crop consumptive use requirements.

Root Zone Model

To support water budget development for each Land Surface System water use sector, the IDC daily root zone water budget model was used to develop an accurate and consistent calculation of historical crop ET (ET_c) and other water budget components in the root zone. A daily root zone water budget is a generally accepted and widely used method to estimate effective rainfall (ASCE, 2016 and ASABE, 2007).

Flows through the root zone and plant surfaces of irrigated lands were modeled using a stand-alone tool, that can also be linked to the Integrated Water Flow Model (IWFM), known as the IWFM Demand Calculator (IDC). The physically-based IDC version 2015.0.0036 (DWR, 2015) is developed and maintained by the California Department of Water Resources (DWR). For developing SWS water budgets, a daily IDC was used as a stand-alone root zone model independent of IWFM. For developing the integrated SWS and GWS water budgets in the MCSim model, this daily IDC application was converted to a monthly application, recalibrated to equal monthly flows by component in the SWS water budgets, and then integrated with the Chowchilla Subbasin C2VSim application. The IDC application thus served as the foundation for coupling the SWS water budget to the groundwater model used in GSP development.

IDC was used to develop time series estimates for the following water budget components:

- ET of applied water
- ET of precipitation
- Infiltration of applied water
- Infiltration of precipitation
- Uncollected surface runoff of applied water (estimated as negligible in the Chowchilla Subbasin)
- Uncollected surface runoff of precipitation
- Change in root zone storage

Details regarding the improved crop coefficients used by IDC for estimating ET are described in the Crop Water Use section below. Additional details regarding development of the full IDC root zone water budget, including major inputs, are provided in **Appendix 2.F.g.**

Land Use Data

Accurate land use areas are required for determining crop consumptive use (ET) and for developing an accurate root zone model. Thus, the objective of the land use analysis was to develop Madera and Merced County-wide annual spatial crop acreage datasets from which annual crop areas in the Chowchilla Subbasin and each subregion were derived. The procedure used for land use data development is described in **Appendix 2.A.**

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP regulations) are summarized above in **Section 2.1** Description of the Plan Area (**Figure 2-2** and **Table 2-1**). The Urban land use category includes urban, industrial, and semi-agricultural lands. Industrial land use in the Subbasin covers only a small area, so these lands were included in the Urban water use sector. Between 1989 and 2015, the expansion of agricultural and urban lands has coincided with a reduction in native vegetation across the Subbasin.

Agricultural land uses are also detailed in **Section 2.1** above (**Figure 2-3** and **Table 2-2**). Across the Subbasin, agriculture has historically been dominated by orchard crops, mixed pasture, alfalfa, and corn. In particular, orchard acreage, which includes primarily almonds and pistachios, has more than tripled since 1989. As these crops have higher consumptive water use requirements than many other commodities grown in the Subbasin, agricultural water demand has increased in recent years. Dairy land use and water use are included in the agricultural land water balance in the Chowchilla Subbasin, as the majority of water used by dairies is applied to crops (approximately 90%).

Detailed land use summaries are provided for each subregion in **Appendix 2.F.**

Crop Water Use

The daily IDC root zone water budget application described above was used to develop an accurate and consistent calculation of historical crop ET (ET_c) using the widely accepted reference ET-crop coefficient method (ASCE, 2016). Crop coefficients for major crops, native vegetation, and urban areas were derived from actual ET (ET_a) estimated by the Surface Energy Balance Algorithm for Land (SEBAL) for 2009. Remotely sensed energy balance ET results account for soil salinity, deficit irrigation, disease, poor plant stands, and other stress factors that affect crop ET. Studies by Bastiaanssen, et al. (2005), Allen, et al. (2007 and 2011), Thoreson, et al. (2009) and others have found that when performed by an expert analyst, seasonal ET_a estimates produced by SEBAL are within plus or minus five percent of actual crop ET. For crops grown in the Chowchilla Subbasin, annual historical ET_c was computed by the IDC application using the quality controlled CIMIS ET_o and these local, remote sensing derived crop coefficients. The aforementioned IDC root zone model parsed these ET_c estimates into the ET of applied water and ET of precipitation estimates used in the Chowchilla Subbasin water budgets.

Urban Water Use

Urban water use was computed in the IDC application through the urban land use module (see **Appendix 2.F.g.**). This module simulates demands of municipal water users, including domestic well users, state small water systems, small community water systems, medium and large community water systems, and non-community water systems. Inputs to the urban module include: annual population estimates for urban and residential areas in the Subbasin; groundwater pumping records for City of Chowchilla, or estimates based on annual population records and average per capita water use; fraction of total water used indoors versus outdoors; and parameters dictating runoff, evapotranspiration, and infiltration.

Surface Water Data

In the Land Surface System, surface water inflows primarily include surface water deliveries and riparian, appropriative, or prescriptive water rights deliveries to agricultural lands.

Surface water deliveries are reported by CWD in its monthly water summary records for 1981-2018 and in its STORM deliveries database for 2000-2018. The STORM delivery database is the water ordering and delivery management software used by Chowchilla Water District which is used to track all delivery events to turnouts within the district conveyance system.

Water rights deliveries – including riparian, appropriative, and prescriptive water rights deliveries – are comprised of water that is diverted directly to riparian parcels from adjacent waterways. Deliveries along the Chowchilla River system are reported by monthly or annual district or user records and by the State Water Resources Control Board's Electronic Water Rights Information Management System (eWRIMS). Deliveries along Fresno River to water rights holders in TTWD and Madera County are also reported by eWRIMS. In the water budget, reported water rights diversions are subtracted from the total flows along their respective waterways.

When monthly records are unavailable, annual records are distributed to monthly values in proportion to the monthly pattern of ET of applied water provided by the root zone model during the irrigation season. Missing records were estimated based on the quality control procedures described following the component data source descriptions.

Groundwater Extraction

Groundwater extraction was calculated as the Land Surface System water budget "closure" term – the difference between all other estimated or measured inflows and outflows from each water use sector. Groundwater extraction was selected as the closure term because groundwater pumping data is generally unavailable across the Subbasin. Also, groundwater extraction serves as a relatively large inflow to the Land Surface System, resulting in lower relative uncertainty when calculated as a closure term compared to smaller flow paths following the procedure outlined by Clemmens and Burt (1997).

2.2.3.3.2 Rivers and Streams System

At the Subbasin level, the Rivers and Streams System includes all inflows and outflows from natural waterways that cross a portion of the Subbasin, including intermittent and ephemeral streams. The San Joaquin River, a perennial waterway flowing along the Subbasin boundary, was not explicitly included in the water budgets[53], although estimates of boundary seepage were included in the Subbasin and subregion estimates of net recharge from the SWS.

Detailed Rivers and Streams System water budget components are summarized for the entire Chowchilla Subbasin in **Table 2-16** along with a brief description of the estimation technique and information sources

[53] The San Joaquin River does not cross the lateral boundaries of the Chowchilla Subbasin, as defined above, and San Joaquin River flows are thus not considered surface water inflows to the subbasin within this water budget. A portion of infiltration of surface water from the San Joaquin River is considered to cross the subbasin boundaries into the groundwater system and is included in the calculation of the subbasin estimates of overdraft and net recharge from SWS.

for each. Additional detailed components unique to individual subregion water balances are summarized in **Appendix 2.F.**

Surface Water Data

Surface water data includes primarily surface water inflows and surface water outflows for each of the major waterways within the Chowchilla Subbasin. A surface hydrology map summarizing the Chowchilla Subbasin inflows, outflows, and available data sources is provided in **Figure 2-85**. Surface water diverted under surface water rights is included in the associated agencies' GSA water budgets found in **Appendix 2.F.**

Inflow and outflow data sources and estimation procedures are described for each waterway below.

Chowchilla Bypass

The Chowchilla Bypass is located in the western part of the Chowchilla Subbasin, serving as a flood control channel operated via gates along the San Joaquin River during times when San Joaquin River flows would exceed the river's downstream capacity. Inflow data for Chowchilla Bypass at its head below the control structure were assembled using a combination of DWR's Water Data Library (WDL) records (1982-1991) and California Data Exchange Center (CDEC) records (1997-2017). Daily average flow values were summarized as monthly and annual volumes. Missing records were estimated based on the quality control procedures described following the component data source descriptions.

Subbasin inflows were estimated by adjusting the CDEC and WDL records for estimated seepage and evaporation from the measurement point to the Chowchilla Subbasin boundary inflow point. Downstream of where the Fresno River enters the Chowchilla Bypass, the waterway is known as the Eastside Bypass.

Table 2-16. Subbasin Rivers and Streams System Water Budget Detailed Components and Estimation Techniques.

Detailed Component	Category	Data Type	Waterway	Calculation/Estimation Technique	Information Sources
Surface Inflows	Inflow	Surface Water Data	Chowchilla Bypass	Calculated from SLDMWA CBP station measurements adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	SLDMWA CBP station, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Chowchilla River	Reported Buchanan Dam flood releases	USACE records
			Dutchman Creek	Estimated as equal to Received Legrand water reported by CWD	CWD monthly water supply reports
			Fresno River	Calculated from MID recorder measurements (downstream of convergence with Dry Creek) adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 4, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Madera Canal	Reported Madera Canal flood releases	USBR records for Madera Canal Miles 33.6 and 35.6
Spillage	Inflow	Surface Water Data	Berenda Slough, Ash Slough, Chowchilla River	Reported by CWD monthly records; estimated as average monthly values of available records.	CWD SCADA records
Runoff of Precipitation	Inflow	Meteorological Data	All	Calculated in IDC root zone water budget as daily rainfall runoff using SCS curve number analysis.	Root zone simulation model, NRCS soils characteristics, CIMIS precipitation data
Evaporation	Outflow	Meteorological Data	All	Estimated from reference ET, evaporation coefficient, and estimated water surface area.	Fresno State/Madera/Madera II CIMIS Stations
Infiltration of Surface Water	Outflow	Soils Data	All	Estimated from wetted area and estimated seepage coefficient by soil type	NRCS soil survey, GIS waterway attributes analysis
Flood Diversions	Outflow	Surface Water Data	Chowchilla River, Ash Slough, Berenda Slough	Calculated from CWD delivery records during Buchanan Dam and Madera Canal flood releases	CWD STORM delivery database, CWD monthly water supply reports, USACE records, USBR records
Water Rights Deliveries[1]	Outflow	Surface Water Data	All	Reported riparian/appropriative/prescriptive water rights deliveries during flood releases and/or natural flood flows; estimated from streamflow and crop ET when records not available	CWD delivery records, eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Surface Outflows	Outflow	Closure Term	All	Calculated as the difference of total inflows and total outflows from the Water Use Sector water balance	Closure Term

[1] Includes riparian, appropriative, and prescriptive water rights deliveries during flood releases and/or natural flood flows along Subbasin waterways.

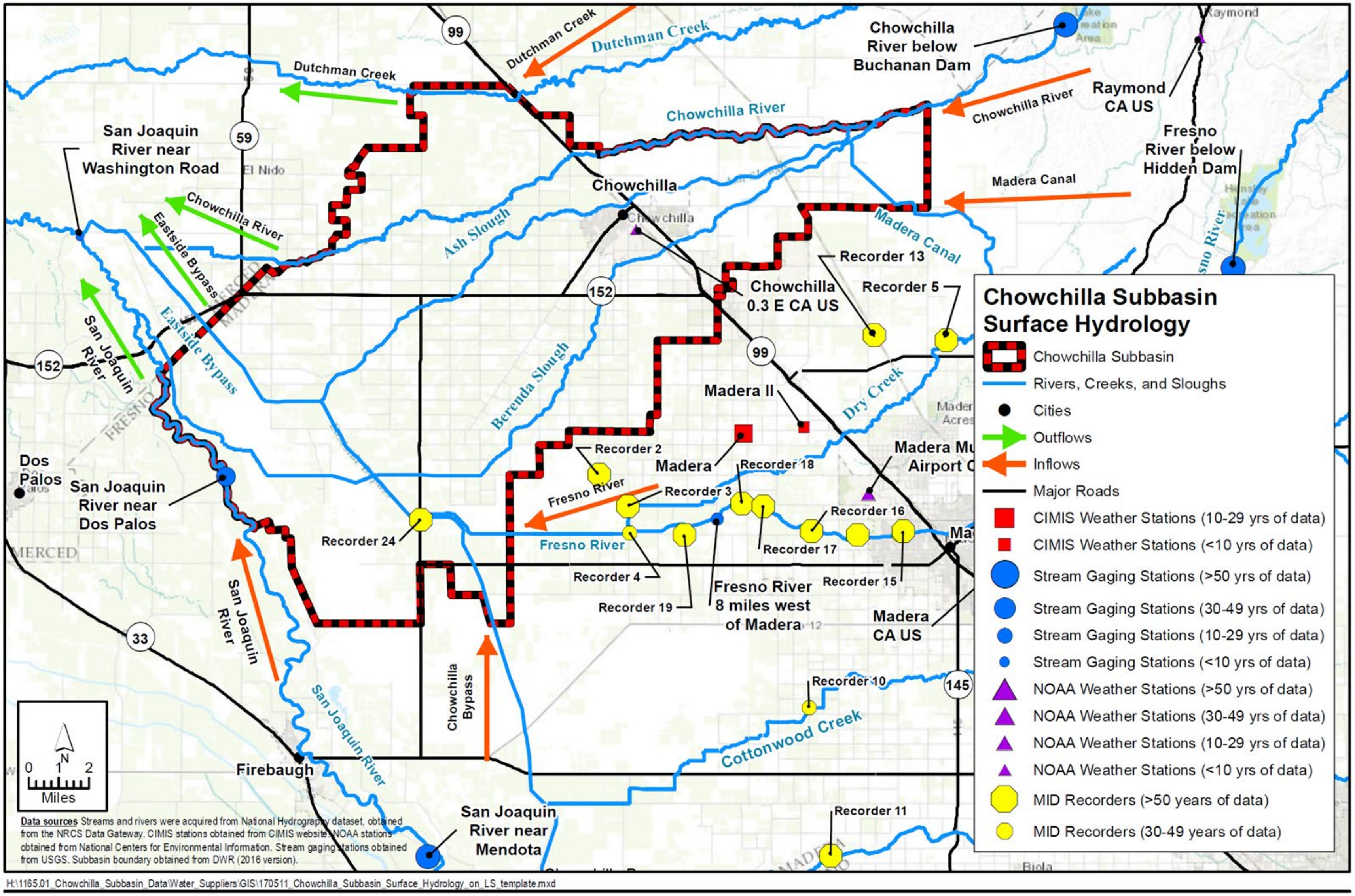

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Figure 2-85. Chowchilla Subbasin Inflows and Outflows.

Chowchilla River

Inflow data for Chowchilla River were assembled from daily USACE records of irrigation and flood releases from Eastman Lake at Buchanan Dam upstream of the northeastern Subbasin boundary. Daily records of irrigation releases and flood releases in cubic feet per second (cfs) were available for 1981-2017.

During non-flood releases, the Chowchilla River is considered part of the CWD conveyance system, while at other times the Chowchilla River is considered a natural waterway. During non-flood releases, flows along Chowchilla River reach C-2 also contribute seepage that is allocated to SVMWC, per an agreement between SVMWC and CWD. Irrigation releases and water rights deliveries are accounted as inflows to the CWD GSA Canal System and/or SVMWC Rivers and Streams accounting center, and flood releases are accounted as inflows to the Subbasin Rivers and Streams System.

Subbasin inflows along Chowchilla River to the Rivers and Streams System were estimated by adjusting the associated daily data for estimated seepage and evaporation along the portion of the river downstream of Buchanan Dam and upstream of the Subbasin boundary.

Fresno River

Inflow data for the Fresno River were assembled from records provided by MID from its extensive network of recorders, which measure key inflows and outflows from the MID conveyance system and waterways within the Madera Subbasin. Fresno River inflows to Chowchilla Subbasin were derived from “Recorder 4: Fresno River Rd. 16” records available for years 1951-2018. This recorder measures flow in the Fresno River where it exits the MID service area, downstream of the location where Dry Creek joins the Fresno River and approximately 4 miles upstream of the Subbasin boundary. Thus, Dry Creek flows are accounted as part of the Fresno River inflow.

Surface inflows were estimated from these records with adjustment for estimated seepage and evaporation from the portion of the river downstream of the Recorder 4 measurement site and upstream of the Chowchilla Subbasin boundary.

Madera Canal

The Madera Canal enters the Chowchilla Subbasin along its eastern boundary and runs northwesterly through Madera Co GSA, terminating near the inflows to Ash Slough, Berenda Slough, and the lower Chowchilla River. Located along the canal are two delivery points to CWD at miles 33.6 and 35.6.

Surface inflows to Chowchilla Subbasin were assembled from USBR CVP recorded irrigation deliveries and flood deliveries at Madera Canal Miles 33.6 and 35.6. Daily records of irrigation deliveries and flood deliveries in cubic feet per second (cfs) were provided by CWD for 1978-2018.

During irrigation releases, Madera Canal inflows are considered part of the CWD conveyance system. During flood releases, water discharged from Madera Canal Miles 33.6 and 35.6 are considered to enter natural waterways in the Subbasin. Thus, irrigation releases are accounted as inflows to the CWD GSA Canal System accounting center, and flood releases are accounted as inflows to the Subbasin Rivers and Streams System.

Madera Canal inflows to the Subbasin Rivers and Streams system were estimated from flood release records by adding an adjustment for estimated seepage and evaporation that occurred in the portion of the Madera Canal between the Mile 33.6 and Mile 35.6 measurement points and the Chowchilla Subbasin boundary.

Water Rights Deliveries

Water rights deliveries from the Rivers and Streams System include riparian, appropriative, and prescriptive water rights deliveries to riparian parcels during flood releases and/or natural flood flows along Subbasin waterways. Water rights deliveries data sources are described above in the Land Surface System components descriptions.

Flood Diversions

While irrigation releases from Buchanan Dam and Madera Canal serve as the major source of water delivered by CWD for irrigation, a portion of flood releases is also diverted from waterways within CWD for irrigation. These flood diversions were calculated as the volume of water required to supply reported CWD deliveries during available flood releases from Buchanan Dam and Madera Canal.

Surface water deliveries are reported by CWD in its monthly water summary records for 1981-2018 and in its STORM deliveries database for 2000-2018, as described in the Land Surface System components descriptions above. Daily records of flood releases are available for Buchanan Dam during 1981-2017 and for Madera Canal during 1978-2018.

Spillage from CWD

Excess flows in the CWD conveyance system are released at spill sites into Berenda Slough, Ash Slough, and Chowchilla River. Monthly spillage volumes were assembled from CWD SCADA data available between 1995-2017. Missing records were estimated based on the quality control procedures described following the component data source descriptions.

San Joaquin River

The San Joaquin River flows along the western Subbasin boundary but does not cross the lateral boundaries of the Chowchilla Subbasin. Thus, flow along the San Joaquin River was not explicitly included in surface water inflows to the Subbasin water budget. Only a portion of infiltration of surface water from the San Joaquin River is considered to cross the Subbasin boundaries into the groundwater system and is included in the Subbasin estimates of overdraft and net recharge from SWS.

To develop these seepage estimates, measured inflow data were assembled for 1980-2013 from WDL records of USGS site 11256000 (“San Joaquin River near Dos Palos”), located near the town of Dos Palos in Merced County. Seepage was calculated based on these available inflows and the waterway attributes of San Joaquin River reaches along the Subbasin boundary, following the process described below. These seepage estimates were found to be consistent with San Joaquin River Restoration Study values.[54] For the section of the San Joaquin River bordering the Chowchilla Subbasin, half of the total estimated seepage was assigned to the Subbasin.

Meteorological Data

As in the Land Surface System water budgets, meteorological data from CIMIS and NOAA NCEI weather stations was used in calculating weather-related inflows and outflows to the Rivers and Streams system. These components are summarized below.

[54] Friant Water Users Authority Natural Resources Defense Council. 2002. *San Joaquin River Restoration Study Background Report,* Chapter 2: Surface Water Hydrology.

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified previously in **Table 2-15** multiplied by the waterway surface area and a free water surface evaporation coefficient of 1.05 from UCCE (1989) and ASCE (2016). When, based on streamflow records and related water balances, water was estimated to be in the waterway reach, evaporation was estimated. Evaporation was calculated on a reach-by-reach basis along each waterway and summed for all waterway reaches within the Subbasin and for each subregion.

Runoff of Precipitation

Runoff of precipitation was calculated by the IDC root zone water budget as the component of total uncollected runoff attributed to precipitation. The IDC application uses a modified version of the SCS curve number (SCS-CN) method to estimate runoff of precipitation. Curve numbers are used as described in the National Engineering Handbook Part 630[55] (USDA, 2004, 2007) based on land use or cover type, surface treatments (e.g. straight rows, bare soil), hydrologic condition, and hydrologic soil group. Additional details regarding IDC root zone water budget development are provided in **Appendix 2.F.g.**

Soils Data

As in the Land Surface System water budget, soils data from SSURGO was used in calculating infiltration from the Rivers and Streams System.

Infiltration of Surface Water

Infiltration of surface water (seepage) was calculated based on the wetted area and seepage characteristics of each waterway reach, as determined from a detailed waterway analysis to identify reach dimensions, soil types, soil distribution, and associated seepage characteristics based on NRCS soils data. Seepage was first calculated on a reach-by-reach basis along each waterway and summed for all reaches in each subregion. Total Subbasin seepage was calculated as the sum of seepage in all subregions.

2.2.3.3.3 Canal System

In the Chowchilla Subbasin, the Canal System includes all canals in the CWD conveyance system as well as natural waterways used to convey irrigation releases or water rights deliveries. Other than the TTWD GSA, which uses pipelines to convey water to different areas, all other subregions do not contain subregion-wide irrigation water distribution systems.

Detailed Canal System water budget components are summarized in **Table 2-17** for CWD GSA. This table also includes brief descriptions of the estimation techniques and information sources for each component. Details for each component are briefly summarized below.

[55] Table 1. Runoff curve numbers for agricultural lands.

Table 2-17. Chowchilla Water District Canal System Water Budget General Detailed Components and Estimation Techniques.

Detailed Component	Category	Data Type	Calculation/Estimation Technique	Information Sources
Irrigation Releases from Buchanan Dam	Inflow	Surface Water Data	Reported Buchanan Dam irrigation releases	USACE records
Irrigation Releases from Madera Canal	Inflow	Surface Water Data	Reported Madera Canal irrigation releases	USBR records for Madera Canal Miles 33.6 and 35.6
Flood Diversions to CWD	Inflow	Surface Water Data	Calculated from CWD delivery records during combined Buchanan Dam and Madera Canal flood releases	CWD STORM delivery database, CWD monthly water supply reports, USACE records, USBR records
Infiltration of Surface Water (Seepage)	Outflow	Closure Term	Calculated as the difference of total inflows and total outflows from the Canal System water budget	Closure Term
Evaporation	Outflow	Meteorological Data	Estimated from reference ET, evaporation coefficient, and estimated canal surface area.	Fresno State/Madera/Madera II CIMIS Stations
Spillage	Outflow	Surface Water Data	Reported by CWD monthly records; estimated as average monthly values of available records.	CWD SCADA records
Surface Water Deliveries	Outflow	Surface Water Data	Measured by CWD	CWD STORM delivery database, CWD monthly water supply reports
Water Rights Deliveries during Irrigation Releases	Outflow	Surface Water Data	Reported riparian/appropriative/prescriptive water rights deliveries to growers in TTWD, SVMWC and Madera Co GSA – East and Madera Co GSA – West during irrigation releases	CWD delivery records

Surface Water Data

Surface water data includes diversions of irrigation releases and flood releases from various sources and surface water outflows from canals, including spillage and deliveries. Inflow and outflow data sources and estimation procedures are briefly described below.

Irrigation Releases to CWD

Diversions to the CWD distribution system include irrigation releases from Buchanan Dam along the Chowchilla River and irrigation releases from Madera Canal at Mile 33.6 and Mile 35.6. Irrigation releases from both sources converge and are distributed downstream along Chowchilla River, Berenda Slough, and part of Ash Slough. These waterways serve as an integral part of the CWD conveyance system as they are used to distribute water to CWD canals. For water budget accounting, diversions to CWD include all irrigation releases from Buchanan Dam and Madera Canal at the measurement points described for each waterway in the Rivers and Streams System component descriptions above. Daily records of irrigation releases were available for Buchanan Dam during 1981-2017 and for Madera Canal Mile 33.6 and 35.6 during 1978-2018.

Flood Diversions to CWD

Flood diversions to CWD are described in the Rivers and Streams System component descriptions above

Spillage

Spillage from the CWD conveyance system is described in the Rivers and Streams System component descriptions above.

Surface Water Deliveries

Surface water deliveries from the CWD conveyance system are described in the Land Surface System component descriptions above.

Water Rights Deliveries during Irrigation Releases

Water rights deliveries include all riparian, appropriative, and prescriptive water rights deliveries to riparian parcels. These deliveries occur during both the irrigation releases and flood releases and/or natural flood flows along Subbasin waterways. When appropriative and prescriptive water rights deliveries coincide with irrigation releases, they are accounted for within the CWD Canal System water budget. Data sources for all Water rights deliveries are described above in the Land Surface System components descriptions.

Meteorological Data

As in the Land Surface System and Rivers and Stream System water budgets, meteorological data from CIMIS and NOAA NCEI weather stations was used in calculating evaporation from the CWD Canal System.

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified in **Table 2-15** multiplied by the free water surface evaporation coefficient of 1.05 from UCCE (1989) and ASCE (2016) and the total surface area of CWD canals and waterways used in conveying irrigation releases.

Soils Data

As in the Land Surface System and Rivers and Streams System water budgets, soils data from SSURGO was used in calculating infiltration from the Canal System.

Infiltration of Surface Water

Similar to the Rivers and Streams System water budgets, infiltration of surface water (seepage) can be calculated based on the wetted area and seepage characteristics of each subregion’s conveyance system. However, due to the relative uncertainty of canal wetted area characteristics and soil conditions combined with higher certainty of diversions to the canal system and deliveries from the canal system, seepage was instead calculated as the Canal System closure term. During non-flood releases along the Chowchilla River, some seepage along reach C-2 is allocated to SVMWC. Per an agreement between SVMWC and CWD, 70% of non-flood seepage along reach C-2 is allocated to SVMWC, and 30% is allocated to CWD.

2.2.3.3.4 Inflow and Outflow Data Quality Control

Quality control procedures were applied to identify data gaps and data values outside of plausible ranges. Data gaps were filled with monthly estimates based on available daily, monthly, or annual data and historical average monthly patterns of streamflow and crop water demand by hydrologic water year type according to the San Joaquin Valley WYI described in Section 2.2.3.1 above.

Surface Water Data

For months with missing surface water data, the monthly volume was estimated as the average volume of that same month calculated across all years of the same water year type. When the number of years with available data for developing water year type monthly averages was less than five, the five water year types were grouped into simply “Wet” and “Dry” years. “Wet” years were defined as wet or above normal, and the “Dry” years were defined as below normal, dry, or critical.

For years with annual stream inflow/outflow data, monthly volumes were estimated as a portion of the measured annual volume distributed by the average monthly pattern of flow observed during water years of the same type.

For years with annual deliveries or diversions data, monthly volumes were estimated as a portion of the measured annual volume distributed by the average monthly pattern of crop water demand as calculated by the IDC root zone water budget for lands receiving those deliveries.

Meteorological Data, Soils Data, and Root Zone Water Budget Inputs

Quality control procedures applied to meteorological data, soils data, and other data prepared for IDC root zone water budget development are described in **Appendix 2.F.f** and **2.F.g.**

2.2.3.3.5 Uncertainties in Water Budget Components

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

1. The uncertainty in each independently estimated water budget component is estimated as a percentage representing approximately a 95% confidence interval. These uncertainties are estimated based on professional judgement.
2. Assuming random, normally-distributed error, the standard deviation is estimated as the confidence interval divided by 2 for each independently estimated component.

3. The variance is estimated for each component as the square of the standard deviation for each independently estimated component.
4. The variance in the closure term is estimated as the sum of variances for each independently estimated component.
5. The standard deviation in the closure term is estimated as the square root of the sum of variances.
6. The 95% confidence interval in the closure term is estimated as twice the estimated standard deviation.

Estimated uncertainties were calculated following the above procedure for the Subbasin water budgets as well as all subregion water budgets. **Table 2-18** provides a summary of typical uncertainty values associated with major SWS inflows and outflows. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

2.2.3.4 Historical Water Budget Analysis

The conceptual water budget model for the Chowchilla Subbasin and the subregions identified in **Table 2-9** was previously presented and discussed in Section 2.2.3.1. It is structured to include separate but related water budgets for the SWS and for the underlying GWS.

This section presents SWS water budget components within the Chowchilla Subbasin as per GSP regulations for the historical base period (1989 through 2014) and 2015. These are followed by a summary of the water budget results by accounting center. The historical water budgets for each subregion are presented and discussed in **Appendices 2.F.a.** through **2.F.e.** along with summaries of subregion land use data relevant to water budget development.

2.2.3.4.1 Surface Water Inflows

Surface water inflows include surface water flowing into the basin across the basin boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

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

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Local Supplies

Local supply inflows to the Chowchilla Subbasin include surface water inflows along Chowchilla Bypass; pre-1914, riparian, and prescriptive water rights on the Chowchilla River; and water received from Legrand Dam.

Local Imported Supplies

Chowchilla Subbasin does not receive local imported supplies.

CVP Supplies

Agencies with CVP contracts can receive CVP supplies in the Chowchilla Subbasin. These CVP supplies include Buchanan Dam irrigation and flood releases received via Chowchilla River and Millerton Reservoir irrigation and flood releases received via Madera Canal. Millerton Reservoir releases are diverted to Chowchilla Water District from Madera Canal Mile 33.6 and Mile 35.6. Irrigation releases from both sources are accounted as inflows to the CWD GSA water budget Canal System, while flood releases are accounted as inflows to the Subbasin Rivers and Stream System.

Table 2-18. Estimated Uncertainty of Subbasin Water Budget Components.

Flowpath Direction (relative to SWS)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	5%	Estimated streamflow measurement accuracy
	Deliveries	Measurement	6%	Estimated delivery measurement accuracy (accuracy required for Reclamation contractors)
	Water Rights Deliveries	Measurement	10%	Estimated measurement accuracy.
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Calculation	20%	Typical uncertainty when calculated for Land Surface System water balance closure;
Outflows	Surface Water Outflows	Measurement	15%	Estimated streamflow measurement accuracy with adjustment for infiltration and evaporation.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and measured streamflow data compared to field measurements.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	20%	Estimated water budget accuracy; typical value calculated for Subbasin-level net recharge from SWS.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within Chowchilla Subbasin.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the Subbasin is considered relatively minimal and is expected to enter the Subbasin along the waterways above as natural flows following relatively large storm events and are accounted as part of local supplies. Precipitation runoff from lands inside the Subbasin is internal to the surface water system and is thus not considered as surface inflows to the Subbasin boundary.

Summary of Surface Inflows

Surface water inflows by water year type are summarized in **Figure 2-86** and **Table 2-19**. During the study period, surface water supplies vary greatly with water year type, with substantial local supply inflows during wet years that are reduced in above normal years and remain relatively constant during all other year types. CVP supplies remain more consistent between years. Total surface water inflows range from under 70 taf during average critical years to over 900 taf during average wet years.

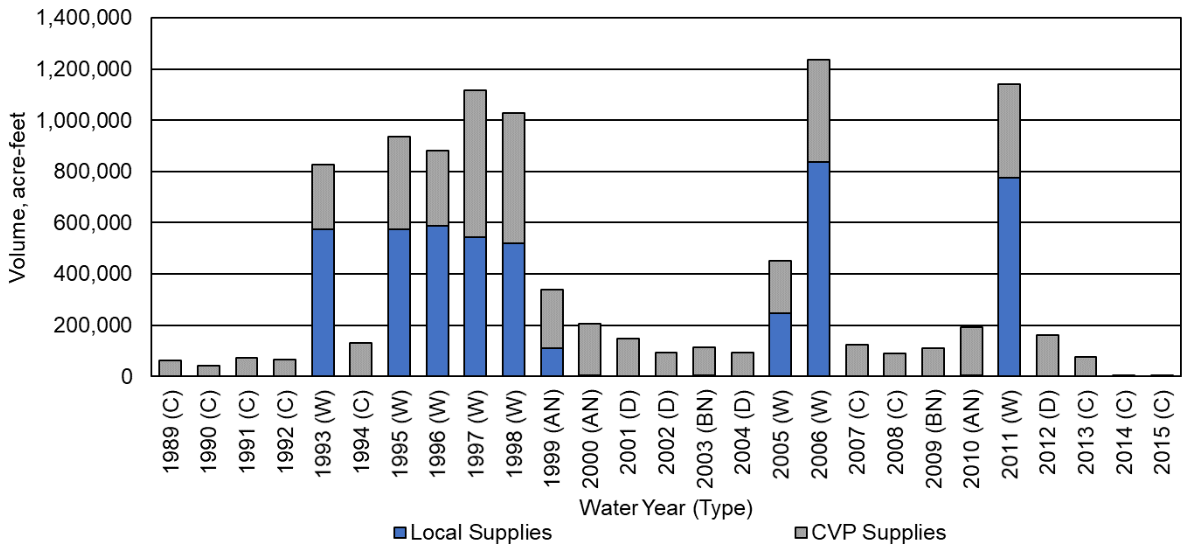

Figure 2-86. Chowchilla Subbasin Surface Water Inflows by Water Source Type.