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Section 3: Sustainable Management Criteria

> *23 CCR § 354.22. Introduction to Sustainable Management Criteria: This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.*

The Sustainable Groundwater Management Act (SGMA) requires each Groundwater Sustainability Agency (GSA) to develop a Groundwater Sustainability Plan (GSP, or Plan) that outlines definitions of “significant and unreasonable” impacts to sustainability indicators (California Water Code [CWC] § 10727(a)). Furthermore, SGMA defines Sustainable Management Criteria (SMC) as measurable steps towards a Sustainability Goal, which culminates in the absence of undesirable results within 20 years of Plan implementation.

SGMA defines six sustainability indicators (CWC § 10721(x)), which are used to determine if “significant and unreasonable” impacts occur for beneficial users and uses of groundwater:

1. Chronic Lowering of Groundwater Levels,
2. Reduction of Groundwater Storage
3. Seawater Intrusion
4. Degraded Water Quality
5. Land Subsidence
6. Depletions of Interconnected Surface Water (ISW)

This Section focuses on all sustainability indicators except for “Seawater Intrusion” which does not apply to the Basin. The avoidance of significant and unreasonable impacts to sustainability indicators is guided by SMC, which include three components:

- Minimum thresholds (MTs): “a numeric value for each sustainability indicator used to define undesirable results” (23 CCR § 351(t))

- Measurable Objectives (MOs): “specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin” (23 CCR § 351(s))

- Interim Milestones (IMs): “a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan” (Title 23, California Code of Regulations (23 CCR § 351(q)))

SMC are thus “management goalposts” that inform discrete actions to be taken over the management and implementation horizon and provide a quantitative means to evaluate progress towards the Sustainability Goal. The scientifically-informed SMC presented herein have been designed to protect beneficial uses and users of groundwater in the basin against significant and unreasonable impacts that may be caused by unsustainable groundwater management, and reflect the values expressed in stakeholder-driven discussions. The specific beneficial uses and users this Plan emphasizes include domestic, agricultural, and public wells,[1] groundwater dependent ecosystems (GDE),[2] and interconnected surface waters (ISW) that support sensitive aquatic habitats and species such as salmonids.[3] Detailed Technical Memoranda for each of these uses and users are provided as Appendices to this Section; within this Section, an overview of these uses and users and the specific, quantitative criteria that demonstrate the avoidance of significant and unreasonable impacts to these users is presented and explained.

The SMC for groundwater levels, storage, and interconnected surface water have been co-developed within an integrated approach to promote ease and efficiency of monitoring and interpretation. As more information is collected, and understanding of the Basin improves over time, certain SMC may change, for instance, during five-year Plan updates. However, at the time of Plan submission, the SMC in this Section reflect the best available science applied to the sustainable management of groundwater in the Basin. These SMC will ensure the Basin operates in a steady condition over the implementation horizon, and achieves then maintains the Sustainability Goal beyond the implementation period ending in 2042.

This Section of the Plan first presents the Sustainability Goal (**Section 3.1**). Next, significant and unreasonable definitions for each of the six sustainability indicators are presented and discussed (**Section 3.2**), followed by SMC for each sustainability indicator – these include MTs (**Section 3.3**), followed by MOs and IMs (**Section 3.4**). Finally, the network of Representative Monitoring Points at which SMC will be measured for each sustainability indicator (**Section 3.5**) is described, and data gaps to be addressed during the implementation period are reviewed.

3.1 Sustainability Goal (23 CCR § 354.24)

> *23 CCR § 354.24. Sustainability Goal: Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.*

The Sustainability Goal of the Basin is to protect and ensure the long-term viability of groundwater resources for domestic, urban, agricultural, industrial, and environmental beneficial users of groundwater. The Sustainability Goal will be achieved by rigorous assessment of potential impacts to these beneficial users, and scientifically-informed management that avoids significant and unreasonable impacts to beneficial uses and users of groundwater.

The overarching Sustainability Goal of the Basin is rooted in a vision of cooperative, multi-benefit, multi-stakeholder coordination to protect all beneficial uses and users of groundwater

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[1] See **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria** (October 1, 2021)

[2] See **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin** (April 21, 2021)

[3] See **Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management** (June 18, 2021)

and maintain a healthy, sustainable groundwater basin through the implementation period and beyond. This Plan acknowledges that climate change, unplanned growth, and complex inter-basin coordination all challenge sustainable groundwater management. Thus, this Plan advances solutions to these challenges via:

- SMC rigorously tested on data and modeling of historical and projected groundwater use, analyzed specifically with respect to the most sensitive groundwater users (vulnerable wells, GDEs, and ISW) and designed to avoid significant and unreasonable impacts to these users;
- the shared use of a regional integrated surface and groundwater model that spans the Basin and neighboring basins to the north and south (North American and Cosumnes basins), thus accounting for inter-basin flows, regional conjunctive use, and projected water use in each basin;
- improved monitoring and scientific studies across the Basin to refine models and address data gaps;
- substantial inter-basin and inter-agency coordination on conjunctive use projects and management actions already underway (**Section 4**) that are estimated to increase net basin storage over the implementation period and that will support sustainable pumping, bolster well reliability, improve GDE water access, and maintain critical surface water flows.

Next, undesirable results for beneficial users of groundwater are defined and quantified, which informs the following sections detailing SMC designed to avoid these undesirable results.

3.2 Undesirable Results (23 CCR § 354.26)

> *23 CCR § 354.26. Undesirable Results*
> *(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*
> *(b) The description of undesirable results shall include the following:*
> *(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*
> *(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*
> *(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.*
> *(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

(d) *An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

SGMA states that Undesirable Results occur "when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin". Definitions for undesirable results that pertain to each of the six sustainability indicators are qualitatively presented in this section, and quantitatively defined in the following sections on SMC, including MTs (**Section 3.3**), and MOs and IMs (**Section 3.4**).

3.2.1 Undesirable Results for Chronic Lowering of Groundwater Levels

3.2.1.1 Potential Causes of Undesirable Results

Undesirable Results due to chronic lowering of groundwater levels in the Basin may be caused by an *increase in outflows from groundwater*, a *decrease in inflows to groundwater*, or *a combination of both* that results in substantial groundwater level decline and significant and unreasonable impacts to beneficial users.

Undesirable Results may be caused by a combination of factors, such as excessive groundwater pumping, climate change with increased evapotranspiration and reduced recharge, and unsustainable management of groundwater use in neighboring subbasins.

Sustained groundwater pumping can create undesirable results when it exceeds the basin sustainable yield,[4] which is 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 § 10721(x)(1)). Major uses of groundwater in the Basin include pumping for agricultural, urban, industrial, and rural domestic use. Hence, expansion of groundwater use associated with irrigated agriculture, groundwater substitution transfers, urban development, industry, and/or rural residential growth (although *de minimis* extractors are unlikely to substantially impact the overall water budget) that outstrips the Basin's sustainable yield may cause Undesirable Results. Importantly, the Basin may stay within the limits of the sustainable yield, but still cause Undesirable Results in a subarea of the Basin if the spatial distribution of pumping and recharge in the subarea significantly changes and creates local water budget conditions that lead to persistent groundwater level decline.

Climate change is expected to bring an increasingly drier and warmer California climate (Diffenbaugh et al., 2017; Cook et al., 2015) characterized by more frequent, more spatially extensive heat waves and extended droughts (Tebaldi et al., 2006; Lobell et al. 2011) which typically occur during dry summer months. In addition to putting pressure on groundwater extraction to supplement lost surface water supply, an increasingly drier climate will increase evapotranspiration (ET), which may result in increased agricultural demand and less groundwater recharge.

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[4] The Basin sustainable yield in the SASb is expected to increase over time, as conjunctive use projects and management actions add water to groundwater storage during wet years, which may be recovered later as needed during dry years. At the time of writing, sustainable yield estimates are still preliminary.

Extended droughts and heat waves may also reduce precipitation and streamflow, and thus reduce recharge and stream leakage into the Basin from these inputs. Furthermore, streamflow reduction may reduce imported surface water diversions and by extension, recharge from irrigation return flow.

Finally, water management decisions made in adjacent basins may alter cross-basin hydraulic gradients and thus reduce stream leakage and subsurface inflow from adjacent basins or reverse the flow direction altogether. Inter-basin coordination and cross-boundary flow management is critical.

The GSAs in the Basin will coordinate with the relevant agencies and stakeholders – both in the Basin and in adjacent basins – to set SMC and implement projects and management actions that avoid Undesirable Results related to the chronic lowering of groundwater levels.

3.2.1.2 Criteria to Define Undesirable Results

Stakeholder-driven discussions that considered impacts to beneficial users of groundwater helped define the criteria to classify Undesirable Results due to the chronic lowering of groundwater levels. Potential impacts and the extent to which they are considered significant and unreasonable were determined by the GSAs with input by technical advisors and members of the public. During GSP development, potential Undesirable Results (specifically related to groundwater level decline) for beneficial users of groundwater identified by stakeholders included the following issues:

- percentage of domestic, agricultural, or public wells going dry,
- need for well rehabilitation (lowering pumps and deepening wells),
- reduction in the pumping capacity of existing wells,
- financial burden to beneficial users of groundwater,
- adverse impacts to environmental uses and users, including interconnected surface water (ISW) and groundwater-dependent ecosystems (GDEs),
- substantial reduction of surface water flows that threaten salmonid habitat and migration;
- substantial loss of GDEs;
- land subsidence that impacts critical infrastructure (canals and roads).

Based on these values (and the absence of existing or anticipated land subsidence, see **Section 3.2.5**), the level of impact to beneficial users of groundwater level that constitute undesirable results for chronic lowering of groundwater were summarized to three quantitative criteria for vulnerable wells, GDEs, and ISW:

1. **percentage of impacted domestic, agricultural, or public wells exceeds 5% for any well type**

2. **percentage decrease in potential GDE area exceeds 5%**

3. **percentage decrease in ISW reach length exceeds 5%; percentage decrease in the 50th percentile of ISW streamflow exceedance during October-December spawning months exceeds 10% of historical conditions**

The scientific rationale behind Undesirable Results is based on a determination of impact analyses to beneficial users of groundwater and discussed in detail in **Section 3.3.1.1**.

Criteria to define undesirable results for chronic lowering of groundwater are:

> ***Significant and unreasonable chronic lowering of groundwater levels resulting from groundwater extraction occurs when more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years.***

As discussed in **Section 3.3.1**, MTs for groundwater level are based on historic and projected groundwater lows, which occur during the 2012-2016 drought and the drought based on repeated hydrology (a modeling assumption). Thus, declines beyond MTs at 25% of monitoring wells for 3 consecutive years is designed to reflect the anticipated return of a 4 year drought similar in intensity to the 2012-2016 drought, plus an additional 3 years of drought to account for hydrologic uncertainty. Importantly, impacts to beneficial users at these thresholds were tested and do not suggest the presence of significant and unreasonable impacts.

Moreover, SGMA specifies that “chronic lowering of groundwater levels” indicates continued groundwater level decline over the implementation horizon.

> *(CWC § 10721(x)(1)): Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.*

Thus, the quantitative *criteria* to identify Undesirable Results consider reasonable hydrologic variability (e.g., water year type) that may be experienced in the Basin, the interaction of this hydrologic variability with projected water use and climate change at an inter-basin scale, and the long-term trajectory of groundwater levels in non-drought periods.

3.2.1.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Groundwater

Undesirable Results that stem from chronic lowering of groundwater levels will primarily impact shallow well users, ISW, and GDEs. If lowering groundwater levels in confined clays causes land subsidence, critical infrastructure could be impacted, and subsurface contaminants may be mobilized, but projected groundwater budgets do not suggest either of these will happen in the Basin.

If groundwater levels decline, shallow domestic, agricultural, public, and industrial wells that supply groundwater may become partially or fully dewatered and require physical rehabilitation such as pump lowering and well deepening (Gailey et al, 2019; Pauloo et al, 2020; EKI, 2020; Pauloo et al., 2021). Shallow, domestic wells tend to be impacted first as groundwater levels fall, and rural residents may be faced with the significant financial burden of well rehabilitation. Lower groundwater levels also imply increased pumping costs for all groundwater well users, but these costs tend to be negligible compared to the costs of well rehabilitation (EKI, 2020).

The magnitude and direction of depletions of ISW depend on hydraulic gradients between the surface water and adjacent groundwater. Hence, lowering groundwater levels that propagate to streams may steepen hydraulic gradients and cause additional depletions of ISW that reduce in-stream flows, prevent salmonid migration, impact riparian ecosystems, and reduce surface water availability for downstream beneficial users of surface water with riparian or appropriative surface water rights. These beneficial users of surface water may be GSAs and associated users within the Plan area, or users outside of the Plan area.

GDEs are “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR § 354.24(m)). Hence, lowering groundwater levels may disconnect vegetative GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow (especially during dry months), thus impacting riparian ecosystems and aquatic species associated with GDEs.

3.2.1.4 Relationship to Other Sustainability Indicators

Sustainable management of groundwater levels can directly address the avoidance of other sustainability indicators that correlate with groundwater levels. Chronic lowering of groundwater level may impact the other sustainability indicators and GDEs in the following ways:

- **Reduction of Groundwater Storage**: Groundwater level is a two-dimensional representation of groundwater storage (three-dimensional). Lowering groundwater levels generally indicate groundwater storage reduction.

- **Seawater Intrusion**: This sustainability indicator is not applicable in the Basin.

- **Degraded Water Quality**: As in the case of depletions of ISW, lowering groundwater levels may alter hydraulic gradients and thus change groundwater flow paths and cause contaminant migration to previously unimpacted areas. Moreover, lowering of groundwater levels may also leach arsenic-rich water from fine-grained sediments (Smith et al., 2018) in localized areas.

- **Land Subsidence**: Lowering groundwater levels and reduction of storage in certain fine-grained sediments can cause land subsidence and deformation of the land surface that damages critical infrastructure such as canals and roads. Land subsidence is a combination of *elastic* and *inelastic* subsidence. In the latter case, the subsidence incurred is permanent. Such impacts are not anticipated in the Basin.

- **Depletions of ISW**: Groundwater level defines the steepness of the hydraulic gradient between ISW and saturated groundwater, and hence the rate, volume, and direction of ISW depletion. Dropping groundwater levels can result in increased ISW depletion.

- **Impacts to GDEs**: Although not technically a sustainability indicator according to SGMA, GDEs are still a beneficial user of groundwater. Lowering groundwater levels may disconnect GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow, thus impacting GDE-associated aquatic species.

3.2.2 Undesirable Results for Reduction of Groundwater Storage

3.2.2.1 Potential Causes of Undesirable Results

Chronic lowering of groundwater levels is directly correlated with reduction of groundwater storage. Thus, groundwater levels may be used as a proxy for groundwater storage, and the potential causes of Undesirable Results related to reduction in groundwater storage are identical to those related to chronic lowering of groundwater levels (**Section 3.2.1.1**).

3.2.2.2 Criteria to Define Undesirable Results

Due to the direct correlation between groundwater levels and storage, the quantitative criteria used to determine Undesirable Results due to reduction of groundwater storage are identical to those for chronic lowering of groundwater levels (**Section 3.2.1.2**):

> ***Significant and unreasonable reduction of groundwater storage resulting from groundwater extraction occurs when more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years.***

Additionally, GSAs will track and project groundwater storage with the CoSANA model, and calibrate groundwater storage estimates based on data collected throughout the Basin.

3.2.2.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Groundwater

As before, potential effects of Undesirable Results on beneficial uses and users of groundwater due to reduced groundwater storage are identical to those outlined due to chronic lowering of groundwater levels (**Section 3.2.1.3**).

3.2.2.4 Relationship to Other Sustainability Indicators

Potential effects of Undesirable Results on beneficial uses and users of groundwater due to reduced groundwater storage are identical to those outlined due to chronic lowering of groundwater levels (**Section 3.2.1.4**), except that storage and groundwater levels are related in the following manner:

- **Chronic Lowering of Groundwater Levels**: Groundwater storage is the three-dimensional equivalent of groundwater level (two-dimensional) over a depth. Reduction in groundwater storage generally indicates groundwater level decline, and vice versa.

3.2.3 Undesirable Results for Degraded Groundwater Quality

Significant and unreasonable degradation of groundwater quality is the degradation of water quality that would impair beneficial uses of groundwater within the South American Subbasin (SASb) or result in failure to comply with groundwater regulatory thresholds including state and federal drinking water standards and Basin Plan water quality objectives.

The violation of water quality objectives, which are established in accordance with the CWC to protect beneficial uses of waters, is arguably significant and unreasonable. Also, based on the

State's 1968 antidegradation policy,[5] water quality degradation inconsistent with the provisions of Resolution No. 68-16 may also be significant and unreasonable. In the Subbasin, the Central Valley Water Board and the State Water Board enforce compliance with water quality objectives and determine if water quality degradation is inconsistent with Resolution No. 68-16.

Federal and state water quality standards, water quality objectives defined in the Basin Plan, and the management of known and suspected contaminated sites within the Basin will continue to be the jurisdictional responsibility of the relevant regulatory agencies. The role of the GSAs is to provide additional local monitoring and oversight of groundwater quality, report issues to appropriate parties with jurisdiction over water quality, and to evaluate and monitor, as needed, water quality effects of projects and actions implemented to meet the requirements of other sustainability management criteria.

As noted above, groundwater in the Basin is used for a variety of beneficial uses including agricultural, industrial, domestic, and municipal water supply. Groundwater supports groundwater-dependent ecosystems (GDEs) and instream environmental resources in some areas. These beneficial uses, among others, are protected, in part, by the CVRWQCB through the water quality objectives adopted in the Basin Plan. Projects and management actions implemented as a result of the GSP need to consider, and monitor for, potential impacts to groundwater quality that could cause degradation below these water quality objectives and affect beneficial uses of groundwater in the Basin.

The constituents of concern in the Basin, and their associated regulatory thresholds, are listed in **Section 2.3.4**. The quantification of an undesirable result is included in the discussion of maximum thresholds in **Section 3.3.3**.

3.2.3.1 Criteria to Define Undesirable Results

> **More than 10% of groundwater quality wells exceed maximum thresholds in each aquifer zone (1/10 wells and 1/11 wells in the upper and lower zones respectively).**

Maintaining high water quality is important to GSAs, and these conservative criteria reflect that value.

3.2.3.2 Potential Causes of Undesirable Results

Future activities by the SASb GSAs with potential to negatively affect water quality may include changes to pumping in the Basin, declining groundwater levels, and recycled water projects. Altering the location or rate of groundwater pumping could change the direction of groundwater flow, which may result in a change in the overall direction in which existing or future contaminant plumes move and thus, potentially compromise remediation efforts.

The ongoing contaminated site remediation efforts in the Basin as described in **Section 2.1** are effectively managed and are regulated by agencies with jurisdiction over the monitoring, reporting and compliance activities. In the Basin, existing leaks from underground storage tanks (USTs) are currently being managed and additional degradation is not anticipated from these

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[5] State Water Resources Control Board. "Resolution No. 68-16: Statement of Policy with Respect to Maintaining High Quality of Waters in California", California, October 28, 1968.

known contaminant sources. New leaks from USTs may locally impact groundwater quality, depending on the contents of the UST, which may include petroleum hydrocarbons, solvents, or other contaminants. Such sources will be regulated by the State Water Board. Agricultural activities in the Basin are dominated by vineyards and pasture production. The risk for fertilizer nitrate leaching from these activities is considered low (Harter et al., 2017). The Basin is not currently categorized as a priority subbasin for nitrates under the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program managed by the Central Valley Water Board.

3.2.3.3 Potential Effects of Undesirable Results on Beneficial Uses and Users

Concerns over potential or actual non-attainment of the beneficial uses designated for groundwater in the Basin are related to certain constituents measured at elevated or increasing concentrations, and the potential local or regional effects that degraded water quality can have on such beneficial uses.

The following provides greater detail regarding the potential impact of poor groundwater quality on several major classes of beneficial users:

- Municipal Drinking Water Users – Under California law, agencies that provide drinking water are required to routinely sample groundwater from their wells and compare the results to state and federal drinking water standards for individual chemicals (primary and secondary MCLs). Groundwater quality that does not meet state drinking water standards may render the water unusable for that use or may cause increased costs for treatment. For municipal suppliers, impacted wells may potentially be taken offline until a solution is found, depending on the configuration of the municipal system in question. Where this temporary solution is feasible, it will add stress to and decrease the reliability of the overall system.

- Rural and/or Agricultural Residential Drinking Water Users – Residential users not located within the service areas of the local municipal or private water suppliers will typically obtain their water supply through private domestic groundwater wells. Such wells may not be monitored routinely, and their groundwater quality may be unknown unless the landowner has initiated testing and shared the data with other entities. Degraded water quality in such wells can lead to rural residential use of groundwater that does not meet potable water standards and may result in the need for installation of new or modified domestic wells and/or well-head treatment that will provide groundwater of acceptable quality.

- Agricultural Users – Irrigation water quality is an important factor in crop production and has a variable impact on agriculture due to different crop sensitivities. Impacts from poor water quality (e.g., elevated salinity) may include declines in crop yields, crop damage, changes in crops that can be grown in an area, and other effects. Salinity levels in ambient groundwater in the SASb are generally deemed to be high quality and not impacting agricultural uses.

- Environmental Uses – In gaining streams, poor quality groundwater could possibly affect GDEs, instream environments, and their resident species by supplying nutrients to streamflow. However, there are limited gaining stream reaches in the SASb and ambient groundwater has low nutrient levels, greatly reducing such concerns in the Basin.

3.2.3.4 Relationship to Other Sustainability Indicators

Groundwater quality typically cannot be used to predict responses of other sustainability indicators. However, groundwater quality can, in some circumstances, be affected by changes in groundwater levels and reductions in groundwater storage or can affect ISW quality, as described below.

- Groundwater Levels – In some basins, declining groundwater levels potentially can lead to increased concentrations of constituents of concern in groundwater and may alter the existing hydraulic gradient, which can result in the movement of contaminated groundwater plumes. Changes in water levels may also mobilize some contaminants that may be present in unsaturated soils. In such cases, the maximum thresholds established for groundwater quality may influence groundwater level minimum thresholds by affecting the location or number of projects, such as groundwater recharge or conjunctive use projects. In the SASb, these issues are not of general concern. Contaminated plumes are highly regulated and sufficiently managed in the SASb, as described in **Section 2**, including the use of groundwater wells as barriers to prevent plume migration and use of extensive ongoing monitoring networks. Recharge projects will use high quality surface water, which will have a positive impact on nitrate and specific conductivity in the SASb. The Harvest Water project (**Section 4.4.1**) will introduce recycled water with higher nitrate and specific conductivity concentrations than ambient groundwater, but will not cause groundwater quality to exceed maximum thresholds for these constituents of concern (Ascent Environmental, 2020).

- Groundwater Storage – Groundwater quality at or near the maximum threshold for nitrate in specific wells may result in limited use of those wells. The groundwater quality evaluation described in **Section 2.3** indicates that such occurrences in SASb would be rare and would not impact attainment of groundwater storage SMC in SASb. Minor net reductions in groundwater pumping where surface water replaced groundwater supply to address elevated nitrate concentrations would be insignificant.

- Depletion of ISW – Groundwater quality at or near maximum thresholds may affect stream water quality. However, most of the stream reaches within the SASb are losing reaches and, therefore, groundwater quality will not influence surface water quality in these reaches. There are, however, gaining stream reaches, especially within the southern Cosumnes and Mokelumne Rivers. The GSAs and Regional San will evaluate the relationship between surface and groundwater quality data from wells in this area, including Harvest Water monitoring wells, when these data become available. The results of this evaluation will be included in the next five-year evaluation report.

- Seawater Intrusion – This sustainability indicator is not applicable in this Subbasin.

- Subsidence – Subsidence has been evaluated and is not a problem in SASb. Conditions will continue to be monitored but no impacts associated with groundwater quality are anticipated.

3.2.4 Undesirable Results for Depletions of Interconnected Surface Water

3.2.4.1 Potential Causes of Undesirable Results

Depletions of ISW are related to chronic lowering of groundwater levels via changes in the hydraulic gradient. Darcy's Law is a fundamental tenet of groundwater hydrogeology that explains this ISW depletion.[6] It states that the amount of water that flows through an aquifer (e.g., ISW depletion) is proportional to the hydraulic gradient (in this case, the difference between stream stage elevation and adjacent groundwater elevation).

Hence, declines in groundwater level which increase the hydraulic gradient also increase ISW depletion. Due to the strong dependence of increased ISW depletion on lowering of groundwater levels, the potential causes of Undesirable Results due to depletions in ISW are identical to those for groundwater level decline (**Section 3.2.1.1**).

Interestingly, increased streamflow due to climatic variability (or conjunctive use that leaves more water in streams) may increase the duration of stage elevation at times and thus increase the stream to groundwater hydraulic gradient and hence, ISW depletion. In fact, the CoSANA integrated hydrologic model shows that wet periods are associated with increased seepage into groundwater along major surface water bodies. However, increases in stream seepage due to relatively wet conditions should not be confused with ISW depletion caused by unsustainable groundwater management, but rather, hydrologic and streamflow variability. Taking this hydrologic behavior into consideration, monitoring of near-stream groundwater levels which represent the impacts of *pumping*, are used to develop SMC and monitor for ISW depletion, instead of the hydraulic gradient. Reduced streamflow and reduced baseflow to streams, particularly during dry critical salmonid migration months (October – December) may threaten aquatic ecosystems, thus special attention is paid towards the maintenance of flows during these dry months in projected management scenarios.

3.2.4.2 Criteria to Define Undesirable Results

> *23 CCR § 351(o): "Interconnected surface water" refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.*

Active ISW depletion is occurring in the basin according to CoSANA-calculated stream seepage and data analysis that indicates losing conditions (i.e., groundwater elevation less than stream stage elevation along major surface water reaches at seasonal time scales (**Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management**). ISW depletion shown in the CoSANA model and data analyses are explained by historical groundwater pumping in the Basin and adjacent basins. Therefore, this Plan acknowledges that ISW depletion is occurring in the Basin, and extends the assumptions and methodology of Hall, Babbitt, Saracino, and Leake (2018), that a basin with active ISW

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[6] Darcy's Law, $Q = K \cdot A \cdot i$ states that the volumetric rate of flow *Q* is proportional to the hydraulic conductivity (*K*, or resistance to flow), the cross-sectional area (*A*, in this case, of the streambed), and the hydraulic gradient *i* (in this case, the difference between stream stage and adjacent groundwater level). Thus, as the difference in stream stage and groundwater level increases, say due to groundwater pumping, the hydraulic gradient (*i*) increases, which makes streamflow depletion (*Q*) increase.

depletion should emphasize management actions that arrest groundwater levels, which arrest hydraulic gradients, and finally, arrest streamflow depletion.

Given the practical difficulty of measuring stream seepage (it must be modeled), and the strong dependence of ISW beneficial users on streamflow during critical months, the criteria to define undesirable results for ISW depletion are based on maintaining ISW locations (not disconnecting ISW) and maintaining ISW flows (not depleting surface flows), rather than maintaining ISW seepage (although this is calculated and discussed).

First, historical and present-day groundwater and surface water data (**Section 2.2**) are used to classify surface water reaches as "Interconnected" or "Disconnected," in order to separate ISW from surface water that is *not* "hydraulically connected at any point by a continuous saturated zone to the underlying aquifer." Disconnected reaches are considered out of the scope of sustainable groundwater management due to persistent disconnection from groundwater over the period of record from spring 2005 to present-day fall 2019 (**Appendix 3-A**). Depths to groundwater along Disconnected reaches are significantly lower than the bottom of the streambed clogging layer, and thus disconnected from actions that affect the groundwater levels in the Basin. Actions developed for groundwater management by the GSAs are not expected to have an impact on Disconnected reaches. After reaches are classified as Interconnected (ISW) or Disconnected, SMC are developed for ISW reaches.

CoSANA was used to estimate ISW locations, depletion volume, rate, and streamflow near the groundwater level MT (**Section 3.3.1**), which represents a worst-case ISW depletion scenario. Then, MTs for ISW depletion (**Section 3.3.4**) are defined at representative wells consistent with groundwater level and groundwater storage MTs such that hydraulic gradients are maintained at or above critical levels to avoid significant and unreasonable impacts. Importantly, the wells selected to monitor ISW depletion were chosen because they represent changes in groundwater level caused by groundwater pumping, and not near-stream influences, like stream seepage. Each ISW monitoring well is assigned to particular stream reach, and paired with stream gages. Three locations lack adequate, high-frequency, stream gage and groundwater monitoring and these are discussed in the Data Gap subsection, **Section 3.5.5**. Finally, a detailed monitoring well selection criteria is available in **Appendix 3-A**.

Significant and unreasonable depletion of ISW occurs when the percentage decrease in ISW reach length exceeds 5%, or when percentage decrease in the 50th percentile of ISW streamflow exceedance during October-December spawning months exceeds 10% of historical conditions. The rationale behind these criteria is that anything less than a maintenance of roughly current conditions plus reasonable hydrologic variability constitutes an undesirable result. Impacts to ISW were simulated at groundwater level MTs to confirm the avoidance of undesirable results. Using groundwater level at wells as a proxy:

> ***Significant and unreasonable depletion of interconnected surface water resulting from groundwater extraction occurs when more than 25% (3/10 wells) of representative monitoring wells for ISW fall below their MTs for 3 consecutive years.***

Importantly, MTs associated with ISW depletion are measured at a subset (10 wells) of the groundwater level monitoring network (see **Appendix 3-A** for details), and thus, a particular reach may temporarily experience impacts but the Basin as a whole does not experience undesirable results. It is important therefore, to remember that over the implementation period and beyond, modeling suggests that ISW conditions are expected to remain similar to current conditions or improve, although climate change uncertainties may pose challenges.

3.2.4.3 Potential Effects of Undesirable Results on Beneficial Uses and Users of Surface Water

Depletions of ISW caused by groundwater level decline may impact riparian and wetland ecosystems, habitat, fish, special species, recreation, and other environmental users of surface water. Moreover, beneficial users of surface water inside and outside of the basin (e.g., water rights holders) may be impacted by streamflow reduction caused by ISW depletion resulting from unsustainable groundwater management. Lowering groundwater levels may disconnect vegetative GDEs from saturated groundwater or reduce baseflow to streams that depend on groundwater baseflow. A detailed overview of the beneficial users and uses of surface waters is provided in **Appendix 3-A**.

3.2.4.4 Relationship to Other Sustainability Indicators

Increased ISW depletion results from chronic lowering of groundwater levels when lowering groundwater levels and reduction of groundwater storage lead to an increase in the stream-aquifer hydraulic gradient, and hence, increased depletion. Therefore, by effectively managing groundwater levels that reflect an expanding cone of depression in centers of pumping, ISW depletion can also be managed. Moreover, monitoring and forecasting basin-wide storage also provides a big picture view of how ISW depletion may be impacted, although spatially distributed changes in groundwater level are much more useful in isolating local-scale ISW impacts.

3.2.5 Undesirable Results for Land Subsidence

An undesirable result occurs when subsidence substantially interferes with beneficial uses of groundwater and surface land uses.

3.2.5.1 Potential Causes of Undesirable Results

Subsidence occurs due to of compaction of (typically) fine-grained aquifer materials (i.e., clay) resulting from groundwater overdraft, however these aquifer materials are only moderately present in the Subbasin, mainly constricted to the western side of the Basin, and groundwater depletion estimates are not sufficient to lead to significant land subsidence.

3.2.5.2 Criteria to Define Undesirable Results

Significant and unreasonable subsidence is not historically observed in the Basin. The aquifer materials are only moderately likely to present such a risk and only in certain areas of the Basin. Therefore, it is reasonable to declare that any moderate land subsidence caused by the chronic lowering of groundwater levels at a greater magnitude than historically observed occurring in the Basin would be considered significant and unreasonable.

Pumping-induced inelastic subsidence of greater than 0.1 foot [0.03 m] in any single year and a cumulative 0.5 foot [0.15 m] in any five-year period (across the region of greatest land subsidence in the basin) could significantly interfere with surface land use if left unmonitored.

This is set at the same magnitude of estimated error in the Interferometric Synthetic Aperture Radar (InSAR) data (+/- 0.1 foot [0.03 m]), which is currently the only tool consistently available for this Basin for measuring subbasin-wide land subsidence consistently each year.

3.2.5.3 Potential Effects of Undesirable Results on Beneficial Uses and Users

Undesirable Results would occur when substantial interference with land use occurs, including significant damage to critical infrastructure such as building foundations, roadways, other urban infrastructure elements, canals, pipes, and other water conveyance facilities, including flooding agricultural practices.

3.2.5.4 Relationship to Other Sustainability Indicators

By mainly managing groundwater pumping and avoiding the undesirable result of chronic lowering of groundwater levels, the possibility of land subsidence will be mitigated. Mitigating land subsidence through sustainably managed groundwater levels in the Basin will also mitigate impacts to undesirable groundwater storage declines.

3.2.6 Undesirable Results Summary

Table 3-1: Summary of Criteria to Identify Undesirable Results for Each Sustainability Indicator

Sustainability Indicator	Criteria to Identify Undesirable Results
Chronic lowering of Groundwater Levels	*More than 25% (12/45 wells) of representative monitoring wells for groundwater level and storage in the Basin fall below their MTs for 3 consecutive years.*
Reduction of Groundwater Storage	*Criteria for Chronic Lowering of Groundwater Levels (above) used as proxy (**Section 3.3.2**).*
Degraded Groundwater Quality	*More than 10% of groundwater quality wells exceed maximum thresholds in each aquifer zone (1/10 wells and 1/11 wells in the upper and lower zones respectively).*
Depletion of Interconnected Surface Water	*More than 25% (3/10 wells) of representative monitoring wells for ISW fall below their MTs for 3 consecutive years.*

3.3 Minimum Thresholds (23 CCR § 354.28)

> *23 CCR § 354.28. Minimum Thresholds*
>
> *(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.*
>
> *(b) The description of minimum thresholds shall include the following:*
>
> *(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.*

> *(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.*
> *(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.*
> *(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.*
> *(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.*
> *(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.*

Minimum thresholds (MTs) are numeric values set at Representative Monitoring Points (RMPs), that quantitatively define the values that may cause Undesirable Results for a given Sustainability Indicator if exceeded during the planning and implementation horizon. This section presents MTs for each Sustainability Indicator in the Basin.

3.3.1 Minimum Threshold for Chronic Lowering of Groundwater Levels

23 CCR § 354.28. Minimum Thresholds

> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> > *(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:*
> > > *(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.*
> > > *(B) Potential effects on other sustainability indicators.*

Of all the sustainability indicators, groundwater levels are the easiest to understand and monitor, they directly relate to key beneficial uses of water, they can be used to interpolate groundwater level maps over space and time which are key for analysis, and they provide valuable calibration targets for groundwater flow models. For these reasons, this Plan emphasizes MTs and a monitoring approach built on groundwater level data, and relating the groundwater storage and ISW depletion sustainability indicators to the chronic lowering of groundwater levels, and GDE beneficial users. This, in this subsection, MT development for chronic lowering of groundwater is related to vulnerable wells, GDEs, and ISW.

3.3.1.1 Minimum Threshold Development

Minimum thresholds for chronic lowering of groundwater levels in the Basin were defined based on an analysis of historical, present-day, and projected groundwater level trends. Moreover, MT development considered climate change and extended drought conditions that may pose challenges to achieving the Plan’s MOs during the implementation time horizon, as well as simulations of projects and management actions that improve basin storage and increase groundwater levels.

CWC §10727.2(b)(4) states that "The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015". Thus, the starting assumption in setting Basin MTs is that a return to previously experienced historically low groundwater level conditions observed after 2015-01-01 would *not* result in significant and unreasonable impacts to beneficial uses and users of groundwater. By contrast, groundwater level declines *in excess* of relatively recent groundwater level lows experienced in the Basin around 2015-01-01 could represent unknown, significant and unreasonable impacts to beneficial uses and users.

First, these assumptions were tested with modeling and data analysis to estimate impacts to beneficial users (i.e., vulnerable wells, ISW, GDEs) assuming a return to historically low groundwater level conditions observed after 2015-01-01 (henceforth, post-2015 low)[7]. Results suggest minimal impact to beneficial uses and users of groundwater and support the assertion that a return to the post-2015 low would not lead to significant and unreasonable impacts on beneficial uses and users of groundwater.

However, future projected water use, inter-basin changes in flow, and climatic variability may put strain on SASb groundwater levels and cause even lower groundwater levels that those experienced after 2015-01-01. Therefore, a second round of analyses were conducted on 4 scenarios run by the CoSANA model, to "stress test" MTs lower than the post-2015 low caused by the combined effect of projected groundwater use, the impacts of climate change, and the benefits offered by regional conjunctive use and groundwater banking projects[8]. Across all scenarios evaluated, climate change reduced groundwater levels with impacts most acutely observed in ISW and GDEs; vulnerable wells were largely unaffected owing to their relatively deep depths compared to groundwater levels. Being closer to the land surface, GDEs and ISW are more easily impacted. Conversely, projects and management actions (PMA) substantially contributed to basin sustainability by offsetting the impacts of climate change and leading to the avoidance of significant and unreasonable impacts to ISW, GDEs, and vulnerable wells.

Thus, in this Plan, MTs are set at each RMP (**Table 3-4**) at the post-2015 low or the lowest groundwater level in the projected scenario with PMA and climate change, whichever is lower.[9]

The MT can be interpreted as the *lowest anticipated groundwater level assuming moderate temperature increases due to climate change, the best estimate of future water demand from water agencies, and the continued implementation of projects and management actions* (**Figure 3-1**).

Furthermore, because Undesirable Results due to chronic lowering of groundwater occur when "more than 25% (12/45 wells) of representative monitoring wells for groundwater levels and storage in the Basin fall below their MTs for 3 consecutive years" (**Section 3.2.1.2**), and numerical model simulations suggest the lowest groundwater levels during hydrologic conditions experienced from 2012-2016, the definition of, and criteria used to identify Undesirable Results,

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[7] The post-2015 low typically occurs in the fall of 2015 at most RMPs and is thus at times referred to as the "2015 fall low".

[8] For GSP planning purposes, only projects with adequate funding and a high probability of implementation (i.e., Harvest Water, OHWD recharge, regional conjunctive use – see Section 4) were considered. Henceforth these highly feasible, in-motion projects and management actions are referred to as PMA.

[9] In about half of representative monitoring points for groundwater 53% (25/45 wells), projected management and climate change resulted in lower groundwater levels than the post-2015 low, although declines were minimal. The range (0 - 15.3 ft), median (0.5 ft), and mean (2.8 ft) values by which post-2015 lows are exceeded by those implied under the projected scenario tend to occur away from ISW and GDEs and are shown to not impact vulnerable wells.

can be interpreted as *groundwater level conditions comparable to the combined impact of a 7 year-long extended drought*.

Importantly, groundwater levels may at times decline beyond MTs, but in non-drought years and over the long-term 20-year implementation time horizon of the Plan (and beyond), the basin is projected stay above MTs, trend towards Measurable Objectives (MOs), and achieve the Sustainability Goal. The Plan may also be granted an extension of five years beyond the 20-year sustainability timeframe if there is need for an extension, and if the Basin has made progress towards MOs and adopts a feasible work plan for achieving the Sustainability Goal within the extension timeframe (CWC Section 10727.2(b)(3)).

3.3.1.2 Groundwater Level Analysis: trends, water year type, projected water use, well protection, impacts to GDEs, ISW depletion

Groundwater level analysis and interpolation were used to evaluate the impact of historically observed groundwater conditions (and MTs based historical conditions) on well failure (i.e., domestic, agricultural, and public wells), depletions of ISW, and impacts to groundwater dependent ecosystems (GDEs). Although some Basin RMPs have historical groundwater level data as far back as 1970, these monitoring well data are sparse and insufficient for basin-wide interpolation and analysis. However, from spring 2005 to fall 2019, groundwater level data density is adequate for interpolation, thus data during this period were analyzed at a seasonal level (**Figure 3-2**) and used to define MTs .[10] The impact of these MTs on well protection measures, ISW depletion, and impacts to GDEs were assessed and found to not lead to significant and unreasonable impacts.

Trends: Trends, or linear projections based on groundwater level hydrographs over a time frame, were considered but not used to define MTs for two reasons. First, most groundwater level trends at RMPs in the Basin (**Figure 3-4**) are not unambiguously upwards or downwards across the period of record, and hence, in this Basin the direction and magnitude of the resulting trendline is highly sensitive to the selected historical period.[11] Second, the period of record at RMPs are often not equivalent and contain missing data points, which give the points that are present excessive leverage (i.e., outlier influence over the slope of the resulting trendline). Therefore, the approach to define MTs developed in this Plan is based on observed groundwater conditions, water year type, projected water use, well protection, and the avoidance of impacts to ISW and GDEs.

Water Year Type: Hydrographs and interpolated groundwater elevation maps demonstrate seasonal oscillations that correspond to recharge and pumping (**Figure 3-3**), increasing groundwater levels during above normal and wet water year types (**Figure 3-1**), and declining groundwater levels during dry and critical water year types (**Figure 3-1**). Prolonged dry and critical water year types have historically led to increased groundwater use to supplement unavailable surface water supply in the Basin. Conjunctive use and other projects and management actions (see **Section 4**) during wet periods are expected to bolster groundwater levels and thus and reduce groundwater level drawdown in the Basin during dry and critical water year types.

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[10] These groundwater level analyses extend the historical and current groundwater level summary presented in Chapter 2.

[11] Strong dependence of the trendline on the historical period chosen is demonstrated in hydrologic research, which shows that differences in the historical period used to project groundwater level trends can result in significantly different modeling results. For example, Pauloo et al., 2000 demonstrate that the difference between 1998-2017 and 2008-2017 linear groundwater level projections leads to a doubling of estimated well failure in California’s Central Valley.

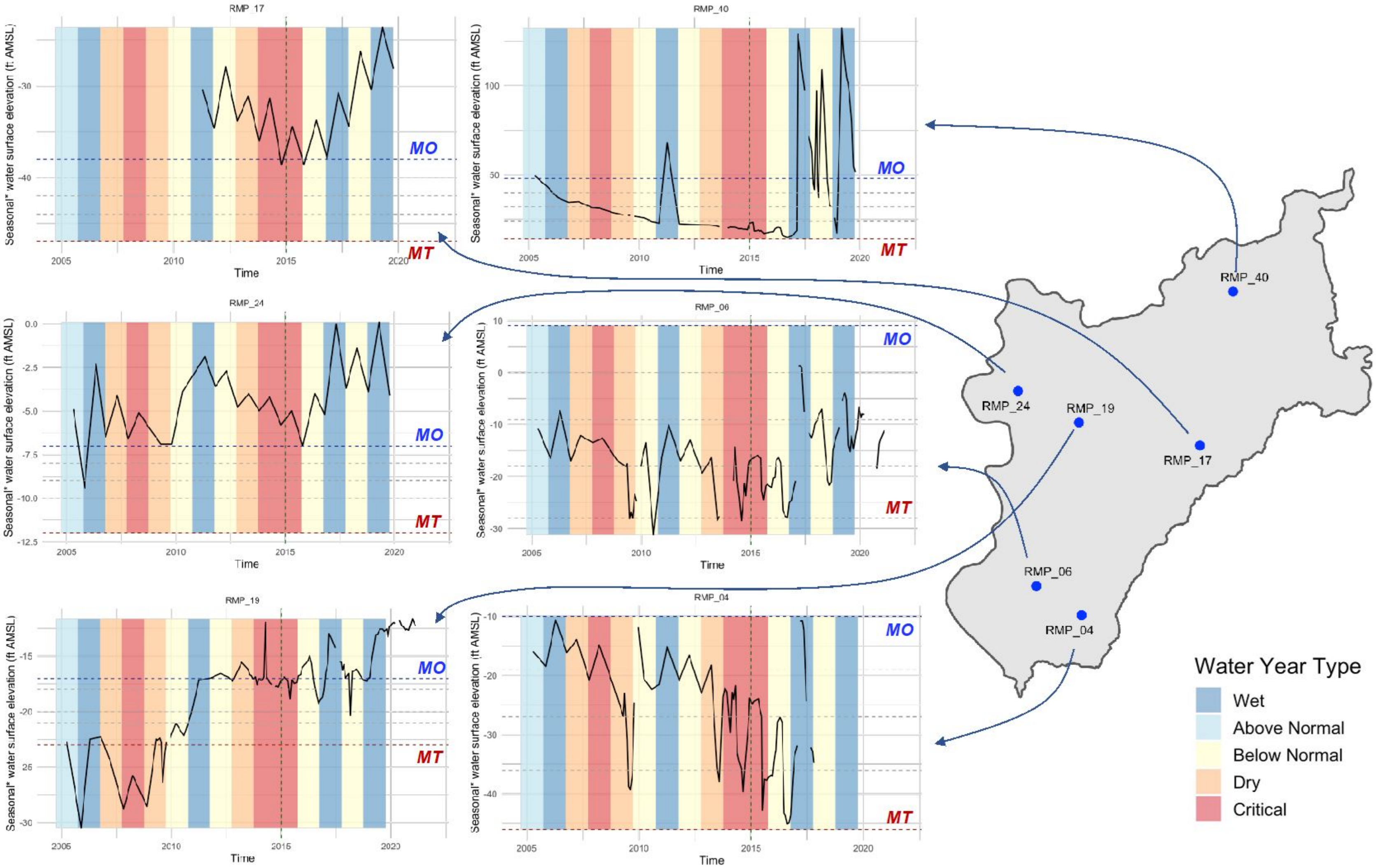

Figure 3-1: MTs, MOs, and IMs at 6 example RMPs in the GSP groundwater elevation monitoring network (Figure 3-13). MTs (red vertical dashed lines) are set at the lowest level in the projected budget (first column of hydrographs) or the 2015 low (second column of hydrographs), whichever is lower. MOs are set at the mean post-2015 low groundwater level and adjusted by the head difference between the 2015 low and the projected budget – for instance, this difference is negative where declines are expected, and positive within and near the Harvest Water plan area (a groundwater mound is expected). Interim milestones are spaced at integer values between the MT and MO. A green vertical dashed line at 2015-01-01 is drawn for reference.

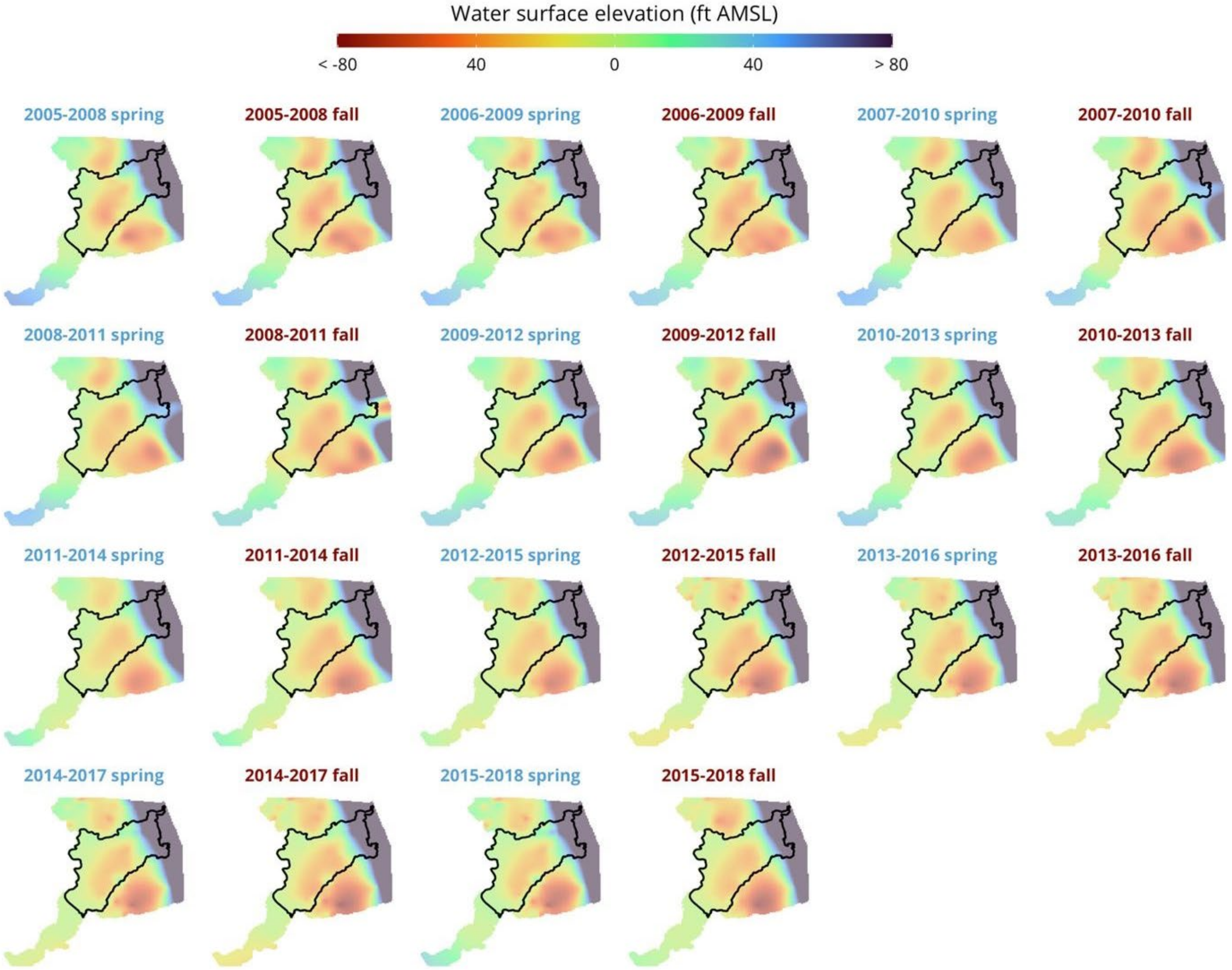

Figure 3-2: **Seasonal, 4 year running mean interpolated groundwater elevations in the Basin from spring 2005 to fall 2018.** Levels show seasonal oscillation, with generally higher (blue) groundwater elevation in spring, and generally lower (red) groundwater elevation in the fall. Higher elevations occur along surface water corridors (north, south and west basin boundaries). Groundwater flows from areas of high (blue) to low (red) elevation. Mapping suggests groundwater flow inwards towards the center of the basin, coincident with areas of groundwater pumping.

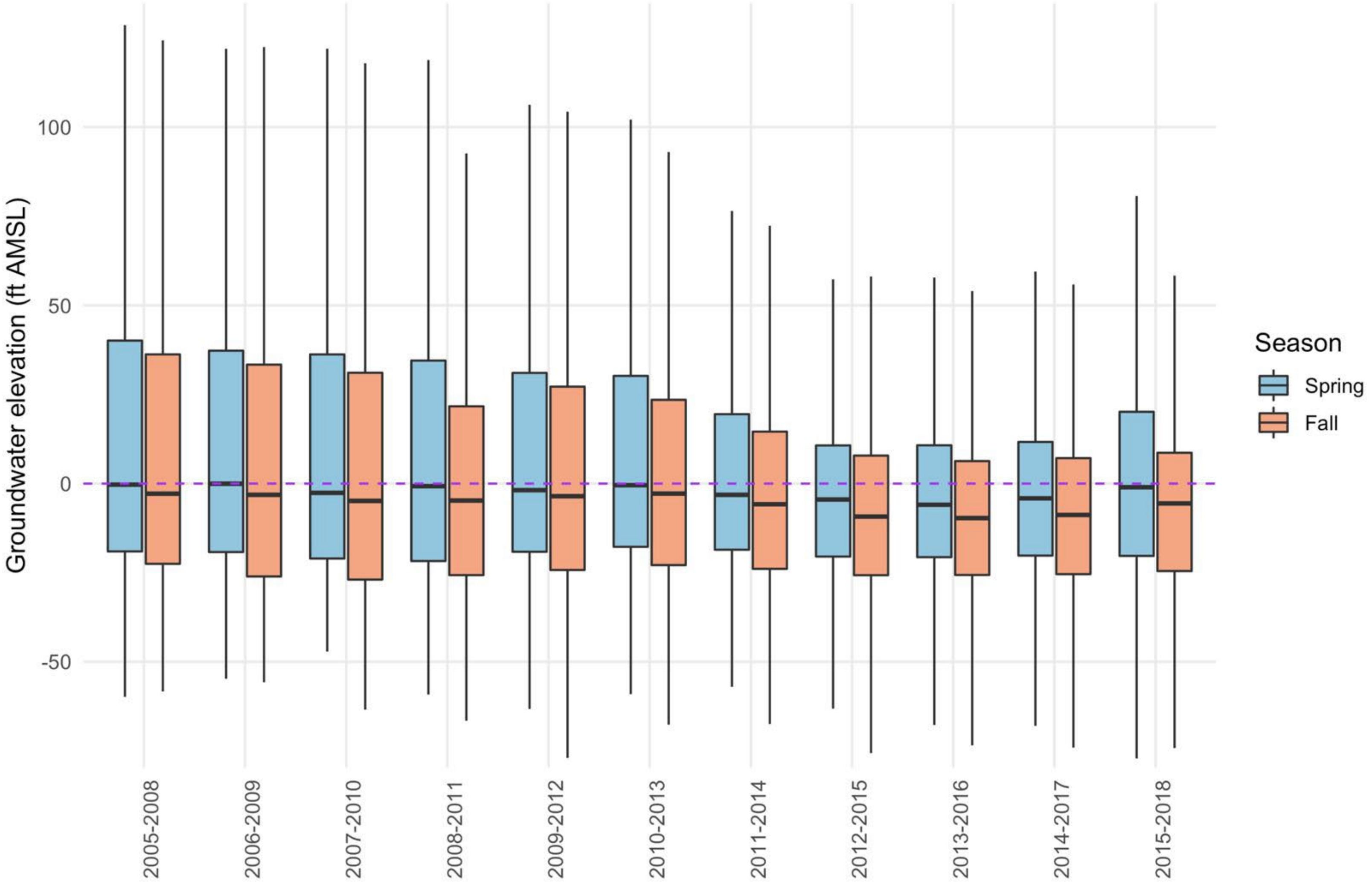

Figure 3-3: **Seasonal summary of interpolated groundwater elevations in the Basin** show oscillating seasonal medians, with consistently higher groundwater elevation in spring, and lower groundwater elevation in fall. Median fall groundwater elevation decreases over the period of record and reaches its lowest value during the average period of 2013-2016 due to the combined impact of 4 years of drought. After this minimum, spring and fall median groundwater levels trend upward. A purple, horizontal dashed line is shown at mean sea level elevation (0 feet) for reference.

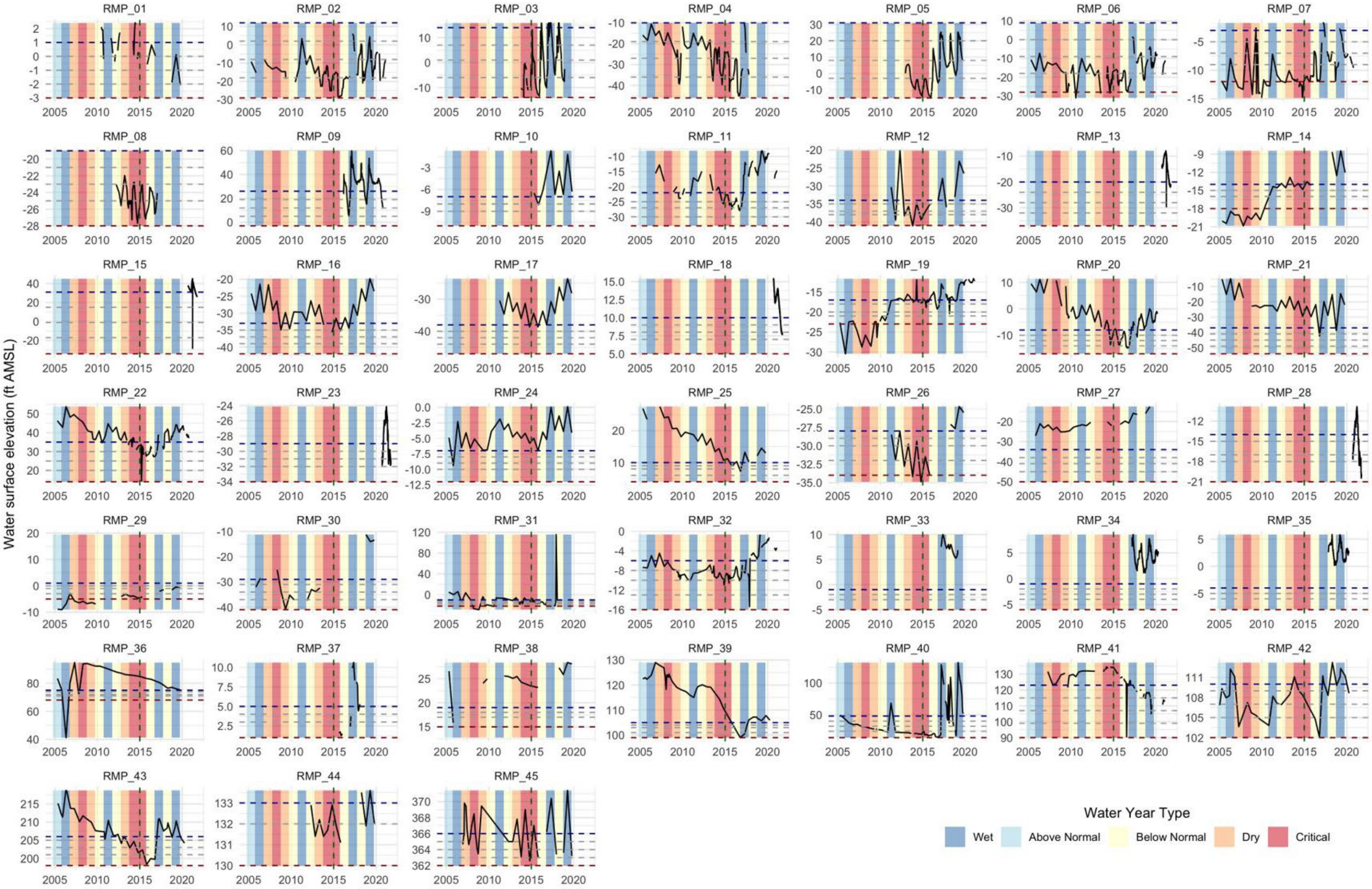

Figure 3-4: **Groundwater elevation and SMC at all 45 RMPs in the Basin.**
SMCs (Table 4) are drawn as horizontal dashed lines and indicate the MO, IMs and MT. In cases when the MT and MO differ by 3 feet or less, the operational flexibility is small, and an interim milestone may overlap with the MT or MO (**Table 3-4**). A green vertical dashed line at 2015-01-01 is drawn for reference. Of these wells, 10 double as ISW monitoring wells. c

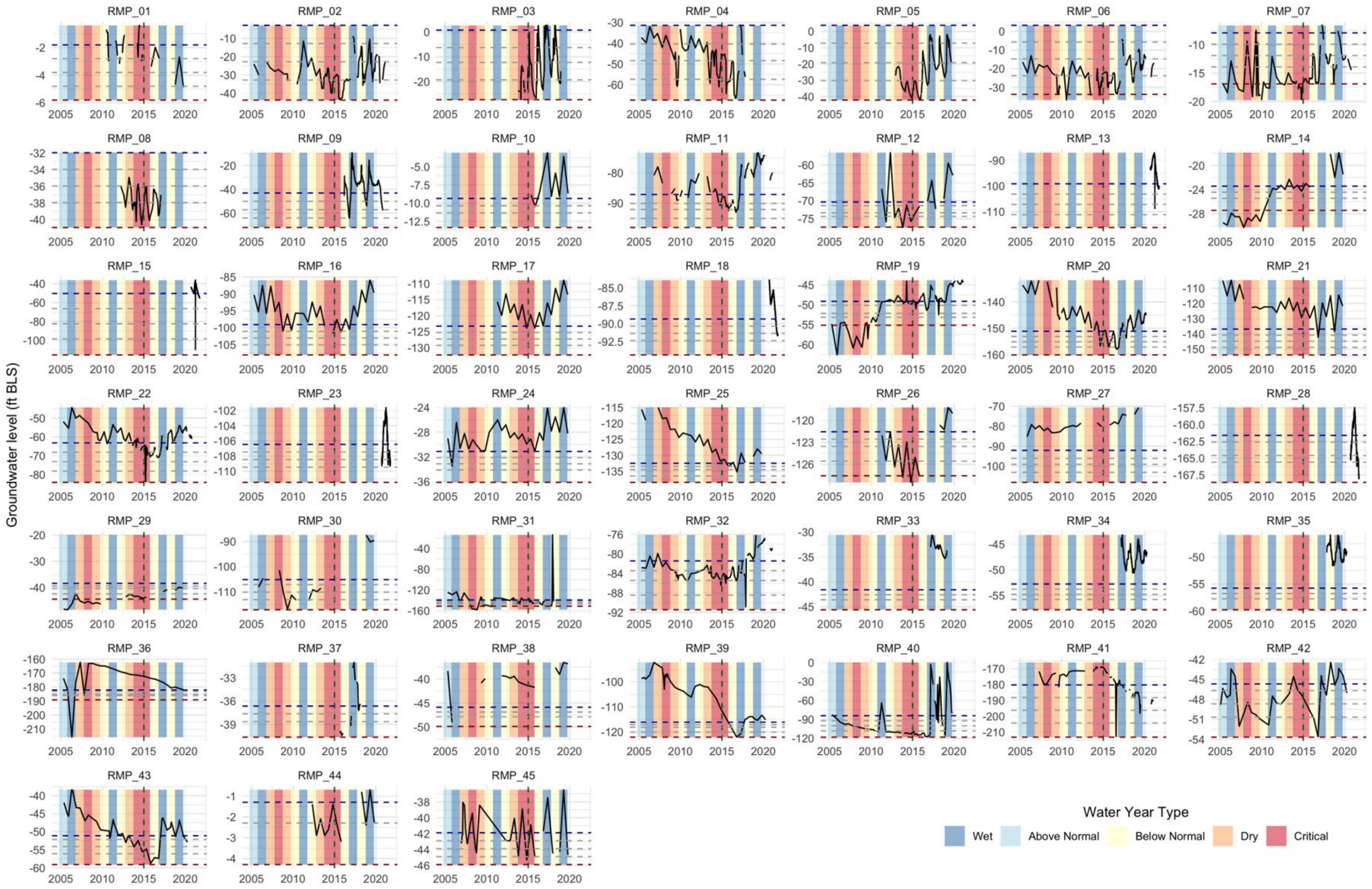

Figure 3-5: **Depth to groundwater and SMC for all 45 RMPs in the Basin.** See **Appendix 3-B** for an RMP ID to SITE CODE key.

Projected Water Use: The CoSANA model was used to simulate:

- the combined effects of projected water use in the Basin;
- projects and management actions (PMA) already underway (Harvest Water, OHWD recharge, and regional conjunctive use); and
- climate change.

Estimates of future groundwater basin storage, groundwater level, and seepage from streams were then used to analyze impacts to key beneficial users of groundwater including: vulnerable wells (**Figure 3-6**), GDEs (**Figure 3-7**), and ISW (**Figure 3-9, Figure 3-10**). Results show minimal impacts to vulnerable wells, GDE area, and ISW locations and flow assuming projects and management actions occur, and median climate change outcomes are experienced.[12] Due to their importance as beneficial users of groundwater that the GSAs aim to protect, three attached technical memoranda detail in-depth studies and recommended management criteria for vulnerable wells, GDEs, and ISW.[13]

In all subsections that follow, groundwater level conditions at Fall 2015 are compared to groundwater level conditions at Fall 2015 in the repeated hydrology and corresponding to Fall 2065 (**Figure 3-16**). Scenario abbreviations are:

- ***Baseline***: fall 2015
- ***Projected***: projected groundwater use
- ***Projected CC***: projected groundwater use with a median climate change warming scenario
- ***Projected PMA***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use)
- ***Projected PMA CC***: projected groundwater use considering feasible, in-progress projects and management actions (Harvest Water, OHWD recharge, regional conjunctive use) and with a median climate change warming scenario

Climate change (CC) scenarios are driven by changes in temperature and streamflow provided by the American River Basin Study (USBR, 2020) “central tendency” scenario, which reflect median temperature and precipitation outcomes. See **Section 2.4** for a more detailed description of this climate change scenario and the rationale for its use.

Well Protection: A detailed analysis of well protection is presented in **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria**, and a summary is given here.

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[12] Significant variation in climate change scenarios is controlled for by evaluating the median outcome. Temperature primarily drives water consumption in conjunction with a land use model and assumes no intervention or land use change. Thus, modeled water use is conservative.

[13] See **Appendix 3-C: Vulnerable well impact analysis in the South American Subbasin: well inventory, historical groundwater trends, and analysis to inform Sustainable Management Criteria** (October 1, 2021), **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin** (April 21, 2021), and **Appendix 3-A: Interconnected Surface Water (ISW) in the South American Subbasin: Characterization of Historical and Present-day Conditions, and Approaches for Monitoring and Management** (June 18, 2021).

The impact of a return to post-2015 low groundwater levels on wells in the Basin was evaluated and did not suggest significant and unreasonable impacts to wells exceeding 5% for any well type measures. Next, projected groundwater levels for each of the forward-simulated scenarios were analyzed alongside well construction information; results did not suggest a significant and unreasonable increase in impacts to wells (**Figure 3-6**). These results are unsurprising, as no wells were reported dry in the Basin during the 2012-2016 drought according to data from Cal OPR (Pauloo et al., 2020).

Well Completion Reports (CA-DWR, 2020) in the Basin were analyzed alongside groundwater elevation data to estimate the number of active wells (i.e., by filtering out wells older than a specified retirement age) assumed to be in operation at present-day groundwater level initial conditions (i.e., wells not already dry at initial groundwater level conditions). Next, potential significant and unreasonable impacts to vulnerable wells were evaluated at the lower of the post-2015 low or the lowest projected groundwater level (MTs). The count, cost, and location of impacted wells was estimated assuming MT levels were reached across the entire Basin.

The initial set of active wells included all wells completed on or after 1989-01-01 (31-year retirement age) with pump locations (estimated as 30 feet of operating margin above the total completed depth) below the present-day groundwater level (following Pauloo et al., 2021). To evaluate the sensitivity of retirement age on impacted wells, a second analysis was conducted for all wells completed on or after 1980-01-01 (40-year retirement age).

Results across all scenarios evaluated suggest a range of 7-15 wells would be impacted under 31-year and 40-year retirement ages, and accounting for uncertainty in projected management and climate change (**Figure 3-6**). For a conservative estimate of PMA with climate change, impacted well count is around 2-3% of domestic wells and 1-2% of public wells, and 1-2% of agricultural wells, primarily in the greater Sacramento urban area. This is unsurprising, as groundwater level simulations indicate drawdown in these areas – areas which are also far away from the agriculture-rural interface where most vulnerable domestic wells are located. These well impact percentages align with GSA-driven definitions of unreasonable results to vulnerable wells.

Further, unacceptable well impacts are defined as dewatering or lost access to groundwater at a well that requires well deepening or pump lowering. Well rehabilitation costs for impacted wells, assuming a return to the MT at all RMPs, were estimated at around \$300,000 - \$700,000 following the cost structure of Pauloo et al. (2021), EKI (2020), and Gailey (2019), but would likely be less, as significant and unreasonable impacts occur when 25% of RMPs exceed MTs (**Section 3.2.1.2**), and less expensive rehabilitation costs such as pump lowering may be more appropriate in some situations (e.g., when operating margin exists). Estimated well impacts and their associated rehabilitation costs have been discussed with GSAs and shared during public meetings to solicit feedback from groundwater users in the basin, including domestic well users. The GSAs are committed to using information gleaned in these conversations and public meetings, and the insights in these analyses to design a shallow well rehabilitation fund to address well protection costs in the Basin (**Appendix 3-C**).

Furthermore, GSAs in the Basin are committed to engaging and coordinating with vulnerable well owners to anticipate, mitigate, and help remediate impacts to wells that directly result from unsustainable groundwater management.

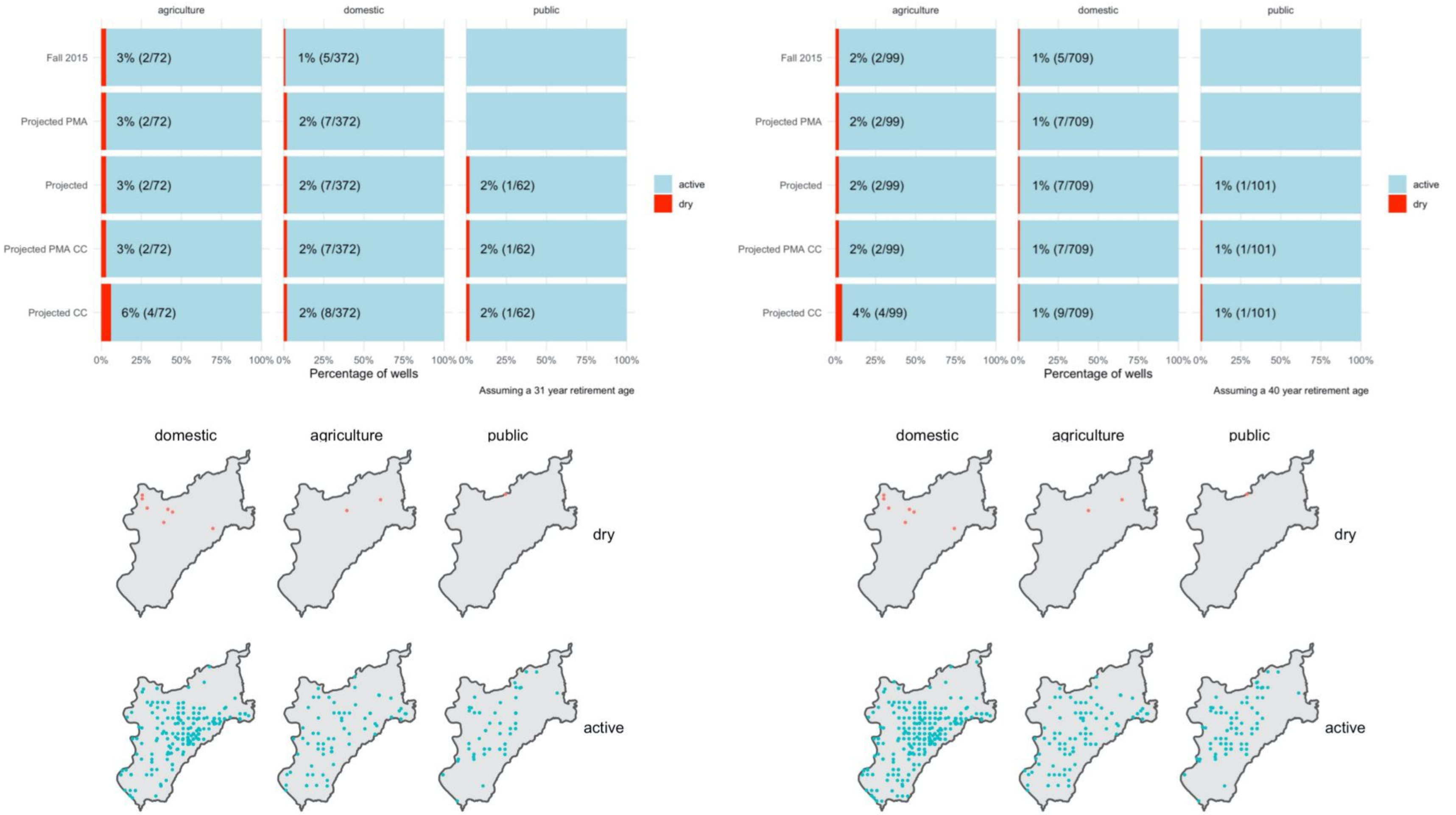


Figure 3-6: Vulnerable well impact analysis of a Fall 2015 baseline and 4 projected management conditions show little appreciable difference, even when accounting for a 31-year (left) and 40-year (right) well retirement age. Projected = Projected water use in the Basin. PMA = projects and management actions including Harvest Water, OHWD recharge, and regional conjunctive use. CC = climate change. Bar plots show well impact summary statistics for all scenarios and well types. Maps show results for the "Projected PMA CC" scenario on which groundwater level MTs are based.

GDE Protection: A detailed analysis of well protection is presented in **Appendix 3-D: Groundwater Dependent Ecosystems in the South American Subbasin**, and a summary is given here.

GDEs were mapped using best available datasets across the Basin, and special status species were cataloged. The analysis focused on plant species which provide habitat for these special status species, in addition to providing valuable ecosystem functions and recreational benefits. The maximum reported rooting depths of the plant species found in the Basin range from near-surface for grasses like creeping wildrye (3.84 feet) to deep-rooted trees like the Valley Oak (24.31 feet). Rooting depths of species within the Basin show that the Valley Oak (Quercus lobata) was found to exhibit the largest rooting depth. Because plants can extract moisture from pore spaces away from the roots themselves, a threshold depth of 30 feet was used as a cutoff for the maximum depth of groundwater that could reasonably be accessed by a GDE within the Basin. Areas within the Basin where depth to groundwater is consistently greater than 30 feet are assumed incapable of supporting non-wetland GDE communities and by extension, any GDEs. In the context of identifying GDEs, this 30-foot depth threshold is conservative and overly inclusive as shallower groundwater is required to support a broader array of healthy GDEs for most plant species.

The historical areas occupied by potential GDEs were then classified into 4 categories (GDE, Potential GDE – likely, Potential GDE – unlikely, Not GDE) by relating observed, interpolated historical groundwater levels to GDE polygons and an assumed 30-foot rooting depth. Over the historical period analyzed (2005-2018), GDEs are found to occupy 43.2% of Potential GDE polygons considered (11,340 / 26,245 acres).

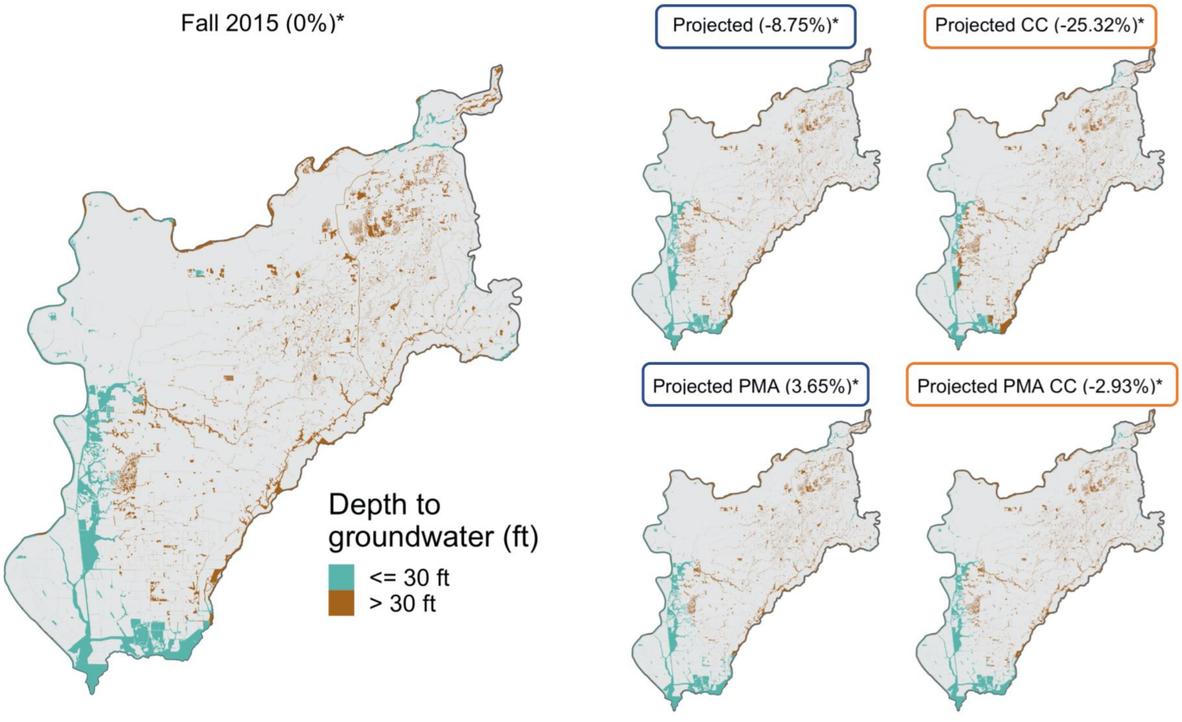
Next, NDVI was calculated across the 4 categories described above to determine historical variance in vegetation health. NDVI in GDE categories is consistently higher than non-GDE categories, which suggests remotely sensed estimates of plant health capture significant differences between GDE and non-GDE polygons.

These analyses informed the development of two quantitative criteria which may be used during Plan implementation to detect if GDE area or health fall below historically observed values (**Table 3-2**).

Table 3-2: Criteria to determine changes in GDE area and health that exceed historically observed minima

Criteria	Historical minimum observed	Quantitative metric
A: Proportion of Mapped Potential GDE Classified as “Assumed GDE” in Tier 1 GDE Likelihood Analysis	2013-2016 Fall	44%
B: Lowest Median NDVI for “GDE” in Tier 2 GDE Likelihood Analysis	June 2009	0.023

If either criteria A or B are observed for 3 consecutive years, Undesirable Results for GDEs occur. Importantly, 44% represents the minimum area of Potential GDE polygons classified as GDEs in the historical record and occurs during the 2012-2016 drought. Thus, a decline in GDE area (determined by a 30 ft depth to groundwater) exceeding 44% indicates a deviation from historically observed values and an undesirable result.



*compared to the 'Fall 2015' scenario

Figure 3-7: Impact analysis of projected groundwater level scenarios (described in **Figure 3-6**) shows appreciable GDE impacts without PMA. However, PMA substantially buffer against impacts to GDEs, even given climate change, and especially in the southern portion of the Basin near the Harvest Water project. Percent changes reported are with respect to the Fall 2015 GDE area. For example, the “Projected PMA” scenario (projected conditions with projects and management actions) results in a 3.65% increase in potential GDE area compared to Fall 2015. The “Projected” and “Projected PMA” scenarios (blue border) should be compared, and the “Projected CC” and “Projected PMA CC” scenarios (orange border) should be compared. In each pair of comparable scenarios, scenarios with PMA lead to a less than 5% reduction of GDE area, and are generally more protective of GDEs than scenarios without PMA.

Projected management changes groundwater elevation, which directly impacts groundwater access for plants. Results indicate that PMA result in a 3.65% increase in potential GDE area to a -2.93% decrease in GDE area, depending on climate change. Without PMA, GDE area may decrease from -8.75% to -25.32%, depending on climate change. Percent change in all scenarios was evaluated with respect to a Fall 2015 baseline. Overall, considering climate uncertainties, results suggest that projected groundwater use with PMA is likely to maintain GDE area consistent with historical levels and thus avoid undesirable results experienced at the 44% area criteria for historical GDEs.

GSAs in the Basin are committed to cooperative, multi-benefit projects in coordination with land trusts, resource conservation agencies, neighboring basins, and other stakeholders to anticipate and mitigate impacts to GDEs that directly result from unsustainable groundwater management.

Avoidance of ISW Depletion: A detailed analysis of the scientific studies that led to the development of ISW SMC are presented in **Section 3.2.4** and **Appendix 3-A**, and a summary is given here.

A return to post-2015 low groundwater levels was evaluated and did not suggest significant and unreasonable reduction in ISW location, streamflow, or seepage. Compared to a Fall 2015 baseline, ISW locations in each of the projected scenarios evaluated do not appreciably change (**Figure 3-9**). These analyses indicate that significant and undesirable impacts to ISW are avoided at groundwater level MTs set at the lower of the post-2015 low (typically occurring in Fall 2015) or the low under projected management with PMA and climate change.

SGMA defines ISW as “surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted” (23 CCR § 351(o)). Thus, seasonal groundwater elevation mapping was used to separate persistently disconnected, stream nodes from connected nodes, and reach-level “Disconnected” and “Interconnected” classifications were assigned based on connection history (**Figure 3-8**). SMCs were then developed for Interconnected reaches. ISW characterization is consistent with ISW characterization in The Nature Conservancy’s ICONS web tool (TNC, 2021) and those in adjacent basins (North American and Cosumnes basins) that share boundaries with the South American Subbasin.

At Interconnected reaches in the Basin, CoSANA-calculated stream seepage indicates present-day and historical ISW depletion (**Section 3.2.4**). The magnitude of ISW depletion is controlled by the relative elevation between ISW and adjacent groundwater (i.e., the hydraulic gradient) – thus a management approach that arrests groundwater level decline also arrests the hydraulic gradient and places an upper limit on expected ISW depletion. However, for this monitoring approach to work, wells must be selected to capture the effects of an expanding cone of depression and a steepening of the hydraulic gradient which will eventually propagate to ISW and cause depletion. Hydraulic gradient analysis along transects from ISW were used to identify an appropriate distance (3,000 ft) from ISW at which to monitor hydraulic gradients, and this informed the subset of shallow groundwater level monitoring wells to use. Then, groundwater levels at these wells in projected management scenarios were related to impacts to ISW locations, streamflow, and seepage.

Projected management with PMA leads to a -2.62% to 0% reduction in ISW reach length depending on climate change and calculated over CoSANA stream nodes, which is within the 5% reduction in ISW reach length determined as significant and unreasonable. Note that the metrics to calculate ISW reach connection depend on sufficient groundwater level elevation data nearby and under ISW, as well as accurate ISW streambed elevation. Some uncertainty exists in these data which may be addressed in the future with high-resolution mapping and site surveys (**Section 3.5.5**).

Furthermore, ISW streamflow exceedance during the Chinook salmon fall-run (October – December) spawning migration was evaluated (**Figure 3-10**) under each projected scenario and compared to baseline flow conditions (e.g., current long-term fall conditions from 1969-2018). Maintenance of flows (especially during dry months) is most important in the undammed Cosumnes River which is a focal point of local conservation efforts. By contrast, flows in the American and Sacramento rivers are heavily managed. Findings suggest sufficient flows to support spawning migration in Projected and Projected PMA scenarios, and importantly, that projected groundwater management will increase streamflow in the lower Cosumnes River compared to the current conditions baseline scenario and scenarios without PMA. Climate change has a substantial negative impact on streamflow that would cause greater than 10% change in the 50th percentile of exceedance flows in all rivers. Importantly, streamflow declines result from climate-driven changes in stream inflow (USBR, 2020), not unsustainable groundwater management. Reduced impacts to streamflow in the Cosumnes (compared to the American and Sacramento rivers) is largely due to benefits from the Harvest Water recharge project. This underscores the importance of multi-benefit conjunctive use and groundwater banking projects to offset the impacts of climate change (e.g., reduced streamflow).

Table 3-3: October-December simulated streamflow for the American, Cosumnes, and Sacramento rivers under current conditions (Baseline), and projected scenarios (also see Figure 3-10).

River	Scenario	10th percentile (cfs)	25th percentile (cfs)	50th percentile (cfs)	75th percentile (cfs)	90th percentile (cfs)	% Difference in 50th percentile exceedance compared to Baseline
American	Baseline	4037	2714	2025	1283	914	0%
American	Projected PMA	4019	2699	2005	1266	892	-1%
American	Projected PMA CC	2346	2181	701	584	507	-65%
American	Projected	4020	2692	2000	1261	888	-1%
American	Projected CC	2337	2177	694	579	503	-66%
Cosumnes	Baseline	1662	523	154	47	35	0%
Cosumnes	Projected PMA	1695	564	178	59	45	16%
Cosumnes	Projected PMA CC	1752	462	143	52	37	-7%
Cosumnes	Projected	1679	537	164	52	40	6%
Cosumnes	Projected CC	1742	443	134	48	34	-13%
Sacramento	Baseline	36150	19323	13857	11294	8554	0%
Sacramento	Projected PMA	36441	19537	13969	11424	8672	1%
Sacramento	Projected PMA CC	24794	14612	11300	8206	6822	-18%
Sacramento	Projected	36421	19514	13943	11401	8648	1%
Sacramento	Projected CC	24763	14585	11270	8181	6797	-19%

A general concern is that groundwater management in the Basin may negatively impact critical flows for fish passage. Multiple studies report minimum flow targets at Michigan Bar for fish passage on the Cosumnes River. Anderson et al. (2004), Fleckenstein et al., (2004), Mount et al. (2001), which estimate flows of 32.8, 54.7, and between 40-45 cfs, respectively. Most recently, hydraulic modeling by US Fish and Wildlife Service (USFWS) as part of an initial passage analysis identified 180 cfs as the minimum bypass flow condition for both the McConnell and Michigan Bar locations along the Cosumnes River. Therefore, at the time of writing, the range of flow conditions required for fish passage based on the best available science ranges from 32-180 cfs. A 90% exceedance probability for the 32 cfs flow target reported by Anderson et al. (2004) is achieved in current conditions and in all scenarios evaluated (**Table 3-3**). Further, a 75% exceedance probability for the 45 cfs target from Mount et al (2001) is met across all scenarios. The projected PMA scenario has a median exceedance probability at 177 cfs, which is close to the USFWS estimate of 180 cfs needed for fish passage. Climate change has outsized effects of simulated streamflow and deserves more attention.

Future studies may investigate functional flow metrics for the river, but insofar as SGMA pertains to flow in the Cosumnes, modeling suggests that projected management will not appreciably change streamflow from current conditions, thus avoiding significant and unreasonable impacts to beneficial users of groundwater. More work is needed to assess climate change impacts to ISW (**Section 3.5.5**) and will be completed before the 5 year plan update (2027).

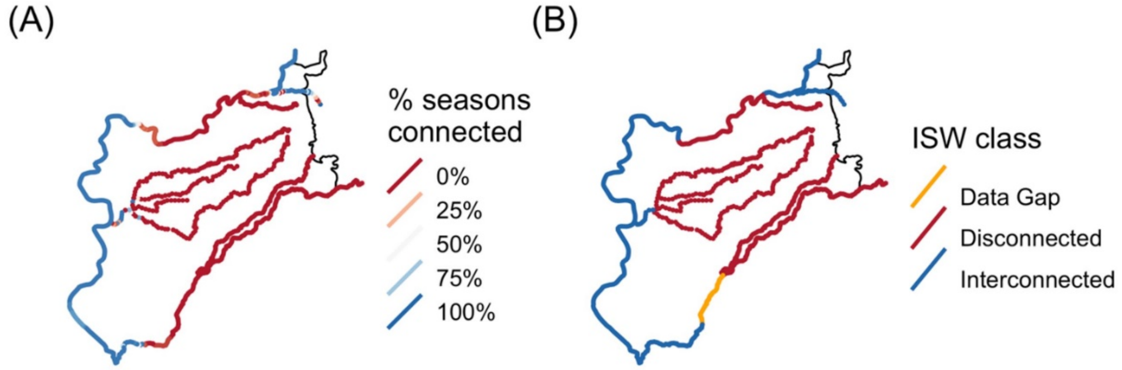
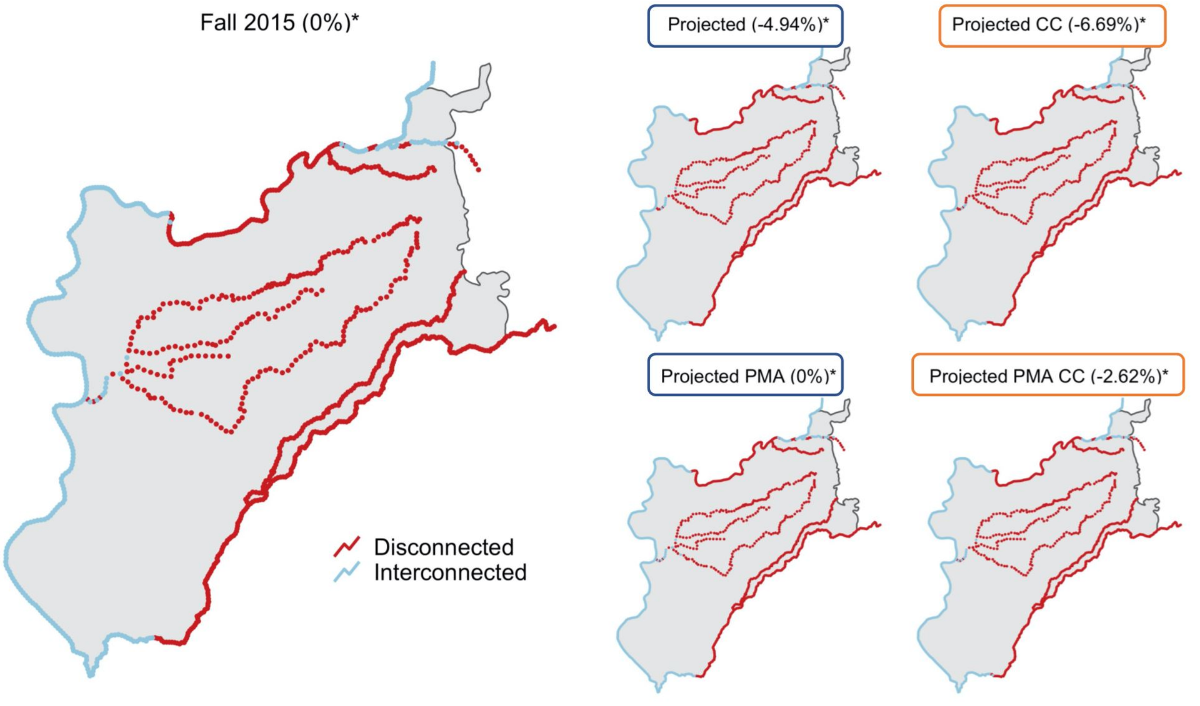


Figure 3-8: **Interconnected and Disconnected stream nodes and reaches** are defined by computing (A) the percentage of seasons evaluated from 2005 – 2018 where average groundwater elevation intersects the clogging layer of the streambed. (B) Disconnected stream reaches have a majority of stream nodes that are persistently disconnected from groundwater at all seasons evaluated, whereas Interconnected reaches are conservatively defined as having a majority of nodes connected for > 0% of all seasons evaluated. The Cosumnes River approximately between Deer Creek and Twin Cities Road is disconnected on a seasonal level, but some evidence of sub-seasonal connection exists, thus it is considered a data gap for planning purposes and more research is needed to understand stream-aquifer interactions in this region.



*compared to the 'Fall 2015' scenario

Figure 3-9: Impact analysis of projected groundwater level scenarios (described in **Figure 3-6**) shows minimal impacts to ISW reach length across scenarios suggesting the avoidance of significant and unreasonable disconnection events. As with GDEs, the introduction of PMA prevents stream disconnection compared to scenarios without PMA. The "Projected" and "Projected PMA" scenarios (blue border) should be compared, and the "Projected CC" and "Projected PMA CC" scenarios (orange border) should be compared. In each pair of comparable scenarios, scenarios with PMA lead to a less than 5% reduction of ISW reach length compared to a 2015 baseline, and are generally more protective of ISW than scenarios without PMA.

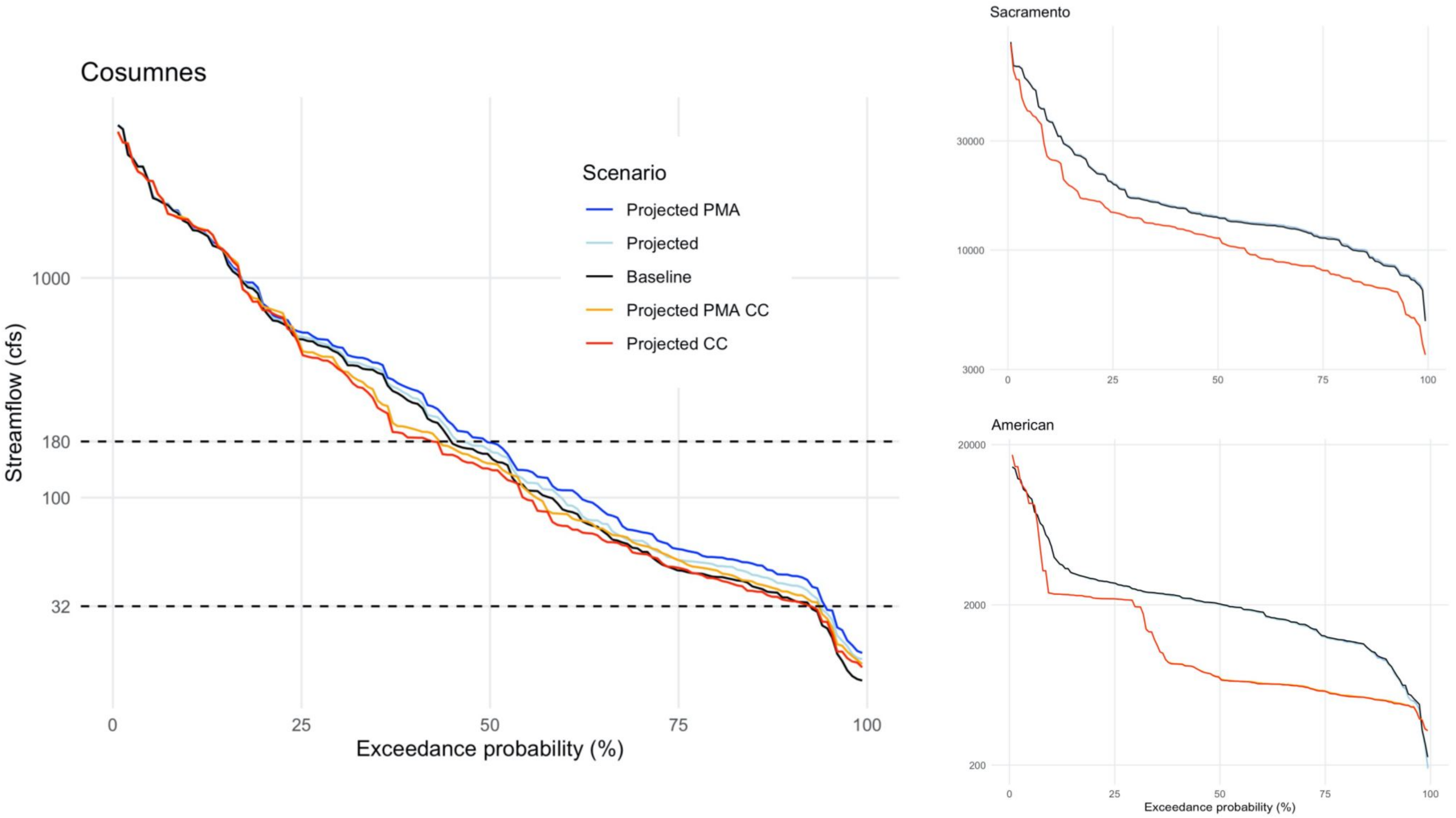


Figure 3-10: All projected scenarios (described in **Figure 3-6**) show minimal impacts to October-December streamflow exceedance (**Table 3-3**) at ISW locations along the Cosumnes, Sacramento, and American rivers when compared to current conditions baseline flows (black solid line). American and Sacramento flows are only impacted by climate change and the absence of PMA (overlapping red and orange lines). In the Cosumnes, PMA introduction improves flow conditions, and projected management does not differ from current conditions. Black dashed horizonal lines on the leftmost plot indicate the envelope of flow target values reported by literature to support fish passage during low-flow October-December spawning months. The lower bound of this envelope (32 cfs) has a 90% exceedance probability across all scenarios which implies fish passage during spawning months. Due to modeling constraints, flows are estimated at the downstream outlets of the Cosumnes and Sacramento Rivers in the model domain. American River flows are estimated at H Street Bridge. Note the log-scale y-axis.

Figure 3-11: Probable ISW reaches by name, Probable Disconnected reaches, and GSAs in the Basin.
Classification of reaches follows the methodology summarized in **Section 3.3.1.2**, **Figure 3-8**, and **Appendix 3-A**. Grey points indicate the locations of ISW RMPs in the GSP monitoring network.

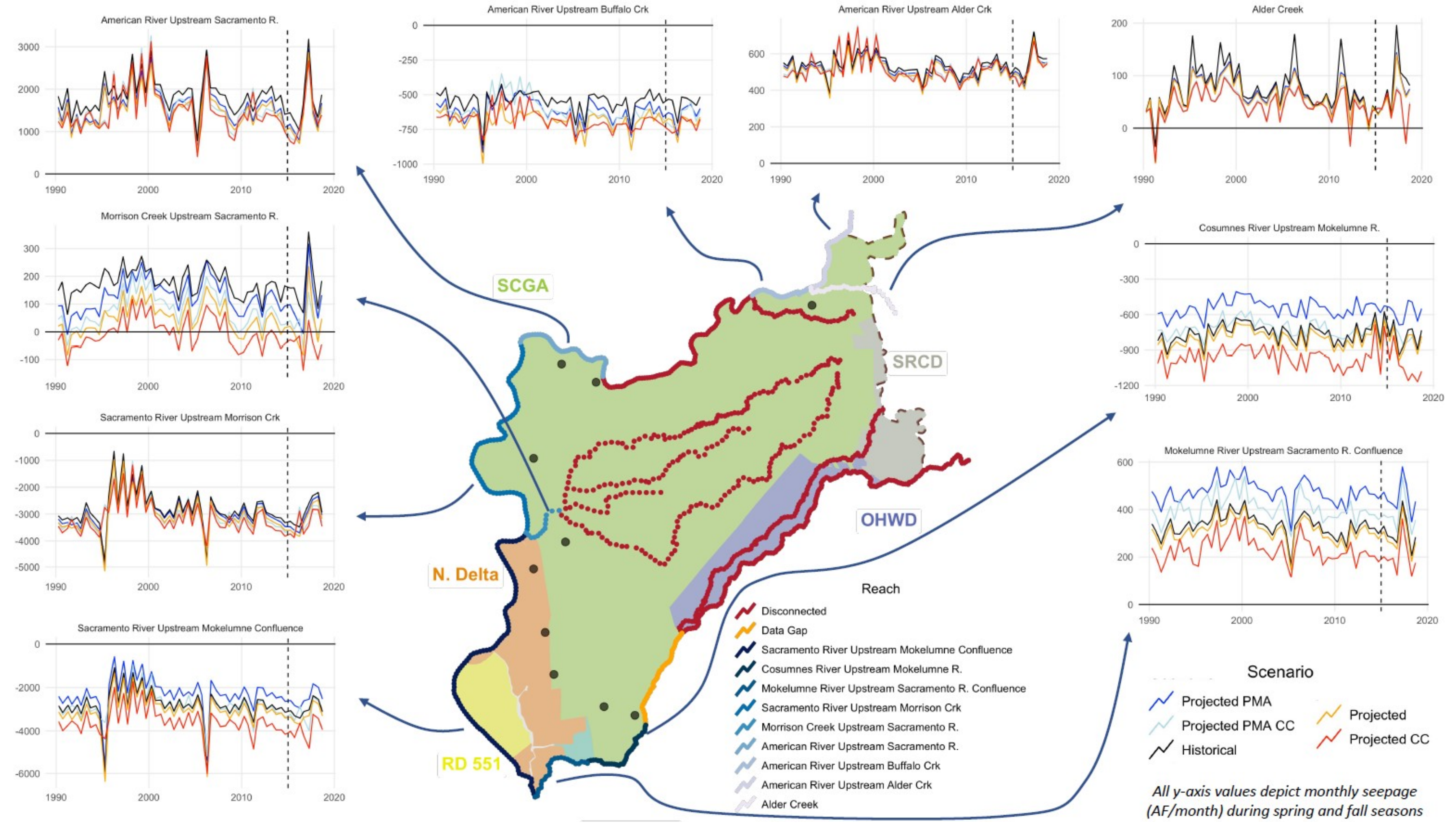


Figure 3-12: **Seasonally averaged ISW depletion estimated by CoSANA at ISW designated reaches** over the current conditions baseline model simulation is relatively constant. Negative numbers indicate losing stream conditions (stream loss to groundwater) and positive numbers indicate gaining stream conditions (stream gain from groundwater). Spring (February - April) and fall (August - October) depletion rates are averaged per month in each 3-month seasonal window. A black vertical dashed line at 2015-01-01 is drawn for reference, and a black solid horizontal line at y = 0 indicates the transition from

gaining to losing conditions. Most scenarios have little impact on seepage. The Cosumnes and Mokelumne gain more under projected conditions, even with climate change. Morrison Creek loses more in all scenarios.

Notably, reaches of the Cosumnes River approximately between Deer Creek and Twin Cities Road are disconnected on an average seasonal timescale, but evidence of short-term, flashy, sub-seasonal connection has been found. The role of these short-term connection events, and the prevalence of significant subsurface heterogeneity and perched zones make this region difficult to model and monitor. Thus, these reaches of the Cosumnes are considered a data gap for planning purposes, and more research and inter-basin coordination is needed to determine the nature of surface and groundwater interactions in this region. It is expected that by the next plan update (2027), a revised determination of ISW in this area will be developed (**Section 3.5.5**).

GSAs in the Basin are committed to cooperative, multi-benefit projects in coordination with land trusts, resource conservation agencies, neighboring basins, and other stakeholders to anticipate and mitigate impacts to ISW – and the beneficial users they support – that directly result from unsustainable groundwater management.

Impacts to adjacent basins: MTs were developed in coordination with the neighboring North American Subbasin and Cosumnes Subbasin. GSAs in these three basins will continue to coordinate the details of their Plans to model and evaluate the impact of MTs, and more broadly, MOs and project and management actions (PMAs) on achieving joint sustainability goals. No significant and unreasonable impacts resulting from management actions in the SASb are noted in adjacent basins.

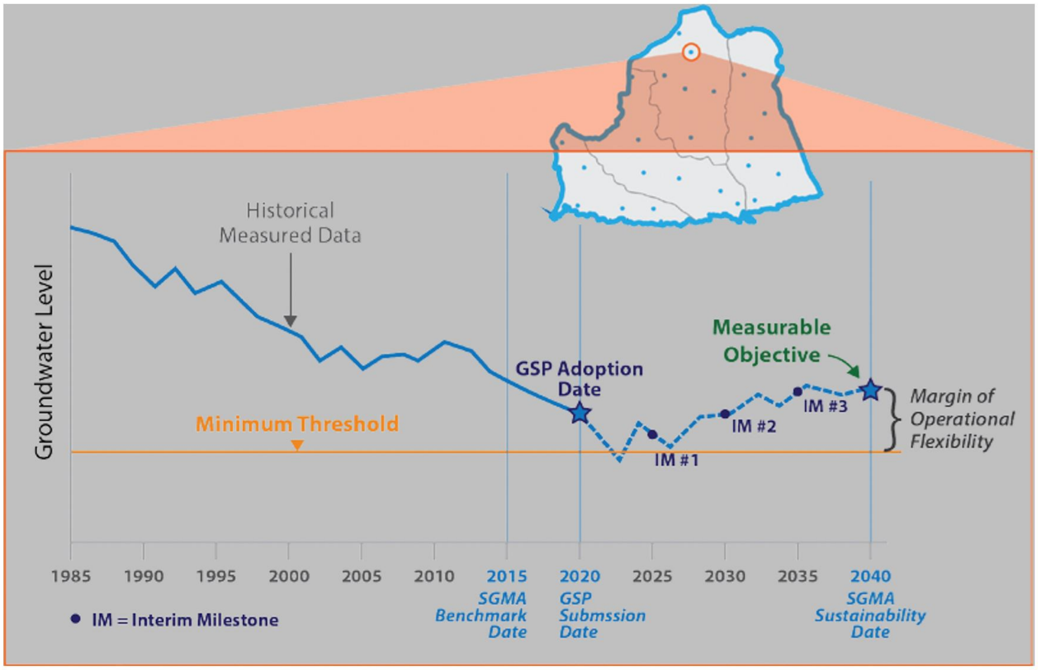


Figure 3-13: **Minimum threshold, measurable objective, interim milestones, and operational flexibility at an example representative monitoring point,** drawn from DWR Best Management Practices (CA-DWR, 2017).

3.3.1.3 Developed Minimum Thresholds

As discussed in **Section 3.3.1**, developed minimum thresholds for chronic lowering of groundwater levels (**Table 3-4**) are based on a consideration of analyses that find the absence of significant and unreasonable dewatering of vulnerable wells (e.g., domestic, agricultural, and public wells), depletions of ISW, impacts to GDEs, and impacts to adjacent basins. The Basin's developed minimum thresholds are expressly designed with beneficial users of groundwater in mind. They represent groundwater levels which, if reached across the entire basin would result in significant and unreasonable impacts to these beneficial users. However, the identification of Undesirable Results which occurs when 25% of monitoring wells exceeds MTs for 3 consecutive years is also designed to be conservative: analyses of impacts to beneficial users assume 100% of the Basin reaches the MT surface. Thus, the impacts actually experienced if criteria to identify Undesirable Results are observed are likely to be less severe than analyses suggest (25% versus 100% of RMPs exceeding MTs).

Importantly, some RMPs are in critical monitoring locations, but may lack historical data or perforation interval information. These data gaps will be addressed during the Plan implementation by collecting monitoring data and performing field investigations (**Section 3.5.5**); thus, the MTs presented herein (**Table 3-4**, **Figure 3-15**) may change in the five-year Plan update pending new information.

To ease interpretation and implementation, MTs are rounded to the nearest integer value.

Table 3-4: Sustainable management criteria for groundwater level decline, storage, and ISW depletion.

All 45 RMP wells in the network are used to track groundwater level and storage sustainability indicators, and a subset of 10 wells is used to track ISW depletion ("ISW RMP" column). For a graphical view of MOs, MTs, and IMs, see **Figure 3-4**. See **Appendix 3-B** for an RMP ID to SITE CODE key.

Well ID	MT (ft AMSL)	Date last measured	Last measured elevation (ft AMSL)	Interim milestones (ft AMSL) (c)			MO (ft AMSL)	Operational flexibility (ft)	ISW RMP(d)	Depth (ft)	Perforated interval (ft)	Lng (NAD83)	Lat (NAD83)
				IM (2027)	IM (2032)	IM (2037)							
RMP_01(a)	-3	10/8/20	-3	-2	-1	0	1	4		20	NA-NA	-121.467	38.2604
RMP_02	-29	2/10/21	-8	-18	-8	2	12	41	TRUE	334	NA-NA	-121.39	38.2939
RMP_03	-14	12/8/18	-3	-6	1	7	14	28		39.5	30-40	-121.382	38.2967
RMP_04	-46	10/16/17	-35	-36	-27	-19	-10	36	TRUE	165	NA-NA	-121.422	38.3009
RMP_05	-15	9/4/19	8	-3	8	20	31	46		43	38-43	-121.379	38.31263
RMP_06	-28	2/11/21	-11	-18	-9	0	9	37	TRUE	125	88-125	-121.474	38.327
RMP_07	-12	10/14/20	-10	-9	-7	-5	-3	9	TRUE	200	NA-NA	-121.483	38.361
RMP_08	-28	1/23/17	-24	-25	-23	-21	-19	9		200	NA-NA	-121.455	38.3728
RMP_09	-3	10/29/20	12	5	12	19	26	29		97	57-97	-121.31944	38.379167
RMP_10	-11	10/16/20	-8	-9	-8	-8	-7	4	TRUE	175	135-175	-121.495	38.4125
RMP_11	-33	2/10/21	-15	-30	-27	-25	-22	11		NA	125-250	-121.324	38.415
RMP_12	-41	11/6/19	-27	-38	-37	-35	-34	7		508	NA-NA	-121.374	38.4202
RMP_13	-37	9/27/21	-21	-32	-28	-24	-20	17		119	90-119	-121.2396	38.4322723
RMP_14	-18	10/21/20	-12	-16	-16	-15	-14	4	TRUE	170	NA-NA	-121.462	38.4343
RMP_15	-34	9/27/21	26	-17	-1	15	31	65		121.5	73-113	-121.25129	38.439918
RMP_16	-42	10/14/20	-25	-39	-37	-35	-33	9		210	NA-NA	-121.303	38.4425
RMP_17	-47	10/14/20	-30	-44	-42	-40	-38	9		300	NA-NA	-121.286	38.4532
RMP_18	5	9/27/21	8	7	8	9	10	5		111.5	70-111.5	-121.20294	38.471742
RMP_19	-23	2/10/21	-12	-21	-20	-18	-17	6		382	149-375	-121.425	38.4738
RMP_20	-17	10/15/20	-8	-14	-12	-10	-8	9		NA	130-655	-121.231	38.478
RMP_21(b)	-54	10/14/20	-41	-49	-45	-41	-37	17		340	NA-NA	-121.261	38.4798
RMP_22	14	10/15/20	37	20	25	30	35	21		135	68-135	-121.18	38.493
RMP_23	-34	9/25/21	-32	-32	-31	-30	-29	5		216	196-206	-121.31398	38.500392
RMP_24(a)	-12	10/16/20	-5	-10	-9	-8	-7	5	TRUE	172	NA-NA	-121.495	38.5021
RMP_25	4	10/14/20	11	6	8	9	10	6		130	NA-NA	-121.22	38.5038
RMP_26	-34	10/21/20	-25	-32	-30	-29	-28	6		425	132-140	-121.302	38.519
RMP_27	-50	10/7/20	-34	-45	-41	-38	-34	16		164	132-164	-121.363	38.5223
RMP_28	-21	9/27/21	-20	-18	-17	-15	-14	7		420	275-420	-121.25873	38.527911
RMP_29	-5	10/7/20	19	-3	-1	0	1	6		72	NA-NA	-121.428	38.5343
RMP_30(a)	-41	10/21/20	-13	-37	-34	-31	-29	12		236	150-231	-121.339	38.5469
RMP_31(a)	-22	1/23/18	-13	-18	-15	-12	-10	12		562	302-462	-121.259	38.5543
RMP_32(a)	-16	2/10/21	-4	-13	-10	-8	-6	10		125	63-125	-121.32401	38.558
RMP_33(a)	-5	2/18/19	7	-3	-3	-2	-1	4	TRUE	215	27-47	-121.43028	38.5637222
RMP_34(a)	-6	4/10/20	5	-4	-3	-2	-1	5		215	185-205	-121.42397	38.5671944
RMP_35(a)	-8	4/3/20	3	-6	-5	-5	-4	4		310	175-195	-121.42581	38.5679444
RMP_36(a)	68	10/14/20	74	71	72	74	75	7		675	180-200	-121.187	38.5707
RMP_37(a)	1	2/16/18	5	3	4	5	5	4	TRUE	240	200-229	-121.466	38.5784
RMP_38	15	10/7/20	26	17	18	18	19	4		85	NA-NA	-121.317	38.5849
RMP_39	99	4/8/20	106	101	103	104	105	6		NA	79-102	-121.2051	38.5889223
RMP_40	14	10/10/19	52	24	32	40	48	34		150	NA-NA	-121.248	38.5914
RMP_41	90	1/20/21	113	99	107	115	123	33		285	197-269	-121.162	38.592
RMP_42	102	4/7/20	109	105	107	109	110	8	TRUE	NA	67-72	-121.20659	38.6260795
RMP_43	198	4/8/20	204	201	203	205	206	8		NA	128-138	-121.17881	38.6358326
RMP_44	130	10/20/20	131	132	132	133	133	3		170	135-165	-121.188	38.6578
RMP_45	362	10/15/20	362	363	364	365	366	4		85	55-85	-121.117	38.6895

(a) These 8 RMPs are in critical monitoring locations, but data is only available after 2018, thus data gaps cause MTs and MOs to be set close to or at present day levels. MTs, MOs, and interim milestones (IMs) for these points are based on the best available information at these monitoring locations but are expected to change in the Plan update as more information becomes available. Moreover, most of these sites are 15-minute interval stations what will provide valuable insight into stream-aquifer interactions.

(b) The MT for this data point is based on the 2009 fall low due to a significant data gap between 2014 and 2019.

(c) When the operational flexibility, or difference between MOs and MTs is 3 feet or less, one or more IMs may be the same as MOs due to rounding of SMCs to integer values.

(d) When TRUE, this indicates the well is also used to monitor for ISW depletion in addition to groundwater level and storage sustainability indicators.

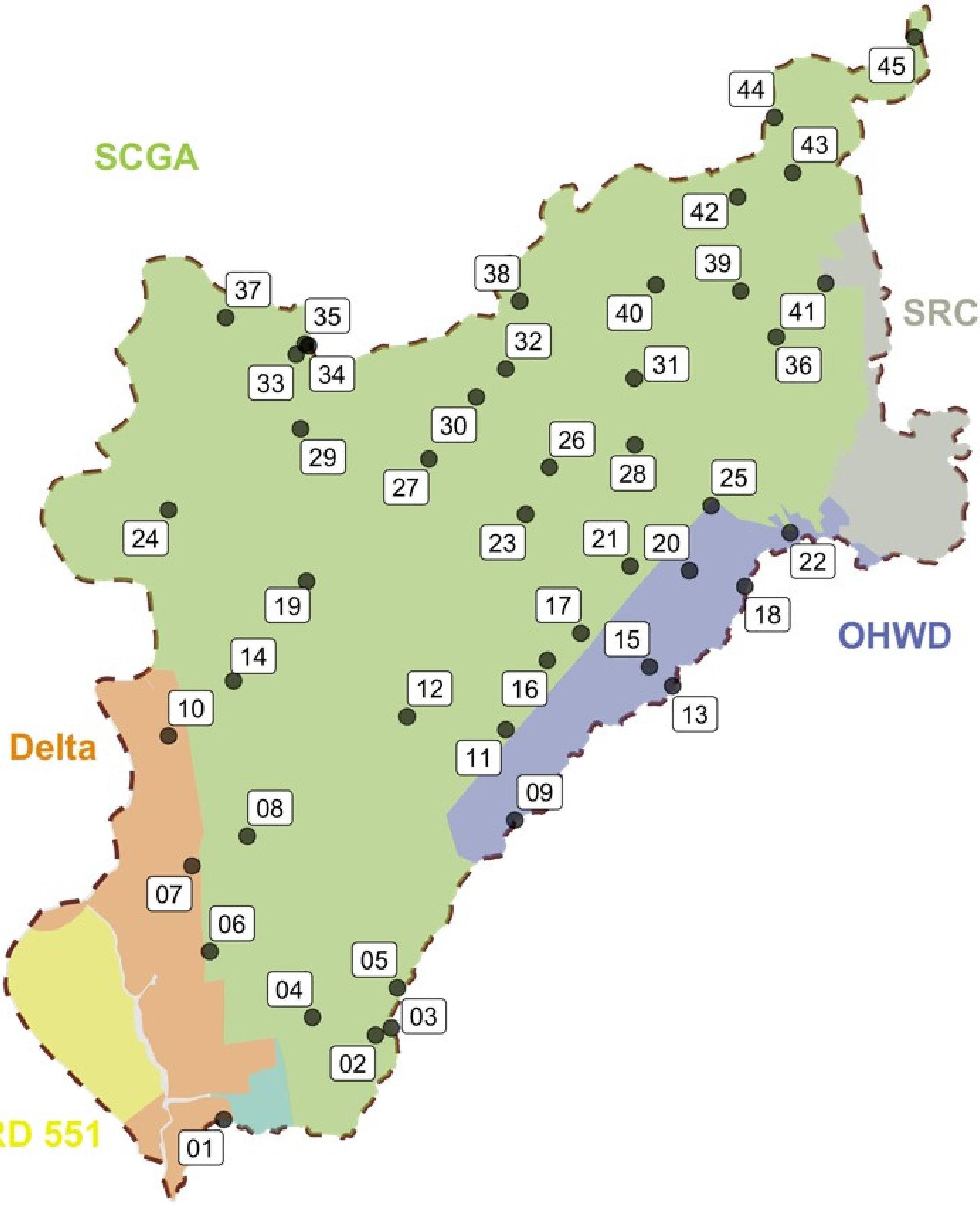


Figure 3-14: **RMP IDs from Table 3-4 are ordered from South to North to permit easy interpretation. Note that "RMP_" prefixes are removed to aid visualization.** See **Appendix 3-B** for an RMP ID to SITE CODE key.

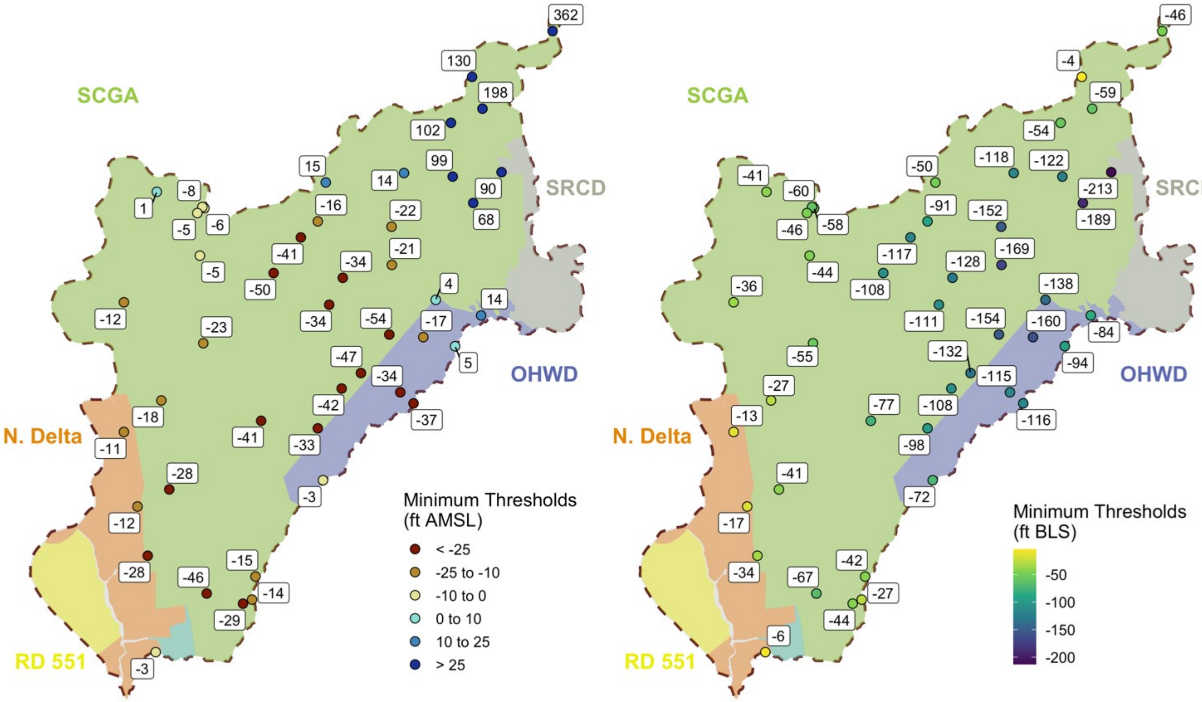


Figure 3-15: **Groundwater level and storage minimum thresholds at 45 RMPs in the Basin.**

3.3.2 Minimum Threshold for Reduction of Groundwater Storage

> *23 CCR § 354.28. Minimum Thresholds*
>
> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> *(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.*
> *(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.*

The minimum threshold for the reduction in groundwater storage is the rate or volume of groundwater which can be withdrawn from the Basin without leading to undesirable results. Groundwater storage change is not directly measurable. Rather, it is estimated by the CoSANA groundwater flow model, which depends on accurate groundwater levels and a robust HCM. Groundwater storage is the three-dimensional equivalent of groundwater level (two-dimensional) over a depth, and reduction of groundwater storage generally indicates (and is associated with) groundwater level decline.

Given that the MT for chronic lowering of groundwater (**Section 3.3.1**) protects beneficial uses and users of groundwater, and that groundwater level and storage are directly correlated, groundwater level MTs are used as a proxy for the reduction of groundwater storage sustainability indicator MTs.

The use of groundwater level as a proxy for the reduction of groundwater storage requires that "minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of [reduction in groundwater storage] will be prevented" according to CA-DWR Best Management Practices, (CA-DWR, 2017).

To demonstrate that SMC for the chronic lowering of groundwater level protect against significant and unreasonable reduction in groundwater storage, the change in groundwater storage under the current conditions baseline was compared to the change in storage implied under projected groundwater management and climate change scenarios (**Figure 3-16**). In three of four scenarios evaluated, the lowest basin storage experienced occurs around simulation year 2065 (a repeat of 2015 hydrology), yet at this global minimum in the storage estimate, the basin storage still exceeds the fall 2015 low. The Basin has historically avoided overdraft, and through substantial investment in conjunctive use and recharge projects, is on track to avoid overdraft during and after Plan implementation. As before only currently implemented projects are considered in these storage projections (Harvest Water, OHWD recharge, regional conjunctive use).

Because groundwater level SMC are set based on spatially distributed modeled head differences which are then applied to observed groundwater level data, the spatial un-evenness of changes in groundwater storage are captured at RMPs, and it is unlikely that the Plan's groundwater level MTs would lead to significant and unreasonable reduction of groundwater storage. Hence, MTs for reduction of groundwater storage in the Basin are identical to those related to chronic lowering of groundwater level.

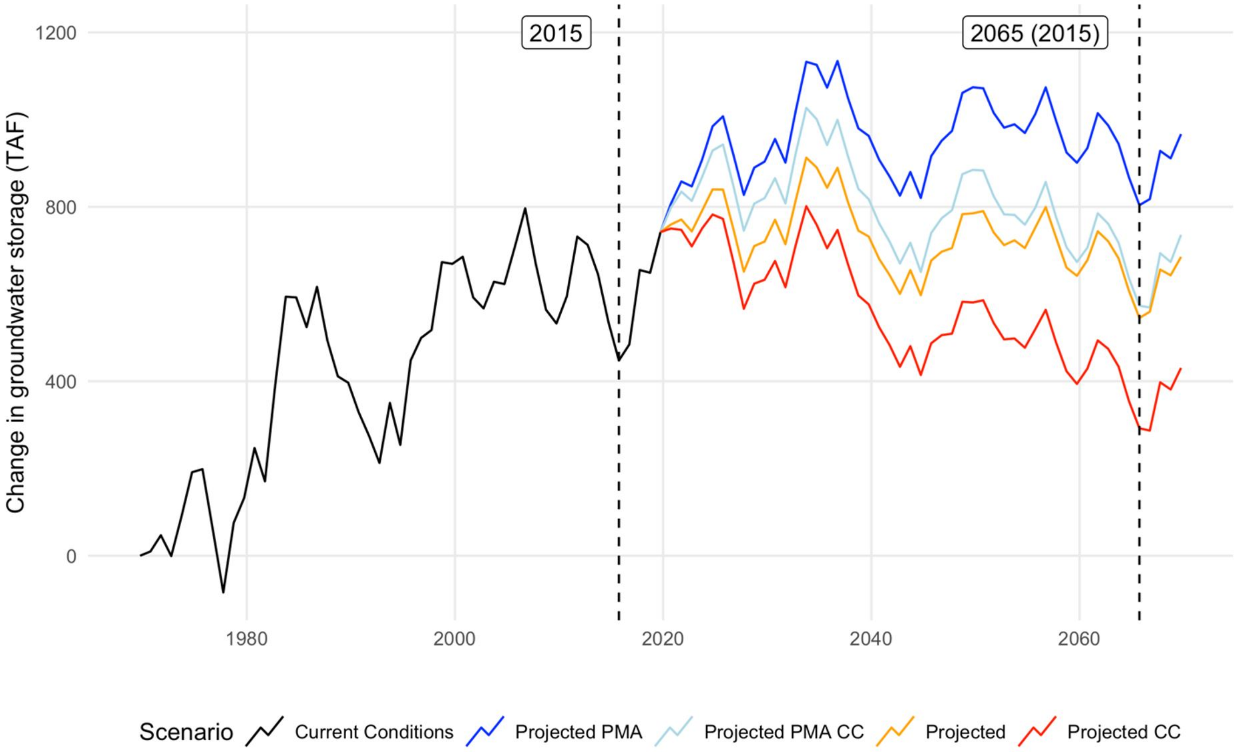


Figure 3-16: Cumulative change in groundwater storage under the current conditions baseline (black line), and the four scenarios (dark blue, light blue, orange, and red line) evaluated to aid in development of Basin SMC. Importantly, projects and management actions (PMA) increase storage, and climate change (CC) reduces storage. For consistency, all points represent September groundwater storage changes.

3.3.3 Maximum Threshold for Degraded Groundwater Quality

Because water quality degradation is typically associated with increasing, rather than decreasing concentration of constituents, the GSAs have decided to not use the term “minimum threshold” in the context of water quality, but instead use the term “maximum threshold” for the water quality sustainability indicator.

Maximum thresholds for groundwater quality in the Subbasin have been defined using existing groundwater quality data, beneficial uses of groundwater in the Subbasin, and existing pertinent water quality regulations, including water quality objectives defined under the Sacramento-San Joaquin Basin Plan, Title 22 Primary and Secondary MCLs, and consultation with the GSP Working Group members and stakeholders (see **Section 2.2.3**). As a result of this process, SMCs were developed for two of the constituents of concern in the Subbasin: nitrate and specific conductivity. The selected maximum thresholds for the concentration of each of the constituents of concern and their associated regulatory thresholds are shown in **Table 3-5**.

Significant and undesirable results are experienced if these maximum thresholds are exceeded in 10% of the monitoring wells.

Table 3-5: **Constituents of concern and the associated maximum thresholds. Maximum thresholds also include no more than 10% of wells exceeding the maximum threshold for concentration listed here.**

Constituent	Maximum Threshold	Regulatory Threshold
Nitrate as Nitrogen	5 mg/L, trigger only 9 mg/L, trigger only 10 mg/L, MT	10 mg/L (Title 22 Primary MCL)
Specific Conductivity	900 micromhos/cm, trigger only 1600 micromhos/cm, MT	900 – 1600 micromhos/cm (Title 22 SMCL)

Triggers

The GSAs will use concentrations of the identified constituents of concern (nitrate and specific conductivity) below the maximum threshold as triggers for action in order to proactively avoid the occurrence of undesirable results. Trigger values are identified for both nitrate as nitrogen and specific conductivity, as shown in **Table 3-5**. The trigger value and associated definition for specific conductivity is the 90% upper limit or 90th percentile value for a calendar year. The trigger value for nitrate is 90% of the Title 22 MCL. Approaching or exceeding a trigger will be reported to the Regional Water Board in the annual reports and the five-year evaluations to solicit their recommendations.

Information and Methodology Used to Establish Maximum Thresholds and Measurable Objectives

Two constituents of concern (nitrate and specific conductivity) were identified as such due to measured exceedances of water quality standards or water quality objectives during the past 30 years and/or stakeholder input and prevalence as a groundwater contaminant of concern in California. A detailed discussion of the concerns associated with elevated levels of each constituent of concern is described in **Section 2.2.3**. Because the constituents of concern were identified using current and historical groundwater quality data, the list may be reevaluated during future GSP updates. In establishing maximum thresholds for groundwater quality, the following information was considered:

- Feedback about water quality concerns from stakeholders.
- An assessment of available current and historical groundwater quality data from production and monitoring wells in the Subbasin.
- An assessment of historical compliance with federal and state drinking water quality standards and water quality objectives.
- An assessment of trends in groundwater quality at selected wells with adequate data to perform an assessment.

- Information regarding sources, control options, and regulatory jurisdiction pertaining to constituents of concern.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding maximum thresholds and associated management actions.

The current and historical groundwater quality data used in the effort to establish groundwater quality maximum thresholds are discussed in **Section 2.2.3**. Based on a review of these data, applicable water quality regulations, Subbasin water quality needs, and information from stakeholders, the GSAs reached a determination that the state drinking water standards (MCLs/SMCLs) are appropriate to define maximum thresholds for groundwater quality (**Table 3-5**). The established maximum thresholds for groundwater quality protect and maintain groundwater quality for existing or potential beneficial uses and users. Maximum thresholds align with the state standards for nitrate and specific conductivity, and the Title 22 MCLs and SMCLs.

New constituents of concern may be added with changing conditions and as new information becomes available.

Method for Quantitative Measurement of Maximum Thresholds

Groundwater quality will be measured in representative monitoring wells as discussed in **Section 3.5**. Statistical evaluation of groundwater quality data obtained from available water quality data obtained from the monitoring network will be performed. The maximum thresholds for constituents of concern are shown in **Table 3-5** and **Figure 3-30**, which shows “rulers” for each of the two identified constituents of concern in the Subbasin with the associated maximum thresholds, measurable objectives, and triggers.

3.3.4 Minimum Threshold for Depletions of Interconnected Surface Water

Like reduction of groundwater storage, it is not possible to directly measure depletions of ISW. Rather, these depletions are estimated by the CoSANA integrated surface and groundwater flow model. Importantly, the depletion volume and rate depend on the hydraulic gradient, or relative elevation, between ISW bodies and groundwater.

As before, the use of groundwater level as a proxy for depletions of ISW requires that “minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of [depletions of ISW] will be prevented” (CA-DWR, 2017).

As detailed in **Section 3.3.1**, MTs based on the fall 2015 low groundwater level and groundwater levels based on projected use do not suggest significant and unreasonable depletions of ISW or deviations in streamflow compared to the current conditions baseline. Groundwater level MTs (**Figure 3-15 and Table 3-4**) arrest hydraulic gradients at the lower of post-2015 groundwater levels or projected low groundwater levels in the PMA CC scenario. ISW depletion rates assuming MTs are reached were evaluated and found to not appreciably differ from present day conditions (**Figure 3-12**). In fact, the lower Cosumnes River and Mokelumne

River become more gaining over time due to benefits from the Harvest Water recharge site. Morrison creek becomes more losing in all projected scenarios due to increased pumping in the Sacramento urban area, but it remains interconnected, and the reduced baseflow from surrounding areas is not considered a significant and undesirable result.

Notably, the depletion rate may temporarily increase during wet years when surface water stage increases, which increases the hydraulic gradient and drives stream seepage into groundwater. The CoSANA model captures this hydrologic response during wet year types, but for the purposes of this Plan, which concerns the deleterious impact of groundwater extraction on stream depletion, monitoring of groundwater level measurements that indicate an expanding cone of depression are prioritized. Nonetheless, to better understand complex, sub-seasonal stream-aquifer interactions, high frequency (i.e., 15-minute interval) flow gauges have been installed in reaches immediately upstream of interconnected surface waters along the southern Cosumnes River (**Figure 3-25**).

There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Subbasin.

3.3.5 Minimum Threshold for Land Subsidence

The minimum threshold for land subsidence in the Basin is set at no more than 0.1 foot [0.03 m] in any single year and a cumulative 0.5 foot [0.15 m] in any five-year period, resulting in no long-term permanent subsidence. This is set at the same magnitude of estimated error in the InSAR data (+/- 0.1 foot [0.03 m]), which is currently the only tool available for this subbasin for measuring subbasin-wide land subsidence consistently each year.

The minimum thresholds selected for land subsidence for the Basin area have been selected as a preventative measure to ensure the maintenance of current ground surface elevations and as an added safety measure for potential future impacts not currently present in the Basin and nearby basins. This avoids significant and unreasonable rates of land subsidence in the Basin, which are those that lead to a permanent subsidence of land surface elevations that impact infrastructure and agricultural production in the Basin and neighboring groundwater subbasins.

Given that the Basin is currently at the measurable objective and not expected to experience significant or unreasonable subsidence, it is not anticipated that the land subsidence minimum threshold will significantly affect any of the interests of beneficial uses and users of groundwater or land uses and property interests. However, it is possible that if the current subsidence rates steepen, that there might be an impact to groundwater pumping (e.g., wells could be physically damaged, or conservation measures enacted). However, given the specific nature of the variable aquifer geology across the Basin, it would likely be confined to a subarea of the Basin where a combination of groundwater overdraft and localized clay layers would operate together to display an inelastic subsidence signal (potentially on the west side of the Basin). However, either of these cases are not currently anticipated to coexist in the Basin at significant and unreasonable levels.

There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Basin.

Land subsidence in the Basin will be quantitatively measured by use of primarily InSAR data (DWR-funded TRE Altamira or other similar data products). If there are areas of concern for inelastic subsidence in the Basin (i.e., exceedance of minimal thresholds) observed in the InSAR data, then ground-truthing studies could be conducted to conclude if the signal is potentially related to changes in land use and agricultural practices, or from groundwater extraction. If it is determined to be resulting from groundwater extraction and is significant and unreasonable, then ground-based elevation surveys might be needed to monitor the situation more closely.

The single CGPS (Continuous Global Positioning System) station in the Basin (UNAVCO station #P274) does not show significant and unreasonable inelastic subsidence during its period of record from 2005-2020 (see **Figure 2.3-41**) The CGPS station is also on the very edge of the Basin boundary, as well as near the larger subsidence subareas within the Basin (i.e., Delta and Elk Grove subareas). The InSAR and CGPS data at the location of the CGPS station compare well with one another (see **Figure 2.3-41**), demonstrating that the InSAR data product is an adequate management tool for land subsidence in the Basin.

The minimum threshold applies to the entire Basin area.

3.4 Measurable Objectives and Interim Milestones (23 CCR § 354.30)

23 CCR § 354.30. Measurable Objectives

> *(a) Each Agency shall establish measurable objectives, including interim milestones in*
> *(b) increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.*
> *(c) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.*
> *(d) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.*
> *(e) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.*
> *(f) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.*
> *(g) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.*
> *(h) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.*

Measurable objectives (MOs) are "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR § 351(s)). Interim milestones are "target value[s] representing measurable groundwater conditions, in increments of five years" (23 CCR § 351(q)) used to chart progress towards the Sustainability Goal quantified in the MOs.

Importantly, MOs provide a "margin of operational flexibility under adverse conditions" (23 CCR § 354.30(d)), quantified by the difference between MOs and MTs at each RMP. Operational flexibility is especially important in the Basin, as significant recharge-intensive projects and anticipated conjunctive use management actions require operational space to fill and drawn down the aquifer in wet and dry periods respectively.

Attainment of MOs not only ensures that the Basin avoids undesirable results for beneficial uses and users of groundwater, but also that the Basin is put on a long-term path of sustainable groundwater management. MOs developed herein achieve the Basin's stated Sustainability Goal.

3.4.1 Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels

Like MTs (**Section 3.3.1.1**), MOs were quantified following evaluation of historical groundwater levels at RMPs. MOs were defined as the average post-2015 groundwater level at RMPs (**Figure 3-17**), which can be interpreted as the average spring and fall groundwater level over a roughly present-day period (2015-2019), which contains 1 critical year, 2 below normal years, and 2 wet years. Moreover, if the MT was reduced because projected groundwater levels (in the PMA CC scenario) show a decline, the MO was also reduced by a proportional amount. Lastly, MOs were *increased* in 8 RMPs within or nearby the Harvest Water recharge project[14], where model simulations indicate groundwater levels will increase upwards of 25 feet in the main recharge zone. Increasing MOs near the Harvest Water recharge site reflects an aspirational goal of increasing groundwater levels in the southern SASb to provide multiple benefits: higher groundwater levels to exercise this portion of the Basin, increased baseflow to streams, and improved flows in the lower reaches of the Cosumnes River, and the Mokelumne and Sacramento Rivers.

Thus, MOs are generally near present-day groundwater levels: some MOs are greater than the last-measured value at RMPs, and others are less than the last measured value. Because MOs are established based on historically observed variation in groundwater elevation at RMPs, the operational flexibility, or difference between MTs and MOs (**Table 3-4**, **Figure 3-18**) also varies per RMP based on local site-specific conditions.

Three Interim Milestones (IMs) at five-year intervals were defined by dividing the range of operational flexibility between the MO and MT at each RMP into 4 regions, such that the Basin makes linear progress towards MOs in each five-year increment. For clarity, in five years following Plan submission (2027), it is projected that the Basin will make 25% progress towards MOs; in 10 years following Plan submission (2032), it is projected that the Basin will make 50% progress; in 15 years following Plan submission (2037) it is projected that the Basin will make

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[14] The RMPs for which MOs were increased in and adjacent to the Harvest Water recharge area are: RMP_01, RMP_02, RMP_03, RMP_04, RMP_05, RMP_06, RMP_07, and RMP_08.

75% progress; and finally, in 20 years following Plan submission (2042), it is projected that the Basin will meet its long-term Sustainability Goal. Thus, the IMs in 2042 are equal to the MOs.

Importantly, the operational flexibility (difference between MT and MO) varies across sites (**Figures 3-18 and 3-21**). A small or large operational flexibility should not be misinterpreted as overly conservative or potentially damaging, but rather, based on observed groundwater elevation at that site (**Figure 3-4**). Differences in the range of groundwater elevation at a particular site are the result of hydrologic processes and geology (i.e., storage coefficient), and local water use (i.e., pumping, recharge, and other budget terms).

As before with MTs, the MOs and IMs in this Plan are rounded to the nearest integer value to ease interpretation.

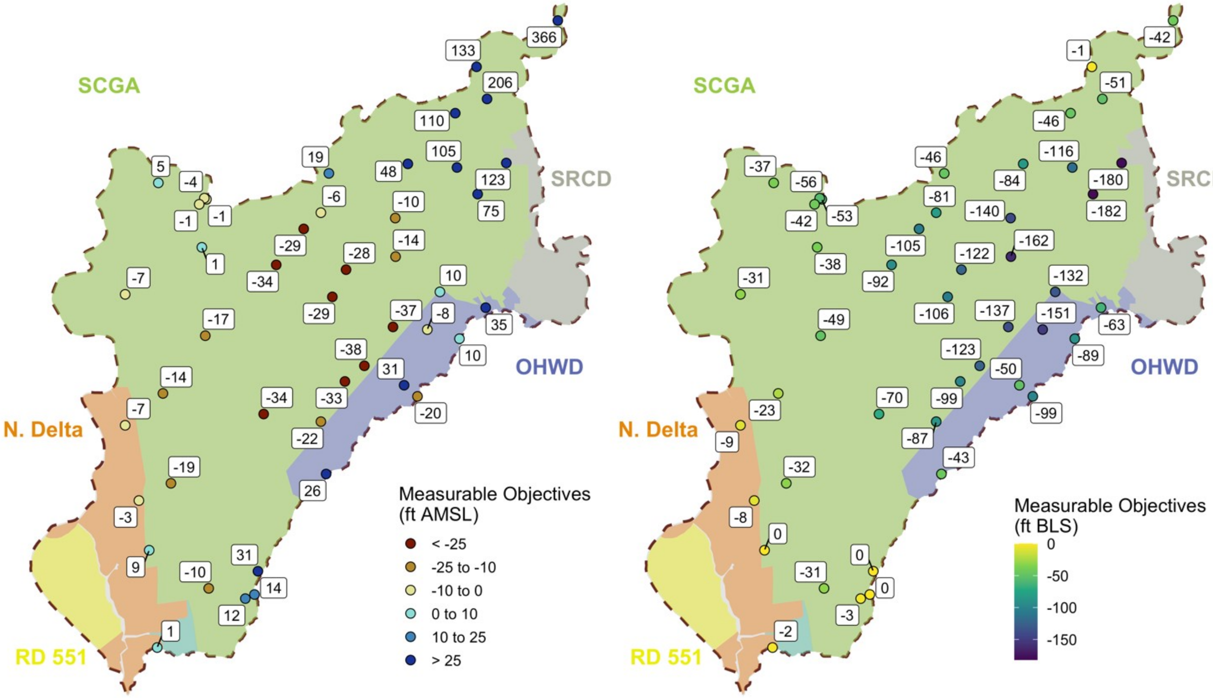

Figure 3-17: Groundwater level and storage measurable objectives at 45 RMPs in the Basin.

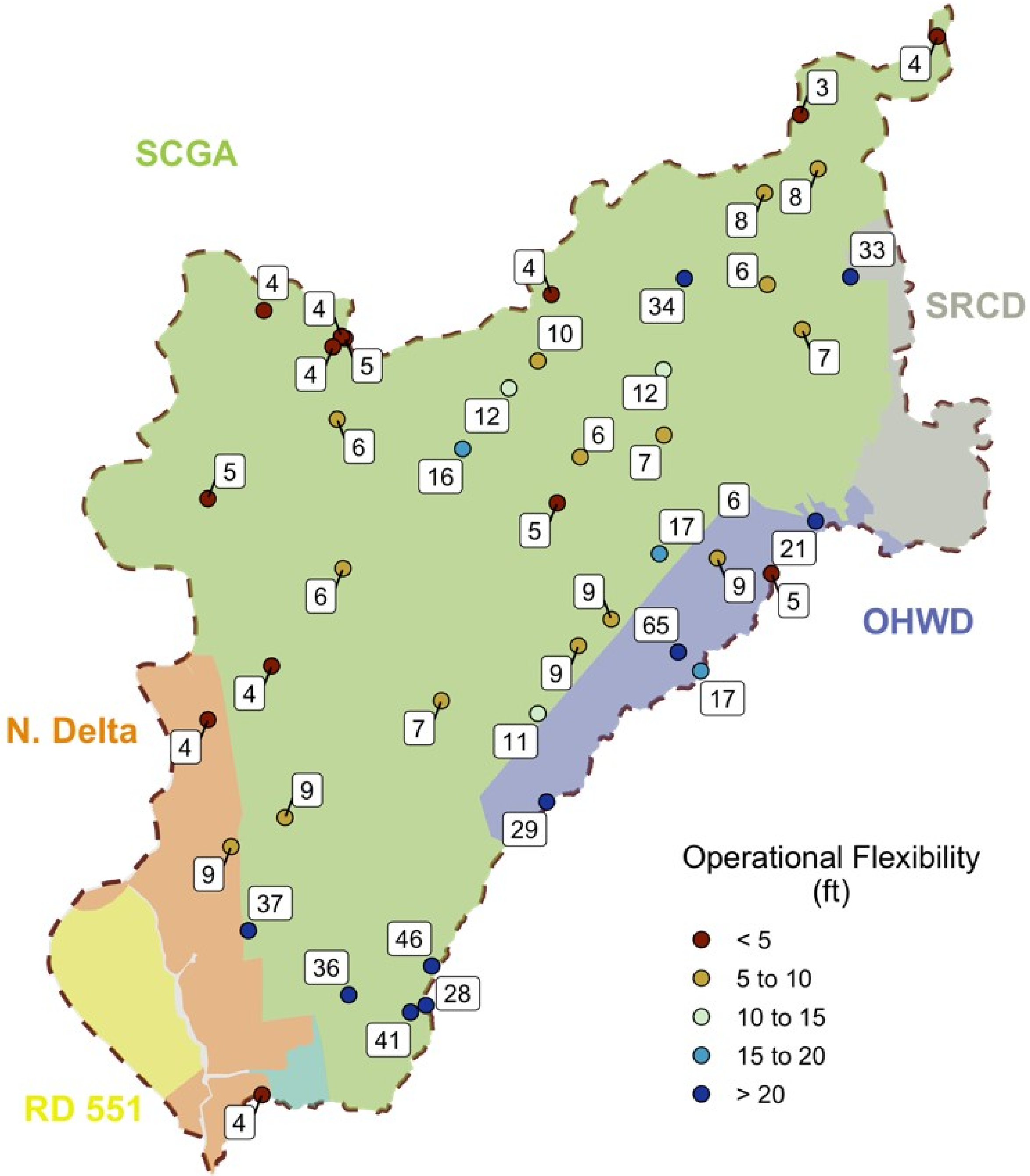

Figure 3-18: **Groundwater level and storage operational flexibility (difference between MT and MO) at 45 RMPs in the Basin.**

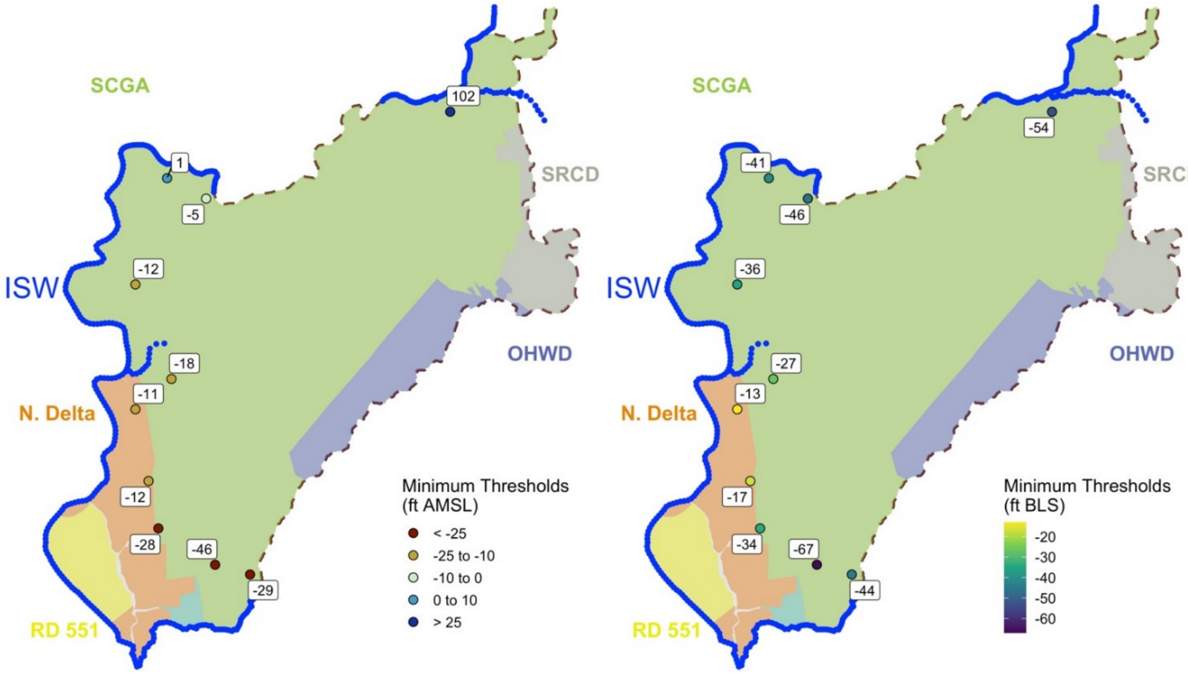

Figure 3-19: Interconnected surface water minimum thresholds at 10 RMPs in the Basin.

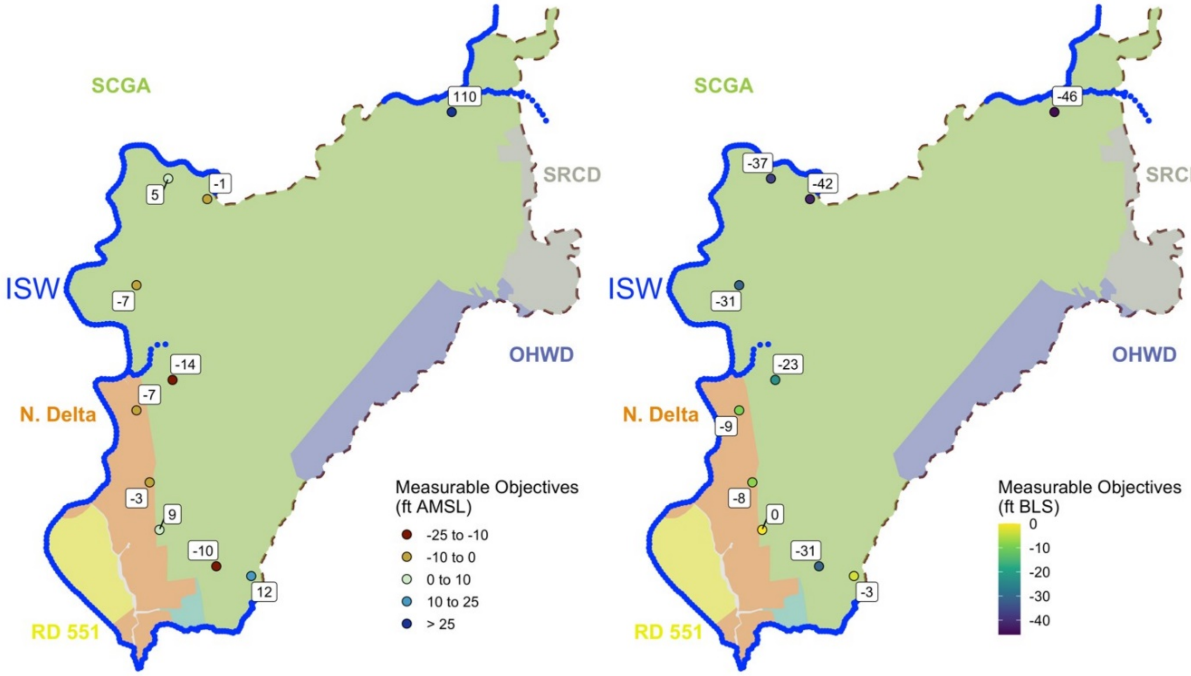

Figure 3-20: Interconnected surface water measurable objectives at 10 RMPs in the Basin.

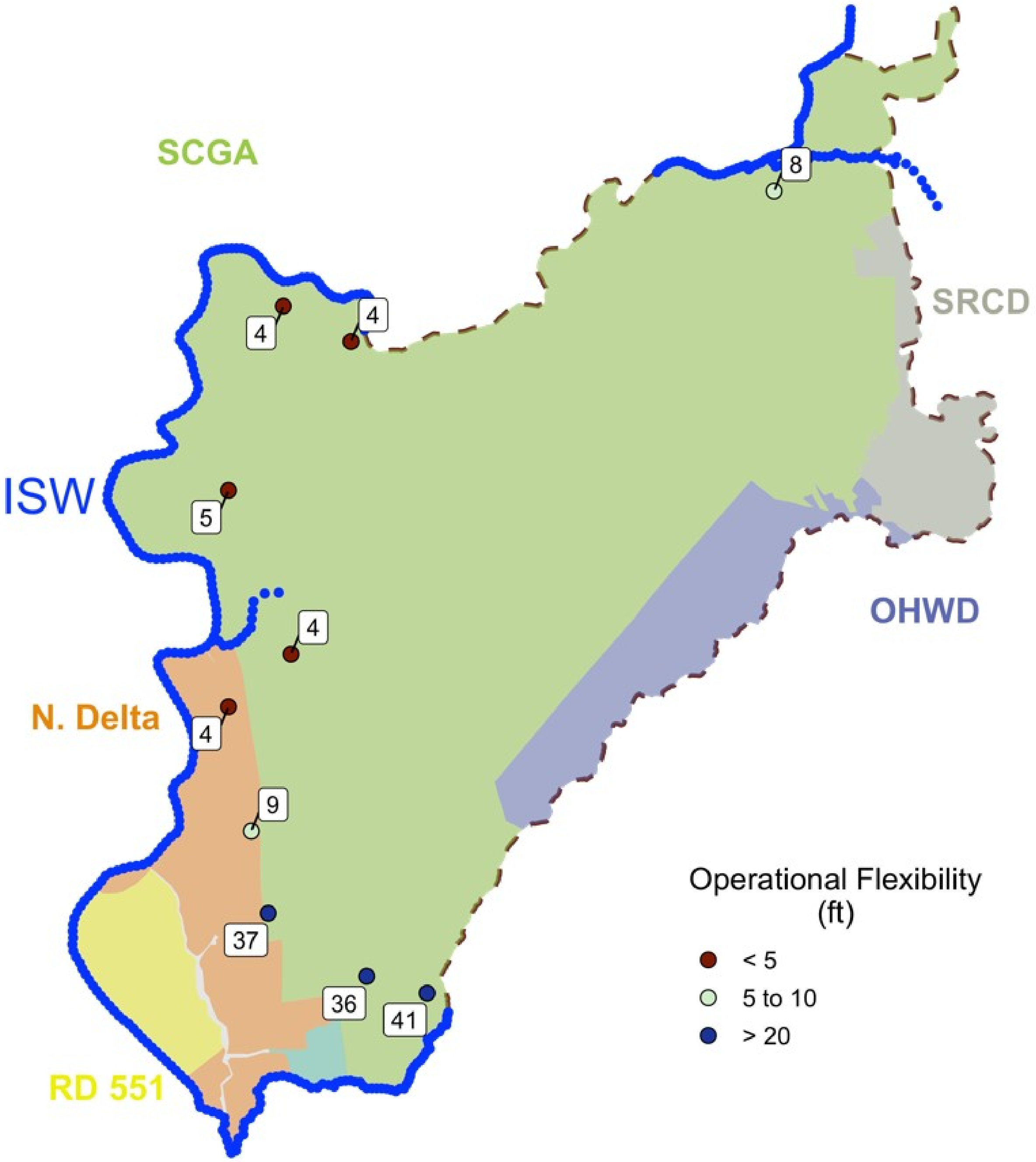

Figure 3-21: **Interconnected surface water operational flexibility (difference between MT and MO) at 10 RMPs in the Basin.**

3.4.2 Measurable Objective and Interim Milestones for Reduction of Groundwater Storage

As before with MTs, chronic lowering of groundwater levels and reduction of groundwater storage are directly correlated, and groundwater level is used as a proxy for groundwater storage (**Section 3.3.2**). Thus, MOs and IMs for reduction of groundwater storage are identical to those set for chronic lowering of groundwater levels (**Table 3-4**), and these values provide reasonable operational flexibility for the Basin.

3.4.3 Measurable Objective and Interim Milestones for Degraded Groundwater Quality

Within the Basin, the measurable objectives for water quality are established to provide an indication of desired water quality at levels that are sufficiently protective of beneficial uses and users. Measurable objectives are defined on a well-specific basis, with consideration of historical water quality data.

Description of Measurable Objectives

The groundwater quality MOs for nitrate and specific conductivity for wells within the SASb monitoring network, where the concentrations of these constituents of concern historically have been below the maximum thresholds for water quality in recent years, is to continue to maintain concentrations at or below the current range, as measured by long-term trends. For wells where the concentrations of constituents of concern have ever historically exceeded or been equal to the maximum thresholds, the measurable objective is 90% of the maximum threshold.

Specifically, for nitrate and specific conductivity, the goal will be to meet MOs in a minimum of nine groundwater quality monitoring wells in each of the aquifer layers (which corresponds to about 90% of wells monitored). In addition, no significant increase in long-term trends should be observed in levels for each of the two constituents of concern in more than one groundwater quality monitoring wells in each of the aquifer layers (i.e., approximately 10% of wells in the monitoring network). The proposed MOs for nitrogen and specific conductivity at the selected wells within the Basin are listed in **Table 3-6**.

Table 3-6: **The proposed measurable objectives for nitrogen and specific conductivity at the selected wells within the Subbasin.**

Well ID	Facility or Water System Name	Aquifer Layer	Measurable Objectives	
			Nitrogen	Specific Conductivity
3400375-001	Slavic Missionary Church Inc	Lower	5	140
3410015-020	Golden State Water Co. - Cordova	Lower	9.0*	160
3410015-022	Golden State Water Co. - Cordova	Lower	1.6	220
3410023-015	Cal Am Fruitridge Vista	Lower	1.13	570
3410029-015	SCWA - Laguna/Vineyard	Lower	0.5	420
3410029-026	SCWA - Laguna/Vineyard	Lower	0.5	190
3410029-027	SCWA - Laguna/Vineyard	Lower	0.5	172
3410704-001	SCWA Mather-Sunrise	Lower	0.5	150
L10007396297-MW-40B	Kiefer Landfill	Lower	1.9	220
S7-SAC-SA10	Unknown	Lower	1.74	272
3410020-009	City of Sacramento Main	Upper	3.77	339
3410029-002	SCWA - Laguna/Vineyard	Upper	3	310
3410029-016	SCWA - Laguna/Vineyard	Upper	1	190
3410029-029	SCWA - Laguna/Vineyard	Upper	2	296
3410033-006	Florin County Water District	Upper	7.23	340
L10005519750-MW-G(S)	Unknown	Upper	9.0*	620
L10008601447-MW-13	Elk Grove Class III Landfill	Upper	4.18	410
3400101-001	Hood Water Maintenance Dist	Upper	0.5	290
3410029-024	SCWA - Laguna/Vineyard	Upper	0.9	396
3410029-025	SCWA - Laguna/Vineyard	Upper	0.5	1060
3901216-001	Unknown	Upper	1.3	1320*

* The maximum historical value has been above the maximum thresholds, i.e., MCL or SMCL. Therefore, the MO has been set equal to 90% of the maximum thresholds.

Path to Achieve Measurable Objectives

The SASb GSAs will support the protection of groundwater quality by monitoring groundwater quality conditions and coordinating with appropriate regulatory agencies with jurisdiction to regulate groundwater quality in the Basin. All future projects and management actions implemented by the GSAs will comply with state and federal water quality standards and Basin Plan water quality objectives, and will be designed to maintain or improve groundwater quality for all uses and users and avoid causing unreasonable groundwater quality degradation. The GSAs will review and analyze groundwater quality monitoring data as part of GSP implementation in order to evaluate any changes in groundwater quality. The need for additional studies on groundwater quality will be assessed through GSP implementation.

Using monitoring data collected as part of project implementation, the GSAs will develop information (e.g., time-series plots of water quality constituents) to demonstrate that projects and management actions are operating to maintain or improve groundwater quality conditions in the Basin and to avoid unreasonable groundwater quality degradation. Should the concentration of a constituent of interest meet or exceed its maximum threshold as the result of GSA project implementation, the GSA will implement measures to address such an occurrence. This process is illustrated in **Figure 3-31**.

Exceedances of the maximum threshold for specific conductivity and nitrate will be referred to the CVRWQCB. Where the cause of an exceedance is unknown, the GSAs may choose to conduct additional or more frequent monitoring.

Interim Milestones

As existing groundwater quality data indicate that groundwater in the Basin generally meets applicable state and federal water quality standards for nitrate and specific conductivity, the objective is to maintain existing groundwater quality. Interim milestones are therefore set to maintain groundwater quality equivalent to the measurable objectives established for nitrate and specific conductivity, with the goal of maintaining water quality within the historical range of values.

3.4.4 Measurable Objective and Interim Milestones for Depletions of Interconnected Surface Water

As before with MTs, chronic lowering of groundwater levels and depletions of ISW are interrelated in that reductions in groundwater elevation in the Basin that increase the hydraulic gradient between ISW bodies and groundwater also lead to increased stream depletion. Arresting groundwater level decline and maintaining groundwater levels above MTs ensures that ISW depletion volumes will not lead to significant and unreasonable outcomes for beneficial users of ISW (**Section 3.2.4**). Wells were carefully chosen to detect gradient changes associated with a potential expanding cone of depression to ISW depletion, and scenario analysis of ISW reach length, streamflow, and seepage at projected groundwater level thresholds was conducted to relate groundwater level conditions to ISW conditions. Groundwater level is thus used as a proxy for ISW depletion and MOs and IMs for reduction of stream depletion are identical to those set for chronic lowering of groundwater levels (**Table 3-4**). These values provide reasonable operational flexibility for the Basin. The MTs, MOs, and IMs for ISW depletion are measured at a subset (10 wells) of the groundwater level and storage monitoring network (**Figure 3-12** to **Figure 3-14**).

3.4.5 Measurable Objective and Interim Milestones for Land Subsidence

Land subsidence is not known to be significant in the SASb. Previous efforts to quantify land subsidence in the Basin have yielded results showing minor amounts of subsidence having occurred in the Basin. Such efforts have mainly been through leveling profiles studied between 1947 and 1966, a 2008 DWR- and the US Bureau of Reclamation-authorized subsidence project throughout the Sacramento Valley using GPS technology (Frame Surveying & Mapping, 2008), and DWR’s Sacramento Valley 2017 GPS Survey program, all of which demonstrated that subsidence has been very minimal across the Basin.

Recent InSAR data provided by DWR (TRE Altamira) show no significant or unreasonable subsidence occurring during the period of June 2015 to September 2019 (**Figure 2.3-40**). Small fluctuations observed in these datasets are mainly in two areas: 1.) the Sacramento-San Joaquin Delta area, and 2.) the Elk Grove area. The Delta area of the Basin is likely affiliated with subsurface organic deposit dynamics (CA-DWR, 1995). The Elk Grove area signal is likely connected to small declines of groundwater levels historically present in this area (SCGA, 2016).

The specific geology of the geologically older alluvial aquifer materials comprising the east side of the Basin is not known to contain the thicker clay confining units that typically exhibit inelastic subsidence due to excessive groundwater pumping (i.e., overdraft conditions). While the west side of the Basin contains more fine-grained materials susceptible to inelastic subsidence than the east side, it is more of a cause for awareness than concern for future subsidence impacts to infrastructure in the Basin.

The guiding MO of this GSP for land subsidence in the Basin is the maintenance of current ground surface elevations. This measurable objective avoids significant and unreasonable rates of land subsidence in the Basin, which are those that lead to a permanent subsidence of land surface elevations that impact infrastructure and agricultural production. As this subsidence measurable objective is essentially already met, the specific goal is to maintain this level of land subsidence (i.e., essentially at a similar magnitude to the InSAR data error) throughout the implementation period.

Land subsidence in the Basin is expected to be maintained throughout the implementation period via the sustainable management of groundwater pumping through the groundwater level measurable objectives, minimum thresholds, and interim milestones, as well as the fact that the aquifer geology is not very likely to be susceptible to significant and unreasonable subsidence, even under groundwater overdraft conditions.

The margin of safety for the subsidence MO was established by setting a MO to maintain current surface elevations and opting to monitor subsidence throughout the implementation period, even though there is no historical record of significant and unreasonable subsidence and a major portion of the aquifer is not deemed to be likely to succumb to inelastic subsidence. This is a reasonable margin of safety based on the past and current aquifer conditions and is more reasonable to the alternative action of simply setting the subsidence indicator as ‘not applicable’ in the Basin due to current and documented historical evidence.

As the current MO is set to maintain the present land surface elevations of the Basin, the interim milestones are set as check-in opportunities to review year-to-year subsidence rates from the previous five-year period to assess whether there are longer-period subsidence trends than what is observed in the annual reviews. The MOs and associated IMs apply to the entire Basin area.

3.5 Monitoring Network

23 CCR § 354.34(d)-(j):

> *(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.*
> *(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.*
> *(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:*
> *(1) Amount of current and projected groundwater use.*
> *(2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.*
> *(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.*
> *(4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.*
> *(g) Each Plan shall describe the following information about the monitoring network:*
> *(1) Scientific rationale for the monitoring site selection process.*
> *(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.*
> *(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.*
> *(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.*
> *(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.*
> *(j) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.*

3.5.1 Description of Monitoring Network (23 CCR § 354.34)

Monitoring is fundamental to measure progress towards Plan management goals. The GSP monitoring network will characterize groundwater and surface water conditions in the Basin and evaluate hydrologic changes that occur during Plan implementation. This section explains the approach to develop the monitoring network for groundwater, storage, and the interconnection of surface water and groundwater, such that the network provides sufficient temporal frequency and spatial density to evaluate the effectiveness of the Plan.

Monitoring network data is used to evaluate impacts to beneficial uses and users of groundwater, monitor changes in groundwater conditions relative to sustainable management criteria (MOs, MTs, and IMs), and quantify annual changes in water budget components. Data from the network also provides an ongoing record for future assessments of groundwater conditions and informs adaptive management on the path to sustainability, thereby protecting against the Undesirable Results linked to, for example, the decline of groundwater level or the deterioration of groundwater quality. Ongoing monitoring during the plan implementation phase minimizes risk for exceeding maximum water quality thresholds and supports the GSAs in implementing timely projects and management actions.

The scientific rationale for assembling the GSP monitoring network for each sustainability indicator is based on a three-step approach (**Figure 3-22**). First, all existing wells in the Basin were reviewed. Second, a subset of these wells was selected based on selection criteria including well location, monitoring history, and well construction information. “Selected” wells were presented to the working group and subjected to a second set of selection criteria including site access. “Selected” wells with adequate site access are considered “Confirmed” monitoring points. “Confirmed” wells are the representative monitoring points at which SMC are defined (**Table 3-4**). These points are strategically selected to maximize lateral and vertical coverage, ensure historical and present-day data, and secure reliable site access during plan implementation.

Figure 3-22: General framework for monitoring site selection (Section 3.5).
To assess monitoring well suitability, all existing wells were reviewed according to selection criteria. Selected wells were then subjected to a second set of screening criteria including site access considerations. Wells that meet selection criteria and site access considerations are considered “Confirmed” and are present in the GSP monitoring network.

The criteria (well location, monitoring history, well information, well access) used to confirm wells is discussed below:

Well Location

Strategic siting and design of a well network is important to ensure adequate spatial distribution, coverage, and well density. The well network must not only be laterally expansive but also span the vertical dimension and capture different depths of the principal aquifer that require monitoring. Beyond capturing general hydrologic trends, it is especially important to monitor areas within or adjacent to planned GSP projects and management actions at the appropriate temporal frequency, and areas where existing or legacy operations may threaten groundwater quality for beneficial uses and users. Where monitoring wells are not present, statistical methods are used to aid in extrapolating data from existing monitoring sites to the entire Basin.

Monitoring History

Wells with a long historical record provide valuable insight into trends and baseline conditions. Thus, candidate wells with current data, but also a historical record dating prior to 2005 were prioritized as monitoring candidates. Moreover, candidate wells with near present-day measurements were also prioritized.

Well Information

Beyond well location information and reliable site access, well construction information including well depth and depth of screened interval(s) are essential to interpret monitoring results and to ensure adequate vertical monitoring coverage of the principal aquifer. At a minimum, selected wells should have well depth information. Although perforation interval is not present for each well in the “Confirmed” monitoring network, it was essential to include these wells to provide adequate lateral coverage. Data gaps will be addressed in future field work during the GSP implementation period.

Well Access

Most monitoring wells in the Basin are on private land. The ability to access wells to collect data is a limiting factor in a successful monitoring network; thus, local agencies that collect monitoring data were consulted to confirm candidate wells with reliable site access.

3.5.2 Monitoring networks in the Basin

Based on the Basin’s historical and present-day conditions (**Section 2.3**), the groundwater level and storage, groundwater quality, and ISW are the main sustainability indicators to be monitored to evaluate progress towards the Basin’s sustainability goal. Land subsidence and seawater intrusion were not found in the Basin and thus do not have monitoring networks (23 CCR § 354.34(j)).

A general overview of the monitoring network associated with each of these sustainability indicators is discussed below. Additional network details are provided in each sustainability indicator’s subsection.

Groundwater level is used as a proxy for reduction in storage and ISW depletion, thus the monitoring networks for level, storage, and ISW are complimentary; of the 45 wells in the level and storage network, 10 of those wells are in the ISW monitoring network. The water quality monitoring network is separate from the network for groundwater level, storage and ISW depletion. Each monitoring network is described below in greater detail.

Groundwater Elevation Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:*
>
> *(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.*
>
> *(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.*

The groundwater elevation monitoring network is designed to demonstrate groundwater occurrence, level, flow directions, and hydraulic gradients between the principal aquifer and surface water features.

The initial list of groundwater level monitoring wells included 167 monitoring wells from:

- Department of Water Resources (DWR)
- Omochumne-Hartnell Water District (OHWD)
- University of California Davis (UCD)
- Sacramento State University (CSUS)
- Sacramento County
- Bureau of Reclamation
- Sacramento Central Groundwater Authority (SCGA)
- Historical calibration data in regional hydrologic models (SVSIM and SacIWRM)
- Aerojet

Next, these data were narrowed down by considering the following criteria:

- At least depth or perforated interval are present, preferably both;
- Measured water level data are available at least through 2019 (this criterion was relaxed in locations where spatial coverage is lacking);
- A preference is given to wells with data prior to 2005; and
- The well has at least five historical measurements.

Annual pumping in the Basin exceeds 10,000 acre-feet/year per 100 square miles, and thus, DWR Best Management Practices (CA-DWR, 2017) and Sophocleous (1983) suggest a density of 4 monitoring wells per 100 square miles to collect representative measurements. The surface area of the SASb is 388 square miles, which suggests a need for at least 16 monitoring wells and a lateral coverage of 24.25 square miles per well. The groundwater elevation monitoring network (**Figure 3-23**) uses 45 monitoring wells and covers 92% of the Basin area according to spatial coverage estimates by Sophocleous (1983).

The Basin has one principal aquifer with most groundwater production occurring in the middle Laguna and Mehrten formations (**Section 2-2**). The monitoring network spans these formations (**Figure 3-24**) and provides adequate vertical coverage across unconfined, semiconfined, and confined systems. Importantly, monitoring well density is appropriate to extrapolate seasonal groundwater elevation maps to support the shallow well protection analysis, GDE impact analysis, and to monitor seasonal changes in hydraulic gradients that indicate changes in ISW depletion.

Monitoring frequency (**Figure 3-25**) is important to characterize groundwater and surface water dynamics. All wells will collect at least biannual measurements in spring (mid-March) and fall (mid-October) in line with DWR Best Management Practices (CA-DWR, 2017). Wells in or adjacent to the Harvest Water Recharge management zone will collect monthly measurements. All well IDs with the prefix “ACR”, “MW” and “SS” are within the vicinity of the Cosumnes and Sacramento Rivers and will collect high-frequency 15-minute interval data to improve understanding of stream-aquifer interactions. Specifically, these measurements will be paired with high-frequency 15-minute interval stream gauge data at two locations along the Cosumnes River to improve understanding in this important ecosystem.

Monitoring standards and conventions are consistent with 23 CCR § 352.4, which outline data and reporting standards for groundwater level measurements.

Groundwater Storage Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.*

Groundwater level is used as a proxy for groundwater storage (**Section 3.3.2**), thus the groundwater storage monitoring network is identical to the network for groundwater level. Observations obtained at the groundwater level monitoring network will directly inform integrated surface and groundwater modeling in the Basin as model calibration targets.

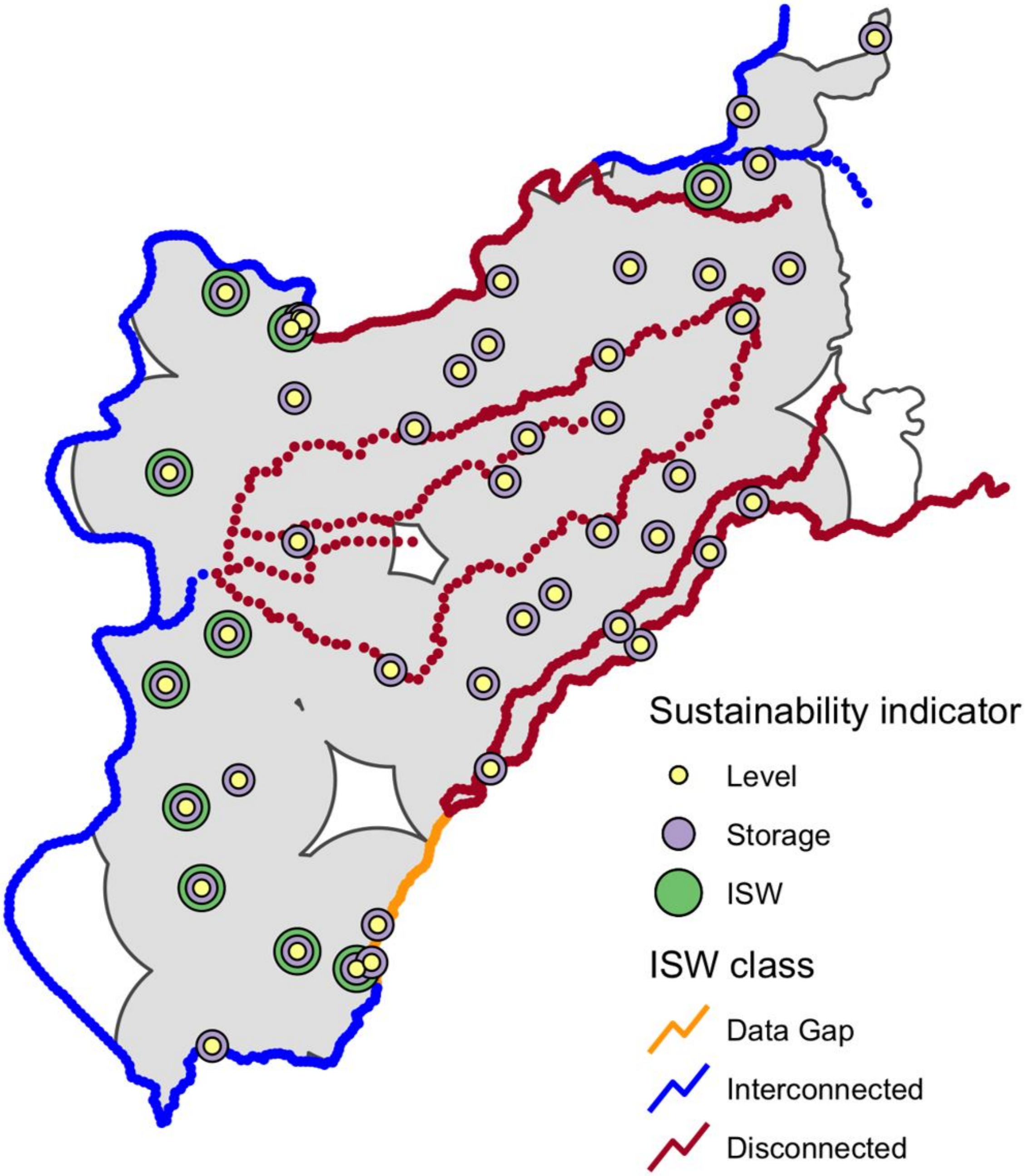

Figure 3-23: Monitoring network for groundwater level, storage, and ISW depletion sustainability indicators.

Network density is depicted with grey, circular 24.25 square mile buffers around each monitoring point that are joined to show the 92% lateral coverage of the network.

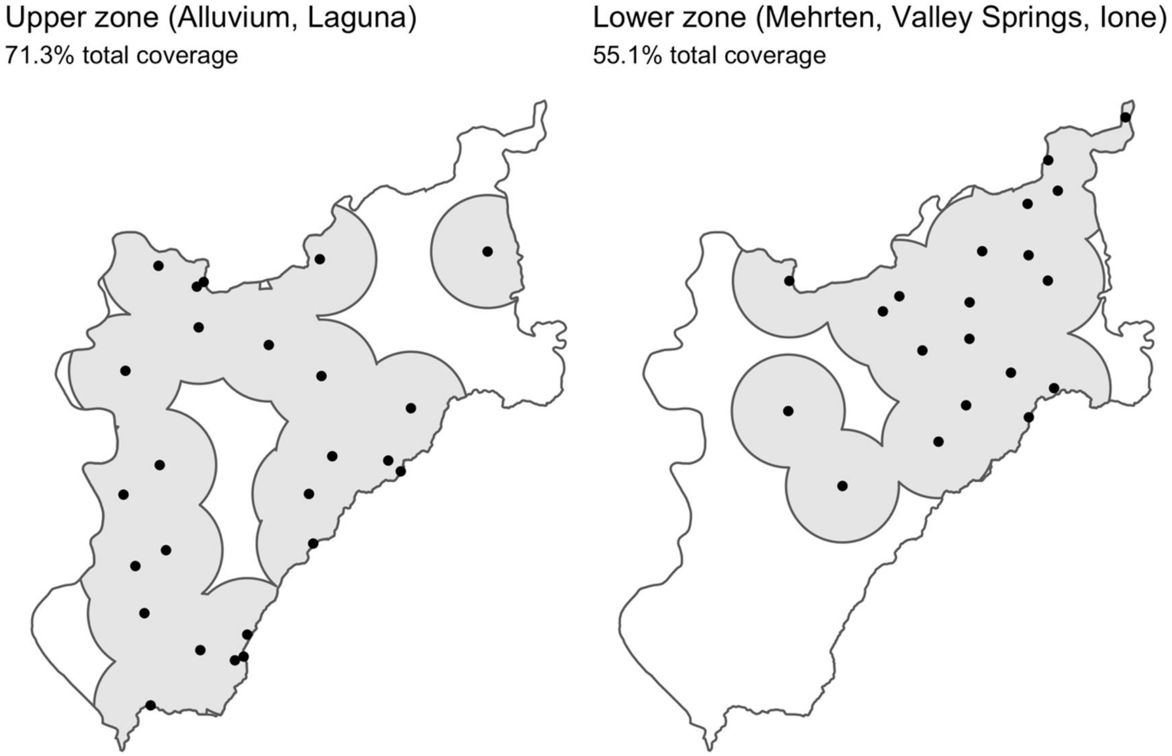

Figure 3-24: Density of monitoring locations in the upper and lower zone of the principal aquifer. Depth to groundwater increases in the north and northwest of the Basin, as does density of deeper monitoring wells. Major water bearing production formations are the Laguna and Mehrten. Circular 24.25 square mile buffers are shown in grey around each monitoring point and joined to show the lateral coverage of the network.

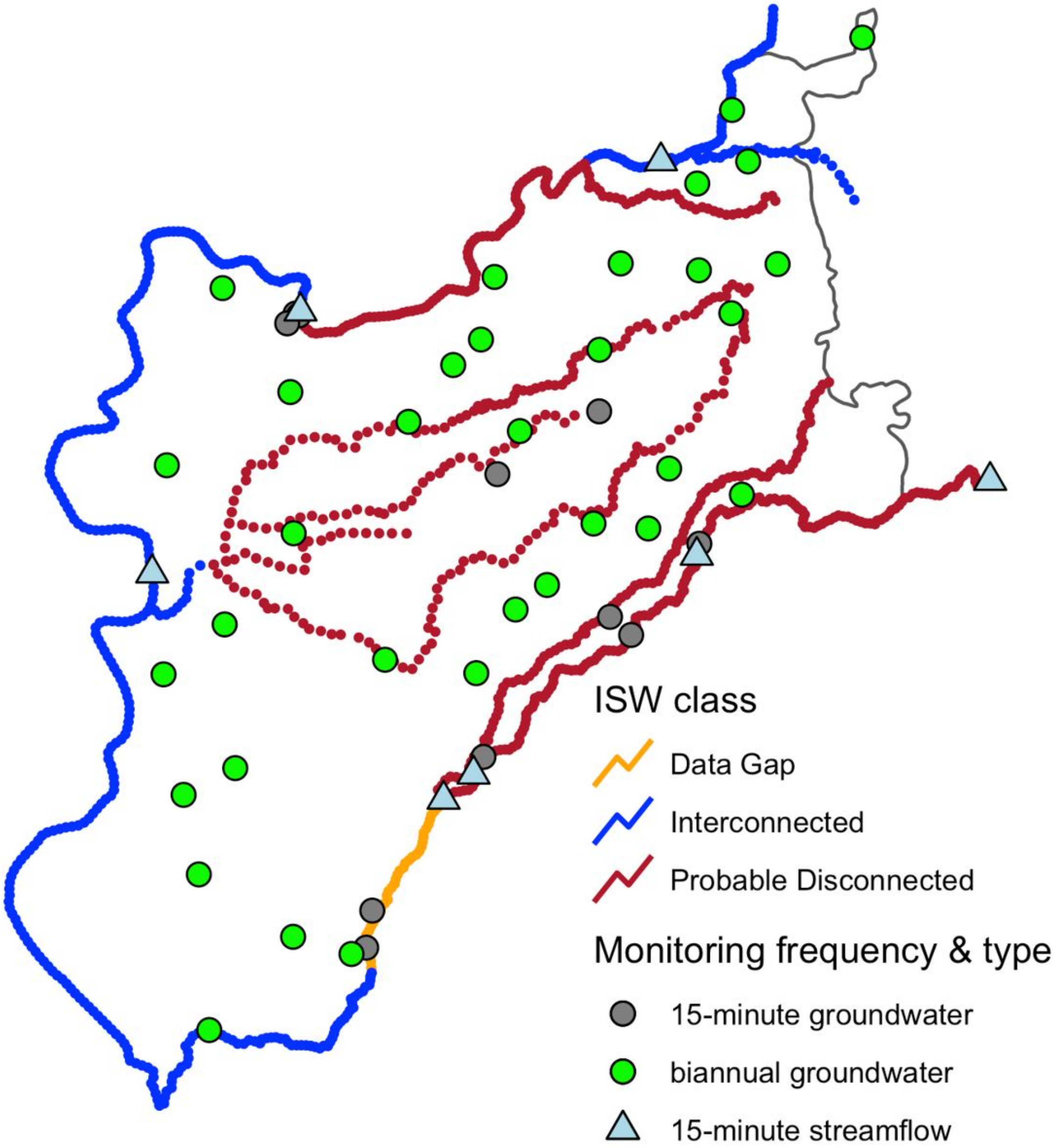

Figure 3-25: **Monitoring frequency for representative monitoring points in the network for level, storage, and ISW depletion.**
Streamflow locations are a combination of USGS (Michigan Bar, Fair Oaks, Freeport), NOAA (H Street, McConnell), and LWA-installed (ACR_181, ACR_189) gauging stations.

Groundwater Quality Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.*

The objective of the groundwater quality monitoring network design is to capture sufficient spatial and temporal detail to understand groundwater quality in the Basin. The data from the network will provide an ongoing water quality record for future assessments of groundwater quality. The spatial and temporal coverage of the groundwater quality monitoring network will be designed to allow the GSAs to take an effective and efficient adaptive management approach in protecting groundwater quality, to minimize the risk for exceeding *maximum* water quality thresholds,[15] to support the GSAs in implementing timely projects and actions, and ultimately, to contribute to compliance with water quality objectives throughout the Basin.

Apart from groundwater quality problems associated with four contamination sites (Aerojet-General Corporation, Mather AFB, Union Pacific, and Inactive Rancho Cordova Test Site), the Basin currently maintains very good groundwater quality, as described in **Section 2.3.4**. Existing wells used for monitoring groundwater quality in the Basin include public water supply wells and monitoring wells at groundwater contamination sites. Coordination will be conducted between existing monitoring programs and the GSA to develop an agreement for data collection responsibilities, monitoring protocols, and data reporting. Wells in existing programs are almost exclusively located within and near the urban areas of the Basin.

Groundwater quality monitoring in the Basin in support of the GSP will rely largely on existing wells used for monitoring groundwater quality in the monitoring network. Groundwater quality samples will be collected and analyzed in accordance with the monitoring protocols outlined in **Section 3.5.3.2**. The monitoring network will use information from existing programs in the Basin that already monitor for specific constituents of concern, and from other programs where these constituents could be added as part of routine monitoring efforts in support of the GSP. New wells will only be incorporated into the network as necessary to obtain information that will fill spatial gaps in data gathered at existing wells.

The existing network will be augmented with additional wells within Regional San's Harvest Water Project (explained in **Section 4**) area that covers agricultural lands in the southern portions of the Basin. These wells will be suitably located to obtain representative spatial coverage and understanding of groundwater quality in the Basin to enable adequate spatial coverage (distribution and density) to characterize groundwater quality conditions at a local and basin-wide scale for all beneficial uses.

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[15] In the context of water quality sustainability indicator, the term “maximum threshold” is used instead of “minimum threshold”.

As many of the wells in the Basin are used for public water supply, an extensive record of water quality data is available for most wells. Using the geographic location and screen elevation information of the municipal or monitoring wells with historical groundwater quality records, an initial list of existing wells with groundwater quality measurements was created for inclusion in the monitoring network. Water quality monitoring well locations and depths were intersected with the three-dimensional COSANA texture model (**Section 2.2.1**) to determine the geologic formations monitored by each well. Geologic formations were assigned to each well by aligning the depth ranges occupied by the formation and the screened interval or depth of the monitoring well at each well location. When present, the screened interval of the monitoring well was used to assign geologic formation; otherwise, the depth of the well was used. Two of the wells did not have depth or screened interval information. These data gaps will be addressed by sending cameras down the well casing as part of the GSP implementation activities.

The initial list of groundwater quality monitoring wells was created using data downloaded from the GAMA Groundwater Information System Data Download.[16] Data were downloaded for Sacramento County on May 22, 2020, and includes groundwater quality data from the following sources:

- Department of Pesticide Regulation (DPR)
- Department of Water Resources (DWR)
- Lawrence Livermore National Laboratory
- State and Regional Water Board Regulatory (Electronic Deliverable Format (EDS) and Irrigated Agricultural Land Waiver (AGLAND))
- State Water Board, GAMA Program water quality data (GAMA, USGS)
- State Water Board, Division of Drinking Water public supply well water quality (DOW)
- U.S. Geological Survey (USGS)

Additional data were obtained directly from GEI Consultants, Inc., which developed the Subbasin's 2016 Alternative Plan.

Evaluating these data, the initial list of groundwater quality monitoring wells includes 157 wells with historical data for both nitrogen and total dissolved solids (TDS) measurements screened within either of the aquifer layers. To narrow down the number of wells, the following criteria were considered:

- Both nitrogen and TDS are measured at the same well;

- Measured water quality data are available at least through 2018 (this criterion was relaxed especially in the lower aquifer to provide a better spatial coverage); and

- The well has at least five historical measurements.

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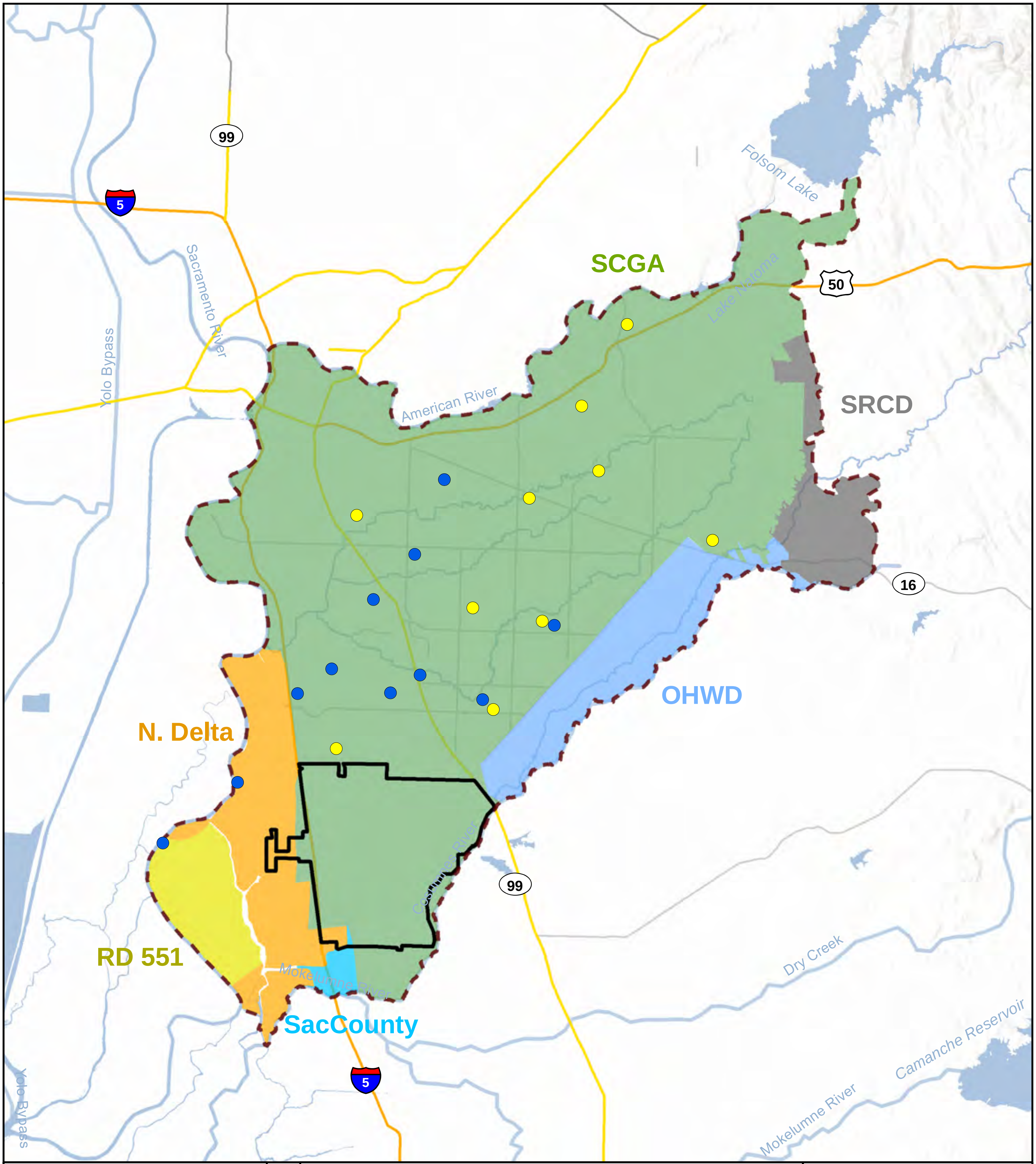
[16] http://geotracker.waterboards.ca.gov/gama/datadownload

A total of 64 wells met these criteria as listed in Table A-1 in **Appendix 3-E** along with the name of their corresponding facility or water system, and the GSA within which the well is located. This list was further narrowed down to avoid inclusion of redundant monitoring wells that are within the proximity of each other. As shown in **Figure 3-26**, the final proposed groundwater monitoring network includes 11 wells screened within the upper aquifer layer (**Table 3-7**) and 10 monitoring wells screened through the lower aquifer layer (**Table 3-8**). The GSA within which each well is located will potentially be responsible for collection and management of the monitoring data during GSP implementation. While there is no definitive rule for the appropriate density of groundwater monitoring points needed in a basin, Hopkins (1984) incorporates a relative well density based on the degree of groundwater use within a given area and suggests that basins pumping more than 10,000 acre-feet per year must have at least four monitoring wells per 100-square miles. This would suggest that each well roughly covers an area occupying 25-square miles. Using this well-density assumption, wells screened within the upper and lower layers of the aquifer would cover approximately 36% (**Figure 3-27**) and 47% (**Figure 3-28**) of the Basin area, respectively. These wells provide a good coverage of mainly central portions of the Basin. As mentioned earlier, coordination will be conducted with Aerojet to add at least one of their wells to the monitoring network. Furthermore, Harvest Water Project, which covers approximately 10% of the Basin area in the southwest, plans to monitor groundwater quality within its project area. The GSA plans to coordinate with the Harvest Water Project to include two additional monitoring wells within their project area. The northwestern portions of the Basin covers urban areas of the City of Sacramento with no issues related to nitrogen or TDS concentrations. Therefore, monitoring concentrations of these constituents within the northern portions of the Basin is not necessary.



South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-26

Legend

● Lower Layer GWQ Monitoring Points

● Upper Layer GWQ Monitoring Points

▭ Harvest Water

▭ South American Subbasin

GSA

🟧 N. Delta

🟦 OHWD

🟨 RD 551

🟩 SCGA

⬛ SRCD

🟦 SacCounty

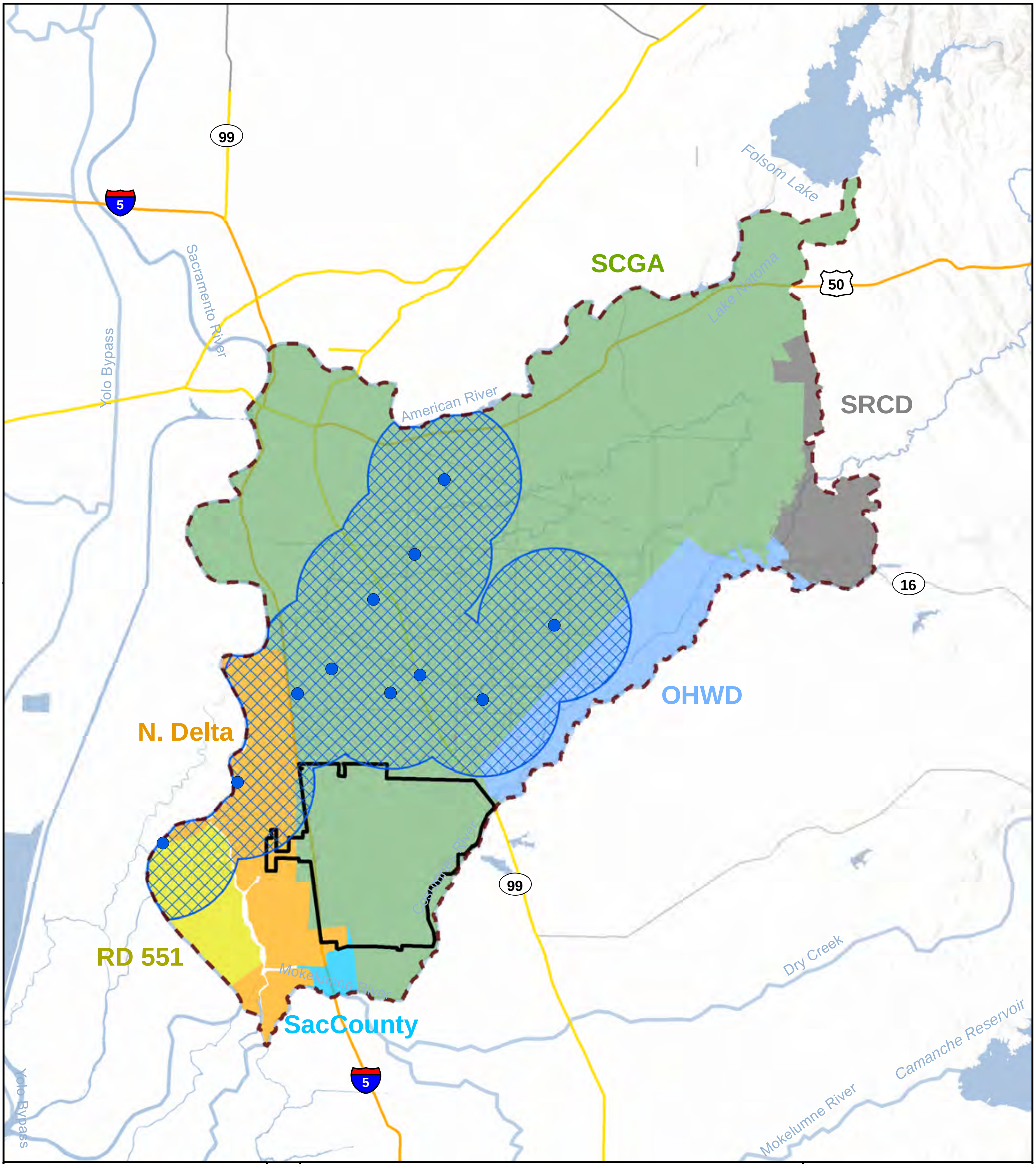
0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 10 2021

Figure Exported: 10/19/2021 By: OlinA Using: C:\Users\olina\Dropbox (LWA)\Olin A\601.0.3 - GSP 2020, LF\SAS GIS - Template and Final Figures\Figure 3-26 - Water Quality Monitoring Network_6 GSAs - Oct 2021.mxd



South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-27

Legend

- ● Upper Layer GWQ Monitoring Points
- ▨ Upper Layer GWQ Wells Buffer
- ☐ Harvest Water
- ⬚ South American Subbasin

GSA

- 🟧 N. Delta
- 🟦 OHWD
- 🟨 RD 551
- 🟩 SCGA
- ⬛ SRCD
- 🟦 SacCounty

0 1.25 2.5 5 Miles

N

South American SUBBASIN

Map Created: 10 2021

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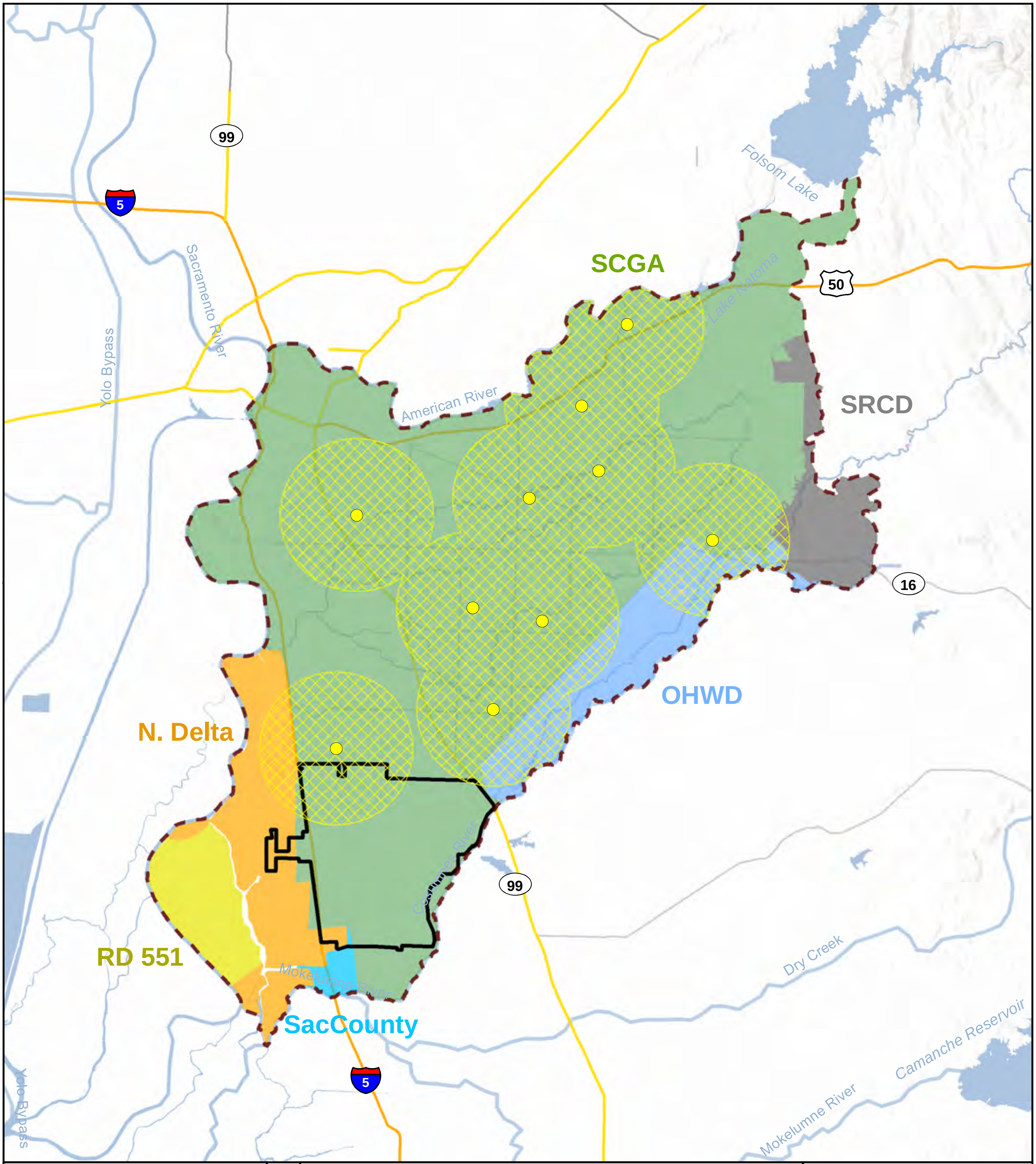

South American Subbasin GSP

Proposed Water Quality Monitoring Network

Figure 3-28

Legend

- ● Lower Layer GWQ Monitoring Points
- ▨ Lower Layer GWQ Wells Buffer
- ▭ Harvest Water
- ▭ South American Subbasin

GSA

- 🟧 N. Delta
- 🟦 OHWD
- 🟨 RD 551
- 🟩 SCGA
- ⬛ SRCD
- 🟦 SacCounty

0 1.25 2.5 5 Miles

N

South American SUBBASIN

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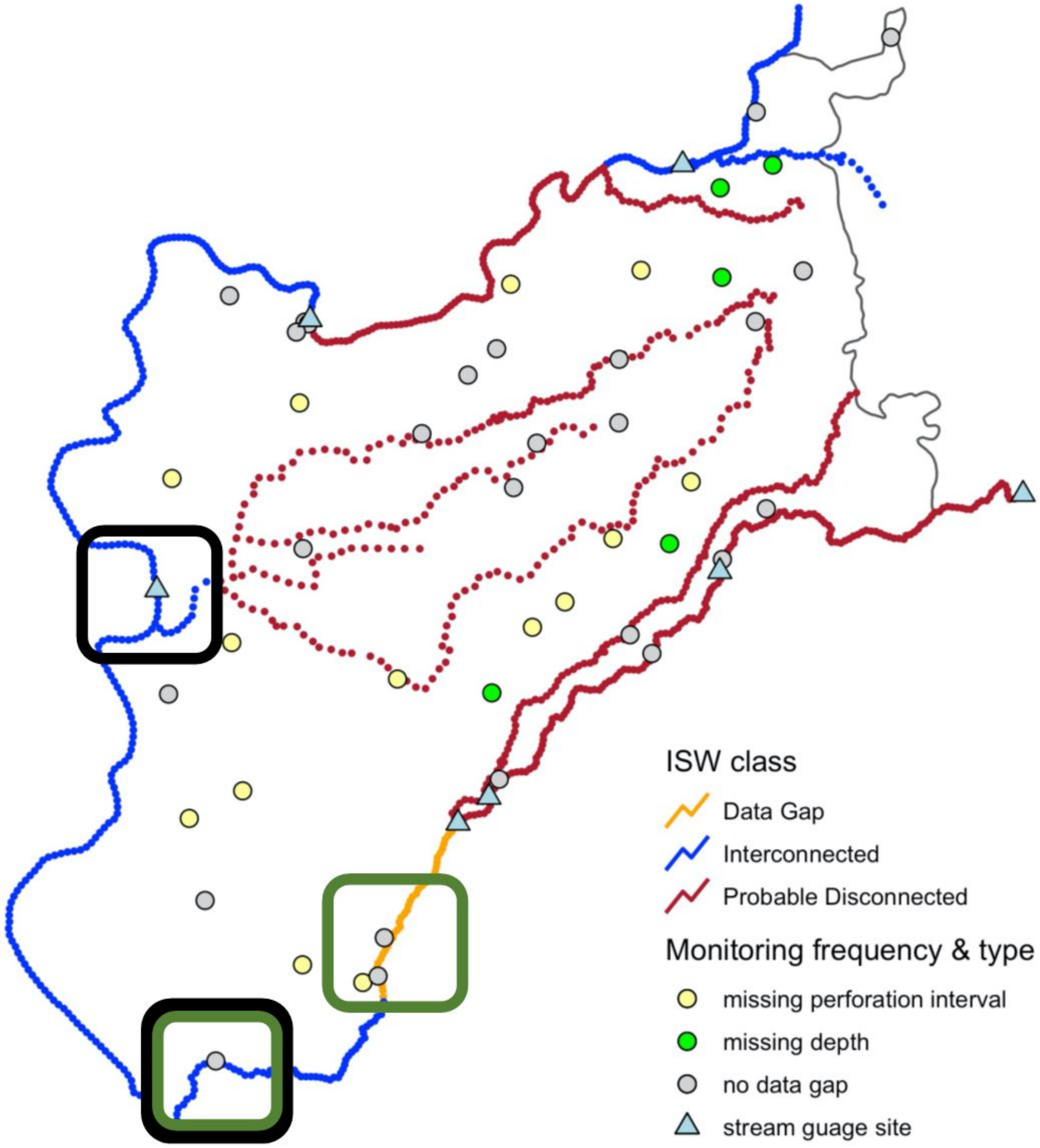


Figure 3-29: **Data gaps to be addressed** include obtaining depth (light green) and perforation interval (yellow) at groundwater monitoring wells, adding two stream gauges in the lower Cosumnes River (at dark green boxes) and pairing them with 15-minute interval groundwater data, and adding two 15-minute interval groundwater monitoring sites (at black boxes) to pair with 15-minute stream gauge data.

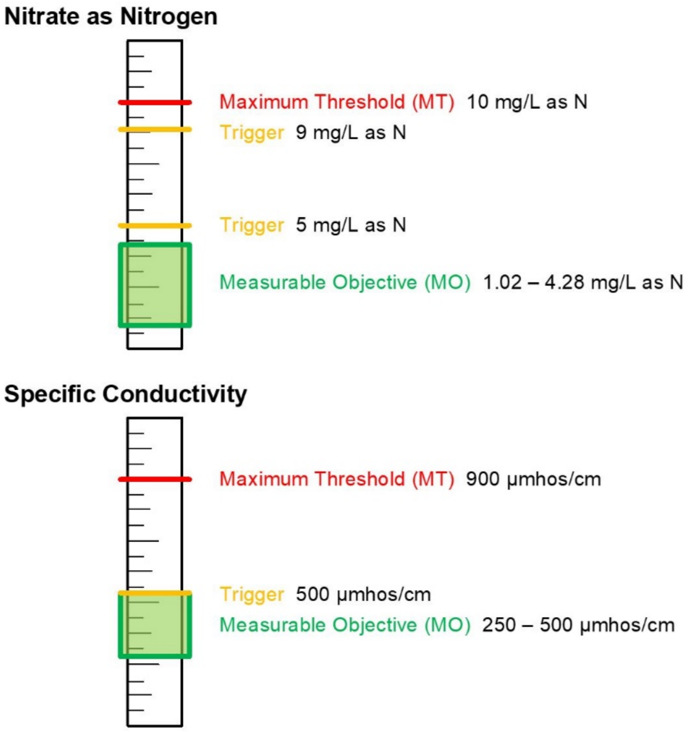
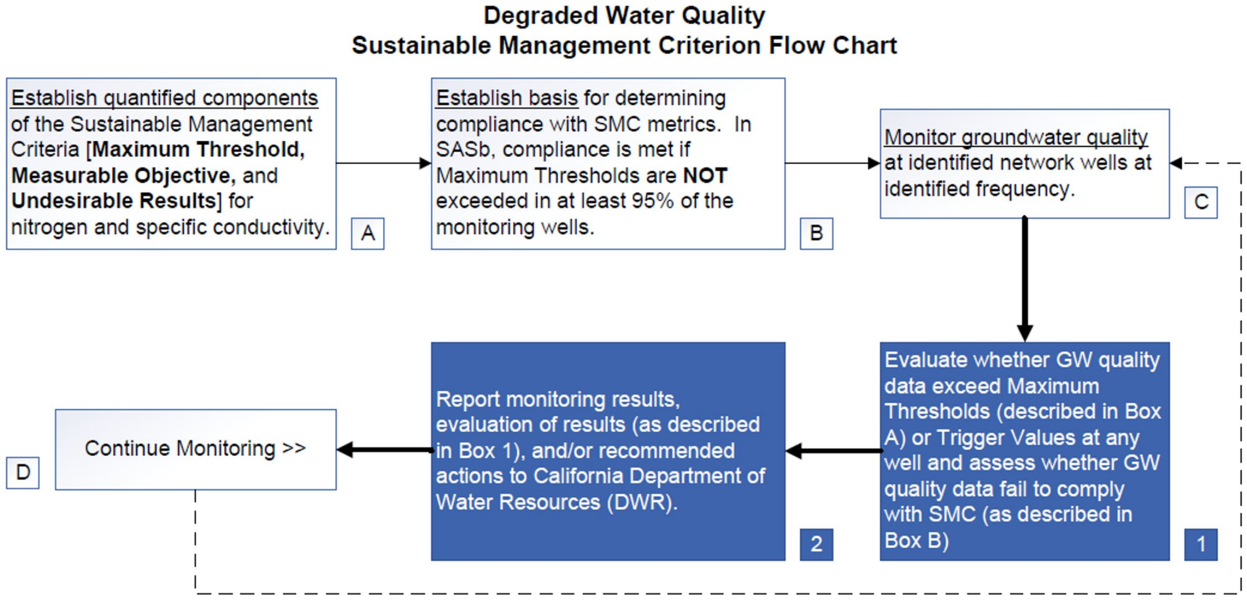


Figure 3-30: **Degraded water quality rulers for the constituents of concern in the South American Subbasin.**



Establish quantified components of the Sustainable Management Criteria [**Maximum Threshold, Measurable Objective,** and **Undesirable Results**] for nitrogen and specific conductivity.

Establish basis for determining compliance with SMC metrics. In SASb, compliance is met if Maximum Thresholds are **NOT** exceeded in at least 95% of the monitoring wells.

Monitor groundwater quality at identified network wells at identified frequency.

Evaluate whether GW quality data exceed Maximum Thresholds (described in Box A) or Trigger Values at any well and assess whether GW quality data fail to comply with SMC (as described in Box B)

Report monitoring results, evaluation of results (as described in Box 1), and/or recommended actions to California Department of Water Resources (DWR).

Figure 3-31: **Degraded water quality sustainable management criteria flow chart** - used to identify probable courses of action when metrics for the sustainability indicator are not met.

Table 3-7: Groundwater Quality Monitoring Wells in the Upper Aquifer Zone

			Nitrogen Measurements			TDS Measurements			Logic for Selection
Well ID	**Facility or Water System Name**	**GSA**	**From**	**To**	**# of records**	**From**	**To**	**# of records**	
3410020-009	City of Sacramento Main	SCGA	11/16/1988	2/4/2020	13	11/16/1988	2/4/2020	23	Spatial representation Long monitoring records
3410029-002	SCWA - Laguna/Vineyard	SCGA	2/21/1991	2/13/2020	9	2/21/1991	2/13/2020	26	Spatial representation Long monitoring records for TDS
3410029-016	SCWA - Laguna/Vineyard	SCGA	7/1/1988	2/10/2020	9	7/1/1988	2/10/2020	24	Proximity to GWE monitoring wells Spatial representation Long monitoring records
3410029-029	SCWA - Laguna/Vineyard	SCGA	10/25/2001	2/13/2020	7	10/25/2001	2/13/2020	17	Spatial representation Long monitoring records
3410033-006	Florin County Water District	SCGA	7/13/1990	6/13/2019	10	7/13/1990	3/19/2019	48	Spatial representation Long monitoring records
L10005519750-MW-G(S)	Unknown	SCGA	5/6/2014	12/10/2019	9	5/6/2014	12/10/2019	7	Proximity to GWE monitoring wells Historical exceedance from nitrogen limits
L10008601447-MW-13	Elk Grove Class III Landfill	SCGA	9/25/2014	9/19/2019	12	9/25/2014	9/19/2019	13	Proximity to GWE monitoring wells Relatively high number of measurements
3400101-001	Hood Water Maintenance Dist	Northern Delta	2/19/2008	2/11/2020	3	3/21/2001	11/13/2018	9	Spatial representation
3410029-024	SCWA - Laguna/Vineyard	SCGA	8/26/2002	5/22/2014	5	8/26/2002	5/10/2018	16	Spatial representation
3410029-025	SCWA - Laguna/Vineyard	SCGA	3/21/2001	5/22/2014	6	3/21/2001	5/14/2019	17	Spatial representation
3901216-001	Unknown	Northern Delta	5/22/2002	2/16/2017	4	5/22/2002	2/12/2018	9	Spatial representation Historical exceedance from nitrogen limits

Table 3-8: Groundwater Quality Monitoring Wells in the Lower Aquifer Zone

			Nitrogen Measurements			TDS Measurements			
Well ID	**Facility or Water System Name**	**GSA**	**From**	**To**	**# of records**	**From**	**To**	**# of records**	**Logic for Selection**
3400375-001	Slavic Missionary Church Inc	SCGA	6/8/2012	6/8/2012	1	7/9/2003	3/8/2019	14	Spatial representation
3410015-020	Golden State Water Co. - Cordova	SCGA	5/27/1986	1/14/2014	11	5/27/1986	1/8/2019	32	Proximity to GWE monitoring wells Historical exceedance from TDS limits
3410015-022	Golden State Water Co. - Cordova	SCGA	5/19/1993	5/25/2017	11	5/19/1993	1/15/2019	24	Spatial representation Long monitoring records
3410023-015	Cal Am Fruitridge Vista	SCGA	2/15/1991	1/11/2018	7	2/15/1991	1/19/2017	29	Spatial representation Long monitoring records
3410029-015	SCWA - Laguna/Vineyard	SCGA	7/1/1988	5/23/2018	9	7/1/1988	5/7/2019	22	Spatial representation Long monitoring records for TDS
3410029-026	SCWA - Laguna/Vineyard	SCGA	10/25/2001	5/11/2017	8	10/25/2001	8/15/2019	17	Spatial representation
3410029-027	SCWA - Laguna/Vineyard	SCGA	11/19/2003	2/5/2019	5	11/19/2003	5/22/2018	15	Proximity to GWE monitoring wells Long monitoring records
3410704-001	SCWA Mather-Sunrise	SCGA	8/27/2002	6/4/2014	5	10/25/1999	5/6/2019	18	Spatial representation
L10007396297-MW-40B	Kiefer Landfill	OHWD	9/2/2014	4/24/2019	8	5/7/2014	4/24/2019	5	Proximity to GWE monitoring wells Long monitoring records
S7-SAC-SA10	Unknown	SCGA	11/2/2017	11/2/2017	1	11/2/2017	11/2/2017	1	Spatial representation

An assessment of the monitoring results for both spatial density and monitoring frequency suitability based on the proposed monitoring network will be performed to determine the need for expansion of the network with additional wells. This assessment is planned within the first five years of GSP implementation. Further evaluations of the monitoring network will be conducted on a five-year basis, particularly with regard to the sufficiency of the monitoring network in meeting the GSP's monitoring objectives. The monitoring network may be modified or expanded in the future based on an evaluation of the data collected or changes in land use.

Land Subsidence Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.*

The InSAR data provided by DWR (TRE Altamira) have spatial coverage for much of the Basin (considering the point data, while the rasters are interpolated for the entire subbasin area). These data are the only subsidence dataset currently available for the Basin and are consistent with the data and reporting standards outlined in 23 CCR § 352.4. The data have adequate temporal coverage for the Subbasin as well with annual rasters (beginning and ending on each month of the coverage year), cumulative rasters, and monthly time series data for each point data location.

The single CGPS station in the Subbasin (UNAVCO station #P274) is on the very edge of the Basin boundary, as well as near the larger subsidence subareas within the Basin (i.e., Delta and Elk Grove subareas). The InSAR and CGPS data at the location of the CGPS station compare well with one another (see **Figure 2.3-41**) demonstrating that the InSAR data product is an adequate management tool for land subsidence in the Basin. If subsidence was a great future concern, or even a significant one at present, future planned station locations for CGPS could be proposed. However, as this is not the case, no future CGPS stations are proposed for the Basin at this time.

As subsidence is not a significant concern for the Basin at present and likely not into the future, the InSAR data will most likely be sufficient for the monitoring network. If this changes due to anomalies detected in the InSAR data, ground truthing, elevation surveying, and GPS studies might need to be conducted to be understand this unlikely situation in more detail.

The InSAR-based subsidence monitoring network allows sufficient monitoring both spatially and temporally to adequately assess that the measurable objective (which is currently in attainment) is being maintained.

The InSAR data provided by DWR (TRE Altamira) or equivalent InSAR satellite data products are sufficient to adequately resolve land subsidence estimates in the Subbasin spatially and temporally. While CGPS stations offer higher accuracy and frequency, satellite-based InSAR data are available monthly and are less accurate than CGPS data (although it is close enough for the management purposes of this GSP to be equivalent). However, InSAR data points are so many more times more numerous than are even feasible with CGPS stations (1,000s of individual points vs. a few stations) for a given basin that this is the preferable method given funding constraints. InSAR data can also be utilized to determine if and where future CGPS or ground-based elevation surveys should be sited.

Subsidence is not of substantial present or future concern, thus CGPS stations are proposed for the Subbasin at this time.

The InSAR data provided by DWR (TRE Altamira) have adequate spatial coverage for much of the Basin (considering the point data, while the rasters are interpolated for the entire subbasin area). The data have adequate temporal coverage for the Basin as well, consisting of annual rasters (beginning and ending on each month of the coverage year), cumulative rasters for the full time period (2015-2019), and monthly time series data for each point data location. These temporal frequencies are adequate for understanding short-term, seasonal, and long-term trends in land subsidence.

Interconnected Surface Water Monitoring Network

> *23 CCR § 354.34(c): Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:*
>
> *(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.*
>
> *(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.*
>
> *(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.*
>
> *(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.*

Groundwater level is used as a proxy for ISW depletion (**Section 3.2.4**). Thus, the surface water depletion monitoring network is complimentary with the network for groundwater level. The surface water depletion network consists of a subset of the wells which are strategically sited between ISW and pumping zones and in the upper zone of the principal aquifer (**Appendix 3-A**). Observations obtained at these key locations in the groundwater level monitoring network will directly inform integrated surface and groundwater modeling in the Basin as model calibration targets.

Moreover, through partnerships with GSAs and historical data availability, stream gauges that collect 15-minute interval data (**Table 3-9**) will be paired with 15-minute interval groundwater elevation data at specific locations along the American, Sacramento and Cosumnes Rivers. Paired observations will improve understanding of stream-aquifer exchange (via hydraulic gradient analysis) at a sub-seasonal timescale and inform sustainable and adaptive management of ISW in the Basin.

Table 3-9: Stream Gauge Monitoring Locations in the Basin

ID	Name	Latitude (NAD83)	Longitude (NAD83)
ACR_189	ACR_189	-121.32475	38.371660
ACR_181	ACR_181	-121.20423	38.466710
11335000	Michigan Bar	-121.04417	38.500278
SAMC1	H St	-121.42311	38.569014
11447650	Freeport	-121.50208	38.455775
MCNC1	McConnell	-121.34091	38.360702
11446500	Fair Oaks	-121.22667	38.635556

Data gaps along ISW reaches in the southern Cosumnes River and Sacramento River where 15-minute interval streamflow is available, but 15-minute groundwater elevation is not, will be addressed before the next Plan update by installing high-frequency monitoring sensors at existing biannually measured wells that will be paired with adjacent stream gauges.

3.5.3 Protocols for Data Collection and Monitoring (23 CCR § 352.2)

Establishment of monitoring protocols will ensure that collected data are accurate, representative, reproducible, and contain all required information. All groundwater elevation measurements, groundwater quality sample collection, and testing will follow the established protocols for consistency throughout the Basin and over time as outlined under each sustainability indicator's subsection.

3.5.3.1 Groundwater Level

Groundwater level data collection may be conducted remotely via telemetry equipment, or with an in-person field crew. The following section provides a brief summary of monitoring protocols for groundwater level collection. Establishment of protocols will ensure that data collected for groundwater elevation are accurate, representative, reproducible, and contain all required information. All groundwater level data collection in support of this GSP is required to follow the established protocols for consistency throughout the Basin and over time. These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

All groundwater elevation measurements are referenced to a consistent elevation datum, known as the Reference Point (RP). For monitoring wells, the RP consists of a mark on the top of the well casing. For most production wells, the RP is the top of the well's concrete pedestal. The elevation of the (RP) of each well is surveyed to the National Geodetic Vertical Datum of 1929 (NGVD 29). The elevation of the RP is accurate to at least 0.5 foot.

Groundwater level measurements are taken to the nearest 0.01 foot relative to the RP using procedures appropriate for the measuring device. Equipment is operated and maintained in accordance with manufacturer's instructions, and all measurements are in consistent units of feet, tenths of feet, and hundredths of feet.

Groundwater elevation is calculated using the following equation:

$$GWE = RPE - DTW$$

Where GWE is the groundwater elevation, RPE is the reference point elevation, and DTW is the depth to water.

In cases where the official RPE is a concrete pedestal, but the hand soundings are referenced off the top of a sounding tube, the measured DTW is adjusted by subtracting the sounding tube offset from the top of the pedestal.

All groundwater level measurements must include a record of the date, well identifier, time (in 24-hour military format), RPE, DTW, GWE, and comments regarding factors which may influence the recorded measurement such as nearby production wells pumping, weather, flooding, or well condition.

Manual Groundwater Level Measurement

Groundwater level data collected by an in-person field crew will follow the following general protocols:

- Prior to sample collection, all sampling equipment and the sampling port must be cleaned. Manual groundwater level measurements are made with electronic sounders or steel tape. Electronic sounders consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water. Some production wells may have lubricating oil floating on the top of the water column, in which case electric sounders will be ineffective. In this circumstance steel tape may be used. Steel tape instruments consist of simple graduated lines where the end of the line is chalked so as to indicate depth to water without interference from floating oil.

- All equipment is used following manufacturer specifications for procedure and maintenance.

- Measurements must be taken in wells that have not been subject to recent pumping. At least two hours of recovery must be allowed before a hand sounding is taken.

- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.

- Equipment is sanitized between well locations in order to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

Data Logger Groundwater Level Measurement

Telemetry equipment and data loggers can be installed at individual wells to record continuous water level data, which is then remotely collected via cell phone towers to a central database which may be accessed in a web browser in the Stakeholder Data Portal. Installation and use of data loggers must abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level in order to properly install and calibrate the transducer. This is done following the protocols listed above.

- All data loggers installations follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.

- Data loggers are set to record only measured groundwater level in order to conserve data capacity; groundwater elevation is calculated from these measurements, and knowledge of the cable length and ground surface elevation.

- In any log or recorded datasheet, site photographs, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are all recorded.

- The sampler notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for natural barometric pressure changes.

- All data logger cables are secured to the well head with a well dock or another reliable method. This cable is marked at the elevation of the reference point to allow estimates of future cable slippage.

- Data logger data is periodically checked against hand measured groundwater levels to monitor electronic drift, highlight cable movement, and ensure the data logger is operating correctly. This check occurs at least annually, typically during routine site visits.

- For wells not connected to a supervisory control and data acquisition (SCADA) system, transducer data is downloaded as necessary to ensure no data is overwritten or lost. Data is entered into the data management system as soon as possible. When the transducer data is successfully downloaded and stored, the data is deleted or overwritten to ensure adequate data logger memory. All wells in the Basin on continuous monitoring are on a SCADA system with the exception of Sacramento State wells (ID beginning with “SS”).

3.5.3.2 Groundwater Quality

Sample collection will follow the USGS *National Field Manual for the Collection of Water Quality Data* (USGS 2015) and *Standard Methods for the Examination of Water and Wastewater* (Rice et al., 2012), as applicable, in addition to the general sampling protocols listed below.

The following section provides a brief summary of monitoring protocols for sample collection and analytical testing for evaluation of groundwater quality. Establishment of and adherence to these protocols will ensure that data collected for groundwater quality are accurate, representative, reproducible, and contain all required information. All sample collection and testing for water quality in support of this GSP are required to follow the established protocols for consistency throughout the Subbasin and over time. All testing of groundwater quality samples will be conducted by laboratories with certification under the California Environmental Laboratory Accreditation Program (ELAP). These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

Wells used for sampling are required to have a distinct identifier, which must be located on the well housing or casing. This identifier will also be included on the sample container label to ensure traceability.

Event Preparation

- Before the sampling event, coordination with any laboratory used for sample analysis is required. Pre-sampling event coordination must include the scheduling of the laboratory for sample testing and a review of the applicable sample holding times and preservation requirements that must be observed.
- Sample labels must include the sample ID, well ID, sample date and time, personnel responsible for sample collection, any preservative in the sample container, the analyte to be analyzed, and the analytical method to be used. Sample containers may be labelled prior to or during the sampling event.

Sample Collection and Analysis

- Sample collection must occur at, or close to, the wellhead for wells with dedicated pumps and may not be collected after any treatment, from tanks, or after the water has travelled through long pipes. Prior to sample collection, the sample collector should clean all sampling equipment and the sampling port. The sampling equipment must also be cleaned prior to use at each new sample location or well.
- Sample collection in wells with low-flow or passive sampling equipment must follow protocols outlined in the EPA's *Low-flow (minimal drawdown) ground-water sampling procedures (*Puls and Barcelona, 1996) and USGS Fact Sheet 088-00 (USGS, 2000), respectively. Prior to sample collection in wells without low-flow or passive sampling equipment, at least three well casing volumes should be purged prior to sample collection to make sure ambient water is being tested. The sample collector should use best professional judgement to ensure that the sample is representative of ambient groundwater. If a well goes dry, this should be noted and the well should be allowed to return to at least 90% of the original level before a sample is collected.

- Sample collection should be completed under laminar flow conditions.
- Samples must be collected in accordance with appropriate guidance and standards and should meet specifications for the specific constituent analyzed and associated data quality objectives.
- In addition to sample collection for the target analyte (e.g., nitrate), field parameters, including temperature, pH, and specific conductivity, must be collected at every site during well purging. Field parameters should stabilize before being recorded and before samples are collected. Field instruments must be calibrated daily and checked for drift throughout the day.
- Samples should be chilled and maintained at a temperature of 4° C and maintained at this temperature through delivery to the laboratory responsible for analysis.
- Chain of custody forms are required for all sample collection and must be delivered to the laboratory responsible for analysis of the samples to ensure that samples are tested within applicable holding limits.
- Laboratories must use reporting limits that are equivalent, or less than, applicable data quality objectives.

3.5.3.3 Land Subsidence

The DWR Groundwater Monitoring Protocols, Standards, and Sites BMP does not cite a standard approach for the monitoring of land subsidence but does provide various approaches to making determinations of land subsidence using varying data collection methods. The GSA will monitor all subsidence data annually. If any additional data become available, they will be evaluated and incorporated into the GSP implementation. If the annual subsidence rate is greater than minimum threshold, further study will be needed.

Regarding the technical specifications of the DWR InSAR data (TRE Altamira) used in developing this SMC, the following text is from the California Natural Resources Agency (CNRA) data access webpage (https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence):

> This statewide InSAR subsidence dataset was acquired as part of DWR's SGMA technical assistance to provide important SGMA relevant data to GSAs for GSP development and implementation. The dataset is formatted to support the production of maps and graphs that show the extent, cumulative total, and annual rate of land subsidence.
>
> Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based remote sensing technique that measures vertical ground surface displacement changes at high degrees of measurement resolution and spatial detail. TRE processed Sentinel-1A InSAR data over the study area between January 1, 2015 and September 19, 2019 and calibrating them to data from 232 stations of the regional network of Continuous Global Positioning System (CGPS) stations. TRE provided the resulting time series data of vertical displacement values for point locations on a grid with 100 meter spacing, with values representing averages of vertical displacement measurements within the immediate 100 by 100 meter square areas of each point. Gaps in the spatial coverage of the point data are areas with insufficient data quality. The period of record for the point time series data varies by area, starting as early as January 1, 2015 and as late as June 13, 2015. TRE also provided 2 sets of GIS rasters;

annual vertical displacement and total vertical displacement relative to the common start date of June 13, 2015, both in monthly time steps. An Inverse Distance Weighted (IDW) method with a maximum search radius of 500 meter was used to interpolate the rasters from the point data.

Towill, Inc. (Towill), also under contract with DWR as part of DWR's SGMA technical assistance, conducted an independent study comparing the InSAR-based vertical displacement point time series data to data from 160 CGPS stations that were not used for calibrating the InSAR data, as well as 21 CGPS stations that were used for calibrating InSAR data in Northern California. The goal of this study was to ground-truth the InSAR results to best available independent data.

The National Standard for Spatial Data Accuracy (NSSDA), developed by the Federal Geographic Data Committee (Document Number FGDC-STD-007.3-1998), offers a well-defined statistic and testing methodology for positional accuracy of geospatial data derived from various surveying methods including satellite remote sensing. The NSSDA is based on comparison of data from the tested dataset to values from an independent source of higher accuracy. For this study, variation in vertical displacement of California's ground surface over time, as measured from interferometric synthetic aperture radar (InSAR) satellites, was statistically compared to available ground based continuous global positioning systems (CGPS) data.

Tested: 16 mm vertical accuracy at 95% confidence level.

As tested by the processes described, this analysis provides statistical evidence that InSAR data accurately measured vertical displacement in California's ground surface to within 16 mm for the period January 1, 2015 through September 19, 2019. This statement of accuracy is based on the assumptions that the number, distribution, and characteristics of CGPS check point locations provide a representative sample of the entire study area and of the entire InSAR dataset, and that the CGPS data constitutes an independent source of higher accuracy. This statement of accuracy applies to the state-wide dataset and may vary for regional or localized area subsets.

The Department of Water Resources makes no warranties, representations or guarantees, either expressed or implied, as to the accuracy, completeness, correctness, or timeliness of the information in this dataset, nor accepts or assumes any liability arising from use of these data. Neither the Department nor any of the sources of this information shall be responsible for any errors or omissions, or for the use or results obtained from the use of this information. A Groundwater Sustainability Agency is not required to use these data, and their use does not guarantee the adequacy of a Groundwater Sustainability Plan that relies on such data. (CNRA)

3.5.4 Reporting Monitoring Data to the Department (23 CCR § 354.40, § 352.4)

Monitoring data will be stored in the data management system and a copy of the monitoring data will be included in each Annual Report submitted electronically to the DWR. All reporting standards and information shall follow the guidelines outlined in 23 CCR § 352.4.

3.5.5 Assessment and Improvement of the Monitoring Network (23 CCR § 354.38)

The GSP and each five-year assessment report will include an evaluation of the monitoring networks, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin. Evaluation of data gaps must consider whether the spatial and temporal coverage of data is sufficient and whether monitoring sites are providing reliable and representative data. The description of identified data gaps will include the location and basis for determining data gaps in the monitoring network as well as local issues and circumstances that limit or prevent monitoring. These data gaps will be addressed by describing steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

Data gaps to be filled (**Figure 3-26**) before the next Plan update will improve and expand SMC (**Table 3-4**). These data gaps fall into 3 main categories: information improvement, monitoring expansion, and SMC revision.

Information Improvement

Not all monitoring points in the monitoring network contain construction information. After a thorough review of well completion reports and available information in the Basin, 5/45 wells are missing a total completed depth, and 15/45 wells are missing a description of the perforated interval (**Figure 3-26**, red and purple dots). No wells are missing both depth and perforated interval, as selection criteria mandates that at least one of these is present to understand vertical extent covered by the well. These data gaps will be addressed before the five-year Plan update in 2027. During field visitations to the monitoring sites, cameras and measuring tapes will be used to determine total completed depths and screened intervals depths.

Streamflow projections demonstrate significant reductions in all climate change scenarios, especially along the Sacramento and American rivers. More modeling is required to assess the impact of climate change on ISW and will be completed by the next 5 year plan update (2027).

A data gap along the Cosumnes River between Deer Creek and Twin Cities Road will be further investigated in terms of surface and groundwater interaction. Short term, sub-seasonal interaction is observed, but the reach remains disconnected on a seasonal average basis. It is unclear if short term interconnections events play an important role in the maintenance of habitat, species, or other beneficial uses and users. To address these data gaps, additional stream gage and continuous monitoring will be installed in the area, and GSAs will coordinate the Cosumnes subbasin GSAs and other stakeholders and technical experts to assess ISW presence/absence in the area. This data gap will be addressed before the next 5 year plan update (2027).

Streambed elevation is used to determine if a reach interconnects to adjacent groundwater by a comparison of their relative elevations. High resolution elevation mapping of ISW and other surface water bodies that provide ecological and recreational benefits can directly inform improved models and analyses of surface and groundwater interaction. Present day elevation data is likely sufficient to delineate ISW reaches but may be improved in the Cosumnes River.

Monitoring Expansion

The network needs two more stream gauges in the southern reaches of the Cosumnes River both above and below the point where analysis suggests ISW is present (**Figure 3-26**, green boxes). One stream gauge will be installed near an existing 15-minute interval groundwater monitoring site, and the second should be installed along the Mokelumne River upstream of the Sacramento River Confluence.

The network needs two more 15-minute interval monitoring wells (**Figure 3-26**, black boxes), which may be achieved by outfitting existing monitoring wells in the network with sensors and telemetry. These wells will be paired with 15-minute interval stream gauge stations and enable high-resolution monitoring of complex stream-aquifer interactions. Computed hydraulic gradients will improve understanding of sub-seasonal river-aquifer exchange.

GSAs in the Basin will coordinate with the adjacent Cosumnes Subbasin in order to strategically locate these high-frequency flow gauges and monitoring wells.

SMC Revision

Eight (8) representative monitoring points are in critical monitoring locations, but data is only available after 2018. Thus, data gaps in the historical record cause MTs and MOs to be set close to, or at present day, levels because the historical record only contains relatively wet water year types from 2018 onward. MTs, MOs, and IMs for these points (**Table 3-4**) are thus based on the best available information at the time of Plan submission but are expected to change in the five-year Plan update as more information becomes available at these sites. Moreover, 5/8 these sites are high-frequency, 15-minute interval stations what will provide valuable insight into stream-aquifer interactions.