6. SUSTAINABLE MANAGEMENT CRITERIA

GSP regulations provide a framework for locally-defined and quantitative *sustainable management criteria*, which allow the GSAs to quantitatively measure and track ongoing sustainable management. These criteria include a sustainability goal, which has been developed as a mission statement for the GSP. Additional criteria include specific terminology from SGMA; a brief summary[1] of these terms – and the application of each – are provided below:

- Undesirable Results (URs[2]) – significant and unreasonable adverse conditions for any of the six sustainability indicators defined in the GSP regulations.
- Minimum Threshold (MT[2]) – numeric value used to define undesirable results for each sustainability indicator at representative monitoring sites.
- Measurable Objective (MO[2]) – numeric goal to track the performance of sustainable management at representative monitoring sites.
- Interim Milestone (IM[2]) – target numeric value representing measurable groundwater conditions, in increments of five years, as set by the GSAs as part of the GSP.

Collectively, these criteria define sustainable groundwater management by:

- quantifying groundwater conditions to avoid, along with associated warning signs (URs and MTs);
- identifying favorable groundwater conditions and operational parameters (MOs); and
- providing targets for monitoring Subbasin progress toward achieving the sustainability goal (MTs, MOs, and IMs).

6.1. SUSTAINABILITY GOAL

A sustainability goal provides a mission statement for what the GSAs wish to achieve through sustainable management. GSP regulations provide requirements for a GSP Sustainability Goal, as follows:

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[1] Sustainable management criteria are more fully defined in SGMA (CWC 10721(a) – (ab) and GSP regulations (§351(a) – (an)).

[2] Because of the frequency of use, and to facilitate review of the text, the terms “undesirable results” “minimum threshold,” “measurable objective,” and “interim milestone” are abbreviated as “UR”, “MT”, “MO”, and “IM” respectively, throughout remaining sections of the GSP. However, the terms are spelled out in un-abbreviated form where helpful for context and clarity or when contained in a direct quotation.

> 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. (§354.24).

In the Best Management Practices (BMPs) document on sustainable management criteria, DWR recommends that one succinct, common sustainability goal be developed for the entire Subbasin.

The requirements and guidance for a GSP sustainability goal were reviewed in a public meeting of the STRGBA GSA Technical Advisory Committee (TAC) in February 2021. That meeting was followed with a technical memorandum prepared by the technical team, in part, to assist TAC members with development of a goal. The memorandum summarized GSP requirements and how the sustainability goal fits within the overall sustainable management criteria process.

Based on TAC feedback, DWR guidance, and GSP requirements, the TAC Planning Group[3] developed a draft sustainability goal reviewed by the TAC at a public meeting on May 12, 2021. At that meeting, additional comments on the sustainability goal were received from stakeholders and TAC members. Those comments were incorporated into the draft sustainability goal presented below.

The Sustainability Goal of the Modesto Subbasin GSP is to provide a sustainable groundwater supply for the local community and for the economic vitality of the region. Groundwater levels, storage volume, and quality will be actively managed by the STRGBA GSA to:

- *Operate the Subbasin within its sustainable yield to support beneficial uses including municipal, domestic, agricultural, industrial, and environmental;*
- *Maintain a reliable, accessible, and high-quality groundwater supply, especially during droughts;*
- *Manage groundwater levels such that beneficial uses of interconnected surface water are not adversely impacted by groundwater extractions;*
- *Optimize conjunctive management of local surface water and groundwater resources;*
- *Avoid adverse impacts from future potential land subsidence associated with groundwater level declines;*

[3] The TAC Planning Group is a small working group composed of representatives from the TAC to guide the GSP process and provide recommendations to the full TAC.

- *Cooperate and coordinate with GSAs in neighboring subbasins to avoid undesirable results along the shared Subbasin boundaries.*

This goal will be achieved within the 20-year implementation period and maintained throughout the planning horizon through a robust monitoring program and a series of projects and management actions that involve groundwater recharge, in lieu surface water use, conservation, stormwater management, and other strategies to be developed and modified over time through adaptive management.

The sustainability goal is supported by information provided in GSP chapters on the plan area (**Chapter 2**) and basin setting (**Chapters 3** and **5**). Specific information used to inform the sustainability goal included the identification of land and water use in the Subbasin (**Chapter 2**), ongoing conjunctive management of surface water and groundwater (**Chapter 2.**), delineation of the base of fresh water and groundwater in storage (**Section 3.1.3**), the establishment of Principal Aquifers (**Section 3.1.4**), groundwater conditions (**Sections 3.2**), and historical and projected water budgets (**Chapter 5**). Additional considerations of basin conditions that support the sustainability goal are described in the following section.

6.2. SELECTION OF SUSTAINABLE MANAGEMENT CRITERIA

Six sustainability indicators are defined in the GSP regulations to represent groundwater conditions that, when determined to be significant and unreasonable, cause undesirable results. The avoidance of undesirable results is the foundation for sustainable groundwater management. Accordingly, these sustainability indicators are analyzed in the Modesto Subbasin to define undesirable results and other sustainability criteria, including MTs, MOs, and IMs. A representative monitoring network is established for each applicable indicator to track these conditions throughout the implementation and planning horizon.

Those six indicators and their associated icons developed by DWR are illustrated below.

Chronic Lowering of Water Levels	**Reduction of Groundwater in Storage**	**Seawater Intrusion**	**Degraded Water Quality**	**Inelastic Land Subsidence**	**Depletion of Inter-connected Surface Water**

6.2.1. Sustainability Considerations in the Modesto Subbasin

As explained in subsequent sections, this GSP analyzes conditions related to the six sustainability indicators that support definitions for undesirable results. SGMA legislation states that the GSAs are not required to address undesirable results that occurred before – and have not been corrected by – January 1, 2015 (§10727.2 (b)(4)). Accordingly, the focus for several indicators is to avoid future conditions that could lead to undesirable results.

Basin conditions as of 2015 and management considerations for each sustainability indicator are summarized in **Table 6-1**, along with the respective GSP section where each indicator is analyzed. General locations for the conditions described in the table are shown on **Figure 6-1** with certain areas highlighted by the sustainability indicator icons for reference.

Table 6-1: Sustainability Considerations for Modesto Subbasin

	Basin Conditions	Undesirable Results in Modesto Subbasin as of 2015?	Management Considerations	GSP Sect.
	Declining water levels are occurring, primarily in the eastern Subbasin. Other local areas experienced water level declines during drought.	Yes	Adverse impacts to public and domestic water supply wells caused by declining water levels. Water levels will be managed to avoid future impacts.	**6.3**
	Overdraft conditions, primarily in areas where groundwater is the primary source of supply.	Yes	Over-pumping in certain areas has caused water level declines, which impact beneficial uses of both groundwater and surface water. GSP will arrest overdraft conditions.	**6.4**
	Not applicable to this inland Subbasin.	No	None	**6.5**
	Groundwater concentrations for certain constituents of concern exceed drinking water standards over widespread areas of the Subbasin. Groundwater extractions, GSA projects, and GSA management actions may have the potential to degrade water quality in the future.	No	Historical water quality impacts have not been caused by GSA management activities, and therefore are not undesirable results as defined in this GSP. GSAs need to manage Subbasin groundwater so as not to further degrade groundwater quality.	**6.6**
	No documented impacts from land subsidence in Subbasin; potential for compressible clays to cause land subsidence in the future.	No	If groundwater levels are managed at or near historic low levels, the potential for future undesirable results can be avoided.	**6.7**
	Streamflow depletions have increased over time, especially on the Tuolumne and Stanislaus rivers. All 3 river boundaries remain interconnected, and no current impacts to surface water rights have been identified. Modeling predicts increased depletions in the future.	No	GSAs are not responsible for correcting conditions before 2015. However, modeling predicts future streamflow depletions that may lead to undesirable results. GSAs will manage water levels to reduce future increases in streamflow depletions.	**6.8**

As indicated in **Table 6-1**, the Modesto Subbasin has experienced undesirable results associated with chronic lowering of water levels and reduction of groundwater in storage. These conditions have occurred primarily within and around the Non-District East Management Area (NDE MA) as shown on **Figure 6-1**. Over the historical study period, agricultural production has expanded in the eastern Subbasin where groundwater is the primary source of water supply. Over-pumping in this area has led to water level declines expanding into other areas, which exacerbated conditions during the 2014-2016 drought and caused impacts to both public and domestic water supply wells. During this time, more than 150 domestic wells failed (indicated on **Figure 6-1** by the small black dots). As explained in **Section 6.3**, most of the impacted wells appear to have been replaced with deeper wells. Nonetheless, some wells remain vulnerable to future multi-year droughts, including two areas highlighted on **Figure 6-1**.

As indicated in **Table 6-1**, the GSAs have determined that the seawater intrusion sustainability indicator, as described in GSP regulations, does not apply to the Modesto Subbasin; as such, no sustainable management criteria have been selected for this indicator (see **Section 6.5**).

As indicated in **Table 6-1**, undesirable results have not been experienced for the degraded water quality sustainability indicator even though numerous constituents of concern have been detected above drinking water standards over time. Undesirable results for this indicator refer to water quality impacts specifically *caused* by GSA management (see **Section 6.6.1**), which has not yet been initiated. The water quality icon on **Figure 6-1** is located in the City of Modesto where water quality is actively managed through groundwater extractions, wellhead treatment, and other operational strategies. Future GSA management will focus on protection against further degradation that could be caused by GSA activities.

As indicated in **Table 6-1**, no impacts from land subsidence have been observed in the Subbasin. However, basin conditions indicate that land subsidence could occur if water levels continue to decline. Compressible clay layers within and below the Corcoran Clay have been associated with land subsidence in other portions of the Central Valley. Areas within the extent of the Corcoran Clay are highlighted on **Figure 6-1** as most susceptible to land subsidence.

The Stanislaus, Tuolumne, and San Joaquin rivers are all interconnected surface water as defined by SGMA (see icons on **Figure 6-1**). Projected water budget analyses indicate increased streamflow depletion will occur in the future, which could lead to undesirable results unless water level declines are arrested (see **Section 6.8**).

The overall process for developing sustainable management criteria is discussed in the following section. Subsequent sections document the sustainable management criteria for each sustainability indicator (**Section 6.3** through **6.8**).

6.2.2. Public Process for Sustainable Management Criteria

An interactive and public process was established by the STRGBA GSA to develop sustainable management criteria for the Modesto Subbasin. The Tuolumne GSA participated through an agreement with Stanislaus County, a member agency of the STRGBA GSA. The STRGBA GSA formed a technical advisory committee (TAC) composed of GSA member agencies, who reviewed and commented on technical presentations throughout the GSP development process. The TAC formed a small planning group to guide development of technical analyses to support the process.

TAC meetings generally followed the monthly STRGBA GSA meetings (typically held on the 2nd Wednesday of each month at 1:30pm). The STRGBA GSA Chair led the TAC public meetings – with input from stakeholders – for development of recommended sustainable management criteria to be incorporated into the GSP. TAC meetings were held according to the Brown Act and technical presentations on sustainable management criteria were typically posted on the STRGBA GSA website prior to the meetings. In general, presentations provided information on the following topics relating to sustainable management criteria:

- requirements from the GSP regulations,
- relevant hydrogeological conditions in the Modesto Subbasin,
- recommendations from the DWR BMP on Sustainable Management Criteria, and
- examples from adjacent or other relevant subbasins.

Steps taken during this process were provided in a technical memorandum in February 2021 – information from which has been incorporated into this GSP chapter. The steps are summarized below:

1. Analyze the <u>six Sustainability Indicators,</u> applying conditions from the Basin Setting.
2. Define <u>Undesirable Results (URs)</u> as specific groundwater conditions to avoid.
3. Assign <u>minimum threshold (MTs)</u> for each indicator as a metric that can be used to define undesirable results.
4. Select <u>measurable objectives (MOs)</u> for each indicator as an operational target metric to avoid operating too close to the MT and to avoid undesirable results.
5. Develop i<u>nterim milestones (IMs)</u> that show progress toward each MO over the 20-year planning horizon.
6. Develop a <u>Sustainability Goal</u> that culminates in the absence of undesirable results (**Section 6.1**).

The sustainability indicators were introduced at the public GSP kickoff meeting on September 12, 2018 and were considered during development of the technical portions of the Plan Area (**Chapter 2**) and basin setting (**Chapters 3 and 5**). A TAC meeting focused solely on the sustainable management criteria was held on November 13, 2019, when the TAC considered examples of sustainable management criteria from neighboring subbasins.

Historical water budgets, zone budgets, and projected future water budgets were developed, presented, and discussed throughout 2020 (see details on the water budgets in **Chapter 5**).

More than 15 public TAC meetings were focused on sustainable management criteria, monitoring networks, and management areas. During these meetings, undesirable results were established, and MTs and MOs were selected. Sustainable management criteria, including undesirable results, MTs and MOs were quantified for each representative monitoring site for all three principal aquifers and the four management areas.

6.2.3. Management Areas

Regulations allow for the establishment of management areas within a Subbasin to facilitate implementation of the GSP. A management area can be operated differently from the others and can also define different sustainable management criteria. The GSP must explain the reason for creating each management area and provide rationale for the proposed operation of each; in particular, operation of one management area cannot cause undesirable results in other areas.

In the Modesto Subbasin management areas have been developed to facilitate GSP implementation of projects and are based on areas of similar water supplies and similar ongoing water management activities. Four management areas have been established in the Modesto Subbasin as shown on **Figure 6-2** and listed below (approximate acres as calculated in GIS):

- Modesto ID Management Area (101,914 acres)
- Oakdale ID Management Area (49,893 acres)
- Non-District East Management Area (77,218 acres)
- Non-District West Management Area (15,777 acres)

Boundaries of the first two management areas coincide with the current service area boundaries of Oakdale ID and Modesto ID (**Figure 6-2**). These areas also include most of the urban areas within the Subbasin including Modesto, Oakdale, most of Waterford, and parts of Riverbank. In these two management areas, surface water is available for conjunctive use and supplements groundwater supply for beneficial uses. Specifically, Oakdale ID conjunctively manages Stanislaus River water and groundwater within the Oakdale ID Management Area. Similarly, Modesto ID manages Tuolumne River water and groundwater conjunctively throughout the Modesto ID Management Area.

Surface water supply in these management areas was originally developed for agricultural uses but has been expanded over time to also provide drinking water supplies (e.g., City of Modesto) or non-potable urban uses. As a result, close coordination and partnerships already exist between STRGBA GSA member agencies within the Modesto ID and Oakdale ID management areas. Delineation of management areas coincident with current Modesto ID and Oakdale ID service area boundaries allow for seamless coordination of ongoing management activities with new management responsibilities under SGMA.

The Non-District East Management Area and Non-District West Management Area are located on lands outside of the two large irrigation district boundaries where management is currently coordinated through Stanislaus County[4] as a member agency of the STRGBA GSA. The Non-District West Management Area is the smaller of the two and contains lands between the rivers and Modesto ID and Oakdale ID management areas along the rim of the western Subbasin. Surface water is also available in this management area through riparian rights along the river boundaries. Delineation of these lands as a separate management area combines areas of similar water supply activities in the western Subbasin to facilitate GSA management.

The Non-District East Management Area is defined as lands in the eastern Subbasin outside of the Oakdale ID and Modesto ID management areas. Unlike the other management areas, surface water has not been widely available for water supply; groundwater has served as the primary water supply for the expanding agricultural production in the Non-District East Management Area.

As described above and explained in more detail in subsequent sections of **Chapter 6**, the Non-District East Management Area is the primary area with declining water levels in the Subbasin. Accordingly, projects and management actions are prioritized for this management area in order to achieve the Subbasin's Sustainability Goal.

Most of the infrastructure required for GSP projects will need to be developed in the Non-District East Management Area by local landowners. The Non-District East Management Area will need to develop agreements and partnerships with both the Modesto ID and the Oakdale ID management areas to bring additional water supply into the area.

As indicated by the information above, the delineation of management areas shown on **Figure 6-2** facilitates the future management activities anticipated by the GSP.

6.2.4. Organization of Sustainability Indicators

Each sustainability indicator is discussed separately in **Sections 6.3** through **6.8** below. Information within each of these sections is organized similarly and tracks the order of GSP requirements provided in *Subarticle 3. Sustainable Management Criteria*. Headings and subheadings in the subsequent sections are as follows:

- Introduction including regulatory definitions
- Definition of Undesirable Results along with quantitative criteria that are used to define when and where undesirable results would occur.
    - Causes of Undesirable Results

[4] As mentioned previously, Stanislaus County also represents the Tuolumne GSA by agreement.

    - Potential Effects on Beneficial Uses and Users of Groundwater
- Quantification of minimum thresholds (MTs) followed by the six requirements for MT analysis in the regulations
    - Justification and support for MTs
    - Relationship of MTs to other sustainability indicator MTs and how GSAs determined that undesirable results would be avoided
    - Impacts of MTs on adjacent subbasins
    - Effects of MTs on beneficial uses and users of groundwater
    - Consideration of State, Federal, or local standards in MT Selection
    - Quantitative measurement of MTs
- Quantification of interim milestones (IMs).
- Quantification of measurable objectives (MOs)

The description of the Plan Area (**Chapter 2**) was used to provide the context for groundwater wells and the overall water resources for the Subbasin. The hydrogeologic conceptual model and groundwater analyses (**Chapter 3**) were used to understand the basin conditions relevant to sustainability. The historical, current, and projected future water budgets (**Chapter 5**) were used to analyze overdraft conditions, streamflow depletions, and subsurface flows with adjacent subbasins. Water budgets were also used to establish a sustainable yield for the Subbasin that analyzed sustainable management criteria required to avoid undesirable results.

Collectively, these analyses informed and supported the selection of sustainable management criteria as discussed for each sustainability indicator below.

6.3. CHRONIC LOWERING OF GROUNDWATER LEVELS

SGMA defines an undesirable result for the chronic lowering of groundwater levels as a "significant and unreasonable depletion of supply if continued over the planning and implementation horizon" (§10721 (x)(1)). As described in **Section 3.2.4**, DWR estimated the amount of fresh groundwater supply beneath the Modesto Subbasin at about 14 million acre feet (MAF) in 1961. An analysis of the historical water budget (WY 1991 – WY 2015) estimates a depletion of about 1.1 MAF of this supply over the 25-year period (about 43,000 AFY, see **Figure 5-20** and **Table 5-8**), about 8 percent of the estimated total supply. Most of the deficit likely occurred in recent years with increases in agricultural water demand; this indicates that about 13 MAF of groundwater remains in storage.

Although significant amounts of fresh groundwater remain in the Subbasin, the chronic lowering of groundwater levels has created adverse impacts to numerous water supply wells. Because wells are the primary method for accessing groundwater for beneficial uses, adverse impacts to water supply wells can lead to undesirable results. As such, the emphasis of this sustainability indicator is depletion of *accessible* supply and focuses on adverse impacts to Subbasin supply wells. This emphasis is also consistent with GSP regulations, which note that depletion of supply should be considered "*at a given location*" (§354.28(c)(1)), such as at a well.

The SGMA definition of chronic lowering of groundwater levels also addresses water level declines within the context of overdraft and storage as shown below:

> 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. (§10721 (x)(1)).

This definition allows for water level declines during drought as long as such declines do not result in undesirable results and as long as water levels recover to acceptable levels over average hydrologic conditions. Accordingly, the analysis of the chronic lowering of groundwater levels focuses on long-term trends of water level declines that do not recover during wet periods.

Undesirable results, including causes and impacts to beneficial uses, are described below in **Section 6.3.1**. The undesirable result definition, along with criteria to quantify where and when undesirable results will occur, is provided in **Table 6-3** at the end of **Section 6.3.1**. **Section 6.3.2** describes the quantification of minimum thresholds (MTs). **Section 6.3.3** provides the approach and selection of measurable objectives (MOs). Interim milestones that cover all of the applicable sustainability indicators are described in **Section 6.9**.

6.3.1. Undesirable Results for Chronic Lowering of Groundwater Levels

As summarized previously, groundwater level declines in the Modesto Subbasin are the combined results of overdraft and multi-year drought conditions. Over-pumping, primarily in the Non-District East Management Area (NDE MA) (**Figure 6-1**), has contributed to a historical Subbasin overdraft of about 43,000 AFY (**Section 5.1.4** and **Table 5-6**). Groundwater level declines associated with this overdraft have propagated outside of the NDE MA and affected water levels in adjacent areas to the west where additional water supply wells have been impacted (see estimated areas of vulnerable domestic wells on **Figure 6-1**).

Impacts to water supply wells are exacerbated during droughts. Chronic declines in groundwater levels are accelerated due to less availability of surface water for water supply, decreased recharge from decreases in precipitation and runoff, and/or increased irrigation demand due to higher temperatures. If groundwater declines are not arrested following a drought, future droughts will begin with even lower water levels, resulting in increased impacts to water supply wells and beneficial uses that worsen with each drought.

In addition to impacts to wells as described below, the lowering of groundwater levels may also lead to undesirable results for the other sustainability indicators such as reduction of groundwater in storage, land subsidence, depletions of interconnected surface water and adverse impacts to groundwater dependent ecosystems (GDEs). These impacts are summarized in **Section 6.3.2.2** and described separately for each indicator in remaining sections of this chapter.

6.3.1.1. Causes of Undesirable Results – Adverse Impacts to Wells

The combination of over-pumping and drought caused widespread adverse impacts to Subbasin water supply wells during drought conditions WY 2014 – WY 2017, resulting in undesirable results. Even though well owners appear to have mitigated most of these impacts, GSAs intend to arrest water level declines so that future impacts to water supply wells can be avoided or mitigated. Adverse impacts to water supply wells caused by chronic lowering of groundwater levels are discussed below.

In general, lower water levels increase pumping costs. If water levels fall below the pump intake, costs may be incurred for pump lowering and/or other well modifications. Further declines can result in water levels falling below the top of well screens, potentially decreasing capacity or well integrity due to geochemical changes, biological clogging, and/or air entrainment. Water level declines can also damage wellbore equipment, such as pumps or casing, from cavitation or other mechanisms. If water levels fall below the bottom of the well and do not sufficiently recover, the well is dewatered and would require replacement. Older wells, shallow wells, and/or wells with casing integrity issues typically have a higher risk of failure.

In the Modesto Subbasin, the STRGBA GSA member agencies responsible for public drinking water supplies documented numerous adverse impacts to public supply wells caused by declining water levels during drought (WY 2014 to WY 2017). During that period, declining water levels provided an opportunity to observe impacts associated with the historic low levels throughout much of the Subbasin. Most agencies observed a decrease in capacity and well efficiency. Some drinking water wells failed due to collapsed casing or other problems. More than 150 domestic wells were also adversely impacted (locations on **Figure 6-1**).

Significant adverse impacts to water supply wells in the Modesto Subbasin during this drought period are summarized in **Table 6-2** as follows.

Table 6-2: Adverse Impacts to Wells Associated with Declining Groundwater Levels

Adverse Impacts to Water Supply Wells from 2014 – 2017	Agencies Reporting Impacts
159 dry[1] or failed domestic wells (most were more than 50 years old and less than 100 feet deep)	Stanislaus County
Loss of capacity in municipal wells (pump replaced and lowered)	City of Waterford
Replace or deepen pumps in 3 agency wells; OID landowners also complained of well issues	Oakdale Irrigation District

[1]For purposes of this table, a "dry" domestic well does not necessarily mean that water levels in the aquifer have declined below the bottom of the well; well failures are also associated with water levels falling below a shallow pump intake or below the top of well screens such that capacity is adversely affected.

As indicated in **Table 6-2**, not all beneficial users of groundwater wells in the Modesto Subbasin experienced adverse impacts during the 2014 to 2017 drought. During this period, the cities of Riverbank and Oakdale were able to operate their deep drinking water supply wells without interruption. Similarly, Modesto ID did not experience well problems. The City of Modesto did not experience well impacts directly related to the drought but had water quality problems that could be exacerbated if groundwater levels continue to decline in the Subbasin. In the western Subbasin, groundwater levels experienced relatively small declines (less than 10 feet) and recovered quickly after 2016.

Most well impacts in **Table 6-2** occurred in the central-eastern Subbasin due to the presence of numerous water supply wells in areas of more significant water level declines (**Figure 6-1**; see also hydrographs on **Figure 3-25**). Although the 159 reported domestic well failures occurred throughout the Subbasin, most failures were concentrated in the eastern half of the Subbasin (**Figure 6-1**). Although most of these domestic wells appear to have been replaced, areas with vulnerable domestic wells have been identified along the Tuolumne and Stanislaus rivers (dashed areas on **Figure 6-1**). More details and analyses of failed and replacement domestic wells are provided in **Section 2.3.3**.

The City of Waterford is located within the vulnerable area along the Tuolumne River, where one of its primary water supply wells required replacing and lowering of a well pump during the 2015 drought (**Table 6-2**). Near the vulnerable area along the Stanislaus River, Oakdale ID reported water level declines of 20 feet to 50 feet from 2005 to 2020 in its deep water supply wells. Since 2016, water levels have continued to decline about 1.3 feet per year in the main service area and 2 to 4 feet per year in eastern OID. These declines caused adverse impacts to Oakdale ID deep agency wells. In addition, many landowners complained to Oakdale ID regarding private well issues.

Finally, the outreach team noted impacts to a few private wells as reported on the Modesto Subbasin Stakeholder Survey (see Chapter 4). Out of 12 responses from well owners, two reported either capacity or water quality issues with their well; the remaining 10 responders did not report well issues during the 2014-2017 drought.

6.3.1.2. Potential Effects on Beneficial Uses

Adverse impacts described above affect all beneficial uses of groundwater accessed through wells including municipal, domestic, industrial, and agricultural water supply. Any of these impacts can also affect property interests.

For agricultural users, impacts can increase costs, delay irrigation operations, and result in damage to crops. For industrial users, well issues can affect operational costs, delay goods and services, or adversely affect industrial processes relying on a specific groundwater quality. For public water suppliers, well impacts can increase wellfield operational costs, reduce pressure in distribution systems, cause water quality concerns, or even jeopardize the ability to provide a reliable and safe drinking water supply.

Impacted domestic well owners during the 2014-2017 drought reported the need for trucked water, use of temporary or permanent storage tanks, purchase of bottled water, lowering of well pumps, drilling of replacement wells, and other measures. A valley-wide shortage of drillers caused significant delay in the ability to lower a pump or otherwise modify/replace a well. In addition, domestic well owners in the Modesto Subbasin are often without financial resources necessary to replace their household water supply. Many domestic wells are located in underrepresented and economically disadvantaged communities where wells are the only available drinking water source.

Although this sustainability indicator is focused on adverse impacts to wells, chronic lowering of groundwater levels can also adversely impact environmental uses of groundwater, including GDEs (**Section 3.2.8**). Given that GDEs in the Modesto Subbasin are primarily located along the three river boundaries, GDE impacts are also affected by the interconnected surface water sustainability indicator, as discussed in **Section 6.8**.

Many of these adverse well impacts that occurred during the 2014-2017 drought appear to have been mitigated. Public water suppliers have secured groundwater supply from new or modified wells. Proposed GSP projects will increase surface water deliveries for municipal supply in both Waterford and Modesto (see **Chapter 8**).

Most of the failed domestic wells appear to have been replaced. DWR well completion records indicate that about 236 new domestic wells have been drilled since 2015 – about 1.5 times the number of previously-reported failed wells. Although data are insufficient to provide a one-to-one match, most new wells are near the estimated location of a failed well and appear to be replacement wells[5].

Since 2016, only three domestic wells have been reported as being impacted from lower water levels. These domestic wells were reported to be dry as of August and September 2021 as indicated on the DWR Household Water Supply Shortage Reporting System

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[5] The DWR database of domestic wells has been recognized to be incomplete, with uncertainty associated with numbers of wells, exact location, and well construction (including screen intervals, pump settings, or total depth. See analysis of domestic wells in **Section 2.3.2**.

(Household Water Supply Shortage Reporting System (ca.gov)). Of those three wells, the two in the City of Modesto were shallow wells with total depths of 29 feet and 79 feet. The reported failed well in the City of Oakdale had a total depth of 149 feet.

SGMA does not require the protection of all groundwater wells or the correction of historical undesirable results. For this GSP, the widespread impacts to water supply wells during the 2014-2017 drought (which were caused by then-historic groundwater level declines) are considered to be undesirable results. Although impacts appear to be mostly mitigated at current groundwater levels, the GSP strives to avoid similar undesirable results in the future by arresting chronic groundwater level declines in the Subbasin.

To assess potential undesirable results in the future, an analysis was conducted in 2024 of potential impacts to existing water supply wells if additional groundwater level declines occur. This analysis addressed potential impacts to water supply wells of groundwater levels declining to the MT groundwater elevations and to the IMs established for WY 2027, where the 2027 IMs are below the MTs. The methodology and results of this analysis are described in **Section 6.3.3.1**.

6.3.1.3. Modesto Subbasin Definition of Undesirable Results

Based on the information summarized above and additional information presented in previous sections of this GSP (especially **Sections 2.3.2** and **3.2**), the definition of undesirable results focuses on maintaining access to groundwater supply through Subbasin wells.

Regulations also require that the undesirable result definition include quantitative criteria defining when and where groundwater conditions can cause an undesirable result (§354.26(b)(2)). These criteria include the number of monitoring sites/events where MT exceedances may create those conditions; criteria recognize that a single MT exceedance at one monitoring site during one monitoring event may not be sufficient to cause an undesirable result. This framework allows for clear identification as to when an undesirable result is triggered.

The undesirable result definition for the Modesto Subbasin, along with the criteria that may lead to an undesirable result, is summarized in the table below.

Table 6-3: Undesirable Results for Chronic Lowering of Groundwater Levels

	Undesirable Results Definition	Principal Aquifer(s)
Chronic Lowering of Groundwater Levels	Undesirable results are defined as significant and unreasonable groundwater level declines – either due to multi-year droughts or due to chronic declines where groundwater is the sole supply – such that water supply wells are adversely impacted in a manner that cannot be readily managed or mitigated. An undesirable result will occur when at least 33% of representative monitoring wells exceed the MT for a principal aquifer in 3 consecutive Fall monitoring events.	All

As indicated in the criteria above, an undesirable result is triggered when a third or more of the monitoring wells in each principal aquifer exceed the MT during three consecutive Fall monitoring events. To provide context for these criteria, additional Subbasin considerations are provided below.

At this time, the monitoring network for chronic lowering of water levels contains 61 wells distributed among the three principal aquifers. Maps of these representative monitoring well locations are provided in **Chapter 7** (**Figures 7-1**, **7-2**, and **7-3**). The number of wells in each principal aquifer are summarized below along with the number of wells that could trigger an undesirable result (i.e., 33 percent):

- Western Upper Principal Aquifer: 17 wells (33% - 6 wells)
- Western Lower Principal Aquifer: 5 wells (33% - 2 wells)
- Eastern Principal Aquifer: 39 wells (33% - 13 wells)

The number of representative monitoring wells that could trigger an undesirable result condition is relatively small (i.e., between 2 and 13 wells for each principal Aquifer), which provides protection for water supply wells in the Subbasin. The number of wells allowed to exceed the MTs are commensurate with the area of the aquifer being monitored. For example, the western aquifers cover about 56,000 acres while the Eastern Principal Aquifer is about three times as large (190,000 acres). Therefore, the number of wells associated with exceedances in the Eastern Principal Aquifer is much larger.

In addition, the areas that could cause undesirable results represent a relatively small percentage of the Subbasin – about 8 percent for exceedances in the western aquifers and about 25 percent of the Subbasin for exceedances in the Eastern Principal Aquifer. This indicates that undesirable results will be triggered when a relatively small area of the

Subbasin exceeds the MT. In this manner, the undesirable results definition and criteria are protective against widespread exceedances of the MT.

Data gaps are recognized in the monitoring networks for both the Eastern Principal Aquifer and the Western Lower Principal Aquifer. Additional wells are planned for these networks in the initial years of GSP implementation (see Chapter 8). Accordingly, the number of wells with MT exceedances required to trigger undesirable results may need to be revised going forward.

The number of monitoring events with MT exceedances is also considered in the undesirable results definition in **Table 6-3**. This provides some flexibility for future drought conditions whereby wells are allowed to exceed the MT in drought as long as periods of decline are relatively short, and ongoing projects/management actions support subsequent water level recovery above the MTs. The use of three consecutive Fall semi-annual monitoring events is based on observation that three critically dry years (WY 2013 – WY 2015, see **Figure 3-2**) lead to previous undesirable results. Most of the adverse impacts to wells used to define undesirable results began at the end of this three-year period (i.e., Fall 2015) and extended throughout 2016. As described above, previous impacts to wells have been managed and mitigated for current (2021) groundwater elevations. The undesirable results criteria above are selected to avoid undesirable results during future multi-year droughts.

Even though monitoring will be conducted on a semi-annual basis (i.e., Spring and Fall), criteria limit the MT exceedances to Fall monitoring events. This focuses GSP management on long-term trends rather than seasonal fluctuations and is more protective against undesirable results. A partial Spring recovery above the MT may not indicate an improvement to an overall declining water level trend. When considered in the context of water year type, a comparison of Fall events allows for a better management tool for differentiating a short-term decline versus a longer term decline below the MT.

Collectively, these criteria provide a reasonable management approach for avoidance of undesirable results for chronic lowering of groundwater levels in the Modesto Subbasin.

6.3.2. Minimum Thresholds for Chronic Lowering of Groundwater Levels

Regulations require that the quantitative MT metric for this indicator be "the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results" (§354.28 (c)(1). In the Modesto Subbasin, MTs are quantified as the low groundwater elevation from WY 1991 – WY 2020 at representative monitoring sites for all three Principal Aquifers.

While water levels have continued to decline in eastern portions of the Subbasin, the MT period contains the historic low water level for much of the Subbasin. Many of the selected MTs occurred in the 2015-2016 time period associated with drought conditions (**Figure 6-1**).

However, some areas of the western Subbasin reached a historic low during the early to mid-1990s before surface water was available to the City of Modesto.

Table 6-5 states the selected approach for the MTs; the MT value at each representative monitoring well is presented in **Chapter 7**, which describes the GSP monitoring network (see **Section 7.1.1**). Hydrographs of all monitoring network wells with MTs and MOs are provided in **Appendix F**.

Table 6-4: Minimum Thresholds for Chronic Lowering of Groundwater Levels

	Minimum Thresholds	Principal Aquifer(s)
Chronic Lowering of Groundwater Levels	Minimum thresholds are set as the historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data.	All

Information from the basin setting used to support these MTs are summarized in the following section.

6.3.2.1. Justification and Support for Minimum Thresholds

GSP regulations require that MTs for this indicator be supported by:

- The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.
- Potential effects on other sustainability indicators. (§354.28 (c)(1)(A)(B)).

Historical declines in groundwater levels across the Subbasin are discussed throughout **Section 3.2** and specifically in **Section 3.2.2**; associated water year types are based on the detailed information in **Section 4.2.2.1** (also see **Figure 3-2**). **Figures 3-21** through **3-25** present hydrographs showing rates of decline in selected wells with relatively long water level records across the Subbasin. **Figure 6-1** provides locations of failed domestic wells from 2014 to 2017, representing undesirable results caused by groundwater level declines (also discussed in **Section 2.3.3** and shown on **Figure 2-15**). **Figure 2-17** shows the location of new and/or replacement domestic wells drilled since the 2015 drought.

As indicated by the hydrographs on **Figures 3-24 and 3-25**, water level declines become progressively larger from west to east in the Subbasin, especially since recent drought conditions began in WY 2013. Although wells with water level data are sparse in the NDE MA, groundwater levels in eastern-most wells have declined about 40 feet over the last seven years (decline rate of about 5.7 feet per year; see hydrograph 20 on **Figure 3-25**).

Rates of groundwater level declines are summarized briefly by principal aquifer below.

- Western Upper Principal Aquifer (**Figures 3-21** and **3-22**): Water levels in this principal aquifer have been relatively shallow and stable throughout the study period with minimal – but observable – declines during drought. Water levels have recovered to near pre-drought levels in almost every well shown and no significant long-term water level declines have been observed. Depth to water ranges from less than 10 feet bgs to about 40 feet bgs. Most of historic low water levels occurred during 2015-2016 drought conditions. Some wells near the City of Modesto exhibit historic low water levels during the 1990s drought when groundwater was primarily the City's sole water supply (see hydrographs 7 and 8 on **Figure 3-22**). The availability of surface water to supplement the City's drinking water supply allowed water levels to recover. During more recent droughts, water levels in these wells have generally remained above the previous historic low levels.

- Western Lower Principal Aquifer (**Figure 3-23**): Although water levels have been tracked in numerous wells in the western Subbasin, many wells are screened in both the Western Upper Principal Aquifer (unconfined) and the Western Lower Principal Aquifer (confined). Wells known to be screened only in the Western Lower Principal Aquifer are sparse; nonetheless, water levels appear to be relatively stable with small declines during drought (about 10 feet to 20 feet) followed by recovery in post-drought years. The decline and recovery for hydrograph 11 on **Figure 3-23** is due to the change in surface water availability for the City of Modesto as described above. Larger seasonal fluctuations are observed on the hydrographs due to the confined nature of the aquifer and its use by active pumping wells.

- Eastern Principal Aquifer (**Figures 3-24** and **3-25**): Overall declines are observed in the Eastern Principal Aquifer, with increasing rates of decline and total declines from west to east. For wells in the western portion of the aquifer, long-term declines are relatively small (less than about 10 feet) over the study period (see hydrographs 12 and 13 on **Figure 3-24**). Wells slightly farther to the east exhibit declines during the 2015 drought of about 20 feet with only partial recovery (hydrographs 14, 15, and 16 on **Figure 3-24**).

  Wells in the eastern Subbasin have experienced the largest declines, both during drought and over the long term since at least the mid-2000s (**Figure 3-25**). As shown by hydrograph 20 on **Figure 3-25**, eastern wells have overall declines of about 40 feet during the recent drought and long-term declines since the mid-2000s. During that time, water demand in the eastern Subbasin increased due to the expansion of irrigated agriculture and changes in cropping patterns (see discussion in **Section 2.2** and **Figure 2-8**). In the eastern Subbasin, long-term rates of decline are up to about

2.7 feet/year; rates of decline during drought are up to about 6 feet/year (**Figure 3-25**).

Water level declines in the eastern Subbasin occur primarily in the NDE MA (**Figure 6-1**). However, local over-pumping in that area appears to have propagated westward, causing water level declines in other management areas – especially in eastern Oakdale ID MA. The area of water level declines also appears to be expanding to the north and south, intercepting groundwater that would typically be flowing toward the river boundaries.

The GSP intends to arrest these high rates of expanding water level declines by establishing MTs at the historic low water level observed (or estimated, if data are not available) during WY 1991 – WY 2020. Using this time period, MTs were selected for the 61 wells in the representative monitoring network for chronic lowering of groundwater levels; those MTs are discussed in **Section 7.1.1**, posted on **Figures 7-1**, **7-2**, and **7-3**, and listed in **Table 7-1**. Almost all of the selected MTs represent one of three time periods:

- Fall 2015 groundwater elevation (most western Subbasin wells)
- Fall 1991 groundwater elevation (a few wells near the City of Modesto)
- Fall 2020 groundwater elevations (most eastern Subbasin wells)

For most western wells, the MT was typically defined by 2015-2016 water levels. Even if water levels continue to decline in the eastern Subbasin while the GSP is being implemented, projects and management actions will have to be sufficient for water levels to recover back to the selected MT. The following conditions were considered when setting the MT at the historic low groundwater elevation:

- Replacement wells and other well improvements appear to have mitigated impacts from low water levels during the 2015-2016 drought conditions.
- The large number of new and deeper domestic wells drilled since 2015 can reasonably be assumed to accommodate current low water levels, with some tolerance for future droughts.
- The analysis in **Section 2.3.3** indicates that MTs will avoid the widespread failures of about five percent of the total domestic wells drilled in the Subbasin that occurred during the 2015 drought conditions. Uncertainties associated with data gaps regarding domestic wells limit the ability to accurately identify the exact number of wells subject to impacts (see also **Section 9.5.3**).
- The Subbasin is not currently experiencing widespread adverse impacts to water supply wells that occurred in 2015-2016 and formed the basis for its undesirable result definition.
- Most of the MTs are commensurate with recent Fall 2020 water levels; no additional undesirable results were identified during that Fall period.

- As of Spring 2021, groundwater levels are within about 10 feet of the MT; several wells are below the MT.

Collectively, these considerations support the selection of the MTs for chronic lowering of groundwater levels.

6.3.2.2. Relationship between MTs of Each Sustainability Indicator

Regulations require a description of the relationship between the MTs for each sustainability indicator and how the GSAs have determined that basin conditions at each MT will avoid undesirable results (§354.28(b)(2)). To facilitate a comparison between MTs, a summary table of MTs for each sustainability indicator is provided below. Justification for the approach to the MTs for each indicator is provided in subsequent GSP sections, as indicated in the table.

Table 6-5: Summary of Minimum Thresholds by Sustainability Indicator

Sustainability Indicator	Minimum Threshold (MT)	GSP Section
Chronic Lowering of Groundwater Levels	Low groundwater elevation WY 1991 – WY 2020	**6.3.2**
Reduction of Groundwater in Storage	Low groundwater elevation WY 1991 – WY 2020	**6.4.2**
Seawater Intrusion	Not applicable	**6.5**
Degraded Water Quality	MCL of each Constituent of Concern	**6.6.2**
Land Subsidence	Low groundwater elevation WY 1991 – WY 2020	**6.7.2**
Interconnected Surface Water	Fall 2015 groundwater elevation	**6.8.2**

As indicated in the table above, the historic low groundwater elevation – as observed or estimated during the period WY 1991 – WY 2020 – has been selected as the MT for three of the six sustainability indicators (chronic lowering of groundwater levels, reduction of groundwater in storage, and land subsidence).

Groundwater elevations are also used as a proxy for interconnected surface water MTs but are set differently from other water level MTs. To be more protective of basin conditions along the three river boundaries, MTs for interconnected surface water are set as the Fall 2015 groundwater elevations. This approach is consistent with the need to guard against projected increases in streamflow depletion by the water budget modeling analyses (**Section 5.1.4.3**). In particular, projected increases in average streamflow depletions from the Stanislaus and Tuolumne rivers could lead to undesirable results. This approach is discussed in more detail in **Section 6.8**.

As discussed previously and indicated in the table above, the seawater intrusion indicator has been determined by the GSAs as not applicable to the inland Modesto Subbasin. Accordingly, no MTs have been set for seawater intrusion.

A different approach to MTs was used for the degraded water quality sustainability indicator. MTs for that indicator are set as the California drinking water standard for water quality constituents of concern most applicable to the Modesto Subbasin. This MT approach will not conflict with the other MTs for the Subbasin. Further, the MTs set for the other sustainability indicators are supportive of the MTs for degraded water quality, as described in more detail in **Section 6.6**.

The interrelatedness of the MTs among the four sustainability indicators with groundwater levels as a proxy are summarized below.

- MTs for chronic lowering of groundwater levels are used as a proxy for reduction of groundwater in storage and land subsidence for all three Principal Aquifers. Therefore, the MTs will not present conflicts between these three indicators.

- As explained in **Sections 6.4**, the use of groundwater elevations as a proxy for reduction of groundwater in storage is supported by the sustainable yield analysis (**Section 5.3**), whereby the historic low water levels are correlated directly to a sustainable yield volume for the Subbasin (267,000 AFY), which avoids undesirable results and also meets the requirement to use a volume as the metric for the reduction of groundwater in storage indicator (see **Section 6.4.2**).

- As explained in **Section 6.7**, the historic low water level is also an appropriate MT for land subsidence. By preventing significant groundwater level declines below the historic low level, the depressurization/dewatering of compressible subsurface clay layers can be avoided (see Section 6.7). Because this mechanism has been the primary cause of land subsidence in the Central Valley, the use of MTs for chronic lowering of groundwater levels as a proxy is supported (**Section 6.7.2**).

- The MTs for interconnected surface water are sufficiently close to the MTs for chronic lowering of water levels. Many of the MTs for chronic lowering of water levels are either the same or within only a few feet of the MTs for interconnected surface water. Accordingly, there are no conflicts between these two MT data sets. The use of water levels as a proxy for the interconnected surface water MTs is supported by the sustainable yield analysis in **Section 5.3** and demonstrates the ability of the aquifer to meet selected MTs for both sustainability indicators under the same basin conditions (see also **Section 6.8**).

Although presentation and review of technical information and selection of MTs by the TACs generally occurred one sustainability indicator at a time, basin conditions and sustainable yield analyses support the interrelatedness of the MTs. (Basin conditions that supported chronic lowering of water levels were discussed in **Section 6.3.2.1** above). Sustainable yield analyses were conducted interactively for future conditions and sustainable management criteria to determine how MTs could be achieved on a Subbasin-wide basis (**Section 5.3**). By first setting MTs to correct overdraft conditions and arrest future groundwater elevation declines, all of the other sustainability indicators in the Modesto Subbasin could be supported. The application of consistent methodologies in each principal aquifer and in each of the four management areas (**Figure 6-2**) allow the collective MTs to work well together to avoid undesirable results and support sustainable groundwater management.

Notwithstanding the protective MTs above, preventing all impacts to water supply wells may be difficult where large numbers of densely spaced water supply wells are pumping at maximum capacities during drought conditions. Closely spaced pumping wells can cause interference with other wells, even if basin-wide water levels are managed at reasonable levels. Well interference between two closely spaced wells is not included in the undesirable results definition and will be managed locally, as needed. By setting MTs at historic low groundwater elevations across most of the Subbasin, regional long-term declines will be arrested and significant and unreasonable adverse impacts to water supply wells can be avoided.

6.3.2.3. Impacts of MTs on Adjacent Subbasins

Regulations require consideration of how Modesto Subbasin MTs impact the ability of an adjacent subbasin to achieve its sustainability goal. Significant technical similarities among the Modesto Subbasin and its three neighboring subbasins facilitate this process. For example, all of the subbasins have delineated principal aquifers in the same manner. In addition, all of the adjacent subbasins are linked to the Modesto Subbasin by a shared river boundary (i.e., Turlock Subbasin south of the Tuolumne River, Eastern San Joaquin Subbasin north of the Stanislaus River, and the Delta-Mendota Subbasin west of the San Joaquin River, see **Figure 6-1**). Due to the shared interconnected surface water along these rivers, MTs in each of the subbasins have been set in a similar manner.

There is also significant inter-basin coordination occurring among GSAs and member agencies across all of these subbasins. Multiple member agencies are actively involved in the GSP process in both the Modesto Subbasin and one of the adjacent subbasins.

For example, in the Eastern San Joaquin (ESJ) Subbasin to the north, both Oakdale ID and Stanislaus County are member agencies of ESJ GSAs and actively participated in GSP development for that subbasin. Oakdale ID has service areas and operations in both the Modesto and the ESJ subbasins, located along a large portion of the boundary between the two. Stanislaus County also provides consistent coordination in the Delta Mendota Subbasin to the west. In addition, members of the technical consulting team and outreach team in the Modesto Subbasin were also involved in GSP development in both the ESJ and Delta Mendota subbasins.

In the Turlock Subbasin to the south, several member agencies are represented in both the Turlock and Modesto subbasins, including Stanislaus County, City of Modesto (with pumping wells in the Turlock Subbasin), and the City of Waterford (which operates the water supply system for Hickman in the Turlock Subbasin). Also, Turlock ID and Modesto ID coordinate on diversions from the Tuolumne River to provide a large supply of Tuolumne River water to both subbasins. Finally, the GSP technical consulting team is the same in both Turlock and Modesto subbasins and has developed one integrated surface water-groundwater model for coordinated GSP analyses.

Through coordination activities by these member agencies, additional coordination meetings with adjacent subbasin representatives, and review of draft and completed GSPs, the MTs selected for chronic lowering of water levels in the three adjacent subbasins have been considered together. In brief, the Modesto Subbasin MTs are not expected to either cause undesirable results or adversely impact GSP implementation in adjacent subbasins, as summarized below.

6.3.2.3.1. Eastern San Joaquin Subbasin

The MTs for chronic lowering of water levels in the ESJ Subbasin are defined as the shallower groundwater elevation of the following (ESJGWA, 2019):

- the deeper of 1992 and 2015-2016 historical groundwater levels with a buffer of 100 percent of the historical range applied, or
- the 10th percentile domestic well total depth of wells within a 3-mile radius of the monitoring well.

MTs have been set for 20 representative monitoring wells in the ESJ Subbasin, four of which are within about three miles from the shared boundary with the Modesto Subbasin (02S07E31N001, 02S08E08A001, Burnett-OID4, and 01S10E26J001M; see Figure 3-2 in ESJGWA, 2019). All of the MTs set for the ESJ monitoring wells appear to be lower than the closest Modesto Subbasin MTs.

For example, the closest ESJ Subbasin well to the Modesto Subbasin is Burnett (OID4), located across the Stanislaus River from Modesto Subbasin monitoring wells Allen (OID1) and Birnbaum (OID3). The Burnett MT is 60.7 feet msl (Table 3-1 in ESJGWA, 2019) and the Birnbaum and Allen MTs are 74 and 75 feet msl, respectively (see **Figure 7-7**). MTs for all three wells are based on 2015 groundwater elevations, although the ESJ monitoring well has a buffer equal to the historical water level range (see first bullet above). As indicated by these values, MTs in the ESJ Subbasin are lower, but close to the MTs in the Modesto Subbasin. Accordingly, the MTs do not appear to conflict across the Subbasin boundary and MTs in the Modesto Subbasin are not expected to adversely impact GSP implementation in the ESJ Subbasin.

ESJ Subbasin MTs for chronic lowering of water levels are also used as a proxy for the reduction of groundwater in storage, land subsidence, and interconnected surface water. Therefore, these MTs represent the best MTs for evaluation of potential impacts across the shared Stanislaus River boundary. Finally, as noted above, Oakdale ID operates within its service areas on both sides of this boundary and has GSP monitoring and management responsibilities in both subbasins. This close coordination allows the tracking of potential impacts in each subbasin going forward.

6.3.2.3.2. Delta-Mendota Subbasin

Sustainable management criteria in the adjacent Delta-Mendota Subbasin are provided in the Northern & Central Delta-Mendota Regions GSP (W&C and P&P, 2019). In that GSP, the MTs for water levels are defined as the hydrologic low groundwater level for the Upper Principal Aquifer and 95 percent of the hydrologic low groundwater level for the Lower Principal Aquifer. Because these low groundwater levels generally occurred in WY 2015, and MTs along the San Joaquin River in the Modesto Subbasin are also set at WY 2015 levels (for interconnected surface water – see **Table 6-5**), there should be no conflict in MTs along this boundary.

Because the shared San Joaquin River boundary between the Delta-Mendota Subbasin and the Modesto Subbasin is relatively short, there are no representative monitoring wells in the Delta-Mendota Subbasin along that boundary. The two closest wells are 06-004 (Upper Aquifer) and 06-003 (Lower Aquifer), both located about three miles to the southwest from the southwestern corner of the Modesto Subbasin. MTs for those two wells are 14.8 feet msl and -8.6 feet msl, respectively.

In the Modesto Subbasin, the closest representative monitoring wells in equivalent principal aquifers are Canfield 90 (Western Upper Principal Aquifer) and MRWA-3 (Western Lower Principal Aquifer). MTs for chronic lowering of water levels in those wells are 32 feet msl and 28 feet msl, respectively. Given the higher elevations and distance from representative monitoring locations, the MTs in these two subbasins do not conflict and are not expected to adversely impact GSP implementation in either Subbasin.

6.3.2.3.3. Turlock Subbasin

By selecting MTs for the chronic lowering of groundwater levels at the historic low groundwater elevations, MTs in the inland portions of the Subbasin are slightly lower in some places than in the Turlock Subbasin. However, the methodology for selecting MTs along the shared Tuolumne River boundary is identical for both subbasins. Along that boundary MTs are set at the Fall 2015 groundwater elevations in the Modesto Subbasin for interconnected surface water (**Table 6-5**; see also **Section 6.8**). Sustainable yield analyses indicate very small subsurface flows between the two subbasins (within about 1,000 AFY) along the approximate 35-mile river boundary (see **Table 5-15** for the net subsurface flows between the two subbasins). These conditions suggest that there will be no adverse impacts on GSP implementation from MTs in the Modesto Subbasin on Turlock Subbasin MTs.

6.3.2.4. Effects of MTs on Beneficial Uses and Users of Groundwater

By arresting groundwater level declines in the Subbasin, long-term use of groundwater will become more sustainable and provide benefits to all beneficial uses of groundwater in the

Subbasin. However, there are consequences to maintaining these MTs for some current beneficial uses of groundwater.

In brief, the current level of groundwater use will not be able to be sustained without sufficient projects or management actions to replenish the Subbasin. This will require maintenance of water levels in deep wells that could otherwise accommodate additional declines. In the NDE MA, where growers are currently reliant on groundwater for agricultural beneficial uses, significant investment in projects and supplemental water will be required to support the current level of agricultural production. If projects cannot meet the sustainable yield, demand reduction will need to be considered, which could negatively affect property interests in the Subbasin.

Conversely, the beneficial uses of public water suppliers and domestic well owners will be supported by the MTs. Although water levels will be allowed to decline somewhat during drought conditions, the Subbasin will not be subject to the continual historic lows that would occur with deeper MTs. With improved long-term maintenance of water levels, municipal water suppliers will avoid the loss of expensive public drinking water supply wells as has been documented in public meetings (e.g., by the City of Waterford). The need for widespread domestic well replacements can also be avoided (see **Table 6-1**).

The prevention of further water level declines will also support the potential GDEs that have been identified in the Subbasin, most of which are located along the river boundaries (see **Section 3.2.8**). Even more protective MTs have been set along the rivers as described in more detail in **Section 6.8.2**.

6.3.2.5. Consideration of State, Federal, or Local Standards in MT Selection

GSP regulations require that GSAs consider how the selection of MTs might differ from other regulatory standards. For the chronic lowering of groundwater levels, the MT consists of quantified water levels in each representative monitoring well, which present no conflicts with regulatory standards.

6.3.2.6. Quantitative Measurement of Minimum Thresholds

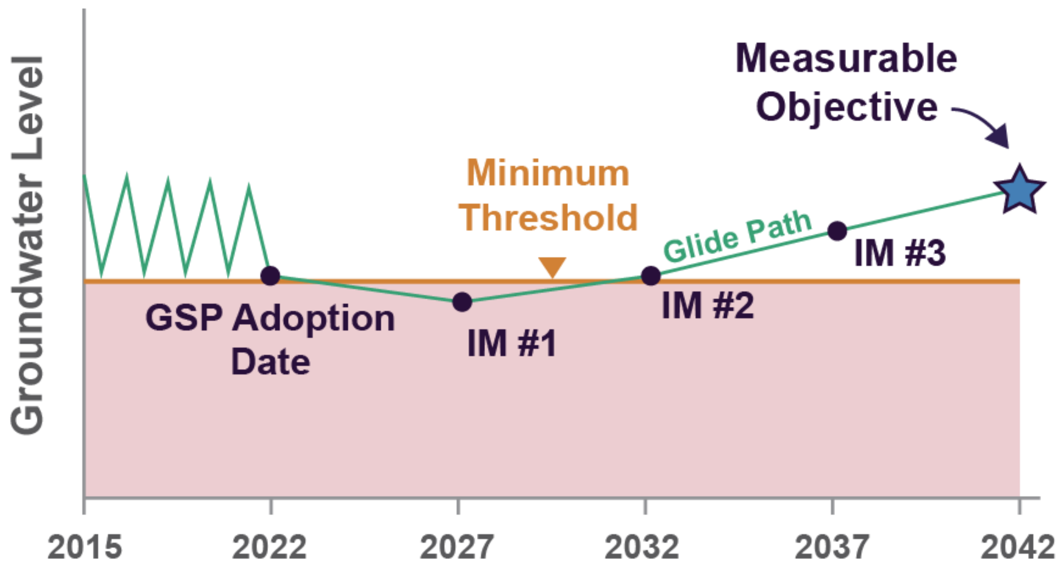
As stated above, the MTs for the chronic lowering of groundwater levels will be monitored by quantitatively measuring water levels in representative monitoring well networks for each principal aquifer as described in **Chapter 7** (Monitoring Network) of this GSP (see **Section 7.1.1**, **Table 7-1**, and **Figures 7-1** through **7-3**. Monitoring will occur on a semi-annual basis, in Spring and Fall, to represent the seasonal high and low water level and to adhere to basin-wide water level sampling protocols (**Section 7.2.4**).

6.3.3. Interim Milestones for Chronic Lowering of Groundwater Levels

GSP regulations define an interim milestone (IM) as "a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan." For the Modesto Subbasin, water levels are used as a metric for the IMs, consistent with the metric being used for MTs and MOs for all sustainability indicators except degraded water quality.

IMs provide a glide path for the Modesto Subbasin to reach its sustainability goal. The incremental approach recognizes that the path to sustainability is determined by the timing and effectiveness of GSP implementation, including projects and management actions designed to avoid undesirable results. For the Modesto Subbasin, a glide path provides needed flexibility for MAs of the Subbasin that will continue to have declines – at rates dependent on future hydrologic conditions – until projects and management actions are implemented.

The following graphic prepared by DWR illustrates the concept of how IMs relate to the MT and MO. As shown, the IMs provide a glide path to sustainable management whereby MTs and MOs are maintained to avoid undesirable results.



In this conceptual graphic, the pink area represents water levels below the MT as designated in a representative monitoring well (i.e., an MT exceedance). In this example, water levels are expected to continue to decline after the GSP is adopted while projects are brought online. This concept acknowledges that the aquifer response to projects and management actions will take time. Interim milestones are illustrated in increments of five years following Plan adoption to define the glide path from undesirable results to the MO and achieving sustainable management by 2042.

In the Modesto Subbasin, long-term declines have occurred in NDE MA (**Figure 6-1**) and have expanded into the Oakdale ID MA (**Figure 6-2**). Accordingly, 2027 target values below the MT have been developed for representative monitoring wells in these management areas.

The amount of the anticipated declines between adoption and 2027 is dependent on future unknown hydrologic conditions. Since drought conditions began in WY 2013, dry hydrologic conditions have persisted in the Subbasin. Water year types as categorized by the DWR San Joaquin Valley indices since 2014 are summarized in the following table.

Table 6-6: Water Year Hydrologic Classification Indices Since 2014

Water Year	Water Year Type San Joaquin Valley Water Year Index
2014	Critically Dry
2015	Critically Dry
2016	Dry
2017	Wet
2018	Below Normal
2019	Wet
2020	Dry

Source : https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

As shown in the table, five out of seven water years between WY 2014 and WY 2020 have been categorized as below normal, dry, or critically dry. Water level declines associated with the last seven years may continue if hydrologic conditions do not improve, and/or if the aquifer response to GSP project implementation is delayed.

In order to plan for a worst-case scenario, a 2027 IM has been developed for declining wells based on the declines observed over the last seven years. By 2032, projects and management actions are expected to support water level recovery and the 2032 IM is set as the MT. If needed, the IM for 2037 is defined as the halfway point between the MT and MO. This trajectory is similar to the DWR conceptual diagram illustrated above. The 2027 IMs are provided in **Chapter 7** (see **Table 7-1** and **Table 7-3**) and shown on the hydrographs in **Appendix F**.

IMs have been designated conservatively for monitoring wells in the Oakdale ID MA and the NDE MA but will not be used to defer implementation of GSP projects or management actions. A summary of the projects and management actions is provided in Chapter 8.

6.3.3.1. Impacts to Wells and Beneficial Uses in the Modesto Subbasin

For GSP revision in 2024, an analysis was conducted to determine the potential impacts to water supply wells in the Modesto Subbasin due to groundwater levels decreasing to MTs and reaching IMs (established for 2027), where the 2027 IMs are below the MTs.

The well impacts analysis addresses all water supply wells with construction information in the Modesto Subbasin. Records of municipal, industrial, domestic and agricultural water supply wells were compiled into a database from three sources: the GSP data management system (DMS), wells added to the C2VSimTM model since the GSP was submitted in January 2022, and DWR's Online System of Well Completion Reports (OSWCR, DWR February 2024).

The analysis includes 4,563 water supply wells with construction information in the Modesto Subbasin. **Figure 6-3** shows the locations of the Representative Monitoring Wells (RMWs) in the chronic lowering of groundwater level monitoring network and the water supply wells included in this analysis. On this figure, the water supply wells used in the analysis are shown as gray dots, the RMWs are shown as blue circles and the RMWs with 2027 IMs below the MTs are shown as blue circles with green halos.

The well records were combined into a database for evaluation in comparison to water levels in the RMWs. The well records were mapped and then grouped according to the nearest RMW in the same principal aquifer unit. **Figure 6-4** illustrates the well groups associated with each RMW.

The depth of the MT elevation and the depth of the 2027 IM elevation at the RMW was compared to the depth of each well associated with that RMW. A well was considered dry at the MT if the depth to the MT at the RMW is below the total depth of the well. Wells whose total depths were shallower than the MT elevation were considered to have been dry. Similarly, a well was considered dry if the depth to the 2027 IM elevation at the RMW is below the total depth of the well.

A summary of the well impacts analysis results is provided in **Table 6-7**. The analysis indicates that 126 wells went dry at the MT groundwater elevation, which corresponds to 2.8 percent of the wells in the analysis. All but one of the wells dry at the MT groundwater elevation are located in the Eastern Principal Aquifer and one is located in the Western Upper Principal Aquifer. No wells dry at the MT groundwater elevation are located in the Western Lower Principal Aquifer. Wells impacted at the MT are shown on **Figure 6-5**. Please note that the points on the map may represent locations of more than one well because some wells from the OSWCR database are commonly located at the center of the section.

Table 6-7. Summary of Well Impacts Analysis Results

Statistic	Principal Aquifer			Subbasin Total
	Western Upper	Western Lower	Eastern	
Count of Wells	953	280	3,330	4,563
N Wells with MT Exceedance	1	0	125	126
N Wells with IM Exceedance	1	0	154	155
N Additional Wells with IM Exceedance	0	0	29	29
% of Wells with MT Exceedance	0.1%	0%	3.8%	2.8%
% of Wells with IM Exceedance	0.1%	0%	4.6%	3.4%
% of Additional Wells with IM Exceedance	0.0%	0%	0.9%	0.6%

The analysis indicates that 29 additional wells could go dry at the 2027 IM elevation, where the IM elevation is below the MT elevation. This corresponds to 0.6 percent of the wells in the analysis and represents the impact of lowering groundwater levels below the MT to the 2027 IM. All these impacted wells are located in the Eastern Principal Aquifer. Wells impacted at the 2027 IM, where below the MT, are shown on **Figure 6-6**. Similar to **Figure 6-5**, the points on the map may represent the location of more than one well.

In general, impacted wells are older and shallower than the average age and depth of wells in the Subbasin. These well characteristics are summarized in **Table 6-8**. Wells in the Subbasin are on average 32 years old, while wells dry at the 2027 IM, where below the MT, are on average 46 years old. The average depth of the wells in this analysis is 219 feet, while the average depth of wells impacted at the 2027 IM, where below the MT, is 162 feet.

Table 6-8: Well Age and Depth Characteristics

		All Analysis Wells	Additional Wells Dry at IM
Count	Number of Wells	4,563	29
	Number of Wells with Age	3,626	23
Age (years old)	Oldest	76	67
	Mean Age	32	46
	Median Age	34	47
	Youngest	1	10
Depth (ft BGS)	Shallowest Well Depth	20	96
	Mean Depth	219	162
	Median Depth	187	163
	Deepest Well Depth	1,512	236

As discussed in **Section 6.3.2**, the MTs are the historic low groundwater elevation observed from WY 1991 to WY 2020. In total, 126 wells with construction are indicated as dry at the MT, representing 2.8 percent of wells in Subbasin in this analysis. As shown on **Figure 6-5**, the wells indicated dry at the MT are primarily in the Eastern Principal Aquifer. The MTs defined at RMWs in the Eastern Principal Aquifer represent measured groundwater elevations between Fall 2015 and Fall 2020.

Section 2.3.3 documented that 159 domestic wells were reported as dry or failed from 2014 to 2017 in Stanislaus County. The 126 wells identified as dry at the MT in this analysis are comparable, with differences resulting from limitations of the available information. For example, the dataset for this analysis includes only those wells with construction information. Second, the wells included in this analysis represent all records of wells with construction information, regardless of well age or status. Third, this analysis includes all water supply wells, not just domestic wells. Finally, not all wells that went dry between 2014 and 2017 may have been reported to the counties.

Fourteen RMWs in the monitoring network for chronic lowering of groundwater levels monitoring network have 2027 IMs that are below MTs. For these RMWs, the 2027 IM below the MT represents a hypothetical future condition.

The GSAs recognize the potential for groundwater levels to decline below the MT while projects and management actions are being implemented. The GSAs are in the process of developing a Well Mitigation Program to mitigate potential impacts to water supply wells. For the Revised GSP, the GSAs have committed to implementing the Well Mitigation Program through a signed Resolution, provided in **Appendix X**. The program will begin no later than January 31, 2026, will cover eligible mitigation claims accrued after January 31, 2022 (the date the original GSP was adopted) and will continue for the duration of the GSP Implementation Period or until groundwater sustainability is achieved.

As described in **Chapter 8**, the GSAs will implement projects and management actions to ensure that declining groundwater levels reach their inflection point in 2027, and then recover and rise to meet their MT elevation by 2032. The GSAs will respond promptly to dry well claims through its Well Mitigation Program and therefore dry wells will be addressed without delay. Because dry wells will be mitigated promptly through the Well Mitigation Program, potential impacts to land uses and property interests will also be mitigated.

6.3.3.1.1. Limitations of Well Impacts Analysis

This well impacts analysis has the following limitations:

- The analysis is limited to wells whose records include well construction information. Well records without construction information are not included in this analysis.
- Well records with construction information most commonly include total depth, but not screened interval. Therefore, water levels are compared to the total depth of the well.
- Well records do not indicate well status and therefore, it is assumed that all wells are active water supply wells. Older shallower wells have not been removed from the analysis even though some may no longer be active.
- Well records do not include information on pumping equipment, so assessment of the effects of water level changes on pumping costs is not possible.
- Well locations based on well records from OSWCR are uncertain. Over 90 percent of the well records included in this analysis are from OSWCR. Approximately 60 percent of these well records are located by address and the remainder are located based on the Public Land Survey System (PLSS) section centers.

6.3.3.2. Impacts to Other Sustainability Indicators

Analyses were conducted to evaluate potential impacts of lowering groundwater levels below the MTs to the 2027 IMs, where below the MTs, on other sustainability indicators including degradation of water quality, land subsidence and depletion of interconnected surface water.

6.3.3.2.1. Degradation of Water Quality

An analysis was conducted to evaluate potential impacts on the degradation of water quality sustainability indicator of lowering groundwater levels below the MTs to the 2027 IMs, where 2027 IMs are below the MTs. Groundwater quality monitoring in the Modesto Subbasin focuses on seven regionally important constituents of concern (COCs) that have the highest potential to cause undesirable results: nitrate, tetrachloroethene (PCE), 1,2,3-trichloropropane (TCP), arsenic, uranium, total dissolved solids (TDS), and dibromochloropropane (DBCP).

Water quality data for the COCs monitored in the Modesto Subbasin were downloaded and evaluated from the State Water Resources Control Board (SWRCB) Groundwater Ambient Monitoring and Assessment Program (GAMA) portal website. The water quality data were filtered to include 207 GAMA wells with known construction and sufficient data of at least one COC. The locations of these GAMA wells and the RMWs are presented on **Figure 6-7**.

Groundwater levels at each RMW were compared to concentrations of the COCs at the nearest five GAMA wells to assess correlation between changes in groundwater elevations in RMWs and COC concentrations in monitored wells. Specifically:

- For each RMW, a hydrograph of groundwater levels over time was compared to time-concentration plots of the COCs at the five closest GAMA wells.
- The screened interval depths for each RMW were compared to the screened interval depths of the five closest GAMA wells.
- Other factors were also considered, including the distance between the RMW and the GAMA well and the length of hydrograph record.
- Groundwater level trends were compared to water quality concentrations at GAMA wells screened in the same aquifer and in close proximity to the RMW.
- The comparison focused on visual identification of potential trends and/or relationships between water levels in the RMW and COC concentrations in the closest five GAMA wells.

The ability to compare water quality to groundwater levels was limited by the number and location of GAMA wells. As shown on **Figure 6-7**, most of the GAMA wells are concentrated within the municipalities. Within the Corcoran Clay extent, most of the GAMA wells are in the Western Lower Principal Aquifer, with few in the Western Upper Principal Aquifer. The GAMA wells in the Eastern Principal Aquifer are primarily in the western region of the aquifer within the City of Modesto and along the river boundaries. Many of the RMWs with 2027 IMs below the MTs are not near GAMA wells.

The ability to compare groundwater quality to groundwater levels was also limited by the availability of groundwater level data. For example, several GAMA wells with increasing nitrate, uranium, and TDS trends are located in the Western Lower Principal Aquifer. However, there are only five RMWs in the Western Lower Principal Aquifer, with sparse groundwater elevation data before 2020. The lack of groundwater elevation data makes it difficult to compare groundwater levels to water quality.

A clear relationship between concentrations of any of the COCs and groundwater levels at RMWs was not apparent. At most GAMA wells, nitrate was the only COC with a sufficient number of detections above the reporting limit to compare to groundwater levels. Several GAMA wells near RMWs had detections of arsenic, uranium, TDS, and DBCP over the past 20 years. Few GAMA wells had a sufficient number of detections of TCP or PCE to evaluate.

There was no clear relationship between nitrate concentrations and groundwater levels. Several GAMA wells showed increasing nitrate concentrations over the past 20 years. However, nitrate concentrations in other nearby wells within a similar distance from the same RMW had declining trends or did not have a clear trend. For example, three GAMA wells within one mile of RMW Riverbank OID-13 had increasing nitrate trends, while two GAMA wells within one mile of the same RMW had decreasing nitrate trends.

Several factors may cause increasing nitrate concentrations. Nitrate concentrations are often higher in shallower portions of an aquifer due to the surface discharge of nitrate from septic tanks or the infiltration of nitrate from animal operations or fertilizer. Groundwater level declines can cause increased nitrate concentrations at depth by intensifying the downward migration of nitrate-rich shallow groundwater. However, even without declining groundwater levels, historical nitrate discharge (i.e., legacy loading) can be transported to deeper parts of the aquifer. Additionally, wells that are screened both above and below the Corcoran Clay can serve as conduits for nitrate-rich water.

Several GAMA wells had detections of arsenic over the past 20 years. However, in most of these wells, arsenic concentrations fluctuated over time and did not show a clear trend.

While most wells with uranium or TDS detections did not show a clear trend, several wells in the Western Lower Principal Aquifer had increasing uranium, TDS and nitrate trends. However, these GAMA wells were miles from an RMW with historical water level measurements, making a comparison to groundwater levels impossible.

The increasing uranium, TDS, and nitrate concentrations are likely due to the drawdown of shallow, bicarbonate and nitrate-rich water to deeper portions of the aquifer. This process is described in a USGS study of Modesto public supply wells by Jurgens et al., 2008. Saline, nutrient-rich water from irrigation return flow can be transported to deeper parts of the aquifer through the intermittent operation of public supply wells screened both above and below the Corcoran Clay.

Several GAMA wells in the Eastern Principal Aquifer show declining DBCP concentrations. These declining concentrations do not appear to correlate with water level trends.

The review of historical water quality information and groundwater elevations in the Modesto Subbasin using best available data showed no clear relationship between COC concentrations and groundwater levels. The absence of a relationship, especially between declining groundwater levels and COC concentrations, suggests that lowering groundwater levels from the MTs to the 2027 IMs, where the 2027 IMs are below the MTs, should not affect the degradation of water quality sustainability indicator.

6.3.3.2.2. Land Subsidence

An analysis was conducted to evaluate whether there is a significant effect on the land subsidence sustainability indicator from lowering groundwater levels below the MT to the 2027 IM, where the 2027 IM is below the MT.

As described in **Section 3.2.6**, no impacts from inelastic land subsidence are known to occur in the Modesto Subbasin. Significant rates of land subsidence are not occurring. As presented on **Figure 3-60** and discussed in **Section 3.2.6**, InSAR data from June 2015 to October 2020 indicate no land subsidence over most of the Subbasin. One small area of land subsidence is indicated within the Corcoran Clay extent in the northwest corner of the Subbasin (up to 0.24 inches/year). Small amounts of vertical displacement are also indicated within the central and eastern Subbasin (up to 0.36 inches/year).

The western Subbasin is considered most susceptible to future land subsidence because it is underlain by the Corcoran Clay. The Corcoran Clay is known as a key subsidence factor throughout the San Joaquin Valley. The Eastern Principal Aquifer is less susceptible to subsidence because it is more consolidated with no known regional clay zones like the Corcoran Clay. The GSP presents a strategy for minimizing subsidence in the western principal aquifers by maintaining groundwater levels at or above historical low levels (the MTs).

The RMWs with 2027 IMs below the MTs are located within the Oakdale ID and NDE Management Areas. These wells are shown on **Figure 7-3.** These RMWs are within the Eastern Principal Aquifer and far from the edge of the Corcoran Clay. Lowering groundwater levels from the MT to the 2027 IM at these RMWs will not affect groundwater levels within the extent of the Corcoran Clay or near the Corcoran Clay boundary. There are no RMWs with 2027 IMs below the MTs within the Corcoran Clay extent in either the Western Upper Principal Aquifer or the Western Lower Principal Aquifer.

Because the RMWs with 2027 IMs below the MTs are in the Eastern Principal Aquifer and not close to the edge of the Cocoran Clay, lowering groundwater elevations to the 2027 IMs will not result in groundwater elevations declining to below the top of the Corcoran Clay. Therefore, it is unlikely that groundwater at the 2027 IMs, where below the MTs, will have an impact on land subsidence.

6.3.3.2.3. Depletion of Interconnected Surface Water

An analysis was conducted to evaluate whether there would be a significant effect on the depletion of interconnected surface water sustainability indicator from lowering groundwater levels below the MT to the 2027 IM, where the 2027 IM is below the MT.

As stated in **Section 6.8**, the Stanislaus River, Tuolumne River and San Joaquin River represent interconnected surface water. Groundwater occurs above the base elevation of the channel on an average basis, allowing groundwater to interact with surface water. C2VSimTM results indicate that the groundwater system and river system remain connected throughout the 50-year implementation and planning horizon. If depletion increased significantly more than indicated from modeling, groundwater could become disconnected from surface water. Future projected increases in streamflow depletion results in a net loss of streamflow from the river systems compared to a net gain in streamflow over historical conditions. Beneficial uses could be adversely impacted at these predicted levels of streamflow depletion even if the groundwater and surface water remain connected. Accordingly, the projections for future streamflow depletions are considered undesirable results.

As described in **Section 9.5.1.3**, data gaps exist for monitoring and management of interconnected surface water along the river boundaries. A management action to improve the monitoring network provides for additional shallow monitoring wells to be installed along the rivers over time. Since GSP submittal in January 2022, the Modesto Subbasin GSAs have developed a plan for installing additional monitoring wells throughout the Subbasin to fill data gaps in the GSP monitoring network. This plan includes additional monitoring wells along the river boundaries for the interconnected surface water monitoring network.

The methodology for the interconnected surface water analysis focused on the RMWs with 2027 IMs below their MTs that are within the interconnected surface water monitoring network. There are five RMWs in the interconnected surface water monitoring network with 2027 IMs below their MTs: three along the Stanislaus River (Allen OID-01, Birnbaum OID-03, and Marquis OID-10) and two along the Tuolumne River (Quesenberry 223 and MW-9). There are no RMWs along the San Joaquin River with 2027 IMs below the MTs. The locations of these RMWs are shown on **Figure 7-5**.

The analysis included a comparison of the MT and 2027 IM elevations at these RMWs to the elevation of the nearest stream node invert elevation. The stream node invert elevations are from the C2VSimTM model, where stream nodes are spaced approximately one-half mile apart from one another along the Stanislaus and Tuolumne rivers. The invert elevations represent the base of the stream channel, or thalweg. The analysis also includes an evaluation of the groundwater elevation change from the MT to the 2027 IM and the distance between the RMW and the river.

A summary of this analysis is provided in **Table 6-9**. The results show that the MT and 2027 IM elevations are either both above or both below the nearest stream node invert elevation. There are no RMWs where the MT elevation is above the nearest stream node invert elevation and the IM elevation is below the nearest stream node. This means that it is unlikely that lowering groundwater levels from the MT to the 2027 IM will result in groundwater levels declining from above the base of the river channel to below the base of the river channel.

Table 6-9: Summary of Interconnected Surface Water Analysis

Representative Monitoring Well	*Minimum Threshold (MT)*	*Interim Milestone (IM)*	*Nearest Stream Node Invert Elevation (feet MSL)*	*Distance from Well to Nearest Stream Node (ft)*	*MT Above or Below Nearest Stream Node*	*IM Above or Below Nearest Stream Node*
Stanislaus River						
Allen OID-01	75	61	86	7,162	below	below
Birnbaum OID-03	74	61	85	5,728	below	below
Marquis OID-10	86	78	78	5,783	above	above
Tuolumne River						
Quesenberry 223	89	72	67	4,205	above	above
MW-9	150	138	119	5,637	above	above

Along the Stanislaus River, the MT and 2027 IM elevations are both above the stream node invert elevation at Marquis OID-10. At Allen OID-01 and Birnbaum OID-03, both the MT and 2027 IM elevations are below the nearest stream node invert elevations. Allen OID-01 is approximately 7,200 feet from the Stanislaus River and has a 14-foot elevation change from the MT to the 2027 IM. Birnbaum OID-03 is approximately 5,700 feet from the Stanislaus River and has a 13-foot elevation change from the MT to the 2027 IM.

Along the Tuolumne River, the MT and 2027 IM elevations are both above the stream node invert elevations at both RMWs.

It is uncertain whether lowering groundwater levels 13 or 14 feet at two RMWs more than a mile from the Stanislaus River will significantly increase streamflow depletion. This will depend on local hydrogeology and river stage. The GSP recognizes groundwater conditions along the river boundaries as a data gap and this data gap will need to be filled to help answer this question. Furthermore, DWR plans to issue future guidance documents about interconnected surface water that may help the GSAs fill this data gap.

6.3.4. Measurable Objectives for Chronic Lowering of Groundwater Levels

GSP regulations define measurable objectives (MOs) as “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” (§351(s)). The MO is used to target desired groundwater conditions and provide a margin of operational flexibility above the MTs.

For chronic lowering of water levels, the MT represents a “floor” for maintenance of low water levels, with allowance for short-term exceedances by less than a third of representative monitoring wells during droughts (see **Table 6-5**). Accordingly, water levels will be managed generally between the MT and anticipated high water levels that occur during wet periods.

This operational range is represented by the midpoint between the MT and high water levels observed over average hydrologic conditions. Using the average hydrologic condition for the historical water budget study period of WY 1991 – WY 2015, the MO is defined as the midpoint between the selected MT and the high water level during that period (usually observed in 1998) for each representative monitoring location as summarized in the following table.

Table 6-10: Measurable Objectives for Chronic Lowering of Groundwater Levels

	Measurable Objectives	Principal Aquifer(s)
Chronic Lowering of Groundwater Levels	Measurable objectives are established as the midpoint between the historical high groundwater elevation and the MT at each representative monitoring location.	All

Each representative monitoring well is assigned a quantitative MO; these data are provided in **Chapter 7** (see **Table 7-1**).

Setting the MO at the midpoint between the MT and the high-water level results in a very small margin of operational flexibility for some western Subbasin wells screened in the Western Upper Principal Aquifer. In the far western areas of the Subbasin, water levels are shallow, and historical water levels have not fluctuated significantly. As a result, the MO is close to the MT; in some portions of the western Subbasin, there are only a few feet between the MO and the MT in representative monitoring wells. Setting the MO higher would not be consistent with the need to manage shallow groundwater such that existing agricultural land use can be preserved. MOs and MTs may require future adjustment to allow for more operational flexibility in the future.

It is also recognized that this methodology may be setting MOs higher than may be easily attained if ongoing drought conditions persist. At the time of preparation of this GSP, most years since the end of the historical study period (WY 2015) have been dry; these conditions may have reset the range of future expected high water levels in the Subbasin.

Nonetheless, this approach to MO selection provides a reasonable method to quantify desired groundwater conditions using best available data. Compliance with selected sustainable management criteria will be reported in GSP Annual Reports and revisited in the five-year GSP evaluation for possible adjustment as needed.

6.4. Reduction of Groundwater in Storage

SGMA defines an undesirable result for the groundwater in storage sustainability indicator as “significant and unreasonable reduction of groundwater storage.” (§10721 (x)(2)). GSP regulations require that the MT for the reduction of groundwater in storage be set as “a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results" (§354.28(c)(2)). This requirement contains almost identical language as the SGMA definition of sustainable yield.[6] In addition, regulations require the MT for this indicator to be supported specifically by the sustainable yield. The sustainable yield analysis for the Modesto Subbasin is presented in **Section 5.3** and discussed in the context of this indicator throughout the remaining subsections of **Section 6.4**, as well as throughout the remaining sections of **Chapter 6**.

Although the Modesto Subbasin is not at risk of depleting a large percentage of its total volume of groundwater supply, the ongoing depletion due to pumping larger volumes from the groundwater basin than can be reasonably replenished (overdraft conditions) requires mitigation to meet the Subbasin sustainability goal. As discussed in **Section 6.3**, the chronic lowering of groundwater levels in the Modesto Subbasin is caused primarily by overdraft conditions, illustrating the close relationship between these two indicators.

As explained in subsequent subsections, sustainable management criteria for chronic lowering of groundwater levels are used as a proxy for the reduction of groundwater in storage criteria. GSP regulations allow for use of groundwater elevations as a proxy metric when there is a significant correlation between groundwater levels and the metric for the other indicator (DWR, 2017). In this case, that metric is the volume of groundwater that can be extracted without causing undesirable results.

The definition of undesirable results for reduction of groundwater in storage, including causes and impacts to beneficial uses, is described in **Section 6.4.1** below, along with additional criteria to quantify where and when undesirable results occur. **Section 6.4.2** describes the selection and quantification of MTs, along with the justification and rationale. **Section 6.4.3** provides the approach and selection of MOs. Interim milestones that cover all of the applicable sustainability indicators are described in **Section 6.9**.

6.4.1. Undesirable Results for Reduction of Groundwater in Storage

As described in **Chapter 5**, the historical reduction of groundwater in storage is estimated at about 43,000 AFY (see **Table 5-8**). This reduction is primarily related to overdraft[7], which is determined to be unsustainable and thereby an undesirable result in this GSP.

Modeling analyses of projected future conditions indicate that historical overdraft conditions could potentially improve to about 11,000 AFY but would do so at the expense of significant streamflow depletion of the rivers along the Subbasin boundaries (compare net gains/discharges to streams from historical to projected conditions in **Table 5-8**). These

[6] SGMA defines sustainable yield as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." (§10721(w)).
[7] Other causes of reduction of groundwater in storage include net subsurface outflows or contributions to baseflow in rivers or streams.

increases in projected streamflow depletions have also been determined to be an undesirable result.

The causes of groundwater conditions that lead to undesirable results for the reduction of groundwater in storage are described below. Impacts to beneficial uses are also discussed.

6.4.1.1. Cause of Undesirable Results

In the Modesto Subbasin, the reduction of groundwater in storage is caused by over-pumping primarily in the NDE MA in the eastern Subbasin (**Figure 6-1**). In this area, surface water is generally not available, and groundwater has provided the primary supply for the expansion of irrigated agriculture and conversion to crops with higher water demand. Over-pumping has caused lowering of water levels in this area.

Because overdraft conditions cause chronic lowering of groundwater levels, overdraft contributes to all of the undesirable results associated with that indicator (**Section 6.3.1.1** and **6.3.1.3**). Overdraft also contributes directly to undesirable results for each of the remaining applicable sustainability indicators.

Ongoing overdraft conditions are expected to expand the area of low groundwater levels to the north and south beneath the Stanislaus and Tuolumne rivers, resulting in significant and unreasonable streamflow depletions and impacts to surface water uses (see **Section 6.8.1.1** and **6.8.1.3**). Overdraft conditions can lower water levels in areas where poorer groundwater quality occurs at depth and contribute to undesirable results for the degradation of water quality (see **Section 6.6.1.1** and **6.6.1.3**). Finally, overdraft conditions can also contribute to undesirable results for land subsidence if the lowering of water levels depressurize or dewater subsurface compressible clays. Where this occurs, significant amounts of land subsidence could be triggered and ultimately cause significant and unreasonable impacts to land uses and/or critical infrastructure – defined in this GSP as undesirable results (see **Section 6.7.1.1** and **6.7.1.3**)

6.4.1.2. Potential Effects on Beneficial Uses

The reduction of groundwater in storage causes lowering of water levels, which in turn, affects beneficial uses of groundwater and wells. As such potential effects on beneficial uses for reduction of groundwater in storage also includes the potential effects for chronic lowering of water levels as documented in **Sections 6.3.1.2** and **6.3.1.3**.

Recognizing that the volume of usable groundwater in the Modesto Subbasin is relatively large, and the base of freshwater is deep, a large groundwater supply would be accessible with sufficiently deep wells. However, the increased costs associated with installation and pumping lifts could ultimately place limits on beneficial uses of groundwater. With the large number of wells in the Subbasin, increased costs could be substantial and could also negatively impact land use and property interests.

Operating the Subbasin at significantly deeper levels also has the potential to pump groundwater with increased constituents of concern at depth. Deeper groundwater is often confined and subject to a geochemical environment that can impact the quality of drinking water supplies, increase public agency operational costs, and increase the potential for water quality impacts on water aesthetics such as odor or taste. Certain constituents, such as iron and manganese, can also cause impacts to groundwater conveyance pipes and fixtures. In addition, depth-related constituents can be associated with health effects if drinking water standards are exceeded (see also **Section 6.6.1.2**).

If overdraft contributes to land subsidence, beneficial users could experience adverse impacts to the physical ground surface, affecting surface operations, land uses, and potentially affecting property interests. Costs to repair or maintain infrastructure could increase; damage to roads or bridges may be associated with public safety concerns (see **Section 6.7.1.2**).

If overdraft results in inducing additional surface water from rivers, streamflow depletions could increase, potentially affecting all surface water beneficial uses including habitat, surface water rights holders, riparian vegetation, among others (see **Section 6.8.1.2**).

6.4.1.3. Modesto Subbasin Definition of Undesirable Results

Based on the information summarized above and supported in other chapters of this GSP, a definition of undesirable results has been developed for *Reduction of Groundwater in Storage* in the Modesto Subbasin.

Regulations require that the undesirable result definition include quantitative criteria used to define when and where groundwater conditions can cause an undesirable result (§354.26(b)(2)). These criteria address the number of monitoring sites and events that an MT can be exceeded before causing an undesirable result. These criteria recognize that a single MT exceedance at one monitoring site may not indicate an undesirable result. This framework also allows clear identification for when an undesirable result is triggered under the GSP. The undesirable result and associated criteria are provided in the following table.

Table 6-11: Undesirable Results for Reduction of Groundwater in Storage

	Undesirable Results Definition	Principal Aquifer(s)
Reduction of Groundwater in Storage	An undesirable result is defined as a significant and unreasonable reduction of groundwater in storage that would occur if the volume of groundwater supply is at risk of depletion and is not accessible for beneficial use, or if the Subbasin remains in a condition of long-term overdraft based on projected water use and average hydrologic conditions. An undesirable result will occur when at least 33% of representative monitoring wells exceed the MT for a principal aquifer in 3 consecutive Fall monitoring events.	All

The use of 33 percent of the representative monitoring wells is based on the chronic lowering of groundwater levels criteria as discussed in **Section 6.3.1.3**. The use of three Fall events for triggering undesirable results recognizes that short-term declines during drought are anticipated as long as reductions of groundwater in storage are eliminated over average hydrologic conditions. SGMA allows for reduction of groundwater in storage during droughts if water levels subsequently recover (see introductory paragraphs in **Section 6.3** above; see also **Section 6.3.1.3**).

The change in groundwater in storage is a required element for the GSP annual reports and will be documented annually in those reports over time. Over average hydrologic conditions, this element can be used to substantiate the correlation of overdraft conditions to the combination of MT exceedances for each principal aquifer as provided in the definition above.

The MTs selected for this indicator use MTs from the chronic lowering of water levels as a proxy, as presented in the following section.

6.4.2. Minimum Thresholds for Reduction of Groundwater in Storage

As indicated in the previous sections, reductions of groundwater in storage resulting from overdraft can be partially offset by inducing recharge from rivers (baseflow) or increasing subsurface inflows from other subbasins. Each of these can cause undesirable results relating to either streamflow depletions or adverse impacts to adjacent beneficial uses of groundwater. However, overdraft conditions can be corrected through projects and management actions such that undesirable results are avoided as demonstrated by an analysis of sustainable yield using the integrated surface water-groundwater model developed for the GSP (C2VSimFG-TM).

Under such an analysis – presented in **Section 5.3** – groundwater demand is reduced iteratively in areas of over-pumping until sustainable management criteria is met. The resulting sustainable yield for the Subbasin is used to inform and confirm the sustainable management criteria selected for the sustainability indicators. The sustainable yield is also used to guide locations and volumes required for projects and management actions.

For the Modesto Subbasin, the analysis estimated a sustainable yield of about 267,000 AFY (see the total volume of groundwater production in **Table 5-15**). Given that future projected groundwater production in the Subbasin has been estimated at 314,000, an increase in supply or reduction in demand that adds approximately 47,000 AFY is required to bring the Subbasin into sustainability.

The sustainable yield modeling analysis incorporated the sustainable management criteria for chronic lowering of water levels and was also shown to eliminate overdraft in the Subbasin over the 50-year implementation and planning horizon (**Section 5.3**; see **Figure 5-58**). Accordingly, both the chronic lowering of water levels criteria and elimination of overdraft are correlated to the sustainable yield of 267,000 AFY. This volume can be applied as a metric for reduction of groundwater in storage and linked directly to management criteria for the chronic lowering of groundwater levels indicator.

In this manner, the selection of a volume as the required metric for the reduction of groundwater in storage indicator is met (i.e., 267,000), and justification is provided by the sustainable yield modeling that the chronic lowering of water levels criteria can be applied as a proxy for the reduction of groundwater in storage sustainability indicator.

Table 6-12: Minimum Thresholds for Reduction of Groundwater in Storage

	Minimum Thresholds	Principal Aquifer(s)
Reduction of Groundwater in Storage	Minimum thresholds are defined as the historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data. (Chronic Lowering of Groundwater Levels MT as a proxy.)	All

It is recognized that sustainable yield is not a fixed number and will vary over time with changes in land use, hydrologic conditions, and GSP implementation of projects and management actions. Nonetheless, this sustainable yield represents the current best available estimate to use as a required metric for the MT of this indicator.

6.4.2.1. Justification and Support for Minimum Thresholds

In the BMP on sustainable management criteria, DWR lists several technical topics to consider when selecting an MT for reduction of groundwater in storage. Those considerations, along with a summary of relevant information from the basin setting (and other related portions of the GSP), are provided below:

- Historical trends, water year types, and projected water use: In the Modesto Subbasin the historical conditions of overdraft were analyzed annually over a 25-year period and summarized for conditions in each of the management areas. As indicated on **Figure 5-3**, 17 of the 25 years experienced a net reduction of groundwater in storage, primarily due to overdraft. As indicated in **Table 5-9**, this imbalance even occurred in water year types of above normal precipitation. As indicated on **Figure 5-16**, much of this imbalance occurs in the NDE MA where annual water budgets indicated a new extraction from groundwater in storage in this area. Specifically, only 3 of the 25 years indicate more recharge than extraction in the NDE MA. Net extractions occurred in the NDE MA during every year since 1991. Water level declines described in **Section 6.3.2.1** support the water budget analysis in the NDE MA (see also **Figure 3-25**).

Projected water budgets are shown annually for the 25-year period on **Figure 5-40** and confirm the continuation of overdraft conditions into the future. As indicated in the discussion on sustainable yield above, the avoidance of undesirable results estimated over-pumping of about 47,000 AFY, primarily in the NDE MA, as compared to the projected future water use in the Subbasin (see **Table 5-15**).

- Groundwater reserves needed to withstand future droughts: During recent drought conditions from WY 2013 through WY 2020, groundwater declines in the Subbasin were observed to range from less than 10 feet in the western Modesto ID MA to more than 40 feet in some areas of the NDE MA (see **Figures 3-21** through **3-25**). With about 13 MAF of fresh groundwater in storage to depths of more than 1,000 feet in some areas, groundwater reserves will be available to meet future demands under sustainable yield conditions.

- Whether production wells have ever gone dry: As described in **Section 2.3.2**, more than 150 domestic wells failed during the 2014 – 2016 drought of record. Additional adverse impacts to public supply wells related to water level declines were also documented (see **Section 6.3.1.1** and **Table 6-2** above). Since that time, well impacts appear to have been mitigated with the installation of more than 200 new and typically deeper domestic wells. Accordingly, the MTs are set at historical low groundwater levels and projects and management actions have been developed to avoid widespread well failures in the future (see **Chapter 8**).

- Effective storage of the basin: As mentioned previously, the Subbasin contains more than about 13 MAF of fresh groundwater in storage and overall depletion of groundwater supply is unlikely (**Section 3.2.4**. **Figure 3-18** illustrates the thickness of fresh groundwater in storage (between current groundwater level and the base of freshwater) across the Subbasin.

- Understanding of well construction and potential impacts to pumping costs: Well construction was considered in adverse impacts to public water supply wells summarized in **Section 6.3.1.3** above. Most of those wells were sufficiently deep for water supply during the 2015 drought; however, adverse impacts associated with declining water levels were documented (**Section 6.3.1.** and **Table 6-2**). By setting MTs close to current levels, existing Subbasin wells are supported.

- Adjacent Subbasin MTs: MTs for chronic lowering of groundwater levels are compared to and analyzed for each adjacent subbasin in **Sections 6.3.2.3.1** through **6.3.2.3.3** above. The Modesto Subbasin and all adjacent subbasins are using these

MTs as a proxy for the reduction of groundwater in storage indicator; accordingly, those analyses apply to both indicators.

6.4.2.2. Relationship between MTs of Each Sustainability Indicator

Regulations require a description of the relationship between the MTs for each sustainability indicator and how the GSAs have determined that basin conditions for each MT will avoid undesirable results (§354.28(b)(2)). As previously discussed, the MTs for each sustainability indicator are summarized in **Table 6-5** and discussed in **Section 6.3.2.2**.

Section 6.3.2.2 also describes the relationship between the MT for chronic lowering of water levels and the MTs for each of the remaining sustainability indicators. Because the MTs for reduction of groundwater in storage are the same as the MTs for chronic lowering of water levels, that discussion would be identical for the reduction of groundwater in storage. As such, please refer to **Section 6.3.2.2** for this required component of the GSP.

6.4.2.3. Impacts of MTs on Adjacent Subbasins

Regulations require consideration of how Modesto Subbasin MTs impact the ability of an adjacent subbasin to achieve its sustainability goal. For the reduction of groundwater in storage sustainability indicator, all three adjacent subbasins – the ESJ Subbasin, the Delta-Mendota Subbasin and the Turlock Subbasin – are also using the MTs for the chronic lowering of groundwater levels as a proxy. Therefore, the considerations of how Modesto Subbasin MTs impact adjacent subbasin MTs are already analyzed for this sustainability indicator through the proxy. As such, please refer to **Section 6.3.2.3** for this required component of the GSP (see **Sections 6.3.2.3.1** through **6.3.2.3.3** on each of the three adjacent subbasins).

6.4.2.4. Effects of MTs on Beneficial Uses and Users of Groundwater

Benefits of these MTs on the beneficial uses and users of groundwater provide a balanced groundwater basin and eliminate overdraft conditions. As such, groundwater level declines are generally arrested. Long term benefits include a more sustainable groundwater supply for all beneficial uses, including municipal, industrial, domestic, agricultural, and environmental uses.

The effects of these conditions on beneficial uses and users of groundwater are similar to those stated for the chronic lowering of groundwater levels; as such, please refer to **Section 6.3.2.4** for this required component of the GSP.

6.4.2.5. Consideration of State, Federal, or Local Standards in MT Selection

GSP regulations require that GSAs consider how the selection of MTs might differ from other regulatory standards. For the reduction of groundwater in storage indicator, the MT consists of quantified water levels in each representative monitoring well. Accordingly, there are no conflicts with regard to other regulatory standards.

6.4.2.6. Quantitative Measurement of Minimum Thresholds

As stated above, the MTs for the chronic lowering of groundwater levels are used as a proxy for monitoring reduction of groundwater in storage. Accordingly, the representative monitoring network, along with individual MTs and MOs, for chronic lowering of water levels are also applied to the reduction of groundwater in storage indicator.

MTs will be monitored by quantitatively measuring water levels in representative monitoring wells for each principal aquifer as described in **Chapter 7** (Monitoring Network – see **Section 7.1.2**). Monitoring will occur on a semi-annual basis, in Spring and Fall, to represent the seasonal high and low water level and adhere to water level sampling protocols (**Section 7.2.4**). **Table 7-1** provides the quantitative MTs for each representative monitoring well used to monitor both chronic lowering of groundwater levels and reduction of groundwater in storage. Representative monitoring wells for both indicators are shown on **Figures 7-1** through **7-3**.

6.4.3. Interim Milestones for Reduction of Groundwater in Storage

As described previously, the chronic lowering of water levels criteria are applied as a proxy for the reduction of groundwater in storage sustainability indicator. By extension, the interim milestones for chronic lowering of water levels are used as a proxy for the reduction in groundwater in storage sustainability indicator.

6.4.4. Measurable Objectives for Reduction of Groundwater in Storage

In the same manner that the MTs for chronic lowering of groundwater levels are used as a proxy for the reduction in groundwater in storage, the same MOs are also applied to this indicator, as provided in the following table.

Table 6-13: Measurable Objectives for Reduction of Groundwater in Storage

	Measurable Objectives	Principal Aquifer(s)
Reduction of Groundwater in Storage	Measurable objectives are established at the midpoint between the historical high groundwater elevation and the MT at each representative monitoring location. (Using Chronic Lowering of Groundwater Levels as a proxy).	All

Even though GSP regulations note that reduction in groundwater in storage is controlled by a single value for the Subbasin (in this case, 267,000 AFY), the management of that single value is manifested by applying chronic lowering of water levels criteria as a proxy for reduction of groundwater in storage including both the MTs and MOs at the same representative monitoring wells. MOs are listed for representative monitoring wells on **Table 7-1** for chronic lowering of groundwater levels, which are used as a proxy for reduction of groundwater in storage.

6.5. SEAWATER INTRUSION

GSP regulations define *Seawater Intrusion* as “the advancement of seawater into a groundwater supply that results in degradation of water quality in the basin and includes seawater from any source.” The minimum threshold for the indicator “sh*all be defined by a chloride concentration isocontour*…where seawater intrusion may lead to undesirable results.” Further, the seawater intrusion minimum threshold must consider the effects of “*current and projected sea levels*” (§354.28 (c)(3) *emphasis added*).

Typically, these conditions would occur in a coastal groundwater basin where aquifers are in hydraulic communication with the open ocean, either directly or indirectly by interconnected waterways such as bays, deltas, or inlets. As an inland basin, the Modesto Subbasin is not directly or indirectly connected to the open ocean. The Subbasin aquifers are separated from the Pacific Ocean by the bedrock units of the Coast Ranges; further Subbasin aquifers are more than 10 miles upgradient from the edge of the Sacramento-San Joaquin Delta and not influenced by deltaic seawater intrusion. GSAs in the Eastern San Joaquin Subbasin to the north have determined that seawater is not occurring nor is likely to occur in that subbasin, even though elevated salinity has been encountered in groundwater and the subbasin is closer the Sacramento-San Joaquin Delta. Elevated salinity conditions do not exist in the Modesto Subbasin such that a chloride concentration isocontour could be developed and used for the MT as required by the regulations.

GSP regulations state that if GSAs are “able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur…” then sustainable management criteria are not required to be established (§354.26 (d)). To assess the applicability of the seawater intrusion indicator to the Modesto Subbasin, the technical team provided both a public presentation to the TAC (January 2021) as well as a technical memorandum on the issues (March 23, 2021). At a public meeting of the STRGBA GSA on April 14, 2021, the GSAs made the determination “that seawater intrusion does not exist and is not likely to occur in the future, and therefore a seawater intrusion sustainability indicator is not applicable in the Modesto Subbasin (Resolution 2021-2).

6.6. DEGRADATION OF WATER QUALITY

Degraded water quality is unique among the sustainability indicators in that other regulatory agencies have the primary responsibility for groundwater quality. SGMA does not authorize or mandate GSAs to duplicate these efforts. The GSAs are not responsible for enforcing drinking water requirements or for remediating groundwater quality problems caused by others (Moran and Belin, 2019). Similar to the other sustainability indicators, GSAs are not required to correct degraded water quality that occurred before January 1, 2015. Further, the existing regulatory framework does not require the GSAs to take affirmative actions to manage existing groundwater quality.

However, SGMA does give the GSAs the authority to regulate groundwater extractions and groundwater levels. In addition, GSAs are responsible for development and implementation of projects and management actions to bring the Subbasin into sustainable groundwater conditions. Given these authorities, GSA activities have the potential to impact groundwater quality; this GSP focuses on avoidance of these potential impacts.

- To protect against GSA impacts to water quality in the future, the GSAs intend to:
- track water quality annually through existing monitoring programs,
- assess the potential for GSA impacts to water quality, and
- confer and coordinate with other regulatory water quality agencies and regulated water quality coalitions in the Subbasin to ensure ongoing protection groundwater quality in the Subbasin.

Because most of the public drinking water suppliers in the Modesto Subbasin are also member agencies of the GSAs, there is already close coordination between water quality regulators and GSA members including the cities of Modesto, Riverbank, Oakdale, and Waterford.

The undesirable results associated with degraded water quality, including causes and impacts to beneficial uses, are described in **Section 6.6.1** below. **Section 6.6.2** describes the quantification of minimum thresholds (MTS), along with justification on how MTs avoid undesirable results. **Section 6.6.3** provides the approach and selection of MOs. Interim milestones (IMs) are described in **Section 6.9** but are not set for this sustainability indicator.

6.6.1. Undesirable Results for Degraded Groundwater Quality

SGMA defines an undesirable result for the water quality sustainability indicator as "significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies." (§10721 (x)(4)). GSP guidance clarifies that GSAs are only responsible for degraded water quality caused by GSA management activities including regulation of pumping and water levels, along with projects and management actions (Moran and Belin, 2019). Such GSA activities that could lead to undesirable results are described in more detail below.

6.6.1.1. Causes of Undesirable Results

GSA management could potentially affect groundwater quality in several ways. GSAs could allow groundwater level declines in areas where poorer quality groundwater occurs at depth. In those areas, groundwater quality in water supply wells could be adversely impacted. In addition, GSA-allowed groundwater extractions could alter hydraulic gradients and local groundwater flow directions such that degraded water quality could spread laterally into un-impacted areas. Groundwater pumping can also induce the vertical migration of constituents of concern into un-impacted deeper aquifers.

High salinity groundwater is inferred to exist in the Modesto Subbasin below the base of fresh water. Although the base of fresh water is designated as the bottom of the groundwater basin, deep pumping could induce groundwater with elevated total dissolved solids (TDS) to migrate vertically into a well and/or into the freshwater zone of the aquifer. These actions could locally impair water supply and potentially reduce the amount of freshwater in the Subbasin. Deep wells that pump elevated concentrations of constituents of concern may also need to be abandoned to prevent conduits for migration of low quality groundwater.

GSP-related projects and management actions also have the potential to impact groundwater quality. For example, recharge projects could introduce water with constituents of concern or affect the migration of existing constituents. GSP regulations specifically require consideration of whether projects or management actions could inadvertently exacerbate the migration of contaminant plumes.

In the Modesto Subbasin, public water suppliers have noted some deterioration in water quality during recent drought conditions, especially constituents of concern arsenic and TDS; these observations suggest that concentrations of these constituents may be elevated at depth. However, nitrate, which is sourced from the surface has also increased in many areas, perhaps in wells with deeper screens that now pull from shallower, nitrate-impacted groundwater. The City of Modesto has conducted numerous investigations of water quality issues in their wellfields and notes that correlations between constituent concentration and depth are complex.

Degraded water quality can impair groundwater supplies, causing restrictions and/or costs for operation of drinking water supply wells. Increasing costs to provide a reliable and safe drinking water supply could lead to undesirable results. Costs and impacts for domestic wells are also a concern because those wells often represent the sole water supply for the household. Impacts to other beneficial uses other than drinking water supply could also lead to undesirable results. Certain constituents can harm crops, limit water supply for certain industrial processes, harm pipes, cause accelerated corrosion or clogging of fixtures, cause staining on bathtubs and sinks, produce bad taste or odor, and cause acute or chronic health effects.

In the Modesto Subbasin, seven constituents of concern have been identified as having the most likely potential for causing undesirable results based on widespread exceedances of MCLs and adverse impacts on public water suppliers in the Subbasin. Those constituents have been of most concern to STRGBA GSA member agencies as documented in a July 2019 public workshop on Subbasin water quality.

The constituents of concern are associated with a variety of sources including both naturally occurring (geogenic) conditions and human related (anthropogenic) activities. The naturally occurring constituents of concern may be elevated at certain depths or in certain aquifer layers and may be of most use in tracking impacts from GSA management of groundwater levels.

The anthropogenic constituents of concern, including nitrate, TCP and PCE (and some sources of TDS), are likely sourced at or near the ground surface where human-related activities occur. This suggests that shallow aquifers are more often impacted from these constituents. However, pumping can cause downward migration of these constituents into deeper aquifers either through more permeable portions of an aquitard or in conduits such as wells.

GSA management activities that cause degraded water quality and lead to significant operations costs and impaired groundwater supply are incorporated into the GSP definition of undesirable results. Specific impacts on beneficial users of groundwater from these conditions are summarized below.

6.6.1.2. Potential Effects on Beneficial Uses

As summarized above, degraded water quality can impair water supply and create considerable operational costs or constraints on public water suppliers. Public water suppliers may need to inactivate or abandon impacted wells, re-distribute wellfield pumping, blend contaminants with clean wells or surface water, drill additional wells, install wellhead or regional treatment facilities, and/or make other operational changes. Immediate notifications to customers may also be required.

If constituents of concern impact domestic wells, residents may lose their water supply; if water quality is not well known in domestic wells, impacts to public health and safety could occur. Agricultural and industrial uses of groundwater could also be adversely impacted as summarized in the previous section. Finally, environmental beneficial uses of groundwater could be impacted; for example, if pumping caused the migration of high salinity groundwater into freshwater areas, GDEs could be affected.

For the Modesto Subbasin, six of the seven constituents of concern have primary maximum contaminant levels (MCLs) that are associated with health concerns such as toxicity (i.e., nitrate, uranium) or carcinogens (i.e., arsenic, TCP, DBCP, and PCE). Accordingly, elevated concentrations of these constituents in drinking water can cause deleterious health effects. Wellhead treatment has been installed on numerous drinking water supply wells to manage these constituents. In particular, the City of Modesto has removed numerous water supply wells from service over time to manage local water quality issues (as indicated by the water quality icon on **Figure 6-1**). Constituents with concentrations above the health-based MCLs significantly affect operations and costs for public water suppliers to ensure a safe drinking water supply.

The regulatory drinking water standard for TDS is not health based and is referred to as a secondary MCL, which is related to aesthetics of the water such as taste or odor. However, public water suppliers incur costs for managing TDS concentrations to provide low salinity groundwater for customer satisfaction. In addition, elevated TDS concentrations in groundwater can also impact agricultural beneficial users by limiting crop yields and causing other operational problems. TDS can also limit industrial beneficial uses for industrial processes requiring low salinity water.

6.6.1.3. Modesto Subbasin Definition of Undesirable Results

Based on the information summarized above and presented in the basin setting, a definition for undesirable results has been developed for degraded water quality in the Modesto Subbasin. Regulations also require that the undesirable result definition include quantitative criteria used to define when and where groundwater conditions can cause an undesirable result (§354.26(b)(2)). This framework allows clear identification for when an undesirable result is triggered under the GSP; definition and criteria are provided below.

Table 6-14: Undesirable Results for Degraded Water Quality

	Undesirable Results Definition	Principal Aquifer(s)
Degraded Water Quality	An Undesirable Result is defined as significant and unreasonable adverse impacts to groundwater quality as indicated by a new (first-time) exceedance of, or further exceedance from, an MCL for a constituent of concern that is caused by GSA projects, management actions, or management of groundwater levels or extractions such that beneficial uses are affected and well owners experience an increase in operational costs. An undesirable result will occur when a Subbasin potable water supply well in the defined monitoring network reports a new (first-time) exceedance of an MT or an increase in concentration above the MT for a Modesto Subbasin constituent of concern that results in increased operational costs and is caused by GSA management activities as listed above.	All

The undesirable result is highly protective in that it requires analysis of every first-time exceedance of an MT or an increase above the MCL of an MT for any of the seven constituents of concern in each potable supply well monitored for that constituent. These criteria ensure that all key data are analyzed with respect to GSA activities. The GSAs will conduct this analysis on an annual basis.

To accomplish this annual analysis, historical data for each potable water supply well in the network must be reviewed on an annual basis to determine if the constituent has been exceeded in that well in the past. Each new (i.e., first-time) exceedance or increase in concentration above the MT – occurring after GSP adoption – must be tracked and analyzed separately to determine if such a concentration could have been caused by GSA regulated groundwater levels, extractions, or projects/management actions, and if additional operational costs are incurred by the well owner. If so, the concentration represents an undesirable result by definition.

This analysis will consider the recent groundwater elevations and extractions near each impacted well. Data will be analyzed in the context of the historical record to establish correlations between groundwater levels, monitoring well locations and construction, and water quality analyses. Changes in water levels and water quality in nearby wells will be incorporated into the analysis. Each constituent of concern will be analyzed using information on sources, historical records of nearby and regional wells, and occurrence/concentrations with respect to the principal aquifer and well screens.

Increases in concentration will also be tracked to comply with the MO described in **Section 6.6.3** below. Hydrographs and chemographs will be used to support the analyses, as needed. Analyses will be coordinated with local public agencies providing drinking water supply including member agencies of the GSAs. Data and analyses will be summarized in annual reports and coordinated with the regulatory agencies responsible for water quality. Any undesirable results will be identified, and GSAs will coordinate with regulatory agencies on options and mitigation measures for water quality impacts.

The MTs are quantified in the following section. The MOs are quantified in subsequent **Section 6.6.3**.

6.6.2. Minimum Thresholds for Degraded Water Quality

GSP regulations require that the MT metric for degraded water quality be set at the water quality measurement that indicates degradation at the monitoring site (DWR, 2017). Regulations also require the consideration of state and federal standards and Basin Plan water quality objectives when setting the MT.

The seven constituents of concern have already exceeded MCLs over a relatively widespread area in Subbasin principal aquifers. Accordingly, MCLs (including primary and secondary MCLs) are set as the MTs and are expressed as follows.

Table 6-15: Minimum Thresholds for Degraded Water Quality

	Minimum Thresholds	Principal Aquifer(s)
Degraded Water Quality	Minimum thresholds are set as the primary or secondary California maximum contaminant level (MCL) for each of seven (7) constituents of concern: • Nitrate (as N) - 10 mg/L • Arsenic - 10 ug/L • Uranium - 20 pCi/L • Total dissolved solids (TDS) - 500 mg/L • Dibromochloropropane (DBCP) - 0.2 ug/L • 1,2,3-Trichloropropane (TCP) - 0.005 ug/L • Tetrachloroethene (PCE) - 5 ug/L.	All

6.6.2.1. Justification and Support for Minimum Thresholds

Analysis of existing groundwater quality conditions in the Modesto Subbasin is provided in **Section 3.2.5 as** part of the basin setting. As explained in the text, the analysis included potential constituents of concern based on a review of the water quality database, local knowledge of constituents of concern from previous studies, and identified by GSA member agencies and stakeholders at a public TAC meeting in July 2019. Public water suppliers, including the City of Modesto, shared information on constituents of concern that have been identified in their drinking water wells over the historical study period. Other GSA members identified other potential constituents of concern that had been the target of several ongoing water quality programs including the Irrigated Lands Regulatory Program (ILRP) and Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS).

As presented in **Section 3.2.5**, data for these potential constituents of concern were analyzed over a 25-year study period based on available data. Analyses included development and posting of average and recent water quality data on Subbasin maps, along with various statistical analyses for concentration distribution, temporal trends and occurrence by principal aquifers (when known) (see **Tables 3-4**, **3-5**, and **3-6**).

Based on these analyses seven constituents of concern were selected for assignment of an MT and further characterization on an annual basis based on elevated concentrations over a relatively widespread area of the Subbasin. These constituents have been the most difficult to manage according to public water suppliers. The constituents also include a variety of sources and occurrences across the Subbasin to provide a more comprehensive tracking of groundwater quality. Specifically, the constituents include:

- naturally occurring constituents (arsenic, uranium, TDS)
- special constituents with widespread areas of multiple non-point sources (nitrate, TCP, DBCP)
- constituents associated with industrial point sources and environmental investigations (PCE).

Data were evaluated for all three principal aquifers in the Subbasin because all are used for drinking water supply. The City of Modesto is the largest drinking water supplier and has wells in all three principal aquifers. The cities of Riverbank, Oakdale, and Waterford have municipal supply wells in the Eastern Principal Aquifer (see **Figure 2-13**). In addition to these providers, more than 75 smaller water systems scattered throughout the Subbasin also have wells in each of the principal aquifers. Numerous domestic wells also occur in both western and eastern principal aquifers. However, very few wells or drinking water systems are located in the eastern third of the Subbasin, (i.e., generally east of Waterford and Oakdale. See **Figures 2-10, 2-13**, **2-14**, and **6-1**).

Summary information is provided below on the seven constituents of concern assigned an MT; more detailed information is provided in **Section 3.2.5.3** including statistical analyses and temporal trends over a 25-year study period (1995 through 2019) and numerous water quality distribution maps on **Figures 3-35** through **3-52**.

6.6.2.1.1. Nitrate

Nitrate is the most widespread constituent of concern in both the California Central Valley and the Modesto Subbasin (see **Section 3.2.5**). Because of its serious health effects, the MCL of 10 mg/L of nitrate as N is selected as the MT. Sources, median and maximum concentrations, and occurrence of nitrate in Modesto Subbasin groundwater are described in **Section 3.2.5.3** and shown on **Figures 3-35** and **3-36**. Elevated nitrate concentrations are detected in all principal aquifers, including the confined Western Lower Principal Aquifer below the Corcoran Clay. Nitrate concentrations have exhibited a slightly increasing trend over the 25-year study period.

The widespread occurrence of nitrogen in California's Central Valley is being regulated by the Central Valley RWQCB under several programs (in addition to individual site regulatory orders). Those programs include the General Dairy Order (Dairy Order), the ILRP, and CV-SALTS. Nitrate concentrations in domestic wells are being mitigated through the Nitrate Control Program, which involves management areas with mandates to provide safe drinking water to impacted well owners (**Section 2.4.4**).

6.6.2.1.2. Arsenic

Arsenic is a naturally occurring trace element in the rocks, soils, and groundwater of the Modesto Subbasin. Given its toxicity, the MT has been set at the arsenic MCL of 10 micrograms per liter (µg/L). Other water quality investigations have indicated that arsenic concentrations are higher in older and deeper groundwater samples (see **Section 3.2.5.3**). Although elevated arsenic has been detected in all principal aquifers, average concentrations are much higher in the Western Upper Principal Aquifer and Wester Lower Principal Aquifer than in the Eastern Principal Aquifer. Arsenic concentrations appear to be decreasing in Subbasin wells over the 25-year study period. Additional information on the occurrence and concentrations of arsenic in Modesto Subbasin groundwater is included in **Section 3.2.5.3** and shown on **Figures 3-39** and **3-40**.

6.6.2.1.3. Uranium

Uranium is another naturally occurring trace element largely derived from granitic rocks in the Sierra Nevada. It is toxic and associated with health effects; the MT is set at the MCL of 20 picocuries per liter (pCi/L). Uranium has been detected at or above the MCL in shallow and intermediate depth wells in the City of Modesto wellfield; about nine wells have been taken offline due to elevated uranium concentrations. In general, concentrations of uranium are higher in the Western Upper Principal Aquifer compared to the other two aquifers. This occurrence is consistent with the geochemical conditions that lead to mobilization of uranium in the aquifers (**Section 3.2.5.3**). Over the 25-year study period, uranium concentrations have exhibited an increasing trend in Modesto Subbasin groundwater. Additional information on the occurrence and concentrations of uranium is included in **Section 3.2.5.3** and shown on **Figures 3-41** and **3-42**.

6.6.2.1.4. Total Dissolved Solids

TDS represents the total concentration of anions and cations in groundwater and is a useful indicator of mineralization, salt content, and overall groundwater quality. TDS generally meets drinking water standards in the Subbasin with only 14 percent of the TDS samples exceeding the upper limit California Secondary MCL of 1,000 mg/L. Most samples also meet the MT recommended secondary MCL for drinking water of 500 mg/L. The lower secondary MCL is used as the MT to address recommended concentrations for both drinking water and irrigation of some Modesto Subbasin crops (see **Section 3.2.5.3**) and to provide for a more protective water quality analysis.

Average and recent concentrations of TDS in groundwater samples are provided on **Figures 3-37** and **3-38**, respectively. As indicated on the maps, TDS concentrations are generally lowest in the central Subbasin, especially in the urban areas around Modesto, Oakdale, Riverbank, and Waterford. Elevated concentrations occur in the western Subbasin (in the San Joaquin National Wildlife Refuge) and in southwest Modesto.

Even though elevated TDS is inferred to occur in deeper portions of the Subbasin (below the base of freshwater), the statistical analysis in **Section 3.2.5.3** indicates that the highest TDS concentrations have been observed in the Western Upper Principal Aquifer (i.e., in the western Subbasin as indicated above). However, these high concentrations were not necessarily widespread and may indicate local point sources of TDS, especially near the San Joaquin River.

Additional information on the occurrence and concentrations of TDS in Modesto Subbasin groundwater is included in **Section 3.2.5.3** and shown on **Figures 3-37** and **3-38**.

6.6.2.1.5. 1,2,3-Trichloropropane (TCP)

TCP is a manufactured chlorinated hydrocarbon used for degreasing and previously associated with soil fumigants, which were widely used in agriculture through most of the 1980s. The chemical was banned in the 1990s. The MT is set at the MCL of 0.005 µg/L, which was only recently established (effective 2018). As a result, historical data for TCP in groundwater are sparse.

Elevated TCP concentrations have been detected in mostly urban areas, including Modesto, Riverbank, and Waterford, likely due to the increased sampling in drinking water supply wells. Even though TCP has been associated with relatively widespread application throughout the Central Valley, elevated concentrations are relatively sparse and localized in the Modesto Subbasin. This may indicate a lack of historical use in the Subbasin with just a few local point sources indicated. Elevated concentrations have not been detected in the Western Lower Principal Aquifer, indicating a surficial source and local protection against vertical migration by the Corcoran Clay.

Additional information on the occurrence and concentrations of TCP in Modesto Subbasin groundwater is included in **Section 3.2.5.3** and shown on **Figures 3-49** and **3-50**.

6.6.2.1.6. Dibromochloropropane (DBCP)

DBCP was a widely used pesticide (nematocide and soil fumigant) in the Central Valley prior to being banned in the late 1970s.Due to its mobility and toxicity, the MT is set at the MCL of 0.2 ug/L.

Concentrations are relatively low in the Modesto Subbasin with about 14 percent of the samples from the historical database exceeding the MCL. Similar to TCP, DBCP has not been detected in the Western Lower Principal Aquifer. In addition, data indicate a declining trend of concentrations over time, likely due to its long-term ban. Additional information on the occurrence and concentrations of DBCP in Modesto Subbasin groundwater is included in **Section 3.2.5.3** and shown on **Figures 3-47** and **3-48**.

6.6.2.1.7. Tetrachloroethene (PCE)

PCE is a volatile organic compound (VOC) developed as an industrial solvent. PCE has been widely used in a variety of industrial applications including as a dry cleaning fluid. Discharges from a number of dry cleaners in the City of Modesto have resulted in local contaminant plumes of PCE, all of which are being managed by other local regulatory agencies responsible for water quality. PCE has also been detected at Modesto Subbasin landfills and other sites under regulatory investigations and remediation. At least seven City of Modesto wells have installed wellhead treatment systems for managing PCE impacts. The MT is set at the California and Federal MCL of 5 ug/L.

Elevated concentrations of PCE are generally associated with point sources of the contaminant including industrial and commercial sites. Similar to TCP and DBCP, PCE has not been detected in the Western Lower Principal Aquifer, indicating surficial sources and protection by the Corcoran Clay.

Additional information on the occurrence and concentrations of PCE in Modesto Subbasin groundwater is included in **Section 3.2.5.3** and shown on **Figures 3-51** and **3-52**.

6.6.2.2. Relationship between MTs of Each Sustainability Indicator

Regulations require a description of the relationship between the MTs for each sustainability indicator and how the GSAs have determined that basin conditions at each MT will avoid undesirable results (§354.28(b)(2)). To facilitate a comparison between MTs, a summary of MTs for each sustainability indicator was provided in **Table 6-5** and discussed previously in **Section 6.3.2.2**.

As provided in **Section 6.3.2.2**, the MCLs for each constituent of concern – selected as the MTs – would not interfere with the MTs for the other sustainability indicators. All other MTs consist of groundwater elevations that are at or above the historic low water in the Subbasin. As such, the groundwater level MTs are protective against increases in constituents of concern that occur primarily at depth. Further, because these groundwater level MTs are similar to recent water levels across the Subbasin, hydraulic gradients would not be altered substantially that might cause migration of constituents into previously un-impacted areas.

In this manner, the MTs for the other sustainability indicators are supportive of the MTs for degraded water quality and cause no conflicts for groundwater management. The constituents will be tracked on an annual basis and analyzed with respect to changes in groundwater levels and extractions to determine if GSA management activities might be impacting groundwater quality.

GSA member agencies have already been coordinating with regulatory agencies responsible for drinking water quality in the Subbasin. In addition, these agencies are actively engaged with regulated water quality coalitions that have ongoing monitoring programs for certain Modesto Subbasin constituents of concern including the Nitrate Control Program and CV-Salts. Representatives from the Valley Water Collaborative – a coalition responsible for implementing the Nitrate Control Program (NCP) – provided a presentation at a public TAC meeting in December 2020. Many Subbasin landowners are directly participating in the NCP, providing additional opportunities for coordination.

Finally, as previously stated, multiple GSA member agencies are responsible for drinking water quality and routinely coordinate with water quality regulatory agencies. Because the drinking water standard (MCLs) are the target for both the water quality coalitions mentioned above and the water quality regulatory agencies, the selection of the MCLs as the MTs is consistent with other water quality programs. In this manner, the GSAs have determined that the MTs will avoid undesirable results.

6.6.2.3. Impacts of MTs on Adjacent Subbasins

Regulations require consideration of how Modesto Subbasin MTs impact the ability of an adjacent subbasin to achieve its sustainability goal. As summarized in more detail in **Section 6.3.2.3**, similar principal aquifers, shared interconnected surface water boundaries, and multiple GSA member agencies that overlap both the Modesto Subbasin and adjacent subbasins have facilitated setting MTs in the Modesto Subbasin that will not adversely impact adjacent subbasins GSP implementation.

Additional water quality considerations for MTs in each adjacent subbasin are summarized below.

6.6.2.3.1. Eastern San Joaquin Subbasin

The MT for degraded water quality in the ESJ Subbasin is defined as a TDS concentration of 1,000 mg/L TDS in representative monitoring wells, none of which occur along the shared subbasin boundary with the Modesto Subbasin. Rather, water quality monitoring is focused along the western rim of the ESJ Subbasin where TDS concentrations are of most concern in the ESJ Subbasin. The closest water quality monitoring well more than six miles north of the Modesto Subbasin. In addition, MTs for interconnected surface water, set at 2015 groundwater elevations along the Stanislaus River, are set similarly in both subbasins. Finally, water budget analyses for sustainable yield conditions indicate that subsurface flow is relatively small and occurs from the ESJ Subbasin into the Modesto Subbasin. Therefore, MTs in the Modesto Subbasin are not expected to conflict or affect the MTs in the ESJ Subbasin.

6.6.2.3.2. Delta-Mendota Subbasin

The Delta-Mendota Northern & Central GSP focused on constituents that are linked to groundwater elevations or other groundwater-management activities. Undesirable results are to be triggered if TDS, nitrate, or boron exceed the MCL or water quality objectives (WQOs) in three consecutive sampling events in non-drought years or additional degradation where current groundwater quality already exceeds the MCLs or WQOs. An undesirable result would also occur if a recharge project exceeded 20 percent of the aquifer's assimilative capacity without justification of a greater public benefit.

MTs were set at each monitoring site based on these criteria. As indicated in the GSP, there are no representative monitoring sites adjacent to the shared river boundary with the Modesto Subbasin (see the Delta-Mendota representative monitoring wells for degraded water quality on Figures 6-4 and 6-5 in W&C and P&P, 2019). The closest monitoring wells are 06-004 in the Upper Aquifer and 0-003 in the Lower Aquifer, located about three miles to the southwest of the southwestern corner of the Modesto Subbasin.

At those wells, the MTs for TDS are 4,000 mg/L and 2,000 mg/L for the Upper Aquifer and Lower Aquifer, respectively. The MTs for nitrate (as N) are 80 mg/L and 50 mg/L for the Upper Aquifer and Lower Aquifer, respectively. These MTs are much higher than the MCLs established for the MTs in the Modesto Subbasin. In addition, the closest monitoring wells are upgradient and would not be impacted by any degraded groundwater quality in the Modesto Subbasin.

In addition, water budget analyses indicate a net subsurface inflow from the Delta Mendota Subbasin into the Modesto Subbasin for projected future and sustainable yield conditions (**Table 5-15**). Collectively, the 3-mile distance from the nearest monitoring well, the upgradient location of the Delta-Mendota wells, the higher MTs for TDS and nitrate in the Delta-Mendota Subbasin, and the indicated subsurface flow direction into the Modesto Subbasin indicate that MTs in the Modesto Subbasin will not impact MTs for degraded water quality or impact GSP implementation in the Delta-Mendota Subbasin.

6.6.2.3.3. Turlock Subbasin

The Turlock Subbasin has defined undesirable results for degraded water quality in a similar manner to the Modesto Subbasin, using MCLs for six of the seven Modesto Subbasin constituents of concern as the MTs. Both subbasins have similar water quality issues and will coordinate the tracking and analysis across the Tuolumne River boundary.

In addition to the coordination of sustainable management criteria, two member agencies in the Modesto Subbasin - the City of Modesto and the City of Waterford[8] – monitor for groundwater quality in both subbasins, allowing for close coordination of any water quality issues along the Tuolumne River boundary. Water quality data for both subbasins will be analyzed annually using similar data sources and methods, which will allow for close

[8] The City of Waterford operates drinking water supply wells for the community of Hickman in the Turlock Subbasin.

coordination of any degraded water quality across the two subbasins. Analyses in both subbasins will be conducted to determine if GSA management of groundwater extractions, levels, or GSP projects/management actions are impacting groundwater quality. These analyses will be presented in Annual Reports for each subbasin.

6.6.2.4. Effects of MTs on Beneficial Uses and Users of Groundwater

The setting of MCLs as the MTs is protective with respect to the avoidance of undesirable results. By protecting drinking water quality, the long-term quality and quantity of useable groundwater for all beneficial uses will be preserved.

The City of Modesto has been historically impacted by water quality problems in their wellfields. About 18 water supply wells had to be removed from service for impacts related to arsenic, nitrate, or uranium (see **Section 3.2.5.3**). Another 9 water supply wells have been taken offline due to TCP or PCE contamination. To address these issues, the City has conducted numerous water quality studies and is currently completing a wellfield investigation and feasibility study to identify remedial options for wellfield management. Those independent studies and Subbasin-wide annual tracking of groundwater quality will each inform the other, providing a better understanding of degraded water quality in the Subbasin.

The commitment to analyze a large groundwater quality dataset across the Subbasin on an annual basis will improve GSA understanding of water quality in each Principal Aquifer and lead to better management practices. Expanded and ongoing data collection and analysis will also support ongoing regulatory monitoring, allowing others to evaluate their local water quality monitoring data in the context of Subbasin-wide water quality. For example, an improved understanding of water quality with depth allows future wells to be sited and designed such that water quality is optimized. Overall, these improvements will support all beneficial uses of groundwater in the Subbasin.

6.6.2.5. Consideration of State, Federal, or Local Standards in MT Selection

In setting MTs for degraded water quality, GSP regulations require that GSAs consider local, state, and federal water quality standards applicable to the Subbasin (354.28(c)(4)). As provided above, the degraded water quality sustainability indicator relies on California MCLs for the MT; in this manner, the MT adheres to drinking water quality standards set by California, which are either as protective or more protective than federal standards. The MCLs are also consistent with the local standards and water quality objectives (WQO) in the Central Valley RWQCB Basin Plan for the San Joaquin River Basin (2018). Accordingly, there are no conflicts with regard to regulatory standards.

6.6.2.6. Quantitative Measurement of Minimum Thresholds

As stated above, the MTs for the degradation of water quality will be quantitatively monitored through existing monitoring programs that are being managed by the SWRCB and uploaded to the public GeoTracker website. These water quality data are monitored by public agencies, regulated coalitions, and others in representative monitoring wells for each Principal Aquifer using regulatory-approved sampling protocols. Data will be downloaded from the State GeoTracker water quality website and supplemented with data from the salt and nutrient regulatory programs in the Subbasin (see **Section 2.4.4**). Water quality data will be analyzed for constituents of concern in each Principal Aquifer as described in **Chapter 7** (Monitoring Network) of this GSP (see **Section 7.1.4**). Analyses will be included in the Subbasin GSP annual reports.

These data are considered comprehensive for characterization of water quality in the Subbasin. More than 300 wells with water quality data for Modesto Subbasin constituents of concern were available from GeoTracker from January 2020 to May 2021; these water quality monitoring sites are shown on **Figure 7-4** as part of the GSP monitoring network and tabulated in **Appendix G**. As shown on **Figure 7-4**, wells are distributed throughout the Subbasin but focused in areas of drinking water supply wells (see **Figure 2-10**). This is appropriate given the emphasis on drinking water supply impacts (i.e., MCL exceedances) in the definition of undesirable results.

Although monitored wells will change from year to year based on regulatory monitoring requirements, public water suppliers generally monitor and report water quality data for all active drinking water wells (see **Figure 2-13**). GeoTracker also includes water quality monitoring data from sites with contaminant plumes as a part of the RWQCB regulatory programs (see summary data on **Figure 4-57**). As indicated in **Appendix G**, monitoring sites consist of municipal supply wells, monitoring wells, and domestic wells. Although most domestic wells are currently sampled for nitrate only (**Appendix G**), the SWRCB is planning to expand water quality monitoring in those wells, adding additional constituents of concern including most of those in the Modesto Subbasin.

Additional wells from supplemental regulatory programs are also either included on GeoTracker or available for public download to allow for a broad analysis of water quality on an annual basis. Monitoring programs for TDS and nitrate are conducted by the Eastern San Joaquin Water Quality Coalition (ESJWQC) in coordination with the CV-SALTS program and the Nitrate Control Program, which requires growers in management zones to ensure safe drinking water supplies for well owners impacted by nitrate concentrations (see **Section 2.4.4**). As a result of this large dataset, the GSAs are not planning to develop a separate GSP water quality monitoring network, and no water quality sampling will be conducted by the GSAs.

However, GSAs will ensure that projects and management actions comply with regulatory water quality requirements. GSAs will consider appropriate constituents, MCLs, and water quality objectives (WQOs) as projects are initiated to avoid undesirable results. Potential water quality considerations for currently proposed projects will be evaluated through the CEQA process as projects are implemented.

6.6.3. Interim Milestones for Degraded Water Quality

Interim milestones are not defined for the degraded water quality sustainability indicator.

6.6.4. Measurable Objectives for Degraded Water Quality

To avoid exacerbation of the nature and extent of current groundwater quality by management activities, the GSAs are using the MOs to establish a target water quality condition whereby GSA management does not cause an increase in historical concentrations of constituents of concern (i.e., further degradation of water quality). This target is managed by the definition of measurable objectives for degraded water quality as follows.

Table 6-16: Measurable Objectives for Degraded Water Quality

	Measurable Objectives	Principal Aquifer(s)
Degraded Water Quality	Measurable objectives are defined as the historical maximum concentration of each constituent of concern at each representative monitoring location.	All

The same monitoring data summarized in **Section 6.6.2.6** above will be used to analyze MOs for the constituents of concern (see also **Figure 7-4**).

6.7. LAND SUBSIDENCE

SGMA defines an undesirable result for land subsidence as "significant and unreasonable land subsidence that substantially interferes with surface land uses" (§10721 (x)(5)). In general, land subsidence can interfere with land use by causing damage to either the natural land surface (e.g., surface fissures) or to structures on the land surface (e.g., roads or pipelines). Potential impacts from land subsidence are documented in **Section 3.2.6** and summarized in **Section 6.7.1.1** below.

As described in **Section 3.2.6**, there have been no known impacts from inelastic land subsidence in the Modesto Subbasin. Land subsidence associated with groundwater extraction has been documented across large segments of the San Joaquin Valley since the 1950s, but these areas are located significant distances to the south of the Modesto Subbasin (see **Figure 3-58**).

However, as explained in the remainder of **Section 6.7**, the potential for future land subsidence in the Subbasin cannot be dismissed, given the presence of the Corcoran Clay, the decline of groundwater levels in certain management areas, and the results of recent GPS station monitoring and remote sensing data. As a protective measure, sustainable management criteria for the land subsidence sustainability indicator have been selected for all principal aquifers in the Modesto Subbasin.

Because there have been no known impacts from land subsidence, it is difficult to determine what rates of subsidence would lead to undesirable results. For the Modesto Subbasin, the sustainable management criteria for chronic lowering of water levels were developed to arrest groundwater level declines caused by groundwater extraction (**Section 6.3**). As such, those criteria would protect against future land subsidence (see **Section 6.7.1.1**). Accordingly, the sustainable management criteria, including MTs set as the historical low groundwater levels for WY 1991 through WY 2020, are used as a proxy for land subsidence sustainable management criteria.

Potential undesirable results, including causes and impacts to beneficial uses, are described in **Section 6.7.1** below, with a definition of undesirable results provided at the end of the section. **Section 6.7.2** describes the quantification of minimum thresholds (MTs) and provides additional information on rationale and coordination of MTs in adjacent subbasins. **Section 6.7.3** provides the approach and selection of measurable objectives (MOs). Interim milestones that cover all of the applicable sustainability indicators are described in **Section 6.9**.

6.7.1. Undesirable Results for Land Subsidence

Vertical displacement of the land surface can be caused by a variety of mechanisms, including extraction of oil and gas, the wetting of collapsible soils, piping of sediment from underground pipeline or tank leaks, collapse from underground mining facilities, tectonic activity along geological faults, and other conditions. This GSP only focuses on land subsidence related to groundwater extraction. The following sections summarize the physical processes that could potentially cause future land subsidence in the Modesto Subbasin as well as the related causes and effects of potential undesirable results.

6.7.1.1. Causes of Undesirable Results for Land Subsidence

Areas of the San Joaquin Valley have had impacts from land subsidence related to groundwater pumping, which has lowered water levels within and below the thick and compressible Corcoran Clay. For example, land subsidence in the Merced Subbasin to the south occurred in this manner (W&C, 2019) (see **Figure 3-58**).

As pumping removes groundwater from storage, the pore pressure and support of the aquifer framework are reduced, and sediments can be realigned and compacted at depth. This compaction is typically associated with thick and compressible clay layers. Subsurface compaction reduces the volume of subsurface sediments, causing the ground surface to depress. The processes and mechanisms that result in land subsidence are more complex than summarized herein, but the concept of subsurface compaction is typically used to provide a general understanding of the process. Additional information is summarized in **Section 3.2.6** and illustrated on **Figure 3-57**.

The western Modesto Subbasin within the extent of the Corcoran Clay is thought to be the area most susceptible to future land subsidence (see red striped area on **Figure 6-1**). Recent processing of satellite data to analyze vertical displacement – referred to as InSAR[9] – suggests that no land subsidence has recently occurred in the western Subbasin (see **Figure**

[9] InSAR refers to Interferometric Synthetic Aperture Radar data.

3-59). However, data show some small amounts of vertical displacement in the eastern Modesto Subbasin (see **Figure 3-59**). It is not known whether this vertical displacement is related to groundwater extraction or other mechanisms described in **Section 6.7.1** above.

Nonetheless, the hydrogeological conditions in the western Subbasin and the InSAR data in the eastern Subbasin highlight the need for monitoring and management. Because groundwater drains slowly from compacted clay layers, there is a time lag between the triggering mechanisms that cause land subsidence and the actual depression on the land surface. A slow and small rate of decline in the land surface can go unnoticed until disruption of infrastructure or other physical manifestation of the problem occurs.

The processes above describe the causes of potential land subsidence, but the causes of undesirable results are related to the adverse impacts that land subsidence could have on land uses. For example, the documented land subsidence in the California Central Valley has caused numerous adverse impacts that could lead to undesirable results if they occurred in the Modesto Subbasin. Land subsidence could interfere with land use through a physical alteration of the ground surface, such as fissures, cracks, or depressions or by damaging physical structures on the ground surface such as buildings or infrastructure.

Adverse impacts are likely to occur in urban areas where numerous buildings, utilities, and pipelines are present. In addition, areas of groundwater wells could experience casing or other wellbore damage. Impacts have also been documented along surface water canals and transportation corridors, with damage to canals, roads, freeways or bridges. These impacts could cause an interruption to vital services or increase risks to public health and safety. In addition to physical damage, land subsidence can also affect gravity drainage in sewers, pipelines, or water conveyance canals and can also increase the risk of flooding (LSCE, 2014; W&C, 2019; W&C and P&P, 2019).

In consideration of these adverse impacts, the Modesto Subbasin GSAs incorporated impacts to infrastructure into its undesirable result definition. Definitions from GSPs in adjacent subbasins, including the Delta-Mendota and the Eastern San Joaquin subbasins, were also reviewed (W&C and P&P, 2019; ESJGWA, 2019). The definition of undesirable results for the Modesto Subbasin is provided in **Section 6.7.1.3** below.

6.7.1.2. Effects on Beneficial Uses of Groundwater

Two commonly cited effects on almost all beneficial users of groundwater in the Central Valley include damage to casings in water supply wells and interference with water canal capacity and conveyance (LSCE, 2014). Widespread collapse of well casings resulting from land subsidence have been well-documented in numerous areas. Near El Nido, California, well casings have been observed protruding above the land surface, in some cases with the connected concrete well pad suspended in the air (LSCE, 2014). Casing damage typically requires well replacement, resulting in significant costs to beneficial users of groundwater.

Given the close linkage between groundwater and surface water use in the Central Valley, land subsidence impacts on water conveyance facilities can have a negative impact on the beneficial uses and users of groundwater. Land subsidence has reduced freeboard and flow capacity in large water conveyance canals such as the Delta-Mendota Canal, the California Aqueduct, and the Friant-Kern Canal. Repairs to restore conveyance capacity along critical segments of the Friant-Kern Canal alone is estimated to cost as much as $200 million or more (FWA, 2018). In the Merced Subbasin GSP, undesirable results for land subsidence were related primarily to the viability of the Eastside Bypass Canal, where subsidence has caused a reduction in freeboard and capacity over the last 50 years. These impacts to surface water canals can result in an increase in groundwater pumping, often from groundwater basins already experiencing overdraft conditions, which can lead to a depletion in water supply.

Subsurface compaction of clay layers also causes permanent removal of groundwater from storage. Although the usable storage capacity of an aquifer is not substantially impacted by the dewatering and compaction of clay layers, there is some amount of groundwater that is permanently lost. Pumping an identical amount of groundwater after this loss can result in a lower water level than before the clay layer was drained. Lower groundwater levels can result in higher pumping lift costs and other negative effects on beneficial uses of groundwater (see **Section 6.3.1.2**) (LSCE, 2014).

Land subsidence could also disrupt activities on the land surface including agricultural production. Changes to the land surface, such as with fissures or depressions, could affect how both surface water and groundwater is conveyed onto and within productive agricultural parcels. These effects could create inefficiencies in beneficial groundwater use or interferences with agricultural land uses.

Finally, any of the above activities that lead to increased groundwater pumping would also have the potential to affect environmental users of groundwater including potential GDEs (**see Section 3.2.8** and **Figure 3-60**).

6.7.1.3. Modesto Subbasin Definition of Undesirable Results

In consideration of the land use and infrastructure impacts summarized above, an undesirable result has been developed for the Modesto Subbasin. Regulations require that the undesirable result definition include quantitative criteria used to define when and where groundwater conditions can cause an undesirable result (§354.26(b)(2)). These criteria address the number of monitoring sites and events that an MT can be exceeded before causing an undesirable result while recognizing that a single MT exceedance at one monitoring site may not indicate an undesirable result. Criteria also allow for a clear identification when an undesirable result is triggered.

The definition of undesirable results is provided as follows.

Table 6-17: Undesirable Results for Land Subsidence

	Undesirable Results Definition	Principal Aquifer(s)
Land Subsidence	An Undesirable Result is defined as significant and unreasonable inelastic land subsidence, caused by groundwater extraction and associated water level declines, that adversely affects land use or reduces the viability of the use of critical infrastructure. An undesirable result will occur when 33 percent of representative monitoring wells exceed the MT in three consecutive Fall monitoring events.	All

The criteria for triggering an undesirable result were developed for the chronic lowering of water levels indicator as discussed in **Section 6.3.1.3** and are applied as a proxy for the land subsidence sustainability indicator.

Accordingly, the monitoring networks for both land subsidence and chronic lowering of water levels are identical. As stated in **Section 6.3.1.3**, 33 percent is equivalent to 6 of 17 wells in the Western Upper Principal Aquifer, 2 of 5 wells in the Western Lower Principal Aquifer, and 13 of 39 wells in the Eastern Principal Aquifer.

MT exceedances are limited to 3 consecutive Fall monitoring events to avoid the potential seasonal component of elastic land subsidence. Elastic subsidence may occur in the fall, during low water level conditions, only to rebound during the spring, during high water level conditions. Data from a GPS station in the Subbasin illustrates this seasonal rebound (see **Section 3.2.6**, information on existing GPS stations). If groundwater elevations are managed at or above the MTs on a regional and multi-year basis, potential undesirable results for land subsidence should be avoided.

Water level monitoring will be supplemented by annual screening of InSAR data. These data will be re-evaluated with the water level monitoring network in the five-year GSP evaluation. If InSAR data indicate increasing rates of subsidence, the monitoring network will be bolstered by additional monitoring, such as the installation of GPS stations, in targeted areas of the Subbasin. In addition, the criteria could also be adjusted to be more protective.

6.7.2. Minimum Thresholds for Land Subsidence

As provided in the GSP regulations, the MT for land subsidence "shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results" (§354.28(c)(5)). Given the lack of undesirable results associated with land subsidence in the Modesto Subbasin, it is not possible to correlate a rate of subsidence to undesirable results. As explained in more detail below, available data sets indicate no land subsidence over most of the Subbasin. InSAR data indicate very low rates of vertical displacement in the central and eastern Subbasin, but this may also be due to irrigation on clay-rich soils or other land surface modifications associated with agricultural operations (see **Figure 3-6**). Additional supporting technical information on land subsidence in the Modesto Subbasin is provided in **Section 3.2.6** and summarized below in **Section 6.7.2.1**.

Because the greatest risk for land subsidence in the Modesto Subbasin is the dewatering/depressurization of clays, setting MTs at historic low groundwater levels (WY 2015 – WY 2020) was viewed as a reasonable strategy for minimizing future subsidence. In this manner, groundwater levels would be protective against worsening conditions that could lead to future undesirable results for land subsidence. Because the chronic lowering of water level MTs were developed to arrest water level declines in the Subbasin, they serve as reasonable MTs for avoidance of undesirable results for land subsidence. As such, chronic lowering of water levels MTs are used as a proxy for directly monitoring for land subsidence as follows.

Table 6-18: Minimum Thresholds for Land Subsidence

	Minimum Thresholds	Principal Aquifer(s)
Land Subsidence	Minimum thresholds are defined as the historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data. (Using Chronic Lowering of Groundwater Levels as a proxy.)	All

Additional support and justifications for the MTs, along with the quantitative criteria for the combination of MT exceedances provided in the undesirable results definition, are discussed in the following section.

6.7.2.1. Justification and Support for Minimum Thresholds

GSP regulations require that the MTs for land subsidence be supported by:

- Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence, including an explanation of how these uses and interests were determined.
- Rationale for establishing MTs in consideration of the above effects
- Maps and graphs showing the extent and a rate of land subsidence in the basin that defines the MT and MO.

With regards to the identification of land uses and property interests that are likely to be affected by land subsidence, potential effects of land subsidence on property interests are mentioned above in **Sections 6.7.1.1** and **6.7.1.2**. These effects on beneficial uses are general and hypothetical because no effects on beneficial uses caused by land subsidence have been identified in the Subbasin.

As mentioned previously, InSAR data published by DWR provides the best available vertical displacement data for the Subbasin. **Figure 3-60** illustrates cumulative vertical displacement over more than five years, from June 2015 through October 2020. As indicated by the dark gray areas, there is no negative vertical displacement (land subsidence) over most of the Subbasin. Only one small area of land subsidence is indicated within the extent of the Corcoran Clay. This area, located in the northwest corner of the Subbasin in the San Joaquin Wildlife Refuge, indicates a rate of land subsidence of up to 0.24 inches per year.

InSAR data indicate larger rates of vertical displacement in the central-southeastern Subbasin (orange and brown on **Figure 3-60**). Data in this area indicate a vertical displacement rate of about 0.12 inches per year with rates up to about 0.36 inches per year in two small, isolated areas (**Figure 3-60**). This area is outside of the Corcoran Clay and is characterized by relatively shallow, consolidated aquifers (i.e., Mehrten Formation) that would be less likely to experience significant land subsidence than areas with compressible clays.

In addition, there are clay-rich soils and multiple restrictive layers (e.g., duripan) in the eastern Subbasin that could be the cause of these small rates of vertical displacement (rather than groundwater extractions) (see **Figure 3-6**). For example, clay soils can be subject to swelling when wetted. In addition, the disruption of restrictive layers on agricultural lands could also result in small local differences in surface elevation, as can other agricultural operations. However, this area is also associated with increasing groundwater extractions over the historical study period, and the potential for land subsidence associated with these extractions cannot be ruled out at this time.

The map on **Figure 3-59** also shows the locations of three existing global positioning system (GPS) stations[10] along Highway 99, within the extent of the Corcoran Clay. The two northern stations are in Salida, and the southern station is in Modesto. These existing stations, monitored by other programs, provide highly accurate ground surface elevation data. Data available from the northern (August 2006 to December 2007) and southern (November 2006 to July 2001) GPS stations indicate that there has been no inelastic land subsidence at those locations. The central station indicates a rate of land subsidence of about 0.048 inches per year (less than 5 inches over 100 years), for the period of August 2008 to June 2014 (see **Section 3.2.6** for more information).

Increased rates of subsidence are often triggered during drought conditions (LSCE, 2014); the available recent land subsidence data in the Modesto Subbasin were collected during the long-term (and ongoing) drought conditions that resulted in historic low water levels throughout the Subbasin. It is not possible to know whether the current rates will continue beyond the drought.

[10] Installed and operated by the U.S. Bureau of Reclamation in connection with the San Joaquin River Restoration Program.

Collectively, these data suggest that significant rates of land subsidence are not occurring in the Modesto Subbasin. Accordingly, MTs are selected to be protective against triggering significant rates of subsidence in the future. All of the information and data reviewed to date indicate that undesirable results from land subsidence could be avoided by arresting the ongoing water level declines in the Subbasin. By setting MTs at the historical low, water level declines are controlled, and any current land subsidence is not exacerbated. As indicated above, the MTs for chronic lowering of groundwater levels are being used as a proxy for land subsidence MTs because these MTs manage groundwater levels near or above historic low groundwater levels (WY 1991 – WY 2020).

As an additional protective measure, the GSAs intend to download and review DWR's InSAR data on an annual basis, for screening purposes. As illustrated on **Figure 3-59**, the InSAR data cover the entire extent of the Subbasin. Data will be used for ongoing evaluation of the rate and extent of land subsidence. The data will be re-evaluated for the five-year evaluation in 2027. If significant rates of subsidence have occurred between 2022 and 2027, additional monitoring, such as additional wells or GPS stations, will be installed in areas of concern.

In this manner, the GSAs will ensure that the potential for impacts to land uses from land subsidence is not missed. This approach is reasonable, based on the best available data in the Modesto Subbasin.

6.7.2.2. Relationship between MTs of Each Sustainability Indicator

Regulations require a description of the relationship between the MTs for each sustainability indicator and how the GSAs have determined that basin conditions at each MT will avoid undesirable results (§354.28(b)(2)). To facilitate this comparison, MTs for each sustainability indicator were summarized in **Table 6-5,** as discussed above in **Section 6.3.2.2**.

Because the MTs for chronic lowering of groundwater levels are being used as a proxy for land subsidence, the interaction between the MTs for land subsidence and the other MTs is the same as for chronic lowering of water levels. As such, please refer to **Section 6.3.2.2** above for meeting this regulatory requirement for the land subsidence sustainability indicator. These sustainability indicators are also analyzed separately in other subsections of **Chapter 6**, as referenced in **Table 6-5**.

6.7.2.3. Impacts of MTs on Adjacent Subbasins

Regulations require consideration of how Modesto Subbasin MTs impact the ability of an adjacent subbasin to achieve its sustainability goal. As summarized in more detail in **Section 6.3.2.3**, similar principal aquifers, shared interconnected surface water boundaries, and multiple GSA member agencies that overlap both the Modesto Subbasin and adjacent subbasins have facilitated setting MTs in the Modesto Subbasin that will not adversely impact adjacent subbasins GSP implementation. Additional details relevant to each adjacent subbasin are summarized below.

6.7.2.3.1. Eastern San Joaquin Subbasin
ESJ Subbasin MTs for chronic lowering of water levels are also used as a proxy for the reduction of groundwater in storage, land subsidence, and interconnected surface water. Therefore, the analysis presented for the chronic lowering of water levels in **Section 6.3.2.3.1** provides the technical rationale for concluding that MTs in the Modesto Subbasin for land subsidence will not adversely affect GSP implementation in the ESJ Subbasin.

6.7.2.3.2. Delta Mendota Subbasin
Land subsidence is a prevalent issue in the Delta-Mendota Subbasin, with impacts to infrastructure of statewide importance (such as the California Aqueduct and the Delta-Mendota Canal). However, no significant land subsidence has been documented near the Modesto Subbasin. Most of the subsidence maps in the Northern & Central Delta-Mendota GSP either do not contain data or do not indicate significant amounts of land subsidence along its shared San Joaquin River boundary with the Modesto Subbasin (see Figures 5-113, 5-114, and 5-116 in W&C and P&P, 2019). The closest UNAVCO GPS station (P255) along the Delta-Mendota Canal is located approximately nine miles to the west of the Modesto Subbasin, and data from 2007 to 2018 at that station did not indicate inelastic land subsidence.

For the Northern & Central Delta-Mendota GSP, land subsidence MTs in the management area adjacent to the Modesto Subbasin are based on an acceptable loss in distribution capacity in subbasin canals, to be determined in a future study (W&C and P&P, 2019). The closest subsidence monitoring station to the Modesto Subbasin is more than two miles to the southwest of the Modesto Subbasin boundary (04-002), and the MT had not yet been quantified. However, given that MTs are set at the historical low groundwater levels, no impacts on land subsidence in the Delta-Mendota Subbasin would be anticipated. In addition, MTs for interconnected surface water are the Fall 2015 groundwater elevations along the San Joaquin River, providing even more protection for the adjacent subbasin (see **Section 6.8.2.3.2**). Given these conditions, no impacts are expected on GSP implementation in the Delta-Mendota Subbasin.

6.7.2.3.3. Turlock Subbasin
Both the Turlock Subbasin and Modesto Subbasin have approved MTs for interconnected surface water that are based on Fall 2015 water levels along both sides of the Tuolumne River (see **Section 6.8.2.3.3**). In that manner, the two GSPs are coordinating on MTs and avoiding undesirable results for streamflow depletion. Accordingly, MTs in the Modesto Subbasin for land subsidence will not have an adverse impact on GSP implementation in the Turlock Subbasin.

6.7.2.4. Effects of MTs on Beneficial Uses and Users of Groundwater
The setting of MTs is protective with respect to the avoidance of undesirable results. However, the MTs place operational constraints on agricultural wells and other water supply wells, especially during long-term multi-year droughts. Because the MTs for chronic lowering of water levels are used as a proxy for land subsidence, all of the same effects on

beneficial uses and users of groundwater discussed previously also apply to this indicator (see **Section 6.3.2.4**).

Shallow groundwater levels in the Western Upper Principal Aquifer create operational issues for agriculture and groundwater pumping is required in some areas to drain fields and allow access for farming. Given the small fluctuations in these wells, maintaining water levels at MTs may impose restrictions on these extractions and limit beneficial uses of groundwater. However, the definition of undesirable results allows for short-term declines and criteria for undesirable results focus on the lowest seasonal levels (Fall). These criteria will assist with the necessary operational pumping of shallow groundwater in the western Subbasin.

Notwithstanding the constraints placed on various well owners, groundwater users would benefit from the control and mitigation of potential impacts from land subsidence in the future. Those impacts could negatively affect agricultural or urban land uses or other beneficial uses of groundwater as explained in **Section 6.7.1** above.

6.7.2.5. Consideration of State, Federal, or Local Standards in MT Selection

GSP regulations require that GSAs consider how the selection of MTs might differ from other regulatory standards. For land subsidence, the MT consists of managing water levels in each representative monitoring well, which would not conflict with other regulatory standards.

6.7.2.6. Quantitative Measurement of Minimum Thresholds

As stated above, the MTs for land subsidence will be monitored by quantitatively measuring water levels as a proxy in representative monitoring well networks for each applicable Principal Aquifer as described in **Section 7.1.5** of this GSP. Monitoring will occur on a semi-annual basis, in Spring and Fall, to represent the seasonal high and low water level and adhere to water level sampling protocols (**Section 7.2**).

For land subsidence, supplemental monitoring is also planned. To provide a backstop for the uncertainties associated with future rates and extents of land subsidence, the GSAs also intend to use the annual DWR-published InSAR data as a screening tool. Those data cover the entire extent of the Subbasin and will provide a valuable tool for evaluating future vertical displacement. When combined with the annual data on groundwater extractions and groundwater elevations, the InSAR data can be used to identify areas where vertical displacement rates are changing and provide areas of the Subbasin where additional monitoring may be warranted. Data from existing GPS stations will be incorporated in the annual analysis, as available. Collectively, InSAR and GPS stations will serve as future land subsidence screening tools and, if necessary, will help identify optimal locations for either additional wells or future GPS stations.

6.7.3. Interim Milestones for Land Subsidence

As described previously, the chronic lowering of water levels criteria are applied as a proxy for the land subsidence sustainability indicator. By extension, the interim milestones for chronic lowering of water levels are used as a proxy for the land subsidence sustainability indicator.

6.7.4. Measurable Objectives for Land Subsidence

The MO for land subsidence is the midpoint between the MT and the historical high water level (WY 1991 – WY 2020). This is the same approach as for chronic lowering of water levels and is developed at the same representative monitoring sites.

Table 6-19: Measurable Objectives for Land Subsidence

	Measurable Objectives	Principal Aquifer(s)
Land Subsidence	Midpoint between the historical high groundwater elevation and the MT at each representative monitoring location. (Using Chronic Lowering of Groundwater Levels as a proxy)	All

6.8. Depletion of Interconnected Surface Water

SGMA defines an undesirable result for the interconnected water sustainability indicator as "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." (§10721 (x)(6)). In the Modesto Subbasin, the Tuolumne, Stanislaus, and San Joaquin rivers are all interconnected surface water. Along these boundary rivers, groundwater occurs above the channel invert elevation on an average basis, allowing groundwater to interact with surface water. All three rivers are interconnected during historical, current, and projected future conditions (**Figure 6-1**).

STRGBA GSA member agencies Modesto ID and Oakdale ID manage surface water supplies from the Tuolumne River and Stanislaus River, respectively. The districts provide local management of diversions and conveyance of surface water for municipal drinking water (City of Modesto), non-potable municipal uses, and agricultural supply. Agency experience was used to guide the analysis of streamflow depletions and undesirable results. Both agencies provided information and data to incorporate into the integrated surface water-groundwater model (C2VSim-TM) for streamflow depletion analyses under historical, current, and projected future water budgets (see **Chapter 5**). Agencies also provided expertise on potential undesirable results for surface water rights. Modesto ID and the consultant team also coordinated with TID on information along the Tuolumne River; TID operates New Don Pedro Dam for releases to the Tuolumne River for water supply.

The undesirable results, including causes and impacts to beneficial uses, are described in **Section 6.8.1** below, with a definition of undesirable results at the end of the section that includes criteria to quantify where and when undesirable results would occur. **Section 6.8.2** describes the quantification of MTs. **Section 6.8.3** provides the approach and selection of

MOs. IMs that cover all of the applicable sustainability indicators (except degraded water quality) are described in **Section 6.9**.

6.8.1. Undesirable Results for Interconnected Surface Water

Analyses of groundwater conditions and water budget modeling in the Modesto Subbasin highlight the linkages between groundwater extractions, reduction of groundwater in storage, and interconnected surface water. In its Water Budget BMP, DWR notes that increases in groundwater extraction will initially result in a decline in groundwater in storage. However, over time, this decline in storage will be ultimately balanced by decreases in groundwater flow to streams (DWR, 2016a). This condition will induce groundwater recharge, removing water from the rivers (streamflow depletion). Although beneficial to water levels and storage, this streamflow depletion may impact beneficial uses of surface water including municipal, agricultural, and environmental uses.

Modeling shows that increased streamflow depletion (i.e., net groundwater recharge) along the Modesto Subbasin boundaries is associated with groundwater level declines. This observation indicates that water levels along the rivers can be used as a proxy for streamflow depletions if the water level declines can be shown to be protective against undesirable results.

Groundwater level monitoring for this purpose is best accomplished with a series of shallow monitoring wells adjacent to and transitioning away from the river. Although not ideal, current GSP monitoring wells are relatively close to the rivers and are screened in the unconfined aquifers that are connected to the rivers. When coupled with stream gage data and ongoing modeling, current wells are likely to be sufficient for monitoring surface water-groundwater conditions in the short term (see **Section 7.1.6**, **Table 7-2**, and **Figure 7-5**). Over time, additional monitoring wells will be added to the interconnected surface water monitoring network. A management action to improve the monitoring network provides for additional shallow monitoring wells to be installed along the rivers over time (**Chapter 8**).

6.8.1.1. Causes of Undesirable Results

In the Modesto Subbasin, groundwater extractions – primarily in the NDE MA – have lowered groundwater levels locally and in adjacent areas to the west. These extractions intercept groundwater that would have naturally flowed toward the river boundaries, depleting some amount of baseflow to the rivers. This streamflow depletion increases over time during the historical study period (note the declining amounts of stream/aquifer interaction as groundwater outflow, as shown in blue on **Figure 5-20**).

Modeling of projected future conditions suggests that the area of groundwater level declines will expand to the north and south toward the Stanislaus and Tuolumne rivers and cause increases in streamflow depletion (compare the net river gains/losses between historical and projected conditions in **Table 5-8)**. Groundwater extractions in other parts of the Subbasin also contribute to this depletion, especially along the rivers. In the projected conditions scenario, both the Tuolumne and Stanislaus rivers transition from net gaining streams to net losing streams, a continuation of a trend that began in recent years.

If depletion increased significantly more than indicated from the modeling, the groundwater system could become disconnected from the surface water system. At that point, groundwater would no longer contribute baseflow to the river. Lower groundwater levels would induce more recharge from the river, significantly depleting flows; these conditions would produce an undesirable result.

In the Modesto Subbasin, integrated surface water-groundwater modeling indicates that the groundwater system and river system remain connected through the 50-year implementation and planning horizon under future projected conditions. This indicates that even if future water levels declined to the extent estimated, connection between the two systems could be maintained. The projected streamflow depletions average about 26,000 AFY, only about one percent of the total river outflows from the Subbasin.

Nonetheless, these future projected increases in streamflow depletion result in a net loss of streamflow from the river systems compared to a net gain in streamflow over historical conditions. In addition, beneficial uses could be adversely impacted at these predicted levels of streamflow depletion even if the groundwater and surface water systems remain connected (see **Section 6.8.1.2** below). Accordingly, the projections for future streamflow depletions are considered undesirable results in this GSP.

GSAs are not required to correct undesirable results that occurred prior to January 1, 2015. Rather, the GSAs intend to protect against future projected increases in depletions and set a "floor" at 2015 conditions. In this manner, future projected declines in groundwater elevations will be managed, and future projections for streamflow depletion will be reduced.

6.8.1.2. Potential Effects on Beneficial Uses

Beneficial uses of the three Modesto Subbasin rivers are provided in the Basin Plan for the Sacramento River Basin and the San Joaquin River Basin (CVRWQCB, 2018). All three rivers are associated with almost all categories of beneficial uses including municipal (including potential uses), agricultural, and/or industrial supply; recreation; freshwater habitat, migration, and spawning; and wildlife habitat. The three rivers also support large riparian corridors. A preliminary evaluation of vegetative and wetland areas mapped by TNC as natural communities commonly associated with groundwater (NCCAG) indicates potential GDEs along most of the river reaches in the Modesto Subbasin (DWR, 2018d) (see **Section 3.2.8**).

Although predicted future streamflow over the 50-year baseline conditions are not precise, the predicted depletions result in lower streamflow during low flow conditions. These changes could exacerbate drought conditions on the rivers and adversely affect all beneficial uses that rely on surface water.

Both Modesto ID and Oakdale ID noted that more water would have to be released over time to meet current downstream flow requirements. This would make operation of the river more difficult, especially during low-flow conditions, and provide less water supply for municipal and agricultural beneficial uses during times when water demands are high.

In addition to adverse impacts to surface water rights holders, these conditions could also adversely impact flows needed to support fish and other wildlife. The large riparian corridors along the river could be adversely impacted. Lower groundwater levels adjacent to the rivers could impact GDEs and other environmental uses of groundwater that occur along the Subbasin river boundaries.

6.8.1.3. Modesto Subbasin Definition of Undesirable Results

The definition of undesirable results for interconnected surface water in the Modesto Subbasin is based on the causes and effects discussed above, along with additional information from the basin setting and water budgets (**Chapters 3** and **5**). Regulations also require that the undesirable result definition include quantitative criteria used to define when and where groundwater conditions can cause an undesirable result (§354.26(b)(2)). These criteria set the number of monitoring sites and events to determine where and when an MT can be exceeded before causing undesirable results. This framework recognizes that a single MT exceedance at one monitoring site may not indicate an undesirable result. The criteria also allow clear identification for when an undesirable result is triggered under the GSP.

The definition of undesirable results along with the quantitative combination of MT exceedances that cause undesirable results are provided below.

Table 6-20: Undesirable Results for Interconnected Surface Water

	Undesirable Results Definition	Principal Aquifer(s)
Interconnected Surface Water	An Undesirable Result is defined as significant and unreasonable adverse impacts to the beneficial uses of surface water caused by groundwater extraction. An undesirable result will occur on either the Tuolumne or Stanislaus rivers when 33% of representative monitoring wells for that river exceed the MT in three consecutive Fall monitoring events. An undesirable result will occur on the San Joaquin River when 50% of representative monitoring wells for that river exceed the MT in three consecutive Fall monitoring events.	All

The 50% criterion for the San Joaquin River is because there are only two representative monitoring wells along the San Joaquin River, and MT exceedances in both wells (100%) is difficult to justify. This criterion may change when additional wells are added to the monitoring network along the San Joaquin River. An exceedance in only one well may not lead to undesirable results as being set in this GSP, so incorporating additional wells is a priority for improvements to the monitoring network. This and other improvements are included as an implementation action in **Chapter 9**.

The total number of current wells and the number of MT exceedances allowed by the undesirable result definition are summarized below. The monitoring network is described in **Chapter 7** and shown on **Figure 7-5**.

- Tuolumne River: 10 wells (33% - 3 wells)
- Stanislaus River: 8 wells (33% - 3 wells)
- San Joaquin River: 2 wells (50% - 1 well)

The MT exceedance is limited to three consecutive Fall events (semi-annual monitoring). Spring events will be monitored but not used in the criterion because the increase in Spring water levels would not be representative of potential negative impacts during low flows on the rivers.

These criteria were incorporated into the sustainable yield modeling (**Section 5.3**), which demonstrated that these criteria could be met using simulated hydrographs at wells along the river. Sustainable yield conditions indicate significant decreases in streamflow depletion at each of the three rivers as discussed below.

6.8.2. Minimum Thresholds for Interconnected Surface Water

GSP regulations require the metric for interconnected surface water MTs to be "the rate or <u>volume of surface water depletions</u> caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results" (§354.28(c)(6)) (<u>emphasis added</u>). As explained in **Section 6.8.1.1**, the modeling projections of future volumes of streamflow depletion have been determined by the GSAs to be undesirable results and is caused by lower groundwater levels. Therefore, specific groundwater levels can be directly correlated to these volumes of streamflow depletion and used as a proxy for interconnected surface water MTs.

The link between streamflow depletion volume and groundwater levels is confirmed by a sustainable yield modeling analysis described in **Section 5.3**. For this analysis, groundwater extractions were reduced to test aquifer response to groundwater level MTs, resulting in a reduction in projected surface water depletions and elimination of net depletions over the Subbasin. That is, there was a net contribution to streamflow from the groundwater system at the Subbasin outflow (i.e., the downstream point past the confluence of the Stanislaus and San Joaquin rivers). By managing water levels at or near the Fall 2015 groundwater elevations, modeling showed that the projected net depletions could be eliminated.

Accordingly, MTs for this sustainability indicator are defined at the 2015 groundwater elevations as follows.

Table 6-21: Minimum Thresholds for Interconnected Surface Water

	Minimum Thresholds	Principal Aquifer(s)
Interconnected Surface Water	Minimum Thresholds are defined as the low groundwater elevation observed in Fall 2015 at each representative monitoring location.	Western Upper and Eastern Principal Aquifers

6.8.2.1. Justification and Support for Minimum Thresholds

GSP regulations require that the MTs be supported by:

- Location, quantity, and timing of depletions of interconnected surface water
- A description of the groundwater and surface water model used to quantify surface water depletion (§354.28(c)(6)(A)(B)).

Background information for the interconnected surface water analysis is provided in **Section 3.2.7**, followed by a preliminary analysis of potential GDEs, which occur along the river boundaries (**Section 3.2.8** and **Figure 3-60**). The historical, projected, and sustainable yield water budgets provide a detailed assessment of groundwater-surface water interaction and are presented in **Chapter 5**. As described above in **Section 6.8.2**, the sustainable yield analysis in **Section 5.3** was used to support the selection of MTs for this indicator. These collective analyses are summarized below.

In brief, the Tuolumne, Stanislaus, and San Joaquin rivers are interconnected surface water as defined by SGMA. The surface water-groundwater interaction is dynamic, with recharge and baseflow varying along segments of the river both seasonally and over time. This dynamic system of mixed gaining and losing segments along the Tuolumne and Stanislaus rivers is the result of both natural interactions and managed operations. As mentioned previously, both rivers are actively managed to provide critical water supplies for the Modesto, Turlock, and Eastern San Joaquin subbasins. The San Joaquin River has less variability and has the largest flows of the three Subbasin rivers. The segment of the San Joaquin River along the western Modesto Subbasin can be characterized as a net gaining reach during both historical and projected future conditions.

The location, quantity, and timing of deletions of these interconnected rivers were analyzed using the integrated surface water-groundwater model C2VSimTM. This local model is based on the DWR regional C2VSimFG-BETA2 model, which has been revised to include local water budget data for both the Turlock and Modesto subbasins in order to simulate the river boundary more accurately. Local surface water and groundwater data from the Eastern San Joaquin Subbasin to the north was also incorporated into the modeling analyses. These revisions provided increased ability and accuracy for modeling interconnected surface water across the northern and southern river boundaries. Documentation of the revised C2VSim-TM model is provided in **Appendix C** of this GSP.

Interconnected surface water was analyzed with C2VSimTM for historical, current, and future projected water budget conditions including separate average annual water budgets for the Modesto Subbasin surface water systems (see **Table 5-2**). Total surface water inflows into the Subbasin historically have averaged about 2,547,000 AFY[11] for all three river systems, with about one-half consisting of the San Joaquin River flows. Surface water outflows are estimated at 2,770,000 AFY under historical conditions as measured at the confluence of the Stanislaus River and the San Joaquin River at the northwest corner of the Modesto Subbasin (**Table 5-2**).

During historical conditions, all three rivers were net gaining on an average annual basis with baseflow contributions of about 61,000 AFY (see the net of the Modesto Subbasin total gains from groundwater (baseflow) and losses to groundwater (seepage/recharge) under historical conditions in **Table 5-2**). Under future conditions, streamflow seepage is projected to increase in all three rivers, resulting in net depletions on both the Tuolumne and Stanislaus rivers over the 50-year period of analysis. Smaller streamflow depletions are projected to occur along the San Joaquin River, but the river remains a net gaining stream overall.

Historical conditions represent an average over a 25-year period. During that time, streamflow depletions increased along each of the Subbasin rivers as groundwater extractions increased, especially after about 2005. **Figure 5-20** illustrates this increase by showing overall smaller groundwater outflows to the surface water system from WY 2005 to WY 2015 (see annual estimates represented by the stream/aquifer interaction shaded blue on **Figure 5-20**). **Figure 5-25** shows the relatively small amount of total streamflow that is affected by the groundwater system.

To reduce the potential for projected future depletions to cause undesirable results, groundwater level declines associated with groundwater extractions need to be arrested. By managing groundwater at or above 2015 groundwater levels, sustainable yield modeling predicts significant improvements in the future projections. A summary of these improvements is shown in the following table.

Table 6-22: Improvements to Interconnected Surface Water under Sustainable Yield Conditions

Modesto Subbasin Surface Water	Projected Future Baseline Conditions (AFY)	Sustainable Yield Conditions (AFY)	Increase in Baseflow* under Sustainable Yield Conditions (AFY) (%)

[11] As footnoted in **Table 5-2**, some diversions occur upstream of the inflow measurement point into the Subbasin and are not included in these totals.

Total GW-SW Interaction	26,000	-15,000	41,000	158%
San Joaquin River	-9,000	-13,000	4,000	44%
Tuolumne River	11,000	-11,000	22,000	200%
Stanislaus River	24,000	9,000	15,000	63%

Positive numbers represent net recharge from surface water to groundwater (i.e., streamflow depletion, also referred to as a net losing river) over average hydrologic conditions.
Negative numbers represent a net contribution to surface water (SW) from groundwater (GW) (i.e., net baseflow, also referred to as a net gaining river) over average hydrologic conditions.
**"Increase in baseflow" refers to the larger contributions to surface water from groundwater (i.e., lower amounts of streamflow depletion) under Sustainable Yield Conditions.*

As shown in the table above, net streamflow depletion in the Modesto Subbasin rivers is estimated at 26,000 AFY under the projected future baseline conditions. Under sustainable yield conditions, which incorporated the 2015 groundwater elevation MTs, the projected future streamflow depletion is eliminated, and the overall surface water system returns to a net gaining condition. Sustainable yield conditions indicate an increase of 41,000 AFY of baseflow over projected future conditions. Additional details of these data are provided in **Section 5.1.4.4** for projected conditions (see also **Table 5-2** and **Figure 5-24**); additional details on the sustainable yield analysis are provided in **Section 5.3** (see **Table 5-15** and **Figure 5-24**).

6.8.2.2. Relationship between MTs of Each Sustainability Indicator

Regulations require a description of the relationship between the MTs for each sustainability indicator and how the GSAs have determined that basin conditions at each MT will avoid undesirable results (§354.28(b)(2)). **Table 6-5** summarizes the MTs for the sustainability indicators.

The use of 2015 groundwater levels as a proxy for interconnected surface water coordinates well to the other sustainability indicators, most of which are also tied to similar or identical water levels. The relationship between the MTs for interconnected surface water and the other MTs are summarized below:

MTs for interconnected surface water are either identical or a few feet higher than the MTs selected for chronic lowering of water levels to allow more protection against streamflow depletions along the rivers. For the 20 wells along the rivers that are included in the monitoring networks for both the chronic lowering of groundwater levels and interconnected surface water indicators, MTs vary by four feet or less (compare **Figures 7-1** and **7-3** with **Figure 7-5**). These differences are not sufficient to create a conflict for GSP implementation and management.

MTs for reduction of groundwater in storage and land subsidence are the same as those for the chronic lowering of water levels. As such, interaction of those MTs with interconnected surface water MTs occurs in the same manner as discussed above (see also **Section 6.4.2** and **6.5.2**).

MTs have not been selected for the Seawater Intrusion indicator because it is not applicable to the inland Turlock Subbasin (see **Section 6.5**).

MTs for interconnected surface water will not affect water quality and, as such, will not conflict with degraded water quality MTs. In addition, by setting MTs at the Fall 2015 groundwater levels along the rivers, groundwater will continue to contribute fresh water to the rivers. (see also **Section 6.6**).

Although these MTs were considered and approved separately for each of the sustainability indicators separately, the TAC reviewed technical presentations on how the MTs for each indicator coordinates with the others. Technical information and modeling analyses were reviewed both by mangers and representatives in the TAC planning group as well as in public TAC meetings held in tandem with monthly STRGBA GSA meetings.

6.8.2.3. Impacts of MTs on Adjacent Subbasins

Regulations require consideration of how Modesto Subbasin MTs impact the ability of an adjacent subbasin to achieve its sustainability goal. As summarized in more detail in **Section 6.3.2.3**, similar principal aquifers, shared interconnected surface water boundaries, and multiple GSA member agencies that overlap both the Modesto Subbasin and adjacent subbasins have facilitated setting MTs in the Modesto Subbasin that will not adversely impact adjacent subbasins GSP implementation. Additional details relevant to each adjacent subbasin are summarized below.

6.8.2.3.1. Eastern San Joaquin Subbasin

ESJ Subbasin MTs for chronic lowering of water levels are also used as a proxy for the reduction of groundwater in storage, land subsidence, and interconnected surface water. Given that the MTs for interconnected surface water are either the same or only a few feet higher than the MTs for the chronic lowering of water levels, the previous analysis in **Section 6.3.2.3.1** is applicable to this indicator. Information in that section provides the technical rationale for concluding that MTs in the Modesto Subbasin for interconnected surface water will not adversely affect GSP implementation in the ESJ Subbasin.

6.8.2.3.2. Delta-Mendota Subbasin

The Delta-Mendota Northern & Central GSP defines undesirable results for interconnected surface water as a percentage increase in streamflow depletions that is to be determined within the first five years of GSP implementation. A quantitative MT is not set due to insufficient data. The data to be incorporated into the evaluation will be collected from two wells along the San Joaquin River south of the Modesto Subbasin (see wells 03-001 and 03-003 on GSP Figure 6-7 *in* W&C and P&P, 2019). In the interim, the GSP selects a narrative

MO, which states “no increased depletions of surface water occur as a result of groundwater pumping.” (W&C and P&P, 2019).

In the absence of a quantitative MT for interconnected surface water, the MT for the Modesto Subbasin seems sufficiently high to not interfere with the Delta-Mendota Subbasin achieving its sustainability goal. As mentioned previously, MTs for chronic lowering of water levels have been set similarly in both subbasins adjacent to the San Joaquin River. Sustainable yield modeling shows that MTs for the San Joaquin River in the Modesto Subbasin are correlated to conditions that contribute a net baseflow of 13,000 AFY (**Table 6-22**), an amount that differs from the average historical net baseflow of only 1,000 AFY (i.e., 14,000 AFY; subtract outflows from inflow for the San Joaquin River on **Table 5-8**). With this contribution to baseflow and MTs from 2015 conditions on both sides of the river, the MT for interconnected surface water in the Modesto Subbasin would not be expected to negatively impact implementation of the Delta-Mendota Northern & Central GSP.

6.8.2.3.3. Turlock Subbasin

MTs selected in both subbasins are Fall 2015 groundwater levels for the interconnected surface water sustainability indicator along the shared Tuolumne River boundary. Representatives from both subbasins have determined that future projected depletions of streamflow on the Tuolumne River may lead to undesirable results and have selected groundwater levels as a proxy for monitoring interconnected surface water and avoiding those future conditions (see **Table 6-22** above).

Further, GSAs in both subbasins have tested the MTs through similar sustainable yield modeling analyses (**Section 5.3**) to ensure that interconnected surface water conditions are protected. Results of the sustainable yield modeling indicate similar net contributions to baseflow on both sides of the river (16,200 AFY from Turlock Subbasin compared to 11,000 AFY from Modesto Subbasin).

6.8.2.4. Effects of MTs on Beneficial Uses and Users of Groundwater

The setting of MTs is protective with respect to the avoidance of undesirable results related to streamflow depletion. By arresting groundwater level declines along the river boundaries, the net future projected streamflow depletions can be substantially reduced or eliminated at each of the Modesto Subbasin rivers, and long-term use of groundwater can become more sustainable. Environmental uses of surface water and groundwater would also be supported.

However, there will be consequences on current uses of groundwater. The MTs will not be able to be achieved without sufficient projects or management actions to raise and maintain water levels along the Subbasin river boundaries. This will require significant investment in projects to replenish the Subbasin. Although projects identified in Chapter 8 of this GSP appear to provide sufficient supplemental water supply to achieve the MTs, a management action of demand reduction is included in the GSP as a backstop in the event that projects and associated aquifer response are not as expected. In that case, both agricultural beneficial uses and property interests could be negatively impacted if demand reduction is required to meet the Subbasin sustainability goal.

6.8.2.5. Consideration of State, Federal, or Local Standards in MT Selection

GSP regulations require that GSAs consider how the selection of MTs might differ from other regulatory standards. For interconnected surface water, the MT consists of water levels quantified at each representative monitoring well. Surface water rights holders on the Stanislaus and Tuolumne rivers estimate that the MTs will not adversely impact surface water rights and will allow for compliance with state and federal requirements. Accordingly, there are no conflicts with regard to other regulatory standards.

6.8.2.6. Quantitative Measurement of Minimum Thresholds

As stated above, the MTs for interconnected surface water will be monitored by quantitatively measuring water levels in representative monitoring wells along the river boundaries as described in **Chapter 7** (see **Section 7.1.6**, **Table 7-2,** and **Figure 7-5**). Monitoring will occur on a semi-annual basis, in Spring and Fall, to represent the seasonal high and low water level and will adhere to water level sampling protocols (**Section 7.2**).

6.8.3. Interim Milestones for Interconnected Surface Water

The chronic lowering of water levels criteria are applied as a proxy for the interconnected surface water sustainability indicator. By extension, the interim milestones for chronic lowering of water levels are used as a proxy for the interconnected surface water sustainability indicator.

As described in **Section 6.3.3**, 2027 IMs below the MT were developed for RMWs in the OID and NDE Management Areas. There are five RMWs in the interconnected surface water monitoring network along the Stanislaus River and the Tuolumne River that have 2027 IMs below the MTs. No RMWs along the San Joaquin River have 2027 IMs below the MTs.

6.8.4. Measurable Objectives for Interconnected Surface Water

Similar to the other sustainability indicators, the MO for interconnected surface water is set as the midpoint between the high groundwater elevation and the MT in each of the representative monitoring wells. As explained in **Section 6.3.3**, the MTs represents a “floor” for maintenance of low water levels, with allowance for short-term exceedances during droughts. Accordingly, water levels will be managed over an operational range generally occurring between the MT (with temporary exceedances) and anticipated high water levels that occur during wet periods.

Table 6-23: Measurable Objectives for Interconnected Surface Water

	Measurable Objectives	Principal Aquifer(s)
Interconnected Surface Water	Measurable objectives are established at the midpoint between the MT and the historical high groundwater elevation at each representative monitoring site.	Western Upper and Eastern Principal Aquifers

6.9. SUMMARY OF SUSTAINABLE MANAGEMENT CRITERIA AND ADAPTIVE MANAGEMENT

Collectively, the sustainable management criteria discussed in this GSP chapter provide a robust set of criteria to avoid undesirable results and achieve the Modesto Subbasin sustainability goal. Sustainable management criteria provided in multiple tables above are summarized in **Table 6-24**, including the definition of undesirable results, minimum thresholds (MTs), and measurable objectives (MOs) for all sustainability indicators applicable to the Modesto Subbasin GSP.

Modesto Subbasin GSAs note that this initial sustainable management criteria employs new SGMA terminology and represents reasonable estimates for sustainable management of groundwater through the planning horizon. Nonetheless, it is recognized that sustainable management criteria – including the definition of undesirable results – may require adjustment in the future.

Improvements to the GSP monitoring network including new installations of monitoring wells are incorporated into this GSP. As the GSAs implement the GSP and monitoring network, additional information will be routinely compiled and analyzed to evaluate aquifer response to the initial sustainable management criteria.

GSAs recognize that monitoring results may indicate that the initial undesirable results definition and MTs require adjustment in the future. Actual MTs that lead to undesirable results may be higher or lower than those selected in **Table 6-24** as projects and management actions are implemented. Consistent with the concept of adaptive management, the GSAs report compliance and GSP implementation in Annual Reports. The GSAs will also re-evaluate the criteria in the five-year GSP evaluation and make appropriate adjustments to ensure that the Subbasin meets its sustainability goal within the GSP implementation period as required.

Table 6-24: Sustainable Management Criteria Summary

Sustainability Indicator	Undesirable Result Definition		Minimum Thresholds (MTs)	Measurable Objectives (MOs)	Principal Aquifers	GSP Section
	Narrative	Quantitative				
Chronic Lowering of Groundwater Levels	Undesirable results are defined as significant and unreasonable groundwater level declines – either due to multi-year droughts or due to chronic declines where groundwater is the sole supply – such that water supply wells are adversely impacted in a manner that cannot be readily managed or mitigated.	An undesirable result fwill occur when at least 33% of representative monitoring wells exceed the MT for a principal aquifer in 3 consecutive Fall monitoring events.	Historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data.	Midpoint between the historical high groundwater elevation and the MT at each representative monitoring location.	All Principal Aquifers	6.3
Reduction of Groundwater in Storage	An Undesirable result is defined as significant and unreasonable reduction of groundwater in storage that would occur if the volume of groundwater supply is at risk of depletion and is not accessible for beneficial use, or if the Subbasin remains in a condition of long-term overdraft based on projected water use and average hydrologic conditions.	An undesirable result will occur for a principal aquifer when at least 33% of representative monitoring wells exceed the MT for for that principal aquifer in 3 consecutive Fall monitoring events.	Historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data. (Chronic Lowering of Groundwater Levels as a proxy.)	Midpoint between the historical high groundwater elevation and the MT at each representative monitoring location. (Chronic Lowering of Groundwater Levels as a proxy.)	All Principal Aquifers	6.4
Seawater Intrusion	Not applicable in the Modesto Subbasin.	N/A	N/A	N/A	N/A	6.5
Degraded Water Quality	An Undesirable Result is defined as significant and unreasonable adverse impacts to groundwater quality as indicated by a new (first-time) exceedance of or further exceedance from an MCL of a constituent of concern (COC), that is caused by GSA projects, management actions, or management of groundwater levels or extractions such that beneficial uses are affected and well owners experience an increase in operational costs.	An undesirable result will occur when a Subbasin potable water supply well in the defined monitoring network reports a new (first-time) exceedance of an MT or an increase in concentration above the MT for a Modesto Subbasin constituent of concern (COC) that results in increased operational costs and is caused by GSA management activities as listed at left.	Minimum thresholds are set as the primary or secondary California maximum contaminant level (MCL) for each of seven (7) constituents of concern (COCs): Nitrate (as N) - 10 mg/L Arsenic - 10 ug/L Uranium - 20 pCi/L Total dissolved solids (TDS) - 500 mg/L Dibromochloropropane (DBCP) - 0.2 ug/L 1,2,3-Trichloropropane (TCP) - 0.005 ug/L Tetrachloroethene (PCE) - 5 ug/L.	Historical maximum concentration of each constituent of concern (COC) at each representative monitoring location.	All Principal Aquifers	6.6
Inelastic Land Subsidence	An Undesirable Result is defined as significant and unreasonable inelastic land subsidence, caused by groundwater extraction and associated water level declines, that adversely affects land use or reduces the viability of the use of critical infrastructure.	An undesirable result will occur when 33 percent of representative monitoring wells exceed the MT in three consecutive Spring monitoring events.	Historic low groundwater elevation observed or estimated during WY 1991 – WY 2020 at each representative monitoring location, based on available data. (Chronic Lowering of Groundwater Levels as a proxy.)	Midpoint between the historical high groundwater elevation and the MT at each representative monitoring location. (Chronic Lowering of Groundwater Levels as a proxy.)	All Principal Aquifers	6.7
Interconnected Surface Water	An Undesirable Result is defined as significant and unreasonable adverse impacts to the beneficial uses of surface water caused by groundwater extraction.	An undesirable result will occur on either the Tuolume or Stanislaus rivers when 33% of representative monitoring wells for that river exceed the MT in three consecutive Fall monitoring events. An undesirable result will occur on the San Joaquin River when 50% of representative monitoring wells for that river exceed the MT in three consecutive Fall monitoring events. The 50% criterion is based on the small number of representative montiroing wells currently avilable for the San Joaquin River and may change when additional wells are added to the monitoring network.	Low groundwater elevation observed in Fall 2015 at each representative monitoring location.	Midpoint between the historical high groundwater elevation and the MT at each representative monitoring site.	Western Upper Principal Aquifer and Eastern Principal Aquifer	6.8

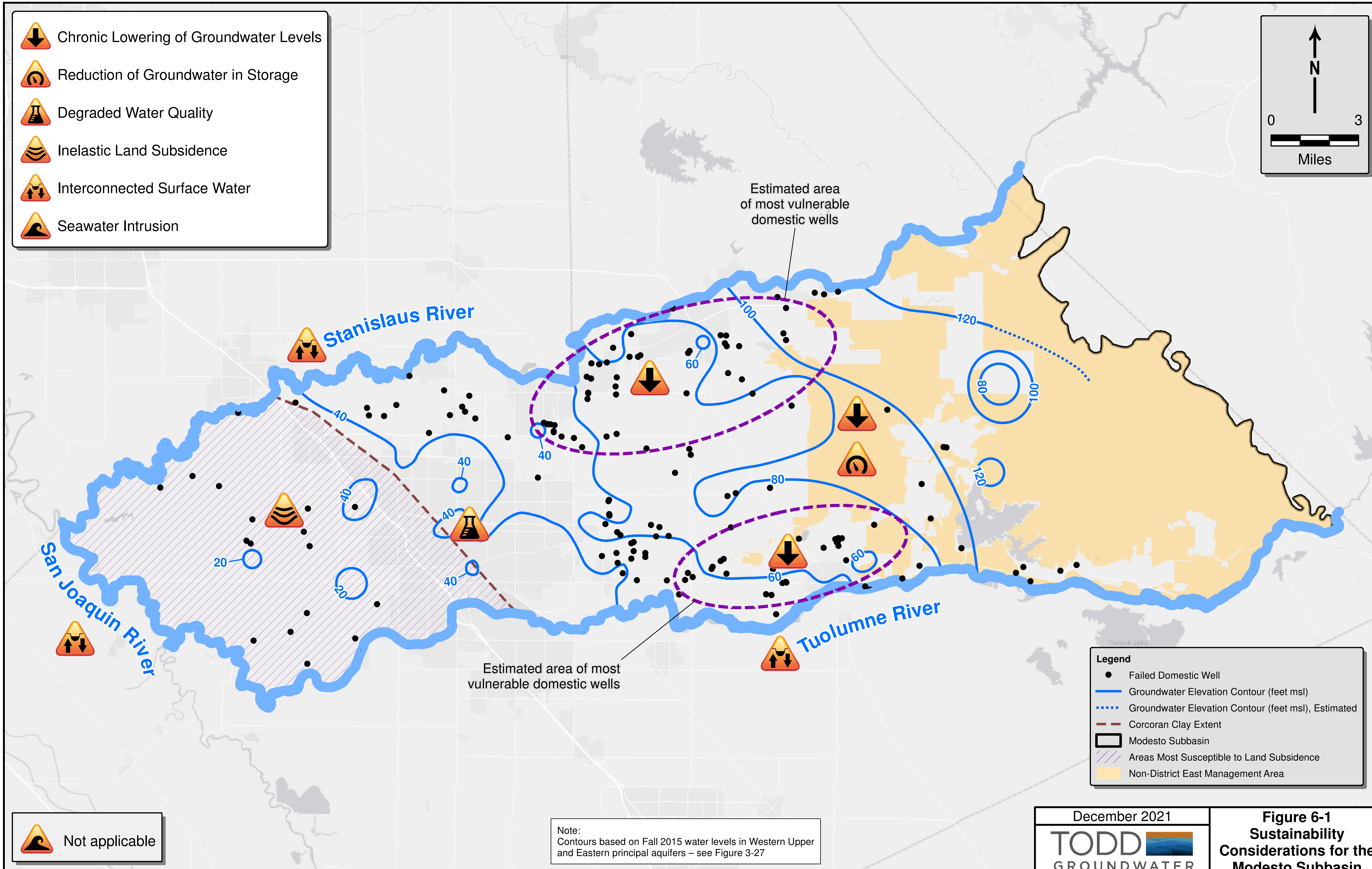


Figure 6-1
Sustainability Considerations for the Modesto Subbasin

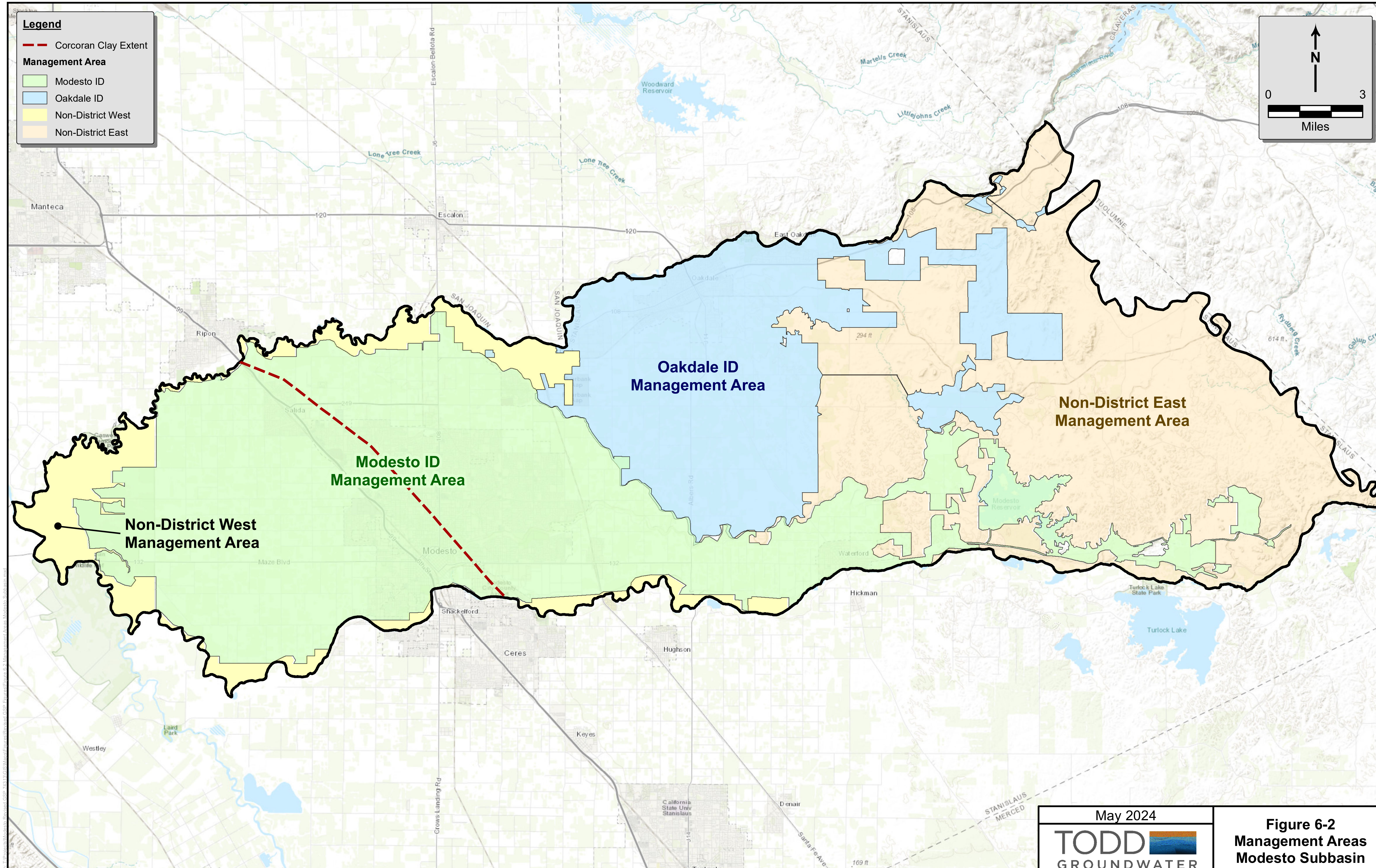


Figure 6-2
Management Areas
Modesto Subbasin

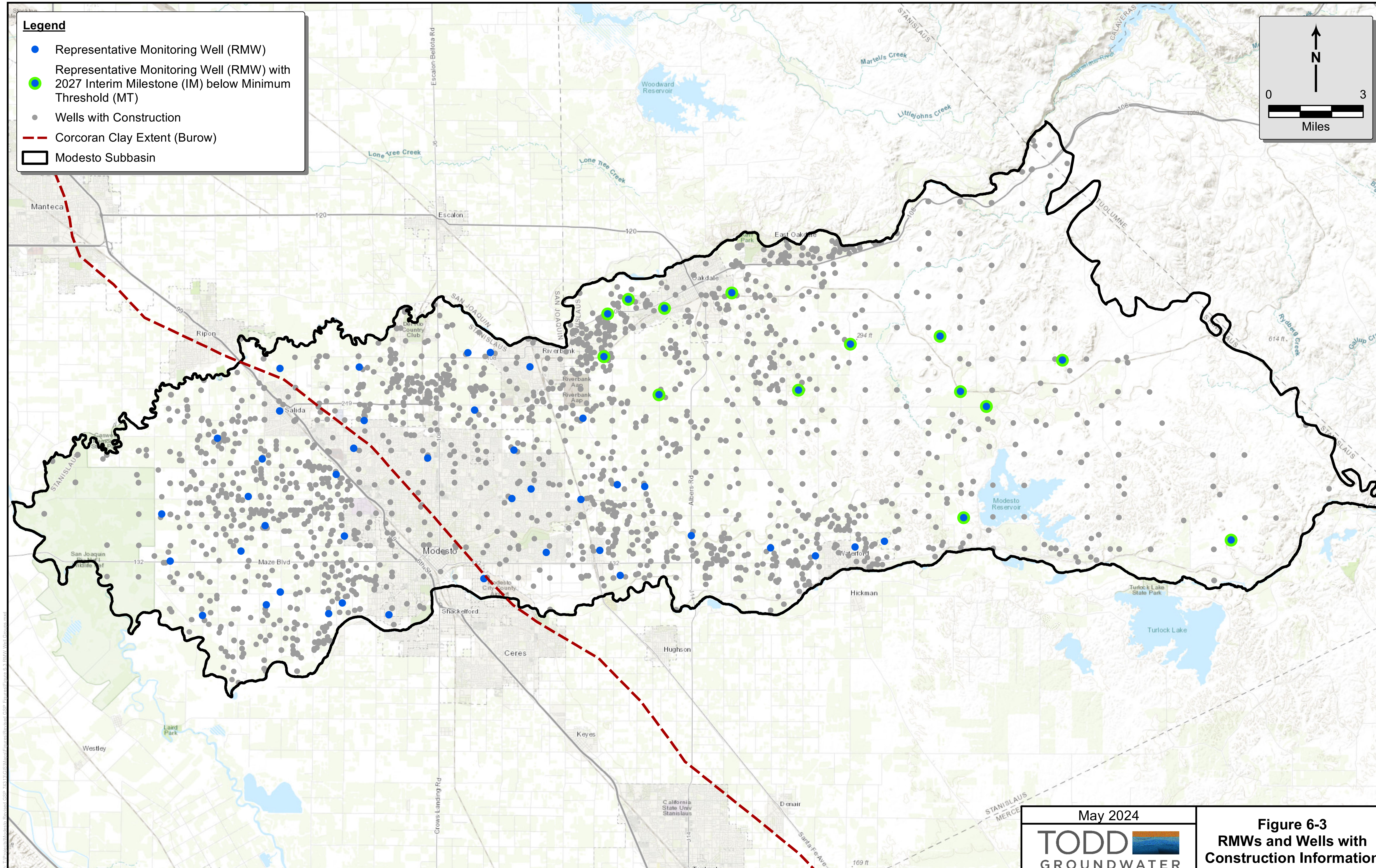


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Figure 6-3
RMWs and Wells with Construction Information

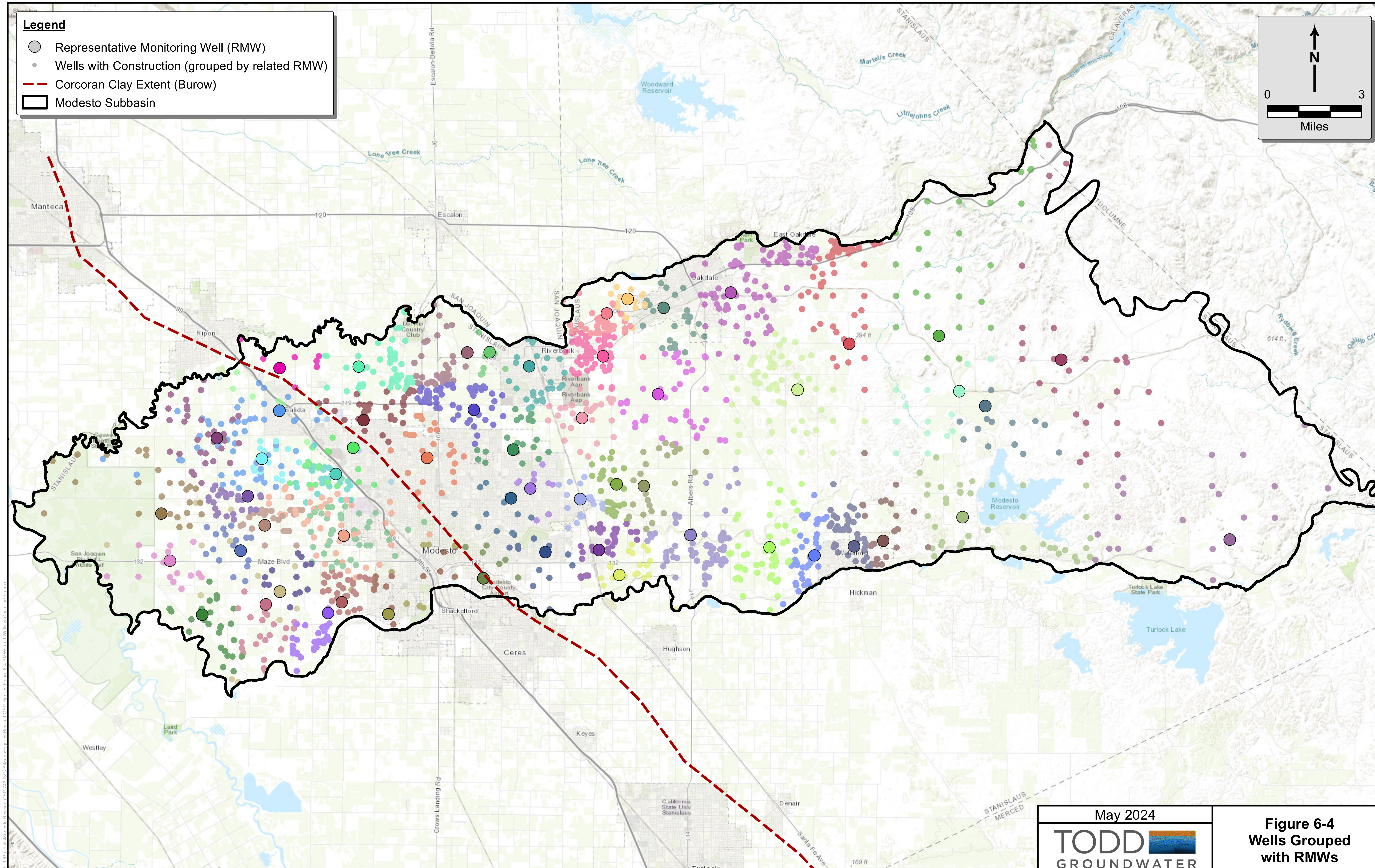

Figure 6-4
Wells Grouped with RMWs

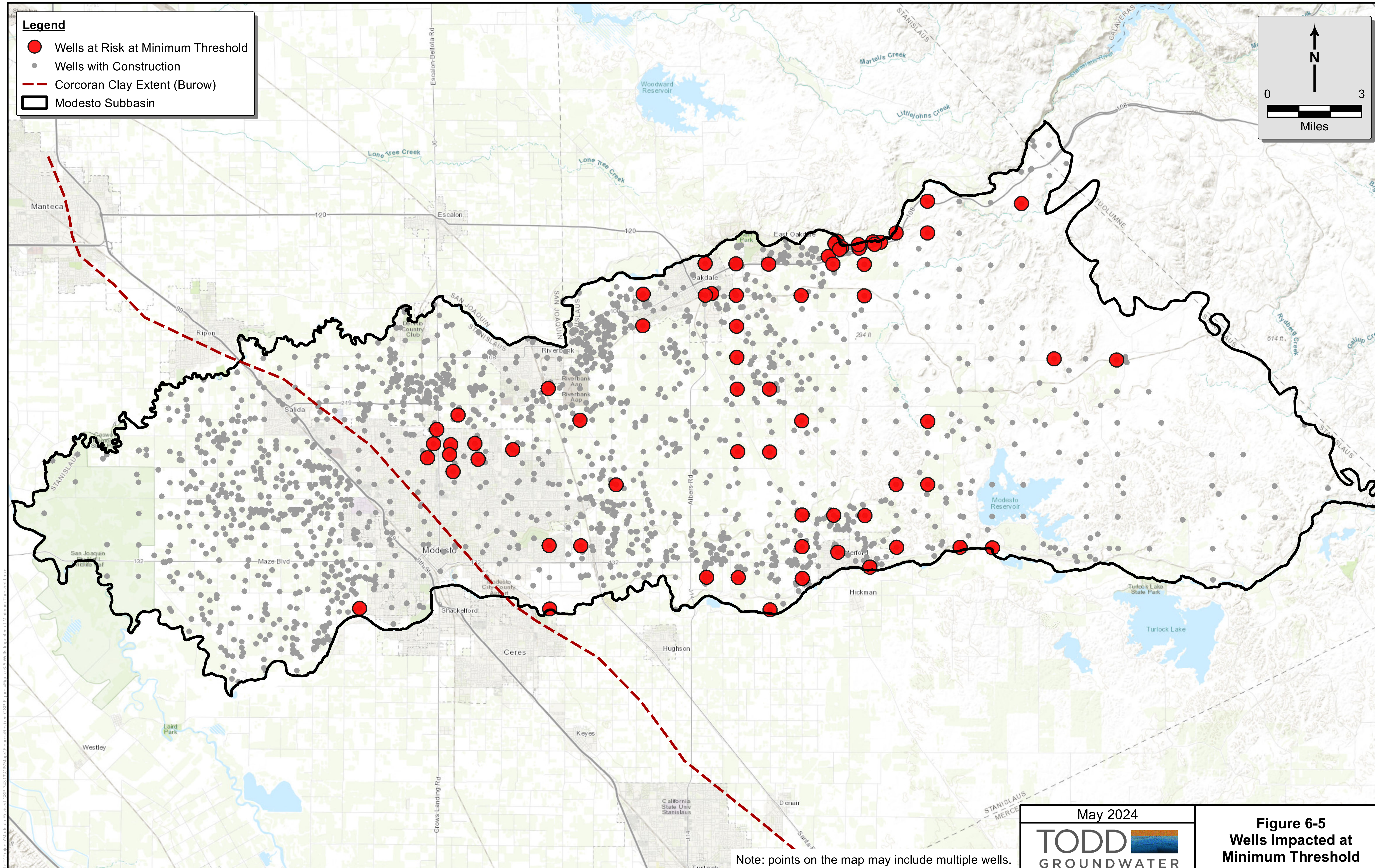

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Figure 6-5
Wells Impacted at Minimum Threshold

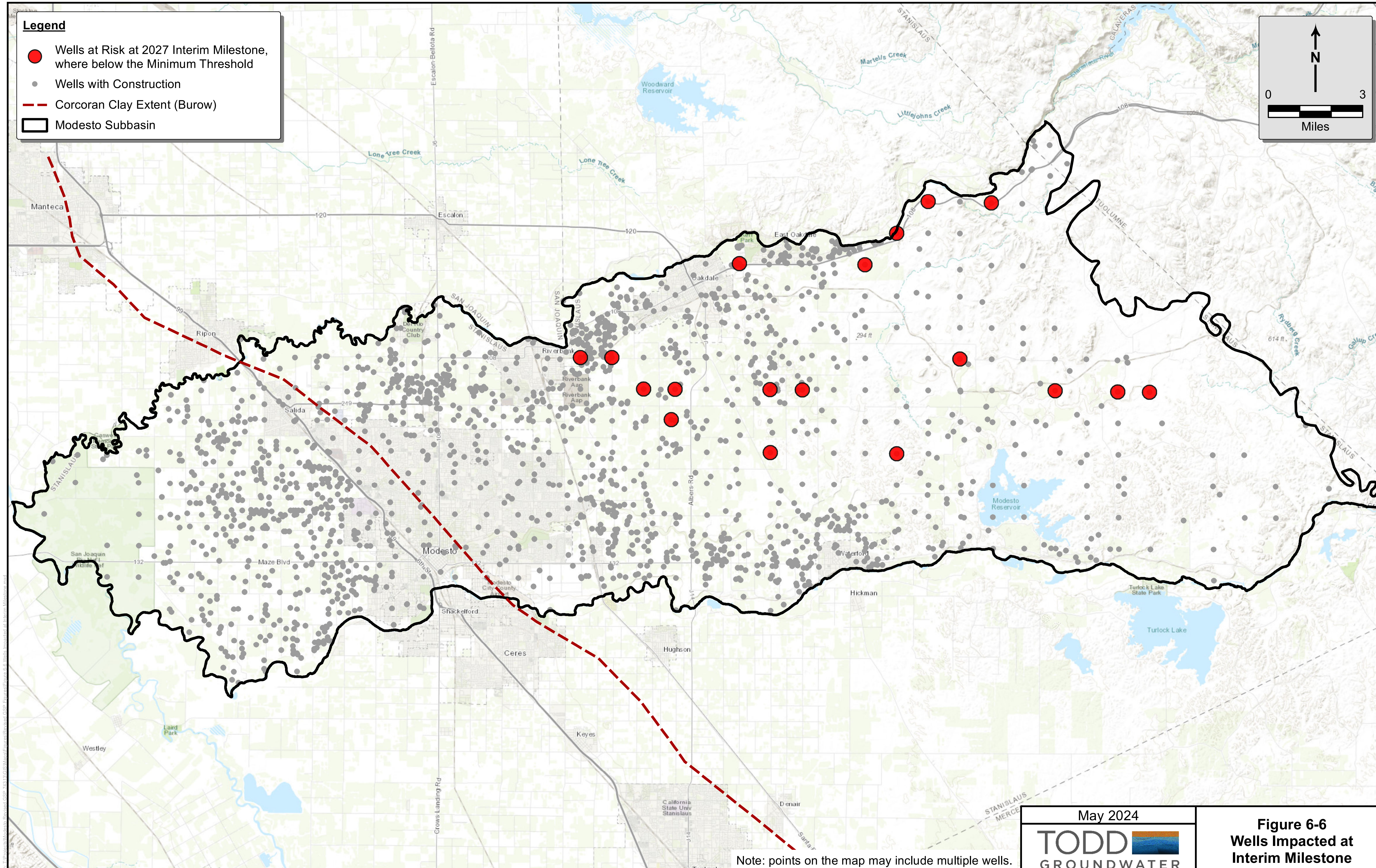

Figure 6-6
Wells Impacted at Interim Milestone

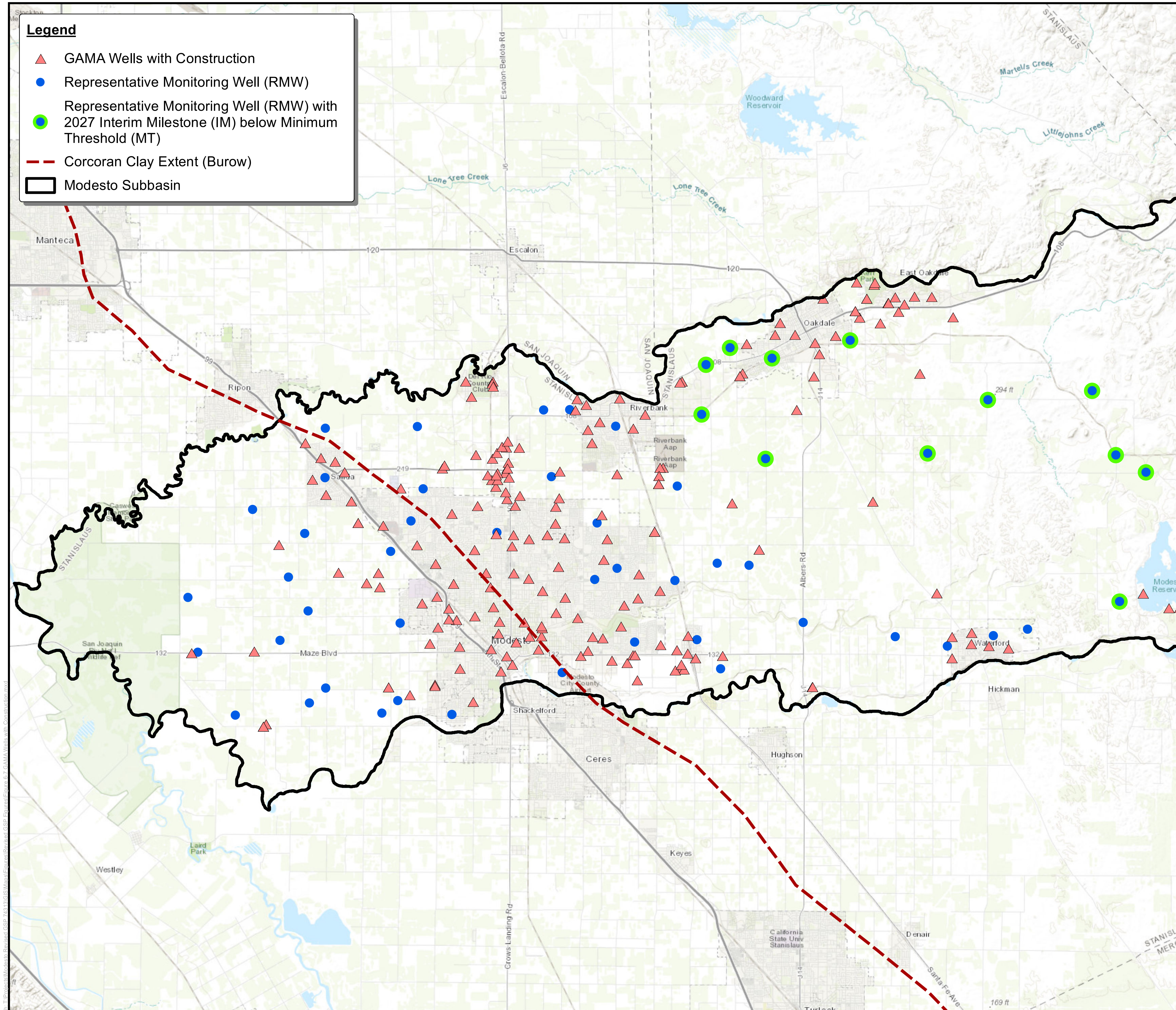

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Figure 6-7
GAMA Wells with Construction