



California Department of Water Resources
Sustainable Groundwater Management Program

November 2017

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Best Management Practices for the
Sustainable Management of Groundwater

Sustainable
Management Criteria

BMP

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Sustainable Management Criteria

Best Management Practice

1. OBJECTIVE

The Department of Water Resources (the Department) developed this Best Management Practice (BMP) document to describe activities, practices, and procedures for defining the sustainable management criteria required by the Groundwater Sustainability Plan Regulations (GSP Regulations).¹ This BMP characterizes the relationship between the different sustainable management criteria – the *sustainability goal*, *undesirable results*, *minimum thresholds*, and *measurable objectives* – and describes best management practices for developing these criteria as part of a Groundwater Sustainability Plan (GSP).

The Sustainable Groundwater Management Act (SGMA)² and GSP Regulations specify the requirements of a GSP. This BMP does not impose new requirements, but describes best management practices for satisfying the requirements of SGMA and the GSP Regulations. A Groundwater Sustainability Agency (GSA) is not required to follow this BMP when developing a GSP, but whatever methodology is adopted by a GSA must be reasonable and supported by the best available information and best available science.³ While this document describes methods by which a GSA may approach the task of establishing sustainable management criteria recommended as best management practices by the Department, adopting the methods recommended in this BMP does not guarantee approval of the resulting GSP by the Department.

Examples provided in this BMP are intentionally simplified and are intended only to illustrate concepts. GSAs should not consider the level of detail in any of these simplified examples (e.g., the number of minimum thresholds defined in a hypothetical basin, the number of minimum thresholds that constitute an undesirable result, etc.) to be appropriate for their GSP.

2. INTRODUCTION

SGMA defines *sustainable groundwater management* as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.⁴ The avoidance of undesirable results is thus critical to the success of a GSP.

GSP Regulations collect together several requirements of a GSP under the heading of “Sustainable Management Criteria” in Subarticle 3 of Article 5.⁵ Sustainable management criteria include:

- **Sustainability Goal**

- **Undesirable Results**
- **Minimum Thresholds**
- **Measurable Objectives**

The development of these criteria relies upon information about the basin developed in the *hydrogeologic conceptual model*, the description of current and historical groundwater conditions, and the *water budget*.

Key terms are *italicized* the first time they are presented, indicating that a definition for the term is provided in the Key Definitions section located at the end of this document.

SGMA REQUIREMENT TO QUANTIFY SUSTAINABILITY

The enactment of SGMA in 2014 was a landmark effort to manage California's groundwater in a sustainable manner. The SGMA legislation established definitions of undesirable results, introduced the statutory framework and timelines for achieving sustainability, and identified requirements that local agencies (i.e. GSAs) must follow to engage the beneficial uses and users of groundwater within a basin, among many other important topics. The GSP Regulations developed by the Department specify the documentation and evaluation of groundwater conditions within a basin and the requirements for the development and implementation of plans to achieve or maintain sustainability required by SGMA.

As described in SGMA, sustainable conditions within a basin are achieved when GSAs meet their sustainability goal and demonstrate the basin is being operated within its *sustainable yield*. Sustainable yield can only be reached if the basin is not experiencing undesirable results. The GSP Regulations focus the development of GSPs on locally-defined, quantitative criteria, including undesirable results, minimum thresholds, and measurable objectives. Undesirable results must be eliminated through the implementation of projects and management actions, and progress toward their elimination will be demonstrated with empirical data (e.g., measurements of groundwater levels or subsidence). Quantitative sustainable management criteria allow GSAs to clearly demonstrate sustainability and allow the public and the Department to readily assess progress.

Properly documenting the requirements identified in Subarticle 3, Introduction to Sustainable Management Criteria, in Article 5 of the GSP Regulations, is imperative to maintaining an outcome-based approach to SGMA implementation and must be completed for the Department to consider the approval of a GSP.

3. PRELIMINARY ACTIVITIES

A GSA will need to understand the basin's physical condition, the overlying management and legal structures, and the basin's water supplies and demands prior to developing sustainable management criteria. As a result, before a GSA begins the process of developing sustainable management criteria, the following activities should be completed:

Understand the Basin Setting

A thorough understanding of the historical and current state of the basin is necessary before sustainable management criteria can be set. Much of this understanding is gained in the development of a hydrogeologic conceptual model, water budget, and description of groundwater conditions. For more information, see the [Hydrogeologic Conceptual Model BMP](#), [Water Budget BMP](#), and [Modeling BMP](#).

Inventory Existing Monitoring Programs

Minimum thresholds and measurable objectives are set at individual representative monitoring sites. GSAs should compile information from existing monitoring programs (e.g., number of wells and their construction details, which aquifers they monitor). As sustainable management criteria are set, monitoring networks may need to be expanded and updated beyond those used for existing, pre-SGMA monitoring programs. Additional information on monitoring networks is included in the [Monitoring Networks and Identification of Data Gaps BMP](#).

Engage Interested Parties within the Basin

When setting sustainable management criteria, GSAs must consider the beneficial uses and users of groundwater in their basin. Consideration of the potential effects on beneficial uses and users underpin the minimum thresholds. GSAs must explain their decision-making processes and how public input was used in the development of their GSPs. There are specific SGMA requirements for GSAs to engage with interested parties within a basin. For more information about requirements of engagement, refer to the [Stakeholder Communication and Engagement Guidance Document](#).

4. SETTING SUSTAINABLE MANAGEMENT CRITERIA

This section describes the development of sustainable management criteria. The section is organized as follows:





- Assessment of *sustainability indicators*, significant and unreasonable conditions, *management areas*, and representative monitoring sites
- Minimum thresholds
- Undesirable results
- Measurable objectives
- Sustainability goal

This organization follows a chronological ordering that GSAs can use as they plan for sustainable management criteria development, although they do not have to proceed in that order. Furthermore, setting sustainable management criteria will likely be an iterative process. Initial criteria may need to be adjusted to address potential effects on the beneficial uses and users of groundwater, land uses, and property interests. The GSA should evaluate whether the sustainable management criteria, as a whole, adequately characterize how and when significant and unreasonable conditions occur, and define a path toward sustainable groundwater management in the basin.

ASSESSMENT OF SUSTAINABILITY INDICATORS, SIGNIFICANT AND UNREASONABLE CONDITIONS, MANAGEMENT AREAS, AND REPRESENTATIVE MONITORING SITES

Sustainability Indicators

Sustainability indicators are the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, become undesirable results.⁶ Undesirable results are one or more of the following effects:

-  Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. 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
-  Significant and unreasonable reduction of groundwater storage
-  Significant and unreasonable seawater intrusion
-  Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies

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Significant and unreasonable land subsidence that substantially interferes with surface land uses



Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

The significant and unreasonable occurrence of any of the six sustainability indicators constitutes an undesirable result.

The default position for GSAs should be that all six sustainability indicators apply to their basin. If a GSA believes a sustainability indicator is not applicable for their basin, they must provide evidence that the indicator does not exist and could not occur. For example, GSAs in basins not adjacent to the Pacific Ocean, bays, deltas, or inlets may determine that seawater intrusion is not an applicable sustainability indicator, because seawater intrusion does not exist and could not occur. In contrast, simply demonstrating that groundwater levels have been stable in recent years is not sufficient to determine that land subsidence is not an applicable sustainability indicator. As part of the GSP evaluation process, the Department will evaluate the GSA's determination that a sustainability indicator does not apply for reasonableness.

Sustainability Indicators in the Context of SGMA versus the California Water Plan

The term "sustainability indicator" is used in GSP regulations to refer to "any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x)." It is important to note that the term 'sustainability indicator' is not unique to SGMA. The California Water Plan Update 2013 includes a California Water Sustainability Indicators Framework that uses the term 'sustainability indicator' in a way that differs from SGMA. Sustainability indicators in the context of the California Water Plan inform users about the relationship of water system conditions to ecosystems, social systems, and economic systems.

Water managers and users should not confuse sustainability indicators in the context of SGMA with sustainability indicators associated with the California Water Plan or with any other water management programs.

Significant and Unreasonable Conditions

GSA must consider and document the conditions at which each of the six sustainability indicators become significant and unreasonable in their basin, including the reasons for justifying each particular threshold selected. A GSA may decide, for example, that localized inelastic land subsidence near critical infrastructure (e.g., a canal) and basinwide loss of domestic well pumping capacity due to lowering of groundwater levels are both significant and unreasonable conditions. These general descriptions of significant and unreasonable conditions are later translated into quantitative undesirable results, as described in this document. The evaluation of significant and unreasonable conditions should identify the geographic area over which the conditions need to be evaluated so the GSA can choose appropriate representative monitoring sites.

Use of Management Areas

A GSA may wish to define *management areas* for portions of its basin to facilitate groundwater management and monitoring. Management areas may be defined by natural or jurisdictional boundaries, and may be based on differences in water use sector, water source type, geology, or aquifer characteristics. Management areas may have different minimum thresholds and measurable objectives than the basin at large and may be monitored to a different level. However, GSAs in the basin must provide descriptions of why those differences are appropriate for the management area, relative to the rest of the basin.

Using the land subsidence example from the preceding subsection, GSAs in the hypothetical basin may decide that a management area in the vicinity of the canal is appropriate because the level of monitoring must be higher in that area, relative to the rest of the basin. GSAs may also desire to set more restrictive minimum thresholds in that area relative to the rest of the basin.

While management areas can be used to define different minimum thresholds and measurable objectives, other portions of the GSP (e.g., hydrogeologic conceptual model, water budget, notice and communication) must be consistent for the entire GSP area.

Representative Monitoring Sites

Representative monitoring sites are a subset of a basin's complete monitoring network, where minimum thresholds, measurable objectives, and *interim milestones* are set. Representative monitoring sites can be used for one sustainability indicator or multiple sustainability indicators. **Figure 1** shows how different combinations of representative monitoring sites can be used to assess seawater intrusion and lowering of groundwater levels in a hypothetical groundwater basin.

GSA's can only select representative monitoring sites after determining what constitutes significant and unreasonable conditions in a basin. Using the example discussed in the preceding subsections, the GSA would use a different combination of representative monitoring sites for localized inelastic land subsidence than it would for basinwide groundwater level decline. The GSA must explain how the combination of representative monitoring sites selected for each sustainability indicator can assess the significant and unreasonable groundwater condition.

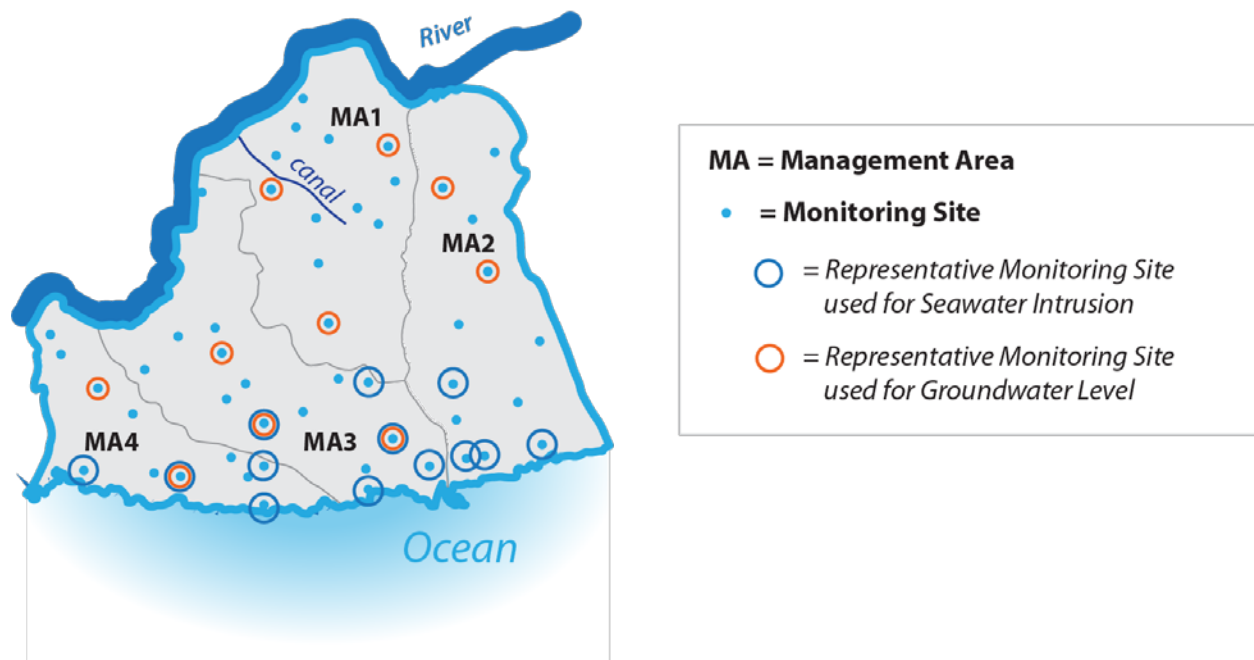


Figure 1. Example Monitoring Network and Representative Monitoring Sites

MINIMUM THRESHOLDS

A minimum threshold is the quantitative value that represents the groundwater conditions at a representative monitoring site that, when exceeded individually or in combination with minimum thresholds at other monitoring sites, may cause an undesirable result(s) in the basin. GSAs will need to set minimum thresholds at representative monitoring sites for each applicable sustainability indicator after considering the interests of beneficial uses and users of groundwater, land uses, and property interests in the basin. Minimum thresholds should be set at levels that do not impede adjacent basins from meeting their minimum thresholds or sustainability goals.

Required Components for all Minimum Thresholds

GSP Regulations require six components of information to be documented for each minimum threshold.⁷ The six components (in italicized text) and considerations for how they should be addressed are as follows:

1. *The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.*

The GSP must include an analysis and written interpretation of the information, data, and rationale used to set the minimum threshold. For instance, if a groundwater level minimum threshold is set to protect shallow domestic supply wells, the GSA should investigate information such as the depth ranges of domestic wells near the representative monitoring site, aquifer dimensions, groundwater conditions, and any other pertinent information.

2. *The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.*

The GSP must describe the relationship between each sustainability indicator's minimum threshold (e.g., describe why or how a water level minimum threshold set at a particular representative monitoring site is similar to or different to water level thresholds in nearby representative monitoring sites). The GSP also must describe the relationship between the selected minimum threshold and minimum thresholds for other sustainability indicators (e.g., describe how a water level minimum threshold would not trigger an undesirable result for land subsidence).

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3. *How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.*

The GSP must describe how the minimum threshold has been set to avoid impacts to adjacent basins. This can be supported by information such as an interbasin agreement, documentation of coordination with GSAs in adjacent basins, and general descriptions of how the minimum threshold is consistent with sustainable management criteria in adjacent basins. Information provided for this component will likely be enhanced beyond the initial GSP in future annual reports and five-year updates. It may be important to inform GSAs in adjacent basins where minimum thresholds are planned and their quantitative values.

4. *How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.*

The GSP must discuss how groundwater conditions at a selected minimum threshold could affect beneficial uses and users. This information should be supported by a description of the beneficial uses groundwater and identification of beneficial uses, which should be developed through communication, outreach, and/or engagement with parties representing those beneficial uses and users, along with any additional information the GSA used when developing the minimum threshold.

5. *How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.*

The GSP must discuss relevant standards that pertain to the sustainability indicator and justify any differences between the selected minimum threshold and those standards. For instance, the GSP will need to justify why a different level was used if a water quality minimum threshold is set at a different level than a state or federal maximum contaminant level (MCL).

6. *How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.*

Subarticle 4 of the GSP Regulations addresses monitoring networks. The GSP must document the metrics that will be monitored (e.g., groundwater level, groundwater quality) as well as the frequency and timing of measurement (e.g., twice per year in the spring and fall).

Descriptions for these six components are required for all minimum thresholds. However, descriptions for individual components can be shared for multiple minimum thresholds, where appropriate (e.g., in some instances a single description could be provided to describe how a group of minimum thresholds were selected to avoid causing undesirable results in an adjacent basin).

Required Minimum Threshold Metrics for Each Sustainability Indicator

In addition to the six components described above that apply to all minimum thresholds, the GSP Regulations contain specific requirements and metrics for each sustainability indicator.⁸ The purpose of the specific requirements is to ensure consistency within groundwater basins and between adjacent groundwater basins.

Specific requirements for the metrics used to quantify each sustainability indicator are listed below and shown in **Figure 2**:

- The minimum threshold metric for the **chronic lowering of groundwater levels** sustainability indicator shall be a groundwater elevation measured at the representative monitoring site.
- The minimum threshold for **reduction of groundwater storage** is a volume of groundwater that can be withdrawn from a basin or management area, based on measurements from multiple representative monitoring sites, without leading to undesirable results. Contrary to the general rule for setting minimum thresholds, the reduction of groundwater storage minimum threshold is not set at individual monitoring sites. Rather, the minimum threshold is set for a basin or management area.
- The minimum threshold metric for **seawater intrusion** shall be the location of a chloride isocontour. Contrary to the general rule for setting minimum thresholds, the seawater intrusion minimum threshold is not set at individual monitoring sites. Rather, the minimum threshold is set along an isocontour line in a basin or management area.
- The minimum threshold metric for **degraded water quality** shall be water quality measurements that indicate degradation at the monitoring site. This can be based on migration of contaminant plumes, number of supply wells, volume of groundwater, or the location of a water quality isocontour within the basin. Depending on how the GSA defines the degraded water quality minimum threshold, it can be defined at a site, along the isocontour line, or as a calculated volume.
- The minimum threshold metric for **land subsidence** shall be a rate and the extent of land subsidence.
- The minimum threshold metric for **depletion of interconnected surface waters** shall be a rate or volume of surface water depletion.







Sustainability Indicators	 Lowering GW Levels	 Reduction of Storage	 Seawater Intrusion	 Degraded Quality	 Land Subsidence	 Surface Water Depletion
Metric(s) Defined in GSP Regulations	<ul style="list-style-type: none"> Groundwater Elevation 	<ul style="list-style-type: none"> Total Volume 	<ul style="list-style-type: none"> Chloride concentration isocontour 	<ul style="list-style-type: none"> Migration of Plumes Number of supply wells Volume Location of isocontour 	<ul style="list-style-type: none"> Rate and Extent of Land Subsidence 	<ul style="list-style-type: none"> Volume or rate of surface water depletion

Figure 2. Minimum Threshold Metrics

Examples and Considerations for Minimum Thresholds

The following provides graphical examples and considerations for use by GSAs when setting minimum thresholds. The following subsections are organized by sustainability indicator and are illustrative examples only, as GSAs may have other considerations when setting minimum thresholds.

Chronic Lowering of Groundwater Levels Minimum Threshold

Figure 3 illustrates a hypothetical groundwater level hydrograph and associated minimum threshold at a representative monitoring site. In this hypothetical example, the GSA set the minimum threshold at some level below conditions at the time of GSP submission. Note that this and many subsequent examples in this document use 2020 as the hypothetical GSP submission date. The actual GSP submission date required by SGMA varies. GSPs must be submitted by January 31, 2020 for high- and medium-priority basins determined by the Department to be critically overdrafted. All other high- and medium-priority basins must submit GSPs by January 31, 2022.

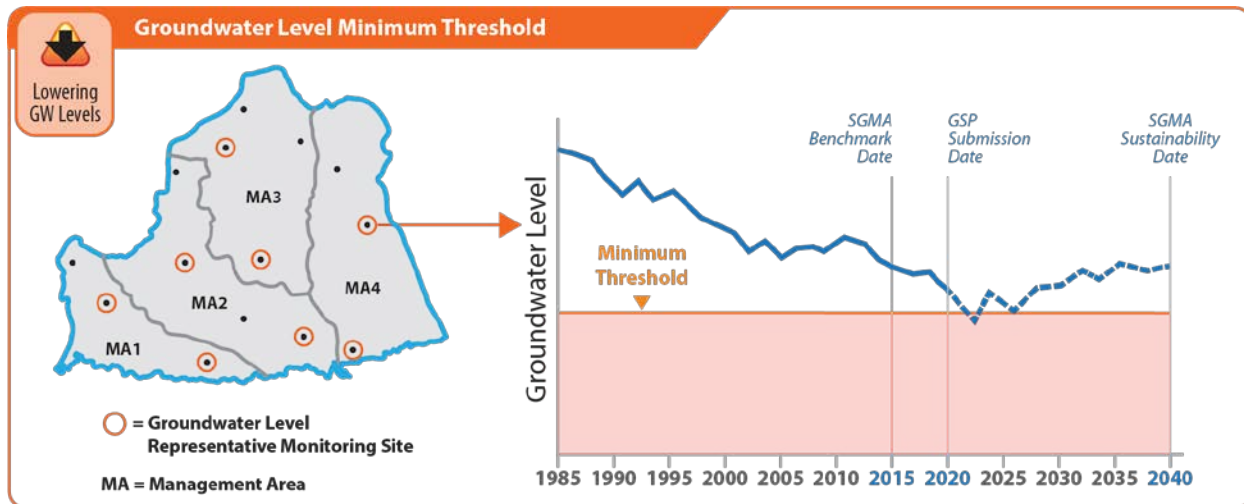


Figure 3. Example Groundwater Level Minimum Threshold Established at a Representative Monitoring Site

Considerations when establishing minimum thresholds for groundwater levels at a given representative monitoring site may include, but are not limited to:

- What are the historical groundwater conditions in the basin?
- What are the average, minimum, and maximum depths of municipal, agricultural, and domestic wells?
- What are the screen intervals of the wells?
- What impacts do water levels have on pumping costs (e.g., energy cost to lift water)?
- What are the adjacent basin's minimum thresholds for groundwater elevations?
- What are the potential impacts of changing groundwater levels on groundwater dependent ecosystems?
- Which principal aquifer, or aquifers, is the representative monitoring site evaluating?

Reduction in Groundwater Storage Minimum Threshold

Figure 4 illustrates a hypothetical graph depicting the volume of groundwater available in storage through time, and the associated minimum threshold for the basin.

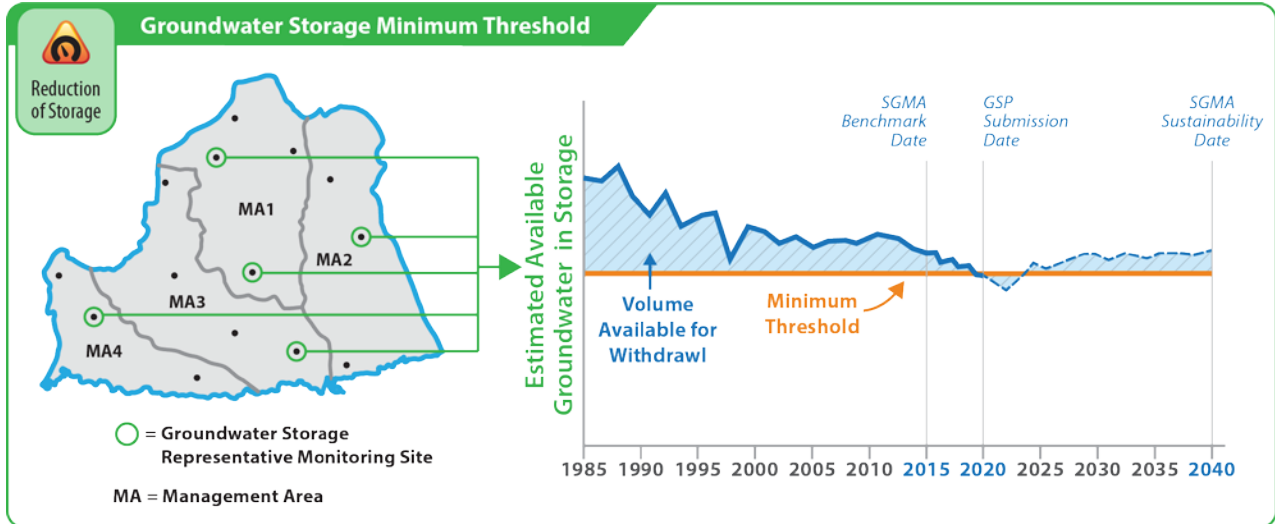


Figure 4. Example Groundwater Storage Minimum Threshold Established at the Basin Scale

Considerations when establishing the minimum threshold for groundwater storage may include, but are not limited to:

- What are the historical trends, water year types, and projected water use in the basin?
- What groundwater reserves are needed to withstand future droughts?
- Have production wells ever gone dry?
- What is the effective storage of the basin? This may include understanding of the:
 - Average, minimum, and maximum depth of municipal, agricultural, and domestic wells.
 - Impacts on pumping costs (i.e., energy cost to lift water).
- What are the adjacent basin’s minimum thresholds?

Seawater Intrusion Minimum Threshold

Figure 5 illustrates hypothetical chloride isoconcentration contours for two aquifers in a coastal basin. The isoconcentration contours are used as minimum thresholds for seawater intrusion.

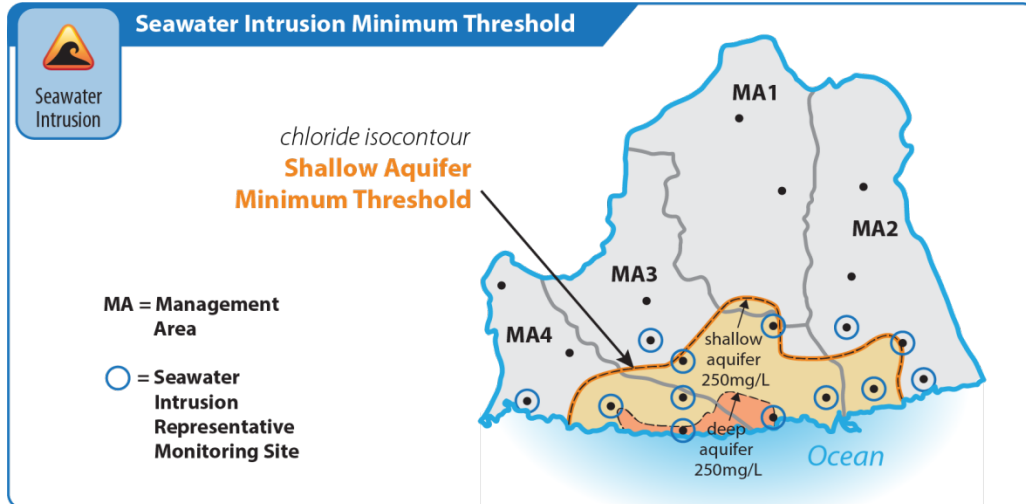


Figure 5. Example Seawater Intrusion Minimum Threshold Established at the Chloride Isocontour

Considerations when establishing minimum thresholds for seawater intrusion at a given isocontour location may include, but are not limited to:

- What is the historical rate and extent of seawater intrusion in affected principal aquifers?
- How are land uses in the basin sensitive to seawater intrusion?
- What are the financial impacts of seawater intrusion on agricultural, municipal, and domestic wells?
- What are the Regional Water Quality Control Board Basin Plan objectives?
- What are the adjacent basin's minimum thresholds?

Degraded Groundwater Quality Minimum Threshold

Figure 6 illustrates two hypothetical minimum thresholds for groundwater quality in a basin. The minimum threshold depicted on the top graph is associated with point source contamination (e.g., PCE released from a dry cleaner) and the minimum threshold depicted on the lower graph is associated with nonpoint source contamination (e.g., nitrate in groundwater from regional land use practices).

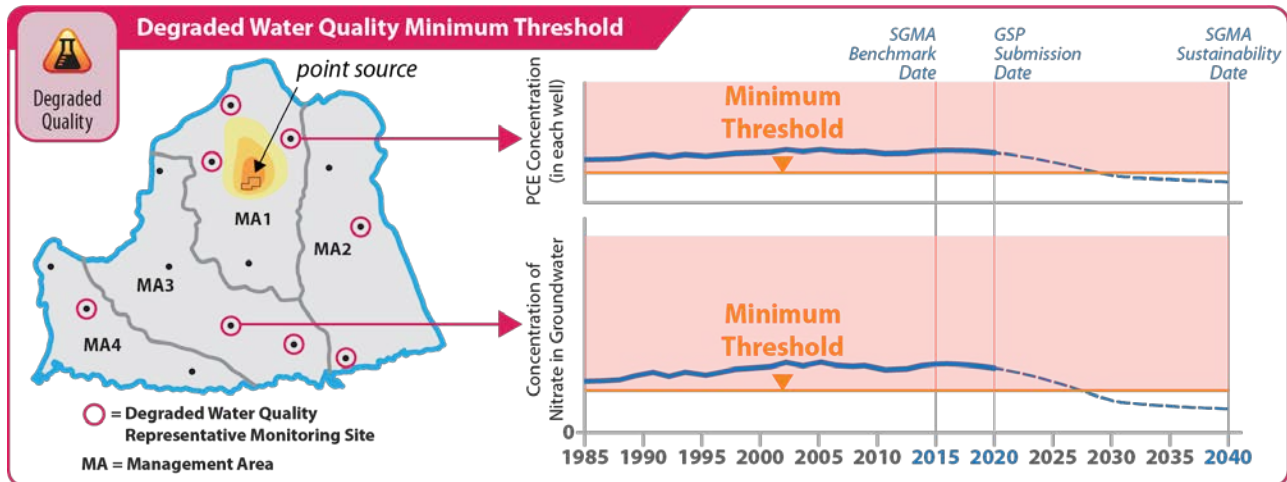


Figure 6. Example Degraded Water Quality Minimum Threshold Established for Point and Nonpoint Source Pollutants

Considerations when establishing minimum thresholds for water quality may include, but are not limited to:

- What are the historical and spatial water quality trends in the basin?
- What is the number of impacted supply wells?
- What aquifers are primarily used for providing water supply?
- What is the estimated volume of contaminated water in the basin?
- What are the spatial and vertical extents of major contaminant plumes in the basin, and how could plume migration be affected by regional pumping patterns?
- What are the applicable local, State, and federal water quality standards?
- What are the major sources of point and nonpoint source pollution in the basin, and what are their chemical constituents?
- What regulatory projects and actions are currently established to address water quality degradation in the basin (e.g., an existing groundwater pump and treat system), and how could they be impacted by future groundwater management actions?
- What are the adjacent basin's minimum thresholds?

Land Subsidence Minimum Threshold

Figure 7 illustrates a hypothetical minimum threshold for land subsidence in a basin. The minimum threshold depicts a cumulative amount of subsidence at a given point.

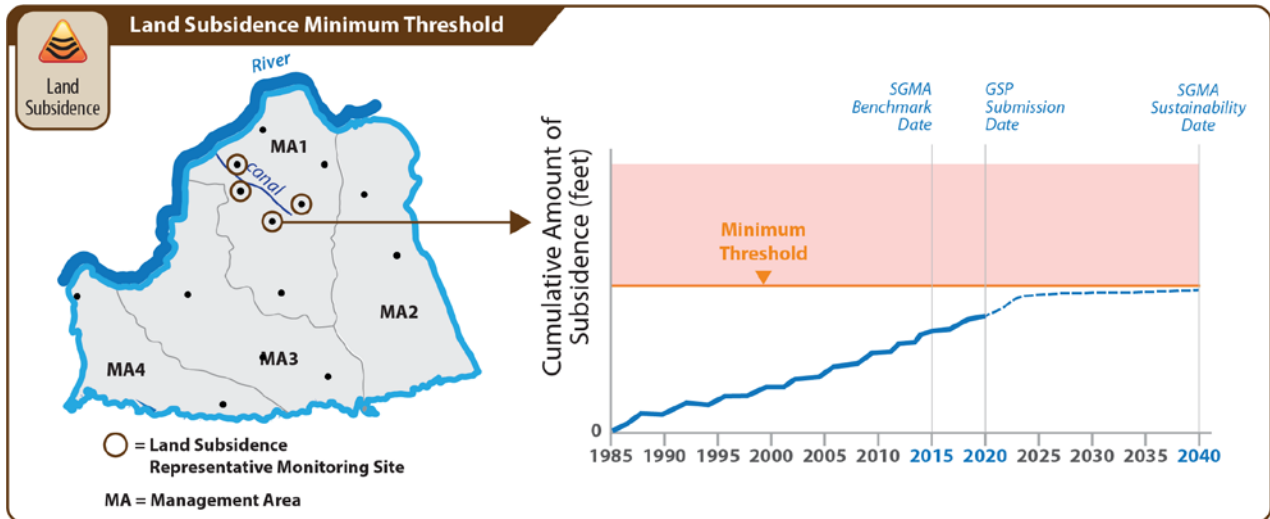


Figure 7. Example Land Subsidence Minimum Threshold

Considerations when establishing minimum thresholds for land subsidence at a given representative monitoring site may include, but are not limited to:

- Do principle aquifers in the basin contain aquifer material susceptible to subsidence?
- What are the historical, current, and projected groundwater levels, particularly the historical lows?
- What is the historical rate and extent of subsidence?
- What are the land uses and property interests in areas susceptible to subsidence?
- What is the location of infrastructure and facilities susceptible to subsidence (e.g., canals, levees, pipelines, major transportation corridors)?
- What are the adjacent basin’s minimum thresholds?

Depletion of Interconnected Surface Water Minimum Threshold

Figure 8 shows a hypothetical minimum threshold for depletion of interconnected surface waters. This example presents the potential stream depletion rate (or volume) due to groundwater pumping simulated by the basin’s integrated hydrologic model. Other approaches for demonstrating stream depletion, instead of the use of a numerical model, may be valid.

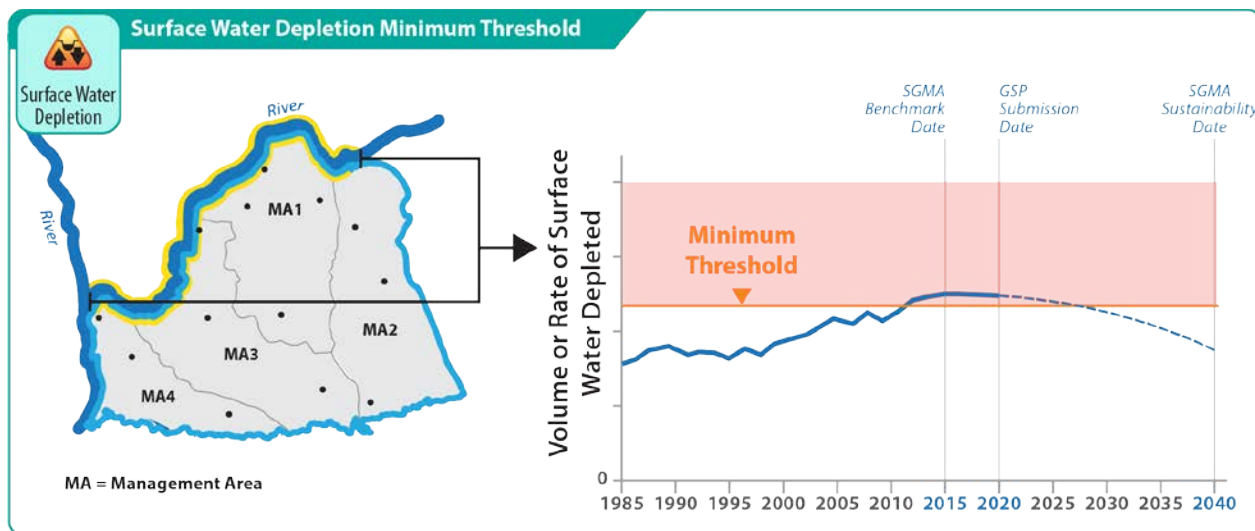


Figure 8. Example of Depletion of Interconnected Surface Water Minimum Threshold

Considerations when establishing minimum thresholds for depletions of interconnected surface water may include, but are not limited to:

- What are the historical rates of stream depletion for different water year types?
- What is the uncertainty in streamflow depletion estimates from analytical and numerical tools?
- What is the proximity of pumping to streams?
- Where are groundwater dependent ecosystems in the basin?
- What are the agricultural and municipal surface water needs in the basin?
- What are the applicable State or federally mandated flow requirements?

Using Groundwater Elevations as a Proxy

GSP Regulations allow GSAs to use groundwater elevation as a proxy metric for any (or potentially all) of the sustainability indicators when setting minimum thresholds⁹ and measurable objectives¹⁰, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics.¹¹

Two possible approaches for using groundwater elevation as a proxy metric for the definition of sustainable management criteria are:

- (1) Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only

chronic lowering of groundwater levels but other sustainability indicators at a given site.

- (2) Identify representative groundwater elevation monitoring sites where minimum thresholds and measurable objectives based on groundwater levels are developed for a specific sustainability indicator. In other words, the use of a groundwater level minimum threshold is not intended to satisfy the minimum threshold requirements for chronic lowering of groundwater but is intended solely for establishing a threshold for another sustainability indicator.

Subsidence as an Example

As described below, either approach could be applied to subsidence.

- **Approach 1** – Groundwater level minimum thresholds are above historical low groundwater levels. The GSA determines and documents that avoidance of the minimum thresholds for groundwater levels will also ensure that subsidence will be avoided. In this approach, the GSA would be applying the same numeric definition to two undesirable results – chronic lowering of groundwater and subsidence (**Figure 9**).
- **Approach 2** – The GSA has determined that specific areas are prone to subsidence, knows what the historical low groundwater levels are for those areas, and has demonstrated that no additional inelastic land subsidence will occur as long as groundwater levels remain above historical lows. The GSA develops minimum thresholds for land subsidence based on groundwater levels for the areas prone to subsidence (**Figure 9**). These land subsidence representative monitoring sites are not necessarily included as representative monitoring sites for groundwater level decline.

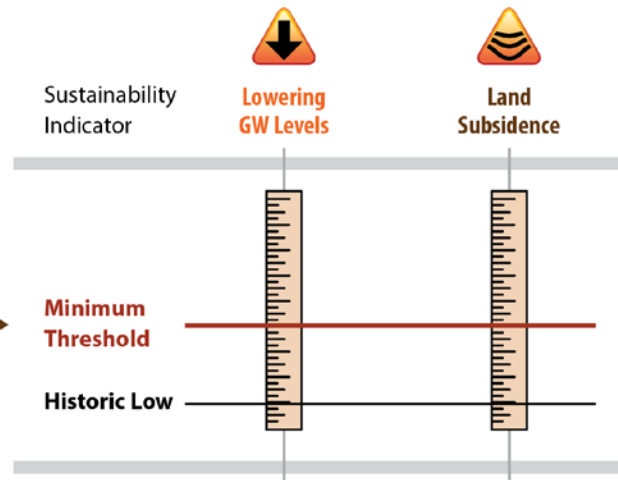
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EXAMPLE 1

Groundwater elevation as a proxy for land subsidence



- = Groundwater Level Representative Monitoring Site
- = Land Subsidence Representative Monitoring Site
- MA = Management Area



Metric

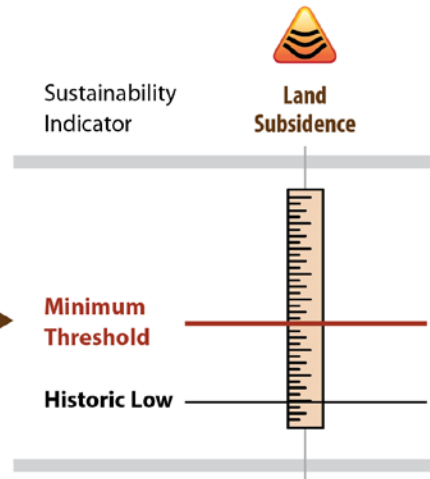
- **Groundwater Elevation**
(metric defined in GSP Regulations)
- **Groundwater Elevation as a proxy**
(with demonstration of significant correlation between groundwater elevation and land subsidence)

EXAMPLE 2

Groundwater elevation as a proxy for land subsidence



- = Land Subsidence Representative Monitoring Site
- MA = Management Area



Metric

- **Groundwater Elevation as a proxy**
(with demonstration of significant correlation between groundwater elevation and land subsidence)

Note: This example uses groundwater elevation as a proxy metric for the land subsidence sustainability indicator, but groundwater elevation can be used as a proxy for other sustainability indicators.

Figure 9. Example of Using Groundwater Elevation as a Proxy for Subsidence Monitoring

UNDESIRABLE RESULTS

Undesirable results occur when conditions related to any of the six sustainability indicators become significant and unreasonable. Undesirable results will be used by the Department to determine whether the sustainability goal has been achieved within the basin.

All undesirable results will be based on minimum thresholds exceedances. Undesirable results will be defined by minimum threshold exceedances at a single monitoring site, multiple monitoring sites, a portion of a basin, a management area, or an entire basin. Exceeding a minimum threshold at a single monitoring site is not necessarily an undesirable result, but it could signal the need for modifying one or more management actions, or implementing a project to benefit an area before the issue becomes more widespread throughout the basin. However, the GSP must define when an undesirable result is triggered.

The GSP must include a description for each undesirable result. Undesirable results must be agreed upon by all GSAs within a basin. If there is more than one GSP in the basin, a single undesirable result description must be agreed upon and documented in the coordination agreement.

GSP Regulations require three components for each undesirable result.¹² The three components (in italicized text) and considerations for how they should be addressed are as follows:

1. *The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*¹³

The GSP document the factors that may lead to, or have led to, undesirable results. These factors may be localized or basinwide. An example of a localized cause for undesirable results is a group of active wells that are inducing significant and unreasonable land subsidence in a nearby canal. An example of a basinwide cause is general overpumping of groundwater that leads to a significant and unreasonable reduction of groundwater storage. There will often be multiple causes for groundwater conditions becoming significant and unreasonable, and GSAs must investigate each. Even if a basin does not currently have undesirable results, the GSP Regulations require GSAs to consider the causes that would lead to undesirable results and define undesirable results using minimum thresholds.

2. *The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria*

*shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*¹⁴

The GSP Regulations require undesirable results to be quantified by minimum threshold exceedances. GSAs have significant flexibility in defining the combinations of minimum threshold exceedances that constitute an undesirable result. GSAs should evaluate multiple spatial scales when setting the criteria for undesirable results. Consider an example of two basins. In the first basin, 50 percent of wells have water levels below their assigned minimum threshold. In the second basin, all wells have water levels above their minimum thresholds except for one well where water levels are 800 feet below the minimum threshold. Both basins likely have an undesirable result. GSAs should define their undesirable results to be protective of both scenarios.

3. *The potential effects of the undesirable result on beneficial uses and users of groundwater, land uses, and property interests.*¹⁵

The GSA, having acquired information regarding beneficial uses and users of groundwater in the basin, land uses, and property interests tied to groundwater, should describe the effects of each of the potential undesirable results for the basin. The description should make clear how potential effects on beneficial uses and users were considered in the establishment of the undesirable results.

Experiencing Undesirable Results

Avoidance of the defined undesirable results must be achieved within 20 years of GSP implementation (20-year period). Some basins may experience undesirable results within the 20-year period, particularly if the basin has existing undesirable results as of January 1, 2015. The occurrence of one or more undesirable results within the initial 20-year period does not, by itself, necessarily indicate that a basin is not being managed sustainably, or that it will not achieve sustainability within the 20-year period. However, GSPs must clearly define a planned pathway to reach sustainability in the form of interim milestones, and show actual progress in annual reporting.

Failing to eliminate undesirable results within 20 years, or failing to implement a GSP to achieve the sustainability goal established for a basin, will result in the Department deeming the GSP inadequate and could result in State Water Resources Control Board intervention. Failing to meet interim milestones could indicate that the GSA is unlikely to achieve the sustainability goal in the basin.

Example of Undesirable Results

This section provides a simplified example to illustrate the relationship between certain sustainable management criteria. The example is for one sustainability indicator

(lowering groundwater levels, using the metric of groundwater elevation. The concepts in the example could be extended to other sustainability indicators using other metrics.

In the example, a hypothetical basin has set minimum thresholds, interim milestones, and measurable objectives for groundwater levels (**Figure 10**) at a network of eight representative monitoring points; to simplify this example, the criteria are assumed to be the same at each well. After considering the conditions at which lowering of groundwater levels would become significant and unreasonable, the GSA has determined that minimum threshold exceedances (i.e., groundwater levels dropping below the minimum threshold) at three or more representative monitoring sites would constitute an undesirable result.

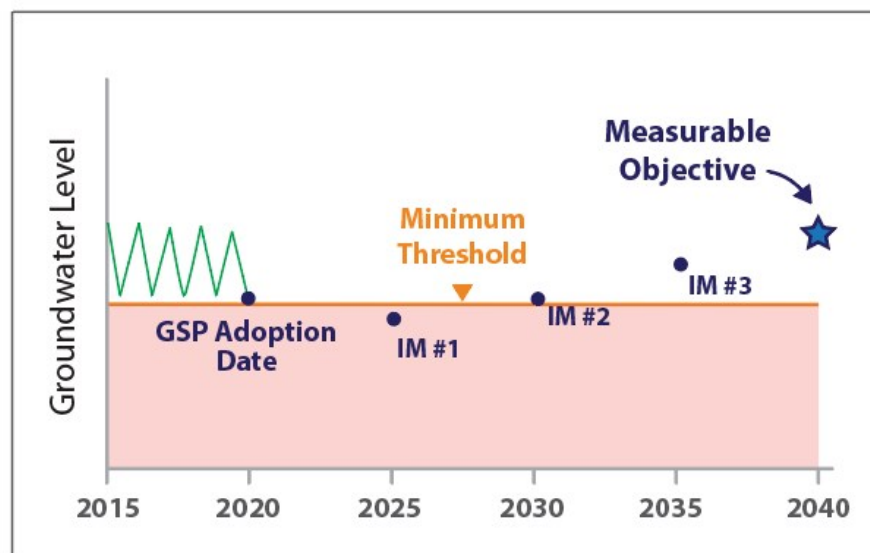


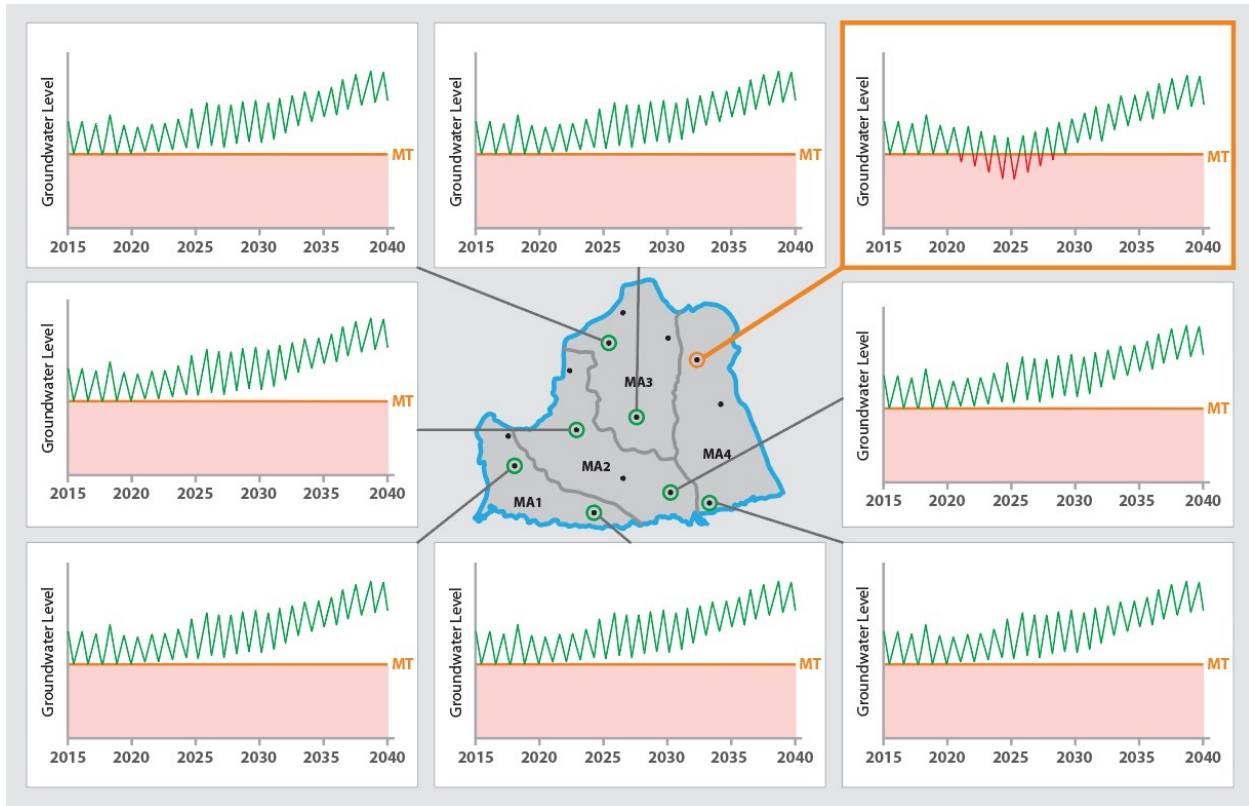
Figure 10. Example Minimum Threshold, Interim Milestones (IM), and Measurable Objective

In each of the following scenarios, the GSA monitors groundwater levels at the representative monitoring sites for the 20-year period following GSP submission.

Scenario 1 – Minimum Threshold Exceedances without an Undesirable Result

In this scenario (**Figure 11**), one of the eight representative monitoring wells has periodic minimum threshold exceedances over a several-year period after submission of the GSP. After this period, groundwater levels at the representative monitoring site increase and remain above the minimum threshold. Groundwater levels at all other representative monitoring sites remain above the minimum threshold for the entire 20-year period following GSP submission. Groundwater levels at all sites are at or above the measurable objective at the end of the 20-year period. Despite periodic minimum threshold exceedances at one representative monitoring well, the basin never

experienced an undesirable result for this sustainability indicator. The original GSP submission foresaw potential minimum threshold exceedances as shown by the first five-year interim milestone set below the minimum threshold.



**Figure 11. Example Groundwater Level Representative Monitoring Sites – Scenario 1
Scenario 2 – Minimum Threshold Exceedances with Undesirable Results Eliminated Within 20 Years**

In this scenario (**Figure 12**), three of the eight representative monitoring wells have periodic minimum threshold exceedances over a several-year period after submission of the GSP. After this period, groundwater levels at the three representative monitoring sites increase and remain above their respective minimum thresholds. Groundwater levels at all other representative monitoring sites remain above the minimum threshold for the entire 20-year period following GSP submission. Groundwater levels at all sites are at or above the measurable objective at the end of the 20-year period.

As opposed to Scenario 1, this basin did experience an undesirable result during the period of minimum threshold exceedance at the three representative monitoring wells. However, the basin was sustainably managed because the GSA planned for a period of minimum threshold exceedances via their interim milestones, and because the GSA implemented necessary projects and management actions to eliminate the undesirable result and achieve the measurable objective.

Note that if the GSAs in this hypothetical basin had not planned for continued groundwater level decline via appropriate interim milestones, or had not implemented the necessary projects and management actions to eliminate the undesirable result, the Department could have determined that the GSA was not likely to achieve the sustainability goal for the basin within the 20-year period.

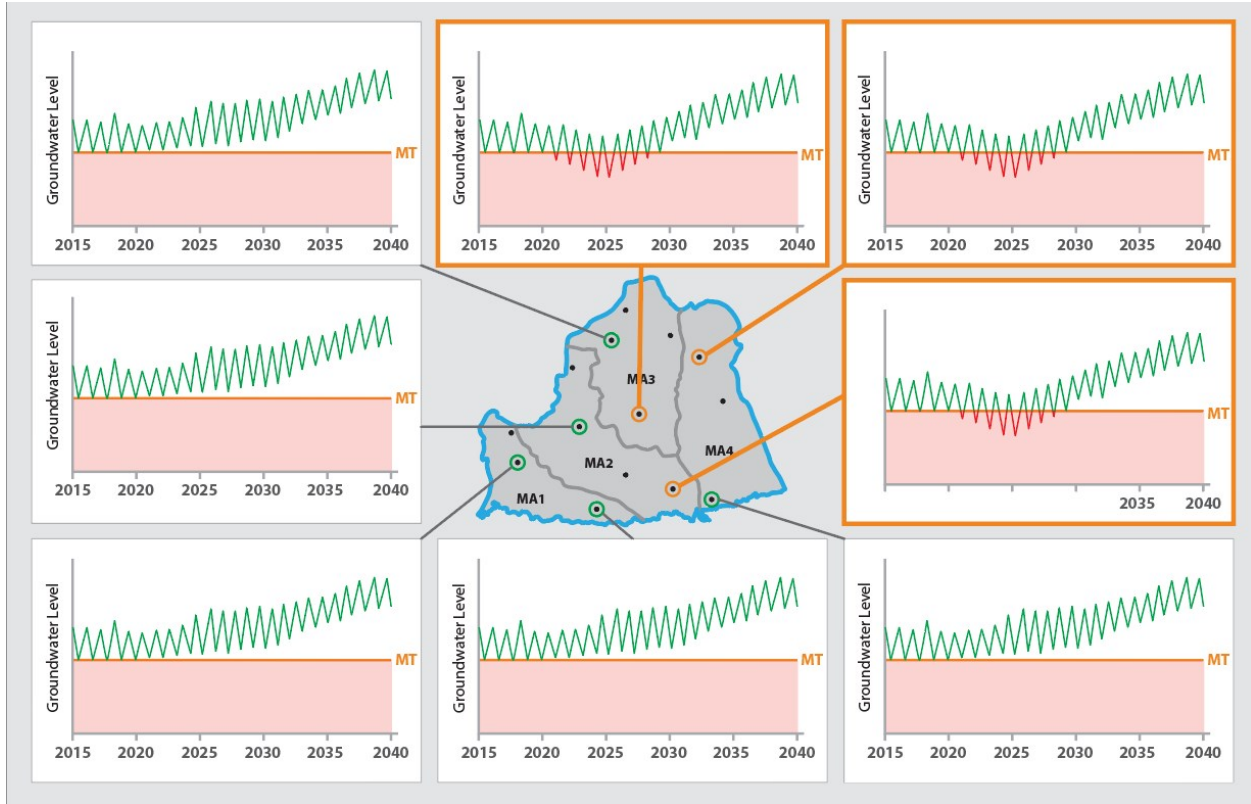


Figure 12. Example Groundwater Level Representative Monitoring Sites – Scenario 2

Scenario 3 – Minimum Threshold Exceedances with Undesirable Results Not Eliminated Within 20 Years

In this scenario (Figure 13), three of the eight representative monitoring wells have minimum threshold exceedances beginning approximately five years after submission of the GSP. Unlike Scenario 2, groundwater levels continue to decline at the three representative monitoring sites throughout the 20-year period following GSP submission, and are well below both their minimum thresholds and interim milestones. The basin experiences an undesirable result when the three wells begin exceeding their minimum thresholds, and the undesirable result persists throughout the 20-year period. Sustainable groundwater management was not achieved in the basin for this scenario.

Although this example shows undesirable results persisting for the 20-year period, in a real situation the Department would likely determine that the GSA was unlikely to achieve the sustainability goal at one of the interim milestones, thereby triggering State

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intervention much earlier in the 20-year period. It is beyond the scope of this example or this document to discuss details of State intervention, but it is important to note that State intervention can occur within the 20-year period following GSP submittal.

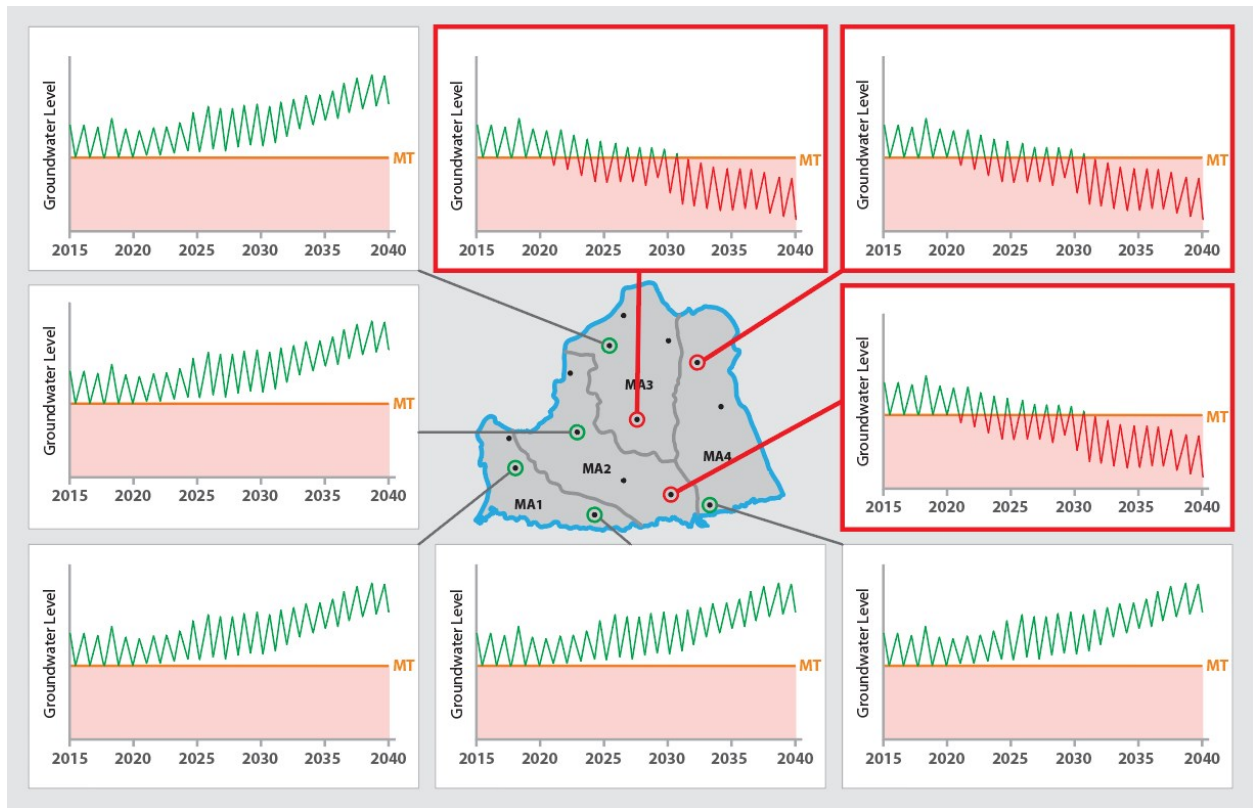


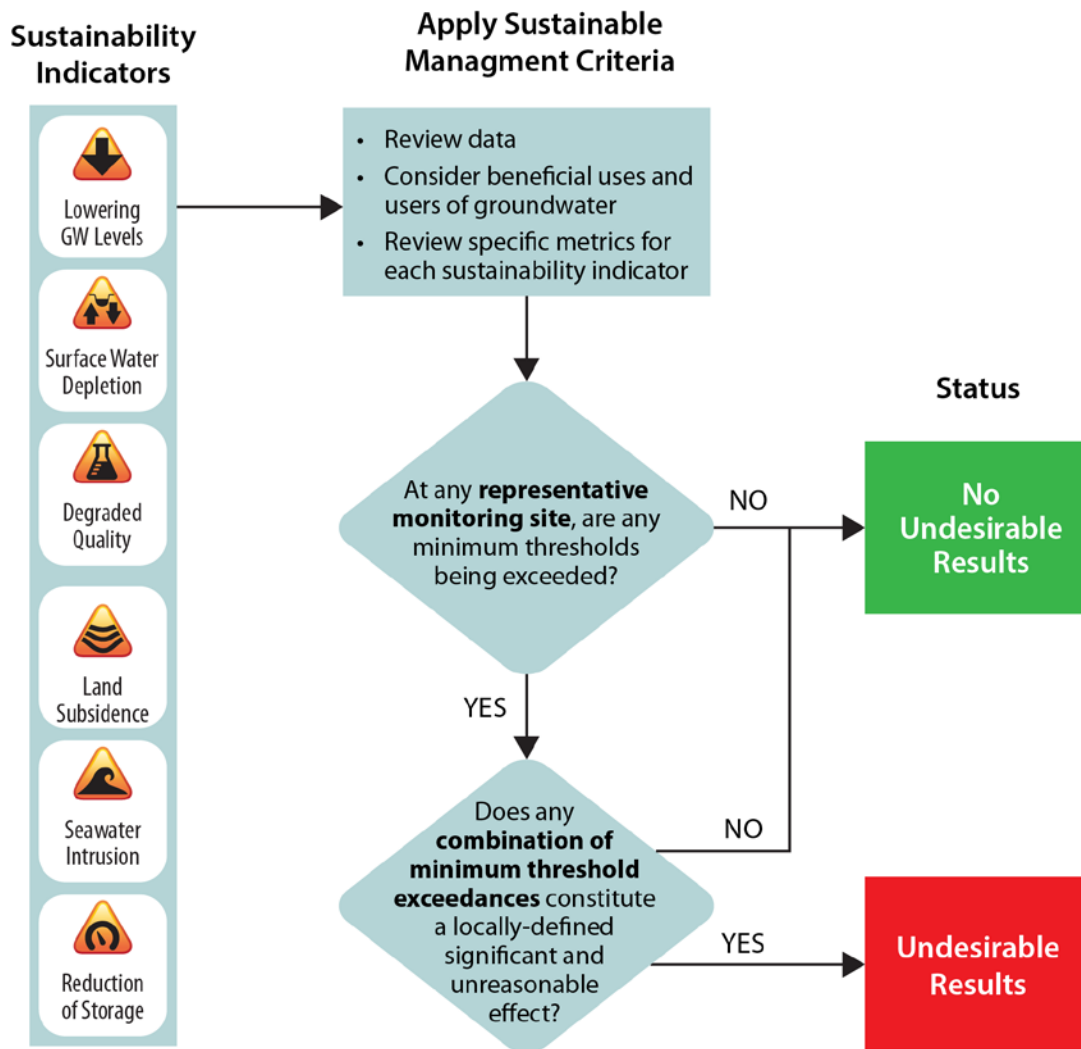
Figure 13. Example Groundwater Level Representative Monitoring Sites – Scenario 3

Relationship between Sustainability Indicators, Minimum Thresholds, and Undesirable Results

Sustainability indicators are the six effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, are undesirable results. For example, surface water depletion due to groundwater pumping is a sustainability indicator because it is an effect that must be monitored to determine whether it has become significant and unreasonable.

Sustainability indicators become undesirable results when a GSA-defined combination of minimum thresholds is exceeded. Those combinations of minimum threshold exceedances define when a basin condition becomes significant and unreasonable.

The relationship between sustainability indicators, minimum thresholds, and undesirable results is shown in the illustration below.



MEASURABLE OBJECTIVES

Measurable objectives are quantitative goals that reflect the basin's desired groundwater conditions and allow the GSA to achieve the sustainability goal within 20 years. Measurable objectives are set for each sustainability indicator at the same representative monitoring sites and using the same metrics as minimum thresholds. Measurable objectives should be set such that there is a reasonable margin of operational flexibility (**Figure 14**) between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities. There are exceptions to this general rule. For example, if the minimum threshold for land subsidence is zero, the measurable objective may also be zero. Projects and management actions included in GSPs should be designed to meet the measurable objectives, with specific descriptions of how those projects and management actions will achieve their desired goals.

In addition to the measurable objective, interim milestones must be defined in five-year increments¹⁶ at each representative monitoring site using the same metrics as the measurable objective, as illustrated in **Figure 14**. These interim milestones are used by GSAs and the Department to track progress toward meeting the basin's sustainability goal. Interim milestones must be coordinated with projects and management actions proposed by the GSA to achieve the sustainability goal. The schedule for implementing projects and management actions will influence how rapidly the interim milestones approach the measurable objectives (i.e., the path to sustainable groundwater management).

The Department will periodically (at least every five years) review GSPs to determine, among other items, whether failure to meet interim milestones is likely to affect the ability of the GSA(s) in a basin to achieve the sustainability goal.¹⁷

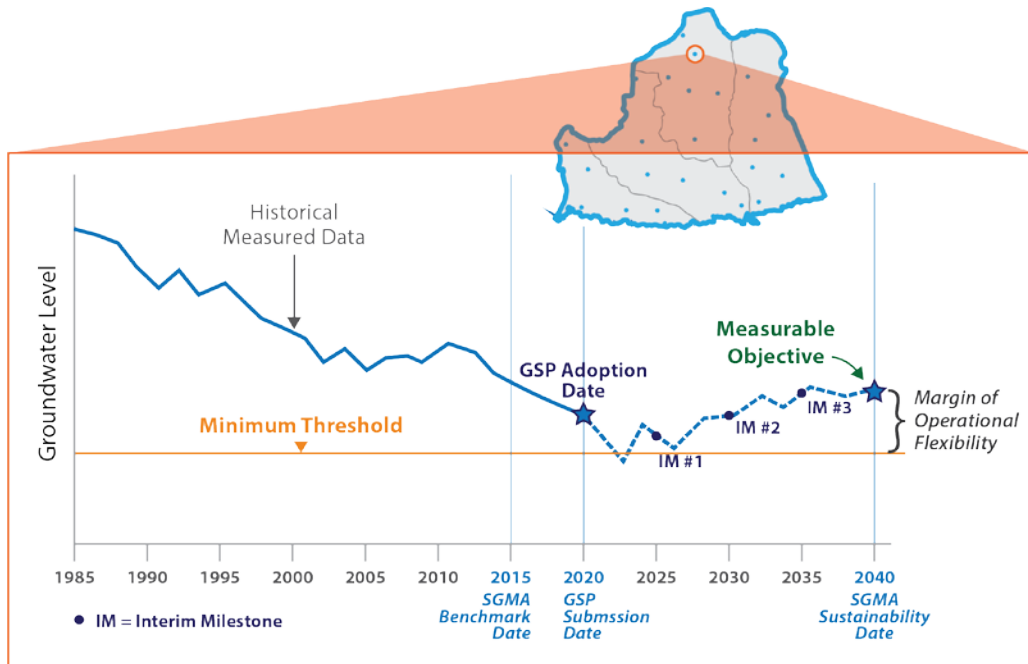


Figure 14. Relationship between Minimum Thresholds, Measurable Objectives, Interim Milestones (IM), and Margin of Operational Flexibility for a Representative Monitoring Site

The Path to Sustainable Groundwater Management

There will be many paths to sustainable groundwater management based on groundwater conditions and locally-defined values. **Figure 14** shows the relationship between minimum thresholds, measurable objectives, interim milestones, and margin of operational flexibility for a hypothetical basin. In the example used for **Figure 14**, groundwater levels are predicted to initially decline for the first five years after GSP adoption, and then rise over the subsequent 15 years to meet the measurable objective. At five-year increments, there are interim milestones to check the basin's progress towards the measurable objective. In **Figure 14**, the measured data never drops below the minimum threshold. This is just one example of a path towards reaching sustainability. The Department recognizes that there are different sustainability paths based on basin conditions, future supply and demand forecasts, and implementation of groundwater improvement projects. Three additional potential paths to sustainability are illustrated in **Figure 15**.

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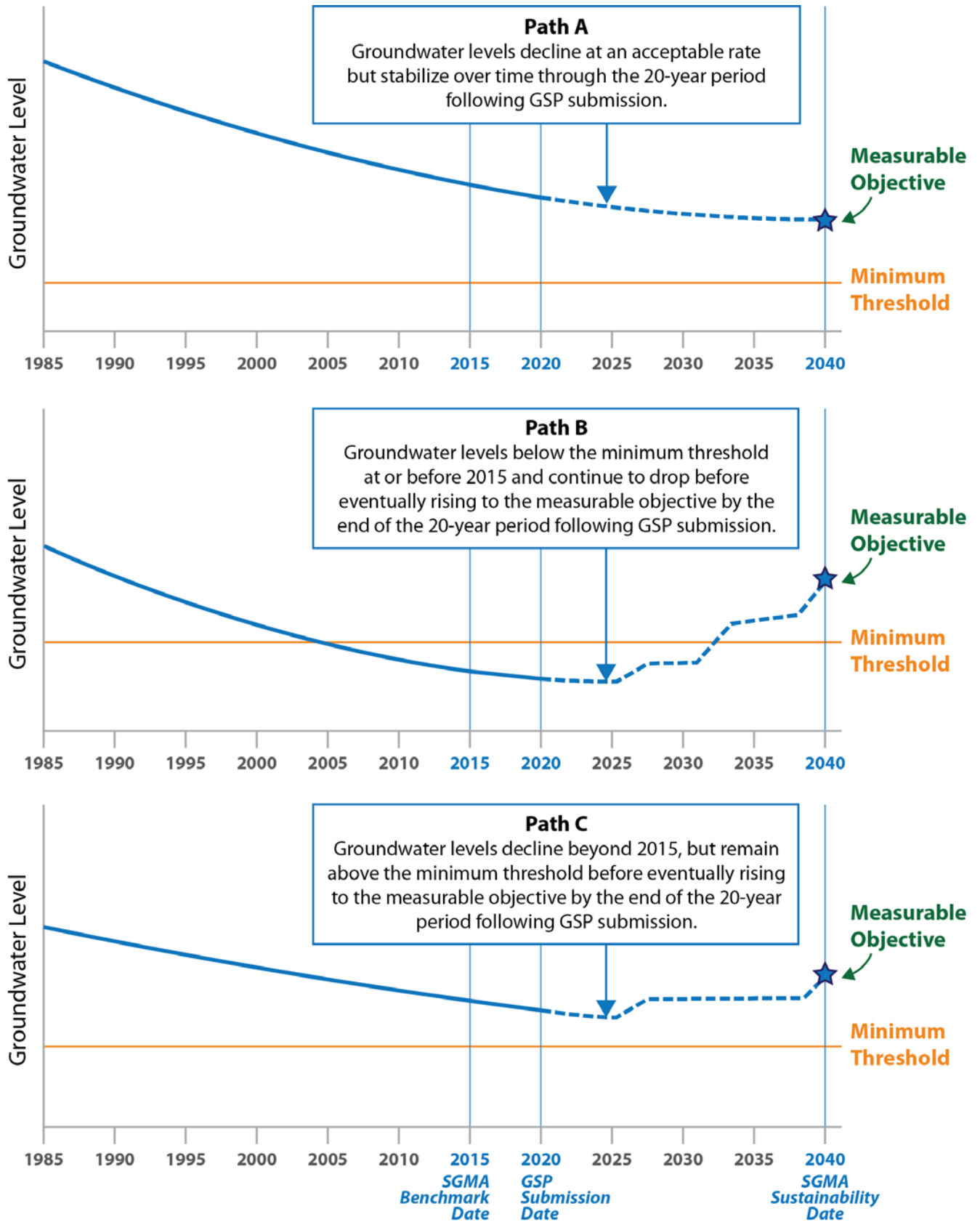


Figure 15. Potential Paths to Sustainability

Measurable Objectives when an Undesirable Result Occurred before January 1, 2015

SGMA states that a GSP “may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015.” Once minimum thresholds have been developed and an undesirable result numerically defined, the GSA may evaluate whether that undesirable result was present prior to January 1, 2015. This evaluation is not possible until the GSA has defined what constitutes a significant and unreasonable condition (an undesirable result).

If the evaluation indicates that an undesirable result occurred prior to January 1, 2015, the GSA must set measurable objectives to either maintain or improve upon the conditions that were occurring in 2015. The GSA must plan a pathway, indicated by appropriate interim milestones, to reach and maintain the 2015 conditions within the 20-year implementation timeline.

SUSTAINABILITY GOAL

GSA's must develop a sustainability goal that is applicable to the entire basin. If multiple GSPs are developed for a single basin, then the sustainability goal must be presented in the basinwide *coordination agreement*.

The sustainability goal should succinctly state the GSA's objectives and desired conditions of the groundwater basin, how the basin will get to that desired condition, and why the measures planned will lead to success.

Unlike the other sustainable management criteria, the sustainability goal is not quantitative. Rather, it is supported by the locally-defined minimum thresholds and undesirable results. Demonstration of the absence of undesirable results supports a determination that basin is operating within its sustainable yield and, thus, that the sustainability goal has been achieved.

GSA's should consider the following when developing their sustainability goal:

- **Goal description.** The goal description should qualitatively state the GSA's objective or mission statement for the basin. The goal description should summarize the overall purpose for sustainably managing groundwater resources and reflect local economic, social, and environmental values within the basin.
- **Discussion of measures.** The sustainability goal should succinctly summarize the measures that will be implemented. This description of measures should be consistent with, but may be less detailed than, the description of projects and management actions proposed in the GSP. Examples of measures a GSA could implement include demand reduction and development of groundwater recharge projects. The goal should affirm that these measures will lead to operation of the basin within its sustainable yield.
- **Explanation of how the goal will be achieved in 20 years.** The sustainability goal should describe how implementation of the measures will result in sustainability. For example, if the measures include demand reduction and implementation of groundwater recharge projects, then the goal would explain how those measures will lead to sustainability (e.g., they will raise groundwater levels above some threshold values and eliminate or reduce future land subsidence).

Note that most of the sustainability goal can only be finalized after minimum thresholds and undesirable results have been defined, projects and management actions have been identified, and the projected impact of those projects and management actions on groundwater conditions have been evaluated. Therefore, completion of the sustainability goal will likely be one of the final components of GSP development.

Role of Sustainable Yield Estimates in SGMA

In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results.

Sustainable yield estimates are part of SGMA's required basinwide water budget. Section 354.18(b)(7) of the GSP Regulations requires that an estimate of the basin's sustainable yield be provided in the GSP (or in the coordination agreement for basins with multiple GSPs). A single value of sustainable yield must be calculated basinwide. This sustainable yield estimate can be helpful for estimating the projects and programs needed to achieve sustainability.

SGMA does not incorporate sustainable yield estimates directly into sustainable management criteria. Basinwide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the six sustainability indicators.

CONCLUSIONS

The key to demonstrating a basin is meeting its sustainability goal is by avoiding undesirable results. Sustainable management criteria are critical elements of the GSP that define sustainability in the basin.

Before setting sustainable management criteria, the GSA should understand the basin setting by establishing a hydrogeological conceptual model, engage stakeholders, and define management areas as applicable. This document addresses best management practices for developing sustainable management criteria, including minimum thresholds, undesirable results, measurable objectives, and the sustainability goal.

Setting sustainable management criteria can be a complex, time consuming, and iterative process depending on the complexity of the basin and its stakeholders. GSAs should allow sufficient time for criteria development during the GSP development process. The public should be engaged early in the process so their perspectives can be considered during sustainable management criteria development. To ensure timely stakeholder participation, it may be useful for GSAs to set a timeline for development of the sustainable management criteria.

5. KEY DEFINITIONS

The key definitions related to sustainable management criteria development outlined in applicable SGMA code and regulations are provided below for reference.

SGMA Definitions ([California Water Code 10721](#))

- (d) “Coordination agreement” means a legal agreement adopted between two or more groundwater sustainability agencies that provides the basis for coordinating multiple agencies or groundwater sustainability plans within a basin pursuant to this part.
- (r) “Planning and implementation horizon” means a 50-year period over which a groundwater sustainability agency determines that plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield.
- (u) “Sustainability goal” means the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield.
- (v) “Sustainable groundwater management” means the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.
- (w) “Sustainable yield” means 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.
- (x) “Undesirable result” means one or more of the following effects caused by groundwater conditions occurring throughout the basin:
 - (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. 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.
 - (2) Significant and unreasonable reduction of groundwater storage.
 - (3) Significant and unreasonable seawater intrusion.
 - (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

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- (5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.
- (6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Groundwater Sustainability Plan Regulations ([California Code of Regulations 351](#))

(g) “Basin setting” refers to the information about the physical setting, characteristics, and current conditions of the basin as described by the Agency in the hydrogeologic conceptual model, the groundwater conditions, and the water budget, pursuant to Subarticle 2 of Article 5.

(h) “Sustainability indicator” refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x).

(q) “Interim milestone” refers to a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan.

(r) “Management area” refers to an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors.

(s) “Measurable objectives” refer to 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.

(t) “Minimum threshold” refers to a numeric value for each sustainability indicator used to define undesirable results.

(x) “Plan” refers to a groundwater sustainability plan as defined in the Act.

(y) “Plan implementation” refers to an Agency’s exercise of the powers and authorities described in the Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities.

(ag) “Statutory deadline” refers to the date by which an Agency must be managing a basin pursuant to an adopted Plan, as described in Water Code Sections 10720.7 or 10722.4.

NOTES

¹ See 23 CCR § 350 *et seq.*

² See Water Code § 10720 *et seq.*

³ See 23 CCR § 355.4(b)(1)

⁴ See Water Code § 10721(v)

⁵ See 23 CCR § 354.22 *et seq.*

⁶ See 23 CCR § 351(ah); *see also* Water Code § 10721(x).

⁷ See 23 CCR § 354.28(b)

⁸ See 23 CCR § 354.28(c)

⁹ See 23 CCR § 354.28(d)

¹⁰ See 23 CCR § 354.30(d)

¹¹ See 23 CCR § 354.36(b)

¹² See 23 CCR § 354.26(b)

¹³ See 23 CCR 354.26(b)(1)

¹⁴ See 23 CCR 354.26(b)(2)

¹⁵ See 23 CCR 354.26(b)(3)

¹⁶ See 23 CCR § 354.30(e)

¹⁷ See 23 CCR § 355.6(c)(1)