### 6.4.3 *Evaluation of Multiple Minimum Thresholds*

23 Cal. Code Regs § 354.26 *(c). The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Kaweah Subbasin GSAs will utilize multiple wells to monitor and manage the GSAs and Subbasin. A detailed description of each GSA's monitoring network are included in the Monitoring Network Section of their respective GSPs.

### 6.4.4 *Potential Effects on Beneficial Uses and Users*

Using the above-described criteria, the GSAs evaluated potential undesirable results to agricultural, domestic, industrial, and municipal beneficial uses. Overall, based on the best available data, the projects and management actions to be implemented by each GSA are predicted to decelerate and arrest chronic lowering of groundwater levels by 2040. Potential impacts to wells associated with groundwater level declines in the transition period between 2020 and 2040 were evaluated through an analysis of well completed depths (see Appendix 6-1). Potential effects of lowered groundwater levels on the various beneficial uses of groundwater in the Kaweah Subbasin are as follows:

*Agricultural* – Potential effects to agricultural beneficial uses and users from lowered groundwater levels include financial impacts to lower pumps, repair/replace wells, and increased pumping costs. Analysis of well depths that could be affected by lowering groundwater levels to the minimum thresholds has been completed (see Appendix 6-2).

*Domestic* – Some domestic uses and users of groundwater may be impacted by continued lowering of groundwater levels during the transition period from January 2020 to December 2040. Analysis of well depths that could be affected by lowering groundwater levels to the minimum thresholds has been completed (see Appendix 6-2). Lowering groundwater levels below the total depth of shallow domestic wells could lead to added costs to haul in water supplies, tie into other available supplies, consolidation with existing water service providers, or requiring other form of mitigation

*Industrial & Municipal* – Potential effects to industrial beneficial uses and users from lowered groundwater levels include financial impacts to lower pumps, repair/replace wells, and increased pumping costs. Analysis of well depths that could be affected by lowering groundwater levels to the minimum thresholds has been completed (see Appendix 6-2).

To address potential effects on agricultural, domestic and industrial beneficial uses and ensure access to water until the Subbasin reaches a sustainable groundwater level condition, each GSA will adopt a Mitigation Program or Programs consistent with the framework described further in the next section. Because of this mitigation, the resulting impacts as described herein during the implementation period are not considered significant and unreasonable.

### *6.4.5 Mitigation Program*

The Subbasin is committing to developing a Mitigation Program that evaluates and protects beneficial users from lowering groundwater levels and subsidence. The core tenants of well mitigation are coordinated here; however, each GSA will develop and implement GSA-specific programs based on the localized needs of their jurisdictions. The GSAs will take appropriate action to implement the Program no later than June 30, 2023. The key factors to be included are listed below. A draft well mitigation plan template is included in Appendix 6-3.

- Identification of the priority wells to be mitigated, with approximate quantification
- An investigation and vetting process to confirm well priority and impacts
- A listing of the mitigation methods, including both short and long-term options
- Estimated costs of mitigation methods and funding mechanism(s)
- Implementation schedule

## 6.5 Groundwater Storage

23 Cal. Code Regs § 354.26*(a). Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

The Groundwater Storage minimum thresholds are the same as groundwater levels and groundwater elevations across the GSA and Subbasin and were used to calculate the amount of groundwater in storage below the Minimum Thresholds to the base of the aquifer. An undesirable result in groundwater storage may be significant and unreasonable if the total amount of water in storage was less than the estimated amount of groundwater in storage below the Minimum Threshold or other factors identified in section 6.4 occur.

### *6.5.1 Causes leading to Undesirable Results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with groundwater storage are caused by the same factors as those contributing to groundwater level declines. Given assumed hydrogeologic parameters of the Subbasin, direct correlations exist between changes in water levels and estimated changes in groundwater storage.

### *6.5.2 Criteria to Define Undesirable results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to 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.*

The water-level sustainability indicator is used as the driver for calculated changes in groundwater storage. Given assumed hydrogeologic parameters of the Subbasin, direct correlations exist between changes in water levels and estimated changes in groundwater storage, and water levels are to serve as a metric for groundwater storage reductions as well. As such, when one-third of the Subbasin representative monitoring sites for water levels exceed their respective minimum thresholds, an undesirable result for storage will be deemed to occur. The current estimated volume of groundwater in storage in the Subbasin of 15 to 30 MAF is sufficient such that further depletion over the implementation period is not of a level of concern such that an undesirable result would emerge during the GSP implementation period.

### *6.5.3 Potential Effects on Beneficial Uses and Users*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

The potential effects to beneficial uses and users of reductions in groundwater storage are essentially the same as for declines in water levels. In most cases, the direct correlation is with declines in levels; however, some beneficial uses may be tied more specifically to loss of groundwater in storage.

## 6.6 Land Subsidence

23 Cal. Code Regs § 354.26*(a). Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

Land subsidence may be considered significant and unreasonable if there is a loss of a functionality of a structure or a facility to the point that, due to subsidence, the structure or facility cannot reasonably operate without either significant repair or replacement.

### *6.6.1 Causes leading to Undesirable Results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

*Geology* - The geology of the Subbasin appears to have greater potential for subsidence the further west you go. Generally, it is understood that the multi-aquifer area has the greatest potential for subsidence due to the presence of the deep confined aquifer. However, even in the single aquifer area, there are disconnected clays that appear to be deposited similarly to the Corcoran Clay. These clays also have the potential to subside, but do not seem to have the high potential of other areas because the aquifer is not fully confined. This speaks to why there is still subsidence in eastern portions of the Subbasin, east of the Corcoran Clay.

*Deep Aquifer* - The Subbasin understands that deep pumping from pressurized aquifer zones is primarily related to subsidence. In the Kaweah Subbasin this would generally be below the Corcoran Clay. However, the specific zone below the Corcoran Clay that is subsiding is not currently known. It is also understood that some small component of subsidence is related to water level declines in the upper aquifer.

*Declining Levels & Drilling Deeper* - The Subbasin understands that the chronic lowering of groundwater levels is related to the triggers for subsidence. As groundwater levels decline, landowners choose to drill deeper wells to restore their access to available groundwater supplies. When new deeper wells are drilled, the geology below the previous well and above the base of the new well is subjected to new impacts from the new well. Generally, the Subbasin views the effort to stabilize groundwater levels as critical to future success in dealing with subsidence. As groundwater pumping is reduced across the Subbasin, groundwater level declines will diminish, and fewer wells will be drilled deeper which will reduce the development of subsidence across the Subbasin.

Undesirable results associated with subsidence are caused groundwater pumping from deep wells that tap pressurized zones with fine grained deposits that experience declining groundwater levels. Some GSA Management Areas experience greater adverse impacts than others. Over-pumping during drought periods, which may result in new lows in terms of groundwater elevations, is of particular concern based on current scientific understanding of subsidence trends in this region.

### *6.6.2 Criteria to Define Undesirable results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to 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.*

The Kaweah Subbasin GSAs understand that impacts from subsidence have been occurring in the Kaweah Subbasin for many years. However, the rate of subsidence has seemed to increase significantly around 2007. Deep wells have collapsed with compression failures, the ground surface has slowly changed elevations over time, and some linear systems dependent on grade have experienced capacity reductions. Also, during the same period many other facilities have not experienced those negative impacts, and why some have versus others not is still very difficult to understand. Shallow wells are generally not viewed as being at risk of subsidence impacts. The

Kaweah Subbasin GSAs have attempted to consider all local infrastructure, land uses and groundwater users relative to current and potential subsidence impacts and develop a view of groundwater conditions (Minimum Threshold elevations) that would avoid Undesirable Results in the Subbasin.

The Kaweah Subbasin GSAs understand that groundwater wells are very important infrastructure for all landowners across the Subbasin. For this reason, the Kaweah Subbasin GSAs view that an Undesirable Result (UR) would occur if a significant portion of the existing deep wells in the Kaweah Subbasin became inoperable (collapsed) due to subsidence. The Kaweah Subbasin GSAs understand that the Friant-Kern Canal is a facility of statewide importance (critical infrastructure) that delivers San Joaquin River surface water to parties in the Kaweah Subbasin and beyond. For that reason, the Kaweah Subbasin GSAs also view that a UR would occur if the capacity of the Friant-Kern Canal was significantly impacted by subsidence. The Kaweah Subbasin GSAs understands that local flood control channels are very important infrastructure for all landowners across the Kaweah Subbasin. For that reason, the Kaweah Subbasin GSAs view that a UR would occur if the capacity of flood control channels in the Subbasin are significantly impacted by subsidence. And lastly, the Kaweah Subbasin GSAs understand that certain main canals are very important for landowners across the Kaweah Subbasin because their function is critical to continued use of surface water in Subbasin, which reduces demand for groundwater and provides the ability to recharge aquifers in wet years. For that reason, the Kaweah Subbasin GSAs view that a UR would occur if the capacity of certain main canals in the Subbasin are significantly impacted by subsidence.

Subsidence RMS sites will be monitored for ground surface elevation annually each fall. The primary criteria for evaluation will be the reduction in land surface elevation from the beginning of the Implementation Period (if that data is available). There will be two methods of identifying an Undesirable Result (UR) for the Subbasin. For the area outside of the Friant-Kern Canal alignment, when one-third of the Subbasin RMSs outside the Friant-Kern Canal band decline below their respective MT elevations, that will be viewed as a UR. For a one-mile band on either side of the Friant-Kern Canal, if any of the MT elevations in that band reach an MT elevation that will be viewed as a UR.

The primary criteria and metric the GSAs will monitor will be the total amount of reduction in land surface elevation and areal extent of such elevation changes.

For many of the impacts listed above, subsidence is only a problem when it is differential in nature i.e., elevation shifts across the areal extent of infrastructure deemed of high importance. For example, subsidence linearly along a major highway is manageable if gradual in its occurrence. In contrast, localized subsidence traversing across a highway, if sizable, would cause major cracking of the pavement surface and become a significant hazard to travelers. The same comparisons may be made for other infrastructure as well.

If an exceedance of a minimum threshold at a monitoring site occurs, the applicable GSA will reach out to the County, cities, water districts, and others, both public and private, and inquire as to any infrastructure that has been damaged which may require a corrective course of action if deemed necessary. A broad areal extent of land subsidence thus may not be of major concern, with the exception of the associated loss of aquifer system water storage capacity.

#### *6.6.3 Potential Effects on Beneficial Uses and Users*

> 23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

The Kaweah Subbasin GSAs understand that impacts from subsidence have been occurring in the Kaweah Subbasin for many years. Some of the understood impacts are briefly discussed below:

*Flood Channels* - Rivers and creeks generally begin in watersheds in the foothills and mountains east of the Subbasin and flow downhill to the southwest toward the historic Tulare Lake. Part of the Kaweah Subbasin's history involves regular floods, and that is why dams were built on local rivers and streams to protect communities and farmlands from regular flood events. However, even though the dams exist, they only provide protection up to a certain magnitude flooding event. Subsidence has not been observed to diminish the capacity of local flood channels, but it theoretically could impact capacity under the right circumstances. Also, subsidence could cause a change to the amount of sediment that is moved by the system. However, there are parties responsible for the maintenance of these channels and incremental impacts are likely being addressed through maintenance.

*Local Flooding* - Ground surface changes can affect flood zones as well as flood control levees. Local flood control levees are maintained by agencies responsible for maintaining their effectiveness. In 2017 a local flood control levee was raised by several feet to address subsidence concerns, but that was the first such project on that levee in decades and it was completed in just a few months. The planned development of new recharge projects and the increased use of wet year surface water should more than mitigate potential modifications to existing flood zones.

*Local Canals* - These linear facilities are very important related to GSA Management Strategies. If their capacity is significantly impacted, it may require GSAs to shift to greater pumping reductions.

*Regional Canals* - These linear facilities, like the Friant-Kern Canal, usually have regional significance and have users across large sections of the Southern San Joaquin Valley. The cost of repairing subsidence impacts on these facilities are too expensive for the Kaweah Subbasin to bear. For that reason, other management strategies like pumping restrictions to stabilize groundwater levels will be imposed instead.

*Shallow Wells* - Shallow wells that do not have significant exposure to the confined aquifer below the Corcoran Clay do not appear to be at risk from subsidence.

*Deep Wells* - Wells that have significant exposure to the confined aquifer below the Corcoran Clay are at risk of collapse due to subsidence that is mostly linked to that zone. A preliminary estimate of significant and unreasonable impacts can be established by looking at well construction practices. Subsidence mainly occurs in the deeper aquifers, and therefore well collapse due to subsidence typically only affects deeper wells. Conversations with local well drillers and suppliers indicates that deeper wells are now commonly outfitted with compression sleeves (personal communication). These compression sleeves allow well casings to telescope in response to subsidence, preventing casing collapse (Turnbull, 2022). Each compression sleeve allows 6 feet of compression, and often wells are equipped with 1 or 2 sleeves (personal communication). This allows for 6 to 12 feet of subsidence without causing collapse.

*Railroads* - There are several railroads throughout the Subbasin that convey goods along predefined routes and the facilities also have flood control structures, like culverts, along their alignments. The observed grade changes that have occurred from subsidence do not appear to be significant for local railroads and their culverts appear to be staying stable with adjacent properties. However, steep localized subsidence can be a significant issue in terms of the cost of repairs.

*Natural Gas Pipelines* - Along Highway 99 there is a significant natural gas pipeline. Over the past several years this facility has been worked on at various points, but it appears the efforts related to issues other than subsidence.

Differential land subsidence may impact surface infrastructure such as building foundations, paved streets/highways, and water conveyance systems.

The Kaweah Subbasin GSAs have attempted to consider all local infrastructure, land uses and groundwater users relative to current and potential subsidence impacts and develop a view of groundwater conditions (MT elevations) that would avoid Undesirable Results in the Subbasin. Again, the Kaweah Subbasin GSAs view that stabilized groundwater levels as critical to the future success of dealing with subsidence. As groundwater pumping is reduced across the Subbasin, groundwater level declines will diminish, and fewer wells will be drilled deeper which will reduce the development of subsidence across the Subbasin.

### 6.6.4 Evaluation of Multiple Minimum Thresholds

23 Cal. Code Regs § 354.26 *(c). The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Kaweah Subbasin GSAs will use measurements taken at multiple subsidence benchmarks and Interferometric Synthetic Aperture Radar (InSAR) data to monitor and manage subsidence in the GSA and Subbasin. A detailed description of each GSA's monitoring networks are included in the Monitoring Networks Section of their respective GSPs.

### 6.6.5 Mitigation Program

The Subbasin is committing to developing a Mitigation Program that evaluates and protects beneficial users from certain land subsidence impacts. The core tenants of subsidence mitigation are coordinated in the Mitigation Program through this Coordination Agreement; however each GSA will develop and implement GSA-specific programs based on the localized needs of their jurisdictions. The GSAs will take appropriate action to implement the Program no later than June 30, 2023. The key factors to be included below. A draft well mitigation plan template is included in Appendix 6-3.

- Identification of the priority land surface infrastructure to be mitigated, with approximate quantification
- An investigation and vetting process to confirm priority and impacts
- A listing of the mitigation methods, both short and long-term options
- Estimated costs of mitigation methods and funding mechanism(s)
- Implementation schedule

## 6.7 Degraded Water Quality

23 Cal. Code Regs § 354.26*(a). Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

An undesirable result may be significant and unreasonable if groundwater quality is adversely impacted by groundwater pumping and recharge projects and these impacts result in groundwater no longer being generally suitable for agricultural irrigation and/or domestic use.

### *6.7.1 Causes leading to Undesirable Results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with water quality degradation can result from pumping localities and rates, as well as other induced effects by implementation of a GSP, such that known plumes and contaminant migration could threaten production well quality. Well production depths too may draw out contaminated groundwater, both from naturally occurring and man-made constituents which, if MCLs are exceeded, may engender undesirable results. Declining groundwater levels may or may not be a cause, depending on location. In areas where shallow groundwater can threaten the health of certain agricultural crops, rising water levels may be of concern as well.

### *6.7.2 Criteria to Define Undesirable results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to 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.*

Should one-third of all Subbasin designated water quality monitoring sites exhibit a minimum threshold exceedance, and those exceedances are all associated with GSA actions, an undesirable result will be deemed to occur. Groundwater quality degradation will be evaluated relative to established MCLs or other agricultural constituents of concern set by applicable regulatory agencies. The metrics for degraded water quality shall be measured by MCL compliance or by other constituent content measurements where appropriate. These metrics will include measurements for the following constituents where applicable:

- Arsenic
- Nitrate
- Chromium-6
- DBCP
- TCP
- PCE
- Sodium
- Chloride
- Perchlorate
- TDS

As explained in Section 5.3.4, in regions where agriculture represents the dominant use of groundwater, Agricultural Water Quality Objectives will serve as the metric as opposed to drinking water MCLs within public water supply jurisdictions. An exceedance of any of the MCL or Agricultural Water Quality Objectives as defined herein at any representative monitoring sites will trigger a management action within the applicable Management Area or GSA, subject to determination that the exceedance was caused by actions of the GSA. MCLs and water quality objectives are listed in each of the Kaweah Subbasin GSPs and these are subject to changes as new water quality objectives are promulgated by the State of California and the Federal EPA. The Subbasin will provide updates in our annual reports and GSP Updates throughout the implementation periods of 2020 to 2040.

### *6.7.3 Potential Effects on Beneficial Uses and Users*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

The potential effects of degraded water quality from migrating plumes or other induced effects of GSA actions include those upon municipal, small community and domestic well sites rendered unfit for potable supplies and associated uses, and/or the costs to treat groundwater supplies at the well head or point of use so that they are compliant with state and federal regulations. Potential effects also include those upon irrigated agricultural industries, as certain mineral constituents and salt build-up can impact field productivity and crop yields.

### *6.7.4 Evaluation of Multiple Minimum Thresholds*

23 Cal. Code Regs § 354.26 *(c). The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Subbasin, in coordination with other GSAs in the basin will utilize multiple wells to monitor water quality and manage the GSA and basin. A detailed description of the GSA's monitoring network is included in the Monitoring Networks Section of their respective GSPs.

## 6.8 Interconnected Surface Waters

Interconnected surface waters within the Kaweah Subbasin are a significant data gap that needs more development through collection of additional data and further studied through the development of a technical analysis tool. The East Kaweah and Greater Kaweah GSAs are developing a work plan to collect data and analyze interconnected surface water presence and potential impacts from groundwater pumping (see Management Action Section of each respective GSP for more detail on these work plans.

### *6.8.1 Causes Leading to Undesirable Results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with interconnected surface waters are understood to be caused by several factors. Some of these factors may include groundwater pumping, drier hydrology, and changes within the upper watershed, or some combination of those factors. Within the Kaweah Subbasin, there are currently significant data gaps related to understanding the potential locations of interconnected surface waters and their nexus to depletions caused by groundwater pumping. More information is intended to be developed and shared through a work plan being coordinated and implemented by the East and Greater Kaweah GSAs. The preliminary schedule for the work plan is in Table 6-2. Pending data gathered and/or timing of such data, there may be shifts or re-ordering of phases/tasks to better adapt and facilitate completion.

**Table 6-2 Anticipated Interconnected Surface Water Work Plan Schedule**

| Phase | Description | Estimated Timeline |
|---|---|---|
| 1 | Additional research; data gap filling (monitoring well installation, stream gauge installation, etc.); data collection | October 2022 – June 2024 |
| 2 | Analytical Tool Development – the type of tool will be determined with additional data and research | March 2023 – December 2023 |
| 3 | Interconnection Analysis and Determination | January 2024 – July 2024 |
| 4 | SMC Development and Incorporation into 2025 GSP | July 2024 – January 2025 |

### *6.8.2 Criteria to Define Undesirable results*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to 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.*

The Kaweah Subbasin (East Kaweah and Greater Kaweah GSAs specifically) are implementing a work plan that is intended to provide a clearer definition of where potentially interconnected surface waters are located and to what extent adverse impacts related to groundwater pumping are present and can be defined and quantified. At the current time (July 2022), the primary criteria and metric for defining and quantifying adverse impacts and undesirable results will be the estimated percentage of losses within potentially interconnected channels, measured as a rate or volume of depletion of surface water, until the work plan provides more information. Currently, there is not sufficient data to definitively set rate of depletions on other data. Increased channel losses reduce the amount of surface water that can be delivered throughout the Kaweah Subbasin. Delivery of surface water is a critically important part of sustainably managing the Kaweah Subbasin, thus impacts that reduce the ability to deliver surface water can become significant and unreasonable and ultimately lead to an undesirable result. The initial percentages being used for SMC are 50% losses due to groundwater pumping for the MT and 30% losses due to groundwater pumping for the MO. The East Kaweah and Greater Kaweah GSS will implement a work plan intended to fill data gaps by the 2025 GSP Update. Better definition and criteria for significant and unreasonable impacts and, ultimately, undesirable results in the locations identified as having interconnected surface waters are envisioned to be available from the proposed work plan.

#### *6.8.3 Potential Effects on Beneficial Uses and Users*

23 Cal. Code Regs § 354.26 *(b). The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

Currently identified potential beneficial uses/users related to interconnected surface water within the East and Greater Kaweah GSA regions of the Kaweah Subbasin are surface water users, riparian and/or groundwater dependent ecosystems, and water rights holders. As more data becomes available, the Work Plan may add or subtract to these uses/users in whole or part of the reaches of the selected waterways. The potential effects of depletions to interconnected surface water, when approaching or exceeding minimum thresholds and thus becoming an undesirable result include:

- Increased losses in interconnected surface waterways used for surface water conveyance, reducing water supply reliability and volumes.
- Negatively and significantly impacting the health of riparian and/or groundwater dependent ecosystems.
- Violating laws and doctrines governing California's surface water rights.

#### *6.8.4 Evaluation of Multiple Minimum Thresholds*

23 Cal. Code Regs § 354.26 *(c). The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Kaweah Subbasin GSAs will utilize a variety of methods, to be determined based on data gained through the implementation of the work plan, to monitor and manage interconnected surface waters in the GSA and Subbasin. Further detail necessary for properly evaluating interconnected surface water and the potential relationship to groundwater pumping in the Kaweah Subbasin is anticipated to be gained through implementation of the work plan.

## 6.9 Seawater Intrusion

### *6.9.1 Undesirable results*

23 Cal. Code Regs § 354.26 *(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

There is no potential for seawater intrusion to occur in the Kaweah Subbasin as described more thoroughly in the basin setting. Thus, no criteria need to be established.

# Appendix 6-1 of the Coordination Agreement

**Technical Approach for Developing Chronic Lowering of Groundwater Levels Sustainable Management Criteria in the Kaweah Subbasin**

July 27, 2022

# Technical Approach for Developing Chronic Lowering of Groundwater Levels Sustainable Management Criteria in the Kaweah Subbasin

*Prepared for:*

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# Contents

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## Tables



## Figures

# Appendices

# ACRONYMS & ABBREVIATIONS

DWR ..............California Department of Water Resources
EKGSA ..........East Kaweah Groundwater Sustainability Agency
GKGSA..........Greater Kaweah Groundwater Sustainability Agency
GSA................Groundwater Sustainability Agency
GSP ................Groundwater Sustainability Plan
MKGSA .........Mid-Kaweah Groundwater Sustainability Agency
MO .................measurable objective
MT..................minimum threshold
SGMA ............Sustainable Groundwater Management Act
SMC ..............Sustainable Management Criteria
Subbasin.........Kaweah Subbasin
WCR ..............Well Completion Report

# 1 INTRODUCTION

This technical report describes the methodology applied to a revision of the chronic lowering of groundwater level sustainable management criteria (SMC) for the San Joaquin Valley - Kaweah Subbasin (Subbasin). The revisions are in response to the California Department of Water Resources (DWR) incomplete determination of the three Groundwater Sustainability Plans (GSPs) submitted in January 2020. The three GSPs are being implemented by three Groundwater Sustainability Agencies (GSAs) covering the entirety of the Subbasin: East Kaweah GSA, Greater Kaweah GSA, and Mid-Kaweah GSA (Figure 1).

DWR provided a staff report with a statement of findings explaining the incomplete determination for the Subbasin GSPs. The staff report states, "The Plan does not define sustainable management criteria for chronic lowering of groundwater levels in the manner required by Sustainable Groundwater Management Act (SGMA) and the GSP Regulations." DWR's findings specified the following:

1. *The GSPs do not define metrics for undesirable results and minimum thresholds based on avoiding a significant and unreasonable depletion of groundwater supply, informed by, and considering, the relevant and applicable beneficial uses and users in their Subbasin.*
2. *The GSPs do not describe specific potential effects from the chronic lowering of groundwater levels and depletion of supply that would be significant and unreasonable to beneficial uses and users of groundwater, on land uses and property interests, and other potential effects and, therefore, constitute an undesirable result.*
3. *The GSPs do not consider how minimum thresholds developed for one sustainability indicator will affect other related sustainability indicators."*

The GSAs are given up to 180 days from the receipt of DWR's staff report to address the deficiencies for chronic lowering of groundwater levels SMC. This report provides the technical support to fulfill that purpose.

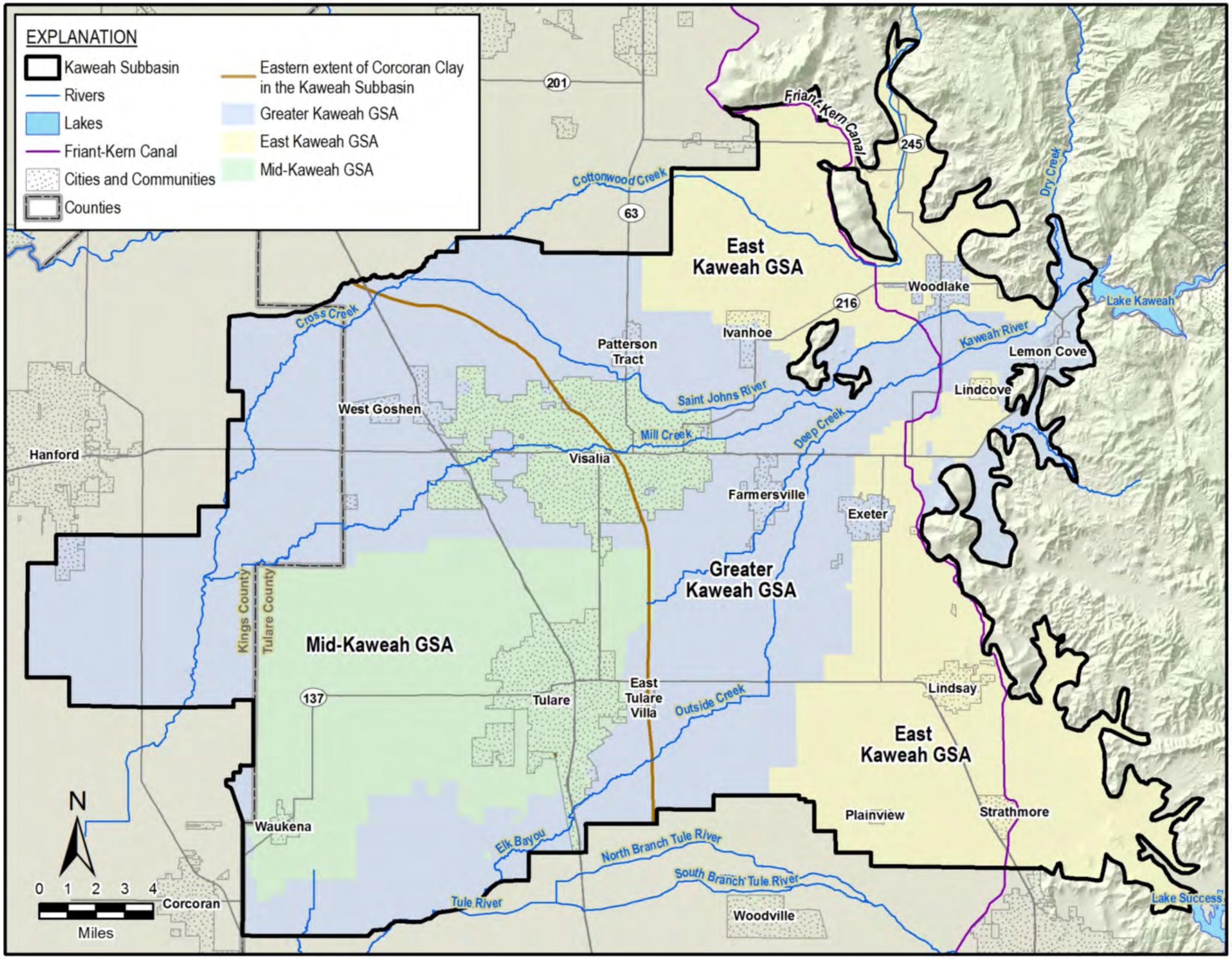


Figure 1. Groundwater Sustainability Agencies in the Kaweah Subbasin

## 1.1 General Approach Used to Develop Sustainable Management Criteria

Chronic lowering of groundwater levels SMC are developed to protect relevant and applicable beneficial uses and users of groundwater in the Subbasin. Beneficial users of groundwater are domestic pumpers, disadvantaged communities, small water systems (2 to 14 connections), municipal water systems (>14 connections), agricultural pumpers, California Native American Tribes, environmental users, and entities engaged in monitoring and reporting groundwater elevations. Understanding the types of users and their access to groundwater is the first step taken to inform what the GSAs and their stakeholder groups consider significant and unreasonable impacts to those users.

Since wells are how users access groundwater, the approach used to develop SMC is based on water supply well depths. The depth of wells across the Subbasin varies by depth to groundwater and beneficial user type. Because of well depth variability, the Subbasin is subdivided into analysis zones based on GSP management area boundaries, clusters of beneficial user types, aquifers, and completed well depths. Completed well depth statistics inform significant and unreasonable groundwater levels, with the SMC being based on protecting at least 90% of all water supply wells in the Subbasin.

## 1.2 Data Sources and Quality Control

Information used for establishing the chronic lowering of groundwater levels SMC include:

- Completed depths, screen depths, and locations of wells installed since January 1, 2002, and included in DWR's Well Completion Report (WCR) dataset (Figure 2). Only well records drilled since 2002 are used for analysis to filter out wells that may have been abandoned or no longer represent typical modern depths for active wells and current groundwater elevations. Data download date was March 1, 2022.
- Historical groundwater elevation data from DWR's California Statewide Groundwater Elevation Monitoring Program, SGMA Portal Monitoring Network Module, and individual water agencies.
- Maps of current and historical groundwater elevation contours.

The WCR dataset does not contain a complete accurate dataset, however, it is the best public source of data available. Approximately one-third of the wells drilled from 2002 on did not have well completion depths and could not be used in the analysis. For purposes of well depth analyses, we assumed the available wells with depth information are typical of depths in the Subbasin.

Well logs were reviewed for wells with completion depths less than 100 feet. This review generally found that either 1) the planned well use field was incorrectly classified as a water supply well when it was supposed to be a destroyed or remediation well, or 2) the completed well depth field was the depth of the conductor casing (often 50 feet) and not the bottom of the completed well. These inaccuracies were corrected. Furthermore, where coordinates of wells are unavailable, DWR locates the well in the middle of the Public Land Survey System section.

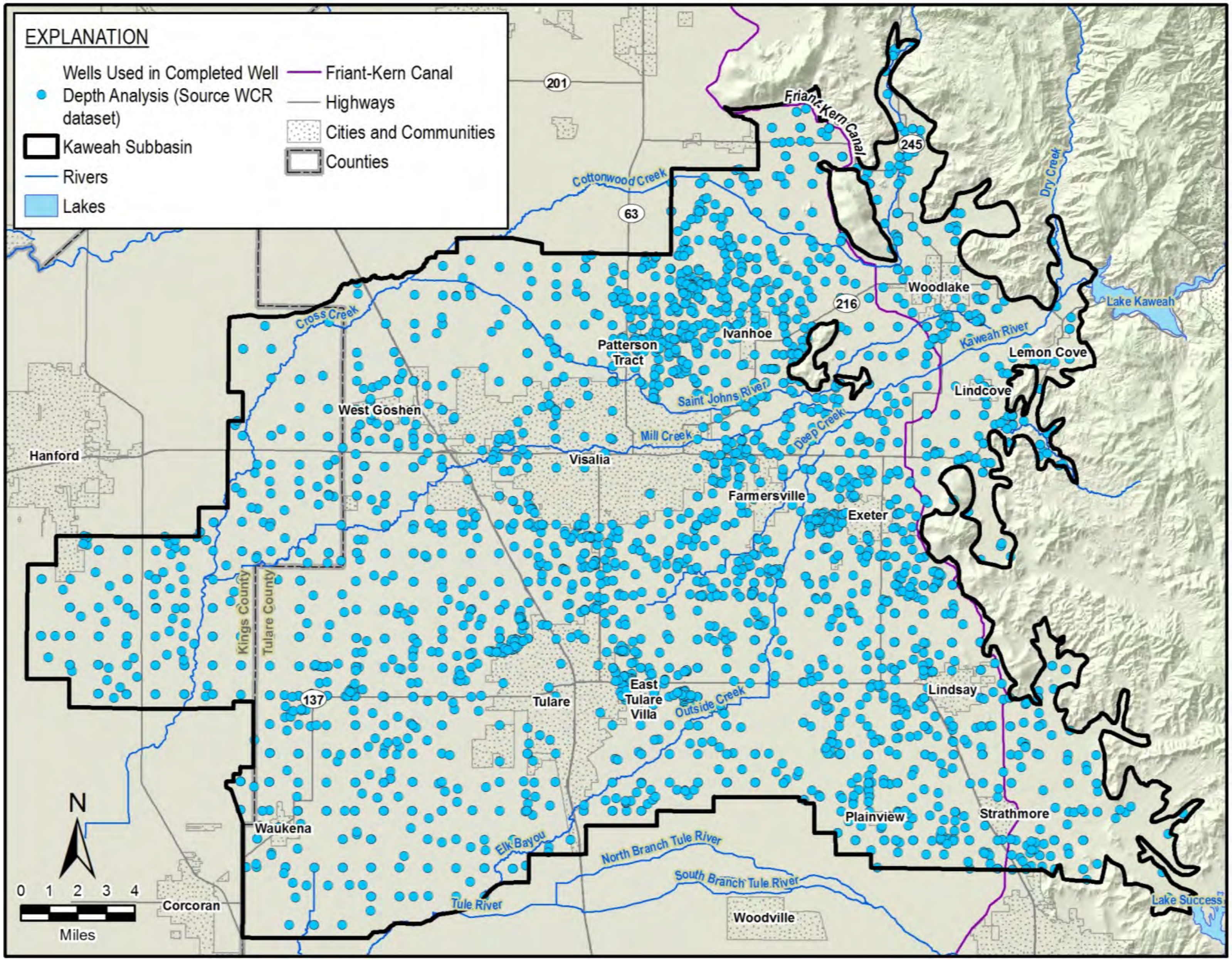



Figure 2. Location of WCR Water Supply Wells Used for Completed Well Depth Analysis

# 2 PROCESS USED TO ESTABLISH MINIMUM THRESHOLDS

Minimum thresholds (MTs) are derived from groundwater elevations that protect at least 90% of all water supply wells drilled since January 1, 2002, in each analysis zone, and that do not result in a greater rate of decline over water years 2020 to 2040 than experienced over a specific historical time period. Groundwater elevations representing MTs are set at representative monitoring sites identified in the Monitoring Network section of the GSPs.

The process for developing MTs is based on a comparison of three methodologies. The process is generally to:

1. Develop analysis zones based on GSP management areas, aquifer type, beneficial user types, and similar completed well depths (described in Section 2.1.1).
2. Identify water supply wells drilled since January 1, 2002, with well screen depth information or a completed well depth.
3. Designate water supply wells to either the Upper, Lower, or Single Aquifer System based on a set of assumptions (described in Section 2.1.2).
4. Designate representative monitoring sites to either the Upper, Lower, or Single Aquifer System (described in Section 2.1.2).
5. Estimate MT depths through Methodology 1 by calculating the 90th percentile well completion depth for water supply wells in each analysis zone and aquifer (described in Section 2.1.3).
6. Apply the 90th percentile protective depth corresponding to the representative monitoring sites' aquifer designation and analysis zone (described in Section 2.1.4).
7. Estimate MT depths through Methodology 2 by projecting relevant base period groundwater level trends to 2040 for each representative monitoring site (described in Section 2.1).
8. Compare elevations resultant from protective depths (Step 6) and projecting a groundwater levels trend out to 2040 (Step 7). The initial MT for the representative monitoring site is the higher elevation of the two methods (Figure 3).
9. Contour the representative monitoring site MTs obtained in Step 8 for the unconfined aquifers (Single and Upper Aquifer Systems) to determine if the MT surface is relatively smooth. If there are anomalous MTs, remove the anomalous points and interpolate the final MT elevations at these points from MT contours generated by excluding the anomalous sites. This is shown as Method 3 in Figure 3.

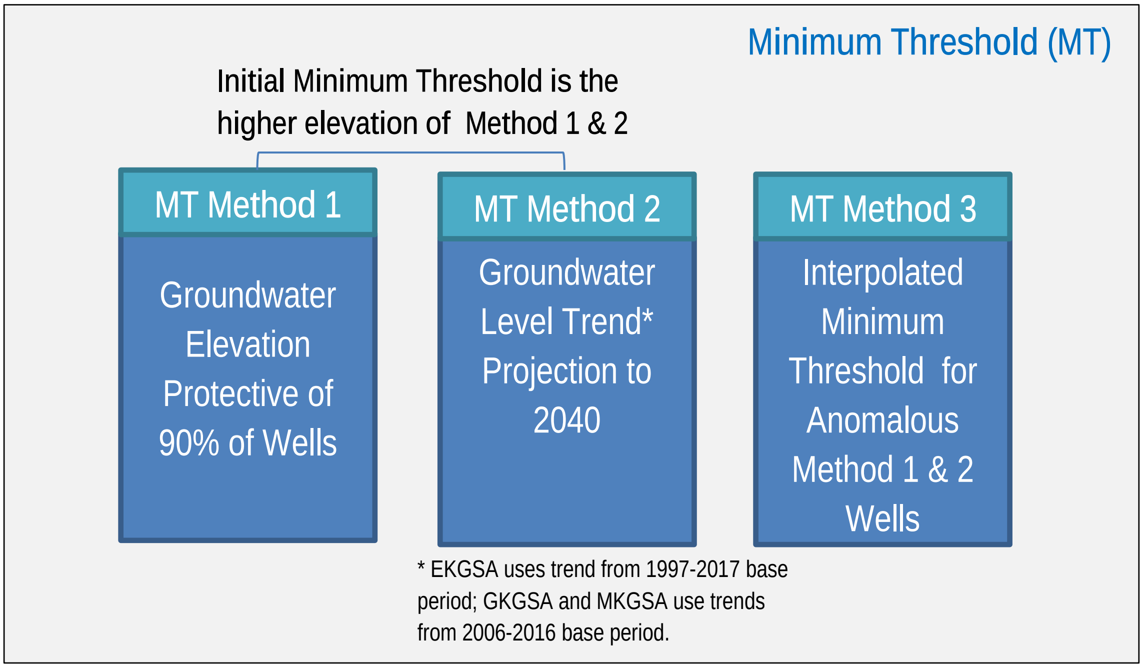



Figure 3. Minimum Threshold Methodologies

## 2.1 Methodology 1, Protective Elevations

The primary methodology for establishing MTs is designed to protect at least 90% of all wells in the Subbasin. This approach is protective of most beneficial uses and users of groundwater. The 90% threshold was chosen in acknowledgment that it is impractical to manage groundwater to protect the shallowest wells. More importantly, the GSAs wanted to set elevations based on well records of active wells, and not wells that may be destroyed or replaced. Because there is no active well registry to provide more accurate records, there is uncertainty regarding which wells are active. For example, the 2012-2016 drought was a period when approximately 480 wells in the Subbasin were reported dry according to the DWR's Dry Well Reporting System and a record number of wells were drilled in the Subbasin (Figure 4). Wells replaced by new deeper wells during this time are those that are presumed part of the shallowest 10% of wells in the dataset used to determine protective elevations. In consideration of the abovementioned factors, the GSA Managers selected 90% so that the dataset used to establish minimum thresholds contained well records reflective of current active wells.

Given approximately 10% of wells are shallower than the protected elevations, the GSAs in the Subbasin are in the process of establishing a Well Mitigation Program to assist impacted well owners.

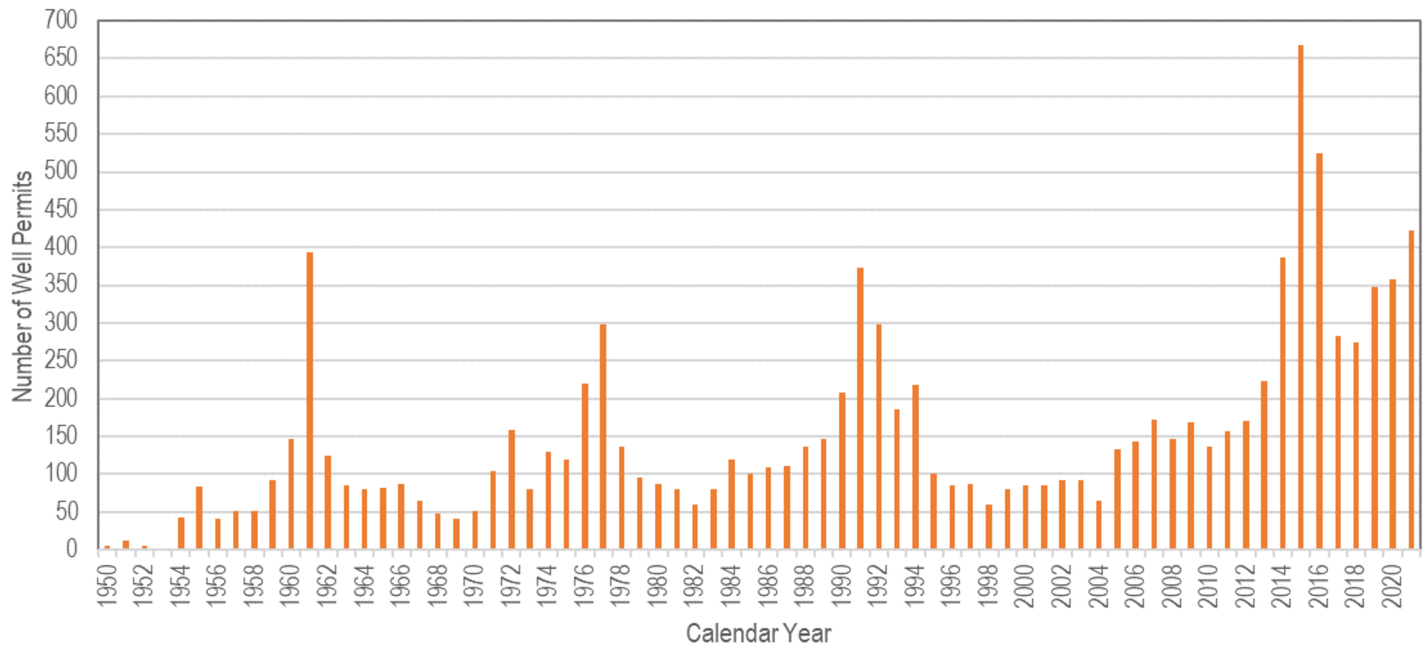



Figure 4. Annual Number of Water Supply Wells Drilled in the Kaweah Subbasin from 1950 to 2021

A total of 3,353 water supply well records from the WCR dataset are used for identifying significant and unreasonable groundwater elevations for beneficial groundwater users and uses. Criteria used to select well records from the WCR dataset include:

- The wells are drilled after January 1, 2002
- The wells are water supply wells with a planned purpose of domestic supply (includes DACs and private domestic wells), agricultural use, industrial use, or public supply (includes small water systems and municipal wells), and
- The wells have completed well depth data.

### 2.1.1 Analysis Zones

Because well depths vary with location, unique protective elevations are set for analysis zones that divide the Subbasin. The analysis zones are intended to group wells that would experience similar impacts by accounting for GSP management areas, groundwater elevations, base of aquifer, aquifer type, beneficial user type, land use, and similar completed well depths. A total of 39 spatial analysis zones are delineated (Figure 5). Twenty-three zones (analysis zones 1-23) cover the Single Aquifer System east of the limit of the Corcoran Clay shown on Figure 5. Sixteen zones (analysis zones 24-39) underlain by Corcoran Clay are split into an Upper and Lower Aquifer System based on the depth of the Corcoran Clay (described in Section 2.1.2). The Corcoran Clay is delineated vertically and spatially from recent airborne electromagnetic data acquired in the Subbasin by Stanford University (Kang *et al*., 2022).

### 2.1.2 Aquifer Designations

Aquifer designations are assigned to wells in the WCR dataset and the GSAs' representative monitoring sites based on available construction information and Corcoran Clay extent, depth, and thickness. As shown on Figure 6, the Corcoran Clay is a prominent confining geologic unit that underlies the western portion of the Subbasin and pinches out below the eastern portion of the Subbasin. The clay surface dips slightly with shallower occurrence to the east than the west. The Corcoran Clay is between 290 and 490 feet deep and up to 80 feet thick in the Subbasin.

All wells located east of the Corcoran Clay extent are designated as in the Single Aquifer System (Figure 6). Where the Corcoran Clay is present, wells are designated as Upper Aquifer System if the bottom of the well is above the bottom of the Corcoran Clay, and Likely Upper if the bottom of the well is within 50 feet of the bottom of the Corcoran Clay. Wells are designated as Lower Aquifer System if the top of its screen is within or below the Corcoran Clay. Wells are designated as Likely Lower if the total depth of the well with unknown screen depth is more than

50 feet below the bottom of the Corcoran Clay, or it is screened from less than 50 feet below the Corcoran Clay to more than 50 feet below the Corcoran Clay.

For wells without construction information that are underlain by the Corcoran Clay, groundwater level hydrographs are compared with hydrographs of other wells with construction information in the same analysis zone to determine in which aquifer the well is likely screened. Wells are designated as assumed Upper or assumed Lower Aquifer System based on similarities in seasonal and long-term groundwater level trends. Groundwater level hydrographs for representative monitoring sites are grouped by analysis zone and aquifer in Appendix A.

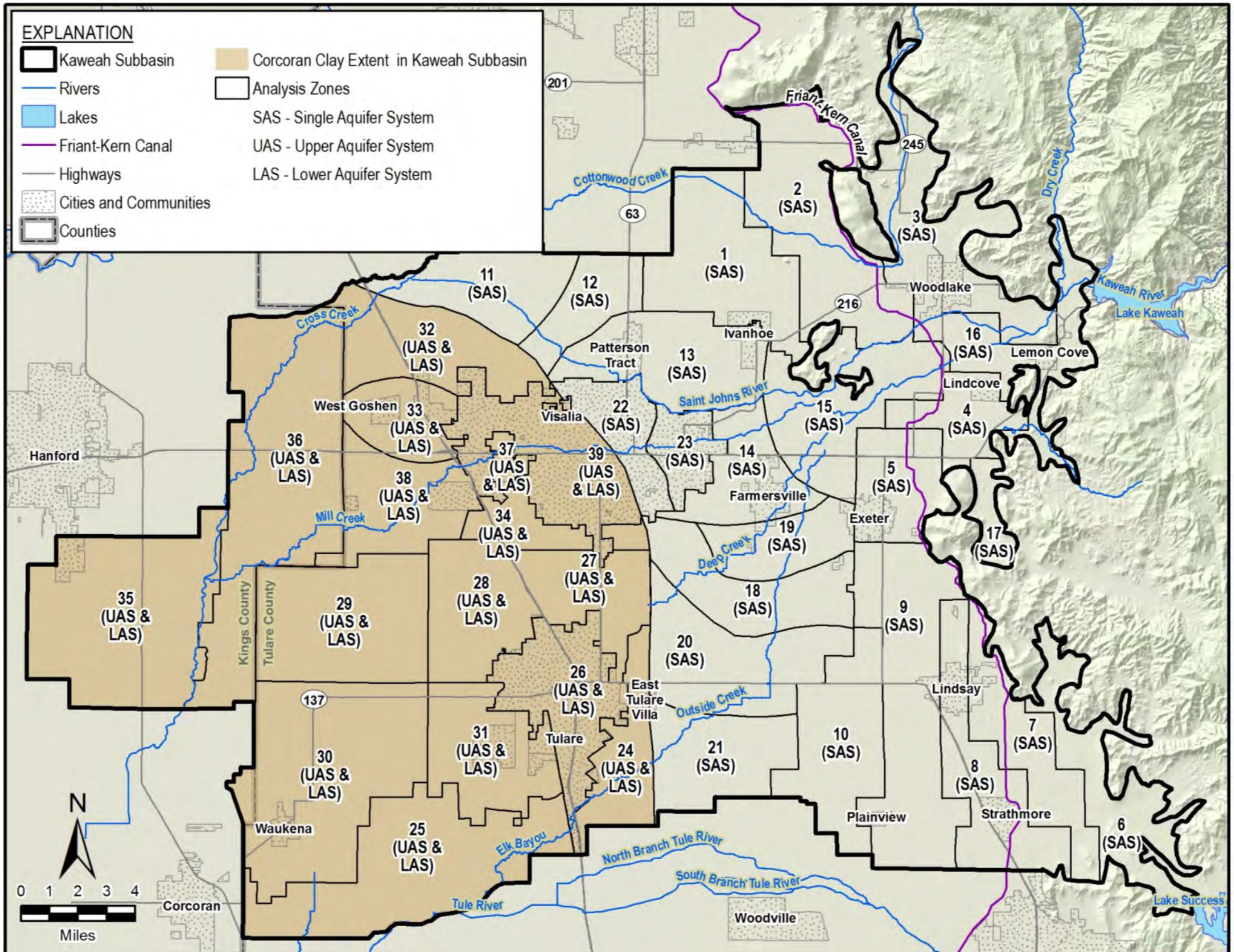


Figure 5. Kaweah Subbasin Analysis Zones

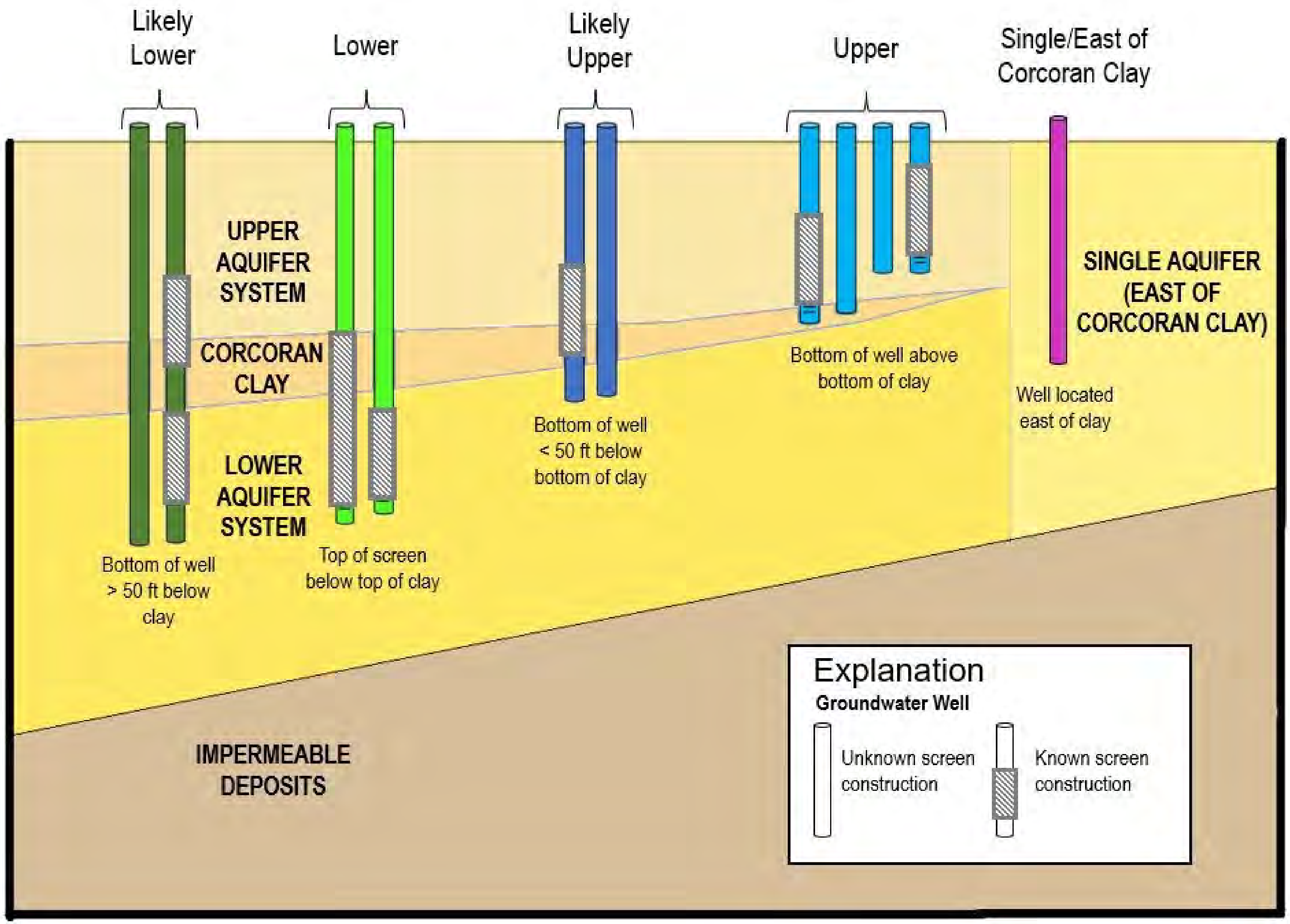



Figure 6. Kaweah Subbasin Aquifer Designation Assumptions

### 2.1.3 Completed Well Depth Analysis

Completed well depth is analyzed rather than total depth or depth of screens for the following reasons.

- Total depth drilled is typically deeper than the completed depth. Sometimes the difference can be quite large if the bottom portion of the well is not considered water bearing enough by the driller and is backfilled up to where the well is to be screened.
- More wells in the WCR dataset have completed depth information than well screen information. Of the wells with completed well depth information, 80% of those wells have screen depths. Since it is typical that wells are screened near the bottom of the completed well, more wells could be used in the analysis if completed well depth is used rather than screen depth.

Completed well depths vary by well use type, depth to groundwater, and aquifer. Figure 7 though Figure 13 depict the distribution of well use type and completed well depths across the Subbasin. Figure 7 shows a histogram of completed well depths across the entire Subbasin. Wells used in analysis are designated an aquifer system according to the assumptions outlined in Section 2.1.2.

Most wells in the Subbasin are completed to depths between 100 and 700 feet. The most common completed well depth is 350 to 400 feet, with about 700 total wells drilled to this depth. Well depth by type and aquifer is reviewed to assess which beneficial users would be impacted by lower groundwater levels. Figure 8 through  Figure 10 are aquifer-specific histograms of completed well depth by well use type. Most supply wells in the Subbasin are either used for agricultural or domestic water supply. Agricultural wells are more numerous than other types of water supply wells and also cover the widest range of depths, including the deepest depths of all wells. Overall, the shallowest wells tend to be domestic supply wells with few domestic wells installed deeper than 450 feet. There are relatively fewer public supply wells, with the majority less than 450 feet deep, although there are some that are deeper than 800 feet.

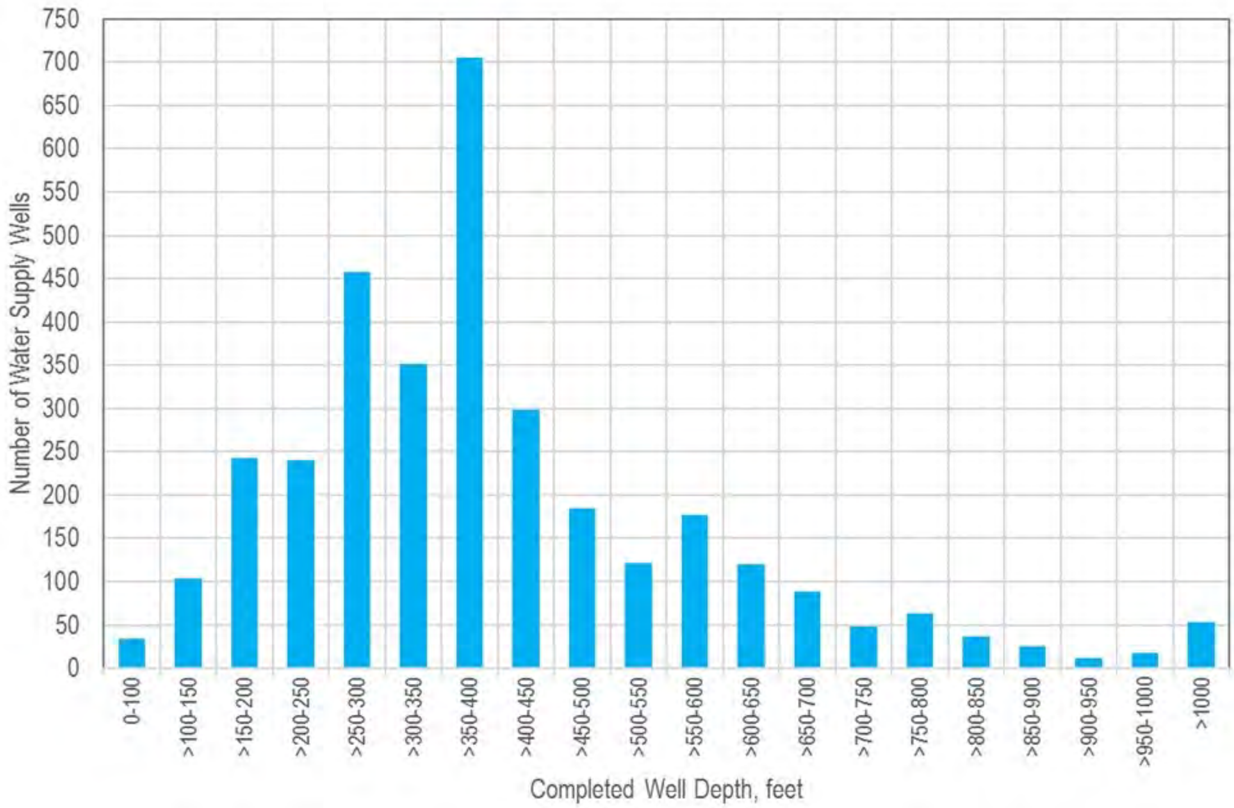



Figure 7. Histogram of Completed Wells Depths for Water Supply Wells in the Kaweah Subabsin

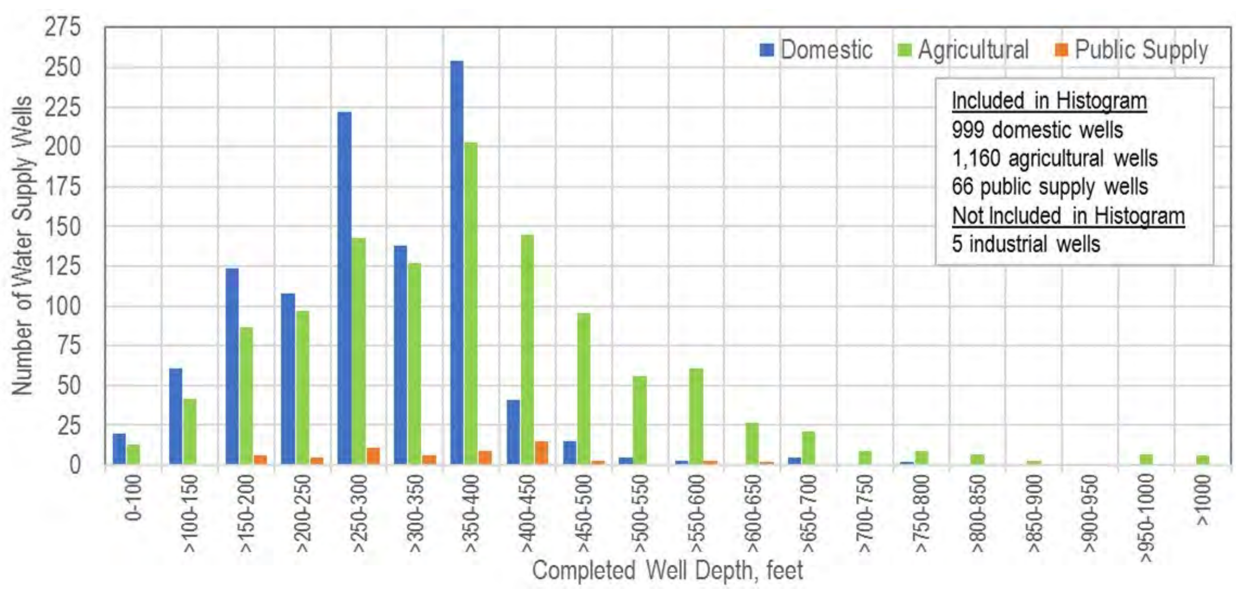



Figure 8. Histogram of Completed Well Depths for Single Aquifer System Water Supply Wells

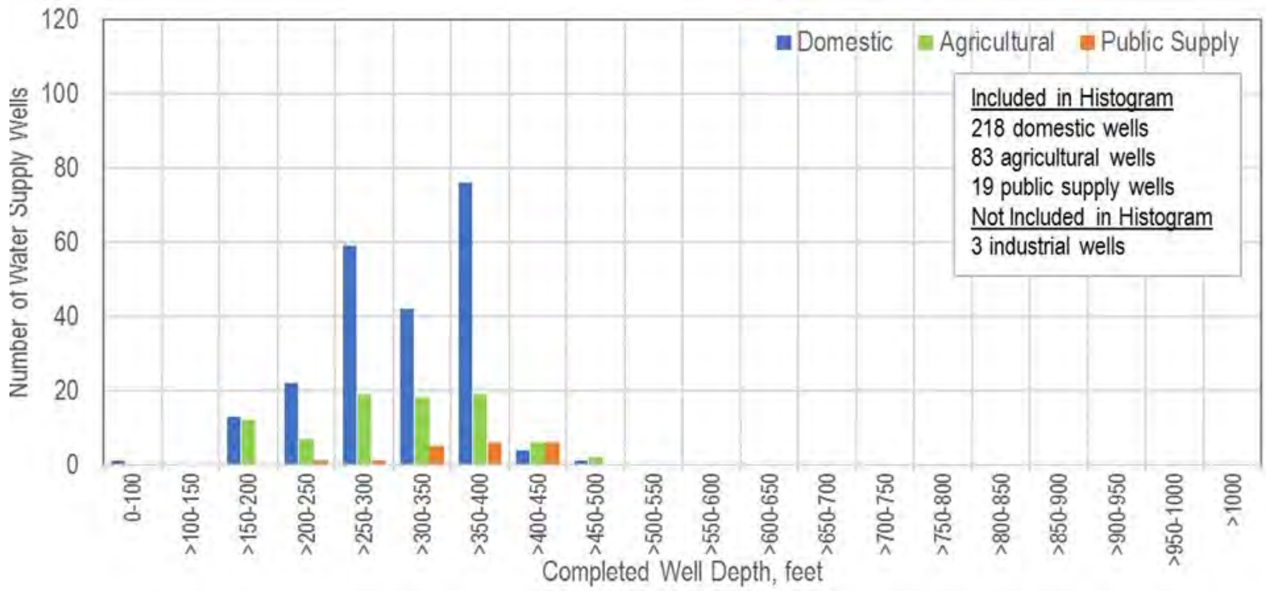


Figure 9. Histogram of Completed Well Depths for Upper Aquifer System Water Supply Wells

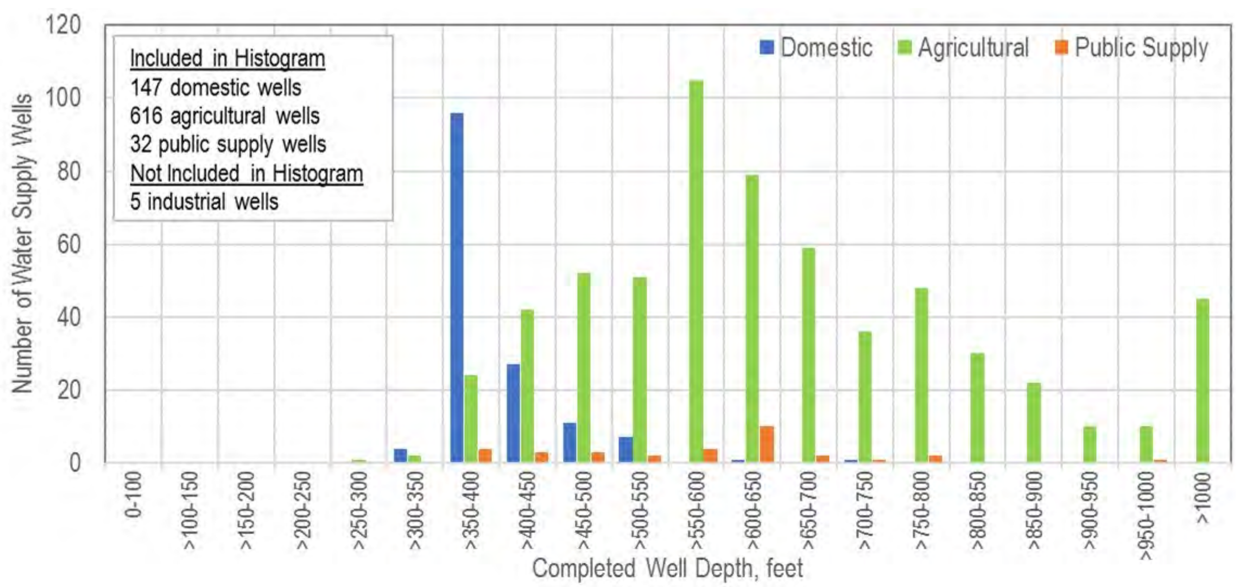


Figure 10. Histogram of Completed Well Depths for Lower Aquifer System Water Supply Wells

The number, depth, and type of water supply wells completed in each of the three aquifer systems are summarized below:

- The Single Aquifer System contains the most wells (2,232) and greatest well density (6.1 wells per square mile) of the three aquifer systems. It also has some of the shallowest wells in the Subbasin, with depths less than 100 feet (Figure 8). It has similar numbers of domestic (999) and agricultural wells (1,160), though overall domestic wells are shallower. About 60% of wells shallower than 200 feet in the Single Aquifer System are domestic wells and about 40% are agricultural wells.
- The Upper Aquifer System has the fewest total wells of the three aquifers (323) and has a well density of about 1 well per square mile. About 2.5 times as many domestic wells (218) as agriculture supply wells (83) are completed in the Upper Aquifer System, as shown on Figure 9. The shallowest wells in the Upper Aquifer System are between 150 and 200 feet, which is slightly deeper than the Single Aquifer System. This is because groundwater levels are deeper in the western portion of the Subbasin underlain by the Corcoran Clay. About 60% of wells in the top 100 feet of the saturated Upper Aquifer System (from 150 to 250 feet) are domestic wells and 40% are agricultural wells.
- The Lower Aquifer System wells are screened mostly below the Corcoran Clay and are generally deeper than 300 feet ( Figure 10). The dataset analyzed has 803 wells and a well density of about 2.5 wells per square mile. About 77% of wells screened in the Upper Aquifer System are agricultural wells (616). However, since most domestic wells are installed shallower than 450 feet and most agricultural wells are installed deeper than 450 feet, there are more domestic wells than agricultural wells in the shallower portions of the Lower Aquifer System. In total, about 65% of wells that are less than 450 feet deep are domestic wells and 35% are agricultural wells.

Completion well depths are evaluated by analysis zone because their depths vary spatially due to different groundwater depths across the Subbasin. Appendix B contains histograms of completed well depth by water use type and analysis zone. Figure 11 through Figure 13 show the proportions of well use types distributed across the Subbasin by analysis zone. By grouping wells in analysis zones, the predominant well use depths in the zone influence statistics used to determine protective groundwater elevations. For example, analysis zone 19 on Figure 11 has more domestic wells than other well use types which means the completed depth statistics derived from wells in the zone are influenced more by domestic wells than other use types.

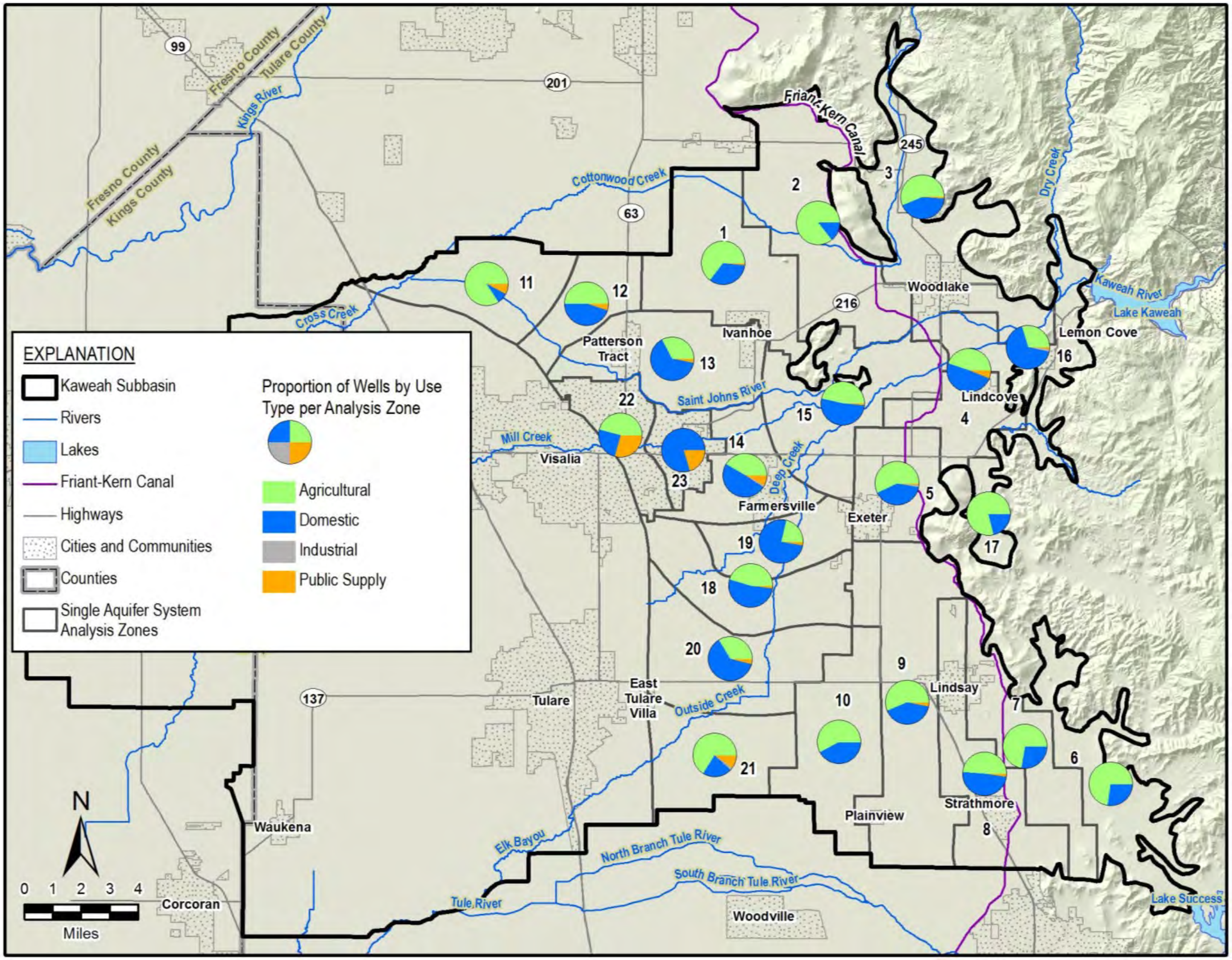



Figure 11. Single Aquifer System Well Use Types by Analysis Zone

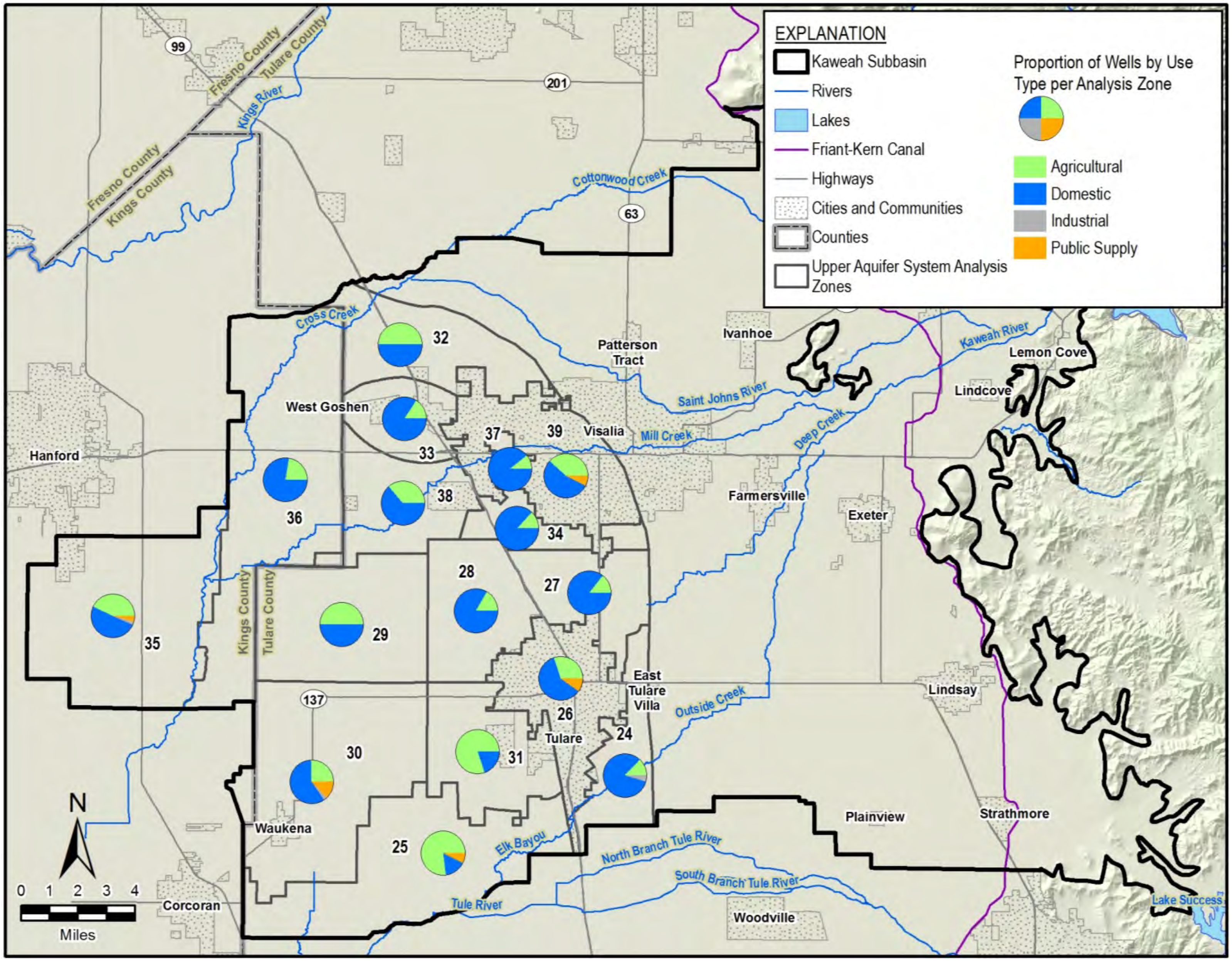



Figure 12. Upper Aquifer System Well Use Types by Analysis Zone

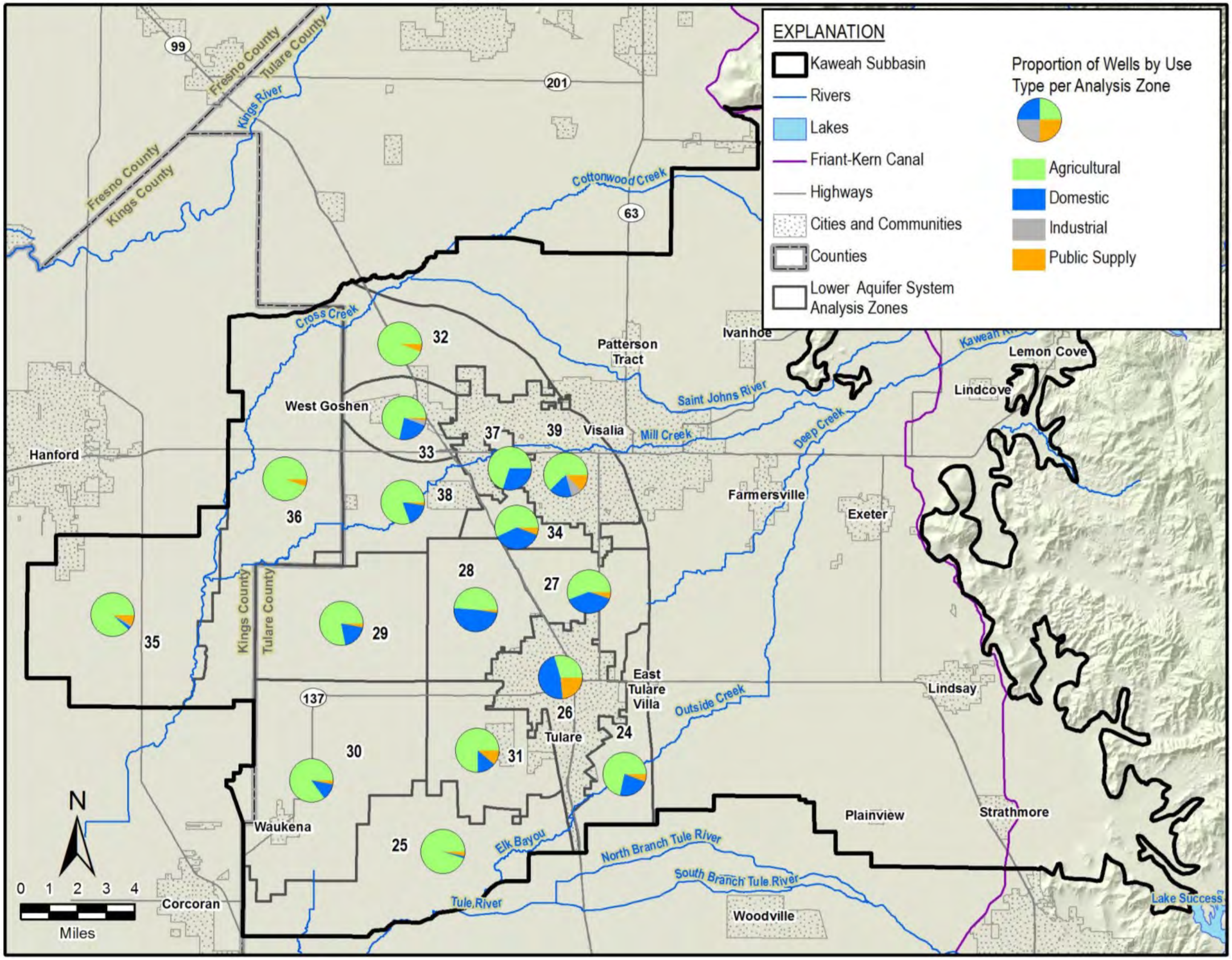



Figure 13. Lower Aquifer System Well Use Types by Analysis Zone

Well type spatial variability within the various aquifer systems is described below:

- The Single Aquifer System wells are relatively evenly split between domestic and agricultural use as shown on Figure 11. Wells around the margins of the Subbasin, including analysis zones 1, 2, 3, 11, and 17 are predominantly used for agriculture, while wells near the Kaweah River distributaries in the middle of the Subbasin such as zones 16, 19, 20, and 23 are predominantly used for domestic purposes. Visalia is the only area with greater than 20% public supply wells (analysis zones 22 and 23).

- The Upper Aquifer System is predominantly pumped by domestic wells as shown on Figure 12. However, there are parts of the Subbasin that are not heavily populated and nearly all wells are used for agriculture (analysis zones 25 and 31). Other areas with a relatively even number of domestic and agricultural supply wells include analysis zones 29 and 35 to the west and 32 to the north. Public supply wells make up less than 20% of all wells in each analysis zone, with the most concentrated distribution near Waukena (analysis zone 30).

- The Lower Aquifer System is primarily pumped by agricultural wells but there are a few areas near Tulare and Visalia where domestic wells make up between 25% to 50% of all wells (Zones 26, 27, 28, 34, and 37). Areas with the greatest number of public supply or industrial wells are in Tulare (analysis zone 26) and Visalia (analysis zone 39).

### 2.1.4 Protective Elevations

To calculate a groundwater elevation minimum threshold based on protection of active water supply wells, a statistical approach using percentiles was taken to develop a realistic view of active wells given well status uncertainties. A percentile well depth, or percentage of wells that would be deeper than a particular depth, was calculated for each analysis zone and aquifer. For example, the 90th percentile well depth (for wells ranked from deepest to shallowest), is the depth that 90% of wells are deeper than or equal to. This means 10% of wells are shallower than the 90th percentile depth. The 10% shallowest completed well depth are not used in the analysis as it is likely they are no longer active.

Selecting the 90th percentile recognizes the uncertainty in the accuracy and completeness of the DWR WCR dataset and accounts for destroyed or replaced shallower wells. The impracticability of managing the Subbasin to the shallowest wells is an additional factor leading to consensus amongst the three GSAs to, at a minimum, protect 90% of all water supply wells.

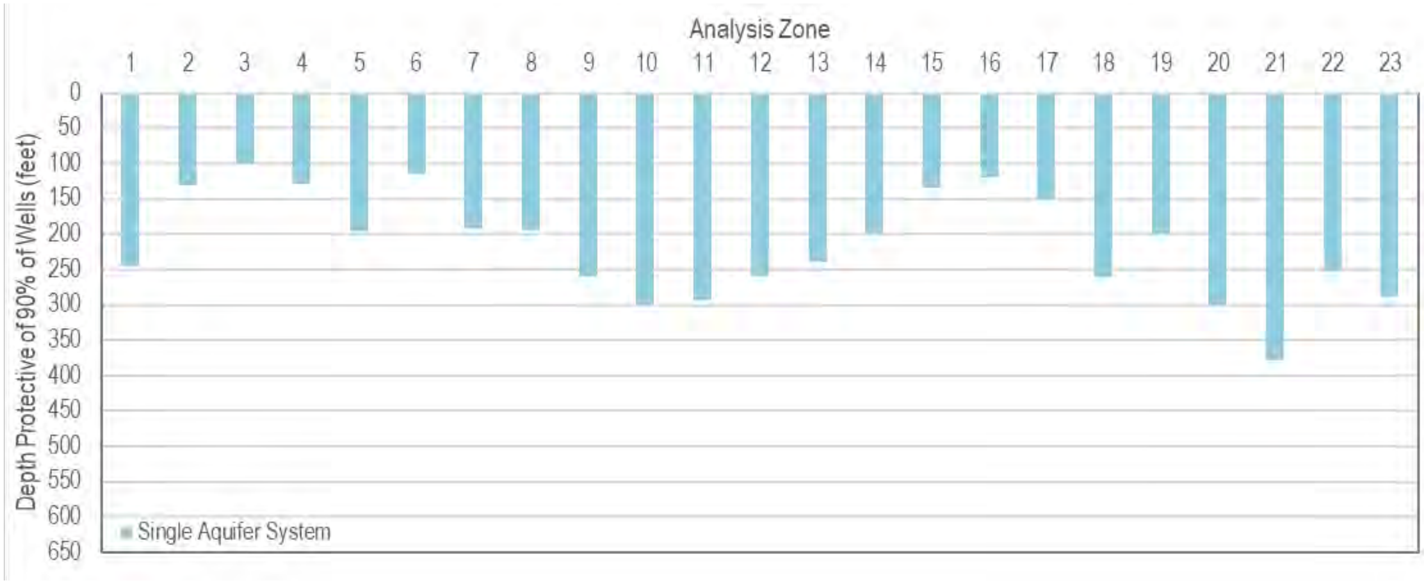
The 90th percentile completed well depths are calculated for each of the analysis zones by aquifers using the data described in Section 1.2. The analysis was not performed on a particular well use type but for all water supply wells within each analysis zone. Figure 14 shows the protective elevation depths for the three aquifer systems by analysis zone.

Protective well depths follow similar trends as the well completion statistics. The protective well depths are generally shallowest for the Single Aquifer System (Table 1), followed by the Upper Aquifer System, with the deepest protective depths in the Lower Aquifer System. The median protective well depth is 200 feet for the Single Aquifer System, 241 feet for the Upper Aquifer System, and 400 feet for the Lower Aquifer System. The range of protective depths are 100 to 378 feet for the Single Aquifer System, 168 to 300 feet for the Upper Aquifer System, and 380 to 606 feet for the Lower Aquifer System.

Table 1. Summary of Protective Elevations Statistics by Aquifer

| Aquifer | 90th Percentile Protective Depth (feet below ground surface) | | |
|---|---|---|---|
| | Minimum | Median | Maximum |
| Single Aquifer System | 100 | 200 | 378 |
| Upper Aquifer System | 168 | 241 | 300 |
| Lower Aquifer System | 380 | 400 | 606 |

The number of well records in the WCR dataset with construction information, above or below the protective elevation are summarized in Table 2. As mentioned previously, some of these shallow wells are likely destroyed and replaced with deeper wells, Domestic well depths tend to be shallower than wells used for other purposes, so a slightly higher number and percentage of domestic wells are potentially impacted by groundwater declines compared to other wells. Of the 297 wells shallower than the 90$^{th}$ percentile well depth, 58% are domestic wells, 39% are agricultural wells, and 3% are public supply wells. However, in total, 90% of all well types installed since January 2002 are deeper than protective well depths, including 88% of domestic wells, 94% of agricultural wells, and 92% of public supply wells. Although the full set of WCR wells lacks construction information for many wells, if it is assumed the percentages of well use type and depth are the same for the full set of WCR wells as the subset of wells with construction information, the subset percentages may be used to scale up the number of potentially impacted wells to the full set of WCR wells.



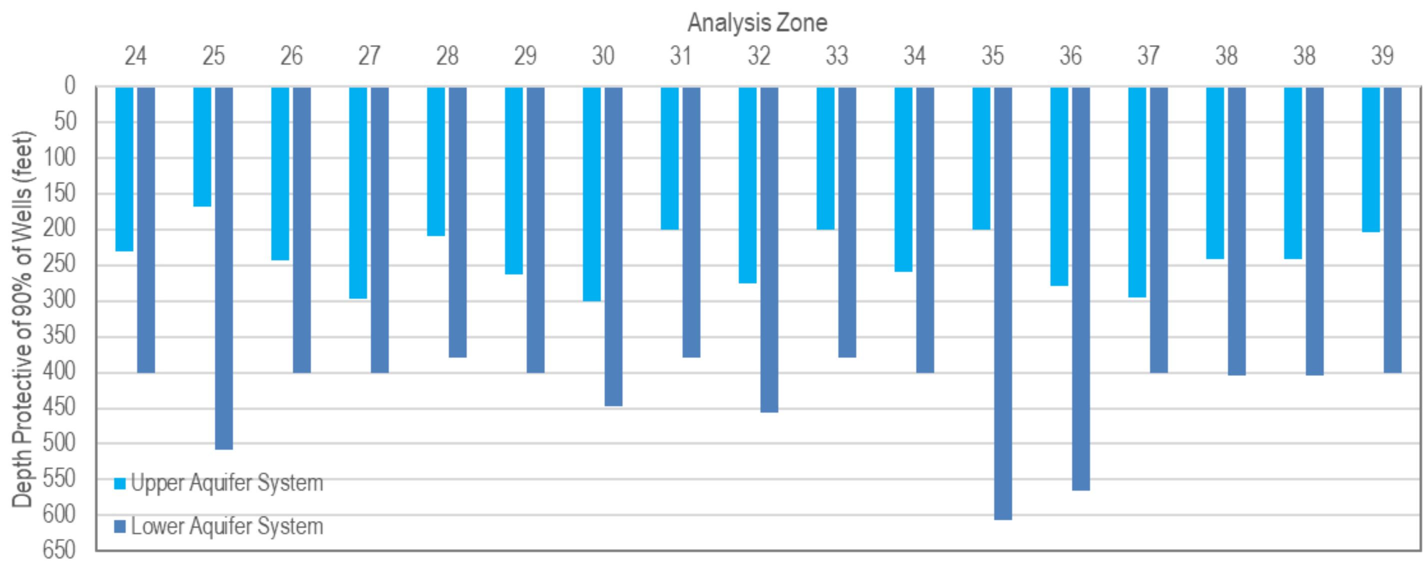




Figure 14. Analysis Zone Depths Protective of 90% of Water Supply Wells in the Kaweah Subbasin

Table 2. Summary of Basinwide Potential Well Impacts of Groundwater Levels at 90% Protective Depths Using WCR Well Records with Construction Information

| Well Use Type | Deeper than 90% Protective Depth | | Shallower than 90% Protective Depth | | Total Number |
|---|---|---|---|---|---|
| | Number of Wells Deeper than the Protective Depth | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | |
| Domestic | 1,193 | 39% | 171 | 58% | 1,364 |
| Agricultural | 1,742 | 57% | 117 | 39% | 1,859 |
| Public Supply | 108 | 4% | 9 | 3% | 117 |
| Industrial | 13 | 0% | 0 | 0% | 13 |
| Total | 3,056 | | 297 | | 3,353 |

The number of well records in the WCR dataset of wells with construction information, potentially impacted at the 90% protective depth for each of the three aquifer systems are summarized in Table 4. Domestic wells in the Single Aquifer System will be the most impacted if groundwater levels fall to the protective elevation, followed by agricultural wells. Lower Aquifer System agricultural wells will be impacted more than domestic wells because of the greater number of agricultural wells in the Lower Aquifer System ( Figure 10). The Upper Aquifer System has the least potentially impacted wells, with more domestic wells than agricultural wells potentially impacted.

Table 3. Summary of Potential Well Impacts of Groundwater Levels at 90% Protective Depths by Aquifer Using WCR Well Records with Construction Information

| Well Use Type | Single Aquifer System | | Upper Aquifer System | | Lower Aquifer System | | Total |
|---|---|---|---|---|---|---|---|
| | Number of Potentially Impacted Wells | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | |
| Domestic | 135 | 63% | 19 | 68% | 17 | 30% | 171 |
| Agricultural | 74 | 35% | 9 | 32% | 34 | 61% | 117 |
| Public Supply | 4 | 2% | 0 | 0% | 5 | 9% | 9 |
| Industrial | 0 | 0% | 0 | 0% | 0 | 0% | 0 |
| Total | 213 | | 28 | | 56 | | 297 |

The East Kaweah Groundwater Sustainability Agency (EKGSA) and Greater Kaweah Groundwater Sustainability Agency (GKGSA) areas are those with the greatest number of wells shallower than the 90% protective depth (Table 4). This is because the Single Aquifer System underlies all of the EKGSA and a portion of the GKGSA, and it is the aquifer with the largest number of potentially impacted wells above the 90% protective depth. The GKGSA has the greatest total number of potentially impacted wells and the Mid-Kaweah Groundwater Sustainability Agency (MKGSA) has the fewest. The GSA areas are shown on Figure 1. Table 4 also summarizes the density of potentially unprotected wells within each GSA area. The EKGSA has the greatest overall density at 0.63 wells per square mile, GKGSA has 0.42 wells per square mile, and MKGSA the lowest density at 0.22 wells per square mile.

The protective elevation for each representative monitoring site is calculated by subtracting the analysis zone-specific 90th percentile protective depth from the representative monitoring site's surface elevation. Appendix C lists the 90% protective elevations for all the representative monitoring sites.

Table 4. Summary of Potential Well Impacts with Groundwater Levels at 90% Protective Depths by GSA Using WCR Well Records with Construction Information

| Well Use Type | East Kaweah GSA | | | Greater Kaweah GSA | | | Mid-Kaweah GSA | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Potentially Impacted Wells | | Well Use Type Percentage in GSA | Potentially Impacted Wells | | Well Use Type Percentage in GSA | Potentially Impacted Wells | | Well Use Type Percentage in GSA | |
| | Number | Wells per Square Mile | | Number | Wells per Square Mile | | Number | Wells per Square Mile | | |
| Domestic | 58 | 0.32 | 52% | 93 | 0.27 | 64% | 17 | 0.10 | 49% | 171 |
| Agricultural | 50 | 0.27 | 45% | 47 | 0.14 | 32% | 18 | 0.11 | 51% | 117 |
| Public Supply | 3 | 0.02 | 3% | 6 | 0.02 | 4% | 0 | 0 | 0% | 9 |
| Industrial | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 |
| Total | 111 | 0.61 | | 151 | 0.43 | | 35 | 0.22 | | 297 |

## 2.2 Methodology 2, Groundwater Level Trend

This method extrapolates groundwater level trends for individual representative monitoring sites over a selected base period out to 2040. In all cases the trend is a decline with a rate that varies across the Subbasin. The EKGSA used a different base period than the GKGSA and MKGSA base period as described below. If the MT is derived from this method, it means groundwater levels are set to protect more than 90% of wells in the analysis zone while not allowing groundwater levels to decline at a greater rate than the base period.

In the EKGSA, groundwater level trends over a historical 21-year base period (1997-2017) are projected to 2040. EKGSA critically analyzed the projected 2040 groundwater levels and determined the magnitude of potential impacts likely to occur due to the current pumping and recharge regime. In cases where projected groundwater levels mirror the condition of the basin before the 1950s, when Central Valley Project brought in surface water supplies, or were not sufficiently protective of aquifer storage capacity it was determined that returning groundwater conditions similar to pre-1950 is undesirable. In EKGSA’s eastern analysis zones (also called threshold regions), some initial MT elevations were increased due to the shallow depth to the bottom of the aquifer. Groundwater level MTs are established for each of the EKGSA’s 10 analysis zones based on available groundwater level trend data for wells within each analysis zone. EKGSA representative monitoring sites within an analysis zone are therefore assigned the same MT groundwater elevations.

For representative monitoring sites in the GKGSA and MKGSA, the groundwater level trend base period projected to 2040 is the 11-year period from 2006 to 2016. The 2006-2016 base period represents a more recent period that reflects recent pumping patterns and includes the effects of the 2012-2016 drought.  Unlike EKGSA which assigns a single MT to all representative monitoring sites within an analysis zone, GKGSA and MKGSA representative monitoring sites all have unique MTs based upon the 11-year groundwater level trend.

## 2.3 Methodology 3, Interpolated Minimum Threshold

After estimating MTs using methodologies 1 and 2, some GKGSA and MKGSA representative monitoring site MTs were determined to be anomalously low compared to neighboring monitoring sites because the wells’ 2006-2016 groundwater level trend are much steeper than adjacent representative monitoring sites. There are four sites in the Single Aquifer System and three sites in the Upper Aquifer System where this occurs.

For representative monitoring sites with anomalously low MTs derived from the higher of Methodology 1 and 2 elevations, MTs were raised to an elevation determined by interpolating from MT contours. The contours are generated from the representative monitoring site MTs without the seven sites as control points. Figure 15 identifies the resultant MT contours and identifies the seven sites with pre-adjusted and adjusted MTs labeled. The result of using Methodology 3 is that MTs were interpolated into a smooth surface of MTs without any significant level change (“cliffs”) between representative monitoring sites.

## 2.4 Selection of Method to Use for Minimum Threshold

For each representative monitoring site, the elevations based on the 90% protective depth (Method 1) and groundwater levels trend (Method 2) are compared. The higher of the two elevations is selected as the MT. If the groundwater level trend elevation is higher than the protective elevation, more than 90% of wells in the analysis zone are protected. Appendix C includes the elevations for both methods and highlights the elevation of the method used for MTs.

Even though multiple methods are used by the GSAs to establish MTs, contours of MTs for the Single and Upper Aquifer Systems (unconfined) and the Lower Aquifer System (confined) onFigure 15 and Figure 16, respectively, demonstrate MTs across the Subbasin do not show abnormal differences between RMS and MTs decrease in elevation from east to west similar to groundwater elevations.

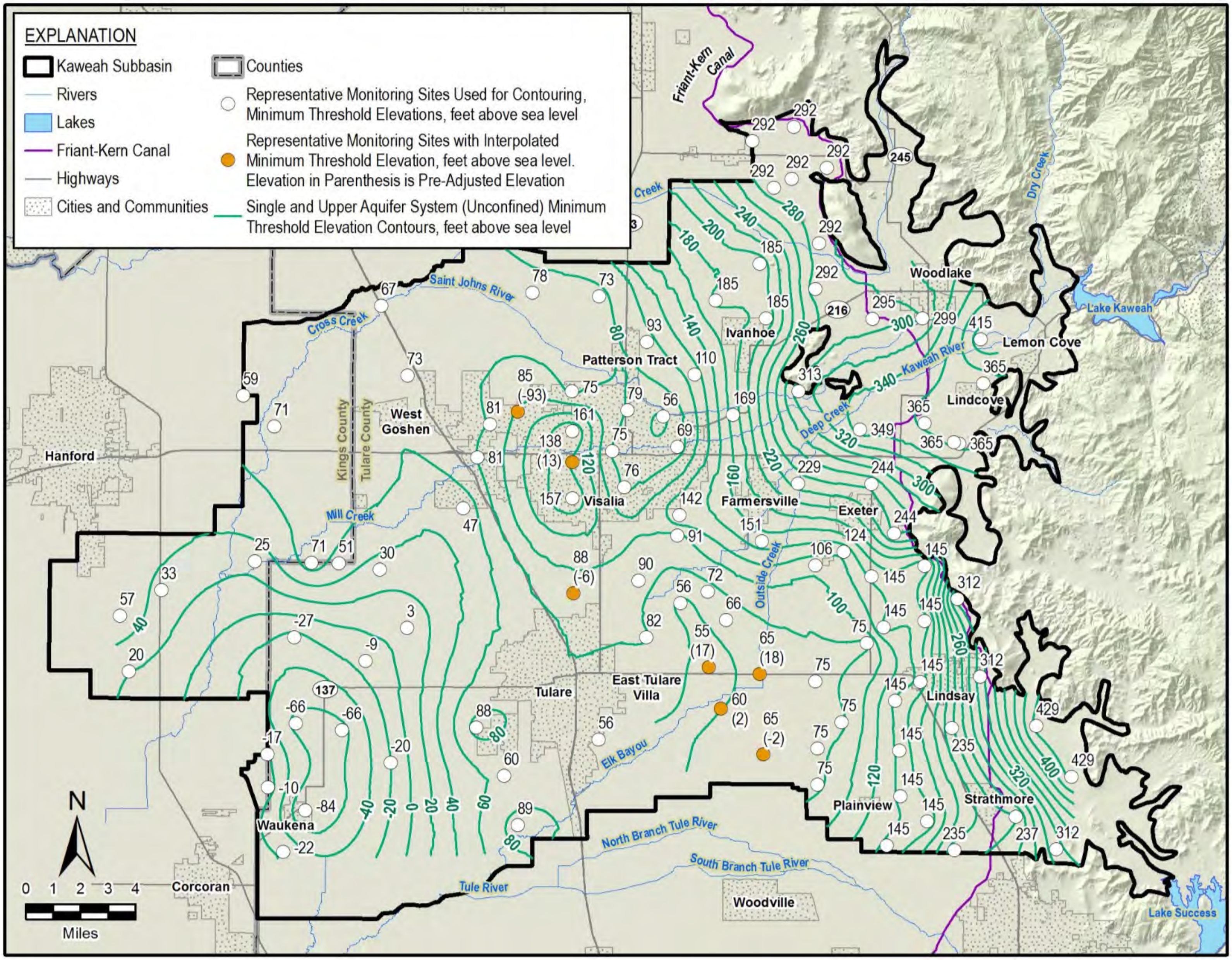



Figure 15. Single and Upper (Unconfined) Aquifer System Minimum Threshold Contours Across the Kaweah Subbasin

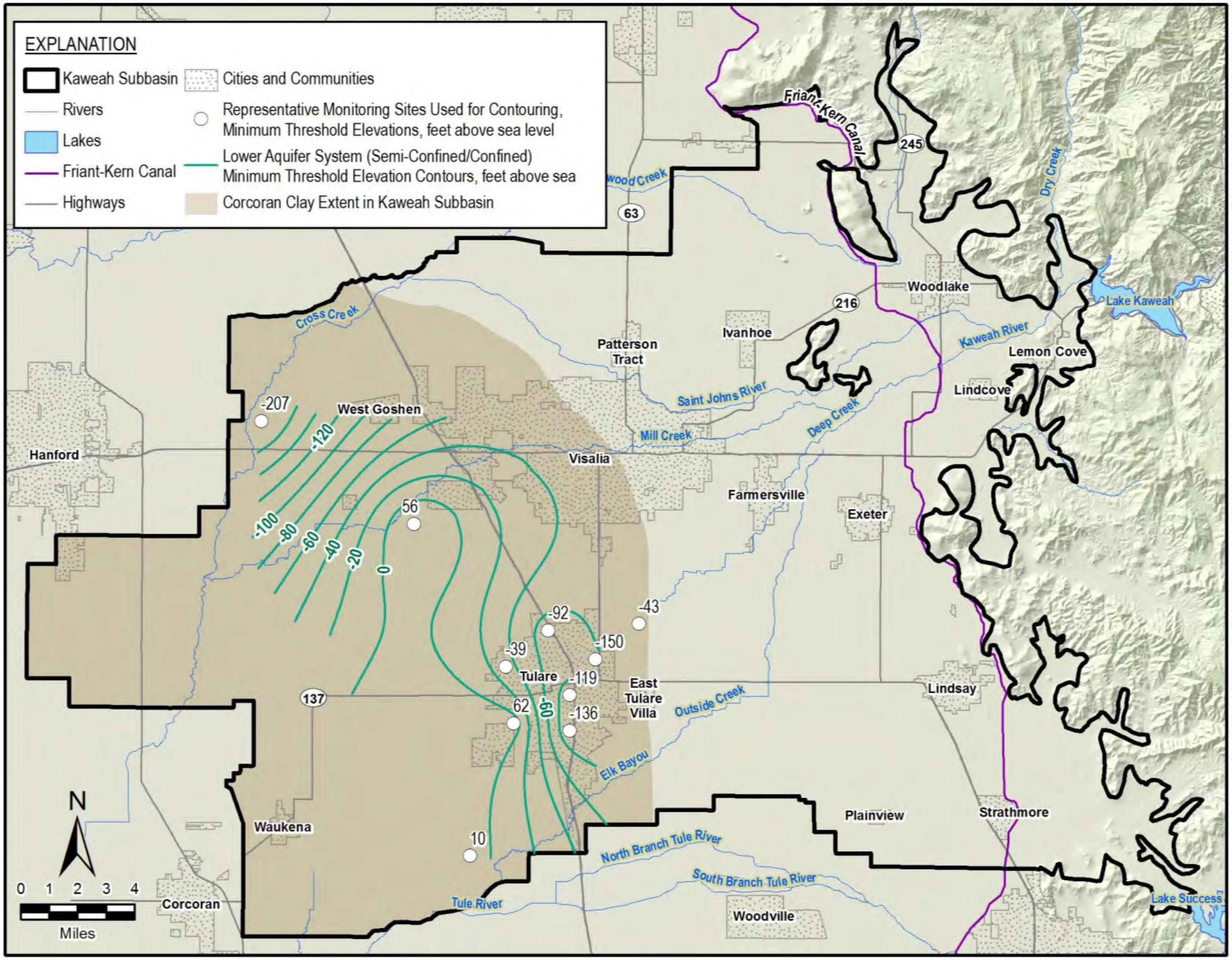



Figure 16. Lower Aquifer (Semi-Confined/Confined) System Minimum Threshold Contours Across the Kaweah Subbasin

# 3 PROCESS USED TO ESTABLISH MEASURABLE OBJECTIVES AND INTERIM MILESTONES

## 3.1 Measurable Objective Methodologies

Measurable objectives (MOs) are established at groundwater elevations higher than MTs to provide operational flexibility and reflect the GSAs' desired groundwater conditions in 2040. The margin of operational flexibility accounts for droughts, climate change, conjunctive use operations, other groundwater management activities, and data uncertainty. The GSAs in the Kaweah Subbasin are managing their groundwater sustainability to meet the MO in 2040.

The EKGSA MOs are based on Spring 2017 groundwater levels. Spring 2017 was a wet year that followed the 2012-2016 drought. This approach applies to wells where the MT is based on the 1997-2017 groundwater level trend projection described in Section 1.1 and shown on Figure 17.

The GKGSA and MKGSA MOs are based on one of two methods, depending on which methodology was used to set MTs. Figure 17 graphically shows the relationship between the different MT and MO methodologies.

MO Method 1, Groundwater Level Trend Projection to 2030:

- For GKGSA and MKGSA representative monitoring sites with MTs derived from the groundwater level trend projection, the MO is the 2006-2016 groundwater elevation projected to 2030 (Figure 18).
- For representative monitoring sites where the MT is set using the protective elevation, and the difference between the MT and groundwater elevation trend projected to 2030 is 20 feet or more, the MO is the 2006-2016 groundwater elevation projected to 2030 (Figure 18).

MO Method 2: 5-Year Drought Storage Based on 2006-2016 Trend

- For representative monitoring sites where the MT is set using the protective elevation, and the difference between the MT and groundwater elevation trend projected to 2030 is less than 20 feet, the MO is set at an elevation that provides for 5 years of drought storage above the MT. Five years of drought storage is determined as the groundwater level change occurring over 5 years using the 2006-2016 groundwater level trend (Figure 19). The groundwater level change is added to the MT elevation to establish the MO elevation (Figure 19).

- For representative monitoring sites where anomalously low MTs are adjusted by interpolating from MT contours, the MO is set at an elevation that provides for 5 years of drought storage above the adjusted MT.

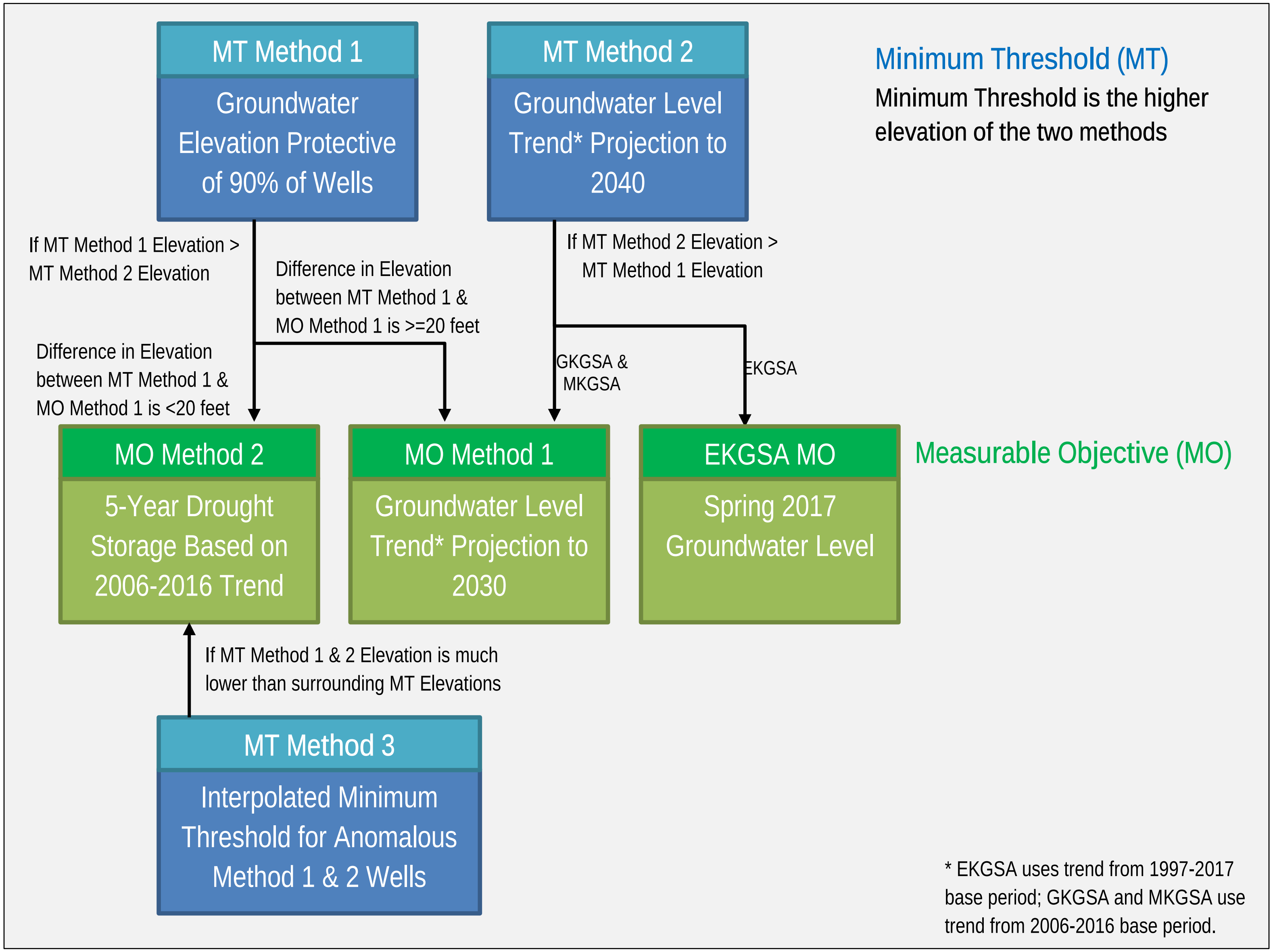



Figure 17. Relationship Between Minimum Threshold and Measurable Objective Methodologies

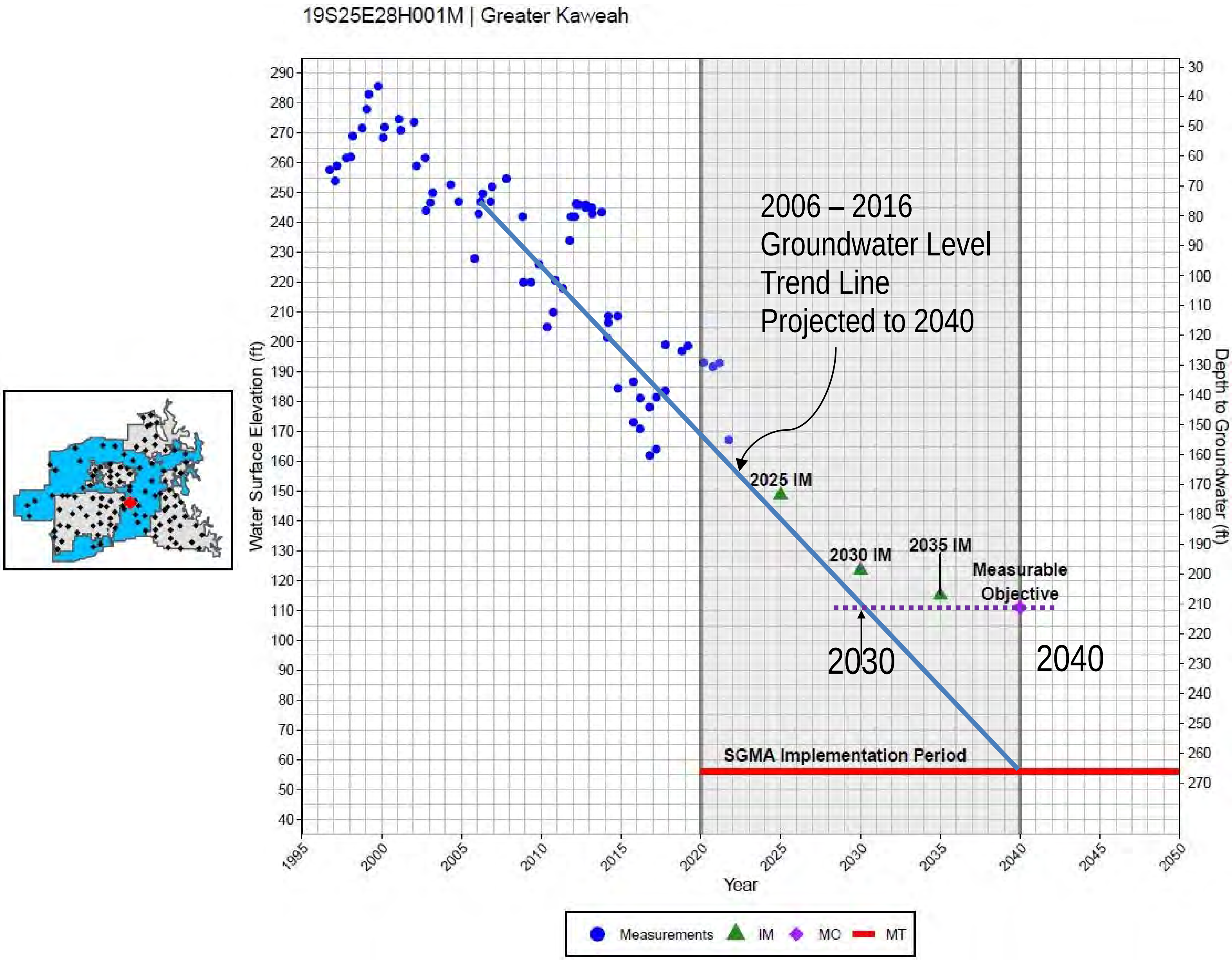



Figure 18. Example Hydrograph Showing Projection of 2006 – 2016 Trend Line

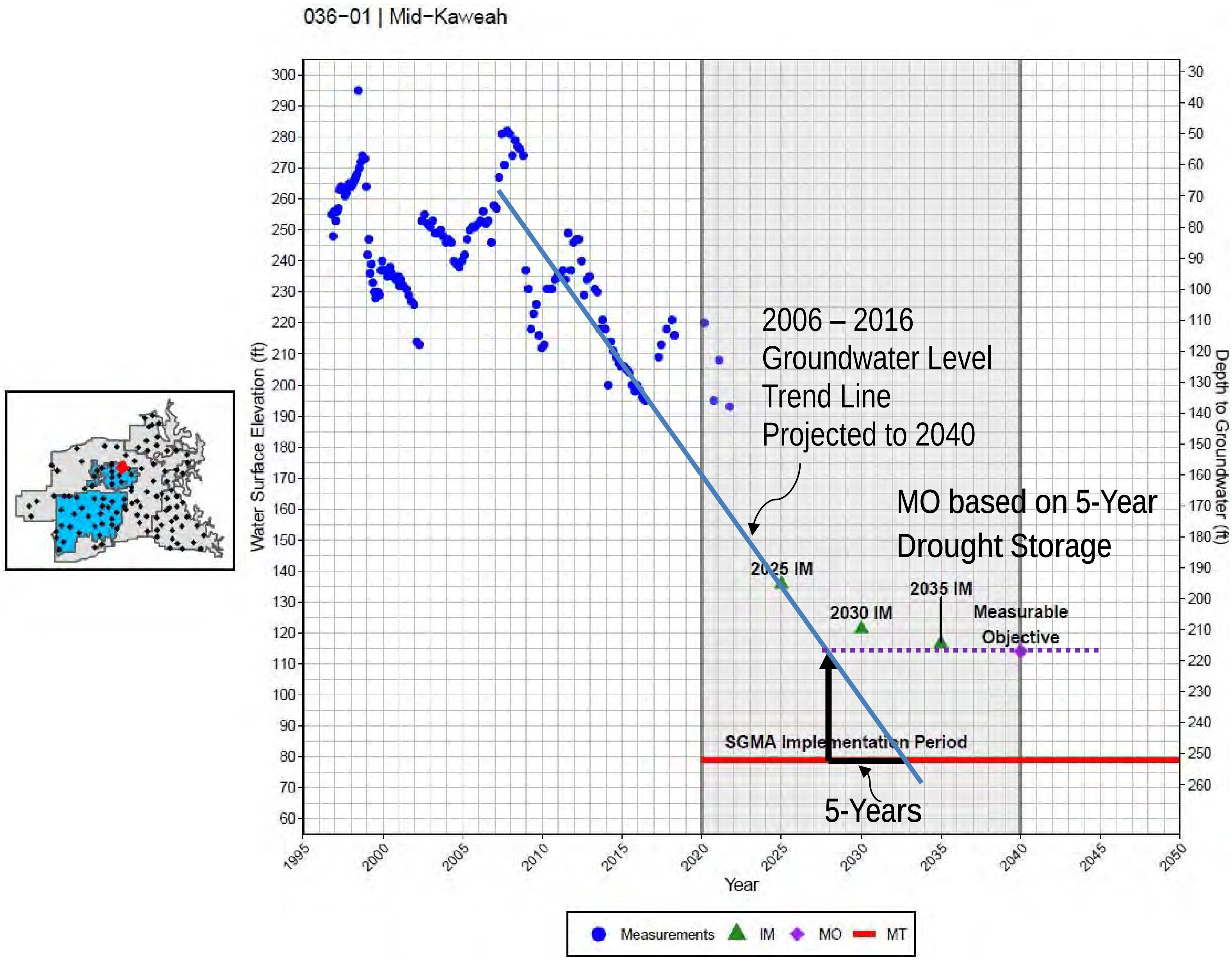



Figure 19. Example Hydrograph Showing Measurable Objective Based on 5-Year Drought Storage

## 3.2 Interim Milestone Methodology

Interim milestones for all representative monitoring sites take the form of a curve that flattens out toward 2040 when the MO is reached. The curve shape is determined based on implementation of projects and management actions over the next 18 years.

For the EKGSA, interim milestones are proportional to percent of overdraft to be corrected in 5-year intervals through implementation period. The interim milestones leading to groundwater level stabilization are unique to each analysis zone but follow the same incremental mitigation rate for correction of 5%, 25%, 55%, and 100% by 2025, 2030, 2035, and 2040, respectively.

Interim milestones for GKGSA and MKGSA representative monitoring sites are based on incrementally decreasing groundwater level change over time based on the following:

- 2025 interim milestone– extend the 2006-2016 groundwater level trend to 2025
- 2030 interim milestone –elevation at two-thirds of the elevation difference between the 2025 interim milestone and the MO
- 2035 interim milestone - elevation at two-thirds of the elevation difference between the 2030 interim milestone and the MO

The method for setting GKGSA and MKGSA interim milestones is illustrated on Figure 20.

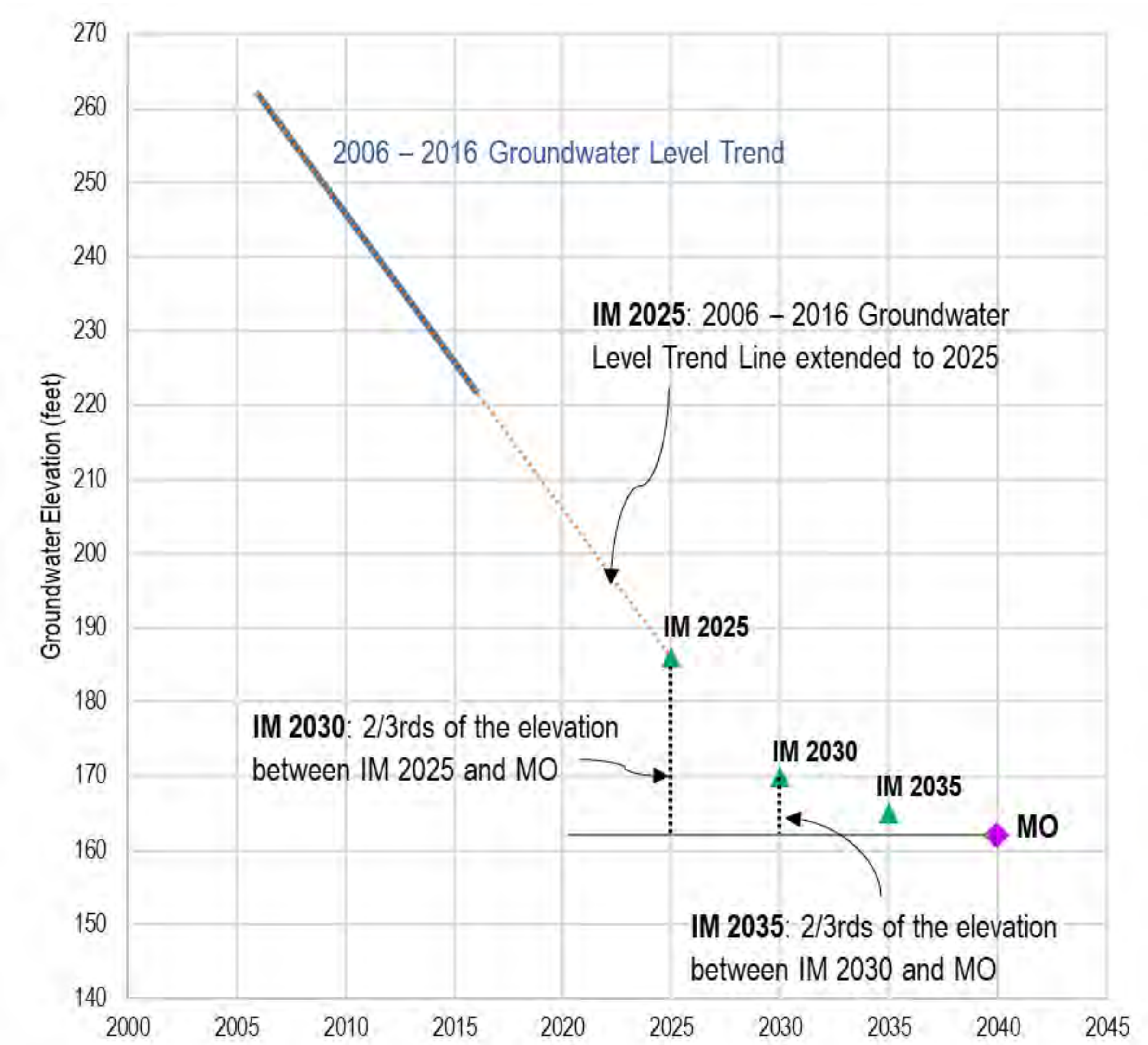



Figure 20. Example of Interim Milestone Method for GKGSA and MKGSA Represenative Monitoring Sites

# 4 REFERENCES

Kang, S., Knight, R., & Goebel, M. (2022). Improved imaging of the large-scale structure of a groundwater system with airborne electromagnetic data. *Water Resources Research*, 58, e2021WR031439. https://doi.org/10.1029/2021WR031439

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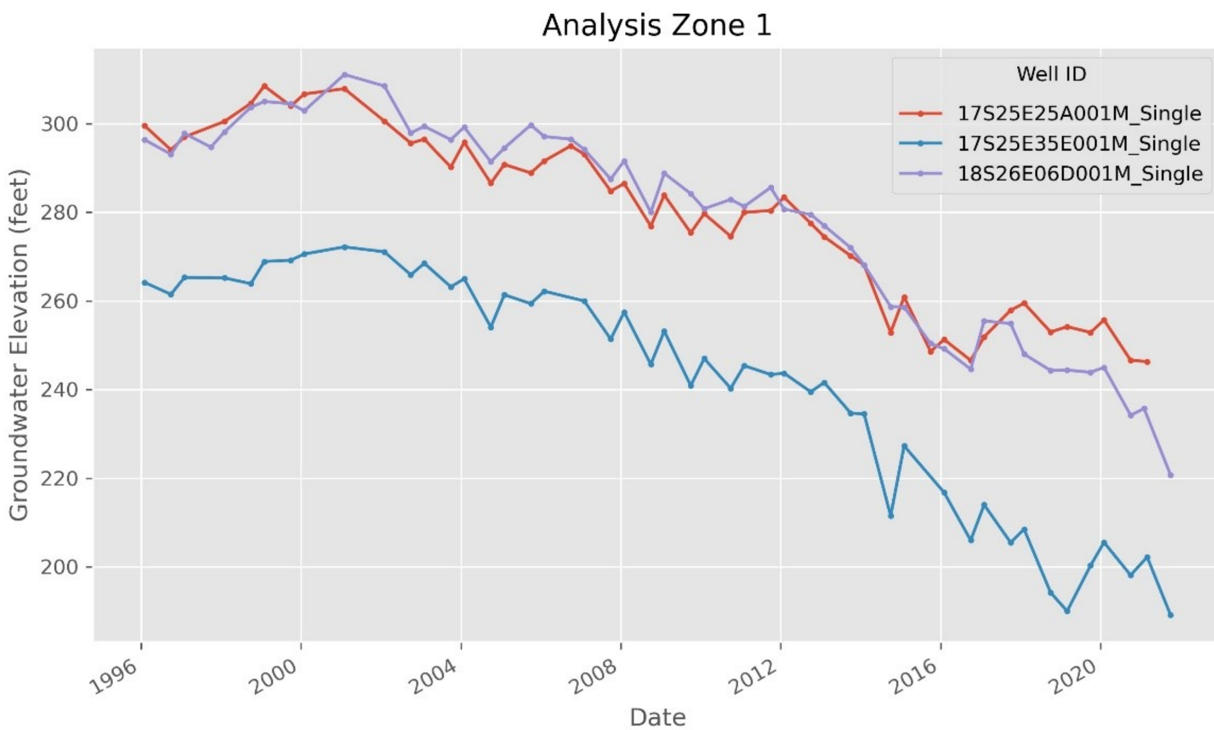
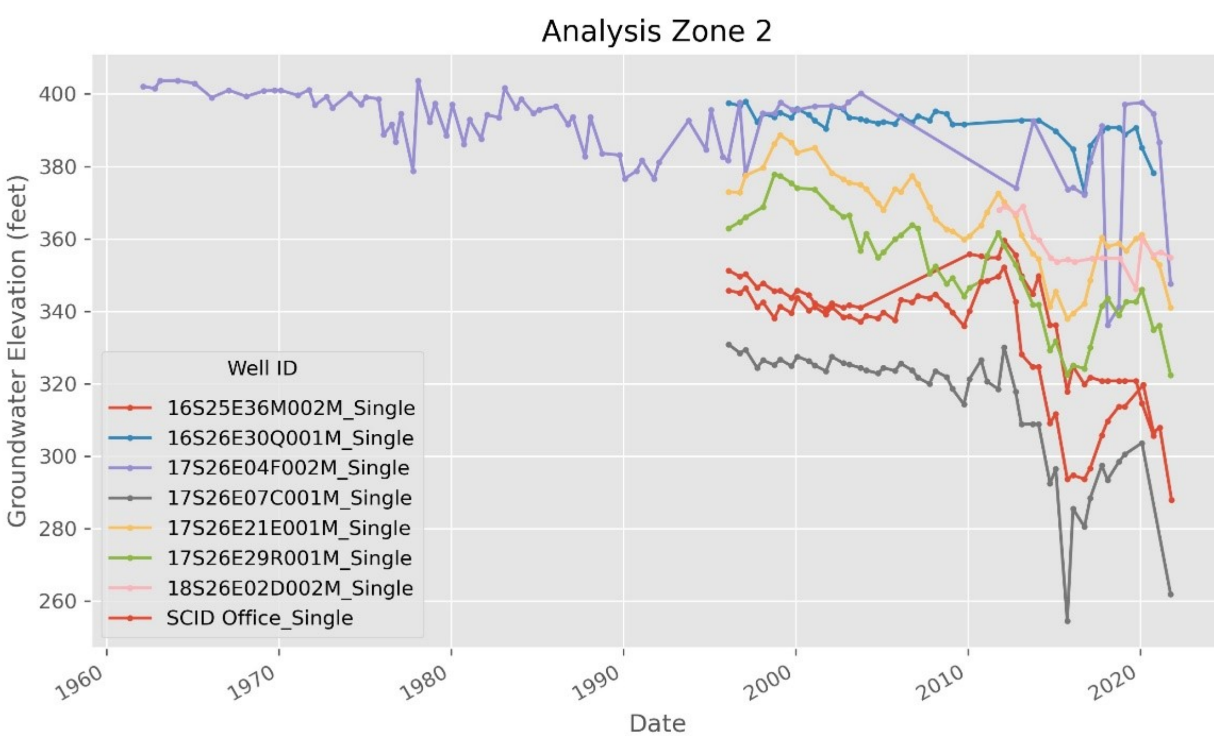
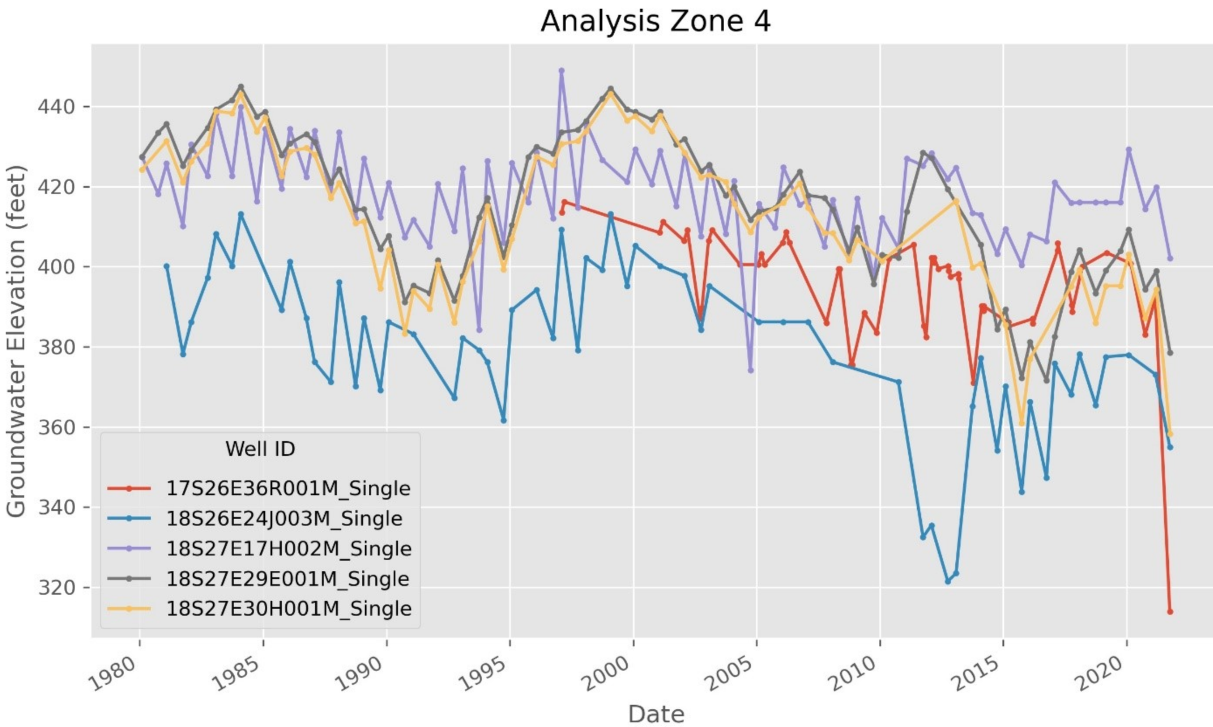
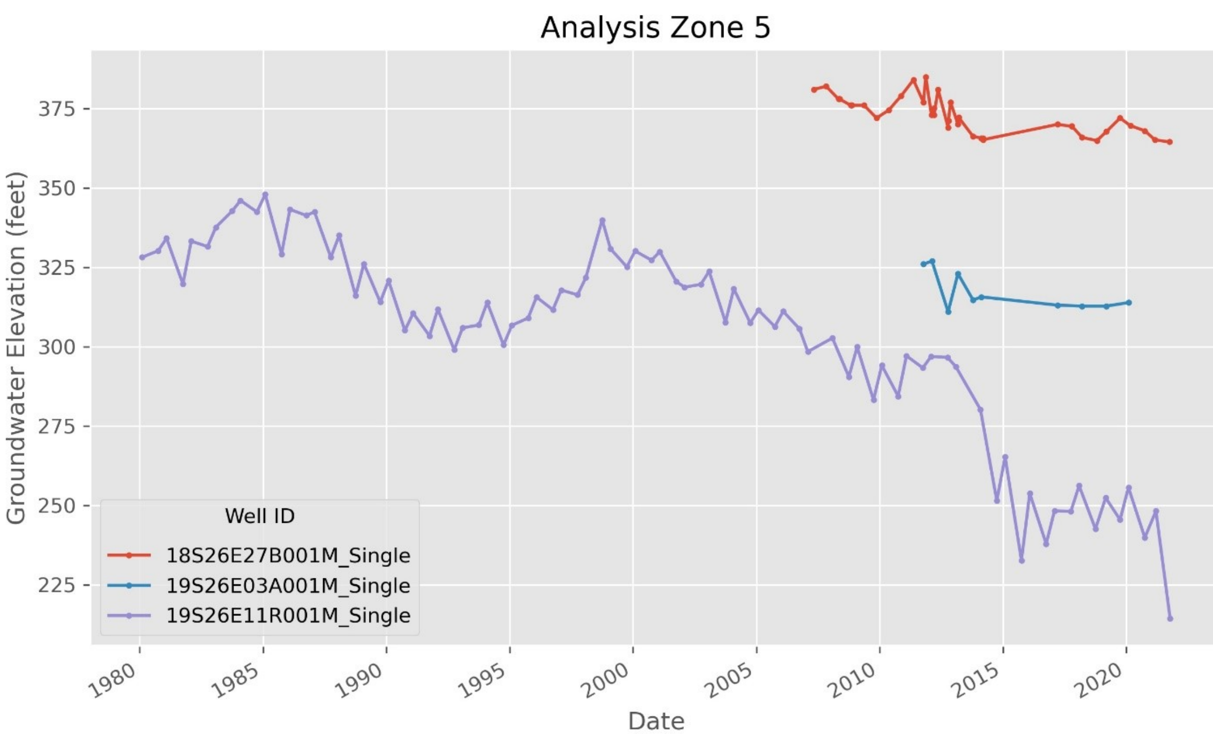
# Appendix A

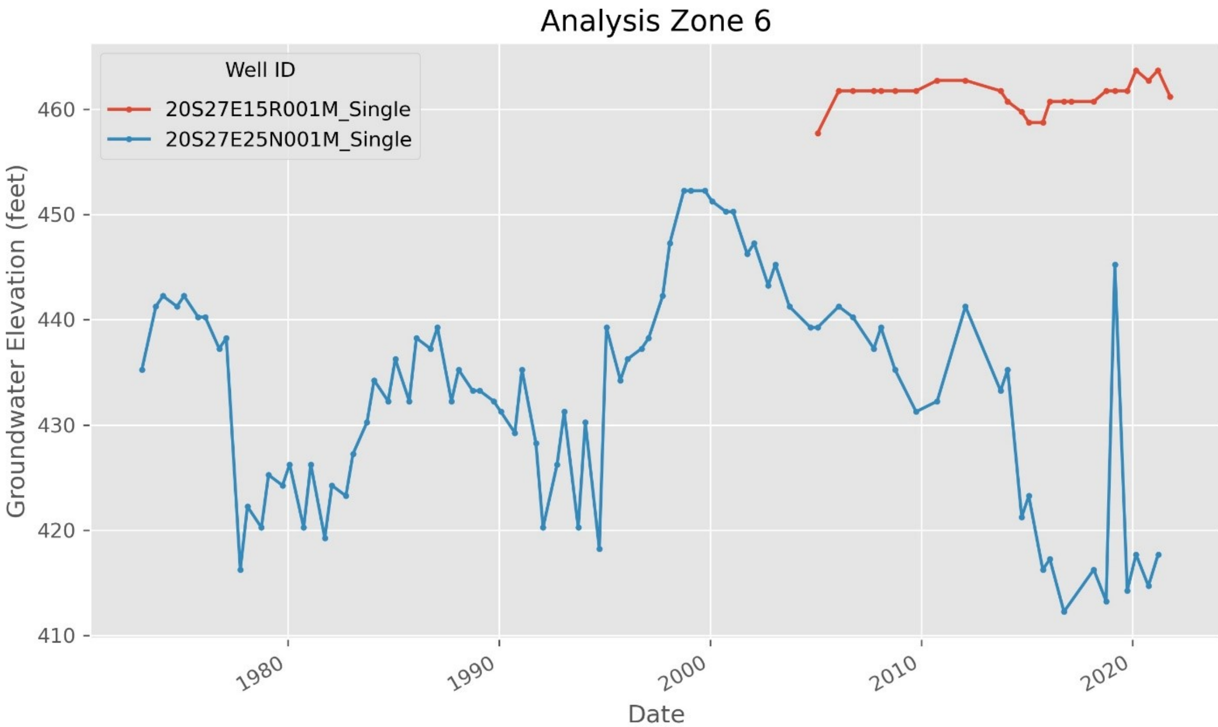
# Representative Monitoring Site Hydrographs by Aquifer and Analysis Zone

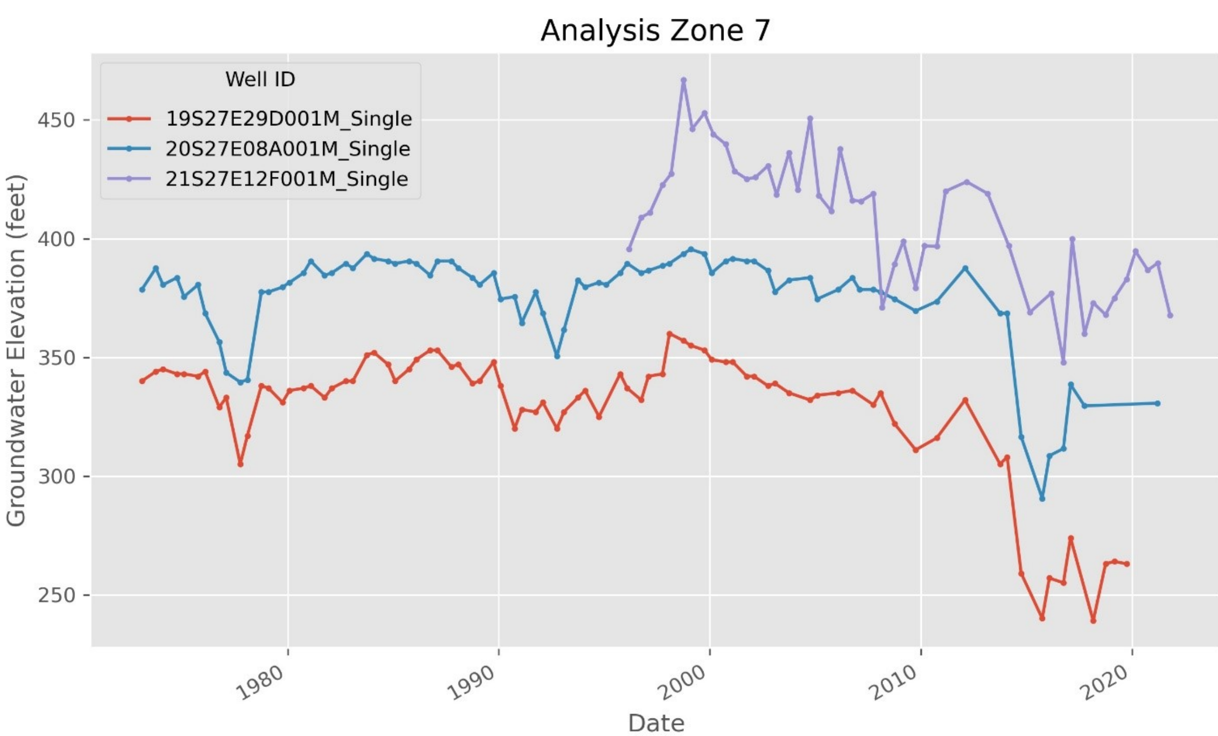

Analysis Zone 1
Well ID
17S25E25A001M_Single
17S25E35E001M_Single
18S26E06D001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date

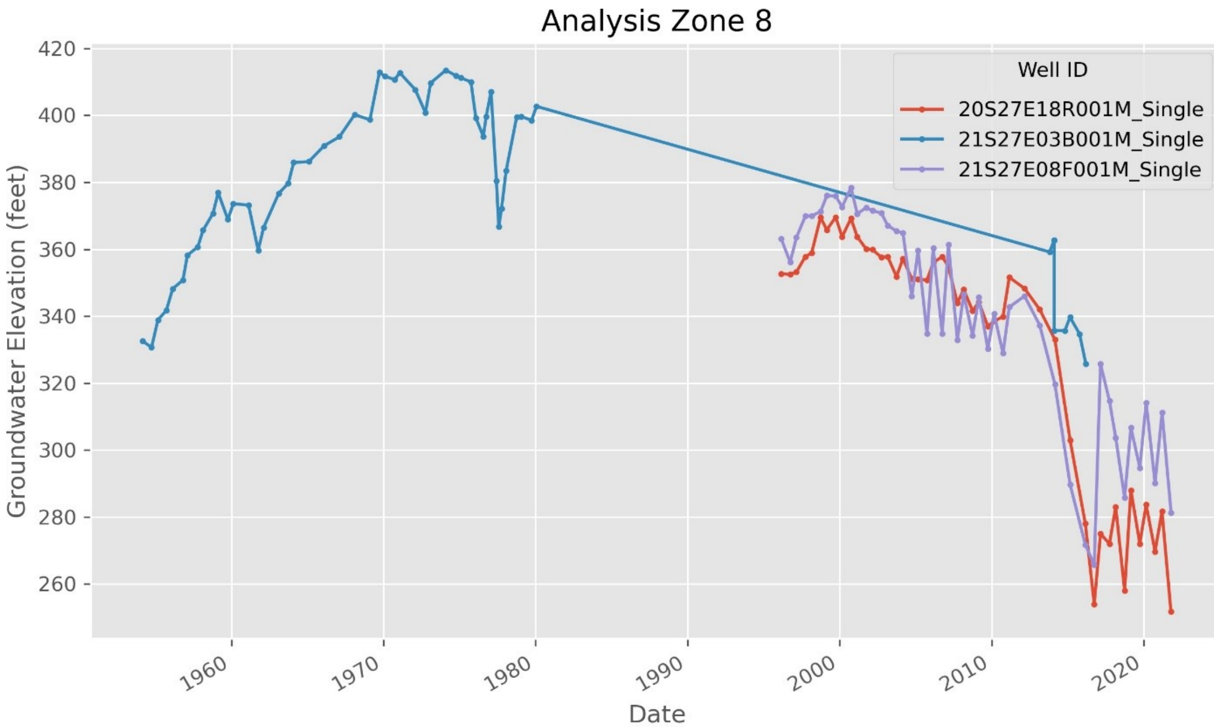

Analysis Zone 2
Well ID
16S25E36M002M_Single
16S26E30Q001M_Single
17S26E04F002M_Single
17S26E07C001M_Single
17S26E21E001M_Single
17S26E29R001M_Single
18S26E02D002M_Single
SCID Office_Single
Groundwater Elevation (feet)
400
380
360
340
320
300
280
260
1960
1970
1980
1990
2000
2010
2020
Date

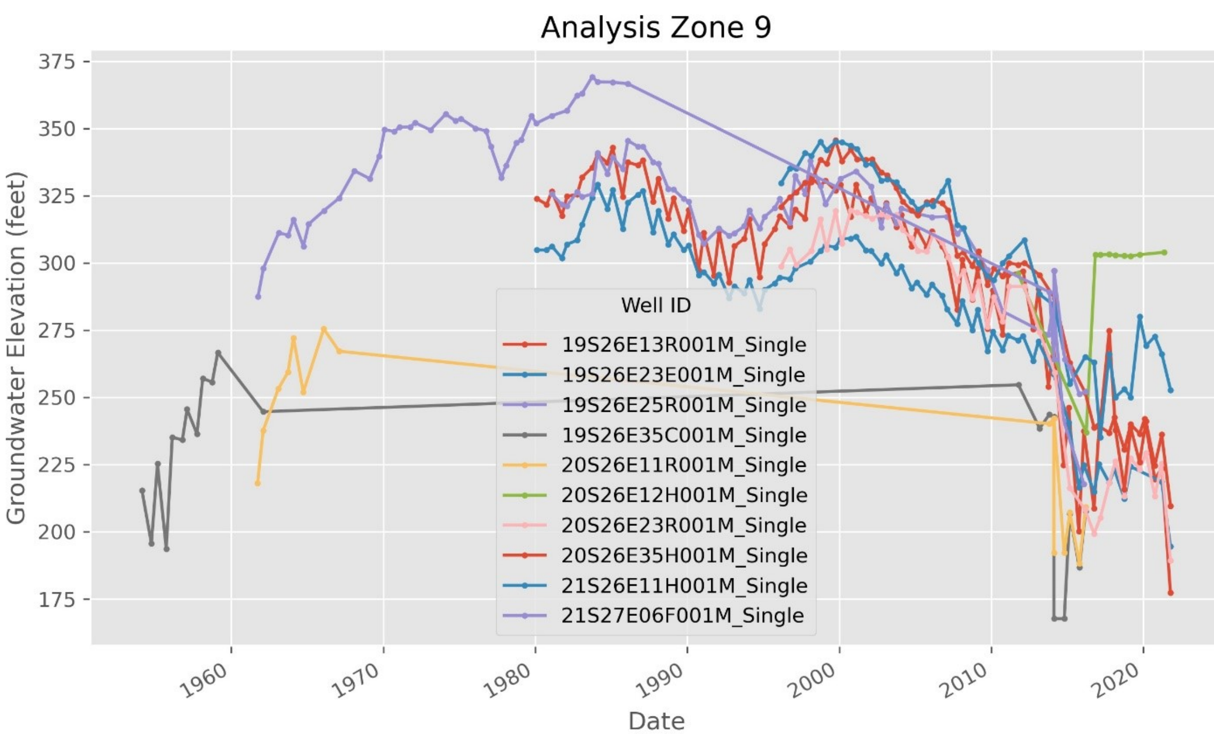

Analysis Zone 4
Groundwater Elevation (feet)
440
420
400
380
360
340
320
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date
Well ID
17S26E36R001M_Single
18S26E24J003M_Single
18S27E17H002M_Single
18S27E29E001M_Single
18S27E30H001M_Single

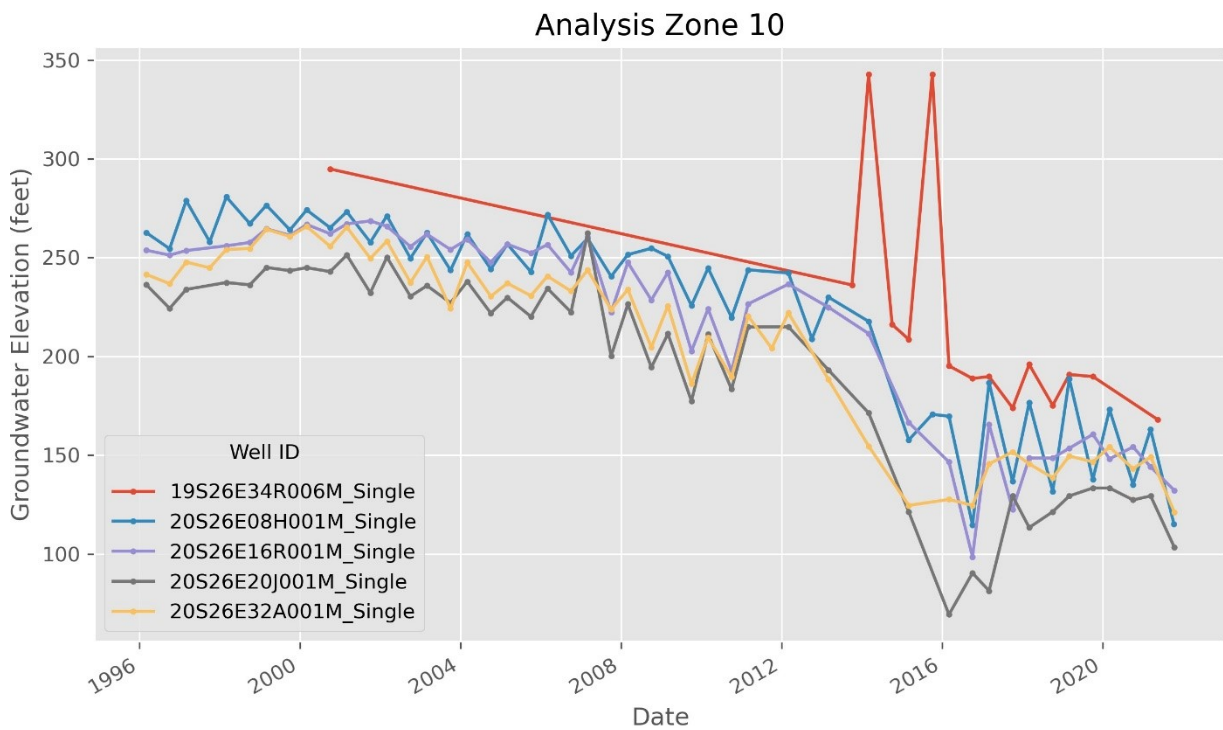

Analysis Zone 5
Groundwater Elevation (feet)
375
350
325
300
275
250
225
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date
Well ID
18S26E27B001M_Single
19S26E03A001M_Single
19S26E11R001M_Single

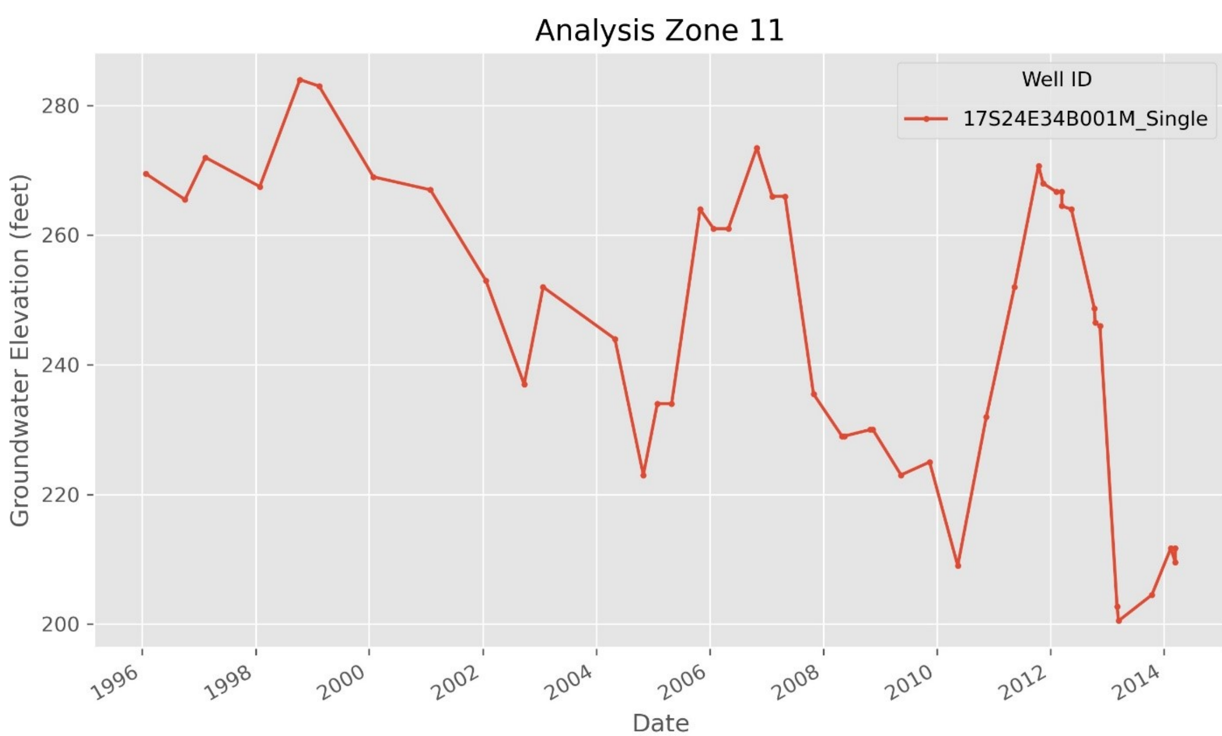

Analysis Zone 6
Well ID
20S27E15R001M_Single
20S27E25N001M_Single
Groundwater Elevation (feet)
410
420
430
440
450
460
1980
1990
2000
2010
2020
Date

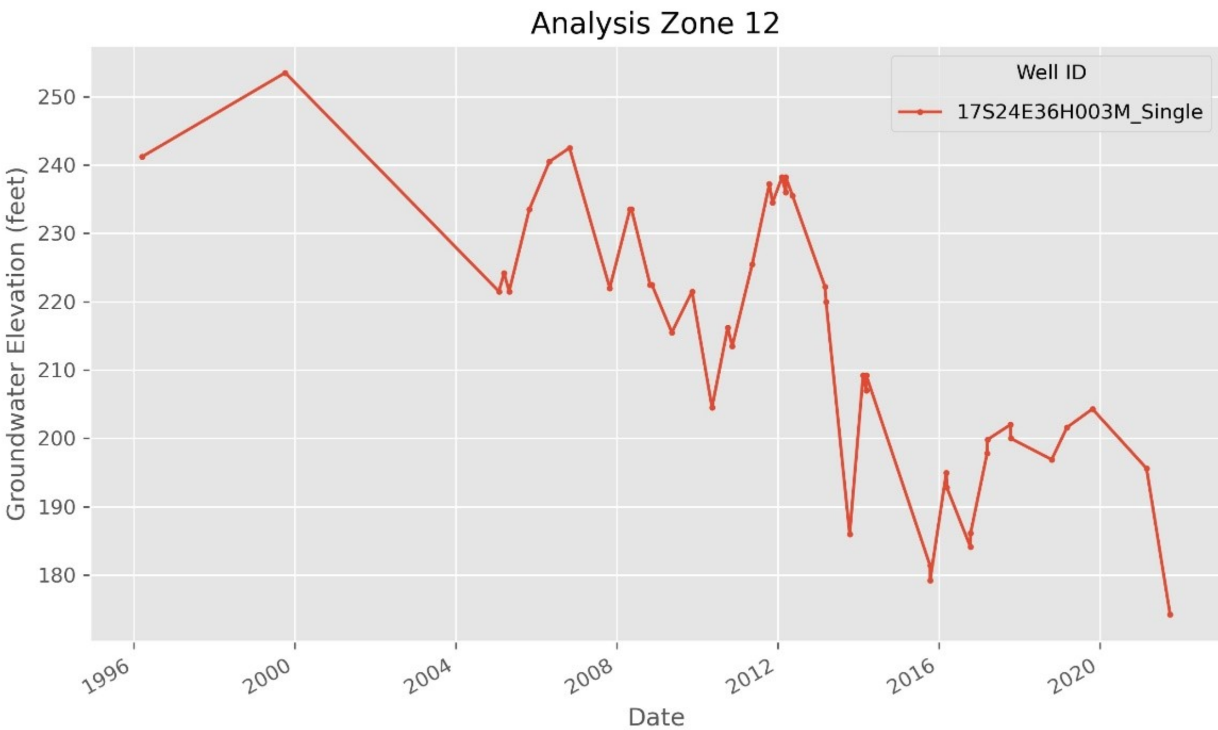

Analysis Zone 7
Well ID
19S27E29D001M_Single
20S27E08A001M_Single
21S27E12F001M_Single
Groundwater Elevation (feet)
250
300
350
400
450
1980
1990
2000
2010
2020
Date

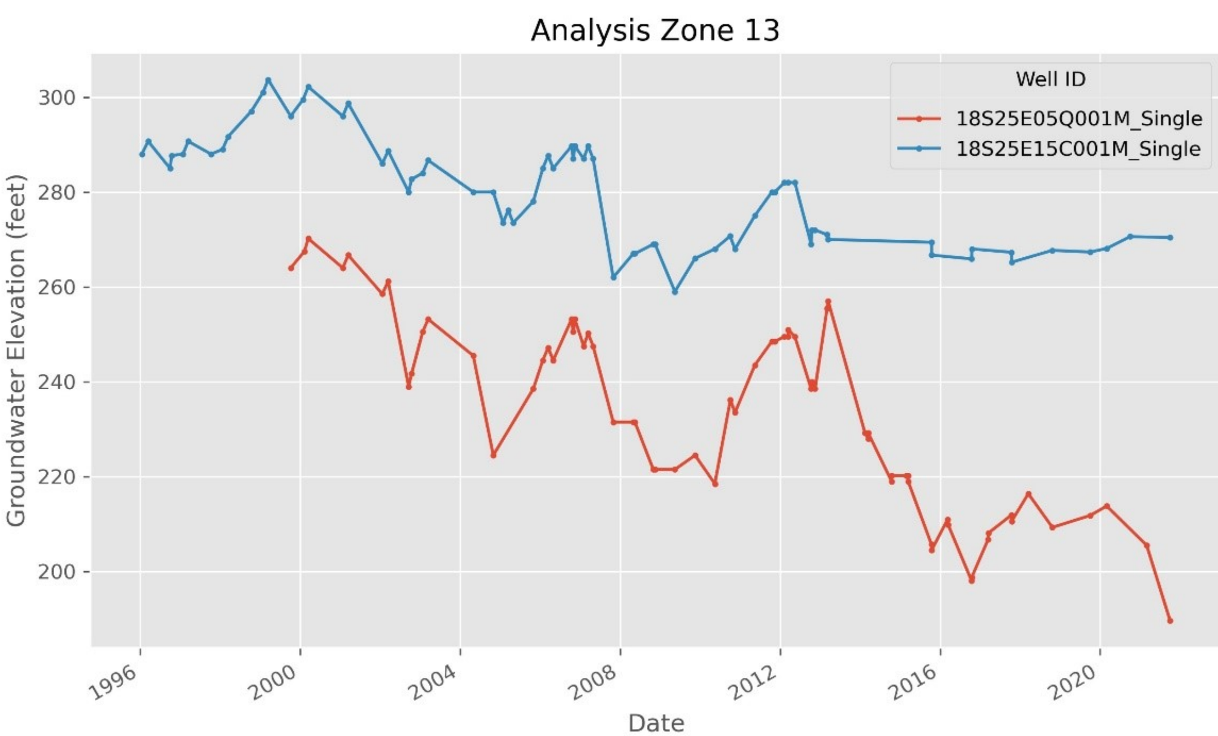

Analysis Zone 8
Well ID
20S27E18R001M_Single
21S27E03B001M_Single
21S27E08F001M_Single
Groundwater Elevation (feet)
Date
420
400
380
360
340
320
300
280
260
1960
1970
1980
1990
2000
2010
2020

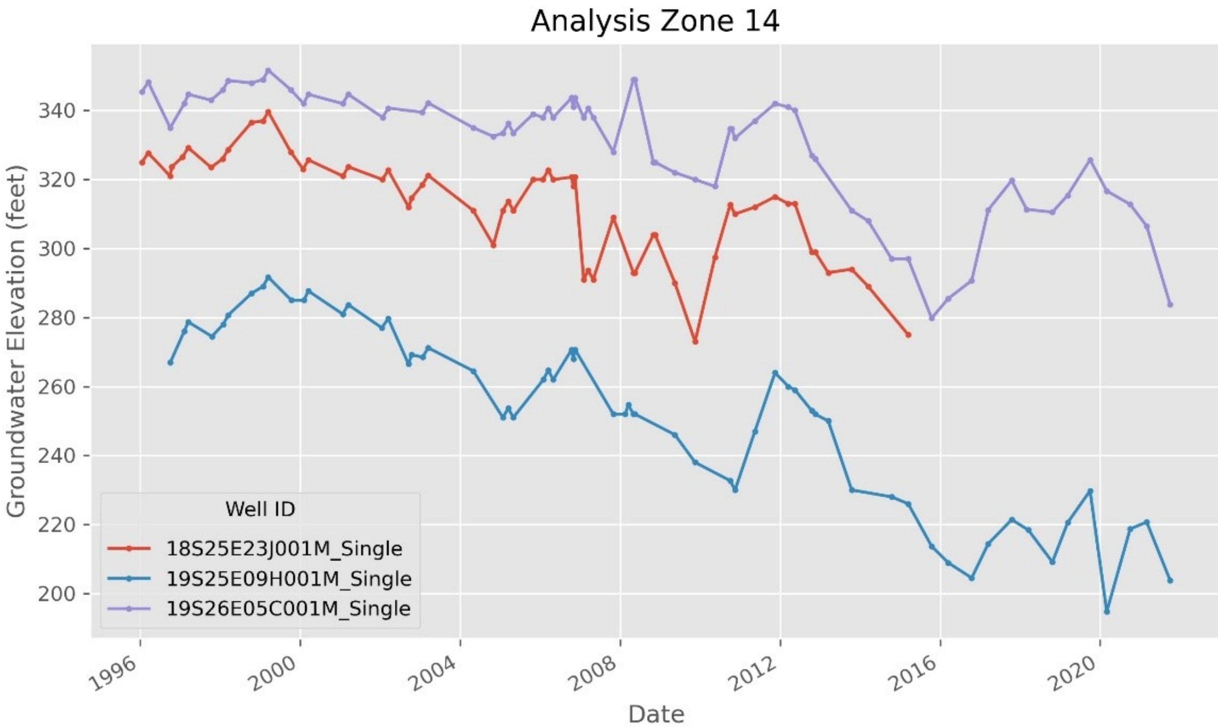

Analysis Zone 9
Well ID
19S26E13R001M_Single
19S26E23E001M_Single
19S26E25R001M_Single
19S26E35C001M_Single
20S26E11R001M_Single
20S26E12H001M_Single
20S26E23R001M_Single
20S26E35H001M_Single
21S26E11H001M_Single
21S27E06F001M_Single
Groundwater Elevation (feet)
Date
375
350
325
300
275
250
225
200
175
1960
1970
1980
1990
2000
2010
2020

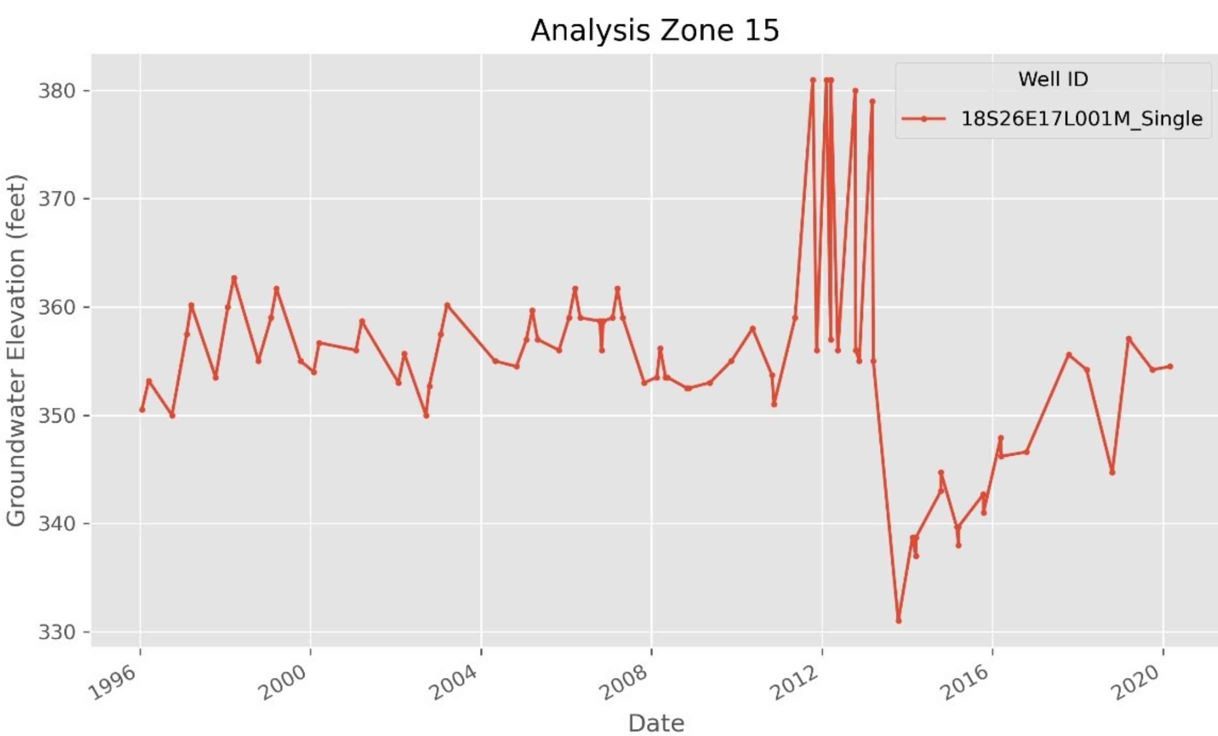

Analysis Zone 10
Groundwater Elevation (feet)
Date
Well ID
19S26E34R006M_Single
20S26E08H001M_Single
20S26E16R001M_Single
20S26E20J001M_Single
20S26E32A001M_Single
350
300
250
200
150
100
1996
2000
2004
2008
2012
2016
2020

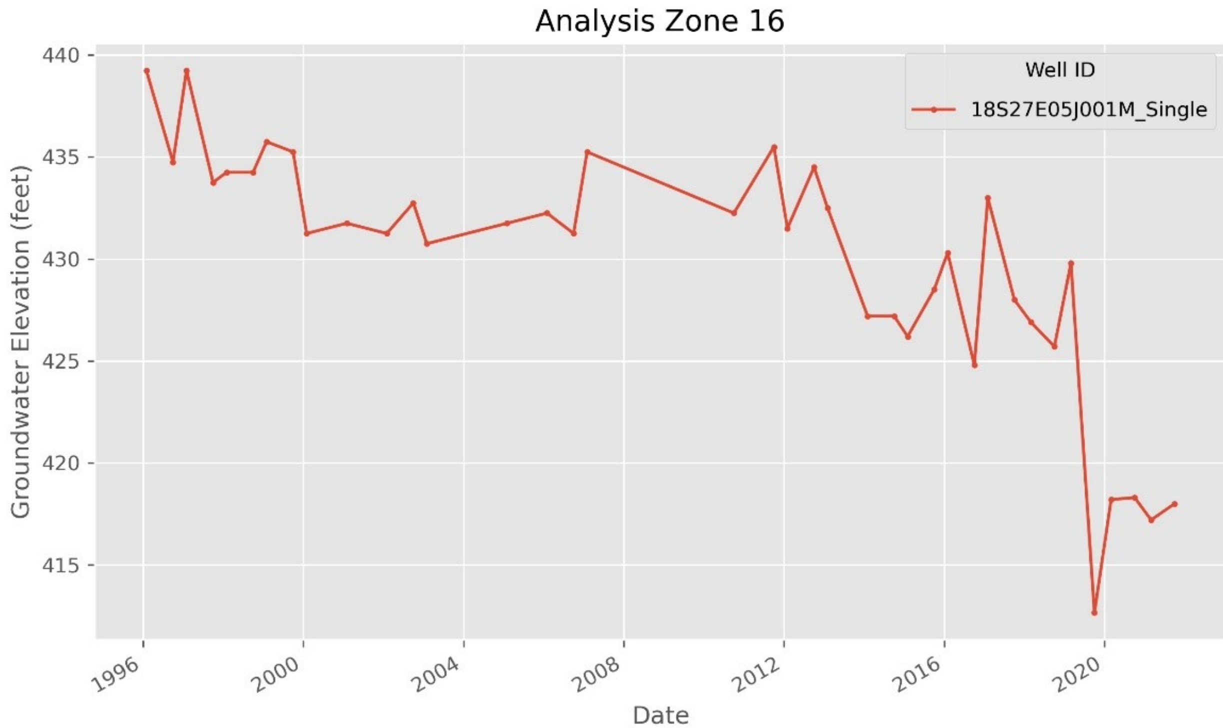

Analysis Zone 11
Groundwater Elevation (feet)
Date
Well ID
17S24E34B001M_Single
280
260
240
220
200
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

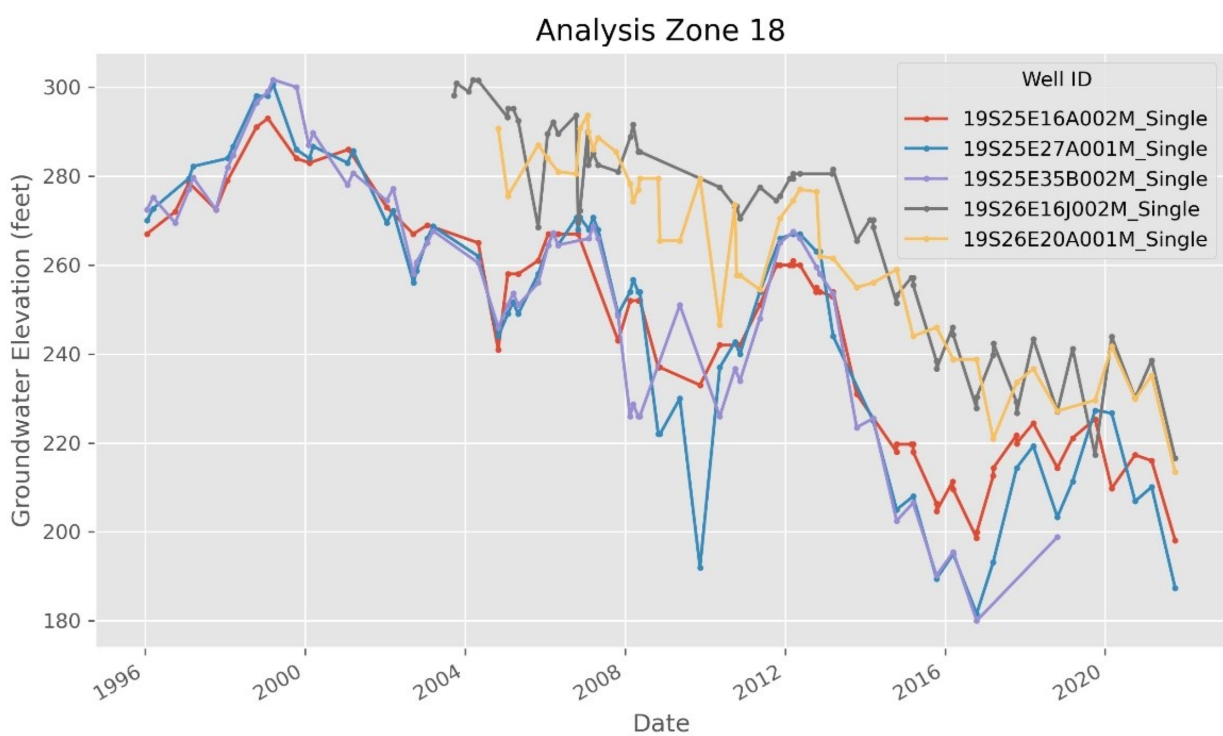

Analysis Zone 12
Well ID
17S24E36H003M_Single
Groundwater Elevation (feet)
250
240
230
220
210
200
190
180
1996
2000
2004
2008
2012
2016
2020
Date

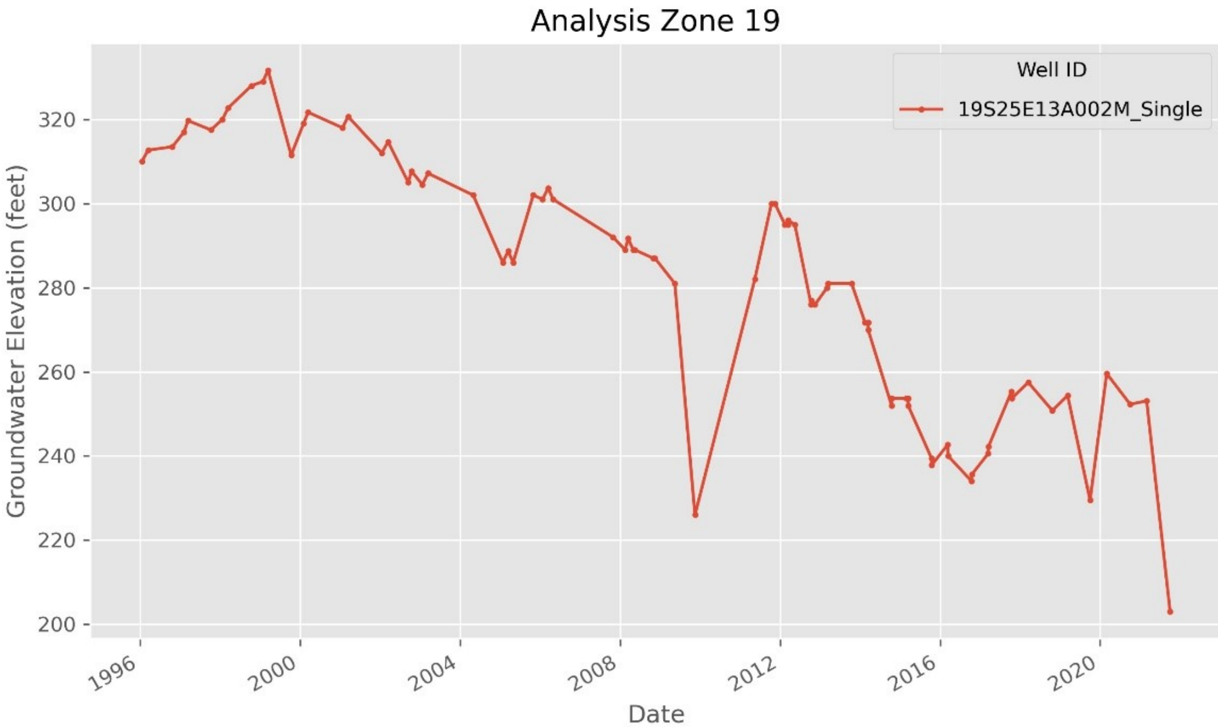

Analysis Zone 13
Well ID
18S25E05Q001M_Single
18S25E15C001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date

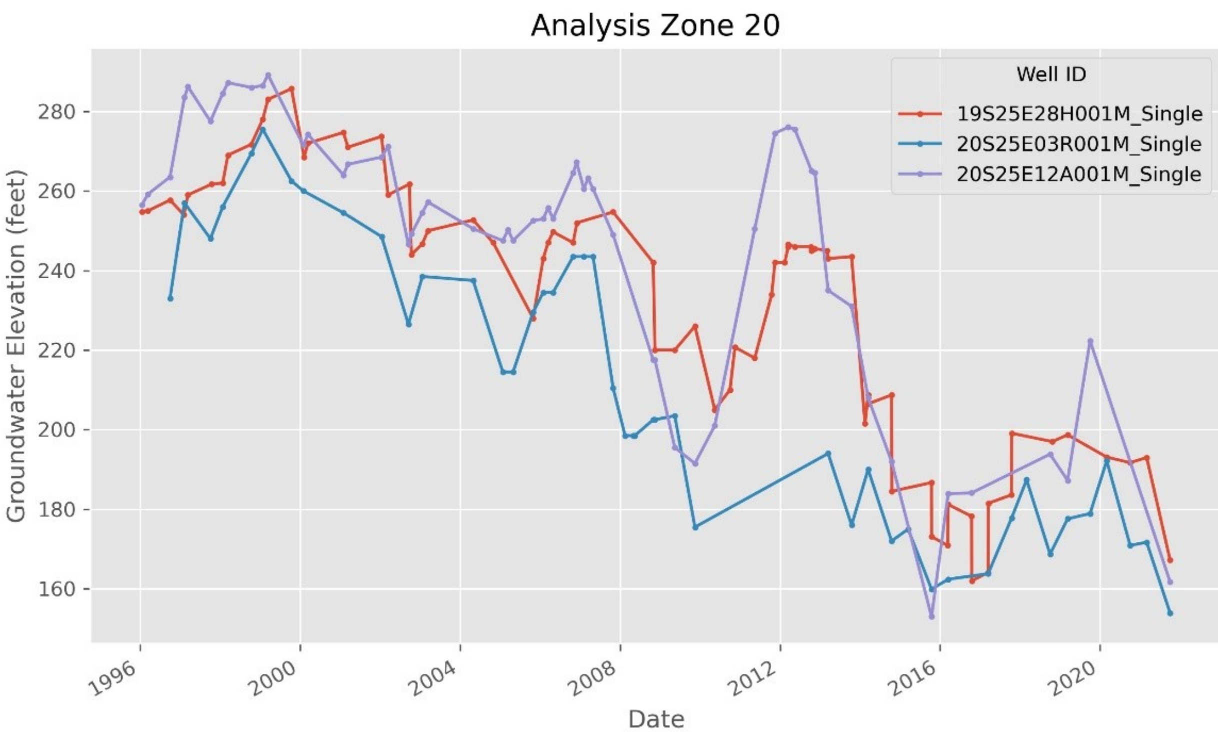

Analysis Zone 14
Groundwater Elevation (feet)
Date
Well ID
18S25E23J001M_Single
19S25E09H001M_Single
19S26E05C001M_Single
200
220
240
260
280
300
320
340
1996
2000
2004
2008
2012
2016
2020

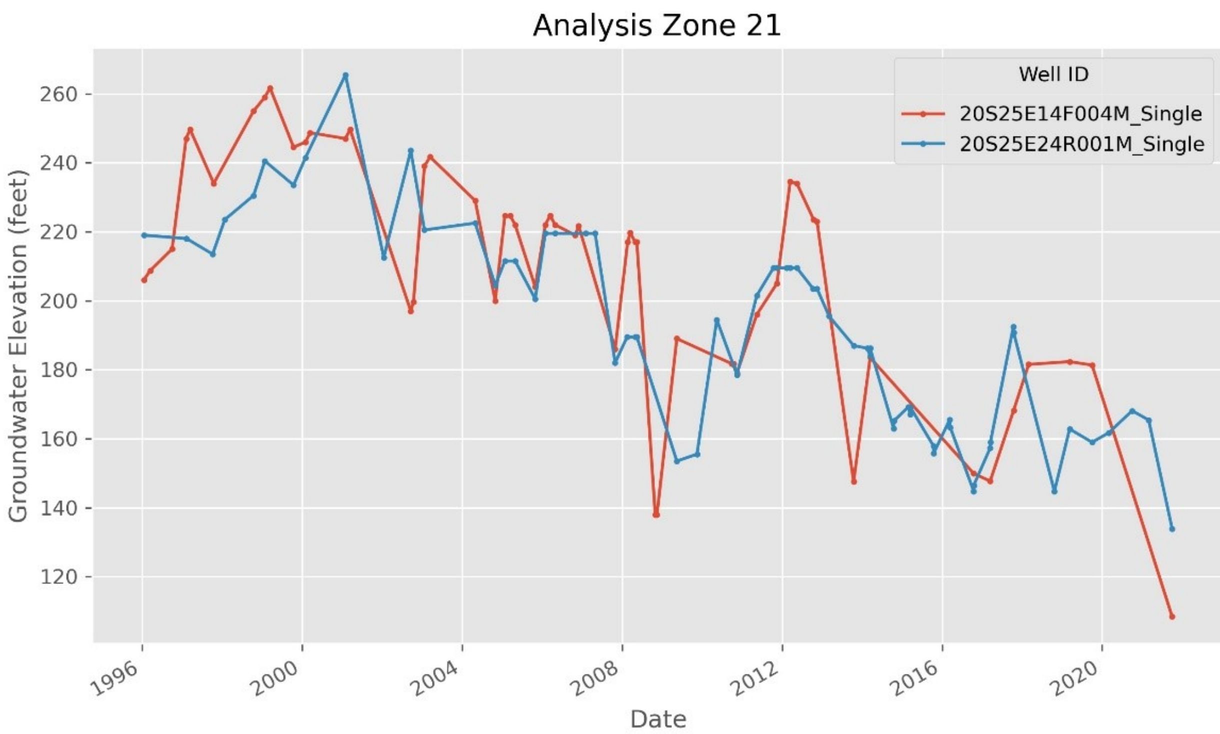

Analysis Zone 15
Groundwater Elevation (feet)
Date
Well ID
18S26E17L001M_Single
330
340
350
360
370
380
1996
2000
2004
2008
2012
2016
2020

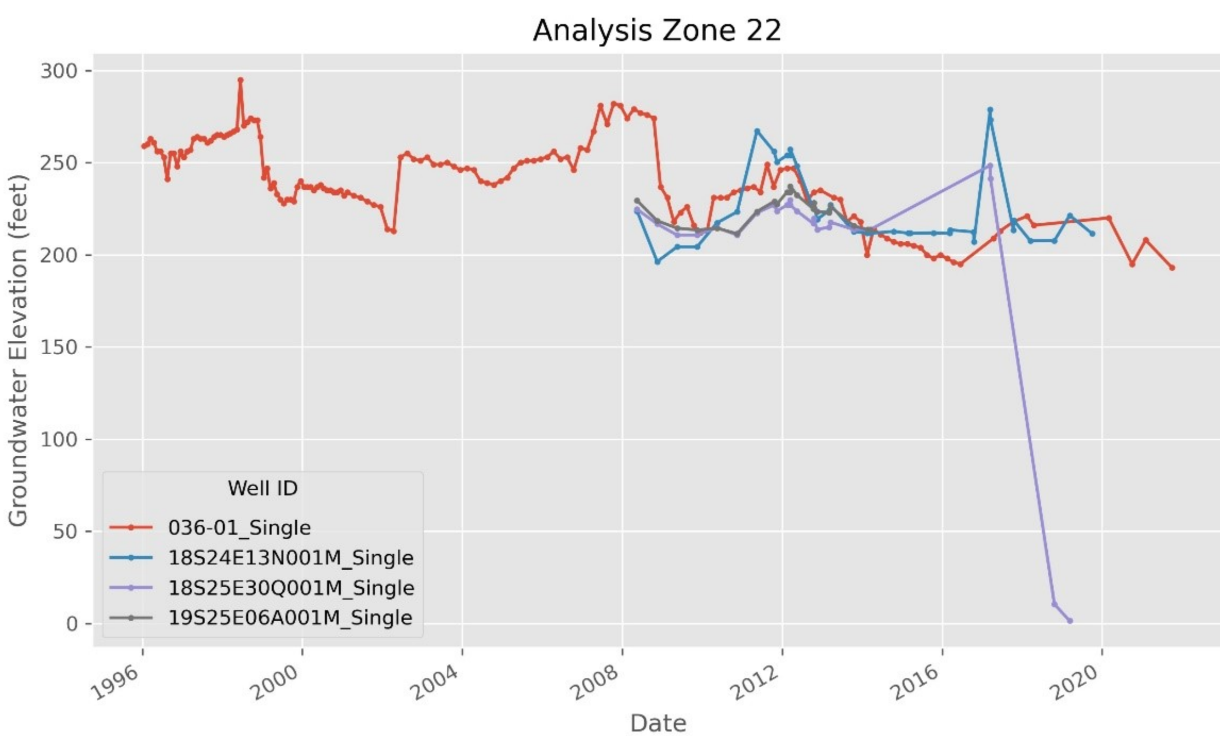

Analysis Zone 16
Well ID
18S27E05J001M_Single
Groundwater Elevation (feet)
440
435
430
425
420
415
1996
2000
2004
2008
2012
2016
2020
Date

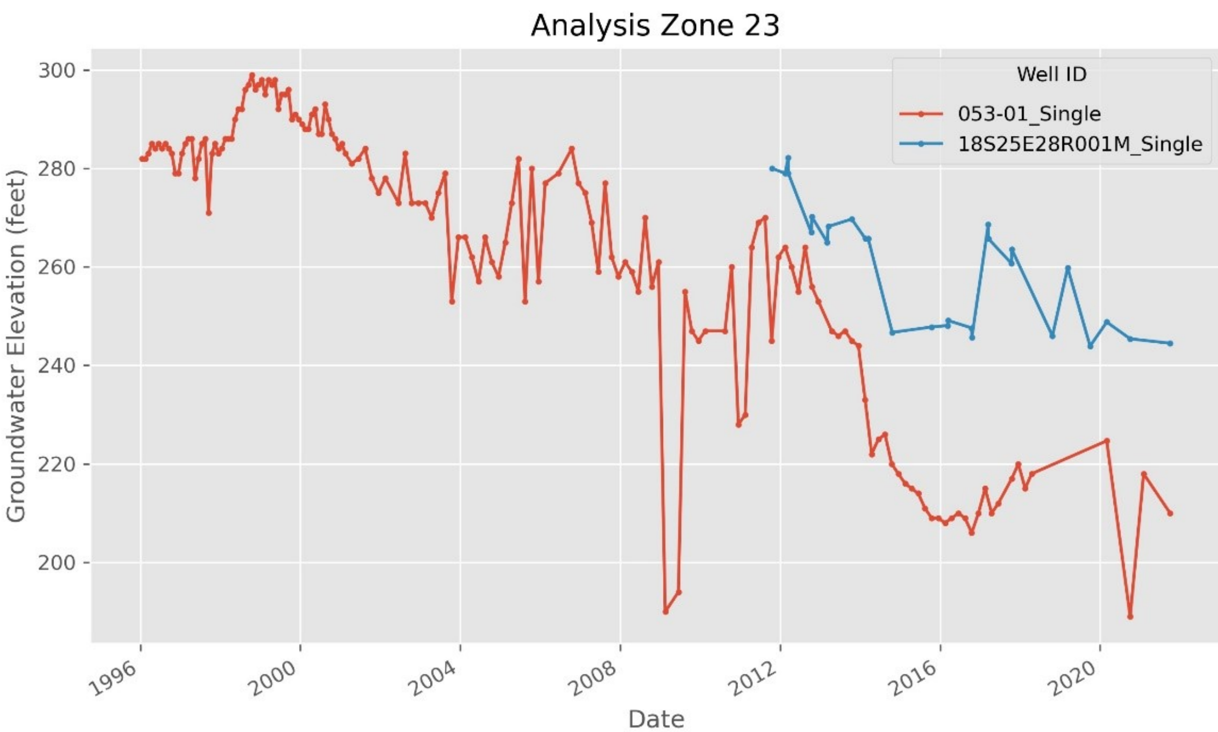

Analysis Zone 18
Well ID
19S25E16A002M_Single
19S25E27A001M_Single
19S25E35B002M_Single
19S26E16J002M_Single
19S26E20A001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
180
1996
2000
2004
2008
2012
2016
2020
Date

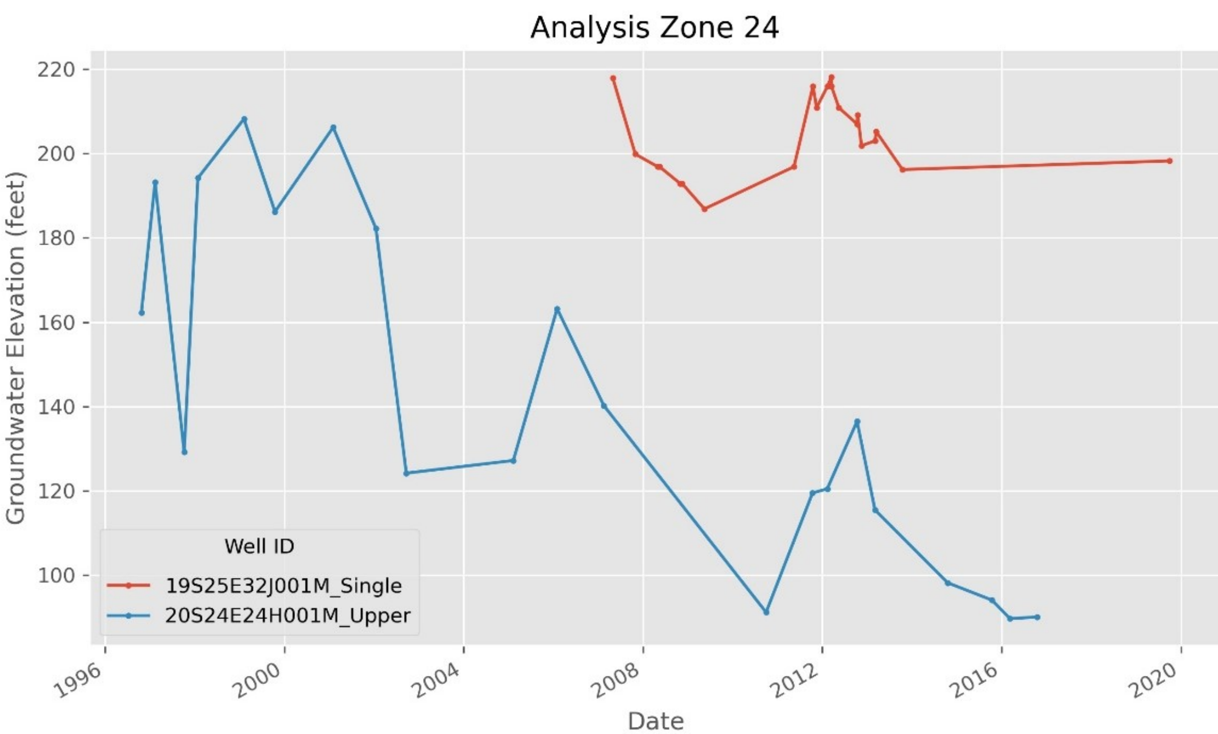

Analysis Zone 19
Well ID
19S25E13A002M_Single
Groundwater Elevation (feet)
200
220
240
260
280
300
320
1996
2000
2004
2008
2012
2016
2020
Date

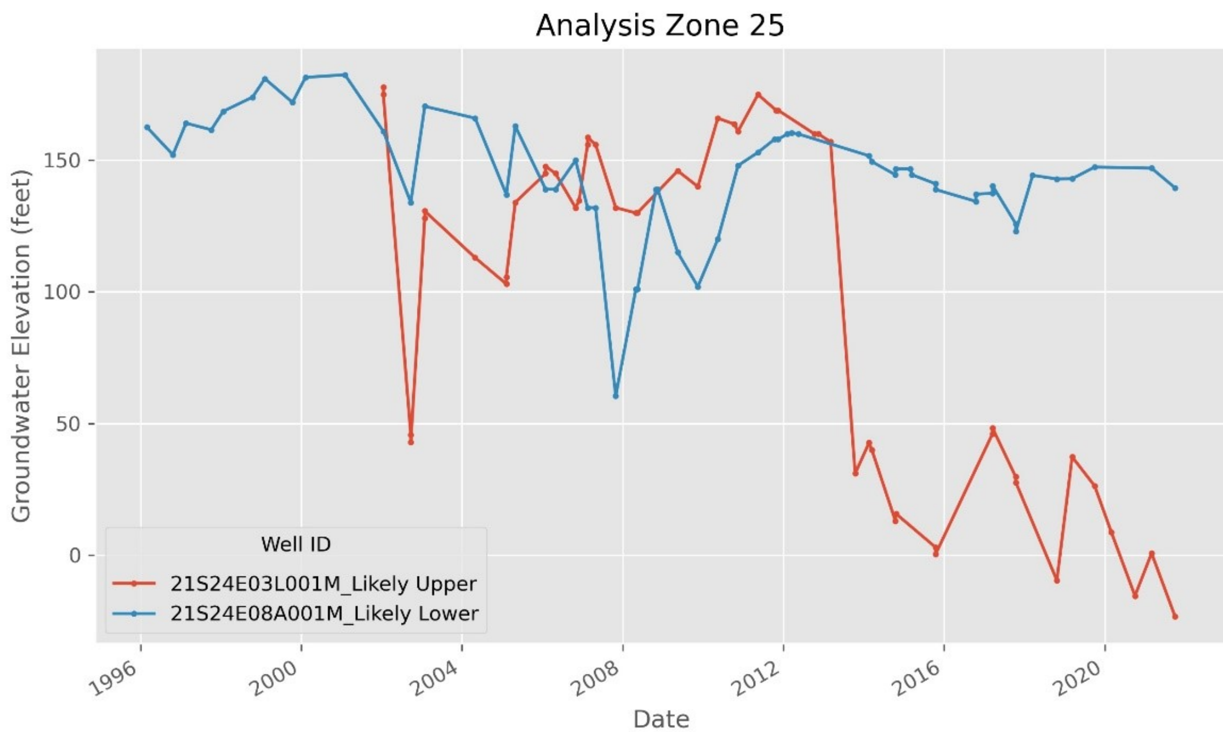

Analysis Zone 20
Well ID
19S25E28H001M_Single
20S25E03R001M_Single
20S25E12A001M_Single
Groundwater Elevation (feet)
160
180
200
220
240
260
280
1996
2000
2004
2008
2012
2016
2020
Date

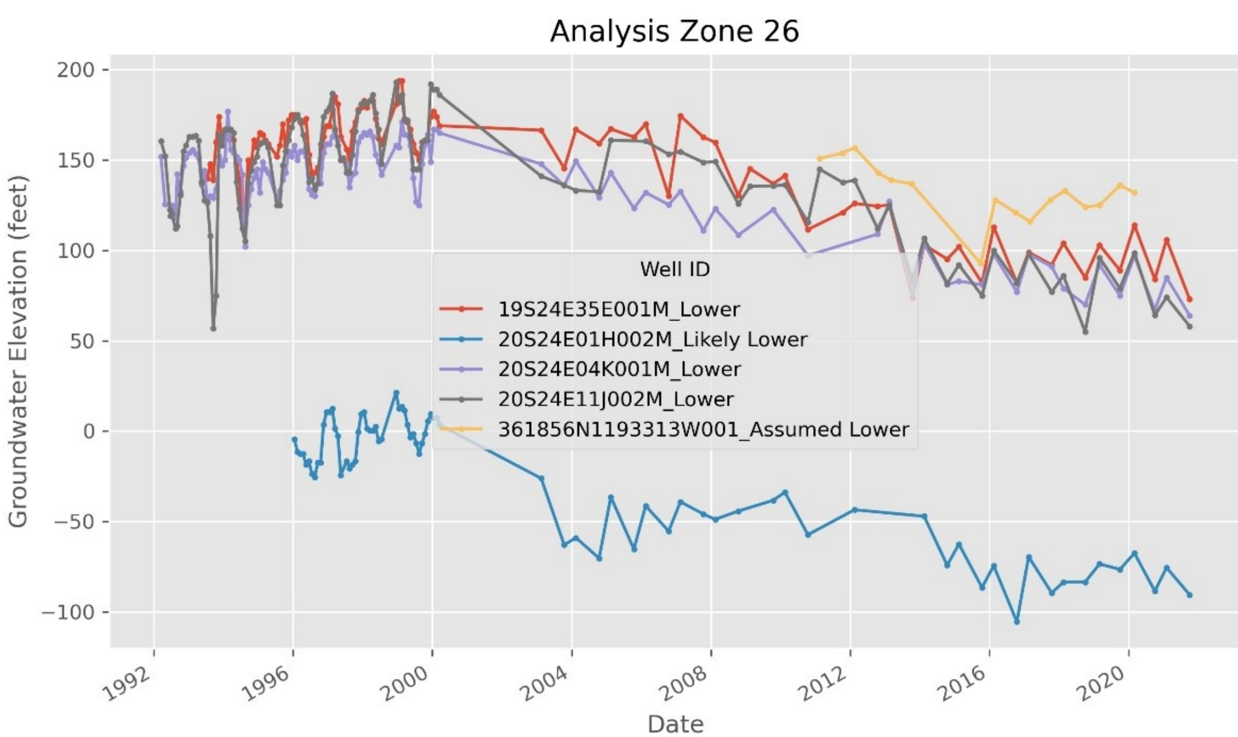

Analysis Zone 21
Well ID
20S25E14F004M_Single
20S25E24R001M_Single
Groundwater Elevation (feet)
260
240
220
200
180
160
140
120
1996
2000
2004
2008
2012
2016
2020
Date

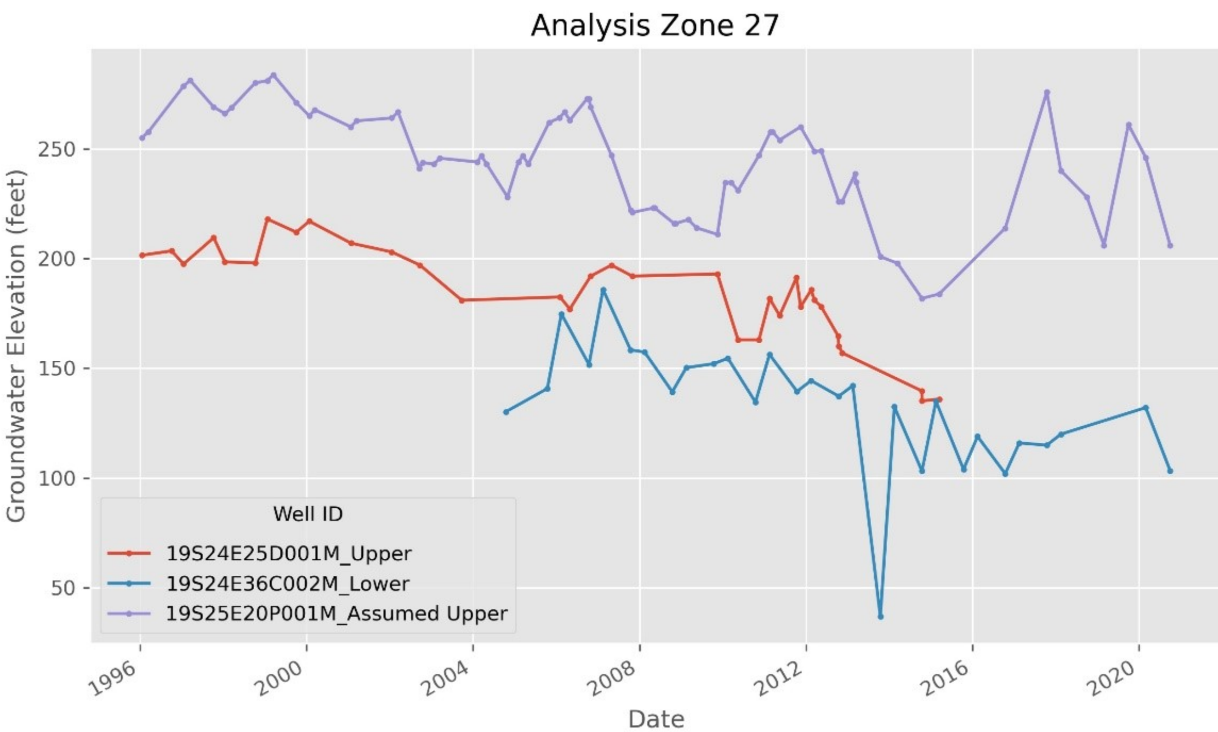

Analysis Zone 22
Well ID
036-01_Single
18S24E13N001M_Single
18S25E30Q001M_Single
19S25E06A001M_Single
Groundwater Elevation (feet)
300
250
200
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date

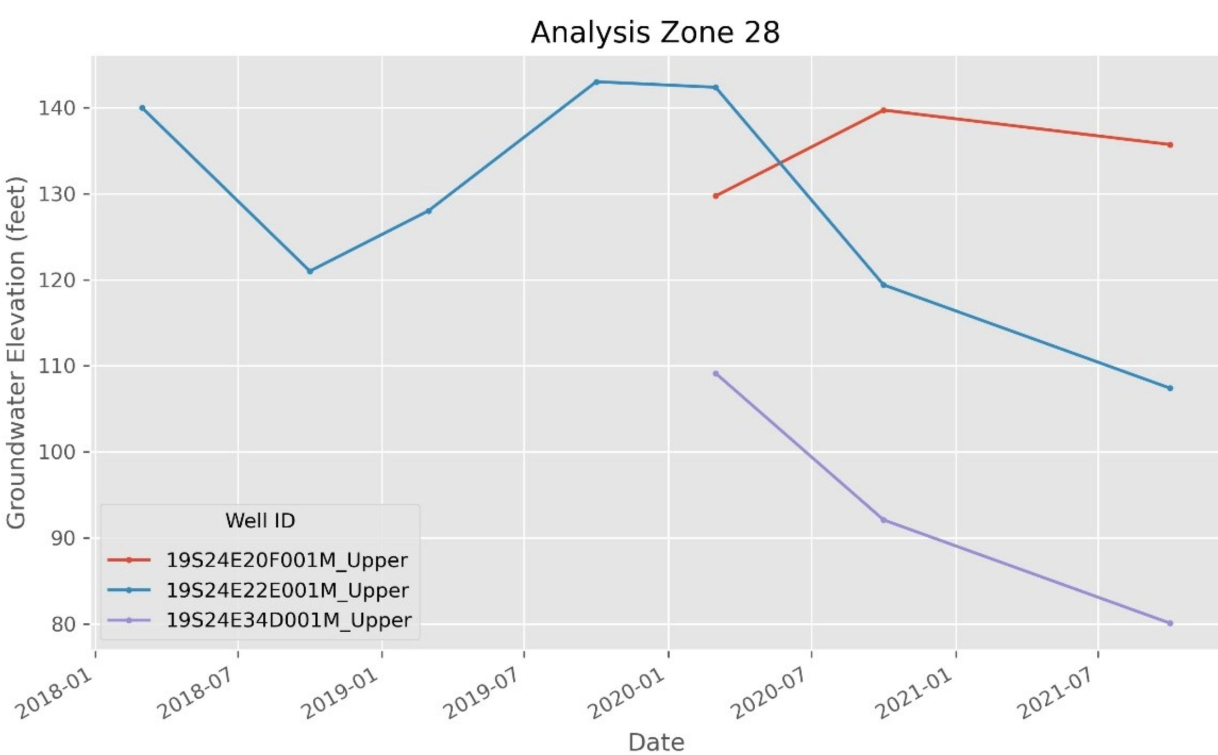

Analysis Zone 23
Well ID
053-01_Single
18S25E28R001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date

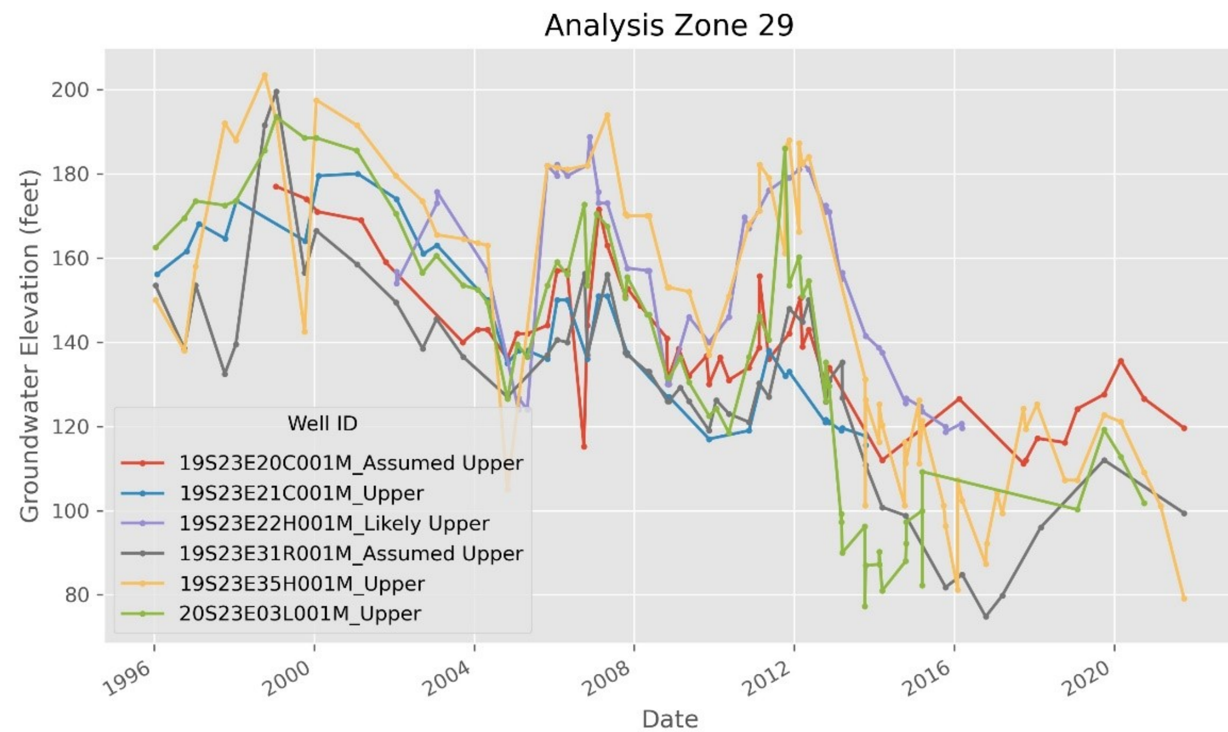

Analysis Zone 24
Well ID
19S25E32J001M_Single
20S24E24H001M_Upper
Groundwater Elevation (feet)
220
200
180
160
140
120
100
1996
2000
2004
2008
2012
2016
2020
Date

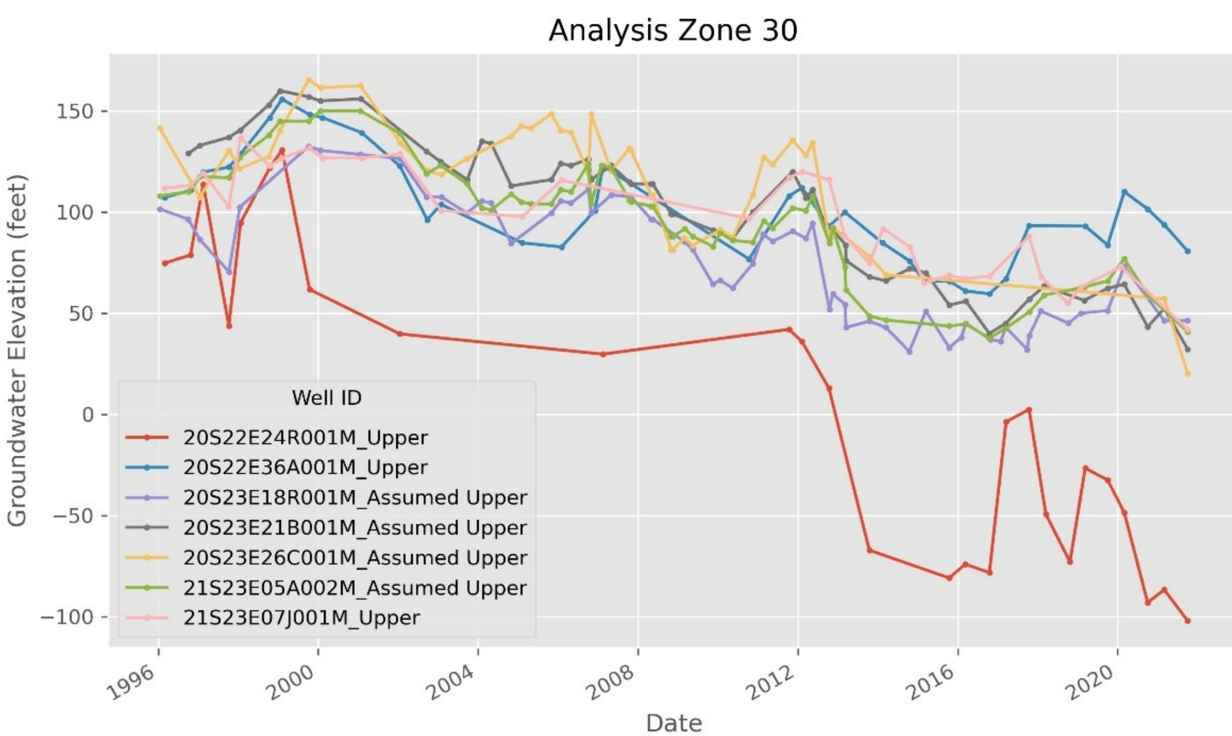

Analysis Zone 25
Groundwater Elevation (feet)
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
21S24E03L001M_Likely Upper
21S24E08A001M_Likely Lower

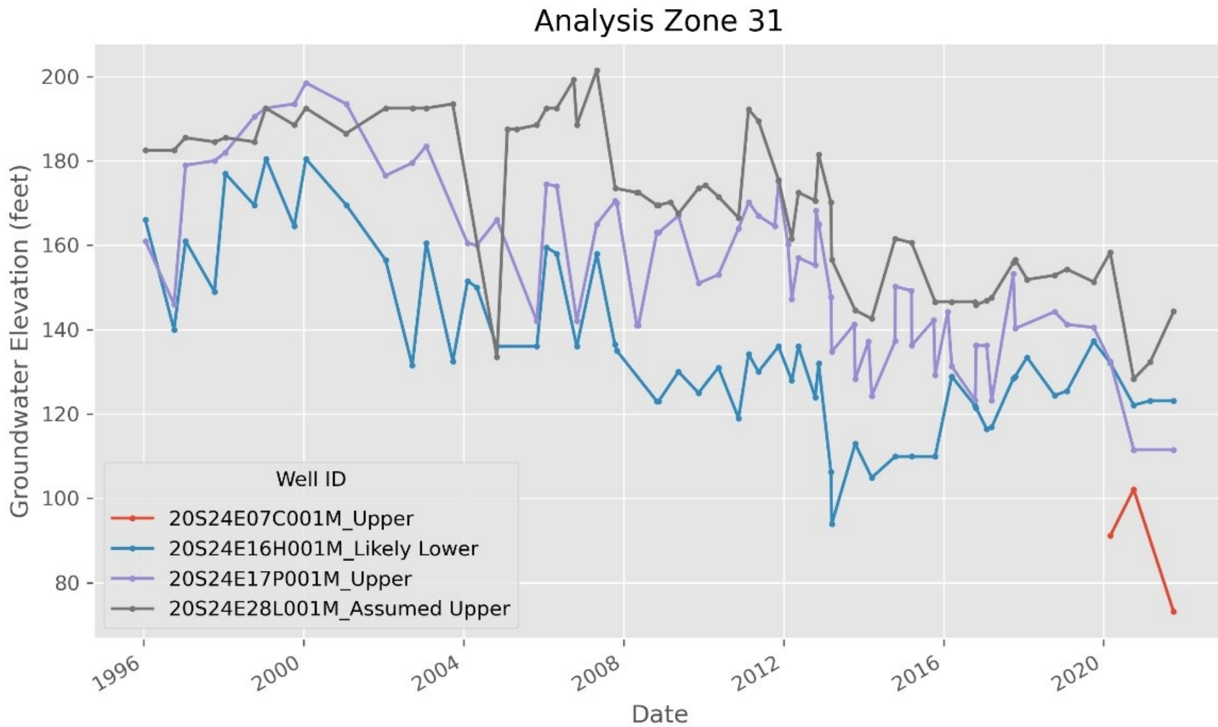

Analysis Zone 26
Groundwater Elevation (feet)
200
150
100
50
0
−50
−100
1992
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S24E35E001M_Lower
20S24E01H002M_Likely Lower
20S24E04K001M_Lower
20S24E11J002M_Lower
361856N1193313W001_Assumed Lower

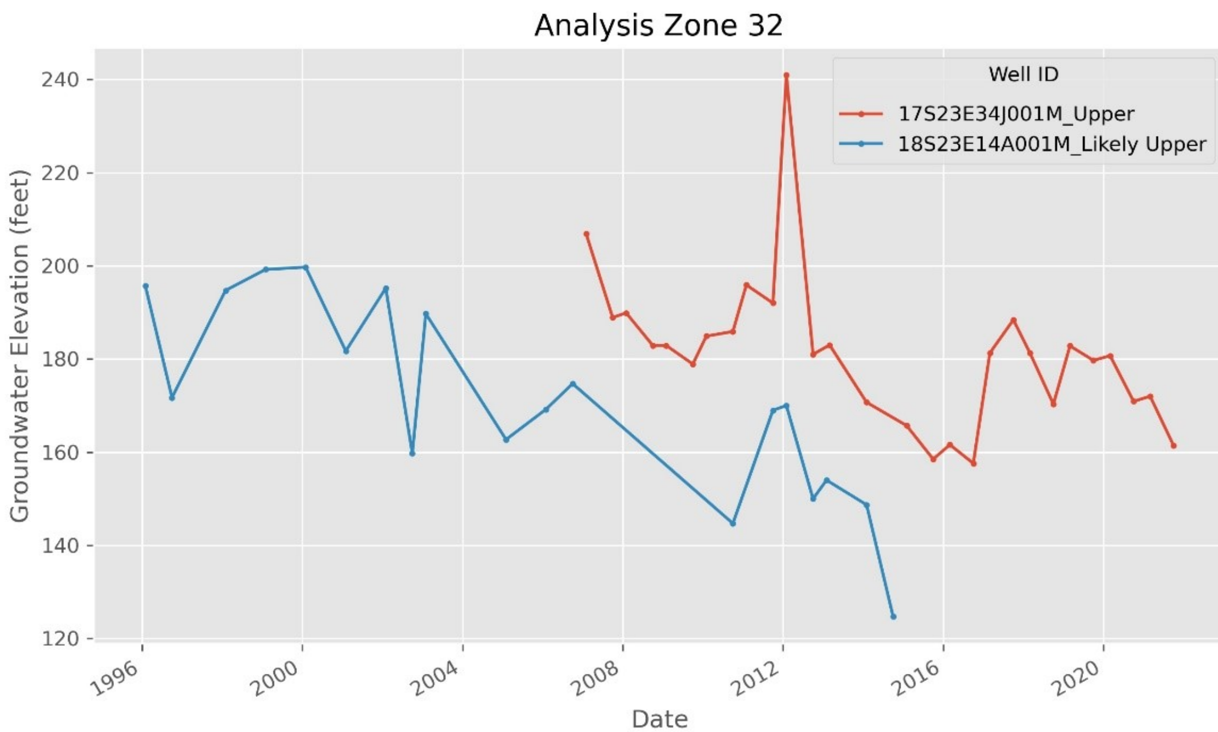

Analysis Zone 27
Groundwater Elevation (feet)
250
200
150
100
50
Well ID
19S24E25D001M_Upper
19S24E36C002M_Lower
19S25E20P001M_Assumed Upper
1996
2000
2004
2008
2012
2016
2020
Date

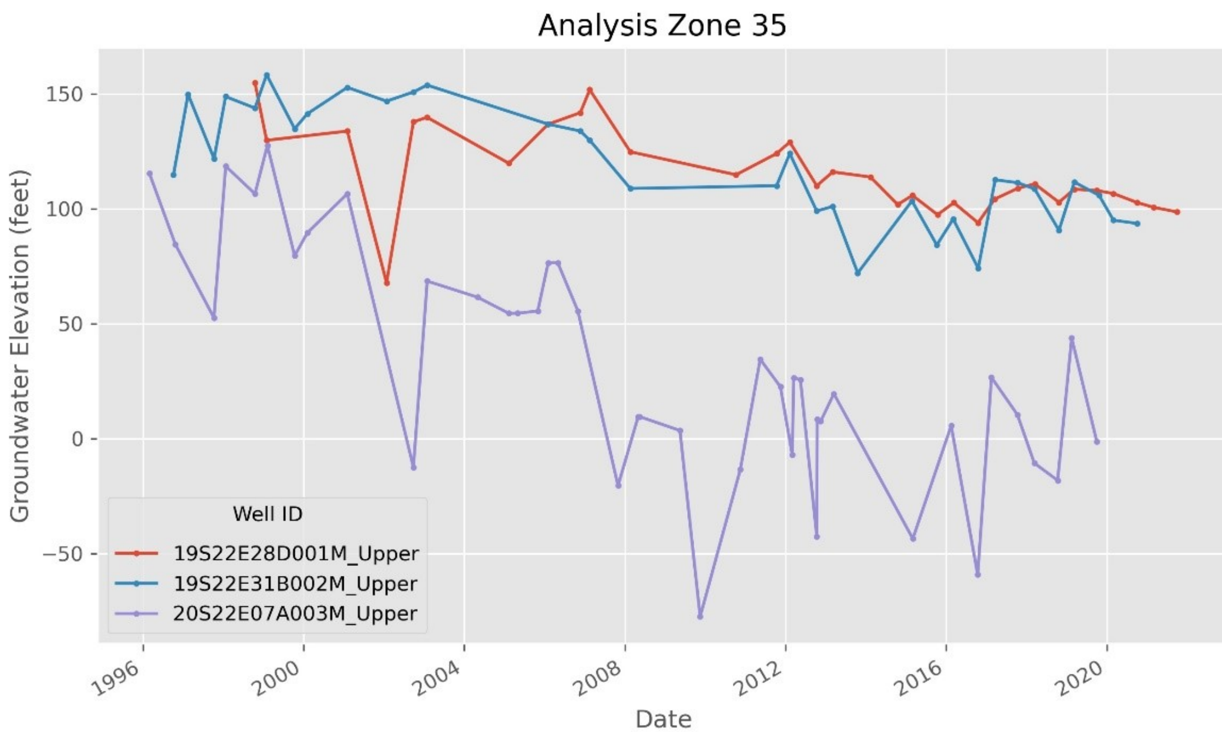

Analysis Zone 28
Groundwater Elevation (feet)
140
130
120
110
100
90
80
Well ID
19S24E20F001M_Upper
19S24E22E001M_Upper
19S24E34D001M_Upper
2018-01
2018-07
2019-01
2019-07
2020-01
2020-07
2021-01
2021-07
Date

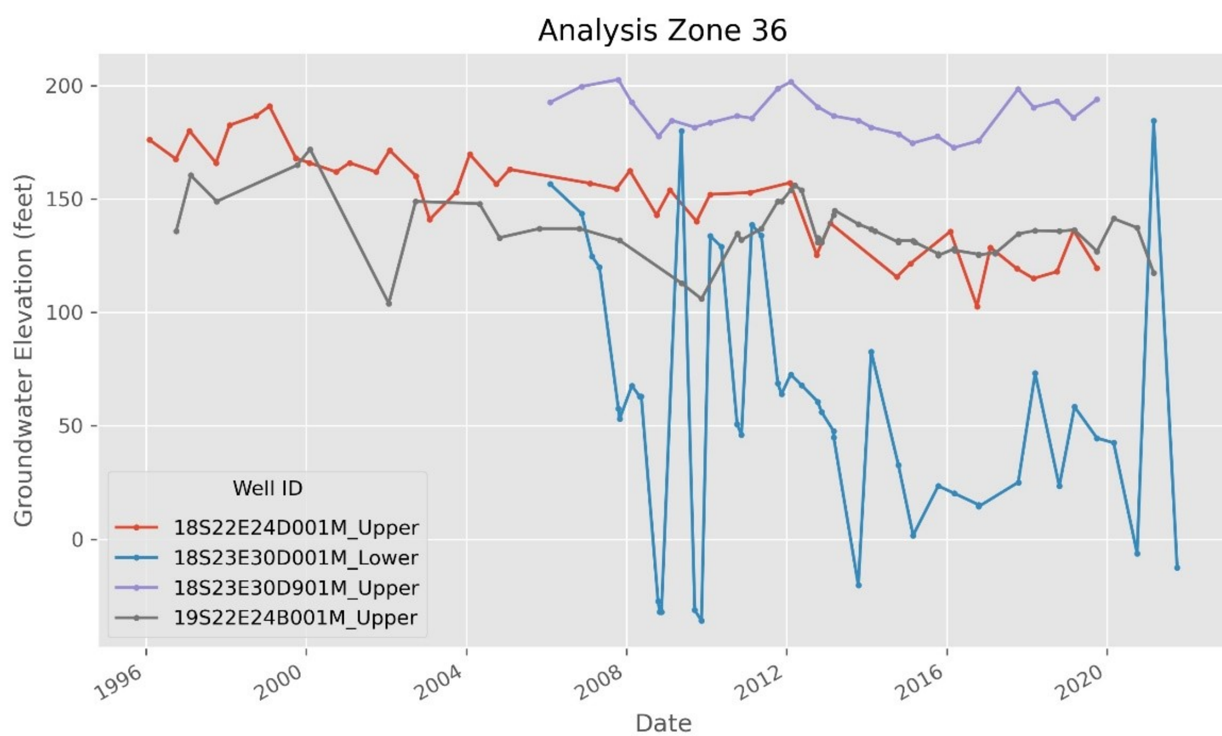

Analysis Zone 29
Groundwater Elevation (feet)
Date
Well ID
19S23E20C001M_Assumed Upper
19S23E21C001M_Upper
19S23E22H001M_Likely Upper
19S23E31R001M_Assumed Upper
19S23E35H001M_Upper
20S23E03L001M_Upper

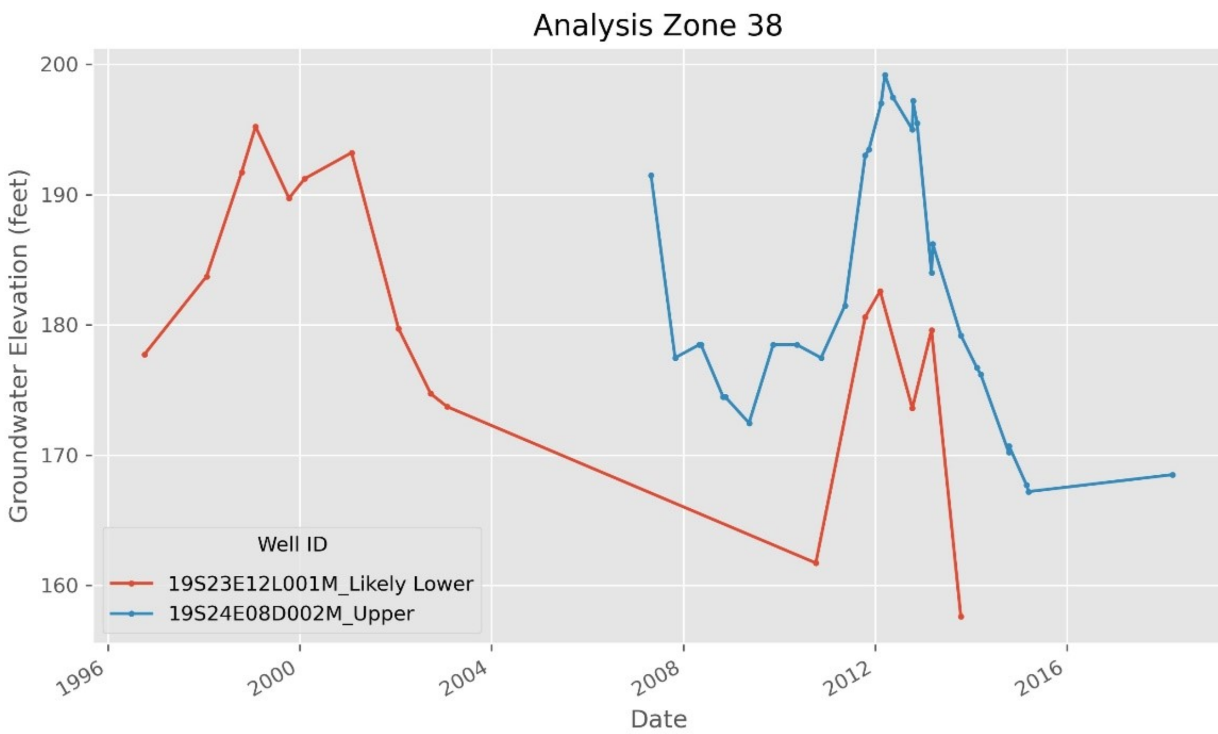

Analysis Zone 30
Groundwater Elevation (feet)
Date
Well ID
20S22E24R001M_Upper
20S22E36A001M_Upper
20S23E18R001M_Assumed Upper
20S23E21B001M_Assumed Upper
20S23E26C001M_Assumed Upper
21S23E05A002M_Assumed Upper
21S23E07J001M_Upper

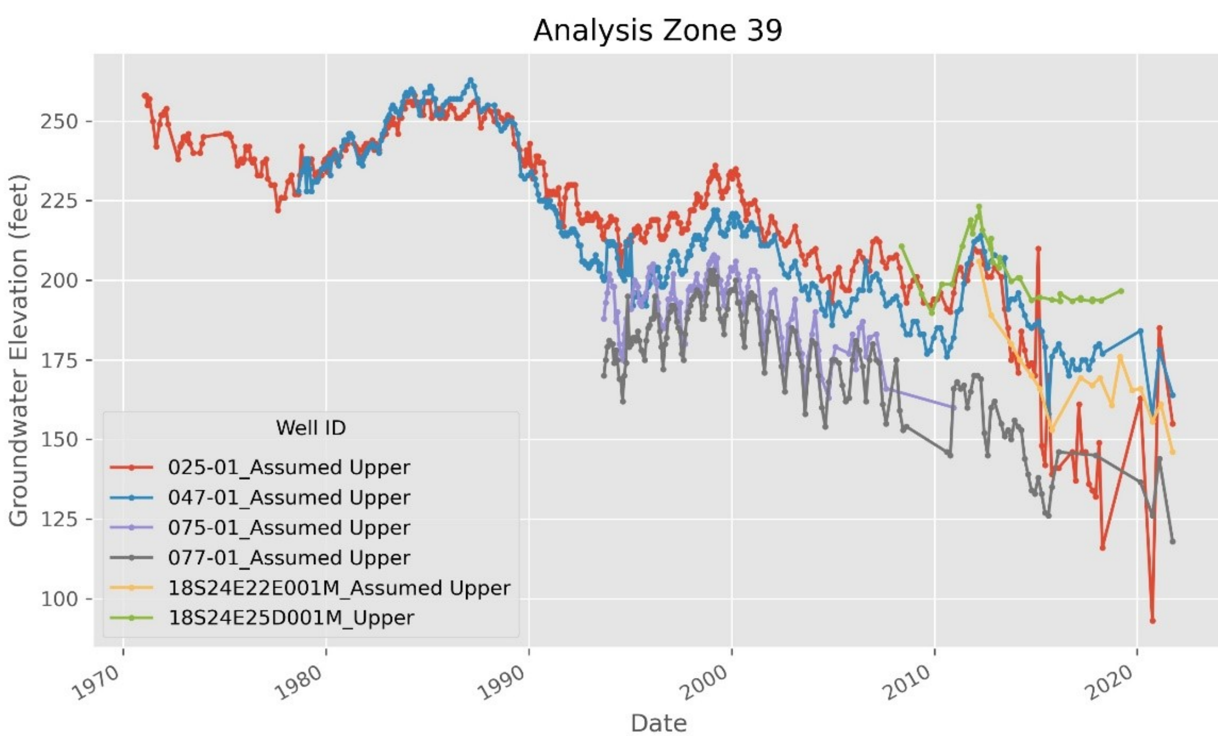

Analysis Zone 31
Groundwater Elevation (feet)
Date
Well ID
20S24E07C001M_Upper
20S24E16H001M_Likely Lower
20S24E17P001M_Upper
20S24E28L001M_Assumed Upper
200
180
160
140
120
100
80
1996
2000
2004
2008
2012
2016
2020


Analysis Zone 32
Groundwater Elevation (feet)
Date
Well ID
17S23E34J001M_Upper
18S23E14A001M_Likely Upper
240
220
200
180
160
140
120
1996
2000
2004
2008
2012
2016
2020


Analysis Zone 35
Groundwater Elevation (feet)
150
100
50
0
−50
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S22E28D001M_Upper
19S22E31B002M_Upper
20S22E07A003M_Upper


Analysis Zone 36
Groundwater Elevation (feet)
200
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
18S22E24D001M_Upper
18S23E30D001M_Lower
18S23E30D901M_Upper
19S22E24B001M_Upper

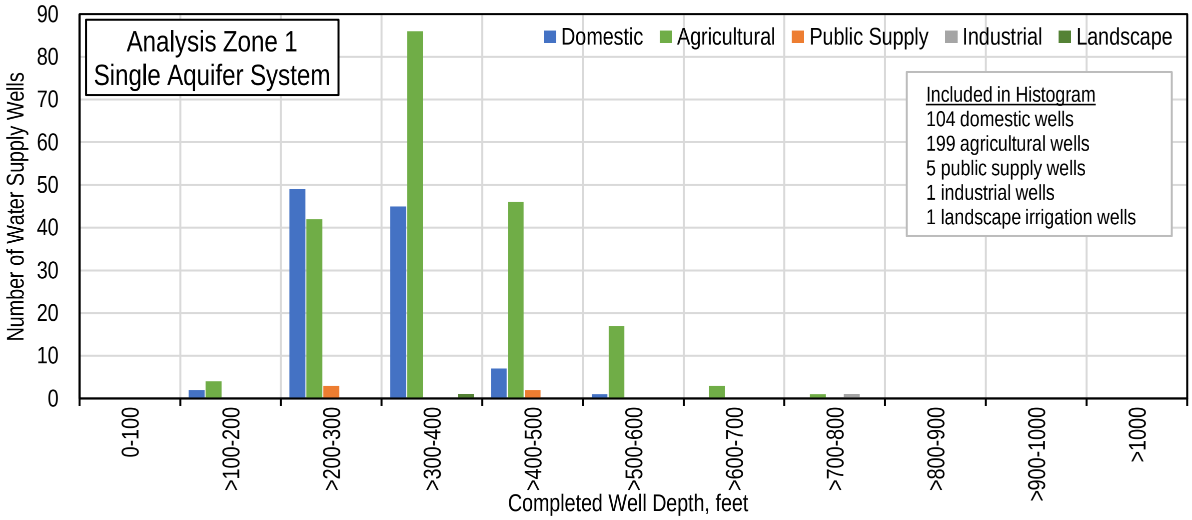

Analysis Zone 38
Groundwater Elevation (feet)
200
190
180
170
160
1996
2000
2004
2008
2012
2016
Date
Well ID
19S23E12L001M_Likely Lower
19S24E08D002M_Upper

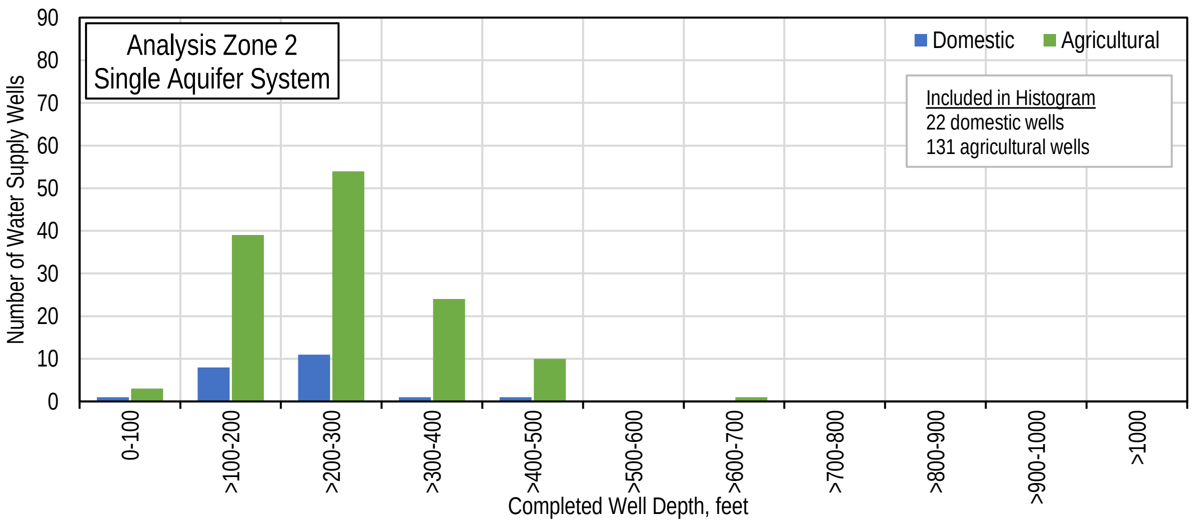

Analysis Zone 39
Groundwater Elevation (feet)
250
225
200
175
150
125
100
1970
1980
1990
2000
2010
2020
Date
Well ID
025-01_Assumed Upper
047-01_Assumed Upper
075-01_Assumed Upper
077-01_Assumed Upper
18S24E22E001M_Assumed Upper
18S24E25D001M_Upper

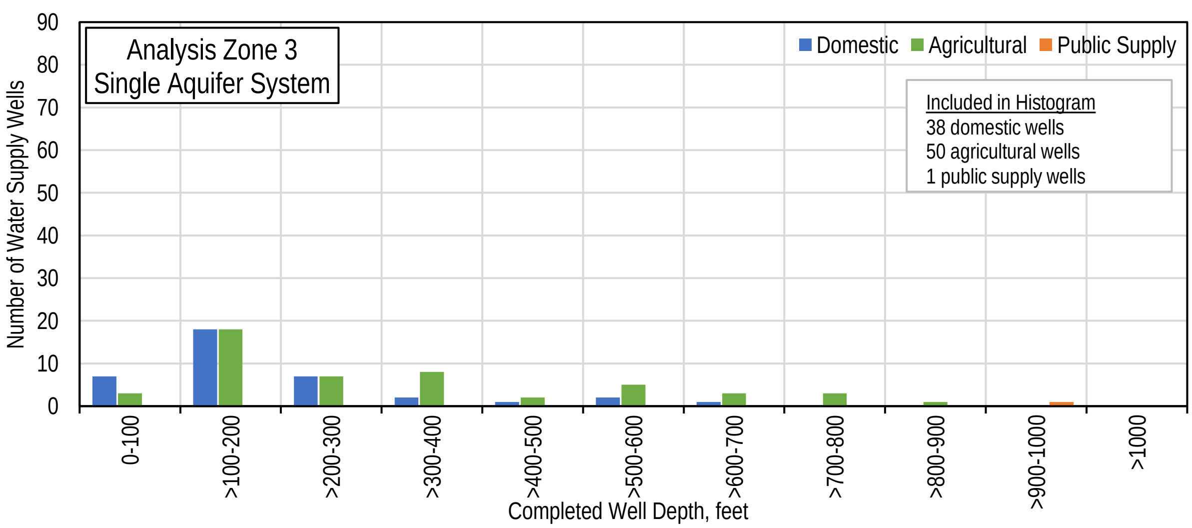
MONTGOMERY
& ASSOCIATES

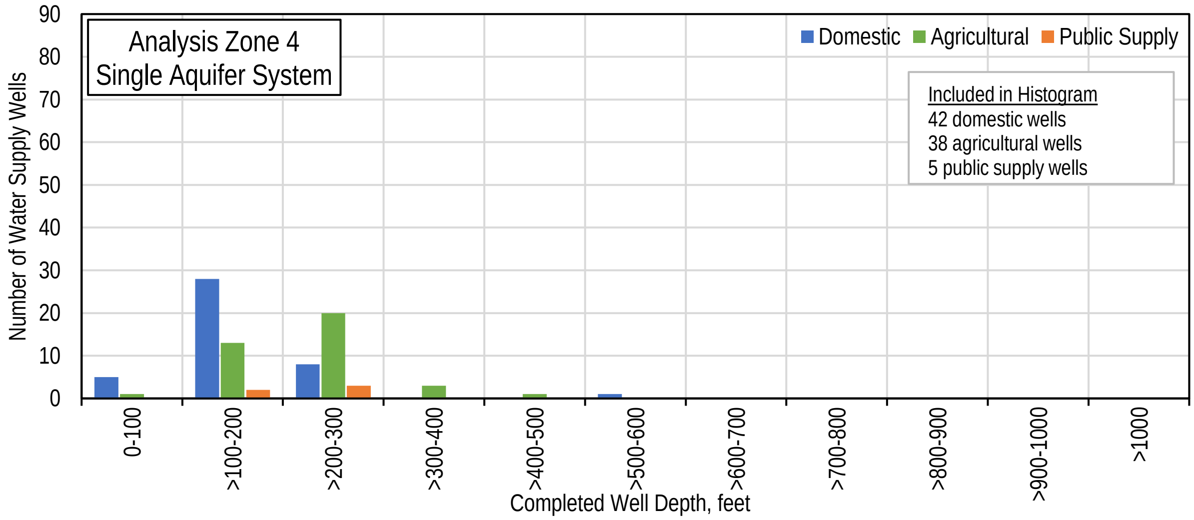
# Appendix B

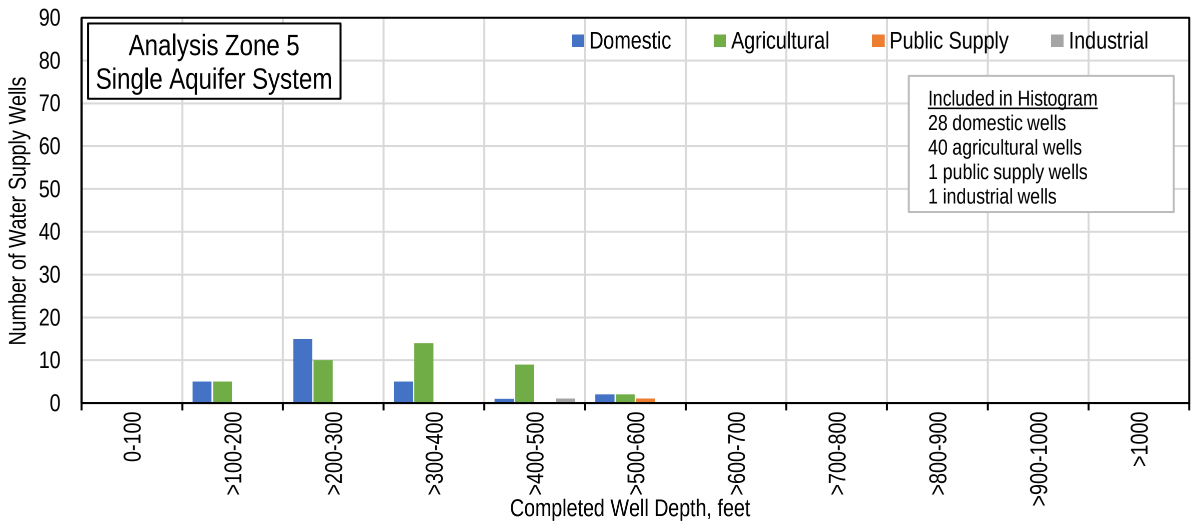
# Completed Well Depth Histograms by Analysis Zone

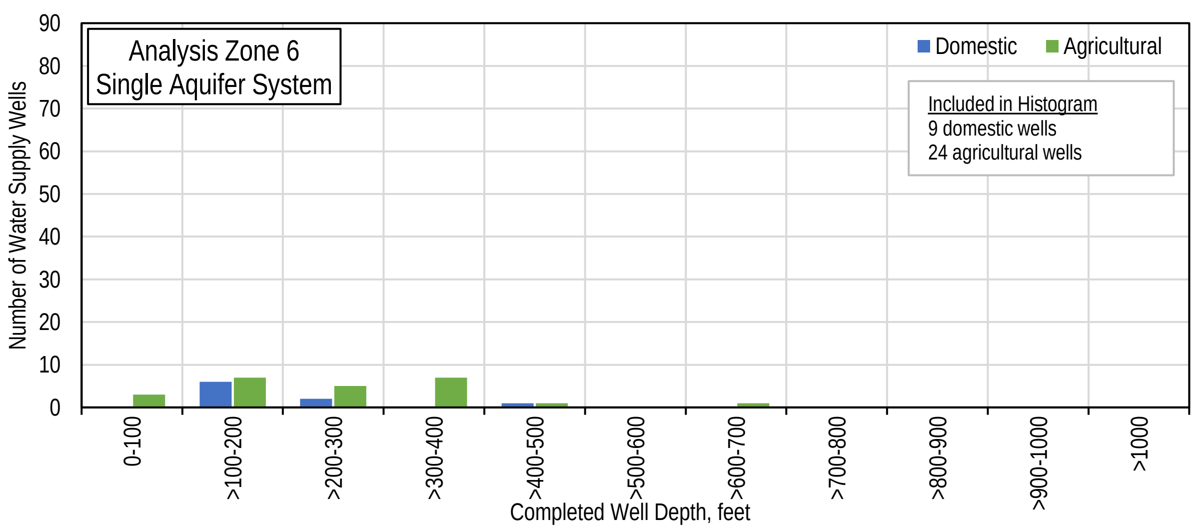

Analysis Zone 1
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Landscape
Included in Histogram
104 domestic wells
199 agricultural wells
5 public supply wells
1 industrial wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

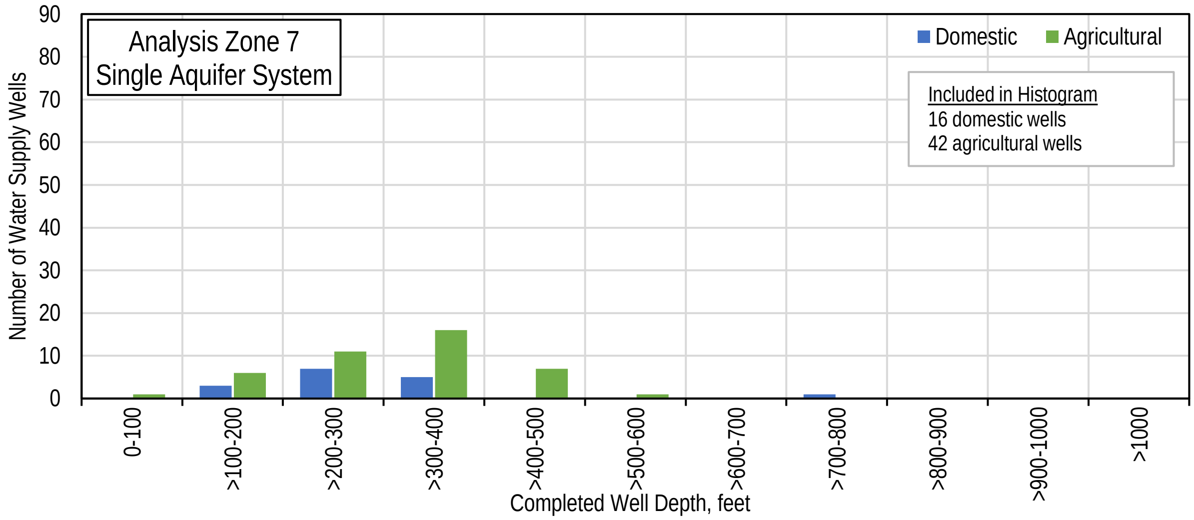

Analysis Zone 2
Single Aquifer System
Domestic
Agricultural
Included in Histogram
22 domestic wells
131 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

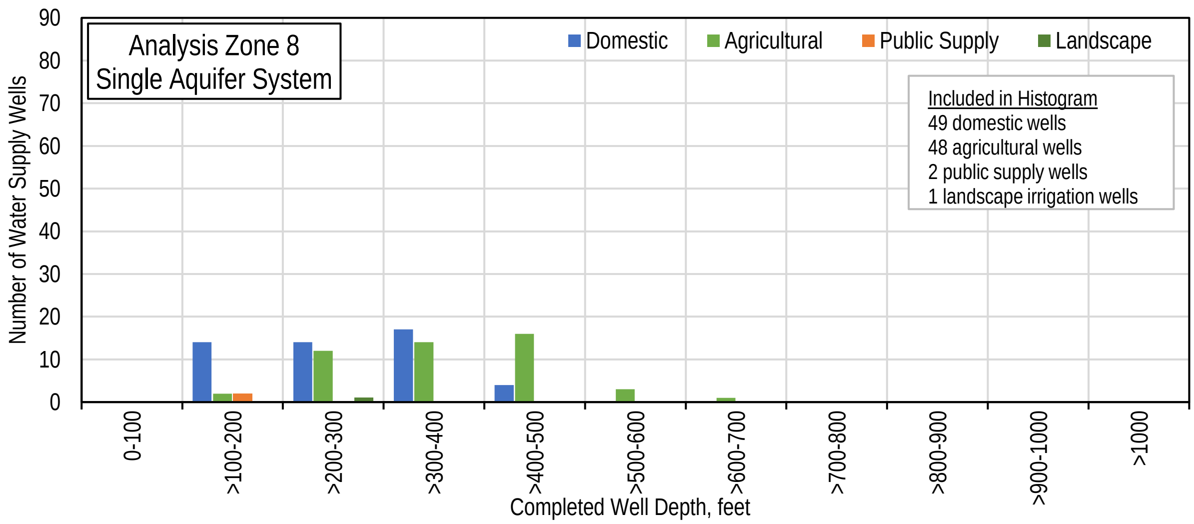

Analysis Zone 3
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
38 domestic wells
50 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

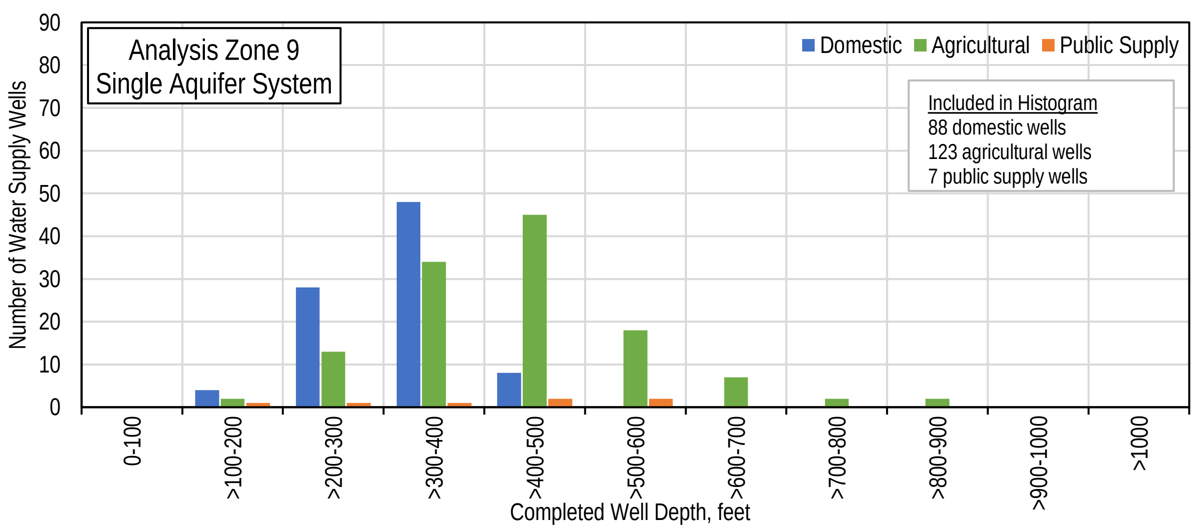

Analysis Zone 4
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
42 domestic wells
38 agricultural wells
5 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

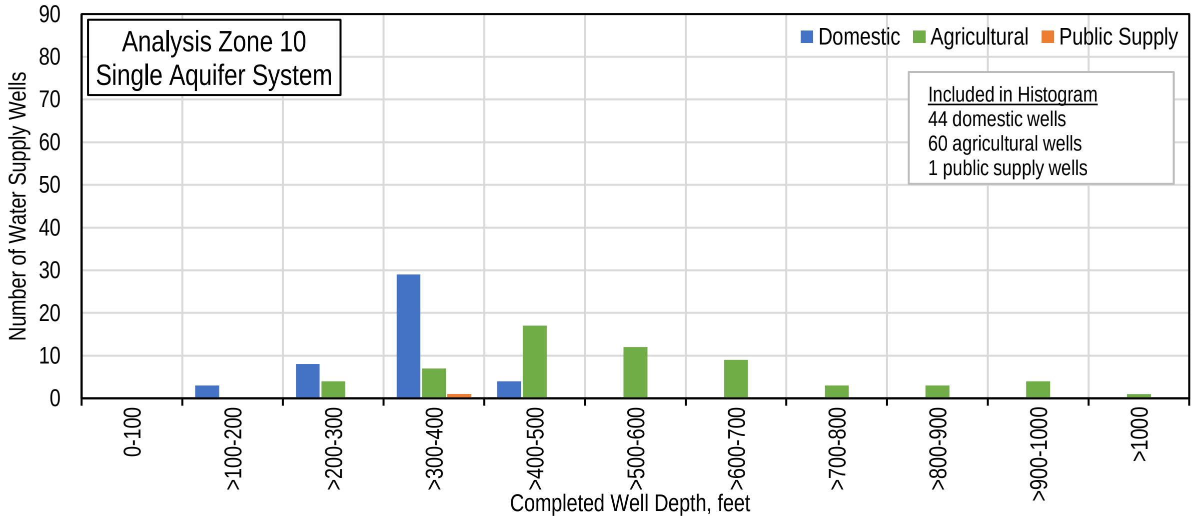

Analysis Zone 5
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
28 domestic wells
40 agricultural wells
1 public supply wells
1 industrial wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

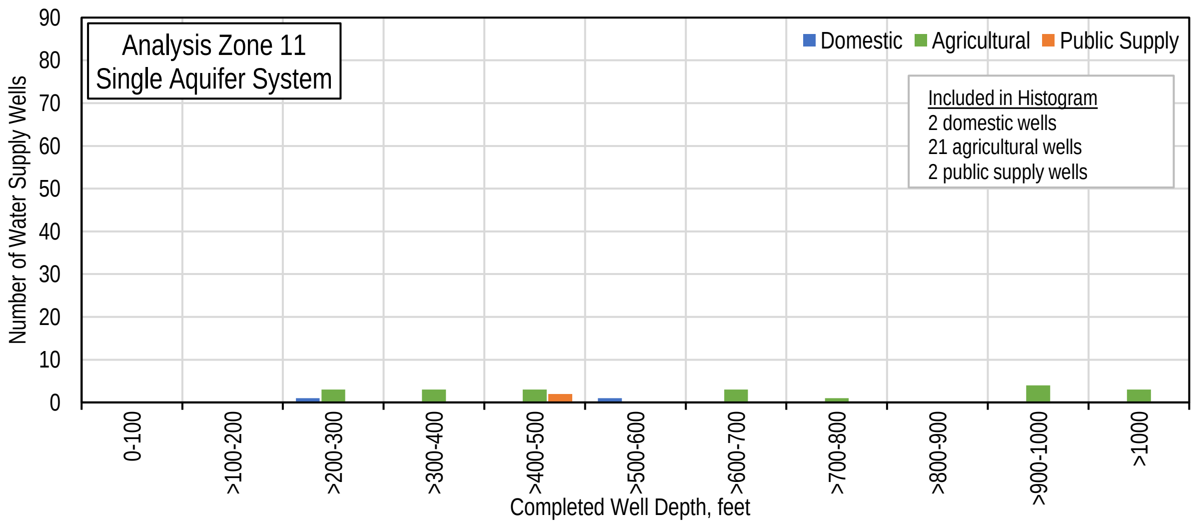

Analysis Zone 6
Single Aquifer System
Domestic
Agricultural
Included in Histogram
9 domestic wells
24 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

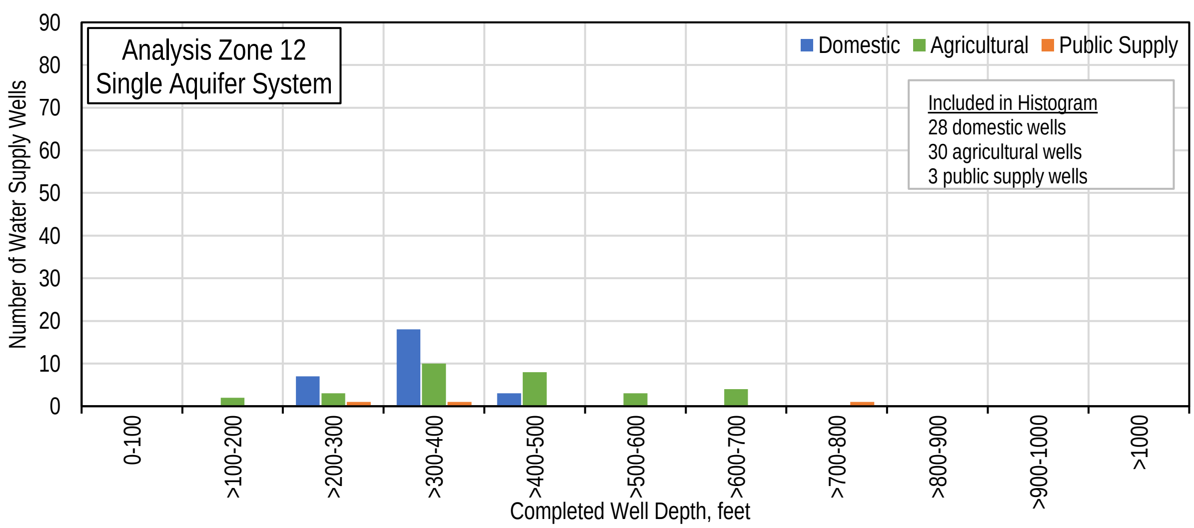

Analysis Zone 7
Single Aquifer System
Domestic
Agricultural
Included in Histogram
16 domestic wells
42 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

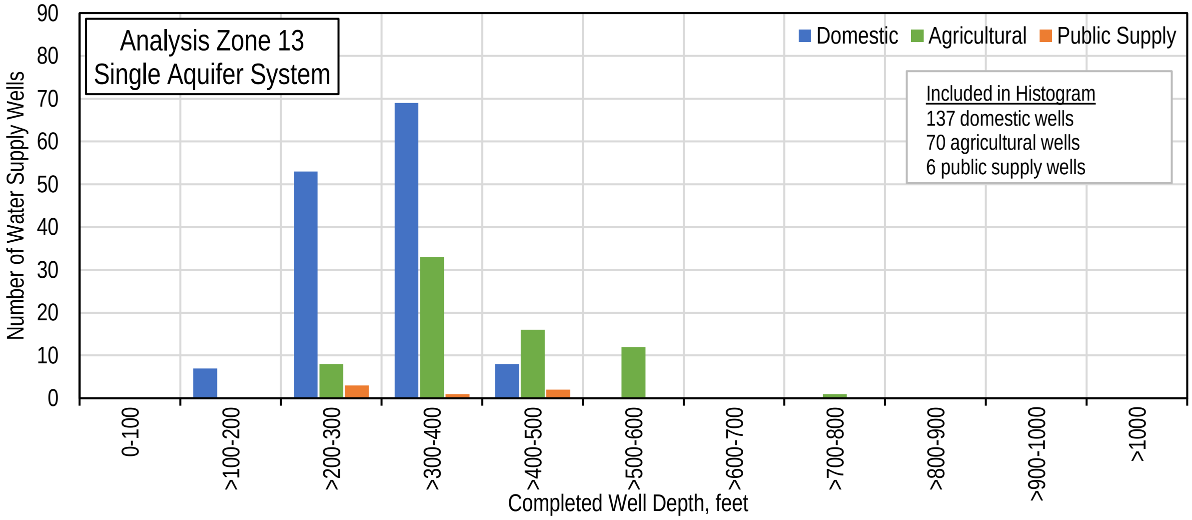

Analysis Zone 8
Single Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
49 domestic wells
48 agricultural wells
2 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

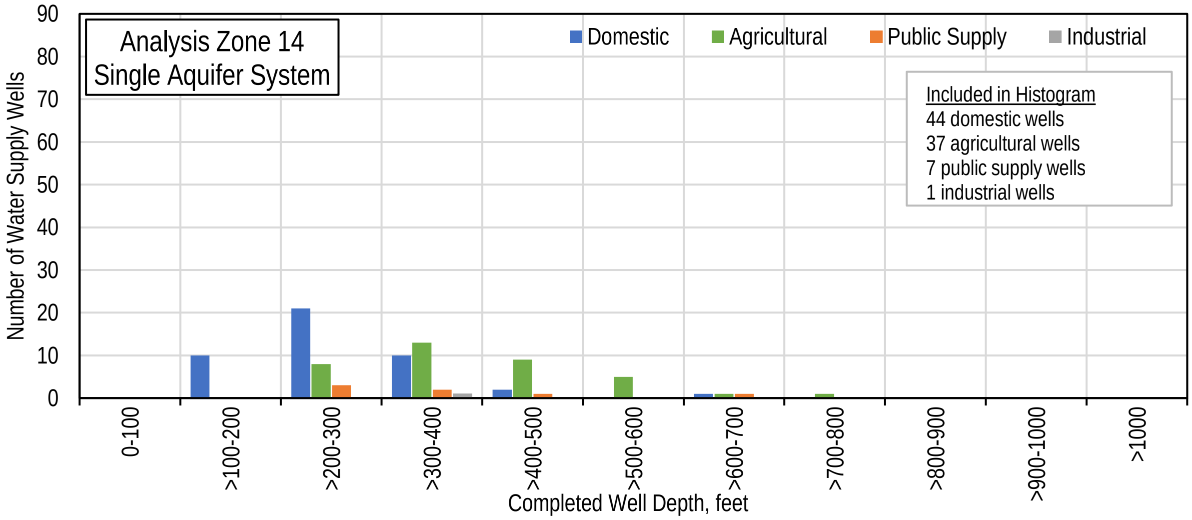

Analysis Zone 9
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
88 domestic wells
123 agricultural wells
7 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

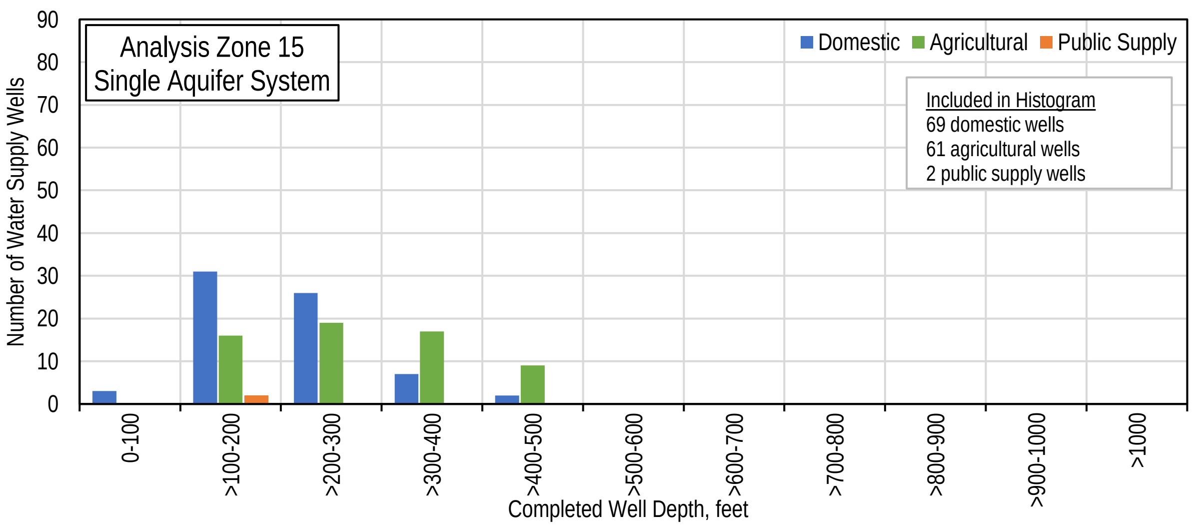

Analysis Zone 10
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
44 domestic wells
60 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

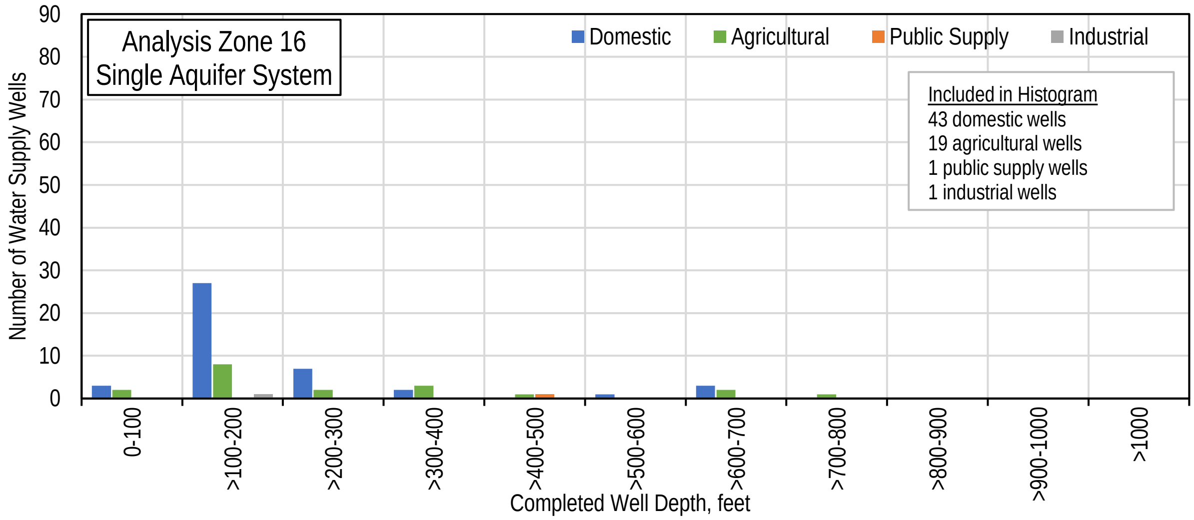

Analysis Zone 11
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
2 domestic wells
21 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

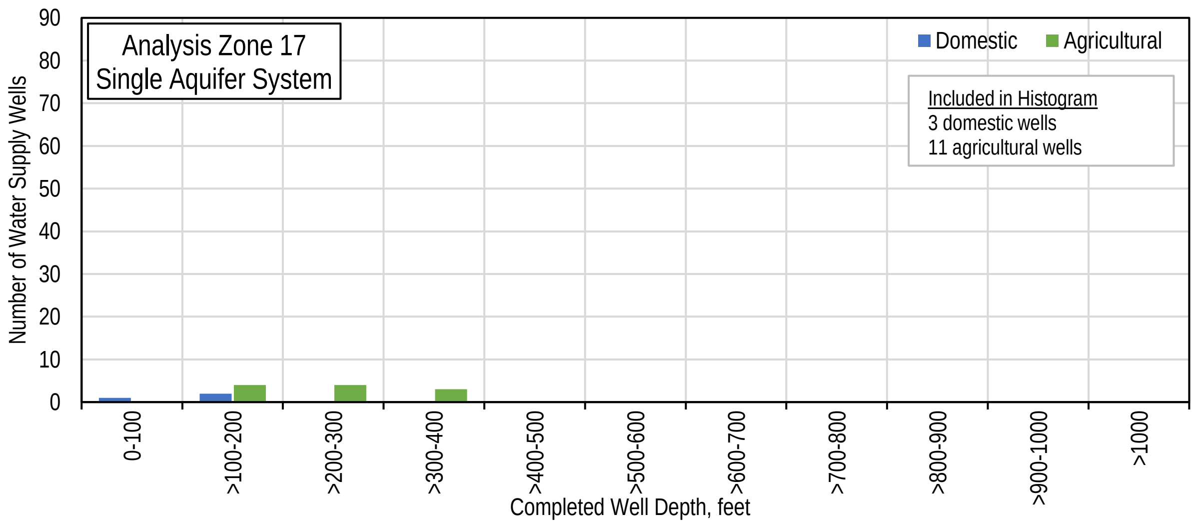

Analysis Zone 12
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
28 domestic wells
30 agricultural wells
3 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

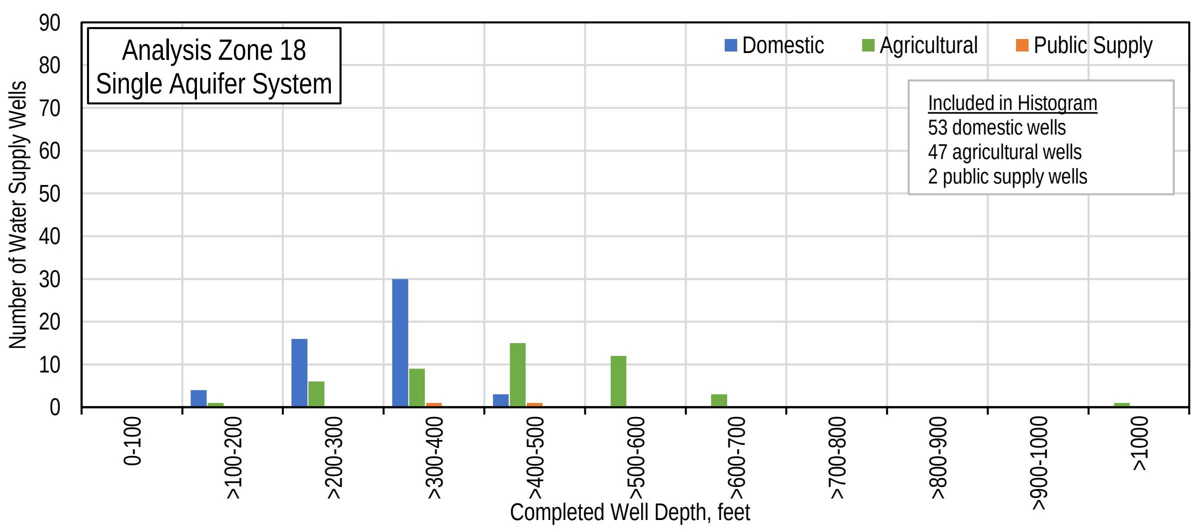

Analysis Zone 13
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
137 domestic wells
70 agricultural wells
6 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

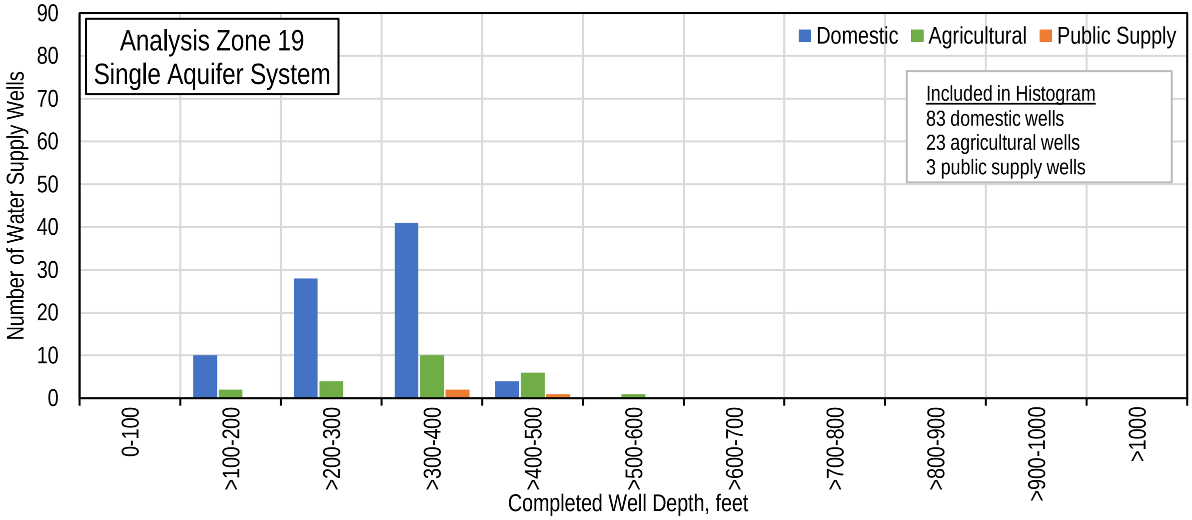

Analysis Zone 14
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
44 domestic wells
37 agricultural wells
7 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

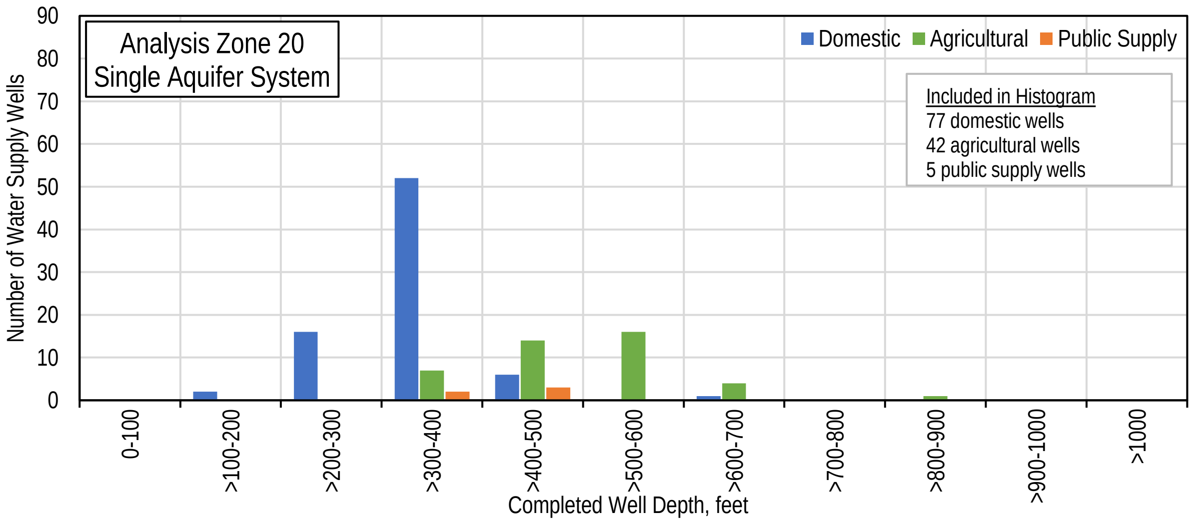

Analysis Zone 15
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
69 domestic wells
61 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

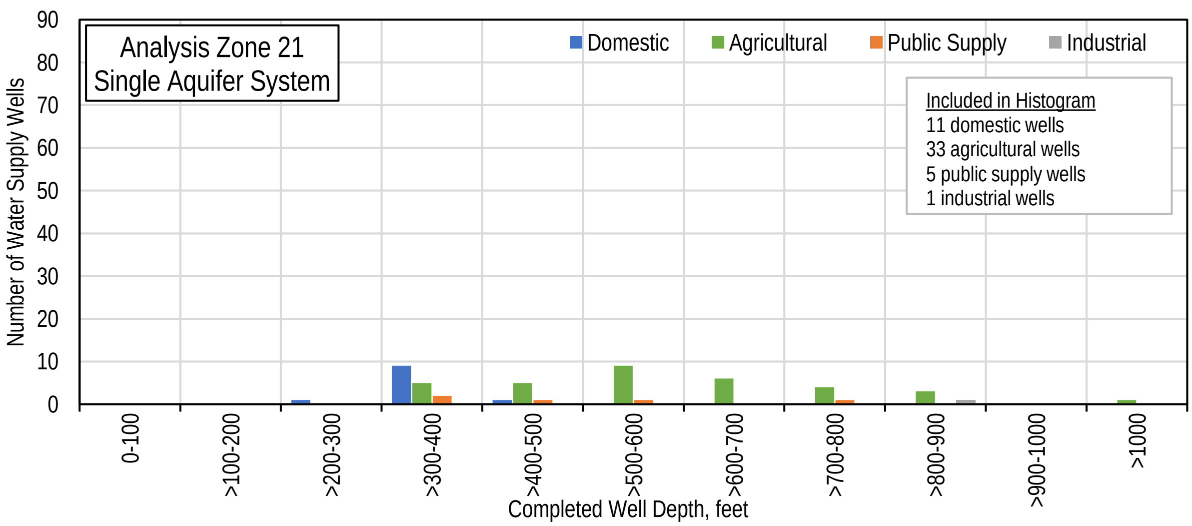

Analysis Zone 16
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
43 domestic wells
19 agricultural wells
1 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

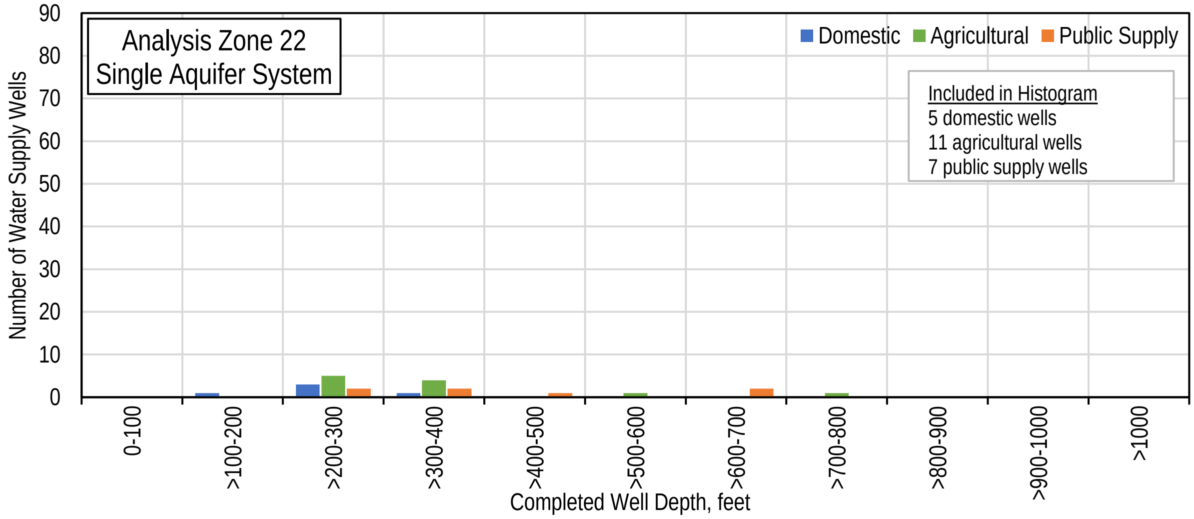

Analysis Zone 17
Single Aquifer System
Domestic
Agricultural
Included in Histogram
3 domestic wells
11 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

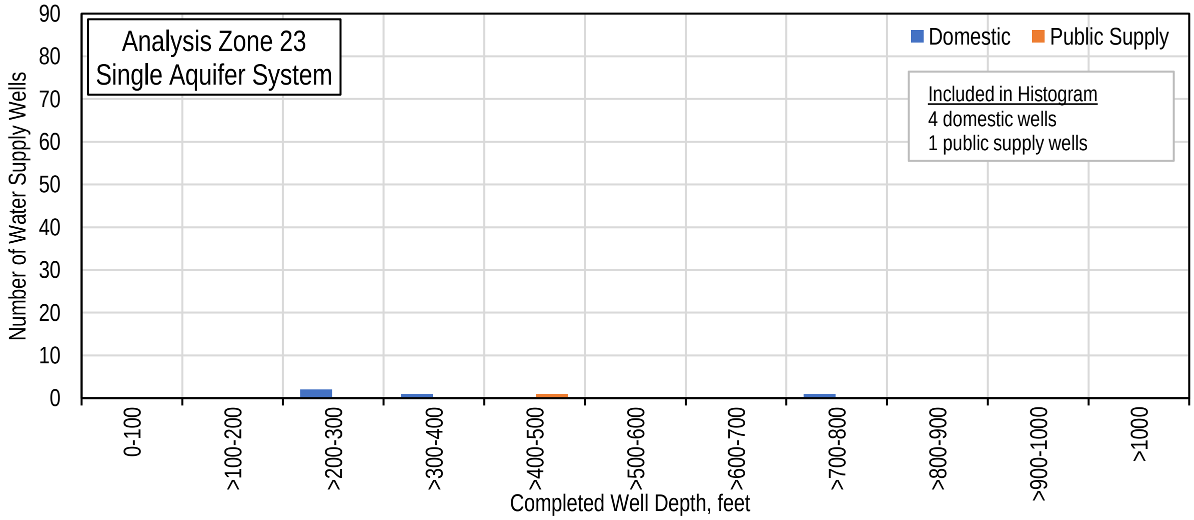

Analysis Zone 18
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
53 domestic wells
47 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

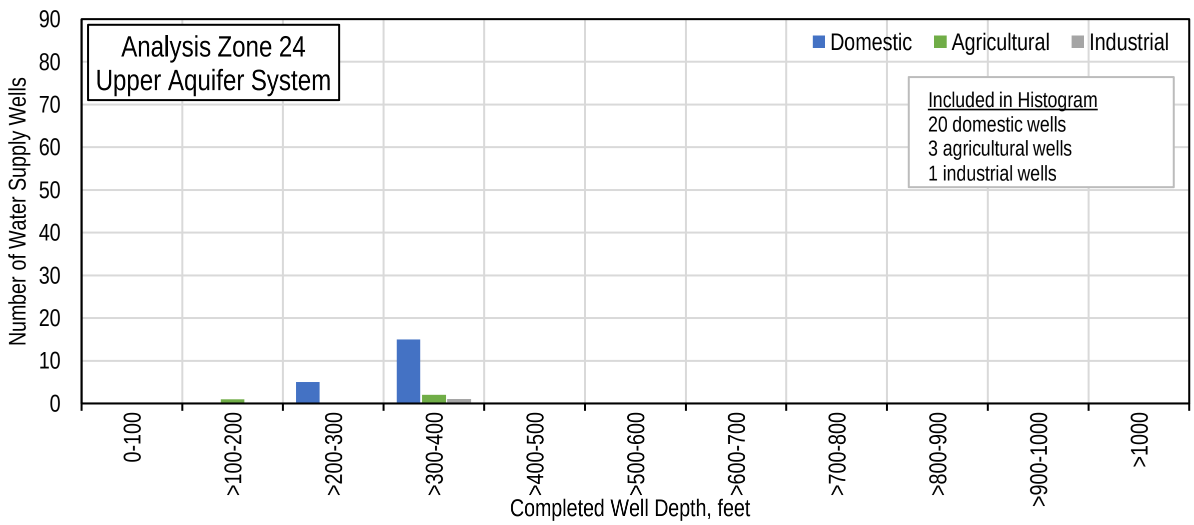

Analysis Zone 19
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
83 domestic wells
23 agricultural wells
3 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

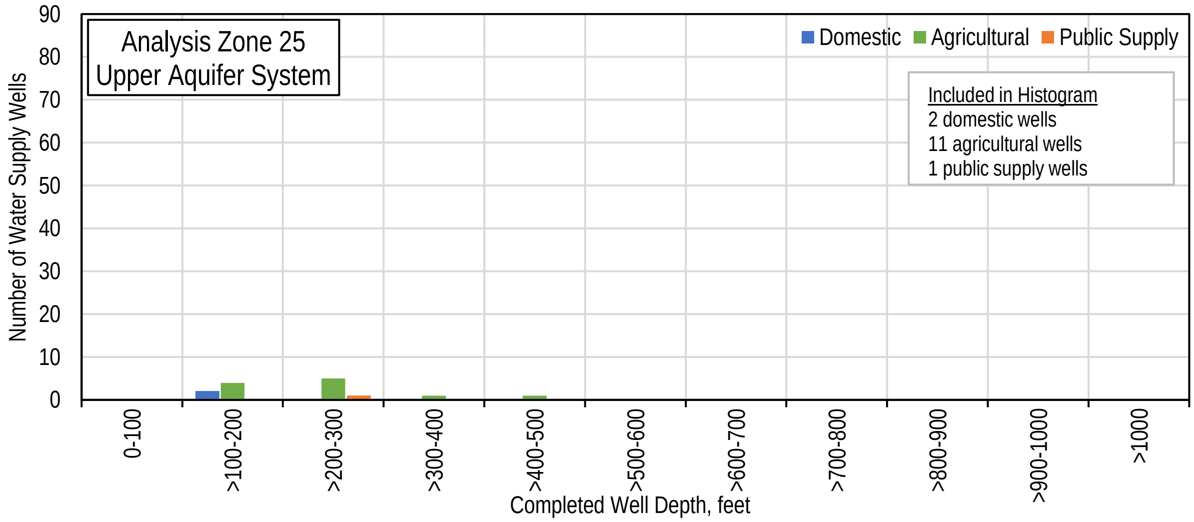

Analysis Zone 20
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
77 domestic wells
42 agricultural wells
5 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

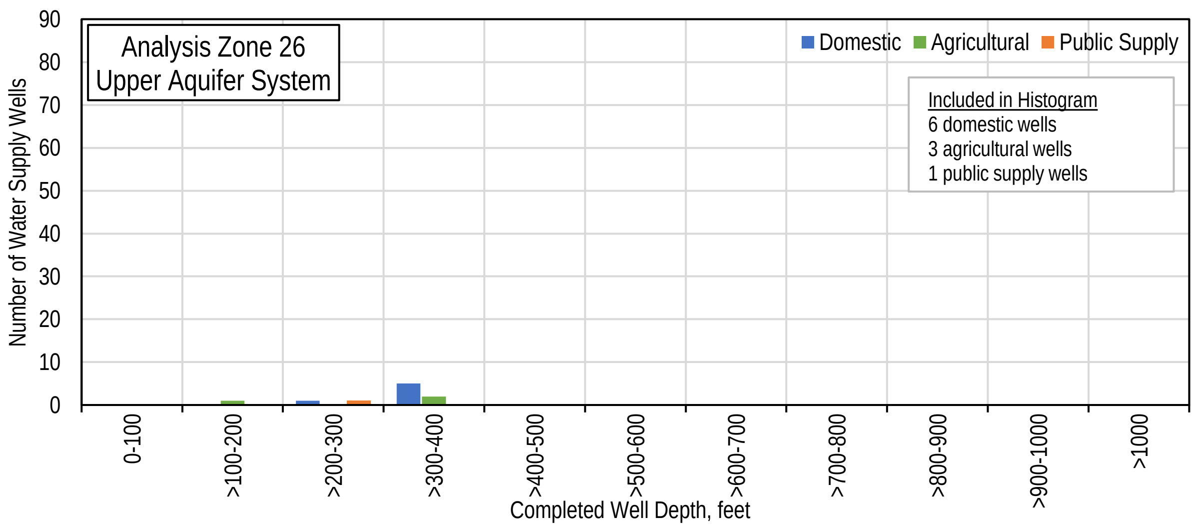

Analysis Zone 21
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
11 domestic wells
33 agricultural wells
5 public supply wells
1 industrial wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

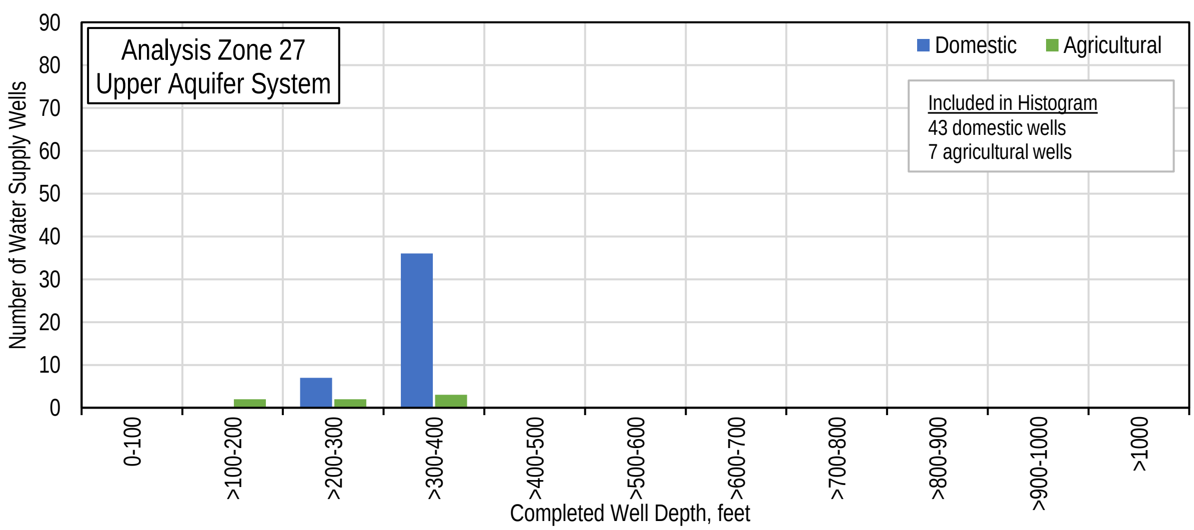

Analysis Zone 22
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
11 agricultural wells
7 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

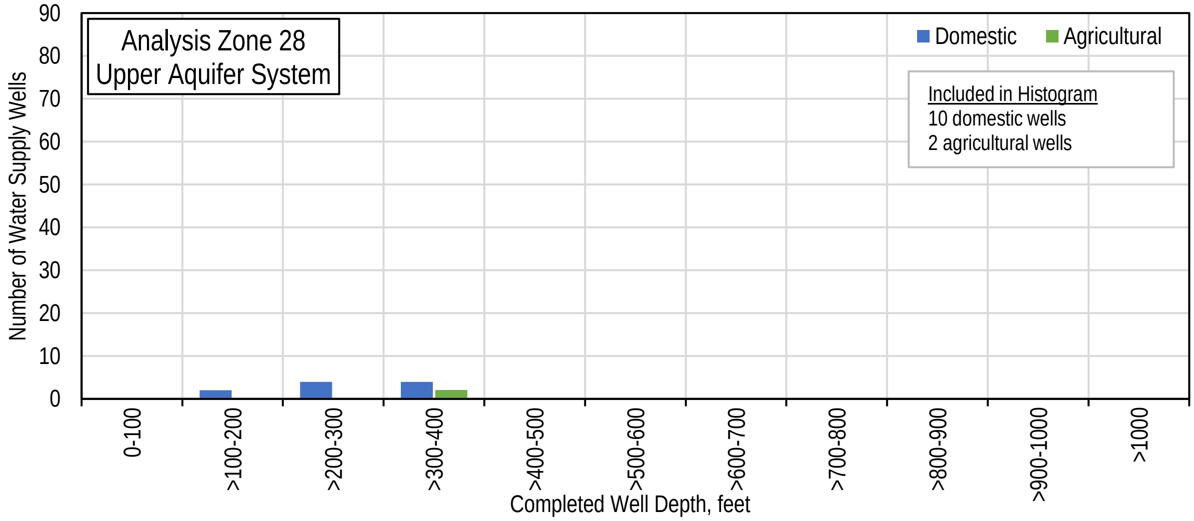

Analysis Zone 23
Single Aquifer System
Domestic
Public Supply
Included in Histogram
4 domestic wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

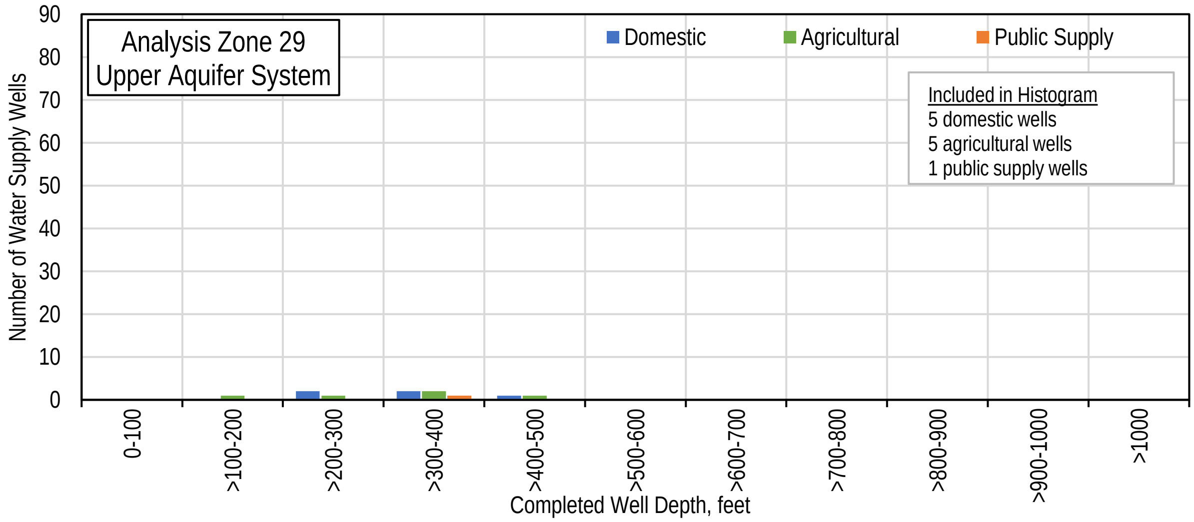

Analysis Zone 24
Upper Aquifer System
Domestic
Agricultural
Industrial
Included in Histogram
20 domestic wells
3 agricultural wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

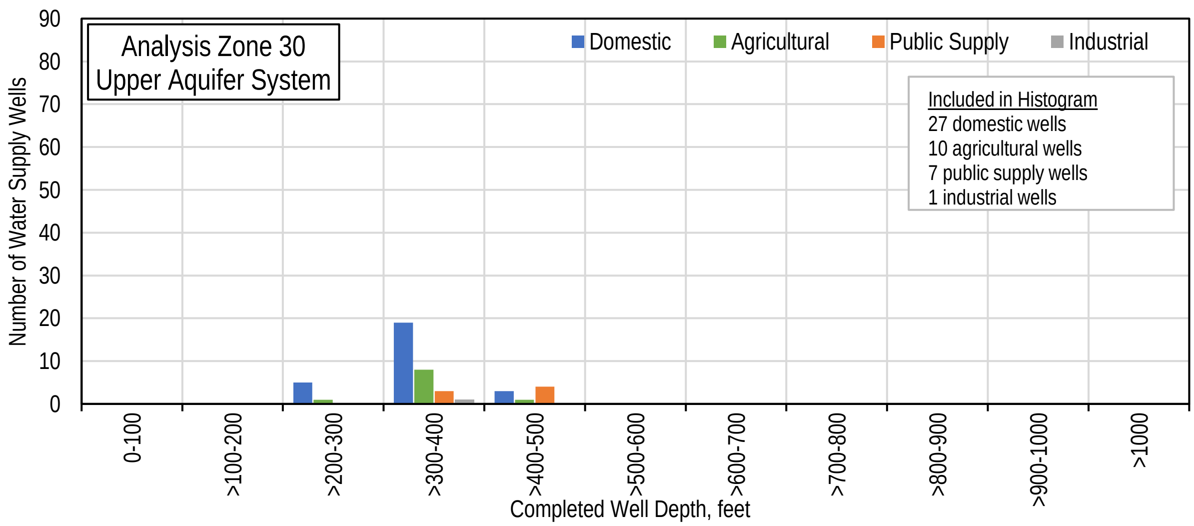

Analysis Zone 25
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
2 domestic wells
11 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

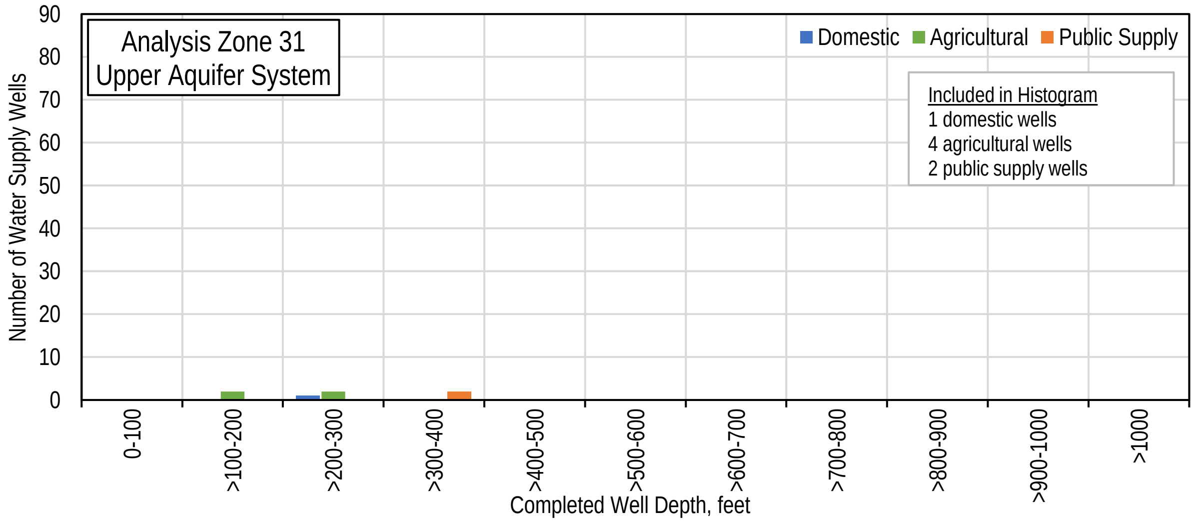

Analysis Zone 26
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
6 domestic wells
3 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

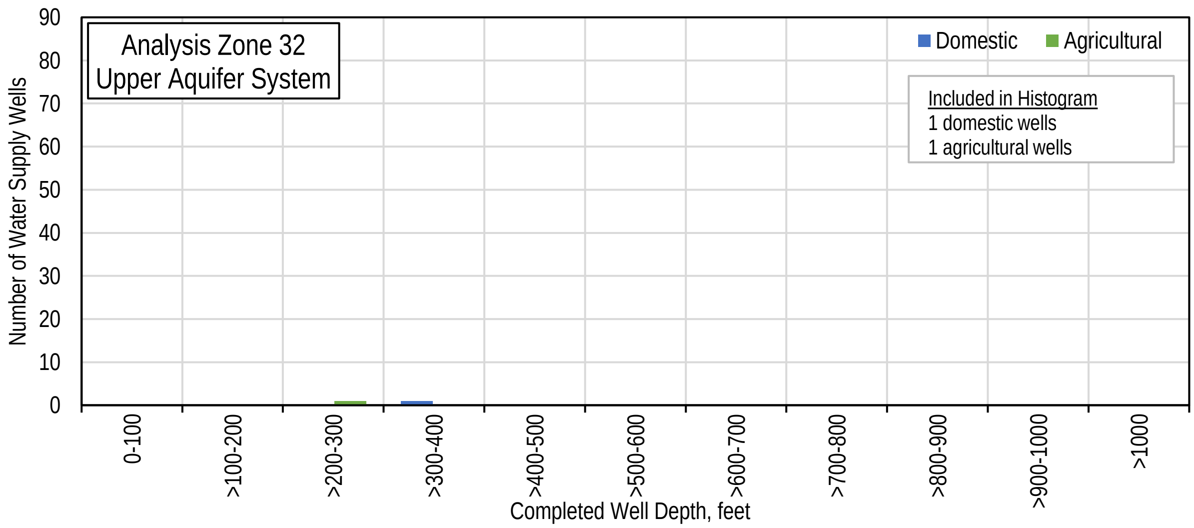

Analysis Zone 27
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
43 domestic wells
7 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

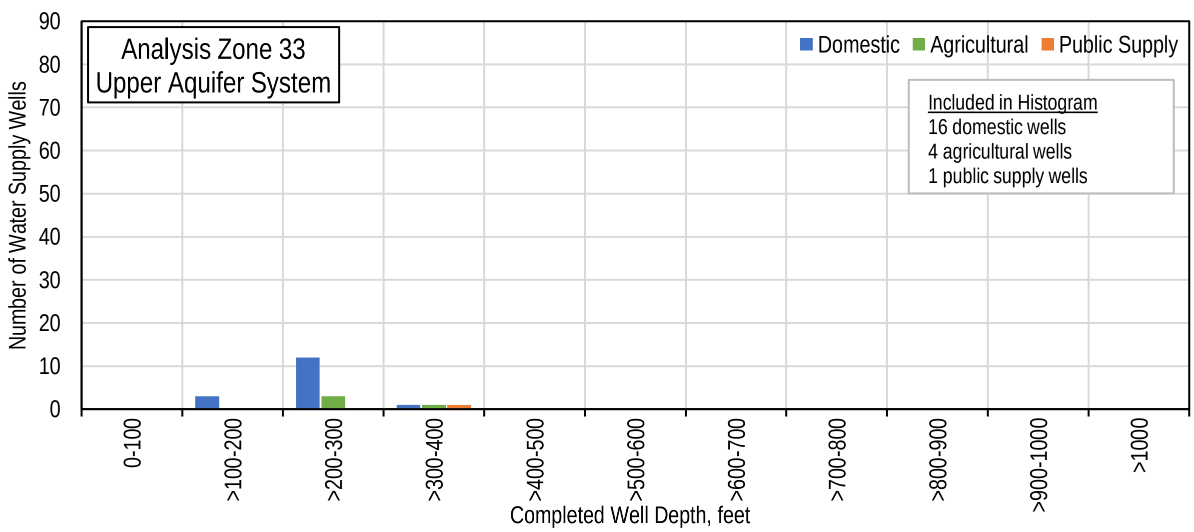

Analysis Zone 28
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
10 domestic wells
2 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

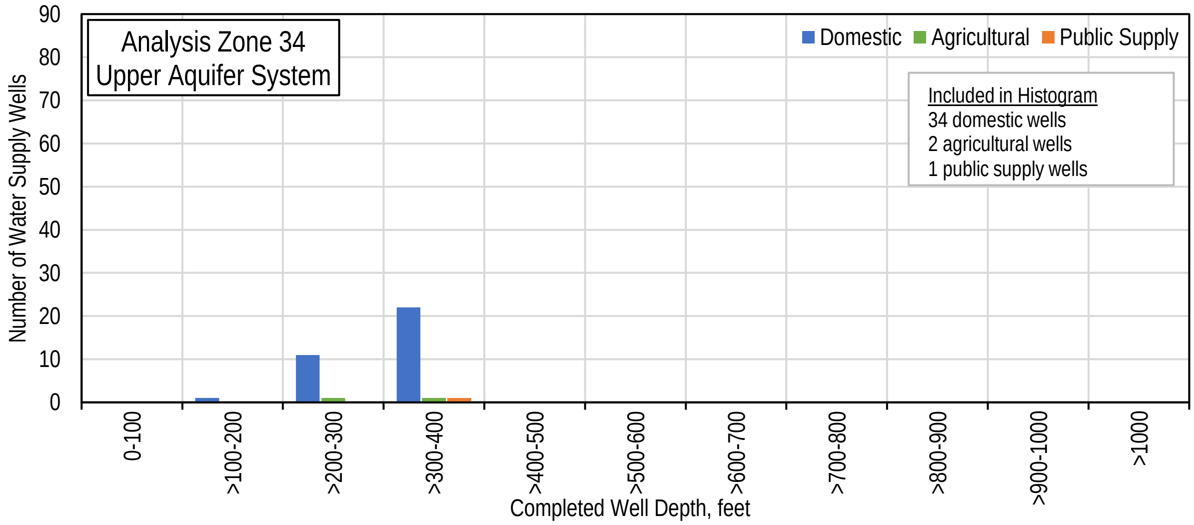

Analysis Zone 29
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
5 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

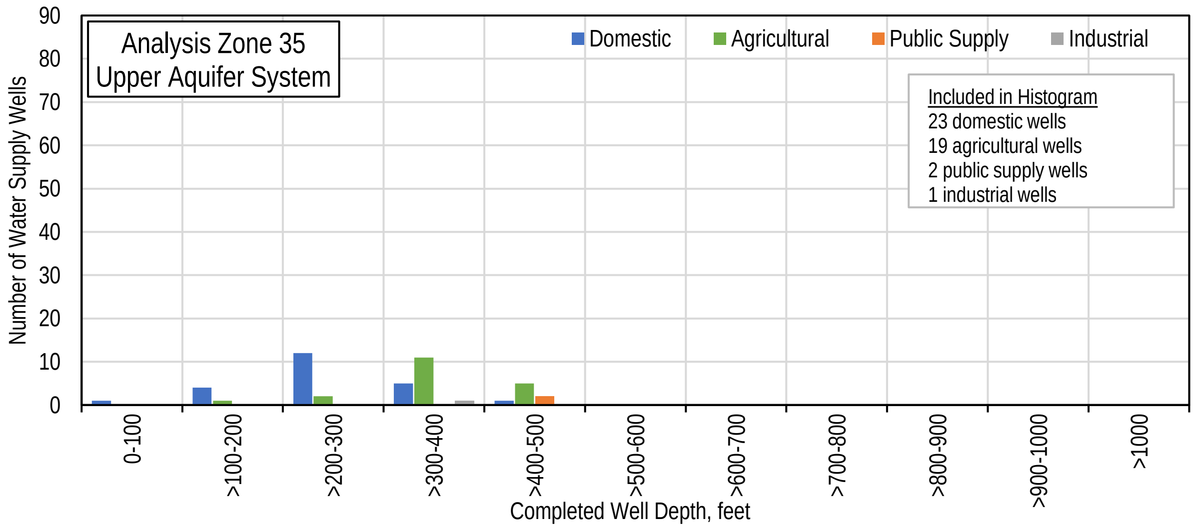

Analysis Zone 30
Upper Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
27 domestic wells
10 agricultural wells
7 public supply wells
1 industrial wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

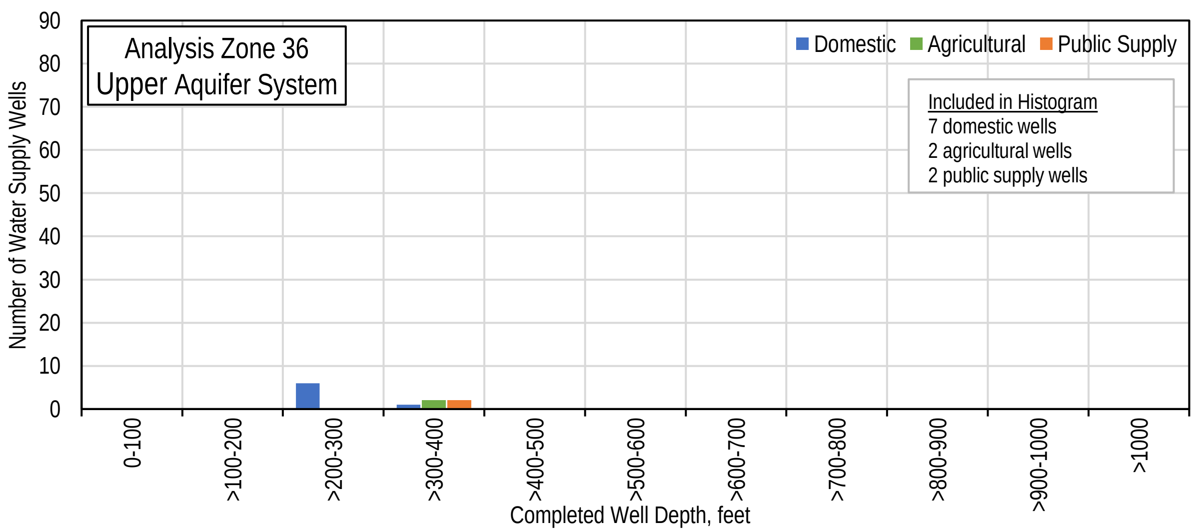

Analysis Zone 31
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
1 domestic wells
4 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

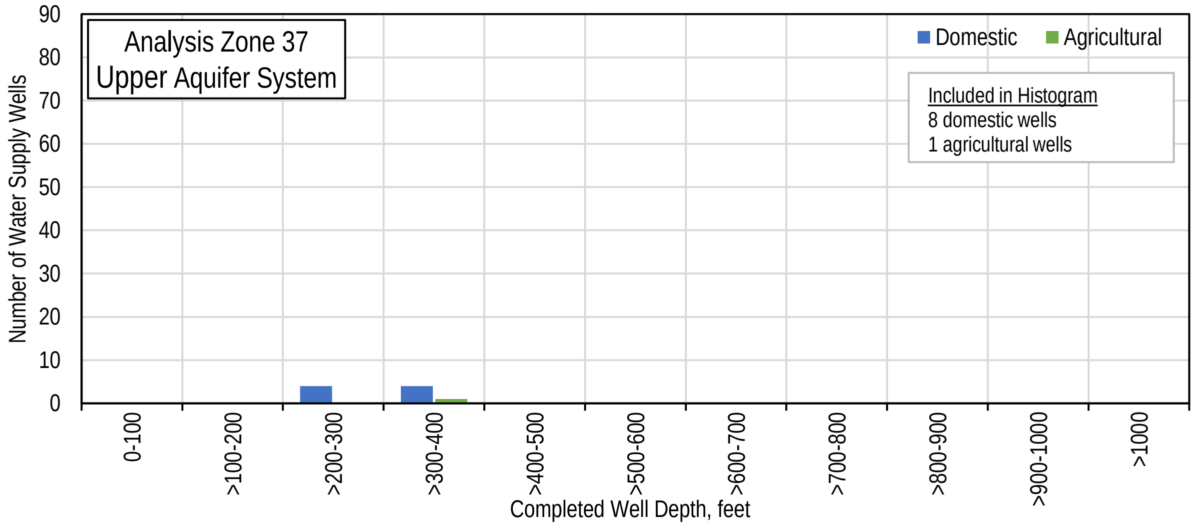

Analysis Zone 32
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
1 domestic wells
1 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

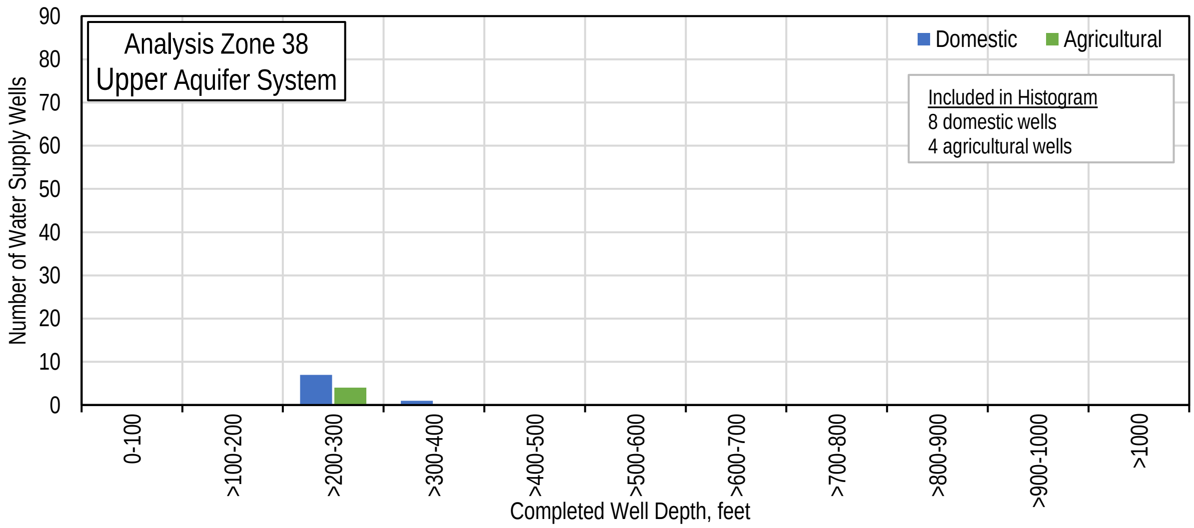

Analysis Zone 33
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
16 domestic wells
4 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

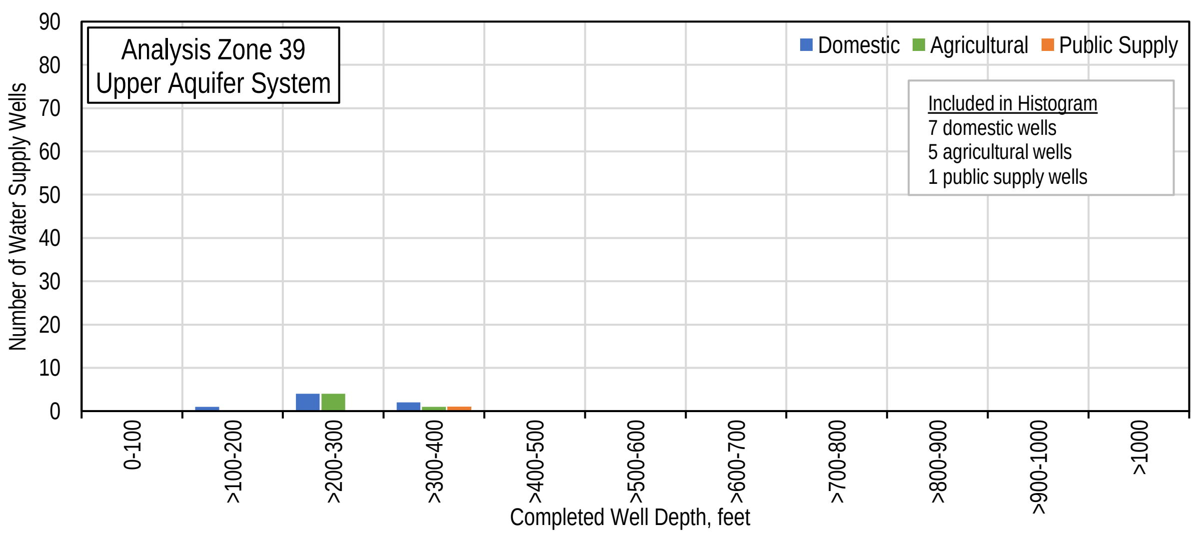

Analysis Zone 34
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
34 domestic wells
2 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

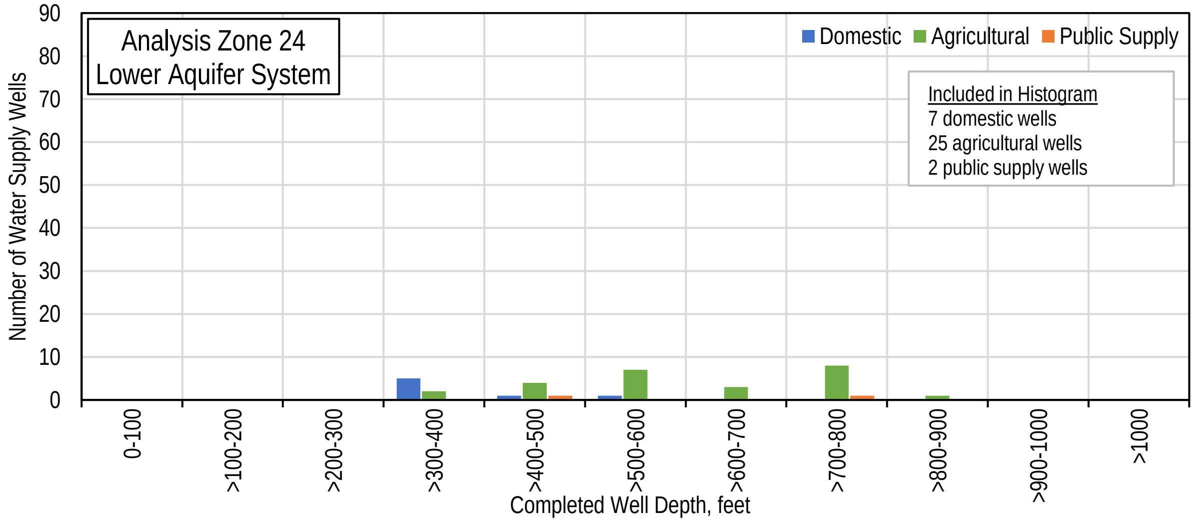

Analysis Zone 35
Upper Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
23 domestic wells
19 agricultural wells
2 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

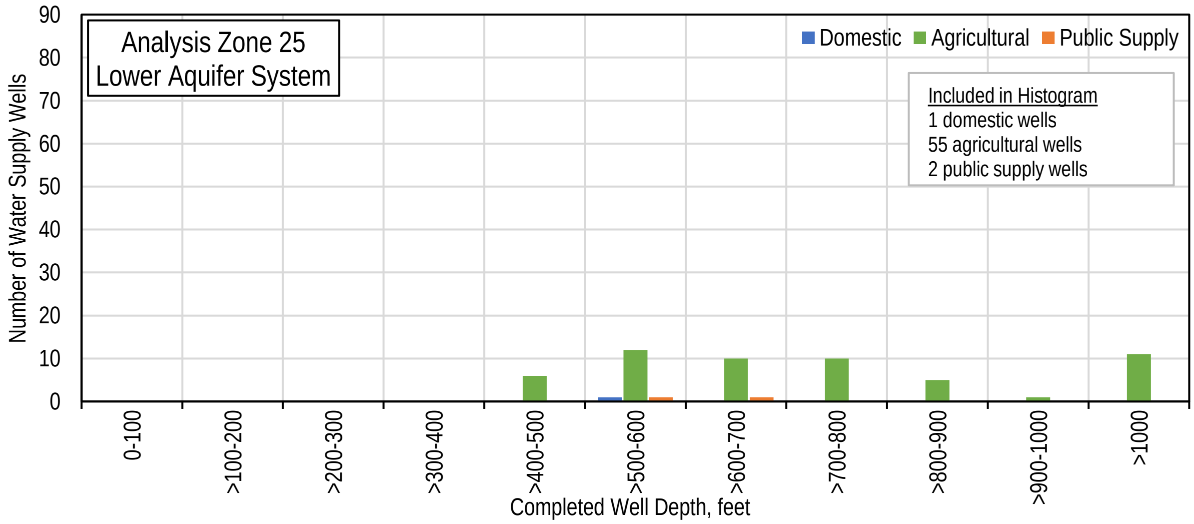

Analysis Zone 36
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
2 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

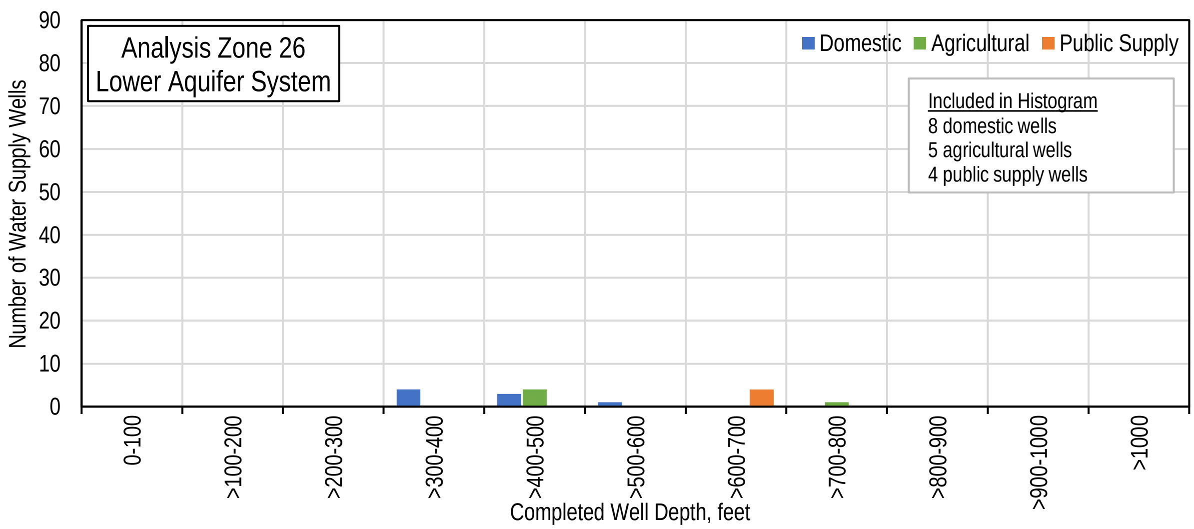

Analysis Zone 37
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
8 domestic wells
1 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

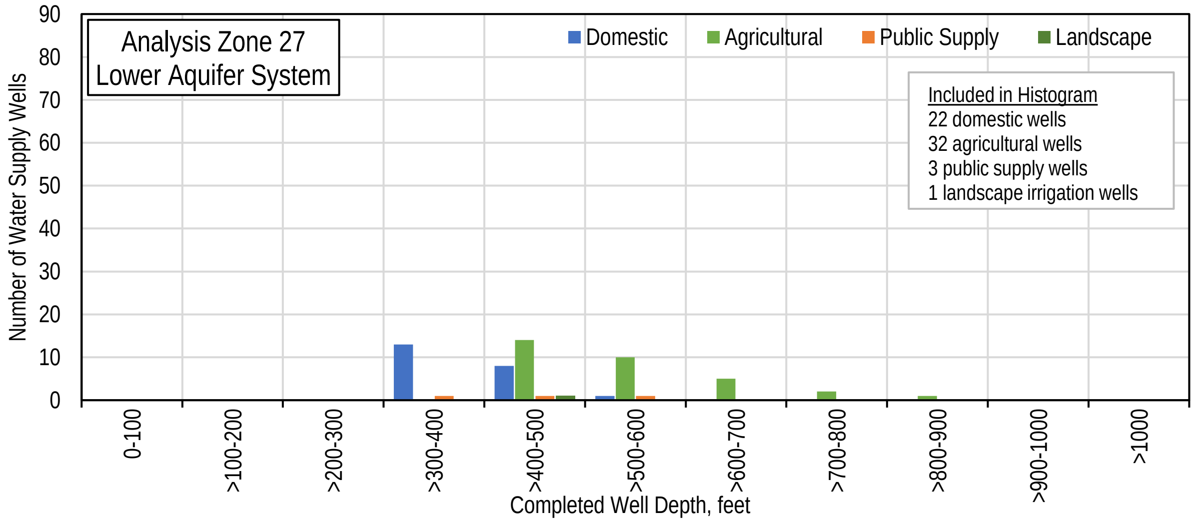

Analysis Zone 38
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
8 domestic wells
4 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

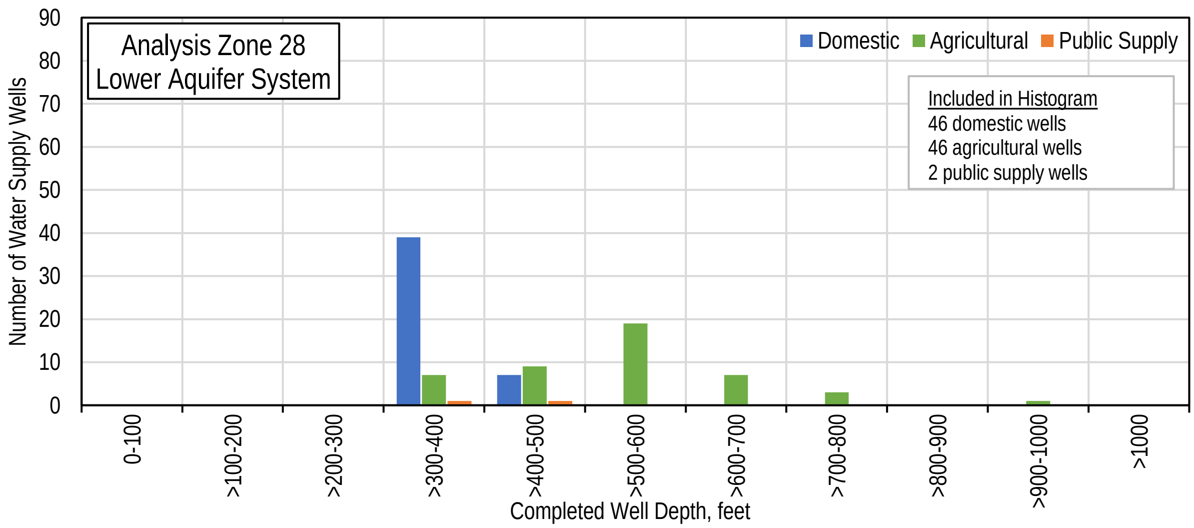

Analysis Zone 39
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
5 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

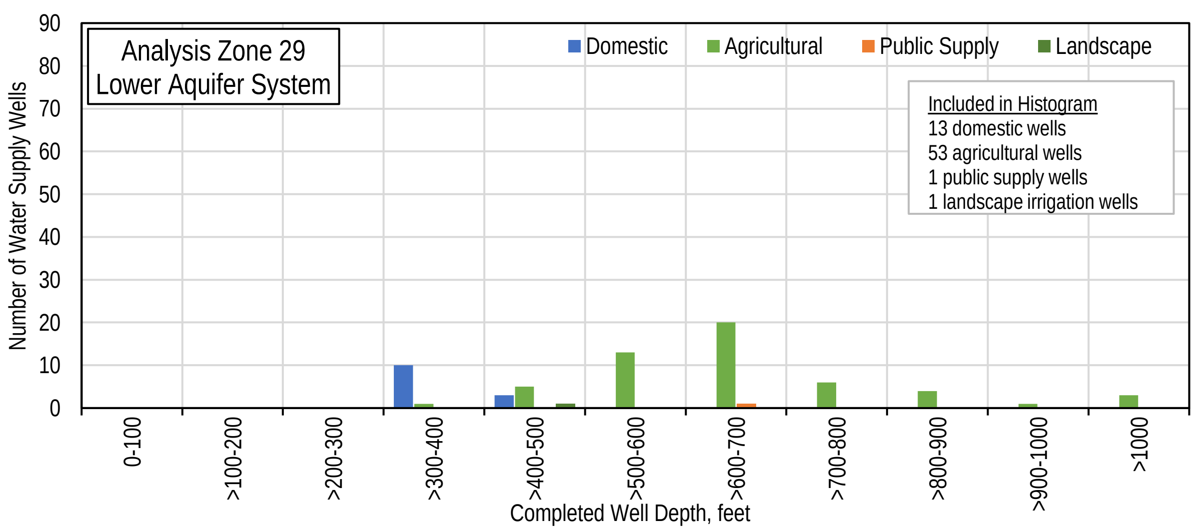

Analysis Zone 24
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
25 agricultural wells
2 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

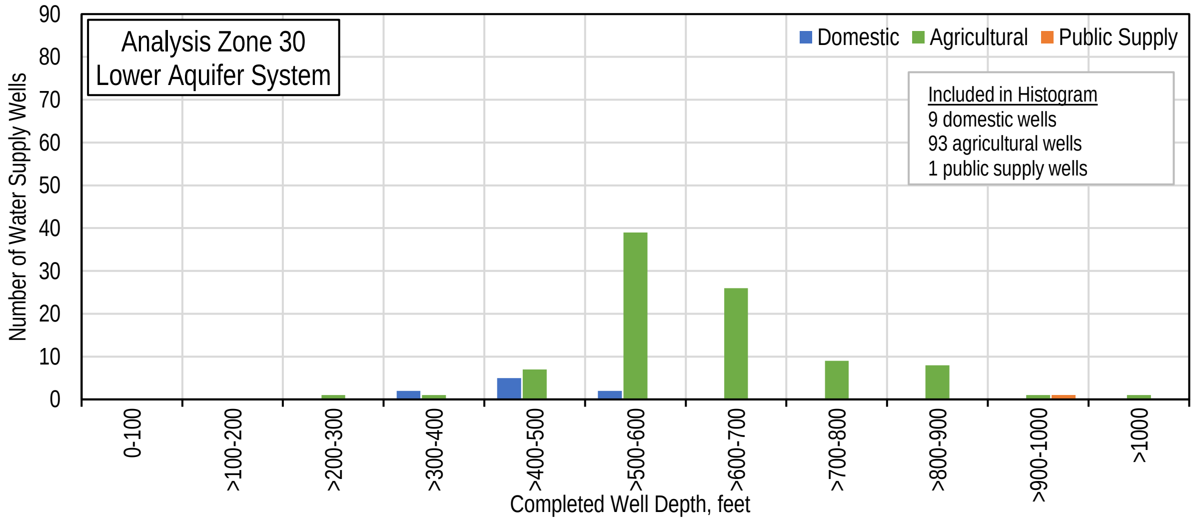

Analysis Zone 25
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
1 domestic wells
55 agricultural wells
2 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

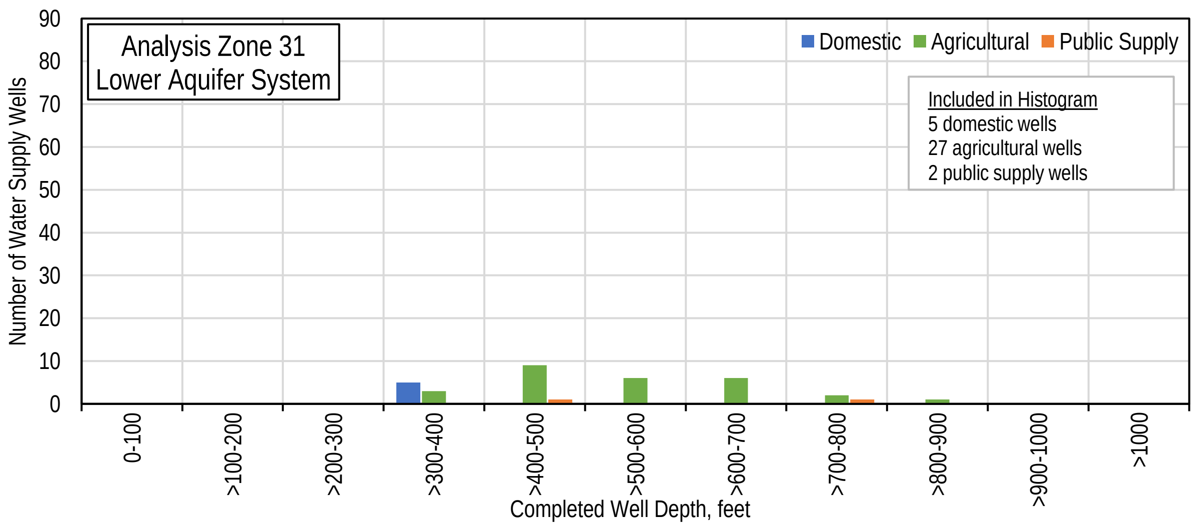

Analysis Zone 26
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
8 domestic wells
5 agricultural wells
4 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

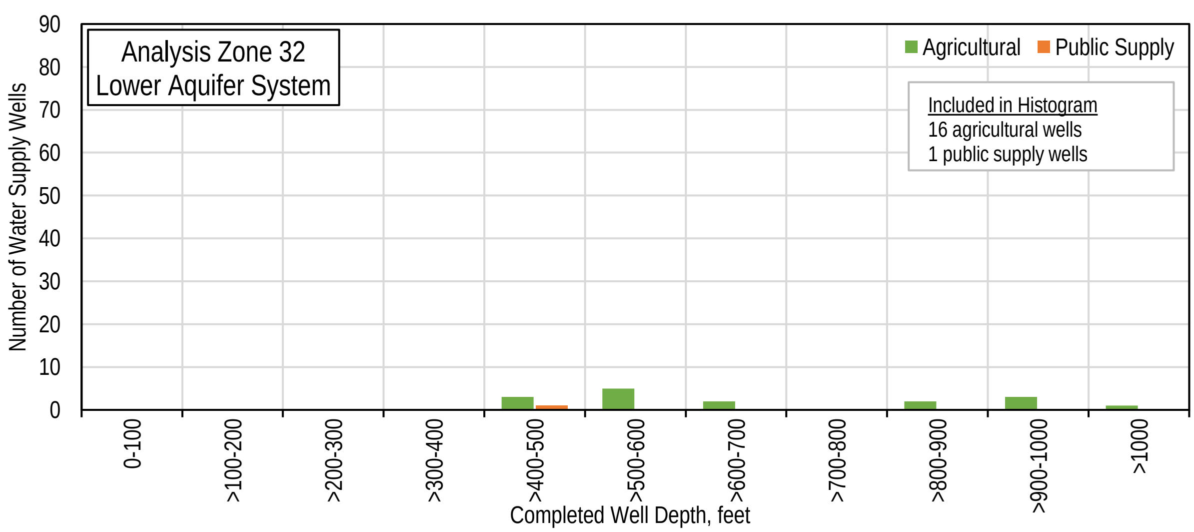

Analysis Zone 27
Lower Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
22 domestic wells
32 agricultural wells
3 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

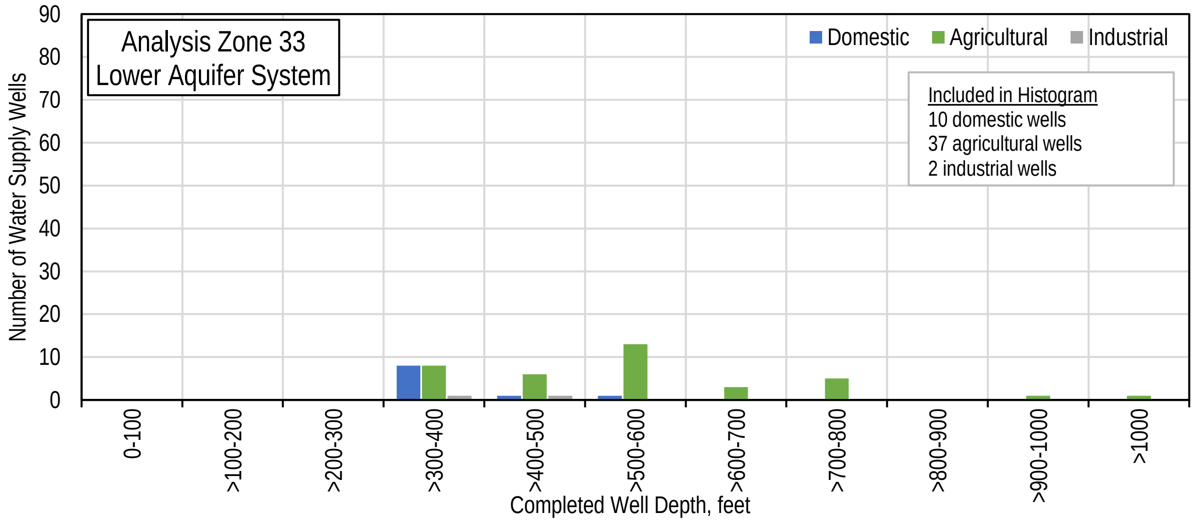

Analysis Zone 28
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
46 domestic wells
46 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

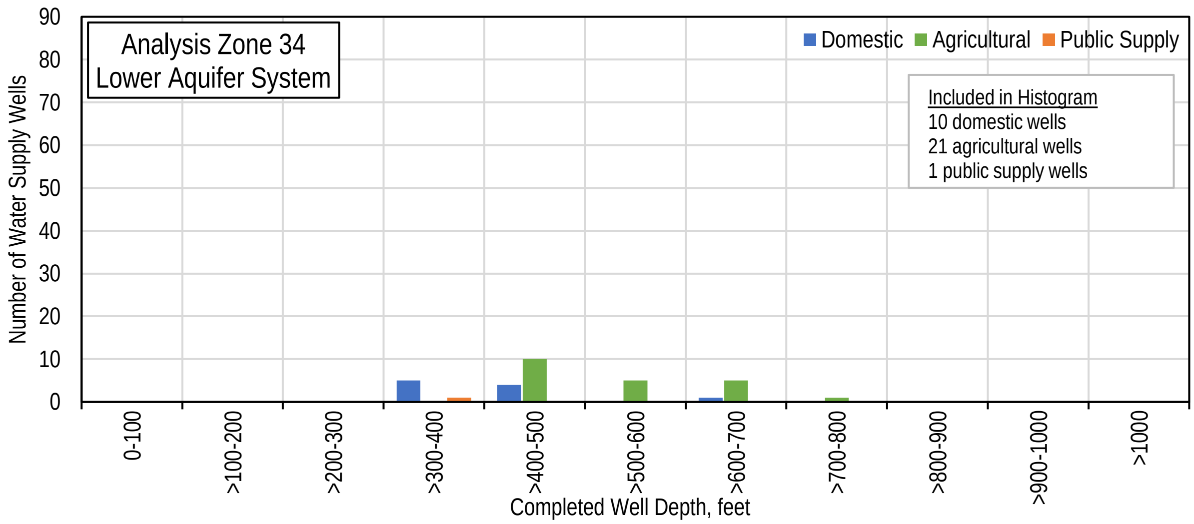

Analysis Zone 29
Lower Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
13 domestic wells
53 agricultural wells
1 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

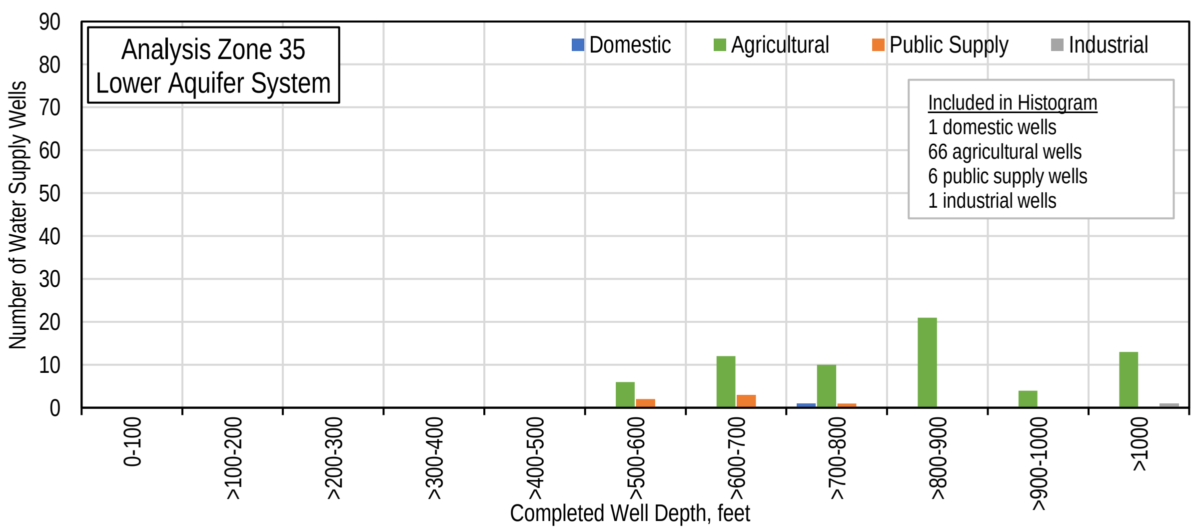

Analysis Zone 30
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
9 domestic wells
93 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

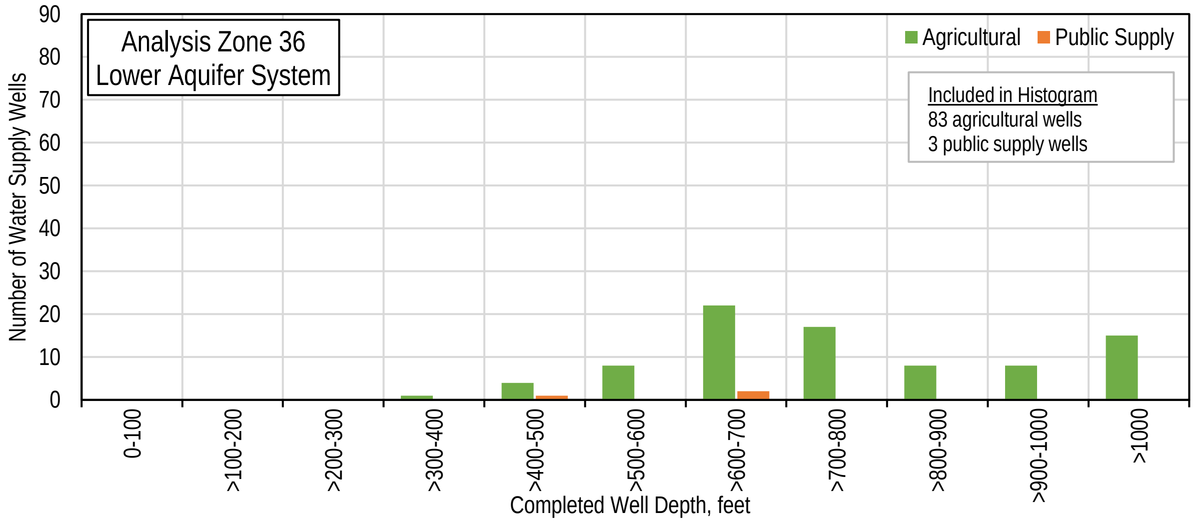

Analysis Zone 31
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
27 agricultural wells
2 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

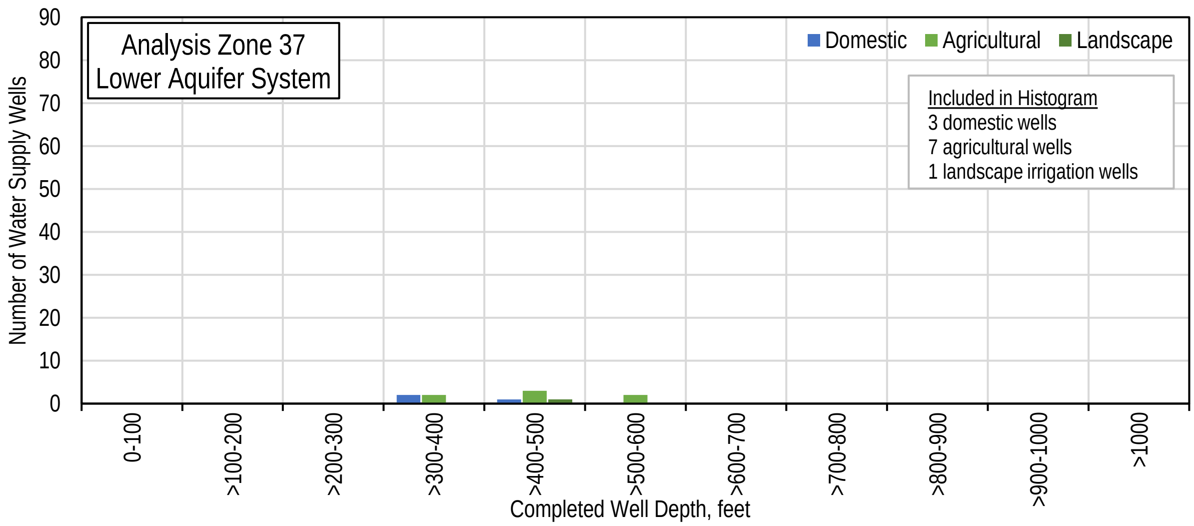

Analysis Zone 32
Lower Aquifer System
Agricultural
Public Supply
Included in Histogram
16 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

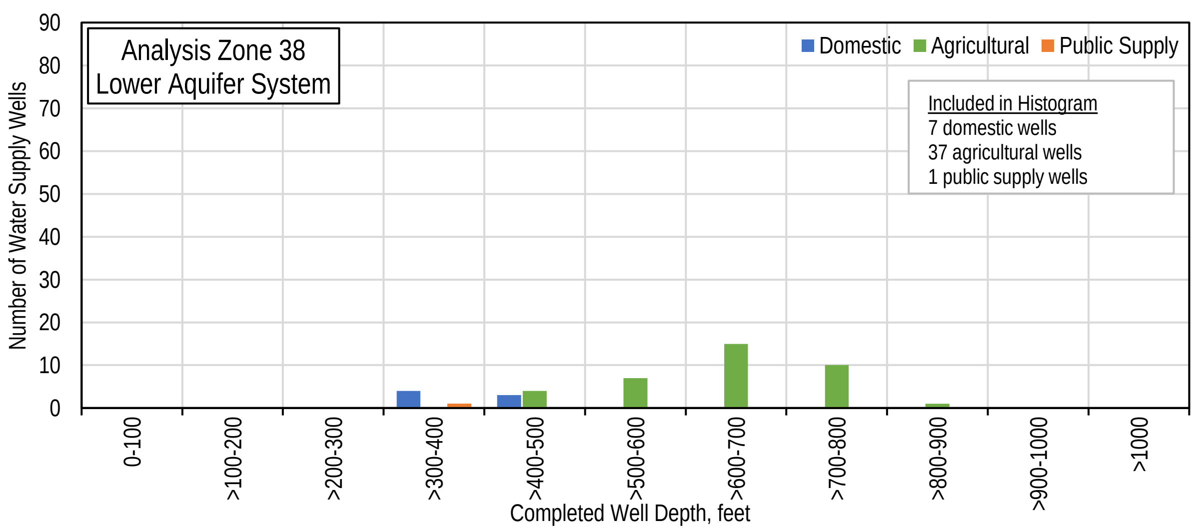

Analysis Zone 33
Lower Aquifer System
Domestic
Agricultural
Industrial
Included in Histogram
10 domestic wells
37 agricultural wells
2 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

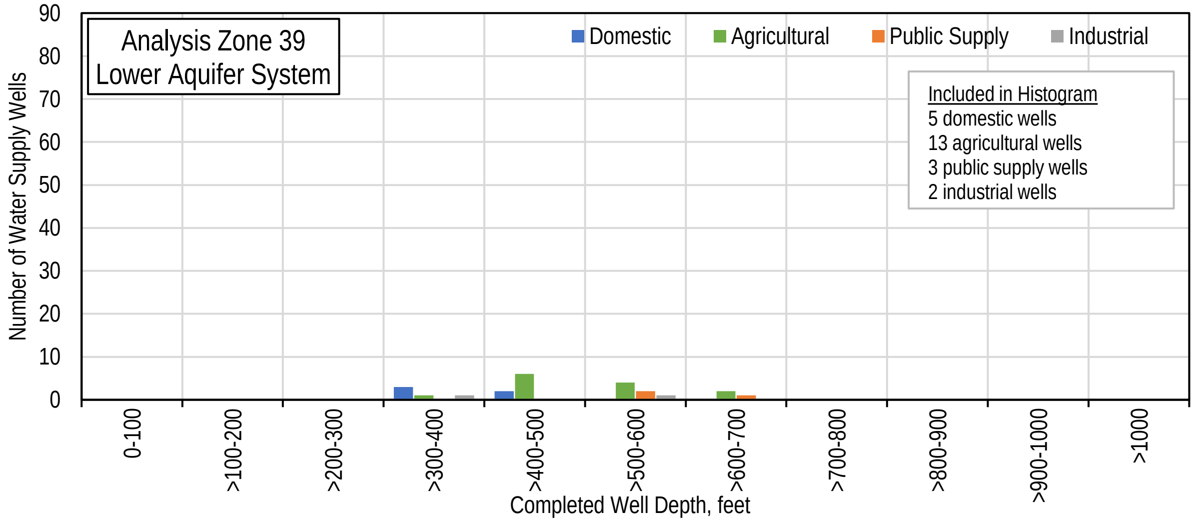

Analysis Zone 34
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
10 domestic wells
21 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 35
Lower Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
1 domestic wells
66 agricultural wells
6 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 36
Lower Aquifer System
Agricultural
Public Supply
Included in Histogram
83 agricultural wells
3 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 37
Lower Aquifer System
Domestic
Agricultural
Landscape
Included in Histogram
3 domestic wells
7 agricultural wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 38
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
37 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 39
Lower Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
5 domestic wells
13 agricultural wells
3 public supply wells
2 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet



2009

MONTGOMERY & ASSOCIATES

# Appendix C

## 90% Protective Elevations (Methodology 1), Groundwater Level Trend Elevations (Methodology 2), and Interpolated Minimum Threshold (Methodology 3) for Representative Monitoring Site Minimum Thresholds

90% Protective, Groundwater Level Trend, and Interpolated Minimum Threshold Elevations for Kaweah Subbasin Representative Monitoring Sites

| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 16S25E36M002M | 16S25E36M002M | East Kaweah | Single | 2 | 260 | 292 | - |
| 16S26E30Q001M | 16S26E30Q001M | East Kaweah | Single | 2 | 285 | 292 | - |
| 17S25E25A001M | 17S25E25A001M | East Kaweah | Single | 1 | 124 | 185 | - |
| 17S25E35E001M | KSB-2107 | East Kaweah | Single | 1 | 110 | 185 | - |
| 17S26E04F002M | KSB-2369 | East Kaweah | Single | 2 | 276 | 292 | - |
| 17S26E07C001M | 17S26E07C001M | East Kaweah | Single | 2 | 233 | 292 | - |
| 17S26E21E001M | KSB-2354 | East Kaweah | Single | 2 | 266 | 292 | - |
| 17S26E29R001M | 17S26E29R001M | East Kaweah | Single | 2 | 269 | 292 | - |
| 18S26E02D002M | 18S26E02D002M | East Kaweah | Single | 2 | 295 | 292 | - |
| 18S26E06D001M | 18S26E06D001M | East Kaweah | Single | 1 | 130 | 185 | - |
| 18S26E24J003M | 18S26E24J003M | East Kaweah | Single | 4 | 306 | 365 | - |
| 18S27E17H002M | 18S27E17H002M | East Kaweah | Single | 4 | 327 | 365 | - |
| 18S27E29E001M | 18S27E29E001M | East Kaweah | Single | 4 | 330 | 365 | - |
| 18S27E30H001M | 18S27E30H001M | East Kaweah | Single | 4 | 327 | 365 | - |
| 19S26E03A001M | 19S26E03A001M | East Kaweah | Single | 5 | 207 | 244 | - |
| 19S26E11R001M | 19S26E11R001M | East Kaweah | Single | 5 | 198 | 244 | - |
| 19S26E13R001M | 19S26E13R001M | East Kaweah | Single | 9 | 123 | 145 | - |
| 19S26E23E001M | Lindsay Well 15 | East Kaweah | Single | 9 | 103 | 145 | - |
| 19S26E25R001M | 19S26E25R001M | East Kaweah | Single | 9 | 98 | 145 | - |
| 19S26E34R006M | Lindsay Well 14 | East Kaweah | Single | 10 | 43 | 75 | - |
| 19S26E35C001M | 19S26E35C001M | East Kaweah | Single | 9 | 88 | 145 | - |
| 19S27E29D001M | 19S27E29D001M | East Kaweah | Single | 7 | 197 | 312 | - |
| 20S26E08H001M | KSB-2333 | East Kaweah | Single | 10 | 30 | 75 | - |
| 20S26E11R001M | 20S26E11R001M | East Kaweah | Single | 9 | 100 | 145 | - |
| 20S26E12H001M | Lindsay Well 11 | East Kaweah | Single | 9 | 112 | 145 | - |
| 20S26E16R001M | 20S26E16R001M | East Kaweah | Single | 10 | 39 | 75 | - |
| 20S26E20J001M | 20S26E20J001M | East Kaweah | Single | 10 | 32 | 75 | - |
| 20S26E23R001M | 20S26E23R001M | East Kaweah | Single | 9 | 98 | 145 | - |
| 20S26E32A001M | KSB-2344 | East Kaweah | Single | 10 | 35 | 75 | - |
| 20S26E35H001M | 20S26E35H001M | East Kaweah | Single | 9 | 104 | 145 | - |
| 20S27E08A001M | 20S27E08A001M | East Kaweah | Single | 7 | 211 | 312 | - |
| 20S27E15R001M | 20S27E15R001M | East Kaweah | Single | 6 | 354 | 429 | - |
| 20S27E18R001M | 20S27E18R001M | East Kaweah | Single | 8 | 194 | 235 | - |
| 20S27E25N001M | 20S27E25N001M | East Kaweah | Single | 6 | 363 | 429 | - |
| 21S26E11H001M | 21S26E11H001M | East Kaweah | Single | 9 | 110 | 145 | - |
| 21S27E03B001M | 21S27E03B001M | East Kaweah | Single | 8 | 237 | 235 | - |
| 21S27E06F001M | 21S27E06F001M | East Kaweah | Single | 9 | 119 | 145 | - |
| 21S27E08F001M | 21S27E08F001M | East Kaweah | Single | 8 | 199 | 235 | - |
| 21S27E12F001M | 21S27E12F001M | East Kaweah | Single | 7 | 287 | 312 | - |
| SCID Office | SCID Office | East Kaweah | Single | 2 | 243 | 292 | - |

| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 17S23E34J001M | KSB-1161 | Greater Kaweah | Upper | 32 | -5 | 67 | - |
| 17S24E34B001M | KSB-1580 | Greater Kaweah | Single | 11 | 5 | 78 | - |
| 17S24E36H003M | KSB-1775 | Greater Kaweah | Single | 12 | 55 | 73 | - |
| 17S26E36R001M | KSB-2690 | Greater Kaweah | Single | 4 | 299 | 288 | - |
| 18S22E24D001M | KSB-0818 | Greater Kaweah | Upper | 37 | -38 | 59 | - |
| 18S23E14A001M | KSB-1222 | Greater Kaweah | Upper | 32 | 5 | 73 | - |
| 18S23E30D001M | KSB-0905 | Greater Kaweah | Lower | 36 | -311 | -207 | - |
| 18S23E30D901M | KSB-0903 | Greater Kaweah | Upper | 36 | -26 | 71 | - |
| 18S25E05Q001M | KSB-1936 | Greater Kaweah | Single | 13 | 93 | 81 | - |
| 18S25E15C001M | KSB-2058 | Greater Kaweah | Single | 13 | 109 | 110 | - |
| 18S25E23J001M | KSB-2147 | Greater Kaweah | Single | 14 | 164 | 169 | - |
| 18S26E17L001M | KSB-2297 | Greater Kaweah | Single | 15 | 250 | 313 | - |
| 18S26E27B001M | KSB-2466 | Greater Kaweah | Single | 5 | 199 | 349 | - |
| 18S27E05J001M | KSB-2822 | Greater Kaweah | Single | 16 | 328 | 415 | - |
| 19S22E24B001M | KSB-0856 | Greater Kaweah | Upper | 36 | -36 | 25 | - |
| 19S22E28D001M | KSB-0616 | Greater Kaweah | Upper | 35 | 33 | 19 | - |
| 19S22E31B002M | KSB-0531 | Greater Kaweah | Upper | 35 | 27 | 57 | - |
| 19S23E12L001M | KSB-1259 | Greater Kaweah | Lower | 38 | -129 | 56 | - |
| 19S23E21C001M | KSB-1055 | Greater Kaweah | Upper | 29 | -9 | 51 | - |
| 19S25E09H001M | KSB-2017 | Greater Kaweah | Single | 14 | 142 | 92 | - |
| 19S25E13A002M | KSB-2200 | Greater Kaweah | Single | 19 | 151 | 114 | - |
| 19S25E16A002M | KSB-2015 | Greater Kaweah | Single | 18 | 75 | 91 | - |
| 19S25E27A001M | KSB-2089 | Greater Kaweah | Single | 18 | 72 | 57 | - |
| 19S25E28H001M | KSB-2021 | Greater Kaweah | Single | 20 | 23 | 56 | - |
| 19S25E32J001M | KSB-1937 | Greater Kaweah | Upper | 24 | 82 | 49 | - |
| 19S25E35B002M | KSB-2139 | Greater Kaweah | Single | 18 | 66 | 47 | - |
| 19S26E05C001M | KSB-2291 | Greater Kaweah | Single | 14 | 171 | 229 | - |
| 19S26E16J002M | KSB-2411 | Greater Kaweah | Single | 18 | 106 | 124 | - |
| 19S26E20A001M | KSB-2322 | Greater Kaweah | Single | 18 | 92 | 106 | - |
| 20S22E07A003M | KSB-0550 | Greater Kaweah | Upper | 35 | 20 | -28 | - |
| 20S22E24R001M | KSB-0889 | Greater Kaweah | Upper | 30 | -73 | -17 | - |
| 20S22E36A001M | KSB-0890 | Greater Kaweah | Upper | 30 | -79 | -10 | - |
| 20S24E24H001M | KSB-1783 | Greater Kaweah | Upper | 24 | 51 | 56 | - |
| 20S25E03R001M | KSB-2095 | Greater Kaweah | Single | 20 | 8 | 17 | 55 |
| 20S25E12A001M | KSB-2197 | Greater Kaweah | Single | 20 | 17 | 18 | 65 |
| 20S25E14F004M | KSB-2114 | Greater Kaweah | Single | 21 | -72 | 2 | 60 |
| 20S25E24R001M | KSB-2203 | Greater Kaweah | Single | 21 | -63 | -2 | 65 |
| 21S24E03L001M | KSB-1535 | Greater Kaweah | Upper | 25 | 89 | -24 | ** |
| 21S24E08A001M | KSB-1425 | Greater Kaweah | Lower | 25 | -262 | 10 | - |

| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 025-01 | KSB-1696 | Mid-Kaweah | Upper | 39 | 112 | 13 | 138 |
| 036-01 | KSB-1884 | Mid-Kaweah | Single | 22 | 79 | 27 | - |
| 047-01 | KSB-1699 | Mid-Kaweah | Upper | 39 | 107 | 157 | - |
| 053-01 | KSB-1977 | Mid-Kaweah | Single | 23 | 52 | 56 | - |
| 075-01 | KSB-1447 | Mid-Kaweah | Upper | 39 | 81 | 60 | - |
| 077-01 | KSB-1427 | Mid-Kaweah | Upper | 39 | 81 | 33 | - |
| 18S24E13N001M | KSB-1689 | Mid-Kaweah | Single | 22 | 69 | 75 | - |
| 18S24E22E001M | KSB-1526 | Mid-Kaweah | Upper | 39 | 103 | -139 | 85 |
| 18S24E25D001M | KSB-1690 | Mid-Kaweah | Upper | 39 | 114 | 161 | - |
| 18S25E28R001M | KSB-2014 | Mid-Kaweah | Single | 23 | 54 | 69 | - |
| 18S25E30Q001M | KSB-1819 | Mid-Kaweah | Single | 22 | 75 | 34 | - |
| 19S23E20C001M | KSB-0994 | Mid-Kaweah | Lower | 29 | -12 | 71 | - |
| 19S23E22H001M | KSB-1168 | Mid-Kaweah | Upper | 29 | 3 | 30 | - |
| 19S23E31R001M | KSB-0946 | Mid-Kaweah | Upper | 29 | -27 | -72 | - |
| 19S23E35H001M | KSB-1226 | Mid-Kaweah | Upper | 29 | 3 | -101 | - |
| 19S24E08D002M | KSB-1384 | Mid-Kaweah | Upper | 38 | 47 | 38 | - |
| 19S24E20F001M | KSB-1408 | Mid-Kaweah | Upper | 28 | 75 | Drilled after 2016 | - |
| 19S24E22E001M | KSB-1545 | Mid-Kaweah | Upper | 28 | 86 | Drilled after 2016 | - |
| 19S24E25D001M | KSB-1709 | Mid-Kaweah | Upper | 27 | 2 | -6 | 88 |
| 19S24E34D001M | KSB-1536 | Mid-Kaweah | Upper | 28 | 77 | Drilled after 2016 | - |
| 19S24E35E001M | KSB-1628 | Mid-Kaweah | Lower | 26 | -109 | -92 | - |
| 19S24E36C002M | KSB-1903 | Mid-Kaweah | Lower | 27 | -98 | -43 | - |
| 19S25E06A001M | KSB-1862 | Mid-Kaweah | Single | 22 | 76 | 35 | - |
| 19S25E20P001M | KSB-1905 | Mid-Kaweah | Upper | 27 | 24 | 90 | - |
| 20S23E03L001M | KSB-1129 | Mid-Kaweah | Upper | 29 | -9 | -81 | - |
| 20S23E18R001M | KSB-0948 | Mid-Kaweah | Upper | 30 | -66 | -173 | - |
| 20S23E21B001M | KSB-1071 | Mid-Kaweah | Upper | 30 | -66 | -126 | - |
| 20S23E26C001M | KSB-1206 | Mid-Kaweah | Upper | 30 | -64 | -20 | - |
| 20S24E01H002M | KSB-1770 | Mid-Kaweah | Lower | 26 | -289 | -150 | - |
| 20S24E04K001M | KSB-1506 | Mid-Kaweah | Lower | 26 | -123 | -39 | - |
| 20S24E07C001M | KSB-1320 | Mid-Kaweah | Upper | 31 | 58 | Drilled after 2016 | - |
| 20S24E11J002M | KSB-1695 | Mid-Kaweah | Lower | 26 | -119 | -121 | - |
| 20S24E16H001M | KSB-1538 | Mid-Kaweah | Lower | 31 | -115 | 62 | - |
| 20S24E17P001M | KSB-1431 | Mid-Kaweah | Upper | 31 | 58 | 88 | - |
| 20S24E28L001M | KSB-1477 | Mid-Kaweah | Upper | 31 | 58 | 60 | - |
| 21S23E05A002M | KSB-0976 | Mid-Kaweah | Upper | 30 | -84 | -141 | - |
| 21S23E07J001M | KSB-0922 | Mid-Kaweah | Upper | 30 | -36 | -22 | - |
| 361856N1193313W001 | KSB-1706 | Mid-Kaweah | Lower | 26 | -136 | -287 | - |

Note. bolded elevation indicates the minimum threshold assigned to the representative monitoring site

# Appendix 6-2 of the Coordination Agreement

**Well Impact Analysis Hydrographs**

# 1 SUMMARY PURPOSE

This summary describes all water supply well completion data available for the San Joaquin Valley - Kaweah Subbasin (Subbasin) since January 1, 2002. The purpose of this summary is estimate for the number of wells that may be impacted by groundwater levels declining to elevations protective of 90% of wells in the Subbasin (described in Appendix 5A). These estimates can be used by the Groundwater Sustainability Agencies (GSAs) to develop well mitigation plans for their respective Groundwater Sustainability Plans (GSPs).

The majority of minimum thresholds described in Appendix 5A are at higher elevations than elevations protective of 90% of wells. The estimates of potentially impacted wells therefore overestimate the number of wells. However, since these estimates are to be used for determining the magnitude of wells to be addressed by mitigation plans, they can be considered worst-case estimates.

# 2 WELL RECORDS IN THE KAWEAH SUBBASIN

A majority of water supply wells installed in the Subbasin since 2002 have well construction information available from Department of Water Resources (DWR) Well Completion Reports submitted by well drillers. These well records are used to develop chronic lowering of groundwater level sustainable management criteria (SMC), as described in Appendix 5A. This summary supplements potential well impacts described in Appendix 5A by including wells without completed well depth information.

## 2.1 Data Sources and Quality Control

Well completion information compiled in this appendix is from the DWR Well Completion Report (WCR) dataset, downloaded on March 1, 2022. The WCR dataset does not contain a complete accurate dataset, however, it is the best public source of data available. For example, some wells in the dataset are likely dry or have been destroyed. To filter out wells that may have been abandoned or no longer represent typical modern well depths and current groundwater elevations, only well records drilled since 2002 are used for analysis. Furthermore, well completion reports are not always accurately located. Where coordinates of wells are unavailable, DWR locates the well in the middle of the Public Land Survey System section. The location given by DWR in the WCR dataset is used in this analysis.

## 2.2 Total Well Records

The majority of water supply well records used in the analysis have known well depths, and the well use type for wells without well depth data are generally proportional to those with depth information. The number of wells installed in the Subbasin both with and without known well depths are included in Table 1. Approximately 3,758 supply wells have been installed in the Subbasin since 2002. Of these, 3,353, or about 89%, have well completion data in the WCR dataset and are used in the SMC analysis described in Appendix A. The proportion of wells used for various purposes is nearly identical for the full WCR dataset compared to the subset of wells with known depths; almost all supply wells are either used for agricultural use (55%) or domestic use (41%). Comparatively small numbers of wells are used for public supply (3%), and industrial (1%) purposes. Since the subset of wells with known depths includes a majority of well records in the dataset and closely approximates well types installed in the Subbasin, it is an appropriate dataset to use to develop mitigation plans.

Table 1. Water Supply Well Records by Use Type

| Well Use | All Water Supply Well Records from Jan 1, 2002 | | Well Records with Depth Information | |
|---|---|---|---|---|
| | Number of Wells | Percentage | Number of Wells | Percentage |
| Agricultural | 2,061 | 55% | 1,859 | 55% |
| Domestic | 1,546 | 41% | 1,364 | 41% |
| Public Supply | 129 | 3% | 117 | 3% |
| Industrial | 22 | 1% | 13 | <1% |
| TOTAL | 3,758 | - | 3,353 | - |

## 2.3 Well Records by GSA

Table 2 summarizes the number of well records by well use type for each GSA. There are approximately 1,276 well records in East Kaweah, 1,814 in Greater Kaweah, and 668 in Mid-Kaweah.

Table 2. Summary of Wells by GSA

| Well Use Type | East Kaweah | | Greater Kaweah | | Mid-Kaweah | | Total |
|---|---|---|---|---|---|---|---|
| | Number of Wells | Percentage | Number of Wells | Percentage | Number of Wells | Percentage | |
| Domestic | 463 | 36% | 814 | 45% | 269 | 40% | 1,546 |
| Agricultural | 793 | 62% | 914 | 50% | 354 | 53% | 2,061 |
| Public Supply | 17 | 1% | 71 | 4% | 41 | 6% | 129 |
| Industrial | 3 | <1% | 15 | 1% | 4 | 1% | 22 |
| Total | 1,276 | - | 1,814 | - | 668 | - | 3,758 |

## 2.4 Well Records by Analysis Zone

Well records from each analysis zone may be used by GSAs for well mitigation plans. The total number of well records in each aquifer zone is summarized in Table 3. Figure 1 shows the location of the analysis zones.

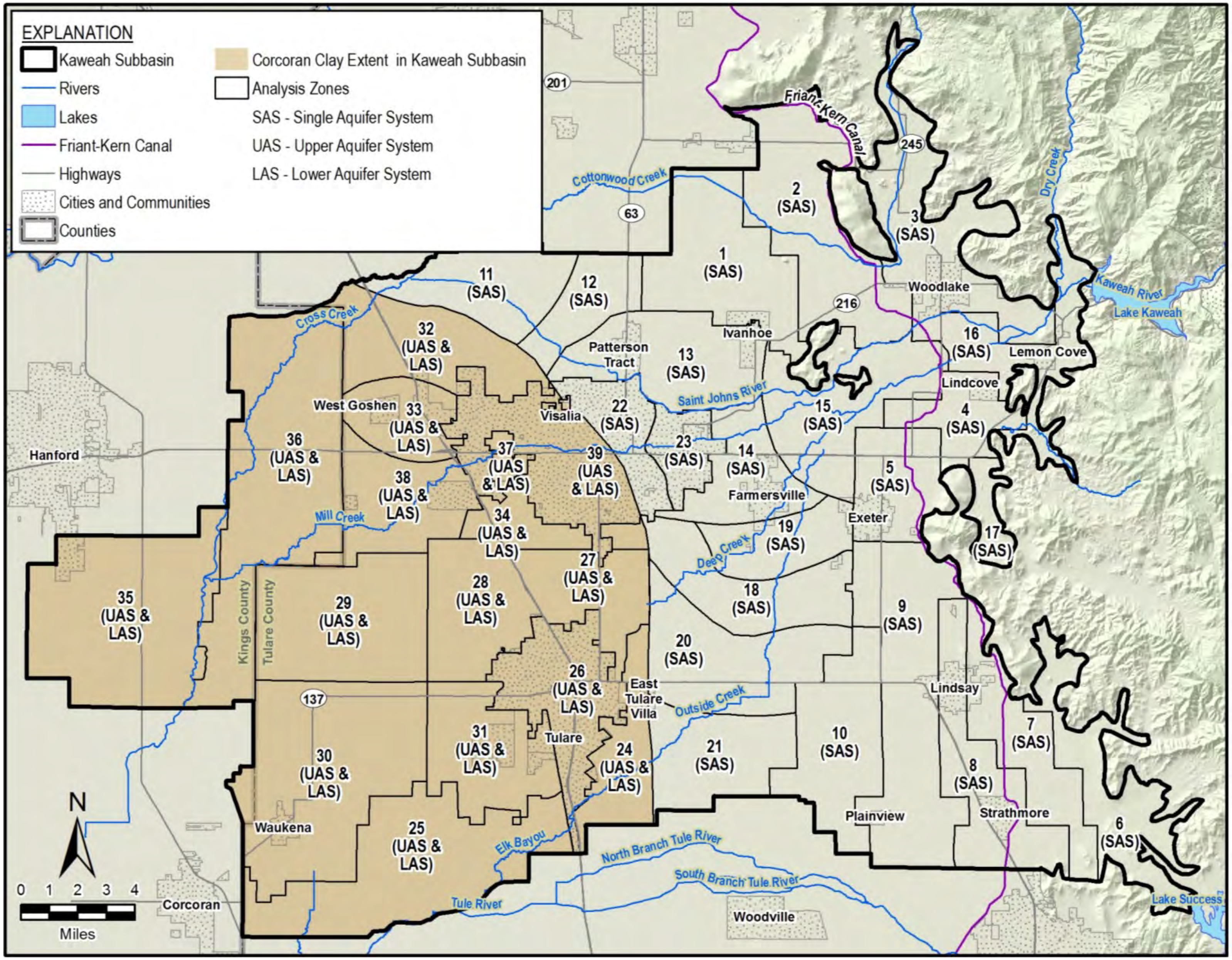



Figure 1. Kaweah Subbasin Analysis Zones

Table 3. Total Well Records by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 211 | 118 | 1 | 5 | 335 |
| 2 | 149 | 23 | 1 | 0 | 173 |
| 3 | 52 | 39 | 0 | 1 | 92 |
| 4 | 46 | 42 | 0 | 6 | 94 |
| 5 | 43 | 29 | 1 | 1 | 74 |
| 6 | 25 | 9 | 0 | 0 | 34 |
| 7 | 46 | 18 | 0 | 0 | 64 |
| 8 | 51 | 56 | 0 | 2 | 109 |
| 9 | 137 | 99 | 0 | 7 | 243 |
| 10 | 69 | 52 | 0 | 1 | 122 |
| 11 | 24 | 2 | 0 | 2 | 28 |
| 12 | 33 | 30 | 0 | 3 | 66 |
| 13 | 85 | 146 | 0 | 7 | 238 |
| 14 | 42 | 52 | 1 | 7 | 102 |
| 15 | 65 | 73 | 0 | 2 | 140 |
| 16 | 19 | 46 | 1 | 1 | 67 |
| 17 | 11 | 3 | 0 | 0 | 14 |
| 18 | 56 | 62 | 0 | 3 | 121 |
| 19 | 25 | 87 | 0 | 3 | 115 |
| 20 | 55 | 88 | 0 | 5 | 148 |
| 21 | 38 | 12 | 1 | 5 | 56 |
| 22 | 16 | 6 | 0 | 7 | 29 |
| 23 | 3 | 7 | 0 | 1 | 11 |
| 24 | 33 | 33 | 1 | 2 | 69 |
| 25 | 70 | 3 | 0 | 4 | 77 |
| 26 | 14 | 18 | 0 | 7 | 39 |
| 27 | 49 | 75 | 0 | 4 | 128 |
| 28 | 50 | 69 | 0 | 2 | 121 |
| 29 | 61 | 19 | 0 | 2 | 82 |
| 30 | 108 | 52 | 1 | 10 | 171 |
| 31 | 33 | 8 | 0 | 4 | 45 |
| 32 | 18 | 1 | 3 | 1 | 23 |
| 33 | 44 | 32 | 3 | 1 | 80 |
| 34 | 25 | 52 | 1 | 2 | 80 |
| 35 | 89 | 29 | 4 | 9 | 131 |
| 36 | 87 | 8 | 0 | 6 | 101 |
| 37 | 9 | 15 | 0 | 0 | 24 |
| 38 | 43 | 16 | 0 | 2 | 61 |
| 39 | 27 | 17 | 3 | 4 | 51 |
| Total | 2,061 | 1,546 | 22 | 129 | 3,758 |

# 3 POTENTIALLY IMPACTED WELLS

## 3.1 Well Records Shallower than Protective Well Depth by GSA

Wells shallower than protective well depths described in Appendix 5A may be impacted should groundwater elevations approach or exceed minimum thresholds during GSP implementation. The total number of well records shallower than protective well depths in each GSA is estimated using the percentage of wells shallower than the 90th percentile well depth by well use type. Selection of the 90th percentile well depth accounts for uncertainty in the data, especially regarding the likelihood the shallowest wells have been destroyed and replaced during ongoing dry conditions and declining groundwater levels. The analysis is completed using only wells with known well depths. The majority of minimum thresholds described in Appendix 5A are at higher elevations than elevations protective of 90% of wells. The tables that follow therefore overestimate the number of potentially impacted wells. However, since these estimates are to be used for determining the magnitude of wells to be addressed by mitigation plans, they can be considered worst-case estimates.

Table 4 through Table 6 show the approximate number of impacted wells in each GSA, including wells with unknown well depths.

- East Kaweah GSA – approximately 122 wells may be impacted, including 64 domestic wells, 55 agricultural wells, and 3 public supply wells (Table 4).
- Greater Kaweah GSA – approximately 167 wells may be impacted, including 105 domestic wells, 55 agricultural wells, and 7 public supply wells (Table 5).
- Mid-Kaweah GSA – approximately 43 wells may be impacted, including 22 domestic wells and 21 agricultural wells (Table 6).

Table 4. East Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells per square mile) |
| Domestic | 418 | 58 | 14% | 463 | 64 | 0.35 |
| Agricultural | 721 | 50 | 7% | 793 | 55 | 0.30 |
| Public Supply | 16 | 3 | 19% | 17 | 3 | 0.02 |
| Industrial | 2 | 0 | 0% | 3 | 0 | 0 |
| Total | 1,157 | 111 | | 1,276 | 122 | 0.67 |

Table 5. Greater Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells / square mile) |
| Domestic | 732 | 96 | 13% | 814 | 105 | 0.30 |
| Agricultural | 829 | 49 | 6% | 914 | 55 | 0.16 |
| Public Supply | 64 | 6 | 10% | 71 | 7 | 0.02 |
| Industrial | 8 | 0 | 0% | 15 | 0 | 0 |
| Total | 1,633 | 151 | | 1,814 | 167 | 0.48 |

Table 6. Mid-Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells / square mile) |
| Domestic | 214 | 17 | 8% | 269 | 22 | 0.13 |
| Agricultural | 309 | 18 | 6% | 354 | 21 | 0.13 |
| Public Supply | 37 | 0 | 0% | 41 | 0 | 0 |
| Industrial | 3 | 0 | 0% | 4 | 0 | 0 |
| Total | 563 | 35 | | 668 | 43 | 0.26 |

## 3.2 Well Records Shallower than Protective Well Depth by Analysis Zone

The total number of well records within each analysis zone may be used by the GSAs to estimate potential impacts to be addressed by Well Mitigation Programs. The approximate number of well records that are shallower than the protective well depth in each aquifer zone are summarized in Table 7. Figure 1 shows the location of the analysis zones.

Table 8. East Kaweah GSA Potentially Impacted Wells Summarized by Analysis ZoneTable 8 through Table 10 summarize estimated GSA-specific potential well impacts by well use type.

Table 7. Basinwide Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 15 | 19 | 0 | 0 | 34 |
| 2 | 15 | 3 | 0 | 0 | 18 |
| 3 | 2 | 2 | 0 | 0 | 4 |
| 4 | 2 | 7 | 0 | 0 | 9 |
| 5 | 3 | 4 | 0 | 0 | 7 |
| 6 | 3 | 1 | 0 | 0 | 4 |
| 7 | 6 | 1 | 0 | 0 | 7 |
| 8 | 1 | 9 | 0 | 1 | 11 |
| 9 | 7 | 14 | 0 | 2 | 23 |
| 10 | 3 | 7 | 0 | 0 | 10 |
| 11 | 2 | 1 | 0 | 0 | 3 |
| 12 | 3 | 3 | 0 | 0 | 6 |
| 13 | 1 | 16 | 0 | 1 | 18 |
| 14 | 0 | 10 | 0 | 0 | 10 |
| 15 | 5 | 10 | 0 | 0 | 15 |
| 16 | 2 | 4 | 0 | 0 | 6 |
| 17 | 1 | 1 | 0 | 0 | 2 |
| 18 | 2 | 11 | 0 | 0 | 13 |
| 19 | 2 | 6 | 0 | 0 | 8 |
| 20 | 0 | 14 | 0 | 0 | 14 |
| 21 | 3 | 2 | 0 | 0 | 5 |
| 22 | 3 | 1 | 0 | 0 | 4 |
| 23 | 0 | 2 | 0 | 0 | 2 |
| 24 | 2 | 4 | 0 | 0 | 6 |
| 25 | 8 | 1 | 0 | 0 | 9 |
| 26 | 2 | 0 | 0 | 0 | 2 |
| 27 | 2 | 4 | 0 | 0 | 6 |
| 28 | 1 | 3 | 0 | 0 | 4 |
| 29 | 2 | 2 | 0 | 0 | 4 |
| 30 | 7 | 8 | 0 | 0 | 15 |
| 31 | 2 | 1 | 0 | 0 | 3 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 33 | 3 | 4 | 0 | 0 | 7 |
| 34 | 0 | 6 | 0 | 1 | 7 |
| 35 | 7 | 1 | 0 | 2 | 10 |
| 36 | 8 | 1 | 0 | 1 | 10 |
| 37 | 0 | 1 | 0 | 0 | 1 |
| 38 | 0 | 6 | 0 | 2 | 8 |
| 39 | 2 | 1 | 0 | 0 | 3 |
| Total | 131 | 191 | 0 | 10 | 332 |

Table 8. East Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 15 | 19 | 0 | 0 | 34 |
| 2 | 15 | 3 | 0 | 0 | 18 |
| 3 | 2 | 2 | 0 | 0 | 4 |
| 4 | 1 | 5 | 0 | 0 | 6 |
| 5 | 2 | 3 | 0 | 0 | 5 |
| 6 | 3 | 1 | 0 | 0 | 4 |
| 7 | 6 | 1 | 0 | 0 | 7 |
| 8 | 1 | 9 | 0 | 1 | 11 |
| 9 | 7 | 14 | 0 | 2 | 23 |
| 10 | 3 | 7 | 0 | 0 | 10 |
| Total | 55 | 64 | 0 | 3 | 122 |

Table 9. Greater Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 2 | 0 | 0 | 3 |
| 5 | 1 | 1 | 0 | 0 | 2 |
| 11 | 2 | 1 | 0 | 0 | 3 |
| 12 | 3 | 3 | 0 | 0 | 6 |
| 13 | 1 | 16 | 0 | 1 | 18 |
| 14 | 0 | 10 | 0 | 0 | 10 |
| 15 | 5 | 10 | 0 | 0 | 15 |
| 16 | 2 | 4 | 0 | 0 | 6 |
| 17 | 1 | 1 | 0 | 0 | 2 |
| 18 | 2 | 11 | 0 | 0 | 13 |
| 19 | 2 | 6 | 0 | 0 | 8 |
| 20 | 0 | 14 | 0 | 0 | 14 |
| 21 | 3 | 2 | 0 | 0 | 5 |
| 22 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 |
| 24 | 2 | 4 | 0 | 0 | 6 |
| 25 | 8 | 1 | 0 | 0 | 9 |
| 30 | 0 | 0 | 0 | 0 | 0 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 33 | 3 | 4 | 0 | 0 | 7 |
| 34 | 0 | 6 | 0 | 1 | 7 |
| 35 | 7 | 1 | 0 | 2 | 10 |
| 36 | 8 | 1 | 0 | 1 | 10 |
| 37 | 0 | 1 | 0 | 0 | 1 |
| 38 | 0 | 6 | 0 | 2 | 8 |
| Total | 55 | 105 | 0 | 7 | 167 |

Table 10. Mid-Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 22 | 3 | 1 | 0 | 0 | 4 |
| 23 | 0 | 2 | 0 | 0 | 2 |
| 24 | 0 | 0 | 0 | 0 | 0 |
| 26 | 2 | 0 | 0 | 0 | 2 |
| 27 | 2 | 4 | 0 | 0 | 6 |
| 28 | 1 | 3 | 0 | 0 | 4 |
| 29 | 2 | 2 | 0 | 0 | 4 |
| 30 | 7 | 8 | 0 | 0 | 15 |
| 31 | 2 | 1 | 0 | 0 | 3 |
| 39 | 2 | 1 | 0 | 0 | 3 |
| Total | 21 | 22 | 0 | 0 | 43 |

## Appendix 6-3:

# Kaweah Subbasin Mitigation Program Framework

MITIGATION PROGRAM FRAMEWORK
KAWEAH COORDINATION AGREEMENT APPENDIX 6
Groundwater Levels and Land Subsidence

**Introduction**

Sustainable Management Criteria identified in each of the Kaweah Subbasin GSAs have been developed to avoid significant and unreasonable impacts to domestic, municipal, agricultural, and industrial beneficial uses and users of groundwater. However, analysis based on available data suggests that numerous wells may be impacted during the implementation period between 2020 and 2040 as a result of continued lowering of groundwater levels.[1] Wells, land use, property and infrastructure may also be impacted from land subsidence during this period.

As a result of the foregoing, the Kaweah Subbasin GSAs agree to each individually implement a Mitigation Program (Mitigation Program) subject to the following minimum requirements and subject to the schedule provided herein. The purpose of the Mitigation Program is to mitigate for continued overdraft pumping for groundwater levels and land subsidence. Each Kaweah Subbasin GSA will adopt and implement a Mitigation Program to identify impacts caused by pumping within the GSA's boundaries that may require mitigation. Each Mitigation Program will separately identify the impacts to beneficial uses that the Mitigation Program is intended to address. Each Mitigation Program will include a claim process to address impacts to: (i) domestic and municipal wells; (ii) agricultural wells; and (iii) critical infrastructure. Because the Mitigation Program will resolve impacts from groundwater management, significant and unreasonable results to wells and land uses that may occur prior to reaching Minimum Thresholds will be avoided.

**Mitigation Program Framework**

Each GSA shall include a Mitigation Program as a project or management action identified in that GSA's GSP, describing the following elements:

*Identification of Need for Mitigation*

The Mitigation Program will begin with a plan to establish the process for identification of wells or land uses in need for mitigation. The process may include: 1) an application process by the landowner or well user; or 2) data collection by the GSA and outreach to the affected user. The GSPs in the Subbasin set Measurable Objectives and Minimum Thresholds based on 2015 groundwater levels and land elevation. Impacts from that point further will be evaluated as potentially affected due to the allowance of some level of continued overdraft.

[1] See Technical Appendix 5A, Technical Approach for Developing Chronic Lower of Groundwater Levels Sustainable Management Criteria in the Kaweah Subbasin for a detailed description of the establishment of MT; Technical Appendix 5C, Potential Well Impact Summary.

*Evaluation*

Once a potential well or land use has been identified as possibly impacted, an evaluation will occur by the GSA to determine whether the well has been adversely impacted by declining groundwater levels or by land subsidence which have been identified as occurring because of allowable continued overdraft conditions.

*Qualifications*

GSAs may qualify mitigation based on a user's compliance with the GSA's GSP, Rules & Regulations, and other laws or regulations. For example, a user who has caused or contributed to overdraft may not qualify for the Mitigation Program.

*Mitigation*

Once a well has been identified as adversely impacted due to declining groundwater levels or land subsidence, the proper mitigation to alleviate impacts must be determined. This could be any of the following:

For groundwater level impacts, this could include any of the following:

1) Repairing the well;
2) Deepening the well;
3) Constructing a new well;
4) Modifying pump equipment;
5) Provide temporary or permanent replacement water;
6) Coordinate consolidation with existing water systems; or
7) With the consent of the affected user, providing other acceptable means of mitigation.

For land use impacts, this could include any of the following:

1) Increased restrictions in groundwater extractions for certain regional areas;
2) Repair to canals, turnouts, stream channels, water delivery pipelines, and basins;
3) Repair to damaged wells;
4) Addressing flood control;
5) Repair to other damaged infrastructure including highways, roads, bridges, utilities, and buildings; or
6) With the consent of the affected user, providing other acceptable means of mitigation.

Various factors may reflect the proper mitigation methods for the specific well or land use at issue. For example, age, location, the financial impact to the beneficial user as a result of mitigation, and the beneficial user of the well may reflect which mitigation measures are optimal.

*Outreach*

Public outreach and education will be provided during development of the Mitigation Program and prior to implementation by each GSA. Prior to implementation, extensive outreach will be geared toward notifying landowners of the Mitigation Program requirements, facilitate how to qualify for the Mitigation Program, and how to apply for assistance. Outreach will be offered in multiple languages as appropriate for the GSA. Outreach methods could include workshops, mailings, flyers, website postings, Board meeting announcements, etc.

Common elements developed at the Kaweah Subbasin level shall be shared with the public through coordinated workshops and public meetings. As material and data become available, the Kaweah Subbasin GSAs will coordinate workshops for the public to attend. While special workshops can be utilized, the Kaweah Subbasin GSAs will utilize the quarterly Kaweah Subbasin Management Committee (Management Committee) meetings as a resource to share Workplan updates. The Management Committee is a coordinated meeting between representatives from each GSA, and the public is invited to attend and participate in the meetings. Meetings shall be noticed on GSA websites and shall be sent to interested parties. Interested parties are collected on an ongoing basis in the Kaweah Subbasin. Individual outreach plans specific to each GSA Mitigation Program shall be developed and shared with the public via individual outreach efforts at each.

*Mitigation Program Adoption Schedule*

Each GSA will formulate and implement a mitigation claims process for domestic and municipal use impacts within the first quarter of 2023, and complete all other aspects of the Mitigation Program by June 30, 2023. The initial claims process shall include reference to local programs and resources from the County, State, non-profit organizations, and the Kaweah Basin Water Foundation.

As the Kaweah Subbasin GSAs anticipate that the individual Mitigation Programs will require time to be developed and established in a public and transparent fashion, in the interim, the Kaweah Subbasin GSAs will coordinate the development of an Interim Domestic Well Mitigation Program at a yet to be determined funding level and emergency criteria to make the limited funding available for drinking water well mitigation.

*Mitigation Program Funding Source*

Each GSA will develop a funding mechanism for the Mitigation Program, which is dependent on the specific GSA needs for specific expected impacted wells, critical infrastructure, and land uses within each GSA. Funding is anticipated to be available for each GSA's Mitigation Program through implementation of assessments, fees, charges, and penalties. In addition, the GSAs will explore grant funding. The State has many existing grant programs for community water systems and well construction funding. County, state, and federal assistance will be needed to successfully implement the respective Mitigation Programs. Each GSA may, separately or in coordination with other GSAs, also work with local NGOs that may be able to provide assistance or seek grant monies to help fund the Mitigation Program. GSAs may act individually or collectively to address and fund mitigation measures.

Below is a list of funding being sought within the Kaweah Subbasin:

- The Safe and Affordable Funding for Equity and Resilience (SAFER) Program through the California State Water Resources Control Board
- Household Water Well Program through the United State Department of Food and Agriculture
- Household Water Well System Grant Program through the United State Department of Food and Agriculture

*Annual Reporting and Mitigation Evaluations*

The Kaweah Subbasin GSAs intend to utilize the Annual Report submitted to DWR to report on and update progress on the Mitigation Program(s).

With the information presented, the Kaweah Subbasin GSAs anticipate pursuing locating and refining the potential number of wells impacted by lowering of groundwater levels to the MTs in the Kaweah Subbasin. The Kaweah Subbasin GSAs intend to leverage new tools developed by the California Department of Water Resources such as the Dry Domestic Well Susceptibility Tool and well surveys to establish a refined estimate of drinking water well impacts. The Kaweah Subbasin GSAs will continue to evaluate impacts to beneficial uses and users of Land Subsidence.

# Appendix 5B

# Technical Approach for Developing Chronic Lowering of Groundwater Levels Sustainable Management Criteria in the Kaweah Subbasin

MONTGOMERY
& ASSOCIATES
Water Resource Consultants

July 27, 2022

# Technical Approach for Developing Chronic Lowering of Groundwater Levels Sustainable Management Criteria in the Kaweah Subbasin

*Prepared for:*

East Kaweah Groundwater Sustainability Agency
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# Contents

## Tables



## Figures

# Appendices

# ACRONYMS & ABBREVIATIONS

DWR ..............California Department of Water Resources
EKGSA ..........East Kaweah Groundwater Sustainability Agency
GKGSA..........Greater Kaweah Groundwater Sustainability Agency
GSA................Groundwater Sustainability Agency
GSP ................Groundwater Sustainability Plan
MKGSA .........Mid-Kaweah Groundwater Sustainability Agency
MO .................measurable objective
MT..................minimum threshold
SGMA ............Sustainable Groundwater Management Act
SMC ..............Sustainable Management Criteria
Subbasin.........Kaweah Subbasin
WCR ..............Well Completion Report

# 1 INTRODUCTION

This technical report describes the methodology applied to a revision of the chronic lowering of groundwater level sustainable management criteria (SMC) for the San Joaquin Valley - Kaweah Subbasin (Subbasin). The revisions are in response to the California Department of Water Resources (DWR) incomplete determination of the three Groundwater Sustainability Plans (GSPs) submitted in January 2020. The three GSPs are being implemented by three Groundwater Sustainability Agencies (GSAs) covering the entirety of the Subbasin: East Kaweah GSA, Greater Kaweah GSA, and Mid-Kaweah GSA (Figure 1).

DWR provided a staff report with a statement of findings explaining the incomplete determination for the Subbasin GSPs. The staff report states, "The Plan does not define sustainable management criteria for chronic lowering of groundwater levels in the manner required by Sustainable Groundwater Management Act (SGMA) and the GSP Regulations." DWR's findings specified the following:

1. *The GSPs do not define metrics for undesirable results and minimum thresholds based on avoiding a significant and unreasonable depletion of groundwater supply, informed by, and considering, the relevant and applicable beneficial uses and users in their Subbasin.*
2. *The GSPs do not describe specific potential effects from the chronic lowering of groundwater levels and depletion of supply that would be significant and unreasonable to beneficial uses and users of groundwater, on land uses and property interests, and other potential effects and, therefore, constitute an undesirable result.*
3. *The GSPs do not consider how minimum thresholds developed for one sustainability indicator will affect other related sustainability indicators."*

The GSAs are given up to 180 days from the receipt of DWR's staff report to address the deficiencies for chronic lowering of groundwater levels SMC. This report provides the technical support to fulfill that purpose.

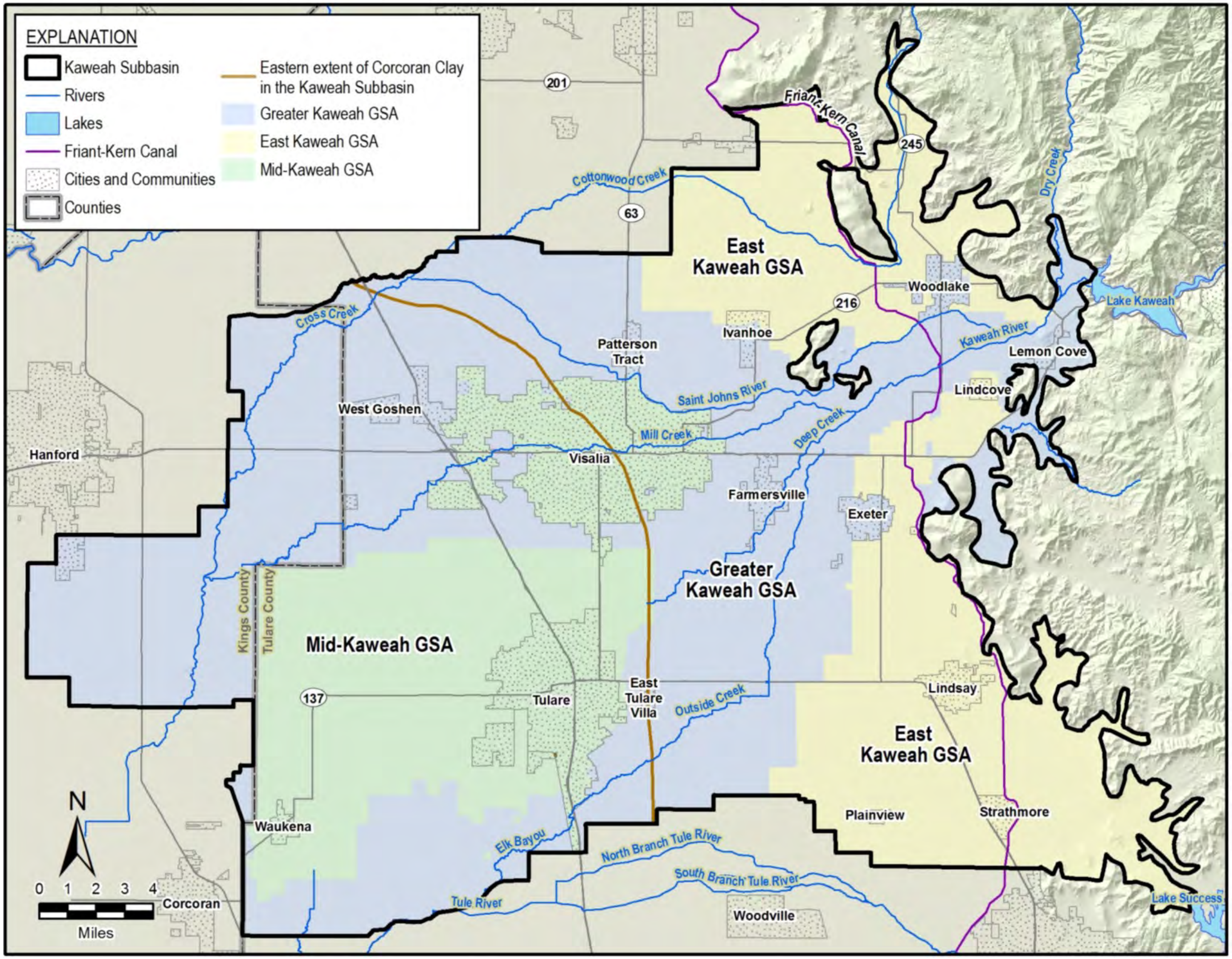



Figure 1. Groundwater Sustainability Agencies in the Kaweah Subbasin

## 1.1 General Approach Used to Develop Sustainable Management Criteria

Chronic lowering of groundwater levels SMC are developed to protect relevant and applicable beneficial uses and users of groundwater in the Subbasin. Beneficial users of groundwater are domestic pumpers, disadvantaged communities, small water systems (2 to 14 connections), municipal water systems (>14 connections), agricultural pumpers, California Native American Tribes, environmental users, and entities engaged in monitoring and reporting groundwater elevations. Understanding the types of users and their access to groundwater is the first step taken to inform what the GSAs and their stakeholder groups consider significant and unreasonable impacts to those users.

Since wells are how users access groundwater, the approach used to develop SMC is based on water supply well depths. The depth of wells across the Subbasin varies by depth to groundwater and beneficial user type. Because of well depth variability, the Subbasin is subdivided into analysis zones based on GSP management area boundaries, clusters of beneficial user types, aquifers, and completed well depths. Completed well depth statistics inform significant and unreasonable groundwater levels, with the SMC being based on protecting at least 90% of all water supply wells in the Subbasin.

## 1.2 Data Sources and Quality Control

Information used for establishing the chronic lowering of groundwater levels SMC include:

- Completed depths, screen depths, and locations of wells installed since January 1, 2002, and included in DWR's Well Completion Report (WCR) dataset (Figure 2). Only well records drilled since 2002 are used for analysis to filter out wells that may have been abandoned or no longer represent typical modern depths for active wells and current groundwater elevations. Data download date was March 1, 2022.
- Historical groundwater elevation data from DWR's California Statewide Groundwater Elevation Monitoring Program, SGMA Portal Monitoring Network Module, and individual water agencies.
- Maps of current and historical groundwater elevation contours.

The WCR dataset does not contain a complete accurate dataset, however, it is the best public source of data available. Approximately one-third of the wells drilled from 2002 on did not have well completion depths and could not be used in the analysis. For purposes of well depth analyses, we assumed the available wells with depth information are typical of depths in the Subbasin.

Well logs were reviewed for wells with completion depths less than 100 feet. This review generally found that either 1) the planned well use field was incorrectly classified as a water supply well when it was supposed to be a destroyed or remediation well, or 2) the completed well depth field was the depth of the conductor casing (often 50 feet) and not the bottom of the completed well. These inaccuracies were corrected. Furthermore, where coordinates of wells are unavailable, DWR locates the well in the middle of the Public Land Survey System section.

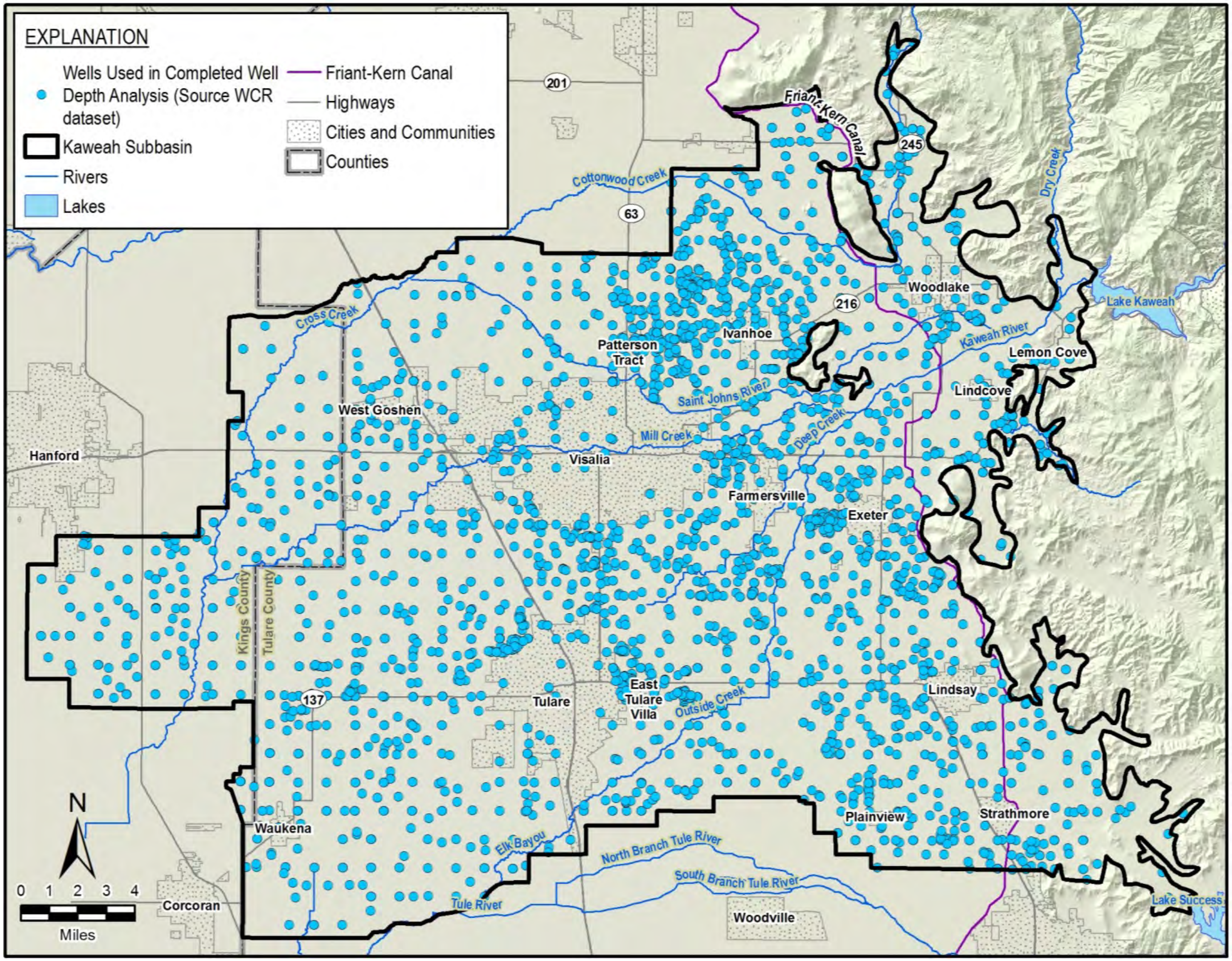



Figure 2. Location of WCR Water Supply Wells Used for Completed Well Depth Analysis

# 2 PROCESS USED TO ESTABLISH MINIMUM THRESHOLDS

Minimum thresholds (MTs) are derived from groundwater elevations that protect at least 90% of all water supply wells drilled since January 1, 2002, in each analysis zone, and that do not result in a greater rate of decline over water years 2020 to 2040 than experienced over a specific historical time period. Groundwater elevations representing MTs are set at representative monitoring sites identified in the Monitoring Network section of the GSPs.

The process for developing MTs is based on a comparison of three methodologies. The process is generally to:

1. Develop analysis zones based on GSP management areas, aquifer type, beneficial user types, and similar completed well depths (described in Section 2.1.1).
2. Identify water supply wells drilled since January 1, 2002, with well screen depth information or a completed well depth.
3. Designate water supply wells to either the Upper, Lower, or Single Aquifer System based on a set of assumptions (described in Section 2.1.2).
4. Designate representative monitoring sites to either the Upper, Lower, or Single Aquifer System (described in Section 2.1.2).
5. Estimate MT depths through Methodology 1 by calculating the 90th percentile well completion depth for water supply wells in each analysis zone and aquifer (described in Section 2.1.3).
6. Apply the 90th percentile protective depth corresponding to the representative monitoring sites' aquifer designation and analysis zone (described in Section 2.1.4).
7. Estimate MT depths through Methodology 2 by projecting relevant base period groundwater level trends to 2040 for each representative monitoring site (described in Section 2.1).
8. Compare elevations resultant from protective depths (Step 6) and projecting a groundwater levels trend out to 2040 (Step 7). The initial MT for the representative monitoring site is the higher elevation of the two methods (Figure 3).
9. Contour the representative monitoring site MTs obtained in Step 8 for the unconfined aquifers (Single and Upper Aquifer Systems) to determine if the MT surface is relatively smooth. If there are anomalous MTs, remove the anomalous points and interpolate the final MT elevations at these points from MT contours generated by excluding the anomalous sites. This is shown as Method 3 in Figure 3.

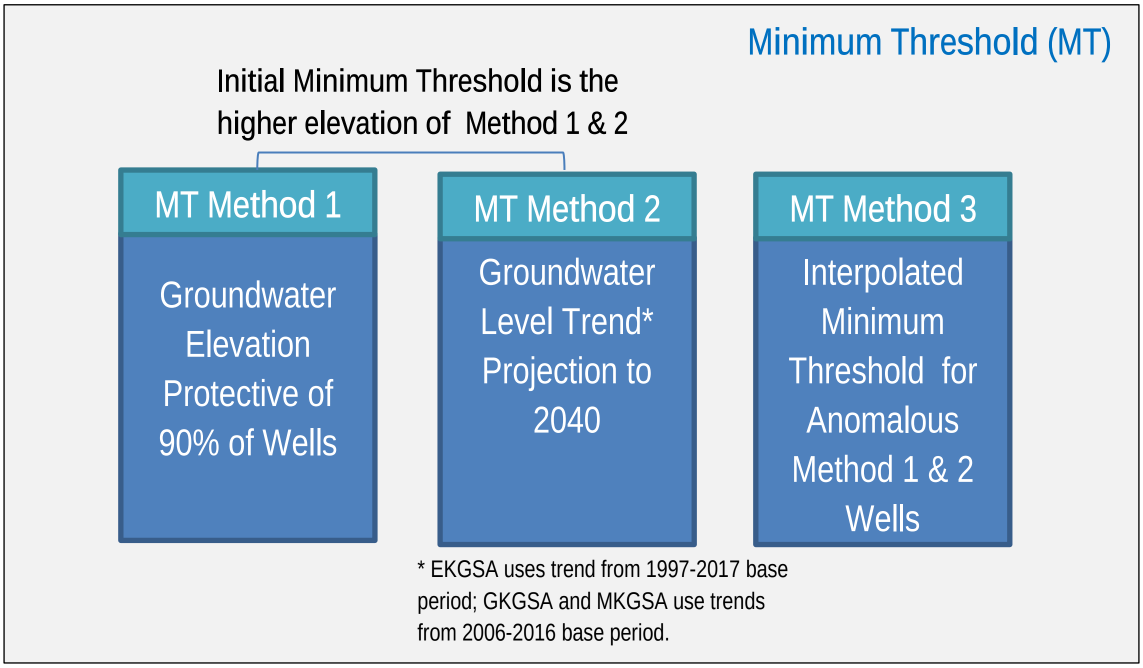



Figure 3. Minimum Threshold Methodologies

## 2.1 Methodology 1, Protective Elevations

The primary methodology for establishing MTs is designed to protect at least 90% of all wells in the Subbasin. This approach is protective of most beneficial uses and users of groundwater. The 90% threshold was chosen in acknowledgment that it is impractical to manage groundwater to protect the shallowest wells. More importantly, the GSAs wanted to set elevations based on well records of active wells, and not wells that may be destroyed or replaced. Because there is no active well registry to provide more accurate records, there is uncertainty regarding which wells are active. For example, the 2012-2016 drought was a period when approximately 480 wells in the Subbasin were reported dry according to the DWR's Dry Well Reporting System and a record number of wells were drilled in the Subbasin (Figure 4). Wells replaced by new deeper wells during this time are those that are presumed part of the shallowest 10% of wells in the dataset used to determine protective elevations. In consideration of the abovementioned factors, the GSA Managers selected 90% so that the dataset used to establish minimum thresholds contained well records reflective of current active wells.

Given approximately 10% of wells are shallower than the protected elevations, the GSAs in the Subbasin are in the process of establishing a Well Mitigation Program to assist impacted well owners.

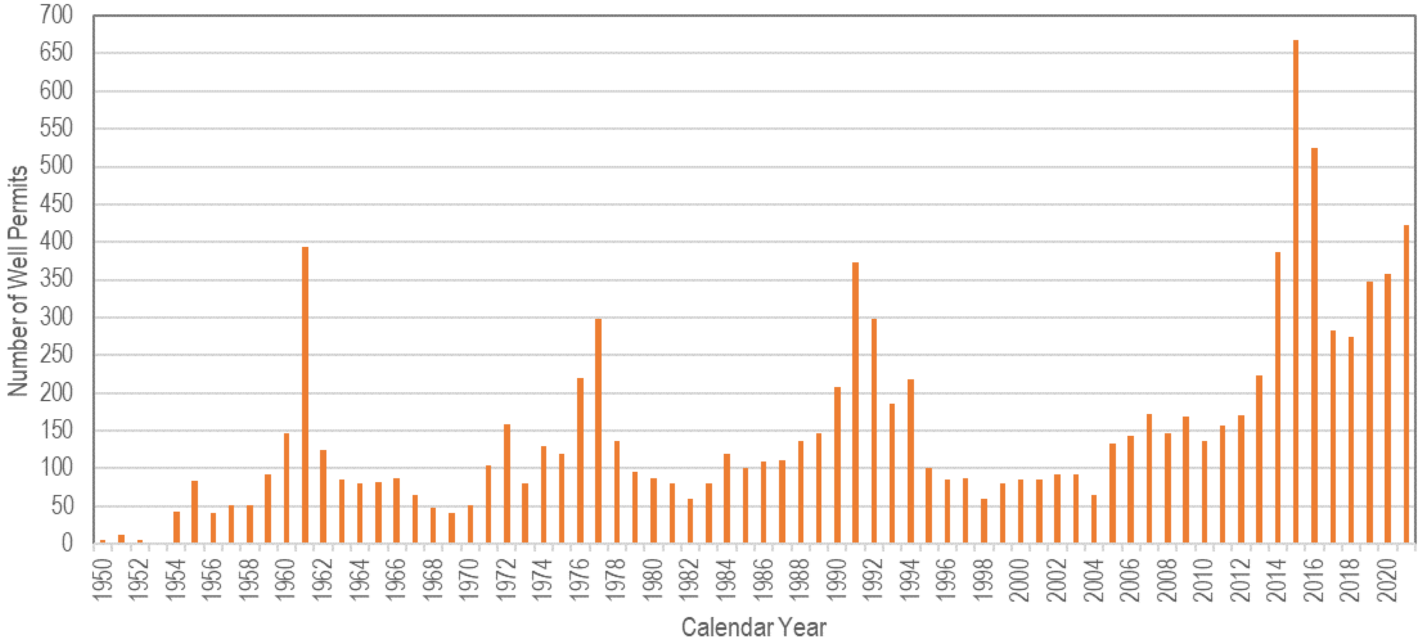



Figure 4. Annual Number of Water Supply Wells Drilled in the Kaweah Subbasin from 1950 to 2021

A total of 3,353 water supply well records from the WCR dataset are used for identifying significant and unreasonable groundwater elevations for beneficial groundwater users and uses. Criteria used to select well records from the WCR dataset include:

- The wells are drilled after January 1, 2002
- The wells are water supply wells with a planned purpose of domestic supply (includes DACs and private domestic wells), agricultural use, industrial use, or public supply (includes small water systems and municipal wells), and
- The wells have completed well depth data.

### 2.1.1 Analysis Zones

Because well depths vary with location, unique protective elevations are set for analysis zones that divide the Subbasin. The analysis zones are intended to group wells that would experience similar impacts by accounting for GSP management areas, groundwater elevations, base of aquifer, aquifer type, beneficial user type, land use, and similar completed well depths. A total of 39 spatial analysis zones are delineated (Figure 5). Twenty-three zones (analysis zones 1-23) cover the Single Aquifer System east of the limit of the Corcoran Clay shown on Figure 5. Sixteen zones (analysis zones 24-39) underlain by Corcoran Clay are split into an Upper and Lower Aquifer System based on the depth of the Corcoran Clay (described in Section 2.1.2). The Corcoran Clay is delineated vertically and spatially from recent airborne electromagnetic data acquired in the Subbasin by Stanford University (Kang *et al*., 2022).

### 2.1.2 Aquifer Designations

Aquifer designations are assigned to wells in the WCR dataset and the GSAs' representative monitoring sites based on available construction information and Corcoran Clay extent, depth, and thickness. As shown on Figure 6, the Corcoran Clay is a prominent confining geologic unit that underlies the western portion of the Subbasin and pinches out below the eastern portion of the Subbasin. The clay surface dips slightly with shallower occurrence to the east than the west. The Corcoran Clay is between 290 and 490 feet deep and up to 80 feet thick in the Subbasin.

All wells located east of the Corcoran Clay extent are designated as in the Single Aquifer System (Figure 6). Where the Corcoran Clay is present, wells are designated as Upper Aquifer System if the bottom of the well is above the bottom of the Corcoran Clay, and Likely Upper if the bottom of the well is within 50 feet of the bottom of the Corcoran Clay. Wells are designated as Lower Aquifer System if the top of its screen is within or below the Corcoran Clay. Wells are designated as Likely Lower if the total depth of the well with unknown screen depth is more than

50 feet below the bottom of the Corcoran Clay, or it is screened from less than 50 feet below the Corcoran Clay to more than 50 feet below the Corcoran Clay.

For wells without construction information that are underlain by the Corcoran Clay, groundwater level hydrographs are compared with hydrographs of other wells with construction information in the same analysis zone to determine in which aquifer the well is likely screened. Wells are designated as assumed Upper or assumed Lower Aquifer System based on similarities in seasonal and long-term groundwater level trends. Groundwater level hydrographs for representative monitoring sites are grouped by analysis zone and aquifer in Appendix A.

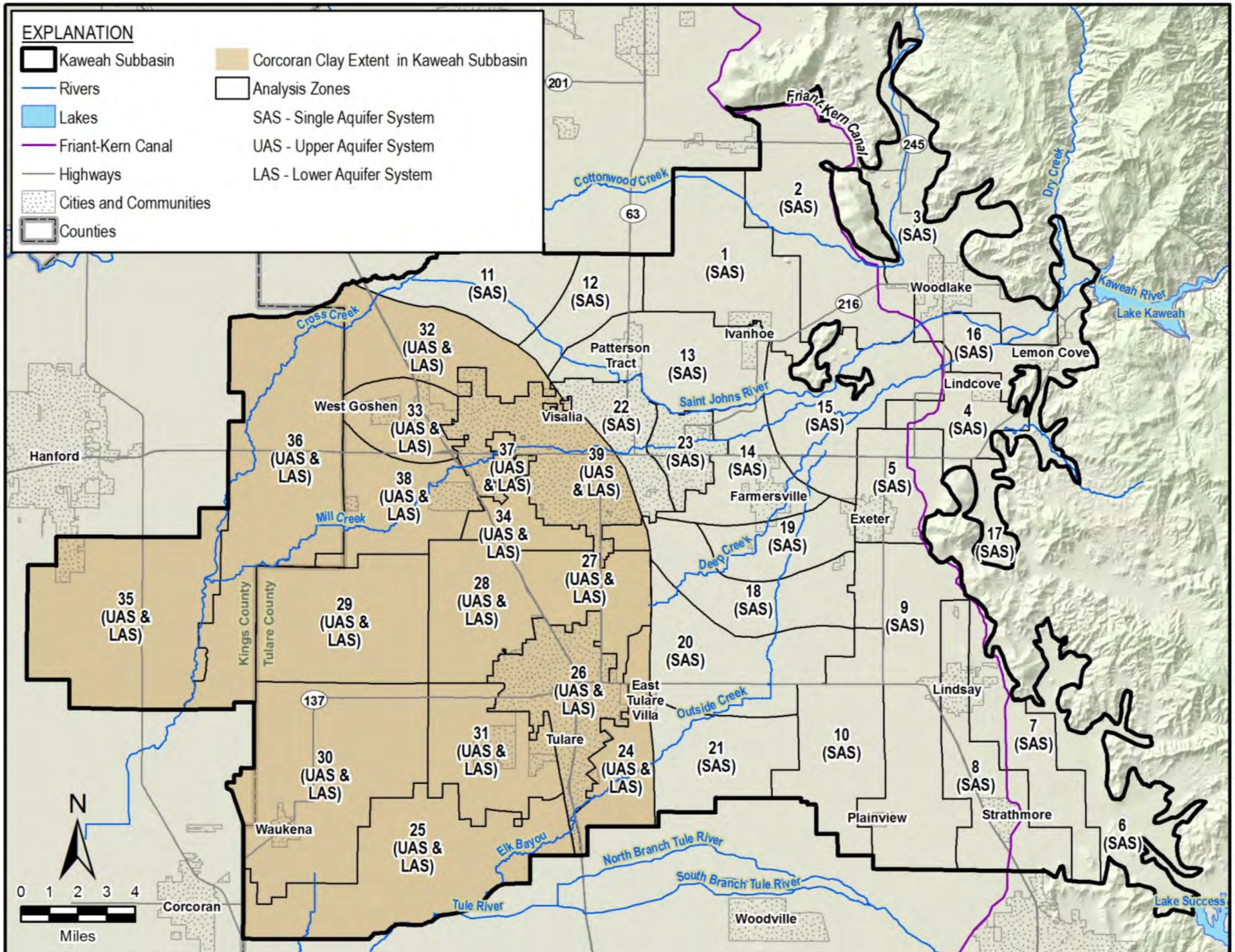



Figure 5. Kaweah Subbasin Analysis Zones

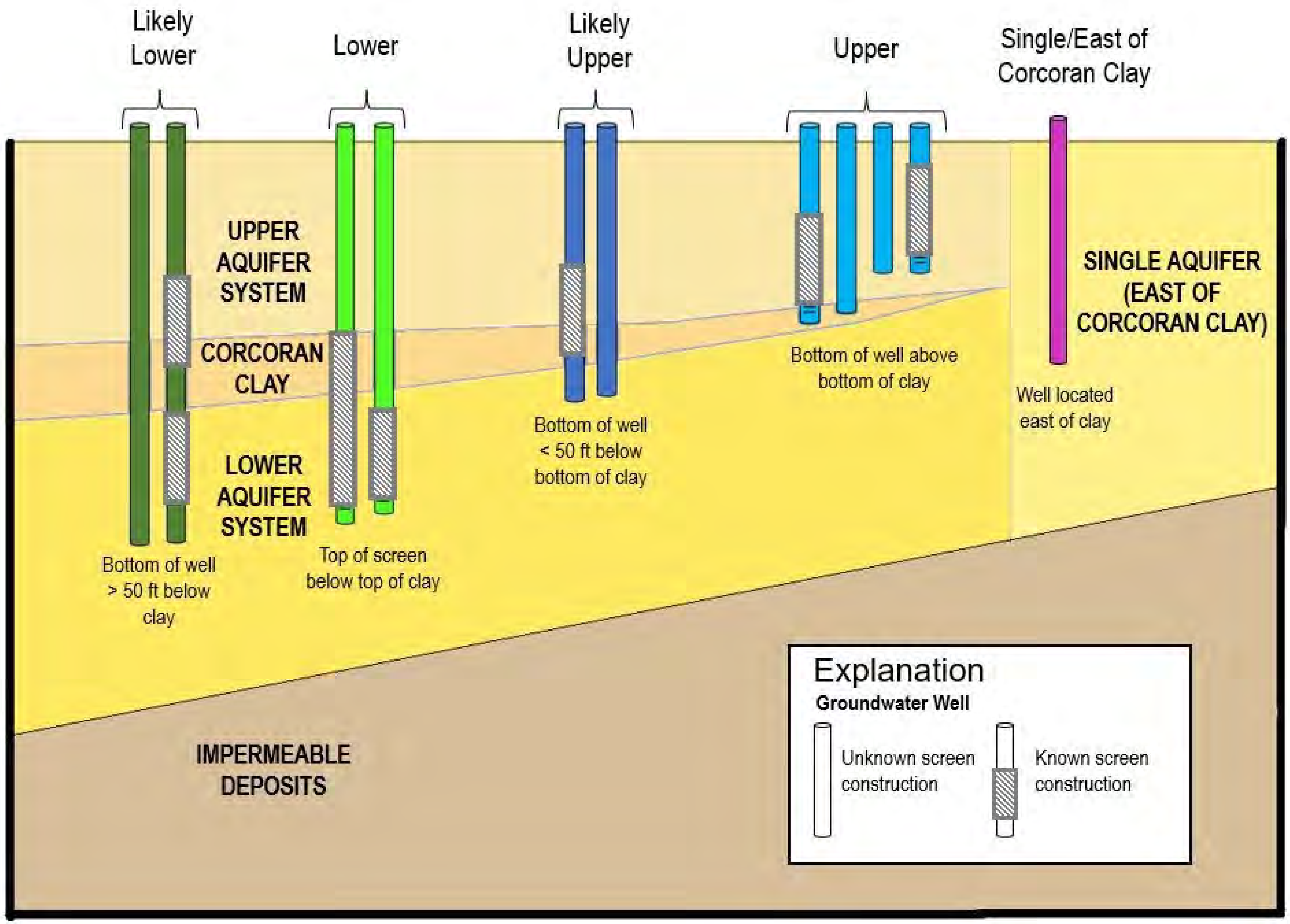



Figure 6. Kaweah Subbasin Aquifer Designation Assumptions

### 2.1.3 Completed Well Depth Analysis

Completed well depth is analyzed rather than total depth or depth of screens for the following reasons.

- Total depth drilled is typically deeper than the completed depth. Sometimes the difference can be quite large if the bottom portion of the well is not considered water bearing enough by the driller and is backfilled up to where the well is to be screened.
- More wells in the WCR dataset have completed depth information than well screen information. Of the wells with completed well depth information, 80% of those wells have screen depths. Since it is typical that wells are screened near the bottom of the completed well, more wells could be used in the analysis if completed well depth is used rather than screen depth.

Completed well depths vary by well use type, depth to groundwater, and aquifer. Figure 7 though Figure 13 depict the distribution of well use type and completed well depths across the Subbasin. Figure 7 shows a histogram of completed well depths across the entire Subbasin. Wells used in analysis are designated an aquifer system according to the assumptions outlined in Section 2.1.2.

Most wells in the Subbasin are completed to depths between 100 and 700 feet. The most common completed well depth is 350 to 400 feet, with about 700 total wells drilled to this depth. Well depth by type and aquifer is reviewed to assess which beneficial users would be impacted by lower groundwater levels. Figure 8 through Figure 10 are aquifer-specific histograms of completed well depth by well use type. Most supply wells in the Subbasin are either used for agricultural or domestic water supply. Agricultural wells are more numerous than other types of water supply wells and also cover the widest range of depths, including the deepest depths of all wells. Overall, the shallowest wells tend to be domestic supply wells with few domestic wells installed deeper than 450 feet. There are relatively fewer public supply wells, with the majority less than 450 feet deep, although there are some that are deeper than 800 feet.

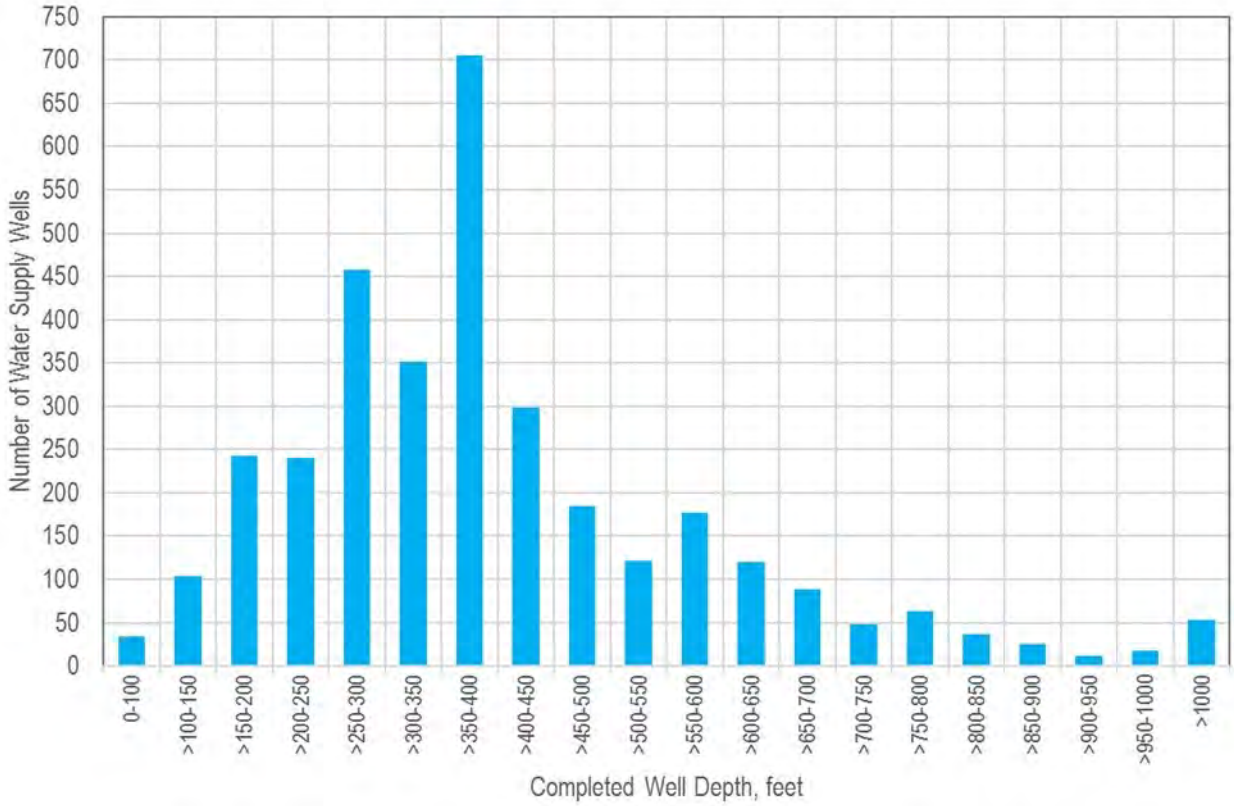



Figure 7. Histogram of Completed Wells Depths for Water Supply Wells in the Kaweah Subabsin

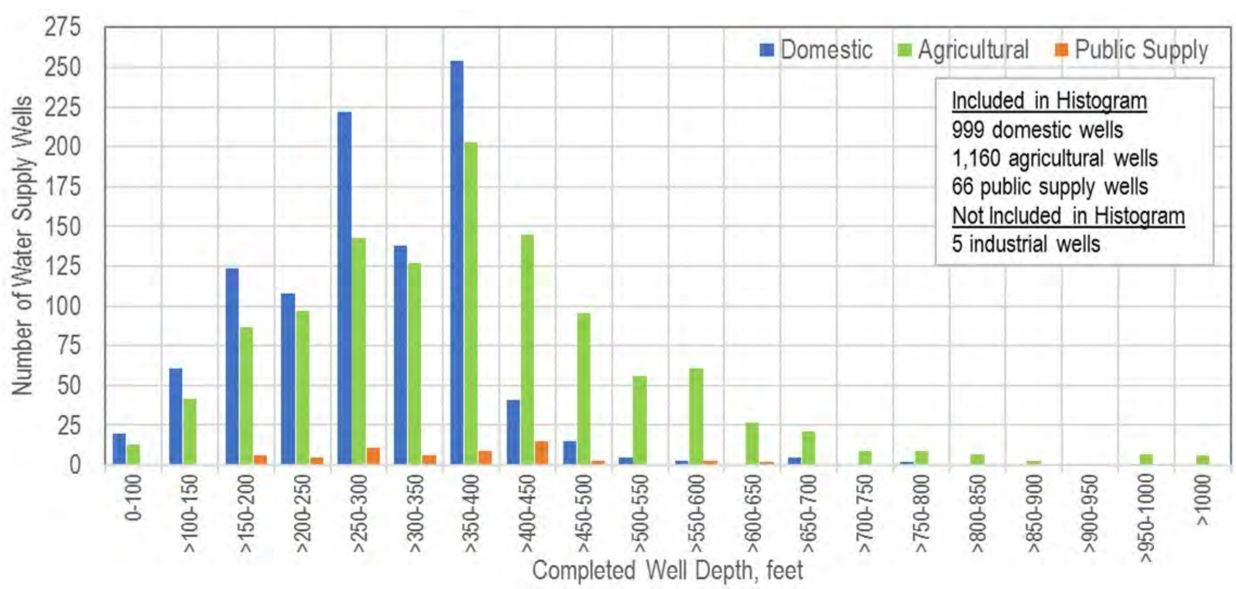



Figure 8. Histogram of Completed Well Depths for Single Aquifer System Water Supply Wells

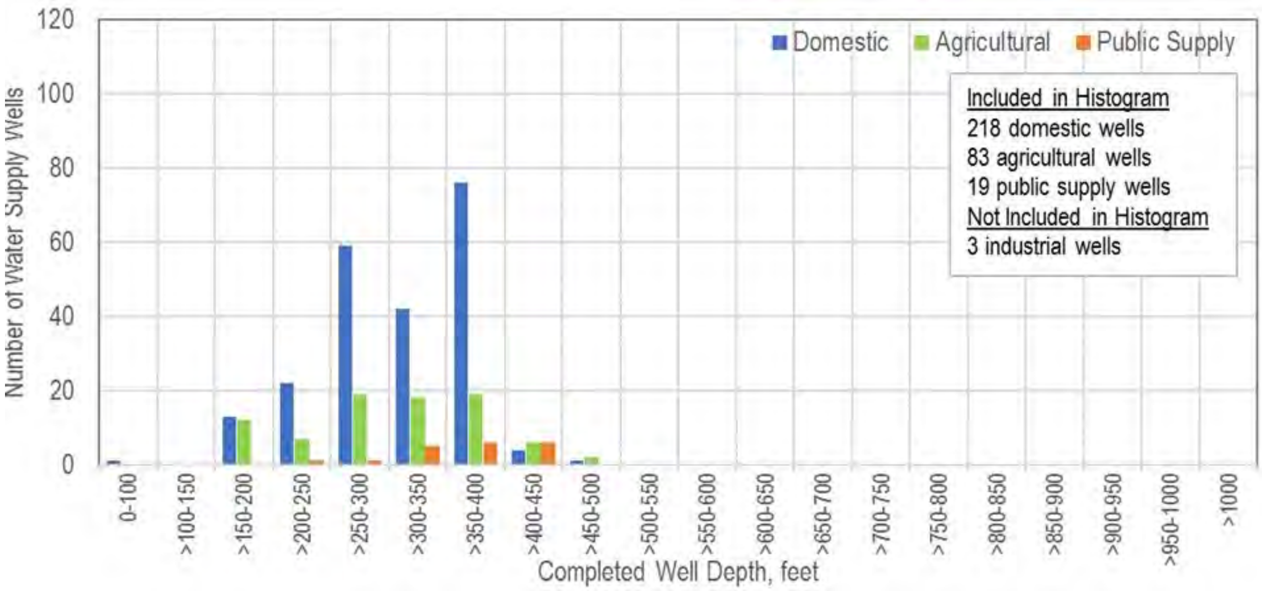



Figure 9. Histogram of Completed Well Depths for Upper Aquifer System Water Supply Wells

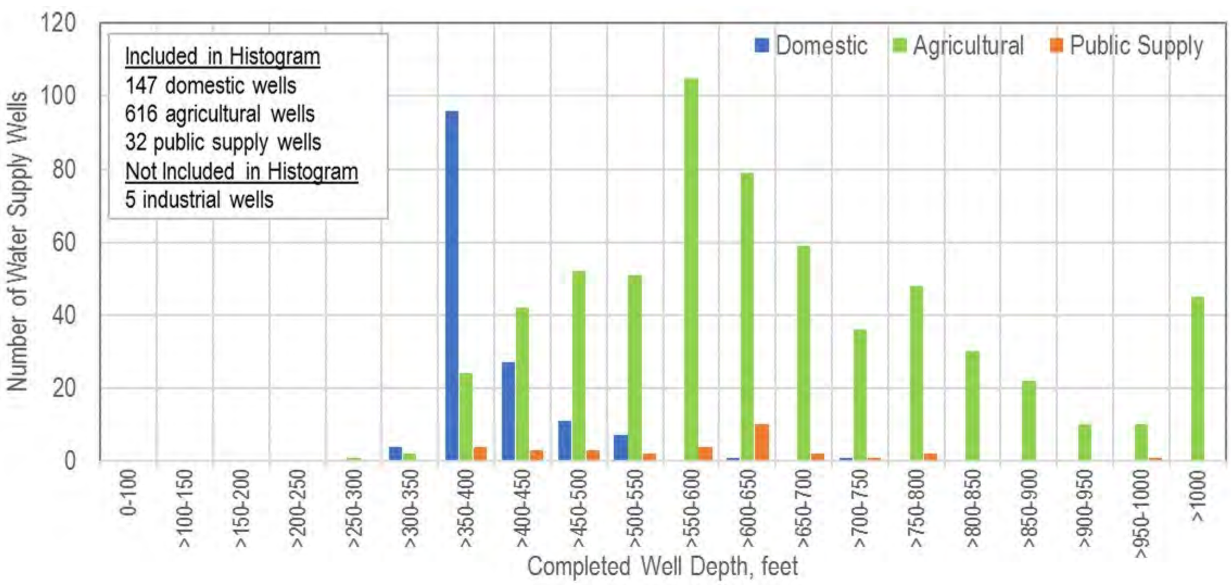



Figure 10. Histogram of Completed Well Depths for Lower Aquifer System Water Supply Wells

The number, depth, and type of water supply wells completed in each of the three aquifer systems are summarized below:

- The Single Aquifer System contains the most wells (2,232) and greatest well density (6.1 wells per square mile) of the three aquifer systems. It also has some of the shallowest wells in the Subbasin, with depths less than 100 feet (Figure 8). It has similar numbers of domestic (999) and agricultural wells (1,160), though overall domestic wells are shallower. About 60% of wells shallower than 200 feet in the Single Aquifer System are domestic wells and about 40% are agricultural wells.
- The Upper Aquifer System has the fewest total wells of the three aquifers (323) and has a well density of about 1 well per square mile. About 2.5 times as many domestic wells (218) as agriculture supply wells (83) are completed in the Upper Aquifer System, as shown on Figure 9. The shallowest wells in the Upper Aquifer System are between 150 and 200 feet, which is slightly deeper than the Single Aquifer System. This is because groundwater levels are deeper in the western portion of the Subbasin underlain by the Corcoran Clay. About 60% of wells in the top 100 feet of the saturated Upper Aquifer System (from 150 to 250 feet) are domestic wells and 40% are agricultural wells.
- The Lower Aquifer System wells are screened mostly below the Corcoran Clay and are generally deeper than 300 feet ( Figure 10). The dataset analyzed has 803 wells and a well density of about 2.5 wells per square mile. About 77% of wells screened in the Upper Aquifer System are agricultural wells (616). However, since most domestic wells are installed shallower than 450 feet and most agricultural wells are installed deeper than 450 feet, there are more domestic wells than agricultural wells in the shallower portions of the Lower Aquifer System. In total, about 65% of wells that are less than 450 feet deep are domestic wells and 35% are agricultural wells.

Completion well depths are evaluated by analysis zone because their depths vary spatially due to different groundwater depths across the Subbasin. Appendix B contains histograms of completed well depth by water use type and analysis zone. Figure 11 through Figure 13 show the proportions of well use types distributed across the Subbasin by analysis zone. By grouping wells in analysis zones, the predominant well use depths in the zone influence statistics used to determine protective groundwater elevations. For example, analysis zone 19 on Figure 11 has more domestic wells than other well use types which means the completed depth statistics derived from wells in the zone are influenced more by domestic wells than other use types.

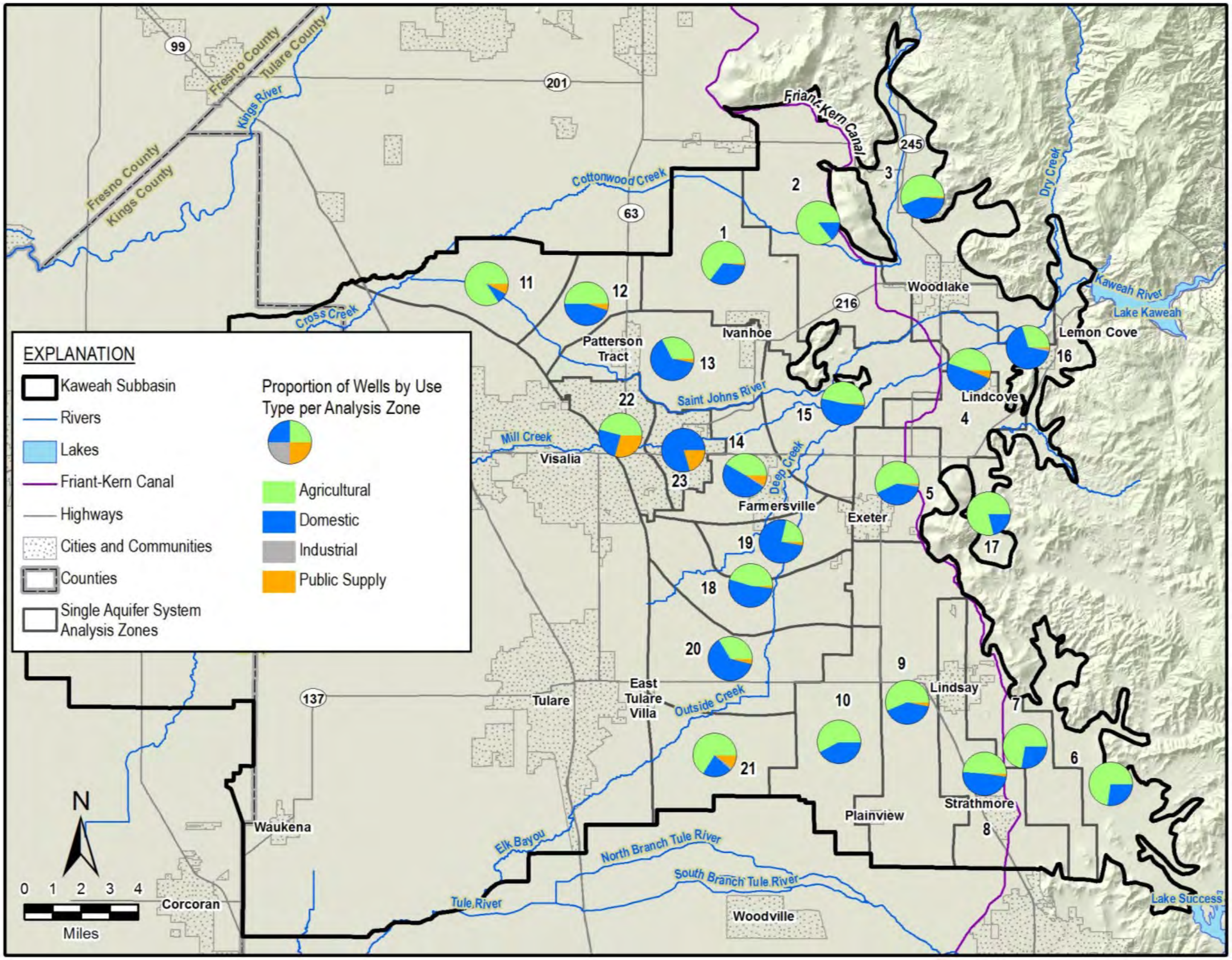



Figure 11. Single Aquifer System Well Use Types by Analysis Zone

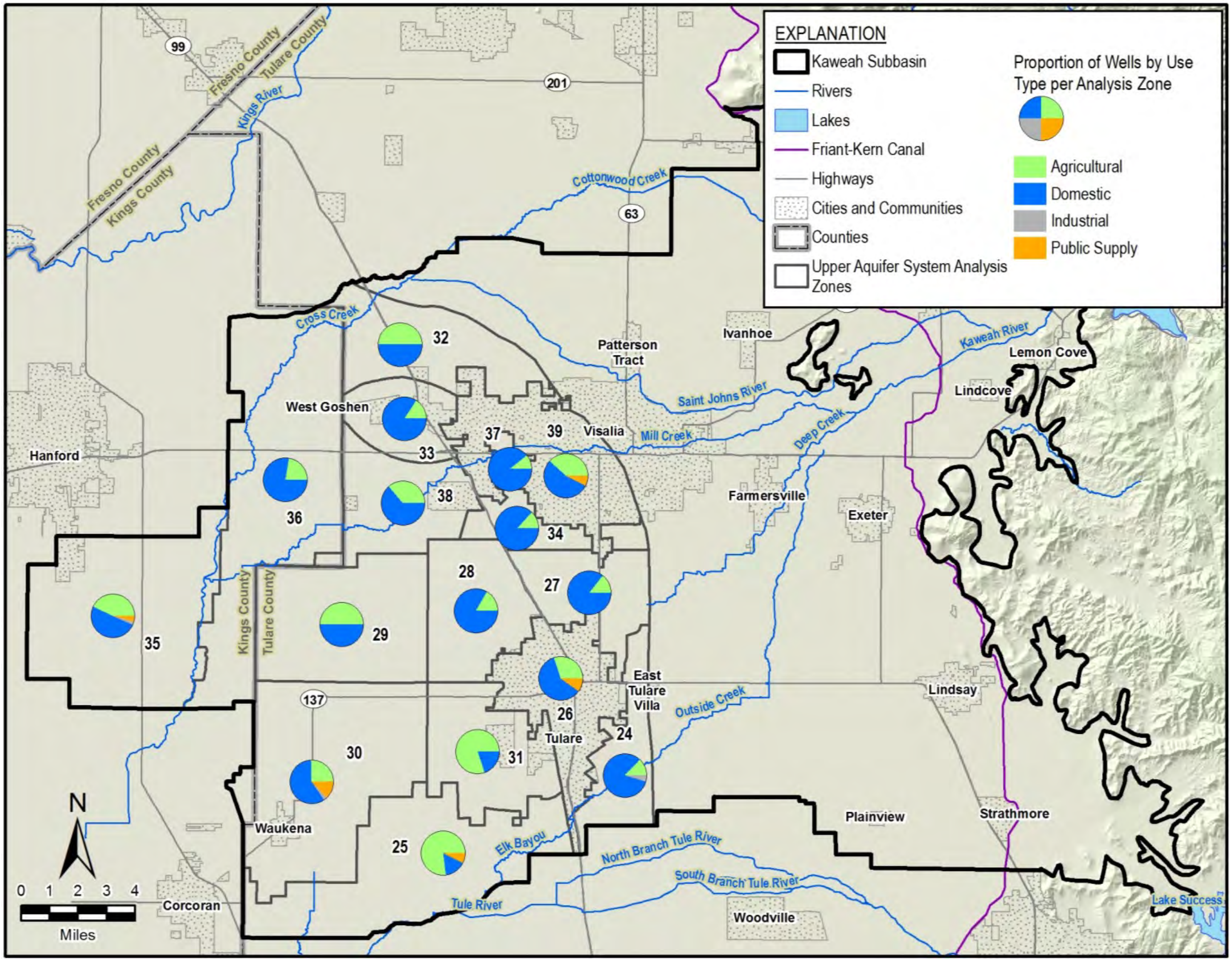


Figure 12. Upper Aquifer System Well Use Types by Analysis Zone

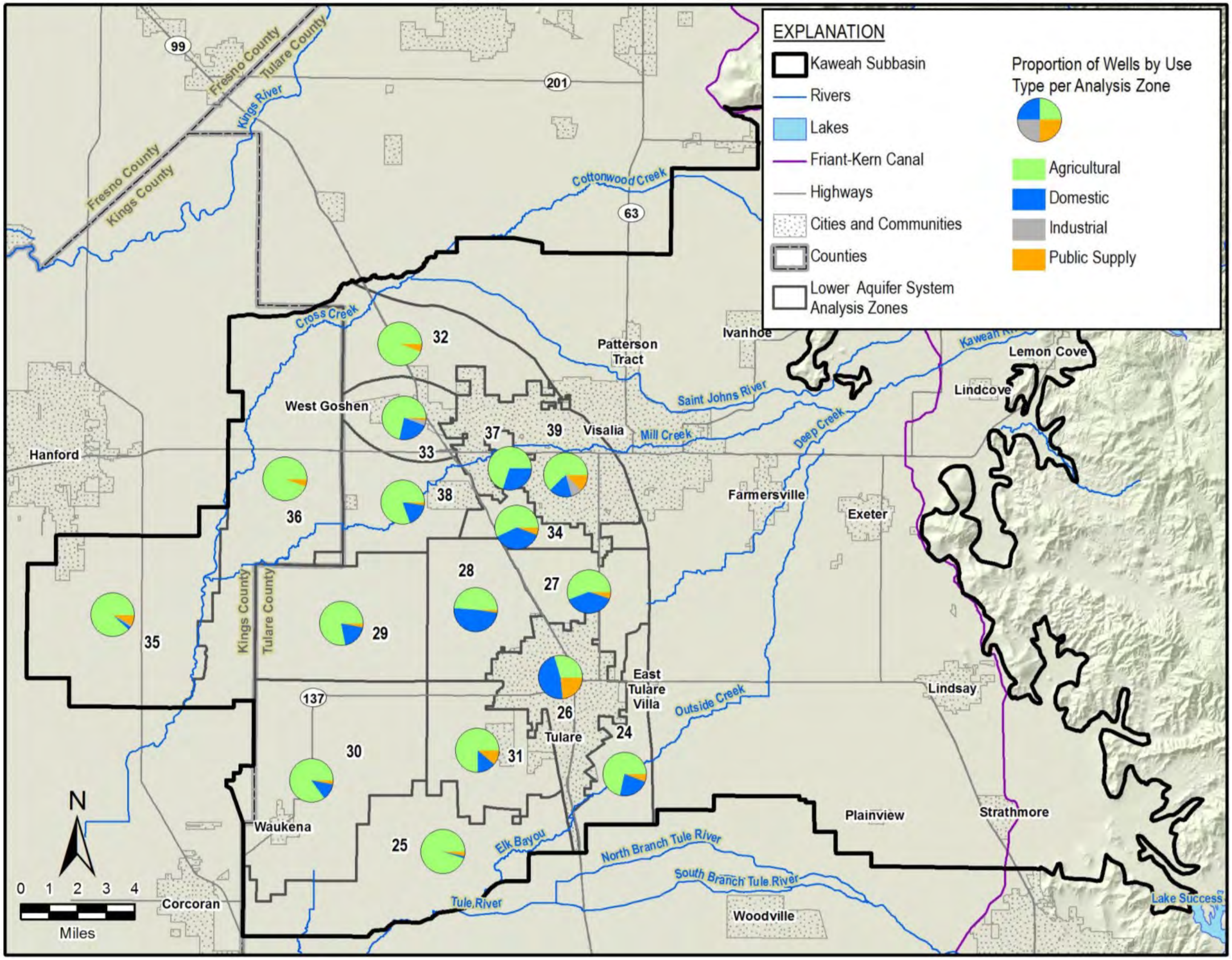


Figure 13. Lower Aquifer System Well Use Types by Analysis Zone

Well type spatial variability within the various aquifer systems is described below:

- The Single Aquifer System wells are relatively evenly split between domestic and agricultural use as shown on Figure 11. Wells around the margins of the Subbasin, including analysis zones 1, 2, 3, 11, and 17 are predominantly used for agriculture, while wells near the Kaweah River distributaries in the middle of the Subbasin such as zones 16, 19, 20, and 23 are predominantly used for domestic purposes. Visalia is the only area with greater than 20% public supply wells (analysis zones 22 and 23).
- The Upper Aquifer System is predominantly pumped by domestic wells as shown on Figure 12. However, there are parts of the Subbasin that are not heavily populated and nearly all wells are used for agriculture (analysis zones 25 and 31). Other areas with a relatively even number of domestic and agricultural supply wells include analysis zones 29 and 35 to the west and 32 to the north. Public supply wells make up less than 20% of all wells in each analysis zone, with the most concentrated distribution near Waukena (analysis zone 30).
- The Lower Aquifer System is primarily pumped by agricultural wells but there are a few areas near Tulare and Visalia where domestic wells make up between 25% to 50% of all wells (Zones 26, 27, 28, 34, and 37). Areas with the greatest number of public supply or industrial wells are in Tulare (analysis zone 26) and Visalia (analysis zone 39).

### 2.1.4 Protective Elevations

To calculate a groundwater elevation minimum threshold based on protection of active water supply wells, a statistical approach using percentiles was taken to develop a realistic view of active wells given well status uncertainties. A percentile well depth, or percentage of wells that would be deeper than a particular depth, was calculated for each analysis zone and aquifer. For example, the 90th percentile well depth (for wells ranked from deepest to shallowest), is the depth that 90% of wells are deeper than or equal to. This means 10% of wells are shallower than the 90th percentile depth. The 10% shallowest completed well depth are not used in the analysis as it is likely they are no longer active.

Selecting the 90th percentile recognizes the uncertainty in the accuracy and completeness of the DWR WCR dataset and accounts for destroyed or replaced shallower wells. The impracticability of managing the Subbasin to the shallowest wells is an additional factor leading to consensus amongst the three GSAs to, at a minimum, protect 90% of all water supply wells.

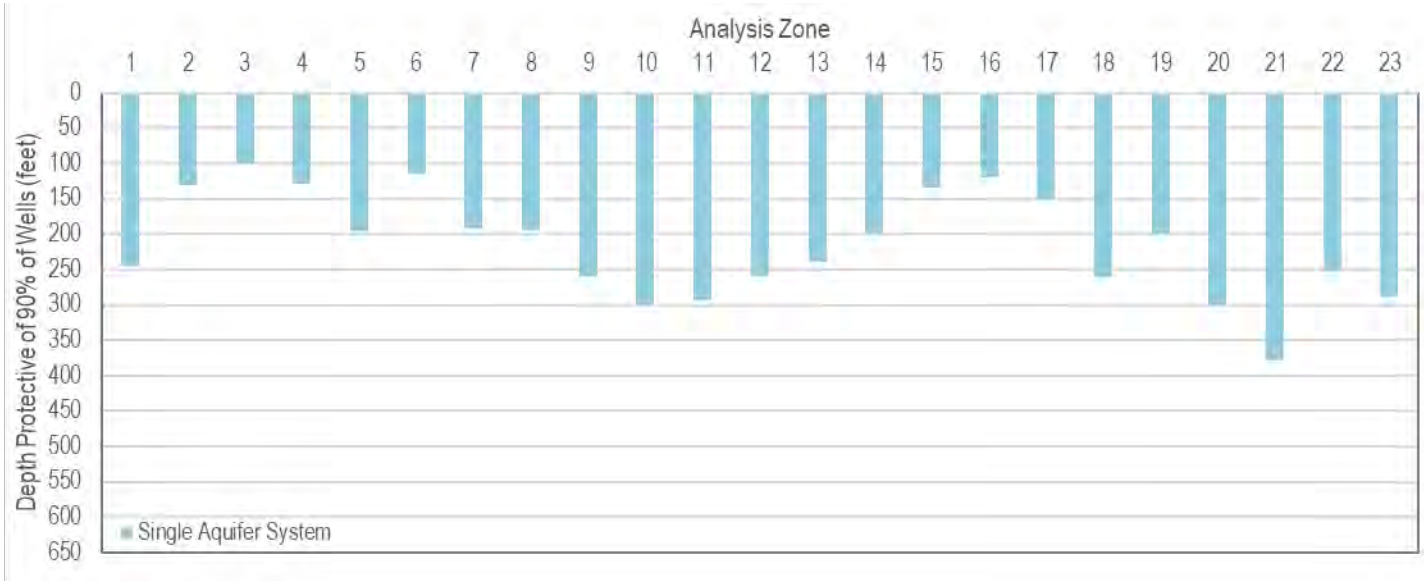
The 90th percentile completed well depths are calculated for each of the analysis zones by aquifers using the data described in Section 1.2. The analysis was not performed on a particular well use type but for all water supply wells within each analysis zone. Figure 14 shows the protective elevation depths for the three aquifer systems by analysis zone.

Protective well depths follow similar trends as the well completion statistics. The protective well depths are generally shallowest for the Single Aquifer System (Table 1), followed by the Upper Aquifer System, with the deepest protective depths in the Lower Aquifer System. The median protective well depth is 200 feet for the Single Aquifer System, 241 feet for the Upper Aquifer System, and 400 feet for the Lower Aquifer System. The range of protective depths are 100 to 378 feet for the Single Aquifer System, 168 to 300 feet for the Upper Aquifer System, and 380 to 606 feet for the Lower Aquifer System.

Table 1. Summary of Protective Elevations Statistics by Aquifer

| Aquifer | 90th Percentile Protective Depth (feet below ground surface) | | |
|---|---|---|---|
| | Minimum | Median | Maximum |
| Single Aquifer System | 100 | 200 | 378 |
| Upper Aquifer System | 168 | 241 | 300 |
| Lower Aquifer System | 380 | 400 | 606 |

The number of well records in the WCR dataset with construction information, above or below the protective elevation are summarized in Table 2. As mentioned previously, some of these shallow wells are likely destroyed and replaced with deeper wells, Domestic well depths tend to be shallower than wells used for other purposes, so a slightly higher number and percentage of domestic wells are potentially impacted by groundwater declines compared to other wells. Of the 297 wells shallower than the 90$^{th}$ percentile well depth, 58% are domestic wells, 39% are agricultural wells, and 3% are public supply wells. However, in total, 90% of all well types installed since January 2002 are deeper than protective well depths, including 88% of domestic wells, 94% of agricultural wells, and 92% of public supply wells. Although the full set of WCR wells lacks construction information for many wells, if it is assumed the percentages of well use type and depth are the same for the full set of WCR wells as the subset of wells with construction information, the subset percentages may be used to scale up the number of potentially impacted wells to the full set of WCR wells.



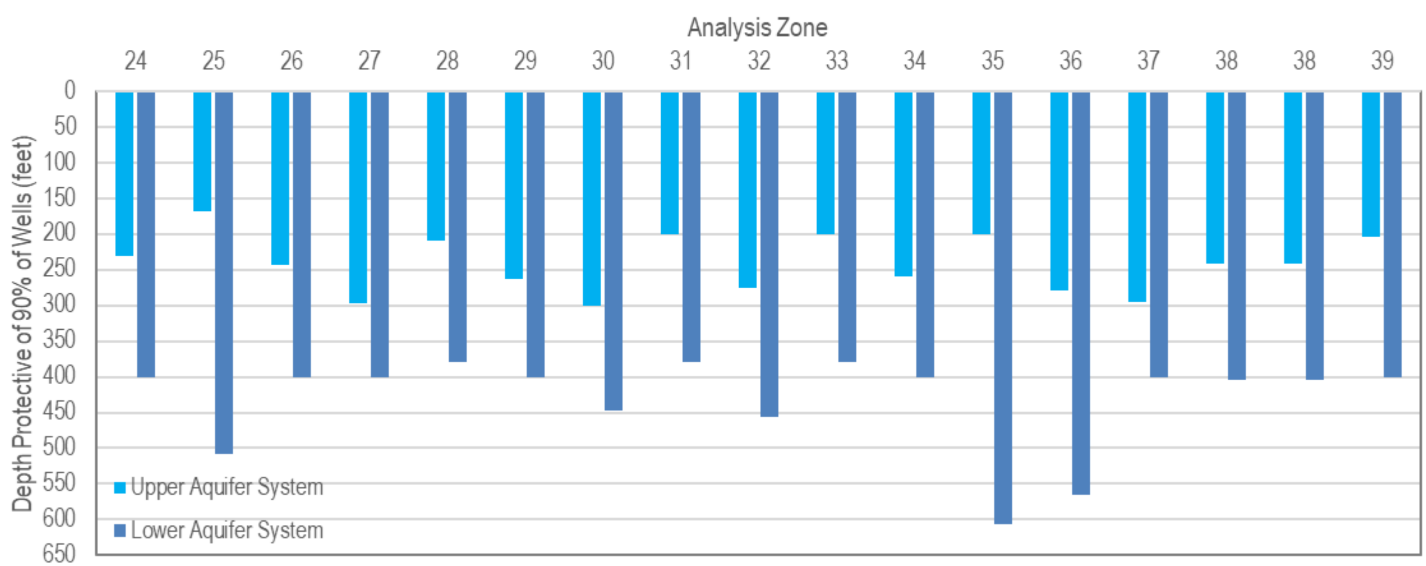




Figure 14. Analysis Zone Depths Protective of 90% of Water Supply Wells in the Kaweah Subbasin

Table 2. Summary of Basinwide Potential Well Impacts of Groundwater Levels at 90% Protective Depths Using WCR Well Records with Construction Information

| Well Use Type | Deeper than 90% Protective Depth | | Shallower than 90% Protective Depth | | Total Number |
|---|---|---|---|---|---|
| | Number of Wells Deeper than the Protective Depth | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | |
| Domestic | 1,193 | 39% | 171 | 58% | 1,364 |
| Agricultural | 1,742 | 57% | 117 | 39% | 1,859 |
| Public Supply | 108 | 4% | 9 | 3% | 117 |
| Industrial | 13 | 0% | 0 | 0% | 13 |
| Total | 3,056 | | 297 | | 3,353 |

The number of well records in the WCR dataset of wells with construction information, potentially impacted at the 90% protective depth for each of the three aquifer systems are summarized in Table 4. Domestic wells in the Single Aquifer System will be the most impacted if groundwater levels fall to the protective elevation, followed by agricultural wells. Lower Aquifer System agricultural wells will be impacted more than domestic wells because of the greater number of agricultural wells in the Lower Aquifer System ( Figure 10). The Upper Aquifer System has the least potentially impacted wells, with more domestic wells than agricultural wells potentially impacted.

Table 3. Summary of Potential Well Impacts of Groundwater Levels at 90% Protective Depths by Aquifer Using WCR Well Records with Construction Information

| Well Use Type | Single Aquifer System | | Upper Aquifer System | | Lower Aquifer System | | Total |
|---|---|---|---|---|---|---|---|
| | Number of Potentially Impacted Wells | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | Number of Potentially Impacted Wells | Well Use Type Percentage | |
| Domestic | 135 | 63% | 19 | 68% | 17 | 30% | 171 |
| Agricultural | 74 | 35% | 9 | 32% | 34 | 61% | 117 |
| Public Supply | 4 | 2% | 0 | 0% | 5 | 9% | 9 |
| Industrial | 0 | 0% | 0 | 0% | 0 | 0% | 0 |
| Total | 213 | | 28 | | 56 | | 297 |

The East Kaweah Groundwater Sustainability Agency (EKGSA) and Greater Kaweah Groundwater Sustainability Agency (GKGSA) areas are those with the greatest number of wells shallower than the 90% protective depth (Table 4). This is because the Single Aquifer System underlies all of the EKGSA and a portion of the GKGSA, and it is the aquifer with the largest number of potentially impacted wells above the 90% protective depth. The GKGSA has the greatest total number of potentially impacted wells and the Mid-Kaweah Groundwater Sustainability Agency (MKGSA) has the fewest. The GSA areas are shown on Figure 1. Table 4 also summarizes the density of potentially unprotected wells within each GSA area. The EKGSA has the greatest overall density at 0.63 wells per square mile, GKGSA has 0.42 wells per square mile, and MKGSA the lowest density at 0.22 wells per square mile.

The protective elevation for each representative monitoring site is calculated by subtracting the analysis zone-specific 90th percentile protective depth from the representative monitoring site's surface elevation. Appendix C lists the 90% protective elevations for all the representative monitoring sites.

Table 4. Summary of Potential Well Impacts with Groundwater Levels at 90% Protective Depths by GSA Using WCR Well Records with Construction Information

| Well Use Type | East Kaweah GSA | | | Greater Kaweah GSA | | | Mid-Kaweah GSA | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Potentially Impacted Wells | | Well Use Type Percentage in GSA | Potentially Impacted Wells | | Well Use Type Percentage in GSA | Potentially Impacted Wells | | Well Use Type Percentage in GSA | |
| | Number | Wells per Square Mile | | Number | Wells per Square Mile | | Number | Wells per Square Mile | | |
| Domestic | 58 | 0.32 | 52% | 93 | 0.27 | 64% | 17 | 0.10 | 49% | 171 |
| Agricultural | 50 | 0.27 | 45% | 47 | 0.14 | 32% | 18 | 0.11 | 51% | 117 |
| Public Supply | 3 | 0.02 | 3% | 6 | 0.02 | 4% | 0 | 0 | 0% | 9 |
| Industrial | 0 | 0 | 0% | 0 | 0 | 0% | 0 | 0 | 0% | 0 |
| Total | 111 | 0.61 | | 151 | 0.43 | | 35 | 0.22 | | 297 |

## 2.2 Methodology 2, Groundwater Level Trend

This method extrapolates groundwater level trends for individual representative monitoring sites over a selected base period out to 2040. In all cases the trend is a decline with a rate that varies across the Subbasin. The EKGSA used a different base period than the GKGSA and MKGSA base period as described below. If the MT is derived from this method, it means groundwater levels are set to protect more than 90% of wells in the analysis zone while not allowing groundwater levels to decline at a greater rate than the base period.

In the EKGSA, groundwater level trends over a historical 21-year base period (1997-2017) are projected to 2040. EKGSA critically analyzed the projected 2040 groundwater levels and determined the magnitude of potential impacts likely to occur due to the current pumping and recharge regime. In cases where projected groundwater levels mirror the condition of the basin before the 1950s, when Central Valley Project brought in surface water supplies, or were not sufficiently protective of aquifer storage capacity it was determined that returning groundwater conditions similar to pre-1950 is undesirable. In EKGSA's eastern analysis zones (also called threshold regions), some initial MT elevations were increased due to the shallow depth to the bottom of the aquifer. Groundwater level MTs are established for each of the EKGSA's 10 analysis zones based on available groundwater level trend data for wells within each analysis zone. EKGSA representative monitoring sites within an analysis zone are therefore assigned the same MT groundwater elevations.

For representative monitoring sites in the GKGSA and MKGSA, the groundwater level trend base period projected to 2040 is the 11-year period from 2006 to 2016. The 2006-2016 base period represents a more recent period that reflects recent pumping patterns and includes the effects of the 2012-2016 drought. Unlike EKGSA which assigns a single MT to all representative monitoring sites within an analysis zone, GKGSA and MKGSA representative monitoring sites all have unique MTs based upon the 11-year groundwater level trend.

## 2.3 Methodology 3, Interpolated Minimum Threshold

After estimating MTs using methodologies 1 and 2, some GKGSA and MKGSA representative monitoring site MTs were determined to be anomalously low compared to neighboring monitoring sites because the wells' 2006-2016 groundwater level trend are much steeper than adjacent representative monitoring sites. There are four sites in the Single Aquifer System and three sites in the Upper Aquifer System where this occurs.

For representative monitoring sites with anomalously low MTs derived from the higher of Methodology 1 and 2 elevations, MTs were raised to an elevation determined by interpolating from MT contours. The contours are generated from the representative monitoring site MTs without the seven sites as control points. Figure 15 identifies the resultant MT contours and identifies the seven sites with pre-adjusted and adjusted MTs labeled. The result of using Methodology 3 is that MTs were interpolated into a smooth surface of MTs without any significant level change ("cliffs") between representative monitoring sites.

## 2.4 Selection of Method to Use for Minimum Threshold

For each representative monitoring site, the elevations based on the 90% protective depth (Method 1) and groundwater levels trend (Method 2) are compared. The higher of the two elevations is selected as the MT. If the groundwater level trend elevation is higher than the protective elevation, more than 90% of wells in the analysis zone are protected. Appendix C includes the elevations for both methods and highlights the elevation of the method used for MTs.

Even though multiple methods are used by the GSAs to establish MTs, contours of MTs for the Single and Upper Aquifer Systems (unconfined) and the Lower Aquifer System (confined) onFigure 15 and Figure 16, respectively, demonstrate MTs across the Subbasin do not show abnormal differences between RMS and MTs decrease in elevation from east to west similar to groundwater elevations.

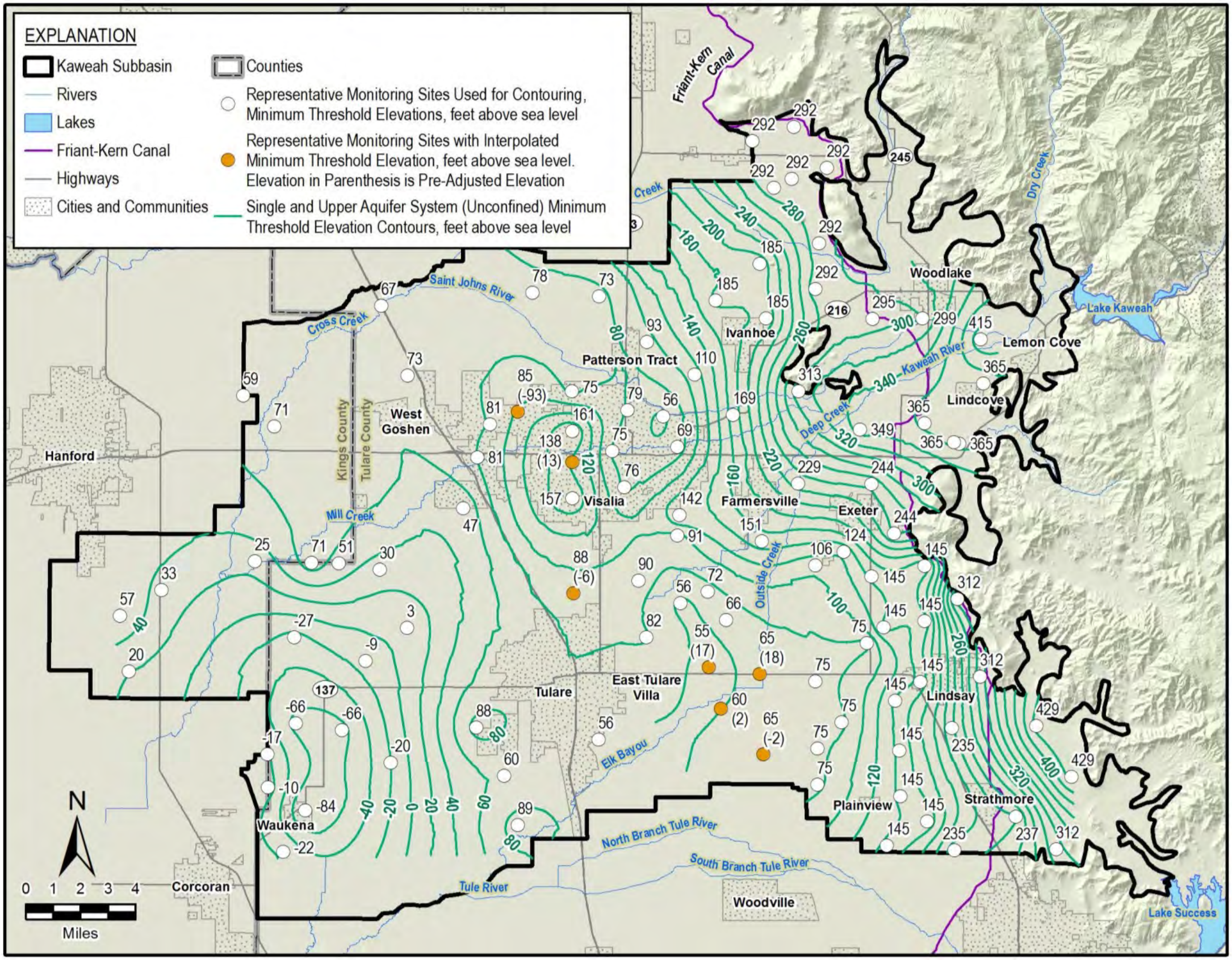



Figure 15. Single and Upper (Unconfined) Aquifer System Minimum Threshold Contours Across the Kaweah Subbasin

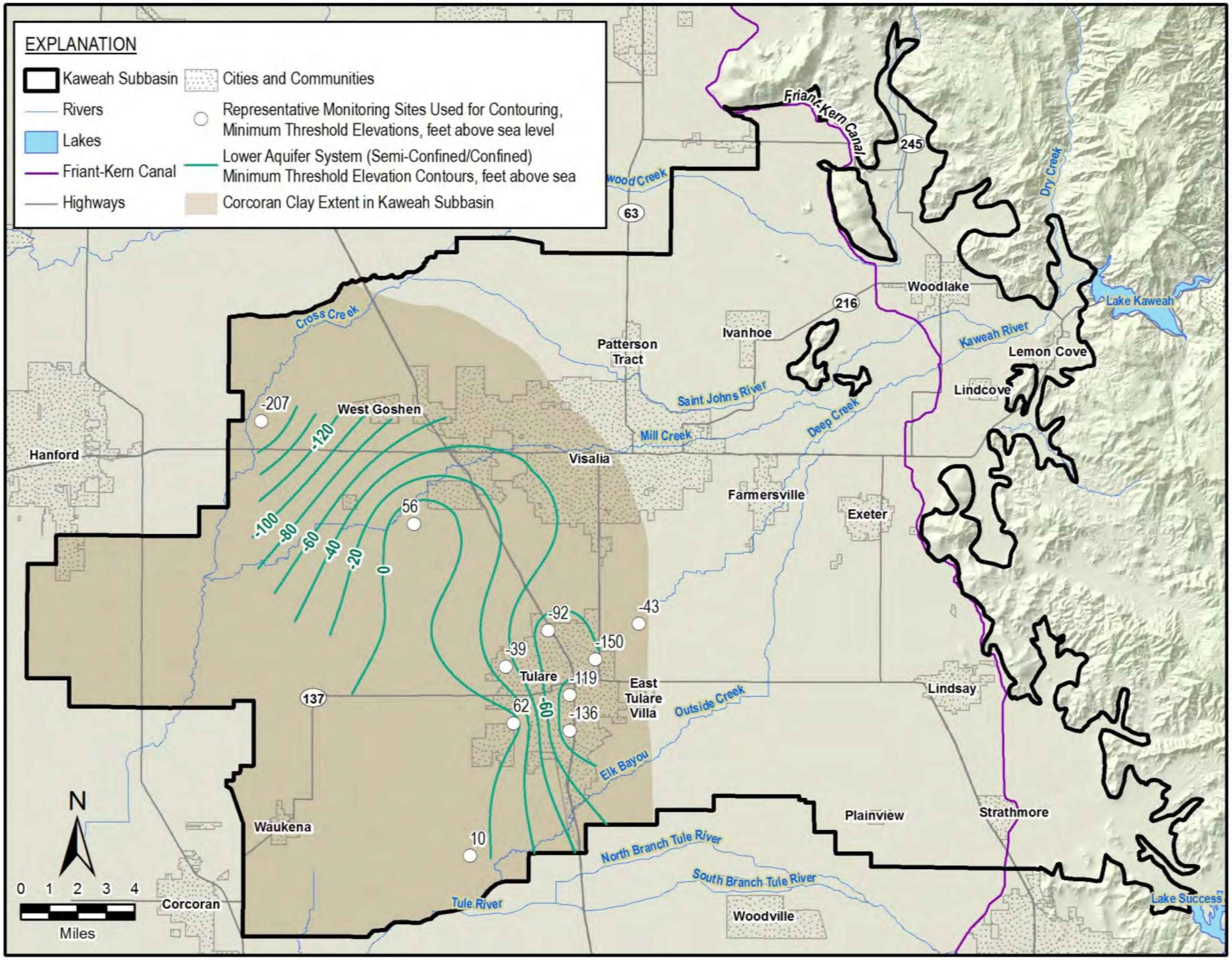



Figure 16. Lower Aquifer (Semi-Confined/Confined) System Minimum Threshold Contours Across the Kaweah Subbasin

# 3 PROCESS USED TO ESTABLISH MEASURABLE OBJECTIVES AND INTERIM MILESTONES

## 3.1 Measurable Objective Methodologies

Measurable objectives (MOs) are established at groundwater elevations higher than MTs to provide operational flexibility and reflect the GSAs' desired groundwater conditions in 2040. The margin of operational flexibility accounts for droughts, climate change, conjunctive use operations, other groundwater management activities, and data uncertainty. The GSAs in the Kaweah Subbasin are managing their groundwater sustainability to meet the MO in 2040.

The EKGSA MOs are based on Spring 2017 groundwater levels. Spring 2017 was a wet year that followed the 2012-2016 drought. This approach applies to wells where the MT is based on the 1997-2017 groundwater level trend projection described in Section 1.1 and shown on Figure 17.

The GKGSA and MKGSA MOs are based on one of two methods, depending on which methodology was used to set MTs. Figure 17 graphically shows the relationship between the different MT and MO methodologies.

MO Method 1, Groundwater Level Trend Projection to 2030:

- For GKGSA and MKGSA representative monitoring sites with MTs derived from the groundwater level trend projection, the MO is the 2006-2016 groundwater elevation projected to 2030 (Figure 18).
- For representative monitoring sites where the MT is set using the protective elevation, and the difference between the MT and groundwater elevation trend projected to 2030 is 20 feet or more, the MO is the 2006-2016 groundwater elevation projected to 2030 (Figure 18).

MO Method 2: 5-Year Drought Storage Based on 2006-2016 Trend

- For representative monitoring sites where the MT is set using the protective elevation, and the difference between the MT and groundwater elevation trend projected to 2030 is less than 20 feet, the MO is set at an elevation that provides for 5 years of drought storage above the MT. Five years of drought storage is determined as the groundwater level change occurring over 5 years using the 2006-2016 groundwater level trend (Figure 19). The groundwater level change is added to the MT elevation to establish the MO elevation (Figure 19).

- For representative monitoring sites where anomalously low MTs are adjusted by interpolating from MT contours, the MO is set at an elevation that provides for 5 years of drought storage above the adjusted MT.

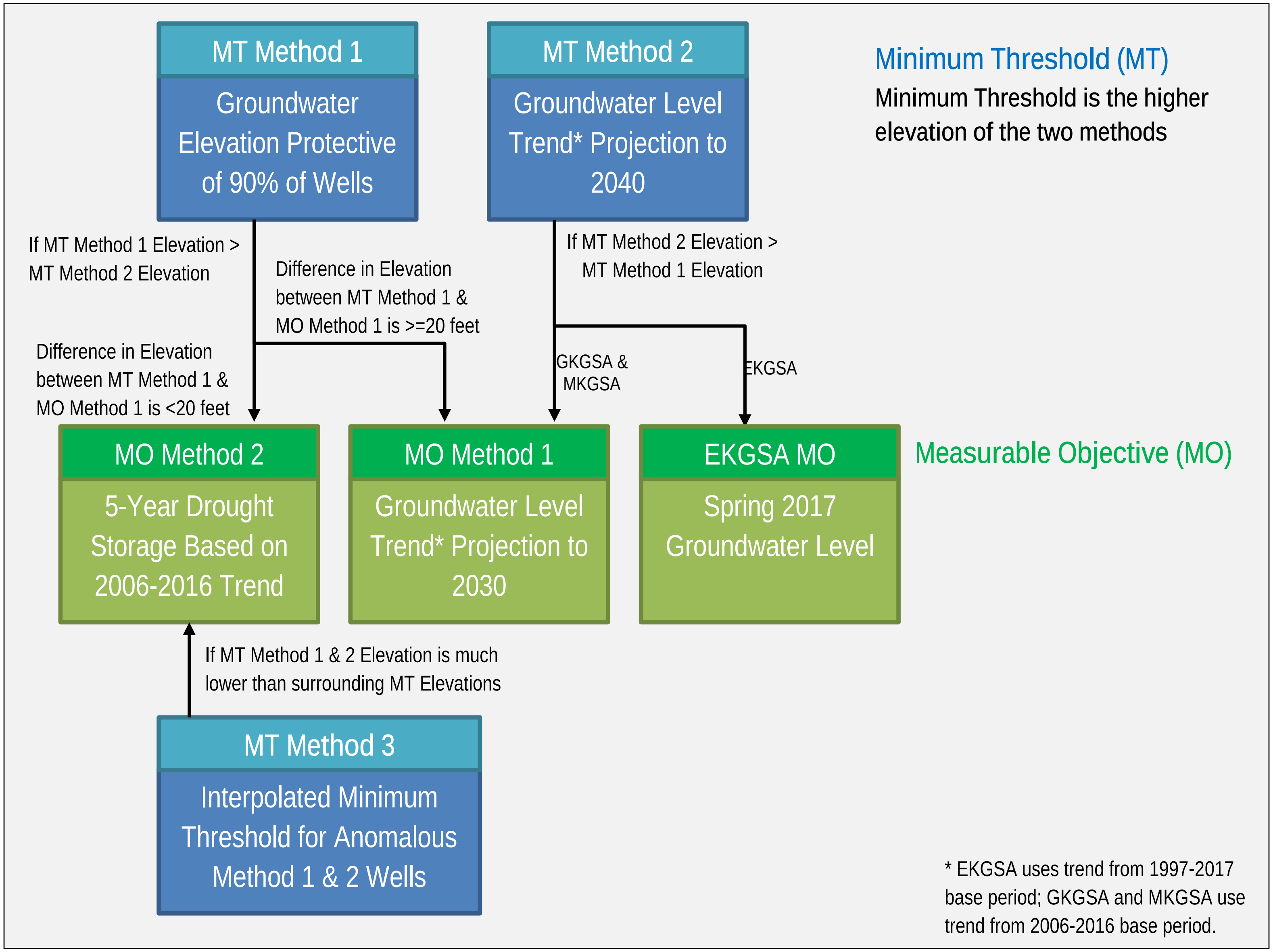



Figure 17. Relationship Between Minimum Threshold and Measurable Objective Methodologies

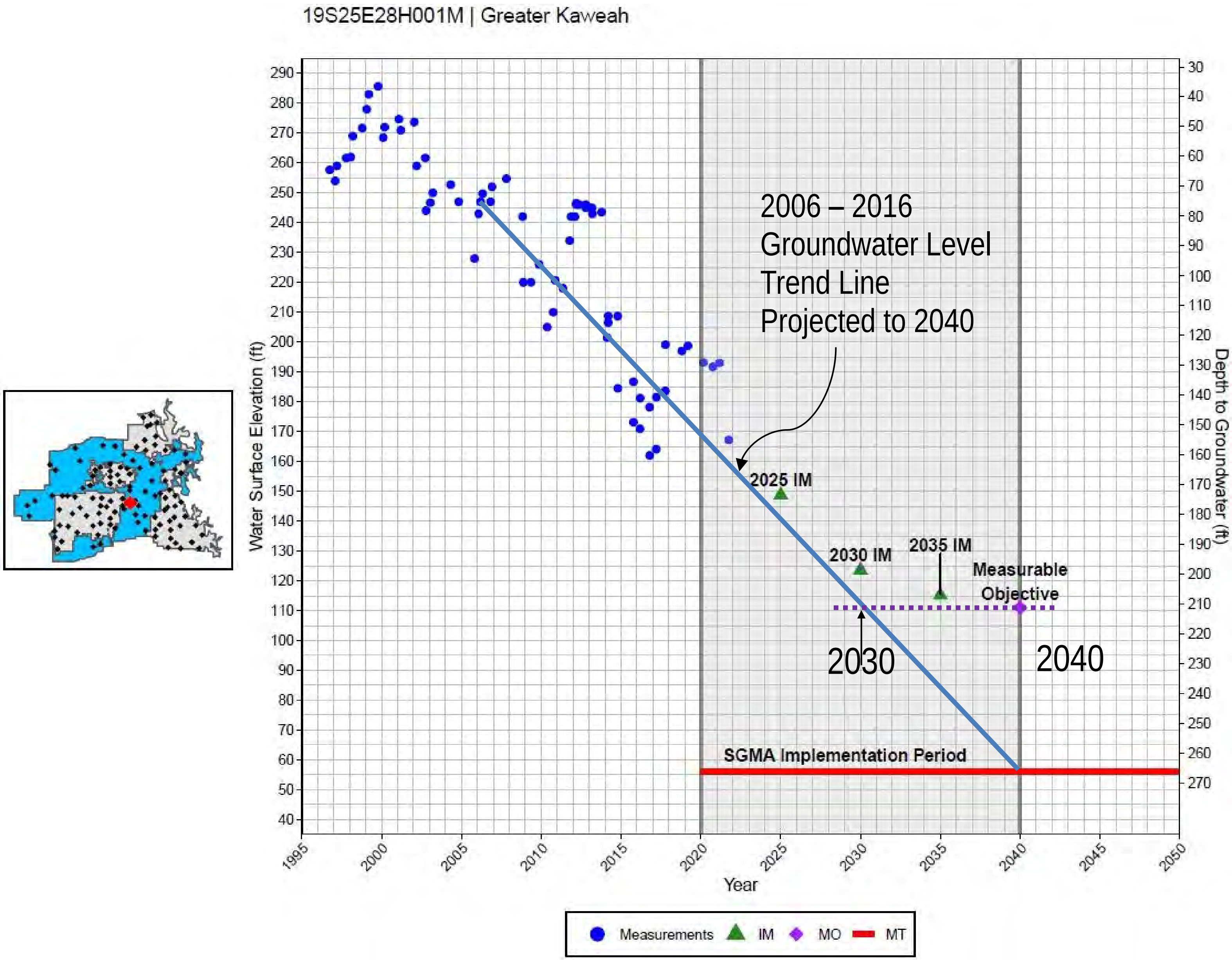



Figure 18. Example Hydrograph Showing Projection of 2006 – 2016 Trend Line

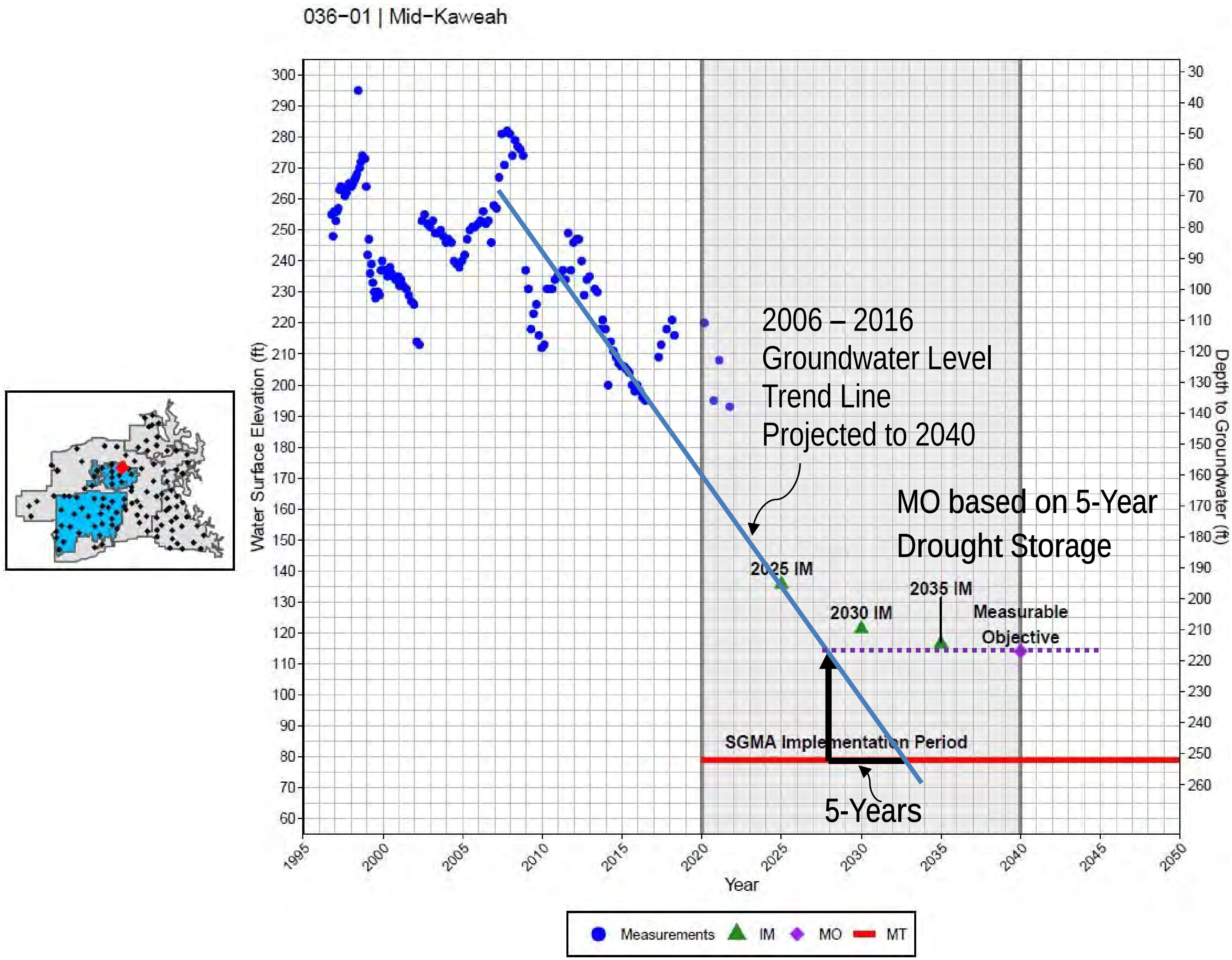



Figure 19. Example Hydrograph Showing Measurable Objective Based on 5-Year Drought Storage

## 3.2 Interim Milestone Methodology

Interim milestones for all representative monitoring sites take the form of a curve that flattens out toward 2040 when the MO is reached. The curve shape is determined based on implementation of projects and management actions over the next 18 years.

For the EKGSA, interim milestones are proportional to percent of overdraft to be corrected in 5-year intervals through implementation period. The interim milestones leading to groundwater level stabilization are unique to each analysis zone but follow the same incremental mitigation rate for correction of 5%, 25%, 55%, and 100% by 2025, 2030, 2035, and 2040, respectively.

Interim milestones for GKGSA and MKGSA representative monitoring sites are based on incrementally decreasing groundwater level change over time based on the following:

- 2025 interim milestone– extend the 2006-2016 groundwater level trend to 2025
- 2030 interim milestone –elevation at two-thirds of the elevation difference between the 2025 interim milestone and the MO
- 2035 interim milestone - elevation at two-thirds of the elevation difference between the 2030 interim milestone and the MO

The method for setting GKGSA and MKGSA interim milestones is illustrated on Figure 20.

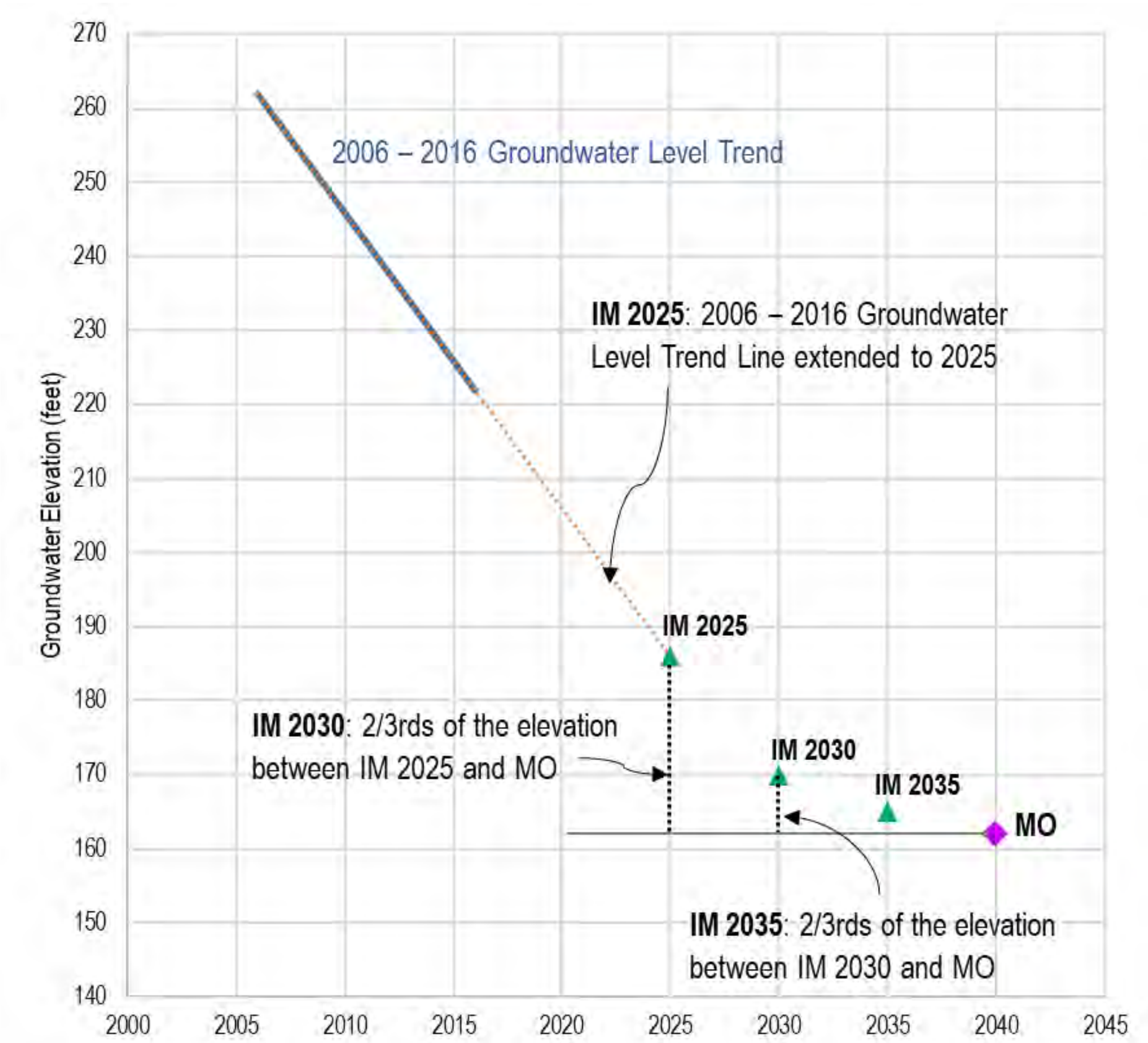



Figure 20. Example of Interim Milestone Method for GKGSA and MKGSA Represenative Monitoring Sites

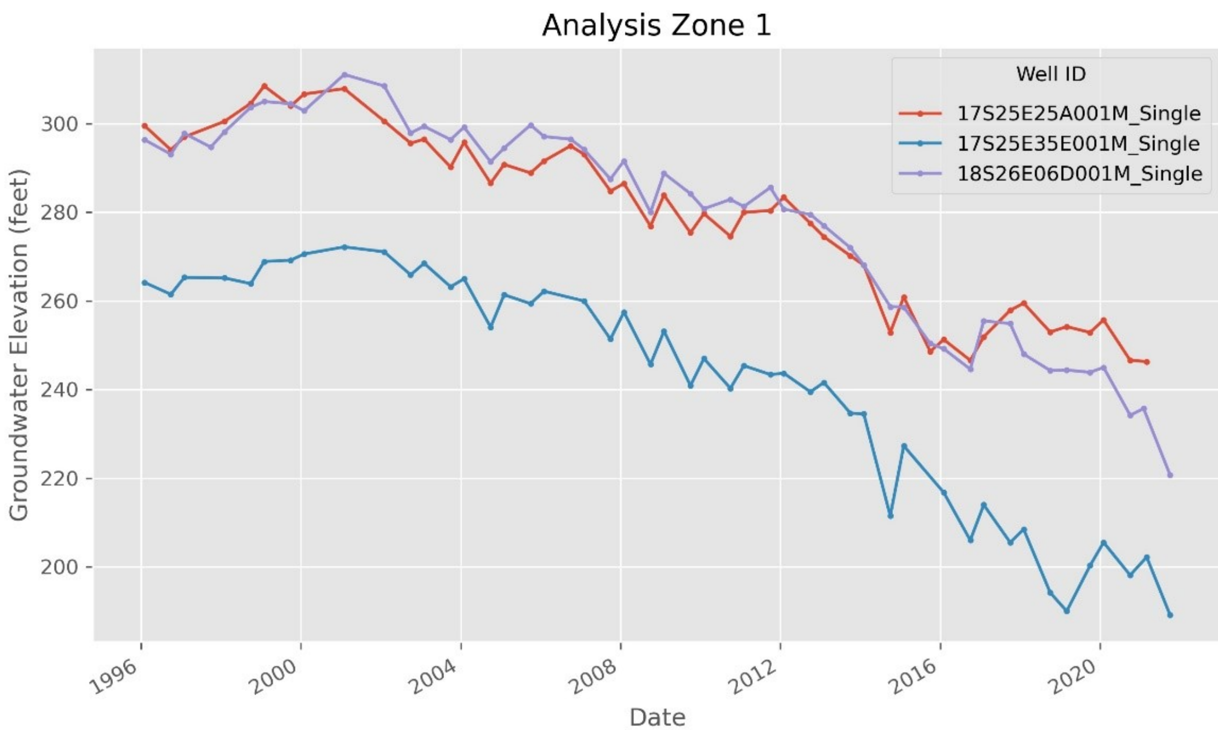
# 4 REFERENCES

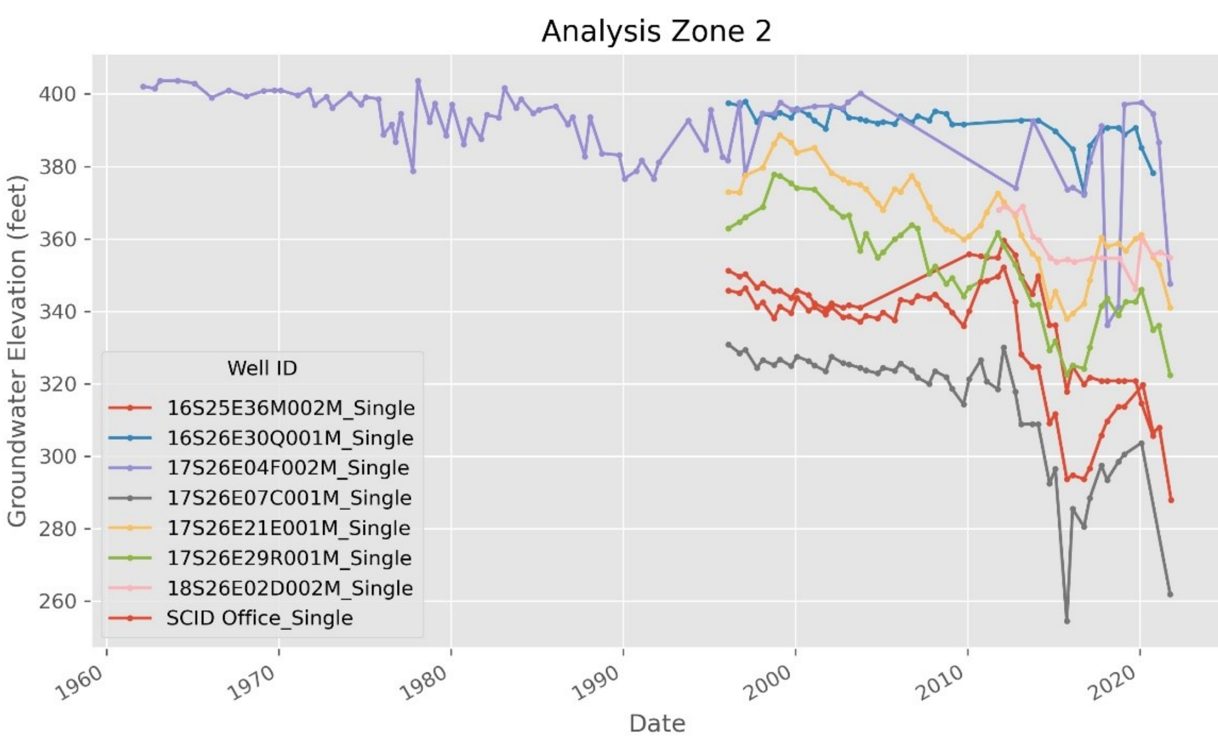
Kang, S., Knight, R., & Goebel, M. (2022). Improved imaging of the large-scale structure of a groundwater system with airborne electromagnetic data. *Water Resources Research*, 58, e2021WR031439. https://doi.org/10.1029/2021WR031439

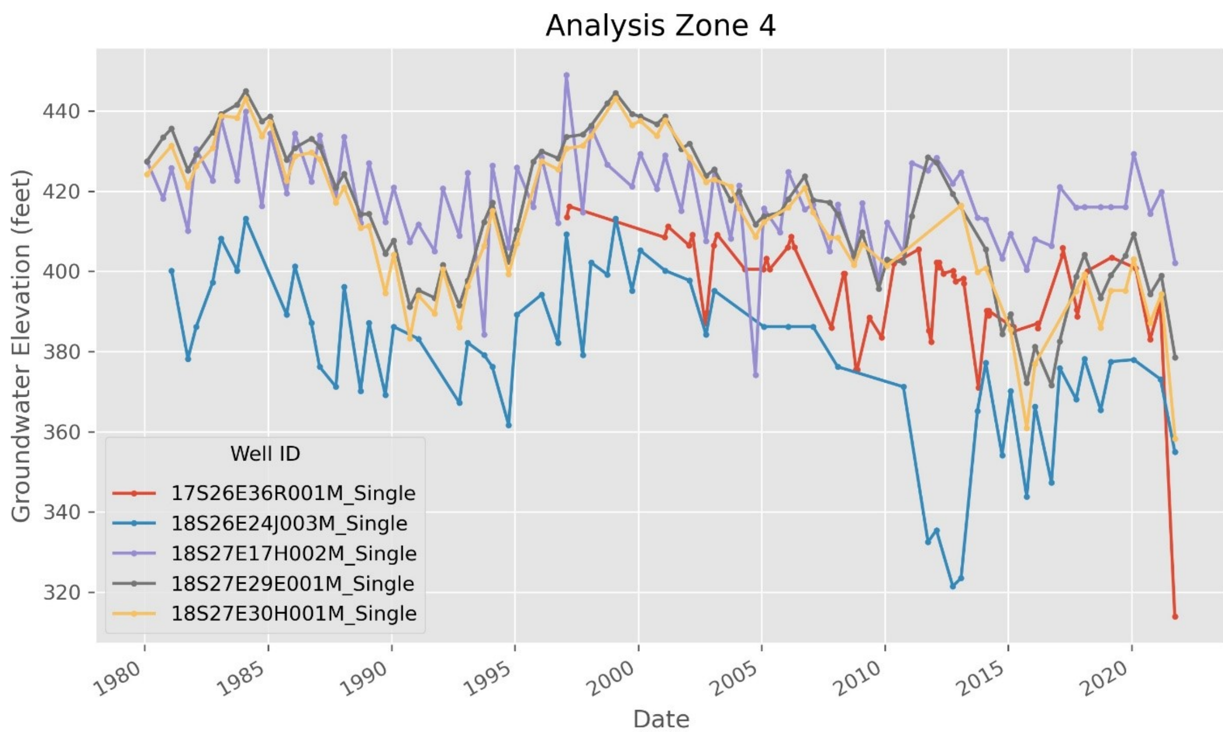
MONTGOMERY & ASSOCIATES

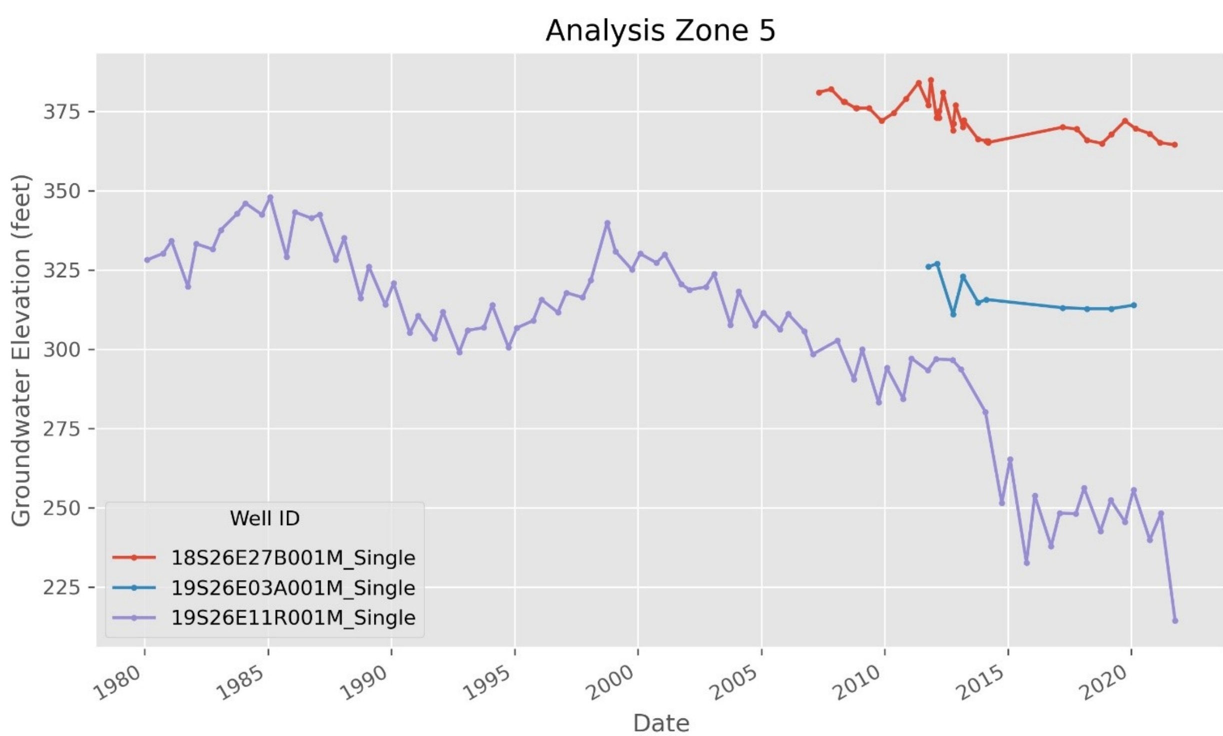
# Appendix A

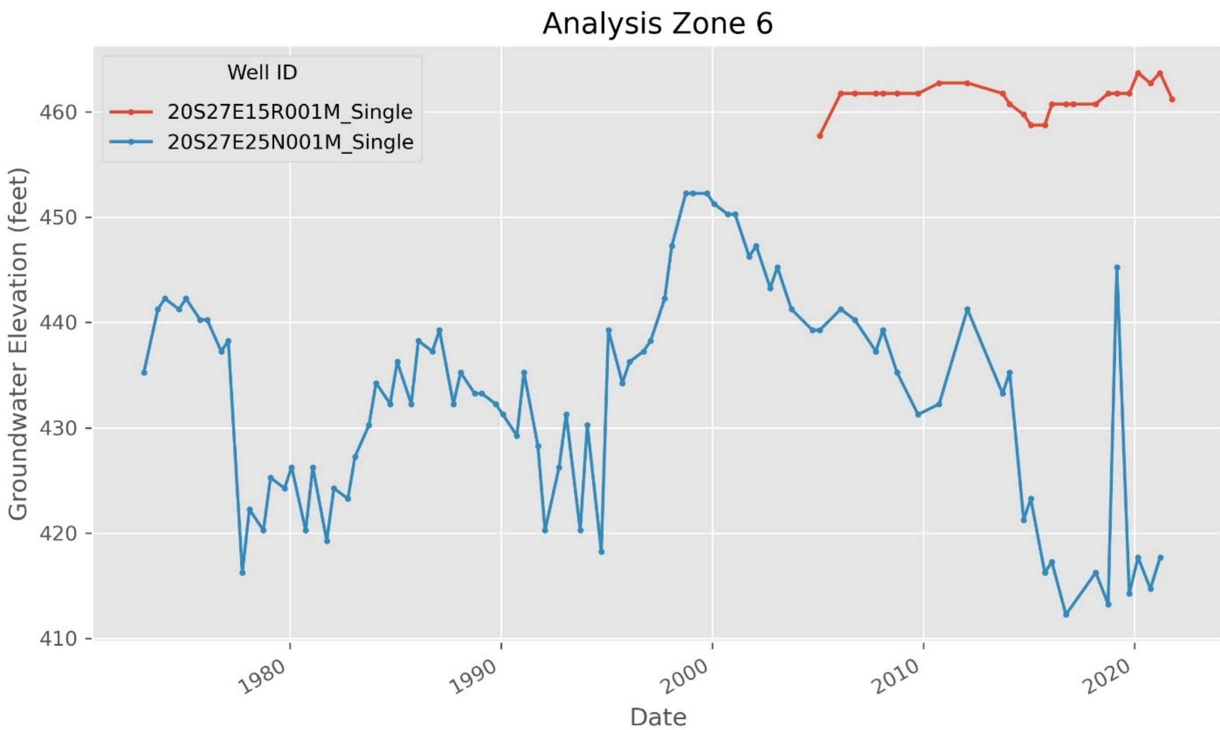
# Representative Monitoring Site Hydrographs by Aquifer and Analysis Zone

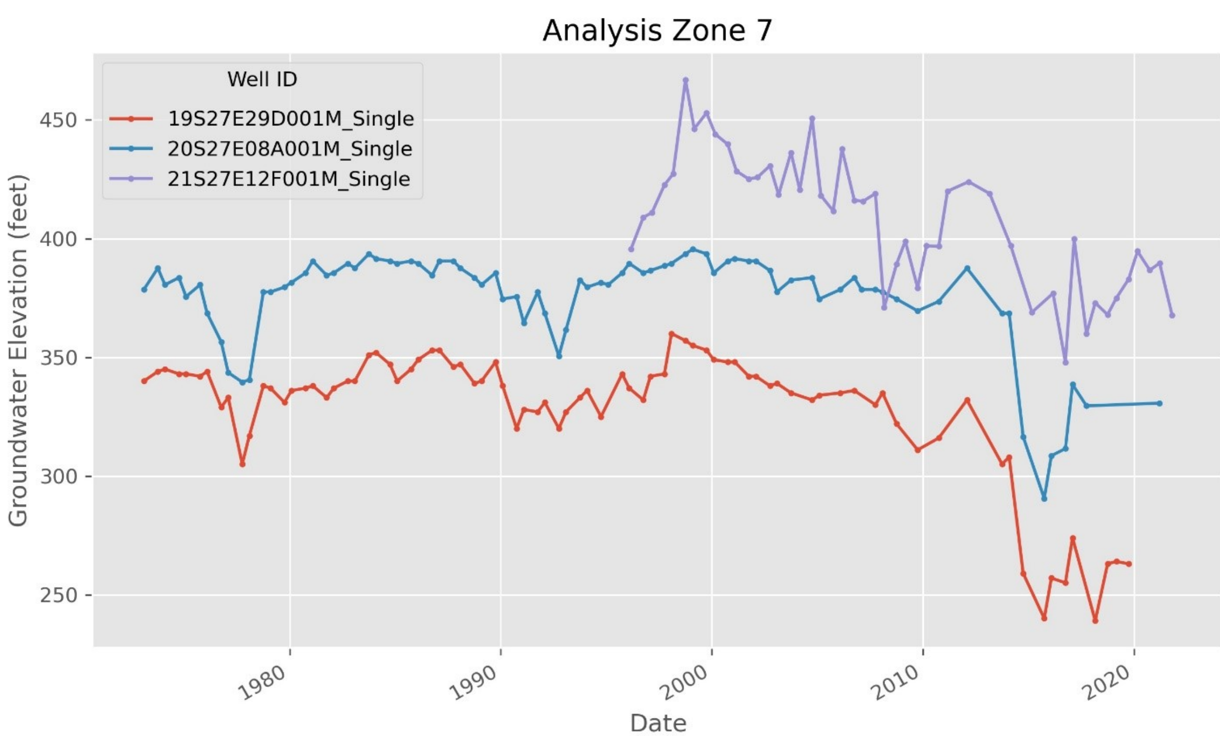

Analysis Zone 1
Well ID
17S25E25A001M_Single
17S25E35E001M_Single
18S26E06D001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date

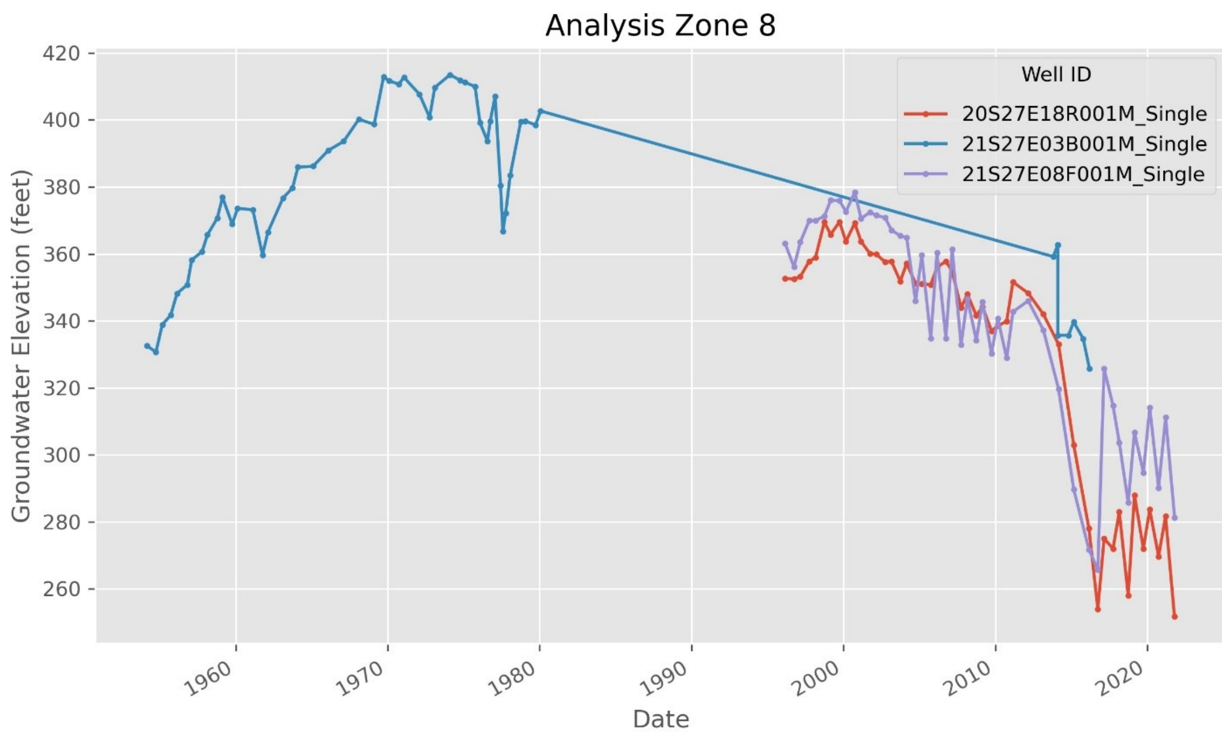

Analysis Zone 2
Well ID
16S25E36M002M_Single
16S26E30Q001M_Single
17S26E04F002M_Single
17S26E07C001M_Single
17S26E21E001M_Single
17S26E29R001M_Single
18S26E02D002M_Single
SCID Office_Single
Groundwater Elevation (feet)
400
380
360
340
320
300
280
260
1960
1970
1980
1990
2000
2010
2020
Date

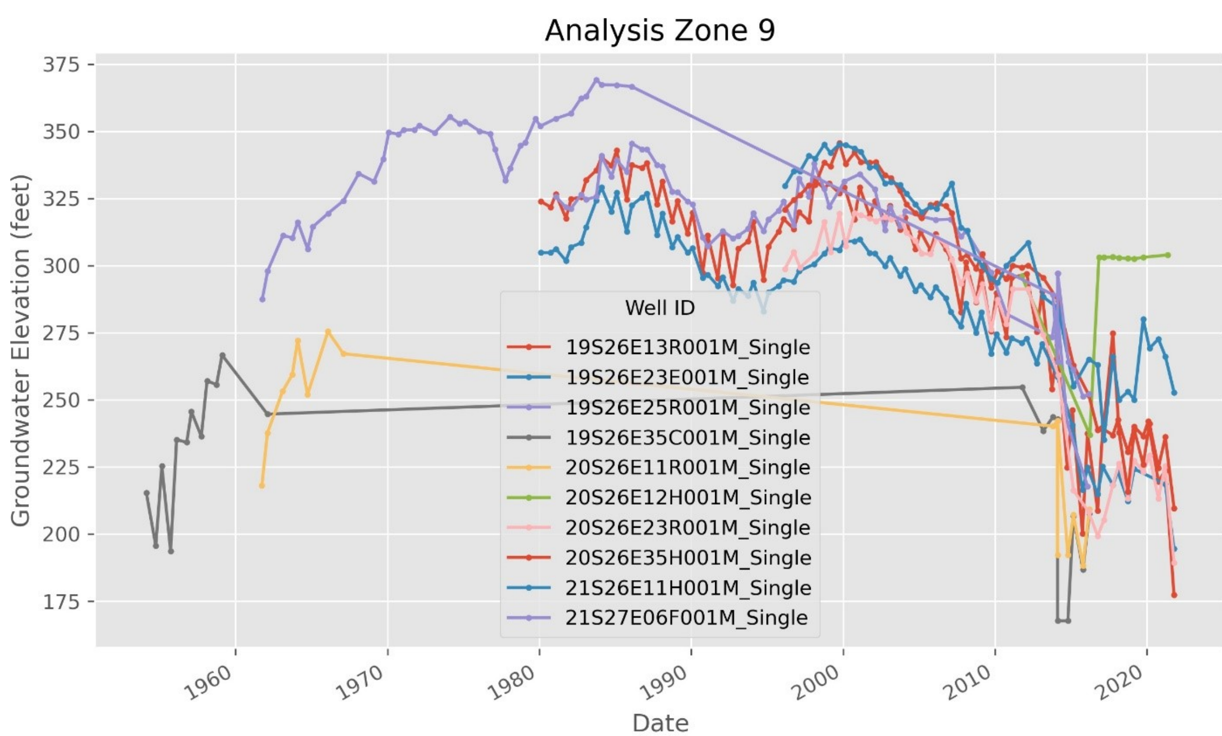

Analysis Zone 4
Groundwater Elevation (feet)
440
420
400
380
360
340
320
Well ID
17S26E36R001M_Single
18S26E24J003M_Single
18S27E17H002M_Single
18S27E29E001M_Single
18S27E30H001M_Single
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

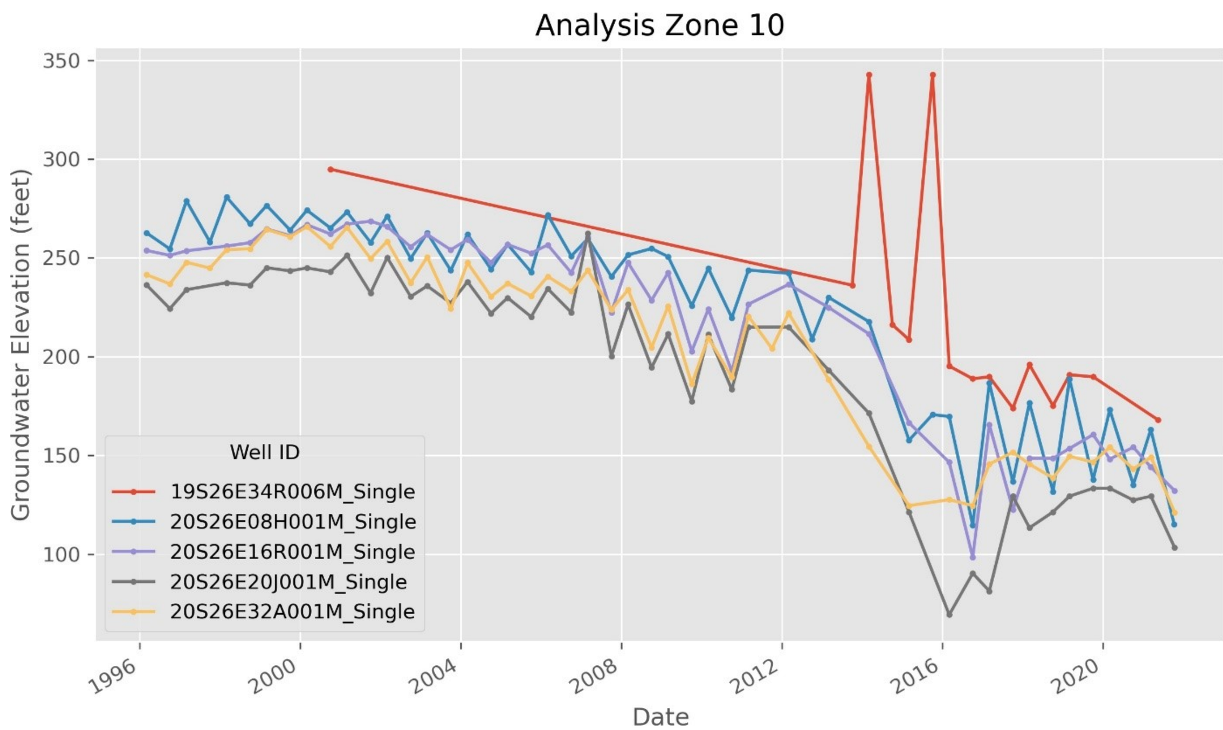

Analysis Zone 5
Groundwater Elevation (feet)
375
350
325
300
275
250
225
Well ID
18S26E27B001M_Single
19S26E03A001M_Single
19S26E11R001M_Single
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date

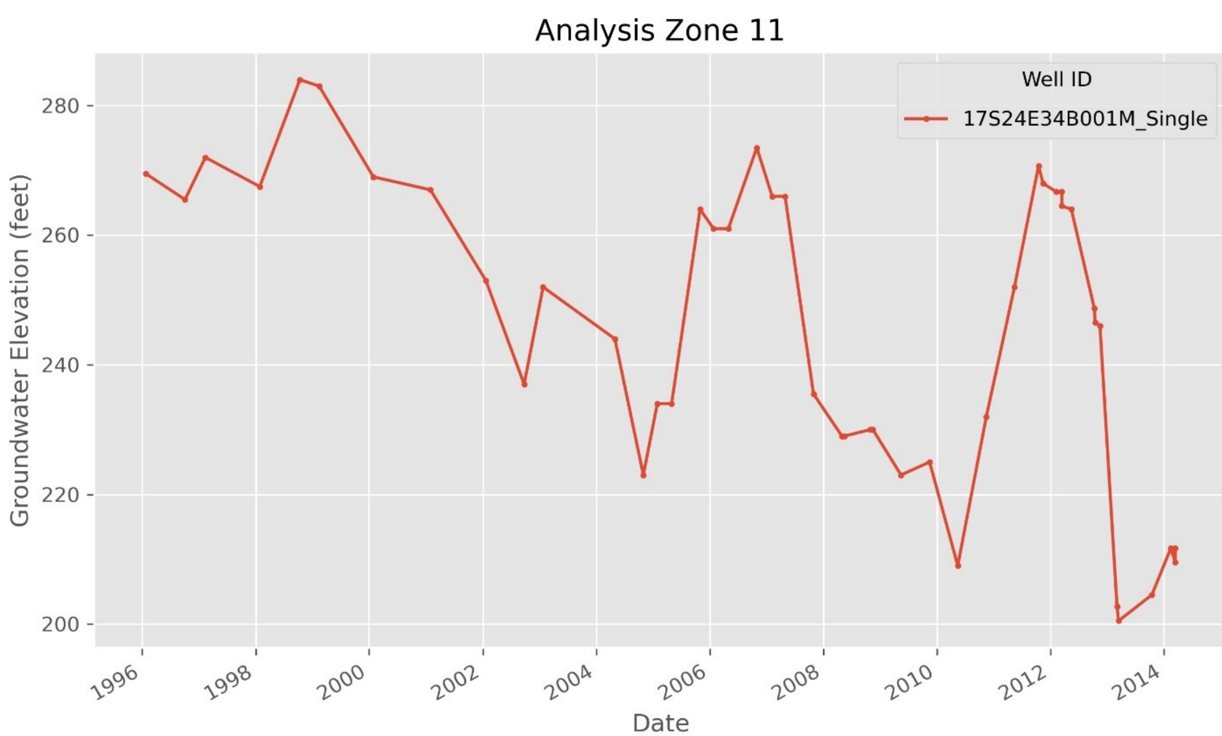

Analysis Zone 6
Well ID
20S27E15R001M_Single
20S27E25N001M_Single
Groundwater Elevation (feet)
460
450
440
430
420
410
1980
1990
2000
2010
2020
Date

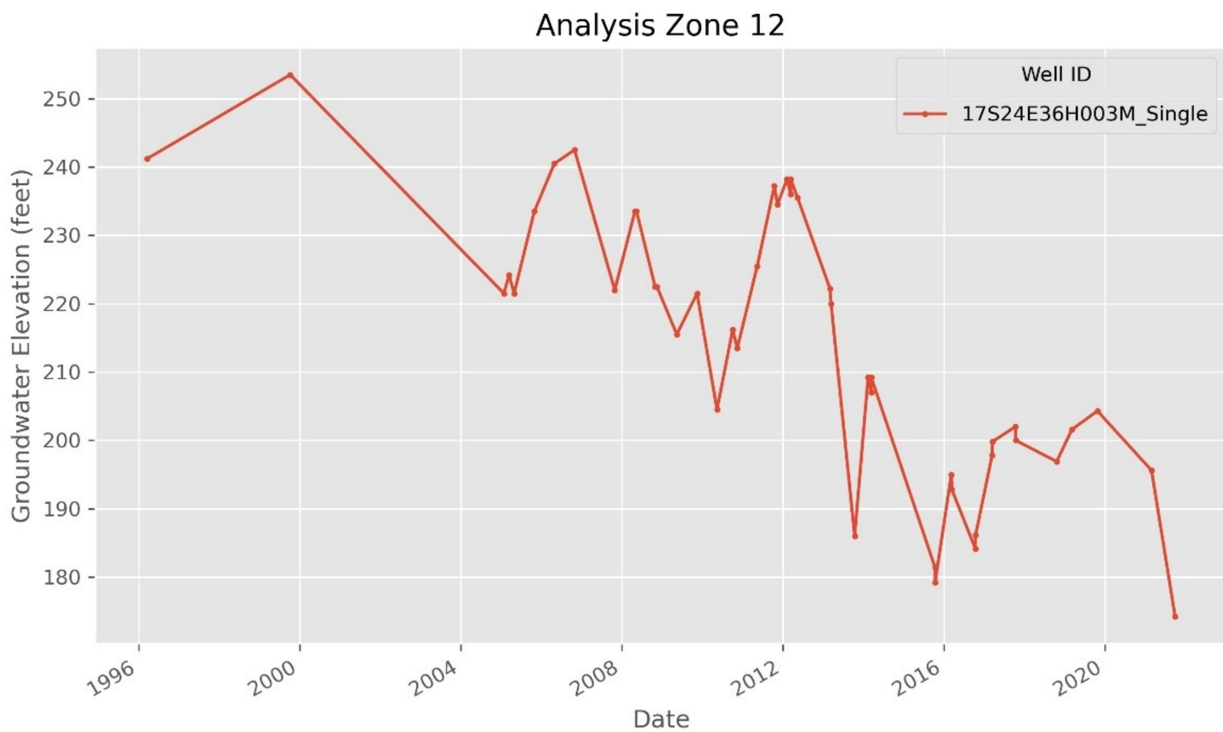

Analysis Zone 7
Well ID
19S27E29D001M_Single
20S27E08A001M_Single
21S27E12F001M_Single
Groundwater Elevation (feet)
450
400
350
300
250
1980
1990
2000
2010
2020
Date

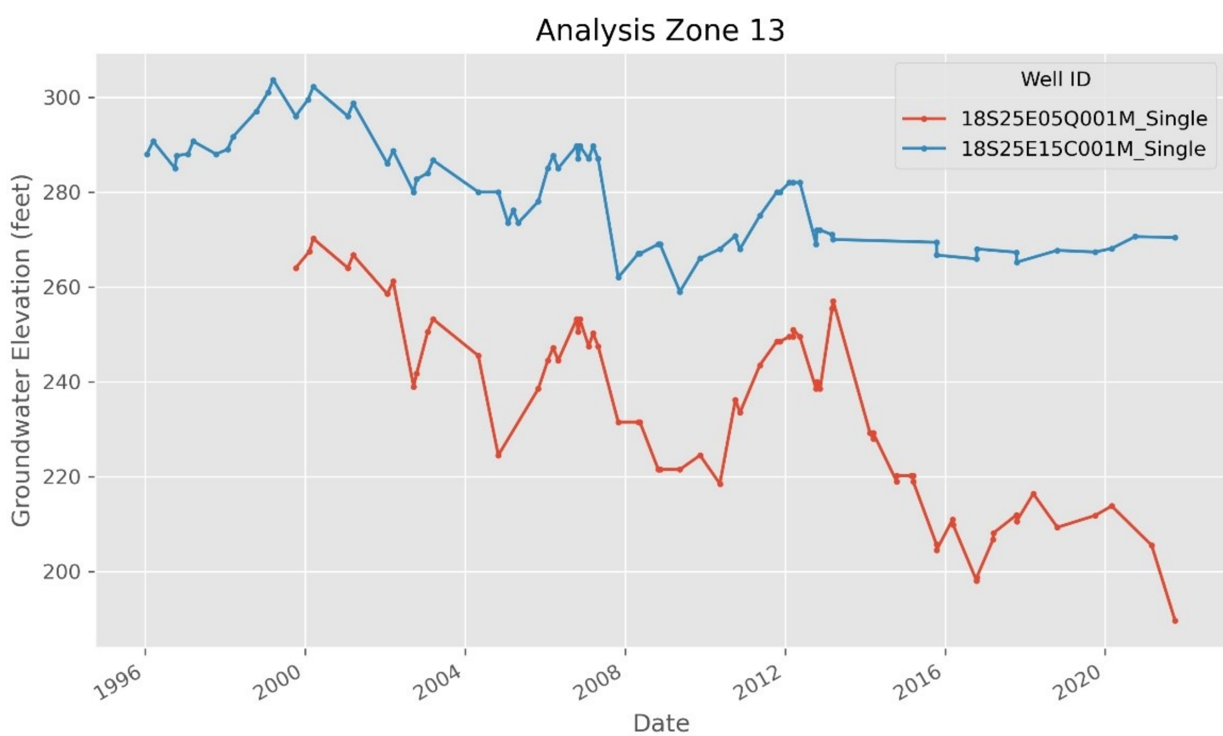

Analysis Zone 8
Groundwater Elevation (feet)
Date
Well ID
20S27E18R001M_Single
21S27E03B001M_Single
21S27E08F001M_Single
420
400
380
360
340
320
300
280
260
1960
1970
1980
1990
2000
2010
2020

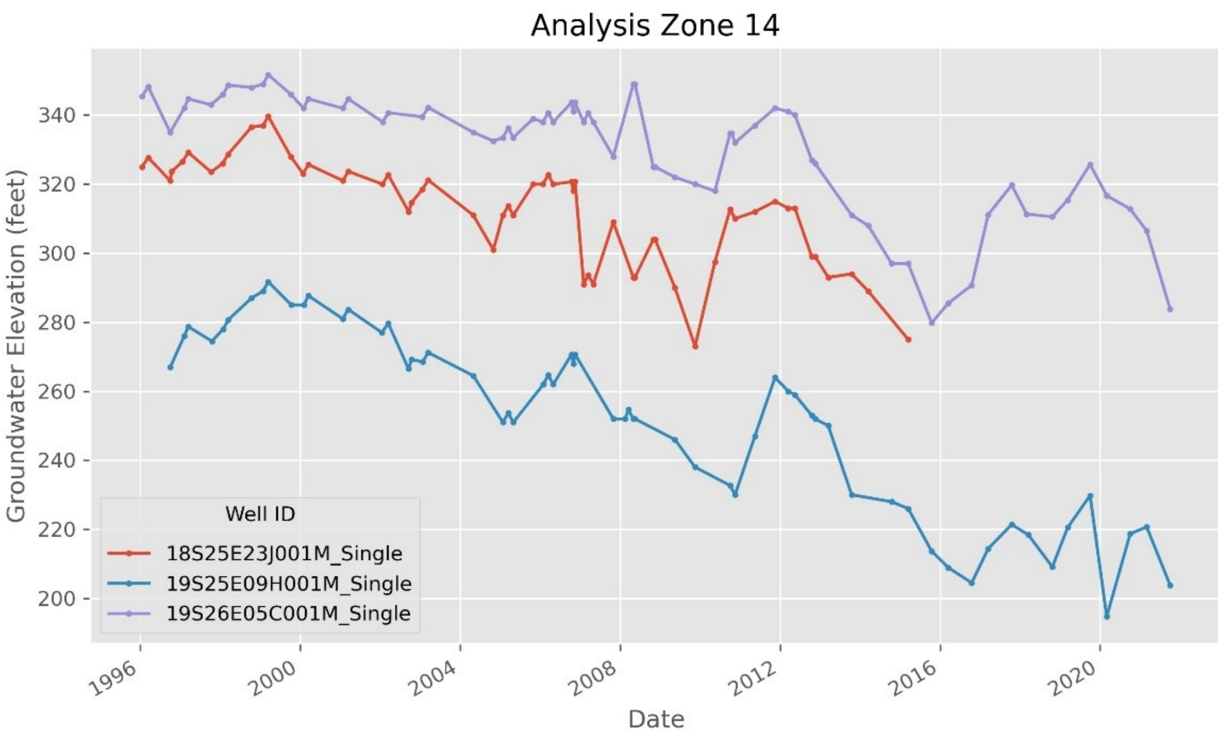

Analysis Zone 9
Groundwater Elevation (feet)
Date
Well ID
19S26E13R001M_Single
19S26E23E001M_Single
19S26E25R001M_Single
19S26E35C001M_Single
20S26E11R001M_Single
20S26E12H001M_Single
20S26E23R001M_Single
20S26E35H001M_Single
21S26E11H001M_Single
21S27E06F001M_Single
375
350
325
300
275
250
225
200
175
1960
1970
1980
1990
2000
2010
2020

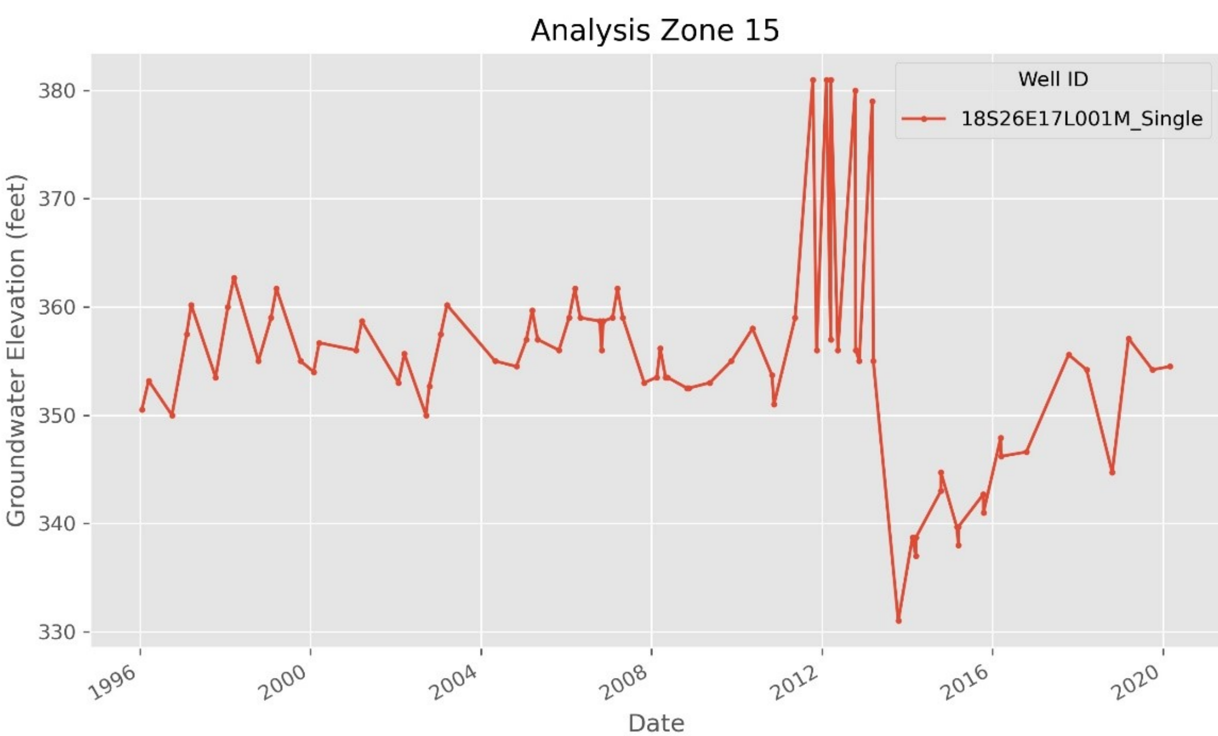

Analysis Zone 10
Groundwater Elevation (feet)
350
300
250
200
150
100
Well ID
19S26E34R006M_Single
20S26E08H001M_Single
20S26E16R001M_Single
20S26E20J001M_Single
20S26E32A001M_Single
1996
2000
2004
2008
2012
2016
2020
Date

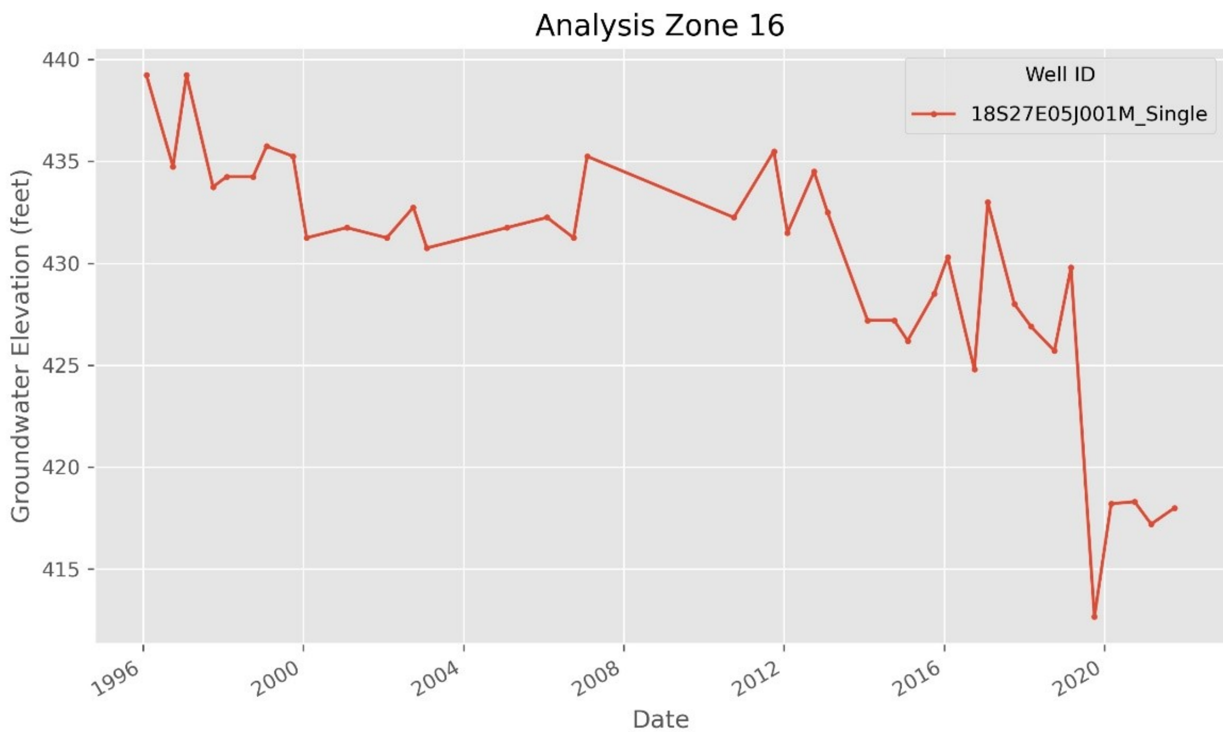

Analysis Zone 11
Groundwater Elevation (feet)
280
260
240
220
200
Well ID
17S24E34B001M_Single
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Date

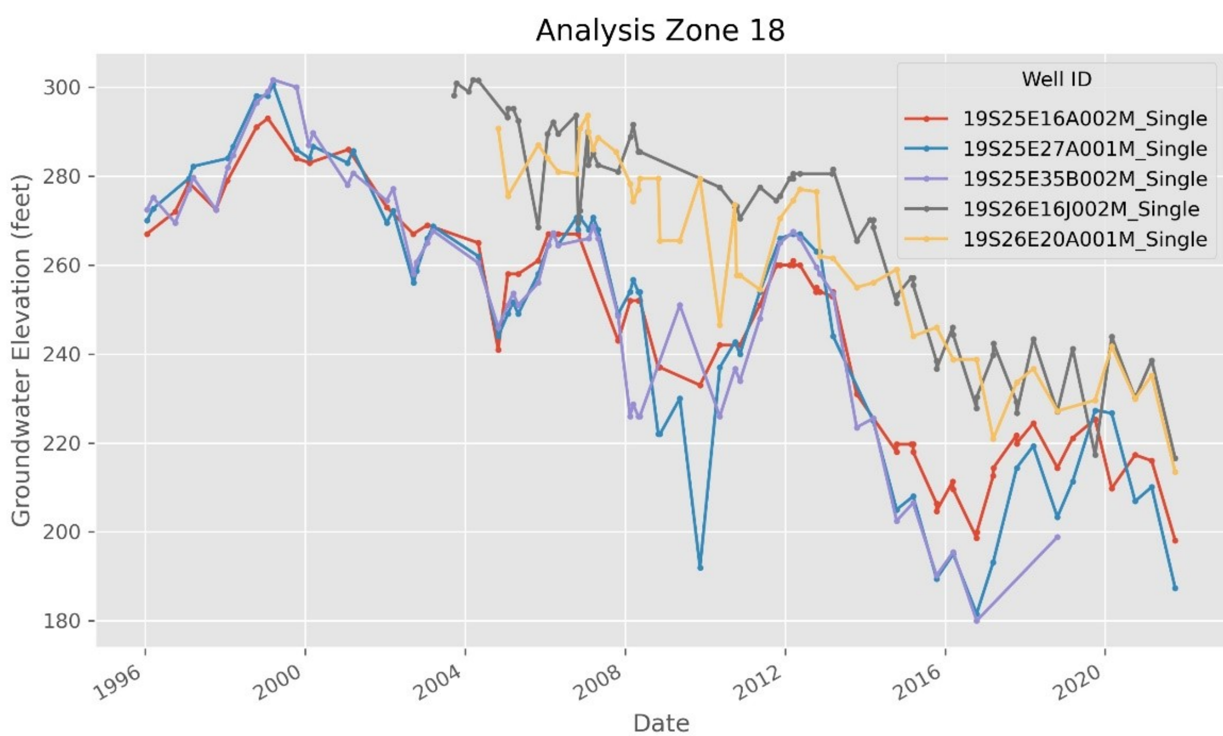

Analysis Zone 12
Well ID
17S24E36H003M_Single
Groundwater Elevation (feet)
250
240
230
220
210
200
190
180
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 13
Well ID
18S25E05Q001M_Single
18S25E15C001M_Single
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 14
Groundwater Elevation (feet)
340
320
300
280
260
240
220
200
Well ID
18S25E23J001M_Single
19S25E09H001M_Single
19S26E05C001M_Single
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 15
Groundwater Elevation (feet)
380
370
360
350
340
330
Well ID
18S26E17L001M_Single
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 16
Well ID
18S27E05J001M_Single
Groundwater Elevation (feet)
440
435
430
425
420
415
Date
1996
2000
2004
2008
2012
2016
2020


Analysis Zone 18
Well ID
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19S25E27A001M_Single
19S25E35B002M_Single
19S26E16J002M_Single
19S26E20A001M_Single
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220
200
180
Date
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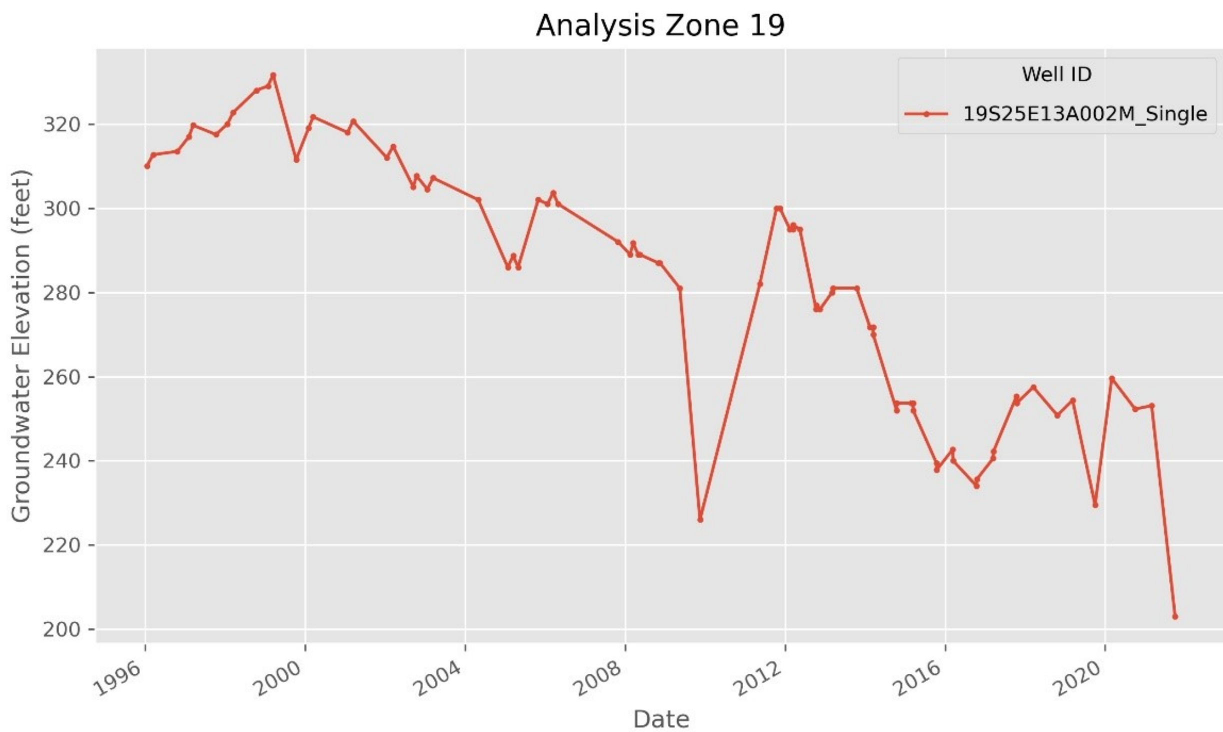
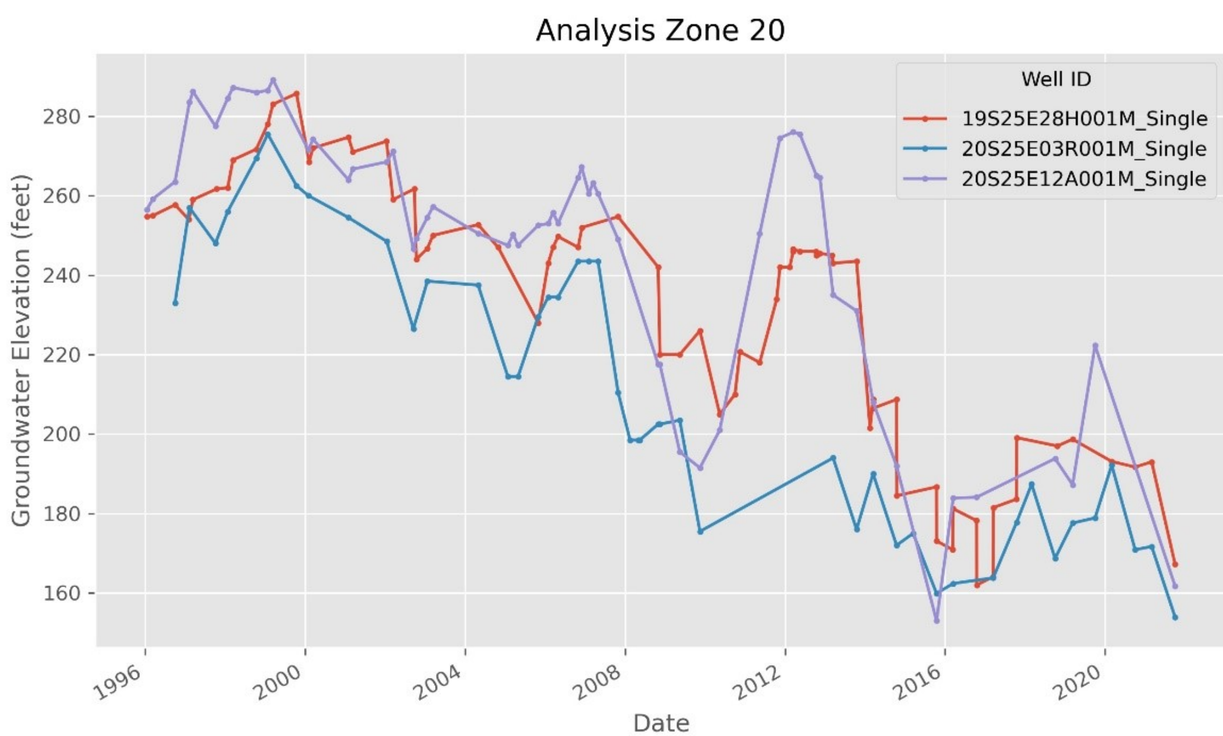
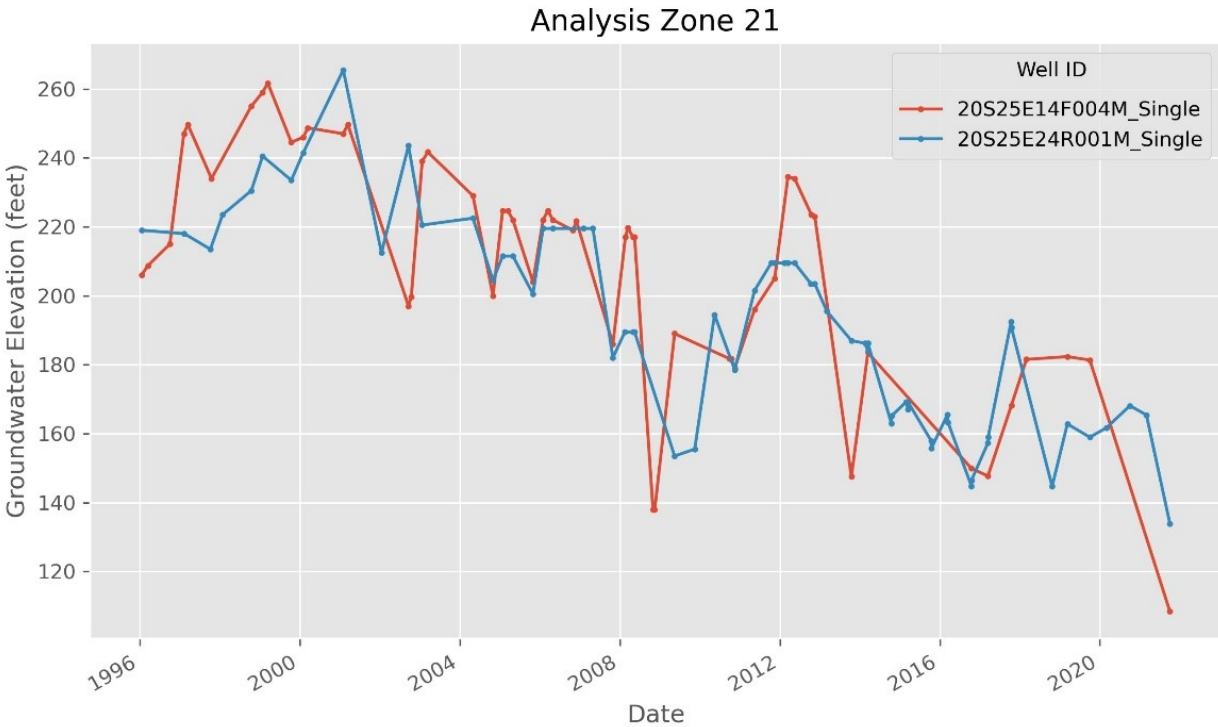
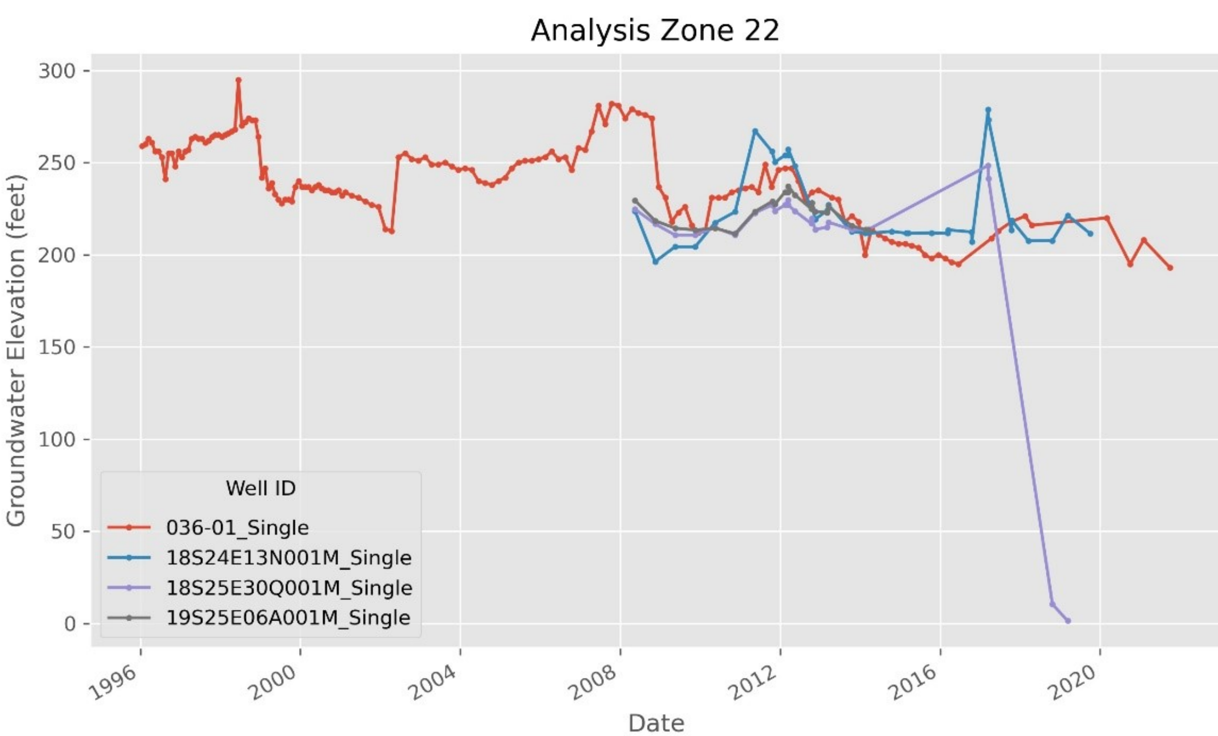
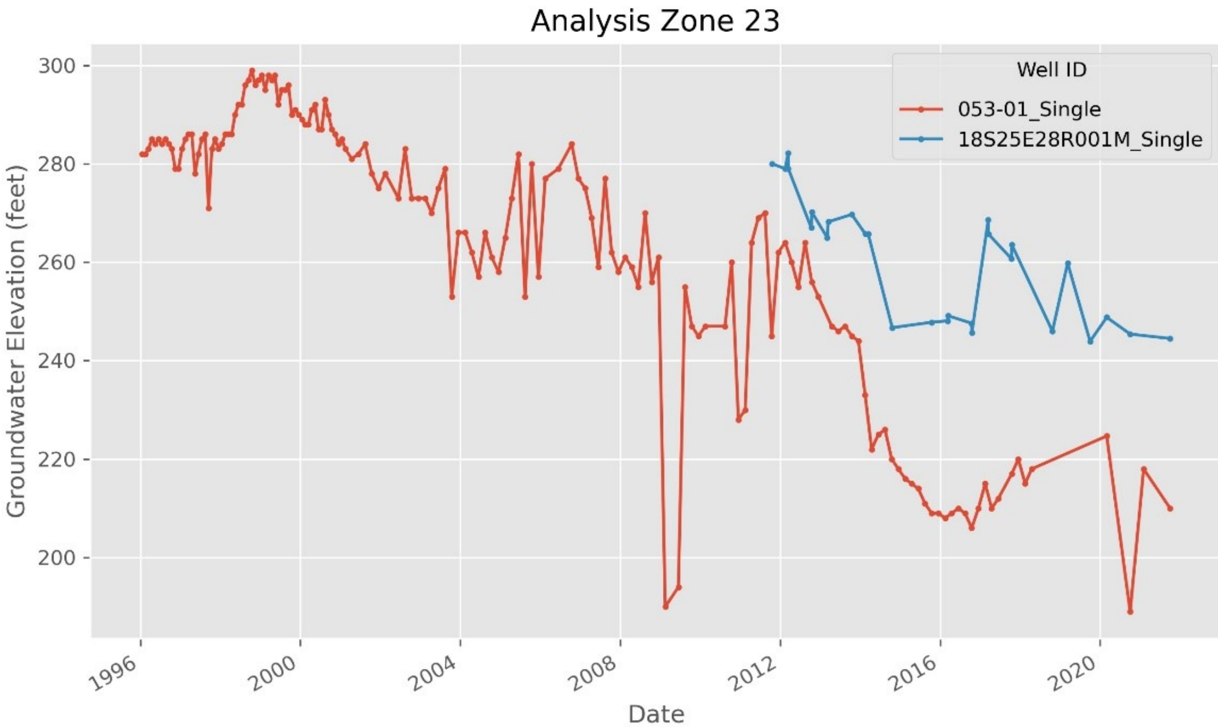
2000
2004
2008
2012
2016
2020

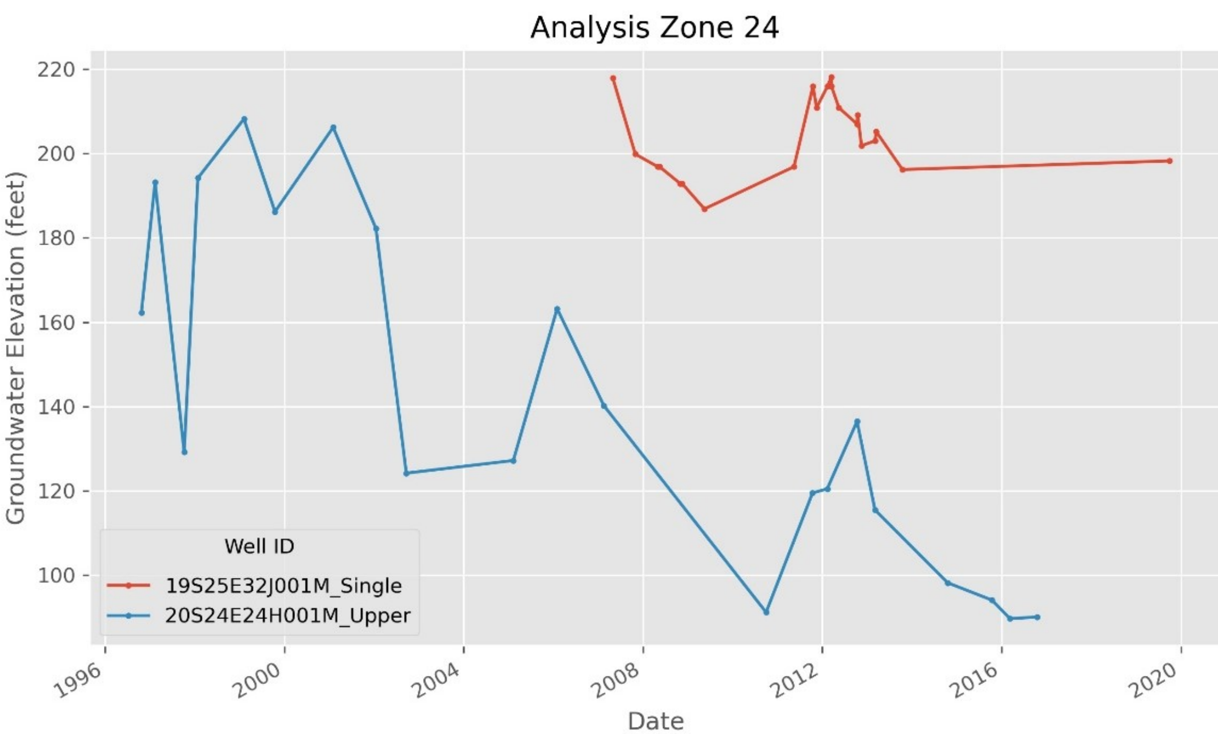

Analysis Zone 19
Well ID
19S25E13A002M_Single
Groundwater Elevation (feet)
320
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date

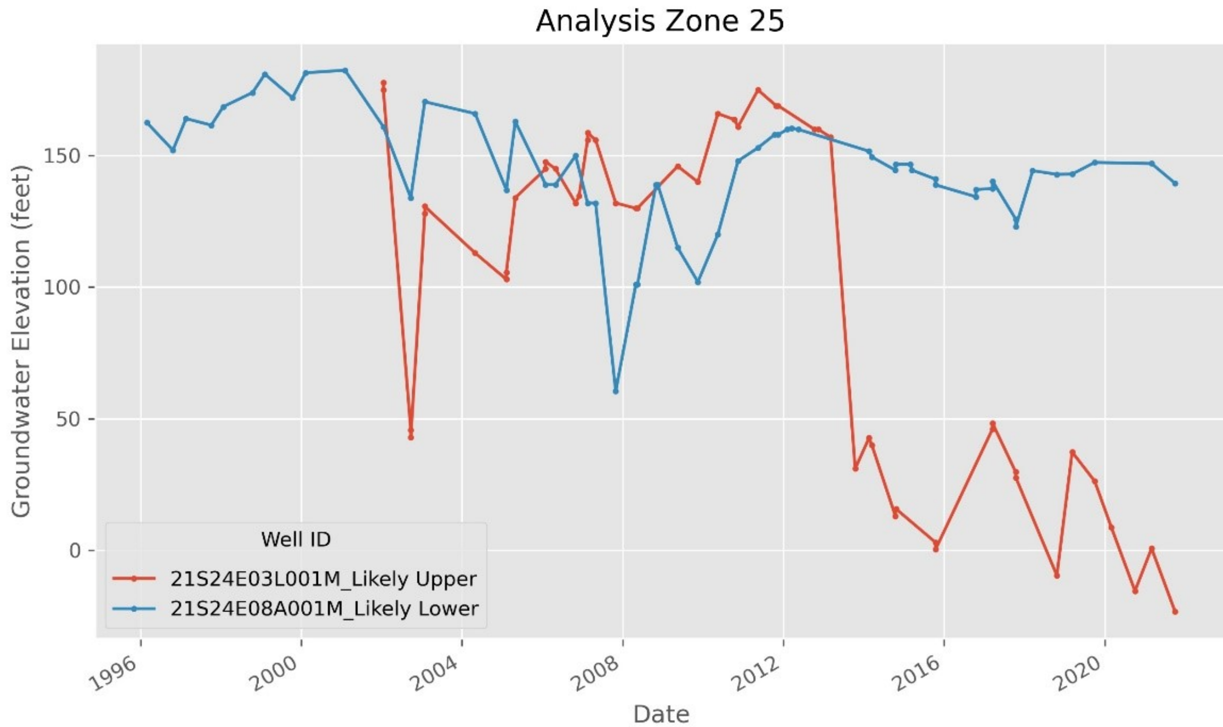

Analysis Zone 20
Well ID
19S25E28H001M_Single
20S25E03R001M_Single
20S25E12A001M_Single
Groundwater Elevation (feet)
280
260
240
220
200
180
160
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 21
Well ID
20S25E14F004M_Single
20S25E24R001M_Single
Groundwater Elevation (feet)
260
240
220
200
180
160
140
120
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 22
Well ID
036-01_Single
18S24E13N001M_Single
18S25E30Q001M_Single
19S25E06A001M_Single
Groundwater Elevation (feet)
300
250
200
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date


Analysis Zone 23
Groundwater Elevation (feet)
300
280
260
240
220
200
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
053-01_Single
18S25E28R001M_Single


Analysis Zone 24
Groundwater Elevation (feet)
220
200
180
160
140
120
100
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S25E32J001M_Single
20S24E24H001M_Upper


Analysis Zone 25
Groundwater Elevation (feet)
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
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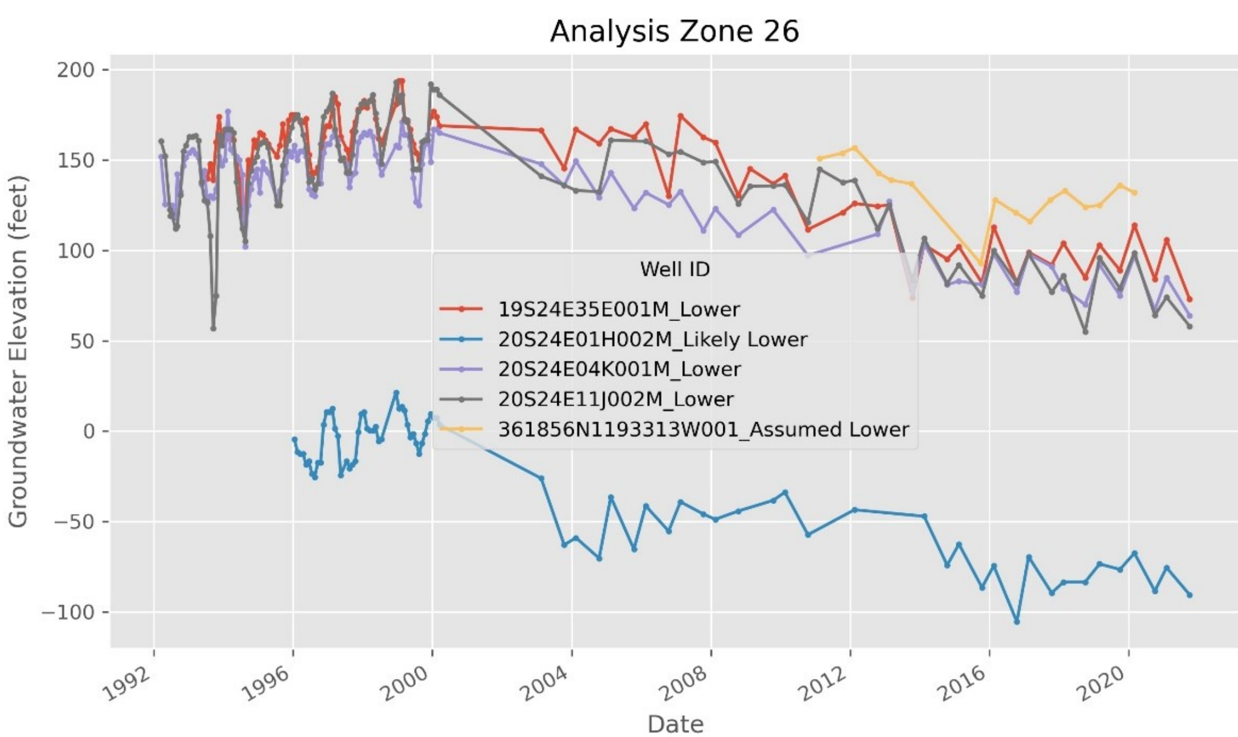
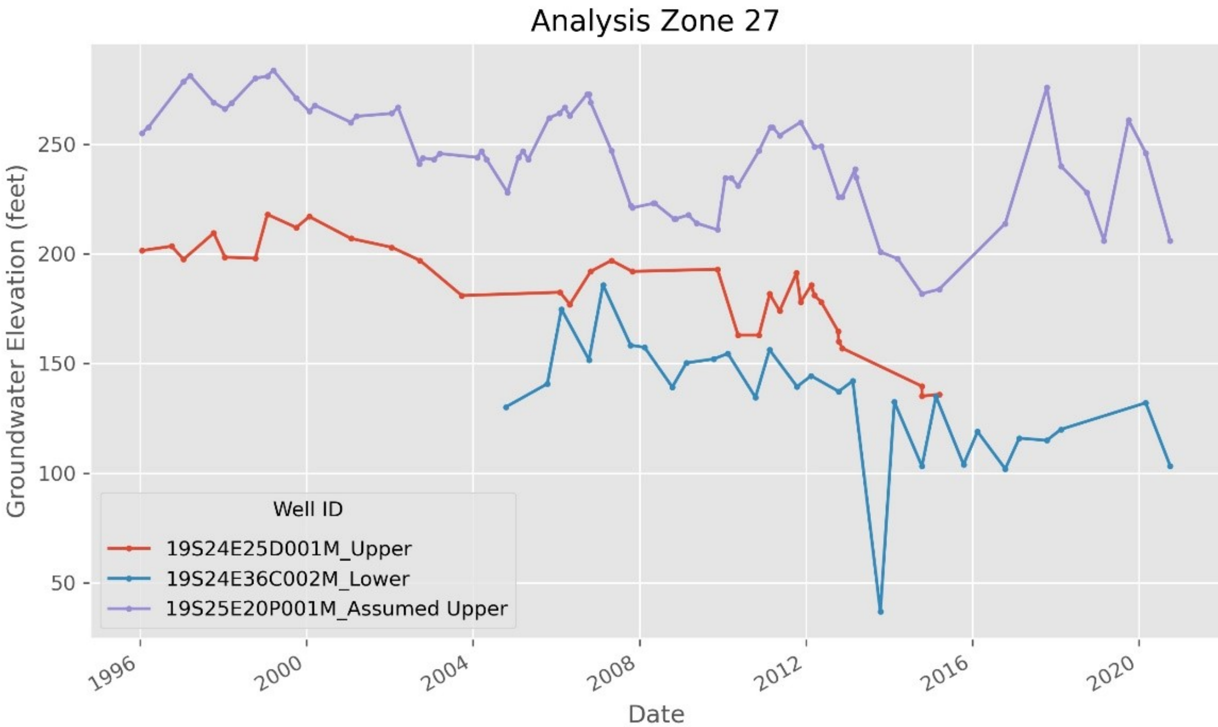
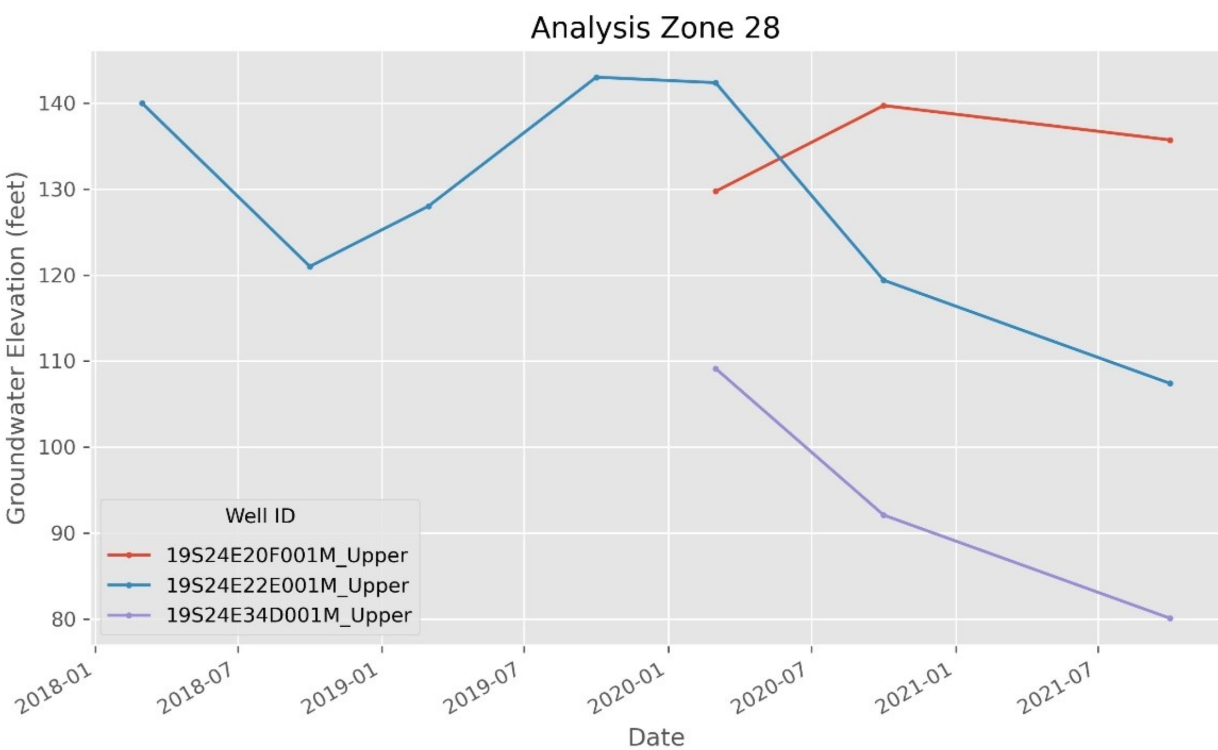
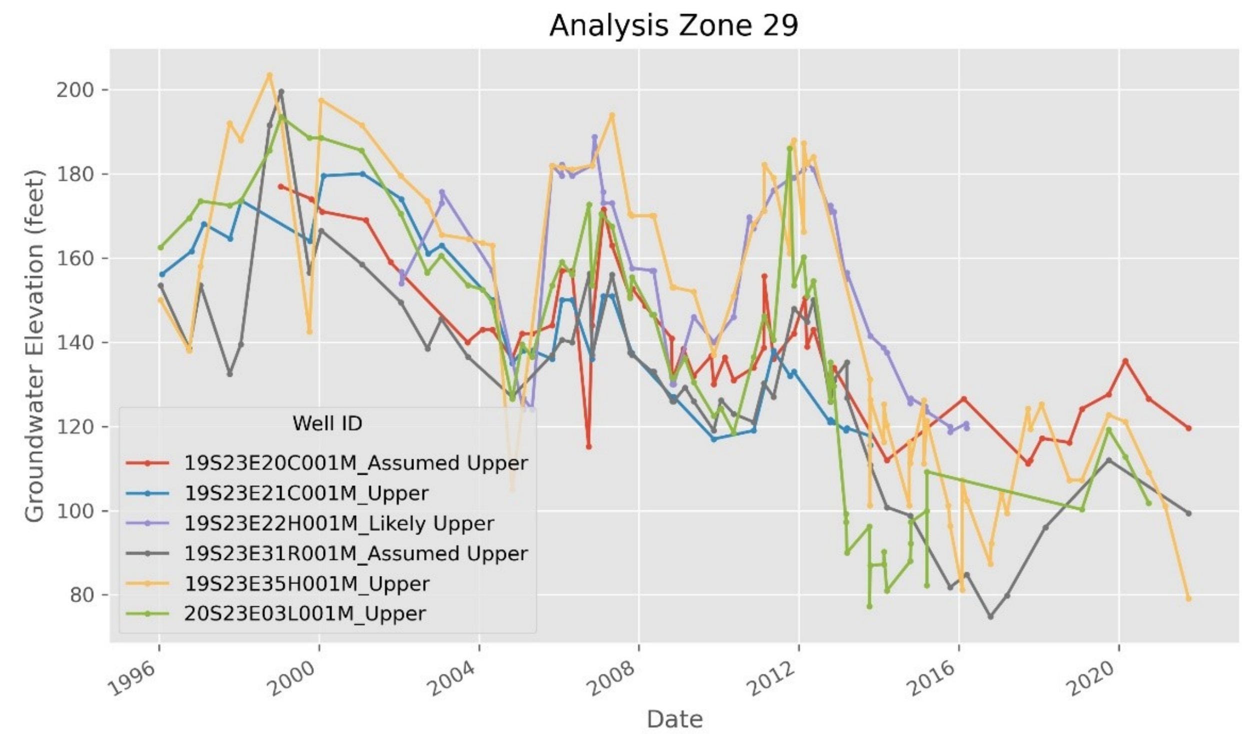
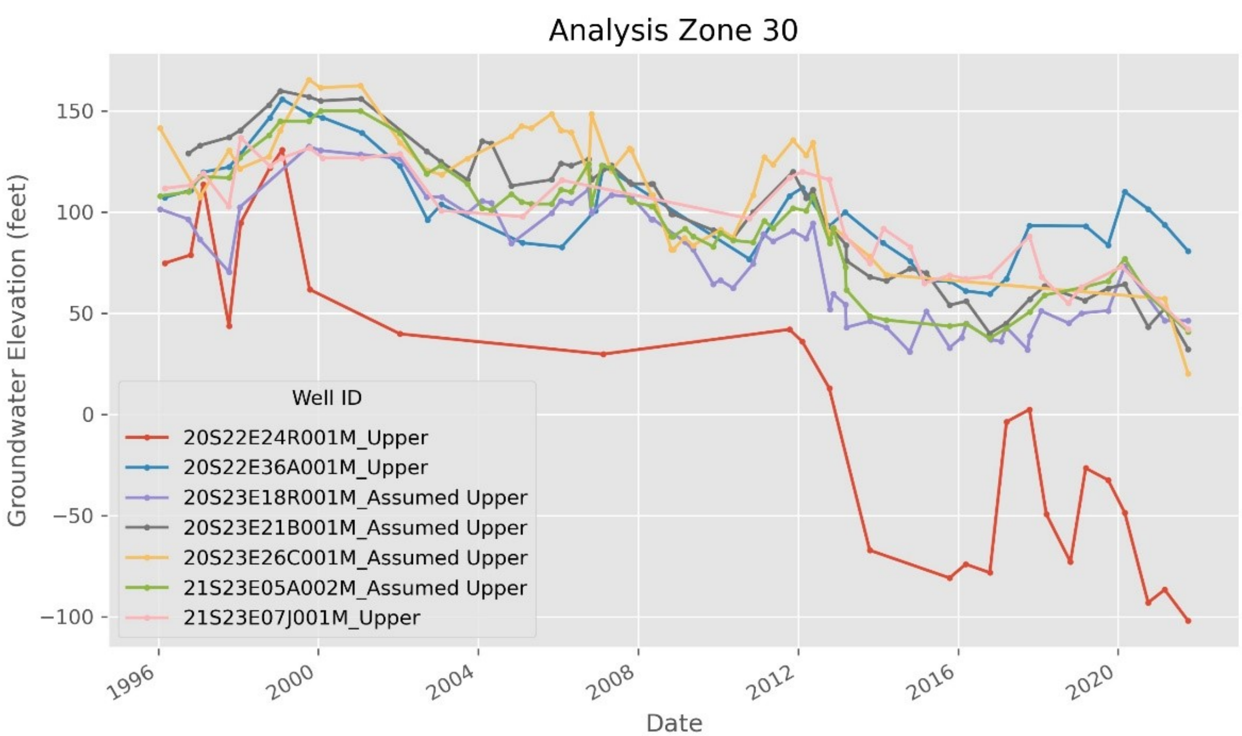
21S24E08A001M_Likely Lower

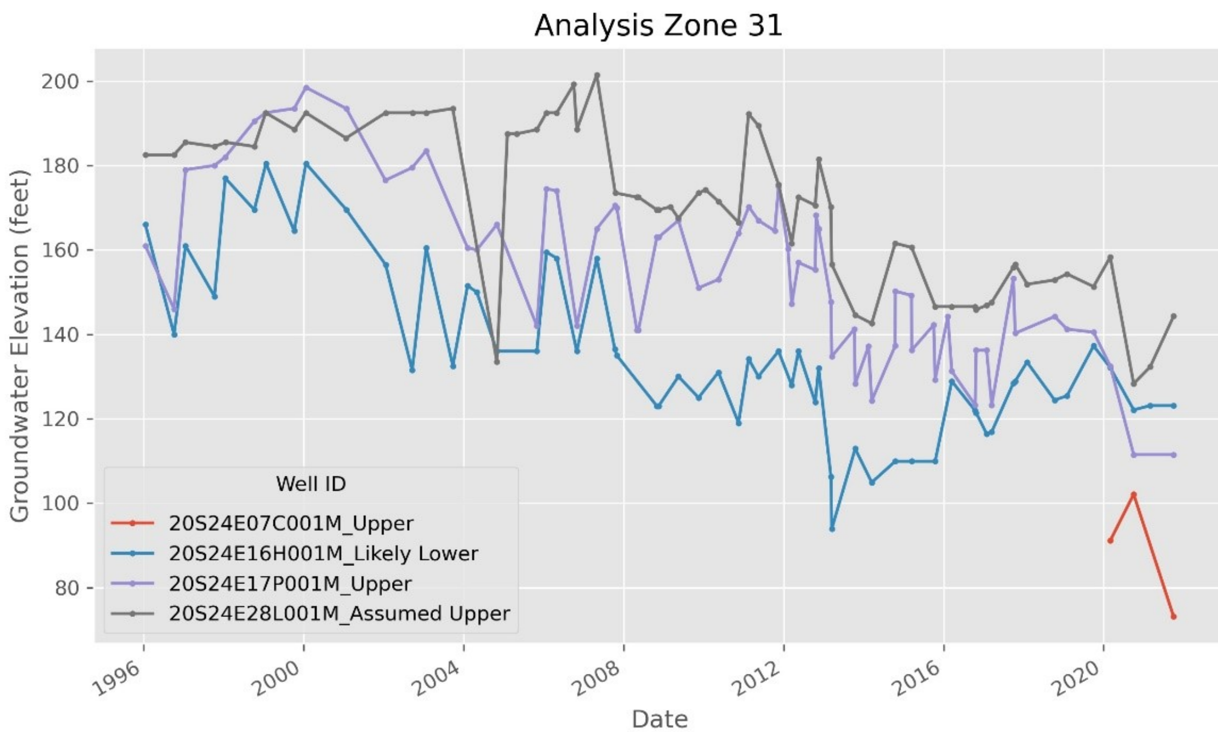

Analysis Zone 26
Groundwater Elevation (feet)
200
150
100
50
0
−50
−100
1992
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S24E35E001M_Lower
20S24E01H002M_Likely Lower
20S24E04K001M_Lower
20S24E11J002M_Lower
361856N1193313W001_Assumed Lower

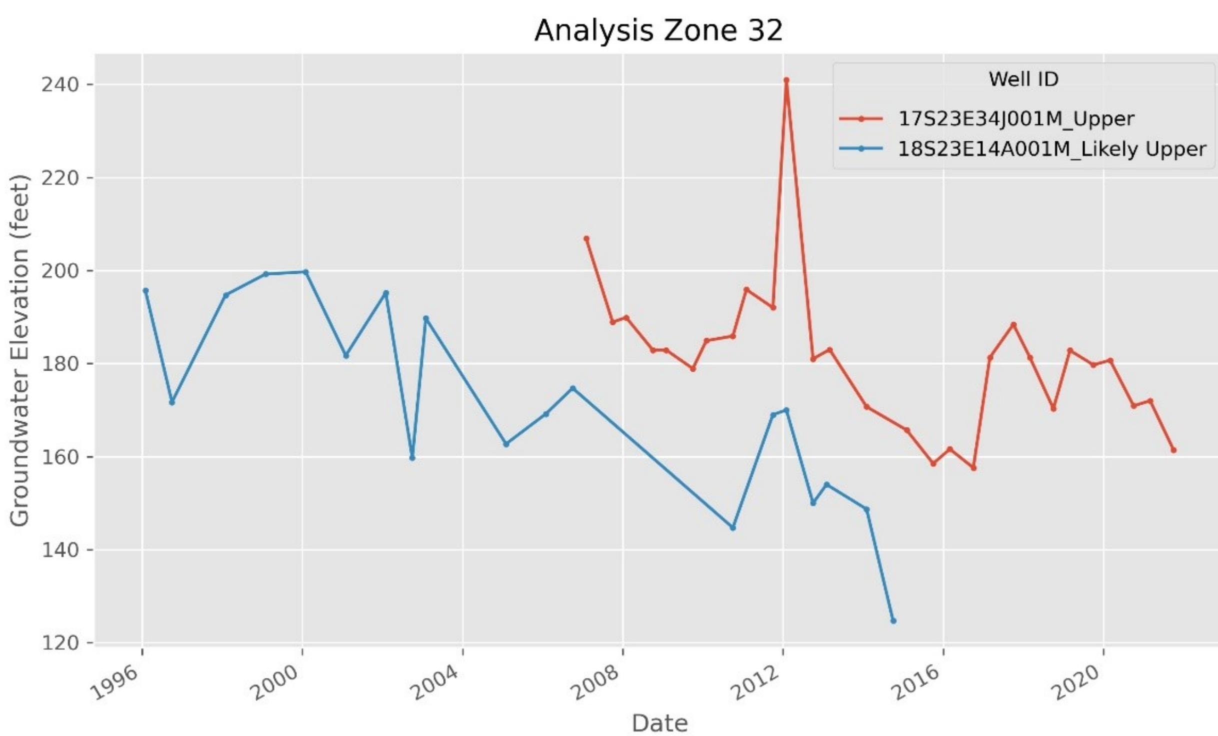

Analysis Zone 27
Groundwater Elevation (feet)
250
200
150
100
50
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S24E25D001M_Upper
19S24E36C002M_Lower
19S25E20P001M_Assumed Upper

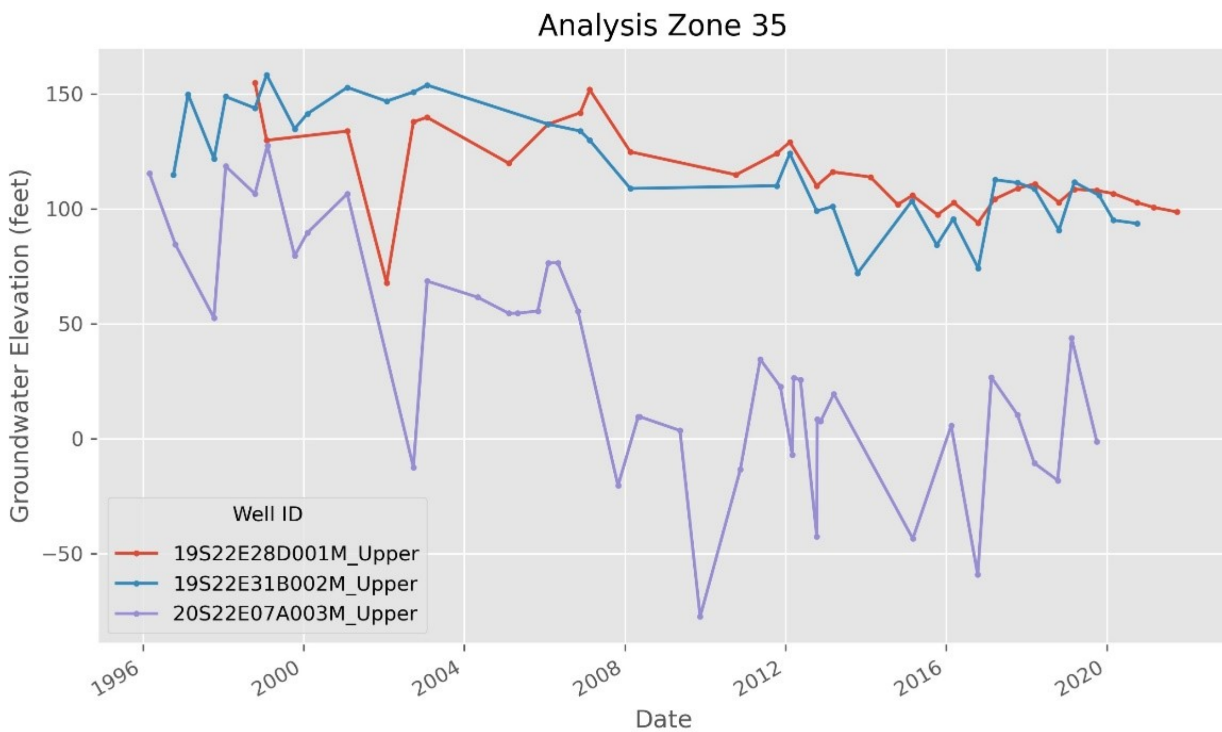

Analysis Zone 28
Groundwater Elevation (feet)
140
130
120
110
100
90
80
2018-01
2018-07
2019-01
2019-07
2020-01
2020-07
2021-01
2021-07
Date
Well ID
19S24E20F001M_Upper
19S24E22E001M_Upper
19S24E34D001M_Upper

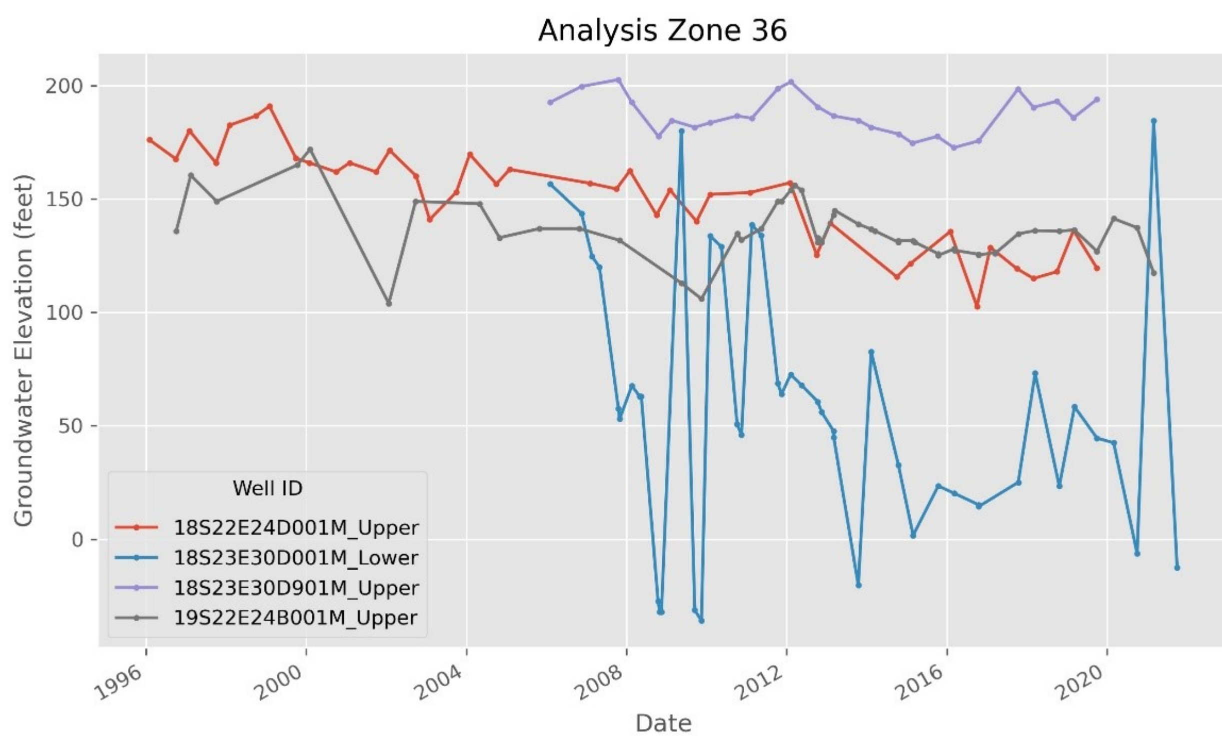

Analysis Zone 29
Groundwater Elevation (feet)
200
180
160
140
120
100
80
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S23E20C001M_Assumed Upper
19S23E21C001M_Upper
19S23E22H001M_Likely Upper
19S23E31R001M_Assumed Upper
19S23E35H001M_Upper
20S23E03L001M_Upper

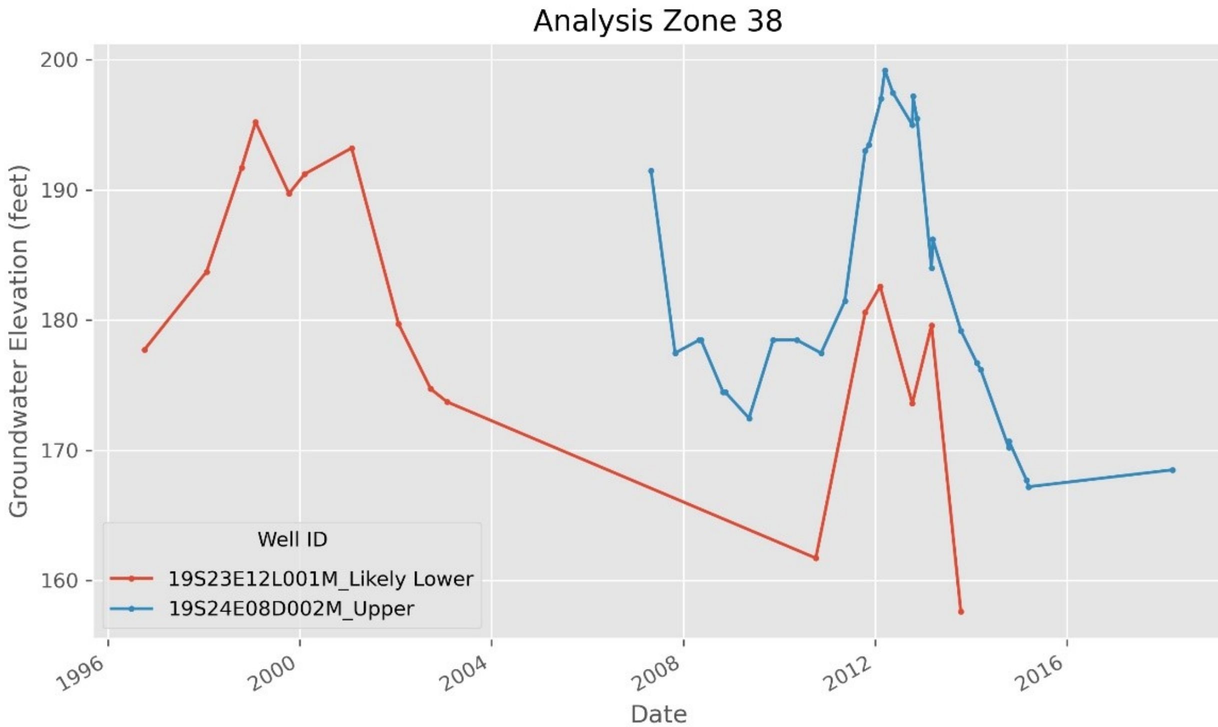

Analysis Zone 30
Groundwater Elevation (feet)
150
100
50
0
−50
−100
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
20S22E24R001M_Upper
20S22E36A001M_Upper
20S23E18R001M_Assumed Upper
20S23E21B001M_Assumed Upper
20S23E26C001M_Assumed Upper
21S23E05A002M_Assumed Upper
21S23E07J001M_Upper

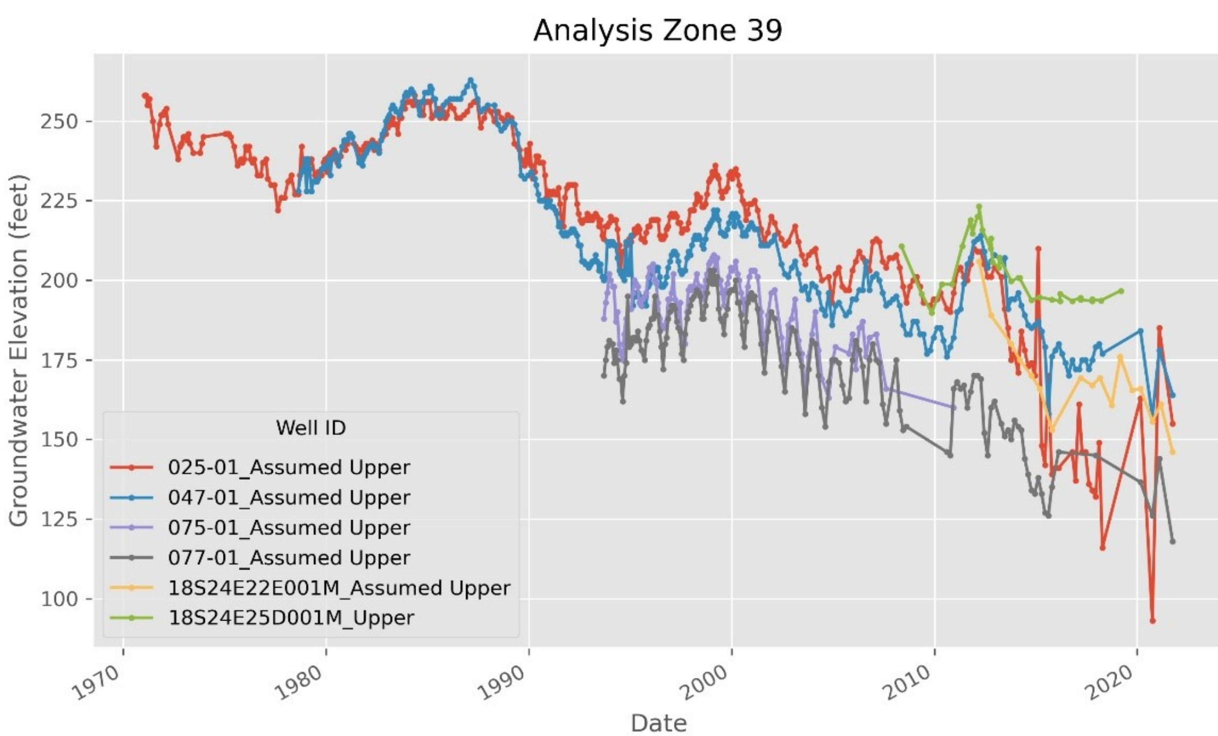

Analysis Zone 31
Groundwater Elevation (feet)
200
180
160
140
120
100
80
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
20S24E07C001M_Upper
20S24E16H001M_Likely Lower
20S24E17P001M_Upper
20S24E28L001M_Assumed Upper


Analysis Zone 32
Groundwater Elevation (feet)
240
220
200
180
160
140
120
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
17S23E34J001M_Upper
18S23E14A001M_Likely Upper


Analysis Zone 35
Groundwater Elevation (feet)
150
100
50
0
−50
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
19S22E28D001M_Upper
19S22E31B002M_Upper
20S22E07A003M_Upper


Analysis Zone 36
Groundwater Elevation (feet)
200
150
100
50
0
1996
2000
2004
2008
2012
2016
2020
Date
Well ID
18S22E24D001M_Upper
18S23E30D001M_Lower
18S23E30D901M_Upper
19S22E24B001M_Upper

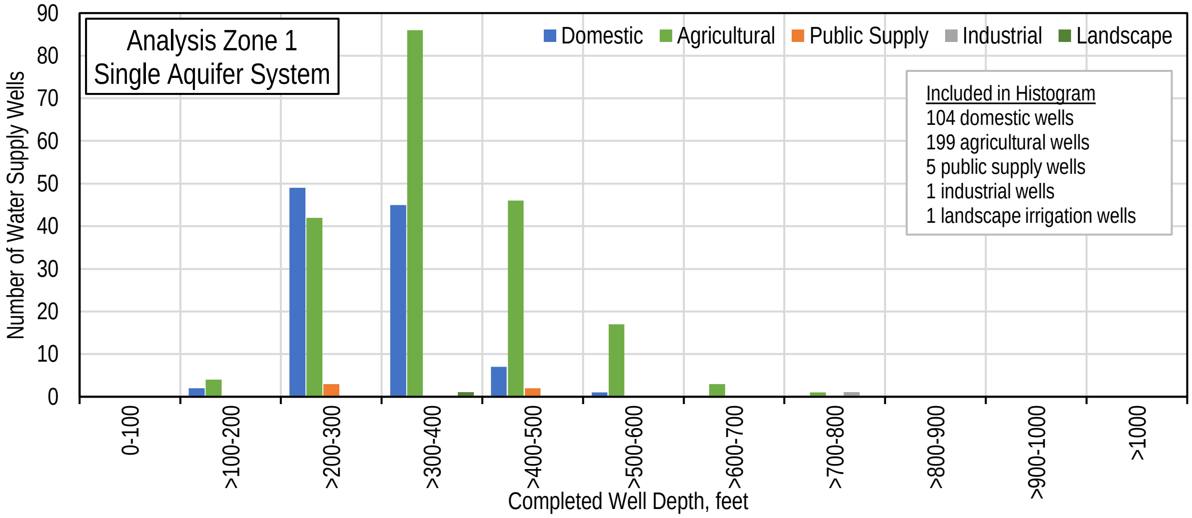

Analysis Zone 38
Groundwater Elevation (feet)
200
190
180
170
160
1996
2000
2004
2008
2012
2016
Date
Well ID
19S23E12L001M_Likely Lower
19S24E08D002M_Upper

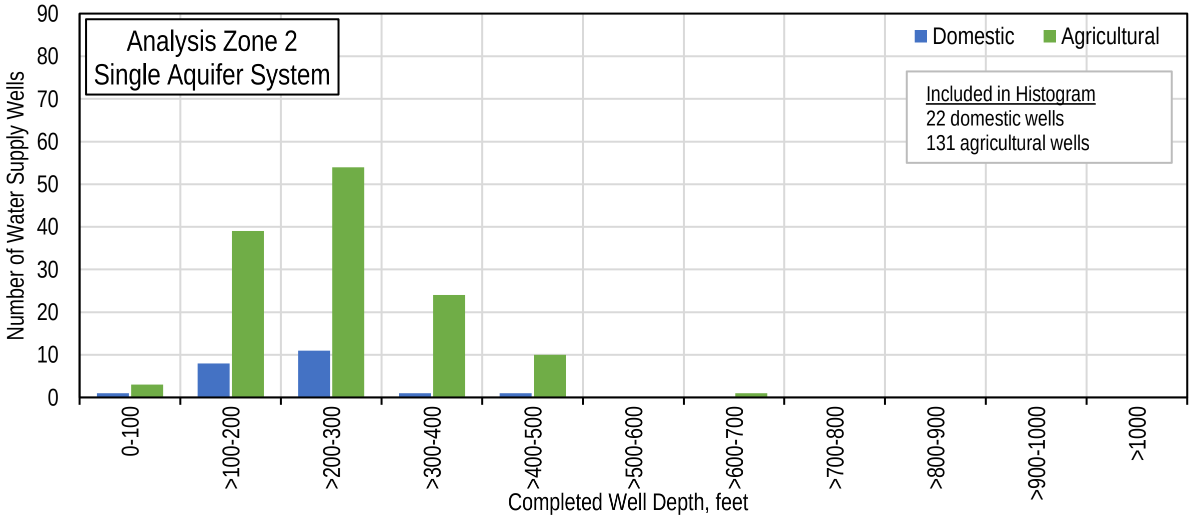

Analysis Zone 39
Groundwater Elevation (feet)
250
225
200
175
150
125
100
1970
1980
1990
2000
2010
2020
Date
Well ID
025-01_Assumed Upper
047-01_Assumed Upper
075-01_Assumed Upper
077-01_Assumed Upper
18S24E22E001M_Assumed Upper
18S24E25D001M_Upper

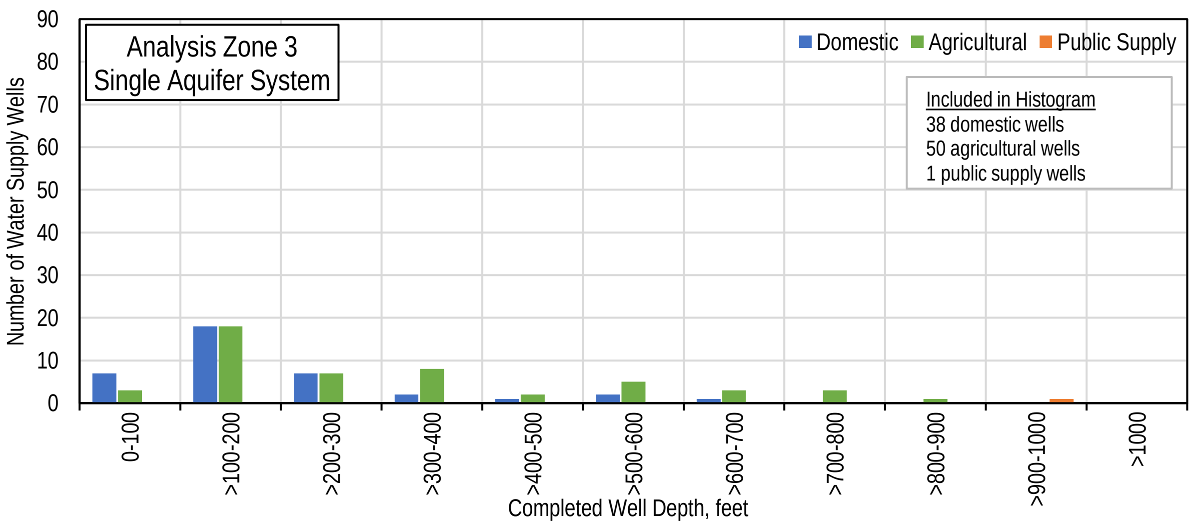
MONTGOMERY & ASSOCIATES

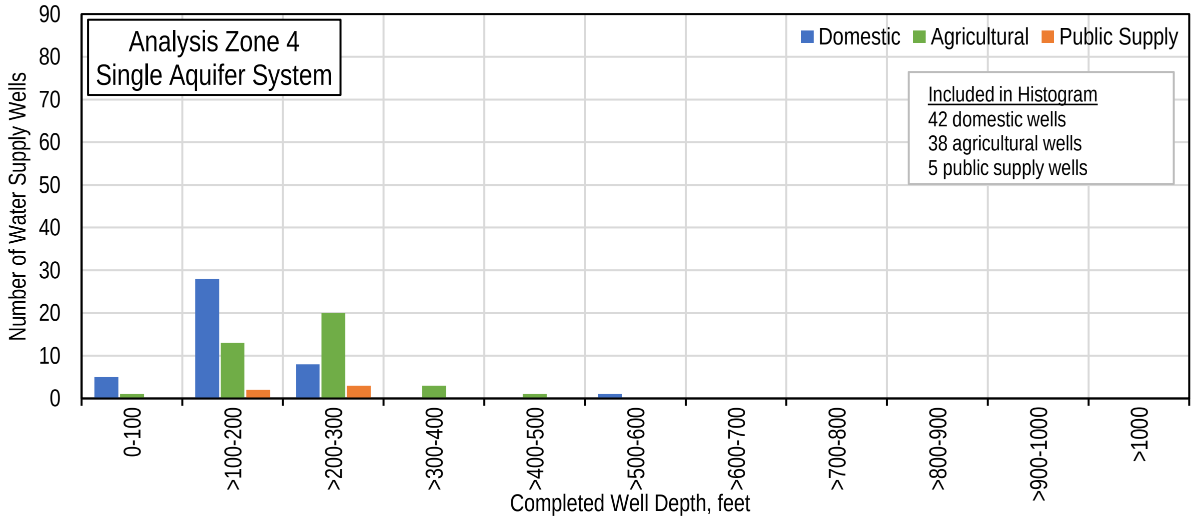
# Appendix B

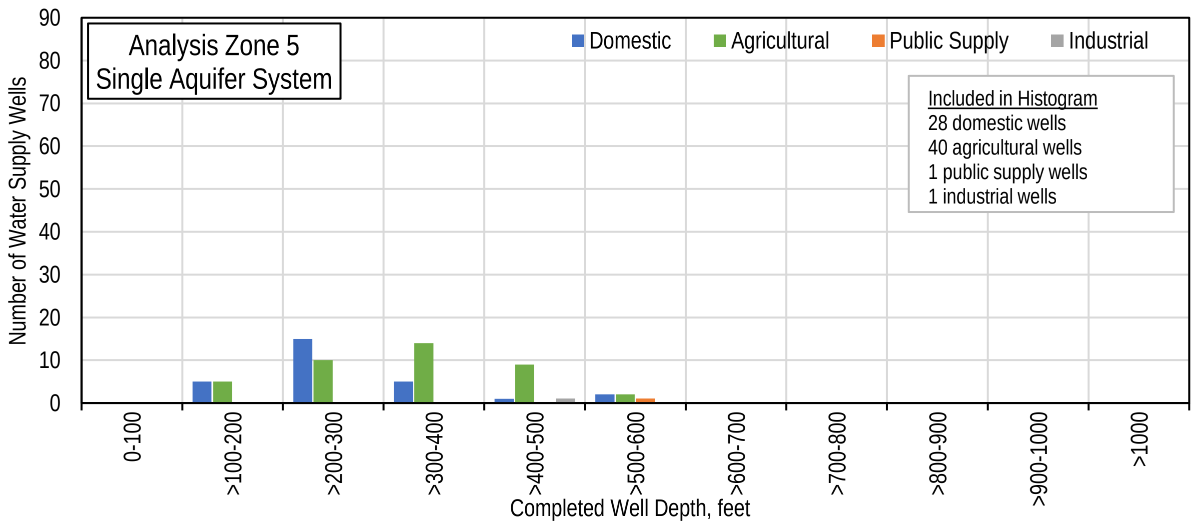
# Completed Well Depth Histograms by Analysis Zone

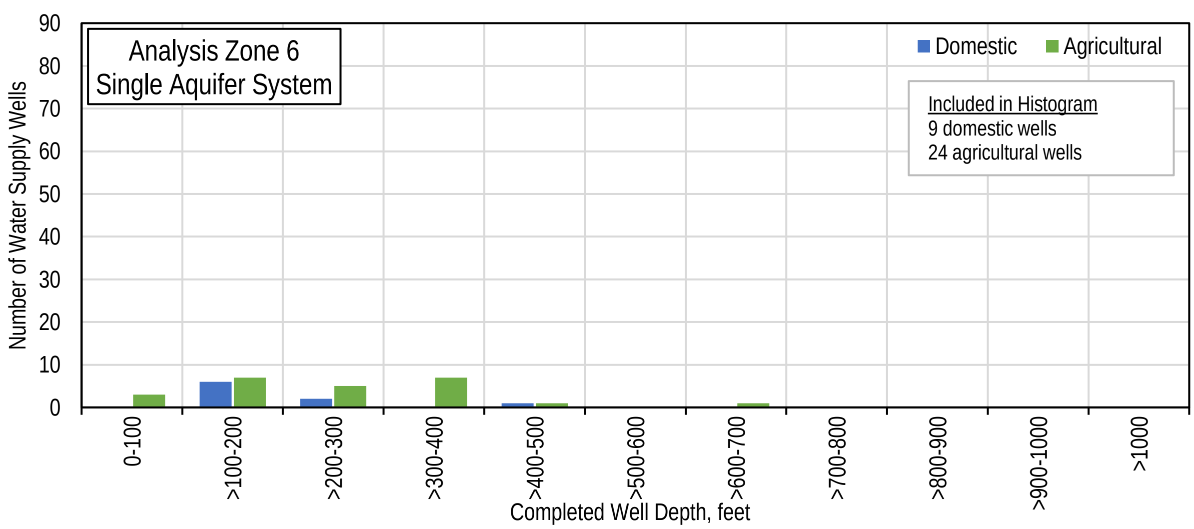

Analysis Zone 1
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Landscape
Included in Histogram
104 domestic wells
199 agricultural wells
5 public supply wells
1 industrial wells
1 landscape irrigation wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

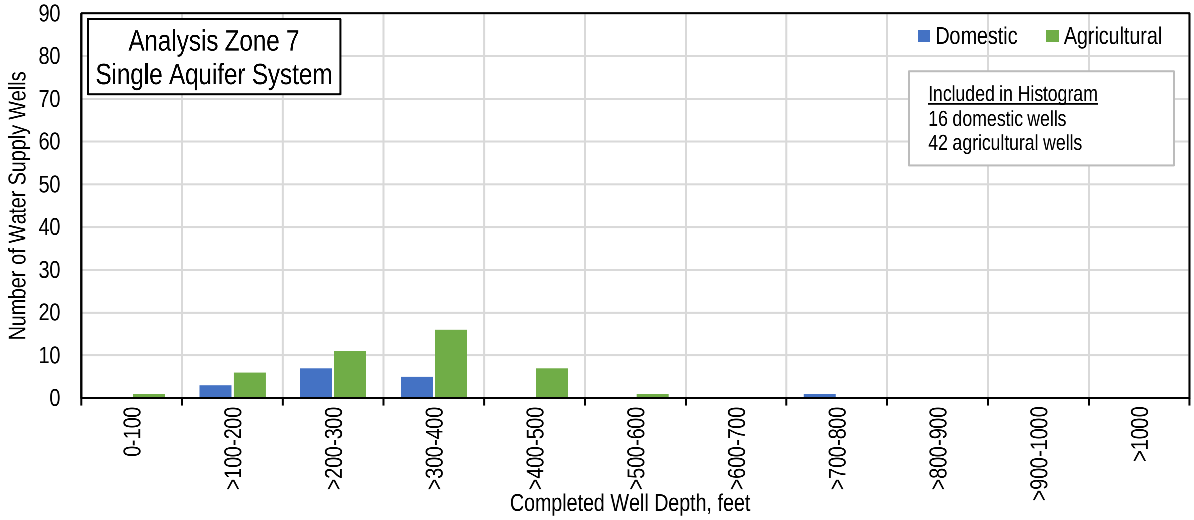

Analysis Zone 2
Single Aquifer System
Domestic
Agricultural
Included in Histogram
22 domestic wells
131 agricultural wells
Number of Water Supply Wells
Completed Well Depth, feet

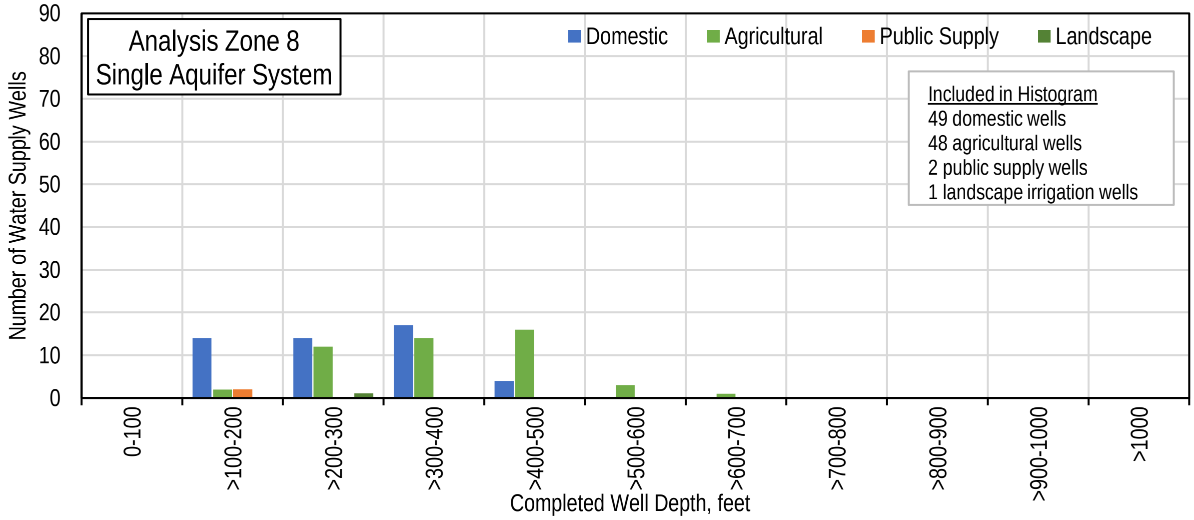

Analysis Zone 3
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
38 domestic wells
50 agricultural wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

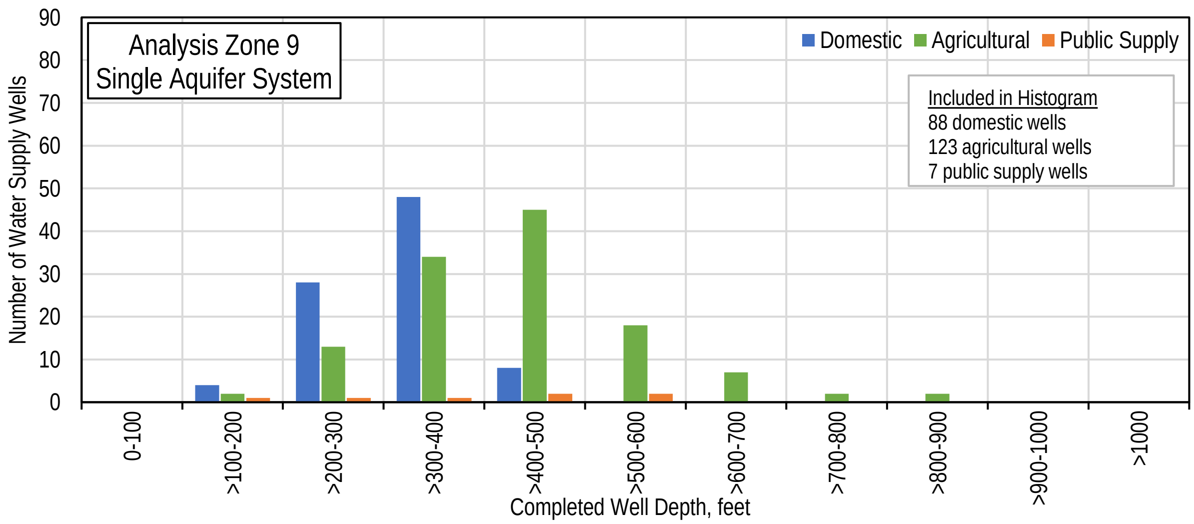

Analysis Zone 4
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
42 domestic wells
38 agricultural wells
5 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

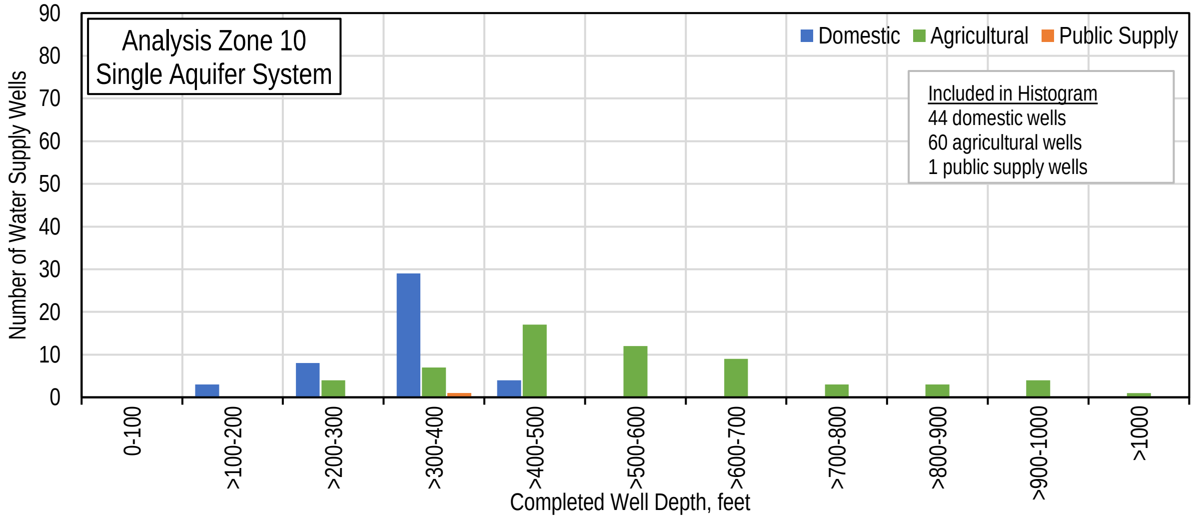

Analysis Zone 5
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
28 domestic wells
40 agricultural wells
1 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

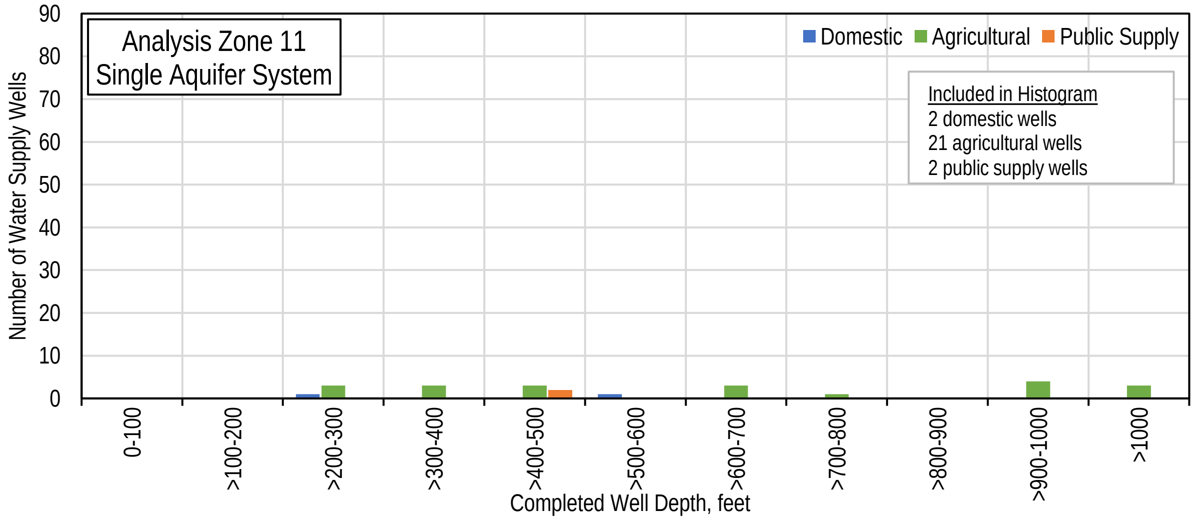

Analysis Zone 6
Single Aquifer System
Domestic
Agricultural
Included in Histogram
9 domestic wells
24 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

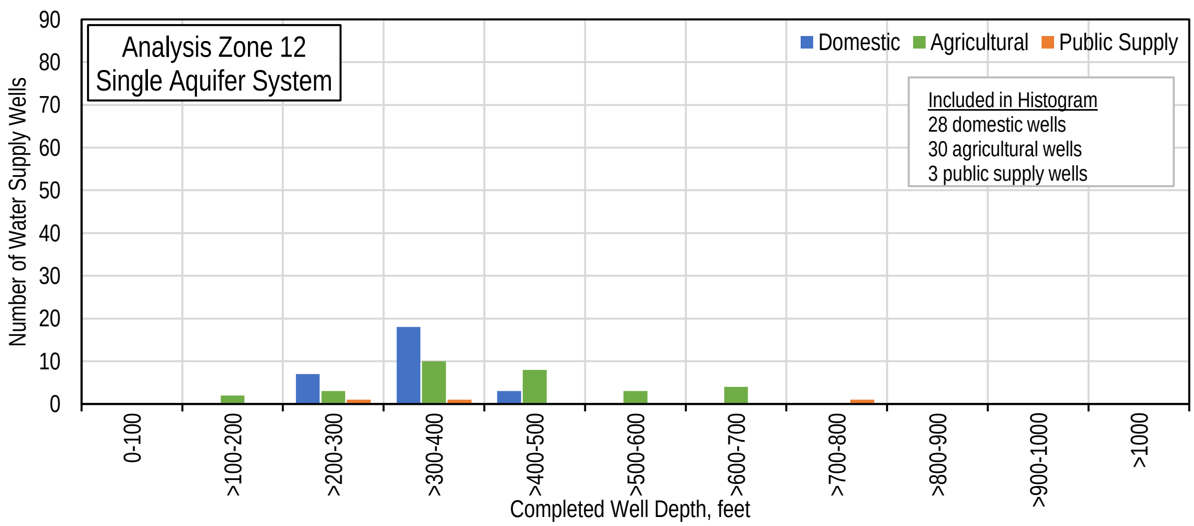

Analysis Zone 7
Single Aquifer System
Domestic
Agricultural
Included in Histogram
16 domestic wells
42 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

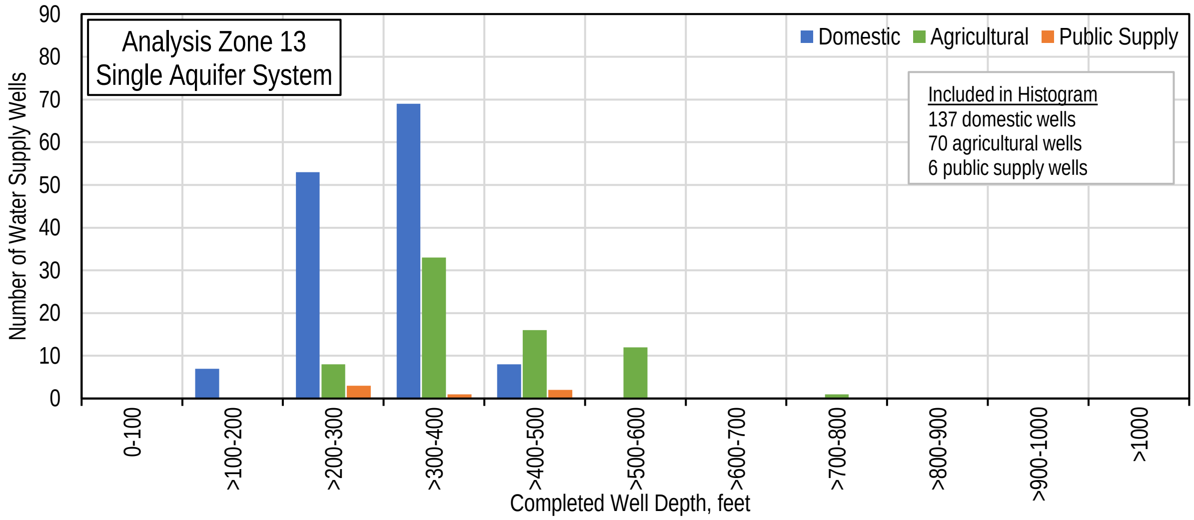

Analysis Zone 8
Single Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
49 domestic wells
48 agricultural wells
2 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
Completed Well Depth, feet

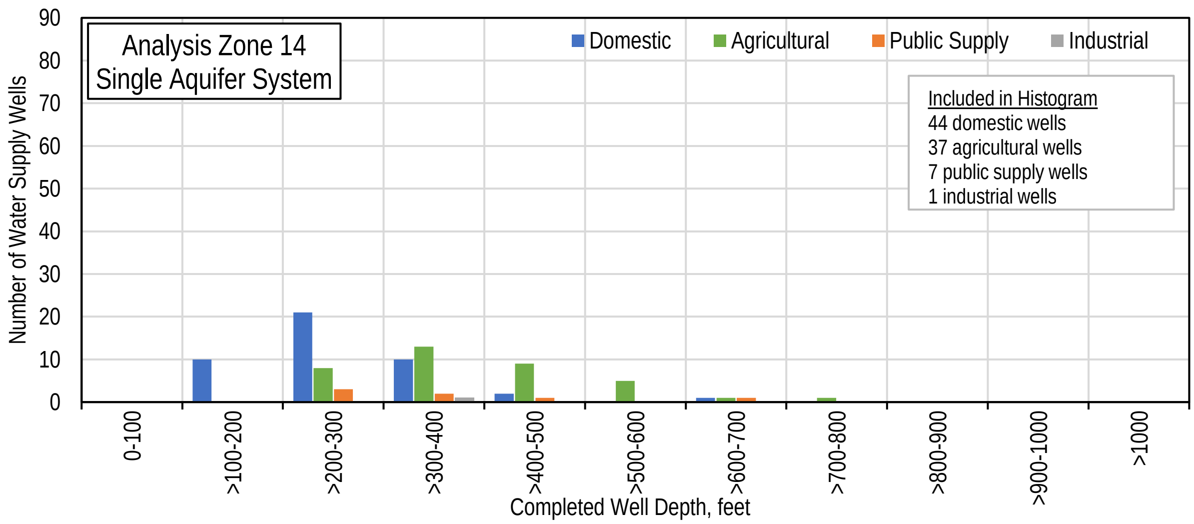

Analysis Zone 9
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
88 domestic wells
123 agricultural wells
7 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

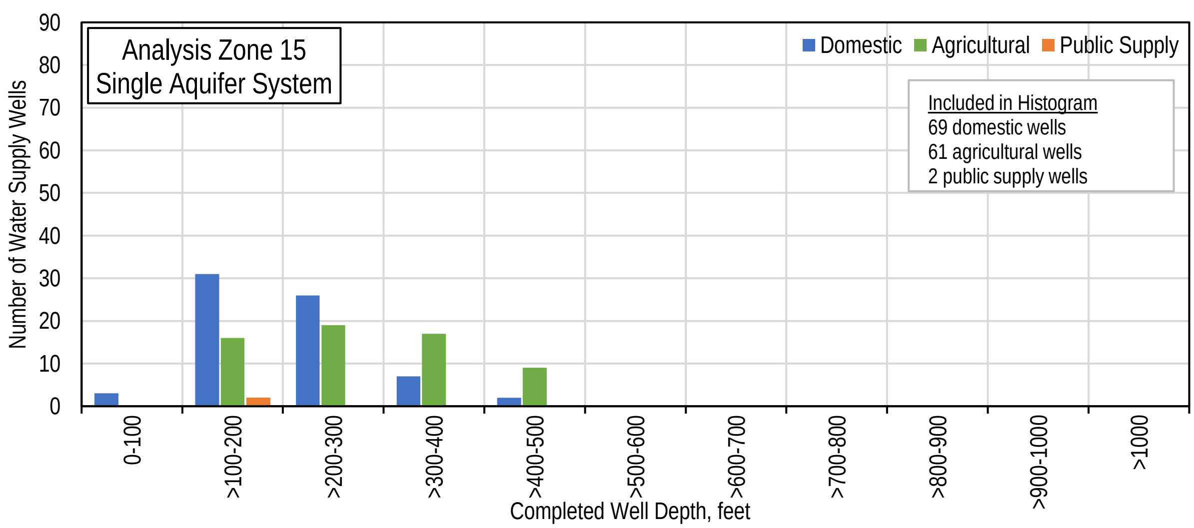

Analysis Zone 10
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
44 domestic wells
60 agricultural wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

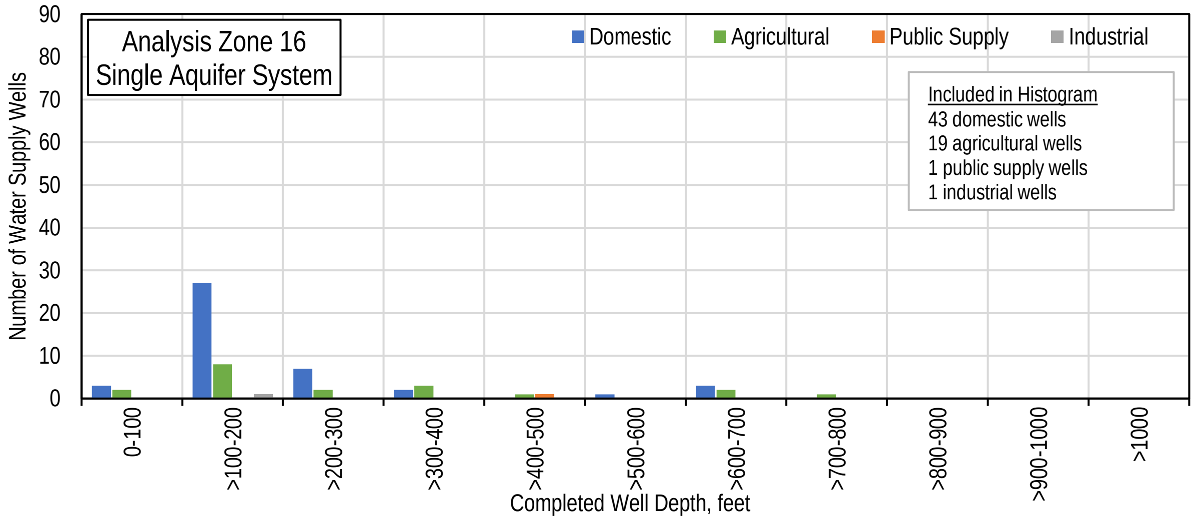

Analysis Zone 11
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
2 domestic wells
21 agricultural wells
2 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

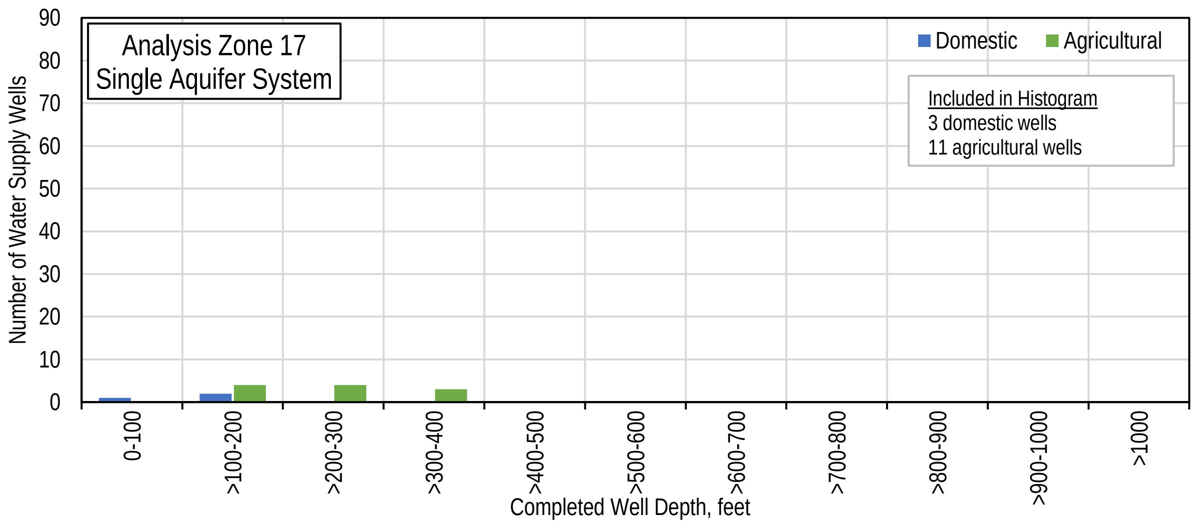

Analysis Zone 12
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
28 domestic wells
30 agricultural wells
3 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

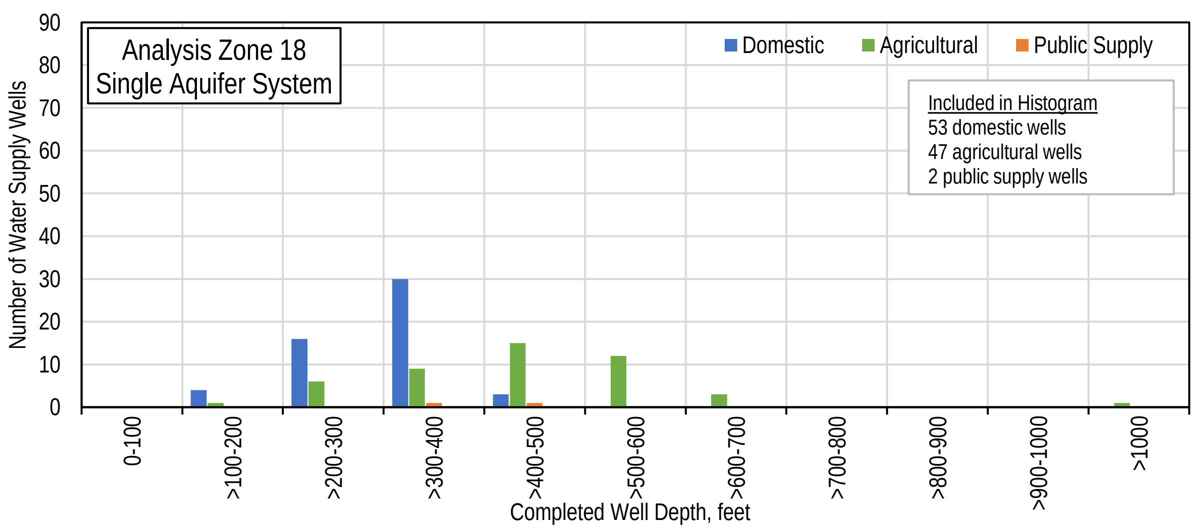

Analysis Zone 13
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
137 domestic wells
70 agricultural wells
6 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

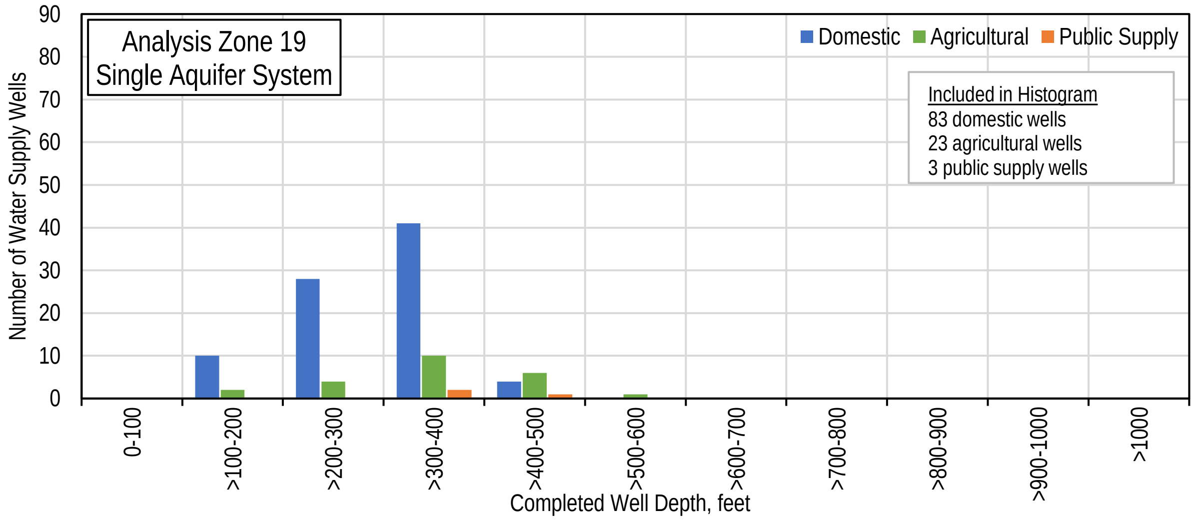

Analysis Zone 14
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
44 domestic wells
37 agricultural wells
7 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

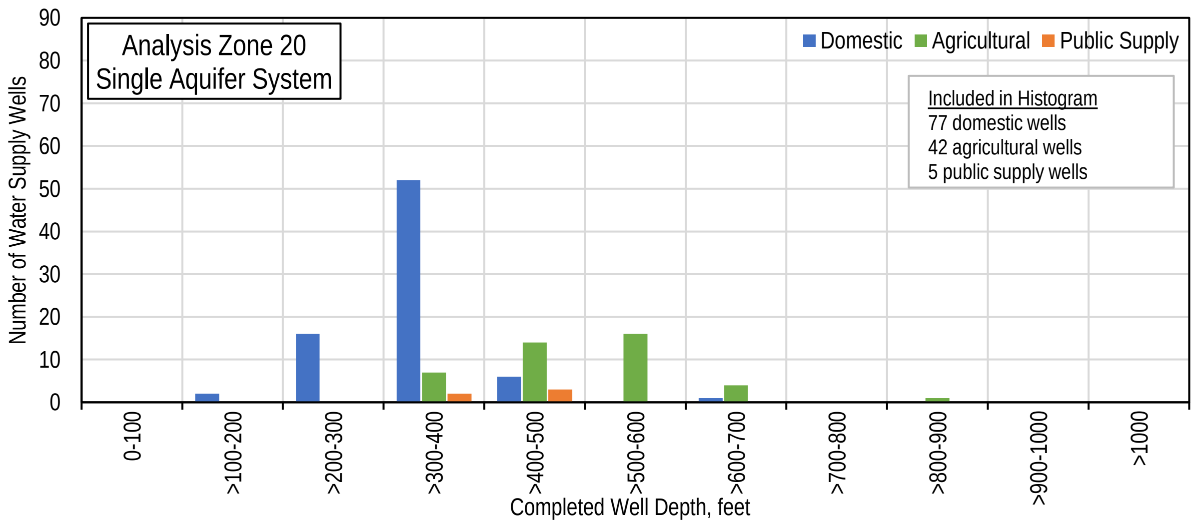

Analysis Zone 15
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
69 domestic wells
61 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

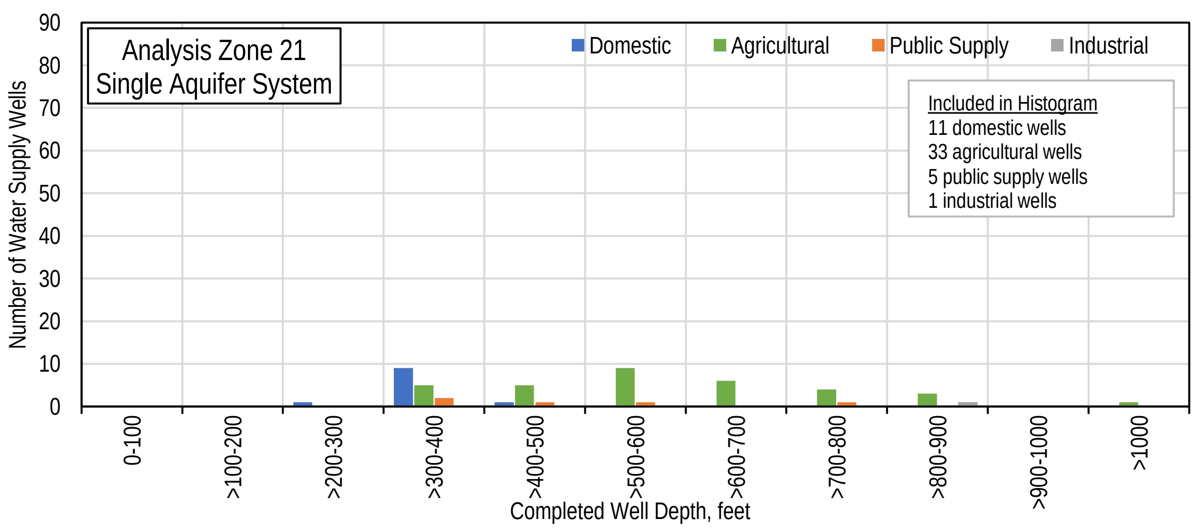

Analysis Zone 16
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
43 domestic wells
19 agricultural wells
1 public supply wells
1 industrial wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

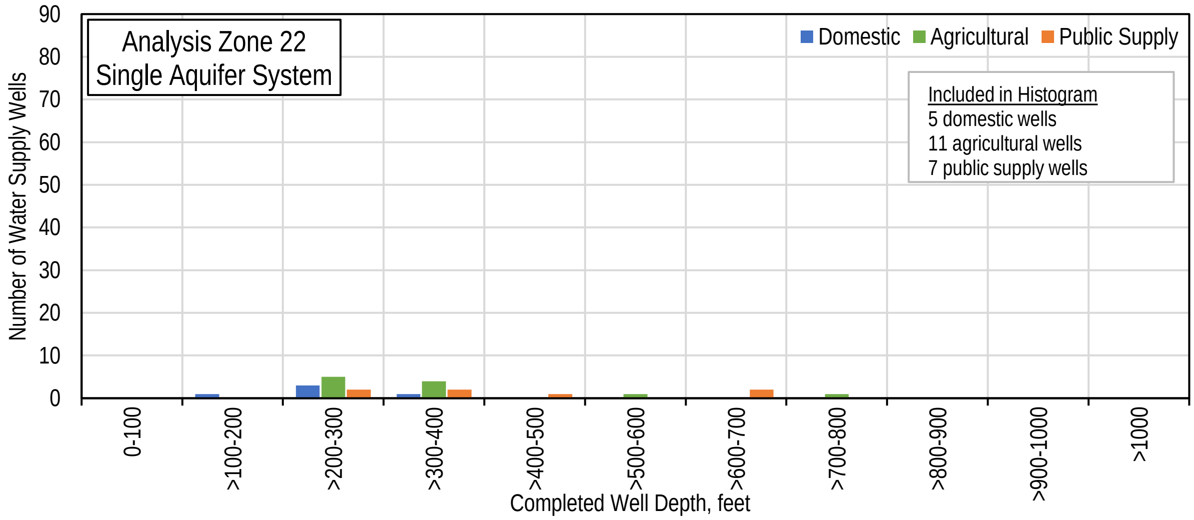

Analysis Zone 17
Single Aquifer System
Domestic
Agricultural
Included in Histogram
3 domestic wells
11 agricultural wells
Number of Water Supply Wells
Completed Well Depth, feet

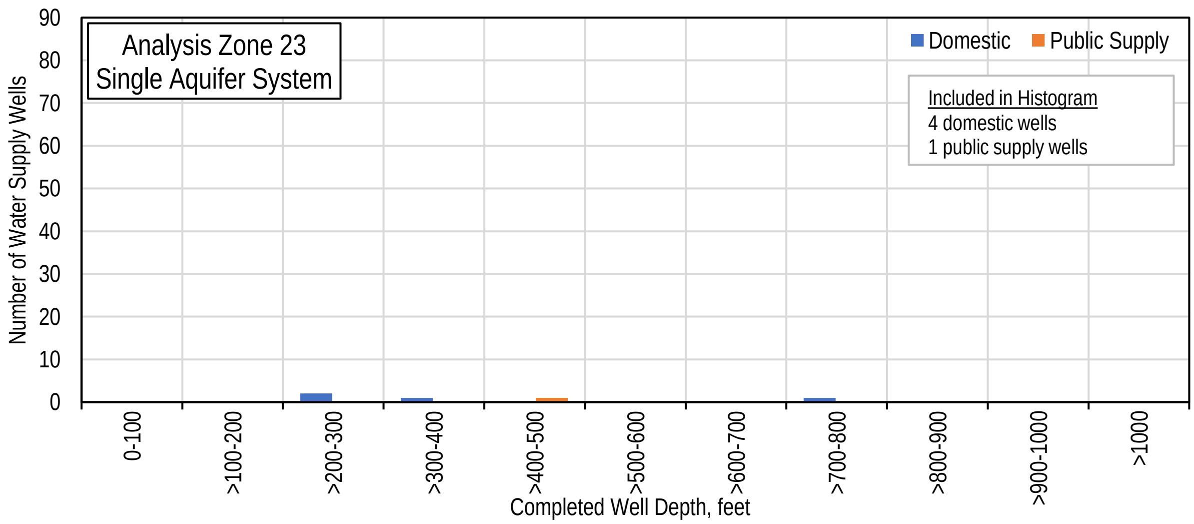

Analysis Zone 18
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
53 domestic wells
47 agricultural wells
2 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

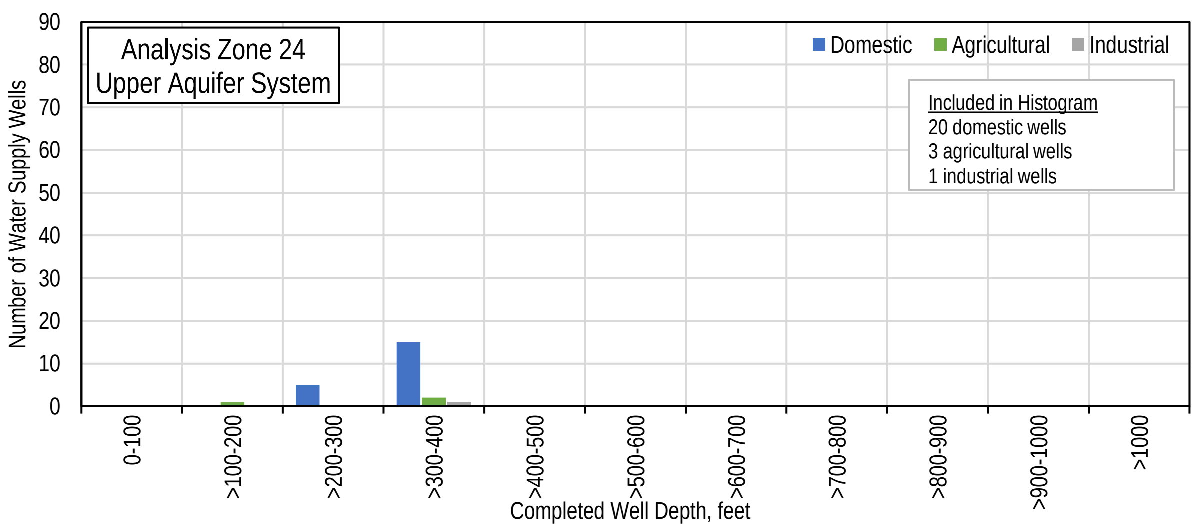

Analysis Zone 19
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
83 domestic wells
23 agricultural wells
3 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

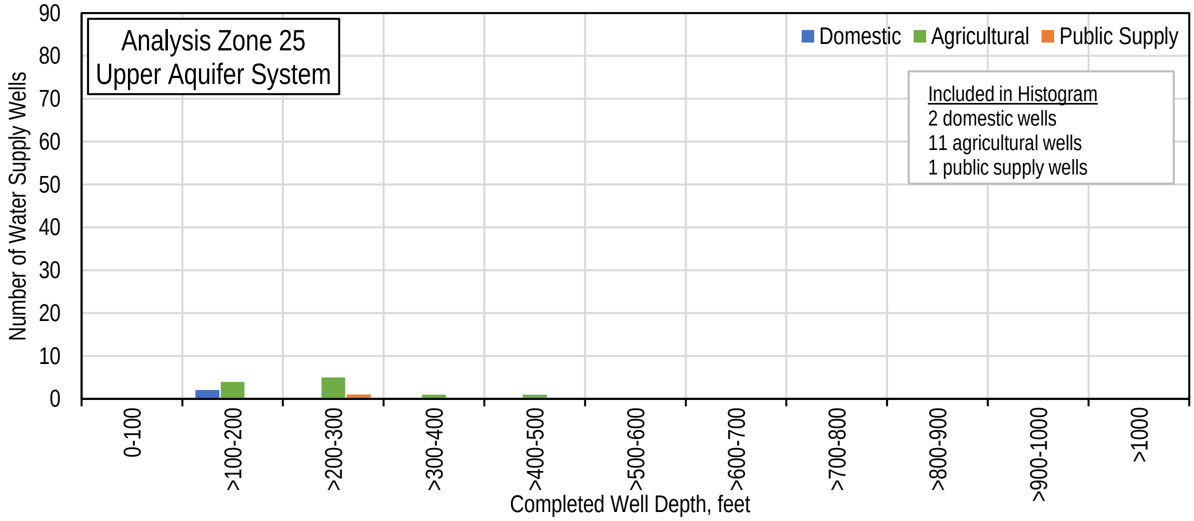

Analysis Zone 20
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
77 domestic wells
42 agricultural wells
5 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

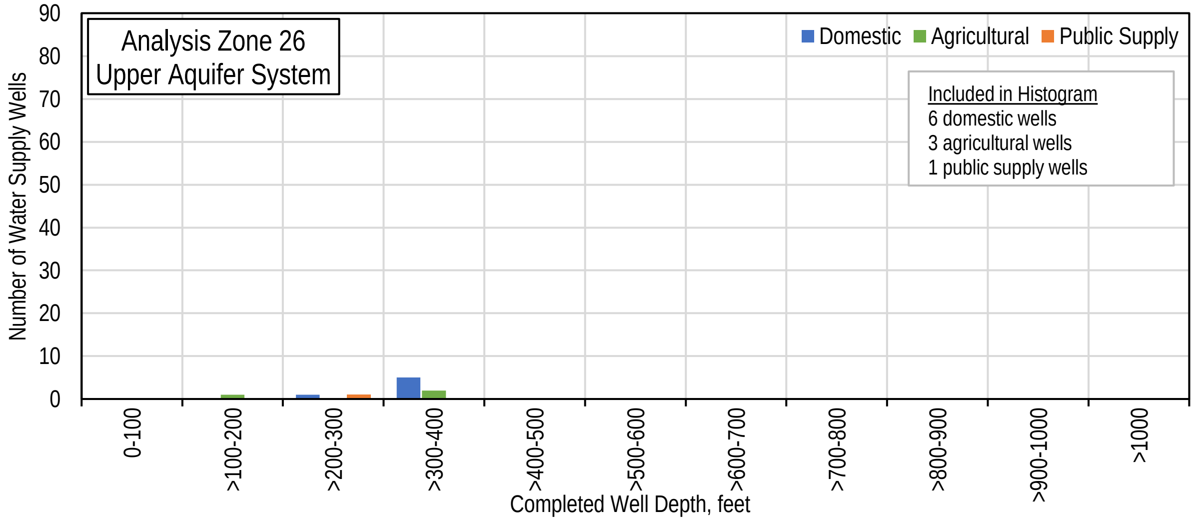

Analysis Zone 21
Single Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
11 domestic wells
33 agricultural wells
5 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

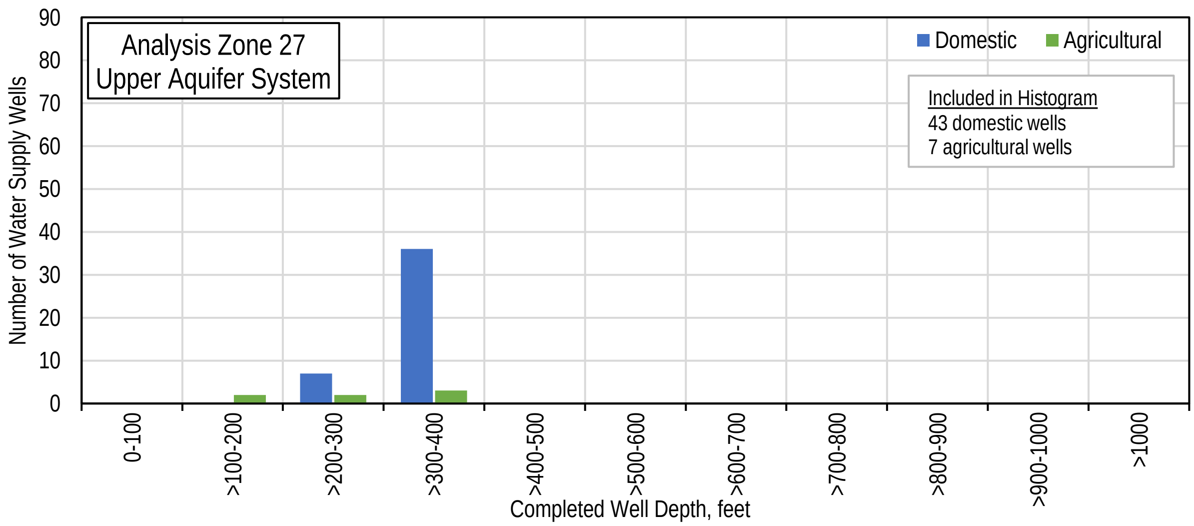

Analysis Zone 22
Single Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
11 agricultural wells
7 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

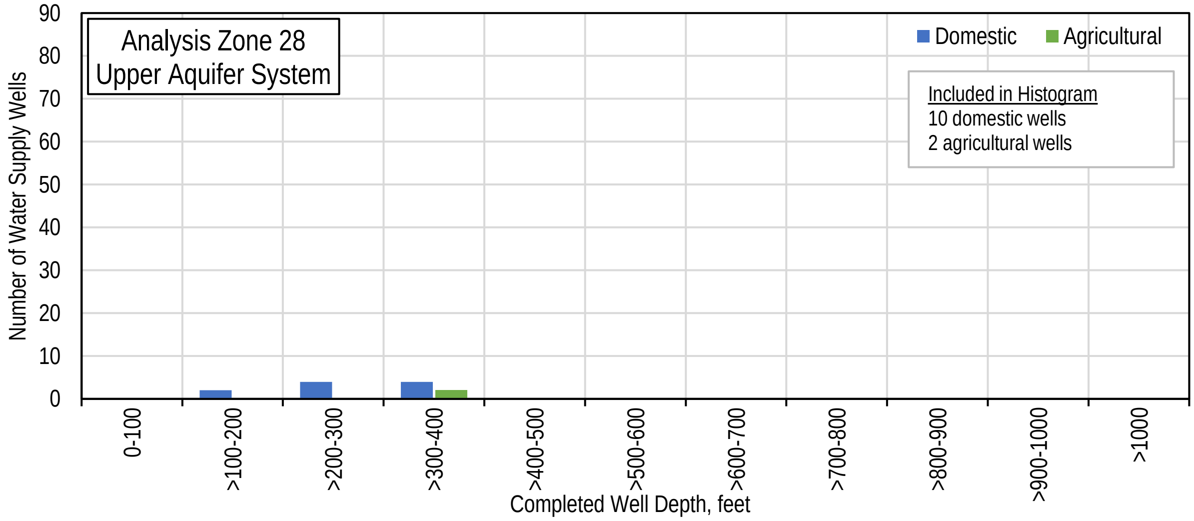

Analysis Zone 23
Single Aquifer System
Domestic
Public Supply
Included in Histogram
4 domestic wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

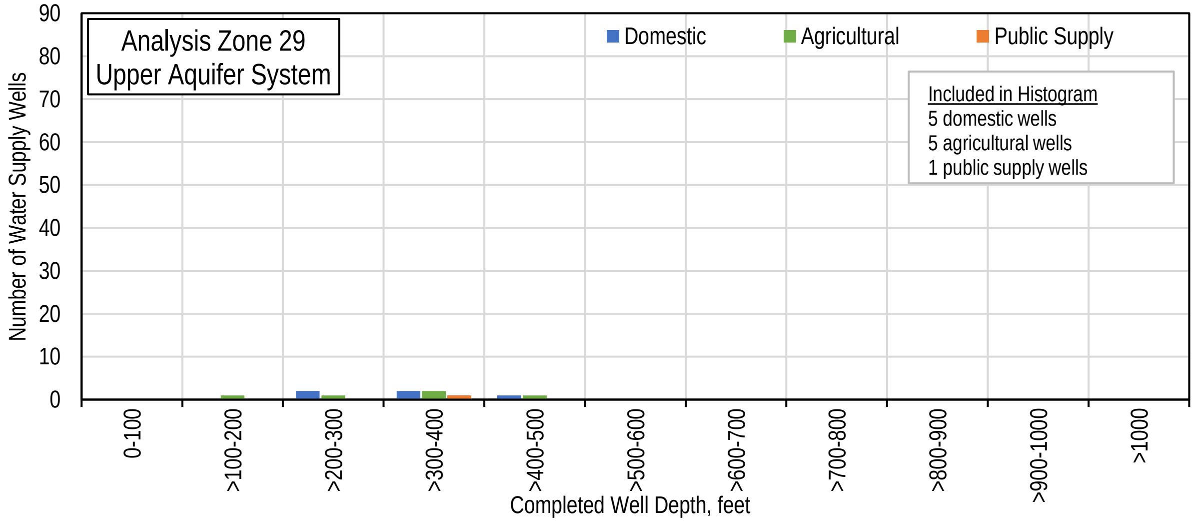

Analysis Zone 24
Upper Aquifer System
Domestic
Agricultural
Industrial
Included in Histogram
20 domestic wells
3 agricultural wells
1 industrial wells
Number of Water Supply Wells
Completed Well Depth, feet

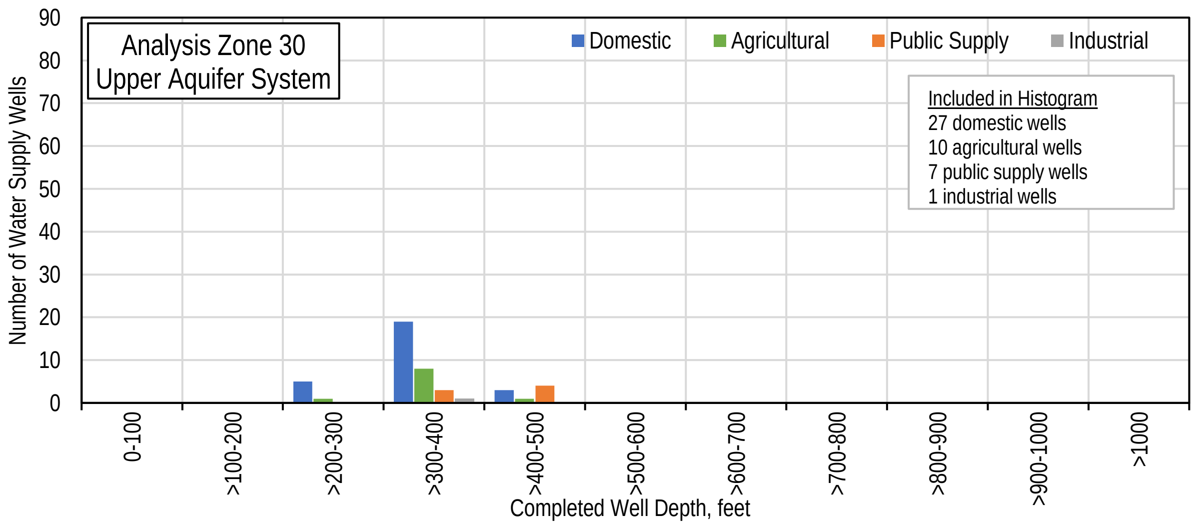

Analysis Zone 25
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
2 domestic wells
11 agricultural wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

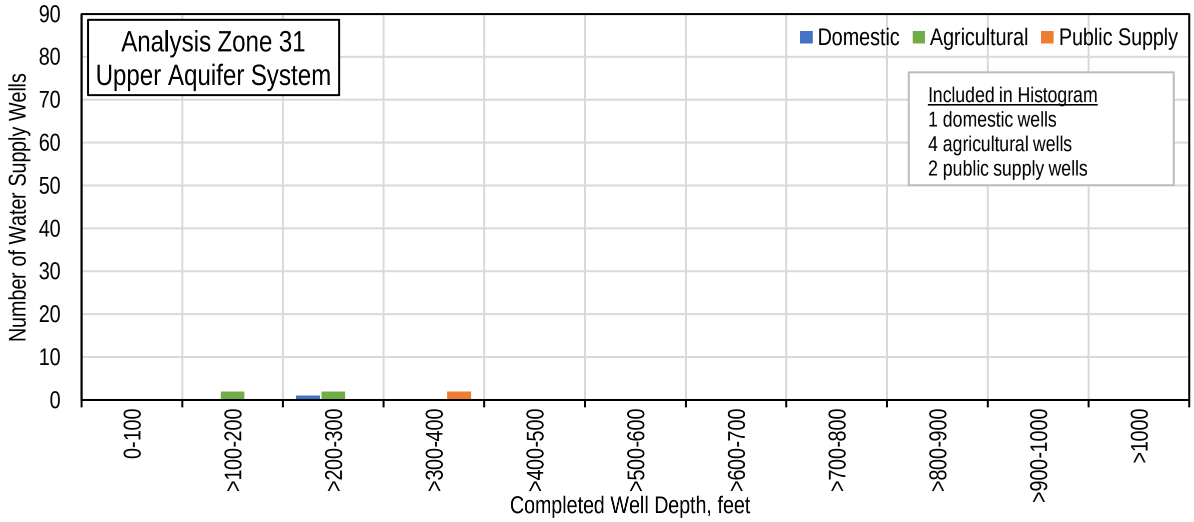

Analysis Zone 26
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
6 domestic wells
3 agricultural wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet

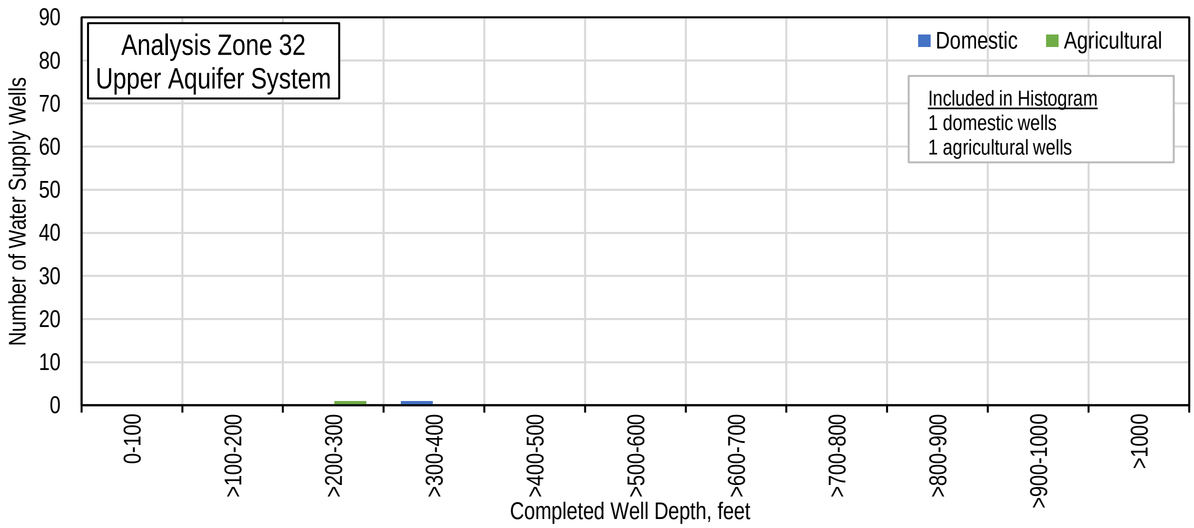

Analysis Zone 27
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
43 domestic wells
7 agricultural wells
Number of Water Supply Wells
Completed Well Depth, feet

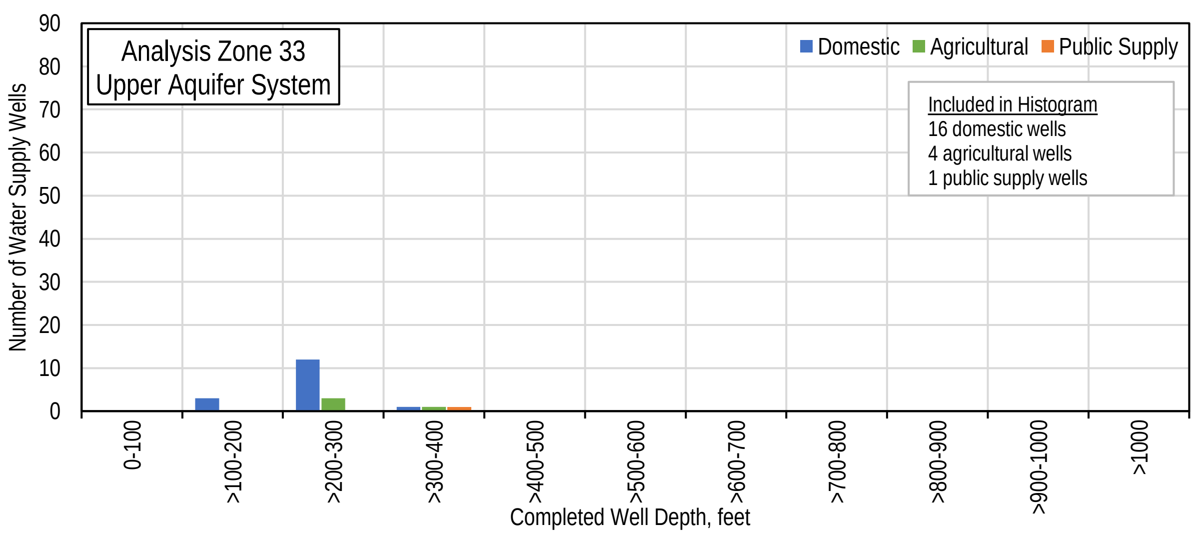

Analysis Zone 28
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
10 domestic wells
2 agricultural wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

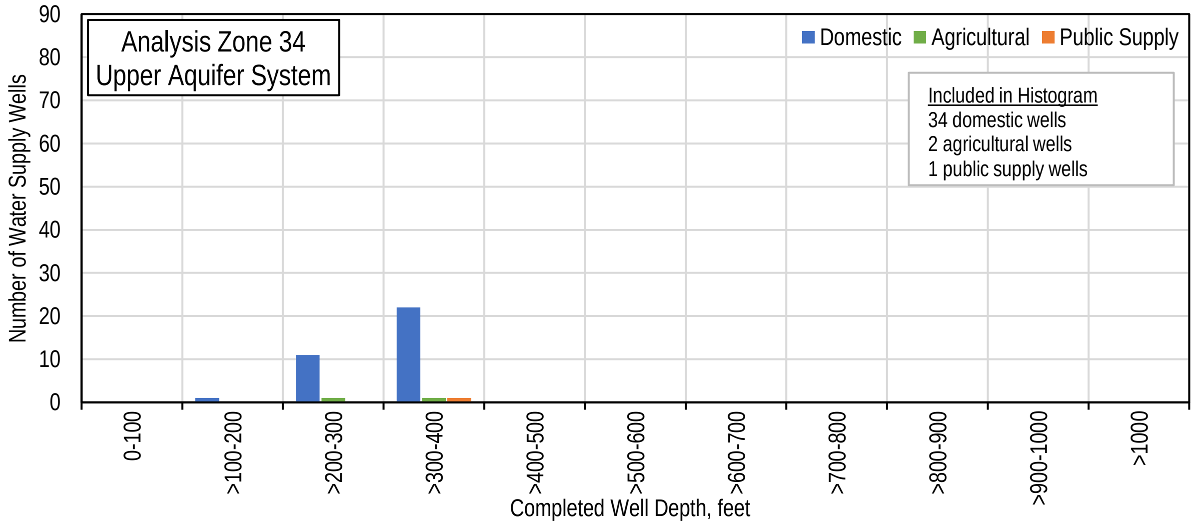

Analysis Zone 29
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
5 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

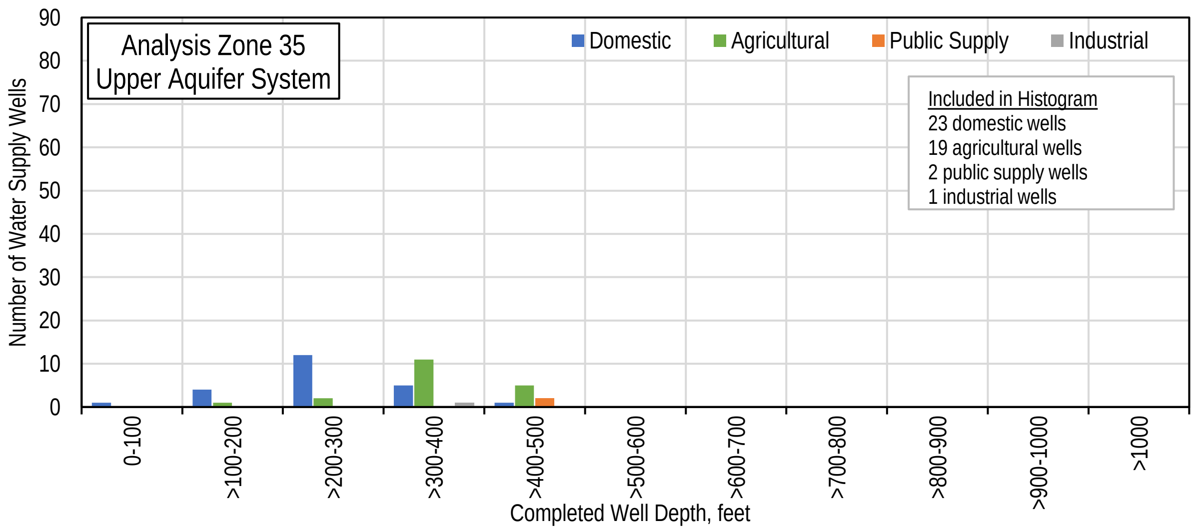

Analysis Zone 30
Upper Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
27 domestic wells
10 agricultural wells
7 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

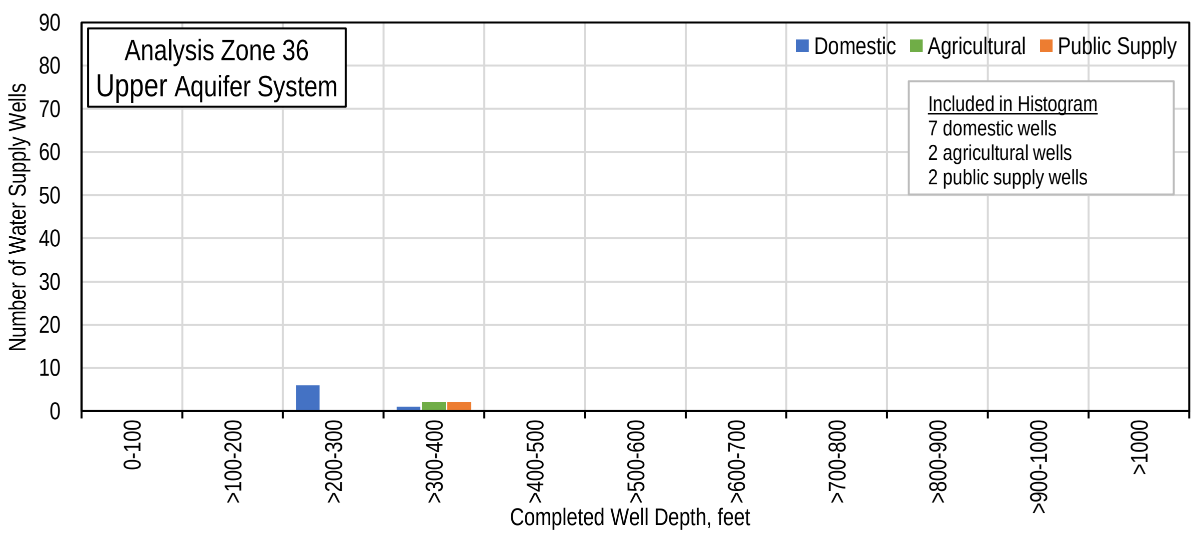

Analysis Zone 31
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
1 domestic wells
4 agricultural wells
2 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

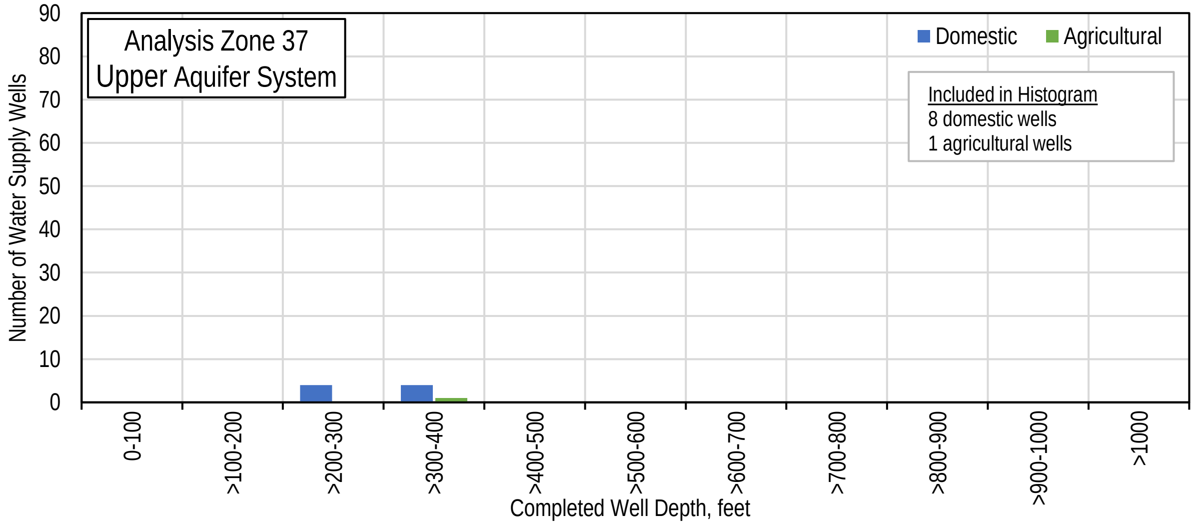

Analysis Zone 32
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
1 domestic wells
1 agricultural wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

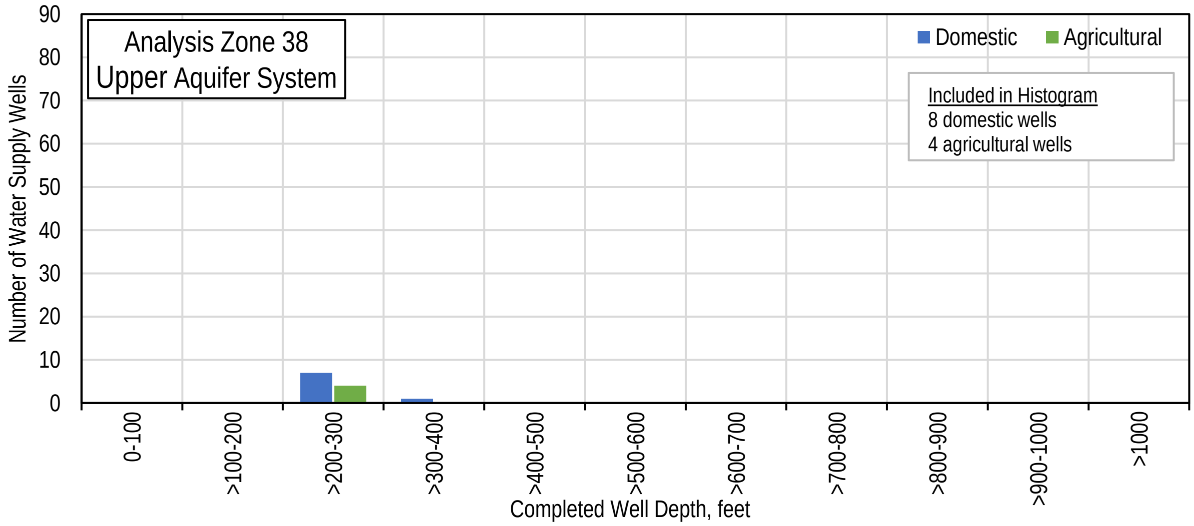

Analysis Zone 33
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
16 domestic wells
4 agricultural wells
1 public supply wells
Number of Water Supply Wells
Completed Well Depth, feet
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000

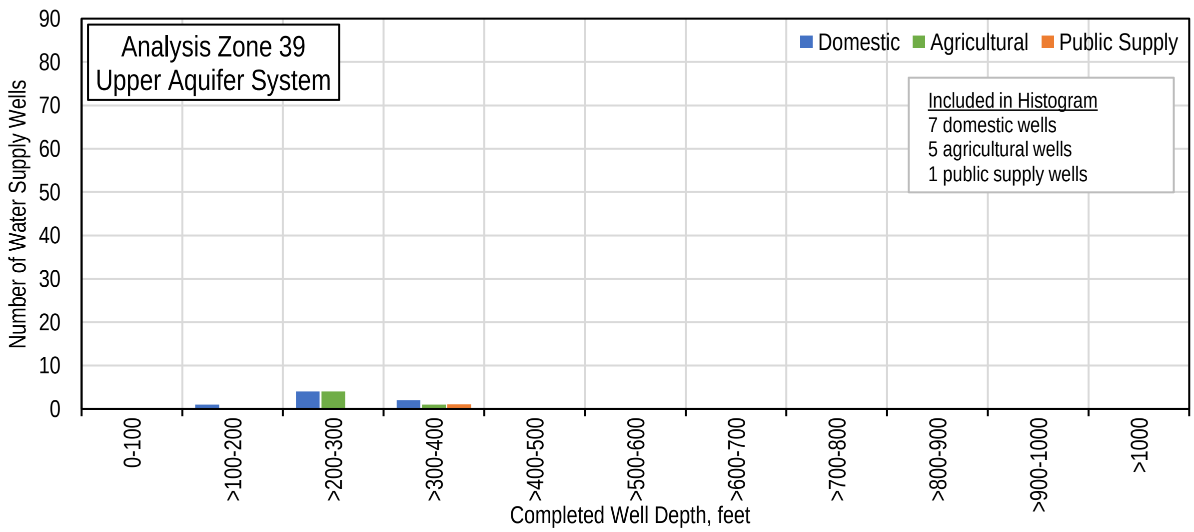

Analysis Zone 34
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
34 domestic wells
2 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

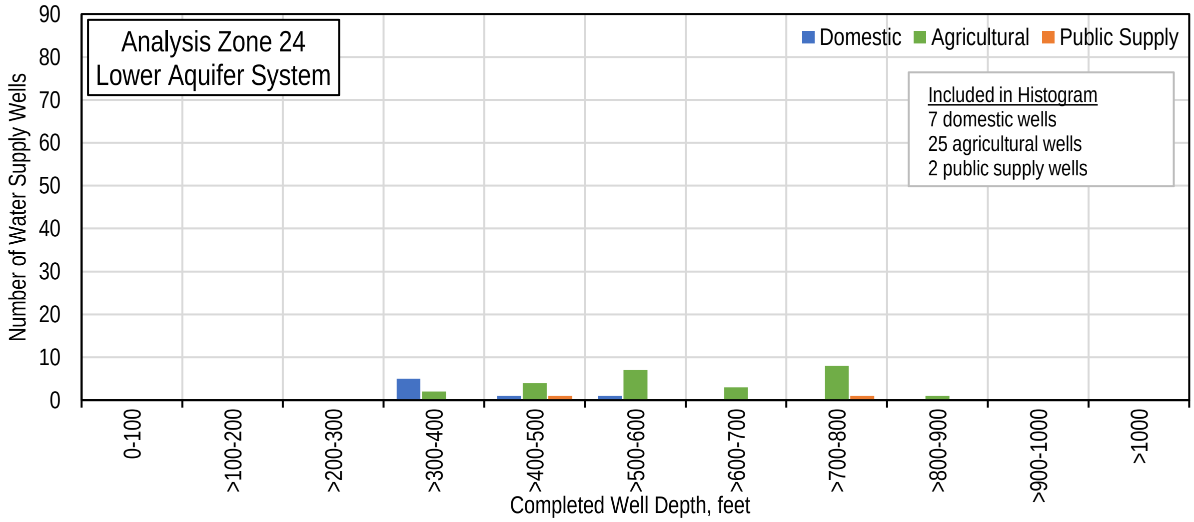

Analysis Zone 35
Upper Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
23 domestic wells
19 agricultural wells
2 public supply wells
1 industrial wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

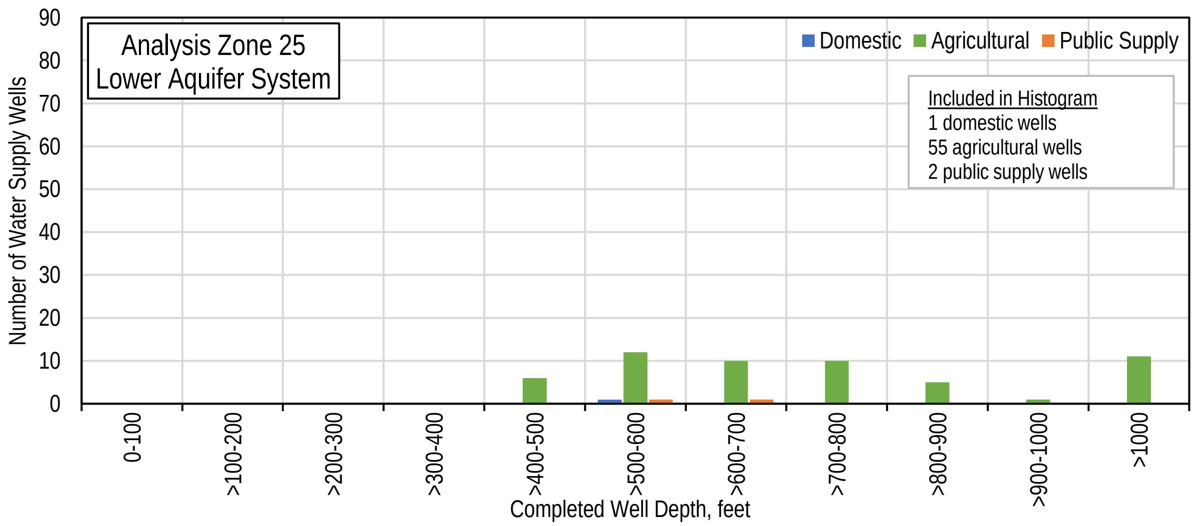

Analysis Zone 36
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
2 agricultural wells
2 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

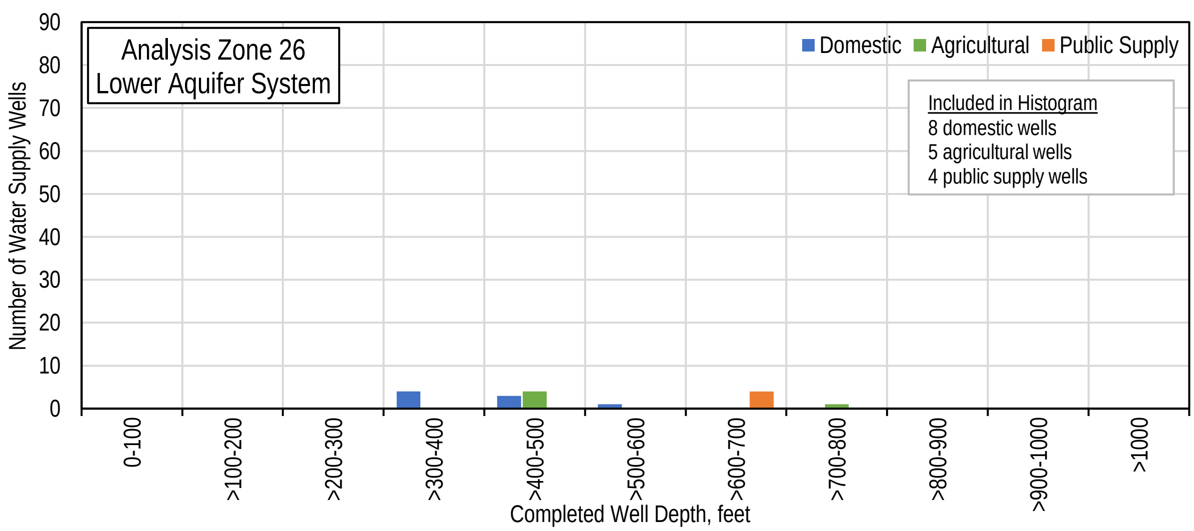

Analysis Zone 37
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
8 domestic wells
1 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

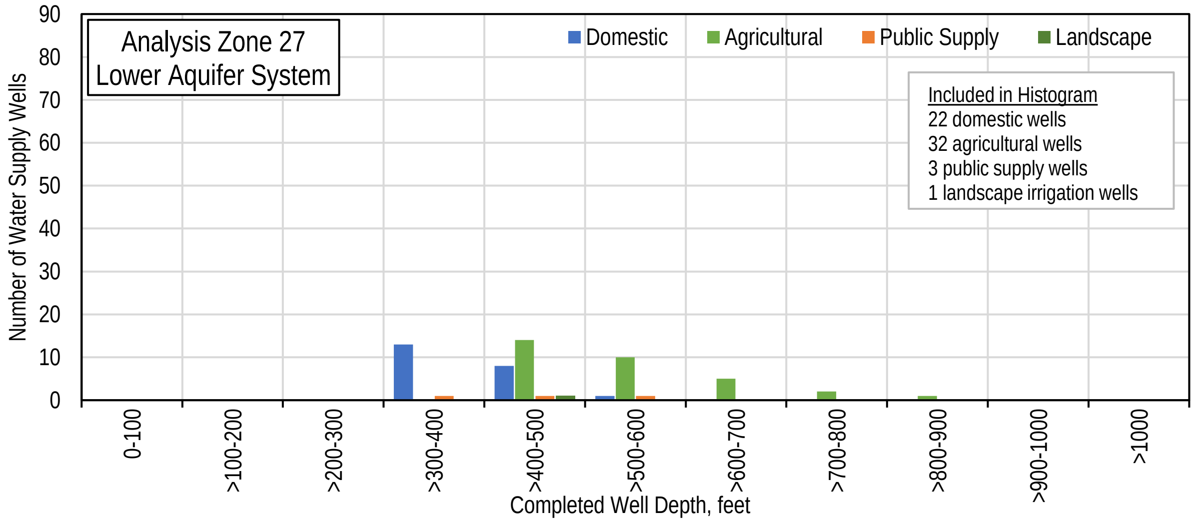

Analysis Zone 38
Upper Aquifer System
Domestic
Agricultural
Included in Histogram
8 domestic wells
4 agricultural wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

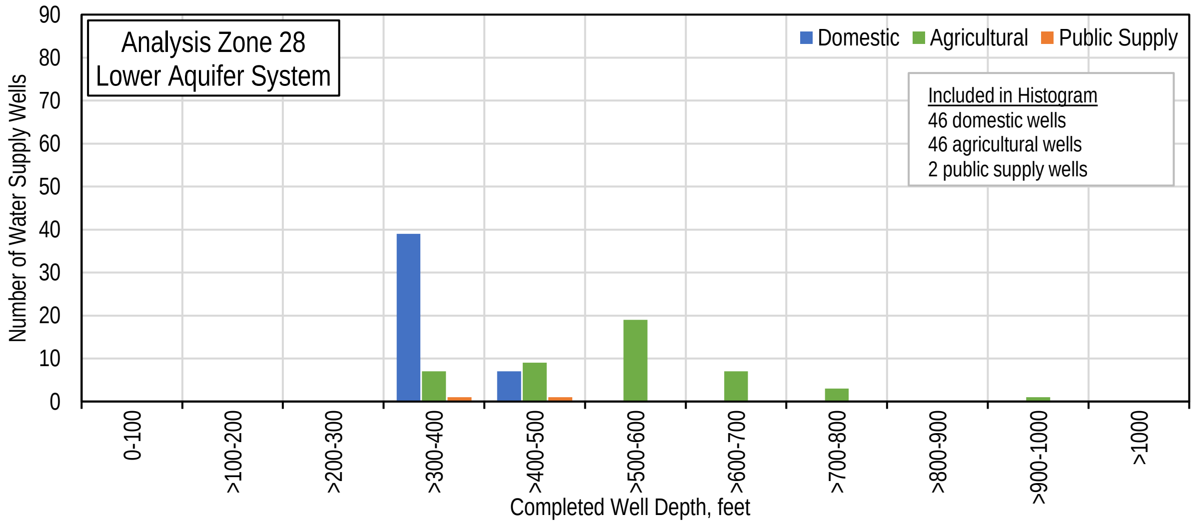

Analysis Zone 39
Upper Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
5 agricultural wells
1 public supply wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

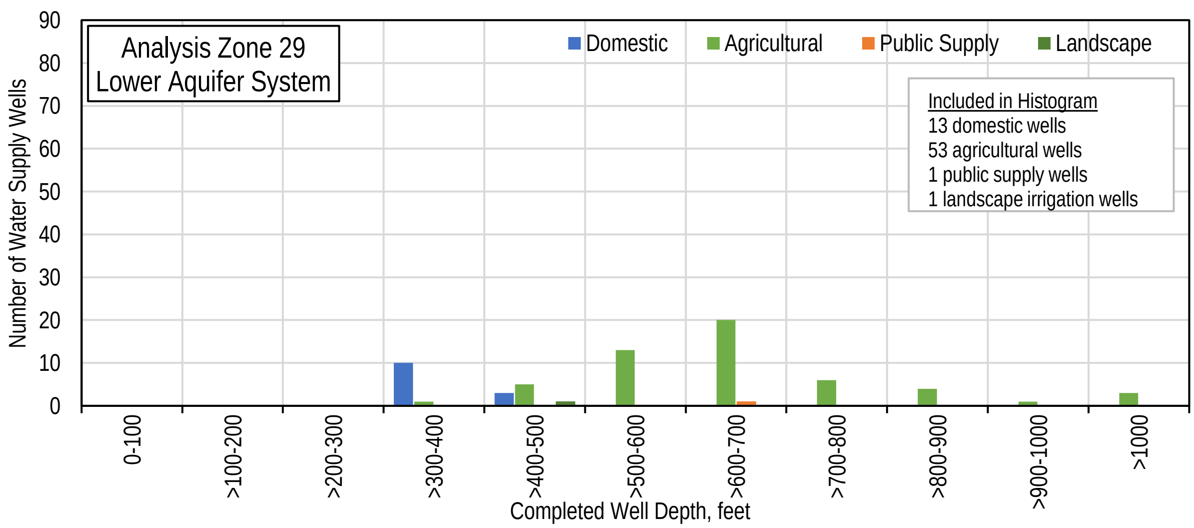

Analysis Zone 24
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
25 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

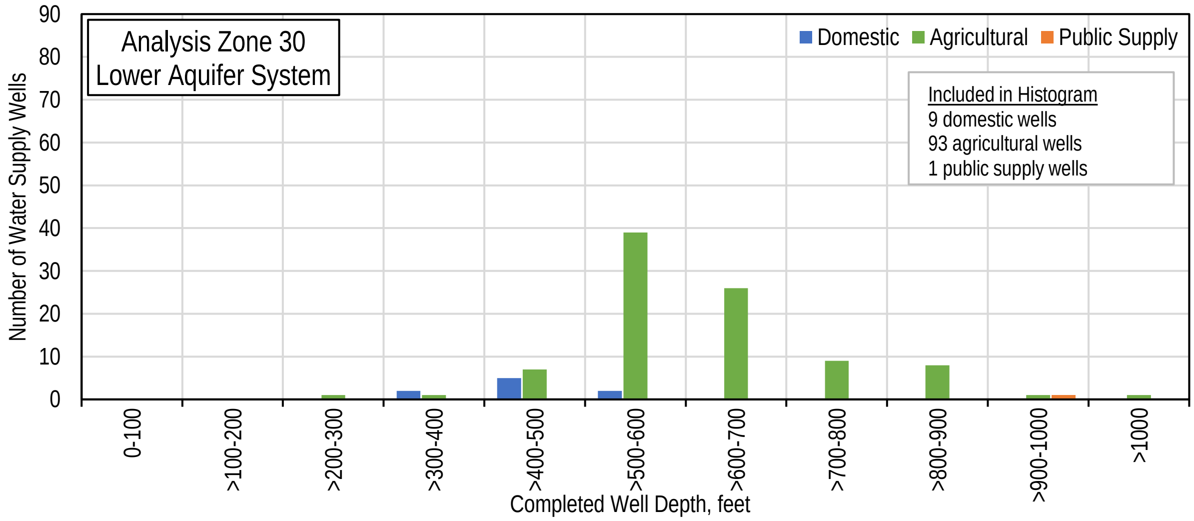

Analysis Zone 25
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
1 domestic wells
55 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

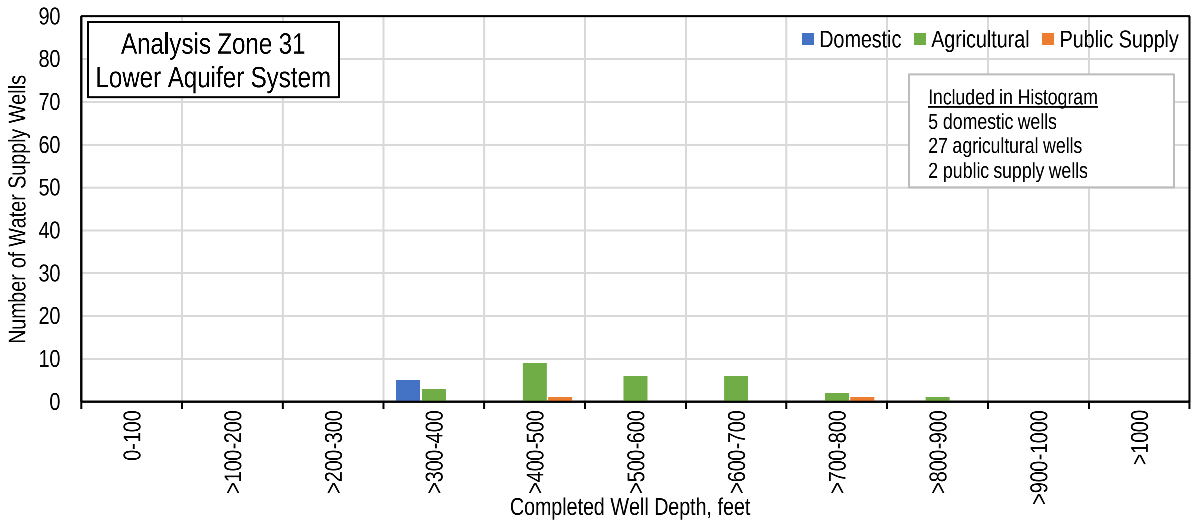

Analysis Zone 26
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
8 domestic wells
5 agricultural wells
4 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

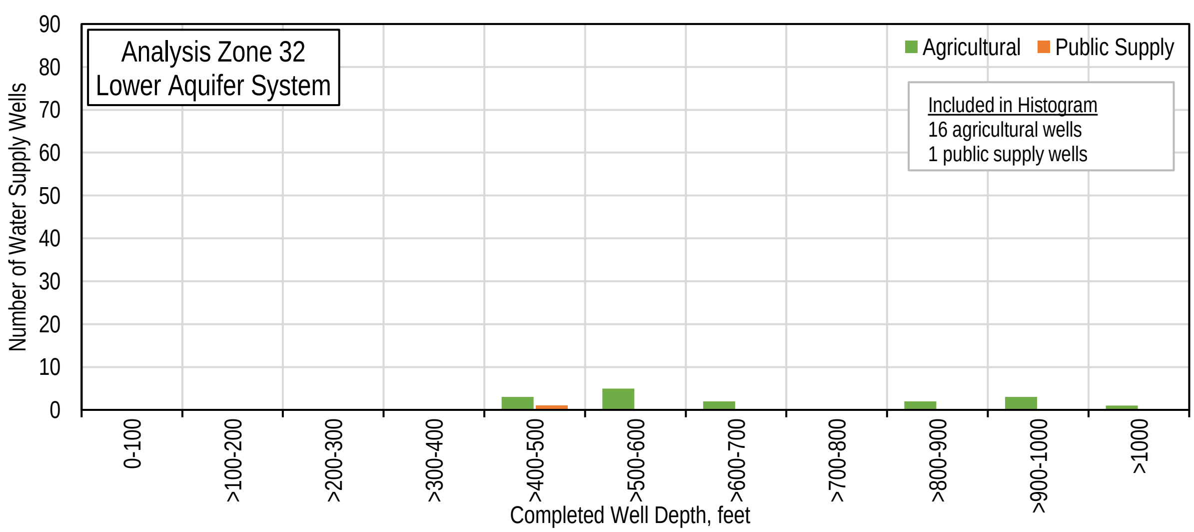

Analysis Zone 27
Lower Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
22 domestic wells
32 agricultural wells
3 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

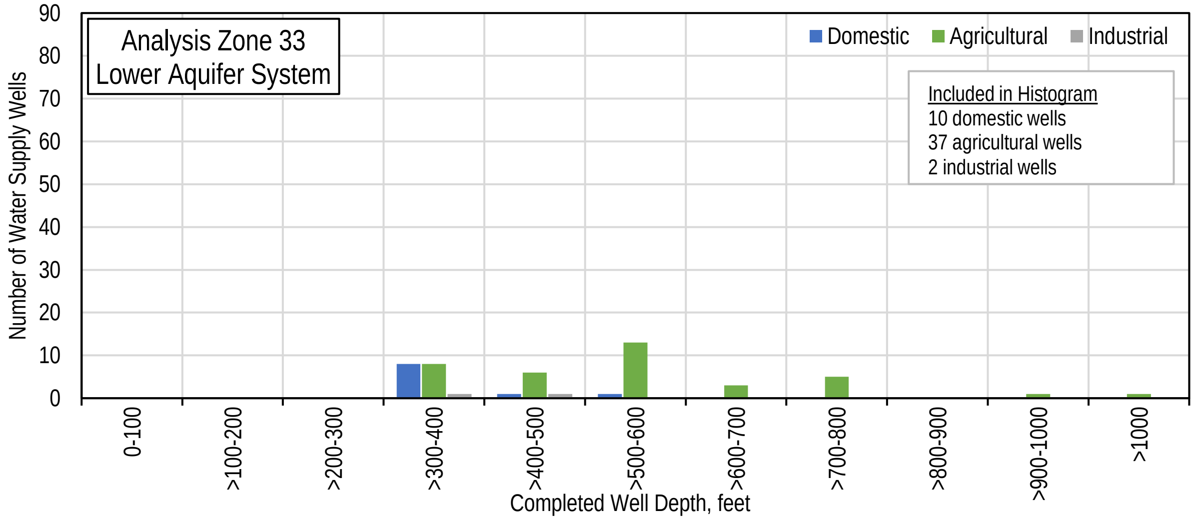

Analysis Zone 28
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
46 domestic wells
46 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

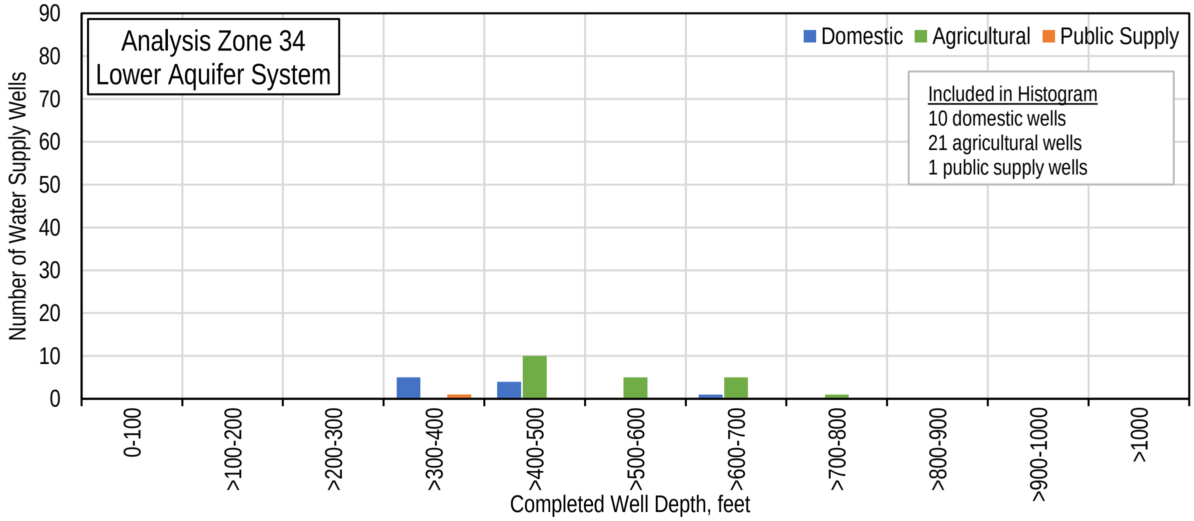

Analysis Zone 29
Lower Aquifer System
Domestic
Agricultural
Public Supply
Landscape
Included in Histogram
13 domestic wells
53 agricultural wells
1 public supply wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

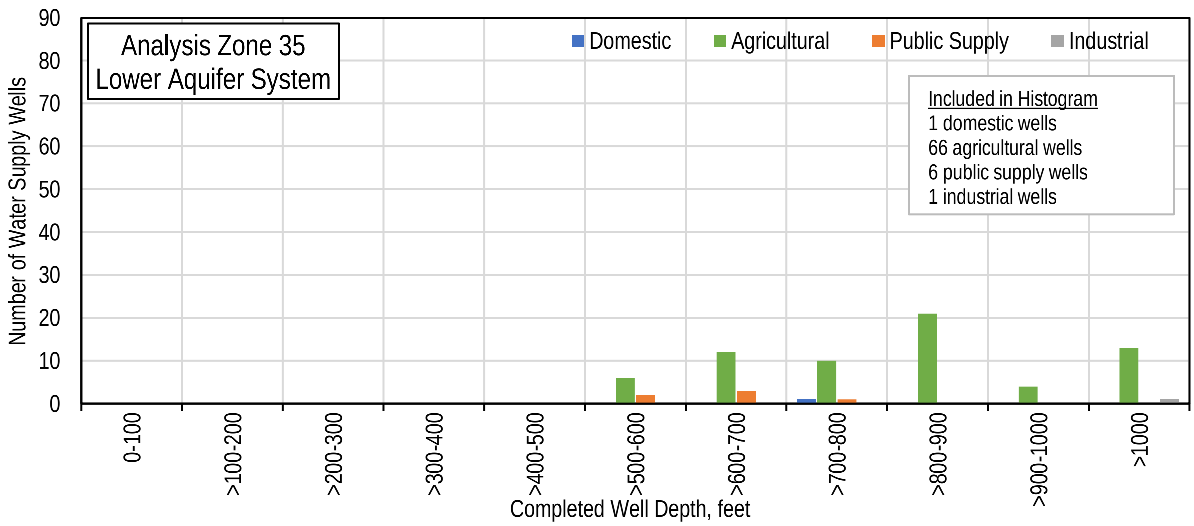

Analysis Zone 30
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
9 domestic wells
93 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

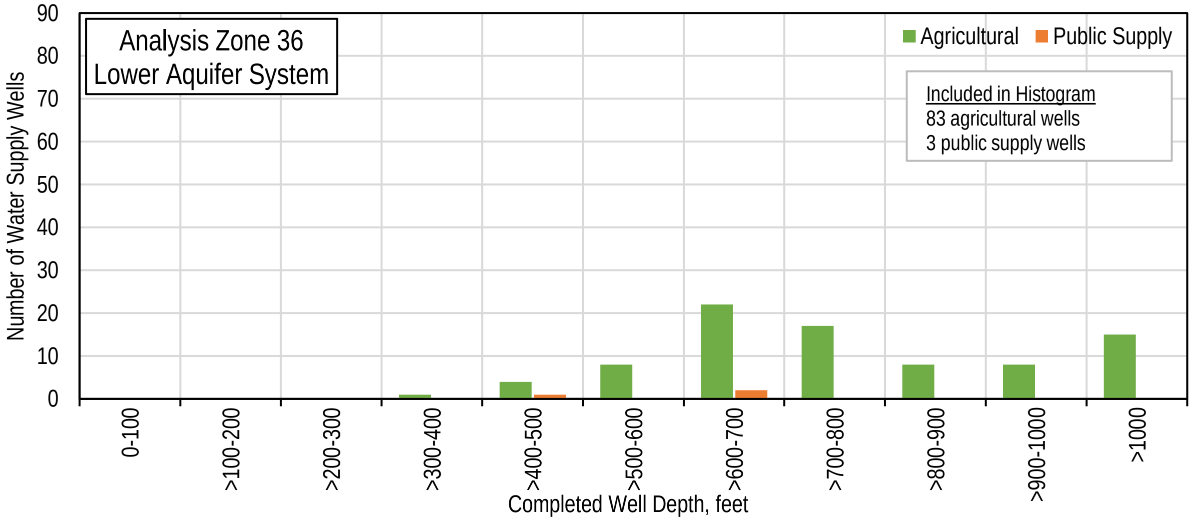

Analysis Zone 31
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
5 domestic wells
27 agricultural wells
2 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

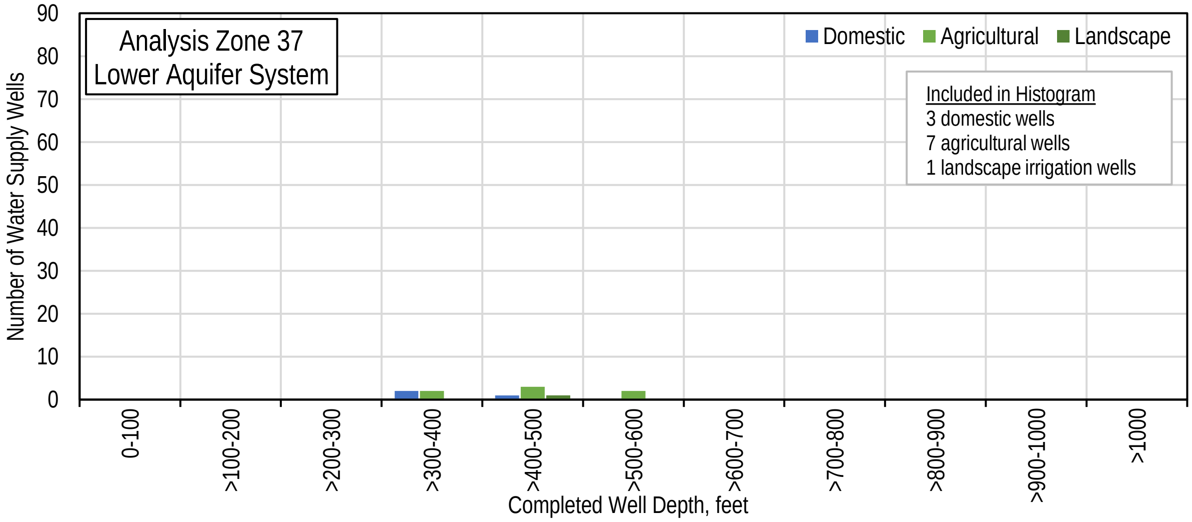

Analysis Zone 32
Lower Aquifer System
Agricultural
Public Supply
Included in Histogram
16 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

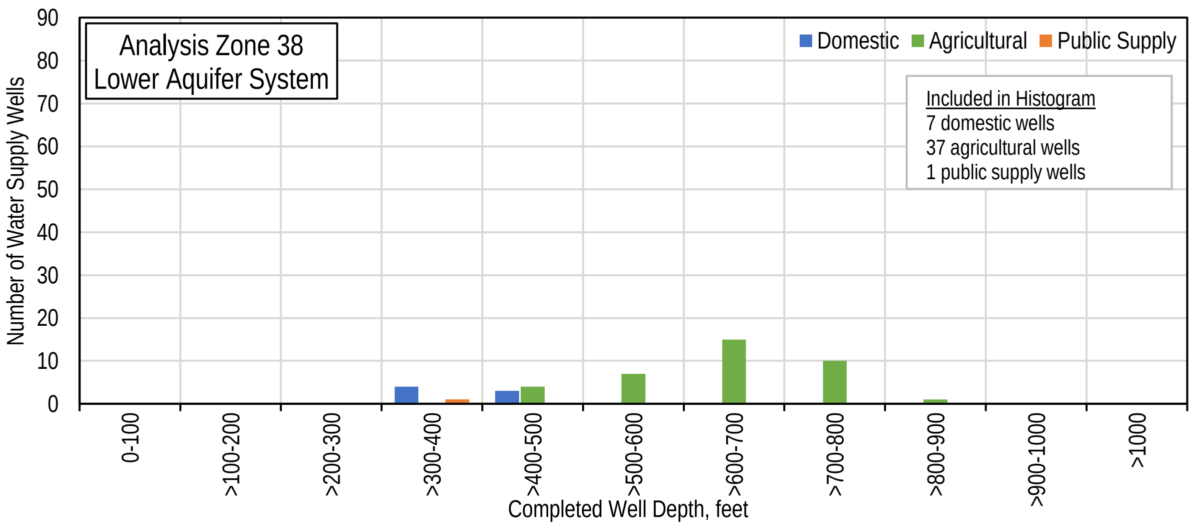

Analysis Zone 33
Lower Aquifer System
Domestic
Agricultural
Industrial
Included in Histogram
10 domestic wells
37 agricultural wells
2 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

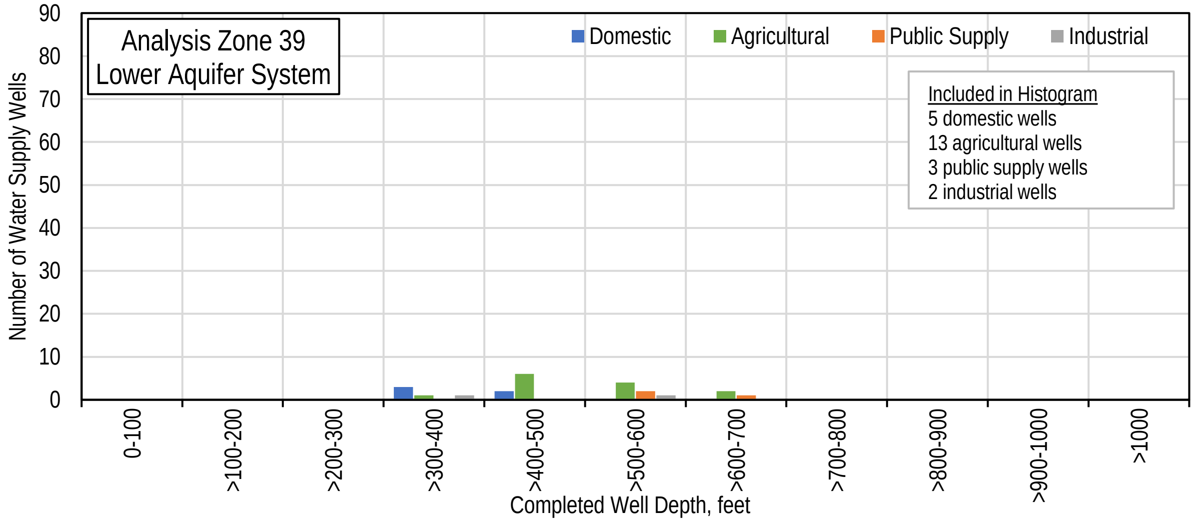

Analysis Zone 34
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
10 domestic wells
21 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 35
Lower Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
1 domestic wells
66 agricultural wells
6 public supply wells
1 industrial wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 36
Lower Aquifer System
Agricultural
Public Supply
Included in Histogram
83 agricultural wells
3 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 37
Lower Aquifer System
Domestic
Agricultural
Landscape
Included in Histogram
3 domestic wells
7 agricultural wells
1 landscape irrigation wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 38
Lower Aquifer System
Domestic
Agricultural
Public Supply
Included in Histogram
7 domestic wells
37 agricultural wells
1 public supply wells
Number of Water Supply Wells
0
10
20
30
40
50
60
70
80
90
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet


Analysis Zone 39
Lower Aquifer System
Domestic
Agricultural
Public Supply
Industrial
Included in Histogram
5 domestic wells
13 agricultural wells
3 public supply wells
2 industrial wells
Number of Water Supply Wells
90
80
70
60
50
40
30
20
10
0
0-100
>100-200
>200-300
>300-400
>400-500
>500-600
>600-700
>700-800
>800-900
>900-1000
>1000
Completed Well Depth, feet

MONTGOMERY & ASSOCIATES

# Appendix C

## 90% Protective Elevations (Methodology 1),
## Groundwater Level Trend Elevations (Methodology 2), and
## Interpolated Minimum Threshold (Methodology 3)
## for Representative Monitoring Site Minimum Thresholds

90% Protective, Groundwater Level Trend, and Interpolated Minimum Threshold Elevations for Kaweah Subbasin Representative Monitoring Sites

| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 16S25E36M002M | 16S25E36M002M | East Kaweah | Single | 2 | 260 | 292 | - |
| 16S26E30Q001M | 16S26E30Q001M | East Kaweah | Single | 2 | 285 | 292 | - |
| 17S25E25A001M | 17S25E25A001M | East Kaweah | Single | 1 | 124 | 185 | - |
| 17S25E35E001M | KSB-2107 | East Kaweah | Single | 1 | 110 | 185 | - |
| 17S26E04F002M | KSB-2369 | East Kaweah | Single | 2 | 276 | 292 | - |
| 17S26E07C001M | 17S26E07C001M | East Kaweah | Single | 2 | 233 | 292 | - |
| 17S26E21E001M | KSB-2354 | East Kaweah | Single | 2 | 266 | 292 | - |
| 17S26E29R001M | 17S26E29R001M | East Kaweah | Single | 2 | 269 | 292 | - |
| 18S26E02D002M | 18S26E02D002M | East Kaweah | Single | 2 | 295 | 292 | - |
| 18S26E06D001M | 18S26E06D001M | East Kaweah | Single | 1 | 130 | 185 | - |
| 18S26E24J003M | 18S26E24J003M | East Kaweah | Single | 4 | 306 | 365 | - |
| 18S27E17H002M | 18S27E17H002M | East Kaweah | Single | 4 | 327 | 365 | - |
| 18S27E29E001M | 18S27E29E001M | East Kaweah | Single | 4 | 330 | 365 | - |
| 18S27E30H001M | 18S27E30H001M | East Kaweah | Single | 4 | 327 | 365 | - |
| 19S26E03A001M | 19S26E03A001M | East Kaweah | Single | 5 | 207 | 244 | - |
| 19S26E11R001M | 19S26E11R001M | East Kaweah | Single | 5 | 198 | 244 | - |
| 19S26E13R001M | 19S26E13R001M | East Kaweah | Single | 9 | 123 | 145 | - |
| 19S26E23E001M | Lindsay Well 15 | East Kaweah | Single | 9 | 103 | 145 | - |
| 19S26E25R001M | 19S26E25R001M | East Kaweah | Single | 9 | 98 | 145 | - |
| 19S26E34R006M | Lindsay Well 14 | East Kaweah | Single | 10 | 43 | 75 | - |
| 19S26E35C001M | 19S26E35C001M | East Kaweah | Single | 9 | 88 | 145 | - |
| 19S27E29D001M | 19S27E29D001M | East Kaweah | Single | 7 | 197 | 312 | - |
| 20S26E08H001M | KSB-2333 | East Kaweah | Single | 10 | 30 | 75 | - |
| 20S26E11R001M | 20S26E11R001M | East Kaweah | Single | 9 | 100 | 145 | - |
| 20S26E12H001M | Lindsay Well 11 | East Kaweah | Single | 9 | 112 | 145 | - |
| 20S26E16R001M | 20S26E16R001M | East Kaweah | Single | 10 | 39 | 75 | - |
| 20S26E20J001M | 20S26E20J001M | East Kaweah | Single | 10 | 32 | 75 | - |
| 20S26E23R001M | 20S26E23R001M | East Kaweah | Single | 9 | 98 | 145 | - |
| 20S26E32A001M | KSB-2344 | East Kaweah | Single | 10 | 35 | 75 | - |
| 20S26E35H001M | 20S26E35H001M | East Kaweah | Single | 9 | 104 | 145 | - |
| 20S27E08A001M | 20S27E08A001M | East Kaweah | Single | 7 | 211 | 312 | - |
| 20S27E15R001M | 20S27E15R001M | East Kaweah | Single | 6 | 354 | 429 | - |
| 20S27E18R001M | 20S27E18R001M | East Kaweah | Single | 8 | 194 | 235 | - |
| 20S27E25N001M | 20S27E25N001M | East Kaweah | Single | 6 | 363 | 429 | - |
| 21S26E11H001M | 21S26E11H001M | East Kaweah | Single | 9 | 110 | 145 | - |
| 21S27E03B001M | 21S27E03B001M | East Kaweah | Single | 8 | 237 | 235 | - |
| 21S27E06F001M | 21S27E06F001M | East Kaweah | Single | 9 | 119 | 145 | - |
| 21S27E08F001M | 21S27E08F001M | East Kaweah | Single | 8 | 199 | 235 | - |
| 21S27E12F001M | 21S27E12F001M | East Kaweah | Single | 7 | 287 | 312 | - |
| SCID Office | SCID Office | East Kaweah | Single | 2 | 243 | 292 | - |

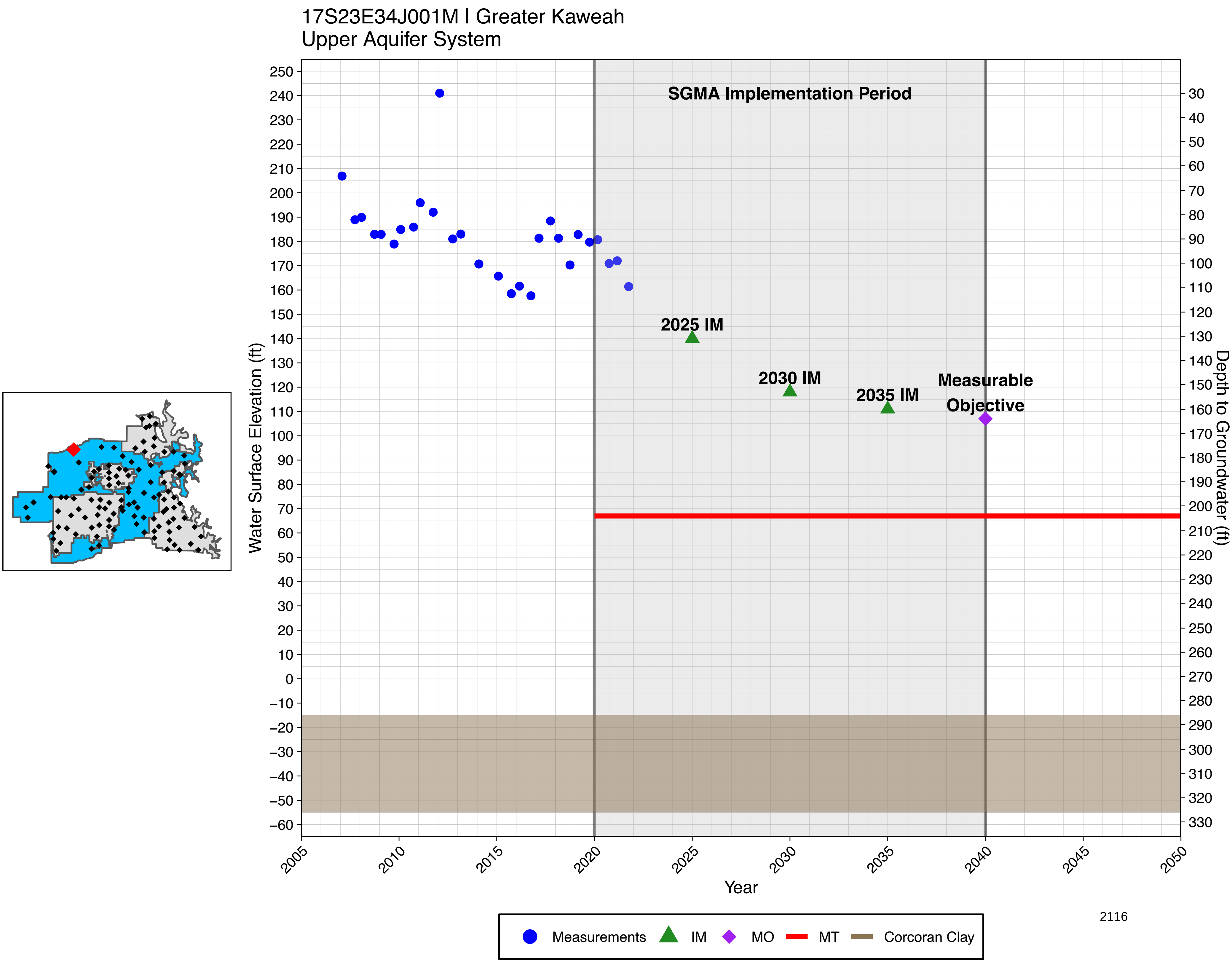
| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 17S23E34J001M | KSB-1161 | Greater Kaweah | Upper | 32 | -5 | 67 | - |
| 17S24E34B001M | KSB-1580 | Greater Kaweah | Single | 11 | 5 | 78 | - |
| 17S24E36H003M | KSB-1775 | Greater Kaweah | Single | 12 | 55 | 73 | - |
| 17S26E36R001M | KSB-2690 | Greater Kaweah | Single | 4 | 299 | 288 | - |
| 18S22E24D001M | KSB-0818 | Greater Kaweah | Upper | 37 | -38 | 59 | - |
| 18S23E14A001M | KSB-1222 | Greater Kaweah | Upper | 32 | 5 | 73 | - |
| 18S23E30D001M | KSB-0905 | Greater Kaweah | Lower | 36 | -311 | -207 | - |
| 18S23E30D901M | KSB-0903 | Greater Kaweah | Upper | 36 | -26 | 71 | - |
| 18S25E05Q001M | KSB-1936 | Greater Kaweah | Single | 13 | 93 | 81 | - |
| 18S25E15C001M | KSB-2058 | Greater Kaweah | Single | 13 | 109 | 110 | - |
| 18S25E23J001M | KSB-2147 | Greater Kaweah | Single | 14 | 164 | 169 | - |
| 18S26E17L001M | KSB-2297 | Greater Kaweah | Single | 15 | 250 | 313 | - |
| 18S26E27B001M | KSB-2466 | Greater Kaweah | Single | 5 | 199 | 349 | - |
| 18S27E05J001M | KSB-2822 | Greater Kaweah | Single | 16 | 328 | 415 | - |
| 19S22E24B001M | KSB-0856 | Greater Kaweah | Upper | 36 | -36 | 25 | - |
| 19S22E28D001M | KSB-0616 | Greater Kaweah | Upper | 35 | 33 | 19 | - |
| 19S22E31B002M | KSB-0531 | Greater Kaweah | Upper | 35 | 27 | 57 | - |
| 19S23E12L001M | KSB-1259 | Greater Kaweah | Lower | 38 | -129 | 56 | - |
| 19S23E21C001M | KSB-1055 | Greater Kaweah | Upper | 29 | -9 | 51 | - |
| 19S25E09H001M | KSB-2017 | Greater Kaweah | Single | 14 | 142 | 92 | - |
| 19S25E13A002M | KSB-2200 | Greater Kaweah | Single | 19 | 151 | 114 | - |
| 19S25E16A002M | KSB-2015 | Greater Kaweah | Single | 18 | 75 | 91 | - |
| 19S25E27A001M | KSB-2089 | Greater Kaweah | Single | 18 | 72 | 57 | - |
| 19S25E28H001M | KSB-2021 | Greater Kaweah | Single | 20 | 23 | 56 | - |
| 19S25E32J001M | KSB-1937 | Greater Kaweah | Upper | 24 | 82 | 49 | - |
| 19S25E35B002M | KSB-2139 | Greater Kaweah | Single | 18 | 66 | 47 | - |
| 19S26E05C001M | KSB-2291 | Greater Kaweah | Single | 14 | 171 | 229 | - |
| 19S26E16J002M | KSB-2411 | Greater Kaweah | Single | 18 | 106 | 124 | - |
| 19S26E20A001M | KSB-2322 | Greater Kaweah | Single | 18 | 92 | 106 | - |
| 20S22E07A003M | KSB-0550 | Greater Kaweah | Upper | 35 | 20 | -28 | - |
| 20S22E24R001M | KSB-0889 | Greater Kaweah | Upper | 30 | -73 | -17 | - |
| 20S22E36A001M | KSB-0890 | Greater Kaweah | Upper | 30 | -79 | -10 | - |
| 20S24E24H001M | KSB-1783 | Greater Kaweah | Upper | 24 | 51 | 56 | - |
| 20S25E03R001M | KSB-2095 | Greater Kaweah | Single | 20 | 8 | 17 | 55 |
| 20S25E12A001M | KSB-2197 | Greater Kaweah | Single | 20 | 17 | 18 | 65 |
| 20S25E14F004M | KSB-2114 | Greater Kaweah | Single | 21 | -72 | 2 | 60 |
| 20S25E24R001M | KSB-2203 | Greater Kaweah | Single | 21 | -63 | -2 | 65 |
| 21S24E03L001M | KSB-1535 | Greater Kaweah | Upper | 25 | 89 | -24 | ** |
| 21S24E08A001M | KSB-1425 | Greater Kaweah | Lower | 25 | -262 | 10 | - |

| Unique Well ID | Local Well ID | GSA | Aquifer System | Analysis Zone | Methodology 1 90% Protective Elevation (feet) | Methodology 2 Groundwater Level Trend Projection Elevation (feet) | Methodology 3 Interpolated Minimum Threshold (feet) |
|---|---|---|---|---|---|---|---|
| 025-01 | KSB-1696 | Mid-Kaweah | Upper | 39 | 112 | 13 | 138 |
| 036-01 | KSB-1884 | Mid-Kaweah | Single | 22 | 79 | 27 | - |
| 047-01 | KSB-1699 | Mid-Kaweah | Upper | 39 | 107 | 157 | - |
| 053-01 | KSB-1977 | Mid-Kaweah | Single | 23 | 52 | 56 | - |
| 075-01 | KSB-1447 | Mid-Kaweah | Upper | 39 | 81 | 60 | - |
| 077-01 | KSB-1427 | Mid-Kaweah | Upper | 39 | 81 | 33 | - |
| 18S24E13N001M | KSB-1689 | Mid-Kaweah | Single | 22 | 69 | 75 | - |
| 18S24E22E001M | KSB-1526 | Mid-Kaweah | Upper | 39 | 103 | -139 | 85 |
| 18S24E25D001M | KSB-1690 | Mid-Kaweah | Upper | 39 | 114 | 161 | - |
| 18S25E28R001M | KSB-2014 | Mid-Kaweah | Single | 23 | 54 | 69 | - |
| 18S25E30Q001M | KSB-1819 | Mid-Kaweah | Single | 22 | 75 | 34 | - |
| 19S23E20C001M | KSB-0994 | Mid-Kaweah | Lower | 29 | -12 | 71 | - |
| 19S23E22H001M | KSB-1168 | Mid-Kaweah | Upper | 29 | 3 | 30 | - |
| 19S23E31R001M | KSB-0946 | Mid-Kaweah | Upper | 29 | -27 | -72 | - |
| 19S23E35H001M | KSB-1226 | Mid-Kaweah | Upper | 29 | 3 | -101 | - |
| 19S24E08D002M | KSB-1384 | Mid-Kaweah | Upper | 38 | 47 | 38 | - |
| 19S24E20F001M | KSB-1408 | Mid-Kaweah | Upper | 28 | 75 | Drilled after 2016 | - |
| 19S24E22E001M | KSB-1545 | Mid-Kaweah | Upper | 28 | 86 | Drilled after 2016 | - |
| 19S24E25D001M | KSB-1709 | Mid-Kaweah | Upper | 27 | 2 | -6 | 88 |
| 19S24E34D001M | KSB-1536 | Mid-Kaweah | Upper | 28 | 77 | Drilled after 2016 | - |
| 19S24E35E001M | KSB-1628 | Mid-Kaweah | Lower | 26 | -109 | -92 | - |
| 19S24E36C002M | KSB-1903 | Mid-Kaweah | Lower | 27 | -98 | -43 | - |
| 19S25E06A001M | KSB-1862 | Mid-Kaweah | Single | 22 | 76 | 35 | - |
| 19S25E20P001M | KSB-1905 | Mid-Kaweah | Upper | 27 | 24 | 90 | - |
| 20S23E03L001M | KSB-1129 | Mid-Kaweah | Upper | 29 | -9 | -81 | - |
| 20S23E18R001M | KSB-0948 | Mid-Kaweah | Upper | 30 | -66 | -173 | - |
| 20S23E21B001M | KSB-1071 | Mid-Kaweah | Upper | 30 | -66 | -126 | - |
| 20S23E26C001M | KSB-1206 | Mid-Kaweah | Upper | 30 | -64 | -20 | - |
| 20S24E01H002M | KSB-1770 | Mid-Kaweah | Lower | 26 | -289 | -150 | - |
| 20S24E04K001M | KSB-1506 | Mid-Kaweah | Lower | 26 | -123 | -39 | - |
| 20S24E07C001M | KSB-1320 | Mid-Kaweah | Upper | 31 | 58 | Drilled after 2016 | - |
| 20S24E11J002M | KSB-1695 | Mid-Kaweah | Lower | 26 | -119 | -121 | - |
| 20S24E16H001M | KSB-1538 | Mid-Kaweah | Lower | 31 | -115 | 62 | - |
| 20S24E17P001M | KSB-1431 | Mid-Kaweah | Upper | 31 | 58 | 88 | - |
| 20S24E28L001M | KSB-1477 | Mid-Kaweah | Upper | 31 | 58 | 60 | - |
| 21S23E05A002M | KSB-0976 | Mid-Kaweah | Upper | 30 | -84 | -141 | - |
| 21S23E07J001M | KSB-0922 | Mid-Kaweah | Upper | 30 | -36 | -22 | - |
| 361856N1193313W001 | KSB-1706 | Mid-Kaweah | Lower | 26 | -136 | -287 | - |

Note. bolded elevation indicates the minimum threshold assigned to the representative monitoring site

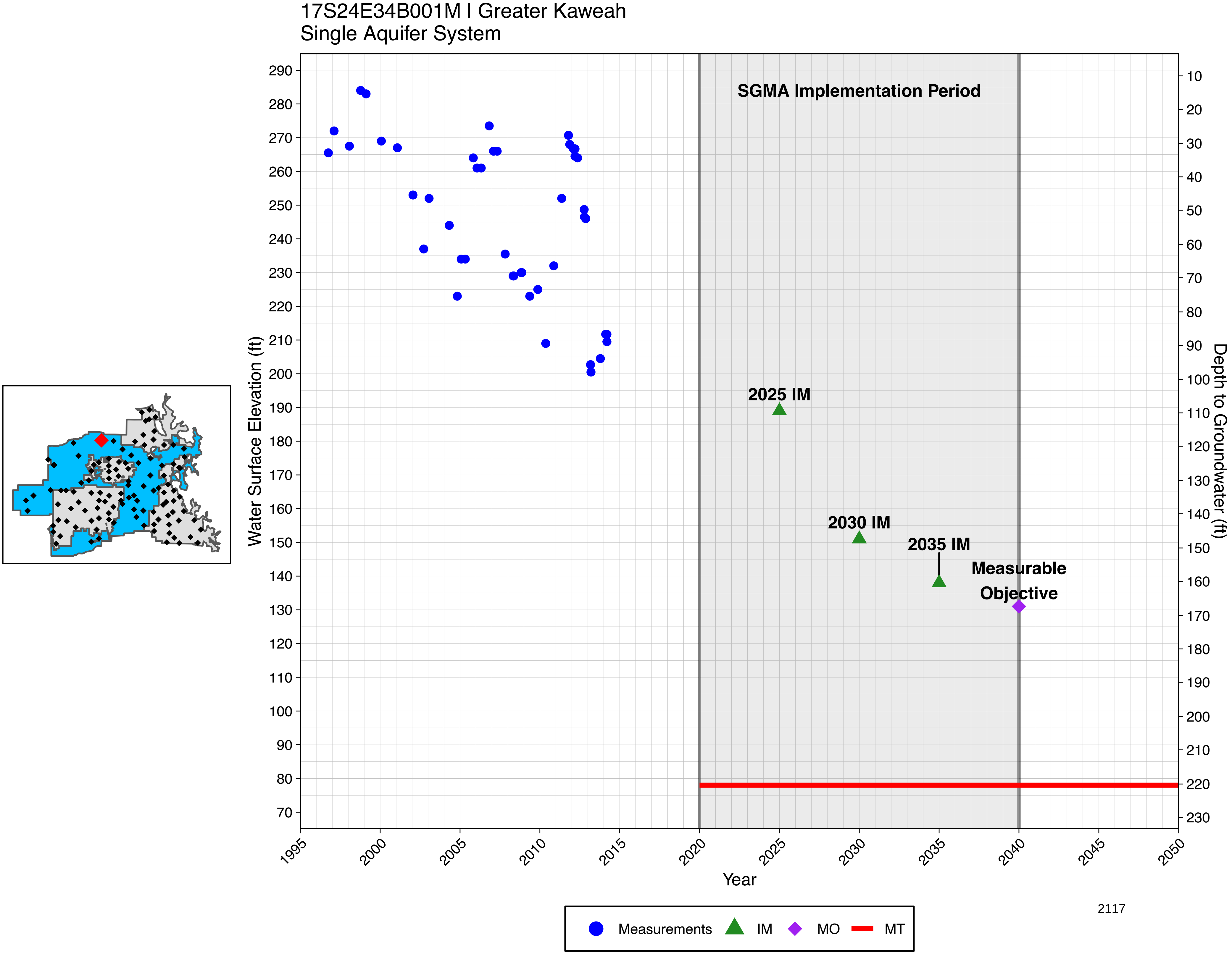
# Appendix 5C

## Sustainable Management Criteria Hydrographs for Groundwater Levels

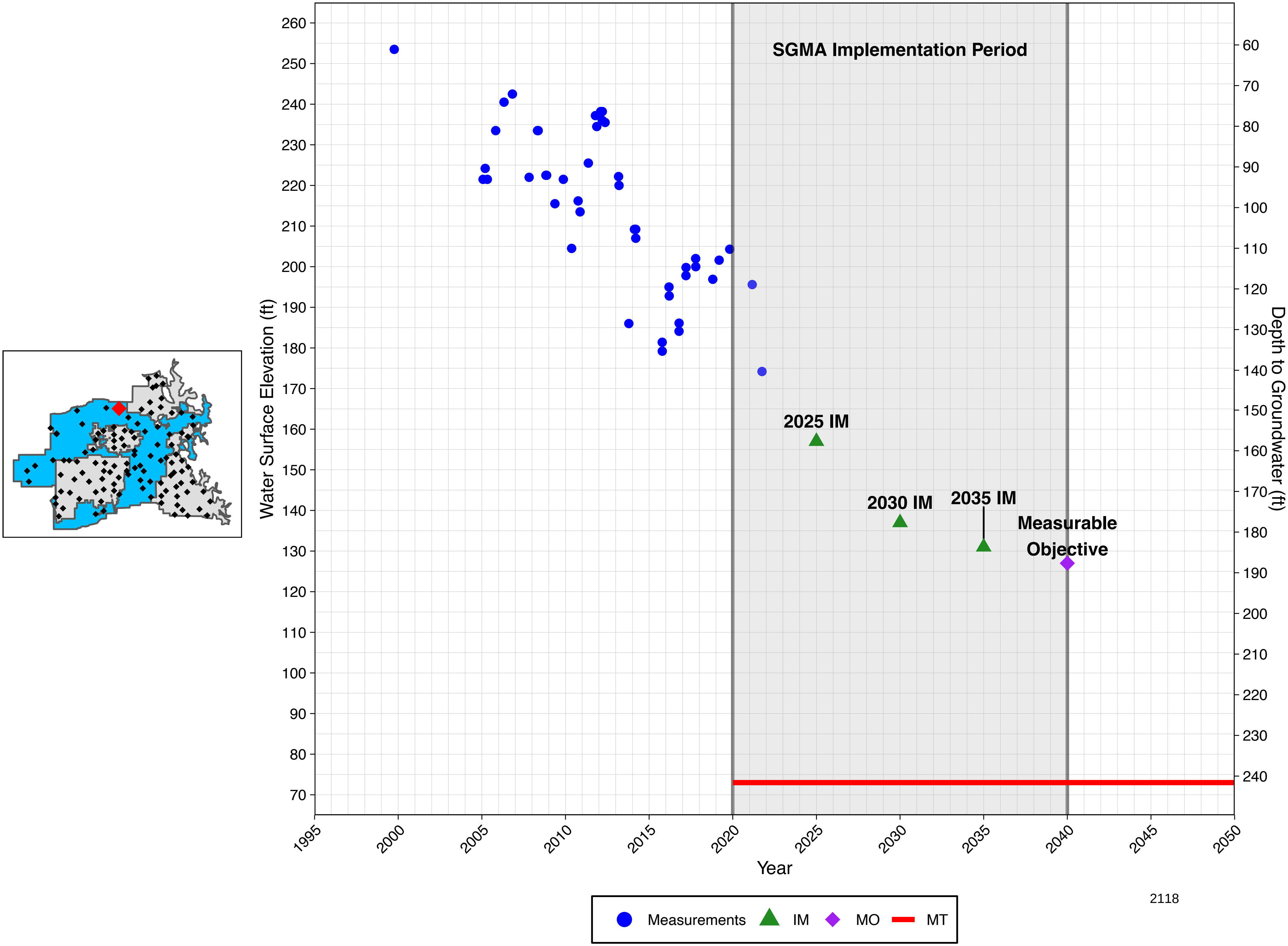


17S23E34J001M | Greater Kaweah
Upper Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable
Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
Corcoran Clay

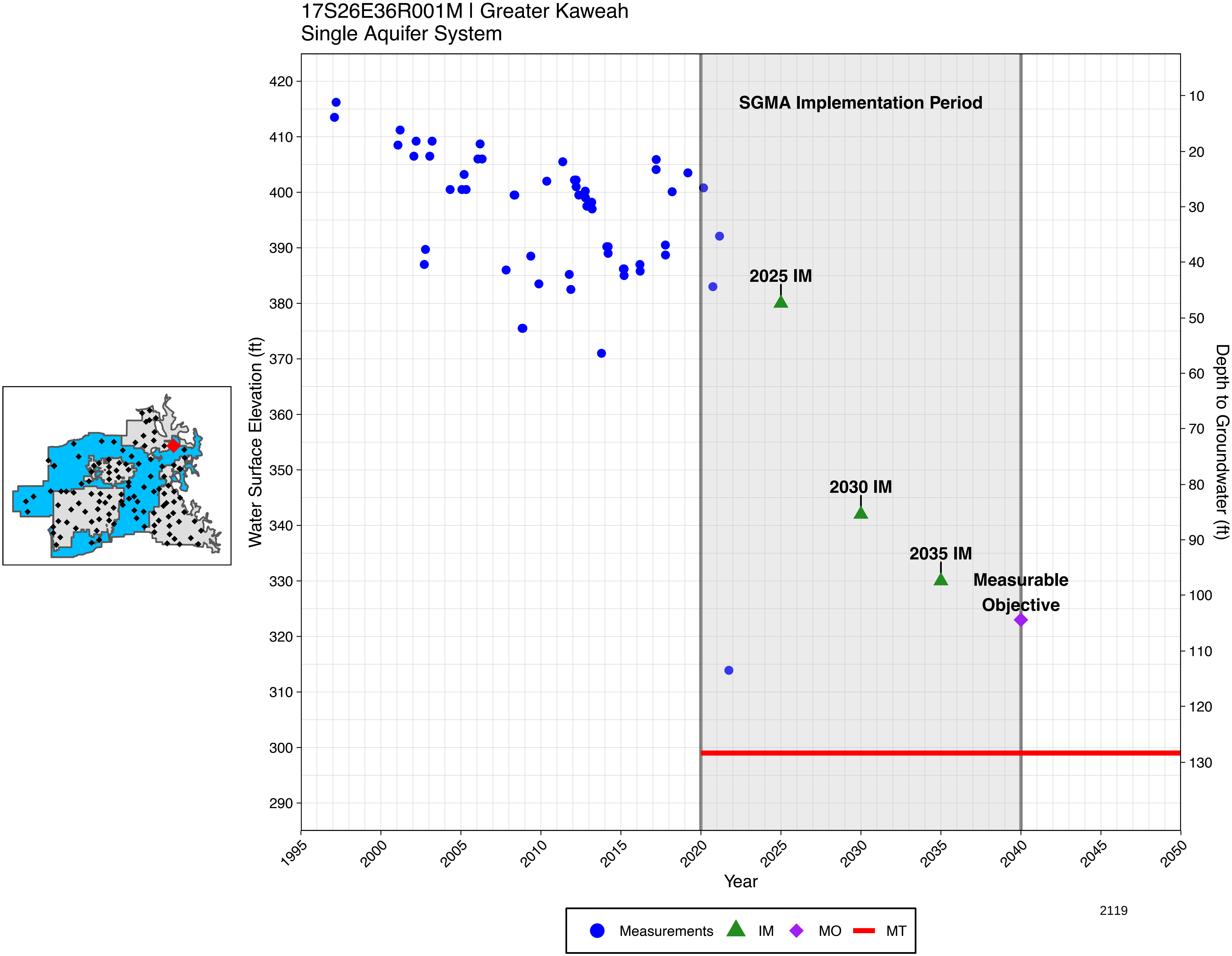

2116


17S24E34B001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
2117

17S24E36H003M I Greater Kaweah
Single Aquifer System



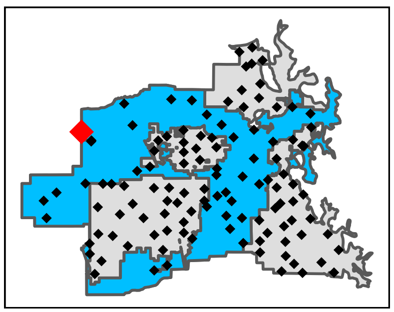

2118

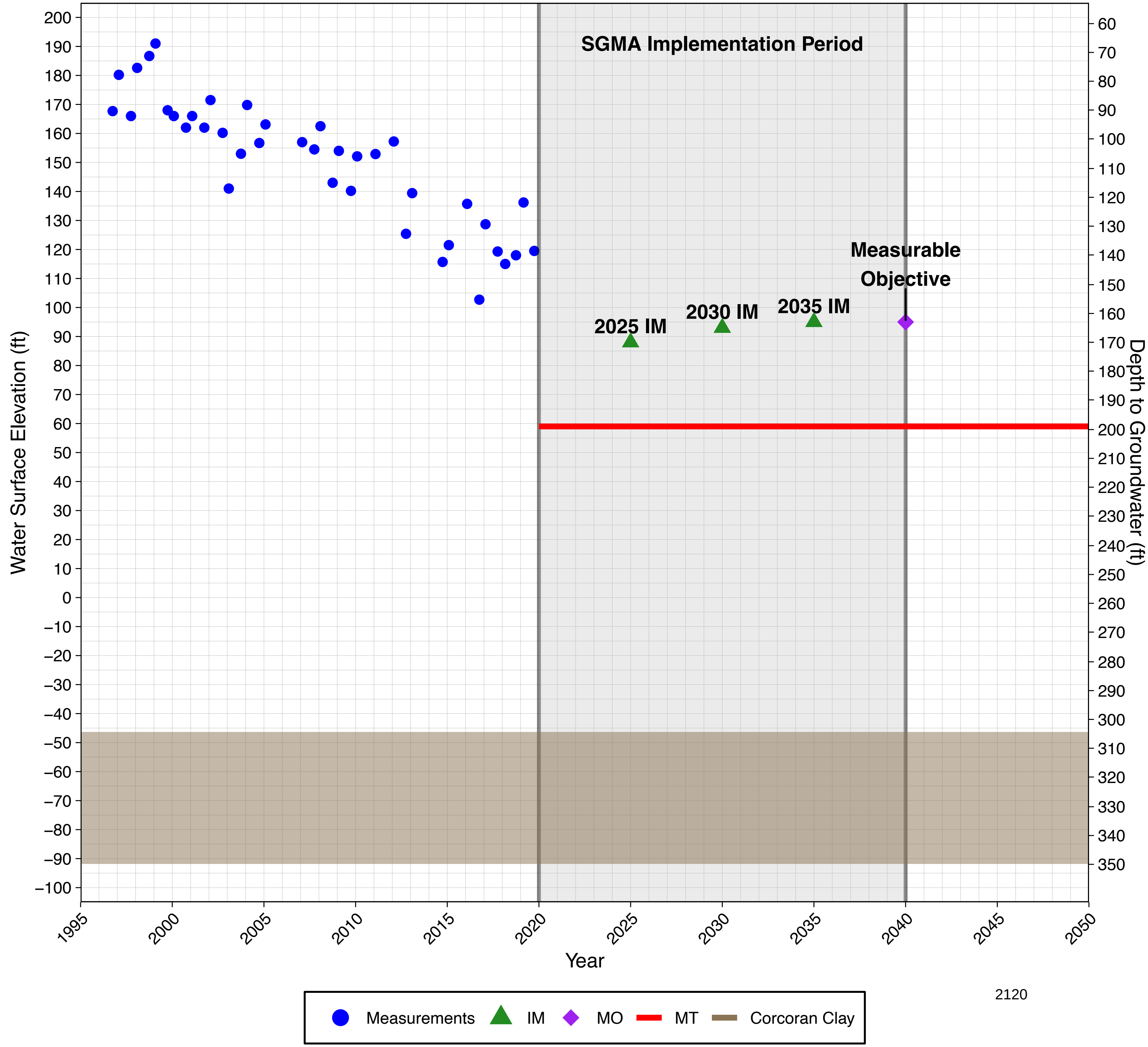


17S26E36R001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT


2119

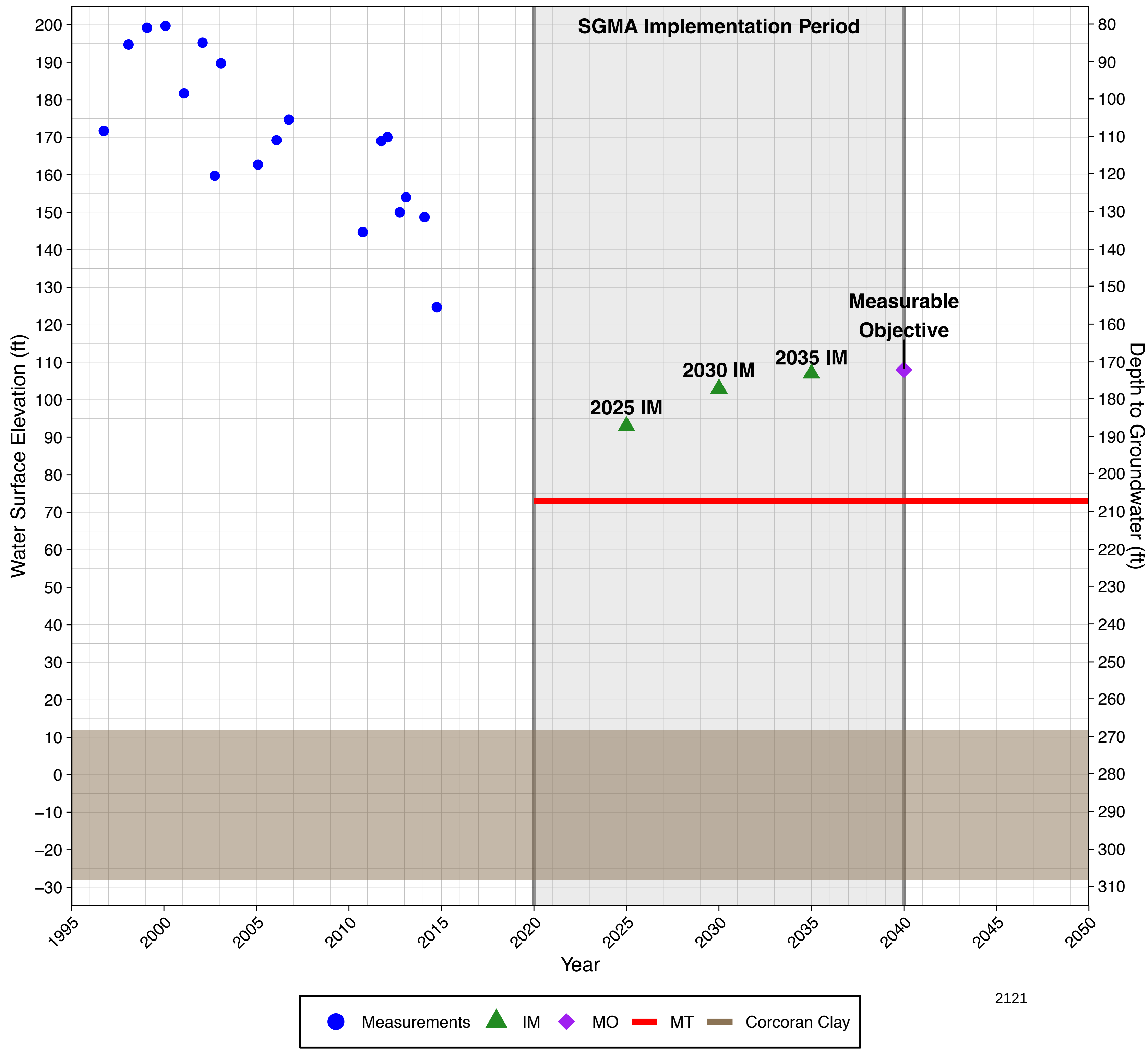
18S22E24D001M | Greater Kaweah
Upper Aquifer System

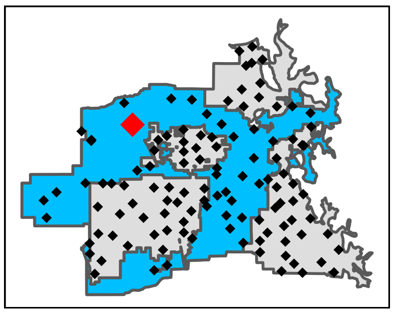





2120

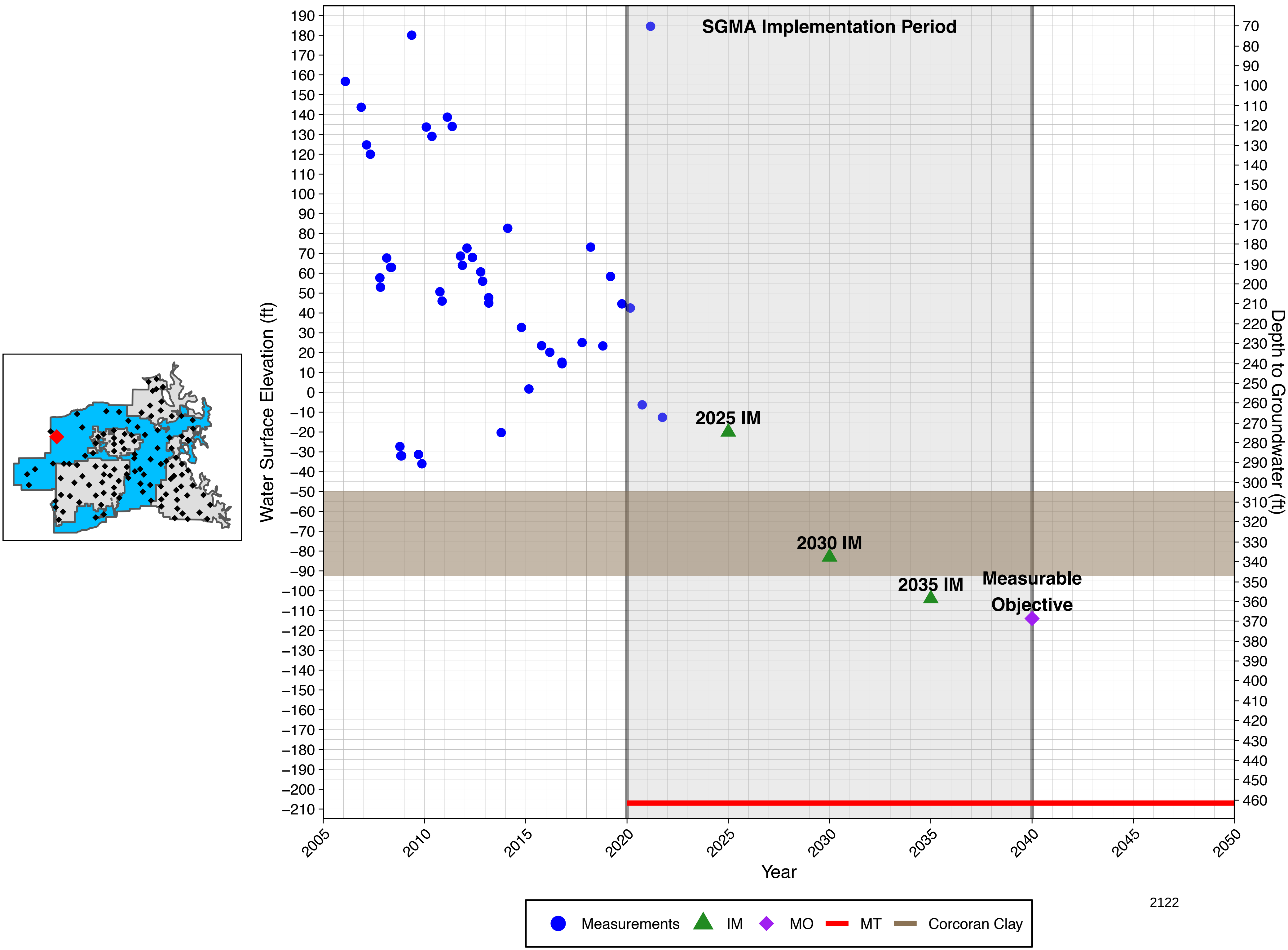
18S23E14A001M | Greater Kaweah
Upper Aquifer System



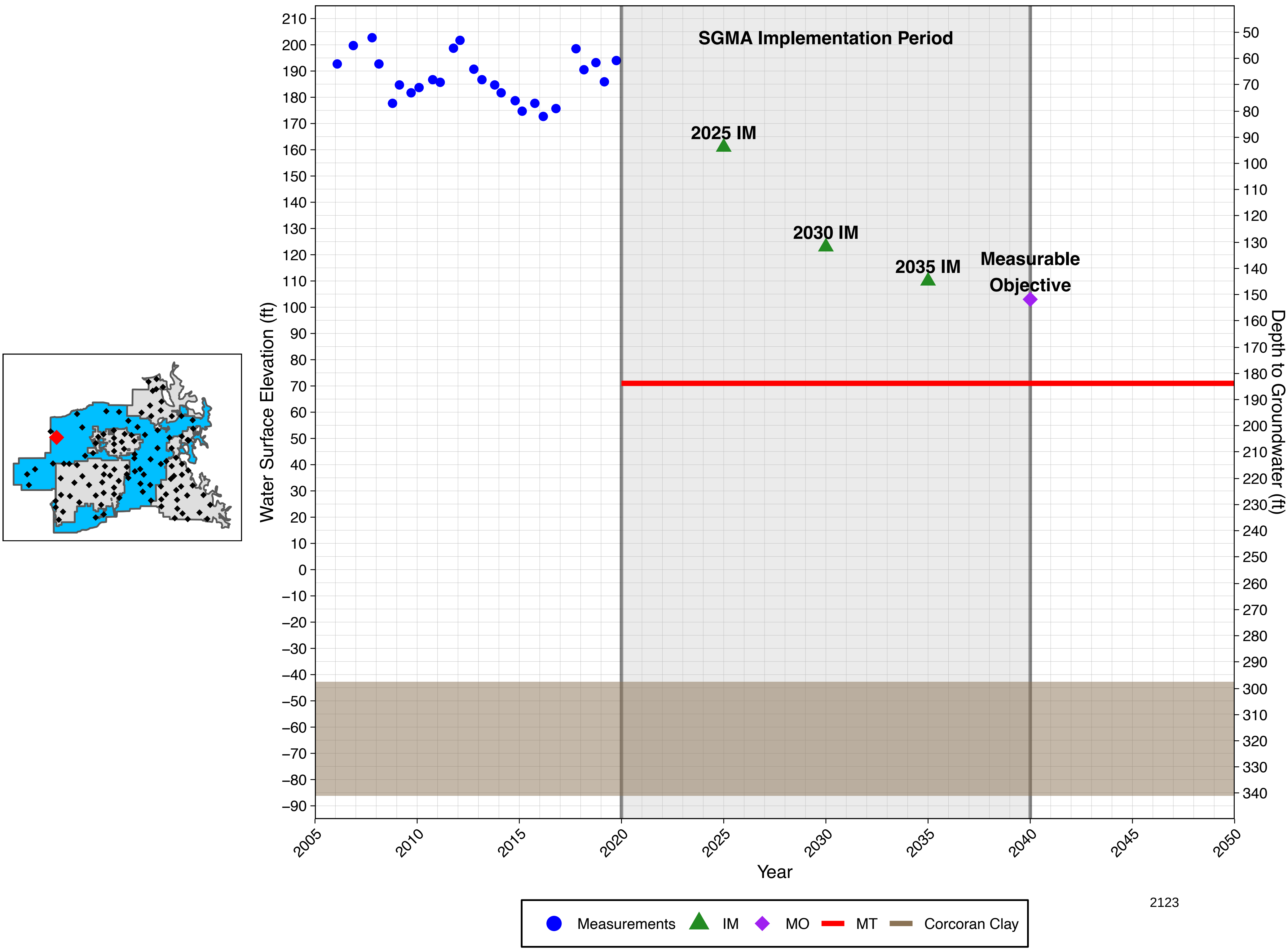
2121

18S23E30D001M | Greater Kaweah
Lower Aquifer System

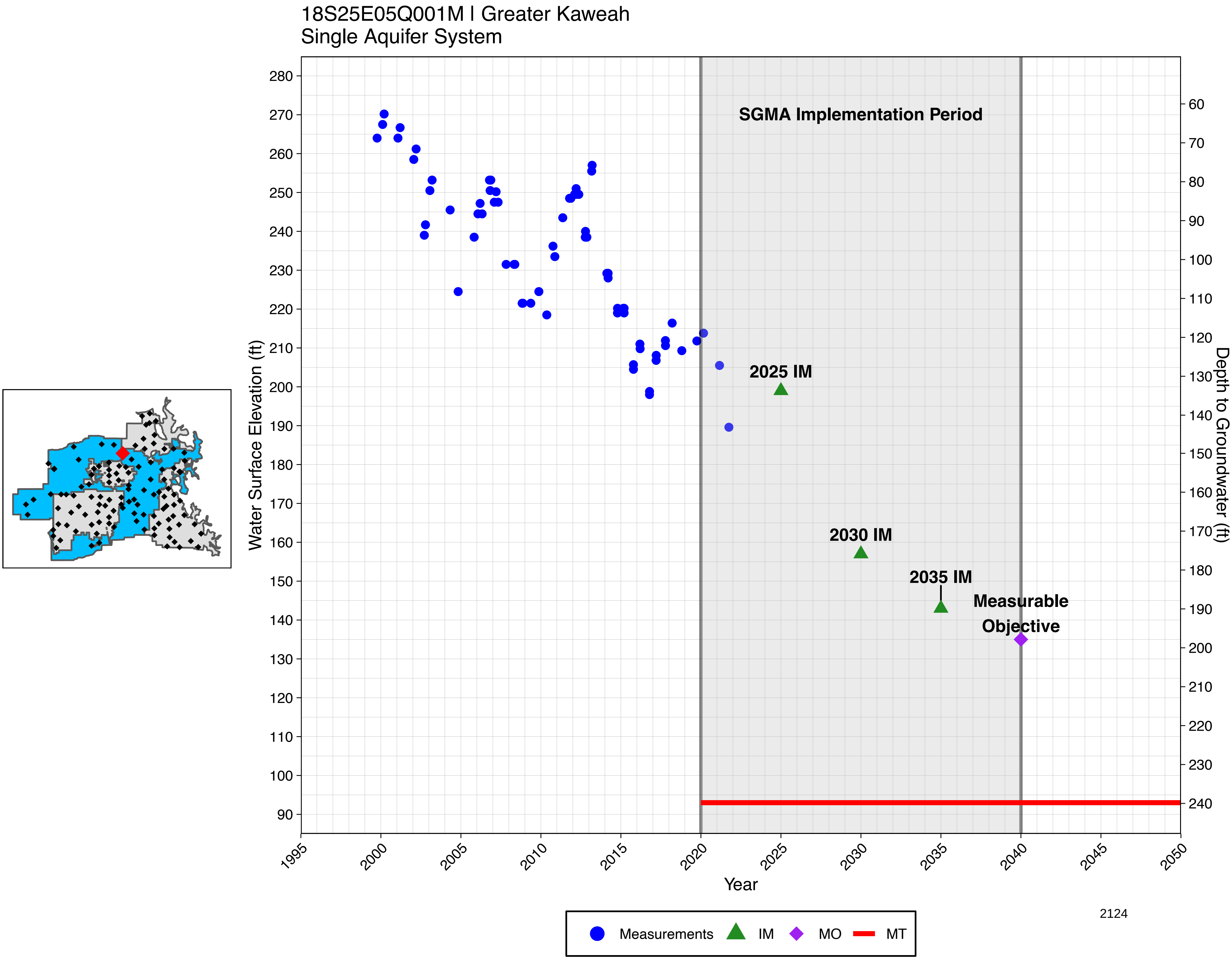



2122

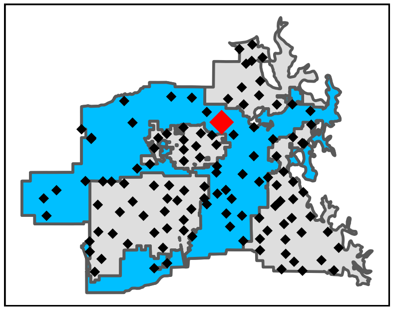
18S23E30D901M | Greater Kaweah
Upper Aquifer System

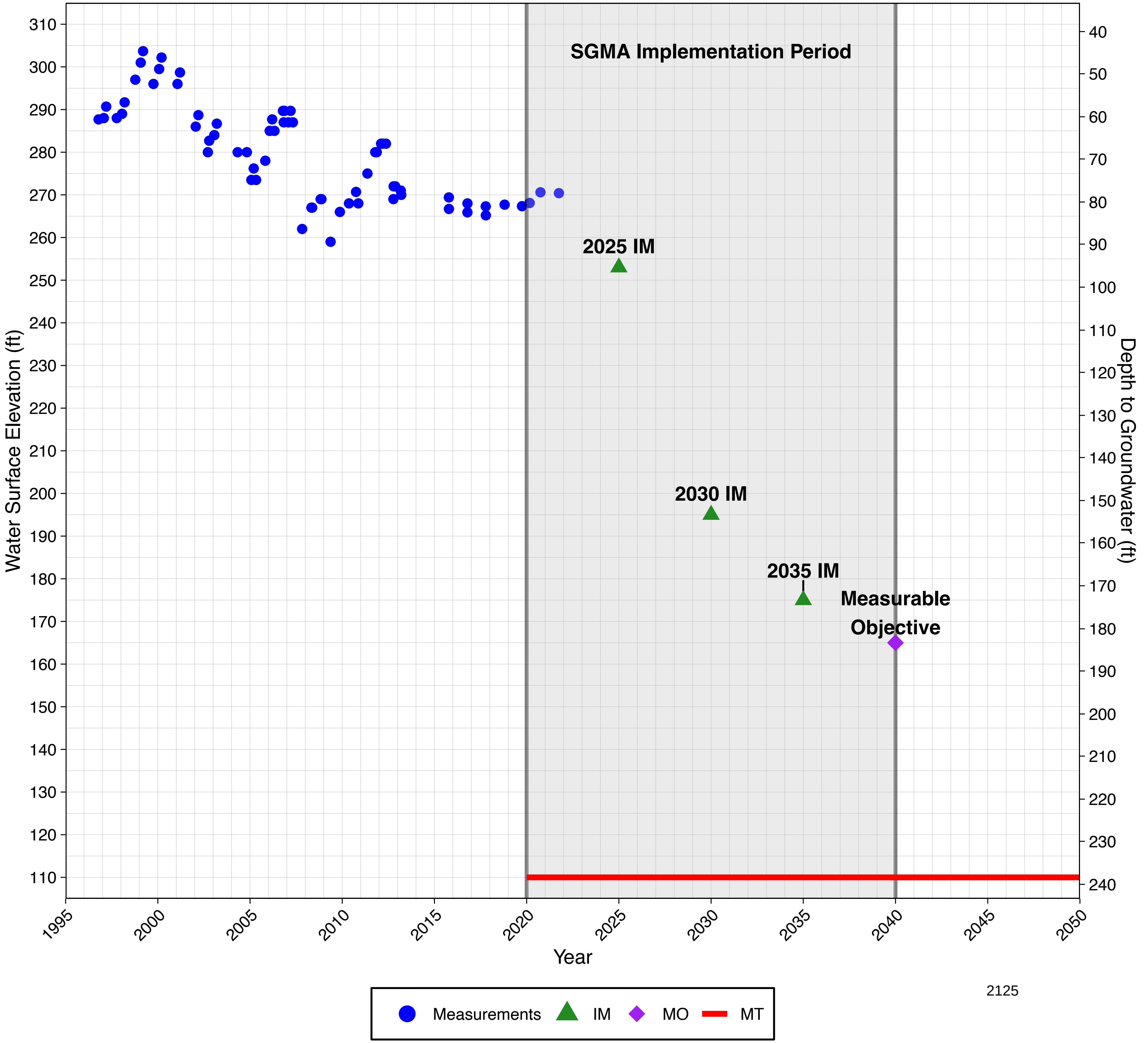


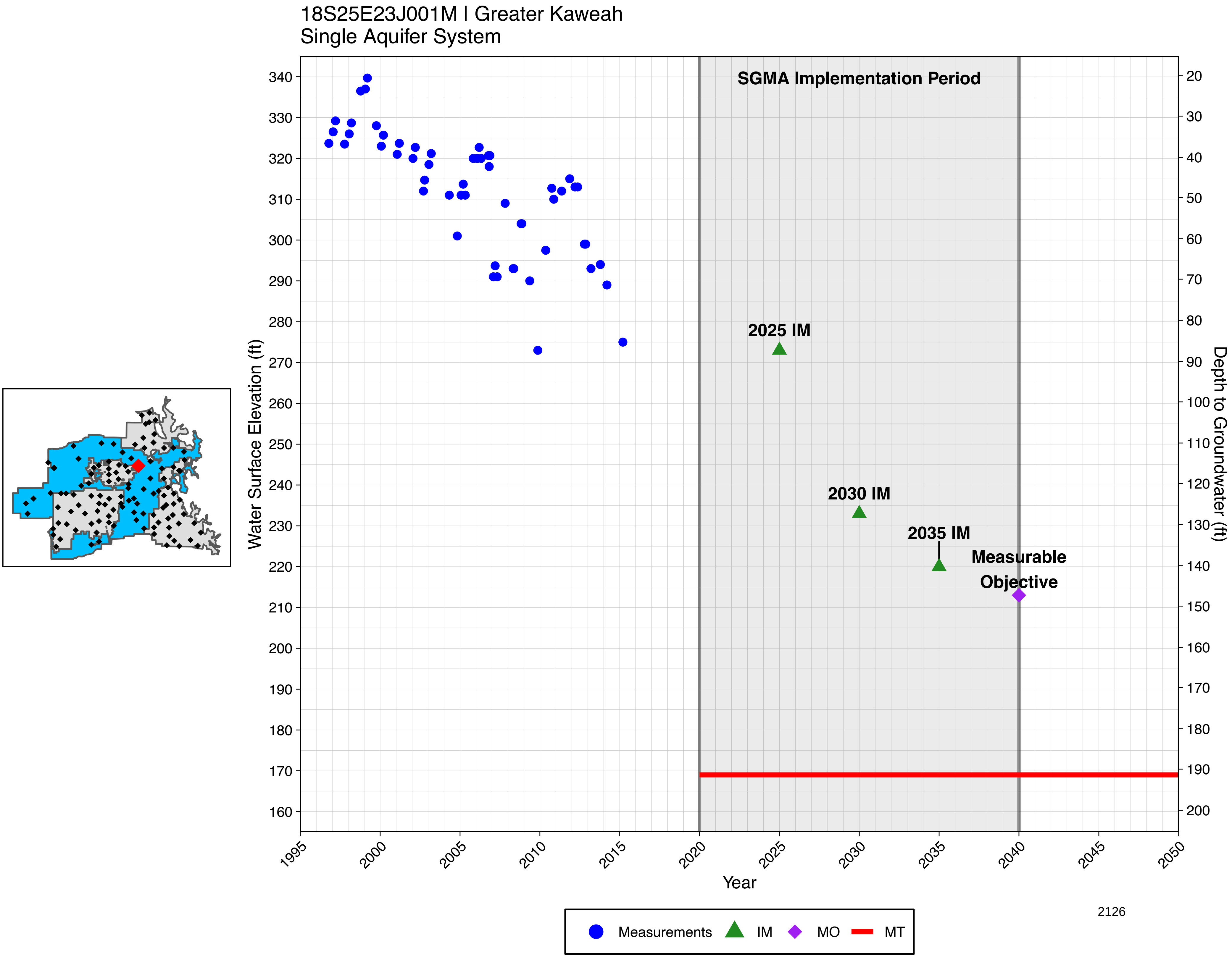

2123


18S25E05Q001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
2124

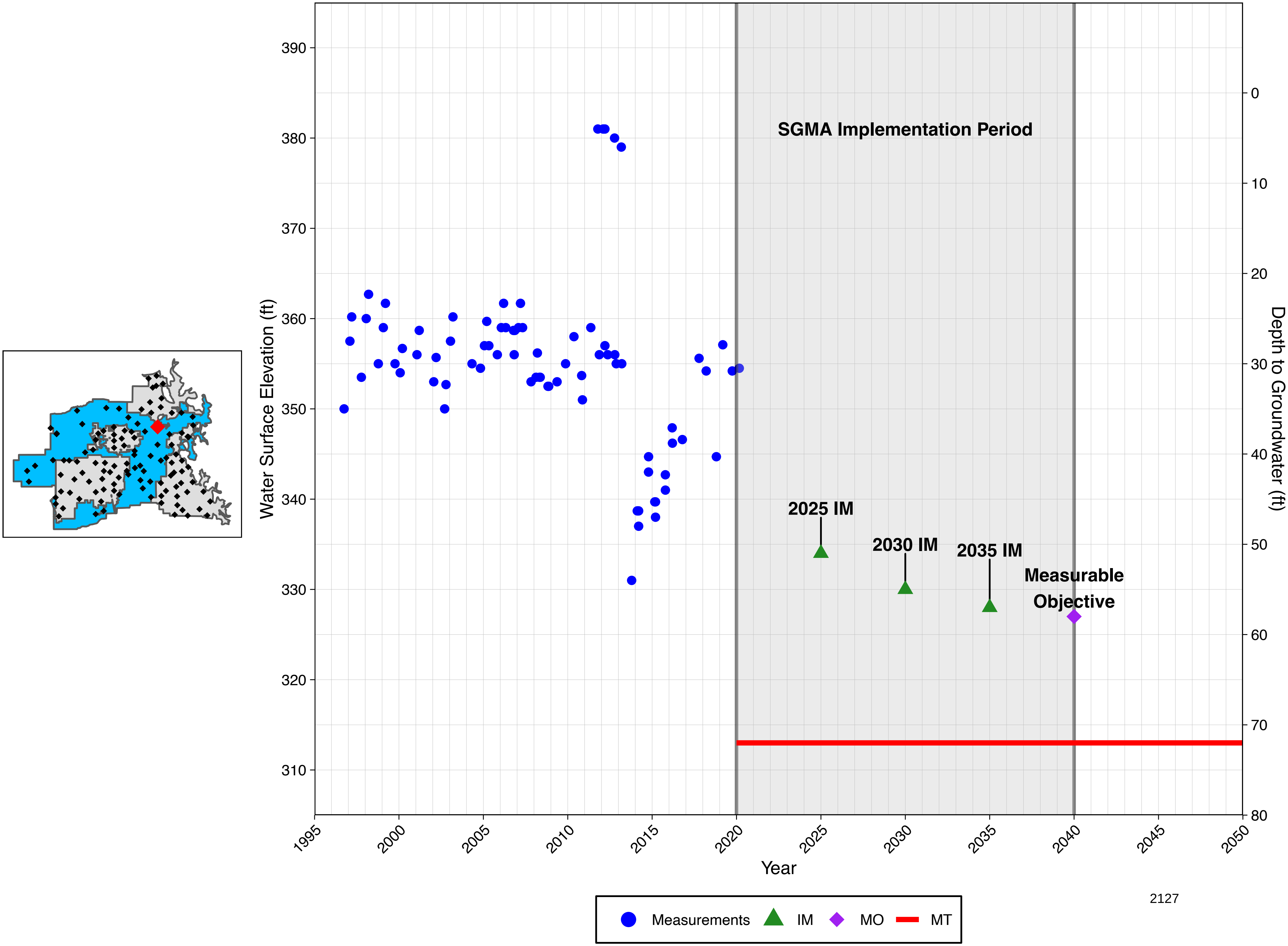
18S25E15C001M | Greater Kaweah
Single Aquifer System





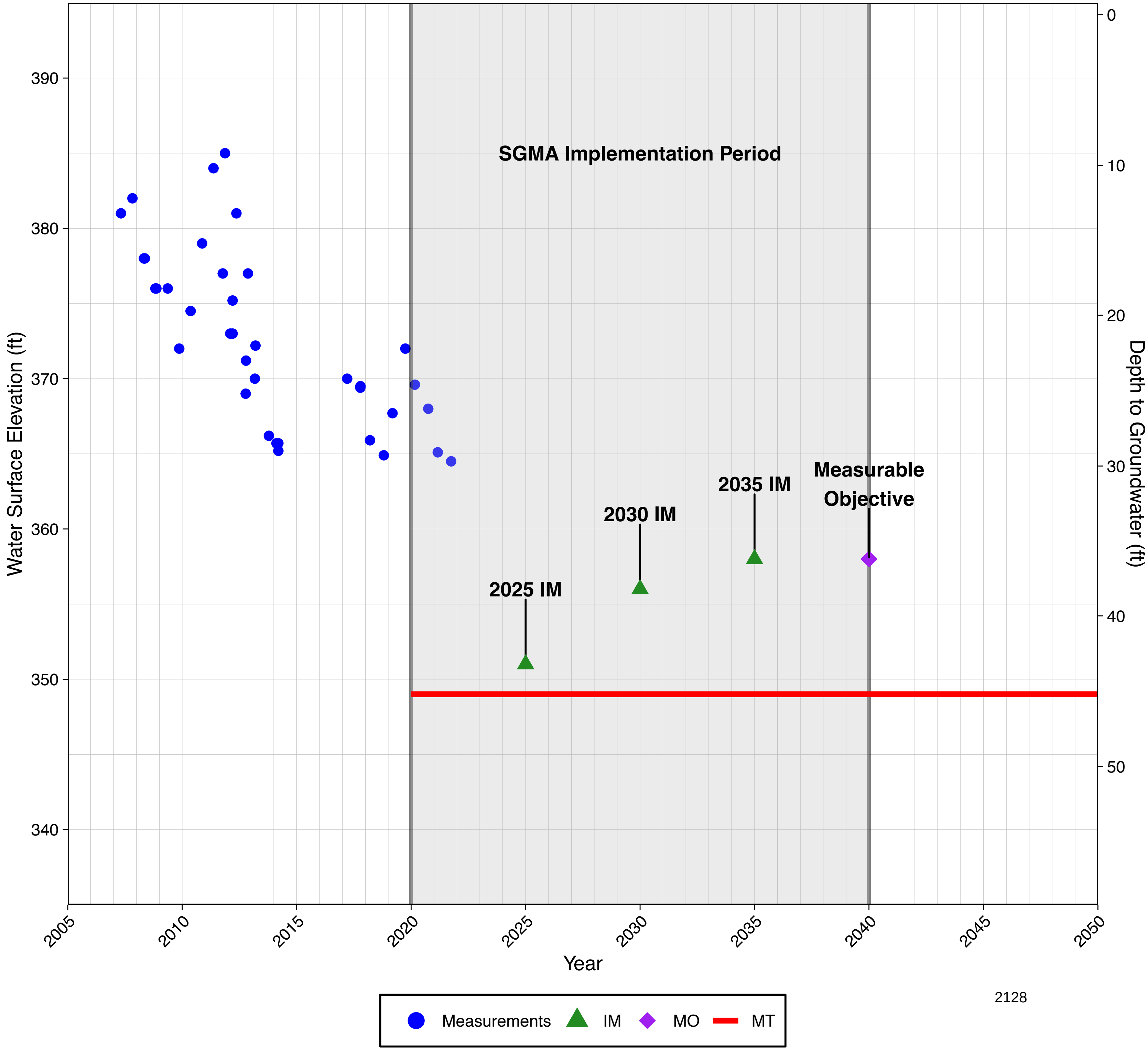

18S25E23J001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
2126

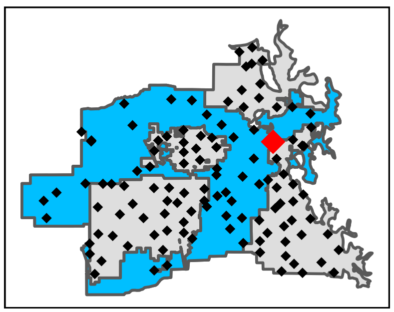
# 18S26E17L001M | Greater Kaweah
Single Aquifer System



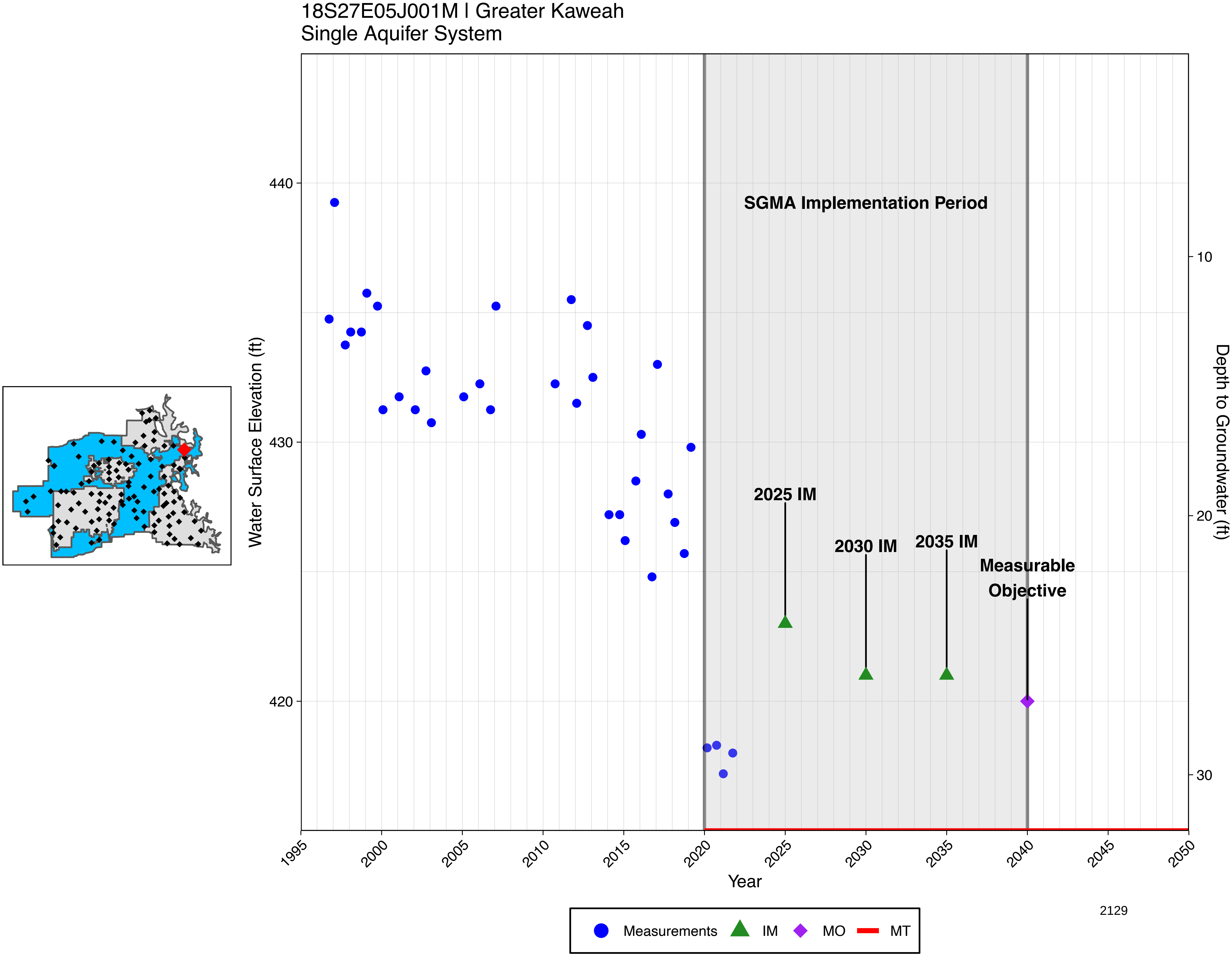

2127

18S26E27B001M | Greater Kaweah
Single Aquifer System

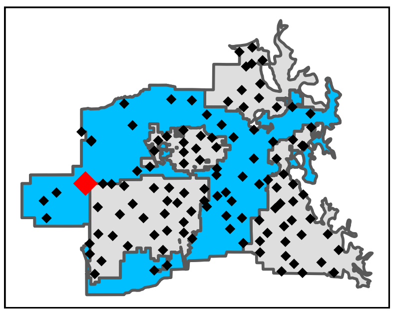


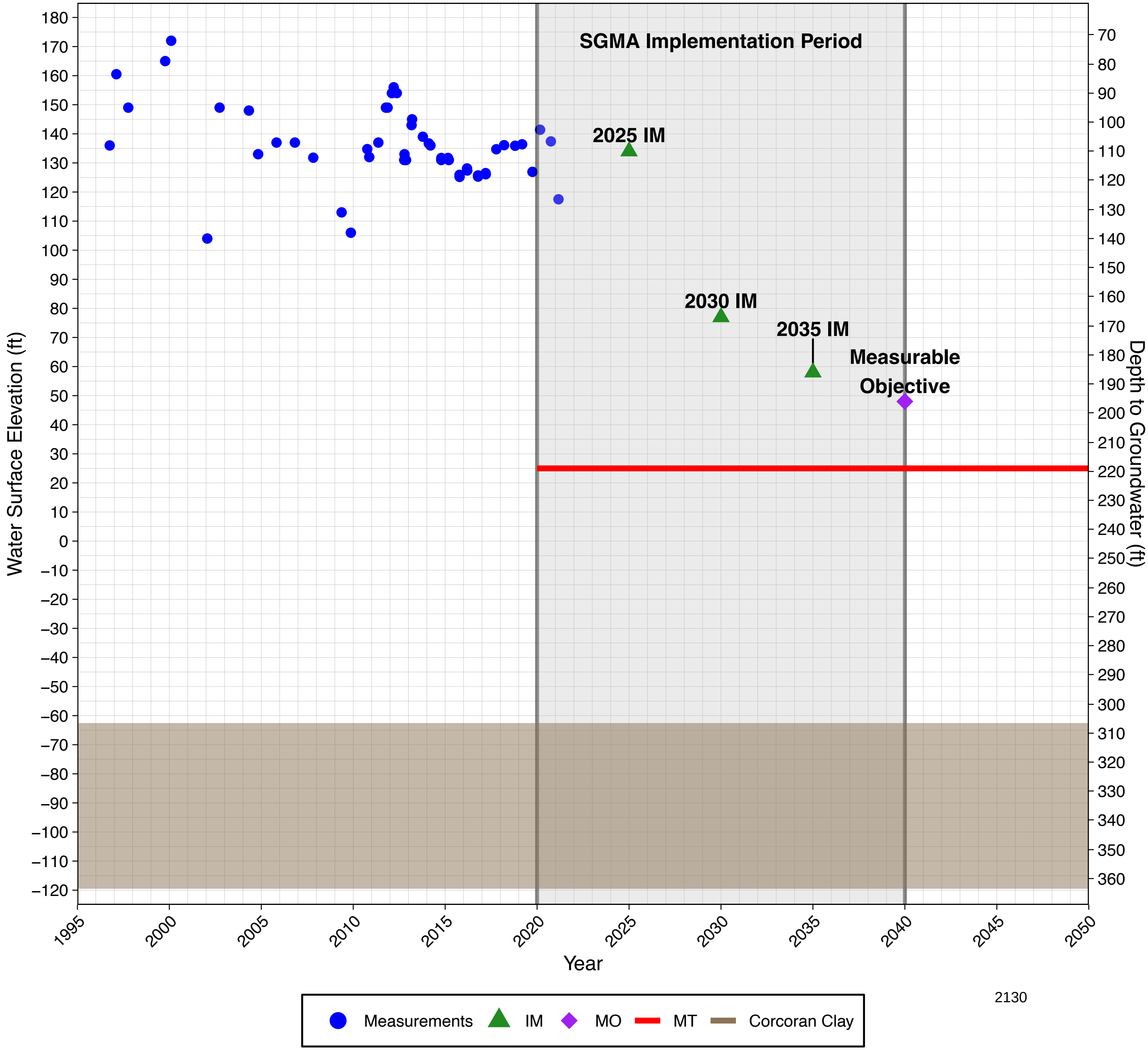



2128

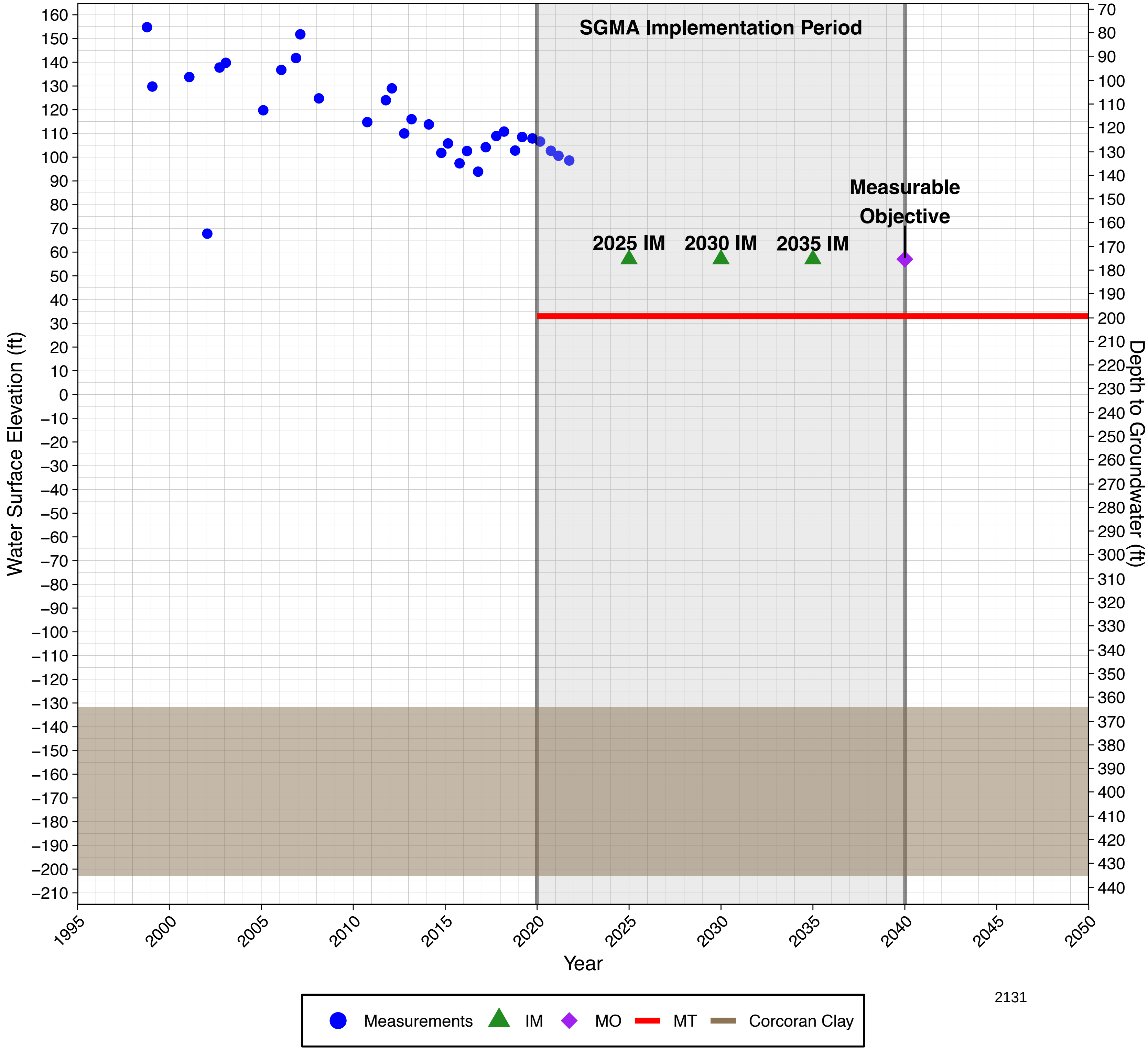

18S27E05J001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
440
430
420
10
20
30
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Measurements
IM
MO
MT

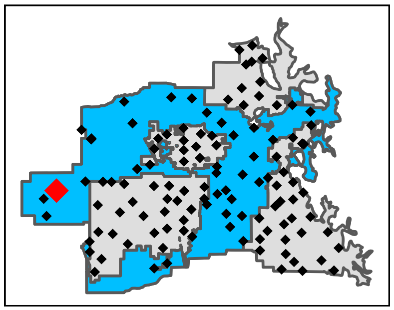
19S22E24B001M | Greater Kaweah
Upper Aquifer System





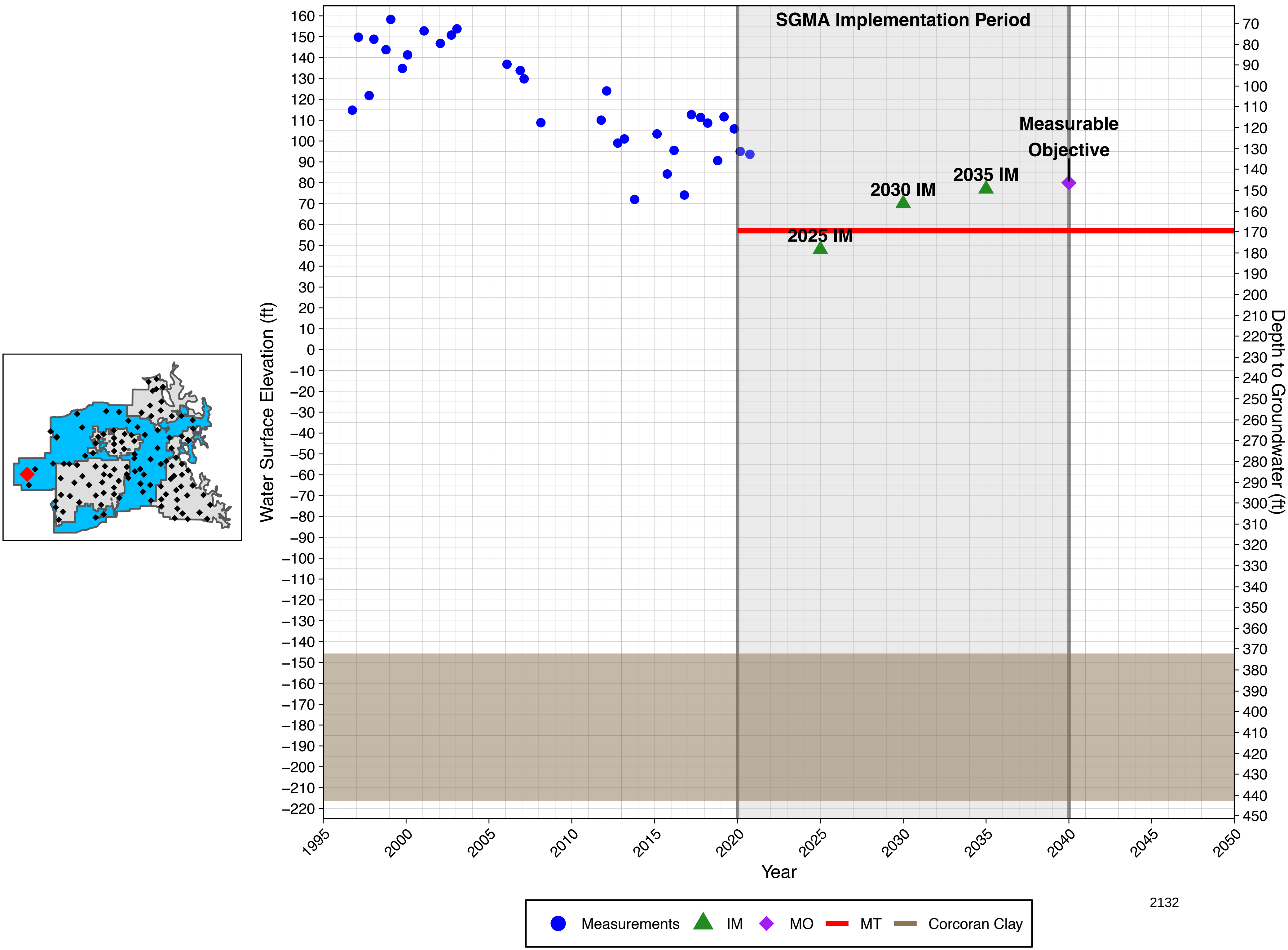
19S22E28D001M | Greater Kaweah
Upper Aquifer System



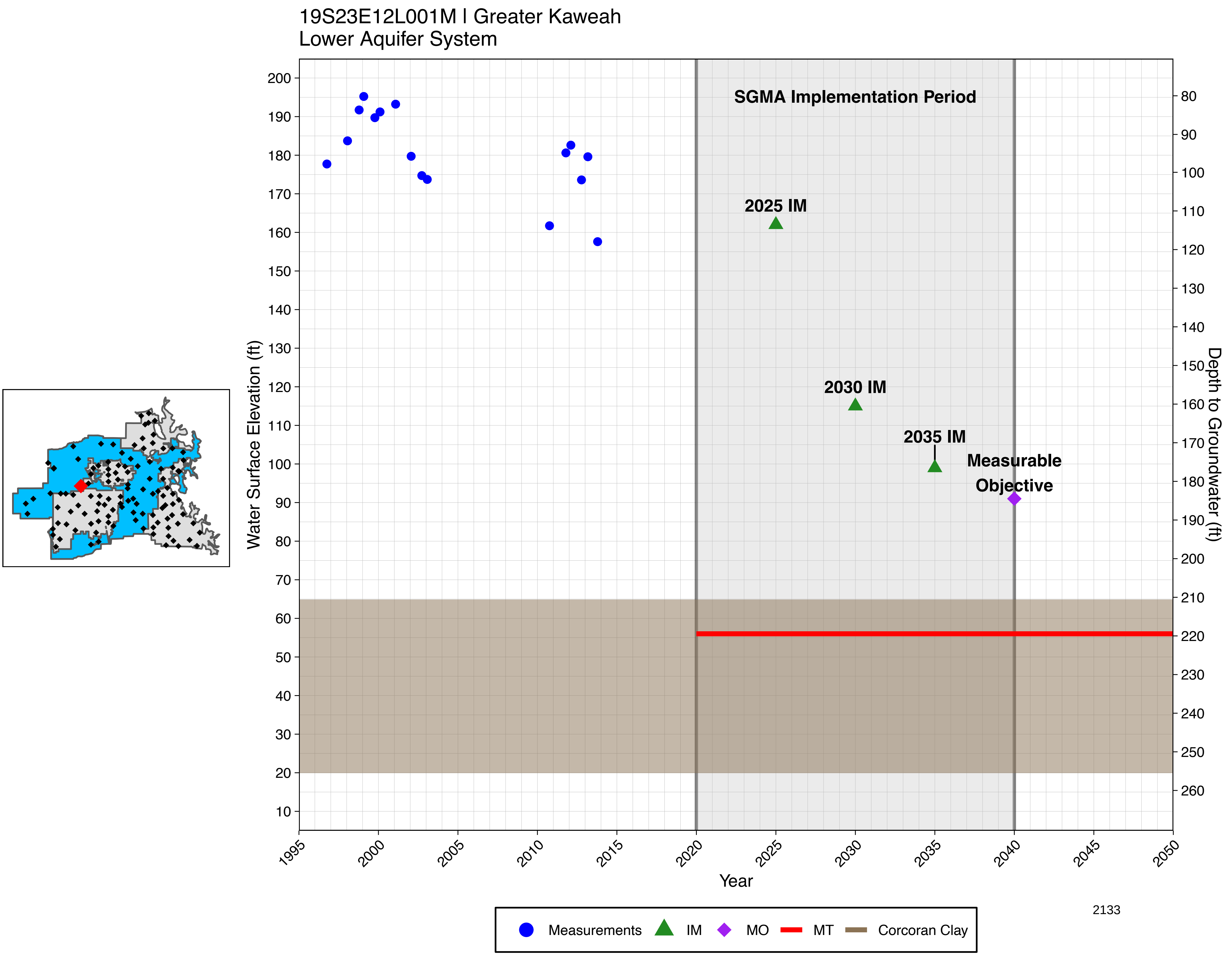



2131

## 19S22E31B002M | Greater Kaweah
## Upper Aquifer System

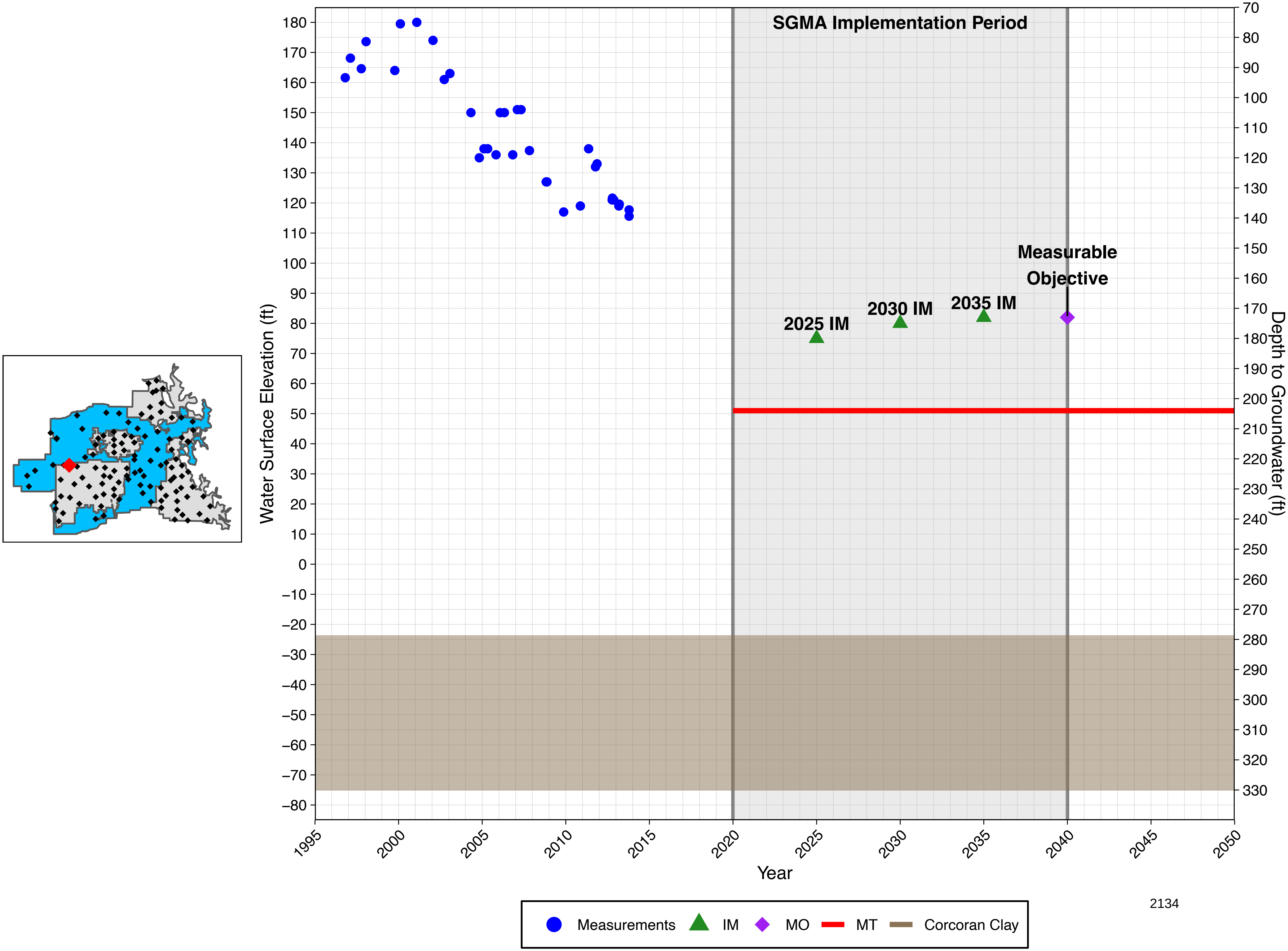



2132



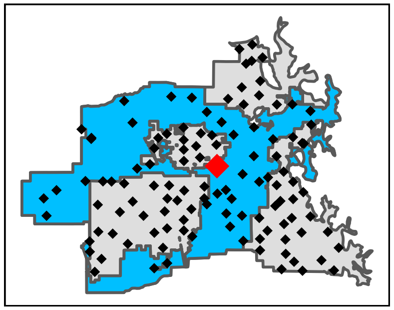
19S23E12L001M | Greater Kaweah
Lower Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
2133
Measurements
IM
MO
MT
Corcoran Clay

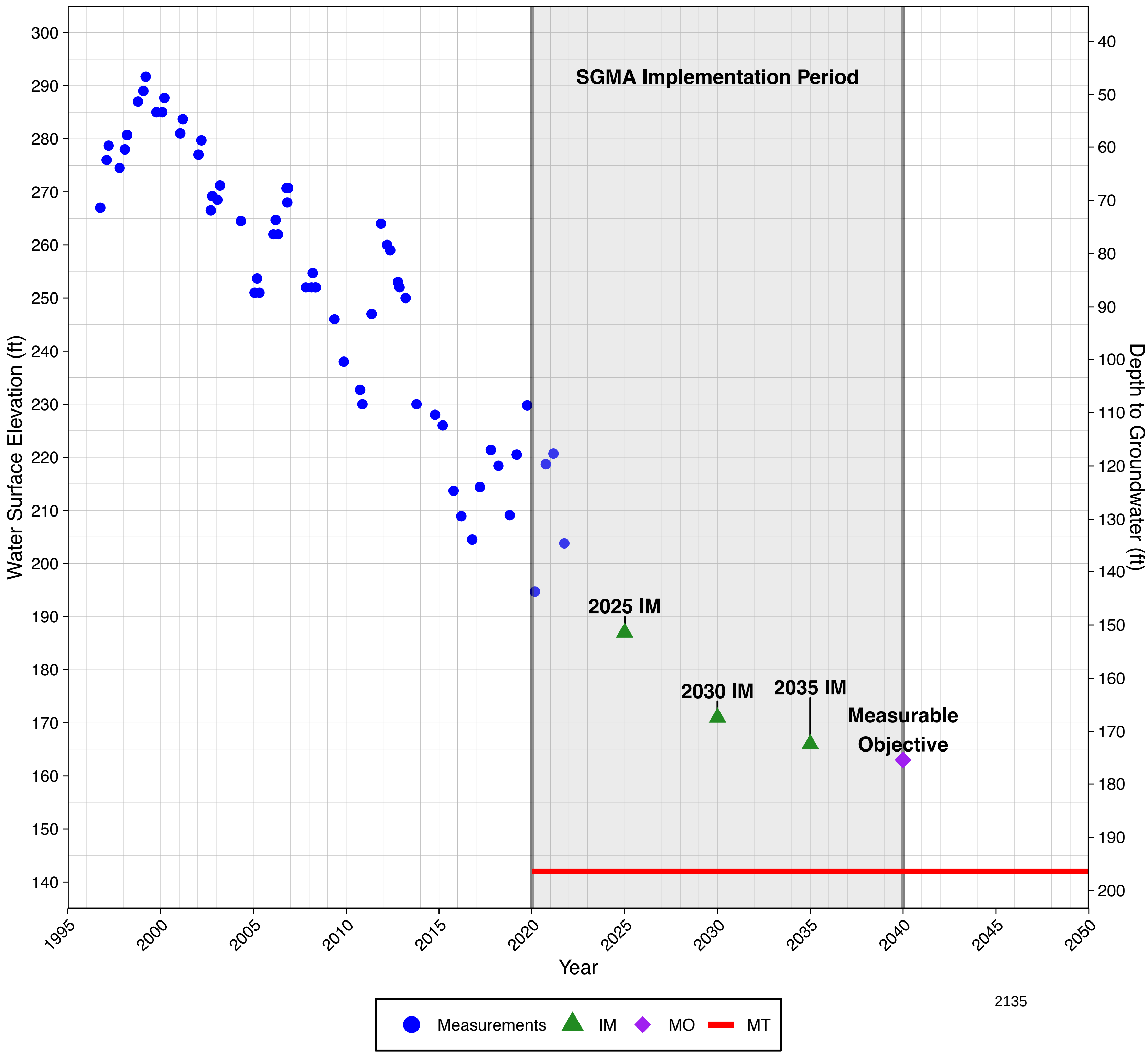
19S23E21C001M | Greater Kaweah
Upper Aquifer System

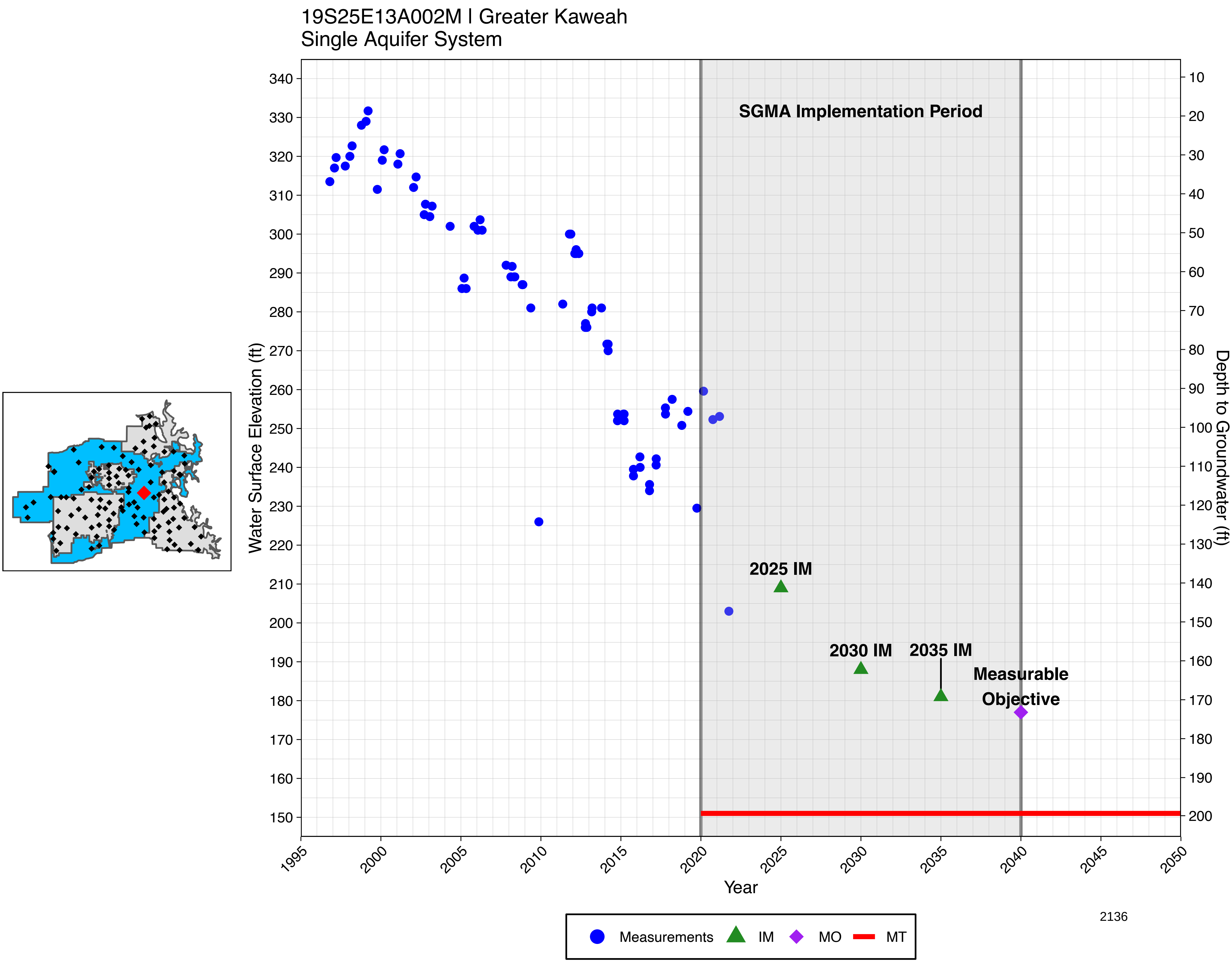


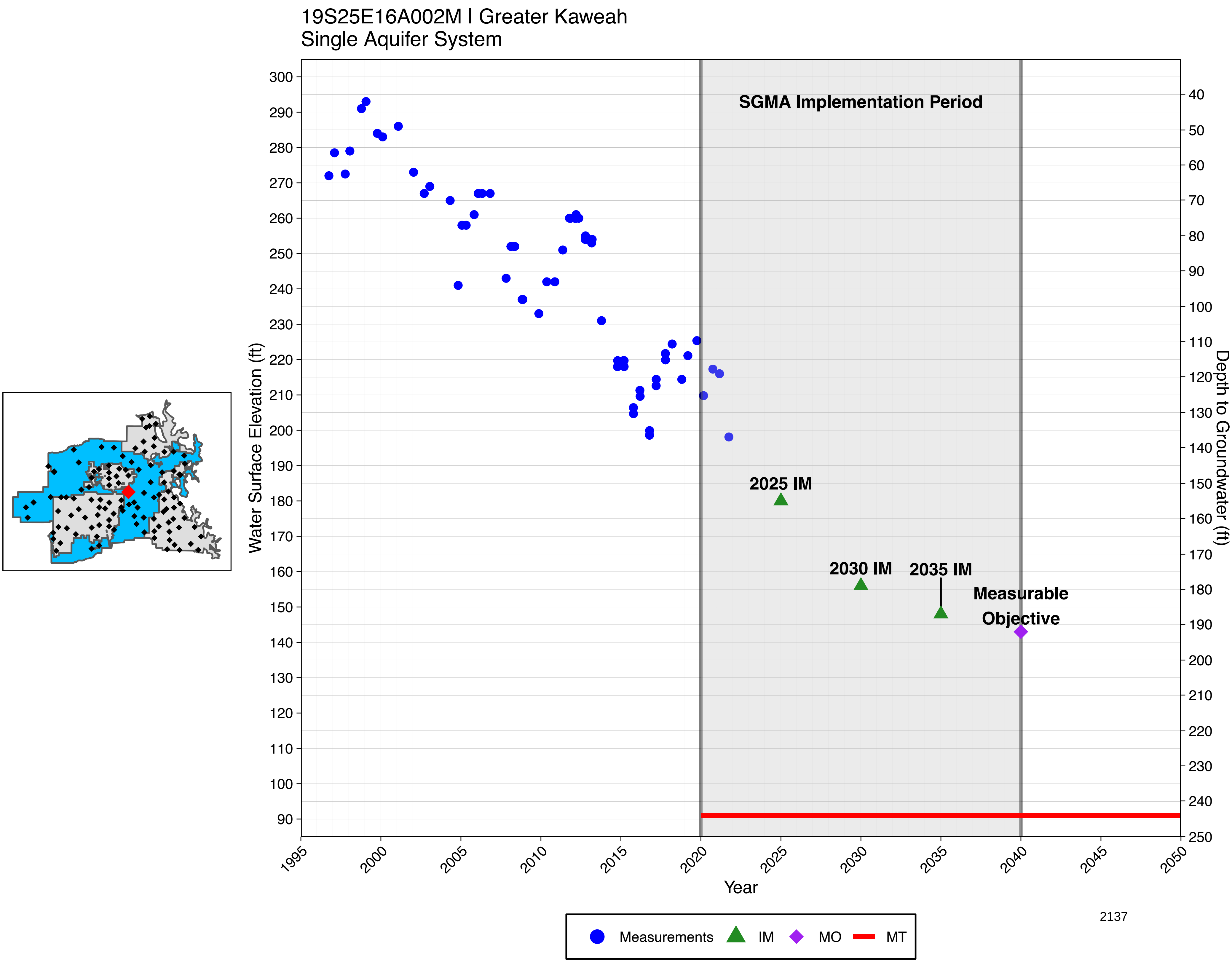

2134

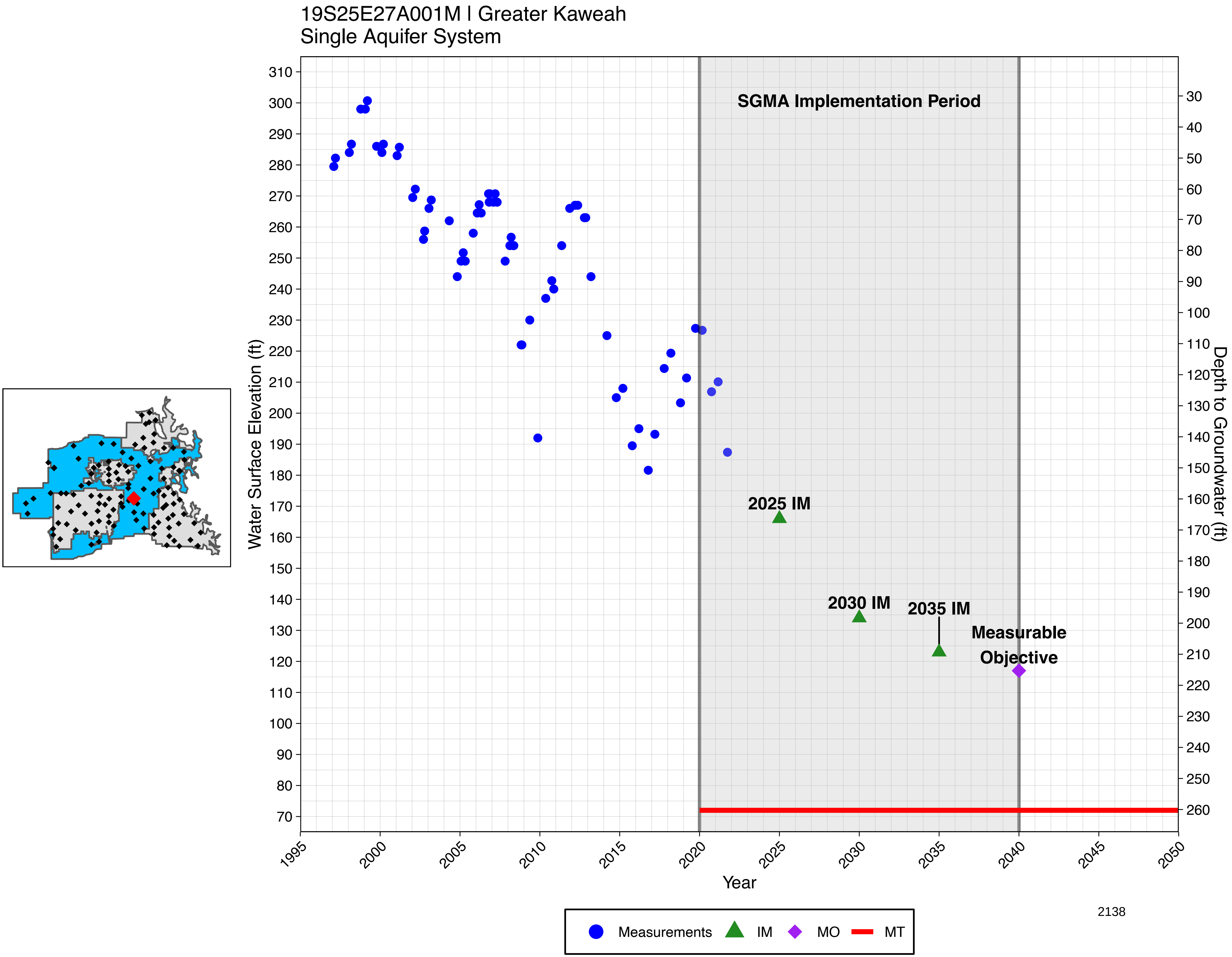
19S25E09H001M | Greater Kaweah
Single Aquifer System





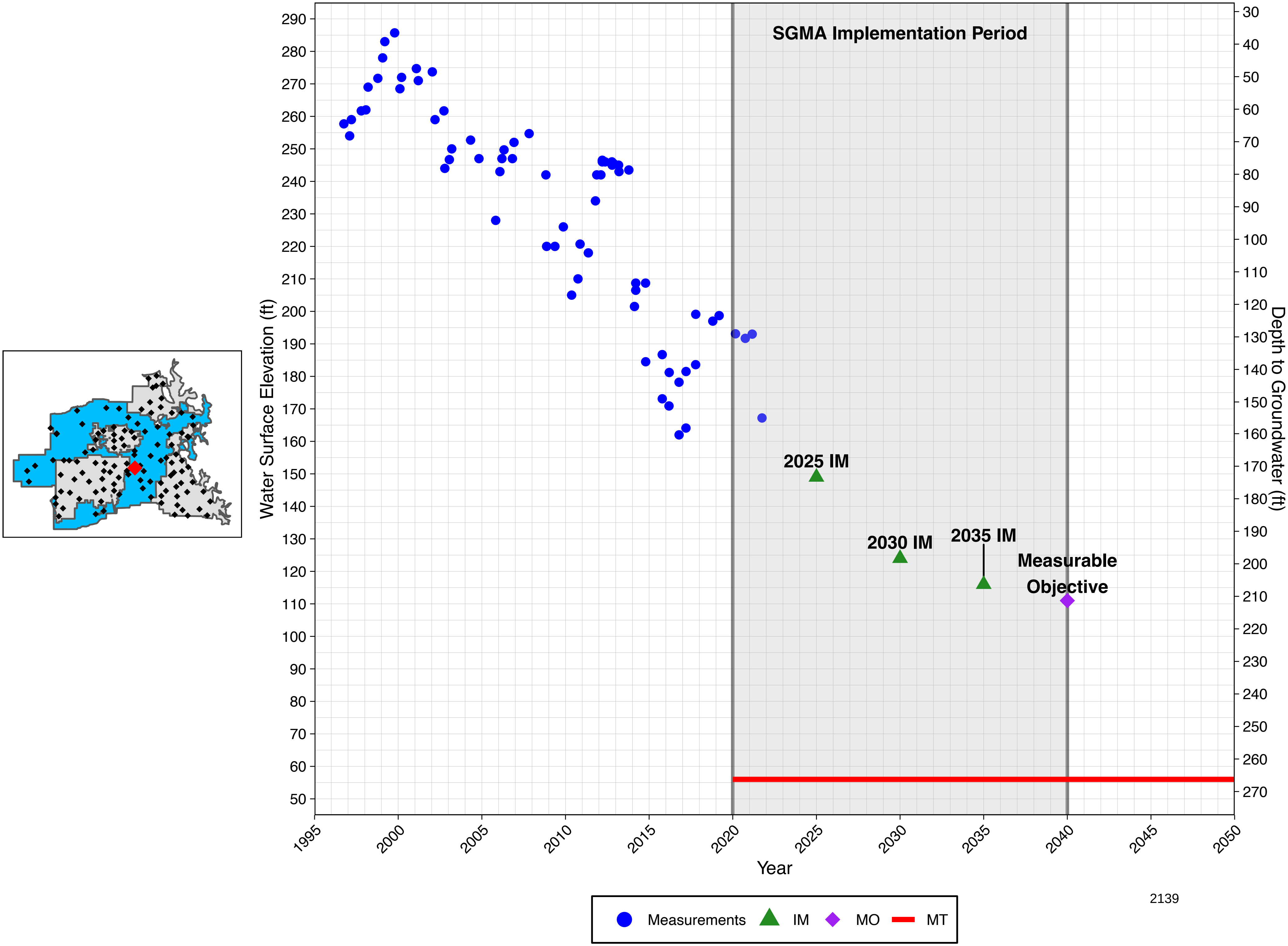

19S25E13A002M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT


19S25E16A002M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
2137

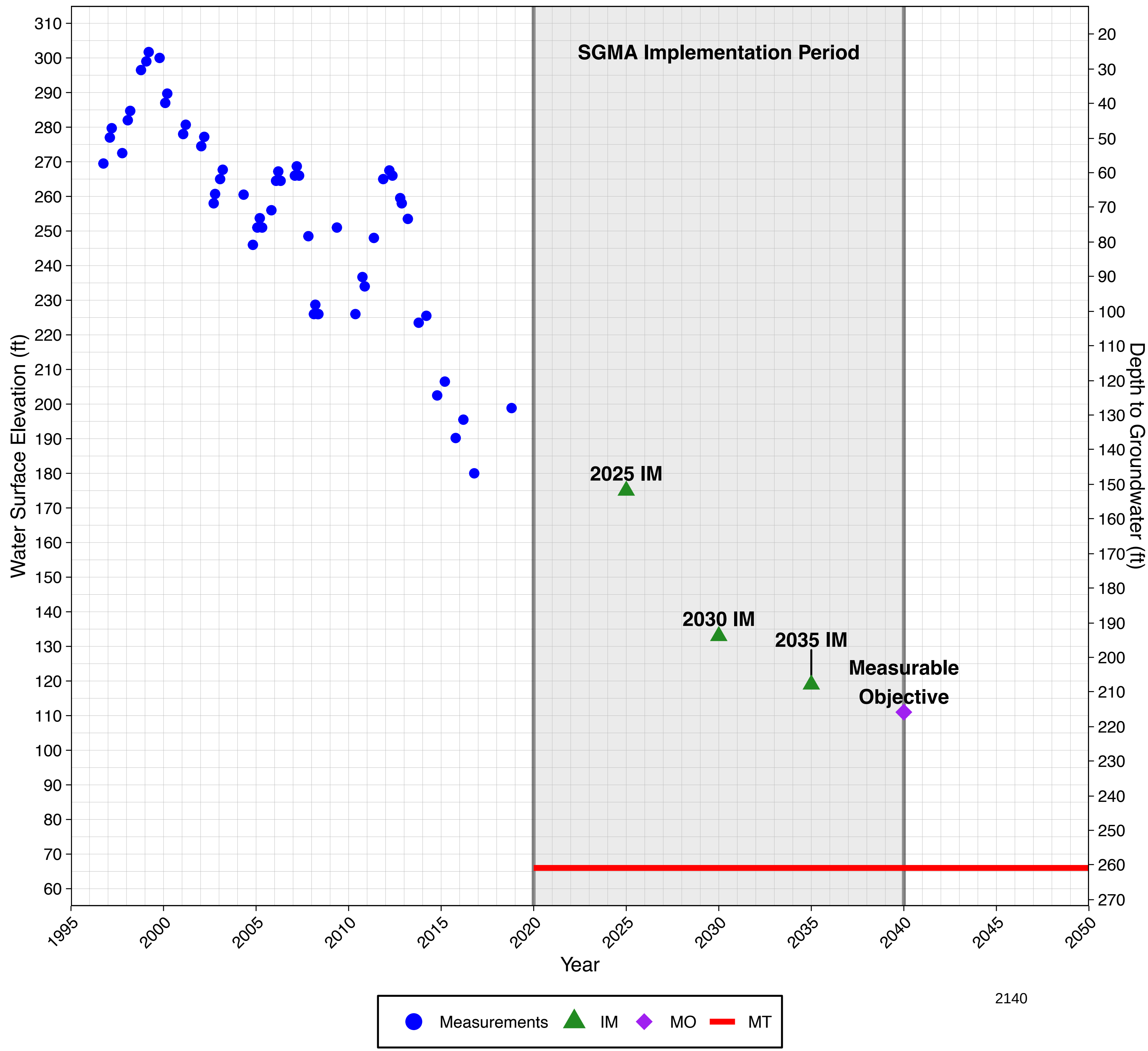


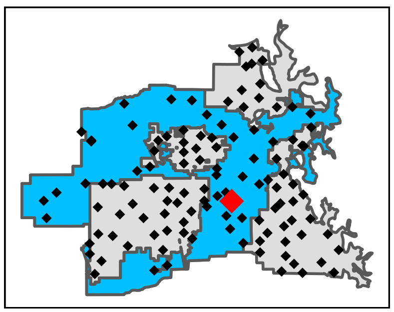
19S25E27A001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
2138
Measurements
IM
MO
MT

# 19S25E28H001M | Greater Kaweah
Single Aquifer System



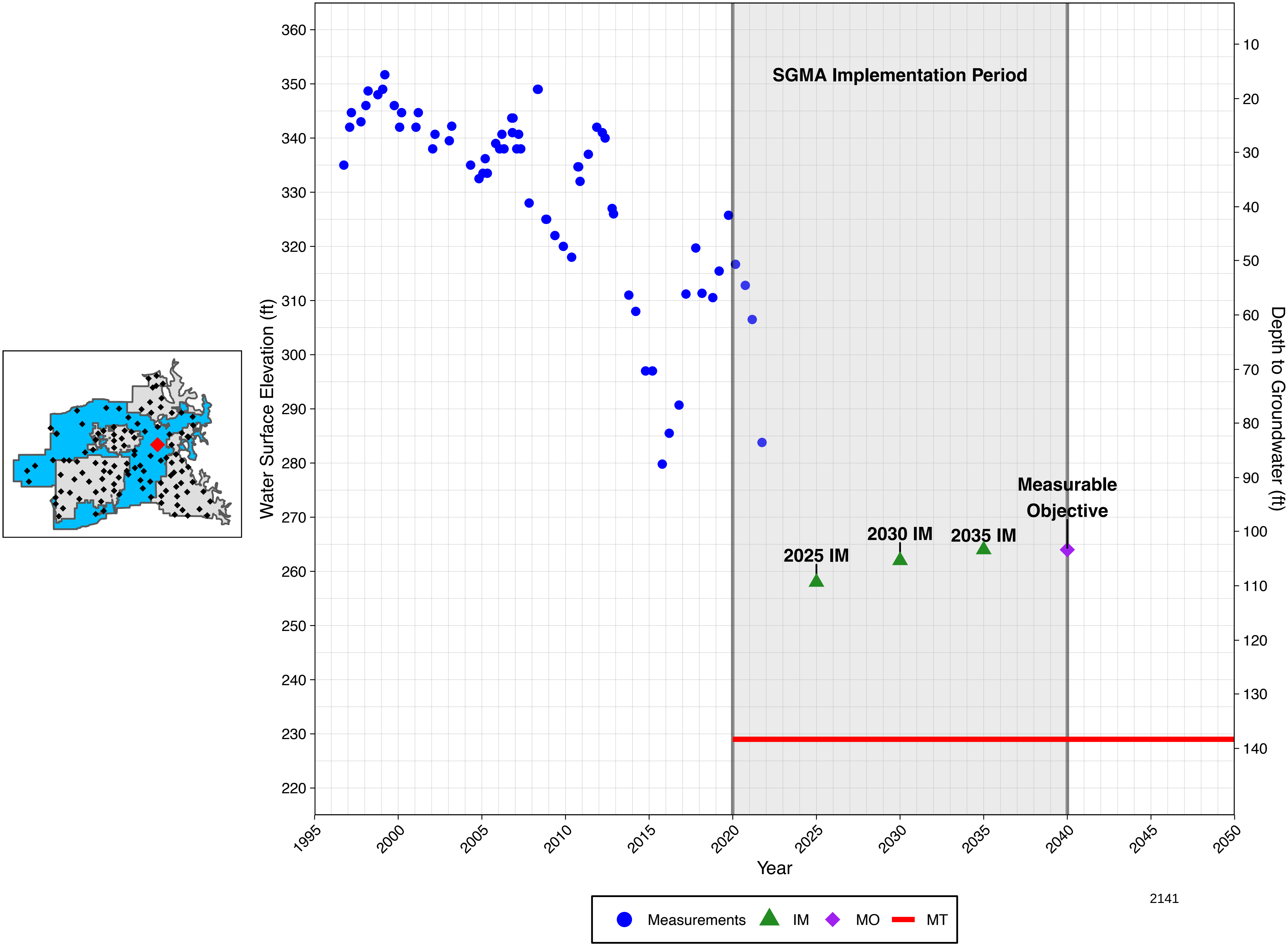
19S25E35B002M | Greater Kaweah
Single Aquifer System



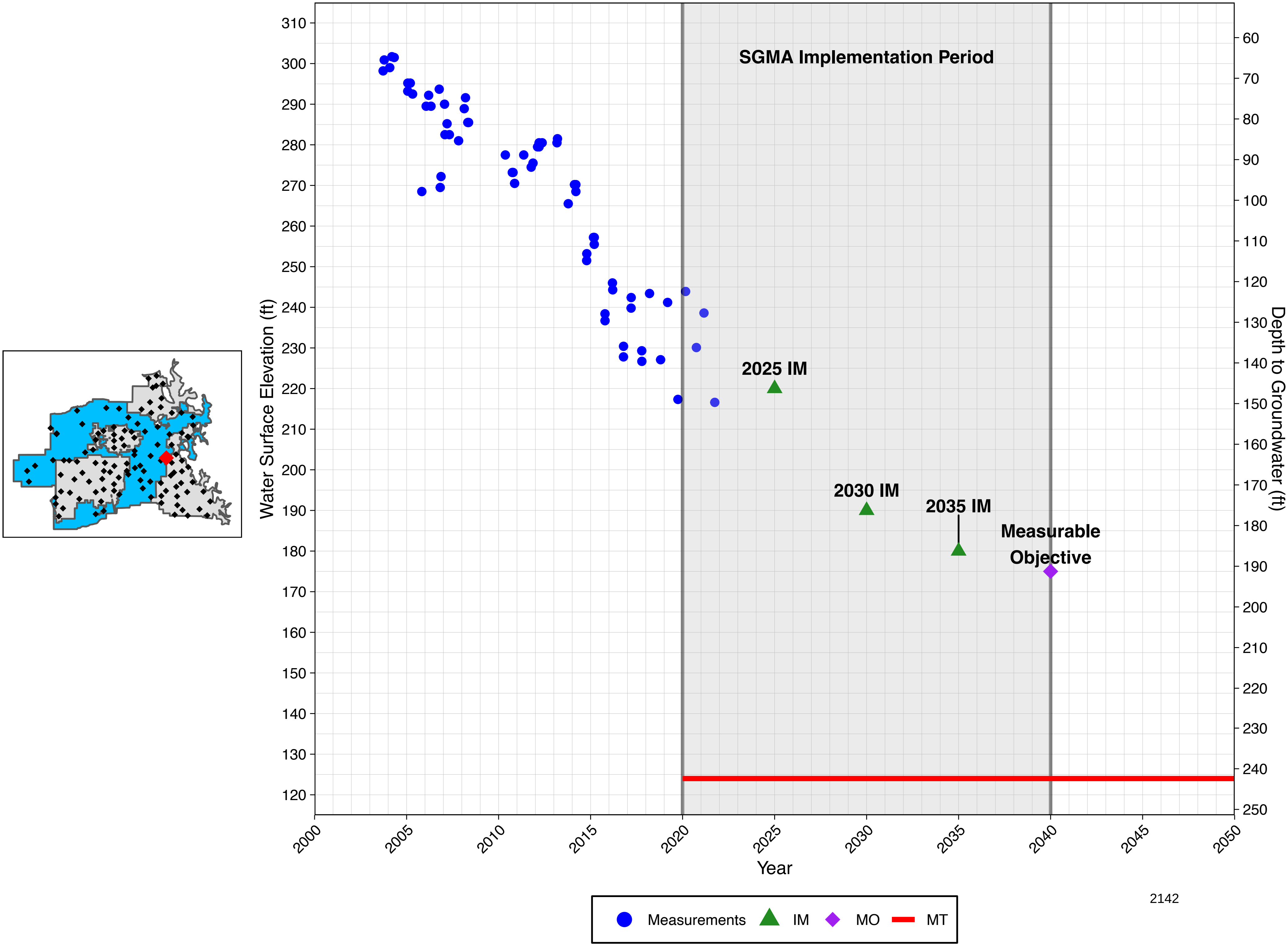



2140

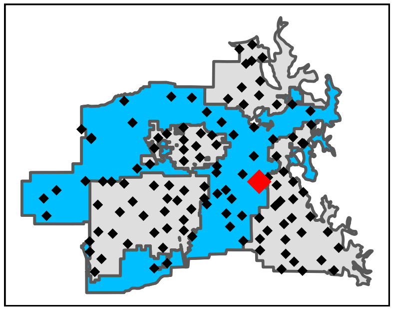
19S26E05C001M | Greater Kaweah
Single Aquifer System

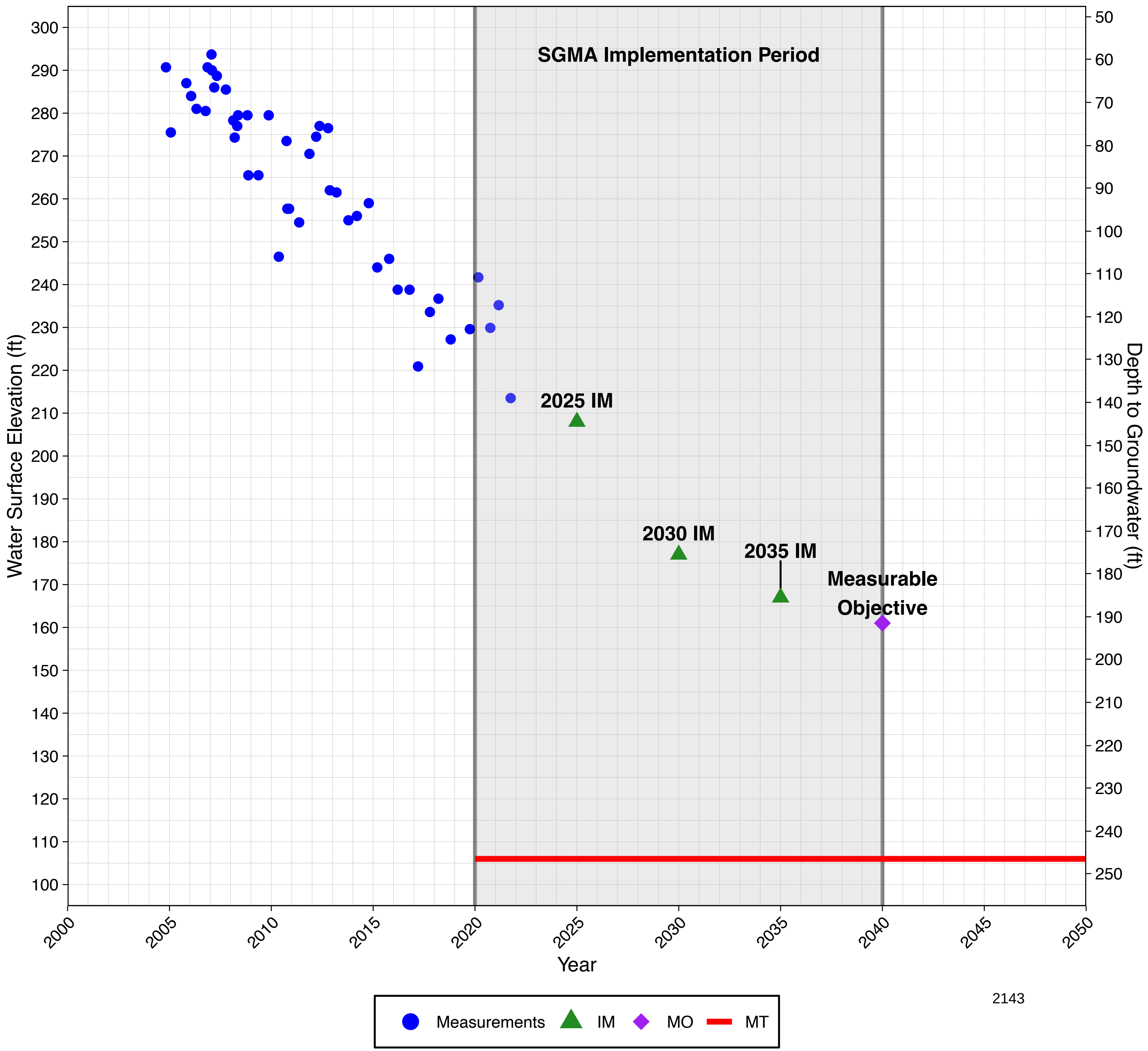


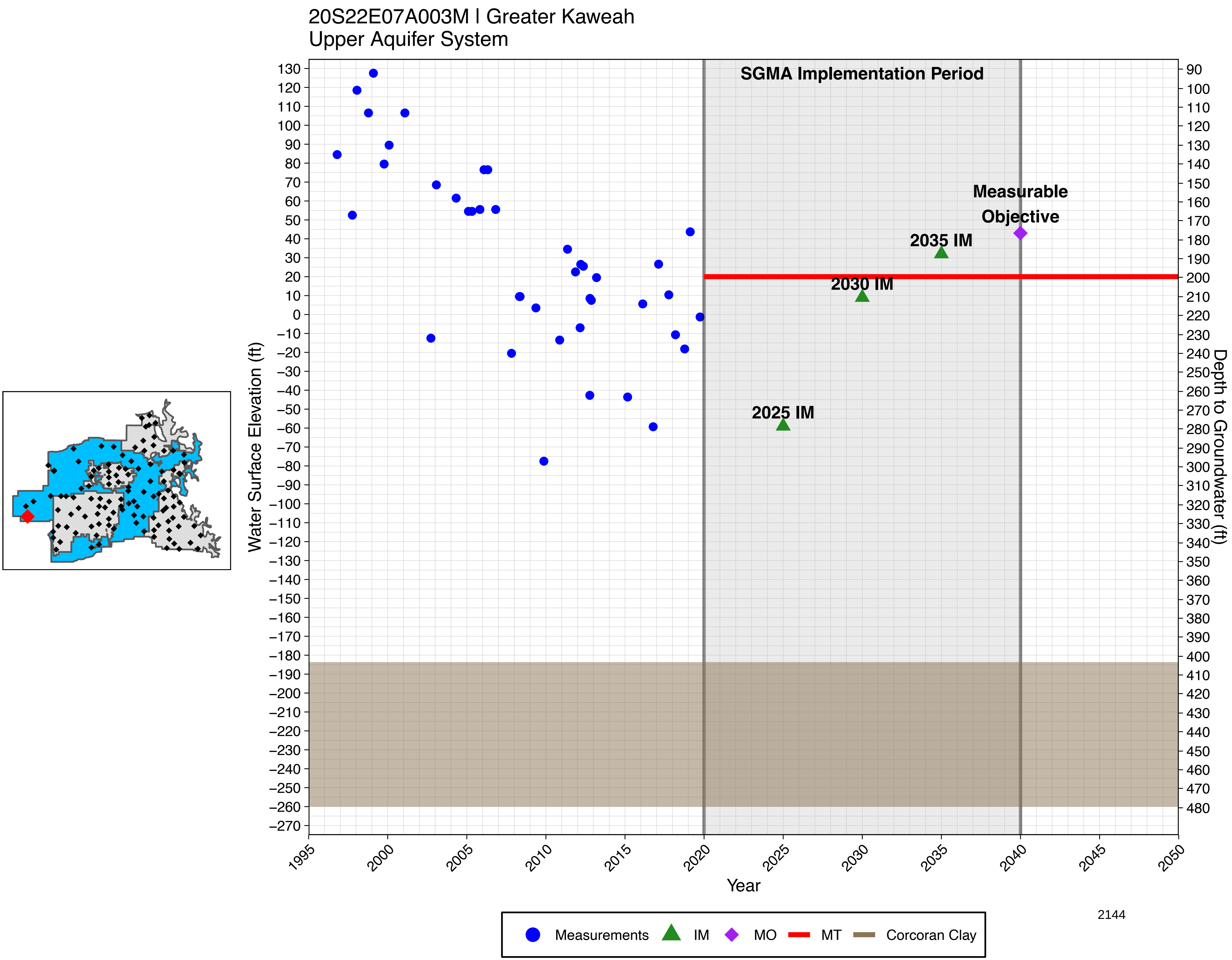
19S26E16J002M | Greater Kaweah
Single Aquifer System



19S26E20A001M | Greater Kaweah
Single Aquifer System

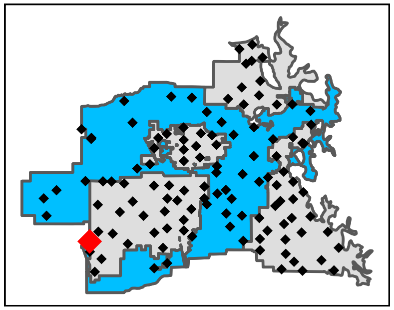


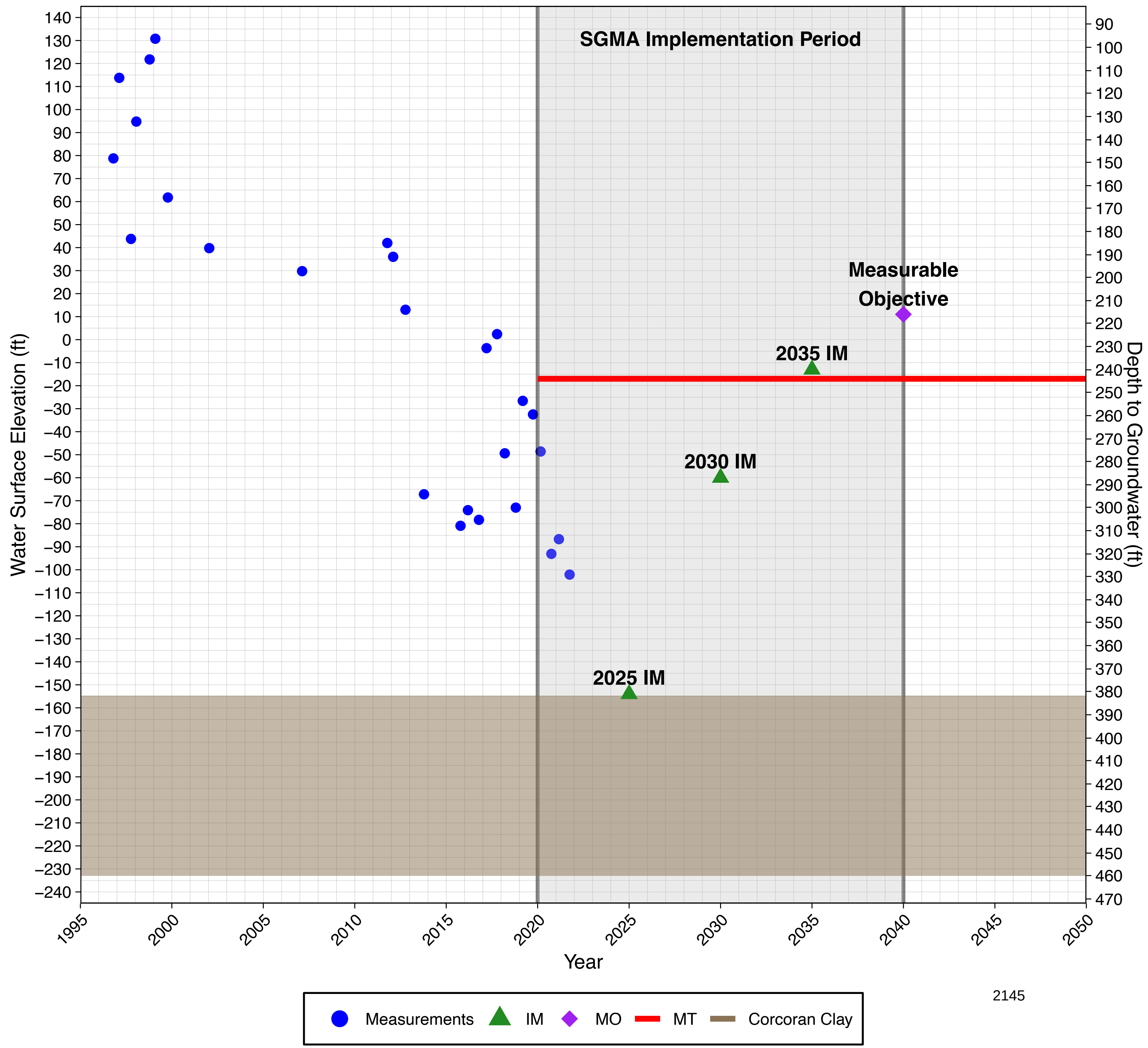




20S22E07A003M | Greater Kaweah
Upper Aquifer System
SGMA Implementation Period
Measurable Objective
2035 IM
2030 IM
2025 IM
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT
Corcoran Clay
2144

20S22E24R001M | Greater Kaweah
Upper Aquifer System





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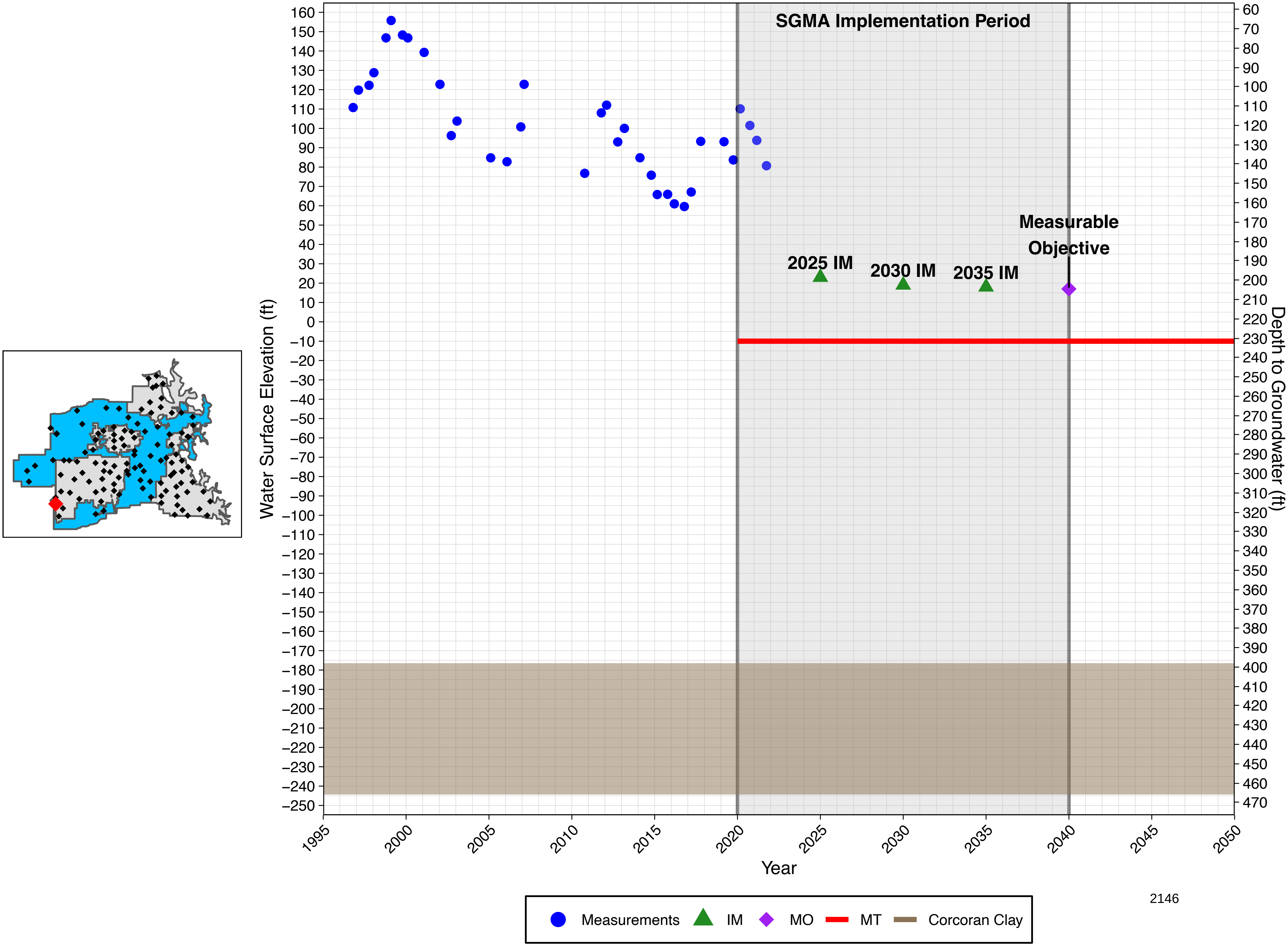
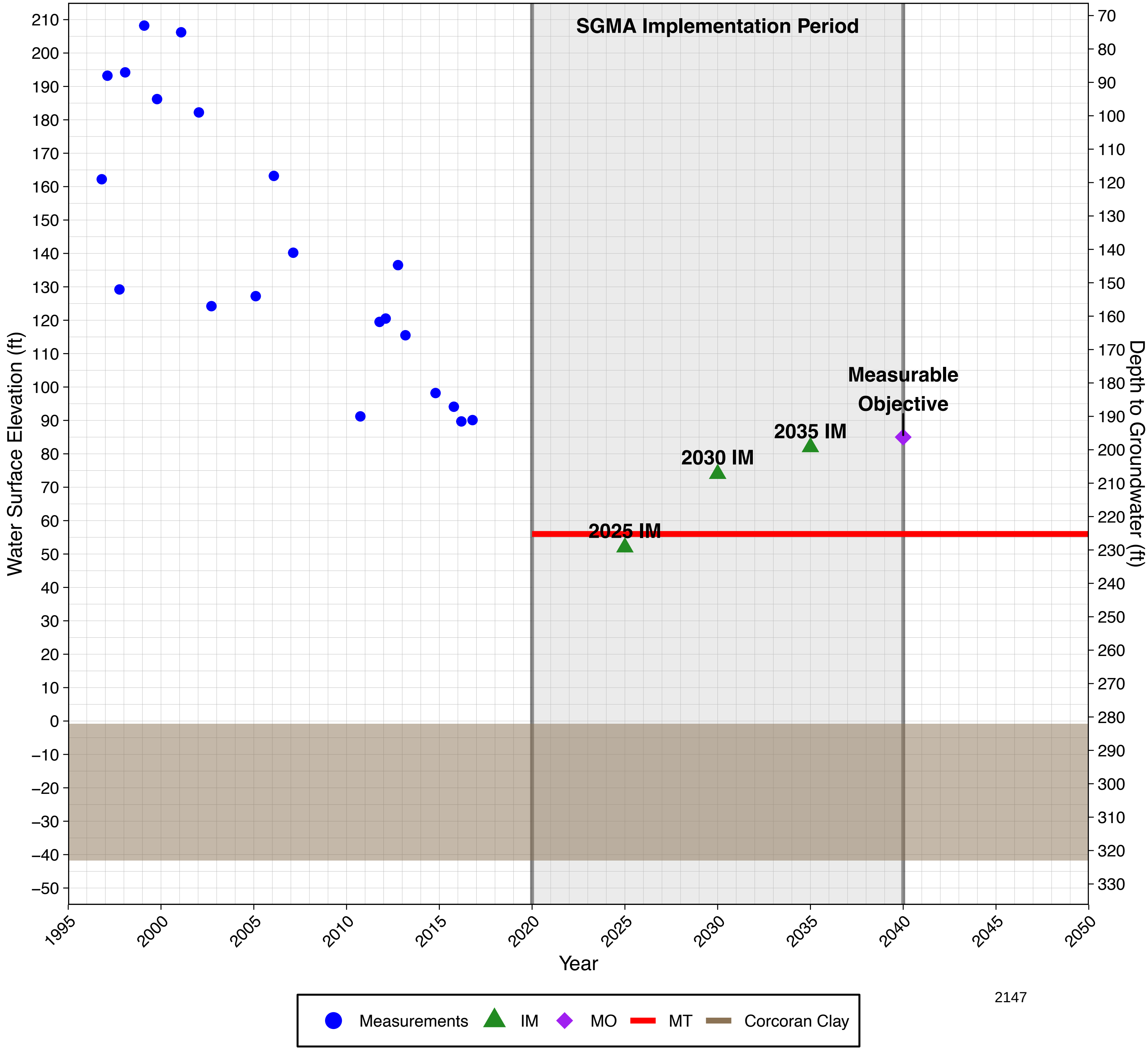
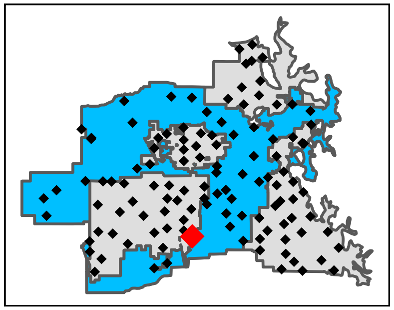
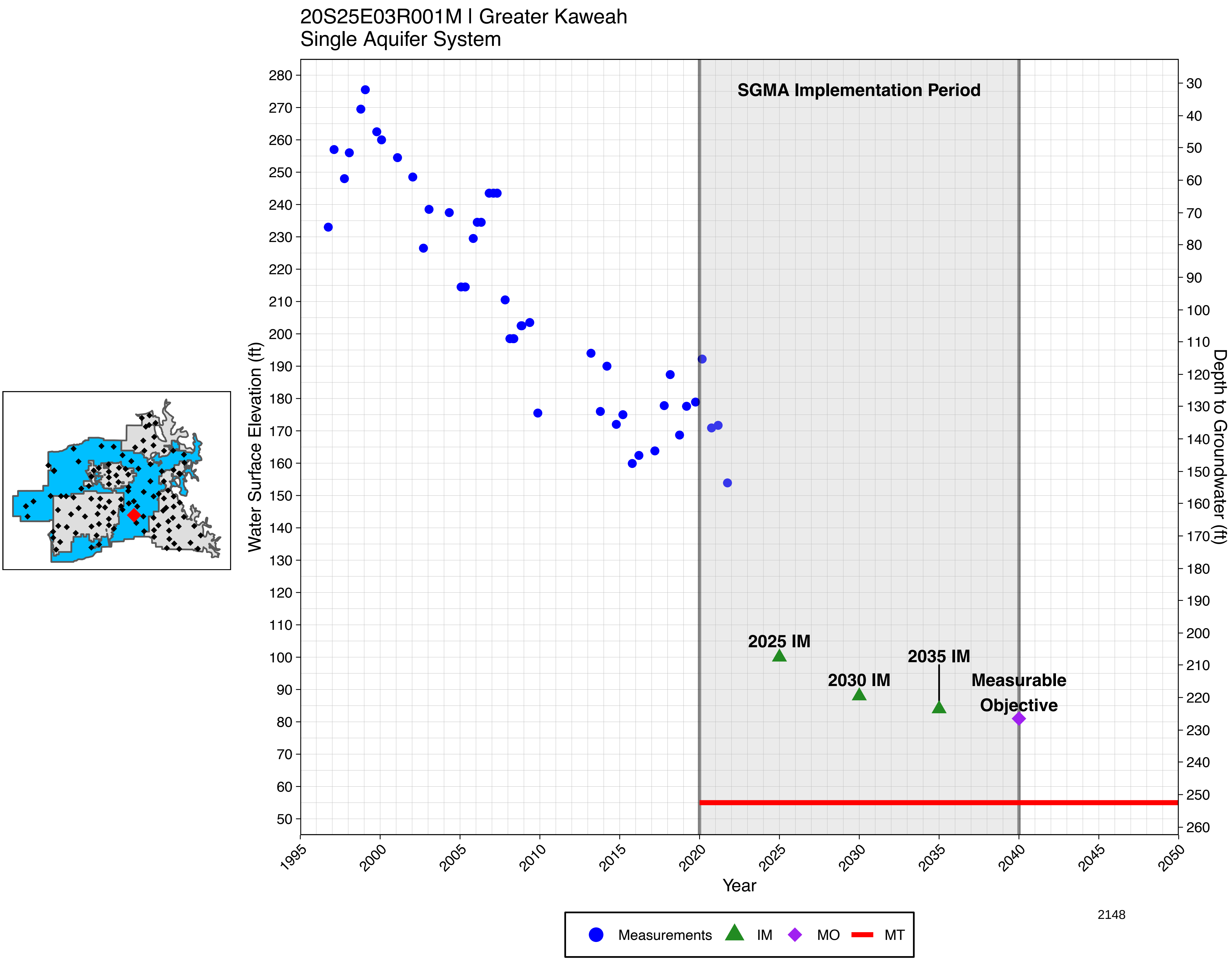
Upper Aquifer System



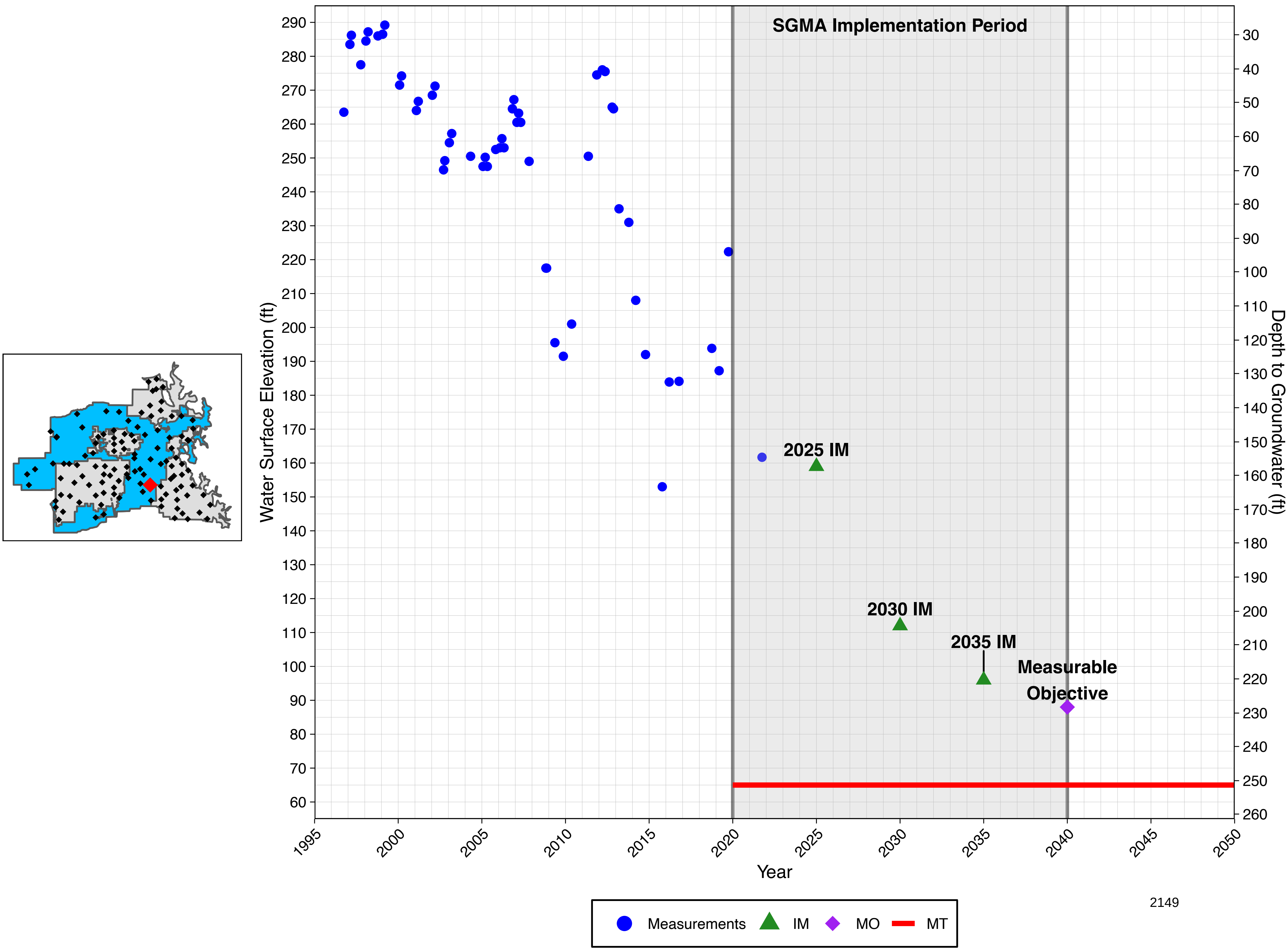
20S24E24H001M | Greater Kaweah
Upper Aquifer System



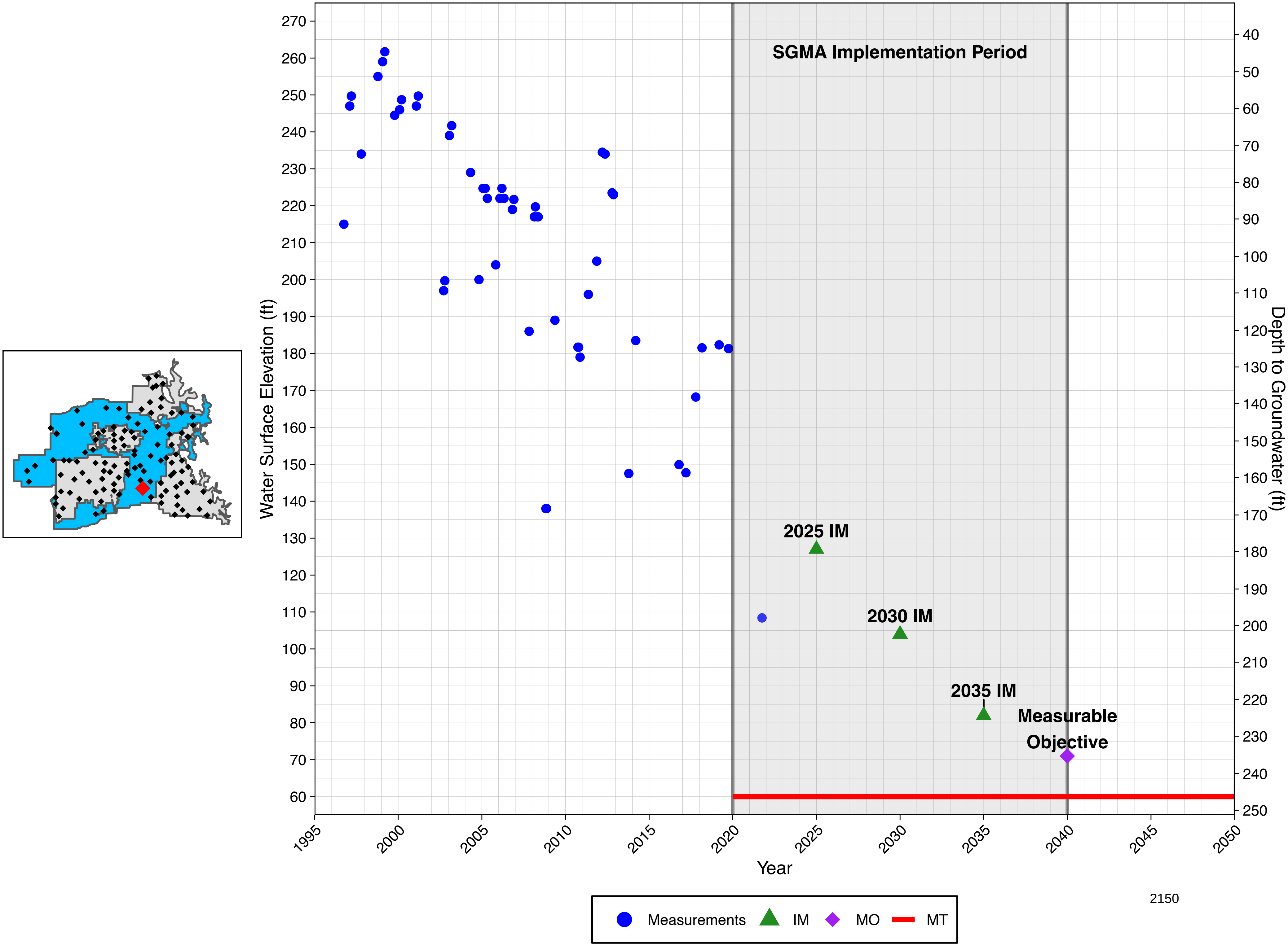




20S25E03R001M | Greater Kaweah
Single Aquifer System
SGMA Implementation Period
2025 IM
2030 IM
2035 IM
Measurable
Objective
Water Surface Elevation (ft)
Depth to Groundwater (ft)
Year
Measurements
IM
MO
MT

20S25E12A001M | Greater Kaweah
Single Aquifer System

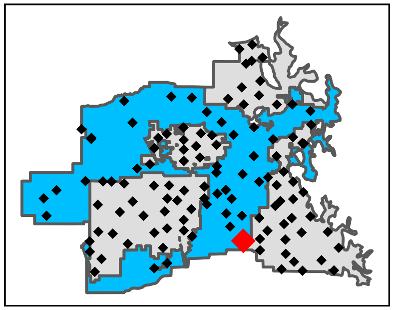


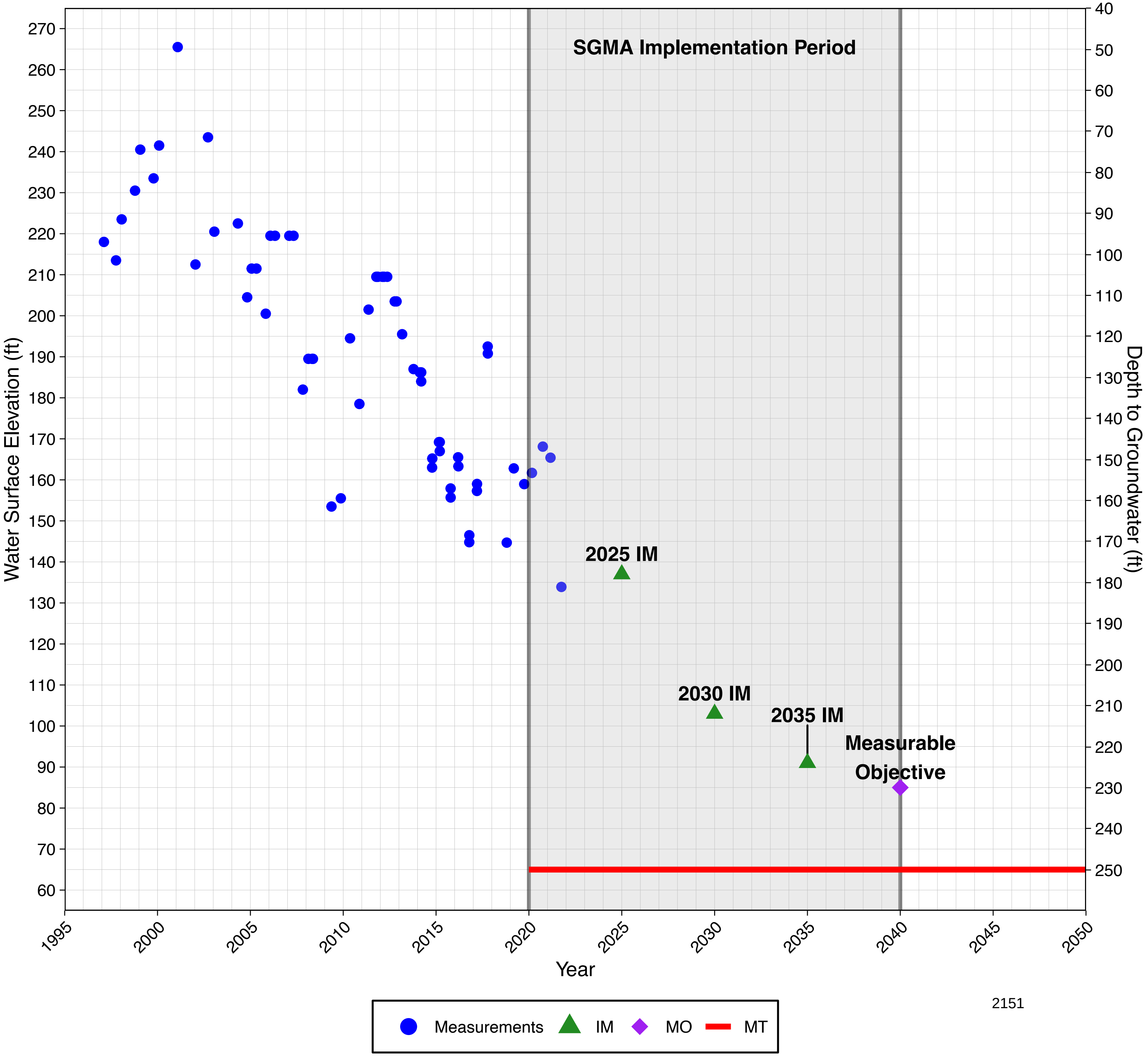
20S25E14F004M | Greater Kaweah
Single Aquifer System



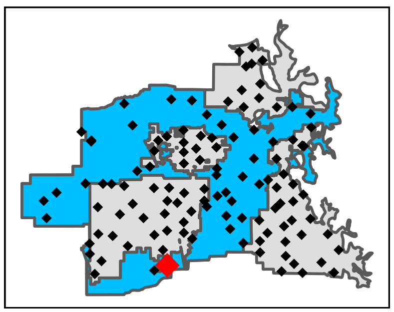

2150

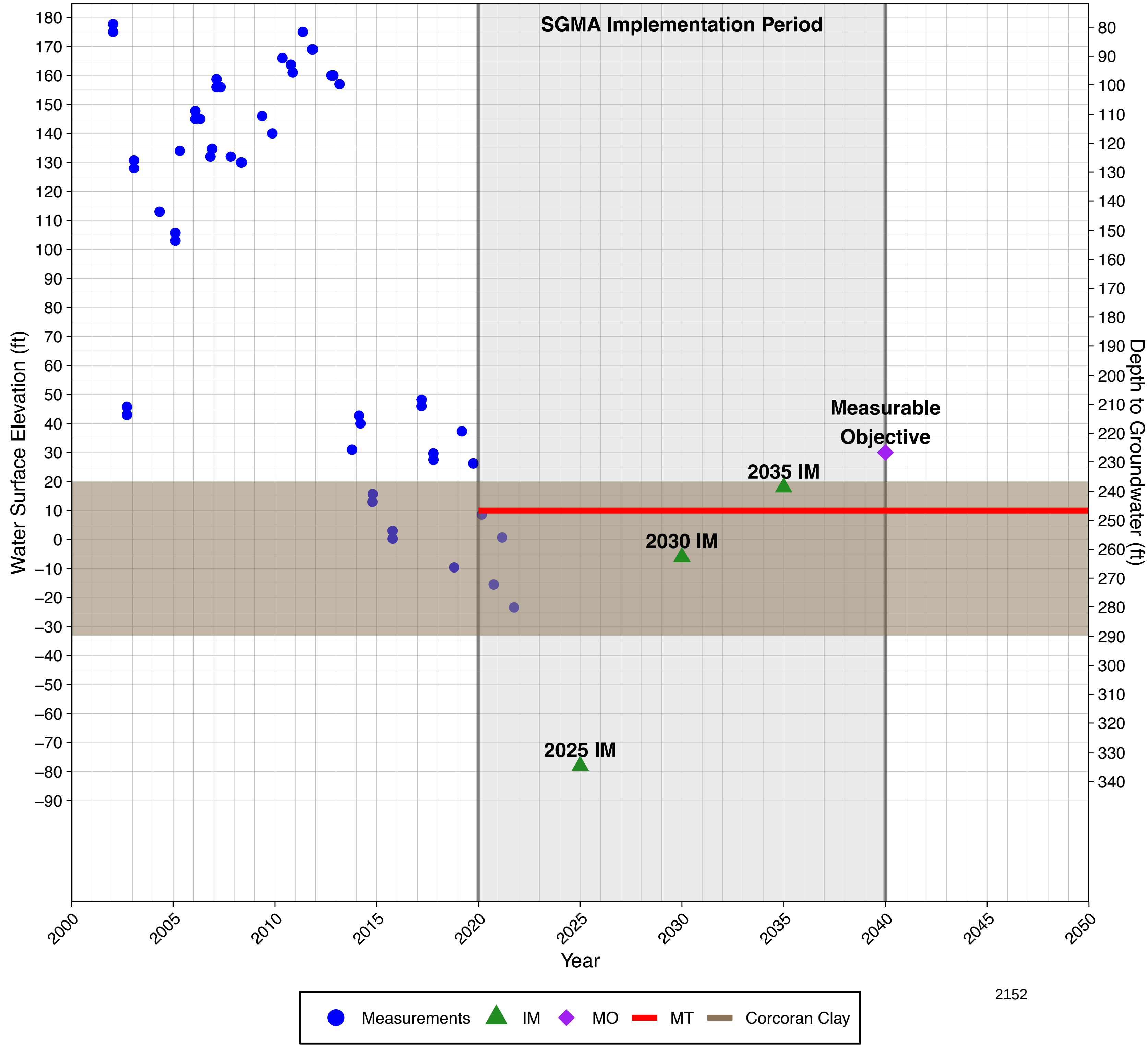
20S25E24R001M | Greater Kaweah
Single Aquifer System





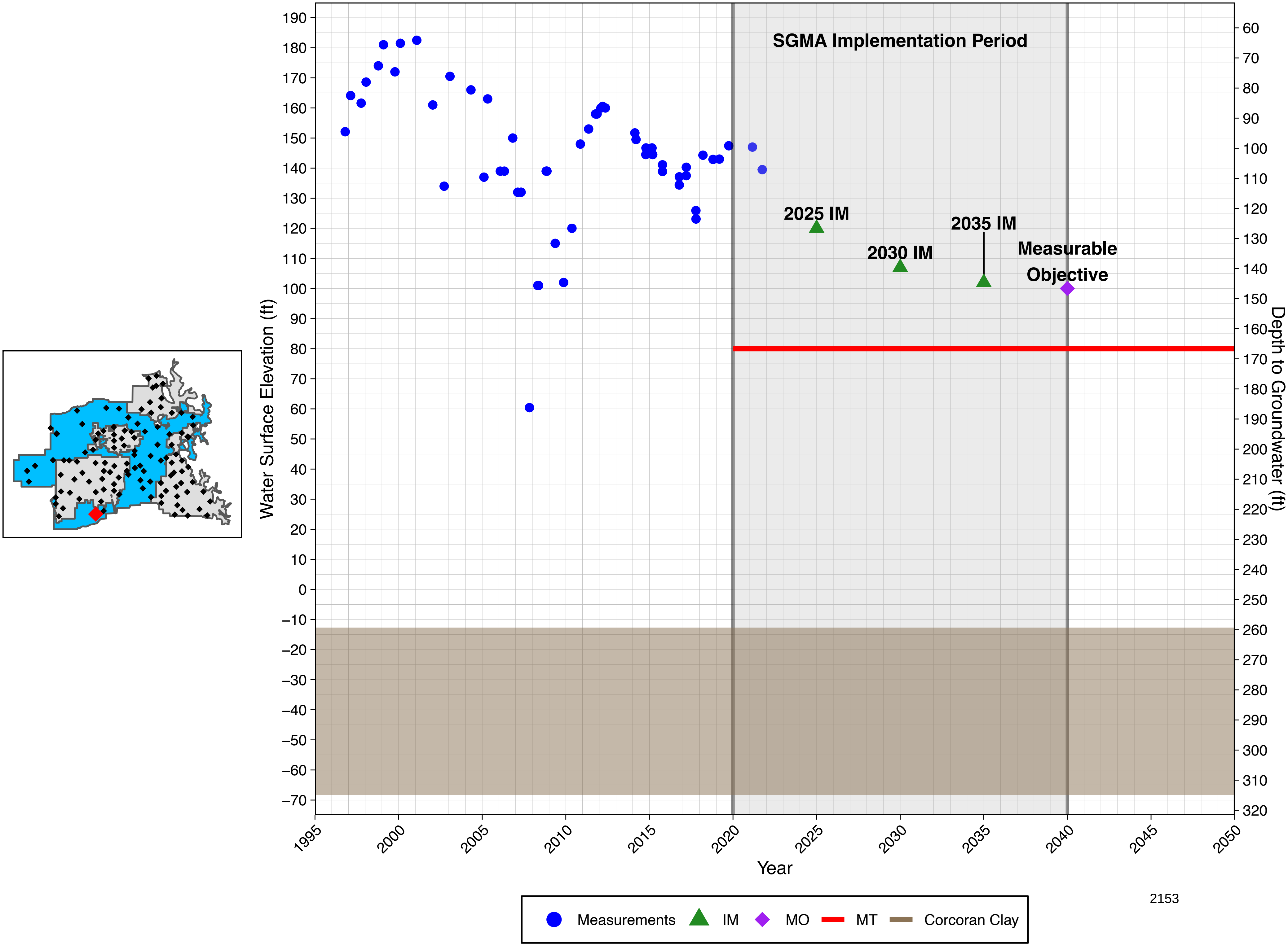
21S24E03L001M | Greater Kaweah
Lower Aquifer System






2152

## 21S24E08A001M | Greater Kaweah
Upper Aquifer System



# Appendix 5D

## Well Impact Analysis Hydrographs

# 1 SUMMARY PURPOSE

This summary describes all water supply well completion data available for the San Joaquin Valley - Kaweah Subbasin (Subbasin) since January 1, 2002. The purpose of this summary is estimate for the number of wells that may be impacted by groundwater levels declining to elevations protective of 90% of wells in the Subbasin (described in Appendix 5A). These estimates can be used by the Groundwater Sustainability Agencies (GSAs) to develop well mitigation plans for their respective Groundwater Sustainability Plans (GSPs).

The majority of minimum thresholds described in Appendix 5A are at higher elevations than elevations protective of 90% of wells. The estimates of potentially impacted wells therefore overestimate the number of wells. However, since these estimates are to be used for determining the magnitude of wells to be addressed by mitigation plans, they can be considered worst-case estimates.

# 2 WELL RECORDS IN THE KAWEAH SUBBASIN

A majority of water supply wells installed in the Subbasin since 2002 have well construction information available from Department of Water Resources (DWR) Well Completion Reports submitted by well drillers. These well records are used to develop chronic lowering of groundwater level sustainable management criteria (SMC), as described in Appendix 5A. This summary supplements potential well impacts described in Appendix 5A by including wells without completed well depth information.

## 2.1 Data Sources and Quality Control

Well completion information compiled in this appendix is from the DWR Well Completion Report (WCR) dataset, downloaded on March 1, 2022. The WCR dataset does not contain a complete accurate dataset, however, it is the best public source of data available. For example, some wells in the dataset are likely dry or have been destroyed. To filter out wells that may have been abandoned or no longer represent typical modern well depths and current groundwater elevations, only well records drilled since 2002 are used for analysis. Furthermore, well completion reports are not always accurately located. Where coordinates of wells are unavailable, DWR locates the well in the middle of the Public Land Survey System section. The location given by DWR in the WCR dataset is used in this analysis.

## 2.2 Total Well Records

The majority of water supply well records used in the analysis have known well depths, and the well use type for wells without well depth data are generally proportional to those with depth information. The number of wells installed in the Subbasin both with and without known well depths are included in Table 1. Approximately 3,758 supply wells have been installed in the Subbasin since 2002. Of these, 3,353, or about 89%, have well completion data in the WCR dataset and are used in the SMC analysis described in Appendix A. The proportion of wells used for various purposes is nearly identical for the full WCR dataset compared to the subset of wells with known depths; almost all supply wells are either used for agricultural use (55%) or domestic use (41%). Comparatively small numbers of wells are used for public supply (3%), and industrial (1%) purposes. Since the subset of wells with known depths includes a majority of well records in the dataset and closely approximates well types installed in the Subbasin, it is an appropriate dataset to use to develop mitigation plans.

Table 1. Water Supply Well Records by Use Type

| Well Use | All Water Supply Well Records from Jan 1, 2002 | | Well Records with Depth Information | |
|---|---|---|---|---|
| | Number of Wells | Percentage | Number of Wells | Percentage |
| Agricultural | 2,061 | 55% | 1,859 | 55% |
| Domestic | 1,546 | 41% | 1,364 | 41% |
| Public Supply | 129 | 3% | 117 | 3% |
| Industrial | 22 | 1% | 13 | <1% |
| TOTAL | 3,758 | - | 3,353 | - |

## 2.3 Well Records by GSA

Table 2 summarizes the number of well records by well use type for each GSA. There are approximately 1,276 well records in East Kaweah, 1,814 in Greater Kaweah, and 668 in Mid-Kaweah.

Table 2. Summary of Wells by GSA

| Well Use Type | East Kaweah | | Greater Kaweah | | Mid-Kaweah | | Total |
|---|---|---|---|---|---|---|---|
| | Number of Wells | Percentage | Number of Wells | Percentage | Number of Wells | Percentage | |
| Domestic | 463 | 36% | 814 | 45% | 269 | 40% | 1,546 |
| Agricultural | 793 | 62% | 914 | 50% | 354 | 53% | 2,061 |
| Public Supply | 17 | 1% | 71 | 4% | 41 | 6% | 129 |
| Industrial | 3 | <1% | 15 | 1% | 4 | 1% | 22 |
| Total | 1,276 | - | 1,814 | - | 668 | - | 3,758 |

## 2.4 Well Records by Analysis Zone

Well records from each analysis zone may be used by GSAs for well mitigation plans. The total number of well records in each aquifer zone is summarized in Table 3. Figure 1 shows the location of the analysis zones.

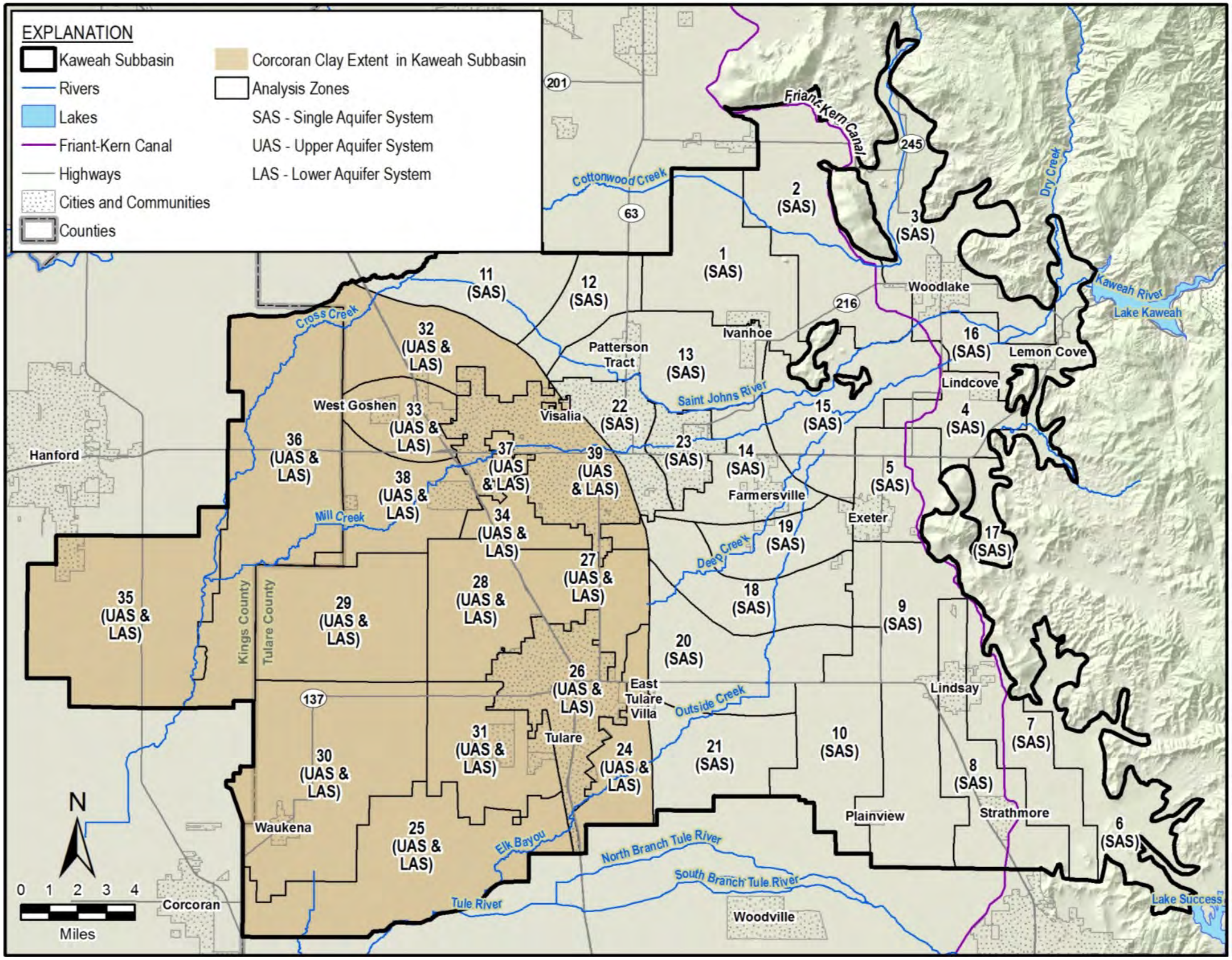



Figure 1. Kaweah Subbasin Analysis Zones

Table 3. Total Well Records by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 211 | 118 | 1 | 5 | 335 |
| 2 | 149 | 23 | 1 | 0 | 173 |
| 3 | 52 | 39 | 0 | 1 | 92 |
| 4 | 46 | 42 | 0 | 6 | 94 |
| 5 | 43 | 29 | 1 | 1 | 74 |
| 6 | 25 | 9 | 0 | 0 | 34 |
| 7 | 46 | 18 | 0 | 0 | 64 |
| 8 | 51 | 56 | 0 | 2 | 109 |
| 9 | 137 | 99 | 0 | 7 | 243 |
| 10 | 69 | 52 | 0 | 1 | 122 |
| 11 | 24 | 2 | 0 | 2 | 28 |
| 12 | 33 | 30 | 0 | 3 | 66 |
| 13 | 85 | 146 | 0 | 7 | 238 |
| 14 | 42 | 52 | 1 | 7 | 102 |
| 15 | 65 | 73 | 0 | 2 | 140 |
| 16 | 19 | 46 | 1 | 1 | 67 |
| 17 | 11 | 3 | 0 | 0 | 14 |
| 18 | 56 | 62 | 0 | 3 | 121 |
| 19 | 25 | 87 | 0 | 3 | 115 |
| 20 | 55 | 88 | 0 | 5 | 148 |
| 21 | 38 | 12 | 1 | 5 | 56 |
| 22 | 16 | 6 | 0 | 7 | 29 |
| 23 | 3 | 7 | 0 | 1 | 11 |
| 24 | 33 | 33 | 1 | 2 | 69 |
| 25 | 70 | 3 | 0 | 4 | 77 |
| 26 | 14 | 18 | 0 | 7 | 39 |
| 27 | 49 | 75 | 0 | 4 | 128 |
| 28 | 50 | 69 | 0 | 2 | 121 |
| 29 | 61 | 19 | 0 | 2 | 82 |
| 30 | 108 | 52 | 1 | 10 | 171 |
| 31 | 33 | 8 | 0 | 4 | 45 |
| 32 | 18 | 1 | 3 | 1 | 23 |
| 33 | 44 | 32 | 3 | 1 | 80 |
| 34 | 25 | 52 | 1 | 2 | 80 |
| 35 | 89 | 29 | 4 | 9 | 131 |
| 36 | 87 | 8 | 0 | 6 | 101 |
| 37 | 9 | 15 | 0 | 0 | 24 |
| 38 | 43 | 16 | 0 | 2 | 61 |
| 39 | 27 | 17 | 3 | 4 | 51 |
| Total | 2,061 | 1,546 | 22 | 129 | 3,758 |

# 3 POTENTIALLY IMPACTED WELLS

## 3.1 Well Records Shallower than Protective Well Depth by GSA

Wells shallower than protective well depths described in Appendix 5A may be impacted should groundwater elevations approach or exceed minimum thresholds during GSP implementation. The total number of well records shallower than protective well depths in each GSA is estimated using the percentage of wells shallower than the 90th percentile well depth by well use type. Selection of the 90th percentile well depth accounts for uncertainty in the data, especially regarding the likelihood the shallowest wells have been destroyed and replaced during ongoing dry conditions and declining groundwater levels. The analysis is completed using only wells with known well depths. The majority of minimum thresholds described in Appendix 5A are at higher elevations than elevations protective of 90% of wells. The tables that follow therefore overestimate the number of potentially impacted wells. However, since these estimates are to be used for determining the magnitude of wells to be addressed by mitigation plans, they can be considered worst-case estimates.

Table 4 through Table 6 show the approximate number of impacted wells in each GSA, including wells with unknown well depths.

- East Kaweah GSA – approximately 122 wells may be impacted, including 64 domestic wells, 55 agricultural wells, and 3 public supply wells (Table 4).
- Greater Kaweah GSA – approximately 167 wells may be impacted, including 105 domestic wells, 55 agricultural wells, and 7 public supply wells (Table 5).
- Mid-Kaweah GSA – approximately 43 wells may be impacted, including 22 domestic wells and 21 agricultural wells (Table 6).

Table 4. East Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells per square mile) |
| Domestic | 418 | 58 | 14% | 463 | 64 | 0.35 |
| Agricultural | 721 | 50 | 7% | 793 | 55 | 0.30 |
| Public Supply | 16 | 3 | 19% | 17 | 3 | 0.02 |
| Industrial | 2 | 0 | 0% | 3 | 0 | 0 |
| Total | 1,157 | 111 | | 1,276 | 122 | 0.67 |

Table 5. Greater Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells / square mile) |
| Domestic | 732 | 96 | 13% | 814 | 105 | 0.30 |
| Agricultural | 829 | 49 | 6% | 914 | 55 | 0.16 |
| Public Supply | 64 | 6 | 10% | 71 | 7 | 0.02 |
| Industrial | 8 | 0 | 0% | 15 | 0 | 0 |
| Total | 1,633 | 151 | | 1,814 | 167 | 0.48 |

Table 6. Mid-Kaweah GSA Potentially Impacted Wells

| Well Use Type | Well Records with Known Depth | | | All Well Records | | |
|---|---|---|---|---|---|---|
| | Number of Wells | Number of Potentially Impacted Wells | Percentage Potentially Impacted Wells | Number of Wells | Number of Potentially Impacted Wells | Density of Impacted Wells (wells / square mile) |
| Domestic | 214 | 17 | 8% | 269 | 22 | 0.13 |
| Agricultural | 309 | 18 | 6% | 354 | 21 | 0.13 |
| Public Supply | 37 | 0 | 0% | 41 | 0 | 0 |
| Industrial | 3 | 0 | 0% | 4 | 0 | 0 |
| Total | 563 | 35 | | 668 | 43 | 0.26 |

## 3.2 Well Records Shallower than Protective Well Depth by Analysis Zone

The total number of well records within each analysis zone may be used by the GSAs to estimate potential impacts to be addressed by Well Mitigation Programs. The approximate number of well records that are shallower than the protective well depth in each aquifer zone are summarized in Table 7. Figure 1 shows the location of the analysis zones.

Table 8. East Kaweah GSA Potentially Impacted Wells Summarized by Analysis ZoneTable 8 through Table 10 summarize estimated GSA-specific potential well impacts by well use type.

Table 7. Basinwide Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 15 | 19 | 0 | 0 | 34 |
| 2 | 15 | 3 | 0 | 0 | 18 |
| 3 | 2 | 2 | 0 | 0 | 4 |
| 4 | 2 | 7 | 0 | 0 | 9 |
| 5 | 3 | 4 | 0 | 0 | 7 |
| 6 | 3 | 1 | 0 | 0 | 4 |
| 7 | 6 | 1 | 0 | 0 | 7 |
| 8 | 1 | 9 | 0 | 1 | 11 |
| 9 | 7 | 14 | 0 | 2 | 23 |
| 10 | 3 | 7 | 0 | 0 | 10 |
| 11 | 2 | 1 | 0 | 0 | 3 |
| 12 | 3 | 3 | 0 | 0 | 6 |
| 13 | 1 | 16 | 0 | 1 | 18 |
| 14 | 0 | 10 | 0 | 0 | 10 |
| 15 | 5 | 10 | 0 | 0 | 15 |
| 16 | 2 | 4 | 0 | 0 | 6 |
| 17 | 1 | 1 | 0 | 0 | 2 |
| 18 | 2 | 11 | 0 | 0 | 13 |
| 19 | 2 | 6 | 0 | 0 | 8 |
| 20 | 0 | 14 | 0 | 0 | 14 |
| 21 | 3 | 2 | 0 | 0 | 5 |
| 22 | 3 | 1 | 0 | 0 | 4 |
| 23 | 0 | 2 | 0 | 0 | 2 |
| 24 | 2 | 4 | 0 | 0 | 6 |
| 25 | 8 | 1 | 0 | 0 | 9 |
| 26 | 2 | 0 | 0 | 0 | 2 |
| 27 | 2 | 4 | 0 | 0 | 6 |
| 28 | 1 | 3 | 0 | 0 | 4 |
| 29 | 2 | 2 | 0 | 0 | 4 |
| 30 | 7 | 8 | 0 | 0 | 15 |
| 31 | 2 | 1 | 0 | 0 | 3 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 33 | 3 | 4 | 0 | 0 | 7 |
| 34 | 0 | 6 | 0 | 1 | 7 |
| 35 | 7 | 1 | 0 | 2 | 10 |
| 36 | 8 | 1 | 0 | 1 | 10 |
| 37 | 0 | 1 | 0 | 0 | 1 |
| 38 | 0 | 6 | 0 | 2 | 8 |
| 39 | 2 | 1 | 0 | 0 | 3 |
| Total | 131 | 191 | 0 | 10 | 332 |

Table 8. East Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 1 | 15 | 19 | 0 | 0 | 34 |
| 2 | 15 | 3 | 0 | 0 | 18 |
| 3 | 2 | 2 | 0 | 0 | 4 |
| 4 | 1 | 5 | 0 | 0 | 6 |
| 5 | 2 | 3 | 0 | 0 | 5 |
| 6 | 3 | 1 | 0 | 0 | 4 |
| 7 | 6 | 1 | 0 | 0 | 7 |
| 8 | 1 | 9 | 0 | 1 | 11 |
| 9 | 7 | 14 | 0 | 2 | 23 |
| 10 | 3 | 7 | 0 | 0 | 10 |
| Total | 55 | 64 | 0 | 3 | 122 |

Table 9. Greater Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 3 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 2 | 0 | 0 | 3 |
| 5 | 1 | 1 | 0 | 0 | 2 |
| 11 | 2 | 1 | 0 | 0 | 3 |
| 12 | 3 | 3 | 0 | 0 | 6 |
| 13 | 1 | 16 | 0 | 1 | 18 |
| 14 | 0 | 10 | 0 | 0 | 10 |
| 15 | 5 | 10 | 0 | 0 | 15 |
| 16 | 2 | 4 | 0 | 0 | 6 |
| 17 | 1 | 1 | 0 | 0 | 2 |
| 18 | 2 | 11 | 0 | 0 | 13 |
| 19 | 2 | 6 | 0 | 0 | 8 |
| 20 | 0 | 14 | 0 | 0 | 14 |
| 21 | 3 | 2 | 0 | 0 | 5 |
| 22 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 |
| 24 | 2 | 4 | 0 | 0 | 6 |
| 25 | 8 | 1 | 0 | 0 | 9 |
| 30 | 0 | 0 | 0 | 0 | 0 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 33 | 3 | 4 | 0 | 0 | 7 |
| 34 | 0 | 6 | 0 | 1 | 7 |
| 35 | 7 | 1 | 0 | 2 | 10 |
| 36 | 8 | 1 | 0 | 1 | 10 |
| 37 | 0 | 1 | 0 | 0 | 1 |
| 38 | 0 | 6 | 0 | 2 | 8 |
| Total | 55 | 105 | 0 | 7 | 167 |

Table 10. Mid-Kaweah GSA Potentially Impacted Wells Summarized by Analysis Zone

| Analysis Zone | Agricultural Well Records | Domestic Well Records | Public Well Records | Industrial Well Records | Total Well Records |
|---|---|---|---|---|---|
| 22 | 3 | 1 | 0 | 0 | 4 |
| 23 | 0 | 2 | 0 | 0 | 2 |
| 24 | 0 | 0 | 0 | 0 | 0 |
| 26 | 2 | 0 | 0 | 0 | 2 |
| 27 | 2 | 4 | 0 | 0 | 6 |
| 28 | 1 | 3 | 0 | 0 | 4 |
| 29 | 2 | 2 | 0 | 0 | 4 |
| 30 | 7 | 8 | 0 | 0 | 15 |
| 31 | 2 | 1 | 0 | 0 | 3 |
| 39 | 2 | 1 | 0 | 0 | 3 |
| Total | 21 | 22 | 0 | 0 | 43 |

# Appendix 5E

# Technical Approach for Developing Subsidence Sustainable Management Criteria in the Kaweah Subbasin

July 27, 2022

# Technical Approach for Developing Subsidence Sustainable Management Criteria in the Kaweah Subbasin

*Prepared for:*

East Kaweah Groundwater Sustainability Agency
Greater Kaweah Groundwater Sustainability Agency
Mid-Kaweah Groundwater Sustainability Agency

*Prepared by:*

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## Contents



## Tables

# Figures

# ACRONYMS & ABBREVIATIONS

1-D Model .....1-Dimensional Compaction Numerical Model
DWR ..............California Department of Water Resources
EKGSA ..........East Kaweah Groundwater Sustainability Agency
GSA................Groundwater Sustainability Agency
GSP ................Groundwater Sustainability Plan
InSAR ............Interferometric Synthetic Aperture Radar
SGMA............Sustainable Groundwater Management Act
SMC ..............Sustainable Management Criteria
Subbasin.........Kaweah Subbasin
TID.................Tulare Irrigation District
USGS .............United States Geological Survey

# 1 INTRODUCTION

This technical report describes the methodology for developing land subsidence sustainable management criteria (SMC) for the San Joaquin Valley - Kaweah Subbasin (Subbasin). The revisions are in response to the California Department of Water Resources' (DWR) incomplete determination of the 3 Groundwater Sustainability Plans (GSPs) submitted in January 2020 (DWR, 2022). The 3 GSPs are implemented by 3 Groundwater Sustainability Agencies (GSAs) covering the entirety of the Subbasin: East Kaweah GSA, Greater Kaweah GSA, and Mid-Kaweah GSA.

DWR provided a staff report with a statement of findings explaining the incomplete determination for the Subbasin GSPs. The staff report states, "the Plan does not define sustainable management criteria for subsidence in the manner required by Sustainable Groundwater Management Act (SGMA) and the GSP Regulations." DWR's findings specified the following:

- Because Mid-Kaweah and Greater Kaweah did not define subsidence criteria based on conditions that would substantially interfere with land surface uses and users in the Subbasin, Department staff have no basis for evaluating whether continued subsidence predicted by the Plans (potentially 15 feet in the next 20 years in the southwest portion of the Subbasin) would cause significant and unreasonable impacts to land surface uses.
- The East Kaweah GSP better comports with expectations based on the GSP Regulations to develop sustainable management criteria for subsidence. The East Kaweah GSP states that an undesirable result would occur if there were "significant loss of functionality of a structure or a facility to the point that, due to subsidence, the feature cannot be operated as designed requiring either retrofitting or replacement." The East Kaweah GSP identified the Friant-Kern Canal as critical infrastructure for users in the GSA area and determined that a loss of more than 10% of its capacity would be unacceptable. The East Kaweah GSP identified that subsidence over 9.5 inches cumulatively would result in the 10% loss in capacity and, therefore, used 9.5 inches of cumulative subsidence as the minimum threshold.
- The differences between Greater Kaweah and East Kaweah GSPs creates the potential for inconsistency in groundwater management between the Subbasins GSPs. A portion of the Greater Kaweah GSP area bisects the East Kaweah GSP area in the vicinity of the Friant Kern Canal. Greater Kaweah's subsidence minimum thresholds in this area allow for 1.0 to 1.2 inches per year of subsidence, or 20 to 24 inches cumulatively over the 20-year implementation period. Neither the East Kaweah nor the Greater Kaweah GSPs nor the Subbasin Coordination Agreement explain how up to 24 inches of subsidence in the

Greater Kaweah area can be accommodated without interfering with the 9.5-inch limit set by East Kaweah to protect the conveyance capacity of the Friant-Kern Canal. The GSPs will need to reconcile this apparent discrepancy.

DWR's recommended corrective actions include the following:

- Mid-Kaweah and Greater Kaweah must define sustainable management criteria for land subsidence in the manner required by SGMA and the GSP Regulations. The GSAs should develop criteria, including minimum thresholds, measurable objectives, interim milestones, and undesirable results based on the amount of subsidence that would substantially interfere with land surface uses. Developed criteria should be supported with information on the effects of subsidence on land surface beneficial uses and users and the amount of subsidence that would substantially interfere with those uses and users.
- Greater Kaweah also must explain how their minimum thresholds in the vicinity of identified critical infrastructure (i.e., the Friant Kern Canal) will not substantially interfere with the Canal's use (identified by East Kaweah GSA as an undesirable result). Address how the amount of potential cumulative subsidence allowed for by Greater Kaweah's subsidence rates, which currently exceeds the amount identified by East Kaweah that would cause an undesirable result, are compatible or provide revised rates for the eastern portion of the Subbasin that are compatible.

The GSAs were given up to 180 days from the receipt of DWR's staff report to address the deficiencies for land subsidence SMC. This document and the GSP revisions fulfill that purpose.

## 1.1 General Approach Used to Develop Sustainable Management Criteria

The general approach described herein focuses on estimating future total subsidence over various time horizons and addressing potential damage to water conveyance infrastructure and deep wells. No reliable direct correlation between total subsidence and well collapse has been found. Significant and unreasonable impacts to deep wells are based on commonly used well designs that accommodate subsidence. In the future, should more detailed and local information become available on damage to wells caused by subsidence, this information would be used to re-evaluate the impact of subsidence on well infrastructure.

## 1.2 Data Sources

In response to DWR comments, the GSAs reviewed the data sources and methods used to select subsidence SMCs. Information and tools used for establishing revised subsidence SMC include:

- Groundwater level monitoring in the Subbasin 1999-2021
- Historical Interferometric Synthetic Aperture Radar (InSAR) measured subsidence data
- Local subsidence benchmark monitoring data
- Possible future groundwater elevations based on revised minimum thresholds
- A 1-Dimensional Compaction Numerical Model (1-D Model) developed by Stanford University researchers
- A subsidence spreadsheet prediction tool developed for the GSAs to simplify and extrapolate subsidence predictions from 1-D Model to the rest of the Subbasin
- Water conveyance infrastructure locations

# 2 METHODOLOGY USED TO ESTIMATE FUTURE SUBSIDENCE

The methodology presented in this section estimates the total future subsidence that is the basis for setting minimum thresholds. Total subsidence is the annual sum of active subsidence caused by the most recent year's lowering of groundwater levels and any residual subsidence from previous years. The method uses historical groundwater elevations, historical subsidence measurements, the 1-D subsidence model, a subsidence spreadsheet prediction tool, and revised chronic lowering of groundwater levels minimum thresholds to establish estimated rates of total future maximum (worst-case) subsidence.

The 1-D model was built and calibrated using the following data and approach:

- An initial model was developed using Fall groundwater levels to simulate historical subsidence between 1999 and 2021.
- The model was calibrated against 2015 to 2021 subsidence data collected using InSAR available from DWR.
- The model was extended from 2021 through 2070 using minimum thresholds as the ultimate groundwater elevations.
    - Chronic lowering of groundwater levels minimum thresholds described in Appendix 5A are used to estimate a groundwater elevation trend between 2021 and 2040.
    - The minimum threshold "worst-case" groundwater elevations are held stable in the model between 2040 and 2070.

The 1-D model results are used to develop a simplified subsidence spreadsheet prediction tool to extrapolate the 1-D model predictions to other areas in the Subbasin. The subsidence predictions from the spreadsheet tool are used to evaluate the impact that subsidence might have on conveyance infrastructure if groundwater levels stabilize in 2040 at the chronic lowering of groundwater levels minimum thresholds.

## 2.1 1-Dimensional Compaction Numerical Model

A 1-D Model developed by Stanford University researchers (Lees *et al.*, 2022) estimates subsidence in two locations in and adjacent to the Subbasin. Stanford University researchers calibrated historical subsidence at the South Hanford and Tulare Irrigation District (TID) Sites, shown on Figure 1 (Lees *et al*., 2022). Only the results from the South Hanford Site are published by Lees (2022). Stanford researchers used the calibrated 1-D Model to estimate the amount of future subsidence through 2070 at the two sites if groundwater elevation declines to the minimum thresholds.

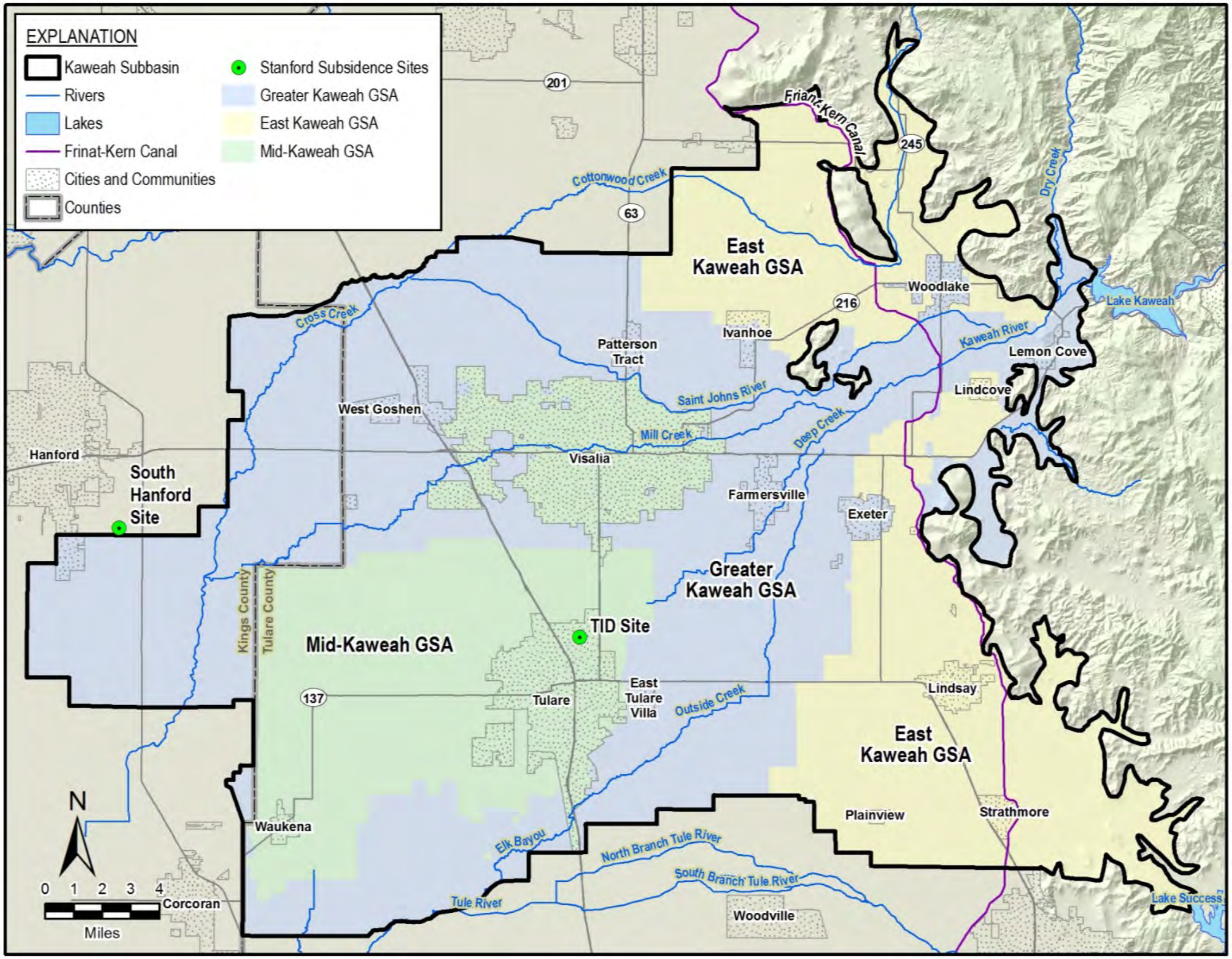



Figure 1. Subsidence Prediction Locations, derived from Lees *et al.*, 2022

### 2.1.1 Data Sources and Equations

The 1-D Model is built using governing equations for clay compaction with reduction in groundwater head. The equations were originally described in the late 1970s in a United States Geological Survey report (Helm, 1975). The Lees *et al.* (2022) model uses the number and thickness of various clay layers from geophysical logs, historical groundwater elevation data, and historical subsidence estimates from 1952 to 2017 to build and calibrate a model to match subsidence observations. Multiple physical parameters are adjusted to assess sensitivity and uncertainty and develop a range of potential solutions. The calibration results in reasonable values for vertical hydraulic conductivity, specific storage, initial stress, aquifer depth, and the residual timescale for subsidence (Lees *et al.*, 2022).

### 2.1.2 1-D Model Results

The 1-D model results show significant residual subsidence related to overdraft in the Subbasin is expected to occur for many decades following stabilization of groundwater elevations (Lees *et al.*, 2022). Most compaction, about 90 to 94% at the South Hanford site, occurs in the lower aquifer below the Corcoran Clay.

The model's subsidence predictions for the worst case of groundwater elevations declining and stabilizing at the minimum thresholds are shown on Figure 2 for the South Hanford site and Figure 3 for the TID site. The blue lines on these figures show historical and predicted shallow aquifer groundwater elevations. The red lines on these figures show historical and predicted deep aquifer groundwater elevations. These lines demonstrate how groundwater elevations equilibrate at minimum thresholds beginning in 2040. The yellow line on these figures is the model-estimated subsidence, and the green dots are the measured subsidence from InSAR data.

Predicted subsidence at the South Hanford site is about 27 feet from 2020 to 2040 and about 18 feet from 2040 to 2070, for a total future subsidence of 45 feet. Predicted subsidence at the TID site is about 13 feet from 2020 to 2040 and about 8 feet from 2040 to 2070, for a total future subsidence of 21 feet. Models for both sites show residual subsidence continuing for decades after groundwater elevations stabilize in 2040. Figure 2 and Figure 3 do not show expected subsidence, but rather the maximum subsidence under worst-case conditions.

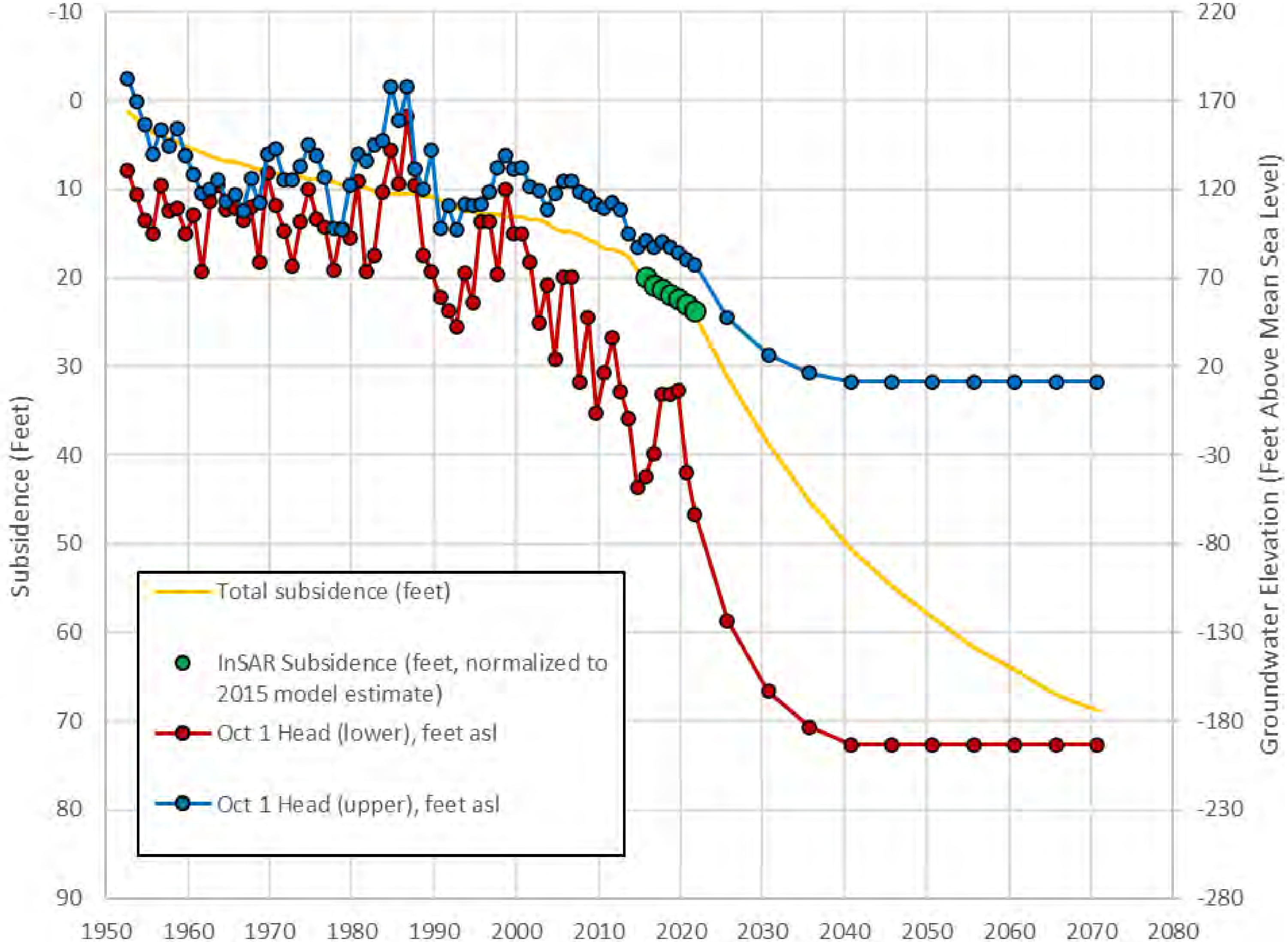



Figure 2. South Hanford Site Subsidence and Groundwater Elevation Time-Series, derived from Lees *et al*., 2022

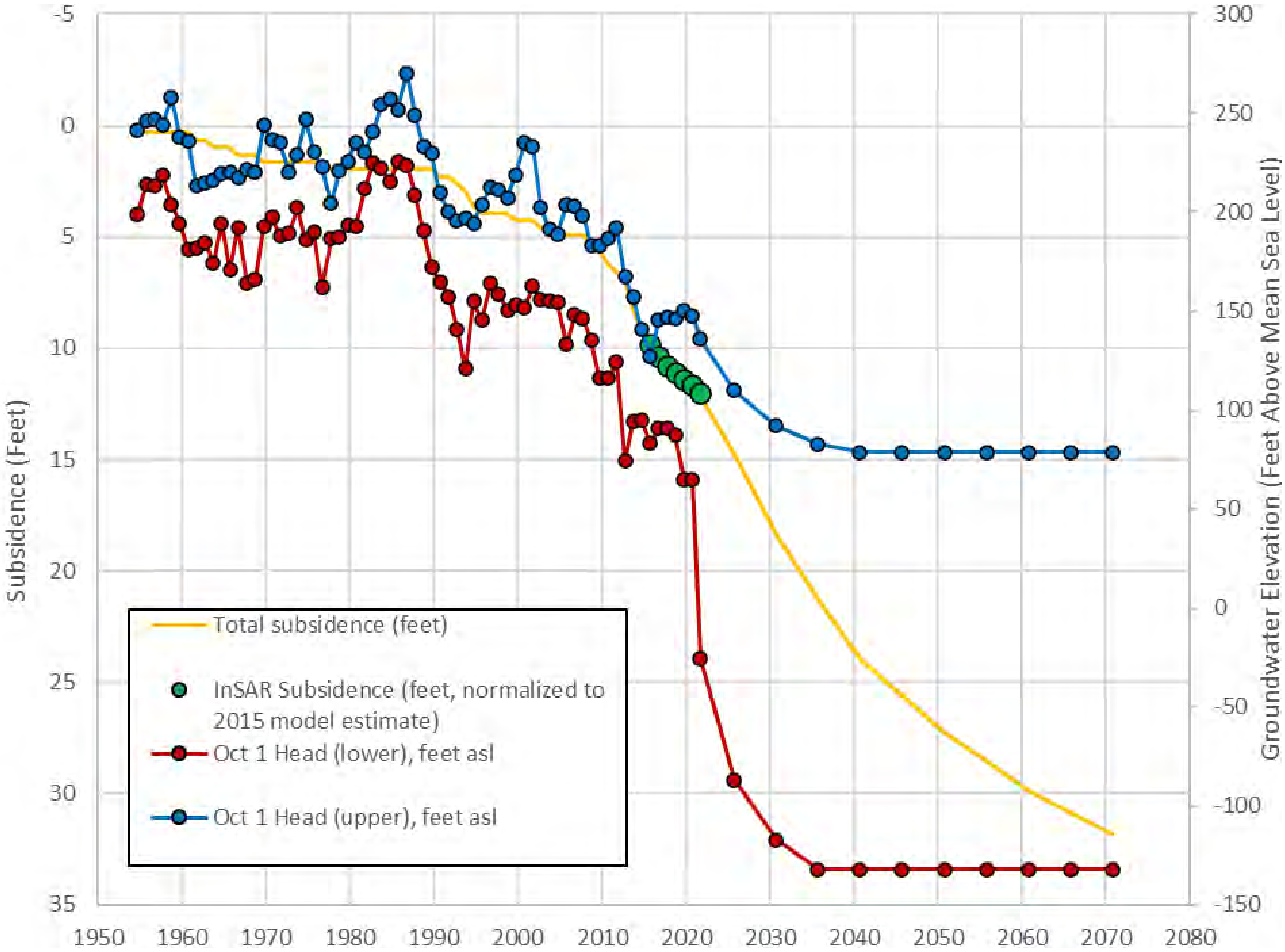



Figure 3. TID Site Subsidence and Groundwater Elevation Time-Series, derived from Lees *et al.*, 2022

### 2.1.3 Subsidence Spreadsheet Prediction Tool

Results from the 1-D Model are used to develop a simple spreadsheet tool to predict subsidence spatially throughout the Subbasin. A grid of 77 points plotted at 2-mile intervals is used to extrapolate the 1-D Model subsidence predictions (Figure 4). This grid is chosen to align with the United States Geological Survey's (USGS) textural model of the San Joaquin Valley (Faunt, 2009). The spreadsheet tool is used to predict subsidence at each point from 2020 to 2040, and from 2040 to 2070 based on historical groundwater elevation trends and chronic lowering of groundwater levels minimum thresholds provided by the GSAs.

### 2.1.4 Spreadsheet Tool Data Sources

The parameters in the spreadsheet tool are historical groundwater elevation, groundwater elevation minimum threshold, and estimated clay thickness. Fall groundwater elevation from the GSP groundwater model for years 1999 through 2017 and recent manual measurements in 2021 are used to estimate annual groundwater elevations. Groundwater elevation time series are compiled for the Lower and Upper Aquifer Systems in areas where the Corcoran Clay is present and for the Single Aquifer System in areas where Corcoran Clay is absent. An initial estimate of fine sediment thickness is derived from the USGS' textural model of the San Joaquin Valley. The textural model lumps silts and clays and therefore overestimates total clay thickness.

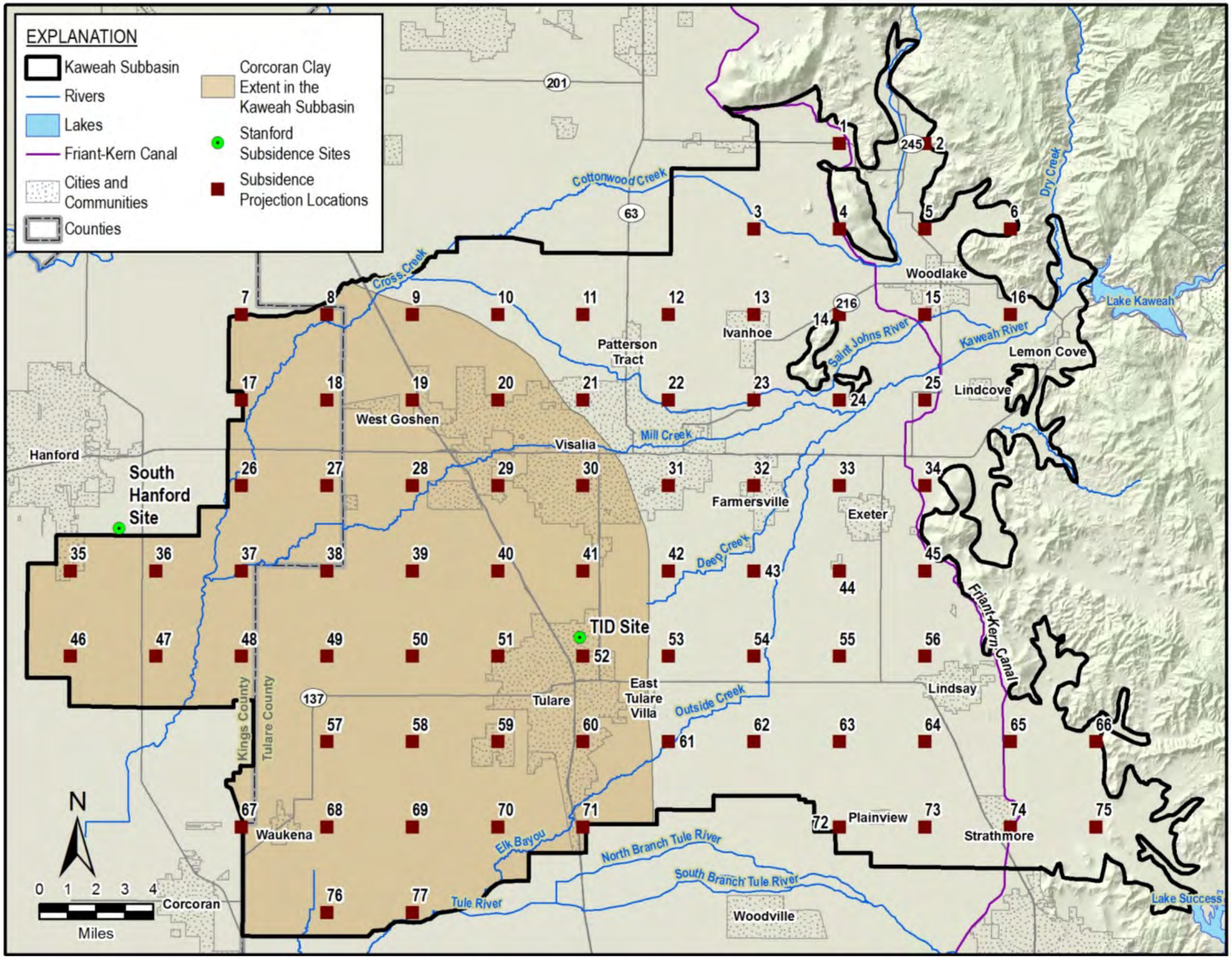



Figure 4. Subsidence Prediction Locations

### 2.1.5 Equations to Extrapolate Subsidence Across the Subbasin

A simplified set of equations is developed to extrapolate subsidence predicted from the 1-D Models for the South Hanford and TID sites to other locations with less refined data. An identical set of equations and variables are matched in the spreadsheet tool to the 1-D Model results at both the South Hanford and TID sites, only changing clay thickness to reflect site specific clay thickness at each site from geophysical logs.

A simplified equation for cumulative subsidence (Equation 1) is developed using scaling factor (Equation 2) and residual subsidence (Equation 3). These equations are empirical approximations of the more complex, physically based set of compaction equations described in Lees *et al*., 2022 and Helm, 1975:

**Equation 1**

$$Cumulative\ Subsidence = (Overdraft \times scaling\ factor) + \sum_{0}^{n} residual\ subsidence_{(n)}$$

**Equation 2**

$$Scaling\ factor = total\ clay\ thickness^2 \times scaling\ coefficient$$

**Equation 3**

$$Residual\ subsidence_{(n)} = Active\ subsidence_{(n)} \times residual\ subsidence\ factor$$

Where n is the number of previous years of subsidence.

#### 2.1.5.1 Equation 1: Cumulative Subsidence

$$Cumulative\ Subsidence = (Overdraft \times scaling\ factor) + \sum_{0}^{n} residual\ subsidence_{(n)}$$

The cumulative subsidence estimate is the sum of active subsidence from overdraft in the current year and residual subsidence from overdraft in all prior years. Active subsidence for the current year is calculated only if groundwater levels drop below the previously lowest measured groundwater levels.

Subsidence is influenced by groundwater levels in both the Upper and Lower Aquifer Systems. Lees *et al.* estimated that 93% of subsidence is related to overdraft in the Lower Aquifer System, and 7% of subsidence is related to overdraft in the Upper Aquifer System. Therefore, active subsidence is calculated for each aquifer and then weighted according to the percentages identified by Lees *et al*., 2022. In the Single Aquifer System area where the Corcoran Clay is not present, 7% of overdraft is assumed to contribute to subsidence because the Single Aquifer System is unconfined, like the Upper Aquifer System. Consequently, overdraft in the Single Aquifer System does not appear to cause as much subsidence as overdraft below the Corcoran Clay. This is supported by very little historical subsidence east of the Corcoran Clay observed in InSAR data from 2015 to 2022 (DWR InSAR data), or in DWR data from 1954 to 2006 (DWR TRE Altamira data), despite some observed historical overdraft.

#### 2.1.5.2 Equation 2: Scaling Factor

$$Scaling\ factor = total\ clay\ thickness^2 \times scaling\ coefficient$$

A consistent scaling factor was applied to equation 1 by using a single scaling coefficient throughout the Subbasin and varying the total clay thickness. The clay thickness for South Hanford and TID sites was assigned using geophysical logs collected during well installations. Clay thickness was adjusted at other sites to calibrate the model as discussed in Section 2.1.7. The scaling coefficient is fit to the South Hanford and TID site data and held constant for the 77 prediction sites. This coefficient simplifies the governing differential equation described in Lees *et al*., 2022, that incorporates vertical hydraulic conductivity, storage coefficient, and the sum of squared individual clay layer thicknesses.

#### 2.1.5.3 Equation 3: Residual Subsidence

$$Residual\ subsidence_{(n)} = Active\ subsidence_{(n)} \times residual\ subsidence\ factor$$

A simplified equation was developed to account for residual subsidence from previous years' active subsidence. The equation multiplies the active subsidence in any previous year by a residual subsidence factor that decreases over time. The equation is designed to add a lesser amount of residual subsidence over time as the effects of past overdraft diminish. The residual subsidence factor, shown on Figure 5, was fit to the 1-D Model data for South Hanford and TID sites and then applied throughout the Subbasin.

As an example, Figure 5 shows that after 50 years, only 20% of the active subsidence from the first year is added to the total subsidence calculation. Lees *et al*. (2022) and other research on subsidence has found that residual subsidence can occur for long periods, even after groundwater elevations stabilize. For example, at the South Hanford site, Lees *et al*. predicted that significant subsidence occurs for at least 64 years after overdraft stops and groundwater elevations are held constant. This long residual subsidence is due to much slower head equilibration and compaction in thick clay interbeds. Lees *et al*. acknowledges that this approach is conservative as they expect that the compressibility of clays will reduce over time as clays near ultimate compaction.

### 2.1.6 Spreadsheet Tool Development

Figure 6 shows how calculations from the spreadsheet tool fit the model used by Lees *et al*. for the South Hanford and TID sites. The results from Lees *et al*. are shown in yellow, and the results from the spreadsheet tool are shown in blue.

As shown on Figure 6, the spreadsheet tool is calibrated to groundwater elevation and subsidence from 1954 to 2017 to present. The 1954 to 1998 groundwater level and subsidence data are available at the South Hanford and TID sites, but not throughout the Subbasin. Subsidence predictions throughout the Subbasin were therefore based only on groundwater elevation data available from 1999 to 2021 and future estimated groundwater levels.

To demonstrate the effect of limiting the groundwater level data in the spreadsheet tool to data collected between 1999 and 2021, the fit between the spreadsheet tool using only data between 1999 and 2021 at the TID and South Hanford sites is shown with the Lees *et al*. results on Figure 7. The results on Figure 7 are not as accurate as the results using the more extensive groundwater elevation dataset from 1954 to 2017, shown on Figure 6. This is because residual subsidence from overdraft prior to 1999 is not accounted for in the Figure 7 results. However, Figure 7 shows that the error in the spreadsheet diminishes over time, suggesting the spreadsheet model remains valid for estimating long-term subsidence.

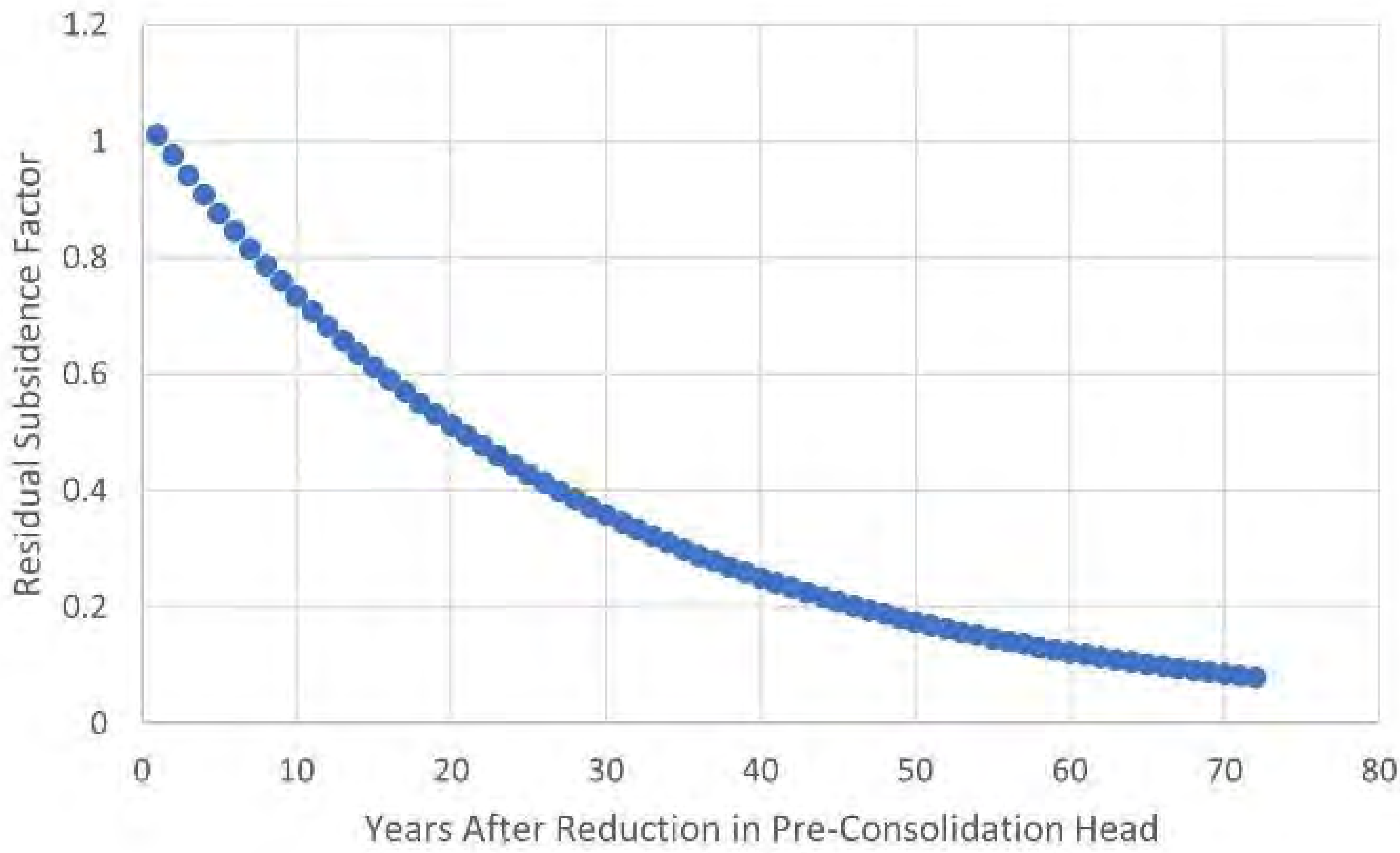
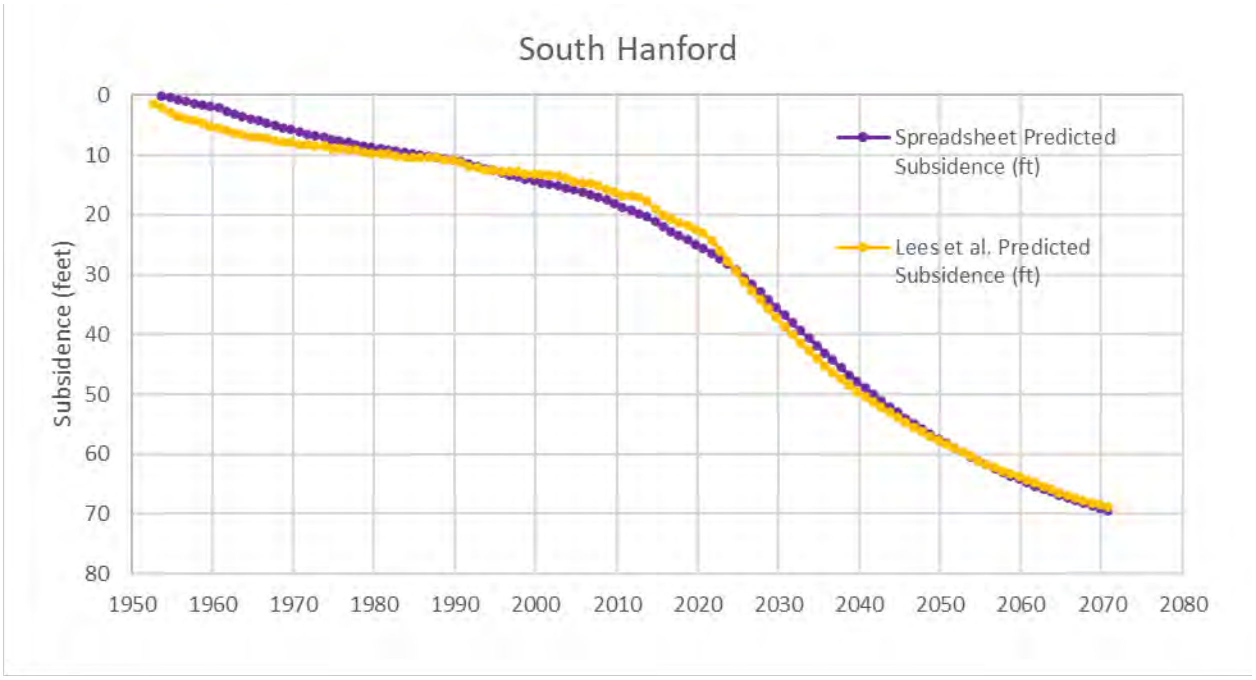



Figure 5. Residual Subsidence Factors for Years After Reduction in Pre-Consolidated Head



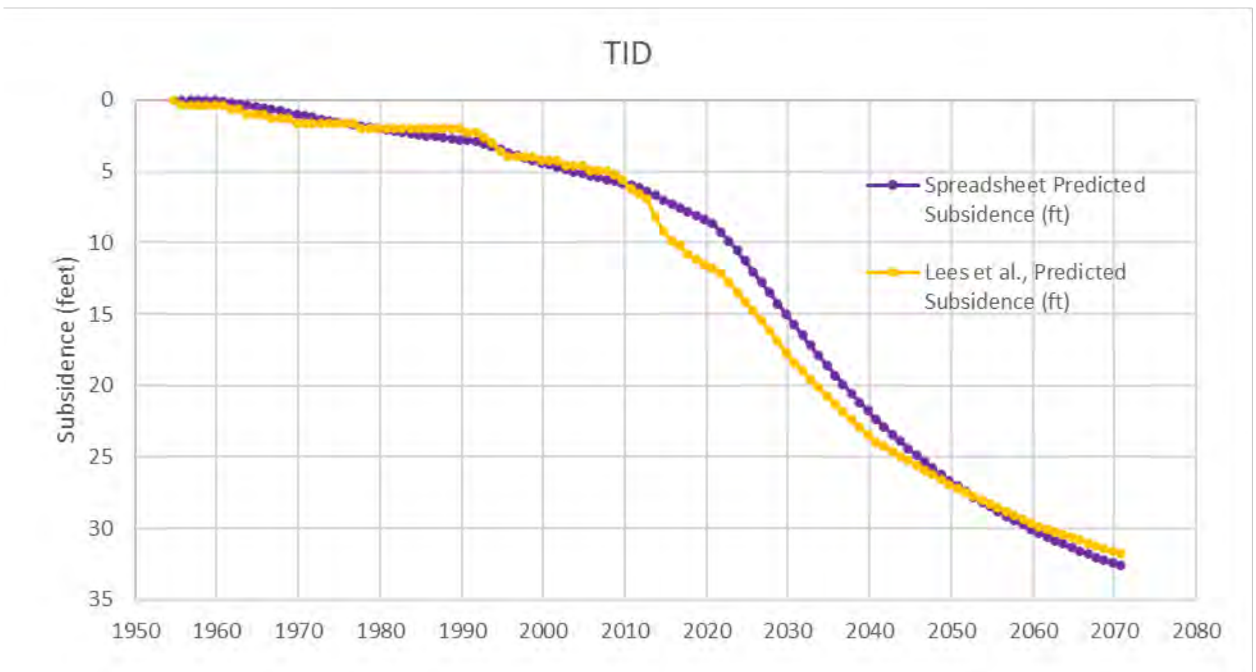




Figure 6. Spreadsheet and Model Predicted Subsidence at South Hanford and TID Sites, 1954-2070

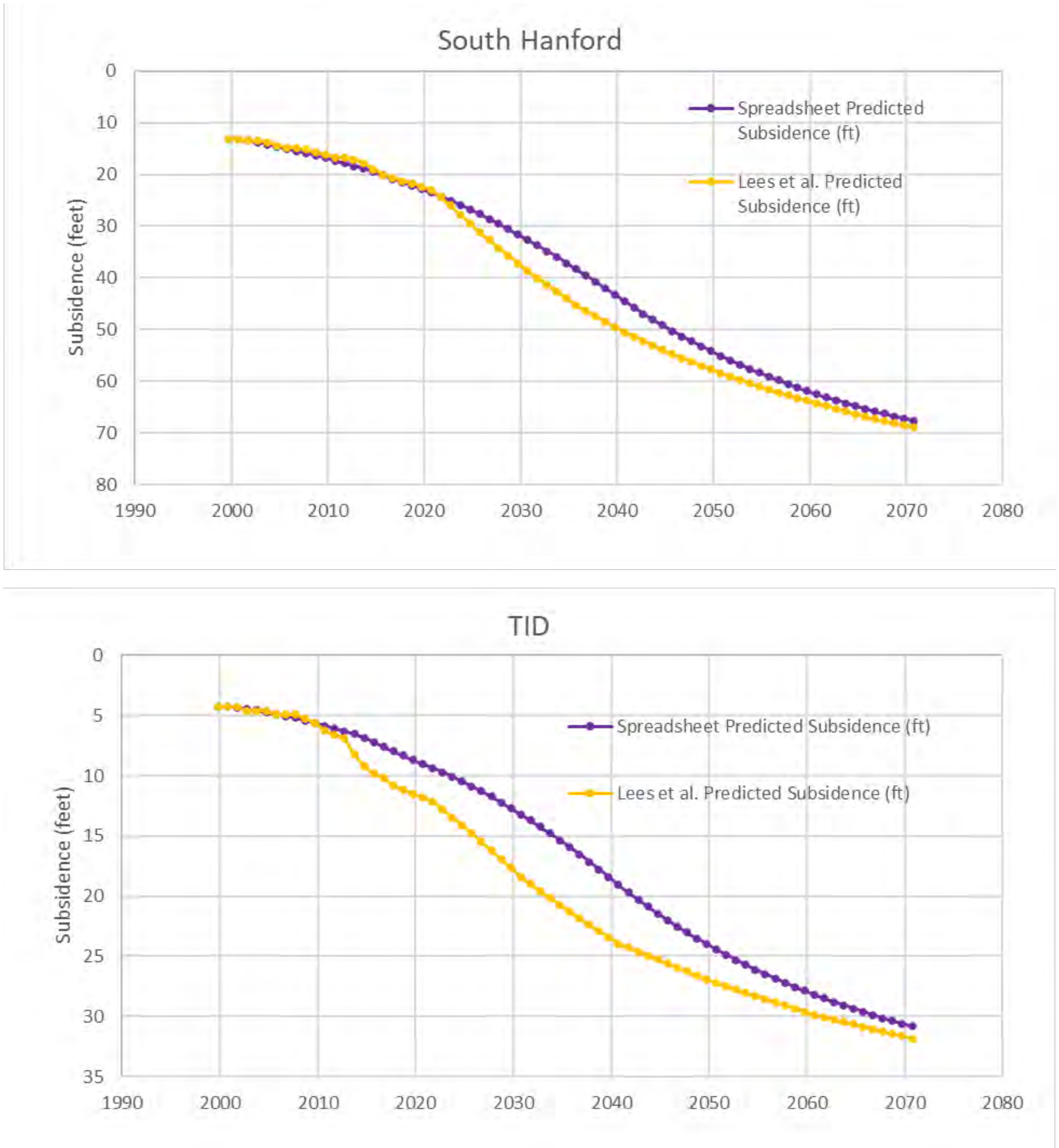



Figure 7. Spreadsheet and Model Predicted Subsidence at South Hanford and TID Sites, 1999-2070

### 2.1.7 Spreadsheet Tool Calibration

Total clay thickness is adjusted to calibrate the spreadsheet tool to match subsidence measured by InSAR between 2015 and 2021. The calibrated clay thickness is shown on Figure 8. This figure represents the total clay thickness, not the thickness of specific clay layers such as the Corcoran Clay. A comparison of the InSAR measured subsidence and calibrated model predicted subsidence is shown on Figure 9. Where subsidence was greatest in the western portion of the Subbasin, the model was calibrated to estimate slightly less subsidence than the InSAR data to account for underprediction shown on Figure 7. InSAR measured little to no subsidence in the eastern portion of the Subbasin where the Corcoran Clay is absent. The spreadsheet tool is not developed to estimate elastic subsidence or increase in land surface elevation when groundwater elevations increase, so subsidence in the eastern portion of the Subbasin may be slightly overestimated by this simplified approach.

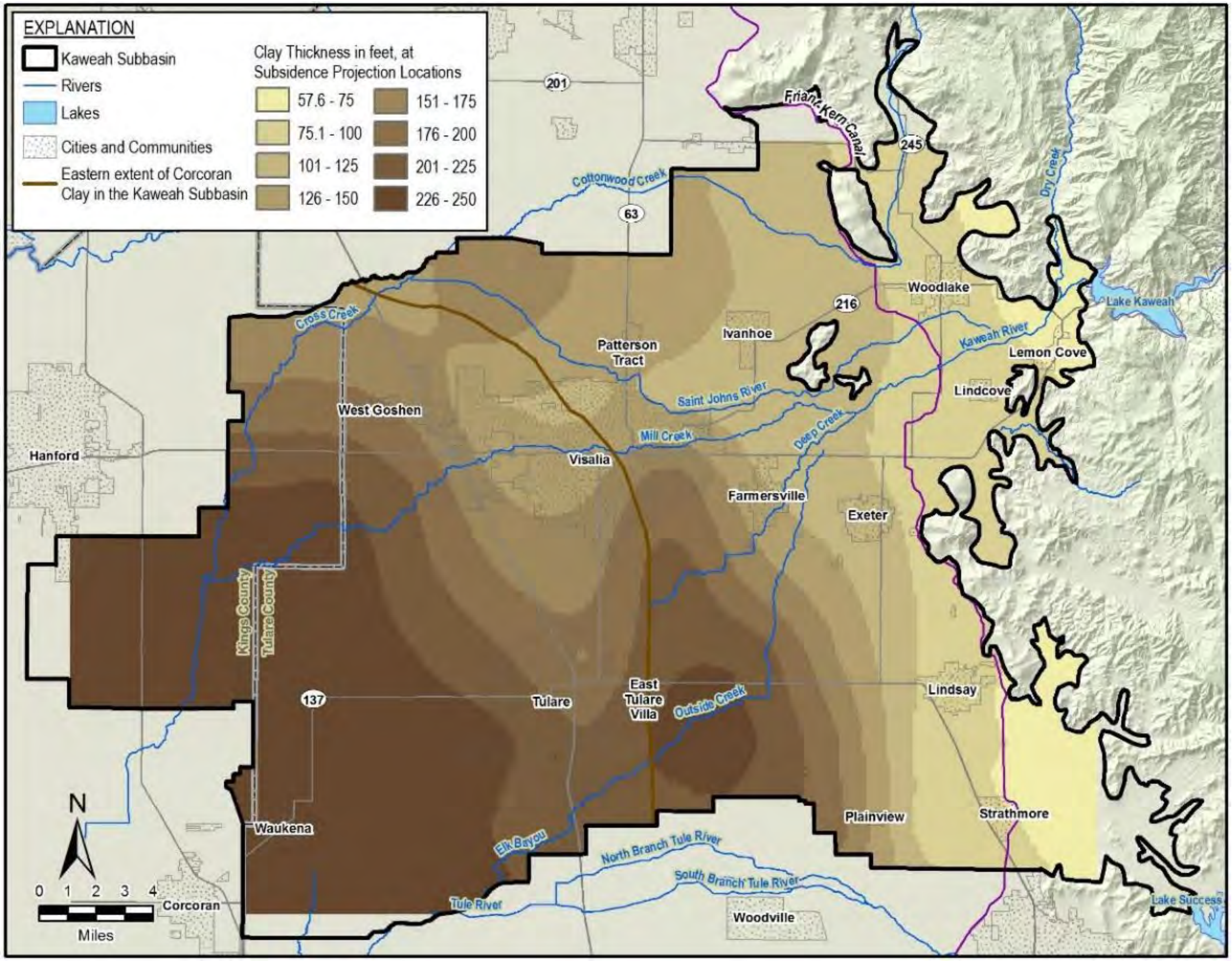


Figure 8. Clay Thickness from Spreadsheet Tool Calibration

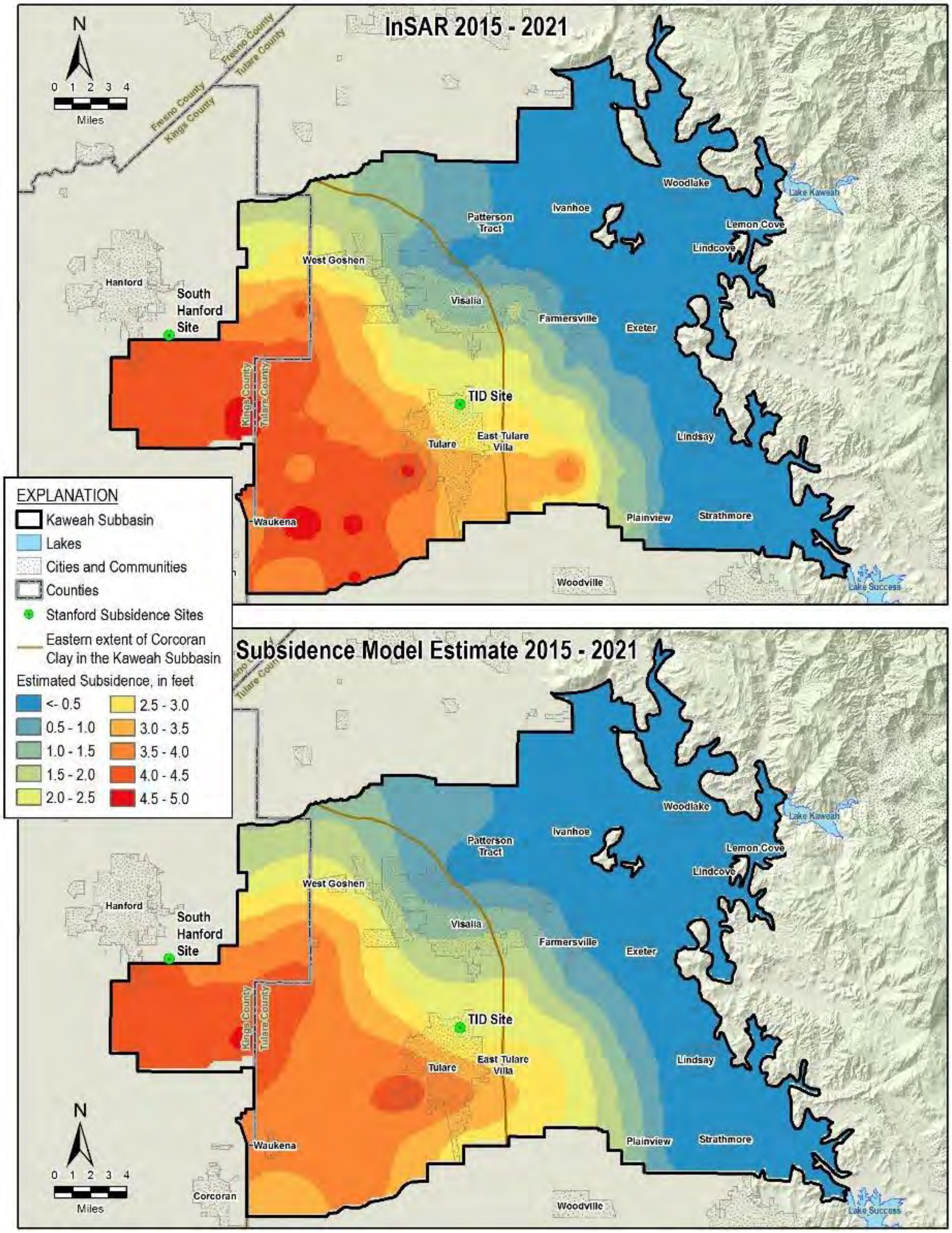



Figure 9. Subsidence from InSAR (top) Compared to Spreadsheet Model Estimate from 2015 to 2021 (bottom)

### 2.1.8 Spreadsheet Tool Results

Subsidence in the Subbasin is projected using the spreadsheet tool to continue over the SGMA planning and implementation horizon. This is substantiated by the results published by Lees *et al.*, 2022, which estimates up to 10 feet of subsidence will occur at the South Hanford site even if groundwater level declines are halted immediately.

#### 2.1.8.1 Subsidence at Groundwater Elevation Minimum Thresholds

If groundwater elevations decrease and stabilize at the minimum threshold, up to 20.2 feet of subsidence could occur between 2020 and 2040 (1 foot/year) as shown on Figure 10. Up to 22.9 feet of subsidence could occur between 2040 and 2070 (0.76 feet/year) as shown on Figure 11. These results are similar to the 1-D model results at the South Hanford site, which predicts approximately 27 feet of subsidence between 2020 and 2040, and 18 feet of subsidence from 2040 to 2070.

All subsidence between 2040 and 2070 is residual subsidence. The model assumes that the Subbasin achieves sustainability in 2040, and no new subsidence is activated over the ensuing 30 years. The subsidence shown on Figure 11 is the cumulative result of progressively less subsidence every year since 2040.

Figure 12 shows that Subbasin-wide subsidence could range between less than 1 foot and 43.1 feet over the full 50-year planning and implementation horizon. This equates to subsidence rates up to 10.4 inches per year. The greatest subsidence is located near the South Hanford site. Very little subsidence is predicted to occur along the eastern edge of the Subbasin.

Subsidence is measured in the Subbasin at a series of subsidence monitoring points, shown on Figure 13. The estimated subsidence when groundwater elevations stabilize at the minimum thresholds is shown for each subsidence measuring point in Table 1 as both a total subsidence and an equivalent subsidence rate.

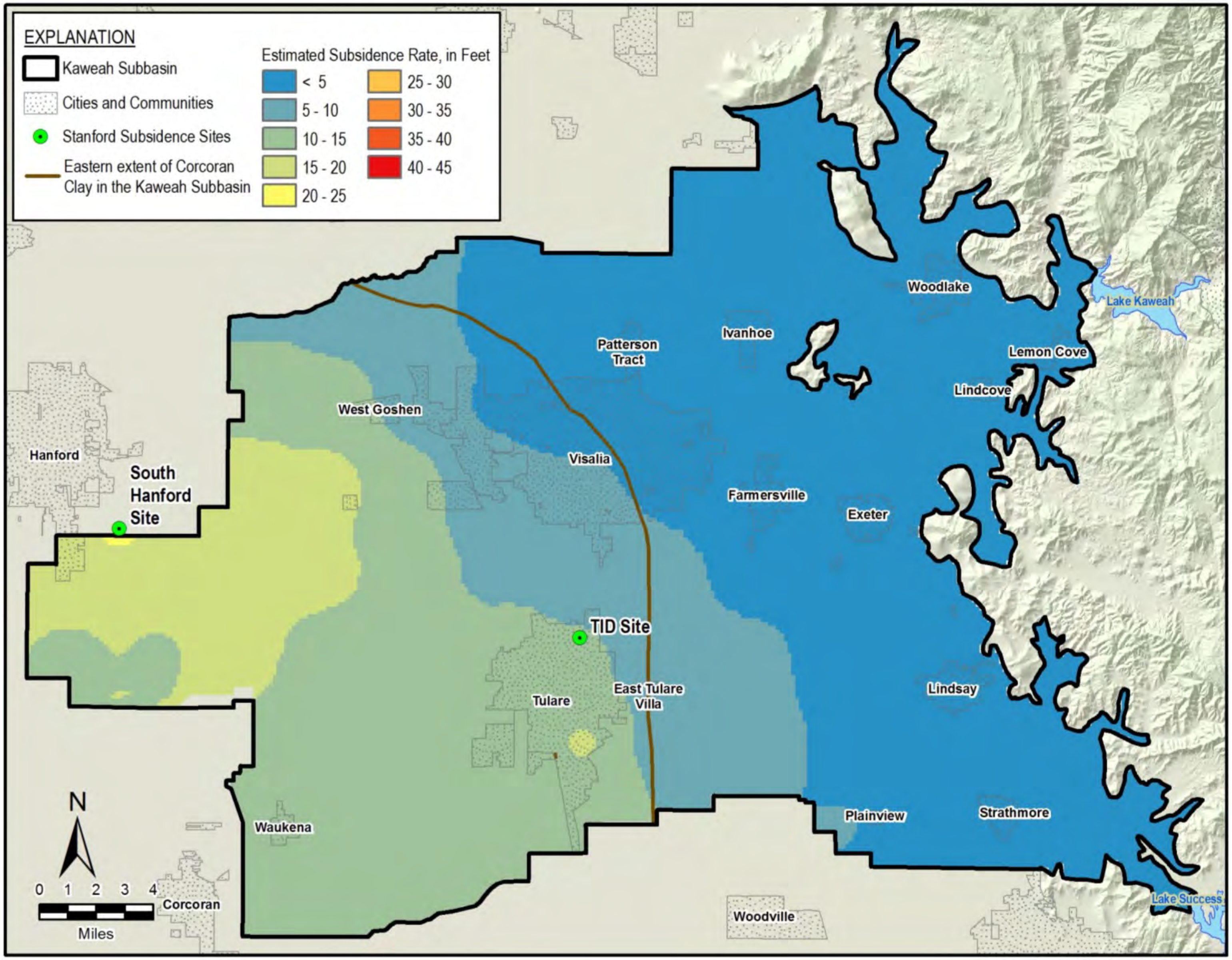



Figure 10. Spreadsheet Tool Estimated 2020 to 2040 Subsidence when Groundwater Levels Stabilize at Minimum Thresholds

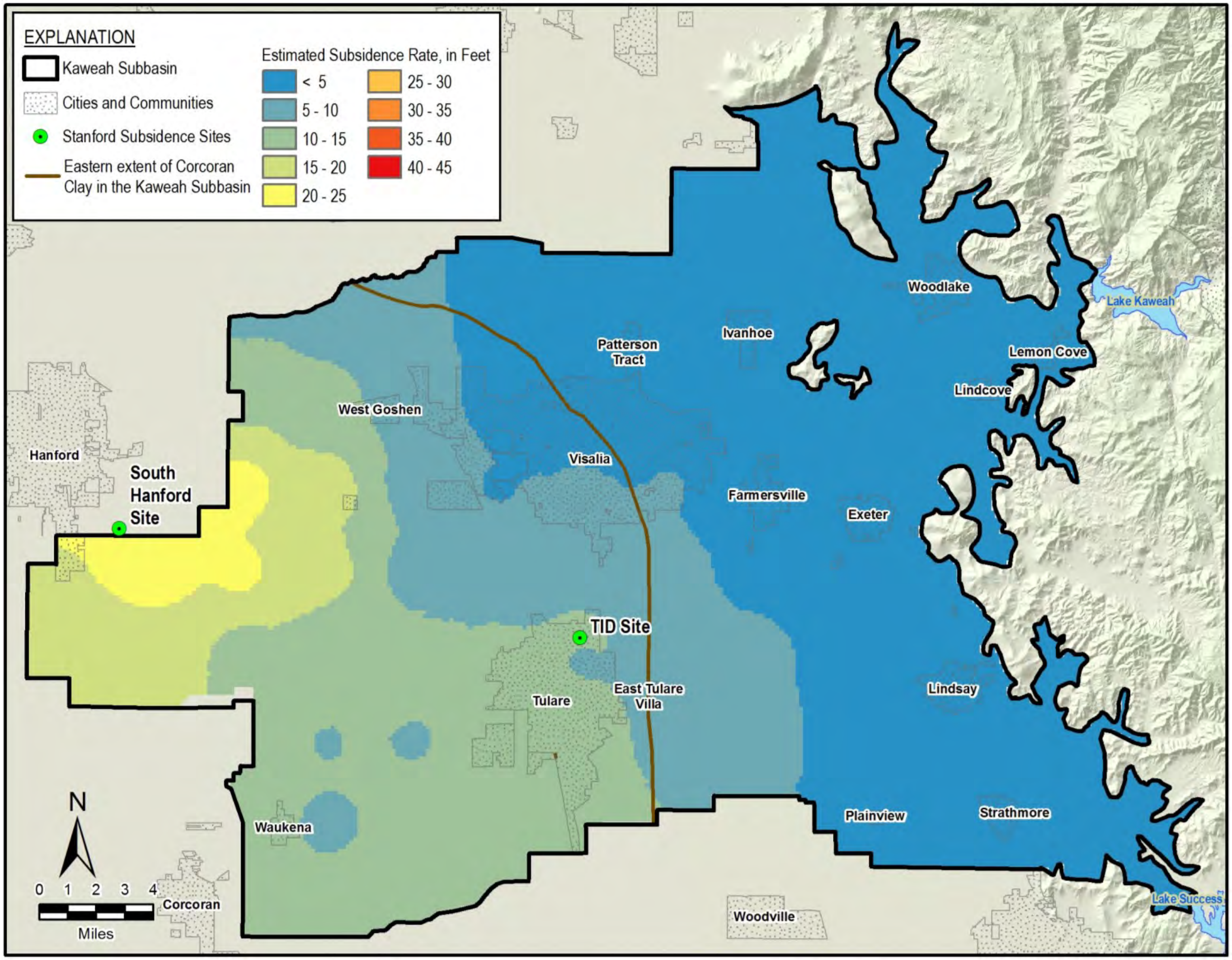



Figure 11. Spreadsheet Tool Estimated 2040 to 2070 Subsidence when Groundwater Levels Stabilize at Minimum Thresholds

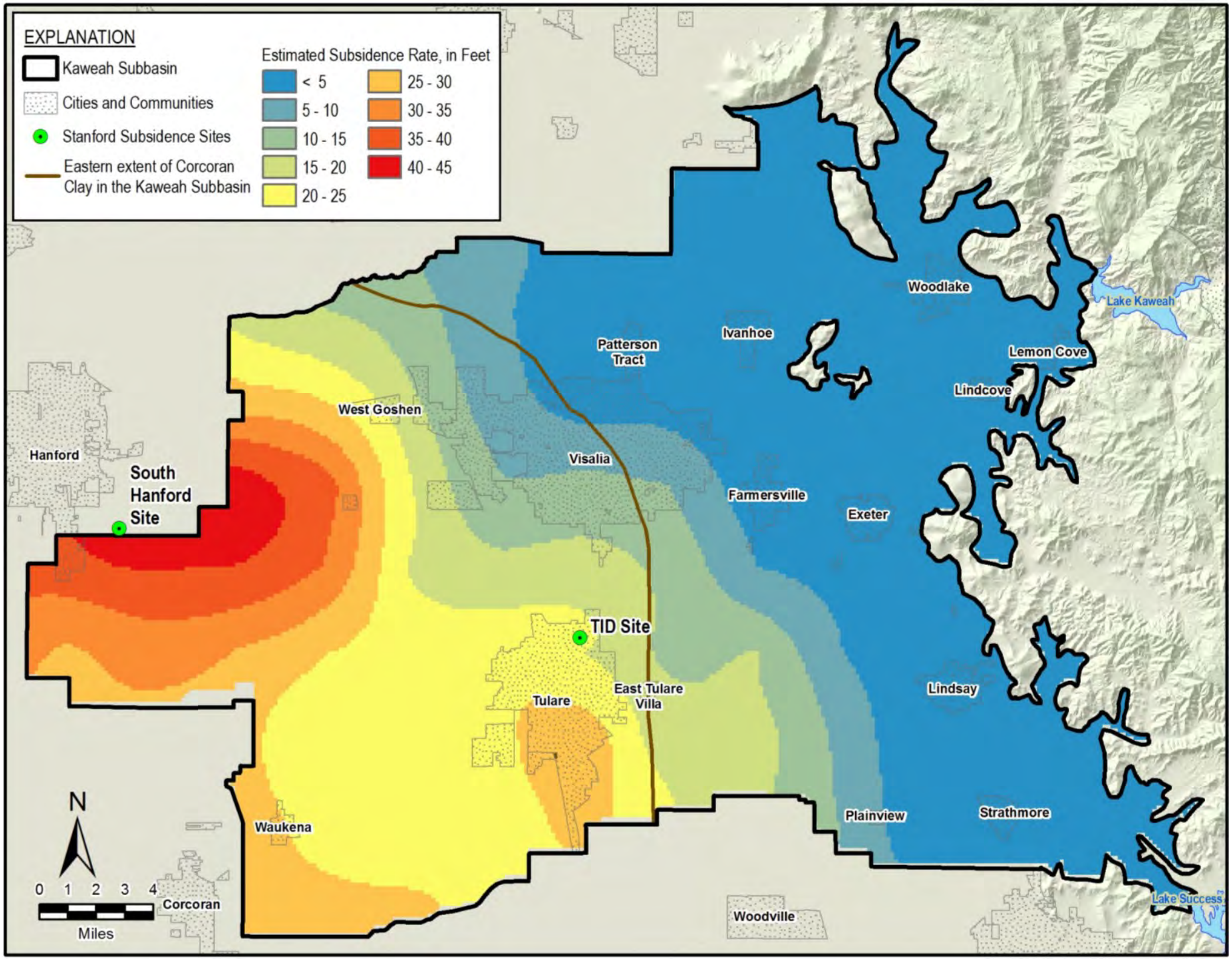



Figure 12. Spreadsheet Tool Estimated 2020 to 2070 Subsidence when Groundwater Levels Stabilize at Minimum Thresholds

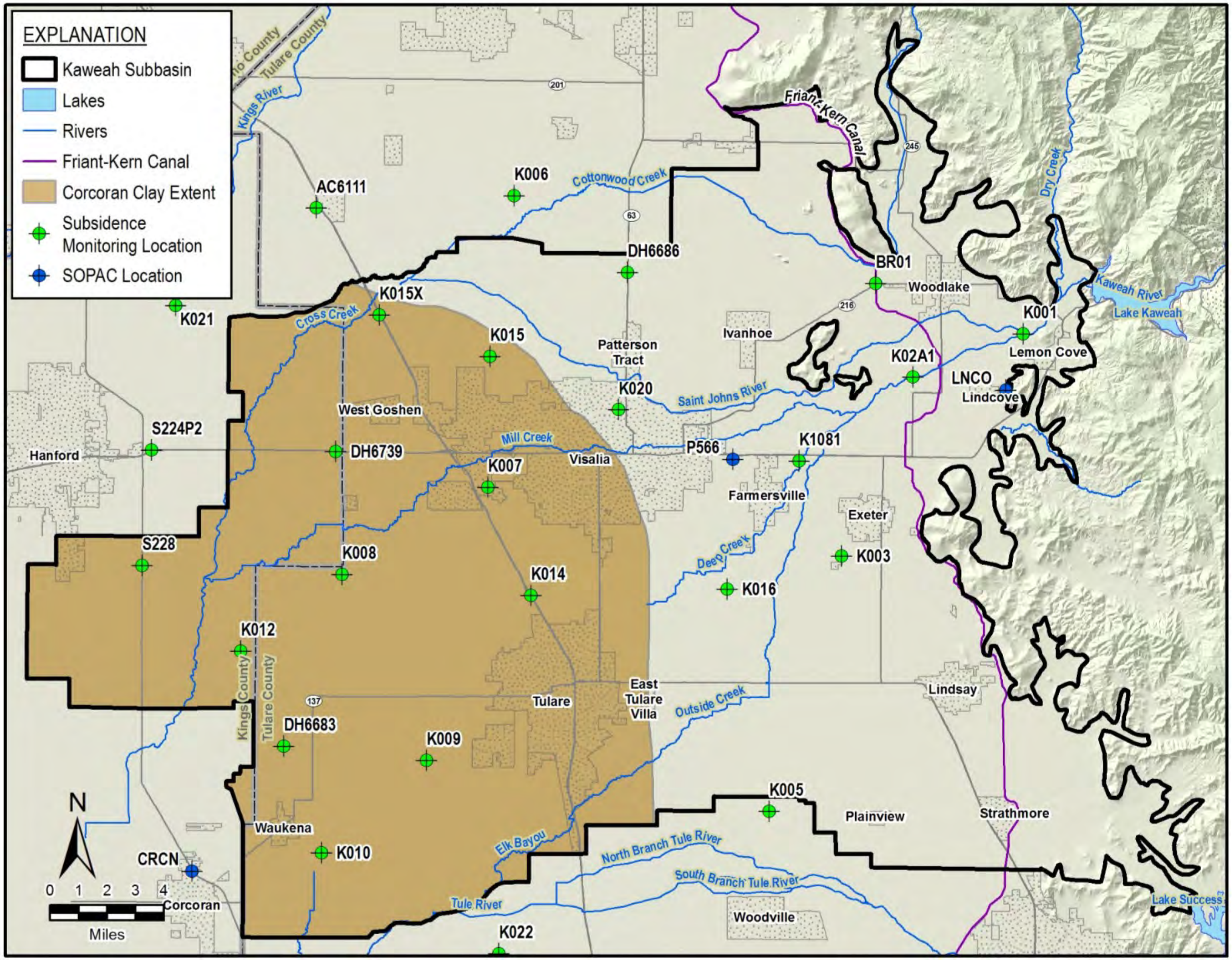


Figure 13. Subsidence Monitoring Points in and Around the Kaweah Subbasin

Table 1. Estimated Subsidence at Subbasin Monitoring Points when Groundwater Levels Stabilize at Minimum Thresholds

| Subsidence Monitoring Point | 2020 to 2040 | | 2040 to 2070 | | 2020 to 2070 | |
|---|---|---|---|---|---|---|
| | Annual Subsidence (inch/year) | Total Subsidence (feet) | Annual Subsidence (inch/year) | Total Subsidence (feet) | Annual Subsidence (inch/year) | Total Subsidence (feet) |
| BR01 | 0.2 | 0.3 | 0.1 | 0.2 | 0.1 | 0.5 |
| DH6683 | 7.6 | 12.7 | 4.4 | 10.9 | 5.7 | 23.6 |
| DH6686 | 0.9 | 1.6 | 0.8 | 1.9 | 0.8 | 3.5 |
| DH6739 | 9.5 | 15.9 | 6.1 | 15.2 | 7.5 | 31.1 |
| K001 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.4 |
| K003 | 0.7 | 1.2 | 0.6 | 1.4 | 0.6 | 2.6 |
| K007 | 3.9 | 6.6 | 2.0 | 5.0 | 2.8 | 11.6 |
| K008 | 9.8 | 16.3 | 6.2 | 15.5 | 7.6 | 31.8 |
| K009 | 6.7 | 11.1 | 3.9 | 9.9 | 5.0 | 21.0 |
| K010 | 7.9 | 13.2 | 4.3 | 10.9 | 5.8 | 24.0 |
| K012 | 10.3 | 17.2 | 5.0 | 12.6 | 7.1 | 29.8 |
| K014 | 5.9 | 9.9 | 3.7 | 9.2 | 4.6 | 19.1 |
| K015 | 2.1 | 3.5 | 1.3 | 3.2 | 1.6 | 6.7 |
| K015X | 4.5 | 7.5 | 2.5 | 6.3 | 3.3 | 13.8 |
| K016 | 2.6 | 4.4 | 2.1 | 5.2 | 2.3 | 9.5 |
| K020 | 1.1 | 1.9 | 0.9 | 2.2 | 1.0 | 4.0 |
| K02A1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.4 |
| K1081 | 0.3 | 0.5 | 0.1 | 0.4 | 0.2 | 0.9 |
| P566 | 0.9 | 1.4 | 0.6 | 1.6 | 0.7 | 3.0 |
| S228 | 10.8 | 18.0 | 9.0 | 22.5 | 9.7 | 40.5 |

#### 2.1.8.2 Subsidence at Groundwater Elevation Measurable Objectives

If groundwater elevations decrease and stabilize at the measurable objectives in 2040, up to 18.9 feet of subsidence could occur between 2020 and 2040, as shown on Figure 14. Up to 16 feet of subsidence could occur between 2040 and 2070 as shown on Figure 15.

All subsidence between 2040 and 2070 is residual subsidence. The model assumes that the Subbasin achieves sustainability at the measurable objectives in 2040, and no new subsidence is activated over the ensuing 30 years. The subsidence shown on Figure 15 is the cumulative result of progressively less subsidence every year since 2040.

Figure 16 shows that subbasin-wide subsidence could range between less than 0.02 feet and 34.8 feet over the full 50-year planning and implementation horizon. This equates to subsidence rates of between 0.005 and 8.3 inches per year. The greatest subsidence is located near the South Hanford site and very little subsidence is predicted to occur along the eastern edge of the Subbasin.

The estimated subsidence when groundwater elevations stabilize at the measurable objective is shown for each of the subsidence measuring points in Table 2 as both a total subsidence and an equivalent subsidence rate.

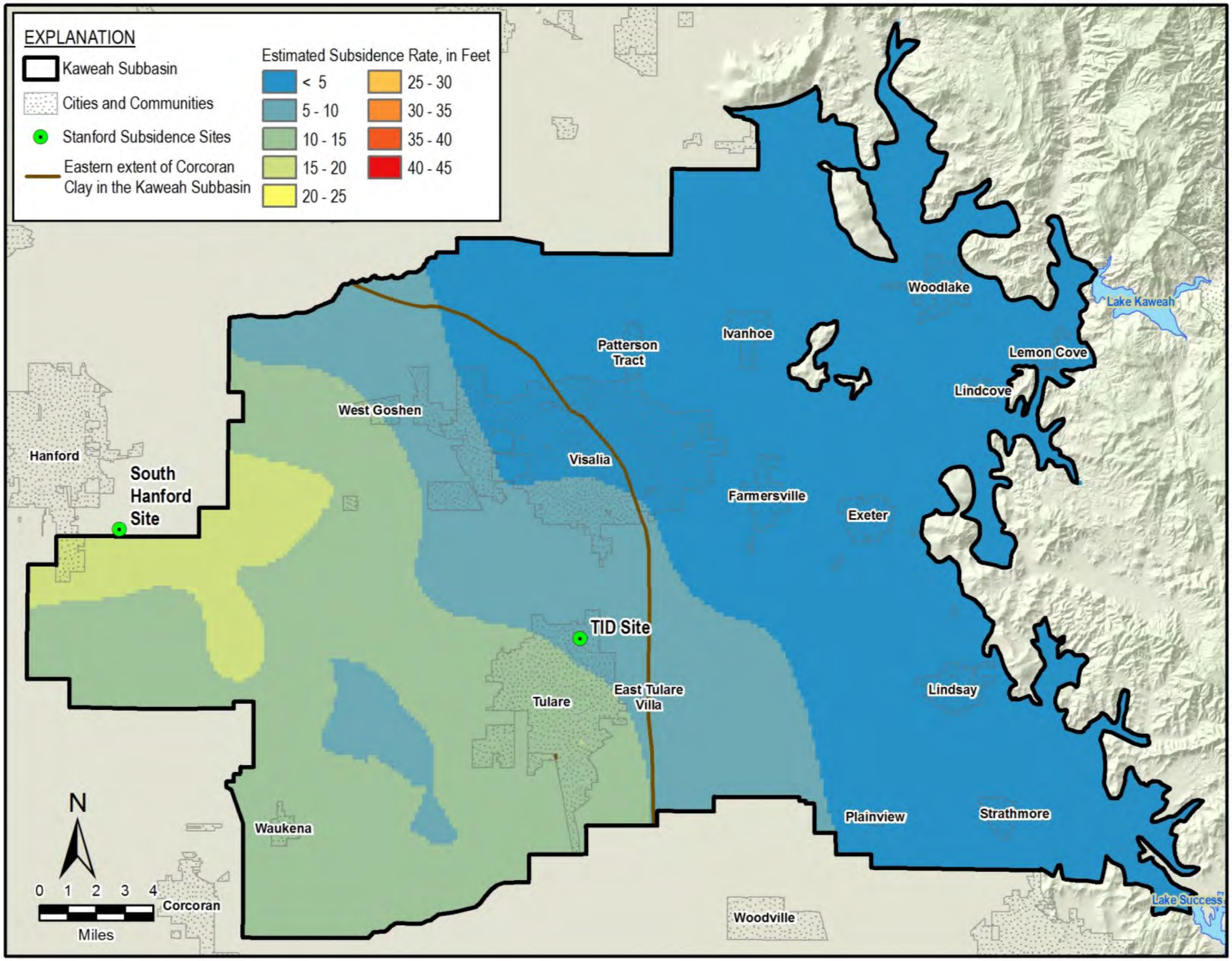



Figure 14. Spreadsheet Tool Estimated 2020 to 2040 Subsidence when Groundwater Levels Stabilize at Measaurable Objectives

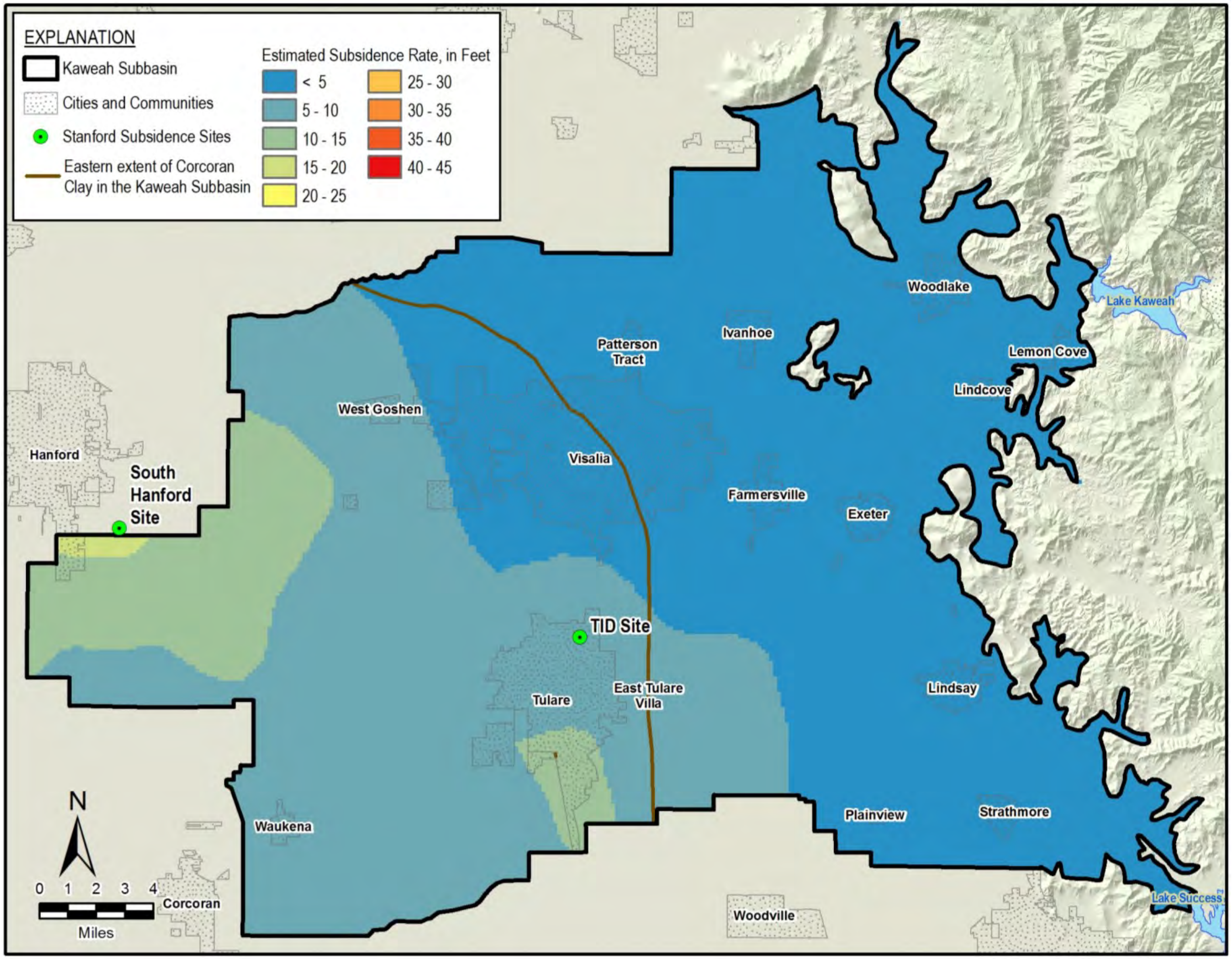



Figure 15. Spreadsheet Tool Estimated 2040 to 2070 Subsidence when Groundwater Levels Stabilize at Measaurable Objectives

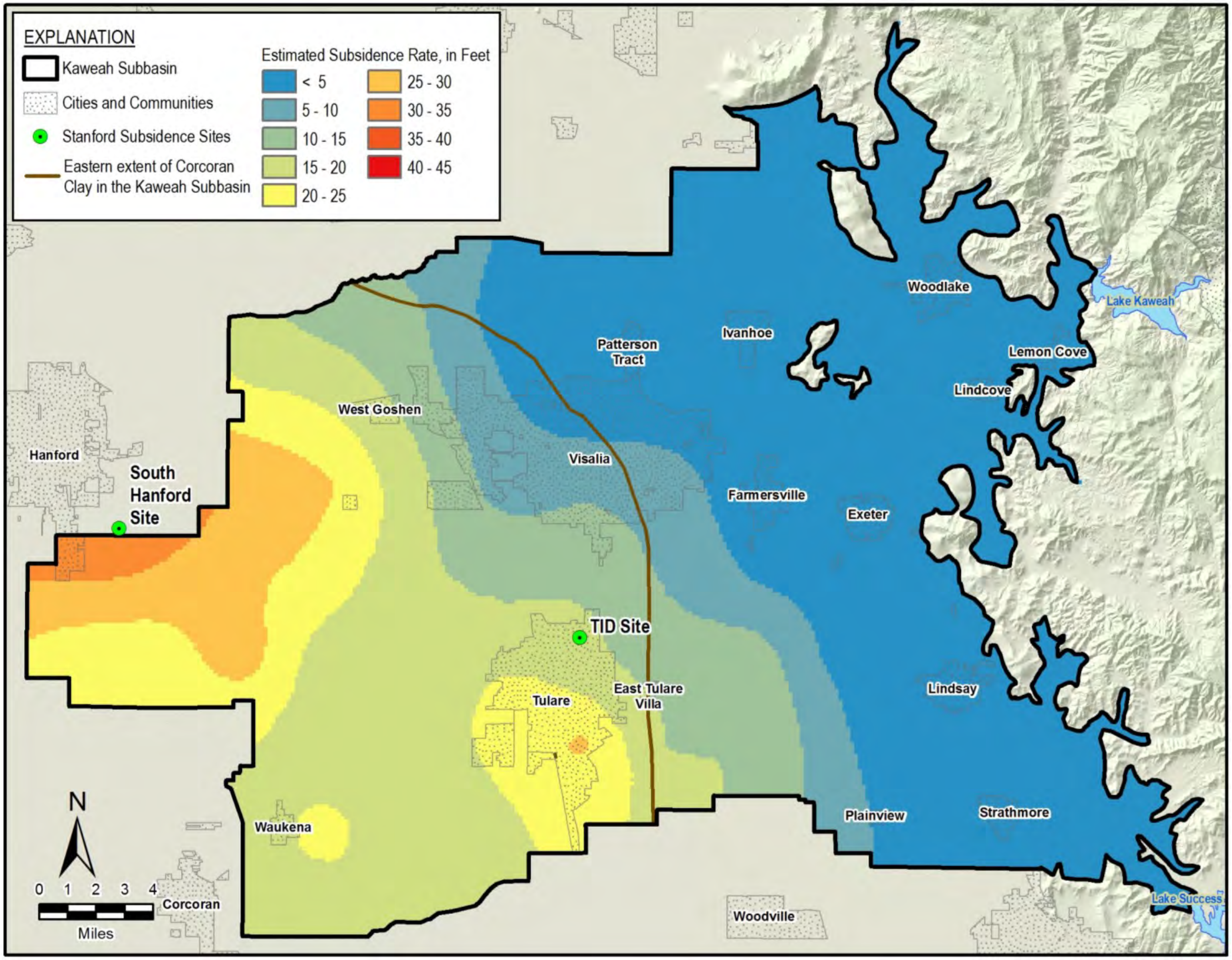


Figure 16. Spreadsheet Tool Estimated 2020 to 2070 Subsidence when Groundwater Levels Stabilize at Measaurable Objectives

Table 2. Estimated Subsidence at Subbasin Monitoring Points when Groundwater Levels Stabilize at Measurable Objectives

| Subsidence Monitoring Point | 2020 to 2040 | | 2040 to 2070 | | 2020 to 2070 | |
|---|---|---|---|---|---|---|
| | Annual Subsidence (inch/year) | Total Subsidence (feet) | Annual Subsidence (inch/year) | Total Subsidence (feet) | Annual Subsidence (inch/year) | Total Subsidence (feet) |
| BR01 | 0.2 | 0.3 | 0.1 | 0.2 | 0.1 | 0.5 |
| DH6683 | 6.8 | 11.4 | 3.0 | 7.5 | 4.5 | 18.9 |
| DH6686 | 0.8 | 1.3 | 0.4 | 1.0 | 0.5 | 2.3 |
| DH6739 | 8.1 | 13.4 | 3.7 | 9.2 | 5.4 | 22.6 |
| K001 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.4 |
| K003 | 0.6 | 1.0 | 0.3 | 0.7 | 0.4 | 1.7 |
| K007 | 3.3 | 5.6 | 1.4 | 3.5 | 2.2 | 9.1 |
| K008 | 7.8 | 12.9 | 3.4 | 8.5 | 5.1 | 21.4 |
| K009 | 6.0 | 9.9 | 2.7 | 6.9 | 4.0 | 16.8 |
| K010 | 7.3 | 12.1 | 3.3 | 8.1 | 4.9 | 20.3 |
| K012 | 9.8 | 16.4 | 4.4 | 11.0 | 6.6 | 27.4 |
| K014 | 5.2 | 8.7 | 2.4 | 6.0 | 3.5 | 14.7 |
| K015 | 1.9 | 3.1 | 0.8 | 2.1 | 1.2 | 5.2 |
| K015X | 4.3 | 7.1 | 2.0 | 5.1 | 2.9 | 12.2 |
| K016 | 2.3 | 3.8 | 1.2 | 3.0 | 1.6 | 6.8 |
| K020 | 0.9 | 1.5 | 0.5 | 1.2 | 0.7 | 2.7 |
| K02A1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 |
| K1081 | 0.3 | 0.6 | 0.1 | 0.3 | 0.2 | 0.9 |
| P566 | 0.8 | 1.4 | 0.4 | 1.1 | 0.6 | 2.5 |
| S228 | 9.8 | 16.4 | 5.8 | 14.4 | 7.4 | 30.8 |

## 2.2 Impact of Subsidence on Conveyance Infrastructure

Infrastructure in the Subbasin that may be affected by subsidence include roads, bridges, gas and water pipelines, power lines, canals, ditches, flood control waterways, railroad tracks, and wells. Although InSAR data show that up to 5 feet of subsidence has occurred in the Subbasin between 2015 and 2021, a survey of local infrastructure impacts indicated there has been no widespread damage caused by subsidence other than damage noted to water conveyance infrastructure and groundwater wells.

Subsidence predictions from the spreadsheet tool described in Section 2.1.8 are used to evaluate potential impacts to water conveyance infrastructure in the Subbasin, including subsidence along the Friant-Kern Canal and other important conveyance infrastructure described below. Water conveyance infrastructure including the Friant-Kern Canal and other important local conveyance is shown on Figure 17.

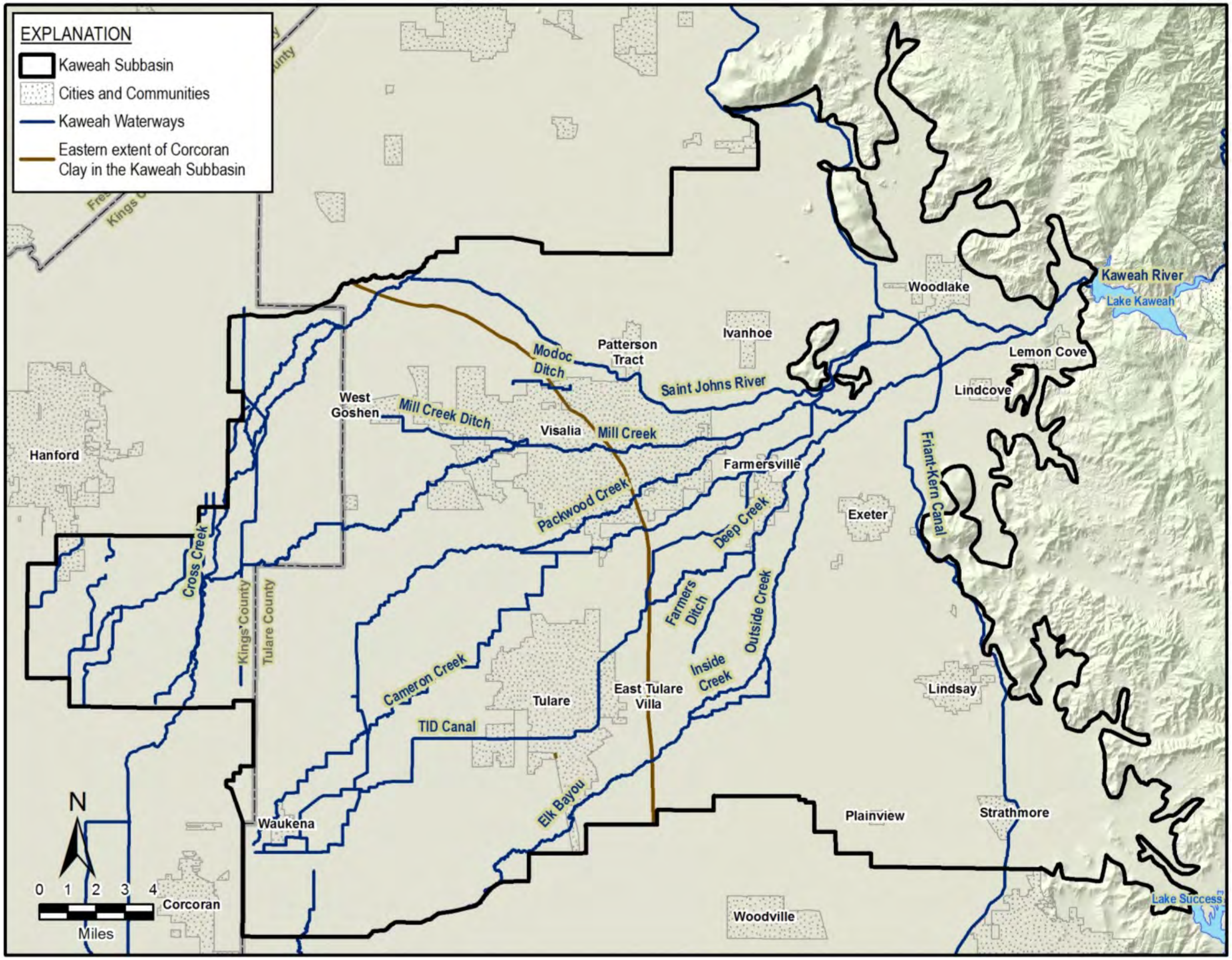



Figure 17. Conveyance Infrastructure Locations

### 2.2.1 Friant-Kern Canal

The East Kaweah Groundwater Sustainability Agency (EKSGA) identified the Friant-Kern Canal as the sole conveyance infrastructure in their portion of the Subbasin with potential to experience significant and unreasonable impacts due to subsidence. The EKGSA determined that a 10% loss of capacity would be significant and unreasonable. Using canal cross section and elevation data, EKGSA estimated that approximately 10 inches of total subsidence in the Subbasin would reduce the canal carrying capacity by 10%. This equates to a 50-year subsidence rate of 0.2 inches per year.

The subsidence spreadsheet tool was used to estimate the maximum subsidence along the Friant-Kern Canal. Figure 18 shows the maximum predicted subsidence along the Friant-Kern canal between 2020 and 2040 when groundwater levels are held at minimum thresholds. The maximum subsidence is 0.69 feet, or 0.41 inches per year. Figure 19 shows the maximum predicted subsidence between 2040 and 2070 when groundwater levels are held at minimum thresholds. The maximum subsidence is 0.69 feet, or 0.28 inches per year. Figure 20 shows the maximum predicted subsidence between 2020 and 2070 when groundwater levels are held at minimum thresholds. The maximum subsidence is 1.4 feet, or 0.34 inches per year.

Figure 21 shows the maximum predicted subsidence along the Friant-Kern Canal between 2020 and 2040 when groundwater levels are held at measurable objectives. The maximum subsidence is 0.55 feet, or 0.33 inches per year. Figure 22 shows the maximum predicted subsidence between 2040 and 2070 when groundwater levels are held at measurable objectives. The maximum subsidence is 0.39 feet, or 0.16 inches per year. Figure 23 shows the maximum predicted subsidence between 2020 and 2070 when groundwater levels are held at measurable objectives. The maximum subsidence is 0.94 feet, or 0.23 inches per year.

Estimated subsidence along the Friant-Kern Canal is greatest where it enters and leaves the Subbasin, which suggests there may be boundary errors in the analysis. These estimates at the boundaries are not considered reliable. Except for the boundaries, the greatest subsidence is estimated where the canal abuts the foothills in the middle of the Subbasin near the City of Exeter. The subsidence at this point is likely the maximum reliable subsidence from this analysis and is shown in Table 3. To date, very little subsidence has been noted in this area, as discussed in Section 2.1.7. Therefore, based on the model results, 10 inches (or 0.83 feet) of subsidence is possible, but not likely to occur and no significant impacts from subsidence to the Friant-Kern Canal are anticipated in the Subbasin.

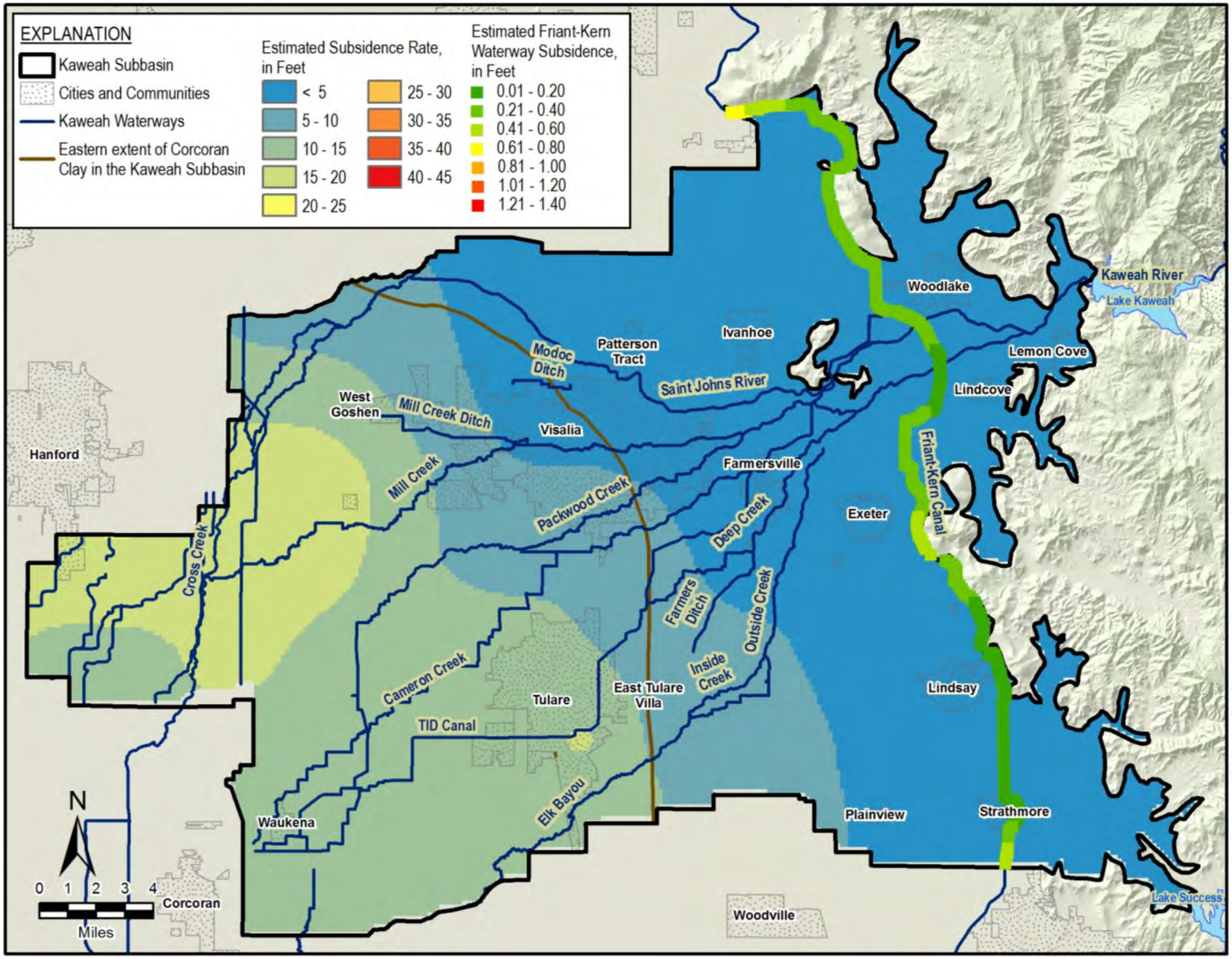



Figure 18. Estimated 2020 to 2040 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Minimum Thresholds

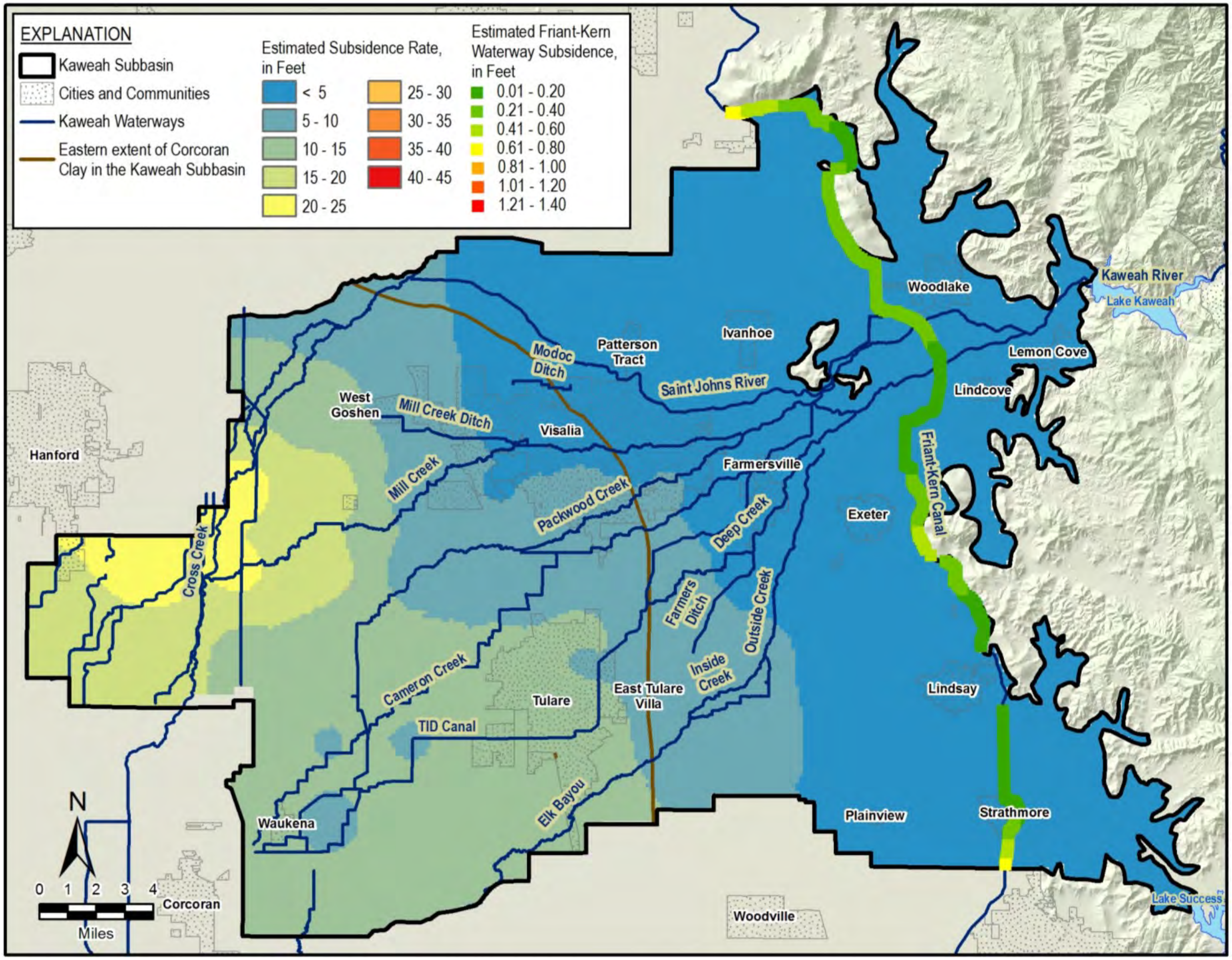



Figure 19. Estimated 2040 to 2070 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Minimum Thresholds

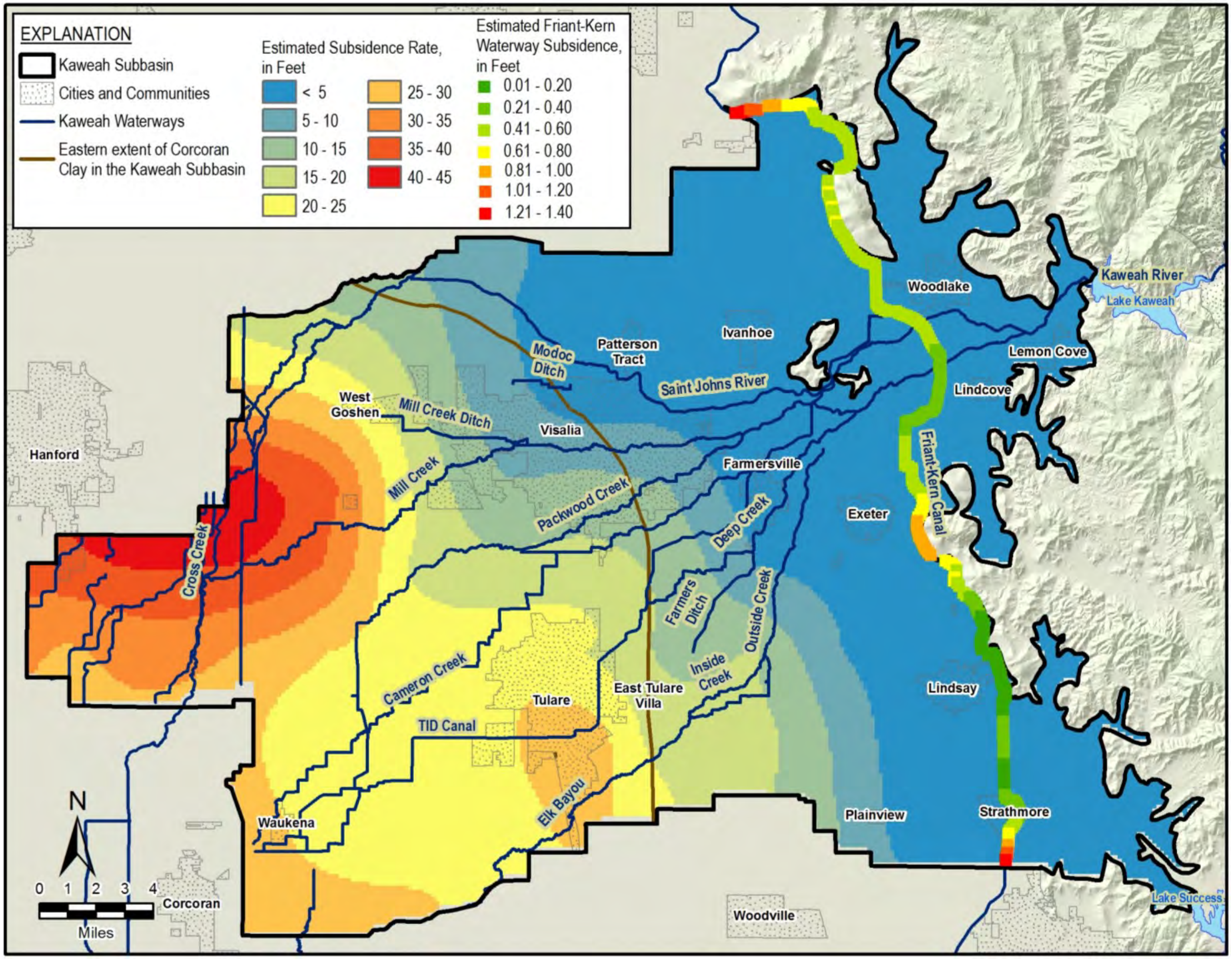



Figure 20. Estimated 2020 to 2070 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Minimum Thresholds

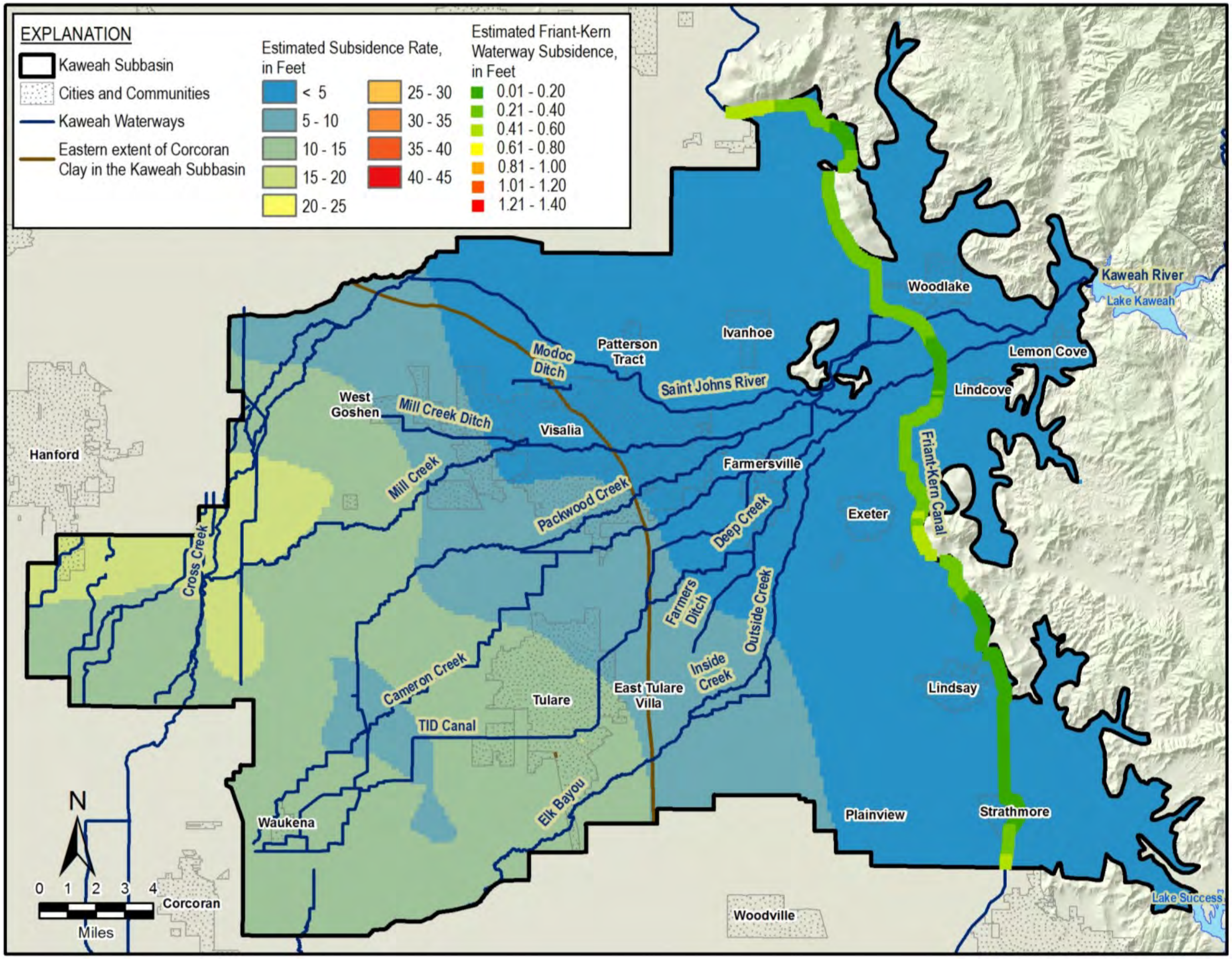



Figure 21. Estimated 2020 to 2040 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Measurable Objectives

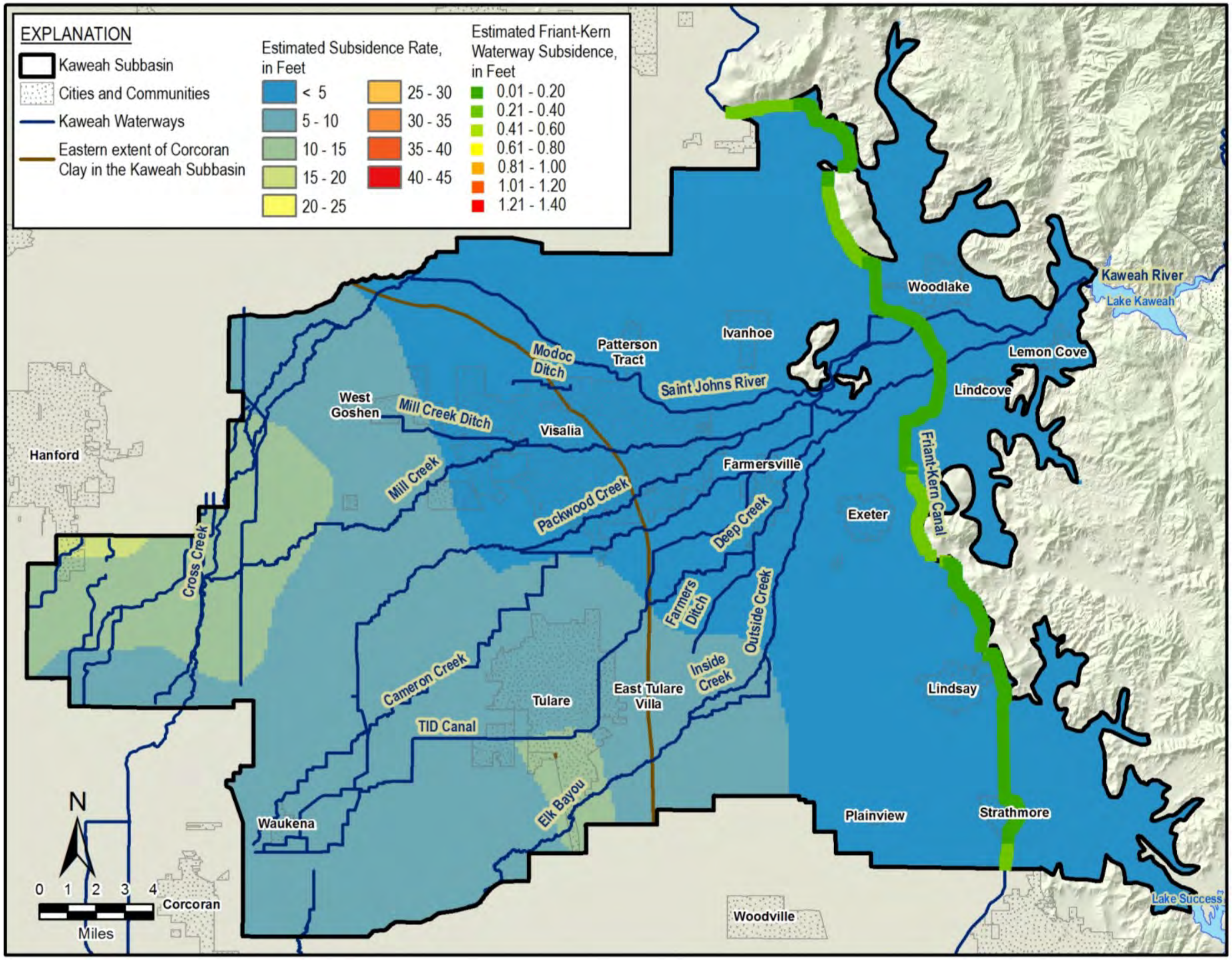



Figure 22. Estimated 2040 to 2070 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Measurable Objectives

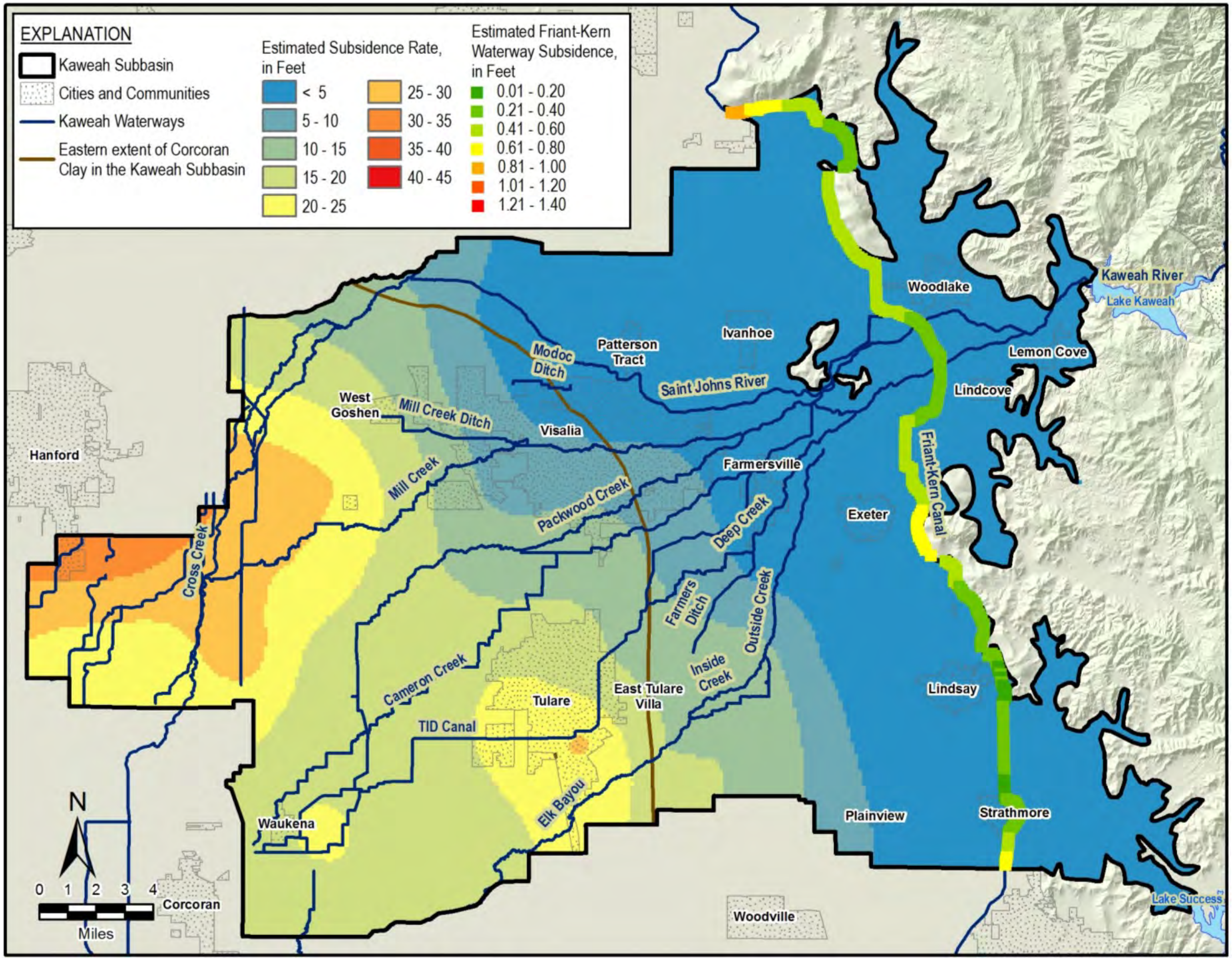



Figure 23. Estimated 2020 to 2070 Subsidence in Along Friant-Kern Canal when Groundwater Levels Stabilize at Measurable Objectives

Table 3. Maximum Estimated Subsidence Along the Friant-Kern Canal Near Exeter

| Time Period | Total Subsidence (feet) | Equivalent Subsidence Rate (inch/yr) |
|---|---|---|
| Groundwater Levels Stabilize at Minimum Thresholds | | |
| 2020 to 2040 | 0.50 | 0.30 |
| 2040 to 2070 | 0.43 | 0.17 |
| 2020 to 2070 | 0.93 | 0.22 |
| Groundwater Levels Stabilize at Measurable Objectives | | |
| 2020 to 2040 | 0.42 | 0.25 |
| 2040 to 2070 | 0.26 | 0.10 |
| 2020 to 2070 | 0.68 | 0.16 |

### 2.2.2 Conveyance Infrastructure

The capacity of water conveyance infrastructures other than the Friant-Kern canal is impacted only if they subside more upstream than downstream, because the subsidence flattens the conveyance gradient and causes a reduction in capacity. The GSAs determined that a 10% loss of capacity in any of these conveyances would be significant and unreasonable.

Based on experience with the TID main canal, the 10% loss of capacity is equated to differential subsidence where a waterway's upstream subsidence is 1 foot more than its downstream subsidence over 1.5 miles. Each major waterway is analyzed using the total subsidence maps shown in Section 2.1.8, and greater than 1 foot of differential subsidence over 1.5 miles is predicted on 11 conveyance reaches.

Figure 24 through Figure 26 show the locations of conveyance infrastructure that would potentially be significantly impacted for various levels of subsidence. Figure 24 through Figure 26 show which conveyance infrastructures may be significantly impacted if groundwater levels are held at minimum thresholds. Figure 27 through Figure 29 show which conveyance infrastructures may be significantly impacted if groundwater levels are held at measurable objectives. These figures show the number and extent of conveyance infrastructure that should be included in the GSA's mitigation plans.

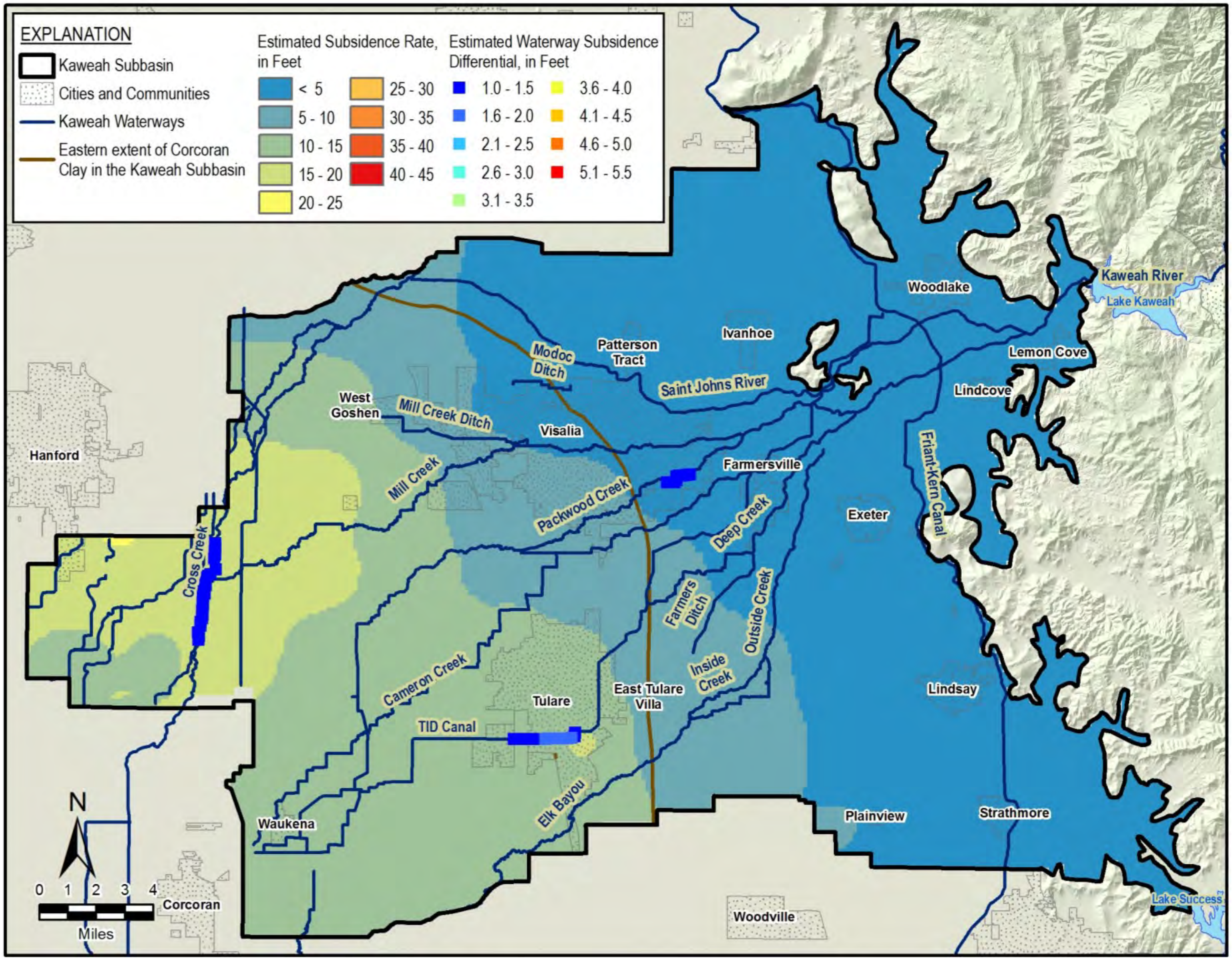



Figure 24. Estimated 2020 to 2040 Subsidence Impacts to Conveyance Infrastructure when Groundwater Levels Stabilize at Minimum Thresholds

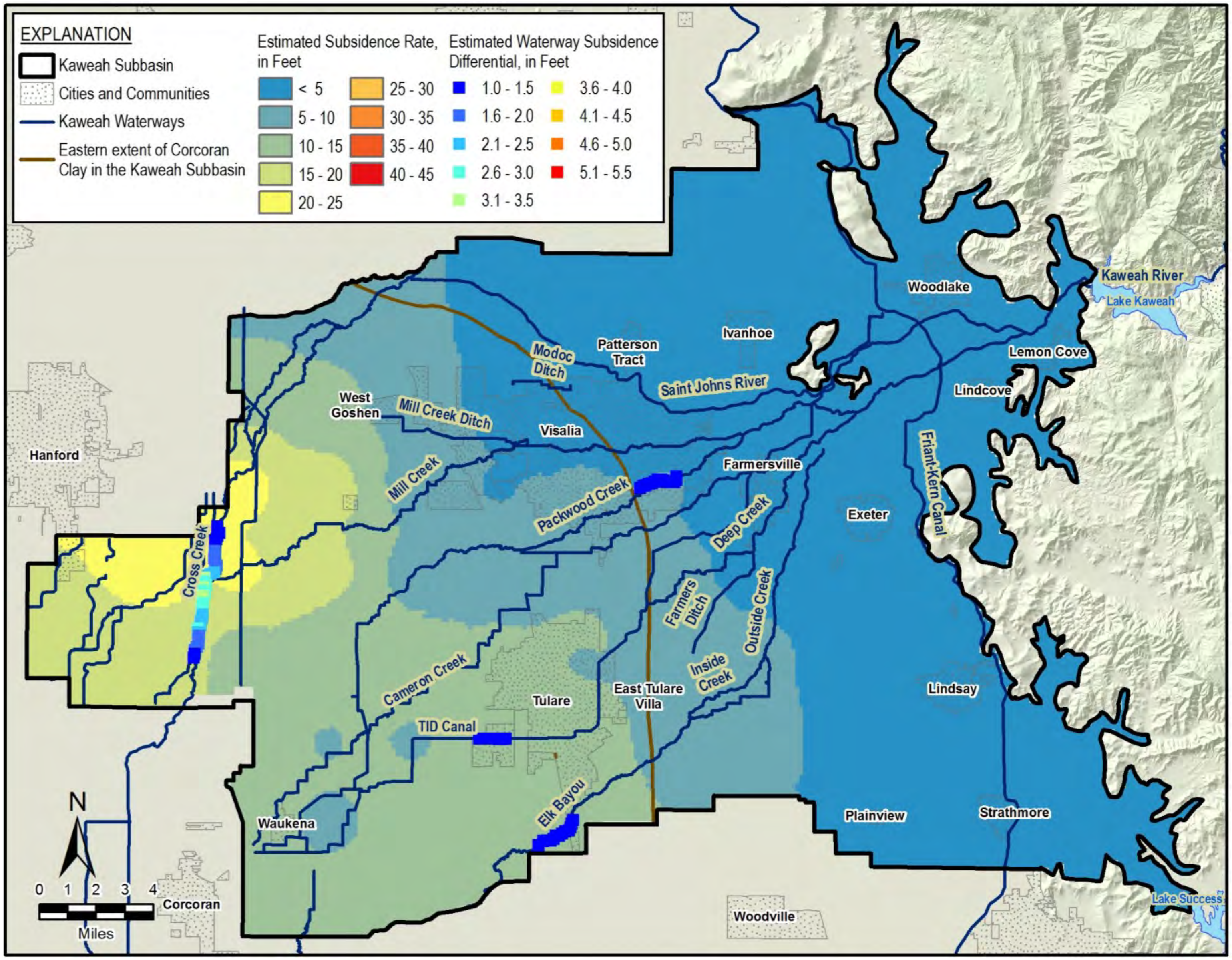



Figure 25. Estimated 2040 to 2070 Subsidence Impacts to Conveyance Infrastructure when Groundwater Levels Stabilize at Minimum Thresholds