Eastern San Joaquin Subbasin Groundwater Sustainability Plan

Draft Deliverable 3

June 2019

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ACRONYMS

1,2,3-TCP	1,2,3-Trichloropropane
AB	Assembly Bill
ACP	agricultural conservation program
AF	acre-feet
AF/year	acre-feet per year
ALOS	Advanced Land Observing Satellite
AWMPs	Agricultural Water Management Plans
bgs	below ground surface
BMP	best management practice
B.P.	before present
Cal Water	California Water Services Company Stockton District
California State Parks	California Department of Parks and Recreation
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	Consumer Confidence Reporting
CCWD	Calaveras County Water District
CDEC	California Data Exchange Center
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEDEN	California Environmental Data Exchange Network
cfs	cubic feet per second
CGPS	continuously operating Global Positioning System
CNRA	California Natural Resources Agency
CSJWCD	Central San Joaquin Water Conservation District
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability

CVRWQCB	Central Valley Regional Water Quality Control Board
CWC	California Water Code
DACs	Disadvantaged Communities
DDW	Division of Drinking Water
DER	Department of Environmental Resources
DMS	data management system
DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	Department of Pesticide Regulations
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
EC	electrical conductivity
ED	Economic Development
EPA	Environmental Protection Agency
ESJWRM	Eastern San Joaquin Water Resources Model
ETo	evapotranspiration
EWMPs	efficient water management practices
FB	Financing and Budgeting
GAMA	groundwater ambient monitoring and assessment
GBA	Groundwater Basin Authority
GDE	groundwater dependent ecosystem
GICIMA	Groundwater Information Center Interactive Mapping Application
GIS	Geographic Information System
GMP	Groundwater Management Plan
gpm	gallons per minute
GPS	Global Positioning System
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWA	Groundwater Authority
GWA Board	Groundwater Authority Board of Directors
HCM	Hydrogeologic Conceptual Model
ICU Program	Integrated Conjunctive Use Program
IGC	Inter-governmental Coordination
ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
IRGMP	Integrated Regional Groundwater Management Plan
IRWMP	Integrated Regional Water Management Plan
IS	infrastructure and services
JP	Joint Partnerships
JPA	Joint Powers Agreement
LLNL	Lawrence Livermore National Laboratory
LU	land use

Ma	millions of years ago
Margin	Margin of Operational Flexibility
MAC	Mokelumne-Amador-Calaveras
MAF	million acre feet
mg/L	milligrams per liter
MHI	median household income
MOA	memorandum of agreement
MokeWISE	Mokelumne Watershed Interregional Sustainability Evaluation
MS	Microsoft
MUD	Municipal Utilities Department
MWH	Montgomery Watson Harza
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NDWA	North Delta Water Agency
NRCS	Natural Resource Conservation Service
NSJWCD	North San Joaquin Water Conservation District
NWIS	National Water Information System
OID	Oakdale Irrigation District
OSWCR	Online System for Well Completion Reports
PDF	portable document format
PFIP	Public Facilities Implementation Plan
PFOA	perfluorooctantoic acid
PFOS	perfluorooctanesulfonic acid
PG&E	Pacific Gas and Electric Company
PI	Public Information
PS	persistent scatter
PSP	Plans, Strategies, and Programs
PSR	Planning Studies and Reports
RDR	Regulation and Development Review
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCDER	Stanislaus County Department of Environmental Resources
SCWSP	South County Water Supply Program
SDACs	Severely Disadvantaged Communities
SDWA	South Delta Water Agency
SEWD	Stockton East Water District
SGMA	the Sustainable Groundwater Management Act
SJCFCWCD	San Joaquin County Flood Control and Water Conservation District
SJV	San Joaquin Valley
SMCL	secondary maximum contaminant levels
SNMP	Salt and Nutrient Management Plan

SO	Services and Operations
SRA	State Recreation Area
SS	specific storage
SSJID	South San Joaquin Irrigation District
State ID	State Well Numbering System identification
SVRA	State Vehicular Recreation Area
SWRCB	State Water Resources Control Board
SY	specific yield
TDS	total dissolved solids
TSS	Technical Support Services
UNAVCO	University NAVSTAR Consortium
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFW	United States Fish & Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UWMPs	Urban Water Management Plans
WDL	Water Data Library
WDR	Waste Discharge Requirement
WID	Woodbridge Irrigation District
Workgroup	Groundwater Sustainability Workgroup

This document includes the working draft of Chapter 4: Sustainable Management Criteria that will be included as part of the Eastern San Joaquin Subbasin Groundwater Sustainability Plan (Eastern San Joaquin GSP). This chapter satisfies § 354.24, § 354.26, § 354.28, § 354.30, § 354.34, § 354.36, and § 354.38 of the Sustainable Groundwater Management Act (SGMA) Regulations. The Sustainable Management Criteria chapter addresses undesirable results, minimum thresholds, and measurable objectives for the six sustainability indicators. The chapter contains three main subsections:

- **Sustainability Goal –** This section provides a description of sustainability goal, including information from the basin setting used to establish the sustainability goal and a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield.
- **Sustainability Indicators –** This section describes the sustainable management criteria developed for each of the six sustainability indicators (Chronic Lowering of Groundwater Levels, Reduction in Groundwater Storage, Degraded Water Quality, Seawater Intrusion, Land Subsidence, Depletion of Interconnected Surface Water) and provides information on the approaches used in development.
- **Monitoring Network –** This section provides information on the representative monitoring network, as well as the broader monitoring network for the Subbasin. Protocols for data collection and monitoring are discussed, and a plan to assess and improve the monitoring network is identified.

4. SUSTAINABLE MANAGEMENT CRITERIA

Several requirements of GSPs fall under the heading of “Sustainable Management Criteria”. These criteria include:

- Sustainability Goal
- Undesirable Results
- Minimum Thresholds
- Measurable Objectives

The Eastern San Joaquin GSP developed these criteria based on information about the basin developed in the hydrogeologic conceptual model (Section 3.2), the water budget (Section 3.3), the descriptions of current and historical groundwater conditions (Section 3.4), and input from stakeholders during the GSP development process. The sustainable management criteria were developed by working with the Advisory Committee, GWA Board, and Workgroup meetings over several months in 2018 and into 2019.

This GSP considers the six sustainability indicators defined by SGMA in the development of sustainable management criteria. SGMA allows several pathways to meet the distinct local needs of each groundwater basin, including development of sustainable management criteria, usage of other sustainability indicators as a proxy, and identification of indicators as not being applicable to the basin. This GSP relies on groundwater levels as a proxy for minimum thresholds and measurable objectives for reduction in groundwater storage, land subsidence, and depletion of interconnected surface water.

4.1 SUSTAINABILITY GOAL

The CWC defines sustainable groundwater management as “the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.” (CA Water Code Section 10721.) The sustainability goal reflects this requirement and succinctly states the GSAs’ objectives and desired conditions of the Subbasin:

The sustainability goal description for the Eastern San Joaquin Subbasin is *to maintain an economically-viable groundwater resource for the beneficial use of the people of the Eastern San Joaquin Subbasin by operating the basin within its sustainable yield or by modification of existing management to address future conditions. This goal will be achieved through the implementation of a mix of supply and demand type projects consistent with the GSP implementation plan* (see Section X).

Groundwater levels in the Subbasin may continue to decline during the implementation period. However, as projects are implemented and basin operations are modified sustainable groundwater management will be achieved and elevations will stabilize on a long-term average basis. Throughout the implementation period, despite the possible decline of groundwater elevations, the Subbasin will be managed to prevent undesirable results. This sustainability goal is supported by locally-defined minimum thresholds that will avoid undesirable results. Demonstration of stable groundwater levels on a long-term average basis combined with the absence of undesirable results will ensure the basin is operating within its sustainable yield and the sustainability goal will be achieved.

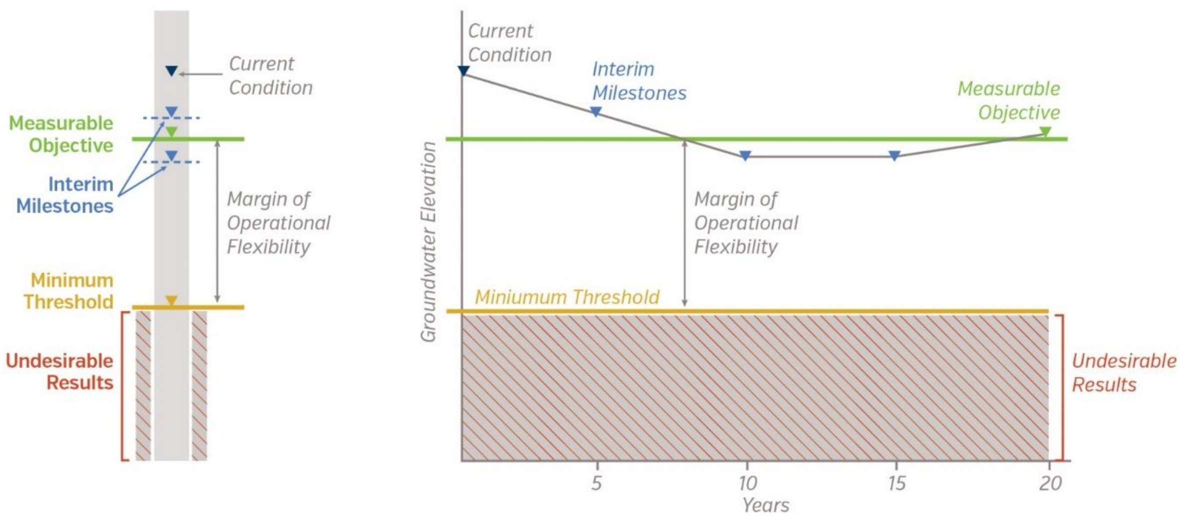
A DISCUSSION OF MEASURES AND EXPLANATION OF HOW GOAL WILL BE ACHIEVED TO BE DEVELOPED FOLLOWING FURTHER DISCUSSION OF PROJECTS AND MANAGEMENT ACTIONS.

Sustainable Management Criteria Definitions

- **Undesirable Results** – Significant and unreasonable negative impacts associated with each sustainability indicator, avoidance of which is used to guide development of GSP components
- **Minimum Threshold** – Quantitative threshold for each sustainability indicator used to define the point at which undesirable results may begin to occur
- **Measurable Objective** – Quantitative target that establishes a point above the minimum threshold that allows for a range of active management in order to prevent undesirable results
- **Interim Milestones** – Targets set in increments of five years over the implementation period of the GSP to put the basin on a path to sustainability
- **Margin of Operational Flexibility** – The range of active management between the measurable objective and the minimum threshold

See Figure 4-1 for a graphic that demonstrates the relationship between the Sustainable Management Criteria terms.

Figure 4-1: Sustainable Management Criteria Definitions Graphic (Groundwater Levels Example)



4.2 SUSTAINABILITY INDICATORS

4.2.1 Chronic Lowering of Groundwater Levels

4.2.1.1 Undesirable Results

4.2.1.1.1 Description of Undesirable Results

SGMA defines undesirable results related to chronic lowering of groundwater as:

> *Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.*

An undesirable result for chronic lowering of groundwater levels in the Eastern San Joaquin Subbasin is experienced if sustained groundwater levels are too low to satisfy beneficial uses within the Subbasin over the planning and implementation horizon of this GSP. Potential impacts and the extent to which they are considered significant and unreasonable are determined by the GWA Board and with input by the Advisory Committee, Workgroup, and members of the public. During development of the GSP, potential undesirable results identified by stakeholders included a significant and unreasonable:

- Number of wells going dry
- Reduction of in the pumping capacity of existing wells
- Increase in pumping costs due to greater lift
- Need for deeper well installations or lowering of pumps

4.2.1.1.2 Identification of Undesirable Results

An undesirable result is considered to occur during GSP implementation when at least 25 percent of representative monitoring wells used to monitor groundwater levels (5 of 20 wells in the Subbasin) fall below their minimum level thresholds for two consecutive years that are categorized as non-dry years (below-normal, above-normal, or wet), according to the San Joaquin Valley Water Year Hydrologic Classification. The lowering of groundwater levels during consecutive dry or critically-dry years is not considered to be unreasonable, and would therefore not be considered an undesirable result, unless the levels do not rebound to above the thresholds following those consecutive non-dry years.

4.2.1.1.3 Potential Causes of Undesirable Results

The Eastern San Joaquin Subbasin is currently designated as an overdrafted basin by the Department of Water Resources. Potential causes of future undesirable results for the chronic lowering of groundwater levels sustainability indicator could result from insufficient pumping offset/reduction in the basin that results in localized or basin-wide groundwater level lowering, or delays in implementation of GSP programs or projects due to increased demand or regulatory, permitting, or funding obstacles.

4.2.1.1.4 Potential Effects of Undesirable Results

If groundwater levels were to cause undesirable results, effects could include de-watering of a subset of the existing groundwater infrastructure, starting with the shallowest wells, which are generally domestic wells; and adverse effects on groundwater-dependent ecosystems, to the extent connected with the production aquifer. Lowering levels to this degree could necessitate changes in irrigation practices and crops grown and could cause adverse effects to property values and the regional economy. Additionally, undesirable results due to declining groundwater levels could adversely affect current and projected municipal uses translating into increased costs for potable water supplies. Furthermore, reduced groundwater levels could drive increased surface water depletions that may impact the beneficial uses of the surface water within the Subbasin.

4.2.1.2 Minimum Thresholds

The minimum thresholds for chronic lowering of groundwater levels are the shallower of 1992 and 2015-2016 historical groundwater levels with a buffer of 100 percent of historical range applied, *or* the 10th percentile domestic well total depth of wells within a 3 mile radius of the monitoring well,[1] whichever is shallower at each representative monitoring well site.

To develop these thresholds, members of the GWA Board, Advisory Committee, and Workgroup evaluated the potential for undesirable results based on past, present, and future conditions. In addition to anecdotal on-the-ground data, data from DWR and GSAs, as well as information from reports and planning documents, were used to identify how a given area falls into any one of three general conditions: 1) Areas with significant and unreasonable existing issues, 2) Areas that previously had issues, and 3) Areas that have never had issues. Each of the three conditions scenarios correspond to a different pathway to setting minimum thresholds. Areas were considered without undesirable results if no significant and unreasonable issues were identified based on input from GSAs and stakeholders and review of prior planning documents.

- Areas with significant and unreasonable existing issues: these areas are considered to have undesirable results, and minimum thresholds are set to 2015 in accordance with SGMA legislation. No areas were identified by the GWA Board or other stakeholders under this condition scenario within the Subbasin.
- Areas that previously had issues: for areas with historical but not current significant and unreasonable results (as identified by GSAs, stakeholders, and prior planning documents), historical levels were considered in the development of minimum thresholds in addition to existing basin management criteria.
- Areas that have never had issues: in areas that have never had issues, discussions on values drove identification of potential thresholds, and minimum thresholds were developed based on the preservation of future beneficial uses.

The GSP authors reviewed prior groundwater-related planning documents in the Subbasin – including Integrated Regional Water Management Plans, the 2004 Groundwater Management Plan, Agricultural Water Management Plans, and the MokeWISE Water Program – and relied upon these documents as a starting point for setting minimum thresholds under SGMA. The 2014 IRWM indicates Fall 1992 groundwater elevation levels as a historical low benchmark for the Subbasin, stating “The Eastern San Joaquin Groundwater Basin contour measured in 1992 is proposed as the basin management framework baseline. Groundwater fell to its lowest recorded elevation in 1992 following a significant drought period and it is considered undesirable to drop below this level.” (2014, ESJ IRWMP.) This language, although not developed within the SGMA framework, describes what could potentially be considered as a starting point for developing minimum thresholds under SGMA.

[1] A radius of 2 miles was used in for well 03N07E21L003 to reflect domestic well depths in close proximity to the Mokelumne River

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Fall 1992 groundwater levels were examined and compared to levels following the recent drought (Fall 2015-2016) using groundwater elevation data from officially monitored CASGEM wells, voluntarily monitored CASGEM wells, clustered and nested wells, and San Joaquin County database wells. This examination evidenced that groundwater elevation levels in some areas of the Subbasin have recovered since 1992, with much of the central portion of the Subbasin showing an increase of greater than 10 feet. However, groundwater elevation levels in other portions of the Subbasin have further decreased below 1992 levels without undesirable effects, such as a significant and unreasonable number of wells going dry or impact to GDEs, being observed by GSAs and other stakeholders. In many cases, areas that experienced undesirable effects in 1992 put mitigation measures in place, often deepening wells, meaning that 1992 groundwater levels would no longer trigger undesirable effects.

To develop a greater understanding of potential impacts to beneficial uses experienced under historical low groundwater elevations, the deepest conditions between fourth quarter 1992 and 2015-2016 groundwater levels were examined. These years were chosen based on the threshold language in the IRWMP and also to capture the end of the two most recent droughts. Fourth quarter 2014 data was used in the northwest corner of the Subbasin, where data is limited.

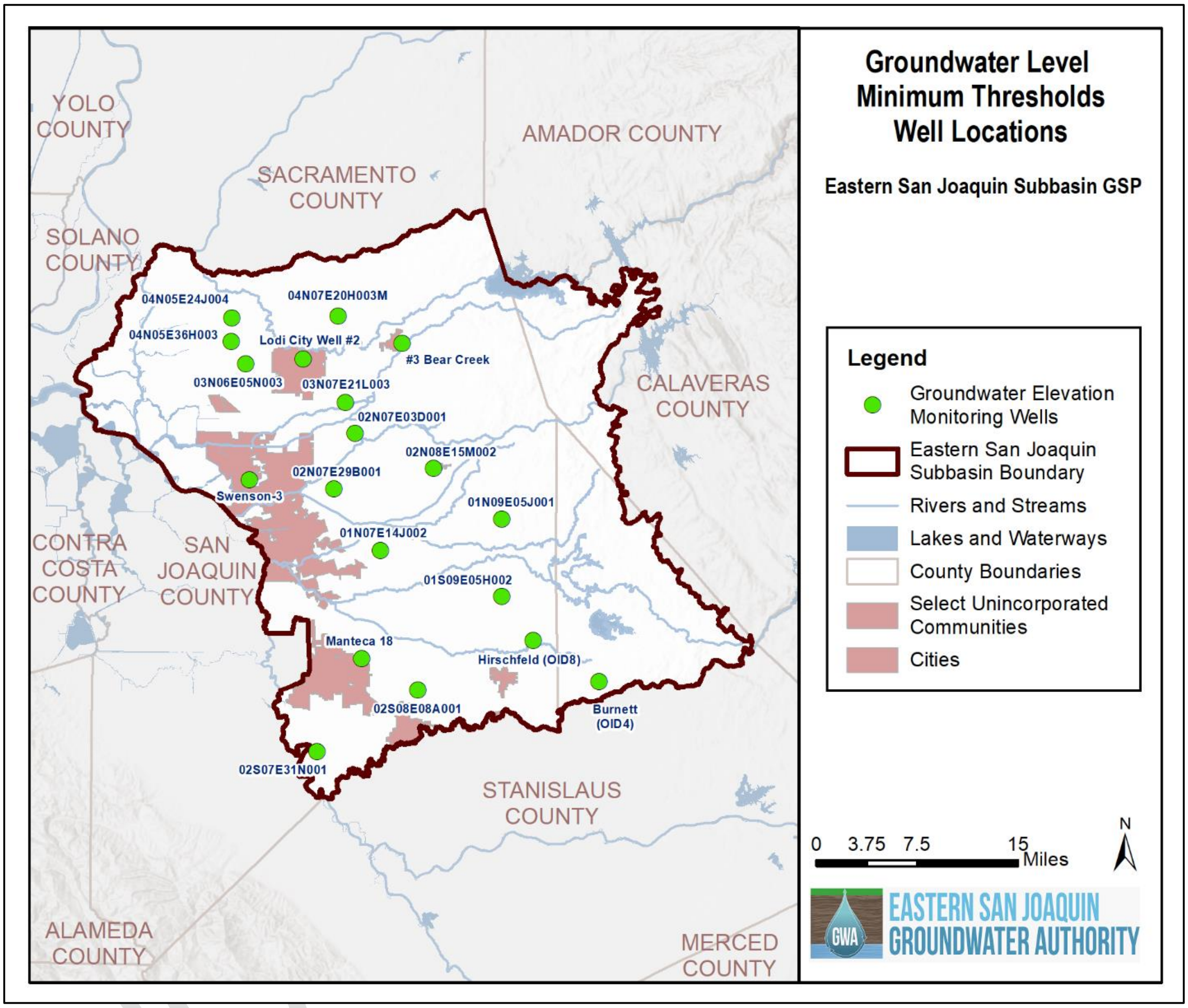
Individual GSAs confirmed understanding of the historical lows based on their experience and data, provided feedback on groundwater conditions for their GSAs, and indicated if undesirable results could occur if the minimum threshold was set deeper than the lower of 1992 and 2015-2016 based on their understanding. From there, GSAs identified potential wells to be included in the representative monitoring network for the groundwater level sustainability indicator based on the adequate spatial coverage, availability of historical data, and reliability of monitoring well. For the majority of the Subbasin, no undesirable effects were identified based on stakeholder input, even at historical low groundwater elevations. As a starting point, a potential minimum threshold was considered for each representative monitoring well based on the lower of 1992 or 2015-2016 values unless otherwise indicated. A buffer was subtracted from the minimum 1992 or 2015 groundwater elevation. The buffer was calculated by finding the difference between the minimum and maximum groundwater level over the historical record for each representative monitoring well. The subtraction of the buffer provides a range in which groundwater levels may continue to decline during implementation of projects and management actions until sustainable yield is reached. The buffer allows for flexibility but would avoid significant and unreasonable impacts to groundwater levels.

The GWA Board determined that dewatering of domestic wells may be a potential undesirable result that could potentially be used to confirm the adequacy of the minimum threshold methodology. Domestic wells are generally shallower than agricultural and municipal wells and thus more sensitive to undesirable effects such as wells going dry. Additionally, the loss of a domestic well usually results in a loss of water for consumption, cooking, and sanitary purposes, which can often have substantial impacts on the users of the water and can be financially difficult for the well owner to replace. The 10th percentile domestic well depth (i.e., the depth of the top 10th percent most shallow well) was examined within a radius around the monitoring well representative of local conditions. A radius of 3 miles around the representative monitoring well was used in all cases except for well 03N07E21L003, where a 2-mile radius was used due to variations in local well depth due to proximity to the Mokelumne River. An average of 400 domestic wells were captured within a 3-mile radius of each representative monitoring well, covering approximately 76% of the domestic wells in the Subbasin. In cases where the 10th percentile domestic well depth was shallower than the historical drought low with the buffer, that value was developed as the threshold to prevent undesirable results associated with dewatering wells in the Subbasin. Domestic well data was retrieved from OSCWR, and information on casing, screening, and age of well is not available in most locations. The 10th percentile well depth was developed due to the uncertainty in the database and to account for domestic wells may have been drilled to a very shallow depth and/or have reached the end of their useful lives. Using this threshold, impact to the deepest 90 percent of domestic wells is considered a significant and unreasonable impact.

Figure 4-2 shows the location of groundwater level representative monitoring wells throughout the Eastern San Joaquin Subbasin. Table 4-1 lists the corresponding numeric minimum thresholds at each representative monitoring well as well as the basis criteria applied.

Additional data on the monitoring wells, including hydrographs of historical observed data, domestic well analysis, and modeled projected conditions data is provided in Appendix A. Supplemental Data for Chronic Lowering of Groundwater Levels Minimum Threshold.

Figure 4-2: Location of Representative Monitoring Wells for Groundwater Levels



Note: An additional well is being added in Eastside GSA

Table 4-1: Minimum Thresholds for Chronic Lowering of Groundwater Levels

Narrative Description		
The minimum threshold is set at the shallower of 1992 and 2015-2016 groundwater levels with a buffer of 100 percent of historical range applied, *or* the 10th percentile domestic well depth, whichever is shallower.		
Numeric Minimum Thresholds		
Well ID	**Minimum Threshold (feet MSL)**	**Basis for Threshold**
01S09E05H002	-49.8	10th percentile domestic well depth
01N07E14J002	-114.4	10th percentile domestic well depth
Swenson-3	-26.6	2015 groundwater level with a buffer of 100 percent of historical range
02N08E15M002	-124.1	2016 groundwater level with a buffer of 100 percent of historical range
#3 Bear Creek	-72.3	2016 groundwater level with a buffer of 100 percent of historical range
Lodi City Well #2	-39.9	10th percentile domestic well depth
Manteca 18	-16.7	10th percentile domestic well depth
04N07E20H003M	-81.7	2016 groundwater level with a buffer of 100 percent of historical range
03N07E21L003	-102.5	10th percentile domestic well depth*
Hirschfeld (OID-8)	8.0	10th percentile domestic well depth
Burnett (OID-4)	60.8	2015 groundwater level with a buffer of 100 percent of historical range
02S07E31N001	1.5	1992 groundwater level with a buffer of 100 percent of historical range
02S08E08A001	0.6	2016 groundwater level with a buffer of 100 percent of historical range
02N07E03D001	-122.8	10th percentile domestic well depth
01N09E05J001	-86.8	10th percentile domestic well depth
02N07E29B001	-130.1	10th percentile domestic well depth
04N05E36H003	-33.5	2015 groundwater level with a buffer of 100 percent of historical range
03N06E05N003	-37.5	2015 groundwater level with a buffer of 100 percent of historical range
04N05E24J004	-33.6	2015 groundwater level with a buffer of 100 percent of historical range

* Minimum threshold is based on 10th percentile domestic well depth, calculated using a 2-mile radius around selected monitoring well

Note: An additional well is being added in Eastside GSA

4.2.1.3 Measurable Objectives and Interim Milestones

Measurable objectives are quantitative goals that reflect the desired Subbasin condition and allow the Subbasin to achieve its sustainability goal. The measurable objective is set to allow a reasonable margin of operational flexibility (Margin) between minimum thresholds to allow for active management of the basin during dry periods without reaching the minimum threshold. The Margin is intended to accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities. The Margin is defined as the difference between the minimum threshold and measurable objective.

The measurable objective for chronic lowering of groundwater levels is defined as the lower of 1992 or 2015-2016 groundwater level values.

Table 4-2 lists the measurable objectives for each representative monitoring well. The Margin is defined at each well as the difference between the minimum and maximum groundwater level over the historical record for that well.

Table 4-2: Measurable Objective for Chronic Lowering of Groundwater Levels

Narrative Description	
The measurable objective is set at the deeper of 1992 and 2015-2016 groundwater levels.	
Numeric Measurable Objectives	
Well ID	**Measurable Objective (feet MSL)**
01S09E05H002	-19.7
01N07E14J002	-70.4
Swenson-3	-19.3
02N08E15M002	-69.7
#3 Bear Creek	-50.3
Lodi City Well #2	-3.5
Manteca 18	5.1
04N07E20H003M	-36.7
03N07E21L003	-59.0
Hirschfeld (OID-8)	31.5
Burnett (OID-4)	79.7
02S07E31N001	13.0
02S08E08A001	24.0
02N07E03D001	-80.0
01N09E05J001	-53.5
02N07E29B001	-80.4
04N05E36H003	-7.5
03N06E05N003	-16.5
04N05E24J004	-8.6

Note: An additional well is being added in Eastside GSA

To assist the Subbasin in reaching the measurable objective for groundwater levels, interim milestones for 2025, 2030, and 2035 are developed to keep implementation on track. Interim milestones are based on achieving the sustainability goal within the 20 year time period provided by SGMA.

Table 4-3 shows the 5-year milestones, which follow a stepwise trend between the current condition and the measurable objective.

Table 4-3 Interim Milestones for Chronic Lowering of Groundwater Levels

Narrative Description					
5-year milestones are assumed to remain similar to current for the first 10 years and then follow along a linear trend between the current condition and the measurable objective.					
Numeric Interim Milestones					
Well ID	**Current Condition* (mg/L TDS)**	**Measurable Objective (mg/L TDS)**	**Interim Milestones**		
			2025	**2030**	**2035**
01S09E05H002	-8.7	-19.7	-8.7	-8.7	-14.2
01N07E14J002	-49.9	-70.4	-49.9	-49.9	-60.15
Swenson-3	-19.3	-19.3	-19.3	-19.3	-19.3
02N08E15M002	-63.2	-69.7	-63.2	-63.2	-66.45
#3 Bear Creek	-49.3	-50.3	-49.3	-49.3	-49.8
Lodi City Well #2	0.6**	-3.5	0.6	0.6	-1.45
Manteca 18	9.1	5.1	9.1	9.1	7.1
04N07E20H003M	-35.5	-36.7	-35.5	-35.5	-36.1
03N07E21L003	-51.5	-59	-51.5	-51.5	-55.25
Hirschfeld (OID-8)	31.5	31.5	31.5	31.5	31.5
Burnett (OID-4)	79.7	79.7	79.7	79.7	79.7
02S07E31N001	13.8**	13	13.8	13.8	13.4
02S08E08A001	22.2**	24	22.2	22.2	23.1
02N07E03D001	-61.7	-80	-61.7	-61.7	-70.85
01N09E05J001	-20.2	-53.5	-20.2	-20.2	-36.85
02N07E29B001	-49.8**	-80.4	-49.8	-49.8	-65.1
04N05E36H003	-5.1	-7.5	-5.1	-5.1	-6.3
03N06E05N003	-14.1	-16.5	-14.1	-14.1	-15.3
04N05E24J004	-6.2	-8.6	-6.2	-6.2	-7.4

* Current Condition is the fall 2015 groundwater level

** Current Condition is the average of fall groundwater levels for 2013-2016

Note: An additional well is being added in Eastside GSA

4.2.2 Reduction in Groundwater Storage

4.2.2.1 Undesirable Results

4.2.2.1.1 Description of Undesirable Results

The undesirable result related to reduction in groundwater storage is defined in SGMA as:

> *Significant and unreasonable reduction in groundwater storage.*

An undesirable result for reduction in groundwater storage in the Eastern San Joaquin Subbasin is experienced if sustained groundwater storage volumes are too low to satisfy beneficial uses within the Subbasin over the planning and implementation horizon of this GSP.

Undesirable results related to groundwater storage in the Subbasin have not occurred historically, are not currently occurring, and are not likely to occur in the future. As discussed in the current and historical groundwater conditions section of this GSP (Section 3.4.2), there is a large volume (approximately 53 million acre-feet [MAF]) of freshwater in storage. Previous analysis of groundwater storage using the ESJWRM showed a range of fluctuation from 1996 to 2015 of approximately 0.001 percent per year. See Section 3.4.2 for additional quantification of groundwater storage. A discussion of the geology of the Subbasin can be found in Section 3.2.

4.2.2.1.2 Identification of Undesirable Results

An undesirable result occurs when storage is insufficient to satisfy beneficial uses within the Subbasin. It is roughly estimated that groundwater demand for beneficial use occurs within the top 23 MAF of the Subbasin. Therefore, undesirable results would occur if groundwater storage were reduced to less than 30 MAF.

4.2.2.1.3 Potential Causes of Undesirable Results

Although the Subbasin has enough fresh groundwater in storage to sustain groundwater pumping in conditions of overdraft for centuries, dramatic increases in reliance on groundwater, severe drought, or other major changes in groundwater management over time could cause the volume of freshwater in groundwater storage to decline to a significant and unreasonable level.

4.2.2.1.4 Potential Effects of Undesirable Results

If groundwater levels were to reach levels causing significant and unreasonable undesirable results, effects could include running out of fresh groundwater to access in drought years. Increased cost of access, reduction in beneficial uses, such as domestic supply and changes to agriculture.

4.2.2.2 Minimum Thresholds

This GSP uses groundwater level minimum thresholds as a proxy for the reduction in groundwater storage sustainability indicator.

GSP regulations allow GSAs to use groundwater levels as a proxy metric for any sustainability indicator, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics. In order to rely on groundwater levels as a proxy, one approach suggested by DWR is to:

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site* (DWR, 2017)*.*

Minimum thresholds for groundwater levels will effectively avoid undesirable results for reduction of groundwater storage. As noted above, the amount of groundwater in storage in the Subbasin is approximately 53 MAF and the undesirable result of reducing beneficial uses would not occur until storage reached 30 MAF. The minimum threshold for groundwater levels would create a reduction of approximately 1.2 MAF acre feet of storage.[1] Minimum thresholds and measurable objectives for groundwater levels can therefore be used as a proxy for reduction in groundwater storage because groundwater levels are sufficiently protective against occurrences of significant and unreasonable reduction in groundwater storage.

4.2.2.3 Measurable Objectives and Interim Milestones

As chronic lowering of groundwater levels is used as a proxy for reduction in groundwater storage, the measurable objectives and interim milestones for the reduction in groundwater storage sustainability indicator are the same measurable objectives and interim milestones for the chronic lowering of groundwater levels sustainability indicator as set forth in Section 4.2.2.3.

[1] Volumes based on ESJWRM estimates calculated assuming all representative monitoring wells for groundwater levels reached their minimum thresholds across the Subbasin for a conservative estimate of Subbasin storage reduction

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4.2.3 Degraded Water Quality

4.2.3.1 Undesirable Results: Degraded Water Quality

4.2.3.1.1 Description of Undesirable Results

The undesirable result related to degraded water quality is defined in SGMA as:

> *Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.*

An undesirable result for degraded water quality in the Eastern San Joaquin Subbasin is experienced if groundwater management activities cause significant and unreasonable impacts to the long-term viability of domestic, agricultural, municipal, environmental, or other beneficial uses over the planning and implementation horizon of this GSP.

Salinity is the only water quality constituent for which minimum thresholds are established in the Eastern San Joaquin Subbasin. Although other constituents, including arsenic, nitrogen, and sulfate are evaluated in the Current and Historical Groundwater Conditions section of this GSP, these constituents are managed through existing management and regulatory programs within the Subbasin. Additionally, SGMA does not give GSAs land use authority, so a nexus must be present between groundwater conditions and groundwater pumping activities. Programs such as the CV-SALTS and ILRP focus on improving water quality by managing septic and agricultural sources of salinity and nutrients. Additionally, point-source contaminants are managed and regulated through a variety of programs by RWQCB, Department of Toxic Substances Control (DTSC), and the US Environmental Protection Agency (EPA). Through monitoring, the GSP will document these constituents and identify opportunities for coordination with existing programs. A description of existing regulations and requirements for these constituents is provided in Section 3.4.4. Through coordination with existing agencies and through monitoring, the GWA will know if such regulations are being met.

TDS was selected for the evaluation of sustainable management criteria for salinity under this sustainability indicator, as historical data for TDS are more widely available in the Eastern San Joaquin Subbasin than other constituents used to measure salinity, such as electrical conductivity (EC) or chloride. This decision was made by the GWA Board based on the greater availability of TDS data in the Subbasin. TDS data are available through existing monitoring programs such as the CV-SALTS program and GAMA program or through monitoring or regulatory agencies such as USGS, DWR, SWRCB, and the Central Valley Water Board WDR Dairy program. GSA members and their affiliates including Cal Water and the cities of Stockton, Lodi, Manteca, and Lathrop, provided TDS data from existing monitoring wells.

4.2.3.1.2 Identification of Undesirable Results

Undesirable results occur during GSP implementation when more than 25 percent of representative monitoring wells (3 of 10 sites) exceed the minimum thresholds for water quality for two consecutive years and where these concentrations are the result of groundwater management activities.

4.2.3.1.3 Potential Causes of Undesirable Results

Elevated TDS concentrations in the Subbasin are the result of natural processes and overlying land use activities (O'Leary, Izbicki, and Metzger; 2015). Pumping in excess of recharge has resulted in declining aquifer water levels and led to an increase of salinity in groundwater wells since the 1950s (O'Leary, Izbicki, and Metzger; 2015). Within the Subbasin, there are three primary sources of salinity, as discussed in Section 3.4.4 of this GSP.

4.2.3.1.4 Potential Effects of Undesirable Results

If groundwater quality were degraded resulting in undesirable results, the effect would potentially include: reduction in usable supply of groundwater, domestic wells being dewatered, increased treatment costs, and required access to alternate supplies can be unaffordable for small users. Some water quality issues could potentially cause more impact to agricultural uses than municipal or domestic uses, depending on the impact of the contaminant to these water use sectors. Water quality degradation may cause potential changes in irrigation practices, crops grown, adverse effects to property values, and other economic effects. Additionally, reaching undesirable result levels for groundwater quality could adversely affect current and projected municipal uses, and users could have to install treatment systems or seek alternate supplies.

4.2.3.2 Minimum Thresholds

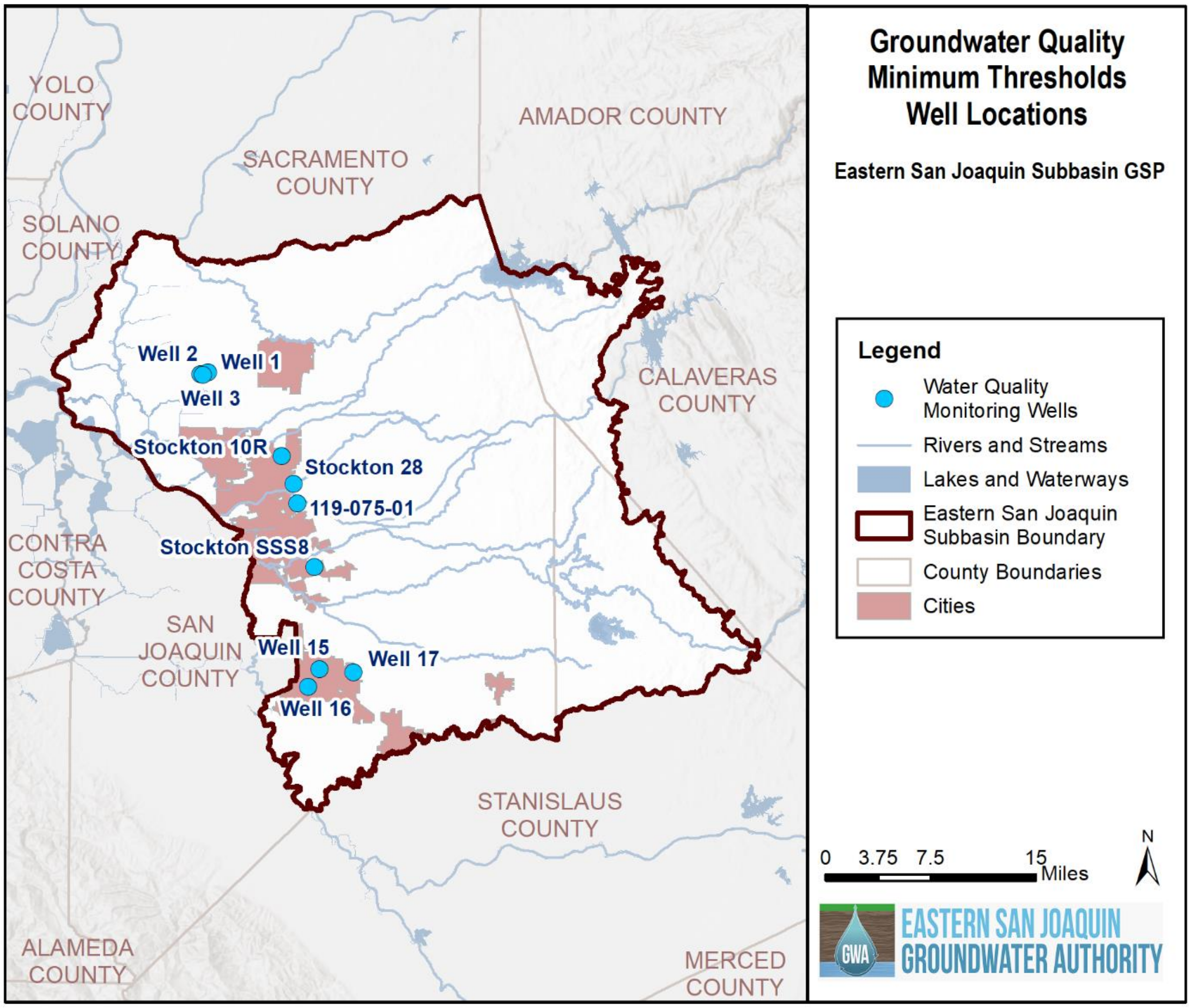
The minimum threshold for degraded water quality is 1,000 mg/L TDS at all representative monitoring well locations, shown in Figure 4-3.

Minimum thresholds for this sustainability indicator are focused on addressing the major groundwater quality issue of salinity by monitoring TDS as a representative constituent of salinity and preventing future water quality degradation due to pumping.

The minimum threshold of 1,000 mg/L was defined by considering two primary beneficial uses as risk of undesirable results related to salinity: drinking water quality and agriculture uses. The minimum threshold was defined by the GWA Board and reflects input from agricultural and municipal stakeholders, including local drinking water purveyors and the local agricultural community. A meeting was held in Fall 2018 with GSA representatives in areas impacted by high salinity. Representatives from San Joaquin County, City of Lodi, City of Manteca, City of Stockton, and Cal Water were in attendance. Additionally, members of the Workgroup who represent the interests of local growers provided input on the salinity levels at which crops begin to become impacted by salinity.

In the development of minimum thresholds, beneficial uses of groundwater as a drinking water supply and as an agricultural supply were considered. For drinking water, the TDS SMCL was considered. As noted in the Current and Historical Conditions section of this GSP, the SWRCB Division of Drinking Water has established SMCLs for TDS in drinking water supplies. SMCLs are established for aesthetic reasons such as taste, odor, and color and are not based on public health concerns. For TDS, the SMCL is 500 mg/L (recommended) and the upper SMCL is 1,000 mg/L (State Water Resources Control Board). The SWRCB has set a short-term standard of 1,500 mg/L which is a temporary concentration generally allowed only under rare circumstances (State Water Resources Control Board). For agricultural uses, crop tolerances in the Subbasin were considered which ranged by crop type from 900 mg/L TDS for almonds up to 4,000 mg/L TDS for wheat. (Texas A&M AgriLife Extension) Crop tolerances are more focused on fruit and nut trees and vineyards, as these crops cover more than half of the acreage of the Subbasin. These crop types have lower crop tolerances of TDS, in the range of 900-1,000 mg/L; any standard in this range is considered protective of these crop types and therefore the majority of Subbasin crops.

Figure 4-3: Location of Representative Monitoring Wells for Water Quality



4.2.3.3 Measurable Objectives and Interim Milestones

The measurable objective for degraded water quality is 600 mg/L TDS at all representative monitoring well locations.

600 mg/L was developed based on the TDS recommended SMCL for drinking water of 500 mg/L and adding a 100 mg/L buffer to meet the needs of wells used for both drinking water and agricultural wells. In addition to agricultural uses, the crop tolerance for turf is 750 mg/L; the minimum threshold is more stringent than this and will protect landscape uses are against impacts of high salinity groundwater. (Texas A&M AgriLife Extension)

To ensure the Subbasin meets the measurable objective for groundwater quality, interim milestones for 2025, 2030, and 2035 are developed to keep implementation on track. Table 4-4 shows the 5-year milestones, which follow along a linear trend between the current condition and the measurable objective. Interim milestones are based on the measurable objective and will be coordinated with projects and management actions.

Table 4-4: Interim Milestones for Degraded Water Quality

Narrative Description					
5-year milestones follow along a linear trend between the current condition and the measurable objective.					
Numeric Interim Milestones					
Well ID	**Current Condition* (mg/L TDS)**	**Measurable Objective (mg/L TDS)**	**Interim Milestones**		
			2025	**2030**	**2035**
Well 1	500	600	525	550	575
Well 2	510	600	532.5	555	577.5
Well 3	510	600	532.5	555	577.5
Stockton 10R	322	600	391.5	461	530.5
Stockton 26	350	600	412.5	475	537.5
Stockton SSS8	370	600	427.5	485	542.5
Well 15	300	600	375	450	525
Well 16	280**	600	360	440	520
Well 17	300**	600	375	450	525
119=075-01	300	600	375	450	525

* Current Condition is the average TDS for 2015-2018 except where indicated
** Current Condition is the average TDS for 2012-2018

4.2.4 Seawater Intrusion

4.2.4.1 Undesirable Results

4.2.4.1.1 Description of Undesirable Results

The undesirable result related to seawater intrusion is defined in SGMA as:

Significant and unreasonable seawater intrusion

An undesirable result for seawater intrusion in the Eastern San Joaquin Subbasin is experienced if sustained groundwater salinity levels caused by seawater intrusion and due to groundwater management practices are too high to satisfy beneficial uses within the basin over the planning and implementation horizon of this GSP.

The Eastern San Joaquin Subbasin is not in a coastal area and seawater intrusion is not currently present. Undesirable results related to seawater intrusion are not currently occurring and are not reasonably expected to occur (see Section 3.4.3).

There is, however remote, the possibility of future seawater intrusion due to potential future changes in the San Joaquin Delta that could be caused by sea level rise. This GSP develops minimum thresholds and measurable objectives that include monitoring for chloride and an analysis of isotopic ratios to identify the source of high salinity (see Section 4.2.4.4).

4.2.4.1.2 Identification of Undesirable Results

Undesirable results are considered to occur during GSP implementation when 2,000 mg/L chloride reaches an established isocontour line and where these concentrations are caused by intrusion of a seawater source as a result of groundwater management activity.

4.2.4.1.3 Potential Causes of Undesirable Results

If seawater intrusion does become an issue in the future, the cause of undesirable results would be seawater coming from surface waters in the San Joaquin Delta either due to climate change and associated sea level rise or significant changes in Delta management practices.

4.2.4.1.4 Potential Effects of Undesirable Results

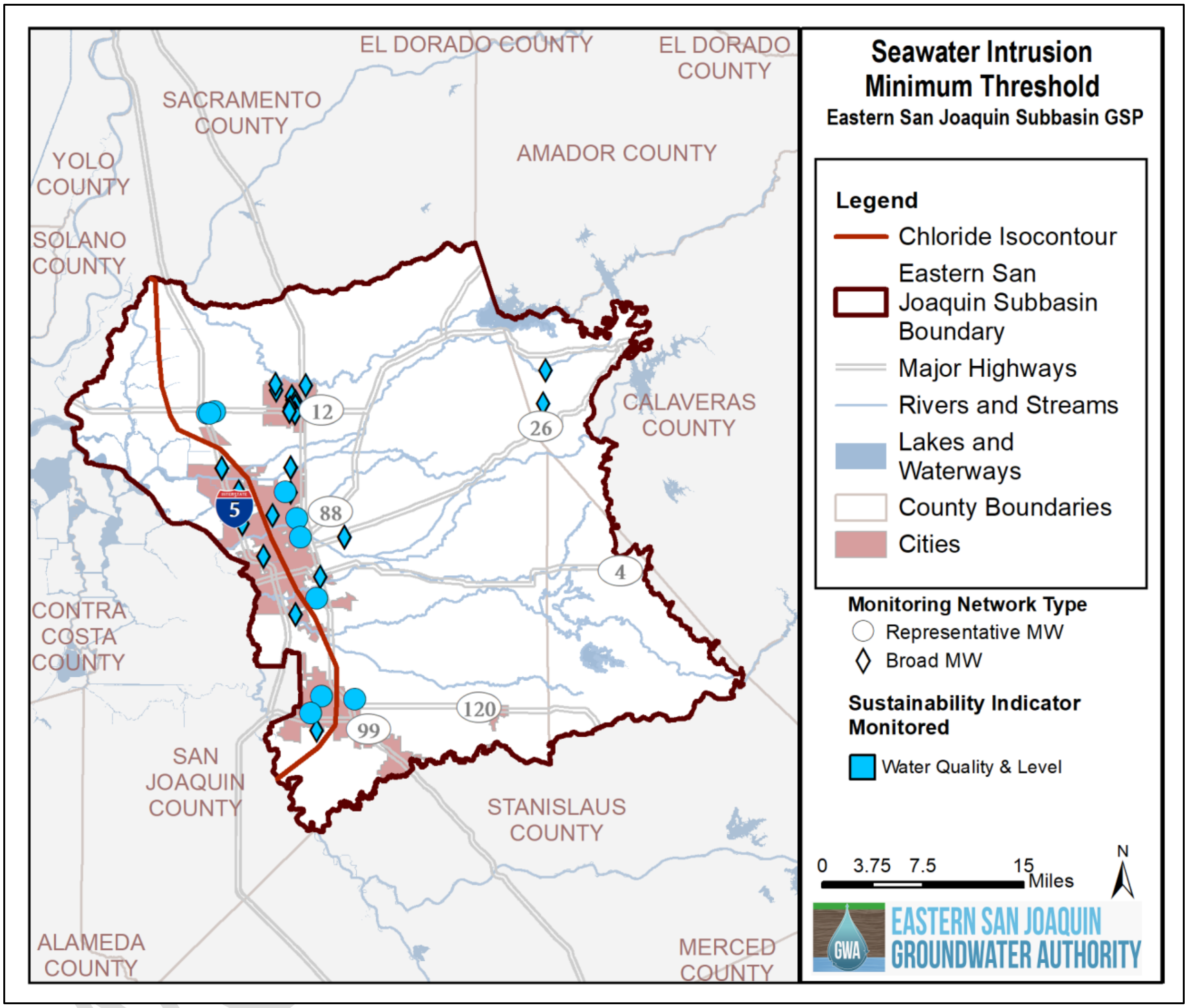
Similar to the effects of undesirable results for degraded water quality, increased salinity due to seawater intrusion could potentially cause a reduction in usable supply to groundwater users, with domestic wells being most vulnerable as treatment costs or access to alternate supplies can be high for small users. Water quality degradation due to seawater intrusion could cause potential changes in irrigation practices, crops grown, adverse effects to property values, and other economic effects. It could also adversely affect current and projected municipal uses, and users could have to install treatment systems or seek alternate supplies.

4.2.4.2 Minimum Thresholds

The minimum threshold for seawater intrusion is a 2,000 mg/L chloride isocontour line. 2,000 mg/L chlorides is approximately 10% of seawater chloride concentrations (19,500 mg/L) and was developed as a minimum threshold based on consideration of existing management practices in other areas of the state including Monterey County and Fox Canyon. This threshold incorporates input for stakeholders for multiple meetings and was reviewed by the GWA Advisory Committee and Board.

The minimum threshold contour line for seawater intrusion is shown in Figure 4-4. The contour would be between the most westernmost monitoring points and the next most-westerly points monitored for water quality in the Subbasin monitoring network (see Section 4.3), to serve as a sentinel.

Figure 4-4: Seawater Intrusion Minimum Threshold Chloride Isocontour Line



4.2.4.3 Measurable Objectives and Interim Milestones

The measurable objective for seawater intrusion is the current condition, using 2015-2018 average chloride concentrations.

The 5-year interim milestones follow along a linear trend between the current condition, using 2015-2018 average chloride concentrations, and the measurable objective. Interim milestones are based on the measurable objective and will be coordinated with projects and management actions.

4.2.4.4 Trigger and Actions

An action plan is in place as part of this GSP to trigger additional monitoring and analysis at detections of 1,000 mg/L chloride in the monitoring network to confirm seawater source. Assessing high-chloride water sources to determine origin involves determining water type from major-ions, and evaluating stable isotope concentrations (O'Leary et al., 2015). The ratio of chloride to iodide is also used to differentiate high-chloride water sources besides seawater (O'Leary et al., 2015). These assessment tools would be used to provide the GSAs adequate time to develop groundwater management strategies to address any seawater intrusion before the 2,000 mg/L chloride minimum threshold is reached.

4.2.5 Land Subsidence

4.2.5.1 Undesirable Results

4.2.5.1.1 Description of Undesirable Results

The undesirable result related to land subsidence is defined in SGMA as:

> *Significant and unreasonable land subsidence that substantially interferes with surface land uses.*

An undesirable result for land subsidence in the Eastern San Joaquin Subbasin is experienced if the occurrence of land subsidence substantially interferes with beneficial uses of groundwater and infrastructure within the basin over the planning and implementation horizon of this GSP.

4.2.5.1.2 Identification of Undesirable Results

An undesirable result occurs when subsidence substantially interferes with beneficial uses of groundwater and surface land uses. Subsidence occurs as result of compaction of subsurface materials due to the dewatering of subsurface materials. Undesirable results would occur when substantial interference with land use occurs, including significant damage to canals, pipes, or other water conveyance facilities.

4.2.5.1.3 Potential Causes of Undesirable Results

Potential causes of future undesirable results for land subsidence would include significant increases in groundwater production beyond what is currently projected, resulting in dewatering of compressible clays in the subsurface, which are not known to be common in the Eastern San Joaquin Subbasin, as indicated by historical absence of subsidence. Corcoran Clay is one type of subsurface material that is predisposed to compression. See section 3.2.X for a description of Corcoran Clay extent in the Subbasin.

4.2.5.1.4 Potential Effects of Undesirable Results

If land subsidence conditions were to reach undesirable results levels, the adverse effects could potentially cause an unrecoverable loss of groundwater storage and damage to infrastructure, including water conveyance facilities and flood control facilities. This could impact the ability to deliver surface water, resulting in increased groundwater use, or could impact the ability to store and convey flood water. These could have adverse effects to property values or public safety.

4.2.5.2 Minimum Thresholds

This GSP uses groundwater level minimum thresholds as a proxy for the land subsidence sustainability indicator. As such, the minimum thresholds for the land subsidence sustainability indicator are the same as the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator.

GSP regulations allow GSAs to use groundwater levels can be used as a proxy metric for any sustainability indicator, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics. DWR requires the GSP (DWR, 2017):

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site.*

This GSP uses groundwater levels as a proxy metric for the land subsidence sustainability indicator. There is significant correlation between groundwater levels and land subsidence, with land subsidence being driven by a lowering of groundwater levels in the aquifer. Further, the use of groundwater levels as a proxy is necessary, given the lack of direct monitoring for land subsidence in the Subbasin.

Land subsidence can only occur if two conditions are met: (1) subsurface materials are dewatered and (2) those dewatered subsurface materials are compressible. Historical declines in groundwater levels have not resulted in subsidence (see Section 3.4.5), suggesting that subsurface materials in the geologic units historically affected by groundwater elevation fluctuations are not compressible. If the basin were to operate within the margin of operational flexibility for groundwater levels, future dewatering would continue to occur in the same geologic units historically affected by groundwater elevation fluctuations (see Section 3.2.6 for the 5 geologic cross sections of the Subbasin). It is anticipated that additional declines in groundwater levels would affect dewatered materials at a depth no deeper than 205 feet[1], at which depth materials are consistent with historical dewatering, which resulted in no known subsidence. As a result, projected elevation declines are not expected to result in subsidence, and groundwater level minimum thresholds are protective.

4.2.5.3 Measurable Objectives and Interim Milestones

As chronic lowering of groundwater levels is used as a proxy for land subsidence, the measurable objectives and interim milestones for the land subsidence sustainability indicator are the same measurable objectives and interim milestones as the chronic lowering of groundwater levels sustainability indicator found in Section 4.2.1.3.

[1] Based on deepest groundwater level threshold depth to water at well 02N08E15M002.

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4.2.7 Depletion of Interconnected Surface Water

Depletion of interconnected surface water is a reduction in flow or levels of surface water caused by groundwater extraction. This reduction in surface water flow or levels, at certain magnitudes or timing, may have adverse impacts on beneficial uses of surface water and may lead to undesirable results. Quantification of depletions is relatively challenging and requires significant data on both groundwater levels near streams and stage information supported by groundwater modeling.

4.2.7.1 Undesirable Results

4.2.7.1.1 Description of Undesirable Results

The undesirable result related to d*epletions of interconnected surface water* is defined in SGMA as:

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

The undesirable result for depletions of interconnected surface water in the Eastern San Joaquin Subbasin is depletions that result in reductions in flow or levels of major rivers and streams that are hydrologically connected to the basin such that the reduced surface water flow or levels have a significant and unreasonable adverse impact on beneficial uses of the surface water within the Subbasin over the planning and implementation horizon of this GSP.

Major rivers and streams that potentially have a hydraulic connection to the groundwater system in certain reaches are the Calaveras River, Dry Creek, Mokelumne River, San Joaquin River, and Stanislaus River. Many of the smaller creeks and streams are solely used for the conveyance of irrigation water and these systems have not been considered in the analysis of depletions.

4.2.7.1.2 Identification of Undesirable Results

Undesirable results would occur if groundwater extractions depleted interconnected streams and there was not sufficient surface water to supply domestic, agricultural, or fish and wildlife demands. An undesirable result would occur if depletions resulted in the release of stored surface water to meet fish and wildlife requirements, in the decrease of acreage or yield of agriculture crops that have a more senior water right than the groundwater extractor, the reduction in availability of surface water for domestic supplies, or potentially the elimination of groundwater dependent ecosystems.

4.2.7.1.3 Potential Causes of Undesirable Results

Potential causes of undesirable results would include increased groundwater extractions near groundwater dependent ecosystems, reduced recharge due to drought, and increased groundwater demand along interconnected corridors.

4.2.7.1.4 Potential Effects of Undesirable Results

If depletions of interconnected surface water were to reach levels causing undesirable results, effects could include reduced flow and stage within rivers and streams in the Subbasin to the extent that insufficient surface water would be available to support diversions for agricultural uses, diversions for urban uses, or to support regulatory environmental requirements. This could result in increased groundwater production, changes in irrigation practices and crops grown, and could cause adverse effects to property values and the regional economy. Reduced flows and stage, along with potential associated changes in water temperature, could also negatively impact aquatic species in the rivers and streams. Such impacts are tied to the inability to meet minimum flow requirements, which are defined for the Mokelumne, Stanislaus, and San Joaquin Rivers, which, in turn, are managed through operations at Camanche Dam, Woodbridge Dam, New Melones, and other reservoirs.

4.2.7.2 Minimum Thresholds

This GSP uses groundwater level minimum thresholds as a proxy for the depletion of interconnected surface water sustainability indicator. As such, the minimum thresholds for the interconnected surface water sustainability indicator are the same as the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator.

GSP regulations allow GSAs to use groundwater levels as a proxy metric for any sustainability indicator, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics. The following approach from DWR is used to justify the proxy metric (DWR, 2017):

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site.*

To use the minimum thresholds for chronic lowering of groundwater levels as a proxy for interconnected surface water, the stream depletions which would occur when undesirable results for groundwater levels are reached must not be significant and unreasonable.

Current or historical issues associated with the depletion of interconnected surface water were not indicated to be significant and unreasonable based on discussions at GWA Board, Advisory Committee, and Workgroup meetings and through input from GSA staff. Based on this input, it was assumed that historical conditions are protective of beneficial uses related to interconnected surface water. Therefore, the historical depletions simulated by ESJWRM's historical calibration (documentation in Appendix X) are assumed to have no associated undesirable results. If groundwater levels were to fall lower than historical levels, there is an associated level of additional depletions that would occur, quantified below.

The ESJWRM was used to estimate the volume of depletions associated with groundwater levels that would be classified as undesirable results (non-dry year pairings where 25 percent or more wells fall below their minimum thresholds). The sustainable conditions scenario (see Section 3.3.6) does not result in groundwater level undesirable results, but the projected conditions scenario (see Section 3.3.4.3) does result in groundwater level undesirable results. The additional stream losses that occurred in the projected conditions scenario compared to the historical calibration are estimates of depletions as they can be linked directly to simulated increases in groundwater pumping. The additional depletions in the projected conditions scenario are 50,000 AFY, which is approximately 1% of total stream outflows from the Subbasin to the north. As the reduction in total stream flows is small, no impact is expected to the beneficial users of interconnected surface water in the Subbasin. Depletions greater than an increase of 50,000 AFY would not occur because at this point the sustainability indicators for groundwater elevations would be triggered and would be protective of any further depletions. Therefore, groundwater level thresholds are protective of the depletion of interconnected surface water.

4.2.7.3 Measurable Objectives and Interim Milestones

As chronic lowering of groundwater levels is used as a proxy for depletions of interconnected surface water, the measurable objectives and interim milestones for the depletion of interconnected surface water sustainability indicator are the same as the measurable objectives and interim milestones for the chronic lowering of groundwater levels sustainability indicator.

4.3 MONITORING NETWORKS

monitoring networks in the Eastern San Joaquin Subbasin dedicated to monitoring short-term, seasonal, and long-term trends in sustainability indicators. There are four networks; a broad network for water levels, a representative network for water levels, a broad network for water quality, and a representative network for water quality. These monitoring networks are tools for the GWA and allow the GWA to compile data on key sustainability indicators and monitor groundwater trends on a variety of temporal and spatial scales. The objective of these monitoring networks is to detect undesirable results in the basin as described in the Sustainable Management Criteria section of this GSP. The data and trends will allow the GWA to detect changes in basin conditions, meet sustainability goal, avoid minimum thresholds, and evaluate the effectiveness of projects and management actions implemented. Ultimately, the monitoring network and associated data will guide decisions to prevent undesirable results occurring within the GSP implementation timeframe. Other objectives of the monitoring networks, as defined by DWR, include:

- Demonstrate progress toward achieving measurable objectives described in the Plan
- Monitor impacts to the beneficial uses or users of groundwater
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Quantify annual changes in water budget components

The monitoring networks are intended to monitor for chronic lowering of groundwater levels, degraded water quality, and seawater intrusion. As discussed in the Sustainable Management Criteria section, the following sustainability indicators will be evaluated using groundwater levels as a proxy: reduction in groundwater storage, land subsidence, and depletion of interconnected surface water.

The schedule and costs associated with monitoring and implementation will be discussed in the Implementation Section of the GSP.

4.3.1 Monitoring Network for Chronic Lowering of Groundwater Levels

This section provides information on how the groundwater level monitoring networks were developed, criteria for selecting dedicated monitoring wells, monitoring frequency, spatial density, and summary protocols. The two networks that collect data for groundwater levels include:

- **Representative Monitoring Network** – These wells will be used to monitor sustainability in the Subbasin. These wells are used to determine compliance with minimum thresholds and measurable objectives for the groundwater level sustainability indicator.

- **Broad Monitoring Network**– Additional wells are included as part of the broad monitoring network to collect additional information and to maintain a robust network for evaluation. Wells part of the broad monitoring network are not used to determine compliance with minimum thresholds or measurable objectives.

4.3.1.1 Representative Monitoring Network for Groundwater Levels

Representative monitoring wells represent conditions in the basin and are located in areas that indicate the long term, regional changes in its vicinity. Table 4-5 identifies and summarizes the 20 representative monitoring wells for groundwater levels. Well locations were shown previously in Figure 4-2.

Table 4-5: Representative Monitoring Wells for Groundwater Levels

Representative Monitoring Network Wells (Groundwater Levels)						
Local Well ID	**CASGEM Site Code**	**Monitoring Agency**	**Well Depth (ft.)**	**Screen Interval (ft.)**	**Measurement Period (years)**	**Measurement Count**
Swenson-3	380067N1213458W003	SJC	204	194 - 204	2014 - 2018	10
01S09E05H002	378824N1210000W001	SJC	256	148 - 256	1991 - 2018	47
Burnett (OID4)	377909N1208675W001	Stanislaus County	501	168 - 249	2005 - 2019	26
02N07E03D001	380578N1212017W001	SJC	484	130 - 484	1990 - 2018	49
04N07E20H003M	381843N1212261W001	SJC	180	164 - 180	1972 - 2019	103
02S07E31N001	377136N1212508W001	SJC	Unknown*	Unknown*	1991 - 2018	45
02S08E08A001	377810N1211142W001	SJC	180	50 - 180	1991 - 2018	47
01N07E14J002	379316N1211665W001	SJC	556	168 - 556	1991 - 2018	47
01N09E05J001	379661N1210011W001	SJC	750	100 - 750	2011 - 2018	12
02N07E29B001	379976N1212308W001	SJC	202	130 - 202	1989 - 2018	41
02N08E15M002	380206N1210943W001	SJC	Unknown*	Unknown*	2011 - 2013	5
03N07E21L003	380909N1212153W001	SJC	Unknown*	Unknown*	1991 - 2013	39
03N06E05N003	381317N1213524W001	SJC	292	252 - 292	1991 - 2018	44
04N05E36H003	381559N1213727W001	SJC	112	50 - 112	1971 - 2018	88
04N05E24J004	381816N1213723W001	SJC	190	150 - 190	1991 - 2018	47
#3 Bear Creek	n/a	LCSD	780	0 - 780	2011 - 2018	23
Lodi City Well #2	n/a	City of Lodi	315	109 - 310	1989 - 2016	122
Hirschfeld (OID8)	n/a	Stanislaus County	408	88 - 179	2005 - 2016	23
Well 18	n/a	City of Manteca	350	109 - 349	1997 - 2018	65
* Indicates wells is a voluntarily monitored as part of the CASGEM program and monitoring agency is not required to provide well depth or screen interval information **Note:** An additional monitoring will be added in Eastside GSA.						

Representative groundwater level sites were selected by several different criteria. These include:

1. **Adequate Spatial Distribution –** Representative monitoring does not require the use of all wells that are spatially "clumped" together within a portion of the Basin. Adequately spaced wells will provide greater Basin coverage with fewer monitoring sites.

2. **Robust and Extensive Historical Data –** Representative monitoring sites with longer and more robust historical data provide insight into long-term trends that can provide information about groundwater conditions through varying climatic periods such as droughts and wet periods. Historical data may also show changes in groundwater conditions through anthropogenic effects as well. While some sites chosen may not have extensive historical data, they may still be selected because there are no wells nearby with longer records.

3. **Increased Density in Heavily Pumped Areas –** Selection of additional wells in heavily pumped areas such as in the central portion of the Basin and other agriculturally intensive areas will provide additional data where the most groundwater change occurs.

4. **Increased Density near Areas of Geologic, Hydrologic, or Topologic Uncertainty** – Having a greater density of representative wells in areas of uncertainty, such as around faults or large elevation gradients may provide insightful information about groundwater dynamics to improve management practices and strategies.

5. **Wells with Multiple Depths** – The utilization of wells with different screen intervals is important to collect data on the groundwater conditions at different elevations within the aquifer. This can be achieved by using wells with different screen depths that are close to one another, or by using multi-completion wells.

6. **Consistency with BMPs –** Using published BMPs provided by DWR will promote consistency across all basins and promote compliance with established regulations.

7. **Adequate Well Construction Information –** Well information such as perforation depths, construction date, and well depth should be considered and encouraged when considering wells to be included.

8. **Professional Judgement** – Professional judgement is used to make the final decision about each well, particularly when more than one suitable well exists in an area of interest.

9. **Maximum Coverage –** Any monitoring network well that was suitable for use in the representative network was used to maximize spatial and vertical density of monitoring.

4.3.1.2 Broad Monitoring Network for Groundwater Levels

The broad monitoring network includes 107 wells which will monitor groundwater levels as part of the broad monitoring network (see Figure 4-5). These wells are not used to determine compliance with the measurable objectives and minimum thresholds. Wells that are part of the broad monitoring network will collect groundwater level data for informational purposes and will help maintain a robust groundwater level monitoring network. Data from this network will be available through the Data Management System (see Chapter 5) and will be reported in Annual Reports to DWR.

There are 76 sells included in the broad monitoring network are primarily wells used in CASGEM, a program that has tracked seasonal long-term groundwater elevation trends in the Subbasin since 2009. CASGEM wells were selected to be included in the broad monitoring network for groundwater level monitoring based on three key qualifications:

1. Existing data source with a historical data record;

2. Provides reliable, consistent data with repeatable data collection methods; and

3. Many wells are new, having been constructed within the past ten years when the CASGEM program was enacted.

The broad monitoring network also includes 16 nested and/or clustered wells monitored as part of the CASGEM program and/or by the USGS. These 16 wells were selected to be included in the broad monitoring network for groundwater levels for the following reasons:

1. Existing data source with a historical data record;

2. Many wells are new, having been constructed within the past ten years when the CASGEM program was enacted;

3. Construction details, including total depth, hole depth, and screen intervals, for these wells are widely available; and

4. Wells are screened at multiple depths and can provide data for many depths.

The broad monitoring network also includes 15 identified local water quality wells that are included as part of the groundwater water quality monitoring network (located near cities of Stockton, Lodi, and Manteca, and San Joaquin County's Flag City wells) will be monitored for groundwater levels as part of the broad monitoring network for groundwater levels.

Figure 4-5: Broad Monitoring Network for Groundwater Levels

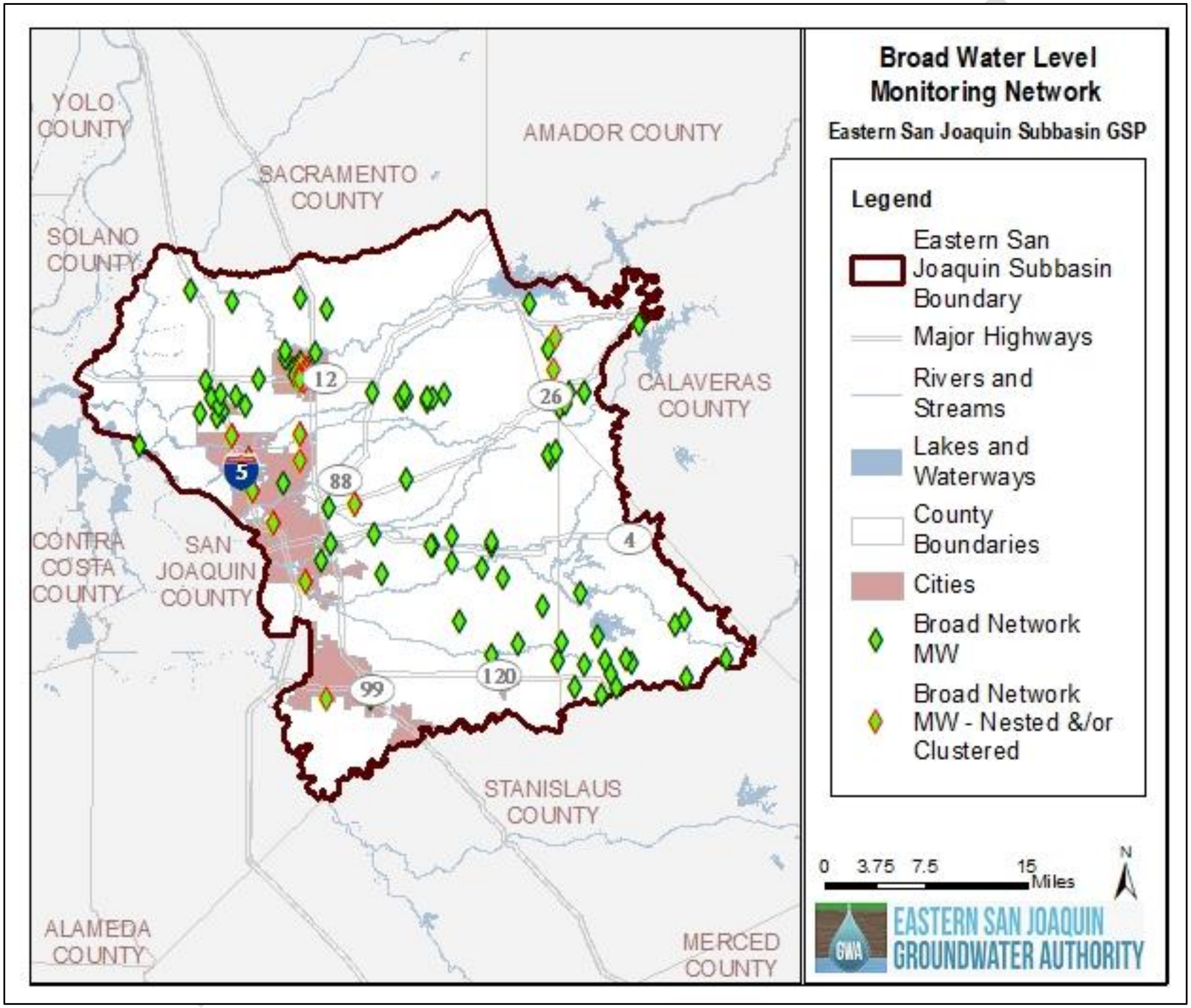


Table 4-6 provides the breakdown on type of wells included in the broad monitoring network for groundwater levels.

Table 4-6: Groundwater Level Monitoring Wells in the Broad Monitoring Well Network

Well Type	Number of Wells Selected for Broad Monitoring Network
CASGEM	76
Existing Clustered and/or Nested Wells	16
Identified Local Water Quality Wells	15
Total	**107**

4.3.1.3 Monitoring Protocols for Groundwater Level Data Collection and Monitoring

Groundwater monitoring protocols are essential to producing quality data measurements and protecting the water quality of monitoring wells. Existing protocol resources include DWR's *Groundwater Elevation Monitoring Guidelines* (CA DWR, 2010) and USGS's *National Field Manual* (USGS, 2015). Protocols are established to improve consistency in data and ensure comparable methodologies.

Typical groundwater level measurement equipment used by agencies include electric sounders, data loggers, steel tapes, and air gauges. Regardless of the instrumentation used in the field, each groundwater level data measurement must include: well identification number, measurement date, reference point and land surface elevation, depth to water, method of measuring water depth, and measurement quality codes.

DWR released a BMP for monitoring protocols, in the *Best Management Practices for the Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites*, included as Appendix X. The monitoring protocols described in DWR's BMP recommend that groundwater level measurements are taken in a manner to ensure data are:

- Taken from the correct location, well ID, and screen interval depth
- Accurate and reproducible
- Representative of conditions that inform appropriate basin management data quality objectives
- Recorded with all salient information to correct, if necessary, and compare data
- Handled in a way that ensures data integrity.
- Taken using a CASGEM-approved water-level measurement methods to ensure consistency across measurements. Methods include:
    - Establishing a reference point
    - Using one of four approved methods (steel tape, electric sounding tape, sonic water-level meter, or pressure transducer) to measure groundwater levels

Existing wells, monitored under the CASGEM program, already use these procedures in the collection of groundwater level data. These protocols and existing resources will be used when possible in data monitoring and collection in support of this GSP.

4.3.1.4 Frequency and Timing of Groundwater Level Monitoring

Representative monitoring network wells for groundwater levels will be monitored quarterly, and those in the broad monitoring network will be monitored semi-annually in March and October to capture the seasonal high and low groundwater levels.

Frequency of groundwater level monitoring is cited in the *Draft Monitoring Networks and Identification of Data Gaps Best Management Practice* (DWR, 2016) which presents guidance on monitoring frequency based on the type of monitoring, aquifer type, confinement, recharge rate, hydraulic conductivity, and withdrawal rate. While semi-annual monitoring is required for groundwater levels, DWR guidance recommends monthly sampling of groundwater levels for the Eastern San Joaquin Subbasin based on aquifer type, volume of long-term aquifer withdrawals, and recharge potential. Sampling frequencies were developed based on this guidance in combination with a consideration of sampling costs.

A quarterly monitoring frequency for representative monitoring wells, and a semi-annual monitoring frequency for the broad monitoring network will generate data that is useful for monitoring for the long term, regional trends in groundwater level conditions. These measurements are also valuable for local groundwater management and for investigating local pumping's effects on nearby wells. This frequency meets the goal of a successful monitoring schedule which provides enough data to adequately interpret changes in groundwater levels and fluctuations over short and long-term periods as these fluctuations could be the result of storm events, droughts or other climatic variations, seasons, and anthropogenic activities.

4.3.1.5 Spatial Density of Groundwater Level Monitoring Network

The goal of the groundwater level monitoring network is to provide adequate coverage of the entire aquifer within the Subbasin. This includes the ability to monitor and identify groundwater changes across the basin through time. The spatial location of monitoring wells in the networks were based on proximity to other monitoring wells and ensuring adequate coverage near other prominent features such as faults or production wells. Monitoring wells in close proximity to active pumping wells could be influenced by groundwater withdrawals, thus skewing static level monitoring.

To achieve a suitable monitoring network density, DWR recommends selecting existing, dedicated groundwater monitoring wells with known construction information over production wells to incorporate into the network. When deciding on the number of groundwater wells to be monitored in a basin to adequately represent static water levels (and corresponding elevations), the following factors should be considered:

- Known hydrogeology of the basin
- Slope of the groundwater table or potentiometric surface
- Existence of high-volume production wells and the frequency of their use
- Availability of easily accessible monitoring wells

In 2010, DWR released *Groundwater Elevation Monitoring Guidelines*, which discusses the selection and requirements for new wells to be incorporated into groundwater level monitoring networks (DWR, 2010). The recommended network density ranges from 0.2 to 10 groundwater monitoring wells per 100 square miles depending on local pumping rates. The Subbasin is approximately 1,195 square miles. Based on the recommendations by DWR, the number of monitoring wells for the Eastern San Joaquin Subbasin should range from 2.4 to 119.5 wells per 100 square miles, as summarized in Table 4-7.

Table 4-7: DWR Monitoring Well Density Recommendations

Reference	Monitoring Well Density (wells per 100 sq. miles)	Recommended No. of Monitoring Wells in the Subbasin
Heath (1976)	0.2-10	2.4 – 119.5
Sophocleous (1983)	6.3	75.9
Hopkins (1994)		
Basins pumping more than 10,000 AFY per 100 miles	4.0	47.8

Spatial density of the groundwater level monitoring network was calculated for both the representative monitoring network and the broad monitoring network, as summarized in Table 4-8. The density of the representative monitoring network is 1.7 wells per 100 square miles, a total of 20 monitoring wells, which falls into the lower to mid range of DWR's recommendations. However, in combination with the broad monitoring network, a total of 127 wells are monitored for groundwater levels (approximately 11 wells per 100 square miles), which exceeds DWR's recommendations.

Table 4-8: Groundwater Level Monitoring Network Density

Monitoring Network	No. of Wells	Well Density (Wells per 100 sq. miles)
Representative Monitoring Network	20	1.7
Broad Monitoring Network	107	9.0
Combined Representative Monitoring Network and Broad Monitoring Network	127	10.6

4.3.2 Monitoring Network for Reduction in Groundwater Storage

As described in Section 4.2.2, groundwater levels will be used as a proxy for the reduction in groundwater storage sustainability indicator. As such, sustainable management criteria for groundwater storage will be monitored through the groundwater levels monitoring networks, described in Section 4.3.1.

4.3.3 Monitoring Networks for Degraded Water Quality

Groundwater quality monitoring is conducted through both representative and broad groundwater well monitoring networks. This section will provide information on how the monitoring networks were developed, criteria for selecting dedicated monitoring wells, monitoring frequency, spatial density, and summary protocols.

The representative monitoring network are used to determine compliance with minimum thresholds and measurable objectives developed for the degraded water quality sustainability indicator. The broad monitoring network includes additional wells to maintain a robust network for evaluation and information collection. Wells part of the broad monitoring network are not used to determine compliance with minimum thresholds or measurable objectives.

Monitoring networks monitoring for water quality will test for TDS, cations and anions, arsenic, and field parameters including pH, EC, and temperature. Arsenic will be monitored for informational purposes and to track trends in arsenic concentrations. The GSP does not include sustainability goals, measurable objectives, or minimum thresholds for arsenic.

4.3.3.1 Representative Monitoring Network for Groundwater Quality

Ten representative monitoring wells were selected for monitoring groundwater quality. These wells are currently monitored and managed by City of Manteca, Cal Water, City of Stockton, and San Joaquin County. Table 4-9 identifies and summarizes the agencies with the 10 representative monitoring wells selected for the groundwater quality monitoring network, which shown previously in Figure 4-3.

Table 4-9: Representative Monitoring Network Wells for Water Quality

Well ID	Monitoring Agency	Well Depth (ft.)	Screen Interval (ft.)	Current Condition Average TDS (2015 – 2018) (mg/L)	Measurement Period (years)	Measurement Count
Representative Monitoring Network Wells						
Well 1	San Joaquin County (Flag City)	170	120 – 170	500	2008 - 2018	8
Well 2	San Joaquin County (Flag City)	180	130 – 180	510	2008 – 2016	7
Well 3	San Joaquin County (Flag City)	Unknown	Unknown	510	2013 - 2016	3
Stockton 10R	City of Stockton	Unknown	177 – 277	322	1998 - 2018	6
Stockton 28	City of Stockton	Unknown	178 – 278	350	1998 - 2018	6
Stockton SSS8	City of Stockton	Unknown	177 - 277	370	1998 - 2018	4
Well 15	City of Manteca	Unknown	81 – 181	300	1998 - 2018	7
Well 16	City of Manteca	Unknown	80 – 180	-	1998 - 2018	6
Well 17	City of Manteca	Unknown	97 - 197	-	1998 - 2018	6
119-075-01	Cal Water	580	176 – 276	300	1979 - 2018	15

Representative monitoring wells were selected based on their ability to represent conditions in the basin and indicate long-term, regional changes in groundwater quality conditions. GSAs in areas affected by high TDS levels identified wells to be used as representative monitoring wells that met the following criteria:

1. **Adequate Spatial Distribution –** Historically, high TDS concentrations have occurred in the western portion of the Subbasin, near the San Joaquin River and urban areas; as such, the majority of representative monitoring wells are located in the western half of the Subbasin. Monitoring wells are located both within areas of high TDS concentrations, to observe and monitor TDS trends, and adjacent to high TDS areas, to observe potential TDS movement.

2. **Extensive Historical Data –** Wells with longer records of TDS monitoring were preferentially selected over wells with short or sporadic records. Monitoring wells with historical TDS records provide insight on long-term trends and the groundwater condition responses to varying climatic periods such as droughts and wet periods and/or anthropogenic effects.

3. **A Range of TDS Concentrations** – Wells with historically "low" TDS concentrations near areas with high salinity were looked at to alert a change in groundwater quality conditions and a possible migration of salinity.

4. **Known Well Construction Information –** Wells with known construction data, including total depth, screen intervals, and construction date, were preferred. Knowledge of the depth at which water quality measurements are taken would better describe the representative conditions of specific portions of the aquifer.

5. **Current TDS Monitoring Program** – Wells currently monitored for TDS were preferred over wells not currently monitored for water quality constituents. These wells are already equipped with monitoring equipment and have protocols underway to ensure accurate and consistent measurements and represent a current asset for the Subbasin that can be further utilized.

6. **Consistency with BMPs –** DWR's published BMPs were used as guidance documents to ensure consistency across all basins and ensure compliance with established regulations.

7. **Professional Judgement** – Professional judgement was used to make the final decision about each well, particularly when more than one suitable well exists in an area of interest.

4.3.3.2 Broad Monitoring Network for Groundwater Quality

In addition to the representative monitoring network wells, 21 additional wells will monitor groundwater quality as part of the broad monitoring network (see Figure 4-6). The purpose of including these wells in the broad monitoring network is to better monitor for potential spread of salinity and to maintain a robust network for evaluation as part of 5-year GSP updates. These wells are not used to determine compliance with the measurable objectives or minimum thresholds. These 21 wells overlap with the broad monitoring network for groundwater levels. Data from this network will be available through the Data Management System (see Chapter 5) and will be reported in Annual Reports to DWR.

The broad monitoring network for water quality includes 5 identified local water quality wells and 16 clustered/nested wells that are also monitored for groundwater levels in the broad monitoring network for groundwater levels (Section 4.3.1.2). Table 4-10 identifies the wells included in the broad monitoring network for water quality.

Figure 4-6: Broad Monitoring Network for Groundwater Quality

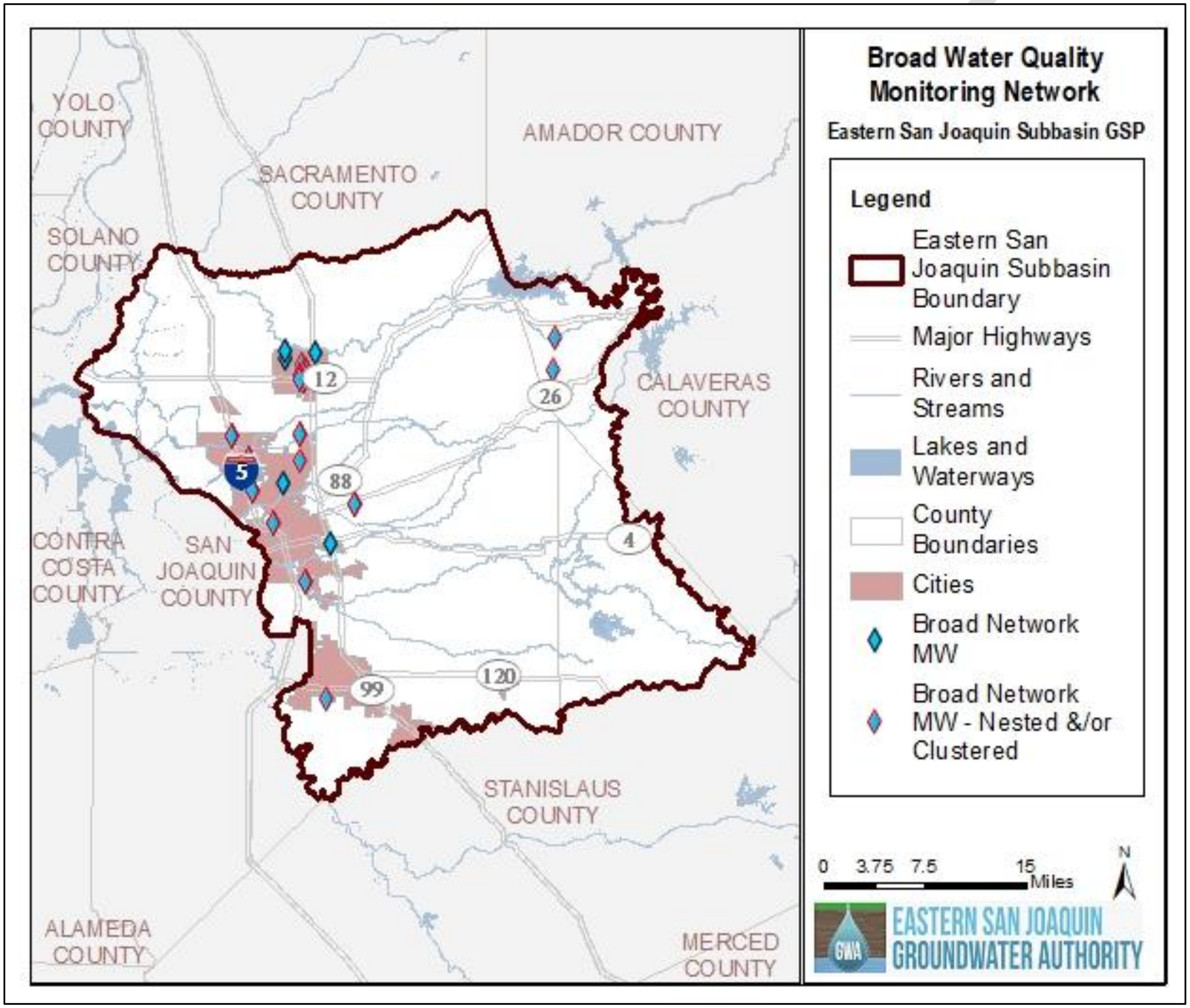


Table 4-10: Wells in the Broad Monitoring Network for Groundwater Quality

Well ID	Monitoring Agency	Well Depth (ft.)	Screen Interval (ft.)	Current Condition Average TDS (2015 – 2018) (mg/L)	Measurement Period (years)	Measurement Count
Broad Monitoring Network Wells (Water Quality)						
Identified Local Water Quality Monitoring Wells						
119-059-01	Cal Water	520	169 – 269	250	1979 – 2018	15
119-069-01	Cal Water	530	180 – 280	190	1979 – 2018	13
#5	City of Lodi	230	Unknown	135	2009 – 2018	4
#7	City of Lodi	422	Unknown	120	2008 – 2017	4
#11R	City of Lodi	465	140 – 462	120	2009 – 2018	4
Clustered and/or Nested Wells						
Under Development						

4.3.3.3 Monitoring Protocols for Groundwater Quality Data Collection and Monitoring

Groundwater quality data sampling protocols are based on DWR's *Best Management Practices for the Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites* (CA DWR, 2016), which cites the USGS's 1995 publication *Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data* (USGS, 1995). The BMP recommends groundwater quality monitoring protocols and also recommends using the USGS *National Field Manual for the Collection of Water Quality Data* (USGS, 2015) for additional protocols. These publications include protocols for equipment selection, setup, use, field evaluation, sample collection techniques, sample handling, and sample testing.

Groundwater quality sampling protocols recommended in the BMP include ensuring that:

- Groundwater quality data are taken from the correct location
- Groundwater quality data are accurate and reproducible
- Data represents conditions that inform appropriate basin management and are consistent with the data quality objectives
- Data are handled in a way that ensures data integrity
- All salient information is recorded to normalize, if necessary, and compare data

Monitoring protocols for groundwater quality sampling are included in Appendix X.

4.3.3.4 Frequency and Timing of Groundwater Quality Monitoring

Groundwater quality measurements will be collected semi-annually for both the representative monitoring network wells and the broad monitoring network wells.

Although DWR does not provide specific recommendations on the frequency of monitoring for TDS, concentrations of groundwater quality, especially salinity, do not fluctuate significantly throughout a year to require multiple samples per year. No existing monitoring wells were found to be monitored continuously for groundwater quality (such monitoring is typically performed only for EC and temperature), nor were there agencies that reported ongoing, non-regulatory, regularly scheduled groundwater quality monitoring programs.

Table 4-11 identifies the historical frequency of groundwater quality monitoring conducted for local water quality wells by each monitoring agency.

Table 4-11: Historical Groundwater Quality Monitoring at Identified Local Water Quality Wells

Agency	Data Record	Historical Monitoring Frequency (Approx.)
Cal Water	1979 - 2018	Approx. every 3 years
City of Lodi	2008 - 2018	Approx. every 3 years[1]
City of Manteca	1975 - 2017	Monthly
City of Stockton	1989 - 2016	Quarterly
San Joaquin County – Flag City	2009 - 2017	Annually

[1]TDS has not been regularly monitored at sites around the White Slough Water Pollution Control Facility.

4.3.3.5 Spatial Density of Groundwater Quality Monitoring Wells

DWR's *Monitoring Networks and Identification of Data Gaps BMP* states "The spatial distribution must be adequate to map or supplement mapping of known contaminants" (DWR, 2010). The goal of the groundwater quality monitoring network is to adequately cover the Subbasin to accurately characterize salinity concentrations and trends. This includes both spatial coverage and temporal coverage in order to identify changes in groundwater quality over time.

As discussed in Section 0, DWR's *Monitoring Networks and Identification of Data Gaps BMP* identifies different sources and calculations for establishing monitoring network densities on a Subbasin-specific case. These density calculations and guidance are summarized in Table 4-7. The spatial density of the groundwater quality monitoring network was calculated for both the representative monitoring network and the broad monitoring network, as summarized in Table 4-12. A total of 10 monitoring wells comprise the representative monitoring network; a density of 0.9 wells per 100 square miles. The density of the broad monitoring network, a total of 26 monitoring wells, is 1.2 wells per 100 square miles. The total number of wells and monitoring network densities meet DWR's recommendations, identified in Table 4-7.

Table 4-12: Groundwater Quality Monitoring Network Density

Monitoring Network	No. of Wells	Well Density (Wells per 100 sq. miles)
Representative Monitoring Network	10	0.8
Broad Monitoring Network	21	1.8
Combined Representative Monitoring Network and Broad Monitoring Network	31	2.6

4.3.4 Monitoring Network for Seawater Intrusion

The seawater intrusion monitoring network uses the same monitoring wells and monitoring strategies as the groundwater quality representative monitoring network. Chloride concentrations will be monitored at the degraded water quality representative monitoring networks wells to develop a chloride isocontour line (see Section 4.2.4.2).

4.3.5 Monitoring Network for Land Subsidence

As described in Section 0, groundwater levels will be used as a proxy for the land subsidence sustainability indicator. As such, sustainable management criteria for land subsidence will be monitored through the groundwater levels monitoring network, described in Section 4.3.1.

4.3.6 Monitoring Network for Depletion of Interconnected Surface Waters

As described in Section 4.2.6, groundwater levels will be used as a proxy for the depletion of interconnected surface water sustainability indicator. As such, sustainable management criteria for interconnected surface water will be monitored through the groundwater levels monitoring network, described in Section 4.3.1.

4.3.7 Data Gaps

Groundwater level monitoring data gaps exist in areas where data is limited. Specifically, areas of high data needs include monitoring near streams, Subbasin boundaries, and the central area of groundwater depression. Additionally, areas without multiple completion wells present limitation to information collection. Additional sampling taken within these identified areas will provide more information about groundwater levels and trends in the indicated locations.

Groundwater quality monitoring data gaps have three components:

1. **Spatial Distribution:** Monitoring wells are mainly focused in the western portion of the Subbasin, as this area has historically had the highest concentrations of TDS. Additional sampling performed within these identified areas will provide more information about salinity in the indicated locations.

2. **Well construction data:** As shown in Appendix X, the majority of groundwater quality monitoring wells are screened in intervals between 100 to 300 feet bgs. Only one well is screened below this interval, to a depth of 467 feet bgs. Both deeper and shallower groundwater quality monitoring wells are needed to better understand the spatial distribution of salinity concentrations in the Subbasin.
3. **Monitoring Frequency:** Temporally, groundwater quality monitoring occurs at different frequencies across the Subbasin, dependent on the monitoring agency responsible (summarized in Table 4-11). The groundwater quality monitoring network under the GSP will utilize a standardized, quarterly monitoring schedule to ensure all wells are sampled regularly.

4.3.7.1 Plan to Fill Data Gaps

Data gaps will be filled by leveraging existing wells and by constructing new wells through TSS funding, future grant funding, and GSA funding. In total, there are 12 proposed new monitoring well sites (Figure 4-7); these wells will also be measured for groundwater levels and groundwater quality. Two of these wells will be built using funding awarded to the Subbasin by DWR's Technical Support Services (TSS) program. The TSS program provides support to GSAs during GSP development. The two new wells drilled using DWR's TSS funding will improve the density and sampling frequency for groundwater quality monitoring within data gap areas. The remaining ten wells will be funded by the GWA. The new wells are distributed throughout the Subbasin and increase coverage near streams, Subbasin boundaries, and in the central area of groundwater depression.

The DWR's USGS *National Field Manual for the Collection of Water Quality Data* will be used as a guide for installing new monitoring wells, as recommended by DWR's BMP (DWR, 2010). Requirements are summarized in Table 4-13. The DWR's *California Well Standards, Bulletin 74-90 (Supplement to Bulletin 74-81)* will also be used.

Figure 4-7: Proposed New Monitoring Well Locations (Shown in Orange)

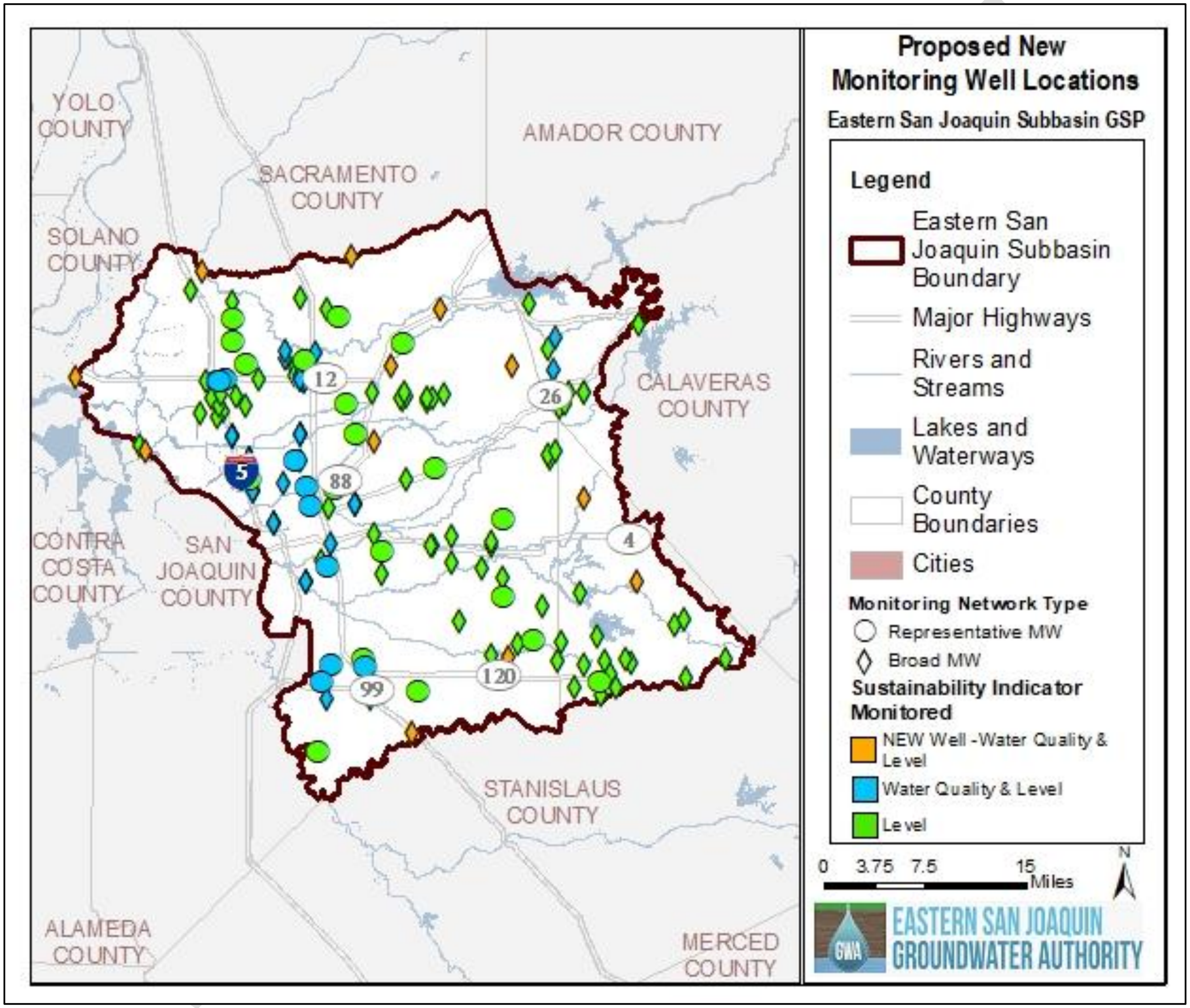


Table 4-13: Considerations for Well Selection and Well Installation

Well Location
• Location conforms to the study's network design for areal and depth distribution. • Land-use/land-cover characteristics, if relevant, are consistent with study objectives. • Site is accessible for equipment needed for well installation and sample collection.
Hydrogeologic Unit(s)
• Hydrogeologic unit(s) that contribute water to the well can be identified. • Depth and thickness of targeted hydrogeologic unit(s) are known or can be determined. • Yield of water is adequate for sampling (typically, a minimum of 1 gallon (3.785 liters) per minute).
Well Records, Description, Design, Materials, and Structure
• Available records (for example, logs of well drilling, completion, and development) have sufficient information to meet the criteria established by the study. • Borehole or casing/screen diameter is adequate for equipment. • Depth to top and bottom of sample-collection (open or screened) interval is known (to determine area contributing water to well). • Length of well screen is proportional to the vertical and areal scale of investigation. • Well has only one screened or open interval in one aquifer, if possible. (Packers can be used to isolate the interval of interest, but packers might not completely isolate zones in unconsolidated or highly fractured aquifers. If packers are used, materials of construction must be compatible with analytes to be studied.) • Top of well screen is several feet below mean annual low-water table to reduce chances of well going dry and to avoid sampling from unsaturated intervals. • Filter pack is of a reasonable length (a long interval compared with length of screened or open interval usually results in uncertainty as to location of the source of water to well). • Well-construction materials do not leach or sorb substances that could alter ambient target-analyte concentrations. • Well-structure integrity and communication with the aquifer are sound. (Checks include annual depth-to-bottom measurements, borehole caliper and downhole-camera video logs, and aquifer tests.)
Pump Type, Materials, Performance, and Location of Sampler Intake
• Supply wells have water-lubricated turbine pumps rather than oil-lubricated turbine pumps. (Avoid suction-lift, jet, or gas-contact pumps, especially for analytes affected by pressure changes, exposure to oxygen, or that partition to a gas phase.) • Pump and riser-pipe materials do not affect target-analyte concentrations. • Effects of pumping rate on measurements and analyses have been or will be evaluated. • Samples intake is ahead of where water enters treatment systems, pressure tanks, or holding tanks.

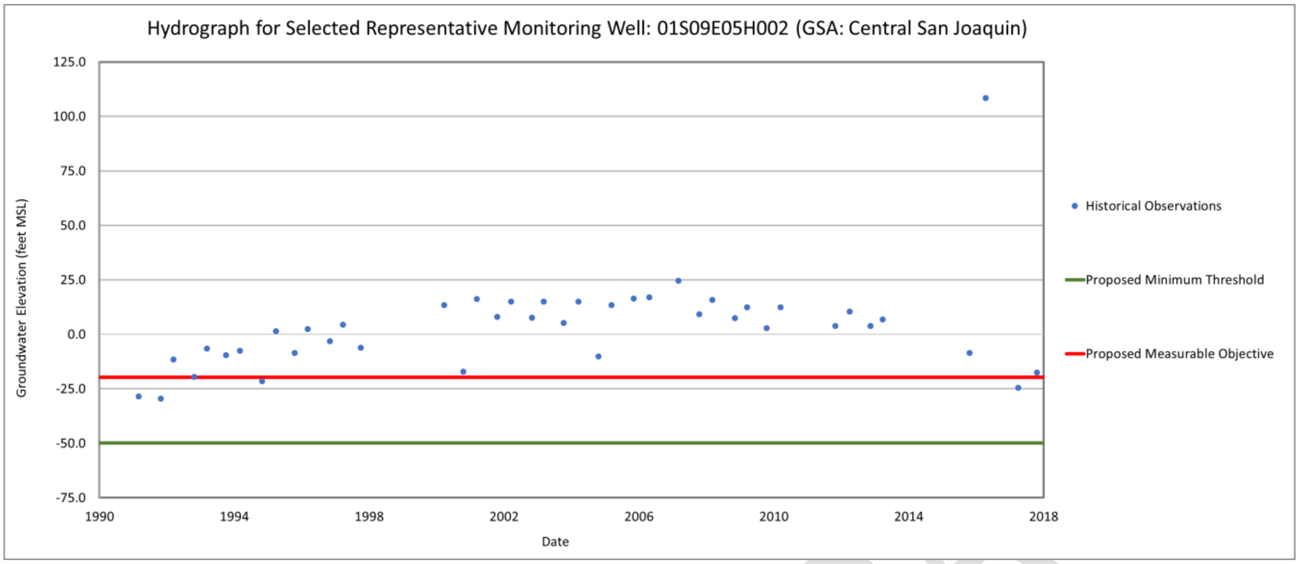
Source: (Wilde)

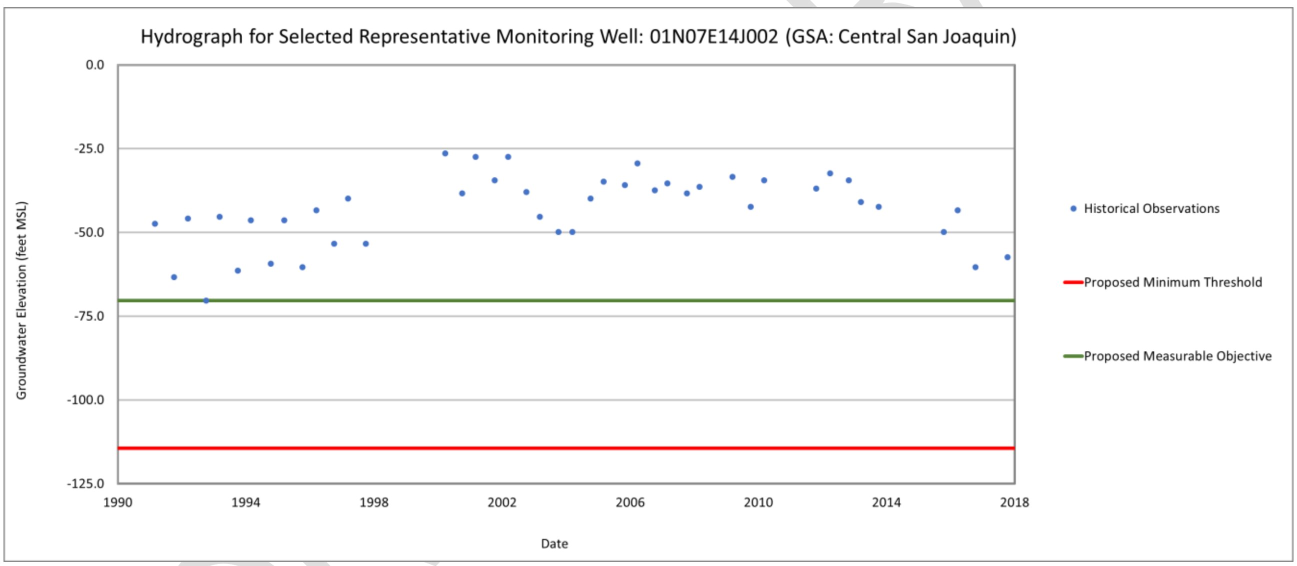
APPENDIX A. SUPPLEMENTAL DATA FOR CHRONIC LOWERING OF GROUNDWATER LEVELS MINIMUM THRESHOLDS

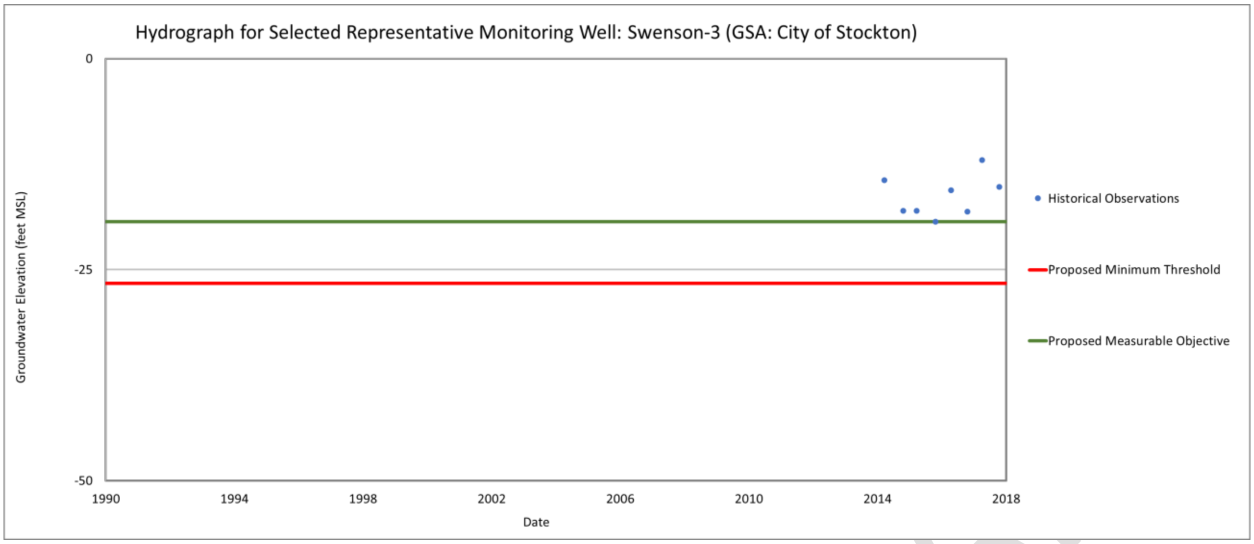
CASGEM ID	Local ID	GSA Well is Located In	Historical Drought Low (1992 or 2015-16) (ft bgs)	Historical Drought Low (1992 or 2015-16) (ft msl)*	Year of Historical Drought Low	Total Well Depth (ft bgs)	Calculated Buffer (ft msl)*	Depth of 10th Percentile Nearby Domestic Well (ft bgs)	Depth of 10th Percentile Nearby Domestic Well (ft msl)*	Historical Drought Low + Buffer (DTW) (ft bgs)	Historical Drought Low + Buffer (ft msl)*	Proposed Minimum Threshold (ft msl)*	Proposed Measurable Objectives (ft msl)*	Average Groundwater Elevation (ft msl)*	Current Groundwater Elevation (ft msl)*
378824N1210000W001	01S09E05H002	Central San Joaquin Water Conservation District	127.0	-19.7	1992	-	54.3	150.4	-49.8	181.3	-74.0	-49.8	-19.7	0.7	-17.6
379316N1211665W001	01N07E14J002	Central San Joaquin Water Conservation District	124.0	-70.4	1992	176.0	44.0	149.0	-129.0	168.0	-114.4	-114.4	-70.4	-43.5	-57.4
380067N1213458W003	Swenson-3	City of Stockton	23.3	-19.3	2015	-	7.3	100.0	-97.4	30.6	-26.6	-26.6	-19.3	-16.3	-15.2
380206N1210943W001	02N08E15M002	Linden County Water District	153.5	-69.7	2016	403.0	74.5	205.0	-124.1	228.0	-144.2	-124.1	-69.7	-41.7	-69.7
Not in CASGEM	#3 Bear Creek	Lockeford Community Services District	146.0	-50.3	2016	-	22.0	168.0	-122.9	168.0	-72.3	-72.3	-50.3	-45.6	-46.3
Not in CASGEM	Lodi City Well #2	City of Lodi	56.6	-4.9	1992	-	35.0	96.0	-56.3	91.6	-39.9	-39.9	-4.9	13.8	0.6
Not in CASGEM	Manteca 18	City of Manteca	41.0	5.1	2015 & 2016	-	21.8	100.0	-58.2	62.8	-16.7	-16.7	5.1	10.8	7.1
381843N1212261W001	04N07E20H003M	North San Joaquin Water Conservation District	114.2	-36.7	2016	180.0	45.0	138.0	-110.3	159.2	-81.7	-81.7	-36.7	-16.1	-32.8
380909N1212153W001	03N07E21L003	North San Joaquin Water Conservation District	117.0	-59.0	2016	-	43.5	156.4	-109.4	160.5	-102.5	-102.5	-59.0	-36.5	-59.0
Not in CASGEM	Hirschfeld (OID-8)	Oakdale Irrigation District	100.5	31.5	2015	-	23.6	144.0	-11.5	124.1	8.0	8.0	31.5	44.2	31.8
377909N1208675W001	Burnett (OID-4)	Oakdale Irrigation District	108.2	79.7	2015	249.0	18.9	135.0	28.2	127.1	60.8	60.8	79.7	90.1	80.1
377136N1212508W001	02S07E31N001	South Delta Water Agency	11.0	13.0	1992	226.0	11.5	95.0	-62.5	22.5	1.5	1.5	13.0	14.6	16.0
377810N1211142W001	02S08E08A001	South San Joaquin GSA	49.4	24.0	2016	180.0	23.4	104.0	-42.2	72.8	0.6	0.6	24.0	29.1	23.0
380578N1212017W001	02N07E03D001	Stockton East Water District	137.0	-80.0	2016	484.0	52.0	170.0	-122.8	189.0	-132.0	-122.8	-80.0	-46.0	-71.7
379661N1210011W001	01N09E05J001	Stockton East Water District	207.0	-53.5	1992	750.0	120.2	198.0	-86.8	327.2	-173.7	-86.8	-53.5	-15.2	-16.3
379976N1212308W001	02N07E29B001	Stockton East Water District	122.5	-80.4	1992	202.0	60.6	165.0	-130.1	183.1	-141.0	-130.1	-80.4	-51.7	-47.4
381559N1213727W001	04N05E36H003	Woodbridge Irrigation District	30.0	-7.5	2015	112.0	26.0	83.0	-63.9	56.0	-33.5	-33.5	-7.5	5.6	6.4
381317N1213524W001	03N06E05N003	Woodbridge Irrigation District	42.0	-16.5	2015	292.0	21.0	77.4	-55.3	63.0	-37.5	-37.5	-16.5	-8.6	-7.0
381816N1213723W001	04N05E24J004	Woodbridge Irrigation District	30.0	-8.6	2015	190.0	25.0	75.5	-65.5	55.0	-33.6	-33.6	-8.6	3.5	5.3

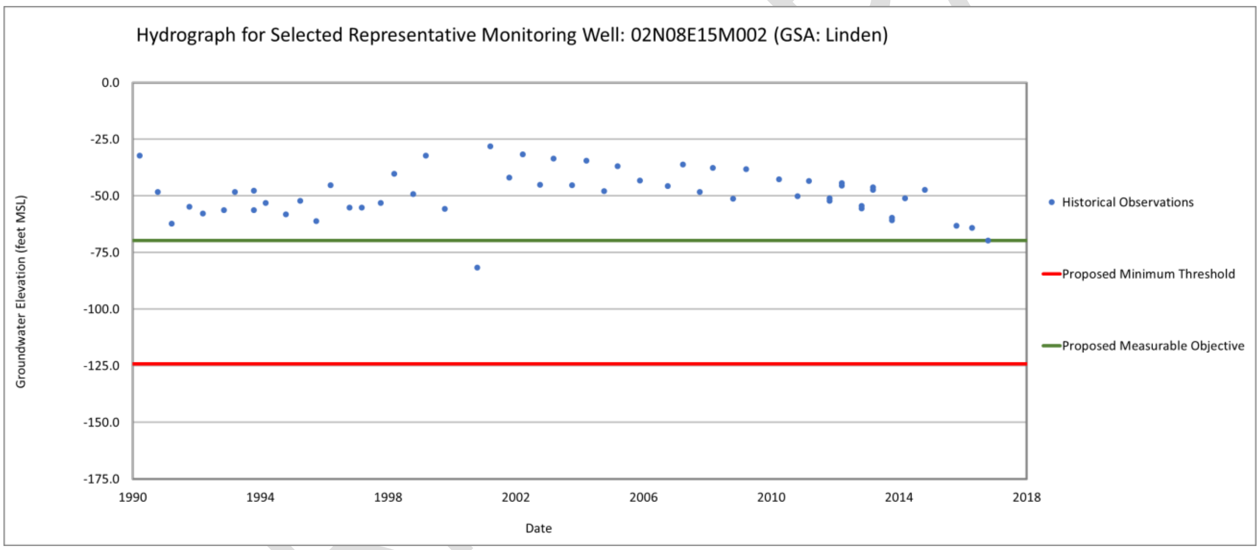
*Groundwater elevation levels are reported in feet MSL

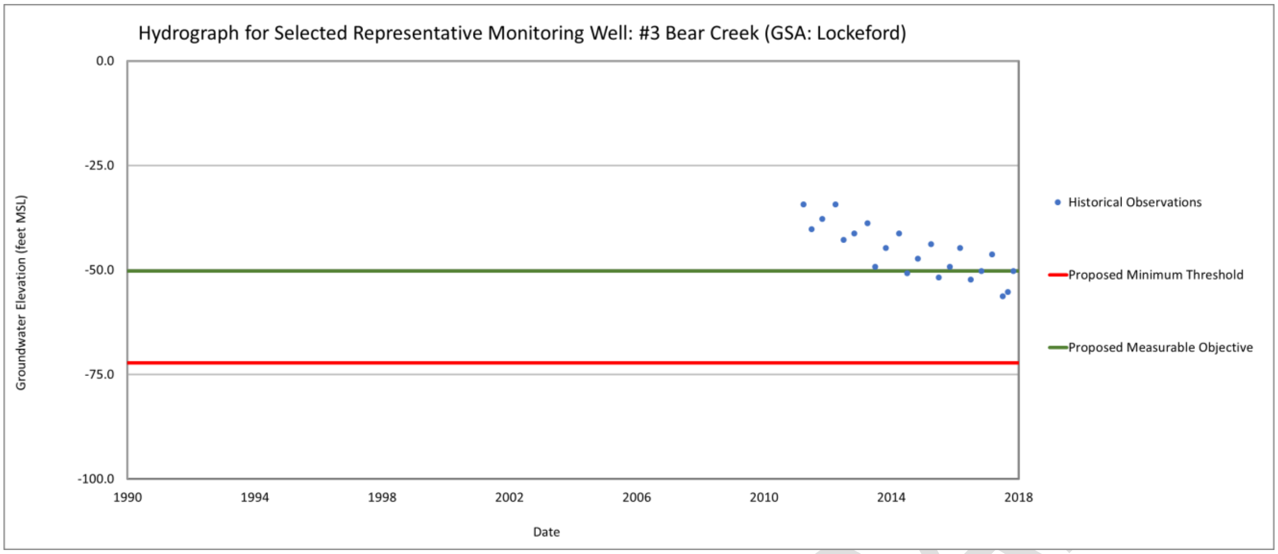
APPENDIX B. GROUNDWATER LEVEL REPRESENTATIVE MONITORING WELL HISTORICAL HYDROGRAPHS

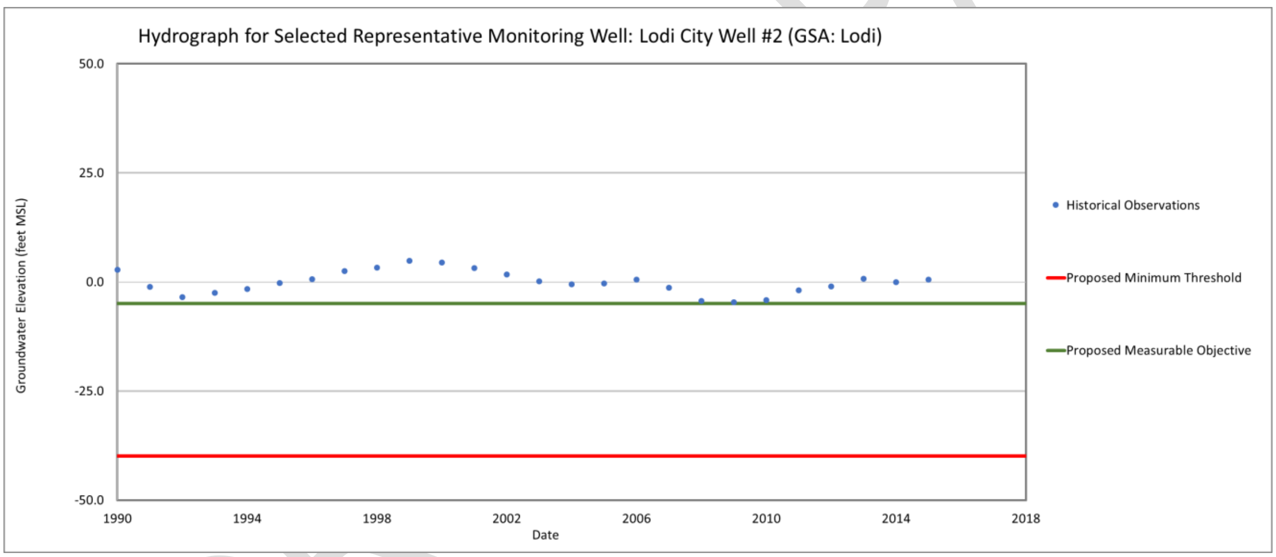

Hydrograph for Selected Representative Monitoring Well: 01S09E05H002 (GSA: Central San Joaquin)
Groundwater Elevation (feet MSL)
125.0
100.0
75.0
50.0
25.0
0.0
-25.0
-50.0
-75.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

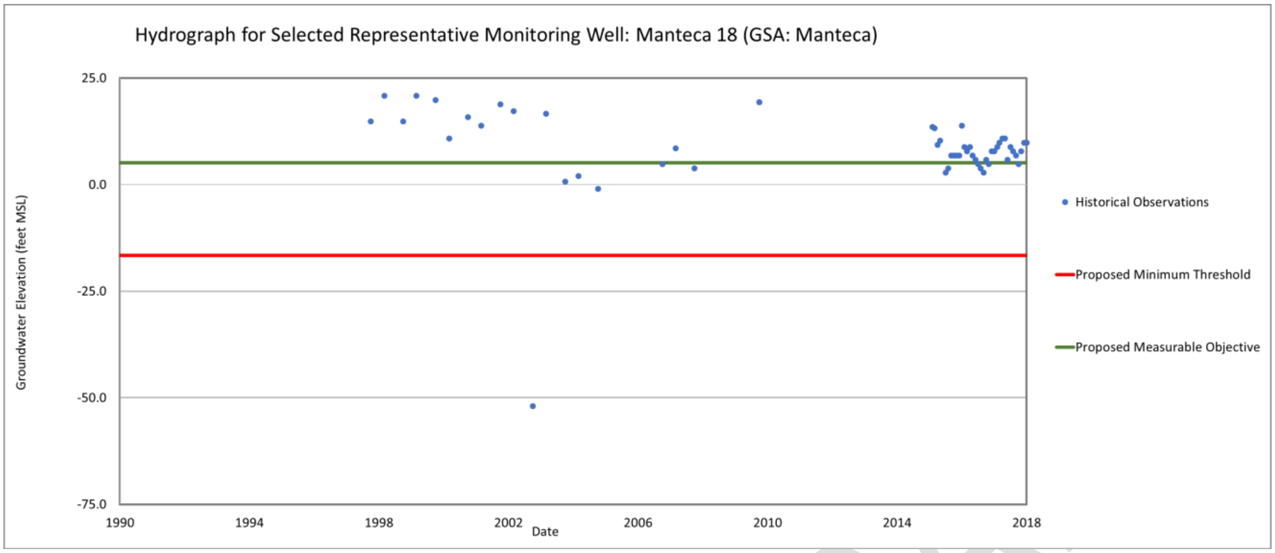

Hydrograph for Selected Representative Monitoring Well: 01N07E14J002 (GSA: Central San Joaquin)
Groundwater Elevation (feet MSL)
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

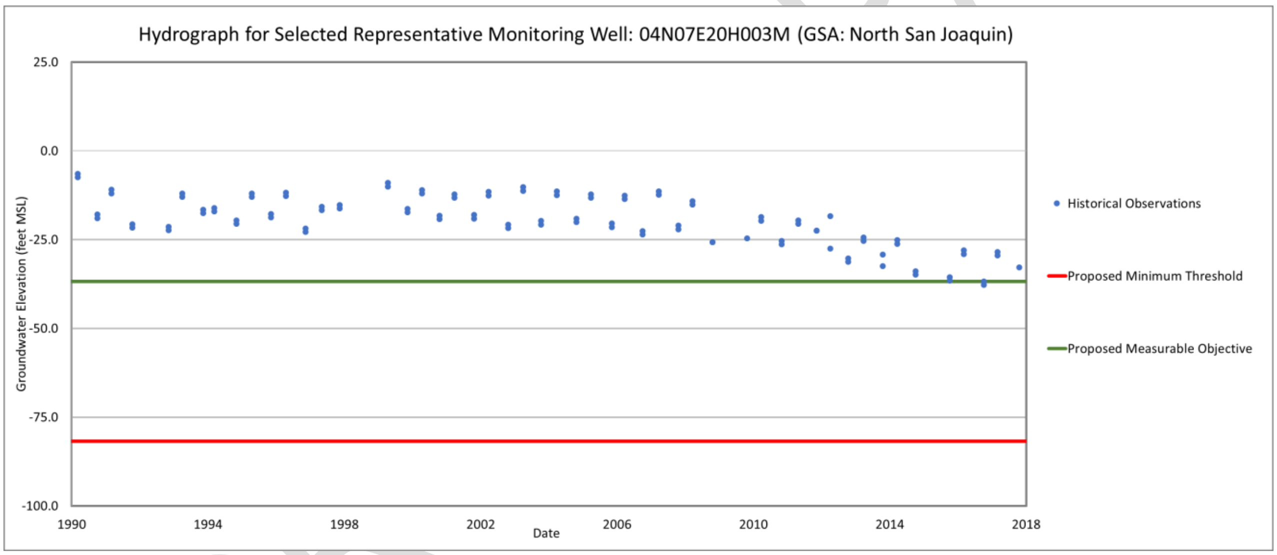

Hydrograph for Selected Representative Monitoring Well: Swenson-3 (GSA: City of Stockton)
Groundwater Elevation (feet MSL)
0
-25
-50
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

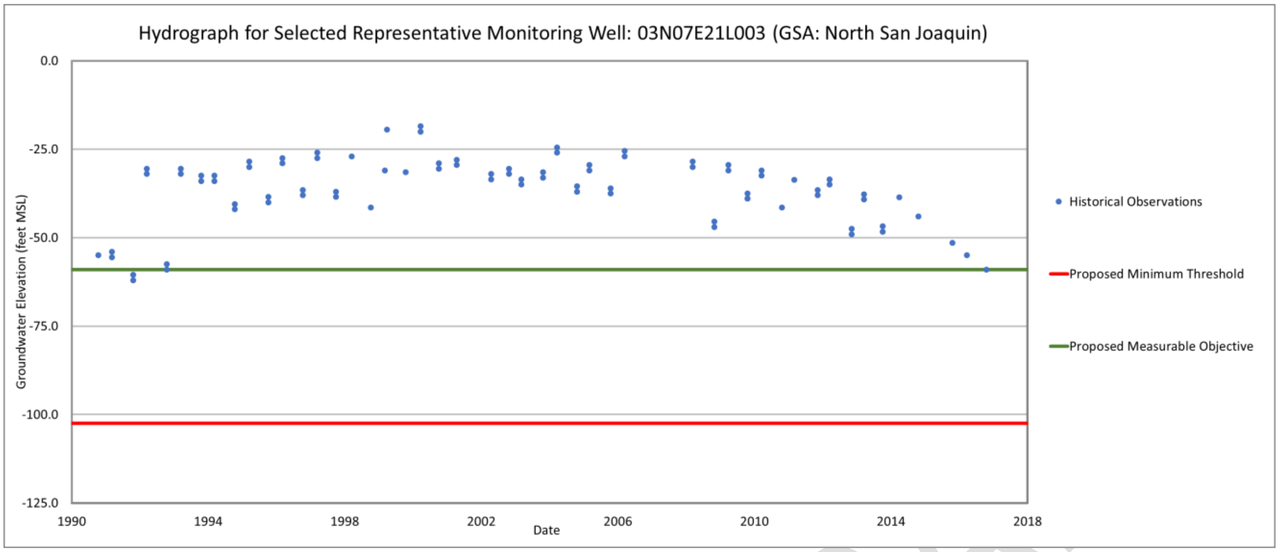

Hydrograph for Selected Representative Monitoring Well: 02N08E15M002 (GSA: Linden)
Groundwater Elevation (feet MSL)
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
-175.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

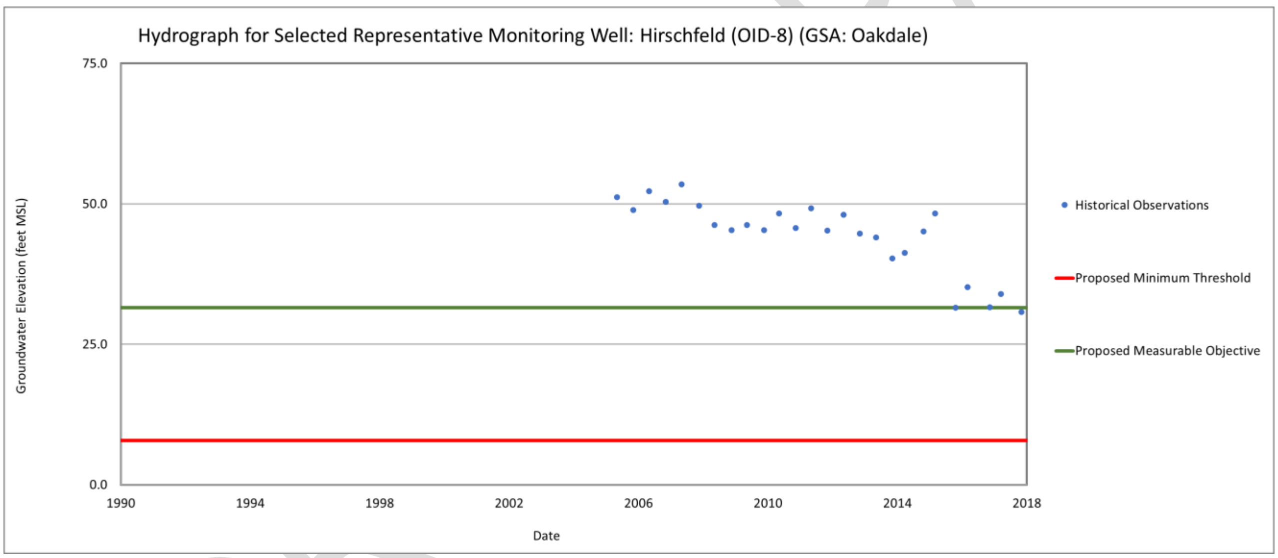

Hydrograph for Selected Representative Monitoring Well: #3 Bear Creek (GSA: Lockeford)
Groundwater Elevation (feet MSL)
0.0
-25.0
-50.0
-75.0
-100.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

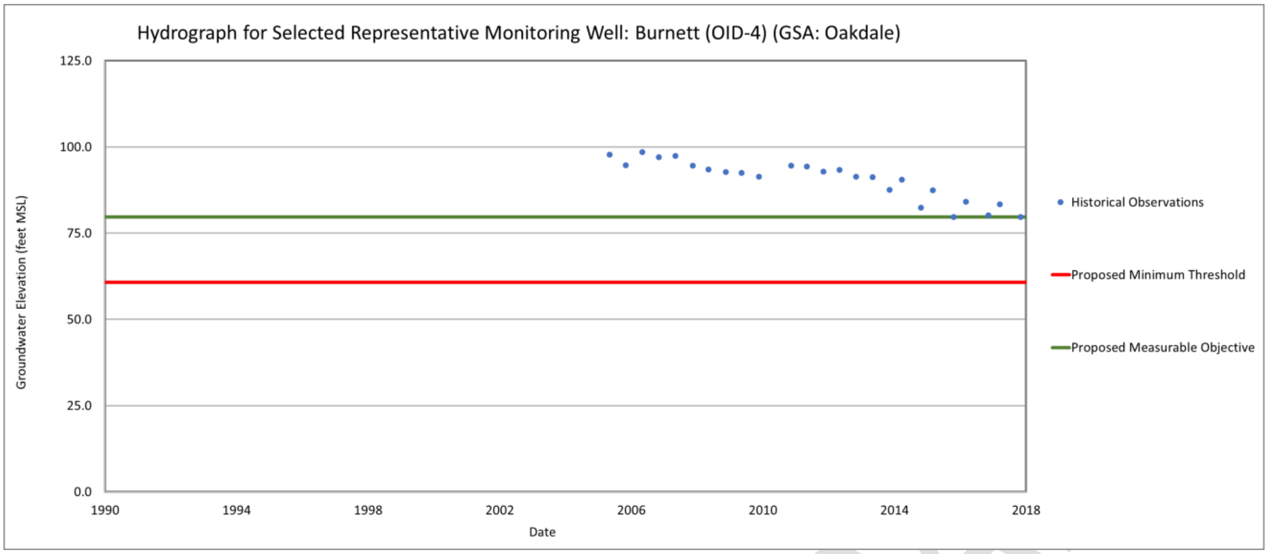

Hydrograph for Selected Representative Monitoring Well: Lodi City Well #2 (GSA: Lodi)
Groundwater Elevation (feet MSL)
50.0
25.0
0.0
-25.0
-50.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

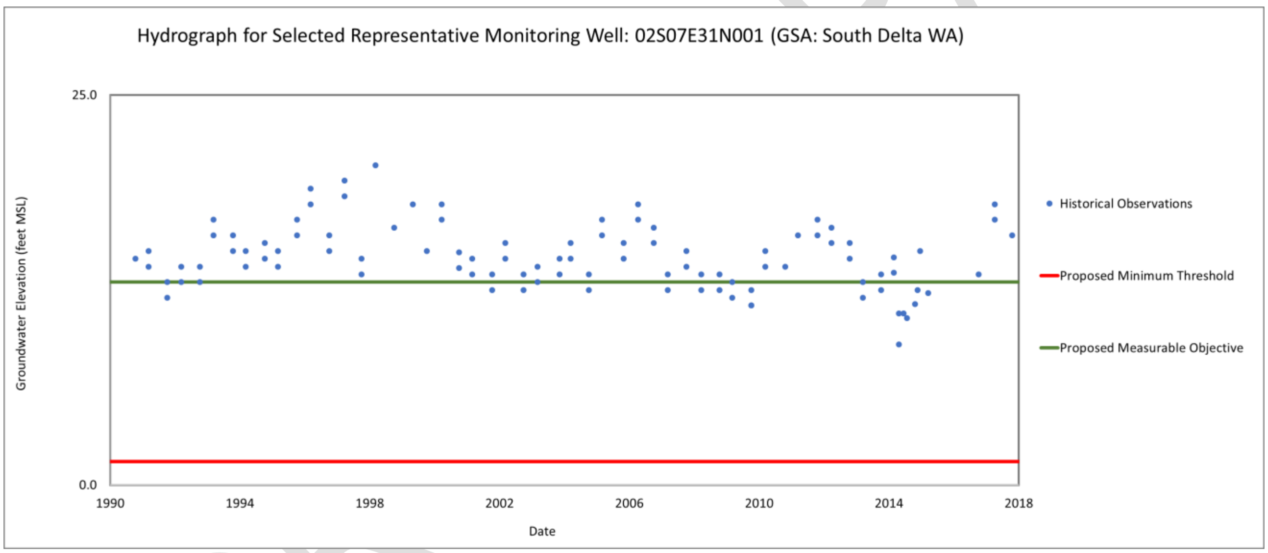

Hydrograph for Selected Representative Monitoring Well: Manteca 18 (GSA: Manteca)
25.0
0.0
-25.0
-50.0
-75.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

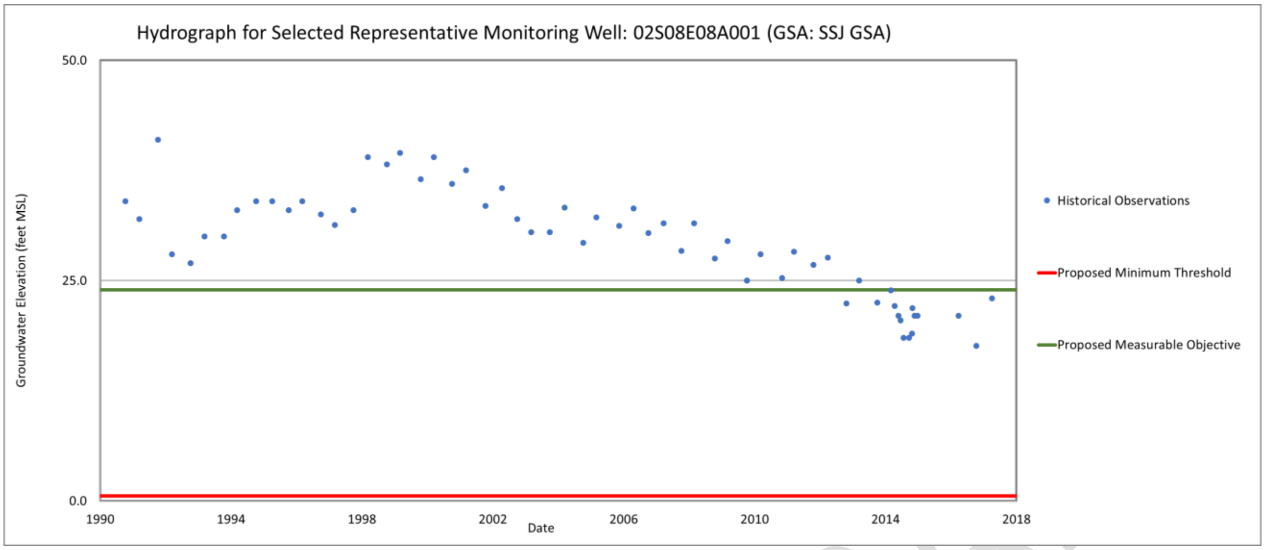

Hydrograph for Selected Representative Monitoring Well: 04N07E20H003M (GSA: North San Joaquin)
25.0
0.0
-25.0
-50.0
-75.0
-100.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

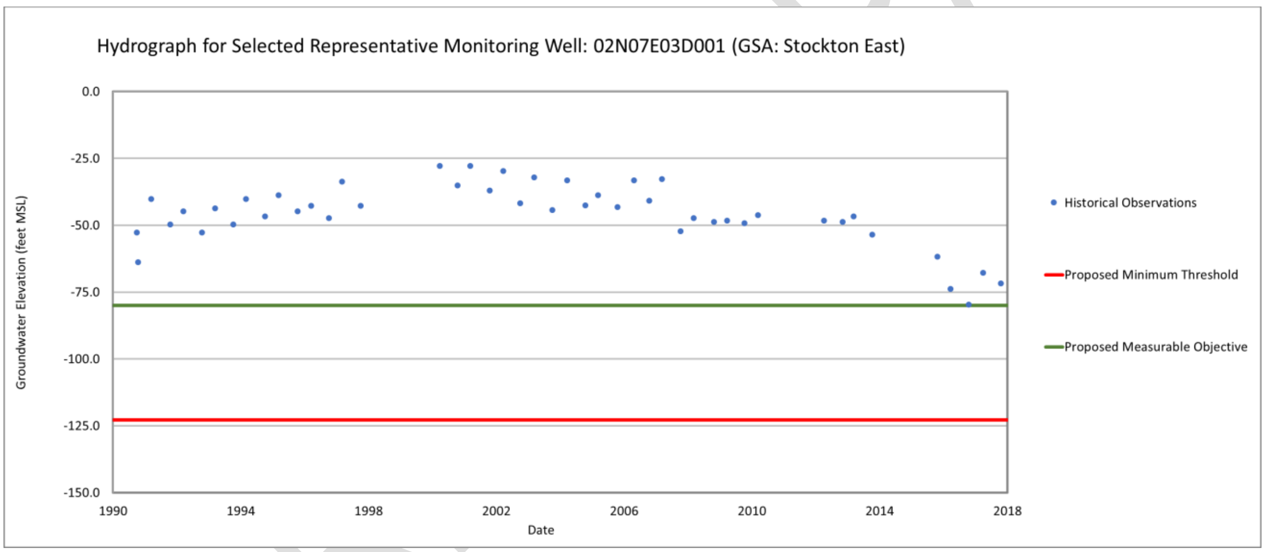

Hydrograph for Selected Representative Monitoring Well: 03N07E21L003 (GSA: North San Joaquin)
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

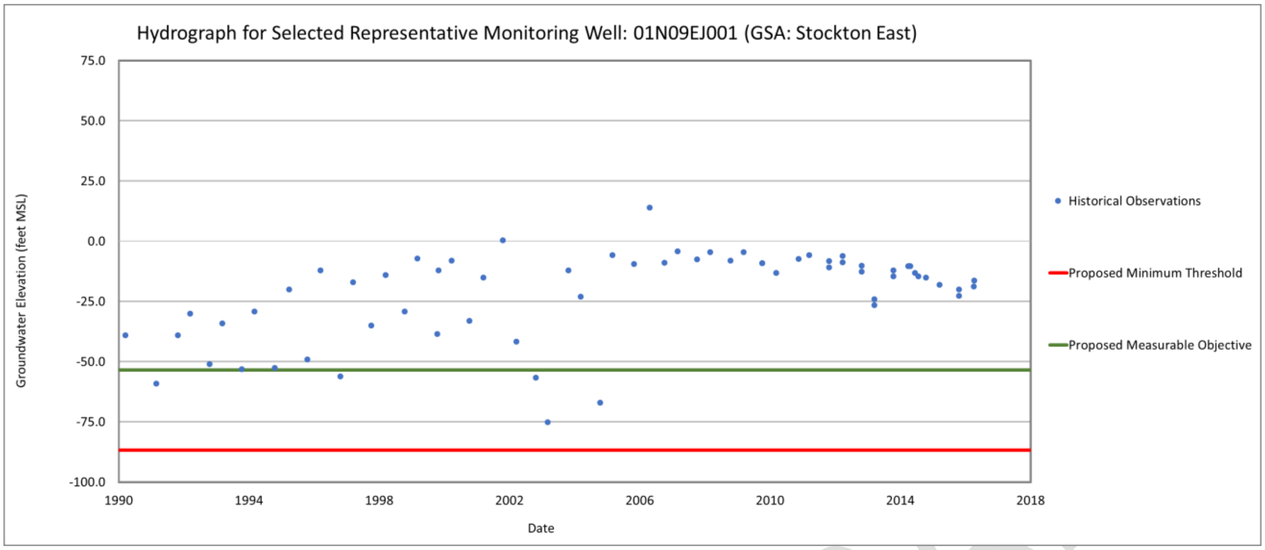

Hydrograph for Selected Representative Monitoring Well: Hirschfeld (OID-8) (GSA: Oakdale)
75.0
50.0
25.0
0.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

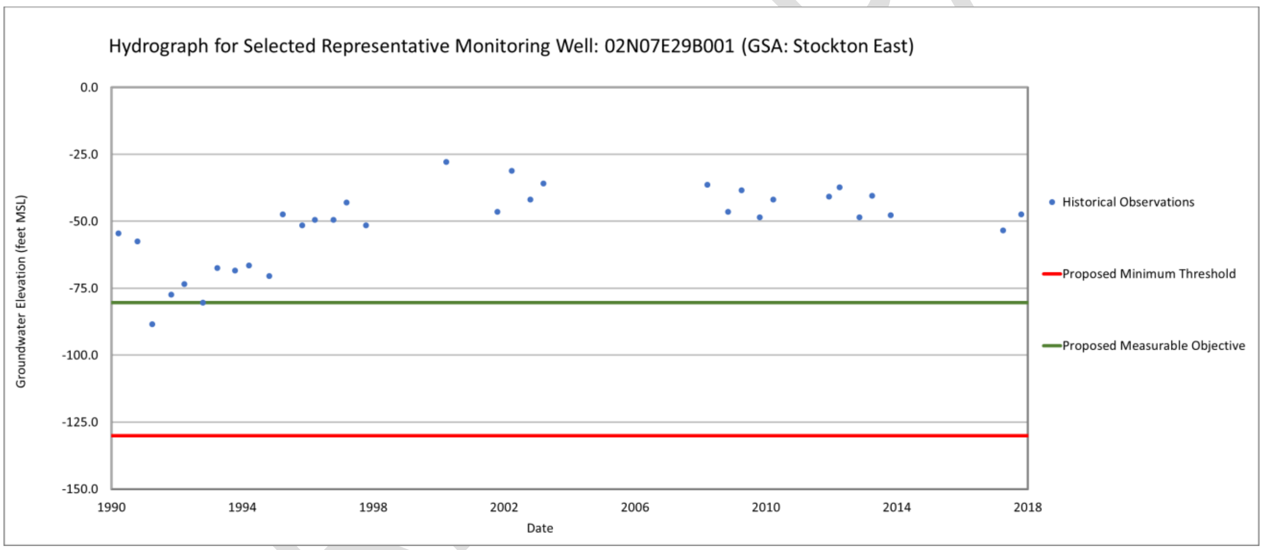

Hydrograph for Selected Representative Monitoring Well: Burnett (OID-4) (GSA: Oakdale)
Groundwater Elevation (feet MSL)
125.0
100.0
75.0
50.0
25.0
0.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

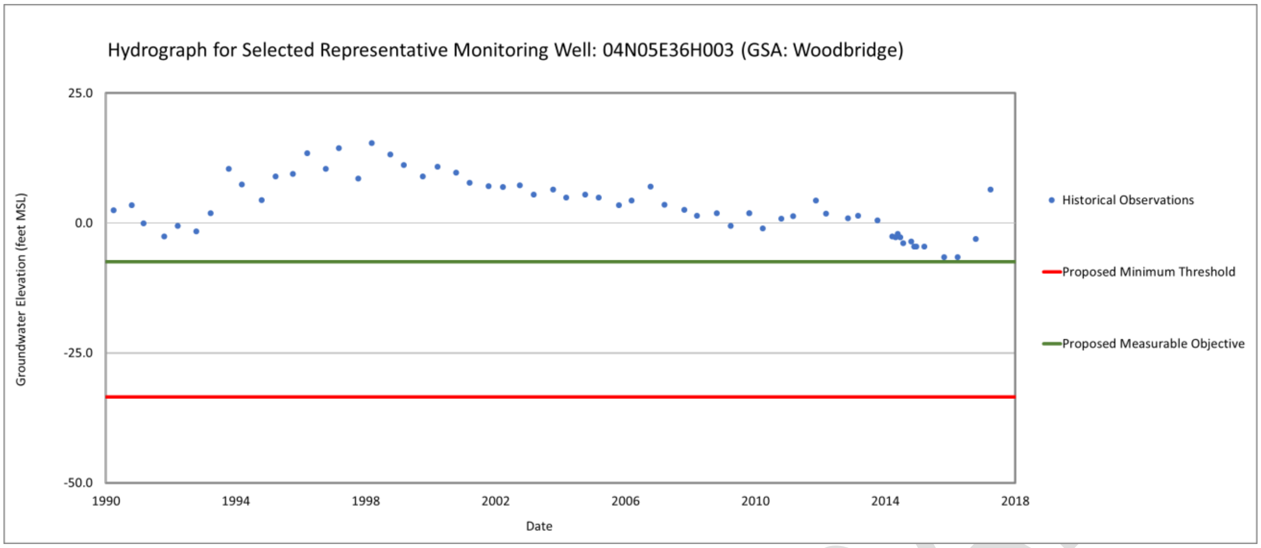

Hydrograph for Selected Representative Monitoring Well: 02S07E31N001 (GSA: South Delta WA)
Groundwater Elevation (feet MSL)
25.0
0.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

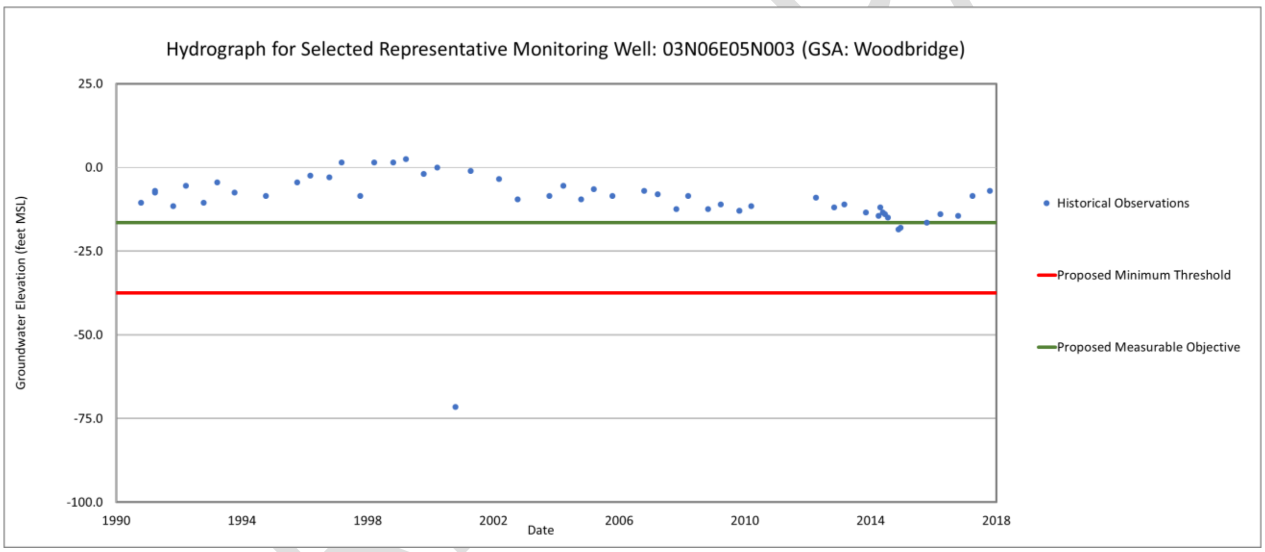

Hydrograph for Selected Representative Monitoring Well: 02S08E08A001 (GSA: SSJ GSA)
Groundwater Elevation (feet MSL)
50.0
25.0
0.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective

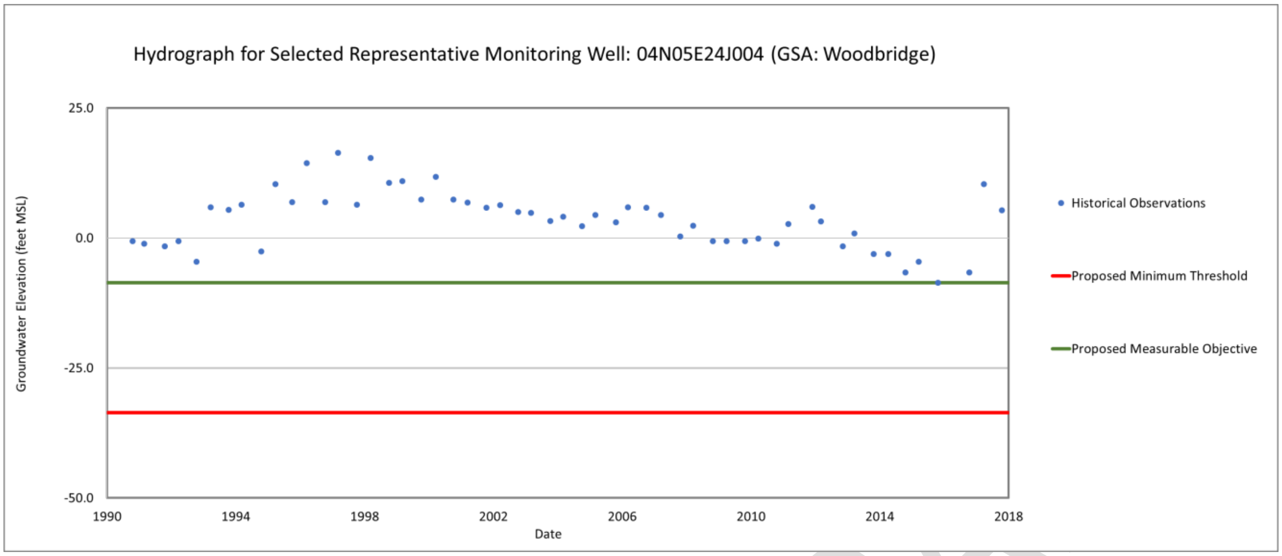

Hydrograph for Selected Representative Monitoring Well: 02N07E03D001 (GSA: Stockton East)
Groundwater Elevation (feet MSL)
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective


Hydrograph for Selected Representative Monitoring Well: 01N09EJ001 (GSA: Stockton East)
75.0
50.0
25.0
0.0
-25.0
-50.0
-75.0
-100.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective


Hydrograph for Selected Representative Monitoring Well: 02N07E29B001 (GSA: Stockton East)
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective


Hydrograph for Selected Representative Monitoring Well: 04N05E36H003 (GSA: Woodbridge)
25.0
0.0
-25.0
-50.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective


Hydrograph for Selected Representative Monitoring Well: 03N06E05N003 (GSA: Woodbridge)
25.0
0.0
-25.0
-50.0
-75.0
-100.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective


Hydrograph for Selected Representative Monitoring Well: 04N05E24J004 (GSA: Woodbridge)
25.0
0.0
-25.0
-50.0
Groundwater Elevation (feet MSL)
1990
1994
1998
2002
2006
2010
2014
2018
Date
Historical Observations
Proposed Minimum Threshold
Proposed Measurable Objective