Section 4. Monitoring Networks

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4.1 Introduction to Monitoring Networks § 354.32

The GSAs in the Tule subbasin have prepared a coordinated Monitoring Plan, the Tule Subbasin Monitoring Plan (the TSMP), **Attachment 1** to this GSP. This section of the GSP summarizes the TSMP and details the portions of the TSMP for each sustainability indicator applicable to the Tule Subbasin that are within the Agency.

4.2 Monitoring Network

4.2.1 Monitoring Network Objective § 354.34(a); § 354.34(b)

The objectives used in developing the subbasin monitoring plan are provided in **Chapter 1.1** of Attachment 1 TSMP.

4.2.1.1 Progress Towards Achieving Measurable Objective § 354.34(b)(1); § 354.34(b)(2); § 354.34(b)(3); § 354.34(b)(4)

Annually the Agency will prepare reports documenting the results from the prior year monitoring activities. Utilizing the data collected each year, the Tule Subbasin Data Management System will be updated to enable analysis of groundwater conditions and progress toward achieving sustainability goals.

Each year during the Plan implementation period, results from annual monitoring will be compared to the interim milestones and minimum threshold numerical targets established in Section 3 of this Plan. If measured data indicates an exceedance of an interim milestone, the Agency may make adjustments to the Project and Management Actions described under **Section 5** to keep the GSA on track toward meeting sustainability goals.

Minimum thresholds, interim milestones, and measurable objectives were established at each RMS within the Agency and the quantitative values for minimum thresholds and measurable objectives are provided in **Section 3.5** of this Plan. Criteria for selecting RMS were based on the Agency's established management areas which correlate to the beneficial users of groundwater within the area. Additional discussion for potential impacts to beneficial users of groundwater relative to the established minimum threshold for each of the applicable sustainability indicators is provided in **Section 1.4.3**, **Section 2.5,** and **Section 3.5** of this Plan.

4.2.2 Monitoring Network Design § 354.34(j)

The Agency monitoring network has been established to monitor data from the four (4) sustainability indicators that may have the potential to cause significant and unreasonable effects within the Tule Subbasin (defined in **Section 3.4**), including:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage;
- Degraded water quality, and

- Land subsidence.

The sustainability indicators of seawater intrusion and depletion of interconnected surface water are not applicable to the Agency. One sustainability indicator, seawater intrusion, does not apply within the Tule Subbasin (defined in the Tule Subbasin Setting, **Attachment 2)**. For depletion of interconnected surface water (ISW), a preliminary monitoring network for the Subbasin has been developed (see ***Attachment 6***, *Tule Subbasin Interconnected Surface Water*) though RMSs and Sustainable Management Criteria (SMCs) have not been established.

The following sections provide a brief summary of the process, information, and procedures that were incorporated into the development of the Agency monitoring network and is supported by the TSMP, which was developed for all GSAs within the Tule Subbasin to meet the requirements of SGMA regulation pertaining to the monitoring networks.

The TSMP is intended to adapt to the data being collected, allowing for the addition or removal of monitoring features, changes in monitoring frequency, and updates to alternative monitoring methodologies, as the monitoring evolves during the Plan Implementation period.

4.2.2.1 Monitoring Network Rationale § 354.34(g)(1)(3)

The rationale and process for selecting RMS is described in **Chapter 2.0** of Attachment 1 TSMP relative to the sustainability indicator being described.

The minimum thresholds, measurable objectives, and interim milestones for the four (4) applicable sustainability indicators have been established at the RMS within Agency management areas and the quantitative values are listed in **Section 3.5** of this Plan.

4.2.2.2 Spatial Density and Frequency of Measurement § 354.34(d); § 354.34(f)(1); § 354.34(f)(2); § 354.34(f)(3); § 354.34(h)

The locations of RMS sites in the subbasin are provided in **Figure A1-2**, **Figure A1-3**, and **Figure A1-4** with additional details listed in **Table A1-1, Table A1-2, Table A1-3,** and **Table A1-6** of Attachment 1 TSMP.

The criteria considered during the selection of RMS location included primarily: aquifer characteristics, current and projected groundwater uses, and beneficial uses and users of groundwater and are discussed throughout **Chapter 2.0** of Attachment 1 TSMP for each sustainability indicator.

Existing monitoring features and monitoring network wells were utilized as RMS if the technical data of these sites was adequate for the purposes of the monitoring network under this Plan. The areas where existing monitoring features and networks did not provide adequate coverage of sustainability indicators were identified as data gaps in **Chapter 4.0** of Attachment 1 TSMP, and recommended monitoring features needed to assess data gaps were provided.

The locations and frequency measurements of Agency RMS sites are described in **Section 4.2.3** of this GSP.

4.2.2.3 Monitoring Protocols and Reporting Standards § 354.34(g)(2); § 354.34(i)

Monitoring protocols relative to each sustainability indicator are described in **Chapter 2.0** of Attachment 1 TSMP. Additionally, a subbasin-wide data management system (DMS) is described (see **Chapter 5.0**, Attachment 1 TSMP) to provide a consistent database amongst the Tule Subbasin GSAs for data and reporting standards.

4.2.2.4 Existing Monitoring § 354.34(e); § 354.34(f)(4)

Existing water resource monitoring and management programs specific to the Agency that were incorporated into the TSMP were introduced and described in **Section 1.4.9** of this Plan. **Table A1-7** in **Chapter 5.3** of Attachment 1 *TSMP* lists existing data sources and monitoring programs that are coordinated with the Tule Subbasin monitoring networks.

4.2.3 Representative Monitoring § 354.36(a); § 354.36(b)(1); § 354.36(b)(2); § 354.34(c)

Chapter 3.0 of Attachment 1 TSMP describes representative monitoring in the Tule Subbasin by identifying one or more RMS within each management area for monitoring one or multiple sustainability indicators. **Section 4.2.3.1** through **Section 4.2.3.6** of this Plan references the TSMP chapter for the corresponding sustainability indicator and further provides a list of each RMS in the Agency.

As noted in **Section 2.5** of this Plan, the Agency is not subdivided into separate management areas**.**

4.2.3.1 Chronic Lowering of Groundwater Levels § 354.34(c)(1)(A); § 354.34(c)(1)(B)

Groundwater levels will be monitored as described in **Chapter 2.1** of Attachment 1 TSMP*.* The Agency will monitor groundwater levels at RMS within the Agency shown on **Figure 4-1**. The methods used to establish the RMS and the frequency of monitoring are discussed in **Chapter 3.1** of Attachment 1 TSMP. Existing and proposed RMS identified for monitoring groundwater levels in the upper and lower aquifer in the Tule Subbasin are included in **Table A1-1** and **Table A1-2** and mapped in **Figure A1-2** and **Figure A1-8** of Attachment 1 TSMP.

Within the Agency,5 RMS have been identified for monitoring groundwater levels semiannually (spring and fall). **Table 4-4** lists these RMS and describes the aquifer the monitoring site is representative of, and well construction details.

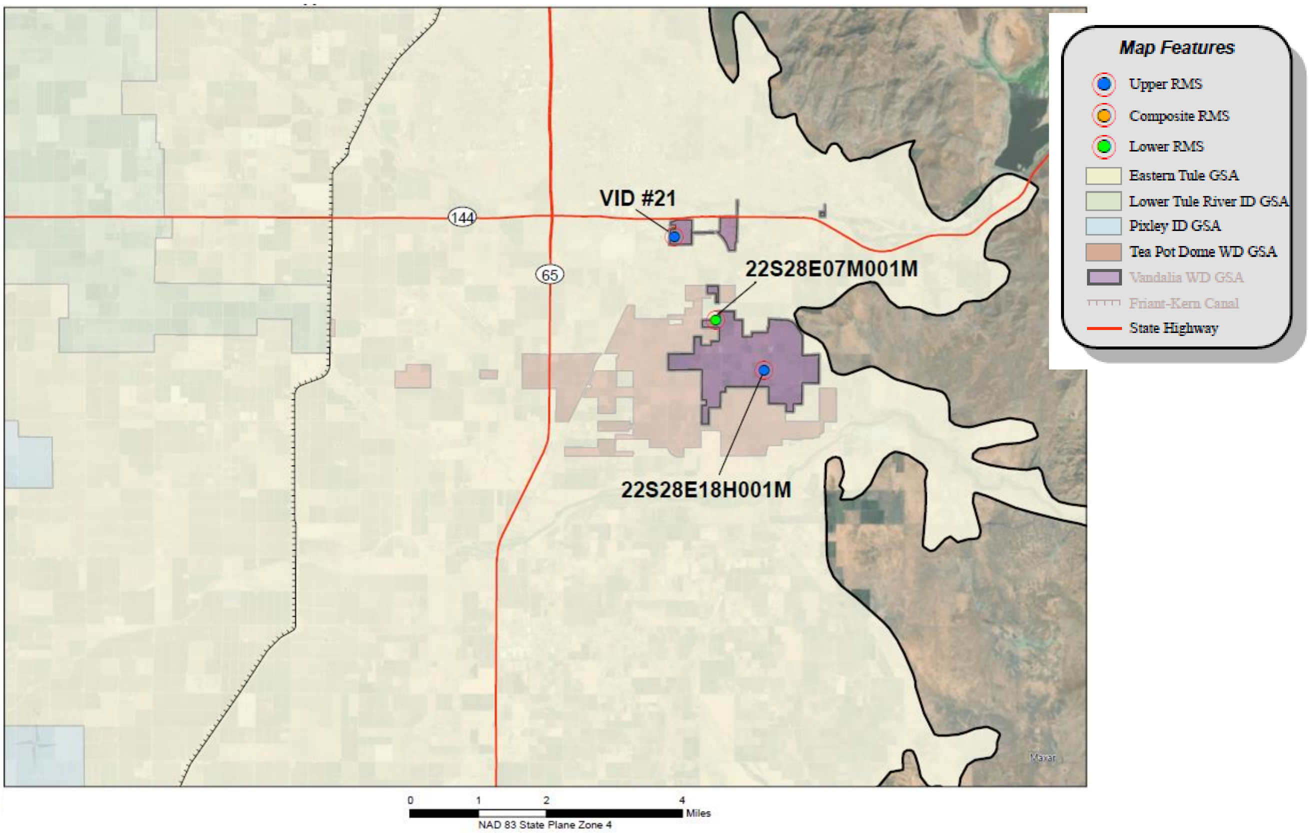

Figure 4-1: RMS for Monitoring Groundwater Levels

Table 4-1: RMS for Monitoring Groundwater Levels

RMS Well ID	Management Area	Aquifer	Total Depth *(ft bgs)*	Top of Screen *(ft bgs)*	Bottom of Screen *(ft bgs)*
VID #21	Vandalia W.D.	Upper	N/A	N/A	N/A
22S/28E-18H001	Vandalia W.D.	Upper	N/A	N/A	N/A
22S/28E-07M001	Vandalia W.D.	Lower	N/A	N/A	N/A
ETGSA-01U	Vandalia W.D.	Upper	52	27	47
ETGSA-01L	Vandalia W.D.	Lower	140	120	140

4.2.3.2 Reduction in Groundwater Storage § 354.34(c)(2)

Annual change in groundwater storage within the Agency will be estimated using either of the methods identified in **Section 3.6** of Attachment 2 *Tule Subbasin Coordination Agreement*, utilizing changes in groundwater levels as a proxy for storage change. The estimated change in annual groundwater storage will be estimated for both the upper and lower aquifers.

Upper Aquifer

The change in storage for the upper aquifer will be estimated based on the following equation:

$$V_w = S_y A \Delta h$$

Where:

V_w	=	the volume of groundwater storage change (acre-ft).
S_y	=	specific yield of aquifer sediments (unitless).
A	=	the surface area of the aquifer within the Tule Subbasin/GSA (acres).
Δh	=	the change in hydraulic head (i.e. groundwater level) (feet).

The calculations will be made using a Geographic Information System (GIS) map of the Tule Subbasin discretized into 600-foot by 600-foot grid cells to allow for spatial representation of aquifer-specific yield and groundwater level change.

The areal distribution of specific yield for the Upper Aquifer will be based on the values obtained from the updated calibrated groundwater flow model of the Tule Subbasin.[1]

The areal distribution of change in hydraulic head across the Tule Subbasin will be estimated by plotting the difference in groundwater level at wells that were measured in the fall of two water years and then interpolating the subbasin-wide changes in groundwater levels in GIS using a kriging algorithm. Annual changes in the hydraulic head (groundwater level) at any given location will be assigned to the overlapping grid cell.

The change in groundwater storage will be estimated for each grid cell by multiplying the change in groundwater level by the specific yield and then by the area of the cell.

Lower Aquifer

As the majority of the lower aquifer in the Tule Subbasin is under confined conditions, the change in storage associated with groundwater level changes is a function of the compressibility of the sediments and, to a lesser degree, the compressibility of water. In the Tule Subbasin, prolonged lowering of groundwater levels has resulted in notable subsidence at the land surface, which reflects significant compression of low permeability interbeds (hereafter referred to as aquitards) within the lower aquifer. This compression, which expels water from these aquitards, is considered a negative change in storage.

The annual change in storage for the lower aquifer is equated to the volume of water associated with the compression of aquitards in that year. This approximation is based on the premise that this volume is equal to the volume of land subsidence that occurred during this time. The change in storage of the lower aquifer was estimated based on the following equation:

$$V_w = A \Delta b$$

[1] Thomas Harder & Co., 2021. Update to the Groundwater Flow Model of the Tule Subbasin. Prepared for the Tule Subbasin MOU Group. June 2021.

Where:

V_w	=	the volume of water released from (or taken into) storage (acre-ft).
A	=	the surface area of the aquifer within the Tule Subbasin/GSA (acres).
Δb	=	the change in aquitard thickness (i.e., subsidence) (feet).

The calculations will be made using a GIS map of the Tule Subbasin discretized into 1,000-foot by 1,000-foot grid cells to allow for spatial representation of land subsidence. The change in aquitard storage will be estimated for each grid cell by multiplying the InSAR land subsidence by the area of the cell and then summing the total storage change within the Agency.

4.2.3.3 Seawater Intrusion § 354.34(c)(3)

Seawater intrusion does not occur in the Tule Subbasin for reasons described in **Chapter 2.2.3** of Attachment 2 *Tule Subbasin Setting.*

4.2.3.4 Degraded Water Quality § 354.34(c)(4)

Degraded water quality will be monitored as described in **Chapter 2.4** at the monitoring locations shown in **Figures A1-13 through A1-18** of Attachment 1 TSMP. The Agency will evaluate groundwater quality conditions using data collected under separate groundwater quality regulatory programs. These programs include public water systems, for compliance with the requirements of Title 22[2] Consumer Confidence Reports (CCR), Tule Basin Water Quality Coalition (TBWQC)[3] for compliance with the requirements of General order R5-2013-0120 and other sources that would provide an additional representation of groundwater quality conditions.

The Constituent of Concern (COC) varies depending on the suitability of the groundwater, whether agricultural or drinking water beneficial use associated with the RMS well. Each of the COC to be monitored by the Agency at the RMS wells to serve as indicators for changes in groundwater quality are identified in **Section 3.4.3.4.**

The analysis used to determine the beneficial uses at each RMS well consisted of querying DWR well completion reports, public water systems, and schools using ArcGIS. A detailed breakdown of the steps to conduct the analysis is described below.

- Create a layer in ArcGIS by combining data from the following:
- Well locations and well types from DWRs Well Completion Report Mapping Application
- Boundaries of SWDIS Public Water Systems
- Boundaries of Community/Urban areas from LAFCO
- Overlay groundwater quality locations of RMS wells and create a 1-mile buffer for analyzing.

[2] California Division of Drinking Water, 2018
[3] Tule Basin Water Quality Coalition (TBWQC), 2017

- Summarize the data identified in step 1 relative to each groundwater quality RMS well 1-mile buffer.
- Define the groundwater quality RMS well as representative of drinking water and/or agricultural beneficial pumping beneficial use.

Wells types are categorized as drinking water, agricultural, or not applicable based on a breakdown in **Table 4-2: Categories of Well Types.**

Table 4-2: Categories of Well Types

Drinking Water	Agricultural	Not Applicable
Domestic	Irrigation - Agricultural	Cathodic Protection
Public	Other Irrigation	Destruction Monitoring
Water Supply	Water Supply Irrigation - Agricultural	Destruction Unknown Soil Boring
Water Supply Domestic	Water Supply Irrigation - Agriculture	Monitoring
Water Supply Public	Water Supply Stock or Animal Watering	Other Destruction
		Test Well
		Test Well Unknown
		Unknown
		Vapor Extraction
		Vapor Extraction n/a
		Water Supply Industrial
		Blanks

Within the Agency 14 RMS have been identified for monitoring groundwater quality annually; eleven wells are perforated in the upper aquifer and three wells are perforated in the lower aquifer. Each has been designated as a drinking water RMS well or Agricultural RMS well based on the results from the above-described analysis and are displayed as such in **Figures 4-2 and 4-3**. **Tables 4-3 and 4-4** list these RMS for the upper and lower aquifers, respectively.

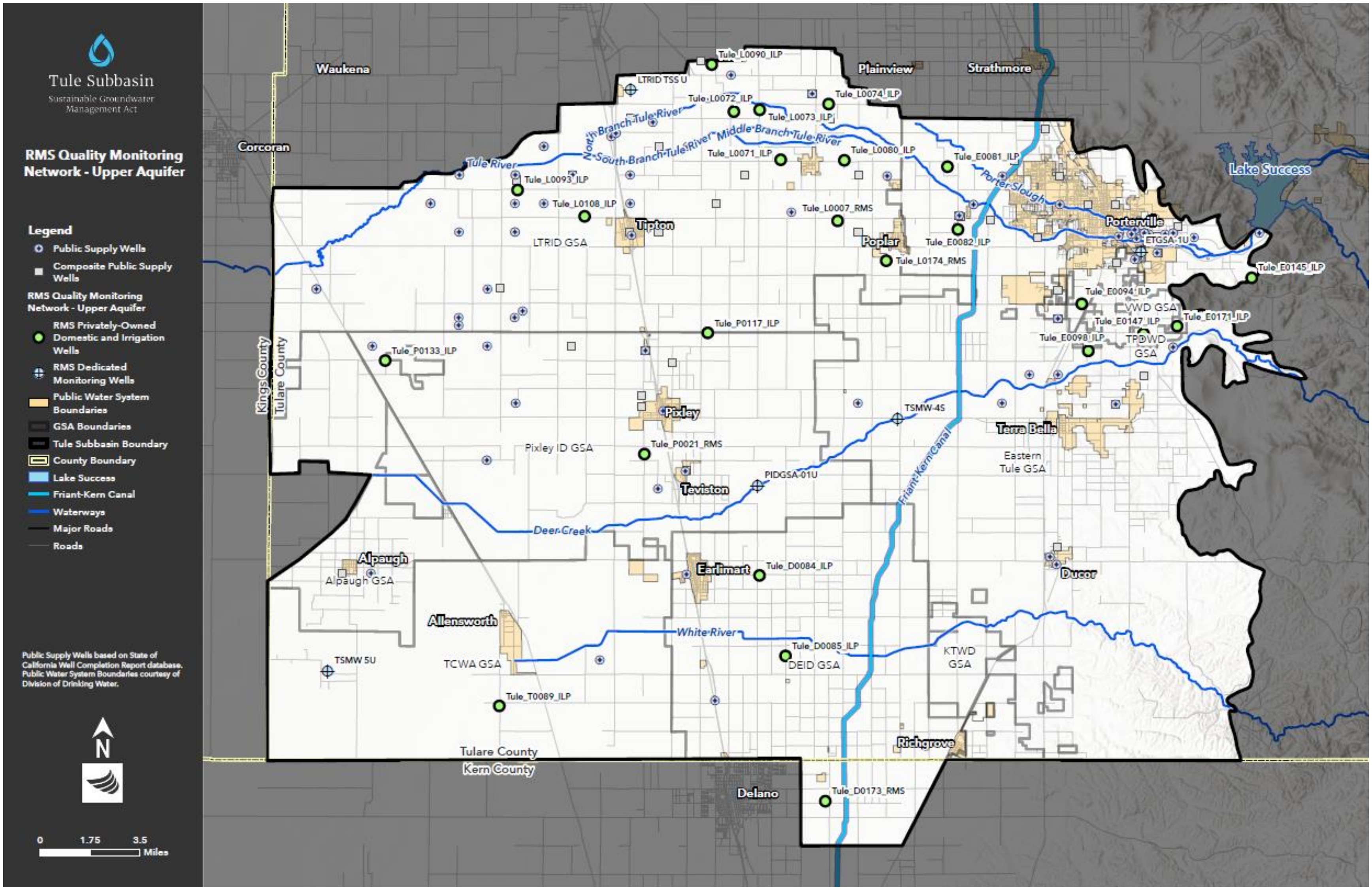

Figure 4-2: Upper Aquifer RMS for Monitoring Groundwater Quality

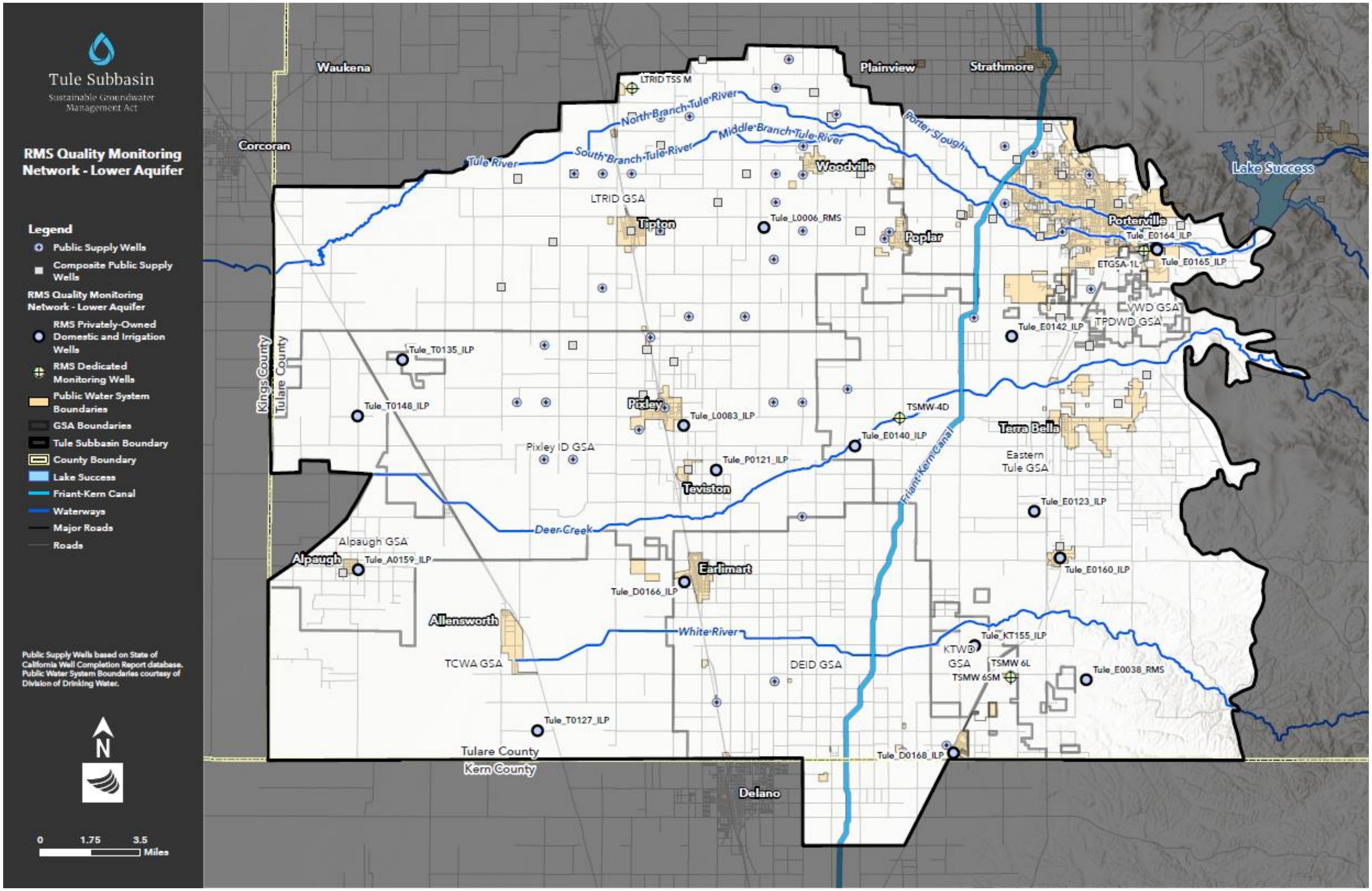

Figure 4-3: Lower Aquifer RMS for Monitoring Groundwater Quality

Table 4-3: Upper Aquifer RMS for Monitoring Groundwater Quality

GSA Name	Master Well ID	ILRP Well ID	Township-Range-Section	Well Name/ Well Log	WCR	Total Depth *(ft bgs)*	Top of Screen *(ft bgs)*	Bottom of Screen *(ft bgs)*	Aquifer	Lat	Long
Vandalia WD GSA	N/A	N/A	22S/28E-01G01	VID #21	N/A	N/A	N/A	N/A	Upper	36.04704	-119.0069
	N/A	N/A	22S/28E-18H01	22S/28E-18H001	N/A	N/A	N/A	N/A	Upper	36.01859	-118.9833
	N/A	N/A	N/A	ETGSA-01U	N/A	52	27	47	Upper	36.048557	-118.99301

Table 4-4: Lower Aquifer RMS for Monitoring Groundwater Quality

GSA Name	Master Well ID	ILRP Well ID	Township-Range-Section	Well Name/ Well Log	WCR	Total Depth *(ft bgs)*	Top of Screen *(ft bgs)*	Bottom of Screen *(ft bgs)*	Aquifer	Lat	Long
Vandalia WD GSA	N/A	N/A	22S/28E-07M01	22S/28E-07M01	N/A	N/A	N/A	N/A	Lower	36.02933	-118.996
	N/A	N/A	N/A	ETGSA-01L	N/A	140	120	140	Lower	36.048557	-118.99301

4.2.3.5 Land Subsidence § 354.34(c)(5)

Land subsidence within the Tule Subbasin will be monitored as described in **Chapter 2.5** of Attachment 1 *TSMP*. Within the GSA, RMS for land subsidence will consist of InSAR data points. RMS for land subsidence are shown in **Figure 4-4** and listed in **Table 4-5**.

Table 4-5: GPS Representative Monitoring Sites for Land Subsidence

RMS ID	Management Area	GPS Coordinates	
		Latitude	Longitude
V0048_InSAR	Vandalia WD	36.02085	-118.986131
V0049_InSAR	Vandalia WD	36.048132	-118.992112

DRAFT

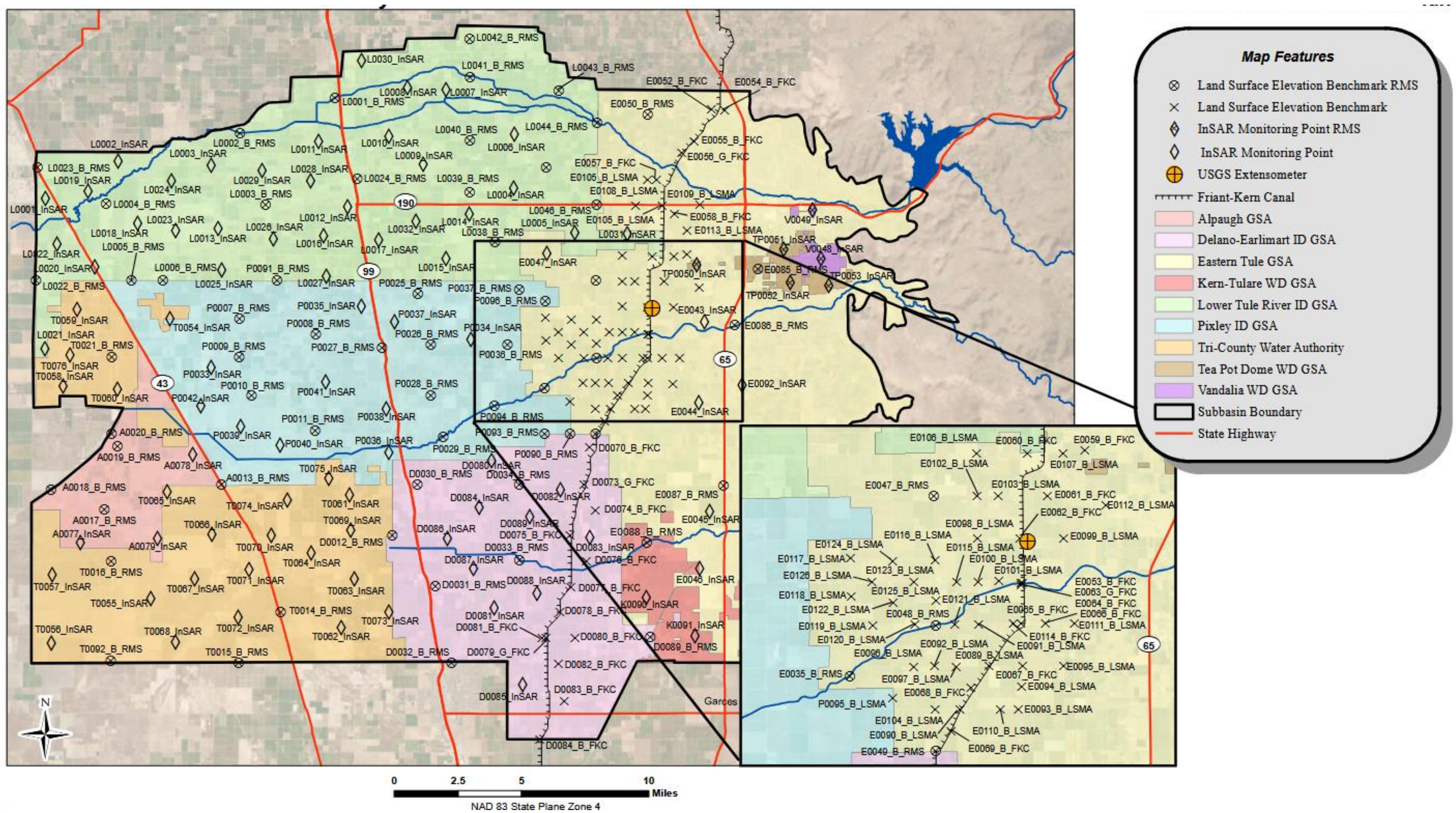

Figure 4-4: RMS for Monitoring Land Subsidence

4.2.3.6 Interconnected Surface Water § 354.34(c)(6)(A); § 354.34(c)(6)(B); § 354.34(c)(6)(C); § 354.34(c)(6)(D)

Evaluation of groundwater levels in the upper reaches of the Tule River and Deer Creek suggests that groundwater is at least periodically interconnected with surface water in these areas. This is supported by the presence of groundwater dependent ecosystems in these areas. The best available data to date indicate that the portion of the Agency near the Tule River, which includes the VWD recharge basins and wellfield, is located near the area of potential ISW conditions. As described in Section 4.2.2, a preliminary monitoring network for ISWs has been developed but RMSs and SMCs for ISW have not been established. The Agency will continue to monitor groundwater levels near the Tule River.

At the time of publishing this version of the Agency GSP, the CDWR Best Management Practice (BMP) for managing depletions of interconnected surface water has not been made available. Once the BMP is available, the Agency will evaluate the suggested best practices and revisit interconnected surface water identification and monitoring.

Until the CDWR BMP for interconnected surface water is available, the Tule Subbasin has identified an interim monitoring network that includes a combination of surface water flow monitoring and groundwater level monitoring. Stream flow and channel losses in the Tule River will continue to be monitored based on gaged flow below Success Dam and at Rockford Station downstream of Porterville. Stream flow will also continue to be monitored at the gage in Deer Creek at Road 272. Existing monitoring wells that will be used to inform the presence/absence of interconnected surface water are shown in **Figure A1-6** of Attachment 1 TSMP. The nested ETGSA-01U and L located within the Agency boundaries is part of the preliminary monitoring network though it is noted that groundwater levels measured in these wells are influenced by VWD recharge operations and may not be instructive for monitoring ISW conditions. Further, none of the wells in the preliminary network are ideally located or constructed for this purpose and none are located within the Agency. Also, the proposed monitoring wells identified in **Figure A1-12** of Attachment 1 TSMP to address data gaps are also not within the Agency. As additional data becomes available, the Agency will annually reevaluate the need for ISW monitoring and management.

4.3 Assessment and Improvement of Monitoring Network § 354.38(a); § 354.38(e)(1); § 354.38(e)(2); § 354.38(e)(3); § 354.38(e)(4)

Chapter 4.0 of Attachment 1 TSMP provides the following general statement regarding the monitoring network developed for the Tule Subbasin:

> *“The TSMP is both flexible and iterative, allowing for the addition or subtraction of monitoring features, as necessary, and to accommodate changes in monitoring frequency and alternative methodologies, as appropriate.”*

Annually, data will be collected that will provide a better understanding of the groundwater conditions in the Tule Subbasin and how the actual groundwater conditions react to the projects and management actions proposed by each GSA within the subbasin. At a minimum, the monitoring network will be evaluated on a 5-year basis and adjustments will be made accordingly. Additionally, when minimum threshold exceedances or adverse impacts to beneficial uses and users of groundwater within and adjacent to the subbasin occur, the monitoring networks will be evaluated for potential improvement to better understand the sources and causation leading to these occurrences.

4.3.1 Data Gaps § 354.38(b); § 354.38(c)(1); § 354.38(c)(2); § 354.38(d)

Chapter 4.1 in Attachment 1 *TSMP* identifies data gaps with the Tule Subbasin and provides recommended features to address the data gaps.

Groundwater level monitoring is the predominant data gap within the Agency, as described in **Chapter 4.1** of Attachment 1 TSMP, although other data gaps have been identified for groundwater quality, land subsidence monitoring, and ISW. To date, seven new monitoring wells (one single completion, two clustered wells, and four nested wells) have been completed. To address the groundwater level data gaps, 35 new dedicated monitoring wells have been proposed for monitoring the various aquifers within the Tule Subbasin (see **Chapter 4.1.1.1** of Attachment 1 TSMP). Of these, nine are located within the Agency (see **Figure 4-6**). Funding generated during the Plan Implementation Period, described in **Section 6** of this Plan, may be used to further develop the monitoring features where there are data gaps.

4.4 Reporting Monitoring Data to the Department § 354.40

Chapter 5.0 of Attachment 1 TSMP provides a detailed description of the Tule Subbasin Data Management System, that each of the agencies will utilize for reporting monitoring data according to the standardized monitoring protocols at RMS discussed within this Plan.

Data stored in the DMS will be assembled in standardized formats as required for the annual and 5-year reports to the Department.

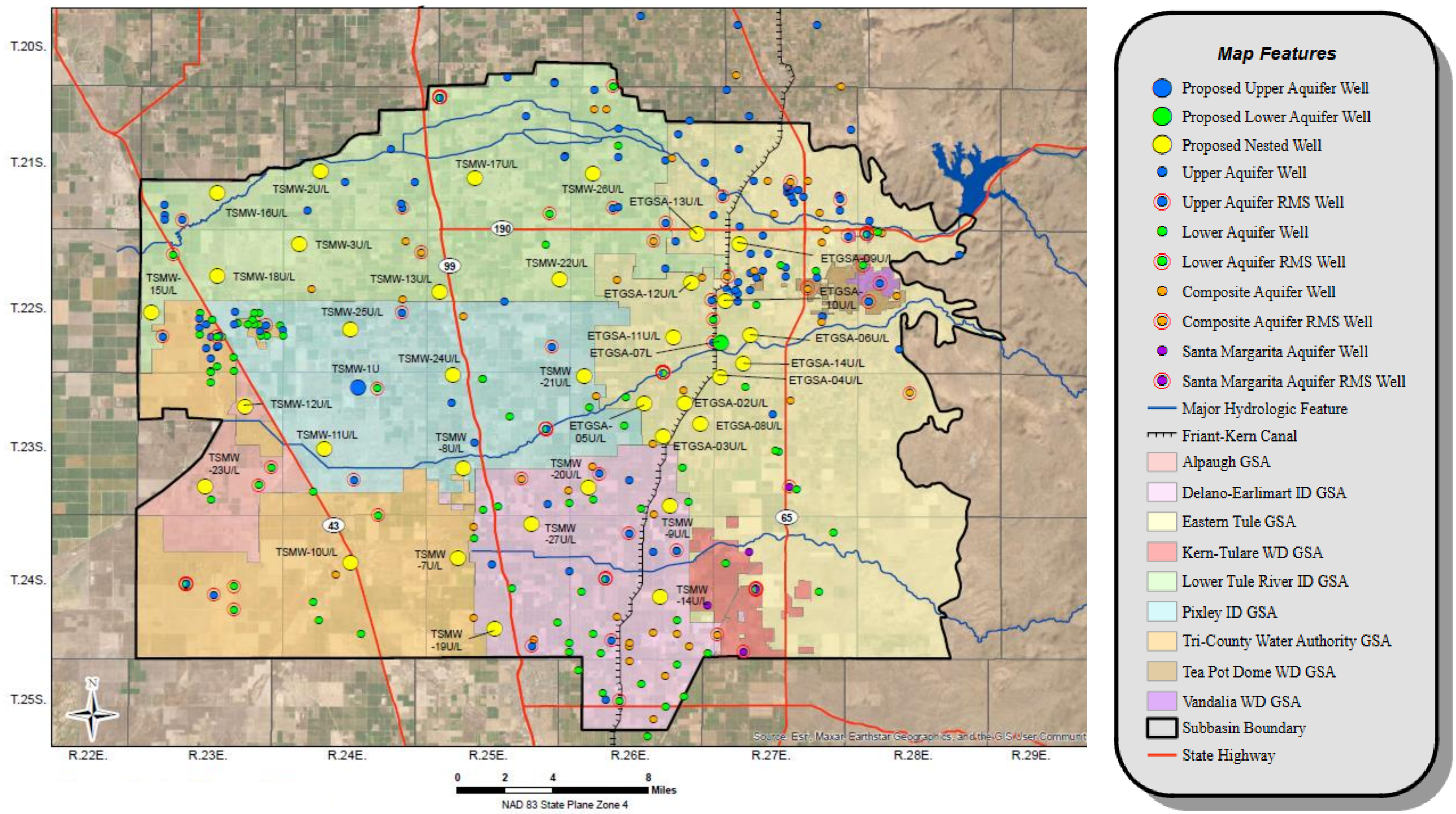

Figure 4-5: Proposed Groundwater Level Monitoring Wells to Fill Data Gaps