Division are primarily Sierra floodplain deposits, whereas beneath the south part, Diablo floodplain deposits are predominant.

Subsurface Geologic Cross Section E-E' (**Figure 3-14**), modified from Hotchkiss and Balding (1971), extends from the northeast near Copa De Oro Avenue and Brito Road to the southwest near Delta Road and the boundary of T11S and T12S, between the Outside Canal and the DMC. The Corcoran Clay dips to the northeast along the southwest part of the section, and to the southwest along the northeast part. Sierra deposits are predominant above the Corcoran Clay whereas Diablo Range deposits are predominant below the Corcoran Clay along this section. A thin wedge of Sierra deposits is present at a depth of about 600 feet along the east part of the Southern Division along this section.

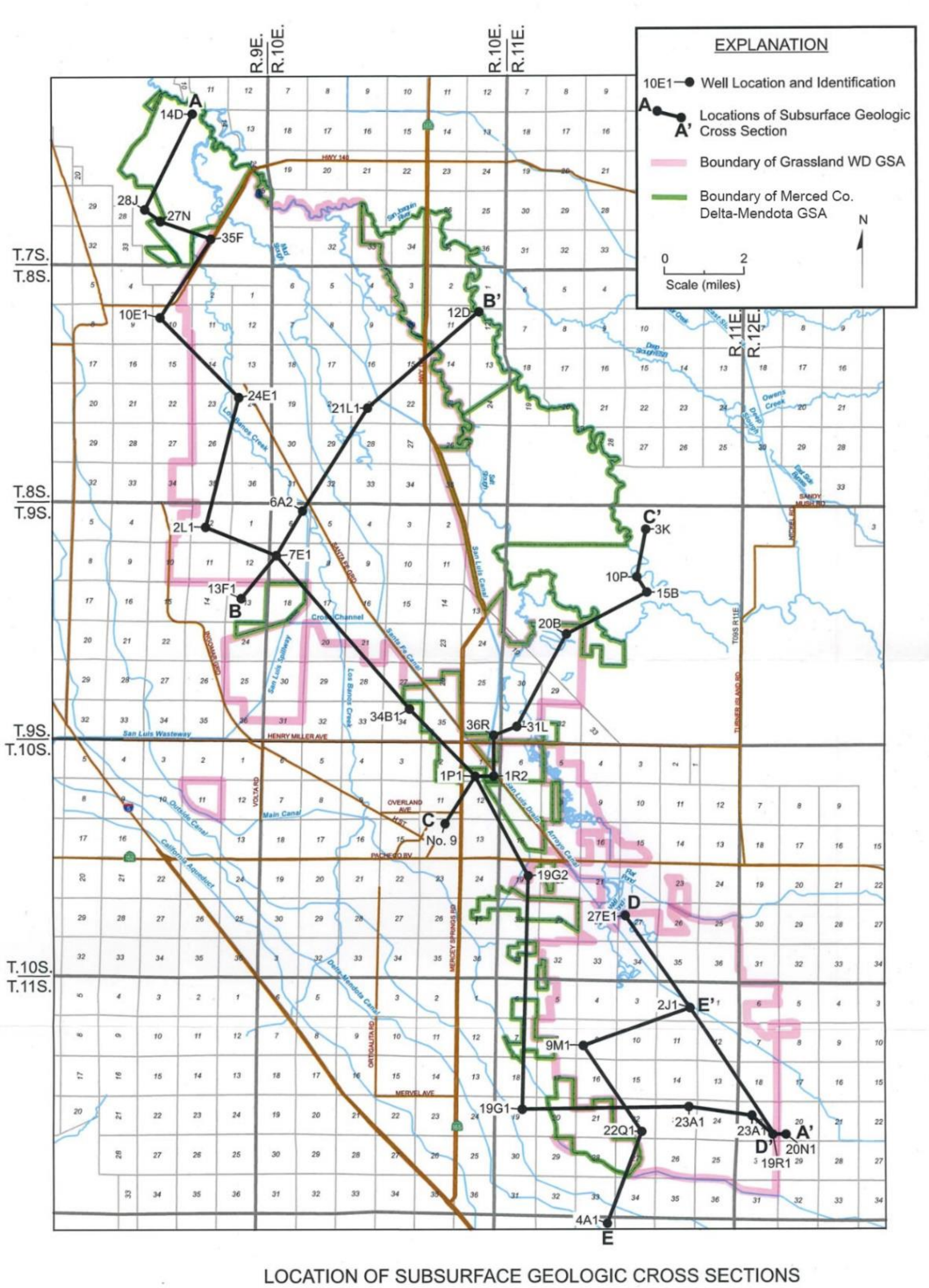


Figure 3-9: Location of Subsurface Geologic Cross Section

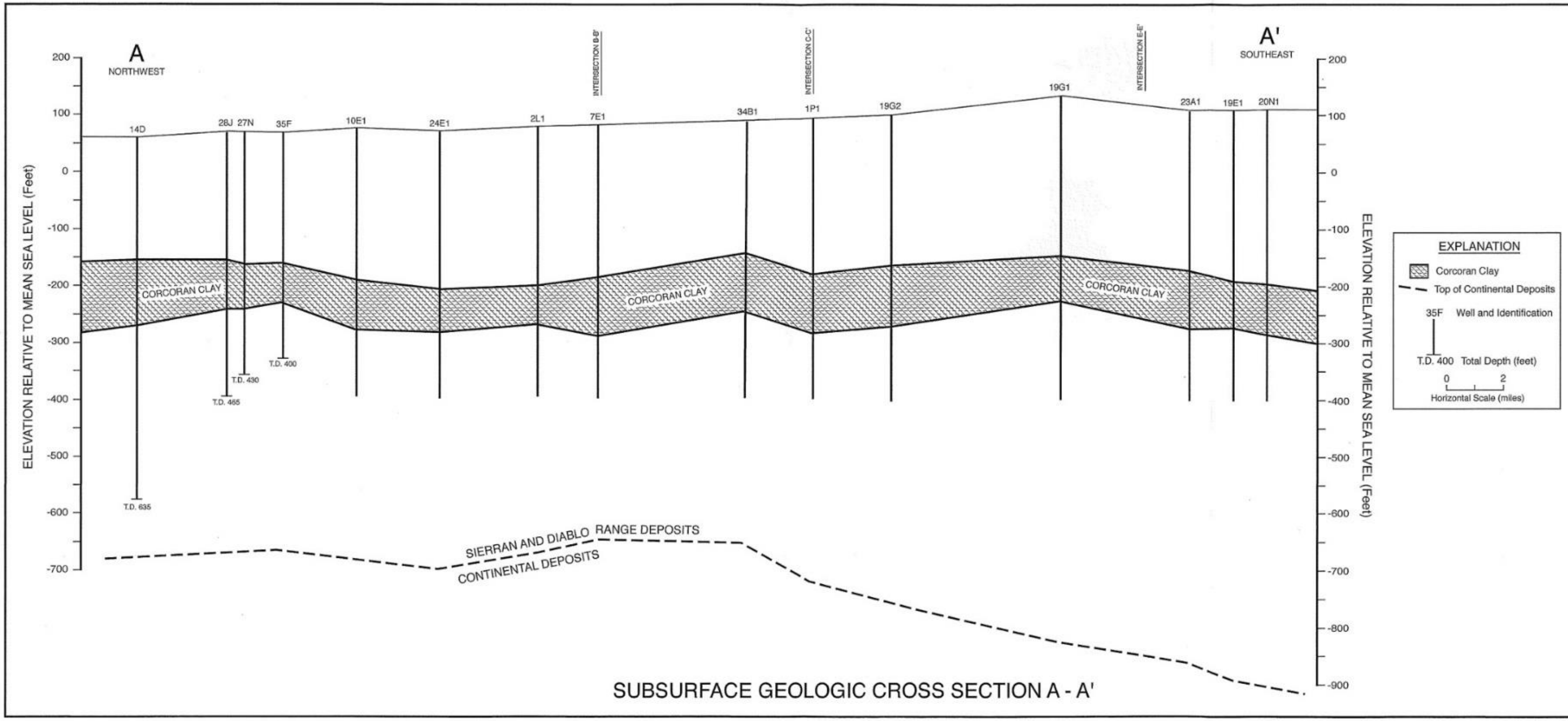


Figure 3-10: Subsurface Geologic Cross Section A-A'

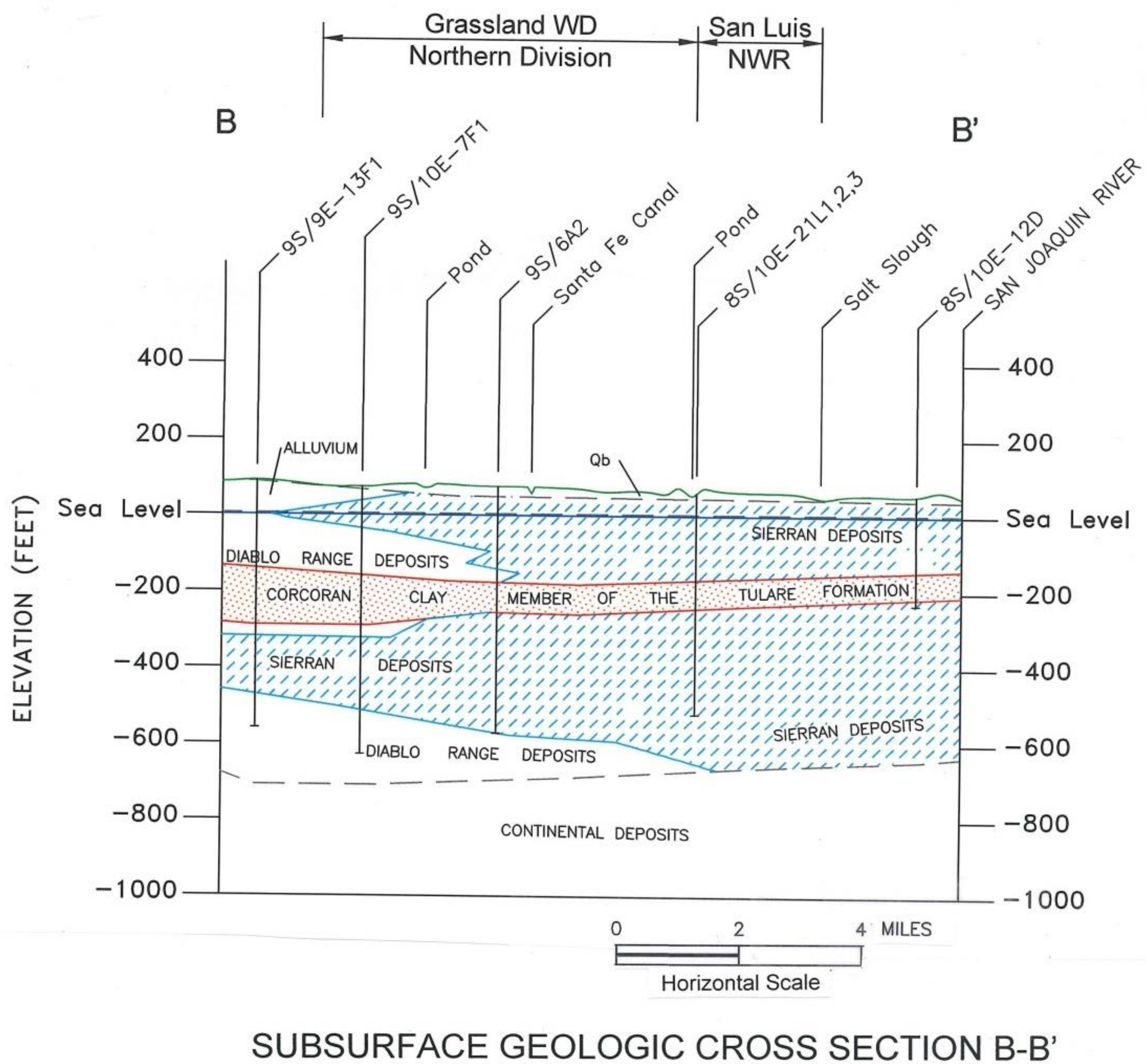


Figure 3-11: Subsurface Geologic Cross Section B-B'

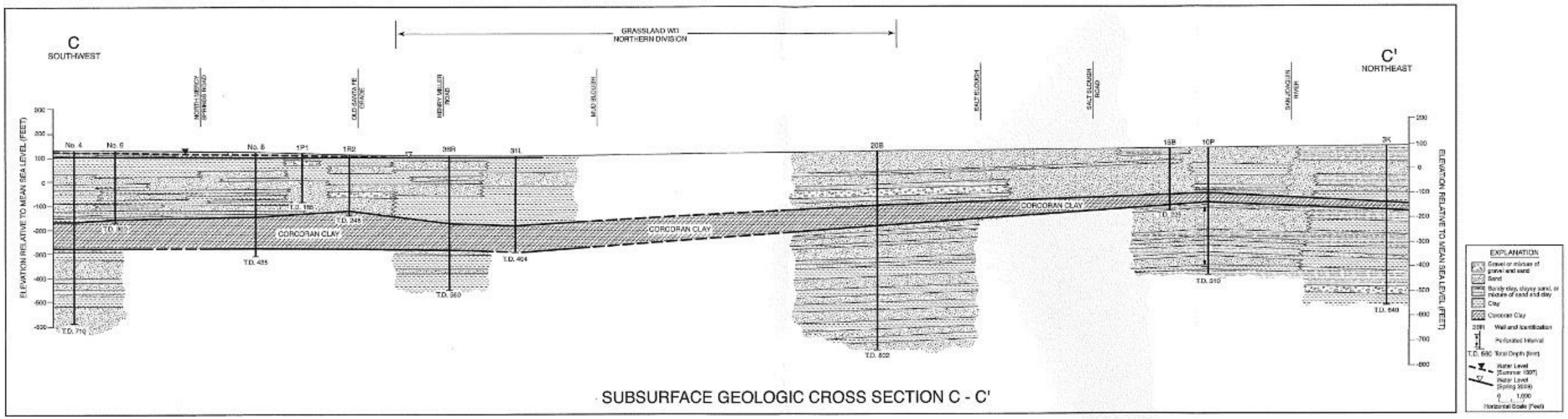


Figure 3-12: Subsurface Geologic Cross Section C-C'

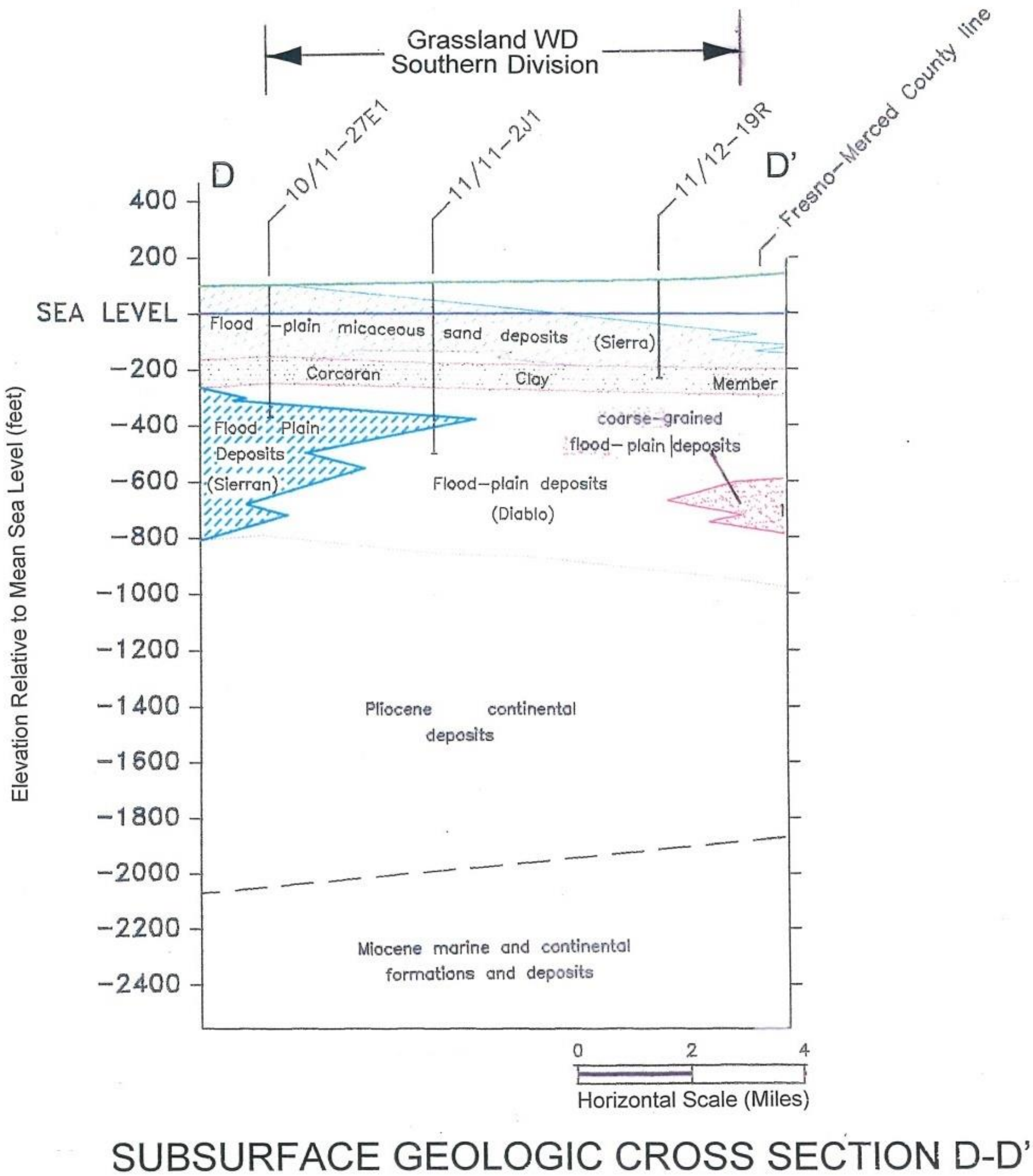


Figure 3-13: Subsurface Geologic Cross Section D-D'

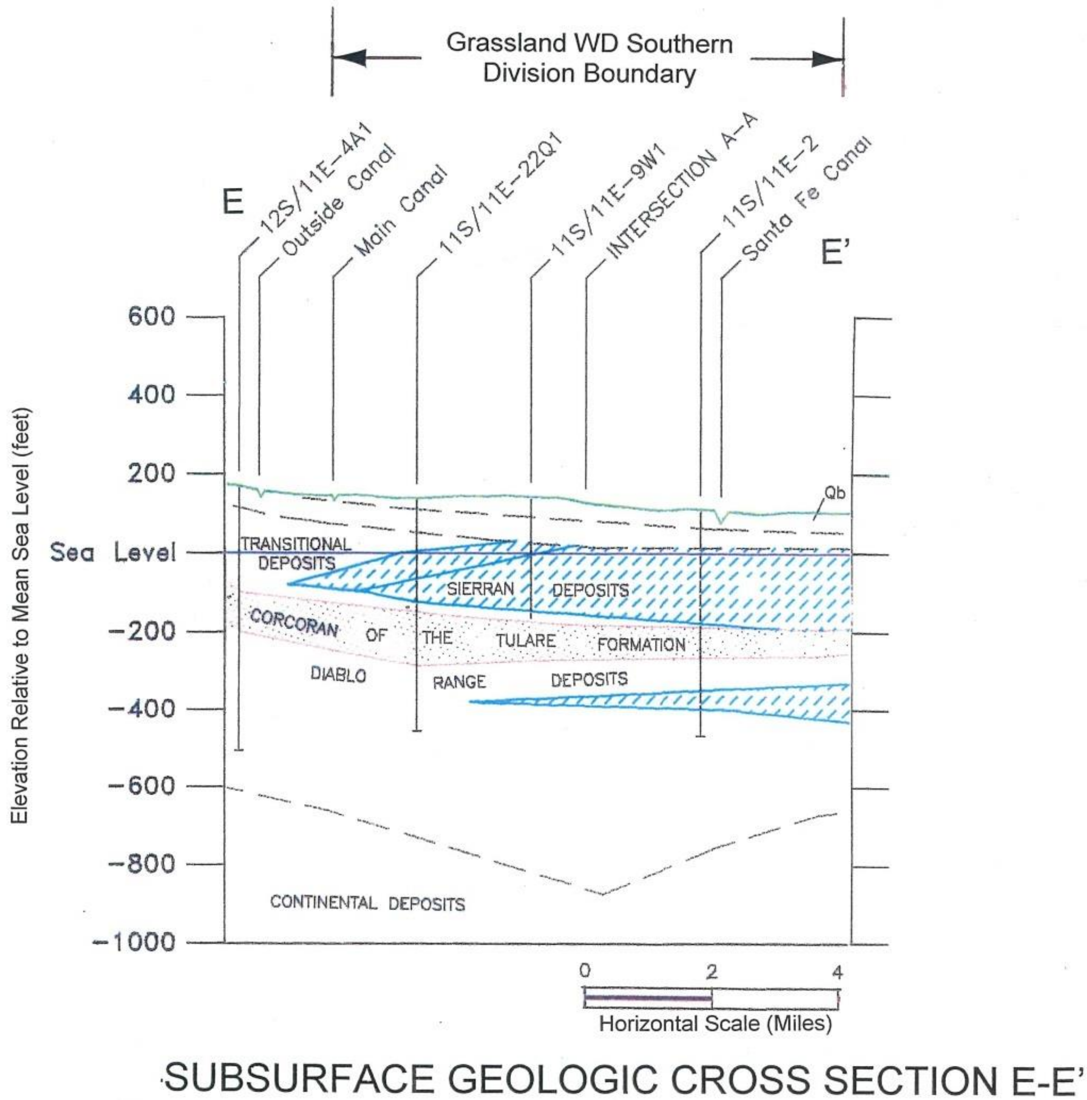


Figure 3-14: Subsurface Geologic Cross Section E-E'

3.2 Groundwater Conditions

3.2.1 Groundwater Use and Well Data

3.2.1.1 Primary Uses of Each Aquifer

Legal Requirements:

§354.14(b)(4)(e) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

The GGSA provided driller's logs and electric logs for test holes and water supply wells in and near the Plan Area. Logs for the federal wildlife refuges, state refuges, and other areas were obtained from the DWR. Most upper aquifer wells generally extend to near the top of the Corcoran Clay, and thus range from about 200 to 300 feet deep. The deepest water supply wells with records in the north part of the area are from about 780 to 870 feet deep. The deepest water supply wells with records in the south part of the area are about 600 to 700 feet deep. Most water supply wells either tap the upper aquifer or lower aquifer. Wells are primarily used for managed wetlands and crop irrigation. One publicly available groundwater connection serves drinking water to visitors at the San Luis National Wildlife Refuge visitor center. There are a limited number of domestic wells in the Plan Area ("de minimis extractors" under SGMA) that supply water to seasonal recreational properties.

3.2.2 Water Levels

Legal Requirements:

§354.16(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.

(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

Water-level records are available from three primary sources in the area evaluated. Included are records from DWR, GGSA, and the SJRECWA.

3.2.2.1 Depth to Water

In Spring 2018, the GGSA installed shallow monitor wells at ten sites to allow monitoring of shallow water levels. In early March 2018, the depth to water in these wells ranged from about one to five feet. Except for two of these wells, depth to water was 2.5 feet or less. In August-September 2018, depth to water in these wells ranged from 4.2 to 9 feet. Except for two wells, depth to water ranged from about 5.0 to 7.0 feet. These measurements indicate that the groundwater is shallow enough, particularly in the spring and early summer, to be directly evaporated. The GGSA provided a report on February 1, 2016 entitled Incremental Level 4 Groundwater Development Project Initial Study and Negative Declaration. This project allows the Grassland Water District to acquire up to 29,000 acre-feet per year of privately held groundwater supplies and/or exchange a portion of its surface water for such groundwater supplies. Data for 21 wells were provided in that report, most of which are along the Santa Fe Canal and tap the upper aquifer. Records for this project indicate that static water levels in most upper aquifer wells were from about 10 to 20 feet deep during 2012-14. On the other hand, static water levels in two lower aquifer wells ranged from about 80 to 100 feet deep.

In Fall 2015, nested monitor wells were installed at three sites in the GGSA. Two nested well sites are located in the North Division near the San Luis Drain and Taglio Road and the Santa Fe Canal and Cottonwood Road, respectively. An additional nested wells site is located in the South Division near Santa Fe Grade and north of Charleston Avenue. The static water level in one Northern Division upper aquifer monitor well was 16 feet deep in Fall 2015. The static water levels in two upper aquifer wells at the Southern Division site were about 26 feet deep at that time. The static level in three lower aquifer wells at a Northern Division site ranged from about 50 to 100 feet deep in Fall 2015. The static water levels in four lower aquifer wells at the other Northern Division site ranged from about 80 to 90 feet deep at that time.

3.2.2.2 Water Level Elevations and Direction of Flow

Water level elevation and direction of groundwater flow maps for both the upper aquifer and lower aquifer have been prepared by KDSA for the SJRECWA service areas, and these maps extend into part of the area evaluated. These maps were prepared to show both normal (Fall 1981) and drought conditions (Spring 1992).

Upper Aquifer

For the north part of the area, water level elevations in Fall 1981 ranged from about 60 to 90 feet above sea level and indicated a north to north-northeasterly direction of groundwater flow. Groundwater was moving from the CCID west of the North Division through the Northern Division toward the San Joaquin River. The water level elevations and direction of groundwater flow in Spring 1992 were essentially the same, indicating little variation in groundwater flow direction with climatic conditions. For the south part of the area, water level elevations in Fall 1981 ranged from about 90 to 120 feet above mean sea level. The direction of groundwater flow was primarily to the north or northwest. The groundwater in the upper aquifer was flowing toward the Northern Division. Groundwater inflow was coming from the CCID, Pacheco Water District, and Panoche Water District. The water level elevations and directions of groundwater flow in Spring 1992 were essentially the same, again indicating little variation with climatic conditions.

Figure 3-15 shows water level elevations and the direction of groundwater flow for the upper aquifer for Spring 2015. Essentially, the same water level elevations and direction of groundwater flow were present beneath the area north of Highway 152 and south of Highway 152 as in Fall 1981. Water level elevations exceeded 130 feet above mean sea level near the south boundary of the area evaluated (Merced Avenue) and were less than 70 feet near the north boundary. A cone of depression was located east and northeast of Los Banos, coincident with the locations of numerous wells which pump into the GWD water system.

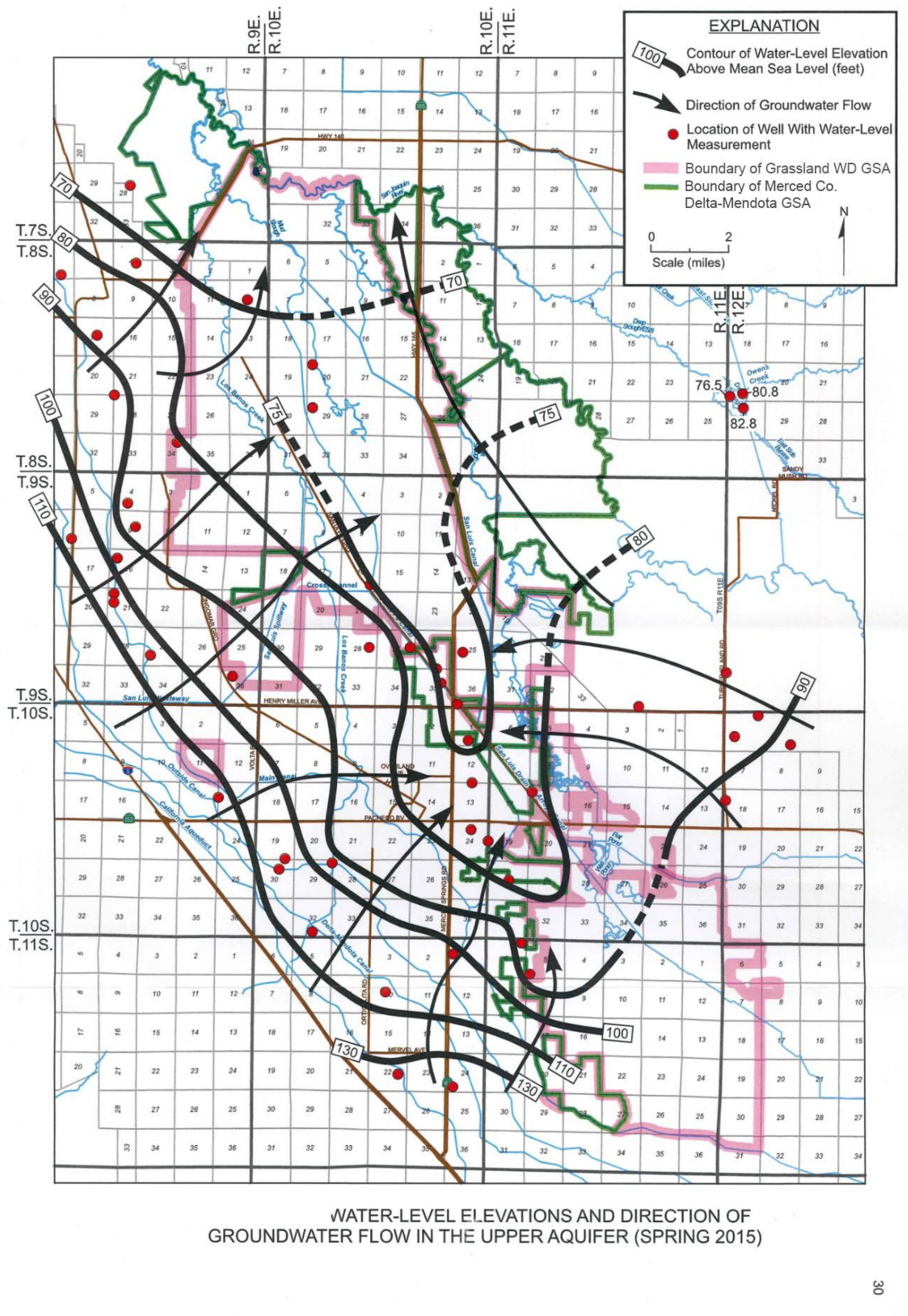


Figure 3-15: Water Level Elevation and Direction of Groundwater Flow in the Upper Aquifer (Spring 2015)

Groundwater in the Southern division of the Plan Area was primarily moving to the north towards this depression. In the Northern Division and south of the Cross Channel, groundwater was also moving toward the northwest. There was a groundwater divide north of Henry Miller road in the east part of the area evaluated. Northeast of this divide, groundwater moved towards the San Joaquin River.

Lower Aquifer

For the Northern Division, water level elevations ranged from less than 40 feet above mean sea level to about 60 feet in Fall 1981. There was a depression cone indicated beneath the Northern Division. Groundwater inflow was coming from the CCID on the west and northwest, the CCID and Plan Area Southern Division to the south, and the San Luis Canal Company, Turner Island W. D., and an undistricted area to the northeast.

For the Southern Division, water-level elevations in Fall 1981 ranged from about 60 feet above mean sea level east of Los Banos to 30 feet near the south end of the Plan Area. Groundwater was flowing into the Southern Division from the northeast and north-northeast, primarily from the San Luis Canal Company and CCID. Groundwater outflow was to the south and southwest toward the Pacheco Water District and Panoche Water District. Water level elevations in Spring 1992 ranged from about 65 feet above mean sea level east of Los Banos to about 10 feet near the south end of the Southern division. The lower water levels to the south compared to Fall 1981 were likely due to higher amounts of lower aquifer pumpage in the Panoche Water District and nearby areas during the drought.

Figure 3-16 shows water elevations and the direction of groundwater flow for the lower aquifer in Spring 2015. There was a groundwater divide near Henry Miller Avenue. North of the divide, groundwater flowed into a depression beneath the north part of the area. South of the divide, groundwater flowed to the south into the Panoche Water District and Westlands Water District. In the north part of the area, water levels in the lower aquifer were about 60 to 90 feet deeper than in the upper aquifer. In the south part of the area, water levels in the lower aquifer were about 50 to 110 feet deeper than in the upper aquifer.

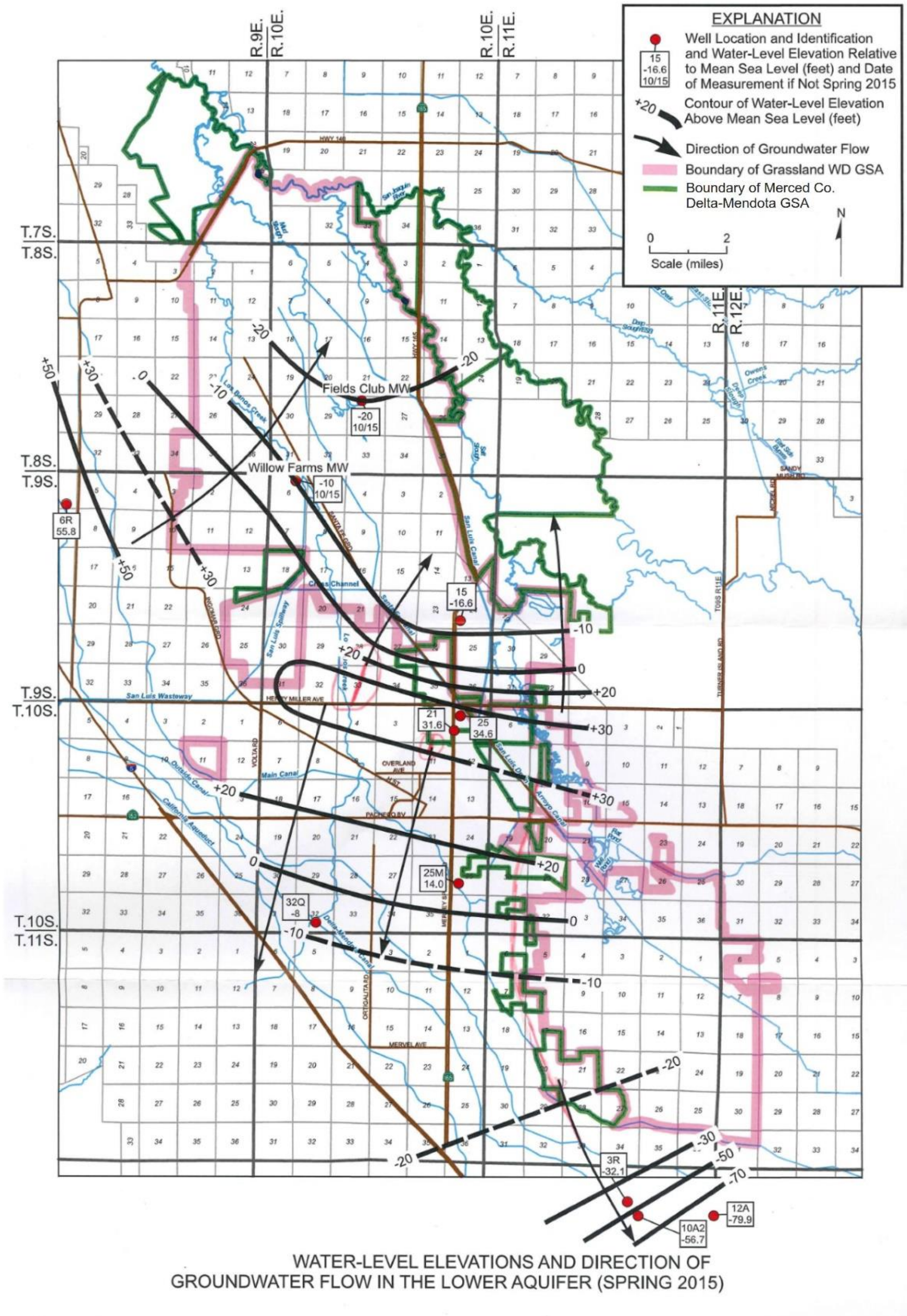


Figure 3-16: Water Level Elevations and Direction of Groundwater Flow in the Upper Aquifer (Spring 2015)

3.2.2.3 Water Level Fluctuations

Water level measurements and hydrographs for wells in and near the Plan Area were obtained from DWR websites and from the CCID. In addition, the GGSA provided water-level data for a number of wells for 2012-14.

Upper Aquifer

Long-term water level records are available for seven upper aquifer wells within or near the Northern Division:

T8S/R9E-10E1, 13E1, and 34G1
T8S/R10E-17N2 and 30E1
T9S/R9E-3C1 and 36P1

Water levels in five of these wells have risen over the long-term, extending back to the 1960s or 1970s. Water levels in two of these wells were relatively stable. **Figure 3-17** shows representative water level hydrographs for CASGEM wells in the Northern Division. Water levels in the wells have temporarily fallen during drought periods such as the early 1990s and then have recovered.

Long-term water level records are available for 13 upper aquifer wells in or near the Southern Division.

T1OS/R10E-1M1
T1OS/R11E-17E1, 32N1, and36A1
T11S/R11E-4N1, 6B1, 12P1, 12P3, 17E1, and 17E2
T11S/R12E-8C1, 30H1, and 30H2

Figure 3-18 shows representative water level hydrographs for two CASGEM wells in or near the Southern Division. Water levels in these wells have either risen or been relatively stable during the past several decades. Levels appear to be recovering from slight declines during the recent severe drought, in particular 2014 and 2015.

Static water levels in a number of upper aquifer wells in the Plan Area were measured prior to pumping and about a day after pumping stopped for the wetlands during 2012-14. Water level differences between pre-pumping and post-pumping were generally only several feet. In a number of cases, the post-pumping water levels were shallower than those prior to pumping. The upper aquifer water level fluctuations are indicative of an unconfined aquifer. They indicate that there has been no groundwater overdraft in the Plan Area as a whole. This is consistent with conditions in the surrounding parts of the CCID and San Luis Canal Co. service areas.

Lower Aquifer

Depth to water in lower aquifer wells has been substantially deeper than in upper aquifer wells, commonly from 50 to 100 feet deep. Long term water level records aren't available for wells solely tapping the lower aquifer in the Plan Area. However, continuous records from 2011-2016 are available for two Volta area wells which tap both the upper and lower aquifers. Records for these wells indicate very quick water level recovery after pumping stops. In 2012, water levels were much shallower after pumping stopped than they were prior to pumping.

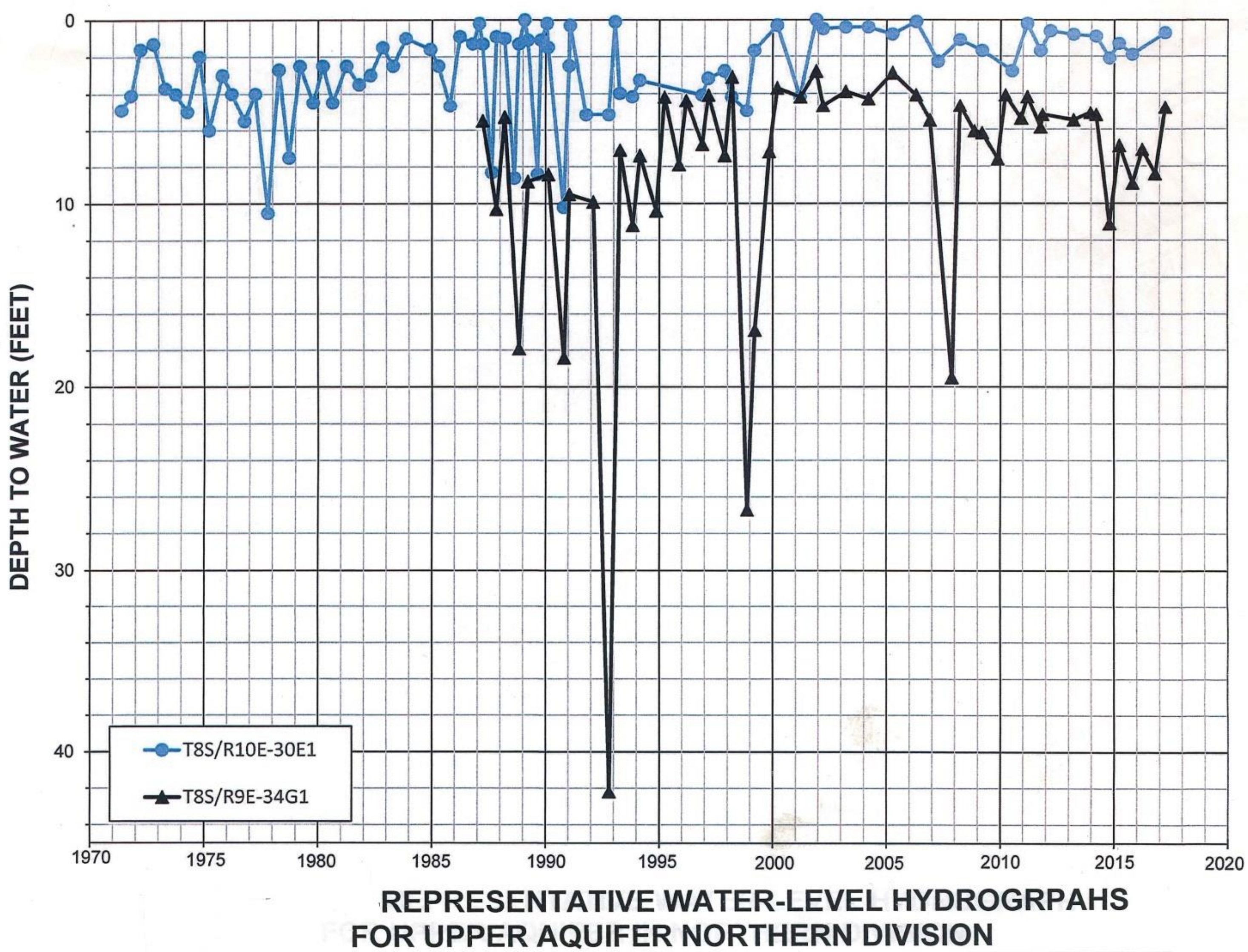


Figure 3-17: Water Level Hydrographs for Upper Aquifer Northern Division

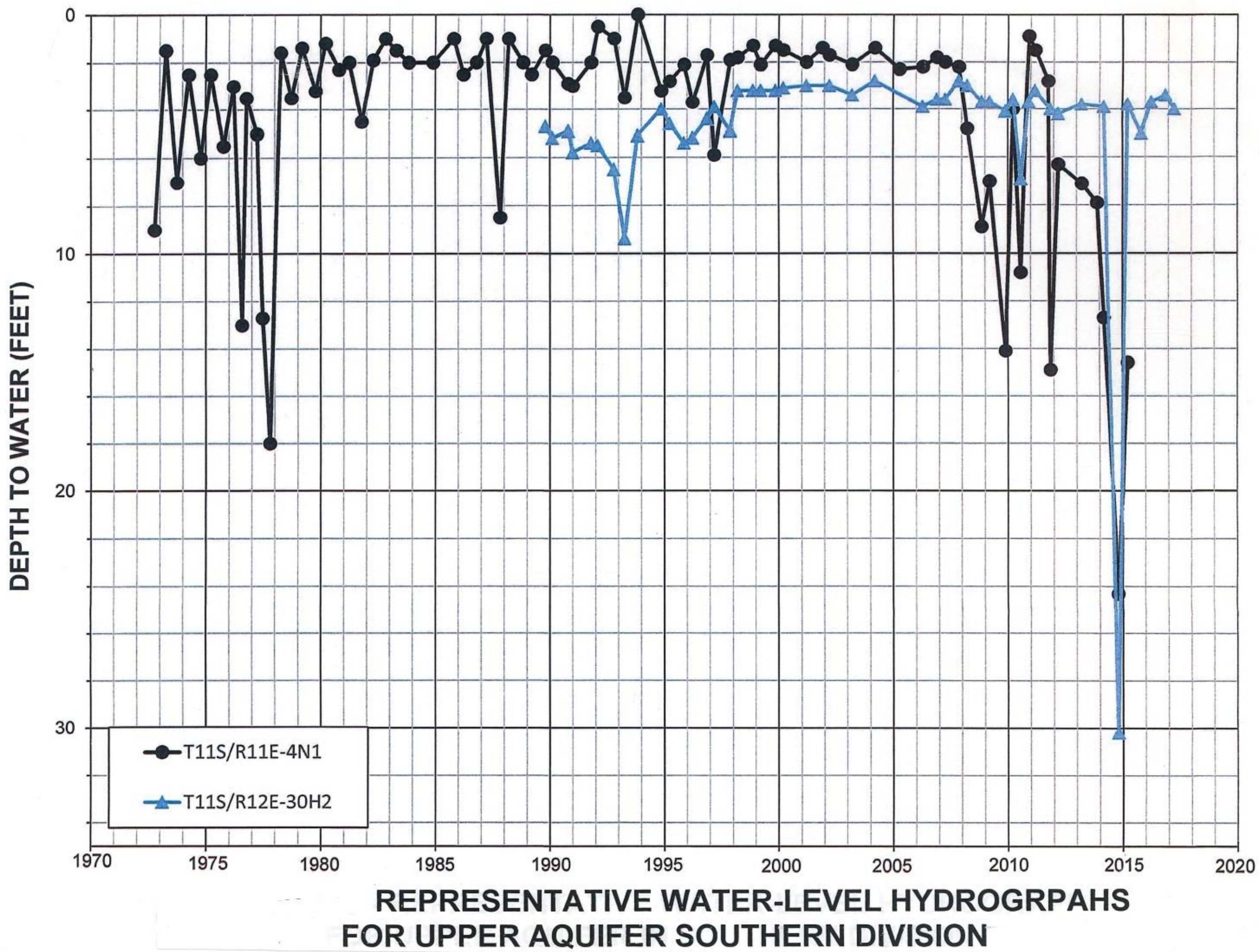


Figure 3-18: Water Level Hydrographs for Upper Aquifer Southern Division

3.2.3 Potential Sources of Groundwater Recharge

Legal Requirements:

§354.14(d)(4) Physical characteristics of the basin shall be represented on one or more maps that depict delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

Figure 3-19 shows major potential sources of recharge to groundwater in the area evaluated, including wetlands and agricultural lands. The major sources of recharge are groundwater inflow, seepage from conveyance facilities, and deep percolation from the wetlands. The Plan Area has imported an average of 150,000 acre-feet per year of Central Valley Project refuge water supplies from the DMC (see **Figure 3-5)** for associated water delivery points). Summers Engineering estimated that an average of about 29,000 acre-feet per year have been recharged through unlined conveyance canals within the District. For the upper aquifer, groundwater inflow is primarily from the southwest and south. For the lower aquifer, groundwater in the Northern Division flows into the Plan Area from almost all directions. In the Southern Division, groundwater inflow was from the north-northwest and northeast. Also, because hydraulic heads are lower in wells tapping the lower aquifer than in those tapping the upper aquifer, there is a trend for downward flow of groundwater through the Corcoran Clay. Amounts of this downward flow in the SJREC service area were estimated by KDSA (1997b).

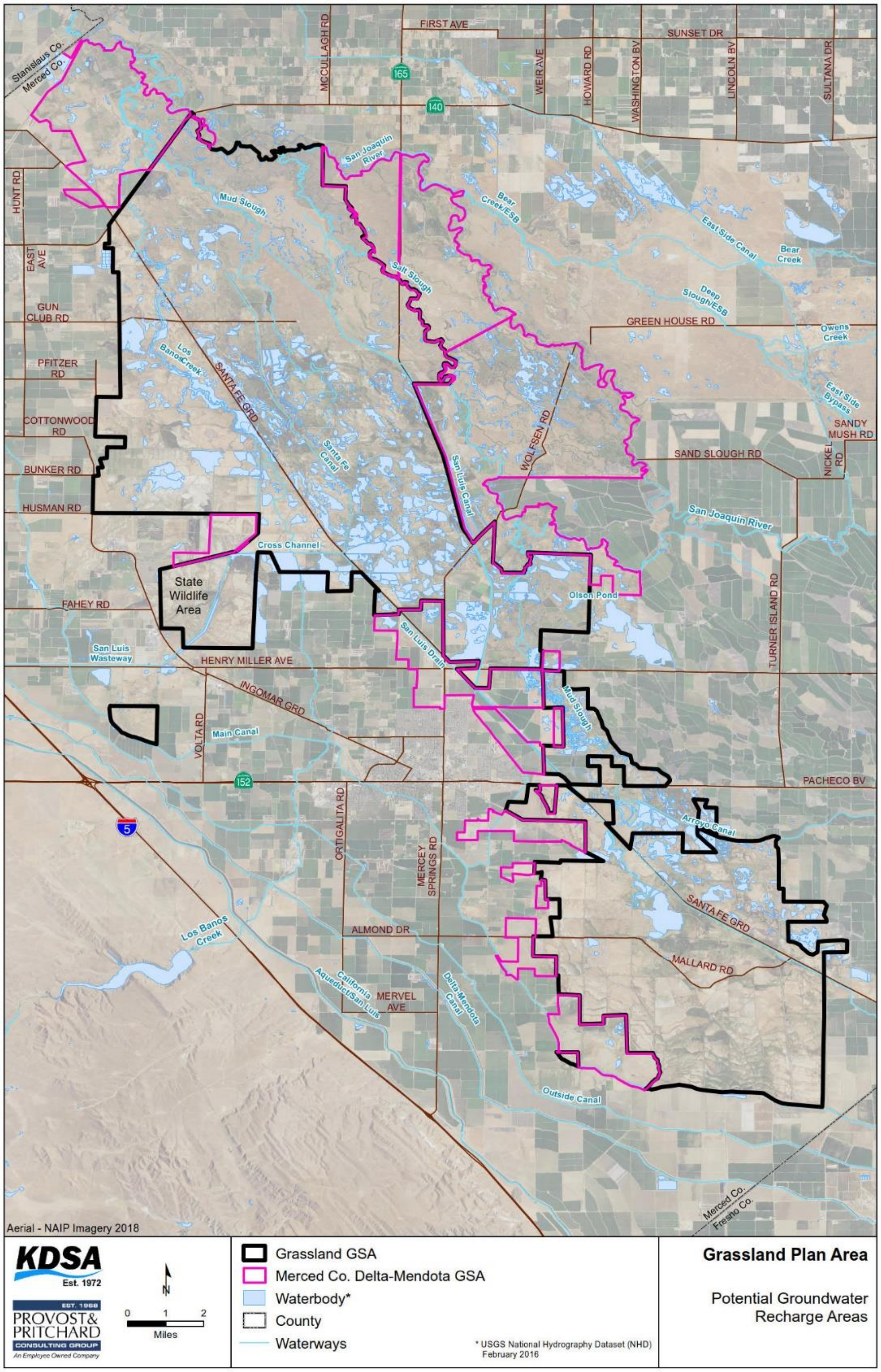


Figure 3-19: Potential Groundwater Recharge Areas

3.2.4 Potential Sources of Groundwater Discharge

Legal Requirements:

§354.14(d)(4) Physical characteristics of the basin shall be represented on one or more maps that depict delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

Groundwater is discharged from the upper aquifer through pumping wells, groundwater outflow toward the San Joaquin River, downward flow of groundwater through the Corcoran Clay, and through evaporation or evapotranspiration of shallow groundwater. Groundwater discharge from the lower aquifer is primarily from pumping wells and groundwater outflow from the Southern Division.

3.2.5 Aquifer Characteristics

Legal Requirements:

§354.14(b)(4)(b) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.

The GGSA provided pumping rates for 23 wells in the GWD groundwater pilot program. Pumping rates ranged from about 500 to 3,700 gpm. Pumping rates for most of these wells ranged from about 1,350 to 2,300 gpm. Pump tests are available for some of these wells.

3.2.5.1 Transmissivities

Aquifer transmissivities were assembled based on aquifer tests on wells in or near the area evaluated. Specific capacities for upper aquifer wells can be multiplied by a factor of 1,500 to estimate the transmissivity for areas where aquifer tests aren't available. Similarly, specific capacities for lower aquifer wells can be multiplied by 2,000 to estimate the transmissivity[1]. In addition to these estimates, KDSA (2018) determined transmissivities for specific flow estimates along some of the boundaries within the Plan Area. For the upper aquifer, these included several inflow segments on the west side, segments near the south and east side of the Northern Division, and two inflow segments near the southwest side of the Southern Division. For the lower aquifer, transmissivity values were developed for segments northwest, west, south, and northeast of the Northern Division.

Outflow segments were developed for areas south and southeast of the Northern Division. KDSA (2018) determined aquifer transmissivities for the upper and lower aquifers from the results of aquifer tests and specific capacity values for wells in the SJRECWA service areas. KDSA (2018) indicated that transmissivities for the various segments for upper aquifer flow ranged from about 100,000 to 190,000 gallons per day (gpd) per foot. The highest values were generally along the area near the southwest boundary and along the east edge of the southern part of the area evaluated. For the lower aquifer, transmissivities ranged from about 60,000 to 160,000 gpd per foot.

[1] Thomasson et al. (1960) developed conversion factors between specific capacity and transmissivity in U.S. Geological Survey Water-Supply Paper 1464.

3.2.5.2 Vertical Hydraulic Conductivities

The vertical hydraulic conductivity of the Corcoran Clay at this location was determined to be less than 0.001 gpd per square foot. For the SJRECWA service areas, an average vertical hydraulic conductivity for the Corcoran Clay was estimated to be 0.0075 gpd per square foot. This higher value was indicated to be due to thinner Corcoran Clay in many areas compared to that at the leaky aquifer test site (110 feet) and to the presence of more well conduits compared to those near the leaky aquifer test site.

3.2.5.3 Storativity

Values for the specific yield from textural descriptions of deposits tapping the upper aquifer are the best way to estimate specific yields. The USGS has estimated specific yields in many parts of the San Joaquin Valley. Based on the subsurface geologic cross sections available, an average specific yield of 12 percent is used for the upper aquifer. Storage coefficients for strata confined by the Corcoran Clay are sparse in this area. However, a one-week long leaky aquifer test was conducted using wells located along the DMC near Russell Avenue in January 1997 (KDSA, 1997b). This best value for storage coefficient for the lower aquifer for the test was 0.001.

3.2.6 Changes in Groundwater Storage

Legal Requirements:

§354.16(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

Changes in storage for coarse-grained deposits in the lower aquifer are shown to be insignificant, as the aquifer remains full of water despite water level declines. However, land subsidence has occurred due to compaction of clays and the volume of land subsidence can be used to estimate the decrease in storage for confining beds in the lower aquifer, including the Corcoran Clay. For the upper aquifer, long-term water level changes can be used to determine storage changes during periods when the water levels declined significantly. Due to the relatively small changes in storage, year-to-year changes are often insignificant (except during severe droughts). Water levels in upper aquifer wells have slightly risen over the long-term. Thus, two changes in storage for the upper aquifer were evaluated: 1) annual decreases in storage during droughts, and 2) long-term increases in storage.

<u>Northern Division</u>

Annual water level declines during the 1987-93 drought averaged 1.4 feet per year. For an acreage of about 72,000 acres and an average specific yield of about 12 percent, the annual loss in groundwater storage was about 12,000 acre-feet per year. As in most areas, water level hydrographs for wells showing these declines indicated full recovery within several years after the drought ended. Long term water level hydrographs for the area evaluated indicate an average water level rise of about 0.04 foot per year. This equates to an increase in groundwater storage averaging about 350 acre-feet per year. Over a 30-year period, this would total about 10,500 acre-feet.

<u>Southern Division</u>

Annual water level declines during the droughts of 1987-93 and 2008-14 indicate average annual water level declines of 1.7 feet per year. For an area of about 32,000 acres and an average specific yield of about 12 percent, this annual loss in groundwater storage was about

6,500 acre-feet per year. It should be noted that water-level hydrographs for the period following the first of these droughts generally indicate full recovery within a few years. Long-term hydrographs indicate an average water level rise of about 0.04 foot per year. The increase in groundwater storage would be about 150 acre-feet per year. Over a 30-year period, this would total about 4,500 acre-feet.

3.2.7 Land Subsidence

Legal Requirements:

§354.16(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or best available information.

Historically, there was little subsidence monitoring throughout most of the Plan Area. However, land surface elevations were periodically measured along Highway 152 between Los Banos and Highway 99 (**Figure 3-20**). Near Los Banos, little subsidence was indicated, due to the paucity of pumpage from the lower aquifer in this area. Prior to about 2000, most of the land subsidence along Highway 152 was east of the Eastside Bypass, where numerous wells were present that pumped from the lower aquifer. Starting in about 2008, many more wells tapping the lower aquifer were constructed south of Red Top, both east and west of the Bypass. Pumping of these wells had caused significant land subsidence as of 2016. **Figure 3-21** shows land subsidence determined by the USBR for July 2012-December 2016.

Using this data, subsidence contours were developed by KDSA, and are shown for the area evaluated and to the east. Near the west edge of the north part of the area evaluated, subsidence was about 0.05 foot. Near the eastern edge of the north part of the area evaluated, subsidence was averaged to be about 0.5 foot. Near the west edge of the south part of the area evaluated, subsidence was about 0.3 foot and about 0.6 foot near the east edge. In both divisions, subsidence increased to the east-northeast. There is some pumpage from lower aquifer wells in the area evaluated and adjoining areas. To the east of the area evaluated, the subsidence increased to more than 2.0 feet for July 2012-December 2016. Land subsidence in part of that area decreased after December 2016 due to mitigating measures that were enacted.

3.2.8 Groundwater Quality

Legal Requirements:

§354.14(b)(4)(d) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.

Recent information on the chemical quality of groundwater in the area evaluated was derived primarily from the GWD report of February 1, 2016 on the Incremental Level 4 Groundwater Development Project and from the installation of the nested monitor wells at the three sites. Monitoring plans require that the GWD have samples from the District's surface water channels analyzed. The GWD's Board of Directors has adopted a surface water quality objective for TDS of 2,500 mg/l.

Figure 3-22 shows recent groundwater quality data for the area evaluated. The 22 supply wells with chemical analyses generally indicated the quality of groundwater acceptable for pumping into the GGSA system. Much worse quality groundwater is present at some locations; however, only in certain depth intervals that are not tapped by these wells.

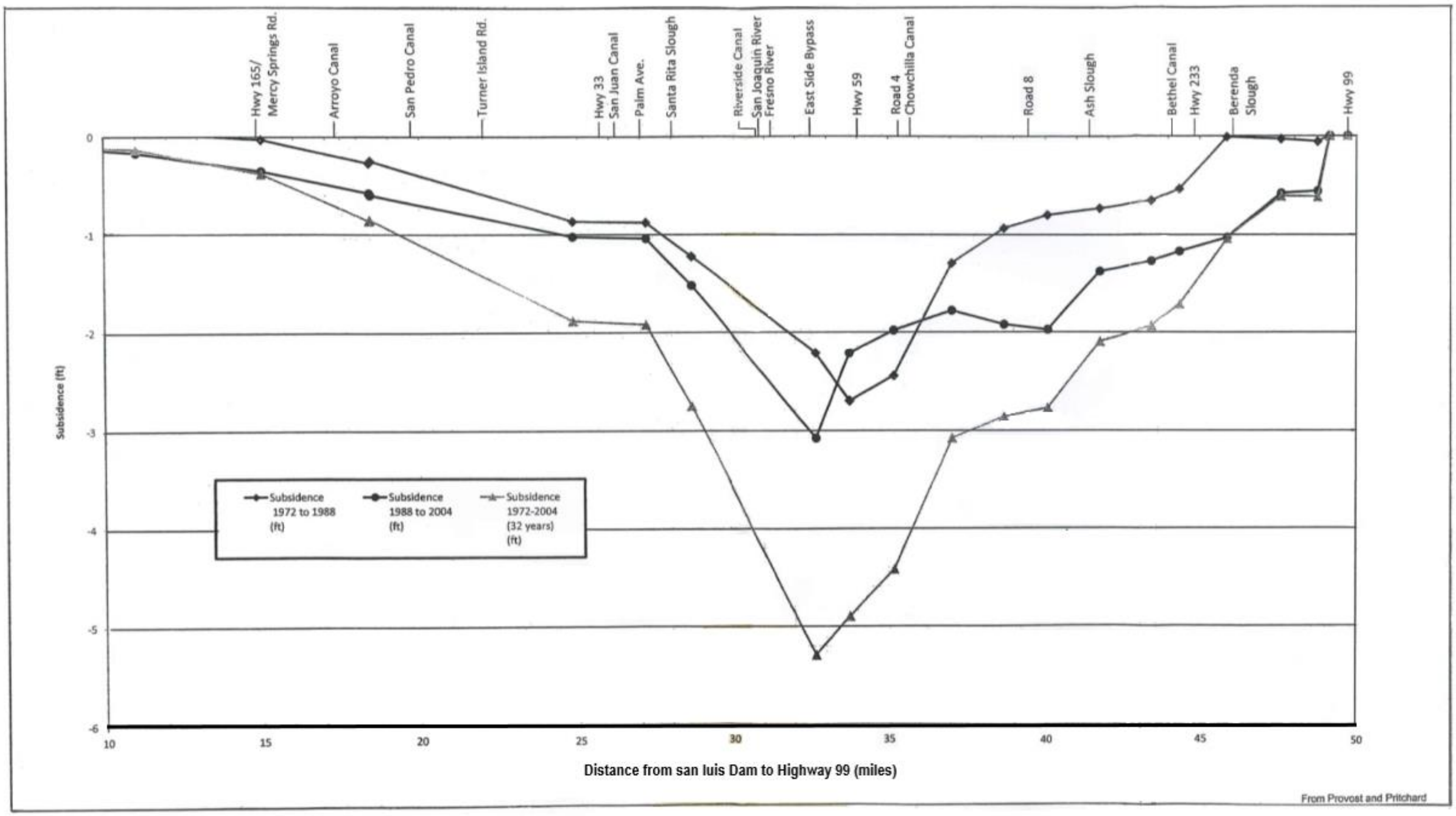


Figure 3-20: Historical Land Surface Elevations Along Highway 152 Transect

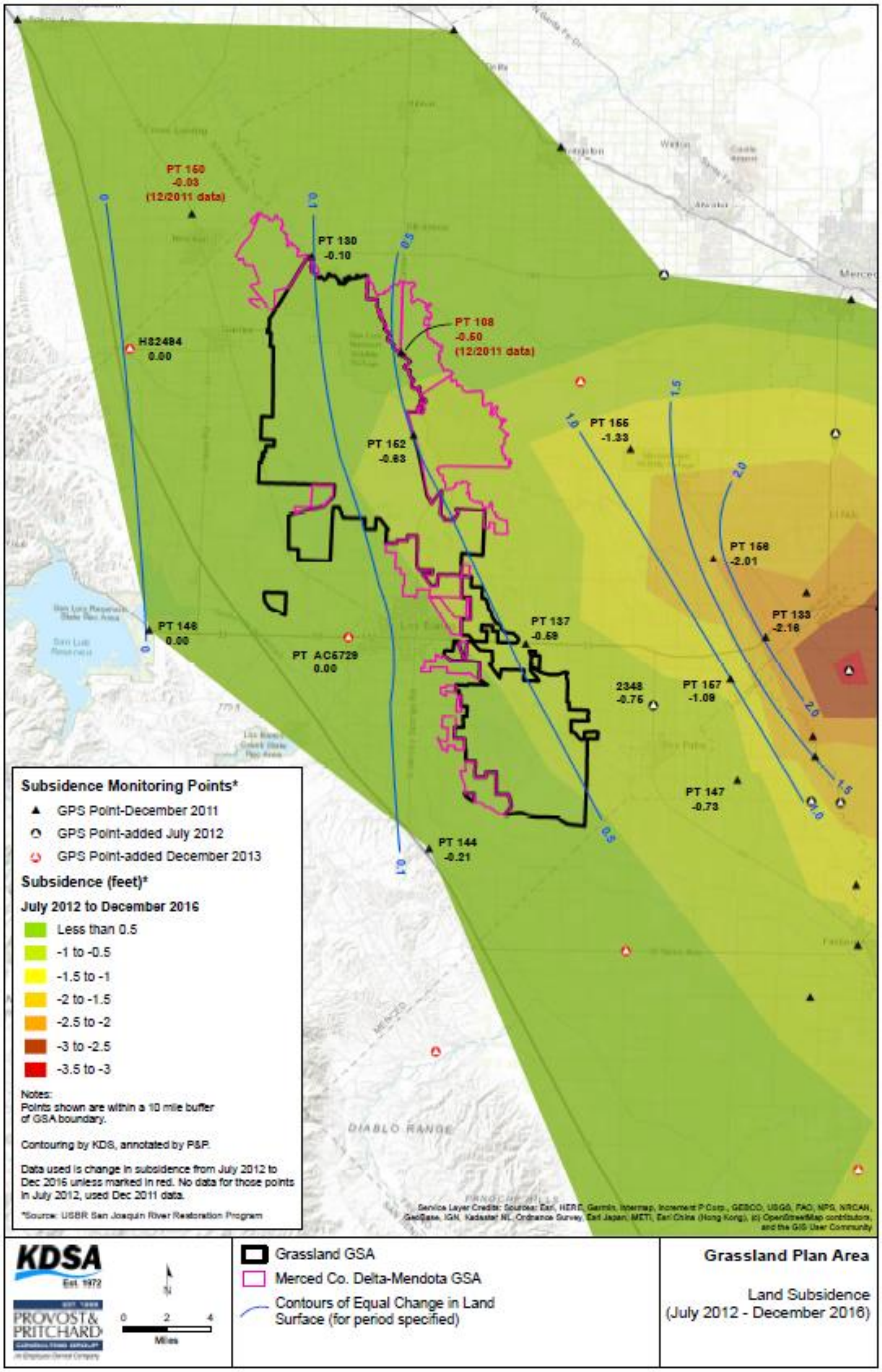


Figure 3-21: Land Subsidence

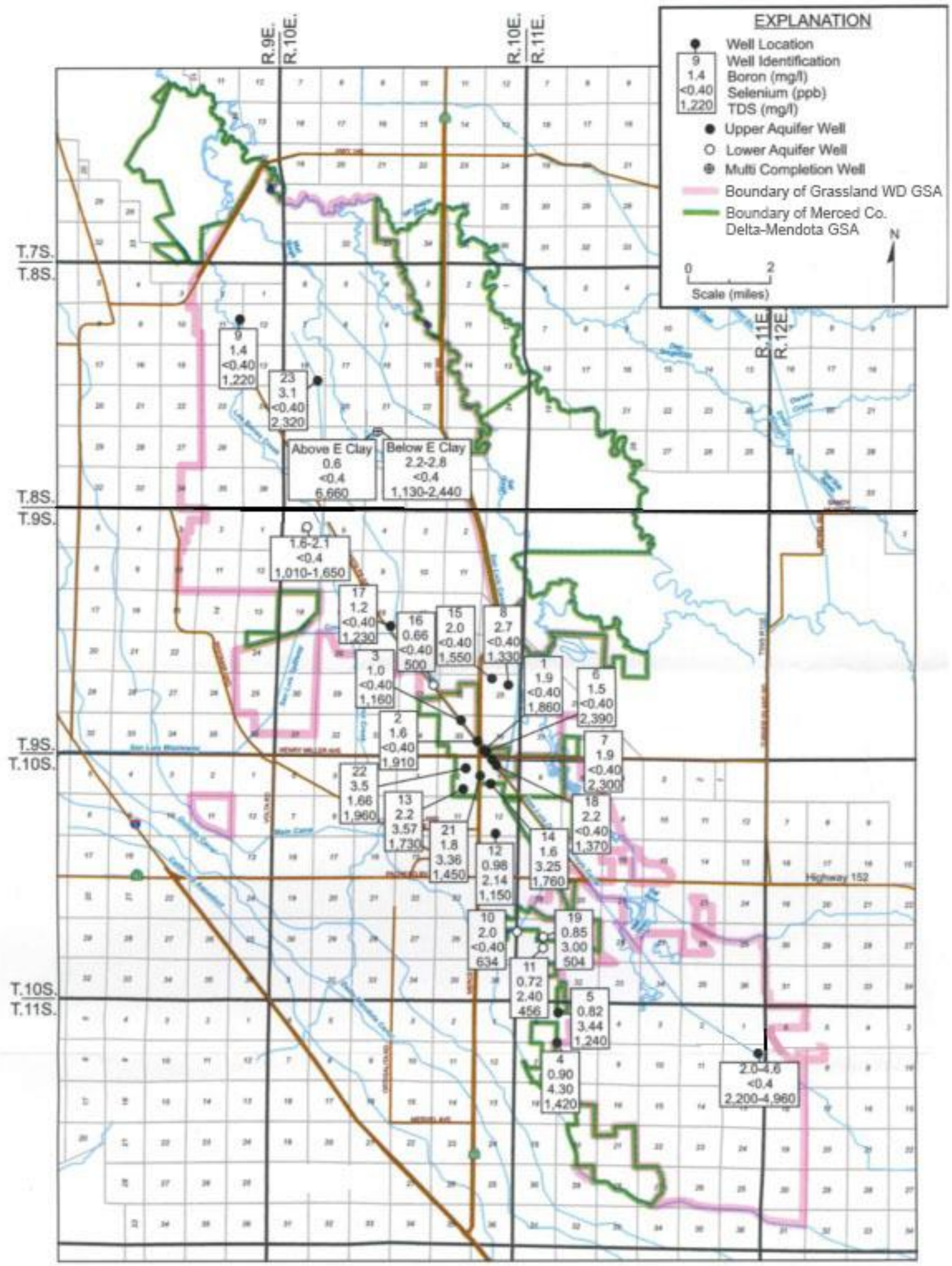


FIGURE 23 - GROUNDWATER QUALITY IN THE GWD

Figure 3-22: Groundwater Quality

Northern Division

Most of the chemical analyses for the Northern Division are of wells within about five miles of Los Banos. Data is also included from the two sites where nested monitor wells were installed. TDS concentrations in water from upper aquifer supply wells north of Highway 152 ranged from 1,160 to 2,390 mg/l. TDS concentrations exceeding 2,000 mg/1 were present in water from a well near Gun Club Road and two other wells near Henry Miller Road and the Santa Fe Canal. TDS concentrations of less than 1,500 mg/1 were present in water from a well near Carnation Road near the north edge of the Plan Area and from six other wells between Highway 152 and Husman Road.

Water from a lower aquifer well north of China Camp Road and near the Santa Fe Canal had a TDS concentration of 500 mg/1.

At one site, water samples were collected from both above and below the Corcoran Clay. The water sample from above the Corcoran Clay had a TDS concentration of 6,660 mg/1. For water samples collected from below the Corcoran Clay, TDS concentrations ranged from 1,130 to 2,440 mg/1.

At one site, water samples were collected only from below the Corcoran Clay as brackish groundwater was indicated above the clay. TDS concentrations ranged from 1,010 to 1,650 mg/1.

Southern Division

All five of the sampled supply wells in the Southern Division were located along the west side of the Plan Area between Pioneer and Almond Drive Road. Two of these wells were upper aquifer wells and three were lower aquifer wells. TDS concentrations in water from the upper aquifer wells ranged from 1,240 to 1,470 mg/l. Three wells that tapped the lower aquifer had TDS concentrations ranging from 456 to 634 mg/l.

At the sites, water samples were collected from two depth intervals above the Corcoran Clay. TDS concentrations ranged from 2,200 to 4,960 mg/1. The electric log for the test hole at the site indicated high salinity groundwater in the lower aquifer below the Corcoran Clay. A similar situation has been found in groundwater elsewhere in the Dos Palos area and to the southeast.

3.2.9 Interconnected Surface and Groundwater Systems

Legal Requirements:

§354.16(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or best available information.

The only locations in the area evaluated where groundwater is known to be in direct hydraulic communication with a stream is along a nine-mile-long reach of the San Joaquin River on the north edge of the San Luis NWR (**Figure 3-4**). A series of shallow monitoring wells have been installed by Reclamation as part of the SJRRP. Water level maps indicate that groundwater in the upper aquifer discharges to the river along this reach. The GGSA has installed a network of shallow (10 to 20 feet deep) observation wells in the District. Monitoring of these wells will provide more definitive information on the relationship between shallow groundwater and streamflow at these same locations.

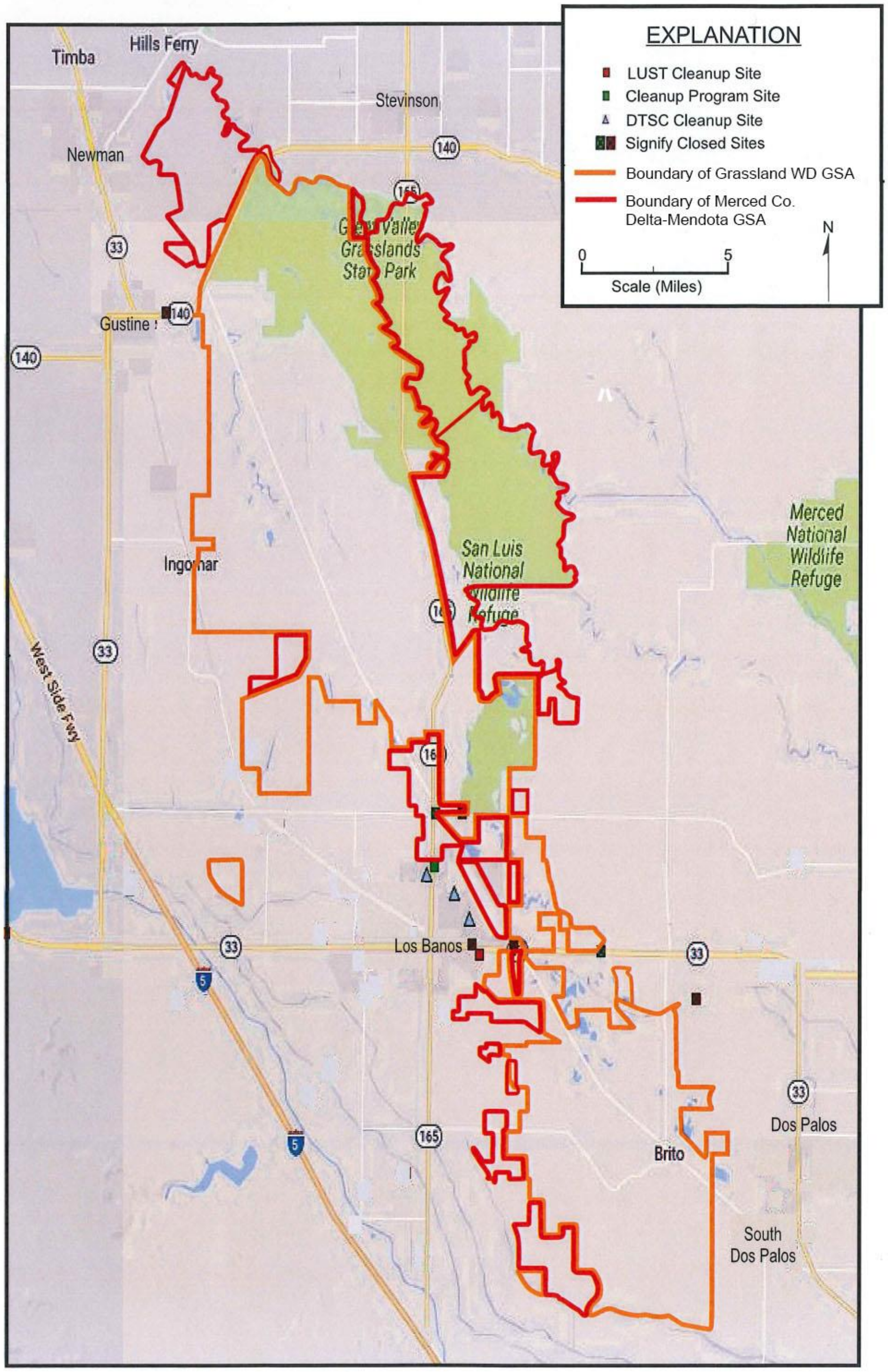
3.2.10 Known Contamination Sites

Legal Requirements:

§354.16(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

Figure 3-23 shows known groundwater contamination sites within the vicinity of the area evaluated, as taken from the Central Valley Regional Water Quality Control Board Geotracker website. There are very few sites within the Plan Area, and they are listed as closed sites.

55



KNOWN CONTAMINATION SITES

Figure 3-23: Known Contamination Sites

3.3 Water Budget Information

Legal Requirements:

§354.18
(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

A water budget is crucial to sustainable groundwater management. Quantifying historic, current, and projected conditions and overdraft allows a deeper understanding of water use and, in turn, allows GSAs to set supply augmentation and demand mitigation objectives if necessary. The water budget for the Grassland Plan Area was developed using information gathered from various sources including the hydrogeologic conceptual model and groundwater conditions report, precipitation and evapotranspiration databases, measurements of inflows and outflows to the system, and other relevant data. This information was coordinated at the Subbasin level to develop a consistent methodology for a Subbasin wide water budget (see Common Chapter – **Appendix A**).

GSP regulations stipulate the need to use the best available information and the best available science to quantify the water budget for the basin. Best available information is common terminology that is not defined under SGMA or the GSP Regulations. Best available science, as defined in the GSP Regulations, refers to the use of sufficient and credible information and data, specific to the decision being made and the time frame available for making that decision, which is consistent with scientific and engineering professional standards of practice. The best available information at the time the GSP is developed may be limited spatially and temporally. It is the intention of the GSAs within the Plan Area to continue to evaluate data gaps, compile data, seek additional sources, and improve means and methods of analyzing data moving forward in order to provide a clear and accurate description of the annual Groundwater Conditions and development of future Water Budgets.

3.3.1 Description of Groundwater Model

Legal Requirements:

§354.18
(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.
(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

GSP Regulations do not require the use of a numerical computer model to quantify and evaluate water budget conditions and the potential impacts to beneficial uses and users of groundwater. However, if a model is not used, the GSA is required to describe in the GSP an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

There is a lack of sufficient data regarding water use and cropping patterns in some parts of the Plan Area during the historically average period chosen by the Subbasin. In order to gain a greater understanding of operational and natural conditions in the Plan Area, the GSAs decided to use an analytical accounting tool to quantify the water budget conditions for specific year types where data was prevalent. This allowed the Plan Area to project historic trends into the future using actual data while incorporating factors that may alter these trends such as climate change and land use. The analytical accounting tool was also chosen to alleviate costs, to provide clarity in assumptions and data that were used, and to prevent the need to use unrealistic assumptions in order to calibrate a computer model. Such models can be very complicated and commonly produce results well outside of the expected range of error when limited data is available for analysis. This is especially true when dealing with systems like groundwater and land subsidence. The development of these complex groundwater models requires the results of local data, contour maps, trusted external data sets and equations, and physical observation and surveys.

Numerical groundwater models must be calibrated with actual data to determine their accuracy. The Central Valley Hydrologic Model Version 2 (CVHM2) numerical groundwater model was initially considered by other GSP Groups in the Subbasin to develop the required water budgets. However, it was determined that the model was not adequately calibrated within the Subbasin and did not provide an accurate estimate of actual conditions. The Plan Area participants chose instead to utilize available data and develop an analytical spreadsheet model for water budget accounting. Using actual data under these circumstances represents the best available information. Within the Subbasin this method is considered equally effective, if not more effective, than the numerical model. The GSAs will consider using an adequately calibrated groundwater model once their datasets are developed, if a model would be likely to produce more accurate results. It should be noted that existing models were referenced during the development of this water budget.

The complete water budget, including historic, current, and projected, for the Plan Area was developed using information from the hydrogeologic conceptual model and the groundwater conditions summary developed by Kenneth D. Schmidt & Associates and discussed earlier in this chapter along with data from sources such as the California Irrigation Management Information System (CIMIS), DWR, Irrigation Training & Research Center (ITRC), and California Data Exchange Center (CDEC), among others. Data from these sources as well as internal monitoring data and other publicly available information were utilized. The water budget methodology and data collection were coordinated with the other Delta-Mendota GSAs through the implementation of the Coordination Agreement and associated Coordination Committee and Technical Subcommittee.

In its January 2022 determination letter for the six the Delta-Mendota Subbasin (Subbasin), including the Common Chapter, the California Department of Water Resources (DWR) concluded that the Common Chapter did not adequately explain how each GSP used the same data and methodologies as the others (defined as “Deficiency 1”). DWR pointed to the water budgets contained in the six GSPs and compiled as the Subbasin water budget in the Common

Chapter and concluded that the chosen "sum-of-the-parts" approach made it uncertain whether the GSPs utilized the same data and methodologies to develop a Subbasin-wide water budget.

To address this deficiency, the GSAs in the Subbasin met to develop consistent definitions for their water budget components and reorganized the data in a more consistent fashion to conform with the component definitions. While the specific data used to develop the water budgets has not changed, the revised water budgets presented in the Revised Common Chapter reflect more coordinated Subbasin-wide water budgets using common definitions. A detailed explanation of the coordinated water budget components is also included in the Common Chapter, along with a discussion of the data and methodologies used. The reader is therefore referred to the amended Common Chapter for the SGMA-required historic, current and projected water budget for the Delta-Mendota Subbasin. A clean copy of the Revised Common Chapter is presented in **Appendix A** and a track changes version of the Revised Common Chapter is presented in **Appendix G**.

3.3.1.1 Period of Record

The period of record chosen to analyze the historic data was water year (WY) 2003 to 2012, covering an average hydrologic period. In August 2018, the Delta-Mendota Subbasin Coordination Committee approved the coordinated historic period of WY 2003 to 2012 and the current year of 2013 for the Subbasin. The projected water budget was analyzed from 2014 – 2070. The hydrologically average period was developed using San Joaquin River – Full Natural Flow (SJR FNF) data, the DWR water year index, and precipitation data at nearby gaging stations. A 50-year average of SJR FNF runoff was evaluated from 1966 to 2015, which was approximately 1.83 million AF. An alternative period from 1990 – 2015 was considered for potential analysis. A series of analyses were done for periods ranging from 1990-2015, but the period between 2003 and 2012 was chosen because:

- The average represented nearly 100% of the 50-year average for hydrological conditions (**Table 3-4**).
- The period was recent and reflects recent land use and regulatory conditions.
- It met the minimum 10-year requirement.
- The period did not end in a severe drought.
- It had a balanced number of water-year types.
- The data for the period would be more readily available given it is relatively recent.

Additional detail on the development of the historic water budget and hydrological average period can be found in ~~section 3.3.4.~~ **Appendix D**.

3.3.1.2 Representative Water Years

Because of the limited data in the Plan Area, representative years were chosen for specific water year types: 2013 for the average/dry year, 2015 for the critical year, and 2017 for the wet year. Water year types were determined using the DWR water-year index. Data from these years were compiled to develop an annual water budget and then used as surrogates for the 2003-2012 water years. They were also used as surrogates for the projected water budget. Average and dry years were combined into a single category because surface water allocations and groundwater pumping tend to be unchanged during these year types. Changes in groundwater pumping only occur during wet years when there is surplus water available, reducing the need to pump supplemental groundwater, and during critical years when surface water allocations are reduced increasing the need for additional groundwater extraction.

3.3.1.3 Changes in Land Use

The extensive managed wetlands within the Grassland Plan Area form a landscape that changes from month to month. The Plan Area is made up of private managed wetlands, federal and state wildlife refuge, and a small amount of farmland. Unlike most geographical areas where agricultural and urban land uses remain fairly static, the Plan Area is dynamic, changing as wetlands are flooded, drained, and irrigated. Because of this, evapotranspiration and seepage were analyzed in greater detail on a monthly timescale. Shapefile data provided by Point Blue Conservation Science and Ducks Unlimited were used to develop monthly maps of the extent of the wetland ponding, in acres (see **Figure 3-24** and **Figure 3-25**). This helped to determine which types of wetland vegetation were present monthly, for accurate estimates of evapotranspiration of vegetation and water surfaces. Changes in the wetland area required seepage from wetland ponds to be also analyzed monthly.

3.3.1.4 Aquifer Significance

There are two principal aquifers in the Plan Area: the upper unconfined and the lower confined aquifer, separated by the Corcoran Clay, which are described in the aquifer characteristics portion of the HCM. Groundwater is pumped from both the upper and lower aquifer, with very little water pumped from the lower aquifer within the Plan Area. Only total pumping is calculated, and the water budgets do not differentiate between upper and lower aquifer contributions. Further investigations will be needed to separate upper aquifer pumping from lower aquifer pumping. This will require development of a Plan Area-wide database to log well completion, perforation locations, and the volume of water pumped. The database will require interpretation by an experienced hydrogeologist. Groundwater monitoring will help quantify each aquifer’s total amounts of groundwater extracted and the recovery of the both aquifers over time. Hydrographs, contour maps, and subsidence trends were used to calculate change in storage and sustainable yield for each aquifer and these are provided in the corresponding sections of this GSP.

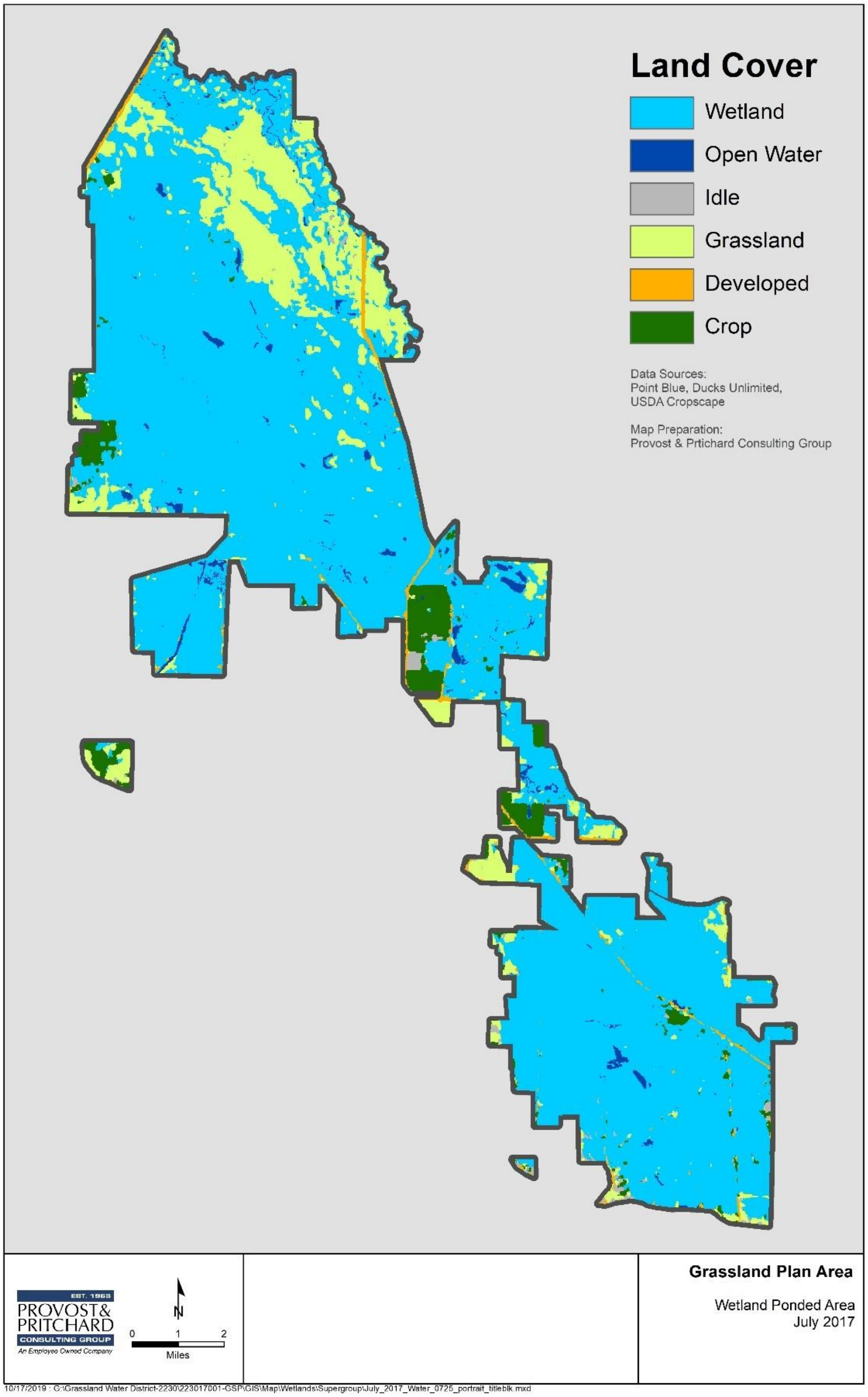


Figure 3-24: Wetland Ponded Area – July 2017

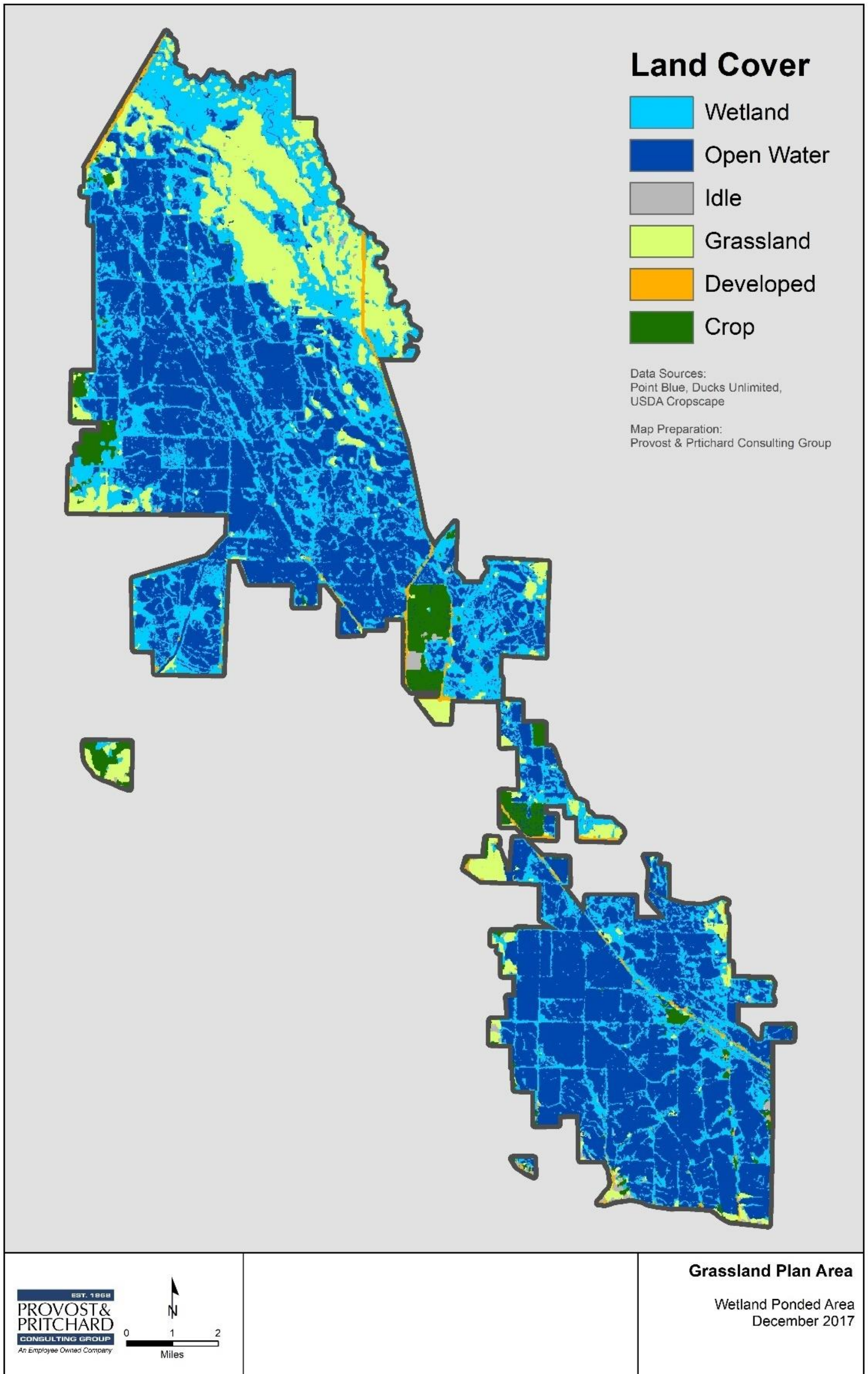


Figure 3-25: Wetland Ponded Area – December 2017

3.3.2 Method for Quantification of Inflows and Outflows

Legal Requirements:

§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(1) Total surface water entering and leaving a basin by water source type.
(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.
(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

Quantification of inflows and outflows to the Plan Area were necessary to develop the historic, current, and projected water budgets. Some variables were estimated, using the best available science and methods, due to a lack of measured data. Inflows and outflows were broken down by water source and use. Each of the parameters described below is incorporated into the water budget spreadsheet tool. DWR's diagram displaying typical inflows and outflows for the atmospheric system, land surface system, and groundwater system is shown in **Figure 3-26**. For the purposes of the Grassland GSP's water budget, the analysis looks at the land surface system and the groundwater system, any losses to or gains from the atmospheric system are accounted for in the land surface system as evaporation or precipitation. Results of the historic, current, and projected water budget are provided in subsequent sections of this chapter.

In its January 2022 determination letter for the six Groundwater Sustainability Plans (GSPs) in the Delta-Mendota Subbasin (Subbasin), including the Common Chapter, the California Department of Water Resources (DWR) concluded that the Common Chapter did not adequately explain how each GSP used the same data and methodologies as the others (defined as "Deficiency 1"). DWR pointed to the water budgets contained in the six GSPs and compiled as the Subbasin water budget in the Common Chapter, and concluded that the chosen "sum-of-the-parts" approach made it uncertain whether the GSPs utilized the same data and methodologies to develop a Subbasin-wide water budget.

To address this deficiency, the Subbasin's Groundwater Sustainability Agencies (GSAs) met to develop consistent definitions for their water budget components, and reorganized the data in a more consistent fashion to conform with the component definitions. While the specific data used to develop the water budgets has not changed, the revised water budgets presented in the amended Common Chapter reflect more coordinated Subbasin-wide water budgets using common definitions. A detailed explanation of the coordinated water budget components is also included in the Common Chapter, along with a discussion of the data and methodologies used. The reader is therefore referred to the amended Common Chapter for the SGMA-required historic, current and projected water budget for the Delta-Mendota Subbasin.

The initial results of the historic, current, and projected water budget were provided in subsequent sections of this chapter. However, because some components of the original Grassland GSP water budget were reorganized for consistency with the other GSPs in the Subbasin, the initial water budget is now presented in **Appendix D**. A crosswalk of the reorganization of some components from the initial Grassland GSP water budget and the revised Subbasin wide water budget is shown in **Figure 3-27(a) and (b)**.

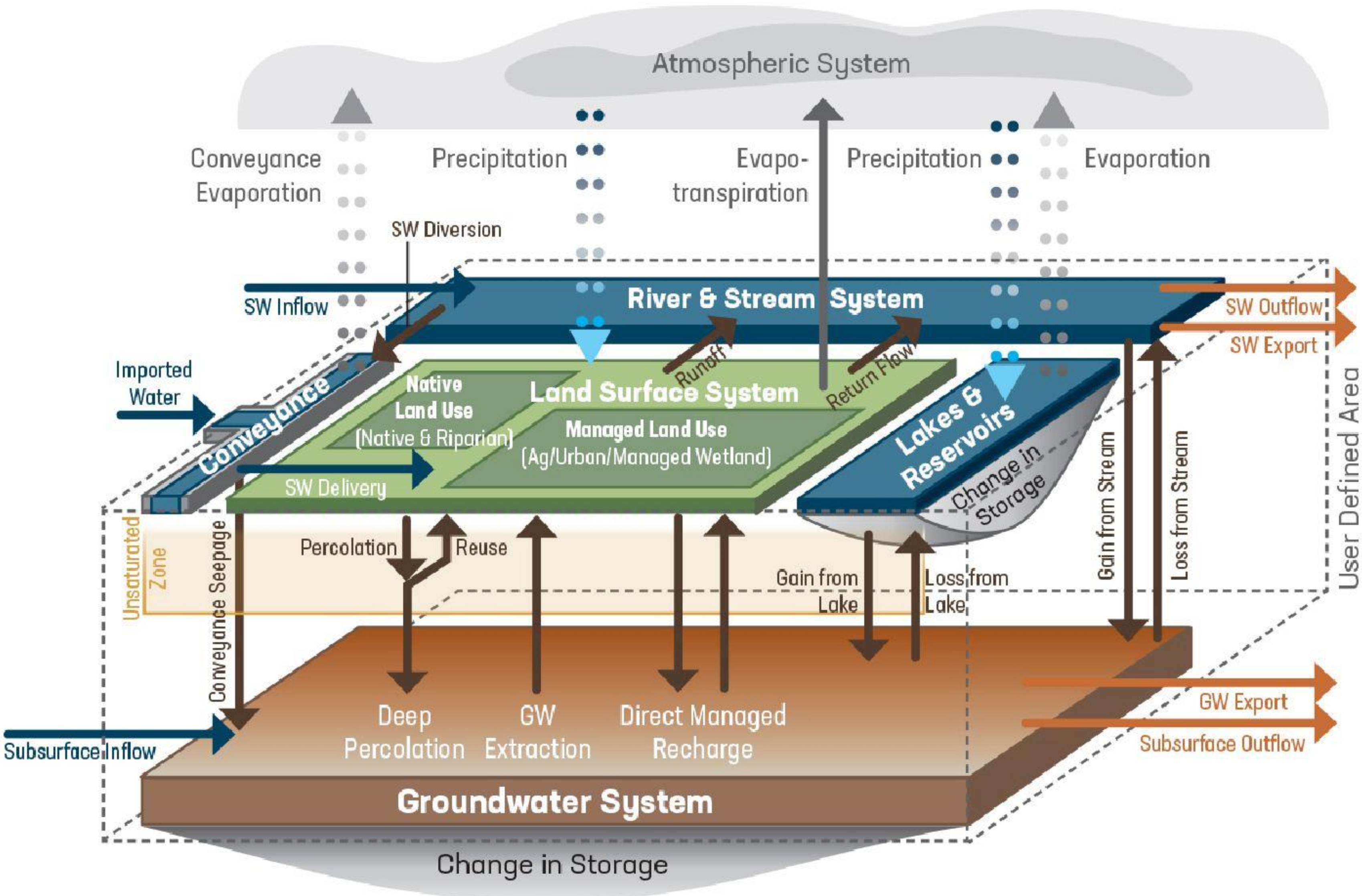
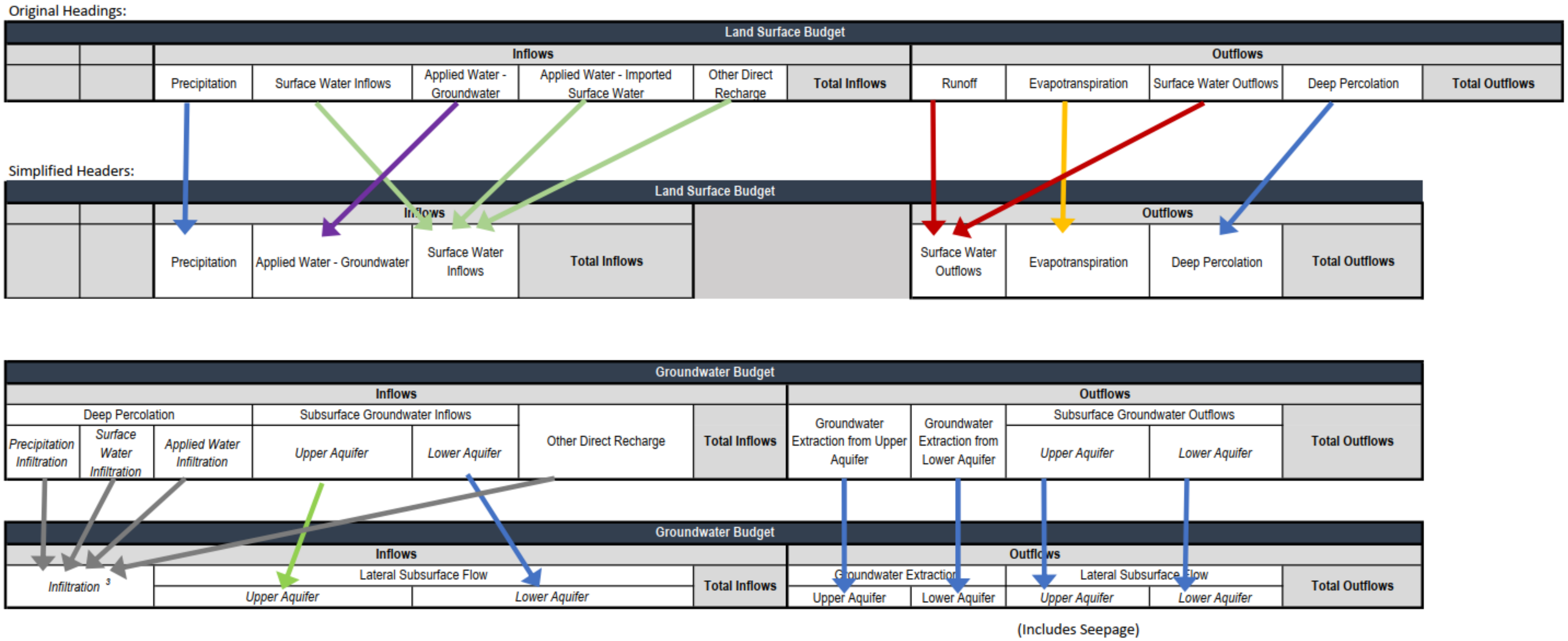


Figure 3-26: DWR Water Budget Graphic



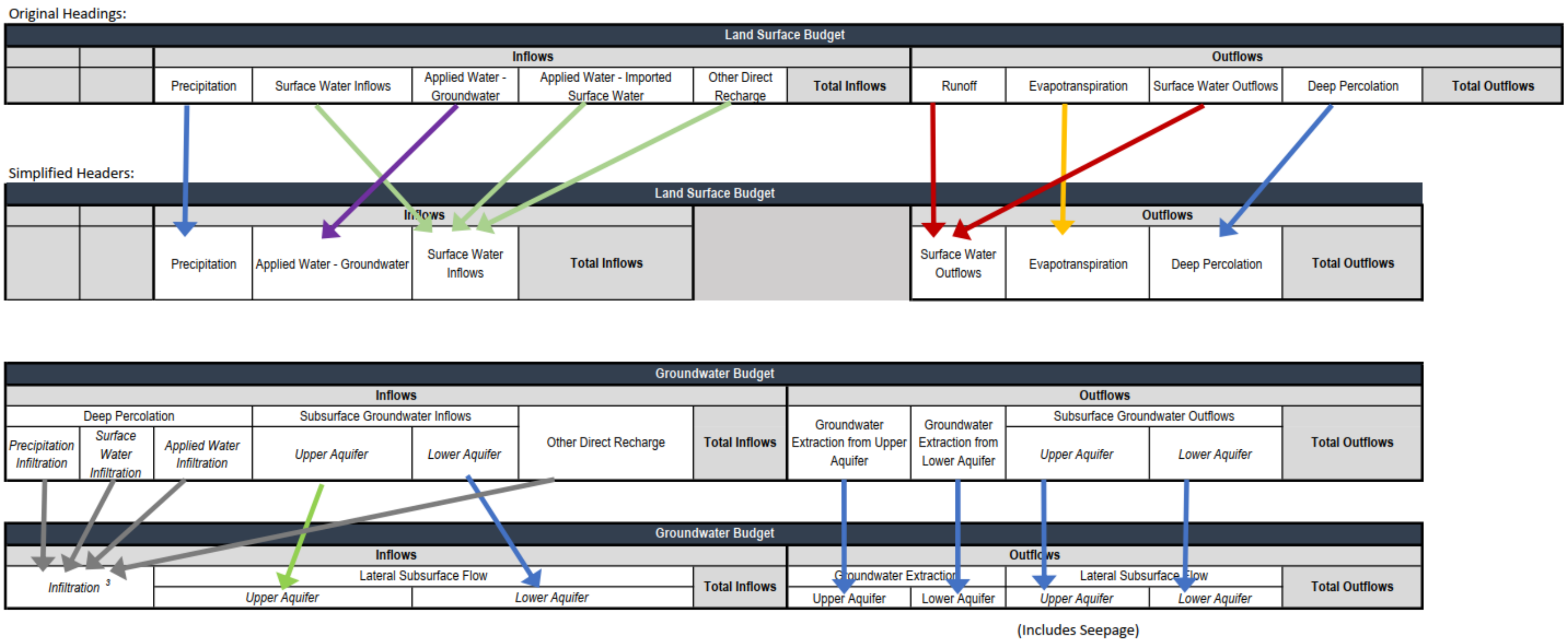
Notes:

1. Combined with the Surface Water Inflows category from original water budget in GSP. Surface Water Inflows represents unmetered, non-CVP inflows. Applied Water - Imported Surface Water quantifies federally contracted CVP water, 21 flood water, and *imported* groundwater.

2. Combined with the Surface Water Outflows category from original water budget in GSP. In the GSP, all metered surface water outflows that weren't runoff was considered Surface Water Outflows.

3. Quantifies Precipitation Infiltration, Surface Water Infiltration, Applied Water Infiltration, and Other Direct Recharge from the previously submitted water budget. Other Direct Recharge is defined as pond seepage in the GSP and for this simplified water budget it is considered infiltration.

Figure 3-277(a): Water Budget Crosswalk, Historic-Current (2003-2012)



Notes:

1. Combined with the Surface Water Inflows category from original water budget in GSP. Surface Water Inflows represents unmetered, non-CVP inflows. Applied Water - Imported Surface Water quantifies federally contracted CVP water, 21 flood water, and *imported* groundwater.

2. Combined with the Surface Water Outflows category from original water budget in GSP. In the GSP, all metered surface water outflows that weren't runoff was considered Surface Water Outflows.

3. Quantifies Precipitation Infiltration, Surface Water Infiltration, Applied Water Infiltration, and Other Direct Recharge from the previously submitted water budget. Other Direct Recharge is defined as pond seepage in the GSP and for this simplified water budget it is considered infiltration.

Figure 3-287(b): Water Budget Crosswalk, Projections Simplified

3.3.2.1 Land Surface System Inflows

Imported Surface Water

Both the GGSA and the MCDMGSA (Monitoring ZonesSubareas 1 and 2, respectively, See **Figure 2-1**) have lands within their jurisdictions that receive federally contracted CVP surface water from USBR for private, state, and federal refuges. During wet water years, they also have the ability to receive Section 215 flood water from USBR. An additional source of surface water includes groundwater imported from outside of the GSA that is pumped into Monitoring ZoneSubarea 2 and delivered to managed wetlands in Monitoring ZoneSubarea 1 through the surface water delivery system (see Groundwater discussion below). Total values for delivered surface water for Monitoring ZoneSubarea 1 can range from 125,000 AF during critically dry years to nearly 270,000 AF during wet years. In Monitoring ZoneSubarea 2 surface water deliveries range from 31,000 AF during critically dry years to 52,000 AF during a wet year. This category was reorganized into the Surface Water Inflows category in the updated Water Budget table.

Surface Water Inflows

Non-CVP surface water inflows occur from surrounding agricultural districts and local waterways due to the low-lying elevation of the Plan Area. These inflows are accounted for in the surface water totals above. Typically, these inflows are unmetered but have been quantified using observed flow rates as they pass into the Plan Area, along with known watershed capacity characteristics. Surface water inflows have decreased over time with increased agricultural irrigation efficiencies. Non-CVP surface water inflows to Monitoring ZoneSubarea 1 (GGSA area) are estimated at 30,600 AF under the current water budget and 33,800 AF under the average historic water budget. Some of these non-CVP surface water inflows may flow through into Monitoring ZoneSubarea 2 (MCDMGSA area), but there are few independent sources of non-CVP surface water inflows to Monitoring ZoneSubarea 2. Therefore, no additional value for non-CVP surface water inflows was assigned to Monitoring ZoneSubarea 2 in the development of the Plan Area water budgets.

Precipitation

Monthly precipitation data was collected from the Los Banos CIMIS station for the surrogate water years. The same station was used to analyze data for the projected water budgets; however, data interpolated from the PRISM model was used in representative years prior to the installation of the CIMIS station (see **Section 3.3.4.4, Projected Water Budget**). The PRISM model calculates precipitation and evapotranspiration values in locations where monitoring stations do not exist and during years prior to the establishment of data collection. During the historically average period, rainfall ranged from slightly less than 4 inches in 2013 to 14 inches in 2005.

Precipitation either is utilized by plants as effective precipitation and evapo-transpired as an output from the surface water system, leaves the surface water system as precipitation runoff, or enters the groundwater system and becomes deep percolation as an input to the groundwater system and an output from the surface water system. These will be detailed further in their respective sections.

Effective Precipitation

Effective precipitation is the amount of rainfall that is beneficially used by vegetation. For managed wetlands, effective precipitation is considered to be any precipitation that has the potential to satisfy monthly evapotranspiration (ET) requirements. Precipitation that is in excess of ET requirements is considered runoff and contributes to surface water outflow.

For agricultural land, effective precipitation is calculated as 50% of total annual precipitation for the October-September water year. This 50% effective precipitation assumption is a commonly used method. Based on the Plan Area hydrology consultant's experience with calculating effective precipitation for other agricultural water balances, water transfers, and GSPs, the 50% assumption is known to produce results that are consistent with the more time-intensive Macgillivray method developed by DWR, which requires monthly time steps for precipitation data. The DWR method is based on the set of three equations seen below as **Equation 3-1** (1989 Macgillivray report for DWR).

Equation 3-1 Effective Precipitation

$$Nov - Feb = -0.54 + (0.94 * P)$$
$$Mar = -1.07 + (0.837 * P)$$
$$Oct = -0.06 + (0.635 * P)$$

Where P = Precipitation for the months listed in inches

Groundwater

Groundwater pumping is metered in the GGSA (Monitoring Zone~~Subarea~~ 1 for Water Budget purposes) and much of the MCDMGSA (Monitoring Zone~~Subarea~~ 2). Groundwater pumping for areas within Monitoring Zone~~Subarea~~ 2 that are not metered was estimated using a consumptive use of applied water method (**Equation 3-2**). All consumptive use within the unmetered areas is assumed to be met with groundwater. Pumping was calculated as vegetation/crop demand with an irrigation efficiency factor of 80% applied to account for losses, primarily deep percolation into the aquifer. Groundwater pumping is an outflow to the groundwater system and an inflow to the land surface system.

Equation 3-2 Groundwater Pumping

$$GW = \left[\frac{(CD)}{IE}\right]$$

Where:
GW = Groundwater Pumped for Irrigation
CD = Crop Demand
IE = Irrigation Efficiency

Total groundwater extraction in Monitoring Zone~~Subarea~~ 1 ranges from less than 3,000 AF during wet years to almost 20,000 AF during all other year types. Monitoring Zone~~Subarea~~ 2 pumping ranges from nearly 30,000 AF in most year types to about 37,000 AF during critically dry years. Additional considerations were taken for groundwater pumped within Monitoring Zone~~Subarea~~ 2 that is used within Monitoring Zone~~Subarea~~ 1 for wetland habitat purposes. This groundwater pumping is metered and accounted for as groundwater outflow from Monitoring Zone~~Subarea~~ 1 (labelled Groundwater Monitoring Zone~~Subarea~~ 2 → Monitoring Zone~~Subarea~~ 1).

Demand due to Irrigation Efficiency

Irrigation efficiencies were estimated for agricultural lands in the Plan Area. Efficiencies are estimated using the combination of actual irrigation practices and distribution system design. Irrigation methods were assigned to specific crop types based on known irrigation trends. Typical efficiencies of each irrigation method were used to estimate irrigation efficiency as it relates to irrigation practices, which was close to 80%. The irrigation efficiencies were used to estimate groundwater pumping for private agricultural lands in Monitoring Zone~~Subarea~~ 2 as described in the groundwater description above.

Irrigation efficiencies are not a direct input or output from the surface water system. The volume of groundwater that is pumped to meet demands resulting from irrigation efficiency is assumed to percolate back into the groundwater system, essentially netting in no change to the water budget. Water returning to the groundwater system as a result of irrigation efficiencies is described in further detail in the section below titled Deep Percolation of Irrigation Water.

3.3.2.2 Surface System Outflows

Runoff of Precipitation

Runoff of precipitation is estimated as the amount of precipitation that cannot be effectively used on the landscape. Only during wet years is runoff of precipitation considered to be a large contributing factor to the water budget. It is assumed that a majority of the precipitation is either consumptively used by vegetation, percolated back into the ground, or evaporated. This analysis was conducted where data was available within the Plan Area, with the exception of some portions of Monitoring Zone~~Subarea~~ 2 (including the West Bear Creek and San Luis Units of the San Joaquin National Wildlife Refuge, and the China Island Unit of the North Grasslands State Wildlife Area), where runoff data is not available. The Plan Area participants will work with landowners and agencies in those areas to obtain this information in order to refine the water budget in future GSP updates. This category was reorganized into the Surface Water Outflows category in the updated Water Budget table.

Evapotranspiration

Evapotranspiration values for vegetation (ET_v) in the Plan Area were developed using vegetation coefficients Howes, Fox, and Hutton (2015) al. This paper developed evapotranspiration coefficients (K_v) for wetland and upland vegetation and also published K values for other rainfed vegetation. K_v values were used with reference ET (ET_o) to calculate ET_v.

Vegetation categories included open water, large stand seasonal wetlands, moist soil vegetation, rainfed vegetation, and crops (grassland, idle land). Developed land was also considered, but it was assumed that water on this land use type would be precipitation only and be attributed to runoff. The vegetation coefficients (Kv/Kc) and ETo values for the land use types are shown in **Table 3-1.**

Table 3-1: Vegetation Coefficients and ET for Natural Vegetation Types

Vegetation Coefficients and ET For Natural Vegetation Types				
	Kv/Kc (annual average, inches)	Wet Year ET_o 59.53 annual, inches	Normal/Dry Year Total ETo 59.39 annual, inches	Critical Year Total ET_o 57.75 annual, inches
		Wet Year $ET_{kc/kv}$ (annual average, inches)	Normal/Dry Year $ET_{kc/kv}$ (annual average, inches)	Critical Year $ET_{kc/kv}$ (annual average, inches)
Moist Soil Veg Vegetation	0.37	0.10	0.10	0.10
Large Stand Seasonal Wetlands	0.89	0.40	0.41	0.39

Open Water	0.87	0.39	0.39	0.38
Grassland	0.37	0.10	0.10	0.10
Idle Land	0.37	0.10	0.10	0.10

Using acreages of each land use type, total acre-feet of ET per month was calculated for each Monitoring ZoneSubarea for each year type and is summarized in **Table 3-2** below.

Table 3-2: Evapotranspiration (AFY) by SubareaMonitoring Zone

Evapotranspiration (AFY)		
	Monitoring ZoneSubarea 1 (GGSA)	SubareaMonitoring Zone 2 (MCDMGSA)
Wet	204,800	96,200
Normal/Dry	210,100	99,500
Critical	170,600	89,200

Evaporation of Channels and Ponds

Evaporation from water delivery channels and wetland ponds was calculated for all surfaces of waterbodies in the Plan Area during the evapotranspiration calculation, using vegetation coefficients from Howes' document that included ET estimates for open water. The surface area of each water body was determined using surveyed areas and aerial images. Total ET for the open water irrigation channels and ponds was included in **Table 3-2.**

3.3.2.3 Groundwater System Inflows

Inflows to groundwater are any sources of water that contribute to the groundwater aquifer as a result of natural or managed inflow. Inflows may come from surface water or adjacent boundary groundwater flow. Inflows from surface water include recharge from natural bodies of water, losses from irrigation and conveyance systems, and managed or intentional recharge.

Deep Percolation of Irrigation Water

Deep percolation of agricultural irrigation water is an inflow from the land surface to the groundwater. Deep percolation of irrigation water is calculated using the assumption that all applied water in excess of the evapotranspiration (due to irrigation inefficiencies) infiltrates past the root zone and makes it back into the groundwater system (**Equation 3-3**). Deep percolation of irrigation water was only calculated for agricultural lands in Monitoring ZoneSubarea 2. Any deep percolation of water used for irrigation of managed wetlands was accounted for in the analysis of pond seepage and is not considered in this calculation. This category was combined with all of the other percolation inflow categories and reorganized into the Infiltration category.

Equation 3-3 Deep Percolation of Irrigation

$$Deep\ Percolation\ of\ Irrigation\ Water = \left[\frac{(ET)}{IE}\right] - (ET)$$

Where:

ET = Evapotranspiration
IE = Irrigation Efficiency

Deep Percolation of Precipitation

Deep percolation of precipitation is an inflow from the land surface system to the groundwater system. Deep percolation of precipitation is estimated to be 10% of total annual precipitation based on previously made assumptions and known hydrogeologic characteristic of the area. This category was combined with all of the other percolation inflow categories and reorganized into the Infiltration category.

Deep Percolation of Rivers, Streams, Channels, and Ponds

Deep percolation of water from surface water bodies, natural or managed, is often called seepage or infiltration. Seepage of water in surface water bodies is typically affected by soil permeability, channel width, and water depth. Other factors that can affect seepage include sedimentation of silts in channels, decaying vegetative matter, groundwater levels, and hydraulic gradients. Several sources and existing studies were examined to develop seepage estimates. The seepage analysis evaluated the following sources of data:

- The Grassland Water District Groundwater Management Plan
- Studies from the San Joaquin River Restoration Program (SJRRP)
- Saturated hydraulic conductivity maps developed using NRCS mapping layers (See **Section 3.1, HCM**)
- Soil texture and hydrologic grouping maps
- Irrigation delivery data

This category was combined with all of the other percolation inflow categories and reorganized into the Infiltration category.

Deep Percolation of Channels and Streams

Surface water delivery systems incidentally infiltrate water through the soil in unlined canals and storage and regulating reservoirs. According to the GWD Groundwater Management Plan, an estimated 18% of delivered water is lost due to seepage in the wetland water delivery canals. Therefore, 18% of total surface water deliveries was used to estimate seepage losses from channels within each Monitoring Zone~~Subarea~~ for each water year type. Deep percolation from natural streams and channels that deliver spill water from neighbors or flood waters is also included in the estimated 18% of total surface water deliveries. This category was combined with all of the other percolation inflow categories and reorganized into the Infiltration category.

Local River Seepage

The portion of the San Joaquin River that runs along the eastern edge of the Plan Area is a gaining stream; therefore, there is no contribution from the river to the groundwater system. Streams that flow through the Plan Area are included in the estimates for deep percolation of channels. Losses to the SJR are accounted for in the Discharges & Consumptive Use/Lateral Flow of Groundwater in the Groundwater Outflow section below. This category was reorganized into the Infiltration category.

Pond Seepage

A mass balance method was used to calculate seepage from wetland habitat ponds. System gains and losses were quantified. Losses included evapotranspiration as described previously, surface water outflow from the Plan Area, and seepage of ponded water. Gains included effective precipitation and water deliveries. Seepage was quantified using **Equation 3-4** Total Seepage.

Equation 3-4 Total Seepage

$$Total\ Seepage = (ET + Outflow) - (EP + Water\ Deliveries)$$

Where:
ET = Evapotranspiration
EP = Effective Precipitation

Seepage rates for the flooded habitat were determined while ponded areas were full and receiving "maintenance" deliveries to compensate for losses. The volume of pond seepage was calculated using **Equation 3-4** Total Seepage for months where water deliveries for maintenance flow were provided. The monthly volume was converted to an average monthly loss rate over the ponded area. Using this method an average seepage rate of approximately 0.25 feet/month or 0.0082 feet/day was established. When a 0.25 foot/month loss rate was applied to the total acreage of open water for each month, total losses were approximately 67,000 AF. These losses also include losses from channels and streams, quantified as 18% of total surface water deliveries. By subtracting the seepage of the channels from the total seepage, it was determined that approximately 8.6% of the total applied surface water returns to the groundwater system. This category was reorganized into the Infiltration category.

Intentional Groundwater Recharge

There is no intentional groundwater recharge in the Plan Area; however, recharge from the ponded habitat results in gains to groundwater system, some of which is assumed to leave the groundwater system as described in **Section 3.3.2.4**.

Groundwater Inflow

Groundwater movement occurs due to hydraulic gradients. Calculations of groundwater movement use transmissivity values based on aquifer tests (see **Section 0**), groundwater level contours and cross- boundary flow directions (see **Section 3.2.2.2**). Transmissivity changes with depth due to variations in aquifer material. For the Plan Area, an average transmissivity value was used for each boundary line to estimate the thickness of the aquifer, based on available data. Therefore, the GGSA and MCDMGSA worked with the neighboring SJRECGSA, which had sufficient internal data to develop groundwater flow contours as groundwater contours were unavailable or inconsistent for some years in areas adjacent to and within the Plan Area. The SJRECGSA assisted KDSA in calculating the average-per-mile outflows from the SJRECGSA boundary adjacent to the Plan Area. These numbers were used to calculate Plan Area inflows. The Subsurface Groundwater Inflows to the upper and lower aquifers were recategorized to the Lateral Subsurface Flow to the upper and lower aquifers, respectively.

Other Recharge

There are no other known recharge components.

3.3.2.4 Groundwater System Outflows

Groundwater Pumping

Groundwater is pumped from both the upper and lower aquifers in the Plan Area. Pumping is not separated by aquifer for the purposes of this water budget and was explained in detail previously in the surface water discussion.

Subsurface Groundwater Outflow

Groundwater outflow was calculated the same way as inflow. Limited data was available for areas adjacent to and within the Plan Area. All groundwater outflow from the Grassland Plan Area leaves the Delta-Mendota Subbasin boundary and enters the Merced Subbasin. This category was reorganized from Subsurface Groundwater Outflows from the upper and lower aquifers to Lateral Subsurface Flows from the upper and lower aquifers, respectively.

Groundwater Pumped in Monitoring Zone~~Subarea~~ 1 and Delivered in Monitoring Zone~~Subarea~~ 2

Groundwater is pumped from portions of Monitoring Zone~~Subarea~~ 2 and delivered to Monitoring Zone~~Subarea~~ 1 through the surface water delivery system, where it is applied to habitat. This groundwater is accounted for in Monitoring Zone~~Subarea~~ 2 as pumped groundwater (labelled "Groundwater Monitoring Zone~~Subarea~~ 2 → Monitoring Zone~~Subarea~~ 1) and is accounted for in Monitoring Zone~~Subarea~~ 1 as surface water inflow. This category was reorganized into the Groundwater Extraction from the Upper Aquifer category under the Projected Groundwater Outflow Budget.

Discharges & Consumptive Use/Lateral Flow of Groundwater

Since the estimated inputs to the groundwater system are greater than the estimated outflows throughout most of the Plan Area, additional losses from the groundwater system were quantified as a "closing term" (in water accounting, where one part of a water budget is back-calculated using the other terms), to reflect other uses of groundwater as a result of the difference in physical change in storage. Additional losses from the groundwater system are assumed to be either passively discharged to surface water from the shallow groundwater table or consumptively used by GDE vegetation in the Plan Area, which may also be associated with localized lateral flow gradients. The total additional losses from this parameter range from 14,000 AFY to 58,000 AFY for the entire Plan Area. These outflows are included in the water budget under the category "Other Consumptive Use of Groundwater" and are labelled as "Discharge to Surface Water/Consumptive use by GDEs/Lateral Flow." Both of these categories were reorganized into the Lateral Subsurface Flow to the Upper Aquifer category under the Projected Groundwater Outflow Budget.

Discharges to Surface Water

Discharges to surface water occur when the groundwater table is at or above the elevation of adjacent surface water. Discharges from the groundwater system are known to enter the SJR adjacent to the Plan Area. Additional monitoring is needed to detect discharge locations and quantities. Discharges to some ditches, canals, and sloughs are also possible as groundwater elevation rises during the irrigation season and wet periods. Although discharges to surface water are not directly quantified, it has been determined based on water operator's experiences that during wet years, certain wetland units retain water in volumes that exceed precipitation, even without active surface or groundwater deliveries. In addition, water runoff from the Plan Area is sometimes greater than the volume of applied water and precipitation. In these wet years, it is estimated that passive discharges of shallow groundwater to surface water during wet years are greater than consumptive use of groundwater by vegetation. Pumping of groundwater is low in wet years due to wetland water needs being met by reliable deliveries of surface water and above average precipitation.

Consumptive Use/Lateral Flow of Shallow Groundwater

Consumptive use of groundwater is defined as the evapotranspiration of shallow groundwater by vegetation. During average/dry years and critically dry years, consumptive use is greater than applied water (both surface and groundwater), signifying that additional near-surface water sources are likely present for use in wetland habitats. This deficiency in available water for wetland consumptive use may also create a local gradient that allows groundwater to move laterally from ponded areas or areas with greater access to surface water to areas with less access to surface water. It should be noted that lateral flow may be induced in nearby areas where groundwater pumping is the main source of water.

3.3.3 Quantification of Overdraft and Sustainable Yield

Legal Requirements:

§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(4) The change in the annual volume of groundwater in storage between seasonal high conditions.
(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
(6) The water year type associated with the annual supply, demand, and change in groundwater stored.
(7) An estimate of sustainable yield for the basin.

3.3.3.1 Overdraft/Change in Groundwater Storage

Overdraft happens when more water is flowing out of the aquifer than is being replenished. Overdraft is synonymous with a negative change in groundwater storage. This is also the change in available water within an aquifer or the change in available storage space in an aquifer. Change in storage is typically based on annual seasonal high groundwater level measurements (Specific Yield Method), or a comparison of groundwater inflows and outflows (Inflow/Outflow Method). In the Specific Yield Method, s~~S~~easonal high groundwater level measurement trends are plotted on water level hydrographs in order to observe long-term changes in water level for a single well. Seasonal high measurements are also used to create water level elevation contour maps. Hydrographs and contour maps are compared by location and from year to year, respectively, to calculate a change in groundwater storage. In the Inflow/Outflow Method, ~~In highly regulated systems it is also possible to quantify change in storage using~~ the change in storage is quantified by summing the groundwater inflows and outflows; however, calculations of subsurface groundwater flows are still dependent on seasonal high contour maps to determine subsurface inflow and outflow gradients.

There are two primary aquifers in the Plan Area, the upper unconfined aquifer and the lower confined aquifer. Upper aquifer change in storage is calculated using changes in the amount of water available for use from year to year, and can be calculated using the Inflow/Outflow Method (**Equation 3-6**) or the Specific Yield Method (**Equation 3-5**). The lower aquifer change in storage is the loss of the system's ability to store water due to compaction of fine-grained deposits observed as land subsidence and is calculated in the Subsidence Mapping Method for the lower aquifer.

For the upper unconfined aquifer, change in storage was calculated using both the Specific Yield Method and Inflow/Outflow Method for each year type. An annual change in storage for the hydraulic base period was calculated using the results of the Specific Yield Method for each year type in the annual water budget spreadsheet (**Table 3-3**), which averaged the change in storage over the 10-year period, based on year type. ~~The Inflow/Outflow Method was not used to determine change in storage because of the limited amount of data available. However, t~~The results of the Specific Yield method were used to inform and calibrate the inflow and outflow components of the water budget (i.e., the Specific Yield method was used to check against the Inflow/Outflow Method.) ~~the use of the Inflow/Outflow method for other water budget parameters.~~

Due to a current lack of water level data, lower aquifer change in storage is calculated by proxy as the loss of the system's ability to store water due to compaction of fine-grained deposits, observed as land subsidence and calculated using the Subsidence Mapping Method. See **Table 3-2** for a summary of changes in storage for the Plan Area.

Upper Aquifer Overdraft/Change in Storage

Specific Yield Method

Equation 3-5 was used to calculate annual change in groundwater storage based on average annual measured water level decline, developed using water level hydrographs and contour maps, and specific yield. As defined in the HCM, the average specific yield for the Plan Area is 0.12 feet, and average changes in water levels across the Plan Area for specific water year types range from +1.4 feet during wet years to -1.5 feet during critical years. When applied to the 10-year average hydrologic period there was an increase of approximately 0.2 feet per year. This Specific Yield Method for calculating annual change in groundwater storage is described in **Equation 3-5**:

Equation 3-5 Groundwater Storage Change (Specific Yield Method)

$$\Delta\, Storage = SY * \Delta WL * A$$

Where:
SY = Specific Yield (%)
ΔWL = Change in Water Level (feet/year)
A = Area of GSA (acres)

Inflow/Outflow Method

The Inflow/Outflow Method is based on the water budget difference between inflow to the area (supply sources) and outflow from the area (uses). **Equation 3-6** shows the method. ~~Change in storage was not calculated using this method but may be used in the future as estimates of actual inflow and outflow parameters are obtained.~~

Equation 3-6 Groundwater Storage Change (Inflow/Outflow Method)

$$\Delta\, Storage = Inflows - Outflows$$

Where:
Inflows = Groundwater system inflows
Outflows = Groundwater system outflows

The water budgeting process generally used the Inflow/Outflow Method, and this method was used in the Coordinated Delta-Mendota Water Budget. The average change in storage calculated using the Specific Yield Method was used to help estimate some of the other water budget parameters, such as the closing term that includes consumptive use of groundwater by GDEs and groundwater discharges to the surface water system. This was achieved by setting the Inflow/Outflow parameter for change in groundwater storage as equal to the Specific Yield result for change in storage. Once values were developed for water budget parameters using the Inflow/Outflow method, individual water years during the hydrologic average base period were inserted as required for the Coordinated Delta-Mendota Water Budget.

Since some of the values for the Inflow/Outflow Method were calculated using the average period, values were unavailable for various year types. This created additional error when using the Inflow/Outflow Method to calculate change in storage for individual years. ~~The specific yield method is the preferred method for determining average change in storage for the unconfined groundwater because of the error in the annual inflow/outflow method.~~

Subsidence Mapping Method

Long-term change in storage in the lower aquifer can be directly correlated to subsidence. Due to a lack of water level and specific yield data for the lower aquifer, subsidence mapping was used to calculate a change in lower aquifer storage (as described in **Chapter 5**) using the following formula:

Equation 3-7: Groundwater Storage Change (Subsidence Mapping)

$$\Delta\, Storage = Average\ \Delta GS * A$$

Where:
Average ΔGS = Average Change in Ground Surface Elevation (feet)
A = Area of GSA (acres)

The average change in ground surface elevation was calculated over the available period of record from local surveys and USBR and SJRRP monitoring data from 2011-2017. An average annual rate of subsidence from that period amounted to a 0.075-foot loss. The subsidence mapping method is the preferred method for determining average change in storage in the lower aquifer per year. As a result of limited groundwater elevation in the lower aquifer and limited understanding of the lower aquifer in the Plan Area, change in lower aquifer groundwater storage using subsidence mapping was performed for the entire Plan Area, it was not done by any individual GSA.

Table 3-3: Average Annual Change in Storage Summary

	Plan Area	Equation Used
Upper Aquifer (based on rate of water level change)	0.19 feet/year	$\Delta\ Storage = SY * \Delta WL * A$ Where: SY = Specific Yield (%) ΔWL = Change in Water Level (feet/year) A = Area of GSA (acres)
Lower Aquifer (based on rate of land subsidence)	-0.075 feet/year	$\Delta\ Storage = Average\ \Delta GS * A$ Where: Average ΔGS = Average Change in Ground Surface Elevation (feet) A = Area of GSA (acres)

3.3.3.2 Sustainable Yield

The Plan Area does minimal pumping on a per-acre basis, and undesirable results have not been observed. It is unknown whether increases in pumping will affect the groundwater storage volume or cause undesirable results. Because of the lack of understanding regarding how pumping affects the aquifer, calculating sustainable yield can be complicated. The Plan Area experiences a positive change in groundwater storage on average, and therefore a calculation of sustainable yield for the Plan Area may be underestimated. It is also unknown how other factors, such as shallow groundwater discharges to surface water, or consumptive use of groundwater by GDEs, affect sustainability.

The Delta-Mendota Coordination Committee developed a basinwide sustainable yield estimation for the upper aquifer, as required by SGMA, using the change in storage from the historic water budget (WY2003-2012) – see **Section 4.3.4** of the Common Chapter. Improved sustainable yield estimates should be prepared as additional data are collected over the first five years. The basinwide analysis resulted in an Upper Aquifer Sustainable Yield estimate of~~ranging from 325~~ 403,000 AF.~~ to 480,000 AF~~~~., demonstrating the Subbasin's estimated Upper Aquifer sustainable yield without implementing any projects and management actions (low end of range) and the Subbasin's estimated Upper Aquifer sustainable yield considering the implementation of projects and management actions (high end of range).~~

Based on observed extractions from the Lower Aquifer during WY2015 (see Section 4.3.4 of the Common Chapter), t~~T~~he basinwide estimates for the Lower Aquifer sustainable yield are approximately ~~250~~101,000 AFY over the approximately 750,000-acre Subbasin. Sustainable yield is not uniform throughout the Subbasin, and it will be the responsibility of the GGSA and MCDMGSA to monitor groundwater conditions that may result from lower aquifer pumping. Additional information on the sustainable yield development for the upper and lower aquifer is available in **Appendix A – Common Chapter**.

3.3.4 Current, Historical, and Projected Water Budget

Legal Requirements:

§354.18 (c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

A detailed explanation of the revised coordinated water budget components is included in the Common Chapter, **Appendix A**, along with a discussion of the data and methodologies used. The reader is therefore referred to the amended Common Chapter for the SGMA-required historic, current, and projected water budget for the Delta-Mendota Subbasin. A track changes version of the Revised Common Chapter is presented in **Appendix G**.

The initial results of the historic, current, and projected water budget for the Grassland Plan Area were provided in subsequent sections of this chapter. However, because some components of the original Grassland water budget were reorganized for consistency with the other GSPs in the Subbasin, the initial water budget is now presented for reference purposes only, in **Appendix D**. A crosswalk of how certain components of the initial Grassland GSP water budget are categorized in the revised Subbasin-wide water budget is shown in **Figure 3-27**.

3.3.4.1 Current Water Budget

Legal Requirements:

§354.18 **(**c) (1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information. (d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget: (2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

The current water budget is just a snapshot, while the historic water budget more accurately portrays the cause and effect of different parameters in the Plan Area. The Delta-Mendota Subbasin chose 2013 as the current year. Since 2013 was also used as the surrogate year for the average/dry year water budget, data was readily available; however, annual data was not available for each individual parameter, so data was supplemented from other average/dry years to develop a value for some parameters. Data gaps include annual groundwater inflow and outflows and flow to the lower aquifer from the upper aquifer.

Table 3-4: 2013 - Current Water Budget (Combined Descriptions per Revised Common Chapter)

Description			Historic and Current Period (acre feet/year)
Inflows	Precipitation		30,400
	Applied Water – Groundwater		52,100
	Applied Water - Surface Water Inflows		270,000
	Total Inflows		**352,500**
Outflows	Runoff		27,100
	Evapotranspiration		309,600
	Deep Percolation		56,400
	Total Outflows		**393,100**
Inflows	Infiltration		76,500
	Lateral Subsurface Flow	*Upper Aquifer*	25,600
		Lower Aquifer	NA
	Total Inflows		**102,100**
Outflows	Groundwater Extraction from Upper Aquifer		52,100
	Groundwater Extraction from Lower Aquifer		0
	Lateral Subsurface Flow	*Upper Aquifer*	51,000
		Lower Aquifer	NA
	Total Outflows		**103,100**
Change in Storage	Estimated Annual Change in Groundwater Storage	Inflows	102,100
		Outflows	103,100
		Change in Storage - Upper Aquifer	-1,000
		Change in Storage - Lower Aquifer	See Table 3-2
		Change in Storage - Total	-1,000

			Plan Area
Inflows	Precipitation		30,400
Inflows	Surface Water Inflows		30,600
Inflows	Applied Water - Groundwater		52,100
Inflows	Applied Water - Imported Surface Water		239,400
Inflows	Other Direct Recharge		0
Inflows	Total Inflows		352,500
Outflows	Runoff		300
Outflows	Evapotranspiration		309,600
Outflows	Surface Water Outflows		26,800
Outflows	Deep Percolation		56,400
Outflows	Total Outflows		393,100
Inflows	Deep Percolation	*Precipitation Infiltration*	300
Inflows	Deep Percolation	*Surface Water Infiltration*	48,600
Inflows	Deep Percolation	*Applied Water Infiltration*	7,500
Inflows	Subsurface Groundwater Inflows	*Upper Aquifer*	25,600
Inflows	Subsurface Groundwater Inflows	*Lower Aquifer*	NA
Inflows	Other Direct Recharge		20,100
Inflows	Total Inflows		102,100
Outflows	Groundwater Extraction from Upper Aquifer		52,100
Outflows	Groundwater Extraction from Lower Aquifer		0
Outflows	Subsurface Groundwater Outflows	*Upper Aquifer*	3,400
Outflows	Subsurface Groundwater Outflows	*Lower Aquifer*	NA
Outflows	Other Consumptive Use of Groundwater	*Flow to Lower Aquifer*	19,600
Outflows	Other Consumptive Use of Groundwater	*Discharge to Surface Water/Consumptive use by GDEs/Lateral Flow*	14,400
Outflows	Other Consumptive Use of Groundwater	*Groundwater Subarea 2 → Subarea 1*	13,600
Outflows	Total Outflows		103,100
Change in Storage	Estimated Annual Change in Groundwater Storage	Inflows	102,100
Change in Storage	Estimated Annual Change in Groundwater Storage	Outflows	103,100
Change in Storage	Estimated Annual Change in Groundwater Storage	Change in Storage - Upper Aquifer	(1,000)
Change in Storage	Estimated Annual Change in Groundwater Storage	Change in Storage - Lower Aquifer	See Table 3-2
Change in Storage	Estimated Annual Change in Groundwater Storage	Change in Storage - Total	(1,000)

3.3.4.2 Historical Budget

Legal Requirements:

§354.18
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:
(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.
(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.
(C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.
(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:
(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

In accordance with GSP regulations, a base period must be selected so that the analysis of sustainable yield is performed for a representative period with minimal bias that might result from the selection of an overly wet or dry period while recognizing changes in other conditions including land use and water demands. The base period should be selected considering the following criteria: long-term mean annual water supply; inclusion of both wet and dry periods; antecedent soil conditions; adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the basin.

As previously mentioned, the historical water budget was prepared using data from water years 2003-2012, which represents a typical hydrologic base period for the Subbasin based on flow in the San Joaquin River. In building the water budget, full natural flow of the SJR was evaluated for the duration of the historic record going back to 1901 in order to establish a long-term average flow rate. The period of WY 2003-2012 was chosen because it represents a recent average period that lies outside the most recent drought. The full natural flow (also known as unimpaired flow) was also compared to precipitation records in the area and the SJR water year index. The percent water year is based on DWR's water year index for the San Joaquin River. For simplification purposes, above normal and below normal years were grouped into "normal years," and dry and critically dry years were grouped into "dry years," with the exception of Shasta Critical water years in which surface water allocations are reduces to 75%. **Table 3-5** shows the full natural flow and percent water year of the SJR for the average historical period chosen.

Table 3-5: Average Historical Period – SJR Full Natural Flows

Water Year	Water Year Type	Runoff (AF)	Percent Water Year
2003	Normal	1,450,000	81%
2004	Dry	1,131,000	63%
2005	Wet	2,830,000	158%
2006	Wet	3,181,000	177%
2007	Dry	684,000	38%
2008	Dry	1,117,000	62%
2009	Dry	1,455,000	81%
2010	Normal	2,029,000	113%
2011	Wet	3,305,000	184%
2012	Dry	832,000	46%
Average Percent Water Year			100.3%

All other parameters for factoring inflow and outflow have been described in **Section 3.3.2** and are summarized in **Table 3-6**. Surface water system outflows are reported as greater than inflows, which is likely explained by the outflow of shallow groundwater to the surface water system or through consumptive use by GDEs. In addition, because managed wetlands within the Plan Area routinely receive less than the full Level 4 water supply needed for optimal wetland management, some wetlands may experience lower-than-estimated outflows through evapotranspiration.

The historical water budget was prepared for an average 10-year period where each parameter was analyzed independently and averaged both over a 10-year period, and on a year-by-year basis, as required by DWR. On an average annual basis, the water budget for the Plan Area shows a positive average change in storage of approximately 3,200 AFY in the upper unconfined aquifer (see **Table 3-6**). As discussed previously the Plan Area has significant amounts of surface water and is minimally dependent on groundwater. Groundwater is replenished and likely flows out of the Plan Area as a result of the heavy application of surface water to the area.

Table 3-6: Historical Water Budget Summary

Grassland GSP Historic Water Budget (Combined Descriptions per Amended Common Chapter)		
Period of Record: 2003 - 2013		
Land Surface Budget		Annual Average (acre-feet/year)
	Description	
Inflows		
1)	Precipitation	34,300
2)	Applied Water - Groundwater	46,900
3)	Surface Water Inflows	283,900
	Total Inflows	***365,100***
Outflows		

1)	Surface Water Outflows	30,100
2)	Evapotranspiration	307,300
3)	Deep Percolation	62,400
	Total Outflows	***399,800***
Groundwater Budget	**Description**	**Annual Average (acre-feet/year)**
Inflows		
1)	Infiltration	*83,300*
2)	Subsurface Groundwater Inflows	
	Upper Aquifer	*25,600*
	Lower Aquifer (not enough data to calculate)	*0*
	Total Inflows	***108,900***
Outflows		
1)	Groundwater Extraction	
	Upper Aquifer	*46,900*
	Lower Aquifer	*N/A*
2)	Lateral Subsurface Flow	
	Upper Aquifer	*59,300*
	Lower Aquifer	*N/A*
	Total Outflows	***106,200***
Change in Storage	***Estimated Annual Change in Groundwater Storage***	-
	Inflows	***108,900***
	Outflows	***106,200***
	Change in Storage	***2,700***

Grassland GSP Historic Water Budget		
Period of Record: 2003 - 2013		
Land Surface Budget	**Description**	**Annual Average (acre-feet/year)**
Inflows		
1)	Precipitation	34600

Grassland GSP Historic Water Budget		
Period of Record: 2003 - 2013		
2)	Surface Water Inflows	33800
3)	Applied Water - Groundwater	46300
4)	Applied Water - Surface Water Diversions	251400
5)	Other Direct Recharge	0
-	***Total Inflows***	***366100***
Outflows	-	-
1)	Runoff	2310
2)	Evapotranspiration	307000
3)	Surface Water Outflows	28000
4)	Deep Percolation	63000
-	***Total Outflows***	***400300***
Groundwater Budget		**Annual Average (acre-feet/year)**
-	**Description**	
Inflows		
1)	Deep Percolation	-
-	*Precipitation Infiltration (included in SW infiltration)*	*300*
-	*Surface Water Infiltration (losses from canals & conveyance)*	*51330*
-	*Applied Water Infiltration (0 if ET is greater than surface water inflows - losses)*	*11300*
2)	Subsurface Groundwater Inflows	-
-	*Upper Aquifer*	*25600*
-	*Lower Aquifer (not enough data to calculate)*	*0*
3)	Other Direct Recharge (pond seepage)	*20970*
-	***Total Inflows***	***109500***
Outflows	-	-
1)	Groundwater Extraction from Upper Aquifer	*46300*
2)	Groundwater Extraction from Lower Aquifer	*0*
3)	Subsurface Groundwater Outflows	*3400*
4)	Other Consumptive Use of Groundwater	-
-	*Flow to Lower Aquifer*	*19600*
-	*Discharge to Surface Water/Consumptive use by GDEs*	*27600*
-	*Exported Groundwater*	*9500*
-	***Total Outflows***	***106400***
-	-	
Change in Storage	-	-

Grassland GSP Historic Water Budget	
Period of Record: 2003 - 2013	
Estimated Annual Change in Groundwater Storage	
Inflows	*109600*
Outflows	*106400*
Change in Storage	*3200*

3.3.4.3 Projected Water Budget

Legal Requirements:

§354.18
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:
(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.
(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.
(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.
(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:
(3) Projected water budget information for population, population growth, climate change, and sea level rise.

The goal of a projected water budget is to estimate future baseline conditions in response to GSP implementation. The projected water budget must use 50 years of historical precipitation, evapotranspiration, and streamflow while using the most recent land use and water supply information as the baseline condition. In formulating future baseline conditions, the effects of climate change on water availability and use must be considered.

A yearly sequence was chosen to line up historical data to projected years from 2018 to 2070. A similar historic period to the recent drought was identified from 1975-1977. The following year 1978 was used as the first projected year and corresponded to 2017. The historical sequence of years from 1978 through 2017 was used in the projected water budget to represent future water years 2017 through 2056. For the years 2012-2017, which would correspond to projected years 2052-2056, climate change factors were not available, so surrogate years were chosen based upon water year type. **Table 3-7** shows the matching surrogate years for this period. For the years 2057-2070 the historical water years of 1965-1978 were used in sequence.

Table 3-7: Surrogate Projected Years

Surrogate Years for 2012-2017	
Historical Year	Surrogate Year

2012	2001
2013	1992
2014	1976
2015	1977
2016	2002
2017	2011

A simplified model was used to calculate the projected water budget for 2020-2070. Precipitation and ET components were calculated based upon historical measurements. For projected land use, cropping was maintained at 2017 acreages for all future years. No communities are within the GSAs, so population growth was not considered. Cross-boundary groundwater flows had the greatest uncertainty and were set during the calibration of the model. Other components were formulated by selecting and applying conditions based on four different water year types. Three types were identified based upon historical indices of the San Joaquin River: Dry, Normal, Wet. The fourth water year type, Shasta Critical, was identified as a critically dry year when reductions to surface water allocations may be experienced. Water year types were kept the same for projected years and were not recalculated based upon climate change. For each year type water budget components had specified volumes which were applied to the projected year from which the climate was derived. Wet years were represented with values from 2017, average/dry years from 2013, and Shasta Critical years from 2015.

Historical precipitation, evapotranspiration, and streamflow were not continuously recorded within the Plan Area for any 50-year period which necessitated using modeled climate data to project future conditions. Surface water allocations were kept the same and the effects of climate change on streamflow were not quantified due to the high-priority water right that the GSAs have for habitat use. Precipitation and minimum and maximum temperature measurements were obtained from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) historical datasets (http://www.prism.oregonstate.edu/, Daly et al.,1994). PRISM is a gridded monthly dataset that includes monthly temperature maximum and minimum and precipitation accumulation. All PRISM grid cells that are either fully or partially within the GSAs' boundaries were considered for the period of interest. The segmented maximum temperature, minimum temperature, and precipitation values were averaged for each parameter by month in the period.

Historical evapotranspiration measurements are not available for the GSAs before the mid-1980s implementation of the California Irrigation Management Information System (CIMIS). Thus, monthly evapotranspiration was calculated with PRISM temperature data using the Hargreaves-Samani equation (Hargreaves and Samani, 1982) from the DWR California Simulation of Evapotranspiration of Applied Water (Cal-SIMETAW) model (Orang et al., 2013). This equation (shown as **Equation 3-7)** provides a monthly reference ET estimate derived from mean temperature and long-term average radiation for a centroid of the Plan Area. This model was used to calculate monthly reference ET values.

Equation 3-7: Hargreaves-Samani Equation

$$ETo = 0.0023\,(T_{mean} + 17.8) * \sqrt{T_{max} - T_{min}} * R_a$$

where: *ETo* is reference monthly evapotranspiration
T is monthly temperature
Ra is the monthly average extraterrestrial radiation at the given latitude

Precipitation and derivation of ET from PRISM were used in the baseline calculations for the model. To consider the effects of climate change, DWR provided a dataset containing factors to apply to historical data. This method, known as climate period analysis, preserves the historical variability while dampening or amplifying the magnitude of events based upon projected changes in precipitation and temperature. The provided climate change factors for two future 30-year periods, centered on 2030 and 2070, were derived from statistical analysis of an ensemble of 20 global climate model projections.

Using the same method as was used with the PRISM grid, the monthly climate change factors provided by DWR were averaged over the spatial extent of the Plan Area. The monthly change factors were then applied to the PRISM-derived monthly precipitation and ET and then summed by water year. The 2030 climate change factors, which are applicable to the climate period of 2016-2045, were used for projected years through 2045. For the projected years of 2046-2070, the 2070 climate change factors were used.

In addition to the uncertainties of changes in climate, there were other factors that affected the projected change in storage calculations such as variability in subsurface flows and consumptive use of groundwater. The water budget was computed for each projected year individually, so inter-year trends and variability did not affect water budget components. The lack of inter-year variability may have led to compounding effects of wet or dry years. Since every dry year was 2015, a four-year drought would result in four consecutive projections of 2015 conditions. If this sequence of years were to occur, the years would be either slightly wetter or dryer, resulting in different availabilities of water and changes in management that would consume a different volume of water.

Projected changes in population were not made because there are no communities within the Plan Area, and the existing protected status of the majority of land in the Plan Area is not expected to support population growth. Effects of drought and water shortage beyond the conditions of the historical data were not considered. The most recently calculated vegetation coefficients were used to determine consumptive use, but it is unknown how the coefficients will change under future management and climate change. There are also limitations in the ability to predict future conditions for flows in the San Joaquin River. The SJRRP projects have increased flows from those that occurred during the 10-year average hydrologic period. These are not accounted for in the specific year types used to project current conditions due to uncertainty of implementation. In addition existing climate change projections expect increases in flood releases which will likely occur earlier in the year and at higher rates than they have historically resulting in more high-flow periods that would in turn increase seepage, associated groundwater flows, and availability of water in surface water systems. A summary of the projected water budget (with climate change) is summarized in **Table 3-8**, below, and the full projected water budget can be seen in **Appendix D – Projected Water Budget**.

Table 3-8: Projected Water Budget Summary

Description (Combined Descriptions per Revised Common Chapter)			Projected Period Average 2014-2070 (acre-feet/year)
Inflows	Precipitation		94,256
	Applied Water - Groundwater		45,467
	Surface Water Inflows		275,095
	Total Inflows		**414,818**
Outflows	Surface Water Outflows		55,011
	Evapotranspiration		298,380
	Deep Percolation		72,135
	Total Outflows		**425,526**
Inflows	Infiltration		84,104
	Lateral Subsurface Flows	*Upper Aquifer*	26,389
		Lower Aquifer	NA
	Total Inflows		**110,493**
Outflows	Groundwater Extraction from Upper Aquifer		52,037
	Groundwater Extraction from Lower Aquifer		0
	Lateral Subsurface Flows	Upper Aquifer	57,007
		Lower Aquifer	0
	Total Outflows		**109,044**
Change in Storage	Estimated Annual Change in Groundwater Storage	Inflows	110,493
		Outflows	109,044
		Change in Storage - Upper Aquifer	1,450

Parameter		Projected Period Average 2014-2070 (acre-feet/year)
Inflows	~~Precipitation~~	~~94,256~~
	~~Surface Water Inflows~~	~~41,953~~
	~~Applied Water - Groundwater~~	~~45,467~~
	~~Applied Water - Imported Surface Water~~	~~233,142~~
	~~Other Direct Recharge~~	~~0~~

	~~Total Inflows~~		~~414,818~~
~~Outflows~~	~~Runoff~~		~~26,721~~
	~~Evapotranspiration~~		~~298,380~~
	~~Surface Water Outflows~~		~~28,290~~
	~~Deep Percolation~~		~~72,135~~
	~~Total Outflows~~		~~425,526~~
~~Inflows~~	~~Deep Percolation~~	~~*Precipitation Infiltration*~~	~~789.4736842~~
		~~*Surface Water Infiltration*~~	~~47,212~~
		~~*Applied Water Infiltration*~~	~~15,415~~
	~~Subsurface Groundwater Inflows~~	~~*Upper Aquifer*~~	~~26,389~~
		~~*Lower Aquifer*~~	~~NA~~
	~~Other Direct Recharge~~		~~20,688~~
	~~Total Inflows~~		-
~~Outflows~~	~~Groundwater Extraction from Upper Aquifer~~		~~44,488~~
	~~Groundwater Extraction from Lower Aquifer~~		~~0~~
	~~Subsurface Groundwater Outflows~~	~~Upper Aquifer~~	~~1,900~~
		~~*Lower Aquifer*~~	~~0~~
	~~Other Consumptive Use of Groundwater~~	~~*Flow to Lower Aquifer*~~	~~19,600~~
		~~*Discharge to Surface Water/Consumptive use by GDEs/Lateral Flow*~~	~~35,507~~
		~~*Groundwater Subarea 2 → Subarea 1*~~	~~7,549~~
	~~Total Outflows~~		~~109,044~~
~~Change in Storage~~	~~Estimated Annual Change in Groundwater Storage~~	~~Inflows~~	~~110,494~~
		~~Outflows~~	~~109,044~~
		~~Change in Storage - Upper Aquifer~~	~~1,450~~

3.4 Management Areas

Legal Requirements:

§354.20 (a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.
(b) A basin that includes one or more management areas shall describe the following in the Plan:

The GGSA and MCDMGSA will be managing the Plan Area as one unit.

4 Sustainable Management Criteria

Legal Requirements:

§354.22 This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

SGMA defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. The avoidance of undesirable results is important to the success of a GSP. Several requirements from GSP regulations have been grouped together under the heading of Sustainable Management Criteria (SMC), including a Sustainability Goal, Undesirable Results, Minimum Thresholds, and Measurable Objectives for various indicators of groundwater conditions. Development of these Sustainable Management Criteria ~~is dependent on basin information developed and presented in the hydrogeologic conceptual model, groundwater conditions, and water budget chapters of the Grassland GSP (DWR, 2017).~~was coordinated at the Subbasin level through the Coordination Committee and Technical Subcommittee.

Indicators for the sustainable management of groundwater were determined by SGMA based on factors that are important to the health and general well-being of the public. There are six indicators that must be monitored throughout the planning and implementation period of the GSP including groundwater levels, groundwater storage volume, land subsidence, water quality, interconnected surface water, and seawater intrusion. This chapter will describe the indicators and why they are significant and will define management thresholds for the Plan area.

The Sustainable Management Criteria described herein were prepared following the requirements set forth in the California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2, Article 5, Subarticle 3 (§354.22 through §354.30).

4.1 Sustainability Goal

Legal Requirements:

§354.24 Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

The Delta-Mendota Subbasin sustainability goal is a general description of the objectives of the GSP and for the Basin: *The Delta-Mendota Subbasin will manage groundwater resources for the benefit of all users of groundwater in a manner that allows for operational flexibility, ensures resource availability under drought conditions, and does not negatively impact surface water diversion and conveyance and delivery capabilities. This goal will be achieved through the implementation of the proposed projects and management actions to reach identified measurable objectives and milestones through the implementation of the GSP(s), and through continued coordination with neighboring subbasins to ensure the absence of undesirable results by 2040.*

The success of the GSP is reflected in the avoidance of undesirable results as described in section 4.3 Undesirable Results. This allows a significant amount of flexibility in defining and implementing Sustainable Management Criteria in the absence of undesirable results.

It is the intent of the Grassland Plan Area participants and the members of the Delta-Mendota Subbasin to work collaboratively to continue to better understand the basin characteristics by establishing a coordinated network of monitoring locations and reporting requirements. This will help to recognize existing hydrogeological patterns to better refine Sustainable Management Criteria in future GSP updates. It is the goal of the Grassland Plan Area and other Basin members to establish criteria and implement programs and projects to monitor and manage groundwater levels and storage, protect water quality, and reduce the effects of subsidence in a manner that is open to the public and stakeholders.

4.2 Sustainability Indicators

The Grassland GSP Area participants will monitor groundwater conditions that correspond to sustainability indicators established by DWR (**Figure 4-1**). These sustainability indicators are groundwater levels, change in storage, seawater intrusion, water quality, land subsidence, and depletions of interconnected surface water. SMCs (including measurable objectives and minimum thresholds) are developed for each applicable indicator by setting values in which undesirable results would be avoided and sustainability would be obtained. These values are intended to define the range in which groundwater is in a sustainable condition. For example, exceedance of a measurable objective would initiate additional investigations or monitoring to determine if significant and unreasonable effects are being experienced as a result of exceeding that SMC. Should an indicator exceed SMC values for any length of time without triggering significant and unreasonable effects, SMCs could be reconsidered and revised in future GSP updates. Conversely, should significant and unreasonable effects be experienced prior to a SMC exceedance, values may also be reconsidered and revised.

Figure 4-1: Sustainability Indicators

4.3 Undesirable Results

Undesirable results are defined by DWR. Definitions for specific sustainability indicators are provided in Section 10721 of the SGMA regulations:

Groundwater Levels

> *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.

Groundwater Storage Volume

Significant and unreasonable reduction of groundwater storage.

Sea Water Intrusion

Significant and unreasonable seawater intrusion.

Water Quality

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

Subsidence

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

Interconnected Surface Water

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

It is incumbent of agencies to define potential significant and unreasonable effects within each basin or plan area. This is the basis for establishing the SMC and allows flexibility for Plan implementation. Undesirable Results will be discussed in greater detail for each sustainability indicator in the following sections.

4.3.1 Undesirable Result Development

Legal Requirements:

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

Delta-Mendota Subbasin

Undesirable Results were defined by DWR as described above. It is the intent of SGMA to allow basins and GSAs to determine how groundwater conditions could cause significant and unreasonable effects and how significant and unreasonable effects could cause an Undesirable Result. ~~Because of the dynamics of the Delta-Mendota Subbasin, a broad definition of Undesirable Results was developed to expand on DWR's definition, while allowing flexibility for GSAs and plan areas to define them on a local level.~~ The Delta-Mendota Subbasin Coordination Committee participants have defined Undesirable Results for the applicable sustainability indicators as:

Groundwater Levels

~~*Significant and unreasonable chronic decrease in water level, as defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through either intra- and/or inter-basin actions.*~~

Chronic changes in groundwater levels that diminish access to groundwater, causing significant and unreasonable impacts to beneficial uses and users of groundwater.

Groundwater Storage Volume

~~*Significant and unreasonable chronic decrease in groundwater storage, as defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through either intra- and/or inter-basin actions.*~~

A chronic decrease in groundwater storage that causes a significant and unreasonable impact to the beneficial uses and users of groundwater.

Sea Water Intrusion

Not defined – Inapplicable.

Water Quality

~~Significant and unreasonable degradation of groundwater quality, as defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through either intra- and/or inter-basin actions and/or activities.~~
Degradation of groundwater quality as a result of groundwater management activities that causes significant and unreasonable impacts to beneficial uses and users of groundwater.

Subsidence

~~Changes in ground surface elevation that cause damage to critical infrastructure that would cause significant and unreasonable reductions of conveyance capacity, damage to personal property, impacts to natural resources or create conditions that threaten public health and safety.~~
Changes in ground surface elevation that cause damage to critical infrastructure, including significant and unreasonable reductions of conveyance capacity, impacts to natural resource areas, or conditions that threaten public health and safety.

Interconnected Surface Water

~~Significant and unreasonable depletion of surface water, as defined by each GSP Group, that has an impact on the beneficial users of surface water in the Subbasin through either intra- and/or inter-basin actions and/or activities.~~
Depletions of interconnected surface water as a direct result of groundwater pumping that cause significant and unreasonable impacts on natural resources or downstream beneficial uses and users.

~~More detailed definitions for undesirable results were developed at the Plan Area level to consider localized groundwater conditions, known or potential issues, resiliency and risk tolerance of beneficial users, and potential mitigation actions. After development of undesirable result criteria, definitions and methodologies were shared among the Delta-Mendota Subbasin technical committee members to address any concerns or inconsistencies in development or understanding of problems within the Basin.~~

Grassland Plan Area

The Grassland GSP Technical Working Group, comprised of the Grassland Water District General Manager, District Engineer, Water Master, Science Programs Manager, General Counsel, and technical consultants, coordinated during numerous meetings with the Coordination Committee to develop SMCs. The collaboration provided the opportunity to discuss at length the local understanding of undesirable results, beneficial users, and existing data from which to establish SMCs. Considerations were made regarding historic groundwater conditions, aquifer characteristics, groundwater quality, well construction, spatial distribution of groundwater production and monitoring wells, other existing infrastructure, adjacent agencies and basins, and previous experience.

The Grassland GSP Technical Working Group condensed their evaluation of potential impacts to the following topics:

- Impacts that could be experienced in the Grassland Plan Area and Subbasin-wide due to changing groundwater conditions
- Resiliency of the aquifer to changes in groundwater conditions
- Resiliency of beneficial users
- Financial and environmental tolerance to impacts

The purpose was to analyze potential impacts, determine at which point the impacts become significant and unreasonable, and develop SMCs based on the most vulnerable beneficial users.

The discussion at the plan level ultimately determined the most limiting beneficial user to all applicable sustainability indicators was habitat productivity. The SMC evaluation discussed in ~~this chapter~~ the initial Grassland GSP ~~reflects~~ reflected the objective to maintain habitat productivity and avoid impacts from groundwater pumping on these systems. As a result, the less sensitive beneficial users, such as agriculture, ~~are~~ were assumed to be protected under successful Plan implementation.

In its January 2022 determination letter for the six GSPs in the Subbasin, DWR concluded that the definitions of significant and unreasonable effects, and the Sustainable Management Criteria adopted by each GSP Group, were not adequately coordinated (defined as “Deficiency 2” and “Deficiency 3”). To address these deficiencies, the Subbasin’s Groundwater Sustainability Agencies (GSAs) met frequently, through the Coordination Committee and Technical Committee, to develop consistent definitions of significant and unreasonable effects, and to establish consistent Sustainable Management Criteria. A detailed explanation of these changes is also included in the Common Chapter. A track changes version of the Revised Common Chapter is provided in **Appendix G**.

Significant and unreasonable undesirable results, as qualitatively defined by the Coordination Committee (see Common Chapter Tables CC-16 to CC-23) and applied to the Grassland Plan Area, are outlined below:

Groundwater Levels

~~*Lowering of groundwater levels would lead to increased costs associated with higher total lift, lowering pumps, need to drill deeper wells, or costs securing alternative water sources. Impacts to habitat would require mitigation, including alternative water supplies and habitat restoration.*~~
Significant and unreasonable impacts to beneficial uses and users of groundwater are substantially increased costs associated with higher total pumping lift, lowering pumps, drilling deeper wells or otherwise modifying wells to access groundwater, securing alternative water sources, or required mitigation of groundwater dependent ecosystems. Significant and Unreasonable is quantitatively defined as exceeding the MT at more than 50% of representative monitoring sites by aquifer in a GSP area.

Groundwater Storage

~~*Insufficient water storage necessary to maintain critical habitat. Reduction in storage would lead to increased costs associated with higher total lift, lowering pumps, and costs associated with the need to either drill deeper wells or secure alternative water sources. Impacts to habitat would require mitigation, including alternative water supplies and habitat restoration.*~~
A significant and unreasonable impact to beneficial uses and users of groundwater is insufficient water storage to maintain beneficial uses and natural resource areas in the Subbasin, including the conjunctive use of groundwater.

Sea Water Intrusion

Not applicable. The Pacific Coast and San Francisco Bay are both greater than 55 miles from the border of the Grassland Plan Area and geologically separated by the Coastal Range.

Water Quality

~~*Degradation of groundwater quality resulting in reduced ability to develop and manage groundwater for habitat productivity.*~~
Significant and unreasonable impacts to beneficial uses and users of groundwater as a result of groundwater management activities are the migration of contaminant plumes or elevated concentrations of constituents of concern that reduce groundwater availability, and the degradation of surface water quality as a result of groundwater migration that substantially impair an existing beneficial use. Significant and unreasonable is quantitatively defined as exceeding the MT at more than 50% of representative monitoring sites by aquifer in a GSP area where current groundwater quality (as established in the Subbasin's GSPs) does not exceed 1,000 mg/L TDS.

Subsidence

~~*Damage to infrastructure, permanent loss of conveyance capacity beyond mitigation, and potential inability to flood or drain by gravity and associated habitat impacts.*~~
Significant and unreasonable damage to conveyance capacity from inelastic land subsidence is structural damage that creates an unmitigated and unmanageable reduction of design capacity or freeboard.
Significant and unreasonable impacts to natural resource areas from inelastic land subsidence are unmitigated decreases in the ability to flood or drain such areas by gravity.

Significant and unreasonable threats to public health and safety from inelastic land subsidence are those that cause an unmitigated reduction of freeboard that allows for flooding, or unmitigated damage to roads and bridges.

Interconnected Surface Water
~~*Groundwater pumping in the Grassland Plan Area does not influence surface water depletion. Reduction of interconnected surface water bodies and associated groundwater dependent ecosystems (GDEs) that would require reduction in groundwater pumping (no management activities have depleted interconnected surface water in the Grassland Plan Area within the historical period). A significant and unreasonable undesirable result would impair any habitats directly associated with interconnected surface waters.*~~
Significant and unreasonable impacts on natural resources or downstream beneficial uses and users of groundwater are a reduction in available surface water supplies for natural resource areas, and reductions in downstream water availability as a result of increased streamflow depletions along the San Joaquin River when compared to similar historic water year types.

4.3.2 Causes of Groundwater Conditions Leading to Undesirable Results

Legal Requirements:

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

At present there are no conditions resulting in undesirable effects in the GSA. Going forward there are factors that have the potential to cause changes leading to undesirable effects such as the following:

1. **Climate Change**
   a. The State of California Department of Water Resources predicts that warmer conditions could lead to more intense rain events and less snowpack in the state. The Plan Area's surface water supply allocation is based on the Shasta Reservoir index and associated shortage provisions. The reliability of surface water supplies may be influenced by both the increased precipitation and the reduction in snowmelt to the reservoir.
   b. The same studies indicate that increased temperatures could result in higher evapotranspiration rates which would increase demand.
   c. Some studies suggest more variability in water year types with dry years becoming more dry and wet years becoming more wet, which could lead to more flooding in wet years and more severe droughts in dry years.

2. **Changing Crop Patterns**. Agriculture makes up only six percent of the Grassland Plan Area. Agricultural land use may change in the 20-year planning horizon, affecting the evapotranspiration demand of the system. Historically, the Grassland Plan Area has sustainably met the evapotranspiration demands of crops and wetlands through imported surface water supplies and a small amount of supplemental groundwater pumping. The underlying aquifer is replenished via deep percolation generated from precipitation, a network of unlined earthen water conveyance facilities, seasonal and permanent wetland water management within the Plan Area, and from irrigation practices on agricultural lands. The trend is projected to continue into the future due to the surface water supply reliability from the federal Central Valley Project, protected

wildlife refuges owned and operated by the State and Federal agencies, and conservation easements established on the vast majority of the Plan Area. More information regarding the water demands and deep percolation are outlined in **Chapter 3, Section 3**.

3. **Access to Surface Supply**. Wetlands that make up the majority of the Grassland Plan Area have historically received reliable surface water deliveries under the Central Valley Project Improvement Act, which are anticipated to continue in the future as they are mandated under law. The Level 2 wetland water supply allocation is based on the Shasta Reservoir Index, with reductions of no more than 25% in critically dry years.

4.3.3 Significant and Unreasonable Impacts & Threshold Exceedances Defining Undesirable Results

Legal Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

Upper Aquifer Groundwater Levels and Groundwater Storage
There are no significant and unreasonable effects of groundwater level declines or changes in groundwater storage in the Grassland Plan Area, and the initial projected water budget in **Chapter 3.3** indicateds future sustainability in the Grassland Plan Area (see **Appendix D**). Recognizing that neighboring influences and the factors identified in **Section 4.3.2** may contribute to changes in the projected sustainability, the Grassland Plan Area participants worked with the Coordination Committee and developed groundwater level and groundwater storage thresholds that recognize the beneficial use most sensitive to significant and unreasonable lowering of groundwater levels, habitat productivity. See table CC-16 and Table CC-18 of the Common Chapter – **Appendix A**, incorporated here by reference.

The qualitative definitions stated above for significant and unreasonable undesirable results note that the lowering of groundwater levels or decreased groundwater storage would lead to substantially increased costs associated with higher total lift, lowering pumps, need to drill deeper wells or costs of securing alternative water sources. Such effects would be considered significant and unreasonable if they resulted from substantial lowering of groundwater levels that led to substantially increased costs.

The qualitative definitions above also note that impacts to habitat would require mitigation, including alternative water supplies and habitat restoration. The impacts of declining groundwater levels or decreased storage on habitat would take the form of drier ground conditions, unhealthy or less productive wetland plant populations that provide food and cover for wildlife, and the need to deliver increased amounts of surface water in lieu of near-surface groundwater. These are examples of the conditions for which mitigation would be required within the Plan Area.

Observed groundwater level lows were identified across the Grassland Plan Area from 2000 to present. No significant and unreasonable impacts to habitat productivity (or other beneficial users) associated with lowered groundwater levels or changes in groundwater storage in the

Grassland Plan Area were experienced within this period. The undesirable result was conservatively quantified as a ~~twenty percent~~ lowering of groundwater elevation from the representative groundwater level monitoring sites' recent historical (~~2000 to 2019~~as of 2016) groundwater elevation low. In other words, an undesirable result would occur if the groundwater elevation at more than 50% of ~~a~~ monitoring sites drops ~~20%~~ below the previously measured low. Compliance will be measured on a four-year rolling average. For most monitoring sites the recent historical low was measured during the severe drought years in 2014, 2015, or 2016. The minimum threshold is described in more detail in **Section 4.4.1**.

~~Recognizing the shallow groundwater requirements for habitat conservation that cover a spatially influential area and the lack of historically experiencing undesirable results in the Grassland Plan Area, the criterion used to assess when effects of groundwater conditions cause undesirable results are defined qualitatively and quantitatively in **Table 4-1**:.~~

Table 4-1: Significant and Unreasonable Undesirable Results – Water Levels and Groundwater Storage

Significant and Unreasonable Undesirable Results		
-	Groundwater Levels	Groundwater Storage
Qualitative Definition of Significant and Unreasonable Undesirable Results	Lowering of groundwater levels would lead to increased costs associated with higher total lift, lowering pumps, and need to drill deeper wells or secure alternative water sources. Impacts to habitat would require mitigation, including alternative water supplies and habitat restoration.	Insufficient water storage necessary to maintain critical habitat. Reduction in storage would lead to increased costs associated with higher total lift, lowering pumps, and costs associated with the need to either drill deeper wells or secure alternative water sources. Impacts to habitat would require mitigation, including alternative water supplies and habitat restoration.
Quantitative Definition of Significant and Unreasonable Undesirable Results	If a twenty percent or greater decrease from the recent historical (2000 to 2019) groundwater level lows are experienced or exceeded at more than fifty percent of the representative monitoring network wells for three consecutive years, then it can be assumed that significant and unreasonable undesirable results have occurred.	

Although not defined as quantification of an undesirable result, the Grassland Plan Area also recognizes that if a twenty percent or greater decrease from the recent historical (2000 to 2019) groundwater elevation low is experienced at a single representative upper-aquifer monitoring network well for three consecutive years, then the area may require further investigation and mitigation. This focus offers an opportunity to localize any necessary mitigation to the affected area.

The representative water elevation monitoring sites provide meaningful spatial coverage of the Grassland Plan Area and will provide insight into whether changes in water elevation conditions are localized or regionwide. If meaningful changes occur in greater than fifty percent of wells (as detailed in) there is assumed to be a Plan Area-wide need for mitigation. Additionally, the temporal consideration of three consecutive yearsa four-year rolling average allows for the natural fluctuations in hydrology and rebound potential of the habitat.

The GSAs in the Subbasin also recognize the need to develop acute, single-year thresholds at each representative monitoring site that will protect the most vulnerable beneficial users there. For the Grassland GSA, the most vulnerable beneficial users will likely be habitat. These single year thresholds will be developed during the initial stages of Plan implementation.

Lower Aquifer Groundwater Levels and Groundwater Storage

Lower aquifer representative monitoring wells have been identified for the monitoring network. However, little historic data exists, as lower aquifer pumping is not prevalent in the Plan Area. The Grassland Plan Area participants will monitor the identified sites and with the gathered data, and intend to establish numeric meaningful interim goals, measurable objectives, and minimum thresholds for lower aquifer groundwater levels in future GSP Updates. The sustainable management criteria for lower aquifer storage are based on inelastic land subsidence, which is the primary drive of change in storage in that aquifer. The criteria are described in Table CC-16 and Table CC-18 of the Common Chapter – **Appendix A**.

Interconnected Surface Water
The Grassland Plan Area Participants and other GSP Groups in the Subbasin defined significant and unreasonable undesirable results of interconnected surface water as ~~"reduction of interconnected surface waterbodies and associated GDEs that would require reduction in groundwater pumping."~~"a reduction in available surface water supplies for natural resource areas, and reductions in downstream water availability as a result of increased streamflow depletions along the San Joaquin River when compared to similar historic water year types." Essentially, any noticeable ~~reduction~~increase in the volume of ~~groundwater flows reaching~~surface water flows leaving the SJR ~~from~~and replenishing groundwater within the Plan Area could create an undesirable result, as it would signify an area-wide lowering of the historically high water table in the Plan Area. This would adversely affect not only the existing riparian corridors along the SJR but it might also impact the groundwater-dependent plant communities throughout the Plan Area. However, there is no indication that historical groundwater pumping in the Plan Area has not influenced surface water depletion and no management activities have depleted interconnected surface waters in the Plan Area within the historic period.

The San Joaquin River (SJR) is the only major natural surface waterbody in the Grassland Plan Area. **Chapter 3.3** identifies the groundwater inflows and outflows. It is assumed based on this analysis, groundwater contours, and hydrogeologist input that there is a net inflow from the Grassland Plan Area to the SJR, designating it as interconnected and a gaining stream in this section.

The presumed causations of this are related to: (1) the protected status of the majority of managed wetlands within the Plan Area, through both public lands protection as state wildlife areas and national wildlife refuges and permanent conservation easements held on private wetlands; (2) existing state and federal "No Net Loss" policies[2] regarding wetland preservation which caution that wetlands in the Grassland Plan Area should retain their spatial extent; and (3) the presence of shallow clay layers that hold groundwater close to the surface. Therefore, the Grassland Plan Area has historically maintained shallow depth to water in much of the area in order to retain wetland habitat. The protected status of managed wetlands in the Plan Area in conjunction with the "No Net Loss" policy and existing hydrogeologic conditions are indications that the Plan Area will continue to sustain shallow groundwater in the wetland areas and produce a net positive flow to the SJR. It is projected that sustainability will continue and there will be no significant and unreasonable depletion of interconnected surface water.

In the event that the groundwater levels in areas within or outside of the wetlands were to significantly decline, the steepened gradient of the applied water for wetland habitat conservation to the areas of lowered groundwater would likely result in impairment to those habitats or increased costs to irrigate and maintain the wetland systems. Both of these scenarios can be assumed to produce an undesirable result, as the groundwater gradient flowing towards the SJR may be impeded.

[2] *See* https://obamawhitehouse.archives.gov/the-press-office/2015/11/03/mitigating-impacts-natural-resources-development-and-encouraging-related, *and* https://www.waterboards.ca.gov/rwqcb5/board_decisions/tentative_orders/1504/2_5_wetlands/5_wet_policies_sum.pdf.

Therefore, the Grassland GSP Technical Working Group and Plan Area participants have decided to use water elevation SMCs as a proxy for interconnected surface water, on an interim basis until replacement thresholds based on a rate or volume of interconnected surface water losses can be established for the Subbasin (see **Section 5.3.2**). The definition of significant and unreasonable undesirable results is shown again in **Table 4-2.**The minimum thresholds, measurable objectives and interim goals are set forth in Table CC-23 of the Common Chapter – **Appendix A**. A track changes version of the Revised Common Chapter is presented in **Appendix G**.

Table 4-2: Significant & Unreasonable Undesirable Results – Interconnected Surface Water

Significant and Unreasonable Undesirable Results	
-	Interconnected Surface Water
Qualitative Definition of Significant and Unreasonable Undesirable Results	Grassland Plan Area groundwater pumping does not influence surface water depletion. Reduction of interconnected surface water bodies and associated GDEs would require reduction in groundwater pumping (no management activities have depleted interconnected surface water in the Grassland Plan Area within the historical period). A significant and unreasonable undesirable result would impair any habitat directly associated with interconnected surface waters.
Quantitative Definition of Significant and Unreasonable Undesirable Results	If a twenty percent or greater decrease from the recent historical (2000 to 2019) upper aquifer groundwater level lows are experienced or exceeded at more than fifty percent of the representative monitoring network wells for three consecutive years, then it can be assumed that significant and unreasonable undesirable results have occurred.

Although not defined as quantification of an undesirable result, the Grassland Plan Area also recognizes that if a twenty percent or greater decrease from the recent historical (2000 to 2019) groundwater elevation low is experienced at a single representative upper-aquifer monitoring network well for three consecutive years, then the area may require further investigation and mitigation. This focus offers an opportunity to localize any necessary mitigation to the affected area.

Sea Water Intrusion
Not defined – Inapplicable.

Upper Aquifer Water Quality
Although no degradation in groundwater quality has been observed historically, there is potential for water quality to experience degradation due to activities outside the Plan Area, which may compromise habitat health. The Grassland Water District monitors salt and additional constituents, such as boron and selenium, under the GWD Surface and Groundwater Monitoring Program.

There are several potential causes of groundwater quality degradation that could lead to undesirable results. These include, but are not limited to:

- Fertilizers: Although fertilizers are not used in managed wetlands, the accumulated effects of fertilizer nutrient application and other land management practices on lands outside of the managed wetland complex could lead to accumulation of constituents of concern in groundwater
- Salinity: The accumulated effects of salinity from repeated source water recycling, irrigation and pumping patterns outside the wetland complex

- Waste Discharge: The accumulated effects of regulated and unregulated waste discharge streams from wastewater treatment facilities, septic systems, industry, and food processors outside the wetland complex
- Contaminant Plumes: Groundwater pumping mobilizing groundwater contaminant plumes, although there are no known contaminant plumes affecting the Plan Area

The Grassland Plan Area will continue to monitor for declining groundwater levels that could cause pumped groundwater to have higher concentrations of some naturally occurring constituents that may cause habitat productivity and health concerns or aesthetic concerns.

The Grassland Plan Area regularly experiences variations in salinity tolerance, even within the same beneficial uses. Agricultural areas are more sensitive to higher salt and boron concentrations. The Central Valley Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan) for the Central Valley notes that certain waterways within the planning area, such as Mud Slough and wetland water supply channels, are of limited use for irrigated agriculture because "elevated natural salt and boron concentrations may limit this use to irrigation of salt and boron tolerant crops" (CRWQCBCVR, 2018). For similar reasons those same waterways, as well as Salt Slough, are not designated for municipal and domestic water supply.

The Grassland Plan Area will continue to monitor for declining groundwater levels that can cause pumped groundwater to have higher concentrations of some naturally occurring constituents that may cause habitat productivity and health concerns or aesthetic concerns (see **Section 5.1.2**). ~~With consideration to the shallow groundwater requirements for habitat conservation that cover a spatially influential area and the lack of historical undesirable results in the Grassland Plan Area, the criteria used to assess when effects of groundwater quality cause undesirable results are defined in **Table 4-3.**~~ Salinity is used as a key indicator for water quality because it affects all beneficial uses within the Plan Area and the Subbasin and is the primary constituent of concern under existing regulatory programs ~~(due to the rarity of fertilizer or pesticide applications within the Plan Area)~~.

~~**Table 4-3: Significant & Unreasonable Undesirable Results - Water Quality**~~

~~Significant and Unreasonable Undesirable Results~~	
	~~Water Quality~~
~~Qualitative Definition of Significant and Unreasonable Undesirable Results~~	~~Degradation of groundwater quality that results in reduced ability to develop and manage groundwater for habitat productivity.~~
~~Quantitative Definition of Significant and Unreasonable Undesirable Results~~	~~If a TDS measurement of 2500 mg/L or greater is experienced at more than fifty percent of the representative monitoring network wells for three consecutive years, then it can be assumed that significant and unreasonable results may have occurred.~~

The sustainable management criteria adopted for the Subbasin are described in Table CC-19 of the Common Chapter – **Appendix A** – and are based on TDS levels that are acceptable for drinking water supplies. It must be emphasized that groundwater and surface water in the

Grassland Plan Area is not a source of drinking water supply, and TDS levels routinely exceed drinking water standards. Representative monitoring sites that exceed the numeric sustainable management criteria will be referred to existing regulatory programs in the Subbasin, which are described in the Common Chapter. The Grassland Plan Area participants are longtime contributors and participants in these regulatory programs. Although not defined as quantification of an undesirable result, the Grassland Plan Area also recognizes that if a TDS measurement of 2500 mg/L or more is observed at a single representative monitoring network well for three consecutive years, then the area may require further investigation and mitigation. This focus offers an opportunity to localize any necessary mitigation to the affected area.

As with the representative groundwater level monitoring network, the representative quality monitoring network provides meaningful spatial coverage of the Grassland Plan Area and will provide insight into whether changes in water quality conditions are localized or regionwide. To allow for the variety of salinity tolerance in the Plan Area, the threshold exceedances will be evaluated on a three-year basis. However, iIn accordance with GWD's longstanding groundwater quality policy, GWD does not accept groundwater for habitat use if the TDS concentration is 2,500 mg/L or above or causes an increase in surface water TDS concentration by more than 200 mg/L. These standards were set in the 1980s, have also been adopted by USBR for wetlands in the Plan Area, and have been successfully implemented to protect the health of wetlands and wildlife in the Plan Area for more than 30 years. Although the quality of water delivered within the Plan Area has a much lower TDS concentration than 2,500 mg/L due to blending with higher-quality CVP surface water supplies and the 200 mg/L maximum increase standard, the 2,500 TDS standard is a longstanding benchmark for significant and unreasonable results in the Plan Area.

Subsidence

The Grassland Plan Area has not experienced undesirable results related to subsidence, which is thought to be caused by the compaction of clays due to lower aquifer pumping. Lower aquifer pumping in the Plan Area has historically been negligible, rendering the Grassland Plan Area participant's contribution to subsidence-related impacts insignificant. However, subsidence caused by pumping outside of the Plan Area does pose a risk of creating undesirable results within the Plan Area. Significant and unreasonable undesirable results for subsidence are defined in **Table 4-4.**The sustainable management criteria adopted for subsidence in the Subbasin are described in Table CC-21 of the Common Chapter – **Appendix A**.

Table 4-4: Significant & Unreasonable Undesirable Results - Subsidence

Significant and Unreasonable Undesirable Results	
-	Subsidence
Qualitative Definition of Significant and Unreasonable Undesirable Results	Damage to infrastructure, permanent loss of conveyance capacity beyond mitigation, and potential inability to flood or drain by gravity and associated habitat impacts
Quantitative Definition of Significant and Unreasonable Undesirable Results	If a subsidence monitoring station experiences an increase in subsidence greater than the interim 5-year milestones in a three-year period

The interim milestones follow the historic subsidence rates at various monitoring locations and rates—none of which have historically experienced subsidence-related adverse impacts. In the

~~event that an interim milestone is exceeded within three years, it can be assumed that a significant and unreasonable undesirable result has occurred.~~

Future Assessment of Undesirable Results
After Plan implementation, if it is determined that there were no adverse effects to habitat health, the definition of significant and unreasonable effects leading to undesirable results may be reevaluated in future updates of the GSP. The Grassland Plan Area participants also recognize the opportunity to assess impacts to other beneficial users and revise the criteria in the event that currently unknown and unintended undesirable results were to occur.

4.3.4 Effects on Beneficial Users

Legal Requirements:

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

During the Grassland GSP Technical Working Group's SMC development process, there were several unanimously identified impacts that could become significant and unreasonable. These included impairments to habitat health, wells becoming unproductive, and water quality negatively impacted to the point of causing degradation of wetland habitat, crops, or productivity. However, the Grassland Plan Area is not currently experiencing undesirable impacts, nor has it experienced undesirable impacts in the past.

Negative effects to the SJRRP, domestic users, and adjacent agencies were also considered during the development of definitions of significant and unreasonable effects. There is no indication that other beneficial users have experienced any adverse effects due to current management practices in the Grassland Plan Area, which is unlikely to experience aquifer overdraft. There are actions in place to ensure the protection of conditions in, adjacent to, and downstream of the SJR in order to prevent impacts to beneficial users of both surface water and groundwater. These are discussed in greater detail in **Chapter 2 – Plan Area**.

There are a limited number of domestic wells within the Grassland Plan Area, most of which supply non-potable water to seasonal recreational properties that use bottled water or similar alternate supplies for drinking and cooking. Naturally occurring salinity in the upper water table has historically made these supplies unsuitable for potable use. The small number of private domestic wells qualify as "de minimis extractors" under SGMA and will be managed by landowners as necessary.

Adjacent agencies have been consulted, and it is agreed that groundwater conditions and practices in the Grassland Plan Area are unlikely to cause any significant and unreasonable impacts. However, neighboring agencies are experiencing undesirable results in their GSAs, the most significant being subsidence. Several agencies are experiencing loss of and damage to infrastructure as a result of subsidence. Therefore, significant and unreasonable effects were defined with consideration to subsidence as a limiting factor when possible. Grassland Plan Area participants will continue to work with neighboring agencies to monitor groundwater conditions and prevent undesirable results.

4.3.5 Evaluation of Multiple Minimum Thresholds

Legal Requirements:

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

Although minimum thresholds for the sustainability indicators are consistent across the Grassland Plan Area, the GSAs recognize the value in applying the minimum thresholds to multiple monitoring sites in order to best reflect the conditions of the localized baseline and the meaning of future measurements. Based on the hydrologic conditions in the Plan Area and the defined undesirable results, a combination of minimum thresholds is not required to assess whether an undesirable result is occurring in the Grassland Plan Area and Delta-Mendota Subbasin. Sustainability indicators and quantification of undesirable results can be assessed independently or collectively.
The assessment for groundwater levels, groundwater storage, and interconnected surface water requires an evaluation of the tennine representative monitoring sites in the upper aquifer (for all three indicators) and six representative sites in the lower aquifer (for groundwater levels and groundwater storage), as well as their unique water surface elevation values. The water quality assessment will evaluate three representative monitoring sites in the upper aquifer, threefour representative sites in the lower aquifer, and their respective TDS measurements. The site-specific method of assessment provides the opportunity to assess whether any impacts are localized or regionwide. See **Chapter 5** for greater detail on the monitoring network.

The Delta-Mendota Subbasin's **Common Chapter** (**Appendix A**) addresses the considerations of the basin-wide SMC analysis. as being a sum-of-the-parts method, with the position that each GSP group has the most informed understanding of their respective beneficial users, finances, infrastructure, hydrology, and other contributing parameters for SMC development.

Each GSP Group The Coordination Committee developed their sustainable management criteria consistent with the GSP Regulations, Article 5 Plan Contents, Subarticle 3 Sustainable Management Criteria (§ 354.2 through 354.30). DWR's Draft Best Management Practices for the Sustainable Management of Groundwater Sustainable Management Criteria BMP (2017) document was also used when and where applicable at the discretion of each GSP Group.

4.3.6 Sustainability Indicators Not Considered

Legal Requirements:

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

Seawater Intrusion
The Grassland Plan Area is located 55 miles and several mountain ranges from the Pacific Ocean. Seawater intrusion is not applicable to the area.

More detail on decisions for omitting the development of this parameter can be found in **Chapter 2– Plan Area** and **Chapter 3 – Basin Setting**.

4.4 Minimum Thresholds

Legal Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

Minimum Thresholds (MT) were developed for all sustainability indicators except for seawater intrusion. These MTs were developed to address the potential significant and unreasonable effects that could be caused by changes in groundwater conditions causing an Undesirable Result. ~~In the case of water levels, groundwater storage, and interconnected surface water, the same MTs were established for all of the representative upper aquifer groundwater level monitoring sites.~~ Three of the upper aquifer and all of the lower aquifer representative monitoring wells identified for the representative monitoring networks have no historical data. The Grassland Plan Area participants will monitor these representative sites and use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds in future GSP Updates.

Undesirable results were defined specifically for the Grassland Plan Area in **Section 4.3** for all sustainability indicators. The Minimum Thresholds use known Basin/Plan Area characteristics and available data to quantify rates, elevations, and concentrations at which an undesirable result may be experienced.

4.4.1 Description of Minimum Thresholds

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

Table 4-1 identifies the MTs for each sustainability indicator and specific MT measurements for water levels at selected representative monitoring sites. Maps depicting the representative monitoring networks can be found in **Chapter 5**.

Table 4-1: Minimum Thresholds

Sustainability Indicator	Threshold Description	Monitoring Site ID	Minimum Threshold	Threshold Units
Upper Aquifer Water Levels, Upper Aquifer Groundwater Storage, & Interconnected Surface Water	The upper aquifer minimum threshold is set to not exceed a 20% lowered water elevation from the recent historical low set uniquely at each representative monitoring site. "Recent Historical" is defined as the period from 2000 to the present.	2PU-3	44	WSE (feet)
		1PU-1	58	WSE (feet)
		08S09E34G001M	52	WSE (feet)
		08S10E30E001M	56	WSE (feet)
		11S12E30H002M	91	WSE (feet)
		11S11E04N001M	77	WSE (feet)
		1MU-1	These three upper aquifer monitoring wells do not have historical data; however, the Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds.	
		1MU-2		
		1MU-3		
Lower Aquifer Water Levels & Lower Aquifer Groundwater Storage	Lower aquifer representative monitoring wells have been identified for the monitoring network. However, no historical data exists for these wells. The Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds in future GSP Updates.	1ML-1	See threshold description.	
		1ML-2		
		1ML-3		
		1ML-4		
		1ML-5		
		1ML-6		
Sea Water Intrusion	Not Applicable	N/A	N/A	N/A

Sustainability Indicator	Threshold Description	Monitoring Site ID	DMS ID	Minimum Threshold	Threshold Units
Upper Aquifer Water Levels	The minimum threshold is set at a fixed elevation at each Monitoring Site, equivalent to the historic seasonal low prior to the end of Water Year 2016. To account for future year-to-year variations in hydrology, compliance with the fixed historic seasonal low threshold will be compared with a 4-year rolling average of annual groundwater level measurements.	2PU-3	19-003	90.5	WSE (feet)
		1PU-1	11-013	76.8	WSE (feet)
		08S09E34G001M	11-014	68.1	WSE (feet)
		08S10E30E001M	11-015	72.8	WSE (feet)
Lower Aquifer Water Levels	Lower aquifer representative monitoring wells have been identified for the monitoring network; however, no historical data exists. The Grassland Plan Area participants will continue monitor the sites and intend to use the gathered data to establish meaningful minimum thresholds for the Year 5 interim goal.	11S12E30H002M	11-017	90.2	WSE (feet)
		11S11E04N001M	11-016	83.1	WSE (feet)
		1MU-1	11-007	79.9	WSE (feet)
		1MU-2	11-008	82.3	WSE (feet)
		1MU-3	11-009	63.4	WSE (feet)
		3PU-2	11-019	27.0	WSE (feet)
		1ML-1	11-001	TBD	WSE (feet)
		1ML-2	11-002	TBD	WSE (feet)
		1ML-3	11-003	TBD	WSE (feet)
		1ML-4	11-004	TBD	WSE (feet)
		1ML-5	11-005	TBD	WSE (feet)
		1ML-6	11-006	TBD	WSE (feet)

4.4.1.1 Upper Aquifer Groundwater Levels, Groundwater Storage, and Interconnected Surface Water Threshold Development

Legal Requirements:

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:
(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.
(B) Potential effects on other sustainability indicators.
(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.
(6) Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:
(A) The location, quantity, and timing of depletions of interconnected surface water.
(B) A description of the groundwater and surface model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.

Minimum thresholds for groundwater levels, groundwater storage (using groundwater levels as a proxy), and interconnected surface water were developed considering the upper aquifer as the principal source aquifer for the Grassland Plan Area. Minimum thresholds were developed using the existing conditions of the basin within the Grassland Plan Area and with due consideration to the historically high-water level localized in the Plan Area. were developed for each RMS using common data and coordinated assumptions to consider hydrologic trends in the Basin. An equivalent process was used in both the Upper Aquifer and Lower Aquifer within the Subbasin.

Groundwater Levels

Chapter 5 describes the representative water level monitoring network in greater detail. The site selection was developed to provide enough spatial coverage to represent the variety of groundwater conditions that may occur across the Plan Area and sites were selected based on historical data available to establish SMCs.

The initial criteria for a representative monitoring network were based on wells that had at least three years' worth of data from 2000 to present. However, wells that did not meet the data requirements were also added to the monitoring network and will be used for contouring efforts as well as to supplement the understanding of the groundwater conditions associated with the five applicable sustainability indicators. There were multiple instances where representative monitoring sites were identified for the monitoring network even though no historical data existed for the site. The Grassland Plan Area participants will monitor the sites and intend to use the gathered data to further establish meaningful interim goals, measurable objectives, and minimum thresholds in future GSP Updates.

Interconnected Surface Water

It is understood that the Grassland Plan Area maintains wetland habitat in the Plan Area via a cycle of imported surface water deliveries rather than by groundwater pumping. The application of surface water results in a sustainable system as identified in **Chapter 3**. Historically, the SJR is interconnected to the stretch adjacent to the Grassland Plan Area for most of the year during most water years. The GSAs plan to establish an interconnected surface water monitoring network within the Subbasin to further establish a rate of volume of surface water depletions. Until a rate or volume of interconnected surface water depletions can be developed, T the Grassland Plan Area's contribution to the interconnection can be quantitatively measured by the upper aquifer groundwater levels across the Plan Area, as the groundwater flow trends towards the SJR and contributes a net inflow to the river. Any disruptions to that contribution are best assessed on a regional basis rather than on a site-specific scale. The representative water level monitoring used for assessing upper aquifer groundwater levels will also serve as the interim monitoring and SMC evaluation method for interconnected surface water and will assess the location, quality, and timing of depletions of the SJR as a result of Grassland Plan Area management actions. Additionally, the Water Budget and ongoing upper aquifer groundwater level contouring effort described in **Chapter 3** and the **Appendix A – Common Chapter** will effectively serve as supplemental tools to assess the groundwater levels and flow direction in the Plan Area.

Groundwater Storage

Groundwater levels are directly related to upper aquifer and lower aquifer storage and will be used as a proxy for groundwater storage volume changes (see **Section 3.2.6**). To calculate the volume of groundwater storage, the water levels gathered from the representative water level monitoring sites will be plotted and contours will be developed to understand groundwater levels in the Grassland Plan Area. A volume of groundwater storage can be assessed using the specific yield, water levels, and acreage.

Most of the upper aquifer representative monitoring wells have only three years' worth of groundwater levels and have conflicting temporal measurement periods. None of the lower aquifer representative monitoring wells have adequate historical data to develop a meaningful volumetric minimum threshold, as groundwater contours are dependent on spatial coverage of data measured under similar temporal conditions such as a seasonal high or seasonal low. Therefore, the minimum thresholds for groundwater storage in the upper aquifer are defined as the same thresholds set for water levels. The minimum thresholds for groundwater storage in the lower aquifer are based on inelastic land subsidence, as detailed in Table CC-21, given the relationship between observed inelastic subsidence caused by groundwater extraction and the loss in groundwater storage. The Grassland Plan Area participants plan to reassess the minimum thresholds in future GSP updates and expect improved data quality and quantity after implementation of the representative monitoring program.

Additionally, in the event that significant and undesirable results to beneficial uses or users are realized prior to reaching a minimum threshold, the Plan Area participants recognize the need to mitigate and reassess SMC development for future GSP updates. If a threshold has been exceeded, yet no undesirable results occur, the same opportunity to reassess SMC development may be exercised.

4.4.1.2 Subsidence Threshold Development

Legal Requirements:

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:
(A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including and explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.
(B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

The Corcoran Clay that underlies the Plan Area is composed of inelastic clay minerals. Inelastic subsidence occurs when clay particles in the lower aquifer that are composed of certain minerals collapse when dewatered or subjected to rapid pressure reductions, resulting in the clay structure compacting and being unable to re-expand to its original thickness, despite replenishment causing rises in groundwater levels. Therefore, impacts related to subsidence in the Grassland Plan Area can be directly associated with pumping activities from wells perforated below the Corcoran Clay.

The Delta-Mendota Subbasin has experienced localized instances of severe subsidence and resulting infrastructural impacts. Although the Grassland Plan Area is within the Subbasin, it has not experienced the same rates of subsidence as the northern and southern areas of the Delta-Mendota Subbasin, and the Grassland Plan Area's influence on subsidence is insignificant considering that pumping from the lower aquifer is negligible in the Plan Area.

The Grassland Plan Area participants evaluated recent historical trends in subsidence in the Plan Area using USBR subsidence mapping and analysis from KSA as identified in **Chapter 3**. By using geographic information systems (GIS) to analyze the USBR ground surface file and incorporating the KSA calibration, the average subsidence rate was determined to be 0.075 ft/year during the period of 2011 to 2017.

Impacts to water available for habitat conservation serves as the limiting land use; however, impacts to agricultural irrigation were also considered when evaluating what the significant and unreasonable impacts would be in the Plan Area. The most likely impact is that subsidence would affect the critical infrastructure conveying water used for agricultural and habitat irrigation. Historically, the Plan Area has not experienced subsidence-induced disruptions to conveyance capacity. The current rate at which subsidence is occurring within the Grassland Plan Area is neither currently yielding nor projected to yield significant and unreasonable undesirable results. ~~Therefore, t~~The minimum threshold for the Subbasin was set to not exceed two additional feet of subsidence by 2040, as measured by the historical annual average rate of subsidence from December 2011 to December 2018, defined at each of the three representative monitoring sites: 108, 137, and 152. The minimum threshold is described in Table CC-~~6~~21 of the Common Chapter – **Appendix A**. ~~(**Table 4-5**)~~.

See **Figure 3-21** in **Chapter 3** for a map depicting the extent and rate of land subsidence. ~~that had influence on development of the minimum threshold, interim goals, and measurable objective at 2040.~~ The Delta-Mendota Subbasin's Common Chapter **(Appendix A)** further explains the extent of subsidence on a basin-wide scale.

4.4.1.3 Water Quality Threshold Development

Legal Requirements:

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be used on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

As described in prior sections, there are several potential causes of groundwater quality degradation that could lead to undesirable results, such as fertilizer application on adjacent lands, salt accumulation, chemical spills, wastewater discharges, naturally occurring elements, and the mobilization of groundwater plumes.

GWD has developed and has been maintaining a Groundwater Monitoring Plan designed to monitor the key groundwater quality constituents based on the beneficial uses and wetland habitat tolerances of the area. The Groundwater Monitoring Plan uses state and federal water quality standards applicable to the beneficial uses to define the local standards.

GWD's Groundwater Monitoring Plan was considered in conjunction with the groundwater quality assessment developed by KSA in **Chapter 3** ~~in order to identify salinity in terms of TDS when establishing water quality sustainable management criteria~~. The minimum threshold is ~~consistent with~~more stringent than GWD's Groundwater Monitoring Plan threshold concentration of 2,500 mg/L TDS at each well head (**see Section 4.3.3**), because it was established at the Subbasin level and is focused on drinking water uses. The minimum threshold is described in Table CC-19 of the Common Chapter – **Appendix A**.

There are no known groundwater contaminant plumes in the Grassland Plan Area. As identified earlier in this chapter, the upper aquifer is the primary source aquifer in the Plan Area; however, water quality will be monitored, and SMCs will be analyzed in both the upper and lower aquifers. See **Chapter 5** for further details regarding the additional monitoring efforts that will be used to supplement the understanding of all five applicable sustainability indicators.

4.4.1.4 Relationship Between Thresholds

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

Thresholds were developed considering:

1. Who are the beneficial users of groundwater?
2. How are/could they be impacted?
3. To what level does the impact become significant and unreasonable?

These questions were developed independently of groundwater conditions and historical trends in order to determine what problems existed or were likely to develop and at which point mitigation would become too expensive or logistically infeasible. Considering that the

Grassland Plan Area has not and is not expected to experience significant and unreasonable effects as a result of current groundwater conditions, land use practices, projected trends, or groundwater uses, it made sense to reach out to neighboring agencies to see what impacts they were experiencing.

The ~~Grassland Plan Area considered both the Plan Area and~~ Coordination Committee considered the Delta-Mendota Subbasin groundwater conditions in light of the five applicable sustainability indicators ~~(and specifically the lack of undesirable results)~~ as the driving influence when developing the minimum thresholds. The Plan Area participants recognize influences from neighboring agencies as the greatest hindrance to achieving their sustainability goals and are committed to communication with neighboring agencies as pivotal to GSP success.

Water Levels, Groundwater Storage, and Interconnected Surface Water
The minimum thresholds for water levels, groundwater storage, and interconnected surface water are consistent, based on their direct relationship to water levels and the sustainability goal of avoiding undesirable results. Groundwater storage is traditionally measured by evaluating groundwater levels and the safe yield of a defined area. Therefore, the water level thresholds were also appropriate to use for groundwater storage thresholds for the upper aquifer, as the significant and unreasonable undesirable results of both are recognized and water levels and groundwater storage are both identified by the depth to water.

The Grassland Plan Area's reliable imported surface water supply and management of wetland habitat has resulted in high groundwater levels and produces a net inflow to the SJR. On an interim basis before a rate or volume of interconnected surface water can be established, ~~Rather than measuring levels directly adjacent to the river,~~ the water levels dispersed across the Plan Area will ~~also~~ be measured as they are ~~also~~ indicative of the groundwater level trends induced by applied irrigation for habitat conservation. The water level thresholds set for the representative monitoring network were deemed a conservative interim metric for assessing and maintaining interconnected surface water ~~by the Grassland Plan Area participants~~.

~~Significant water level declines could negatively impact water quality. If water quality deteriorates to the level of the minimum threshold, wetland habitats may not be able to sustain productivity required for ecosystem functionality. Growers could also potentially experience a decrease in crop yield. The best way to mitigate an accumulated salt concentration is to leach the salt through the soil column. The water level threshold will be evaluated in the event that the TDS-based water quality threshold is exceeded or habitats are showing symptoms of impairment induced by poor water quality.~~

Subsidence
The recent historical rate of subsidence in the Plan Area is insignificant compared to other areas of the Subbasin, and there are no existing impacts or potential needs for infrastructure upgrades beyond the implementation horizon. Subsidence is unlikely to affect either water quality or water levels or groundwater storage in the upper aquifer. The upper aquifer serves as the primary source aquifer for the Plan Area. The minimum thresholds for subsidence are low and are intended to protect against the unreasonable lowering of groundwater levels or loss of groundwater storage in the lower aquifer.

Groundwater Quality
It is assumed that groundwater quality will remain appropriate for irrigation and wetland purposes with continued close monitoring and implementation of GWD's established

Groundwater Monitoring Plan. GWD's efforts will continue into the GSP planning horizon. To comply with the requirements of SGMA, groundwater quality SMCs were set to address the potential for impairment to the most limiting beneficial use: habitat conservation drinking water, although drinking water users are not present in the Grassland GSP Area. Should groundwater quality become an issue, it may become necessary to extract water from one location within the Plan Area for use in another or to strategically deliver surface water for blending purposes. The District does not predict that water quality will impact the Plan Area by necessitating the deepening of wells or requiring the use of the lower aquifer due to water quality issues in the upper aquifer. Groundwater quality is unlikely to affect groundwater levels or subsidence rates.

4.4.1.5 Groundwater Level Proxy

Legal Requirements:

§354.28 (d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Upper Aquifer Groundwater Storage

Water level elevations in the upper aquifer will be used as a proxy for groundwater volume in storage in the upper aquifer. The volume of groundwater storage will be quantified on an annual basis using a large network of hydrographs and contour maps as described in **Chapter 3.3 – Water Budget** using changes in groundwater elevation, specific yield of the aquifer, and acreage of the Plan Area. Attempting to quantify the volume of groundwater storage at a single representative well using water level elevation should be avoided; however, it can be a good indicator of sustainability without having to quantify all uses and extractions. A more robust data set using water level should be employed for quantifications of volume when it becomes available through increased monitoring. This method of calculation is a widely used and acceptable substitution for determining changes in groundwater storage and considers all sources of groundwater.

Interconnected Surface Water

The Grassland Plan Area has historically maintained a shallow depth to water in much of the area, which supports wetland habitat. The protected status of most wetlands in the Plan Area, the "No Net Loss" policy, and the existence of shallow clay layers identified in **Section 4.3** results in the Plan Area sustaining shallow groundwater in the wetland areas and producing a net positive flow to the SJR. The gradient of groundwater flows produced by the management activities in the Plan Area is currently understood as the primary influencer to the SJR connection adjacent to the Plan Area and is not expected to change.

Therefore, the Grassland GSP Technical Working Group and Plan Area participants The Coordination Committee made the decision to use groundwater level SMCs across the Plan AreaSubbasin, representing a variety of land uses to evaluate gradient influences, as an appropriate interim proxy for interconnected surface water.

4.4.1.6 Effects on Adjacent Basins

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following: (3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The Grassland Plan Area participants have performed outreach internally with other members of the Delta-Mendota Groundwater Subbasin and have been supportive of inter-basin coordination efforts made by the Coordination Committee, such as a data sharing agreement with Westlands Water District in the Westlands Subbasin through the Northern and Central GSP group. After review of the Grassland Plan Area's historic and projected sustainable determinations regarding overdraft, and interbasin coordination performed by the Delta-Mendota Coordination Committee members with neighboring agencies, it is considered unlikely that implementation of the Plan and Minimum Thresholds will affect neighboring basins. Careful consideration was given to existing conditions outside the Plan Area and further coordination efforts will be ongoing. See the Delta-Mendota Subbasin **Common Chapter** (**Appendix A**) for more details on inter-basin coordination.

4.4.1.7 Affects to Beneficial Uses and Users

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following: (4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Groundwater Levels, Groundwater Storage, and Interconnected Surface Water.
Implementation of these minimum thresholds is not likely to affect any beneficial uses and users of groundwater, except for potentially increasing costs to fund future projects and management actions. It is not the intention of the Grassland Plan Area participants to restrict access to groundwater unless undesirable results begin to ~~occur~~occur, and substantial evidence indicates specific wells are causing impacts. Thresholds may establish conditions that would require mitigation to continue accessing groundwater at specific locations.

The minimum thresholds are intended to prevent the necessity of lowering pumps or deepening wells in order to continue to access groundwater, treating groundwater of decreasing quality, losing habitat or crop productivity, or adversely affecting riparian habitat health due to impacts to the positive groundwater gradient towards the SJR.

Subsidence
Maintaining a rate of subsidence that is minimal and does not exceed two additional feet by 2040 should avoid impacts to~~no greater than recent historical subsidence may eventually impact~~ the conveyance capacity of critical water conveyance infrastructure. There is a potential for uneven ground surface movement to cause changes to the flow of gravity conveyance canals and damage to underground infrastructure that may require changes and updates to irrigation systems or other types of mitigation. In the event these types of impacts begin to occur prior to experiencing the minimum threshold, the Grassland Plan Area will reevaluate the SMCs' definitions.

Groundwater Quality
Adverse changes in groundwater quality may require additional sources of surface water to be imported into the Plan Area or relocation of wells to areas with better water quality. It is also possible that wells would require treatment of water prior to irrigation in order to prevent loss of habitat or crop production.

The Grassland Plan Area is anticipating continuing to operate consistent with the sustainability goals and GSP success will be measured by the avoidance of undesirable results. If minimum thresholds are exceeded yet undesirable results are not realized, the Grassland Plan Area participants may reevaluate SMC determinations and revise for the following GSP Update.

4.4.1.8 Relation to State or other Existing Standards

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

Groundwater Levels, Groundwater Storage, and Interconnected Surface Water
Groundwater levels have not been directly regulated federally, locally, or statewide prior to the adoption of SGMA and GSP implementation. However, wetlands that function based on shallow groundwater, including riparian wetlands along the SJR, are regulated under the federal Clean Water Act and recently adopted state wetland dredge and fill regulations and have been considered in the decision to establish conservative minimum thresholds and measurable objectives.

Subsidence
Subsidence has never been regulated under federal or state law or programs until SGMA.

Water Quality
State, federal, and local water quality regulations and programs applicable to the Grassland Plan Area are outlined in **Chapter 2**. All have been considered and have influenced the development of the water quality SMCs ~~to match existing local thresholds~~.

4.4.1.9 Threshold Measurement Methods

Legal Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater Levels, Groundwater Storage, Interconnected Surface Water
Groundwater levels, and groundwater storage thresholds by proxy, will be measured biannually to correlate with seasonal high and low groundwater levels and the monitoring schedule set forward by the Delta-Mendota Subbasin Coordination Committee. Groundwater levels will be taken as depth to water measurements in feet and converted to water surface elevations.

Subsidence
Subsidence will be surveyed at discrete reference points biannually in the summer and winter to correlate with monitoring efforts currently underway by USBR. Subsidence will be reported as a relative ground surface elevation for both thresholds and contouring efforts. ~~Thresholds have been identified at each discrete location and summarized in **Table 4-5**.~~ Additional monitoring information is outlined in the Delta-Mendota Subbasin **Common Chapter (Appendix A)** and **Chapter 5**.

Groundwater Quality
Groundwater quality will be measured in the summer. ~~Thresholds have been identified for each constituent at each site in **Table 4-5** and results will be reported in the units provided.~~ Water quality will be analyzed in a professional laboratory. Additional monitoring requirements and information are outlined in **Chapter 5,** Delta-Mendota Subbasin **Common Chapter** and **Common Monitoring Technical Memorandum**.

4.5 Measurable Objectives

Measurable objectives were developed to simulate a no-impact scenario based on historical trends or known levels at which impacts might occur. This is not to be confused with significant and unreasonable impacts, which for the purpose of this GSP show the level at which mitigation either becomes unaffordable or physically infeasible. For the purposes of this GSP, the term "measurable objective" serves as the quantitative point at which the sustainability goal has been realized at 2040 and the "interim goals" or "interim milestones" quantitatively reflect the sustainability goal being achieved within five-year increments corresponding with GSP Update submittal periods of 2025, 2030, and 2035.

Legal Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

4.5.1 Groundwater Levels, Groundwater Storage, & Interconnected Surface Water

Unlike most GSPs within critically overdrafted basins, the Grassland Plan Area is not projected to significantly deviate from the sustained groundwater levels it has historically experienced. Therefore, the interim goals and measurable objectives are reflective of a sustained system. The measurable objective is conservatively quantified as the representative groundwater level monitoring sites' recent historical high (preferably Water Year 2015 unless data is not available).~~(2000 to 2019) groundwater elevation low.~~ In other words, an exceedance of the measurable objective would occur if the seasonal high groundwater elevation at a monitoring site drops below the previously measured high. Compliance will be measured on a four-year rolling average to account for year-to-year variability in water levels~~low~~. For most monitoring sites the recent historical ~~low~~high was measured during the severe drought years in 2014, 2015, or 2016.

For the 2025 interim goal, the Grassland Plan Area participants will continue to gather data to complete the establishment of MOs and MTs at representative monitoring sites in the Lower Aquifer. In addition, the Subbasin will complete a monitoring network of interconnected surface water sites, including existing and additional sites, to estimate the influence of groundwater on gains and losses in the San Joaquin River. The Plan Area will also identify potential areas outside the Subbasin inducing chronic lowering of groundwater levels, while continuing to coordinate and develop shorter-term, acute groundwater elevation thresholds. The 2030 and 2035~~The~~ interim goals are defined as a water surface elevation ~~greater than~~at or above the measurable objective. The upper aquifer groundwater level interim goals and measurable objectives are listed below in **Table 4-2**, except for three upper aquifer representative water level monitoring wells that do not have historical data. The table outlines the site-specific measurable objective and interim goals for groundwater levels, groundwater storage, and interconnected surface water. The rationale for groundwater levels being used as a proxy for groundwater storage (upper aquifer) and interconnected surface water (interim) SMC development is identified in **Section 4.4.1.5**

Table 4-2: Water Level SMCs, Groundwater Storage, & Interconnected Surface Water SMCs

Representative Monitoring Well	2025 Interim Goal WSE (ft)	2030 Interim Goal WSE (ft)	2035 Interim Goal WSE (ft)	2040 Measurable Objective WSE (ft)	Minimum Threshold WSE (ft)
Upper Aquifer Groundwater Levels, Groundwater Storage, & Interconnected Surface Water					
3PU-1	>56	>56	>56	56	44
1PU-1	>73	>73	>73	73	58
08S09E34G001M	>66	>66	>66	66	52
08S10E30E001M	>70	>70	>70	70	56
11S12E30H002M	>113	>113	>113	113	91
11S11E04N001M	>97	>97	>97	97	77
1MU-1	Three upper aquifer monitoring wells do not have historical data; however, the Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds.				
1MU-2					
1MU-3					
Lower Aquifer Groundwater Levels & Groundwater Storage					
1ML-1	Lower aquifer representative monitoring wells have been identified for the monitoring network. However, no historical data exists. The Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds in future GSP Updates.				
1ML-2					
1ML-3					
1ML-4					
1ML-5					
1ML-6					

Monitoring Site ID	DMS ID	2025 Interim Goal WSE (ft)	2030 Interim Goal WSE (ft)	2035 Interim Goal WSE (ft)	2040 Measurable Objective WSE (ft)	Minimum Threshold WSE (ft)
Upper Aquifer Groundwater Levels						
2PU-3	19-003	≥91.8	≥91.8	≥91.8	≥91.8	90.5
1PU-1	11-013	≥80.4	≥80.4	≥80.4	≥80.4	76.8
08S09E34G001M	11-014	≥80.7	≥80.7	≥80.7	≥80.7	68.1
08S10E30E001M	11-015	≥75.7	≥75.7	≥75.7	≥75.7	72.8

11S12E30H002M	11-017	≥116.6	≥116.6	≥116.6	≥116.6	90.2
11S11E04N001M	11-016	≥92.8	≥92.8	≥92.8	≥92.8	83.1
1MU-1	11-007	≥91.1	≥91.1	≥91.1	≥91.1	79.9
1MU-2	11-008	≥93.2	≥93.2	≥93.2	≥93.2	82.3
1MU-3	11-009	≥77.3	≥77.3	≥77.3	≥77.3	63.4
3PU-2	11-019	≥27.0	≥27.0	≥27.0	≥27.0	27.0
Lower Aquifer Groundwater Levels						
1ML-1	11-001	TBD Lower aquifer representative monitoring wells have been identified for the monitoring network; however, no historical data exists. The Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals, measurable objectives, and minimum thresholds in future GSP Updates.				
1ML-2	11-002					
1ML-3	11-003					
1ML-4	11-004					
1ML-5	11-005					
1ML-6	11-006					

The water level between the measurable objective and the minimum threshold is recognized as the operational flexibility, accounting for drought periods, land use changes, and allowance of opportunities to mitigate effects prior to experiencing ~~a three-year sustained minimum threshold exceedance.~~water level data that exceeds the established minimum threshold on a four-year rolling average at more than 50% of representative monitoring sites. To achieve sustainability and Plan success, the Grassland Plan Area participants will continue to manage the various land uses within the operational flexibility identified in **Table 4-3.** The projected water budget in **Chapter 3.3** anticipates a sustainable system based on historical data.

Table 4-3: Water Level , Groundwater Storage, & Interconnected Surface Water Upper Operational Flexibility

Water Surface Elevation – Upper Aquifer Measurable Objective and Interim Goals			
GSP Well ID	Measurable Objective at 2040 (WSE, ft)	Operational Flexibility (WSE, ft)	Minimum Threshold (WSE, ft)
3PU-1	56	12	44
1PU-1	73	15	58
08S09E34G001M	66	14	52
08S10E30E001M	70	14	56
11S12E30H002M	113	22	91
11S11E04N001M	97	20	77

Water Surface Elevation				
Monitoring Site ID	**DMS ID**	Measurable Objective (WSE, ft)	Operational Flexibility (ft)	Minimum Threshold (WSE, ft)
Upper Aquifer Groundwater Levels				
2PU-3	19-003	≥91.8	1.3	90.5
1PU-1	11-013	≥80.4	3.6	76.8
08S09E34G001M	11-014	≥80.7	12.6	68.1
08S10E30E001M	11-015	≥75.7	2.9	72.8
11S12E30H002M	11-017	≥116.6	26.4	90.2
11S11E04N001M	11-016	≥92.8	9.7	83.1
1MU-1	11-007	≥91.1	11.2	79.9
1MU-2	11-008	≥93.2	10.9	82.3
1MU-3	11-009	≥77.3	13.9	63.4
3PU-2	11-019	≥27.0	0	27.0

4.5.2 Subsidence

The measurable objective is reflective of coordination with neighbors regarding lower aquifer impacts to regional subsidence considering the negligible volume of lower aquifer pumping occurring in the

Grassland Plan Area. The measurable objective and respective interim goals for inelastic subsidence are outlined in Table CC-211619 of the Common Chapter – **Appendix A.** The measurable objective is to minimize inelastic land subsidence, with no additional subsidence after 2040. and respective interim goals are outlined in **Table 4-8**. The measurable objective is set to an average not to exceed the historical annual average rate of subsidence from December 2011 to December 2018 at each respective site. The Interim Goals are set to reflect any subsidence rate greater than the measurable objective or the historical annual average rate of subsidence from December 2011 to December 2018.no more than one foot of additional inelastic subsidence in the first five years of GSP implementation, no more than one half foot of additional inelastic subsidence in the second five years of GSP implementation, and no more than 0.25 foot of additional inelastic subsidence in the third five years of GSP implementation, with no more than two feet of additional subsidence by 2040.

Table 4-8: Subsidence SMCs

Subsidence SMCs					
Monitoring Point	2025 Interim Goal	2030 Interim Goal	2035 Interim Goal	2040 Measurable Objective	Minimum Threshold
	Annual Average Rate of Subsidence (feet, NAVD 1988)				
108	Slower than -0.08	Slower than -0.08	Slower than -0.08	-0.08	-0.11
152	Slower than -0.1	Slower than -0.1	Slower than -0.1	-0.10	-0.15
137	Slower than -0.11	Slower than -0.11	Slower than -0.11	-0.11	-0.13

The pathway to achieving sustainability is strongly influenced by the Delta-Mendota Subbasin coordination, considering that the Grassland Plan Area's lower aquifer pumping is insignificant. The operational flexibility between the measurable objective and the minimum threshold is outlined in **Table 4-9**. The measurable objective to achieve sustainability is not to exceed the existing annual average subsidence rate seen from December 2011 to December 2018 and to encourage adjacent lower aquifer pumpers to improve upon lower aquifer groundwater reliance. This provides slightly more flexibility than the minimum threshold, which allows for the slightly higher subsidence rates seen from December 2011 to December 2015 and captures greater effects from sustained drought conditions.

Table 4-9: Subsidence Operational Flexibility

Subsidence Operational Flexibility			
GSP Well ID	Measurable Objective at 2040	Operational Flexibility	Minimum Threshold
	Annual Average Rate of Subsidence (feet, NAVD 1988)		
3PU-1	-0.08	-0.03	-0.11
1PU-1	-0.10	-0.05	-0.15
08S09E34G001M	-0.11	-0.02	-0.13

4.5.3 Water Quality

Water quality measurable objectives were established at each site uniquely, recognizing the historical electrical conductivity (EC) maximum values and applying a twenty-percent increase in concentration. EC was chosen for the measurable objectives because this is the salinity measurement method that is commonly used for groundwater quality monitoring programs within the Plan Area (see **Section 5.1.2**). Unlike TDS, EC is readily measurable and does not require lab analysis, which allows for better real-time water quality management. In contrast, TDS was chosen for the minimum threshold because it represents a longstanding threshold for acceptance of water for wetland use in the Plan Area. In addition to real-time EC measurements, both TDS and EC are reported in lab analyses for the existing water quality monitoring programs. Significant and unreasonable undesirable results were not experienced in instances in which the Grassland Plan Area reached the historic high EC concentration. **Table 4-10** Water quality measurable objectives were established by the GSP groups within the Subbasin using the upper limit of 1,000 mg/L TDS for drinking water, defined by the California secondary maximum contaminant level standards for TDS in drinking water. Table CC-9619 in the Common Chapter outlines the measurable objective and interim goals set at each representative water quality monitoring site. Operational flexibility is the range between the measurable objective for salinity (measured in EC) and the minimum threshold of 2,500 mg/L (measured in TDS).

There is no gradual decline to these water quality levels, as the Grassland Plan Area participants anticipate maintaining their water system within existing water quality parameters and would require more data to meaningfully perform a groundwater quality trend analysis.

As more information is obtained, interim goals may be refined to reflect the understanding of groundwater quality conditions in the Plan Area. It should be acknowledged that salinity standards are still being developed by water quality experts and regulatory agencies in the Central Valley, and thus may need to be revised in the future.

The plan to achieve water quality sustainability in the Grassland Plan Area lies in maintaining and managing the goals of other existing programs in the Plan Area. The understanding of groundwater quality is anticipated to improve with implementation of the representative water quality monitoring network.

~~Table 4-10: Water Quality SMCs~~

Water Quality Sustainable Management Criteria					
Representative Monitoring Well	2025 Interim Goal	2030 Interim Goal	2035 Interim Goal	2040 Measurable Objective	Minimum Threshold
	EC (µS/cm)	EC (µS/cm)	EC (µS/cm)	EC (µS/cm)	TDS
Upper Aquifer					
1PU-1	<2,028	<2,028	<2,028	2,028	2,500
2PU-1	<2,196	<2,196	<2,196	2,196	2,500
2PU-3	<1,080	<1,080	<1,080	1,080	2,500
Lower Aquifer					
1PL-1	Lower aquifer representative water quality monitoring sites have been identified; however, no historical data exists. The Grassland Plan Area participants will monitor the sites and intend to use the gathered data to establish meaningful interim goals and measurable objectives in future GSP Updates.				2,500
2PL-1					2,500
1PL-2					2,500
1PL-3					2,500

4.5.4 Additional Measurable Objective Elements

Legal Requirements:

§354.30 (f) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for finding of inadequacy of the Plan.

No additional objective elements were set for this GSP.

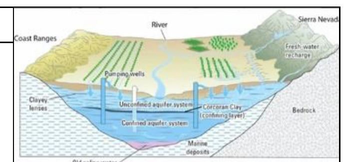
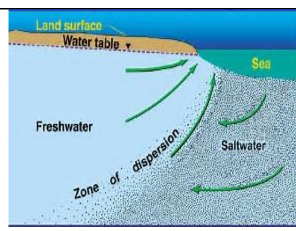
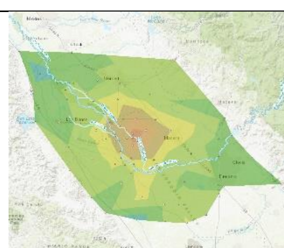
5 Monitoring Network

Legal Requirements:

§354.32 This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

A comprehensive monitoring network is a fundamental component of groundwater management and is needed to measure progress toward groundwater sustainability. Below, **Table 5-1** includes the indicators necessary to monitor in order to comply with SGMA monitoring and reporting requirements. Monitoring programs for the five applicable sustainability indicators are described in this chapter, including the history of the monitoring programs, proposed monitoring to comply with SGMA, and the adequacy and scientific rationale for each monitoring network.

Table 5-1: Monitoring Requirements

Groundwater Levels: Monitoring of static groundwater levels each spring and fall		Groundwater Storage: Monitoring the annual change in groundwater storage	
Seawater Intrusion: Intrusion of seawater into local aquifers *(This is not applicable to the GGSA or MCDMGSA.)*		Water Quality: Monitoring for water quality degradation that could impact available groundwater supplies	
Land Subsidence: Monitoring surface land subsidence caused by groundwater withdrawals		Depletion of Interconnected Surface Water: Monitoring loss of permanent connections between surface water and groundwater	

5.1 Description of Monitoring Network

Legal Requirements:

> **§354.34(a)** Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan Implementation.

This chapter describes the representative monitoring network and supplemental monitoring efforts currently being implemented by entities within the Plan Area, and the representative monitoring network that will be used by the GGSA and MCDMGSA for the Plan Area. The results and data from historical monitoring efforts can be found in **Chapter 3.2 – Current and Historical Groundwater Conditions**. These monitoring efforts will continue to collect data into the future to determine short-term, seasonal, and long-term trends in groundwater and related surface water conditions. Data from the internal representative monitoring network will be reported to the Delta-Mendota Subbasin for tracking existing conditions and threshold exceedances of any criteria or thresholds. This data will yield information necessary to support the implementation of this Plan, evaluation of the effectiveness of the Plan, and decision-making for the Plan Area.

Delta-Mendota Subbasin Representative Monitoring Networks

The Delta-Mendota Subbasin Common Chapter describes the coordination of each GSP's representative monitoring network:

As required by Subarticle 4. Monitoring Networks of the GSP regulations, the GSPs must include a monitoring network for each sustainability indicator, in addition to describing the monitoring protocols and data management to be followed in implementing the GSP monitoring program. Given the variability of conditions within the Delta-Mendota Subbasin, each GSP Group developed their individual monitoring networks, in coordination with their neighboring GSP Groups, such that the subbasin-wide monitoring programs is simply a compilation of those coordinated individual monitoring networks.

Grassland Plan Area Representative Monitoring Networks

The representative monitoring networks are sites specifically identified to monitor and evaluate sustainable management criteria (SMCs). These sites contribute to an understanding of hydrogeologic conditions and their relationship to groundwater pumping as well as the spatially dispersed data necessary to develop groundwater-level and subsidence contours and characterizations of changes in storage and water quality. Data obtained from these sites will be used for the evaluation and calculation of water budget updates, any future reconsideration of sustainable management criteria, and the refinement of groundwater level contours, water quality assessments, and subsidence analysis.

Supplemental Data

Data obtained via GWD's monitoring program (**Section 5.1.2, Density of Monitoring Sites and Frequency of Measurements**), state and federal monitoring, and additional publicly available monitoring programs will be used to supplement the representative monitoring network data. The Grassland Plan Area participants acknowledge the benefit of merging existing monitoring programs with GSP monitoring efforts.

Potential Future Monitoring Network

There are monitoring sites within or adjacent to the Grassland Plan Area that were not included in the representative monitoring network due to a lack of temporal data consistency. These sites will continue to be monitored under GWD's monitoring program and are included in the Grassland Plan Area's Potential Future Monitoring Network. The intention of this network is to recognize that the data obtained from additional monitoring efforts can be useful in the analyses required by SGMA and may be useful for inclusion in future GSP updates. These additional sites are considered supplemental to the Representative Monitoring Networks identified in **Section 5.4** and are not subject to SMC analyses unless otherwise decided upon by Plan participants in future GSP updates.

5.1.1 Monitoring Network Objectives

Legal Requirements:

§354.34(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the effects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

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

The objectives of the Grassland GSP monitoring network, consistent with the Delta-Mendota Subbasin Common Chapter, are as follows:

1. Establish a baseline for future monitoring.
2. Provide warning of potential future problems.
3. Generate information for water resources evaluation.
4. Quantify annual changes in water budget components.
5. Develop meaningful long-term trends in groundwater characteristics.
6. Provide comparable data from various locales within the Plan Area.
7. Demonstrate progress toward achieving measurable objectives and interim goals in the Plan.
8. Monitor changes in groundwater conditions relative to minimum thresholds, measurable objectives, and sustainable management criteria.
9. Monitor impacts to the beneficial uses or users of groundwater.

5.1.2 Implementation of Monitoring Network

Existing Monitoring – Water Quality, Water Levels, and Interconnected Surface Water

GWD has maintained a groundwater level monitoring program (GWMP) that includes pre- and post-pumping season water level measurements and is approved by USBR for the acquisition of refuge water supplies under the federal Refuge Water Supply Program. For the past several years, DWR has also asked local agencies to collect and report groundwater level data under the California Statewide Groundwater Elevation Monitoring (CASGEM) program. Data from these wells was recorded in an electronic database and submitted to the San Luis Delta Mendota Water Authority (SLDMWA) for inclusion in the CASGEM program.

The GWD also identified similar objectives in its Groundwater Management Plan:

- Measure water level fluctuations within wells in the District and evaluate the data for change in storage conditions.
- Measure water quality in wells and evaluate for potential water quality degradation.
- Submit water level data to the California Statewide Groundwater Elevation Monitoring (CASGEM) program.

GWD's groundwater quality monitoring program includes the collection of analytical grab samples at each wellhead least twice a year: at the beginning of the pumping season and just prior to the end of the pumping season. These samples are analyzed for selenium, EC, TDS, and boron. During the pumping season, wells are also tested for EC on a weekly basis, along with surface water upstream and downstream of each well. Annual summaries of groundwater quality trends are reviewed by the District's Board of Directors and submitted to the USBR in annual reports. This monitoring effort extends to all wells that provide groundwater for wetland habitat within the GGSA, including wells located adjacent to the GGSA and within the MCDMGSA. The CDFW maintains a similar groundwater monitoring and reporting program for groundwater wells that produce water for wetland habitat on state wildlife areas within the MCDMGSA.

GWD's Real Time Water Quality Monitoring Network (RTWQMN) currently consists of approximately 30 real-time monitoring stations located at key inflow, delivery, confluence, and drainage points that continuously measure surface water flow, EC, temperature, and pH. Additionally, current groundwater monitoring plans require GWD to monitor for TDS, selenium, and boron in surface water channels monthly in order to ensure continued compliance with the water quality objectives of the Central Valley Regional Water Quality Control Board (CVRWQCB).

The constituent with the greatest potential for negative impact in the Plan Area is salinity. Chapter 4 identifies the potential concerns of salinity and details a plan to assess SMCs for TDS ~~and EC~~. Groundwater and surface water monitoring programs will continue and may expand as needed to comply with SGMA monitoring requirements. Monitoring for selenium and boron will continue independently of SGMA, compliant with the GWD's and CDFW's monitoring programs. In the event of a trend of groundwater or surface water quality deteriorating in such a way that would impact beneficial users of groundwater, the Plan Area participants recognize the necessity of updating the SMCs and water quality monitoring to reflect concern for potential impacts.

The San Joaquin River Improvement Project and Grassland Bypass Project improve water quality in the Plan Area's wildlife refuges and wetlands, sustain the productivity of 97,000 acres of farmland, and foster cooperation between area farmers and regulatory agencies in drainage management and the reduction of selenium and salt loading to surface water. The projects are located south of the Plan Area and are operated by the San Joaquin Valley Drainage Authority, the Grassland Basin Drainers group, USBR, and the SLDMWA. Under agricultural drainage improvements by the USBR, sub-surface agricultural drainage from a large portion of the 370,000-acre Grasslands Watershed west of the San Joaquin River in Merced County has been shifted from discharging into wetland areas to discharging to the San Luis Drain and Mud Slough, a tributary to the San Joaquin River. In 2019 the project will cease discharging agricultural drainage water and has been proposed to be managed as a storm water bypass project around the wetland complex going forward.

The San Joaquin Valley Drainage Authority has agreed to install 5 multi-completion monitoring wells along the common boundary between the GGSA and the San Joaquin River Improvement Project, also known as the drainage reuse area, to begin to monitor subsurface migration of salt. The results of this supplemental monitoring data will be considered during GSP updates.

Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 to address pollutant discharges to surface water and groundwater from commercially irrigated lands. The primary purpose of the ILRP is to address key pollutants of concern, including salinity, nitrates, and pesticides introduced through runoff or infiltration of irrigation water and stormwater. The program is administered by the Central Valley Regional Water Quality Control Board (RWQCB or Regional Board). The Westside San Joaquin River Watershed Coalition serves as the third-party group for the landowners within the Western San Joaquin River Watershed. The Waste Discharge Requirements (WDRs) under General Order R5-2014-0002, which apply to landowners within the Western San Joaquin River Watershed, were adopted by the RWQCB on January 9, 2014.

To date, the Coalition has monitored surface water quality, and groundwater quality is being monitored under the recent groundwater trend monitoring program and groundwater quality management plan released in March 2017. Fourteen wells are monitored annually at representative locations in high monitoring priority areas for constituents including nitrate, EC, pH, dissolved oxygen, temperature, and turbidity. Nitrate is the primary constituent of concern for the Coalition. However, the Plan Area is in the lowest monitoring priority area and is not within a high vulnerability area for nitrate. Nitrate management plans are not required by the RWQCB because managed wetlands within the Plan Area help play a role in improving groundwater quality and do not apply nitrogen fertilizer.

Other Agencies

Several other agencies play important roles in the monitoring of groundwater quality. These include the RWQCB, U.S. Environmental Protection Agency (EPA), Department of Toxic Substances Control (DTSC), U.S. Geological Survey (USGS), USBR, and State Water Resources Control Board (SWRCB). The GSP participants make efforts to collect and review pertinent water quality data published by these agencies. GWD also provides annual groundwater and surface water quality monitoring reports to USBR, CDFW, USFWS, and RWQCB.

Existing Monitoring – Subsidence

While some local agencies in the San Joaquin Valley monitor for land subsidence, the majority rely on monitoring performed by regional water agencies or the state and federal governments. Measurement and monitoring for land subsidence are performed by a variety of agencies including USGS, USBR, U.S. Army Corps of Engineers (USACE), University NAVSTAR (Navigation Satellite Timing and Ranging) Consortium (UNAVCO), and various private contractors. Interagency efforts between the USGS, USBR, the U.S. Coast and Geodetic Survey (now the National Geodetic Survey), and DWR have resulted in an intensive series of investigations that have identified and characterized subsidence in the San Joaquin Valley. NASA also measures subsidence in the Central Valley and has maps on its website that show the subsidence for a defined period. Several subsidence monitoring sites are located within and adjacent to the Plan Area and are actively monitored as part of the San Joaquin River Restoration Program. These sites are included in the representative monitoring network.

The SLDMWA and Central California Irrigation District maintain land subsidence monitoring programs. The Grassland Plan Area participants will continue to follow the results of these established monitoring programs, collaborate with the agencies to mitigate problems associated with land subsidence, and participate in the development of both intra- and inter-basin solutions.

Grassland Plan Area - Representative Monitoring Networks

Additionally, new monitoring networks have been developed (**Figure 5-1, Figure** 5-2**,** and **Figure 5-3**) for the purposes of GSP compliance and improvement of the hydrogeologic understanding of the Grassland Plan Area. Existing networks will be enhanced when necessary using the Data Quality Objective (DQO) process, which follows the U.S. EPA *Guidance on Systematic Planning Using the Data Quality Objective Process* (EPA, 2006). The DQO Process is also outlined in the DWR's Best Management Practices for monitoring networks (DWR, 2016a) and monitoring protocols (DWR, 2016b).

The DQO process includes the following:

1. State the problem.
2. Identify the goal.
3. Identify the inputs.
4. Define the boundaries of the area/issue being studied.
5. Develop an analytical approach.
6. Specify the performance or acceptance criteria.
7. Develop a plan for obtaining data.

The DQO process helps ensure a repeatable and robust approach to collecting data with a specific goal in mind.

5.1.3 Description of Monitoring Network

Legal Requirements:

§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

The Grassland Plan Area's monitoring efforts address the five applicable sustainability indicators and are organized into three representative monitoring networks:

(1) Representative water quality monitoring network
(2) Representative water level monitoring network
(3) Representative subsidence monitoring network

The wells identified in the representative water level and groundwater quality monitoring networks include wells perforated in the upper aquifer and wells perforated in the lower aquifer. The two distinct aquifers are substantially separated by the Corcoran Clay and are the two principle aquifers in the Plan Area. The lack of historical data from the wells that perforate down to the lower aquifer has prevented establishment of meaningful sustainable management criteria in the 2020 Grassland GSP for all sustainability indicators excepting water quality (for which the criteria are the same for the upper and lower aquifer). Lower aquifer wells are identified as representative monitoring sites and will undergo monitoring associated with GSP implementation. The data collected will be used for groundwater contouring and will facilitate further SMC development in future GSP updates for the lower aquifer. Thus, at this time SMC for water levels have been developed only for the upper aquifer.

Representative Groundwater Quality Monitoring Network
The groundwater quality monitoring network (**Table 5-2** and **Figure 5-1**) includes three upper aquifer wells. To achieve representative spatial coverage and characterize the conditions of both aquifers underlying the Grassland Plan Area, three~~four~~ lower aquifer representative water quality monitoring wells are also included in the network. Existing data indicates that groundwater quality is relatively consistent across broad expanses of the Plan Area. The monitoring sites were selected at representative locations in the south, central, and northern portions of the Plan Area. Other GSP groups in the Delta-Mendota Subbasin have identified water quality monitoring sites that are close to but outside of the Plan Area which will provide additional relevant data (see **Common Chapter (Appendix A) Figures CC-74 and CC-75**).

Table 5-2: Representative Groundwater Quality Monitoring Network Sites

~~Representative Groundwater Quality Monitoring Network~~	
~~Upper Aquifer~~	
~~1PU-1~~	~~Sufficient historical data available to establish SMCs.~~
~~2PU-1~~	
~~2PU-3~~	
~~Lower Aquifer~~	
~~1PL-1~~	~~Lower aquifer representative monitoring wells have been identified for the monitoring network. However, historical data is limited. The Grassland Plan Area participants will monitor the sites and establish meaningful interim goals and measurable objectives with the gathered data in future GSP Updates if feasible.~~
~~2PL-1~~	
~~1PL-2~~	
~~1PL-3~~	

Representative Groundwater Quality Monitoring Network	
Upper Aquifer	
LT	Sufficient historical data available to establish SMCs.
2PU-1	
M3	
Lower Aquifer	
1PL-1	The Grassland Plan Area participants will continue to monitor this site and establish a meaningful measurable objective and minimum threshold with the gathered data in the Year 5 interim goal.
1PL-2	Sufficient historical data available to establish SMCs.
1PL-3	

Representative Water Level Monitoring Network

The groundwater level representative monitoring network (**Table 5-3** and **Figure** 5-2) is made up of nine upper aquifer wells, four of which have been and will continue to be monitored by DWR, and three of which are associated with two multicompletion well sites and do not have adequate historical data for SMC development. The lower aquifer representative water level monitoring network is comprised of six wells from three multicompletion well sites and also have limited historical data. After data is acquired during the implementation phase from the sites that do not have historical data, meaningful thresholds will be established and identified in GSP Updates. Existing data indicates that groundwater levels are relatively consistent across broad expanses of the Plan Area. The monitoring sites were selected at representative locations in the south, central, and northern portions of the Plan Area. Other GSP groups in the Delta-Mendota Subbasin have identified groundwater level monitoring sites that are close to but outside of the Plan Area, which will provide additional relevant data (see **Common Chapter (Appendix A) Figures CC-72 and CC-73**).

This network serves as the representative monitoring network for three of the sustainability indicators:

(1) Water levels
(2) Groundwater storage (upper aquifer)
(3) Interconnected surface water

Descriptions of their relationship to groundwater levels and spatial distribution are outlined in **Section 5.1.3.1**.

Table 5-3: Representative Water Level Monitoring Network Sites

~~Representative Water Level Monitoring Network~~	
~~Upper Aquifer~~	
~~2PU-3~~	~~Historical data available to establish SMCs.~~
~~1PU-1~~	
~~08S09E34G001M~~	
~~08S10E30E001M~~	
~~11S12E30H002M~~	

~~11S11E04N001M~~	
~~1MU-1~~	~~Three upper aquifer monitoring wells have limited historical data; however, the Grassland Plan Area participants will monitor the sites and establish meaningful interim goals, measurable objectives, and minimum thresholds with the gathered data if feasible.~~
~~1MU-2~~	
~~1MU-3~~	
~~Lower Aquifer~~	
~~1ML-1~~	~~Lower aquifer representative monitoring wells have been identified for the monitoring network. However, historical data is limited. The Grassland Plan Area participants will monitor the site and establish meaningful interim goals, measurable objectives, and minimum thresholds with the gathered data in future GSP Updates if feasible.~~
~~1ML-2~~	
~~1ML-3~~	
~~1ML-4~~	
~~1ML-5~~	
~~1ML-6~~	

Representative Water Level Monitoring Network	
Upper Aquifer	
2PU-3	Historical data available to establish SMCs.
1PU-1	
08S09E34G001M	
08S10E30E001M	
11S12E30H002M	
11S11E04N001M	
3PU-2	
2PU-3	
1MU-1	
1MU-2	
1MU-3	
Lower Aquifer	
1ML-1	Historical data available to establish SMCs.
1ML-2	
1ML-3	
1ML-4	
1ML-5	
1ML-6	

Representative Subsidence Monitoring Network

The representative subsidence monitoring network (**Table 5-4** and **Figure 5-3**) is comprised of three USBR-monitored subsidence survey benchmarks (108, 137, and 152) located within and near the Plan Area. Although these three sites will specifically be examined for SMC analysis (**Chapter 4**), the understanding of subsidence in the Delta-Mendota Subbasin and Plan Area may require the examination of supplemental subsidence monitoring data from all publicly available sources due to the limited spatial extent of the monitoring network.

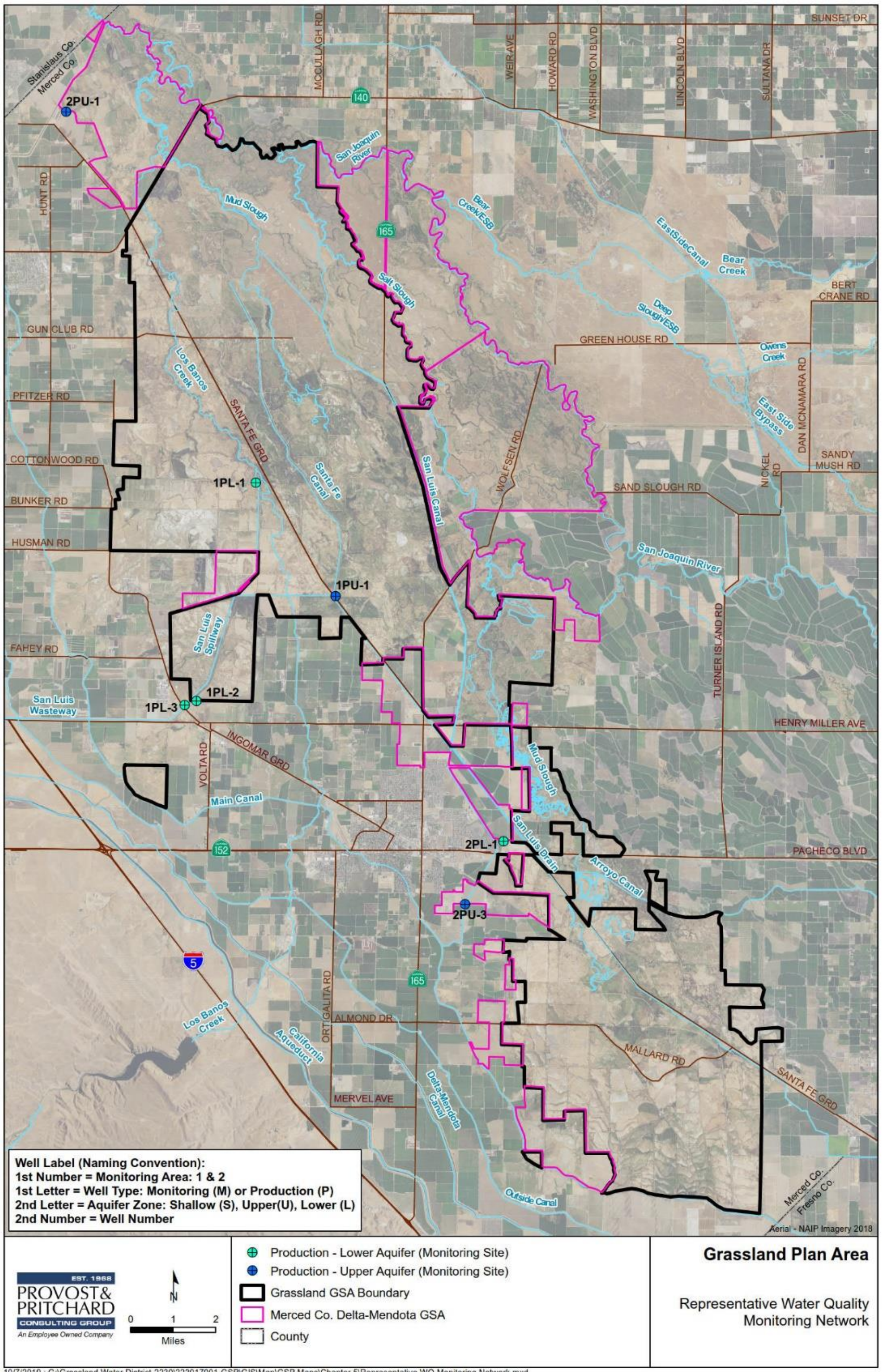
Table 5-4: Representative Subsidence Monitoring Network

Representative Subsidence Monitoring Network

USBR Monitoring Sites	
108	Historical data available to establish SMCs.
152	
137	

Monitoring Networks Not Considered

The Grassland Plan Area is geographically distanced from the Pacific Coast in such a way that prevents any impacts related to seawater intrusion in the Plan Area. Therefore, a seawater intrusion monitoring network is not feasible, necessary, or required.



10/7/2019 : G:\Grassland Water District-2230\223017001-GSP\GIS\Map\GSP Maps\Chapter 5\Representative WQ Monitoring Network.mxd

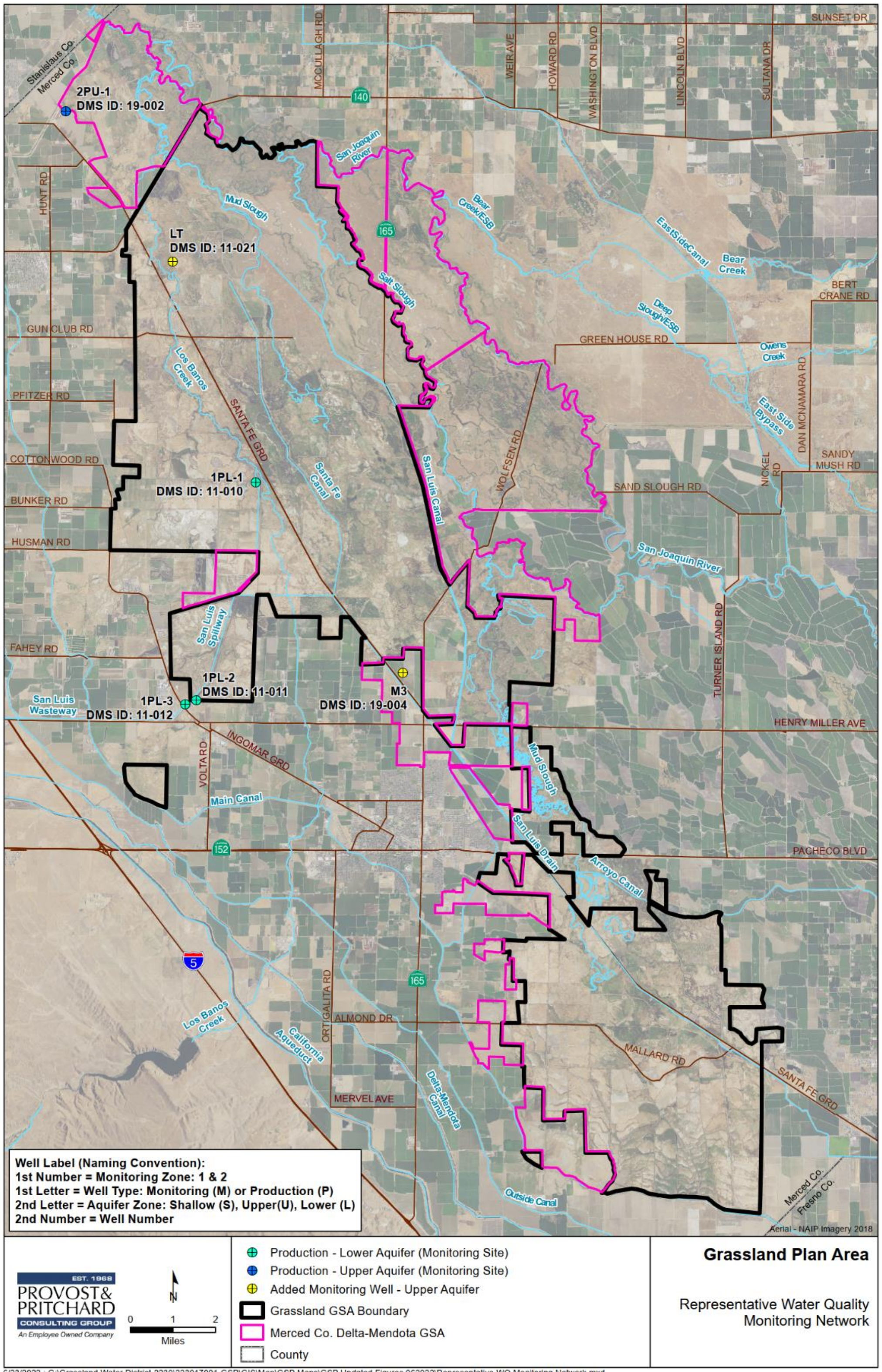


Figure 5-1: Representative Water Quality Monitoring Network

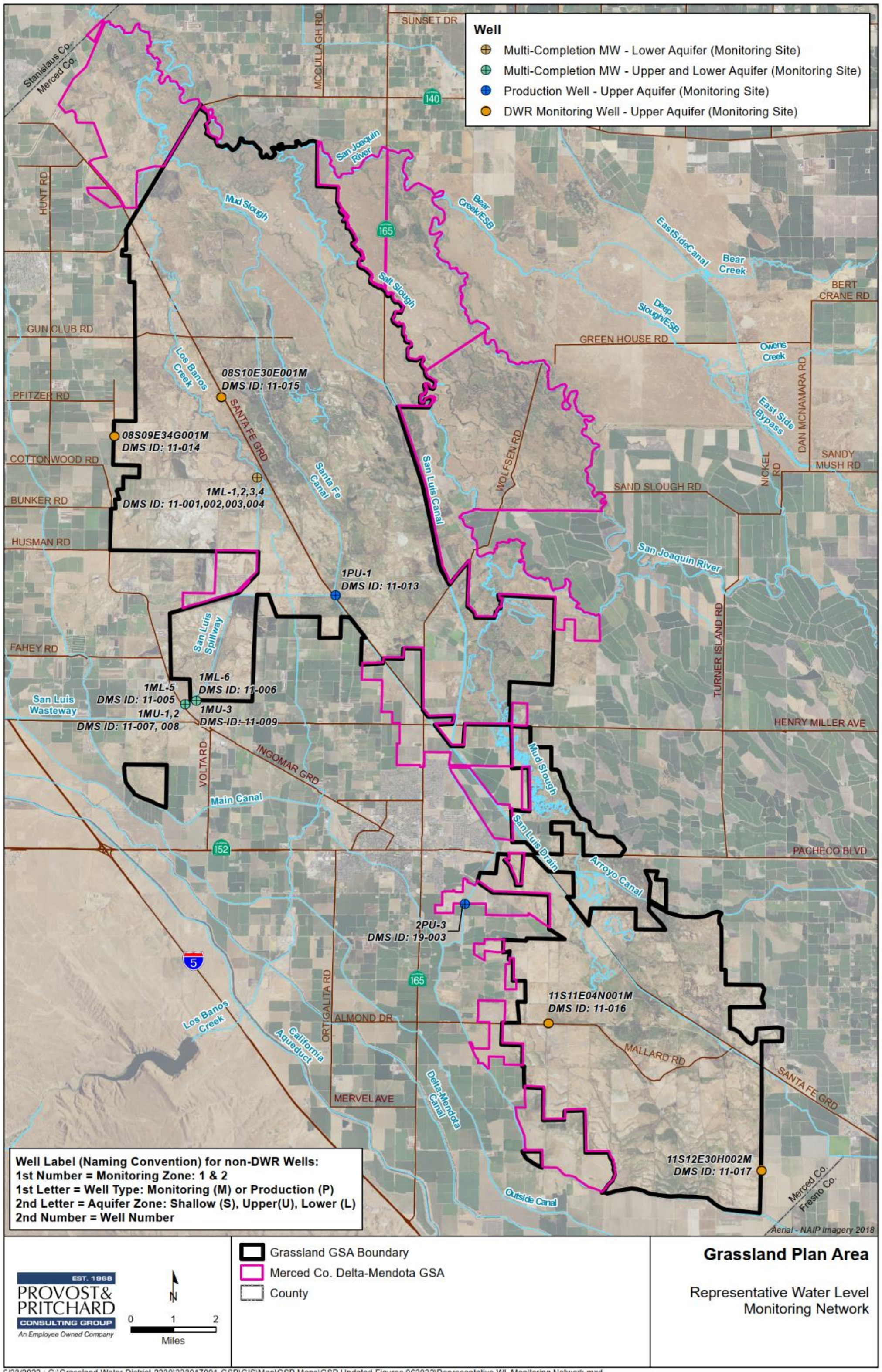
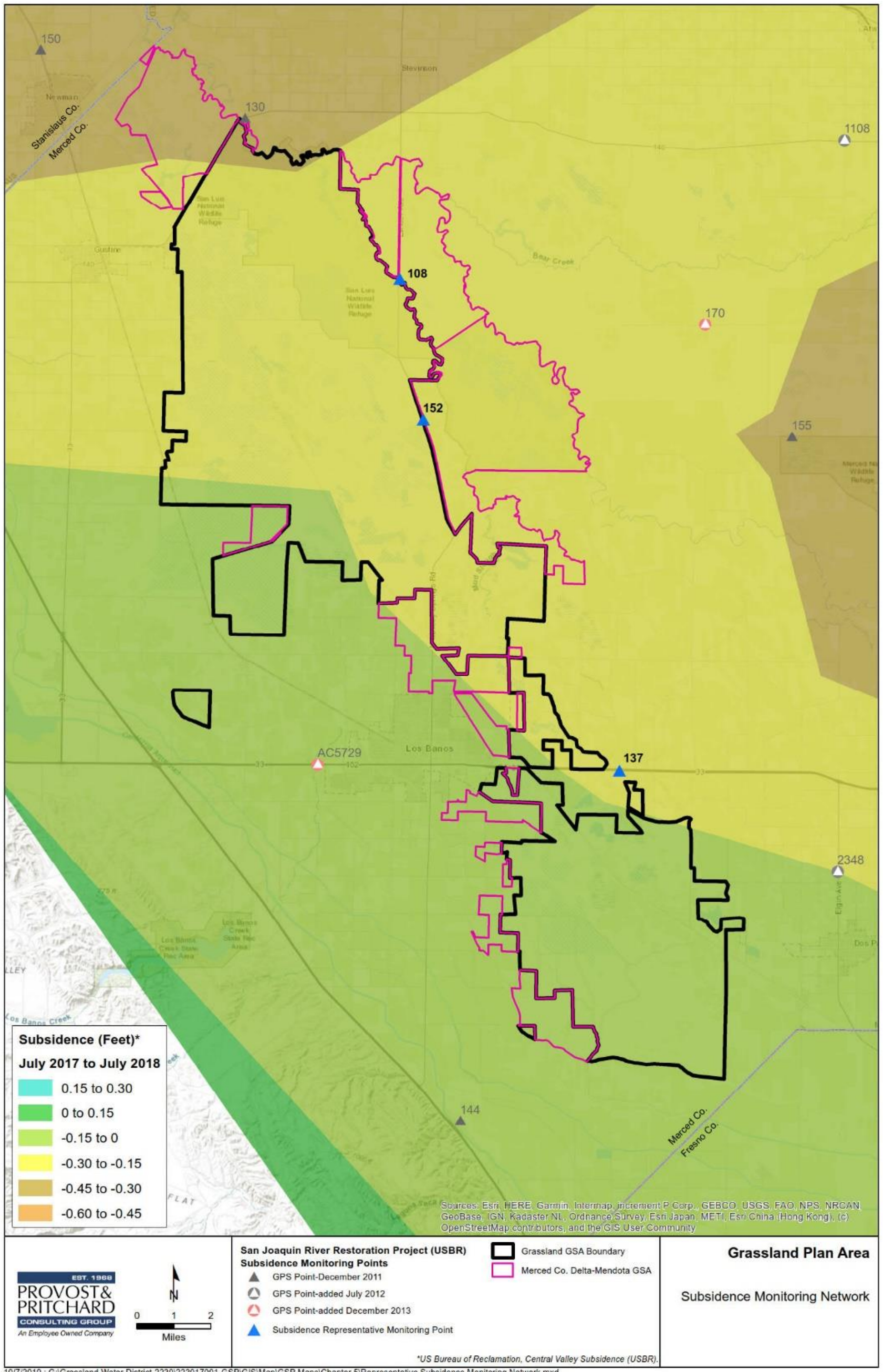


Figure 5-2: Representative Water Level Monitoring Network



10/7/2019 : G:\Grassland Water District-2230\223017001-GSP\GIS\Map\GSP Maps\Chapter 5\Representative Subsidence Monitoring Network.mxd

Figure 5-3: Representative Subsidence Monitoring Network

5.1.3.1 Groundwater Levels

Legal Requirements:

§354.34©(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:

(A) A sufficient density of monitor wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.

(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

The representative water level monitoring network was developed by identifying wells with adequate spatial and temporal coverage to develop meaningful SMCs. The following questions were the focus of the Grassland Plan Area Technical Working Group during the process for developing the representative water level monitoring network.

Temporal:

- Of the wells within the Grassland Plan Area, which have measurements from at least three years within the period of 2000 to present?
- If a public agency monitors the well, is the responsible agency anticipated to continue to monitor this site?
- Is the well accessible for monitoring?
- Is the well perforated in the primary source aquifer to better monitor Grassland Plan Area participants' impacts on the hydrogeology through the implementation period?

Spatial:

- Does the proposed network provide sufficient spatial coverage across the Plan Area?
- Does the proposed network recognize both the upper aquifer and the lower aquifer?

<u>Temporal Coverage</u>
Certain wells that did not meet the temporal criteria were nonetheless included in the representative monitoring network. These wells will be monitored to increase the hydrologic understanding of the Plan Area, refine SMCs, and facilitate groundwater contours.

<u>Spatial Coverage</u>
Hopkins and Anderson (2016) provide recommendations for groundwater-level monitor well densities. The recommended densities range from one well per 150 square miles to one well per 25 square miles based on the quantity of groundwater pumped. A density of one well per 75 square miles is recommended for areas that use between 10,000 and 100,000 AF of groundwater per year and experience little water-level fluctuation or less than a 20-foot decrease in groundwater levels per decade. The Grassland Plan Area meets these criteria and is approximately 163 square miles. The density of water level monitoring sites is one well per 18 square miles for the upper aquifer and one well per 27 square miles for the lower aquifer; therefore, the representative water level monitoring network will exceed the minimum monitoring density suggested above. (See
Figure 5-2).

Monitoring Frequency

The groundwater levels will be monitored in January in order to be consistent with the Delta-Mendota Subbasin's spring measurement period as well as consistent with the seasonal high for the Plan Area. Groundwater levels will undergo their seasonal low measurement between September and October, consistent with the Delta-Mendota Subbasin coordinated effort. Spring measurements are typically designed to capture the recovery of the groundwater basin after demands have been met the previous year (seasonal high). Fall measurements typically capture a period prior to pond flood and after peak irrigation has ceased before any natural recovery has taken place (seasonal low). The two measurements together show the full effects of groundwater use in a given year. Due to the function of the managed wetlands, groundwater levels will be monitored at times that best reflect the seasonal high and low in the Plan Area.

5.1.3.2 Groundwater Storage

Legal Requirements:

§354.34(c)(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.

Upper Aquifer Groundwater Storage Calculations

Table 3-2 and **Section 3.3.3.1** Identify and outline the calculated change in storage of the Plan Area. Upper aquifer groundwater storage change will be estimated by utilizing the Specific Yield and Inflow/Outflow Methods. The Specific Yield Method estimates upper aquifer groundwater storage by multiplying local specific yield values by the overall change in groundwater elevation levels in the upper aquifer as determined using multiple hydrographs and contour maps prepared by the hydrogeological consultant. The Specific Yield Method is used as a check against the Inflow/Outflow Method. Specific yield values were identified in the hydrogeological conceptual model (**Chapter 3.1**).

Refer to **Chapter 3** for figures depicting the well coverage used for contour development. All available and relevant water level data from wells in the Plan Area will be used for the calculations associated with groundwater storage reporting requirements.

The process for calculating storage for the upper aquifer is detailed in **Section 3.3.3.1**.

Lower Aquifer Groundwater Storage Calculations

Due to insufficient historical water level data for wells that perforate below the Corcoran Clay and the complexity of calculating lower aquifer groundwater storage using water levels, subsidence was used as an initial proxy to quantify change in lower aquifer storage. Excessive lower aquifer pumping can induce inelastic compaction, which occurs when the structure of the overlying clay is compromised such that it is unable to expand to its original thickness even when groundwater levels rise to pre-pumping conditions. See **Section 5.1.3.5** for more information regarding the Grassland Plan Area's subsidence monitoring.

The method for calculating groundwater storage for the lower aquifer includes the following steps:

1. Develop subsidence contours or evaluate publicly available subsidence contours.
2. Using GIS, determine the change in land surface elevation.
3. Multiply land surface elevation by acreage to determine volumetric change.

The Plan Area participants recognize that there is insufficient data to identify changes in groundwater storage that do not result in subsidence. New lower aquifer monitoring sites are included in the representative groundwater level monitoring network, and data collected during GSP implementation will be used in the future to help calculate volumetric changes in storage.

5.1.3.3 Seawater Intrusion

Legal Requirements:

§354.34(c)(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.

Given the distance separating the Plan Area from the Pacific Ocean, seawater intrusion from the ocean into the freshwater aquifer is not a concern. In addition, there are no saline water lakes in or near the GSA. As a result, seawater intrusion is not discussed hereafter in this chapter.

5.1.3.4 Water Quality

Legal Requirements:

§354.34(c)(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.

Water quality monitoring is an important aspect of groundwater management in the area and serves the following purposes:

- Spatially characterize water quality according to soil types, soil salinity, geology, surface water quality, and land use
- Compare constituent levels at a specific well over time (i.e., years and decades)
- Assess the extent of groundwater quality problems in specific areas
- Identify groundwater quality protection and enhancement needs
- Assess water treatment needs
- Identify impacts of recharge and surface water use on water quality
- Monitor the migration of contaminant plumes

The questions guiding the Grassland Plan Area Technical Working Group's process for developing the representative water level monitoring network were repeated for the representative water quality network:

Temporal:

- Of the wells within the Grassland Plan Area, which have measurements from at least three years within the period of 2000 to present?
- If a public agency monitors the well, is the responsible agency anticipated to continue to monitor this site?
- Is the well accessible for monitoring?
- Is the well perforated in the primary source aquifer in order to better monitor Grassland Plan Area participants' impacts on the hydrogeology through the implementation period?

Spatial:
- Does the proposed network provide spatial coverage of 1 well per 75 square miles, as recommended in Hopkins and Anderson (2016)?
- Does the proposed network recognize both the upper aquifer and the lower aquifer?

Spatial Coverage
The water quality spatial coverage criteria mimics that of the water level network and exceeds the recommendation under Hopkins and Anderson (2016)*)* for a minimum density of one monitoring site per 75 square miles. **Figure 5-1** depicts the spatial coverage of the network, which is adequate considering that groundwater pumping within the Grassland Plan Area is significantly less than 100,000 AF and covers the spatial extent of approximately 163 square miles. Additionally, the groundwater level network includes coverage of both the upper and lower aquifer, which will improve data quality and quantity after monitoring of the new or previously unmonitored sites during GSP implementation. The water quality monitoring spatial coverage equals one well per 54 square miles in the upper aquifer and one well per 41 square miles in the lower aquifer.

Supplemental Monitoring
GWD, in cooperation with USBR, the Department of Fish and Wildlife (CDFW), and the United States Fish and Wildlife Service, has implemented a Real-Time Water Quality Monitoring Program (RTWQMP). The RTWQMP currently consists of 30 stations located at major points of acceptance, delivery, canal system confluences, and drainages of the Plan Area. The RTWQMP continuously monitors stage, flow, temperature, pH and salinity (EC). Real-time water quality monitoring data is proofed on a weekly basis through a Quality Assurance Program Plan (QAPP). The QAPP includes site visitations where technicians conduct sensor maintenance, calibration, and instantaneous and redundant flow and EC measurements to ensure that the data is representative and comprehensive. Surface water flow monitoring is evaluated at delivery points depicted in **Figure 5-5**.

5.1.3.5 Land Subsidence

Legal Requirements:

§354.34(c)(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.

Although significant subsidence has been measured within the Delta-Mendota Subbasin, it has occurred outside of the Grassland Plan Area and has been associated with pumping from the lower aquifer beneath the Corcoran Clay (see this GSP **Section 3.3.3.1**). The upper aquifer serves as the primary source aquifer for the Grassland Plan Area with an insignificant amount of pumping from below the Corcoran Clay. Therefore, groundwater pumping activities within the Plan Area are not expected to contribute to land subsidence, although there is still a need to monitor subsidence that influences the Grassland Plan Area.

The USBR uses a variety of data described in detail in this section for its regional subsidence monitoring network in and around the Plan Area as well as conducts annual ground-truthing activities. USBR utilizes this information to develop subsidence contours. The USBR's subsidence survey benchmarks in the Plan Area and beyond are shown in **Figure 5-4.** Three of these USBR survey benchmarks that are within and adjacent to the Plan Area were identified for the representative monitoring network.

Supplemental Monitoring

See **Figure 5-4** for a compilation of subsidence monitoring locations that may provide supplemental data for the representative subsidence monitoring network identified in **Figure 5-3**. A more detailed discussion of the available subsidence data sources is outlined below.

Subsidence Monitoring Methods and Technology

Several methods for measuring subsidence are available and are discussed below:

> *Continuous Global Positioning System.* Subsidence can be measured using continuous global positioning system (CGPS) data. Various USGS studies obtain CGPS data from the NAVSTAR UNAVCO Plate Boundary Observatory (PBO) network of continuously operating GPS stations. The PBO is the geodetic component of UNAVCO, a consortium of research institutions whose focus is measuring vertical and horizontal plate boundary deformation across the western United States using high-precision measurement techniques. CGPS data is measured to one hundredth of a millimeter with a relatively low standard deviation.
>
> *Extensometers.* Extensometers measure compaction and expansion of the aquifer system. As the surrounding soils move, the distances between reference points change, which allow for continuous measurement of subsidence. Extensometers are costly to install and require frequent maintenance and calibration. In the 1950s and 1960s, the USGS, DWR, and other agencies installed several borehole extensometers in the San Joaquin Valley. There are presently no known extensometers within the Plan Area. Extensometers have a relative accuracy of approximately 1/100th of a foot.
>
> *InSAR.* During the last decade, the USGS and other groups have been using data from radar-emitting satellites in a technique called InSAR (interferometric synthetic-aperture radar). This form of remote sensing compares radar images from each pass of an InSAR satellite over a study area to determine changes in the elevation of the land surface. InSAR has a relative accuracy within fractions of an inch.
>
> *LiDAR.* DWR and USBR utilize Light Detection and Ranging (LiDAR) coupled with land elevation surveys to monitor subsidence. LiDAR utilizes a laser device that is flown above the earth’s surface. LiDAR is known to be accurate down to less than a tenth of a foot as measured in root-mean-square deviation, an accuracy level very similar to that of surveying.
>
> *Surveying.* In the past, subsidence measurement has relied upon optical (spirit level) surveying devices and laser and global positioning satellite (GPS) survey equipment. This type of measurement is still done today, usually along established highways and water conveyance facilities such as levees and canals. The relative accuracy of GPS surveying is approximately +/- 1 inch.

Subsidence Monitoring Programs

Measurement and monitoring for subsidence are performed by a variety of agencies including USGS, DWR, USBR, USACE, NAVSTAR UNAVCO, and various private contractors.

Continuous Global Positioning System Stations. There are two CGPS Stations near the Plan Area. The CGPS stations provide daily horizontal and vertical data at these locations with records starting as early as 2004. The CGPS stations also show subsidence or uplift at locations near the Plan Area. The PBO and the Scripps Orbit and Permanent Array Center (SOPAC) upload and process the data from the network of CGPS stations and produce graphs depicting the horizontal and vertical change in a point's location through time. The nearest CGPS stations are in Los Banos and Gustine with none within the Plan Area boundary. Information on CGPS stations can be found at the following website: https://www.unavco.org/instrumentation/networks/status/pbo/gps

NASA Monitoring Network. NASA obtains subsidence data by comparing satellite images of Earth's surface over time. For the last few years, InSAR observations from satellites and aircraft have been used to produce the subsidence maps. More information can be found on their website: https://www.nasa.gov/jpl/nasa-california-drought-causing-valley-land-to-sink

San Joaquin River Restoration Program. Currently, USBR in conjunction with DWR, USGS, and USACE obtains subsidence data twice yearly and has published maps of the results in July and December since 2012 as part of the San Joaquin River Restoration Program (SJRRP). The subsidence areas shown in these maps cover the entire Plan Area. The USBR has been monitoring subsidence along the river and bypass levees as part of the restoration effort. More information can be found on their website: http://www.restoresjr.net/monitoring-data/subsidence-monitoring/

USGS Monitoring Network. A subsidence monitoring network consisting of 31 extensometers was installed by the USGS in the 1950s to quantify the subsidence occurring in the San Joaquin Valley. By the 1980s, the land subsidence monitoring efforts had decreased. Since then, a new monitoring network has been developed. The new network includes refurbished extensometers from the old network, CGPS stations, and InSAR. More information can be found on the USGS website: https://ca.water.usgs.gov/land_subsidence/california-subsidence-measuring.html

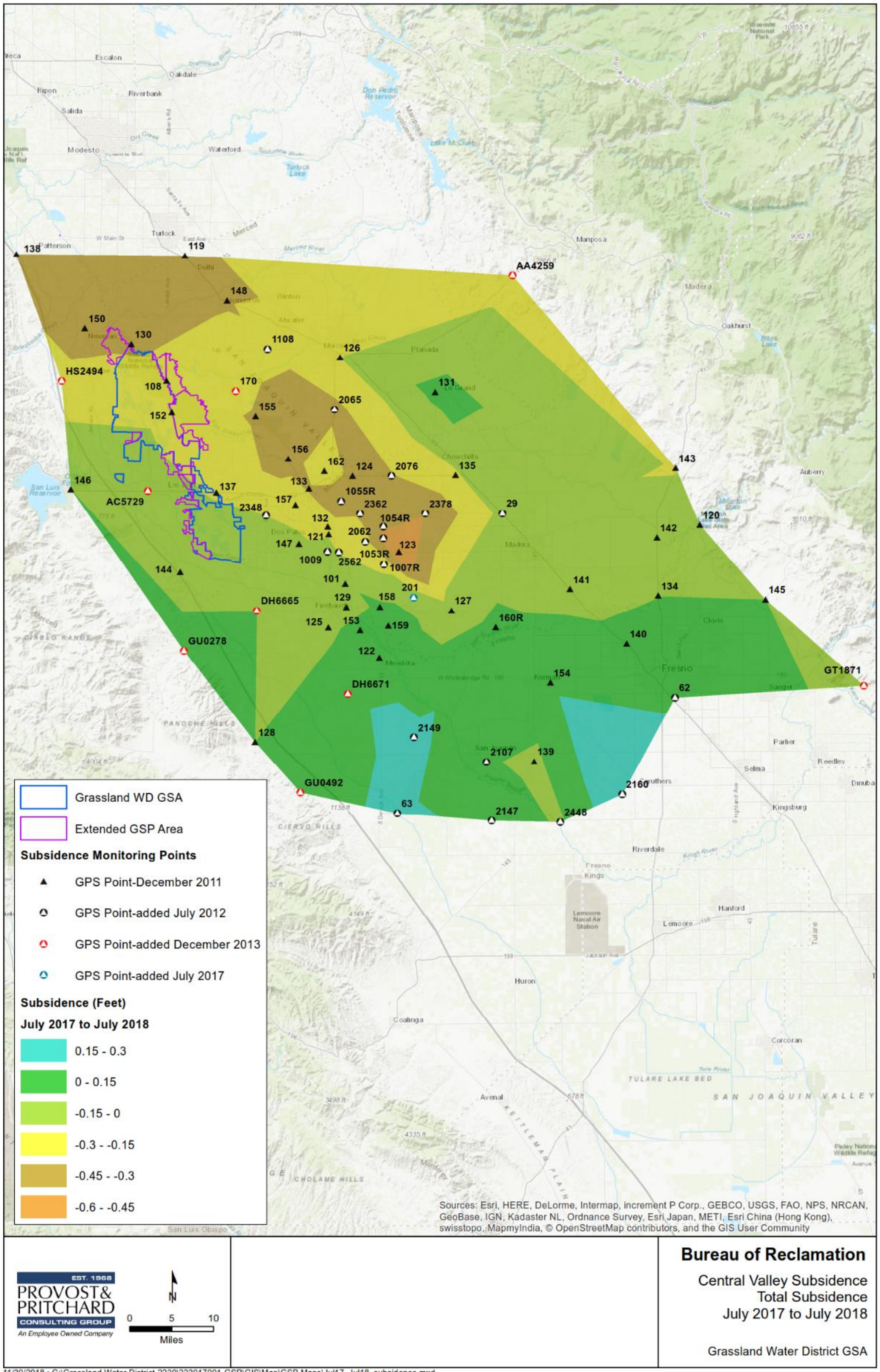


Figure 5-4: Supplemental Subsidence Monitoring Network

5.1.3.6 Depletion of Interconnected Surface Water

Legal Requirements:

> **§354.34(c)(6)** Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
> (A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
> (B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
> (C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
> (D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

The Plan Area is adjacent to the San Joaquin River (SJR) along the northern edge of the San Luis National Wildlife Refuge, also referred to as Reach 5 of the SJR. Water level maps indicate the potential for groundwater to discharge to the San Joaquin River from the upper aquifer.

Water level maps indicate that the SJR has historically experienced a net inflow from the Grassland Plan Area. This can be attributed to historically high groundwater levels and requirements to sustain a large land area in wetland habitat conservation. The analysis of Grassland Plan Area impacts on interconnected surface water will be evaluated by assessing groundwater levels across the Plan Area in the representative water level monitoring network depicted in
Figure 5-2**.** See **Chapter 4.8** and **Appendix A** – Common Chapter Table CC-23 for more information on assessing interconnected surface water SMCs.

The understanding of the flow conditions, period of flow, variations, and other factors in the SJR stretch adjacent to the Grassland Plan Area will further be evaluated using available supplemental data. The water budget analysis required for annual reporting in the Plan Area will be further understood by analyzing depth to water measurements and upper aquifer groundwater contours developed from the representative water level monitoring network, monitoring by other GSP groups in the Delta-Mendota Subbasin, and the Grassland GSP participants' supplemental monitoring efforts.

Supplemental Monitoring

San Joaquin River Restoration Program
The SJRRP has installed a network of shallow monitoring wells to monitor the relationship between groundwater and stream flow in this area. Most Plan Area participants are beneficial users of surface water; however, surface water is also delivered from sources other than the SJR as described in **Chapter 2**. Although surface and groundwater in the Plan Area flow toward the SJR, most surface water in the Plan Area is delivered within the GGSA and to state and federal wildlife areas in the MCDMGSA. Non-CVP water is also routinely delivered to adjacent agricultural and habitat areas. Due to the relatively minimal pumping and the depth and distance of wells from the river, there has been no observation that pumping has impacted surface water intended for other users along the SJR. The SJRRP monitoring network data will be reviewed to assess this assumption.

Surface water flow in the San Joaquin River adjacent to the Plan Area is monitored at the San Joaquin River near Stevenson (SJS) station and at the Freemont Ford Bridge (FFB) station. Surface water flow rates and stage levels are monitored by DWR and USGS respectively. Data is available on the California Data Exchange Center (CDEC) website. The Plan Area members are currently coordinating with the SJRRP and will continue to do so in order to monitor groundwater-surface water interactions and river flow losses in the adjacent reaches of the river to ensure that surface water is unimpaired by groundwater users.

Grassland Water District

All CVP contract water delivered to and by GWD is monitored and measured by USBR or its contractual wheeling agents. GWD's inflow, internal flow and outflow measurements, and recording procedures were established under the direction of GWD's General Manager and are currently being accounted for by GWD's Water Department and Watermaster. All water delivery is based on a water year beginning March 1 and ending on the last day of February of the following year.

GWD, in cooperation with USBR, the CDFW, and the USFWS, has implemented a Real-Time Water Quality Monitoring Program (RTWQMP). Surface water flow is evaluated at the water delivery points depicted in **Figure 5-5**. The QAPP includes site visitations where technicians conduct sensor maintenance, calibration, and measurements of EC and instantaneous and redundant flow to ensure that the data is representative and comprehensive.

MCDMGSA State and Federal Refuges

This vast network of freshwater marshes (permanent, semi-permanent, and seasonal wetlands), upland grasslands, and riparian corridors in the MCDMGSA's state and federal refuges is the result of decades of wetland preservation, restoration, and collaborative conservation agreements between private wetlands, California State Parks, CDFW, the Wildlife Conservation Board, the Natural Resources Conservation Service, and USFWS.

These land managers partner with several wetland-related conservation organizations that provide direct services, including the protection and enhancement of wetland water supply, construction and maintenance of wetland conveyance and facilities, and habitat restoration and improvements.

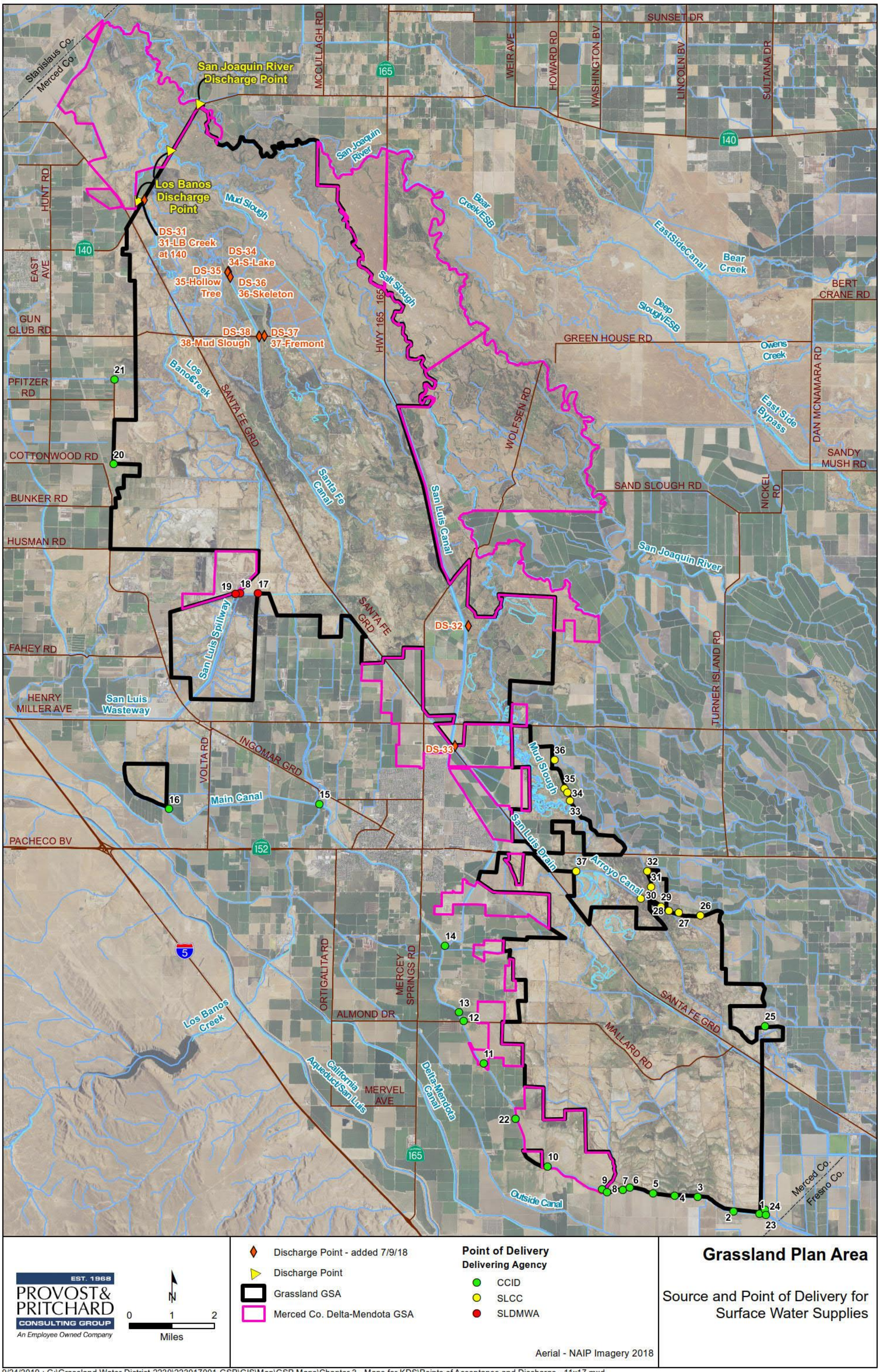


Figure 5-5: Supplemental Surface Water Monitoring Points

5.1.4 Adequacy of Monitoring Network

Legal Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

The subbasin-level monitoring networks are a compilation of the representative monitoring networks developed by each GSP Group. The monitoring networks for each applicable sustainability indicator for each GSP Group were developed in accordance with the GSP Regulations Article 5 Plan Contents, Subarticle 4 Monitoring Networks (§ 354.21 – 354.40). DWR's Best Management Practices for the *Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites BMP* (2016b) and *Monitoring Networks and Identification of Data Gaps BMP* (2016a) documents were used when and where applicable at the discretion of each GSP group in developing monitoring networks and monitoring protocols. For more information on the subbasin-level monitoring networks, see the Delta-Mendota Subbasin **Common Chapter (Appendix A)**.

For additional information regarding the Grassland Plan Area's representative monitoring networks, see **Section 5.1.5**, **Section 5.1.6**, and **Section 5.4.**

5.1.5 Density of Monitoring Sites and Frequency of Measurements

Legal Requirements:

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:
(1) Amount of current and projected groundwater use.
(2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
(4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The density or spatial coverage of monitoring sites is discussed above in **sections 5.1.3.1** and **5.1.3.4**. The density and frequency of monitoring was influenced by the determinations made below:

- The amount of current and projected groundwater use (**Chapter 3.3.4 Current, Historical, and Projected Water Budget**)
- Aquifer characteristics (**Chapter 3.2 Current and Historical Groundwater Conditions**)
- Potential impacts to beneficial users (**4.3.4. Effects on Beneficial Users**)
- Data coverage sufficient to demonstrate an understanding of aquifer response (**Section 5.5.2**)

Each GSP Group will utilize agreed-upon protocols, (i.e., industry standards and best management practices) to ensure the collection of comparable data using comparable methods. Additionally, the following minimum monitoring frequency for each applicable sustainability indicator was agreed upon by the Delta-Mendota Subbasin Coordination Committee and

Technical Working Group (see **Common Chapter Section 6.1.2**) at a meeting on June 18, 2019:

Chronic lowering of groundwater levels/reduction in groundwater storage – Twice per year, with seasonal high groundwater elevation data collected between February and April and seasonal low groundwater elevation data collected between September and October.

Degraded groundwater quality – Once per year between May and July.

Depletions of interconnected surface water – Twice per year in conjunction with groundwater level monitoring

Subsidence – Publicly available subsidence data will be used along with locally-collected data; three data points at minimum will be collected annually during the first five years of GSP implementation. The Grassland GSP participants have selected three USBR sites that historically have reported data annually.

The monitoring periods are summarized in **Table 5-5**: Delta-Mendota Subbasin Monitoring Frequency

It may be that more information will be needed to monitor specific areas in and near the Plan Area. If additional monitoring points or frequencies are necessary, they will be recognized in the 5-year Plan update. See the Delta-Mendota Subbasin **Common Chapter Section 6** for more information and a map of the Delta-Mendota Subbasin representative monitoring networks.

Table 5-5: Delta-Mendota Subbasin Monitoring Frequency

Delta-Mendota Subbasin Coordinated Monitoring Frequency		
Monitoring Parameter	**Frequency**	**Period of Measurement Notes**
Groundwater Levels	Bi-Annually (spring & fall)	Spring: February 1st and April 30th Fall: September 1st to October 31st
Water Quality	Annually	May 1st to July 31st

[1]The Delta-Mendota Subbasin GSP participants agree to coordinate collecting three data points within the first five years of GSP implementation, at a minimum. The Grassland GSP participants identified three USBR monitoring sites that historically report data annually.

5.1.6 Monitoring Network Information

Legal Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

5.1.6.1 Rationale for Site Selection

Legal Requirements:

§354.34(g)(1) Scientific rationale for the monitoring site selection process.

Groundwater Levels and Quality
The scientific rationale for the groundwater level monitoring network includes the following:

- The network meets the minimum density goal of 1 well per 75 square miles
- Aquifer conditions are represented. Wells have been chosen to monitor various types of influences such as agricultural land uses, wetland areas, and boundary conditions
- Wells have known construction information
- Wells have quality long-term historical data

The following scientific rationale will be used to add new wells:

- Avoid wells perforated across multiple aquifers where feasible
- Select dedicated monitoring wells over production wells where feasible
- Select wells with available construction information (i.e., depth, perforated interval)

Land Subsidence
As stated previously, the USBR, DWR, USGS, USBR, USACE, UNAVCO, and various local entities including the SLDMWA and San Joaquin River Exchange Contractor Water Authority maintain land subsidence monitoring programs. The Plan Area participants will continue to follow the results of this established monitoring program and collaborate with the aforementioned agencies.

If additional monitoring locations are added, the following scientific rationale will be used:

- Add sites that are showing obvious signs of subsidence based on regional contour data
- Add sites that can be easily surveyed and tied back to a nearby monument
- Add sites where the ground surface is unlikely to be modified by future construction and will remain undisturbed
- Add sites in areas where the geology and soil types present the greatest potential for subsidence

Depletion of Interconnected Surface Water
The scientific rationale for the representative water level network applies to the analysis for depletion of interconnected surface water. Water level contour maps indicate the SJR has historically experienced a significant net inflow from the Grassland Plan Area, partially due to water supplies imported into the subbasin by the CVP. The historically high groundwater levels and requirements to sustain a large land area in wetland habitat conservation also facilitate the

significant net inflow to the SJR. The SMC analysis of Grassland Plan Area management impacts on interconnected surface water will be evaluated by assessing the groundwater levels across the Plan Area in the representative water level monitoring network depicted in **Figure** 5-2**.** See **Chapter 4.5** for more information on assessing interconnected surface water SMCs. SMCs for interconnected surface water will be further refined as data gaps are filled.

5.1.6.2 Consistency with Data and Reporting Standards

Legal Requirements:

§354.34(g)(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

The data gathered through the monitoring networks is consistent with the standards identified in Section 352.4 of the California Code of Regulations related to Groundwater Sustainability Plans.

- Data reporting units (e.g., Water volumes shall be reported in acre-feet, etc.)
- Monitoring site information (e.g., Site identification number, description of site location, etc.)
- Well attribute reporting (e.g., CASGEM well identification number, casing perforations, etc.)
- Map standards (e.g., Data layers, shapefiles, geodatabases shall be submitted in accordance with the procedures described in Article 4, etc.)
- Hydrograph requirements (e.g., Hydrographs shall use the same datum and scaling to the greatest extent practical, etc.)

5.1.6.3 Corresponding Sustainability Indicator, Minimum Threshold, Measurable Objective, and Interim Goals

Legal Requirements:

§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim goals that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.

The quantitative values for minimum thresholds, measurable objectives, and interim goals that will be measured at the representative monitoring network sites associated with water levels, groundwater storage, and interconnected surface water are described in **Chapter 4, Table 4-2.** Those associated with the subsidence monitoring network are described in **Chapter 4, Table 4-8**, and those associated with the water quality monitoring network are described in **Chapter 4, Table 4-10.**

5.2 Monitoring Locations Map

Legal Requirements:

§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

The location of the representative monitoring network specific sites across the entire Delta-Mendota Subbasin are depicted in the **Common Chapter (Appendix A).** The location of representative monitoring sites for the Plan Area are depicted in **Figures 5-1, 5-2, and 5-3** above, and are described in **Tables 5-2, 5-3, and 5-4**. Measurement frequencies are shown in **Table 5-5**.

5.3 Monitoring Protocols

Legal Requirements:

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Groundwater level, groundwater quality, and land subsidence monitoring will follow the protocols identified in the *Monitoring Protocols, Standards, and Sites BMP* (DWR, 2016b). Existing groundwater monitoring plans will also continue to be followed.

The following comments and exceptions to the BMP should be noted:

- SGMA regulations require that groundwater levels be measured to the nearest 0.1 feet. The BMP suggests measurements to the nearest 0.01 feet; however, this is not feasible for most measurement methodologies. In addition, this level of accuracy would have little value since groundwater contours maps typically have 10-or-more-foot intervals, and storage calculations are based on groundwater levels rounded to the nearest foot. The accuracy of groundwater level measurements will vary based on the well type and condition.
- If used in a well suspected of contamination or if there are obvious signs of contamination, well sounding equipment will be decontaminated after use.
- Wells will be surveyed to a horizontal accuracy of 0.1 feet.
- The BMP states that measurements each spring and fall should be taken “preferably within a 1- to 2-week period.” This is likely not feasible due to the large number of wells in the GSA. The monitoring periods defined in this Chapter identify a period in which the seasonal high and low will be reflected.
- If a vacuum or pressure release is observed, then water level measurements will be re-measured every 5 minutes until they have stabilized.
- In the field, water level measurements will be compared to previous records; if there is a significant difference, then the measurement will be verified.
- When monitoring for water quality, field parameters for pH, electrical conductivity, and temperature will also be monitored. A run time before sampling will be calculated to determine whether a well has been purged adequately to allow monitoring.

5.4 Representative Monitoring

Legal Requirements:

§354.36 Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

See the figures in **Section 5.1.3** for the representative monitoring in the Grassland Plan Area (The Delta-Mendota Subbasin Common Chapter includes more information on the Subbasin-wide monitoring network, which is a compilation of the six Delta-Mendota GSP group's respective representative monitoring networks):

- **Figure 5-1** for the representative water quality monitoring network
-
- **Figure** 5-2 for the representative water level monitoring network
- **Figure 5-3** for the representative subsidence Monitoring network

5.4.1 Description of Representative Sites

Legal Requirements:

§354.36(a) Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim goals are defined.

DWR has referred to representative monitoring as utilizing a subset of wells or monitoring points in a management area. The representative monitoring sites identified are spatially dispersed to represent any variability in groundwater conditions across the Plan Area. See **Chapter 3** for more information on the spatial variety of groundwater conditions. Based on existing conditions, DWR's Monitoring Network BMP's, and Hopkins and Anderson (2016) the Plan Area well network is sufficient to monitor groundwater and will continue to use available water level data to assess groundwater conditions.

For water level, water quality, interconnected surface water, subsidence, and groundwater storage, the representative monitoring sites were identified based on the following criteria:

1. At least three years' worth of data to develop a meaningful minimum threshold or measurable objective
2. Of the available data, at least three of the measurements occurred within the historical period to present
3. There is enough spatial coverage within the Plan Area to represent the variability in groundwater conditions

Despite not meeting all the criteria identified above, additional sites were identified for inclusion in the representative monitoring networks with the intention of monitoring during GSP implementation. The data obtained during the implementation period will be used to develop meaningful SMCs and improve hydrologic understanding.

See **Section 5.1.3** for a description and maps of the representative monitoring networks. See **Chapter 4** for more information on defining minimum thresholds, measurable objectives, and interim goals.

5.4.2 Use of Groundwater Elevations as Proxy for Other Sustainability Indicators

Legal Requirements:

§354.36(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following: (1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy. (2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

The Grassland Plan Area is using groundwater elevation monitoring as a proxy in conjunction with subsidence data to evaluate groundwater storage and interconnected surface water.

Upper Aquifer ~~& Lower Aquifer~~ Groundwater Storage
Water elevations will be used as a proxy for groundwater storage volume in ~~both~~ the upper aquifer ~~and the lower aquifer~~ once sufficient data is collected from designated monitoring sites (until that time, subsidence data will be used to help determine groundwater storage for the lower aquifer). The volume of groundwater storage will be quantified on an annual basis using a larger network of hydrographs (where data exists) and contour maps as described in **Chapter 3.3– Water Budget** and in the Common Chapter (**Appendix A**) using changes in groundwater elevation, specific yield of the aquifer, and acreage of the Plan Area.

Interconnected Surface Water
The Grassland Plan Area has historically maintained shallow depth to water throughout the area. The Plan Area is the lowest-lying area in the Subbasin and all upper aquifer flow contours lead to and through the Plan Area and then on to the SJR. Additionally, the "No Net Loss" wetland legal mandate and other protections for wetlands identified in **Section 4.3** would result in the Grassland Plan Area continuing to sustain shallow groundwater in the wetland areas, producing a significant net positive flow to the SJR. The upper aquifer groundwater gradient in the Plan Area is currently understood as the primary influencer to the SJR connection adjacent to the Plan Area (see **Section 3.3**).

The Grassland GSP participants made the decision to use water level SMCs across the Plan Area and represent a variety of land uses to evaluate gradient influences as an appropriate interim proxy for interconnected surface water, until a volume of rate or flow can be established for the Subbasin. There are few monitoring locations along the SJR and the high groundwater levels and direction of groundwater flow within the entire Plan Area produce a net outflow to the SJR (see **Section 3.2.2.2** and **Figure 3-15**).

5.5 Assessment and Improvement of Monitoring Network

5.5.1 Review and Evaluation of Monitoring Network

Legal Requirements:

§354.38(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.

The monitoring network will continue to be developed and refined as data is gathered and analyzed. The GSAs will review the monitoring network annually to ensure that the monitoring points identified represent the regional conditions within the Plan Area. Any proposed changes will be noted in the annual report and implemented prior to the next measurement period to the extent feasible. It should be noted that the effectiveness of the monitoring network may not be apparent for several reporting periods.

5.5.2 Identification of Data Gaps

Legal Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

There are three general types of data gaps to consider for monitoring networks:

1. **Temporal**: Insufficient frequency of monitoring
2. **Spatial**: Insufficient number or density of monitoring sites in a specific area
3. **Insufficient quality of data**: Data may be available but of poor or questionable accuracy. Poor data could lead to incorrect assumptions or biases. The data may not appear consistent with other data in the area or with past readings at the monitoring site. The monitoring site may not meet all the desired criteria to provide reliable data. Past experiences have shown that well location information on well construction reports is often poor, making it difficult or impossible to match wells with their well logs

Following are discussions on data gaps in each existing monitoring network:

Groundwater Levels and Groundwater Storage
Temporal Data Gaps: Temporal data gaps caused the most inconsistency in monitoring historical trends in the Plan Area. Most groundwater monitoring in the Plan Area began within the past ten years. Another limitation to temporal data was a lack of regular monitoring during the transition from the Water Data Library to the CASGEM program.

Spatial Data Gaps: There is a historical lack of groundwater level monitoring in the lower aquifer, primarily due to the small number of lower aquifer wells in the Plan Area. Additional lower aquifer data will be acquired through the implementation phase. Representative well site spatial coverage meets recommended densities, includes both the upper and lower aquifer, and is representative of various locations within the Plan Area; therefore, it is not seen as a data gap going forward.

Quality of Data: Wells with historical data have no construction information for depth and perforated interval. When well construction information is available, it is often hard to match with specific wells, limiting the usefulness of historical data. These wells do not provide ideal data points, but the Plan Area participants will continue to collect well construction logs and other data, including conducting video surveys.

Groundwater Quality

Temporal Data Gaps: Entities in the Plan Area including the GWD and CDFW have collected a substantial amount of groundwater quality data from the upper aquifer and will continue to do so under ongoing monitoring programs and as part of SGMA implementation.

Spatial Data Gaps: There is a historical lack of groundwater quality monitoring in the lower aquifer, primarily due to the small number of lower aquifer wells in the Plan Area. Additional lower aquifer data will be acquired through the implementation phase. The Groundwater Quality Monitoring Network's spatial coverage meets recommended densities, includes both the upper and lower aquifer, and is representative of various locations within the Plan Area.

Quality of Data: The Plan participants use modern technology and laboratory analysis to collect and report water quality monitoring data, which will continue. This is not considered a data gap.

Land Subsidence

Temporal Data Gaps: The USBR and others have been collecting subsidence data from many monitoring points within the Central Valley for many years; however, the comprehensive data used for the USBR's study is limited to data from 2011 to present. Data prior to 2011 has been deemed unnecessary, as metadata is rare and summaries may not cover the area of interest or may contain large temporal gaps. There is limited historical subsidence data within the Plan Area boundaries to compare with current rates of subsidence at newly installed monitoring points.

Spatial Data Gaps: Although three representative subsidence monitoring points are identified in the Grassland Plan Area, the understanding of subsidence can be improved by assessing at a regional scale. The Plan Area participants will review subsidence data outside of the Plan Area in order to supplement this understanding.

Quality of Data: Although several subsidence monitoring points exist within and adjacent to the Plan Area, there are currently no extensometers or other devices that can physically measure aquifer compaction, because subsidence has not caused undesirable results in the Plan Area. If funding is made available, an extensometer could be installed to better monitor subsidence.

Depletion of Interconnected Surface Water

Temporal, Spatial, and Data Quality Gaps: There is limited historical groundwater level monitoring data available from directly along the SJR within the Grassland Plan Area, which is a temporal, spatial, and data quality gap. However, there are very few groundwater wells located in this part of the Plan Area. The influence of management activities on the interconnection of the SJR in this specific reach is best analyzed by assessing the greater Plan Area and adjacent Merced Subbasin. The representative water level monitoring network will also serve as the monitoring network for interconnected surface water.

5.5.3 Plans to Fill Data Gaps

Legal Requirements:

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following: (1) The location and reason for data gaps in the monitoring network. (2) Local issues and circumstances that limit or prevent monitoring. (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

Historical collections of the data for groundwater levels, groundwater storage, groundwater quality, land subsidence monitoring networks, and depletion of interconnected surface water contain many temporal gaps. Efforts will be made to gain better access to any available historical data sets for incorporation into the data management system to assist in developing a greater understanding of changing groundwater conditions in order to more accurately generate projections of future trends. With the establishment of representative monitoring networks and adoption of monitoring frequencies under this GSP, future temporal data gaps are not anticipated.

To address spatial data gaps in the lower aquifer, multi-completion monitoring wells have been installed throughout the Plan Area, and a number of newly established lower aquifer monitoring sites will be monitored during the implementation period. The lower aquifer data gaps will be filled as data is acquired through the implementation phase associated with the representative monitoring sites.

5.5.4 Monitoring Frequency and Density

Legal Requirements:

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following: (1) Minimum threshold exceedances. (2) Highly variable spatial or temporal conditions. (3) Adverse impacts to beneficial uses and users of groundwater. (4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The frequency and density of the proposed monitoring programs are discussed in previous sections. The programs are considered adequate to provide sufficient monitoring data to satisfy SGMA requirements according to the provided criteria. The monitoring network may be modified or enhanced if deemed necessary when groundwater conditions are compared to sustainability goals.

5.6 Reporting Monitoring Data to the Department

Legal Requirements:

§354.40 Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

GGSA has an internal monitoring and reporting system that will serve as a supplemental data management system (DMS) to the Delta-Mendota Subbasin DMS (DMSDMS). The GGSA DMS and DMSDMS will facilitate annual reporting. GGSA will coordinate with MCDMGSA and other plan participants to coordinate monitoring efforts and gather necessary data as defined in this chapter. Data will be entered into the DMS by staff and consultants as measurements are recorded or received. Data necessary for coordination with the Delta-Mendota Subbasin will be submitted to the SLDMWA for entry in the DMSDMS. Data relative to the GSP development can be made available for review upon request.

6 Projects and Management Actions to Achieve Sustainability

As demonstrated in the Basin Setting Chapter, the Grassland Plan Area is currently sustainable and not experiencing any undesirable results. The following section is provided to demonstrate projects currently being implemented by GGSA to maintain sustainability and also to demonstrate GGSA's work to facilitate regional projects for the good of the Plan Area, agencies within the DM Subbasin, and other Basins.

Legal Requirements:

§ 354.44. Projects and Management Actions
(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.
(b) Each Plan shall include a description of the projects and management actions that include the following:
(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:
(A) A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.
(B) The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.
(2) If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.
(3) A summary of the permitting and regulatory process required for each project and management action.
(4) The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.
(5) An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.
(6) An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.
(7) A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.
(8) A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.
(9) A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.
(c) Projects and management actions shall be supported by best available information and best available science.
(d) An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.

6.1 Project 1 – North Grassland Water Conservation and Water Quality Control Project (NGWCWQCP)

6.1.1 Project Description

The North Grassland Water Conservation and Water Quality Control Project (NGWCWQCP or Project) aims to develop additional surface water to assist GWD in meeting its water demand within the GGSA. High-quality water from the District's water conveyance system and maintenance flows from managed wetlands in the northern portion of the District will be captured prior to leaving GWD during fall and early winter. Recovered water will be recirculated and returned to GWD's conveyance system to meet a portion of fall and winter demand. The amount of surface water available for recirculation through the NGWCWQCP facilities is expected to vary based on Level 2 CVP refuge water supply allocations, with an estimated 11,700 to 16,000 acre-feet per year available in years with 100% allocation (125,000 AF) and an estimated minimum of 5,200 acre-feet per year available in years with reduced Level 2 allocations (75% allocation: 93,750 AF). Based on the historical reliability of Level 2 water supplies, it is estimated that the average annual yield of the project will be approximately 14,000 acre-feet per year.

Implementation of the NGWCWQCP requires improvements to two existing District conveyances and the construction of two pipelines, three pump stations, and various water control structures to capture and recirculate water that would otherwise leave the District. Real-time monitoring stations will also be installed to allow the District to better control the quantity and quality of water entering and leaving the District's wetland complex. Annual project operation is expected to begin during the wetland flood-up in late September and continue through early February of the following year. Other benefits of the Project include improved District operational flexibility, improved aquifer sustainability, reduction in groundwater extractions, and better management of water resources, such as wetlands drawdown discharge into the San Joaquin River.

6.1.2 Measurable Objectives

The main objective of this project is to capture and recirculate an average of 14,000 acre-feet per year of high-quality water from District conveyance systems and maintenance flows from managed wetlands. The amount of recovered water will vary each year between an estimated 5,200 and 16,000 acre-feet based on Level 2 CVP refuge water supply allocations. Captured and recirculated flow rates, volumes, and quality will be measured at multiple Project real-time monitoring stations for monitoring and reporting purposes and to ensure water quality standards are continuously being met. The Project will allow for better water management within the District by improving the ability to manage wetland drawdown and discharges into the San Joaquin River while also improving basin sustainability.

6.1.3 Circumstances for Implementation

The NGWCWQCP is currently under construction by the District and is anticipated to become operational in the fall of 2019. The Project was initiated after drought resulted in reduced surface water supplies for the District in 2014 and 2015. The Project is being implemented to develop additional surface water supplies to assist GWD in meeting its water demands within the GSA while improving basin sustainability. The Project will help ensure that adequate water supplies are available to meet wetland habitat requirements, especially in the spring and summer.

6.1.4 Permitting and Regulatory Process

The Project is currently under construction, and thus all associated construction and environmental permits have been completed. No additional permits are needed for Project operation, but all recovered and recirculated water must meet all existing and any new water quality standards, including TDS, boron, and selenium concentration limits.

6.1.5 Project Schedule

The Project is currently under construction and is expected to be operational by fall of 2019.

6.1.6 Project Benefits

The NGWCWQCP will recover and recirculate up to 16,000 acre-feet per year of high-quality water from District conveyance systems and maintenance flows from managed wetlands. This amount will vary based on Level 2 CVP refuge water supply allocations from an estimated 5,200 acre-feet per year at 75% allocation up to 16,000 acre-feet per year at 100% allocation. Water that would otherwise flow out of the District will be recovered and recirculated under this project and will be used to meet fall and winter water demands within the District. Recirculated water could be used to supplement District water demands in years of insufficient Incremental Level 4 water allocations. There will be a small amount of groundwater recharge from conveyance system seepage losses, which could have a positive effect on groundwater levels and quality since the recovered water will typically be of higher quality than the groundwater. Additionally, the water supply generated from this project will extend the inundation period and provide additional spring irrigations on up to 16,000 acres of seasonal wetland, further improving recharge in GSP area CVPIA wetlands.

6.1.7 Project Implementation

This project will be implemented by GWD as an integral piece of the District's operations and overall effort to improve basin sustainability. It will be implemented, managed, and operated by GWD. Project implementation includes improvements to two existing District conveyances along with the construction of two pipelines, three pump stations, and various water control structures to capture and recirculate water that would otherwise leave the District. The Project also includes continuous monitoring of Project flow rates, volumes, and water quality.

6.1.8 Legal Authority

Grassland Water District will own, operate, and manage all Project facilities.

6.1.9 Project Cost Estimate/Acre-Foot of Yield

The cost of Project implementation is approximately $17.7 million. Assuming an average annual yield of 14,000 acre-feet and an additional $20,000 every 5 years for operations and maintenance, this equates to a cost of $65 per acre-foot of permanent water supply over a 20-year period.

6.1.10 Management of Groundwater Extractions and Recharge

There are no groundwater extractions as part of this Project. Groundwater extractions in the District could be reduced by meeting water demands with recirculated water instead of through groundwater pumping. Indirect groundwater recharge will occur in any unlined conveyance systems being constructed as part of the Project.

6.2 Project 2 – North Valley Regional Recycled Water Program (NVRRWP)

6.2.1 Project Description

The North Valley Regional Recycled Water Program (NVRRWP or Project) will ultimately convey tertiary treated municipal and industrial wastewater, or recycled water, from the Cities of Modesto, Ceres, and Turlock to the DMC using new pump stations and pipelines. The pump station and the 6.5-mile, 54-inch diameter pipeline from the City of Modesto's wastewater treatment plant to the DMC has already been constructed and is in operation. The 7-mile, 42-inch pipeline from the City of Turlock's wastewater treatment plant to the City of Modesto's wastewater treatment plant is currently under construction. Recycled Project water is metered at the DMC inlet facility and is delivered to DPWD and south-of-Delta public wildlife refuge areas within the GGSA and MCDMGSA. In 2018, the City of Modesto delivered approximately 14,700 acre-feet of recycled water through the Project facilities. CVPIA refuges within the GGSA and surrounding public wetlands within MCDMGSA took delivery of approximately 5,500 acre-feet of the available recycled water. The total Project yield, once the Turlock component is constructed, is estimated to be up to 26,000 AFY. Adjusted for urban growth projections, the future Project yield is estimated to be up to 59,000 AFY.

Long-term Water Service Agreements (WSAs) were executed between DPWD and the Cities of Modesto and Turlock in October 2015 and May 2016, respectively, that give DPWD exclusive rights to Project water through 2060 with a renewal option and acknowledgement of DPWD's right to deliver Project water to refuges. In addition, DPWD executed a Water Acquisition and Exchange Agreement with the USBR in 2016 that will last through 2060 with an option to renew. The agreement gives the USBR rights to acquire and deliver 20% of Project water from DPWD to CVPIA refuges. After adjusting for urban growth projections, the 20% of Project water available for refuges is estimated to be 11,800 acre-feet per year. The remaining 80% of DPWD's Project water will be exchanged with the USBR to cover DMC water wheeling costs. Of this 80%, 10% will be available to CVPIA refuges at no cost. Therefore, approximately 28% of Project water will be delivered to wetlands within GGSA and its MCDMGSA public wetlands. In 2018, GWD and DPWD secured a Proposition 1 grant from the California Natural Resources Agency (CNRA) to help cover the long-term costs of acquiring Project water for the refuges. DPWD also has the option of offering more Project water to the CVPIA refuges. In 2018, approximately 5,500 acre-feet was delivered to the refuges. Water costs for the refuges shall not exceed the cost of Project water paid by DPWD landowners, with a maximum cost of $225 per acre-foot plus conveyance costs.

6.2.2 Measurable Objectives

The current yield of the Project is 16,500 acre-feet per year and the amount is expected to increase with construction of the Turlock segment. The total yield of recycled water delivered to

DPWD for its members and the refuges is estimated to be 59,000 acre-feet per year under future urban growth projections. Under current operations, approximately 28% (4,620 acre-feet per year) will be delivered to the refuges through long-term acquisitions agreements and exchanges with DPWD and USBR. In the future, an estimated 11,800 acre-feet per year (after adjusting for urban grown projections) of recycled water will be diverted to refuges within GGSA and its surrounding area. Project water is metered at the DMC inlet facility.

6.2.3 Circumstances for Implementation

California's drought conditions and restrictions on San Joaquin-Bay Delta pumping have resulted in reduced surface water supplies for GWD and DPWD. The Project is being implemented to develop additional surface water supplies to assist both districts in meeting their water demands within their respective Plan Areas and to improve basin sustainability. The Project will help ensure that adequate water supplies are available to meet wetland habitat requirements while providing DPWD with a vital source of surface water for its landowners.

6.2.4 Permitting and Regulatory Process

Since part of the project is already constructed and the remaining portions are under construction, no additional permits or regulatory requirements will be required for construction. Project operations are governed by the already-executed WSAs between DPWD and the Cities of Turlock and Modesto, a Water Acquisition and Exchange Agreement between DPWD and the USBR, and a Grant Agreement between DPWD and the CNRA. Stringent water quality standards will need to be met for all Project water delivered and diverted.

6.2.5 Project Schedule

The pump station at the City of Modesto's wastewater treatment plant, the 54-inch diameter pipeline from the plant to the DMC, and the DMC inlet facility are constructed and operational. The 42-inch diameter pipeline conveyance system from the City of Turlock's wastewater treatment plant to the City of Modesto's wastewater treatment plant is currently under construction with an anticipated completion date of 2019.

6.2.6 Project Benefits

California's drought conditions and restrictions on Sacramento-San Joaquin Delta pumping have resulted in reduced surface water supplies for GWD and DPWD. The NVRRWP will provide a consistent and reliable surface water source to meet irrigation and refuge water demands and promote basin sustainability. The Project is already yielding up to 16,500 acre-feet per year with a minimum of 4,620 acre-feet per year for the refuges. In the long-term, the Project is expected to yield up to 59,000 acre-feet per year with an estimated 11,800 acre-feet per year for the refuges (based on urban growth projections). DPWD has the option to sell or exchange additional water to the USBR for use on the refuges.

In addition, the Project will reduce the region's reliance on other water supplies, both from south of the Delta and from the Delta itself while eliminating the discharge of treated wastewater into the San Joaquin River from the Cities of Modesto, Ceres, and Turlock.

6.2.7 Project Implementation

The Project will be a coordinated effort, implemented by the Cities of Modesto, Turlock, and Ceres; DPWD; Stanislaus County; USBR; and GWD.

6.2.8 Legal Authority

The facilities connecting the City of Modesto wastewater treatment plant to the DMC will be owned, operated, and maintained by the City of Modesto. The conveyance facilities connecting the City of Turlock's wastewater treatment plant to the City of Modesto's wastewater treatment plant will be owned, operated, and maintained by the City of Turlock. Deliveries to refuges will be managed by DPWD and governed by WSAs between DPWD and the Cities of Turlock and Modesto, a Water Acquisition and Exchange Agreement between DPWD and the USBR, and a Grant Agreement between DPWD and CNRA.

6.2.9 Project Cost Estimate/Acre-Foot of Yield

The first phase of the project, consisting of the pump station at the City of Modesto's wastewater treatment plant, the pipeline from the plant to the DMC, and the DMC inlet facilities, had a construction cost of $44 million. The next phase, which consists of conveyance facilities from the City of Turlock's wastewater treatment plants to the City of Modesto's wastewater treatment plants, has an estimated construction cost of $32 million. Environmental review, project design, and other planning costs are estimated at $10 to $12 million for a total estimated project cost of $86 to $88 million. Assuming operations and maintenance are included in existing annual operations for the DMC and treatment facilities, this Project would produce water for $30 per AF over a 50-year project life expectancy.

DPWD has secured several state and federal grants for a portion of the Project costs. Water costs for the refuges will not exceed the cost of Project water paid by DPWD landowners, with the cost capped at $225 per acre-foot plus conveyance costs. Both the USBR and the State of California have committed more than $25 million each for the Project, which should cover the delivery of water to CVPIA wetlands through 2060.

6.2.10 Management of Groundwater Extractions and Recharge

There are no explicit groundwater extractions or recharges as part of the Project. Groundwater extractions in GWD could be reduced by meeting refuge water demands with recycled or exchanged water instead of through groundwater pumping. Surface water exchanged with DPWD could be used by its users in-lieu of groundwater pumping or for recharge purposes, improving basin sustainability.

6.3 Project 3 – Flood Water Capture

6.3.1 Project Description

The GSAs may expand and improve conjunctive use of surface water and groundwater by adopting an integrated "Flood-MAR" resource management strategy that uses flood water from local rivers and streams for managed aquifer recharge (MAR) on agricultural lands, managed wetlands, riparian corridors, and floodplains. The GSAs will continue to utilize excess surface water flows from the San Joaquin River in accordance with procedures established by the Refuge Water Supply Program administered by USBR.

6.3.2 Measurable Objectives

The goal is to more beneficially use local flood water sources to strategically improve aquifer recharge. The measurable objective is the volume of managed aquifer recharge from floodwater applications, in acre-feet, and the measurement of any resulting groundwater extractions.

6.3.3 Circumstances for Implementation

The U.S. Bureau of Reclamation has historically delivered excess surface water flows from the San Joaquin River to the Plan Area for managed wetland use in wet years. Deliveries are measured and accounted for as Incremental Level 4 water to meet the demands of wetland habitat areas in compliance with the CVPIA. Under these circumstances, groundwater pumping is reduced in proportion to excess surface water deliveries.

6.3.4 Permitting and Regulatory Process

The GSAs receive approval from the USBR for diversion and recharge of excess flows from the San Joaquin River, under the Refuge Water Supply Program. If flood recharge projects are developed for the benefit of agricultural landowners within the Plan Area, they will be consulted. USBR in turn will apply for and receive any necessary permits from the State Water Resources Control Board, including but not limited to permit changes under Assembly Bill 658 (2019-2020).

6.3.5 Project Schedule

The project will take place in wet years on an ongoing basis, when water is available. In the meantime, the GSAs will consider adoption of a formal Flood-MAR resource management strategy, in coordination with USBR, before the 5-year GSP update for this Plan.

6.3.6 Project Benefits

When groundwater pumping is reduced in proportion to excess surface water deliveries, the upper aquifer is recharged to maintain sustainability, improve groundwater levels and groundwater quality, and benefit groundwater dependent ecosystems.

6.3.7 Project Implementation

The Project will be a coordinated effort, implemented by the GGSA, MCDMGSA, and USBR, in coordination with CDFW, USFWS, and agricultural landowners within the Plan Area.

6.3.8 Legal Authority

The USBR owns and manages water rights on the San Joaquin River.

6.3.9 Project Cost Estimate/Acre-Foot of Yield

Project implementation would be associated with the cost of water, wheeling, monitoring and analysis to recharge areas and is estimated to be less than $100 per acre foot.

6.3.10 Management of Groundwater Extractions and Recharge

Excess surface water from flood flows and storm events would expand the wetted footprint or maintain the extent for longer duration resulting in a net increase to recharge and diminish or fully augment the need to pump groundwater during those events.

6.4 Management Actions for Future Consideration

The Grassland Plan Area is currently sustainable as managed; however, in order to more efficiently gather data, share resources, and maintain existing sustainability, it may be necessary to implement additional management programs. Listed below are some potential management actions that could be implemented as necessary in the future. This list is not intended to act as a plan for implementation, rather as a plan for consideration and future development. Should it become necessary to implement one of the management actions listed below or consider other management actions for implementation, the GGSA will further define the required criteria as set forth in **Section 354.44** of the GSP regulations.

Table 6-1: Management Actions

#	Management Action	Description	Measurable Objective
1	**Require new developments (non-*de minimis* extractors) to prove sustainable water supplies**	The GSAs may adopt a policy to require new developments (non-*de minimis* extractors) to prove their usage of sustainable water supplies based upon current Sustainable Management Criteria. The GSAs may review and comment on environmental review documents for proposed development projects to ensure a sustainable water balance and the adoption of corresponding mitigation measures. Requires County support.	The goal is to ensure that new developments (non-*de minimis* extractors) do not cause the Plan Area to exceed the current GSP groundwater sustainable yield and groundwater supplies are consumed or retained within the Plan Area boundary. The measurable objective is proven new development water balance with the goal of 0.0 acre-feet groundwater overdraft /year.
2	**Registration of extraction facilities**	The GSAs may adopt a policy to require registration of groundwater extraction facilities within the Plan Area. Requires County support.	The goal is to improve the GSAs' database of groundwater extraction locations in order to support ongoing monitoring and other management actions. The measurable objective is the number of new registered facilities.
3	**Require self-reporting of groundwater extraction, water level, and water quality data**	The GSAs may adopt a policy to require groundwater users in the Plan Area (excluding *de minimis* extractors) to self-report groundwater extractions, static water levels, and water quality data twice per year.	The goal is to improve the GSAs' data collection for groundwater extractions, water levels, and the water quality monitoring network and to improve future water budget and sustainable yield development.

#	Management Action	Description	Measurable Objective
4	**Groundwater quantification methods**	The GSAs may adopt a policy to determine the method or methods to quantify groundwater extractions. The GGSA may consider a variety of methods including, but not limited to 1) aerial flyovers or remote sensing of irrigated areas, 2) annual crop surveys alongside aerial flyovers or remote sensing of irrigation areas including crop coefficients, 3) energy records and meter calibrations, 4) flow meter readings of pumped water, 5) remote sensing of evapotranspiration, and 6) other methods.	The goal is to accurately and efficiently quantify annual groundwater extractions. The measurable objective is the measured volume of groundwater extraction in acre-feet.
5	**Recycled water use**	The GSAs may explore further opportunities to utilize recycled water from nearby communities.	The goal is to maintain existing sustainability by securing affordable and reliable water supplies that are sourced locally or regionally. The measurable objective is the volume of additional recycled water delivered in acre-feet.
6	**Recharge estimation methods**	The GSAs may adopt a policy to better estimate recharge occurring from managed wetland uses within the Plan Area. The GSAs may consider a variety of methods, likely based on field measurements of inflows, outflows, pond levels, and groundwater elevations. The GSAs may conduct soil and percolation studies to better understand site-specific recharge.	The goal is to more accurately estimate recharge occurring from wetlands uses, which will improve both water budget estimates for the area and the representation of the area in groundwater models.
7	**Increasing access to surface water**	The GSAs may adopt a policy to define a method by which surface water can be conveyed to groundwater users within the Plan Area. The GSAs may consider a variety of structures that adhere to the limitations of available water supplies and allowable water uses.	The goal is to provide groundwater users in the Plan Area access to surface water to offset groundwater use. The measurable objective is the volume of surface water delivered to growers without previous access to surface water.
8	**Canal or basin infrastructure incentives**	The GSAs may adopt a policy to encourage groundwater extractors through incentives to develop infrastructure for surface water deliveries.	The goal is to incentivize the construction of new water conveyance and storage infrastructure to increase surface water access to growers in the Plan Area. The measurable objective is the capacity of any constructed conveyance canals or storage basins.

7 Plan Implementation

7.1 Estimate of GSP Implementation Costs

Implementation of the Plan will begin upon adoption. Funding is considered on a 5-year basis to coincide with Plan updates. The first annual report will be due April 2020. Costs for implementation include administrative costs, professional services, and monitoring and reporting. The administrative portion includes public outreach which covers time and materials for staff, consultants, and deliverables for GSA board meetings and other public events, along with insurance and other overhead costs of managing the GGSA and MCDMGSA. Professional services costs include time and materials for staff; consultants for technical, legal, and political issues that may arise during implementation; and basin-wide coordinated efforts outside of the Plan Area. Monitoring and reporting costs include management of the data management system and annual monitoring (sampling, lab analysis, data collection) and reporting (data analysis, mapping, and report development). Costs are preliminary and are not marked up for inflation. These costs also do not include project development, construction or rehabilitation of infrastructure, additional monitoring sites, supplemental Plan Area analyses, additional grant development or administration, changes due to future SGMA legislation, or added compliance requirements. Costing will be refined using actual costs as the Plan is implemented.

Table 7-1: Plan Implementation Costs

	2020-2024	2025-2029	2030-2034	2035-2039	2040
Administration Costs					
Public Outreach	40,000	40,000	40,000	40,000	8,000
Insurance	50,000	50,000	50,000	50,000	10,000
Other Overhead	25,000	25,000	25,000	25,000	5,000
Professional Services					
Agency Management	1,000,000	1,000,000	1,000,000	1,000,000	200,000
Technical Consultants	250,000	250,000	250,000	250,000	0
Legal Services	200,000	200,000	200,000	200,000	40,000
Governmental/Legislative	250,000	250,000	250,000	250,000	50,000
Coordinated Cost	250,000	250,000	250,000	250,000	50,000
Monitoring & Reporting					
DMS	50,000	50,000	50,000	50,000	10,000
Annual Monitoring	100,000	100,000	100,000	100,000	20,000
Annual Reporting	100,000	100,000	100,000	100,000	20,000
Total	2,315,000	2,315,000	2,315,000	2,315,000	413,000
Annual Average	463,000	463,000	463,000	463,000	413,000

Public Outreach - Includes $5,000 per year during years outside of GSP updates for approximately 2 GSA board meetings per year held to direct and approve expenditures for monitoring and annual report development and $20,000 for years in which the GSP is updated for up to 2 workshops, drafting of outreach materials, and printing, posting, and other document delivery costs.

Insurance – Includes $5,000 per year as a portion of previous insurance requirements.

Other Overhead – Includes $5,000 per year for other incidental costs that will likely be shared with overlapping agencies within Grassland GSA and Merced County Delta-Mendota GSA.

Agency Management – Includes salaries and benefits for day-to-day operation of GSAs and Plan implementation such as annual monitoring, Basin-wide coordination, and development of Plan updates. This includes $160,000 per year for the four years prior to GSP updates, which covers 10% of annual workload for four professional employees to perform monitoring and annual report development. This also includes $440,000 for GSP update years to cover 25% of annual workload for four professionals to develop GSP, coordinate with Basin-wide committees, and complete other SGMA related tasks.

Technical Consultants – Includes a one-time cost of $250,000 every 5-years for GSP development and implementation costs.

Legal Services – Includes $100,000 for legal consulting per year.

Government/Legislative Cost – Includes $50,000 per year for internal and consultant costs to participate in future SGMA or related groundwater legislation development.

Coordinated Cost – Includes payment for Basin-wide annual reporting and GSP development by an outside agency. Costs include a $20,000 annual cost for coordinated annual report development and $150,000 for GSP update development.

DMS – Includes $10,000 per year for routine maintenance and updating of data management system and data requests and gathering by Plan Area staff. This cost does not include the Coordinated DMS cost, which has been included in the total annual Coordinated Cost above.

Annual Monitoring – Includes $20,000 per year for annual monitoring of groundwater conditions for representative monitoring network and wells proposed for inclusion in future Plan updates.

Annual Reporting – Includes $20,000 per year for data analysis and materials development for annual reports.

Costs will be split between GGSA and MCDMGSA as appropriate, beginning in 2020 when GSP implementation begins. Some tasks may be performed independently by GSAs while others will require coordination and development of an appropriate cost share agreement. Considerations will be made for agency area, benefitting parties, and location of monitoring points. This estimate includes salaries and benefits for employees of GSAs working on GSP implementation and development as well as expenses for outside consulting and other incidental costs. Costs should be refined in future Plan updates to reflect annual report development and any incurred Plan implementation costs.

7.2 Identify Funding Alternatives

The annual operational costs have already begun, and recently approved rate increases for water deliveries are being used to fund GGSA operations and activities required by SGMA. These activities include retaining consulting firms and other professional services to provide GSP development oversight in order to lead the GGSA through the steps for initial GSP development and future SGMA compliance. Expenses consist of administrative support, agency management, and annual monitoring and reporting, which are assumed to be ongoing expenses. Other expenses include the development of 5-year updates. Possible additional expenses could include the development of management actions, SGMA-specific studies, and grant writing for additional funding.

GWD has adopted Resolution 18-001, which has increased water delivery rates for the first time since 2004 and secured funds to generate sufficient revenue to fund GSP development costs, annual GSA management costs, and expenses associated with the implementation of the GSP. Assessments for refuge water service will increase by $12 per acre (an area-based rate) between 2019 and 2022, and non-CVP agricultural water deliveries will increase by $9 per acre-foot per year (a volume-based rate) between 2019 and 2022. GWD has developed estimated budget projections that include SGMA regulatory compliance costs through Fiscal Year 2028.

Annual operating costs for MCDMGSA will be initially funded through the County of Merced. The MCDMGSA is considering mechanisms for funding the GSA through landowner fees within the MCDMGSA management area. Any funding through fees will be conducted according to the California Water Code, the California Government Code, or any other applicable legal requirements.

Several grants have been made available to both GGSA, its member agencies GWD and GRCD, and MCDMGSA. These include grants from DWR, CDFW, and the Department of Conservation. Additional grant funding will be sought to offset the costs of Plan implementation, monitoring, and updating, including but not limited to:

- Proposition 1 and Proposition 68 Grant Funding
- Federal Grant funding opportunities
- Data Management Grant
- Well videoing/inspection Grant

7.3 Schedule for Implementation

Implementation of the Plan has already begun. Data is being gathered at representative monitoring sites, coordination between Basin members is underway in anticipation of the first annual report, and projects to reduce potential impacts are being developed and constructed. However, it should be noted that the Plan Area is currently sustainable and is not experiencing undesirable results based on existing groundwater conditions and Sustainable Management Criteria. Pumping in the Plan Area is minimal; therefore, only existing projects that are currently under construction are considered in the implementation schedule, which include the North Grassland Water Conservation and Water Quality Control Project and the North Valley Regional Recycled Water Program (see Sections 6.1 and 6.2). Both of these projects have an anticipated completion date of 2019. If the need or funding arises, the GGSA and MCDMGSA may consider implementing additional programs or projects that will assist in strengthening the sustainable management of the Plan Area. Management of the GSA, annual monitoring, and GSP implementation will be ongoing processes. The data management system, annual reporting, and 5-year Plan updates are defined in the following sections.

7.4 Data Management System

GGSA has an internal monitoring and reporting system, which has been described in detail in Chapters 2 and 5. GGSA will coordinate with MCDMGSA and other plan participants to coordinate monitoring efforts and gather necessary data as defined in **Chapter 5 – Monitoring Network**. Data will be entered into the Data Management System (DMS) by staff and consultants as measurements are recorded or received. Data necessary for coordination with the Subbasin will be submitted to the SLDMWA for entry in the Basin-wide DMS. Data relative to the GSP development can be made available for review upon request.

7.5 Annual Reporting

Legal Requirements:

§ 356.2. Annual Reports
Each Agency shall submit an annual report to the Department by April 1 of each year following the adoption of the Plan. The annual report shall include the following components for the preceding water year:
(a) General information, including an executive summary and a location map depicting the basin covered by the report.
(b) A detailed description and graphical representation of the following conditions of the basin managed in the Plan:
(1) Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:
(A) Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.
(B) Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.
(2) Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.
(3) Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.
(4) Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.
(5) Change in groundwater in storage shall include the following:
(A) Change in groundwater in storage maps for each principal aquifer in the basin. (B) A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.
(c) A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.

An annual report will be developed each year that details Plan Area operations (extraction volume, surface water use, total water use, recharged surface water), groundwater conditions (groundwater levels, groundwater storage change), and progress of GSP implementation in accordance with SGMA regulation §356.2. – Annual Reports.

7.6 Periodic Evaluations

Legal Requirements:

§ 356.4. Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.
(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.
(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.
(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.
(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:
(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.
(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.
(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.
(f) A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.
(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.
(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.
(i) A description of completed or proposed Plan amendments.
(j) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.
(k) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733.

The Plan will be evaluated at least every five years and whenever the GSP is amended. The evaluation will consider current groundwater conditions, status of projects or management actions, potential needs to update Sustainable Management Criteria or other Plan elements, changes in the monitoring network, new information or data available, existing or new data gaps or actions and monitoring implemented to close data gaps, applicable enforcement or legal actions implemented, and coordination efforts with other agencies in accordance with SGMA regulation §356.4. – Periodic Evaluation by Agency.

8 References and Technical Studies

California Data Exchange Center. (n.d.). Retrieved September 5, 2019, http://cdec.water.ca.gov/

California Department of Toxic Substances Control. (n.d.). *EnviroStor*. Retrieved September 27, 2019, https://www.envirostor.dtsc.ca.gov/public/

California Department of Water Resources (DWR). (1981). *California Water Well Standards. California's Groundwater Bulletin 74-81.* Department of Water Resources. http://wdl.water.ca.gov/well_standards/b74-81chap1a.html

California Department of Water Resources (DWR). (1991). *California Water Well Standards: Supplement to Bulletin 74-81. California's Groundwater Bulletin 74-90.* Department of Water Resources. http://wdl.water.ca.gov/well_standards/well_standards_content.html

California Department of Water Resources (DWR). (2006). *Bulletin 118.* Department of Water Resources. https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118#

California Department of Water Resources (DWR). (2010, December). *Groundwater Elevation Monitoring Guidelines.* https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/CASGEM/Files/CASGEM-DWR-GW-Guidelines-Final-121510.pdf

California Department of Water Resources (DWR). (2016a, December). *Monitoring Networks and Identification of Data Gaps BMP*. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps.pdf

California Department of Water Resources (DWR). (2016b, December). *Monitoring Protocols, Standards, and Sites BMP*. https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Monitoring_Protocols_Final_2016-12-23.pdf

California Department of Water Resources (DWR). (2017, November). Draft *Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria*. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT.pdf

California Department of Water Resources (DWR). (2018a, April). *Water Available for Replenishment.* Department of Water Resources. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/WAFR/Final/Water-Available-for-Replenishment---Final-Report.pdf

California Department of Water Resources (DWR). (2018b, December). *Agricultural Land & Water Use Estimates.* Retrieved from California Department of Water Resources: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates

California Department of Water Resources (DWR). (2018c). *Guidance for Climate Change Data Use during Groundwater Sustainability Plan Development.* Retrieved from California Department of Water Resources: https://data.cnra.ca.gov/dataset/sgma-climate-change-resources

California Department of Water Resources (DWR). (n.d.). *SGMA Data Viewer for Land Subsidence*. Retrieved September 5, 2019, https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub

California Division of Oil, Gas, and Geothermal Resources. (n.d.). *Well Search for Well Record Electric Logs*. https://secure.conservation.ca.gov/WellSearch

California Open Data Portal. (n.d.). *Estimated Subsidence in the San Joaquin Valley between 1949-2005.* Retrieved September 5, 2019, https://data.ca.gov/dataset/estimated-subsidence-in-the-san-joaquin-valley-between-1949-2005

California Open Data Portal. (n.d.). *NASA JPL InSAR Subsidence Data.* Retrieved September 5, 2019, https://data.ca.gov/dataset/nasa-jpl-insar-subsidence-data

California Regional Water Quality Control Board Central Valley Region (CRWQCBCVR). (2018, May). *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, Fifth Ed*. https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr_201805.pdf

California Water Boards. (n.d.). *GAMA Groundwater Information System*. Retrieved September 27, 2019, https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/

California Water Boards. (n.d.). *Wetland Policies*. Retrieved September 27, 2019, https://www.waterboards.ca.gov/rwqcb5/board_decisions/tentative_orders/1504/2_5_wetlands/5_wet_policies_sum.pdf

California Water Resources Control Board. (n.d.). GeoTracker. Retrieved September 27, 2019, http://geotracker.waterboards.ca.gov/

City of Los Banos 2030 General Plan Update. (2009). Retrieved September 27, 2019, http://losbanos.org/wp-content/uploads/2013/09/plan_gp_entire.pdf

Daly, C., Neilson, R. P., & Phillips, D. L. (1994). A statistical-topographic model for mapping climatological precipitation over mountainous terrain. *Journal of applied meteorology*, *33*(2), 140-158. https://journals.ametsoc.org/doi/abs/10.1175/1520-0450%281994%29033%3C0140%3AASTMFM%3E2.0.CO%3B2

Davis, G. H., Green, J. H., Olmsted, F. H., & Brown, D. W. (1959). *Ground-Water Conditions and Storage Capacity in the San Joaquin Valley California.* USGS. Water Supply Paper 1469. https://pubs.er.usgs.gov/publication/wsp1469

Environmental Defense Fund (EDF). (2017). *Groundwater Trading as a Tool for Implementing California's Sustainable Groundwater Management Act.* https://www.edf.org/sites/default/files/documents/water-markets.pdf

Grasslands Groundwater Sustainability Agency (GGSA). (2016, February 1). *Incremental Level 4 Groundwater Development Project Initial Study and Negative Declaration*.

Hargreaves, G. H. & Allen, R. (2003). *History and Evaluation of Hargreaves Evapotranspiration Equation*. Journal of Irrigation and Drainage Engineering. https://ascelibrary.org/doi/10.1061/%28ASCE%290733-9437%282003%29129%3A1%2853%29

Hargreaves, G. H., & Samani, Z. A. (1982). Estimating potential evapotranspiration. *Journal of Irrigation and Drainage*, *108*(3), 225-230. https://cedb.asce.org/CEDBsearch/record.jsp?dockey=0035047

Hopkins, J., & Anderson, B. (2016, September). *A Field Manual for Groundwater-Level Monitoring at the Texas Water Development Board.* User Manual 52. http://www.twdb.texas.gov/groundwater/docs/UMs/UM-52.pdf

Hotchkiss, W.R., and Balding, G.O. (1971). *Geology, Hydrology, and Water Quality of the Tracy-Dos Palos Area, San Joaquin Valley, California.* USGS. Open-File Report 72-169. https://pubs.er.usgs.gov/publication/ofr72169

Howes, D.J., Fox, P., and Hutton, P.H. (2015). *Evapotranspiration from Natural Vegetation in the Central Valley of California: Monthly Grass Reference-Based Vegetation Coefficients and the Dual Crop Coefficient Approach.* *http://www.itrc.org/papers/etnatural.htm*

Kenneth D. Schmidt & Associates (KDSA). (1997a). *CCID Groundwater Conditions in the Area between Mendota and Crows Landing.*

Kenneth D. Schmidt & Associates (KDSA). (1997b). *Amounts of Downward Flow in the SJREC Service Area.*

Kenneth D. Schmidt & Associates (KDSA). (1997 and 2013). *Subsurface Geologic Cross Sections.*

Kenneth D. Schmidt & Associates (KDSA). (2018). *Hydrogeologic Conceptual Model and Groundwater Conditions for the Grassland Water District Expanded GSP.*

MacGillivray, N. A., & Jones, M. D. (1989). *A Field Study to Assess Consumptive Use of Winter Rains by Spring and Summer Crops.* DWR.

Meade, R.H. (1967). *Petrology of Sediments Underlying Areas of Land Subsidence in Central California*. USGS. Professional Paper 497-C. https://pubs.er.usgs.gov/publication/pp497C

Merced County. (2013). *2030 Merced County General Plan Background Report.* Retrieved September 27, 2019, http://www.co.merced.ca.us/DocumentCenter/View/6768/GP-Background-Report?bidId=

Merced County Department of Public Health. (n.d.). *Well Systems*. Retrieved September 27, 2019, http://www.co.merced.ca.us/2247/Well-Systems

ObamaWhiteHouse. (2015, November 3). *Presidential Memorandum: Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment*. Retrieved

September 27, 2019, https://obamawhitehouse.archives.gov/the-press-office/2015/11/03/mitigating-impacts-natural-resources-development-and-encouraging-related

Orang, M. N., Snyder, R. L., Shu, G., Hart, Q. J., Sarreshteh, S., Falk, M., & Eching, S. (2013). California simulation of evapotranspiration of applied water and agricultural energy use in California. *Journal of Integrative Agriculture*, *12*(8), 1371-1388. https://water.ca.gov/LegacyFiles/landwateruse/models/Cal-SIMETAW.pdf

Page, R. W. (1973). *Base of fresh ground water (approximately 3,000 micromhos) in the San Joaquin Valley, California.* USGS. Hydrologic Atlas 489. https://pubs.er.usgs.gov/publication/ha489

San Joaquin River Restoration Program. (n.d.). *Subsidence Monitoring.* Retrieved September 5, 2019, http://www.restoresjr.net/monitoring-data/subsidence-monitoring/

San Joaquin River Restoration Program. (n.d.). *Water Quality.* Retrieved September 5, 2019,*:* http://www.restoresjr.net/restoration-flows/water-quality/

Thomasson, H., Olmsted, F., & LeRoux, E.F. (1960). *Geology, Water Resources and Usable Ground-Water Storage Capacity of part of Solano County, California.* USGS. Water Supply Paper 1464. https://pubs.er.usgs.gov/publication/wsp1464

University NAVSTAR Consortium (UNAVCO). (n.d.). *PBO GPS Stations Network Monitoring*. Retrieved September 27, 2019, https://www.unavco.org/instrumentation/networks/status/pbo/gps

United States Bureau of Reclamation (USBR). (2018, July). *Agrimet Irrigation Guide.* Retrieved from United States Bureau of Reclamation: https://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency

United States Geological Survery (USGS). (2017, March 20). *USGS Land Subsidence Resources*. Retrieved from California Water Science Center: https://ca.water.usgs.gov/land_subsidence/california-subsidence-resources.php

United States Geological Survey (USGS). (n.d.). *Land Subsidence in California.* Retrieved September 5, 2019, https://ca.water.usgs.gov/land_subsidence/

United States Environmental Protection Agency (EPA). (2006). *Guidance on Systematic Planning Using the Data Quality Objectives Process*. https://www.epa.gov/sites/production/files/documents/guidance_systematic_planning_dqo_process.pdf

Williamson, A.K., Prudic, D.E., & Swain, L.A. (1989). *Ground-Water Flow in the Central Valley, California.* USGS. Professional Paper 1401-D. https://pubs.er.usgs.gov/publication/pp1401D

Appendix A – Common Chapter

Appendix B – Kenneth D Schmidt & Associates - HCM and GW Conditions Report

Appendix C – Water Conservation Plan Annual Report

Appendix D – Projected Water Budget

Appendix E – Memorandum of Agreement

Appendix F – Communication and Engagement Plan

Appendix G – Track Changes of Revisions to Grassland GSP and Common Chapter

Delta-Mendota
Groundwater Subbasin

Groundwater Sustainability Plan:
Revised Common Chapter

Prepared by:

August 2019; Revised June 2022

Difficulty Accessing Material

If you have difficulty accessing any material in this document, please contact us in writing or via telephone and we will work with you to make the information available. You can direct your request to:

ATTN: ~~Andrew Garcia~~John Brodie
San Luis and Delta-Mendota Water Authority
842 6th Street
Los Banos, CA 93635
Telephone (209) 826-1872~~(209) 832-6229~~
Email: ~~andrew.garcia~~john.brodie@sldmwa.org

Table of Contents

Tables

Figures

Appendices

Appendix A – Coordination Agreement
Appendix B – Common Technical Memoranda
Appendix C – – Preparation Checklist for GSP Submittal
Appendix D – Interbasin Agreements
Appendix E – Delta-Mendota Subbasin Communications Plan
Appendix F – Summaries of Coordinated Public Workshops
Appendix G – Examples of Promotional Materials from Public Workshops
Appendix H – List of Stakeholders and Community Organizations Contacted

Acronyms

AB 3030	1992 California Assembly Bill 3030
AWMP	Agriculturale Water Management Plan
BMP	Best Management Practice
CASGEM	California Statewide Groundwater Elevation Monitoring
CCC	Columbia Canal Company
CCF	Climate Change Factors
CCID	Central California Irrigation District
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CVO	Central Valley Operations
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DAC	Disadvantaged Community
DMC	Delta-Mendota Canal
DPWD	Del Puerto Water District
DWR	California Department of Water Resources
ET	Evapotranspiration
ET_c	Total Crop Evapotranspiration
ET_{iw}	Crop Evapotranspiration of Irrigation Water
ET_{misc}	Miscellaneous Evapotranspiration including; canal evaporation, consumptive use of phreatophytes, etc.
FCWD	Firebaugh Canal Water District
FNF	Full Natural Flow
GAMA	Groundwater Ambient Monitoring and Assessment
gpm	gallons per minute
GRCD	Grassland Resource Conservation District
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan

Acronyms

GWD	Grassland Water District
HCM	Hydrogeologic Conceptual Model
HMRD	Henry Miller Reclamation District
IM	interim milestone
IRWM	Integrated Regional Water Management
JPA	Joint Powers Authority
KDSA	Kenneth D. Schmidt and Associates
MAF	million acre-feet
MO	measurable objective
MSL	Mean Sea Level
MT	minimum threshold
NASA JPL	National Aeronautics and Space Administration Jet Propulsions Laboratory
P&P	Provost and Pritchard Consulting Group
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SB 372	2017 California Senate Bill 372
SGMA	Sustainable Groundwater Management Act
SGWP	Sustainable Groundwater Planning
SJREC	San Joaquin River Exchange Contractors
SJRECWA	San Joaquin River Exchange Contractors Water Authority
SJRIP	San Joaquin River Improvement Program
SJRRP	San Joaquin River Restoration Program
SLDMWA	San Luis & Delta-Mendota Water Authority
SMC	Sustainable Management Criteria
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TDS	Total Dissolved Solids
TIWD	Turner Island Water District

Acronyms

TNC	The Nature Conservancy
UNAVCO	University NAVSTAR Consortium
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USF&WS	U.S. Fish & Wildlife Service
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WDL	Water Data Library
WMP	Water Management Plan
WSIP	Water Storage Investment Program
WWD	Westlands Water District
WY	Water Year

DISCLAIMER

The work products presented in this Common Chapter and associated Technical Memoranda (Appendix B) are a compilation of work completed by the six (6) individual Groundwater Sustainability Plan (GSP) regions under the direction of a Professional Geologist (PG) or Professional Engineer (PE) as indicated by the stamps on the respective GSP Executive Summaries. The signature here represents work completed in compiling the Common Chapter from these individual GSPs, and the signing Professional Engineer assumes no responsibility for any errors or misleading statements presented therein. Compilation of the Common Chapter, exclusive of work conducted for the individual GSPs, and revisions to this Common Chapter haves been prepared under the oversight of Leslie Dumas, P.E. and the signature below is specifically for that compilation.

Responsible Engineer Seal (If required)

1. INTRODUCTION

1.1 Purpose of Common Chapter

The 23 Groundwater Sustainability Agencies (GSAs) overlying the Delta-Mendota Subbasin (Subbasin) have prepared six Groundwater Sustainability Plans (GSPs) that, together, encompass the entire Subbasin area (**Figure CC-1Figure CC-1**). -These GSPs have been prepared in a coordinated manner under the oversight of the Delta-Mendota Subbasin Coordination Committee (Coordination Committee) and in accordance with the Delta-Mendota Subbasin Coordination Agreement (Coordination Agreement) for the Subbasin. -This Common Chapter has been prepared as means of integrating key parts of the six GSPs to meet subbasin-level requirements per the Sustainable Groundwater Management Act (SGMA) and the Emergency GSP regulations (DWR, 2016).

On January 21, 2022, the Subbasin received a Consultation Initiation Letter (CIL) from the California Department of Water Resources (DWR). The CIL identified four potential deficiencies across the six Subbasin GSPs which may preclude DWR's approval, as well as potential corrective actions to address each potential deficiency. The CIL thus initiated consultation between DWR, the Subbasin Point of Contact, Plan Managers, and the Subbasin's GSAs. This Common Chapter has been revised to incorporate changes required to reflect the Subbasin's response to the deficiencies identified in the CIL, based on direction provided by the Coordination Committee, the Delta-Mendota Technical Working Group (Technical Working Group), the Subbasin GSAs and DWR. This revised Common Chapter, along with the attached cover letter, are intended to document how the deficiencies identified in the CIL were addressed in the revised Subbasin GSPs and this revised Common Chapter.

This revised Common Chapter, along with the six Subbasin GSPs, Coordination Agreement (**Appendix A**) and Common Technical Memoranda (**Appendix B**), meets regulatory requirements established by the California Department of Water Resources (DWR) as shown in the completed *Preparation Checklist for GSP Submittal* (**Appendix C**). The Common Technical Memoranda summarize the common data sets, assumptions and methodologies used during preparation of the six Subbasin GSPs.- The reader is referred to the individual GSP (and their associated Executive Summaries) for information, data, and GSP requirements specific to each GSP Plan Area.

1.2 Delta-Mendota Subbasin

The Delta-Mendota Subbasin (DWR Basin 5-022.07) is located in the San Joaquin Valley Groundwater Basin and adjoins nine (9) subbasins of the San Joaquin Valley Groundwater Basin. The Delta-Mendota Subbasin boundaries generally corresponds to DWR's California's Groundwater Bulletin 118 – Update 2003 (Bulletin 118) groundwater basin boundaries. Changes made to the Subbasin boundaries as part of the SGMA planning process include the following:

- A jurisdictional internal boundary modification made in 2016 to extend the boundary of the Delta-Mendota Subbasin eastward to include all of Aliso Water District.
- A jurisdictional internal boundary modification made in 2016 to bring areas that straddle the Delta-Mendota Subbasin and adjacent subbasins fully within the Delta-Mendota Subbasin. This

modification adjusted areas from the southern boundary of the Delta-Mendota Subbasin and the Westside Subbasin in coordination with Westlands Water District, and moved the eastern boundary of the Delta-Mendota Subbasin from the Madera Subbasin into the Delta-Mendota Subbasin in coordination with Aliso Water District. The modification also moved areas from the Tracy Subbasin into the Delta-Mendota Subbasin so that Del Puerto Water District and West Stanislaus Irrigation District were fully within the Delta-Mendota Subbasin, and cleaned up boundaries between the Delta-Mendota Subbasin and the Kings Subbasin to conform with the boundaries of Tranquillity Irrigation District and the Traction Ranch property (bounded on the east by Mid-Valley Water District).

- A jurisdictional internal boundary modification made in 2018 to modify the boundary between the Delta-Mendota and the Chowchilla Subbasins to follow the western boundary of Triangle T Water District and the southern boundary of Clayton Water District. This modification moved approximately 700 acres of land from the Chowchilla Subbasin into the Delta-Mendota Subbasin.

The western San Joaquin Valley is a highly agricultural region with an economy dependent on that industry. There are no large cities or industries in the Delta-Mendota Subbasin to provide an alternative economic base; hence the availability of Central Valley Project (CVP) imported supplies and surface water supplies (primarily from the San Joaquin and Kings River) are essential elements to the economic health of the region. Other uses of CVP and surface water in the Subbasin are for municipal and industrial (M&I) purposes and wildlife refuge water supply.

Groundwater is a key component of overall water supplies in the Delta-Mendota Subbasin. Agricultural and wildlife refuge needs may be supplemented by groundwater for areas with access to CVP water. Other landowners within the Subbasin may rely wholly on groundwater for irrigation and/or potable purposes. Municipal and industrial (M&I) water use, which is a small share of total water use in the Subbasin, occurs primarily within the cities, and predominantly uses groundwater to meet those demands. The largest M&I use areas in the Delta-Mendota Subbasin, based on 2015 population estimates from the U.S. Census Bureau, are the cities of Patterson (population 21,498) and Los Banos (population 37,457) (U.S. Census Bureau, 2015).

As previously noted, most communities within the Delta-Mendota Subbasin have economies greatly dependent on agricultural production. These communities include Patterson, Grayson, Tranquillity, Mendota, Firebaugh, Dos Palos, Los Banos, Santa Nella, Newman, Gustine, Crows Landing, Westley, Volta, and Vernalis.

1.3 Disadvantaged Communities within the Delta-Mendota Subbasin

A disadvantaged community (DAC) is defined as a community with a Median Household Income (MHI) less than 80% of the California statewide MHI. The California Department of Water Resources (DWR) compiled U.S. Census Bureau's American Community Survey (ACS) data from 2012 to 2016; these data were used in GIS to identify DACs within the Delta-Mendota Subbasin. California's average statewide MHI from 2012 to 2016 is $63,783; thus, a community with an MHI less than or equal to $51,026 is considered a DAC. Based on these criteria, 93% of the geographic area of the Subbasin is considered disadvantaged. Furthermore, a community with an MHI of less than 60% of the California statewide

MHI, meaning an MHI of less than or equal to $38,270, is considered a severely disadvantaged community (SDAC). According to the U.S. Census ACS 2012-2016 data, there are a number of SDACs throughout the Subbasin.- See Figure CC-2Figure CC-2 for a map of the DACs and SDACs throughout the Delta-Mendota Subbasin.

As noted above, a significant portion of the Subbasin contains DACs. Of the total population of 117,120 within the Subbasin, 80% of the population lives within a DAC, with 93% of the Subbasin's total geographic area consisting of DACs. Table CC-1Table CC-1 includes the proportion of DACs in the Subbasin based on population and geographic area.

Table CC-1: DACs as a Percentage of the Delta-Mendota Subbasin

Area	Geographic Area (Square Miles)	% Based on Geographic Area	Population	% Based on Population
DAC (including SDAC)	1,109	93%	93,786	80%
Delta-Mendota Subbasin	1,194		117,120	

Table CC-2Table CC-2 includes Census Designated Places that are DACs in the Delta-Mendota Subbasin, with their associated MHIs and percentage of the California MHI from the ACS 5-Year 2012-2016 average. Several DACs in the Subbasin have considerably lower MHI than 80% of the California Statewide MHI and are further designated as Severely Disadvantaged Communities (SDACs). In Table CC-2Table CC-2, SDACs are indicated in bold text. Note that according to the U.S. Department of the Interior Indian Affairs, as of January 2017, there are no listed federally recognized tribes within the Region (Mosley, 2017).

Table CC-2: DAC and SDAC Census Designated Places in Delta-Mendota Subbasin

Census Designated Place (CDP)	Median Household Income (MHI)	% of CA MHI
City of Dos Palos	**$36,509**	**57%**
City of Firebaugh	**$36,181**	**57%**
City of Gustine	**$37,770**	**59%**
City of Los Banos	$45,751	72%
City of Mendota	**$26,094**	**41%**
City of Newman	$52,783	83%
Crows Landing	**$26,786**	**42%**
Dos Palos Y (CDP)	**$16,656**	**26%**
Grayson	**$29,787**	**47%**
Madera County	$45,490	74%
Merced County	$43,066	70%
Fresno County	$45,963	72%
Santa Nella	**$27,778**	**44%**

Census Designated Place (CDP)	Median Household Income (MHI)	% of CA MHI
South Dos Palos	$41,992	66%
Tranquillity	**$30,441**	**48%**
Volta	$48,250	76%
Westley	**$23,375**	**37%**

Data Sources:
1. U.S. Census ACS data from 2012 to 2016 provided by DWR Mapping Tool.
2. MHI data are from the 2016 Census, and percent of CA MHI is calculated based on the 2012-2016 Statewide MHI. Bold rows indicate severely disadvantaged communities (less than 60% of CA Statewide MHI).

1.4 Economically Disadvantaged Areas within the Delta-Mendota Subbasin

An economically distressed area (EDA) is defined by the State of California as a "municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 10,000 persons or less, with an annual median household income that is less than 85% of the statewide median household income, and with one or more of the following conditions as determined by the (sic) Department of Water Resources:

1. Financial hardship
2. Unemployment rate at least two percent higher than the statewide average
3. Low population density (CA Assembly, 2014)."

U.S. Census GIS data provided by DWR were used to identify EDAs in the Delta-Mendota Subbasin. Figure CC-3~~Figure CC-3~~ shows the location of EDAs within the Delta-Mendota Subbasin

A significant portion of the Subbasin contains EDAs. Of the total population of 117,120 within the Subbasin, 87% live in areas that meet EDA Criterion 2, 20% live in areas that meet EDA Criterion 3, and 87% live in areas that meet Criteria 2 or 3. In all, 93% of the geographic area within the Subbasin consists of areas considered to meet either EDA Criteria 2 or 3. Table CC-3~~Table CC-3~~ includes the proportion of EDAs in Subbasin based on population and geographic area.

Table CC-3: EDAs as a Percentage of the Delta-Mendota Subbasin

Area	Geographic Area (Square Miles)	% Based on Geographic Area	Population	% Based on Population
EDA Criterion 2	1,112	93%	102,407	87%
EDA Criterion 3	1,004	84%	23,688	20%
EDA Criteria 2 or 3	1,112	93%	102,407	87%
Delta-Mendota Subbasin	1,194		117,120	

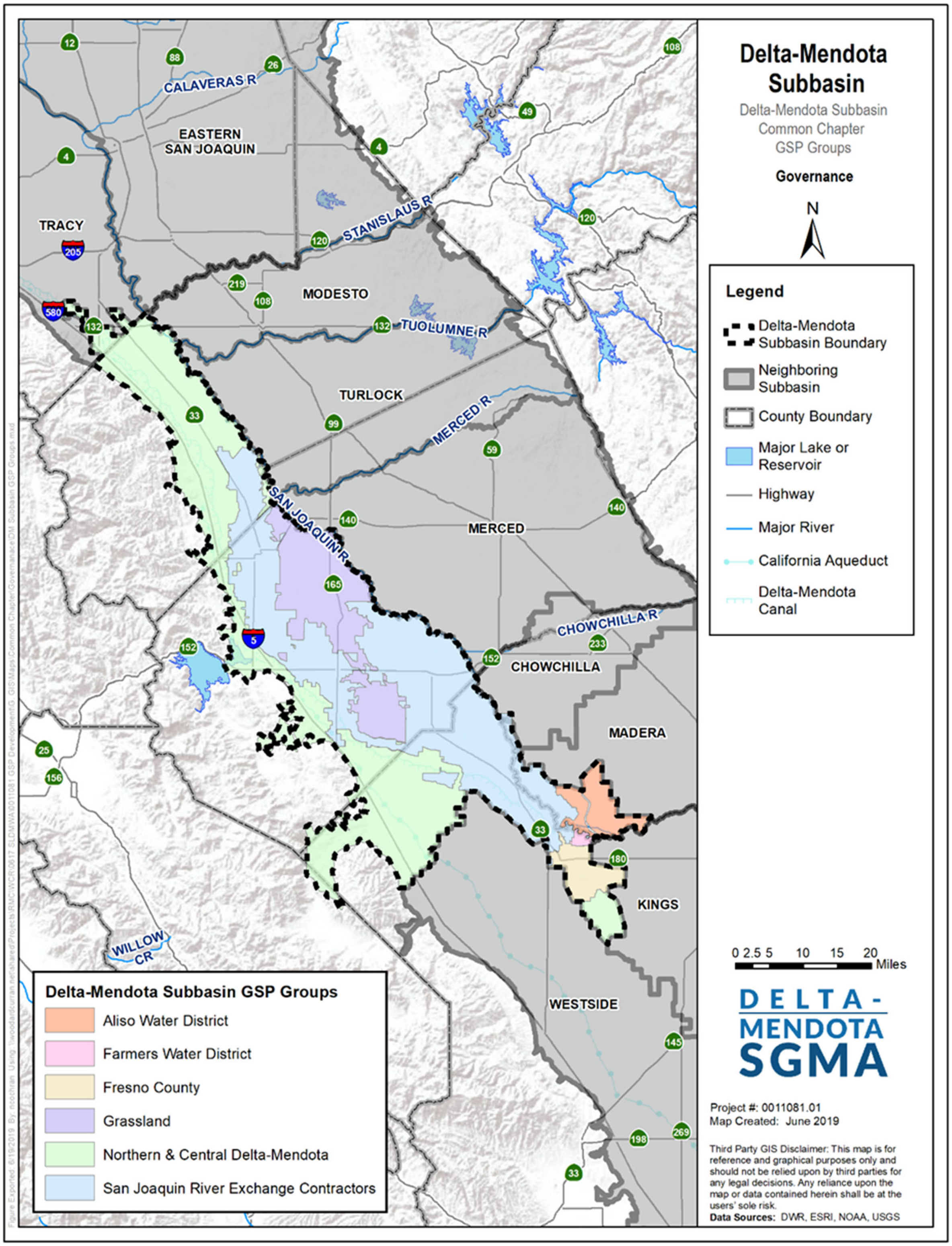

Delta-Mendota Subbasin
Delta-Mendota Subbasin
Common Chapter
GSP Groups
Governance
N
Legend
Delta-Mendota Subbasin Boundary
Neighboring Subbasin
County Boundary
Major Lake or Reservoir
Highway
Major River
California Aqueduct
Delta-Mendota Canal
Delta-Mendota Subbasin GSP Groups
Aliso Water District
Farmers Water District
Fresno County
Grassland
Northern & Central Delta-Mendota
San Joaquin River Exchange Contractors
CALAVERAS R
EASTERN SAN JOAQUIN
TRACY
STANISLAUS R
MODESTO
TUOLUMNE R
TURLOCK
MERCED R
SAN JOAQUIN R
MERCED
CHOWCHILLA R
CHOWCHILLA
MADERA
KINGS
WESTSIDE
WILLOW CR
0 2.5 5 10 15 20 Miles
DELTA-MENDOTA SGMA
Project #: 0011081.01
Map Created: June 2019
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk.
Data Sources: DWR, ESRI, NOAA, USGS

Figure CC-1: Delta-Mendota Subbasin and GSP Regions

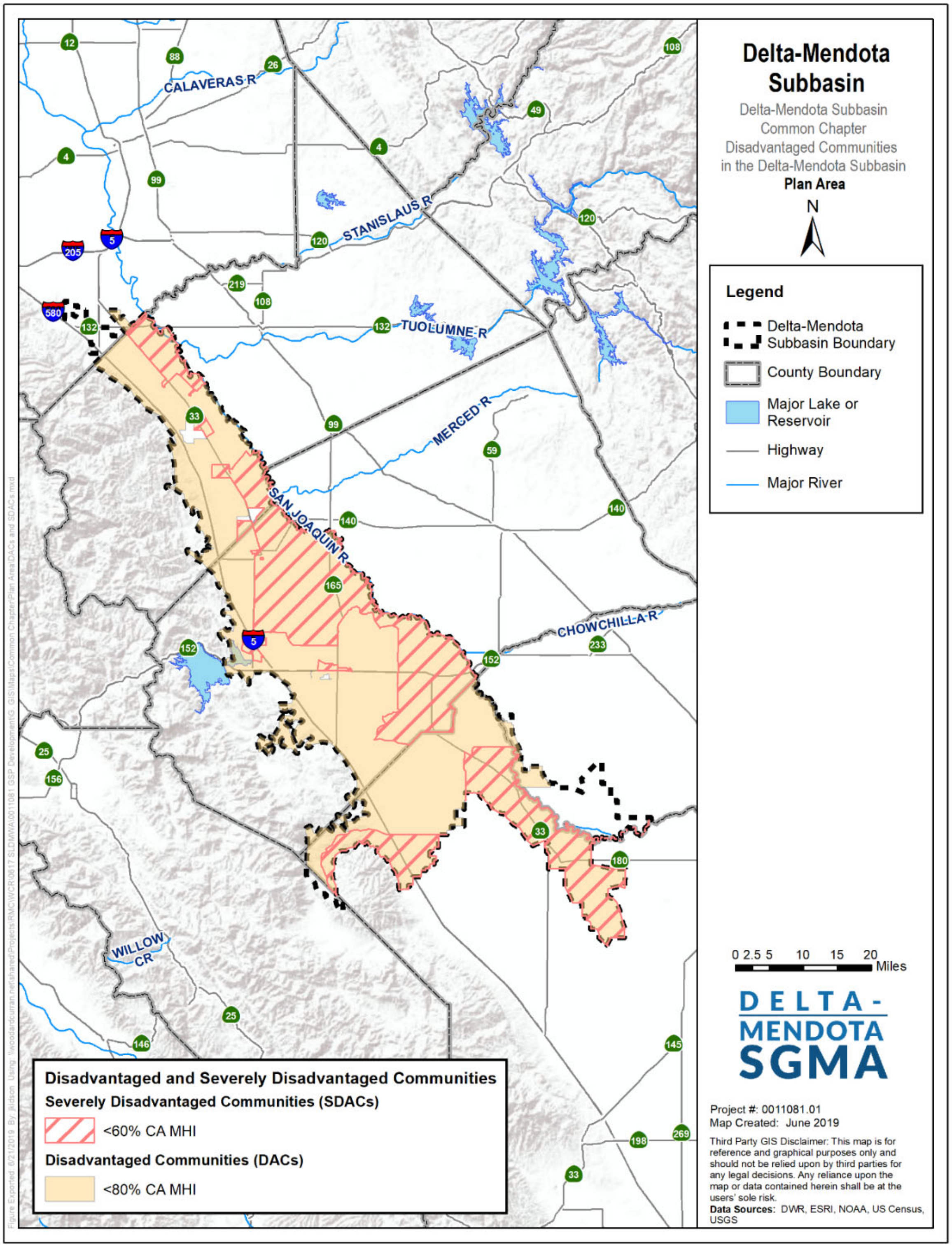

Delta-Mendota Subbasin
Delta-Mendota Subbasin
Common Chapter
Disadvantaged Communities
in the Delta-Mendota Subbasin
Plan Area
N
Legend
Delta-Mendota Subbasin Boundary
County Boundary
Major Lake or Reservoir
Highway
Major River
CALAVERAS R
STANISLAUS R
TUOLUMNE R
MERCED R
SAN JOAQUIN R
CHOWCHILLA R
WILLOW CR
0 2.5 5 10 15 20 Miles
DELTA-MENDOTA SGMA
Project #: 0011081.01
Map Created: June 2019
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk.
Data Sources: DWR, ESRI, NOAA, US Census, USGS
Disadvantaged and Severely Disadvantaged Communities
Severely Disadvantaged Communities (SDACs)
<60% CA MHI
Disadvantaged Communities (DACs)
<80% CA MHI

Figure CC-2: Disadvantaged and Severely Disadvantaged Communities in the Delta-Mendota Subbasin

DELTA-MENDOTA SGMA

WOODARD &CURRAN

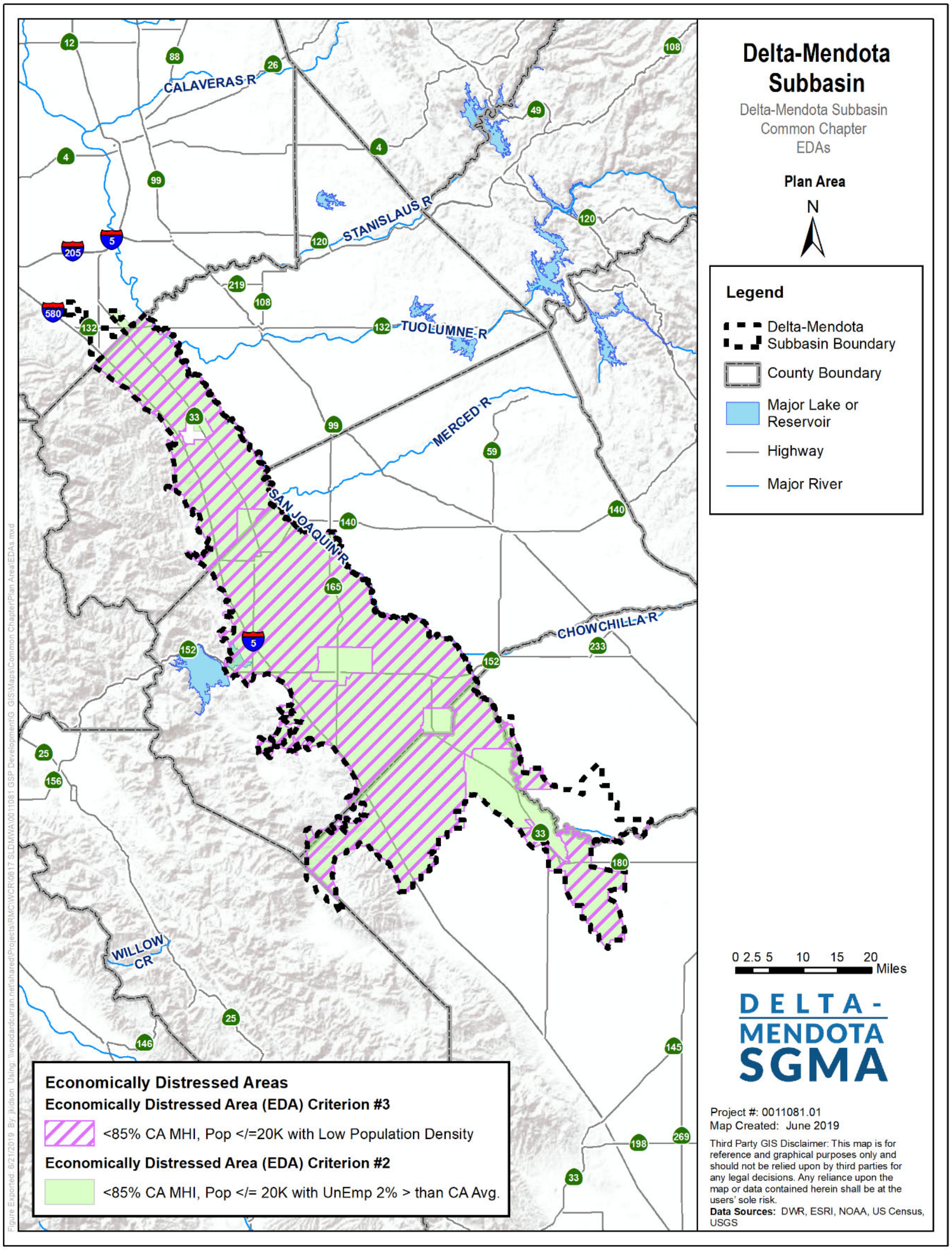


Figure CC-3: Economically Distressed Areas in the Delta-Mendota Subbasin

2. DELTA-MENDOTA SUBBASIN GOVERNANCE

This section includes information pursuant to Article 5. Plan Contents, Subarticle 1. Administrative Information, § 354.6 (Agency Information) as well as Subarticle 8. Interagency Agreements (§ 357.2 Interbasin Agreements and § 357.4 Coordination Agreements), as required by the Groundwater Sustainability Plan (GSP) Regulations. Agency Contact information for the Delta-Mendota Subbasin and the plan manager is included in this section. The organization and management structure, as well as the legal authority of each Groundwater Sustainability Agency (GSA) in the Delta-Mendota Subbasin, is detailed and accompanied by GSA boundary maps and a description of intra-basin and inter-basin coordination agreements in place for the development and implementation of the GSPs overlying the Delta-Mendota Subbasin.

Agency Contact Information

This Common Chapter to the six GSPs for the Delta-Mendota Subbasin has been prepared in a cooperative manner by the following GSAs in the Delta-Mendota Subbasin:

Northern & Central Delta-Mendota Region GSP

- Patterson Irrigation District GSA
- West Stanislaus Irrigation District GSA
- DM-II GSA
- City of Patterson GSA
- Northwestern Delta-Mendota GSA
- Central Delta-Mendota GSA
- Widren Water District GSA
- Oro Loma Water District GSA

San Joaquin River Exchange Contractors (SJREC) GSP

- San Joaquin River Exchange Contractors Water Authority GSA
- Turner Island Water District-2 GSA
- City of Mendota GSA
- City of Firebaugh GSA
- City of Los Banos GSA
- City of Dos Palos GSA
- City of Gustine GSA
- City of Newman GSA
- Madera County – 3 GSA
- Portion of Merced County – Delta-Mendota GSA
- Portion of Fresno County Management Area B GSA

Grassland GSP

- Grassland GSA
- Portion of Merced County – Delta-Mendota GSA

Aliso Water District GSP

- Aliso Water District GSA

Farmers Water District GSP

- Farmers Water District GSA

Fresno County GSP

- Fresno County Management Area A GSA
- Portion of Fresno County Management Area B GSA

The plan areas covered by each of the six Subbasin GSPs is show in **Figure CC-1**~~**Figure CC-1**~~. **Figure CC-4**~~**Figure CC-4**~~ through **Figure CC-6**~~**Figure CC-6**~~ show the location of the GSAs comprising the six GSP regions. These GSAs are coordinating development and implementation of the six GSPs under the Coordination Agreement, as described below in Section 2.1.

The ~~initial~~ current Plan Manager for the coordinated Delta-Mendota Subbasin GSPs is ~~Andrew Garcia~~John Brodie, Water Resources Program Manager ~~Senior Civil Engineer~~ for San Luis & Delta-Mendota Water Authority (SLDMWA). Mr. ~~Garcia~~ Brodie can be contacted as follows:

Mr. ~~Andrew Garcia~~John Brodie, Plan Manager
Delta-Mendota Subbasin
842 6th Street
Los Banos, CA 93635
Phone: (209) -826-1872~~832-6200~~ / Fax (209) -833-1034
Error! Hyperlink reference not valid.john.brodie@sldmwa.org

Contact information for each GSP plan administrator can be found in the respective GSPs. The DWR Point of Contact is shown below.

Department of Water Resources ~~(DWR)~~ Point of Contact

The point of contact for the Delta-Mendota Subbasin is:

Christopher Olvera
Department of Water Resources
Christopher.Olvera@water.ca.gov
(559) 230-3373

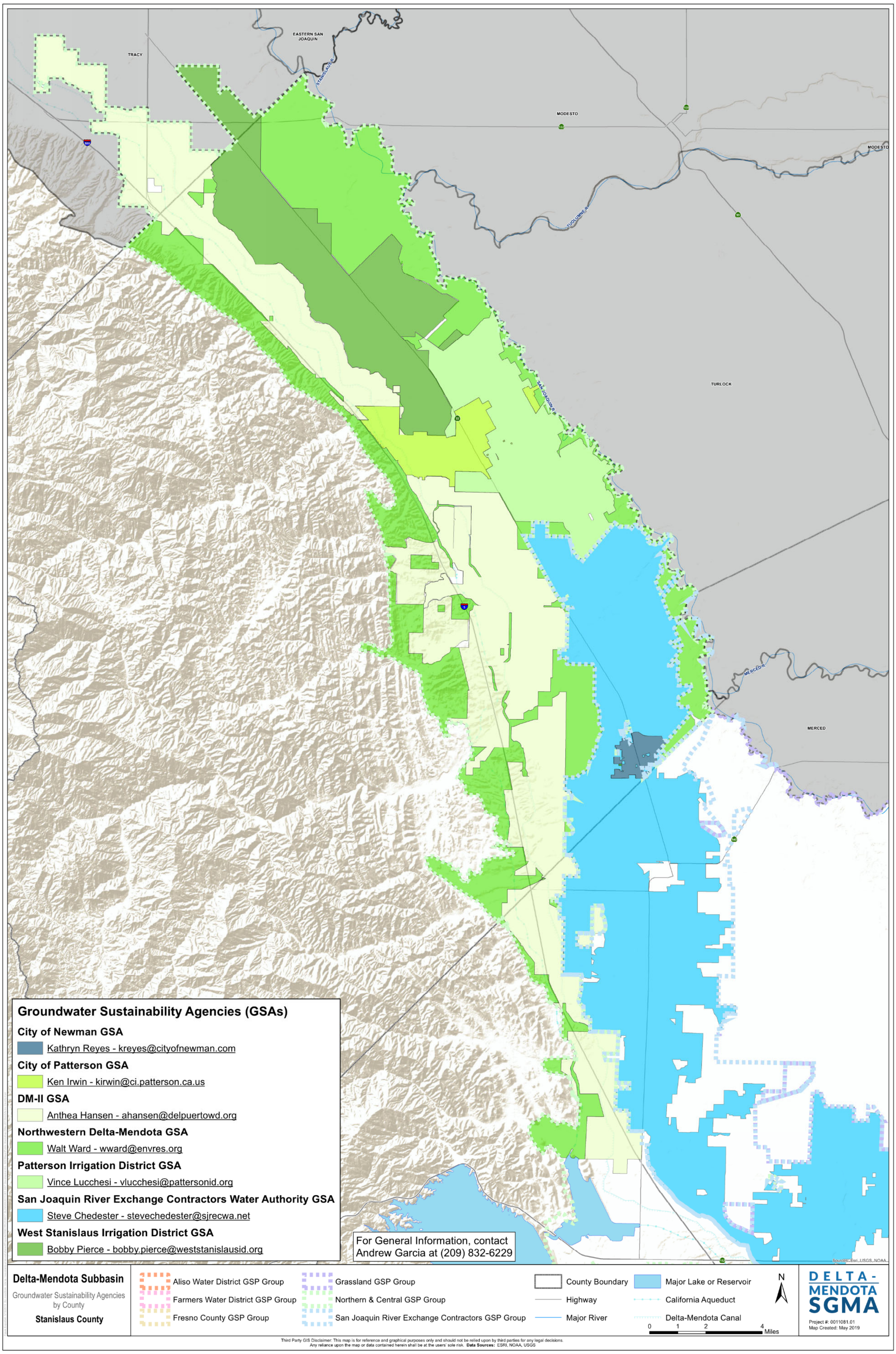


Figure CC-4: GSAs in the Delta-Mendota Subbasin – Stanislaus County

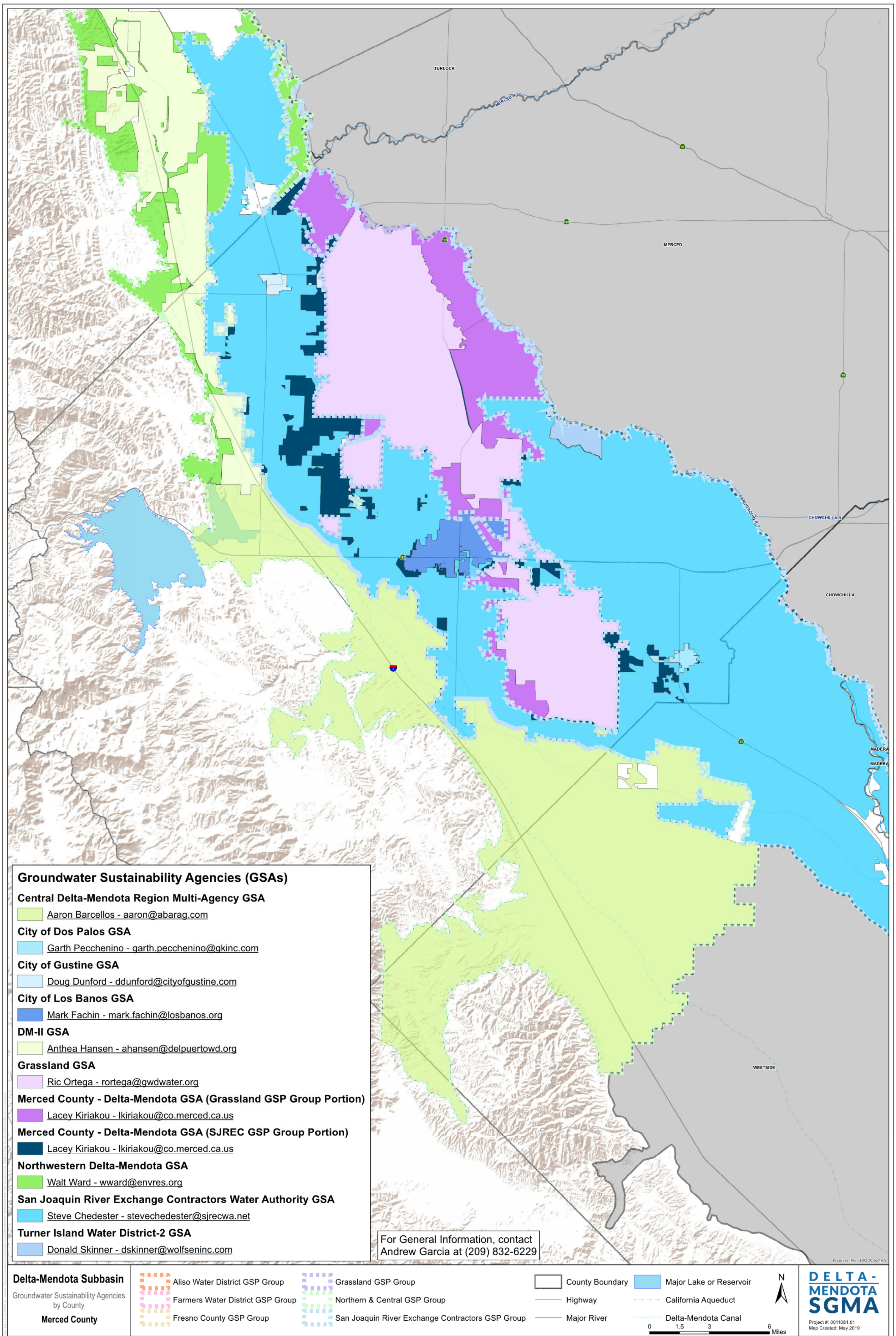


Figure CC-5: GSAs in the Delta-Mendota Subbasin – Merced County

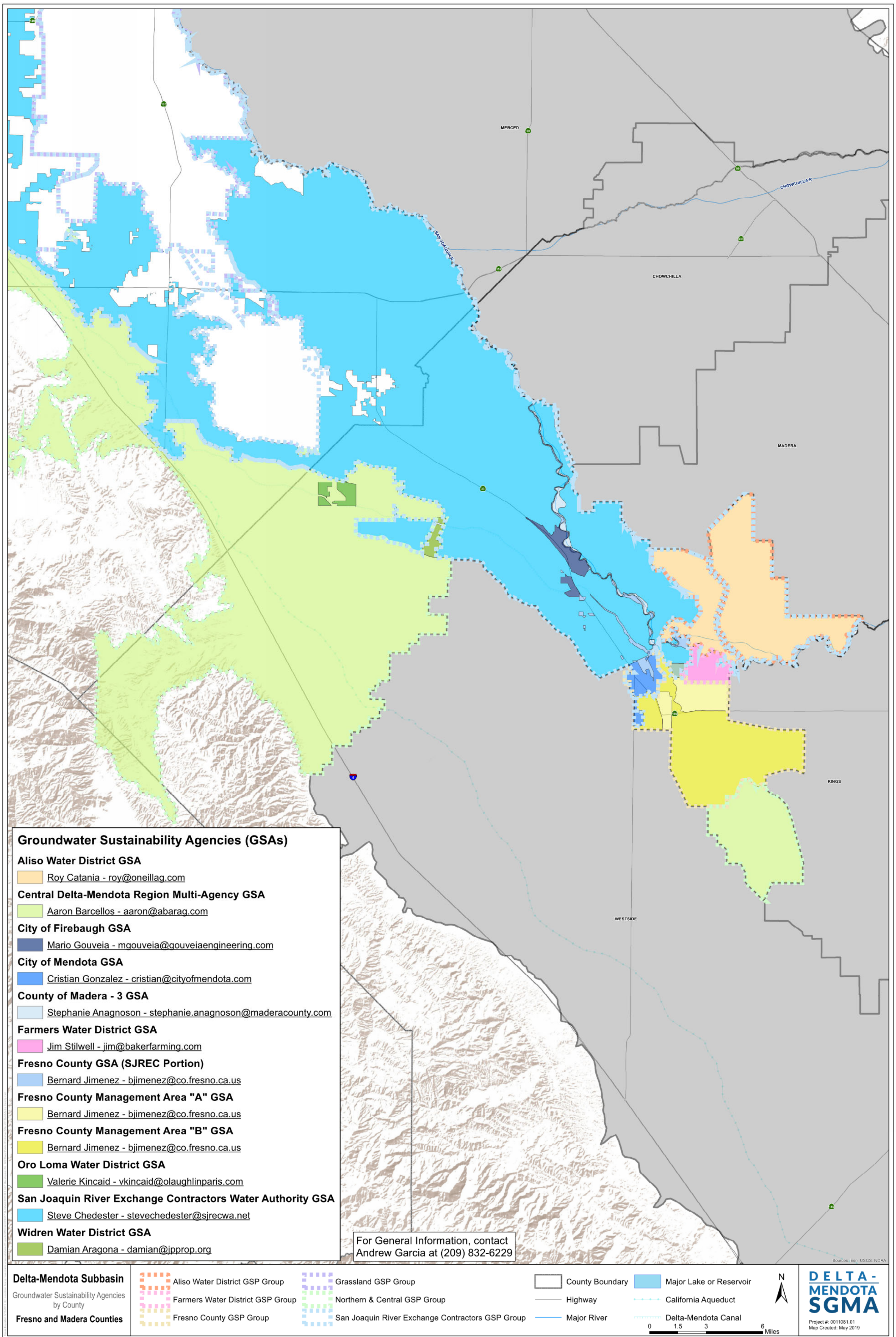


Figure CC-6: GSAs in the Delta-Mendota Subbasin – Fresno and Madera Counties

2.1 GSA and GSP Coordination and Governance

This section includes a description of intra-basin coordination agreements, which are required where there is more than one GSP prepared for a groundwater basin, and inter-basin coordination agreements, which are optional agreements between neighboring groundwater subbasins, pursuant to Article 8. Interagency Agreements, § 357.4. Coordination Agreements and § 357.2 Interbasin Agreements.

2.1.1 Delta-Mendota Subbasin SGMA Governance Structure

The GSAs within the Delta-Mendota Subbasin adopted and executed a Coordination Agreement on December 12, 2018 to comply with the SGMA requirement that multiple GSAs within a given subbasin must coordinate when developing and implementing their GSPs (see Intra-Agency Coordination subsection above for more information). Additionally, a Cost Sharing Agreement was signed and executed by the same parties on December 12, 2018. **Figure CC-5** shows the SGMA governance structure within the Delta-Mendota Subbasin. In addition to the two members appointed to represent each of the Northern & Central Delta-Mendota GSP Region and the San Joaquin River Exchange Contractors (SJREC) GSP Region on the Delta-Mendota Subbasin Coordination Committee as voting members, the Grassland GSP Region, Farmers Water District GSP Region, Fresno County Management Areas A & B GSP Region, and Aliso Water District GSP Region all have appointed one voting member each for a total of eight voting members.

Three working groups were formed under the auspices of the Delta-Mendota Subbasin Coordination Committee: -the Technical Working Group, the Communications Working Group and the DMS Working Group. Representatives of each GSP region participate ion each working group.

Table CC-4: Delta-Mendota Subbasin Coordination Committee Members

GSP		GSA	Agency	Coordination Committee Members	
				Primary	Alternate
Northern & Central Delta-Mendota Region GSP	Northern Delta Mendota Region Management Committee	Patterson Irrigation District GSA	Patterson Irrigation District	Vince Lucchesi	Walt Ward
			Twin Oaks Irrigation District		
		West Stanislaus Irrigation District GSA	West Stanislaus Irrigation District		
		DM-II GSA	Del Puerto Water District		
			Oak Flat Water District		
		City of Patterson GSA	City of Patterson		
		Northwestern Delta-Mendota GSA	Merced County		
			Fresno County		
	Central Delta-Mendota Region Management Committee	Central Delta-Mendota GSA	San Luis Water District	Ben Fenters	Lacey Kiriakou
			Panoche Water District		
			Tranquillity Irrigation District		
			Fresno Slough Water District		
			Eagle Field Water District		
			Pacheco Water District		
			Santa Nella County Water District		
			Mercy Springs Water District		
			Merced County		
			Fresno County		
		Widren Water District GSA	Widren Water District		

GSP	GSA	Agency	Coordination Committee Members	
			Primary	Alternate
	Oro Loma Water District GSA	Oro Loma Water District		
San Joaquin River Exchange Contractors GSP	San Joaquin River Exchange Contractors Water Authority GSA	Central California Irrigation District	Jarrett Martin, Alejandro Paolini	Chris White, John Wiersma
		Columbia Canal Company		
		Firebaugh Canal Water District		
		San Luis Canal Company		
	Turner Island Water District-2 GSA	Turner Island Water District		
	City of Mendota GSA	City of Mendota		
	City of Firebaugh GSA	City of Firebaugh		
	City of Los Banos GSA	City of Los Banos		
	City of Dos Palos GSA	City of Dos Palos		
	City of Gustine GSA	City of Gustine		
	City of Newman GSA	City of Newman		
	County of Madera – 3 GSA	County of Madera		
	Portion of Merced County – Delta-Mendota GSA	County of Merced		
	Portion of Fresno County Management Area B GSA	County of Fresno		
Grassland GSP	Grassland GSA	Grassland Water District	Ric Ortega	Ken Swanson
		Grassland Resource Conservation District		
	Portion of Merced County Delta-Mendota GSA	County of Merced		

GSP	GSA	Agency	Coordination Committee Members	
			Primary	Alternate
Farmers Water District GSP	Farmers Water District GSA	Farmers Water District	Jim Stilwell	Don Peracchi
Fresno County GSP	Fresno County – Management Area A	County of Fresno	Buddy Mendes	Glenn Allen or Augustine Ramirez
	Fresno County – Management Area B	County of Fresno		
Aliso Water District GSP	Aliso Water District GSA	Aliso Water District	Joe Hopkins	Board Secretary (Ross Franson)

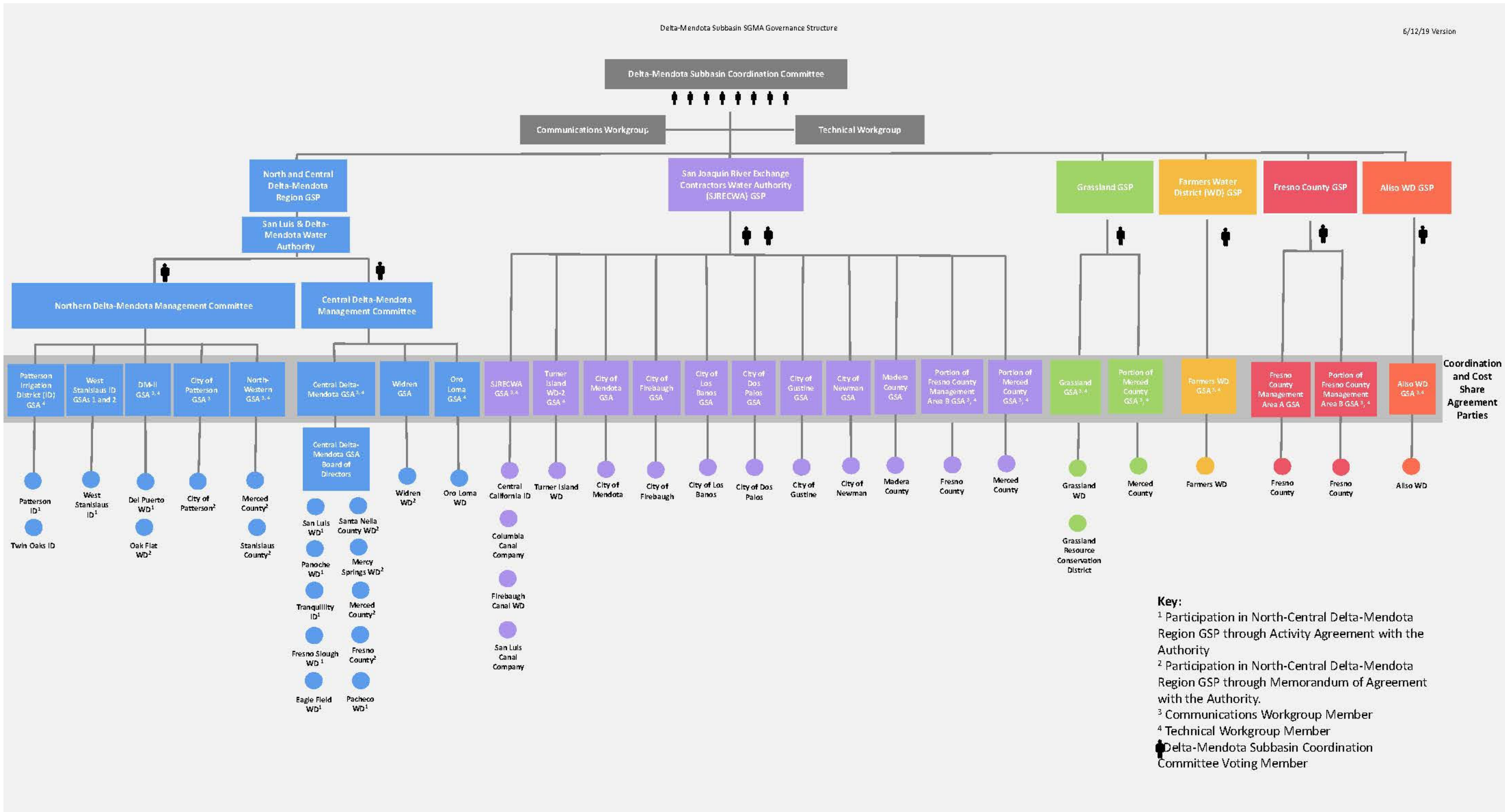


Figure CC-7: Governance Structure of the Delta-Mendota Subbasin

2.1.2 Intra-Basin Coordination

The Delta-Mendota Subbasin Coordination Agreement (Coordination Agreement), effective as of December 12, 2018, has been signed by all participating agencies in the Delta-Mendota Subbasin; a copy of this agreement is included in **Appendix A**. The purpose of the Agreement, including technical reports to be developed after the initial execution of this Agreement, is to comply with SGMA requirements and to ensure that the multiple GSPs within the Subbasin are developed and implemented utilizing the same datasets, methodologies and assumptions, that the elements of the GSPs are appropriately coordinated to support sustainable subbasin management of groundwater resources, and to ultimately set forth the information necessary to show how the multiple GSPs in the Subbasin will achieve the sustainability goal as determined for the Subbasin in compliance with SGMA and its associated regulations.

A key goal of basin-wide coordination is to ensure that the Subbasin GSPs utilize the same data and methodologies during their plan development and that elements of the Plans necessary to achieve the sustainability goal for the basin are based upon consistent interpretations of the basin setting, as required by SGMA and associated regulations. The Coordination Agreement defines how the coordinated efforts will be achieved and documented, and also sets out the process for identifying the Plan Manager. The Coordination Agreement is part of each individual GSP within the Delta-Mendota Subbasin.

The Coordination Agreement for the Delta-Mendota Subbasin covers the following topics:

1. Purpose of the Agreement, including:
    a. Compliance with SGMA and
    b. Description of Criteria and Function;
2. General Guidelines, including:
    a. Responsibilities of the Parties and
    b. Adjudicated or Alternative Plans in the Subbasin;
3. Role of San Luis & Delta-Mendota Water Authority (SLDMWA), including:
    a. Agreement to Serve,
    b. Reimbursement of SLDMWA, and
    c. Termination of SLDMWA's Services;
4. Responsibilities for Key Functions, including:
    a. Coordination Committee,
    b. Coordination Committee Officers,
    c. Coordination Committee Authorized Action and Limitations,
    d. Subcommittees and Workgroups,
    e. Coordination Committee Meetings, and
    f. Voting by Coordination Committee;
5. Approval by Individual Parties;
6. Exchange of Data and Information, including:
    a. Exchange of Information and
    b. Procedure for Exchange of Information;
7. Methodologies and Assumptions, including:
    a. SGMA Coordination Agreements,

   b. Pre-GSP Coordination, and
   c. Technical Memoranda Required;
8. Monitoring Network
9. Coordinated Water Budget
10. Coordinated Data Management System
11. Adoption and Use of the Coordination Agreement, including:
   a. Coordination of GSPs and
   b. GSP and Coordination Agreement Submission;
12. Modification and Termination of the Coordination Agreement, including:
   a. Modification or Amendment of Exhibit "A" (Groundwater Sustainability Plan Groups including Participation Percentages),
   b. Modification or Amendment of Coordination Agreement, and
   c. Amendment for Compliance with Law;
13. Withdrawal, Term, and Termination;
14. Procedures for Resolving Conflicts;
15. General Provisions, including:
   a. Authority of Signers,
   b. Governing Law,
   c. Severability,
   d. Counterparts, and
   e. Good Faith; and
16. Signatories of all Parties

Coordination During GSP Implementation

The Coordination Agreement ensures that the multiple GSAs are working cooperatively and collaboratively to ensure GSPs within the Subbasin are developed and implemented utilizing the same methodologies and assumptions and to ultimately establish the processes necessary to show how the multiple GSPs in the Subbasin will be sustainably managed to achieve the Delta-Mendota Subbasin's sustainability goal. The Coordination Committee intends to continue to meet and confer following the submittal of the Subbasin's GSPs and will develop guidelines for GSP implementation between the GSP Groups and update the Coordination Agreement as the Parties to the Agreement deem necessary.

The Coordination Committee will continue meeting regularly following submittal of the Subbasin GSPs in order to develop the guidelines for coordinated implementation of GSPs. The intent of the guidelines will be to outline processes that will ensure the GSAs are progressing toward the Subbasin sustainability goal, while meeting the Annual Reporting requirements or any other requirements agreed upon for purposes of coordination.

Agency Responsibilities

In meeting the terms of the Coordination Agreement, all Parties (meaning the Delta-Mendota Subbasin GSAs) agree to work collaboratively to meet the objectives of SGMA and the Coordination Agreement. Each Party to the Agreement is a GSA and acknowledges that it is bound by the terms of the Coordination Agreement as an individual party.

The Parties have established a Coordination Committee to provide a forum to accomplish the coordination obligations of SGMA. The Coordination Committee operates in full compliance with the Brown Act and is composed of a Chairperson and Vice Chairperson, Secretary, Plan Manager, and a GSP Group Representative and Alternate Representative for each of the six GSP groups. The Chairperson and Vice Chairperson are rotated annually among GSP Groups in alphabetical order. The Secretary assumes primary responsibility for Brown Act compliance. The GSP Group Representatives, who are identified in Table CC-4~~Table CC-4~~, are selected by each respective GSP Group at the discretion of the respective GSP Group, and such appointments are effective upon providing written notice to the Secretary and to each Group Contact. The Coordination Committee recognizes each GSP Group Representative and GSP Group Alternate Representative until the Group Contact provides written notice of removal and replacement to the Secretary and to every other Group Contact. Each GSP Group is required to promptly fill any vacancy created by the removal of its Representative or Alternate Representative so that each GSP Group has the number of validly designated representatives.

Each GSP Group Representative is entitled to one vote at the Coordination Committee, where the Alternate Representative is authorized to vote in the absence of the GSP Group Representative. The unanimous vote of the GSP Representatives from all GSP Groups is required on most items upon which the Coordination Committee is authorized to act, with the exception of certain ministerial and administrative items. Voting procedures to address a lack of unanimity take place upon a majority vote of a quorum of the Coordination Committee and include: straw polls, provisional voting, and delay of voting (see Section 5.6.3 – *Voting Procedures to Address Lack of Unanimity* of the Coordination Agreement). Where the law or the Coordination Agreement require separate written approval by each of the Parties, such approval is evidenced in writing by providing the resolution, Motion, or Minutes of their respective Board of Directors to the Secretary of the Coordination Committee. Minutes of the Coordinate Committee are kept and prepared by the Secretary's appointee and maintained by the Secretary as Coordination Agreement records and are available to the Parties and the public upon request. Meeting agenda and minutes are posted on the Delta-Mendota website (www.deltamendota.org).

The Coordination Committee may appoint subcommittees, working groups, and otherwise direct staff made available by the Parties. Subcommittees or working groups may include qualified individuals possessing the knowledge and expertise to advance the goals of the Coordination Agreement on the topics being addressed by the subcommittee or working group, whether or not such individuals are GSP Group Representatives or Alternate Representatives. Tasks assigned to subcommittees, working groups, or staff made available by the Parties may include developing technical data, supporting information, and/or recommendations on specialized matters to the Coordination Committee. One GSP Group Representative or Alternate Representative is required to vote on behalf of the GSP Group at the subcommittee level. If no GSP Group Representative or Alternate Representative is present, one individual working on a subcommittee on behalf of the Parties in a GSP Group votes on behalf of the GSP Group. Subcommittees report voting results and provide information to the Coordination Committee but are not entitled to make determinations or decisions that are binding on the Parties.

The Coordination Committee is authorized to act upon the following items:

1. The Coordination Committee reviews, and consistent with the requirements of SGMA, approves the Technical Memoranda that compose the Common Chapter (see *Coordinated Data and Methodology*);
2. The Coordination Committee is responsible for ongoing review and updating of the Technical Memoranda as needed; assuring submittal of annual reports; providing five-year assessments and recommending any needed revisions to the Coordination Agreement; and providing review and assistance with coordinated projects and programs, once the GSPs have been submitted to and approved by DWR;
3. The Coordination Committee reviews and approves work plans, and in accordance with the budgetary requirements of the respective Parties, approves annual budget estimates of Coordinated Plan Expenses presented by the Secretary and any updates to such estimates provided that such estimates or updates with supporting documentation are circulated to all Parties for comment at least thirty (30) days in advance of the meeting at which the Coordination Committee will consider approval of the annual estimate;
4. The Coordination Committee is authorized to approve changes to Exhibit "A" (Groundwater Sustainability Plan Groups including Participation Percentages) to the Agreement and to recommend amendments to terms of the Agreement;
5. The Coordination Committee may assign work to subcommittees and workgroups as needed, provide guidance and feedback and ensure that subcommittees and workgroups prepare work products in a timely manner;
6. The Coordination Committee directs the Plan Manager in the performance of its duties under SGMA; and
7. The Coordination Committee provides direction to its Officers concerning other administrative and ministerial issues necessary for the fulfillment of the above-enumerated tasks.

Additional information regarding the roles, responsibilities, and duties of the Coordination Committee can be found in Section 5 – *Responsibilities for Key Functions* of the Coordination Agreement.

Exchange of Information

Timely exchange of information is a critical aspect of GSP coordination. All parties to the Coordination Agreement have agreed to exchange public and non-privileged information through collaboration and/or informal requests made at the Coordination Committee level or through subcommittees designated by the Coordination Committee. To the extent it is necessary to make a written request for information to another Party, each Party designates a representative to respond to information requests and provides the name and contact information of the designee to the Coordination Committee. Requests may be communicated in writing and transmitted in person or by mail, facsimile machine, or other electronic means to the appropriate representative as named in the Coordination Agreement. The designated representative is required to respond in a reasonably timely manner. Nothing in the Agreement shall be construed to prohibit any Party from voluntarily exchanging information with any other Party by any other mechanism separate from the Coordination Committee.

The Parties agree that each GSP Group shall provide the data required to develop the Subbasin-wide coordinated water budget but, unless required by law, will not be required to provide individual well or parcel-level information in order to preserve confidentiality of individuals to the extent authorized by law, including but not limited to Water Code Section 10730.8, subdivision (b). To the extent that a court order, subpoena, or the California Public Records Act is applicable to a party, the Party in responding to a request made pursuant to that Act for release of information exchanged from another Party shall notify each other Party in writing of its proposed release of information in order to provide the other Parties with the opportunity to seek a court order preventing such release of information.

Dispute Resolution

Procedures for conflict resolution have been established within the Coordination Agreement. In the event that a dispute arises among Parties as it relates to the Coordination Agreement, the disputing Party or Parties are to provide written notice of the basis of the dispute to the other Parties within thirty (30) calendar days of the discovery of the events giving rise to the dispute. Within thirty (30) days after such written notice, all interested Parties are to meet and confer in good faith to informally resolve the dispute. All disputes that are not resolved informally shall be settled by arbitration. In such an event, within ten (10) days following the failed informal proceedings, each interested Party is to nominate and circulate to all other interested Parties the name of one arbitrator. Within ten (10) days following the nominations, the interested Parties are to rank their top three among all nominated arbitrators, awarding three points to the top choice, two points to the second choice, and one point to the third choice and zero points to all others. Each interested Party will then forward its tally to the Secretary, who tabulates the points and notifies the interested Parties of the arbitrator with the highest cumulative score, who shall be the selected arbitrator. The Secretary may also develop procedures for approval by the Parties for selection of an arbitrator in the case of tie votes or in order to replace the selected arbitrator in the event such arbitrator declines to act. The arbitration is to be administered in accordance with the procedures set forth in the California Code of Civil Procedure, Section 1280, *et seq.*, and of any state or local rules then in effect for arbitration pursuant to said section. Upon completion of arbitration, if the controversy has not been resolved, any Party may exercise all rights to bring legal action relating to the controversy.

Coordinated Data and Methodology

Pursuant to SGMA, the Coordination Agreement ensures that the individual GSPs utilize the same data and methodologies for developing assumptions used to determine: 1) groundwater elevation; 2) groundwater extraction data; 3) surface water supply; 4) total water use; 5) changes in groundwater storage; 6) water budgets; and 7) sustainable yield. The Parties have agreed to develop agreed-upon methodologies and assumptions for the aforementioned items prior to or concurrent with the individual development of GSPs. This development is facilitated through the Coordination Committee's delegation to a subcommittee or working group of the technical staff provided by some or all of the Parties. The basis upon which the methodologies and assumptions have been developed includes existing data/information, best management practices, and/or best modeled or projected data available and may include consultation with DWR as appropriate.

The data and methodologies for assumptions ~~described~~described in Water Code Section 10727.6 and Title 23, California Code of Regulations, Section 357.4 to prepare coordinated plans are set forth in Technical Memoranda prepared by the Coordination Committee for each of the following elements: Data and Assumptions; Hydrogeologic Conceptual Model; Coordinated Water Budgets; Sustainable Management Criteria (SMC); Coordinated Monitoring Network; Coordinated Data Management System, and Adoption and Use of the Coordination Agreement. The Technical Memoranda have been subject to the unanimous approval of the Coordination Committee and once approved, have been attached to and incorporated by reference into the Coordination Agreement without formal amendment of the Coordination Agreement being required. The Parties have agreed that they will not submit this Coordination Agreement to DWR until the Technical Memoranda described herein have been added to the Coordination Agreement. The Technical Memoranda created pursuant to the Coordination Agreement are to be utilized by the Parties