CALIFORNIA DEPARTMENT OF WATER RESOURCES

California's Groundwater Conditions Semi-Annual Update: March 2023

Executive Summary

California is at the start of the fourth year of the most recent drought that began in 2020. The current drought has followed the droughts of 2007-2009 and 2012-2016. Our communities, agriculture, and the environment all continue to be impacted from the effects of drought.

Climate change continues to have profound effects on the state's hydrologic cycle. More frequent droughts are but one of the prominent effects of climate change. The term "weather whiplash" describes the significant swings between droughts and floods that are now experienced in California. The significant series of atmospheric river storms California experienced at the end of 2022 and start of 2023 are an example of weather whiplash. Despite providing necessary relief to surface water storage, the storms also caused disastrous flooding in some locations. It will take more than a series of storms to make up for years of deficits in both surface water and groundwater reservoirs.

As of the publication of this update, the extent of the overall effect from the storms is still unclear. The large snowpack and higher storage volume in surface reservoirs will provide a boost to surface water resources, agriculture, and the environment. However, groundwater reserves, stressed from many years of overdraft and climate change effects have not been able to become adequately replenished due to increasing demand on groundwater during repeated droughts and the much slower process of natural recharge. The data used in this semi-annual update pre-dates the recent storms and will not reflect any of the recent storm conditions or recharge within our groundwater basins. Future updates may allow us to see improvements in conditions within groundwater basins, but it will take several years, or even decades of normal or above average conditions combined with appropriate management actions to counter the decades of depletion of our groundwater resources.

California continues to invest in ensuring the resiliency of groundwater resources. The Sustainable Groundwater Management Act (SGMA) of 2014 set forth a vision that all the state's groundwater basins be sustainably managed by 2042. The state has invested in planning, implementation, and technical assistance to help reach that goal. Further, the state has been proactive in addressing the effects of climate change on our groundwater resources. In 2022, the Governor released California's Water Supply Strategy, Adapting to a Hotter, Drier Future, which describes how recurrent and longer periods of extreme dry weather is the new climate reality of California and could diminish our existing water supply by up to 10% by 2040. Replenishing the state's groundwater basins is a key element of this strategy. The state continues to make investments to modernize water infrastructure and management, and has facilitated emergency drought response efforts, as well as projects by local and state agencies, to address current and future drought impacts and become more resilient. The Department of Water Resources (DWR) also continues to award funding for drought relief assistance to small and urban communities to address water supply challenges and sustainable groundwater management funding to help build long-term resilience at both local and regional levels.

Groundwater provides up to 58 percent of the state's total water supply in dry years, and over 80-percent of Californians depend on groundwater for some portion of their water supply. Groundwater serves as a drought buffer and a critical component to the state's climate adaptation strategy, but without sustainable groundwater management, negative effects such as overdraft, dry wells, land subsidence, stream depletion, and groundwater quality degradation can occur and have historically been observed in various parts of the state. During the current drought, Governor Newsom's drought emergency proclamations have improved drought response by accelerating data collection, improving dry well reporting and drinking water assistance, requiring local well permitting coordination, and providing regulatory relief for groundwater recharge projects under specified circumstances to mitigate drought impacts.

This report is the latest in a series of Semi-annual Groundwater Conditions Updates, last published in October 2022. These updates are part of the informational resources associated with DWR's California's Groundwater (Bulletin 118). This report uses groundwater data received electronically by DWR as of February 15, 2022, through the conclusion of Water Year 2022, and the start of Water Year 2023. For a statewide summary of Water Year (WY) 2022 water conditions, see DWR's Water Year 2022 Brochure. The most recent groundwater data is available on the California's Groundwater Live website, which is updated on a daily basis as data is received by DWR. Additional data and information are available in the CNRA Open Data and Water Data Library websites.

Since the enactment of SGMA in 2014, great strides have been made by local agencies and the state to collect, report, and disseminate groundwater data and improve management of groundwater resources. This update compiles the best available data to illustrate the current conditions of California's groundwater resources. The disparity in reporting periods for various groundwater data sets in this semi-annual report is due to an inherent lag between local groundwater data collection in the field and reporting to DWR. Furthermore, the frequency of groundwater data collection is not the same for all data types. As a result, it is possible that all data collected locally for the period of analysis may not have been included in the summary and analysis presented in this semi-annual report.

Key Findings

Drought

- Sixteen of the last 23 years have had below average precipitation and 13 of these years were classified as “Dry” or “Critical” water years, resulting in a cumulative deficit of over 50 inches of precipitation, on average statewide since 2000 (**Figure 1** and **Figure 3**).
- Recent storms are refilling reservoirs and contributing to an above average snowpack for WY 2023, however groundwater basins remain depleted and are unlikely to recharge to pre-drought conditions this year (**Figure 5**, **Figure 6**, and **Figure 7**).

Groundwater Levels

- Fifty-five percent of groundwater level measurements collected in fall (August, September, and October) 2022 are at or near historic low measurements. 36% of measurements are lowest on record (**Table 2** and **Figure 6**).
- Fall 2022 groundwater levels were at or below the levels at the end of the 2012 - 2016 statewide drought despite the occurrence of two above average years (2017 and 2019) and a wet start to WY 2021 (based on the 5-year change data, **Table 1** and **Figure 5**).
- The Tulare Lake Hydrologic Region shows that 55 percent of monitored wells had a one-year decline in water levels, a higher percentage than all other hydrologic regions (**Figure 4**).
- Over the last 20-years more than 46 percent of statewide wells had a decreasing trend in groundwater levels statewide (**Table 3** and **Figure 7**).

Groundwater Extraction and Change in Storage

- During the WY 2021, over 18 million acre-feet of extraction was reported across 94 basins that submitted GSP/Alternative annual reports, of which 16.2 million acre-feet occurred in the Central Valley basins.
- During the WY 2021, over 7.9 million acre-feet of decline in groundwater storage was reported across the 94 basins that submitted GSP/Alternative annual reports, of which 7.1 million acre-feet decline occurred in the Central Valley basins.
- The largest decline in groundwater in storage occurred in the Tulare Lake Hydrologic Region that also reported the largest volume of groundwater extraction and the most widespread declines in groundwater levels., further highlighting the region's reliance on groundwater during dry years.

Land Subsidence

- The Tulare Lake Hydrologic Region has the most areas of subsidence with about 3,500 square miles of area experiencing greater than 0.1 feet of subsidence during WY 2022.
- The Sacramento River Region experienced the greatest relative increase in areas and rates of subsidence in WY 2022.

Well Infrastructure

- During WY 2022, 3,736 domestic and 1,578 irrigation wells were installed statewide, as reported to DWR. The 3,736 domestic wells is the most installed in a single year since the end of the last drought in 2016 with 10% of all statewide domestic wells were installed within the last 8 water years.
- Approximately half as many irrigation wells were installed during critical WY 2022 compared to critical WY 2015 near the end of the previous 2012-2016 drought.
- Tulare County accounted for 19% of all new irrigation wells installed in the WY 2022.
- A total of 1,494 dry wells were reported in WY 2022, the most of any year since the dry well reporting program started in 2013.

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Introduction

A series of atmospheric river storms hit California in late 2022 and early 2023, resulting in significant rainfall amounts and snow accumulation. While this precipitation and snowfall will have a positive effect on surface water resources, groundwater resources take much longer to recover from years of overdraft. For example, the very wet year of 2017 did not significantly improve long-term groundwater level declines and subsidence impacts that resulted from the preceding drought of 2012-16. Additional wet weather will help improve water supplies throughout the state, but recovery of groundwater basins generally requires longer timescales and improved management of groundwater use.

Significant progress continues to be made by local agencies and the state to collect, report, and disseminate groundwater data and manage groundwater resources, in support of the implementation of the Sustainable Groundwater Management Act (SGMA) of 2014. Groundwater Sustainability Plans (GSPs) have been developed, and are in the implementation phase, for basins providing 98% of the total groundwater supply in the state. DWR continues to work toward making periodic groundwater monitoring data, annual groundwater use data, and change in groundwater storage data, reported by GSAs, publicly available. DWR also maintains the California's Groundwater Live website and provides datasets available for download from the CNRA Open Data website, for access to recent groundwater data. DWR also is working to improve timely reporting of groundwater data. Additional relevant groundwater data resources are discussed towards the end of this report.

Drought and Groundwater in California

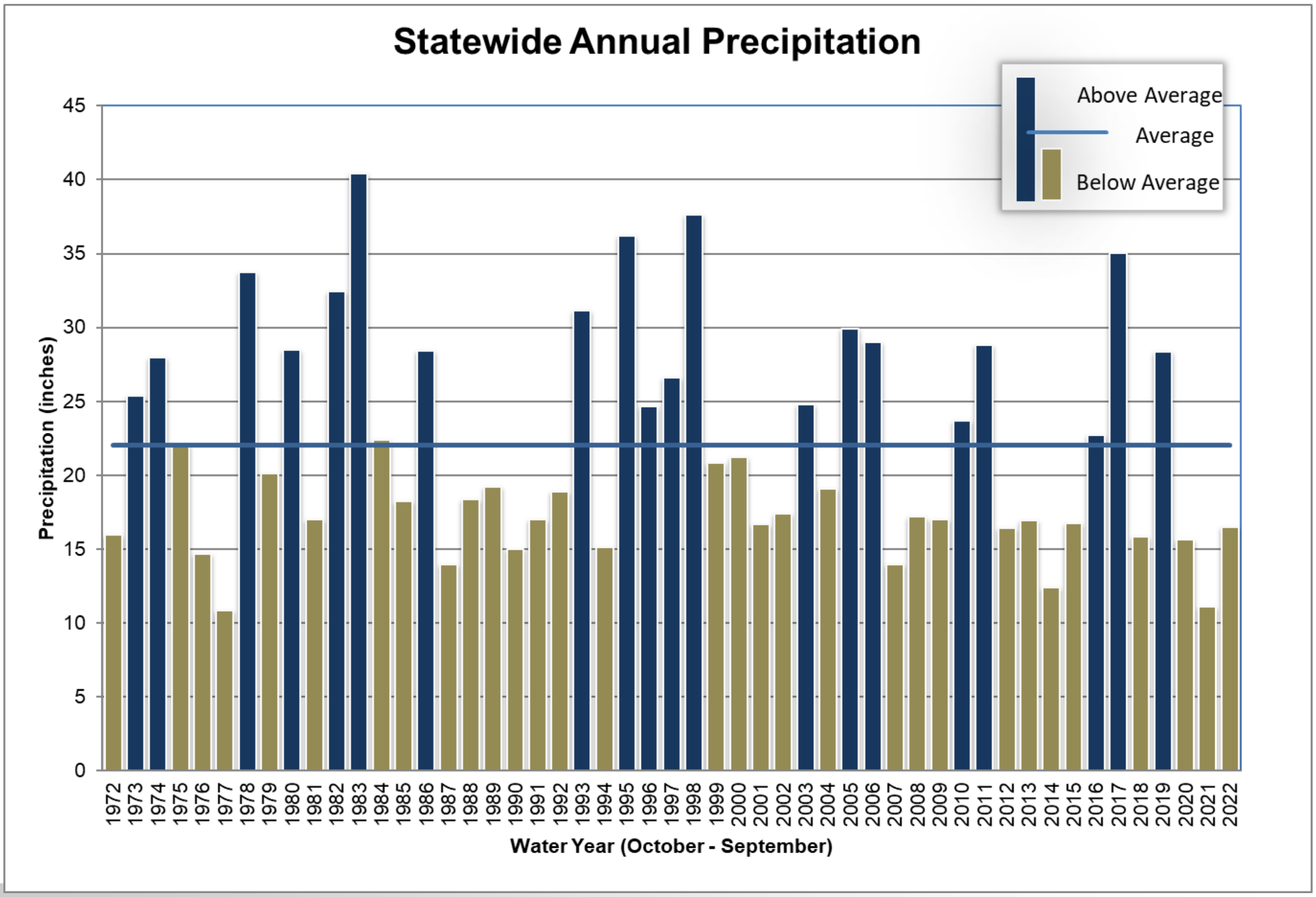
Late December 2022, and early January 2023 saw one of the wettest three-week periods in California's history, following the three driest years on record. A series of nine atmospheric river storms brought extreme rainfall to much of the state, with some areas receiving almost an average years' worth of rainfall in this short time span. These storms provided a significant snowpack across the Sierra Nevada. The storms also resulted in localized flooding in many areas of the state. These storms represented what some have called "weather whiplash," a term that describes California's extreme weather volatility with large, short-term swings between drought and flood conditions.

The heavy precipitation received during the three-week period provided much needed relief for the state's stressed water resources. The precipitation did much toward filling our surface reservoirs that had reached extreme low levels during this drought. In addition, the snowpack will continue to generate runoff into summer of 2023, and further augment our surface water resources and provide some recharge to aquifers. However, the extent of these storms is unlikely to end the current drought. While this water year has seen a strong start, the most import indicator will be the April 1 snowpack measurement, when it is typically at its highest.

Precipitation and snowmelt runoff loses a large portion to evapotranspiration, but a significant portion of the total runoff also flows into streams and rivers. A much smaller portion of runoff infiltrates into aquifers as groundwater recharge. As such, depleted groundwater aquifers take much longer to recover than surface storage. Whereas surface storage can see notable increases in water levels seasonally or even after a single significant storm event, it can take years to decades to recover depleted groundwater basins. Groundwater managers are increasingly seeking demand reductions and targeted managed aquifer recharge in areas where feasible, to augment the amount of natural recharge that enters the aquifer systems.

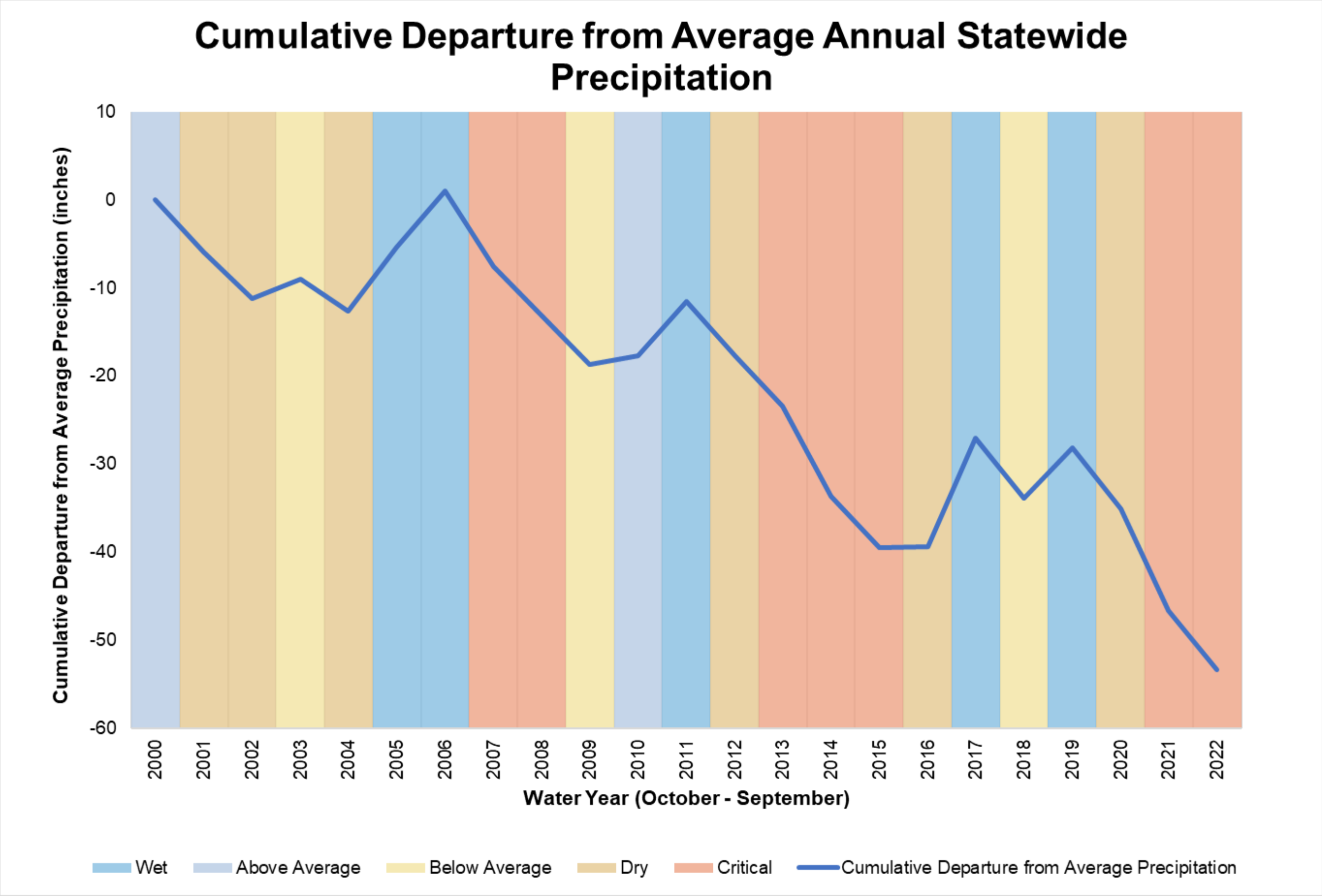
Despite recent wet conditions, California is experiencing dryer than average conditions over a longer term. It is reported in a recent study published in the Nature Climate Change journal that 2000-2022 is the driest 22-year stretch on record in at least 1,200 years in California. Historical data shows that 16 of the 23 years during the 2000-2022 period had below average annual statewide precipitation (**Figure 1**).

Figure 1: Statewide Annual Precipitation, NOAA National Centers for Environmental Information, (Climate at a Glance: U.S. Time Series, Precipitation).



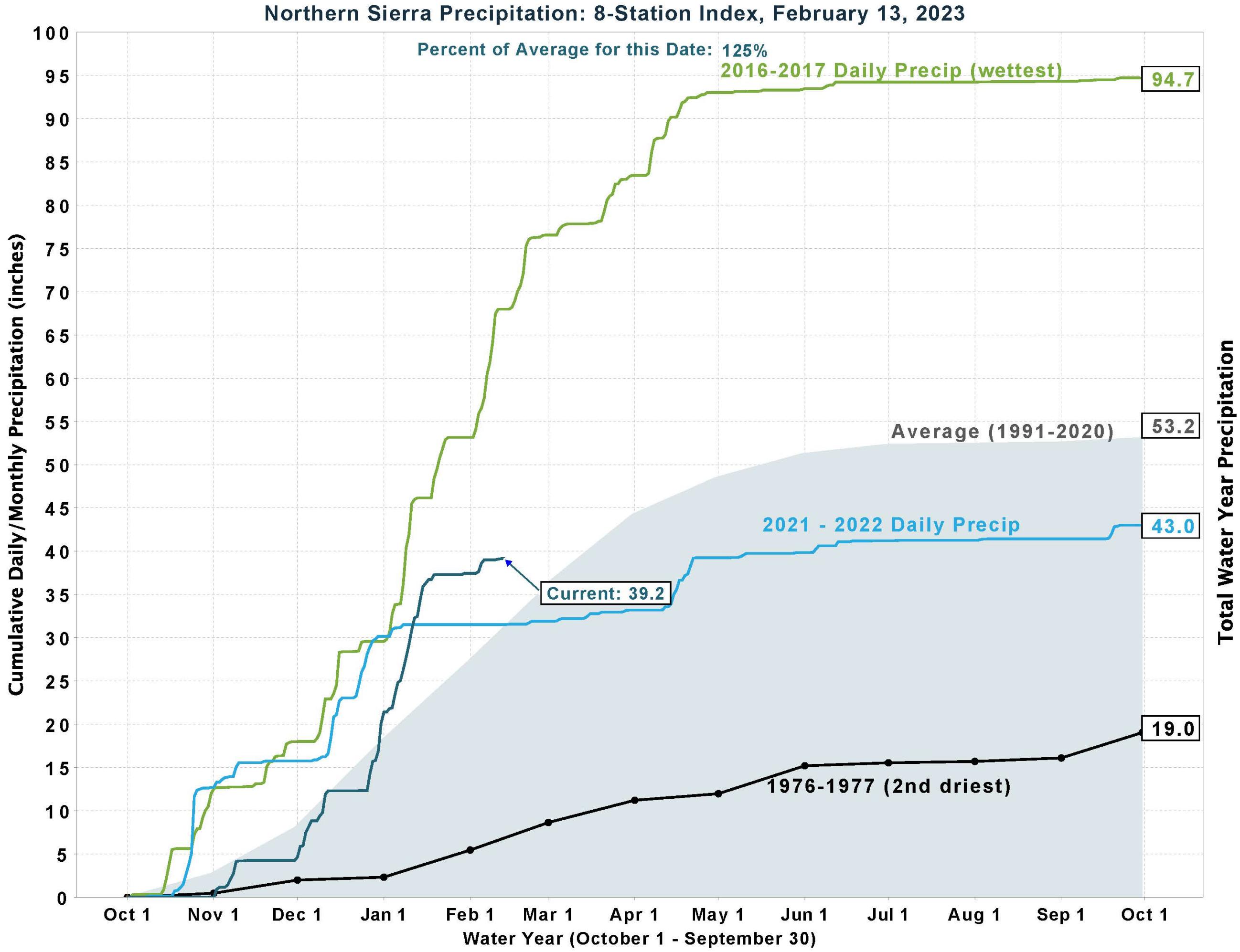
The cumulative departure from the average annual statewide precipitation (**Figure 2**) for the 2000-2022 period shows the accumulated precipitation deficit during this period.

Figure 2: Cumulative Departure from Average Annual Statewide Precipitation based on data from NOAA National Centers for Environmental Information, (Climate at a Glance: U.S. Time Series, Precipitation).



Seasonal variations in statewide precipitation can also be substantial, as shown in **Figure 3** for the Northern Sierra 8-Station Precipitation Index. The State had an exceptionally wet season from the beginning of WY 2022 from October through the end of December 2021; it was on track to match the wettest year on record (2017) in the Northern Sierra, where most of the state's precipitation falls. However, January, February, and March 2022 were the driest on record dating back over 100 years, ultimately leading to a water year with nearly 20% below average annual precipitation. As described at the beginning of this section, the current water year is trending wetter than average but that does not guarantee that wetter than average conditions for the year will prevail.

Figure 3: Northern Sierra Precipitation: Average precipitation (53.2 inches) with highest in 2016-2017 WY (94.7inches), current 2022-2023 WY (up to February 13) precipitation (39.2 inches), last water year (43.0 inches), and second driest on record (19.0 inches) based on [CDEC Sierra Precipitation 8-Station Index](https://cdec.water.ca.gov).



Water stored in reservoirs, snowpack, and groundwater basins is used in times of the year with less precipitation (such as summer months). In below average water years, groundwater basins are relied upon even more heavily for supply when other sources are less available and some Californians rely solely on groundwater for drinking water. However, long-term reliance on groundwater as a drought buffer is not sustainable as historically managed and used. Groundwater basins are often impacted during drought by less recharge due to reduced precipitation and an increase in pumping due to lack of other available water sources. Historical data shows that this overuse of groundwater combined with a decreased recharge caused by lower precipitation over the last 20 years has prevented groundwater level recovery in many areas of the state (See section below for more details).

Status of California's Groundwater Conditions

Changes in groundwater levels, especially groundwater level declines during drought, can indicate potential vulnerabilities to groundwater wells, the environment, and areas susceptible to land subsidence and water quality degradation. Groundwater level data provides valuable information on seasonal fluctuations, long-term changes, trends in groundwater storage, and susceptibility to land subsidence. Groundwater levels are measured on a regular schedule in a variety of groundwater wells located throughout the state. Late summer and early fall measurements generally capture the post-irrigation seasonal low groundwater levels. Groundwater level data are collected by DWR and also collected and reported to DWR by GSAs implementing SGMA, by Monitoring Entities participating in the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, and other data collectors.

The maps shown in **Figure 4, Figure 5, Figure 6,** and **Figure 7** depict how groundwater levels have changed over time. **Figure 4** and **Figure 5** show one-year and five-year change in groundwater levels during the fall season. **Figure 6** uses percentile statistics to show if groundwater levels are comparatively high or low to what has been observed in the past for a specific well. **Figure 7** uses trend analysis of groundwater levels for wells having measurements in at least 10 water years over a 20-year period to illustrate the long-term trend (a well's water level increasing or decreasing trend over a 20-year period).

The groundwater level change maps display, in accompanying bar charts, the percentage of wells with various ranges of increases and decreases in groundwater levels by the entire state and hydrologic regions. **Table 1** summarizes the statewide information for one-year and five-year changes shown in the groundwater level change maps.

Table 1: Statistical Summary of Groundwater Level (GWL) Changes from fall 2022 (As shown in **Figure 4** and **Figure 5**). Water Year Type as defined by the Sacramento River 8-Station Index, Department of Water Resources, California Data Exchange Center, WSIhist (ca.gov).

Period (Water Year Types)	Total Well Count	Decrease > 25 ft	Decrease 5 to 25 ft	No Significant Change (Less than +/- 5 ft)	Increase 5 to 25 ft	Increase >25 ft
1-Year GWL Change (Critical vs Dry): Fall 2022 compared to Fall 2021	5,234	3.6%	21.5%	64.3%	8%	2.6%
5-Year GWL Change (Post-last Drought): Fall 2022 compared to Fall 2017	4,104	14.4%	37.0%	38.1%	8.5%	2.0%

The one-year change data (**Table 1** and **Figure 4**) show more declines than increases in groundwater levels, as expected in the third year of statewide drought conditions. From fall 2021 to fall 2022, approximately 25 percent of measured wells show more than five feet of decline in groundwater levels, and only 10 percent show more than five feet of increase in water levels from the previous fall season. Approximately 65 percent of the statewide well measurements indicate no significant changes (less than +/- 5 feet) in net water level. The Tulare Lake Hydrologic Region outpaces all other hydrologic regions in the state with 55 percent of wells showing one-year declines in water levels. Two of the ten Hydrologic Regions, South Lahontan and Colorado River, showed very little change in groundwater levels.

The previous drought in California lasted from 2012 through 2016 and ended with one of the wettest years on record in 2017. For several years after the 2012-2016 drought groundwater levels increased in some areas, but by fall 2021 groundwater levels fell below the 2016 groundwater levels in many parts of the state (Groundwater Conditions Report, Water Year 2021). Additionally, the five-year change data (**Table 1** and **Figure 5**) shows that in most areas of the state groundwater levels have dropped below the 2017 levels. Thus, fall 2022 groundwater levels were at or below the levels at the end of the 2012-2016 statewide drought despite the occurrence of two above average years and a wet start to the 2021water year. Statewide, between fall 2017 and fall 2022 over 50 percent of wells experienced more than five feet of decline in groundwater levels while approximately 10 percent of wells had increasing water levels, illustrating the variable nature of groundwater level depletion and recovery across the state. Tulare Lake, Sacramento River, and San Joaquin River Hydrologic Regions outpaces the other hydrologic regions in the state with over 70 percent of wells showing five-year declines in water levels. The South Coast Hydrologic Region showed 30 percent of wells with increasing water levels over 5 feet, the most among all the other hydrologic regions.

For wells with longer periods of record, such as those shown in **Figure 6**, historic low water levels can be used as to indicate the potential for negative impacts, such as land subsidence or dry wells. **Figure 6** shows how groundwater levels for August, September, and October 2022, compare to previous groundwater levels collected during the same months, and indicates where groundwater is comparatively high or low to what has been observed in the past. Well measurement data in the map and chart are categorized by percentile class comparing measurement at that well with at least 10-years of measurements for that month for the period of record. The dataset shown in this figure uses percentile statistics to determine if groundwater levels are at an all-time low, below average, average, above average, or at an all-time high in monitoring wells. Groundwater levels for much of the state are at or near historic lows (55% of groundwater measurements collected in Aug, Sep, Oct 22). The percentiles observed from for August, September, and October 2022 are summarized in **Table 2**.

Table 2: Statistical Summary of percentile classes for August, September, and October (As Shown in **Figure 6**). Water Year Type as defined by the Sacramento River 8-Station Index, Department of Water Resources, California Data Exchange Center, [WSIhist (ca.gov).](WSIhist (ca.gov))

Percentile Class	Total Well Count	Lowest on Record	Less 10%	10-25%	25-50%	50-75%	75-90%	Greater 90%	Highest on Record
Statewide Percentile Class for Aug, Sep, and Oct. of 2022	2190	36%	19%	15%	16%	10%	6%	2%	3%

It is important to consider groundwater recovery over the long-term. **Figure 7** shows the 20-year trend of groundwater level change over time by depicting the magnitude of decreasing or increasing groundwater level trends in wells over the period WY 2002 to WY 2022. This period includes droughts from 2007 to 2009, 2012 to 2016, and the current drought (2020 to present). During this 20-year period of stressed water resources and increased groundwater use, more than 46 percent of statewide wells had a decreasing trend in groundwater levels while just over 10 percent of wells demonstrate an increasing trend. The percent changes observed from WY 2002 to WY 2022 are summarized in **Table 3**.

Figure 7 also shows several clusters of wells with steep groundwater level declines across the state during the most recent 20-year period. These trends were more pronounced in the southern Central Valley, although the north end of the valley shows a continued decrease of groundwater levels of up to 2.5 feet per year. Areas of steep decline include the western edge of the Sacramento Valley in the Sacramento River Hydrologic Region, the southeastern part of the San Joaquin Valley in the San Joaquin River Hydrologic Region, and most groundwater basins within the Tulare Lake Hydrologic Region. Moderate groundwater level declines are found in the North Coast, North Lahontan, South Coast, and South Lahontan Hydrologic Regions. There are notable increases in groundwater levels in the basins in the southeastern portion of the Sacramento Valley. The Central Coast and Colorado River Hydrologic Regions show the highest overall percentage of wells with groundwater level increases; however, relatively few wells were analyzed in these regions. The San Francisco Bay Hydrologic Region has the most stable groundwater levels of all regions.

Table 3: Statistical Summary of Groundwater Level Trend Map (**Figure 7**)

Period	Total Well Count	Decrease > 2.5 ft	Decrease 0.01 - 2.5 ft	No Significant Trend	Increase 0.01 - 2.5 ft	Increase > 2.5 ft
20-Year Trend: 2002 to 2022	4822	10.9%	35.4%	37.6%	10.4%	0.8%

Figure 4: Statewide and hydrologic region groundwater level change map for one-year period between fall 2021 and 2022. See **Table 1** for specific groundwater level statistics. Map and charts based on available data from the DWR Water Data Library as of 02/01/2023.

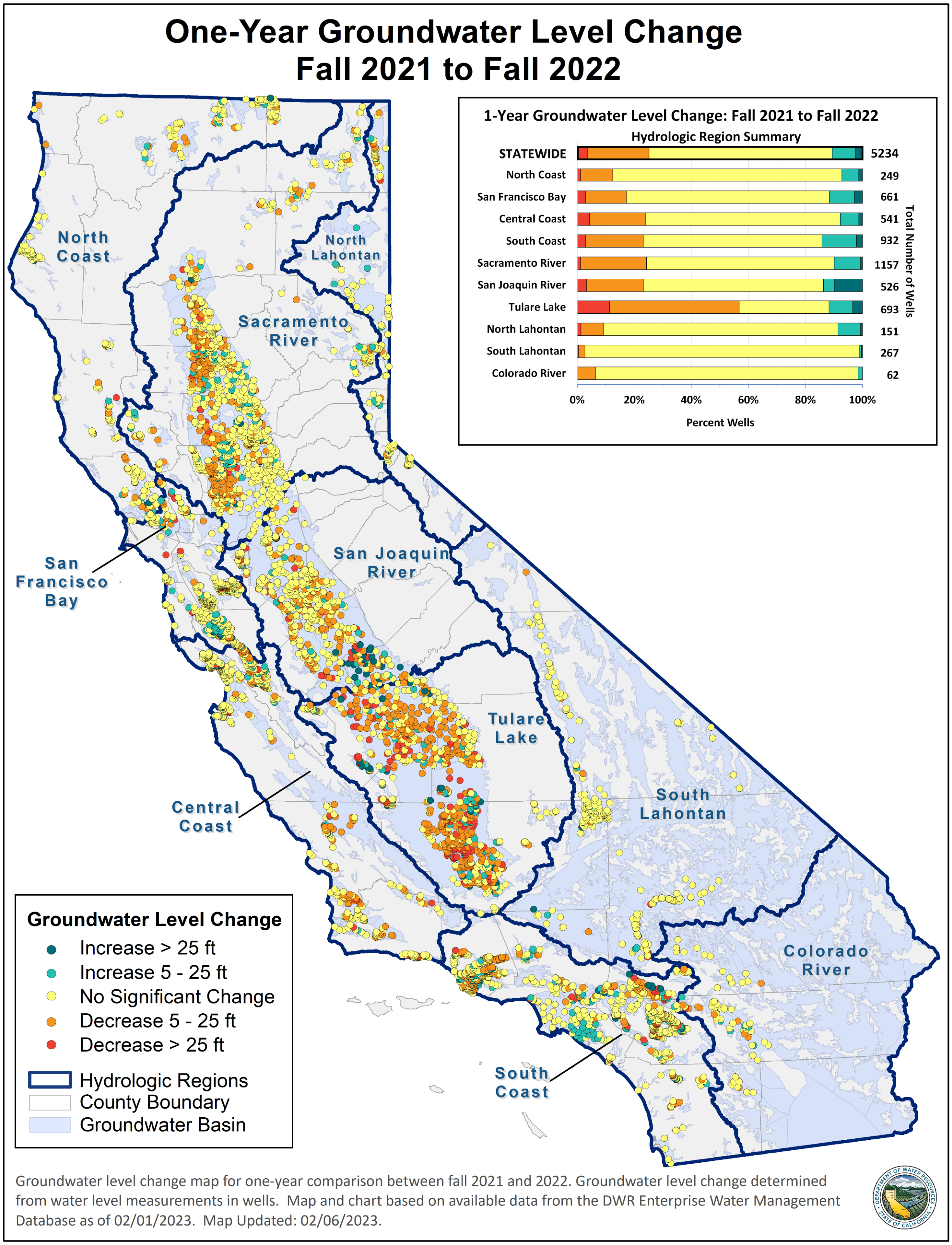
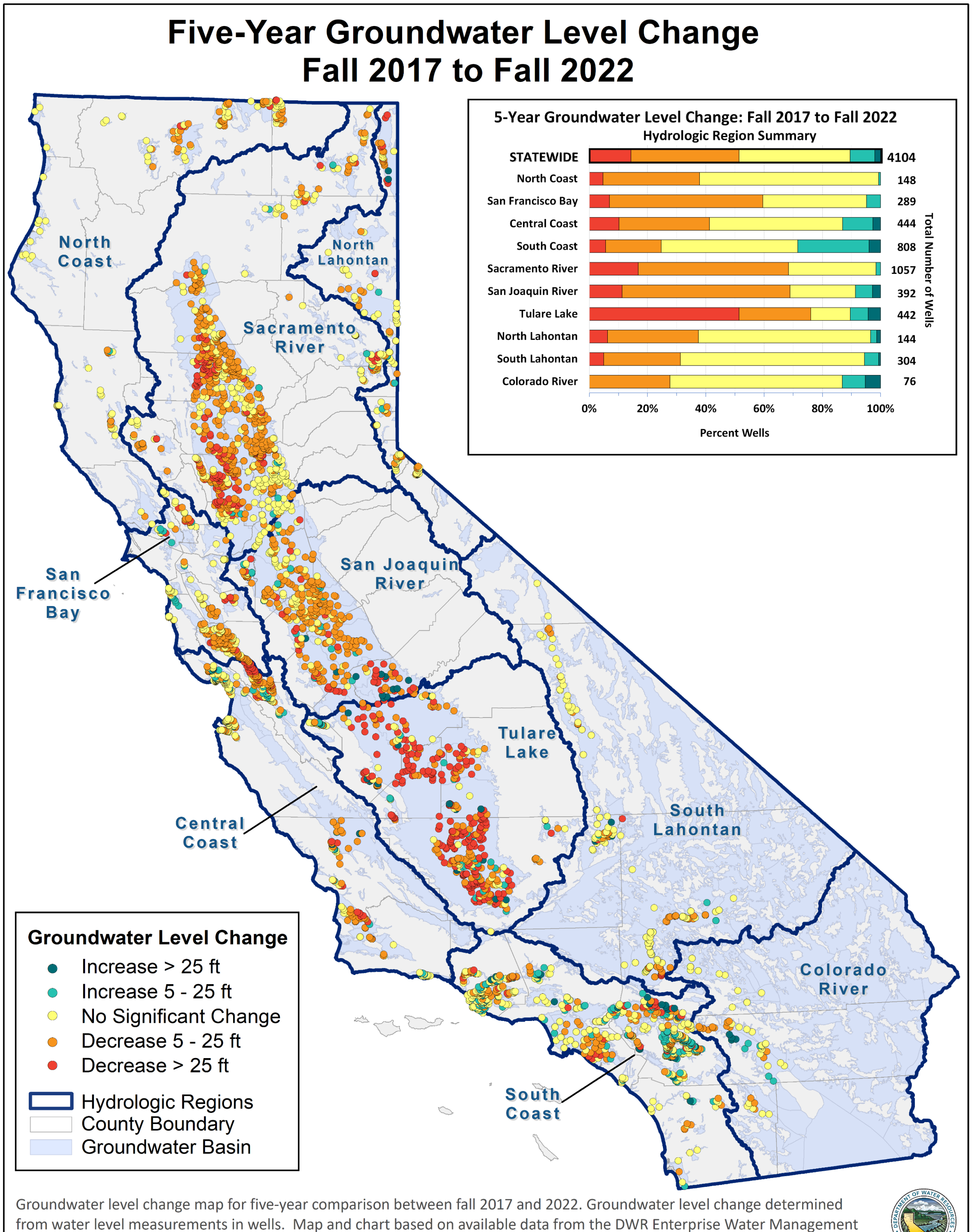
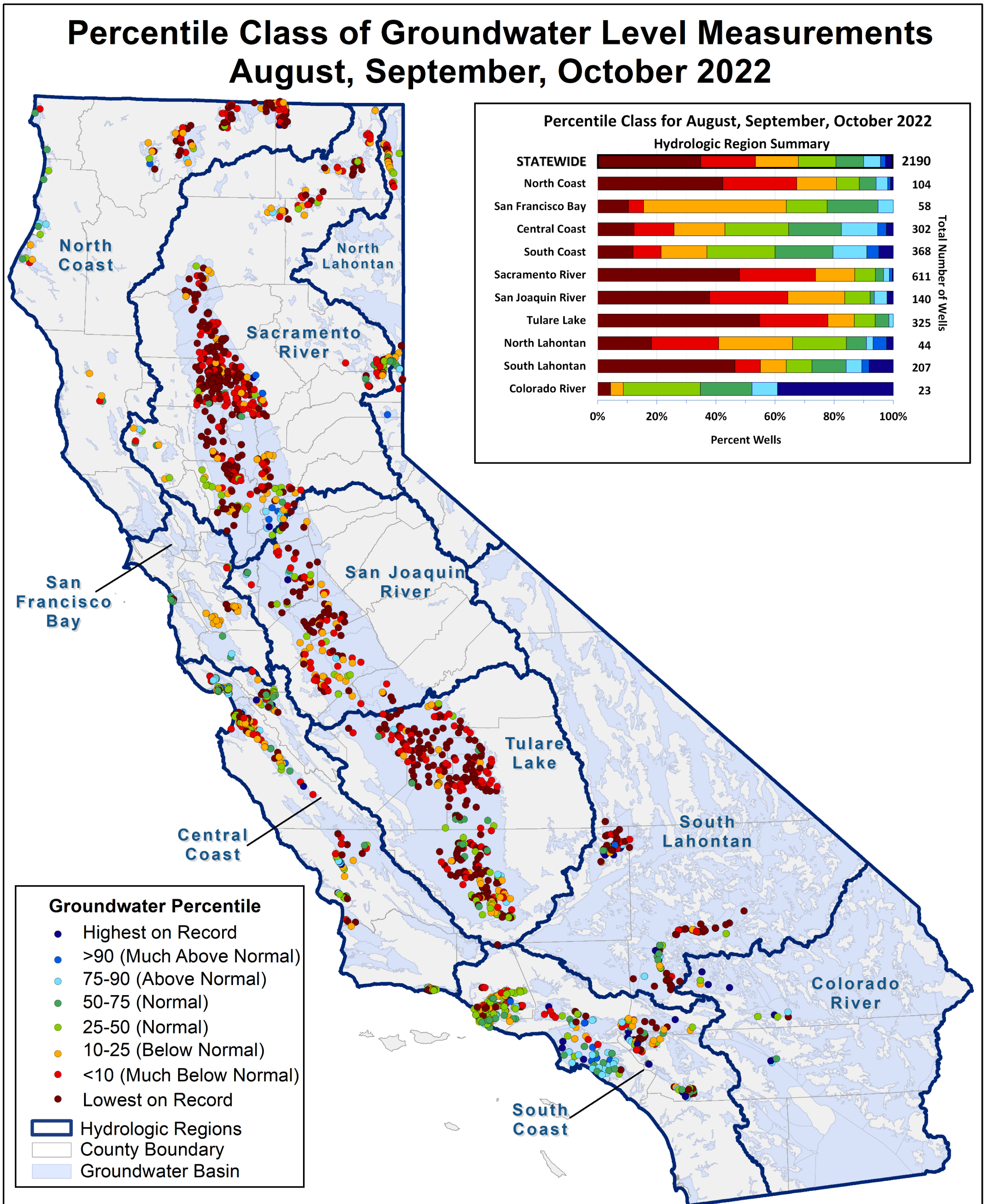


Figure 5: Statewide and hydrologic region groundwater level change map for five-year period between fall 2017 and 2022. See **Table 1** for specific groundwater level statistics. Map and charts based on available data from the DWR Water Data Library as of 02/01/23.



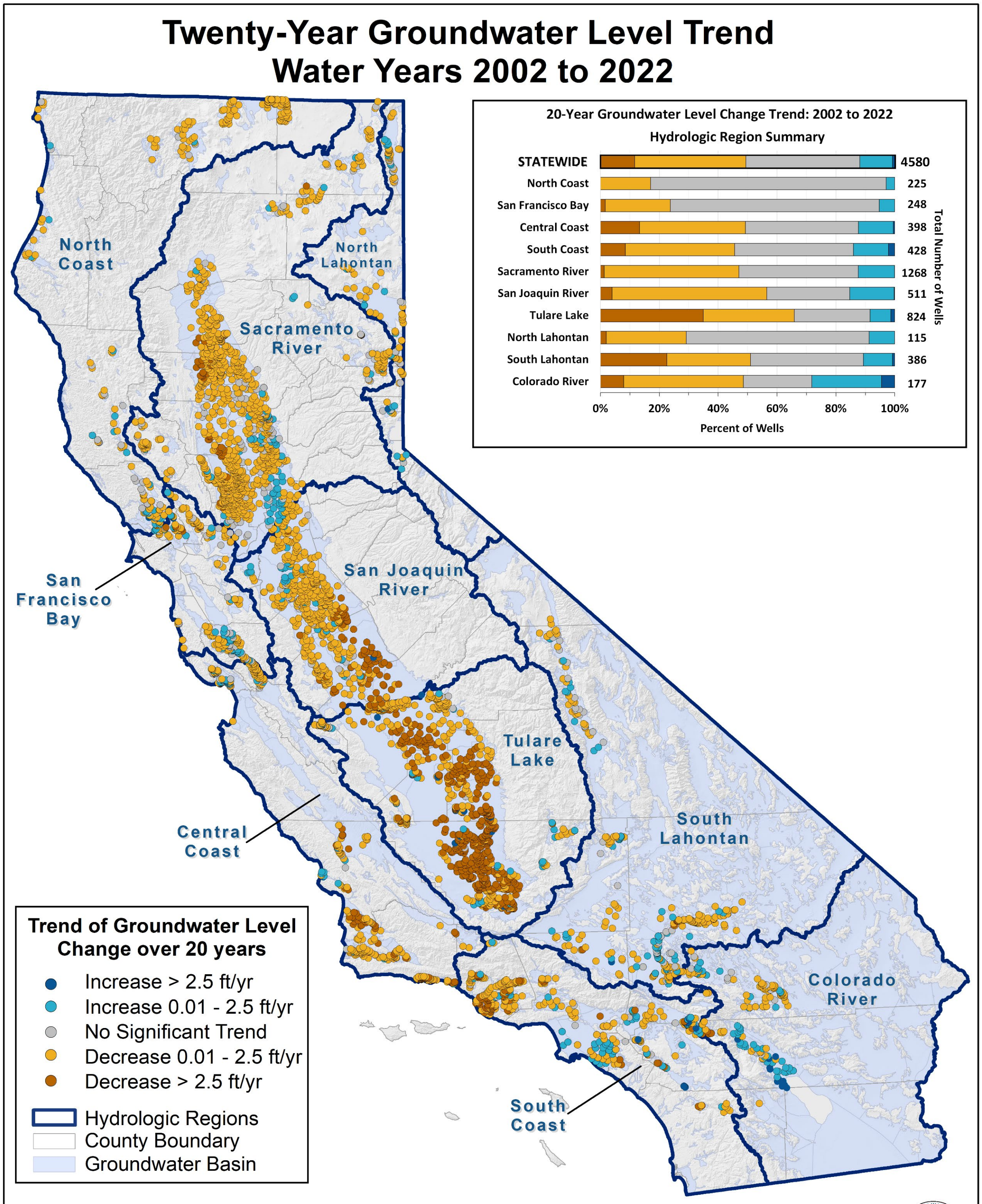
Groundwater level change map for five-year comparison between fall 2017 and 2022. Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Enterprise Water Management Database as of 02/01/2023. Map Updated: 02/06/2023.

Figure 6: Statewide and hydrologic region groundwater level percentile map for Groundwater wells with at least ten years of measurements in the months of August, September, and October. See **Table 2** for specific groundwater level statistics. Map and charts based on available data from the DWR Water Data Library as of 02/01/2023.



Groundwater level percentile class for August, September, and October 2022. Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Enterprise Water Management Database as of 02/01/2023. Map Updated: 02/16/2023.

Figure 7: Statewide and hydrologic region groundwater level trend analysis map for WYs 2002-2022. See **Table 3** for specific groundwater level statistics. Map and charts based on available data from the DWR Water Data Library as of 02/01/2023.



Groundwater level trend map for 20-year period between Water Years 2002 to 2022. Groundwater level trend determined from water level measurements in wells. Map and chart based on available data from the DWR Enterprise Water Management Database as of 02/01/2023. Map Updated: 02/06/2023.

Groundwater Extraction and Change in Storage Data from GSPs

As part of the SGMA process, DWR receives Groundwater Sustainability Plan (GSP) / Alternative Annual Report datasets from GSAs every year in April for the previous water year. Starting in 2020 for critically over-drafted basins, and 2022 for high and medium priority basins, DWR has received annual data for groundwater extraction, surface water supply, total water use, and change in storage volumes for each of the basins subject to SGMA. Data records within each dataset correspond either to an entire basin or one of multiple GSP areas that collectively correspond to an entire basin. While the sources and assumptions behind the numbers reported by each GSP vary by basin, the GSP/Alternative Annual Reports reflect the best available data provided by locals. Locally reported groundwater extraction and changes in storage can be compared against changes in groundwater elevations to establish trends, improve understanding about how aquifers respond to changes, and better inform decision making and management strategies related to groundwater use and depletion. GSP/Alternative Annual Report data is available to the public on the CNRA Open Data web application.

The GSP reporting process requires that information for the previous water year ending in September is not reported until April of the following year. Because the process is still relatively new for most medium and high priority basins, only a single year (WY 2021) of data is available, as of writing of this report, for all basins subject to SGMA. It is anticipated that the next round of data (WY 2022) will become available in April of 2023. While data is currently limited, it does offer insight into how basins are being operated. The information below summarizes some information provided in the GSP/Alternative Annual Reports, reported in April 2022.

As part of the GSP/Alternative Annual Reports, GSAs provide information about groundwater extraction and changes in groundwater in storage within a basin, for a single water year. For WY 2021, groundwater basins with the highest groundwater extraction per area (total groundwater pumped normalized by basin area, reported as AF/Acre) are listed in **Table 4**, and the basins with the highest total groundwater extraction (AF) are listed in **Table 5**. **Figure 8** depicts groundwater extractions (per area and total) for basins subject to SGMA for WY 2021. During WY 2021, over 18 million acre-feet of extraction was reported across the state within the 94 basins that submitted GSP/Alternative Annual Reports. The Kern County, Kings, and Kaweah basins in the San Joaquin Valley used the most groundwater, accounting for 2.5-, 2.3-, and 1-million-acre feet respectively. The greatest extraction per area, occurred in the Chowchilla, Fillmore, and Kaweah basins, with extraction rates of 2.57, 2.51, and 2.35 acre-feet per acre. The extraction volumes closely correlate to reported change in storage.

Table 4: WY 2021 Groundwater Extraction per Area by Basin. Top 10 basins as volume and normalized by basin area. Extraction values based on data reported through 2021 GSP/Alternative annual reports.

Basin (Top 10 ranked by groundwater extraction per area)	**Groundwater Extraction per Area (AF/Acre)**	Groundwater Extraction (AF)	Basin Area (Acres)
San Joaquin Valley – Chowchilla	**2.57**	374,360	154,574
Santa Clara River Valley – Fillmore	**2.51**	56,787	22,586
San Joaquin Valley – Kaweah	**2.35**	1,036,600	441,048
San Joaquin Valley – Kings	**2.34**	2,293,436	981,323
San Pasqual Valley	**1.91**	6,667	3,498
San Joaquin Valley – Tule	**1.86**	887,530	447,590
San Joaquin Valley – Madera	**1.72**	597,030	347,667
San Joaquin Valley – Turlock	**1.60**	557,200	348,187
Big Valley	**1.59**	800,754	512,606
San Joaquin Valley – Merced	**1.56**	267,980	184,917

Table 5: WY 2021 Groundwater Extraction by Basin. Top 10 basins as total volume. Extraction values based on data reported through 2021 GSP/Alternative annual reports.

Basin (Top 10 ranked by groundwater extraction)	**Groundwater Extraction (AF)**	Groundwater Extraction Rates (AF/Acre)	Basin Area (Acres)
San Joaquin Valley – Kern County	**2,471,156**	1.38	154,574
San Joaquin Valley - Kings	**2,293,436**	2.34	22,586
San Joaquin Valley - Kaweah	**1,036,600**	2.35	441,048
Sacramento Valley - Colusa	**977,230**	1.35	981,323
San Joaquin Valley - Tule	**887,530**	1.85	3,498
San Joaquin Valley - Eastern San Joaquin	**809,327**	1.06	447,590
San Joaquin Valley - Merced	**800,754**	1.56	347,667
San Joaquin Valley - Tulare Lake	**652,448**	1.22	348,187
Sacramento Valley - Yolo	**635,000**	1.17	512,606
San Joaquin Valley - Westside	**632,000**	1.02	184,917

Table 6 provides a list of the basins with the greatest change in groundwater in storage volume (AF) and **Table 7** lists basins with the greatest change in groundwater in storage per area (change in groundwater in storage normalized by basin area, reported as AF/Acre). **Figure 9** shows the reported change in storage for each of these basins for the same time period. During WY 2021, a 7.9 million acre-feet decrease of groundwater in storage was reported across the 94 basins. The Kern County, Kings, and Kaweah basins saw the greatest decrease of groundwater in storage, approximately 1.8 MAF, 890 TAF, and 520 TAF respectively. The Tulare Lake hydrologic region, where the greatest extraction and change in storage occur, also exhibits the highest percentage of wells with decreasing groundwater levels (**Figure 10**).

As the SGMA process continues and more data becomes available over time, trends and long-term analysis can be conducted at the basin scale to offer additional insight into water management across the state. Future semi-annual groundwater conditions reports will build upon newly available data from GSP/Alternative annual reports to draw insights to groundwater management across the state.

Table 6: WY 2021 Change in Storage per Area by Basin. Top 10 basins as a volume and normalized by basin area. Change in storage values based on data reported through 2021 GSP/Alternative annual reports.

Basin (Top 10 ranked by change in storage by area)	**Change in Storage per Area (AF/Acre)**	Change in Storage (AF)	Basin Area (Acres)
Santa Clara River Valley - Piru	**-3.53**	-38,500	10,897
Ventura River Valley - Upper Ventura River	**-1.56**	-8,240	5,278
Butte Valley	**-1.48**	-118,000	797,739
San Joaquin Valley - Kaweah	**-1.18**	-520,000	441,048
San Joaquin Valley – Kern County	**-1.02**	-1,812,211	1,782,318
Ojai Valley	**-1.01**	-5,950	5,913
San Joaquin Valley - Kings	**-0.91**	-890,000	981,323
San Joaquin Valley - Turlock	**-0.85**	-294,700	348,187
Sacramento Valley - Antelope	**-0.79**	-150,000	19,091
Sacramento Valley - South Yuba	**-0.74**	1,000	109,020

Table 7: WY 2021 Change in Storage by Basin. Top 10 basins as a volume and normalized by basin area. Change in storage values based on data reported through 2021 GSP/Alternative annual reports.

Basin (Top 10 ranked by total change in storage)	**Total Change In Storage (AF)**	Change In Storage Rates (AF/Acre)	Basin Area (Acres)
San Joaquin Valley - Kern County	**-1,812,211**	-1.02	10,897
San Joaquin Valley - Kings	**-890,000**	-0.91	5,278
San Joaquin Valley - Kaweah	**-520,000**	-1.18	797,739
Sacramento Valley - Colusa	**-418,000**	-0.58	441,048
Sacramento Valley - Yolo	**-390,000**	-0.72	1,782,318
San Joaquin Valley - Tule	**-343,000**	-0.72	5,913
San Joaquin Valley - Merced	**-318,880**	-0.62	981,323
San Joaquin Valley - Turlock	**-294,700**	-0.85	348,187
San Joaquin Valley - Delta-Mendota	**-289,700**	-0.38	19,091
Sacramento Valley - Red Bluff	**-164,000**	-0.60	109,020

Figure 8: Statewide Groundwater Extraction Reported by Basin map for one-year period between fall 2020 and 2021. See **Table 4** and **Table 5** for specific groundwater extraction statistics. Map and charts based on available data from GSP/Alternative annual reports of 02/01/2023.

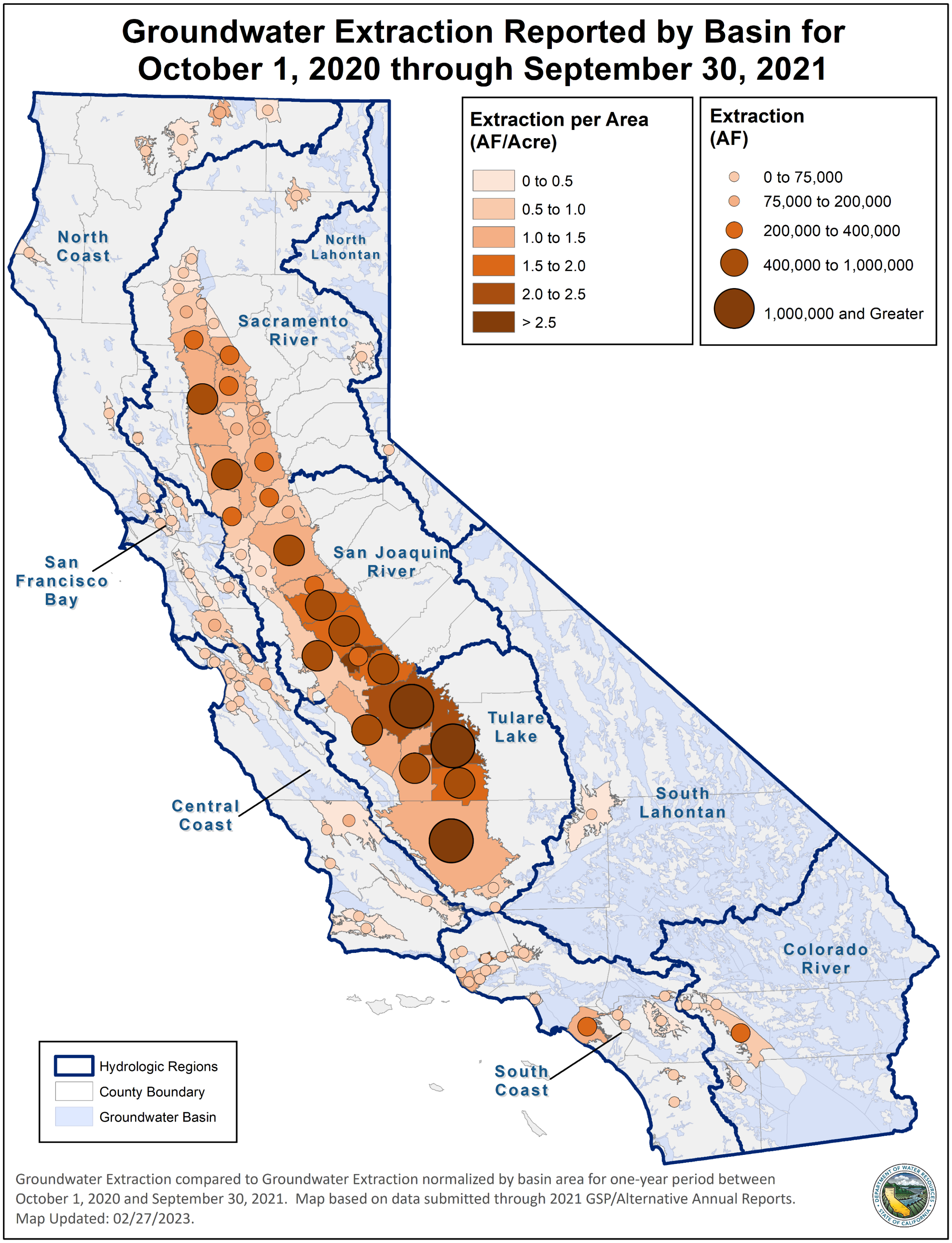


Figure 9: Statewide Groundwater Storage Reported by Basin map for one-year period between fall 2020 and 2021. See **Table 6** and **Table 7** for specific change in storage statistics. Map and charts based on available data from GSP/Alternative annual reports of 02/01/2023.

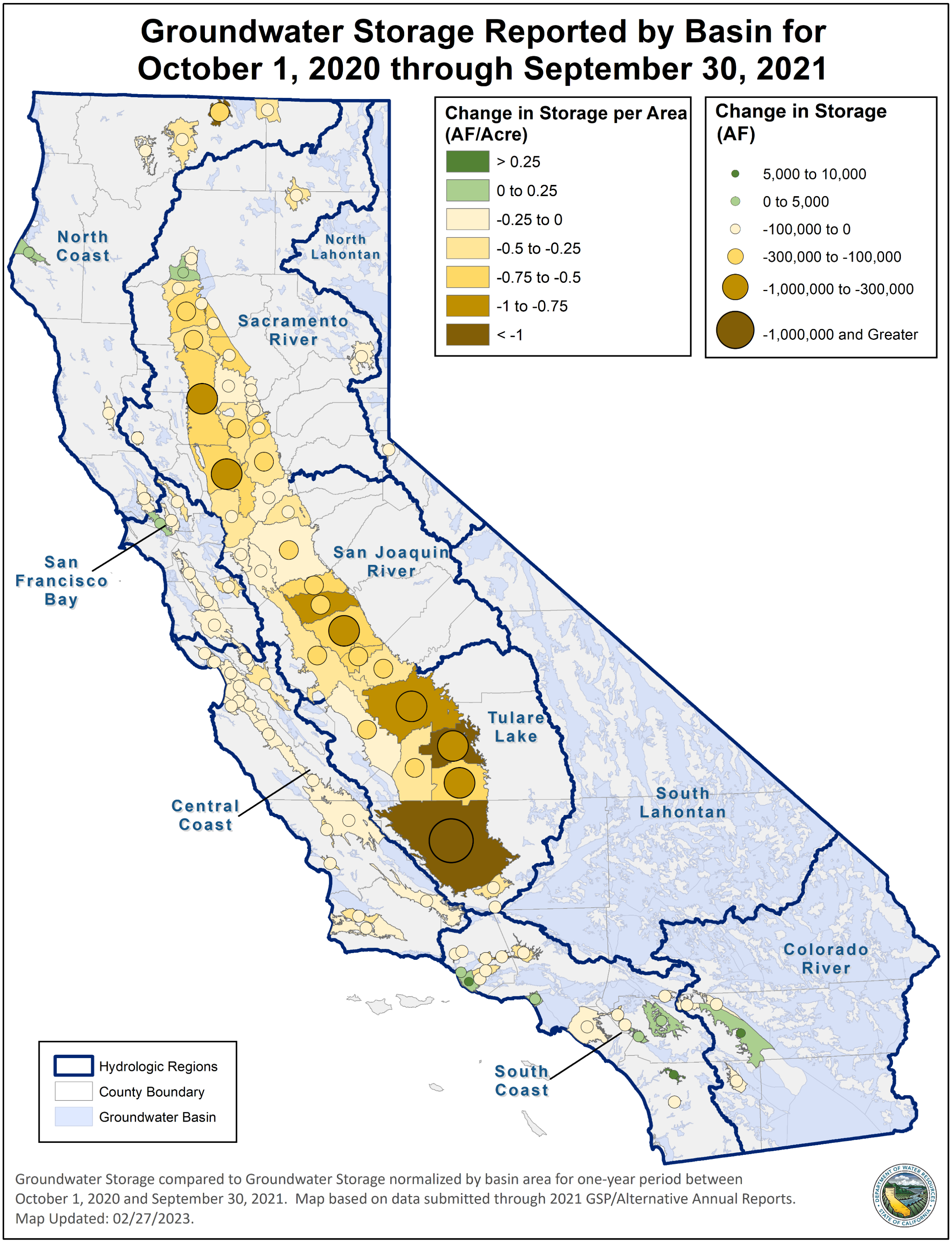
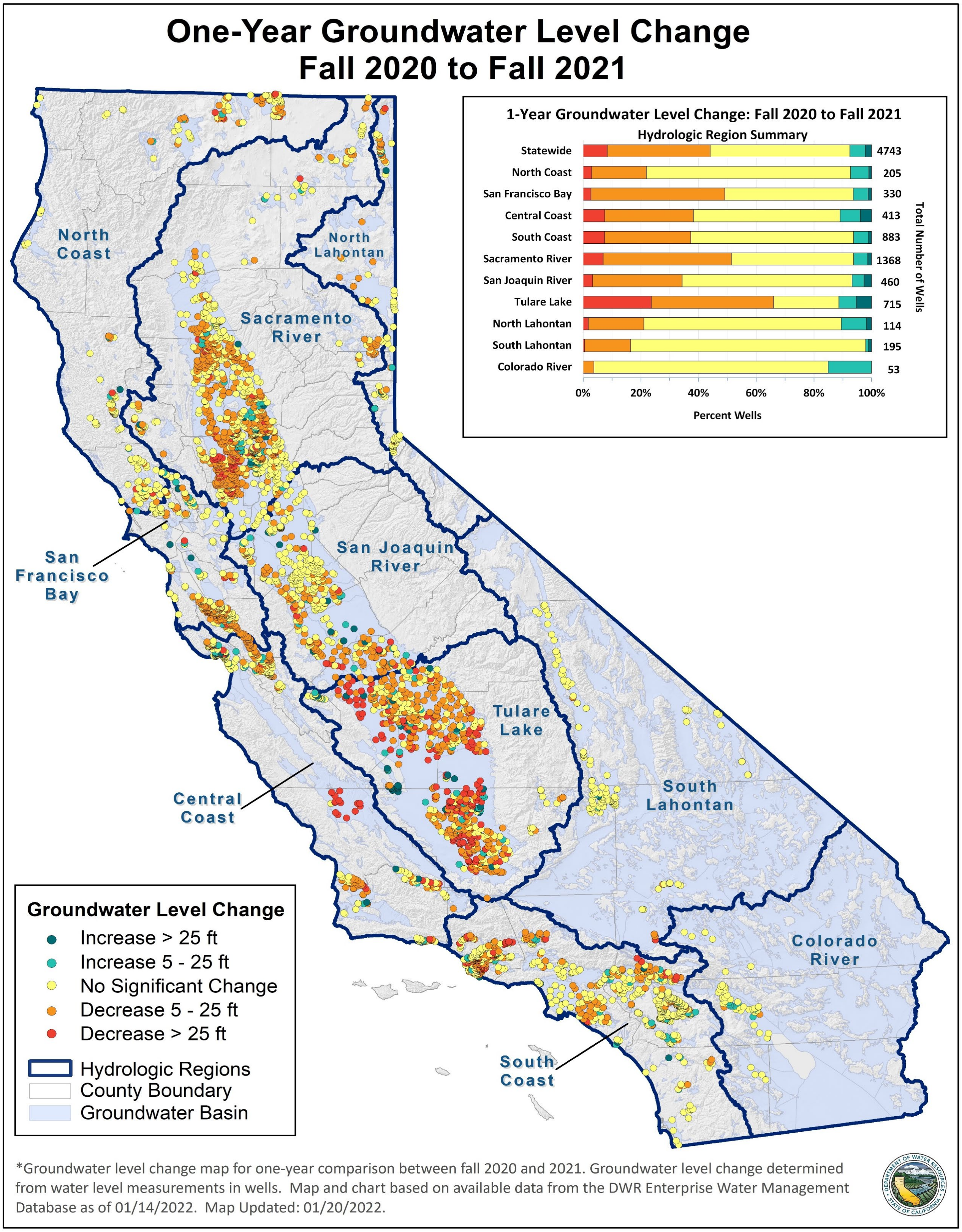


Figure 10: Statewide and hydrologic region groundwater level change map for one-year period between fall 2020 and fall 2021. Map and charts based on available data from DWR Water Data Library as of 02/01/2023.



Land Subsidence

Land subsidence has been documented throughout the last century in certain areas of the state resulting in over 30 feet of vertical displacement or "sinking" of the land surface in some areas. This has caused damage and reduced capacity to water conveyance infrastructure, reduced groundwater storage availability for future use, and caused damage to other critical infrastructure. Since 2015, there have been significant improvements to the state's subsidence monitoring network, most notably the processing and reporting of satellite based Interferometric Synthetic Aperture Radar (InSAR) data, which provides monthly subsidence data for more than 150 groundwater basins and covers about 40,000 mi^2. In response to a recent drought executive order to accelerate subsidence data collection and reporting, DWR has increased the reporting frequency of monthly InSAR data from annually to quarterly to provide more up-to-date information. Vertical ground surface displacement estimates are derived from the InSAR data that are collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA, under contract with DWR. This report includes figures, tables, and discussion of land subsidence data for WY 2022 in comparison to the most recent 5 years (WY 2018 through WY 2022). **Table 8** provides a summary of vertical displacement rates observed in the InSAR dataset in WY 2022 and for the period from WY 2018 through WY 2022.

Table 8: Total Area (in square miles) of Subsidence (Subs.) and Uplift Corresponding to Displacement Rate (ft/yr)

	Uplift >0.1 ft/yr	Subs. >0.1 ft/yr	Subs. >0.2 ft/yr	Subs. >0.4 ft/yr	Subs. >0.6 ft/yr	Subs. >0.8 ft/yr	Subs. >1 ft/yr
WY 18-22	23	4,276	2,323	990	400	17	0
WY 22	0	5,435	3,692	1,754	922	433	81

Three figures are provided in this report to display the location and magnitude of statewide land subsidence rates for the one-year period for WY 2022 (from October 2021 to October 2022) (**Figure 11**), for the 5-year period for WY 2018 through WY 2022 (from October 2017 to October 2022) (**Figure 12**), and for all individual years from WY 2016 through WY 2022 (**Figure 13**).

Figure 11 shows the annual rate of vertical displacement in feet/year for October 2021 to October 2022. Annual displacement rates are shown in seven categories: subsidence of 0.1-0.2 feet/year, 0.2-0.4 feet/year, 0.4-0.6 feet/year, 0.6-0.8 feet/year, 0.8-1 feet/year, and greater than 1 foot/year, and uplift of greater than 0.1 feet/year.

Figure 12 shows the average annual rate of vertical displacement in feet/year for October 2017 to October 2022. Annual displacement rates are shown in seven categories: subsidence of 0.1-0.2 feet/year, 0.2-0.4 feet/year, 0.4-0.6 feet/year, 0.6-0.8 feet/year, 0.8-1 feet/year, and greater than 1 foot/year, and uplift of greater than 0.1 feet/year.

Figure 13 shows statewide maps of the annual rate of vertical displacement in feet/year for all individual years from WY 2016 to WY 2022. Annual displacement rates are shown in seven categories: subsidence of 0.1-0.2 feet/year, 0.2-0.4 feet/year, 0.4-0.6 feet/year, 0.6-0.8 feet/year, 0.8-1 feet/year, and greater than 1 foot/year, and uplift of greater than 0.1 feet/year.

Figure 11: Statewide annual subsidence map for October 2021 to October 2022. See **Table 8** for specific subsidence level statistics. Map and charts based on available data from the CNRA Open Data as of 12/28/2022.

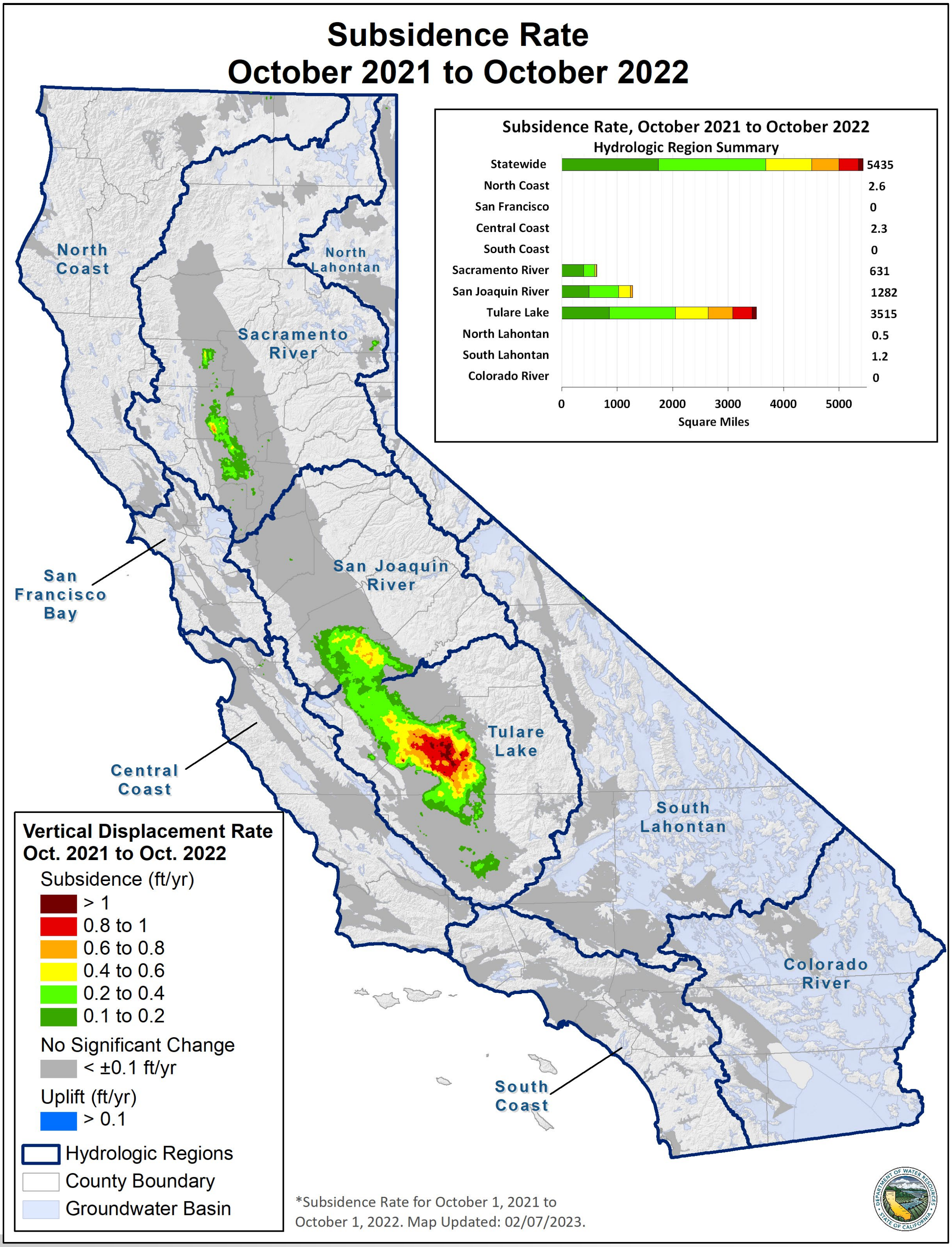


Figure 12: Statewide average annual subsidence map for October 2016 to October 2022. See **Table 8** for specific subsidence level statistics. Map and charts based on available data from the CNRA Open Data as of 12/28/2022.

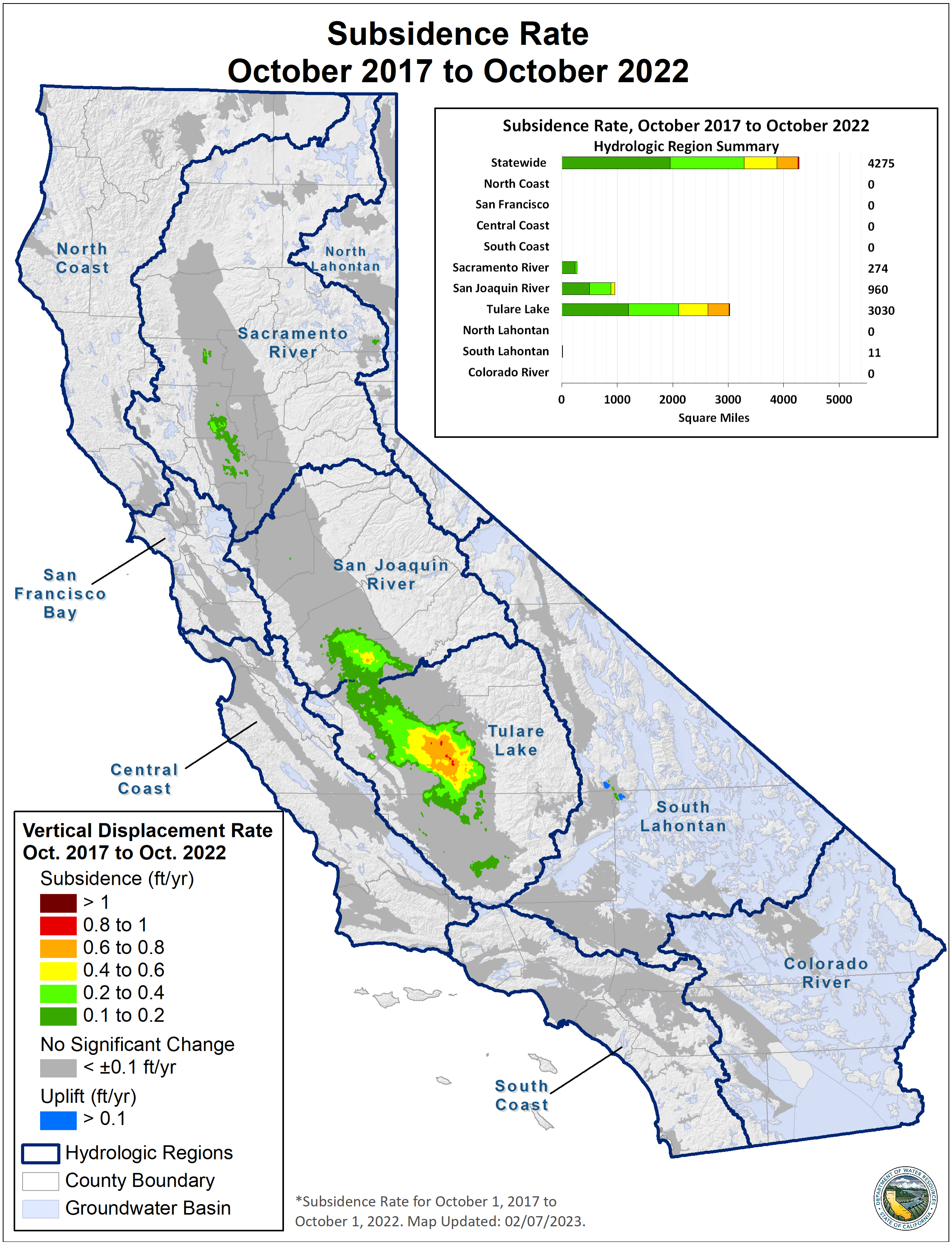
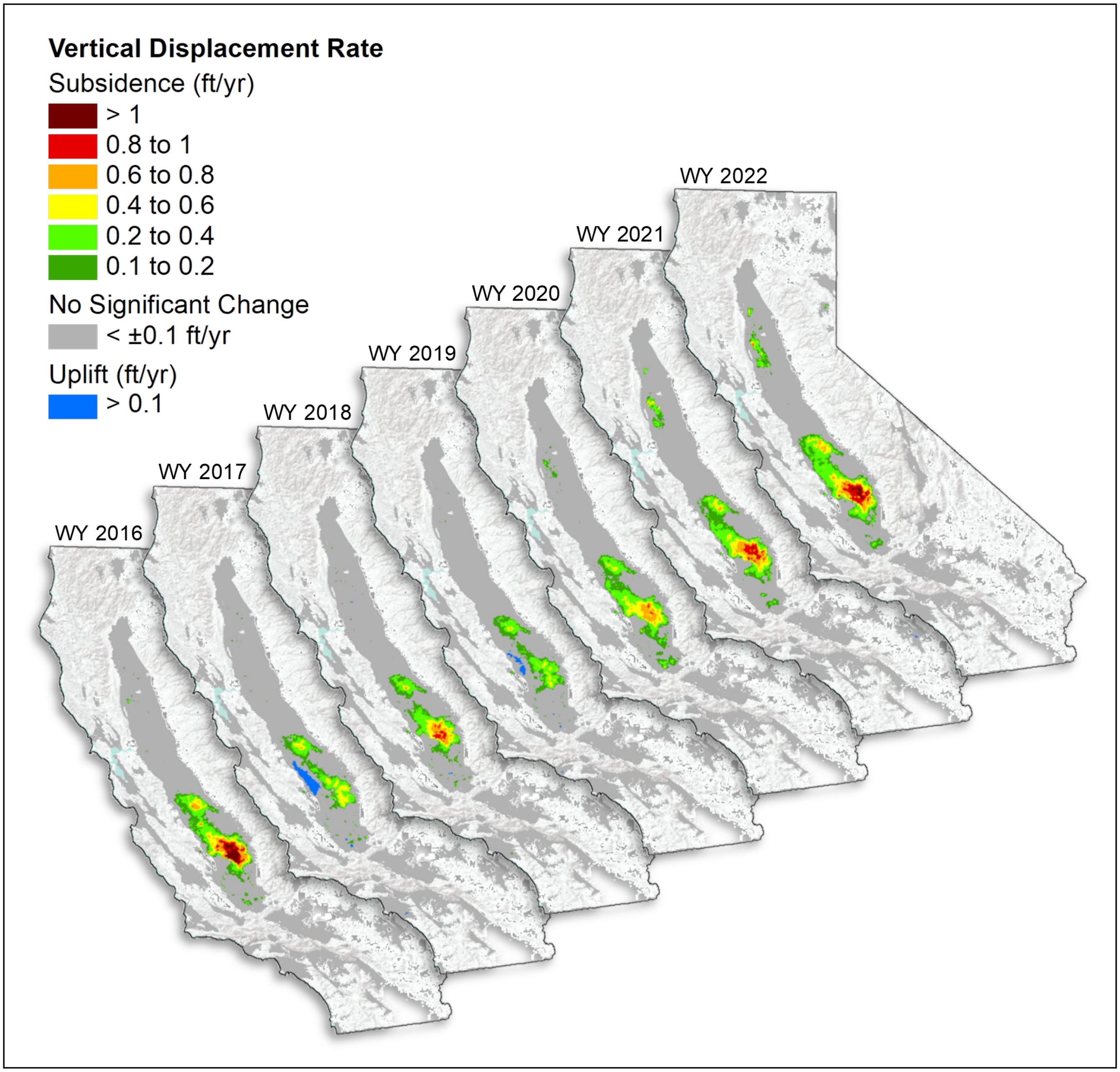


Figure 13: Statewide annual subsidence maps for WYs 2016 through 2022. Maps are based on available data from the CNRA Open Data as of 12/28/2022.



As observed during the previous 2012–2016 drought, increased groundwater extraction during the current drought is again resulting in accelerated land subsidence in parts of the Central Valley. For the October 2021 to October 2022 period, statewide data show a total area of about 5,400 square miles with recorded subsidence greater than 0.1 feet, and about 80 square miles recording greater than 1 foot of subsidence. The Tulare Lake Hydrologic Region has the most areas of subsidence with about 3,500 square miles of area experiencing greater than 0.1 feet of subsidence during the October 2021 to October 2022 period, followed by the San Joaquin River Region with about 1,300 square miles, and the

Sacramento River Region with about 600 square miles. Of those Regions, the Sacramento River Region experienced the greatest relative increase in areas of subsidence with rates greater than 0.1 feet per year compared to the average rate over the last 5 years.

Well Infrastructure

Many factors influence the type and number of groundwater extraction wells (well infrastructure) drilled in California, such as climate conditions, surface water supplies, groundwater level changes, legislative actions, age of the well and other local conditions. Well completion reports (WCR) are submitted to DWR through the Online System for Well Completion Reports (OSWCR) when a well is installed, replaced, or destroyed. California Water Code Section 13751 requires that WCRs be submitted to DWR within 60 days of the completion of the work. As such, there is up to a 2-month delay in the reporting of well construction information. This report includes a summary of data submitted to OSWCR over the last eight water years (2015 – 2022) for groundwater extraction wells classified as domestic or irrigation wells, as well as an accounting of reported well installations for the period of October 1, 2022, through January 31, 2023, based on data available through OSWCR on February 1, 2023.

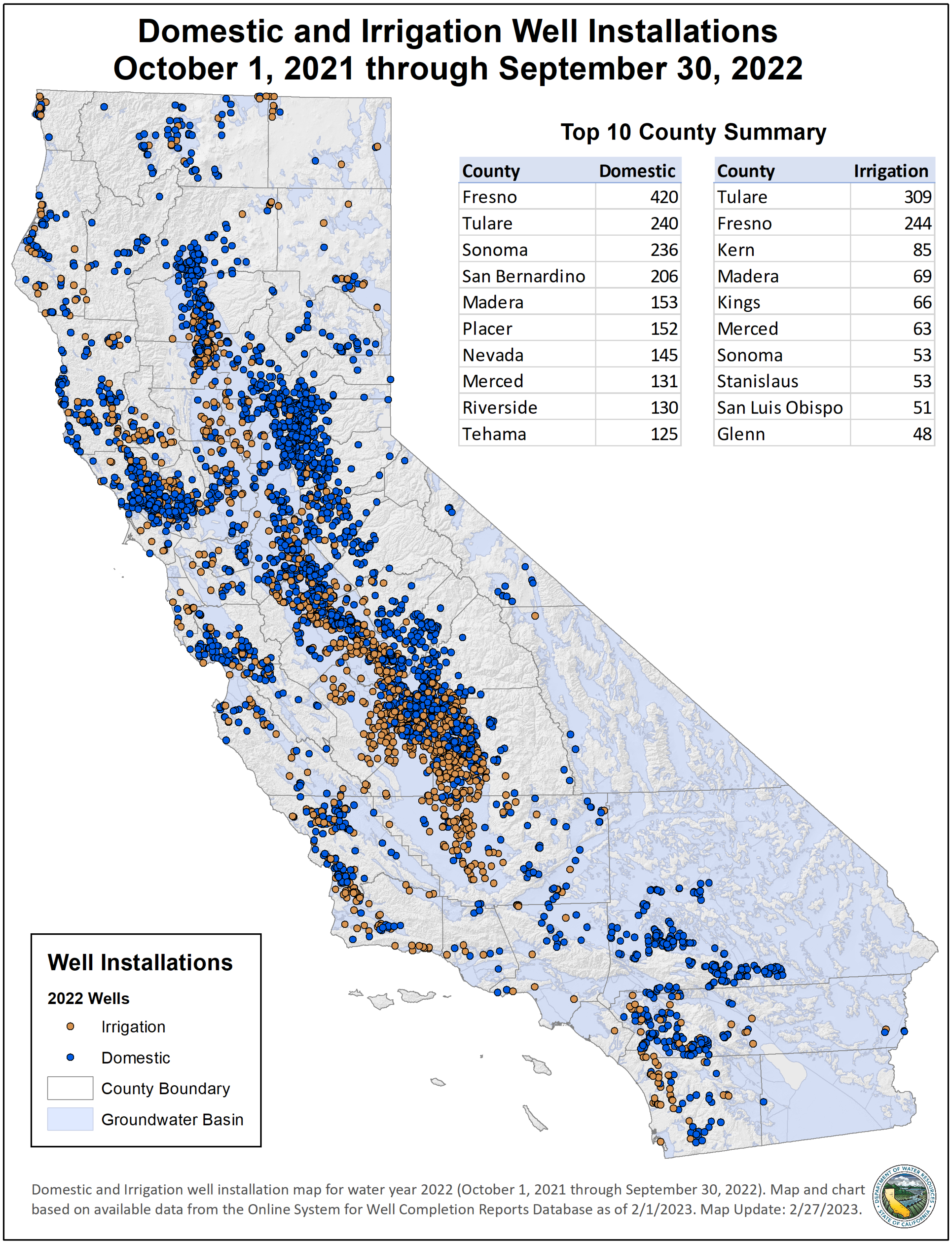
This report also provides an eight-year summary of dry water wells reported by members of the public to DWR's Dry Well Reporting System. Reporting is voluntary, so the actual numbers of dry wells and/or the number of resolved dry wells may be higher than what is reported in the database.

An 8-year summary and year-to-year statistics of domestic, irrigation, and dry wells are provided in **Table 9**. The data go back to the WY 2015, which captures the end of the previous drought (2012 – 2016). The total number of domestic and irrigation wells installed since 1977 are also provided for context. The water year type designations shown here are based on the San Joaquin Valley Water Year Hydrologic Classification Index, because no statewide water-year type index currently exists. **Figure 13** shows the domestic and irrigation wells installed during the WY 2022 and **Figure 14** shows the same information for the past 5 water years (2018 – 2022). As stated in the Introduction, WY 2022 groundwater data used in this semi-annual report includes data received electronically by DWR as of January 31, 2023.

Table 9: Statewide Summary of Newly Installed Domestic and Irrigation Wells and Number of Dry Well Reporting. *Dry Well Reporting started in 2013, whereas the database of WCRs for domestic and irrigation wells are considered to be complete since 1977

Type of Wells	Total since 1977*	8 Year Total (WY 2015 to WY 2022)	5 Year Total (WY 2018 to WY 2022)	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020	WY 2021	WY 2022	WY 2023 through January 31, 2023
				Critical	Dry	Wet	Below Average	Wet	Dry	Critical	Critical	TBD
Domestic Wells	278,775	26,782	15,715	3,527	4,409	3,131	2,635	2,743	3,002	3,599	3,736	769
Irrigation Wells	61,067	14,534	5,561	3,041	2,867	1,487	1,116	1,334	1,334	1,777	1,578	280
Dry Wells Reported	5,345	4,669	2,515	1442	546	166	86	46	75	814	1,494	297

Figure 14: Statewide newly installed domestic and irrigation wells map for WY 2022. See **Table 9** for specific well data. Map and charts based on available data from the CNRA Open Data as of 01/31/2023.

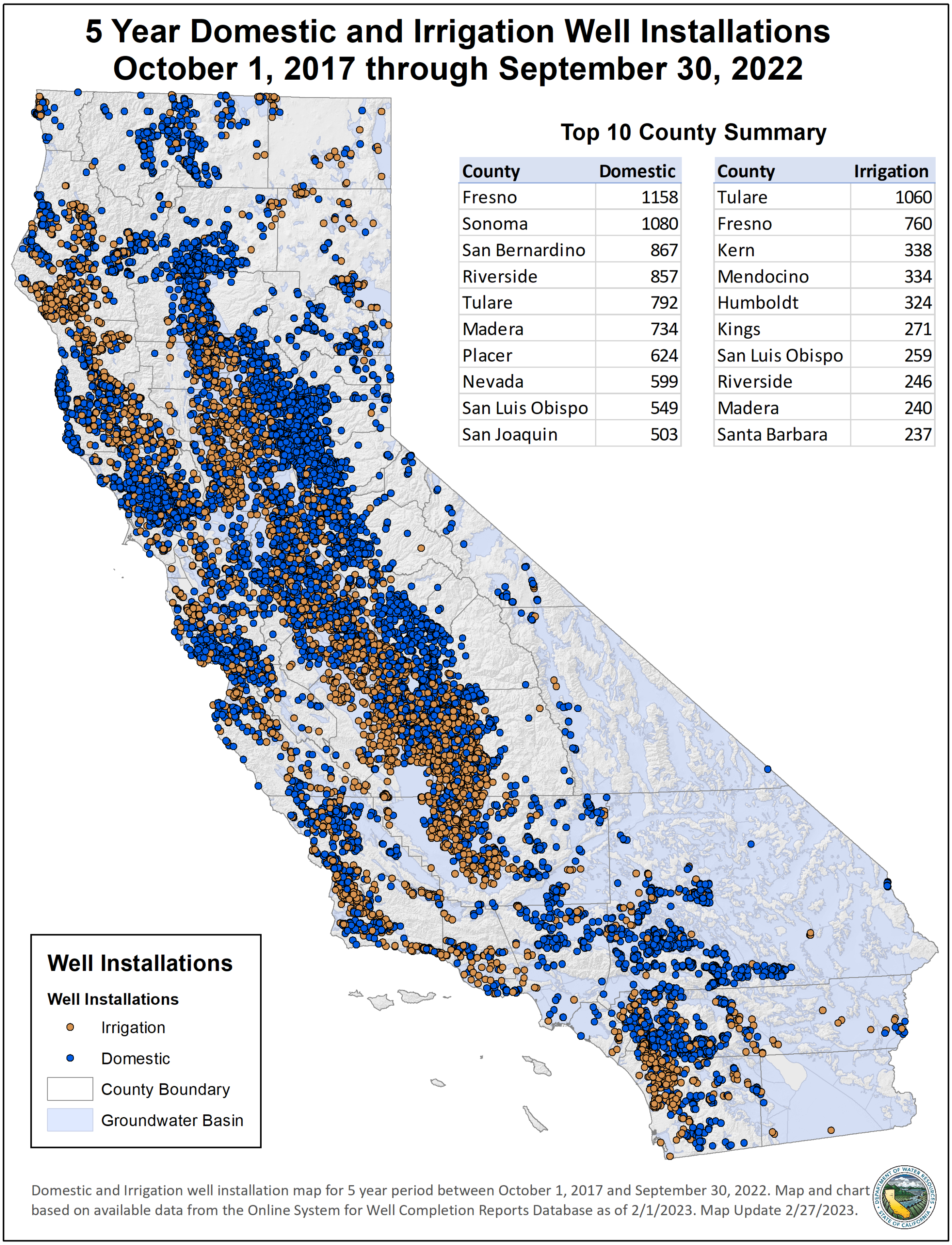


County	Domestic
Fresno	420
Tulare	240
Sonoma	236
San Bernardino	206
Madera	153
Placer	152
Nevada	145
Merced	131
Riverside	130
Tehama	125

County	Irrigation
Tulare	309
Fresno	244
Kern	85
Madera	69
Kings	66
Merced	63
Sonoma	53
Stanislaus	53
San Luis Obispo	51
Glenn	48

Domestic and Irrigation well installation map for water year 2022 (October 1, 2021 through September 30, 2022). Map and chart based on available data from the Online System for Well Completion Reports Database as of 2/1/2023. Map Update: 2/27/2023.

Figure 15: Statewide newly installed domestic and irrigation wells map for 5-year period from WY 2018 through 2022. See **Table 9** for specific well data. Map and charts based on available data from the [CNRA Open Data](#) as of 01/31/2023.



County	Domestic
Fresno	1158
Sonoma	1080
San Bernardino	867
Riverside	857
Tulare	792
Madera	734
Placer	624
Nevada	599
San Luis Obispo	549
San Joaquin	503

County	Irrigation
Tulare	1060
Fresno	760
Kern	338
Mendocino	334
Humboldt	324
Kings	271
San Luis Obispo	259
Riverside	246
Madera	240
Santa Barbara	237

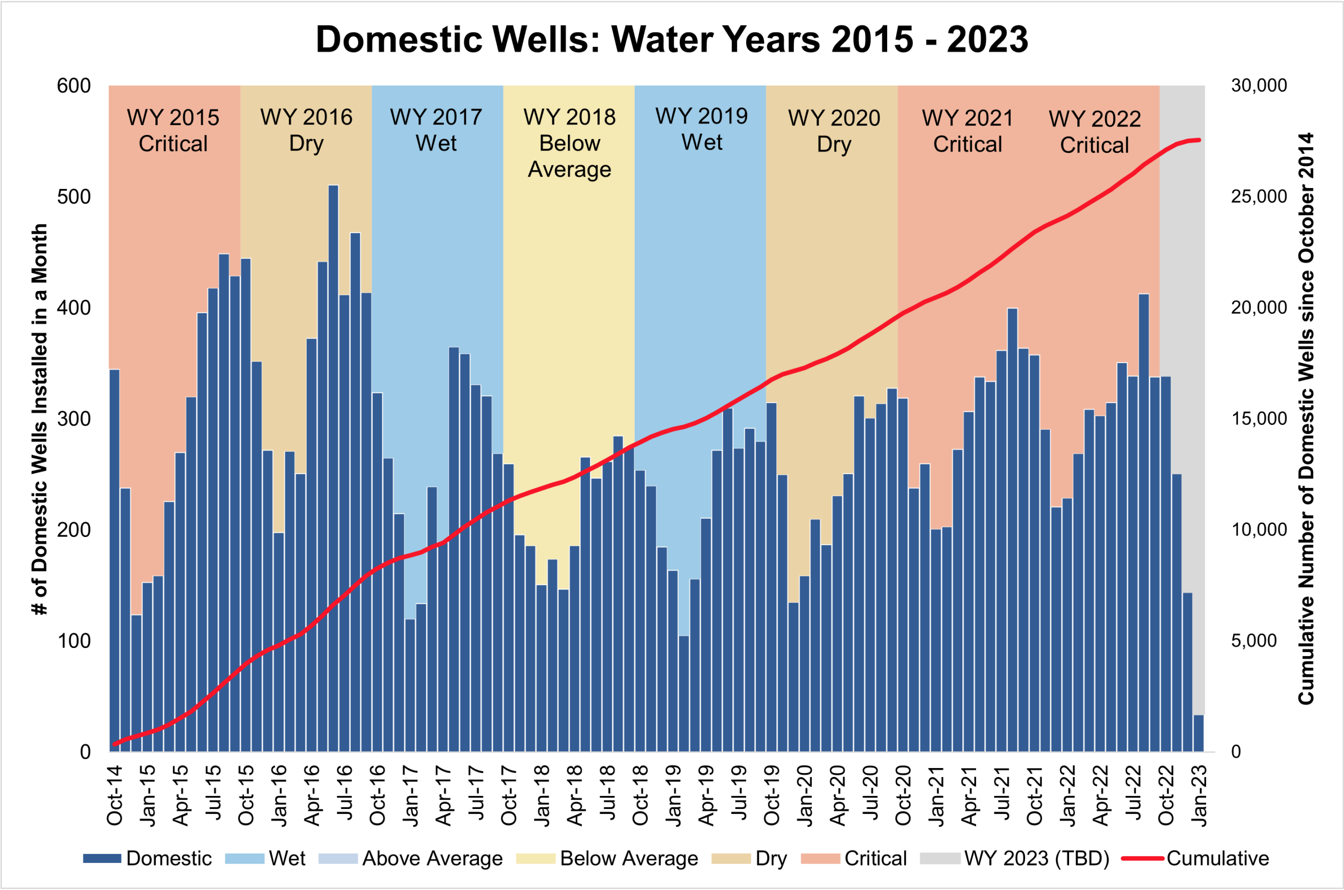
Domestic Wells

Domestic (household) wells provide water to millions of people throughout California. During the WY 2022, a total of 3,736 new domestic wells were reported to be installed in the state. During the last eight water years (since October 2014), a total of 26,782 domestic wells have been installed, accounting for approximately 10% of the total 278,755 domestic wells installed since 1977. The year-to-year number of new domestic wells has fluctuated from a low of 2,635 in WY 2018 to a high of 4,409 in WY 2016. Since the beginning of the WY 2023 (October 1, 2022, through January 31, 2023), 769 new domestic wells were reported to be installed in the state.

The location of new domestic and irrigation wells installed in California during the WY 2022 is shown in **Figure 14**. The counties with the highest number of new domestic wells were Fresno (420), Sonoma (240), and Tulare (236). The spatial distribution shows numerous domestic wells being installed outside of the 515 groundwater basins, in volcanic and fractured rock aquifers across the state, highlighting the dependence on groundwater in these areas. The trend for new well installations during the WY 2022 is consistent with the spatial distribution seen over the past 5 water years, as shown in **Figure 15**.

A monthly timeseries of new domestic well installations since October 2014 is presented in **Figure 16** along with a cumulative graph. The number of new domestic wells is typically influenced by changes in populations and new home construction, which is strongly influenced by economic cycles. New domestic wells could also be replacement wells for wells that went dry during a drought.

Figure 16: Monthly Domestic Well Installations with Cumulative Curve (October 2014 through January 2023)



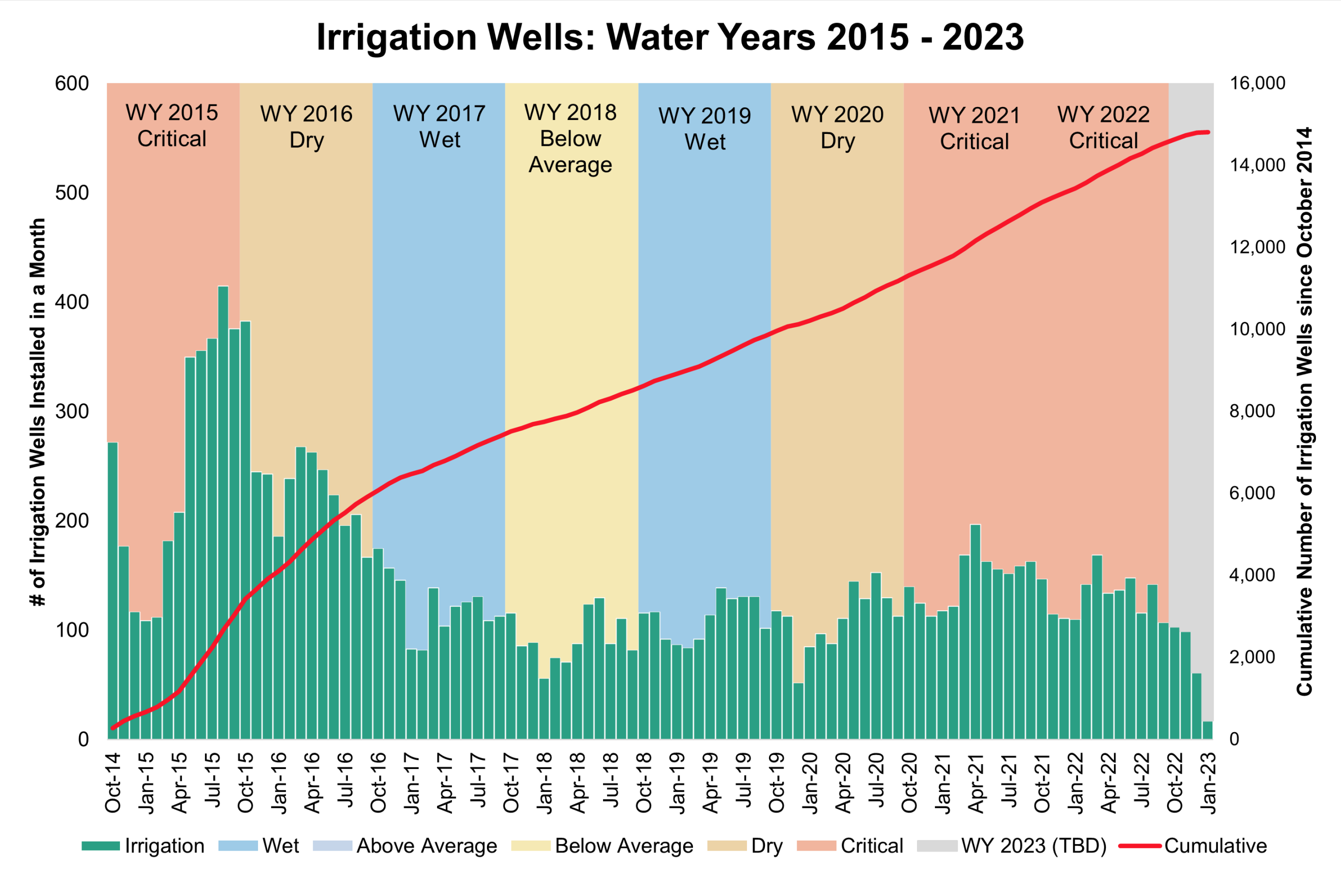
Irrigation Wells

Irrigation wells typically have higher capacity and pump more groundwater than do domestic wells to provide water to farms that feed millions of people throughout California and the world. During WY 2022, a total of 1,578 new irrigation wells were reported to be installed in the state. Over the last eight full water years since October 2014, a total of 14,534 irrigation wells have been installed across the state, accounting for approximately 24 percent of the 61,067 irrigation wells installed statewide since 1977. The year-to-year number of new irrigation wells has fluctuated from a low of 1,116 in WY 2018 to a high of 3,041 in WY 2015. Since the beginning of the WY 2023 through January 2023, 280 new irrigation wells were reported to be installed in the state.

Figure 14 shows the location of newly installed irrigation wells in WY 2022. New irrigation wells that have been installed in California are much less geographically spread throughout the state when compared with the geographic spread of domestic wells. In WY 2022, Tulare County had more new irrigation wells (309) installed than any other county in the state, accounting for approximately one out of every five new irrigation wells (19 percent). Neighboring Fresno County (244) and Kern County (85) ranked 2nd and 3rd respectively for most new irrigation well installations. These three counties combined account for 40 percent of all new irrigation wells installed in WY 2022. In contrast, 29 California counties had less than 10 new irrigation wells installed, and seven counties had no new irrigation wells installed in WY 2022. Looking back at the past 5 water years, Tulare, Fresno, and Kern County have seen the most irrigation well installations, similar to the trend in 2022. Mendocino and Humboldt County in the North Coast had the 4th and 5th most irrigation wells installed over the past 5 years as show in **Figure 15**. In 2022, the majority of irrigation wells were installed in the Central Valley.

A monthly timeseries of new installations of irrigation wells since October 2014 is presented in **Figure 17**, along with a cumulative graph. Installation trends for new irrigation wells reflect changes in annual precipitation and drought conditions but may also be influenced by other factors such as local and state ordinances, laws, or executive orders, cropping trends, irrigation methods, or the availability of alternative agricultural water supplies. A combined total of 5,908 new irrigation wells were installed during WY 2015 and WY 2016 towards the end of the 2012 – 2016 drought. This also coincides with the enactment of SGMA in 2014 and the most severe drought conditions during that time period. Since then, the annual trend of irrigation well installations has remained relatively stable, with small uptick during WY 2021 and WY 2022 in response to the continuing drought. The 1,578 irrigation wells installed in WY 2022 is about half as many as were installed in WY 2016. This is likely a result of drought actions related to well permitting.

Figure 17: Monthly Irrigation Well Installations with Cumulative Curve (October 2014 through January 2023)



Dry Well Reporting

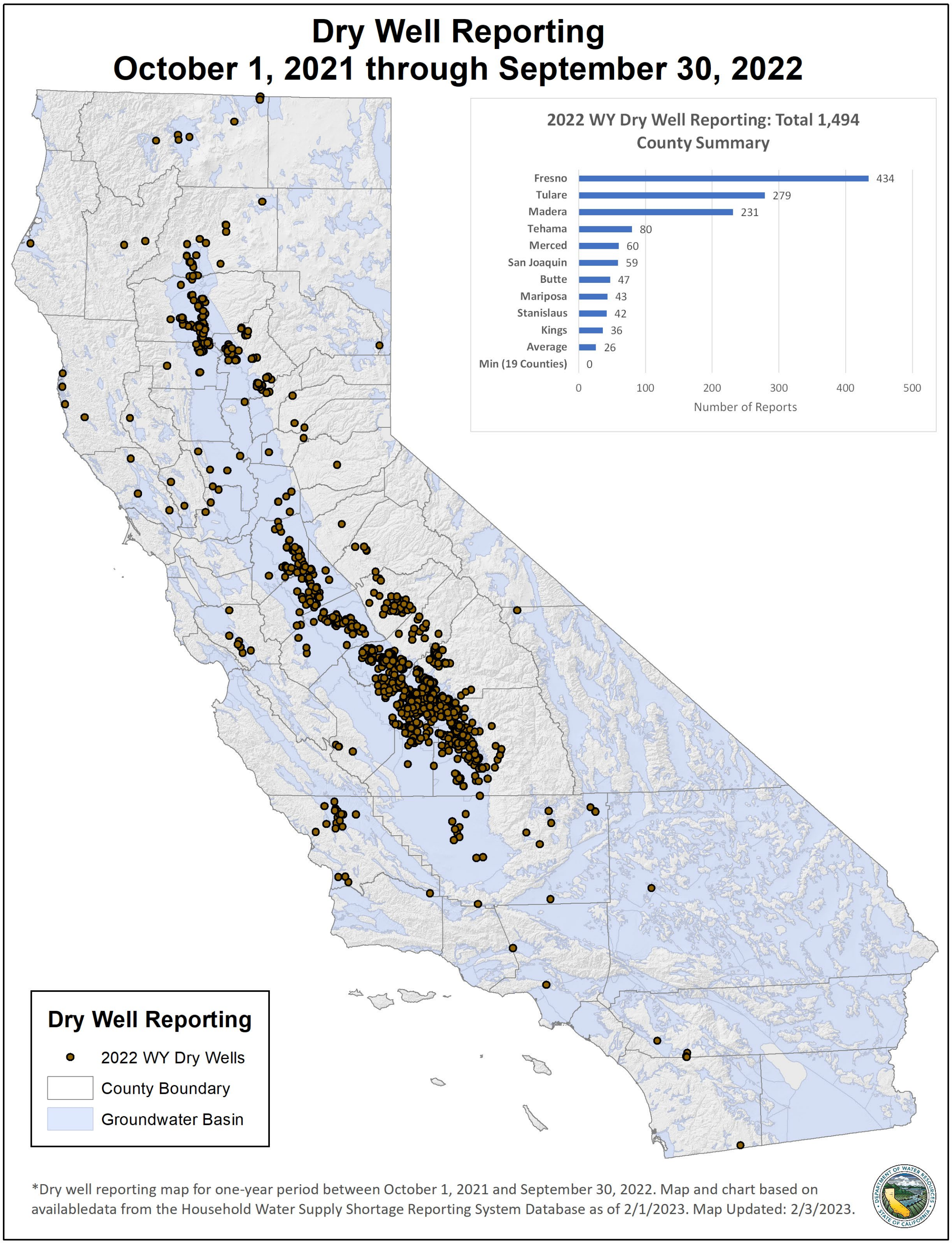
Dry well reporting is an important tool to track areas where changes in local groundwater conditions may be impacting beneficial uses and users of groundwater in California for household water uses. It is also a key indicator of areas where drought assistance is most needed. As California continues to experience climate-driven severe drought conditions, leading to less available precipitation and snowmelt, and extreme heat, Californians rely heavily on groundwater to meet their water supply needs. Reports of dry wells naturally increase during extended dry periods as groundwater use increases and groundwater levels decline.

DWR manages the [Dry Well Reporting System] where Californians experiencing problems with their private, self-managed wells that are not served by a public water system can voluntarily report dry wells and be connected with entities providing local assistance for drought. DWR's Dry Well Reporting System was originally developed during the 2012-2016 drought. Based on feedback from counties, the system has been updated to directly and immediately notify local agencies, including county officials, water agencies, and GSAs, when household water supply well outages are reported in their region. The system helps centralize and disseminate information statewide when well outages are reported. This centralized reporting system helps ensure that local and State agencies are quickly notified and can respond to provide available resources such as interim water supplies or appropriate funding sources to help address the issues. Dry well reports submitted to the Dry Well Reporting database can document a new domestic well that went dry or a resolution to a previously reported dry well. Since the system has been updated, more dry well reports are likely being submitted to the Dry Well Reporting database than were submitted in the past. DWR provides a statewide statistical summary of locally reported dry wells on the Dry Well Reporting System website. The summary includes a cumulative report of dry wells by county, a map showing the statewide distribution of dry wells, and an accounting of dry wells reported to the state by quarter from 2013 to present.

The submission of these dry well reports is voluntary so the data may not represent the actual number of dry wells occurring across the state, only the ones submitted to the Dry Well Reporting System. This report includes a summary of data submitted to the Dry Well Reporting System over the last eight water years (2015 – 2022) as well as an accounting of reported dry wells for the WY 2023 through January 31, 2023, based on data available in the system on February 1, 2023.

In WY 2022, a total of 1,494 new dry well reports were received by DWR compared to 814 in WY 2021. The 1,494 dry well reports is the most in any single year since the dry well reporting program started in 2013. Since the beginning of the WY 2023 through January 31, 2023, 297 new dry wells have been reported. A total of 4,669 new dry well reports were received over the last eight full years (2015-2022), and a total of 5,358 dry well reports have been received since 2013. The year-to-year number of dry well reports has fluctuated from a low of just 46 in WY 2019 to a high of 1,494 in WY 2022. For full year-to-year statistics of dry well reporting over the last eight-years see **Table 9**. The locations of reported dry wells in WY 2022 are shown in **Figure 18**.

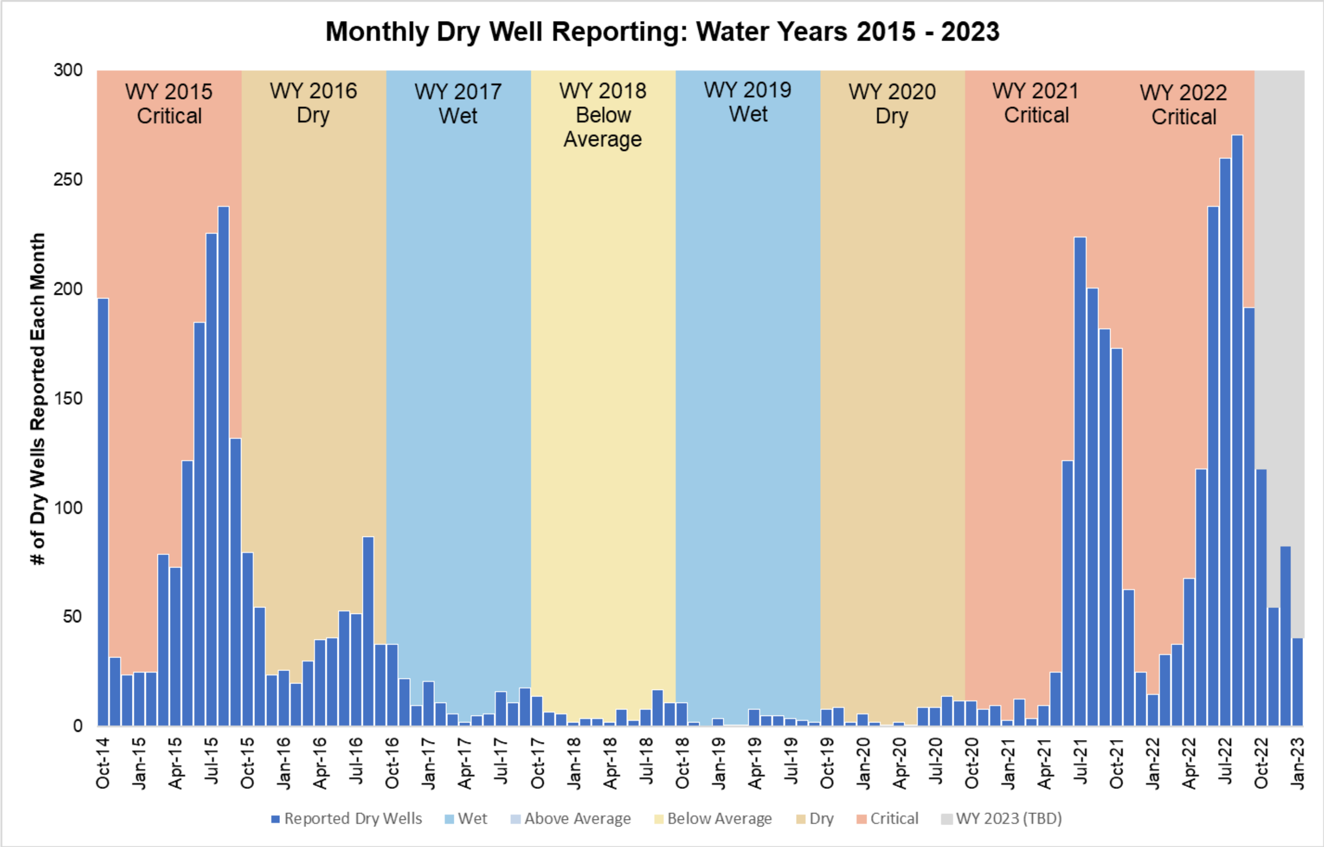
Figure 18: Statewide one-year reported dry wells map for WY 2022. Map and charts based on available data from the CNRA Open Data as of 02/1/2023.



In WY 2022, the highest number of dry well reports were received in Fresno County (434), Tulare County (279), and Madera County (231). These three counties account for approximately two out of every three dry well reports (63 percent) received statewide in WY 2022. Twenty-four counties reported between 1 and 10 dry wells and 19 counties reported zero dry wells.

The statewide trend for dry well reporting over the past eight water years (2015-2022) shows a correlation between extended dry periods and the number of dry well reports. More dry wells were reported during the critical years of 2015, 2021, and 2022 than any other period. **Figure 19** shows a monthly timeseries of dry well reports from October 2014 to January 2023.

Figure 19: Monthly Dry Well Reporting (October 2014 through January 2023)

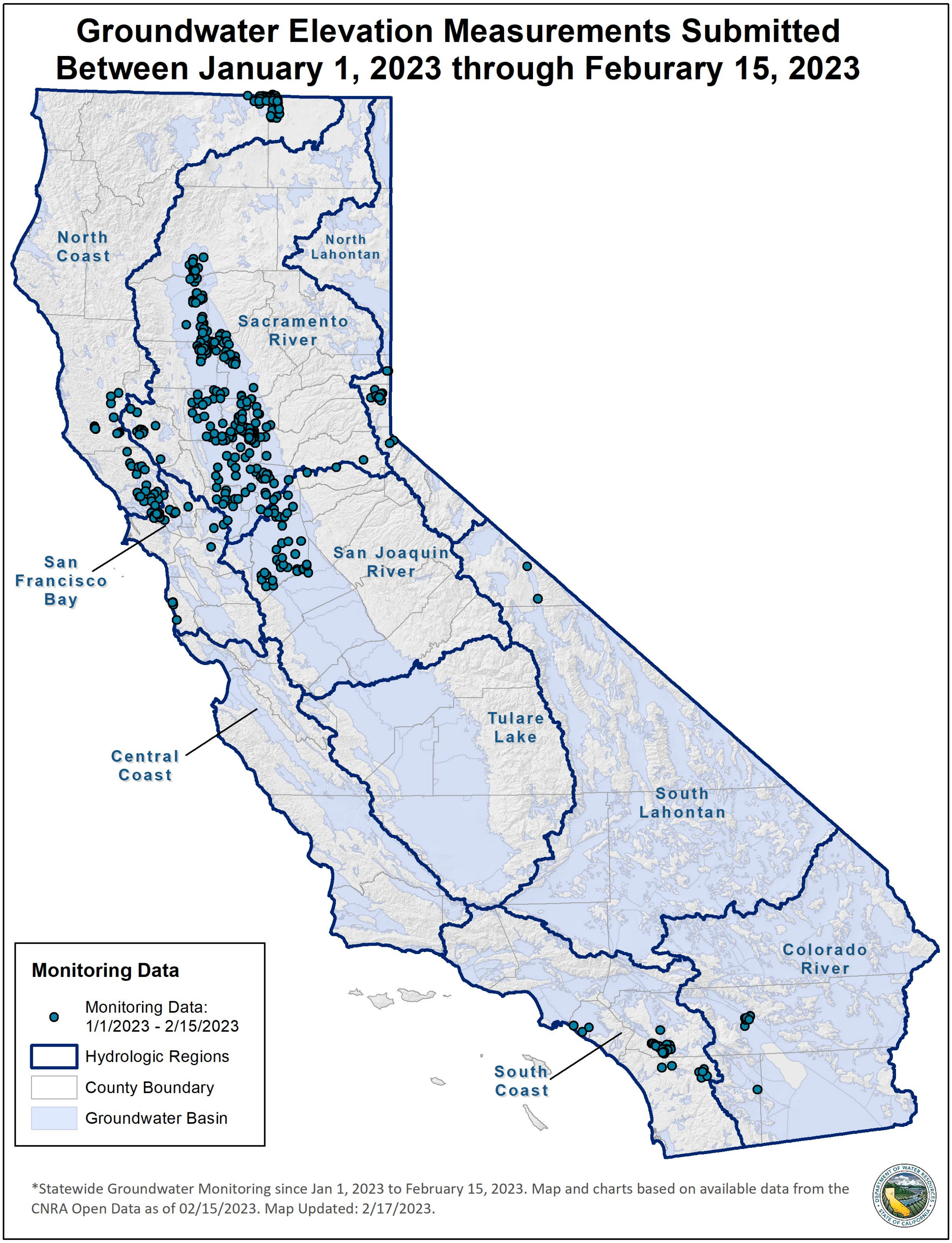


Current Events in Groundwater Conditions

Even with recent storms and natural recharge occurring, current groundwater conditions are difficult to report due to limitations in data collection and reporting. High frequency groundwater level data collection and reporting is necessary for understanding real-time conditions. Measuring groundwater levels regularly and at high frequencies provides critical information on the supply and conditions of groundwater.

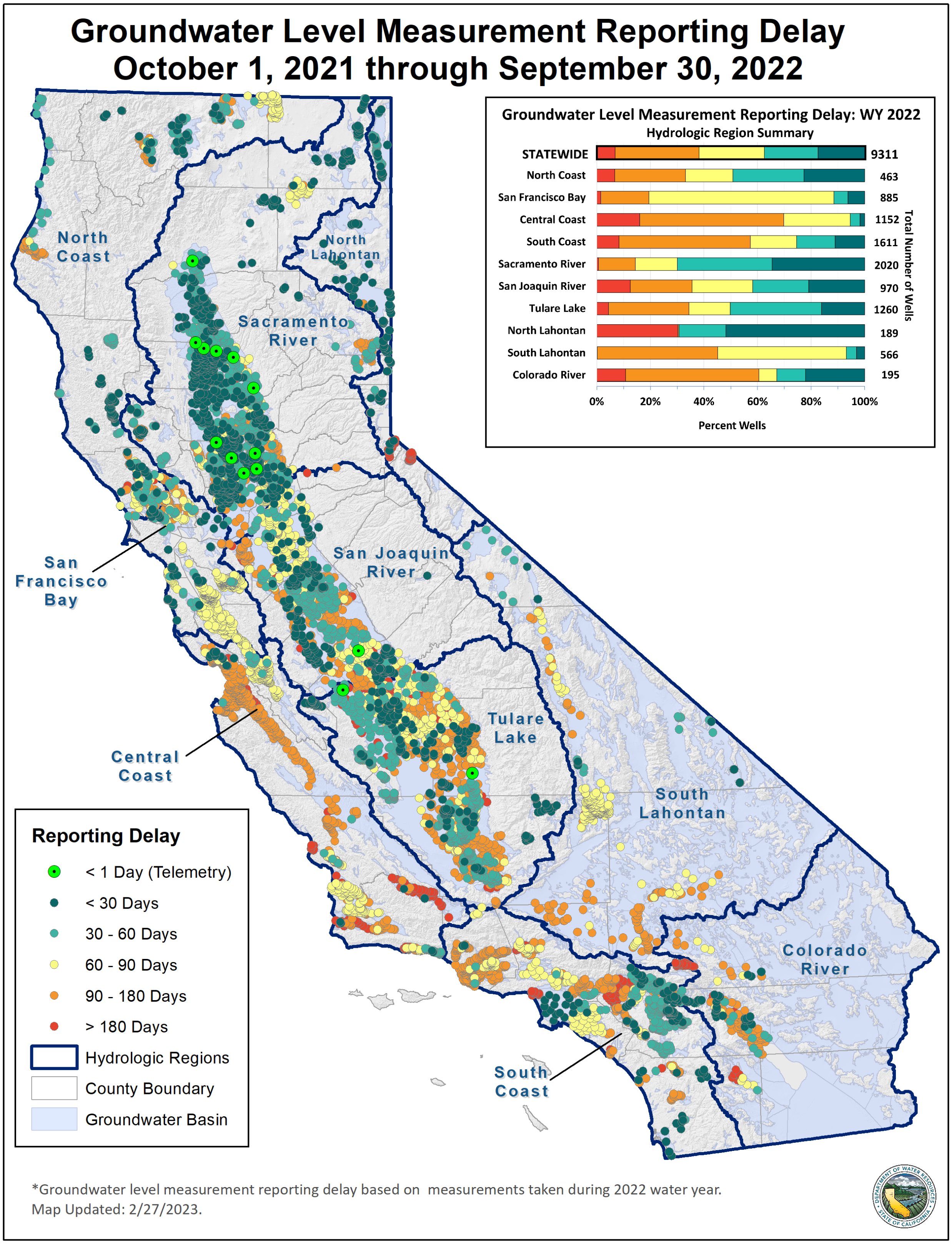
Figure 20 is a map of wells reporting groundwater level measurements collected between January 1 and February 15, 2023. The 601 wells measured during this time period account for about 6% of total wells (9,311) measured and reported during the WY 2022. Most of these wells are located within the northern half of the state within the Sacramento River, North Coast, and portions of the San Joaquin River and South Coast hydrologic regions. The remaining hydrologic regions may have collected groundwater level measurements but have not yet reported groundwater level data to DWR. Furthermore, some regions may not collect or report any groundwater level data for winter 2022/23. A total of 840 measurements were collected from the 601 wells shown, 464 of which were collected by DWR. The limited temporal and spatial coverage of the data makes it difficult to draw any conclusions on recent groundwater conditions such as the groundwater level response to the storms of January 2023.

Figure 20: Statewide groundwater level data reported for data collected between January 1 and February 15, 2023. Map based on available data from the CNRA Open Data as of 02/15/2023.



An evaluation of groundwater level data collection and submittal was completed for WY 2022. **Figure 21** shows the data reporting lag for measurements collected from wells throughout the state, based on data received by DWR in the WY 2022. The figure presents the average number of days between the measurement date and submittal date for measurements collected from a well. The submittal lag time is divided into groups of 0 to 30 days, 30 to 60 days, 60 to 90 days, 90 to 180 days, and over 180. Real-time data collected from telemetered monitoring sites are highlighted on the map. The average time to submit groundwater level data to DWR for WY 2022 was about 85 days after collection. Seventeen percent of wells reported monitoring data within 30 days of the measurement date and 37% of wells report data within 60 days of measurement. Nearly 24% of wells take between 60 and 90 days to report recorded data and 38% of wells take over 90 days. These delays in data reporting inhibit the ability to draw conclusions on recent events as the data is often unavailable.

Figure 21: Statewide Groundwater Level Measurement Reporting Delay for WY 2022. Map and charts based on available data from the CNRA Open Data as of 02/01/2023.



In addition to the time it takes to report groundwater data, the frequency at which measurements are taken also plays a role in accurately portraying current conditions. **Figure 22** shows the monitoring frequency of wells throughout the state based on the WY 2022. Data collection frequency was calculated based on the number of measurements taken at each well in WY 2022. Of the 9,311 wells shown on the map, over the data collection for 64% is semi-annually to quarterly, 22% is monthly to bi-monthly, 2% is weekly, and 1% is daily or continuously. 12% of the wells only recorded 1 measurement during the year.

Figure 23 is a sample hydrograph that shows how disparities in data collection frequency can mischaracterize groundwater level highs and lows. Under most conditions, the regional groundwater response to recharge and extraction is slow enough that continuous monitoring is not necessary. With monthly data collection some of the smaller fluctuations in groundwater elevation could be missed, however in most cases monthly collection is sufficient for capturing seasonal highs and lows and long-term trends in groundwater levels. Semi-annual data collection is the most common frequency across the state but is also the least representative of seasonal groundwater conditions. Semi-annual collection is useful for capturing the trends and behavior of the aquifer, the ability to capture the actual peaks and valleys requires careful timing of groundwater level measurements. As shown in **Figure 22**, the monthly measurements closely mirror the data captured by the continuous data collection. In the hydrograph shown in **Figure 22**, semi-annual measurements taken in the spring (April) and fall (October) fail to capture the true highs and lows of groundwater conditions.

Figure 22: Statewide Groundwater Level Measurement Collection Frequency for WY 2022. Map and charts based on available data from the [CNRA Open Data] as of 02/01/2023.

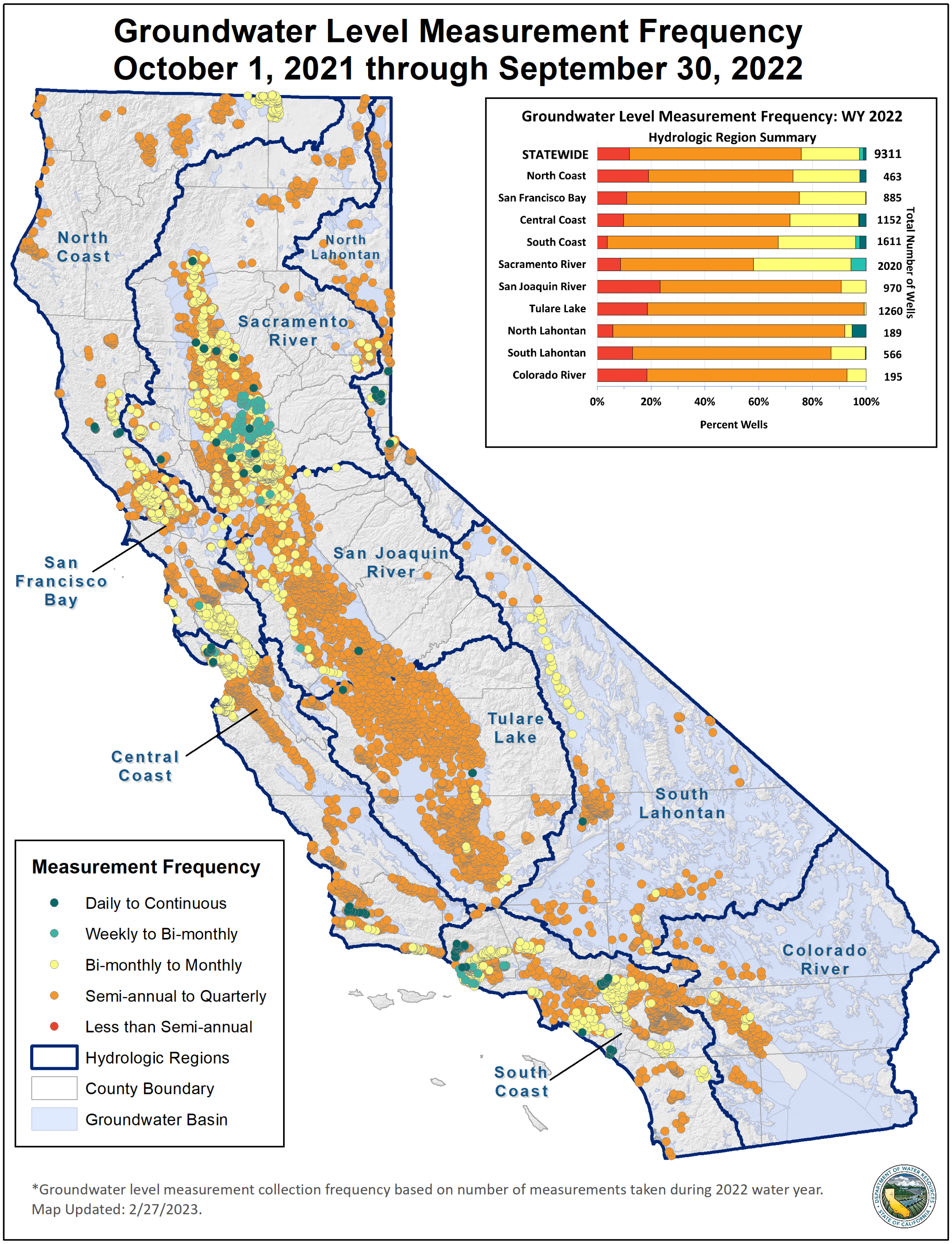
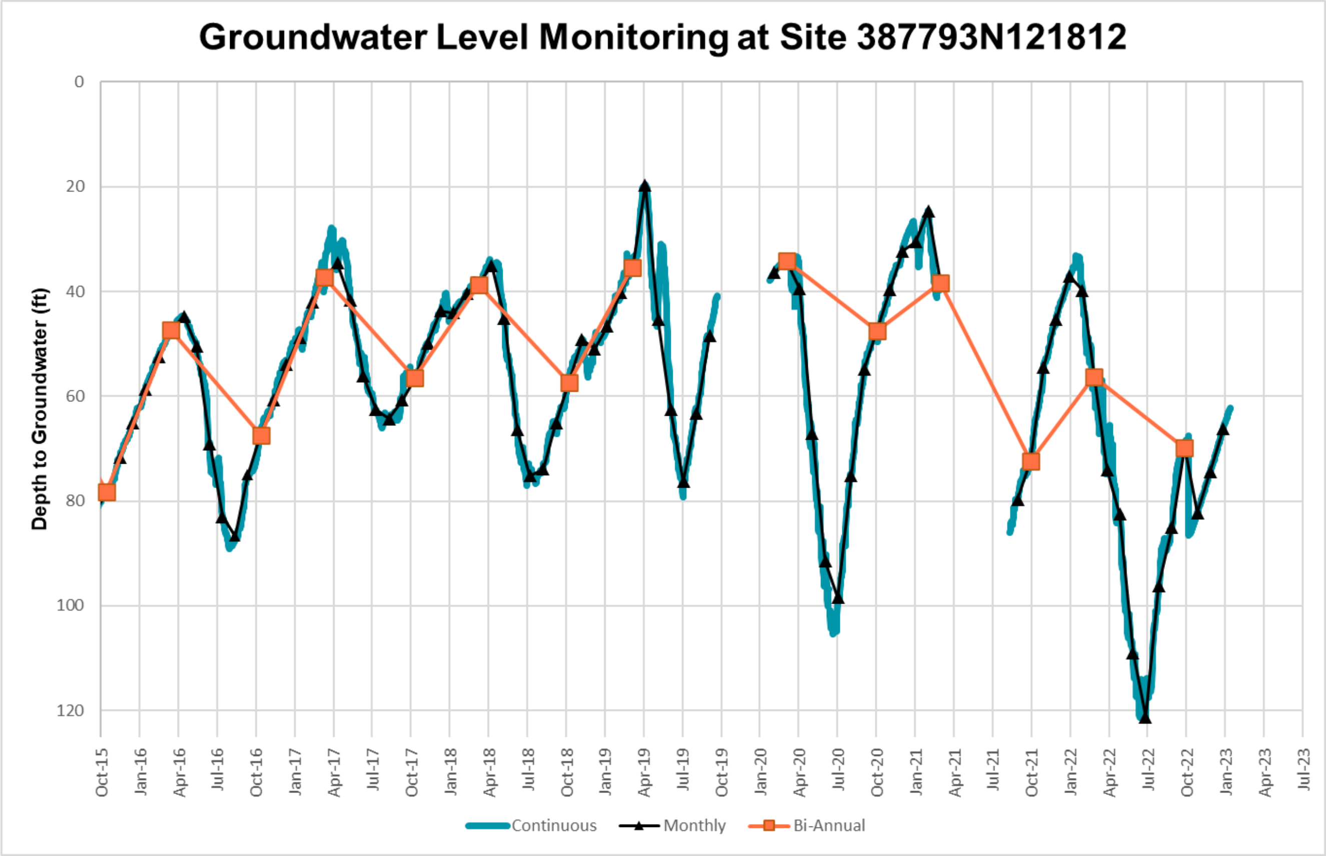


Figure 23: Groundwater Measurement Frequency Graph comparing biannual, monthly, and continuous data collection at Groundwater Monitoring Site 387793N121812. Data available on the Water Data Library Site.



Data reporting delay, infrequent data collection, and groundwater recharge rates all contribute to the inability to assess the full effect of recent weather events on groundwater conditions. Measured data is often not available for analysis until weeks or even months after the monitoring occurs. The majority of wells across the state only measure data 2 to 4 times a year. While this is sufficient for capturing long term trends, more frequent monitoring is required to accurately assess the short-term impacts of specific weather events.

There are four primary sources of groundwater elevation data that is used in evaluating groundwater conditions. Since 2011, data was typically reported to CASGEM semi-annually, often in the fall and spring, to capture the peak high and low values in groundwater elevations. Since the final submittal of GSPs in 2022, semi-annual data is also reported yearly in the following April after collection, allowing for more reliable data but with a considerable gap between collection and reporting. In the northern regions of the State, DWR's Northern and North Central regional offices collect groundwater elevation data from select wells on a monthly basis. The state also operates sites with automated recorders that collect continuous monitoring data taken at 15-minute to one-hour intervals with most of the monitoring sites are visited once every month or two, when readings are off-loaded to from data recorders, then finalized and published.

To fully report groundwater conditions in real-time, improvements to the data collection frequency and reporting time is necessary. Telemetry is a valuable tool for effective management of groundwater resources, as it provides a means to collect accurate and timely data that can be used to make informed decisions about groundwater use and conservation as well as help monitor the effectiveness of water management practices and identify areas in need of improvement. DWR with support from USGS, operates 14 sites to record groundwater elevation and subsidence data on a near-real-time basis through telemetry and is in the process of deploying more telemetry sites statewide throughout 2023. Expanding the use of telemetry in developing DWR's statewide, representative groundwater monitoring network improves data-driven water management decision-making at a local and regional scale throughout California enabling communities to plan for and meet the growing demands placed on water resources. Greater resiliency is made possible through improved access to timely, high-quality data.

Closing Thoughts

As the drought continued through the WY 2022, groundwater continued to serve as a vital resource for the state. The impact of three consecutive dry years was reflected in groundwater levels where 55% of fall measurements were at or near historic lows. These measurements matched or exceeded the lows seen at the end of the 2012 – 2016 drought despite the occurrence of two above average years in between. For the October 2021 to October 2022 period, statewide data show a total area of about 5,400 square miles with recorded subsidence greater than 0.1 feet, and about 80 square miles recording greater than 1 foot of subsidence. The continued reliance on groundwater is also highlighted by the continued installation of domestic and irrigation wells across the state. During the WY 2022, 3,736 domestic and 1,578 irrigation wells were installed statewide, with the 3,736 domestic wells being the most since the end of the last drought in 2016. Nearly 1,500 dry wells were reported in the WY 2022, the most of any year on record since the dry well reporting program started in 2013.

No single wet season is going to remedy the significant effects that drought has on our groundwater resources. Multiple above average years are needed to start to recover from extreme drought conditions, and numerous consecutive wet years are needed to fully recover groundwater storage. California communities are increasingly reliant on groundwater supplies during drought years and maintaining groundwater supplies is a key strategy to long term water reliability and resilience.

As weather patterns have become more variable and extreme from the effects of climate change, resulting in more frequent and consequential droughts and high flow events, the replenishment of depleted groundwater basins is becoming an essential part of California's long-term water resilience and drought mitigation efforts. Managed aquifer recharge is a long-term drought strategy to capture water when it is available during peak flows and to store that water underground for use during droughts periods. To successfully replenish groundwater basins, the state is committed to expediting groundwater recharge. This is a key action in the Governor's "Water Supply Strategy: Adapting to a Hotter, Drier Future" that was released in August 2022, outlining the necessary strategies to secure a more reliable water supply in the face of aridification and climate change.

During the series of storms across California in late 2022 and early 2023, groundwater recharge was taking place naturally, where water slowly percolates into the ground, greatly benefiting our groundwater aquifers. In addition to natural recharge, managed recharge projects are being implemented across the state. Projects that capture available precipitation, stormwater, or floodwaters to recharge depleted groundwater basins need to be initiated early and be ready to capture high flows when they are available during each wet season, typically October through April in California.

Groundwater recharge projects have been planned and implemented for decades in some areas of the state, but the recent storms provide a great opportunity and reminder of the importance of recharge projects. Local agencies can capture excess water from creeks and rivers and divert that water through conveyance infrastructure to key groundwater recharge facilities, such as percolation ponds, spreading fields, and onto working agricultural lands. These types of projects require specific permits. DWR, in coordination with the State Water Board and California Department of Fish and Wildlife, is working to streamline the regulatory process to help local agencies expedite implementation of groundwater recharge projects. Mariposa Creek in Merced County is the first pilot project, with DWR's assistance, to receive a permit (Jan. 6, 2023). While there is currently no state central repository of groundwater recharge projects, and as a result, no complete accounting of annual statewide recharge amounts, DWR expects to see improved groundwater elevation conditions from incidental and intentional recharge projects, as monitoring of groundwater levels throughout the state continues into the spring of 2023.

Under SGMA, DWR assists local groundwater agencies who are planning and carrying out groundwater recharge projects to help replenish groundwater basins and ensure the long-term reliability of groundwater for future years. DWR has already begun advancing local groundwater recharge projects through financial assistance. DWR awarded $68M to 42 specific groundwater recharge projects in 2021 and 2022 that provide nearly 117,000 acre-feet of potential groundwater recharge potential. These projects are currently underway. DWR is also evaluating an additional 52 groundwater recharge projects with a total project cost of about $211M. These projects may be awarded grant funding in 2023, based on the availability of funding. These projects, once constructed, will increase the potential capacity of getting more water underground. From 2021 through the end of 2023, DWR will have administered $350 million in grants to support local groundwater management, including groundwater recharge projects.

Considerable progress has been made by local agencies and the state towards achieving sustainable water management, despite dry and arid conditions, after the passage of SGMA and subsequent development and implementation of groundwater sustainability plans accompanied by data collection, reporting, and dissemination. Yet, we must acknowledge that data gaps exist, in terms of geographic coverage, frequency, and reporting lag, all of which hinder our ability to fully understand and report the current conditions of groundwater in a timely manner. Work towards collecting real-time data using telemetry at more sites across the state have fast-tracked progress towards drought-related planning and decision-making. Furthermore, financial assistance provided by the state has accelerated our progress towards sustainability and resiliency.