Butte County Department of Water and Resource Conservation

Groundwater Status Report

2019 Water Year

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Acronyms and Definitions

2019 WY – 2019 water year means the 2019 hydrological year spanning from October 1, 2018 – September 30, 2019 designated by the calendar year in which it ends.

BMOs - Basin Management Objectives means the levels which have been established for acceptable groundwater conditions in Butte County for groundwater elevations, groundwater quality related to saline intrusion and land subsidence. Measurements that fall outside of a BMO for a specific parameter can trigger a BMO Alert Stage.

CASGEM - California Statewide Groundwater Elevation Monitoring Program means the program developed by the California Department of Water Resources pursuant to Water Code Section 10920 et seq., or as amended mandating statewide groundwater elevation monitoring to track seasonal and long-term trends in basins throughout the state.

Department - Butte County Department of Water and Resource Conservation means a Butte County department formed on July 1, 1999 with the mission to manage and conserve water and other resources for the citizens of Butte County.

DWR - California Department of Water Resources means the state agency established in 1956 by the California State Legislature to protect, conserve, develop and manage much of California's water supply.

GSA - Groundwater Sustainability Agency means one or more local agencies with water supply, water management, or land use responsibilities within a groundwater basin that implement the provisions of the Sustainable Groundwater Management Act.

GSP - Groundwater Sustainability Plan means a plan of a groundwater sustainability agency proposed or adopted pursuant to the Sustainable Groundwater Management Act.

SGMA - Sustainable Groundwater Management Act means a package of bills collectively signed into law September 16, 2014 requiring local sustainable management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results, providing the state with broad oversight authority and the ability to intervene.

TAC - Butte County Water Commission Technical Advisory Committee means the seven member committee nominated by the Water Commission and appointed by the Board as defined under Chapter 33 of the Butte County Code.

Executive Summary - 2019 Water Year

The 2019 water year (2019 WY) which ran from October 1, 2018 to September 30, 2019 started out dry until mid- to late-November when rains began and continued relatively consistently until tapering down through the months of March and April. Over 30 atmospheric rivers occurred within this time period with many occurring in northern California, contributing to the year's wet conditions until about early April when dry conditions returned. The late spring rains from mid- to late-May also contributed to the water year overall. Average statewide precipitation on September 30, 2019 was 131%. Overall the 2019 WY had above average rainfall, snow pack and runoff conditions. Water supply conditions led to a 75% allocation for State Water Project contractors statewide.

The 2019 WY was classified as a *wet* water year type for the Sacramento Valley. It followed a *below normal year*, a *wet year* another *below normal year*, two *critical years*, and a *dry year*. According to the Northern Sierra Precipitation 8 Station Index, the 2019 WY ended on September 30, 2019 with 70.7 cumulative inches of precipitation, 137% of the long-term average. Another way to characterize hydrologic conditions is to review the amount of runoff flowing into streams and rivers in a given year. The Sacramento River Region unimpaired runoff as of September 30, 2019 was 24.7 million acre-feet, which is about 138% of average and significantly higher than the previous year's average at the same time of 75%. The snowpack statewide on April 1, 2019 was 162% of the April 1 average. With carryover storage in the reservoirs from 2018 in the beginning of the water year and wet conditions throughout the year, statewide reservoir storage was 128% of average at the end of the 2019 WY.

A return of wetter conditions in 2019 from the *below normal year* of 2018 brought modest increases to groundwater levels, specifically in groundwater dependent areas of the county. The Butte County Department of Water and Resource Conservation (Department), in cooperation with the California Department of Water Resources (DWR) Northern Region Office, conducts four (spring, July, August and fall) groundwater level measurements annually. Both spring and fall groundwater levels in 2019 were approximately 3 feet higher on average compared to the spring and fall of 2018 respectively (see Tables 5 and 7). Close to 30% of the monitored wells with Alert Stages assigned to them remained at a spring and / or fall Alert Stage 1 or 2, indicating levels remained near historical lows in some areas (Table 9 and Table 10 and map in Appendix C).

The Department conducted its eighteenth year of groundwater quality trend monitoring for evidence of saline intrusion from July 31, 2019 to August 2, 2019. All samples were within the acceptable range for electrical conductivity and pH, and temperatures remained relatively consistent. The 2019 Water Quality Trend Monitoring Report can be found in Appendix D and highlights are included in this report.

Subsidence is monitored by periodic land surveys and continuously by extensometers. No inelastic land subsidence was detected in Butte County from an evaluation of the extensometer records in the Butte subbasin.

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Foreword

This report presents the status of groundwater conditions and ground surface elevation monitoring based on data collected by Butte County and the California Department of Water Resources (DWR) during the 2019 Water Year (2019 WY), October 1, 2018 - September 30, 2019. The fall measurements taken in mid-October 2019 are also included since they reflect conditions and activities of the 2019 WY. The report gives general information regarding locations of wells and land subsidence monitoring sites, statistics related to groundwater level trends and historical precipitation information. This report was prepared by the Butte County Department of Water and Resource Conservation (Department) with assistance from the California Department of Water Resources (DWR), Northern Region and the Butte County Water Commission Technical Advisory Committee (TAC). This report complies with reporting requirements established in Chapter 33, Chapter 33A of the Butte County Code, and the California Statewide Groundwater Elevation Monitoring program (CASGEM).

In November 1996, the voters in Butte County approved "AN ORDINANCE TO PROTECT THE GROUNDWATER RESOURCES IN BUTTE COUNTY." One of the stated purposes of the ordinance was that "the groundwater underlying Butte County is a significant water resource which must be reasonably and beneficially used and conserved for the benefit of the overlying land by avoiding extractions which harm the Butte Basin aquifer, causing exceedance of the safe yield or a condition of overdraft." The ordinance is now codified as Chapter 33 of the Butte County Code relating to groundwater conservation. Section 3.01 – "Groundwater Planning Process" requires the preparation of a groundwater status report based upon the data gathered and analyzed pursuant to Section 3.02 – "Groundwater Monitoring". Until 2010, this reporting was completed by the Butte Basin Water Users Association.

In 2000, the Butte County Board of Supervisors amended Chapter 33, the Groundwater Conservation Ordinance, to require the Groundwater Status Report be delivered by February of each year. In 2010, the Water Commission designated the Department as the entity responsible for creating and submitting the annual report. Over the years, as responsibilities and water resource programs including advisory committees have shifted more and more to the County, the Butte Basin Water Users Association participation declined. In 2012, its members voted to dissolve the organization after twenty years of serving the region.

In February 2004, the Butte County Board of Supervisors adopted the Groundwater Management Ordinance which was codified as Chapter 33A of the Butte County Code. Chapter 33A calls for the establishment of a monitoring network and Basin Management Objectives (BMOs) for groundwater elevation, groundwater quality related to saline intrusion and land subsidence. The BMO concept was incorporated into California Water Code §10750 et. seq., as a component of AB 3030 Groundwater Management Plans. On September 28, 2004, the Butte County Board of Supervisors formally approved Resolution 04-181 adopting the countywide AB 3030 Groundwater Management Plan that includes components of the BMO program. In 2011, Chapter 33A was amended and retitled to "Basin Management Objectives" requiring a report each February on how well the basin management objectives are being met. The foregoing actions by the Board allow the reporting of groundwater conditions from both Chapter 33 and 33A to be consolidated into a single report to be submitted by the Department on an annual basis in February.

The Groundwater Status Report is in the process of undergoing revisions over the next few years in order to meet requirements of the Sustainable Groundwater Management Act (SGMA). On September 16, 2014, Governor Brown signed into law a package of bills collectively called SGMA. SGMA requires local management of groundwater subbasins, and provides the state with broad oversight authority and the ability to intervene. Local management of subbasin(s) are the responsibility of a local public agency or combination of local agencies that designate themselves as the "Groundwater Sustainability Agency" (GSA) for all or a portion of their subbasin. Local public agencies eligible to be a GSA must have water supply, water management or land-use responsibilities. GSA formation was required by June 30, 2017, with the consequence of the California State Water Resources Control Board assuming management of any subbasin(s) unable to meet these requirements. Basin boundary modifications were approved by DWR in 2018 which reduced the number of subbasins in Butte County from four to three; the Vina, Butte and Wyandotte Creek subbasins. All three of the existing groundwater subbasins within Butte County have established GSAs covering the entirety of the subbasins.

Discussions among GSAs to establish governance structures to manage groundwater and develop Groundwater Sustainability Plans (GSPs) for these subbasins began in earnest in 2018. A Joint Powers Authority forming the Wyandotte Creek GSA was executed in 2018 with a subsequent amendment signed into place in 2019. The Wyandotte Creek GSA is the exclusive GSA for the Wyandotte Creek subbasin. In 2019, a Joint Powers Authority forming the Vina GSA was executed. The Vina GSA is responsible for groundwater management for the majority of the subbasin. The Rock Creek Reclamation District GSA is responsible for a smaller portion of the subbasin. The Butte subbasin governance was finalized in late 2019 with a Cooperation Agreement amongst the eleven GSAs in the subbasin who will work together to develop and implement one GSP for the subbasin. GSAs must prepare and implement GSPs for their subbasin or their portion of their subbasin or face the prospect of state intervention. GSPs must be adopted by January 31, 2020 for subbasins that are in critical overdraft condition or by January 31, 2022, for all other subbasins. Since the subbasins in Butte County are not in critical overdraft, GSPs will be submitted by January 31, 2022. GSPs must contain the same elements as those in Groundwater Management Plans. Additionally, GSPs must include a water budget covering a 50-year planning horizon, measurable objectives, minimum thresholds and interim milestones (every five years) that will lead to sustainability in 20 years. GSPs must address "undesirable results" that include chronic lowering of groundwater levels and significant and unreasonable reduction in groundwater storage, degradation of water quality, land subsidence and surface water depletions. GSPs are exempt from the California Environmental Quality Act but projects or actions to implement the plan are not exempt. GSAs must submit annual reports to DWR by April 1st. The annual report must include the following information:

- Groundwater elevation data

- Annual aggregated data identifying groundwater extraction for the preceding water year
- Surface water supply used for, or available for use for groundwater recharge or in-lieu use
- Total water use
- Change in groundwater storage

The first annual report will not be required until 2022. The approach will be to modify this County Annual Groundwater Status Report to meet the requirements of the annual reports that must be submitted by GSAs for each subbasin.

In addition, in light of new requirements of SGMA, revisions to Chapter 33A were approved in 2019 to continue the transition of groundwater management in Butte County from the BMO program to implementation of SGMA in each of the three subbasins in Butte County. The BMO program has been a critical component of the County's water management effort over the past fifteen years. The BMO program has made enormous progress in developing, analyzing and disseminating factual information on local groundwater conditions. The strengths and benefits of the BMO program will be incorporated into the governance, GSPs and outreach established under SGMA. As a result, revisions to Chapter 33A include an expiration date for the ordinance of January 31, 2022 to align with the final deadline for submittal of GSPs to DWR under SGMA for subbasins in Butte County. In the meantime, monitoring and reporting of groundwater conditions (levels, water quality and land subsidence) will continue, but will become consistent with the extents of the three subbasins managed under SGMA and new revised subregions will replace the original 16 sub-inventory units for reporting purposes. This annual report continues to make this transition in the tables and maps included in the appendices. Additional revisions to Chapter 33-A of the Butte County Code include the dissolution of the Water Advisory Committee as well as removal of the individual sub-inventory unit reports previously included as appendices in past reports.

The CASGEM program was amended to the Water Code in 2009 through the enactment of SBx7-6, Groundwater Monitoring, as part of the Comprehensive Water Package. CASGEM mandates statewide groundwater elevation monitoring to track seasonal and long-term trends in basins throughout the state. The legislation created a statewide program to collect groundwater elevation data, facilitate collaboration among monitoring entities, and develop a means of reporting groundwater data to the public. The Department has this responsibility as the monitoring and reporting entity for Butte County. As described in the Butte County CASGEM Monitoring Plan, the Butte County CASGEM program will utilize approximately 72 wells from the network for the CASGEM program. These 72 wells comprise primarily dedicated monitoring wells. A map of these locations can be located in Appendix B.

Data from published reports prepared for the Department are included throughout this document where relevant, and the referenced documents are listed in Appendices or as references, as well as being available on the Department's website at www.buttecounty.net/waterresourceconservation. All past years' Groundwater Status Reports and BMO documents are also available on the Department's website.

Hydrologic Conditions

A number of data sources and indices are available to characterize and compare hydrologic conditions within or amongst particular years. The data sources typically report hydrologic data on a water year basis, or the 12-month period from October through September. The 2019 WY began on October 1, 2018 and ended on September 30, 2019. The 2019 WY was classified as a *wet year* for the Sacramento Valley. At the end of the 2019 WY on September 30, 2019, statewide hydrologic conditions were as follows: precipitation was 131% of average; runoff was 135% of average; and reservoir storage, 128% of average. Sacramento River Region unimpaired runoff observed through September 30, 2019 was about 24.7 million acre-feet, which is about 138% of average. For comparison, Table 1 shows the volume and percent of average runoff for the previous water years from the *wet year* of 2011, through the 2019 WY. Colors represent the corresponding water year type as also depicted in Figure 2.

Table 1. Sacramento River Region Unimpaired Runoff (Million Acre-Feet)

WATER YEAR (TYPE)	2011 (WET)	2012 (BELOW NORMAL)	2013 (DRY)	2014 (CRITICAL)	2015 (CRITICAL)	2016 (BELOW NORMAL)	2017 (WET)	2018 (BELOW NORMAL)	2019 (WET)
UNIMPAIRED RUNOFF (MILLLION ACRE-FEET)	25.2	11.8	11.9	7.5	9.2	17.4	37.9	12.7	24.7
% OF AVERAGE	138%	65%	65%	41%	51%	98%	212%	71%	138%

The Northern Sierra 8-Station Precipitation Index (Figure 1) serves as a precipitation index for the Sacramento River hydrologic region by averaging measurements taken at the following precipitation stations: Blue Canyon, Brush Creek Ranger Station, Mineral, Mount Shasta City, Pacific House, Quincy Ranger Station, Shasta Dam, and Sierraville Ranger Station.[1] This index provides a representative sample of the region's major watersheds: the upper Sacramento, Feather, Yuba, and American Rivers, which produce inflow to some of California's largest reservoirs - the source of much of the state's water supply. The 2019 WY ended with 70.7 cumulative inches of precipitation which is 137% of the long term (1966 - 2015) average of 51.8 inches. The 2019 WY curve is labeled "2018 - 2019 (current)" on Figure 1.

Figure 2 shows the water year type classifications based on the Sacramento Valley 40-30-30 Index going back to 1960 along with the 1960 – 2019 average (8.07). The Sacramento Valley was classified as a *wet year* in 2019 with an index value of 9.3 (Figure 2). Water year classification systems provide a means to assess the amount of water originating in a watershed.

Water year classification systems are useful in water planning and management and have been developed for several hydrologic basins in California. The Sacramento Valley 40-30-30 Index was developed by the California State Water Resources Control Board for the Sacramento hydrologic basins based on Sacramento River runoff. This system defines one *"wet"* classification, two

[1] http://cdec.water.ca.gov/cgi-progs/products/PLOT_ESI.pdf

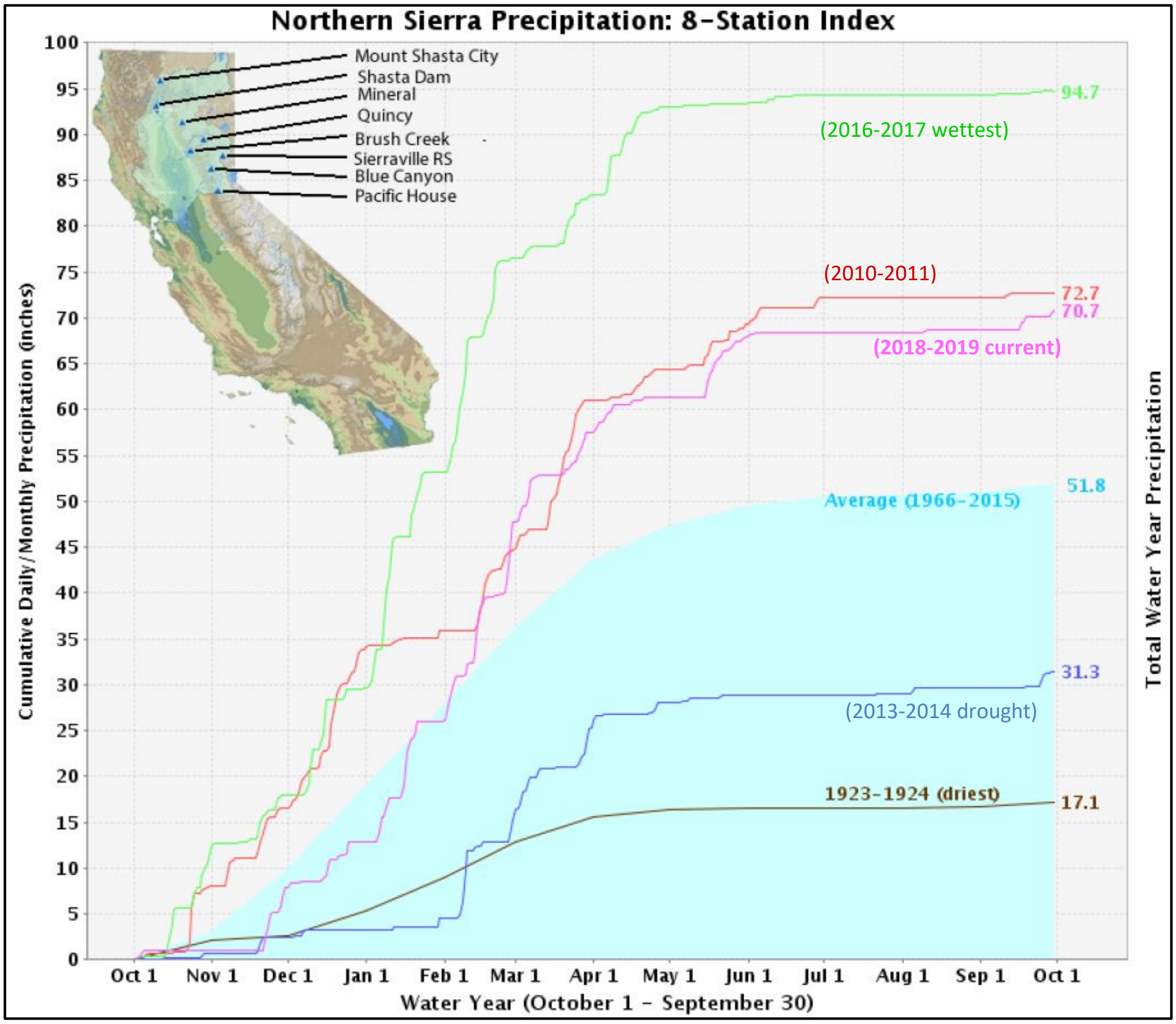

Figure 1. Northern Sierra Precipitation: 8 Station Index Data for Water Year 2019

"normal" classifications (*above normal* and *below normal*), and two *"dry"* classifications (*dry and critical*), for a total of five water year types.

The Sacramento Valley 40-30-30 Index is computed as a weighted average of the current water year's April - July runoff forecast (40%), the current water year's October - March runoff (30%), and the previous water years index (30%). A cap of 10 million acre-feet is put on the previous year's index to account for required flood control reservoir releases during *wet years*. Sacramento River runoff is the sum of the Sacramento River flow at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake[2].

[2] http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST

Sacramento Valley water year hydrologic classifications are as follows:

Water Year Type	Water Year Index
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5 and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

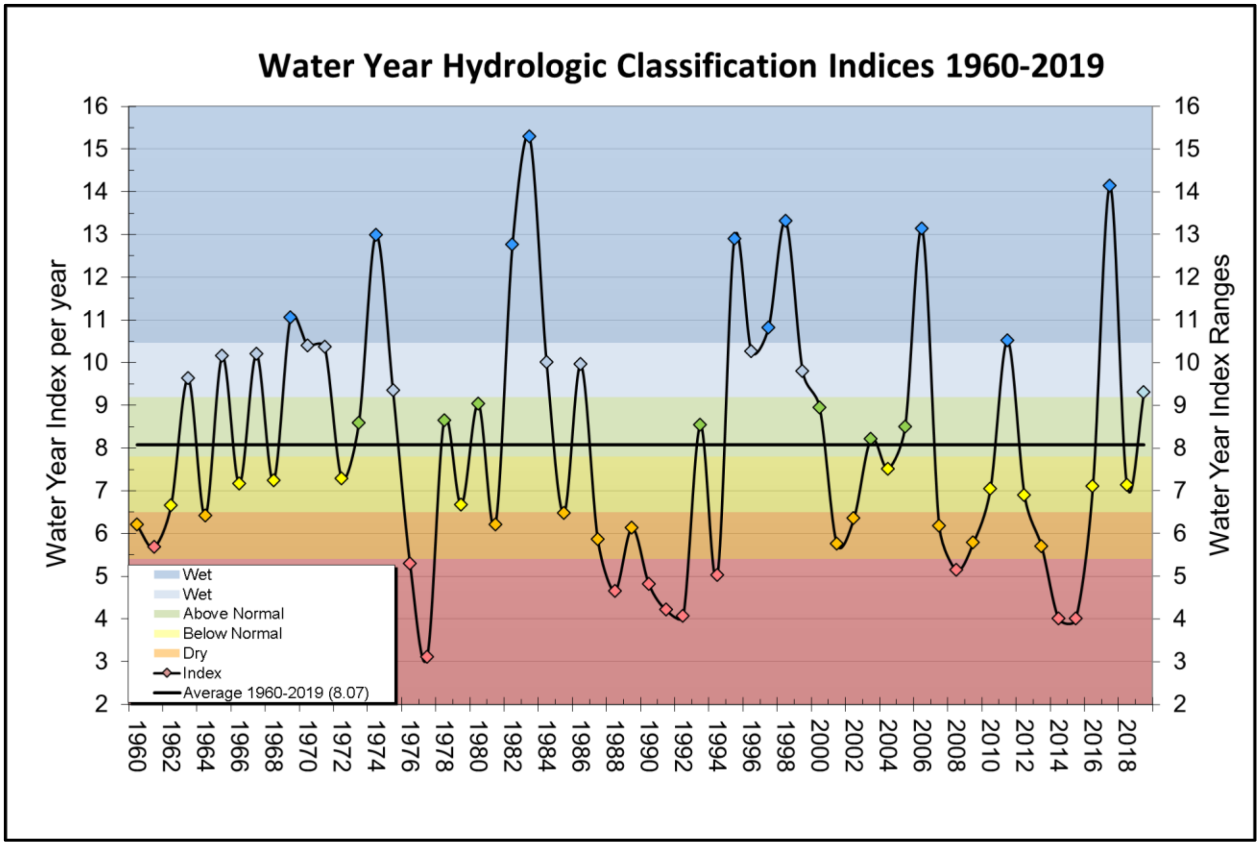

Figure 2. Sacramento Valley Water Year Types and 1960 – 2019 Average (40-30-30 Index)

Precipitation

Figure 3 shows the total annual precipitation at the Western Canal Climatological Observation Station for the 58-year period of water years 1960 through 2019. Precipitation for the 2019 WY measured within the Western Canal Water District's jurisdiction totaled 34.12 inches. This was 12.97 inches above or 161% of the 50-year (1960-2010) average of 21.15 inches.

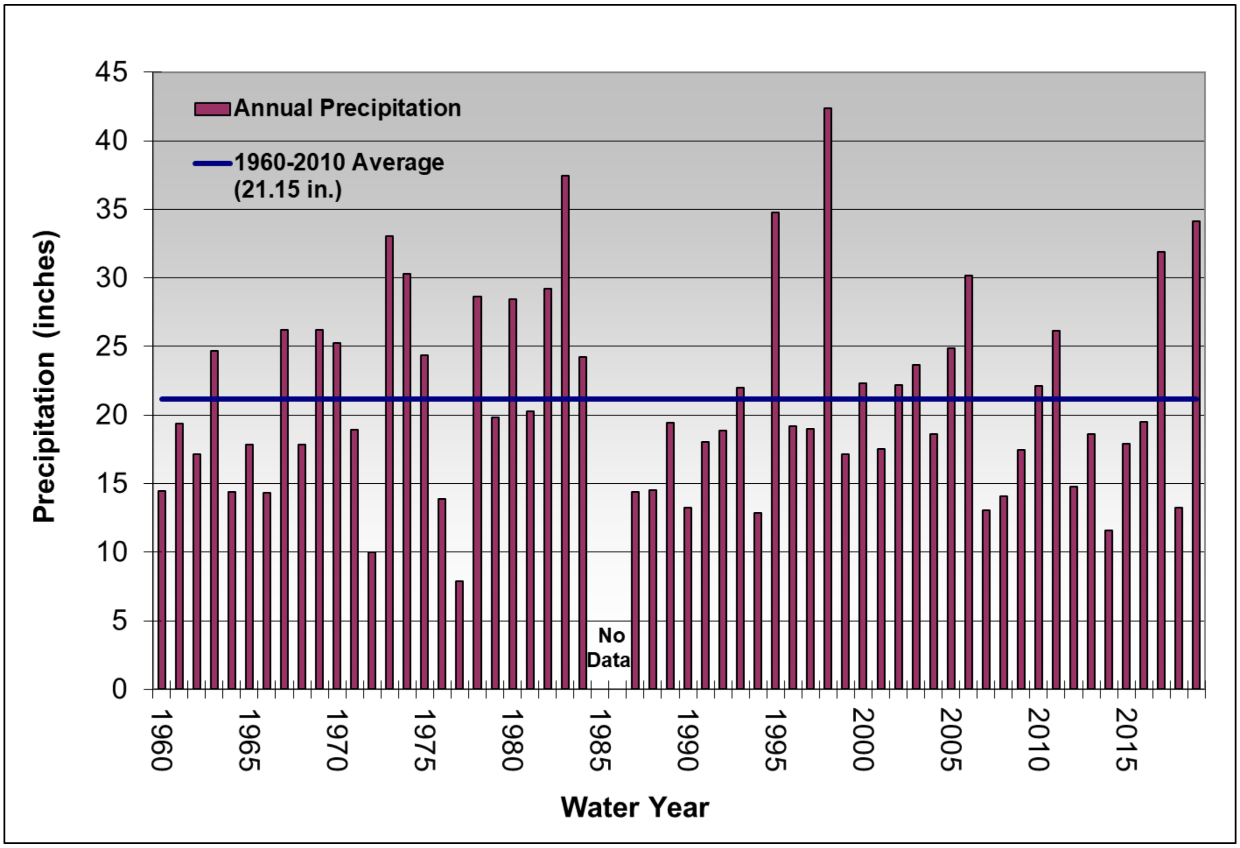

Figure 3. Annual Precipitation Observed from 1960 to 2019 at the Western Canal Climate Station

The timing of rainfall in the valley influences irrigation water use. The daily precipitation in the 2019 WY reported from the California Irrigation Management Information System station in Durham provides an indication of when and how much rainfall occurred in order to understand how it may have affected the irrigation season (Figure 4).

Figure 4 shows daily precipitation and storm activity throughout the fall, winter and spring. Eleven events measuring over one-inch of precipitation in a single day occurred in the 2019 WY. Due to the wet spring from March, April and May rains, the irrigation season began later than usual, likely near the beginning of May in most areas throughout the County. According to discussions with growers in the Durham / Chico area, a significantly decreased amount of water use was required for frost protection this water year as compared to the previous year. While the requirements varied by specific site, approximately only two nights were irrigated for frost protection throughout the spring from late-February to early March.

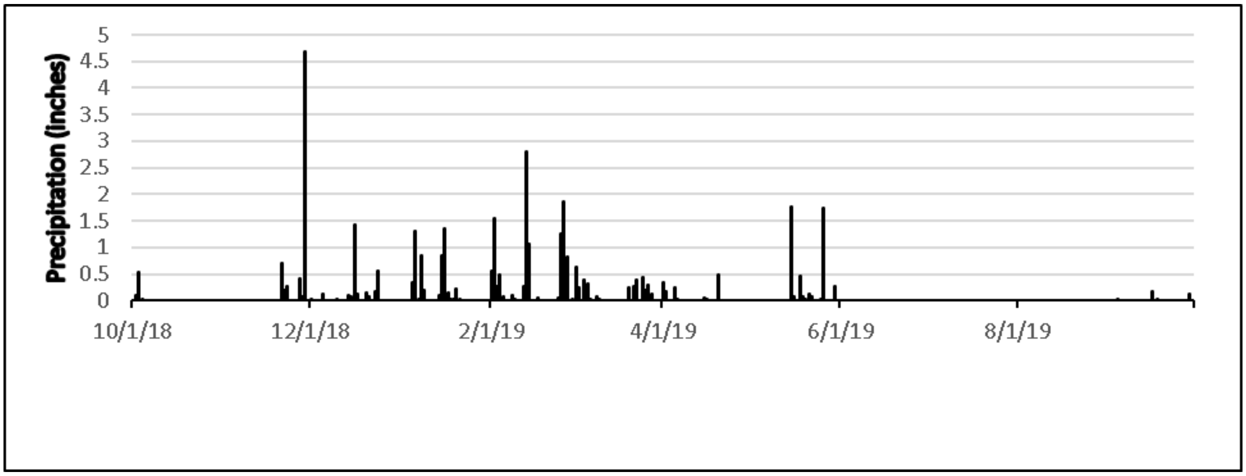

Figure 4. Daily Precipitation during the 2019 Water Year at the California Irrigation Management Information System Station in Durham, CA

Feather River Surface Water Diversions

Surface water is an important component of the water supply and has benefits to aquifer recharge in the Butte subbasin. During the 2019 WY, a total of 959,895 acre-feet of surface water was diverted by Western Canal Water District and the Joint Water Districts Board. Diversions in the 2019 WY increased by 22,891 acre-feet from the 2018 water year amount and by approximately 317,839 acre-feet more than in 2015. Rice growers did not participate in fallowing water transfers in 2019 and late-May precipitation led to reductions in planted acreage and lower water deliveries than in years with dry late-spring conditions. In the 2015 water year, Western Canal Water District and the Joint Water Districts Board had a 50% curtailment of their surface water deliveries due to the drought. It was the first curtailment in 23 years. Reliable surface water supplies reduce or eliminate the need for groundwater pumping (except when curtailments occur) and provide some recharge to the subbasin. This results in generally shallow and stable groundwater conditions in these areas. Table 2 summarizes diversions in acre-feet to Western Canal Water District and the Joint Water Districts Board for water years 2000 to 2019.

Table 2. Surface Water Diversions (acre-feet) for the Western Canal Water District and the Joint Water Boards for Water Years 2000 to 2019

Water Year	Western Canal Water District	Joint Water Districts Board*	Total
2000	314,737	707,018	1,032,392
2001	302,784	718,489	1,021,562
2002	305,460	597,529	902,989
2003	271,867	682,403	954,270
2004	329,700	790,663	1,120,363
2005	284,188	750,128	1,034,316
2006	294,898	743,345	1,038,243
2007	318,159	824,286	1,142,445
2008	332,500	740,748	1,073,248
2009	327,184	711,693	1,038,877
2010	313,196	689,518	1,002,714
2011	288,912	718,771	1,007,683
2012	309,213	706,671	1,015,884
2013	324,128	731,560	1,055,688
2014	319,073	654,696	973,769
2015**	249,965	392,091	642,056
2016	283,071	546,999	830,070
2017	263,179	617,454	880,633
2018	284,192	652,812	937,004
2019	282,389	677,506	959,895

* The Joint Water Districts Board includes the Biggs-West Gridley Water District, the Butte Water District, the Richvale Irrigation District and the Sutter Extension Water District.

** 50% Curtailment of surface water deliveries occurred this year due to drought

Groundwater Conditions

Monitoring Frequency

Butte County Codes, Chapter 33 and 33A, call for the establishment of a monitoring network for groundwater quality related to saline intrusion, land subsidence and groundwater levels. The Groundwater Quality Trend Monitoring Program is designed to track single monitoring events throughout the county during the peak irrigation season on an annual basis. The data is collected each July or August at the peak of irrigation season to establish baseline levels across the county to detect changes, which may require further investigation.

Monitoring frequency for land subsidence is conducted on a continuous basis by extensometers. Groundwater level monitoring occurs four times per year. Sections 33-4 of the Butte County

Code enacted in 1996 and 33A-8 of the Butte County Code enacted in 2004 state that groundwater level measurements shall be taken from all designated monitoring wells at least four times per year, during the months of March, July, August and October. DWR and the Department share the monitoring duties during each monitoring event. DWR conducts the majority of the March, August and October measurements while the Department collects all of the measurements every July.

Groundwater Quality Trend Monitoring

Temperature, pH and electrical conductivity are recorded for water samples from a network of thirteen wells throughout the county. These parameters provide the basis to evaluate groundwater conditions for evidence of saline intrusion.

Program Background

The Butte County Groundwater Quality Trend Monitoring Program is required by the Groundwater Conservation Ordinance (Chapter 33 of the Butte County Code) and administered through the BMO Ordinance (Chapter 33A of the Butte County Code). Degraded water quality is a common effect of over-utilizing groundwater resources and can occur by saline intrusion from, among other sources, marine formations underlying freshwater aquifers. In Butte County, the primary freshwater bearing formations include the Tuscan Formations, and overlying alluvium deposits, basin deposits and the Riverbank and Modesto Formations. A number of marine formations beneath the Tuscan Formation make up the underlying saline aquifer system.[3] Increasing salinity in groundwater wells could indicate over utilization of groundwater resources. To ensure sustainable management of local groundwater resources, monitoring efforts need to provide baseline trends related to salinity. This program is not designed to characterize specific groundwater contamination due to pollutants.

Results are evaluated against established water quality standards and BMOs. Data that fall outside of a BMO for a specific parameter as described in Table 3 below can trigger a BMO Alert Stage. For example, if the temperature of groundwater from a well is more than 5 degrees Celsius (^{o}C) outside of the historical range of measurements of that well, a BMO Alert Stage is reached. If the pH of the groundwater at a well is below 6.5 or above 8.5, a BMO Alert Stage is reached for that well. A BMO Alert Stage for electrical conductivity is reached if a measurement is greater than 900 micro-Siemens per centimeter (µS/cm) for drinking water or greater than 700 µS/cm for water used for agricultural purposes. These ranges are based on secondary water quality standards established by the US Environmental Protection Agency. Secondary standards relate to the taste, odor, color, corrosivity, foaming and staining properties of water whereas primary standards are based on health considerations.

[3] Fulton, Allan. “Seeking an Understanding of the Groundwater Aquifer systems in the Northern Sacramento Valley: An Update”. Article No. 1 – September 2005

Parameter	Basin Management Objective
Temperature	Within 5° Celsius of the historic range of temperatures for that well
pH	Between 6.5 and 8.5
Electrical Conductivity	< 900 µS/cm for drinking water < 700 µS/cm for agricultural water

Table 3. Butte County Basin Management Objectives for Water Quality

Summary Highlights from 2019

- No BMO exceedances / Alert Stages were recorded for any of the monitoring wells for temperature, electrical conductivity or pH
- All 13 wells were sampled July 31, 2019 through August 2, 2019
- Temperatures remained relatively consistent in all water samples and were within acceptable ranges
- All measurements were within the acceptable range for pH
- All samples were within the acceptable range for electrical conductivity
- No evidence of saline intrusion was detected
- A positive correction factor was applied to the electrical conductivity measurements due to complications in probe calibrations

Water quality parameters have naturally occurring variability, so year-to-year changes are expected and nothing in this year's measurements give cause for further investigation or analysis. Further investigation would be advisable if values were to fall outside of acceptable ranges. The 2019 Water Quality Trend Monitoring Report (Interdepartmental Memorandum) can be found in Appendix D.

2019 Results

To date, groundwater temperatures have been relatively consistent in all wells. Temperature is a standard parameter measured when assessing water quality and is important because it affects chemical reactions that may occur in groundwater. Also, considerable changes in temperature could be an indication of other source waters migrating into the aquifer system such as stream seepage or flow from a different aquifer system. All 2019 groundwater quality measurements were within their respective temperature BMO and within 5^{o} C of their historical ranges. All but one of the 2019 measurements were within 1.0^{o} C of the wells average historic temperature. The lowest groundwater temperature reading was in the M & T well (17.5^{o} C) and the highest was in the Thermalito domestic well (22.6^{o} C). The Thermalito domestic well was 2.9^{o} C higher than the well's recorded 11-year average. At this well, the groundwater temperature was recorded from a water sample taken after purging the well with the outdoor household hose, versus irrigating with sprinklers to purge the well as had been done in previous years. This may have affected the results.

Measurements for pH remained relatively stable compared to previous years in all groundwater sampled. The lowest pH was found in the Western Canal East well (6.9) and the highest pH was found in the Llano Seco well (8.1). All measurements for pH were within the secondary water quality thresholds of 6.5 - 8.5.

Electrical conductivity measures the ability of a solution to conduct an electrical current due to the presence of ions. Observed readings for electrical conductivity can have a large range, up to 447 µS/cm at one particular well (Western Canal West), yet 2019 measurements were all well within the secondary water quality thresholds established by State and Federal regulatory agencies. A positive correction factor was applied to the 2019 results per recommendation of the Butte County Water Commission TAC, due to an error in the calibration of the probe. Calibration was originally performed using calibration standards too high in concentration for the instrument; resulting in relatively low readings. Using corrected values, the highest electrical conductivity measurement was from the Esquon well (515 µS/cm) and the lowest was from the Llano Seco well (188 µS/cm). The greatest change compared to 2018 electrical conductivity levels occurred in the Thermalito domestic area well which increased in value by 102 µS/cm; however, this may be due to the well purging method as described above. Appendix D contains a monitoring network map, data tables and graphs.

Land Subsidence

Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials often caused by groundwater or oil extraction. To date, no inelastic land subsidence has been recorded in Butte County. The potential effects of land subsidence include differential changes in elevation and gradients of stream channels, drain and water transport structures, failure of water well casings due to compressive stresses generated by compaction of aquifer system, and compressional strain in engineering structures and houses.

Land subsidence in the Sacramento River, San Joaquin River and Tulare Lake Basins would most likely occur as a result of aquitard consolidation. An aquitard is a saturated geologic unit that is incapable of transmitting significant quantities of water. As the pressure created by the height of water (i.e. head) declines in response to groundwater withdrawals, aquitards between production zones are exposed to increased vertical loads. These loads can cause materials in aquitards to rearrange and consolidate, leading to land subsidence. Factors that influence the rate and magnitude of consolidation in aquitards include mineral composition, the amount of prior consolidation, cementation, the degree of aquifer confinement and aquitard thickness. Subsidence has elastic and inelastic deformation components. As the head lowers in the aquifer, the load that was supported by the hydrostatic pressure is transferred to the granular skeletal framework of the formation. As long as the increased load on the formation does not exceed the pre-consolidation pressure, the formation will remain elastic. Under elastic conditions, the formation will rebound to its original volume as hydrostatic pressure is restored. However, when the head of the formation is lowered to a point where the load exceeds pre-consolidation pressure, inelastic deformation may occur. Under inelastic consolidation, the formation will undergo a permanent volumetric reduction as water is expelled from aquitards[4].

Butte County will prevent or limit inelastic subsidence as required through Chapter 33. To determine whether subsidence is occurring, a subsidence monitoring network has been established throughout Butte County consisting of observation stations (Appendix E) and extensometers (Appendix B) managed by DWR.

The observation stations are a result of DWR's efforts to establish a subsidence monitoring network across the valley to capture changes in subsidence. The observation stations are established monuments with precisely surveyed land surface elevations. They are distributed throughout the County such that the entire county is well represented. In 2008, DWR along with numerous partners performed the initial GPS survey of the observation stations to establish a baseline measurement for future comparisons. The network was resurveyed again in 2017 using similar methods and equipment as those used in the 2008 survey and results were analyzed to depict the change in elevation at each station between those two years. Results of the survey are available here https://water.ca.gov/News/News-Releases/2019/January/Survey-Shows-Areas-of-Land-Subsidence and a map of the project observation station locations and results of the changes between both years are found in Appendix E.

Extensometers are installed in wells or boreholes and are a more site specific method of measuring land subsidence as they can detect changes in the thickness of the sediment surrounding the well due to compaction or expansion. These instruments are capable of detecting very slight changes in land surface elevation on a continuous basis with an accuracy of +/- 0.01 feet or approximately 3 millimeters (mm). The three extensometers in Butte County have a period of record beginning in 2005 and were chosen by DWR based on a high likelihood of seeing subsidence in these areas if it were to occur, based on the presence of known clay and other fine grained deposits in these areas. Data are available through July 2019 and can be found in the DWR Water Data Library[5]. While seasonal displacement of – 9.13 mm (+/- 0.3 mm) have been recorded at one of these extensometers (Figure 5) during 2006 a *wet* water year and 2015 a *critical* water year, changes in ground surface elevations are slight and remain at or above baseline levels in 2019. To date, no inelastic land subsidence has been recorded in Butte County.

4 http://water.usgs.gov/ogw/pubs/fs00165/
5 http://wdl.water.ca.gov/waterdatalibrary/docs/Hydstra/index.cfm

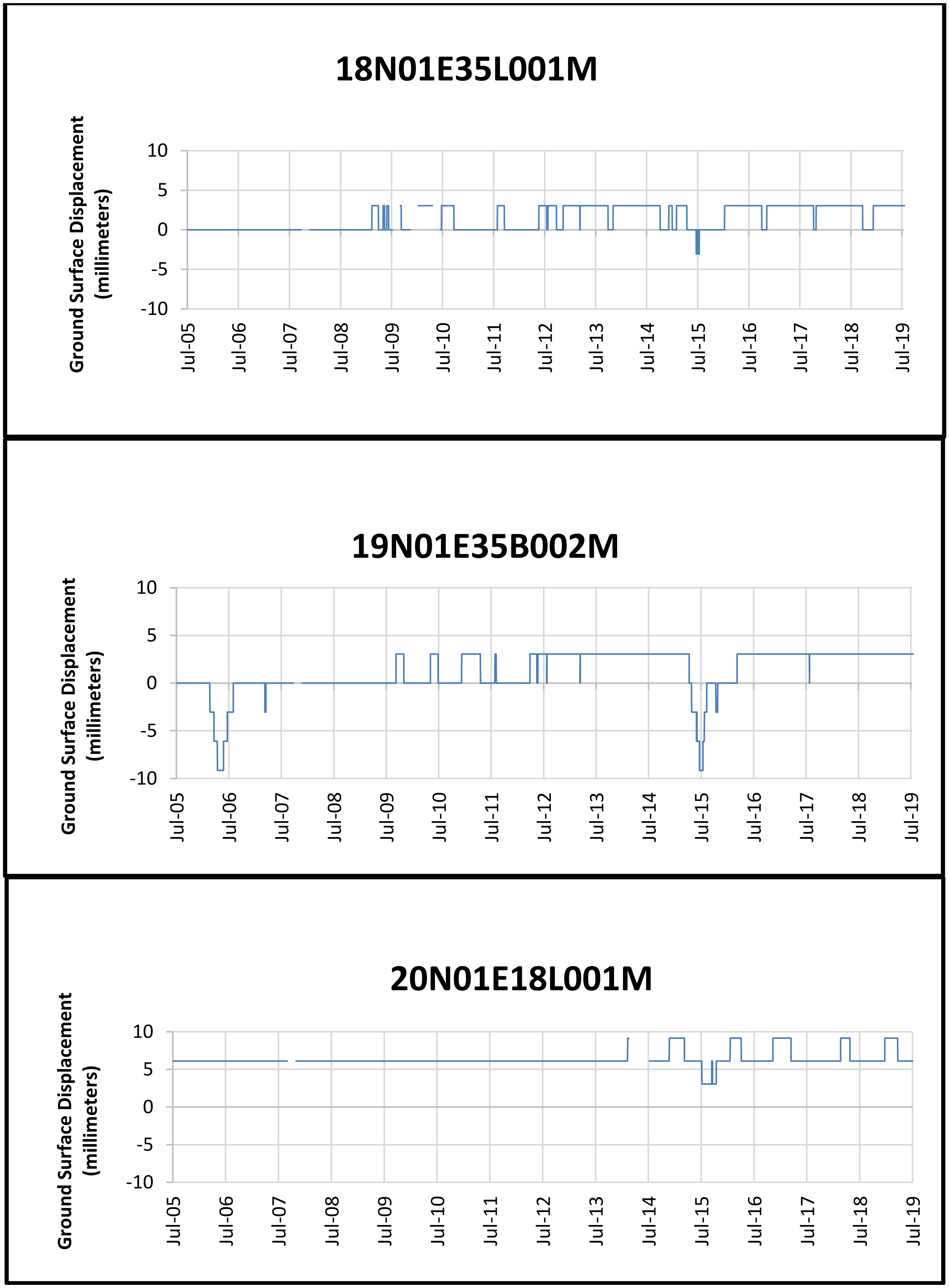

Figure 5. Ground Surface Displacement in Millimeters at the Extensometer Sites within Butte County

Well Permits

Well permits are issued by the Butte County Department of Environmental Health for all wells drilled throughout the County. Although the number of well permit applications do not necessarily reflect the number of wells actually drilled, the numbers provide a general indication of the development of the groundwater resource and potential drilling activities. According to the 2016 Water Inventory and Analysis Report, Butte County had over 12,000 domestic wells and 2,500 irrigation wells in 2015. When combined with municipal, monitoring and other well types (stock water, test wells, abandoned or unidentified wells) the total well count in the county in 2015 was about 17,554[6]. Table 4 shows the number of well permit applications received by the Department of Environmental Health for the following categories from 2006 – 2019; small diameter, large diameter and well repairs and deepening.

Table 4. Number of Well Permit Applications per Water Year in Butte County

Well Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Small Diameter	260	228	176	188	140	77	102	221	259	175	129	95	115	184
Large Diameter	17	24	36	29	16	16	21	28	71	68	37	17	24	21
Well Repair & Deepening	4	9	15	20	10	9	7	10	17	19	10	1	5	10

Note: Water years 2006, 2011, 2017 and 2019 were all *wet years*, all others are *below normal, dry,* or *critical years.*

Small Diameter wells have a casing diameter of eight inches or less.
Large Diameter wells have a casing diameter greater than eight inches, generally for irrigation.
Well Repairs & Deepening refers to an existing well deepened to access groundwater in a deeper zone of the aquifer likely because the water level in the well has fallen below the bottom of the well.

Well deepening permits are an indication that the existing well infrastructure is not sufficient given the current groundwater levels. During dry periods and drought, as water levels fall in areas with heavy groundwater use (i.e. Durham / Dayton, Vina and the Chico urban area etc.), shallower domestic wells become especially vulnerable and may "go dry." This means the groundwater level in the well falls below the elevation of the pump in the well or below the bottom of the well itself. A pump can be lowered further into a well if it is deep enough and accessible to do so without requiring a permit from the County. If the well is not deep enough to lower a pump, it may be possible to deepen the well. Well permits are issued by the County for well owners to deepen wells; however homeowners should enlist a licensed well driller to conduct the work.

Groundwater Level Monitoring

Groundwater levels typically fluctuate seasonally amongst years. Seasonal fluctuation of groundwater levels occur in response to groundwater pumping and recovery, land and water use

[6] Butte County Water Inventory and Analysis, 2016

activities, recharge and natural discharge. Precipitation, applied irrigation water, local creeks and rivers and other water bodies such as the Thermalito Forebay and Afterbay all recharge groundwater in Butte County. Groundwater pumping for irrigation typically occurs from April to September although depending on the timing of rainfall, it may shift earlier and / or later into the season. Consequently, groundwater levels are usually highest in the spring and lowest during the irrigation season in the summer months.

Long-term fluctuations occur when there is an imbalance between the volume of water recharged into the aquifer and the volume of water removed from the aquifer, either by extraction or natural discharge to surface water bodies. If, over a period of years, the amount of water recharged to the aquifer exceeds the amount of water removed from the aquifer, then groundwater levels will increase. Conversely, if, over time, the amount of water removed from the aquifer exceeds the amount of water recharged then groundwater levels decline. These long-term changes can be linked to various factors including increased or decreased groundwater extraction or variations in recharge associated with wet or dry hydrologic cycles.

Currently 128 wells are monitored for groundwater levels in Butte County as part of the BMO program, 74 of them are assigned BMO spring Alert Stages and 64 are assigned fall Alert Stages. These wells consist of a mixture of domestic and irrigation wells, along with dedicated observation wells and 10 California Water Service Company municipal supply wells in Chico and Oroville. Approximately 59 of the wells measured by DWR and the Department are equipped with data loggers (i.e. transducers) which continuously monitor and record hourly changes in groundwater levels. These and the remaining wells are measured by hand four times per-year, in March, July, August and October. From 2014 to 2016, groundwater levels were measured monthly from April through October due to severe drought conditions. The approximate locations of groundwater level wells monitored in Butte County are shown in Appendix B as well as those designated as CASGEM wells to track long-term trends throughout the County. The groundwater level monitoring methods are consistent with the procedures described in the California Department of Water Resources' Groundwater Elevation Monitoring Guidelines (December 2010)[7].

Groundwater elevations are measured using a steel tape, electric sounder or by pressure transducers. The accuracy of the groundwater level measurement range is either 0.01 feet or 0.1 feet depending on the equipment used. In addition to the groundwater level monitoring conducted by Butte County and DWR, California Water Service Company currently measures monthly groundwater levels in approximately 60 municipal groundwater supply wells in the Chico urban and Oroville areas. Ten of these wells are included in the BMO program and nine of them have Alert Stages assigned to them.

Data from groundwater level monitoring can be obtained through DWR and the Department's websites. The primary access to the data is through the CASGEM program (https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-

[7] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/CASGEM/Files/CASGEM-DWR-GW-Guidelines-Final-121510.pdf

Monitoring--CASGEM). The CASGEM program was part of legislation passed in 2009, SBx7-6, which mandates statewide groundwater elevation monitoring to track seasonal and long-term trends in subbasins throughout the state. As a result of this legislation, DWR migrated the groundwater level data from the Water Data Library to the CASGEM database. DWR has reintroduced access to groundwater monitoring data through an updated Water Data Library (http://wdl.water.ca.gov/waterdatalibrary/). Groundwater level data is also available through DWR's online SGMA Data Viewer tool available at (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer). Summary data tables of groundwater surface elevations from spring, summer and fall measurements are included in Appendix F and are available from the Department's website.

Change in Groundwater Levels: 2018 to 2019

The 2019 WY was classified as a *wet year* with relatively wet conditions as measured by the Northern Sierra 8 Station Index. Groundwater conditions responded as expected to the wet winter as compared to the previous water year which was recorded as a *below normal* water year with generally higher groundwater levels in 2019 compared to 2018. The overall average change in observed groundwater levels from spring of 2018 to spring of 2019 was an increase of three feet. Of the 116 comparable wells, 99 of them had a higher spring level when compared to 2018. The average increase was 4.2 feet and of the 15 wells that had lower measurements in 2019 compared to 2018, the average decrease was -2.0 feet (Table 5). The wet winter conditions of the 2019 WY, led to higher groundwater levels particularly in the areas to the north and east of Chico and the Durham area, which also experienced some of the greatest declines during the 2012 - 2015 drought period.

Table 5. Groundwater Elevation Change of all Butte County BMO program wells from Spring of 2018 to Spring of 2019

Number of wells		Change (ft.)	Subregion
116	Average Groundwater Level Change	3.4	
	Median Groundwater Level Change	3.0	
99	Average Increase	4.2	
	Median Increase	3.6	
	Max Increase	13.2	Vina South
15	Average Decrease	-2.0	
	Median Decrease	-0.5	
	Max Decrease	-10.7	Wyandotte Creek South

Note: Groundwater level measurements characterized as "Questionable measurements" i.e. measurements taken during pumping, when nearby pumps were operating or taken from wells pumped recently were not included in the data. Two wells measured had no groundwater level change between spring of 2018 and spring of 2019.

In order to better understand the context of the 2018 to 2019 WY change in spring groundwater levels and how the change between the 2018 and 2019 water years compares to changes between other recent years pre- and post-drought (2012 – 2016), the cumulative amount of average groundwater level change between consecutive years was compiled for the last eight water years for all wells monitored in Butte County with high quality data. Figure 6 depicts this change beginning with the 2012 water year set as zero for the baseline change as 2012 was a *below normal year* following a *wet year* (2011) prior to the drought of 2012 - 2016. The color in the points on the lines correspond to the water year type and the background colors in the graph correspond to the range of values that characterize each type of water year (*wet, above normal, below normal, dry and critical*) as described earlier. As depicted in Figure 6, the overall average change in spring groundwater levels between water years 2012 and 2013 was a 2.0 foot decline. Between 2013 and 2014 another 4 foot decline was observed bringing the overall change from baseline (pre-drought) conditions down 6 feet. Over the next three years (2015 to 2017), groundwater levels increased along with the water year index values as expected. The very wet conditions of water year 2017 (the wettest year on record) brought groundwater levels back up overall on average by almost 5 feet which left levels slightly higher (0.4 feet) than 2012 conditions. While the *below normal year* of 2018 brought additional declines, the most recent 2019 WY brought levels back up 3.4 feet, resulting in groundwater levels 0.8 feet above 2012 conditions. It is important to note that this is a broad picture of how Butte County's groundwater levels have changed due to the fact that the data depicts an average change for all wells throughout the county and there can be wide variations in how groundwater levels respond to water year conditions over different areas of the county, between individual wells in the same area, amongst different types of wells and amongst wells with varying depths and screening intervals amongst other factors.

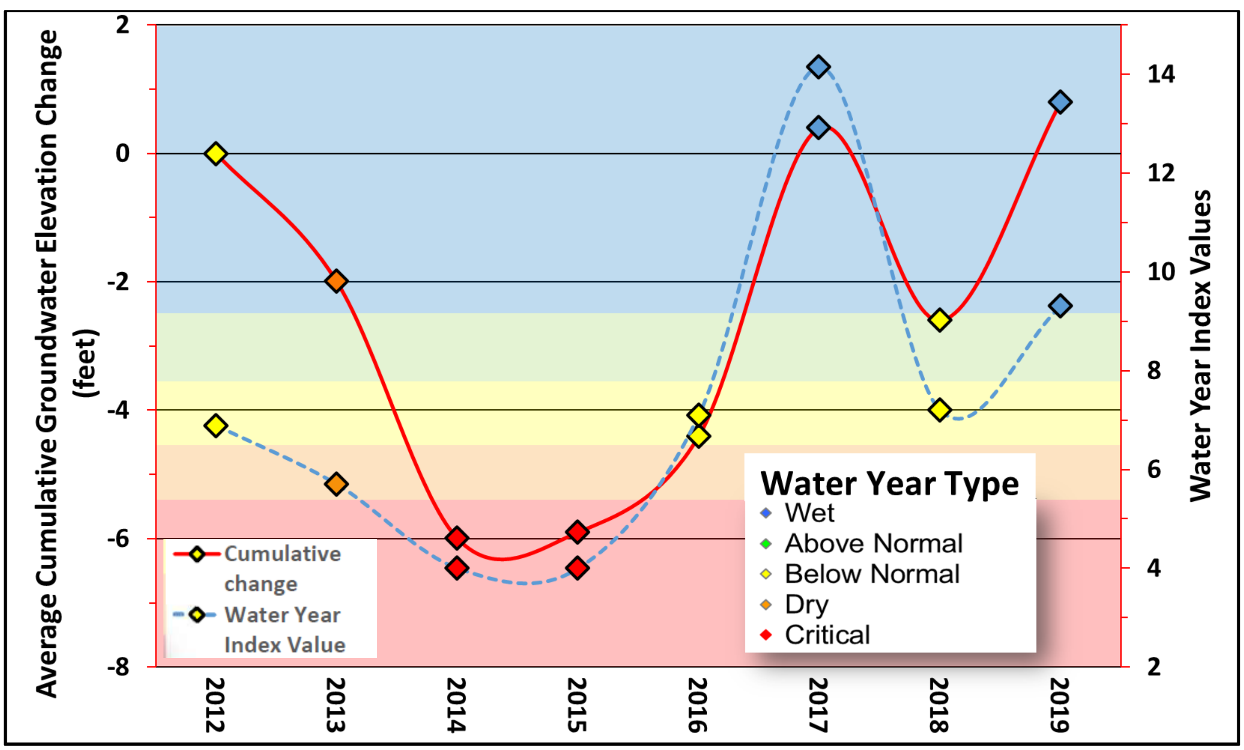

Figure 6. Cumulative Average Change of the Spring Groundwater Level Change in all Monitoring Wells from Water Years 2012 to 2019 and Water Year Index Values and Ranges

Summer measurements, as required by Chapter 33A, are conducted in July and August each year during periods of peak irrigation pumping. This results in more questionable measurements because measured or nearby wells are more likely to be pumping during the irrigation season than in the spring or fall. However, a number of wells in certain areas have a qualitative BMO related to maintaining summer groundwater levels at a level that will assure an adequate and affordable irrigation groundwater supply. Therefore, even though the data is less consistent because of direct pumping effects on water elevations, it provides a baseline for summer groundwater conditions on a regional scale. Summer data is reported by averaging the July and August measurements for each well. Summer groundwater levels in 2019 were 5.8 feet higher on average compared to groundwater levels in the summer of 2018 (Table 6). Even with questionable measurements included, these measurements and comparisons primarily reflect static groundwater conditions (non-pumping).

Table 6. Average Groundwater Elevation Change from Summer 2018 to Summer 2019 in all Butte County BMO program wells

Number of wells		Change (ft.)	Area
125	Average Groundwater Level Change	5.8	
	Median Groundwater Level Change	4.2	
106	Average Increase	7.3	
	Median Increase	5.9	
	Max Increase	24.7	Vina South
18	Average Decrease	-2.4	
	Median Decrease	-1.4	
	Max Decrease	-19.7	Butte

Note: Groundwater level measurements characterized as "Questionable measurements" (i.e. measurements taken during pumping, when nearby pumps were operating or taken from wells pumped recently) are included in the data due to the frequency of these observed field conditions. One well measured had no groundwater level change between summer of 2018 and summer of 2019.

Similar to spring of 2019, groundwater levels increased in the fall of 2019 in most areas compared to 2018 fall levels by an overall average change of 3.2 feet (Table 7). Of the 116 comparable well measurements, 99 of them had a higher 2019 fall level (average increase of 4.4 feet) than the corresponding 2018 fall measurement. Of the 14 measurements that were lower in 2019 compared to 2018, the average decrease was -4.9 feet. Hydrographs of individual groundwater level conditions in specific wells provide greater historical context for groundwater level trends (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer) and the groundwater level change maps (Appendix G) show where the greatest changes occurred.

Table 7. Groundwater Elevation Change from Fall of 2018 to Fall of 2019 in all Butte County BMO program wells

Number of wells		Change (ft.)	Area
116	Average Groundwater Level Change	3.2	
	Median Groundwater Level Change	3.6	
99	Average Increase	4.4	
	Median Increase	4.4	
	Max Increase	11.5	Vina South
14	Average Decrease	-4.9	
	Median Decrease	-2.2	
	Max Decrease	-22.8	Vina South

Note: Groundwater level measurements characterized as "Questionable measurements" (i.e. measurements taken during pumping, when nearby pumps were operating or taken from wells pumped recently) are not included in the data. Three wells measured had no groundwater level change between fall of 2018 and fall of 2019.

Seasonal Groundwater Level Change

In areas dependent on groundwater supplies for irrigation, groundwater levels decline as pumps turn on and the irrigation season progresses. To capture the effect of irrigation season pumping on groundwater conditions, summer levels are compared to spring levels of the same year. Table 8 compares groundwater levels in spring 2019 to summer 2019. Overall, the average decrease from spring of 2019 to summer of 2019 was -7.9 feet.

Table 8. Groundwater Elevation Change from Spring of 2019 to Summer of 2019 in all Butte County BMO program wells

Number of wells		Change (ft.)	Area
121	Average Groundwater Level Change	-7.9	
	Median Groundwater Level Change	-6.4	
11	Average Increase	0.9	
	Median Increase	0.6	
	Max Increase	3.9	Vina South
107	Average Decrease	-9.0	
	Median Decrease	-7.7	
	Max Decrease	-27.8	Vina South

Note: Groundwater level measurements characterized as "Questionable measurements" (i.e. measurements taken during pumping, when nearby pumps were operating or taken from wells pumped recently) are included in the data due to the frequency of these observed field conditions. Three wells measured had no groundwater level change between spring of 2019 to summer of 2019.

Basin Management Objectives

BMOs are established for a majority of the wells in the monitoring network; 58% of the wells for spring measurements and 51% of those monitored in the fall. BMOs are determined from historical data collected from each specific well as described in detail below. When a measurement fails to achieve the BMO for the well, a BMO Alert Stage of 1, 2 or 3 is reached depending on how low groundwater levels are recorded. When a BMO Alert Stage is reached, the Department increases outreach to stakeholders, seeks an evaluation by the TAC and may conduct additional monitoring. The BMO program has transitioned into a more SGMA relevant program and will sunset on the deadline for GSP submittals which is January 31, 2022. In the meantime, BMOs provide a standardized way to evaluate spring and fall changes in groundwater levels. Two methods are used to determine BMOs, as described in Chapter 33A.

Historic Range Method

This method has two procedures depending upon the period of record for the well. The first procedure is for wells that have a period of record beginning any time before 1970. Measurements up through 2006 are used to set the Alert Stage 1 threshold by taking the historical low reading and adding 20% of the range of measurements, calculated from the first year on record through 2006. Measurements at or below this threshold and above the historical low would indicate an Alert Stage 1. Measurements at or below the historical low would indicate an Alert Stage 2. The measurements plotted after 2006 are for reference purposes only, and are not included in the calculation of the range.

The second procedure is for wells that have a period of record beginning after 1970. For these wells, the historical low measurement prior to 2006 indicates an Alert Stage 1. The historical low measurement minus the range of measurements indicates an Alert Stage 2. The measurements plotted after 2006 again are for reference purposes only, and are not included in the calculation of the range.

Specific Depth Method

For this method, the BMO is set at five feet below the average spring groundwater level calculated for the well. An Alert Stage 1 is reached if the spring measurement falls five feet below the average groundwater level (calculated from the first year on record through 2006). An Alert Stage 2 is reached if spring groundwater levels, for a second consecutive year, remain five feet below the average groundwater level established for the well. An Alert Stage 3 is reached if the spring groundwater level falls ten feet below the average spring groundwater level established for the well. All of the sub-inventory units previously established for this program utilize the historical range method, except for Richvale and Western Canal which use the specific depth method. The specific depth method does not have corresponding fall BMOs.

Summary of Alert Stages Reached

A number of wells reached Alert Stages for both spring and fall BMOs in 2019. No wells reached an Alert Stage 3 (specific depth method only). The number of wells at an Alert Stage for 2008 - 2019 with spring and fall BMOs assigned are shown in Table 9 and Table 10, respectively.

Table 9. Number of Wells in Spring BMO Alert Stages from 2008 to 2019

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Alert 1	27	33	25	24	25	20	26	22	17	13	19	16
Alert 2	0	6	3	0	4	15	21	25	25	11	19	9
Alert 3	0	0	0	0	0	0	0	0	0	0	0	0
Total	26	37	28	24	29	35	45	46	42	24	36	25

Note: Alert Stage 3 only applies to spring measurements and are not established for fall measurements

Table 10. Number of Wells in Fall BMO Alert Stages from 2008 to 2019

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Alert 1	26	27	24	5	24	21	19	13	20	21	22	10
Alert 2	2	1	2	2	6	14	18	26	18	8	13	7
Total	29	30	26	9	32	39	40	41	39	30	36	17

Figure 7 provides a graphical representation of the number of wells in Alert Stages 1 or 2 throughout the past twelve years over the varying water year types. The percentage of wells in either an Alert Stage 1 or 2 of those with assigned Alert Stages are also depicted. Only half of all of all of the wells monitored in the fall every year have Alert Stages assigned to them. This is due to the fact that a significant number of wells were added to the monitoring network between 1999 and 2001 and did not have a sufficient period of record to establish Alert Stages and BMOs. During this time period, the 2011 water year, a *wet* water year, had the lowest percentage (13%) of wells in Alert Stage 1 or 2, followed by the 2019 WY which had the second lowest percentage of wells in Alert Stage (30%) of the years depicted. The 2015 water year, a *critical* water year and the last year of the 2012 – 2015 drought, had the highest percentage (74%) of wells in Alert Stages 1 and 2.

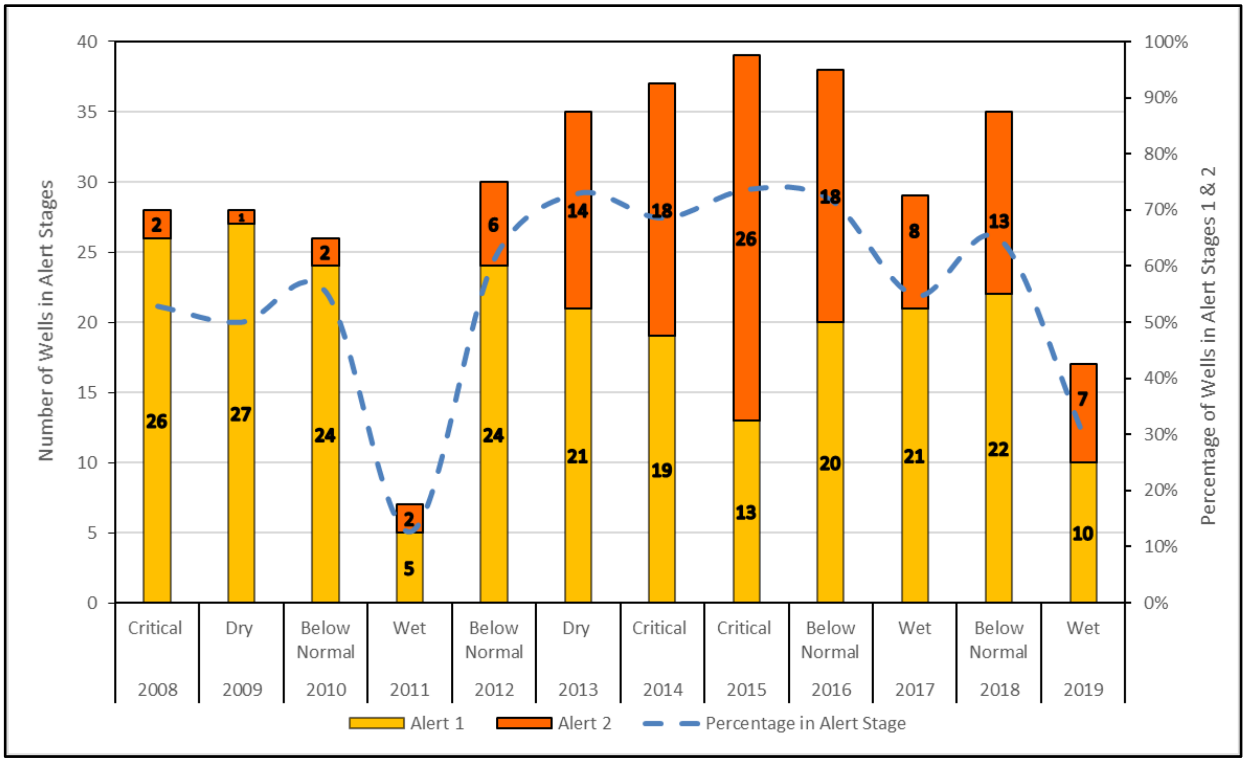

Figure 7. Number and Overall Percentage of Wells with Fall Alert Levels 1 and 2 from 2008 to 2019 and Water Year Type

Additional details on groundwater conditions for specific wells can be found in the DWR SGMA Data Viewer Tool (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer). Past Annual Groundwater Status Reports included individual BMO reports prepared for the sixteen sub-inventory units in Butte County. As the Department continues to adaptively manage SGMA responsibilities and transition this Annual Groundwater Status Report to meet SGMA requirements for GSPs, changes to the BMO program are underway as described earlier, including the removal of individual sub-inventory units BMO reports from the annual report. Future annual reports / GSPs will provide additional information regarding groundwater conditions and the sustainability of current and future groundwater management will be not only be more relevant, but also more enforceable.

The BMO reports from previous annual reports can be accessed from the Department's website under 'REPORTS' then 'GROUNDWATER STATUS REPORT' and 'View Previous Reports' at: https://www.buttecounty.net/waterresourceconservation/viewpreviousyears