Agenda Item #5

Butte County Department of Water and Resource Conservation

Groundwater Status Report

2017 Water Year

Submitted February 2018

Executive Summary- 2017 Water Year

The 2017 water year started strong with over four inches of rain in October and each month after that through April had one or more significant storms that brought multiple inches of precipitation. The wet winter led to a new record for the Northern Sierra 8-station index making 2016-2017 the wettest year on record, surpassing the previous record that occurred in 1982-1983. In April of 2017, Governor Brown lifted the drought emergency declaration for most of California that had been in effect since January 2014. Overall, the 2017 Water Year was characterized by wet conditions, high runoff, and increased groundwater levels throughout Butte County. In many parts of the state, focus shifted from drought to flood response including the extensive evacuation ordered due to the Oroville Spillway incident. From one extreme to another, 2017 WY brought both challenges and relief for water managers across the state.

The 2017 water year began October 1, 2016 and was classified as a wet year for the Sacramento Valley. It followed a below normal year, two critical years, and a dry year. The wet conditions were a welcome relief from a historically dry period with little rain and snow. According to the Northern Sierra Precipitation 8 Station Index, the 2017 WY ended on September 30, 2017 with 94.7 cumulative inches of precipitation, 183% of the long-term average. The *statewide* total annual precipitation was about 165% of the long-term average. Another measure of hydrologic conditions is the amount of runoff to streams and rivers. The Sacramento River Region unimpaired runoff during the 2017 WY was 37.9 million acre-feet (MAF), which is about 212% of average. April 1 snowpack statewide was 160% of the April 1 average. The robust runoff and snowpack helped fill reservoirs across the state. Storage in the state's reservoirs as 2017 WY ended held 120% of their historical average. Although by some measures 2017 was a historically wet year, it joins only two other wet years (2006 and 2011) in the past 12 years that were otherwise classified as critical, dry or below normal.

The wet conditions of 2017 provided a welcome improvement to groundwater conditions throughout the basin in Butte County. Although groundwater levels increased significantly, this one wet year did not make up for the cumulative effect of the multiple dry years that resulted in significant declines, particularly in groundwater dependent areas. Even as groundwater levels have come up, they continue to be near historical lows where declines during the drought were greatest. The Department, in cooperation with the Department of Water Resources Northern Region Office, conducts four (spring, July, August, fall) groundwater level measurements annually. Spring groundwater levels in 2017 were almost 5 feet higher on average compared to the spring of 2016 (see Table 4). Fall groundwater levels in October 2017 were about three feet higher on average compared to October 2016. Although the number of wells in alert 1 or 2 have declined, others remain at a spring and/or fall alert stage 1 or 2 indicating levels remain near historical lows (Table 8 and Table 9).

The Department conducted its sixteenth year of groundwater quality trend monitoring for evidence of saline intrusion during July 24-27 and August 3, 2017. All samples were within the acceptable range for electrical conductivity and pH, and temperatures remained relatively

consistent. The 2017 Water Quality Trend Monitoring Report can be found in Appendix D and highlights are included later in this report.

Subsidence is monitored by periodic land surveys and by use of extensometers. No inelastic land subsidence was detected in Butte County from an evaluation of the extensometer records in the Western Canal, Richvale, and Biggs-West Gridley sub-inventory units. A Sacramento Valley-wide GPS survey was conducted during 2017. Results of the survey will be available in 2018 and will provide additional land subsidence data throughout the county to better measure and detect possible subsidence.

Table of Contents

Executive Summary- 2017 Water Year i
Foreword 1
Hydrologic Conditions 4
Precipitation 7
Feather River Surface Water Diversions 8
Groundwater Conditions 9
Monitoring Frequency 9
Groundwater Quality Trend Monitoring 9
Land Subsidence 11
Well Permits 13
Groundwater Level Monitoring 13
Change in Groundwater Levels: 2016 to 2017 15
Seasonal Groundwater Level Change 16
Basin Management Objectives (BMOs) 17

Well Numbering System — Appendix A
Butte County Monitoring and CASGEM Network Maps — Appendix B
Groundwater Level Alert Stage Maps — Appendix C
2017 Water Quality Trend Monitoring Report — Appendix D
Spring, Summer, & Fall BMO Summary Tables — Appendix E
DWR Groundwater Level Contour & Change Maps — Appendix F
Basin Management Objective Reports — Appendix G

East Butte Sub-basin
- Biggs-West Gridley SIU
- Butte SIU
- Butte Sink SIU
- Cherokee SIU
- Esquon SIU
- Pentz SIU
- Richvale SIU
- Thermalito SIU
- Western Canal SIU

West Butte Sub-basin
- Angel Slough SIU
- Durham-Dayton SIU
- Llano Seco SIU
- M&T SIU

Chico Urban Area SIU
Vina Sub-basin/SIU
North Yuba Sub-basin/SIU

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 2017 water year, October 1, 2016 - September 30, 2017. The fall measurements taken in mid-October 2017 are also included since they reflect conditions and activities of the 2017 water year. The report gives general information regarding locations of wells and extensometers, statistics related to groundwater level trends, historical precipitation information and hydrographs depicting groundwater levels over time (included in the individual BMO reports in Appendix G). This report was prepared by the Butte County Department of Water and Resource Conservation (Department) with assistance from DWR, Northern Region and the Technical Advisory Committee. 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 (BBWUA).

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 21st of each year. In 2010, the Water Commission designated the Department of Water and Resource Conservation 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 has 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 (GMP) that includes the components of the BMO program. In 2011, Chapter 33A was amended and retitled to "Basin Management Objectives (BMO)" and now requires the BMO report be submitted in February of each year. The foregoing actions by the

Board allow the reporting of groundwater conditions from Chapter 33 and 33A to be consolidated into a single report to be submitted by the Department on an annual basis in February.

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 (Appendix B). The 72 wells comprise primarily dedicated monitoring wells and some key wells identified in the Annual Groundwater Status Report.

Data from published reports prepared for the Butte County Department of Water and Resource Conservation 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 Butte County Department of Water and Resource Conservation website.

The Groundwater Status Report will undergo revisions in the next few years in order to meet requirements of the Sustainable Groundwater Management Act. On September 16, 2014, Governor Brown signed into law a package of bills collectively called the Sustainable Groundwater Management Act. The Sustainable Groundwater Management Act requires local management of groundwater basins, and provides the state with broad oversight authority and the ability to intervene. Local management of basins is the responsibility of a local public agency or combination of local agencies that designate themselves as the "Groundwater Sustainability Agency" for all or a portion of their basin. Local public agencies eligible to be a Groundwater Sustainability Agency (GSA) must have water supply, water management or land use responsibilities. If no Groundwater Sustainability Agency is formed by June 30, 2017, the State Water Board could assume management of that basin. All four of the groundwater basins within Butte County have established GSAs covering the entirety of the basin and met the requirements of this first important deadline. Groundwater Sustainability Agencies must prepare and implement Groundwater Sustainability Plans ("Plan") for their basin or their portion of their basin or face the prospect of state intervention. Plans must be adopted by January 31, 2020, for basins that are in critical overdraft condition or by January 31, 2022, for all other basins. Since the basins in Butte County are not in critical overdraft, Plans will have to be submitted by January 31, 2022. Plans must contain the same elements as those in Groundwater Management Plans. Additionally, Plans must include a water budget covering a 50 year planning horizon, measurable objectives and interim milestones (every 5 years) that will lead to sustainability in 20 years. Plans 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. Plans are exempt from the California Environmental Quality Act but projects or actions to implement the plan are not exempt.

Groundwater Sustainability Agencies must submit an annual report to DWR by April 1st. The 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 2023. A likely approach will be to modify the County's annual Groundwater Status Report to meet the requirements of the report that must be submitted by Groundwater Sustainability Agencies for each basin.

Hydrologic Conditions

There are a number of data sources and indices available to characterize hydrologic conditions. The data sources typically report hydrologic data on a water year basis, or the 12-month period from October through September. The 2017 WY began on October 1, 2016 and ended on September 30, 2017. The 2017 WY was classified as *wet* for the Sacramento Valley. At the end of the 2017 WY on September 30, 2017, *statewide* hydrologic conditions were as follows: precipitation was 165% of average; runoff was 215% of average; and reservoir storage, 120% of average. Sacramento River Region unimpaired runoff observed through September 30, 2017 was about 37.9 million acre-feet (MAF), which is about 212% of average. For comparison, Table 1 shows the volume and percent of average runoff for the previous water years since the last wet year occurred in 2011.

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

WATER YEAR	2017	2016	2015	2014	2013	2012	2011
UNIMPAIRED RUNOFF (MAF)	37.9	17.4	9.2	7.5	11.9	11.8	25.2
% OF AVERAGE	212%	98%	51%	41%	65%	65%	138%

The Northern Sierra 8-Station Precipitation Index (Figure 1) serves as a wetness 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 2017 WY ended with 94.7 cumulative inches of precipitation which is 183% of the long term average. The 2017 WY surpassed the previously recorded wettest year of 1982-1983 that had 88.5 cumulative inches. The 2017 WY curve is labeled "2016-2017 Daily Precip (wettest)" on Figure 1.

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

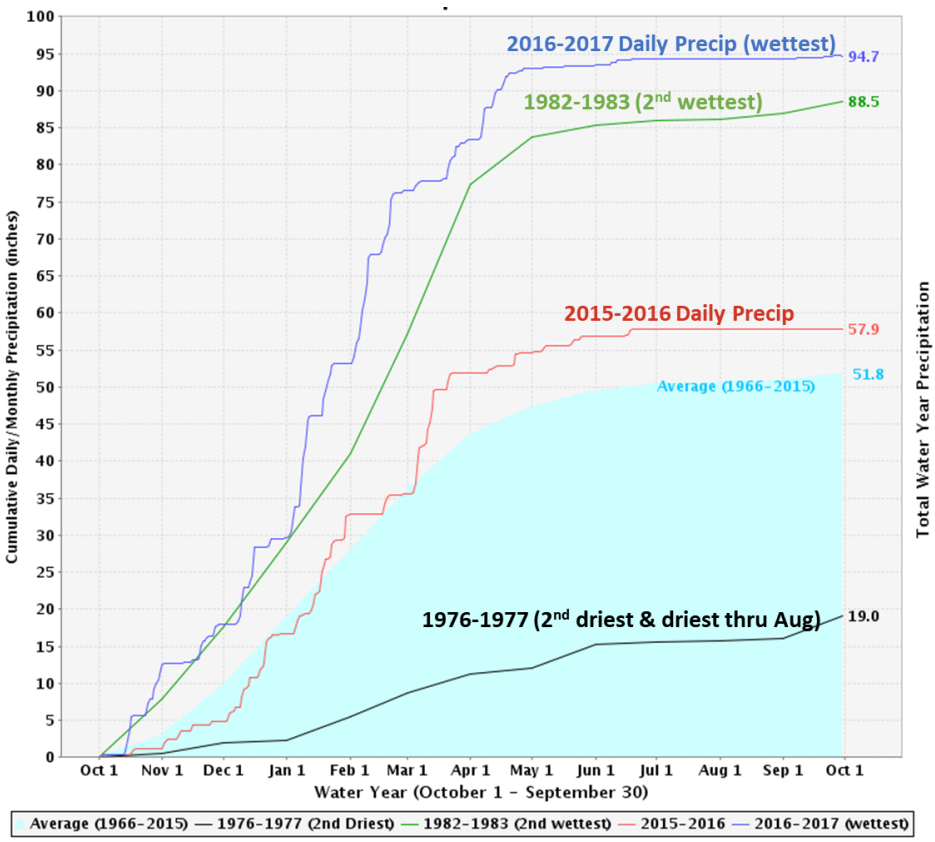

Figure 1. Northern Sierra Precipitation: 8 Station Index

Figure 2 shows the water year type classifications based on the Sacramento Valley 40-30-30 Index going back to 1960. The Sacramento Valley was classified as *wet* for the 2017 WY with an index value of 14.9 (Figure 2). Water year classification systems provide a means to assess the amount of water originating in a basin.

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 State Water Resources Control Board (SWRCB) for the Sacramento hydrologic basins based on Sacramento River runoff. This system defines one *"wet"* classification, two *"normal"* classifications (above 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 percent), the current water year's October-March runoff (30 percent), and the previous water year's index (30 percent). A cap of 10 MAF 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 Classification is:

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

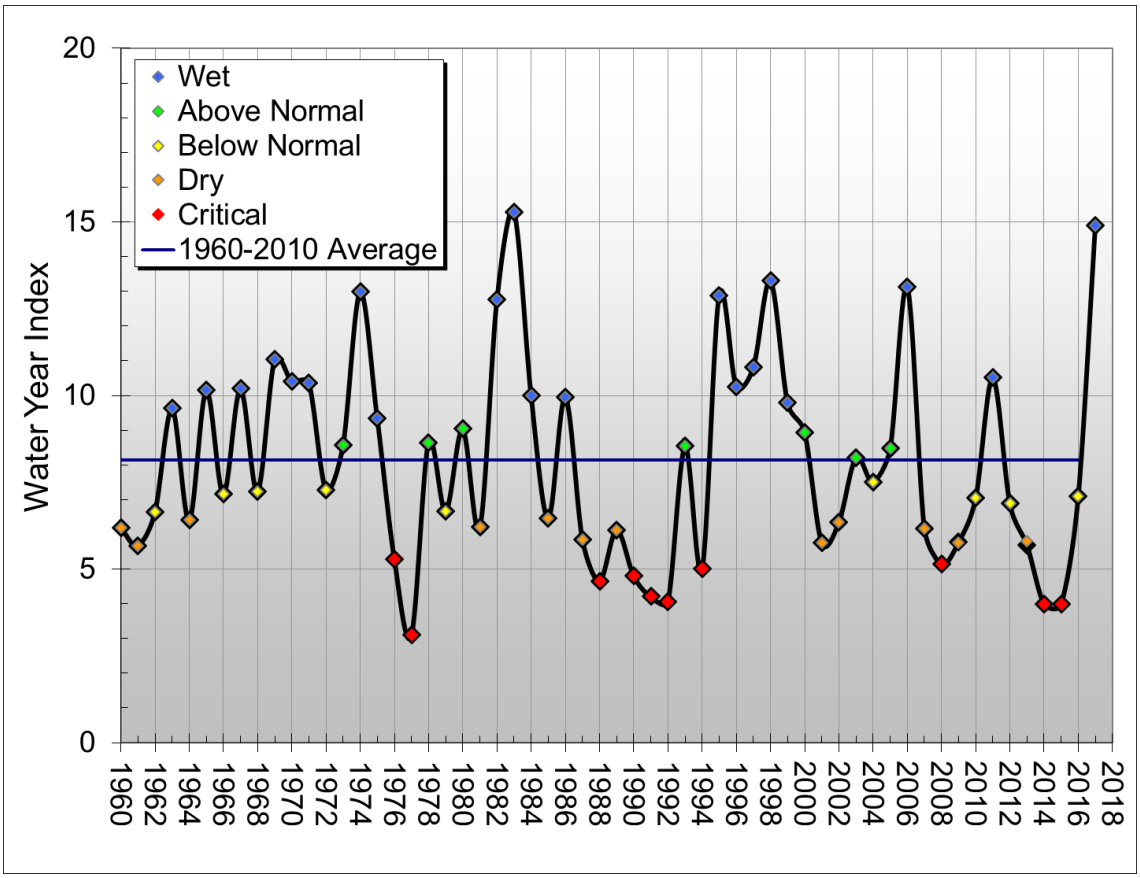

Figure 2. Sacramento Valley Water Year Type Index 40-30-30

Precipitation

Figure 3 shows the total annual precipitation at the Western Canal Station for the 57-year period, water years 1960 through 2017. Precipitation for the 2017 WY measured at Western Canal Water District's Climatological Observation Station totaled 31.9 inches (151% of average). This is 10.74 inches above the 50-year average of 21.15 inches.

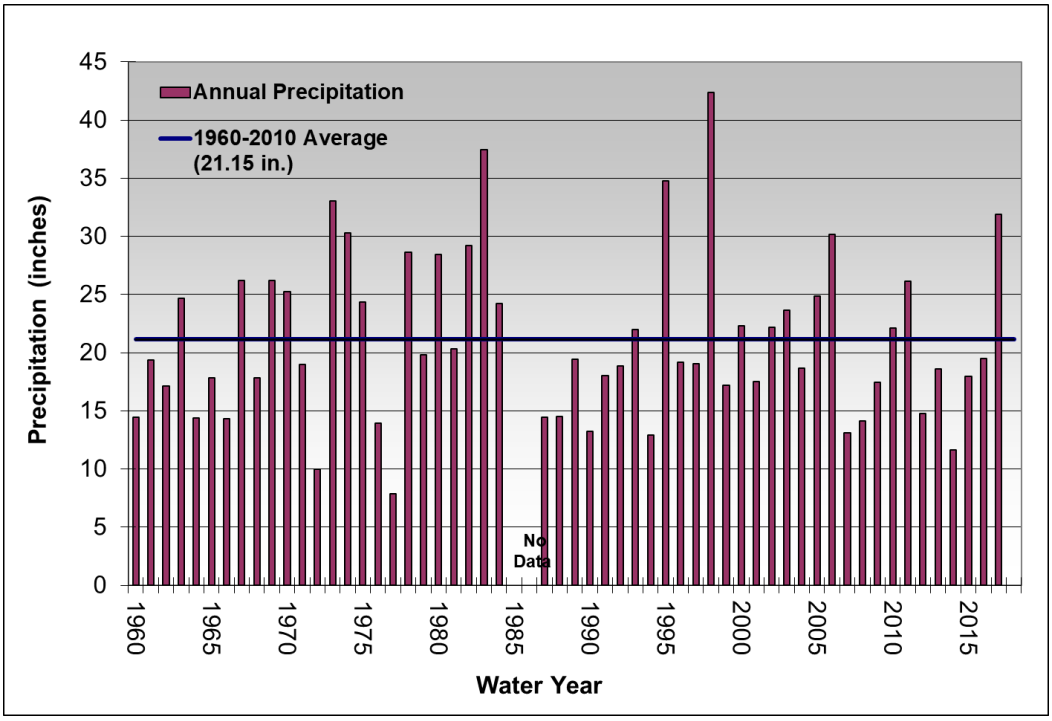

Figure 3. Annual Precipitation 1960-2017 Water Years -Western Canal Climate Station

The timing of rainfall in the valley influences irrigation water use. The daily precipitation in the 2017 WY reported from the California Irrigation Management Information System (CIMIS) station in Durham provides an indication of when and how much rainfall occurred and how that may affect the irrigation season (Figure 4). The graph of daily precipitation shows storm activity throughout the fall, winter, and spring with nine separate storm events measuring over 1 inch of precipitation in a single day. Due to the wet spring, the irrigation season began later than usual, likely near the beginning of May. According to discussion by the Water Advisory Committee, water use for frost protection was needed for 4-5 nights at the end of February.

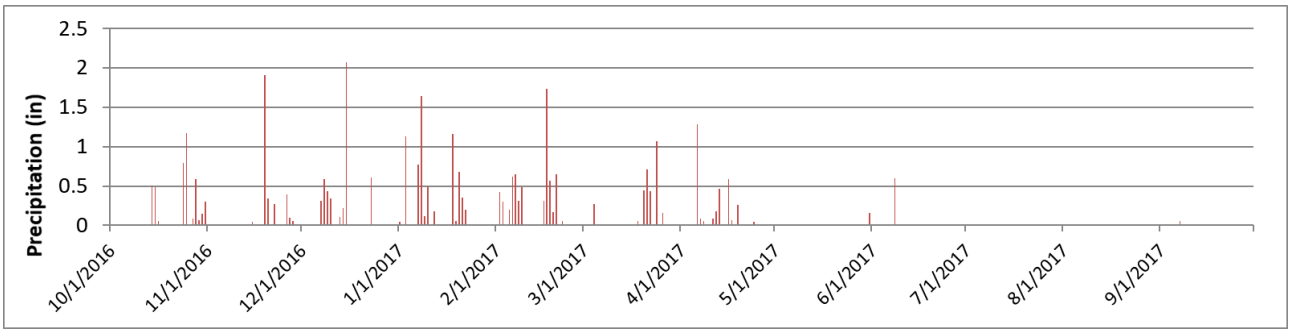

Figure 4. Daily Precipitation (inches) - Durham CIMIS station

Feather River Surface Water Diversions

Surface water is an important component of the water supply and has benefits to aquifer recharge in the Butte Basin. During the 2017 WY, 880,633 acre-feet (AF) of surface water was diverted by Western Canal Water District (WCWD) and the Joint Water Districts Board. The 2017 WY diversions increased by 50,563 AF from the 2016 WY amount and over 200,000 AF more than in 2015. However, the amount of surface water diversions was below normal years due to a reduction in planted rice acreage. Rice acreage was reduced due to unusually wet field conditions late into the spring. In the 2015 WY, WCWD 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 basin. This results in generally shallow and stable groundwater conditions in these district areas. Table 2 summarizes diversions in acre-feet to Western Canal Water District and the Joint Water Districts Board for water years 2000 to 2017.

Table 2. Surface Water Diversions (acre-feet)

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

* Joint Water Districts Board includes Biggs-West Gridley Water District, Butte Water District, Richvale Irrigation District, and Sutter Extension Water District.
** 50% Curtailment of surface water deliveries due to drought

Groundwater Conditions

Monitoring Frequency

Butte County Code, Chapter 33 and 33A, calls 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 (4) times per year, during the months of March, July, August, and October. The California Department of Water Resources (DWR) and the Butte County Department of Water and Resource Conservation (Department) share the monitoring duties. DWR conducts the spring, fall and August measurements while the Department does the July measurement. As part of County's drought assessment activities, the frequency of groundwater elevation monitoring was increased to monthly monitoring from March to October in 2014-2016.

Groundwater Quality Trend Monitoring

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

Highlights from 2017

- 12 of the 13 wells were sampled July 24-27 and August 3, 2017
- 1 well was temporarily inaccessible
- Temperatures remained relatively consistent in all water samples
- All measurements were within the acceptable range for pH
- All samples were within the acceptable range for electrical conductivity
- No evidence of saline intrusion

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 the acceptable range. The 2017 Water Quality Trend Monitoring Report can be found in Appendix D.

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 Basin Management Objective (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 can trigger a BMO Alert Stage. For example, if the temperature is more than five degrees outside of the historical range of measurements a BMO Alert Stage is reached. If the pH is below 6.5 or above 8.5, a BMO Alert Stage is reached. A BMO Alert Stage for electrical conductivity (EC) is reached if the measurements are greater than 900 µS/cm for drinking water or greater than 700 µS/cm for agricultural water use. These ranges are based on secondary water quality standards established by the US Environmental Protection Agency (US EPA). Secondary standards relate to the taste, odor, color, corrosivity, foaming, and staining properties of water whereas primary standards are based on health considerations.

2017 Results

To date, temperature has 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. The 2017 measurements were all within 1.0 ^{o}C of the average temperature for each well. The 16 year temperature range for all wells is less than 5 ^{o}C. The lowest temperature reading was in the M&T well (17.2 ^{o}C) and the high was in the Pentz well (21.6 ^{o}C).

Measurements for pH remained relatively stable compared to previous years. The highest pH was found in the Llano Seco well (7.7) and the lowest in the Chico Urban Area and Western Canal (East) (7.0). All measurements for pH were well within the secondary water quality thresholds of 6.5-8.5

Electrical conductivity (EC) 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 a particular well (Western Canal-west), yet 2017 measurements were all well within the secondary water quality thresholds established by State and Federal regulatory agencies. The highest EC measurement was from the M&T well (498 µS/cm) and the lowest was from the Thermalito well (136 µS/cm). Appendix D contains a monitoring network map, data tables, and graphs.

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

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, drains, and water transport structures, failure of water well casings due to compressive stresses generated by compaction of aquifer systems, 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, three extensometers measure land surface displacement in Butte County (Figure 5). These extensometers have a period of record beginning in 2005 and continuously monitor for subsidence. Records are available by contacting DWR Northern Region or from the Northern Region website[5]. To date, no inelastic land subsidence has been recorded in Butte County.

Figure 5. Extensometer Locations (continuous data available online)

[4] http://water.usgs.gov/ogw/pubs/fs00165/

[5] http://www.water.ca.gov/groundwater/data_and_monitoring/northern_region/LandSubsidence/available_data.cfm

Extensometer data is shown in Figure 6 for each monitoring station. For practical purposes, the error in measurements is about +/- 0.01 feet so the graphs include only changes greater than this amount which are negative indicating subsidence (rather than uplift). Data is available through August 2, 2017. A Sacramento Valley-wide GPS survey was conducted during 2017. Results of the survey will be available in 2018 and will provide additional land subsidence data throughout the county to better measure and detect possible subsidence.

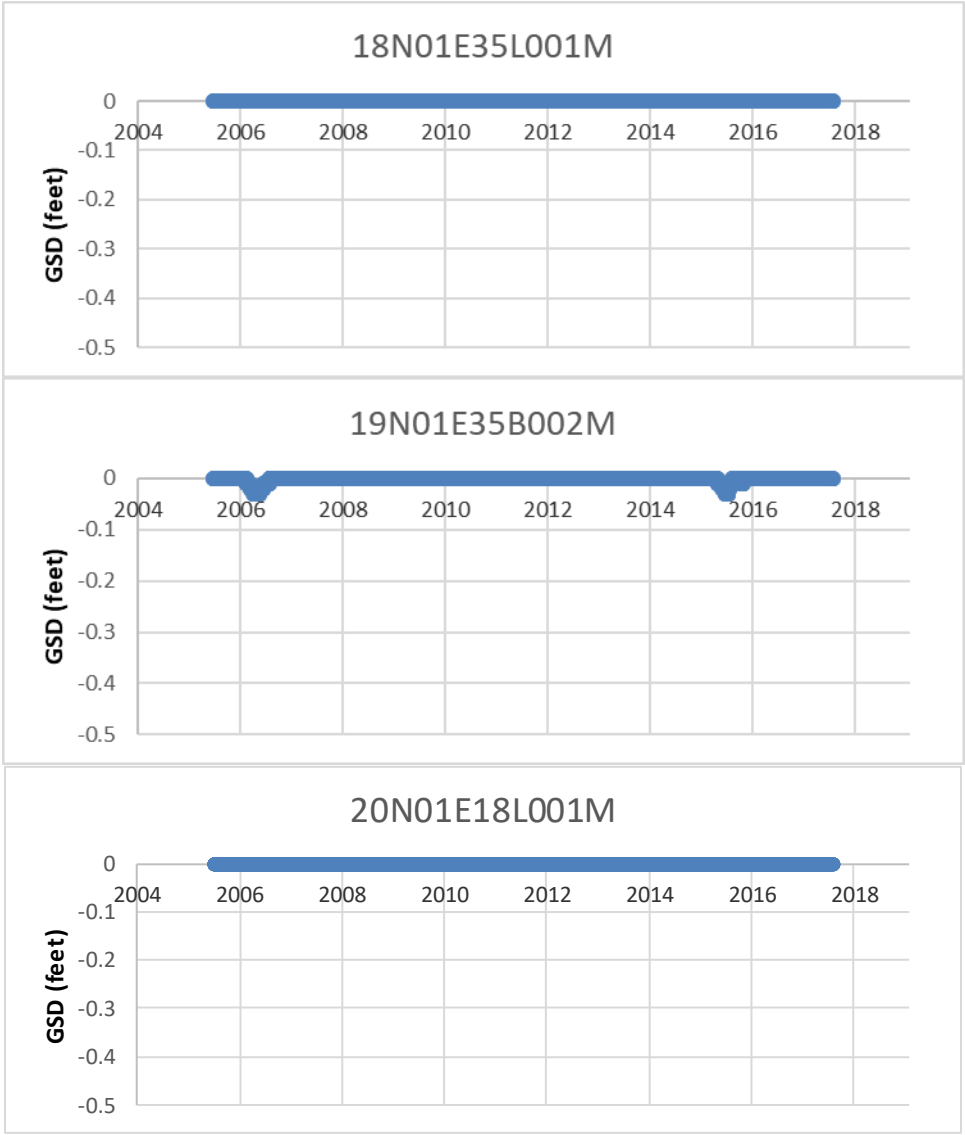

Figure 6. Ground Surface Displacement (GSD) in Feet

Well Permits

Well permits are issued by the Butte County Department of Environmental Health for all water wells drilled throughout the county. Although the number of well permit applications does 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 has over 12,000 domestic wells and 2,500 irrigation wells. When combined with municipal, monitoring and other well types (stock water, test wells, abandoned, or unidentified wells) the total well count in the county is about 17,554[6]. Table 3 shows the number of well permit applications received by the Department of Environmental Health for the following categories from 2006-2017: Small Diameter, Large Diameter, and Well Repairs and Deepening. Each of the categories is described below Table 3.

Table 3. Number of Well Permit Applications Per Water Year

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

** 2006, 2011 and 2017 were wet years, all others are below normal, dry, or critical water years*

Small Diameter- wells with a casing diameter of 8 inches or less.
Large Diameter- wells with a casing diameter greater than 8 inches, generally for irrigation.
Well Repairs & Deepening- an existing well is 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, 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. In this case, the pump can be lowered if the well is deep enough and allows for that. This does not require a permit from the County. If the well is not deep enough, it may be possible to deepen it. Well permits are issued for this activity and homeowners should enlist a licensed well driller to conduct the work.

Groundwater Level Monitoring

Groundwater levels typically fluctuate seasonally and from year to year. Seasonal fluctuation of groundwater levels occur in response to groundwater pumping and recovery, land and water use activities, recharge, and natural discharge. Precipitation, applied irrigation water, local creeks and rivers, and the Thermalito Forebay and Afterbay all recharge groundwater in Butte County. Groundwater pumping for irrigation typically occurs April-September although depending on the

[6] Butte County Water Inventory and Analysis, 2016

timing of rainfall, it may shift earlier and later. 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 127 wells are monitored for groundwater levels in Butte County as part of the BMO program (77 of them are assigned BMO spring alert levels). These wells consist of a mixture of domestic and irrigation wells, along with dedicated observation wells and ten Cal Water municipal supply wells in Chico and Oroville. Approximately 59 of the 127 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. The groundwater level monitoring methods are consistent with the procedures described in the Department of Water Resources' Groundwater Elevation Monitoring Guidelines (December 2010)[7].

Groundwater elevations are measured using a steel tape, electric sounder, or by transducers. The accuracy of the groundwater level measurement is approximately one tenth of a foot. In addition to the groundwater level monitoring conducted by Butte County and the DWR, California Water Service Company currently measures monthly groundwater levels in approximately sixty municipal groundwater supply wells in the Chico Urban and Oroville areas. Ten of these wells are included in the BMO program and assigned alert stages.

Data from groundwater level monitoring can be obtained through DWR and the Department's websites. The primary access to the data is through the California Statewide Groundwater Elevation Monitoring (CASGEM) program (http://www.water.ca.gov/groundwater/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 basins throughout the state. As a result of this legislation, DWR migrated the groundwater level data from the Water Data Library (WDL) to the CASGEM database. DWR has reintroduced access to groundwater monitoring data through an updated WDL.

[7] http://www.water.ca.gov/groundwater/casgem/documents.cfm

(http://www.water.ca.gov/waterdatalibrary/). Summary data tables of groundwater surface elevations from spring, summer, and fall measurements are included in Appendix E and are available from the Department's website.

Change in Groundwater Levels: 2016 to 2017

The 2017 water year was classified as a wet year with record wet conditions as measured by the Northern Sierra 8 Station Index. Groundwater conditions responded positively to the wet winter with generally higher groundwater levels in 2017 compared to 2016. The overall average change in observed groundwater levels from spring 2016 to spring 2017 was an increase of 4.8 feet. Of the 116 comparable wells, 97 of them had a higher spring level compared to 2016. The average increase was about 6.0 feet. Of the 19 wells that had lower measurements in 2017 compared to 2016, the average decrease was about 1.3 feet (Table 4). The historically wet winter led to significantly higher groundwater levels, particularly in the Chico and Durham areas that experienced some of the greatest declines during the 2012-2015 drought period. In general, increases in groundwater levels throughout the basin in 2017 were in line with the declines observed in the worst of the drought years (spring 2013 to spring 2014), but were not enough to compensate for the cumulative effect of multiple dry years of the drought.

Table 4. Groundwater Elevation Change- Spring 2016 to Spring 2017

Well Count		Change (ft)	SIU
116	**Average GWL Change**	**4.8**	
	Median GWL Change	4.0	
97	**Average Increase**	**6.0**	
	Median Increase	5.5	
	Max Increase	24	*Chico Urban Area*
19	**Average Decrease**	**-1.3**	
	Median Decrease	-1.2	
	Max Decrease	-3.6	*Biggs/West Gridley*

Note: Wells with Questionable Measurements not included

Summer measurements, as required by Chapter 33A, are conducted in July and August during peak pumping for irrigation. 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 the sub-inventory units (SIUs) 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. The summer groundwater levels in 2017 were about 4 feet higher on average compared to groundwater levels in 2016 (Table 5). Even with questionable measurements included, these measurements and comparisons primarily reflect static groundwater conditions (non-pumping).

Table 5. Groundwater Elevation Change- Summer 2016 to Summer 2017

Well Count		Change (ft)	SIU with Min/Max
115	**Average GWL Change**	**4**	
	Median GWL Change	**4**	
97	**Average Increase**	**5**	
	Median Increase	5	
	Max Increase	16	M&T
18	**Average Decrease**	**-1**	
	Median Decrease	-0.5	
	Max Decrease	-2.2	Biggs W. Gridley

Note: DOES include Questionable Measurements (i.e. pumping, nearby pump operating, pumped recently) because they are very common due to summer pumping

Like spring levels, fall water levels in 2017 increased in most areas compared to 2016 fall levels by an overall average change of about 3 feet (Table 6). Of the 113 comparable well measurements, 91 of them had a higher 2017 fall level (average increase of 4 feet) than the corresponding 2016 fall measurement. Of the 22 measurements that were lower in 2017 compared to 2016, the average decrease was about 2 feet. Hydrographs in the individual BMO reports provide greater historical context for groundwater level trends (Appendix G) and the groundwater level change maps (Appendix F) show where the greatest increases occurred.

Table 6. Groundwater Elevation Change- Fall 2016 to Fall 2017

Well Count		Change (ft.)	SIU
113	**Average GWL Change**	**3**	
	Median GWL Change	3	
91	**Average Increase**	**4**	
	Median Increase	4	
	Max Increase	12	*Vina*
22	**Average Decrease**	**-2**	
	Median Decrease	-1	
	Max Decrease	-11	*Butte Sink*

Note: Wells with Questionable Measurements not included

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 7 compares groundwater levels in spring 2017 to summer 2017. Overall, the average decrease from spring to summer 2017 was about 9 feet.

Table 7. Groundwater Elevation Change- Spring 2017 to Average Summer 2017

Well Count		Change (ft)	SIU with Min/Max
112	**Average GWL Change**	**-9**	
	Median GWL Change	-9	
7	**Average Increase**	**1**	
	Median Increase	1	
	Max Increase	2.5	Pentz
105	**Average Decrease**	**-10**	
	Median Decrease	-10	
	Max Decrease	-27	Vina

Note: DOES include Questionable Measurements (i.e. pumping, nearby pump operating, pumped recently) because they are very common due to summer pumping

Basin Management Objectives (BMOs)

BMOs are established for most of the wells in the monitoring network (77 of 127 wells for spring measurements and 69 of 127 for fall). BMOs are determined from historical data collected for the specific well. When a measurement fails to achieve the BMO for the well, a BMO Alert Stage is reached. When a BMO Alert Stage is reached, the Department increases outreach to stakeholders, seeks an evaluation by the Technical Advisory Committee and may conduct additional monitoring. Under the BMO program, stakeholders from the SIU participate in the evaluation and outreach of BMO data. The 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 dating back to at least 1970. Measurements up through 2006 are used to set the BMO. The BMO is set by taking the historical low reading and adding 20% of the range of measurements, calculated from the first year on record through 2006. Measurements below the BMO 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 SIUs 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.

A number of wells reached Alert Stages for both spring and fall BMOs in 2017. No wells reached an Alert Stage 3 (specific depth method only). The number of wells at an Alert Stage for 2008-2017 spring and fall BMOs are shown in Table 8 and Table 9, respectively.

Table 8. Spring BMO Alert Stages

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Alert 1	26	31	25	24	25	20	24	21	17	13
Alert 2	0	6	3	0	4	15	21	25	25	11
Alert 3	0	0	0	0	0	0	0	0	0	0
Total	26	37	28	24	29	35	45	46	42	24

Table 9. Fall BMO Alert Stages

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Alert 1	27	29	24	7	26	23	21	16	21	22
Alert 2	2	1	2	2	6	16	19	25	18	8
Total	29	30	26	9	32	39	40	41	39	30

*Alert 3 only applies to spring measurements

Additional details on groundwater conditions can be found in the BMO reports (Appendix G) prepared for the sixteen SIUs in Butte County. These SIUs are located in one of four groundwater sub-basins: Wyandotte Creek, East Butte, West Butte, and Vina. The BMO reports include information on monitoring activities, current conditions, BMOs, hydrographs, and recommendations from stakeholders. Additionally, the BMO reports include hydrographs on wells that are selected for the program's network but do not have a corresponding BMO. These wells were either key monitoring wells that were monitored prior to the BMO program or are wells recently added to the monitoring network. The recently added wells are typically dedicated monitoring wells and do not yet have enough data to establish a BMO Alert Stage.

The 2018 BMO reports (Appendix G) for each of the sixteen SIUs can be accessed from the Department's website under 'Reports' then 'Groundwater Status Reports' at: http://www.buttecounty.net/waterresourceconservation.